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Die Entstehng von AbriBlüften an der Treffelhausener Berghalbinsel

Jens Hotming, Helmut Scheel

RESUM

La muntanya peninsular de Treffelhausen, situada a 45 km. E. SE. de Stuttgart, forma part de Jura Souabe. La gran quantitat d'estructures geològiques permet de percebre les més diverses influències en la formació de les falles. En el transcurs de les exploracions, hem pogut constatar que són les bases margoses de l'Oxfordià 1 i del Kimeridgià 1 les que es desplacen, contradint així l'opinió general de que els blocs calcaris eren els qui Iliscaven.

La prova d'això l'ha constituit el descobriment d'una superfície de Iliscada a les bases margoses. A més, no se sabia encara que quan l'aigua es filtra per aquestes bases, aquestes són capaces d'inflar-se fins a cert nivell, originant-se una modificación de la seva consistència, afavorida pel canvi d'ions. Vegetació, masses, tremolors de terra, etc., influeixen també en la formació de falles.

RESUMEN

La montaña peninsular de Treffelhausen, situada a 45 km. ESE de Stuttgart, forma parte del Jura Souabe. La gran cantidad de estructuras geológicas permite percibir las más diversas influencias sobre la formación de las fallas. A lo largo de las exploraciones, hemos constatado que son las bases margosas del Oxfordiense 1 y del Kimeridgiense 1 que se desplazan, contradiciendo así la opinión general de que los bloques calizos se deslizan. La prueba la ha constituido el descubrimiento de una superficie de deslizamiento en las bases margosas. Además, no se sabía todavía que cuando el agua se filtra en estas bases, éstas son capaces de hincharse bajo un cierto nivel, comportando una modificación de consistencia favorecida por el cambio de iones. Vegetación, masas, temblores de tierra, etc... influyen igualmente en la formación de fallas.

SUMMARY

The peninsular hill of Treffelhausen situated 45 km ESE of Stuttgart is part of the Swabian Alb. Due to various geological sturctures it is possible to consider the most differing influences on the formation of sliding fissures. During researches we determined that the movements take place in the marl strata of Oxfordium 1 and Kimeridgium 1. This refutes the general opinion that calcerous blocks slide on the marl surface. This could be proved by discovering a sliding area in the marl strata. Besides, it was not yet known that above a certain level the marl is capable of increasing its volume if water gets into the strata. This leads to a modification of consistency which is additionally furthered by ion exchange. Moreover, vegetation, talus-slopes, earthquakes, etc. also play a part in this formation.

Beschreibung der Treffelhausener Berghalbinsel

Die 10.5 km lange und 8 km breite Treffelhausener Berghalbinsel wird begrenzt von den Bächen Eyb, Fils und Lauter. Bei Treffelhausen besteht eine 1.2 km breite Landbrücke zwischen dem Eybund dem Lautertal. Der durchwegs bewaldete Trauf erhebt sich an einer Stelle bis 350 m über die Talsohle, hat aber in der Regel eine Höhe von ca. 200m. Die durchschnittliche Höenlage der Hochfläche, mit ihrem 50 km langen Trauf, liegt bei 650 m. NN. Der Messelstein, der sich am nordwestlichen Rand des Gebietes befindet, ist mit 749 m. NN. die höchste Erhebung. Die 30 km^2 groBe Hochlläche wird in erster Linie landwirtschaftlich genutzt, aber auch forstwirtliche Nutzflächen sind vorhanden.

Geologie

Die Sedimentgesteine der Schwäbischen Alb wurden im Zuge der Alpenbildung mitgehoben und erfuhren durch die Schwarzwald-Vogesen-Hebung eine Kippung von 2-3 % nach Südosten. Duch geologische Mulden, Sättel und Verwerfungen kann sie örtlich jedoch wesentlich höher oder sogar entgegengesetzt sein. Eine Schichtlagerungsmulde bei Geislingen sowie die Filstalstörung, welche sich in das Eybtal hinein fortsetzt, verändern den Fallwinkel der Schichten. Beide wirken sich auf die Entwässerung des Gebietes aus. Störungen wie auch die Klüftigkeit des Gesteines vermindern die Scherfestigkeit der Gesteinsschichten. In den Mergelnkann dies eindringendes Wasser noch weiter herabsetzen. Die Festigkeit der einzelnen Mergellagen variiert von Ort zu Ort durch die unterschiedlichen Anteile von festen Gesteinbestandteilen und Fossilien. Grenzflächen zwischen Mergel und Festkörperanteilen ermöglichen dem Wasser leichter durch die Mergelschichten zu sickern, jedoch dürfte es seinen Weg meist entlang von größeren Klüften suchen. Solche Klüfte bilden auch die gröBtmögliche Angriffsfläche für den erosiven und korrosiven Abtragungsmechanismus des Wassers, so daB diese häufig ideale Voraussetzungen für eine Talentwicklung bilden. Diesen Vorgang kann man gut am Fils-und Eybtal beobachten. Analog zu den anderen rheinorientierten Flüssen hat sich das Eybtal sehr rasch tief in den Albkörper eingeschnitten, wodurch sich relativ steile Hänge ausgebildet haben. Durch die Abtragung von Gesteinsschichten Können sich parallel zur Hangkante

Hangentlastungsklüfte gebildet haben, die eine zusätzliche Störung des Gesteins bewirken.

Durch die Eintiefung des Vorfluters senkte sich das Karstwasserniveau, was eine Tieferlegung der Quellhorizonte zur Folge hatte. Heute ist der höchst gelegene Karstwasseraustritt der Eybursprung in 615 m.NN. und zugleich die einzig bedeutendere Quelle, die sich noch im Schichtgrenzbereich des weißen Jura gamma/delta befindet. Die meisten Quellen des Gebietes liegen auf einem tieferen Quell-horizont im Bereich Weißer Jura alpha/beta.

Im Südwesten des Gebietes liegen die Quellen bereits im Braunen Jura. Die oberen Schichten des Braunen Jura epsilon bis zeta sind ebenfalls tonig.

Die Entstehungstheorie

Bei der eingehenden Beschäftigung mit Abrißklüften wurden immer wieder markante Erscheinungen an den verschiedensten Abrißklüften beobachtet: Dies waren z. B Quellen unterhalb von Abrißgebieten, ein zick-zackförmiger Spaltenverlauf, wenn der Abriß diagonal zum Kluftgitter erfolgte. Weiterhin stellten wir fest, daß an südseitigen Hängen die Abrißklüfte im Verhältnis zum Gesteinsversatz breiter sind als an nördlichen. Wesentlich für die Genese ist jedoch die Schubwulst, die sich vor dem Driftblock gebildet hat, während sich dieser bewegte. Von großer Bedeutung für diese Theorie war das Auffinden einer Harnischfläche in den Mergelschichten, die eindeutig beweist, daß es Bewegungen in den Mergelschichten gibt.

Nachdem uns nun diese Anhaltspunkte gegeben waren, suchten wir nach einer Theorie, welche jedock in der Literatur nicht gefunden werden konnte. Nun wurde von uns eine völlig neuartige entwickelt. Generell sind im Arbeistgebiet zwei grundsätzlich verschiedene Entstehungsarten zu unterscheiden:

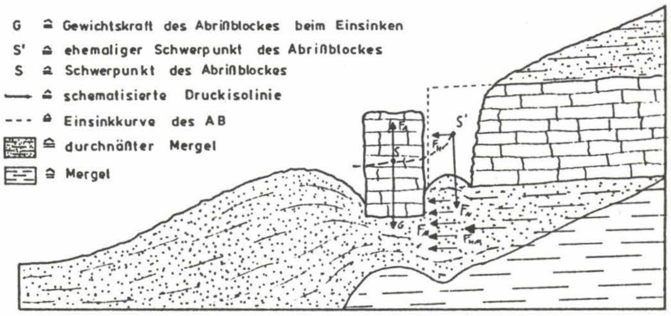
- Die Entstehung auf erosive Weise
- Die Entstehung auf die WMTG-Weise (Wasser-Mergel-Transport-Gleitweise.)

Die Entstehung auf erosive Weise

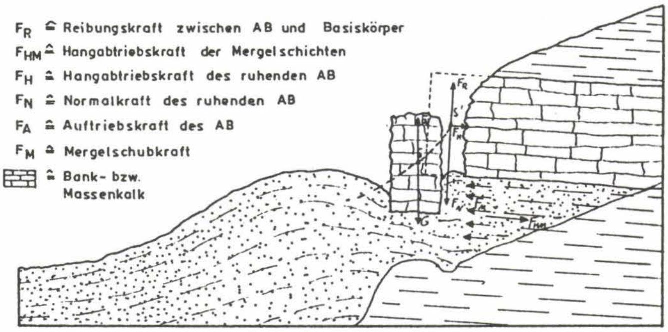
Die erosive Entstehung soll hier nur kurz abgehandelt werden. Sie beruht auf einer mechanischen Versteilung der Hänge, wodurch sich die wirksame Grundfläche verkleinert, die die Normalkraft F_N des Abrißblockes und des Mergels auf den Untergrund überträgt. Ist nun die Grundfläche so klein, daß F_N für $-F_N$ zu groß wird, beginnt der Mergel durch ein Abdriften in Talrichtung den Hang wieder abzuflachen bis wieder eine genügend kleine Flächenlast erreicht ist.

Die Entstehung auf die WMTG-Weise

Durch wasserwegsame Klüfte gelangt Niederschlagswasser zu den Mergelschichten und weicht diese im Laufe der Zeit auf. Mergel besitzt die Eigenschaft, bei Wasseraufnahme sein Volumen zu vergrößern, also aufzuquellen. Steht er aber unter großem Druck, wie dies unter der Hochfläche der Treffelhausener Berghalbinsel der Fall ist, so kann er durch die starke Komprimierung kein Wasser aufnehmen. Das Wasser wird gezwungen, oberhalb der Mergelschichten durch die Klüfte der Bank-bzw. Massenkalke bergauswärts zu fließen. Durch die geringe Überlagerung im Traufbereich ist der Gesteinsdruck nicht mehr so groß. Hier kann Wasser in die Mergel eindringen, wobei ein Aufquellen der Mergel oberhalb der Druckisolinie erfolgen kann. Die Druckisolinie wirkt sich ab dem Punkt aus, wo der Mergel durch bergauswärtiges Nachlassen des Gesteinsdruckes die Möglichkeit besitzt Wasser aufzunehmen. Diese Linie dürfte eine mehr oder weniger steile Gerade sein, wobei sie unterhalb des Traufübergansgsbereiches des Weißen Jura alpha/beta und gamma/delta ihren tiefsten Punkt erreicht und danach in einem gewissen Abstand im Berg das Talprofil nachzeichnet. Daraus ist ersichtlich, daß das Schichtfallen für diese Linie nicht von Bedeutung ist. Sehr wohl von Bedeutung ist die Schichtneigung für die Betrachtung der Gewichtskraft G des Abrißblockes, die im ruhenden Zustand durch die beiden Ableitungskräfte F_N und F_H (Hangabtriebskraft) ersetzt wird. Eine der wichtigsten Kräfte für die Entstehung eines Abrisses ist F_N, die senkrecht zu der schiefen Ebene der Schichten wirkt. Wenn man nun die Wirkungslinie von F_N mit der Druckisolinie der Wasseraufnahmefähigkeit des Mergels korreliert, erkennt man, daß im Süden die Wirkungs-linie sehr viel eher auf die Druckisolinie trifft als im Norden, wo die Wirkungslinie sehr steil bergauswärts verläuft. Im Norden befindet sich also gegenüber dem Süden mehr durchfeuchteter Mergel unter der Auflagefläche, die F_N des Abrißblockes auf den Mergel überträgt. Dabei ist zu erkennen, daß mehr durchnäßter Mergel einen kleineren Widerstand F_N entgegensetzt. Somit ist im Norden eher ein Einsinken möglich als im Süden. Wenn nun die Gegenkraft-F_N des Mergels der F_N des Abrißblockes nicht mehr gewachsen ist, sinkt der Abrißblock in den Mergel ein. Dadurch sind die wirksamen Kräfte nicht mehr F_N und F_N, sondern nur G, die durch das Schicht-fallen bedingt auf eine kleinere Fläche eine größere Kraft ausübt und somit zum schnelleren und tieferen Eindringen führt. Eine Kraft, die G entgegen wirkt, ist die Auftriebskraft F_A nach dem Archimedischen Prinzip.



A



B

Bis jetzt wurden nur kräfte betrachtet, die zum Einsinken des Blockes in Beziehung stehen. Für die Spaltenbildung ist jedoch eine andere Kraft von entscheidender Bedeutung. Dies ist die Kraft des aufquellenden Mergels F_M, die während der Ausdehnungsphase an dem Punkt beginnt, wo die Druckisolinie den Schichtgrenzbereich zwischen Kalken und Mergeln schneidet. Der bergauswärtige «Transport» des Abrißblockes kann nur dann beginnen, wenn der Block bereits ein Stück weit in den Mergel eingesunken ist. Des weiteren besteht die Möglichkeit, daß der Driftblock mit den Mergelschichten auf den darunterliegenden abgleiten kann, was durch Wasseransammlung im Mergelschichtgrenzbereich erleichtert wird. Dieses «Gleiten», sowie F_M werden durch ein Schichtfallen bergauswärts in ihrer Wirkungsweise begünstigt, jedock wirkt die Reibungskraft F_R zwischen den Mergelschichten dagegen. Durch das Zusammenspiel der verschiedenen Kräfte bewegt sich der Schwerpunkt des Abriß-blockes entlang einer Kurve. Wird nun F_N für $-F_N$ zu groß, so wirkt G und der Block sinkt zunächst entlang der G-wirkungslinie senkrecht ein, wobei F_A proportional mit dem Einsinken wächst. Nun hat F_M einen Angriffspunkt am Abrißblock und transportiert diesen bergauswärts. Bei Betrachtung der Druckisolinie wird der durchnässte Mergel, unter der Auflagefläche des Blockes, durch die Bergauswärtsbewegung immer mächtiger, wobei er weiter einsinken kann und hierdurch für F_M mehr Angriffsfläche bietet. Durch die Kompensierung von

G, durch F_A, steigt die Transportstrecke im Verhältnis zum Einsinken immer weiter an und die Kurve flacht ab, was durch Gleiten verstärkt werden kann. Zu F_M kann sich an der Südseite des Gebietes F_H des Mergels und des Abrißblockes dazuaddieren. Im Norden würde sie sich als Gegenkraft auswirken.

Für das Einsinken gibt es lokale Unterschiede, die vom Kluftfallen abhängen. Zeigt dies nach Norden, so tritt an nördlichen Hängen zwischen Basikörper und Abrißblockes Reibung auf. Sie wird durch die südwärts weisende F_H des Abrißlockes verstärkt, was sich negativ auf das Einsinken desßlockes auswirkt. Zeigt das kluftfallen nach Süden, so tritt hier nur Haftreibung auf. Im Süden müßte es entgegengesetzt sein, um gleiche oder ähnliche Wirkung zu erzielen. An jedem Punkt der Einsinkkurve ist die Tangente der resultierende Kraftvektor aus der horizontalen und vertikalen Kraftkomponente. Durch diese Darlegungen ist offensichtlich, daß die resultierende Bewegungslinie im Norden steiler als im Süden verlaufen wird. Zu diesen theoretischen Überlegungen muß jedoch hinzugefügt werden, daß durch Mitwirkung der erosiven Entstehungsweise diese Kurve nochverändert werden kann.

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Granitoid Corrasional caves in California

Dave Bunnell & Bob Richards

RESUM

Les coves formades en granit són classificades sovint com a coves de «talus», «boulder» o «purgatory». Moltes coves d'aquest tipus estan formades, únicament, per cavitats amb un sostre sobreposat entre grans blocs. A Califòrnia hi ha dos exemples a destacar de coves granítiques, la formació de les quals cal atribuir–la a l'acció corrosiva dels corrents d'aigua actius que circulen al seu sí. L'aigua que flueix per les sorgències transporta, a través de les cavitats, gran quantitat de sediments, formant profunds avencs, empremtes de corrent i altres formacions de corrosió vadosa. El sistema Greenhorn és, possiblement, la cavitat més profunda de granit del món (152 m. de profunditat) i, potser, la més llarga, amb més de 1,8 Km, topografiats. El sistema recentment explorat de Millerton Lakes conté 3 segments que totalitzen més d'un quilòmetre. D'ell cal destacar els més de 320 m. de passadissos de canó continu, amb un promig de 10 m. d'altura i 1,5 m. d'amplada.
El treball versará sobre els factors geològics que condueixen a la formació ďaquests tipus de coves que se surten dels esquemes més corrents.

RESUMEN

Las cuevas formadas en granito son clasificadas a menudo como cuevas de «talus» «boulder» o «purgatory». Muchas cuevas de este tipo están formadas únicamente por cavidades con techo superpuesto entre grandes bloques. En California hay dos ejemplos destacables de cuevas graníticas, que deben su formación a la acción corrosiva de los cursos activos que circulan a través de ellas. Las aguas que fluyen por manantiales transportan a través de las cavidades grandes volúmenes de agua cargada de sedimentos, formando profundas simas, huellas de corriente y otras formaciones de corrosión vadosa. El sistema Greenhorn es posiblemente la cavidad más profunda del mundo en granito, cerca de 152 m. de profundidad y quizás la más larga, con más de 1,8 km. topografiados. El sistema recientemente explorado de Millerton Lakes contiene 3 segmentos totalizando más de 1 km. Es notable por tener más de 320 m. de pasadizos de cañón contínuo con un promedio de 10 m. de altura y 1,5 m. de anchura. En el trabajo se discutirá sobre los factores geológicos que llevan a la formación de estas cuevas que salen de lo corriente.

SUMMARY

Caves formed in granite are often classed as «talus», «boulder» or «purgatory» caves. Many such caves are composed simply of roofed–over cavities between boulders. In California there are two outstanding examples of granitoid caves which owe their formation to the corrasive action of active streams which flow through them. Spring floodwaters carry high volumes of sediment–laden water through the caves, forming large potholes, scallops, and other vadose corrasional speleogens. The Greenhorn system may be the world's deepest granite cave at 152 m of depth, and perhaps the longest with over 1.8 km surveyed. The recently explored Millerton Lakes system contains 3 segments totalling over 1 km. It is notable for having over 320 meters of unbroken canyon passage averaging 10 m high and 1.5 m wide. The paper will discuss geological factors leading to the formation of these unusual caves.

The Quartzitic Speleological District of the Parque Florestal Estadual do Ibitipoca, Minas Gerais, Brazil

Rui Campos Perez
Wilson Roberto Grossi
Fundação Centro Tecnològico de Minas Gerais-CETEC

RESUM

Localitzat entre les serralades de Mantequeira i Ibitipoca (Minas Guerais, Brasil), el districte espeleològic del «Parque Forestal Estadual do Ibitipoca (Parque Forestal del Estado de Ibitipoca) comprèn 12 cavitats de quarsites. La major part d'aquestes cavitats aconsegueixen desenvolupaments compresos entre els 300 y 600 m., amb vàries galeries i sales que sobrepassen, en molt, els 20 m., tant d'alçada com d'amplària.

Les peculiars dimensions, la diversificació microclimàtica, els aspectes «cenic» de les cavitats, fan d'aquest un districte espeleològic únic en el seu gènere a Minas Gerais i potser en tot el Brasil, la qual cosa fa que aquesta regió sigui de gran interés per al desenvolupament sistemàtic de la investigació científica i per a les activitats turístiques.

RESUMEN

Localizado entre las cordilleras de Mantequeira e Ibitipoca en Minas Guerais, Brasil el districto espeleológico del Parque Forestal Estadual do Ibitipoca (Parque Forestal del Estado de Ibitipoca) incluye 12 cavidades en cuarcitas. La mayor parte de estas cavidades alcanzan desarrollos entre 300 y 600 m., con varias galerías y salas que sobrepasan en mucho los 20 m. tanto de altura como de anchura.

Las peculiares dimensiones, la diversificación microclimática, los aspectos «cenic» de las cavidades, hacen de éste un distrito espeleológico único en su clase en Minas Gerais y quizás, en Brasil, en consecuencia se valorizan estos lugares para el desarrollo sistemático de la investigación científica y actividades turísticas.

SUMMARY

Located between the Mantiqueira and Ibitipoca mountain ranges, in Minas Gerais, Brazil, the speleological district of the Parque Florestal Estadual do Ibitipoca (Ibitipoca's State Forest Park) comprises 12 caves inserted in quartzites.

Most of these caves reach developments between 300 and 600 meters, with several galleries and halls measuring as much as 20 meters in height and width.

The peculiar dimensions, the microclimatic diversification and the cenic aspects of the caves make this speleological district unique in its kind in Minas Gerais and, perhaps, in Brazil, therefore qualifying their sites to the systematic development of scientific reseach and supervised tourism activities.

Introduction

The earliest reference concerning the occurrence of caves developed in quartzitic rocks at the Serra do Ibitipoca (Ibitipoca Sierra), in the municipality of Lima Duarte, state of Minas Gerais, Brazil, is registered in «Memórias Corográficas», 1922, by Álvaro da Silveira.

A later mention of such caves, almost fully transcribed from the above reference, is found in «As grutas em Minas Gerais», edited by the Departamento Geral de Estatística, Belo Horizonte, 1939.

The following notes are based on three field surveys made by the authors, in June and July, 1985, and January, 1986.

In this paper, the authors consider a speleological district as being an area of relevant, although local, incidence of caves within a speleogical province, regardless of the carbonatic or non-carbonatic nature of the terrain where such caves are inserted.

Location

The speleological district of the Serra do Ibitipoca is located within the limits of the twenty years old Parque Florestal Estadual do Ibitipoca –P.F.E.I. (Ibitipoca's State Forest Park) in Lima Duarte, Minas Gerais.

This park is managed by the Instituto Estadual de Florestas I.E.F. (State Forests Institute). Its area is about 1480 ha, being limited in its east and west borders, respectively, by the Ibitipoca and Mantiqueira mountain ranges. It is crossed from north to south by the Salto river (see location map, chart SF. 23-X-C-VI-1, Bias Fortes, esc. 1:50.000; IBGE, 1976).

Geology and Geomorphology

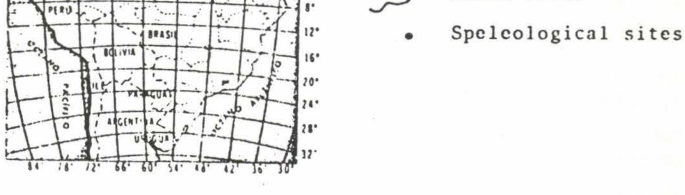
Within the P.F.E.I.'s borders, the Ibitipoca and Mantiqueira sierras are constituted by thick strata of quartzites belonging to the Piedade Complex (Silva et al., 1978).

These sierras compose a large synform structure within which occur fault scarps and canyons, both paralel or transverse to the Salto river.

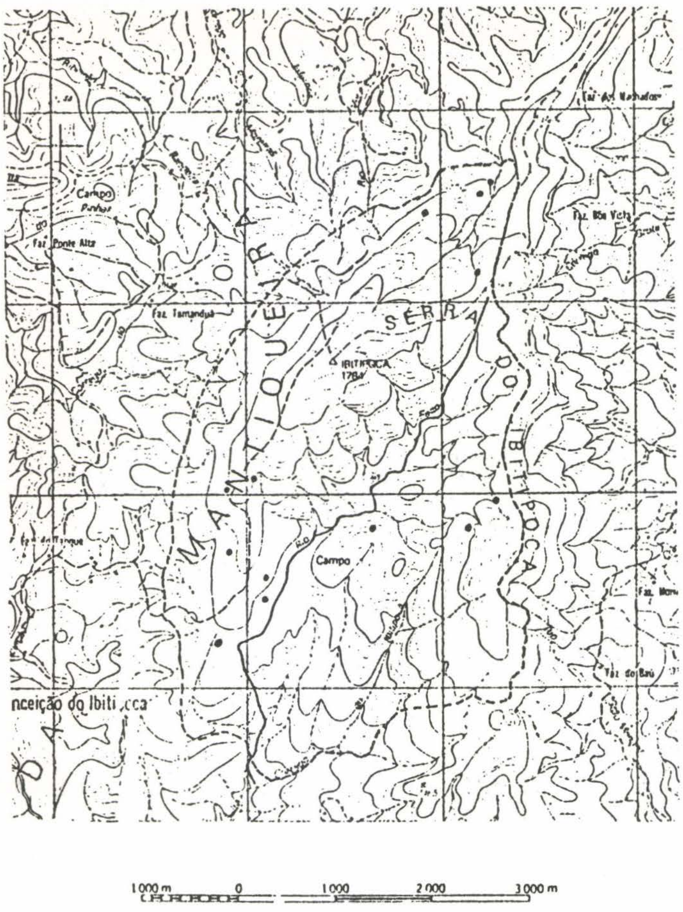
The culminating features in the area are the Ibitipoca (altitude 1.784 m), Pião (altitude 1.707 m), Vargem Grande (altitude 1.686 m.) and Lagoa Seca (altitude 1.660 m) peaks. The Salto River begins at an altitude of 1.640 m and reaches its lowvest point within the P.F.E.I.'limits at 1.100 m., after a descent of 5 kilometers.

The outcroping quartzites are weathered and washed to a high degree, and frequently folded and foliated.

At least two kinds of quartzite were observed: a very coarse, very pure quartzite, with carbonatic matrix absent, and a fine, clay rich quartzite. Both eventually contain variable amounts of



P.F.E.I. location



muscovite and sericite; close to quartz dykes and veins, garnet and tourmaline occur as accessory minerals.

Speleology

Up to now, about 13 speleological sites have been identified in the P.F.E.I.: grutas Ponte de Pedra, das Bromélias, da Cruz, dos Três Arcos, dos Moreiras, do Pião, dos Viajantes, dos Coelhos, do Martiniano, do Fugitivo, da Cachoeirinha, do Monjolinho and das Dobras.

Some of then are constituted by more than three caves, inserted between altitudes of 1.350 and 1.650 meters. It is extremely probable that other caves, still unknown, will be found in the area.

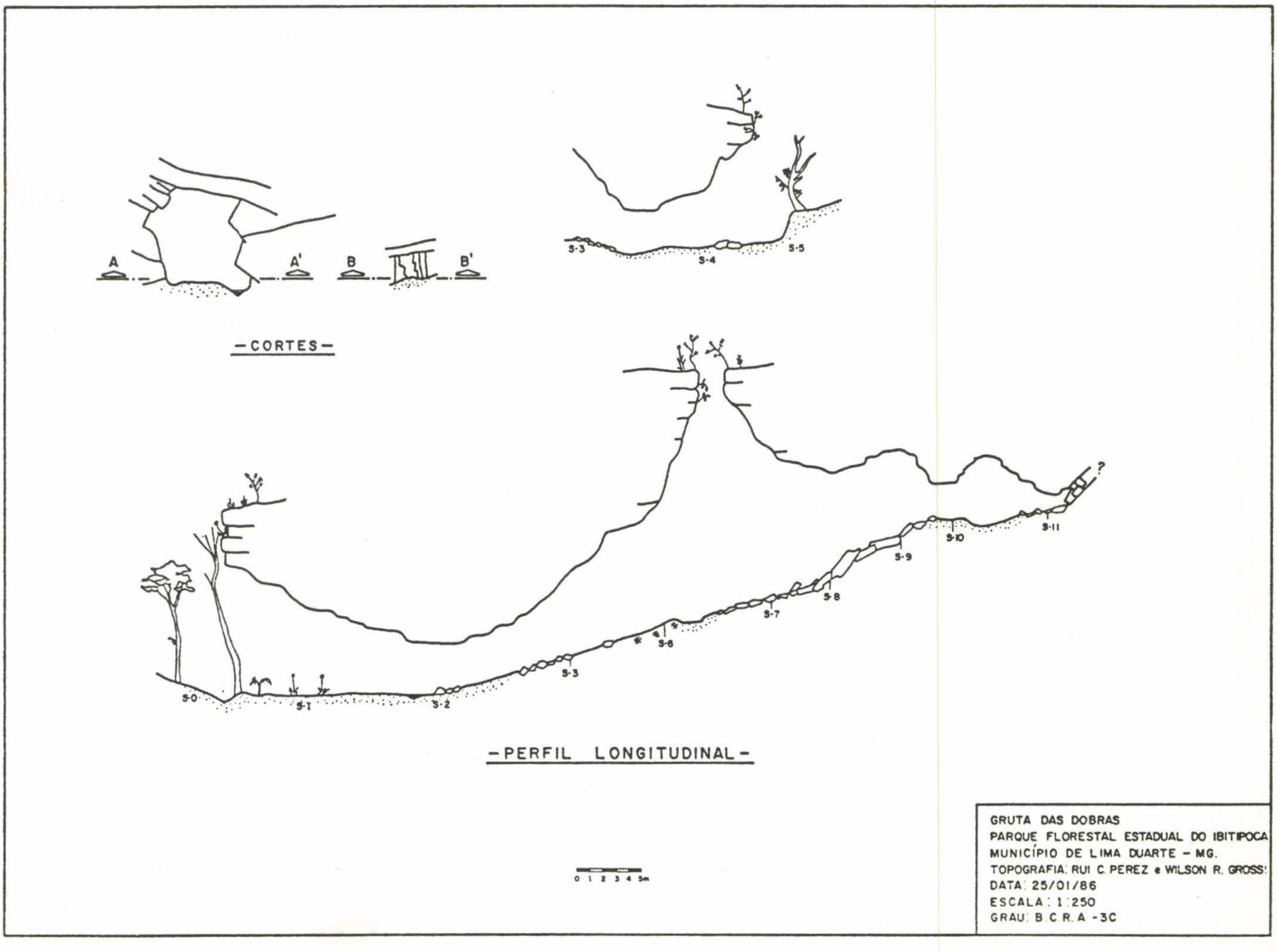
During the three field surveys help in 1985 and 1986, the authors visited and partially explored most of the sites mentioned above.

Many of the caves reach development between 300 and 600 meters, with several galleries, rooms and halls measuring as much as 20 meters in height and width.

Regarding their genesis and evolution, clastic or erosion process predominated or are in course, depending mainly on the grain sizes of the quartzites. The former case is connected to the coarse rocks and the latter to the fine, clay rich, ones. Of couse, in both cases the tectonic structures have a decisive role in the general size and orientation of the halls, rooms and galleries. Cemented reconstruction forms are virtually absent, with the exception of a few, but remarkable, silica speleothemes.

The visited caves have very diversified climates, hence sheltering a multitude of life forms well adapted to darkness.

One of the caves already explored and mapped, the Gruta das Dobras (Folds Cave), synthetically described below, may ilustrate the importance of the speleological district of the P.F.E.I.



The Gruta das Dobras is situated at an altitude of 1.550 meters, with a linear development of 82 meters and the greatest difference in the floor level being of 14 meters. Its two entrances are close to each other and a tiny creek flows from a long fracture near the largest one, as shown in the map. The main development is a slope covered with fallen boulders from the ceiling and walls, some sand and a deep layer of bird guano.

This cave is developed in coarse quartzite and some recumbent folds are clearly noticeable on its walls. Its genesis was defined by the structural features, the fractures and the clastic processes hence activated. The longitudinal profile and sections show areas where the cave is enlarged due to the fall of the foliated ceiling; the great amount of fallen boulders and the skylight enhance such reasoning.

This cave has also a great importance from an ornithologic point of view, because it periodically shelters a huge population of birds called «andorinhão de coleira falha» *(Streptoprocne biscutata),* a species that has been found in Minas Gerais, up to now, only in the P.F.E.I. This year, about 400 specimens were observed together in the Gruta das Dobras, a hundred of which have been rung for the sake of migration control, as part of a long term research program supported by the I.E.F.

Present Situation

All the caves and ecosystems within de Parque Florestal Estadual do Ibitipoca –P.F.E.I. are under management of the Instituto Estadual de Florestas –I.E.F.

The peculiar features and dimensions, the microclimatic diversification and the remarkable scenic aspects of the caves make this speleological district unique in its kind in Minas Gerais and, perhaps, in Brazil, therefore qualifying their sites to the systematic development of scientific research, besides tourism programs.

Full suport for carefully supervised tourism and camping activities is being implanted by the I.E.F.

Also, a geo-speleological characterization project for the P.F.E.I. has been proposed by the authors and is supposed to begin in March'86, with the support of the I.E.F. and the Fundação Centro Tecnológico de Minas Gerais –CETEC (Technological Center of Minas Gerais Foundation).

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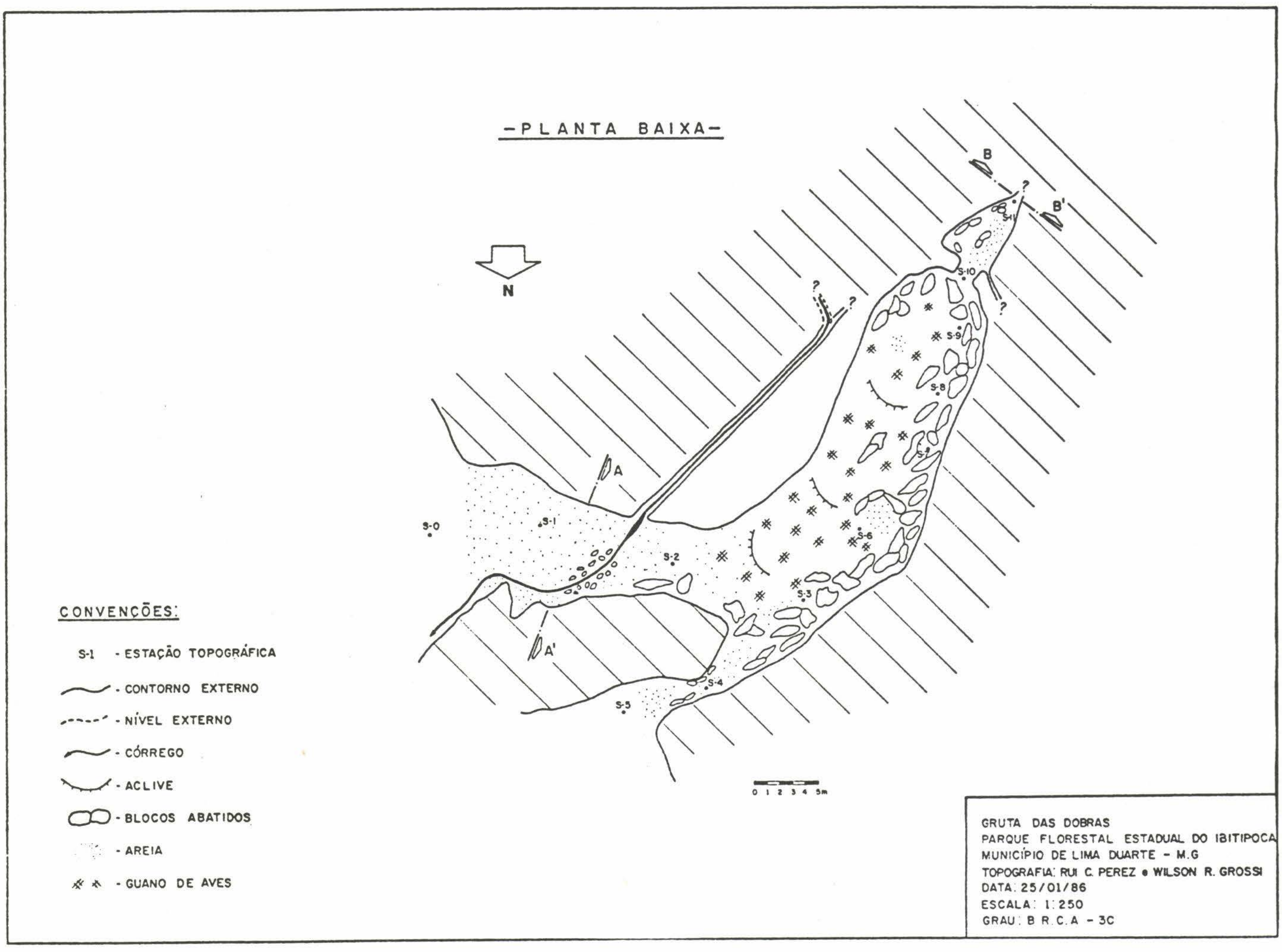

Cavidades en rocas cuarcíferas del grupo Roraima, Venezuela

Por Franco Urbani P.
Universidad Central de Venezuela, Dept. de Geología y Sociedad Venezolana de Espeleología

RESUM

Entre el 1972 i el 1976 es van explorar les espectaculars coves d'Antana i Sarisariñama en els relleus quarsítics del sud de Veneçuela i es van deduir algunes idees genètiques. Fins l'any 1977 es varen estudiar moltes coves, normalment més petites però amb sistemes actius molt instructius (Uratany, Guaiquinima Aonda, Aguapira, etc). Aquest treball va ajudar a comprendre millor el fenomen, fent possible defensar en l'actualitat hipòtesis bastant senzilles. El procés es va iniciar amb l'erosió del material de cimentació de les roques silíciques, que van perdre ràpidament els grans. Aquesta tasca d'arenització de les roques exposades a l'acció ambiental va anar en augment a través de les diaclasses, plans d'estratificació, etc. En els llocs més propicis l'aigua pot començar a drenar lentament en els punts més baixos, originant-se «chanelways by piping» i iniciant-se l'elevació de les coves observades. En els estats d'erosió més avançats, l'exfol-liació i l'enderrocament de les parets de la cova contribueixen a engrandir cada cop més les galeries. Els punts de drenatge poden trobar-se, com a molt, 400 m. més avall, com és el cas d'Aonda, o bé tant sols a uns pocs metres. D'aquesta manera, la progressió d'aquests fenòmens, tant a petita com a gran escala, acaba originant coves verticals i/o horitzontals.

RESUMEN

Entre 1972-1976 se exploraron las espectaculares cuevas de Antana y Sarisariñama en los relieves cuarcíticos del Sur de Venezuela y se dedujeron algunas ideas genéticas. Hasta 1977 fueron estudiadas muchas otras cuevas normalmente más pequeñas pero sistemas activos muy instructivos (Urutany, Guaiquinima, Aonda, Aguapira, etc.). Este trabajo ayudó a comprender mejor el fenómeno, permitiendo en la actualidad defender una hipótesis bastante sencilla. El proceso se inició con la erosión del material de cimentación de las rocas silícicas, perdiendo rápidamente los granos, este trabajo de arenitización *en las rocas expuestas y avanzó a través de las diaclasas, planos de estratificación, etc. En los lugares adecuados el agua puede empezar a drenar lentamente en los puntos más bajos, produciéndose «chanelways by* piping*», dando lugar a un levantamiento en las cuevas observadas. En estados de erosión más avanzados la exfoliación y el derrumbamiento ayudan a ensanchar las galerías. Los puntos de drenaje pueden estar como mucho 400 m más abajo como en Aonda, o bien solamente algunos metros, de este modo los trabajos tanto a pequeña como a gran escala originan cuevas verticales y/u horizontales.*

SUMMARY

In 1972-1976 the spectacular Autana and Sarisariñama caves developed in the quartzitic mountains of southern Venezuela were explored and several genetic ideas were pointed out. Since 1977 many more caves were studied usually much smaller but very instructive active systems (Urutany, Guaiquinima, Aonda, Aguapira, etc.). This work helped to understand better the phenomena permiting now to postulate a rather simple working hypothesis. The process starts by weathering the rock siliceous cementing material loosing slowly the grains, this process of arenitization *works on the exposed rocks and advances through joints, bedding planes, etc. In appropiate places water may slowly start draining at lower points generating chanelways by* piping *giving rise to the observed caves. In more advanced stages erosion, exfoliation and collapses help to enlarge the passages. The draining points may be as much at 400 m below as in Aonda or just a few meters, so the process works as well in large and small scale producing vertical and/or horizontal caves.*

Introducción

Aspectos geológicos: En el estado Bolívar y Territorio Federal Amazonas al sur de Venezuela, aflora parte del escudo Precámbrico de Guayana, caracterizado por rocas ígneo-metamórficas con edades tan antiguas como 3,4 Ga, cubiertas discordantemente por rocas sedimentarias del Grupo Roraima (1, 8-1, 5 Ga), cuya localidad tipo es el Monte Roraima en el área de la frontera triple entre Venezuela, Brasil y Guayana. La morfología típica de las regiones donde aflora el Grupo Roraima lo constituye las grandes mesetas con paredes verticales, que pueden llegar a más de un Km de desnivel, tal como en Auyantepuy donde se encuentraa el Churún-Merú (o Salto Angel) la cascada más alta del mundo. La litología predominante de Roraima son *arenitas cuarcíferas* y minoritariamente arenitas líticas, feldespáticas, conglomerados, arcosas, wacas cuarcíferas, lutitas y limolitas interestratificadas. Estudios realizados en varias localidades han mostrado evidencias de metamorfismo de bajo grado (aparentemente de contacto) con desarrollo de pirofilita y andalusita. Debe apuntarse que el cemento de las arenitas es fundamentalmente sílice autigénico, a diferencia de algunas, zonas europeas, donde se desarrollan cavidades en areniscas, pero éstas son calcáreas o están relacionadas con rocas carbonáticas. Un resumen geológico de Guayana puede consultarse en GONZALEZ DE JUANA et. al. (1980).

Exploraciones: Por primera vez en 1972 se explora una cavidad en rocas de Roraima, fue la Cueva Autana con características únicas en su tipo (COLVEE, 1973; S.V.E., 1976a), pero fue sólo después de otras dos exploraciones cuando surge una hipótesis aceptable sobre su origen (GALAN, 1982).En 1976 se estudian las simas en Sarisariñama (S.V.E., 1976b), donde las claras relaciones de campo hicieron posible la presentación de una hipótesis, según la cual las cavidades se formaron por un proceso de *tubificación* (piping), actuando sobre una roca transformada localmente a un material tan friable, donde al simple contacto de la mano ésta se desmorona (es extremadamente dura y maciza cuando está fresca). También se postuló un proceso de alteración hidrotermal como responsable del proceso de transformación de la roca fresca al material deleznable (URBANI, et al., 1976; URBANI, 1981). «Una reevaluación de los datos de campo y laboratorio, no sustenta adecuadamente la idea de alteración hidrotermal, por consiguiente no la utilizaremos hasta que no hayan datos más convincentes. De todos modos conviene dejar abierta la posibilidad de que procesos endógenos (actividad hidrotermal, etc.) puedan haber generado «zonas débiles» que luego serían más fácilmente atacadas por la meteorización química».

En 1977 se explora el sistema activo de Guaiquinima (SZCZERBAN *et al.*, 1977), y las cavidades de Urutany, El Abismo y El Tigre (S.V.E., 1977). En 1983 se descubre la Sima Aonda (−362 m) actualmente la más profunda de Venezuela (S.V.E.., 1983). En los años 1984-1986 se estudian las zonas del Río Aponguao (dos cavidades), Aguapira (11 cavidades), Kukenán (cuatro cavidades) y Auyantepuy (cinco cavidades) (S.V.E., 1986). Este trabajo exploratorio, junto al reconocimiento aéreo y el análisis de fotografías aéreas han mostrado la existencia de cavidades (o al menos su posibilidad), en la mayor parte de las mesetas de Roraima. Se nota también que la mayoría (o al menos los mayores) de estos fenómenos, se encuentran localizados en las cercanías a zonas con desniveles abruptos, ya sean los grandes escarpes externos de las mesetas, o escarpes menores dentro de ellas, cañones amplios o estrechos, valles en V, etc. Algunos sitemas de poco desnivel se desarrollan siguiendo el suave buzamiento de las rocas.

Para enero de 1986 las cavidades topografiadas con mayor desarrollo son: Sima de la Lluvia de Sarisariñama (1.352 m), Sima Menor de Sarisariñama (1.179 m), Cueva Aguapira 6 (680 m), Cueva Autana (653 m) y Cueva El Tigre (485 m). Las de mayor desnivel son: Sima Aonda (–362 m), Sima Auyantepuy Norte (–320 m), Sima Mayor de Sarisariñama (–314 m), Sima Aonda Este 2 (–295 m), Sima Aonda Sur 2 (–290 m), Sima Menor de Sarisariñama (–248 m) y Sima de la Lluvia (–202 m). Más detalles sobre estas formas en rocas de Roraima puede consultarse en URBANI (1986).

Origen de las formas: Una hipótesis de trabajo

Observaciones de campo: Las cavidades se generan por la remoción mecánica de los granos de arena de cuarzo, actuante sobre las rocas cuarcíferas previamente transformadas a un material friable. Esta alteración se produce a través de las superficies intergranulares, por algún mecanismo que actúa sobre el material cementante de los granos.

Consideraciones teóricas: La meteorización química de rocas cuarcíferas como las de Roraima, actúa por la disolución del cuarzo [«$SiO_2 + 2H_2O = H_4SiO_4$»], que es esencialmente independiente del pH en el intervalo 3-7 de las aguas de la zona. En las arenitas cuarcíferas el cemento silíceo le imparte mucha consistencia a la roca, pero su disolución aún en pequeñas cantidades hace que la cohesión disminuya casi «exponencialmente». MARTINI (1981-1984 b) muestra que debido a la poca solubilidad del cuarzo y especialmente su tasa de disolución extremadamente baja, la *disolución pueda actuar no solamente a través de diaclasas sino también intergranularmente,* permitiendo la transformación de las rocas macizas y duras a masas deleznables (muy porosas y permeables), sobre las cuales pueden actuar los procesos de remoción mecánica. En un modelo matemático muestra que este lento proceso de disolución, pudiera permitir que fisuras del orden de 2 micrones de ancho y con profundidades de unos 100 m, puedan ensancharse hasta 100 micrones en un período de 300 años. Concluye entonces que las formas cársicas no están controladas solamente por la solubilidad, sino también en alto grado por la tasa de disolución del mineral involucrado.

Una hipótesis de trabajo:

1.ª etapa: La meteorización química de la roca disuelve el cuarzo a través de las superficies intergranulares de los granos primarios del mismo material, produciendo una decementación *(arenización)* paulatina de la roca. En las zonas cercanas a los grandes escarpes, donde hay una gran densidad de fracturas que pueden alcanzar mucha profundidad, por medio de ellas el proceso continúa hacia abajo y eventualmente puede extenderse lateralmente a través de los planos de estratificación.

2.ª etapa: Cuando la porosa y permeable zona decementada alcanza o es alcanzada por una «superficie abierta» (pared de los escarpes o la superficie de un valle a una cota inferior), empieza a actuar sobre ella el proceso de *tubificación* («piping»), en cuyas etapas iniciales requiere de una alta presión de agua (MARTINI, 1984 a). Esto último puede cumplirse fácilmente en las zonas de borde de los grandes escarpes donde los sistemas hidrológicos pueden tener desniveles de decenas a centenares de metros.

3.ª etapa: Una vez iniciado el proceso de *tubificación,* se pueden originar *galerías* en alguna parte del sistema. En un principio podrán funcionar en condiciones freáticas, lo cual facilita la *tubificación,* posteriormente al aumentar sus secciones (y/o disminuir el caudal de agua), podrán pasar a condiciones vadosas, donde la erosión y colapsos pueden ser importantes para incrementar diámetros. A medida que los conductos se hagan mayores, los colapsos actuarán más intensamente y los bloques desprendidos, eventualmente podrán ser removidos por la meteorización y erosión. En esta etapa de crecimiento volumétrico de la cavidad, pueden surgir muchas variaciones dependiendo de factores litológicos, estructurales e hidrológicos locales, que explicarían la diversidad de formas generadas, desde enormes cavidades (Sarisariñama y Auyantepuy), hasta pequeños sistemas (Río Aponguao), así mismo pueden generarse cavidades predominantemente verticales y/o horizontales.

4.ª etapa: Cuando cesa la circulación del agua la cavidad deja de ser activa y se interrumpen los procesos de disolución intergranular, *tubificación* y erosión. Sobre estas cavidades podrán actuar otros procesos como la solifluxión, colapsos y exfoliación, esto último actúa principalmente sobre rocas muy isotrópicas, conviertiéndose en un factor importante de ensanchamiento de galerías (e.g.: Cueva Autana, GALAN, 1983).

Otros comentarios: En algunos sistemas donde se ha estudiado la zona de sumideros, la circulación hídrica subterránea y las cavidades de las surgencias, no se encuentra comunicación entre las dos últimas partes. Esto es debido a que las galerías se hacen muy estrechas o no existen, ya que el fondo de las cavidades usualmente está colmado por un material suelto muy permeable constituido por arena y fragmentos de rocas de todo tamaño, permitiendo el paso del agua sin que necesariamente existan galerías explorables. La cota de la surgencia se convierte en el nivel de base local de excavación, y todo el sistema actúa como un gran «reloj de arena», pudiendo haber un enorme volumen de material listo para ser desalojado (parte superior del «reloj»), uno o varios «conductos» estrechos (estrechez del «reloj») total o parcialmente llenos del material, y la surgencia al exterior del sistema (parte baja del «reloj»). Para terminar, creemos que este modelo es aplicable en forma general a todas las formas conocidas, pero es necesario realizar mucha investigación adicional para explicar detalles individuales, por ejemplo, la causa por la cual en algunas cavidades se observan niveles más alterados que otros, a pesar de que aparentemente estaría involucrada la misma roca original, o cuales son los factores controlantes de la ubicación de las cavidades conocidas, etc.

Carso vs. Pseudocarso

La definición clásica de carso, se basa en la existencia de una circulación subterránea del agua a través de cavidades, con sumideros y resurgencias. Las formas superficiales son muy diversas: varían desde pequeña escala (acanaladuras y «lapiaz»), escala intermedia (depresiones como dolinas y uvalas, formas residuales como torres y conos), hasta gran escala (poljes, valles secos y gargantas). En el subsuelo pueden existir cavidades a toda escala. Asi mismo, existe el proceso reversible disolución-precipitación de minerales.

Para las formas que nos ocupan, algunos autores han empleado el término *carso* (e.g.: WHITE *et al.,* 1966; URBANI, 1981) y otros *pseudocarso* (e.g.: GALAN, 1983; POUYLLAU & SEURIN, 1985). Como todas las características del párrafo anterior se encuentran en las rocas de Roraima, preferimos utilizar el término *carso* aun cuando se trate de rocas «poco solubles». No consideramos apropiado clasificar estas formas como *pseudo-cársicas* o *pseudo-cualquier-otra-cosa* ya que son formas reales formadas por un proceso, donde la disolución juega un papel crucial, pero en menor proporción y en una forma completamente distinta a lo que ocurre en el carso típico de rocas «solubles». Por consiguiente, proponemos: (1) Ampliar el concepto de sistema geomórfico cársico para incluir las formas desarrolladas en rocas cuarcíferas de modo que: «El hundimiento del agua y su circulación subterránea es la esencia de los procesos cársicos. Las formas cársicas pueden estar excavadas total o parcialmente por disolución, y otros procesos pueden contribuir a incrementar sus dimensiones; cuando esto último ocurre en forma mayoritaria, la disolución juega esencialmente un papel precursor inicial» (definición modificada de FORD, 1978) (2) Si la anterior definición no satisface a los carsólogos, y se deja el término *carso* sólo para rocas «solubles», entonces preferimos crear un nuevo término para estos fenómenos, y al igual que el nombre de la región italo-yugoeslava del *caso* sirvió para denominar la *topografía tipo carso (karst)*, los fenómenos aquí descritos pudiéramos incluirlos dentro de una *topografía tipo roraima*. Nosotros preferimos esta última alternativa, pero esta decisión le corresponde a la opinión internacional.

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Thermokarst in Siberia (USSR)

Jaromír DEMEK
Czech Speleological Society, Praha, Czechoslovakia

RESUM

Es coneix amb el nom de termocarst el procés de fusió del gel d'un terreny, acompanyat d'un enfonsament local i de la formació de depressions i cavitats. Aquest terme va ésser introduït per M.M. Yermoloyev a l'U.R.S.S., l'any 1932, essent actualment molt utilitzat en geologia, geomorfologia i carstologia.

A les regions termocàrstiques s'hi originen formes subterrànies i subaèries, com coves, túnels, pous en forma d'embut, valls seques, etc. El termocarst té lloc a regions on el terreny suporta un elevat contingent de gel. L'autor presenta cavitats en dipòsits de loess, provocades per la fusió de venes de gel. També descriu buits semblants en túnels desenvolupats en llots al·luvials, que formen sistemes complexes. El procés de formació d'aquestes cavitats segueix essent degut a fenòmens de subfusió («piping»). Els fenòmens termocàrstics poden ésser considerats com a formes intermitges entre el carst glacial (l'origen del qual és degut a la fusió del gel glaciar) i les formes pseudocàrstiques (originades per la subfusió).

RESUMEN

Por termokarst se conoce el proceso de disolución del hielo del terreno, acompañada por su hundimiento local y la formación de depresiones y cavidades. Este término fue introducido por M.M. Yermoloyev en la URSS en 1932, siendo actualmente muy utilizado en geología, geomorfología y karstología.

En las regiones de termokarst se originan formas subterráneas y subaéreas tales como cuevas, túneles, pozos embudiformes, valles secos, etc. El termokarst se da en las regiones donde el terreno posee un elevado contenido de hielo. El autor presenta cavidades en depósitos de loess, debidas a la fusión de venas de hielo. También describe vacíos semejantes a túneles desarrollados en barros de aluvión, que forman sistemas complejos. El proceso de formación de estas cavidades continúa debido a fenómenos de subfusión (piping). Los fenómenos termokársticos pueden clasificarse como formas situadas entre karst glacial –cuyo origen se debe a la fusión del hielo glaciar,– y formas pesudokársticas, –cuyo origen se debe a subfusión–.

SUMMARY

Thermokarst is the process of melting of the ground ice accompanied by local collapse of the ground and the formation of depressions and cavities. The term thermokarst was induced by M.M. Yermolayev in the USSR 1932 and is now widely used in geology, geomorphology and karstology. In thermokarst regions, subterrean and subaerial forms develop such as caves, tunnels, funnel-shaped pits, dry valleys etc. Thermokarst occurs in regions having a considerable contents of ice in the ground. The autohor describes caves in loess deposits originating due to the melting of ice veins. Tunnels- like hollows are described developed in silty loams forming complex systems. Cavities are further developing due to the suffosion –piping–. Themokarst forms can be classified as forms situated between glacial karst –originating due to melting of glacial ice– and pseudokarst forms –originating due to suffosion–.

It is difficult to establish to what extend pseudokarst can be considered karst. Pseudokarst is the name given to phenomena developed on non-limestone rocks, but which resemble karstic forms. Thermokarst is the process of melting of the ground ice and the consequences of this, i.e. the process is the same as in kettle-hole formation in a glacier (so-called cryokarst). Ice is a soluble mineral and the melting give rise to analogous landforms as in limestone rocks. The melting of the ground ice in permafrost areas is accompanied by local collapse of the ground surface and the formation of underground and subaerial forms such as funnel-shaped pits, larger basins with flat bottoms and steep slopes, dry valleys, ponors, caves, etc. The resulting georelief developed by solution of the ground ice in permafrost may be very similar to limestone karst phenomena. Thermokarst features are usually less permanent than comparable forms in limestone areas.

The term «thermokarst» was introduced by M.M. Yermolayev in the USSR in 1932, and in the English language by S.W. Muller in 1944, and is now widely used in textbooks of geology, geomorphology and karsology.

Thermokarst occurs in regions having a considerable ice content in the ground. This is why the most intensive development of thermokarst occur in lowlands. The development of thermokarst is due to the disruption of the thermal equilibrium of the permafrost and the increase in the depth of active layer. The reasons for the disequilibrium and permafrost degradation can be various. Roughly, they can be divided into two groups: climatic and local (CZUDEK-DEMEK, 1970, p. 103).

The deposits of lowland areas in the subnival zone with permafrost often involve numerous thick masses of ground ice. The quantity of ground ice in fluvial, lacustrine and eolian deposits is frequently 80-90 %, of the total volume of deposits. Ground ice is defined as a body of more or less clear ice within frozen ground. Ground ice usually occurs in two basic forms: (1) segregated ice dispersed in the soil and (2) ice veins and ice wedges. Segregated ice is a broad term for soil with a high ice content. Segregated ice lenses vary in thickness from layers a few centimetres thick to massive ice bodies, sometimes tens of metres thick. The size of ice wedges varies considerably in space. In parts of northern Siberia ice wedges attain considerable dimensions, often 3 – 4 m widenear the surface and extending downwards for 5 – 10 m. Some wedges extending downwards to depths in excess of 50 m and being over 10 m wide near the surface.

The distribution of ground ice is also important in thermokarst development. In some deposits most ground ice occurs in upper part of deposits. In other deposits the ground ice is distributed throughout the whole profile. Ground ice can be also found in ice cores of pingos and palsas.

The solution of ground ice can manifest itself in the georelief in different ways. From the geomorphic point of view, the origin of thermokarst forms can be ascribed to lateral permafrost degradation (backwearing) and to permafrost degradation from above (down-wearing) as described below.

Lateral permafrost degradation or backwearing takes place mainly as a result of lateral and vertical river erosion or marine and lacustrine abrasion. The result of these processes are ground ice slumps and thermocirques.

Permafrost degradation from above or down-wearing occurs in flat undissected terrain mainly on watersheds. The most distinct thermokarst forms develop in areas of considerably ground ice, particulary where well developed ice wedges and ice-wedge polygons are present. They have been described in detail from central Siberia (CZUDEK-Demek, 1970, 1973, KACHURIN, 1961, SOLOVIEV, 1962, 1963, and others). The author studied the development of thermokarst landforms on the middle terraces of the Lena and Aldan Rivers in the Central Yakutian Lowlands (USSR). There is much ground ice mainly in the upper loam layer (eolian deposits 20 – 40 m thick). Thick ice veins occupy 30 – 60 % of the terrain surface. In addition, the loams have a segregated ice content of 40-80 %.

The most common landform in which down-wearing thermokarst processes manifest themselves is a circular or oval depression termed an alas. The English terminology having adopted the names given to the formation by the Yakuts themselves. The formation of an alas is a sufficiently familiar event for the local people that they have their own words for the various stages of alas development. Well developed alas is a distinct terrain depression with steep sides and a flat bottom overgrown with green grass around the thaw lake. There are many places in the Central Yakutian Lowlands in which this alas georelief accounts for about a half of the surface area. Alas basins may vary in size from about 100 m to more than 10 km across and from 3 to 40 m in depths.

The melting of ground ice and development of thermokarst landforms has considerably changed the aspect of Arctic Lowlands. In the Central Yakutian Lowlands, 40-50 % of the initial surface has been destroyed by the formation of alases. In the North the lowland on the right Jana River bank has almost completely lost its original appearance and has changed into a system of alas depresions mostly filled by thaw lakes. The thermokarst process from above created the lower level of the lowland, which is situated 10-15 m below the original surface (CZUDEK-DEMEK, 1970, p. 115). Thus the lowlands surface is similar to limestones plateaus with sinkholes.

The coalescence of alases results in thermokarst valleys. In regions where alases develop near each other the ridges separating them are often destroyed., It is the similar proces as in limestone areas, where karst processes are destroing ridges among sinkholes and karst valleys are developing. The ground plan of thermokarst valleys is similar to above mentioned karst valleys displaying unexpected turns, blind spurs, and in places trend against the general inclination of the relief. The greatest part of thermokarst valleys is dry for almost the entire year. Only during the spring snowmelt does water rush down the whole grassy valley bottom.

Due to solution of ice veins are developing gullies on steep slopes. Melting of ground ice is associated with a piping. Especially in cover loams of eolian origin on terraces in the Central Yakutian Lowlands in gullies developed ponors and hollows. Percolating melting water removed solid particles of loams. Original caves developed in loams by solution of ice veins were enlarged by piping. Due to large dimensions of ice veins (more than 40m depth, more than 10 m wide near to the surface) and properties of cover loams originated hollows several tens of meters long and several meters in widhts. On crossing points of ice veins in polygons developed caves. Tubes are preserved along the margins of recently gullied flats such as river terraces of Lena and Aldan Rivers. But some thermokarst hollows were found also on watersheds between Lena and Amga River (CZUDEK-DEMEK, 1973, p. 35).

Common are tubes and caves along the margins of alases. During the development of sides of alases the permafrost degradation is taking place. Ice wedges are melting and on the boundary between ice and loam is flowing thawing water. Thawing water is warmer than surrounding permafrost and segregation ice in loams is melting too. This proces of combined piping and thermoerosion can be called thermopiping.

Funnels and caves forming by thermokarst processes can be divided into (1) primary thermokarst funnels and caves formed due to the solution of ground ice (ice veins, ice wedges, etc.), (2) secondary funnels and caves originated or enlarged due to the thermopiping.

Due to the properties of material (sand, loam, loess, etc.) are thermokarst funnels and caves less permanent than comparable forms in limestone areas. Also by melting of segregation ice in surrounding sediments are hollows filled by mud.

The classification of thermokarst landforms –surficial or underground– is not yet solved. Despite of apparent similarity of topography. Some geologist are of opinion, thar thermokarst is not a variety of karst (FRENCH, 1976, p.105). According to their opinion, karst is term which is applicable to limestone areas where the dominant process-solution –is a chemical one. Underlying the development of thermokarst, however, is a physical, i.e. thermal, process– ground ice melting, which is peculiar to regions underlain by permafrost. On the other side, I already have mentioned, that ice is a soluble mineral and the solution of ground ice in permafrost causes a mass deficiency. This proces is similar to the «real» karst, where solution of limestone causes a mass deficiency. The result of these processes are similar landforms. There it is really difficult to establish to what extend pseudokarst can be considered karst.

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The saline karst formations of Mount Sedom

Giacomo Donini
Guido Rossi

RESUM

Durant dues expedicions espeleològiques dutes a terme els anys 1983 i 1984, es van estudiar els fenòmens càrstics que s'estan generant en el Mont Sedom.

El Mont Sedom té una estructura diapírica salina que s'alça a frec de les aigües del Mar Mort, en la depressió més profunda de la Terra.

Només les falles transcorrents d'aquesta part del món permeten l'aflorament de sediments, constituïts en la seva major part per roques salines d'estructura diapírica.

Les escasses pluges del desert on es troba situat el Mont Sedom han estat les responsables de l'aparició d'un fenomen càrstic molt interessant en els litolipus d'altra solubilitat.

S'ha explorat i estudiat la cova més llarga del món formada en aquest tipus de roques: es tracta del sistema I.C.R.C., de varis quilòmetres de longuitud.

La zona nord del Mont Sedom presenta un tipus de formacions càrstiques diferents degut a diferents situacions tectòniques.

Són també molt interessants els fenòmens mineralògics existents en aquestes coves i les extraordinàries concrecions que han estat objecte d'estudi.

RESUMEN

Durante dos expediciones espeleológicas efectuadas en 1983 y 1984, se estudiaron los fenómenos kársticos que se están desarrollando en el Monte Sedom.

El Monte Sedom tienen una estructura diapírica salina, que se eleva en las orillas del Mar Muerto, en la depresión más profunda de la Tierra.

Solamente las fallas transcurrentes de esta parte del mundo permiten el afloramiento de sedimentos, constituidos en su mayor parte por rocas de sal en estructuras diapírica.

Las escasas lluvias del desierto en el que está situado el Monte Sedom han causado el desarrollo de un fenómeno kárstico muy interesante en los litotipos con alta solubilidad.

Se ha explorado y estudiado la cueva más larga del mundo desarrollada en este tipo de rocas, que es el sistema I.C.R.C., de varios kilómetros.

La zona Norte del Monte Sedom presenta un diferente desarrollo kárstico, causado por distintas situaciones tectónicas.

Son también muy interesantes los fenómenos mineralógicos existentes en estas cuevas y las extraordinarias concreciones que han sido estudiadas.

SUMMARY

During two speleological expeditions effected in 1983 and 1984, the karst phenomena developing in Mt Sedom have been studied.

Mt Sedom is a saline diapiric structure rising on the shores of the Dead Sea, in the deepest depression of the earth.

Just the transcurrent-spreading tectonics of this part of the world allowed he outcropping of sediments constituted for the most part by rock-salt in a diapiric structure.

The scarce rains of the desert into which Mt Sedom is situated caused the evolping of a very interesting karst phenomenon inside lithotypes with high solubility.

The longest cave in the world developing in this kind of rocks, that is the I.C.R.C., System , with a length of some kilometres, has been explored an studied.

The North zone of Mt Sedom presents a different karst development, caused by different tectonic situations.

Very interesting are also the mineralogical phenomena existing into these caves, and the extraordinary concretions which have beeen studied.

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«Cueva del León», Cavernamiento en yeso de la República Argentina

Lipps, Enrique Federico.
KARST, Organización Argentina de Investigaciones Espeleológicas.

RESUM

La «cueva del león» (Las Lajas Neuquén) és la cova de guix més gran explorada a l'Argentina fins a l'actualitat. Ens hauria agradat oferir abans aquest treball, que no és més que una descripció de les dades obtingudes en diverses exploracions. El contingut n'és el següent: topografia i superació de sifons, investigació biològica i geològica, proves microbiològiques, registre de dades climatològiques i de canvis en el nivell freàtic. Aquí considerem les dades preliminars, doncs aquests estudis tindran continuïtat, dins dels projectes del Registre Espeleològic d'Argentina.

RESUMEN

La Cueva del León, Las Lajas Neuquén, es la caverna en yeso más extensa de la República Argentina explorada hasta el momento. Queremos ofrecer este informe anticipado que no es más que un ordenamiento de los datos obtenidos en distintas campañas. Lo realizado comprende: relevamiento topográfico, buceo autónomo en la laguna interior, muestreo biológico y geológico, examen microbiológico, registro de datos climatológicos y variaciones del nivel freático. Estos datos se consideran preliminares y los estudios se continuarán como parte del plan del Catastro Espeleológico Argentino.

SUMMARY

The Lion Cave, Las Lajas Neuquén, is the largest gypsum cave in the Argentinian Republic explored up to date. We would like to offer this paper in advance which is not more than a description of the data obtained in several expeditions. It contents the following; survey, independent diving in the interiopool, biological and geological research, microbiological test, climatological data recording and changes of the phreatic level. Above are considered preliminary data and studies will continue as part of the Argentinian Speleologic Land Register project.

Esta contribución resume los informes de las campañas realizadas entre 1973 y 1984 por los integrantes de Karst, O.A.I.E., en la «Cueva del León».

Hasta el momento es la caverna en yeso más importante de la República Argentina y si bien ha sido suficientemente explorada no se han estudiado con detalle los distintos fenómenos espeleológicos que en ella ocurren.

Es por ello que damos a conocer este anticipo sobre el estado actual de los estudios que se han iniciado. Los datos obtenidos sólo nos permiten de escribir lo que se ha encontrado hasta el momento, sin querer sacar conclusiones debido a lo preliminar e incompleto de los mismos ya que las campañas han sido diferidas en el tiempo por la distancia que nos separa de nuestro objetivo (Zapala-Buenos Aires: 1.400 kms.)

Situación y acceso:

La Cueva del León está situada a unos 34 kms de Zapala y unos 25 kms de Las Lajas, en la Provincia de Neuquén. Su emplazamiento, a una altura de 1310 mts sobre el nivel del mar, está sobre la ladera de uno de los cerros del cordón Curymil.

Sus coordenadas tomadas de la hoja 35 b «Zapala» son: 38° 37' 47"lat y 70° 13' 26"long.

Zona rica en fósiles y restos arqueológicos «es una región sedimentaria con vegetación pobre que se presenta con el tipo de la estepa herbácea; el agua aunque relativamente abundante, es a menudo de pobre calidad» (Lambert, 1949).

El acceso a la cueva se realiza desde Zapala hacia Las Lajas por la Ruta Provincial N.22 y antes de cruzar el Cuchillo Curá se dobla hacia el Este y por sendas se llega al Mallín de la Cueva,

POSICION RELATIVA

donde se halla un puesto y una surgencia. Desde allí se continúa por un único camino que nos deja en la entrada misma de la caverna.

En la zona del cavernamiento existen, cerca de la entrada, conos de absorción cubiertos de arena de unos 8 mts de diámetro y tanto sobre la caverna como en el valle que enfrenta la entrada existen pequeñas grietas que actuarían como sumideros alimentados por el caudal de origen pluvial. La única forma de emisión está representada por la surgencia del Mallín de la Cueva, con un caudal abundante y bastante regular a lo largo del año cuyas aguas son utilizadas para el riego y abastecimiento de agua potable por el puesto.

De encontrarse la relación entre el agua de la laguna interior de la caverna con la de la surgencia se evidenciaría la circulación hídrica del del acuífero del macizo.

Descripción de la caverna

La caverna se desarrolla sobre el denominado «Yeso Principal» y su entrada se abre por el hundimiento de parte del techo. La acción del agua como generadora de la actual morfología no nos queda suficientemente clara. Pareciera una cavidad de formación y funcionamiento freáticos. En algunos sectores el desprendimiento de grandes bloques es evidente y se han formado pequeñas salas. No hemos verificado galerias superiores fósiles.

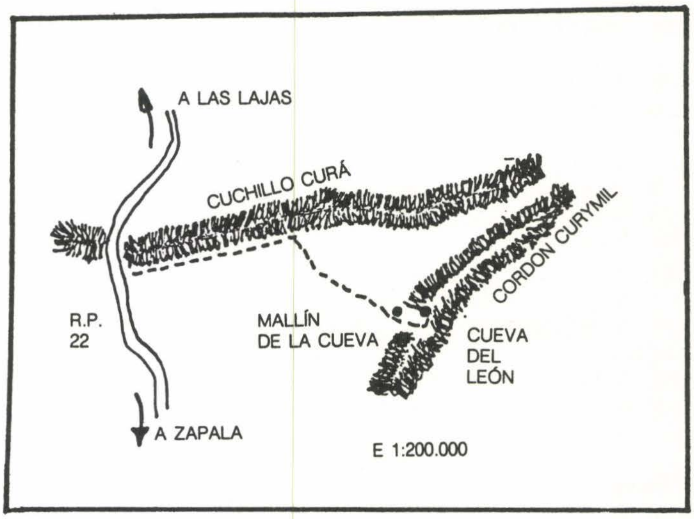
Como macroformas se destacan conjuntos de «golpes de gubia» así como algunas protuberancias nodulosas que se formaron con impurezas insolubles.

Las reconstituciones litoquímicas son prácticamente nulas, limitándose a escasos espeleotemas parietales de material carbonatado muy poco compactos. En cambio el yeso llega a ser tan firme que se llegó a tardar diez minutos en la colocación de cada clavo de expansión para la ubicación del instrumental meteorológico.

Tiene un desarrollo de 947 mts y desde la superficie se accede por una sola boca de entrada natural. Es una típica abertura por hundimiento, de sección semicircular con un diámetro de 3 mts, que se continúa en un talud de arena y cantos con fuerte pendiente. Esta boca da acceso a una gran sala (la Sala de Entrada) cuyo piso está cubierto por un gran cono de derrubios que originan el talud. Éste conviene bajarlo por la izquierda evitándose así bordear grandes bloques y escaladas inútiles.

Luego de bajar el talud la caverna es prácticamente horizontal. La Sala de Entrada divide la caverna en dos tramos bien diferenciados: el ala izquierda, respecto a la entrada, que lleva a la Sala del Lago y el ala derecha que nos dirige a la Sala de las Chimeneas.

Queremos indicar que las toponimias corresponden a las utilizadas por Karst, O.A.I.E., y que se han mantenido en las distintas campañas.



ACCESO A LA CAVERNA

Ala Derecha

La Sala de Entrada se continúa como una amplia galería, siempre sobre un caos de grandes bloques, cuyo lado izquierdo se halla en algunos tramos inundados. Va disminuyendo en altura y ancho hasta un estrecho pasillo que termina en una gran charca cuyas paredes de alrededor muestran los cambios de nivel gracias a las marcas dejadas por guano. Hacia la derecha se abre la Sala de las Chimeneas, cubierta por bloques y un gran cono arenoso originado de las chimeneas del techo. En esta zona de algunas paredes hay mondmilch (de yeso).

Sobre el lado izquierdo se abre La Gatera que desde el año 1983 se halla inundada.

Ala izquierda

Se accede por una pequeña gatera cuya abertura está disimulada por grandes bloques. Luego de 3 mts a la izquierda se abre un divertículo sin continuación, prácticamente colmatado de pequeños bloques, donde hemos colocado un termómetro común.

La gatera se transforma en galeria de amplias dimensiones, ahora inundada, y que da acceso a otra gran sala: la Sala del Lago.

Siempre mirando hacia el interior, a la derecha la pared se continúa bajo el agua pero a la izquierda un gran cono de sedimentos y bloques permite el cruce al otro lado de la sala. El tránsito por el cono debe hacerse con sumo cuidado para que no caigan bloques al lago ya que se entubiarán las aguas y perjudicará la visibilidad para los trabajos de buceo.

Ya del otro lado, se abren dos gateras que bajan mediante una rampa resbaladiza y de estrecho paso que nos llevan a la Sala del Tambor, donde se colocó un termómetro de máxima y de mínima. Desde acá la caverna se continúa en una galeria con algunos divertículos hacia la izquierda y se va reduciendo hasta hacerse impracticable.

Buceo en la laguna subterránea

La visibilidad en el agua de la laguna, calculada en unos 30 mts, nos incitó, ya en la 1.ª campaña en el año 1973, a iniciar las tareas de buceo con la exploración subacuática.

Las inmersiones, debido a las condiciones particulares del buceo en cavernas, se han efectuado extremando las medidas de seguridad, ya que la temperatura del agua (7°C) y la facilidad con que se enturbia la misma dificultaba los trabajos.

Bajo el agua hemos diferenciado tres pozos. En el denomiando Pozo N.° 2, con una profundidad de más de 20 mts, se encuentra una entrada a una posible galería que sospechamos se continúe en alguna sala. Los otros dos pozos no tienen continuaciones.

Breve nota climática

En todas las campañas, aunque de manera muy somera, se hicieron mediciones de temperatura y humedad relativa. Se colocó una estación fija con un termómetro de máxima y de mínima obteniéndose a la fecha una mínima de 8.°C y una máxima de 10.°C. Una estación fija con un termómetro común registró un promedio de 9.°C. Otras mediciones, promediadas en distintos puntos y en distintas fechas, dan dentro del rango de 9.°C de temperatura y del 90 % de humedad relativa.

Las corrientes de aire fueron detectadas con un banderín improvisado de papel de aluminio, comprobándose entradas y salidas intermitentes por la única boca de entrada en comunicación con el exterior por donde evidentemente se produce todo el intercambio gaseoso.

Biología

La caverna no se ha revelado muy interesante en este aspecto. Lo reducido de la fauna verificada parece ser consecuencia de la falta de aporte de alimento externo.

Los métodos de recolección que se utilizaron son los más habituales para estos trabajos. Para la fauna entomológica se colocaron trampas con cebo dispuestas y enterradas en distintos sitios. Como cebo se utilizó queso. Para la captura directa se utilizaron aspiradores de boca.

Sólo se capturaron un ejemplar de Grylloidea (de color pardo claro) y un ejemplar de Culicidae

La presencia de quirópteros fue detectada por guano encontrado en la Sala de las Chimeneas, no habiéndose visualizado a ellos directamente. En la Sala de Entrada se hallaron restos de Cricetidae.

Se hicieron algunas siembras micológicas detectándose colonias de Penicillium y Crysosporium sobre restos orgánicos. De una pared con mondmilch se hizo una siembra para tratar de determinar su origen bioquímico dando resultado negativo. Asimismo el análisis bacteriológico del agua de la laguna también dio negativo.

En la Sala de Entrada, que si bien recibe muy poca luz, permite el desarrollo de algas cianofíceas (Chroococcus sp.) en las paredes, colonización limitada hasta donde llega la iluminación.

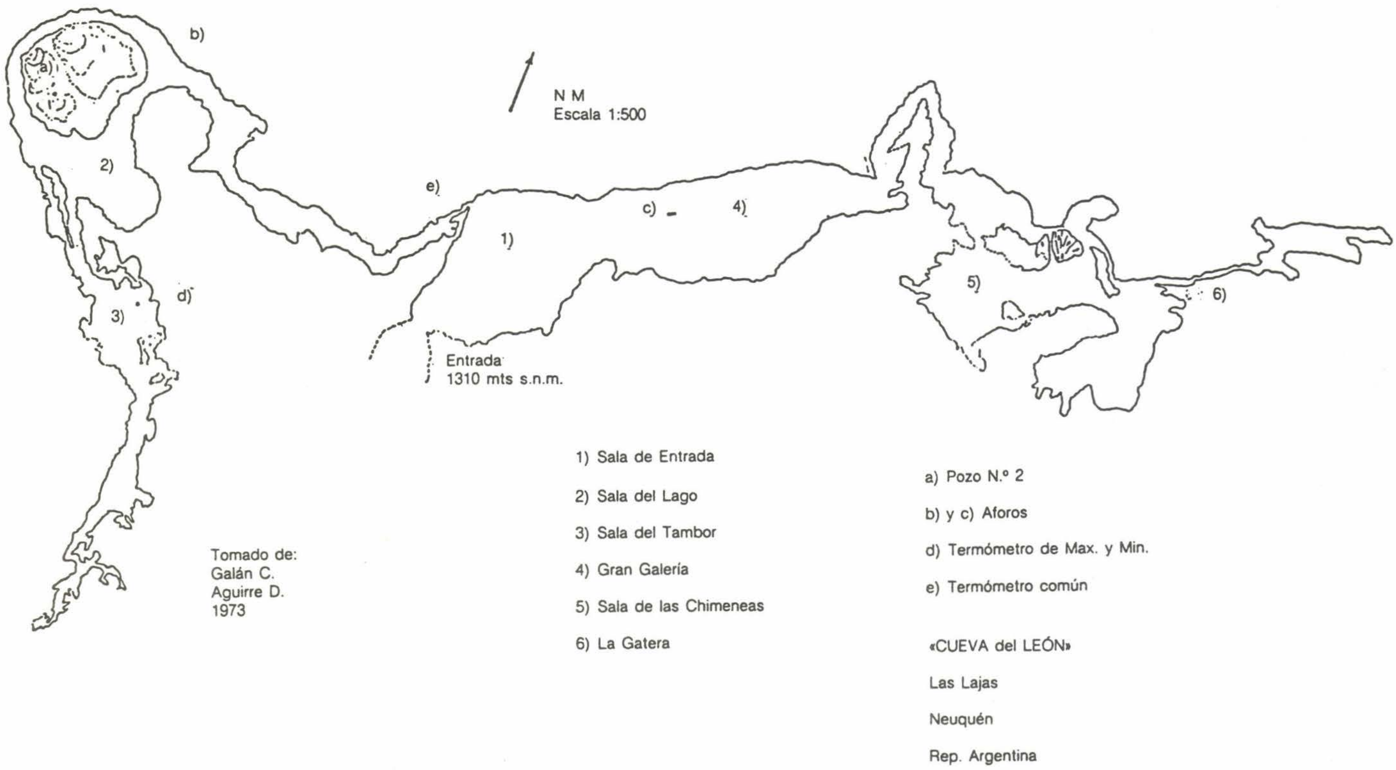
Conclusiones

Este informe pretende invitar a la continuación de los distintos estudios necesarios para el conocimeinto de los fenómenos que ocurren en la caverna. Especialmente el estudio del funcionamiento hidrológico según el régimen de precipitaciones, ya sea midiendo las variaciones del nivel freático para determinar sus ciclos, como proseguir las tareas de buceo para establecer la magnitud de esta reserva de agua.

Por ello consideramos indispensables el cumplimiento de distintos programas de trabajo que se deberían elaborar coordinadamente con los organismos afines y lograr así nuevos aportes que vendrán a enriquecer nuestros conocimiento sobre la «Cueva del León».

Agradecimientos

Este trabajo debe considerarse colectivo, donde han participado los miembros de Karst, O.A.I.E. aunque esté firmado por la persona que lo ha redactado. No podemos dejar de expresar nuestro reconocimiento a Gendarmería Nacional, al Museo de Ciencias Naturales «Bernardino Rivadavia», a la Facultad de Ciencias Exactas y Naturales, U.B.A., al Centro de Actividades Subacuáticas Buenos Aires y a la Dirección de Minería de la Provincia de Neuquén, especialmente en la persona de José Ignacio Garate Zubillaga, que han hecho posible nuestro trabajo con su colaboración desinteresada.



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10212

Pseudokarst in volcanic tuffs of the Paektusan Mt., People's Republic of Korea

Jaromír DEMEK,
Czech Speleological Society, Praha, Czechoslovakia

RESUM

L'autor presenta una sèrie d'observacions de fenòmens pseudocàrstics de la part més alta de les muntanyes de Changbai-han, una zona de muntanyes de naturalesa volcànica pliocèniques i plistocèniques al nord-oest de la República Popular de Corea.

Els fenòmens pseudo-càrstics desenvolupats als turons volcànics són principalment coves originades per la sub-fusió. Aquesta comunicació parla d'una sèrie de coves de sub-fusiò situades en les torrenteres que baixen dels volcans Soyonzibon i Peyonzibon, essent la longitud de les coves de vàries dotzenes de metres. També són freqüents els ponor, les dolines i els avencs originats per fenòmens de sub-fusiò.

RESUMEN

El autor presenta observaciones de fenómenos pseudokársticos en la parte más alta de las Montañas Changbai-han, una zona de montañas volcánicas Plio/Pleistocenas al Noroeste de la República Popular de Corea.

Los fenómenos pseudokársticos desarrollados en las tobas volcánicas son principalmente cuevas debidas a sufusión (piping). Esta comunicación presenta cuevas de sufusión situadas en los barrancos que bajan de los volcanes Soyonzibon y Peyonzibon, siendo la longitud de las cuevas de varias docenas de metros. También son frecuentes los ponor, las dolinas y las simas debidas a fenómenos de sufusión.

SUMMARY

The author presents observations of pseudokarst phenomena in the highest part of the Changbai-han Mts, a Plio/Pleistocene volcanic mountains area in the north-west of the People's Republic of Korea. In volcanic tuffs due to the suffosion /piping/ developed pseudokarst phenomena, mainly caves. In the paper are described suffosion caves in barrancas on volcanoes Soyonzibon and Peyonzibon. Caves are several dozen of meters long. Common are also ponors, dolines and abysses originated due to suffosion.

Pseudokarst is the name given to phenomena developed on non-limestone rocks, but which resemble karstic forms (SWEETING, 1972, p.306). Pseudokarst phenomena have been defined as karst-like features in loess, volcanic ash, as well as bedrock of sandstone, claystone, siltstone, mudstone and tuff. The author presents observations of pseudokarst phenomena made in the highest part of the Changbai-han, a plio/pleistocene volcanic mountain area in the northwest of the People's Republic of Korea.

Volcanic mountains on the boundary between Korea and China originated due to breaking of the China Platform. Planated surface of the China Platform built of granitoids was covered by andesites, trachyts and plateau basalts. Volcanic rocks formed extensive lava plateau punctuated by volcanic centres (volcanic cones, volcanic dome mountains, etc.). More or less flat-lying high plain underlain by extensive lava flows exhibit in studied area elevations between 1400 – 1750 m. Border parts of the lava plateau are dissected by deep incised valleys of Amnokkang and Tumangang Rivers.

The highest and the most prominent volcano in studied area is Mt. Paektusan, which rises to an elevation of 2744 m above the sea level. The top of Paektusan Mt. rises about 900 m above the lava plateau. The volcano exhibit the layered structure, alternating layers of trachyts and ash (stratovolcano). According historical reports the volcano was active 1597,1668 and 1702. During the last eruption the volcano and its vicinity was covered by thick layer of volcanic ash. During the last eruption the upper timber line was higher than today, and we have found buried larch trees in ash. To the east from the volcano is the ash layer on the lava plateau at least 10 m thick. There are other volcanoes in the surroundings of the Paektusan Mt. like Peyonzibon, Soyonzibon, etc. In some parts the ash was consolidated into tuffs.

Climatically the area under study belongs to the type of mild monsoon climate with continental influence. Mean annual temperature on the meteorological station on the Paektusan Mt. is –2.° centigrade. Mean annual precipitation on the lava plateau is between 600 and 800 mm per year. Snow cover during the winter is thin and partly destroyed by severe wind.

The lava plateau is covered by taiga forest. The upper timber line is today about 2000 m above the sea level. The highest parts of the volcanic landscape are bare (so called frost-shatter zone).

Freshly erupted volcanic materials, especially pyroclastics such as volcanic ash and certain tuffs that contains unstable minerals, are highly susceptible to corrosion by rainwater and a variety of karst-like features develop, just as in limestone karst. I have observed in bare volcanic landscape in the vicinity of Mt.

Paektusan very active water erosion and piping. Slopes of Mt. Paektusan and other mentioned volcanoes are deeply dissected by numerous gullies (barrancos). Barrancos exhibit different dimensions and forms. The most barrancos have V-shaped cross profile. The cross profille of other gullies exhibit the U-form. Some gullies are asymmetric in cross profile. During the observation in Summer 1971 the barrancos were dry. The most important process of gully erosion in ash and tuffs is linear water erosion, but in some barrancos we observed also features of mud flows. Many gullies, particularly in uniform ash, advanced headward, maintaining vertical cliffs at the gully headwall. Some cliffs were up to 20 m high. The lenght of barrancos is up to several km, the depth up to several tens of meters.

Pseudokarst features developed is ash and tuffs, especially along the margins of gullies. Smaller forms developed also on watersheds. Piping is very active in ash and tuffs on slopes of Mt. Paektusan, Mt. Peyonzibon, Mt. Soyonzibon, etc. in young volcanic landscapes of Korea. Piping is subterranean erosion iniciated by percolating waters which remove solid particles from clastic rocks to produce tubular underground conduits, caves, etc.

In the saddle between volcanoes Soyonzibon and Peyonzibon begins gully about 10 m deep and with 7 m high headcut. At the base of the headcut I measured the cave 13 m long. The cave was 2,5 m high. At the end of the cave was a vertical pipe. Through pipe came water during the rain and snow melting. Both topographic situations allow steep downward percolation and the escape of water along gully bottoms. Piping is an important element in the headward extension of most barrancos. Water moving through ash and tuff carries fine particles and dissolved materials away from their place of deposition and leaves voids. The voids concentrate the flowing water, accelerate material removal and form piping tubes. This tubes can extend for tens of meters from gully headcut in ungullied watershed areas. I observed such pseudokarst features in many barrancos in the area under study.

Pseudokarst in the vicinity of the Mt. Paektusan produced by piping display disapearing streams, ponors, vertical pipes (piping wells), piping tubes, sinkholes and caves. These features are far less permanent than comparable forms in limestone, and are on a smaller scale. However, there are very numerous and some piping tubes and caves are of considerable dimensions. Also sinkholes and vertical pipes in their bottom are very expresive. Percolating water attacks unstable minerals is ash and tuffs, and solution supports piping.

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Der Konglomeratkarst von Nepal

H. Daniel Gebauer

RESUM

En el recorregut d'alguns rius del Nepal s'hi troben coves d'un cert desenvolupament vertical i horitzontal que s'obren en bancs de conglomerats. El conglomerat posseeix més d'un 80 % de roques no carstificables. Per una diagènesi específica del conglomerat i per una sèrie de situacions hidrològiques a petita i a gran escala, el desenvolupament de dolines, cavitats i corrents subterranis, decorats amb formacions i amb d'altres particularitats càrstiques, pot considerar-se com una intercorrelació de procesos de corrosió i d'erosió.

RESUMEN

A lo largo de algunos ríos del Nepal se encuentran cuevas de cierto desarrollo vertical y horizontal en bancos de conglomerados. El conglomerado posee más de un 80 % de rocas no karstificables. Por una diagénesis específica del conglomerado y situaciones hidrológicas a pequeña y gran escala, el desarrollo de dolinas, cavidades y corrientes subterráneas, decoradas con formaciones y otros rasgos kársticos, puede entenderse como una intercorrelación de procesos de corrosión y erosión.

SUMMARY

Caves of some horizontal and vertical extend are found in conglomerate banks along some nepalese rivers. The conglomerate consists of up to 80 % of rocks which are inert to processes of karstification. Due to a specific diagenesis of the conglomerate and hydrological situacions of small and large scale the development of dolines, caves and subterrean streams decorated with formations and other karstic features can be understood by intermingling processes of corrosion and erosion.

In the Dhaulagiri zone and Gandaki zone of Nepal conglomerate banks have been built up in the pleistocene along the rivers of Kali Gandaki, Seti and Phusre. Remnants of the river-terraces lie nowadays well above the groundwater table and end in steep cliffs liable to landslides if the rivers are not rumbling throug deep and narrow gorges or are restricted to river-caves. In detail studied are the river-terraces near Kusma (PARMA 1985, WALTHAM 1971) and in the Valley of Pokhara (AMATYA 1970, DUNKLEY 1976, DURRANT, SMART, TURNER & WILSON 1979, GEBAUER 1980, 1983, GURUNG 1970 and WALTHAM 1971). The river-terraces are of glacial/fluvial/lacustrin origin and consist of an allochton sedimentary deposit of differing modality. This conglomerate consist of 50 to 80 % calcium carbonate (SHARMA 1975, GURUNG 1970). The river-terraces are built up of alternating layers of differing conglomerate: coarse layers of fluvial origin with solitary boulders dropped by glaciers alternate with finegrained and even crystalline layers of lacustrin deposits.

The upper conglomerate bank

Allmost the complete river-terrace is capped by a coarse conglomerate showing a somewhat greater resistance to weathering. This «cap-rock» is about 15 to 20m thick and shows a very differing modality. It consists of an unlayered mixture of boulders in the size of cars down to dust-fine, even silty sand of phyllites, garnet, gneiss, basalt, lime and much more. The fraction of lime in the conglomerate is between 50 and 80 %, the matrix consists of about an equal share of crystalline calzite and quartz sand. The greater number of caves id developed in the upper conglomerate bank.

The lower conglomerate bank

The larger caves are found in the underlaying conglomerate banks which are at least 40m thick and consist of fine sand with few coarser intrusions. The lower conglomerate banks are built up in many layers of differing resistivity to weathering. They are scarcely lithified, but friable and porous and consist of 50 to 80% of calcite crystals and sands. The rest is rounded quartz sand, a little bit of gypsum and organic residues. Exceptionally interbedded are extremely labile layers of silt.

The largest caves and cave-systems extend into both of the conglomerate banks.

Karst features of Pokhara Valley

The karst features of Pokhara Valley show a broad variety of features known of the classic karst. It is distinguished only by the but partially soluble rock and the more diffuse passability for water in the conglomerate instead of a straight and obvious cleavage. Dolines are found on the surface as well as swallow holes, whilst underground several caves have been described with a linear development of up to 3km and a depth of up to –48m (GEBAUER 1983). Remarkable are the calcite formations which are not expected for conglomerate karst. In accordance to the low percentage of calcium carbonate available in the upper conglomerate formations are few, whilst in the lower one they are quite numerous. Mostly stalactites are found which either seem to redraw the net of cleavage or cover continous stretches of ceiling if the water «emanates» out of the porous rock in coherent areas. Stalagmites are not as often seen but reach a respectable size in spite of the low calcite supply. Sinterterraces, pearl-sinter and the like are found as well.

Development of caves in the conglomerate of Pokhara Valley

The liability to karstification of conglomerates depends on the liability to karstification of it chemical constituent and/or its detrital constituent if the dynamic aspect of transportation takes effect. The conglomerate of Pokhara Valley is developing caves because the cheminal constituent (cement) of the conglomerate consists mostly of soluble calcium carbonate which dissolves and because the nonsoluble detrital remnants are washed away by the heavy monsoon rains.

The development of these caves is characteristicly influenced by the well-rounded, pebble- to boulder-coarse sediment of the upper conglomerate. Well-proportioned curves make up meandering streamways of the horizontal caves and the vaulted ceilings blend continously into the curved cave walls and form statically ideal boughs to hold the lithic load resting on the cave. The bending of the vaults is only disrupted where layers of obviously differing modality follow each other. The character of cave development is not of eager corrosion. It seems as if the waters trickle through the manyfold waysome conglomerate to gain new power of corrosion not at a definite interface between water and air, but rather in a somewhat wishy-washy zone of numerous surfaces given by the porous conglomerate. A solitary pebble, standing out from the surface offer it's point of contact, which is also its point of cementation, in a much higher degree to the carbon-dioxide of the air than a pebble surrounded completely by neighbouring pebbles and/or cementation. A hole, which is left by a missing solitary pebble in an otherwise coberend surface does in the same way endanger the cementation of it's neighbouring pebbles.

The equalizing corrosion gives way to a spherical and retrogressive development of the caves, which simultanously forestalls incasive processes of a larger scale.

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10201

A proposal for a classification system for Granitic Caves

Rabbe Sjöberg.

Dept. of Geography, University of Umeå, Sweden.

RESUM

Aquesta comunicació resumeix els anteriors intents de classificació de les coves obertes en roques granítiques. Basant-se en aquests intents, en referències bibliogràfiques i en altres treballs de camp realitzats durant dues dècades a Suècia i a d'altres països, l'autor proposa una nova classificació. En ella, les cavitats granítiques es divideixen en dues categories principals: A) Cavitats de roca ferma, i B) Cavitats obertes entre dos blocs. La categoria A es divideix, al seu temps, en: 1) Cavitats tectòniques, i 2) Altres tipus de cavitats.

Hi ha altres subdivisions, que es realitzen segons l'origen de la cavitat (és a dir, si aquesta és tectònica, producte de l'acció atmosfèrica o bé de l'abrasió glaciar, fluvial o marina).

Aquest sistema de classificació s'il·lustra posant exemples de coves de diferents parts del món.

RESUMEN

Esta comunicación resume los anteriores intentos de clasificación de las cuevas abiertas en rocas graníticas. Basándose en estos intentos, en referencias bibliográficas y en trabajos de campo desarrollados durante dos décadas en Suecia y otros países, el autor propone una nueva clasificación. En ella las cavidades graníticas se dividen en dos categorías principales: A. Cavidades en roca firme, y B. Cavidades abiertas entre bloques. La categoría A. se divide a su vez en: 1. Cavidades tectónicas, y 2. Otros tipos de cavidades.

Otras subdivisiones se realizan de acuerdo con el origen de la cavidad, sea ésta tectónica, producto de la acción atmosférica, o de la abrasión glaciar, fluvial o marina.

Este sistema de clasificación se describe utilizando para ello ejemplos de diferentes partes del mundo.

SUMMARY

The paper summarizes previous attempts to classify caves in granitic rocks. Based upon these attempts, literature studies and own field-work during two decates in Sweden, as well as in other countries, the author proposes a new classification. Here caves in granitic rocks are classified into two main cathegories: A. Caves in solid rocks, and B. Caves in boulders. Cathegory A is further divided into: 1. fracture caves, and 2. other types of caves.

A further subdivision is based upon cave forming processes, such as tectonic, weathering, glacial, fluvial and marin abrasion. The classification system is described using examples from many parts of the world.

«The state of granite cave research is still mostly descriptive», Brian Finnlayson stressed during the Anglo-french Karst Symposium in 1983. I believe that this statement is fairly correct, although this type of research has been going on for more than one century. In the following the word granitic is used instead of granite to cover rocks as granite, metagreywackes, anothosites and similar rocks of magmatic or metamorphic origin.

In the 19th century several studies of coastal caves were done in Norway by geologists such as Reusch, Rekstad and Oxaal. None of them had any reason to classify different types of caves (Reusch 1877, Rekstad 1900, Oxaal 1913-14).

The first attemt to construct a classification for caves in granite was done by the Swedish geologist H Munthe in 1920. He classified the noncalcareous caves in: sea caves, crevice caves and boulder caves (Munthe 1920). In 1962 a new classification was presented in Sweden by L Tell (Tell 1962), where he discerns three special types of caves in archean rocks. They are: diaclasses and paraclasses, caves in gneiss, glacial phenomena. Later he develops his classification in a paper «Caves in Swedish Archean Rocks with Special Reference to Glacial Phenomena» (Tell 1969).

Munthe's classification was, however mostly restricted to sea caves and although Tell supplemented the weaknesses in Munthe's classification new weaknesses appeared. In particular type 3 «Glacial phenomenons» was too undefined to be useful and it was based on the views of the effect of the glaciations accurate at that time.

Even outside Sweden attempts have been made to construct classification systems for granitic caves. H Trimmel (1968) gives the following classification: Tektonische Höhlen, Überdeckungshöhlen, Windhöhlen, Wasserhöhlen with subgroups Brandungshöhlen, Uferhöhlen and Erosionshöhlen. W Halliday (1974) devided the granitic caves into: talus caves, block creep caves, sea caves, piping caves, stream cut caves and other types of caves. A Bögli (1980) presented an interesting classification based on primary and secondary caves. His classification is shown of fig. 1.

Fig. 1

PRIMARY CAVES	Primary caves in igneous rocks		Vescles, lava-tunnels
	Primary caves in sediments		overcovering caves reef caves tufa shelter
Secondary caves	Exogenous caves	Erosion Weathering	Rock shelters Wind caves River bank caves Surf or Wave cut caves
	Endogenous caves	Tectonic Corrosion Erosion Incasion	Tectonic caves Open joint caves
			Karst caves bedding caves contact caves joint caves

Classification of caves, according to Bögli (1980).

The problem of defining a classificationsystem for granitic caves seem to haver interested several Australian speleologists in the beginning of 1980s. C R Twidale (1982) used the following classification: caves associated with grus, caves associated with fractures, tafoni, split blocks and A-tents. K Kiernan (1982) penetrated the problem thoroughly in a clubmagazine, fig. 2. His classification is mainly based on the cave forming processes. B Finnlayson in 1983 constructed a classification based on caves from Australia and the USA. He discerns: 1. Boulder caves, 1a. boulder piles, lb. boulder filled streams, 2, Open joint caves, 3. Closed joint caves (Finnlayson 1985).

The Norwegian caver I Schröder (1984) presented the following classification: Caves formed by: 1. tectonic and gravity sliding, 2. frost shatterring, 3. wave abrasion, 4. preferentially weathering in brecciated zones and 5. karstic disolution of small marble lenses within gneisses.

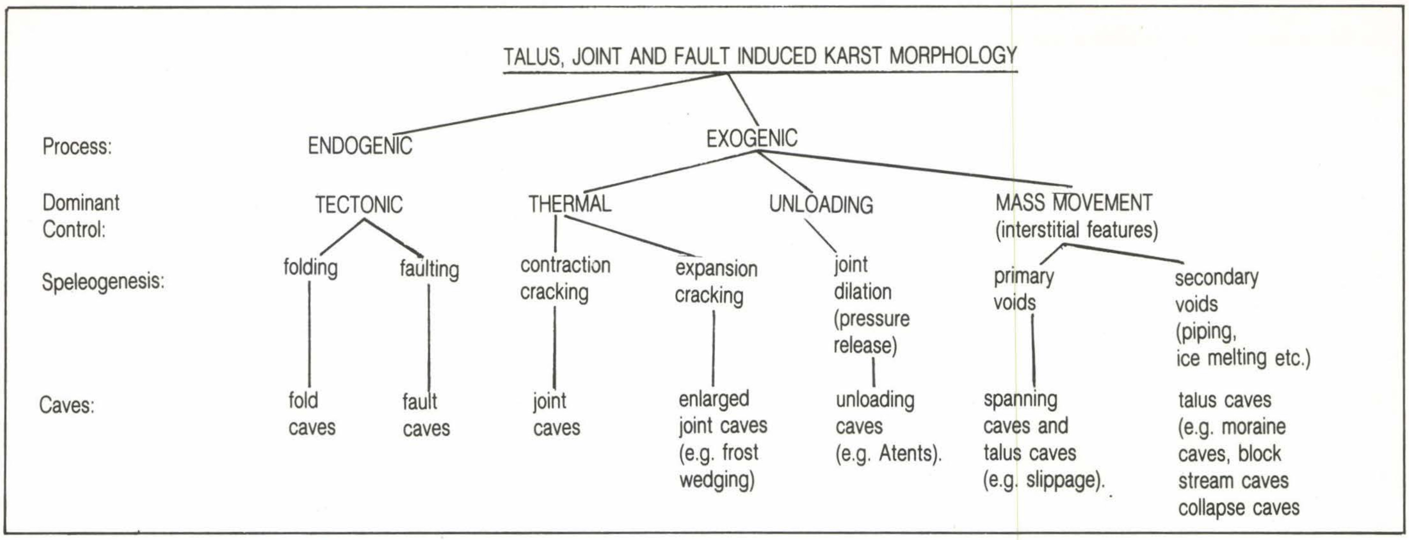
As can be seen all these systems base their classification upon the morphology of the caves and/or the cave forming processes. A problem with almost all of these classifications is that most of them are based on very regional examples or are only useful in specific regions. Exceptions are those by Munthe, Trimmel, Bögli and Kiernan.

My attemp to form a new classification is primarily based on the structur of the cave, fig. 3.

Here we can recognize A. Caves in solid rocks, and B. Caves in boulders. Caves in solid rocks can be devided into two easily recognizable types. First caves associated with fractures and crevices which can have a dip varying from horizontal to vertical. Secondly all other types of caves in solid rocks. Caves which are not formed in solid rocks are called boulder caves.

These three main categories can each further be devided into subgroups, depending on the cave forming processes, or the most prominent process, as most caves truly are polygenetic forms, fig. 4.

Fig. 2.



Classification of caves, according to Kiernan (1982).

Based on field experience and litterature studies I have found tectonic–, (neotectonic–), glacial -, marine abrasion -, and the whole range of weathering processes to be the most common cave forming processes in granites. To a lesser extent also eolian erosion and other erosive processes.

A secondary subdivision is based on the morphography of the cave and clearly recognizeable types of caves within the primary groups of subdivision, e.g. a crevice forming a cave can be open in roof, or covered by rocks and boulders. Tye walls of the crevice can be rough or polished. A cave

Fig. 3.

A. Caves in solid rocks	I. Fracture caves
	II. Other types of caves
B. Caves in boulders	III. Boulder caves

formed by fluvial processes can be in the form of a subvertical giant kettle or more usual, at least in softer rocks, in the form of a stream cut cave (meander cave). The boulders forming a cave can be angular or more or less rounded. The form of the boulders tell us more about the processes and/or the time these boulders have been affected by the geomorphological processes.

The following descriptions of different types of granitic caves are mainly based on examples from Scandinavia, granitic caves from other parts of the world are also considered.

Fracture caves

Most fracture caves are formed along more or less vertical fractures (Holler 1981). In several cases the fractures can be caused by sheet jointing and thus are mainly horizontal (Ljungner 1927-30, Jahns 1943, Twidale 1972, a.o.). A fracture caused by tectonics may under rare circumstances be unaffected by secondary processes and is thus classified as a «tectonic fracture cave», (I.1). This type of cave can have a more or less open roof, or can be covered by rocks and boulders.

Mostly, in glaciated areas, these fracture caves are affected by secondary processes during the different glaciations, «Glacial fracture caves», (I.2). In northern Sweden these caves are mostly covered by till leaving only a small vertical entrance open, (I.2.3.). In other cases the fractures can be covered by huge erratics or horizontally moved types of roches moutonnés, (I.2.2.).

In coastal areas and in iso- and/or eustaticly raised areas the fracture caves mostly are affected by marine abrasion, «Abrasion fracture caves», (Sea caves), (I.3.). In narrow vertical to subvertical fractures or fractures filled by dykes of dolerite etc. a type of cave called «Tunnel cave», (I.3.1.), can be formed (Sjöberg 1981, 82, 83 and 85). In cases of sheet jointing a «Sheet joint cave», (I.3.2.) can be excavated. When the fractures are superseded by smaller joints «Cave shelters», (I.3.3.) are formed.

Fracture caves can also be formed by frost-wedging in wider fractures or by deep-weathering in weaker dykes, or in the granite proper (Kastning 1977), forming «Weathering fracture caves», (I.4.). mostly however, especially frost wedging and weathering cause inkasion in caves.

Other types of caves in solid rocks

These caves are mostly formed by erosive processes. Caves formed by fluvial and glaciofluvial processes are mentioned above. Glacial erosion can erode P-forms big enough to be called caves, (II.2). When marine abrasion is working on rocks not penetrated by joints and fractures small shallow «Beach rock shelters», (II.3.), can be formed.

Different forms of weathering processes are known to form caves. In gneisses smaller caves are formed by frost-wedging, (II.4.1.). In different areas tafoni, big enough to be called caves, are formed and Twidale (1982) mentions tafoni from Antarctica, Hong-Kong, Corsica and Australia etc. as examples of weathering processes such as deept weathering by soil moisture attack beneath the land surface, preferential weathering, granular disitegration due to salt crystallisation and case hardening.

Wind erosion also is known to create caves (II.5.), like other more obscure processes such as cattle-licking etc.

Boulder caves

Boulder caves can be formed by tectonic processes and expecially neotectonics are of great interest. The longest pseudokarstcave in Sweden, Bodagrottorna (2606 m), is formed in a roche moutonnée «blasted» by neotectonics, leaving a complex multi-leveled labyrint among the boulders (Agrell 1982). Several other examples are known in Sweden (Agrell 1981, Sjöberg in print). The huge «talus cave» TSOD in USA may be an example of this process (Caroll 1978). From the inland of Sweden is an example of neotectonics causing a hilltopp to slip downhill along sheeting joints for a couple of meters formi a more than 500 m long cave (Isacsson 1983). The classification is (III.1).

Several caves in glaciated areas are formed in coarce morains, terminal morains and among erratics, (III.2). Caves also exist on the lea-side of roches moutonnées.

Along most granitic coast caves can be formed by the excavation of large boulders by marine abrasion, (III.2). Boulder

Fig. 4.

CLASSIFICATION OF PSEUDOKARST-CAVES IN GRANITIC ROCKS

CAVES

Pseudokarst caves

Secondary caves

I. CRECIVE CAVES	1. Tectonic	open 2. covered
	1a. Neotectonic	1. subvert. displaced
	2. Glacial	1. open 2. covered 3. covered by till
	3. Abrasion «Sea caves»	1. vertical, polished «Tunnel-caves» 2. horisontal, polished «sheet joint caves» 3. rock shelters
	4. Weathered	1. open 2. covered 3. partly filled
II. OTHER TYPES OF CAVES IN SOLID ROCKS	1. Fluvial- or Glacifuvial	1. subvert. giant cettles 2. stream-cut caves 3. other types
	2. Glacial	1. caves in tills 2. other types
	3. Abrasion	1. abrasion hollows 2. beach rock shelters 3. other types
	4. Weathered	1. frost wedging caves 2. tafonis 3. other types
	5. Eolian	
	6. Thermal	
	7. Anthropogen	

Primary caves

III. BOULDER CAVES	1. (Neo) Tectonic	1. split roches moutonneés 2. collapsed mountainlopes
	2. Glacial	1. in angular boulders 2. in rounded boulders 3. in coarse bouldered till
	3. Abrasion	1. in angular boulders 2. in rounded boulders
	4. Weathered	1. in angular boulders 2. in rounded boulders 3. in foliation sheets

caves formed by weathering processes within the glaciated areas mostly occur among piles of boulders formed by frost-wedging at the foot of steep hills, (III.4.1.). In many cases in Scandinavia these voluminous talus can be the result of neotectonics, (III.1.2.).

In areas not affected by the pleistoscene glaciations most granitic caves seem to appear in the form of boulder caves formed by deep weathering, (III.4). Different types are described. Shaw (1980) describes a caves formed below corestones at the foot of granite inselberg in Guyana, (III.4.2). Other caves are described from Australia by Ollier (1965), Finnlaysson (1981, 1985) and Shannon (1975). From High Tatra Mountains in Poland caves of similar type are described by Wojcik (1961). In nubbins and castle coppies caves are found in several parts of the world, e.g. in Portugal (Sjöberg 1982). The splitting, cracking and parting of erratics, corestones and blocks can also form smaller caves (Twidale 1982). Twidale (1982) also describes «A-tents» which forms small triangular caves with only two walls, (III.4.3), and gives examples from several parts of the world. He suggests that A-tents and other minor forms are developed by the release of compressive stress within the rockmasses in which they have evolved.

It is my sincere hope that this attempt to form a classification system for granitic caves will be a step towards a classification which will be useful in all areas with granitic rocks. But not least I hope that the contents of this paper will start a fertile discussion.

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Phénoméne karstique dans les granites alochtones de stara planina (Bulgarie): Genèse et formes morphologiques

St. Chanov, Al. Bendérev, I. Ilieva, Str. Vessélinov

RESUM

A Stara Planina Central (Balcans) podem contemplar un fenomen natural únic: formes cárstiques superficials de granit. Des del punt de vista tectònic, la regió es troba al front del gran plegament de Stara Planina. El gruix del granit alòcton en aquest indret és de l'ordre de 50 a 60 m. La roca autòctona està representada per calcàries senonianes d'un gruix que oscil-la entre els 10 i els 100 m.

Sota les calcàries s'hi troben dipòsits de sorra i argila del Titonià, que fan d'estrat impermeable. Els procesos de carstificació de les calcàries senonianes, tectònicament molt deformades i fissarades, es veuen afavorits per l'aigua meteòrica i superficial que penetra pel granit. La roca alòctona i autòctona ha estat sotmesa a deformacions i a fractures posteriors al plegament, originant-se considerables desnivells en els blocs. La placa granítica ha estat perforada, per accions mecàniques i destruïda en les zones de falles. Els procesos d'infiltració i enfonsament, a causa de la gravetat, han possibilitat la formació d'embuts de dissolució en la massa granítica, típics de les regions càrstiques, amb un diàmetre de 15 a 35 m. i de 2 a 5 m. de profunditat. A causa de la gran permeabilitat dels granits, el petit riu, perd, en aquest sector, gran part del seu cabal, apareixent de nou, en forma de surgència cárstica a uns 2,5 kms. més avall, en un aflorament de les calcàries senonianes. Hom sospita l'existència d'un gran sistema càrstic estès sota el plegament granític. A la regió es coneixen petites coves desenvolupades a la zona que limita l'alòcton i l'autòcton.

RESUMEN

En Stara Planina Central (Balcanes), se encuentra un fenómeno natural único –formas kársticas superficiales en granito. Desde el punto de vista tectónico, la región se encuentra en el frente del gran plegamiento de Stara Planina. El grosor del alóctono granítico en este lugar es del orden de 50-60 m. El autóctono está representado por calizas senonienses de un espesor de 10 a 100 m. Debajo de las calizas se encuentran los depósitos arenoarcillosos del Titonien, que hacen de estrato impermeable. Los procesos de karstificación de las calizas senonienses que están tectónicamente muy deformadas y fisuradas por acción del plegamiento, se ven favorecidas por las aguas atmosféricas y superficiales que penetran por el granito. El alóctono y el autóctono, han sido sometidos a deformaciones y fracturas post-plegamiento, ocasionando considerables desniveles de bloques. La placa granítica es perforada mecánicamente y destruída en las zonas de fallas. Los procesos de infiltración y hundimiento por gravedad, han facilitado la formación de embudos de disolución en el cuerpo granítico, típico de las regiones kársticas, con un diámetro de 15 a 35 m. y de 2 a 5 m. de profundidad. A causa de la gran penetrabilidad de los granitos, el pequeño río, pierde en este sector, gran parte de sus aguas, que aparecen como manantial kárstico a unos 2,5 Km. a lo largo de la corriente del río en un afloramiento de las calizas senonienses. Puede suponerse un gran sistema kárstico bajo el plegamiento granítico. Son conocidas en la región pequeñas cuevas desarrolladas en el límite del alóctono y del autóctono.

RESUME

Dans la partie centrale de la Stara Planina (le Balkan) existe un phénomène naturel unique – des formes karstiques superficielles dans le granite. Du point de vue tectonique, la région est située dans la partie frontale du grand charriage de Stara Planina (Fig.1). Jusqu'a maintenant la région n'a pas fait l'objet de recherches spéléologiques spéciales, mais les données concernant la structure géologique sont assez complètes à cause des recherches géologiques et hydrogéologiques effectuées dans cette région (Grântcharov, 1959). Les riches informations géologiques et géophysiques, complétées para les observations et les recherches des auteurs, incitent à supposer la singularité de ce phénomène, ainsi que l'existance d'un grand système karstique inconnu qui attend ses explorateurs.

Revue géologique

Le type de roche fondamental qui définit la physionomie de la région est le granite calco-alcalin. Ces granites sont alochtones charriés et fortement tectonisés. Leur épaisseur dans la région, déterminée sur la base de forage, varie entre 50 et 80 mètres. A la proximité de la superficie de charriage le granite est mylonitisé. L'épaisseur de la zone mylonitisée est de 70 à 80 mètres. Le bas de cette zone est constitué de roches mixtes de façon tectonique des bandes de calcaires du Sénonien dans la mylonite ou des dépôts de morceaux de conglomérat de Lutétien, formés au cours d'un mouvement différentiel unilatéral sous l'action d'une pression générale méridionale. Au dessus de cette zone sont situés les granites bréchiformes de la zone cataclesée, suivis par les granites bréchiformes de la zone cataclesée, suivis par les granites faiblement cataclasés qui occupent la partie la plus haute. Dans certains endroits le granite est fortement déssagré, moulu.

Le granite est charrié sur des roches de différents âges et constitution lithologique, toutes les formations de la base du charriage sont considérablement tectonisées. Dans la région étudiée la base constituée de sédiments du Tithonique et du Sénonien.

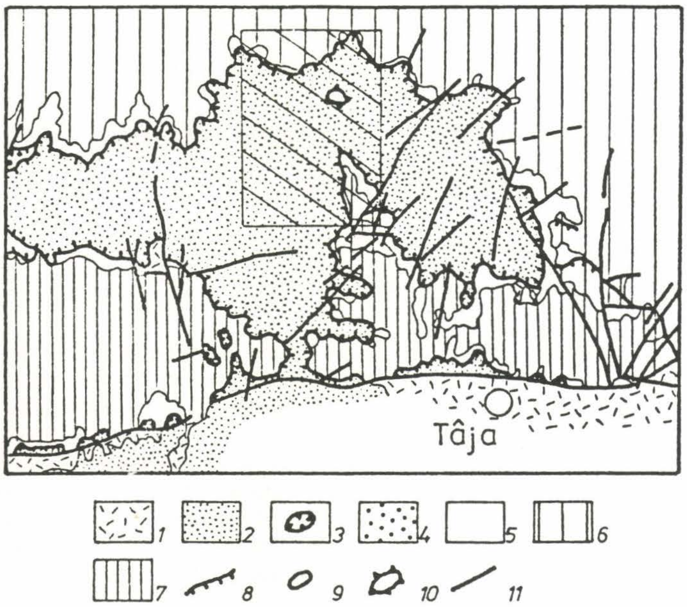

Fig. 1. Schème tectonique de la partie centrale de Stara Planina (d'après Bakirov et al., 1984). La region du développement du phénomène karstique dans les granites est hachurée.
1. dépôts quaternaires, 2. la nappe de charriage de Stara Planina, 3. blocs exotiques de la nappe de charriage de Chipka, 4. nappe de charriage de Chipka, 5. roches du Crétacé supérieur et du Paléogène, 6. roches du Trias, du Jura et du Crétacé inférieur, 7. roches prémesozoïques, 8. nappe, 9. klippe, 10. fenêtre tectonique, 11. failles

Les sédiments du Tithonique sont répandus dans la partie septentrionale de la région leur épaisseur étant de quelques centaines de mètres. Ils sont représentés par des matériaux terrigènes imperméables.

Les sédiments du Sénonien qui sont du type septentrional – Maastrichtien sont disposés dans la région d'une manière discordante sur les sédiments du Tithonique. Ils représentent des calcaires compacts d'une couleur grisâtre avec des filons de calcite et des concrétions de flint. Les calcaires qui ont subi un traitement tectonique fort sont très karstifiés. On y aperçoit des dolines et des fentes élargies. L'épassieur de ces calcaires est de 10 à 100 m. Gisant directement sous les masses alochtones de granite, le charriage de celles–ci a provoqué par endroits des pressurages ou des accumulations de calcaires.

Revue Tectonique

La spécificité caractéristique de la région réside en sa structure de charriage. Les granites de Srêdna Gora ont charrié vers le nord sur une base rocheuse essez hétérogène quant à la constitution lithologique et l'âge. La superficie de glissement est raboteuse, faiblement inclinée vers le sud.

Les calcaires du Sénonien ont supporté la pression d'une manière particulièrement défavorable. Les granites eux–mêmes sont faibles, fortement fissurés, écrasés et même entièrement désagrégés. Cette circonstance a permits au processus de désagrégation de pénétrer à une grande profondeur. Actuellement les eaux de ruissellement filtrent à travers le granite, gagnent le drainage karstique naturel et remontent, sous forme de sources karstiques, vers les calcaires du Sénonien.

La région est traversée d'une faille normale assez longue à orientation E - O qui, avec une autre faille–satélite parallèle trouve un graben prédéterminant la vallée de la rivière Tâja. On y trouve une autre faille orientée à 55° NE dont la lèvre Nord-Ouest est affaissée et un réseau de fissures toutes orientées à 50-55° qui traversent la vallée de la rivière.

Donnees Hydrogéologiques

Dans la région sont présentes des eaux de terrains, de diaclase et de fond karstique. Le niveau des eaux alluvionnaires varie entre 0,5 et 4,0 mètres selon la saison. Les eaux de diaclase sont formées dans les granites. Les sources, alimentées par ces eaux ont le débit insignifiant.

Les eaux de fond karstique sont concentrées dans les calcaires du Sénonien. Les travaux de forage montrent qu'il existe un fort écoulement d'eau souterraine, car dans un des forages, à 99 mètres de profondeur dans les calcaires du Sénonien il a été perdu 1.000 kg d'argile. Dans la région il y a quatre grandes sources karstiques. Elles sont situées au niveau inférieur, à la limite entre les sédiments du Sénonien et du Tithonique et jaillissent de canaux souterrains aux dimensions de 8 à 10 mètres de longueur et de 0,5 mètres de hauteur. Il est déjà prouvé le rapport direct entre leur débit et la quantité des précipitations atmosphériques.

Phenomenes et processus Physico-Géologiques

Les processus de karstification ont atteint aussi bien les calcaires du Triassique moyen que ceux du Sénonien, mais les sources karstiques ne sont concentrées que dans les calcaires du Sénonien. On admet que la région se caractérise par un holokarst typique. Il y a des grottes, des dolines et des effondrements.

Sur la rive gauche de la rivière Tâja, dans les calcaires du Triassique moyen se sont formées des grottes aux dimensions considérables. Le long de la couronne des calcaires du Sénonien on peut apercevoir des grottes d'une longueur de 15 à 20 mètres.

Les processus de karstification dans les calcaires du Sénonien, tectoniquement déformés et fissurés assez fort durant le charriage, sont favorisés par l'agression des eaux atmosphériques et fluviales pénétrant par le granite. Or, l'alochtone et l'autochtone ont subit post-charriage des déformations et des fissurations. Tout celà a contribué à la formation dans les granites des dolines de type entonnoir, typiques pour les régions karstiques. Vu la singularité de ce phénomène, dans notre étude nous aborderons plus en détail les causes de sa génèse.

La plaque de granite, fortement fissurée et déformée par les processus tectoniques ne constitue pratiquement pas un obstacle à la pénétration gravitationnelle en profondeur des eaux atmosphériques et fluviales. Les mesures hydrométriques présentées par Grântcharov (1959) démontrent que la rivière Tâja, dans le domaine des granites perd jusqu'a 600 l/s de ses eaux qui pénètrent par les failles et les fentes pour arriver aux calcaires du Sénonien. Les eaux superficielles qui sont très agressives (le coefficient de saturation par rapport à la calcite est entre $0{,}2.10^{-3}$ à $6{,}7.10^{-3}$) en atteignant les roches carbonatées commencent à les dissoudre. Dans ce cas il en résulte une vive karstification des calcaires du Sénonien de l'autochtone. Nous avons déjà signalé que les travaux de forage ont prouvé la présence d'écoulements souterrains d'eau assez forts, même il s'est produit un effondrement de la tige dans une caverne d'une hauteur de 3 mètres. Cette karstification se reflète directement sur la plaque de granite érodée et susceptible à une destruction mécanique qui permet l'exportation du granite désagrégé. Sur la surface terrestre se forment des dolines de 5 à 35 mètres de diamètre et d'une profondeur d'environ 5 mètres (fig. 2 et 3). On a trouvé plus de 30 formes de ce genre dans la région. Pratiquement ce sont des gorges profondes de 70 à 100 mètres, remplies de matériel détritique qui unissent les formes karstiques superficielles

Fig. 2. Vue sur une des petites dolines dans les granites.

et souterraines dans les calcaries du Sénonien. Leur formation est liée avant tout aux endroits d'entretraverse des grandes failles tectoniques. C'est à ces endroits que la perméabilité du granite est la plus élevée. Les essais ont prouvé qu'une des dolines peut assumer plus de 50 l/s d'eau, une liaison hydrolitique directe existant entre cette doline et la plus grande source karstique dans la région, située au contact des calcaires du Sénonien et des grès du Tithonique.

Fig. 3. Vue sur une des plus grandes dolines dans les granites.

Les recherches géophysiques dans la région ont démontré au moyen des méthodes électriques que les réseaux dont les fissures les plus ouvertes et susceptibles à destruction complémentaire sont celles à orientation NE-SO et NO-SE, ces directions étant généralement propres aux granites. Nos études sur les champs des tensions tectoniques qui ont provoqué la fissuration des calcaires du Sénonien ont démontré que les directions des systèmes des fissures les plus ouvertes (fissure d'extension) sont les mêmes que dans les granites (fig. 4). Figure 5 est une démonstartion de la très bonne coincidence des directions des systèmes principaux des fissures ouvertes, obtenues par une réconstruction des champs des tensions tectoniques à l'aide des fissures de cisaillement dans les calcaires du Sénonien (par la méthode de Nikolaev, 1977) et les axes d'anisotropies électrique, obtenus à l'aide d'un sondage électrique vértical dans des différents azimuts (des données non publiées de Tr. Alexandrov et de D. Tzatchéva) se rapportant surout aux granites de l'alochtone. Cette coincidence des systèmes des fissures les plus ouvertes indique que

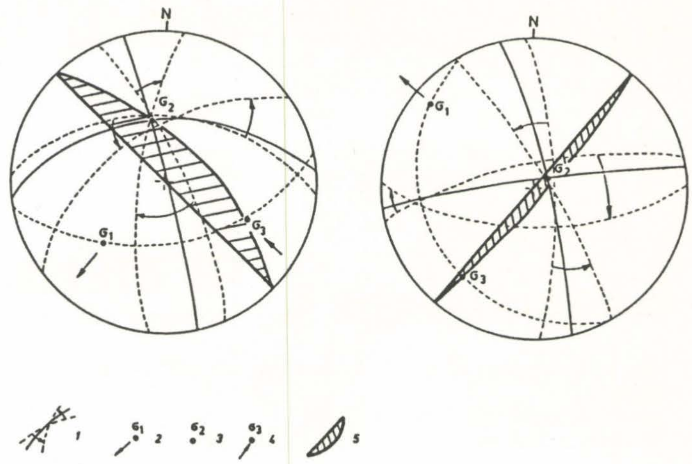

Fig. 4. Reconstruction des champs des tensions tectoniques dans les calcaires du Sénonien.
1. fissures de cisaillement avec l'indication de la direction de leur dispersion, 2. axe d'extension maximale, 3. axe intermédiaire, 4. axe de pression maximale, 5. situation spatiale des fissures d'extension.

celles-ci s'étant formées après la formation du charriage, ont traversé l'alochtone et l'autochtone et ont initié les processus de karstification. Concernant les calcaries les choses sont claires, mais en ce qui concerne les granites le problème est plus compliqué. Comme nous l'avons déjà dit, les processus de suffosion et d'é boulement gravitationnel ont contribué à la formation des dolines en forme d'entonnoirs dans le massif granitique. De cette manière on peut voir des formes exotiques pour les roches de granite, mais typiques pour les régions karstiques.

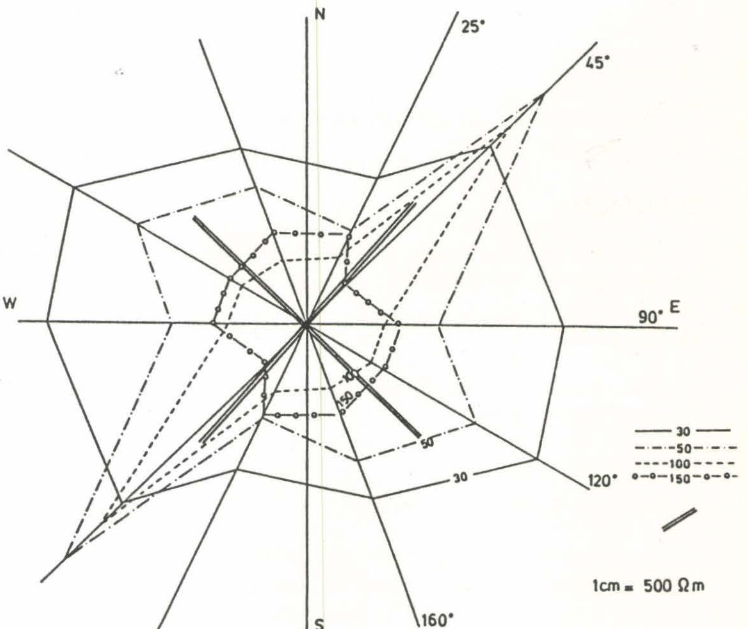

Fig. 5. Diagrammes polaires de a résitivité électrique d'après les résultats des mésures azimutales électrométriques dans les granites et directions des fissures d'extension dans les calcaires du Sénonien.
1. diagrammes polaires de la résistivité électrique à des profondeurs différentes, 2. direction des fissures d'extention dans les calcaires.

Les processus de destruction de granites et d'extraction du matériel ont favorisé aussi la formation de petites grottes sur la superficie du charriage dans la zone mylonitisée qui peut jouer le rôle d'une couche imperméable pour l'eau de diaclase dans les granites. La figure 6 représente la carte d'une grotte de ce type dont la longueur est de 18 mètres.

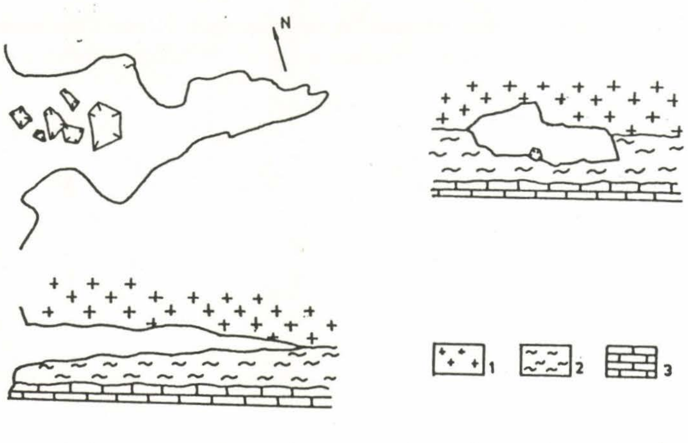

Fig. 6. Scheme d'une grotte située au contact des granites et de la zone de mylonitisation.
1. granites de l'alochtone, 2. zone mylonitisée,
3. calcaires du Sénonien.

Conclusion

Le phénomène karstique présenté dans des granites alochtones a une génesè imposée par deux facteurs: d'une part le traitement tectonique intensif de l'alochtone et de l'autochtone et, d'autre part, les eaux agressives qui font dissoudre chimiquement le matériel détruit des granites de l'alochtone.

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10317

Grotte in depositi fluvio-glaciali. Il Buso del Gicco

Leonardo Busellato
Gianni Petucca

RESUM

Es tracta d'una cavitat que s'obre en dipòsits fluvioglacials referits a un estadi tardà würmià de cimentació variada i amb indicis d'estratificació.

RESUMEN

Se trata de una cavidad que se abre en depósitos fluvio-glaciales referidos a un estado tardío würmiano de cementación variada y con trazas de estratificación.

SUMMARY

That's a cavity that makes way to fluviglacial deposits related to a later würmian stadium of variated cementation and with signs of stratification.

Descrizione e cenni morfologici

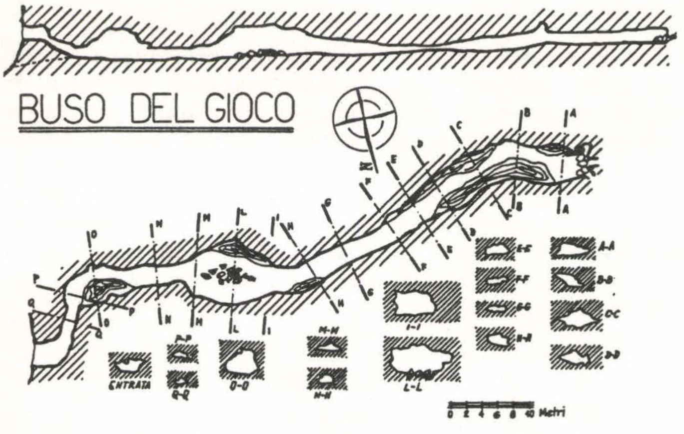
La grotta si apre sulla destra idrografica della Valle dei Cubi, presso il paese di Staro, ad una ventina di metri di dislivello dal torrente e si presenta con un'apertura vagamente triangolare, avente il vertice rivolto in basso.

Oltre l'ingresso la volta si abassa e si procede lungo un cunicolo, inclinato di cerca 35°, avente dimensioni veramente esigue; dopo alcuni metri di strozzatura la volta si innalza bruscamente e si prosegue in una galleria molto ampia, lungo la quale si può procedere assai comodamente fino ad incontrare un nuovo restringimento che porta, dopo dieci metri circa, in una sala di notevoli dimensioni. In questa sono presenti da un lato potenti depositi argillosi, al centro un ammasso di detriti provenienti dalla volta mentre concrezioni sono presenti un pò dovunque sotto forma di esili stalattiti tubolari. A questa sala fa seguito un angusto cunicolo, lungo una quindicina di metri e di sezione constante, al cui termine si ha un nuovo ampliamento; di qui la galleria prosegue con andamento pressochè invariato sino alla fine.

Nell tratto terminale è visibile un cumulo di massi attraverso i quali è probabile sgorghi il ruscello nei periodi di morbida. La cavità non presenta alcuna diramazione e ciò è dovuto probabilmente alla particolare natura geologica del terreno incassante. Infantti qui siamo in presenza di un ampio terrazo costituito da *depositi fluvio-glaciali* di formazione tardo würmiana. Nella massa del deposito sono presenti, in percentuale considerevole, ciotoli di filladi quarzifere, orizzonte presente al letto del terrazzo, si possono notare inoltre ciotoli di arenarie rosso-giallastre, di siltiti argillose, di calcare e di dolomia.

Tutta la massa è debolmente cementata e presenta tracce di stratificazione. La granulometria del deposito è estremamente varia e va dalle argille, alle sabbie e ai ciotoli di dimensioni anche decimetriche.

Sembra poter stabilire che il ruscello, che ha generato la grotta, scorre nella zona di contatto fra due strati di cui l'inferiore, a più alto tenore argilloso, funge da vero e proprio livello di trattenuta. Dato il particolare terreno in cui si apre la grotta, sono necessarie alcune considerazioni sulla circolazione idrica ipogea



e sulla percolazione dell'acqua meteorica attraverso la massa dei depositi fluvio-glaciali che qui osserviamo.

Il corso d'acqua, che attualmente percorre la grotta solo in periodo di morbida, si è aperto inizialmente la strada lungo un giunto di strato, anche si appena accennato. Innanzitutto occorre mettere in risalto che sia i blocchi delle filladi quarzifere sia i blocchi di arenaria silicea presenti nella massa non possono essere attaccati dall'acqua piovana acida per CO_2 disciolta.

L'azione decalcificante si sviluppa quindi solamente sui ciotoli calcarei e sul cemento carbonatico. Così l'acqua circolante lungo il giunto di strato ha operato la corrosione dei ciotoli del letto dello strato superiore con conseguente formazione di piccoli vani nella massa conglomeratica.

La pressione idrostatica e l'azione meccanica hanno facilitato l'opera di formazione di un condotto primario che successivamente ha continuato ad ampliarsi a causa della concomitanza delle azioni chimica, meccanica e graviclastica.

Il deposito conglomeratico sembra presentare una certa permeabilità dovuta ad interstizi fra i clastici, non essendo questi completamente cementati. L'acqua percolante, chimicamente attiva, attraversando la massa conglomeratica aggredisce i ciotoli calcarei ed allo sboccare sulla volta della cavità, cambiando le condizioni di temperatura e pressione, tende a depositare i sali disciolti sottoforma di quelle esili stalattiti tubolari che ornano le volte stesse. La formazione di consistenti depositi concrezionali è impedita dalla rapida evoluzione delle volte dovuta essenzialmente all'azione graviclastica accentuata anche dalle piene del torrente che tendono ad evacuare i clastici ammassati sul pavimento e a erodere le pareti della galleria.

Il torrente in magra sbocca all'esterno attraverso alcune perdite, prossime al condotto di ingresso, che si sviluppano circa lungo il giunto di strato. Notevoli portate hanno difficoltà ad essere smaltite attraverso gli esigui esutori di magra e quindi il livello dell'acqua aumenta tanto da uscire in contropendenza attraverso il condotto percorribile dall'uomo. E' chiaro che sia la pressione idrostatica sia la completa imbibizione della roccia incassante favorisce la disgregazione delle pareti e delle volte mutando la morfologia della cavità.

Non abbiamo altri esempi nella nostra zona di cavità aperte in depositi fluvio-glaciali tardo o post würmiani quindi riteniamo interessante renderlo noto nella speranza di trovare altri casi che ci consentano di approfondire le conoscenze su questo interessante fenomeno.

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Las cuevas de grietas en las margas arcillosas de la parte oriental de la Cuenca Cretácica Checa, Checoslovaquia

Musil, J.
Sociedad Checa de Espeleología,
Organización 5-04 OSIRIS

RESUM

A les margues argiloses del Turonià, a la part oriental de la Conca Cretàcica txeca s'hi han originat moltes «coves de fissures» a causa del moviment dels pendents. Malgrat les investigacions realitzades no és possible de donar una explicació satisfactòria a la problemàtica del pseudocarst de la regió. Això és el que sembla desprende's dels descobriments de noves «coves de fissures», com la cova de Brněnec, de 60 m. de longitud, la prolongació de sistemes ja coneguts de coves i la cova de Rozhraní, de més de 200 m. de longitud.

Actualment ha estat possible d'estudiar detingudament l'espeleogènesi de les coves de Čertovy díry («Forats del Diable») a Bělá, prop de la ciutat de Svitavy. Les coves s'han originat pel moviment de blocs, les causes del qual s'estan estudiant. Se suposa l'existència d'una zona plàstica, on es produeix «creep», la qual es va originar a partir d'una sèrie de transformacions geoquímiques de la glauconita present a les arenisques del Cenomanià marí i a la base del Turonià Inferior i component dels carbonats de les margues argiloses del Turonià Inferior i a partir l'aigua subterrània acumulada a les arenisques i al seu mantell superior.

RESUMEN

En las margas arcillosas del Turoniense en la parte oriental de la Cuenca Cretácica Checa habían originado muchas «cuevas de grietas» por los movimientos de las pendientes. A pesar de las investigaciones anteriores no es posible considerar la problemática del pseudokarst de esta región como concluída. Eso documentan los descubrimientos de las nuevas cuevas de gietas/la cueva de Brněnec –60 m de largo/y la prolongación de los conocidos sistemas de las cuevas/la cueva en Rezhraní –más de 200 m de largo/.

La espeleogénesis fue hasta hoy detalladamente estudiada en las cuevas conocidas de «Čertovy díry/«Agujeros del Diablo»/en Bělá cerca de la ciudad de Svitavy. Las cuevas se originaban por los movimientos de bloques, cuyas causas se examinan. Se presupone la existencia de una zona plástica, en que se produce «creep», la que se originó por causa de las transformaciones geoquímicas entre la glauconita, involucrada en las areniscas del Cenomanian marino y de la base del Turonian inferior, componente del carbonato en las margas arcillosas del Turonian inferior y el agua subterránea que se acumula en las areniscas y su manto superior.

RESUME

Dans les marnes argileuses Turoniennes, dans la partie orientale de la vallée crayause Tchèque, les mouvements des pentes avaient provoqué beaucoup de grottes en crevasses. Malgré les recherches antérieures il n'est pas possible de considérér le problème du pseudokarst comme résolu dans cette région. C'est ce que documentent les découvertes de nouvelles grottes en crevasses –la grotte de Brnënec de 60 de long –et la prolongation des systèmes connus des grottes– la grotte de Rezhrani de plus de 200 m de large.

La spéléogénèse a été jusqu'à présent soigneusement étudiée dans les grottes connues de «Certovy díry/Trous du diable» à Bëlá près de la ville de Svitavy. Les grottes étaient provoquées par les mouvements de blocs, dont on examine les causes. On suppose l'existence d'une zone plastique, dans laquelle se produit «creep», qui fût formée à cause de transformations géochimiques entre la glauconite, mélangée aux grès du Cenomanien marine et de la base du Turonien inférieur, composant du carbonate dans les marnes argileuses du Turonien inférieur et l'eau souterraine qui s'accumule dans les grès et le filon supérieur.

En Checoslovaquia, además de numerosas cuevas cársicas, hay también cuevas pseudocársicas que están vinculadas a diversas rocas, en cuyas investigaciones tiene nuestro país ya una larga tradición/citemos como mímino el trabajo de Kunský/1957. En los últimos años ha intensificado mucho su investigación espeleológica, se ha descubierto una cantidad de nuevas localidades, frecuentemente con las longitudes sorprendentes/por ejemplo la Cueva de detrito de Teplice en las areniscas cretáceas del Planalto de Broumov tiene gracias a los espeleólogos de la Organización 5-03 de Brounov de la Sociedad Checa de Espeleología bajo la dirección del señor Kopeký el largo más de 1 km; la Organización de la SChE 7-01 ORCUS de Bohumín bajo la dirección del señor Wagner ha explorado en la sierra de Beskydy de Moravia y Silesia la Cueva de Cyrilka que con sus 320 m de longitud presenta, hasta la fecha, la más larga cueva de grietas en Checoslovaquia/. A muchos conocimientos valiosos se ha llegado en el estudio de su génesis, clasificación y tipología. Hay que acentuar sobre todo la aportación de las obras de Vítek/1978, 1981, etc./quien ha formado la tipificación morfogenética del pseudocarso que tiene no sólo la importancia regional, sino que en las condiciones del clima moderadamente húmedo es posible generalizarla. A la investigación del pseudocarso en Checoslovaquia ha ayudado mucho la realización de dos Jornadas del Pseudocarso en 1982 y 1985 con la participación internacional en Janovičky cerca de Brounov. Estas Jornadas, organizadas por la SChE, han ayudado en ahondar el interés por el pseudocarso.

El objeto de la presente ponencia es señalar la extensión de las cuevas de grietas en las margas arcillosas de la Cuenca Cretácea Checa, su morfología y desarrollo. Desde el punto de vista de las clasificaciones mundialmente vigentes, ante todo la clasificación física-química de Cigna/1978/, pertenecen estas cuevas unívocamente al pseudocarso. El término técnico cueva de grietas/Crevie-type cave/, en general, lo trajo en la literatura Vítek/ 1978/para las cuevas pseudocársicas que habían originado por el ensanche de la fisura mediante el movimiento al menos de un bloque de roca. Estas cuevas eran antes designadas como cuevas de fisuras que es el término actualmente reservado para cuevas que son resultado de la ampliación de fisuras tectónicas por los procesos de meteorización de rocas. En las margas arcillosas de la Cuenca Cretácea Checa las cuevas de grietas se hallan sobre todo en su parte oriental. A las cuevas se les prestaba atención por parte de varios autores. Las obras más importantes carsológicamente son las de Vítek/1972, 1977/ quien, cartografiando las principales localidades, explicó el origen de estas cuevas de grietas por los movimientos de la pendiente. A pesar de eso no es posible considerar la problemática del pseudocarso en las margas arcillosas como concluída, sea en vista de los futuros descubrimientos y de la prolongación de las cuevas, sea en la explicación de su origen y desarrollo y etc. Eso documentan los resultados de las investigaciones que allí realizan los miembros de la Organización 5-04 OSIRIS de la SChE.

Principales localidades:

La Cueva en Lanšperk– en el valle del río Tichá Orlice. Se trata de la grieta de dirección NE-SW con la longitud de 25 m y la profundidad de 14,5 m.

La Cueva/Sima/del Aire Colado en Hrádek– también en ese valle. Está formada por el sistema de grietas verticales que penetran hasta la profundidad de 38,5 m.

La Cueva Bětník– en el valle del arroyo de Domoradice. La grieta tiene dirección N-S y el largo de 40 m. La hondura es 22 m.

La Cueva Kalvárie/V Dolech/– en el valle del arroyo de Skuhrov cerca de Česka Tředová. El sistema de grietas cruzadas va hasta la hondura de 20 m. La longitud total es 50 m. A consecuencia de la fuerte alteración anterior de rocas por hielo la Cueva Kalvárie presenta hoy día una de las más lábiles cuevas de grietas con un derrumbe muy intenso.

La sima en Horní Újezd– en el valle del Desná. Las grietas con el transcurso principalmente vertical son observables hasta la profundidad de 28 m.

Las Cuevas Čertovy díry/Agujeros del Diablo/– en el valle del arroyo Bělá cerca del pueblo de Bělá. En total 4 cuevas de grietas, de las cuales la mayor tiene 100 m de largo y 15 m de hondo.

Las Cuevas en Brněnec– también en el mismo valle. En total 4 cuevas, cuyas entradas fueron descubiertas por el arranque de las margas arcillosas en la cantera. Las cuevas 1 y 2 son grietas altas y estrechas, en mayor parte destruídas por el arranque, de 10 m de largo. La cueva 3 es morfológicamente análoga a las cuevas de detrito. Es desarrollada en tres pisos, con la longitud total de 60 m y la profundidad de 11 m.

La Cueva en Rozhraní– en el valle del arroyo de Bradlné. Es un sistema complejo de grietas que se cruzan y forman unos pisos; tienen 20 m de hondo y 200 m. de largo. A pesar del derrumbe intenso los miembros de la OSIRIS contínuan aquí en el trabajo de prolongación.

La Cueva cerca de Hřebeč– se halla en la pendiente abrupta de la cuesta de Cresta de Hřebeč. Una serie de grietas intercomunicadas que llegan hasta la profundidad de 10 m.

La Cueva en Velké Opatovice– se encuentra en la pared de la cantera abandonada encima del arroyo de Opatovice. Pese a que una parte del sistema se destruyera por la explotación, el resto tiene 45 m de largo y continúa ámpliamente hacia la hondura.

La Cueva en Boskovice– se encuentra en la cantera en el valle del Bělá. Relicto de la cueva destruída, antaño hasta, ahora tiene 15 m de largo.

Las Cuevas en Dolní Lhota– se encuentran encima de la cantera en el valle del río Svitava. Las grietas de 10 m de hondo, formadas sólo hace unos años en consecuencia de la perturbación de la estabilidad de la pendiente por la explotación superficial en la pedrera.

Las cuevas tienen en su mayoría el carácter de grietas altas y estrechas, orientadas de acuerdo con la dirección original de la fisura tectónica o atectónica. En el perfil diagonal tienen la forma de la letra A, a veces la paredes están casi paralelas o en forma de la letra V y el cielo es constituído de bloques desmoronados y detrito. Con tal que la roca haya sido alterada por diversas causas ya en los planes horizontales, la morfología es distinta. La cueva tiene el carácter de bajas galerías de arrastramiento y frecuentes derrumbes. Los espacios más vastos entre mayores bloques no son altos. Hay aquí una analogía llamativa con las cuevas de detrito. Ambos dichos tipos morfológicos pueden combinarse mútuamente.

De este resumen de cuevas se desprende que se trata de las localidades con el tamaño muy pequeño. Pero lo que a nosotros nos interesa, es su génesis. La morfología de las cuevas, así como las mesoformas superficiales acompañantes/las depresiones, los bloques aislados inclinados, etc./corroboran que la causa principal de su origen son los movimientos de bloques de la pendiente. Las condiciones de origen de estos movimientos de la pendiente son las siguientes/Pašek, Košťàk 1977/:

1/ la colocación horizontal o subhorizontal de las rocas

2/ la existencia de dos diversos conjuntos de rocas, donde las rocas firmes, rígidas estriban en rocas blandas, plásticas

3/ las rocas blandas de la sub-base están desnudas en el pie de la pendiente como consecuencia de la erosión, eventualmente de la intervención del hombre

En esta situación se produce la pendiente inestable. En las rocas blandas de la sub-base ocurre por efecto de la presión del manto superior el fenómeno llamado «creep», el cual pasa episódicamente en corrimiento más rápido. Las rocas de la pendiente en consecuencia del «creep» en la sub-base se rompen en bloques, cuando los planos primordiales incomunicantes son, naturalmente, las fisuras tectónicas. Los bloques se mueven y hunden a su sub-base, originando de este modo las cuevas de grietas entre ellos, produciéndose así la igualación de la estabilidad de la pendiente. Así es posible imaginarse, de manera un poco simplificada, la génesis de cuevas de grietas en las margas arcillosas. La situación, sin embargo, no es así de unívoca. Con exactitud corresponden al esquema por ejemplo la Cueva en Boskovice y las Cuevas en Dolní Lhota. En ambos casos forman la zona plástica las arcillas del Cenomanian de agua dulce en la base de rocas cretáceas. En Boskovice fueron descubiertas por la erosión del Bĕlá, en Dolní Lhota, por la explotación superficial, ¿Pero, qué decir en caso de otras localidades, donde la segunda citada condición del origen de los movimientos de bloques no está aparentemente cumplida? De la estructura geológica de los alrededores de las cuevas resulta que también profundamente debajo del fondo del valle se hallan sólo las rocas rígidas. Sin embargo se dan aquí los movimientos de bloques que dan origen a las cuevas y en el caso del valle del arroyo Bĕlá al sur de la ciudad de Svitavy trataremos de explicar sus causas.

El arroyo Bĕlá es afluente derecho del río Svitava, desembocando en él en la villa de Brnĕnec. Unos 1.500 m al oeste de Brnĕnec pasa por el pueblo de Bĕlá. En la pendiente norte del valle se encuentran los Agujeros del Diablo; las formas superficiales de los movimientos de la pendiente continúan intermitentemente hacia Brnĕnec, donde también se detectaron algunas cuevas. Geológicamente la región es formada por los sedimentos del Cretáceo superior del Sinclinal de Svitavy/Vachtl et al. 1968/, estribados en las rocas metamorfósicas. La base del Cretáceo la forman las arcillitas y areniscas del Cenomanian de agua dulce/capas de Peruc/, siguen las areniscas glauconíticas del Cenomanian marino/capas de Korycany/. El manto superior lo crea la Formación de Bílá Hora del Turonian inferior. La base es formada por las areniscas glauconíticas, luego continúan capas de las espongilíticas margas arcillosas de arena y capas de las espongilíticas margas arcillosas y areniscas. Los sedimentos del Cretáceo fueron alterados tectónicamente por cada fase de la Tectogénesis Sajona y se formaron sistemas de fisuras. Los sedimentos hacen reverencias hacia el norte y noroeste con el declive de 1.°. El valle del Bĕlá es ahondado en las margas arcillosas y en Brnĕnec también en las areniscas glauconíticas de la sub-base. Las cuevas mismas son desarrolladas en las margas arcillosas y areniscas espongilíticas de unos 30 m encima del fondo del valle. Las areniscas glauconíticas contienen casi 20 % de glauconita cuyas propiedades específicas y la importancia para los movimientos de la pendiente explicó Záruba/1961/. El nivel de la superficie del agua subterránea es mantenido por la estructura del sinclinal de la región cretácea y por el borde de la sub-base impermeable en la altura constante de unos 400 m sobre el nivel del mar. El agua subterránea se acumula en las areniscas glauconíticas y su manto superior. Se producen las transformaciones geoquímicas entre la glauconita, el componente del carbonato de las margas arcillosas y el agua subterránea, cuyo resultado es la desagregación de la base del conjunto de las margas arcillosas. Así se origina una zona plástica en la cual se puede producir el «creep». De esta manera está cumplida la segunda condición para el origen de los movimientos de bloques. Hace falta que se produzca todavía el desmantelado erosivo de la zona plástica, pues, el valle ha de ser ahondado hasta debajo el nivel de la superficie del agua subterránea que forma el límite entre los conjuntos firme y plástico de las margas arcillosas. También esta condición está cumplida y poco encima del lugar, donde se cruzan teóricamente la superficie del agua subterránea con el fondo del valle se encuentra la cueva más occidental de los Agujeros del Diablo. El problema pendiente por ahora queda la determinación de la edad de la zona plástica. Pudo formarse después del ahondamiento erosivo del arroyo o antes. Eso, por ahora, no es posible determinar y la discusión acerca de este tema sería demasiado vasta.

En el ejemplo de las cuevas del valle del arroyo Bĕlá fueron mostradas las condiciones cumplidas de la génesis de las cuevas de grietas en las margas arcillosas de la Cuenca Cretácea Checa. La zona plástica aquí se halla presente en la base de las margas arcillosas. La situación análoga existe también en caso de las otras localidades.

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Subjacent karst of evaporites as a cause of huge accumulations of brown coal and their disturbances in Poland

Jerzy Glazek
Warsaw University, Poland

RESUM

La major part dels dipòsits importants de carbó que es coneixen a Polònia es van formar en depressions Pre-badenianes, al llarg de zones de fractura entre les extenses evaporites de Zechstein i les Triàsiques de capes profundes. L'origen d'aquestes depressions s'explica per la gran profunditat (superior als 4 km.) i dissolució subjacent («subrosió») de les evaporites i per la circulació de l'aigua subterrània. Aquesta circulació d'aigua en profunditat fou possible per l'efecte simultani de l'hidrotermalisme, l'elevació i els mecanismes de bombeig glacials.

Probablement aquesta elevació considerable (Oligocè-Miocè Inferior) va generar un hidrotermalisme superior al contemporani i l'activitat volcànica d'aquella època (30-15 M anys) relacionada amb el gran fluxe de calor, resultat de l'acceleració de l'intercanvi d'aigües subterrànies en les roques sedimentàries. Procesos de «subrosió» similars s'activaren durant el Plistocè, a causa de flexions isostàtiques glacials que ocasionaren un bombeig de l'aigua subterrània profunda. Com a conseqüència, aquestes depressions, buidades, es varen emplenar de torba. Aquest carbó revela els desordres deguts al combament subrosional subseqüent.

RESUMEN

La mayoría de los depósitos importantes de carbón conocidos en Polonia se acumularon en depresiones pre-Badenianas a lo largo de zonas de fracturas entre la extensión de las evaporitas de Zechstein y Triásicas en capas profundas. El origen de estas depresiones se pueden explicar por la profundidad (superior a 4 Km.) disolución subyacente («subrosión») de las evaporitas por la circulación del agua subterránea. Esta circulación de agua en profundidad fue posible por el efecto simultáneo del hidrotermalismo, el levantamiento y los mecanismos de bombeo glaciales.

Problablemente el considerable levantamiento (Oligoceno-Mioceno inferior) produjo un hidrotermalismo mucho mayor que el contemporáneo y la actividad volcánica de aquella época (30-15 M años) relacionada con el caudal de calor incrementado que resulta en la aceleración del intercambio de aguas subterráneas en rocas sedimentarias. Los procesos de «subrosión» similares fueron activos en el Pleistoceno debidos a flexiones isostáticas glaciales que produjeron bombeo de agua subterránea profunda. Como resultado estas depresiones vaciadas se rellenaron de turba y este carbón revela desórdenes debidos al combamiento subrosional subsecuente.

SUMMARY

Most of the known thick brown coal deposits in Poland were accumulated in pre-Badenian depressions along fracture zones within the extension of Zechstein and Triassic evaporites in the deep substrate. The origin of these depressions may be explained by the deep /up to 4 km/ subjacent dissolution /subrosion/ of evaporites by groundwater circulation. Such depth of water circulation was enabled by joint effect of hydraulic head, heat lift and glacial pumping mechanisms.

Probably, the considerable uplift /Oligocene-Lower Miocene/ caused much greater than contemporaneous hydraulic head and volcanic activity in that time /30-15 Myr/ connected with increased heat flow resulted in acceleration of deep groundwater exchange in sedimentary rocks. Similar subrosion processes were active in the Pleistocene due to glacial isostatic flexing lexing which caused deep grundwater pumping. In result, subsided depressions were filed with peat and than brown coals revealed disturbances due to subsequent subrosional sagging.

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Magnesite karst in the Slovenské rudohorie Mts. /Czechoslovakia/

Ženiš Pavel – Gaál Ľudovít

RESUM

A les muntanyes de Rudohorie, a Eslovàquia, els complexes carbonífers dolomia-magnesita del Geméricum comprenen el fenomen subterrani càrstic: les cavitats. Aquestes cavitats, en efecte, constitueixen el principal instrument per a la identificació i descripció del carst de magnesita, ja que les magnesites afloren, solament, en una petitíssima extensió de la superfície. La carstificació causant de la gènesi de les cavitats s'associa amb l'erosió atmosfèrica química de les magnesites, en conexió amb els procesos mecànics de les zones més afectades tectònicament.

RESUMEN

En los Mts. Rudohorie en Eslovaquia, los complejos carboníferos dolomía –magnesita del Geméricum comprenden el fenómeno subterráneo kárstico– las cavidades. Estas cavidades en efecto, son el principal instrumento para la identificación y descripción del *karst de magnesita, ya que las magnesitas afloran solamente en una pequeñisima extensión de la superficie. La karstificación causante de la génesis de cavidades se asocia con la erosión atmosférica química de las magnesitas, en conexión con los procesos mecánicos en las zonas más afectadas tectónicamente.*

SUMMARY

In the Slovenské Rudohorie Mts., the Carboniferous dolomite-magnesite complexes of the Gemericum comprise the underground karst phenomena –the caves. These caves are, in fact, the crucial tool in identifying and describing the magnesite karst, since magnesites are outcropping only to a very small extent on the surface. Karstification, causing the genesis of caves, is associated with the chemical weathering of magnesites, in connection with the machanical processes in tectonically most affected zones.

I. Introduction

From the karstification viewpoint, cristalline magnesite belongs, generally, to relatively little known carbonate rocks. This can be explained mainly by the fact that its presence on earth's surface does not attain high amount in comparison with limestones and dolomites. In favourable cases, higher concentrations of magnesite usually represent economically important and in masses exploited raw materials, which, to a certain degree limits the possibilities of detailed investigation of the karst phenomena. On the other hand, the fact needs to be mentioned that it was namely mining works that enabled us to obtain the results, since mainly natural underground caverns, inaccessible from the surface, are a dominant feature of magnesite karst in the Slovenské rudohorie Mts. Obtained data and Knowledge on the magnesite karst are concerning the region of the Western Carpathians, which is, to a certain degree, characteristic by relatively abundant occurrences of crystalline magnesites. They are concentrated in southeastern part of Slovakia /Fig. 1/, mainly in the belt of Carboniferous rocks. They are attributed to the most important mineral raw materials exploited at several deposits. The deposits of magnesite in Czechoslovakia are one of the largest ones in the world.

Fig.1
The position of studied objets. Explanations: triangles –deposits of magnesites with caves; squares –occurrences of magnesites without caves. 1– Podrečany, 2 –Burda, 3 –Lubeník, 4– Dúbrava massif, 5 – Košice /1 – 5 magnesites in the Carboniferous of the Gemericum/; 6 – Kokava, 7 – Hnúšt'a /6 – 7 magnesites in the Veporicum/; 8 – Kavečany /magnesites in the Rakovec Group of the Gemericum/.

II. Magnesites in the Western Carpathians: brief outline of geological and mineralogical background

Geographically, crystalline magnesites occur in the Slovenské rudohorie Mts., its western part also reaches the Lučenec kotlina depression. They can be found at a number of localities, mainly along the Revúca upland and in a lower extent in the eastern part of the Volovské vrchy Mts. and Čierna hora.

Geologically, they relate to three units, different both in age and tectonics. The most important deposits of magnesites are situated in narrow /maximal width of 4 km/ and 70 km long belt of the so-called north-Gemeride Carboniferous /the Dobschau Group/ between Podrečany and Ochtiná. They occur again in the area of Košice, after the absence in the central part of the Gemericum. Certain deposits are situated in the form of tectonic outliers also above the Veporikum. They occur in epizonally metamorphosed sequence of the Upper Carboniferous. Most frequently, they from lenseshaped bodies, positions and nests together with dolomites, in the midst of graphitic, sandy, chloritic and sericitic schists, phyllites, diabase tuffs, tuffites, diabases and conglomerates /Fig. 2/. Apart from magnesite and dolomite, there appear sporadically also limestones and dolomite limestones in carbonate positions. Magnesite /the content exceeding 36 per

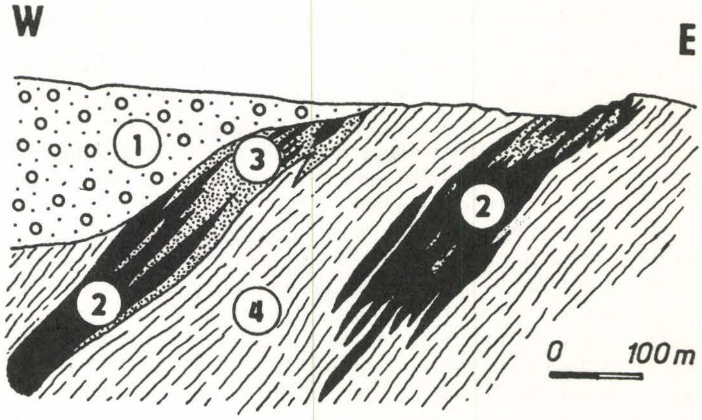

Fig.2
Cross geological section of the magnesite deposit – Košice /according to Korpel', 1963/. Explanations: 1 – gravels, sands, clays /the Košice formation – Pliocene/, 2 – magnesite, 3 – dolomite, 4 – phyllites, sandstones /2 – 4 Carboniferous of the Gemericum/.

cent of MgO/ amounts to 45-49 per cent /Abonyi –Abonyiová, 1981/ at the most important deposits.

Smaller occurrences of magnesites without economic importance can be found in the midst of phyllites of the Rakovec Group /Devonian?/ of the Gemericum in the area Jelšava –Ochtiná and Kavečany. Recently they have also been identified by boreholes near Mníšk and Hnilcom /Grecula –Kobulsh. Ký, 1980/. Several magnesite bodies, together with talc, are placed in the Veporicum crystalline complex, in phyllites and chloritic-talc schists, in the zone between Kokava and Rimavicou and Poloma near Hnúšt'a.

Other magnesite occurrences –those in the Gelnica Group of the Gemericum /Beňka –Snopko, 1974, Turan –Vančová, 1979a/ and also genetically different magnesite occurrences: sedimentary, as a part of evaporites /Turan –Vančová, 1976/ as well as cryptocrystalline associated with weathering of ultrabasic rocks, are all meaningless as to the karstification.

The attention was focused on magnesites of the Carboniferous and only briefly also on the Rakovec Group and the Veporicum. The views on their genesis considerably differentiate. The substantial part of magnesites has most probably originated by metasomatic replacement of original bioherm limestones and partly diagenetic dolomites. Metasomatizing Mg-solutions were the product of metamorphic processes of regional importance, or these solutions were the hydrotherms associated with magmatic processes. Mineralogy of magnesite deposits was studied from a more complex view mainly by Trdlička /1959/ and Abonyi –Abonyiová /1981/. The main minerals in carbonate bodies are: magnesite, dolomite, calcite and at the deposits of the Veporicum talc. Quartz, chlorite, suphides, muscovite are in small amounts, others can be found only in accessory amounts; and there are also some other minerals of the hypergeneous stage of the mineralization. Magnesite occurs in three genertations. Magnesite I /probably diagenetic/ and magnesite III /vein-like/ are seldom occurring. Magnesite II /metasomatic/ is the most wide-spread, fine– to coarse-crystalline, grey-white to dark-grey /dependings on the degree of pigmentation by graphite/. It gains different tints of yellow to dark-brown colour from Fe-oxides by weathering. Dolomite –the second most abundant mineral, is represented by four to five generations. Dolomite I /diagenetic or metasomatic/ is dominant –fine– to medium-grained, light to dark-grey. It forms slightly traceable layered to coarse-lathy positions with some positions and nests of metasomatic magnesite.

III. Detailed characteristic of deposits of the Carboniferous

Outstanding karstification can be traced only on magnesites of the Gemericum Carboniferous, mainly on the largest and at the present time exploited deposits /Podrečany, Burda, Lubeník, Dúbrava massif and Košice/, to a lower extent also on others /Brádno, Ratkovská Suchá, Ploské, Sirk, Ochtiná and others/. At Podrečany there occur five carbonate bodies which are outcropping on the surface, covered by the sediments of the Poltár sequence /Upper Pliocene/ extending to 1300 × 300 m. The dimensions of the main lense are: the length of 650 m, the width of 220 m, the thickness being 80 m. The complex of phyllites, schists and carbonates is overthrusted on the envelope sequence of the Veporicum. It is dipping 30-50 ‰ to the SE. The deposit Burda is formed by the carbonate position in phyllites, with the length of 1500 m and the thicknes of up to 150-200 m. It is built up of mainly dolomite with maximal thicknees of magnesite up to 143 m. It is exposed in the length of 1000 m, of NE-SW direction and with the dip of 25-55° to the SE. The carbonate lense of the deposit Lubeník with maximal length 600 m and the thickness of 100-500 m is situated in the midst of graphitic phyllites. It is exposed on the surface within the length of 300 m. The Dúbrava massif, the largest carbonate body, with its total amount of magnesite is one of the largest deposits in the world /Abonyi – Abonyiová, 1981/. It can be seen on the length of more than 4 km in E-W direction, the dip of 40-60° to the S, the maximal thickness attains 600 m. It is surrounded by sandy, graphitic schists and phyllites with bodies of basic rocks and their tuffs. The locality Košice /see Fig. 2/ is formed by three carbonate bodies, surrounded by phyllites and sand-stones. They are placed in NW-SE direction, dipping 40-60° to the SW. The length of irregular lenses is about 1000 to 1800 m, the width 1100 to 1400 m, the maximal thickness of 200-300 m. A part of the deposit is covered by Neogene sediments.

From the hydrogeological aspect, the dolomite-magnesite complexes often represent independent structures with joint-karst permeability, in relation to the surrounding rocks, they function as the collector. Predominance of groundwater cycles in carbonates is caused by the development of the karst. If the tectonic fault of carbonates is conform with the fault of surrounding rocks, then the cycle of waters is common for both /Klír, 1962/.

IV. The genesis of magnesite karst

The problem of the karst in magnesites of Upper Carboniferous on the territory of Slovakia has already been treated. This karst was studied mainly by Klíŕ /1962/ and later Gaál –Ženiš /1986/. As already mentioned in the description of the most important deposits, the surface karst forms can evolve only in a very limited degree, since magnesites are outcropping only very little on the surface and in small areal extent. A determinig factor for the magnesite karst are, above all, underground caverns –the caves. The origin of magnesite karst is the result of several factors and in comparison with limestones and dolomites, it shows different features in its very essence –the character of weathering of original rock –magnesite. From the chemical point of view, magnesites do not represent pure magnesium carbonate. Mg^{2+} is partly isomorphically replaced by Fe^{2+}, Mn^{2+}, and also Ca^{2+}. Mainly Fe^{2+}, present in the crystalline lattice of magnesite is important in initiating and intesifying the chemical weathering. The FeO contents in Carboniferous magnesites usually vary around 2-3 per cent, but often even more. The increasing MgO content in the majority of deposits is accompanied by the increase of FeO content and also FeO + Fe_2O_3 which provides the evidence for the association of these components /Aboni –Abonyiová, 1981/. Due to the oxidation of Fe^{2+} by atmospheric oxide and also due to the hydratation, Fe^{2+} changes into Fe^{3+} and the resulting product is limonite. Similarly, also Mn^{2+} is changed into hydroxides. Microscopically, the limonitization of magnesite proceeds mainly along the edges of grains and along the cleavage fissure. Other cations Mg^{2+}, Ca^{2+}/ are either leached by water or function in the evolution of hypergeneous carbonates /calcite or also dolomite/ /Trdlička, 1959/. All these secondary products, together with non-soluble restites and relicts of non-decomposed carbonates /mainly dolomite/and weathered silicate rocks, form a part of porous to earthy, brown-coloured mass designated ochre. Certain aggessive role in the decomposition of magnesite can also be played by sulphate ions coming from the weathering of pyrite, occurring mainly in graphitic schists /Turan –Vančová, 1979, Vančová –Turan, 1979/. Generally, also if excluding catalytic effects of Fe^{2+} at physical-chemical weathering of magnesites, the solubility of magnesite is higher in comparison with calcite and dolomite. Free caverns in magnesites originate despite their intensive weathering along the tectonic faults only in a smaller extent, since chemical leaching of carbonate components is not enough sufficient to form free caverns. Al least in the same equal measure, mechanical outflow of chemically resistant limonitic ochres by karst waters along the tectonic faults, is needed. Caverns originated in this way are frequently due to the blocking of drain «channels», also filled with water, also above the level of karst water. Caverns with free space often originate mainly as a consequence of artificial interference –the drainage of faults filled with ochre and water by mining works. As already mentioned, the tectonic predisposition also functions as a determining element conditioning the origin of underground karst forms in magnesites. It is evident that the intensity of karstification is dependent upon the size and thickness of faults and accompanying fissures. Tectonically crushed systems, the places where several faults cross and faults reaching farther into the surrounding rocks, are especially suitable. The dynamic cycle of groundwaters takes place and possibly also mechanical expanding of space. Generally, the karstification along the faults is not continuous, yet it reaches considerable depths. On the surface it is expressed by not clear depression forms; more detailed study is hindered by the ochre weathered envelope. Especially, magnesites from the deposit at Podrečany were very intensively effected by the weathering on the surface. Ochres attain the thickness of up to 40-60 m there. They are covered with the sediments of the Poltár sequence, which indicates already pre-Upper Pliocene karst weathering of magnesites. These are also the only direct evidences of the karstification age practically at all localities, as a matter of course, not considering the present weathering processes.

Dolomites, in space connected with magnesites, have been effected by karstification processes to a lower extent.

These data allow to conclude that the origin of caves in magnesites is the result of the effects of both the chemical weathering /conditioned mainly by the presence of Fe^{2+} in magnesites/, the tectonics and also the dynamic flow of karst waters. All these conditions are met first of all by Carboniferous magnesites. The absence of any of these factors, as evidently testified by deposits in the Rakovec Group /low content of FeO/ and the Veporikum /also low FeO content, faults filled with plastic talc, gradual disappearing of faults into the surrounding chloritic-talc schists/, causes that the karst does not originate /see Fig. 1/.

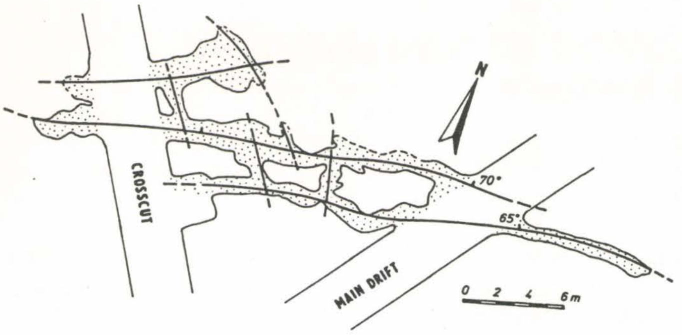

Fig. 3
Tectonic–morphological map of the cave BU–2 /magnesite deposit Burda, 5th horizon – East.

V. Morphology of caves and their secondary filling

All registered karst caverns were dug by underground mining works several tens to the low metres below the surface. In most cases, these spaces were formed on steeply dipping tectonic faults, sporadically also on the border of two lithologically different rocks. On the system of parallel faults and accompanying faults, also differently ramified and mutually connected spaces can originate, yet their general direction is always determined by the main fault /Fig. 3/. The walls of the caverns are usually formed, apart from in situ, by ochred magnesites and veinlets, and nests of non-decomposed dolomite. Allochthonous material is mainly represented by flown loams /Fig. 4/, which in some cases entirely fill originally free caverns. Such fossilated caverns are most common mainly in the levels near the surface of the deposit at Podrečany. The majority of caves have morphologically the character of widened faults /0,X-3 m, only sporadically more/ and chimneys /at the crossing of faults/. The heigt and the length of the space are usually dominant over the width. The length does not exceed several metres to tens of metres, the height of several metres to the low metres. The volumes exceed 500 m^3. Very often they are hydrologically active, which is expressed by moistening and dropping. The longest cave of this type was registered at the deposit Burda. Its length attains 73 m, although a part of it has already been filled with minig waste. The secondary mineral filling is represented by the crusts of palygorskite. The caves in more progressive stage of development than the preceding ones are seldom. Their unique representative is mainly 51 m long cave at the deposit Dúbrava massif with rich decoration, formed by sintre crusts of calcite and aragonite. In the case of aragonite, two morphological types can be distinguished –gravitation and excentric, represented paralelly, to not considerably straw-like up to 40 cm long bunches with complicated aggregation. The vertical flow of karst waters functioned primarily in the formation of these caves, the waters with horizontal direction of flow to a lower degree and in the neighbourhood of the level of original errosion basis. The formation of cave levels due to gradular lowering of karst water level in largere scale is not supposed.

Sporadically are present small rounded corrosion caverns /up to 2 m/, most probably formed below the level of karst water by chemical expanding of small fault systems. Magnesites are ochred not considerably, the walls are usually covered by druse aggregates from tiny crystals of calcite and dolomite, together with leather crusts of palygorskite.

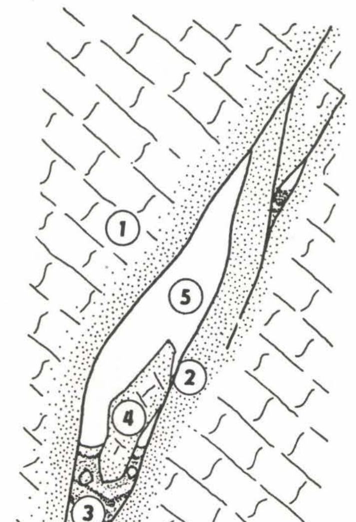

Fig. 4
Idealized cross section of the cavern in magnesites. Explanations: 1 – non–weathered magnesites, ochres in situ, 3 – allochthonous ochre loams, 4 – freed ochre boulder, 5 – free space

VI. Conclusions

Magnesite karst in Slovakia is almost exclusively bound to dolomite–magnesite lense–shaped bodies situated in narrow belt of Carboniferous rocks of the Gemericum, mainly at the deposits Podrečany, Burda, Lubeník, Dúbrava massif and Košice. It is, in fact, represented only by underground karst forms, caves, accessible from mining works. Karstification is genetically the reflection of the chemical weathering, conditioned by oxidation and hydratation of Fe^{2+} present in the crystalline lattice of magnesite, mainly along more pronounced tectonic faults. Free caverns originate mainly by mechanical outflow of products of magnesite weathering/ochres/ by karst waters; the chemical leaching of carbonates plays a secondary role. The caves have evolved along and at the crossing of tectonic faults with steep dip and vertical flow of karst waters. They have the character of expanded faults and chimneys with volume over 500 m^3. Secondary minerals include calcite, dolomite, aragonite and palygorskite.

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Evolución cinemática de unas grietas de desprendimiento por la acción antrópica

Albert Martínez i Rius

RESUM

En el front del mantell del Pedraforca Superior, format per calcàries del Cretaci Inferior i Superior, es van observar, l'any 1984, una sèrie d'esquerdes de desprendiment. *La realització d'una explotació a cel obert d'unes mines de carbó i els materials subjacents del mantell, han produït el desplaçament de les calcàries, a partir de les esquerdes esmentades.*

S'inclou una anàlisi teòrica d'aquest tipus de cavitats.

RESUMEN

En el frente del Manto del Pedraforca Superior formado por calizas del Cretácico Inferior y Superior, se observaron en el año 1984 una serie de grietas de desprendimiento. *La realización de la explotación a cielo abierto de unas minas infrayacentes al manto, han producido el deslizamiento de las calizas a partir de las grietas mencionadas.*

Se incluye un análisis teórico de este tipo de cavidades.

SUMMARY

In the front of the superior Pedraforca Stratum formed by limestones of the Inferior and Superior Cretaceous, a seires of landslide crevices were found in 1984. The exploitation of an open coal mine and the infralying materials of the stratum have produced the landslide of the limestones from the mentioned crevices.

A theoric study on this type of crevices is hereby enclosed.

VULCANOESPELEOLOGIA
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Lava tube cave formation due to a cave crust

Takashi Ohsako
The Japan Society of Volcanospeleology

RESUM

Com a resultat de considerar algunes formes subterrànies en cavitats relacionades amb «cave crust», presentem aquí nous criteris sobre la formació de las cavitats volcàniques, segons las teories proposades per Ohsako el 1982.
S'accepta que, donat que el revestiment de la cova es va formar a partir d'un corrent de lava fosa, les cavitats volcàniques es varen desenvolupar en la lava que flueix amb plasticitat de Bingham, d'acord amb la topografia local i tenint com a punt de partida per la seva formació el canal de lava. Es considera també que la formació de sostres i pisos dins les cavitats volcàniques és deguda a la separació hidrodinàmica dels fluxes de lava, mentre que la formació de les parets depèn del progressiu enderrocament del pis de la cavitat. Tant és així, que la galeria determinada per l'escorça sòlida de la cova es mantindrà fins que el fluxe de lava que l'envolta s'hagi refredat completament.

RESUMEN

Como resultado a considerar algunas formas subterráneas en cavidades relacionadas con «cave crust», se presentan nuevas opiniones sobre la formación de cavidades volcánicas segun las teorías propuestas por Ohsako en 1982.
Se da por sentado ya que la envolvente de la cueva se formó a partir de una corriente de lava fundida, las cavidades volcánicas se desarrollaron en la lava que fluye con plasticidad de Bigham, de acuerdo con la topografía local en el canal de lava como punto de partida de su formación. Y se considera que la formación de techos y pisos en las cavidades volcánicas es debida a la separación hidrodinámica de los flujos de lava y la fromación de las paredes del progresivo hundimiento del piso de la cavidad.
Consecuentemente, la galería determinada por la corteza sólida de la cueva será mantenida hasta que el flujo de lava alrededor de la misma se haya enfriado completamente.

SUMMARY

As a resul of considering some morphologies in caves relating to a cave crust, new views of lava tube cave formation are presented as follows according to the cave crust proposed by Ohsako in 1982.
It is assumed that as the cave crust is formed consecutively in molten lava, a lava tube cave is developed along a flowing lava with Bingham platicity, regarding local topography in lava channel as the starting point of lava tube cave formation. And it is considered that the formation of ceilings and floors of lava tube caves is due to hydrodynamic separation of lava flows, and the formation of sidewalls depends upon the sink of the cave floor.
Consequently, the passage space formed by the solid cave crust will be maintained until the lava flows around the cave have congealed completely.

1030

Cave formations from noncalcareous caves in Kyushu, Japan

Naruhiko Kashima
Department of Geology, Faculty of General Education, Ehime University, Matsuyama, Japan

RESUM

A la part central i a la part sud de Kyushu, al S.O. del Japó, hi sovintegen els volcans quaternaris amb grans calderes i dipòsits de fluxe piroclàstic.
Hi ha també algunes coves no calcàries, tubs de lava i coves d'erosió amb importants colaments de lava i altiplans piroclàstics.
La intenció d'aquest treball és de donar una descripció de les formacions d'aquestes coves no calcàries, del biospeleotema (colònia de diatomees) i dels minerals que hom hi pot trobar (guix i taranakita).

RESUMEN

Volcanes cuaternarios con grades calderas y depósitos de flujo piroclástico están distribuidos por la parte central y Sur de Kyushu al Sudoeste del Japón.

Existen algunas cuevas no calcáreas, tubos de lava y cuevas de erosión en sus notables coladas de lava y mesetas piroclásticas.

El propósito de este trabajo es dar una descripción de la formación de estas cuevas no calcáreas el bio-espeleotema (colonia de diatomeas) y los minerales de cuevas (yeso y taranakita).

SUMMARY

Quarternary volcanoes with large calderas and pyroclastic flow deposits are distributed in central and southern Kyushu, southwest Japan. Some noncalcareous caves, lava-tubes and erosional caves, *occur in their relevant lava flows and pyroclastic plateaus.*

The purpose of this paper is to give a description of the cave formations from these noncalcareous caves; the bio-speleothem (diatomaceous colony) and the cave minerals (gypsum and taranakite).

Introduction

In Japanese Islands, over a few thousand limestone caves are estimated to exist, but an accurated count has not been made. On the other hand, the noncalcareous caves; lava caves and erosional caves are sporadically distributed throughout this country. The studied area (Fig. 1) is a part of Kyushu Island, which lies in the Southwest portion of Japan.

Recent investigations of the noncalcareous caves in Kyushu Island by OGAWA (1981) and FUNAKOSHI et al. (1982) indicate that the lava caves and erosional Shirasu caves are widely distributed. Nevertheless, even today, there are few data relative to the speleo-minerals ins the noncalcareous caves in Kyushu.

This short note produces a special speleothem which consists mainly of diatomaceous colonies and two speleo-minerals from the noncalcareous caves in Kyushu.

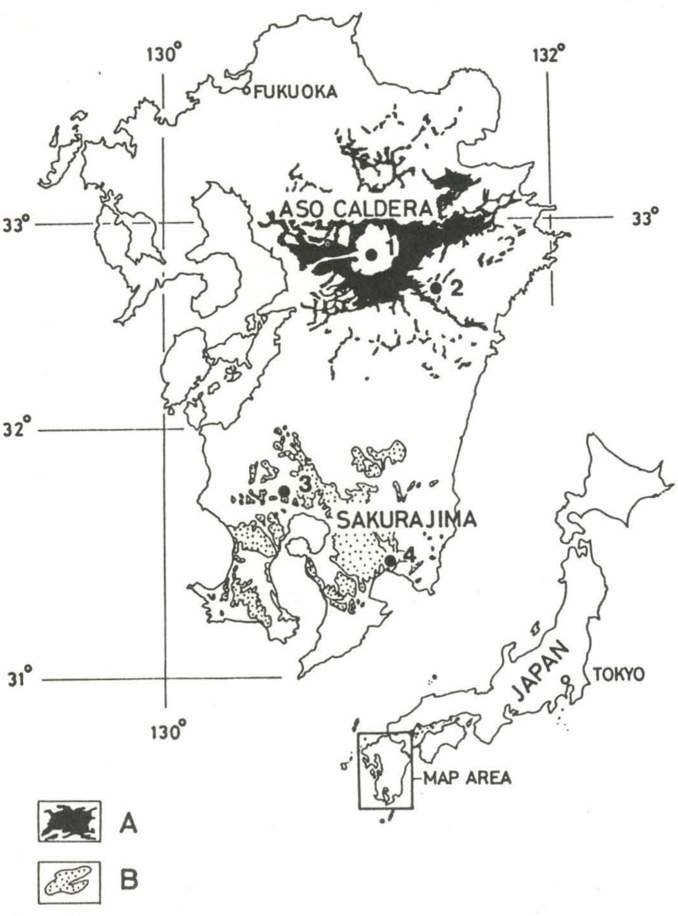

Fig. 1. Geographical and Geological locations of the studied caves. 1: Kometsuka-no-ana Cave, 2: Sakaidani-do Cave, 3: Mizonokuchi-do Cave and 4: Katano-do Cave. a: The Aso pyroclastic flows and B: The so-called «Shirasu».

geological setting and Studied caves

The Aso volcano, located in Central Kyushu, erupted pyroclastic flow in four major eruption cycles before the formation of the Aso caldera in Late Pleistocene age. The Aso pyroclastic flows accompanied with air-fall pyroclastics of these four cycles with intercalation of air-falls and lava flows. Many post-caldera central cones have been formed inside the caldera and one of them is still active.

Kometsuka-no-ana Cave lies about 4 km northwest of the active central volcano cone, Naka-take (1,506 m), Kumamoto Prefecture, at N 32° 54'08'' and EL 31° 02'42''. It is developed in darkgray to black, porous basalt.

Sakaidani-do Cave is located near the southern boundary of the Aso pyroclastic flows which is distributed along valleys in Hinokage-cho, Miyazaki Prefecture, at N 32° 42'07'' and E 131° 23'53''. This erosional cave developed in the basal part of Aso pyroclastic flows.

The so-called «Shirasu», large scale pumice flow deposits, which erupted from caldera volcanoes (Aira, Ata and Ikeda) of Late Pleistocene age is widely distributed over South Kyushu.

Two erosional caves in the Shirasu formations, Mizonokuchi-do Cave, Mizonobe-cho, at N 31° 51'10'' and E 13° 37'21''; Katano-do Cave, Shibushi-cho, at N 31° 31'46'' and El 31° 09'40'', in Kagoshima Prefecture are investigated, preparatorily.

Biospeleothem

At the start, Mr. IRIE of the Kumamoto Education Center found the crystalline cave coral-like formation 2-3 cm in height and 0.5-1 cm in diameter from Sakaidani-do Cave. The X-ray pattern contains no diffraction peaks. Recently, this specimen has been reexamined by scanning microscope and revealed to consist mainly of diatomaceous colonies. Some of the diatom flora, such as genus *Cyclotella,* were recognized.

The distribution of the diatomaceous speleothems was restricted within the cave entrance to threshold zone and occurs primarily as crystalline formations on cave walls, ceilings and breakdown blocks and oriented with respect to cave entrance.

Thin sections showed the structure of an alternation of thin films of clay minerals and very fine detrital matters and the diatomaceous layers.

The chemical composition of the diatomaceous layers of biospeleothem shown in Table 1.

Speleo-minerals

The following recently formed speleo-minerals were identified by X-ray diffraction analysis.

Gypsum $CaSO_4 \cdot H_2O$ Gypsum speleothems was found in Kometsuka-no-ana Cave, Sakaidani-do Cave, Mizonokuchi-do Cave and Katano-do Cave. In Kometsuka-no-ana Cave, gypsum

Table 1. Chemical composition of the diatomaceous layers in biospeleothem by the electron probe microanalyzers(wt%).

Sample numbers	1	2	3	4	5	6	7	8
P_2O_5	----	----	----	----	----	----	----	----
SiO_2	89.83	91.94	88.98	97.36	91.41	88.58	92.61	92.92
TiO_2	----	----	----	----	----	----	----	----
Al_2O_3	0.48	0.83	1.74	0.34	1.26	1.85	0.64	1.54
Cr_2O_3	----	----	----	----	----	----	----	----
FeO	0.03	0.23	0.38	0.00	0.11	0.25	0.02	0.39
MgO	----	----	----	----	----	----	----	----
MnO	----	----	----	----	----	----	----	----
CaO	0.08	0.04	0.03	0.07	0.07	0.08	0.02	0.11
NiO	----	----	----	----	----	----	----	----
Na_2O	----	----	----	----	----	----	----	----
K_2O	----	----	----	----	----	----	----	----
Total	90.43	93.03	91.13	97.77	92.86	90.76	93.29	94.96

Analyst : Yoshifumi Koosaka

occurs as white crystalline, delicate coral-like speleothems and euhedral dentate microcristals. This mineral occurs as pale yellow fine-grained soft aggregates in Skaindani-do Cave. At Mizonokuchi-do Cave, gypsum occurs as white to grayish white, flost-like coatings. Gypsum occurs in Katano-do Cave as a very thin, dark gray crystalline coatings and very small tabular crystals.

Many descriptions have been put forward to explain the genesis of sulfate speleominerals (POHL et al., 1965; GEORGE, 1974 and White,(1976). In Kometsuka-no-ana Cave, the gypsum speleothems may be formed by the reaction to plagioclase in basaltic wall rock to yield calcium cations with the sulfuric acid may be formed the sulfurous gases spouted from active volcano. On the other hand, OBA et al. (1984) reported the presence of very small (less than 5 microns), long prismatic gypsum crystals adhered to the surface of the volcanic ashes erupted out from Sakurajima volcano, Kagoshima Prefecture, South Kyushu. The origin of gypsum crystals, it is reasonable to consider that sulfate anions, calcium cation and water those which were accompanied as volcanic gases just after the eruption. It might be stated that the pyrocalstic flow Shirasu formation contains primary gypsum crystals, there fore there is a large possibility that the source for gypsum speleothem in the erosional Shirasu cave is the reproduction condition contained in the wall rocks.

Taranakite $H_6K_3Al_5(PO_4)_8 \cdot 18H_2O$ Taranakite was identified from Sakaidani-do Cave and Katano-do Cave. It is the characteristic mineral found in bat guano and occurs as wet, white to yellow, fine-grained aggregates.

The Shirasu composed mostly of silica and has the dominance of soda over potash and of lime over ferrous iron oxide. From this chemeical composition indicated that potassium and aluminium of taranakite have been derived from the Shirasu and the other phosphatic acid have been transferred from bat guano.

The speleominerals form only two species in these four noncalcareous lava and erosional caves have been discovered, but these facts suggest that there is a possibility of discovering additional new minerals from the noncalcareous caves in Japan.

Acknowledgements

The author wish to thank Mr. T. IRIE of the Kumamoto Education Center and H. KINOSHITA of the Cave Research Group of Kumamoto for giving invaluable aid in carring out this study and Mr. M. Kato of Ehime Ishi-no-Kai, Mr. T. HIRAOKA, of Matsuyama Technical Highschool, Dr. J. TAKAHASHI of Ehime University for assistance during the field works. The author would like to thank Mr. Y. KOOSAKA of Ehime University for many valuable chemical analysis.

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Contribution to the speleology of Easter Island

Dr. D. Balázs

RESUM

Easter Island (Rapa Nui) és d'origen íntegrament volcànic, constituït per tres volcans de forma triangular. La major part de les roques són laves basàltiques de tipus hawaià.

Segons el seu origen es distingeixen dos tipus de coves: coves marines i tubs de lava. Les coves marines més conegudes són les de Ana Kai Tangata (Canibal Caves) i Ana Toka Rahi Rahi, prop d'Hanga Roa, les quals constitueixen l'únic enclavament d'Easter Island. La major part dels tubs de lava es troben situats en els corrents més recents del cràter de Hiva Hiva, a 5 Km. al N.E. de Hanga Roa. El túnel més accessible és el d'Ana Te Pahn, amb 5 «jameos» (longitud de 500 m., seccions transversals de 8 x 5 m. de promig). La major part dels tubs de lava estan només oberts parcialment o bé són totalment desconeguts. Alguns túnels de lava s'obren al mar.

Són més d'una cinquantena les coves que es coneixen a Easter Island, però són molt poques les que han estat topografiades i estudiades detingudament.

RESUMEN

Easter Island (Rapa Nui) es de origen totalmente volcánico, constituido por tres volcanes de forma triangular. La mayor parte de las rocas son lavas basálticas de tipo hawaiano.

Hay dos tipos de cuevas según su origen; cuevas marinas y tubos de lava. Los ejemplos mejor conocidos de cuevas marinas son: Ana Kai Tangata (Canibal Caves) y Ana Toka Rahi Rahi, cerca de Hanga Roa, y constituyen el único enclave de Easter Island. La mayoría de los tubos de lava están situados en las corrientes recientes de lavas del cráter de Hiva Hiva, 5 Km. al N.E. de Hanga Roa. El túnel más accesible es el de Ana Te Pahn, con 5 jameos (longitud de 500 m., secciones transversales de un promedio de 8 x 5 m.). La mayoría de los tubos de lava están solamente parcialmente abiertos o incluso totalmente desconocidos. Algunos túneles de lava están abiertos al mar.

Hay más de cincuenta cuevas conocidas en Easter Island, pero solamente algunas de ellas han sido topografiadas y estudiadas cuidadosamente.

SUMMARY

Easter Island (Rapa Nui) is entirely volcanic in origin, built up by three volcanoes in a triangular shape. The most abundant rocks are the Hawaiian type basalt lava flows.

According to their origin, there are two types of caves: sea caves and lava tubes. The best known examples of sea caves are: Ana Kai Tangata (Cannibal Caves) and Ana Toka Rahi Rahi, near Hanga Roa, the only settlement of Easter Island. Most of the lava tubes are situated in the young lava flows of Hiva Hiva crater, 5 km NE from Hanga Roa. The most accessible tunnel is Ana The Pahu, with five collapsed entrances (length 500 m, average cross-section 8 x 5 m). Most of the lava tubes are only partially opened or even totally unknown. Some lava tunnels are open to the sea.

There are more tan fifty known caves in Easter Island, but only few of them are carfully mapped and studied.

Easter Island (Isla de Pascua, Rapa Nui) is situated in the South East Pacific about 3800 km W from the Chilean coast and some 4000 km E of Tahiti (lat. 27° 6' S, long. 109° 26' W). It is one of the most isolated islands rising on the middle of East Pacific Rise. The W-E length of the island is 24 km, its width varies between 4-12 km and it has an area of 165 sq. km. The island is entirely volcanic in origin, with lava flows and scoria cones, its maximum height reaches 511 m above the sea level. The climate is sub-tropical, the mean annual temperature is about 21° C, the yearly average raim about 1150 mm. The island is covered with short native grass and low shrub, only a small part of the land is cultivated and artifially forested. The population was 2300 in 1985, of which there were about 1600 natives (rapa nui). Hanga Roa is the only settlement of Easter Island.

Easter Island became known in the world on account of its great stone statues. Many archaeological investigations were carried out, of which the Norwegian Expedition of 1955-56, led by T. Heyerdahl (1961), has reached the best publicity. He studied also the caves of the island from archaeological point of view. Geological investigations were made by L.J. Chubb (1933), A. Lacroix (1936) and M.C. Bandy (1937), but the most complete investigation was carried out by P.E. Baker and his companions (1967, 1974).

According to my knowledge, the Easter Island's caves were first studied by B. Gèze 1975 from speleological point of view, later by a French team: P. Carlier, A. Gautier and others 1978. I made some observations in March 1985 during my one month visit.

Geological fundamentals

Easter Islands is built up by three volcanoes (Fig. 1). The oldest one is the Poike at the E corner of the island (370 m). According to a determination made by D.C. Rex, it has a K/Ar age of 3 m. y. (Baker et al., 1974). The Rano Kau volcano in the SW edge of the island has a caldera with a craterlake of 1,5 km wide. About three third of the island is occupied by the Terevaka volcano (511 m), which is the youngest among them. The first two are typical strato volcanoes, the Terevaka is a fissure volcano with complicated structure (about 70 parasitic pyroclastic cones along the fissures).

The greatest part of the surface is covered by basalt lava flows of different ages and compositions. The most abundant rock type is the Hawaiite (Baker et al., 1974). There are some trachytes and rhyolites, but no sedimentary rocks, except some coral sand in the Anakena Bay.

Most of the caves of Easter Island are developed in basalt lava flows. There are two genetic types: syngenetic caves, which are contemporaneous with solidification of lava flow (lava tubes or lava tunnels, gas bubble holes), and postgenetic caves (sea caves).

The caves of Roiho

The lava caves, especially the tubes or tunnels are short-lived,

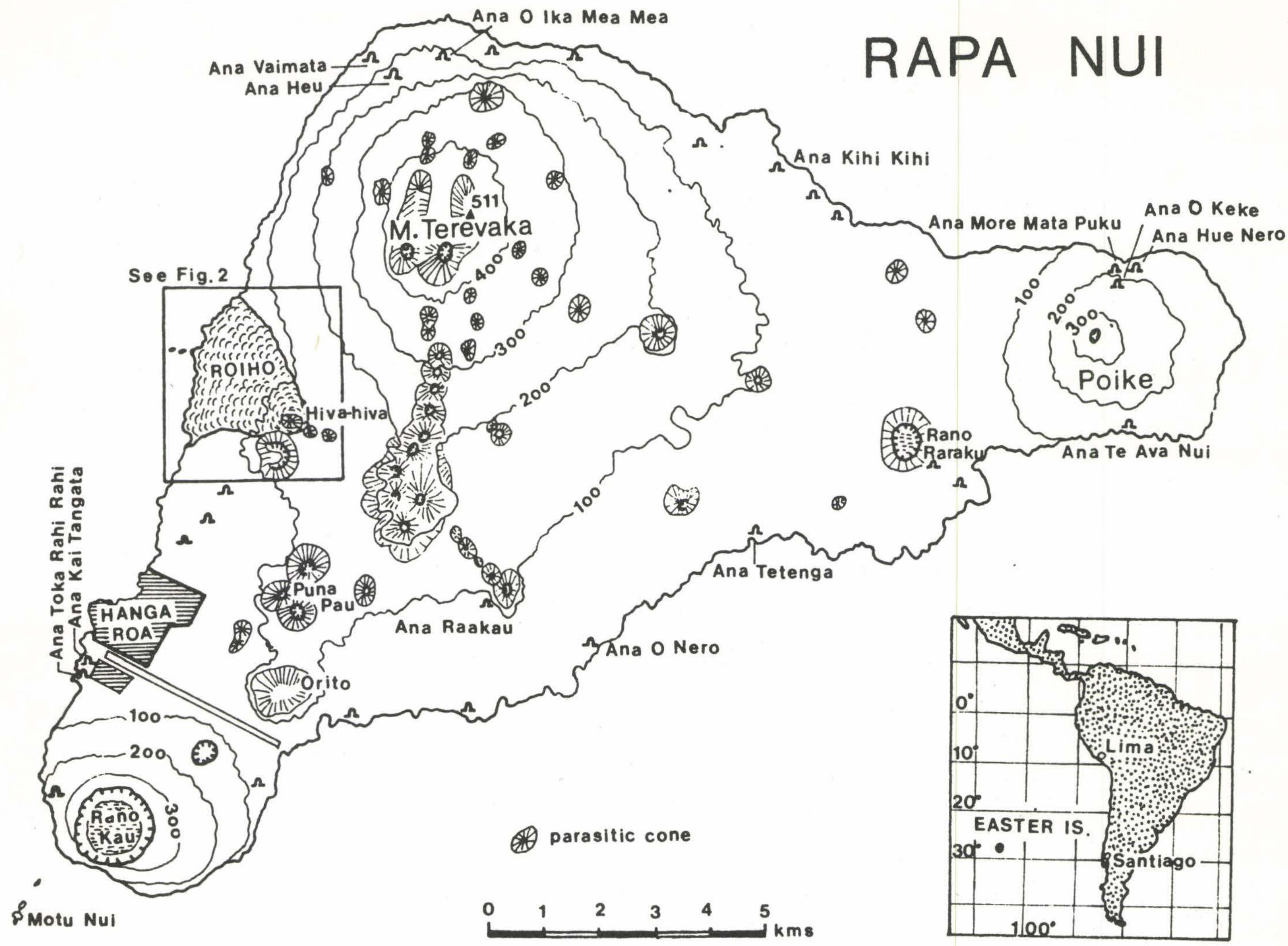

Fig. 1. Map of the Easter Island showing the most important caves

transitory formations, even their recognition is possible by falling in of the roof. Most of the collapsed lava tubes are found on the Roiho lava-field, 5 km NE of Hanga Roa, lying on the SW foot of Terevaka volcano. This is the latest eruption on Easter Island,

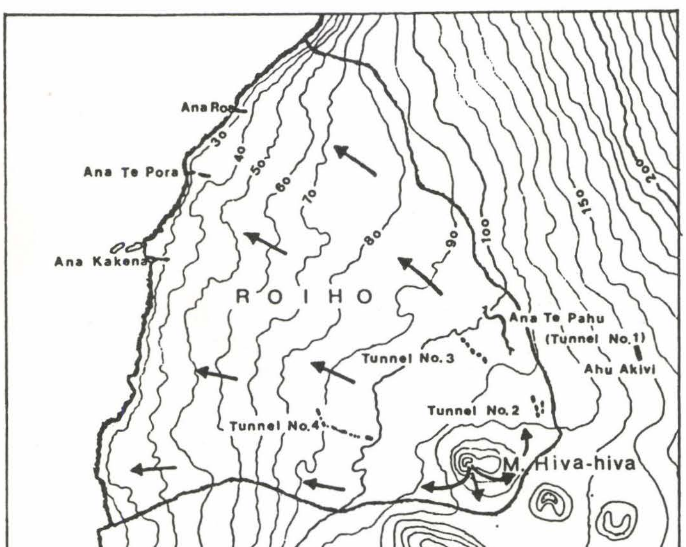

Fig. 2. The Roiho (Hiva-hiva) lava-field with the main lava tubes

may be not older than 3000-4000 years (Fig. 2). The eruption center is the Maunga Hiva-hiva (Maunga = hill), a small parasitic crater 155 m above the sea level /but only 30-40 m above the neighbouring lava-fields. The lava flows moved to N, NW and W direction toward the sea, and occupied an area of about 11 sq. km. The angle of gradient is 2-4°. The lava field abruptly breaks down to the sea by a vertical cliff of 15-25 m.

The latest lava cover has a thickness of about 10-20 m. According to Baker (1974), the Roiho basalt is an olivine tholeiite with distinctly more alkaline affinities. It seems this composition is very suitable for developing empty tubes. Most of the collapsed lava tunnels are concentrated in a radius of 1,5 km from the eruption center. Here the overlying layer of tunnels are only 1-4 m thick, so the roof can fall in easily or even totally destroy.

During my field trips, I could recognize four separated lava tunnels with 20 entrances. The best known of them is the Ana Te Pahu (Ana = cave, Fig. 3.), with 5 entrances and 2 more collapses. The total length of this cave is 540 m with side branches, the sections vary between 6 × 2 and 14 × 5 m. The other 3 tunnels are passable in parts only. Additional tunnels may be supposed on the basis of surface morphology, but the entrances are totally destroyed or they have not still opened up.

There are known lava tubes along the coast too. Some of them open to the sea in the cliffs 15-20 m above the ocean level. The legendary Ana Kakena has 2 «windows» to the sea (Fig. 4).

The internal forms, formations and fillings of the Easter Island's lava tubes are similar to those in other part of the world. Among the syngenetic autochthonous formations ropy floors, lava galleries, lava ribs, lava stalactites and stalagmites etc. can be found. The most abundant allochthonous filling is the alluvial clay

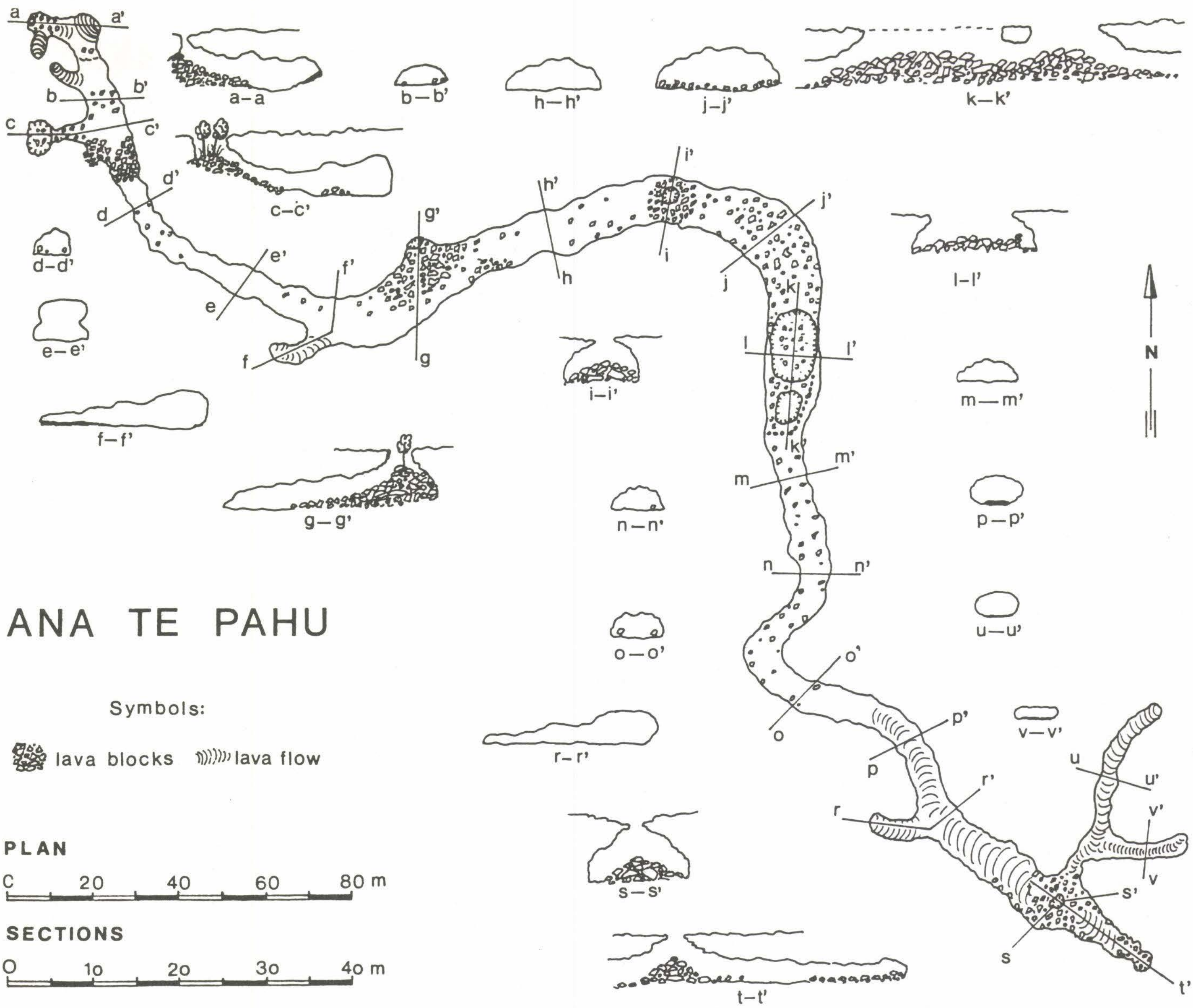

Fig. 3. Map of the lava tunnel «Ana Te Pahu»

washed in the holes. Some of the lava tubes contain periodic or constant water (lake), that was important source for ancient inhabitants. No surface streams exist on Easter Island.

Lava sea caves

Another type of Easter Island's caves are the sea caves developed along the seacoast in the cliffs. These are postgenetic caves eroded by waves and boulders between high and low tide levels.

The best known sea caves are situated about one km SW of Hanga Roa. Here four caves developed in the inside end of the narrow rocky bays (Fig. 5.). The tongue-shape holes penetrate the massive lava rocks up to 15-25 m, with a section 10 × 8 m in the entrance. The smallest one is a dry cave called Ana Kai Tangata «Cannibal Cave», easy to walk in, but the others are active sea caves, and it is difficult and dangerous to enter them during high waves. The most impressive cave is the Ana Toka Rahi Rahi. Some of these sea caves are preformed by old lava tubes open to the sea level.

Conclusion

About fifty caves are known in Easter Island, but many hidden,

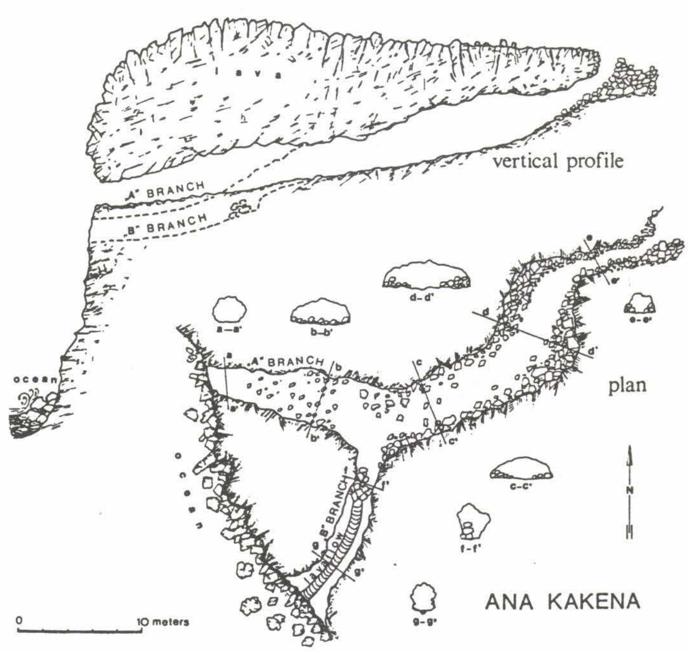

Fig. 4. Map of the Ana Kakena

undiscovered holes still exist. Their systematic investigation would be very desirable because many caves could contain valuable archaeological finds.

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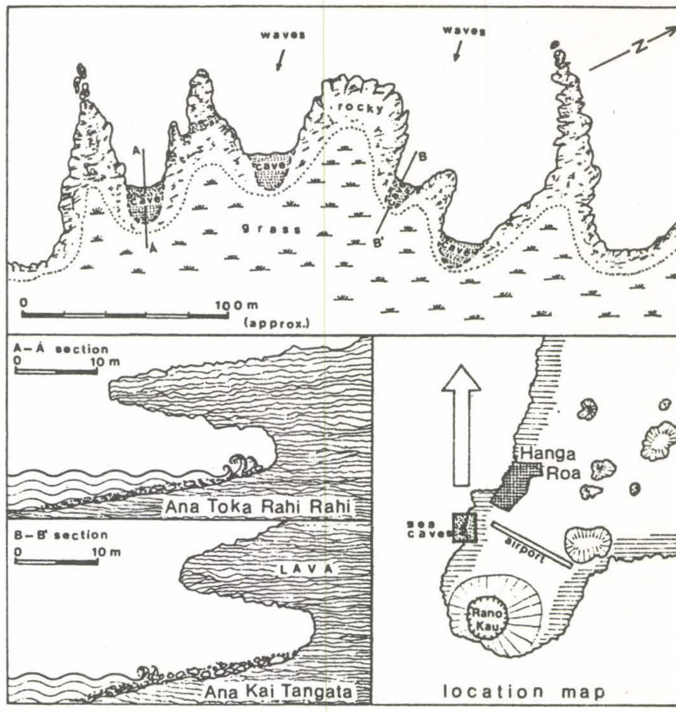

Fig. 5. Sketch of the coast SW from Hanga Roa showing the location of sea caves

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The formation of lava cave

Takanori Ogawa
Japan Volcanospeleological Society

RESUM

En primer lloc, els gasos del corrent de lava finalitzen les unitats del sòl de la cavitat i la «crust».

La «crust» s'enfonsa i el gas construeix les escorces, una a una. L'escorça s'endureix i, més tard, la lava del sòl circula cap a un nivell inferior.

1) Quan la lava és encara fluida defineix les línies de nivell en ambdues parets.

2) Quan la lava acaba dipositant-se en el sól produeix els «shelves (bench)».

3) Quan el pis s'endureix i es mou, el pis de lava endurida es trenca en blocs i raspa les parets.

El desplaçament cap avall del pis erosiona la part que es troba entre les «units caves». Les «unit caves» conecten entre sí i formen la llarga cavitat de tub.

Les teories de les trinxeres no poden aplicar-se a les cavitats del Japó i de Corea.

RESUMEN

Primeramente el gas en la corriente de lava finaliza las unidades del suelo de la cavidad y la crust

La crust se hunde y el gas construye las cortezas una a una.

La corteza se hace más dura y después la lava del suelo circula hacia un nivel inferior.

1) Cuando la lava es fluida marca las líneas de nivel en ambas paredes.

2) Cuando la lava permanece en el suelo produce los shelves (bench)

3) Cuando el piso se endurece y se mueve, el piso de lava endurecida se rompe en bloques y raspa las dos paredes.

El movimiento hacia abajo del piso erosiona la parte que se encuentra entre las unit caves y las unit caves conectan con otras unit caves y forman la cavidad de tubo de lava largo.

Las teorías de las trincheras no se corresponden con las cavidades en Japón y Corea.

SUMMARY

In the first time, the gas in lava flow form the flat unit caves and the crust.

The crust fall off down and the gas makes the crusts one by one.

The crust become hard, and then, the lava of floor travels and level down.

1) When the lava is soft, it makes the level lines on the both side walls.

2) When the lava floor is stayig, it makes the shelves (bench) or lava bridge.

3) When the floor hardens and the floor is moving, the harden lava floor breaks to the blocks and scrapes the both side walls.

The move down of the floor, it is erode the between part of the unit caves and the unit caves connect with the other unit caves and make the long lava tuve cave.

We can't confirm the tseuch theoris to the caves in Japan and Korea.

Introduction

We can't find the clear levee and channel in lava flow field, when the fissur eruption on Miyake Island (south of Tokyo in the Pacific) in Oct. 1983, Mt. Fuji (Japan) and Cheju Island (Korea) are same.

It has been said that Mauna Ulu cave group «C» (1974 lava flow) in Hawaii was formed by conduit drainage.

But in this cave, a flat cavity which at the timne of the eruption, couldn't be observed from the surface of the earth and on whose floor neither the flow nor the subsidence of lava could be detected, is connected with main cave part. We can't explain the existance of this flat cavity by the theory of open channel.

Mauna Ulu caves are the surface cave, so, I think that the formation of lava cave is different from the many other large caves.

We regarded these lava caves in Pahoehoe lava flow with characteristic feature and beleive the important role in the emplacement of the flow.

But, we can find 104 lava caves in Aa lava flow at Mt. Fuji in Japan. Every one must pay attention to the lava caves in Aa lava flow.

I intend to express that can be seen in the interior of caves, mainly in Japan and Korea.

Subject

The viscosity of magma and silicate melt, under the constant pressure, the rise of temperature and the increase of H_2O, Na_2O and K_2O remarkably decrease the viscosity, and TiO_2 and FeO have a great influence on the decrease of viscosity, (fig. 1)

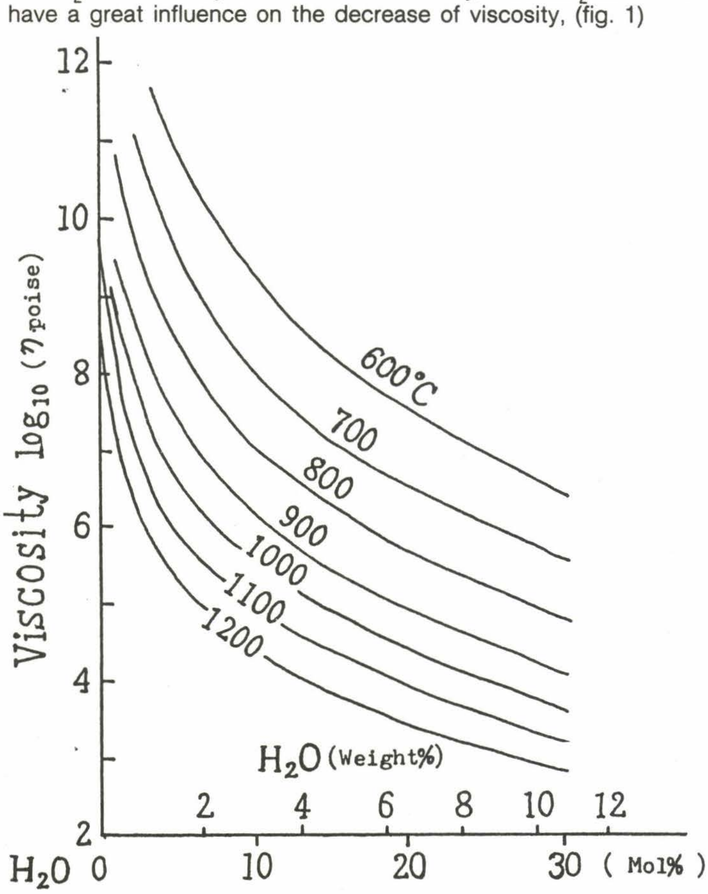

Fig. 1. The viscositi transition by the temperature of obsidian melt and mol H_2O (Shaw, 1965)

For example, when the temperature of lava is higher than that of liquidus, if the temperature rises 100°C, the viscosity decrease to 1/2 or 1/3 of it.

Further laboratory studies have indicated that in liquidus temperature under 20K bar, a melt of tholeitic lava (Kilauea) at 1350°C would have a Newtonian viscosity of about 20 poise and the andesite lava (Crater Lake) is 900 poise at the same temperature.

Generally, though silicate melt has the quality of Newtonian fluid, if the temperature is under the liquidus' one, the amount of crystal increase and it become Bingham fluid. (fig. 2)

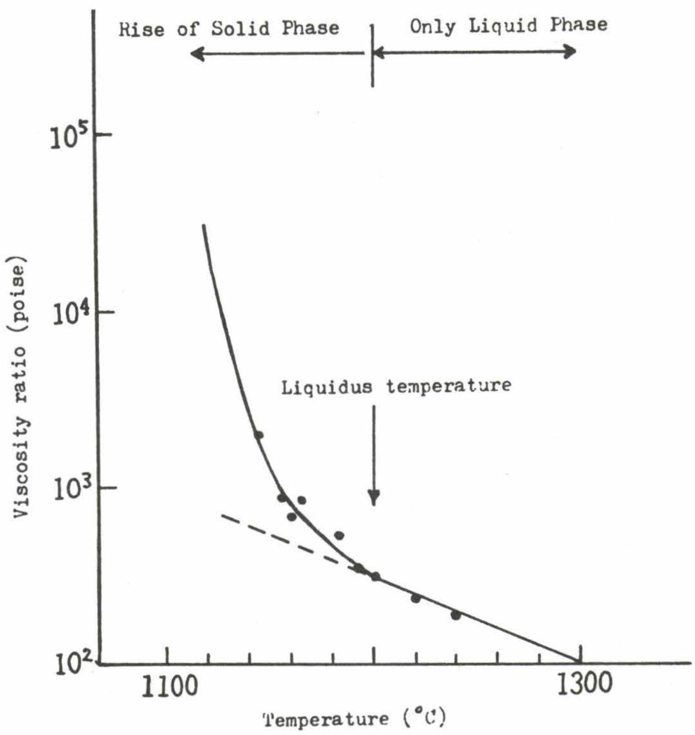

Fig. 2. Viscosity of Soleait lava in Hawaii, under 1 poise (1 poise = 10^{-1} pas.) (Shaw, 1969)

Magma will gradually increase the amount of volatile substance when various kinds of crystals are crystallized. And once the pressure of volatile substance in magma becomes equal to the outer pressure, it come to the second boiling point. Besides, when magma taking in the surrounding rocks, carrries on the composite effect, the volatile substance will get much stronger.

In the condition of Newtonian fluid, vesicle grows in the fluid, and gathers at the upper layer and its bubble magnifies into unit cave.

In case of Bingham fluid, vesicle doesn't grow. But in case of lava flow, vaporized volatile substance including mainly H^2O in magma grows vesicle in succession just like the froth of beer, because of the decrease of pressure. These vesicles gather to the outer layer to grow into big and flat unit caves. The lower lava moves more than the upper cavity. By this movement of lava flow, the floor of unit cave sinks and leaves lava shelves and traces of erosion to both side walls. (fig. 3)

Unit cave floor stands still and gets cold and hard. However, the lava flow of the lower floor starts to move again, the hardened floor, if the stysying time is long, leaves lava bridge, or broken into big blocks, would be carried like a belt conveyer and gouge the both side walls. In this way, it makes conduit between two

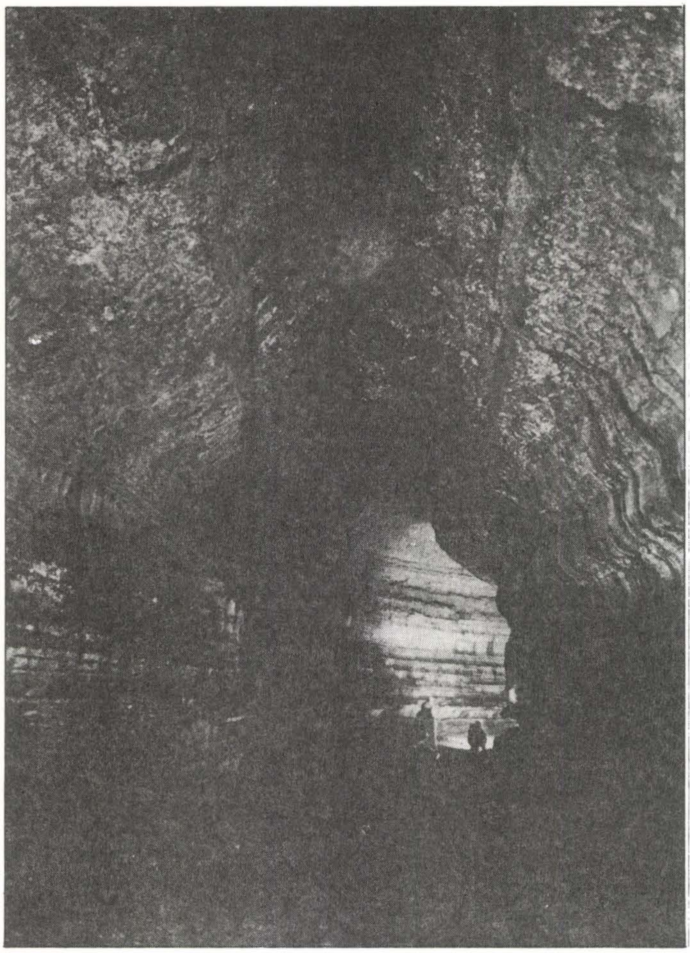

Fig. 3. The lava shelves and traces of erosion to both side walls. Man Jang Gul cave (Cheju Island)

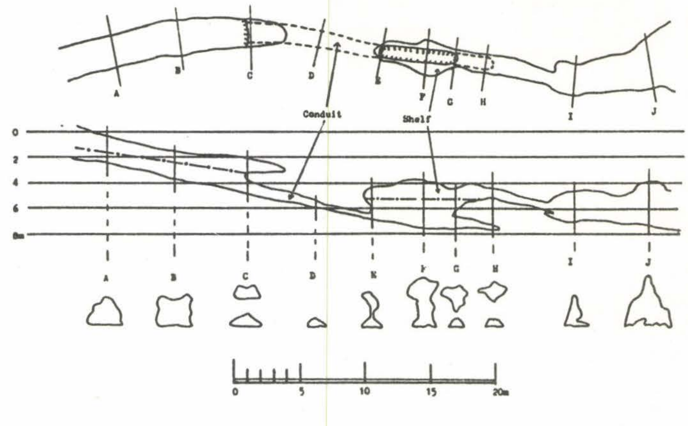

Fig. 4. = a) The part of ZINZA lava cave No.1 at Mt. Fuji

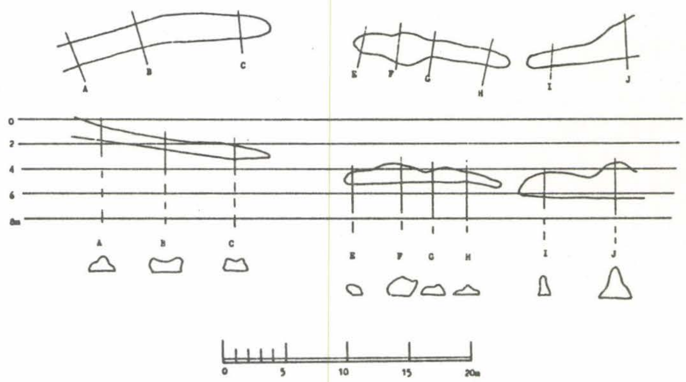

Fig. 4. = b) The state befor the cavities connect with the other.

cavities, as one cavity joins with another, gas moves from one cavity to another. (fig. 4)

We can explain the movement of gas as follows:

1) When the floor is soft lava, it makes the grape type lava stalactites by the pressure of gas which dispersed small pieces of lava into a state of spray, and these particles stuck together one after another in a cluster of stalactites like the grapes.

When the inside of cave is soft and the dropping lava making the stalactites:

2) Stalactite which was bent by the movement of gas.

3) Stalactite on the ceiling that shows many straight parallel lines. (fig. 5)

4) When the floor moved down and the lava shelves are soft, the gas movement make the speleothemes like ripple wave marks on lava shelves. (fig. 6)

5) When the gas pressure goes up in the cave, it makes the large dome, and the gas blows up the lava flow, and there are the blow holes (secondary fumarole) that the lava built, the hill like the cinder cone. (fig. 7)

Suppose lava cave could be made by the lava drains out and the channel built up linings and roofing on the walls, how we can explain the following caves.

a) As in Button Spring cave (Oregon, U. S. A.), the surface of the earth slants of the cave. (fig. 8)

b) Scorpion cave (California, U. S. A). We can see the cavities, pits and 5th level of conduits. (fig. 9)

c) In Bilemot Kul cave (Creju Island, Korea) and Gruts dos Salcoes (Terceira Island, España), a round spiral tube.

d) Tube in tube.

The inside of cave touched with gas, formed the crust and

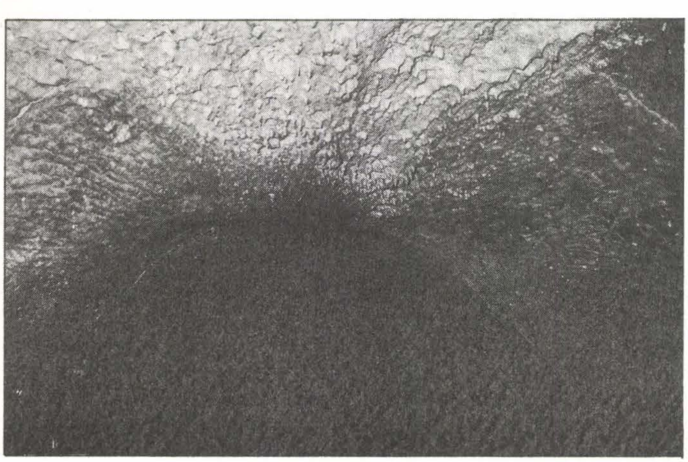

Fig. 5. The straigh parallel lines at the roof. Handul Kul lava cave (Cheju Island, Korea)

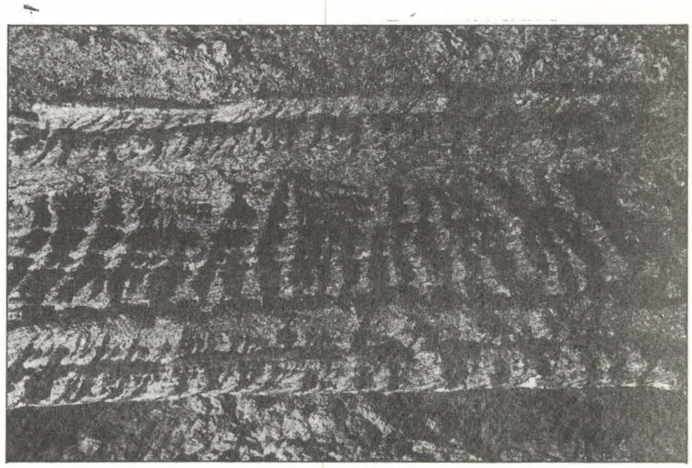

Fig. 6. The gas movement make the ripple wave marks on the lava shelves. Man Jang Gul cave (Cheju Island)

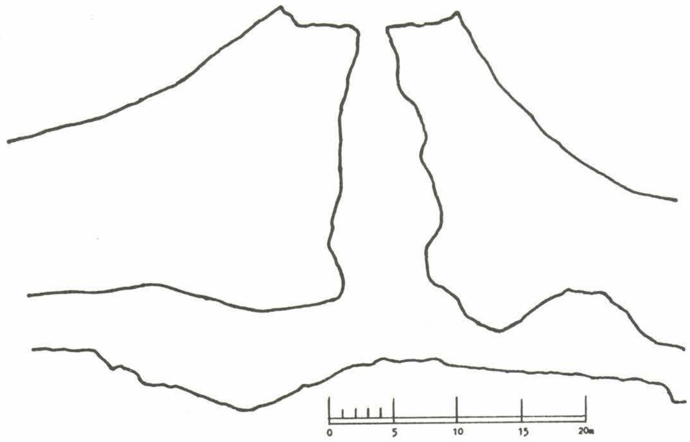

Fig. 7. The blow holl of MOTOSU lava cave No. 1 (494. 3m) at Mt. Fuji

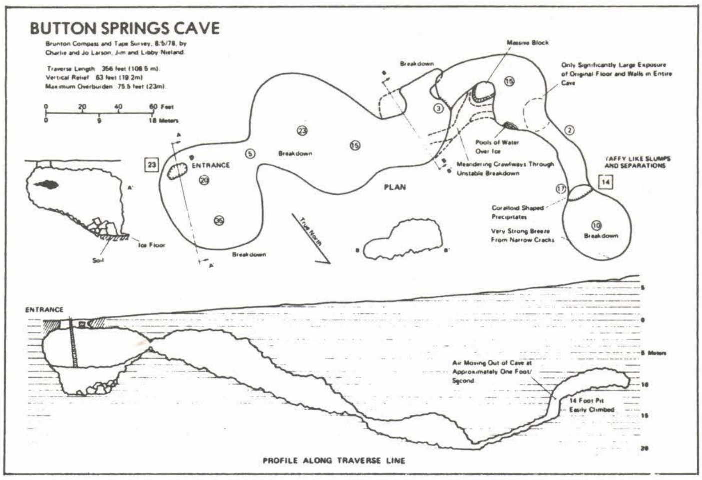

Fig. 8. Button Springs cave (Survey: Larson, C & J and Nieland, L)

lavacicles. Lavacicle like the pipe when the drops of lava are dropping from the between of layerd lava and crack. It can't be formed unless its surface quickly becomes hard and its center part lava dropped out.

The crust around the lava tree mold, it is formed unless its crust quickly become hard contact cooling touched with the tree. (fig. 10)

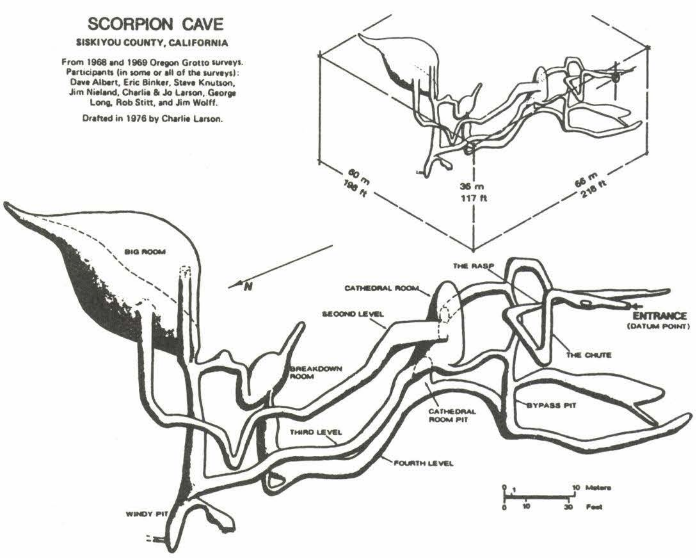

Fig. 9. Scorpion cave (Survey: Oregon Grotto, U. S. A.)

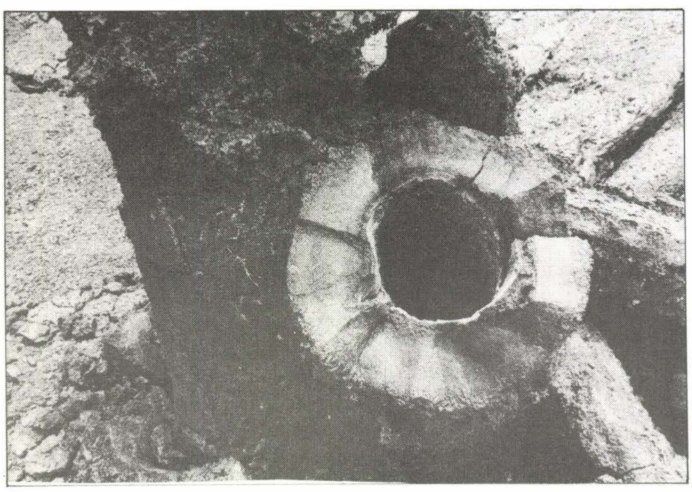

Fig. 10. the crust around the lava tree mold. We can see the columnar joint (Hawaii 1974 lava flow)

When the root isn't scorched, the tree becomes dense again. (fig. 11)

In the case of the compound lava tree mold include the tree fall into decay, the moisture included the compound tree and the ground vaporize by burnig the tree. The vaporized volatile substance make the cavity and the high temperature melt again the lava inside of the cavity. And then, the melt lava make the horizontal floor of cavity above the decay lava tree mold lie down.

By these phenomena it proves that the crust quickly become hard contact cooling with touch the gas.

We can see the columnar joint and the platy joint in the crust. (fig. 12)

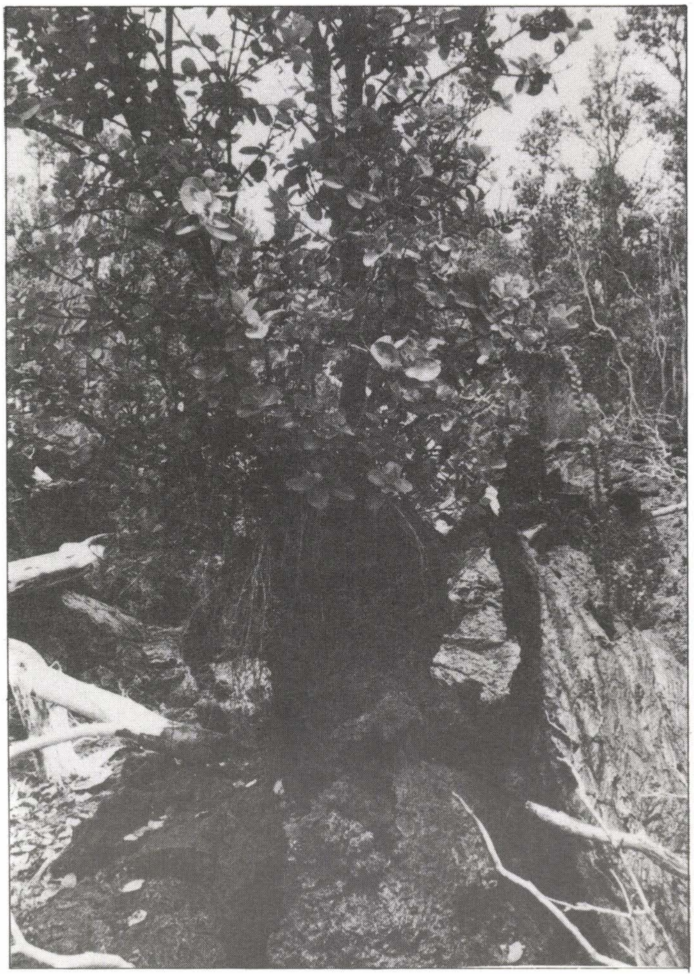

Fig. 11. The lava tree mold which the root isn't scorched, becomes dense again (1974 lava flow, Hawaii)

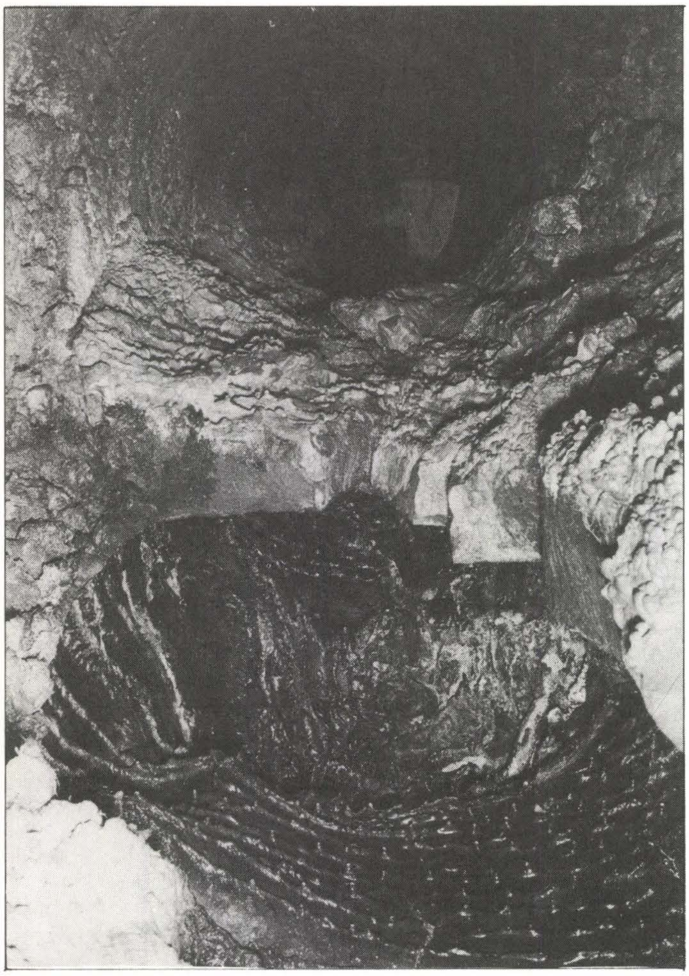

Fig. 12. = a) The compound lava tree mold, the uper part of horizontal floor is the cavity that make the melt again lava, above the decay lava tree mold lie down. (Kenmarubi lava flow, Mt. Fuji)

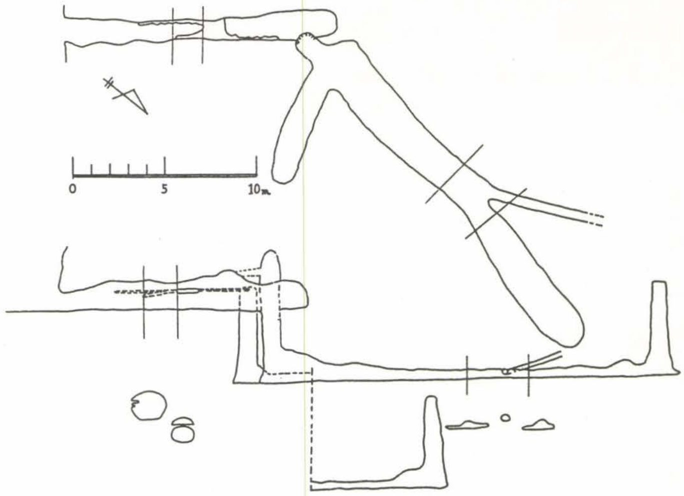

Fig. 12 = b) The compound lava tree mold at Mt. Fuji

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Takanori Ogawa 1-11-21 Kita-Otsuka, Toshma-Ku, Tokyo 170 Japan 07-81-3-915-0560 (Tokyo 915-0560) Japan Volcanospeleological Society

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Geomorfología de la Cueva del Hoyo (El Hierro, Islas Canarias)

J. Sergio Socorro Hernández
Museo de Ciencias Naturales de Sta. Cruz de Tenerife

RESUM

La «cueva del Hoyo» presenta una estructura que la fa diferent a la resta de tubs formats en els corrents de lava. Les ruptures de sostres i parets, així com l'entrada de la cova, presenten masses de «spatter» juntes, les quals avalen el fet de què el corrent de lava va discórrer per aquests materials que ja existien, a causa de l'erosió mecànica i tècnica.

El tub es formà en un terreny de pendent fort, de tal manera que el corrent hagués pogut fàcilment arrossegar grans blocs provinents d'un o més cons soldats, els quals, flotant sobre el material fos, formarien part de l'escorça que va originar el sostre. La superfície interna de la cavitat sofrí una intensa fusió superficial que, afectant principalment material devastador com són les «spatters», comportà la formació d'estalagtites especials de lava que varen recobrir profusament la cavitat.

RESUMEN

«La cueva del Hoyo» tiene una estructura que la hace diferente del resto de tubos formados en las corrientes de lava. Las rupturas de techos y paredes, así como la entrada de la cueva, presentan masas de «spatter» unidas, las cuales dejan bien claro que la corriente de lava fue colocada en estos materiales preexistentes por motivos de la erosión mecánica y técnica.

El tubo fue formado en un terreno de pendiente escarpada, de modo que la corriente hubiera podido arrastrar grandes bloques procedentes de uno o más conos soldados, los cuales flotando en el material fundido formarían parte de la corteza que originó el techo. La superficie interna de la cavidad fue llevada a una intensa fusión superficial que, afectando principalmente material devastador como son los «spatters», se formaron estalagtitas especiales de lava que tapizaron densamente la cavidad.

SUMMARY

«La Cueva del Hoyo» has a structure that makes it different from the usual tubes grown in the lava defiles. The breaks of ceiling and walls, as well as the entrance to the cave, presents spatter masses which make clear that lava flow was placed in this material because of the mechanic and thermic erosion and probably by simultaneus construction.

The tube was formed on a steep-slope land, so that the flow should have drawn great blocks proceeding from one or more spatter-cones, which floating on the melting would take part of the crust that created the ceiling. The inner surface of the cavity was taken to an intense over-melting that, affecting mainly such a blistering material as spatters are, special lava stalactites (vesicular stalactites) were formed covering the cave with great density.

Introducción

La Cueva del Hoyo, situada en las cercanías de Frontera (Fig. 1), es una cavidad irregular que tiene su entrada a unos 8 m de altura, en la pared de una depresión conocida como El Hoyo. En su accidentada vía de acceso se observa un hecho notable y sorprendente. Se llega a la entrada desde un lado, y en todo el recorrido se encuentran masas de escoria encajadas unas con otras, pero no soldadas totalmente (spatter), lo que hace inseguro

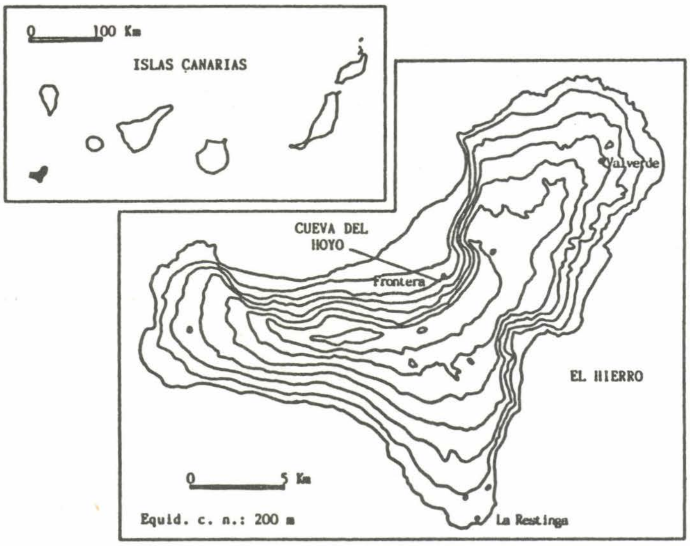

Fig. 1. Situación de la Cueva del Hoyo.

el apoyo sobre este material. Esta estructura se vuelve a observar en los frecuentes desprendimientos de la bóveda y paredes interiores.

La primera referencia que existe, es la debida a Lucas Fernández Navarro, destinándole apenas unas líneas en su trabajo de 1908, «Observaciones geológicas en la isla de El Hierro». Le llamaron la atención sus estalactitas, a las que dedica una de las pocas fotografías del trabajo. Las supone originadas por el «estado notable de fluidez» de las lavas que corrieron por el interior de la caverna.

Fue topografiada por miembros del Grupo de Investigaciones Espeleológicas de la Facultad de Biología de la Universidad de la Laguna (MARTIN et *al,* 1985) y adelantamos un posible mecanismo de formación, pendiente de nuevas observaciones (SOCORRO, 1985), que ahora desechamos como mecanismo fundamental.

Descripción de El Hoyo y corte de la entrada

El Hoyo es el nombre que dan los habitantes de la zona, al vacío donde tiene su entrada la cueva. Puede tratarse de la cabecera de un pequeño barranco cuyo cauce fuera rellenado por erupciones cercanas. Constituye una depresión de unos 60 m de anchura con forma de herradura, de paredes verticales en las que se hallan delgadas coladas basálticas; la mayoría tienen alrededor de 80 cm de espesor, aunque bajo la boca son más delgadas. A veces, entre ellas no existe la típica escoria, sino plastas de lava tipo spatter. Además, se encuentran incluidos bloques voluminosos procedentes de spatter-cones. Es decir, se trata de fragmentos de este tipo de edificios volcánicos que debieron ser arrastrados por corrientes de lava, para finalmente quedar inmersos en ellas. En estas bocas eruptivas los fragmentos de lava se van apilando aún blandos, y por tanto se aplastan por gravedad; la disposición de los spatter en los bloques mencionados se observa claramente inclinada, denotando el desplazamiento sufrido.

La pared de la depresión nos ofrece una sección de la cueva (Fig. 2) en la que se puede apreciar: la forma del canal inicial; el desbordamiento por el lado derecho (según el dibujo) sobre una masa de spatter; y algo de encajamiento en las coladas subyacentes. La pared del canal en el lado de acceso no está tan definida y parece formada en diversos episodios de emisión de lava. Entre cada dos períodos, los límites del canal quedarían emergidos, de forma que la emisión de spatter alcanzaría la pared referida; ésta vería incrementado su grosor, para luego volver a ser cubierta por el fluido que a su vez dejaría una nueva capa de lava solidificada.

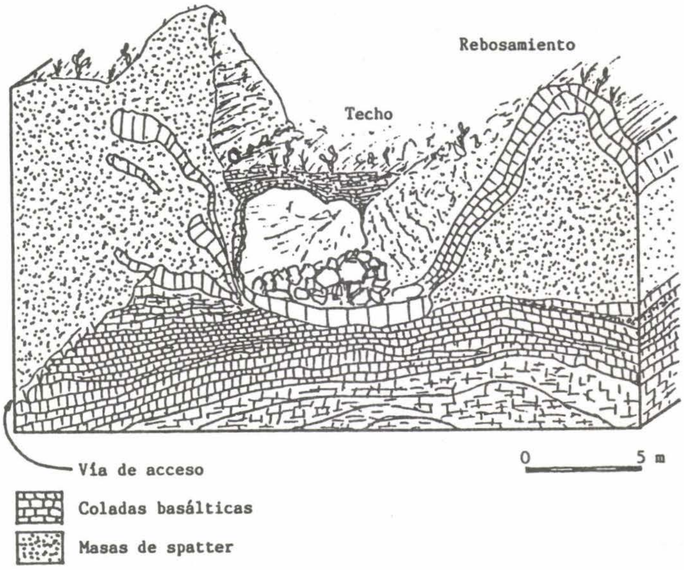

Fig. 2. Corte observado en la entrada de la Cueva del Hoyo.

Descripción de la Cueva del Hoyo

La cavidad presenta un recorrido, aproximadamente rectilíneo, de unos 247 m, que desde su boca se dirige, siempre subiendo, hacia el S y SE. Sus secciones son muy irregulares, encontrándose alturas variables (desde 1 a 8 m) y una anchura que oscila entre 2 y 7 m. Se desarrolla bajo un terreno con una pendiente aproximada de 30º, presentando en su interior pendientes aún mayores.

La estructura descrita para la pared de El Hoyo se repite, en parte, dentro de la cueva, donde los desprendimientos nos ponen al descubierto los materiales presentes. No obstante, el grosor de las coladas visibles no sobrepasa los 30 cm, y es más frecuente la observación de masas caóticas de escoria o de spatter tanto en las paredes como en el techo, aunque lógicamente los desprendimientos se verán facilitados en este material desmenuzado.

Diversos segmentos de la bóveda están completamente tapizados de unas estalactitas de lava especiales que cuelgan en apretada densidad y que hemos denominado estalactitas vesiculares (DIAZ & SOCOORRO, 1985). En ninguna otra cueva hemos hallado estalactitas como éstas, siendo su concentración tan alta que apenas dejan espacio entre ellas. Sólo en algunos hornitos de Timanfaya hemos visto estalactitas similares. Tienen forma de groseros conos invertidois de 5-10 cm de longitud y 4 cm de diámetro basal. Los extremos son romos y la superficie es lisa pero irregular, pues están constituidas por la coalescencia de distintas masas limitadas por una delgada película de lava y muy esponjosas en su interior. Los cortes del techo permiten ver el paso gradual de los spatter a las estalactitas, estando separadas ambas estructuras por una capa de vesícula de menos de 1 cm de grosor (Fig. 3). Esta secuencia nos prueba que las estalactitas se originaron por refusión de los spatter, tal como se explicará en el siguiente apartado.

Sobre las estalactitas y espacios intermedios, hay adheridas multitud de gotas producto de salpicaduras; sus tamaños son muy variados, habiendo gotas tan diminutas como una décima de milímetro. Estas variadas dimensiones junto con algunas formas apreciadas, muestran que se trata de salpicaduras.

Mecanismos de formación

Según el mecanismo que proponíamos en 1985, la cueva se formó merced al edificio construido por las escorias emitidas desde una grieta eruptiva de poca intensidad que coincidió con la pendiente del terreno. En la actualidad, después de nuevas observaciones que nos permitieron contrastar la teoría, no pensamos que la cueva se haya originado fundamentalmente de esa forma. Evidentemente, dada la abundancia de spatter, es probable que el tubo se originara a partir de una erupción con características similares, de la que procederían los materiales observados en techos y paredes, aunque también puede pensarse que estos materiales preexistieran con bastante anterioridad, encajándose la nueva corriente en dicho sustrato por erosión mecánica y térmica.

La formación de este tubo volcánico pudo transcurrir por el modo clásico de los asociados a canal de lava (OLLIER, 1983 y PETERSON & SWANSON, 1974), con algo de encajamiento (Fig. 2) y varias peculiaridades como son: la gran pendiente; la emisión de spatter desde las cercanas bocas eruptivas en conjunción a fluctuaciones del nivel de lava en el canal, que originarían estructuras como las descritas al tratar el corte de la entrada (Fig. 2); y por último, que bloques flotantes de los spatter-cones o procedentes directamente de las bocas eruptivas, pudieron pasar a constituir parte del techo.

La probable cercanía de la fuente de lava, provocaría que la superficie interna del tubo fuera sometida a una intensa radiación calorífica, de manera que se refundiría periódicamente. También no pudo contribuir al proceso de refusión la combustión de gases magmáticos. La vesicularidad de los spatter condiciona su comportamiento ante la refusión, causando las estalactitas descritas. Los spatter conservan su individualidad al caer, amoldándose a los acumulados previamente sin llegar a fusionarse, de forma que es posible encontrar estructuras como la representada en la fig. 3, en la que se distingue la transición entre dos fragmentos de escoria y las estalactitas, separando ambas estructuras un estrato vesicular producto de la liberación de los gases al refundir la escoria. Estos gases liberados ascienden hasta alcanzar la parte del spatter que permanece sólida, acumulándose en la interfase líquido-sólido. En algunas muestras se observa com este mecanismo se vuelve a repetir produciendo estalactitas de segunda generación.

El material refundido caería en masas esponjosas al interior de la gruta o se uniría a puntos cercanos, a la vez que se añadirían las salpicaduras producto de la gran pendiente.

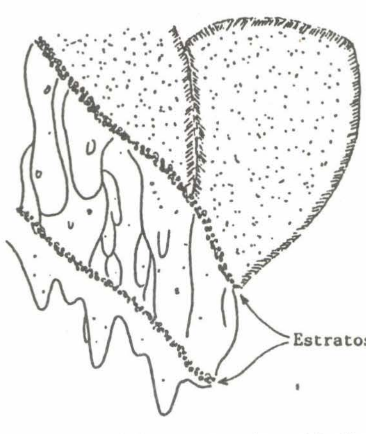

Fig. 3. Corte esquemático del paso de los spatter a las estalactitas vesiculares.

Agradecimientos

Expreso mi agradecimiento a los compañeros del G.I.E.T. de la Universidad de La Laguna por la colaboración prestada en todo momento y al Cabildo Insular de Tenerife por la financiación obtenida a través de su Museo de Ciencias Naturales.

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Travertine Formation in the Plitvice National Park

Stephan Kempe and Kay-Christian Emeis

RESUM

El Parc Nacional de Plitvice preserva un dels més grans i bells emplaçaments de travertins d'Europa. En un antic «cañó» –possiblement una formació d'enfonsament– se succeixen una sèrie de llacs originats per rescloses travertíniques que continuen creixent.

Durant els mesos d'abril i d'octubre de 1983, es varen recollir mostres d'aigua, de sediments i de travertins dels llacs i dels seus tributaris. El càlcul de pCO_2 i de l'índex de saturació de calcita indiquen que el CO_2 s'allibera ràpidament en les surgències càrstiques tributàries i que la calcita es precipita més tard, mentre l'aigua circula pels llacs. El model de càlcul emprat suggereix pèrdues de 10.000 t $CaCO_3$ per any de sediments (seekreide) i de dics de travertins. La investigació micromorfològica SEM de molses suggereix que els mucopolisacàrids produïts per les diatomees tenen un paper essencial per a l'inici de la precipitació de calcita.

Ambdós procesos, l'inorgànic (alliberament de CO_2, que produeix una sobresaturació de calcita) i l'orgànic, semblen ésser els responsables, a gran escala, de la formació del travertí.

RESUMEN

El Parque Nacional de Plitvice atesora uno de los más amplios y bellos emplazamientos de travertinos de Europa. En un cañón antiguo –posiblemente una formación de hundimientos– existen una serie de lagos originados por diques de travertinos que continúan creciendo. En Abril y Octubre de 1983, se recolectaron muestras de agua, de sedimentos y travertinos de los lagos y sus tributarios. El cálculo de PCO_2 e índice de saturación de calcita indican que el CO_2 se libera rápidamente bajo las surgencias kársticas tributarias y que la calcita se precipita más tarde, mientras el agua circula a través de los lagos. El modelo de cálculo sugiere pérdidas de 10.000 t $CaCO_3$ por año en sedimentos (seekreide) y en diques de travertino. La investigación micromorfológica SEM de musgos, sugiere que los mucopolisacáridos producidos por las diatomeas tienen un papel esencial para la iniciación de la precipitación de calcita. Ambos procesos, el inorgánico (liberación de CO_2 que produce una alta supersaturación de calcita) y el orgánico, parecen ser responsables a gran escala de la formación del travertino.

SUMMARY

Plitvice National Park treasures one of the largest and most beautiful travertine sites of Europe. In an older canyon –possible a collapse feature– a series of lakes is ponded behind actively growing tufa dams. In April and October 1983 water, sediment and tufa samples were collected from the lakes and their tributaries. Calculation of PCO_2 and saturation index of calcite shows that CO_2 is released rapidly below tributary karst springs and that calcite is precipitated much later, while the water passes through the lakes. Model calculations suggest loss of 10,000 t $CaCO_3$ per year to sediments (seekreide) and to tufa dams. Micromorphological SEM investigation of moss suggests that diatom-produced mucopolysaccharides play an essential role for initiation of calcite precipitation. Both inorganic processes (degassing of CO_2 which causes high calcite supersaturation) and organic processes seem to be responsible for large scale formation of travertine.

1. Introduction

In April and October 1983 a joint Yugoslavian and German group studied the karst area of Plitvice (Dinarids/Croatia/Yugoslavia). Results of the hydrochemical and electron-microscopic investigacions are given here (for details see Kempe & Emeis, 1985).

Plitvice National Park is famous for its travertine dams, its deep, clear lakes, and its numerous waterfalls (Fig. 1) (Movcan, 1982; Pepeonik, 1977). The narrow lakes occupy a canyon –possibly a collapsed former cave– cut into Triassic, Jurassic, and Cretaceous dolomite and limestone (Polsak, 1979). A wealth of scientific papers exits describing specific aspects of the Park (quoted in Kempe & Emeis, 1985). Travertine growth occurs today as is evident from the lake levels which rise with about 1 cm/year covering old landings. In the geologic past even travertine dams were drowned by faster growing downstream successors (Lake Kozjak). The growth of barrier tops, however, does not inform on the overall deposition rate of $CaCo_3$. Ivekovic (1958) estimated deposition to 600-1500 t $CaCO_3$/yr. Lakes and dams occupy about 2 km^2. Thus a layer 1.2 to 3 m thick is formed in 10,000 yr. With such a rate the barriers could not have formed during the present Interglacial but must be considerably older.

2. Materials and Methods

At 24 stations, including lake profiles, water was collected in April and October 1983 (Fig. 1). Temperature, pH and conductivity were measured in the field. Alkalinity, total hardness (t.H.), Ca^{2+}, Cl^-, and O_2 concentration were titrated by us within 12 h in a laboratory of the National Park. Mg^{2+} was derived by subtracting Ca^{2+} from T.H.. PO_4^{3-} and SiO_2 were determined photometrically. Dissolved organic (DOC) and inorganic carbon (DIC) were fixed with $HgCl_2$ and analyzed at Hamburg. Field results were then used to calculate the CO_2 pressure (PCO_2) and the calcite and dolomite saturation indices (S.I.) using a numeric electrolyte model as described by Wigley (1972) and published by Kempe (1975). All results are given in Kempe & Emeis (1985).

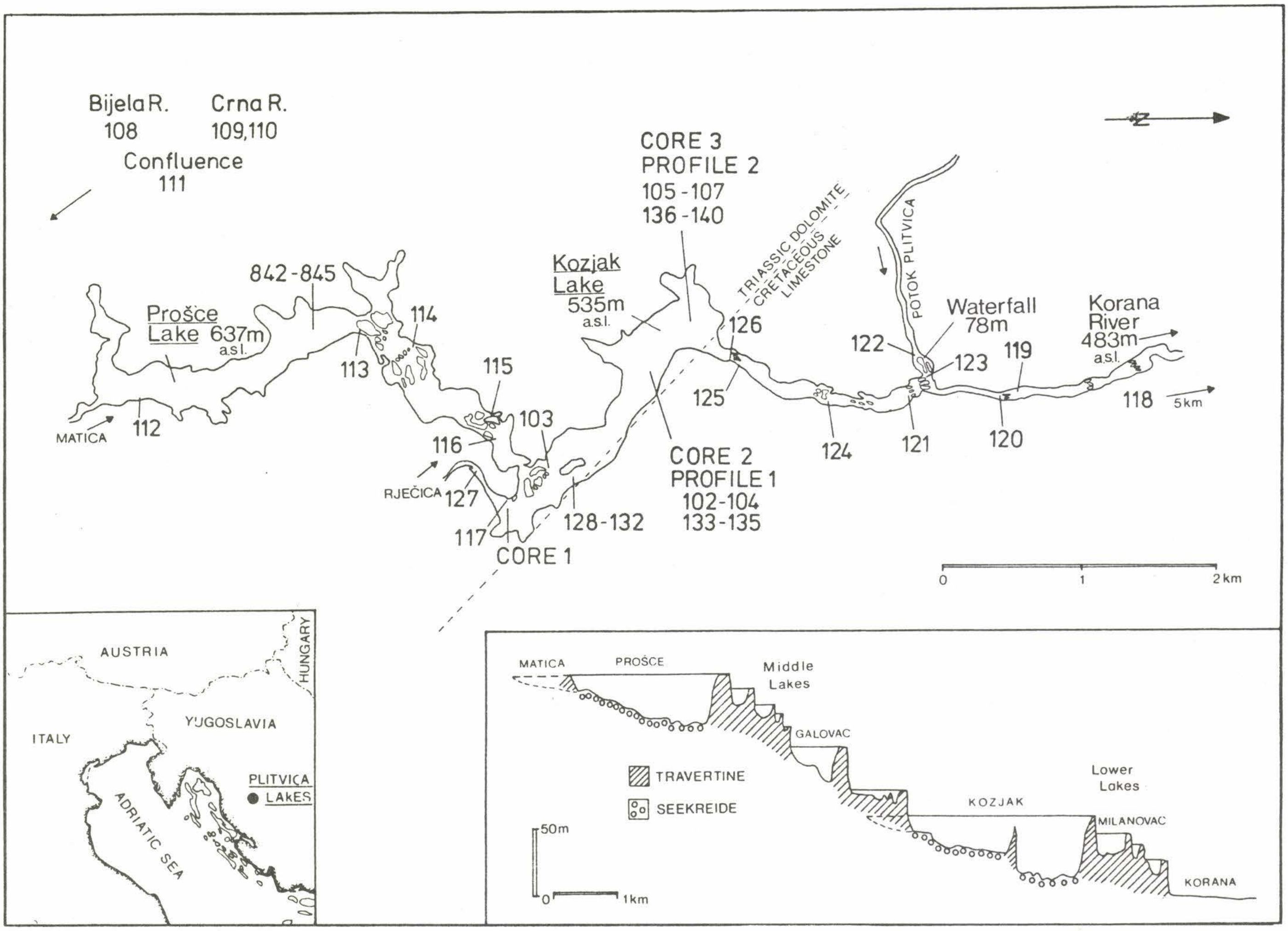


Fig. 1. Plan of the Plitvice Lakes and sample stations 1983 (after Pepeonik, 1974).

3. Downstream Variation of the Hydrochemistry

Four major tributaries feed the Plitvice lakes: The Crna Rijeka and the Bijela Rijeka which combined form the Matica, the Rjecica and the Plitvica creeks. The Matica feeds Lake Prosce (38 m deep, residence time ca. 30 days). Then the water falls down over the dams of the middle lakes and reaches Lake Kozjaz (47 m deep, residence time about 40 days) which also receives the Rjecica. Below Kozjak the lower lakes are traversed and the Plitvica joins the mainstem over a 78 m high waterfall down the side of the Korana canyon. Finally, the water leaves the Park via the Korana forming less and less tufa.

During its downstream course the water warms according to season. Thus temperature serves as a «downstream indicator» (Fig. 2). Due to CO_2 loss the pH increases considerably at the same time. The correlation matrix of all parameters (Fig. 3) reveals, that most parameters vary highly significantly downstream, i.e. with temperature. PCO_2, conductivity, alkalinity, Ca^{2+}, T.H., and total dissolved ions decrease downstream but at the same time the S.I.'s of calcite and dolomite increase significantly. This S.I. increase suggests, that –in spite of ongoing calcite precipitation– the system becomes ever more supersaturated due to further removal of CO_2. Mg^{2+} is not correlated with temperature, it does not decrease downstream, suggesting that no Mg carbonates precipitate. Also O_2 and DOC show insignificant relations with temperature, suggesting that the lakes do not suffer from excess respiration of organic matter (low level of pollution). Other highly significant correlations (Fig. 3) follow from the above scheme of downstream decrease in PCO_2 and $CaCO_3$ concentration. SiO_2 displays only one significant correlation, that with oxygen, suggesting that consumption of SiO_2 produces oxygen, conditions caused, for example, by the growth of diatoms.

In Fig. 4 the increase of temperature (top) and alkalinity (bottom) from tributaries to lakes is plotted. The Bijela Rijeka,

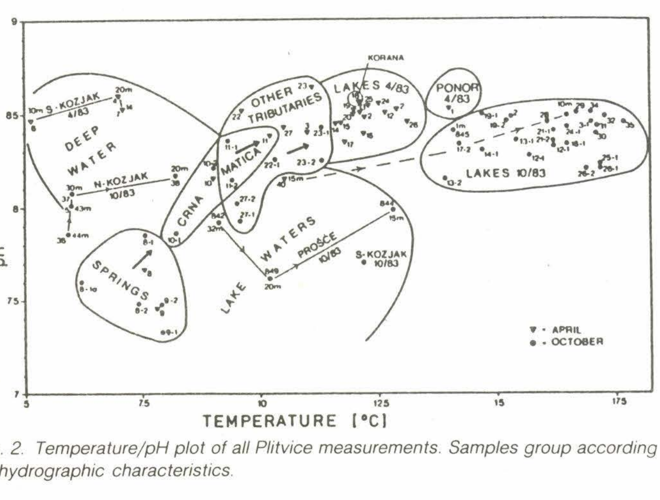


Fig. 2. Temperature/pH plot of all Plitvice measurements. Samples group according to hydrographic characteristics.

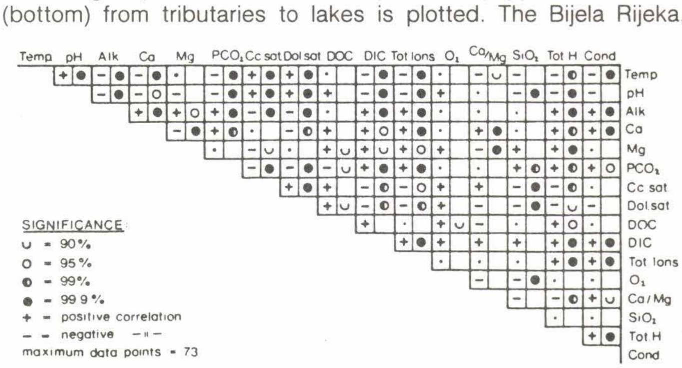


Fig. 3. Correlation matrix for all parameters of all Plitvice samples.

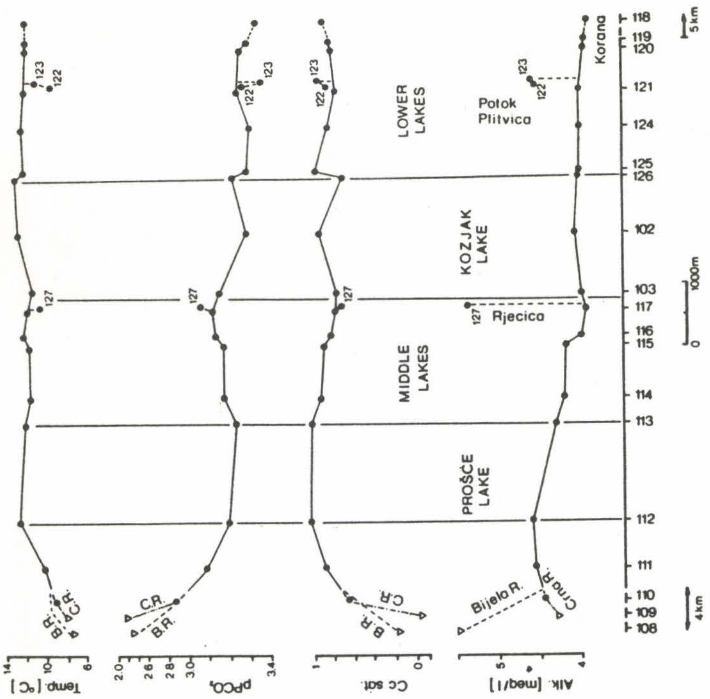


Fig. 4. Downstream variation of temperature, log PCO_2, calcite saturation index and alkalinity for the Plitvice Lakes and most prominent tributaries for April 1983.

Rjecica and Plitvica deliver water of high, the Crna Rijeka or a lower mineralization. The Rjecica «recharges» the system below sample 117, as can be seen by an increase in alkalinity in Lake Kozjak. The plots in the middle show the alterations of the PCO_2 (plotted in log-form) and the calcite S.I The Crna Rijeka spring has a slight calcite undersaturation but a higher PCO_2 (6550 ppmv in April) than the Bijela Rijeka spring (5190 ppmv in April). Both creeks unite and further loose CO_2 –due to rapid turbulent flow-proportionally gaining calcite supersaturation (Fig. 5) Saturation (and alkalinity) starts to drop only during the lake passage (stations 113-117). This clear indication of calcite precipitation is obscured in the lower lakes due to the Rjecica input. CO_2 is measurably lost at waterfalls: between top and base (stations 122-123) of the Slap Plitvice (78 m fall) the PCO_2 drops in April from 580 to 440 = 140 ppmv and in October from 1120–740 = 380 ppmv. The water stays highly supersaturated throughout the lake passage and does not return to saturation even in the outgoing Korona. However, the PCO_2 (470 ppmv in April) dropped to almost air value (340 ppmv). It appears, that for calcite precipitation to occur the water must be of very high calcite supersaturation and must still have the ability to loose

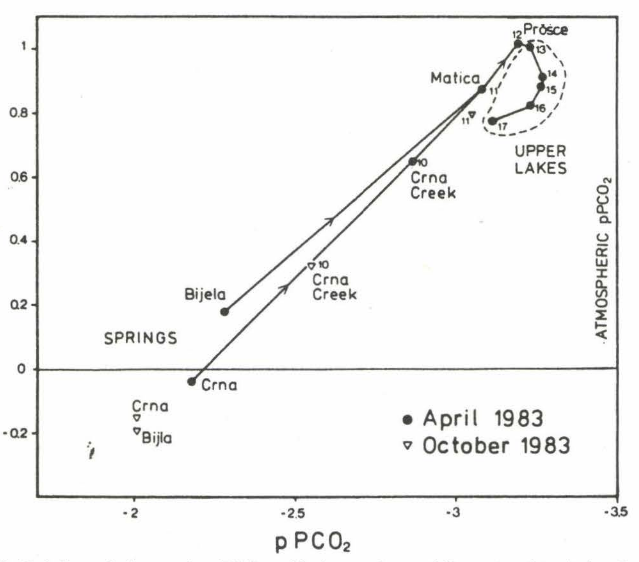


Fig. 5. Relation of decreasing PCO_2 with increasing calcite saturation index for rapidly flowing tributaries to Prosce Lake and slow decline of supersaturation in the upper lakes of Plitvice.

CO_2. High supersaturation alone does not suffice for large scale tufa formation.

4. Physical versus Biological Travertine Growth Factors

The date does not allow to decide if physical or biological processes dominate tufa formation. CO_2 loss in creeks and down waterfalls is physical in nature, thus creating the high calcite supersaturation. However, the formation of calcite precipitates seems to be intimately associated with the occurrence of plants. In the lakes 2μ large euhedral calcite grains (Plate 1) form in the warm epilimnion, suggesting the active role of phytoplankton in their formation. In the lakes calcite grains form unconsolidated «seekreide» type sediments several meters thick. At the dams Bryum and Cratoneuron mosses flourish which quickly are covered by calcite. Investigation with the scanning electron-microscope shown, that the young green leaves are densely covered by pennate diatoms and filamentous blue-green algae (Plate 2). They are glued together by strands of mucopolysaccharides. Further down the leaf calcite grains adhere to the mucopolysaccharides (Plate 3). These grains later grow into a solid sparitic layer of calcite (Plate 4). In an experiment plastic, iron, and copper sponges were exposed to Plitvice lake water (Srdoc, pers. comm.). The plastic and iron material was quickly covered by calcite, not so the copper sponge (Plates 5,6). Copper is toxic for epiphytic diatoms. Without diatoms, no mucopolysaccharides can form and no grains can be attached to the surface. Thus both physical and biological action is responsible for the precipitation of tufa.

5. Mass Balance

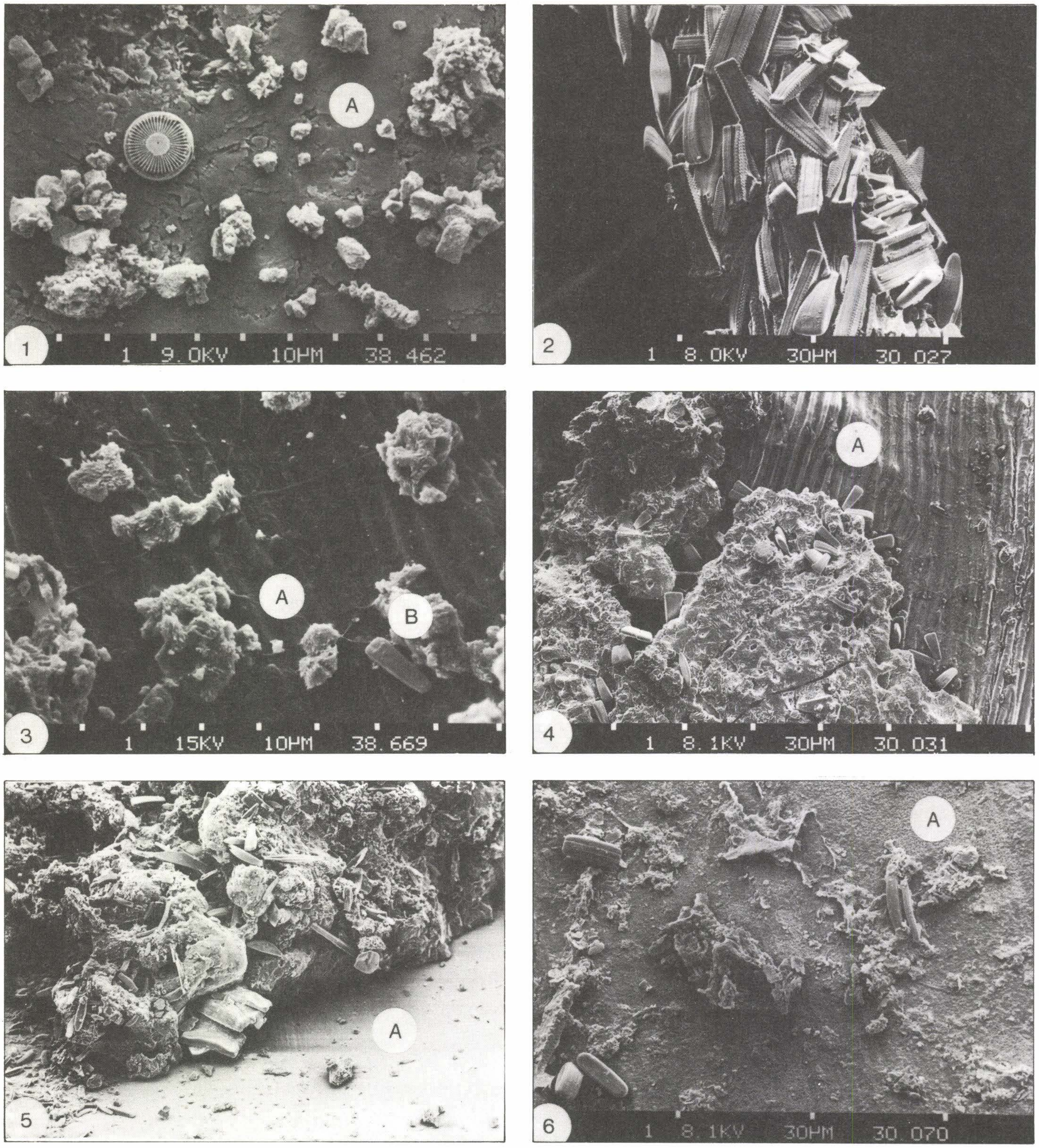
From gagins data (made kindly available by the National Park Service) a model of the water balance was derived (Fig. 6), which together with our measurements, allows to calculate a crude mass balance (Table 1). Summing up inputs and ouptus for total dissolved ions, a $CaCO_3$ loss of 10,500 t occurs per year.

Table 1
Model of Total Dissolved Ions Balance 1980-1981

River	Sample No.	Measurements mg/1	Average mg/1	Discharge m³/sec	Transport g/sec
			Inputs		
Matica	(111)	366;369;365	367	2.93	1074
Rjecica	(127)	401;423;407	410	0.60	246
Plitvica	(122)	362;352;-	357	0.96	343
Kozjak source		(estimated)	370	0.16	59
			sum of input	1722	
			Outputs		
Korana	(119)	315;295;286	299	3.99	1192
sinks in stream bed			299	0.66	197
				sum of output	1389
			Sink		333

333 g TDI/sec = 10 500 t/yr

This value is ten times higher than Ivekovic's (1958) estimate. He did not take the «recharge» effect of tributaries into account but simply used upstream-downstream concentration differences, also he used a much lower average discharge rate (0.6-1.2 m^3/sec, compared to our 5.3 m^3/sec). ON 2 km^2 a deposition of 10 000 t $CaCO_3$/yr would yield 20 m of carbonate rock in 10 000 years.



Plates 1-6: Scanning electron-micrographs of Plitvice sediments, mosses, and artificial substrates. Distance between marks on lower bar is indicated in my.

1: Seekreide particles and cyclic diatom cell from a sediment core (o.2 m subbottom). Calcite particles of hypidiomorphic habitus form aggregates and clusters. A = surface of sample stub (carbon).

2: A sprout of bryum moss densely settled by epiphytic, non-motive pennate diatoms (order Achnanthes, Gomphonema, Navicula).

3: Surface of moss (A). Note filaments of mucupolysaccharide excretions agglutinating $CaCO_3$ particles on surface (B).

4: Bryum surface (A) and advancing calcite cover in different stages of solidification.

5: Surface of a stainless-steel wire (A) exposed to the water for two weeks displays similar incrustations as those on Bryum moss.

6: Settling of diatoms and bacteria on the surface of a copper wire (A) exposed next to the steel wire is inhibited due to the toxidity of Cu to organisms. On the surface amorphous CuO, clay minerals, and minor diatoms are visible but no $CaCO_3$.

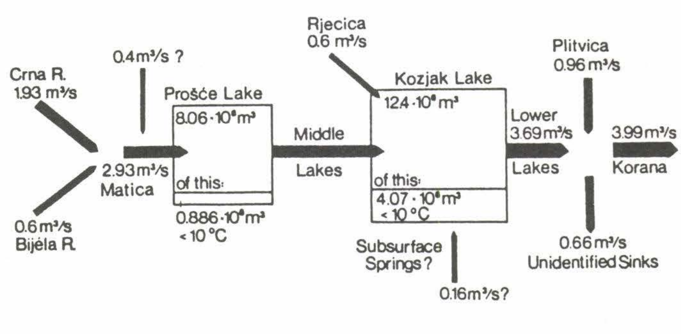


Fig. 6. Model of water balance for Plitvice Lakes.

Thus, this rate could account for the growth of over 50 m high dams and about 8 m of lake deposits (pers. comm. Merkt) within the present Interglacial.

6. Acknowledgements

We like to thank the National Park Plitvice (Dr. L. Brnec-Kostic) for its superb hospitality. Dr. D. Srdoc and Prof. Dr. M.A. Geyh kindly invited us to participate in the project. Financial support was received from the climate project of the German Minister for Research and Technology (BMFT).

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Addresses of the Authors: Dr. Stephan Kempe, Geol.-Pal. Inst., Univ. of Hamburg, Bundesstr. 55, 2000 Hamburg 13, Fed. Rep. of Germany. Tel. 040/4123/5234. Dr. Kay-Christian Emeis, Ocean Drilling Prog., Texas A. & M. Univ., College Station 77843, Tx. USA, Tel. 409/845/5218.

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Trace metal-organic complexes in speleothems

Julia M. James, M. McDonald and K. E. A. Leggett

RESUM

S'han estudiat espelotemes d'Austràlia, Papua Nova Guinea, Amèrica del Nord i d'Amèrica Central per a la detecció de vestigis de metalls complexes orgànics. S'han eleborat nous mètodes d'extracció d'aquests complexes de la matriu carbonatada. Aquests mètodes eviten els canvis que podrien experimentar els complexes, com dissociació i polimerització, durant el seu aïllament. Per a purificar els complexes s'utilizaren mètodes cromatogràfics. El treball analític quantitatiu ha incorporat tècniques que van des de l'activació de neutrons fins a la química humida. Els nexes orgànics i els seus complexes metàl-lics han estat caracteritzats utilitzant una varietat de tècniques espectroscòpiques moleculars, a més d'una ressonància nuclear magnètica de 400 MHz. S'extreuen conclusions referents als orígens dels materials orgànics i dels metalls vestigials. Es parlarà també dels nexes orgànics i de la seva coordinació amb els ions metàlics, així com del paper d'aquests components en la coloració dels espeleotemes.

RESUMEN

Se han examinado espeleotemas de Australia, Papúa Nueva Guinea, América del Norte y Central para trazas de metales –complejos orgánicos. Se han elaborado nuevos métodos de extracción de estos complejos de la matriz carbonatada. Estos métodos impiden los cambios en los complejos tales como disociación y polimerización durante el aislamiento. Una variedad de métodos cromatográficos fue usada para purificar además los complejos. El trabajo analítico cuantitativo ha implicado técnicas que van desde la activación de neutrones hasta la química húmeda. Los nexos orgánicos y sus complejos metálicos han sido caracterizados usando una variedad de técnicas espectroscópicas moleculares, incluyendo 400 MHz de resonancia nuclear magnética. Se presentan conclusiones de los orígenes de los materiales orgánicos y de las trazas de metales. Se hablará de la naturaleza de los nexos orgánicos y su forma de coordinación con los iones metálicos y el papel que tienen estos componentes en los colores de los espeleotemas.

SUMMARY

Speleothems from Australia, Papua New Guinea, North and Central America have been examined for trace metal–organic complexes. New methods of extraction of these complexes from the carbonate matrix have been devised. These methods prevent changes in the complexes such as dissociation and polymerisation during isolation. A variety of chromatographic methods were used to further purify the complexes. The quantitative analytical work has involved techniques ranging from neutron activation to wet chemistry. The organic ligands and their metal complexes have been characterised using a variety of molecular spectroscopic techniques including 400 MHz Nuclear Magnetic

Resonance. Conclusions will be presented as to the origins of the organic materials and the trace metals. The nature of the organic ligands and the form of their coordination to the metal ions and the role these compounds play in colouring speleothems will be discussed.

The classification of cave minerals

Carol A. Hill and Paolo Forti

RESUM

En aquest treball se suggereix que l'esquema de classificació de Hill i Forti, tal i com està representat en Cave Minerals of the World, *sigui utilitzat com a classificació estàndart per als minerals de cavitats de tot el món. Els primers intents van classificar els espeleotemes en esquemes morfològics elaborats, sense aportar massa cosa de cara a un millor coneixement d'aquests. Aquestes classificacions tenien una aplicació limitada, ja que se centraven, principalment, en espeleotemes carbonatats i ignoraven altres tipus de minerals com les halites o els fosfatats. Els sistemes de classificació basats primàriament en el seu origen, també van fracassar, perquè molts espeleotemes tenen un origen complex, basat en més d'un mecanisme hidrològic de disposició.*

La classificació de Hill i Forti combina factors diferents, com poden ser el tipus de cristall, la morfologia i l'origen. Tots els minerals més habituals de les coves, de qualsevol tipus de cristall, s'ajusten adequadament a aquest marc i es dóna també raó dels minerals menys habituals de les coves, com els que abans hem esmentat. També es proposa, en aquest treball, que els noms nous d'espeleotemes s'adaptin, tant a la morfologia com a l'origen d'aquests espeleotemes i que les noves divisions d'espeleotemes siguin aprobades per un consell de mineralòlegs de coves.

RESUMEN

En este trabajo se sugiere que el esquema de clasificación de Hill y Forti, tal como está representado en Cave Minerals of the World, *sea utilizado como clasificación standard para los minerales de cavidades de todo el mundo. Los primeros intentos clasificaron los espeleotemas en esquemas morfológicos elaborados, añadieron poco al conocimiento de éstos. Estas clasificaciones eran de aplicación limitada ya que se centraban principalmente en espeleotemas carbonatados y desconocían otros tipos de minerales como las halitas o los fosfatados. Los sistemas de clasificación basados primariamente en el origen también fracasaron porque muchos espeleotemas tienen un origen complejo basado en más de un mecanismo hidrológico de deposición.*

La clasificación de Hill y Forti combina los factores de tipo de cristal, morfología y origen. Todos los minerales habituales en cuevas de cualquier tipo de cristal se ajustan adecuadamente a este marco y da también razón de los minerales no habituales de cuevas, como los de la categoría precedente. También se propone en este trabajo que los nuevos nombres de espeleotemas se adapten tanto a la morfología como al origen de estos espeleotemas y que los nuevos tipos de divisiones de espeleotemas sean aprobados por un consejo de mineralólogos de cuevas.

SUMMARY

In this paper it is suggested that the classification scheme of Hill and Forti as presented in Cave Minerals of the World, *be used as the standard classification for cave minerals the world over. Early attempts over-classifed speleothems in elaborate morphological schemes that added little to the understanding of those speleothems. These classifications were of limited application because they concentrated mainly on carbonate speleothems and ignored other mineral classes such as the halides or phosphates. Classification systems based primarily on origin failed also because many speleothems have a complex origin based on more than one hydrological mechanism of deposition.*

The classification of Hill and Forti combines the factors of crystal class, morphology, and origin. All of the «normal» cave minerals from any crystal class fit comfortably into its framework, and «unnormal» cave minerals, such as those in the ore-associated category, are also accounted for. It is also proposed in this paper that new speleothem names be appropriate to both the morphology and origin of that speleothem, and that new speleothem type divisions be approved by a board of cave mineralogists.

A «cave mineral» is a secondary mineral deposit formed in any natural subterranean cavity, fissure, or tube which is mansize or larger and which extends past the twilight zone. A «speleothem» has also been defined as a «secondary mineral deposit» in caves (Moore, 1952), but differs from a «cave mineral» in that it refers to the mode of occurrence of a mineral and not to the mineral itself. For example, calcite is a cave mineral, but it is not a speleothem. A calcite stalactite in a cave is a speleothem, while a calcite stalactite in a mine is not. Hill and Forti (1986), in their *Cave Minerals of the World,* identify almost 200 separate, cave mineral species, but only 30 speleothem types. The distinction between a «cave mineral» and «speleothem» must be preserved in any viable classification scheme.

The three basic approaches to the classification of cave minerals/speleothems are: classification by morphology, origin, or chemical class. All three approaches have been taken by cave mineralogists in the past, and all three (when used exclusive of the others) have inherent problems.

1. *Classification by Morphology.* The most frequent method of classifying speleothems is by morphology by the shapes one sees. Stalactites and stalagmites are both primarily dripping water speleothems, but they *look different* because stalactites form on the ceiling while stalagmites form on the floor. Classification based exclusively on morphology without regard to origin results in elaborate schemes that add little to the understanding of speleothems. For example, Halliday (1962) ended up with more morphological classes than there are separate speleothem types. DeSaussure (1953) had and «unexplained» category that had more types in it that any of his other categories. Diaconu (1979) classified morphologically-similar speleothems togheter in the same class (for example, conulites with stalactites), even though the origin of these speleothems are completely different.

Too strict of a classification according to morphology alone can also be troublesome because speleothemic forms often mimic each other, even when origin differs. For example, an antler helictite outwardly resembles a quill anthodite, yet a helictite is formed by capillary solutions oozing through a tiny central canal, whereas an anthodite forms by solutions moving along its outer surface. Also, morphological classifications can get «hung up» on what White (1976) calle *style;* that is, deviant shapes (subtypes) based on different flow rates, rates of deposition, crystal composition, or other factors. For example, a «soda straw» does not look exactly like an ordinary stalactite, having straight, thin-walled sides rather than a upside-down, carrot-like shape, but it forms nearly identical to stalactites, and, in fact, all stalactites begin their growth as soda straws. Based strictly on morphology, soda straws and stalactites should be classified as two separate speleothem types, but based on origin, soda straws should be classified as a subtype of stalactite. Another example are spathites, aragonite, soda-straw stalactites with regularly flaring and receding sides. The origin of aragonite spathites and calcite soda straws is essentially the same, only the crystal form of aragonite shapes the spathite differently so that it exhibits undulating, rather than straight, sides.

2. *Classification by Origin.* A rigorous classification scheme based exclusively on origin is almost purposeless, because the genesis of a speleothem often involves many mechanisms. Again taking the common stalactite for an example: growth occurs primarily by material precipitated from dripping water, but the stalactite is also enlarged by material precipitated from water flowing down along its sides. According to which mode of origin should this speleothem be classified then: by dripping water or by flowing water? Also, the origin of some speleothem types is not known, and this can be a major problem for classifiers.

Gams (1968) and Martini (1984) are two cave mineralogists who classified speleothems on the basis of their genesis. Gams' classifications scheme worked but he only went as far as classifying the common stalactite, stalagmite, shield, and helictite carbonate speleothems. Martini based his classification scheme on whether speleothems were derived from ground water, animal excreta, hydrothermal conditions, a reducing environment, and the like. This scheme is important because it recognized that a diverse variety of environments can influence the growth of cave minerals, but it is of little help in understanding the forces that cause particular speleothem shapes. Also, in many cases, cave minerals can be the result of two or more of these factors; for example, hydroxylapatite is a mineral that is known to be derived either from bat guano or from ground water seeping through phosphatic limestone rock.

3. *Classification by Chemical Class.* Palache et al. (1951), following Edward S. Dana's original classification system, divided minerals into classes based on their anionic constituent (e.g., carbonates, sulfates, halides, nitrates, and so forth). Classification based on chemical class in the most expedient way of classifying cave minerals, but it is less satisfactory when classifying speleothems. For example, a stalactite can be composed of calcite or aragonite or both minerals in a single pendant. Stalactites can also be composed of gypsum, halite, nitromagnesite, chalcanthite, and many other minerals (Hill and Forti mention over 20 different minerals that form as stalactites). A classification scheme based solely on chemical class has the disadvantage that speleothem types must be explained for each mineral species (at least 20 times in the case of stalactites).

White (1976) devised a classification scheme based primarily on chemical class. He divided cave minerals into four main categories: carbonate minerals, evaporite minerals, phosphate and nitrate minerals, and oxide and other minerals, and then he subdivided the carbonate class into flowstone, dripstone, erratics, subaqueous deposits, and moonmilk. White's classification system was probably the first one to work well, and it succeeded as far as the intended scope of his paper, but White's subdivisions are not extensive enough to account for all of the different types of speleothems.

The classification system of Hill and Forti, as presented in *Cave Minerals of the World,* is a practical one, based on a compromise between the three factors of chemical class, morphology, and origin. The basic divisions are by chemical class (carbonates, sulfates, and so forth); then, subdivisions are based on mineral species and/or speleothem types within each chemical class. Where the number of mineral species predominates over the number of speleothem types, then the chemical class is subdivided according to mineral species (e.g., the nitrate caves minerals are subdivided into individual minerals such as nitromagnesite, nitrocalcite, etc.). Where the number of speleothem types predominates over the mineral species in the chemical class, then the class is subdivided according to speleothem types (e.g., the carbonate minerals are subdivided into individual speleothems such as stalactites, stalagmites, etc.). Speleothem type divisions are based primarily on morphology, but they are highly influenced by whatever is known about origin. Speleothem «subtypes» have the same origin as the «type», but exhibit a deviant (albeit closely related) morphology.

The basic differences in the genesis of cave minerals, such as depicted by Martini (1984), are also considered in Hill and Forti's classification scheme. Those minerals formed under ordinary cave circumstances (i.e., those formed from ground water in a «normal» limestone environment) are discussed in the main text. But, cave minerals formed under unusual conditions (i.e., those formed in associations with ore bodies, in caves developed in rock not composed of limestone or dolomite, or under hydrothermal or fumerole conditions) are discussed in an «Other Minerals» section, and are listed without regard to chemical class.

The classification system of Hill and Forti needs to be discussed by cave mineralogists with regard to its philosophical base, and it needs to be «time tested» as far as its practicality. New speleothem types defined on the basis of this classification system should, in the future, be approved by a board of cave mineralogists so that the classification of cave minerals will be consistent over time. New names for speleothem types and subtypes should also be approved by a board of cave mineralogists, and should be based on a speleothem's morphology and/or origin. For exemple, «helictite» is a satisfactory name for a speleothem type because the Greek root «helikos» means to «spiral». «Geysermite» is also satisfactory because it indicates the way in which the speleothem has formed (i.e., by geyser-like action). However, a name like «skullite» (a subtype of cave pearl found in Skull Cave, New York) should not be given official status because it denotes neither morphology or origin.

It is proposed that such matters pertaining to the classification of speleothems be discussed in this and in future International Congresses by an established board of cave mineralogists.

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Pisolits de baixa densitat

Lluis Auroux
Grup Espeològic Congrés, Barcelona

RESUM

Realitzades les mesures de densitats en 722 pisòlits, s'han observat determinats exemplars així com una sèrie d'agrupacions amb uns valors molt baixos, fins i tot molt per sota de la unitat, quant les densitats més freqüents es troben pels voltans de 2,4. S'estudia material provinent de 19 cavitats. De la mateixa manera, es representa el gràfic de distribució pes/densitat i de la proporción entre les densitats aparent i real, buscant alhora uns factors de relació.

RESUMEN

Realizadas mediciones de densidades en 722 pisólitos, se han observado una modalidad de ejemplares incluso agrupaciones, con valores muy bajos, tanto es así, que alcanzan valores mayores a la unidad, cuando las densidades habituales son cercanas a 2,4. Se estudia material provinente de 19 cavidades. Se presenta el gráfico de distribución peso-densidad y el de proporción entre densidades aparentes y reales, en busca de ciertos factores de relación.

RESUME

En faisant des mesures de densités en 722 pisolites, on a observé un modèle d'exemplaire, inclusif des groupes complets qu'ont des valeurs très baisses, en arrivant très au-dessous de l'unité quand les densités normalement obtenues sont prochaines à 2,4. L'étude se fait avec pisolites trouvés dans 19 cavités. Ils sont inclus les graphiques de la distribution poids-densités et de la relation densité apparente et réelle afin de chercher quelques facteurs de relation.

Realitzant la mesura de les densitats dels pisòlits, es trobà que alguns exemplars, fins i tot nius complets, poseïen uns valors molt baixos respecte a les densitats habituals– Perna, 1959. –Ullastre, J. Masriera, A.– 1973. Aquestos valors inclús es situen per sota de la unitat, pel que hi han exemplars que arriben a flotar en el instant de fer la pesada en aigua a la balança hidrostàtica. Aquest fet ha motivat el agrupar i estudiar-los com a grup independent, tot intentant relacionar llurs característiques.

En un treball anterior, –Auroux, Ll. 1982– ja es donaven a conèixer, però ara es presenten resultats més amplis i específics respecte aquesta varietat de concrecions lliures, al haver trobat més material i permetre certes conclusions.

La frontera entre els Pisòlits de Baixa Densitat –PBD– i els de, en podríem dir, de «densitat habitual», és del tot subjectiu, doncs no hi ha cap llei ni línia divisòria, pel que s'ha estimat posar la frontera en el valor de densitat 2,00. Menys de 2,00 serà considerat com a PBD.

En aquest treball sols s'han seleccionat els nius en que tots els pisòlits son PBD. En alguns casos es troben nius amb algun o varis PBD, però aquestos nius han sigut exclosos.

La densitat referida en aquest treball es la Densitat Aparent. Hi han dues classes de densitat, l'aparent i la real. La primera es comptà a partir del volum aparent incloent l'espai ocupat per les porositats internes. La densitat real considera el volum que tindria la matèria, però sense les inclusions esponjoses, com si s'haguès comprimit.

El sistema de medició utilitzat fou el de la balança hidrostàtica i la precisió de l'aparell, ±0,01 g.

Material estudiat:

Exemplars mesurats, 248, provinents de 21 nius de 19 cavitats.

Pes total dels pisòlits, 2339 g.

Densitat mitjana per llei de mescles i aleacions, 1,71

Exemplar de mínima densitat, 0,63 amb un pes de 4,55 g i eixos de 29 × 25 × 22 mm de la Cv. Coventosa, a Cantàbria.

Exemplar de major densitat, 2,00 amb un pes de 20,90 g i eixos de 41,2 × 31,4 × 15 mm de la Cv del Fresno, Asturias.

Exemplar de mínim pes, 0,14 g amb densitat 1,07 i eixos de 10 × 8,7 × 4,1 mm de la Cova de la Moneda, Tarragona.

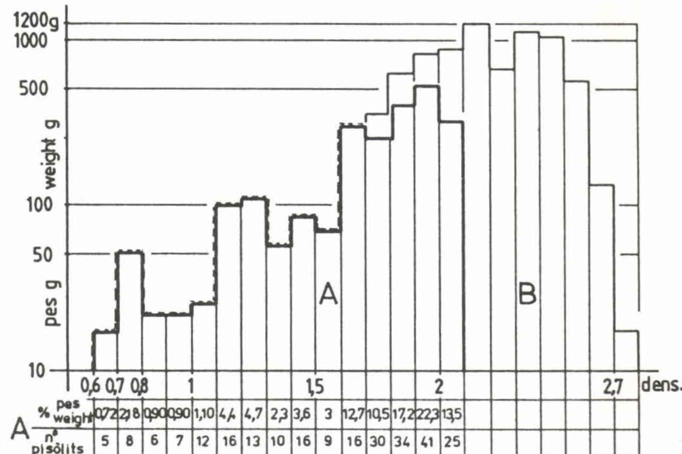
Exemplar de major pes, 55,38 g amb densitat 1,81 i eixos de 45,2 × 39,5 × 36,5 mm de la Surgència de la LLúdriga, Tarragona.

Les agrupacions i nius de PBD sempre s'han trobat aillats d'altres nius, sense relació física entre ells. Com ja s'ha dit, en alguns casos nius de pisòlits normals contenen algunes peces de PBD. No estan sotmesos a goteigs, esquitxos ni turbulències d'aigua, doncs són poc resistents a les accions mecàniques–erosives. Sols en una ocasió es trobà un niu sota fort goteig des d'uns 10 m d'alçada i tots els 11 pisòlits presenten grans marques d'erosió que fins i tot en la majoria els hi deixa el nucli al descobert.

Els PBD es localitzen el fons de gours de qualsevol mida, des de varis metres de diàmetre fins a petits micro-gours, això sí, sempre recoberts de fines acícules o bé concrecions esponjoses de poca consistència. Se'n hi troben també en escorrenties de règim laminar, zones pavimentàries horitzontals amb petites depresions on s'hi acumula l'aigua. Quasi tots estan submergits, però no és rar veure'ls inclús de gran mida i pes, sobre pendents on no s'hi pot acumular l'aigua. En aquest cas, el repartiment de l'aigua pel pisòlit, s'obtè mitjançant la esponjositat del PBD, el que li permet un creixement regular tot i que no estigui submergit.

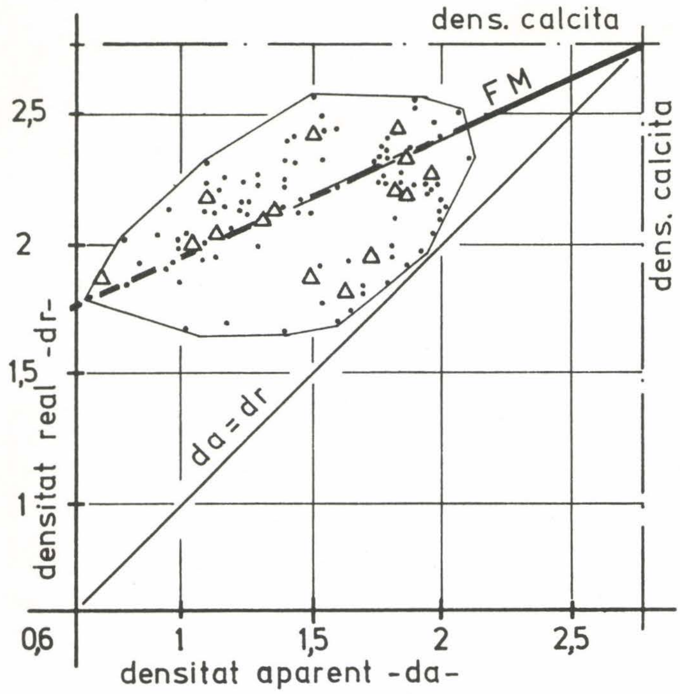
Color: Són de colors molt clars, pàl·lids, tots molt semblants doncs solament van del blanc ós, fins la gamma dels grisos o marrons, però sempre molt suaus.

Textures: Generalment no son textures úniques, sinó combinades. En cas de textues úniques, aquestes són llises, aciculades



A % pes weight	0,72	2,18	0,90	0,90	1,10	4,4	4,7	2,3	3,6	3	12,7	10,5	17,2	22,3	13,5							
A nº pisòlits	5	8	6	7	12	16	13	10	16	9	16	30	34	41	25							
B % pes weight	0,2	0,63	0,27	0,27	0,32	1,2	1,3	0,7	1	0,85	3,6	4,2	7,5	10,2	10,8	14,5	7,9	13,3	12,5	6,7	1,7	0,2
B nº pisòlits	5	8	6	7	12	16	13	10	16	9	16	36	52	57	53	55	51	69	118	80	27	6

Gràfic 1. Relació dels pesos corresponents a cada fracció de densitat.
Gràfic A. 248 pisòlits de densitat màxima dins la fracció 2,00
Gràfic B. 722 pisòlits de totes densitats.



Gràfic 2. Proporció entre densitats. reals i aparents 91 pisòlits PBD. Cada punt correspon a un pisòlit. Cada triangle correspon a la mitjana d'un niu. FM: Funció mitjana total.

i granuloses. Els pisòlits combinats, tenen àres llises, granuloses i botricoidals.

Forma: Cap relació entre les formes si bé son majoria les figures volumètriques, o sigui, creixement regular en els tres eixos, en comparació amb les formes aplanades– discoïdals, en que el predomini de creixement és sols sobre els dos eixos horitzontals.

En el gràfic 1 es relacionen els pesos totals de cada fracció de densitat. La corba –A– correspon als 248 PBD i la –B– a 722 pisòlits de totes densitats, entre els que s'inclouen també els 248 PBD: és per això que les dues corbes coincideixen fins la fracció 1,70. El pes total dels 722 pisòlits és de 7882 g i la densitat mitjana per llei de mescles ha resultat de 2,11.

Volum: En general, els PBD tenen un volum superior, són més grans. Per comprobar-ho es calculen les mitjanes.

Mitjana de volum dels PBD, 5,51 cc.

Mitjana de volum dels altres, 4,87 cc.

Representa que els PBD son un 13 % més voluminosos.

Relació entre Densitat aparent, Da, i Densitat real, Dr: Dels 248 PBD, de 91 exemplars es mesura també la densitat real, amb la intenció de trobar-hi una correspondència.

Número de cavitats a que pertanyen els 91 pisòlits, 15.

Número de nius o agrupacions, 15.

Gamma de Da, 0,63 a 2,00.

Gamma de Dr, 1,67 a 2,59.

El gràfic n.º 2 expressa la situació dels 91 PBD a partir de les dues densitats. La mitjana general de l'àrea de repartiment, s'indica per la línea FM, que finalitza en el punt Da = Dr = 2,72, doncs és la mesura màxima per la calcita.

Si bé no es dedueixen conclusions definitives, s'observen algunes tendències: A mesura que Da creix, va coincidint amb Dr si bé això és normal, doncs les dues no poden sobrepassar les coordenades 2,72, excepte en el cas de pisòlits que tinguin nucli de matèria més densa que la calcita. En cas de Da molt baixes, la divergència es més àmplia, donat que són exemplars molt esponjosos. Les mesures extremes són: Da, entre 0,63 i 2,00; Dr, entre 1,67 i 2,70.

La mesura de les densitats pot portar a engany en el cas de que el pisòlit tingui capes compactes impermeables entre la massa esponjosa, doncs al fer la pesada dins d'aigua, aquesta no arriba a la zona central. En cas de sospita, cal seccionar la perla per garantir la regular distribució de l'aigua. En cas de que el tall es porti a terme amb serra, s'ha de tenir en compte la pèrdua de material.

Conclusions

– L'aspecte dels PBD té en comú el color blanquinós, grisenc o marró clar, amb poca consistència superficial.

– El desenvolupament té lloc en zones mollades o inundades, però sempre exents de goteig i turbulències.

– Els PBD arriben a prendre pesos i mides considerables. El més gran trobat, de la Grallera d'Alçamora, Lleida, pesa 94 g., eixos 56 × 47,5 × 42 mm i densitat 1,94. Dels 248 exemplars, 14 d'ells pesen més de 20 g.

– Les textures queden restringides a granuloses, botricoidals i en molt rares ocasions, aciculades.

– Les agrupacions són en general de pocs exemplars.

– En proporció, els PBD tenen un volum superior en 13 % als de densitat més habitual.

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The origin of sulphates in Castleguard cave, Columbia. Icefields, Canadá

C. J. Yonge
Physics Department, The University of Calgary. Calgary, Alberta, Canadá.

RESUM

La cova de Castleguard és alhora una via activa i de paleodrenatge de l'aigua basal procedent dels Colúmbia Icefields. La part fòssil de la cova, formada per calcàries del Càmbric Mitjà, conté sediments clàstics que es trobaven al descobert quan la cova fou drenada durant l'aprofundiment de la vall glaciar. Revesteixen especial interès les complexes sèries de minerals, desenvolupades durant el paríode sec, com ho són els sulfats, guixos i mirabilita.

Intentant d'esbrinar l'origen dels minerals sulfatats, s'han efectuat mesures isotòpiques del sulfur, carboni, oxigen i hidrogen dels minerals de la roca envoltant i de l'aigua de la cova. En la major part dels casos, s'ha observat que el guix sembla tenir el seu origen en l'oxidació de la pirita de la roca encaixant, suggerint-se un important paper de l'àcid sulfúric en la dissolució de la cova. Si bé tant el guix com la mirabilita varen precipitar per evaporació, aquesta última es va veure molt més afectada per aquest mecanisme. També es podria donar el cas que el dipòsit fos molt més recent i que s'hagués format degut a una major intensitat dels tubs de vent quan es va obrir la cova, durant l'Eocè.

RESUMEN

La cueva de Castleguard es tanto una vía activa como de paleodrenaje para el agua basal procedente de los Columbia Icefields. La porción fósil de la cueva, formada en calizas del Cámbrico Medio, contiene sedimentos clásticos que estaban expuestos cuando la cueva fue drenada durante la profundización del valle glaciar. Aquí son de interés complejas series de minerales desarrollados durante el período seco entre los cuales se encuentran los sulfatos, yesos y mirabilita.

Tratando de resolver el origen de los minerales sulfatados, se han efectuado medidas isotópicas de sulfuro, carbono, oxígeno e hidrógeno en los minerales, en la roca envolvente y en el agua de la cueva. En la mayoría de los casos, el yeso parece tener el origen en la oxidación de la pirita de la roca encajante, sugiriendo un importante papel del ácido sulfúrico en la disolución de la cueva. Mientras que tanto el yeso como la mirabilita fueron precipitados por evaporación, la mirabilita fue mucho más intensamente afectada por este mecanismo, sugiriendo que este es un depósito reciente que, formado cuando los efectos del tubo de viento fueron los mayores cuando la cueva se abrió durante el Holoceno.

SUMMARY

Castleguard Cave is both an active and paleo drainage route for basal water from the Colombia Icefields. The fossil portion of the cave, formed within limestones of Middle-Cambrian age, contains clastic sediments that were exposed as the cave drained during glacial valley-deepening. Complex suites of minerals developed during the dewatering event, of which the sulphates, gypsum and mirabilite are of interest here.

In attempting to resolve the origin of the sulphate minerals, isotopic measurements of sulphur, carbon, oxygen and hydrogen were carried out on the minerals, the bedrock and the cave water. In most cases, gypsum appears to have its origins in the oxidation of bedrock pyrite suggesting an important role of sulphuric acid in cave solution. While both gypsum and mirabilite were precipitated out of solution by evaporation, mirabilite was much more intensely affected by this mechanism suggesting that it is a recent deposit that formed when chimney-wind effects were greatest as the cave was breached during the Holocene.

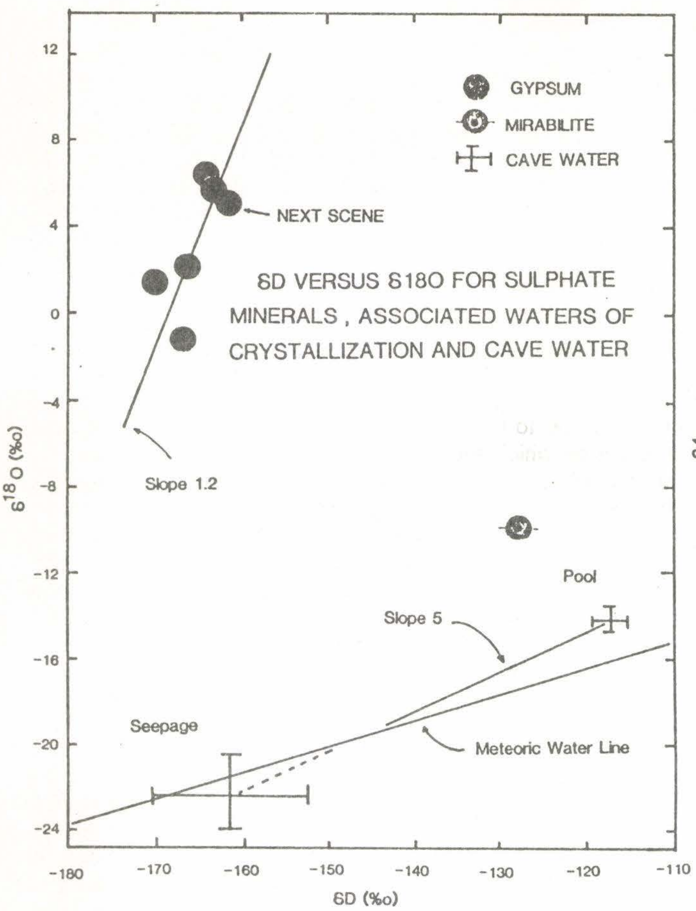
Introduction

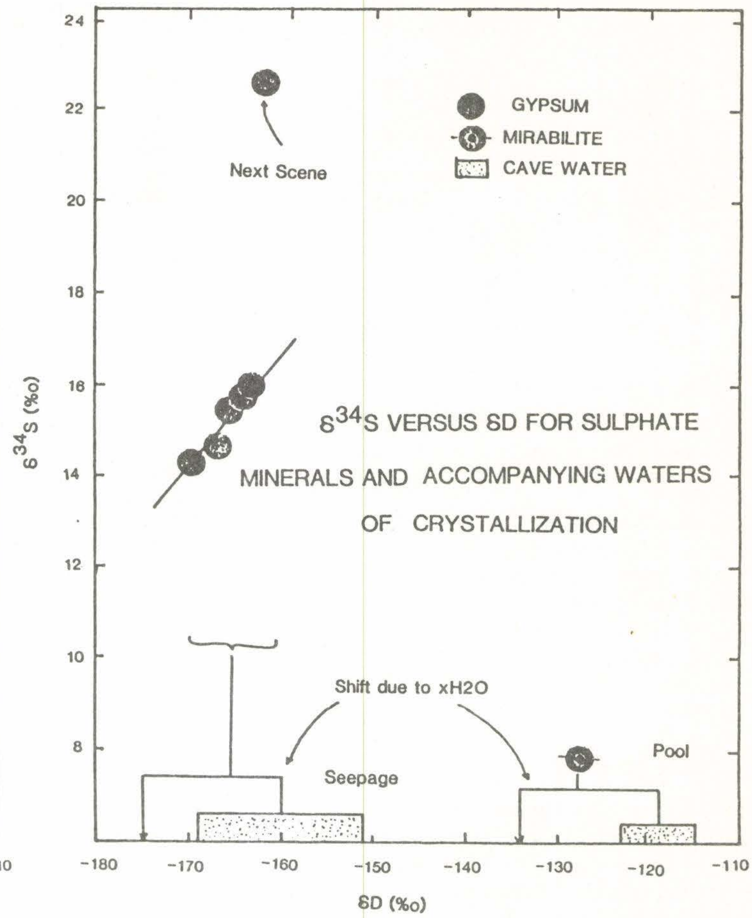
Castleguard Cave, which has an explored length of 18.6 km, is both an active and paleo-drainage route for basal and moulin sink water from the Colombian Icefields in the canadian Rockies (Smart, 1984). The portion of cave contained within the vadose zone of the Stephen, Pika, Eldon and Cathedral Limestone formations of Middle-Cambrian age (Aitken, 1968) contains finely-layered clastic sediments exposed as glacial valley deepening caused the cave to drain (Ford et al., 1983).

Of interest are the sulphate minerals, gypsum, epsomite and mirabilite, which have formed on the walls of the cave or on and within the *in situ* clastic sediments. Some observations have been made on the mineralogy of the cave including stable isotope analyses (Harmon et al., 1983) but most attention was given to the relatively extensive calcite minerals. We have focussed our attention on two of the sulphate minerals and have attempted to resolve their origins with isotopic measurements of sulphur carbon, oxygen and hydrogen made on the minerals, the surrounding bedrock and the cave water. Stable isotope measurements of the sulphate minerals have not been made before.

It appears that simple dissolution of anhydrite from the cave-bearing limestones to account for the presence of gypsum which is often found in caves with low humidities, is not appropiate in Castleguard Cave. The sulphates in Castleguard have undoubtably been precipitated from evaporating cave water but their source may well be from the oxidation of metalliferous sulphides in the adjacent bedrock. The origin of sulphate minerals in caves from a sulphide source has been recognised in more southerly caves (for example, Poulson and White, 1969). Atkinson (1983) in looking at the growth rates of speleothems in the cave finds that sulphuric acid must be present in the cave seepage water in order to account for the ionic load that they support. Oxidation of sulphides can provide the sulphuric acid required to enhance the aggressiveness of the vadose water (Stumm and Morgan, 1981). In fact, there is growing opinion that sulphuric acid rather than carbonic acid may be the major dissolving agent in the formation of caves generally (Lowe, 1985). Our isotopic evidence lends support to this view.

A purely chemical origin for the cave sulphates is not shown unequivocally since mirabilite exhibits isotope ratios that may in part been generated by bacterial activity. Such mechanisms have been discussed by Matzutani and Rafter (1973) and Krouse (1980)





Sampling and analytical procedures

Gypsum and mirabilite were sampled for isotopic analysis. Gypsum is found throughout the cave both as shards of loose crystal aggregates or as clusters of euhedral crystals flaking from the walls and on or within the clastic sediments. The gypsum associated with the sediments occurs as fibrous or needle-like crystals scattered randomly on the exposed surface of varve-like clays and as massive euhedral crystals or tabular or arrow-shaped platelets 2 to 3 cm in length within first few centimetres of the clay. Relative humidity in the regions where gypsum is found is around 96 %. Mirabilite is found as intertwined aggregates of thin, transparent water-soluble needles ca. 1 cm in length lying on dissected sediments banks in the driest portion of the cave where the relative humidity is around 94 %. The bitter salty taste of the mineral suggested that the thenardite as identified by x-ray diffraction was actually present in the cave as the hydrated sodium sulphate, mirabilite ($Na_2SO_4.10H_2O$).

A few grams of gypsum and adjacent limestone bedrock were collected in plastic vials whereas water samples and mirabilite (which loses its water of crystallization at room temperature) were collected in sealed glass bottles. Glass preserves the deuterium/hydrogen content of water samples better than some polymeric materials (Yonge, 1982).

Analyses of waters of crystallization and cave water samples were undertaken using the methods of Coleman et al. (1982) for deuterium content and McCrea et al. (1950) for ^{18}O. Sulphur and oxygen isotope ratios of the sulphates were determined according to the procedures described by Fumitaka et al., (1983) and Shakur (1982) respectively. Analyses of trace sulphur species in the bedrock employed the method described by Ueda and Sakai (1983).

Results and Discussion

The results of the isotope analyses obtained for this study are listed in Table I and illustrated by figures 1,2 and 3.

In figures 1 and 2, gypsum sulphur isotope values can be seen to cluster in the 14 to 16 ‰ range, bracketing the values of 15.5 +/− 0.5 ‰ obtained for trace metallogenic sulphides from the cave-bearing Cathedral and Eldon limestone formations. Pyrite is a possible source for the sulphide and has been observed in all of the platform carbonate units. Atkinson (1983) has shown that pure evaporation cannot account for the calcite Holocene speleothems encountered in the cave and that additional solution of dolomite and/or sulphate must occur in the groundwater prior to its entry into the cave. However, he found that more dolomite was dissolved than would have been expected from incongruent dissolution in the system calcite-dolomite-gypsum. Each mole of oxidised pyrite can yield two moles of sulphuric acid which reacts almost immediately with carbonates to produce sulphates and subsequently evolves CO_2. The CO_2 may then dissolve to produce a further two moles of carbonic acid (Stumm and Morgan, 1981). The oxidation of pyrite as a source of the cave sulphate deposits thus seems a likely mechanism in view of the isotopic and chemical evidence.

One sulphur isotope value at odds with those measured on the above gypsum minerals is the sediment-enclosed gypsum sample from a major side passage known as the Next Scene. This value of 22.6 ‰ is best explained by direct solution of anhydrite followed by reprecipitation of gypsum during dessication of the cave sediments. Sulphate values of 21.7 +/− 1.0 ‰ from trace quantities of anhydrite in the cave-bearing limestones support this view. What remains to be explained is the fact that this sample of gypsum is different in isotopic composition from the others. Presently the side passage in which this mineral was found, runs beneath a considerable exposure of the Arctomys Formation, a thick sequence containing shales, sandstones and dolomites containing lenses of anhydrite. Ancient sink points from which the Next Scene streamway could have been derived would have been situated on the contact between the Arctomys Formation and the platform carbonates. Anhydrite would then have been dissolved as streams flowed over the impervious unit and brought into the cave via the sinks points. The injection of clastic sediments into the Next Scene must have occured prior

TABLE 1 – ISOTOPE DATA FROM CASTLEGUARD CAVE

Cave water	D (V-SMOW) ‰		^{18}O (V-SMOW) ‰
seepage	−160+/-9		−22.4+/−2.0*
	−150(2)**		−20.3(2)
pools	−117(2)		−14.0(2)
Crystallisation water		Cave Temp.° C	Rel Humidity (%)
gypsum (sp,2)	−170(2)	3.0	96
(wf,1)	−167(2)	2.6	96
(sp,1)	−166(2)	2.3	96
(sn,2)	−164(2)	3.0	96
(se,2)	−163(2)	2.6	96
(se,3)	−162(2)	3.5	96
mirabilite(sn,3)	−128(2)	3.5	94

(s = sediment bound, w = wall deposit, P = platelets, f = flakes, n = needles, e = massive euhedral crystals, number refers to location in cave)

Sulphates	^{34}S (CDT) ‰	^{18}O (V-SMOW) ‰
gypsum	14.2	1.2
(wf,1)	14.7	-1.3
(sp,1)	15.5	2.1
(sn,2)	15.8	6.3
(se,2)	16.0	5.6
(se,3)	22.6	5.2
mirabilite(sn,3)	7.8	−10.0
Bedrock	^{34}S (CDT)‰ sulphide	^{34}S (CDT)‰ sulphate
	15.5+/−0.5	21.7+/−1.0

* After Harmon (1983)

to those seen in the main trunk route of the cave, since the main cave does not contain gypsum with a similar isotopic composition of that observed in the Next Scene.

That sulphide is depleted in ^{34}S by 7 ‰ with respect to the sulphate in the bedrock is expected for bacterial reduction of sulphates during diagenesis, although 22.5 ‰ is light for evaporites deposited in the Middle Cambrian; 30 ‰ would be more normal (van Everndingen et al., 1982). Diagenetic effects such as dolomitisation and/or metamorphism may have affected the trace quantities of sulphur species.

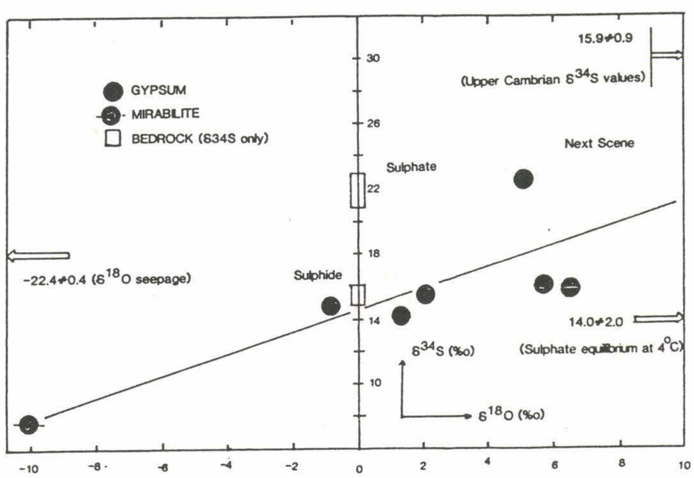
The sulphur isotope compositon of mirabilite is 7.8 ‰ with a concommitant depletion in ^{18}O compared to gypsum. All of the cave sulphates in fact show a vague correlation of sulphur isotope ratios with oxygen isotope ratios suggesting a varying degree of kinetic fractionation (figure 1). A trend towards equilibrium fractionation seems highly unlikely in light of work by Chiba and Sakai (1985) in which the equilibrium of sulphate in sea water was calculated to be 5×10^9 years at a pH of 4 and temperature of 4° C. At pH's of 8.13 to 9.03 and temperatures of around 3° C, equilibrium in Castleguard Cave would take even longer.

One possible mechanism for explaining the sulphur-oxygen isotope compositions may be the presence of bacteria in the ground water (which may also aid processes in the direction of equilibrium). Mizutani and Rafter (1973) showed that sulphur-reducing bacteria preferentially metabolize $^{32}S^{16}O_4$ in the ratio of 1:4 (the ratio here is about 1:2). The cave contains a variety of biota and is recognised as a Wisconsin refugium but bacterial activity on minerals appears to be absent. For example, carbonate «moonmilk» seen as a crusty, pasty deposit in the cave is likely formed as a vapour-phase equilibrium deposit (White and Deike, 1962) rather than by bacterial deposition in which aggregates of fibrous bodies (lublinite) accumulate. Nevertheless, in the absence of other mechanisms, a bacterial origin for mirabilite, and to a lesser extent, gypsum, could explain the isotopic trend of oxygen versus sulphur.

The hydrogen isotope data from waters of crystallization suggest in part an evaporitive mechanism for sulphate precipitation (figures 2 and 3). Gypsum waters of crystallization are depleted in deuterium compared to cave seepage water; a tendency expected for the precipitation of gypsum in thermodynamic equilibrium with its parent solution. However, a shift in values of 15 to 20 ‰ would be expected if equilibrium had been acheived (Fontes and Gonfiantini, 1967) whereas only 6 ‰ is observed. Mild evaporation of the cave waters may have served to enrich the crystallization waters over the expected values. The gypsum from the Next Scene appears to follow the same trend. In fact all the gypsum samples, whether wall or sediment-bound deposits appear to have suffered the same isotopic fractionation with respect to their crystallization waters. With respect to the low evaporative conditions that existed while gypsum was being precipitated, Pohl and White (1965) point out that CO_2 must be released in order for gysum to be deposited in the reaction of a sulphate-bearing solution with calcite. As groundwater frasses into the cave it encounters a lower pCO_2 resulting in a loss of CO_2 from solution. Gypsum found growing on the walls of the cave can be explained by this reaction of sulphate-bearing solutions on bedrock and subsequent loss of CO_2 but so too can the sediment-bound gypsum. Schroeder and Ford (1983) have found that the clastic sediments in the cave can contain up to 60 % calcite glacial flour which would provide a medium on which the sulphate-bearing solutions can react.

The trends of sulphur to hydrogen isotope ratios and oxygen to hydrogen isotope ratios suggests some small but consistent kinetic effects. Note that the oxygen/hydrogen trend does not run parallel the meteoric water line (Dansgaard, 1964) as do the cave seepage waters which have been collected as they emerge unevaporated from joints in the cave roof. We do not at the present time know that these kinetic effects are due to.

Mirabilite crystallization waters appear to be derived from pool-like water that has been quite strongly evaporated. The shift of the crystallization water to lighter values from the standing pool water is probably fortuitous as one would not expect the weakly bonded water to be thermodynamically fractionated to the same extent as gypsum crystallization water. Be that as it may, mirabilite crystallization water is enriched in deuterium compared to seepage water and thus suffered similar evaporative effects as the present standing pools. Speleothems which host flags on their modern portions point to the cave's present day evaporative environment but suggest that evaporation was not strong in the past. In addition, pre-Holocene speleothems have been found growing in isotopic equilibrium with their parent seepage waters, this can only occur in conditions of low evaporation (Gascoyne et al., 1983). Mirabilite has formed in the driest part of the cave (relative humidity 94 %) where evaporation would be expected to be greatest. It is likely in this case that the deposition of Na-sulphate occured as a result of solutions which had become Na-enriched via ion-exchange processes as Mg-rich waters passed through the sediment prior to evaporation.



S & O ISOTOPE RATIOS FOR SULPHATE MINERALS IN CASTLEGUARD CAVE

Conclusions

Most of the sulphate minerals found in the cave appear to have come from sulphides present in the platform carbonates that enclose the cave via pyrite oxidation. Some of the sulphates may have originated directly from an anhydrite source.

Loss of CO_2 with some evaporation as solutions entered the cave may account for the presence of wall and sediment-bound gypsum. Mirabilite, however, appears to have been affected by a strongly evaporating environment with some bacterial effects.

Speleothems that host flags on their modern portions indicate that a strongly evaporative environment is a recent phenomenom which may have occured when the cave was breached during glacial valley deepening following the Wisconsin Glacial Maximum. Gypsum was probably deposited while the cave was essentially sealed and mirabilite was deposited when it was subsequently opened. The onset of bacterial activity in the cave may have occured at this time.

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The Mineralogy and Chemical Constituents of Saltpetre in Six Viginia Caves

David A. Hubbard, Jr., Richard S. Mitchell and Janet S. Herman

Virginia Divison of Mineral Resources – Department of Environmental Sciences, University of Virgínia, USA.

RESUM

A fi d'estudiar millor la composició de salnitre de les coves del sud-est dels Estats Units, es van recollir 35 mostres de minerals i 26 de sediments de 6 coves de salnitre de Virgínia. Tots els minerals de salnitre identificats són deliqüescents. Un dels minerals recollits, identificat per refracció de raigs X, és el nitrat potàssic (KNO_3). Alguns d'aquests minerals de salnitre es van formar per evaporació de percolats i 8 de les 26 mostres de sediments varen poder ésser identificades per difracció de raigs X com a nitrat potàssic i nitromagnesita [Mg $(NO_3)_2$. $6H_2O$]. L'anàlisi química d'aquests sediments percolats ens va donar 20 mostres amb una concentració de nitrats (NO_3^-) superior a 1.000 ppm. Les anàlisis de cations i d'anions dels percolats, indicaren que 21 de les mostres contenien, probablement, nitrocalcita dissolta [$Ca(NO_3)_2$. $4H_2O$]. No obstant, l'elevada humitat atmosfèrica de la primavera i l'estiu del 1.985, impedí la cristal·lització i el posterior estudi per raigs X d'aquest mineral extremadamente deliqüescent.

RESUMEN

Para estudiar mejor la composición de salitre en cuevas del sur-este de los Estados Unidos se recolectaron 35 muestras de minerales y 26 de sedimentos de 6 cuevas de salitre en Virginia. Todos los minerales de salitre identificados son delicuescentes.

Uno de los minerales recolectados identificados con difracción de rayos-X es nitrato potásico (KNO_3). Los minerales de salitre, formados por la evaporación de percolados y nitromagnesita [$Mg(NO_3)_2 \cdot 6H_2O$]. El análisis químico de estos sedimentos percolados proporcionó 20 ejemplares con nitrato (NO_3^-) concentraciones superiores a 1.000 partes por millón (ppm.). Los análisis de cationes y aniones de los percolados indican que 21 de las muestras contienen probablemente nitrocalcita disuelta [$Ca(NO_3)_2 \cdot 4H_2O$]. No obstante las humedades atmosféricas elevadas en la primavera y verano de 1985 excluyeron la cristalización y el estudio por rayo-X de este mineral extremadamente delicuescente.

SUMMARY

In order to better understand the composition of saltpetre in caves of the southeastern United States, 35 mineral and 26 sediment samples were collected from 6 Virginia saltpetre caves. All of the saltpetre minerals identified are collected, and deliquescent. One of the mineral specimens collected, and identified by X-ray diffraction, is niter (KNO_3). Saltpetre minerals which formed by the evaporation of leachates from 8 of the 26 sediment samples were identified by X-ray diffraction as niter and nitromagnesite [$Mg(NO_3)_2 \cdot 6H_2O$]. Chemical analyses of these sediment leachates yielded 20 specimens with nitrate (NO_3^-) concentrations greater than 1000 parts per million (ppm). Cation and anion analyses of the leachates indicate that 21 of the samples probably contain dissolved nitrocalcite [$Ca(NO_3)_2 \cdot 4H_2O$]. However, high atmospheric humidities in the spring and summer of 1985 precluded the crystallization and X-ray study of this extremely deliquescent mineral.

Introduction

Saltpetre was obtained from caves of the southeastern United States (USA) from the late 1700's until the end of the Civil War in 1865. Mining efforts were most intense during the American Revolution (1775-1783), the War of 1812 and the Civil War (1861-1865), when gunpowder made from saltpetre was in great demand. Saltpetre was obtained from caves by leaching petre dirt, or saltpetre earth, combining this liquor with the leachate of wood ashes, and then boiling the resultant solution until nitrate crystallization occured. The composition of the raw cave saltpetre is still poorly understood. Early reports of nitrate minerals have not been verified by modern techniques (Hill, 1981a), because nitrate minerals are deliquescent and do not easily crystallize in the high-humidity environments normally found in southeastern caves (Hill, 1981b, p. 127). In order to further the understanding of the composition of saltpetre in the caves of the southeastern United States, six of Virginia's 70 known saltpetre caves were sample and studied (Figure 1).

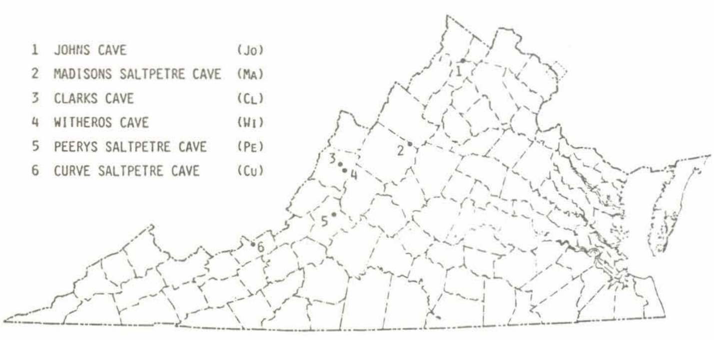

Figure 1. Distribution of saltpetre caves studied in Virginia.

Caves sampled

Johns Cave (Figure 1) is in Frederick County, in limestones and dolomites of the Rockdale Run Formation (Ordovician). Evidence of saltpetre mining in this 100 m long cave includes diggings, old sediment levels on walls and four mounds thought to have been leaching vats. A number of names of initials from the 1780's and 1790's have been observed in the vicinity of the mounds. Kercheval (1833) reported the cave as «remarkable only for its production of saltpetre, and preserving fresh meats in hot weather».

Madisons Saltpetre Cave (figure 1) is located in Augusta County in the limestone and dolomites of the Conococheague Formation (Cambrian). This cave contains about 490 m of passage, 90 m of which are submerged. Evidence of saltpetre operations includes diggings, names and dates, and old sediment levels on the walls. Wall inscriptions were dated as early as the 1770's and include the name of one known supplier to the Continental Army, two names dates 1813, and an inscription by Greenlee Davidson in 1863. According to his diary, Captain Davidson collected specimens of cave earth from this cave for analysis of saltpetre in 1862. Hovey (1897) reported «Jed» Hotchkiss, Stonewall Jackson's map maker, to have said, «Madison's Cave was mined for saltpetre during the three great wars, of the revolution, of 1812, and of the rebellion probably the only cave on the continent of which that can be said».

Clarks Cave (Figure 1) is in Bath County in the Licking Creek Limestone (Devonian). The cave is estimated to contain about 4.8 km of passage; at least a thrid of which was worked for saltpetre. Faust (1964, p. 42) reports that, «evidence indicates that this cave was worked for saltpetre as early as 1740. Mr. (Grady) Clark, who owned this property for many years, reported that his grandfather (Samuel Clark) worked in the cave during the War of 1812». Mining operations during the Civil War were reported by Douglas (1964, p. 152). The extensive workings still contain artifacts of mining activities.

Witheros Cave (Figure 1) is also located in Bath County in the Licking Creek Limestone. Saltpetre was mined in approximately one third of this 3297 m long cave (Simmons, 1981). The saltpetre mining operations were probably of the Civil War era.

Peerys Saltpetre Cave (Figure 1) is in Botetourt County in limestones and dolomites mapped as the Conococheague Formation (Cambrian; Spencer, 1968). Douglas (1964, p. 188) reported Peerys Saltpetre Cave to be over 400 m long. Saltpetre workings extend throughout the cave. Burton Faust (1964, p. 45) stated: «This cave is very likely the place where, it was reported in 1775 that, Charles Lynch had found 'many rocks of GENUINE SALTPETRE'.» Civil War mining operations were reported by the cave's owner, Mrs. Mary Goodwin (Mansfield and Boardman, 1932).

Curve Saltpetre Cave (Figure 1) is located in Giles County in the limestones and dolomites of the Ordocvian part of the Knox Group. The cave was worked for saltpetre throughout its 200 m length. Mining was reportedly during the Civil War (Douglas, 1964, p. 226, Holsinger, 1975). Dates in diggings indicate that some work was carried out before the Civil war.

Methods

Mineral and sediment samples were collected at each of the six caves described above. Mineral specimens consisting of efflorescent crusts or fibers were collected from rock and sediment surfaces of floors, walls, and ceilings. Sediment samples of approximately 2.2 L were collected in the vicinity of old saltpetre workings. Although a variety of sediment types were collected, sampling was generally biased toward well aerated nearly dry sediments of an almost spongy nature with little organic material.

Sediment samples were air dried for approximately one week until they attained a constant weight. A subsample of 700.0 g was taken from each sample, excluding charcoal and large rock fragments. Each subsample was mixed with 500 mL of distilled water in an inverted 1000 mL polyethylene bottle with its bottom removed and with a glass cotton filter in the neck of the bottle. After 24 hours the sample mixture was allowed to drain through filter paper into an Erlenmeyer flask. After an additional 24 hours the mixture was vacuum filtered for additional leachate yield. Approximately 10 mL of leachate was allowed to evaporate from a watch glass for identification by X-ray diffraction and optical microscopy.

Leachate samples were filtered a final time through a 0.45 µm filter and then split. Half of each sample was acidified with concentrated nitric acid. Acidified solutions were diluted and analyzed by atomic absorption for Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+} using an Instrumentation Laboratories model 751 dual-beam spectrophotometer. The unacidified leachate subsamples were diluted and analyzed for Cl^{-}, NO_3^{-}, SO_4^{2-}, and PO_4^{3-} using a Dionex Ion Chromatograph.

Results

The identification of 32 mineral samples is summarized in Table I. Only two of the specimens are nitrate minerals. Samples Pe7B and Pe7C (Peerys Saltpetre Cave) were idenfied as niter (KNO_3). Pe7B occurred as white kinky lintlike fibers approximately 1 cm in length growing on the top and side of a small ledge. Pe7C occurred as clear or white silky hairlike fibers up to 2 cm long growing on the top and side of a small ledge.

The mineralogical composition of the 26 sediment samples is summariezed in Table 2. Only the major minerals were found by whole sample analyses.

Precipitates formed by evaporation of leachate from sediment samples are summarized in the leachate column of Table 2. Gypsum was usually the first compound to form from the leachate. Niter occurred from Cu2 and Cu3 leachates. No niter was observed from leachates of Peerys Saltpetre Cave from which mineral specimens of niter had been collected, but no sediment samples were taken in the vicinity of those mineral occurrences. Nitromagnesite [$Mg(NO_3)_2 \cdot 6H_2O$] was observed to form from leachates when X-ray laboratory humidity was reduced to the low-thirty to mid-forty percent range. At this humidity niter and nitromagnesite were identified from 13 of the 26 leachates. Fifteen leachates did not fully evaporate and no nitrocalcite [$Ca(NO_3)_2 \cdot 4H_2O$] was identified. In only four leachates were no nitrate compounds found upon complete evaporation: Jo2, Jo4, Wi1 and Wi5.

Chemical analyses of the leachates are tabulated in Table 3. Nitrate (NO_3^{-}) values range from a high of 36.210 ppm from Ma2, which corresponds to content of 2.6 percent by weight, to a low of 36 ppm for Jo4. Twenty leachates had nitrate concentrations greater than 3000 ppm. Precipitates obtained from one of these high nitrate leachates, wil, did not include any nitrate compounds. Phosphate (PO_4^{3-}) was below detection limits in the dilutions used.

Sample[1] No.	Composition[2]	Sample[1] No.	Composition[2]
Jo2A	calcite, dolomite	Wi1B	epsomite
Jo2B	calcite, dolomite	Wi1C	epsomite, quartz
Jo3A	calcite, dolomite	Wi1D	epsomite
Jo3B	calcite, dolomite	Wi1E	epsomite
		Wi2A	gypsum
Ma2A	calcite overlying quartz, kaolinite and chalcedony	Wi2B	gypsum
		Wi4B	calcite
Ma2B	amorphous, quartz	Wi4C	gypsum, tr. quartz
Ma2C	gypsum, tr. quartz		
Ma3A	gypsum, tr. quartz	Pe2A	epsomite
Ma3B	gypsum, tr. quartz	Pe3A	nesquehonite
Ma4A	apatite, tr. unknown	Pe7B	niter
		Pe7C	niter
Cl1A	gypsum		
Cl2B	epsomite, tr. calcite	Cu1A	nesquehonite
Cl2C	epsomite	Cu4A	gypsum
Cl3A	gypsum	Cu4B	amorphous powder
		Cu4D	calcite
Wi1A	epsomite	Cu5A	gypsum

[1]first two letters refer to cave name - see Figure 1
[2]identification by X-ray diffraction

Table 1. Mineralogical composition of efflorescent crusts

Sample[1] No.	Sediment[2]	Leachate[2]	Evaporation[3] State
Jo1	quartz, illite, tr. kaolinite, sp. dolomite	gypsum, nitromagnesite	wet
Jo2	quartz, illite, tr. kaolinite, sp. dolomite	gypsum, hexahydrite	dry
Jo4	quartz, illite, tr. kaolinite, sp. dolomite	amorphous, calcite	dry
Ma1	quartz, min. illite, min. kaolinite, min. microcline	gypsum	wet
Ma2	quartz, microcline, tr. illite, tr. kaolinite	gypsum, nitromagnesite	damp
Ma3	quartz, min. kaolinite, min. microcline, tr. illite	gypsum, nitromagnesite	damp
Ma4	quartz, min. microcline	gypsum	wet
Cl1	quartz, illite, sp. albite	gypsum	wet
Cl3	quartz, illite, gypsum, sp. albite, tr. kaolinite	gypsum, nitromagnesite	dry
Cl4	quartz, illite, tr. kaolinite	gypsum	wet
Cl5	quartz, illite, tr. gypsum, tr. kaolinite	gypsum	wet
Wi1	quartz, gypsum, tr. illite	gypsum, hexahydrite	dry
Wi3	quartz, illite, sp. albite	gypsum	wet
Wi4	quartz, gypsum, tr. illite, sp. albite	gypsum, nitromagnesite	wet
Wi5	quartz, illite	gypsum, calcite	dry
Pe1	quartz, dolomite, illite, tr. calcite	gypsum, nitromagnesite	dry
Pe4	quartz, illite, kaolinite	nitromagnesite	dry
Pe5	quartz, kaolinite, tr. illite	nitromagnesite	dry
Pe6	quartz, illite, tr. kaolinite	nitromagnesite, gypsum	wet
Pe7	quartz, illite, dolomite, tr. kaolinite	gypsum, nitromagnesite	damp
Pe8	quartz, illite, kaolinite, tr. dolomite	gypsum	damp
Pe8B	dolomite, quartz, kaolinite, illite, tr. calcite	unknown	wet
Cu1	quartz, illite, sp. dolomite, tr. kaolinite	gypsum, nitromagnesite	dry
Cu2	quartz, illite, tr. kaolinite	amorphous, niter, epsomite	dry
Cu3	quartz, illite, tr. kaolinite, sp. dolomite	niter	dry
Cu5	quartz, illite, tr. kaolinite, sp. dolomite	gypsum	wet

min.: minor
sp.: spot pattern indicates specimen contained only a few grains
tr.: trace

[1]first two letters refer to cave name - see Figure 1
[2]identification by X-ray diffraction
[3]evaporation state at relative humidity in the low-thirty to mid-forty percent range

Table 2. Mineralogical composition of sediments and evaporated leachates

Discussion

The only nitrate mineral found in the six saltpetre caves examined was niter (Table 1). However, evaporation of leachates from these caves resulted in the identification of both niter and nitromagnesite and a thick viscous deliquescente slurry. A similar leachate slurry was considered a solution of calcium nitrate by Maxson (1932). All 15 of the leachate samples indicated as damp or wet on Table 2 contain over 3000 ppm NO_3^{-} (Table 3). These leachates, also high in calcium, are expected to yield nitrocalcite upon complete evaporation. Hill (1981b, p. 131) ranked the nitrate minerals in decreasing order of delinquescent stability in the cave environment as niter, soda-niter ($NaNO_3$), ammonia-niter (NH_4NO_3), nitromagnesite and nitrocalcite. Darapskite [$Na_3(NO_3(SO_4) \cdot H_2O$] could not be ranked «since the vapor pressure over a saturated solution of this salt is unknown». Considering Hill's ranking and the data presented in this paper, the composition of cave saltpetre in these six Virginia caves can be considered a mixture of nitromagnesite and probably nitrocalcite with local concentrations of niter. The possibility that darapskite is present cannot be disconnted.

Significant reduction of Virginia's 12 °C mean cave temperature have been documented in Witheros Cave by V. Tipton during winter months (Hubbard, 1981). Seasonally (January-February), extended periods of cold, low humidity weather can result in low cave humidities. We postulate that the nitrate compounds evaporated from cave leachates may occur seasonally in some Virginia saltpetre caves.

Sample[1] No.	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	NO_3^{-}	SO_4^{2-}
Jo1	2705	2315	100	183	222	22250	383
Jo2	201	85	10	86	2	301	778
Jo3	24	25	7	3	3	36	32
Ma1	3926	612	59	76	253	12980	1037
Ma2	9345	1450	630	2240	195	36210	871
Ma3	4246	857	60	279	10	19620	773
Ma4	3224	852	70	31	13	15190	676
Cl1	1712	280	174	24	187	4544	924
Cl3	1118	803	257	26	178	4580	1780
Cl4	5350	1270	620	89	344	25290	481
Cl5	2713	706	122	104	419	11580	1066
Wi1	788	1783	546	34	508	3824	2034
Wi3	5285	411	115	72	83	18790	773
Wi4	1417	703	299	58	83	4544	1469
Wi5	684	64	36	34	10	67	1592
Pe1	2425	1725	267	214	237	16430	2041
Pe4	676	1426	116	35	236	4652	77
Pe5	43	78	28	22	26	345	164
Pe6	2925	1725	354	234	419	21070	383
Pe7	2265	3130	559	512	919	22670	1554
Pe8	1561	469	44	54	81	4406	614
Pe8B	3102	918	79	118	83	14010	968
Cu1	504	546	45	46	50	3032	735
Cu2	64	41	21	121	9	483	103
Cu3	13	5	4	58	3	42	27
Cu5	716	319	94	47	314	3500	340

[1]first two letters refer to cave name - see Figure 1

Table 3. Cation and anion concentrations in leachate (ppm)

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HUBBARD, D.A., Jr., BOX P.O. 3667, Charlottesville, VA 22903, USA, 804-293-5121, Virginia Division of Mineral Resources.

MITCHELL R.S. and J.S. HERMAN, Clark Hall, University of Virginia, Charlottesville, VA 22903, USA, 804-924-7761, Department of Environmental Sciences.

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Découverte de cendres volcaniques dans de concrétions stalagmitiques datées par $^{230}Th/^{234}U$. Une nouvelle perspective pour la téphrostratigraphie

M. Gewelt et E. Juvingne

RESUM

Una nova associació de minerals volcànics ha estat trobada en concrecions de coves belgues. Les datacions amb $^{230}Th/^{234}U$ de la calcita d'aquestes concrecions ha permès atribuir a aquesta aportació volcànica una edat de 106.000 anys B.P. (± 6.000 anys). Aquesta aportació volcànica (de Remouchamps) encara no havia estat descrita a Bèlgica. Constitueix, doncs, un nou indicador estratigràfic del Plistocè Superior. D'altra banda, els minerals volcànics de «Tuf de Rocourt» s'han trobat igualment en altres concrecions de les coves. Diverses datacions radiomètriques permeten establir nous límits d'edat a aquesta aportació. La tefrostratigrafia es suma ara a les nombroses possibilitats d'estudi que ofereixen les concrecions estalagmítiques (palinologia, datacions radiomètriques, isòtops estables,...).

RESUMEN

Una nueva asociación de minerales volcánicos ha sido hallada en concreciones de cuevas belgas. Las dataciones $^{230}Th/^{234}U$ de la calcita de estas concreciones han permitido atribuir a esta avenida volcánica una edad de 106 más 6 ka B.P. Esta (La Avenida volcánica de Remouchamps) todavía no había sido descrita en Bélgica. Constituye pues, un nuevo indicador estratigráfico del Pleistoceno superior. Por otra parte, los minerales volcánicos de «Tuf de Rocourt» han sido igualmente hallados en otras concreciones de cuevas. Varias dataciones radiométricas permiten dar nuevos límites a la edad de esta avenida. La tesfrostratigrafía se añade ahora a las numerosas posibilidades de estudios que ofrecen ya las concreciones estalagmíticas (palinología, dataciones radiométricas, isótopos estables...).

RESUME

Une nouvelle association de minéraux volcaniques a été trouvée dans des concrétions de grotls belgs. Des datations $^{230}Th/^{234}U$ de la calcite de ces concrétions ont permis d'attribuer un âge de 106 $\pm$ 6 ka B.P. à cette retombée volcanique. Celle-ci (la Retombée volcanique de Remouchamps) n'avait pas encore été décrite en Belgique. Elle constitue donc un nouveau marque stratigraphique du Pléistocène supérieur. D'autre part, les minéraux volcaniques du «Tuf de Rocourt» ont également été retrouvés dans d'autres concrétions de grottes. Plusieurs datations radiométriques permettent de donner de nouvelles limites à l'âge de cette retombée. La téphrostratigraphie d'études qu'offraient déjà les concrétions stalagmitiques (palynologie, datations radiométriques, isotopes stables ...).

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Phosphate minerals in the Butler Cave-Sinking Creek System: geochemistry and characterization by Raman spectroscopy

William B. White

Department of Geosciences and Materials Research Laboratory, The Pennsylvania State University, USA.

RESUM

La Butler Cave-Sinking Creek System, Bath County, Virgínia, conté un considerable complexe de farciments càrstics que van des d'argiles i fins al-luvions, fins a clasts i palets. Els minerals fosfatats apareixen en petites vetes dels sediments clàstics, dispersos entre el granulat clàstic i, tanmateix ben poques vegades, revestint les parets a nivells superiors al dipòsit. Els minerals identificats inclouen la taranaquita, la crandallita, la hidroxiapatita i, possiblement, la sassaïta. La major part dels diferents minerals fosfatats no estan associats amb guano ni amb altres matèries orgàniques. Tots els minerals estan finament granulats. La seva identificació es va dur a terme mitjançant la difracció de pols per raigs X, el microscopi electrònic de scanning i electroscopia de Rama, un experiment d'escombrada amb llum inelàstica, que amida l'espectre vibratori de la mostra. Enfocant el llampec del làsser excitant amb el microscopi òptic i utilitzant una dispersió geomètrica és possible d'obtenir els espectres individualitzats de les minúscules partícules de pols. Presentem també algunes referències d'alguns espectres de minerals fosfatats que es poden trobar més freqüentment a les coves.

RESUMEN

La Butler Cave – Sinking Creek System, Bath County, Virginia, contiene un surtido complejo de rellenos clásticos que van desde arcillas y finos aluviones hasta clastos y cantos rodados. Los minerales fosfatados aparecen en pequeñas vetas en los sedimentos clásticos, dispersos entre el granulado clástico, y rara vez como revestimiento de paredes por encima de los niveles de relleno. Los minerales identificados incluyen la taranakita, la crandallita, la hidroxiapatita y posiblemente la sasaita. La mayoria de los diferentes minerales fosfatados no están asociados con guano ni otras materias orgánicas. Todos los minerales son finamente granulados. La identificación se hizo con difracción de polvo por rayosX, microscopio electrónico de «scanning» y espectroscopia de Rama, un experimento con barrido de luz inelástica que mide el espectro vibracional de la muestra. Enfocando el destello del láser excitante con microscopio óptico y utilizando una geometría de dispersión trasera es posible obtener espectros de los pequeños granulos individualmente. Se presentan referencias de espectros para los minerales de fosfato encontrados comunmente en cuevas.

SUMMARY

The Butler Cave – Sinking Creek System, Bath County, Virginia, contains a complex suite of clastic fills ranging from clays and fine silts to cobble and boulder in–fillings. Phosphate minerals occur within small veins in the clastic sediments, dispersed among the clastic grains, and rarely as wall coatings above the fill levels. Minerals identified include taranakite, crandallite, hydroxyapatite and possibly sasaite. Unlike most cavern phosphate minerals, these are not associated with guano or other organic material. All minerals are very fine-grained. Identification was by powder x-ray diffraction, scanning electron microscopy, and Raman spectroscopy. Raman spectroscopy is an inelastic light scattering experiment that measures the vibrational spectrum of the sample. By focusing the exciting laser beam through microscope optics and using a back-scattering geometry it is possible to obtain spectra on individual small grains. Reference spectra are presented for the phosphate minerals commonly found in caves.

1089

Speleothems in lava tubes of the 1983 eruption at Mt. Etna

R. Cristofolini, A. Marino, G. Puglisi
Istituto di Scienze della Terra, Universitá di Catania - Centro Speleologico Etneo.

RESUM

Durant l'estiu i la tardor del 1984, vàries visites als tubs de lava situats prop de les boques de l'erupció de l'Etna del 1983, van descobrir que gran quantitat d'espeleotemes (estalagtites, estalagmites, crostes, etc.) es van formar en pocs mesos, mentre la perifèria encara estava calenta. Quan es varen prendre les mostres es detectaren temperatures superiors als 50–° C.
Gràcies a l'analísi per XRD, hom va poder detectar la presència de clorurs i sulfats (halita, silvinita, tenardita, aftitalita) en la major part de les mostres. Aquests varen ésser probablement dipositats pel fluxe de fluids molt calents, tant d'origen meteòric com magmàtic.

RESUMEN

Durante el verano y otoño de 1984, varias visitas en los tubos de lava cerca de los orificios de la erupción del Etna de 1983 descubrieron que abundantes espeleotemas (estalagtitas, estalagmitas, costras, etc.) se formaron en pocos meses, mientras la periferia estaba todavía caliente. Cuando se tomaron muestras se detectaron temperaturas superiores a los 50–° C.
Cloruros y sulfatos (halita, silvinita, thenardita, aphthitalita) fueron detectados gracias al análisis por XRD en la mayor parte de las muestras. Fueron depositados probablemente por fluidos que circularon muy calientes tanto de origen meteórico como magmático.

SUMMARY

During summer–autumn 1984 visits into lava tubes next to the vents of the Etnean 1983 eruption (28/3-6/8/1983) showed that abundant speleothems (stalactites, stalagmites, encrustments, ecc.) formed in few months, while the environnement was still warm. When the samples were collected temperature were measured up to 50° C.
Chlorides and sulfates (halite, sylvite, thenardite, aphthitalite) were recognised by XRD analysis in most samples. They were probably deposited by hot circulating fluids either of meteoric or magmatic origin.

10182

Discoveries of caves with unusual crystal forms in the Crimea Karst.

Josef Wagner

RESUM

La zona càrstica de Čatyr Dag, a les muntanyes de Crimea, abarca un total de 43 Km². D'aquesta zona es coneixen 136 coves i avencs la qual cosa representa l'índex més elevat de carstificació de Crimea (3,2 per Km².). Va ser allí on l'any 1970, a la coneguda cova d'Emine-Bojir-Chasar, es va descobrir un nou sector anomenat Ermine-Bojir-Chasar-Nižnyj.

Tot el sistema es va originar arran de la captura d'un riu superficial. La desaparició d'algunes aportacions va originar una descàrrega uniforme de les aigües subterrànies, produïnt-se una acumulació de sediments meteoritzats i travertins. D'aquesta manera, la cavitat va quedar dividida en un conjunt de galeries aïllades i inundades per les aigües càrstiques durant molt temps.

Quasi totes les formes secundàries, parets i sòls estan recoberts d'un nombre excepcional de formacions de calcita de diferents tipus. Són particularment abundants les druses cristal·lines les helictites (de més de 80 cm.) i les excèntriques.

RESUMEN

La zona kárstica de Čatyr Dag en las montañas de Crimea, abarca 43 km². en ella se conocen 136 cuevas y simas, lo que representa el mayor índice de karstificación de Crimea (3,2 por 1 km².). Fue allí donde en 1970 en la conocida cueva Emine-Bojir-Chasar se descubrió un nuevo sector llamado Emine-Bojir-Chasar-Nižnyj.

Todo el sistema se origina a raiz de la captura de un río superficial. La desaparición de algunos aportes originó una descarga uniforme de las aguas subterráneas y produjo una acumulación de sedimentos meteorizados y travertinos. Así la cavidad quedó dividida en un conjunto de galerías aisladas inundadas por las aguas kársticas durante mucho tiempo.

Casi todas las formas secundarias, paredes y suelos están recubiertos con un número excepcional de formaciones de calcita de diferentes tipos. Son particularmente numerosas las drusas cristalinas, helictitas (por encima de 80 cm. y excéntricas).

SUMMARY

The Čatyr Dag karstic area in the Crimean Mountains amounts 43 km², 136 caves and chasms are known there, and represents the largest karsting created on the Crimea (3,2 per 1 km²). There in the famous cave Emine-Bojir-Chasar was discovered in 1970 new part called Emine-Bojir-Chasar-Nižnyj.

The whole system arose as the result of a surface stream absorption. The extinction of some feeding sources caused the uniform outflow of the subterenean waters and brought about an accumulation of the sintered and weathered sediments. Thus the cave was divided into a row of isolated galleries flooded oft with karst water for long time.

Almost all secondary forms, walls and floor are covered with unusual number of calcite forms of various kinds. There are here particularly numerous crystal druses, helictites (up to 80 cm) and eccentrits.

The Crimea Karst is formed by a number of karstic plateaus dividing the Crimea Karst territory into two regions and seventeen karstic areas. The Crimea Karst is formed in a range of mountains stretching along the Black Sea coast. Its present appereance was conditioned by geologic and climatic processes in the Middle and Older Pliocene when the main ridge of the Crimea Mountains which was only slightly raised at that time began to rise. During that process the influence of the erosive activity of surface waters began to be highly intensive. Most atmospheric precipitations did not penetrate into the massif but formed springs and brooks cutting deep furrows and gorges into the plateau. Surface phenomena (sinkholes, ponors) did not exist at that stage. Later on the river network decomposed and large part of the karst waters penetrated underground where the intensive erosive activity continued and gradually the present surface relief has been formed on the plateaus. Today, the Crimea Karst forms several plateaus separated from each other by deep cut valleys through which numerous streams are flowing. The Demerdži, the Karabi, the Aj-Petri, the Čatyr-Dag and the Dolgorukovskoje plateau are the most famous of them.

The Čatyr-Dag Plateau

The Čatyr-Dag karstic area amounts to 43 km^2 and lies at the boundary of the Čatyr-Dag mountain massif. 136 caves and chasms are known there and represent the largest karsting created on the Crimea (3,2 per 1 km^2). A greater part of them is formed by 20-25 m deep chasms. Caves of various types can be seen there as well as ponor chasms frequently creating water collecting systems. The caves and the larger systems are of the corrosive-erosive type and their distribution conforms to the original hydrographic network. The caves and chasms of the lower Čatyr-Dag plateau are represented either by ponor systems (eg the Emine-Bojir-Chasar system), by active passage caves or karst spring caves (Ajanskaja Cave).

The Čatyr-Dag karst is formed on two plateaus. The Upper plateau lies at 1,500 m above sea level (with the highest point Angar Burun, 1,543 m), the Lower plateau is situated at the average height of 1,000 m. The geologic texture is complicated, it is composed of two layers. The upper layer consists of limestones arisen from sediments deposited on the bottom of warm seas in the Upper Jurassic Period. They are about 1,000 m thick and lie on older Trias Layers of the Older Jurrasic Tavrič series of sandstones and conglomerates. Owing to rock-forming processes, these limestone layers were broken into blocks which were exposed to further weathering and karsting.

A number of caves is known in the central part of the erosive system of the Lower plateau, eg the Partisan Cave (320 m long), the Bim Baš Cave (110 m long), the Gugerdžin Cave (60 m long) and the Suuk Cave (210 m long). These caves are genetically connected with Chasm «Move by the Knight» (210 m deep) which was created by the collaps of the bottom of rather small sinkhole above the roof of the cave. In the lower part of the erosive system is the best known Čatyr-Dag cave – the Emine-Bojir-Chasar Cave exceeding 2,400 m in length and 125 m in depth at present. The Čatyr-Dag caves were already known to the first inhabitants of the Crimea which was proven by numerous archaelogical discoveries on the plateau and in the caves. In the Bim-Baš Cave (the Thousand headed Cave) a great number of human skeletons was found as evidence of the crimes of the wild raiders who drove hundreds of native Tartars into the cave and killed them by smoke and fire. Under the Čatyr-Dag top the ruins of an old Greek Temple called Panagia were found which belonged to the sacred places of ancient nations.

The Emine-Bojir-Chasar System

The cave lies at the northern margin of the Lower plateau. The entrance is formed by a 20 m deep tumbling down chasm which passes into a stepwise descending extensive dome and continues by a small window situated approximately 15 m above the bottom into the old known parts. Nearly all the galleries formed at various levels lead to the nearby erosive incision of the Bijuk-Jankoj Dell and to the centre of the massif inthe SW direction. The same orientation has been encountered in many other localities of the massif, but similarly as in the Emine-Bojir-Chasar system their palaeographic and physiographic explanation is unknown. The whole system arose as the result of a surface stream absorption. The extinction of some feeding sources caused the impairment of the uniform outflow of the suberranean waters and brought about an accumulation of the sintered and weathered sediments. Thus the cave was divided into a row of isolated galleries. In the whole system there are many stalagmites and stalactites broken loose and cracked and whole large-sized columns tumbled down (–6 m dia., 6-20 m high) which are often covered by gravel-clay layers resulting from earthquakes which frequently influenced changes in hydrologic regimes observed in number of other Crimea caves.

The Emine-Bojir-Chasar-Nižnyj.

This part of cave was discovered in 1970 and sealed by a concrete stopper. The entrance is formed by a small hole at the bottom of the entry dome of the system and passes over a short meander to a 10-m deep shaft connected with another chasm (12 m deep). A very narrow bend meander «Molnija» continues from the botton of this chasm and leads directly into a 40-m deep chasm. A short airy traverse situated approximately in one half of the shaft leads to a rocky gallery which continues to the middle storeys and to the extensive «Dome of Crystals». The columns of dripstones were so thick-set even in that dome that it was necessary to break through them holes to make further exploring possible. Very thick-set secondary decoration, mostly covered with numerous crystal forms of calcite and helictites is to be found in the middle storeys and especially in the «Dome of Crystals». Rich aggregates of calcite crystals of unusual length and abundance cover almost all the dripstone forms. In the lowest part of the «Dome of Crystals» is a small chasm (–15 m) leading to the «Dome of Ponors» with a thick layer of clayish filings. The cave continues by a tiny window under the roof of the dome through the gallery of «SinterLakes» extending for several hundred of meters where very thick-set dripstone forms and tufts of crystals can be seen again. The gallery widens and leads to the largest dome «Nocturno» (80 m long and 30 m high) where the richest crystal forms can be encountered. Long needle-like and stalky calcite crystals cover every-thing –the walls as well as the floor. Two galleries are leading from the «Nocturno»– the «Gallery of Freedom» and the «Milky Gallery» (500 m long) ending in the «Hall of Red Poppies». In this corridor the crystal druses are of unusual bouquet-like shapes resembling giant chrysanthemums. In the gallery of «Red Poppies» a window was discovered which led to the higher situated storeys ending in the dome «Twenty Years of the Simferopol Speleologic Section» with helictites of unusual length (up to 80 cm) and numerous crystal forms protruding from a lakelet (8 m dia.).

About the genesis of sphalerite stalactites from Silesian-Cracow Zn-Pb mine district.

Paolo Forti (1), Jacek Motyka (2), Marek Szuwarzynsky (3)
(1) Instituto Italiano di Speleologia
(2) Accademia delle Scienze di Cracovia
(3) Miniera di Trzebionka

RESUM

A l'interior de la Mina de Trzebionka es varen trobar estalactites d'esfalerita, dins de petites cavitats càrstiques. La forma d'aquestes estalactites suggereix un desenvolupament en condicions vadoses, inclús si durant el seu creixement no varen poder romandre per sobre del nivell freàtic.

En el present comunicat i partint de la descripció d'aquests espeleotemes singulars de les mines del districte de Silèsis-Cracòvia, s'ha formulat una teoria que justifica la presència de condicions vadoses molt per sota del nivell freàtic.

RESUMEN

En el interior de la mina de Trzebionka se encontraron estalacticas de esfalerita dentro de pequeñas cavidades kársticas: la forma de estas estalacticas sugiere un desarrollo en condiciones vadosas incluso si durante su crecimiento no pudieron estar por encima del nivel freático.

En el presente comunicado, partiendo de la descripción de estos espeleotemas fuera de lo corriente y de las condiciones hidrogeológicas actuales dentro de las minas del distrito de Silesia-Cracovia, se ha sacado una teoría que justifica la presencia de condiciones vadosas muy por debajo del nivel freático.

SUMMARY

Inside the Trzebionka mine stalactites and stalagmites of sphalerite were found inside small karst cavities: the shape of these stalactites suggest a development in vadose conditions, even if during their growth they cannot be above the water table.

In he present paper starting from the description of these unusual speleothems and from the actual hydrological conditions inside the mines of the Silesian-Cracow district, a genetical theory is put forth which justifies the presence of vadose conditions far below the watertable.

Due to théer genesis and development, these spharerite formations have to be considered true cave minerals.

Introduction

Sulphides speleothems were reported from Zn-Pb ore deposits in carbonate rocks since the beginning of this century (BECK, 1901).

At the present galena, sphalerite and marcasite stalactites and flowstones are known from Eastern Alps (DI COLBERTALDO & FERUGLIO, 1963; PERNA, 1972), from Mississippi Valley-type ore districts in the U.S.A. (MC KNIGHT & FISCHER, 1970), from Northern Africa(SUPERCHI 1970) and lastly from the Cracow-Silesian ore district (SOBCZYNSKY & SZUWARZYNSKY, 1975).

Till now these formations have not been considered at all as secondary cave minerals (HILL & FORTI, 1986), but the detailed analysis of the sphalerite speleothems found in the Trzebionka mine in the Cracow-Silesian mine district (see fig. 1) allow to state that they are true cave formations, developed in vadose conditions inside small karst cavities.

In the present paper starting from the description of these unusual speleothems and from the actual hydrological conditions inside the mines of the Silesian-Cracow district, a genetical theory is put forth which justifies the existence of vadose conditions far below the watertable.

The Speleothems

The Silesian-Cracow Zn-Pb mining district is one of the greatest in the world and is situated on the southern edge of the epi-Variscian platform in the proximity of the Carpathian orogen. Ore bodies occur mostly in the Middle Triassic sediments. They closely resemble Mississippi valley-type mineralizations (BOGACZ ET al., 1970; DZULINSKI & SASS-GUSTKIEWICZ, 1980).

In post-Jurassic ages only small supergenic ore concentrations are developed (BOGACZ et al. 1973; PANEK & SZUWARZYNSKI, 1979).

The speleothems are buidt up by sphalerite or marcasite often accompanied by galena. Geochemical analyses carried out on the formations in the Trzebionka mine (MANECKI et al., 1984) fixed their origin in the Tertiary:

The speleothems, beside the difference in chemical composition, can be divided in two different cathegories with respect to their shape and crystalline structure:

1. The speleothems with very small crystal structure, completely composed by sulfides: these are common in all the mine district, from 60 to 250m below the surface

2. Sphalerite speleothems, with a large crystalline structure and inside layers of calcium carbonate (mainly calcite, but also aragonite).

These formations have been found only in the Trzebionka mine from 200 to 250 m below the surface.

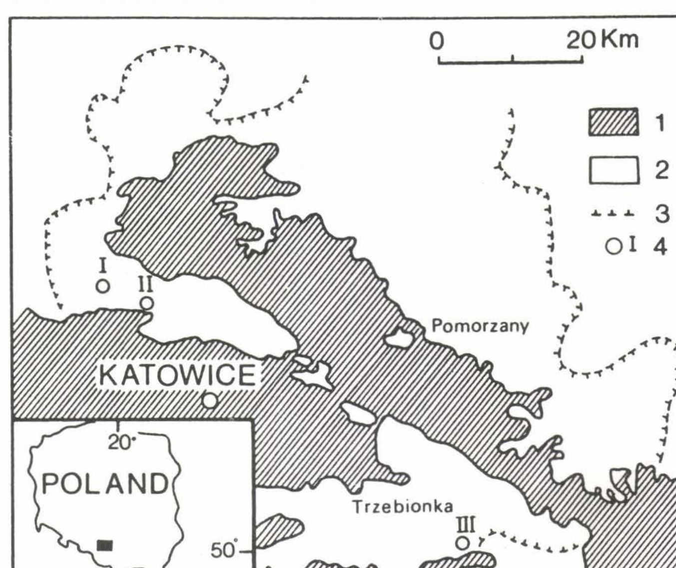

Fig. 1 Geological sceth of the Silesian-Cracow Zn-Pb mine distric: 1. Carboniferous; 2. Trias; 3. boundary of the district; 4. occurence of sulphide speleothems

The shape of the first type of formations consist normally of anthodites (similar to the normal aragonitic ones) up to 17 mm long and 3-4 mm thick in which the sulphides acycular crystals (commonly marcasite but also sphalerite and rarely galena) are very thin and elonged. Bothryoidal stalactites and coralloids are also known. The growing mechanisms for these formations seems to be due to the seeping mineralized fluids inside the voids opened by karst processes in the horst rock.

They are surely phreatic formations and due to the dimensions of the voids in which are developped can't be considered speleothems or cave minerals; moreover, their genesis seems to be equal to that of he other known similar formations found in the other parts of the world.

The second type of concretions, found only in the Trzebionka mine, is more interesting because their shapes strongly suggest vadose, and therefore karst, origin.

They were found normally in small bell shaped cavities at the contact between pelitc dolomite (the ceiling and the walls of the cave) and ore bearing dolomite (the cave floor) (see fig. 2).

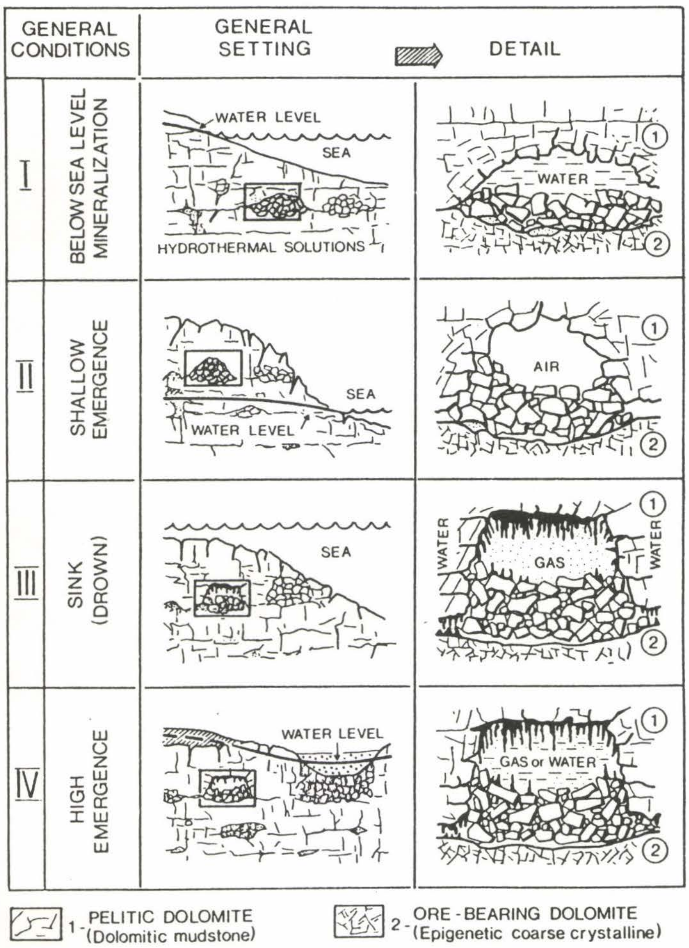

Fig. 2 Genetical steps for the karst cavities and the sphalerite speleothems inside the Trzebionka mine: explanation in text.

These caves had an hydrothermal genesis during the period of the deposition of the ore bodies, with the formation of collapse breccias and karst tubes along joints, but the major part of their development followed the ore formation (DZULINSKI & KUBICZ, 1971; DZULINSKI & SASS GUSTKIEWICZ, 1980). Therefore the stalactites and the other sphalerite formations were generated by remobilization processes.

These speleothems were described in detail by SOBCZYNSKI and SZUWARZYNSKI (1975) and are common in the largest karst cavities (up to 6 m long, 3 m wide, 1 m high) 200-250 m below the surface. The stalactites and the soda straws may reach a length of over 65 mm with an internal (feeding) hole of about 5-6 mm. In some cases also deflected stalactites (helictites) with a capillar of 1 mm or less have been noticed.

The internal structure of the stalactites consists of some layers, up to 1-2 mm thick, of ligth brown sphalerite whose crystals are elonged perpendicularly to the surface of the . In between the sphalerite layers often there are very thin films of calcite or, more rarely, of aragonite: these films sometimes show an internal layered structure. Larger calcite crystals normally cover the walls of the internal feeding hole.

The floor of the cavities is normally covered by a sphalerite flowstone 10-15 mm thick with inside fragments of brocken stalactites.

Sphalerite stalagmites are rarer and always they have been found just under stalactites. They may reach an high of over 40 mm and their internal shape is coherent with that of the upper speleothems consisting of large layers of sphalerite sometimes alternated with thin films of calcite.

In the same area of the Trzebionka mine in which the second type of sphalerite speleothems have been observed, there are also smithsonite, hydrozincite, hemimorfite and barite spleothems, which have been never found in the other places of the Silesian-Cracow mine district, where the first type of sulphides formations can be observed.

Discussion

All the characteristic of the sphalerite speleothems in the Trzebionka mine strongly suggest a vadose genesis for them: the fact to be due to remobilization processes; the shape of the stalactites and of the soda straws; the presence of stalagmites just under the stalactites; the carbonate films in between the sphalerite layers; the presence in the same area of the mine and restricted to it of minerals like smithsonite, hemimorfite and hydrozincite forming speleothems surely of vadose origin.

But these evidencies hit with the fact that the karst cavities were far below the sea level during the development of the speleothems.

In order to solve the problem of the genesis of the sphalerite speleothems of the Trzebionka mine it was necessary to demonstrate the possibility that gas filled voids may exist inside the carbonate formations of the Trzeblionka mine also far below the water table.

The genetical steps we suggest are explained in the sceth in fig. 2 and can be synthetized as:

I. During the Tertiary the uplift of thermal mineralized waters caused the main ore formations and the beginning of the karst processes in phreatic conditions, which essentially lead to the widening of joints in between pelitic and ore bearing dolomite with the genesis of small voids with collapse breccia on the floor.

II. At the end of the mineralization processes a shallow emergence took place so that at least part of the karst cavities may develop in vadose conditions reaching larger dimensions and becoming bell shaped, essentially due to breakdown phenomena.

III. When a new sink restored general phreatic conditions, the bell shaped voids became gas traps, due to their shape and the lithologic properties of the pelitic dolomites, so allowing the presence of small vadose areas deep inside the carbonate formations. In this period, a partial remobilization of the ore deposits lead to mineralized fluids, which, reaching the karst cavities and dripping inside them, gave rise to the sphalerite stalactites and stalagmites.

During the deposition process the chemical behaviour of the dripping waters changed several times thus allowing the deposition of the calcite (or aragonite) films in between the sphalerite layers

IV. At the end of the speleothems deposition the karst cavities become fossils and in most cases were flooded by «normal» waters, but karst processes cannot go on due to the sphalerite flowstones and crusts which preserved the most part of the cavities from corrosion, saving them till nowaday.

To prove the validity of the just outlined genetical schema was necessary to find gas traps evidencies at the depth in which the sphalerite speleothems have been found in the Trzebionka mine.

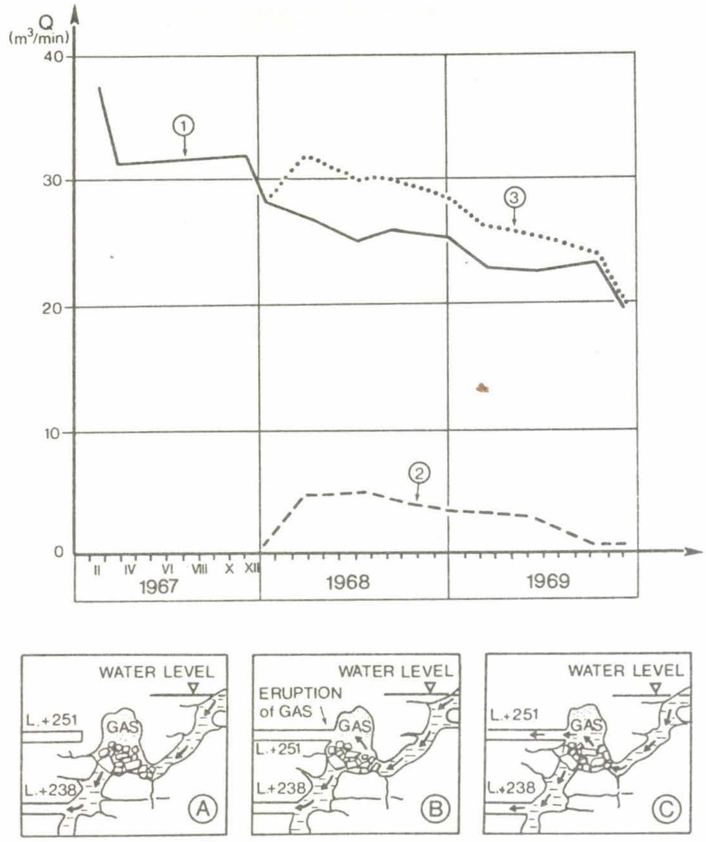

Fig. 3 Olkusz mine: upper: water flow rates from level 238 (1); level 251 (2); and total flow (3). Lower: A. the situation before the digging of the gallery at 251 level; B. the eruption of gas when the 251 gallery came in contact with the karst cavity; C. the stabilized situation with water spring both at 251 and 238 levels

A first indirect proof of it was acheived in the mine of Olkusz (see fig. 3), where in 1967 at the level 238 a.s.l. a gallery reached a karst cavity about 0.5 m in diameter from which a water inlet of 37 cubic meters/min. was measured. In 1968 during the digging of a gallery at the level 251 a.s.l. a breccia was intersected from which an extremely large amount of gas came out and in the mean time the water flow rate at the 238 level went down. After few hours from the breccia begun to flow water at a rate of about 0.7 cubic meter/min. The interpretation of the phenomenon can be easily given as in the lower part of fig.3, thus confirming the presence of gas traps inside the ore bodies of the region.

But a definitive evidence was obtained in the Trzebionka mine during 1983 where drilling a borehole just in the area of the sphalerite stalactites a cave was intersected from which a large amount of a gas with a noticeable CO_2 content (up to 20 %) became to come out. As in the case of the Olkusz mine, after few hours of gas eruption, water sprang flowing at 0.3 cubic meters/min.

Going on with the mining activities the cave was reached and inside it some small sphalerite speleothems were found.

Conclusion

The analyses of the growing steps of the karst cavities inside the Trzebionka mine and of the related peculiar sphalerite stalactites and stalagmites allow to state that these speleothems developed via dripping solution in vadose conditions inside cavities whose dimensions are sufficient to call them caves. Moreover, the presence of the layers of calcite and/or aragonite in both stalactites and stalamites indicates that, during the spleothems growth, «normal depositional» conditions have been, time by time, acheived by the dripping waters.

Lastly, this is the first time in which all the conditions are fitted in order to consider the sphalerite speleothems as true cave minerals

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Humic substances in speleothem matrix – Paleoclimatic significance

Stein-Erik Lauritzen[1], Derek C. Ford[2] and Henry P. Schwarcz[3]
[1] *Department of Chemistry, University of Oslo.*
[2] *Department of Geography, McMaster University, Hamilton, Ontario, Canada*
[3] *Department of Geology, McMaster University, Hamilton, Ontario, Canada.*

RESUM

Sovint els espeleotemes tenen unes franges que van del marró al negre, degudes a la contaminació per matèria orgànica, a l'interior de la matriu de calcita. De diverses mostres pulveritzades es van extreure els àcids húmics i flúvics, mitjançant hidròxid sòdic i àcid clorhídric. Les mostres purificades presentaven una composició similar i espectres d'infrarojos idèntics a les preparacions húmiques autèntiques i als valors de la bibliografia. La degradació oxidativa, la permetilació i el GLC van produir petites quantitats de derivats de l'àcid p-hidroxibenzoic, vanílic i sirúrgic. Totes aquestes propietats ens demostren que el color marró d'alguns espeleotemes és degut als àcids húmic i flúvic, que assoleixen la cavitat, procedents dels sòls superficials, per percolació de l'aigua. Els components húmics són, per tant, mostres excepcionals dels sòls superficials i de l'edat dels espeleotemes. Això obre noves perspectives en l'estudi del paleoclima a partir de dades d'espeleotemes.

RESUMEN

A menudo los espeleotemas tienen unas vetas que van del marrón al negro, debidas a la contaminación por materia orgánica dentro de la matriz de calcita. De muestras trituradas fueron extraídos los ácidos húmicos y fluvicos usando hidróxido sódico y ácido clorhídrico. Las muestras purificadas mostraban una composición elemental similar y espectros de infrarrojos como las auténticas preparaciones húmicas y valores de la bibliografía. La degradación oxidativa, «permethylation» y GLC produjeron pequeñas cantidades de derivados del ácido p-hidroxibenzoico, vanílico y sirúrgico. Todas estas propiedades demuestran que el color marrón de ciertos espeleotemas es debido a los verdaderos ácidos húmico y flúvico que llegan alrededor de la cavidad de los suelos superficiales, por la percolación del agua. Los componentes húmicos son por esto, muestras únicas de los suelos superficiales y de la edad de los espeleotemas. Esto abre un nuevo potencial para el paleoclima a partir de datos de espeleotemas.

SUMMARY

Speleothems often show brown to black banding due to contamination of organic matter within the calcite matrix. Humic and fulvic acids were extracted from crushed samples using sodium hydroxide and hydrochloric acid. Purified samples exhibited similar elemental composition and infrared spectra as authentic humic preparations and literature values. Oxidative degradation, permethylation and GLC separation yielded small amounts of p-hidroxybenzoic, vanillic and syringic acid derivatives. All these properties prove that the brown colour of certain speleothems is due to true humic and fulvic acids brought into the cave environment from surficial soils by the percolation water. The humic compounds are therefore unique samples of the surface soils at the time of speleothem deposition. This opens new potential for paleoclimatic inference from speleothem dates.

Introduction

Speleothems have proved to be important chronostratigraphic markers with implications for geomorphologi, climatology, paleontology and archeology. The main reason for this is, that they possess an unique dating potential through the last 350 ka by the U-series techniques. All additional information that can be related to speleothem deposits is therefore potentially important. This report presents such information from organic matter enclosed within the calcite matrix (Lauritzen 1983).

4.1 Organic matter in speleothem.

Brown colour have long been attributed to impurities within the calcite matrix. Analysis revealed only slight correlation between colour and iron content (Vytras 1973, 1975, Gascoyne 1977). Brown samples also foam upon acid digestion and produce low chemical yields in U-series dating procedures (Gascoyne 1979). These effects were subscribed to possible humic contamination (Bakalowicz, 1983)

4.2 Samples

Five samples of speleothem were selected from different climatic regions, ranging from arctic (Northwest Territories) to the tropics (Puerto Rico), Table I. They had previously been dated by U-series methods, and were selected for their brown to blackish-brown colours. The northern samples displayed the darkest colours.

TABLE I

Speleothem samples, origin, humic content and radiometric age.

Sample	Province	Colour	Min. detr[1].	HA[1]	FA[1]	age, ka
EC	Alberta	Dark Brown	7 800	44.1	196	> 720
JC	S.Dakota	Dark Brown	235	(30.1)	(15.9)	> 350
69001	Nahanni	Black-brown	1 826	287	82	> 350
720305	Nahanni	Dark Brown	50	(0.1)	-	-
S2	V. Wiginia	Brown	31 750	105	1.707	-
PR1	Puerto Rico	Light Brown	33 600	< 2	825	-

[1] Determined gravimetrically, all values in ppm. Numbers in parenthesis uncorrected for ash content.

4.3 Analytical techniques.

Crushed samples were digested and fractionated according to the flow-chart in figure 1. Alternatively, the acid extracts were desalted through dialysis against water through cellophane membranes (cutoff at MW = 12 000), yielding fulvic acids (FA) for combustion and spectroscopic analysis directly. Yields were determined gravimetrically, although an UV-based technique may allow detailed stratigraphic work on the micro-escale in the future.

4.4 Results

The preparative amounts of HA and FA isolated, had a relatively high ash content, probably from Fe and Al hydroxydes. This could be reduced through repeated precipitation steps, but with considerable losses of material. Elemental compositions are

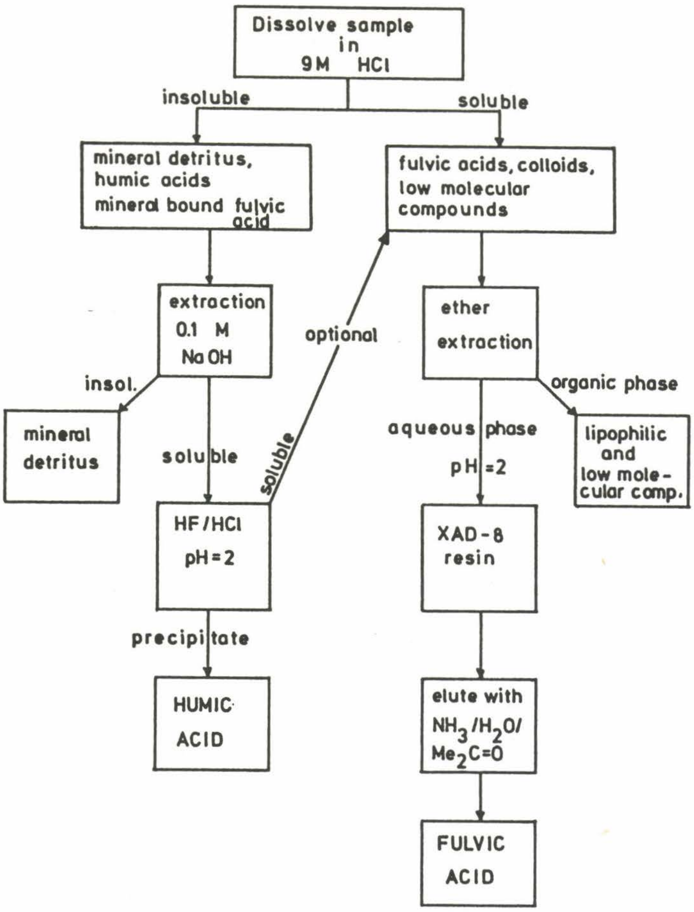

Figure 1. Flowchart for the extraction and fractionation of organic matter in speleothems.

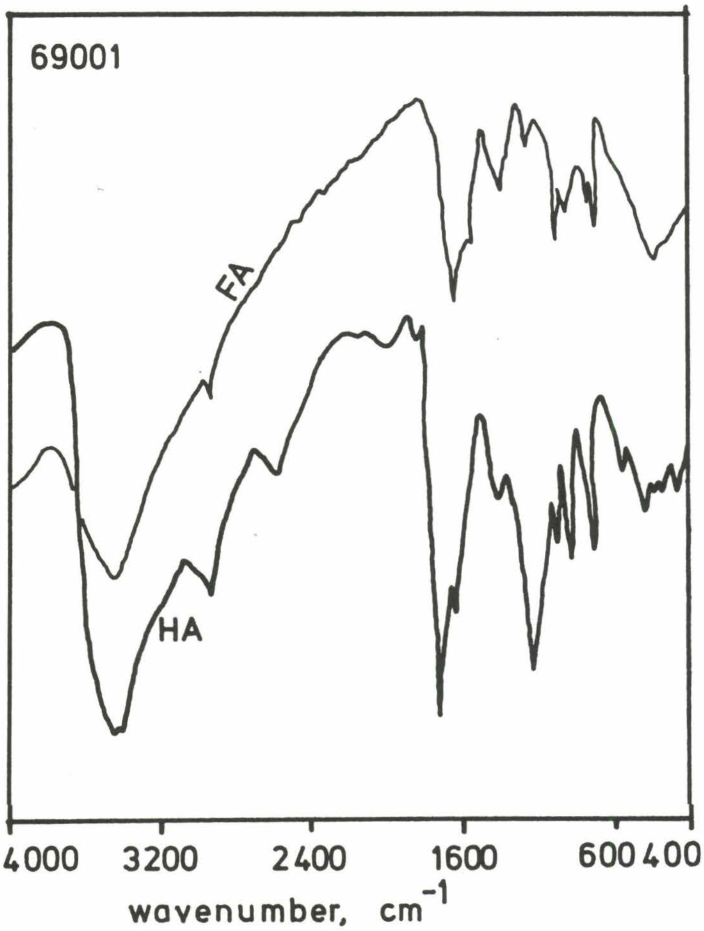

Figure 2. Infrared spectra of humic and fulvic acid extracted from speleothem sample 69001. KBr tablests.

not absolute, only comparable with respect to C/N and C/S ratios. These were in accordance with published ratios for soil HA and FA (Stevenson 1982, Kononova 1966). Infrared spectra were taken in KBr tablets on a Nicolet FT-IR instrument. Two such spectra are shown in Figure 2.

Chemical behaviour, elemental ratios and infrared characteristics all accord well with literature values for soil derived HA and Fa (Stevenson 1982). Similar analyses of authentic preparations of HA and FA from campus soil, West Virginia chernozem and arctic bog humus gave very similar results. We therefore take this as sufficient proofs for that the preparations are true HA and FA, indistinguishable from soil derived matter.

Moreover, there were strong, positive correlations between both HA and FA with inorganic detrital content, even for the very wide geographical sample distribution. Such association may reflect that HA and FA are generally transported in solid phase, adsorbed onto detrital components, like vadose silt.

Attempts of permethylation (Me_2 SO_4/NaOH), followed by oxidative degradation ($KMnO_4$/NaOH) and GLC analysis did produce volatiles in some abundance, but only minor amounts could be ascribed to derivatives of hydroxybenzoic acids. Such derivatives are believed to characterise HA and FA from different soil and vegetation types. A reason for this is the unusually small amounts of available starting material (0.001 of the amount reported in literature), combined with generally low yields reported for this procedure (Stevenson 1982).

One HA and Fa samples were combusted with CuO *in vacuo* and analysed for carbon isotopes. The two FA's were rather similar (n–25 ‰ $\delta 0^{13}$C PDB), whilst the HA were isotopically lighter (–28.4 ‰). Such trends may give important information, but lack of material was again a limiting factor.

Ether extracts of the acid solution (Figure 1), yielded considerable amounts of volatiles, as analysed by GLC, Figure

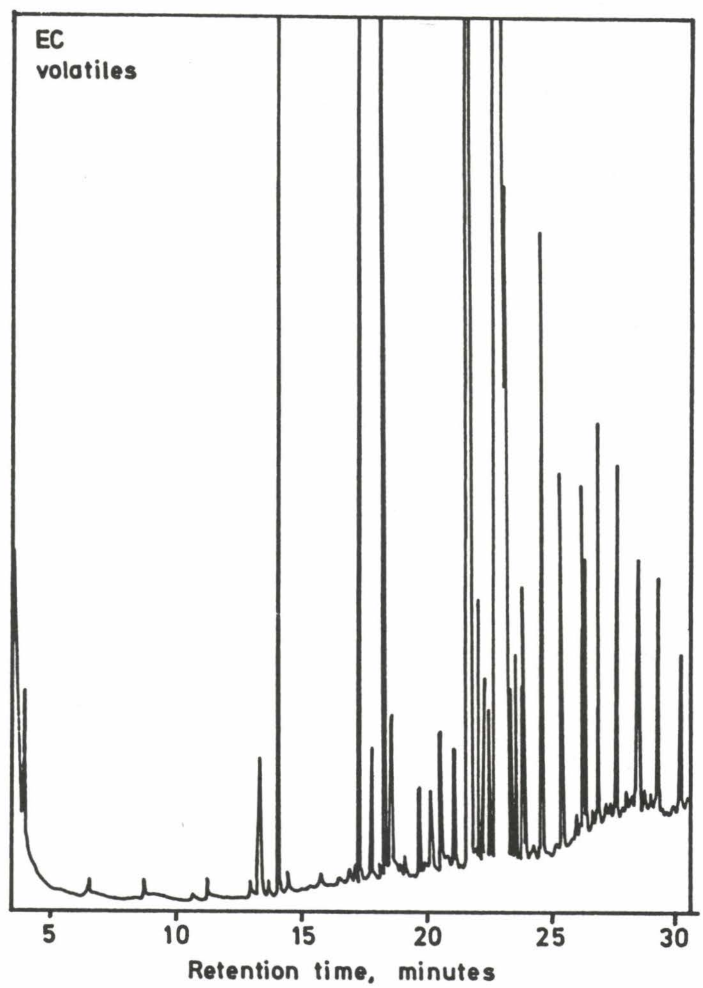

Figure 3. Volatiles from speleothem EC, methylene chloride extract and GLC analysis.

3. Possible contaminants, such as stopcok grease, has been excluded, and further identification (GLC/MS) is in progress. Such volatiles are surprising, but may become important for fingerprinting in speleothem stratigraphy.

Conclusions

Coloured speleothems may contain up to 2000 ppm organics, positively identified as HA and Fa, chemically and spectroscopically indistinguishable from soil derived matter. Considerable research potential still remain with respect to the composition and distribution of these compounds, particularly when the analytical techniques become refined for micro-scale work.

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Estudi d'un niu amb oòlits i pisòlits, de la Cueva de la Lastrilla, Cantàbria.

Lluís Auroux

Grup Espeleològic Congrés, Barcelona

RESUM

Estudi de les característiques físiques d'un niu i del seu contingut de oòlits i pisòlits. S'analitzen detingudament els aspectes morfològics i físics dels exemplars, amb descripció del niu, repartiment del material, granulometria, pes i nombre de peces per fracció, nuclis, relació entre les fraccions, densitats, textures i origen dels nuclis.

RESUMEN

Estudio de las características físicas de un nido y de su contenido de oolitos y pisólitos. Se analizan detenidamente los aspectos morfológicos y físicos de los ejemplares, con descripción del nido, reparto del material, granulometria, peso y número de piezas por fracción, núcleos, relación entre fracciones, densidades, texturas i origen de los núcleos.

RESUME

Etude des caracteristiques physiques d'un nid et de son contenu d'oolites et de pisolites. On réalise l'analysis des aspects morphologiques et physiques des exemplaires, avec description du nid, distribution du matériel, granulométrie, poids et nombre des pièces par rapport aux diamètres, noyaux, rélation entre les fractions, densités, textures et origine des noyaux.

Situació del niu: Dins la Cueva de la Lastrilla, cavitat de 6.400 m de recorregut i 106 de desnivell ascendent, desenvolupada en un sinclinal de calcàries del Aptia-Albia, que es troba al Barrio de Sangazo de Samano, a prop de Castro-Urdiales, Cantàbria.

El niu està situat sobre una terrassa formada per fina sorra que el riu que circula per la cavitat ha sedimentat a un costat de la galeria. La zona motiu del treball, es troba recoberta per una capa de concreció d'uns 40 m^2.

Niu: Depressió en forma d'embut, oberta pel goteig que cau des de 5m d'alçada sobre la capa de concreció. Boca regularment ovalada, amb eixos de 100 × 120 mm i fondària 55 mm. Totalment ple per oòlits i pisòlits, inclús sobresortint del nivell del sòl. Els voltans del niu son grups estalagmítics i una gran quantitat de oòlits i pisòlits que recobreixen una àmplia zona d'un metre de diàmetre amb gruixos de perles que arriben als 50 mm en alguns llocs.

Estratificació dins del niu: El repartiment és per capes en relació al diàmetre de les perles - Fig 1-. Al fons les més petites junt amb sorra molt fina. Cap a la superfície, van augmentant de diàmetre.

Granulometria: la distribució és molt regular entre les fraccions més petites i 1 mm, així com entre 3,2 i 7 mm ⊥ , aquests ultims

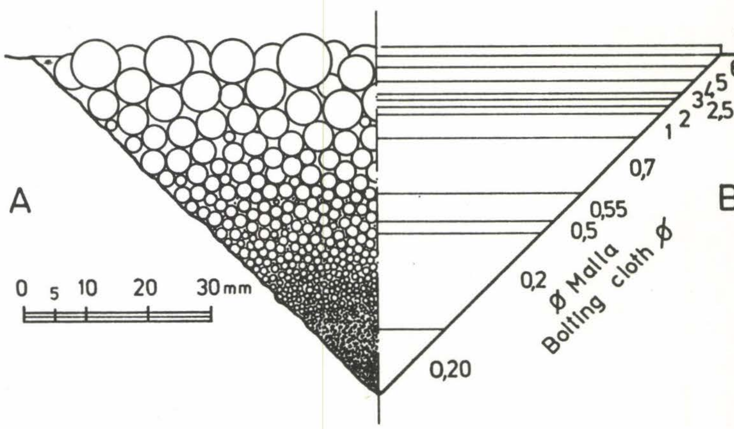

Fig. 1. Distribució de les fraccions dins el niu.
A– Repartiment físic.
B– Repartiment proporcional al volum de cada fracció.

en funció quasi lineal. El pes del reompliment sec és de 249,87g. (MASRIERA, A., ULLASTRE, J. 1975.- AUROUX, Ll. 1978.).- Fig.2 -. S'observa una acusada manca de material entre les fraccions

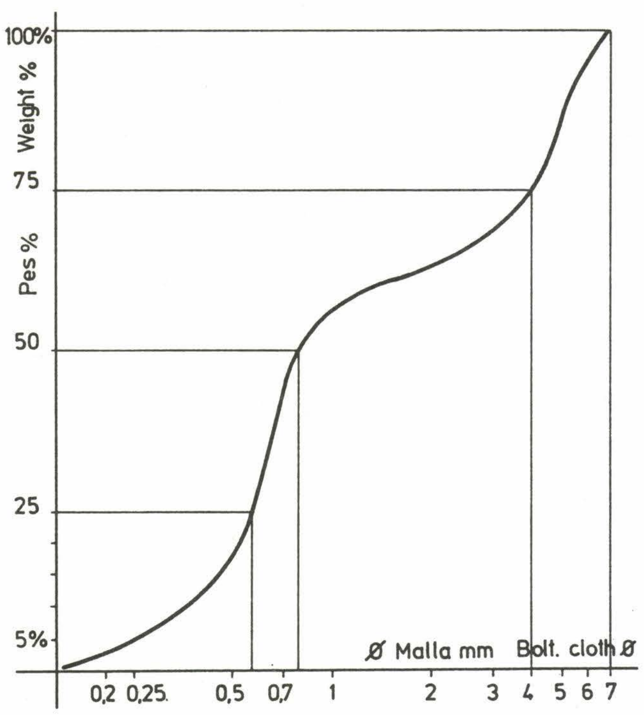

Fig. 2. Distribució granulomètrica acumulativa del reompliment d'oòlits i pisòlits del niu.

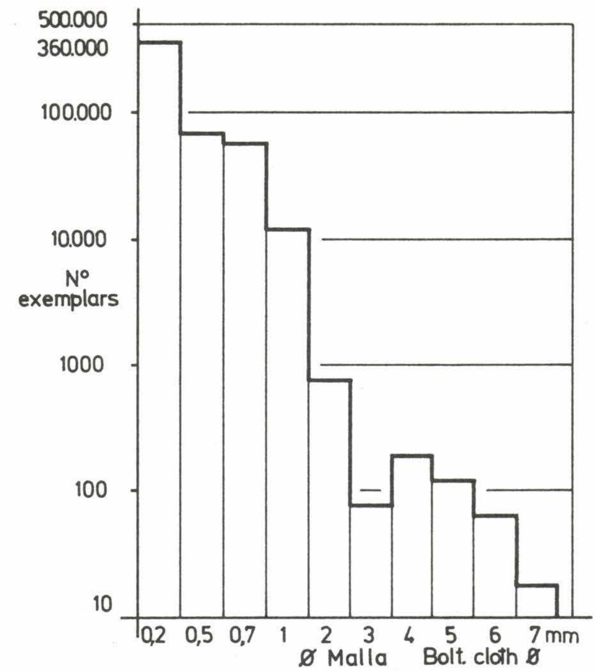

Fig. 3. Gràfic del número de exemplars per cada fracció

I i 3,2. El 50 % del pes correspon al ⊥ 0,9. El 25 % al 0,55. El 75 % al 0,4.

Exemplar d'eix màxim, 12x 8,5 x 4,6 mm, pes 0,60 g, aplanat. irregular, de textura pulida mat.

Exemplar de pes màxim, 0,73 g, eixos 9,5 × 8,7 × 7,4 mm, subesfèric, pulit mat.

Nombre d'exemplars: En total n'hi han 495.000 entre oòlits i pisòlits –Fig. 3–. Les fraccions 4, 5, 6 i 7 s'han comptat tots els pisòlits. Per les fraccions inferiors, s'ha calculat així: Es mesura el volum parcial de cada fracció i es compten els exemplars d'un volum considerat com a patró, variable segons les fraccions, així per la malla de ∅ 0,5 el volum comptat es de 0,5 cc; per la de 0,65 es 1 cc; per la de 1,00 son 4 cc i per 2 i 3 es compten 3 cc. En tots els casos s'ha de procurar que la densitat de compactació es mantigui constant en omplir el volum patró. La tolerància de calcul pot ser estimada en 10 % dins de la fracció 0,2, doncs el càlcul en aquest cas ha estat fet partint d'una esfera de ∅ 0,36 mm i que correspon a la mitjana de volum entre les dues fraccions consecutives 0,2 i 0,5 de malla. En fraccions molt petites el recompte d'oòlits i la mesura del volum patró, possiblement resultaria amb un error superior al del procés utilitzat.

Pes d'un exemplar de cada fracció: Conegut el nombre de oòlits-pisòlits per fracció i el pes corresponent, es calculen els pesos unitaris. Ha resultat una funció regular –Fig. 4–, el que indica que les densitat de reompliment i les formes geomètriques de les perles són molt constans. Taula de pesos per fracció':

Malla 0,2 pes en g 0,000067, Malla 3 pes en g 0,057, Malla 0,55 pes en g 0,00028, Malla 4 pes en g 0,11, Malla 0,65 pes en g 0,0010, Malla 5 pes en g 0,24, Malla 1,00 pes en g 0,0032 Malla 6 pes en g 0,36, Malla 2,00 pes en g 0,014, Malla 7 pes en g 0,61

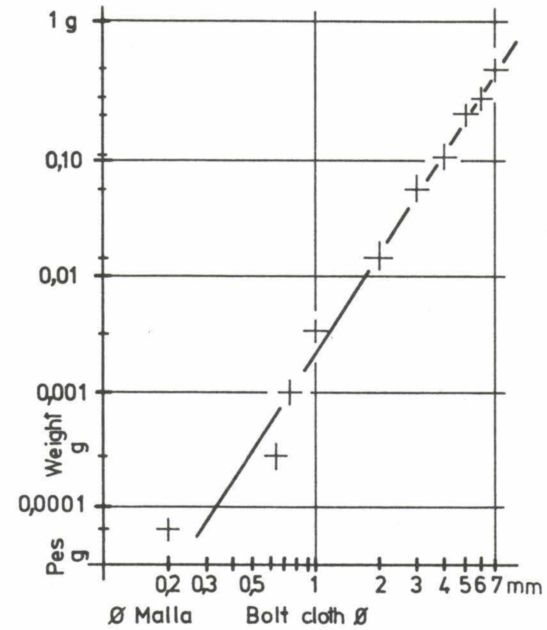

Fig. 4. Gràfic corresponent al pes d'un oòlit o pisòlit dins de cada fracció.

Nuclis: Es interesant conéixer quin tipus de nuclis originen els oòlits, així com si existeix relació entre la fracció i la mida del nucli. Per obtenir els nuclis intactes, es dissolen els oòlits en ClH, el problema està en el cas de què els nuclis siguin calcaris, però abans ja s'havien fet proves i sols en la fracció 0,20 n'hi havien d'aquest tipus; en les altres malles, tots els nuclis han sigut reconeguts. Els resultats són:

Fracció	Eixos (en mm) dels nuclis		% de nuclis		Altres	N.º de peçes atacades
	Màxim	Mínim	Cristall silícic	Aglomerat silícic		
0,20	0,50	0,10	60	30	10	60
0,50	0,70	0,20	66	34	–	50
0,70	1,10	0,30	40	58	2	54
1,00	1,35	0,30	18	72	10	50
0.1,8 ÷ 2,3 de fracció 1,00	1,30	0,30	28	48	24	25

	Fracció					
	0,20	0,50	1,00	2,00	4,00	7,00
Densitat aparent	2,56	2,53	,2,50	2,50	2,53	2,43
Densitat real	2,60	2,59	2,58	2,54	2,57	2,47

Les mides dels nuclis es mantenen iguals a la fracció 1,00 fins a perles amb eixos de 5 mm, però a partir d'aquí, sobtadament passen a tenir nuclis de 3 i 4 mm ∅. Això indica que els oòlits van creixent però, ja dins la categoria de pisòlits, cap ha crescut més de la fracció 4, o sigui, eixos de 5 mm.

Un exemplar de la fracció 7, té el nucli format per un aglomerat de oòlits de diàmetres compresos entre 0,15 i 1,20 mm.

Correspondència entre mida del nucli i mida exterior:

Dins de cada fracció, els nuclis són de mides diverses, si bé la proporció és semblant; 1:5 en la fracció 0,20 i 1: 3,5 en les fraccions 0,50 i 1,00. A mida que l'exemplar és més gran, en proporció el nucli també ho és.

De la fracció 1,00 es trien 25 perles amb els eixos màxims compresos entre 1,80 i 2,30 mm per tal de conèixer millor la frontera dels 2 mm, on acaben els oòlits i comencen els pisòlits. Com a eixos dels nuclis (veure el quadrant anterior), es mantenen els valors de la fracció 1,00 que és d'on s'han escollit, pero varia la proporció dels materials del nuclis, el que indica que aquest repartiment pot ésser variable i a més no guarda relació en cap fracció.

Origen dels nuclis:

Per tal de saber la procedència dels nuclis, es comparen amb la sorra sedimentada pels voltans de la terrassa, comprobant que tenen les mateixes característiques de composició, tant en granulometria com en textura dels grans. Per conèixer la procedència de la sorra, es recullen porcions de pedra de les parets i s'ataquen amb ClH. Observant els restes insolubles, es comproba que els cristalls silícics i d'altres compostos, són de la mateixa composició i fracció de la sorra (MASRIERA, A., ULLASTRE, J. 1975.– AUROUX, L1., 1978), per tant, es pot dir que la sedimentació és provinent de la dissolució de la roca mare.

Densitats: Es mesuren les densitats aparents de les fraccions més representatives amb balança hidrostàtica. En altres treballs ja es parla de densitats de pisòlits (ULLASTRE, J., MASRIERA, A. 1973.– AUROUX L1. 1982 I 1985) però en aquest cas s'ha treballat inclús amb oòlits, doncs no eren coneguts en aquest aspecte. La mesura s'ha fet per pesada conjunta de nombrosos exemplars, especialment en les fraccions més petites, per tant, els valors són la mitjana de totes les peces.

Els valors són molt constans, doncs sols varien un 5,3 % en les densitats aparents i un 5,2 % en les reals.

Infiltració: El volum de la forma geomètrica del niu és 180 cc i la suma dels volums parcials de les fraccions és 195 cc, per tant 15 cc de les fraccions més petites es troben intercalades en les altres de més diàmetre. La infiltració és del 8,33 %.

Morfologia dels oòlits:

La mida més petita de oòlits, correspon a eixos de 0,15 mm, si bé són molt escasos. Els eixos de 0,20 mm són ja nombrosos.

Les formes són esfèriques, alguns allargats però sempre molt regulars. Tant sols dos oòlits, de la fracció 0,20, s'han trobat soldats entre sí, tots els demés absolutament lliures.

Textures:

–Microaciculats. Es troben en totes les fraccions. N'hi ha de dos tipus; amb cristalls de cares llises i amb els cristalls recoberts de petits granets que a mida van creixent, transformen la textura en botrioidal.

–Botricoidals microaciculats. Es troben en totes les fraccions.

–Llisos. Es comencen a trobar a partir de la fracció 1,00 bé siguin mats o brillants. La majoria són mats. A partir de la fraccció 2,00 alguns pisòlits presenten empremtes alveolars d'abrasió.

Es troben textures intermitges de difícil separació, per exemple, els microaciculats es van recobrint de petits granets per les cares dels cristalls, tornant-se botricoidals, però aquesta evolució no es fa de sobte sinó a traves de molts estadis. Els microaciculats estan sotmesos a un procés de rodadura i per abrasió s'arrodoneixen els vèrtexs dels cristalls fins a tornar-se llisos, però també hi ha estadis intermitjos indefinits.

Evolució dels oòlits:

Les línies d'evolució dels oòlits es representen en la Fig. 5.

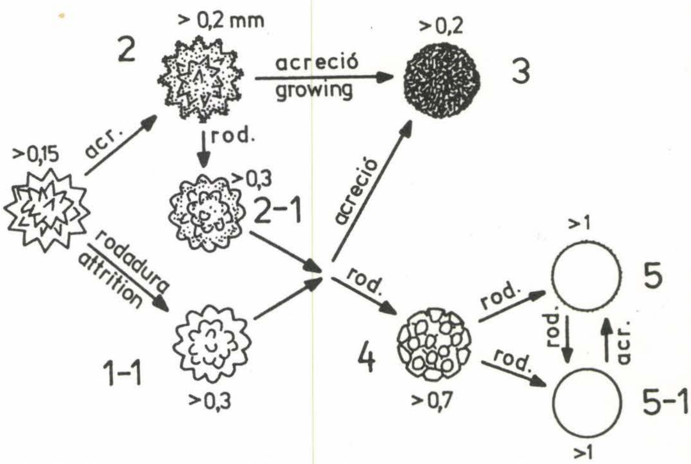

Fig. 5. Línia evolutiva dels oòlits en el niu.

1– Oòlits incipients, aspecte microaciculat.

1-1– Per rodadura es desgasten els vèrtex, però es mantenen intactes les concavitats.

2– Per acreció es recobreixen els cristalls de petits granets, que no arriben a modificar la textura microaciculada.

2-1– Per rodadura segueixen el mateix camí que 1-1, es desgasten les arestes i resten intactes les altres zones.

– Tan els 1-1 com els 2 i els 2-1, poden evolucionar cap a la forma botricoidal microaciculada. L'única transformació dubtosa és la de 1-1 cap a 3, si bé també és lògica.

4– Tant 1-1 com 2-1, en continuar la rodadura acaben perdent del tot els vèrtexs i resten esfèriques amb estries, netes o granuloses, segons provinguin de 1-1 o 2-1 respectivament.

5– En continuar el desgast, desapareixen les estries i l'oòlit adquireix una superfície pulida regular.

5-1– Si la rodadura és molt intensa, adquireixen la textura brillant, si bé pot tornar a la forma 5 en cas de què el creixement predomini sobre el desgast.

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CLIMA I MEDI AMBIENT SUBTERRANI
CLIMA Y MEDIO AMBIENTE SUBTERRANEO
CLIMATE AND SUBTERRANEAN ENVIRONMENT

10308

Air temperature investigations in Vass Imre cave, Jósvafó, Northeastern Hungary

Miklós Gádoros
Budapest, Hungary

RESUM

Des del 1963 s'han estat efectuant estimacions sistemàtiques de la temperatura de l'aire de la cova de Vass Imre.

La temperatura mitjana més enllà de la zona freda de l'entrada s'incrementava de manera constant. L'extensió de la línea recta que representa la temperatura mitjana a través de la zona freda, ens mostra la temperatura mitjana exterior de la cova, com si la zona freda no existís en absolut.

No podem considerar la temperatura mitjana de la cavitat com a dada fiable, doncs dependrà del lloc on es prengui el valor de la temperatura.

La sensibilitat dels termòmetres (0,01 °C) va permetre l'observació de la variació anual de temperatures també a l'interior de la cavitat, on la fluctuació absoluta fou inferior a 1 °C.

Es va observar també que les corbes de variació anual són semblants a la zona freda i a la zona interna de la cavitat.

RESUMEN

Desde 1963 se han venido efectuando mediciones sistemáticas de la temperatura del aire en la cueva Vass Imre.

*La temperatura media más allá de la zona fría de la entrada se incrementaba de modo constante. La extensión de la línea recta, representando la temperatura media a través de la zona fría, muestra la temperatura media exterior en la entrada de la cueva, como si la zona fría no existiera en absoluto.**

No consideramos la temperatura media de la cavidad como dato fiable debido a la dependencia del lugar de la temperatura media.

La sensibilidad de los termómetros (0.01° C), permitió la observación de la variación anual de temperaturas también en el interior de la cavidad, donde la fluctuación absoluta fué inferior a 1 °C.

Se encontró que las curvas de variación anual son similares en la zona fría y en la zona interior de la cavidad.

SUMMARY

Systematic air temperature measurements have been made in Vass Imre cave since 1963.

Mean temperature beyond the entrance cold zone was found to steadily increase. Extension of the straight line depicting mean temperature trough the cold zone shows outside mean temperature at the entrance of the cave, as if the cold zone did not exist at all.

Owing to the site dependence of the mean temperature, we do not consider «cave mean temperature» as reliable data.

Sensitivity of the thermometers /0.01 °C/ allowed observation of the annual variation of temperature also inside the cave where absolute range was lower than 1 °C. We found that the curves of annual variation are similar in the cold zone and in the interior of the cave.

Introduction

Systematic temperature measurements have been made in Vass Imre cave since 1963. Near the entrance, standard meteorological thermometers, occasionally supplemented with thermographs have been used and inside the cave Beckman thermometers with 0.01 °C calibration have been applied. The system of thermometers has been mounted on stands /Gádoros 1969/.

Annual mean temperature along the cave

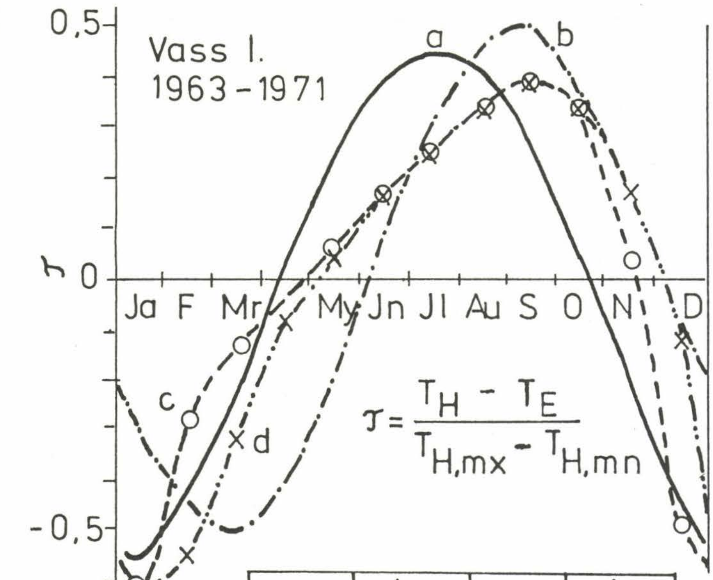
Annual mean temperature beyond the entrance cold zone was found to steadily increase. It is remarkable that extension of the straight line depicting mean temperature trough the cold zone shows outside mean temperature at the entrance of the cave, as if the cold zone did not exist at all.

In order to control the surprising results attained, we analyzed the data measured by Fodor, 1981, in Abaliget cave, Southern Hungary. The analysis gave identical results, with different absolute values, naturally /8.8 oC in Jósvafó and 10.4 °C in Abaliget/. The two temperature curves are presented in Figure 1.

It should be noted that owing to the the site dependence of the mean temperature, we do not consider «cave mean temperature» as reliable data. The value is also dependent on the known or studied lenght of the cawe, thus it is not an unambiguous climate parameter.

Annual variation of the temperature

Sensitivity of the thermometers allowed observation of the annual variation also inside the cave where absolute range vas lower than 1 °C. Moving into the interior of the cave, we found



	a	b	c	d
T_E	8,8	10,0	6,0	9,43
$T_{H,mx}$	19,5	14,7	8,4	9,58
$T_{H,mn}$	-4,7	5,1	2,3	9,20

Figure 1. Annual mean temperature of cave air.
T_a = annual mean temperature outside
T_o = theoretical mean temperature at the entrance
l = distance from the entrance in m
t = temperature in °C
/«Abaliget» From Fodor's, 1981, data/

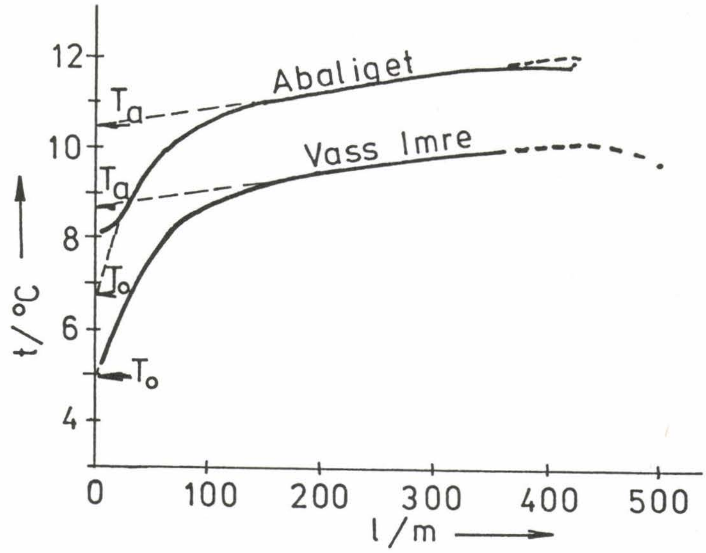


Figure 2. Annual variations
a = Jósvafö, Karst Research Stat., air
b = Jósvafö, Karst Research stat., soil at -2 m
c = Vass Imre cave, 25 m from entrance
d = Vass Imre cave, 200 m from entrance
τ = normalized value of temperature
T_E = annual mean temperature
$T_{H,mx}$ = maximal monthly mean temperature
$T_{H,mn}$ = minmal monthly mean temperature

that mean temperature increases, annual range decreases and minimun values appear at a later point of time. In spite of the substancial decrease in variance, on the other hand, the curves of annual variance are similar in the cold zone and in the interior of the cave, but significantly differ from the curve of outside annual temperature variation. For comparison, in Figure 2 we present in normalized form four curves showing outside temperature, soil temperature at 2 m level, cave air temperature 25 m and 200 m from the entrance. The marked similarity between the two cave curves can be well observed.

In our opinion, characteristic cave temperature variation, as well as the existence of the cold zone is mainly due to cave wind blowing outwards in summer and inwards in winter, generated by the difference between constant rock temperature and variable outside temperatures /chimney effect/.

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10130

Radon Concentrations in Some Italian Caves

Arrigo A. Cigna
ENEA –Dept. Env. Protection and Human Health
I-13040 SALUGGIA VC (Italy)

RESUM

Mitjançant dosímetres passius distribuïts al llarg d'una sèrie de coves, es van mesurar les concentracions de radó, en una investigació duta a terme els anys 1983-1984. Es tractava de debatre la seva distribució referida a la morfologia de les coves i la dosi mitjana efectiva avaluada.

Es va dur a terme una valoració del risc que significava la presència de radó, basada en els procediments més assequibles i corregida pel medi ambient de la cova.

Mentre que el risc per als espeleòlegs i visitant era mínim i, en general, despreciable, el personal encarregat de les coves turístiques podia ésser considerat, en alguns casos, sota la reglamentació inherent a una exposició ocupacional.

RESUMEN

Las concentraciones de Radon fueron medidas mediante dosímetros pasivos distribuidos a lo largo de cuevas en una investigación llevada a cabo en 1983 y 1984; se discute la distribución haciendo referencia a la morfología de las cuevas y la dosis equivalente promedio efectiva evaluada.

Se llevó a cabo una valoración de riesgo que significaba la presencia de Radón, basada sobre los factores más disponibles, corregida dado el medio ambiente de la cueva.

Mientras que el riesgo para espeleólogos y visitantes es muy pequeño y en general despreciable, el personal encargado de cuevas turísticas podría ser considerado en algunos casos bajo las reglas que conciernen a la exposición ocupacional.

SUMMARY

The Radon concentrations were measured by means of passive dosimeters distributed along the caves in a survey carried out in 1983 and 1984; the distribution is discussed with reference to the cave morphology and the average effective dose equivalents were evaluated.

A risk assessment due to the presence of Radon, base upon the best available factors corrected for the cave environment, was also carried out.

While the risk for cavers and visitors is very small and in general negligible, the personnel engaged in commercial caves could be considered in some instances under the rules concerning occupational exposure.

Introduction

In the frame of a national survey to assess the indoor exposure of the Italian population (Sciocchetti et al., 1984) carried out by ENEA (Comitato Nazionale per la Ricerca e lo Sviluppo dell Energia Nucleare e delle Energie Alternative) with the support from the Commission of the European Communities (Contract No BIO-F-480-81-I) an additional investigation was carried out by means of passive dosimeters in some Italian show caves.

Five caves were selected:

Grotta Gigante (Trieste, Friuli-Venezia Giulia): big cavern (about 60 m × 120 m, max height m 100) with entrance from the top, no running water.

Grotta del Vento (Lucca, Toscana): karst system with nearly 3 km of passages, with internal water stream.

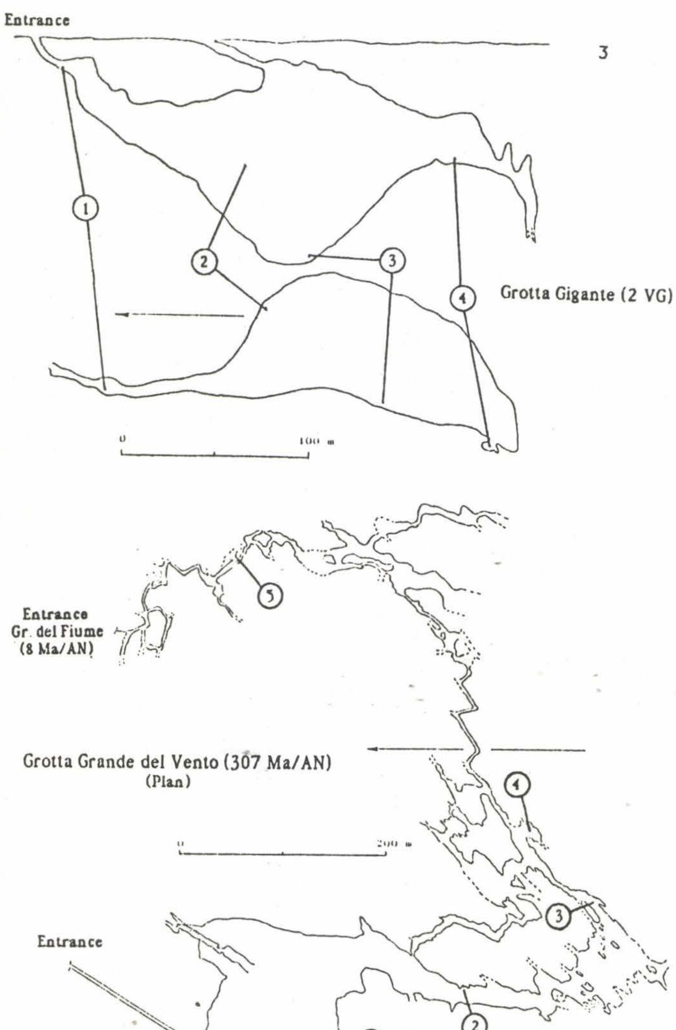


Fig.1

Grotta Giusti (Pistoia, Toscana): horizontal cave, about m 200 long with thermal water (about 35° C), used for speleotherapy.

Grotta Grande del Vento (Ancona, Marche): part of the big karst system Grotta del Fiume-Grotta Grande del Vento with more than 21 km of passages, some lakes and low temperature thermal waters.

Grotte di Castellana (Bari, Puglia): horizontal cave about 2 km long, entrance from the top at one end, shaft with air extractor at the other end.

Instrumentation and measurements

Passive dosimeters with a Radon diffusion cell and a measuring head with as CR-39 plastic detector were used. The detector faced the interior of the diffusion cell behind a membrane filter and measured the Radon gas only. The detectors were read by the ENEA Environmental Measurements Laboratory at the Casaccia Centre (Roma) which designed and supplied the dosimeters also.

The dosimeters were carried to each sampling station within the cave hermetically sealed in a plastic bag; after the exposure to the cave atmosphere the dosimeters were carried back to the laboratory sealed in another plastic bag. In the cave they were placed in a suitable position to avoid dripping water and other possible influences. In one case only a dosimeter was flooded for an unknown length of time.

In fig. 1 and 2 the positions of the dosimeters are reported and the results of Rn^{222} measurements are summarized in Table 1.

These data must be considered as average values referring to the whole integration time and, therefore, they are not influenced by low period variations in the Radon concentration.

The result of station No. 4 in Grotta del Vento should be discarted because the detector was soaked by water when the dosimeter was flooded: the relatively high value is probably due to this immersion and does not refer to the actual Radon concentration in the cave atmosphere.

Other values agree perfectly with the local situations. Those from Grotta Gigante and Grotta del Vento are for all purposes similar. Grotta Giusti, directely influenced by a thermal source without significant air exchanges between indoor and outdoor atmosphere, has the highest values; the values in Grotta Grande del Vento are lower than those measured in the Grotta Giusti but higher than in the first two caves. This cave has a reduced air circulation and is influenced by thermal waters in the lower levels.

Grotte di Castellana have the lowest values on account of the air circulation induced artificially in order to improve air quality for visitors. In particular, the low value of station No. 1 is due o the direct connection with the external atmosphere of the entrance cave while the higher value of station. No. 5 was found in an isolated room (Grotta Bianca) with poor air circulation.

In a previous paper (Cigna & Clemente, 1981) some measurements of Rn^{222} concentrations in Grotta Grande del Vento were carried on by means of the classical two-filter method. The

Table 1.– Radon concentration in some Italian Caves (standard deviation = ± 20 %)

Cave (File No.)	Station No.	Measurement from:	to:	Rn^{222} concentration Bq/m^3	pCi/l
Grotta Gigante (2 VG)	1	1983/05/25	1983/12/13	160	4.3
	2	'	'	150	4.1
	3	'	'	170	4.6
	4	'	'	200	5.4
Grotta del Vento (19 T/LU)	1	1983/05/24	1983/12/12	123	3.4
	2	'	'	190	5.1
	3	'	'	260	7.0
	4	'	'	480	13.0(*)
Grotta Giusti (47 T/PT)	1	1983/12/20	1984/11/08	350	9.5(**)
	2	'	'	410	11.1
	3	'	'	360	9.7
	4	'	'	270	7.3
	5	'	'	340	9.2
Gr. Grande Vento (307 Ma/AN)	1	1983/08/15	1983/11/13	260	7.0
	2	'	'	290	7.8
	3	'	'	240	6.5
	4	'	'	260	7.0
	5	'	'	210	5.7
Gr. di Castellana (8 Pu/BA)	1	1983/08/27	1984/11/05	46	1.2
	2	'	'	78	2.1
	3	'	'	125	3.4
	4	'	'	74	2.0
	5	'	'	180	4.9

(*) flooded.
(**) moved to station 2 during the last three months.

values were higher by a factor 2 than those reported in this paper: the difference is probably due either to a higher Rn^{222} concentration during the measurement (which lasted few hours only) or to some calibration problem of the passive dosimeters. The dosimeters used in this research were calibrated in an experimental Radon chamber (Schiocchetti et., 1984) but, on the other hand, passive dosimeters are still subject to some discrepancy in comparison with «active» dosimeters employing a portable pump to draw air samples through a filter (Khan & Phillips, 1985).

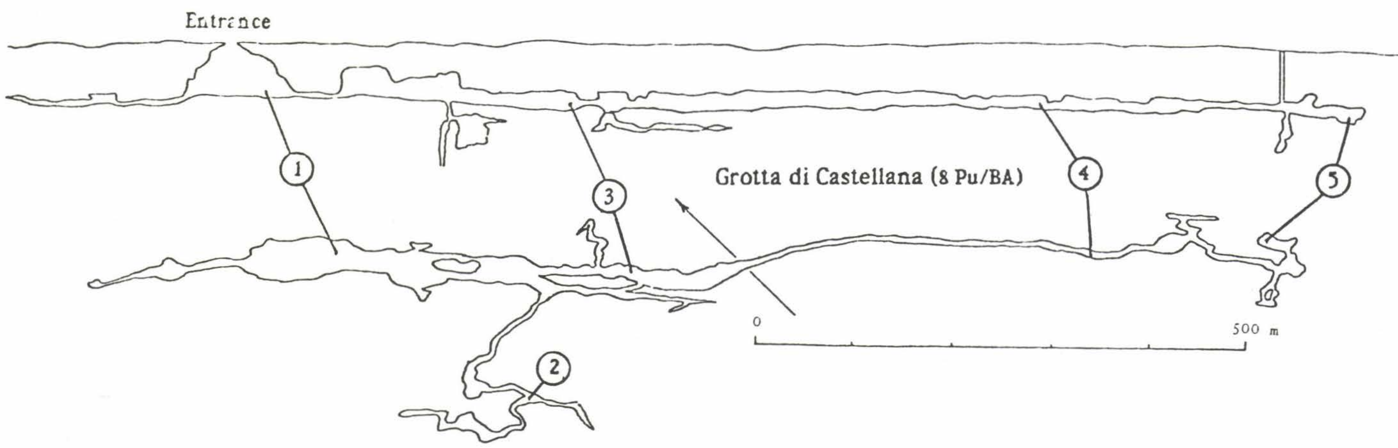
While new types of passive dosimeters are being developed at present to improve their reliability those used now give valuable results at least for a relative comparison. In any case the large spread of the experimental results in a natural environment reduce the importance of very accurate measurements.

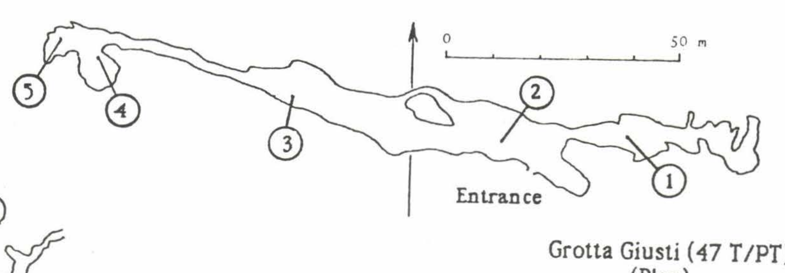
Dosimetry and risk assessment

The dosimetry of Radon and its daughters in the atmosphere is a well known problem complicated by the degree of equilibrium reached by these radionuclides which is influenced by environmental factors. Some data are available for mines but little information exists on the typical environment of caves and spas where the atmosphere is in general very clean and with a high degree of relative humidity.

For this reason it was deemed useful to collect here as much data as possible in a number of different cave environments. These data are reported in Table 2.

Notwithstanding the spread in the values, an evident case on non-equilibrium is present in cave environments and therefore it should be taken into account in dose calculations to avoid any systematic error. A detailed examination of the measurements carried on in Carlsbad Caverns (Pump Room area) by Ahlstrand & Fry (1978) gives additional information on the seasonal variation





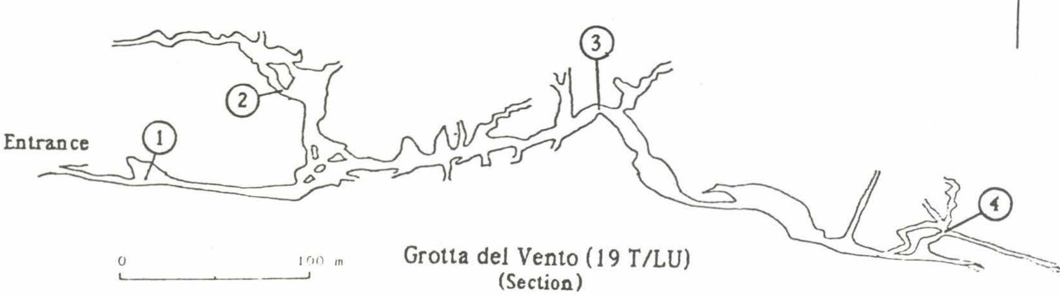
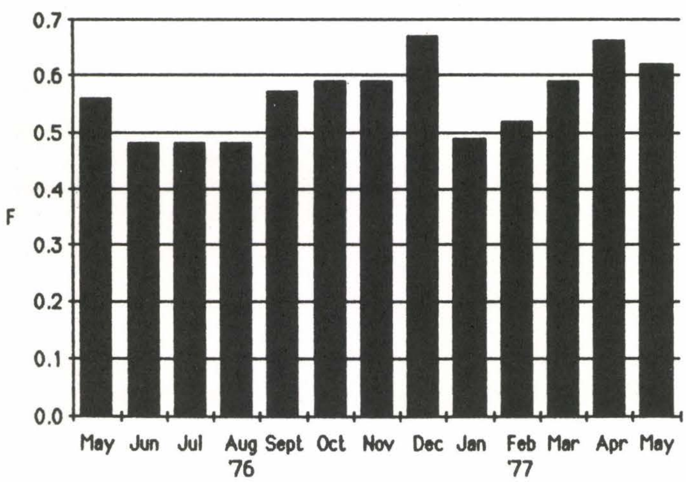


Fig. 2

Table 2.– Equilibrium factor (F) in caves. (F = ratio of equilibrium equivalent concentration of Radon to actual Radon concentration in air).

Cave	F	No. of measurements	Ref.
Carlsbad Caverns, N.M., USA			
Main Cave	0.44	30	Yarborough *et al.*, 1978
id	0.59	4	Ahlstrand, 1980
Lower Cave	0.50	3	Yarborough *et al.*, 1978
New Cave	0.90	3	Yarborough *et al.*, 1978
Pump Room area	0.56	78	Ahlstrand & Fry, 1978
Crystal Cave, Sequoia, Calif. USA	0.90	4	Yarborough *et al.*, 1978
Jewel Cave, South Dakota, USA			
Historic Tour	0.19	2	Yarborough *et al.*, 1978
Scenic Tour	0.81	14	Yarborough *et al.*, 1978
Lehman Cave, Nevada, USA	0.64	70	Yarborough *et al.*, 1978
Mammoth Cave, Kentucky, USA	0.81	22	Yarborough *et al.*, 1978
Oregon Cave, Oregon, USA	0.66	6	Yarborough *et al.*, 1978
Round Spring Cave, Ozark, Mo., USa	0.98	6	Yarborough *et al.*, 1978
Wind Cave, South Dakota, USA	0.46	10	Yarborough *et al.*, 1978
Howe Caverns, New York, USA	0.67	9	Seymore *et al.*, 1980
Grotta Grande del Vento, Marche, Italy	0.69	4	Cigna & Clemente, 1981
Weighted average value	0.62		

of the degree of equilibrium. The monthly average values, plotted in fig. 3, show a small but evident reduction when air circulation in the cave system occurs either in a Summer or Winter situation: in other seasons when the direction of the air flow is uncertain higher values of the equilibrium factor are attained.



From ICRP Publication 32 (ICRP 1977; Breuer 1985) the effective dose equivalent delivered by inhalation of Radon daughters can be evaluated as follows:

$$(WLM) = (rem) = F^*(Bq/m^3 \text{ of } Rn^{222})^*(\text{No. of hours})^*\ 1.59^*\ 10^{-6}$$
$$(Sv) = F^*(Bq/m^3 \text{ of } Rn^{222})^*(\text{No. of hours})^*1.59^*10^{-8}$$

if one Working Level Month (WLM) is assumed to correspond to 10 mSv (= 1 rem) of effective dose equivalent. Very similar results are also obtained if the dosimetric coefficients relative to outdoor inhalation of Radon daughters by members of the public given by UNSCEAR (1982) are used.

The effective dose equivalent affecting members of the public (both cavers and tourists) visiting caves is therefore negligible and without any health significance; on the other hand, in some caves with a high Radon concentration, it may be necessary to take some amelioration in order to comply with radiation protection recommendations for the personnel routinely working in caves, e.g., guides.

By assuming 1000 hoursfrent annually in the caves (about 3 hours per day), with the average Radon concentration given in Table 1, a parametric calculation of the corresponding effective dose equivalents are given in Table 3. New and old units are used for comparison with previously published data.

Table 3.– Effective dose equivalents for individuals spending 1000 hours/year in cave.

Cave	mSv/year	mrem/year	WLM/year
Grotta Gigante	1.7	170	0.17
Grotta del Vento	1.9	190	0.19
Grotta Giusti	3.5	350	0.35
Grotta Grande del Vento	2.5	250	0.25
Grotta di Castellana	1.0	100	0.10

The personnel routinely working in the caves are not classified as workers occupationally exposed (possibly with very few exceptions) and therefore are to be considered as public.

By taking an exposure limit of about 5 WLM/year for workers (ICRP, 1981), the limit for the public is 0.5 WLM/year. But according to ICRP (1977) a further safety factor of 1/5 should be applied for long exposure period. Therefore for individuals spending 1000 hours/year in the first four caves listed in Table 2 some reduction of the cave working time should be considered.

Acknowledgements

The invaluable help of R. Ravalli, V. Micol, V. Verole-Bozzello, F. Utili, S. Macció, G. Campanella and G. Palmisano who took care of the dosimeters in caves is here acknowledged. The author is also very grateful to G. Sciocchetti and P.G. Baldassini for the measurements, to K.A. Yarborough who kindly supplied some fundamental literature, to F. Breuer for the useful discussions and to W. Templeton for the revision of the English text.

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10309

Cave radioactivity-Theory and data

Miklós Gádoros
Budapest, Hungary

RESUM

Les calcàries estan contaminadas amb urani (U) i tori (Th), de tal manera que les cavitats càrstiques poden ésser considerades com a cavitats originàriament rodejades de fonts de radiació.

L'urani, el tori i altres productes sòlids radioactius proporcionen un ju –fons– independent del clima i depenent solament de la contaminació, de l'absorció de la roca i de les mesures de la secció de la cavitat. El seu valor esperat és de 30 μr/h. com a màxim.

Els productes radioactius gasosos (Rn, An, Tn) poden escampar-se per l'aire de la cavitat. El valor de difussió esperat del fluxe de gas és, per al radó, de 1.000 a 10.000 àtoms/m^2. s., depenent de la concentració i difussibilitat de la roca. La concentració de gas en l'aire de la cavitat depèn del fluxe de gas i de fluxe d'aire, aconseguint-se màxims a la primavera i a la tardor.

Si el fluxe d'aire penetra, es produeix, en els 26 primers minuts, la concentració més elevada de Tn, seguida de la de Rn.

Les dades obtingudes i les consideracions teòriques coincideixen.

RESUMEN

Las calizas están contaminadas por Uranio y Th, de modo que las cavidades kársticas pueden ser considerardas como cavidades originariamente rodeadas de fuentes de radiación.

El Uranio, th y los productos sólidos radioactivos proporcionan un ju –fondo– independiente del clima, dependiente solamente de la contaminación y absorción de la roca, y de las medidas de la sección de la cavidad. Su valor esperado es de 30 μr/h. como máximo.

Los productos radioactivos gaseosos /Rn, An, Tn/ pueden esparcirse en el aire de la cavidad. El valor de difusión esperado del flujo de gas para el radón es de 1.000 a 10.000 átomos/m2 s, dependiendo de la contaminación y difusibilidad de la roca. La concentración de gas en el aire de la cavidad depende del flujo de gas y del flujo de aire. Las máximas se esperan en primavera y otoño.

Si entra flujo de aire en los primeros 26 min. se produce la concentración más elevada de Tn, seguida de Rn.

Los datos medidos y las consideraciones teóricas se corresponden.

SUMMARY

Limestones contain U and Th contaminations, thus karst caves may be regarded as cavities primarily surrunded by radiations sources.

U, Th and solid decay products gives a ju –back– ground independent of the climate, dependent only of the contamination and absorption, It's expected value is maximum of 30 μr/h.

Gaseous decay products /Rn, An, Tn/ are capable of diffusion on cave air. The expected value of the diffusion gas flow for radon is 1.000-10.000 atoms/m^{2}s, dependent of the contamination and diffusivity of the rock. The gas concentration in the cave air is dependent of the gas flow and of air flow. Maxima are expected in spring and autumn.

In case of incoming air flow in the first 26 min the Tn thas the highest concentration, later the Rn.

The measured data are in good agreement with the theoretical considerations.

One of the most contraversial questions of cave climate is radioactivity. First its mere existence was debated, later the question has been raised whether radioactivity is a particular characteristic of the individual cave or can be regarded as a universal phenomenon. With knowledge of the source of cave radioactivity and instantaneous values affecting the main parameters, fundamental physico-climatology seem to be clarified.

According to geophysical investigations, limestones contain, on an averge, 2.2 ppm ^{238}U, 0.016 ppm ^{235}U and 1.7 ppm ^{232}Th contaminations. Since all three elements are initial stages of a series of decay, several further membes of wich are also radioactive, karst caves may be regarded as cavities primarily surrunden by radiation sources. Only ju radiatiation /and a small amount of/ β radiation/ diffuses from the rock, wich gives a background independent of the climate, with an expected maximum of approx. 30 μr/h according to geophysical data.

Rónaki, 1968, found 3 ppm U in the Mecsek mountain and Roda et all., 1971, measured 4-5 μr/h total activity in Gombaszög Cave /Southern Czechoslavakia/. Both data are in good agreementr with the above results.

As is known, one member of each of the above three series of decay is gas, wich is capable of difussion into cave air. From the above ratio and the density of the fundamental rock, the density of U and/or Th can be determined and from this atomic density can be derived by Avogadro's Law. Taking into account the constants of decay, we may obtain from this density of gases formed inside the stone. In the case of C_r gas density, λ decay constant and D diffusivity, by solving the midified Fick equation, we obtain for the diffusion flow from the rock

$$I = C_r\lambda D^{1/2}\lambda^{1/2} \quad /atom/m^2/ \qquad 1/$$

if concentration in the air is neglibly low. The results of calculations are depicted in Table, 1, consodering that –according to geophysical data– the diffusivity of limestones is $D= 10^{-7}...10^{-10}$ m^2/s.

	a				b	
	ppm	g/m³	atom/m³		atom/m³	kBq/m³
^{238}U	2,2	5.94	$1.5\ 10^{22}$	$^{222}Rn/Rn$	$3.5\ 10^{10}$	73
^{235}U	0.016	0.043	$1.1\ 10^{20}$	$^{219}Rn/An$	$1.9\ 10^4$	3.4
$^{232}Th.$	1.7	4.6	$1.2\ 10^{22}$	$^{220}Rn/Tn$	$1.5\ 10^6$	19

	c	d	e
	atom/m²sec	mm	sec⁻¹
Rn	500-16.000	7-220	$2.1\ 10^{-6}$
An	0.08-2.6	0.023-0.75	0.176
tn	1.7-53	0.09-2.8	$1.27\ 10^{-2}$

table 1, Radioactive diffusion into the cave
a= density of U/Th
b= density of gsses in the rock
c= diffusion flow
d= diffusion depht
e= decay constant

With knowledge of the diffusion gas flow, cave gas density can also be determined.

a./ If there is *no air flow* a certain elapses of time, equilibrum concentration in the air space will set in, the value of wich calculated in activity is

$$B= IK/S \qquad /Bq/m^3/ \qquad 2/$$

and in atomic density

$$C_c= B/\lambda \qquad /atom/m^3/ \qquad 3/$$

Where B stands for specific activity and/or C_c denotes gas density in cave air, K is the circumference and S designates the area of the cross-section. As can be seen, above a diameter d=4 m, specific activity is lower and in the case of a smaller diameter it is higher than the diffusion flow. Considering the data in Table 1., in cavities with approx. d=4 m effective diameters the expected equilibrum Rn-activity is 1-10 kBq/m^3. Since the products of decay of Rn are also radioactive, total d–activity is three times as high and β– activity will be twice as high as this value. Most of the ratio of activity is supplied by radon /^{222}Rn/, as the ratio of activity of the individual isotopes in equilibrum is

$$B_{An}:B_{Tn}:B_{Rn} \cong 1:20:6.000 \qquad 4/$$

b./ In the case of *incoming air flow,* we obtain both qualitatively and quantitatively different results. As is known, in case of C_{co} initial, C_c end concn. and a constant source, at given t time, concentration of the radioactive substance is

$$C_t=C_c(1-\exp(-\lambda t)) \qquad 5/$$

The time required for equilibrum is approx. 20 sec for An, about 4 min for Tn, while Rn requires more than 2 weeks. Therefore the activity of Rn attain the activity of an only in 80 sec and that of Tn in 26 min /1.600 sec/. It should be noted that considerably long cave sections or entire caves have been taken into consideration and at strong air flow the distance covered in 1.600 sec may imply several kilometers.

Naturally, activity in this case is very low, at 1.600 sec altogether 10-100 Bq/m^3 may be expected.

c./ In the case of *outgoing air flow* the air enters the cave partially or wholly through clefts. In the case of narrow clefts, if the depth of diffusion is similar in size to the width of the cleft, Eq 2 does not hold as the condition $C_c << C_r$ is not fulfilled.

Then

$$C_c=C_r(1+z^{-1})^{-1} \qquad 6/$$

where

$$z=K/(S\sqrt{D\Lambda}) \qquad 7/$$

and in the ratte of concentration increase in Eq 3, apparent decay constants

$$\lambda_1=\lambda(1+z) \qquad 8/$$

must be taken into account. Thus, in air passing through narrow clefts higher concentration is attained more rapidly than in a spacious cave. This is naturally valid for all three gases; in the case of identical cleft sizes, however, the value of z for Tn and An is much lower and since decay in these occurs rather rapidly, the air flowing out of the clefts quickly losses its excess activity. Thus, in te enterior of the cave far from entrance may be expected to be constantly in Tn and An. The activity of Rn, however, strongly air flow dependent, therefore, rather variable in the course of ther year and even in one day.

Unfortunately, we have no avaliable data on diurnal variation. As regards annual variation, Rónaki, 1972, measured maximum values, approx. 12 kBq/m^3 in Abaliget cave and Somogyi, 1982, obtained maximum values in Vass Imre cave approx. 10 kBq/m^3 at the end of summer; both investigators also determined a lower maximum values in spring time; activity was found to be somewhat in midsummer and extremely low in winter. Rónaki measured also Tn and stated that in winter considerable amount of the total activity is derived from Tn whereas in summer the amount of Tn activity is negligible related to the high concentration in Rn.

In our investigations we hawe made approximately 50 series of measurements in more than 30 different caves /in Hungary, Czeechoslovakia and the FRG/, using β and γ GM counters. According to our measurements closely adjacent cave sections or even in different corners of the same hall the amount of activity can be very different. In places without aeration increase can be observed in the acticity of air. Highest annual variation was measured in Szemlöhegy Cave /Budapest/, where in some sites the winter to summer ratio reached even the value of 1:50; among karst caves, highest activity weas found in Abaliget Cave. It also been established that in wet caves substancial amount of the radioactivity of air is linked to water aerosol.

In Figure 1, we present two longitudinal sections of β activity measured in the Jósvafö section of Baradla Cave in different seasons of the year.

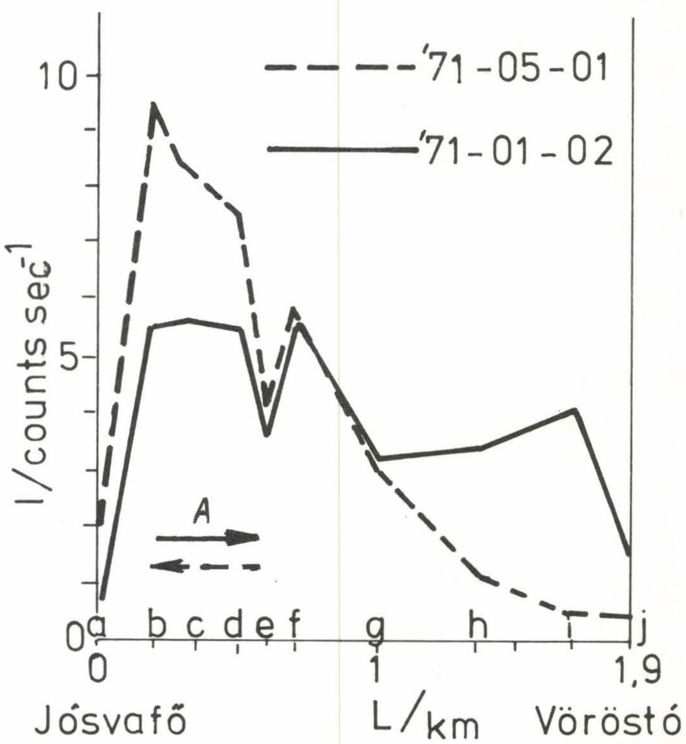

Figure 1, Radioactive longitudinal sections from Baradla Cave, Jósvafö, Hungary. β-activity of the cave-air.
L= distance from the entrance
a,b, etc.=measuring points
A= direction of the cave wind
Not. at Jósvafö entrance: double wind door Vöröstó open for air mooving

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Aerosols in caves – Theoretical considerations

Miklós Gádores and Ferenc Cser

Budapest, Hungary

RESUM

L'hidroaerosol és un component essencial del clima peculiar de les cavitats. Probablement és un factor essencial de la capacitat de cicatrització de les coves i juga un paper fonamental en la formació d'helictites. Són molt escasses les dades bibliogràfiques d'aquests paràmetres, per tant ens hem vist obligats a recórrer a càlculs teòrics per a poder determinar les seves característiques.

Segons els càlculs efectuats, les gotetes inferiors a 10µm., poden ésser estabilitzades en una atmosfera amb una humitat relativa superior al 95 %, a l'igual que les gotetes inferiors a 5µm., amb una mineralització de 700 mg. de Ca^{++} l^{-1}, formant un hidroaerosol de 1 gm^{-3} cca i amb un contingut global de Ca^{++} de 1 mg. m^{-3}. El pH de les gotes soprepassa el 8,5, no obstant no es pot fixar ja que el $CaCO_3$ que contenen les gotes cristal·litza quan es pretén calcular el seu pH.

Hom considera que els aerosols es carreguen elèctricament com a conseqüència, principalment, de la seva evaporació, amb una unipolaritat negativa.

Les poquíssimes dades de què disposem recolzen les consideracions teòriques.

RESUMEN

El hidroaerosol es un componente esencial del clima especial de cavidades. Probablemente es un elemento importante de poder de cicatrización de las cuevas y posee un papel dominante en la formación de helictitas. En la bibliografía se conocen muy pocos datos de medidas, por tanto nos hemos visto obligados a remitirnos a cálculos teóricos para la determinación de sus características.

Según los cálculos las gotitas inferiores a 10 µm pueden ser estabilizadas en una atmósfera con una humedad relativa superior a 95 % como gotitas menores que 5 µm y con su mineralización de 700 mg. Ca^{++} l^{-1} formando un hidroaerosol con cca 1 gm^{-3} con un contenido en conjunto Ca^{++} de 1 mg m^{-3}. El pH de las gotitas sobrepasa 8,5. Sin embargo no puede ser medido, ya que el $CaCO_3$ contenido en las gotitas cristaliza cuando se mide el pH.

Se espera que los aerosoles se carguen eléctricamente como consecuencia de su vaporización principalmente con unipolaridad negativa.

Los poquísimos datos de que disponemos apoyan las consideraciones teóricas.

SUMMARY

The hydroaerosol is an essential component of the special cave climate. It is probable an important element of healing power of the caves and it has dominant role in the formation of helictites. There is only very few measured data known in the literature, therefore we have to be confined to theoretical calculations in determining its characteristics.

According to the calculations dropplets smaller then 10µ m can be stabilized in an atmosphere with a relative humidity greater then 95 % as dropplets smaller then 5µm and with their mineralization of 700 mg Ca^{++} l^{-1} forming a hidroaerosol with cca 1 gm^{-3} with an overall Ca^{++} content of 1 mg m^{-3}. The pH of the dropplets exceeds 8,5. It can not be measured, however, as the $CaCO_3$ content in the dropplets crystallizes when the pH is measured.

The aerosols are expected to be charged electrically as a consequence of their vaporization mainly with negative unipolarity.

The available very few data support the theoretical considerations.

Introduction

They hydroaerosol is one of the essential components of the cave climate which differs qualitatively from the aerosols of the surface. Its importance in the cave is great as it has dominant role in the formation of helictites and it is probable also an essential component of the healing effect of the caves. We have to be confined, however, mainly to theoretical calculations at the determination of the main parameters of the cave aerosols as there is very small amount of measured data known. The reason for this derives from measuring difficulties, as it will be shown later, besides financial and organizational problems, naturally.

We are confined to the investigation of the moist karstic caves of the temperate zone. The water with Ca and Mg hydrocarbonates is dropping in the cave steadily forming a fine spray in the air after falling to dust. The spray partly assures a humidity near to the saturation, partly remains in the air as fine dropplets due to its evaporation. The temperature of the stone conserves a temperature near to 10°C what is just above the yearly mean temperature at the surface. The cave is in limited contact with the surface, it is a semi-close system.

The stability of water dropplets in the cave climate.

The parameters of the dropplets are changing as follows:

1. They are falling due to the gravity,
2. their radius is decreasing due to the evaporation of their water content,
3. their solute is increasing, as a consequence of 2.,
4. their CO_2 content is decreasing.

1. The falling rate of the dropplets in the air is constant, depending on the diameter:

$V_d = 3.1\ 10^{-7} d^2$ /t = 10°C, d < 8 × 10^{-5} m/ (1)

2. The determination of the evaporation rate of the water from the dropplets is more complicated. According to Cser and Maucha, 1968, the time necessary to decreas the initial diameter /d_o/ to d_1 is given by eq. 2/:

$\tau = A \times d_o^2 - d_1^2$ (2)

Where A is a complicated function of the temperature and the humidity. Figure 1. shows the time necessary to evaporate the half volume of a dropp at different initial diameter /d/ and relative humidity /r/. The line STOKES gives the time for a dropp to fall lm without changing its diameter. The auxiliary scale «m» with the dotted lines indicates the falling distance of a dropp with an initial diameter of d until it reaches the half of its original volume at different humidity. As an example: a drop with an initial diameter of 50 μm /d_o/ losses half of its original volume within 17 sec /d_1 = 40μm/ and it falls lm within this time period. If we take the differencies in the altitudes of the caves into consideration it is clear that onyl a small part of the dropps with an initial diameter over 10 μm will form aerosol since they precipitates to the floor within a short time. We have to take also into consideration that the diagram reffers only to pure water, what is evaporates faster than the solutions.

We can conclude, that the probable upper limit of the initial diameter of the dropplets in the aerosol can be given as 20-30 μm.

The diagram concernes to flat surfaces only. If the surface is bent the equilibrium vapor pressure can be given according to Thompson

$e_d = e_s \times /1 + 2.27 \times 10^{-9}\ d^{-1}/$ (3)

where e_d is the vapor pressure of a bent surface with a diameter of d /m/, e_s that of with d = ∞. The diagram of evaporation is obtained with this modification. This is the reason of the presente of lines with a r value 100 % since very small dropps evaporate in supersaturated air, too.

3. As the solutes in the dropps do not evaporate, their concentration increase with decreasing volume. The vapor pressure is decreasing with increasing concentration. According to Rault:

$e_m = e_s \times /1 - m \times M^{-1}/$ (4)

where e_m is the vapor pressure above a solution with m /g 1^{-1}/ concentration of the solute, and M is a constant. In our case, when the solute consists up mainly from Ca and Mg carbonates,

$e_m = e_s \times 1 - 9 \times 10^{-7}\ C_h/$ (5)

where C_h is the hardness of the water expressed in mval units.

The overall effect is the combination of those given above,

$(e_r - e_s) / e_s = e_d/e_s + e_m/e_s - 2$ (6)

Substituting 3/ and 5/ into 6/ we get

$(e_r - e_s) / e_s = 2.27 \times 10^{-9} \times d^{-1} - 9 \times 10^{-7}\ C_h$ (7)

The nomograms corresponding to eq. 7/ are given on Figure 2.

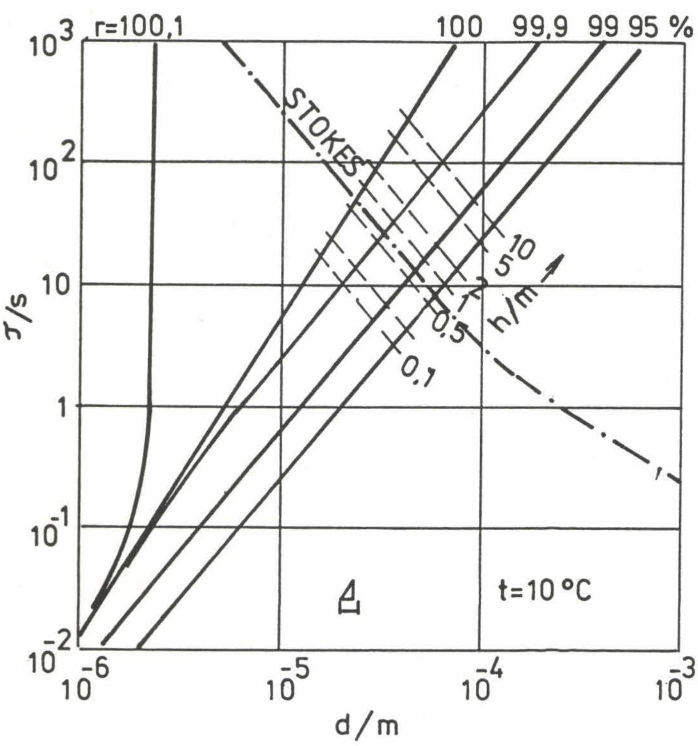

Figure 1.

The time for the evaporation and for the falling.
d_o = initial diameter of the dropp.
τ = time necessary for the evaporation of half of the volume /lines with parameter r/ or the time while the dropp with a constant diameter of d falls 1 m /STOKES line/
r = relative humidity in %
h = the height of falling while the volume decreases to its hald value with d_o and r.
Δ = the change of diameter at the half volume.

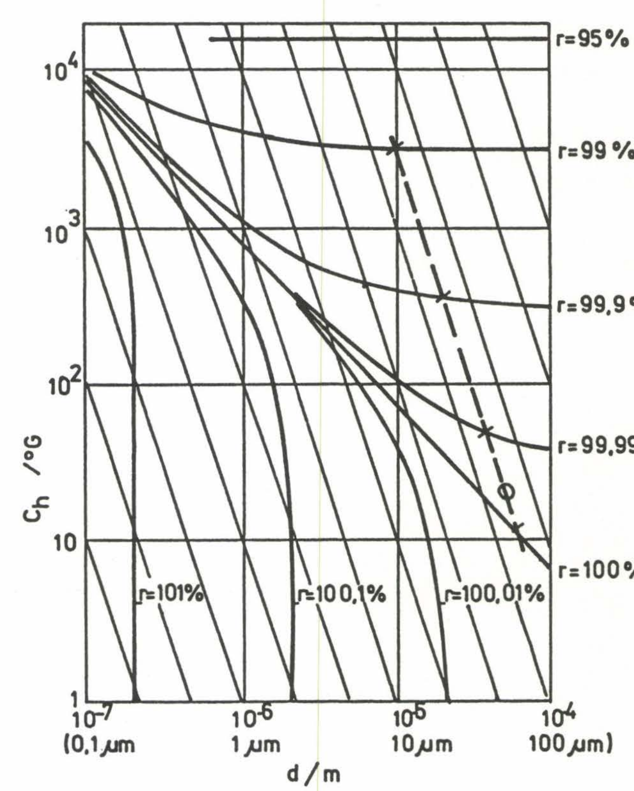

Figure 2.

The mineralization of the water as a function of the diameter and the relative humidity.
d = the diameter of the dropp
r = relative humidity
C_h = mineralization in german degree of hardness
The diameter in equilibrium can be obtained by the intersection of a line parallel with the declined lines drown from the point of the initial diameter and the concentration with actuall humidity.

The abscisse is the diametes of the dropps, the oordinate is the concentration of the solute, both in logarithmic scale.

The parameter is the relative humidity. It is worth to remark, how small changes in the humidity and the temperature result in great differences in the equilibrium vapor pressure.

The declined lines indicate the concentration of the solute parallel with the change in the diameter described by eq. 8/:

$$c = c_o \times d_o^3 \times d^{-3} \qquad (8)$$

It is evident from the Figure that the size and the solute content of the aerosol dropps is very sensitive to the relative humidity. It can also be seen, that each dropps may stabilize its measure if there is sufficient time for the realization. It is interesting to note, that two dropps with the same initial diameter but with different solute content will be stabilized at different diameter and concentration. The dropp what have had the lower concentration will have a lower diameter and a greater solute content than the other one. In the case of $r > 100$ % those dropps will remain in the air whose starting coordinates are at the left side from the r-curve. The greates ones increase their measure and fall out.

4. Until now we supposed that the amount of the solute of the drops remains constant. This is correct when the solvent is a good one. As an example: the relative humidity in an equilibrium with a saturated NaCl solution is 90 %. At $r = 95$ % the diameter of a dropp with an initial diameter of 1,6 μm in an equilibrium is 0.05 μm if its original mineralization was 10 mg NaCl 1^{-1}. The situation is other if the solvent is a bad one like water is for $CaCO_3$. Its equilibrium concentration is 0.25 mval. If the air around the dropp contains 0.1 % of CO_2 this concentration is 1.43 mval. At 1 % of CO_2 it is 2.57 mval. Since the dropps have great specific surface their CO_2 content gets to be in equilibrium with the air very soon, i.e. their original solute of $Ca/HCO_3/_2$ must be mainly in the form of $CaCO_3$. This means, the solution can be estreamly supersaturated. It is also known that the solubility of a crystall increases with its partical growth. The $CaCO_3$ in the aerosol dropps can not be precipitated due to the absence of crystalline nuclea and the increased solubility.

As a consequence of the conception presented above a stabilized aerosol in originated from dropps smaller than 20-30 μm in a relative humidity over 97-98 %. This means, at least an altitude for the dropping of a water dropp over 2 meters needs to form aerosol dropps with sufficient small diameter. The stabilized aerosol is consisted off dropplets smaller than 5 μ, with a $CaCO_3$ content of some tens of mval and a pH value over 8.5.

The quantity of aerosols

Now we have to turn to the quantitative determinations.

We know from the meteorological data, that the vision distance in a mist with a density of 3.2 g m^{-3} is 30 m-s. That for mists with densities of 0.32 and 0.032 m-s are 120 and 600 m-s. We also konw, that a stratus has a density of 0.3 g m^{-3} as a mean value. Although this datum can be refflected to the situation in caves only with reserve, it seems that the upper limit of the aerosol content of the caves can be given under 1 g m^{-3}, remarking, that smaller values are more probable.

We have much better approximations for the change of the density of the aerosols. According to Maucha, 1983, the dropping intensity is five times smaller in autumn than in spring in the Vass Imre cave /Hungary/. There is practical no air motion in April or in October in the caves, i.e. the local differencies must then be greater. In sommer the greater air motion homogenize the aerosol, in winters the incoming air drys the hunidity and hydroaerosol can only be expected in the inner parts of the caves, etc. The reality can not be estimated, since practically there are no data to support or to deviate the hypothese. The measure of the dropplets, their distribution and their change as well as the change of the global density of aerosol as a function of the season could be measured by the recent technical instrumetation, but we have no concrete data at all. Some chemical data of condensed aerosol are already known. The are very usefull to represent the mean relative composition of the cations in the aerosol, and the data can be related to the composition of the dropping water. According to our oppinion, the amount of aerosol and its composition, however can not be measured by condensation methods, Not only the aerosol will be condensed upon cooling, one part of the humidity as well as the solid aerosols will also be precipitated. On the other hand, the condensation depends on the rate of cooling, too. At smaller rate of cooling greater dropps will be precipitated only. The reprducibility of the method is also very wrong as the results depend e.g. on the rate of the air motion etc. The chemical data of Takács et all. 1984, show 0.1-0.5 mg $Ca^{++}m^{-3}$ with an extreme value of 1.45 mg m^{-3} obtained in the Béke cave /Hungary/ with a good accordance of the estimated value of 1 mg m^{-3} of the hypothese.

Finally some remarks to the polaruty of the dropps.

According to Kessler, 1984, the dropplets are ionized mainly with negative polarity what is a natural consequence of their origin /water-fall effect/. As our experiences showed, /Gádoros, 1983/ greater part of the radio-activity of the air in the cave is also connected to the aerosol. The qualitative nature of these phenomena also need some further study.

As a conclusion we have to state, that the study on cave hydroaerosols are much more theoretical hypotheses than experimental results, We have now the questions to be put and the experiments should present the answers.

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BIOSPELEOLOGIA
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Oligochaeta from subterranean waters of West Indian Islands.

Elżbieta Dumnicka

RESUM

El material ha estat recollit per les expedicions d'Amsterdam a les Índies Occidentals, dirigides del professor Jan H. Stock.

En aquest treball s'ha recopilat la fauna d'oligoquets pertanyents a 13 illes, d'on s'han recollit més de 10 mostres. Apareixen oligoquets en un 18,7 % a un 58,3 % de les mostres. Generalment són més abundants en les illes més grans o en aquelles més properes al continent. S'han identificat 21 espécies. N'hi ha de cosmopolites, neotropicals, europees i tres més que són noves per a la ciència.

RESUMEN

Los materiales han sido recolectados por las expediciones de Amsterdam en las Indias Occidentales, dirigidas por el Profesor Jan H. Stock.

En este trabajo se ha representado la fauna de oligoquetos de 13 islas, de las cuales se han recogido más de 10 muestras. Los oligoquetos aparecen en 18,7 % - 58,3 % de muestras, generalmente se encuentran más abundantes en las islas mayores, o aquellas que están situadas más cerca del continente. Se han determinado 21 especies –los hay de especies cosmopolitas, neotropicales, europeas y 3 especies nuevas para la ciencia.

RESUME

Les matériaux ont été collectionnés par Amsterdam Expeditions to the West Indian Islands dirigées par monsieur le professeur Jan H. Stock.

Dans ce travail on a representé la faune d'oligochètes de 13 îles d'où on a recuelli plus de 10 prélèvements. Les oligochetes paraissent dans 18.7 % - 58.3 % de prélèvements, généralement ils se montrent plus souvent sur les plus grandes îles, ou les îles situées plus prés du continent. On a determiné 21 espèces – il y en a des espèces cosmopolites, néo-tropicales, européennes et 3 espèces nouvelles pour la science.

1. Introduction.

The aquatic oligochaetes from West indian Islands are insufficiently known. Few species were found by Michaelsen (1933) on Curaçao, Bonaire and Aruba. From materials collected by Amsterdam Expeditions to West Indian Islands, the family Tubificidae has been described so far (Dumnicka 1983) and the paper concerning the family Naididae is now in press (Dumnicka 1986)

Oligochaetes from the South American continent are kown better: they were studied by E. Marcus du Bois-Reymond (1947, 1949) and G. Righi (1974) in Brasil; in Argentina by Di Persia (1980)- mainly the family Naididae; in lake Titicaca by Cernosvitov (1939). Howmiller (1974), Harman and Mc Mahan (1975) investigated the oligochaetes collected in numerous localities.

2. Study area and methods.

The materials collected by Amsterdam Expeditions to West Indian Islands in the years 1973 - 1978 are very abundant (Stock 1979). They contain 527 samples collected on 24 islands, but oligochaetes were encountered in only 39 % of samples. The work described in this paper been based on materials from 13 of these islands, from which at least 10 samples had been taken.

The studied islands are situated between 10° 57' 56" and 19° 46' 50" latitude North and 59° 25' 33" and 72° 40' 57" longitude West, that is they form an arch between Cuba and the coast of Venezuela (Fig.1). Haiti has the greatest area (76.5 thousands of km^2), other islands are distinctly smaller - from 450 km^2 to 33.7 km^2. The samples were collected in various habitats, mainly subterranean. More than 75 % of the samples were collected in wells, the rest were collected in caves, crevices, boreholes and interstitial waters of the sea- shore and also in brackish and freshwater lakes. Various equipment was used for collecting the samples: the Bou-Rouch biophreatic pump, the Cvetkov self-closing vertical net (small and large) and hand-nets. For each station the chlorinity of the water was determined and a short characteristic provided. It included: the character of the bottom, water depth, pollution, the presence or absence of various groups of animals.

3. Results and discussion

Oligochaetes are common in the subterranean waters of West Indian Islands, but the frecuency of their ocurence is not identical

Table 1. Frequency of oligochaeta on the studied islands

island	No. of samples	No. of samples with olig.	% of samples with olig.	No. of species	remakrs
Haiti	48	23	47.9	12	2 new species
Vieques	11	3	27.3	3	
Tortola	23	10	43.5	4	I group
Virgin Gorda	12	7	41.2	3	
Anegada	15	8	53.3	3	
Anguilla	16	4	25.0	1	
St. Martin	43	14	32.5	3	
Barbuda	16	6	37.5	3	II group
Antigua	15	4	26.6	3	
Barbados	32	6	18.7	1	III group
Curaçao	87	35	40.2	4	
Aruba	24	14	48.3	3	IV group
Venezuela	15	8	53.3	5	1 new species

on all the islands studied. From Haiti to Anegada about half of the samples contained oligochaetes (Table 1). Only on Vieques was this percentage lower. The greatest number of species was found on Haiti. These were mainly species characteristic of America, some cosmopolitan ones, possibly introduced by people and 2 species previously unknown.

The next group of small islands extends from Anguilla to Antigua. Both the percentage of samples with oligochaetes and the number of specimens per sample were lower than on the group of islands near Haiti. Cosmopolitan and South American species were dominant. The lowest number of samples with oligochaetes and the lowest number of determined species was found on Barbados, which is situated away from other islands.

The last group of islands lies near the coast of Venezuela. Oligochaetes were encountered in about half of the collected samples.

A similar frecuency of oligochaetes was found in the samples from Venezuela. These oligochaetes were mainly species of continental origin.

The greatest frequency of ocurence and greatest species diversity was found on Haiti - the biggest island, and also on islands close to the continent. These results confirm the continental origin of the contemporary species of oligochaetes.

The greater part of the material could not be determined down to the species because the specimens from the families Tubificidae and Enchytraeidae and some from the family Naididae, were immature, too young to make identification possible, or deformed by fixation (especially the gills of specimens from the genus Dero). Of the 21 species determined so far, the majority belong to cosmopolitan forms (Table 2). Aulophorus furcatus is the most common species - it ocured on 9 islands out of the 13 selected for this paper. It is a species common in various South American waters - mainly in ponds and other bodies of stagnant waters, even at great depth. Its gills enable it to live in waters, where the amount of O_2 is periodically low.

The family Naididae is represented mainly by the genera Dero and Pristina. The dominance of different species, although belonging to the above mentioned genera is characteristic of stagnant waters of South America. Both these genera are cosmopolitan, but the genus Pristina predominates in the interstitial waters (Kasprzak 1973) and is treated as a stygophilous form. The genus Nais, the most common genus from the family Naididae, has not been found on the studied islands. It is encountered in various water bodies of South America, but it does not predominate there as it does in the Palearctic.

The family Tubificidae is represented here by only 4 species, including 2 species previously unknown.

From the family Enchytraeidae only 2 species were determined and probably one species new to science, belonging to the genus Achaeta, will be described.

On the studied islands some families typical of South America (Phreodrilidae and Opistocystidae) have not been encountered. Phreodrilidae were however present in the samples from the coast of Venezuela. The subterranean waters are inhabited both by cosmopolitan and rare species. The latter include species which have been only sporadically encountered so far, such as Pristina

Table 2. The ocurrence of oligochaete species on the studied islands. (denotations as in Table 3).

species	Haiti	Vieq.	Tort.	Vir. G.	islands Aneg.	Angu.	Barbu.	Antig.		Barba.	Cura.	Arub.	Venez.
Enchytraeidae gen. spp. juv.	++		+	+	++	+++	++	+++		++	++	++	+
Tubificidae gen. spp. juv.	+++	+	+	+	+		++			+	+++	+++	
Aulophorus furcatus (Müll.)	++		+++	+++		+++	+	+		+++	+	+	
Pristina peruviana Cern.	+	+		+									
Dero obtusa Udek.	+	+			+						+		
Enchtytraeus buchholzi Vejd.	+												+
Prsitna aequiseta Bourne	+												
– leideyi Smith	+												
– longidentata Harm.	+												
Dero digitata Müll	+												
Stephensoniana trivandrana (Alyer)	+												
Dero sawayai Marc.			+	+	+++								
Pristina foreli (Pig)		+	+			+++		+					
Aelosoa spp. Ehr.		++			+								
Pristina Idrensis Sperb.							+						
Achaeta spp. Vejd.								+			+	+	
Propappus glandulosus Mich.											+	+	+
Slavina evelinae (Marc)									+				
Fontidrilus papillatus Dumm													+

Table 3. The occurrence of oligochaete species in various habitats.

species	wells	caves	inter. water	crev.	boreh.	springs
Tubificidae gen. spp. juv.	+++	+	++	+	+	++
Enchytraeidae gen. spp. juv.	+++	+	++	+	+	+
Aulophorus furcatus	+++	+			+	+
Dero sawayai	++				+	+
Achaeta spp. juv.	+	+	+			+
Propappus glandulosus	+	+	+			+
Pristina peruviana	+		+			+
Limnodrilus udekemianus	+					+
Enchytraeus buchhoizi	+		+			
Pristina floreli	+++					+
Aeolosoma spp.	++					
Pristina aequiseta	++					
– leidyi	+					
– idrensis	+					
Dero digitata	+					
– obtusa	+					
– haitiensis	+					
Slavina evilinae	+					
Embolocephalus velotinus	+					
Pristina longidentata						+
Stephensoniana trivandrana						+
Spirospermoides stocki						+
Fontidrilus papillatus						+

+ – 1 – 3 specimens in the sample
++ – 4 – 10 specimens in the sample
+++ – more han 10 specimens in the sample

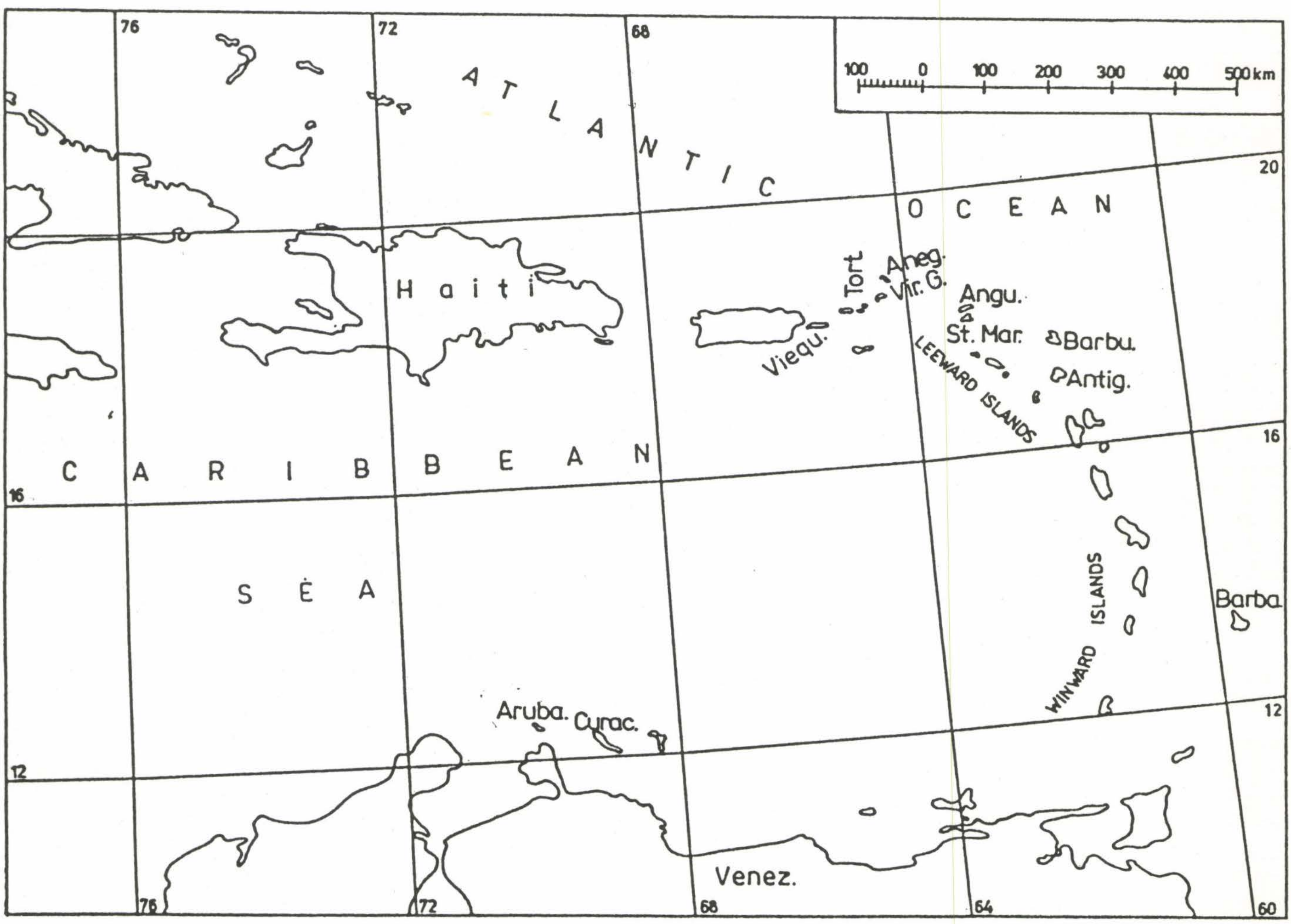

Fig. 1. Map of the studied area.

peruviana and P. longidentata. The discovery of Embolocephalus velutinus and Pristina idrensis, previously known only from Europe, was unexpected. The present state of knowledge about the distribution of oligochaetes is incomplete, thus «surprises» during investigation of new areas cannot be ruled out. Moreover, the species from West Indian Islands differ in some anatomical details from the European populations. This may mean that populations were separated long time ago and their speciation was independent.

On one island, 10 out of 21 determined species were found. This may have been caused by the non-uniform occurrence of oligochaetes on the islands as well as by the inadequate number of collected samples.

The greatest number of samples was collected in wells, and this correspond with the greatest number of determined species (Table 3). There are also numerous species in springs. The species found only in springs cannot be treated as belonging to the subterranean fauna. Their guts were found to contain mainly algae (diatoms) while the species living in wells feed almost exclusively on detritus.

More materials are needed to draw more definite conclusions, and I hope that further expeditions will be organized for this purpose.

I would once again like to express my gratitude to prof. Jan H. Stock for presenting me with the oligochaete material, which has made the writing of this paper possible.

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A new stygobiont amphipod crustacean (Crangonyctidae, *Stygobromus)* from glaciated karst on Vancouver Island, Canada

John R. Holsinger, D. Patrick Shaw***

**Department of Biological Sciences Old Dominion University, Norfolk, Virginia, U.S.A.*

***Department of Zoology University of British Columbia, Vancouver, B.C., Canada.*

RESUM

En aquest treball es descriu una nova espècie de l'amfípod subterrani d'aigua dolça del gènere Stugobromus de l'illa de Vancouver (Canadà), d'on es va recollir, en dues cavitats, els anys 1981-1982. Aquest és el tercer amfípod estigobiont citat del Canadà i l'onzè membre del gènere es troba en indrets situats al nord dels límits meridionals de la glaciació plistocènica. Stygobromus *n. sp. Pertany al grup de* hubbsi*, un conjunt d'espècies hipògees estretament relacionades, que ja fou citat anteriorment a la part occidental dels E.E.U.U., al sud de la Colúmbia Britànica.*

La presència d'aquesta espècie en diverses cavitats d'una illa que ha estat sotmesa a glaciacions i separada del continent, planteja algunes interessants qüestions zoogeogràfiques. Va tenir aquesta espècie accès a l'illa a través de vies intersticials de sediments de grans partícules de sorra de Quadra que va emplenar diverses zones de l'estat de Geòrgia durant el Plistocè més recent?, o prové, tal vegada, d'alguns avantpassats seus que varen viure a l'illa abans no es formés l'estret de Juan de Fuca, a l'Eocè?

RESUMEN

Se describe una nueva especie del anfípodo subterráneo de agua dulce del género Stygobromus *de la Isla de Vancouver, Canadá, de donde se recogió en dos cavidades en 1981-82. Este es el tercer anfípodo estigobionte citado de Canadá y el onceavo miembro del género que se encuentra en localidades situadas al N. de los límites meridionales de la glaciación Pleistocena.* Stygobromus *n. sp. es un miembro del grupo de* hubbsi*, un conjunto de especies hipogeas estrechamente relacionadas, que fué citado previamente de la parte occidental de los Estados Unidos, al Sur de la Columbia Británica.*

La presencia de esta especie en cavidades en una isla que ha sufrido glaciaciones, separada del continente por estrechos marinos, plantea algunas interesantes cuestiones zoogeográficas. ¿Es que esta especie tuvo acceso a la isla desde el continente a través de vías intersticiales en sedimentos de grano grueso de la arena de Quadra, que rellenó partes del Estrecho de Georgia en el Pleistoceno reciente, o quizás proviene de antepasados que vivieron en la isla antes del desarrollo del Estrecho de Juan de Fuca, en el Eoceno?

SUMMARY

A new species of the subterranean frehswater amphipod genus Stygobromus *is being described from Vancouver Island, British Columbia, Canada, where it was collected from two caves in 1981-82. This is the third stygobiont amphipod recorded from Canada and the eleventh member of the genus to be found in localities north of the southern limits of Pleistocene glaciation.* Stygobromus *n. sp. is a member of the* hubbsi *group, an assemblage of closely similar hypogean species that was previously recorded from the western United States south of British Columbia.*

The presence of this species in caves on a glaciated island separated from the mainland by marine straits raises some interesting zoogeographic questions. Did this species gain access to the island from the mainland through interstitial routes in coarse sediments of the Quadra Sand which infilled parts of the Georgia Strait in the late Pleistocene, or did it evolve from ancestors that were present on the island prior to development of the Juan de Fuca Strait in the Eocene?

Introduction

During fieldwork in 1981 and 1982, one of us (DPS) collected blind, white stygobiont amphipod crustaceans from two caves on Vancouver Island, British Columbia, Canada. Samples were taken from drip pools and a stream in several parts of Thanksgiving Cave located southeast of Tahsis, and from a terminal pool in Hourglass Cave located southwest of Lake Cowickan. These caves are located approximately 220 km apart and are developed in separate outcrops of Triassic-age Quatsino limestone. Although other caves on Vancouver Island have been explored biologically, stygobiont amphipods have not been found outside of the two localities listed above.

The Vancouver Island amphipods represent an undescribed species of the widely distributed, subterranean freshwater genus *Stygobromus* (family Crangonyctidae). It is the third stygobiont amphipod to be recorded from Canada and the eleventh member of the genus to be found in localities north of the southern limits of Pleistocene glaciation (see Holsinger 1981). A description of this new species is in preparation by the authors.

Stygobromus n. sp. is a member of the *hubbsi* group, a cluster of morphologically closely allied species previously recognized from the western United States (Holsinger 1974, Ward 1977). As presently defined, the *hubbsi* group consists of 19 described species, all of which occur in areas west of longitude 104°W except *S. putealis* (Holmes) which is recorded from wells in southeastern Wisconsin (see Fig. 1). In addition there are approximately 10 provisionally recognized but undescribed

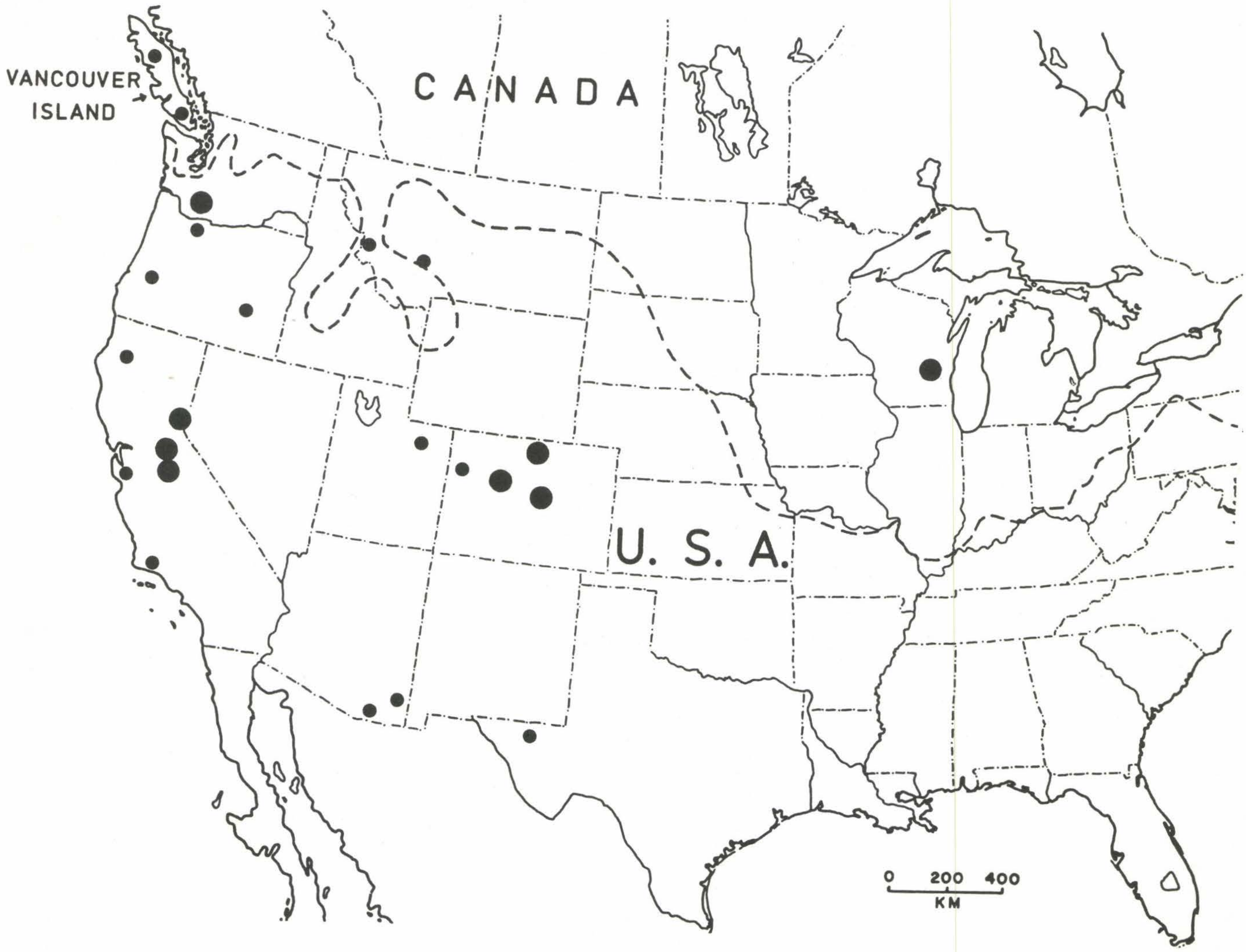

Fig. 1. Geographic distribution of the hubbsi *group of* Stygobromus *in North America. Larger closed circles indicate two or more proximate localities; smaller closed circles indicate single localities. Note the two localities for* Sytgobromus *on Vancouver Island. Heavy dashed line indicates approximate maximum extent of continental glaciation in the Pleistocene. Data from both described and undescibed species are plotted. Map based on Holsinger (in press).*

species in this group from the western United States (Holsinger, unpublished).As shown in Figure 1, the new species from Vancouver Island occurs approximately 320 km farther north than any other member of the *hubbsi* group and is further isolated geographically by virtue of its apparent restriction to an island that is separated from the mainland by deep marine straits. Members of the *hubbsi* group are recorded from a wide variety of subterranean groundwater habitats, including limestone and lava caves, wells, springs, interstices of gravel substrates beneath surface streams (hyporheic), and the outflow of seeps (hypotelminorheic). In addition, two species are recorded from the depths of Lake Tahoe and several are reported from interrumpted surface streams, but like all other species of *Stygobromus* they are of subterranean facies and are considered to be stygobionts (Holsinger 1974, Ward and Holsinger 1981).

Observations and Discussion

The apparent restriction of the Vancouver Island species to the subterranean groundwaters of a glaciated karst region and its geographic isolation from closely related species on the mainland by a substantial marine-water barrier raises some interesting zoogeographic questions. (1) Was this species able to survive one or more periods of glaciation in groundwater refugia beneath the ice? (2) Did this species evolve from freshwater ancestors that were already established on the island prior to development of the Juan de Fuca Strait in the Eocene, or did it gain access to the island from the mainland by dispersal through interstitial routes in coarse sediments of the Quadra Sand which infilled parts of the Georgia Strait in the late Pleistocene?

Vancouver Island is presently isolated from the mainland on the east and south by marine waters of the Georgia and Juan de Fuca straits, respectively. Georgia Strait is a downwarped trough believed to have originated during a period of tectonic activity in the Late Cretaceous (Jeletzky 1965, Sutherland Brown 1966), whereas Juan de Fuca Strait has existed as a major marine embayment since its origin in the Eocene (Mayers and Bennet 1973). Apart from glacial periods when these straits were probably filled with ice, Vancouver Island has been effectively isolated from mainland North America since late in the Eocene.

Stygobromus, as well as all other members of the family Crangonyctidae, is known only from freshwater environments, and marine relatives or putative marine ancestors are completely unknown (Holsinger 1977, in press). Crangonyctids are believed to have lived in freshwaters of the Holarctic region since the time of the Laurasian paleocontinent in the Mesozoic (Holsinger, in press).

Given these observations, let us now examine closely the two zoogeographic questions raised above. Assuming for the moment that *Stygobromus* was present on the island prior to one or more glacial advances in the Pleistocene, what is the possibility that it survived the potentially inimical effects of glaciations? The occurrence of a small but significant number of stygobiont crustaceans, principally amphipods and isopods, in glaciated regions of the Northern Hemisphere, where most cave faunas are thought to be have been extirpated by glacial action, is clearly documented (see Holsinger et al. 1983). In North America, at least six stygobiont amphipods, including the one from Vancouver Island, are either endemic to glaciated regions or represented there by disjunct populations far removed from those in unglaciated regions to the south (Holsinger et al. 1983). To explain these relict distributions, one of us (JRH) has hypothesized elsewhere, that under certain conditions some aquatic subterranean species might have survived extended periods of glaciation in deep groundwater refugia beneath the ice, and that their present ranges have not resulted from northward migrations since Wisconsin time but instead probably reflect very old, preglacial distributions (Holsinger 1978, 1980, 1981). The evidence in support of this theory was reviewed recently by Holsinger et al. (1983) and need not be repeated here. This theory applies with equal weight to Vancouver Island, where caves were probably covered by extensive Pleistocene glaciers, the last of which, the Fraser glaciation, lasted for about 29.000 yr B.P. until about 8.500 yr B.P. (Heusser 1960, Alley and Chatwin 1979, Howes 1981). According to the subglacial refugium model, it is conceivable that *Sygobromus* n. sp., like other congeners in glaciated parts of North America, could have survived one or more periods of glaciation on Vancouver Island.

Turning now to the second question, two alternate hypotheses can be advanced to explain the occurrence of *Stygobromus* n. sp. on Vancouver Island (Holsinger and Shaw, ms. in prep.). The first, which is a vicariance hypothesis, suggest that putative ancestors of the *hubbsi* group species were formerly widely distributed in central and western North America and that the present species have evolved from populations that were geographically isolated throughout the range shown in Figure 1. This theory assumes that the ancestor of *Stygobromus* n. sp. was present on what is now Vancouver Island prior to development of the Juan de Fuca Strait in the Eocene, and that this species has been isolated from other members of the *hubbsi* group for approximately 40 million years. Although very little is known about the rate of morphological change among species of *Stygobromus,* the close morphological similarity of the Vancouver Island species to those on the mainland would suggest a far shorter period of isolation than is implied in this hypothesis.

The second hypothesis, which is based in part on dispersal, suggests an invasion of Vancouver island by *Stygobromus* in the Pleistocene, and is therefore more easily reconciled with the close morphological similarity between the island and mainland species. According to this theory, the most recent potential freshwater link between Vancouver Island and the mainland occurred near the initiation of Fraser glaciation, coincident with deposition of a widespread lithological unit called the Quadra Sand (Clague 1976, 1977). These sands are a north-south diachronous deposit laid down at the tongue and margins of glaciers advancing southward down the Georgia Strait and onto the Puget Sound lowlands. During the period of deposition, parts of Georgia Strait were infilled by sands and gravels pushed forward by advancing glaciers, resulting in extensive flood plains and braided river channels supplied by meltwaters (Clague 1977, Fyles 1983). Assuming that *Stygobromus* was present on the mainland of British Columbia prior to Fraser time, it is conceivable that these organisms colonized interstitial habitats in the flood plain gravels and utilized them as a dispersal route to the island. In further support of the dispersal hypothesis, is the presence of Quadra Sand deposits in the same general vicinity as the cave localities for *Stygobromus* on Vancouver Island. Moreover, considering the great distance and discontinuous belts of cavernous limestone between the two known cave localities, there is a good possibility that this species continues to occupy groundwater habitats outside of caves *per se* and that its present range is therefore determined in part by interstitical dispersal.

Acknowledgments

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Distribution des amphipodes (Crustacea) dans les eaux hypogées interstitielles des alluvions de la save par rapport aux conditions des biotopes

M. Meštrov, Romana Lattinger et M. Kerovac
Institut de zoologie de la Faculté des Sciences naturelles-mathématiques de l'Université de Zagreb

RESUM

Una anàlisi de la fauna dels amfípods s'ha dut a terme durant les investigacions ecològiques de les aigües suberrànies intersticials al llarg del curs del riu Save. Les espècies del gènere Niphargus *són les més abundants:* N. minor, N. longidactylus, N. multipennatus, N. labascensis, N. serbicus, N. lattingerae, N. sp. *A remarcar la presència també de* Bogidiella albertimagni *i* Synurella ambulans.

S'ha estudiat la distribució horitzontal i vertical d'aquests amfípods. El més abundant és N. minor *(42,5 % de tots els amfípods), el qual només ha pogut ésser localitzat en els llocs més influenciats per la pol·lució del riu. En aquests mateixos indrets s'ha trobat també* N. sp., *si bé que en un nombre molt més restringit.*

La influència de l'aigua contaminada s'ha pogut constatar a partir de les variacions sofertes en la concentració d'O_2 i CO_2, en la quantitat de substàncies orgàniques i altres propietats químiques. També segons els bacteris –sobretot coliformes–, segons la penetració de la fauna epigea procedent del llit del riu: Tubificidis (Oligoquets) i les larves de Chironomidis (Dípters).

Altres espècies, com N. longidactylus, *dins les més nombroses, ha estat torbada sovint en llocs on la influència del Save era escassa o bé no es notava en absolut.*

RESUMEN

Un análisis de la fauna de los anfípodos ha sido realizado durante las investigaciones ecológicas de las aguas intersticiales subterráneas a lo largo del río Save. Las especies del género Niphargus *predominan:* N. minor, N. Longidactylus, N. multipennatus, N. labacensis, N. serbicus, N. lattingera, N. sp., Bogidiella albertimagni *y* Synurella ambulans *son singulares.*

Ha sido estudiada la distribución horizontal y vertical de estos Anfípodos.– El más abundante es el N. minor *(42,5 % de todos los Anfípodos), que solamente ha sido hallado en los lugares más influenciados por el río polucionado. En los mismos lugares han sido hallados* N. sp., *aunque en número más restringido.*

La influencia del agua polucionada se ha podido constatar según las variaciones de 0_2 y CO_2, cantidad de substancias orgánicas y otras propiedades químicas: según las bacterias, sobre todo coliformes; según la penetración de la fauna epígea proveniente del lecho del río: Tubificidos (Oligochaeta) y las larvas de los Chironomidos (Diptera). Otras especies, N. longidactylus *como la más numerosa, ha sido hallado más a menudo donde la influencia del Save era débil o bien no existía en absoluto.*

RÉSUMÉ

Une analyse de la faune des Amphipodes est effectuée pendant les recherches écologiques des eaux interstitelles souterraines le long de la rivière Save. Les espèces du genre Niphargus *prédominent:* N. minor, N. longidactylus, N. multipennatus, N. labacensis, N. serbicus, N. lattingerae. N.sp., Bogidiella albertimagni *et* Synurella ambulans *été singulières.*

On a étudié la répartition horizontale et verticale de ces Amphipodes.– Le plus abondant été N. minor *(42,5 % de tous Amphipodes), qui était trouvé seulement sur les endroits les plus influencés de la rivière poluée. Sur les mêmes lieus était trouvé* N.sp., *quoique en nombre plus restreint.*

L'influence de l'eau poluée on a pu constater selon les variations de O_2 et CO_2, quantité des substances organiques et des autres propriétés chimiques; selon la presénce des bacteries, surtout des coliformes; d'après la pénétration de la faune épigée provenant du lit de la rivière: Tubificides (Oligochaeta) et les larves des Chironomides (Diptera). D'autres espèces, N. longidactylus *comme la plus nombreuse, on les a trouvées le plus souvent où l'influence de la Save était faible ou il n'existait pas du tout.*

Introduction

Avec l'augmentation de la surcharge des cours d'eau en matières de rebut, le danger de pollution des eaux hypogées ayant un lien avec ces cours d'eau a augmenté, or elles sont une importante source d'eau potable. Pour cette raison, l'intérêt à l'égard des recherches faites dans les eaux interstitielles s'est accru, étant entendu qu'une plus grande attention est consacrée aux conditions écologiques des régions ayant fait l'objet des recherches, ainsi qu'à leurs biocénoses (Danielopol 1976, 1980; Delamare-Deboutteville 1960; Husmann 1966, 1977, 1982; Meštrov 1960; Ruffo 1961). Les recherches actuelles sont orientées vers la recherche des paramètres pour l'évaluation des interactions des eaux hypogées et épigées, et l'estimation de la qualité des eaux hypogées (Danielopol 1976; Ferrarese et Sambugar 1976; Gibert et al. 1977; Meštrov et al. 1976; Meštrov et Lattinger-Penko 1978; Seyed-Reihani 1982; Dole 1984).

Nous présentons ici l'essai en vue d'établir la dépendance de la faune des amphipodes des eaux interstitielles sur la force de l'influence de l'eau fluviale polluée. En d'autres termes, en vue de trouver également dans les eaux hypogées des paramètres biologiques selon lesquels pourrait être défini le degré de pollution.

Matériaux, lieu et période des recherches

La partie des travaux faite sur le terrain a été effectuée de l'automne 1979 au printemps 1981. Les échantillons d'amphipodes utilisés dans cet exposé ont été recueillis à l'aide de pompes par des tuyaux piézométriques, en septembre, octobre et décembre 1979, et en mars 1980. Nous profitons de cette occasion pour remercier le Dr Gordan Karaman de Titograd, qui les a déterminés.

La puissance et la portée de l'influence des eaux fluviales ont été déterminées par des recherches écologiques, à savoir des analyses des propriétés physico-chimiques, bactériologiques et faunistiques des eaux interstitielles et des eaux de la rivière Save ont été effectuées (Meštrov et al., 1983).

Des recherches des eaux hypogées ont été faites à six postes disposés sur une distance de 84,7 km du cours de la rivière Save (737,4-652,7 km), où ont été disposés des tuyaux piézométriques, individuellement ou en séries. Les postes ont été choisis de façon à ce qu'ils puissent donner un aperçu des eaux hypogées le long du cours et latéralement au cours de la rivière, étant donné qu'à deux stations ont été practiquées des séries de forages en plan perpendiculaire au cours de la rivière (figure 1). A la station III, il y avait 4 groupes ayant chacun 5 tuyaux allant de 0,5 à 7 m de profondeur. La description détaillée des postes est présentée dans l'étude de Meštrov et al., 1983.

Résultats et discussions

Grâce à la disposition des forages sur les lieux choisis, nous avons pu suivre entre Brežice et Sisak les propriétés des eaux hypogées le long de la Save, à différentes profondeurs et distances de la rivière. Dans ce but ont été mesurés simultanément dans les eaux interstitielles et dans la rivière: la température, l'oxygène, le gaz carbonique, l'alcalinité, la dureté de l'eau, les compositions azotées (ammoniaque, nitrates, nitrites), demande en $KMnO_4$, demande biochimique en oxygène (DBO5). Ensuite ont été déterminées les bactéries hétérotrophes et les coliformes, puis quelques groupes physiologiques de bactéries. Une évaluation saprobiologique de l'eau de la Save a également été faite, la composition de la faune des eaux hypogées a été analysée, la densité des populations a été évaluée, ainsi que sa répartition sur l'espace (Meštrov et al. 1983).

Selon les modifications des paramètres mesurés, l'on voit que l'influence des eaux épigées diminue rapidement avec l'éloignement de la rivière et de la profondeur. Ceci est évident par le mode d'oscillation des paramètres mesurés, le changement du nombre des bactéries et des représentants de la faune épigée. A Brežice (poste I), l'influence est indiquée jusqu'à 80 m au minimum; à Podsused (poste II) jusqu'à 200 m des deux côtés de la rivière et à Opatovinski sprud (poste III) jusqu'à 100 m, en fonction du niveau des eaux également. Il est aussi visible que l'influence de la rivière dans la région de ces stations est favorable à la faune car les populations les plus nombreuses et les plus diverses sont développées à cet endroit. C'est peut-être parce que les oscillations des facteurs écologiques ne dépassent pas la valence de ces animaux, et il y a également à cet endroit-là une plus grande accumulation de matières organiques (nourriture).

Le poste Opatovinski sprud est particulièrement intéressant; à l'aide de quatre groupes de forages à des distances différentes de la rivière, et sur la base des paramètres mesurés et des analyses de la faune interstitielle, on a pu y définir la région du biotope hyporhéique. A cet endroit, il a une largeur d'environ 135 m. On a pu y déterminer la profondeur et la largeur de la pénétration de la faune fluviatile dans les interstices des alluvions près de la rivière. Dans le sens contraire, la pénétration dans la zone riveraine de la faune hypogée (phréatique) provenant des eaux hypogées lointaines, et son mélange avec la faune venant de la rivière ou qui vit en permanence dans le milieu hypogé de la rivière (biotope hyporhéique), sont visibles.

Dans les postes en aval (Blato IV, Prevlaka V, Ruča VI), qui ont les propriétés des eaux phréatiques typiques (température uniforme, dureté élevée, peu de O_2, beaucoup de CO_2, peu de bactéries et de matières organiques), la faune s'appauvrit de plus en plus tant en ce qui concerne les taxa que le nombre des exemplaires.

Outre la répartition générale de la faune interstitielle, nous avons particulièrement observé le groupe des crustacés amphipodes.

Au cours des recherches faites dans les eaux interstitielles le long de la rivière Save, 9 espèces d'amphipodes ont été trouvées:

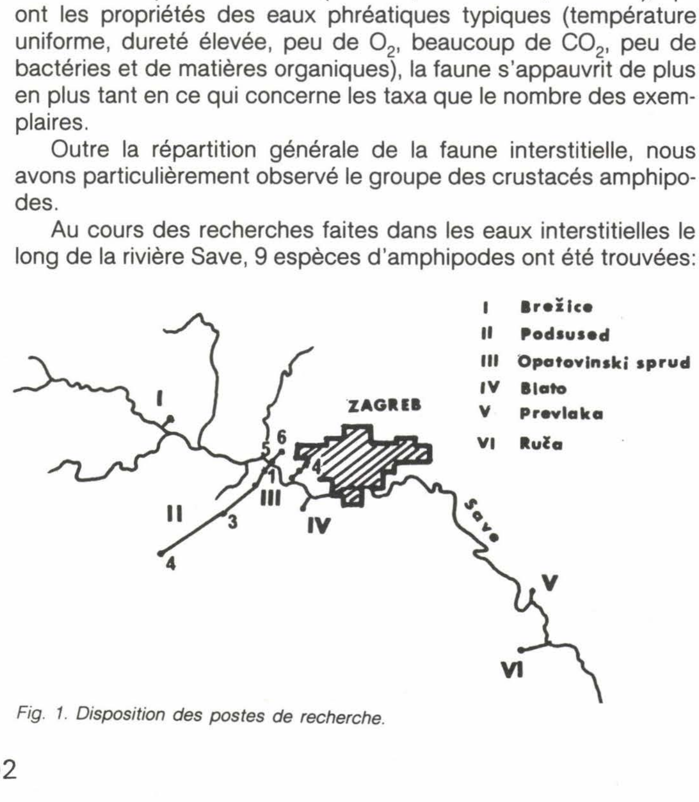


Fig. 1. Disposition des postes de recherche.

Niphargus minor, N. longidactylus, N. multipennatus, N. labacensis, N. lattingerae, N. serbicus, N. sp., Bogidiella albertimagni et *Synurella ambulans.*

Au total ont été recueillis 13.943 exemplaires d'invertébrés macroscopiques, et la part des amphipodes s'y élève à un total de 2,8 % seulement. Par leur nombre, ils sont les deuxièmes parmi les animaux hypogés. Le pourcentage d'amphipodes et le nombre moyen de leurs individus par échatillon (200 l d'eau) sont très différents d'un poste à l'autre, et augmentent, en principe, avec la diminution de l'influence de l'eau de la rivière (figure 2). A Opatovina, un poste où le pourcentage des amphipodes est élevé parmi tous les invertébrés interstitiels (8,8 %), est divergent. C'est ici que l'on trouve le plus grand nombre moyen d'amphipodes par échatillon (21 exemplaires par 200 l d'eau). C'est semblable à un point de Podsused où le pourcentage d'amphipodes estest de 2,4 % de la faune totale, soit en moyenne 9 individus dans 200 l d'eau. Un aussi gran nombre d'amphipodes à ces postes où l'influence de l'eau de la Save est plus forte, peut s'expliquer par le fait que les amphipodes sont représentés para les espèces *N. minor, N. longidactylus* et *N. multipennatus* dont *N. minor* vient, selon nos recherches, exclusivement dans de tels endroits où l'influence est forte; les deux autres espèces ont été trouvées dans des situations écologiques très différentes des eaux interstitielles.

Aux points hors de l'influence de l'eau de la rivière (Blato-IV, Opatovinski sprud-III/4), l'on trouve le plus grand pourcentage d'amphipodes – 16,7, respectivement 12,4 %. Un très petit pourcentage d'amphipodes dans l'ensemble de la faune est aux points qui sont sous l'influence permanente de l'eau de la Save (I, II/I, III/1, III/2).

La diversité des espèces d'amphipodes est différente également d'un point à l'autre. La diversité des espèces d'amphipodes est la moindre aux points où les conditions écologiques sont extrêmes à cause de l'influence des eaux polluées de la Save (I, II/I, III/1, III/2, III/3).

Fig. 2. Densité des populations d'amphipodes (grandeur des circles) et le pourcentage de leurs espèces dans l'ensemble de la faune (segments des cercles).
I-IV = signes de postes
Le nombre au-dessous du signe du poste = le nombre moyen d'exemplaires d'amphipodes dans 200 l d'eau.
Le nombre en parenthèses = pourcentage des amphipoodes dans l'ensemble de la faune.

Parmi les espèces d'amphipodes trouvés, les plus nombreux sont *Niphargus minor,* qui représente 38, 7 % de tous les exemplaires d'amphipodes trouvés. Viennent ensuite les espèces *N. longidactylus* et *N. sp.* qui représentent 29, 7, respectivement 19,7 % des amphipodes. Seule l'espèce *N. multipennatus* est encore un peu plus nombreuse et représente 6,9 % de tous les amphipodes trouvés. Les autres espèces viennent en petit nombre d'exemplaires et seulement dans certains échantillons, à certains postes. Sur la totalité des 13 postes, dans la majorité d'entre eux (7) apparaissent *N. multipennatus* et *N. longidactylus*. L'espèce *N. minor,* la mieux représentée au point de vue du nombre, a été découverte seulement dans trois postes (I, II/5 et III/3).

Conclusions

Sur la base de certaines caractéristiques écologiques du biotope et de la distribution des amphipodes qui y vivent, nous avons pu remarquer que certaines de leurs espèces ont des exigences écologiques différentes, car elles se présentent régulièrement dans des conditions, respectivement dans des zones déterminées.

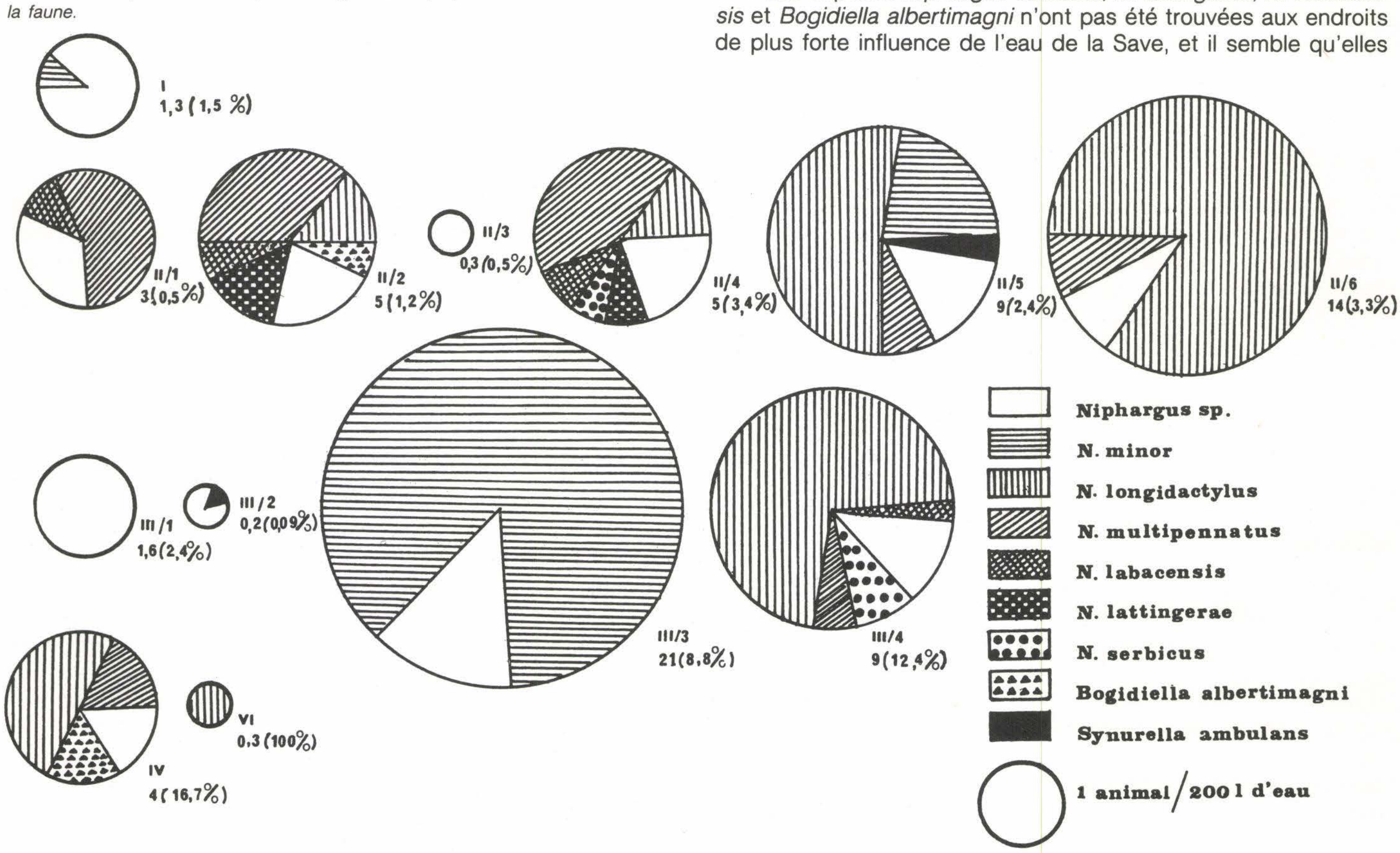
L'espèce *Synurella ambulans* dont on sait qu'elle pénètre assez profondément dans le substrat poreux, a été trouvée aux endroits où l'on a remarqué une forte pénétration de l'eau de la rivière lorsque le niveau des eaux est plus élevé. Comme pour les autres animaux épigés, on peut donc la considérer comme un indicateur d'un lien avec les eaux épigées.

Niphargus minor est l'espèce la plus nombreuse et ne vit que dans les postes où l'eau de la rivière est très polluée.

Quant aux autres espèces, soit qu'elles ne viennent pas aux endroits où l'eau polluée de la rivière exerce son influence, soit qu'elles y vivent par intermittence et en petit nombre, qu'elles sont davantage liées aux eaux interstitielles naturelles où la rivière a exercé une moindre influence. On peut distinguer parmi celles-ci deux groupes, d'après leurs exigences écologiques:

–*Niphargus longidactylus* et *N. multipennatus* ont, semble-t-il, une plus grande valence écologique, car ces espèces vivent dans les eaux interstitielles en dehors de toute influence de pollution de la rivière, mais aussi aux endroits de plus forte influence.

–Les espèces *Niphargus serbicus, N. lattingerae, N. Labacensis* et *Bogidiella albertimagni* n'ont pas été trouvées aux endroits de plus forte influence de l'eau de la Save, et il semble qu'elles



aient une valence écologique plus restreinte et qu'elles soient liées aux eaux interstitielles non polluées.

Ces recherches sont un essai en vue de détecter également dans les eaux hypogées les paramètres biologiques selon lesquels il serait possible de déterminer le degré de leur pollution.

Adresse: Zoologijski zavod PMF (Institut de zoologie). Rooseveltov trg 6, 41000 Zagreb, Yougoslavie.

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The discovery of the ampullary organs in cave salamander Proteus anguinus Laur. (Urodela, Amphibia)

Lili Istenič

Institut of Biology, Edvard Kardelj University of Ljubljana

RESUM

Els problemes de l'endemisme restringit de l'urodel cavernícola Proteus anguinus *van representar un estímul per a una àmplia investigació sobre l'organització de l'animal en relació amb les condicions químiques concretes de les aigües subterrànies del carst dinàric. Els resultats d'aquest estudi van fer possible el descobriment, per primera vegada en un taxó troglobi, d'òrgans sensorials que li permetien la detecció de fenòmens elèctrics dins l'hàbitat. Els òrgans ampul·larials del* Proteus *estan constituïts pels «orgànuls de Bugnion» (1873), els quals s'han seguit considerant com a neuromasts mecanoreceptius. La nova anàlisi morfològica va posar de manifest una sèrie de característiques prou significatives que permetien de relacionar-los amb els electroreceptors ampul·larials que es coneixen en alguns vertebrats d'aigüa dolça. L'anàlisi morgològica funcional referent als detalls estructurals ha demostrat que aquests òrgans del* Proteus *són altament especialitzats i adaptats a la detecció de camps elèctrics, probablement abundants en l'hàbitat del* Proteus *i que han de jugar, per força, un paper important en el sistema de vida troglobi. L'identificació morfològica d'aquests importants òrgans en* Proteus *representa un interessant punt de partida per a la investigació de les formes d'orientació de l'animal.*

RESUMEN

El problema del endemismo restringido del urodelo cavernícola Proteus anguinus *estimuló una investigación extensiva de la organización del animal en relación con condiciones químicas específicas en las aguas subterráneas del karst dinárico. Los resultados también hicieron posible el descubrimiento –por primera vez en un taxón troglobio– de órganos sensoriales para la detección de fenómenos eléctricos en el hábitat. Los órganos ampulariales del* Proteus *están representados por los «pequeños órganos» de Bugnion (1873) que continuaron designándose como neuromastos mecanoreceptivos, el nuevo análisis morfológico descubrió características significativas para los electroreceptores ampulariales conocidos en algunos vertebrados de agua dulce. El análisis morfológico funcional referente a los detalles estructurales ha mostrado que estos órganos en* Proteus *están altamente especializados para la detección de campos eléctricos para los que el auténtico hábitat de* Proteus *parece muy probablemente una fuente especialmente rica, con respecto al indiscutible papel del electrorecepción para el sistema de vida troglobio, la identificación morfológica de estos relevantes órganos en* Proteus *representa un importante punto de partida para la investigación de la orientación del animal.*

SUMARY

The question of restricted endemism of the cave urodele Proteus anguinus stimulated an extensive investigation of the animal's organisation in relation to specific chemical conditions in the underground waters of the Dinarian karst. The results also rendered possible the discovery –firstly in a troglobit taxon– of sense organs for the detection of electrical phenomena in the habitat. The ampullary organs in Proteus are represented in the «small organs» of Bugnion (1873), which have remained designated as developing mechanoreceptive neuromasts. The renewed morphologic analysis displayed characteristics significant for ampullary electroreceptors known in some freshwater vertebrates. The funcional morphological analysis concerning the structural details support the assumption that theses organs in Proteus are highly specialised for the detection of electrical fields for which the authentic habitat of Proteus is very likely an especially wealthy source. In respect to the indisputable role of electroreception for the troglobit mode of life, the morphological indentification of relevant organs in Proteus represents an important turning point for the investigations of the animal's orientation.

Proteus is the only troglobite vertebrate in Europe, and the biggest troglobite animal altogether. Proteus anguinus is as single species a member of the Proteidae family.

The restricted endemism of the neotenous cave salamander Proteus anguinus stimulated an extensive investigation of the animal's organisation in relation to the specific chemical conditions in the underground waters of the Dinarian Karst (**Istenič** 1971, 1982). Morphological investigations of its sensory organs are an important part of the research work combining the study of the specific adaptations of the animal with hydrochemical parameter studies of its environment. They add to the knowledge of known sensory organs in Proteus, like the inner ear (**Istenič and Bulog** 1976, **Bulog** Dissert. 1986) and, on the other hand, help in discovering and analysing new sensory organs and modalities, like taste buds and ampullary organs with their possible role in electroreception.

The histologic sections and the ultrastructure of the apical surface of the sense organs in the buccopharyngeal mucosa have been presented previously (**Istenič** and **Bulog** 1979). The apical parts of the taste buds are exposed on the mucosal surface (and not sunk into a pore). The organs are placed in the central buccal cavity and possible on the edge body surfare, where thay have been so far found at the of the gill slits. The face suggests, that gustoreception with the Proteus may not be limited only to tasting the food consumed, but might be expected to extend its function still further.

Ampullary organs were discovered while research on the structure of Proteus acoustico-lateralis system was taking place. The basic neuromast structure was described by **Bugnion** (1873), and their seismosensory role in Proteus orientation dealt with by **Briegleb** (1962). Morphologically **Durand** (1971) studied the histology and distribution of neuromasts, and compared them to lateral-line system in cave fish (**Thinés** and **Durand** 1973).

When analyzing the histological sections of the snout, our attention was struck by little club-shaped sensory organs, which differ significantly from the bigger bulbous ones. **Bugnion** (1873) desribed them to be developing neuromasts, however light microscopy has shown them to be fully developed sensory organs differing from ordinary neuromasts no only in shape and size but also in the configuration of the sensory epithelium. The morphological resemblance to known ampullary electroreceptors in some freshwater fish as the lung fish Protopterus and brachiopterygian Calamoichtyes (**Roth** and **Tscharntke** 1976), the catfish Ictalurus nebulosus (**Mullinger** 1964, Roth 1969), and to probable electroreceptors that have been discovered in the order Gymnophyona in larval Ichthyophis (**Heterington** and **Wake** 1979) and in several species of the ordo Urodela (**Fritzsch** 1981), proved the conjecture that a new sensory modality, which would be of utmost importance for troglobites, migth have been found. Additional research, making use of the transmission and scanning microspope techniques further substantiated the findings and established the characteristics of ampullary organs (**Istenič** and **Bulog** 1984).

These multicellular sense organs in Proteus occur in the snout and the skin epithelium, resting on a slightly lifted basa membrane. They consist of a short jelly-filled canal and a single ampulla, which is shieldered from neighbouring epitelial cells by mantle cells. The canal leads distally to the surface of the skin and proximally into the pit of the ampulla, establishing connection with apical parts of the sensory and accessory cells. The ampullary cells are restricted to the upper third of the ampulla, their nuclei lying in a circumferential plane. The lower two thirds of the ampulla are densely packed with oblong nuclei of the accesory cells. The canal and the ampullar cells are on the luminal side linked by tight junctions, their free membranes are microvillary differentiated. The apical surface of the sensory cells is characterised by microvilli, which are extremely abundant (–400) and enlarged. The uniform organisation of the apical microvillous part shows a hexagonal pattern. Their length increases from the periphery toward the center of the cell, forming a coniform structure. A basal body was found in some sensory cells whereas a kinocilium was observed only in a single cell.

The research in electroreception has seen a remarkable development in the past two decades. The combination of morphological analyses, electrophysiological measurements and ethological observations offers heuristic perpectives for further researchwork, especially in the study of neuronal connections and the role of the brain centers in the information processing (**Bullock** et al. 1983).

In general most electroreceptive fish live in conditions of poor visibility and as a rule are the electroreceptive properties combined with low visual ability. Under such conditions is electroreception an important sense, contributing to feeding, comunication and orientation efficiency. Two behavioural features related to electroreception in lungfish Protopterus (Roth and Tscharntke 1976) and in Ichthyopis larvae (**Heterington** and **Wake** 1979) are air-gulping and ground feeding. The blind Proteus lives in perpetual darkness, feeds from the ground and has active lungs. Its benthic feeding patterns are documented by older observations and the yield of organisms from its digestive tube (unpublished) whereas gulping of the air was the objet of extensive laboratory (**Istenič** 1971, **Sojar** 1980) and field investigations (**Sojar** et al. 1981). Due to the neoteny Proteus retains the skin sensory equipment characteristic for aquatic vertebrates.

The existence of functional ampullary electroreceptors has also been confirmed in another member of the Urodela – in axolotl Ambystoma mexicanum, for which ethological (**Himstedt** et al. 1982), ultrastructural (**Fritzsch** and **Wahnschaffe** 1983) and electrophysiological (**Münz** et al. 1984) data are avaible.

The morphological characteristic of the Proteus' ampullary organs with their short canals and microvillar cones (densely packed microvilli increase the membrane capacitance indicate specialization for electrical current detection in very diluted cave water where due to resulting high resistance electrical phenomena might be an important source of information.

Ampullary organs are known to detect very weak electrical fields in the environment induced by the activity of organisms and physico-chemical reactions (**Szabo** and **Fessard** 1974). Their biological significance hasn't yet been fully elucitated. In the case of electroreceptive properties of the catfish Ictalurus nebulosus electrophysiological and ethological evidences (**Peters** and **Buwalda 1972, Roth** 1972) has been gathered with data of the electrical fields in the habitat (**Peters** and **Bretschneider** 1972).

to prove that bioelectrical fields are important for the animal in its search for the prey and social behaviour whereas the fields of chemical origin serve for orientation.

Although no direct data are available on the electrical phenomena in the habitat of Proteus, the results of our hydrochemical studies in the Planinska jama (**Istenič** 1979, 1982) suggest that tne electrical fields due to chemical reactions are considerable. Taking into account the karst hydrology notion (**Gams** 1966) owing to interaction of two geomorphological karst, systems the kinetics of the chemical reactions is augmented which further increases the ionic strength of the karstic aquatic environment. Therefore the expression of electrical fields is rather irregular but strong. Highest electrical activity can be expected in cave areas receiving deep saepage water and its lowering in the areas of sinking streams. Analyses of water samples from the peripheral and deeper regions of the Planinska jama have shown, that the water from the two regions periodically differs in oxygen, salt and heavy metal content. Changes of chemical parameters are considerable and owing to their periodical and rel. Stable appearance the resulting electrical properties could be detected by Proteus and used as possible source of information in its migrations.

The fact, that one ampullary sensory cell harbours a kinocilium has triggered interpretations of its relationship with the evolution of the ampullary system. The organs are considered to be part of the lateral-line system and are assumed to have developed by morphological and physiological specialization from ordinary neuromasts with regression of the kinocilium. Acording to a more recent interpretation the ampullary organs developed as a parallel sensory system in the earliest vertebrate evolution; the primitive ampullary cells bears both microvilli and kinocilium. Our thesis, that kinocilium in Proteus ampullary organ could reflect a primary structural condition has been susbtantiated with recent phylogenetic review of vertebrate electroreceptive system in general (**Bùllock** et al. 1983) and the amphibian system in particular (**Münz** et al. 1984). In the phylogenetic line of Urodela the ancient members should possess ampullary organs with primitive sensory cells with kinocilium, which would during further urodelan evolution gradually and completely disappear.

We believe that the research on the ampullary structure and function could lighten up the origin of the Proteus as it was implied by **Albin Seliškar** (1949/50). This approach accepted, Palaeoproteus klatti Herre 1935 was neotenous and lived in the twilight hypoxic tertiary Middle European lake habitat. Its skin sensory organs included the lateral-line neuromasts and the ampullary organs with sensory cells that were equipped with microvilli and kinocilium. As the lakes were slowly drying up, electroreceptors enabled Palaeproteus to see and find shelter in similar conditions in the karstic underground habitats. It was there, that morphological and physioethological development of the Proteus probably took place, including of course, the specialization of its ampullary organs

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Schooling behaviour in cavernicolous fish and their epigean conspecifics

Jakob Parzefall and Susanne Senkel

RESUM

La tendència a formar bancs o agrupacions, àmpliament estesa entre els peixos, depèn de l'existència d'estímuls visuals i de la línia lateral. En absència d'orientació visual, els peixos estudiats fins avui no presenten comportament de tipus gregari. Per aquest motiu el comportament gregari dels peixos no sembla pas controlat per la selecció natural; per tant, i atenent-nos a l'època de colonització de les cavitats subterrànies, aquest caràcter hauria de presentar-se més sovint i ser més variable.

Aquesta hipòtesi s'ha pogut verificar en poblacions cavernícoles de Poecilia mexicana *(Poeciliidae) i* Astyanax fasciatus *(Characidae) comparant-les amb elements de la mateixa espècie epigea. Val a dir que tant sols s'han utilitzat peixos amb ulls (poblacions originals o híbrides) amb una bona resposta òptico-motriu. La tendència a formar bancs de peixos en amdues espècies és significativament reduïda en els peixos cavernícoles i la variabilitat és molt més gran. Aquests resultats es discuteixen en relació a la seva situació ecològica i al seu hàbitat cavernícola.*

RESUMEN

La tendencia a formar bancos o agrupaciones, ámpliamente extendida entre los peces depende de la existencia de estímulos para la vista y la línea lateral. En ausencia de orientación visual los peces estudiados hasta hoy no presentan comportamiento de tipo gregario.

Por este motivo el comportamiento gregario en los peces cavernícolas parece no estar controlado por la selección natural. Por tanto, y en relación a la época de colonización de las cavidades subterráneas, este carácter debería mostrarse más y más variable.

Esta hipótesis se ha verificado en poblaciones cavernícolas de Poecilia mexicana *(Poeciliidae) y* Astyanax fasciatus *(Characidae) comparándolas con elementos de la misma especie epigeos. Tan sólo se han utilizado peces con ojos (poblaciones originales o híbridos) con una buena respuesta ópticomotora. La tendencia a formar bancos en ambas especies es significativamente reducida en los peces cavernícolas y la variabilidad es mayor. Estos resultados se discuten en relación a su situación ecológica y su hábitat cavernícola.*

SUMMARY

The schooling behaviour widley distributed among fish depends on stimuli for the visual and the lateral line system. In the absence of visual orientation the fish species studied up to now do not school.

For this reason the schooling behaviou in cave fish seems to be no longer controlled by selection. So in relation to the time of cave colonisation this trait should become more and more variable.

We have tested this hypothesis in cave populations of Poecilia mexicana *(Poeciliidae) and* Astyanax fasciatus *(Characidae) in comparison to epigean conspecifics. Only eyed fish (original populations and hybrids) with good optomotoric response have been used. The tendency for schooling in both species in significant reduced in the cave fish and the variability increased. The results will be discussed in relation to the oecological situation in the cave habitat.*

1. Introduction

The schooling behaviour is wideley distributed among fish (Senkel, 1983). From different studies on schooling the important role of visual orientation is well known (Partridge and Pitcher, 1980). So it is not surprising that the cave-fish studied did not show this behaviour: in *Caecobarbus geertsi* (Cyprinidae) (Berti and Thines, 1980), *Barbobsis devecchii* (Cyprinidae) and *Uegitglanis zammaranoi* (Clariidae) (Jankowska and Thines, 1982) the fish are in a random spatial distribution in their cave habitats and in aquaria. In *Poecilia mexicana* (Poeciliidae) and *Astyanax mexicanus* (= fasciatus) (Characidae) the fish swim without contact, dispersed throughout the cave pool (Parzefall 1979; 1983). The absence of schooling has also been described in an epigean population of *A. mexicanus* which lives near a cave entrance and shows an affinity to the cave (Romero, 1983). However, in epigean conspecifics of *A. mexicanus* and *P. mexicana* studied in Mexico schooling has been reported as common organisation in the epigean habitat (Parzefall, 1979; 1983).

The question arises whether the cave fish do not school because of the absence of visual orientation or of a genetically based reduction phenomenon. To answer this question individuals of the cave population of *Poecilia mexicana* with functional eyes have been tested for schooling in light and darkness. In *Astyanax mexicanus* only individuals of the population of the Micos cave after selection for functional eyes could be used. For the other population of *A. mexicanus* which is completely blind there could obtained eyed fish for the experiments only after hybridisation with epigean conspecifics. The results in eyed cave-fish and cave-

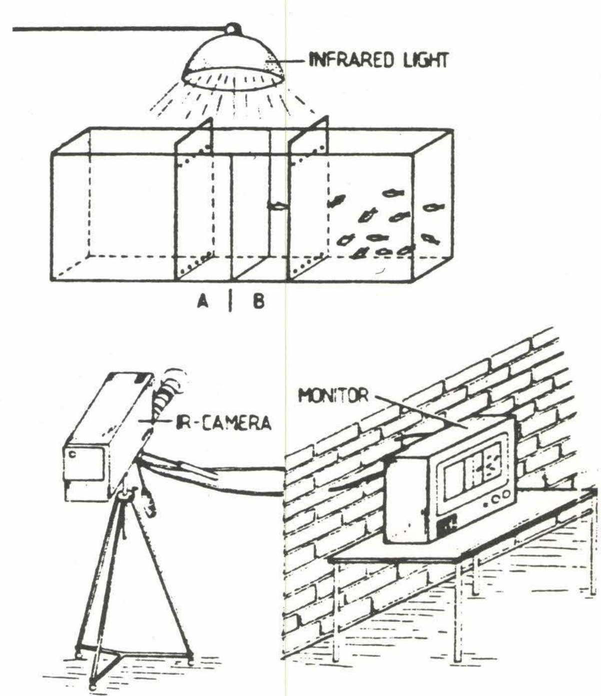

Fig. 1. Test aquarium and infrared videosystem. Choice of the fish for A or B and changes between A and B have been registered.

fish hybrids have been compared with the results of epigean conspecifics.

2. Material and Methods

An epigean population of *Astyanax mexicanus* from Rio Teapao and cave-fish populations from Cave Micos (Wilkens and Burns, 1972) and Cave Piedras have been used. The Piedras fish which are completely blind have been hybridized with the Teapao River fish in the laboratory at the Zoological Institute of Hamburg University.

In *Poecilia mexicana* an epigean population of the Rio Teapao near the town Teapa and one of the Arroyo del Azufre near the cave entrance have been used. The cave-fish have been collected in the inner part of the cave (Chamber XIII, Peters et al. 1973). All animals have been imported directly from Mexico and have been rebred in light in the laboratory at our institute.

The eyed Micos cave fish are the result of a selection conducted in our laboratory by Horst Wilkens.

The visual orientation in all our cave fish and hybrids has been measured by the optomotoric response with a normal test apparatus. It consists of a rotable 25 cm plastic disc on which in a vertical position a 20 cm –high plastic cylinder with 23,5 cm diameter could be mounted. The device was rotated by a reversible, variable speed electric motor. The average speed used was 4 rotations per minute. The visual stimuli were interchangeable striped panels lining the plastic cylinder and consisting of vertical black and white stripes of equal width. The following stripes have been tested: 5,0 mm, 2,5 mm, 1,3 mm and 0,5 mm. They provide visual angles of 2° 30', 1° 1', 39', 15' of arc (Senkel, 1983). The test fish were restained in a 20 cm diameter polyacryl-cylinder hanging in the center. To keep the fish in a definite distance to the stripe-patterns smaller cylinder could be placed into the center of this cylinder. The light intensity in the apparatus was about 630 Lux. Each fish has been tested after a maximal adaptation time of 5 min. during a maximum of 10 min. observation time.

In *Poecilia mexicana* only cave fish with a visual acuity of 15' of arc have been chosen for the observation of schooling. In *Astyanax mexicanus* of the F_2-generation 8 fish with a visual

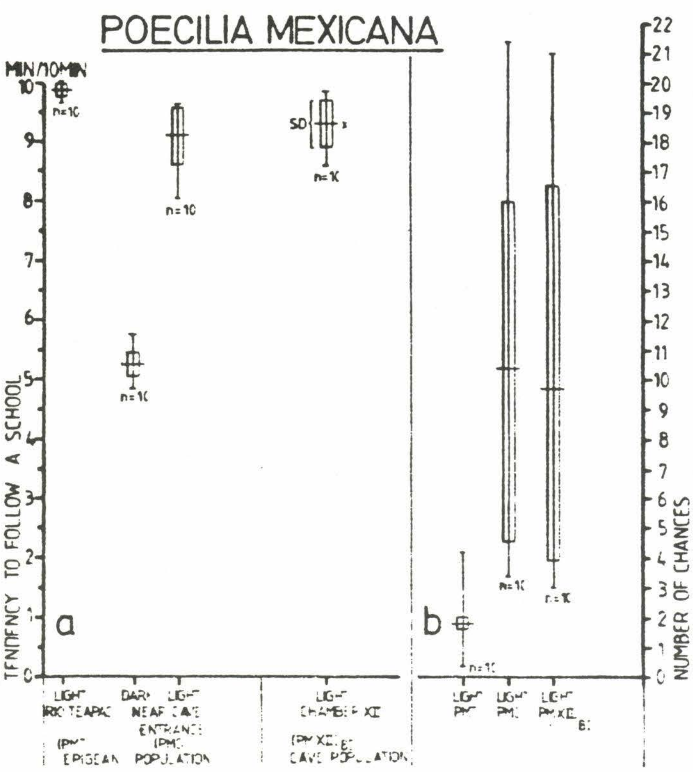

Fig. 2. Poecilia mexicana *a)tendency to follow the school during a 10 min test in three different populations and b) number of changes between A and B (see fig. 1). x = mean, SD = standard deviation.*

acuity of 15' of arc and two with 39' of arc and of the Micos fish 4 individuals with 15', 6 with 39' and 2 with 1° 1' of arc have been used for the observation experiments. In epigean fish and in the F_1-generation no optomotoric response has been measured. The tendency for schooling has been tested by a simple experiment: an observation tank of 300 1 has been separated by transparent perforated screens in three compartments. The ceompartment in the middle was divided in two parts (A and B in fig. 1) by a black line marked on the front pane. The test fish in the middle was able to see the school of conspecifics in the right or in the left compartment. In case of being attracted by the school he should stay in A or B near the school. In addition the number of changes between A and B as a measure of unsteadiness also has been registerd during a 10 min. test. An infrared light with a filter of 800 nm and an infrared TV-camera have been used for the observation in darkness.

In *Poecilia mexicana* only subadult fish have been tested to prevent sexual attraction (Parzefall, 1973). Each fish has been observed 10 times and the mean has been taken. In *Astyanax mexicanus* adult individuals of both sex have been observed once except the F_2-generation in which each fish has been tested 6 times. The results have been analyzed by the t-test and the U-test of Wilcoxon, Mann and Whitney.

3. Results

3.1. The populations of *Poecilia mexicana* (fig. 2a,b)

The epigean fish of the Rio Teapao (PMT) is orientated in visible light nearly all the time of the test to the school. In comparison to this population the tendency to follow the school of conspecifics is already significantly ($p < 0,05$, U-test) reduced in the epigean population (PMO) of the milky water of the Arroyo del Azufre near the cave entrance. There is no difference to the cave population. In both these populations there is a striking increase in the variability.

However, in darkness no preferencee for the school in the test aquarium has been registered as shown for PMO. These data are in accordance with the number of changes (fig. 2b) in the test area betwenn the side with school and side without school: the Teapao population with a tendency for schooling shows a few changes only. In both other populations the changes are significantly higher ($p < 0,05$, U-test) and variable. In darkness the population PMO had a mean of 52 for the number of changes per test.

3.2. The populations of *Astyanax mexicanus* (fig. 3a,b)

The F_1 and the epigean fish of the Rio Teapao show great tendency to follow the school. The F_2-generation with the blind fish of the Piedras cave as well as in the eyed Micos cave fish this tendency is significantly reduce ($p < 0,01$, t-test). But the epigean fish and the F_1-generation studied in darkness with infrared cease schooling ($p < 0,01$, t-test). As in *P. mexicana* the epigean population in visible light has a low number of change (fig. 3b). This number is significantly increased in the F_2-generation ($p < 0.05$, t-test) and the Micos fish ($p < 0,01$, t-test).

The variability for the number of changes and the tendency to follow the school was extremely high in the F_2-generation. Two of these fish did not follow the school despite a good optomotoric response.

4. Discussion

The observation in darkness demonstrates the important role of the visual system for the schooling behaviour in both species studied. Despite good visual orientation cave fish hybrids in *Astyanax mexicanus* show a weeker tendency for schooling than epigean fish and an increased variability in the F_2-generation. Two individuals in the F_2-generation did not react to the school during a series of six tests. From these data one can conclude that in the cave-dwelling *A. mexicanus* there seems to exist a genetically based reduction of schooling behaviour.

In the second species studied, *P. mexicana*, the reduction of

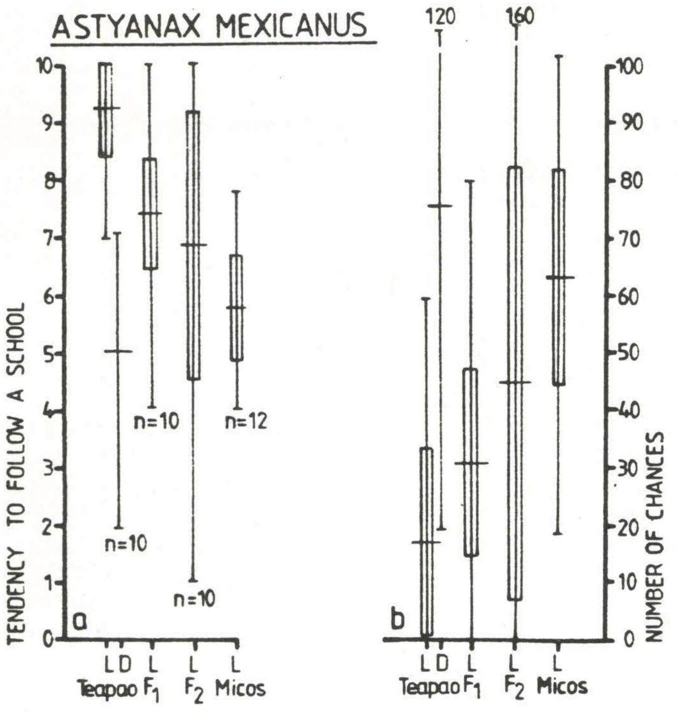

Fig. 3. Astyanax mexicanus *a) tendency to follow the school, b) number of changes between A and B (see fig. 1). L = light; D = dark, F_1 = hybrids between epigean fish and a blind cave fish; F_2 = hybrids of F_1–individuals. Micos = cave fish with eyes, Teapeo–epigean fish.*

the tendency for schooling takes already place in the epigean population near the cave entrance. This can be explained by the ecological situation: the Arroyo del Azufre coming out of the cave has a milky colour which is caused by sulphur Peters et alii (1973). This milky water causes difficulties in visual orientation and therefore in schooling. So the schooling and the visual apparatus are no longer controlled by selection. The results are highly variable characters (Peters et alii, 1973). In the present case the schooling becomes already variable in the milky water outside of the cave and the degree of reduction remains unchanged inside the cave. It seems that during the colonisation of caves the selection may play a minor role compared with the accumulation of neutral mutations and genetic drift (Parzefall, 1986). In addition to schooling circadian locomotory activity (Parzefall, 1986) also becomes variable in cave populations. On the basis of eye and pigment reduction in cave animals Kosswig (1963) developed the hypothesis that the absence of stabilizing selection allows an accumulation of selectively neutral mutations, and that variability decreases during cave live within a population because of mutation pressure. In phylogenetically old cave animals this leads to genetic homozygosity and diminished variability for the reduced patterns. In ecoethological studies one always tries to find a selection pressure as explanation for behaviour changes. But in case of an increasing variability the absence of stabilizing selection should be tested alternatively for explanation. It is possible that this is also an important principle we can find during the colonisation of new habitats.

Summary

Tne schooling behaviour widely distributed among fish depends on stimuli for the visual and the lateral line system. In the absence of visual orientation the fish species studied up to now do not school.

For this reason the schooling behaviour in cave fish seems to be no longer controlled by selection. So in relation to the time of cave colonisation this trait should become more and more variable.

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Evidence of hypoxic conditions in the habitat of the cave salamander Proteus anguinus in the Planinska jama

Lili Istenič
Institut of Biology, Edvard Kardelj University of Ljubljana

RESUM

La consideració del dèficit d'oxigen és una condició important per a l'adaptació del Proteus. *Durem a terme algunes indagacions sobre alguns paràmetres químics referents a l'hàbitat d'aquest animal. Presentarem, concretament, els resultats de les anàlisis químiques efectuades a la cova de «Planiska Jama», on el 1969, a les aigües del llac Putick, es va trobar un dèficit d'oxigen del 80 %. Allí hom va poder constatar un curiós fenomen: aquest baix grau d'oxigenació s'estenia, per igual, des del fons del llac fins a la superfície. Això ha pogut ésser confirmat cins cops, en períodes en què el nivell de les aigües era extremadament baix. Les últimes dades de què es disposa, a l'Est, sobre les condicions d'hipòxia dins l'aigua, varen ésser completades amb anàlisis de l'atmosfera situada per sobre el llac: la proporció d'oxigen (O_2) era de 11 % i la de diòxid de carboni (CO_2) del 0,1 %.*

Diverses dades comparatives d'altres anàlisis, ampliades a d'altres indrets de la cova, van ajudar a una millor interpretació del fenomen: la hipòxia que s'havia pogut constatar era un fenomen normal, relacionat amb l'elevat grau de mineralització del corrent d'aigua subterrani que fluia cap a un punt d'aigües tranquiles del llac.

RESUMEN

La consideración del déficit de oxígeno es una condición importante para la adaptación del Proteus. *Vamos a efectuar investigaciones sobre algunos parámetros químicos del hábitat de este animal. Presentaremos los resultados del análisis químico efectuado en la cueva de «Planiska Jama», donde en 1969, en el Lago Putick, se encontró un déficit de oxígeno del 80 % en el agua. El fenómeno único de que el bajo grado de oxigenación estuviera igualmente extendido desde el fondo hasta la superficie del lago, ha sido confirmado cinco veces en los períodos de nivel del agua extremadamente bajo. Las últimas mediciones en el Este, en 1985, de las condiciones de hipoxia en el agua, fueron completadas con análisis de la atmósfera por encima del lago, donde se encontró: 11 % (O_2) y 0,1 % (CO_2).*

Datos comparativos de análisis químicos ampliados de otras localidades de la cueva ayudaron a la interpretación de que el estado de hipoxia encontrado es un suceso normal relacionado con el alto grado de mineralización en la corriente de agua subterránea que acude a un punto tranquilo del lago.

SUMMARY

The consideration of the oxygen deficit is an important condition for the adaptation of the Proteus, led us to investigate some chemical parameters in the animal's habitat. We will present the results of the chemical analysis undertaken in «Planinska jama» cave, where, in 1969 in the Putick lake, an 80 % oxygen deficit was found in the water. The unique phenomenon that the low degree of oxygenation was equally extended from the ground to the surface of the lake had been conformed five times at the periods of extremely low water stand. The last measurements in the east in 1985 of the hypoxyc conditions in the water were completed with analysis of the atmosphere above the lake, where 11 % [O_2] and 0,1 % [CO_2] was found.

Comparative data of enlarged chemical analysis from other localities in the cave bolstered up the interpretation, that the established hypoxyc state is a regular event connected with the high degree of mineralisation in the underground water flow coming to a stand-still in the lake.

At the starting point of our long terming investigations we connected the endemism of Proteus whith its specialised neotenic nature and we searched in the chemical properties of the cave water the basis for estimation of animal's peculiarities in the sense of energetic adaptations.

The working hypothesis stating that quality of subterranean karst waters in the deepernand unapproachable areas of cave systems are analogous to the conditions in monimolimnion of the natural meromictic lakes **(Hutchinson 1957, Ruttner 1956)** showed common properties such as darkness, constant temperature, increased salt and CO_2 concentrations and deficiency of oxygen. Including the lack of oxygen as an important condition for development of Proteus peculiarities is very controverse in recent biospeleological literature as being based without measurements **(Poulson 1964, Vandel 1964).** So we have made the first testing by experimental checking of Proteus resistance in water with low level of oxygen (1,4 – 0,3 mg 0_2/l). In the Putick lake of the Planinska jama we have measured afterwards oxygen concentration of the water and found values of 2,9 mg0_2/l at the bottom of the lake as well as on its surface (Istenič 1971)

Physiological and biochemical investigations in Proteus have given new data about its oxygen consumption **(Istenič and Sojar 1974) and lung breathing (Sojar 1980, 1981). In the view of depigmentation a high concentration of riboflavin has been prooven in the skin (Istenič and Ziegler 1974).** In the parallel running investigations of the environment we have started to test the regularity of deoxygenation state of the Putick lake. With improved hydrochemical methods, including more localities in the interesting cave regions, we tried to get an insight in special conditions being responsible for deoxygenation.

Our aim is to represent briefly the main results of the hydrochemical investigations and to draw attention to Proteus microhabitat which might fit the anticipated deep cave areas inaccessible to man, with lack of air movement where the troglobites withdraw during their critical life periods **(Jeannel 1941, Huets and Leleup 1954).**

Putick lake is located in speleologically very interesting region of the Rak branch of the Planinska jama which has been object of many discussions due to still uncompletely known flowing-off of waters **(for lit. see Gams 1966, Geol. elab. 1970).** According to previous investigations mixing of water-flows from Javorniki and the sinking stream Rak takes place in the final part of the Rak branch. Putick lake represents captured water while Misterious lake the final siphon system of Javorniki water-flow. Because of uncompletely solved hydrologic problem in this part of the cave it has not been found out which water remains in the Putick lake. The area is hard to approach and accessible only at extremely low water-stand.

The lack of oxygen in Putick lake was estimated in the years of 1971, 1973, 1977, 1979; once the concentration value was below 2 mg 0_2/l. All these examples confirm the unique phenomenon of equal deoxygenation degree from top to the bottom of the lake. The level of CO_2 in the atmosphere above the lake was 0,32 vol. %. In the time of water-level decrease the rate of oxygen consumption remains intensive even within the limits of low oxygenation state. The appearance of water and sediments (cave clay) excludes an explanation that the decaying organisms floated in the lake from outside might bring about the lack of oxygen. Additionally this is confirmed by low phosphate value (0,6 mg PO_4/l) and nitrogen in nitrate form and in concentration which were found in spring – and groudwaters of unpolluted areas **(Ruttner 1957).**

Processes leading to the deoxygenation in the Putick lake were followed with comparision of chemical elements in the water and sediments as well as with measurements of BOD_5/COD in the water samples of Putick lake, of channel and the siphon at different water-levels. Results show **(Istenič 1979, 1981)** that the channel and siphon get water from different hydrographic backgroung and that the Javorniki water-flow from siphon remains at last in the lake. The water-flow from Javorniki brings the suspended material – in terminal phase of mineralisation – which sediments in the lake. In the stagnant water of the Putick lake the intensity of oxygen consumption is still increased with oxydation of inorganic salts and with specific action of the cave clay as ionic exchanger. Mangan has been determined in concentration of 3,5 % $Mn0_4$ in the black crusts on the rocky wall projecting above the lake. The values of BOD_5 exceeded the COD values and were highest in the samples from the bottom and from the bank of the lake. Knowing that microorganisms take part in these processes it would be very interesting to fill the gap of microbiological data with investigations of chemoautotrophic component in the karst underground environment.

Considering that the mineralisation power of the water depends on accessibility of metter for oxydation and after **Stangenberg (1959)** also on filtration, one may expect, that this power is expressed in tight correlation with water percolation in the karst. So the high activity can be expected only in abyss seepaga water flow which is filtered through earth strata where organic substances are strongly decomposed. In the case of Putik lake soch water is caught in a calm restricted area withont, air movenent; morphometric characteristics of this lake offer great surface functional for interaction of water and sediments.

The particularity of the Putick lake to have higher water temperature (3 – 4° C) as the siphon has not been explaned. We can not exclude the possibility of connection with described processes of intensive mineralisation.

The exceptionally dry autumn of 1985 enabled the measurements of hypoxic conditions in Putick lake and to complete them with the fact, that the oxygen level in the atmosphere above the lake was 11 – 14 vol. %. So far the lowest oxygen concentration in the water (1,04 mg 0_2/l) was measured, too. Proteus specimens in the lake showed no visible signs of demage, however two dead fish Lotta sp. were found.

The results of the hydrochemical analyses of simultaneously collected samples from different points of Rak and Pivka branch (fig. 1., graph 1.) include also measurements of calcium, potassium and sodium levels. These are new data about fluctuations of chemical parameters in Proteus complex environment, which role in animal's biology has been far from enough investigated.

Finally the warning should be emphasized that the circumstances in the Putick lake are baund exclusively on the characteristics of abyss seepage water flow. In the recent time of ecological crisis when the pollution from the surface could destroy the sensitive balance of underground environment the generalisation at all cave waters would commit a serious fault: the secondary pollution-bound modifications would be overlooked to which the specialised cave organisms most probably could not face with. Such a mistake would be to generalize the Proteus tolerance for oxygen deficiency to its general resistance.

Prof. Dr. Lili Istenič
Institut of Biology, Edvard Kardelj University of Ljubljana YU-61001 Ljubljana, Aškerčeva 12, POB 141/3, Tel.: 33 26 11. Yugoslavia.

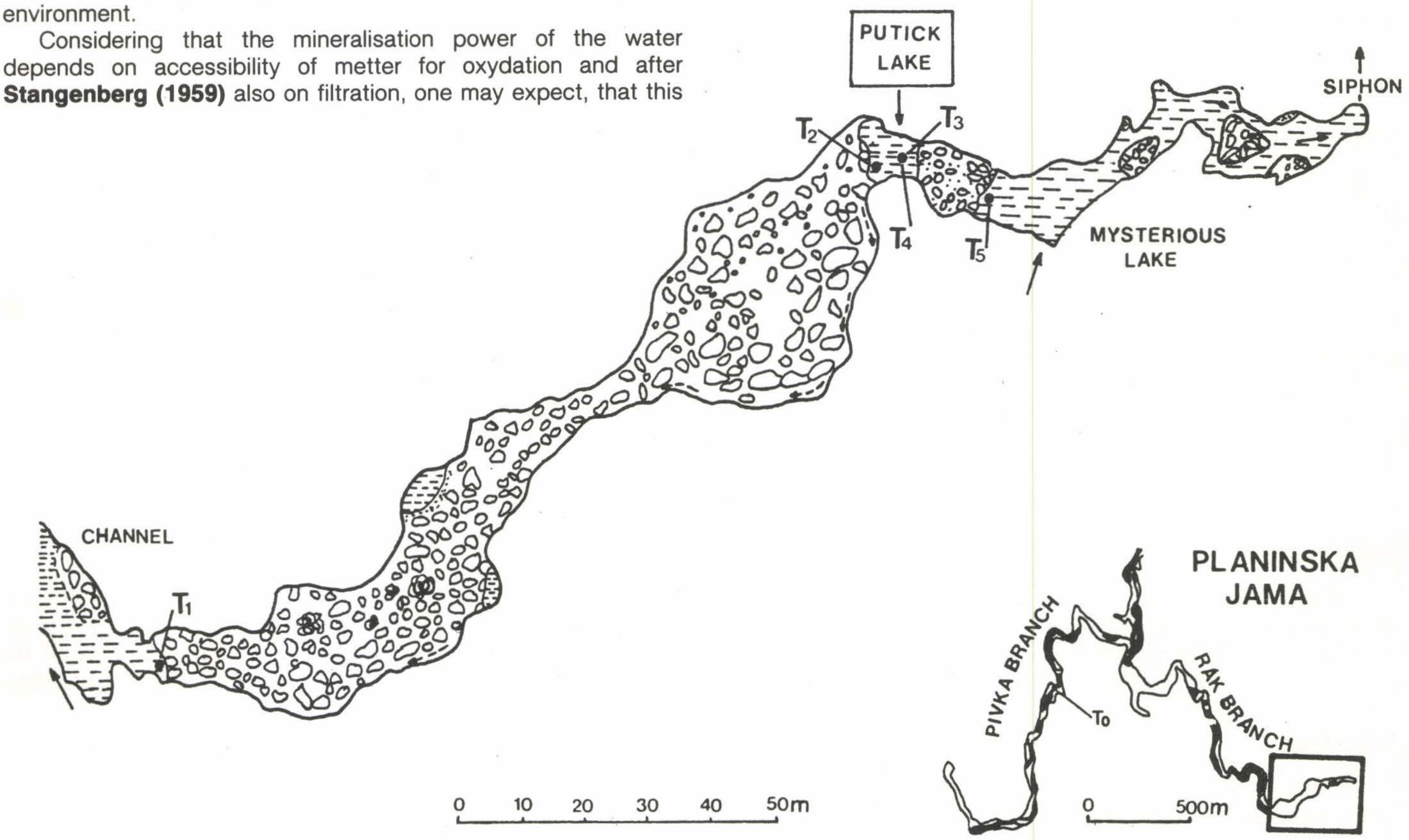
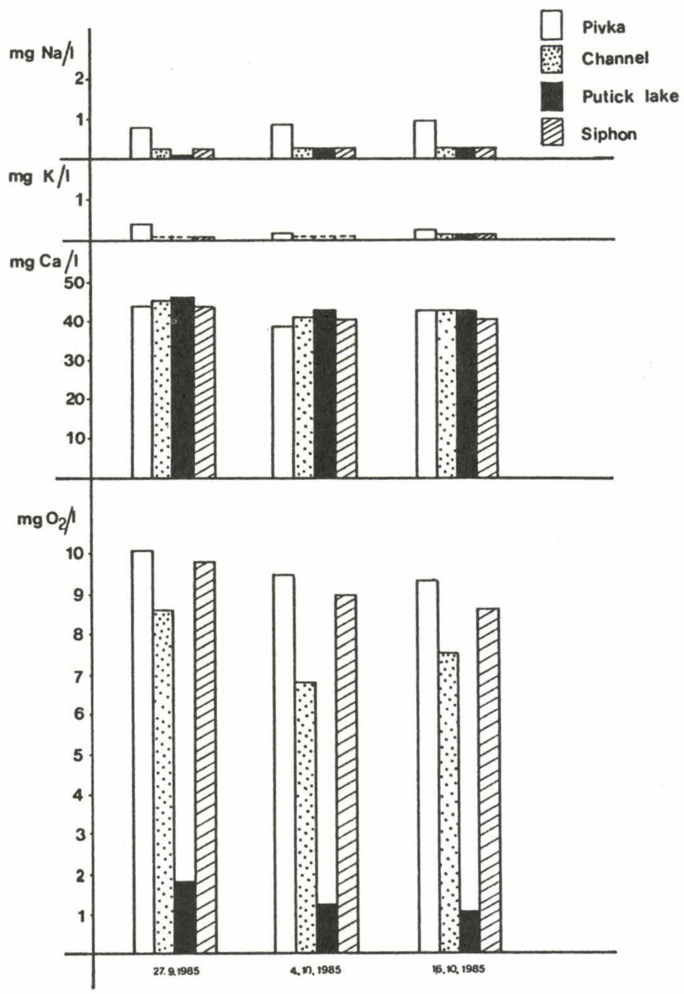


Fig. 1.– Cave Planinska jama with sampling points.



Graph. 1.– Values of the hydrochemical parameters in the Planinska jama.

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12298

Habitat zonation in Underwater caves in the Bahamas

R. J. Palmer, G. F. Warner, P. Chapman and R. J. Trott

RESUM

L'aigua de les cavitats de les Bahames i d'altres indrets conté uns biòtops característics que varien amb l'increment de la distància en direcció a l'interior de la cavitat. En aquestes aigües subterrànies s'han descrit quatre zones d'hàbitats principals, definides a partir de criteris tant físics com biològics.

Es proposa la següent terminologia per a aquestes zones: Arena, Vestíbul, Zona de Transició i Profunda.

RESUMEN

El agua de las cavidades en las Bahamas y en otras partes, contiene unos biotopos característicos que varían con el incremento de la distancia hacia el interior de la cavidad. Se pueden reconocer cuatro zonas principales de hábitats en estas aguas subterráneas de cavidades y se definen por criterios tanto físicos como biológicos. Se propone la siguiente terminología para estas zonas: Arena, Vestíbulo, Zona de Transición y Profunda.

ABSTRACT

Underwater caves in the Bahamas and elsewhere contain a distinctive biota, which changes with increasing distance into the cave. Four major habitat zones within such underwater caves can be recognised, and are defined by both physical and biological criteria. The following terminology is proposed for these zones: Arena, Vestibule, Transition Zone and Deep Cave.

Introduction

Studies in Bahamian and other similar underwater caves (commonly referred to as Blue Holes) over the past few years have indicated that such caves possess a distinctive zonation with respect to their biotic communities. Work carrried out in such caves (Iliffe et al 1983, Warner and Moore 1984, Cunliffe 1985) has confirmed the presence of marine fauna for considerable distances into the dark areas, and has supplied evidence for the existance of a cryptic deep-cave environment separable by a variety of biological and physical parameters from the more biotically diverse environments near the mouths of the caves.

To identify the range of habitats involved, we suggest four broad ecological divisions, progressing inwards from the entrance: Arena, Vestibule, Transition Zone and Deep Cave (Fig. 1).

Identification of habitat zones

The four major divisions are identified as follows:

a) *THE ARENA:* Cave entrances, whether air –or water– filled, provide shelter for a variety of organisms. Many members of such communities are highly mobile, using the cave mouth and entrance passages during rest periods, or during such time as their own predators are abroad. Such trogloxenes (cave visitors) emerge from the cave to forage, and have a distinct sphere of influence outside the cave. In sub-aerial caves, animals such as bats may stray many kilometres from the entrance, but in marine caves such influence tends to be considerably more localised. Herbivorous fish which graze on sessile organisms (algae, seagrasses) surrounding the cave often remain within close range of the cave mouth, to which they can quickly return if danger threatens. Many marine Blue Holes in seagrass and algal beds have a distinct «halo» of overgrazed substrate surrounding the entrance (K. Abbott, pers.comm.). Similar halos, caused by fish and urchin grazing, have been observed round coral patch-reefs (Ogden and Zieman 1977).

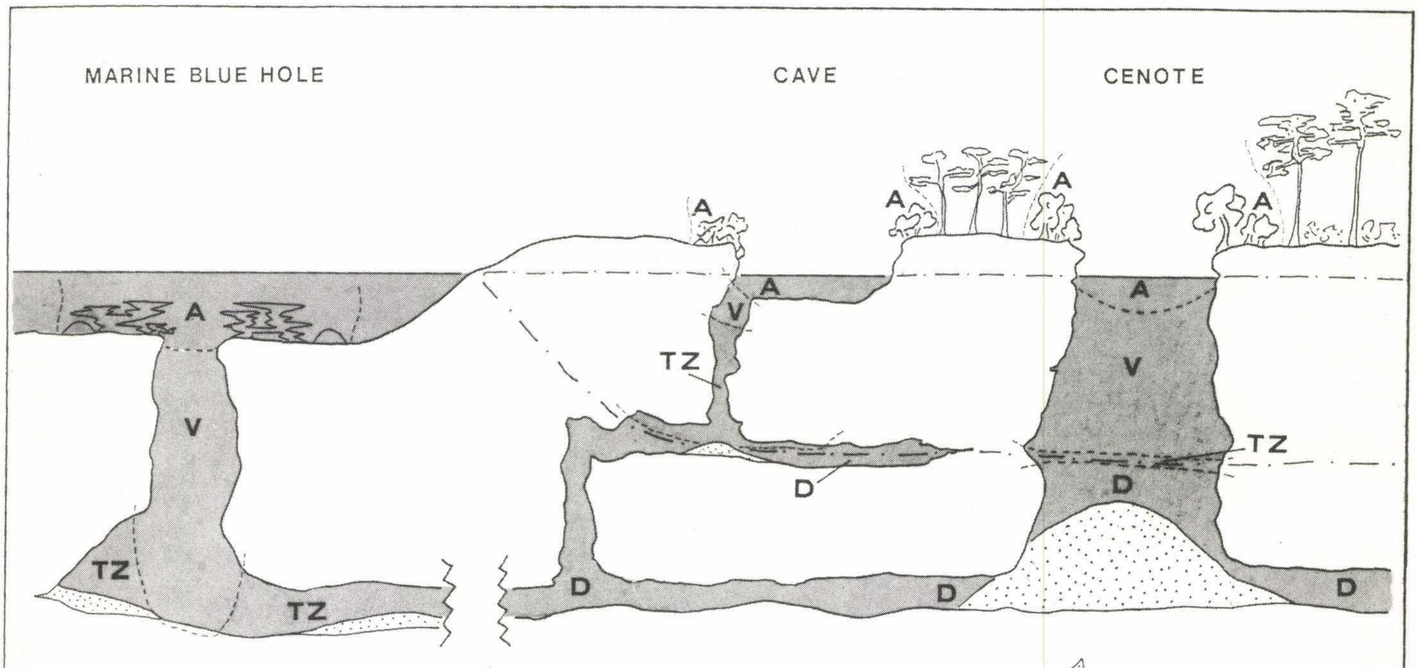
The presence of strong, tidally-related currents within the marine caves (Warner and Moore 1984) provides locally high concentrations of organic material at or near to the cave entrance during the inflow cycle. Such rich supplies of food can stimulate the growth of sessile communities (eg. corals, sponges) and their associated flora and fauna. This results in a different halo: rings of coral growth which surround certain marine caves (eg. The «Doughnut Holes», Benjamin 1984). The currents may also be responsible for the shape of topographical features in the immediate surface vicinity of the entrance (eg. sand bars, rock guillies) which offer particular habitats suitable for colonisation. All of the aforementioned features can be regarded as lying within the Arena of a marine Blue Hole.

In inland entrances to underwater caves, where the entrance lies within a freshwater or saline lake (Proudlove 1984, Cunliffe 1985), then depending on its size, either the entire lake may form the Arena, or only that part of it immediately surrounding the actual cave entrance. It has been noted (Bahamas National Trust 1981) that the terrestial environment immediately surrounding such inland Blue Hole entrances is sufficiently distinctive to be regarded as being an associated community. The presence of saline surface water may encourage the growth of mangrove communities in an otherwise barren area, or where the cave entrance contains fresh water, a halo of broadleaved woodland, often containing an unusual abundance of epiphytes and orchids, may develop within the surrounding Bahamian pine forest or scrub bush. There is a strong case for regarding such unusual cave-associated communitites as belonging within the Arena of inland Blue Holes and caves.

The Arena is therefore that area surrounding the entrance on which the biotic community of the cave and the water movements associated with the cave have a direct and distinctive effect.

b) *THE VESTIBULE:* In underwater caves with a daylight entrance, there is an identifiable biotic zone associated with the presence of lower light levels than those of the Arena. In common with the Arena, the Vestibule hosts a greater density of mobile fauna whan compared with the general marine and lake environment. These include Vestibule –and Arena– feeding species, together with casual visitors sheltering within the enclosed and nutrient rich environment. Herbivorous fish, and many predatory species, rarely proceed further into the cave than the Vestibule, though snappers and squirrelfish have occasionally been observed several hundred metres into marine caves, and some brotulid species venture even further.

Many of the sessile organisms of the Arena occur less frequetly



UNDERWATER CAVE HABITAT ZONATION

in the Vestibule, due to reduced light levels and deeper water. Algae, and hermatypic corals which contain zooxanthellae, are progressively reduced in numbers and can occur no further into the cave than light permits. The walls of the Vestibule are often vertical or near-vertical, and occasionally overhang. Such variation in substrate angle has a distinct local effect on the composition of the biotic community, with the densest and most varied fauna being found on vertical surfaces or beneath overhangs. Growth forms within the Vestibule can be affected by current strength (eg. the hydroid *Thyroscyphus ramosus,* which grows to unusual lengths: Warner and Moore 1984).

In inland Blue Holes and caves, the Vestibule is generally dominated by algal communities, occasionally giving way to dense, colonial bacterial growth at or near to the boundary with the Transition Zone (Smart 1984, Palmer 1985ii and 1986).

The environment offered by inland «cenote» Blue Holes is an interesting one. Normally, the Deep Cave environment can be considered a «relict» environment (see below) but the Vestibule of cenote sites has also been observed to contain species which may be Pleistocene relics, stranded in what are effectivly deep meromictic lakes by fluctuating eustatic sea-levels during the last glacial epoch. The presence, for exemple, of the grapsid crab, *Sesarma angustipes,* and a freshwater presence of the cave-adapted brotulid, *Lucifuga spelaeotes* (more normally found in saline waters), both reported by Proudlove (1984) from a site on Andros, suggests that in such isolated inland Blue Holes the Vestibule fauna may therefore hold considerable palaoecological interest.

The Vestibule of such underwater caves is therefore defined as that part of the cave mouth within the Arena which experiences lower light levels than the Arena, and which extends to the limits of daylight within the cave.

c) *THE TRANSITION ZONE:* This zone extends from the limit of daylight penetration (which may vary seasonally) for some distance into the cave. In marine caves, it generally supports a fauna not unlike that of the darkest recesses of a coral reef (Vasseur 1974). The constant darkness and directional current flow can encourage unusual growth characteristics (eg. serpulids which form pseudostalactites: Mac Intyre et al 1982, Cunliffe 1985, Palmer 1986). Some species of sponge are white, or paler, than in the Arena/Vestibule (eg. *Chondrosia* sp.) and the tasselled growth form of the sponge *Pellina* sp. *(Haliclona aquaeductus)* is characteristic, though also found in the Vestibule (Warner and Moore 1984). There are no ordinary reef fish dwelling within this zone, but there are other predators: crabs, lobsters, cowries and shrimps.

The major part of the fauna of the Transition Zone can be regarded, in speleological terms, as troglophilic –that is, able to live within a cave and to complete the entire life– cycle underground, but which is not exclusively confined to the cave. There are creatures within the Transition Zone which might be regarded as trogloxenes, cave visitors, which preferentially inhabit this zone, but which make regular or occasional visits outside the cave mouth. These include a wide variety of eucarid crustaceans, which are amongst the most mobile of the cave fauna, and which may make occasional migrations to the Vestibule and beyond, using current flow and /or water temperatures as a means of directional orientation.

The density of fauna in this zone is directly related in marine caves, to the strength and presence of tidally-related currents and their ability to transport food material into the cave. Further from the entrance, as currents weaken and become diffuse, sessile populations become increassingy sparse (Warner and Moore 1984) and are generally limited to small sponges and occasional serpulid polychaetes. Organisms feeding on or within sediments deposited by the currents predominate deeper within the zone, should such sediments occur (eg. holothurians: Warner and Moore 1984), and marine microcrustaceans may, with further study, be found to occur within such sediments towards the furthest extent of this zone.

In inland cenote Blue Holes, the Transition Zone may be abrupt and chemical in nature (Smart 1984), a zone of sudden salinity increase with depth where bacterial decomposition of organic debrils floating on the denser saline water causes a sudden local rise in temperature and H_2S concentration. This is often dense enough to stop further light penetration. Similar bacterial action may take place throughout the water –filled micro– fissures of the surrounding limestone at this level, which represents the base of the freshwater lens, and may produce much of the primary food material for the Deep Cave fauna (Stock 1985).

The Transition Zone may extend for several hundred metres in marine caves with a strong current flow and suitable passage morphology, or might be strongly compressed in isolated anchialine caves inland. It is here defined as the zone extending from the limit of daylight to the beginning of the Deep Cave Zone.

d) *THE DEEP CAVE ZONE:* This is identified as that part of an underwater cave in which the fauna is dominated by troglobitic organisms – that is, species which occur only in caves, and which are often specialised accordingly. Temperatures are extremely stable (at around 25°-27° C in Bahamian anchialine caves: Smart 1984, Palmer 1985ii and 1986). Current flow is minimal or non existant, and the original source of organic food input is more likely to be vertical, via meteoric percolation (Cunliffe 1985) as horizontal, via current flow. Water can vary from fresh to ocean-saline, and there may be further variation in water chemistry, particularly in oxygen content, which is commonly lower in cave water than in surface sea –or fresh– water. Environmental conditions that exist in the Deep Cave are likely to preclude the survival of the less cave-adapted members of the troglophilic fauna characteristic of the Transition Zone.

There is considerable evidence to suggest a complex and well-developed Deep Cave faunal community, based on a detritivore/predator chain of bacteria/microcrustacean/cave fish (Yager 1981, Cunliffe 1985, Stock 1985, Palmer 1985ii and 1986). Hart, Manning and Iliffe (1985) have made links between this cave fauna and that of the deep sea, and further suggest that such Deep Cave zones may have served as faunal refuges over very long periods of time. Both they and Howarth (1983) comment on the role of micro-fissure porosity of the host rock in the aquatic cave habitat, and its place in the biological structure and dispersal of cave cummunities. Marine, anchialine and freshwater caves are all likely to be influenced by the movement of small organisms (microcrustacea and bacteria) in larval and adult form through such fissures, and the may form a more important habitat than the larger open cave passages within the Deep Cave zone, providing greater refuge from predation as well as more direct access to meteorically-transported food supplies.

The Deep Cave Zone can be described as being the area of and underwater cave in which the environmental conditions (constant darkness, low O_2 levels and food supply, stable temperatures, minimal current flow) are such that only cave-adapted organisms can maintain a population.

Discussion

The four cave zones described above should be regarded as being general habitat types within Bahamian and other similar underwater caves. The they can ovelap to a significant degree is unarguable. The wide difference in surface environments (Warner and Moore 1984, Palmer 1985i, Trott and Warner 1985), passage morphology (Farr and Palmer 1984, Palmer and Heath 1985), hydrology (Smart 1984, Warner and Moore 1984, Heath and Palmer 1985) and numerous other factors which impact on the cave environment make it unwise to attempt too sharp a delineation between such divisions. There may also be instances in which one or more of these zones may be absent, for example where caves have been infilled to the point where only Arena and Vestibule are available for colonisation. Similarly, inland caves may lack a recogniseable Arena or, where the entrance to the cave lies within an air-filled cavern, may even lack a Transition Zone or Vestibule. There may even be isolated pockets of one zone type enclosed within another, dictated by cave morphology and /or current movements.

Notwithstanding these reservations, we suggest that the nomenclature proposed here will prove useful to future workers, and urge that it be adopted as standard terminology in discussing the biology of such underwater caves.

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1215

Populational study of pimelodella kronei (teleostomi, siluriformes), blind catfish from the upper Ribeira River Valley, southeastern Brazil

Eleonora Trajano

Departamento de Zoologia, Instutito de Biociências da USP Sociedade Brasileira de Espeleología

RESUM

Pimelodella Kronei, *descendent cavernícola del silúrid pimelòdid* P. transitoria, *ha estat trobat a cinc coves de la vall per on discorre el riu Ribeira, al sud de l'estat de São Paulo. La polació de dues de les coves (Areias i Bombas) va ser ja estuadiada per C. Pavan l'any 1945.*

Com a part integrant del meu doctorat, estic investigant l'ecologia de la població més habitual de la cova d'Areias, utilitzant el mètode de marcatge i recaptura. La cova té 7.000 metres de galerias i s'ha format a partir de la unió de dues coves principals. Els corrents d'aigua d'aquestes dues galeries arriben a coincidir, ocasionalment, durant l'època de pluja.

En les 16 recol·leccions que es van dur a terme en un mes, 170 animals van ésser marcats amb tint acrílic. D'entre els 82 que es van recapturar hi figuraven 19 animals que ho van ser dos cops, 10 tres vegades, 5 quatre vegades, 2 cinc cops i 2 sis vegades. Els peixos solien ésser recapturats en el mateix lloc on ja havien estat marcats prèviament; només tres varen ésser recupertats en corrents d'aigua diferents.

RESUMEN

Primelodella kronei, *derivado cavernícola del silúrido primelódido* P. transitoria, *ha sido encontrado en 5 cuevas del valle del río Ribeira al Sur del Estado de São Paulo, la población de 2 cuevas (Areias y Bombas) fué estudiada por C. Pavan en 1945.*

Como parte de mi doctorado estoy investigando la ecología de la población más notable de la cueva de Areias, utilizando el método de marcaje y recaptura. La cueva tien 7.000 metros de galerías y ha sido formada por la unión de dos cuevas principales. Las corrientes de agua de estas 2 galerías llegan a encontrarse ocasionalmente durante la época de lluvia.

En las 16 recolecciones que se llevaron a cabo en un mes, 170 animales fueron marcados con tinte acrílico; entre los 82 que fueron recapturados figuraban 19 animales recapturados 2 veces, 10 tres veces, 5 cuatro veces, 2 cinco veces, 2 seis veces. Los peces tendían a ser recapturados en el mismo sitio donde habían sido marcados; solamente 3 de ellos fuerón recuperados en corrientes de agua distintas.

SUMMARY

Primelodella Kronei, *cave derivative of the primelodid catfish* P. transitoria, *has been found in five caves of the Ribeira River Valley, South São Paulo State. The populations of two caves (Areias and Bombas) were studied by C. Pavan in 1945.*

As a part of my doctorate, I am investigating the ecology of the most conspicuous population, that from Areias Cave, through the mark-recapture method. The cave has 7.000 mts of galleries being formed by the junction of two main ones. The watercourses of these two galleries are occasionally connected during the rainy season.

During the 16 monthy collections 170 animals were marked by means of tattoage with acrylic dyes, of which 82 individuals have been recaptured. These recaptures include: animals recaptured twice-19; three times-10; four times-5; five times-2; six times-2. The fishes tended to be recaptured in the same place where they were marked; only 3 individuals were recaptured in watercourses other than the one where they had been marked. This suggests that the population is small and that the fishe are sedentary.

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The Significance of Large Size on the Biology of the Subterranean Isopod *Caecidotea stygia*

David L. Bechler
Biology Department, Lamar University

RESUM

Un comportament obertament agressiu caracteritza la relació de dues Caecidotea stygia *entre sí. S'han descobert comportaments més subtils i complexes, mitjançant el tacte i, possiblement, per feromones, que fan possible de mitigar aquest comportament agressiu. Independentment dels mecanismes de comunicació, el tamany és un important factor en el comportament biològic de* C. stygia. *Segons les dades de què disposem, a Rice Cave, prefereixen els bassals que no pas els ràpids. Una anàlisi del tamany ens pot suggerir que els individus més grans poden imposar-se als més petits en els bassals. El tamany pot representar també un factor a tenir en compte a l'hora d'elegir el substracte preferit, però amb les dades disponibles no podem avançar cap conclusió en aquest sentit. Els mascles sexualment madurs s'identifiquen pels seus gnatòpods eixamplats, els quals superen la talla mitjana de la població i s'aprofiten de la seva corpolència per a dominar i demostrar la seva predisposició reproductiva a femelles més petites. Els grans* G.stygia *dominen, no solament a elements de la seva pròpia espècie de menor tamany (conespecífics), sinó que és probable que dominin també els* Gammarus trogophilus, *un amfípod troglòfil, localitzat a la cova.*

RESUMEN

Un comportamiento abiertamente agresivo es el significado de la medida en que se comunican dos Caecidotea stygia *entre sí. Se han desarrollado comportamientos más sutiles y complejos por medio del tacto y posiblemente por feromonas, permitiendo una reducción de este comportamiento agresivo. Independientemente de los mecanismos de comunicación, el tamaño es un importante factor en la biología de* C. stygia. *Los datos que tenemos nos indican que en Rice Cave les gustan más los charcos que los rápidos. Un análisis del tamaño sugiere que los individuos grandes pueden coartar parcialmente a los individuos pequeños de los charcos. El tamaño puede ser también un factor en la elección del substrato preferido, pero los datos disponibles no ofrecen una conclusión definitiva sobre ese punto. Los machos sexualmente maduros se identifican por los gnatópodos ensanchados que superan la talla media de la población y utilizan su gran tamaño para dominar y probar la buena disposición reproductiva de hembras más pequeñas. Los grandes* C. Stygia *dominan no solamente a seres de su propia especie de tamaño menor (conespecíficos), sino que es probable que dominen asimismo los* Gammarus trogophilus, *un anfípodo troglófilo encontrado en la cueva.*

SUMMARY

Overt aggressive behavior is one means by which size is communicated between two Caecidotea stygia. *More subtle and complex behaviors involving tactile and possibly pheromonal communication have evolved permitting a reduction of this aggresive behavior. Regardless of the mecanism of communication, size is an important factor in the biology of* C. stygia. *Data indicate that in Rice Cave, pools are preferred over riffles. An analysis by size class suggests that large individuals may be partially restricting smaller individuals from pools. Size may also be a factor in the choice of preferred substrate, but data are less conclusive on this point. Sexually mature males identified by enlarged gnathopods, exceed the mean population size and use their larger size to subdue and test the reproductive readiness of smaller females. Large* C. stygia *not only dominate smaller conspecifics, but are more likely to dominate* Gammarus trogophilus, *a troglophilic amphipod found in the cave.*

Introduction

The size of and organism often strongly influences its biology and has been extensively studied on both vertebrates and invertebrates. Compared to epigean species, few references exist which examine the imortance of body size in hypogean species. Kane and Poulson (1976) found that the larger body size of the carabid beetle *Neaphaenops tellkamfii* enhanced its ability to capture prey items compared to *Pseudanophthalmus menetriesii*. Van Zant, Poulson and Kane (1978) concluded taht the size differences found between syntopic populations of *P. menetriesii* and *P. pubescens* may be related to food utilization. Among amblyopsid fishes, large individuals of *Chologaste agassizi, Typhilichthys subterraneus* and *Amblyopsis spelaea* possess a decided advantage over smaller conspecifics during agonistic bouts (Bechler, 1983). Dominance and access to a localized food source was found to be size related in the isopod, *Caecidotea stygia* (Bechler 1985).

Except for noting the relationship between dominance and food acquisition and body size by *C. stygia,* Bechler (1985) treated the population studied as a single, homogenous unit. In this paper I further examine the relevance of size as it pertains to the biology of *C. stygia,* but now I have divided the population up into separate cohorts based on size.

Materials and Methods

The methodology used in acquiring data in this paper can be found in Bechler (1985). Before, I examined all the macrobenthic crustaceans found in the study site, Rice Cave, and in general treated each species as a uniform population without regard for size classes. In this paper, *C. stygia* is examined by body lengths or size classes based on one millimeter increments. Size of isopods were determined by comparing their apparent lenght to the lenght of lines drawn on a card. Factors examined include dominance hierarchies, resource acquisition (food), habitat preference (riffles vs. pools) (mud vs. rock vs. gravel) and sexual activity.

Study Area

Rice Cave is described in detail in Bechler (1985). Briefly in review, running the length of Rice Cave is a small, narrow stream consisting of alternating pools and riffles. Pools accounted for 78.9 % of the area studied and riffles for 21.1 %. Riffles consist of 78.1 % bare rock, 18.0 % gravel and 3.8 % mud. Pools contained 16.7 % bare rock, 34.1 % gravel 49.2 % mud. The surface topography consists of heavily wooded ravines with steeply sloping sides. Because of this, surface runoff is rapidly carried down to small surface streams and not into the cave stream. Therefore, the cave stream does not experience significant flooding and little detritus is carried into the cave. This makes the cave stream more stable and oligotrophic than systems which are more open and have a high input of water and detritus.

Results

A dominace hierarchy based on size existed among the *C. stygia* in Rice Cave. Twenty-three encounters between individuals of different sizes were observed. Large individuals dominated 91.3 % of the time forcing the retreat of the smaller isopod. During encounters a difference as small as one millimeter was sufficient to cause the smaller individual to retreat. Five encounters between individuals of equal size were observed. Three of these encounters resulted in a standoff with no clear cut winner and two enconuters resulted in definitive winners. Encounters were initiated when the larger individual touched the smaller one with its antennae or bent in the shape of a «U» and touched the smaller individual with its antennae and uropods. If isopods were of equal size they would briefly grapple and push and shove each other until one or both retreated. In such cases the winner pursued the loser a short distance while keeping its antennae in contact with the uropods of the retreating individual.

Small pieces of smelt 10 X 7 X 5 millimeters were placed in pools in order to attract isopods to a localized food source. Access to the bait was dependent on size. Individuals 10 millimeters or larger moved onto the bait first and smaller ones formed a column downstream from the bait. Position within the column was size realted, with smaller individuals found along the margins of the column and larger individuals in the center and front near the bait. On the bait itself, large individuals maintained their position, but smaller ones were constantly shuffling about and acquiescing to the larger ones. After the large individuals hed fed for a period or time they left the bait and the smaller cohorts moved on an fed. While smaller isopods fed, the larger ones moved a short distance from the bait and sat motionless or cleaned themselves. Eventually some of the larger isopods returned to the bait forcing smaller ones off. Dominance at baited sites was again communicated tactilely, but unlike the causal encounters described above, bumping and pushing occurred more often. This was especially true on the bait itself where even small individuals displayed a reluctance to retreat.

The amphipod, *Gammarus troglophilus,* dominated most interactions with *C. stygia* and in high densities eliminated *C. stygia* from pools. In the absence of *G. troglophilus, C. stygia* preferred pools over riffles (Bechler 1985). Table 1 presents data

BODY	POOLS VERSUS RIFFLES			SUBSTRATE PREFERENCE		
size mm	Sample Size(N)	% in Pools	x^2 (df = 1)	Sample Size(N)	% on Mud	x^2 (df = 2)
3	3	66.7	0.29	2	50.0	n.t.
4	8	87.5	0.85	7	42.9	0.62
5	8	87.5	0.85	7	42.9	0.62
6	15	93.3	2.52	8	37.5	1.29
7	14	92.9	2.16	14	57.1	0.68
8	24	95.8	4.83*	23	56.5	n.t.
9	43	88.1	1.62	53	62.8	3.48
10	57	94.7	9.13*	52	71.2	10.78*
11	38	94.7	6.29*	33	60.6	2.67
12	51	100	n.t.	52	59.6	6.69*
13	52	96.2	9.97*	39	56.4	n.t.
14	34	97.1	7.45*	36	75.0	10.91*
15	24	100	n.t.	22	68.2	3.61
16	16	100	n.t.	16	81.3	n.t.
17	13	100	n.t.	13	69.2	2.92
18	7	100	n.t.	7	42.9	0.62
19	1	100	n.t.	1	0.0	n.t.
20	2	100	n.t.	2	50.0	n.t.

indicating that the size of an isopod is related to the probability of it being found in pools. As the size increased, the percent of individuals within a size class found in pools also increased. Isopods less than 8 - 9 millimeters showed no significant preference for pools versus riffles. Between 10 - 14 millimeters a sifnigicant preference for pools was shown, and isopods over 15 millimeters were found exlusively in pools.

Bechler (1985) also reported that *C. stygia* showed a preference for mud substrate within pools. Again as size increased, the percent of isopods within any size class showing a preference for mud also increased (Table 1). Substrate preference was not as clear cut as was the preference for pools versus riffles. There was a general trend for an increased preference for a mud substrate as size increased, but only three size classes between 10-14 millimeters showed a significant preference for mud. Below 9 millimeters, the percent of isopods found on mud ranged between 37.5-57.1 % Between 9-17 millimeters the percent of isopods on mud ranged between 56.4-81.3 %. Above 19 millimeters, the number of isopods observed was too small and sporadic to permit any recognizable trend.

Sexually mature and active males in the Asellidae are dimorphic and possess enlarged gnathopods which makes them distinguishable from females (Fleming, 1973). At least 18 such males were seen during field observations. The smallest dimorphic male was 11 millimeters long, but 50 % of the males observed were 18-24 millimeters in lenght. Mean size for sexually mature males was 16.1 millimeters compared to the population mean of 11.4 millimeters. Seven attemted copulations by three of the largest males were observed. In each case, a male grabbed and mounted a smaller female on her dorsum. All females struggled to escape and were quickly released.

Large size also correlated with successful interspecific interactions between *C. stygia* and the amphipods *G. troglophilus* and *Bacturus brachycaudus*. Out of 38 encounters between *C. stygia* and the two amphipods, *C. stygia* was only able to repel amphipods 18.4 % of the time. Isopods that dominated amphipods were 12 millimeters or greater in length which exceeds the mean population length, 11.4 millimeters. On two occasions isopods were able to gain access to baits being fed upon by *G. troglophilus*. This only ocurred when six or fewer amphipods were on the bait, when amphipods were clumpled on one end of the bait, and the isopods were 14 millimeters or greater in lenght. Otherwise the activity of the amphipods always repelled the isopods.

Conclusions

Data presented clearly indicate a correlation between body size and social dominance, habitat utilization, male sexual maturity and successful interspecific competition. Behavioral observations provided direct evidence that dominance is directly related to size. Overt agressive encounters were seen between isopods of equal size, but were conspicuously absent if a size difference existed. The lack of overt aggression suggests that the tactile communication observed represents a form or ritualization that has supplanted physical aggression. Such a process has been described by Hazlett (1972). Bovbjerg (1956) was ones of the first to document that dominance hierachies in crustaceans can be size related. Since then this relationship has been demonstrated in numerous higher crustaceans (Hyatt, 1983). Interspecifically, size was important since only large *C. stygia* gained access to a food source or dominated the more agressive and active amphipods.

No direct supporting evidence exists linking the aggressive behavior controlling the body size/dominance hierachy to the correlation seen between body size and habitat utilization. It is conceivable that smaller isopods have no preference for water condition or substrate types. But the body size/ dominance hierarchy observed strongly implies that larger amphipods could have aggressively eliminated smaller individuals from pools and mud substracte in the pools. Garthreaux (1978) concluded that agonism is a primary mechanism, by which dominance hierachies are established within populations. He further contends that these dominance hierarchies affect habitat utilization, mating success and dispersal of individuals within the population. The larger than average body size seen in sexually active males may be a consequence of normal sexual maturation or it may result from intrasexual selection (Halliday, 1978). If the latter hypothesis is correct, increased body size would give larger individuals an advantage in gaining accees to females. Ward (1983, 1984) found that large male amphipods *G. pulex*, were better able to gain copulations with females than were smaller individuals but, found no relationship between body size and mating sucess in *G. pulex* (Ward, 1985).

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Notes on the distribution and ecology of remipede crustaceans

Jill Yager

Biological Science Sept. Old Dominlon University
Norfolk, Virginia, U.S.A.

RESUM

L'any 1979 es va descobrir a les Bahames un crustaci troglobi sorprenent. A causa de les característiques d'aquest animal, es va proposar una nova classe, Remipedia. Des del descobriment del primer remipedi (Speleonectes lucayensis), *s'han trobat nous representants d'aquesta classe a coves anquihalines, en tota l'extensió de les Indies Occidentals i a les Illes Canàries. Les investigacions dutes a terme sobre el medi físic, assenyalen una total estratificació vertical de la columna d'aigua. La major part de*

remipedis es van trobar en aigües polihalines de llarga durada, amb molt poc oxigen dissolt, i freqüentment, sota d'una capa de sulfur d'hidrogen. A causa de l'abundància d'algunes de les noves espècies és possible d'obtenir avui molts més detalls sobre la seva morfologia funcional i altres característiques de la classe.

RESUMEN

En 1979 se descubrió en las Bahamas un crustáceo troglobio sorprendente. Debido a las características de este animal, se propuso una nueva clase, Remipedia. Desde el descubrimiento del primer Remipedio el Speleonectes lucayensis, *nuevos representantes de la clase han sido encontrados en cuevas anquihalinas a lo largo de las Indias Occidentales y las Islas Canarias. Investigaciones sobre el medio ambiente físico muestran una completa estratificación vertical de la columna de agua. La mayoría de remipedios se encontraron en aguas polihalinas de larga permanencia, con escaso oxígeno disuelto y frecuentemente debajo de una capa de sulfuro de hidrógeno. Debido a la abundancia de varias de las nuevas especies pueden obtenerse actualmente más detalles respecto a la morfología funcional y características de la clase.*

SUMMARY

In 1979 an unusual troglobitic crustacean was discovered in the Bahamas. Due to the characters of this animal, a new class, Remipedia, was proposed. Since the discovery of the first remipede, Speleonectes lucayensis, *additional representatives of the class have been found in anchialine caves throughout the West Indies and in the Canary Islands. Investigations of the physical environment indicates a complex vertical stratification of the water column. Most remipedes are found in polyhaline waters of long residence time, with low dissolved oxygen and often below a layer of hydrogen sulfide. Due to the abundance of several of the new species, more details concerning the functional morphology and general characteristics of the class are now available.*

Since the discovery of the first remipede, *Speleonectes lucayensis* (Yager, 1981), from Lucayan Cavern in the Bahamas, at least eight additional species have been collected, representing a new family and several new genera. Members of the class Remipedia have been collected from anchialine caves on both sides of the North Atlantic Ocean-- the Bahamas archipelago on the western side, and Lanzarote (Canary Islands) on the eastern side.

Characteristics of Remipedes

Remipedes are characterized by the presence of a cephalic shield, pre-antennal filaments, a large, biramous first antenna, well-developed prehensile feeding appendages and a long trunk with many similar segments, each bearing a pair of biramous swimming appendages (Fig. 1).

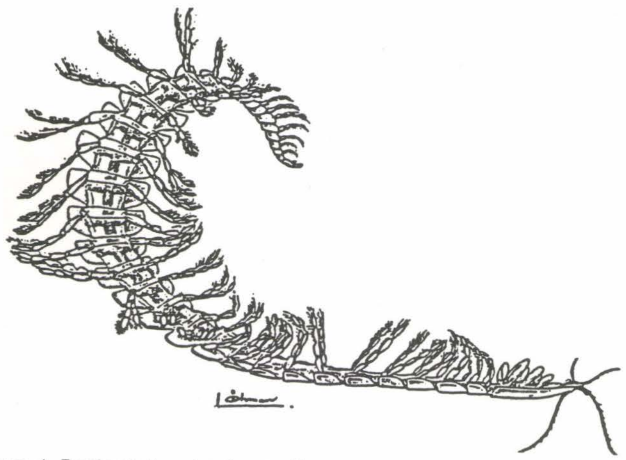

Figure 1. Remipede in swimming position.

Scanning electron microscopy and histological preparations of several remipede species by the author has revealed more information about the anatomy and morphology of these animals. The pre-antennal filaments show the presence of nerve tissue and probably serve in some sensory capacity. The first antenna has an enlarged base which bears several rows of long, lash-like aesthetascs. The aesthetascs are believed to be chemosensory in function, aiding in the detection of prey. Remipedes swim dorsal side down, extending the first antenna forward as they swim. The second antenna beats continuously as the animal swims. This generates a current which keeps water flowing over the aesthetascs for chemoreception.

Remipedes are predatory and their prehensile feeding appendages are important taxonomic characters. In some caves, several species of remipedes are found together in the same general area. The variation of feeding appendages in size and morphology is an apparent adaptation which allows niche partitioning and selection of prey items.

The first maxilla in all species bears a modified claw or fang at the tip. The fang length varies among species. It apparently serves as a «hypodermic needle» to inject prey with a toxin or digestive fluid. Large secretory glands are found at the base of each maxilla and a cuticulized duct has been traced from the base of the appendage to the tip. *In situ* feeding by the remipede *Lasionectes entrichoma* (Yager and Schram, 1986) has been reported by Dennis Williams (pers. comm.). The animal was seen grasping an individual typhlatid shrimp, swimming with it, and later discarding an empty exoskeleton. A preliminary study of gut contents of remipedes revealed an amorphous, nondescript fluid along the entire length of the gut, possibly suggesting predigestion of the prey.

Along with the length of the fang, the first maxilla also varies in size when compared to the other two raptorial appendages. In one species, the first maxilla is huge, while the second maxilla and maxilliped decrease in size and robustness. In another species, the first maxilla is dwarfed by the robust second maxilla and maxilliped. This difference in size ratio can be related to prey specificity. In addition, the tip of the second maxilla and maxilliped have a claw arrangement which appears to be modified for the manipulation of different prey.

Little is known about the life history of remipedes. The protopod of the 14th trunk appendage bears a gonopore. In some individuals, a small porous flap is found beneath the gonopore. Paired ovaries and oocytes have been observed in paraffin sections of individuals. Transmission microscopy of the 14th trunk appendage of one species has revealed the presence of sperm in what appears to be a receptacle in the protopod (Yager, unpublished data). Although juvenile specimens have been collected, they are miniature copies of the adult, bearing at least 12 trunk segments. They differ from the adults by having trunk segments which are rounded and lack distinct lateral pleurae.

Characteristics of the Remipede environment

Anchialine caves of the West Indies typically have a small surface pool of fresch to brackish water. A distinct density interface separates this water from the more dense polyhaline to euhaline water below (Fig. 2). The totally dark, deeper passages may extend horizontally for thousands of meters through the

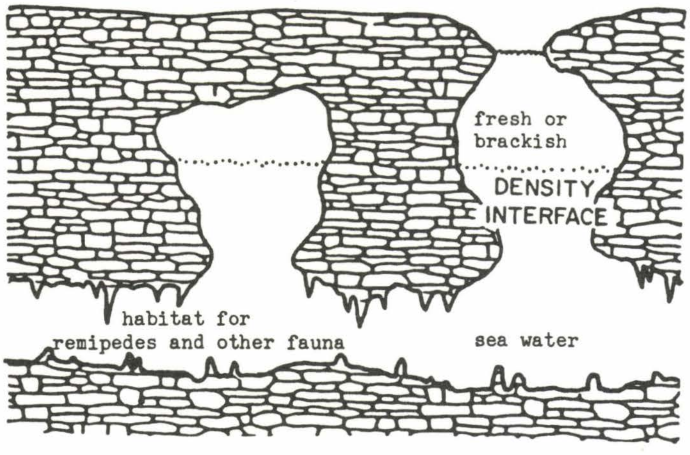

Figure 2. Typical anchialine cave.

porous limestone. Beneath the density interface, the water is characterized by very low oxygen content, in some cases less than 0.1 part per million (ppm), while water above the density interface consistently measures 4-5 ppm. In certain caves, the polyhaline waters have long residence times, as many passages show little or no horizontal tidal movement. There is frequently a 2-3 m layer rich in hydrogen sulfide beneath the density interface (Yager, unpublished data).

A unique assemblage of troglobitic organisms inhabits the environment beneath the density interface, which in some cases is nearly anoxic. Exploration of this environment has resulted in the discovery of many new species of crustacea, including amphipods, thermosbaenaceans, isopods, ostracods, copepods, and shrimp. The inland anchialine cave habitat differs from the marine or ocean bluehole in both biotic and abiotic factors. The ocean cave or bluehole has an opening in the floor of the ocean; strong currents prevent the formation of a distinct density interface, serve to oxygenate the water, and bring in food items. The faunal assemblages of these two cave environments are dissimilar.

For as yet undetermined reasons, the population size of *Speleonectes lucayensis* in Lucayan Cavern appears to be much lower than in other caves which have been surveyed. In over 100 dives in Lucayan Cavern, only about 15 individual have been sighted and only six individuals have been collected. No other remipede species has been collected from this cave. In contrast, a cave on Providenciales in The Turks and Caicos was found to be inhabited by hundreds of individuals of *Lasionectes*, all of the single species. In contrast, five apparently distinct species of remipedes have been collected from the same general region in a single cave on Abaco, Bahamas.

A recent survey of anchialine caves on Long Island, in the Bahamas found caves with many abiotic characteristics in common with ones previously explored, including fresh to brackish surface water with a high dissolved oxygen content and a density interface, below which the salinity increased and dissolved oxygen decreased. Furthermore, several caves had a distinct hydrogen sulfide layer beneath the density interface. The fauna which included amphipods, ostracods, and thermosbaenaceans, resembled those in anchialine caves elsewhere in the Bahamas. Some caves had very large populations of the shrimp *Barbouria cubensis,* and numerous specimens of *Lucifuga spelaeotes,* the blind ophidiid cave fish. However, despite the apparent environmental similarities, remipedes were not found in any of the Long Island caves which were surveyed. The apparent absence of these animals from certain caves on an island in the middle of the known remipede range is perplexing and raises many questions about the ecology, geographic distribution of these organisms.

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Pheromonal and Tactile Communication in the Subterranean Salamander, *Typhlomolge rathbuni*

David L. Bechler
Biology Department, Lamar University, Department of Biology Beaumont, Texas U.S.A.

RESUM

Aigua i rocs acondicionats per un o dos Typhlomolgue rathbuni *foren sotmesos a una sèrie de proves, per a veure com afectaven d'altres individus de la mateixa espècie. Els mascles adults i els joves varen presentar una resposta significativament positiva envers l'aigua de les femelles, però aquestes, en canvi, hi varen mostrar un significatiu rebuig. Les femelles foren clarament atretes per l'aigua acondicionada per mascles i també per l'aigua acondicionada per un mascle i una o dues femelles. Els mascles joves foren també atrets per l'aigua acondicionada per dues femelles. No ha pogut ésser demostrat que algunes de les feromones despreses s'adherissin als substractes de la roca. Un comportament descaradament agressiu, com pot ser mossegar, només es van donar ocasionalment. Colpejar amb la cua, va ser una reacció molt més corrent que no pas la de mossegar i la dugueren a terme individus d'ambdós sexes. El fet que picar amb la cua no ocasionés una reacció excessivament negativa suggereix la possibilitat que aquesta acció vagi encaminada a dispersar les feromones i no representi, en canvi, un mitjà de comunicació tàctil.*

RESUMEN

Agua y piedras condicionadas por uno o dos Typhlomolge rathbuni *fueron sometidas a pruebas respecto a otros sujetos de la misma especie. Los machos adultos y jóvenes mostraron una respuesta significativamente positiva al agua de hembras, pero las hembras mostraron un significativo rechazo. Las hembras fueron significativamente atraídas por agua condicionada por machos y también por agua condicionada por un macho y una hembra o dos. Los elementos jóvenes fueron también atraídos por agua condicionada por dos hembras. No pudo ser demostrado que algunas de las feromonas desprendidas se adhirieran a los substratos de roca. Un comportamiento abiertamente agresivo como morder se dio ocasionalmente. Golpear con la cola fue mucho más corriente que morder y fue efectuado por ambos sexos. El hecho de que golpear con la cola no ocasionara una reacción muy negativa sugiere que posiblemente lo hagan más para dispersar las feromonas que como medio de comunicación táctil.*

SUMMARY

Water and rocks conditioned by one or two Typhlomolge rathbuni *were tested against other conspecifics. Adult males and juvenile showed a significant positive response to water from females, but females showed a significant avoidance. Females were significantly atracted to water conditioned by males and water conditioned by a male and female or two females. Juveniles were also atracted to water conditioned by two females. It could not be demonstrated that any of the pheromones released adhered to rock substrates. Overt aggressive behavior in the form of biting occurred occasionally. Tail beating was much more common than biting and was performed by both sexes. The fact that tail-beating did not elicit a strong negative response suggest that it may be used more to disperse pheromones than to serve as a means of tactile communications.*

Introduction

In the absences of light, hypogean organisms are restricted to four means of communication: tactile, pheromonal, auditory, and electrical. Only pheromonal and tactile communication have been studied in detail for any hypogean species. Parzefall (1981), has reviewed tactile communication in cavefish and studied its ecological correlates in the European cave salamander, *Proteus anguinus* (Parzefall et al. 1981). Bechler (1983) studied tactile communication in the North American blind cavefish family, Amblyopsidae, Pheromonal communication has been studied in *P. anguinus* (Parzefall et al., 1981) and in the hypogean marine crab, *Munidopsis polymorpha* (Parzefall and Wilkens, 1975).

In this paper I report on tactile and pheromonal communication in the Texas blind salamander, *Typhlomolge rathbuni.* Specifically I have tested for inter and intrasexual communication, the nature of any pheromones discovered and the importance of tactile communication as it relates to pheromone communication.

Methods

Specimens were loaned by Southwest Texas State University where they were collected by methods described in Longley (1978). Intra and intersexual communication were tested for by placing a single individual, designated the receiver, in a glass tank 30 x 50 centimeters. One end of the tank was separated by dividers 15 centimeters long and 10 centimeters apart. This produced three compartments which were open to the remainder of the tank. Controls consisted of tap water run from a 40 liter tank into two of the compartments. Water from a second 40 liter tank containing one or two salamanders (male, female, two females or a female and a male), designated the sender(s), was run into a third compartment. The flow rate into each compartment was six millimeters/minute. To prevent bias by a salamander for a particular compartment, each test was run three times and water from the experimental tank was rotated between all three compartments. The purpose of using two animals is the experimental tank was to see if social interactions produced different pheromones. Tests were begun only when the receiver was at the end of the tank opposite the three compartments.

To test whether or not pheromones would adhere to the substrate, three equally sized rocks were placed in a salamander's 40 liter holding tank. One rock was from the salamander's own tank, the second from a different animal's tank and the third had not been in contact with any salamanders. All pheromone tests were conducted for 30 minutes during which time the position of the salamander in the test tank was recorded every 30 seconds. Data taking for all pheromone tests was begun 10 minutes after the water flow had been started or rocks had been placed in the tank.

In order to study tactile communication, one salamander was placed in another animal's tank and observed for 30-120 minutes. Individuals were used more than once but never paired with the same individual more than once. All interactions and times of interactions observed were recorded on tape and later transcribed for analysis.

A severe drought occurred in Texas during this study. Subsequently few animals were obtained and sample sizes were low (six females, two males, two juveniles). Additionally, all 10 animals were not present in the laboratory at one time. Therefore all possible combinations of tests were not conducted. All statistics were conducted using a nonparametric sing test (Gibbons, 1976).

Results

Pheromone tests-one sender: Females displayed a significant avoidance of compartments receiving water from another female's tank ($N = 6$, $z = -4.21$, $P < 0.001$). But they moved freely in and out of control compartments. Females spent a sifnificantly greater amount of time in compartments receiving water from a male's tank than in control comparments ($N = 3$, $Z = 7.60$, P 0.001). Males also showed a significant attraction for water from a female's tank ($n = 2$, $Z = 7.50$, $P < 0.001$). Interstingly, juveniles also showed a significant attraction for water from a female's tank ($N = 2$, $z = 6.20$, $P < 0.05$), but the level of significance was lower than observed for the males.

Pheromones tests-two senders: Females receiving water from two females interacting tactilely showed a significant attraction for the compartment receiving the water ($N = 6$, $z = 4.71$, $P < 0.0002$). Females also showed a significant attraction for water in which a female and a male were interacting tactilely ($N = 3$, $z = 2.21$, $P \times 0.014$). Water conditioned by two interacting females produced a strong negative response by the males ($N = 2$, $z = -7.49$, $P \times 0.0002$), but one male was extremely lethargic and died a few days after the test. The strong negative response occurred because the sick male moved into a control compartment and spent nearly 100 % of a test period there. Again juveniles showed a significant attraction for female conditioned water ($N = 2$, $z = 2.64$, $P \times 0.004$).

Pheromone substrate adherence tests: The most notable fact about these tests was that the test animals showed almost no interest in the rocks placed in their tanks. The sign test was only used to see if the salamanders showed a preference or avoidance for a rock from another individual's tank.

None of the tests were significant (female sender-female receiver, $N = 6$, $z = 0.12$, $P = 0.41$; female sender-male receiver, $N = 2$, $z = -1.25$, $P = 0.11$: female sender-juvenile receiver, $N = 2$, $z = -1.57$, $P = 0.06$). When an animal did encounter a rock, it simply walked past and never showed any type of exploratory behavior or hesitancy.

Tactile Communiation: One incidence of full courtship behavior and two partial incidences were observed. All three incidences closely fit the general pattern described for the Plethodontidae by Slathe and Mecham (1974). A fairly diverse repertoire of tactile behaviors occurs between pairs of courting salamanders in the Plethodontidae. But only two types of tactile communication were observed between pairs of noncourting *T. rathbuni*, tailbeating and biting. Tail-beating was by far the most common act observed and was engaged in by both sexes when contacting a salamander of either sex. It involved a slow, exaggerated undulation of the tail and was performed so that direct contact between the salamanders occurred or it was performed at a distance so only a current of water was propelled against the other salamander. The recipient of tail-beating most often simply swam or walked away, but on occasions made no response at all. Only two individuals were observed to bite another salamander and only one of these repeatedly bit another.

A key point concerning the tactile behaviors observed was that they were relatively infrequent. Nine of 17 female-female pairings produced no observable tactile interactions and three of seven male-female pairings produced no observable tactile pushed past each other or withdrew and moved off in different interactions. If two *T. rathbuni* encountered each other the simply pushed past each other or withdrew and moved off in different directions. Members of a pair which did interact occasionally rubbed their cloacae on the rocks in the tanks suggesting a dispersal of pheromones as seen in other species in the Pletohodontidae (Arnold, 1972)

Conclusions

As found in other salamanders (Madison, 1977, Tristram, 1977; Jaeger and Gergits, 1979; Dawley, 1984a, 1984b), *T. rathbuni* appears to use chemical cues to distinguish between males and females. Both sexes were attracted to water conditioned by the opposite sex. An interesting contrast was found when the response of females receiving water from one female was compared to those receiving water from two females. Females responded positively to water conditioned by two females engaged in tactile communication, but negatively to water conditioned by one female. This suggests that two different pheromones might be involved. The same pheromone that attracts males may repel females. A second pheromone secreted by females attempting to initiate courtship may also be involved and may attract other females which would also be seeking a mate. This second pheromone might be released only during contact with another individual.

Another interesting finding was the attraction juveniles showed for water conditioned by one or two females. Nothing is known about parental care in this species. The Cincinatti, Ohio, zoo has sucessfully bred *T. rathbuni*, but they have always removed the eggs from the female's tank (Personal communication, Dr. Glen Longley). The response of the juveniles suggests that there may be some form of parental care. Another explanation would be that juveniles are attracted to adults because the adults scare up prey items that the juveniles are able to capture. Without further data it cannot be determined which explanation might be correct.

The most common act of tactile communication was tail-beating. Its most likely function is pheromone dispersal. Several facts support this contention. Tail-beating occurred in less than 50 % of all the pairs of salamanders observed. It was a slow and deliberate act and it rarely produced a strong negative response such as rapid and excited flight. It never illicited an aggressive response such as biting. A similar pattern of nonaggressive behavior in sexually active adults combined with pheromonal communication has been reported by Parzefall et al. (1980) for male and female pairs of *P. anguinus*.

Data indicates that the pheromones tested for do not adhere to the substrate. Rather they are only carried in the water. This is in contrast to pheromones produced by *P. anguinus* which marks off breeding territories using a Pheromone that adheres to rocks (Parzefall et al., 1980).

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Contribution to the knowledge of the biology of the yugoslav endemic cave hydroid *Velkovrhia enigmatica* Matjasic & Sket, 1971.

Milan Velikonja
Department of Biology and Institute of Biology, University of Edvard Kardelj, Yugoslavia.

RESUM

L'hidroïdeu cavernícola Velkovrhia enigmatica, fins ara només localitzat a la cova de Planiska jama, ha estat també observat en altres cavitats del carst Dinàric.

La història natural de l'hicroïdeu esmentat, va ésser estudiada en el laboratori. Es van descobrir dos tipus de gonòfors (femella i mascle, respectivament). Els gonòfors es presenten en colònies separades. La larva, del tipus plànula consistent, alliberada en el gonòfor femella, neda al voltant de la colònia durant diversos períodes de temps. Les poblacions de l'hidroïdeu cavernícola, en les condicions del laboratori, experimenten un cicle estacional.

RESUMEN

El hidroideo cavernícola Velkovrhia enigmatica, hasta ahora sólo conocido en la cueva de Planiska jama, ha sido también encontrado en otras cavidades del karst Dinárico.

La historia natural del hidroideo arriba mencionado, fue estudiada en el laboratorio. Se descubrieron dos tipos de gonóforos (hembra y macho respectivamente). Los gonóforos se presentan en colonias separadas, la larva, de tipo plánula consistente, liberada en el gonóforo hembra, nada alrededor durante diferentes períodos de tiempo. Las poblaciones del hidroideo cavernícola expermientan un ciclo estacional en las condiciones de laboratorio.

SUMMARY

The cave hydroid, Velkovrhia enigmatica, hitherto knowm only from the cave Planinska jama, was also found in some other caves of Dinaric karst.

The life-history of the above mentioned hydroid were studied under laboratory conditions. Two types of gonophores (female and male respectively) were found. Gonophores appear on separated colonies. The larva, solid planula, released from the female gonophore, swimm about for different lenghts of time. Populations of the cave hydroid exhibit a seasonal cycle under laboratory conditions.

Introduction

Velkovrhia enigmatica the small Yugoslav endemic cave hydroid is still a puzzling especies. Up to now, investigations of the cave hydroid has a mostly taxonomical character (Matjašič & Sket, 1971; Kuštor, 1977), giving only few biological data (Sket & Matjašič, 1977). Extensive knowlege concerning its ecology, ontogeny and biology is missing. Therefore our investigations will elucidate some of the above metioned unknown aspects in the biology of the cave hydroid.

Material and Methods

At the beginning of the channel Pisani kanal in the Rak branch (Rakov rokav) of the cave Planinska jama, many colonies of *V.enigmatica* were collected. At this site in extremely low water level, dense populations were found. Particularly dense are the populations in still bays, where currents appear to be negligible during low water levels. Since the habitat of *V. enigmatica* is accesible only occasionally (usually at the end of summer and rarely in very cold and dry winters) we decided to study its biology in culture. The hydroid was kept in a refrigerator in 200 ml glass jars at 10 1 °C.

All animals were fed once a week with nauplia (or early stages of metanauplia) of *Artemia salina* which were washed several times with fresh water and then introduced among the tentacles of the hydroid (nauplia, released freely in the culture jars, died and fell to the bottom).

At each feeding all hydrants and newly emerged gonophores were counted.

Fig.1: Position of the caves, in which the cave hydroids were found. 1-The cave Planinska jama, 2-the cave Krška jama, 3-the cave Tounjčica, 4(?)- questionable site, the cave Vjetrenica.

Cave copepods on wich the hydroid presumably feeds in natural conditions, were not available in quantity.

The nonexisting data about water level oscillations in that part of the cave, were substituted by data on month by averages of precipitations measured between the years 1926 and 1965 at five stations in the surroundings of the cave Planinska jama.

All observations were made employing a stereo microscope Zeis SMXX. The light was cut down by an IR filter.

For histological studies, gonophores were fixed in the Bouin solution. 7 um thick slices were stained with haematoxylin-eosin and azan.

Line drawings were made with aid of drawing apparatus Zeiss and stereo microscope Zeiss Laboval.

Results and discussion

1. Ecology and habitat

V. enigmatica was hitherto known only from the surface of some m^2 in the type locality. New data document a quite wide distribution of the animal in the Dinarides (fig. 1):

- The cave Planinska jama (Slovenija-Slovenia, Yugoslavia); a number of localities along the entire Rak branch (Rakov rokav) of the cave (in extension of at least 1 km).
- The cave Krška jama (Slovenija-Slovenia, Yugoslavia); above the resurgence of the river Krka, in an artificial substrate sampler we found two stems, both with hydrants.
- The cave Tounjčica (Croatia-Hrvatska, Yugoslavia); we found live colonies on stones in small pools. Here it lives together with the troglobitic freshwater sponge *Eunapius subterraneus subterraneus* Sket & Velikonja.
- The cave Vjetrenica (Popovo polje in Hercegovina, Yugoslavia); Only one stem with one hydrant was found in a container with living animals and stones from the mentioned cave, kept in Ljubljana. For this reason this site may be questionable.

2. Vertical distribution

Vertical distribution of colonies of *V. enigmatica* in the river bed is limited by the water level. Most of the colonies live below the low water level, although some were found outside of the water in dry summers (Sker & Matjašič, 1977). The upper limit of the vertical distribution in the river bed probably coincides with a nearly(!) steady inundation.

3. Gonophores

Gonophores of both sexes evidently differe in their morphology. In the material brougnt directly from the cave, we found only 4 female and no male gonophores (Sket & Majašič, 1977; own data). The live female gonophores is spherical or slightly elongate in shape. The male gonophore is pear shaped or very elongately elipsoidal. As the female and the male gonophores were never found on the same colonies, we may conclud that colonies are dioecious.

The gonophores spring off in the part of the polyp, called «gastric column» by Bouillon (1967). Due to small number of gonophores , we can used for histological analysis, our idea about their internal structure is rather uncertain. A gonophore begins as an evagination of the entire body wall. the young gonophore contains a simple gastral cavity, but very early in the developement, the gastroderm evaginates into it. Eggs or spermatozoa resp., mature between the ectoderm and the gastroderm. As in the polyp, gastrodermal cells here also contain irregular shaped particles. These are probably food particles, which supply ripening sex cells or embryos respectively (fig. 2). Arragement of the gastroderm in fuly developed gonophores is different in both sexes. Arragement of the gastroderm in the male gonophore is rather centrl (fig.2) whilen in the fermale gonophore it becomes tubular and pushed to the ectoderm (fig.2).

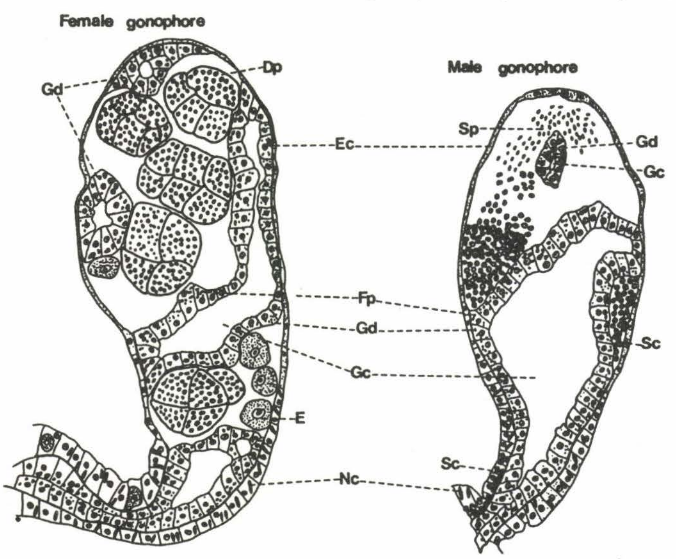

Fig. 2: Longitudinal section of female and male gonophores. Dp-developing planulae, E-eggs, Ec-ectoderm, Fp-food particles, Gc-gastral cavity, Gd-gastroderm, Nc-nematocysts, Sc-spermal cells, Sp-spermatozooids.

4. Larva

The larva is a solid planula, 200 um in length. It glides and swims about slowly from some hours to some days after which it attaches to the substratum with its anterior end. Under laboratory conditions before final adhesion, larva repeatedly attached to the substratum and then released from it. In the 12 day old larva a small cavity appears in the central mass of cells, which later most probably becomes the gastral cavity of the hydroid.

We were unsuccessful in keeping animals (alive) during further development.

5. Seasonality of hydrants and Gonophores

The seasonal rhytmicality in the number of hydrants as well as in gonophore emergence were observed during a two year period. The number of hydrants fluctuate gently between November and July (fig. 3). The number of hydrants in August suddenly decreased and during the following three months the initial state was attained. The average number of hydrants between November to July was 17.4 and in August only 7 hydrants per colony.

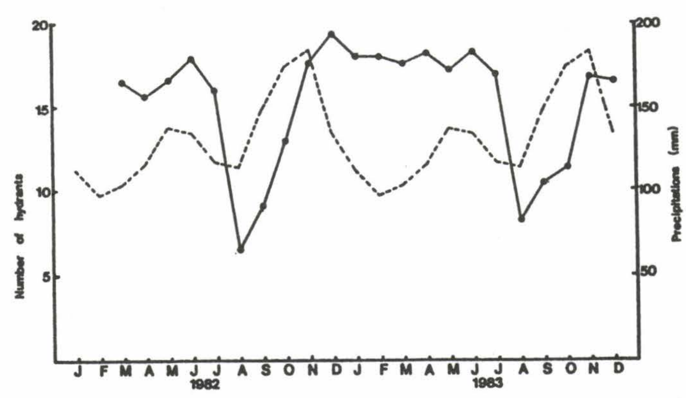

Fig. 3: Seasonal growth of the hydrants. ---- Average month number of the hydrants, counted once a week. - - - Month average precipitations measured during the years 1926-1965.

Similar rhytmicality was observed in the growing together of new gonphores But the maximun number of newly emerged gonophores was observed during January to March (table 4).

The high number of hydrants persists through nine months. It is followed by a sudden degeneration in August and consequently by a three months period of new growth (regeneration?).

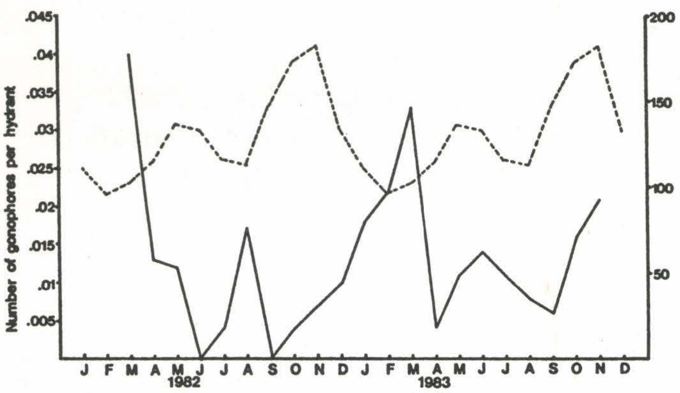

Fig. 4: Seasonal growth cycle of gonophores. ---- Number of gonophores per hydrant. - - - Month average precipitations measured during years 1926-1965.

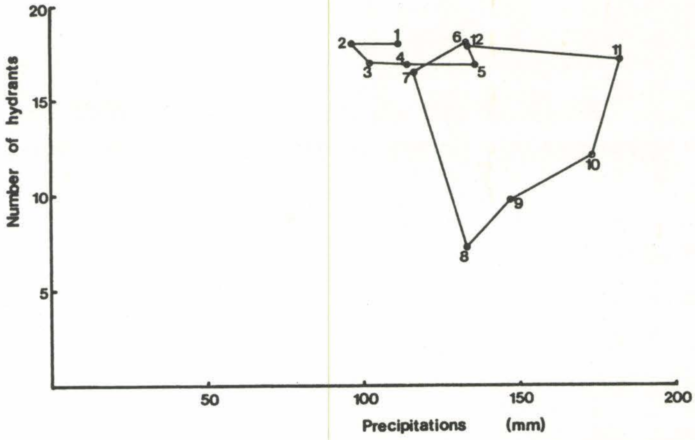

Fig. 5: Direct relation between the number of hydrants and amount of precipitations. Numbers (1,2,3,..) represent months.

Thus in a one year cycle of growth, we can distinguish two stages: the first is relatively constant and lasts from November to July. During this stage the number of hydrants is rather constant. The second stage is charatcterised by a rapid reduction of most hydrants, followed by a gradual development of new ones. This periodicity is in accordance with the periodicity of precipitations. It is highly possible that it is caused by a «flood factor», as pointed out by Hawes (in Vandel 1964). The period of colony regeneration (September-November) coincides with the height of precipitations, due to which waters bring into the underground new quantities of food (tiny animals and organic particles). It is possible, that the reduction of the hydrants is an adaptation to very low water levels in summer months, but it also facilitates survival of colonies outside of the water. The new growth, in this case, is the only urgent consequence of previously reduction. Even the rhitmicality in the accretion of gonophores which have a considerable shift after accretion of hydrants, may be the consequence of the first or the second reason.

We compare, that course, with data of the hydrological conditions, as far as they are accessible to us.

Precipitation data combined with our own experience from occasional visits to the cave indicate that precipitation quantity is followed by quite high water levels in the cave persinsting till the beginning of the next summer, and which are sometimes interrupted by short low level periods in very cold winters. The increase in precipitations in August, usually does not cause a rise in the water level (due to dried out karstic surface).

Table 5 shows the direct relation between quantity of water in cave system (expressed in mm of precipitations) and an average number of hydrants in colonies. The cave system fills up from February to May (the amount of precipitations is increased; points 2 to 5). The lowest level in the cave system is attained in August; though increased precipitations in the same month have no effect on the amount of water in the cave system. Due to technical reasons the whole culture was not feed in July.

In order to find out, what effect could this have on periodic growth, four groups of colonies were starved even during the 4 months of the most active growth. The fact, that no difference appeared between fed and non fed groups, shows that even 4 weeks of starvation (nonfeeding) does not effect the rhitmicality of growth of the whole colony.

In spite of the above mentioned, we can concluded with some certainty, that the seasonal rytmicality of hydroids is adapted, on the one hand to oscillations of food quantities in the natural habitat, and on the other hand, to very low water level in summer months, which facilitates survival of colonies outside of the water. Such rytmicality is retained during regular feeding under laboratory conditions. It seems that such rytmicality is genetically stabilized.

Acknowledgment

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Evaluation of some taxonomically, zoogeographically, or ecologically interesting finds in the hypogean waters of Yugoslavia (in the last decades)

Boris SKET
University E. Kardelj, Ljubljana

RESUM

Taxonòmicament tenen especial interès els únics representants troglobis dels Porífera-Spongillidae, Cnidaria-Hydrozoa i Bivalvia-Dreissenidae.

En el carst Dinàric s'hi reconeixen 4 regions zoogeogràgiques indistintament limitades: les regions continentals NW i SE, delimitades per les zones epilitoral i paralitoral. Mentre que la seva distribució en altres regions ens mostra un fons essencialment històric, l'última regió està principalment determinada (!) pel factor ecològic. Alguns elements presenten una distribució holodinàrica.

La importància física dels «relictes marins» en la fauna cavernícola s'ha vist disminuïda des de diferents punts. El model de distribució de Marifugia *(Polychaeta Serpulimorpha) ens recorda que es troba en un ambient d'aigua dolça. La distribució de diferents* Monolistra *spp. (Isopoda, Sphaeromatidae) ens prova la seva especiació en aigües dolces epigees. Fins i tot la fauna anquihálina de Iugoslàvia presenta algunes característiques límniques (tant taxonòmicament com fisiològica).*

RESUMEN

Taxonómicamente son de especial interés los únicos representantes troglobios de los Porifera-Spongidiae, Cnidaria-Hydrozoa, y Bivalvia-Dreissenidae.

En el karst Dinárico se pueden reconocer 4 regions zoogeográficas indistintamente limitadas: las regiones continentales NW y SE que están delimitadas por las zonas epilitoral y paralitoral. Ya que la distribución en otras regiones muestra un fondo principalmente histórico, la última región está principalmente determinada (!) por la ecología. Algunos elementos muestran una distribución holo-Dinárica.

La importancia física de los «relictos marinos» en la fauna cavernícola se ha visto disminuida desde diferentes puntos. El modelo de distribución de Marifugia *(Polychaeta Serpulimorpha) recuerda el que se encuentra en elementos de agua dulce. La distribución de diferentes* Monolistra *spp. (Isopoda, Sphaeromatidae) prueba su especiación en aguas dulces epigeas. Incluso la fauna anchihaline de Yugoslavia refleja algunos rasgos límnicos (tanto taxonómica como fisiológicamente).*

SUMMARY

Taxonomically particularly interesting are the unique troglobitic representatives of Porifera-Spongillidae, Turbellaria-Temnocephalida, Cnidaria-Hydrozoa, and Bivalvia-Dreissenidae.

Four indistinctly delimited zoogeographical regions may be recognized in the Dinaride karst: the NW and SE continental regions which are bordered by the epilittoral and the paralittoral regions (zones). Since distribution in other regions exhibit mainly historical backgrounds, the latter region is mainly (!) ecologically determined. Some elements exhibit a holo-Dinaric distribution.

The fictive importance of «marine relics» in the cave fauna has been diminished from different points. The distribution pattern of Marifugia *(Polychaeta-Serpulidae) resembles that of the recognized freshwater elements. The distribution-pattern of different* Monolistra *spp. (Isopoda-Sphaeromatidae) gives proof of their speciation in epigean fresh waters. Even the anchihaline fauna of Yugoslavia exhibits some limnic traits (either taxonomically or physiologically).*

Peculiarity of the dinaric cave fauna

The extreme taxonomical diversity of the hypogean fauna in Yugoslavia has been known from the very beginnings of the speleobiology. Also some unique representatives of higher taxa were found either very early or before the past war (*Proteus anquinus* Laurenti 1768, *Marifugia cavatica* Absolon et Hrabe 1930, e.g.). Meanwhile the glory of some other findings was later diminished by findings outside Yugoslavia (e.g. *Dina absoloni* Johansson 1913 is no longer the only troglobitic leech species; Sket 1986a), other interesting animals were found there. And the number of less prominent taxa is steadily increasing.

Stygobitic GASTROPODA of Yugoslavia belong mainly to the ordo Mesogastropoda (scl. Prosobranchia), there are also some Pulmonata (Acroloxidae e.g.). About 135 recognized taxa of the species category in Yugoslavia represent about 40 % of the World register of such taxa (compate Bole & Velkovrh 1986). Copepoda CALANOIDA are represented in the World with less than a dozen troglobitic species. Two new species representing endemic genera were found in Yugoslavia in the last decades (Petkovski 1978, 1981); one of them reaches also the Italian part of the Dinaric System (Stoch 1984). The number of AMPHIPODA species is increasing rapidly, particularly in the genus *Nipharqus;* G. Karaman (1974) enumerated nearly 60 species (not all hypogean !) with many subspecies. Also new related genera have been described. Similar in the case in ISOPODA. Particularly characteristic is the family Sphaeromatidae which with only 4 taxa in 1910 (Racovitza) appeared to be just an odd and rare guest in fresh cave waters. In 1967 20 and in 1986 (Sket) already 30 (genus *Monolistra*) taxa from an important number of localities in Yugoslavia were known, thus representing one of the commonest settlers in our cave waters (only 8 taxa are known outside of Yugoslavia).

Diafolliculina hadzii Matjašič 1962 from Popovo polje in Hercegovina is one of the few freshwater representatives of the large family and the only described cavernicolous representative of the ordo SPIROTRICHA (Ciliata). At least one species more of the same group has still to be described.

Eunapius subterraneus Sket & Velikonja 1984 from Ogulin surroundings in W Croatia is the only known troglobitic representative of SPONGLILLIDAE resp. of the freshwater sponges (Porifera).

About a dozen of species of *Scutariella, Stygodyticola, Bubalocerus, Subtelsonia,* and *Troglocaridicola* (all Matjašič 1958) have been found along the Dinaric Karst area (including Italy), being the only troglobitic representatives of TURBELLARIA TEMNOCEPHALIDA. Only one species is known in Europe from epigean waters. Cf. *Microplana* sp., found in Slovenia seems to be the first troglobitic representative of TRICLADIDA TERRICOLA (Turbellaria). Only immature specimens have been examined till now.

Velkovrhia enigmatica Matjašič & Sket. 1971 (?Bougainvilliidae) from central Slovenia, W Croatia and probably Hercegovina is the only troglobitic representative of the HYDROZOA (and probably of Cnidaria).

Congeria kusceri Bole 1962, inhabiting caves along the Dinarides represents the family DREISSENIDAE; it is most probably the only troglobitic representative of the Bivalvia. It is very doubtful, whether the few *Pisidium* species, known only from caves, are really troglobitic. *Theodoxus (Neritaea) subterrelictus* Schütt 1963 from Hercegovina is the only subterranean representative of the ordo DIOTOCARDIA (= Archaeogastropoda).

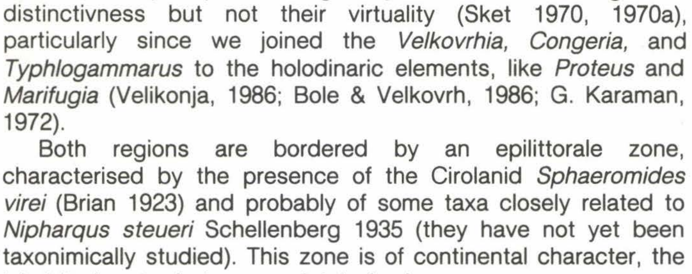
All our cave animals have at least epigean relatives outside Yugoslavia, i.e. no one is the onyl representative of its order. It is worth adding that no troglobitic fishes (Pisces) have been found in Yugoslavia (or in Europe at all).

Zoogeography of the dinaric cave fauna

The zoogeographical partitioning of the cryptic fauna (i.e. fauna of caves, springs, soil, a part of the remaining ground fauna) of the Dinarides is becoming step by step clearer. The borders between the NW and the SE continental regions resp., postulated by Jeannel (1928) as being very distinct are losing their distinctivness but not their virtuality (Sket 1970, 1970a), particularly since we joined the *Velkovrhia, Congeria,* and *Typhlogammarus* to the holodinaric elements, like *Proteus* and *Marifugia* (Velikonja, 1986; Bole & Velkovrh, 1986; G. Karaman, 1972).

Both regions are bordered by an epilittorale zone, characterised by the presence of the Cirolanid *Sphaeromides virei* (Brian 1923) and probably of some taxa closely related to *Nipharqus steueri* Schellenberg 1935 (they have not yet been taxonimically studied). This zone is of continental character, the inhabited water being completely fresh.

Neither of the two above mentioned regions nor the epilittorale zone can be based on present paleogeographical data. Particularly confusing is the fact, that the cirolanid occurs along the Adriatic coast in a virtually unchanged form (*S. virei virei*)



B. Sket: Evalutation...

Fig. 1 Distribution of some Monolistra *spp. in SE Slovenia and adjacent parts of Croatia (L-Ljubljana, Z-Zagreb, R-Rijeka); 1– hypothetical prekarstic drainage directions, 2– actual streams (epigean, hypogean); 3* M. caeca absoloni *Rac., 4* M. c. *ssp., 5* M. c. intermedia *Sket, 6* M. c. caeca *Gerst., 7* M. c. meridionalis *Deeleman; 8* M. racovitzai racovitzai *Strouball, 9* M. r. karamani *Sket, lo* M. r. pseudoberica *Sket, 11* M. r. conopyge *Sket, 12 M. bericum hadzii 13* M. b. *ssp.; ?– subspecific identity uncertain. Note the increased racial differentiation in the NW of the* M. caeca *area, where the river systems must have changed most early. Areas of species are in accordance with ancient epigean river systems.*

which makes a polytop immigration directly from the Sea improbable. Both higher specialized taxa (*S. v. mediodalmatina* Sket 1964, *S. v. montenigrina* Sket 1957) are living a bit further inland.

The most seaward paralittoral zone seems as if being determined by recent ecological conditions. It is a zone of anchihaline cave waters i.e. either brackish or inhabited by an explicitely brackish-water fauna (Sket 1981). Some widely distributed anchihaline species (*Niphargus hebereri* Schellenberg 1933, *Hadzia fragilis* S. Karaman 1932, *Monodella argentarii* Stella 1951, *Diacyclops antrincola* Kiefer 1967) are also present along large parts of the Dinaric coasts, with some, probably relic localities further inland. All of them show clear preferences for the lowest salinities or for fresh water or where competitors are absent.

The Dinaric area (resp. its Adriatic coast) has not been covered by sea to a greater extent than it is presently since the Miocene and a small part of it (part of the Istra Peninsula) was land already in the Paleogene (Prelogović et al. 1975).

Therefore it is most probable that the elements of the present anchihaline fauna inhabited fresh waters between the Paleogene and the Miocene desiccation. Being competitively weak but euryhaline, it was pushed seawards by the stronger freshwater fauna, leaving behind some relic populations (*Hadzia* in the Vjetrenica Cave, *Diacyclops* near Titograd e. g.). This anchihaline fauna regained its present area during the last Quaternary transgression.

Tha Kvarner-Velebit-Region (including the islands Pag and Cres, as well as the coast and islands NE and NW of them) is not included into the paralittoral zone. The characteristically anchihaline *Monodella, Acanthocyclops gordani* Petkovski 1971, *Niphargus salonitanus* S. Karaman 1950 or *N. hebereri* are missing there, *Niphargus* is even in brackish waters representd by species of a more continental character (groups *orcinus, tauri*); *Hadzia* occurs only locally in fresh waters of the KrK Island. Also the widely distributed epigean coastal isopod *Jaera Italica* Kesselyak 1938 in there replaced by the endemic *J. schellenbergi* Kesselyak 1938 (Sket, 1969). The paralittoral elements are present again on the islands Silba and Lošinj as well as on the S end and the W coast of the Istra Peninsula.

We could speculate that a freshwater lake had persisted till the most recent times in the relatively closed Kvarner-Velebit Region during the last transgression. It could have prevented or at least impeded the invasion of the above mentioned fauna by offering good conditions for the persistence of the continental fauna.

Origin of the cave fauna

The presented distribution of the Dinaric anchihaline fauna as well as its hypothetical history gives hold to a supposition, that it is of a freshwater, rather than of a direct marine provenience. The supposition is also supported by the fact that all of our anchihaline species (including the locally polyhaline *Monodella*) occur locally in fresh waters and in all localities prefer water with lowest salinity when free of competitors. The situation on the Dinaric coast may be a particular one, but it demonstrates well how exaggerated the emphasis on the marine provenience of the cave fauna may be.

Chappuis (1926, p.146) already made an assertion that Malacostraca which are so characteristic for the present cave fauna, were widely distributed in surface fresh waters in «early geological periods». It is remarkable that so few spelobiologists accepted his suppositions, emphasizing the marine provenience of cave animals at each occasion. Chappuis' assertions were probably too weakly grounded by arguments; but some prejudices about the shape of freshwater animals may also have been involved. Anyway, the conviction about the (direct ?) marine provenience of the cavernicolous Natantia, Sphaeromatidae, Cirolanidae etc. is expresed in a too great number of papers.

One of the possible (model-) representative groups for marine elements are the mentioned Monolistrini (Sphaeromatidae, Isopoda), particularly as the family in no part of the todays dry land really successfully ruled fresh waters. Chappuis (1927, pp. 143-144) supposes that they too invaded the underground from the epigean fresh waters. Meanwhile most authors neglected his ideas, they were attested by the distribution of particular taxa (species and subpecies) which confirm a speciation in epigean rivers (Sket, 1970a). This is in good accordance with the molecular-genetic datation of speciation in the genus, which must have taken place during the Pliocene (Caccone et al. 1978). The salinity crisis in the Miocene (Hsü, 1972, Hsü et al., 1977) was certainly an event which isolated many animal species invading estuaries or fresh waters from the marine parts of their populations. Our new faunistical data only make the previous picture more convincing, therefore a new sketch of the *Monolistra* distribution in SE slovenia is presented, compared with the hypothetical prekarstic river systems (fig. 1).

Cave fauna (even the anchihaline one !), probably is not everywhere so expressively limnic in its provenience but the dinaric fauna is certainly not an exception in the World.

Pollution

The last group of investigations I want to mention are complex investigations in the Postojna Planina Cave System, particularly in its waters. The selfpurifying ability of a hypogean stream has been investigated in limits of the possibilities forced by complicated hydrological conditions. As in other hypogean waters, an accumulation of nitrates after the degradation of organic matters was observed. Oxygen saturation is achieved already some km past the insurgence of the polluted river Pivka (Sket & Velkovrh 1981).

Also theoretically interesting are observation of the penetration of epigean animals underground. It is supported by increased organic pollution (which may be natural in other localities), showing what an important role food plays in determining the success in competition in hypogean habitats (Sket in press).

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INSECTES
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12237

Cavernicolous campodeids (insecta: diplura) of Mexico

Dr. Lynn M. Ferguson
Department of Natural Sciences
Longwood College, Virginia, USA

RESUM

En aquest treball s'examinen i es descriuen cinquanta-nou col·leccions de diplurs campodèids de coves mexicanes. En compara també la zoogeografia i filogènia d'aquestes espècies de campodèids amb els diplurs cavernícoles, prèviament citats, de Mèxic i Amèrica Central, així com les diverses col·leccions epígees de diplurs de diverses localitas.

RESUMEN

Se examinan y describen cincuenta y nueve colecciones de dipluros campodeidos de cuevas mejicanas. Se compara la zoogeografía y filogenia de estas especies de campodeidos con los dipluros cavernícolas previamente citados de Méjico y América Central, así como con varias colecciones epígeas de dipluros de las mismas localidades.

SUMMARY

Fifty-nine collections of campodeid diplurans from Mexican caves are examined and described. The zoogeography and phylogeny of these campodeid species are compared to the cave diplurans reported previously from Mexico and Central America, as well as to several epigean collections of diplurans from the same localities.

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Updating of *Bathysciinae* of the Iberian Peninsula *Col. Catopidae*)

O. Escolà B.
Museu de Zoologia. Barcelona.

RESUM

Després de la magistral «Monographie des Bathysciinae» *de JEANNEL el 1924, el següent treball de conjunt sobre els* Bathysciinae *d'Espanya va ser efectuat per ESPAÑOL el 1953 i posteriorment per LANEYRIE, el 1967 i 1969 i per GUÉORGUIEV el 1976.*

L'objectiu d'aquest treball és el d'elaborar un catàleg de totes les espècies conegudes de la Península Ibèrica fixant l'ordenació taxonòmica de les sèries filètiques, gèneres, subgèneres, espècies i subespècies, amb alguns grups reordenats, principalment el 1978. Després de cada forma, amb l'autor i any de la descripció, s'indiquen la localitat típica i les col·leccions que conserven els tipus. No coneixem cites de Bathysciinae *de Portugal, així com tampoc ni de les Illes Balears ni Canàries.*

La Posta al dia del conjunt de la subfamília mostra el continu creixement del nombre de taxons així com es perfila una millor definició de les espècies de gran variabilitat o una clarificació de taxa a nivell supraespecífic.

En allò que fa referència a la Península Ibèrica, des de la revisió global per a tot el món de la «Monographie des Bathysciinae» *el 1924 fins a les addicions del 1953 es descrigueren 22 formes noves, des d'aquest darrer any fins al 1969, amb la nova classificació de Laneyrie, 16 espècies o subespècies noves, i des d'aleshores fins a l'actualitat el nombre total s'ha incrementat en unes altres 42 (car s'ha de tenir present que 23 de les espècies o subespècies anteriors han passat a la sinonímia).*

RESUMEN

Después de la magistral «Monographie des Bathysciinae» *de JEANNEL en 1924, el siguiente trabajo de conjunto sobre los* Bathysciinae *de España fue efectuado por ESPAÑOL en 1953 y posteriormente por LANEYRIE, el 1967 y 1969 i por GUÉORGUIEV el 1976.*

El objetivo de este trabajo es el de elaborar un catalálogo de todas las especies conocidas de la Península Ibérica fijando la ordenación taxonómica de series filéticas, géneros, subgéneros, especies y subespecies, con algunos grupos reordenados, principalmente en 1978. Después de cada forma, con el autor y año de la descripción, se indican la localidad típica y colecciones que conservan los tipos. No se concen citas de Bathysciinae *en Portugal así como tampoco en las islas Baleares ni Canarias.*

La Puesta al día del conjunto de la subfamilia muestra el contínuo crecimiento del número de taxones así como se perfila una mejor definición de las especies de gran variabilidad o una clarificación de taxones a nivel supraespecífico.

Por lo que se refiere a la Península Ibérica, desde la revisión global para todo el mundo de la «Monographie des Bathysciinae*» en 1924 hasta la adiciones en 1953 se describieron 22 formas nuevas, desde este último año hasta 1969 con la nueva clasificación de LANEYRIE que aporta 16 especies o subespecies nuevas y desde entonces hasta la actualidad el número total se ha incrementado en otras 42 (teniendo presente que 23 de las especies y subespecies conocidas han pasado a la sinonimia).*

SUMMARY

After the work «Monographie des Bathysciinae*» by JEANNEL (1924) the following writings on the Spanish group were carried out by ESPAÑOL (1953), LANEYRIE (1967, 1969) and by GUÉORGUIEV (1976).*

The aim of this paper is to gather all Bathysciinae *species from the Iberian Peninsula placing the phylectic lines, genera, subgenera, species and subespecies, some groups rearranged mainly in 1978, in systematic order.*

After every form which includes author and year of description, typical locality and collections which keep the types are indicated. No cave records are known for Bathysciinae *neither in the Balearic and Canary Islands nor in Portugal.*

Briging up to date to whole of the subfamily has shown the continuous increase of taxa since 1924. It also points out a more accurate definition of very variable species and a better understanding of supraspecific taxa.

As for the Iberian Peninsula, between the overal revision for all the world in the «Monograpnie des Bathysciinae*» in 1924 and 1953, 22 forms were described. Since then until 1969 the new classification of Laneyrie gave 16 new species or subspecies. From 1969 the total number has increased in 42 (taking into account that 23 have become synonimies).*

The *Bathysciinae* were masterly revised by Jeannal (1911 and 1924) who established the essential supports for the subfamily setting revolutionary opinions on it. Afterwards Español, Laneyrie and this work give a statement of every species of *Bathysccinae* as noted in table I.

We should remark that some taxa have suffered new combinations, synonymies, species which have become subspecies, subgenera have become genera and vice versa, and perhaps one of the more singular is the reunion of the genus *Speophilus* with *Troglocharinus* (BELLÉS et al., 1978). *Speophilus* was the first *Bathysciinae* known from Catalonia (in 1869) and described by Reitter as an independent genus which called Perrinia, in 1985. Jeannel in 1911 had to change this *nomen praeocc.* by *Speophilus.* As *Troglocharinus* was described in 1908 it has priority on *Speophilus.*

Check-list of the species and subspecies of *Bathysciinae* from the Iberian Peninsula

The list is made giving the genus (in capital letters) and every form followed by author and year of description, cave which is the typical locality, municipal boundary, province abbreviated as in cars matriculation which meaning is as it follows:

A: Alacant, B: Barcelona, Bl: Bizcaia (capital: Bilbo), BU: Burgos, CS: Castelló, GI: Girona, HP: Hautes Pyrénées (France), HU: Huesca, L: LLeida, LE: León, M: Madrid, NA: Naparra –Navarra–, O: Oviedo, PA: Palencia, S: Santander (Cantabria), SS: Gipuzkoa –Guipúzcoa– (cap. Donostia –San Sebastián–), T: Tarragona, V: València, VI: Araba –Alava– (cap. Gasteiz –Vitoria–)

	JEANNEL 1924	ESPAÑOL 1953	LANEYRIE 1969	This work 1985
Genera	11	13	13	21
spp.	77	86	86	130
s.spp.	30	43	48	46
Total spp. + s.spp.	107	129	134	176

Table I
Number of genera, species and subspecies in the works which indicate every species of Bathysciinae.

G. ANILLOCHLAMYS Jeann., 1910 — sp. typus: A. tropicus Ab., 1881
bueni Jeann., 1910 — Cv. Andorial.A. Coll.Biosp.
(12) avariae Comas, 1977 — Cv. Forat.Barx.V MZB
tropicus (Ab), 1881 — Cv. Meravelles. Carcaixent.V M N H P
hispanicus Ehl. –inlitt. MNAP
moroderi C.Bol., 1924 — Cv. Meravelles. Llombai.V. Mus. Madrid, Coll. Biosp.
subtruncatus Jeann., 1930 — Cv. Negra Montanejos. CS. Coll. Biosp.
(*baguenai* Jeann., 1930)
aurouxi Esp., 1965 — Cv. Covatilla. Aín. CS. MZB
(34) cullelli Lag., 1978 — Cv. Santa de Serra d'En Galceran. CS Coll. Lagar
S.G. Anillochlamys (Paranillochamys) — (Zariquiey, 1940) sp. typus: P. velox, Zar., 1940
velox Zar., 1940 — Av. Fotx. Tivissa. T. Coll. Zar.
(32) v. montadai Lag., 1963 — Cv. Llúdriga. Tivissa. T. Coll. Lagar
catalonicus Jeann., 1913 — Cv. Santa Montsant. Cornudella. T. Coll. Biosp.
urgellesi Esp., 1965 — Cv. Bonica. S.ª Montsià. T. MZB
(11) G. PSEUDOCHLAMYS Comas, 1977 — sp. typus: P. raholai Zar., 1922
raholai Zar., 1922 — Cv. Tasana. Cadaqués. GI. Coll. Zar.
r. luisbofilli Zar., 1940 — Cv. Malaterra. Roses. GI. Coll. Zar.
(probably it may be synonymous of *P. raholai)*
G. SPELAEOCHLAMYS Dieck, 1870 — sp.typus: S. ehlersi Dieck, 1870
ehlersi Dieck, 1870 — Cv. Joliana. Alcoi. A. Coll. L. von Heyden
(13) verai Comas, 1977 — Cv. Tío Melchor. A. MZB
(27) G. TYPHLOCHLAMYS Esp., 1975 — sp. typus: T. bardisai Esp., 1975
(27) bardisai Esp., 1975 — Av. Barratxina. Xixona. A. MZB
(14) escolai Comas, 1978 — Av. Caldero. Tibi. A. MZB
G. NOTIDOCHARIS Jeann., 1956 — typ.: Speocharis uhagoni Shp.
franzi Jeann., 1956 — Monte Reres. O. Coll. Biosp.
zariquieyi Jeann., 1924 — Pico Leitariegos (en Caboalles). LE. Coll. Biosp.
z. asturiensis Jeann., 1956 Monte Montera (Puente Fierros). O. Coll. Biosp.
ovoideus Jeann., 1956 — Bosque Munielles (circa Cangas Onís). O. Coll. Biosp.
uhagoni (Shp., 1872) — Reinosa. S. Brit. Mus.
u. castilianus Jeann., 1956 Puerto Carrales. BU. Coll. Biosp.
G. SPEOCHARIS Jeann., 1910
Quaestus Schauf., 1861
Quaesticulus Schauf., 1861
arcanus Schauf, 1861 — «Hisp. occ.» (valleys of Saja and Belaya rivers, S) Coll?
perezi Shp., 1872 — «Caves of Cuanes and Cuasande», O. Brit. Mus.
(*clermonti* Jeann., 1913)
(41) sajambrensis Salg., 1980 — Cv. Buseco, Oseja de Sajambre, LE. Coll. Salg.
breuili Jeann., 1910 — Cv. Pindal, Pimiango, O. Coll. Biosp.
sellai Bol., 1924 — Cv. Penicial, Llanes, O. Mus. Madrid

(*s. henrici* Jeann., 1924) SALGADO NOV. SINON., 1978

jeannei Coiff., 1965 — Cv. Vega Teón, Covadonga, O. Coll. Coiff.

(43) j. sotoensis Salg., 1982 — Cv. Sotorriza, Soto Sajambre, LE. Coll. Salg.

(43) j. pongai Salg., 1982 — Cv. Cotazosa II, Cadenava-Beleño, O. Coll. Salg.

(43) recordatrionis Salg., 1982 — Cv. Agua or Venero, Las Cuevas, O. Coll. Salg.

(26) nuptialis Esp., 1973 — Cv. Triángulo, Velilla de Guardo, PA. MZB

(38) olajensis Salg., 1978 — Cv. Carrascal. St.ª Olaja Varga, LE. MZB

occidentalis Jeann., 1911 — Cv. Quintanal, Balmori, Llanes, O. Coll. Biosp.

(*o. obermaieri* Bol., 1924) Cv. la Verde, Porrúa, Llanes, O NOV.SINON. SALGADO, 1978

(40) pseudoccidentalis Salg., 1980 — Cv. Sidrón, Borines-Villamayor, O. Coll. Salg.

(38) espanoli Salg. 1978 — Cv. Cuevona, Ribadesella, O. MZB

(46) luctuosus Salg., 1985 — Cv. Venero, Las Cuevas, O Coll. Salg.

adnexus Schauf. 1961 — «Hisp. occ.», Torrelavega, S., «Cave near Panes»

(44) bergidi Salg., 1983 — Cv. la Gruta, La Barosa, LE. Coll. Salg.

pachecoi Bol., 1915 — Cv. San Román Candano, O Mus. Madrid

(39) mariscali Salg., 1979 — Cv. Tocinos, Caldas de Luna, LE. Coll. Salg.

cisnerosi Per. Ar., 1872 — Cv. Reguerillo, Patones, M. Mus. Madrid

autumnalis Esc., 1898 — Cv. Castillo, Puente-Viesgo, S. Coll. Esc.

a. brevicornis Jeann., 1924 Cv. Hornos Peña, S. Coll. Biops.

(10) angustitarsis Esp., 1950 — Cv. San Lorenzo, Mañaria, Bl. MZB

(*begoniae* Negre, 1965)

vasconicus La Brûl., 1873 — Cv. Albia, Orduña, Bl. Coll. La Brûl.

cisnerosi Rtt., 1885

sharpi Esc., 1898 — Cv. Brujas Scuances, S. Coll. Esc.

(*s. nigricans* Jeann., 1924) Cv. Soldados, Pte. Viesgo, S. Coll. Biosp.

(*s. escalerai* Jeann., 1924) Cv. Covalanas, Ramales, S. Coll. Biosp.

(*s. bolivari* Jeann., 1924) Cv. Cuerdavilloso, Rucandio, S. Coll. Biosp.

escalerai Jeann., 1910 — Cv. Cullalvera, Ramales, S. Coll. Biops.

Breulia mimetica Jeann., 1924 NOV. SINON. SALGADO, 1978

(38) nadali Salg., 1978 — Cv. Cañuela, Arredondo, S. MZB

cantabricus Uhag., 1881 — Cv. Magdalena, Galdames, Bl. Mus. Madrid

flaviobrigensis (Uhag., 1881) — Cv. San Roque Utzcorta, Bl. Mus. Madrid

(*utzcortensis* Rtt., 1885)

(*dissimilis* Coiff., 1965)

noltei Coiff., 1965 — Cv. Goikolau, Lekeitio, Bl. Coll. Coiff.

minos Jeann., 1910 — Cv. Cullalvera, Ramales, S. Coll. Biosp.

(4) (*m. mierensis* C. Bol., 1911) Cv. Cuerdavilloso, Rucandio, S. Mus. Madrid

filicornis Uhag., 1881 — Cv. Monte Serantes, Portugalete, Bl. Mus. Madrid

(*gracilicornis* Jeann., 1911) Cv. S. Roque de Valle, Rasines, S Coll. Biosp.

(*gracilicornis debilis* Bol. 1917) Cv. Mingobalsa, Los Corrales, S Mus Madrid

filicornis seeboldi (Uhag, 1881) — Cv. Magdalena, Galdames, Bl. Mus Madrid

oxypterus C. Bol., 1917 — Cv. Juan Gómez Sámano, S. Mus Madrid

(29) S.G. SPEOCHARIS (ORESIGENUS) (Jeann., 1948) NOV. COMB. ESP. et ESCOL., 1977

jaspei Jeann., 1948 — Cv. Reguerín (Covadonga) O. Coll. Biosp.

(45) S.G. SPEOCHARIS (SPEOGEUS) Salg., 1985

(45) avicularis Salg., 1985 — Cv. Pandanes, Soto Agues Coll. Salg.

(46) amicalis Salg., 1985 — Cv. Subterráneo, Sellaño, Coll. Salg.

(46) a. dilatatus Salg., 1985 — Cv. Venero, Las Cuevas, O Coll. Salg.

G. BREUILIA Jeann., 1910 sp. typus: Adelops triangulum Shp., 1872

triangulum (Shp., 1872) — Potes. O. Brit. Mus. et Coll. Biosp.

(30)G. ESPANOLIELLA Guéorg., 1976 sp. typus: Breuilia tibialis Jeann., 1910

cuneus (Jeann., 1910 sub Breuilia) — Cv. Ventalapera. Bl. Coll. Biosp.

tibialis (Jeann., 1910 sub Breuilia) — Cv. San Roque Liebe. Rasines. S. Coll. Biosp.

(*cendreroi* C. Bol., 1924) Cv. Castillo Noja (partido Santoña). S. Mus. Madrid

urdialensis (C. Bol., 1917 sub Breulia) — Cv. Mingobalsa. Los Corrales de Santullán. S. Mus. Madrid

jeanneli (C. Bol., 1917 sub Breulia) — Cv. Juan Gómez. Sámano. S. Mus. Madrid

(29) (7) G. SPEOCHARINUS Esp. et Escol., 1977

(29) llosesi Esp. et Escol., 1977 — Sima Morterón Hoyo Salzoso Soba. S. MZB

(42) G. BREUILITES Salg., 1980

(42) eloyi Salg., 1980 — Villamayor (Piloña). O. Coll. Salg.

G. BATHYSCIOLA Jeann., 1910

(*Adelops* auct. nec Telk., *Bathyscia* auct. nec Schiödte, *Catopsinus* Motsch. 1868 nom nud.)

zariquieyi C. Bol., 1919 — Vallvidrera. B. Mus. Madr.

z. serratensis Coiff., 1959 — Montserrat. B. Coll. Coiff.

penicillata Jeann., 1924 — Navés. L. Coll. Biosp

madoni Jeann., 1923 — Prats de Molló (France) Coll. Biosp. Spain: St. Sebastià Montmajor (near Berga, B)

greneiri Saul., 1872 — Le Vernet Coll. A. Argod (also: Andorra)

schiodtei schiodtei (Kies., 1850) — Bagnères-de Luchon (HP) (also: Vall d'Aran. L)

s. azuai C. Bol., 1921 — Peña Gorbea VI Mus. Madr.

s. breuili C. Bol., 1921 — Cv. Landarbaso SS Mus. Madr

s. rugosa Shp., 1872 — Zuazo VI Brit. Mus.

s. obermaieri C. Bol., 1918 — Cv. St.ª Elena. Biescas HU Mus. Madrid

aranensis Coiff., 1959 — Artiga Lin (Vall Aran, L) Coll. Coiff.

ovata kiesw, 1850 — Pyrenées (Spain: Vall Aran)

o. catalana Coiff., 1959 — Ripoll. Gl. Coll. Coiff.

o. aragonica Coiff., 1959 — Bono. L. Coll. Coiff.

G. SPEONOMUS Jeann., 1908 sp. typus: S. pyrenaeus (Lesp.)

(8) Speonomus (Parvospeonomus) Bell. et Escol., 1977 — sp. typus: urgellesi Es

delarouzeei (Frm., 1861) — «Grotte d'Arles-sur-Tech» Pyr. Orient. France. Mus. Paris

(*brucki* Frm., 1863)

(*delarouzeei catalonicus* Jeann., 1910)

(*faurai* Jeann., 1910)

(*guimjuani* Zar., 1919)

(*faurai guimjuani* Jeann., 1924)

(*faurai esponellai* Zar., 1935)

vilarrubiasi Zar., 1940 — Cv. Feixasses. St. Feliu de Pallerols. Gl. Coll. Zar.

ugellesi Esp., 1965 — Av. Aranyes. Tordera. B. MZB

(33) canyellesi Lag., 1974 — Av. Pedreres. Gualba. B. Coll. Lag.

S.G. Speonomus s.str.

lopezsellesi Esp., 1950 — Cv. Espoz, on S.ª. Labia NW versant. NA. MZB

n.sp. S. speluncarum group (in litt.) — Sima n.º 2 Reclusa. Hecho. HU. MZB

crypticola Jeann., 1910 — Cv. Forat Negre. Serradell. L. Coll. Biosp.

aurouxi Esp., 1966 — Av. Escletxa Minguera. St. Miquel Vall. L. MZB

(17) antemi Escol., 1973 — Cv. Porredons. Baén. L. MZB

colominasi Zar., 1924 — Cv. Joan d'Os. Tartareu. L.

described as S. (Speonomites) Coll Zar

puncticollis Jeann., 1910 — Cv. Forat Or. Fontllonga. L. Coll. Biosp.

(18) (*puncticollis troglodytes* Jeann., 1910)

(18) (*puncticollis angustior* Jeann., 1910)

puncticollis latrunculus Jeann., 1910 — Cv. Lladre. S.ª Montroig. Isona-Conca d'Allà. L. Coll. Biosp.

(18) (*zariquieyi* Jeann., 1924)

(6) espinosai Bell., 1983 — Cv. Berganui. Bergenui. HU. MZB

scanctigervasi Jeann., 1911 — Mines Canal. Llastarri. L Coll. Biosp.

(20) saforensis Escol. Bell. et Com., 1985 Av. Safor. Llastarri. L MZB
ribagorzanus Jeann., 1911 Cv. St. Salvador. Bonansa. HU. Coll. Biosp.
(19) akarsticus Escol., 1980 Mines Cubilars. Cabdella. L. MZB
(21) porroiensis Escol. et Comas, 1984 Av. Tossal Felis. Porroi Solana. HU MZB
pallaresanus Jeann., 1911 Cv. Saverneda. Sort. L. Coll. Biosp.
andorranus Comas, 1978 Cv. Gorga Margineda. St. Julià Andorra. MZB
latebricola Jeann., 1911 Cv. Espluga Llorna. Espluga Serra. L. Coll. Biosp.
l.elongatus Jeann., 1911 Cv. Sanat. Llastarri. L. Coll. Biosp.
ellipticus Jeann., 1924 Cv. Forat la Bou. Serradell.
(only known 1 ♀) L. Coll. Biosp.
mengeli Jeann., 1910 Cv. Encantades de Toloriu Cavà. L. Coll. Biosp.
(mercedesi Zar., 1922) NEW SINON. Cv Bòfia St. Jaume. Montmajor. L. Coll. Zar.
(16) vinyasi Escol., 1972 Av. Mort. Peramola. L. MZB
cerberus Jeann., 1911 Cv. Espluga Tosses. Bonansa. HU Coll. Biosp.
c. arcticollis Jeann., 1911 Cv. St. Salvador. Bonansa. HU. Coll. Biosp.
(20) tincatincensis Esc. Bell. Com., 1985 Av. Tinc-ca-tinc. Altron. L. MZB
bolivari Esc., 1898 Cv. Peña Fanlo Fanlo. HU IEE
b. luciani Jeann., 1911 Cv. Forau Drolica. Sarsa de Surta. HU Coll. Biosp.
(3) b. altimontanus Bell., 1975 Cv. Garsés. Torla-Fanlo. HU MZB
brieti Jeann., 1911 Cv. Forato Moros. Burgasé. HU Coll. Biosp.
(1) espanyoli Aur. et Bell., 1974 Cv. Molino Aso. Fanlo. HU MZB

S.G. SPEONOMUS (SPEONOMITES) Jeann., 1910 sp. typus: S.(S.) velox Jeann.

velox Jeann., 1910 Cv. Fosca. Vilanova Meià. L. Coll. Biosp.
nitens Jeann., 1910 Cv. Tabaco. Camarasa. L. Coll. Biosp.

S.G. SPEONOMUS (SPEONOMIDIUS) Jeann., 1924 sp. typus: S. crotchi (Shp.)

crotchi Shp., 1872 Cv. Orobe. NA. Brit. Mus.
c. mazarredoi Uhag., 1881 Cv. San Valerio. SS. Mus. Madr.
c. aitzquirrensis C. Bol., 1921 Cv. Aitzkirri. SS. Mus. Madrid.
c. oberthuri Jeann., 1910 Cv. San Adrián. SS. Coll. R. Oberthür

(7) G. EURYSPEONOMUS Jeann., 1919
EURYSPEONOMUS (EURYSPEONOMUS) (Jeann., 1919)

breuli Jeann., 1919 Cv. Martintxurrito. Allí. NA. Coll. Biosp.
(47) *(breuli kilitxketai* Esp., 1945)
mendizabali C. Bol., 1921 Cv. Mendikute. Tolosa. SS. Coll. Biosp.

(7) S.G. EURYSPEONOMUS (URBASOLUS) Esp., 1948

eloseguii Esp., 1948 Cv. Ostalaza. S.ª Urbasa NA IEE
ciaurrizi C. Bol., 1921 Cv. Malkorrandi. Arriba y Ataló. NA. Mus. Madrid.
c. igaratzai Esp., 1945 Cv. Basolo. S.ª. Aralar. NA. IEE

Species incertae sedis
SPEONOMUS

fugitivus Rtt., 1885 «Cave in Montserrat» B Coll. L. von Heyden

G. TROGLOCHARINUS Rtt., 1908 sp. typus: T. ferreri Rtt.
(7)S.G. TROGLOCHARINUS (SPEOPHILUS) (Jeann., 1911) new combation
kiesenwetteri (Dieck, 1869)

(k. sanllorensi Zar., 1924) Cv. St.ª. Agnès. B. Coll. Zar
(k. castellsaperai Zar., 1924) Av. Castellsapera. B Coll. Zar.
k. andresi Escol., 1966 Av. Montserrat. Esparreguer B. MZB
patracoi (Zar., 1922) Cv. Patracó. Esparraguera. B. Coll. Zar.
espanoli (Jeann., 1930) Cv. Traça. Cabra Camp. T. Coll. Lag.
(24) schibii Esp., 1972 Av. Cal Sant. La Llacuna. B. MZB
(48) abenzai (Lag., 1972) Cv. Cal Joan Solé. Pontons. B. Coll. Lag.
(Speophilus) (Trapezodirus) Jeann., 1924)
fonti (Jeann., 1910) Cv. Ormini. Coll Nargó. L Coll. Biosp.
f. zariquieyi (Jeann., 1924) Cv. Guills. Guils Cantó. L. Coll. Biosp. Coll. Zar.
f. infernus (Jeann., 1911) Cv. Diablo. Novés. L. Coll. Biosp.
f. schuttei Esp., 1955 Cv. Font Mentidora. t.m. Pallars Jussà. L. MZB
f. quadricollis (Jeann., 1911) Av. Graller Castellet Tremp. L. Coll. Biosp.
subilsi Esp., 1966 Av. Obaga Grau. Fígols i Alinyà. L. MZB
(9) ludovici Bell. et Deliot 1983 Forat Casa Nova. Fígols i Alinyà. L. Coll. Deliot

TROGLOCHARINUS Rtt., 1908
TROGLOCHARINUS (TROGLOCHARINUS) Rtt., 1908

ferreri Rtt., 1908 Av. Roca. Vallirana. B. Mus. Budapest
f. jeanneli Zar., 1917 Cv. Fou Montaner. Villarana. B. Coll. Zar.
f. codinai Zar., 1917 Cv. Fosca Gavà. B. Coll. Zar. Coll. Biosp., MZB
f. fonti Zar., 1984 Av. Vermell. Begues. B. Coll. Zar., Coll. Biosp., MZB
f. zariquieyi Jeann., 1924 Av. Funiosa. Coll. Zar., Coll. Biosp., MZB
(2) f. pallaresi Bell., 1973 Av. Can Montmany. Palma Cervelló. B. Coll. Bell., MZB
(35) f. abadi Lag., 1981 Cv. Miserachs. St. Sadurní Anoia. B. Coll. Lag.
hustachei Jeann., 1911 Cv. Forat Gel. Llimiana. L. Coll. Biosp.
impellitierii Esp., 1955 Cv. Palomera. Castell-Taús. L. MZB
senenti Escol., 1967 Av. Querant Gran Paús. Vilanova Meià. L. MZB
(49) rovirai Lag., 1975 Cv. Macario. Burgasé. HU Coll. Lag.
(5) variabilis Bell., 1978 Av. Ancosa. Pontons. b. Coll. Zar., MZB
(5) *(espanoli* Zar., 1950 nom. nudum)
v. pinyareti (Zar., 1950) Av. Pinyarets. Montmell. T Coll. Zar et MZB
v. ollai (Zar., 1950) Cv. Olla. Montmell. T. Coll. Zar. et MZB
v. portai (Zar., 1950) Cv. Bolet. St. Quintí Mediona B. Coll. Zar. et MZB
v. arlai (Zar., 1950) Av. Arlà. Albinyana. T. Coll. Zar. et MZB
v. elongatus (Zar., 1950) Cv. Madil. Querol. T. Coll. Zar. et MZB
v. mateui (Zar., 1950) Cv. Garrofet. Querol. T. Coll. Zar. et MZB
v. roselli (Lag., 1952) Av. Foix. Torrelles Foix. B. Coll. Zar. et MZB
v. olerdolai (Lag., 1952) Av. Olèrdola. Olèrdola. B. Coll. Zar. et MZB

G. PERRINIELLA Jeann., 1910

faurai Jeann., 1910 Cv. Rialb. Queralbs. GI Coll. Biosp.
bofilli Zar., 1924 Cv. Encantades. Queralbs. GI Coll. Zar. et MZB

G. TROGLOPHYES Ab., 1894

cenarroi Esp., 1955 Av. Forat Gralles. Bellver de Cerdanya. L. MZB
riberai Esp., 1967 Cv. Manent. Isòvol. L. MZB

G. SPEOCHARIDIUS Jeann., 1919

breuli Jeann., 1919 Cv. Mendikute. SS. Coll. Biosp.
(28) *(filicornis* Jeann., 1919) CV. Ernialde. SS. Coll. Biosp.
bolivari Jeann., 1919 Cv. Arrobieta. SS. Coll. biosp.
(28) vivesi Esp. et Bell., 1980 Si. Ekain'ko Leizea. SS. MZB
(28) G. KOBIELLA Esp. et Bell., 1980
(23) galani Esp., 1970 Guardetxe-Aurre'ko Leizea-1 SS. MZB (described as Speocharidius)
(25) G. ARANZADIELLA Esp., 1973
(25) leizaolai Esp., 1973 Si. Kobeta. SS. MZB
G. ANTROCHARIDIUS Jeann., 1910
orcinus Jeann., 1910 Cv. Gran Febró. La Febró. T. Coll. Biosp.
o. acevedoi Esp., 1953 Forat Castell Formiga. La Riba. T. MZB
(9) G. JOSETTEKIA Bellés et Deliot, 1983
(9) angelinae Bell. et Deliot, 1983 Cv. Akelar. NA Coll. Deliot

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COMAS, J. 1977: Un nuevo *Anillochlamys* de la provincia de Valencia *(Col. Bathysciinae). Speleon*, 23: 21-22.

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ESCOLÀ, O.; COMAS, J. 1983: Les *Bathysciinae* de W de la Noguera Ribagorçana (La Ribargorça, Huesca, Espagne). *Mém. Biosp.*, 10: 257-163.

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Aplicación del modelo de las cadenas de Markov al estudio de la dinámica de poblaciones cavernícolas.

X. Bellés[1] *y C. A Gracia*[2]
(1) Centro de Investigación y Desarrollo (C. S. I. C.)
Jorge Girona Salgado 18-26
08034 – Barcelona. España.
(2) Departamento de Ecología
Facultad de Biología
Diagonal 645
08034 – Barcelona. España.

RESUM

En la present comunicació es comenta l'aplicabilitat del model de les cadenes de Markov en estudis de dinàmica de poblacions cavernícoles. El mètode s'exemplifica mitjançant l'anàlisi de diversos paràmetres relacionats amb la distribució espacial d'una població cavernícola de Speonomus delarouzeei *(Coleoptera: Catopidae).*

Els resultats obtinguts demostren que la mobilitat d'aquests Speonomus *pot ser considerada com un procés estocàstic i estacionari, la qual cosa confirma l'aplicabilitat de les tècniques de marcada i recaptura.*

A més, es demostren diverses preferències ecològiques d'aquests coleòpters cavernícoles. En aquest sentit, val la pena destacar que el temps de retorn *va resultar més curt en el cas d'aquelles estacions que eren més riques en matèria orgànica i més estables des del punt de vista climàtic.*

D'altra banda, es pot estudiar quantitativament la transició entre la cova i la xarxa de microfissures adjacent, amb la qual cosa queda patent l'alta mobilitat d'aquests Speonomus *entre ambdós compartiments.*

RESUMEN

En la presente comunicacion, se comenta la aplicabilidad del modelo de las cadenas de Markov en estudios de dinámica de poblaciones cavernícolas. El método se ejemplifica mediante el análisis de diversos parámetros relacionados con la distribución espacial de una población cavernícola de Speonomus delarouzeei *(Coleoptera: Catopidae).*

Los resultados obtenidos muestran que la mobilidad de estos Speonomus *puede ser considerada como un proceso estocástico y estacionario, lo cual confirma la aplicabilidad de las técnicas de marcaje y recaptura.*

Además, se demuestran diversas preferencias ecológicas de estos coleópteros cavernícolas. En este sentido, merece la pena mencionar que el tiempo de retorno *resultó más corto en el caso de aquellas estaciones que eran más ricas en materia orgánica y más estables desde un punto de vista climático.*

Por otro lado, se puede estudiar cuantitativamente la transición entre la cueva y la red de microfisuras adyacente, quedando patente la alta mobilidad de estos Speonomus *entre ambos compartimentos.*

SUMMARY

In the present communication, the suitability of Markov's chains model to the study of cave population dynamics is discussed. The method is exemplified by the analysis of some parameters related to the spatial distribution of a cave population of Speonomus delarouzeei *(Coleoptera: Catopidae).*

The results obtained show that the mobility of these Speonomus *can be considered as a stochastic and stationary process thus confirming, in this case, the appropriateness of mark-recapture techniques.*

In addition, several ecological preferences of these cave beetles were demonstrated. In this context, it is worth noting that the time of return *was shorter in the case of sampling plots that were richer in organic matter and climatologically more stable.*

Moreover, the transition between the cave and the adjacent network of microfissures was quantified and the results show a high mobility of these Speonomus *from one compartment to the other.*

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Distribution of the iberian bathysciinae (Coleoptera: Catopidae). An explanation

X. Bellés
Centro de Investigación y Desarrollo (C.S.I.C.)

RESUM

Els Bathysciinae ibèrics poden classificar-se en tres grups filogenètics: el grup Anillochlamys, *repartit en una franja subcostanera al NE. d'Ibèria; el grup* Speocharis, *que es troba distribuït per l'àrea Cantàbrica; i el grup* Speonomus, *àmpliament repartit pels Pirineus.*

Diverses dades paleogeogràfiques suggereixen que aquests tres grups estaven ja establerts a Ibèria durant l'Oligocè i, en aquesta època, poden postular-se dos centres de diversificació: l'un localitzat a l'àrea Cantàbrica (on varen evolucionar els Speocharis *i l'altre al NE d'Ibèria (on varen evolucionar els Anillochlamys i els* Speonomus*).*

Les glaciacions plistocèniques varen exercir una considerable influència en determinar, en gran manera, l'areogeografia d'aquests grups i els procesos de colonització carvenícola. Les distribucions actuals coincideixen bàsicament amb àrees que varen ser refugis forestals durant el Würm. En aquesta glaciació, a més, els Pirineus estaven coberts pel gel, la qual cosa fa suposar que varen ser recolonitzats pels Speonomus, *a partir de la regressió del règim glacial.*

RESUMEN

Los Bathysciinae ibéricos pueden clasificarse en tres grupos filogenéticos: el grupo Anillochlamys, *repartido en una franja subcostera al NE de Iberia; el grupo* Speocharis, *que se distribuye en el área Cantàbrica; y el grupo* Speonomus, *ámpliamente repartido en los Pirineos.*

Diversos datos paleogeográficos sugieren que estos tres grupos estaban ya establecidos en Iberia en el Oligoceno y, en esta época, pueden postularse dos centros de diversificación: uno localizado en el área Cantábrica (donde evolucionaron los Speocharis*), y el otro en el NE de Iberia (donde evolucionaron los* Anillochlamys *y los* Speonomus*).*

Las glaciaciones pleistocénicas ejercieron una considerable influencia al determinar, en gran manera, la areografía de estos grupos y procesos de colonización cavernícola. Las distribuciones actuales de los Speocharis *y de los* Anillochlamys *coinciden básicamente con áreas que fueron refugios forestales en el Würm. En esta glaciación, además, los Pirineos estaban cubiertos por el hielo, lo cual hace suponer que fueron recolonizados por los* Speonomus *a partir de la regresión del régimen glaciar.*

SUMMARY

The Iberian Bathysciinae may be classified into three phylogenetic groups: the Anillochlamys *group, spread over a NE strip of Iberia, the* Speocharis *group, distributed on the Cantabrian area, and the* Speonomus *group, widespread in the Pyrenees.*

Several paleogeographical clues suggest that these groups were established in Iberia already in the Oligocene. Furthermore, two centres of diversification can be postulated in this epoch: one located in the Cantabrian area (where the Speocharis *group evolved) and the other in the NE region of Iberia (where the* Anillochlamys *and the* Speonomus *groups evolved).*

Pleistocene glaciations exercised a considerable influence determining, to a large extent, the areography of these groups and processes of cave colonization. The present distributions of the Speocharis *and the* Anillochlamys *coincides basically with areas which were forestal refuges in Würmian times. In addition, since the Pyrenees were ice-covered at that time, it may be assumed that these mountains were recolonized by the* Speonomus *following the glacial regression.*

The Bathysciinae (Coleoptera: Catopidae) from the Iberian Peninsula have been fully treated by different entomologists, especially by R. JEANNEL and F. ESPAÑOL, and may be considered as sufficiently well studied, at least with regard to the systematic and areographical aspects (*cf.* BELLÉS *et al.*, 1978; ESCOLA,1986; BELLÉS, in press).

This background and recent advances made in the knowledge of the paleogeographical evolution of the Mediterranean area (see the recent review by MALDONADO, 1985), have prompted me to outline a reconstruction hypothesis of the succesive steps which have shaped the present areas of distribution of these cave beetles in Iberia.

Composition and present distribution of the iberian bathysciinae

According to JEANNEL (1924), the Iberian Bathysccinae are classified into three phylogenetic groups, *i. e. Speocharis, Anillochlamys* and *Speonomus* (Tabla 1). The *Speonomus* group was further subdivided into two sections: *Bathysciola* and *Speonomus* (BELLÉS *et al.*, 1978) although the distinction was based on ecological criteria rather than on basic morphological features.

The present distribution of these three groups in the Iberian Peninsula is very peculiar and it was previously described by ESPAÑOL (1958) and BELLÉS (in press). The members of the *Speocharis* group occupy the Cantabrian area in addition to an isolated locality in the Guadarrama massif in the centre of Iberia (Fig. 1). The *Anillochlamys* are distributed over a northeastern Mediterranean strip with two apparent discontinuities (Fig. 1). The *Speonomus* are widespread in the Pyrenean area, reaching the Ebro valley; at the western end their distribution is sympatric with that of *Speocharis*, and at the east sector they cover the discontinuity between two faunistic nuclei belonging to the *Anillochlamys* group (Fig. 1).

Origins and main iberian centres of diversification

The phylogenetic connections of these three groups with other Bathysciinae remain poorly understood. The three available studies dealing with the global systematics of the subfamily (JEANNEL, 1924; LANEYRIE, 1967; GUÉORGUIEV, 1976) disagree in most points and a more accurate general classification is needed. Nevertheless, it seems that *Speocharis* shows close affinities whith some west European genera, especially from the Balcanic area (*Hoffmanella* and its allies), *Anillochlamys* is closely related to the genus *Ovobathysciola,* from Sardinia, while *Speonomus* is quite restricted to the Pyrenean area, although, interestingly, they are also represented in Sardinia by a few species belonging to the subgenus *Batinoscelis*, subordinated to *Speonomus.*

Several paleogeographical clues suggest that these basic groups may have been established in the northern part of Iberia at least during the Oligocene. According to BIJU-DUVAL *et al.* (1977), the paleogeographical maps of the Mediterranean area, between the Cretaceous and the Oligocene, look like complicated puzzles because the evolution of the Tethys sea succesively led to changes in the distribution of the emerged lands. Nevertheless,

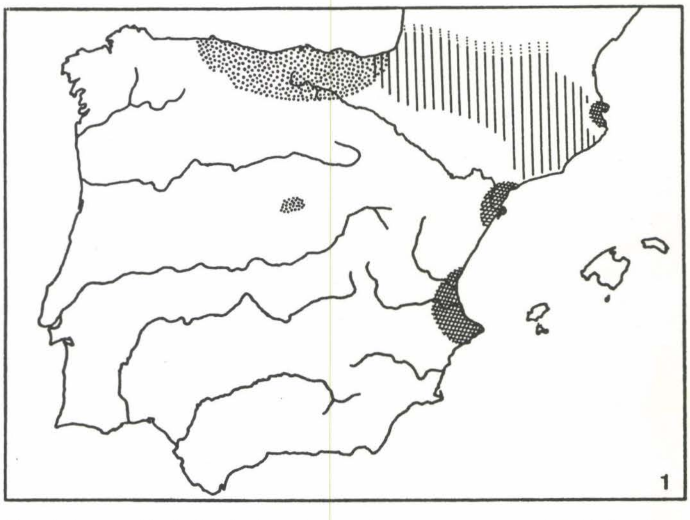

Fig. 1 Geographical distribution of the three groups of Iberian Bathysciinae: Speocharis *(dotted areas),* Anillochlamys *(cross hatching) and* Speonomus *(vertical lines).*

Table 1. Genera of Iberian Bathysciinae. All of them are cavernicolous with the exception of those marked by an asterisc which are typical from superficial cryptic habitats (humus and mosses).

SPEOCHARIS GROUP	*Breuilia* JEANNEL
	Breuilites SALGADO
	Espanoliella GUÉORGUIEV
	Notidocharis JEANNEL*
	Speocharinus ESPAÑOL & ESCOLÀ
ANILLOCHLAMYS GROUP	*Anillochlamys* JEANNEL
	Pseudochlamys COMAS
	Spelaeochlamys DIECK
	Typhlochlamys ESPAÑOL
SPEONOMUS GROUP	*Antrocharidius* JEANNEL
	Aranzadiella ESPAÑOL
	Bathysciola JEANNEL*
	Euryspeonomus JEANNEL
	Josettekia BELLÉS & DELIOT
	Kobiella ESPAÑOL & BELLÉS
	Perriniella JEANNEL
	Speocharidius JEANNEL
	Speonomus JEANNEL
	Troglocharinus REITTER
	Troglophyes ABEILLE

it seems quite clear that at least during the Oligocene there was a continuity of dry lands going from Iberia to Central Europe and to the Balcanic area, which may have allowed important faunistic exchanges between both the eastern and western ends of the Mediterranean area.

It is also worth noting that in this epoch Corsiva and Sardinia broke away from the Protoligurian massif (ALVAREZ, 1976) which also included other drfting microplaques and some areas of Catalonia and Provence.

According to this paleogeographical and phylogenetical information, two important centres of Bathysciinae diversification in the Oligocene can be hypothesized for northern Iberia, one located in the Cantabrian area (where the *Speocharis* group evolved) and the other in the Catalonian area, as a part of the Protoligurian massif (where the *Speonomus* and the *Anilloclamys* groups evolved). From the Oligocene to the Pliocene, the three groups may have carried out active processes of dispersion and progressive colonization of more stable cryptic habitats, mainly as a consequence of the climatic changes, from humid and subtropical to dry and cold, which affected the whole Mediteranean area after the passage between the Mediterranean sea and the Indian ocean was blocked.

Pleistocene glaciations. Main processes of cave colonization and configuration of basic areas of distribution

In fact, the effect of the glaciations in the Iberian Peninsula was quite restricted. During the last one (Würm), the regions covered by ice were limited basically to the Pyrenean area. Nevertheless, a large landscape of tundra spread from these mountains towards the southwest (*cf.* HUETZ, 1970) (Fig. 2). It seems reasonable to suppose that the cryptic fauna, more or less linked to the soil, may have been considerably reduced, if not eliminated, in these tumdra areas, where the frozen soils were from some centimeters to more than one meter deep.

The vegetation map of Iberia during Würmian times (Fig. 2) shows that the present distribution of the *Speocharis* and the *Anillochlamys* groups coincides with areas which were forestal refuges during the Würmian glaciation, whereas the Pyrenees –now occupied by the *Speonomus* group-were covered by ice. This scenario already suggests the succesive steps which may have determined the principal processes of cave colonization and the basic areas of distribution.

The dispersion processes from the two basic centres of diversification, Cantabrian and Catalonian, mentioned above, may have been drastically modified during the Pleistocene glaciations.

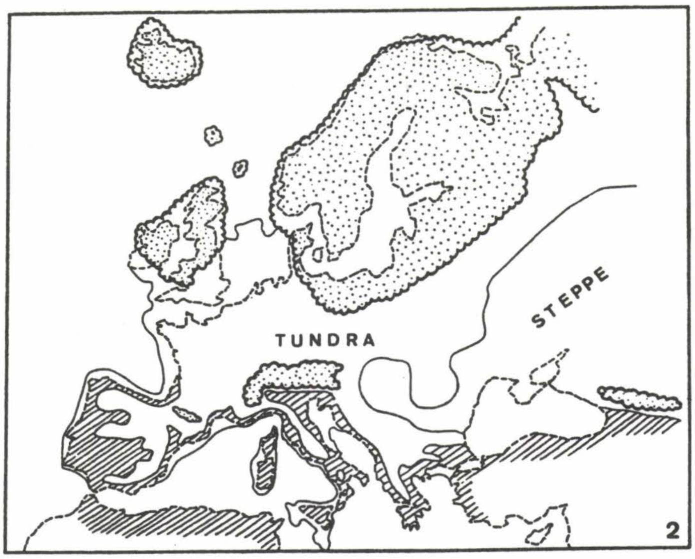

Fig. 2 The vegetation in Europe during the last glaciation (Würm). Dotted: lands which were covered by ice; hatched: forestal refuge areas (From HUETZ, 1970. Slightly simplified).

Accordingly, the glacial regime could have decimated the Pyrenean fauna and those which had reached the tundra areas, reducing the Catalonian and Cantabrian faunas nearly to their original limits. The presence of a member of the *Speocharis* group (*Speocharis cisnerosi*) in the Guadarrama massif (Fig. 1) may be an evidence of the southwards progression of the Cantabrian fauna, which could have remained isolated *in situ* in a refuge area. Likewise, the very peculiar and modified elements belonging to the *Speonomus* group and found at the western border of the Pyrenees (genera *Aranzadiella, Euryspeonomus, Josettekia, Kobiella* and *Speocharidius,* and subgenus *Speonomidius* subordinated to *Speonomus* may be interpreted as a outpost of the pre-glacial dispersion towards the west of these elements of Catalonian origin, which could have remained isolated after the arrival of the glaciations.

Several especies may have colonized the cavernicolous milieu in pre-glacial epochs, but the concentration of cryptic faunas in forest refuge areas could have been an important driving factor favouring the colonization of this milieu, in accordance with the hypothesis of competitive pressure in refuge areas described elsewhere (BELLÉS, in press).

After the regression of the glacial regime, the Pyrenees may have been colonized by the *Speonomus* group, in most cases *via* superficial cryptic habitats (humus, mosses...), but in others perhaps *via* the superficial underground compartment (JUBERTHIE *et al.,* 1980; JUBERTHIE and DELAY, 1981). Nevertheless, progressive specialisation of these beetles may have seriously limited larger migration processes towards the central areas of Iberia, thus explaining the absence of Bathysciinae in the Central and Iberian Systems, with the exception of the above mentioned case of *Speocharis cisnerosi* which resulted from a pre-glacial dispersion.

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FAUNA SUBTERRÀNIA DE CANÀRIES
FAUNA SUBTERRANEA DE CANARIAS
SUBTERRANEAN FAUNA OF CANARY ISLANDS

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La Fauna de las Cuevas Volcánicas en Tenerife (Islas Canarias)

** J.J. Hernández, ** J.L. Martín y **A.L. Medina*

** Museo Insular de Ciencias Naturales de Santa Cruz de Tenerife*
***Depto. de Zoología. Universidad La Laguna (Tenerife, Islas Canarias).*

RESUM

Com a resultat de les investigacions sobre la fauna subterrània realitzades a Tenerife durant els darrers anys, es coneixen actualment més de 20 espècies troglòbies que es troben repartides entre les nombroses coves volcàniques localitzades, pràcticament, en tota l'extensió de l'illa.

La fauna que inclou un major nombre de troglobis és la de la part nord de l'illa i molt especialment als voltants d'Icod de los Vinos, on hi ha els tubs de lava més grans i més abundants de l'illa, como és el cas de la Cueva del Viento. D'altra banda la fauna més pobra en troglobis és la de les zones on l'estructura geològica del subsòl comporta una absència d'esquerdes, impossibilitant d'aquesta manera l'entrada d'animals a les coves. Un exemple d'això el trobem als golerons de lava piroclàstica de la part sud de l'illa i als massissos més antics i erosionats de Teno i Anaga, situats respectivament, al N.O. i N.E.

RESUMEN

Como resultado de las investigaciones sobre fauna subterránea que hemos efectuado en Tenerife durante los últimos años, conocemos actualmente más de 20 especies troglobias que se encuentran repartidas en las cuevas volcánicas que existen en prácticamente toda la extensión de la isla.

La fauna que incluye una mayor número de troglobios, es la de la parte Norte de la Isla, especialmente en los alrededores de Icod de los Vinos, donde hay los mayores y más abundantes tubos de lava, como es el caso de la Cueva del Viento. Por otro lado la fauna más pobre en troglobios es la de las zonas en las que la estructura geológica del subsuelo hace que falten las grietas y por ello evita que los animales pasen a través; son éstos por ejemplo las coladas de lava piroclástica de la parte Sur de la Isla y los macizos más antiguos y erosionados de Teno y Anaga, respecticamente al N.O. y N.E.

SUMMARY

As a result of the researches on the subterranean fauna made by us during the last years in Tenerife, we actually know more than twenty troglobitic species which are distributed along the volcanic caves existing in almost all the stretch of the island.

The fauna including more troglobites is that of the north part of the island, mainly in the surroundings of Icod de los Vinos, where underlay the longest and more abundant lava tubes, as is the Cueva del Viento. On the other hand, the poorest fauna in troglobites is that of the zones which the underground geological structure are lacking cracks, thus preventing the animals to pass through; these are for instance the piroclastic lava flows on the south part of the island, and the older, eroded massifs of Teno and Anaga, respectively at the N.W.and N.E.

Introducción

La isla de Tenerife es, desde el punto de vista espeleológico, una de las islas más ricas del Archipiélago Canario. A lo largo y ancho de sus 2.058 km^2 está salpicada de gran cantidad de cuevas de naturaleza volcánica. Este hecho posibilita que mediante estudios biospeleológicos se pueda investigar, de una forma más o menos generalizada, la fauna tan peculiar que puebla su medio subterráneo.

Por todo ello, el comienzo de las investigaciones bioespeleológicas en Tenerife, hace ahora 5 años aproximadamente, supuso desde el principio un enriquecimiento notable del conocimiento que se poseía sobre la fauna subterránea de la isla. Este estaba limitado a especies predominantemente endógeas, habitantes profundos del suelo como los coleópteros *Bacillopsis franzi, Limnastis gaudini* o *Pseudoplatyderus amblyops* entre otros, así como algunas especies de copépodos de las aguas freáticas. Hoy en día conocemos al menos 24 especies troglobias, muchas de ellas con unas extraordinarias adaptaciones a la vida subterránea y pertenecientes a 8 grupos distintos de artrópodos (Tabla I).

Comentario de las Especies

1. Araneidos. Es uno de los grupos, junto con los coleópteros, más rico en formas estrictamente subterráneas. Actualmente sabemos de la existencia de 7 especies troglobias, de las que 6 pertenecen al género *Dysdera*. Este género presenta una extraordinaria diversidad en las islas. Sólo de Tenerife se conocen 14 especies, de las que 10 son endemismos de la isla (RIBERA et al., en prensa). La existencia de estos troglobios y su presencia en la cuevas hace pensar que probablemente tuvieron estadios iniciales de vida en las grietas del subsuelo superficial (RIBERA et al., op. cit.). Aquí las especies evolucionarían de manera que

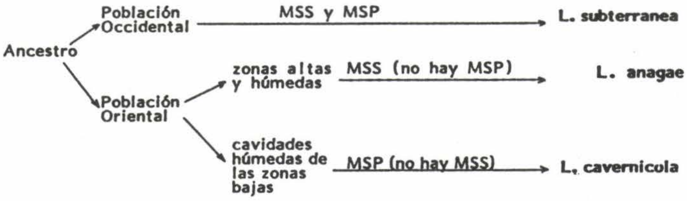
TABLA-1

ORDEN	ESPECIE	ALTITUD	ADAPTACION	REF.
Pseudoscorpionida	Tyrannochthonius superstes	600-800	Troglomorfo	
Araneae	Dysdera ambulotenta	800-1.000	Troglomorfo	18
	Dysdera esquiveli	600-2.200	Troglomorfo	17
	Dysdera unguimmanis	600-1.000	Troglomorfo	18
	Dysdera n. sp.	2.100-2.200	Troglomorfo	
	Dysdera n. sp.	600.1.000	Troglomorfo	
	Dysdera n. sp.	900-950	Troglomorfo	
	Lepthyphantes oromii	0-1.100	Troglomorfo	17
Isopoda	Venezillo tenerifensis	2.100-2.200	Troglomorfo	3
Chilopoda	Lithobius speleovulcanus	600-2.200	Troglomorfo	19
Collembola	Pseudosinella n. sp.	600-1.000		
	Troglopedetes n. sp.	600-1.000		
Blattaria	Loboptera cavernicola	300	Ambimorfo	13
	Loboptera subterranea	0-2.200	Troglomorfo	13
Homoptera	Cixiidae indet.	0-2.200		
Coleoptera	Eutrichopus martini	600-2.200	Ambimorfo	8
	Wolltinerfia tenerifae	800-1.000	Ambimorfo	8-9
	Spelaeovulcania canariensis	600-1.000	Troglomorfo	10
	Canarobius chusyae	900-1.100	Troglomorfo	10
	Canaribios oromii	1.000-2.200	Troglomorfo	10
	Aleocharinae indet.	800-1.000	Troglomorfo	
	Apteranopsis canariensis	1.100-2.200	Troglomorfo	15
	Domene alticola	800-2.200	Troglomorfo	14
	Domene vulcanica	600-800	Troglomorfo	14
Shizomida	Schizomus portoricensis	100-300	Ambimorfo	11-12
Blattaria	Loboptera anagae	800-1.000	Ambimorfo	13
Coleoptera	Limnastis gaudini	600-1.000	Ambimorfo	7
	Curculionidae Anchonini indet.	600-900	Ambimorfo	

les fuera posible la colonización de grietas más profundas y por tanto energéticamente más estrictas. Posiblemente el verdadero hábitat de estas especies sea la amplia red de grietas subterráneas, pues la edad de los tubos volcánicos es obviamente inferior al tiempo que necesitan las especies para adquirir las extraordinarioas características troglobias de muchas de ellas (HOWARTH, 1981; OROMI et al., 1984). Además, la distribución más o menos amplia de algunas de estas especies como *Dysdera esquiveli* por ejemplo, que ha aparecido en cuevas muy distantes entre sí, evidencian que pueden vivir y dispersarse libremente por las grietas del subsuelo. Esto no es por otro lado una peculiaridad de los araneidos, sino que se puede aplicar a todas las especies troglobias.

2. Blatoideos. Recientemente se han descubierto tres nuevas especies de blatélidos en la isla, pertenecientes al género *Loboptera: L. anagae, L. cavernıcola y L. subterranea* (MARTIN Y OROMI, en prensa). Estas tres especies habitan el medio subterráneo de la isla, siendo las dos últimas troglobias. El pattern de distribución está claramente delimitado para cada especie debido a la existencia de barreras subterráneas que impiden la dispersión en algunos puntos de la isla. *L. anagae* está presente en horizontes poco profundos del suelo, en una de las zonas más antiguas de la isla: el Macizo de Anaga, relegada a las cotas más altas donde aún se conserva el bosque húmedo de laurisilva. *L. cavernıcola* se ha encontrado en una sola cueva, prácticamente la única que existe en esta misma zona de Anaga, la denominada Sima Robada, a una cota inferior que la especie anterior. Por último, *L. subterranea* es sin duda el troglobio más abundante de todos los conocidos. Habita el medio subterráneo de prácticamente toda la isla, con la excepción de la zona de Anaga. Se encuentra tanto en los tubos volcánicos como en el medio subterráneo superficial (MSS) de la laurisilva de Teno, zona también de gran antigüedad (+ 6 m.a. según CARRACEDO, 1979).

En la descripción de las especies, MARTIN y OROMI (op. cit.) proponen un modelo de evolución para las tres formas troglobias a partir de un ancestro común, considerando la relación entre la capacidad de dispersión de las mismas y sus posibilidades en función de la efectividad del MSS y del medio subterráneo profundo (MSP) en la isla:



3. Coleópteros. El orden Coleoptera está también bien representado en el medio subterráneo de la isla. Se han encontrado hasta el momento 4 especies de estafilínidos y 5 de carábidos, con 3 géneros exclusivamente subterráneos; *Canarobius, Spelaeovulcania* y *Wolltinerfia* (MACHADO, 1984, 1985 en prensa).

El hallazgo de estafilínidos troglobios en la isla supone un dato de gran interés zoogeográfico y plantea interesantes interrogantes evolutivos. El primer estafilínido descrito fue *Apteranopsis canariensis*, relativamente frecuente en algunas cuevas del Parque Nacional del Teide. Esta especie no se ha encontrado nunca en cotas inferiores a los 1.000 m., y su descubrimiento amplía el mapa de distribución del género *Apteranopsis*, en principio exclusivo de la Berbería Oriental (Argelia y Túnez) (OROMI y MARTIN, 1984). Una interesante novedad es la reciente descripción de dos formas troglobias de estafilínidos del género *Domene; D. vulcanica* y *D. alticola* (OROMI y HERNANDEZ, en prensa). De este género sólo se conocían 3 especies troglobias en cuevas de la vecina región del Atlas (Marruecos). Las especies canarias difieren en algunas características de las especies marroquíes, constituyendo un subgénero distinto y propio de las islas *(Canariomene).*

Entre los carábidos troglobios encontrados en la isla, los primeros descritos fueron 2 Pterostíquidos hallados en el complejo volcánico de Icod de Los Vinos, al N de Tenerife: *Eutrichopus martini* y *Wolltinerfia tenerifae* (MACHADO, 1984, 1985). El primero es una especie relativamente abundante de cuyo género ya se conocían 2 especies epígeas; *E. gonzalezi* y *E. fernandezi. E. gonzalezi* parece ser la más relacionada con la especie troglobia, en cuanto se refiere a la morfología del edeago y configuración del extremo posterior de los esternitos; presenta además un área de distribución que coincide en gran parte con la especie troglobia, aunque lógicamente en el medio epígeo. *Wolltinerfia tenerifae* es una especie mucho más rara que la anterior, habiendo aparecido no sólo en cuevas, sino también en algunas estaciones experimentales de MSS al NW de la isla.

En cuanto al género *Canarobius* posee dos especies anoftalmas; *Cchusyae* y *C. oromii* que curiosamente coexisten en una misma cueva. Ambas especies poseen un carácter primitivo importante, como es la pubescencia muy extendida en los esternitos. Además, *C. chusyae* presenta una adaptación a la vida subterránea ligeramente superior a la de *C. oromii* (MACHADO, en prensa). El género *Spelaeovulcania* cuenta con una sola especie, *S. canariensis,* que es anoftalma y se ha encontrado en 2 cuevas muy distantes en la vertiente N de Tenerife, aunque siempre en escaso número de ejemplares.

En las cuevas de Tenerife suelen aparecer, con relativa frecuencia, otras especies de coleópteros interesantes. Así, en la zona de Icod, hemos encontrado recientemente una especie de curculiónido, perteneciente a un género nuevo de la tribu *Anchonini* (ALONSO ZARAZAGA, comm. pers.). Según AGUIAR (comm. pers.) esta especie es relativamente frecuente en el medio endogeo del norte de la isla.

4. Pseudoescorpiones. Entre los Pseudoescorpiones una interesante especie troglobia, relativamente abundante en cuevas de Icod, es *Tyrannochthonius superstes* (MAHNERT, in litt.), con unas adaptaciones morfológicas muy acusadas.

5. Isópodos. Debido al ambiente tan saturado de humedad que existe en las zonas más profundas de las cuevas de Tenerife, es frecuente encontrar Isópodos, normalmente habitantes del suelo, que pueblan también ese medio cavernícola. También ha aparecido una especie totalmente anoftalma y despigmentada, que podemos considerar troglobia. Hablamos de *Venezillo tenerifensis* que, según DALENS, (1984), ha sufrido una larga evolución en la isla, lo que evidencia un poblamiento antiguo de este género neotropical en Canarias.

6. Otros grupos. Además de estas especies ya comentadas, existen otras que aún no han sido estudiadas, y probablemente hayan más por descubrir. En este sentido es de destacar la presencia de dos nuevas especies de colémbolos pertenecientes a los géneros *Pseudosinella* y *Troglopedetes* (CHRISTIANSEN, in litt.). Otros de los ejemplos lo constituyen los cíxidos (Homoptera), muy frecuentes en algunas cuevas donde abundan raíces, que indudablemente constituyen uno de los principales aportes energéticos externos al ecosistema de estas cuevas lávicas (HERNANDEZ et al., 1985).

Aparte de estas especies propias de las islas existen algunas introducidas que también habitan este medio subterráneo. En este sentido se ha citado la presencia del esquizómido *Schizomus portoricensis* (MARTIN y OROMI, 1984) hallado en la Sima Robada y en la Cueva Honda del Malpaís de Güímar (S. de la isla). Esta especie troglófila es el único representate conocido de este orden en Canarias. Se trata de un partenogenético geográfico que tiene su centro de dispersión en Centroamérica (MARTIN y OROMI, 1984., MARTIN et al., 1985). Otro ejemplo de especie introducida a destacar es el blátido *Periplaneta americana,* frecuente en algunas cuevas de las zonas bajas en la isla.

Discusión

Con todo lo expuesto, vemos que la fauna subterránea de la isla es relativamente rica, con especies interesantísimas tanto desde un punto de vista zoológico como biogeográfico. La mayoría de los troglobios conocidos pueden ser clasificados como troglomorfos (CHRISTIANSEN, 1962), por presentar una acusada adaptación morfológica. Si consideramos su distribución insular, debemos destacar que casi la totalidad de las especies comentadas (89,2 %) se encuentran en las zonas norte y centro de la isla, áreas donde predomina un vulcanismo reciente, normalmente inferior a los 700.000 años (OROMI et al., 1985). Este hecho se traduce en que las especies tienen la posibilidad (y de hecho muchas la utilizan) de distribuirse subterráneamente a través de la compleja red de grietas e intersticios que caracterizan este MSP. Por otro lado, existen en la zona de una mayor antigüedad, superior siempre a los 3 m.a., donde las especies troglobias encuentran limitada su dispersión subterránea a nivel del MSP. Este impedimento puramente geológico puede a veces coincidir con imposibilidades de dispersión a nivel del MSS, causadas por ejemplo, por la regresión de los bosques húmedos de laurisilva lo cual hace inhabitable el MSS. Una combinación de ambas causas puede llevar al acantonamiento geográfico de ciertas poblaciones subterráneas, tal como ocurrió en principio con los ancestros de *L. cavernícola* (MARTIN y OROMI, en prensa), comentado anteriormente.

Una generalización aceptable para el medio cavernícola en Tenerife es que la mayor o menor riqueza de la cubierta vegetal epígea, no parece tener una gran importancia para la existencia de formas troglobias en el subsuelo. Estas necesitan indudablemente una entrada energética mínima que a través de las grietas del suelo procede de los ecosistemas de superficie. De una u otra manera este suministro energético existe, aunque la vegetación sea pobre (HOWARTH, 1979). Cada vez que una nueva colada volcánica se expande por una superficie y, a partir de este aporte energético mínimo, se crea un nuevo hábitat subterráneo que es utilizado por las especies habitantes del MSP de los terrenos circundantes. Estas especies comienzan a llegar y ocupar así el nuevo hábitat. A partir de este punto, un mayor desarrollo de la cubierta vegetal epígea tendrá tal vez, sobre el ecosistema cavernícola la única influencia de aumentar ligeramente su diversidad. En general los valores de la diversidad de las comunidades cavernícolas estudiadas en la isla, son siempre muy bajos lo cual parece ser una constante para este tipo de medios.

Por último, si consideramos el probable origen de estas especies troglobias podrían diferenciarse tres tipos:

a) Las que tienen sus ancestros en especies actuales (o próximas) de superficie autóctonas de la fauna canaria. Son las más abundantes *(Dysdera* spp., *Eutrichopus martini, Lithobius speleovulcanus, Venezillo tenerifensis,* etc.,).

b) Las relícticas, de ancestros desconocidos en nuestra fauna *(Canarobius* spp., *Spelaeovulcania canariensis, Apteranopsis canariensis, Tyrannochthonius superstes) y cuyos parientes más próximos provienen de zonas diversas como Europa Mediterránea norte de Africa, etc...*

c) Las de posición incierta. Aquí incluimos aquellas especies a las que, por los conocimientos actuales no podemos asignarles un estatus fijo. Es el caso de Loboptera spp y Domene *spp., cuyas relaciones con las formas endógeas conocidas se están investigando.*

Indudablemente estas cuevas volcánicas depararán aún muchas sorpresas, que servirán para ir contestando algunas cuestiones de gran interés que hoy nos planteamos. Por ejemplo, ¿De dónde procedieron los ancestros de éstas formas hoy tan evolucionadas?, ¿Qué factores influyeron en la evolución subterránea de estas poblaciones?, ¿Existen relaciones de parentesco entre estos endemismos y las formas epígeas vivientes en la actualidad? Tal vez un mejor conocimiento del MSS volcánico podrá aportar formas de transición que aclaren algunos de estos atractivos enigmas.

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The genus *loboptera* brum. & W (blattaria: blattellidae) in the canary islands and its distribution in the underground compartment

J.L. Martín, I. Izquierdo & P. Oromí

RESUM

Viuen espécies del gènere Loboptera a tres de les illes Canàries: Tenerife, La Palma i El Hierro. De les vuit espècies que es coneixen actualment dues són epígees (L. decipiens *i* L. canariensis); *les sis espècies restants* (anagae, cavernicola, subterranea, fortunata, ombriosa *i* meridionalis) *són endemismes monoinsulars i presenten una adaptació més o menys acusada a la vida subterrània, essent algunes d'elles troglobis vertaders.*

En aquest treball s'efectua una análisi de l'hàbitat i distribució de cada espècie així com de les possibles raons que han conduït a l'aïllament i posterior diferenciació de formes estretament relacionades.

RESUMEN

Viven especies del género Loboptera *en tres de las Islas Canarias: Tenerife, La Palma y El Hierro. Entre las ocho especies que se conocen en la actualidad, dos son epígeas* (L. decipiens *y* L. canariensis); *las seis especies restantes* (anagae, cavernicola, subterranea, fortunata, ombriosa *y* meridionalis) *son endemismos monoinsulares y presentan una adaptación más o menos acusada a la vida subterránea, siendo algunas de ellas troglobios verdaderos. Se efectúa un análisis del hábitat y distribución de cada especie y las posibles razones que han conducido al aislamiento y porterior diferenciación de las formas estrechamente relacionadas son también discutidas aquí.*

SUMMARY

There are species of the genus Loboptera *in three of the Canary Islands: Tenerife, La Palma and Hierro. Amog the eight species already known up today, two are epigeous* (L. decipiens *and* L. canariensis); *the six remaining species* (anagae, cavernicola, subterranea, fortunata, ombriosa *and* meridionalis) *are monoinsular endemics and present a more or less strong adaptation to the subterranean life, some of them being true troglobites. An analysis of the habitat and distribution of each species is made, and the possible reasons leading to the isolation and further differentiation of the close related forms are discussed.*

Introduction

The genus *Loboptera* includes thirteen species throunghout the world, presenting a Palearctic-Mediterranean distribution as indicated in Fig. 1. All of these species are well localized except *L. decipiens,* which spreads over Southern Europe, the Canary Islands, Madeira and Northern Africa.

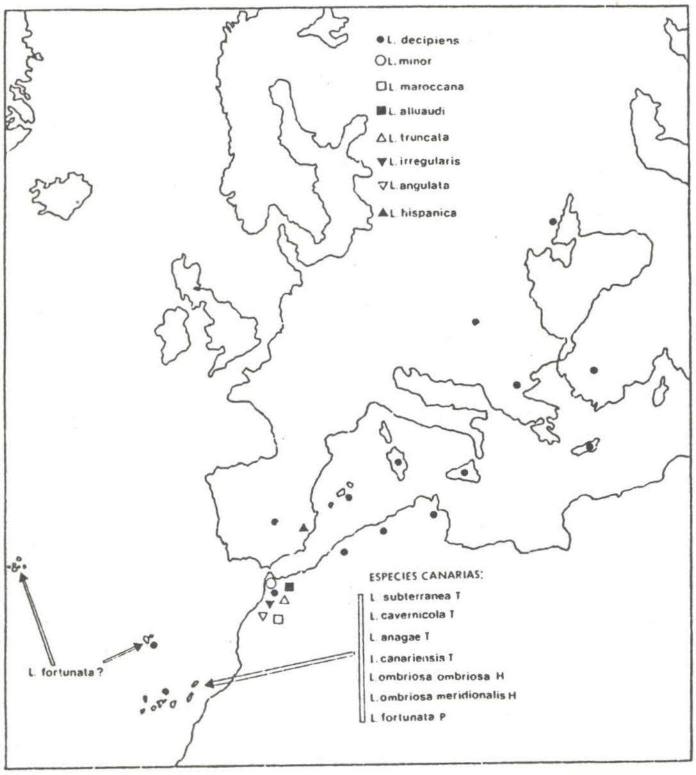

Fig. 1. Distribution of the genus Loboptera *in the world.*

Morroco seems to be the dispersal center of the genus *Loboptera* with its seven different species, though the Canary Islands are also well represented. Up to seven species have been discovered so far in the Canariesy; the following may be found in Tenerife: *L. canariensis* Chop., *L. decipiens* (Germ.), *L. subterranea* Martín & Oromí, *L. anagae* Martín & Oromí and *L. cavernicola* Martín & Oromí (MARTIN & OROMI, en press). *L. fortunata* Krauss is found in La Palma (KRAUSS, 1892) and *L. ombriosa* Martín & Izquierdo in El Hierro. This one has been divided into two subspecies, *L. ombriosa ombriosa* and *L. ombriosa meridionalis* MARTIN & IZQUIERDO, in press).

PRINCIS (1963) found *L. fortunata* both in the Azores and Madeira islands. However, this information is doubtful as any of the twenty one specimens that he analysed were not adult enough to be properly determined. At present, *L. fortunata* is located in the hypogeous habitat of La Palma island exclusively, so it is unlikey to be the same species found both in Madeira and Azores.

The seven species known in the Canary Island may be divided into two grupos. The first group includes *L. decipiens* and *L. canariensis,* two lucicolous species of small size and strong pigmentation, which are always distributed over non-forest areas. The second group is formed by the remaining species which are characterized by a bigger size, reddish colouring and by their subterranean habitat. Thus, *subterranea, cavernicola* and *ombriosa meridionalis* are troglobites of underground life exclusively, and *anagae, fortunata* and *ombriosa* s.str. live in the underground superficial compartment, ocasionally found under rocks on surface.

The other North African and European species of this genus all belong to the first group. In fact, after analizing all types of species, except *angulata* Chop. and *hispanica* Harz, we have noticed they can be fitted into the first group mentioned above. According to the original description of the two exceptions (CHOPARD, 1943; HARZ, 1975), they can also be adjusted to the morphology of the first group.

It seems then that the species included in the hypogeous group are limited to the Canaries, though Princis' specimens (op. cit.), such as *L. fortunata* of Azores and Madeira, may correspond with another species from the some hypogeous group. Then, what needs to be known is whether this group is the result of an evolution process in the archipelago or whether we are dealing with relictual species that are trapped in any of the Macaronesian Islands.

The colonization of the hypogeous environment ought to have taken place in the laurel forest as we gather from the fact that the less modified species are found among the laurel forest, whereas the more adapted ones occupy a hypogeous environment not necessarily dependent of this rain forest. Therefore, these *Loboptera* may show a relictual feature, since such vegetal system represents a relictic flora (CIFERRI, 1962; KUNKEL, 1973). There is evidence that the laurel forest had a greater extension during the Tertiary than today, covering also Northern Africa (DANSEREAU, 1968).

New species of *Loboptera* may be discovered in the near future in the Canary Islands as well as in Northern Africa, and will hopefully contribute to clarify this matter. The hypogeous fauna of some islands such as La Gomera or Gran Canaria or that of Northern Africa is not known enough as to reject the existence of new species related to the present ones.

Apart from whatever the correct alternative is, the original species lived in the forest initially, and then, they expanded their habitat in orden to colonize other environments which were relatively empty such as the underground superficial compartment and the underground deep compartment.

Concerning the lucicolous *decipiens* and *canariensis,* the first of them is a synantropous species which has spread over along with man (PRINCIS, 1963), and it probably arrived at the islands in a historical period. *L. canariensis* is an endemic species, thus, its ancestors ought to have reached the islands before *L. decipiens.* According to CHOPARD (1954), *L. canariensis* is very similar to North African *L. truncata.*

Physical underground compartment dynamics

Before introducing the particular distribution of the hypogeous species of the islands subsoil, we will analyse the formation and destruction of the lava tubes which affects the entire net of fractures and subterranean interstices. It will help us to comprehend whatever reasons may have contributed to cause the differentiation among species.

Occasionally (OROMI et al., 1984), we have pointed out how the mechanical and chemical erosion of the subsoil has filled up all the fractures throung the years. This process takes place also in limestone areas (HOWARTH, 1983; JUBERTHIE, 1983), but it is generally more intense in volcanic region. Hence, the lava tubes have a much shorter life than the calcareous caves.

The oldest areas of the Canaries (older than one million years), do not present lava tubes and the net of fractures from the deep subsoil is filled in completely. The only exception to this are the volcanic pits which due to their vertical formation are more resistent to erosion and can be found in some of the oldest and more eroded massifs. The underground superficial compartment shapes up as a disintegration band of the parent rock just when erosion becomes more apparent (JUBERTHIE, 1983). In some places, this band of materials broken into numerous interstices is developed under a coat of organic soils, which relieves the sudden temperature and humidity changes on surface. When this has taken place, the underground superficial compartment is an ideal habitat for a colonization of this subterranean species.

Another significant aspect is the existence of paleoclimates in the archipelago. The modification in the forest spreading is said to be caused by several climatic variations which happened during the Pleistocene and the Holocene. The degrees of erosion also varied during this time (CRIADO, 1984).

The existence of a special type of underground superficial compartment originally different to that already described is another quality of the volcanic land and it can participate in the distribution of the hypogeous species. This particular type of underground superficial compartment is not formed by an erosive process but is made of scoriaceous strata from the lava flows. The final result is a compartment composed of interspersed layers of fragmented material among other layers of more compactness. This is called volcanic underground superficial compartment (MEDINA & OROMI comm. pers.).

Distribution of the hypogeous *Loboptera* in the Canary Islands

The five colonizing species of the underground compartment of the islands have shown a different degree of adaptation to the hypogeous life (table I). This is related to their respective habitats. Thus, those species living underground are more adapted than those that can be found about the surface. If the greater age of an island supposes a longer time disposal for the adaptation to the hypogeous conditions, it is then related to those levels of morphological adaptation. Those species presenting a greater adaptation to the underground life conditions belong to Tenerife Island, the oldest island of the archipelago, whereas those species existing in La Palma or El Hierro islands still preserve many of the epigeous features.

TABLA I

Species	Pigmentation range	eye development	S	Habitat MSS	MSP	Island	Age m.y.
L. subterranea	X	anophthalmous		X	X	Tenerife	16
L. cavernicola	XX	eye ustability			X	Tenerife	16
L. anagae	XXX	normal	X	X		Tenerife	16
L. ombriosa meridionalis	XX	normal			X	Hierro	1,5
L. ombriosa ombriosa	XXXX	normal	X	X	X	Hierro	1,5
L. fortunata	XXXX	normal	X	X	X?	Palma	3

Nevertheless, it is suprising to learn that some islands keep various hypogeous forms even related among themselves, such as *L. o. ombriosa* and *L.o. meridionalis* in El Hierro, or *L. anagae* and *L. cavernicola* in Tenerife. We have already discussed in another paper (MARTIN & OROMI, op, cit.) that all of the hypogeous *Loboptera* found in Tenerife come from one single ancestor probably. It all makes us inquire into the reasons of the present differentiation.

In order to analyse both the distribution and differentiation of the hypogeous species in the Canary Islands, we have to consider the following: the existence of underground barriers blocking the dispersion about the underground deep compartment, and the expansion and regresion of the laurel forest. This considerable influences upon the habitation of the underground superficial compartment (JUBERTHIE, 1983). The first of these two aspects depends upon the greater age of the soil and its degrees of erosion; the second depends on the climatic changes of the past. The forest regression also affect the species as the could remain isolated in the underground compartment (VANDEL, 1958; PECK, 1980; JUBERTHIE, 1984).

The formation of underground barriers is likely to have caused an initial distinction in the original *Loboptera* of Tenerife. An important deposit of alluvial clay found in La Laguna, Tenerife (at 500 m.h.), forms an example of such barrier (fig. 2). The underground deep compartment is filled up at lower areas because of the lack of eruptions and then the constat erosion (for a longer period of three million years). The underground superficial compartment cannot be colonized as it is too dry. So, the western population became the present *L. subterranea* and the eastern population was recently distinguished as *L. anagae* (which lives at 800-1000 m above the sea level) and as *L. cavernicola* (at 300 m above the sea level).

The distintion between *L. anagae* and *L. cavernicola* came later when the laurel forest extended around 300 meters below

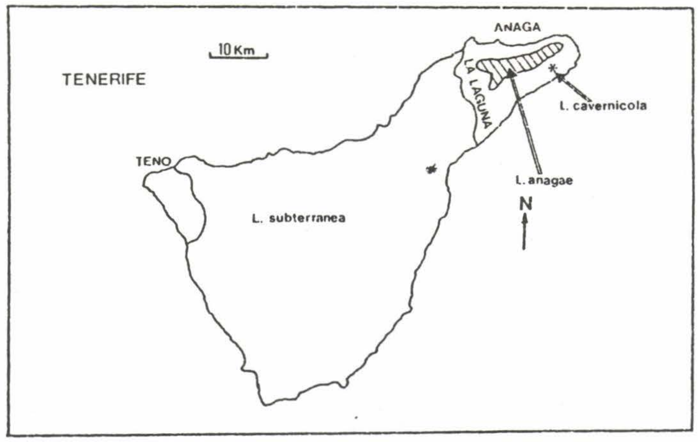

Fig. 2. Hypothetical distribution of the three species of Loboptera *existing in the subsoil of Tenerife.*

its preset level during the past wet period (WILDPRET, comm. pers.). Thus, an organic soil layer covered the lower areas, allowing the colonization of the underground superficial compartment. A single *Loboptera* would spread over by then from the hills down near the sea level. The forest receded during a drought period and the underground superficial compartment begin to dry out. At the same time, the hypogeous species of the same compartment also reduced their spreading areas to the hills only.

According to this hypothesis, some populations remained isolated in caves like Sima Robada during the recesing period, though they continued to be humid because of their significat depth. In some time, this population would differ from those of the hills and would become *L. cavernicola.*

Something similar could have happened in El Hierro islad. The differences found between the two *Loboptera* from this island do not appear clearly enough to consider them as different species. This suggests that this process of evolution has ocurred recently. The distribution area of the two subspecies, *L.o. ombriosa* and *L. o. meridionalis,* is separated by an old basalt band of more than one million years (SCHMINCKE, 1976; PELLICER, 1977), which could form an impassable barrier for both of them (fig. 3).

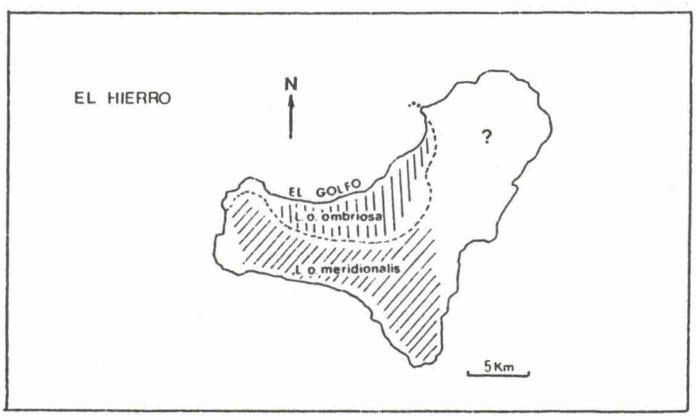

Fig. 3. Hypothetical distribution of the two subspecies of L. ombriosa *existing in the subsoil of Hierro.*

As it happened in Tenerife, other island underwent similar variation of weather conditions which affected the distribution of the original species. During wet period, the laurel forest covered a more extension than today, even descending by the southern slopes of the island (WILPRET, comm. pers.). The *Loboptera* would spread over almost throughout the entire island at this time.

Ater the forest regresion in the following drought period, these southern populations, which had been already accustomed themselves to the underground deep compartment, were the isolated from those of the north, and therefore, they were only to stay in the deep subsoil as the surface dryness increased. The northern populations of El Hierro island continued to live on the surface (in the forest confined inside the area known as El

Golfo), and in both the deep and superficial underground compartment. The old basalt band acted as an effective barrier since the subterranean dispersion was stopped by the low humidity in the underground superficial compartment and by the old age of the underground deep compartment.

We conclude that the distribution studies of the genus *Loboptera* in the Canary Islands reflects the influence of several factors on the distinction of the hypogeous species. The more significant factors are: the paleoclimate and their effect on the islands flora; the existence of a deep and a superficial underground compartment; the islandsage; and the age of specific land within the island. These five «agents» are related in their performance: the paleoclimates affect the forest expansion, which modifies itself the habitation of the undergroung superficial compartment. The geological age of a particular area may avoid the dispersion through the underground deep compartment in the oldest an eroded places. Underground barries are formed when all of these agents impede the dispersion through the deep and superficial underground compartments. Finally, the islands' age will adjust the evolution and adaptation degrees of species in relation to the time disposal for the underground environment colonization.

Acknowledgements

We would like to express our gratitude to M. del Arco, A. Machado and W. Wildpret for their critical comments to this paper, and to A. Bacallado who has translated it to english.

This work was supported by the Autonomous Canarian Government (project n. 19/3-9-84) and by C.A.I.C.Y.T. (project. n. 1962/82). During this study one of us (Martín) held a grant of collaboration between the Canarian Government and Caja Gral. de Ahorros de Canarias for F.I.C.Y.T.

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1296

The fauna of the submarine cave «Túnel de la Atlántida», Lanzarote

Antonio G.-Valdecasas (S.T.D.)
José Luis Fernández (S.T.D.)
José Bedoya (S.T.D.)
Museo Nacional de Ciencias Naturales.

RESUM

En aquest treball oferim un balanç de la fauna cavernícola que viu en el túnel submarí de Jameo del Agua.

Hi podem distinguir almenys dues comunitats diferents: la fauna própiament cavernícola i la cominitat intersticial localitzada en una acumulació de sorra situada a la part més profunda de la cavitat.

Amdues comunitats estan constituïdes per animals relativament «rars», alguns d'ells descrits per primera vegada. S'analitza també la seva similitud amb altres faunes cavernícoles.

RESUMEN

En este trabajo ofrecemos el balance de la fauna cavernícola que vive en el Túnel submarino del Jameo del Agua.

Se pueden distinguir al menos dos comunidades diferentes. La fauna propiamente cavernícola y la comunidad intersticial localizada en un amontonamiento de arena en la parte profunda de la cavidad.

Ambas comunidades están compuestas por animales relativamente «raros», algunos de ellos descritos por primera vez. Se analiza la similaridad con otras faunas cavernícolas.

SUMMARY

In this paper we offer a balance of the cavernicolous fauna that inhabit the submarine tunnel of the Jameo del Agua.

At least two different communities could be distinguish: the proper cavernicolous fauna and an interstitial community located in a sand mountain deep into the cave.

Both communities are composed of relative «rare» animals, some of them described for the first time.

The similarity with other cave faunas is analyzed.

Introduction

The Volcano of La Corona is locates in the NE of the island of Lanzarote (Canary islands). It is at 5 km from the coast. At the time of its origin, around 3.000 years ago, it gave origin to a tunnel that goes toward the sea. Once there, it continues as a submarine cave, of which more than 1.500 m. are already known, but we ignore how much longer it is. The dimensions of the tunnel are variable, but it reaches in some places more than 20 × 10 m. In some streches the top of the tunnel has dropped, originating what is commonly known as «jameo».

Before reaching the sea, its effects could be detectable by the presence of a lagoon in the jameo del Agua and in the lakes of the jameo de los Lagos, where tides cycles are readily observable.

The lagoon of the jameo del Agua can be easily reached from the exterior, and has been recently urbanized.

The first aquatic animal found there was described by Koelbe in 1892. Since then some other animals where found, and this knowledge greatly expanded when the investigations broadened to the submarine cave associates (a short account of the scientific history of the jameo del Agua can be found in G.-Valdecasas, 1985). In This paper we present a balance of the faunistic results on the fauna of the tunnel

Material and Methods

The samples on which this paper is based on, proceed of two expeditions to the tunnel in 1984 and 1985, although only the first had a primary scientific motivation, so 1985 samples were more casual.

Sampling the submarine cave was a challenge. We tried to diversify the sampling methods, and when possible they were used gradually along the cave.

Three different kinds of nets were used. A bait-net, that was lefl at different parts of the cave bottom with null results. Two other nets were a plane net and a circular one, that the speleodivers carried with them and used either at the rock surface or to filter certain amounts of the water column. For the crevices and fissures in the rock a manual pump proved to be very useful, although limited to animals of certain size. All the nets and the pump have attached a plastic bottle with the bottom removed and substituted by fine nylon monofilament.

The material and technics of searching and exploring the cave is dealt in another paper of this Congress (see Bedoya et al., this Congress).

Results

The fauna found in the tunnel can be classified at least in three groups (Table I):

a) Fauna of epigean origin:

b) Fauna of hypogean nature:

- b.1) free living cavernicolous,
- b.2) intertilials organisms.

They are going to be treated in turn.

a) Fauna of epigean origin.

There are two places where animals from the surrounding sea can be incorporated to the cave. One is at the beginning of the submarine part of the tunnel, and the other at 720 m, where fissures at the top allows some animals to go into the cave and have originated a sand mountain of giant proportions (around 11 × 11m.).

As the beginning of the submarine part of the tunnel is not in the open sky, is not readily understood how animals have incorporated to it. The most reasonable explanation is to think in a shift throug the fissures and crevices of the cave rock. At this location cavernicolous and epigean animals coexist: the subterranean crab *Munidopsis polymorpha* and the epigean amphipod *Parhyale hawaiensis*.

At the sand mountain the number of epigean species is higher: we have found several specimens of Antozooa, the decapoda *Stenopus spinosus,* the ofiura *Ophioderma longicaudum* and two specimens of *Holothuria* sp. as well as rest of other marine invertebrates. An abundant tenatocenosis of Mollusca form part of the matrix of the mountain.

Some of the animals living inside the mountain have been found in the outside sea. Two well known cases are the polichaetes *Paradoneis lyra* and *Protodorvillea kefersteini,* both with an ample distribution in the sands of several seas. They are limited to this part of the cave, and are clearly distinguished from *Gesiella jameensis,* a genuine cavernicolous polichaete, that is found along the cave.

Some other taxa of the mountain remain to be allocated in one of these categories, something that can not be done before they are properly identified. Even then, in some cases, it would be necessary to sample the epigean sands surrounding Lanzarote, in order to ascertain the degree of fidelity of that interstitial fauna to the cave.

b.1) Free living cavernicolous

By this term we understand those animals that could live free swimming in the cave and show a certain adaptation to cave conditions. They are mainly constituted by the polichaete *Gesiella jameensis* already mentioned, the mysid *Heteromysoides cotti,* the decapoda *Munidopsis polymorpha,* the amphipoda *Spealaeonicippe buchi* and *Hadzia acutus* (another species of amphipoda is pending description), the isopoda *Curassanthura canariensis* and the remipedia *Morlockia ondinae.*

The laind of adaptations presented by these organisms are mainly the lack of visual organs and despigmentation.

All of them are endemic to the cave, although close relatives have been found either at bathyal depths of the surrounding seas or in caves at the other side of the Atlantic.

They are not restricted to one part of the cave and *Hadzia acutus* has been found in the jameo de los Lagos.

Morlockia, described in 1984, belongs to the class Remipedia, and has been found at the beginning of the cave and in a superior gallerie about 120 m. from the entrance.

It is remarkable that it has remain unknown for so a long time.

b.2) Interstitial fauna

Many authors classify interstitial fauna within cavernicolous one, although it is still a debatable matter (Vandel, 1964). Common propierties are the lack of visual organs and a more or less pronounce adaptation to attenuated environmental conditions. Nevertheless we still think that there are some peculiar adaptations that allow us to distinguish between an interstitial and a proper cavernicolous animal, as we have done in this paper.

The interstitial fauna of the cave concentrated mainly in the sand mountain is very rich: Turbellaria, Gastrotrica, Priapulida, Nematoda, Polichaeta and several groups of Crustacea, especially Copepoda and Ostracoda. Many of these taxa are new species or greatly expand the known distribution of the group. The Nematoda Draconematida and the Priapulida *Tubiluchus* for instance are mentioned for the first time to the west African coast.

TABLE I. FAUNISTIC COMPOSITION OF THE SUBMARINE CAVE OF THE JAMEO DEL AGUA (LANZAROTE)

	E	C	I
Gastrotrica			+
Priapulida			
Tubiluchus			+
Nematoda			
Draconematida			+
Demoscolecida			+
Polichaeta			
Paradoneis lyra			+
Protodorvillea Kefersteini			+
Gesiella jameensis		+	
Crustacea			
Copepoda	+		+
Ostracoda	+		+
Heteromysoides cotti		+	
Cumacea	?		
Munidopsis polymorpha		+	
Spealaeonicippe buchi		+	
Hadzia acutus		+	
Curassanthura canariensis			+
Morlockia ondinae		+	
Stenopus spinosus	+		
Ophioderma longicaudum	+		
Holothuria sp.	+		

E: Epijean; C: Cavenicolous; I: Interstitial.

It is not known if part or all these taxa are found in the surrounding sand of the adyacent sea. Two peculiarities of the sand mountain should be mentioned at this point:

a) there is a lower level of perturbation from the tide cycle, as the flux of water inside the cave is mainly laminar.

b) A relative high concentration of organic matter, originating in the epigean animals that once inside the cave have great difficulties or find impossible to return to the epigean world.

We ignore if these two conditions are enougth to justify the presence in the sand mountain of taxa not found outdoors, or simply a higher amount of them. Only a carefull investigation in the sands outside the tunnel could give a definite answer.

Conclusions

Previous research as well as our own investigations in the submarine cave of Lanzarote «Tunnel de la Atlantida» show that it has a very rich fauna of very different nature: shared epigean animals, truly cavernicolous and interstitials ones. the communities of the cave should not be understood aside those in the exterior sea, especially the communities of the sand surrounding the cave.

The future research on the cave should consider it not only as a natural reserve but as a potential zoological laboratory.

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12286

On the existence of a superficial underground compartment in the canary islands

P. Oromi, A.L. Medina * and M. L. Tejedor ***

Dept. of Zoology (*) and Dept. of Edaphology (**). Univ. of La Laguna. Tenerife.

RESUM

Es presenta, per primera vegada, un estudi de la fauna que colonitza el medi subterrani superficial de les illes Canàries. L'experiència es va dur a terme en la zona volcànica del vessant nord de l'illa de El Hierro, on els sòls són del tipus andisol, bastant joves i per tant poc desenvolupats.

El medi subterrani superficial correspon a l'horitzó C d'aquest sòl, que es desenvolupa en materials basàltics piroclàstics.

Podem classificar el sòl com a «vitran depts», el qual presenta horitzonts A i B. No obstant, i a causa dels talussos de la zona, els horitzons queden reduïts a l'A i al C.

Els sòls són rics en matèria orgànica, són eutròfics i amb poca capacitat de retenció d'aigua.

Exposem una relació d'espècies trobades en aquest medi i podem obsevar una correlació prou significativa amb la fauna de les cavitats que es troben al mateix indret de l'illa: sigui com sigui el nombre d'espècies recollides en el medi subterrani superficial sempre ha estat més gran que el de les coves, utilitzant les mateixes tècniques de trampeig.

REUSMEN

Se presenta por primer vez en estudio de la fauna que coloniza el medio subterráneo superficial en las Islas Canarias. La experiencia fue llevada a cabo en la zona volcánica de la vertiente Norte de la Isla de Hierro, donde los suelos son del tipo andisol bastante joven, y por consiguiente poco desarrollado.

El medio subterráneo superficial corresponde al horizonte C de este suelo, que se desarrolla en materiales basálticos piroclásticos.

El suelo puede ser clasificado como «vitran depts» mostrando los horizontes A y B. Por causa de las laderas de fuerte pendiente en el área de los horizontes quedan reducidos al A y C.

Los suelos son ricos en materia orgánica, eutróficos y de baja capacidad de retención de agua.

Se expone una lista de las especies halladas en este medio y se observa una concordancia bastante elevada con la fauna de las cavidades que se encuentran en las misma parte de la isla: sea como sea el número de especímenes recogidos en el medio subterráneo superficial siempre fue mayor que en cuevas, utilizando las mismas técnicas de trampeo.

SUMMARY

A study of the fauna inhabiting the superficial underground compartment in the Canary Islands is presented for the first time. The experience was carried out in the volcanic land on the north slope of Hierro island, where the soils are quite recent and therefore only slightly evolved. A list of the species found in this environment is displayed, and a rather high agreement with the fauna of the caves existing in the same part of the island is observed. However, the number of specimens collected in the superficial underground compartment was always greater than in caves using the same trapping techniques.

Introduction

Several studies performed through the last years on the cave fauna of the Canary Island, and mainly on that of Tenerife, have proved the existence of various species of troglobites. Some of these species appeared simultaneously in many of the caves searched by us, being these often situated up to 50 km apart from one another. The most representative of these troglobites would be *Loboptera subterranea* Martín & Oromí, which could be found in almost any cave of the island, except in its NE edge known as Anaga (OROMI et al., 1985). This Blattoidea shows a remarkable adaptation to the hypogeous life conditions (MARTIN & OROMI, in press).

The discovery of a superficial underground compartment («milieu souterrain superficiel», MSS) in the French Pyrenees (JUBERTHIE et al., 1980a; 1980b; 1981a) and later in other points of europe (JUBERTHIE et al., 1981b), made us realize that probably the Canaries could be provided with similar underground conditions which could easily explain this particular subsoil distribution, already noted by MARTIN (1982) as probable.

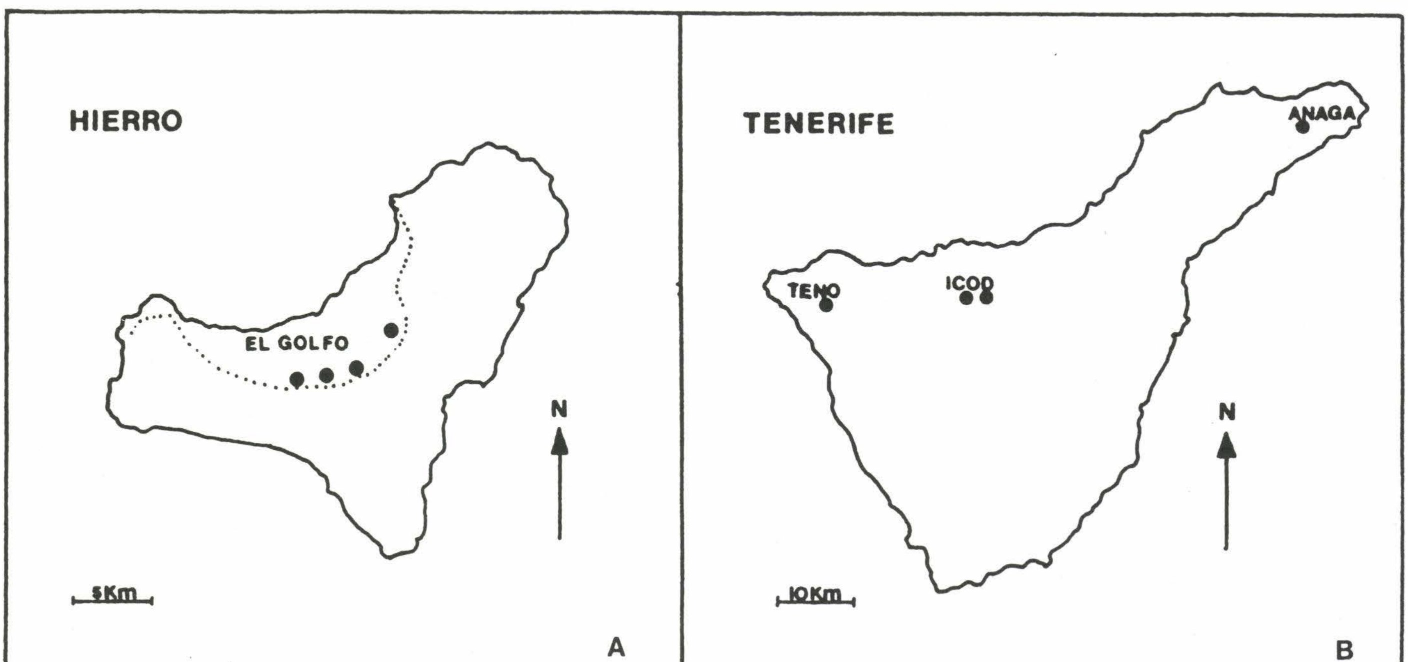
The first exploring test were made under a study supported by the CAICYT (proj. n. 1692/82) in several points of Teno, in the NW of Tenerife (fig. 1 b). This is a considerably old area of the island –from 5 to 7 million years B.P. (SCHMINCKE, 1976)– lacking lava tubes and covered by a dense laurel forest. The results of this study were amazingly successful: many specimens of *loboptera subterranea* appeared rapidly along with a few specimens of *Wolltinerfia tenerifae* Machado, an interesting troglobite belonging to a monospecific genus closely related to a group of pterostichids considered as palaeoendemisms of the Canarian fauna (MACHADO, 1984). This insect was previously known in cavern-like environments only.

Numerous specimens of *L. subterranea,* although none of *W. tenerifae,* were collected during further explorations around Icod which is a geologically more recent area having many lava tubes and covered by a more xeric forest of *Pinus canariensis* Chr. sm. ex D.C. Additional traps were installed later around the NE edge of the island (Anagan area), also in very old soils covered by the laurel forest as it happened in Teno. Lava tubes cannot be found in Anaga an just a pit is situated down at the lowland outside the forest (MARTIN et al., 1985), where *loboptera cavernicola* Martín & Oromí had been picked up already. This was the only known troglobite on this side of the island by then and it is not as transformed as *L. subterranea.* Various specimens from a third species, *L. anagae* Martín & Oromí, were collected in the MSS traps of the upper humid zone. This *L. anagae* is similar to *L. cavernicola* though not as strict on its underground adaptation (MARIN & OROMI, op. cit.).

Finally, we initiated a more detailed research of the MSS in the wooden slopes of El Golfo, Hierro island, taking advantage of several spelaeological expeditions studying the subterranean fauna of this island which were supported by the Canarian Autonomous Government. Two volcanic cavities found at El golfo were also tested on this occasion: Cueva de Mauricio (a lava tube) and Cueva de las Palomas (a volcanic pit).

Methodology

The methodology used in the collection of arthropods was similar to the one chosen by JUBERTHIE et al. (1980a). Our



Localization of the prospected stations in (A) Tenerife and (B) Hierro islands.

method consisted on the placing of pitfall traps into 50-80 cm holes dug on the subsoil in the taluses of a forest track. These traps contained Turquin liquid (TURQUIN, 1973) saturated with NaCl plus a solid bait of beef liver soaked with a solution of Novapim and ethilic alcohol.

Once the traps were installed, the holes were refilled again by using the same soil fragments extracted in the drilling process. A total of 18 traps were set up. Two different samples were taken, the first one in March and the second in November, 1985; the traps remained placed for 25 and 12 days respectively.

Nine samples were taken from these stations which were later analysed in the laboratory, in order to describe the soil profiles.

Results and Discussion

The compartment: The samples from the analysed soil turned out to be edaphologically similar among them. This soil consists of an organic A horizon, whose depth depends on the slope, followed by a C horizon; a B or B(C) horizon was rarely found. C horizon includes a generally basaltic scoria, whose fragments are slightly altered, and thus present a yellowish and sometimes reddish colouring. C horizon is also of great porosity, as the scoria fragments are hardly compact since their origins. The sampling traps were set up rigth in this compartment.

The scoriaceous C level containing the trap usually lies over the compact, basaltic parent rock (fig. 2 a). However, a narrow basaltic layer is found in some of the analysed soil profiles. This layer also appears as a very compact one, seen with no alteration trace either between the organic horizon and the scoria or among the different scoriaceous levels (fig. 2b). Being these soils of a recent formation, this basaltic layer does not seem to produce significant edaphic changes, even though it should obviously influence on the soil permeability. According to the similarities observed in the analysed soils, we will refer to an average profile whose characteristics could be extended to the other stations.

Morphological qualities. –The stations were placed along the Derrabado track as well as in the area of el Salvador, both on El Golfo mountainside between 800 - 900 m a.s.l. They were oriented towards the north on a steep slope which included many fragments of basaltic scoria, and was covered by a dense vegetation of *Myrica faya – Erica arborea* forest. This soil presented a good drainage and did not show any human influence.

The following is a description applying to the various horizons analysed in our research:

Horizon A_{11}: up to 5 cm deep, 5YR/2-1 (dark brownish-reddish) colour, very humid, sandgrava texture, crumby structure, very intensive reaction with NaF, fluffly aspect, apparently low density and with presency of roots.

Horizon A_{12}: from 5 to 40 cm deep, 5YR2/1 (black) colour, also very humid, sandy texture, crumby structure, very intensive reaction with NaF, fluffly aspect, full of roots.

Horzon C: below 40 cm deep, 5YR4/4 (brownish-reddish) colour, humid very solid scoria slightly altered on the surface of its fragments, positive reaction with NaF though neither as quickly nor as intensive as in upper horizons.

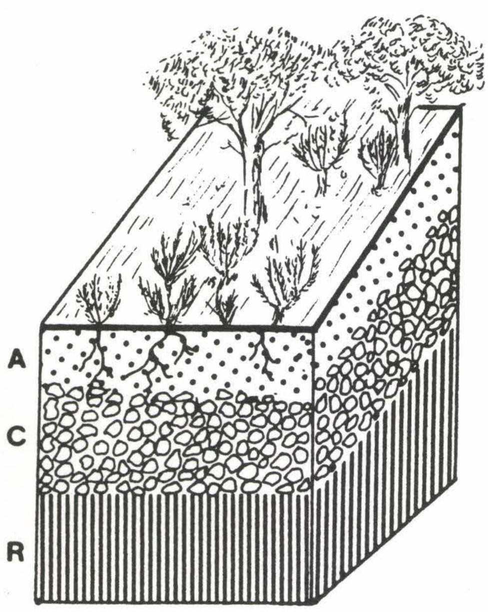
Physico-chemical and mineralogical qualities. –We are dealing with a slightly acid soil due to its recent formation. This is reflected by the positive and not excesive reaction with NaF. This soil is very rich in organic matter and saturated of bases. Relating to the saturating cations of this complex, the major ion is Ca^{++}, followed by Mg^{++}, Na^{+} and K^{+}. The changing capacity values are very low for this kind of soil which indicates its minor evolution. However, they present silica-rich allophanes with variable charges, for there were differences noted between the calculation of the changing capacity at pH 7 and that calculated at pH 8,2. Regarding to the granulometrical analysis, these are sandy soils with a low percentage of clay, which emphasizes their recent formation. Consequently, moisture retention is unimportant. Concerning the mineralogical qualities. volcanic glass is dominant on more than a 60 %. It is constituted by hardly altered primary minerals and we rarely observed the formation of clay minerals in it: just a few traces of haloisite 1:1 clay were detected.

These soils belong to the «andosols» class,, «andosols peu differentiés» subclass (according to the French classification of 1972). It is defined as a melanic horizon due to the dark and strong colour shown by the organic horizon. Thus, the profile will be included in the «ando sol humique» group. According to the Soil Taxonomy (1975) this profile belongs to the «Inceptisol» order, «Andepts» suborder, included in the large «Vitrandepts» group.

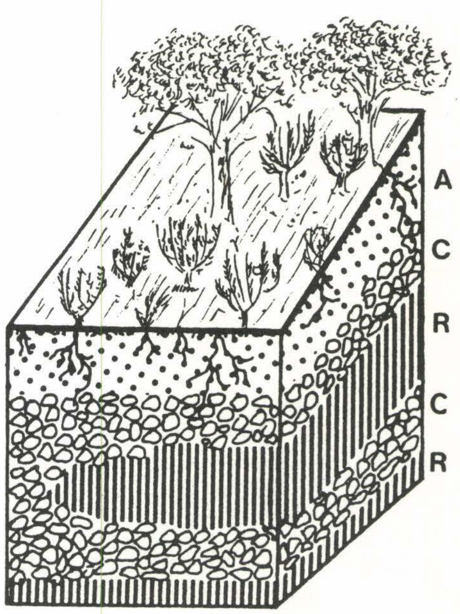
– The fauna: After sampling the 18 stations, the following species appeared.

The presence of theses species and their relative abundance in these soils depended on the various stations. Nevertheless, we could not relate these differences with the possible variables observed, such as horizon depth, temperature, superficial vegetation, etc. As already specified, some traps were located in the C horizon underlying beneath a small compact basaltic layer (fig. 2 b); however, the fauna collected in these traps was as abundant as that of the traps located on the basaltic layers of C horizon, right under the organic horizons.

The setting up of the traps themselves also influenced of the results as many invading species were collected as well. Some of these were *Lehmania valentiana, Insulivitrina* spp., *Metopsia*



A



B

Schematic section of the soil horizons in the volcanic superficial undreground compartment. A: A horizon; C: C horizon; R: basaltic parent rock.

GASTROPODA	Pulmonata	Lehmania valentiana (Férussac)
		Insulivitrina canariensis (Mousson)
		Insulivitrina sp.
		Zonitidae indet.
ARACHNIDA	Acarina	Gen. sp. indet.
	Araneae	Dysdera sp. 1
		Dysdera sp. 2
		Tegenaria sp.
		Linyphiidae indet.
CRUSTACEA	Isodopa	Gen. sp. indet.
MYRIAPODA	Symphyla	Gen. sp. indet.
	Diplopoda	Brachydesmus superans Latzel
		Brachydesmus sp.
	Chilopoda	Lithobius sp.
HEXAPODA	Collembola	Lepidocyrtus sp.
	Blattariae	Loboptera ombriosa s.str. Mart. & Izq.
	Coleoptera	Licinopsis picescens (Woll.)
		Trechus minioculatus Machado
		Trechus flavocinctus gomerae Jeann.
		Medon subcoriaceum (Woll.)
		Metopsis n. sp.
		Atheta sp.
		Tachyporainae indet.
		Laemophloeus granulatus Woll.
		Tarphius camelus Woll.
		Cryptophagus cf. affinis Sturm.
	Lepidoptera	Geometridae indet.
	Diptera	Megaselia sp.
		Calliphora vicina Rob. Desv.
		Calliphora splendens Mcquart
	Hymenoptera	Braconidae indet.

n. sp., *Tarphius camelus, Laemophloeus granulatus,* Geometridae indet., Braconidae indet., and *Calliphora* spp.

Yet, other species prove to be permenent inhabitants of this MSS since they were picked up in the traps of nearby caves even in the deep area of these. The following species of this hypogeus fauna are the more significant: *Loboptera ombriosa,* the carabids *Licinopsis picescens* and *Trechus minioculatus,* and a staphylinid from Tachyporinae subfamily.

Loboptera ombriosa s.str., unkonwn until this research, was also found in the nearby caves though in very little quantities. As it seemed to happen with *L. subterranea* in Tenerife (MARTIN & OROMI, op. cit.), *L. ombriosa* is very frequent in this MSS of Hierro island, as sometimes more than 60 units were collected in one single trap. However, *L. ombriosa* seems to be restricted to the NW area of the island (El Golfo), since another subspecies, *L. ombriosa meridionalis* (MARTIN & IZQUIERDO, in press), was found in the caves from the western and southern arid zone. *L. o. meridionalis* is probably limited to the underground deep compartment, as the MSS is dried out in this area.

Licinopsis picescens was already known by very limited specimens (WOLLASTON, 1864). It was frequently found by us in Cueva de Mauricio and quite numerous too in the MSS of El Golfo (up to 27 specimens on each trap). Even so its pigmentation and morphology are generally those of an epigeous species, its eyes are somewhat reduced, being this clearly a sciaphilous insect (MACHADO, comm. pers.)

Trechus minioculatus is a species of a large size compared to other Canarian *Trechus.* Its eyes are very reduced and uncoloured and it is a familiar inhabitant of the hypogeous environment (MACHADO, in press). It was found in the nearby caves too, and mainly in the MSS but not as frequent as *Loboptera* or *Licinopsis. Trechus minioculatus* was unknown before our underground researches.

The Tachyporinae species features scarcely reduced eyes though depigmented, so they are not likely to be functional eyes. About 80 exx. appeared in the MSS and just 2 exx. in Sima de las Palomas. This species was not known either and was never found in the mould samples made in the same area.

Further species found should add up to the above hypogeous ones, such as myriapods, collembola or *Dysdera,* a genus that has originated several troglobites in Tenerife (RIBERA et al., in press). However, our scarce knowledge on the distribution and habitat of these species in Hierro island does not allow us to consider them as hypogeous right away. We must bear in mind then that subterranean species of Hierro island do not usually show a characteristic, adapted morphology.

Indeed, the species considered by us as MSS typical inhabitat either do not or barely present usual features of troglobites. Moreover, some of them have been occasionally found in the epigeous environment. Relating to this, we should comment that just one real troglomorphic species (CHRISTIANSEN, 1962) have been found up to date in the cavern fauna of Hierro island. It is the reduviidae *Collartida anophthalma* (ESPAÑOL & RIBES, 1983). The other inhabitants of the lava tubes have a moderate or slightly apparent morphological adaptation, being *T. minioculatus* the most advanced example besides the above mentioned, *Collartida.*

If more transformed species could not be found in the searched C horizon in Hierro island, it does not mean that this is not a suitable environment for them but it is that such species do not exist on the island. Thus, it can be directly related to the island age: about 1,5 million years B.P. (CANTAGREL, 1985).

On the contrary, the MSS researched in Tenerife includes more transformed species because of the older age of the island: about 7 million years (CARRACEDO, 1979). This is basically important in order to explain the existence of more than 24 known troglomorphs, being some of them as transformed as the European troglobites, like it occurs with Canarian *Domene vulcanica* (OROMI & HERNANDEZ, in press) or *Dysdera unguimannis* (RIBERA et al., in press).

Regarding to the few times in which *Licinopsis picescens* and *Loboptera ombriosa* has been found semiburied about the surface, we should notice that many of the hypogeous species have occasionally appeared outside their usual environment (PAOLETTI, 1980; HOWARTH, 1983), which is likely to happen in warm climate areas very often (PECK, 1982). So has turned out in the Canaries; as a matter of fact, we have already checked up this phenomenon both in Tenerife and La Palma islands and could notice that *Loboptera anagae* as well as *L. fortunata* can be found in the forest during foggy days.

Conclusions

We are introducing then a new inhabited underground compartment named by us as volcanic MSS. Basically, it consists of C horizon from and andosol not much differentiated which is lying on a compact basaltic parent rock. However, the horizon is sometimes placed under or even in the middle of the crystalline basaltic rock (fig. 2 a, 2b). The main characteristic of this particular MSS is its great porosity which is due to its scoriaceous origin. It is included'n what HOWARTH (1983) would call the mesocavernous zone.

It is important to point out that the term «volcanic MSS» should not include the MSS originated in volcanic ares by edaphological processes described for other kinds of lands already (JUBERTHIE, 1983). These processes such as the formation of a C horizon by the progresive alteration of the compact parent rock or as the accumulation of creep and its later consolidation, also take place in volcanic lands and thus it may become inhabitable, like the one found in Teno, Tenerife. However, such compartments are formed in relatively old soils, whereas the scoriaceous volcanic MSS belongs to recent ones.

The analysis of the MSS fauna of Hierro island proves that the species there found are on a much less advanced evolution phase than those found in Tenerife, in the same MSS. On the other hand, a parallel phenomenon is being observed between the lava tube fauna from both islands, which is certainly caused by the difference of age between the two: it is from 5 to 10 times greater in Tenerife.

The parameter of geological age should be considered in relation to the entire island, instead of considering a specific soil; for it is to be admitted that previously adapted species to a hypogeous environment can migrate towards the most recent soils. For example, the highly adapted and exclusively hypogeus *L. subterranea* is found both in very old soils (in the MSS) and in more recent ones (either in the MSS or in lava tubes).

Finally, it is interesting to point out that exclusive hypogeous species of the MSS were not located in neither of the two islands, since all of these species were also found in volcanic cavities. The extension of the MSS in these islands in probably rather wide and its connections with the lava tubes are very effective to allow the migration of species from one environment to another very easily.

Acknowledgements

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The tropical cave environment and the evolution of troglobites

Francis, G., Howarth
B.P. Bishop Museum, Honolulu, Hawaii, U.S.A.

RESUM

Un recent treball sobre les coves tropicals ha permès de realitzar un examen crític de les teories sobre l'evolució dels troglobis de les coves temperades. Més que no pas relíquies de passats canvis climàtics, els troglobis semblen haver-se tornat altament especialitzats per a l'explotació de recursos dins del sistema de cavitats intercomunicades de tamany mig (mesocavernes) i per a la colonització de les coves adjacents (macrocavernes), tant sols en aquells indrets que presenten aquest medi ambient característic. Aquest medi esdevé massa rude per a la major par d'organismes: és permanentment fosc i humit, amb una total absència de les característiques ambientals més freqüents, amb una complexitat de mescles gasoses letals i subletals, amb recursos alimenticis dispersos, les seves parts rocoses, impenetrables i amb superfícies verticals humides i ressoladisses. Pocs grups d'animals poden explotar aquest biòtop. Segurament les úniques espècies amb possibilitatsd d'èxit siguin les espècies troglòfiles. Segons sembla, els troglobis evolucionen a partir d'espècies que freqüentement es troben, per accident, a les mesocavernes, a través d'un procés adaptatiu. Si es disposa de recursos explotables suficients, un accident fortuït podria comportar l'establiment d'una població que, si reeixeix, podria esdevenir troglòbia per especiació parapàtrica.

RESUMEN

Un trabajo reciente en cuevas tropicales ha permitido realizar un examen crítico de las teorías sobre la evolución de los troglobios de las cuevas templadas. Más que ser reliquias de cambios climáticos, los troglobios parecen haberse vuelto altamente especializados para explotar recursos dentro del sistema de huecos interconectados de tamaño medio (mesocavernas) y para colonizar las cuevas adyacentes (macrocavernas) tan sólo en aquellos sitios en los que se encuentra este medio ambiente único. Su medio ambiente es demasiado rudo para la mayoría de organismos, al ser permanentemente oscuro y húmedo, con ausencia de las características ambientales más frecuentes y con una complejidad de mezclas de gases letales o subletales, recursos alimenticios dispersos, sus partes rocosas impenetrables y superficies verticales húmedas y resbaladizas. Pocos grupos animales pueden explotar este biotopo. Probablemente las especies con posibilidad de éxito sean sólo las troglófilas. Al parecer los troglobios evolucionan de especies que frecuentemente se encuentran por accidente en las mesocavernas, a través de un proceso adaptativo. Si se dispone de recursos explotables significativos, eventualmente un accidente puede establecer una población y, si tiene éxito, puede convertirse en troglobia por especiación parapátrica.

SUMMARY

Recent work in tropical caves has provided a critical test of the theories on the evolution of troglobites developed in temperate caves. Rather than being relicts of changes in climate, troglobites appear to have become highly specialized in order to exploit resources within the system of interconnected mediumsized voids (mesocaverns) and to colonize adjacent caves (macrocaverns) only where their unique environment is found. Their environment is too harsh for most organisms, being perpetually dark and humid, lacking common environmental cues, and with a complex maze-like form, lethal or sublethal gas mixtures, scattered food resources, unforgiving rocky substrates, and wet slippery vertical surfaces. Few animal groups can exploit this biotope. Successful facultative species probably remain troglophilic. Troglobites appear to evolve by a process called adaptive shift from species that are frequent accidentals in the mesocaverns. If significant exploitable resources are available, eventually an accidental may establish a population and, if successful, may become troglobitic by parapatric speciation.

Following the important pioneering studies in Europe and North America, troglobites have been thought to occur almost exclusively in limestone caves in temperate regions beyond the limits of maximum Pleistocene glaciations. They appeared to be relicts of the changing climates and sea levels associated with the waxing and waning glaciers (Vandel 1965, Barr 1968). The often bizarre and seemingly non-adaptive loss of eyes, body color, and other organs displayed by obligate cave animals has long intrigued both laymen and biologists. These changes have been termed «regressive evolution», and various theories based heavily on the apparent relictual distribution of troglobites were proposed to explain the evolution of such apparent «regressive» characters.

In the last decade there has been a virtual revolution in our understanding of cave biology, necessitated by the realization that obligate cave animals also live in nonlimestone caves such as lava tubes, erosional caves, and even voids in fractured rock and talus slopes; that significant specialized cave faunas are found in tropical regions; and taht many obligate cave species are not relicts (Howarth 1983, Juberthie 1983). These discoveries have opened up vast new areas of the world for biospeleological studies. The comparative studies of these newly recognized cave ecosystems will provide significant tests of the conclusions concerning colonization, evolution, ecology, and distribution of troglobites that were developed from the pioneering studies in temperate limestones caves, and a new synthesis is now necessary.

In the new expanded view of the cave environment the subterranean biome is divided into 3 size classes. Troglobites inhabit the 2 larger systems; the mesocaverns, an anastomosing system of voids ranging in size from ca. 0.1 cm to 20 cm in width, and the macrocaverns, which include the cave passages studied in traditional biospeleological research. In cavernous regions these two environments fully interconnect and form a continuous habitat. Most troglobites appear to be adapted to exploit resources in the mesocavernous zone and colonize the macrocaverns only where their special environmental requirements are approximated (Howarth 1983).

The physical environment within the mesocaverns is probably quite similar in both temperate and tropical regions. The temperature is higher and less variable in tropical mesocaverns, and there is a diurnal «winter effect», in which the oscillation of ambient air temperature above and below the underground temperature drives a daily turnover of air, and greater biogenic production of carbon dioxide and other decomposition gases (e.g. methane, carbon monoxide, ammonia). Soil formation and erosion rates are higher in the tropics, leading to a more rapid filling and degrading of both the meso- and macro-caverns there. These environmental factors lead to relatively higher concentrations of the gases of decomposition and concomittant lower concentrations of oxygen, and greater short term variability of these gases and of water vapor. Tree roots are a mucho more important food source in tropical caves because the high water stress has forced many tree species to produce deeply penetrating roots. Roots 30-50 m in depth are common in many tropical cave regions.

Organic food energy is continually being washed into suberranean voids by percolating ground water and sinking streams, or introduced by deeply penetrating plant roots and by dispersing animals. In non-cavernous areas this loss is relatively insignificant because the voids are small. However, where there are extensive systems of larger interconnected subterranean voids the loss can represent a significant resource. Much of this energy is carried out of reach of surface animals because of their inability to locate adequate harvestable energy to maintain their lifestyles, reproduce in perpetual darkness, or cope with the inhospitable environment, including the wet substrate and constantly hydrating atmosphere.

It is this potencial food resource that provides the driving force for the adaptation and evolution of cave species. Troglomorphic populations appear to evolve from pre-adapted habitual accidentals which often establish temporary populations in marginal underground habitats. Once an adaptive shift occurs, allowing a reproducing population to establish itself underground, then it is both the effects of strong new selection pressures and the release from previously strong selection pressures that bring about the remarkable changes that we recognize as troglomorphy.

Most well-adapted troglophiles remain troglophilic, at least as long as their underground habitats remain suitable for them. At the margins of their range or with changing environmental or biotic conditions their underground populations may become more transient and the stage is set for a subsequent adaptive shift and the evolution of a troglobitic population.

It is an absolute fallacy that great change requires great time in evolution. There is abundant and overwhelming evidence both in the fossil record and among living organisms to refute it, e.g., variability of domestic dogs and adaptive radiations on young oceanic islands. Organismic evolution progresses by natural selection on the variable genomic expression within a population. The time necessary for change and whether it occurs depends on 2 factors: degree of selection pressure and the genetic repertoire of the interbreeding population. Some highly modified troglobites are undoubtably ancient relicts and have survived in caves for a very long time, but others, equally troglomorphic, appear to be very young in geological terms. At the other extreme there are old troglophiles, e.g. many nematocerus Diptera.

The inhospitable mesocavernous environment imposes great selection pressures on adapting populations. Founding populations probably begin with one or at most only a few females. Inbreeding and release from previously active selection forces (predation, food and mate recognition, competition, etc.) allow survival of previously supressed genomes, thereby increasing variability and novel gene expression for natural selection to act upon. New selection pressures act to change food- and mate-seeking behavior, physiology to cope with novel, potencially lethal gas mixtures, and wet, maze-like substrates. Loss of unneeded structures (eyes, etc.) proceeds relatively rapidly through release of selection and accumulation of deleterious alleles. For example, if there are 100 genes controlling the development of the eyes, a mutation blocking or reducing the expression of any one of them may cause a reduction or loss of the eye (Culver 1982). Thus in this example reduction may proceed 100 times faster than the mutation rate- if selection is released. The naturally high radiation levels found in caves may increase the mutation rate, thereby further speeding the process.

I have space here for one well-studied example of cave adaptation in Hawaiian lave tubes: the Hawaii Island cave cixiid planthopper, *Oliarus polyphemus*. Previously I have discussed the evolution of the *Caconemobius* crickets (Howarth 1981).

The nearly continual volcanism on Hawaii Island is important in the evolution of cave species by continually creating new habitat and by creating *kipukas*. *Kipukas* are islands of older vegetated substrates surrounded by younger lava flows. Work in Hawaii shows these sparsely vegetated lava flows to be veritable deserts for the rainforest organisms inhabiting the numerous scattered isolated kipukas. However, cave animals can freely exploit resources under these lava flows and freely disperse between kipukas. Therefore, the exploitable habitat is much larger for cave populations than for ther more restricted rainforest relatives, at least in *young* volcanic tenaires. The situation reverses after volcanism wanes and rainforests and leaf litter communities develop on the aging substrates. Mesocavernous habitats and lava tubes degrade, erode, and fill in this aging process so that in older volcanic regions only relict cave species may survive.

Metrosideros polymorpha is the dominant tree in Hawaiian montane rainforests and also the major pioneer on young lava flows. Feeding on the roots of *M. polymorpha* in rainforests on Hawaii Island are nymphs of the native planthopper, *Oliarus inaequalis*. The adults are typical flighted, big-eyed denizens of the rainforests and rarely venture far out on younger lava flows. Adults and numphs are ocasionally found near entrances in caves but are considered accidental in deeper cave passages. E ven though some nymphs may transform in the deep cave, few if any resulting adults would reach the surface and survive to mate and find suitable habitats in which to lay eggs. Thus, much of the *M. polymorpha* root biomass (that on young lava flows and in drier marginal rainforest habitats) is out of reach to *O. inaequalis*.

Over the millenia incipient cave populations of the ancestors of *D. inaequalis* continually became established just as *O. inaequalis* does today. Most eventually died out. The major bottleneck for such a population may have been the ability to locate a mate and reproduce underground. Once a population could do this –bingo!– a large percentage of new *M. polymorpha* habitat was opened up to it, and the population could expand rapidly. For a time backcrosses with the ancestors of *O. inaequalis* in boundary habitats could have added genetic variability for selection, just as the modern plant and animal breeders backcross with wild strains in order to improve domestic strains.

The subterranean habitat is so novel and new selection pressures so strong that the new population diverged morphologically, physiologically, and behaviorly from the surface species, and has become genetically isolated from its ancestors and highly troglomorphic. In contrast to its surface relatives, *O. polyphemus* is pale ghostly white without any trace of eyes or ocelli. Its hind wings are reduced to tiny vestigal lobes while the tegmina have become short thickened flaps partially fused to the thorax. It's tarsal claws are greatly elongated, and the arolia are vestigal, adaptations which allow it to walk on wet rock surfaces. However, it retains the hallmark male genitalic characters which show it to be very closely related to *O. inegualis* (Fennah 1973).

Significantly, there is another closely similar cave cixiid, *O. priola,* in lava tubes on the nearby island of Maui. It also feeds on *M. polymorpha* tree roots. Maui is older and there are few remnant caves remaining in the rainforest. *O. priola* may be a relict, as a close surface relative has not been recognized among the native epigean species. Although its male genitalic characters show that is belongs to the native Hawaiian section of the genus, they show clearly that it represents an entirely independant line of cave adaptation from that of *O. polyphemus.* These 2 cave species are superficially very similar. Such a degree of parallel evolution was unrecognized a few years ago.

O. polyphemus is not yet a relict. It is widespread in cave and mesocavernous habitats only on Hawaii Island, and appears to be far more common and more widely distributed then its close surface relative, *O. inaequalis.* The geological evidence places the age of Hawaii Island between 400,000 and 700,000 years (Dalrymple et al. 1973). How could such a highly specialized cave species evolve in the few hundred thousand years that have elapsed since Hawaii Island rose above sea level?

I propose neotenic development. Nymphs of *O. inaequalis* are partially blind, pale, and able to survive in undeground environments well. They suck xylem sap from tree roots and thus already possess efficient mechanisms to deal with excess water. They are admirably preadapted to life underground, although they are poor dispersers. *O. polyphemus* appears to have evolved from an *O. inaequalis*-like ancestor by retaining the beneficial nymphal characters into adulthood. This would require mutations of only a few regulatory genes to bring it about and thus could have been quite rapid. Neoteny is also recognized in troglobites elsewhere, notably salamanders (Culver 1982).

Striking similarities exist between and among these kipuka and young lava flow environments just described and periglacial, karst terrains, and montane environments. In periglacial environments there are often islands of forests developing in protected sites (e.g. south-facing slopes in the northern hemisphere) separated by more-or-less barren ground. The extensive deposits of young moraines offer vast mesocavernous habitats for dispersing and evolving troglobites. Abundant food resources may also occur underground in periglacial environments from release and transport of organic debris trapped within the glacier. In karst terrains barren rocky ground is often the norm, with surface accumulations of leaf litter and vegetation restricted to cracks and sinkholes. Dispersal between these islands is either on certain rare nights when conditions allow across rock travel, or underground. In montane regions tree-line interdigitates with alpine and supra-alpine zones in protected places along valleys, ridges, slides, etc. Deep, young talus slopes provide abundant mesocavernous habitats and dispersal routes between and among these vegetated islands.

Many troglobites are relicts, especially some of those known from temperate regions, and some of these may have acquired their cave adaptations after the major portion of their surface populations were extirpated by a climatic or biologic change. However, the evidence from Hawaii and other tropical caves demonstrates that such extinction and subsequent isolation of the evolving cave populations is not a necessary prerequsite for troglobite evolution to occur.

Cave faunas have largely developed independantly within each region from the indigenous pre-adapted epigean fauna. Thus, each region has its own unique faunal elements. The fact that in many cases the adaptations to caves (troglomorphy) are so similar even among such diverse independantly evolved cave faunas indicates that cave adaptation is a general process and that selection pressures in the cave environment are very similar.

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FIELD: 12. Biospeleology.

by: Francis G. Howarth, B. P. Bishop Museum, P. O. Box 19000-A, Honolulu, Hawaii 96819 U.S.A.
Telephone: (808) 847-3511.

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Brazilian cave Fauna: Composition and Preliminar Characterization

Eleonora Trajano
Depto. Zoologia, IBUSP Soc. bras. Espeleol.

RESUM

El material zoològic recol·lectat a les coves brasileres, i particularment a aquelles situades al curs alt de la vall del riu Ribeira (SE del Brasil) ens proporciona una visió àmplia i documentada sobre el tema, tot i que les diferències amb allò descrit per a les zones tropicals no són pas molt grans.

Els animals que hom ha trobat amb més freqüència dins aquesta àrea són els següents: ortòpters Phalangopsidae, coleòpters (Carabidae, d'entre altres), dípters com els Chronomidae, miriàpods Polydesmida i Juliformia, opilions Laniators, aranyes (sobretot Scytodidae, Ctenidae i Theridiosomatidae), silúrids i rat penats. Amblipigis i escarbats són també freqüents, excepte a la part més alta del Ribeira.

La fauna present a l'entrada es caracteritza pel predomini d'aràcnids (opilions Goniosominae i aranyes Pholcidae), heteròpters Reduviidae i formes larvàries de dípters Keroptatidae.

D'entre els troglobis terrestres abunden els grups detritívors/ omnívors. No és freqüent trobar-hi depredadors.

RESUMEN

El material zoológico recolectado en las cuevas brasileñas, particularmente en las que están en la parte superior del valle del río Ribeira (Sur-Este del Brasil) proporciona una visión razonablemente buena sobre el tema, el cual aparece no ser demasiado distinto del que se ha descrito para las regiones tropicales.

Los animales encontrados con mas frecuencia en el área incluyen: ortópteros Phalangopsidae: coleópteros (Carabidae, entre otros); dípteros como los Chironomidae; miriápodos Polydesmida y Juliformia opoliones Laniatores; arañas, particularmente Scytodidae, Ctenidae y Theridiosomatidae; silúridos y murciélagos. Amblipigios y cucarachas son comunes, excepto en Ribeira Superior.

La fauna de la entrada se caracteriza por el predominio de arácnidos (opiliones Goniosominae, arañas Pholcidae), heterópteros Reduviidae y formas larvarias de dípteros Keroptatidae.

Entre los troglobios terrestres dominan los grupos detritívoros/omnívoros; no son comunes los depredadores.

SUMMARY

The zoological material collected in Brazilian caves, particularly in those from the Upper Ribeira River Valley (South-eastern Brazil), provides a reasonably good view of the subject, one that does not seem to be much different from that described for other tropical regions.

Animals frequently found throughout the area include: Phalangopsidae crickets; coleopterans (Carabidae, among others); dipterans like the Chironomidae; Polydesmida and Juliformia millipedes; Laniatores opilionids; spiders; particularly Scytodidae, Ctenidae and Theridiosomatidae; catfishes and bats. Amblypygi and cockroaches are common, except for the Upper Ribeira.

The threshold fauna is characterized by the predominance of Arachnida (Goniosominae opilionids, Pholcidae spiders), Reduviidae heteropterans and the larval form Keroplatidae dipterans.

Among the terrestrial troglobites, the detritivorous/omnivorous groups predominate; the predator ones are uncommon.

Introduction

In the last few years a number of caves from various Brazilian limestone regions, mainly those of the Upper Ribeira River Valley, South São Paulo State, were surveyed. The information gathered expands and improves that of our preliminary article (Dessen *et al.*,1980)), allowing a reasonable good picture of the Brazilian cave fauna.

The main Brazilian Speleological Provinces (Karman & Sanchez, 1979) are shown in the figure. Collects were made in the provinces I, II, III and V, and also in sandstone caves of São Paulo and Amazonas States. Data from Minas Gerais State are available in Chaimowicz (1984).

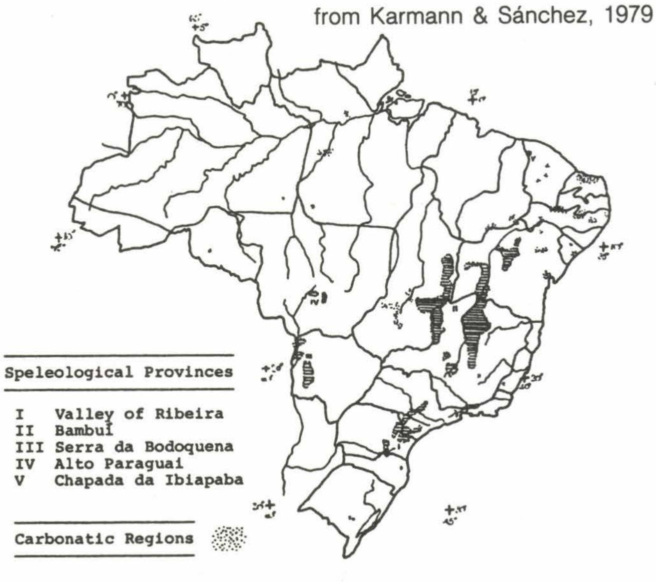
Faunal composition

Due to the limited number of specialists on the groups found in the Brazilian caves, the majority of the specimens were identified to the family level. Even so, this is enough to give an idea of the main taxa inhabiting Brazilian caves and to allow comparision with other regions.

Animals commonly found throughout the studied area include crickets, heteropterans, milipedes, isopods, opilionids and spiders, besides bats and siluriform fishes. The invertebrate aquatic fauna is poorly known and this paper will be restricted to a few comments.

Brazilian speleological provinces ad carbonatic regions

from Karmann & Sánchez, 1979



The commonest spiders are the *Ctenus* spp. (Ctenidae), *Loxosceles* spp. (Scytodidae) and *Plato* Spp. (Theridiosomatidae). Pholcidae spiders are also common, particularly near the entrances. These families have been cited as typical of tropical caves.

Among the opilionids, Palpatores are rare and probably accidental in Brazilian caves. In the Upper Ribeira, the best known region, the gonyleptid Laniatores predominate: the Goniosomatinae are common near the entrances and the Pachylospeleinae related to the Pachylinae and showing troglomorphic characters. in the dark zones of the caves. A small number of phalangodids, well represented in the tropical caves in general, were collected.

Up to now, two Diplopoda orders were recorded in Brazilian caves: the Polydesmida and the Juliformia. Pseudonannolenid juliformids, and leptodesmid, cryptodesmid and oniscodesmid polydesmids were found in the Upper Ribeira, the first two being frequent.

Terrestrial isopods (Oniscoidea) belonging to different families (Styloniscidae, Philosciidae, Platyarthridae, Armadillidae) were collected throughout Upper Ribeira and Bambui provinces. Great part of the populations present troglomorphic characters.

All the identified crickets are phalangopsids and the majority belong to the genus *Endecous,* problaby pre-adapted to the cave life. Some exceptions are *Eidmanacris* spp.

Reduviid heteropte heteropterans are, like in other tropical regions, characteristic of the threshold fauna. Still, at least one troglophile population of a reduviid (*Zelurus variegatus)* was found throughout the dark zones in the Upper Ribeira.

Dipterans and beetles have been regularly collected and identified to family level only in São Paulo State; data about these groups found elsewhere are scanty. The chironomids, observed in great numbers in caves of Goias State, and the larval form of a keroplatid (Mycetophiloidea), typical of the threshold fauna, are among the commonest dipterans found at all places. Phoridae, Ceratopogonidae, Tipulidae, Empididae, and Dixidae, occurring in caves of other countries, were also recorded in the Upper Ribeira.

Beetles recorded in São Paulo include: Carabidae *(Schizogenius ocellatus* from several caves of the Upper Ribeira, showing troglomorphic characters, and *Platynus aequinoctialis,* among others), Ptilodactylidae, Leiodidae Catopinae and Pselaphidae. The first two families were also recorded in Minas Gerais.

The soil fauna, as well, has been systematically surveyed only in the Upper Ribeira, where the presence of collembolans, diplurans, geophilimorph centipedes, pseudoscorpions, acarines and earthworms, was ascertained, as already expected; these animals may be common elsewhere but, due to the lack of information, an actual evaluation of this fauna outside São Paulo State is not allowed. The Entomobryidae are the commonest collembolans, followed by the Sminthuridae. The most collected earthworm was *Amynthas hawaianus,* introduced in the Neotropical region and well succeeded in the colonization of the cave environment; Glossoscolicidae, Ocnerodrilidae and Enchytraeidae were also recorded. One specimen of Symphyla, group not usually found in caves throughout the world, was collected in the Upper Ribeira, too.

A few groups are common in some regions but certainty rare or absent in others. this is the case of the Amblypygi (Damonidae, Phrynidae and Charontidae), not found in São Paulo State, which is outside the geographic distribution of the group. For the same reason, the anomuran crustacean *Aegla,* common in caves of the Upper Ribeira, where it forms troglomorphic populations, do not occur northern of São Paulo.

Furthermore, cockroaches are frequent in the warm caves north of the subtropical Upper Ribeira, where they are rarely seen. In this case, thee limiting factor is other than geographic distribution. One possible explanation is that the caves in the latter region, whose temperature is generally equal or bellow 20° C, are rather cold for these typically tropical animals.

In relation to the aquatic fauna, aside from *Aegla,* a population of Spelaeogriphacea crustaceans can be pointed out. Specimens belonging to a new genus and species of this group, formerly known only from South Africa, were found in a cave from Serra da Bodoquena. Among the vertebrates, the siluriform fishes, including troglomorphic populations, are dominant, being observed wherever water bodies are propitious to fishes. With a few exceptions, the specimens collected are pimelodids *(Pimelodella, Rhamdia, Imparfinis,* among others), trichomycterids *(Trichomycterus),* or loricariids *(Ancistrus, Plecostomus, Loricaria).* Only a few Characiformes, problaby trogloxenes or accidentals, were recorded *(Astyanax, Prochilodus)*

Sandstone cave fauna is basically the same found in limestone caves. Seemingly, the only striking difference is the larger amount of bat guano in sandstone caves, resulting in larger populations of guano-feeding arthropods such as crickets and juliformid millipedes. Problaby associated to this, there have not been found, up to now, troglomorphic animals in these caves.

It was observed that bats tend to distribute through the roosts available in limestone regions like the Upper Ribeira, where the number of such roosts (caves, crevices) is high; so, the bat populations in each cave are generally small (Trajano, 1985). On the other hand, sandstone caves are scanty and smaller, and the bats concentrate, proportioning great amounts of guano. So, the input of energy as guano in general is not high in Brazilian caves like on other tropical regions studied.

From the point of view of the composition, there does not seem to be remarkable differences between Brazilian and other tropical cave faunas. The great majority ot the terrestrial predators are troglophiles, prevailing arachnids (spiders and Amblypygi), followed by reduviid heteropterans, carabid beetles and geophilomorph centipedes. The phalangopsid crickets and the cockroaches (rare or absent in the temperate caves), polydesmid and juliformid millipedes, beetles like the catopines, and dipterans, are, as in other tropical regions, among the commonest representants of the detritivorous/omnivorous terrestrial fauna.

The threshold fauna is also similar to that of other tropical regions, being characterized by the predominance of the Aracnida like Goniosomatinae opilionids and Pholcidae spiders, and Reduviidae heteropterans. The only typical dipteran of this fauna is the larval form of the fungus gnat (Keroplatidae).

Brazilian troglobites, troglophiles and trogloxenes

At the present, it is difficult to apply the concept of troglobites as organisms confined to the subterranean habitat, to the Brazilian cavernicoles. This is due to the lack of intensive, systematic surveys on the epigean fauna for most regions, including that where caves are located. So, our «troglobites» are actually troglomorphic populations.

Up to now, such populations were found for the following taxa: siluriform fishes *(Pimelodella kronei,* from Upper Ribeira; *Trichomycterus* spp. and *Ancistrus* sp., from Bambui province), anomuran crustaceans *(Aegla spp., from Upper Ribeira),* Oniscoidea isopods, Spelaeogriphacea crustaceans, polydesmid millipedes (*Leptodesmus yporangae, Peridontodesmella alba, Yporangiella stygius,* from Upper Ribeira, besides other undescribed ones), pseudoscorpions like *Pseudochthonius strinatii,* gonyleptid opilionids (*Pachaylospeleinae* form Upper Ribeira, among others), and collembolans (Sminthuridae and Entomobrydae). The carabid *Schizogenius ocellatus* and an undescribed pselaphid from Upper Ribeira could be considered troglobites based on reduction of eyes, brachyptery and a slight depigmentation in the latter. Still, it is possible that the typically eyeless and depigmented taxa, like many soil animals recorded, for instance, in the Upper Ribeira, include troglobite populations.

As can be noted, Brazilian troglobites are mainly aquatic organisms or terrestrial detritivorous/omnivorous. The relative rarity of troglobites among the terrestrial predators in tropical caves has been frequently cited in the literature as one of the most notable differences in relation to the temperate ones.

To deduce the troglophile status, it was used the following criteria applied to organisms with epigean characters: distribution throughout the cave, repeated observations (indicating a reasonable sized population), and, in many cases, evidences of a complete life cicle inside the cave (observation of either eggs or cocoons, juveniles and adults). In so doing, it was concluded that the majority of Brazilian cavernicoles recorded are troglophiles. These include the crickets *Endecous* spp. and at least one population of *Eidmanacris*), cockroaches, the heteropteran *Zelurus variegauts,* beetles like the catopines, ptilodactylids and pselaphids (except for the mentioned troglomorphic population), dipterans like chirinomids and at least one population of Phoridae (*Conicera* sp.), part of the collembolan species, juliformid and some polydesmid millipedes, spiders (*Ctenus* spp., *Loxosceles* spp. and *Plato* spp.), Amblypygi, and several Laniatores opilionids. Problaby some trichopterans, like the leptocerids and others found in the Upper Ribeira caves are also troglophiles.

Among the trogloxenes, it could be cited the mammals (bats, opossums, rodents and others) and decapod crustacenas (aeglas, freshwater shrimps and crabs), whose size and degree of mobility let periodic incursions to relatively great depths in caves.

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Bibliografia speleofaunistica della Puglia (Italia del Sud)

Vicenzo, Manghisi – Luigi, de Marzo

Istituto Italiano di Speleologia di Castellana-Grotte – Istituto di Entomologia Agraria, Università di Bari

RESUM

En aquest treball els autors ens donen una relació de més de 150 noms d'espècies pertanyents a la fauna de les cavitats naturals de les Pouilles (Sud d'Itàlia). Es tracta de la primera llista, molt completa, que se'ns ofereix d'aquesta interessant regió que compta, per cert, amb nombroses espècies comuns amb la zona balcànica a la que antigament es trobava anexionada.

RESUMEN

En este trabajo los autores dan una lista de más de 150 títulos concernientes a la fauna de las cavidades naturales de las Pouilles (S. de Italia). Se trata de la primera lista completa ofrecida por esta interesante región que presenta numerosas especies comunes con la zona balcánica a la que estuvo anteriormente unida.

RÉSUMÉ

Dans ce travail, les Auteurs dressent une liste de plus de 150 titres qui concernent la faune des cavités naturelles des Pouilles (Italie du Sud). Il s'agit de la première liste bibliographique complète dressée pour cette intéressante région, qui présente de nombreuses espèces communes à la zone balkanique avec laquelle elle était autrefois conjointe.

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Non-relictual cavernicolous invertebrates in tropical Asian and australasian Caves

Philip Chapman
City Museum, Bristol, U.K.

RESUM

Els tradicionals conceptes «Jeannelians» i «Vandelians» de troglobis (= troglomorfs) insisteixen en el seu llarg aïllament genètic a què han estat sotmesos dins les coves (encetat arran de cataclismes climàtics), en la seva consegüent evolució degenerativa i en la seva residual distribució repartida de forma irregular en àrees càrstiques temperades.

Les coves tropicals de Papua Nova Guinea i Sarawak constitueixen l'habitacle de molts invertebrats terrestres troglomòrfics. La major part pertanyen als taxons de domini local; d'altres, en canvi, pertanyen a taxons desconeguts que, fins ara, no han pogut ésser trobats en altres indrets. Malgrat tot, i mentre no s'estudiïn amb més deteniment els hàbitats críptics superficials, a les zones del carst tropical, és millor pensar que la majoria de cavernícoles troglomòrfics no són espècies relictes. Els troglomorfs tropicals no són necessàriament antics cavernícoles i es troben encara en procés d'especiació. L'especiació en les coves tropicals és possiblement parapàtrica més que no pas alopàtrica. Els invertebreats troglomòrfics adaptats a l'estratègia de la K són més freqüents en conductes estrets, propensos a les inundacions, amb poca circulació d'aire, una atmosfera saturada i un subministrament periòdic de detritus orgànics.

RESUMEN

Los tradicionales conceptos «Jeannelianos» y «Vandelianos» de troglobios (= troglomorfos) hacen hincapié en su largo aislamiento genético en cuevas, iniciado con cataclismos climáticos, su subsiguiente evolución degenerativa y su residual distribución esparcida de forma irregular en áreas kársticas templadas.

Las cuevas tropicales de Papúa Nueva-Guinea y Sarawak contienen muchos invertebrados terrestres troglomórficos. La mayoría pertenecen a los taxones localmente dominantes. Algunos pertenecen a los taxones desconocidos, que hasta el presente no se han encontrado fuera de las cuevas en su localidad. No obstante, mientras se estudian más los hábitats crípticos superficiales en zonas de karst tropical, es más seguro asumir que la mayoría de cavernícolas troglomórficos no son especies relictas. Los troglomorfos tropicales no son necesariamente antiguos cavernícolas y están todavía en proceso de especiación. La especiación en cuevas tropicales es posiblemente parapátrica más que alopátrica. Los invertebrados troglomórficos adaptados a la estrategia de la K son más frecuentes en conductos pequeños propensos a las inundaciones, en donde hay poco movimiento del aire, una atmósfera saturada y un suministro periódico de detritos orgánicos.

SUMMARY

Traditional «Jeannelian» and «Vandelian» concepts of troglobites (= troglomorphs) stress their long genetic isolation in caves initiated by climatic upheavals, their subsequent degenerative evolution, and their patchy, relictual distributions in temperate karstic areas.

The tropical caves of Papua New Guinea and Sarawak contain many troglomorphic terrestrial invertebrates. Most belong to locally dominant endemic taxa. Some belong to taxa not presently known outside caves in their locality. However, until cryptic surface habitats in tropical karst areas receive more study, it is safest to assume that most troglomorphic cavernicoles are not relictual species. Tropical troglomorphs are not necessarily ancient carvernicoles and may be still speciating. Speciation in tropical caves is probably parapatric rather than allopatric. K-adapted troglomorphic invertebrates are most common in small, flood-prone passages near the phreas, where there is little air movement, a saturated atmosphere and a periodic supply of organic detritus.

According to Jeanelian and Vandelian tradition, most highly cave-evolved animals, or «troglomorphs», are supposed to be relicts of ancient hygrophilic faunas, extinct elsewhere. Such species are numerous in caves of temperate regions, because climatic changes associated with the Pleistocene glacial epochs have, by removing adjacent surface populations, set the cavernicoles on an evolutionary course steered by selection pressures peculiar to the cave environment. During cold periods, many temperate caves experienced a reduced food supply, as is seen today in caves of sub-glacial latitudes in northern Europe and America. Under these conditions, the only survivors of the preexistent cave fauna were species which were able to efficiently exploit a poor and erratic food suplly; that is K-selected, highly cave adapted species. Some of these are cryophilic relicts from the taiga-like forests which preceded the advance and followed the retreat of the glaciers (this element was stressed by Barr, 1968) and some are thermophilic relicts of the moist tropical/sub-tropical forests of the Tertiary (this element was stressed by Vandel, 1965). Whatever their origin, relict species are now the most ancient and easily recognized component of modern temperate cave faunas: many are eyeless, depigmented and have attenuated appendages or hypertrophied non-visual sensory apparatus. Some temperate biospeleologists, such as Vandel (1965), seem to have believed that almost all highly troglomorphic species are glacial or pre-glacial relicts. However, recently Deeleman-Reeinhold (1981) has argued that the number of these supposed «relicts», among the European spiders at least, has been exaggerated by bad taxonomy.

In the lowland tropics where Pleistocene glaciations had little discernible impact, and where forest cover remained intact, cavernicolous faunas have not been constructed in the same way as in temperate regions. The caves retain an ancient fauna. There are proportionally fewer «troglomorphic», K-selected cavernicoles and instead the cave community is far more rich in r-selected and intermediate species. These «non-troglomorphic» tropical cavernicoles have been called «troglophiles» by most authors to distinguish them from the few «temperate-troglomorphic», K-selected tropical cavernicoles, which have been termed «troglobites». The assumption has been that the K-selected «troglomorphs» are the true, ancient, cave-evolved troglobites, while the r-selected «non-troglomorphs» are recent colonists, or maintain gene-flow with surface populations and are thus not «true cavernicoles» (sensu Vandel, 1965). However, the so-called tropical «troglophiles» almost certainly include some very ancient cavernicoles. There would seem to be little reason why tropical cavernicoles should be expected to eventually evolve in parellel with K-selected temperate troglomorphs. Tropical caves are often not food-poor, and r-selected species have far more cave niches available to them than do K-selected cavernicoles. The r-selected, guano-associated species may show reduction in eye-size or pigmentation, or not. Often they demostrate considerable polymorphism in selectively-insignificant characters such as pigmentation or eye-development. Such variability may be a truly troglomorphic character in the tropics. Any tendency towards loss of wings, pigment, or eyes in obviously r-selected guanobia in tropical caves is most simply explained in terms of relaxed selection pressure associated with prolonged cavernicolous existence free from gene-swamping by an adjacent surface population. In highly cavernous areas of tropical karst, containing huge bat or swiftlet populations, it would seem likely that the bulk of the populations of many guanobious cockroaches, rhaphidophorid crickets, aderid and leiodid beetles, tineidmoths, gasropods, millipedes, isopods and their predators, live permanently in caves, and presumably have done so for millenia. Guanobious species such as the cricket *Diestrammena mjobergi,* the leiodid beetle *Ptomaphaginus chapmani,* or the tineid moths *Tinea antricola* and *T.porphyropa,* all of which are common in the Mulu caves in Sarawak, are true cavernicoles, known only from caves. They have been described as «troglophiles», rather than as «troglobites», purely because biospeleologists persist in equating «troglobite» with «troglomorphic, K-selected cavernicole». Incidentally, the microphthalmic and poorly-pigmented *Ptomaphaginus chapmani,* described by Peck (1981) as a «troglophile», probably because it retains functional wings, appears to be a relict member of an ancient group which is widely, if patchily, distributed within the tropics.

The Mulu caves in Sarawak do contain a few «temperate-type troglomorphic» species which belong to taxa which are still represented locally by other «non-troglomorphic» cave –and surface– dwelling species. They include an eyeless, white potamid crab, *Cerberusa caeca,* which has an eyed and pigmented congener, *C.tipula,* (Holthuis, 1979), sometimes sharing the same caves. An undescribed translucent prawn with reduced eyes, *Palaemon (Macrobrachium)* sp., inhabits one cave stream within a system elsewhere frequented by at least two other epigean members of the same subgenus. Two or more undescribed «troglomorphic» pholcid spiders are related closely to *Spermophora,* a locally common genus, with epigean and cavernicolous representatives. A «troglomorphic» scorpion, *Chaerilus* sp. has local epigean relatives, and two semi-terrestrial isopods, *Setaphora parvicaputa* and *Paraperiscyphis platyperaeon* (Schultz, 1982) have two forms, one microphthalmic and lightly pigmented, the other larger-eyed and more pigmented, which appear to be zoned in the cave, with the more «troglomorphic» facies almost exclusively found in «deep-cave» microhabitats. The various populations of *Diestrammena mjobergi* in the Mulu caves also vary in their degree of pigmentation and eye regression from one cave to another. None of these species, however, exhibits as spectacular a range of variations in eye –and pigment– regression as do the Tanzanian hypogean cockroach *Alluaudellina cavernicola,* or the rhaphidophorid cricket *Tachycines cuenoti,* from caves in Tonkin (Vandel, 1965). I suggest that these species are true cavernicoles (in the sense of having been shaped by a hypogean existence), as much as the more familiar «temperate troglomorphs» of the Pyrenees, or Jugoslavia.

Some troglomorphic species from Mulu (e.g. the cockroach *Trogloblattella chapmani* Roth (1980), the anthurid isopod *Cyathura chapmani* Andreev (1982), the asellid isopod *Stenasellus chapmani* Magniez (1982a,b), or the amphipod *Bogidiella (Medigidiella) sarawacensis* Stock (1983) have no known relatives in the area. They may be relicts, or not. The invertebrate faunas of hyporheic waters, such as in riverine gravels, and of soils, leaf-litter, or other crytic habitats in Borneo are far too poorly known for such an assertion to be made yet. Indeed, it is inevitable that in time more and more tropical cavernicoles formerly thought to be relict species, will prove to have living relatives, as cryptic non-cave habitats become better studied. An example of the difficulty in assessing «relictualness» is seen in the eyeless nereid polychaete *Namanereis beroni* (Hartmann-Shröder and Marinov, 1977), which was discovered in freshwater pools in a cave at 1.700 m altitude in Papua New Guinea (Chapman, 1985). Other *Namanereis* are widely distributed in marine, brackish, or freshwater habitats at, or near sea-level, but were unknown from the Australasian region, so that at the time of its discovery ten years ago, *N.beroni* seemed to be a «marine relict» (Chapman, 1976). However, more recently, polychaetes have been found inhabiting forest litter in Papua New Guinea (Deharveng, 1981) and these may prove to be related to the cavernicolous *Namanereis*. Other highly troglomorphic cavernicoles in the Papua New Guinea highlands are already known to have close relatives among the endemic surface fauna. Examples are: Five troglomorphic carabid beetles of the locally dominant tribe Agonini (Emberson and Moore, 1982), several cavernicolous paradoxosomatid millipedes, including the highly-troglomorphic *Selminosoma chapmani* (Hoffman, 1978), and the sundathelphusid crabs *Rouxana phreatica (Holthuis, 1982) and* Holthuisana alba *(Holthuis, 1980). The non-relictual nature of the Hawaiian cave fauna is also well known. Howarth (1981) argued that various preadapted Hawaiian rainforest arthropods, and* Caconemobius *crickets (which are primarily adapted to wet rock habitats), have made an adaptive shift to exploit the novel habitat offered by recently-formed caves and mesocavernous habitats. Amazingly, the genus* Lycosa *(called in Hawaii the «big-eyed hunting spiders»), have contributed two troglomorphic species,* Lycosa howarthi *and* Adelocosa anops, *to the Hawaiian cave fauna (Gertsch, 1973). As Gertsch points out, this demonstrates «the ability of big-eyed spiders with seemingly fixed qualities to seize and exploit a habitat opportunity even though its results, essential or total eyelessness, seem antagonistic to their nature» (Gerstch, 1973).*

Terrestrial troglomorphic cavernicoles in the highland caves of Papua New Guinea have clear habitat preferences. They are found almost exclusively in small, blind-ending, flood-prone passages just above the level of the phreas, where slowly-draining flood waters deposit a harvest of food and where air temperature remains fairly constant and atmospheric humidity is close to saturation. This is a similar habitat to that favoured by many temperate cavernicoles, and presumably accounts for the uncannily similar facies of the Papuan cavernicolous agonine beetles and some American counterparts. Some Mulu troglomorphs also favour this habitat, while others occur widely in the damper fossil passages where they feed on scattered faeces of cave swiftlets, Aerodramus vanikorensis. *All the terrestrial troglomorphic species are strongly hygrophilic, as predicted by Howarth (1980).*

We must realize that there is nothing «special» in the process of colonization of caves, or the speciation of cavernicoles. Faced with a virgin cave, the most successful colonists will be those which arrive first and which are best preadapted to the cavernicolous niche which they will eventually occupy. But in the absence of suitably preadapted competitors, virtually any invertebrate can make an adaptive shift to cave life. Speciation in caves does not require major climatic changes, or extinction of adjacent surface populations, any more than such ocurrences are necessary for speciation to occur in any other environment (e.g. see White, 1978). As Culver (1982) has pointed out, «it is rare to find a population of any cave organism that extends from the surface directly into the cave. In most cases it is unlikely that gene flow is retarding adaptation». He might equally have sustituted «speciation» for «adaptation»! Typical «troglophiles», so-called, may be cavernicoles as ancient and, in their own way, as highly cave-evolved as most K-selected temperate «troglobites». It is time that biospeleologists ceased to apply inappropriate temperate criteria in defining the status of tropical cavernicoles.

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Preliminary Summary of the Subterranean Fauna of the Galapagos Islands, Ecuador. [1], [2]
Part I. Introduction and Non-Insect Invertebrates

Stewart B. Peck and Jarmilla Kulalova-Peck

RESUMEN

L'any 1965, N. i J. Leleup varen descobrir la presència d'una fauna sense ulls al sòl i aigües subterrànies a l'arxipièlag de les Galàpagos. L'any 1985 vàrem explorar per a l'estudi de fauna invertebrada 25 tubs de lava, sotabosc i sòl a les tres illes de les Galàpagos. Com a resultat, de la fauna freatobita sense ulls, troglobita i edafobita se'n coneixen fins ara un total de 15 espècies invertebrades que no són insectes i a més a més 17 espècies troglofíliques i edafofíliques.

RESUMEN

En 1965 N. y J. Leleup descubrieron la presencia de una fauna sin ojos en el suelo y aguas subterráneas en el archipiélago de las Galápagos. En 1985 exploramos para el estudio de fauna invertebrada, 25 tubos de lava, escombros del bosque y suelo en las tres islas de Galápagos. Como resultado, de la fauna freatobita sin ojos, troglobita y edafobita se conocen hasta ahora un total de 15 especies invertebradas que no son insectos y además 17 especies troglofílicas y edafobitas.

SUMMARY

In 1985, N. and J. Leleup discovered the presence of an eyeless soil and groundwater fauna in the Galapagos Archipelago. In 1985 we searched for invertebrate faunas in some 25 lava tube caves and in forest litter and soil on three islands of the Galapagos. As a result, the eyeless *phreatobite, troglobite, and edaphobite fauna is now known to total over 15 non-insect invertebrate species, and an additional 17 troglophilic and edaphophilic non-insect species.*

The Galapagos Islands have long been known to scientists and naturalists for their unique flora and fauna, which has evolved in oceanic isolation. Much has been written about the islands and their biota, and especially the plants and vertebrates (see reviews in Berry 1984, Bowman et al. 1966, 1983; Carlquist 1965, 1974, Perry 1984, and Thornton 1971). However, the terrestrial invertebrates remained comparatively little known.

N. and J. Leleup of the Musee Royal de l'Afrique Centrale of Belgium spent 6 months in 1965 on the Galapagos Islands, studying and collecting the invertebrate faunas. The results of their collecting have been reported in three volumes (Leleup 1968, 1970, 1976). Among the interesting results was the discovery of an eyeless subterranean fauna in groundwater and soil habitats. The Leleups sampled in only three caves, and indirectly suggested that a terrestrial troglobite fauna was present, but these species have not been described. The presence of an eyeless or microphthalmic fauna without close epigean relatives indicated to Leleup that this fauna was relictual, and derived from pre-Pleistocene immigrants. He reasoned that the islands were consequently older than the some one million years then usually suggested for their age.

Since that work, information on many additional lava tube cave locations has become available. We received permits to study the soil and cave fauna from the Galapagos National Park Service and the Charles Darwin Research Foundation, agencies responsible for preserving these unique areas and for coordinating research in them. From 10 May to 16 July 1985, we investigated some 25 volcanic caves or cave-like habitats which are described in detail elsewhere (Peck and Peck 1986). The purpose of this report is to provide a summary of the subterranean fauna reported by others, to give a preliminary indication of the taxa we found, and to list the caves or other cryptic habitats they occured in. Unless otherwise noted, all localities are on Santa Cruz Island. An introduction to the early entomology works on the Galapagos is in Linsley and Usinger (1966) and Linsley (1977). Because of space limitations, detailed references are not given to papers in the Leleup volumes. References follow part II of this contribution, and if deleted because of space limitations, are available from the authors.

Annotated Faunal List

Phylum Annelida, Class Oligochaeta, Family Enchytraeidae, edaphobite

Pot worms were in abundance in soil banks in Cueva de Bellavista no 2.

These may have been introduced to the island between 1935 and 1965 (Kastdalen, 1982).

Phylum Mollusca, Class Gastropoda, Order Stylommatophora, Family Subulinidae

Subulina octona (Bruquiere), troglophile

These snails were at moist debris in Cueva de Bellavista no 2. The species is pantropical and distributed by man.

Phylum Arthropoda, Class Crustacea, Order Tanaidacea, Family Tanaidae

Tanais stanfordi Richardson, troglophile

These shrimps were found at Leleup's station G4 (a deep crevice with brackish water, at 50 m elev. and 2 km from the sea) (Monod, in Leleup 1970).

Class Crustacea, Order Decapoda, Family Palaemonidae

Macrobrachium americanum Bate, troglophile

These shrimps occur at Leleup's stations G4, G6, and G23 (= Cueva Iguana at Darwin Station) and in a Grieta pool, 100 m W of P. Ayora on Tortuga Bay trail. The species is widespread from lower California to N. Peru and the Galapagos and Cocos islands.

Order Decapoda, Family Atyidae

Typhlatya galapagensis Monod and Cals (in Leleup, 1970), phreatobite-troglobite

This shrimp has reduced and pigmentless eyes. It is known from brackish subterranean (anchialine) habitats at Leleup's station G4, G14, G22, G23 on Santa Cruz, and G14 on Isabela. We found it in Cueva de Iguana, Grieta del Pozo de Puerto Ayora, and in Grietas at Tortuga Bay, as well as Cueva de la Cadena,

1. *Contribution 394 of the Charles Darwin Research Foundation*
2. *The invertebrate faunas of tropical American caves, part 10*

Isla Isabela. The genus is otherwise unknnown in the Pacific, but blind or small-eyed groundwater species occur in lands in and around the Caribbean Basin, and Ascension Island. It was used in establishing a «generalized track» in a discussion of vicariance Caribbean biogeography (Rosen, 1976, see also Rosen, 1978, Hedges, 1982).

Class Crustacea, Order Amphipoda, Family Melitidae

Galapsiellus leleuporum (Monod), phraeatobite-troglobite

This very small and blind amphipod (originally placed in *Paraniphargus)* was taken with meat baits in deep subterranean fresh water at 5 m elev. at Leleup's station G6 and G22 (brackish water accessible by digging, 1 km from Tortuga Bay) and in a mangrove tidepool 300 m from the sea near the Darwin Station. The genus is thought to be close to and probably derived from *Eriopisa,* a widespread marine genus (Barnard, 1976).

Class Crustacea, Order Isopoda, Family Philoniscidae

Colombophiloscia naevigesta Vandel, edaphobite?

This depigmented and eyeless terrestrial isopod is known from deep crevices and in wet cave entrances at 650 m on Santa Cruz summit prairies. The genus is otherwise known from a small eyed species from a cave at Baños, Ecuador, and an eyeless species from caves at Caripe, Venezuela (Vandel, in Leleup 1968). A total of 14 species of terrestrial isopods are known (in 11 genera) with only 5 endemics in the islands. We found undetermined isopods in Cueva de Bellavista no 2 and Cueva de Sra. Colombia, and on Isabela in Cueva de Sucre and Cueva de Macas.

Class Arachnida, Order Amblypigi, Family Charontidae

Charinus insularis Banks, troglophile

The species was previously known from several islands and on Santa Cruz in a cave 3.5 km N of Puerto Ayora (= Cueva Kubler) and Cueva de Iguana. We found it in Cueva de Sra. Colombia, Cueva de Bellavista no 2, Cuevas de la Finca Kastdalen, Cuevita de los Cyathaes, Cuevas de Finca Vargas, Cueva 2 km S El Chato, Cuevita al Suroeste de Cerro Banderas, Cuevas de Cerro Banderas, and Cueva de Tres Entradas, and on Isabela in Cueva de la Cadena.

Arachnida, Order Acarina, Families undetermined, troglophile?

Undetermined mites were taken in soil and litter in Cueva de Bellavista no 2.

Class Arachnida, Order Schizomida, Family Schizomidae

Schizomus portoricensis (Chamberlin), troglophile

We found the species in Cuevas de Bellavista no 1 and 2, Cueva de Sra. Colombia, and Cuevas de la Finca Kastdalen. It was previously known from the Galapagos from two collections, and is a species widespread in the Caribbean, Central America, and northwestern South America (Rowland and Reddell, 1977).

Class Arachnida, Order Aranea, Family Oonopidae

Gamasomorpha species 2, edaphobite?

This blind and unpigmented spider occurs in deep dam crevices. This and the following blind species of spiders, from among all the other 70 Galapagos spider species, have been suggested by Roth and Craig (in Leleup 1970), following Leleup (1968: 12-14) to be relicts of pre-Pleistocene ancestors. Spiders in this family are often eyeless litter inhabitants.

Class Arachnida, Order Aranea, Family Pholcidae

Coryssocnemis sp. 1, troglobite

This blind and unpigmented spider is known only from Post Office Bay Cave, Isla Floreana. The genitalia are said (Roth and Craig, in Leleup 1970) to be identical to those of the widespread epigean endemic *C. conica* Banks (which may be the ancestor) but the legs are longer in the cave species.

Coryssocnemis sp. 2, troglobite

Found in Cuevas de Bellavista no 1 and 2, Cueva de Sra. Colombia, Cuevas de la Finca Kastdalen, Cueva de Huesos, Cuevas de Vargas, and Cuevas de Cerro Banderas.

Coryssocnemis sp. 3, troglobite

This eyeless species was found in Cueva Sucre, Isla Isabela.

Coryssocnemis conica Banks, troglophile

Found near the entrance of Cueva de Sra. Colombia and on Isabela in Cueva de la Cadena. This epigean endemic species may be the ancestor of the above troglobites.

Class Aranea, Family Pisauridae, Subfamily Rhoicininae

New genus and species, troglobite

This spider is known only from unspecified deep, damp crevices or caves. It has only 6 unpigmented eyespots, while all mainland relatives have 8 eyes (Roth and Craig, in Leleup 1970).

Aranea, Family Prodidomidae (= Gnaphosidae)

New genus and species, troglobite

This blind and unpigmented spider (listed as *Lygromma* sp) is known only from unspecified deep, damp crevices or caves (Roth and Craig, in Leleup 1970).

It may be the species we found in Cueva de Bellavista no. 2 and Cuevas de Vargas.

Aranea, Family Theridiidae

Theridion sp., troglobite

This blind and unpigmented spider was mentioned from unspecified caves and deep, damp crevies (Roth and Craig, in Leleup 1970). We found this species in Cueva de Sra. Colombia, Cuevas de Cerro Banderas, Cueva de Tres Entradas, and Cueva de Cerro Banderas.

Aranea, Family Theridiidae

Theridion sp., troglophile

This eyed species was found in the entrance zone in Cueva 2 km S El Chato, and on Isabela in Cueva de Macas, and Cueva de la Cadena.

Aranea, Family Scytodidae

Scytodes sp., troglophile

This species occurs in cave entrances in Cuevas de Vargas, Cueva de Iguana, Cuevas de la Finca Kastdalen, and on Isabela in Cueva de Macas.

Aranea, Family Salticidae

Darwinneon crypticus Cutler, accidental

This endemic species was found in litter in the bottom of Cueva de Iguana at the Darwin Station. It is also known from upper Scalesia forest (Cutler 1971).

Aranea, other families, accidentals or troglophiles

Ischnothyreus sp. (Cuevas de Vargas); *Zosis geniculatus* (Cueva 2 km S. El Chato, Cueva de Iguana); *Philoponella* sp.? (Cueva de Macas); *Orchestina* sp. (Cueva Bella Vista no. 2); *Metepeira* sp. and *Argyrodes nephilae* (both in Cueva de Cadena).

Order Opiliones, Family Gonlyleptidae, subfamily Prostyginae

Galanomma microphthalma Juberthie, edaphophile, troglophile

This endemic genus and species of harvestman, with unusually small (regressed) and unpigmented eyes, is known from litter in a deep crevice near the Darwin Station, and other sites up to 700 m elev. The affinities are with south and Central America where 13 genera in the subfamily occur. The species is considered the most primitive in the family (Juberthie, in Leleup 1970). We found it in Cuevas de la Finca Kastdalen, Cuevas de Cerro Banderas, and Cuevita al Suroeste de Cerro Banderas.

Order Scorpiones, Family Vejovidae

Hadruroides lunatus Koch, troglophile

This scorpion was found in Cueva de la Cadena on Isabela. It is widespread in the islands.

Order Pseudoscorpiones, Family Chelonethidae

Morikavia albida Bier, edaphophile

This reduced-eyed species was found under rocks in a deep crevice in a cave entrance near the summit of Santa Cruz (Bier, in Leleup 1976).

Order Pseudoscorpiones, Family Chelonethidae

Pseudochthonius galapagensis Bier, edaphophile

This species has eyes reduced to only tiny pigmented specks, and was found in litter in a crevice 1 km from the beach of Tortuga Bay, and in debris in Cueva de Iguana (Bier, in Leleup 1976).

Order Pseudoscorpiones, Family Chelonethidae

Parachernes galapagensis Bier, edaphophile

This species has eyes reduced to indistinctive spots, and was found in litter at the base of a crevice 1 km from the beach of Tortuga Bay. A total of 18 species of Pseudoscorpions are now reported from the Galapagos (Bier, in Leleup 1976).

Class Diplopoda, Order Polydesmida, Family Paradoxosomatidae.

Oxidus gracilis (Koch) troglophile

This is a pan-tropical milliped, carried by commerce. It is known in caves in Jamaica, and was found in Cuevas de Finca Vargas, and elsewhere.

Class Diplopoda, Order Polydesmida, Family Pyrgodesmidae

New Genus and species, Edaphobite and troglophile

This tiny eyeless milliped was found in Cueva de Bellavista no. 2 and in forest soil outside of the cave. It may have been introduced in soil around plant roots.

Class Diplopoda, Order Polydesmida, Family Pyrgodesmidae

Nesodesmus insulanus Chamberlin, edaphobite

This eyeless milliped has been recorded only from Tower Island, but we found it in forest soil on Santa Cruz and Isabela, as well as in Cuevas de Finca Vargas, Cuevas de Cerro Banderas, Cuevita al Suroeste de Cerro Banderas, Cuevas de Finca Kastdalen, Cueva de Bellavista, and on Isabela in Cueva de Sucre.

Class Symphyla, Family Scutigerellidae

Hanseniella sp. edaphobite and (troglophile)

All symphylans are eyelees soil inhabitants. This genus is widely distributed in warm tropical regions and contains about 60 species. We found symphylans in Cueva de Bellavista no. 1 and no. 2, and in Cueva de Finca Vargas.

Hexapoda, Class Collembola, Order and Family undetermined.

Fourteen species of collembola have been found. on the Galapagos, and 4 were described as endemic (Jacquemart, in Leleup 1976). We found undetermined species in Cueva de Bellavista no. 1 and no. 2, Cuevita de los Cyatheas, and Cueva de Iguana.

Hexapoda, Class Diplura, Family Campodeidae

Lepidocampa zeteki Folsom, edaphobite and (troglophile)

Reported from Cueva Kubler (as an unnamed cave 3.5 km NW Puerto Ayora) and other Galapagos sites (Paclt, in Leleup 1976). We found it in Cueva de Bellavista no. 2, and on rat droppings in Cuevita al Suroeste de Cerro Banderas. This blind soil species is also known from many mainland Central and South American localities. It may have been carried by man.

Hexapoda, Class Diplura, Family Parajapygidae

Parajapyx isabellae (Grassi), edaphobite

This eyeless soil species is known from litter in *Scalesia* forests. The species is cosmopolitan and widespread in the United States (Reddell, 1983). It may have been introduced by man.

Department of Biology
Carleton University
Ottawa, Ontario Canada K1S 5B6
(613) 564-5560

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Preliminary summary of the subterranean Fauna of the Galapagos Islands, Ecuador. Part II. The insects, evolution, and biogeography

Stewart B. Peck and Jarmila Kukalova-Peck
Departments of Biology and Geology, Carleton University, Otawa, Canada.

RESUM

La fauna d'insectes de las cuevas i sol de les Galàpagos se sap que consta d'11 espècies troglòbies i edafòbies, 9 troglòfiles i 3 trogloxenes. Una anàlisi de la fauna d'invertebrats que viuen a les coves, sòl i aigües mostra que la ceguera ha estat desenvolupada in situ *des dels avantpassats amb ulls, però també que algunes de les espècies han d'ésser descendents d'avantpassats habitants del sòl que ja eren cecs quan varen arribar a les illes. Aquesta és almenys una excepció a la generalització de que la ceguera dels artròpods (edafòbis) del sòl tenen molt poca tendència a la dispersió, especialment cap a les illes tropicals de l'oceà.*

RESUMEN

Se sabe que la fauna de insectos de las cuevas y suelo de las Galápagos consta de 11 especies troglotas y edafobitas, 9 troglófilos i 3 trogloxenos. Un análisis de la fauna invertebrada de las cuevas, suelo y aguas subterráneas indica que la ceguera ha sido desarrollada in situ *desde los antepasados con ojos, pero que también algunas de las especies deben de ser descendientes de antepasados habitantes del suelo que ya eran ciegos cuando llegaron a las islas. Esta es al menos una excepción a la generalización de que la ceguera de los antrópodos (edajobios) tienen poca tendencia a la dispersión, especialmente hacia las islas tropicales del océano.*

SUMMARY

The cave and soil insect fauna of the Galapagos is now known to contain 11 troglobites and edaphobites, 9 troglophiles, and 3 trogloxene species. An analysis of the entire cave, soil, and groundwater invertebrate fauna indicates that eyelessness has developed in situ *from eyed ancestors, but also that some of the species must be descendants from ancestors which were already eyeless soil inhabitants when they reached the islands. This is at least an exception to the generalization that eyeless soil arthropods (edaphobites) are very poor dispersers, especially to tropical oceanic islands.*

Annotated faunal list of Insecta (s. str.)

Class Insecta, Order Thysanura, Family Nicoletiidae

Nicoletia meinerti Silvestri, edaphobite and troblophile

Found at baits in Cueva Bellavista no 2 as well as in soil and debris near Cueva Iguana. The species is widespread on the mainland of South America in Ecuador and elsewhere, inclunding west Africa, Hawaii, and the Marquesas Islands (Wygodzinsky, 1967). Its presence on the Galapagos is viewed as an introduction by man (Paclt, in Leleup 1976), but we think it is a native because we found it on Isla Española, which has never been colonized.

Class Insecta, Order Blatodea, Family Blateridae

Pycnoscelis surinamensis (Linn.), troglophile

Found in Cueva de Iguana, Cueva de Sra. Colombia, Cuevas de Finca Kastdalen, and Cueva de Bellavista no. 2. This is and introduced and parthenogenetic species, ocurring on many of the islands, and in many tropical caves.

Order Blatodea, Family Blattidae

Periplaneta americana (Linn.), troglophile

This roach was found in Cueva de Bellavista no 2, Cueva 2 km S El Chato, on Isabela in Cueva de la Cadena and on Floreana in Post Office Bay Cave. It is an introduced species, tropicopolitan in distribution, and a frequent cave inhabitant.

Order Blatodea, Family Blatellidae

Ischnoptera, new species, troglobite

This eyeless and depigmented roach is known only from Cueva de Bellavista no 2. The genus occurs in South America, and contains over 60 species.

Order Orthoptera, Family Gryllidae

New genus and species, troglobite?

This eyeless and depigmented cricket is known only from immatures collected in Cueva de Bellavista no. 2.

Order Orthoptera, Family Gryllidae

New genus and species, edaphobite?

This eyeless and depigmented species, seemingly closely related to the previous species, is known only from litter in the fern-sedge zone, Campanento de las Pumas, about 640 m elev., on the S slopes of Sierra Negra, Isabela.

Order Dermaptera, Family Carcinophoridae

Anophthalmolabis leleupi Bridle, edaphobite

This eyeless earwig is known only from soil and litter in Cueva de Iguana. The species seems most closely similar to *Anisolabis caeca* Borelli known from woil in Santa Fe Province, Argentina (Brindle, in Leleup 1968).

Anophthalmolabis n. sp., edaphobite

This eyeless earwig is known only from litter in the fern-sedge zone, Campanento de los Pumas, about 640 m elev., on the S slopes of Sierra Negra, Isabela.

Order Hemiptera, Family Veliidae

Microvelia ashlocki Polhemus, troglophile

Cueva de Iguana, on pool surfaces. Apterous and macropterous adults of this endemic species are known from surfaces of salt and freshwater pools and on pools in deep crevices on Santa Cruz, and Isla Darwin (Froeschner, 1985).

Order Hemiptera, Family Cydnidae

Dallasiellus murinus (Van Duzee), troglophile?

In soil in Cueva de Macas, Isabela. The species occurs on several islands and in mainland Ecuador, where it may be a recent introduction (Froeschner, 1985).

Order Hemiptera, Family Reduviidae, Subfamily Emesiinae

Ploiaria macrophthalma (Dohrn), troglophile

On dark overhanging rocks in Cueva de Iguana. The species is pantropical in distribution and occasionally occurs in caves (Froeschner, 1985).

Order Coleoptera, Family Carabidae, Tribe Anillini

Mystoceridius basilewskyi Reichardt, edaphobite

This very small, eyeless ground beetle is known from humus in a deep crevice at Tortuga Bay, and in *Scalesia* litter near Los Gemelos (Franz, 1978). It seems most close to *Rhegmatobius* of the Mediterranean region, but the South and Central American fauna of this tribe is poorly known (Reichardt, in Leleup 1970). The group occurs virtually worldwide but is scattered in distribution and all species, except some in New Zealand, are completely eyeless. They are presumed to have an extremely low vagility (Moore, 1980), but could be dispersed by man in soil around the roots of nursery stock and other plants. However, the occurrence near Tortuga Bay and in *Scalesia* forest, far removed from agricultural regions, does not suggest introduction of the species by man. Only three species in three genera of Anillines are known in South America, in Peru, Brazil, and Chile (Mateu, 1980).

Mystoceridius wittmeri Franz, edaphobite

Known only from near the spring on the Witrner farm in the highlands of isla Floreana (Franz, 1978).

Family Staphylinidae, Subfamily Staphylininae, Tribe Staphylinini

Belonuchus rufipennis Fabricius, troglophile?

Cueva de Bellavista no 1. The species is widespread in North, Central, and South America (Coiffait, 1981).

Family Staphylinidae, Subfamily Paederinae, Tribe Pinophilini

New genus and species, troglobite

Cueva de Bellavista no 2. This completely eyeless and long-legged, large staphylinid is known only from one male.

Order Coleoptera, Family Tenebrionidae

Ammophorus cavernicola Kaszab, edaphobite?

This small darkling beetle has eyes reduced to 3 facets, and was found under rocks on the summit crater near «Horse Cave». Ten species in the genus occur on the Galapagos, and several in coastal South America (Kaszab, in Leleup 1970; Van Dyke, 1953), and one has been introduced to Hawaii.

Menimopsis (Caecomenimopsis) leleupi Kaszab, edaphobite

This tiny eyeless darking beetle is known only from Santa Cruz under deeply buried stones in humid forest at 200 m, and we took it in Cueva de Iguana at banana baited pit traps. The genus is known to contain one other eyeless species from Iguazu, southern Brazil, and 3 others from the Caribbean islands of Jamaica and St. Vincent (Dajoz, 1975). The most closely related genera are eyeless or have small eyes, and occur in Mexico, Jamaica, Panama, and St. Vincent (Dajoz, 1975; Kaszab, 1977; Lawrence and Doyen, 1979).

Order Coleoptera, Family Curculionidae

Genus and species undetermined, troglophiles?

Litter and soil weevils were found in Cueva de Bellavista no 2, and Cueva de Iguana.

Order Diptera, Family Phoridae

Genus and species undetermined, troglophile

These flies were taken on baits in Cueva de Iguana, and Cueva de Bellavista no 1 and no 2. They are common in caves in many regions.

Order Diptera, Family Tipulidae

Limonia (Dicranomya) galapagoensis Alexander, trogloxene

This craneflies occur in large swarms in many moist caves and were collected in Cueva de Finca Vargas, Cuevas de Cerro Banderas, and in small caves near Puntudo in the Santa Cruz highlands. The species is an endemic.

Order Diptera, Family Drosophilidae

Drosophila (willistoni group) sp., trogloxene

Fruit flies were found in abundance at banana baits in Cueva de Iguana. Order Diptera, Family Sphaeroceridae

Genus and species undetermined, troglophile?

These flies, frequently common in caves, were found only in Cueva de Iguana. Four species are known from the islands.

Order Diptera, Family Sciaridae

Genus and species undetermined

These scavenging flies were on debris in Cueva de Bellavista no 1. Order Hymenoptera, Family Formicidae

Wasmannia auropunctata (Roger), trogloxene?

This introduced fire ant is abundant and dominant on some of the islands and is probably causing the elimination of much of the native soil and litter arthropod faunas (Clarck et al., 1982; Lubin, 1985). We found it entering caves via plant roots hanging from cave ceilings in Cueva de Bellavista no 2, and Cueva de Macas on Isabela.

Order Hymenoptera, Family Formicidae

Genus and species undetermined, trogloxene

These ants were foraging at the edge of the pool in the back end of Cueva de la Cadena, on Isabela.

Discussion

Comparison with Hawaii. Zimmerman (1944) indicated that an endemic soil insect fauna was absent in Hawaii, suggesting that it was because these organisms were poor disperses to oceanic islands. Certainly, the above lists show that there is an endemic, diverse, and highly evolved arthropod fauna in soil, litter, cave, and groundwater habitats in the Galapagos.

Earlier generalizations did not predict that cave faunas would commonly occur on oceanic islands or in tropical areas (Vandel, 1965). Howarth (1973) demonstrated the presence of a lave tube cave fauna in Hawaii (and that fauna has now grown to about

30 eyeless cave species), and Illiffe et al. (1984) have reported faunas of endemic cavernicolous marine invertebrates from flooded lava tubes in the Canary Islands. Parallels exist between the cave faunas of Hawaii and the Galapagos, in that both contain eyeless amphipods, isopods, spiders, pseudoscorpions, crickets, and earwigs, although these cave-soil invasions were independent and were accomplished by different ancestral groups on the two archipelagos. Differences also exist in that Hawaii has eyeless species of a terrestrial amphipod, collembola, and mesoveliid, reduviid, and cixiid bugs, while the Galapagos have an eyeless harvestman, cockroach, and staphylinid beetle. In the Galapagos some of these eyeless terrestrial taxa seem more eurytopic in that they were not found in one habitat only, but occur simultaneously in caves, soil, and/or deep litter.

Biogeographic implications. Rose (1975) offered a model in which the present Galapagos are the westerly part of an archipelago whose more easterly components formerly served as stepping stones for dispersal, and which have since subsided. This view would hold that the islands are not truly oceanic, and would allow up to 40 million years for the origin of the endemic species on them. The alternative and more orthodox view is that the islands have always been oceanic, were formerly more distant, and have come closer to South America as the Nazca plate (on which they ride), has been subducted under South America (Cox, in Bowman 1983).

Recent geological work indicates that the Galapagos have been available for colonization by terrestrial life for 3-4 million years (Bailey, 1976; Hall, 1983; Hickman and Lipps, 1985) and that they are about the same age as the Juan Fernandez Islands (compare Kuschel, 1963 with Stuessey et al., 1984). Within this period of time the fauna has arrived by four possible transport mechanisms as recognized by Zimmerman (1944) for Hawaii: 1) being carried by man; 2) through the air by winds; 3) through the aid organisms such as birds; and 4) over the sea by rafting or marine drift. Porter (1976) analyzed the origin of the Galapagos flora in these categories. Because of space limits, only the eyeless fauna is considered further. Conclusions about species may change as more information in learned about them.

1. Transport by man. Some widespread soil species such as the symphylan, diplurans, and a milliped may have reached the islands in soil around the roots of plants carried by man. These species are most common in soils in disturbed and colonized parts of the islands.

2 and 3. Aerial transport by birds and winds. Some invertebrates such as balooning spiders, may have used this mechanism, but there is little to suggest that this is common for soil and cave species. It is more likely that this was used for dispersal by their ancestors (see Howden, 1977).

4. Marine drift is a reasonable hypothesis for the arrival of the marine and brackish water crustaceans. It is also very likely for the terrestrial invertebrates, especially after one sees the great quantities of vegetation being rafted down the Guayas River and out to sea (at Guayaquil, Ecuador), and into the ocean currents which proceed directly NW to the Galapagos. Also, many large trunks, stumps and logs of forest trees are to be seen washed up on the eastern and souther shores of the islands. However, even though marine drift can transport arthropods, the colonists had to be able to withstand the usually harsh, hot, and arid conditons of the coastal zone of the islands. Eyeless soil faunas are generally though to be of low vagility or poor dispersers partly because they require the protection of their soil environment. Their presence in the Galapagos raises questions about the origins of Galapagos species.

Evolutionary implications. Eyelessness resulted as species adapted to cave and soil environments in organisms such as the shrimp, amphipod, spiders, harvestman, pseudoscorpions, roach, and staphylinid. Where more than one eyeless species is known, they may have descended convergently from a widespread eyed ancestor such as in the pholcid spiders, and perhaps the two crickets and earwigs. However, some of the eyeless species are in taxa with the closest phyletic ancestors occuring on the mainland which are also eyeless. Examples are a milliped, the thysanuran, and the carabid and tenebrionid beetles. The most parsimonious explanation for these is that they descended from eyeless mainland ancestors which dispersed to the islands in an already eyeless condition. That this has happened in the Galapagos should warn one that soil faunas may have more vagility than previously supposed, and their presence may not be proof of previous land bridges, or former continental connections.

Leleup (1965, 1968) suggested that the cryptic fauna may represent relictual faunal elements of ancient and otherwise extinct groups that colonized the Galapagos in the mid-Tertiary. We do not see clear evidence of this, although the relationships of some of the fauna are still obscure. Howarht (1982, 1983) suggests that the Hawaiian cave fauna represents another example of a rather rapid island adaptive radiation from a limited ancestral fauna. This may also be the case for the Galapagos. Both archipelagos lack the «pre-adapted» groups which seem to be ancestral to so much of continental cave faunas. The influence of Pleistocene climatic change as a mechanism promoting the occupation of subterranean environments is a strong component of evolutionary scenarios for continental cave faunas. From evidence in laked bed cores, the Galapagos are now known to also have climatic fluctuations in the late Pleistocene, and probably earlier (Colinvaux, 1972; Colinvaux and Schofield 1976a, 1976b).

Continued field work with cave and soil arthropods is planned in the Galapagos and it will be difficult and expensive, but there must yet remain many unknown taxa that will contribute to an understading of the evolution of this archipelago, and of cave, ground water, and soil arthropods in general.

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Hallazgo de una nueva colonia de hibernación para *Miniopterus schreibersi* en Cataluña

J. Serra-Cobo y A. Montori
Departamento de Zoología. Fac. de Biología. Barcelona.

RESUM

Des de l'any 1952 se sap que l'avenc del Daví allotja un important contingent de Miniopterus schreibersi, *procedent de diversos indrets de Catalunya i del sud de França (BALCELLS 1962, 1964; NADAL et al. 1968). Durant molt de temps aquesta cavitat ha constituït l'únic lloc d'hivernació massiva d'aquesta espècie. Malgrat tot, des del 1.983, hom va sospitar l'existència d'una nova població prou important situada més al sud. Tot i haver-se intensificat la prospecció, aquesta hipòtesi no s'ha pogut confirmar fins a finals de la tardor de 1.985.*

La troballa d'aquesta colònia té importants connotacions ecològiques i biològiques per a un millor coneixement del comportament de M. schreibersi *al N.E. i llevant espanyols.*

En aquesta comunicació s'exposaran les característiques d'aquesta nova població i de la cavitat que l'allotja, detallant, alhora, les nombroses repercussions i hipòtesis sorgides arran d'aquest descobriment.

RESUMEN

Desde 1952 se sabe que el Avenc del Daví alberga un importante contingente de *Miniopterus schreibersi* procedentes de distintas partes de Catalunya y del sur de Francia (BALCELLS 1962, 1964; NADAL et al. 1968). Durante mucho tiempo esta cavidad ha constituido la única cita de hibernación masiva de esta especie. No obstante desde 1983 se creyó en la existencia de otra población importante situada más al sur. A pesar de haber intensificado la prospección esta hipótesis no se ha podido confirmar hasta finales de otoño de 1985.

El hallazgo de esta colonia tiene importantes connotaciones ecológicas y biológicas para un mejor conocimiento del comportamiento de *M. schreibersi* en el NE y levante español.

En esta comunicación se expondrán las características de la nueva población encontrada y de la cavidad albergante, a la vez que se detallan las numerosas repercusiones e hipótesis que surgen a raíz de este descubrimiento.

SUMMARY

It has been known since 1952 that the cave called Avenc del Daví shelters a large group of *Miniopterus schreibersi* form different parts of Catalonia and the south of France (BALCELLS, 1962, 1964; NADAL et al., 1968). For a long time this was the only cavity known to be a mass hibernating roost for this species. In 1983, however, the existence of another large population farther south began to be suspected. But despite the intense search to locate it, this hypothesis could not be confirmed until the end of the 1985 autumn season.

The discovery of this colony has important ecological and biological implications for a better knowledge of the behaviour of *M. schreibersi* in the NE and eastern regions of Spain.

This paper presents the characteristics of the newly found population and of the cavity that shelters it, and reports the many repercussions and hypotheses that derive from this finding.

Introducción

Durante mucho tiempo el Avenc del Daví ha constituido la única localidad de hibernación importante para el murciélago de cueva *Miniopterus schreibersi* en el NE español, siendo objeto por ello, de un gran número de trabajos científicos entre los que destacan los estudios sobre las migraciones (BALCELLS 1954, 1956 b, 1959 b, 1962, 1964 a y b; HEYMER 1964; NADAL et al. 1968; GARGALLO 1970; VIVES, E. y M., 1978; SALVAYRE 1980 y BROS, MIRALLES y REAL, 1981). Dichas investigaciones aportaron abundante información sobre el comportamiento de esta especie en el sector NE de Cataluña y SE francés. Sin embargo, quedaba todavía un gran vacío prospectivo en el área meridional catalana. Así pues, en 1983 se empezó a prospectar el macizo tarraconense de la Mussara con la finalidad de hallar un nuevo refugio de hibernación, que paliase en parte esta laguna anteriormente comentada. Se escogió esta zona por su situación geográfica y sus características fisiográficas. No obstante, hasta diciembre de 1985 no se pudo verificar su existencia. El hallazgo de esta agrupación invernal posibilita efectuar numerosos estudios, al igual como sucedió en el avenc del Daví, que permitirán conocer mejor el comportamiento, la distribución, la biología y las preferencias ecológicas de *M. schreibersi*.

agradecemos la colaboración prestada por: Dr. E. BALCELLS

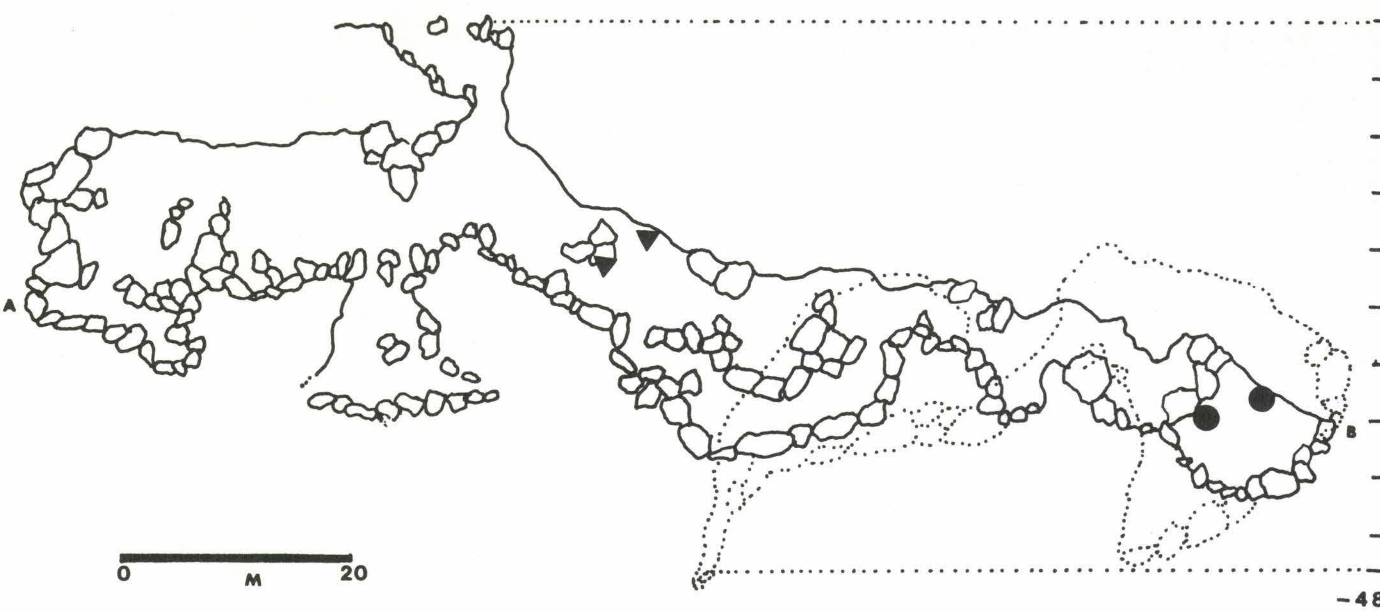

Fig. 1. Topografía del Avenc de Puig d'en Març (BORRAS, J., MIÑARRO, J.M. y TALAVERA, F., 1978) en la que se indica con un ▼ la situación de los Rhinolophus ferrum-equinum *y con una ● la colonia de* Miniopterus schreibersi.

R., N. MACH, J. F. GUASCH, F. PAUNÉ y a todos aquellos que han participado de una forma u otra en esta investigación.

Resultados

La sima se halla ubicada en el municipio de La Riba a 665 metros de altitud, en un terreno de calizas del Muschelkalk. El primer tramo de la cavidad está constituido por una rampa al final de la cual se encuentra un pozo de unos 12 metros de profundidad. Este desemboca en la galería principal que está muy dividida y accidentada debido a la presencia de una gran cantidad de bloques. La profundidad de la sima es de 48 metros y su recorrido de 235 metros (J. BORRAS, J. M. MIÑARRO y F. TALAVERA, 1978).

Se efectuaron tres visitas a esta cavidad: la primera el 1 de junio de 1985 en la que se observaron unos 35 *M. schreibersi* situados de forma dispersa, algunos de ellos estaban en estado de hibernación, y 2 *Rhinolophus ferrum-equinum;* la segunda prospección tuvo lugar el 8 de diciembre de 1985, encontrándose unos 40 *Rh. ferrum-equinum* en una sala contigua a la parte inferior del pozo de entrada y una colonia de 3.500 a 4.000 *M. schreibersi* distribuidos en tres agrupaciones separadas, en la zona más profunda de la sima (ver fig. 1); finalmente, la tercera prospección se efectuó el 12 de enero de 1986, observándose al igual que en la anterior, las agrupaciones de *Rh. ferrum-equinum* –unos 34 individuos– y las de *M. schreibersi* –aproximadamente el mismo número que en la visita anterior– (fig. 1). En esta última inspección se registró la temperatura y la humedad relativa de la sala de hibernación de los murciélagos de cueva, siendo de 9° C y del 91 % respectivamente. En las dos últimas campañas, se capturaron animales para poder obtener una muestra y estimar así el sex-ratio, la longitud del antebrazo y el peso poblacional.

Los resultados se resumen a continuación en las tablas I y II.

TABLA I

Tamaño de la muestra	126
N.º de machos	71
% de machos	56.35
N.º de hembras	55
% de hembras	43.65
Sex-ratio	1:0.77
Antebrazo: $\bar{x}$ = 46,31; S_x = 0.744; n = 100	
Peso: $\bar{x}$ = 15,1; S_x = 1.249; n = 99	

Tabla I. Resultados de la visita efectuada el 8 de diciembre de 1985 al Avenc de Puig d'en Març. Para estimar el sex-ratio se ha tomado una muestra de 126 ejemplares, mientras que para hallar la media y la dispersión del antebrazo y del peso se han controlado 100 y 99 animales respectivamente.

TABLA II

Tamaño de la muestra	455
N.º de machos	230
% de machos	50.55
N.º de hembras	225
% de hembras	49.45
Sex-ratio	1:0.98
Antebrazo: $\bar{x}$ = 46,42; S_x = 0,772; n = 58	

Tabla II. Resultados de la visita efectuada el 12 de enero de 1986 al Avenc de Puig d'en Març. Para estimar el sex-ratio se ha tomado una muestra de 455 individuos, mientras que para hallar la media y la dispersión del antebrazo se han controlado 58 ejemplares.

Se han comparado las longitudes del antebrazo y los pesos de las poblaciones del Avenc del Daví y del Avenc de Puig d'en Març, mediante la prueba estadística de la *D* de Student. El valor de D obtenido para el antebrazo, al comparar las muestras obtenidas el 15 de diciembre de 1984 en el Avenc del Daví y el 8 de diciembre de 1985 en la sima objeto del presente estudio, es de 0.710 con 236 grados de libertad, mientras que para el peso da un valor de *D* = 0.462 con 228 grados de libertad, habiéndose obtenido las muestras el 21 de noviembre de 1985 en el Avenc del Daví y el 18 de diciembre de 1985 en el Avenc de Puig d'en Març.

Discusión

Como ya se ha comentado anteriormente, el hallazgo de esta cavidad, situada en la parte meridional de Cataluña, tiene una gran importancia para el conocimiento de la actividad biológica y ecológica de *M. schreibersi* en el NE español y sur de Francia. El estudio de esta colonia invernal permitirá conocer las relaciones existentes con los otros refugios de hibernación (principalmente el Avenc del Daví y las cavidades del sur francés). También posibilitará obtener nueva información sobre el área de distribución del contingente de quirópteros del Avenc de Puig d'en Març durante el período no invernal. Así caben destacar las relaciones que tiene este refugio de invierno con el Avenc del Daví (situado en el macizo de Sant Llorenç del Munt cerca de Terrassa), no solamente por lo que hace referencia a las características de ambos biotopos (se comentarán más adelante), sino por el intercambio de animales entre las dos cavidades que se ha podido comprobar en distintas ocasiones mediante la técnica del anillamiento. El hallazgo del Avenc de Puig d'en Març ayuda a comprender mejor los movimientos migratorios hacia el sur desde la sima de Sant Llorenç del Munt y en general de los desplazamientos

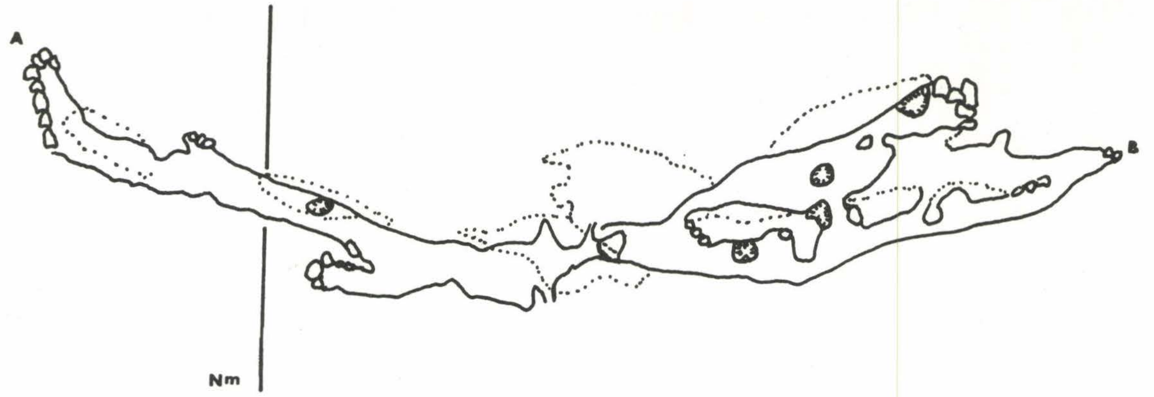

Fig. 2. Representación gráfica de la distribución poblacional y por sexos de las longitudes del antebrazo de los individuos del Avenc de Puig d'en Març.

que efectúa esta especie en la parte meridional de Cataluña, de los que hasta la fecha se tiene muy poca información. La intrínseca relación entre estos dos refugios de hibernación queda bien patente, al comprobar que uno de los murciélagos capturados el 8 de diciembre de 1985 en el Avenc de Puig d'en Març, fue visto el 15 de diciembre de 1985 en el Avenc del Daví.

Es probable que la migración entre estas dos cavidades se realice a través de la depresión del Penedés y no por la línea de costa a través del macizo del Garraf. Este hecho cabría atribuirlo al gran incremento de la actividad humana en la zona, su alteración y su excesiva sequedad, factores que probablemente actuarían de forma negativa en la utilización de este macizo como vía de paso o residencia.

Así pues, existe un intercambio de individuos anual, más o menos pequeño, entre los refugios de hibernación. Este hecho ya fue observado por BALCELLS (BALCELLS, 1962, 1964 y NADAL et al 1968) entre el Avenc del Daví y la cueva del sur francés de Fuillá. A la vista de estos resultados, cabe pensar que una pequeña parte de los murciélagos de cueva pude ir variando de residencia de invernación a lo largo de la costa mediterránea. En este sentido, el Avenc de Puig d'en Març podría tener conexión con poblaciones más sureñas (Castellón y Valencia). Hipótesis que se verificará en posteriores estudios.

Una parte de esta agrupación de invierno, probablemente migrará en primavera a través del valle del Francolí, hacia la Cataluña continental, remontando por los valles del Segre y las Nogueras hasta su residencia veraniega.

Cabe destacar la similitud existente entre las dos simas de hibernación conocidas en Cataluña, tanto a lo que se refiere a condiciones ambientales interiores, situación respecto al mar y localización de la sala de hibernación, como a las características de sus poblaciones de murciélagos. Así en ambas cavidades el lugar donde están aletargados los quirópteros, se halla en la parte más profunda de la cavidad, presentado una temperatura y humedad relativa parecida. Esta situación cabe atribuirla a dos factores: la búsqueda de un microclima constante (sobre todo por lo que hace referencia a la temperatura) y su ubicación en un lugar que ofrezca mayor seguridad.

Los resultados del test de la *D* de Student para comparar el peso y la longitud del antebrazo de los individuos que forman las colonias del Avenc del Daví y del Avenc de Puig d'en Març, muestran que entre estas dos poblaciones no hay diferencias significativas.

Otra característica coincidente entre ambas simas, es la presencia de *Rh. ferrum-equinum,* siendo mucho más numerosa la población de la cavidad tarraconense.

Por lo que hace referencia a las longitudes del antebrazo (fig. 2), se puede ver que existe un cierto desplazamiento hacia la derecha en la distribución de las hembras, lo cual indicaría que una parte de éstas tiene el antebrazo ligeramente mayor que los machos.

Finalmente cabe señalar, que el hallazgo de la colonia del Avenc de Puig d'en Març bifocaliza temporalmente el estudio de *M. schreibersi* en Cataluña y abre una amplia gama de posibilidades e hipótesis, así como sugerentes líneas de investigación.

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The Parietal Association in British Caves

G.T. Jefferson
Department of Zoology, University College, Cardiff, U.K.

RESUM

«L'associació parietal» (sensu *Jeanel) s'ha pogut estudiar en una sèrie de cavitats britàniques. Consisteix en una típica associació d'un cert nombre d'espècies, principalment artròpodes, amb les parets i sostres del vestíbuls de les cavitats, ja sia durant tot l'any o només estacionalment. Segons aquest criteri podem classificar-los, respectivament, com a troglòfils de vestíbul i trogloxens estacionals de vestíbul. El terme «subtroglòfil», aplicat algunes vegades als darrers creiem que és innecessari.*

Les associacions parietals es donen a moltes parts del món i les de la Gran Bretanya, si bé més restringides, són bastant semblants a les de l'Europa continental. Entre els seus membres permanents s'hi inclouen vàries aranyes, en les quals s'observa certa zonació. Les espècies estacionals són, en la seva gran majoria, dípters i lepidòpters hivernants, però els escassos visitants estiuencs posseeixen un tricòpter. Investigacions fetes a d'altres indrets han pogut demostrar que molts trogloxens estacionals sofreixen una diapausa fisiològica, que és també el que deu succeir, molt probablement, a la Gran Bretanya.

RESUMEN

La «Asociación Parietal» (sensu *Jeannel) se puede reconocer en cavidades británicas. Se trata de una característica asociación de un cierto número de especies, principalmente artrópodos, que se da en las paredes y techos de los vestíbulos de las cavidades, algunos durante todo el año pero otros sólo estacionalmente. Estos se pueden clasificar respectivamente como troglófilos de vestíbulo y trogloxenos estacionales de vestíbulo; el término «subtroglófilo» algunas veces aplicado a los últimos, es innecesario.*

Las asociaciones parietales se dan en muchas partes del mundo; y las de Gran Bretaña, aunque más restringidas, son similares a las de Europa continental. Sus miembros permanentes incluyen varias arañas, en las que se observa cierta zonación. Las especies estacionales son la mayoría dípteros y lepidópteros hibernantes pero los escasos visitantes del verano poseen un tricóptero. Investigadores de otras partes han demostrado que muchos trogloxenos estacionales sufren una diapausa fisiológica y es también lo que sucede muy probablemente en Gran Bretaña.

SUMMARY

A «Parietal Association» (sensu *Jeannel) can be recognized in British caves. It is a characteristic association of a number of species, mainly arthropods, occurring on the walls and roofs of cave thresholds, some throughout the year but others only seasonally. These can be classified respectively as threshold troglophiles and seasonal threshold trogloxenes; the term «sub-troglophile» sometimes applied to the latter is unnecessary.*

Parietal associations occur in many parts of the world; that in Britain, although more restricted, is similar to those of Continental Europe. Its permanent members include several spiders showing some measure of zonation. The seasonal species are mostly overwintering Diptera and Lepidoptera but the few summer visitors include a trichopteran. Workers elsewhere have shown that many seasonal trogloxenes undergo a physiological diapause and it seems likely that this is also the case in Britain.

Introduction

The «Parietal Association» is the name which was given by Jeannel (1926) to what he recognized as a characteristic association of species which could be seen on the walls and roofs of cave thresholds in France and other parts of continental Europe. Relatively few species make up the association but considerable numbers of individuals are often present. They are predominantly arthropods, indeed almost exclusively either insects or arachnids.

Although the parietal association is a characteristic one, it is not constant but changes seasonally because although some species remain permanently in the cave and can be considered to be threshold troglophiles, others are seasonal, spending either the summer or winter underground. Jeannel called these seasonal elements «regular trogloxenes», which indeed they are, but many subsequent authors have used the term «subtroglophile». Motas, Decou and Buyghele (1967), in their important paper on the parietal association in Rumania, give the history of this term «subtroglophile», which they also adopt, but there seems to be little justification for it. It can be argued (Hamilton-Smith, 1971) that the Schiner/Racovitza classification should not be applied to the threshold fauna, but if it is then the animals in question must be threshold trogloxenes; they cannot come into any category of troglophiles as they are incapable of completing their whole life cycle underground. They are in no sense partial nor even potential troglophiles and I shall refer to them as «seasonal threshold trogloxenes».

The threshold fauna, including the parietal fauna, has been extensively studied on the European continent; the pioneer work of Jeannel in France and Leruth (1939) in Belgium has been followed by a great number of publications from countries in both eastern and western Europe. In Britain, on the other hand, the threshold fauna has tended to be neglected and the concept of a parietal association has been virtually ignored until quite recently (Jefferson, 1981, 1982 & 1983). More has been done in America, and Graham (1966, 1968a & 1968b) has worked on a number of species belonging to what is clearly a parietal association-in fact he uses the term, although very infrequently.

When I started looking at the threshold fauna, it soon became apparent that Britain has a characteristic parietal fauna very similar to that found in continental Europe. Many of the species are the same, although a little fewer in number, and the nature of the association is similar.

Some elements of the association, particularly the Lepidoptera, had been noticed, and even studied, much earlier but with little appreciation of the significance of the association as a whole. An early observation of overwintering moths in a British cave was made in January 1934 when Tulloch (1935) and some other local naturalist visited a cave in South Wales. Much to his surprise considerable numbers of *Scoliopteryx libatrix* and *Triphosa dubitata* were seen and also «a large black bloated spider» presumably *Meta menardi*. He raised questions about how and why these two species of moths enter caves in such numbers but it was several decades before questions of this sort could be answered as a result of the work of people like Tercafs and Thinès (1972) and Bouvet *et al.* (1974).

The British Parietal Fauna

The list of species recorded from the walls and roofs of British caves is extensive but only those which consistently appear in some numbers can be assigned with confidence to the parietal association. These include the two moths, a trichopteran, a number of Diptera and several spiders; of these the spiders are threshold troglophiles and are therefore permanent members of the association but the moths, the trichopteran and most of the Diptera are seasonal trogloxenes.

The most numerous of the spiders are *Meta menardi* and *Meta merianae* but at least two others should probably also be included in the association; these are *Tegenaria silvestris* and *Nesticus cellulanus*. The spiders are, of course, predators and the stations they adopt in the cave show a fairly consistent zonation with *T. silverstris* just inside the entrance closely followed by *N. cellulanus* and then *M. merianae* and lastly *M. menardi* which sometimes extends into the dark zone. It is not clear what physical gradient or gradients control the zonation; light may well be important but there are other gradients in the threshold and there is the increasing constancy of all physical factors with distance from the entrance. Bourne (1976) has shown that in addition to variation in climatic conditions the configuration of the cave walls also affects the distribution of animals in the threshold.

The moths of the British parietal association are the two already mentioned, *Triphosa dubitata* and *Scoliopteryx libatrix*. They are seasonal trogloxenes spending the winter underground where the females undergo a reproductive diapause (Bouvet *et al.* 1974). In fact some can often be seen in caves over much of the year. It has often been noted that *Scoliopteryx* becomes very torpid when underground but *Triphosa* much less so and the latter may even copulate underground; I have seen this in the Mendip Hills in September and it has also been observed in October in Yorkshire (Dixon, 1974).

Most of the Trichoptera recorded from British caves are accidentals but there is one which can confidently be included in the parietal association as it consistently appears in situations where it could only have flown in as an adult; this is *Stenophylax permistus*, one of the small group of species represented in the continental parietal fauna. *Stenophylax* enters caves in the summer and aestivates there; presumably a reproductive diapause is involved as has been shown to occur in aestivating caddis flies on the Continent (Bouvet, 1975).

Diptera are the most numerous members of the parietal association both in numbers of individuals and of species. The common mosquito, *Culex pipiens pipiens*, is particularly interesting. It has been claimed (Roubaud, 1933) that this sub-species needs to undergo diapause in every third or fourth generation and certainly the autumn generation of adults enters caves in considerable numbers. In one case nine random one square metre quadrats of wall yielded counts of up to 90 with a mean of 42. The main flight into caves takes place in September or October and at these times bats can often be seen flying up and down the threshold, apparently feeding on the mosquitoes. I have examined large numbers of these overwintering individuals and all have been females; in Britain most have left their hibernation sites by the third week in April.

Several mycetophilid flies are trogloxenes and are represented in the parietal association. These include species of *Rymosia, Tarnania* and *Exechia* with *Rymosia fasciata* often being particularly numerous in the winter. The drone fly, *Eristalis tenax* (Syrphidae) also sometimes enters caves in some numbers and overwinters in crevices, usually quite close to the entrance.

The tipulid, *Limonia nubeculosa*, is another interesting dipteran which is part of the parietal association, not only in Britain but also in Europe and much of the United States (Graham, 1966). Matile (1970) quotes figures of 30 and up to 50 per square metre on cave walls in western France and comparable numbers occur as summer visitors in British caves. The function of the sojourn underground is not clear in the case of *L. nubeculosa;* it has even been suggested that perhaps they merely shelter in the cave during the day and emerge at night but it is odd that of all the British crane-flies this is the only one which seems to resort to caves at all consistently.

Another dipteran of the parietal association with a very wide geographical range is *Heleomyza serrata*. According to Leruth (1939) in Belgium they are summer visitors with only odd specimens being seen at other times, but in Britain they seem to be numerous thoughout the year in caves; both sexes are present and copulation has been observed. In view of all this it might be thought that *H. serrata* is a troglophile but this is very unlikely as only adults seem to occur underground. They are not confined to the parietal association and are sometimes seen in appreciable numbers far into the dark zone but only where the depth of overburden is not very great (Jefferson, 1981).

Discussion

It is remarkable that parietal associations of essentially similar composition should occur over such a wide area - in fact over much of the holarctic region. There are, of course, differences: there are rather more species in the European association than in the British and related species may replace each other in different parts of the region. The genus *Triphosa* is an example; in many parts of Europe two species occur in the parietal association, *T. dubitata* and in mountainous areas, *T. sabaudiata* but this latter species does not occur at all in Britain and in North America the genus is represented by another species, *T. haesitata* (Graham, 1968a & b). There are other differences in various parts of the holarctic region but nevertheless the essential similarity of the association over such a vast area is impressive.

The curious selectivity of the parietal association is also striking. Why do so relatively few species belonging to a number of quite distinct groups of insects so consistently and characteristically enter caves when numerous related and equally common species do not? There is also the question of what happens to seasonal trogloxenes having an obligate diapause in those parts of their areas of distribution where there are no caves. What alternative sheltered habitats do they use or can they dispense with hibernation or aestivation, and presumably therefore diapause, in parts of their range?

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Introducción a la Pteridoflora de las Simas Valencianas

Por Juan José Herrero-Borgoñón Pérez
Dpto. de Botánica, Facultad de Biología, Universidad de Valencia.
S.E.S. del Centre Excursionista de Valencia.

RESUM

Es presenten aquí els resultats d'un estudi realitzat sobre la pteridoflora recollida a l'entrada de vint-i-quatre avencs valencians, a l'interior dels quals s'han pogut identificar un total de deu espècies de falgueres. Algunes d'aquestes espècies és freqüent de trobar-les a l'interior dels avencs, mentre que d'altres hi són de forma accidental, destacant d'entre elles Asplenium scolopendrium, *que pot considerar-se com a espècie relicta en tota la zona llevantina. En el catàleg florístic es comenten alguns aspectes ecològics, corològics i biogeogràfics de les espècies trobades, incloent-se també la seva zonació vertical i profunditat a l'interior dels avencs estudiats.*

RESUMEN

Se presentan los resultados de un estudio realizado sobre la pteridoflora recogida en las entradas de venticuatro simas valencianas, en cuyo interior se han podido indentificar un total de diez especies de helechos. Algunas de estas especies aparecen con frecuencia en las simas, mientras que otras lo hacen de forma accidental, destacando Asplenium scolopendrium *que puede considerarse como especie relicta en toda la zona levantina. En el catálogo florístico se comentan algunos aspectos ecológicos, corológicos y biogeográficos de las especies encontradas, incluyéndose también su zonación vertical y profundidad en el interior de las simas estudiadas.*

SUMMARY

The results of a speleo-botanic study carried out about the pteridoflora collected in the entrances to twenty-four Valencian potholes are presented here; ten species of ferns have been identified in their interior. Some of these species appear frequently in the potholes whereas other species are accidental; show up Asplenium scolopendrium that we can consider as a relicit species in the Levant region. Some ecological, chorological, and biogeographical aspects of the found species are commented in the botanical inventory; their vertical zoning and depth in the interior of the studied potholes are also included.

Introducción

El descubrimiento causal, hace ya algunos años, del helecho Asplenium scolopendrium en una sima valenciana, nos movió a intentar conocer su distribución actual en la región de Valencia, en la que es poco frecuente, lo que motivó la visita a diversas cavidades valencianas.

La presente nota es el resultado de las observaciones realizadas en el transcurso de las visitas llevadas a cabo a diversas simas valencianas en busca de la citada especie.

Situación de las simas estudiadas

Se ha estudiado la pteridoflora existente en venticuatro simas de la región de Valencia y sus contornos. A continuación se especifica para cada una de ellas: su nombre, el término municipal en el que se encuentra, la altiutud s.n.m. de la boca, y la cuadrícula de 1 km. del retículo U.T.M. a la que pertenece.

Provincia de CASTELLON
1: Sima del Cinglo Partido (Puebla de Arenoso), 860 m., 30T YK 0342
2: Sima de la Pinosa (Fuente la Reina), 970 m., 30T YK 0335
3: Sima del Lentisco (El Toro), 1.270 m., 30S XK 8822
4: Sima de la Higuera (Caudiel), 930 m., 30S YK 0929

Provincia de VALENCIA
5: Sima de Mataja (Calles), 1.000 m., 30S XK 7705
6: Sima de Cuarte (Chulilla), 400 m., 30S XJ 8388
7: Sima de la Colomera (Bugarra), 270 m., 30S XJ 9286
8: Sima de las Palomas (Chiva), 900 m., 30S XJ 7978
9: Pozo del Moro (Camporrobles), 1.100m., 30S XJ 3792
10: Sima de la Fuente de la Mina n.º 2 (Cofrentes), 400 m., 30S XJ 6745, desarrollada en yesos
11: Sima del Aguila (Picasent), 200 m., 30S YJ 1257

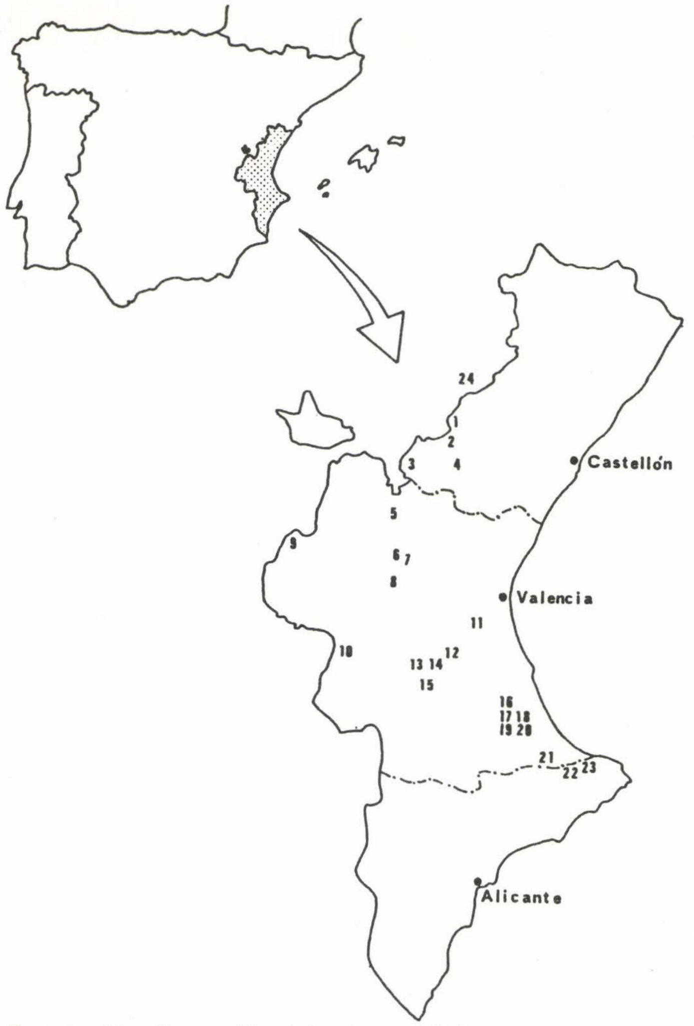

Figura 1 – Situación geográfica de las simas estudiadas

12: Sima del Infierno (Tous), 390 m., 30S YJ 0545
13: Sima de la Llenca del Serrano (Tous), 465 m., 30S YJ 0041
14: Sima del Campillo (Tous), 450 m., 30S YJ 0041
15: Sima de les Gralles (Tous), 290 m., 30S YJ 0133
16: Sima del Toro (Simat de Valldigna), 340 m., 30S YJ 3125
17: Sima Aldaia (Barx), 690 m., 30S YJ 3420
18: Avenc del Simarró (Barx), 690 m., 30S YJ 3420
19: Sima Pilar (Barx), 700 m., 30S YJ 3420
20: Sima Sancho (Pinet), 710 m., 30S YJ 3520
21: Sima Llengua Siervo (Villalonga), 485 m., 30S YJ 4105

Provincia de ALICANTE

22: Avenc Ample (Vall d'Ebo), 540 m., 30S YJ 4900
23: Avenc Estret (Vall d'Ebo), 550 m., 30S YJ 4901

Provincia de TERUEL

24: Sima de la Cespedosa (Linares de Mora), 1.680 m., 30T YK 0868

CATÁLOGO FLORÍSTICO

El catálogo se ha ordenado alfabeticamente para facilitar su consulta.

Adiantum capillus-veneris L.

Especie cosmopolita frecuente en el interior de las simas, situándose en puntos con goteo constante de agua y en paredes rezumantes.

A determinadas profundidades suele presentar fenómenos de enanismo como consecuencia de la escasez de luz, no sobrepasando en algunos casos los 4 cm. de longitud.

Asplenium ceterach L.

Especie mediterránea corriente en las rocas del karst, pudiendo considerar su presencia en el interior de las simas como poco frecuente debido a su carácter fotófilo.

Asplenium fontanum (L.) Bernh.

Especie centroeuropea-atlántica que crece sobre la tierra acumulada en grietas y pequeños salientes de las simas, en

Figura 2 – Catálogo de las especies de pteridófitos identificadas en el interior de las simas valencianas: se indica su frecuencua (F) e intervalo de profundidad (mínima y máxima profundidad, en metros, a que ha sido encontrada dicha especie) (I.P.) en las mismas, así como aquellas localidades en que la especie ha sido hallada fructificada (f).

	SIMAS																									
ESPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	F	I.P.
Adiatum capillus-veneris	5 7			11 25 f					12 16	11 19 f						9 16 f	10 15 f				2 f	44	8 18		9	2 44
Asplenium ceterach						7		0 2 f																	2	0 7
Asplenium fontanum	o 2															9 10 f	10 f			0 6	3			1 8 f	6	0 10
Asplenium onopteris																3,5									1	3,5
Asplenium petrarchae					0 3,5 f	0 7 f	40 f	28 29			0 5 f						7 f		0 4 f						7	0 40
Asplenium ruta-muraria													4									45 52			2	4 52
Asplenium scolopendrium				14 15 f					4,9 16 f						8		17 f	14 16 f			7,5 9,5	42 46 f	8 18 f		8	4.9 46
Asplenium trichomanes	5 7 f	0 8 f	0 5 f	2 14 f		7 f		3 29 f	3,5 9 f			1,5 6		3 f		9 16 f	7 15 f	12 f		0 6 f	7 11	0 52 f	8 20		16	0 52
Polypodium cambricum								0 12 f																	1	0 12
Selaginella denticulata																7									1	7

puntos no expuestos al sol, adquiriendo en algunas ocasiones gran desarrollo.

Asplenium onopteris L.

Especie mediterránea que aparece de forma accidental en las simas, alcanzando escasa profundidad en las mismas.

Asplenium petrarchae (Guérin) DC.

Especie mediterránea que elige para crecer en las simas los puntos más sombríos de éstas.

Asplenium ruta-muraria L.

Especie circumboreal que crece en los puntos de mayor humedad de las simas, alcanzando por lo general escaso desarrollo, sobre todo a determinadas profundidades.

Asplenium scolopendrium L.

Especie submediterránea que normalmente alcanza gran desarrollo (hasta 60 cm. de longuitud) en el interior de las escasas simas valencianas en que aparece, aunque en algunas de ellas, y en determinadas condiciones ecológicas, presenta fenómenos de enanismo (como en el Pozo del Moro, en el Avenc Ample, y en la Sima Llengua Siervo).

Si bien esta especie ya fue citada hace tiempo por CAVANILLES en la Tinança de Benifassá (Castellón) y en la Sierra de Aitana (Alicante), estas citas no han podido ser confirmadas en visitas posteriores a dichas zonas; por lo que las únicas localidades conocidas en la actualidad en la región valenciana corresponden a las ocho simas aquí citadas, junto con la cita correspondiente a la Cova de los Calaveres (Benidoleig, Alicante), en cuyo tramo turístico también ha sido hallada esta especie junto con *Asplenium sagittatum* (DC.) Bange (HERRERO BORGOÑON & MATEO 1984).

Asplenium trichomanes L. subsp. *quadrivalens* Meyer

Figura 3– Area de distribución de Asplenium scolopendrium *L. en la región valenciana: △ antiguas citas de Cavanilles, ● citas en medio cavernícola, □ localidades en que aparecen en el exterior.*

Especies cosmopolita muy frecuente en el interior de las simas, donde puede alcanzar gran desarrollo (hasta 30 cm. de longuitud). Es el helecho más común en las simas valencianas.

Polypodium cambricum L.

Especie submediterránea poco frecuente en las simas valencianas, donde puede alcanzar un buen desarrollo (algunos ejemplares sobrepasan los 40 cm. de longitud).

Selaginella denticulata (L.) Link

Especie mediterránea poco frecuente en el interior de las simas valencianas, donde crece en pequeños entrantes terrosos de las paredes.

Conclusiones

Se puede indicar la presencia en el interior de las veinticuatro simas estudiadas de un total de diez especies de helechos.

La pteridoflora encontrada en las simas valencianas es claramente mediterránea, puesto que este elemento biogeográfico representa el 60 % de la flora recolectada.

Por otro lado, las especies encontradas en las simas valencianas coinciden en un alto porcentaje con las encontradas en las simas baleares (MAHEU 1912, LLORENS 1972, GINES 1983) y catalanas (MAHEU 1909 y 1912, UBACH 1974), siendo estas simas españolas las únicas de las que se dispone de alguna información sobre la pteridoflora que las puebla.

En base a los datos obtenidos hasta ahora, podemos distinguir la siguiente zonación o estratificación vertical de la pteridoflora en el interior de las simas valencianas, a partir del límite exterior de sus bocas:

– Zona externa o de entrada, donde junto a algunos arbustos y lianas aparecen, en lugares bien iluminados, *Asplenium ceterach, Polypodium cambricum, Asplenium onopteris, y Selaginella denticulata.*

– Zona inmediata a la entrada, con una iluminación indirecta aún intensa, y donde alcanza su óptimo la vegetación pteridofítica; en ella aparecen *Asplenium petrarchae, Asplenium fontanum, Asplenium ruta-muraria,* e incluso pueden aparecer *Adiantum capillus-veneris, Asplenium scolopendrium* (sólo en las simas más húmedas), y *Asplenium trichomanes* subsp. *quadrivalens.*

– Zona de transición o intermedia, menos iluminada, donde junto a los últimos espermatófitos (como *Hedera helix* L.) y algunos pteridófitos (como *Adiantum capillus-veneris, Asplenium scolopendrium,* y *Asplenium trichomanes* subsp. *quadrivalens* especialmente), los briófitos esciófilos alcanzan su óptimo gracias a la humedad reinante.

– Zona interna, que comprende los últimos niveles de iluminación compatibles con la fotosíntesis y donde junto a diversas especies de Cianofíceas los últimos briófitos, los mas resistentes a la escasez de luz, entre crecen los que pueden mezclarse protalos de los pteridóficos que crecen en la zona intermedia.

Desde el punto de vista corológico, y en base a los mapas de distribución consultados, actualmente podemos considerar la especie *Asplenium scolopendrium* L. como relicta en el territorio centro-oriental ibérico, ya que aparece solamente en el interior de algunas simas y cuevas (HERRERO-BORGOÑON & MATEO 1984).

Agradecimiento

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A Proposal to Abandon the Schiner-Racovitza Clasiffication for Animals found in Caves

Philip Chapman
City Museum & Art Gallery, Queens Road, Bristol

RESUM

El sistema de Schiner-Racovitza és àmpliament utilitzat pels biospeleòlegs per a distingir tres categories ecològiques dins les cavitats, com si les coves constituïssin una unitat ecològica. Però no és així.

La gran diversitat dels hàbitats d'aigua dolça i salada que s'ha pogut constatar en les cavitats de tot el món tenen en comú un sol tret de profund significat biològic que fa referència als animals que hi habiten, això és, l'absència de llum. Podria ésser convenient, per a classificar totes les espècies lliures que afronten els problemes biològics que suposa la vida en l'obscuritat perpètua, clarificar un xic els termes que hom utilitza normalment a l'hora de referir-se a aquestes espècies. Es tractaria de centrar l'interès de las investigacions en la manera com aquests problemes han estat superats per una sèrie d'organismes que viuen en hàbitats diversos. Jo proposo el terme «estigícola» (= habitant de l'obscuritat) per als animals que viuen en hàbitats sense llum, incloent-hi les cavitats, i «estigoxens» (= visitants de l'obscuritat) per a designar les espècies que efectuen visites periòdiques a aquests hàbitats esmentats. Aquests termes haurien de substituir els de «troglobis», «troglòfils» i «trogloxens» per dues raons d'índole pràctica:

1) La distinció entre «troglòfil» i «troglobi» pot fer-se tant poques vegades de forma empírica que resulta d'un valor pràctic escàs.
2) Aquests termes no es poden fer extensius a la fauna del SUC, a les aigües hiporreiques i a d'altres hàbitats mancats de llum fora de les coves, tots ells de gran interès per als biospeleòlegs.

RESUMEN

El sistema de Schiner-Racovitza es ampliamente utilizado por los bio-espeleólogos para distinguir tres categorías ecológicas en las cavidades, como si las cuevas formasen una entidad ecológica. Pero no es así.

La vastísima serie de hábitats en agua dulce y salada encontrada en cavidades por todo el mundo, comparten un solo rasgo de profundo significado biológico para los animales que allí habitan. Este es, la ausencia de luz. Podría ser conveniente, para clasificar todas las especies libres, que afrontan los problemas biológicos comunes que supone la vida en las oscuridad perpétua, para que el foco de interés de la investigación del modo en que estos problemas han sido superados por una serie de organismos en una serie de hábitats. Yo propongo el término «estigícola» (= habitante de la oscuridad) para animales libres que viven en hábitats oscuros, incluyendo cavidades, y «estigoxenos» (= visitantes de la oscuridad) para especies que hacen visitas periódicas a semejantes hábitats. Estos términos deberían reemplazar «troglobios», «troglófilos» y «trogloxenos» por dos razones prácticas:

1) La distinción entre «troglófilo» y «troglobio» puede hacerse tan escasas veces de forma empírica, que resulta de escaso valor práctico.
2) Estos términos no se pueden acondicionar a las faunas del SUC, aguas hiporreicas y otros hábitats oscuros fuera de las cuevas, de profundo interés para los bioespeleólogos.

SUMMARY

The Schiner-Racovitza system is widely used by cave biologists to distinguish three categories of ecological dependence on caves, as if caves formed an ecological entity. They do not.

The enormously wide range of terrestrial, freshwater and saltwater habitats found in caves worldwide, share just one feature of profound biological significance for the animals which inhabit them. It is the absence of light. It may be convenient to class together all free-living species which face the common biological problems posed by life in perpetual darkness, in order to focus research interest on how those problems have been overcome in a range of organisms, in a range of habitats. I propose the term «stygicole» (= dark-dweller) for free-living animals which inhabit perpetually dark habitats, including caves, and «stygoxene» (= dark-visitor) for species which make recurrent visits to such habitats. These terms should replace «troglobite», «troglophile» and «trogloxene», for two practical reasons:

1) The distinction between «troglophile» and «troglobite» can so seldom be made empirically, that it is of little practical value anyway.
2) These terms cannot accommodate the faunas of the SUC, hyporheic waters and other dark, non-cave habitats of profound interest to biospeleologists.

Armand Viré (1904) proposed the term «biospéologie» to refer to the study of subterranean life. For Vandel (1965) the subterranean environment encompassed soils, air-filled natural and artificial spaces in rocks and soils (including tombs), underground streams, springs, ground waters both in rocks and unconsolidated sediments and possibly spaces within deep leaf litter and beneath carpets of moss. Until recently, most biospeleologists have studied just one part of this subterranean environment: the enterable, air-filled parts of natural caves in limenstone rocks of temperate latitudes. The system originally proposed by Schiner (1854) and supplemented by Racovitza (1907), (the Schiner-Racovitza system), is widely used to categorize the fauna of caves. In this basic form, it recognizes 3 ecological categories: a) **troglobites** obligate cave species that are unable to survive outside of caves; b) **troglophiles,** facultative species that live and reproduce in caves, but are also found in similar, dark, humid, non-cave microhabitats; and c) **trogloxenes,** species that regularly inhabit caves for refuge but normally return to the surface environment to feed. These categories were of use so long as biospeleologists agreed how to distinguish between «caves» and «non-cave» habitats. Unfortunately, over the last 20 years there seems to have been progressively less agreement among authors over what precisely is meant by «caves» or «cave habitats». Glennie (1965), for example, took «caves» to include all habitats which occur within the «hypogean domain», tha is dark, air-or water-filled voids in rocks beneath and excluding the soil, other surface-deposited sediments and the limits of penetration of tree roots. Howarth (1973, 1981), on the other hand, stressed the importance of tree roots as a source of food in the Hawaiian caves, and the importance of water-borne soil and plant detritus in the nutrition of cavernicoles is now well known. Juberthie and Delay (1981) have described a «Superficial Underground Compartment» (SUC) which is populated by a fauna distinct from, but containing elements, of, the local cave fauna.

Size of cavity might be thought to be of crucial importance in defining cave habitats. Howarth (1983) distinguishes three biologically significant size classes of air-filled subterranean cavities: macrocavernous (> 20 cm), mesocavernous (0.1 – 20 cm), and microcavernous (> 0.1 cm). The first will admit large vertebrates (including some biospeleologists), the second is characterized by a microclimate favourable for cavernicolous arthropods, the third is too small to admit most of these and is characteristic of soils. The mesocavernous habitat is well represented in limestone terrains as well as in lava flows, but not only in the hypogean realm. The surface of tropical montane karst is often a jumble of fretted boulders and deep interconnected cracks overlain by a blanket of moss and other vegetation. This dark, non-cave habitat of mesocavernous dimensions must provide an enormous habitable space with an almost unknown fauna. Similarly, animal burrows in soil, spaces in talus, and deep moss carpets and leaf litter all provide habitats of mesocavernous dimensions.

It might be argued that an important feature which sets apart caves from other subterranean habitats is their persistence over long time periods. However, in geological terms, caves are ephemeral, particularly in the tropics, and other subterranean non-cave habitats such as soils and interstitial waters in riverine gravels may persist locally for longer time-spans.

Neither can cave habitats be defined according to available food type or its quantity. Whilst green plants are obviously unable to photosynthesize in the darkness of the cave, photosynthetic products may be available to cavernicoles via plant roots and as fresh plant detritus, etiolated seedlings, etc., and some primary food production is almost certainly carried out in caves by chemoautotrophic bacteria (Jefferson, 1969). Almost any food type which occurs in dark, non-cave habitats will also be available to some cavernicoles from time to time, and while many caves are food-poor, tropical guano caves clearly are not (e.g. see Hill, 1969). Sket (1981) has sought to define caves as spacious yet closed life spaces which have a small energy content and a scarcity of inhabitants, but this is unhelpful as many caves contain areas rich in food, as well as food-poor areas, and food supply may vary seasonally, being poor at times, rich at other times. Besides, any cave which is a «closed life space» will not have a fauna at all.

The «deep-cave» environment (Barr, 1968), is generally subject to less temperature fluctuation than other habitats which receive direct solar irradiation or which are not surrounded by the immense heat-sink represented by thick rock walls. However, cave passages which are traversed by winds, and rock-crevices of the SUC, experience microclimate variations which clearly affect their faunes (Howarth, 1980; Chapman, 1982). Howarth (1980) has argued strongly that saturated, or near-saturated atmosphere is a characteristic of the terrestrial «deep cave» microhabitat, but it would be quite arbitrary to confine a definition of terrestrial cave habitats to those portions which have a relative humidity above a certain value, besides which many clearly noncave habitats, such deep moss carpets, spaces within deep leaflitter and soil may share this microclimate characteristic.

Finally, we come to light. We may distinguish between the «cave threshold» (within the limit of light penetration) and the «cave dark zone» (beyond the limit of light penetration), but as inhabited spaces in unconsolidated riverine sediments or soils, the SUC, deep ocean trenches and even parts of animal burrows may all be in total darkness, this parameter on its own is also of little use in distinguishing hypogean habitats from other subterranean, or simply dark, habitats. However it is an easily measured, discontinuous variable (dark = no light!) of obvious biological importance which can be used to distinguish a group of habitats whose faunas share the common problems of life in darkness.

To summarise thus far: the various habitats within the «hypogean realm», other subterranean habitats and other perpetually dark habitats intergrade in most characteristics to such an extent that **no clear-cut biologically meaningful distinction can be made between perpetually dark «cave habitats» and other perpetually dar non-cave habitats.**

So how are we to distinguish between «troglophiles» (= facultative cave-dwellers) and «troglobites» (= obligate cave dwellers)? Again, the answer is that it is clearly arbitrary to do so in many cases, and indeed, authors such as Barr (1968) have advised dual classification of some cave-frequenting species as: «troglobite-edaphobite» or «troglobite-phreatobite». This would seem unduly clumsy. If a cave-frequenting species is **principally** found in phreatic waters, why not simply call it a «phreatobite»? Because of the difficulty in determining the distributions of cavernicoles in other (non-cave) subterranean habitats, troglobitism is usually inferred from the degree of eye and pigment regression, or pronounced hypertrophy of appendages or sensory apparatus, or «relictualness» (= isolation from other close living relatives). The *de facto* definition of a troglobite might be expressed thus: **a cave species that is unable to survive outside of caves and that has undergone such a long period of genetic isolation in caves that it shows troglomorphic features to a degree well beyond that of other, non-troblobitic members of its taxocene.** Christiansen (1962) has indeed proposed a definition of this sort. However it is obviously quite arbitrary to choose a particular point along the continuum of troglomorphic evolution and to state «troglobitism starts here»!

It is traditional in the literature to define eyed, pigmented species which live and breed in caves and are not know to live and breed outside of caves, as troglophiles. It is assumed, usually in the absence of any substantiating evidence, that such species have not become eyeless and depigmented owing to gene swamping from the portion of their population which occupies «non-cave» habitats, and that if this latter portion of the population were to disappear, eye and pigment loss would surely follow in time. Indeed, «time» has become an unofficial parameter in working definitions of «troglobite» by modern biospeleologists. In common with other authors, I have followed this tradition by categorizing a large proportion of the faunas of newly-discovered tropical caves as «troglophiles» (e.g. Chapman, 1980; 1984), on the morphological grounds that they retained eyes and pigment, though often in reduced form. I have done this simply because there is very little data on the fauna present at «ground level» on the spectacularly eroded karst overlying the caves, or on the epigean relatives of the cavernicoles, nor is such information likely to become available for many years. The fauna of tropical caves is much more amenable to study in many cases than is the adjacent surface fauna, particularly in mountainous areas.

Culver (1982), writing about temperate American caves, states that many «troglophiles» are classified as such «... only because they show little sign of regressive evolution. Other troglophiles have no surface populations near cave populations. For example, *Gyrinophilus porphyriticus* is common in caves in the upper Powell Valley in Virginia and Tennessee, but no surface populations are known from this area. It is very rare to find a population of any cave organism that extends from the surface directly into the cave. In most cases it is unlikely that gene flow is retarding adaptation. It is likely that what we called troglophiles have been in caves for a shorter period of time than what we call troglobites, if only because troglophiles show less regressive evolution... Nonetheless, by any measure available, many troglophiles are very successful in caves».

The assumption that troglomorphic features indicate troglobitism and that absence of clear troglomorphic features indicates nontroglobitism is too often perpetuated by taxonomic specialists who describe new taxa without the benefit of detailed distributional data. An illustrative example occurs in caves of the Gunung Mulu National Park, Sarawak, where the eyeless, white potamid crab *Cerberusa caeca* appears to be more «cave specialized» than is its eyed and pigmented cousin *Cerberusa tipula*. The former was described as a troglobite and the latter as a troglophile (Holthuis, 1979). By «cave specialized» I mean only that *C.caeca* would presumably perish more quickly outside the cave because it has no protection against solar radiation and no means to see approaching danger and so take cover. Actually there is no evidence at all that either species ever occurs outside caves, or that the possession of eyes and pigment puts *C.tipula* at any disadvantage over the eyeless, white *C. caeca* in the darkness of the cave. The two species seldom share the same pools and *C.tipula* is found closer to the cave entrance than is *C.caeca* and may therefore need eyes and pigment during forays into the cave threshold. Does this imply that *C.caeca* is more «cave-adapted», or that it is a more ancient cave-dweller? There is no evidence either way. All we can deduce is that these two species probably have slightly different ecological requirements – they occupy different niches in the cave community. It is quite possible that they have evolved along different routes over a similar time period.

Hamilton-Smith (1971) addressed the problem of how to distinguish troglomosphic «troglobites» from non-troglomorphic species known only from caves. His solution was to retain the «troglobite» category for the former, and to place the latter in a sub-class of troglophiles which he called «second-level troglophiles». However, he was forced to treat as a separate category obligate parasites which are known only from caves, but which are adapted to their host, rather than to the cave environment, and so cannot be judged by the criterion of how «cave-adapted» they are. This seems to me to be an unsatisfactory solution for three reasons: 1) it perpetuates the mixing of ecological and evolutionary criteria and so presupposes that certain troglomorphic characteristics are the only valid indication of specialization to a hypogean niche, 2) it is more complicated than the system it replaces, and 3) it suffers from all the problems posed by the lack of data on the distributions of most cavernicoles. Not surprisingly, the system has attracted few adherents.

A further problem with the Schiner-Racovitza classification system concerns the ecological category «trogloxene». The modern usage of «trogloxene» for species that regularly inhabit caves for refuge, but normally return to the surface to feed (Howarth, 1983) does not apply to those species which live outside caves and enter them to feed on trogloxenes, guanobia, or to make up dietary deficiences (Chapman, 1985; Redmond, 1981). I have used the term «visitors» for such species (Chapman, 1984, 1985). A more fundamental criticism of the Schiner-Racovitza system is that, in order to be consistent, it should make a distinction between facultative and obligate trogloxenes, as it does between facultative and obligate cavernicoles. Facultative trogloxenes are species some of whose individuals or populations use caves as a convenient roost or shelter. However there are other species which appear to be unable to survive permanently away from caves. Examples would be the crickets *Hadenoecus subterraneus* in Kentucky caves (Barr and Kuehne, 1971) and *Dolichopoda* spp. in European caves (Vandel, 1965), or the swiftlet *Aerodramus vanikorensis* in Sarawak (Chapman, 1985). Species within the genus *Aerodramus* have probably evolved echolocation as a means of orientating in the dark interiors of caves, and are thus cave-evolved trogloxenes! The nest structure of *A.vanikorensis* has become cave-adapted and the species reproductive performance is likely to be disastrous outside of caves, so that predation on eggs and chicks probably now obliges it to nest in the remote parts of caves.

Troglomorphic species feature prominently in limestone caves in cool climates (temperate latitudes and at hight altitude in the tropics, but are less frequent in caves of the lowland tropics. However, lowland tropical caves contain rich, complex faunal associations which have a characteristic composition (Brignoli, 1981) and are presumably well adapted to cave life. It is unfortunate that the discipline of biospeleology should have been moulded by studies of temperate cave faunas, so that only those characteristics typical of K-selected temperate troglomorphs are considered as being admissible evidence of cave-specialization. It is possible that «temperate» troglomorphic features may not be adaptive for many lowland tropical cavernicoles, so that it may be inappropriate to define tropical «troglobites» using «temperate criteria». Indeed, while guano-associated species have been debarred from «troglobite» status by most «temperate biospeleologists», Decou (1981) reports that many guanobious species in Cuban caves are obligate cavernicoles, equivalent to temperate «troglobites».

Since the distinction between «troglophile» and «troglobite» clearly cannot be made empirically at present in the majority of cases and as the wide range of terrestrial and aquatic cave, and dark non-cave, habitats intergrade in most characteristics, it seems to me that the Schiner-Racovitza system has outlived its usefulness and should be dropped forthwith. The abandonment of the notion of a «cave environment» and of «troglobites» might lead to more interest among biospeleologists in those adaptive characteristics of physiology and behaviour shown by organisms from a wide range of ecotypes which share the common problems posed by life in perpetual darkness.

It is premature to replace the Schiner-Racovitza system with a new set of generalized ecological categories. We do not yet know what causes the evolutionary trends towards gigantism, depigmentation, eye-reduction or attenuation of appendages seen in some (but not all) inhabitants of some (but not all) cave, or cave-like, perpetually dark habitats. I propose that until sufficient empirical data are available on which to base biologically meaningful categories, biospeleologists should classify subterranean animals according to the particular microhabitat they are known to mainly frequent and to which they are likely to be specialized. Thus «edaphobite», «humicole», «muscicole», «myrmecophile», «termitophile», «pholeophile», «phreatobite», «guanobite», etc., all convey useful information and should be used in place of «troglobite», «troglophile» or «trogloxene». Indeed, it might be useful to coin some more terms to describe species characteristic of the «hyporheic biotope» (e.g. see Stanford and Gaufin, 1974), «anchialine habitats» (e.g. see Holthuis, 1973), «mesocavernous habitats» (Howarth, 1983) perhaps including those of the «Superficial Underground Compartment» (Juberthie and Delay, 1981), and of dark «macrocavernous habitats» (Howarth, 1983). The latter might be termed «cavernicoles», in this restricted sense!

Cavernicoles which display morphological features which are considered to indicate adaptation to their cave environment may be described as «troglomorphic» cavernicoles, or «troglomorphs» (Howarth, 1982), but it should not be assumed that «nontroglomorphs» are not specialized for cave life!

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Nota sobre la distribución espacial de quirópteros cavernícolas de Galicia durante el reposo

José Guitián
Joaquín Giménez
Federación Gallega Espeleología, Sección de Bioespeleología.

RESUM

Aquest article tracta dels resultats obtinguts d'un estudi sobre 2.149 localitzacions de 4 espècies de rat-penats (Chiroptera) de vàries cavitats naturals de Galícia (nord-oest d'Espanya).

Es va estudiar cadascuna de les 4 espècies per separat i s'efectuaren dues valoracions diferents: la distància des del lloc on es trobaven els rat-penats fins a l'entrada de la cavitat i també fins al fons.

Per a cada espècie els resultats foren els següents:

«Rhinolophus ferrum-equinum»	19,00	15,66 DT	&	2,01	1,85 M.
«Rhinolophus hipposideros»	23,68	33,69 DT	&	0,80	0,58 m.
«Plecotus spp»	15,50	8,34 DT	&	1,43	0,63 m.
«Miniopterus schreibersii»	77,72	31,46 DT	&	11,12	4,65 m.

Finalment, s'analitzen els resultats obtinguts, segons les característiques de les cavitats.

RESUMEN

La nota muestra los resultados obtenidos con la localización de 2194 individuos de 4 especies de murciélagos (Chiroptera) en 46 cavidades naturales de Galicia (NO España). Se han tomado dos tipos de medidas para cada individuo localizado: distancia a la entrada de la cavidad y altura sobre el suelo. Los resultados obtenidos fueron los siguientes:

«Rhinolophus ferrum-equinum»	19,00	15,66 DT	y	2,01	1,85
«Rhinolophus hipposideros»	23,68	33,69 DT	y	0,80	0,58 m.
«Plecotus spp»	15,50	8,34 DT	y	1,43	0,63 m.
«Miniopterus schreibersii»	77,72	31,46 DT	y	11,12	4,65 m.

Se discuten los resultados de acuerdo con las características de las cavidades en esta parte de España.

SUMMARY

This article is about the results obteined in a study over 2194 locations of 4 species of bats (Chiroptera) in several natural caves of Galicia (North-Western Spain).

Each one of the 4 species was studied separately, and two different measures were made: the distance from the bat' site to the cave entrance and also the distance to the cave ground.

For every one of them the results were as it follows;

«Rhinolophus ferrum-equinum»	19,00	15,66 DT	&	2,01	1,85
«Rhinolophus hipposideros»	23,68	33,69 DT	&	0,80	0,58 m.
«Plecotus spp»	15,50	8,34 DT	&	1,43	0,63 m.
«Miniopterus schreibersii»	77,72	31,46 DT	&	11,12	4,65 m.

Finally, the different results obteined, according to the characteristics of the caves are discused.

Introducción

El reparto interespecífico de los recursos en el seno de comunidades de Quirópteros, está basado en diferencias en las características del vuelo (FENTON, 1972), modos de alimentarse (KUNZ, 1973) y tamaños de presa (BLACK, 1972; ver también FINDLEY, 1976). En esta nota ensayamos la significación de las diferencias en la localización espacial durante el descanso, básicamente invernal, dentro de las especies más importantes de la comunidad de murciélagos cavernícolas del N.O. Ibérico. Aunque esta variable probablemente no puede compararse en importancia a las formas de acceder a los recursos tróficos, tiene especial interés para diferenciar el comportamiento de las distintas especies durante el período en el que permanecen en reposo.

Material y métodos

Durante el período 1982 a 1984, se han realizado 68 visitas a 46 cavidades naturales de Galicia. Las visitas corresponden a las 4 comarcas de esta región que poseen afloramientos calizos de importancia: Valdeorras (Ourense), Caurel y Louzara, Triacastela y Mondoñedo (Lugo). Los datos de localización corresponden a distintos períodos del año aunque la mayor parte de las prospecciones se llevaron a cabo entre octubre y abril, coincidiendo con la época de mayor ocupación de las cavidades (ver GIMENEZ et al., 1985).

En cada una de las visitas, se tomaron datos sobre el número de individuos y especies presentes, anotándose la distancia de cada individuo al suelo de la cavidad y a la salida al exterior más próxima. Para esta última medida se han utilizado las topografías realizadas por distintos grupos de espeleología deportiva que actuan en Galicia.

Se ha reunido información referente a las especies siguientes: *Rhinolophus ferrumequinum* (RF) 374 localizaciones, *R.hipposideros* (RH) 55, *Miniopterus schreirbersii* (MS) 1752, y *Plecotus* spp. (ver GIMENEZ et al., 1985) (PA) 11. En su conjunto suman un total de 2194 localizaciones.

Resultados y discusión

La tabla 1 reúne los resultados medios obtenidos para cada especie con respecto a las distancias al suelo y a la entrada de las cavidades.

	RF	RH	PA	MS
A la entrada	19 ± 15,66	23,6 ± 33,6	15,5 ± 8,3	77,7 ± 31,4
Al suelo	2 ± 1,85	0,8 ± 0,5	1,43 ± 0,6	11,1 ± 4,6

Tabla 1. Valores medios y desviación típica. Abreviaturas en el texto

Destaca la preferencia por lugares profundos y altos en *Miniopterus. R. hipposideros* se segrega por la escasa altura a la que suele situarse (Figuras 1 y 2).

Consideradas en conjunto, apenas existen diferencias entre la localización de las especies, tanto para distancias a la entrada (F = 1,8 P < 0,25; Análisis de la Varianza), como para distancias al suelo (F = 1,7; P < 0,25). Sin embargo si se estudian diferencias entre pares de especies (tabla 2), los valores más significativos se obtienen para las distancias a la entrada de la cavidad. Esto es, las cuatro especies parecen seleccionar distintos emplazamientos con respecto a la entrada más que con respecto al suelo.

Por otro lado entre aquellas especies que son más similares en cuanto a la forma de agruparse durante el reposo, *R. ferrumequinum, R. hipposideros* y *Plecotus,* que descansan en solitario o en pequeñas formaciones, se dan los valores más significativos con respecto a las dos variables medidas.

Para interpretar los resultados obtenidos en la prueba, conviene tener presente las características de las cavidades en esta parte de España. Un porcentaje en torno al 80 % de las cavidades naturales gallegas conocidas no supera la altura media de 4 m a través de su recorrido. Por el contrario la longitud media de estos refugios es mayor de 100 m. Consecuentemente, la selección de áreas de descanso con respecto al suelo ha de realizarse sobre un espacio disponible menor que con respecto a la entrada.

	RF	RH	PA	MS
RF	–	2,17 *	2,22 *	−1,09
RH	1,84	–	2,34 *	−1,44
PA	2,06	1,06	–	−1,45
MS	−1,06	−1,35	−1,40	–

*Tabla 2. Valores de la t de Student en comparaciones de distancias al suelo y a la entrada; (dcha e izda respectivamente). * P < 0,05.*

Por otro lado, razones de tipo biológico, que separarían a especies que pasan todo el ciclo anual en los mismos refugios, de aquéllas que tan sólo los utilizan en determinadas épocas, pueden condicionar la selección de los emplazamientos.

Finalmente, durante la primera y última parte del reposo inver-

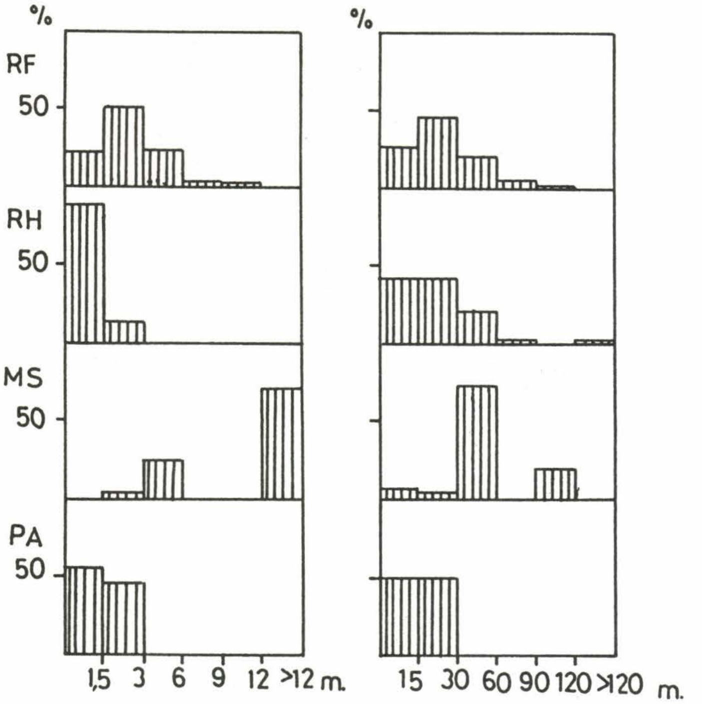

Figura 1.– Porcentajes de localizaciones de cada una de las especies con respecto al suelo (izda) y entrada de las cavidades. Abreviaturas en el texto.

nal, las salidas de los animales para alimentarse, podrían causar el acercamiento a la entrada de la cavidad, lo que supondría un ahorro de tiempo en las incursiones al exterior. La escasez de datos bien repartidos estacionalmente no permiten concretar nada en este sentido. Finalmente, la falta de información reciente acerca del uso del espacio durante el reposo, en otras áreas de España (ver p. ej. las revisiones de TUPINIER, 1982 y CAROL y

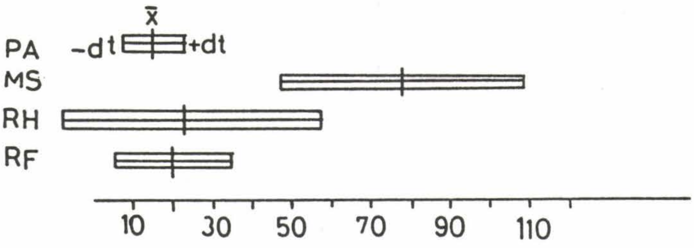

Figura 2.– Distancias a la entrada de la cavidad. Se indican medias y desviaciones. Abreviaturas en el texto.

SAMARRA, 1983) y la poca extensión de la zona de estudio, no permiten una discusión completa de nuestros resultados.

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Les Hydrobides de l'Europe de l'Ouest (Moll.Gast.Prosobr.)

R. Bernasconi
Société Suisse Spéléologie

RESUM

Presentem una ressenya actualitzada de la distribució geogràfica dels Hidròbids a Espanya, França, Benelux, Alemanya, Àustria, Suïsa i Itàlia, utilitzant una classificació simplificada, atenent-nos a les últimes investigacions.

RESUMEN

Presentamos una reseña puesta al día de la distribución geográfica de los hydrobidos en España, Francia, Benelux, Alemania, Austria, Suiza, Italia, utilizando una clasificación simplificada teniendo en cuenta las últimas investigaciones.

SUMMARY

An up-to-date review of the geographical distribution of Hydrobioidea in Spain, France, Benelux, Germany, Austria, Switzerland, Italy, is presented as well as a simplified systematical classification related to the newest researches.

Plusieurs travaux récents ont apporté des connaissances nouvelles sur la systématique des Hydrobioidea, entraînant non seulement des compléments des données déjà acquises, mais aussi des corrections. Il me semble donc utile de tenter une mise à jour des connaisssances actuelles.

Cette mise à jour sera limitée par trois restrictions. Elle sera tout d'abord limitée aux espèces dont l'anatomie a été étudiée; quelques espèces dont les données anatomiques sont trop incomplètes ou incertaines restent cependant d'un classement systématique sujet à caution. Elle sera ensuite limitée géographiquement à l'Europe de l'Ouest, les pays balcaniques ayant fait l'objet d'une révision étendue par RADOMAN 1983. Enfin, elle sera restreinte du point de vue systématique aux Hydrobioidea sensu GIUSTI, PEZZOLI 1980 nec RADOMAN 1983.

Du fait des deux dernières restrictions, seules les familles des Hydrobiidae (y-inclus Orientalidae sensu RADOMAN 1983 = Moitessieridae sensu GIUSTI, PEZZOLI 1980) et Bythinellidae font l'objet de cette mise à jour; les familles des Lithoglyphidae, Emmericidae, Pyrgulidae, Lithoglyphulidae, Micropyrgulidae, Turriscaspida et Baicalidae ne sont pas prises en considération.

La systématique générale adoptée ici est basée sur les dernières données en matière (RADOMAN 1983; BERNASCONI 1984; GIUSTI, BODON 1984); la liste des espèces est basée sur l'ensemble de la littérature spécialisée et tient compte des donnée les plus récentes, en partie même inédites ou sous presse.

Cette mise à jour est présentée de façon concise sous forme de cartes de distribution géographique pour chaque famille et sous-famille (v. Fig. 1 à 8). Elle concerne 91 espèces et sous-espèces distribuées sur 23 genres et sousgenres et 7 familles et sous-familles.

Je me limite à quelques constatations d'ordre général. La plupart des 23 genres d'Hydrobides considérés ici semble avoir une distribution en prépondérance méditérranéenne; Islamia et Sadleriana représentent des éléments balcano-adriatiques et 7 genres (Marstoniopsis et Bythinella; Belgrandiella et Bythiospeum; Hauffenia; Avenionia; Moitessieria) colonisent aussi l'Europe centrale. La sous-famille des Hydrobiinae, qui est probablement la plus primitive, comprend des espèces d'eau saumâtre (Hydrobia)

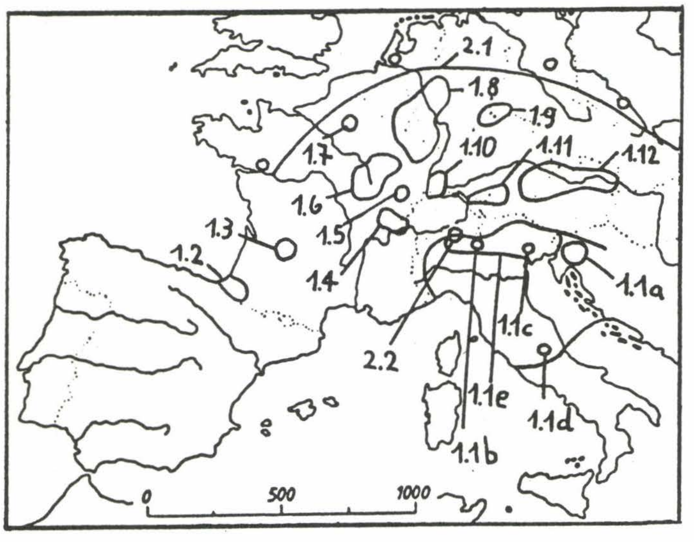

TABLA 1 BYTHINELLIDAE

1.1a	Bythinella schmidti schmidti	1.6a	Bythinella carinulata carinulata
1.1b	Bythinella schmidti ssp.A	1.6b	Bythinella carinulata viridiformis
1.1c	Bythinella schmidti ssp.B	1.7	Bythinella viridis
1.1d	Bythinella schmidti ssp.C	1.8	Bythinella dunkeri
1.1e	Bythinella schmidti insubrica	1.9	Bythinella compressa
1.2	Bythinella reyniesii	1.10	Bythinella bandensis
1.3	Bythinella bicarinata	1.11	Bythinella bavarica
1.4a	Bythinella pupoides pupoides	1.12	Bythinella austriaca
1.4b	Bythinella pupoides phreaticola	2.1	Marstoniopsis scholtzi
1.5	Bythinella vesontiana	2.2	Marstoniopsis insubrica

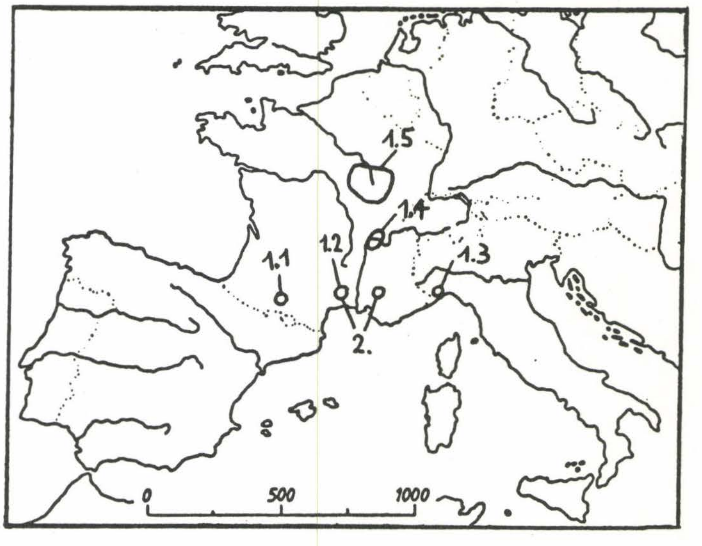

TABLA 3 HYDROBIIDAE Moitessieriinae

1.1	Moitessieria simoniana	2.	Paladilhia pleurotoma
1.2	Moitessieria rolandiana		
1.3	Moitessieria cf simoniana		
1.4	Moitessieria lineolata		
1.5	Moitessieria rayi		

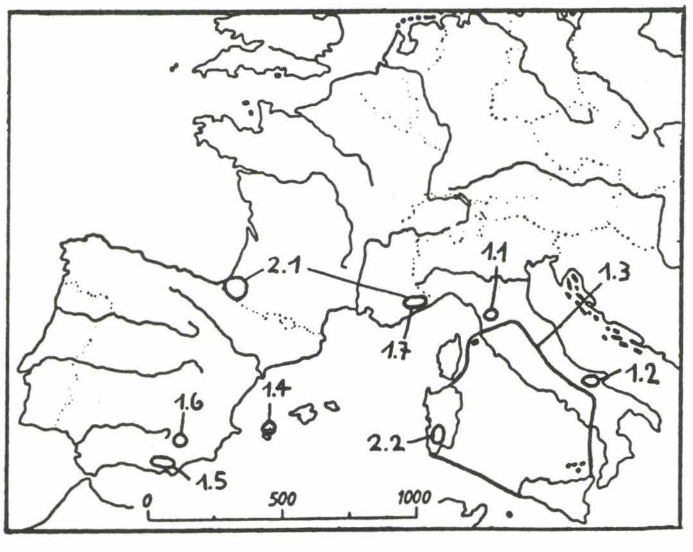

TABLA 2 HYDROBIIDAE Hydrobiinae (d'eau douce)

1.1	Pseudoamnicola lucensis	2.1	Mercuria confusa
1.2	Pseudoamnicola conovula	2.2	Mercuria zopissa
1.3	Pseudoamnicola moussoni		
1.4	Pseudoamnicola gasulli		
1.5	Pseudoamnicola (Corrosella) luisi		
1.6	Pseudoamnicola (Corrosella) falkneri		
1.7	Pseudoamnicola (Corrosella) anteisensis		

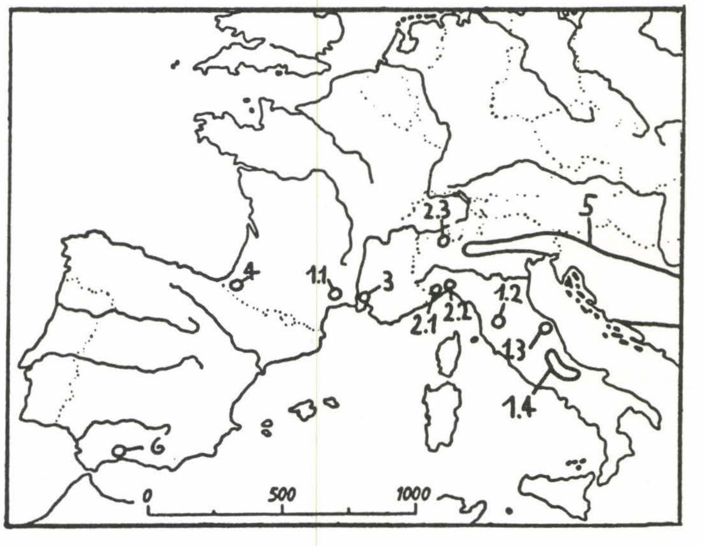

TABLA 4 HYDROBIIDAE Orientaliniinae

1.1	Belgrandia gibba	3.	Fissuria boui
1.2	Belgrandia caprai	4.	Litthabitella elliptica
1.3	Belgrandia mariatheresiae	5.	Sadleriana fluminensis
1.4	Belgrandia minuscula	6.	Horatia gatoa
2.1	Alzoniella finalina		
2.2	Alzoniella sigestra		
2 3	Alzoniella feneriensis		

et d'eau douce (Pseudoamnicola, Mercuria), toutes limitées aux zones côtières. La distribution actuelle des 21 autres genres et sous-genres reflête leur colonisation des eaux continentales, parfois leur déstruction pendant les glaciations et leur recolonisation. Digne de note enfin la coexistence de genres et sous-familles divers, ce qui est peut-être responsable de la variété de combinaisons anatomiques et conchyliologiques que l'on constate.

Nos connaissances malgré tout lacunaires des Hydrobides et les aspects cités ci-dessus rendent très complexe et problématique tout essai de reconstruction quant à leur origine, leur phylogénie et leur colonisation des eaux douces.

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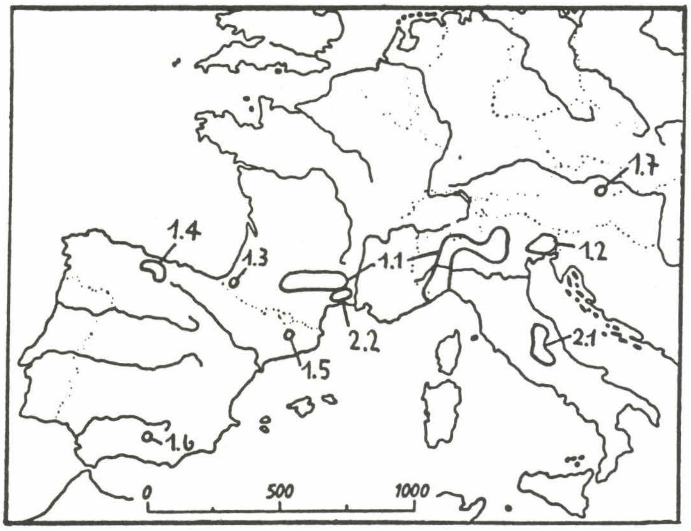

TABLA 5 HYDROBIIDAE Belgrandielliinae I

1.1	Belgrandiella saxatilis	2.1	Arganiella pescei
1.2	Belgrandiella pupula	2.2	Arganiella exilis
1.3	Belgrandiella pyrenaica		
1.4	Belgrandiella cantabrica		
1.5	Belgrandiella ateni		
1.6	Belgrandiella andalucensis		
1.7	Belgrandiella parreysii		

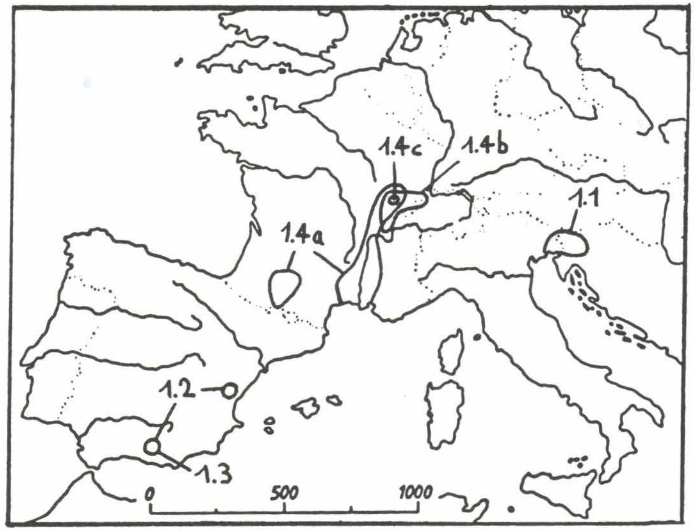

TABLA 7 HYDROBIIDAE Pseudohoratiinae

1.1	Hauffenia tellini	1.4a	Hauffenia minuta globulina
1.2	Hauffenia sturmi	1.4b	Hauffenia minuta minuta
1.3	Hauffenia schuelei	1.4c	Hauffenia minuta spirata

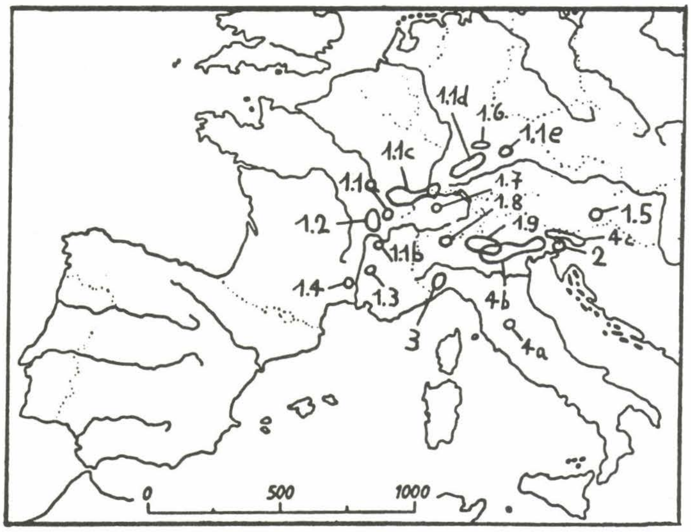

TABLA 6 HYDROBIIDAE Belgrandiellinae II

1.1a	Bythiospeum diaphanum diaphanum	1.8	Bythiospeum (Iglica) pezzoli
1.1b	Bythiospeum diaphanum dorvani	1.9	Bythiospeum (Iglica) forumjulianae concii
1.1c	Bythiospeum diaphanum charpyi	2	Phreatica bolei
1.1d	Bythiospeum diaphanum quenstedti	3	Pseudoavenionia pedemontana
1.1e	Bythiospeum diaphanum lamperti	4a	Paladilhopsis cornucopia cornucopia
1.2a	Bythiospeum bressanum bressanum	4b	Paladilhopsis cornucopia virei
1.2b	Bythiospeum bressanum diasphanoides	4c	Paladilhopsis cornucopia robiciana
1.3	Bythiospeum garnieri		
1.4	Bythiospeum articense		
1.5	Bythiospeum tschapeki		
1.6	Bythiospeum pellucidum		
1.7	Bythiospeum helveticum		

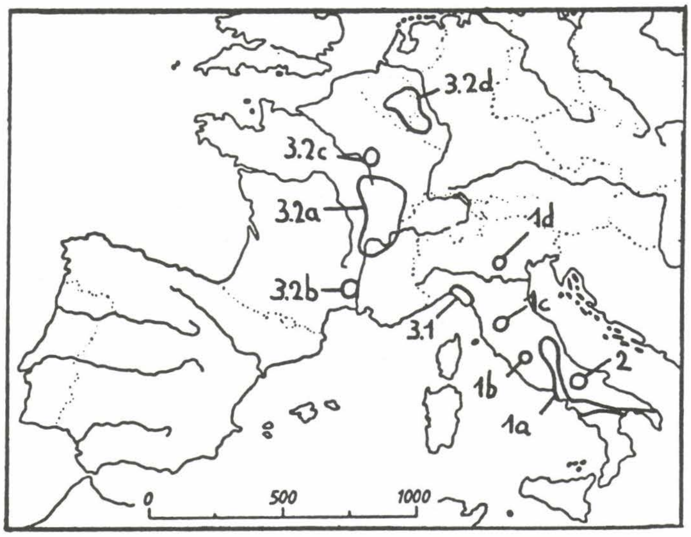

TABLA 8 HYDROBIIDAE Islamiinae

1a	Islamia pusilla pusilla	3.1	Avenionia ligustica, A. parvula
1b	Islamia pusilla ssp.B	3.2a	Avenionia brevis brevis
1c	Islamia pusilla ssp.C	3.2b	Avenionia brevis berengueri
1d	Islamia pusilla ssp.A	3.2c	Avenionia brevis bourguignati
2	Pauluccia minima	3.2d	Avenionia brevis roberti

Chirotteri cavernicoli di Sicilia

B. Zava*, A. Corrao** & E. Catalano***
* Associazione per lo Studio e la Protezione dei Pipistrelli
** Istituto Zooprofilattico Sperimentale della Sicilia
*** Istituto di Zoologia dell Università di Palermo

RESUM

El present estudi analitza les dotze espècies (anomenades més endavant) que s'han trobat fins ara a les cavitats sicilianes. Aquesta compilació s'ha pogut fer, tant a partir de dades bibliogràfiques com a partir de les observacions efectuades des de l'any 1978 al 1985 i s'intenta donar una idea prou àmplia sobre la seva distribució i el seu status dins la regió. A més, proposem una sèrie d'intervencions que es podrien realitzar en algunes de les cavitats que aixopluguen colònies de rat penats amenaçats per l'antrofització.

Espècies examinades: Rhinolophus ferrumequinum *(Schr.)*, Rhinolophus hipposideros *(Bech.)*, Rhinolophus euryale *(Blasius)*. Rhinolopus mehelyi *(Matschie)*, Miniopterus schcreiberai *(Natt.)*, Myotis emerginatus *(Geoffroy)*, Myotis capaccinii *(Bonaparte)*, Myotis myotis *(Borkh.)*, Myotis blythi *(Tomes)*, Pipistrellus pipistrellus *(Schr.)*, Pleocotus austriacus *(Fischer)* *i* Tadarida teniotis *(Rafin.)*

RESUMEN

El presente estudio analiza las doce especies (numeradas más adelante) halladas hasta ahora en las cavidades sicilianas. Se ha deducido por los elementos bibliográficos y por las observaciones realizadas desde el año 1978 al 1985 y abastecen un cuadro sobre la distribución y sobre el estatus de la región. Además son propuestas intervenciones a realizar en algunas otras de las cavidades que cobijan colonias de murciélagos amenazados por la antrofización.

Expecies examinadas: Rhinolophus ferrumequinum *Schr.* Rhinolophus hipposideros *Bech.* Rhinolophus euryale *Balsius*, Rhinolophus mehelyi *Matschie*, Miniopterus schreibersi *(Natt.)*, Myotis emarginatus *(Geoffroy)*, Myotis capaccinii *(Bonaparte)*, Myotis myotis *(Borkh.)*, Myotis blythi *Tomes*, Pipistrellus pipistrellus *(Schr.)*, Plecotus austriacus *(Fischer)*, Tadarida teniotis *(Rafin)*.

RÉSUMÉ

La présente étude analyse les 12 espèces (énumérées au-dessous) trouvées jusqu'à présent dans les cavités siciliennes. Il est déduit par les éléments bibliographiques et par les observations réalisées de 1978 à 1985 et il fournit un premier tableau sur la distribution et sur le status de la région. De plus sont proposées des interventions à réaliser en quelques autres des cavités qui abritent des colonies de chauves-souris menacées par l'antrophisation.

Espéeces examinées: Rhinolophus ferrumequinum *(Schr)*, Rhinolophus hipposideros *(Bech)*, Rhinolophus euryale *(Blasius)* Rhinolophus mehelyi Matschie, Miniopterus schreibersi *(Natt)*, Myotis emarginatus *(Geoffroy)*, Myotis capaccinii *(Bonaparte)*, Myotis myotis *(Borkh)*, Myotis blythi *(Tomes)*, Pipistrellus pipistrellus *(Schr)*, Plecotus austriacus *(Fischer)*, Tadarida teniotis *(Rafin)*.

Introduzione

In Sicilia si conosce l'esistenza di un elevato numero di cavità carsiche e vulcaniche; ciò nonostante ben poco si sa ancora sul loro popolamento faunistico. Gli studi sulla Chirotterofauna sicialina sono altrettanto carenti. Si devono a Klemmer & Krampitz (1954, 1957) e a Kahmmann (1958) alcune raccolte occasionali. Nel 1960 presso l'Università di Catania viene promosso uno studio sistematico della fauna cavernicola siciliana. I risultati delle ricerche sono raccolti nel Catalogo della Fauna cavernicola di Sicilia di Caruso & Costa (1978). Nel 1978 presso l'Instituto di Zoologia dell'Università di Palermo si costituisce un gruppo di lavoro siu Chirotteri al fine di stabilire la distribuzione e lo status delle specie presenti nel territorio siciliano. Negli anni seguenti (1978-1985) vengono verificate le segnalazioni bibliografiche e visitate in collaborazione con i gruppi speleologici 342 cavità site nel territorio. Dalle prime indagini si evince subito che i pipistrelli sono negli ultimi decenni diminuiti sensibilmente. Il declino rilevante delle popolazioni è senza altro imputabile alle stesse cause accertate in Europa (Stebbing & Griffith, 1984): antropizzazione ed uso indiscriminato dei pesticidi. Qui di seguito diamo un elenco completo delle stazioni per specie (alla provincia segue: il nome della cavità secondo il catasto delle rispettive provincie (Mannino, in stampa) (Bella et al., 1982) (Brunelli & Scammacca, 1975) e, ove esiste, il riferimento bibliografico). Per esigenza di spazio siamo costretti a fornire solamente alcune informazioni sullo status delle specie finora catturate. Successivamente verrà pubblicato il lavoro integralmente (Zava et al., in preparazione).

Atropizzazione della cavità

Le grotte siciliane negli ultimi decenni hanno subito un irreversibile processo distruttivo difficilmente intuibile da coloro che non si interessano alla speleologia. Numerose «Cattedrali sotterranee» santuari di una natura apparentemente non violabile, sono state utilizzate come cave, discariche, pozzi neri. I Chirotteri tipicamente troglofili prediligono ambienti ipogei caratterizzati da un elevato grado igrometrico e da una temperatura generalmente poco variabile che si aggira intorno a quella media annuale esterna. Un gran numero di cavità del nostro territorio prive di tali requisiti non vengono occupate. Le poche cavità elette a rifugio ospitano quindi colonie numerose che vi si riproducono da maggio a settembre. I rumori e le luci dei numerosi e frequenti visitatori constituiscono una intollerabile fonte di disturbo che determina una anomala attività riproduttiva. Alcune cavità sono state teatro di vere e propie decimazioni di pipistrelli. Nella primavera 1983 in una cavità alla periferia di Vittoria (Rg) é stata distrutta una intera colonia costituita da circa 500 *Myotis myotis*. Gli abitanti delle case vicine alla cavità, decisi ad eliminare gli innocui animali, riversarono degli interi bidoni di combustibile e vi appiccarono il fuoco. La protezione di un gruppo zoologico importante quale è quello dei Chirotteri deve essere immediata: sarebbe auspicabile che tutte le cavità ospitanti colonie venissero poste sotto vincolo e che i loro ingressi venissero chiusi da cancelli con sbarre orizzontali opportunamente distanziate per il normale passaggio degli animali. In Sicilia l'unica colonia protetta con simili accorgimenti é quella della Grotta dei Pipistrelli della Necropoli di Pantalica–Sortino (Sr).

Contaminazione da pesticidi

Altra causa del declino numerico delle popolazione siciliane é la contaminazione da pesticidi clorurati. Dal 1982 sono in corso presso l'Istituto Zooprofilattico Sperimentale della Sicilia ricerche sulla presenza di residui di pesticidi in pipistrelli. Nello stesso anno veniva scoperta una colonia di pipistrelli morti costituita da circa 600 esemplari appartenenti alle specie *Miniopterus schrei-*

bersi e *Myotis myotis*. Le analisi tossicologiche svolte dimostrarono successivamente che la distruzione della intera colonia era imputabile all'avvelenamento da pesticidi clorurati ed in particolare da pp'=DDT e pp'-DDE. (Corrao et al., 1985). Successivamente furono effettuate ulteriori indagini, tuttora in corso, su esemplari di diverse specie provenienti da stazioni ubicate nel territorio siciliano. Le specie esaminate sono *Rhinolophus ferrumequinum* (6 esemplari), *Miniopterus schreibersi* (6 esemplari), *Myotis myotis* (12 esemplari). I risultati ottenuti, esposti nella tabella n. 1 suggeriscono che la contaminazione dei pipistrelli da pesticidi organoclorurati é un problema di proporzioni più ampie di quanto i dati riportati in letteratura (Clark, 1981) non lascino già intuire. Infatti la presenza di diversi pesticidi nello stesso individuo può determinare un aumento della tossicità del singolo principio tossico per effetto sinergico. Ciò costituisce una seria minaccia di estinzione per tale importante gruppo zoologico. Inoltre, come é noto (Debbie, 1974) i pipistrelli pluricontaminati da pesticidi, a livelli subletali, possono attivare alcune infezioni virali latenti.

Tabella n. 1–Concentrazioni di residui di pesticidi organoclorurati in mg/kg di peso corporeo.

Elenco delle specie Rhinolophidae

Rhinolophus ferrumequinum (Schreber, 1774)

Prov. di Palermo: G. dei Puntali-Carini; G. del Ponte, G. del Roveto, G. Addaura Caprara (Mannino, 1985), G. dei Pipistrelli, G. della Molara, G. degli Spiriti, G. Impisu, G. del Catalano, G. di S. Zita-Palermo; G. del Fico-Torretta; Pozzo del Ghiro e G. del Porcospino Belmonte Mezzagno– G. del Garrone e Zubbione della Pizzuta– Piana degli Albanesi– G. di Cozzo lupu-Godrano, G. dei Porcospini –Altavilla Milicia; G. del Pinto (Catalano e Zava, 1981)– Partinico; G. Siino-Cinisi; G. Monostalla-Balestrate; G. del Convento–Borgetto; G. della Rocca-Cefalù. Prov. di Trapani: G. di Cala Impiso-S. Vito lo Capo. Prov. di Agrigento: Inghiottitoio di S. Angelo Muxaro–S.A. Muxaro; G. dell'Acqua fitusa Il-Cammarata. Provincia di Catania: G. di Monte Corruccio e G. del Tesoro-Linguaglossa (G. Costa com.pers.); G. della Catanese I-Ragalna; G. dell'Immacolatella I-S. Gregorio; G. del Porcospino-Linguaglossa; G. del Burró-Randazzo. Provincia di Siracusa: G. Calafarina-Pachino (Ragonese, 1966, 1968); G. dei Pipistrelli e G. Truvata-Sortino (Klemmer & Krampitz, 1954).

Rhinolphus ferrumequinun		Miniopterus		schreibersiMyotis myotis	
pp'-DDE	< 0.010-0.16	pp'-DDD	< 0.010-0.17	Aldrin	0.11-0.62
pp'-DDT	< 0.010-0.43	pp'-DDE	0.15-0.49	pp'-DDE	< 0.010-0.41
Dieldrin	< 0.010	pp'-DDT	< 0.010-0.22	pp'-DDT	< 0.010-0.65
Endrin	< 0.010-0.28	Dieldrin	0.14-0.29	Dieldrin	0 29-0.43
Eptacloro				Eptacloro	< 0.010-0.44
epossido	0.11-0.22			Lindano	< 0.010-0.69
Metossicloro	< 0.010-0.94			Metossicloro	0.52-1.05

E' la specie piú comune nelle cavità siciliane. Delle stazioni sopra riportate soltanto 10 ospitano colonie costituite da un centinaio di individui. Minacce: antropizzazione e contaminazione da pesticidi clorurati (vedi Tab. 1).

Rhinolophus hipposideros minimus Heuglin, 1861

Prov. di Palermo: G. del Ponte-Palermo; G. di Piano Filici-Godrano; G. di Chiarastella-Baucina. Prov. di Trapani: G. di Cala Impiso-S. Vito lo Capo. Prov. di Catania: G. di Guardo-S. Giovanni La Punta (Caruso & Costa, 1978); G. di Monte Corruccio-Linguaglossa (G. Costa com. pers.). Non sono state mai osservate colonie di questa specie il cui numero superava la dozzina di esemplari. Sembra non avere abitudini gregarie. Minacce: Antropizzazione

Rhinolophus euryale Blasius, 1853

Prov. di Agrigento: G. dell'Acqua fitusa I-Cammarata. Prov. di Siracusa: G. Chiusazza-Floridia; G. dei Pipistrelli-Sortino (Klemmer & Krampitz, 1954); G. Palombara-Siracusa (Sichel & Alicata, 1963).

Le colonie della specie segnalate nella Sicilia Sud-Orientale sono minacciate dalla antropizzazione, la grotta chiusazza é stata recentemente privata dell'accesso principale ostruito con massi di frana siu quali è sorto un edificio prefabbricato i cui scoli fognari defluiscono all'interno di essa.

Rhinolophus mehelyi Matschie, 1901

Prov. di Siracusa: G. Chiusazza-Floridia; G. dei Pipistrelli-Sortino (Kahmann, 1958) (Lanza, 1959) (Felten & Storch, 1970); G. Palombara-Siracusa (Sichel & Alicata, 1963).

La specie è stata osservata esclusivamente nella Sicilia Sud-Orientale. Minacce: antropizzazione.

Vespertilionidae

Miniopterus Schreibersi (Natterer in Kuhl, 1819)

Prov. di Palermo: G. presso Carini (Krampitz, 1957); G. dei Puntiali-Carini; G. della Rocca Busambra-Corleone. Prov. di Trapani: G. del Riccio-S. Vito lo Capo. Prov. di Agrigento: G. dellÁcqua fitusa I-Cammarata. Prov. di Messina: G. S. Andrea-Taormina. Prov. di Catania: G. Immacolatella, G. di S. Gregorio-G. Immacolatella I-San gregorio (Caruso & Costa, 1978); G. della Catanese-Regalna. Prov. di Siracusa: G. dei Pipistrelli-Sortino (Klemmer & Krampitz, 1954); G. Palombara-Siracusa (Caruso & Costa, 1978); G. Chiursazza-Floridia.

Una delle specie più comuni fra i chirotteri cavernicoli presenti nel territorio siciliano, forma colonie costituite da diverse centinaia di esemplari. Minacce: antropizzazione e contaminazione da pesticidi clorurati (Tab. 1).

Myotis emarginatus (E. Geoffroy, 1806)

Prov. di Palermo: G. presso Carini-Carini (Caruso & Costa, 1978). Prov. di Catania: G. di Monte Corruccio-Linguaglossa (Zava & Catalano, in stampa). La segnalazione delle grotte presso Carini della specie in oggetto e di *Myotis capaccinii* risulta errata infatti fra il materiale raccolto da Krampitz (1957) oggi conservato presso il Senckenberg Museum di Francoforte non vi sono esemplari provenienti da Carini. Per quanto riguarda la stazione di Monte Corruccio, numerose visite hanno finora avuto esito negativo.

Myotis capaccinii (Bonaparte, 1837)

Prov. di Palermo: G. presso Carini (Caruso & Costa, 1978) e G. dei Puntuali-Carini. Prov. di Agrigento: G. dellÁcqua fitusa I-Cammarata. Prov. di Siracusa: G. Calafarina-Pachino (Ragonese, 1966 e 1968); G. Chiusazza-Floridia (Caruso & Costa, 1978).

La specie è stata osservata in cavità molto ampie ospitanti grandi colonie in associazione con *Miniopterus schreibersi* e *Myotis myotis*. Minacce: antropizzazione; sono in corso le indagini tossicologiche.

Myotis myotis (Borkhausen, 1797)

Prov. di Palermo: G. presso Carini (Krampitz, 1957), G. dei Puntali e G. dei Carburangeli-Carini; G. della Molara-Palermo; G. dellÁcqua ammucciata-Ciminna; G. dei Brigghi-Altavilla Milicia; G. della Gulfa-Alia; Ipogeo di Castronovo-Castronovo di Sicilia. Prov. di Trapani: G. dei Panni-S. Ninfa (Gulino & Dal Piaz, 1939). Prov. di Agrigento: Cava di Lampedusa-Lampedusa; G. del Giubbo-Caltabellotta (Caruso & Costa, 1978); G. di Montevago-Montevago; G. dellÁcqua fitusa I-Cammarata. Prov. di Messina: G. del Lauro-Alcara Li Fusi. Prov. di Catania: G. Immacolatella-S. Gregorio (Caruso & costa, 1978); G. della Catanese I-Ragalna, G. dei Tre Livelli-Zafferana (Carusso & Costa, 1978). Prov. di Siracusa: G.

Calafarina-Pachino (Ragonese, 1966 e 1968); G. de Pipistrelli-Sortino (Klemmer & Krampitz, 1954); G. Palombara-Siracusa (Caruso & Costa, 1978).

Prov. di Ragusa: Cava di Vittoria-Vittoria.

Specie comune che forma grandi colonie estive. Minacce: antropizzazione e contaminazione da pesticidi clorurati (vedi Tab. 1).

Myotis blythi, Tomes 1857

Prov. di Palermo: G. dei Puntali-Carini.

Prov. di Catania: G. Cantarella e G. Immacolatella I-S. Gregorio (Caruso & Costa, 1978); G. dei Tre Livelli-Zafferana (Caruso & Costa, 1978).

La specie forma colonie miste a *Myotis myotis*. Minacce: antropizzazione.

Pipistrellus pipistrellus (Schreber, 1774)

Prov. di Palermo: G. del Pinto-Partinico (Catalano & Zava, 1981). Due individui sono stati osservati nella cavità sopra indicata in una «Wochenstuben» di *Rhinolophus ferrumequinum*.

Plecotus a. austriacus (Fischer, 1829)

Prov. di Trapani: G. del Lago di Pantelleria-Pantelleria (Felten & Storch, 1970). Prov. di Catania: G. dellÁnnunziata, *Plecotus sp.* (Lanza, 1959, 1961). La specie sembra essere rara nelle cavità siciliane; purtroppo le uniche segnalazioni bibliografiche esistenti non sono state da noi confermate. Infatti la Grotta dell'Annunziata citata da Lanza non è altro che la Grotta Immacolatella I sita a S. Gregrorio: quest'ultima è stata da noi più volte visitata ma della colonia osservata dal Dott. G. Motta non vi é più traccia. Per quanto riguarda la stazione di Pantelleria, un controllo effettuato nell'Agosto 1985 ha rivelato che la cavità in questione é stata adibita a deposito di attrezzi agricoli con la totale ostruzione dell'ingresso.

Molossidae

Tadarida teniotis (Rafinesque, 1814)

Prov. di Palermo: G. della Kalura-Cefalù.

La prima segnalazione della cattura di due esemplari effettuata probabilmente in una cavità di Monte Pellegrino (PA) si deve al Doderlain. (Zava & Catalano, 1984). Nel 1985 è stata scoperta una numerosa colonia di questa specie in alcune fessure che si aprono in due scogli poco distanti dalla costa. Durante l'autunno alcuni individui appartenenti alla colonia sono stati osservati all'interno della cavità citata. Minacce: antropizzazione. Durante il periodo di riproduzione la colonia é stata più volte molestata da vandali e numerosi esemplari sono stati uccisi. (Zava et al., in preparazione) Ringraziamenti.

Siamo profondamente grati a tutti coloro che hanno collaborato alla realizzazione di queste ricerche, ed in particolare a: Giovanni Mannino, Vito Buffa e Roberto Cusimano dellÁssociazione Speleoarcheologica Siciliana, a Giovanni Costa, Luigi Lino e Tiziana Cigna della Delegazione Sicilia Orientale del World Wildlife Fund.

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Indirizzo degli autori:

Bruno Zava- Associazione per lo Studio e la Protezione del Pipistrelli. Via Marchese di Villabianca 24- 90143 tel. 091/301983 Palermo Italia.

Antonio Corrao- Instituto Zooprofilattico Sperimetale della Sizilia. Plazza Generale Turba 62- 90129 tel. 091/489781 Palermo Italia.

Eliodoro Catalano- Instituto di Zoologia dell'Università. Via Archirafi 18 90123- tel. 091/3355580 Palermo Italia.

A taxonomic study of cave spiders of tropical Asia

Christa L. Deeleman-Reinhold.

RESUM

Fruit d'un programa de recerca de F. D. Stone a Tailàndia i de l'expedició de Cambridge a Sumatra l'any 1984, presentem aquí noves dades de les aranyes cavernícoles de l'Àssia tropical.

Es comenten i revisen els resultats, els quals van acompayats d'altres materials i de bibliografia.

S'indiquen les possibles relacions entre elles i amb la fauna de la superfície. A Tailàndia es varen trobar 34 espècies, 3 de les quals tenien ulls reduïts i una d'elles no en tenia. A Sumatra es varen reunir 12 espècies, cap de les quals era troglòbia. Ben poques pertanyen a espècies cosmotropicals més o menys sinantròpiques; la immensa majoria es tracta d'espècies no especialitzades, però molt poques d'aquestes espècies són conegudes amb certesa ja que poden també trobar-se a fora, dins d'una mateixa àrea. La impossibilitat de correlació de moltes de les espècies amb elements de la fauna epigea és deguda probablement al desconeixement que es té d'aquesta última.

Les espècies troglòbies es varen trobar disperses per les principals zones investigades i pertanyen a una varietat de famílies amb una lleugera tendència cap a les aranyes aplogines (primitives).

Un dels descobriments més interessants és un oonòpid cec de Tailàndia, que pot pertànyer al gènere Disderoides. *Fins ara, aquest gènere, consistent en dues espècies cegues, no té cap relació aparent amb la fauna superficial existent.*

RESUMEN

Como resultado principal de un programa de investigación de F. D. Stone en Tailandia y de la Expedición de 1984 Cambridge Sumatra, se presentan nuevos datos de arañas cavernícolas de Asia Tropical. Se comentan y revisan los resultados junto con otro material y bibliografía.

Se fijan las supuestas relaciones entre ellos y con la fauna de la superficie. En Tailandia se encontraron 34 especies, 3 de las cuales tenían ojos reducidos y una carecía de ellos. En Sumatra se recogieron 12 especies, ninguna de las cuales era troglobia. Pocas especies pertenecen a las especies cosmotropicales o más o menos sinantrópicas; la inmensa mayoría consiste en especies no especializadas, pero muy pocas de ellas son conocidas con certeza por hallarse también fuera, en la misma área. El fracaso en la identificación de muchas especies cavernícolas con elementos de la fauna epigea es debido probablemente a la ignorancia de esta última.

Las especies troglobias se encontraron dispersas por todas las principales zonas investigadas y pertenecen a una variedad de familias con una ligera tendencia hacia las arañas aploginas (primitivas).

Uno de los descubrimientos más interesantes es un oonopido ciego en Tailandia, que puede ser asignado al género Disderoides. Hasta ahora este género, consistente en dos especies ciegas, no tiene relación aparente con la fauna superficial existente.

SUMMARY

New data are presented on cave spiders from tropical Asia, resulting mainly from a research programa by F. D. Stone in Thailand and from the Cambridge Sumatra Expedition 1984. The results are discussed and reviewed with other material and litterature.

Supposed relationships with each other and with the surface fauna is assessed. In Thailand, 34 species were found, 3 of which with reduced eyes and one eyeless. In Sumatra, 12 species were collected, none of which troglobitic. A few species belong to cosmo-tropical or more or less synanthropic species; the great majority consists of non-specialized species, but very few of these are known with certainty to occur also outside in the same area. The failure to identify many cave species with elements of the epigean fauna is probably due to ignorance of that latter.

The troglobitic species are found scattered over all the main areas investigated, and belong to a variety of families with a slight bias towards haplogyne (primitive) spiders.

One of the most interesting discoveries is a blind oonopid in Thailand, which can be assigned to the genus Dysderoides. *At present this genus, consisting of two blind species, is without apparent relationship with the existing surface fauna.*

The spider collections resulting from a research project in Thailand by F. D. Stone (B. Bishop Museum, Honolulu) and that of the Cambridge Sumatra expedition were entrusted to me for identification. In this paper the results will be enumerated, commented upon and compared with data from litterature.

Data from tropical Asian cave spiders are scarce. The main source comes from collecting by Simon (1983) in two caves near Manila (9 species, 2 troglobitic), repeated investigations in the Batu cave (14 species described by Fage, 1929, Bristowe, 1952 and Roewer, 1962, 1-2 of which troglobitic) and a biospeleological expedition to Ceylon by Aellen and Strinati (Brignoli, 1972 9 species, none of which troglobitc). During the Papua New Guinea Expedition Beron and Chapman brought back 43 yet unpublished spider species from caves, among which 3 blind oonopids (Brignoli, 1981). Extensive collecting was also done by Chapman in the caves of the Mulu National Park in eastern Sarawak (Chapman, 1982).

Stone's collections from Thai caves, made between 1973 and 1981 are among the most important of tropical Asia and comprise several hundreds of specimen belonging to 36 species, 4 of which troglobitic. Detailed descriptions of this material will be published by myself. The Cambridge Sumatra Expedition to Aceh and Deli came back with 12 species, several endemic, but non troglobitic.

Part of the collected specimens in tropical Asian caves belongs to cosmotropical species of widely distributed synathropic species (also in the Americas): *Scytodes fusca* Walckenaer, *Loxosceles rufescens* (Dufour), *Physocyclus globosus* (Taczanowski), *Heteropoda venatorial L.*, *Theridion rufipes* Lucas and *Uloborus geniculatus* Olivier.

More or less synanthropic spiders with a wide local distribution are *Scytodes venusta* (Thorell), *Uthina luzonica* Simon (also between roots, rock crevices etc.) *Pholcus ceylonicus* Cambridge (also hollow trees, sheds, etc.,) *Titanoeca fulmeki* Roewer and *Psechrus singaporensis* Thorell (also between tree roots, under overhanging rocks and around houses). The pale green *Calapnita vermiformis* Simon, first discovered in a cave near Manila, is now known to live normally in dense rainforests on the underside of large leaves and in distributed over the whole Malay Archipelago. The tiny pholcid *Spermaphora* miser Bristowe, first described from Batu cave, occurs in forestfloor litter in Malaysia, Sumatra and Borneo.

Many of Stone's species are new to science. This does not mean that they are exclusively cave-species, it rather reflects our ignorance of the surface-spider fauna of Thailand, which country is almost a white spot from arachnological point of view. Interesting in this context is our recently made collection of groundspiders of the rain-forest of Khao Yai National Park, situated in the vicinity of one of the investigated areas.

Only one of the 40 spider species (an endemic Ischnothyreus, Oonopidae) was found in common.

The great majority of South East Asian cave spiders in general show no visible adaptations to the underground environment and this suggests that they are not limited to caves, but have invaded them recently from outside. Surprisingly few examples can be given of records of species from both caves and surface: I may mention *Paculla wanlessi* Bourne from Mulu, North Borneo that was found in forest leaflitter and caves; several species of *Althepus* (Ochyroceratidae) were found both in forest and caves. The before mentioned *Ischnothyreus* n. sp., found by Stone in a Thai cave was recently also collected in the Khao Yai National Park, not far from the cave, but situated on a sandstone area. The very primitive spiders of the genus *Liphistius* were thoroughly quested for in the Malay Peninsula by W. C. Sedgwick, both in caves and on the surface; *L. batuensis* Abraham and *L. langkawi* Platnick and Sedgwick in spite of any apparent underground adaptation, were only found in caves in a very limited area. On the contrary, *L. desultor* Schiödte, *L. malayanus* Abraham, *L. murphyorum* Platnick and Sedgwick, *L. yangae* Platnick and Sedgwick and *L. trang* Platnick and Sedgwick were only found on the surface as endemic allopatric species. It should be assumed, then that in this area an ecological segregation, followed by speciation in *Liphistius* has taken place. Probably, genera or spacies groups in the Ochyroceratidae, Pholcidae, Eusparassidae and Nesticidae have split up in innumerable allopatric forms, slightly differing morphologically (a nightmare for taxonomists !) and here, ecological segregation may have ocurred too.

In caves, Eusparassidae are among the most numerous in individuals, mostly of the genus *Heteropoda*, but they are nearly always non-adult. *Heteropoda venatoria* L., the well know «banana spider» or «tropical house spider» has followed Man all over the tropical world; it has been cited from caves, but just as likely cave specimens could belong to one of the as likely cave specimens could belong to one of the countless local endemic species that wander at great speed over the forestfloor. It has been observed that young Eusparassids come down into caves for a safe place to moult.

In the ochyroceratid *Speocera microphthalma* Simon from Luzon caves, males of cave populations differ from those living outside in detritus only by the possession of a highly developed stridulatory organ in the chelicerae, which is absent in males outside. A similar phenomenon is said to occur in the *Spermaphora miser* (Pholcidae) population in Batu cave, which is said to have a stridulatory organ on the abdomen (also in females) not present in specimens outside.

Troglobitic spider species in tropical Asia are scarce. An eusparassid species with reduced eyes from Batu cave (Panaretidius microphthalmus Fage) was placed in the genus *Panaretidius* Simon, which till then was represented by only one species, cave -dwelling but non- adapted, from Tonkin. Non-adult specimens with reduced eyes of similar appearance were found by Stone in Thailand caves and have been listed in this genus in Appendix I. The Eusparassidae, very numerous in species and individuals all over southeastern Asia, are very incompletely known; their taxonomy is confused and no recent revisions have been made; the close relationship of the cavernicolous *Panaretidius* may rest on adaptive convergence and therefore spurious.

The type species of the achyroceratid genus *Psiloderces, P. egeria* Simon is a troglobite with pale colour, much reduced eyes and lengthened limbs. Another troglobitic Psiloderces was discovered by Stone. The pale little spider, pictured i Chapman 1982 in a Mulu cave (p. 145, fig.3) looks like a *Psiloderces* too.. Formerly, the Ochyroceratidae were considered to be generally cavernicolous (Fage, 1912), but at that time the gigantic numbers of species of tiny spiders living in groundlitter and humus in rainforests were hardly known and never categorically investigated. Most of the *Althepus* species probably live both in caves and outside; I found them personally in most rainforests in large linyphiidlike sheetwebs between tree roots, riverbanks etc. and also in caves , but none of these long legged spiders show the slightest tendency to losing pigment or decreasing eye size. I also found many species of normally pigmented *Psiloderces* all over the area in most leaflitter in rainforest. The troglobitic *Psiloderces* species are in my view probably closed related to local forest-dwelling species than to each other.

Eyeless spiders in caves in S. Asia appear to be rarer than in temperate climates. Numerous blind mygalomorphs are known in Central America and Mexico (Gertsch, 1982) whereas in Asia, only one species is known to be blind: *Masteria caeca* from Luzon. This is not so surprising as it seems, because mygalomorphs in general are considerably more frequent in the New world than in the Old.

One rather strange oonopid: *Dysderoides typhlops* Fage was found in a montane cave in northern India, not strictly tropical therefore; another species, also completely eyeless was found in Thailand. The two species are probably closely related, as they both have a protuberance on the mesal side of the chelicerae, which is a derived character, indicating close relationship. More blind oonopids were discovered in New Guinea caves. A totally eyeless tetrablemmid was described from a Sumatra cave and a blind *spermaphora* (Pholcidae) was mentionned from Papua New Guinea (Brignoli 81).Oonopidae, Tetrablemmidae and mygalomorph Dipluridae of the genus *Masteria* are small, humus or soil-dwelling creatures –oonopids are also known from termitenests– –all these are known to lose their eyes relatively easy and they are also considered to be relatively primitive. But not all blind spiders are primitive.

A most intriguing, completely eyeless specimen of the family Clubionidae, subfamily Liocraninae, was discovered in a cave in northern Ceylon by B. Sket. This is the second known troglobitic representative in the world of this large worldwide family and at the same time the first blind entelegyne (a derived polyphyletic group) spider in tropical Asia. Its relationships till now remain obscure, allthough fairly close relatives have been found elsewhere in tropical Asia. I should like to remark here that Ceylon has been the stage of intensive speciation in ground-dwelling clubionids, especially in the genus Oedignatha (subfamily Corinninae). In spite of Ceylon being fairly well investigated in the past, no close relatives of this strange spider have been discovered on the island yet.

Conclusion

In general, the numerical composition of families and genera of the tropical Asian cave fauna reflets more or less the surface fauna of the concerned regions, particularly that which inhabits analogous habitats like rock crevices, hollow trees and detritus. Many species, particularly grounddwellers with nocturnal habits surely are attracted by the guano as food source. Presence or absence of trogoblitic species probably depends a great deal on the type and the depth of the cave and the nature and the extent of the cave-generating rock. Whereas the cave spider fauna of temperate regions and specifically that of the well investigated Mediterranean fauna consist mainly of Dysderidae, Linyphiidae, Leptonetidae and Agelenidae, all essentially families of temperate climates, in tropical Asian caves these families are replaced by representatives of tropical families.

Some families occur in caves both in temperate and tropical climates: Nesticidae, Pholcidae, Scytodidae and Filistatidae, the latter being typical entrance spiders. The ecologial of the Linyphiidae and Leptonetidae is in the tropics taken over by the Ochyroceratidae and possibly *Theridion rufipes*, the Disderidae are replaced by Scytodidae, the genus *Meta* by the Uloboridae. There are a few surprises: a number of families which are abundant in South Asian ground-habitats and other dark moist habitats such as Zodariidae, Clubionidae s. l., Tetrablemmidae, Anapidae and Tlemidae are, with the exception of one blind tetrablemmid, absent from cave spider records. Spiders of the last three families are pinpoint-sized and easily escape attention.

I believe that S. Asian caves still have a lot of intriguing creatures in store, and that further searching efforts in the right places will lead to the discovery of a variety of exciting novelties.

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Appendix I

Species list of cave spiders collected by F. D. Stone in Thailand 1973-1981

Scytodidae
Loxosceles rufescens (Dufour)
Dictis venusta Thorell?
Ochyroceratidae
Althepus new species
Psiloderces new species (troglobite)
Speocera sp.
Oonopiae Oonopiae
Ischnothyreus new species
Ischnothyreus new species (also in forest)
Dysderoides new species (troglobite, eyeless)
Opopaea new species
Pholcidae
Pholcus subgenus *Pholcus* new species
Pholcus subgenus *Uthina* new species
New genus new species
Physocyclus globosus (Taczanowski)
Gnaphosidae
Zelotes new species *apricorum* group
Palicanus new species
Clubionidae
New genus new species
Ctenidae
Ctenus new species (troglibite)
Ctenus spec.
Eusparassidae
Heteropoda spec.
Heteropoda spec
Panaretidius spec. (troglobite)
Zodariidae
Suffucia spec.
palpimanidae
Boagrius new species
Lycosidae
Hippassa spec. Theridiidae
Theridion rufipes Lucas
gen. spec.
gen. spec.
Nesticidae
cf. *Nesticella aelleni* (Brignoli)
cf. *Nesticella buiconghiensis* Lehtinen
Araneidae
Araneus spec
Anapidae
Pseudanapis paroculus Simon
Filistatidae
Pritha spec.
Uloboridae
Philoponella nasuta Thorell?
Philoponella spec.

Appendix II

Species list of cave spiders collected during the Cambridge Sumatra expedition in 1984 in Aceh and Deli.

Scytodidae
Loxosceles rufescens (Dufour)
Scytodes fusca Walckenaer
Ochyroceratidae
Althepus new species
Pholcidae
Pholcus subgenus *Pholcus* new species
Pholcus subgenus *Uthina* new species
Pholcus subgenus *Uthina luzonica* Simon
Eusparassidae
Heteropoda spec.
Oxyopidae
Oxyopes lineatipes C. L. Koch
Theridiidae
Theridion rufipes Lucas
Psechridae
Psechrus singaporensis Thorell
Amaurobiidae
Titanoeca fulmeki Reimoser
Uloboridae
Zosis geniculatus (Olivier)

ANTROPOLOGIA-
PALEONTOLOGIA

ANTROPOLOGIA-
PALEONTOLOGIA

ANTHROPOLOGIE-
PALEONTOLOGIE

ANTHROPOLOGY-
PALEONTOLOGY

ARQUEOLOGIA
ARQUEOLOGIA
ARCHAEOLOGY

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La grotte «Koumelos» Archangelou - Rhodes

Par Anna Petrochilou et Adams Sampson***
** Spéléologue*
***Archéologue*

RESUM

La cova de Koumelos es troba situada cap al S.E. de la zona costanera del poble d'Archangelou Rhodes, a una altitud aproximada de 120 m.

S'obre a la roca calcària i la seva superfície és de 1.400 m².

Està decorada amb magnífiques concrecions i presenta sis sales amb columnes estalactítiques. Ha estat explorada per Anna Petrochilou l'any 1977. L'arqueòleg Dr. Adam Sampson, l'any 1979, va realitzar excavacions en tres sales fins a una profunditat de 1,80 m. i va descobrir restes de l'època neolítica, micènica i hel·lenística: vasos de ceràmica i de pedra, utensilis d'obsidiana, llars de foc amb cendra, restes d'aliments, caixals de psamita, ossos d'animals i d'ocells, closques, etc.

Aquestes troballes pertanyen a dues èpoques. La més antiga, localitzada en dos nivells, és neolítica. La més recent pertany, possiblement, als inicis de l'edat del Bronze.

A través d'aquestes investigacions s'ha pogut demostrar que la cova ha estat habitada periòdicament des del Neolític fins a l'època hel·lenística.

RESUMEN

La cueva Koumelos se halla hacia el S.E. del litoral del pueblo de Archangelou Rhodes a una altitud aproximada de 120 m.

Se abre en las rocas calizas y su superficie es de 1.400 m².

Está decorada con espléndidas concreciones y presenta 6 salas con columnas estalactíticas. Ha sido explorada por Anna Petrochilou en 1977. El arqueólogo Dr. Adam Sampson, en 1979 realizó excavaciones en tres salas hasta una profundidad de 1,80 m. Descubrió estos restos de la época del Neolítico, Micénico, y Helenístico: vasijas de cerámica, de piedra, utensilios de obsidiana, hogares con cenizas, restos de alimentos, muelas de psamita, huesos de animales y pájaros, cáscaras, etc...

Estos hallazgos pertenecen a dos frases.

La más antigua, que se encuentra a dos niveles es neolítica. La más reciente, quizás, pertenece a la primera época del bronce.

A través de estas investigaciones se ha probado que la cueva ha sido habitada por períodos, es decir, de la época del Neolítico hasta la época Helenística.

SUMMARY

The cave Koumelos is situated towards the South East littoral of the village of Archangelou in Rhodes, at an elevation of 120 m. It is opened into calcair and its surface is about 1.400 m². It is decorated with splendid stalactites and stalagmites. It is divided into six sections by stalactic columns. It was exploited by Mrs. Anna Petrochilou in 1977.

In 1979 excavations took place by the Archeologist Dr. Adam. Sampson, in the three frist sections up to 1,80 m depth. He has discovered findings of the Neolithic, Mycenean and Hellenistic period: earth and stone vases, obsidian tools, hearths with ashes, remains of food, mills of sand stone, bones of animals and birds, shells, etc. These discoveries belong to two phases. The more ancient, which is situated in two levels, is Neolithic. The more recent may belong to the early epoque of Bronze. After these discoveries, it is proved that the Cave had been inhabited in periods. That is to say, from the Neolithic Epoque up to the Hellenistic Epoque.

Site - Accessibilite

La grotte de «Koumelos» se situe au sud-est du village d'Archangelos, à une distance de 6 kms de cette localité, dans une région très escarpée du bord de mer. L'entrée de la grotte se trouve approximativement à une altitude de 120 m. Le village d'Archangelos est relié à la cité de Rhodes par une route asphaltée de 33 kms. Un petit chemin de terre commence à Archangelos et se termine après 4 km. Le reste de la distance jusqu'à la grotte est traversé à pied.

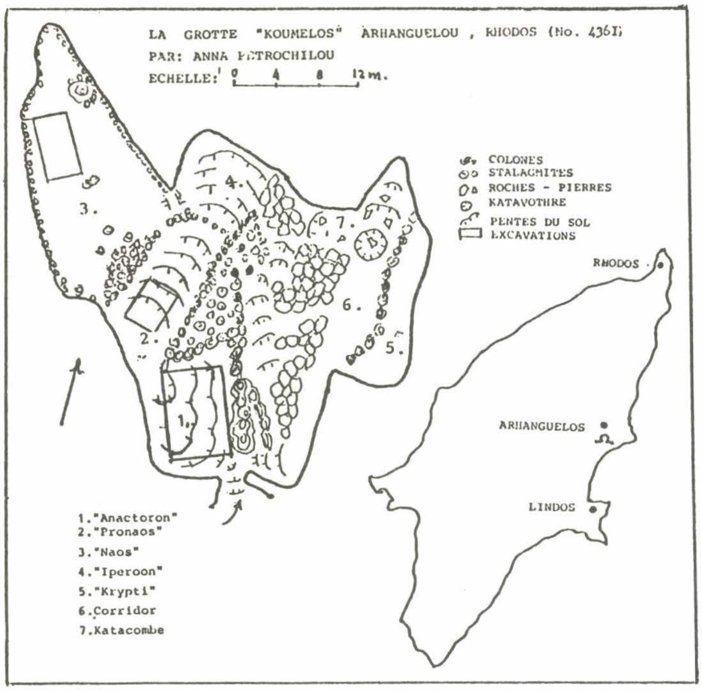
Constitution géologique de la région

La région de l'ouverture de la grotte est constituée de calcaire triasique couvert d'une couche de terre marron, de couches de loupes de chert et de dolomites. Ces couches contiennent des Halobia stiriaca (MOJS) et des Halobia cf. subreticulata (CEMEL). Les formations des asbestes ont été décrites et projetées sur des cartes par E. Mutti, G. Orombelli, R. Pozzi, etc...

Voir «Annales Géologiques des Pays Helléniques, Vol. 22, (1970), (entier).

La Grotte

L'entrée de la grotte est d'une dimension d'1,20 × 1,50 m. Après une descente abrupte, et à une profondeur de 3 m environ, on y trouve la première salle (le «Palais»), dont les dimensions sont de 11 × 8 × 6 m. (longuer, largeur, hauteur) et qui se distingue par ses côtés constitués de merveilleuses colonnes de stalactites. A la gauche de cette salle on trouve une deuxième salle



légèrement en pente, le «Pronaos», d'une dimension de 12 × 5 × 4 m, et un peu plus à gauche encore on trouve la troisième salle d'un niveau horizontal, le «Naos» (Temple), dont les dimensions sont de 19 × 12 × 4-6 m. Ces deux salles sont richement décorées par de magnifiques formations de stalactites. Au plus haut point du «Pronaos» se trouve une rangée de minces colonnes qui séparent le «Pronaos» du «Hyperoon» (partie supérieure de la pièce) dont les dimensions sont de 7 × 8 × 2,50 m. Le côté droit de la grotte, qui a une dimension de 25 × 15 × 3-7 m, est divisé en trois longues sections, par deux rangées de très belles colonnes de stalagmites. Sa partie gauche est couverte de pierres de grande et petite dimensions, qui se sont brisées et sont tombées du plafond. Sa partie droite est une salle appelée «Crypte». En son milieu un corridor mène vers les «Catacombes» dont l'ouverture abrupte a une profondeur accessible de 18,50 m. La surface totale est de 1.400 m^2 (mètres carrés).

Création de la grotte

La grotte a été ouverte par une corrosion qui s'est produite du nord au sud. Les eaux de pluie sont entrées initialment par de petites fissures ouvertes dans la partie la plus haute de la grotte. La corrosion et la pression des eaux qui se sont accumulées progressivement dans la large cavité, ont creusé la grotte de haut en bas sur un angle escarpé. La grotte s'est en même temps élargie vers la droite et vers la gauche. Le phénomène de corrosion a été aidé par les eaux qui s'écoulaient des fissures ouvertes tout le long de la grotte. Le processus d'ouverture a pris fin lorsque les eaux, qui sont entrées en action dans ce processus, ont commencé à s'échapper des fissures produites dans les parties les plus basses du «Pronaos» et du «Naos», et encore bien plus des «Catacombes» où se trouve un fossé d'une profondeur verticale accessible de 18,50 m. Les gouttes d'eau qui tombaient des fissures du plafond ont créé des rangées parallèles de splendides colonnes de stalagmites qui ont séparé la grotte en plusieurs parties. Simultanément les petites et les plus grandes pierres qui se sont détachées du plafond ont été partiellement recouvertes d'un décor de stalagmites. L'entrée de la grotte a été ouverte bien plus tard. La raison en est la suivante:

Du fait de la corrosion, une grande partie du sol au nord-ouest de la grotte –qui n'avait pas d'entrée à ce moment-là– s'est brisée et effondrée. Ceci a provoqué une grande ouverture verticale en direction de la grotte, qui l'a ainsi reliée à la surface terrestre. De nombreux fragments ont roulé vers l'intérieur de la grotte alors que d'autres –les plus grands– se sont glissés eux-mêmes dans la partie la plus basse de l'ouverture laissant seulement un dégagement dans sa partie la plus elevée, qui est l'entrée d'aujourd'hui cet fait a été prouvé par la grande pierre qui se trouve dans la partie la plus basse de l'entrée de la grotte et conserve encore aujourd'hui la même morphologie et correspond au vide laissé dans cette partie du plafond d'où la pierre s'est brisée et effondrée. Les eaux de pluie qui s'infiltraient à l'intérieur de la grotte ont entraîné d'autres matériaux avec elles (terre et galets) qui, progressivement et tout doucemenet ont recouvert les parties les plus basses de la grotte et ont atteint une hauter d'environ 2 m.

L'accumulation de ces matériaux, à ce stade, a finalement recouvert les traces humaines des peuples qui ont utilisé la grotte en tant que domicile au cours de l'époque néolithique et des périodes ulterieures.

Ces traces sont revenues à la lumière au cours des fouilles dirigées en 1979 par l'Archélogue Adams Sampson, qui a exploré les 3 premières salles: c'est-à-dire le «Palais», le «Pronaos» et le «Naos».

Usage périodique de la grotte Koumelo pendant l'age néolithique

Des traces d'usage de l'antiquité ont été remarquées dans la grotte Koumelos dès le debut de sa découverte. Il y avait des céramiques préhistoriques et héllénistiques très proche de l'entrée. Dans les salles 2 et 3 le sol était aplani par des terres qui y entraient avec l'eau de la pluie et il n'y avait sur la surface aucune trace antique. Mais on a supposé que les dépôts antiques se trouvaient dans une plus grande profondeur et on a commencé l'excavation à la salle 2 qui était assez éclairée par l'entrée. Les premières couches qui ont été retranchées avaient une couleur brune et rouge et contenaient des cailloux qui provenaient du dessechement des roches autour de la grotte. Il y avait quelques tessons héllénistiques dans une prof. 0,10-0,15, tandis que dans une prof. 0,20-0,30 il y avait un niveau d'habitation. Dans une plus basse couche il y avait des céramiques de l'ère mycenienne prématurée et dans quelques endroits une fine blanche couche qu'il s'agit, comme on vera plus tard, de cendre volcaneux.

Dans une profondeur 0,50 il y a une pure couche néolithique et aussi dans une prof. 0,65 il y a un niveau bien tracé avec un foyer ellipsoïde crée des couches de cendre. Les remblais au niveau 2 correspondent à une habitation périodique ou continue et représentent une période de conditions climatologiques sèches. Les fines couches de dépôts de la pluie sous le niveau 2 montrent qu'il n'y avait pas une activité humaine dans la grotte pour une grande intervalle probablement. Les dépôts seraient plus nombreux à des périodes plurieuses mais dans ce cas encore leur grosseur ne serait pas non plus grande, parce que la plus grande partie des remblais s'entaissait dans la salle 3.

Dans une prof. 0,85 il y a un troisième niveau d'un gros remblai de couches de cendre. Sur ce niveau il y a une vive activité qui a rapport avec un emmagasinnage ou une conservation d'aliments puisqu'il y a de grands morceaux de zarre et aussi des zarrers entières. Si on observe ces zarres-là avec leurs pointues ou arrondies bases on remarque qu'elles se posaient sur des pierres ou étaient suspendues du plafond de la salle. Les os d'animaux ne sont pas très abondants (ils appartient surtout aux caprins) et cela montre que les habitants ne consommaient dans la grotte qu'une quantité très petite d'aliments et qu'ils avaient un certain bivouac en plein air non loin de la grotte. L'essentiel c'est que dans la plus basse partie du niveau 3 on a découvert deux dents humaines sans d'autres restes de squelette. Puisque le cas d'avoir un arrachement des dents exprès en raison de leur bon état, il faut chercher l'existence d'une première ou deuxième inhumation. De même ceci est remarquable dans une autre grotte de Rhodes (Kalythies) oú les restes humaines étaient plus nombreuses. Il faut supposer qu'en Koumelo les hommes à la première phase utilisaient la grotte pour des inhumations. Probablement cela se passait après dans des périodes où la grotte n'avait aucune autre utilisaton.

Le niveau 3 représente une phase néolithique qui correspond au Néolithique Récent Aegéen 3 (4000-3600 av. J.C.). Un autre niveau 4 appartient à une phase prématurée de la même période, trouvé à une prof. 1,25, et représente la plus ancienne activité de l'homme dans la grotte. Déjà au niveau 4 des stalagmites sont apparus, crées sur des stalactites tombés du plafond, qui cachent presque toute la section de sorte que la fouille soit impossible.

Les couches sur la section B de la salle 3 ont montré presque la même séquence. La couche superficielle (gross. 0,40-0,45) contenait de la terre qui s'accumulait avec les eaux de la pluie. L'absence de céramique est caractéristique ce qui entraîne que dans les périodes de l'ère mycénienne prématurée et après la présence de l'homme dans cet endroit est inexistante.

Au commencement, la présence de la couche de fins grains blancs a été au moins problématique. Cette couche avait une grosseur 0,70 et dans sa plus grande partie ell était pure. Après beaucoup de suppositions, des échantillons ont été donnés dans des laboratoires spécialisés et cela a prouvé qu'il s'agissait de cendre volcaneux. En ce qui concerne sa provenance, la recherche dans des laboratoires et d'autres recherches récentes ont montré que cette couche a rapport avec d'autres qui ont été trouvées et analysées en Crète et dans d'autres îles de Dodécanese (Kos, Tilos, Chalci, Karpathos). Ces cendres sont datés de l'époque de l'explosion du volcan de Santorini, environ 1500-1450 av. J.C. Il parait que la direction des vents à cette époque était sud-ouest ce qui résulte que ces vents ont transporté le cendre et l'ont déposée dans les îles de Dodécanese, à une distance de 250 Km.

On suppose qu'une grosse couche a caché le territoire de Rhodes, détruisant ainsi cultivations et animaux. La grosseur du cendre paraît aussi dans la ville minoenne à Trianda de Rhodes fouillée ces dernières années et sa presence en ce lieu constitue un témoignage chronologique. En ce qui concerne la présence du cendre dans la grotte qui à première vue paraît difficile à expliquer, il faut préciser que ceci se justifie de la place de l'entrée dela grotte qui rassemble des depôts tout autour. L'énorme quantitée du matériel dont si on compte les dimensions de la salle 3 peut s'élever à cent mètres cubes et plus, s'explique seulement des pluies torrentielles qui ont suivi l'explosion ce qui en résulte l'assemblage des masses du cendre dans la salle 3 à cause de son plus bas niveau. Ceci montre aussi la plus basse et la plus grosse partie de la couche qui est pure tandis que la plus haute partie est mélangée avec de la terre qui est entrée paraît-il progressivement dans la grotte.

La caractéristique de la couche blanche est qu'elle a bien dominé les niveaux néolithiques qui se trouvaient juste sous elle. Un niveau d'habitation apparaît à une prof. de 1,55. Il y a des os d'animaux, des coquillages et assez de céramique de la phase Néolithique Récent 4 autor d'une structure arrondie qui pourait être utilisée comme un foyer ou un four. Plus profondément, il y a d'autres niveaux avec beaucoup de restes de brûlure. Sur la dernière couche, avant le sol de la grotte, il y a de l'argile produite à la même place et probablement ceci présuppose un climat humide et chaud.

Conclusions

La recherche à Koumelos a montré qu'aux temps néolithiques les hommes entraient rarement dans la grotte et utilisaient surtout la salle 2. Dans la salle 3 les conditions de demeure sont désagréables à cause de l'humidité et de l'obscurité dense. Dans cette salle l'allumage de feu aurait été difficile, sauf si pendant ce temps les conditions étaient différentes et si la salle s'aérisait bien. De toute façon les traces d'usage humaine sont très peu ici. Aux temps postérieurs, la présence de l'homme dans cette salle serait presque inexistente contrairement à la salle 2 où l'homme, après une pause durable dans l'âge du bronze ancienne et moyenne, a fait son apparition dans l'âge du bronze récente et en suite dans l'ère hellénistique.

L'activité des hommes se localise surtout aux temps néolithiques (Néolithique Récent 3 et 4). On peut supposer une rare habitation dans la grotte à cause du petit nombre des trouvailles et aussi à cause de remblais fins. La grotte est facilement accesible, elle se trouve à côté de la mer et est éclairée dans sa plus grande partie, tandis qu'elle a une orientation méridienne donc elle est convenable pour y demeurer. Mais elle a été utilisée plutôt par circonstances. Les raisons de son abandon ne peuvent être expliquées facilement. Si l'on accepte que les grottes en Grèce ont été utilisées seulement de temps en temps comme des demeures surtout par des bergers ou de pêcheurs (Korikio, grotte de Kitsos, Tharounia, Franchthi, grotte de Kastria) on peut dire que cette raison n'est pas possible à Koumelos parce que dans la grotte il n'y a pas assez de restes. Il faut accepter dans la région autour de Koumelo une petite communauté de bergers ou de pêcheurs qui sont spécialisés à cette espèce de la production d'aliments comme nous montrent l'usage des restes d'autres grottes de la région et aussi des petites installations à côté de la mer. Probablement les pêcheurs et les bergers appartenaient à une région plus étendue («site territory») controllée d'un logis central qui se trouvait à l'intérieur. Donc, ces homes entraient rarement dans la grotte et ceci tantôt pour enterrer leurs morts tantôt pour emmagasinner des aliments ou pour prendre de l'eau des stalactites et tantôt pour échapper à la colère divine et aux maladies. Aujourd'hui même, les visiteurs les plus habituels de la région autour de Koumelos sont encore des pasteurs qui entretiennent surtout des chèvres à cause de la rudesse du paysage.

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Speleoarchaeological Investigations in Belize

Logan McNatt
Thomas Miller

RESUM

Balize va ser un dels centres de la cultura Maia fa mil anys. La seva civilització es va desenvolupar en les grans regions càrstiques Meso-americanes, les quals varen exercir una profunda influència sobre la concepció Maia del seu món físic i es troben paleses en la seva cosmogonia.

Les investigacions sobre la geologia càrstica de Belize surten beneficiades de la simbioasi existent amb la vessant arqueològica: valuoses informacions culturals provenen de la investigació de les cavitats i aquest progressiu coneixement de les pràctiques agrícoles pre-colombines i la seva localització tenen implicacions importants per a l'estudi dels processos geomorfològics.

RESUMEN

Belize fué uno de los centros de la cultura Maya hace 1.000 años. Su civilización se centró en las grandes regiones kársticas Meso-Americanas, las cuales ejercieron una profunda influencia sobre la concepción Maya de su mundo físico, y están expresadas en su cosmogonia.

Las investigaciones de la geología kárstica en Belize se benefician de una simbiosis con la arqueología: valiosas informaciones culturales resultan de la investigación de cavidades, y este progresivo conocimiento de las prácticas de agricultura Pre-Colombianas y de las localizaciones, tienen importantes implicaciones para el estudio de los procesos geomorfológicos.

SUMMARY

Belize was one of the centers of Maya culture 1.000 years ago. Their civilization was located in the great Meso-American karst regions, which exerced a profound influence upon the Maya conception of their physical world and is expressed in their cosmogony.

Geologic karst research in Belize shares a serendepitous symbiosis with archeology: valuable cultural information is produced by cave investigations, and this increasing knowledge of Pre-Columbian agricultural practices and locations has important implications for study of geomorphic processes.

Throughout Meso-America there is abundant evidence of the use of caves in this great karst region by the Maya. This usage has in some form spanned nearly two millenia, continuing in isolated areas to the present. The era of florescence of the Maya culture in known as the Classic Period, occupying approximately the interval of 300-900 A. D. Most evidence for Mayan cave usage dates from the Terminal Classic to Post-Classic, about 700-1000 A. D.

Based upon archeological evidence, colonial records, and modern anthropological research, it appears that Maya visitation was chiefly for ceremonial of religious purposes. Among these were collection of *zuhuyha* (literally «virgin water») from drips for use in ceremonies performed in the caves, as offering sites, and as crematoria, ossuaries, or burial sites. In Belize, as in the Yucatan, they also undoubtedly served as important sources of water for everyday use, especially during the dry season. Clay mining has also been found. The presence of middens is rare, indicating little extended occupation.

Collectively, the Maya may well have been the world's greatest cave explorers. In Belize, most caves not known to have been visited by the Maya are those where surch evidence could conceivably have been destroyed by flooding, or which present mayor physical difficulties in exploration. Evidence exists of Maya penetration to distances of 2 km from the nearest entrance. Pits to 150m depth were descended, apparently by ledges and ladders. The latter were also used to reach remote alcoves and ledges. The long deep lakes of Belize's river caves were apparently the greatest obstacle to exploration. Lighting was accomplished by use of pine torches, and prints show that exploration was barefoot.

Artifacts

Abundant material remains from the Maya visits, much of it incompletely studied. An initial division is that of separation of actual modification of the cave environs from worked offerings. Cave modification consisted of sometimes extensive construction of walls, platforms, terraces, and rooms. Carving of glyphs, wall paintings, and in one instance, clay mining, are other forms. Thirtythree terraces were noted in one room in Belize alone.

Of the second group of remains, ceramics form by far the greatest quantity, including bowls, dishes, pots, vases, effigies, ocarinas, incensarios, etc. Most are unslipped or plain, but impressed designs and even polychrome paintings have been encountered. Unfortunately, ritual destruction of vessels was common, and the vast majority of ceramics lie as smashed, scattered sherds.

Lithics (manos and metetes, celts, blades and spearpoints, barkbeaters, etc.) form the next largest category. Inscriptions on rockslabs and carvings and emplacement of speleothems are also encountered.

Bone, shell, and stone ornaments are found as beads, pendants, and earplugs. Wood is rare and fabric even more so, probably reflecting the difficulties of preservation.

Burials are relatively common of both whole and partial skeletons and skulls, and of all sexes and ages. Associated artifacts in cave burials are rare to non–existent.

Preliminary conclusions to be drawn from cave archeological sites in Belize are that they exhibit relative poverty in comparison to surface temple and ceremonial centers. Elaborate tombs are unknown, the pottery *generally* has a distinct utilitarian appearance, and paintings and worked materials are not of particularly high artistic quality. It has been suggested that caves served the domain of folk culture and shamanistic practice as opposed to the surface constructions of the elite.

Ceramic evidence has generally shown some independence of style and construction from the major known surface sites. Groupings or area boundaries within the cave regions have been tentatively suggested. Because known surface sites within these regions are infrequent and usually small, the ceramics from caves in these areas may ultimately prove to be numerically important in establishment of type sequences.

Stylistic evidence dates most of the ceramics as from the Terminal Classic to Post Classic (800-950 A. D.), but less abundant sherds and radiocarbon dates indicate sporadic use in the Preclassic, increasing to the late Classic. A special problem in cave archeology is the absence of stratigraphic horizons, causing material of different ages to appear time-synchronic.

Geologic Factors in Location

Geologic constraints have been resposible for the geographical distribution of Maya cave sites in Belize. Cretaceous limestones fronting the Maya Mountains of southern Belize host nearly all of the caves in the country. The caves have existed for perhaps millions of years: it is important to note that they greatly predate human occupation of the Western Hemisphere. The Mayan use of the caves is so recent, geologically, that no significant physical change has occurred since that time: we view essentially the same environment as that seen by the Maya.

Geological investigations of Belize caves have been sufficient for a basic outline of cave development there. Various classes of caves occur, influenced by lithology, geologic distribution, climate, etc. The major element in cave development has been the profound influence of invading streams flowing onto the limestone from the higher non-carbonates: these form extensive caverns widely used by the Maya. Isolated collapse chambers of phreatic, but otherwise incompletely understood, origin, are the other major category of importance for Mayan cave studies.

Other than the obvious shelter from weather that the caves provide, physical characteristics of Belizean caves aiding archeological preservation are the constant temperatures (22°-26° C.) and humidities of close to 100 %. Flooding is a problem in some areas in the river caves, and have resulted in alluviation, transport, or destruction of artifacts up to 30 meters above normal river level.

Although surface water is nearly absent from the karsts of Belize, the large aquifer storage of the limestone has created numerous perennial springs in the caves which must have attracted the Maya. The bicarbonate spring and dripwater (which leaves a white rime when boiled or heated) and the diffuse origins (giving a purity unknown in surface streams) may have been at least partially responsible for the respect in which it was held by the Maya.

Conclusion

Geologic investigations in Belize have contributed to archeology by aiding in location of potential sites and explaining the influence of physical phenomena. In contrast, stylistic ceramic sequences, and radio-carbon dates, have enabled calculation of the rate of operation of geomorphic processes (e. g. speleothem precipitation and alluviation) in the recent past.

A serious threat to cave archeology in Belize, and throughout Central America, is the looting of artifacts for sale to North America and Europe. This has been increasing since the early 1960's, and nearly half of the registered cave sites known in Belize have been damaged.

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1323

Cave Archaeology in the Eastern Woodlands of North America

Patty Jo Watson

Departement of Anthropology, Washington University St. Louis, Missouri, U.S.A.

RESUM

Alguns dels més antics jaciments arqueològics del nou món són coves i abrigalls com els de Meadowcroft a Pensilvània, amb una seqüència que comença entre 12.000 a 15.000 B.P. i la cova Guitarreo al Perú, amb dates tant llunyanes en el temps de 10.000 i fins i tot 12.500 B.P. Coves seques i aixo lucs, dins la gran varietat del clima forestal de la zona de l'Est dels E.E.U.U. ens proporcionen una excel·lent informació estratigràfica i cultural, difícil d'obtenir en d'altres jaciments a cel obert. En aquest treball es facilita una informació completa, fent especial esment al Sistema Mammoth Cave de Kentucky i noves informacions d'altres coves en la part central de l'Oest i el Sud.

RESUMEN

Algunos de los más antiguos emplazamientos arqueológicos en el Nuevo Mundo son cuevas y abrigos tales como Meadowcroft en Pensilvania con una secuencia que empieza entre 12.000 a 15.000 B.P. y la cueva Guitarreo en Perú, con fechas tan lejanas en la antiguedad como 10.000 hasta 12.500 B.P. Cuevas secas y abrigos en la gran variedad de clima forestal en la zona del Este de U.S.A. son una fuerte información estratigráfica y cultural que no obtenemos de los emplazamientos abiertos. Se facilita una información más completa haciendo hincapié en el Sistema Mammoth Cave de Kentucky y una nueva información de otras cuevas en la parte central del Oeste y Sur.

SUMMARY

Some of the oldest archaeological sites in the New World are caves and rockshelters, such as Meadowcroft in Pennyslvania with a sequence beginning about 12.000 to 15.000 B.P. and Guitarreo Cave in Peru with dates as far back as 10.000 to 12.500 B.P. Dry caves on rockshelters in the extensive temperate forest zone of the Eastern United States contain an array of stratigraphic and cultural information not available from open sites. On overview of this information is provided, with emphasis on the Mammoth Cave Systen of Kentucky and on new data from other caves in the Midwest and Midsouth.

When people entered the New World about 15.000 years ago, caves and rockshelters in North and South America became depositories for the records of their lives. In the temperate climate of the Eastern Woodlands in North America, preservation of ordinarily perishable prehistoric material occurs only in dry caves and rockshelters, so they are extremely important to an understanding of regional culture history.

Over the past 12.000 years these caves and rockshelters have served as campsites and homes, as mines or quarries, as mortuary facilities, and as shrines or ceremonial retreats for native American peoples. In the last 200 years, some of those same caves and rockshelters have also been used by the invading European population of North America as livestock corrals and occasionally as dwellings or hideouts, as water-sources, as mines, and as tourist attractions. This recent use has, of course, often obscured and destroyed older cultural materials. Nevertheless, a growing body of evidence demonstrates that prehistoric human groups freely entered, explored, and thoroughly used most if not all the accessible caves and shelters provided by their natural environments.

Caves as prehistoric mines and quarries

That there were archeological remains in Mammoth Cave and Salts Cave, west central Kentucky, has long been known by specialists in eastern U.S. prehistory. Between 1875 and 1912, large quantities of artifacts were removed from these caves (especially Salts Cave) by or for F.W. Putnam of the Peabody Museum at Harvard University and Colonel Bennett Young, a private collector of Louisville, Kentucky (most of Young's collection was later acquired by the Museum of the American Indian in New York City). Nels C. Nelson of the American Museum of Natural History excavated the entry chamber or Vestibule of Mammoth Cave in 1916.

More recent archeological work (1963 to the present, Watson et al., 1969; Watson ed. 1974) has documented patterns of exploration and mining in wath is now known to be the world's longest cave –the Mammoth Cave System, including, among others, both Mammoth Cave and Salts Cave– that date between 4.000 and 2.000 years ago. The local population entered the cave repeatedly to mine gypsum (and, doubtless, also the other useful sulfates found there such as mirabilite or Glauber's Salt and epsomite or Epsom Salts), to quarry chert, and perhaps just to explore. They left behind a profusion of torch and campfire debris, fragments of their footgear and other clothing, wooden containers and gourd and gourd-like squash bowls, paleofecal deposits yielding a wealth of dietary information, and –in at least two caves– individual members of the prehistoric human population.

On numerous occasions, the Vestibules of both Salts Cave and Mammoth Cave served as campsites or homes for small aboriginal groups, who left midden deposits one meter or more deep incluiding stone and bone tools and the debris of processing animal and plant foods.

The exploitation pattern followed at Wyandotte Cave in southern Indiana (Munson and Munson 1981) is similar in some ways to that evidenced in the Mammoth Cave system, but exhibits interesting refinements, the most striking of which is the mining of a massive aragonite column (now known as The Pillar of the Constitution) in a room one kilometer from the entrance (Blatchley 1899). Recent investigations in Wyandotte have resulted in more detailed knowledge of prehistoric activity in this large cave. Chert and aragonite were systematically and intensively removed 2000 to 3000 years ago, much of it a problaby traded to various other places in the Midwest (Munson, Munson, and Tankersley 1985; Tankersley 1983).

Another cave with abundant evidence for prehistoric mining activity is Saltpeter Cave in north central Tennessee, where large quantities of chert were dug from the sediments in a big underground room not far from the entrance (Ferguson 1983). Besides quarrying chert nodules, the aboriginal miners undertook preliminary working of the chert in the cave, so that there is an abundance of workshop debris on the cave floor and on the more or less level surfaces or large breakdown boulders in the quarry room. Radiocarbon dates for Salpeter Cave range from 2400 B.C. to 800 B.C.

Intermittently during the nineteenth century, fragments of the skeleton of a giant sloth were found in a large, dry cave in Tennessee that came to be called big Bone Cave. Henry Mercer of the University of Pennsylvania excavated parts of the Cave in 1879 in an attempt to establish the relationship between the sloth remains and the abundant materials left by prehistoric human activities in the same passages (Mercer 1897). He was unable to document contemporaneity of sloth and human, and the archeological as well as the paleontological remains were then ignored for nearly 100 years. During the summer of 1982, however National Speleological Society cavers who were mapping the cave were sufficiently impressed with the quantity and state of preservation of the archeological materials to contact archeologists with experience in Tennessee and Kentucly caves.

As a result of their concern, an investigation of Big Bone Cave archeology has been initiated by Charles Faulkner and George Crothers (University of Tennessee 1983). Robert Stuckenrath and the Smithsonian radiocarbon laboratory have provided C-14 dates as follows: 1615 ± 60 years: A.D. 335; 1595 ± 55 years: A.D. 355; and 440 ± 55 years: A.D. 1510. In addition, several dates from Beta Analytic document aboriginal activity in the cave during the first millennium B.C. (the six Beta dates range from 1050 B.C. to 170 B.C.). Hence, it appears that Big Bone Cave was explored at least intermittently for some 2500 years. So far there is no clear evidence for mining of gypsum or other cave resources, but the cave has been severely disturbed by saltpeter mining and other recent use. It is possible that most of the traces of aboriginal mining have been destroyed.

Footprint Caves

There is another category of cave archeology in the eastern United States that might be called «footprint caves» (Watson 1983). Jaguar Cave and Fisher Ridge Cave in Kentucky, and Sequoyah Cave in Alabama fall into this class. Archeological remains comprise torch fragments (charred and uncharred), torch smudges on passage walls and ceilings, and prints in mud of the bare or slippered feet of the aboriginal cavers. There are approximately 274 complete footprints (of nine diferent people) in Jaguar Cave, about eighteen in Fisher Ridge Cave, and less than half-a-dozen in Sequouah Cave. Footprint caves indicate little more than prehistoric interest in and exploration of local caves, although the abundance and excellent preservation of these traces in Jaguar Cave means that some interesting physical anthropological information can also be derived from them (Robbins et al. 1981). Radiocarbon dates indicate time spans for such exploration from ca. 2500 B.C. to A.D. 1430.

Mortuary Pits and Caves

Another category of archeological materials in caves features human remains. Some caves seem to have been used primarily as disposal places for the dead. This is the case for at least two pit caves on Prewitts Knob near Cave City, Kentucky: Crystal Onyx Cave and Pit of the Skulls (Haskins 1983). The one available radiocarbon date (on bone from Crystal Onyx Cave) is 680 B.C. Thus it appears that the people placing their dead in the pits on Prewitts Knob were al least partially contemporary with the major prehistoric caving activity in the Mammoth Cave system. The present evidence consists of fragmentary skeletal remains (cranial and post-cranial) representing people of both sexes and all ages. The bodies were placed in, or thrown into, pits that have small openings on the surface of the Knob. No grave goods accompany the bones, but there are scatters of chert flakes including occasional tools (projectile points and retouched flakes, for example) in various places on the Knob surface. The chert nodules that furnished the raw material for these items also outcrop on the Knob.

Several aboriginal bodies were found by saltpeter miners in Short Cave (which is adjacent to but outside the southern border of Mammoth Cave National Park) during the nineteenth century. Details are lacking for these finds (see Meloy and Watson 1969; Meloy 1971), but what information is available suggests a late prehistoric placement for at least one of the bodies, which was laid away in a stone-box or stones-slab grave. Similarly, in several Alabama and Georgia caves, the honored dead were ceremoniously interred some 1500 years ago during what is now known as the Copena period (Walthall and DeJarnette 1974).

In Sinking Creek Cave near Bowling Green, Kentucky, recent activity by vandals has exposed and largely destroyed the remains of several prehistoric graves (Wilson 1982; Hensley-Martin in press). This site is somewhat like Short Cave in that it consists of a short piece of trunk passage, open at both ends, that was used as a chert quarry, and as a habitation and burial place by some members of the local prehistoric population. There are no available radiocarbon determinations for Sinking Creek Cave as yet, but the archeological materials indicate an aproximate time span of several thousand years B.C. down to about 1500 years ago.

Ceremonial Caves

In contrast to what we know about the business-like aspect of aboriginal activities in many of the caves just briefly described, Mud Glyph Cave in eastern Tennessee offers clear evidence for ritual or ceremonial use (Faulkner, Deane, and Earnest 1984). Most of the people who went into Mud Glyph Cave seven centuries ago apparently did so for only one purpose: to communicate with or to approach the supernatural.

Aboriginal activity in Mud Glyph Cave dates primarily to the 13th century A.D. and was carried out by the ancestors of the modern Creek or Cheroke (or both). These people incised hundreds of drawings on the mud-covered walls of a 100 meter long passageway, well back in the dark zone of a small, wet cave. The fragile marks have been thoroughly recorded by photographs and maps in an exemplary cooperative project between archeologists and cavers; they are well protected by vigilant landowners and a cave gate designed and constructed by National Speleological Society cavers.

The glyphs are a bewildering palimpsest but include numerous motifs well-known from the iconography of the late prehistoric Mississippian peoples who were ancestors to the Cherokee, Creek, and other historic native American groups. Some of the *dramatis personae* and motifs from historically-recorded mythology are present: horned serpents, turtles, bird men («eagle dancers»). As in the painted caves of France and Spain, it appears that the act of drawing was more important than the finished representation.

Historic Indians of the Southeast believed that springs and caves were entrances to the Underwold. They had great respect and fear for the beings who dwelt below, and who might emerge from the passageways beneath the earth. The evidence from Mud Glyph Cave suggests that at least in a few times and places in the Eastern Woodlands, aboriginal groups must also have regarded caves as places close to or giving access to an underworld inhabited by awesome and powerful beings.

Conclusions

Even such a brief survey as this one is sufficient to indicate the variety of archeological materials in the caves of Eartern North America, and to convey the uniqueness and fragility of many of these remains. Contrary to widely held opinion, ancient people were not universally fearful of caves. Quite the contrary, for several millennia at least, the aboriginal population of the Eastern Woodlands had quite a business-like attitude toward the subterranean world and its resources. It is not until the very latest prehistoric periods that we have any evidence for attitudes of awe, respect, and--perphaps--fear of caves.

Subterranean archeology is more difficult, and occasionally more dangerous, than archeology above ground. But the rewards for the underground archeologist are tremendous: in the unvarying cave environment there is total preservation of ordinarily perishable objects; we also know that those earlier cavers encountered exactly the same physical conditions 500, 1000, 2000, 4000 years ago as we do now. The world beneath the earth's surface presented exactly the same challenges to them as to us, yet seemingly also offered them hidden resources and secret treasures that we can never wholly comprehend.

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La cueva de Román, Clunia. Objeto de una gran obra de ingeniería romana

G.E. Ribereño

RESUM

La cova de Roman s'obre seguint un pla d'estratificació horitzontal, en el subsòl de la ciutat romana de Clunia.

Va constituir una important reserva d'aigua de cara a satisfer les necessitats hídriques dels habitants d'aquesta gran ciutat, ja que, fa 2.000 anys, els enginyers romans van explorar la pràctica totalitat de la seva extensa xarxa de galeries inundades i van obrir túnels i canls al seu interior per a fer així possible l'explotació de tant singular dipòsit natural.

RESUMEN

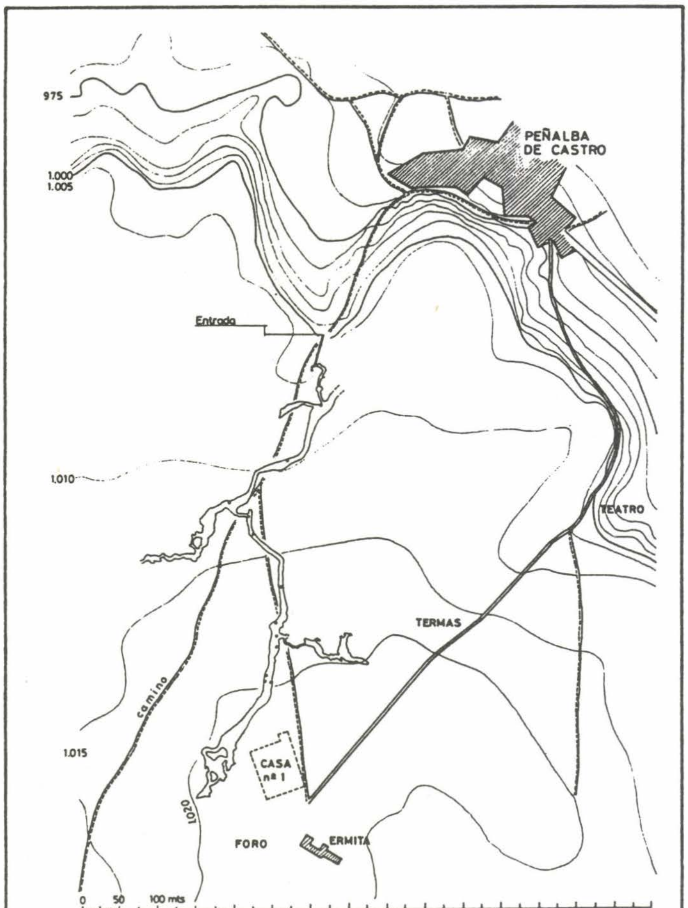
La cueva de Román se abre a favor de una junta de estratificación horizontal, en el subsuelo de la ciudad romana de Clunia.

Constituyó una importante reserva de agua para satisfacer las necesidades que se presentaron a los habitantes de esta gran ciudad, ya que, hace 2.000 años, los ingenieros romanos exploraron la práctica totalidad de su amplia red de galerías inundadas y abrieron pozos, túneles y canales en su interior para hacer posible la explotación de tan singular depósito natural.

SUMMARY

The cave of Román was carved, helped by a joint of horizontal stratification, into the subsoil of the ancient Roman city of Clunia.

It constituted an important reserve of water to satisfy the needs of those who lived in that great city two thousand years ago. The whole extensive network of swamped galleries was explored by Roman experts; and also, tunnels and water-courses were dug inside to make possible the running of such a peculiar natural deposit.



Un gran foro de casi 200 mts. de longitud con una amplia basílica jurídica, un teatro con capacidad para 9200 personas, dos impresionantes edificios termales comparables a las grandes construcciones de las ciudades itálicas o norteafricanas indican el carácter administrativo de la gran ciudad de CLVNIA, de 130 Ha. de extensión, de la que sólo quedan poco menos que los cimientos de su arquitectura.

Un centro urbano de estas características necesitaba un eficiente suministro de agua, servicio que llega a ser problemático en el caso de Clunia, ya que su emplazamiento supera en altitud a los manantiales existentes en varios kilómetros de distancia. La ausencia de acueductos o de complicadas obras de ingeniería ha llevado a la investigación científica a buscar por otro camino la explicación del sistema de abastecimiento utilizado por los romanos.

Es así como en 1913, D. Vicente Hinojal, conociendo la existencia de una galería subterránea (la Cueva de Román) se interna en ella con el propósito de resolver este problema y dar una explicación a la función que pudieran tener varios pozos abiertos en la superficie de la Ciudad. Tras explorar unos 200 metros de galerías y descubrir los primeros lagos subterráneos, Hinojal concluye que «Desde hoy se puede contestar categóricamente que la ciudad disponía de un abundantísimo caudal de aguas sin necesidad de hacer uso de las pluviales ni de la del río Arandilla y manaderos; pues estamos encima de una gran laguna subterránea, quedando con esto explicado el objeto de los tragaluces».

Sin embargo, Ignacio Calvo, que excava en Clunia en 1915, no cree en las afirmaciones de Hinojal. Posteriormente, D. Blas de Taracena excava en la entrada de la cueva descubriendo jambas de piedra de una compuerta de salida de aguas, sin profundizar más en la resolución del problema.

En 1958 D. Pedro de Palol comienza a dirigir las excavaciones de Clunia. Identifica las pequeñas termas del Foro y más tarde descubre el gran conjunto de termas de «Los Arcos», por lo que adquiere especial importancia desvelar definitivamente el sistema utilizado para satisfacer la necesidad de tal cantidad de agua.

En 1976 y 1977 se hacen varios intentos de exploración por parte de su equipo arqueológico, pero las dificultades encontradas requieren la colaboración de un grupo espeleológico preparado material y físicamente, por lo que el G.E. Ribereño, interesado en el estudio de esta cavidad, viene desarrollando desde 1981 un plan de exploración, fotografía y topografía del subsuelo de la ciudad romana. Siempre con la asesoría científica del profesor Palol y su equipo.

Es así como se reconoce el túnel de acceso a la cavidad y los primeros embalses y pozos descubiertos ya por Hinojal. Se encuentran nuevas galerías, canales tallados en el suelo, pozos que comunican con la superficie, en resumen, la adaptación humana de formaciones naturales que seguidamente pasamos a describir.

La cueva de Román se ha creado a favor de una junta de estratificación en los horizontales bancos calizos que se hallan asentados sobre estratos arcillosos y margosos del Mioceno.

Sus galerías suelen presentar una potente sedimentación arcillosa de descalcificación que favorece su estanqueidad, por lo que el agua de infiltración queda embalsada formando lagunas que cubren por completo extensas áreas de la cueva y que llegan a alcanzar hasta 4,5 mts. de profundidad.

Consta de una gran galería de unos 800 mts. de desarrollo, que hemos dado en llamar Principal, en la que predomina la dirección N-S. y de la que parten otras derivaciones de mayor o menor importancia, en ocasiones laberínticas, y todas ellas de las mismas características, es decir, abundante sedimentación arcillosa, desarrollo horizontal y predominio de grandes anchuras respecto a la altura de la bóveda, habiendo casos extremos en que la anchura es de 25 veces mayor que la altura.

El desarrollo topografiado alcanza los 1.600 mts. aunque la exploración, sin estar aún concluida, hace suponer un desarrollo total de unos 3.000 mts.

Los romanos al tener conocimiento de la existencia del embalse subterráneo practicaron una serie de pozos que hicieron coincidir con las galerías inundadas, luego extraían el agua mediante un sistema de cubos en cadena.

Algunos pozos que, encontrándose cerca de un embalse, no tenían contacto directo con él, continuaban excavándose en la superficie de la cueva hasta encontrar el nivel de las aguas, o bien eran asistidos por un pequeño canal.

Al irse destruyendo paulatinamente la ciudad, los escombros cayeron por los pozos hasta colmatarse, otros fueron obstruidos por campesinos y pastores ante el temor de un accidente. Por lo que la mayoría han quedado invisibles desde el exterior y fácilmente localizables, sin embargo, en el interior de la cavidad por la presencia de los conos de escombros que se han formado entre el suelo y la desembocadura del pozo en la bóveda de la cueva.

La obra de los romanos se aprecia ya en la misma entrada de la cavidad, donde Taracena excavó los restos de una compuerta con sus jambas y encajes de piedra para recibir una placa de cierre y evitar la salida de aguas del interior.

El acceso a la cavidad natural está constituido por un túnel excavado en roca, de 90 mts. de longiutd, que va atravesando pequeñas cavidades naturales hasta que conecta con la galería principal. Los tramos artificiales del subterráneo son de trazado recto, aunque la sedimentación ha reducido su altura libre en las zonas próximas a la entrada, sus dimensiones medias en la primera parte son de 1,10 x 1,40, ancho y alto respectivamente.

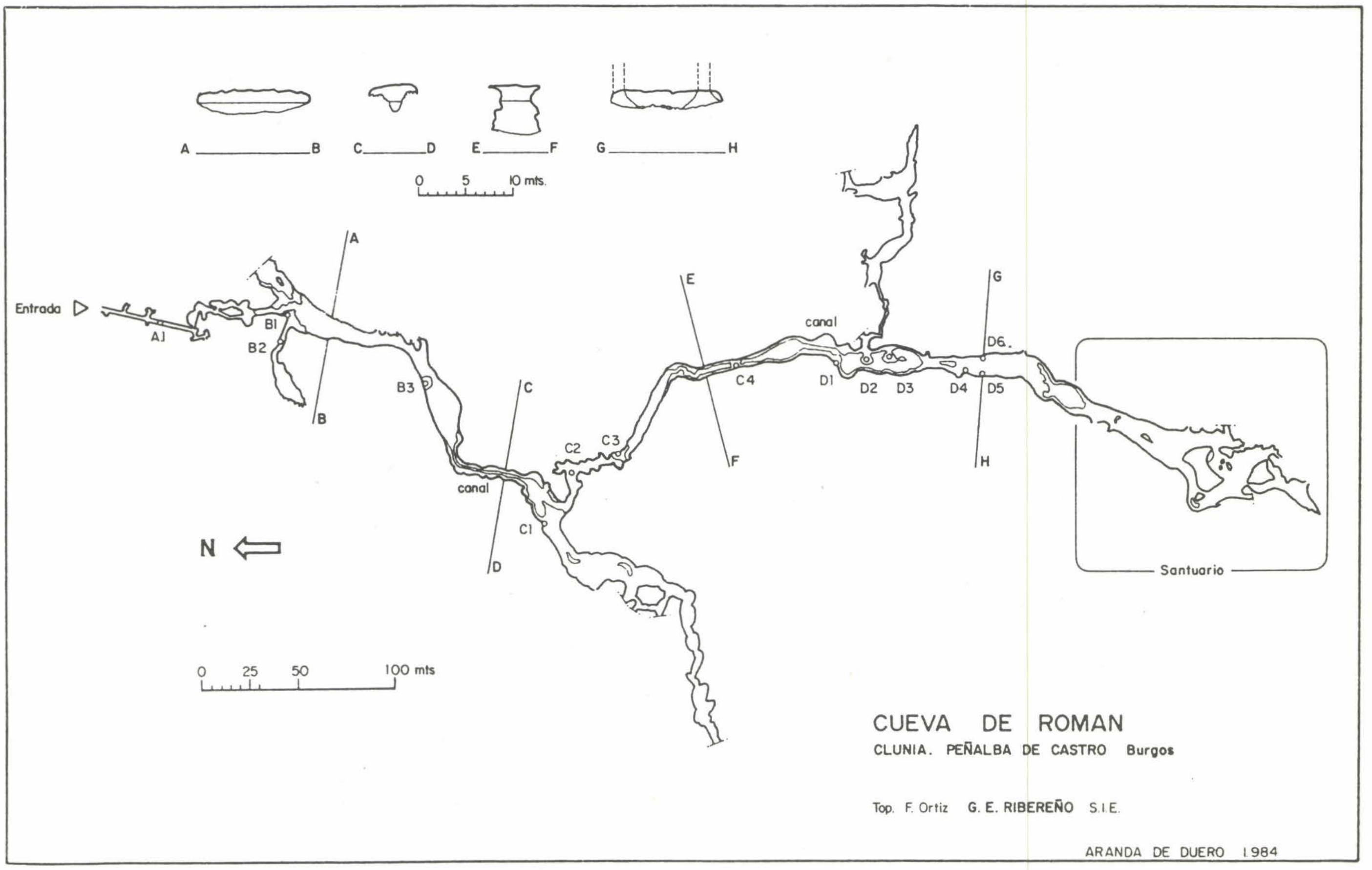
A lo largo del túnel se observan pequeñas hornacinas excavadas en la pared, y el primer pozo (A1), situado a 32 mts. de la entrada; está obstruido únicamente en su cabecera por lo que se puede apreciar su forma cilíndrica y absolutamente vertical. Tiene un diámetro de 1,85 mts. y en sus paredes se abren varios huecos, opuestos y a diferentes alturas, que lo hacen practicable para una persona.

A 45 mts. de la entrada, el túnel se divide en dos direcciones. Hacia la derecha se prolonga 10 mts. más, excavado en la roca hasta que un derrumbe o un cono de tierra de un posible pozo obstruye el paso.

Hacia la izquierda continúa con una galería natural donde la arcilla sedimentada fue excavada y apartada hacia los lados. Antes de llegar a la galería principal existen otros dos tramos excavados en roca.

Ya en la galería principal, a pocos metros del embalse, encontramos el segundo pozo (B1), identificado por un gran cono de tierras y piedras entre las que se puede encontrar cerámica, restos óseos y abundante escombro de la arquitectura urbana.

Hasta el momento hay 14 pozos identificados en la cavidad, oscilando su altura (o profundidad) entre los 7 y los 10 mts. los más cercanos al túnel y los 20 ó 22 mts. los más próximos al foro y, por lo tanto, a la cota más elevada de la altiplanicie. Casi



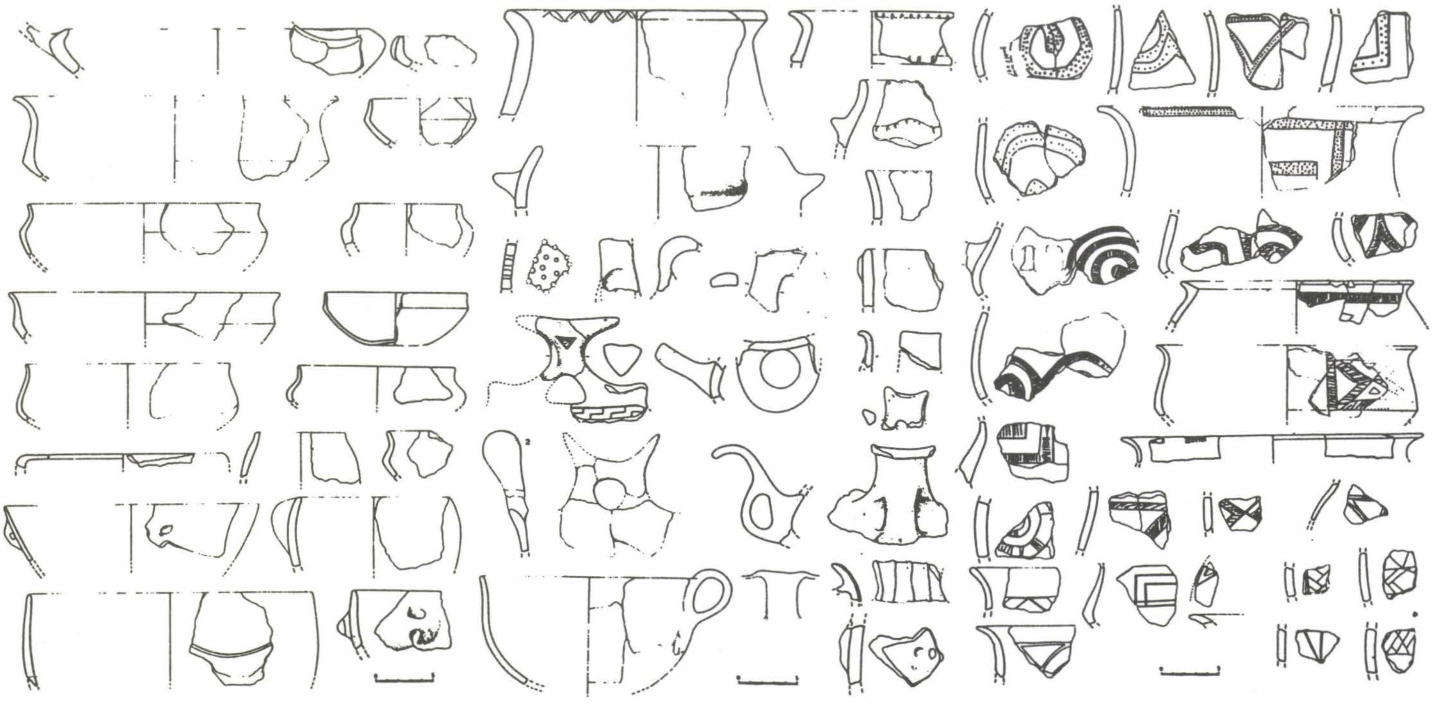
todos ellos se hallan dispuestos a lo largo de la galería principal, siendo fácilmente reconocibles por sus conos con todo tipo de restos arqueológicos; cabe hacer hincapié en la continuada presencia de bloques de piedra tallada procedente de las edificaciones romanas y particularmente abundante en los conos C.2, D.2, D.3 y D.4. Restos humanos, de época romana, aparecen en C.2, C.4, D.3 y D.4, encontrándose en muy buen estado de conservación los que no han tenido contacto directo con el agua.

Entre los pozos B.3 y C.1, en una zona donde una excesiva acumulación de arcilla separaría dos ámbitos lacustres, se abre un canal uniéndolos para compensar, ampliar y unificar el nivel freático útil, a la vez que se solucionan posibles problemas derivados de explotaciones locales desiguales del depósito acuífero. Este canal, de 45 mts. de longitud y 1 mt. de anchura media, está excavado en arcilla y en la propia roca en los puntos en que ésta aparece. Otro canal de similares características se encuentra entre el C.4 y el D.1; en esta ocasión debido a que un derrumbe de la bóveda obstaculizaba la comunicación de la más importante zona de pozos con el embalse más voluminoso.

Estos embalses están alimentados exclusivamente por aguas pluviales. Conscientes de ello, los romanos construyeron la pavimentación de sus calles con piedras de pequeño tamaño de forma que el agua pudiera filtrarse fácilmente entre ellas, en vez de discurrir por la superficie como ocurriría si hubieran utilizado losas. Por otra parte, las aguas residuales eran recogidas por una red de alcantarillado que las evacuaba evitando el contacto con las limpias aguas de la cavidad; éstas eran elevadas a través de los pozos mediante una cadena de sítulas o cubos de madera y armazón de hierro, de los que hemos encontrado algunos ejemplares sumergidos en las inmediaciones de los pozos C.2, C.3 y C.4.

Hemos de resaltar el gran esfuerzo realizado por los obreros que trabajaron en un medio tan hostil, en frías galerías inundadas y sobre una capa de arcilla muy blanda en la que, en algunos puntos, es fácil hundirse hasta las rodillas.

Debido a la necesidad de realizar estos trabajos de acondicionamiento, la cueva fue muy transitada por ellos. Es habitual encontrar señales de su paso en los lugares que por su situación o composición han quedado más protegidos del transcurrir del tiempo. Aún se pueden ver nítidamente huellas de calzado o de pies descalzos impresas en la arcilla, huellas de dedos o el relieve de sus tejidos, marcados al apoyar alguna parte de su cuerpo. A lo largo de la cueva quedan, dispersos, cenizas y restos de teas o antorchas, siendo más abundantes en los lugares de trabajo, como los canales, o en la galería de entrada al santuario. La humedad y temperatura constantes, casi sin variación durante 2.000 años, han hecho posible que esto se conserve; con todo, el goteo de las bóvedas y la arcilla demasiado blanda en los lugares de paso han borrado seguramente la mayoría de estas huellas.



Un posible santuario priapico en la cueva de Roman, Clunia.

G. E. Ribereño

RESUM

L'any 1982, l'exploració de la cova de Roman i el seu estudi arqueològic comportà el descobriment d'un àmbit subterrani on van aparèixer màscares, figuretes i representacions fàl–liques modelades amb argila, juntament amb una sèrie de textos escrits, constituint el què, suposem, podria ésser un Santuari dedicat a una divinitat de la fertilitat. Probablement un autèntic centre de culte priàpic.

RESUMEN

En 1982 la exploración y estudio arqueológico de la cueva de Román dio como resultado el descubrimiento de un ámbito subterráneo en el que aparecen máscaras, figurillas y representaciones fálicas modeladas en arcilla junto a una serie de textos inscritos, formando lo que, suponemos, podría ser un Santuario dedicado a una divinidad de la fertilidad. Probablemente un auténtico centro de culto priápico.

SUMMARY

In 1982 archeological prospecting and investigation of «Cueva de Román» give us the discover of a subsoiled area in which masks, little figures and phallic images (modeled on clay) with a collection of carved texts that constitute, as we suppose, a kind of sanctuary of a fertility god. Probably, an auttentic centre of priapic worship.

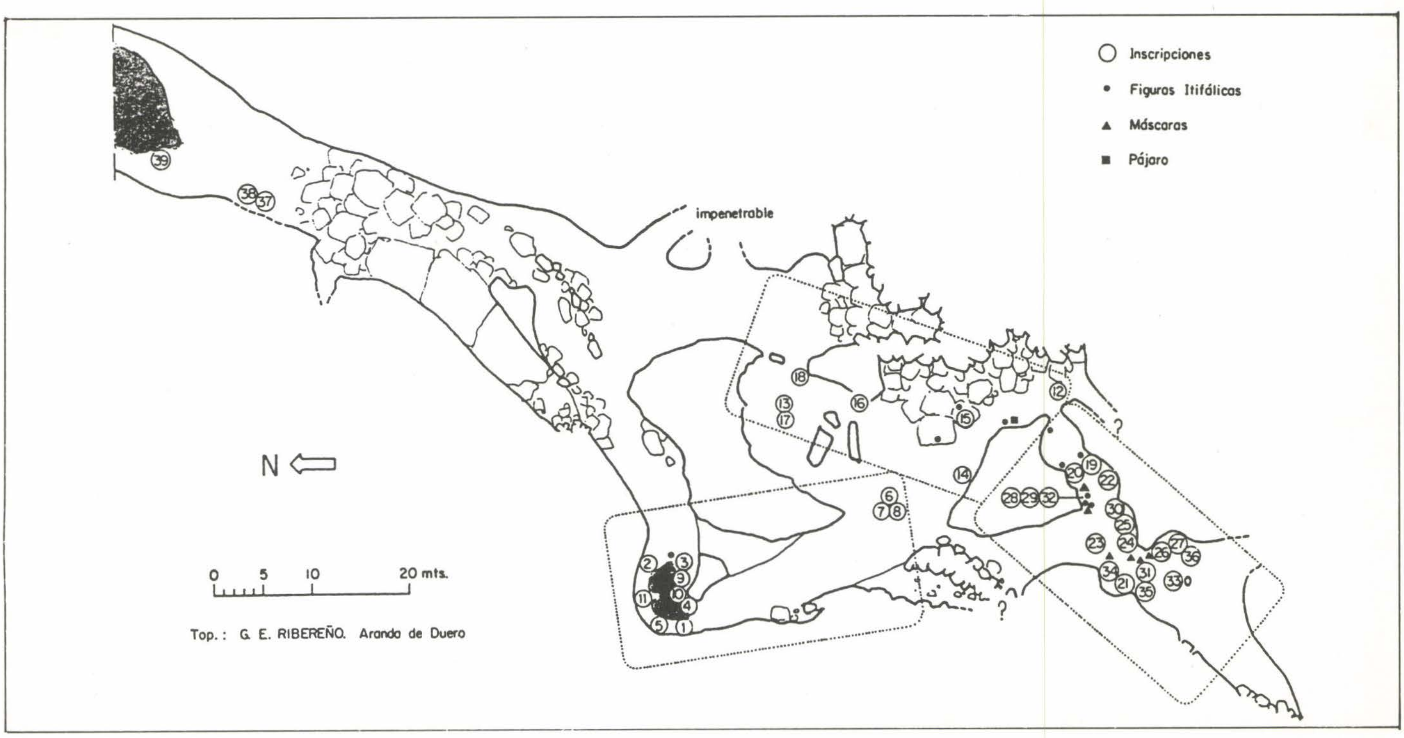
La cueva de Román, desarrollada en la altiplanicie caliza sobre la que se edificó la ciudad romana de Clunia, ha sido objeto de nuestro estudio desde 1981 año en que comenzamos a colaborar con D. Pedro de Palol, director de las excavaciones, y su equipo arqueológico.

El principal objetivo que establecimos fue realizar una meticulosa exploración con el fin de aportar datos para lograr el definitivo conocimiento del sistema de suministro de aguas a la ciudad, ya que, como se ha podido comprobar, la cavidad constituye un importante depósito natural de agua que fue aprovechado por los romanos tras efectuar varias adaptaciones en su interior.

Ese mismo año pudimos reconocer un extensa red de galerías que todavía seguimos explorando con especial cuidado, avanzando a medida que se examina el terreno y prospeccionando mediante inmersión cada metro de galería inundada, pues debido a los trabajos de adaptación fueron muy transitadas por los obreros romanos, dejando abundantes huellas y señales a su paso, que aún pueden verse, aunque con dificultad, al confundirse con los múltiples cuarteamientos y sinuosidades del terreno arcilloso.

En 1982 surgió la sorpresa al explorar los 200 últimos metros de la galería Principal, a partir de los 650 desde la entrada, en los que aparecen gran cantidad de inscripciones, dibujos y estatuillas grabadas y modeladas en arcilla.

El lugar del hallazgo tiene una relativa gran amplitud horizontal y una altura libre predominante de 1 metro. Se halla libre de embalses y ocupado por un espeso manto de arcilla blanda, características, todas éstas, que multiplican la sensación de profundidad y oscuridad que de por sí inspira cualquier ámbito subterráneo.



La constancia de las condiciones ambientales ha propiciado que las inscripciones se encuentren como recién hechas, sobre la superficie cuarteada de un barro finísimo y maleable, con una suave desecación superficial que podría distinguirlas de trazos actuales, los textos suelen ser cortos, de dos o tres palabras, con tamaños de letra que oscilan entre los 2 cms. de los más pequeños y los 15 cms. de altura en los más grandes, aunque hay excepciones. Acompañan a los textos representaciones fálicas modeladas o dibujadas en las placas de arcilla; también aparecen figurillas itifálicas y máscaras.

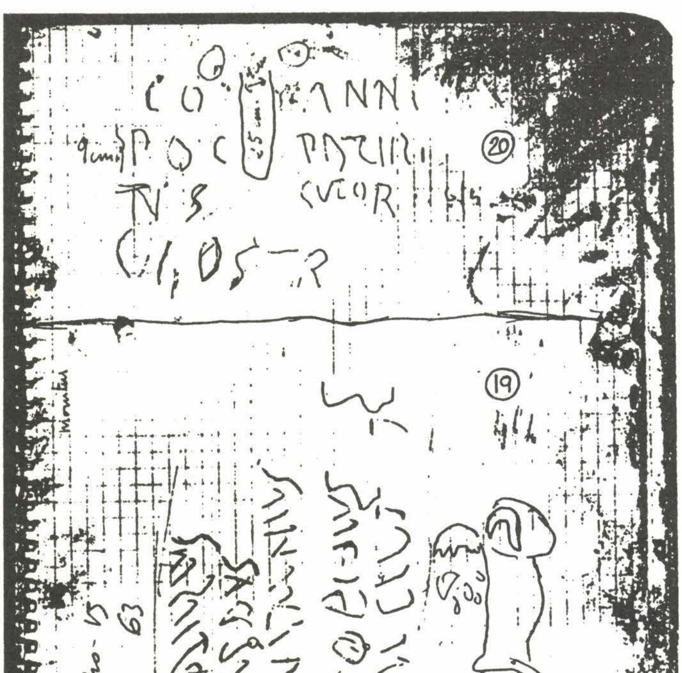
Como decimos, el Santuario se ubica en los últimos metros de la galería Principal. Tras superar la última laguna el nivel del terreno sube suavemente y aparecen las primeras inscripciones entre las que hay una en la que se lee *Soteles*, con grandes letras, y otra mas pequeña, *Titus*.

Más adelante, alrededor de una pequeña charca se distribuye otro grupo de letreros en los que aparecen otros nombres, especialmente el de *Bergius Seranus*, un edil de la ciudad, y *Fabricius*, uno de los quattuorviri. En esta zona no hay figuras; únicamente se encuentra un dibujo fálico.

En la sala central, sobre dos bloques caídos del techo, hay tres pequeñas estatuillas itifálicas; en una de ellas, en un vaso situado a sus pies, se lee *Carisius*. Otros textos aparecen en esta sala, entre ellos *Aionis Hermes, Brito, Priscus* y una de las más interesantes que anuncia, aunque sin nombres, la visita de los IIII Viri de la ciudad.

De esta sala parte una galería en sentido SO. que contiene el conjunto monumental más interesante, formado por dos grandes representaciones fálicas con inscripciones, y una serie de letreros, pequeños falos dispuestos a manera de ofrenda y máscaras masculinas tanto dibujadas como modeladas en arcilla.

El primer gran falo (63 x 15 cms.) modelado en el lateral izquierdo de la galería, corresponde a un exvoto de *Aemilios Fitaus,* presenta grabadas en su superficie siete líneas de texto, dos de ellas sobre el glande. Frente a éste se halla otro falo en altorrelieve sobre una placa de arcilla, con inscripción a ambos lados de la que se lee el nombre de *Annius Paternus.* Otros personajes que aparecen en este conjunto son *L. Domitius, Secundia, Martial, Trebo, Priscus, Atto, T. Cornelius.* etc.



La onomástica documentada en las inscripciones de la Cueva de Román se corresponde con la de la superficie de la ciudad. Hay que señalar una onomástica prelatina, más o menos romanizada, que nos viene dada por Atto, Brito o el edil Bergius Seranus, al lado de este conjunto indígena aparecen nombres genuinamente latinos y bien documentados en la Italia central y meridional.

Una apreciación importante es la correspondiente de nómina entre los magistrados municipales que son conocidos a través de las acuñaciones monetarias de época de Tiberio y los que aparecen en el santuario. Este es el caso del edil Bergius Seranus, probablemente emparentado con el quattuorvir M. Iulius Seranus. Lo mismo cabría pensar del L. Domitius Robustus que aparece en las Monedas, y el L. Domitius documentado sobre la arcilla.

El problema más complejo del conjunto es el de su interpretación. Es evidente que el sentido votivo de los letreros junto a imágenes humanas itifálicas como la de Carisius, o la proliferación de pequeños falos a manera de ofrendas, junto a cabecitas y máscaras, sugiere un lugar de culto fálico asociado a Priapos.

El mismo hecho del lugar, en los manantiales de la ciudad, permite asociar la divinidad con su propio carácter de protector de la fertilidad de la tierra, como se define ya en el mundo helenístico a Príapos, en los versos del himno a Afrodita. Por otra parte, viene asociado a Hermes, como nos dice Herodoto cuando habla de las costumbres griegas de representar a Hermes itifálico. No olvidemos la presencia de Hermes en las inscripciones de la cueva. Hermes fue la divinidad protectora de la fecundidad de plantas y animales, así como de la salud.

Príapos, hijo de Diónisos y de Afrodita, fue represéntate de la inagotable fuerza de la naturaleza. Aunque el culto al falo se perdió en el mundo romano en dioses como Diónisos o Hermes, se conoce bien la literatura y la persistencia del culto Priápico hasta época muy tardía.

La descripción de la cueva de Príapos en el Satiricón de Petronio sugiere el sentido críptico de nuestra cueva de Román. Incluso el atributo a la divinidad del instinto sexual y de la lascivia, que en Petronio está tan presente, podría sugerirlo, por ejemplo, la inscripción en que aparece CUSPRISPRISCVS VENIT, a pesar de la seriedad que parece evidente en la inmensa mayoría de los letreros del Santuario.

Bien conocido es el uso en las ciudades romanas, sobre todo de origen colonial militar, de imágenes y figuras fálicas, ya sea en sus muros o en otros lugares de su arquitectura. Los hemos reconocido en Clunia, en el criptopórtico de la casa n.º 1 en una gran pilastra del cardo que no difiere mucho del enclave del Santuario.

Otro elemento que queremos apuntar es la lectura de *Luto* y *Oblino,* la primera en el falo sobre la placa de barro, y la segunda en el gran falo modelado frente al anterior. Ambos términos, en su significado de cubrir de barro sugieren (En caso de aceptarse plenamente las lecturas) un ritual de propiciar la fecundidad y la fertilidad y/o un recurso medicinal.

La húmeda arcilla del Santuario parece ser un elemento de gran importancia al igual que ocurre en Egipto donde se podría relacionar el barro de las fértiles orillas del delta del Nilo con el culto a Prίapo.

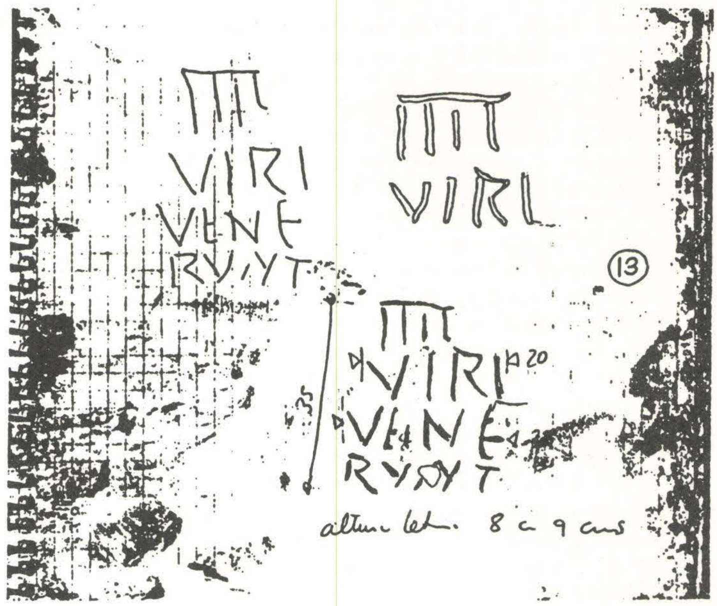
Queda otra circunstancia que no hay que dejar de lado, es la presencia de los magistrados municipales en el Santuario. ¿Se trata de una presencia ritual en favor de lo que el agua, evidentemente relacionada con cualquier culto fertilizante, pueda representar para el progreso de la ciudad?

El conjunto, creemos, es único en nuestra arqueología romana y será preciso acabar de depurar su estudio y llegar a las últimas interpretaciones textuales para su correcta lectura histórica.

D. Pedro de Palol y D. Josep Vilellas están realizando el estudio científico del Santuario, hasta el momento en base a fotografías y dibujos que les proporcionamos y a un reconocimiento en situ de Vilellas. Por lo que sin su trabajo de investigación, que aquí ha quedado reflejado, esta comunicación quedaría reducida a una mera descripción física del hallazgo.

Hay que dejar bien claro que el conjunto está todavía en estudio y que lo que ahora damos aquí es provisional, sujeto a las modificaciones que mejores y más completas lecturas fruto de una exploración más apurada y de la interpretación histórica de nuevos materiales puedan ofrecer.

Como ilustración acompañamos algunos textos del Santuario, un plano y tres fotocopias de dibujos del cuaderno de campo, que consideramos para esta ocasión más nítidos y expresivos que las fotografías.



1. FABRICIVS
   $\overline{\text{IIII}}$ VIR
   HIC
   [FVIT?]
2. BERGIVS SERANVS
   AEDILIS DICIT
   QVISQVIS HVC VENERIT
   [- - -]

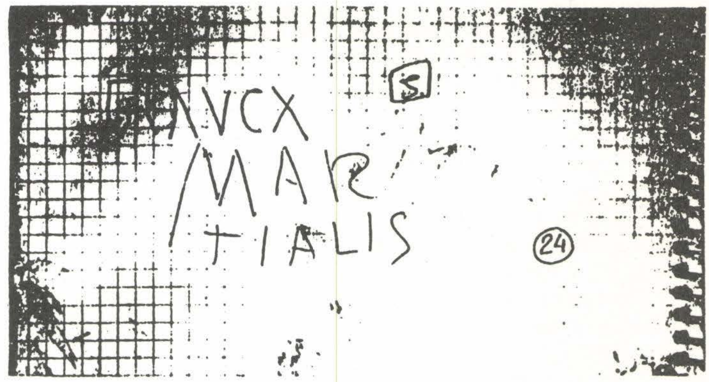
9. AIONIS
   HERMES

13. $\overline{\text{IIII}}$
    VIRI
    VENE
    RVNT

19. AEMILIVS
    FITAVS
    QVIA INTVS
    II OBLITVS
    MELLA

20. ANNI [VS]
    PATER [NVS]
    LVTOR

24. GLAVCA
    MAR
    TIALIS



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Cuevas y abrigos, lugares mágico-religiosos de la prehistoria

R. Blanco

RESUM

Descripció de l'estació d'art esquemàtic del COGULAR de Ruanales de Valderredible (Cantàbria). Aquest conjunt destaca per l'alt contingut simbòlic dels seus esquematismes de finals del Neolític i de l'edat del Bronze. S'extreuen conclusions entorn de la fecundació.

RESUMEN

Descripción de la estación de arte esquemático del COGULAR en Ruanales de Valderredible, Cantabria. Este conjunto destaca por el alto contenido simbólico de sus esquematismos de finales del Neolítico y Edad del Bronce. Se sacan conclusiones en torno a la fecundación.

SUMMARY

Description of schematic art station of the Cogular from Ruanales de Valderredible, Cantabria. This ensemble is remarkable for the end of Neolitic schems and Bronze Age. Conditions on fertilization can be drawn.

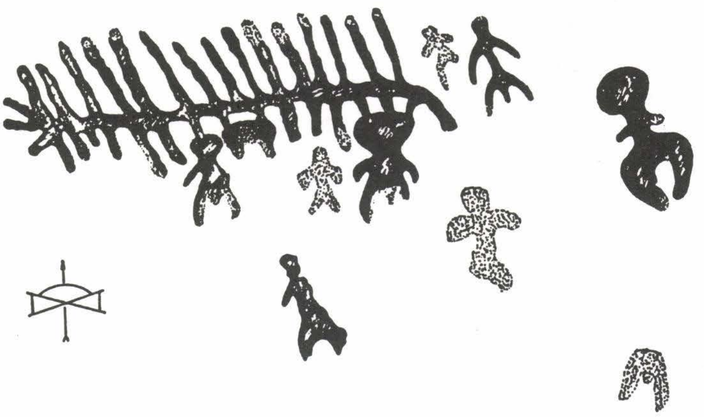
Si en el decir de algunos, todo arte expresa algo del espíritu de su tiempo, debemos considerar que la pintura esquemática puede reflejar esperanzas, temores y entusiasmo de una época, y por qué no el fascinante deseo de mundos más atractivos que el suyo. El hombre primitivo estuvo sometido a poderosas fuerzas que conformaron su comportamiento físico e intelectual, unas de origen natural, comprensible, y otras misteriosas que se escapaban al control de su limitado conocimiento. Sus días transcurrieron bajo la tensión constante que le deparaban los acontecimientos naturales relacionados con su propio mecanismo existencial, y bajo la tensión también de un poder sagrado que ejercía una influencia misteriosa sobre él. Entre las necesidades de lo vital y el miedo a los desconocido, surge en el hombre el sentimiento religioso por el que tratará de hacer que las fuerzas de lo divino le sean propicias. Lo religioso es un intento también de hallar su propia proyección hacia lo cósmico en una búsqueda constante de su identidad relacionada con la gigantesca maquinaria viviente que constituye el Cosmos. Precisamente en esta revelación existencial del hombre a través de la experiencia cosmológica es donde tienen función ritual los símbolos y esquematismos que han de venir en su ayuda para ofrecerle imágenes que trasciendan a sus limitaciones y carencias, revelándole un plano superior de la realidad.

La pintura esquemática si bien carente de valor artístico, debemos considerarla como una forma de arte abstracto que bajo representaciones geométricas, obedece a un rígido simbolismo que origina esquemas al servicio de ideas religiosas.

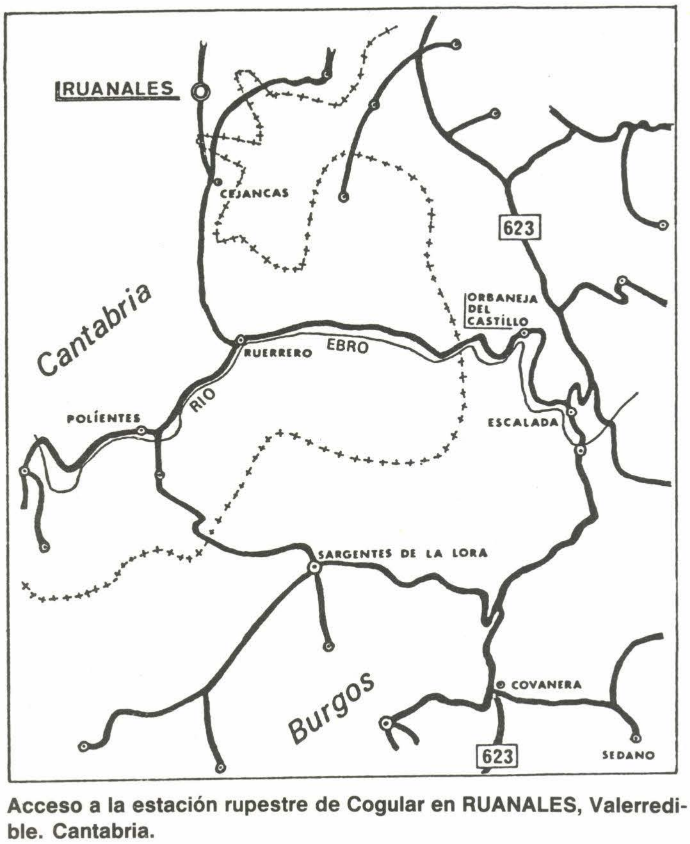
Las cavernas y los abrigos apartados fueron en la prehistoria santuarios de invocación mágica para propiciar en ellos la caza en unos casos y la fertilidad en otros. Los expertos brujos, hechiceros o magos trataron de activar las poderosas fuerzas sobrenaturales que harían posibles sus deseos.

Entre las muchas estaciones de arte esquemático estudiadas, llama nuestra atención principalmente COGULAR en Ruanales de Valderredible, Cantabria por el alto contenido simbólico de sus esquematismos, donde los ritos de fecundación y fertilidad debieron cobrar gran importancia a finales del Neolítico y plenitud de la Edad del Bronce.

En el reducido espacio de esta ponencia nos limitaremos primeramente a desarrollar una breve descripción de los conjuntos de pinturas más significativos, para después argumentar algunas conclusiones sintetizadas en torno a la idea central de la fecundación.



Pinturas esquemáticas de Cogular. Grupo –A–.



Acceso a la estación rupestre de Cogular en RUANALES, Valerredible. Cantabria.

Descripción
Grupo – A

Consta básicamente de una figura ramiforme dispuesta en sentido horizontal, de la cual parecen colgar varios antropomorfos. Dos de ellos se unen por la cabeza a las puntas o ramas inferiores, y un tercero muy deteriorado sólo muestra la cabeza que permanece como los anteriores unida a las puntas que descienden en sentido vertical. Es significativa la perfecta representación de los atributos masculinos que muestran los antropomorfos que cuelgan, como si lo vegetal y por tanto lo cíclico estuvieran en este caso relacionados con la fertilidad y la procreación. En este sentido, también aparece a la izquierda del conjunto otro esquemático poderosamente dotado de virilidad y en aptitud de iniciar un salto o caminar. Otras tres representaciones más se distribuyen en el grupo, faltándoles presencia por hallarse la pintura muy diluída y parte del soporte desprendido de la roca. En la periferia de este panel se pueden contemplar dos antropomorfos más que completan el conjunto con peculiares características por tratarse de representaciones femeninas. Estos a diferencia de los reseñados anteriormente, no disponen de signos masculinos, y sí por el contrario muestran amplios contornos de caderas y acusadas formas femeninas en general.

Grupo – B

A diferencia de los anteriores que fueron realizados en rojo y contornos planos, en este panel las figuras están trazadas con líneas rojas muy finas, y a excepción de un antropomorfo plano, el resto es ejecución lineal. Se compone de cinco representaciones de animal cuadrúpedo formadas esencialmente con el mismo número de rayas e igual disposición de éstas, sin ninguna pretensión artística. Sobre cuatro de los zoomorfos aparecen colocados con la misma intención sendas formas cilíndricas terminadas en glande, y una de ellas con pequeñas rayas alrededor de esta terminación, como señalando la presencia de un fluído o sensibilidad inherente a esta parte. Curiosamente, la disposición de estos signos fálicos no es casual en el conjunto ya que el pintor prehistórico situó dos animales a la derecha y dos a la izquierda, separados entre ambos para formar un rectángulo en cuyo centro se halla la quinta pintura de animal sobre la que se encuentra una representación vulvar realizada con dos circunferencias concéntricas muy irregulares y ovaladas, en la que penetra otra forma cilíndrica similar a las anteriores que parte del animal en sentido ascendente. Sobre este conjunto se halla dispuesta en la parte superior del panel y un poco a la derecha, la figura de una representación humana única en este grupo, como si de vigilar la escena se tratara.

Pinturas esquemáticas de Cogular. Grupo –B–.

Conclusiones

1. Se advierte de inmediato que la actividad desarrollada en el santuario de COGULAR para ejercer la atracción de las fuerzas sobrenaturales, se extendía a las especies, tanto humana como animal.

2. En el grupo –A– se puede apreciar con facilidad la intencionada morfología que diferencia lo masculino de lo femenino, al hombre y a la mujer. Muestran sus atributos sin posibilidad de confusión, para establecer la idea clara del macho y la hembra y la posibilidad también de alguna forma ritual para propiciar la fecundación.

3. Los antropomorfos machos, permítaseme expresarme en términos genéricos, están íntimamente vinculados al arboriforme al estar unidos a este por la cabeza como si de él colgaran o de alguna forma dependieran. La idea del arboriforme expresa posiblemente una relación cíclica entre la fuerza vital del hombre y la Naturaleza. El árbol brota con periodicidad anual, y el hombre según esta relación puede estar sujeto al reloj natural para completar su ciclo biológico.

4. Si en el grupo –A– quedaba reflejada la inquietud del hombre por la continuidad de la vida humana y por tanto la continuidad de la tribu, del grupo –B– se podría desprender la idea complementaria acerca de las exigencias alimenticias necesarias para la supervivencia. Si las proteínas animales fueron decisivas en la dieta alimenticia del hombre, no tendría nada de extraño que éste se preocupara espcialmente en lograr la mayor fertilidad de sus ganados con el control de la fecundación de la hembra mediante procedimientos sistemáticos entre los que podría hallarse el acompañamiento de ésta por varios machos.

Final

En las pinturas de COGULAR se observa cómo la fuerza de la magia fue aplicada posiblemente por un grupo pastoril interesado en fecundar sus ganados y hacerlos fértiles. Es evidente la asociación de representaciones fálicas y vulvares como elementos precisos para la procreación de las especies animales, fuente primaria de una economía alimenticia.

También hallamos en COGULAR antropomorfos con atributos marcadamente masculinos, junto a otros del mismo grupo que al carecer de estos distintivos naturales, pueden señalar la presencia del signo femenino.

Como quiera que sea, la preocupación por la continuidad de la vida se manifiesta constantemente con símbolos y rituales que constituyen las formas características de una religión basada en el dinamismo de unas fuerzas que trascienden a lo puramente material en la unión de los elementos macho y hembra renovadores de vida.

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Gli insediamenti prestorici in grotta nei Monti Carseolani

Silvano Agostini (Geologo)
Vicenzo D'Ercole (Archeologo)
Sopr. Archeologica dell'Abruzzo
Villa Ciomunale 3,
66100 CHIETI, ITALIA

RESUM

En el carst de les Muntanyes de Carseolani (Apenins Centrals) s'hi coneixen alguns assentaments humans prehistòrics localitzats en coves i aixoplucs.

L'àrea és una conexió natural dels Apenins amb l'alineació N.O-S.E. Les valls tenen una longitud de 15 km. i són molt estretes. Les conques no superen mai els 2.000 m. d'altitud. El medi ambient és el típic de les zones càrstiques dels Apenins Centrals i la seva degradació és deguda a la presència ancestral de l'home.

Les restes arqueològiques indiquen (en contrast amb les condicions geogràfiques) contactes preferents amb el món del Lacio, a l'oest, i amb la zona interior dels Abruzzos, a l'est. Per regla general, tots els assentaments, tant històrics com prehistòrics, es troben situats en zones pròximes a surgències càrstiques. Tant és així, que hom pot constatar-ho en els jaciments arqueològics de l'abrigall de Tagliacozzo (amb materials neolítics i romans), a la cova de Beatrice Cenci (amb materials neolítics i del Bronze antic) i a les coves Cola 1 i Cola 2 (amb materials del Neolític i de l'edat del Bronze).

Nosaltres presentem els trets cronològics i tipològics dels assentaments així com les seves relacions amb les zones càrstiques.

RESUMEN

En el karst de los Montes Carseolani (Apeninos Centrales) se conocen algunos asentamientos humanos prehistóricos en cuevas y abrigos.

El área es una conexión natural de los Apeninos con la alineación NO-SE. Los valles tienen una longitud de 15 km. y son muy estrechos, y las cuencas nunca están por encima de los 2.000 m. El medio ambiente es el típico de las zonas kársticas de los Apeninos Centrales y su degradación se debe a la presencia desde antiguo del hombre.

Los restos arqueológicos muestran (en contraste con las condiciones geográficas) contactos preferentes con el mundo del Lacio en el Oeste y con la zona interna de los Abruzzos en el Este. Por regla general todos los asentamientos, tanto históricos *como prehistóricos, se sitúan en la proximidad de surgencias kársticas. Así se constata en los yacimientos arqueológicos del abrigo Tagliacozzo (materiales neolíticos y romanos), la cueva Beatrice Cenci (materiales neolíticos y del Bronce antiguo) y las Cuevas Cola 1 y Cola 2 (con materiales del Neolítico y de la Edad de Bronce).*

Se presentan rasgos cronológicos y tipológicos de los asentamientos, así como sus relaciones con las zonas kársticas.

SUMMARY

Prehistoric archaeological humman settlements are known in some caves and under covers, in the karst area of Carseolani Mountains (Central Apennines).

The area is a natural apennine connection with NW-SE lineament. The valleys are 15 k longe. They are very narrow and the watersheds are never higher than 2.000 mt. The ecological enviroment is typical in central Apennines karst regions.

Ecologial degradation is due to older anthropic presence.

The archaeological evidence shows (in contrast with geographical conditions) preferential connections with «Latium world» in the wesrt and Abruzzo internal area in the East. Historic and prehistoric settlements usually are near karst springs. Here we speack about archaeological sites of: Tagliacozzo Cover (Neolitic-Roman age Materials); Beatrice Cenci cave (Neolitic and First Bronze age materials); Cola 1 and cola 2 Caves (Neolitic and Bronze age materials).

The cronological, typological contests and the relations of the archaeological settienments with the karst area are here illustrated.

La morfologia dei M.ti Carseolani è condizionata dalle caratteristiche litologiche e dall'assetto strutturale definitosi con la tettonica Quaternaria. Le dorsali sono costituite da calcari profondamene carsificati e raggiungono quote non superiori ai 2000 m. .Numerose sono le grotte, i ripari e i piano carsici somitali dove al bosco e alla nuda roccia si sostituiscono estesi pascoli. Nelle valli strette e incassate affiorano terreni pesanti argillo-aranecei, sui versanti impostati lungo piani di faglia prevalgono conoidi e detriti di falda che addolciscono i pendii. L'idrografia è costituita da numerosi bacini chiusi che riversano le loro acque in grotte di attraversamento (Segre A.G. 1948). Non numerose ma puntuali le sorgenti carsiche, di notevole portate e senza esaurimento stagionale. Non di rado la parte terminale dei bacini chiusi è soggetta a impaludamento. La morfologia dei bacini e lembi di depositi terrazzati testimonia che nel Pleistocene superiore il fenomeno era più marcato. Attorno a questi ambienti «Lacustri» uno degli autori ha rinvenuto industrie del Paleolitico medio, contenute in un suolo vertico sepolto. La presenza di ampli pascoli, di zone forestali e di punti acqua obbligati per la fauna e per l'uomo, suggerisce una preliminare correlazione tragli insediamenti e i fattori ambientali. Tutti i siti sin ora noti si pongono infatti a metà versante montano, vicino a sorgenti (Liri, Imele), a inghiottitoi (B.Cenci), nonchè in posizione strategica dei pascoli sommitali e dei percorsi obbligati della selvaggina. Pur confermando direttrici oro-idrografiche appenniniche con sbocco a Nord nell'area Sabina (Turano, Cicolano) e a Sud nell'area Volsco-Latina (Cassini, Sora) la viabilità naturale nei Carseolani mostra numerosi passi e linee favorevoli nelle paleovalli sospese (Villafranchiano) che costituiscono assi verso Ovest (mondo laziale) a verso Est (mondo Italico).

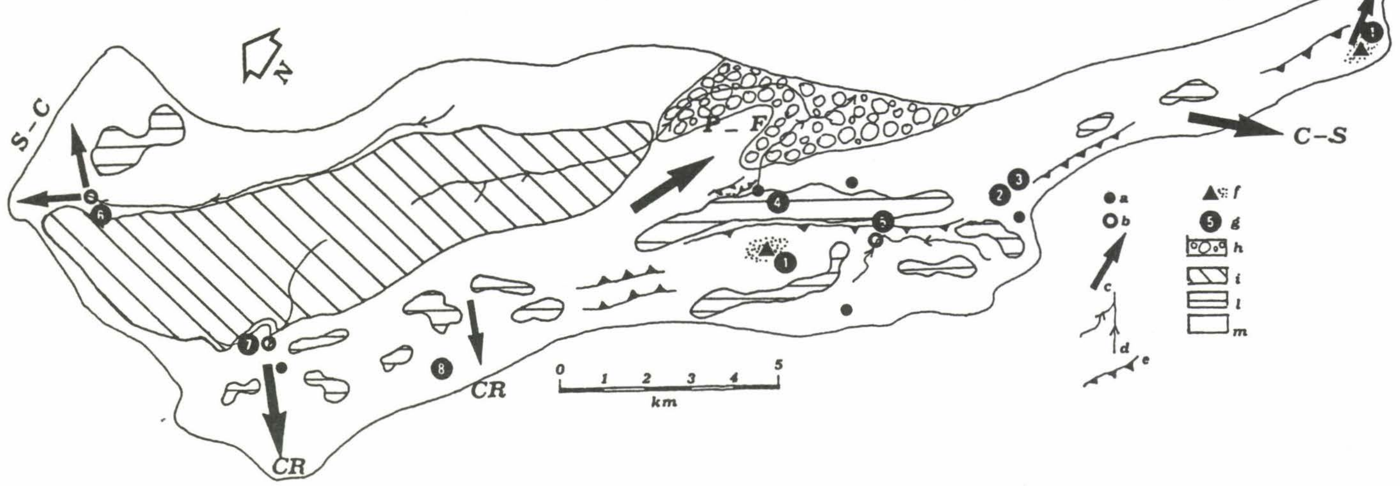
I siti archeologici da noi conosciuti nell'area dei Monti Carseolani sono:

Grotta Cola I (Cappadocia)

La grotta fu utilizzata all'inizio del secolo scorso a fabbrica per il salnitro, asportando e disturbando il deposito preistorico; scavi effettuati nel 1870 (Nicolucci 1878) portarono alla luce molti resti dell'orso delle caverne, un ascia levigata in pietra verde, ceramica ed industria litica attribuita dallo scavatore ad età neolitica. Successivi scavi condotti nel 1956 (Radmilli 1977) all'interno della grotta portarono al rinvenimento di altre ossa di Ursus spelaeus, mentre all'esterno lungo la china furono raccoltto resti ceramici attribuibili all'età del bronzo.

Grotta Cola II (Cappadocia)

Picola cavità resituata da crolli in antico, scavata integralmente nel 1956 (Radmilli 1957) ha restituito una stratigrafia formata da



Tav. 1 CARTA GEOAMBIENTALE E DEI SITI ARCHEOLOGICI PREISTORICI
a) Sorgenti carsiche
b) Inghiottitoi
c) Viabilità naturale; S-C Sabina, Cicolano; CR Piana di Carsoli; P-F, Palentini, conca Fucense; C-S, Cassino, Sora.
d) idrografia principale
e) Scarpate e falesia carsiche con grotte e ripari
f) Depositi lacustri, vertisuoli.
g) 1 Industrie del Paleolitico medio
2 Grotta Cola 1°
3 Grotta Cola 2°
4 Riparo la Difesa di Tagliacozzo
5 Grotta Beatrice Cenci
6 Grottone di Val di Varri (non citato nel testo)
7 Grotta grande del Cervo (non citato nel testo)
8 Rocca di Botte
h) Alluvioni antiche e recenti
i) Complesso argilloso aranaceo, coperture forestali estese, calanchi e frane suoli bruni acidi, suoli bruni lisciviati, suoli bruni e litosuoli.
l) Rendzina, suoli bruni calcarei e litosuoli, rari paleosuoli.
m) Coperture forestali su carso coperto, grize, Karren. Tav. 2/3/4
Tagliacozzo; riparo Monte la Difesa. Materiali neolitici e dell'età del Bronzo.

«trenta cm. di terriccio con ceneri, carboni e frammenti di ceramica medioevale, un focolare preistorico dello spessore massimo, al centro, di 40 cm. e che occupava tutta l'area della grotta». Secondo lo scavatore la grotta fu «utilizzata quale luogo di insediamento... in una fase molto avanzata nell'ambito della cultura di Ripoli» (IV-III millennio).

Grotta Beatrice Cenci (Petrella)

Mai indagata scientificamente: alcuni reperti (inediti) raccolti nelle terre di risulta di scavi clandestini sembrano indicare presenze neolitiche (ceramica figulina) e dell'età del bronzo (probabilmente antica e media iniziale).

Tomba Camerata (Tagliacozzo)

Rinvenuta alla fine del secolo scorso, «scavata nel tufo, e misurava m. 2,20 in lunghezza e m. 0,70 in larghezza. La tomba era ermeticamente chiusa de pezzi dello stesso tufo. Sopra la copertura era un strato di terra vegetale, di m. 0,40. Era orientata ad ovest». (Canale-Parola 1888). All'interno della sepoltura un inumato che recava, intorno al cranio, 18 punte di freccia in selce ed un'ascia piatta di rame (Pigorini 1888); si tratta di una delle rare tertimonianza presenti nella regione, attribuibile all'età eneolitica (III millennio) e messa in rapporto, da alcuni autori, alla cultura di Rinaldone (Lazio-Toscana).

Riparo Monte La Difesa (Tagliacozzo)

Materiali raccolti nel 1972 da un grupo spontaneo (G.A.I.); la tipologia dei reperti indica varia presenze neolitiche (solcature a crudo tipo Sasso, ceramica figulina, decorazioni graffite) e della età del bronzo (anse a nastro tipo protoappenninico B, decorazioni campite in stile appenninico classico, forme, anse e decorazioni del tardo-appenninico). Sembra trattarsi quindi di una frequentazione avvenuta in piena età neolitica (V-IV millennio) e durante le fasi centrali dell'età del bronzo (XVI-XIII sec.). Il materiale è inedito e viene presentato nelle tavole allegate in forma preliminare.

Rocca di Botte

Numerosi reperti (inediti), raccolti in anni recenti nei pressi del cimitero del paese, sono conservati nel museo dell'abbazia di Santa Scolastica di Subiaco; si tratta di materiali ceramici e litici attribuibili alla media età del bronzo (metà del secondo millennio).

Perella Liri

Nella raccolta condotta agli inizi del secolo da Giuseppe Bellucci ed attualmente conservata nel Museo di Perugia, è presente un'ascia a margini rialzati in bronzo «proveniente» da Petrella Liri (Peroni 1961). Si tratta di un'ascia del tipo Battifolle (Peroni 1971) con tallone diritto e lama a margini concavi che rientra nel «primo orizzonte di ripostigli», agli inizi cioè della antica età del bronzo (inizi secondo millennio).

Nessuno dei siti descritti per le sue caractteristiche topografiche e morfologiche, nonchè per l'entità dei depositi (sedimenti naturali e antropizzati) può indiziare una frequentazione che non sia quella stagionale a per alcuni siti ance occasionale. Questo insieme non diminuisce l'importanza degli insediamenti sia per una migliore conoscenza delle aree di frequentazione e diffusione delle culture in questione, sia per l'analisi delle risorse territoriali che si inseriscono nel binomio sussistenza, economia-crescita demografica. Stando allo stato attuale delle ricerche, occasionali e mai pianificate, che evidenziano al momento l'assenza di abitati all'aperto, la frequntazione di grotte e ripari si inserice nella area carseonana come un risposta stagionale di sussistenza a sistemi che trovano nei limitrofi piani Palentini, conca fucense e piana di Carsoli, i loro immediati baricentri insediamentali a tut tutt'oggi noti. L'area carseolana, in definitiva, sembra rappresentare una «riserva» ambientale (caccia, allevamento) stagionale per le aree insediamentali circostanti.

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Arte rupestre en cuevas en los Estados Unidos y Canadá

Russell and Jeanne Gurnee
231 Irving Avenue
Closter, New Jersey 07624
U.S.A.

RESUM

L'art rupestre de les coves, a diferència de l'art rupestre en general, assumeix el fet que l'artista primitiu va crear la seva obra en una obscuritat total, requerint llum artificial per a realitzar la seva tasca. Aquesta subtil distinció exclou el 99 % del què es coneix avui com a art primitiu, cenyint-se a aquelles marques que hom pot trobar en zones remotes endins de la terra. Aquest treball no pretén explicar els motius ni avaluar el mèrit artístic d'aquests treballs, sinó que intenta identificar i aplegar referències i uvicacions de llocs a Nord-amèrica. Les referències inclouen indrets coneguts o ignorats, descripcions d'observadors i especulacions contemporànies sobre possibles descobriments. L'àrea geogràfica inclosa en aquest treball és arbitrària, ja que els límits geogràfics entre els Estats Units i el Canadà no significaven res per a l'artista, que ha deixat mostres palpables de les seves visites a les coves. S'inclou també una bibliografia, amb monografies completes a fi de col·laborar millor en les investigacions.

RESUMEN

El Arte Rupestre en Cuevas, a diferencia del Arte Rupestre asume que el artista primitivo creó su obra en absoluta oscuridad, requeriendo luz artificial para realizar su trabajo. Esta fina distinción elimina el 99 % de las evidencias del trabajo de arte primitivo y se concentra en aquellas marcas colocadas en áreas remotas *bajo tierra. Este trabajo no pretende explicar la motivación o evaluar el mérito artístico de estos trabajos, pero intenta identificar y reunir referencias y ubicaciones de lugares en Norte América. Las referencias incluyen lugares conocidos y perdidos, descripciones por observadores y especulación contemporánea sobre posibles descubrimientos. El área geográfica incluída en este trabajo es arbitraria ya que límites entre los Estados Unidos y Canadá no significan nada para el artista que ha dejado registros tangibles de sus visitas a cuevas. Se incluye una bibliografía con la monografía completa a fin de ayudar en más investigaciones.*

RESUME

L'art rupestre dans les grottes, contrairement â l'art rupestre, implique que l'artiste a créé son oeuvre dans l'obscurité totale, devant employer la lumière artificielle pour réaliser son travail. Cette nuance élimine 99 % des évidences du travail d'art primitif pour se concentrer sur les marques faites dans de endroits éloignés sous terre. Ce rapport ne prétend pas expliquer les motifs ou évaluer le mérite artistique de ces travaux, mais il essait d'identifier et de réunir des références et endroits en Amérique du Nord. Les références incluent des endroits connus et perdus, des descriptions par des observateurs et des spéculations contemporaines sur d'éventuelles découvertes. La zone géographique incluse dans ce rapport est arbitraire, car les limites entre les Etats-Unis et le Canada ne signifient rien pour l'artiste qui a laissé des marques tangibles de ses vues dans les grottes. Une bibliographie avec la monographie complète est jointe afin d'apporter une aide à d'autres investigations.

La cantidad de literatura arqueológica relacionada con el indio americano ha aumentado en volumen a pesar de que la mayoría de los indios no tenía un lenguaje escrito con el cual relatar su historia. Todos los miles de trabajos, libros e informes que han escrito los investigadores se basan en evidencias encontradas en las ruinas de viviendas, lugares de acampar, cuevas y en las historias contadas de boca en boca. Aun los estimados de la fecha de la llegada del hombre al Nuevo Mundo es incierta. En 1930 la duración del tiempo que el hombre ha vivido en Norte América se dijo era menos de 10.000 años. Las autoridades concuerdan que esta fue la fecha en que el último glaciar abrió el puente terrestre a Asia permitiendo la inmigración al continente norteamericano. (Ilustración 1)

Ahora, cincuenta años más tarde, los científicos fijan la fecha del arribo de las primeras gentes a exceder veinte mil años. No hay ningún material «nuevo»; obviamente todo el material que establecería la ocupación primitiva ya existe. Todo lo que se necesita es descubrimiento y entendimiento.

Este «Entendimiento» aumenta diariamente, a medida que las instituciones educativas están conservando datos y produciendo científicos a un ritmo mayor. La duplicación del tiempo calculado de que los indios estaban en el continente norteamericano puede atribuirse a la energía, entusiasmo y estudio de científicos modernos. Esta ampliación del conocimiento continuará y se refinará para proveer una base más amplia sobre la cual elaborar hipótesis. Menos seguro es que se revele nueva información relacionada con la historia del hombre en el Nuevo Mundo. Estamos en una carrera con el tiempo para descubrir nuevas evidencias sobre el hombre primitivo. Como la mayoría de los vestigios de una visitación en los comienzos son frágiles, el clima y las fuerzas naturales operan para destruirlos. Además, las inundaciones de áreas por represas, y la construcción de carreteras, edificios, áreas de estacionamiento, etc. cubren, esconden o perturban lugares que podrían ser importantes para la historia. Como los vestigios son finitos (había tan sólo un cierto número para comenzar), el descubrimiento o pérdida de cualquier pieza reduce por uno el total a encontrarse. (Ilustración 2-a).

El Arte Rupestre ha sufrido particularmente de los efectos del clima, la erosión y el vandalismo. Del estimado de veinte mil lugares en Norte América, muchos no han sobrevivido. Esta pérdida continúa, pero afortunadamente se puede hacer un registro de los dibujos y las pinturas por medio de la fotografía, sin afectar el lugar, proveyendo un registro visual permanente. (Ilustración 2)

El Arte Rupestre en Cuevas –pictografía preservada en los oscuros huecos de cuevas– es extremadamente raro en Norte América. La investigación para este trabajo ha revelado solamente cuatro lugares principales en la literatura norteamericana que podría satisfacer plenamente este criterio. El requisito de oscuridad total y luz artificial no es un requisito imposible ya que hay cientos de cuevas a través de Europa y Asia que tienen tales vestigios y pinturas. Hace treinta años el número de cuevas con pinturas policromadas en México y América Central (aquellas cuevas que requieren luz artificial) era sólo una: la Cueva Juxtlahuaca en Guerrero. Actualmente, hay más de veinte que incluyen dibujos, esculturas, y enterramientos.

Las cuatro cuevas, en particular, en Norte América que creemos proveen ejemplos de un verdadero Arte Rupestre en Cuevas son representativas de los diferentes tipos de trabajos en otras partes del mundo y probablemente no son raras. Habrán otros descubrimientos. Cada uno de los ejemplos de este arte rupestre está en un tipo diferente de cueva y provee claves que podrán guiar hacia otros descubrimientos donde existan condiciones similares.

La Cueva del Lago Tule, Monumento Nacional de Capas de Lava, California

Existen más de 200 conductos de lava en el Monumento Nacional de Capas de Lava, mayormente pequeños remanentes de conductos de lava derrumbados –el más reciente formado hace unos 30.000 años durante la erupción de cercano Cráter Mammoth. Pictografías en pigmentos minerales rojo, amarillo y verde se encuentran en varias de las cuevas; Big Painted («Muy Pintada»), Little Painted («Poco pintada»), Indian Well («Pozo Indio») y en las Cuevas Symbol Bridge («Puente Simbólico»). Sin embargo, los dibujos en muchos de estos conductos de lava se encuentran en áreas luminosas cerca de entradas y están preservadas debido al abrigo de las rocas. La Cueva del Lago Tule que también contiene pictografías es una verdadera cueva oscura de acuerdo con Campbell Grant– aunque tiene dos aberturas hacia la superficie.

Feather Cave («Cueva de la Pluma»), Capitán, Nuevo México

Esta cueva pequeña, una extensión de una cueva de refugio, contiene (en adición a depósitos ceremoniales sin perturbar) algunas pinturas finas. De interés especial es la razón que la población india de Pueblo tenía para el uso de este lugar. En su religión los indios de Pueblo creían que el acceso a la tierra estaba asociado con cuevas. Un túnel natural que conducía a una cámara secreta detrás del refugio llano se ajustaba a esta descripción y, sin duda, dio margen al uso de esta área, que ahora se denomina Feather Cave («Cueva de la Pluma»), para propósitos ceremoniales. Descubrimientos similares se han encontrado en México donde túneles pequeños saliendo de salones de reunión en cuevas han conducido a lugares ceremoniales.

New Cave («cueva Nueva»), Parque Nacional Carlsbad. Nuevo México (Ilustración 5)

Esta enorme cueva está ahora abierta para visitas limitadas bajo la supervisión del Servicio Nacional de Parques de los Estados Unidos. A unos quinientos pies dentro de la cueva hay una pictografía en negro. Esto está asociado con el descubrimiento de algunos objetos en cerámica localizados en la misma área. Sin embargo, el significado de este dibujo geométrico, o posiblemente antropomórfico, es poco claro. Robinson ha especulado que los dibujos son un mapa trazado por los primeros indicios. Lo importante es que demuestra que los primeros habitantes si visitaban cuevas de piedra caliza y de hecho dejaban evidencia artística en gigantescos salones bajo tierra, al igual que el hombre primitivo lo hiciera en las cuevas del sur de Francia.

Jaguar Cave («Cueva del Jaguar»), Tennessee Oriental (Ilustración 6)

El descubrimiento más sorprendente de trabajo de arte en cuevas se ha encontrado en la Cueva del Jaguar, Tennessee. Dibujos hechos en barro blando, plástico no se consideraría usualmente como un registro permanente, sin embargo estos dibujos todavía existen.

Estos cuatro ejemplos no son, ciertamente, los únicos casos aislados de dibujos indios en cuevas. La razón para su selección es estimular la observación e identificación del estilo y del tipo de posibles evidencias en cuevas oscuras. Las pinturas en cuevas son frecuentemente tan frágiles que su supervivencia está amenazada. Por lo tanto, los investigadores son reservados al describir algunas que se conocen y las ubicaciones no se han revelado, a fin de evitar el vandalismo.

Campbell Grant incluyó en su libro sobre Arte Rupestre un mapa mostrando ubicaciones de lugares conocidos en Norte América.

La comparación de este mapa con uno de terreno cárstico de piedra caliza puede ser útil en la búsqueda de lugares de arte en cuevas. Véase (Ilustración 3).

Muchos descubrimientos recientes de vestigios arqueológicos y paleolíticos en cuevas han sido hechos por espeleólogos que también observaron cuadros y dibujos en paredes. Los espeleólogos que estén alerta a la posibilidad de pinturas en cuevas por los primeros indios pueden hacer una valiosa contribución. Notificando a investigadores reconocidos sería posible identificar y estudiar evidencias nuevas encontradas y así ayudar a ampliar el conocimiento de la ocupación y arte de los primeros indios en las cuevas del Hemisferio Occidental.

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PALEONTOLOGIA
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13302

Spanish karstic fillings: The key for Pleistocene ursidae knowledge

T. de Torres (M. Engineer Ph. D.)
Empresa Nacional ADARO de Investigaciones Mineras S.A.

RESUM

En aquesta nota es realitza una revisió dels óssos plistocènics, basada en material enpanyol; material que prové, fonamentalment, de dipòsits càrstics. Es fa també una revisió de la filogènia i de la distribució estratigràfica i geogràfica de les diferents espècies.

RESUMEN

En esta nota se realiza una revisión de los osos pleistocenos basada en el material español, que proviene, principalmente, de rellenos kársticos. Se hace una revisión de la filogenia y distribución estratigráfica y geográfica de las diferentes especies.

SUMMARY

This paper deals of a review of Pleistocene bears, based upon Spanish material, which mainly arises from karstic fillings. We make a review of phylogeny, and geographical and stratigraphical distributions of the different species.

Introduction

During the last years, excavations made in Spain have suppliec a very rich material of fossil bears from different species and ages, which have produced a great amount of new knowledge on phylogeny and stratigraphical and geographical distribution.

Phylogeny

Ursus etruscus G. CUVIER was the common ancestor of the most successfull evolutive trends (speloid and arctoid) of Pleistocene bears in Eurasia.

The speloid evolutive trend is represented by two species which show a more complicated dental morphology, progressive simplified dental formula, and skeleton also progressively more heavily built. The older is *Ursus denin geri* VON REICHENAU, which is substituted at the Riss by the cave bear –*Ursus spelaeus* ROSENMÜLLER-HEINROTH– which dissapeared at the end of the Pleistocene times, probably because of paleolitic man and brown bear demographic pressure.

The arctoid evolutive trend is represented in Europa, until the Upper Riss time, by *Ursus prearctos* BOULE, which is not directly connected with the «true» brown bear –*Ursus arctos* LINNEO– representing an species closely related with its direct ancestor *U.etruscus*.

U.prearctos appeared in the Middle Pleistocene, in populations with local differences but its skeleton was more heavily built and the dental morphology was more complicated.

The polar bear –*Ursus maritimus* PHIPPS– which never was found in Spain, can be placed into the arctoid group. It probably was derivated from an ancestral population of *U.etruscus* or *U. prearctos* isolated in an indeterminated cold period.

The brown bear is a late emigrant which, at the en of the Pleistocene, moved southwrds from Asia, colonizing all Europa, the Mediterranean border of Africa and N. America.

Until the Riss, there is an unfrequent bear in the faunal European panorama: *Ursus mediterraneus* F. MAYOR, closely related with *Ursus minimus* DEVEZE&DEBOUILLET.

Geographical and Stratigraphical distribution in Spain (Fig.-2)

The oldest Spanish fossil bear found in a karstic system is *U.minimus* (sin. *Ursus arvernensis* CROIZET&JOBERT) from Layna (Guadalajara) of Lower Villafranchian age. No Spanish material of this species, arises from no karstic deposits: Gaville (Italy) and Perpignan (France). The Spanish material could be not of a true cave host, but alloctonous material filling karstic fissures.

At the Middle-Upper Villafranchian a true demographical explosion of Ursidae took place with the apparition of *U.etruscus*. The oldest material has been found at the Lower Villafranchian locality of Villarroya (Logroño), but the boom of the species was at the Middle-Upper Villafranchian: Val d'Arno (Italy), Tegelen (Netherland), Saint Vallier (France), all of them non karstics deposits. In Spain, fossil remains of *U.etruscus* have been found at: Villarroya (Logroño), Puebla de Valverde (Teruel), Venta Micena (Granada) and Almenara (Castellón). The last is the only one with a karstic origin.

The first true cave inhabitant has been found at the Gran Dolina (Burgos) of Günz age. Relatively abundant material, comprising adults and cubs bones, have appeaderd. This bear, a more evolutioned species but closely related with its ancestor *U.etruscus* appeared also in Mollet Racó, Barcelona (Mindel) and Pinilla del Valle, Madrid (Riss).

But in Europa *U.etruscus* evolved mainly in a speloid way: enormous increase of teeth size, skull volume (pneumatization) and transversal dimension of postcraneal bones. This phoenomena was probably related with important changes in feeding habits and behaviour.

The first representant of this evolutive trend is *U.deningeri*

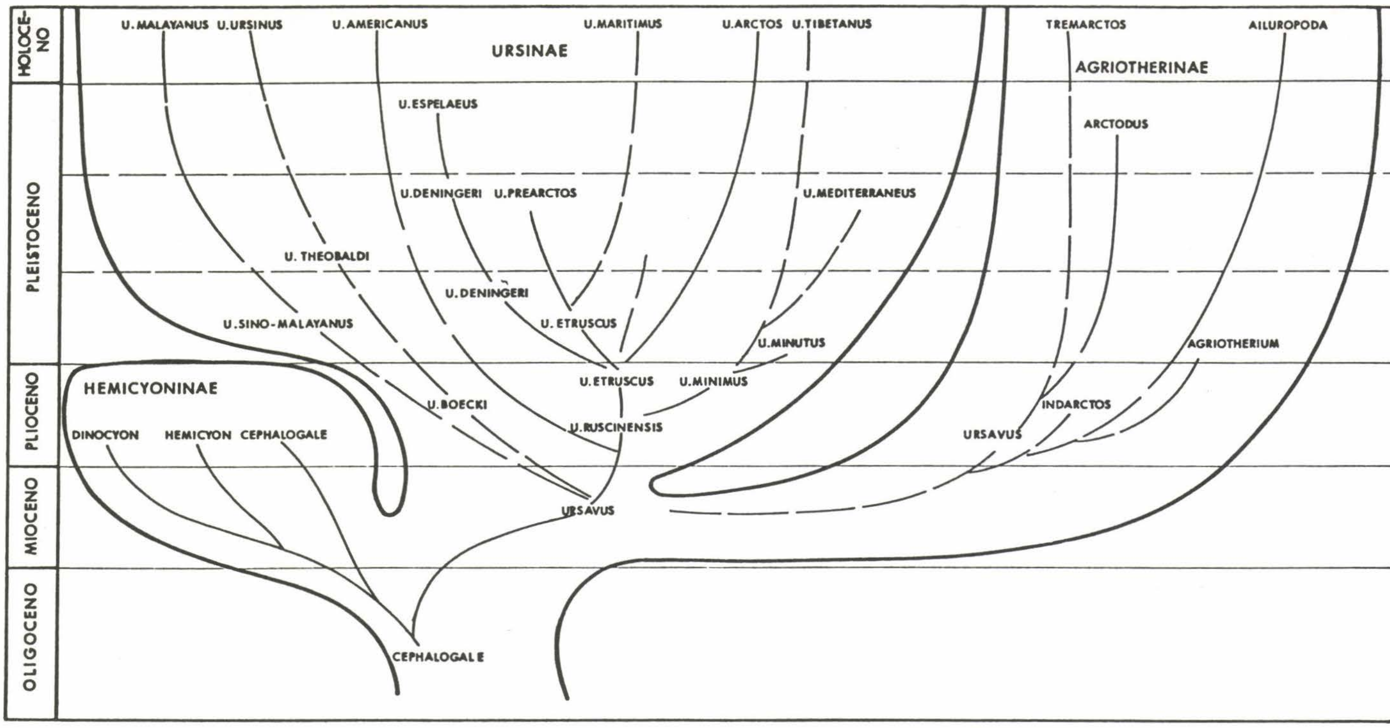

Fig.- 1. *Ursidae Phylogeny. After Erdbrink (1955) and Torres (1984), modified.*

which mainly was found in Europa associated with fluvio-lacustrine sediments. But in Spain there appeared exclusively in caves: Lezetxiki (Guipuzcoa), Cueva Nueva I-II (Segovia), Santa Isabel (Vizcaya) and Cueva Mayor (Burgos) –see Fig.-2–. With the exception of Lezetxiki, of probably Riss age, the other ones are of Mindel age.

The more popular and best known cave user is *U.spelaeus* whose remains have been recovered in caves of all European countries, been unfrequents in open air paleontological sites, with the well konwn exceptions of the loess of Krasnodar and the undersea sediments of the Canal. In the author's opinion the cave bear appeared at the Upper Riss: Tres Simas (Burgos), Lezetxiki (Guipuzcoa) and (?) Troskaeta (Guipuzcoa) –see Fig.-3–, where there are small sized animals. This species, reached a true ecological boom at the Lower Wurm. In Spain, despite of the fact that traces of this species appeared in a great number o caves, only five accummulations of cave bear remains can be specified:

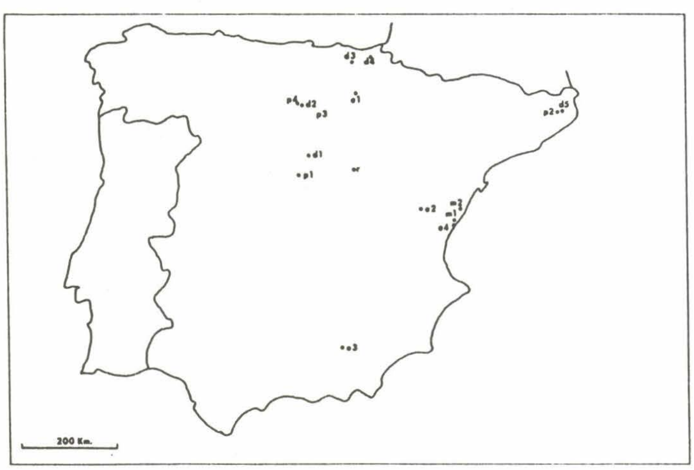

Fig.- 2. *Geographical distribution of less common bear's species finds.* e-U.etruscus: *1.- Villarroya-Logroño (no karstic); 2.- Puebla de Valverde-Teruel (no karstic); 3.- Venta Micena-Granada (no karstic); 4.- Almenara-Castellón (karstic).* r-U.ruscinensis: *Layna-Guadalaja (karstic).* m-U.mediterraneus: *1.- Villaviella-Castellón (karstic); 2.- Cau Borrás-Castellón (karstic).* d-U.deningeri: *1.- Cueva Nueva I-II-Guadalajara (karstic); 2.- Cueva Mayor-Burgos (karstic); 3.- Cueva de Lezetxiki-Guipuzcoa (karstic); 4.- Pardaki-Guipúzcoa (karstic).* p-U. prearctos: *1.- Pinilla-Madrid (karstic); 2.- Mollet Racó-Gerona (karstic); 3.- Palacios de la Sierra-Burgos (karstic); 4.- Gran Dolina-Burgos (karstic).*

Ekain (Deba, Guipuzcoa), El Toll (Moiá, Barcelona), El Reguerillo (Torrelaguna, Madrid), Raclau Viver (Bañolas, Gerona) and Arrikrutz (Oñate, Guipuzcoa). With the exception of the last one, of Wurm III age, the others are of Wurm I age.

Spanish cave bear populations can be grouped in three geographical areas: Cantabric, Mediterranean and Central

The first one is the best known and it is evident that the cave bear was a successful inhabitant of this region: its remains appeared in many caves, whit the exception of those situated in the mountains.

From this area, this specie moved in two different directions –Fig.-3–: crossing the Cantabrian Cordillera reached the low lands

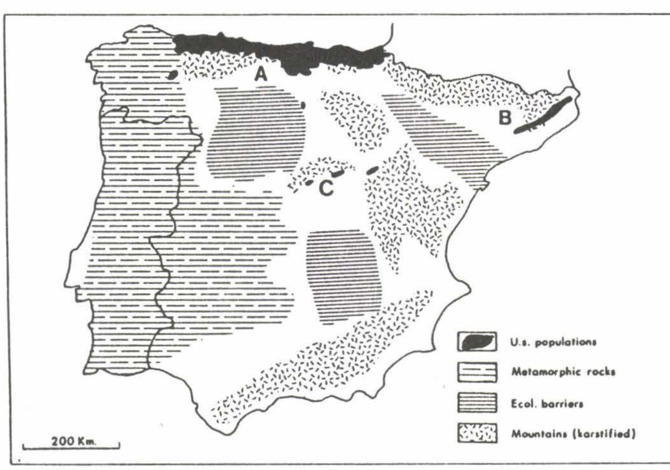

Fig.- 3. *Cave bear distribution in the Iberian Peninsula. A Cantabric area. B Mediterranean Area. C Central Area.*

of Nord Castillia, colonizating some caves of the North of the province of Burgos. Also, moved westwards across non karstifiable areas of Galicia (metamorphic formations), and in a isolated strata intercalated in a metamorphic complex, where some caves were developped,cave bear remains have been found (C. del Purruñal).

The Mediterranean population was not connected with the Cantabrian one, but probably was whit the meridional cave bear populations of France. This group din not move too much southwards, probably because of a kind of ecological barrier stablished by the mouth and lower part of the Ebro River; in the province of Castellon where mainly karstifiable rocks outcrop, the cave bear has never found. And this is strange because this species also lived in river mouths and marsh areas of the Netherlands.

The Central population is the most recently discovered, and is represented, almost exclusively, by the Cueva de El Reguerillo population. The cave bear probably moved southwards, from the Cantabric zone, going around the eastern limits of the Nothern Meseta, which probably acted as ecological barrier, reaching its southern limit, which coincides with the limit of karstifiable rocks, at the Cordillera Central. And it did not surpass the Southern Meseta, bounded by no karstifiable rocks, towards favourable karstic areas of Andalusia.

In conclusion: the Cantabric area was continually occupied by cave bear population from de Upper Riss (Lezetxiki) until the Upper Wurm (arrikrut-Wurm III), with a vestige population which dissappeared at the beginning of Holocene times. Mediterranean and Central population, probably were developped only during the Lower Wurm- the time of maximum successful of the specie.

As it has been said before, there is also an arctoid evolutive trend: *U.prearctos,* of large stratigraphical ad geographical distribution, probably because very low ecological exigences (as its ancestor *U.etruscus*) This specie probably dissappeared under the demographic pressure of the new appeared cave bear populations. It was a true cave dweller and has been located at: Gran Dolina and Palacios de la Sierra (Burgos) of Günz age, Mollet Racó (Gerona) of Mindel age and Pinilla del Valle Madrid of Riss age.

At the lower Würm there is a massive emigration from Asia of the «true» brown bear, *U.arctos,* under the pressure of a drastic climatic changement, colonizating N.America, after crossing the Behring Straits, now frozen, all Europa and the Mediterranean borders of Asia and Africa.

Finally: during the Middle Pleistocene, a small sized species appeared in the Mediterranean border of Spain: *U.mediterraneus,* its remains have been found ossociaded with karstic sediments at Cau Borrás and Villavieja, both of Riss age.

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ESPELEOLOGIA APLICADA

ESPÉLÉOLOGIA APLICADA

SPELEOLOGIE APPLIQUÉE

APPLIED SPELEOLOGY

ADECUACIÓ I CONSERVACIÓ DE CAVITATS TURÍSTIQUES
ADECUACION Y CONSERVACION DE CAVIDADES TURISTICAS
ADEQUATION AND PRESERVATION OF TOURISTICAL CAVITES

14146

Cleaning, restoration and redevelopment of show caves in Australia

John Bonwick, Ross Ellis and Mark Bonwick

RESUM

L'elevat nombre de visitants crea, en la major part de les coves turístiques, un elevat grau de pol·lució i d'altres problemes de manteniment que no es donen en «coves verges». En aquest treball es parla dels contaminants més habituals, de las tècniques per a procedir a la seva supressió i de les mesures preventives que hom hi aplica. Amb les normes actuals, els mètodes utilitzats fins ara no són pas els més adients. En especial per a les Coves de Jenolan, però també per a altres coves turístiques dÁustralia, s'han inventat diversos mètodes per a pal·liar els danys ocasionats, en uns moments en què han fortamente arrelat les iniciatives encaminades a l'arranjament de les coves del país.

RESUMEN

El elevado número de visitantes crea en la mayoría de las cuevas turísticas una polución especial y problemas de mantenimiento que no se dan usualmente en cuevas no urbanizadas. Son tratados los contaminantes, las técnicas para su supresión y medidas preventivas. Con las normas actuales los primitivos métodos de desarrollo dejan mucho que desear. Especialmente en las cuevas de Jenolan, pero también en varias otras cuevas turísticas de Australia, se han puesto en practica diversos métodos para corregir los daños causados en una época en que el concepto de turistificación de las cuevas estaba fuertemente arraigado.

SUMMARY

The high number of visitors in most show caves creates special pollution and maintenance problems of a type not usually found in «wild caves». The contaminants, techniques for their removal and preventative measures are dealt with. By todays standards early development methods leave much to be desired. At Jenolan caves particularly, but also in several other show caves around Australia, various means have been devised for correcting the damage caused in an era when the concept of cave management hardly existed.

Introduction - Brief history and background of the Jenolan experience

Most of the material presented in this paper relates to Jenolan Caves; partly because of the authors' proximity, but more deservedly so because of the pioneering work in this field by the Jenolan staff.

Jenolan Caves were discovered in 1838 (Havard 1934, Dunlop 1967b). By 1848 some public inspections were taking place. In 1880, electric light was used (Havard 1934). Visitor numbers by early 1890 had increaed to 1500 per year (Dunlop 1967a). By the turn of the century, no candles were being used for regular inspections. Subsequent cave discoveries were all developed with electric lighting. In the early 1950's closure of the more difficult and less attractive caves (Newbould 1974) coupled with greatly increased visitor numbers, naturally increased the load on the remaining caves. Cave inspection figures for 1984 were 212,000 (E. Holland, pers. comm.).

The awareness of widespread pollution and the fist tentative steps to deal with it began in 1955 (Newbould 1974). Mr Harman (the appointed Senior Guide the same year) had, over the previous 10 years, observed the correlation between the increassed visitor numbers and the rapid discolouration of speleothems in all the caves. The most abundat pollutant proved to be textile fibres from visitor's clothing.

Initial experiments with detergents and scrubbing brushes proved that much of the contaminating material could be removed, but a more efficient process was required. Harman conceived the idea of steam cleaning the caves. Enquiries around the world for any better ideas proved fruitless, so eventually, in spite of considerable unease, the first experiment with a steam cleaner took place in the Orient Cave in May, 1961, (Newbould 1976). The process appeared to work but some equipment problems had to be solved. In 1968 full time cleaning work on the Orient Cave commenced. It was completed in 1972 (Newbould 1974).

Although the early problems with the steam equipment were overcome, it was still a slow process. If the time to clean the Orient Cave was multiplied by all the other caves it didn't bear thinking about. In 1976 the advantages of using an industrial high pressure water cleaner for cave cleaning were recognised. Work began in the Imperial Cave in February, 1976, using such a cleaner. Its success in time saving at least can be measured by the fact that all the caves then being shown, including the Orient, were cleaned within eight years.

Cleaning machines

Steam Generators - Mr. Harman requested an electrically powered generator right at the start, but, as such a machine could not be located, the first machine used at Jenolan was kerosene powered. The results of the cleaning process were described as excellent, but the machine was rejected because it produced soot (Newbould 1974). A second machine from another company was tried. Water was flashed directly into steam within a small combustion chamber close to the output nozzle, but tests showed it was not satifactory. Cleaner propane fueled machines are now available.

An electric machine was found but it needed changes to make it more portable. The main components were modified so they could be moved separately and then reconnected at each working site. This machine required too much electrical power (30 kW) for it to be connected to the cave lighting system. A heavy supply cable had to be fed into the cave to run it. The machine was still heavy and the steam hose clumsy to use. In spite of these difficulties it was used to clean the Orient Cave completely, taking some 480 days (Newbould 1974, Byfield 1977).

High Pressure Water Cleaners – Two early model machines are still in use at Jenolan. These machines deliver cold water at a pressure of approximately 750 psi (Anon 1976) at the rate of approximately 2.5 GPM. 3/4" garden hose is used for the input supply. From a practical operating point of view this type of machine is a long way in front of any steam generator. It is light and compact enough to be easily moved by one man. Current models of the above mentioned capacity weigh only 50 kg. It has a low power requirement of only 1.5 hp (2kW) and can be connected to the cave lighting system. The pressure hose and the gun are both very light. In most cases a cave need not be closed while it is being cleaned. «Difficult to get at» walls and ceilings may be cleaned from a distance using the long «effective reach» of the water jet.

These machines are now available with a wide range of features: various power sources, hot or cold water, detergent mixing and pressures up to 10.000 psi. There is a «baby» machine about the size of a shoe box that delivers 2 GPM at 400 psi and weighs only 5 kg (Information from Anderson Cleaning Equipment Pty. Ltd.). For cave cleaning the value of hot water or detergent is questionable. From the Jenolan experience there would seem to be little or no advantage in pressures higher than 750 psi. Any higher pressures could result in damage to calcite surfaces.

High pressure water guns are now available with an infinitely variable pressure control that can ben easily fitted to existing equipment. It is a simple flow dividing device that would allow low pressure rinsing at the turn of a knob. Turret mounted nozzles are also available that would allow a quick change from a straight to a fan jet (Information from A.J. Chown Engineering, Sydney).

Vacuum Cleaning – At Jenolan some experiments have been carried out on dry powdery speleothems using a domestic vacuum cleaner. The experiment was limited by the equipment available but it appeared to have possibilities (E. Holland, pers. comm.). Probably the output, that is the pressure end, of a domestic cleaner would be a safe way of blowing dust off. The problem would be to collect it before it settled elsewhere. A high volume filter unit that could pull in airborne dust at a range of 1 or 2 m would be needed. This technique could be applied to speleothems that would be damaged by even the gentlest flow of water. On the other hand industrial cleaners that pick up steel swarf would easily pick up dense pockets of lint close to trails.

Effectiveness of machine cleaning

Steam versus Water – It should be pointed out here that neither process removes the contaminant. It is simply loosened and blasted off elsewhere. Both processes do this quite well and any difference would be marginal. The overall result is highly dependent upon preparatory work, operator skill and post cleaning operations.

Steam or hot water can be used to kill off Lampenflora. Although no experiments took place at Jenolan, overseas reports show a high success rate. If surface temperatures of 70 °C or more can be held for a minute almost all plant material can be killed (Aley 1972). On hard surfaces steam does an excellent job (Williams 1975). Where algae is growing in crevices the heating medium will not reach and it may regenerate. If excessive heat and pressure is used on soft or crusted surfaces, seriuos damage can occur (Lemon 1975).

Fragile Speleothems – It is obvious that the full working pressure of either steam or water machines cannot be applied to fragile decorations such as straws and helictites. Side loads are clearly dangerous. The columner strength of straws is much greater, and this fact was used to advantage during steam cleaning by directing the steam flow from a point vertically beneath them (R. Newbould, pers. comm.). In general, fragile items are handles either by reducing nozzle pressure, or by keeping it well away. Steam or warm water can be allowed to drift onto surfaces where dripping condensate would do the cleaning, rather than any direct force from the machine. Detergent in the water allowed the heat to be cut back further, and a mass of soapy bubbles was allowed to exude over helictites (R. Newbould, pers. comm.).

In the case of high pressure water machines in use at Jenolan the working pressure is fixed, but they have two sizes of round jet nozzles and one fan jet. The latter is used to create a fine mist, directed from several metres away at items to be cleaned. Even without detergent this has proved to be quite effective. The mist, coalescing on dirty straws and helictites returns to the floor as «black rain» (E. Holland, pers. comm.). As a result of these experiments detergent is no longer used in cleaning at Jenolan.

Removal of Graffiti – Pencil can be removed fairly easily. Crayon and lipstick are more difficult (J. Culley, pers. comm.). Where graffiti occurs on surfaces that are not to be washed, a «feathering» technique is used to ease the transition between the cleaned and uncleaned areas.

Calcification of Contaminants – Sometimes hours or even days may be spent changing a dirty grey lump of stone into a sparkling white display. It can be very disappointing for an operator to find, after all this work, that one black pack patch resists all efforts to remove it. The contaminants have, of course, been trapped under fresh calcite. If entrappment has occured, the area is still active or is likely to become active again. The answer is patience; in time the calcite will build up a sufficient thickness to heal any discolouration.

Bruised Calcite – The water jet is quite effective for removing the unsightly impact marks made by picks or rocks. The chalky material and broken crystals are flushed out leaving only the small change in surface level which is much less obvious.

Damage by machine cleaning

Surface Damage – On hard surfaces steam is unlikely to cause any crystal damage providing nozzle temperature is kept below 100 °C (Aley 1972, Lemon 1975). Water pressure at 750 psi is safe enough on suitable surfaces. Higher pressures should be avoided.

Breakages – This is one area where steam could be said to have an advantage. A short distance from the nozzle the energy level begins to dissipate very rapidly. Distant items are therefore protected from inadvertant movements. A solid water jet on the other hand retains a high level of kinetic energy even at a range of 10 or 20 m. Breakages have occured from the use of both steam and water. The low percentage of breakages is a small price to pay in view of the overall improvement to the cave environment.

Damage to Cave Fauna – At Jenolan, no formal examination of cave population was undertaken before or after any of the cleaning operations. However, the guides have made the following observations. In the Orient Cave, faced with steam and detergent, the population moved out. Later, when the cave was being hosed down with clean water the cave life returned (Newbould 1974). The impression gained during high pressure water cleaning is that certain creatures –springtails and wetas– seem to be attracted to areas being cleaned. Areas near bat chambers have been cleaned with no obvious effect on bat activity or population.

Spot cleaning

Lampenflora – While the purist might favour steam over chemicals, there seems to be ample evidence that chemicals in small doses do negligible harm to the cave or its inhabitants.

Bleach (sodium hypochlorite) has been used at Jenolan with good effect. Calcium hypochlorite may be preferable because any residue should be compatible (Rohde & Kerbo 1977, Johnson 1980, Rohde 1982). A butyl-alcohol concentrate has been used in the Congo Caves with success (Oosthuizen, 1981).

Graffiti – Hydrochloric acid has been used with some success (Knutson 1974). One technique for rock walls is to apply a paste consisting of dilute HC1 and cave mud. The mud keeps the acid in contact with the affected area and helps to preserve a natural colour. On calcite surfaces, a strong solution (without mud) is applied and then rinsed off (J. Poleson, pers. comm.). In general –practice on broken pieces first and use caution (Plantz 1977). Graffiti on mud coated walls can be smoothed over using the fan jet at an angle (K. Oliver, pers. Comm.).

Rimstone pools– The cleaning of these and other floor areas containing loose or friable material can be the most time consuming job of all. Because most of the loose material may be natural, high velocity cleaning is not possible. Repeated flooding with water will allow lighter material to be washed away but mostly rimstone pools have to be hand cleaned.

Conclusions

With visitor numbers still climbing, the next few years could be a testing time for Jenolan, a test for the work already done, and a challenge for all concerned to further improve the method. Recently, the Senior Guide kindly showed the authors through the Imperial Cave. They remembered it as a long dusty tunnel that one hurried through to see more interesting things at the other end. Not any more –crystal floors, not seen this century, have suddenly appeared– the whole place sparkles and Lot's Wife positively glows.
«IT IS A NEW CAVE»

Note: An unabridged version of this paper is to be published in the Journal of the Sydney Speleological Society.

Acknowledgements

E. Hamilton-Smith for suggesting that the Jenolan work be recorded. To the guiding staff at Jenolan for close co-operation, especially E. Holland, F. Harman, J. Culley, R. Newbould, J. Poleson, R. Guy, K. Oliver and D. Bramston.

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Address for correspondence: c/o Sydney Speleological Society, P.O. Box 198, Broadway, NSW 2007, Australia.

14287

La conservation des concrétions dans les cavernes aménagées

V. Caumartin

RESUM

Els estudis efectuats han conduit a la lluita contra la corrosió clorofíllica deguda al desenvolupament d'algues, molses i falgueres.
Es pot pensar en dos sistemas de lluita:
– Utilització de productes químics, seleccionats amb criteris estrictes
– Selecció de làmpares elèctriques, els espectres d'emissió de les quals s'apartin, el més possible, dels espectres d'absorció de la clorofilla.

RESUMEN

Los estudios efectuados han conducido a la lucha contra la corrosión clorofílica debida al desarrollo de algas, musgos y helechos. Se puede pensar en dos medios de lucha
– Utilización de productos químicos cuya selección sea efectuada con criterios precisos;
- La selección de lámparas eléctricas cuyos espectros de emisión se aparten el máximo posible de los espectros de absorción de la clorofila.

RESUME

Les études ont porté sur la lutte contre la corrosion chlorophylliennee due au développement des algues, mousses et fougères. Deux moyens de lutte peuvent être envisagés:
– l'utilisation de produits chimiques dont le choix est guidé par des critères précis;
– le choix d'ampoules électriques dont les spectres d'emission s'écartent le plus possible des spectres d'absortion de la chlorophylle.

Il s'agit aussi bien des revêtements stalagmitiques que des formations cristallines isolées. Les phénomènes de corrosion qui les touchent sont, pour le profane, d'origine physico–chimique ou d'origine biochimique; il n'est pas aisé de séparer les deux mécanismes car le CO_2, auquel on attribue à tort tous les méfaits, peut résulter, in situ, d'une activité microbienne mais peut être amené par des eaux en provenance des couches pédologiques où les micro-organismes sont très actifs, ou, tout simplement, résulter d'une quelconque activité physiologique – on a souvent incriminé la respiration des visiteurs–. Cedependant s'il est difficile de séparer les deux types de corrosion, dans la majorité des situations la matière organique est présente, c'est donc là l'essentiel.

On va se trouver en présence de deux situations.

A l'obscurité, aussi bien qu'à la lumière la matière organique est amenée par des courants d'air et planquée sur la pellicule d'eau que recouvre la concrétion. A des déchets de toutes sortes s'ajoutent, à certaines périodes de l'année et en abondance, des éléments particulièrement favorables au développement des germes, pollens, spores dont peu, compte tenu du milieu évolueront; quelles que soient la situation et la saison, une profusion de bactéries les accompagne, on en dénombre autant que sur un sol de culture. Les conditions sont requises: eau, matière organique, bactéries, équilibre ionique du milieu pour qu'une fermentation très active se développe. Dans un premier temps apparaissent des acides organiques neutralisés aux dépens du support calcaire, dans un deuxième temps le gaz carbonique, terme ultime de la dégradation, qui dissout le même support. Comme on le voit, le gaz carbonique est loin d'être le seul responsable. Bien entendu, tout déchet accidentellement abandonné subit le même sort, c'est la raison pour laquelle il vous est conseillé de vous montrer intransigeant sur le comportement des visiteurs.

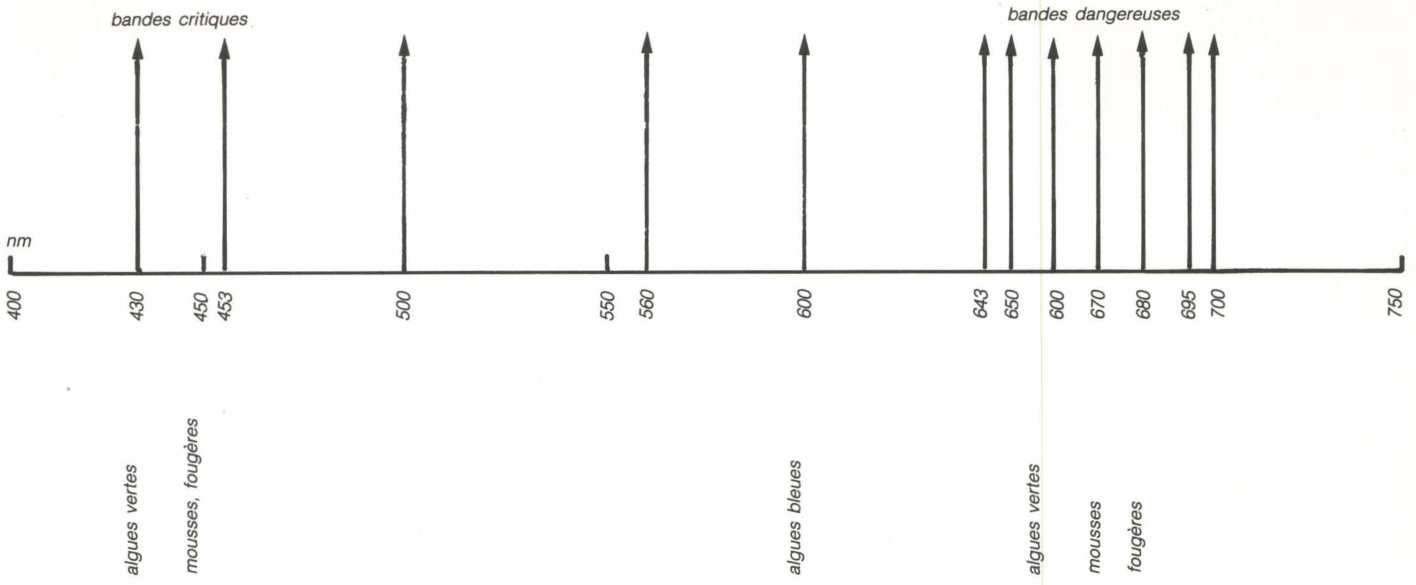
A la lumière,lumière du jour qui pénètre dans les entrées ou lumière artificielle des installations, les spores de végétaux cholorophyliens, amenées comme précédemment, se développent; on se trouve en présence de taches vertes d'algues et bientôt apparaissent, si on n'y prend garde, mousses et fougères. Ici la corrosion est plus spectaculaire. Cette végétation peut vivre aux dépens du gaz carbonique de l'air grâce à sa chlorophylle mais elle a pour celà besoin d'eléments minéraux qu'elle puise dans la concrétion en la désorganisant ou en laissant à sa surface des traces indélébiles. En outre, les débris végétaux qui en résultent nécessairement fermentent et subissent le sort des apports organiques recontrés dans les milieux obscurs. Ici l'action est double et beaucoup plus rapide, c'est pour celà que nous avons toujours insisté sur l'élimination de la végétation chlorophyllienne.

Revenons aux milieux obscurs. Lorsqu'on piège la matière organique qui circule dans une grotte, on s'aperçoit qu'il n'existe pratiquement pas de galerie vierge d'apports mais que, par contre, on peut rencontrer des surfaces réceptrices privilégiées qu'il faut, à défaut d'observation précise, pouvoir localiser à priori. Extrêmement rares sont les grottes à une seule ouverture car une simple fissuration de la roche peut permettre une circulation d'air; on se trouve fréquemment en présence d'un système à deux ou plusieurs ouvertures et la localisation des dépôts organiques en dépend. L'air d'une grotte est à température constante, à plus ou moins quelques degrés près, en toute saison, alors que celui de l'extérieur est plus froid, donc plus lourd, en hiver, plus chaud, donc plus léger, en été. Ceci crée des courants ascendants vers les ouvertures les plus hautes en hiver, descendants vers les ouvertures les plus basses en été, ce qui revient à dire que l'air rentre dans la grotte par le bas en hiver, par le haut en été, plaquant, par voie de conséquence, des pousìeres riches en matière organique active d'été sur les parois des ouvertures hautes, en matière organique morte d'hiver sur les parois des ouvertures basses. On peut tenir un raisonnement analogue en ce qui concerne l'hygrométrie car l'air extérieur est plus pauvre en humidité absolue en hiver, plus riche en été que celui de la grotte; son passage dans la grotte va donc, en hiver, entraîner, en même temps que son réchauffement, un assèchement des parois en contact, en été, une abondante condesation due au refroidissement, à l'endroit même qui reçoit la matière organique. La nature es rétabli curieusement des zones climatiques dans un milieu à température et humidité constantes. Les parties basses sont arides et désertiques, on n'y capture qu'accidentellement des cavernicoles; les parties hautes sont tempérées, très fertiles et les captures y sont plus fréquentes.

Mais il existe d'autres zones privilégiées, dans des cavernes à ouvertures situées à des altitudes différentes (quelques mètres suffisent) dont les galeries se recoupent. C'est ce que nous avons appelé des systèmes en V; dans ce cas, c'est à la pointe du V que se rassemblent condensations et dépôts sans qu'on puisse l'expliquer.

Les zones hautes et les extrémités de V entretiennent une fermentation active et par voie de conséquence la corrosion des supports stalagmitiques et des concrétions; il faut les neutraliser en disciplinat les circulations d'air, c'est ce qui justifie les installations de sas «fonctionnels» aux extrémités des galeries aménagées. Au besoin, la neutralisation périodique, au formol, des activités fermentaires permettra d'éviter leur propagation. Il s'agit de cas extrêmes, particulièrement dangereux, mais on doit également prendre en considération tout dépôt accidentel de matière organique, tout contact même humain qui peuvent, à la longue, avoir des conséquences du même ordre.

Nous allons aborder maintenat le point le plus délicat de la conservation, la lutte contre la végétation chlorophyllienne; c'est un problème d'éclairage. Les végétaux verts, en grotte aussi bien qu'à la lumière du jour, captent, grâce à leur chlorophylle, certaines composantes de la lumière blanche, composantes connues par leur couleur (violet, indigo, bleu, vert, jaune, orangé, rouge) et défines scientifiquement par leur longueur d'onde en nm (nanomètre) et peuvent ainsi, en utilizant l'énergie récupérée, faire la synthèse de composés organiques indispensables à la vie. Mais ils ne captent pas tous les mêmes radiations. En ce qui nous concerne, les mousses, les fougères et les algues vertes utilisent le violet-bleu, puis le rouge, les algues bleues l'orangé-rouge (Les algues rouges n'interviennent pas en grotte). Ci-dessous, indiquées par des flèches sur une échelle graduée en nanomètres les principales longueurs d'onde captées. Ces flèches correspondent à des maxima mais l'absorption se fait selon des bandes plus ou moins étalées, entre 430 et 453 nm, autour de 600 nm, entre 643 et 700 nm; la zone vraiment dangereuse est celle qui se situe entre 643 et 700 nm.



Notons également que la chaleur dégagée par la source de lumière active les développements tout en ternissant les surfaces concrétionnées.

Il convient donc de s'adresser à des systèmes d'éclairage qui n'émettent pas dans les longueurs d'onde chlorophylliennes et que dégagent le moins possible de chaleur. Pour le spectre d'émission, le problème est loin d'être résolu car les fabricants essaient, contrairement à ce que nous attendons, de se rapprocher le plus possible de la lumière solaire.

La technologie moderne s'ecarte du système à filament incandescent que nous avons tous connu. Elle fait appel à une décharge électique dans la vapeur de mercure à basse pression; le rayonnement ultra-violet obtenue est transformé en rayonnement visible au contact de poudres fluorescentes; la couleur obtenue dépend du choix de la poudre. Le système exige un ballast stabilisant la décharge mais les modèles existants, tubulaires, circulaire, en ampoules ont une longue durée de vie et consomment très peu. Nous avons expérimenté, dans cette gamme de production, le blanc chaud Mazda qui ne s'écarte pas complètement de la lumière solaire; les résultats vous ont été communiqués l'an dernier. Elle fait appel également à la décharge haute pression; le rayonnement visible d'un arc électrique est entretenu dans un plasma, à haute température, de gaz et de vapeurs métalliques contenus dans une enceinte isotherme, le brûleur, protégé par un tube ou une ampoule de verre. Les vapeurs métalliques utilisées sont celles du mercure, du sodium, d'un mélange de sodium, thoriu, irridium. On trouve des systèmes à ballast ou à branchement direct sur le secteur; l'un d'eux, monochromatique, est pratiquement achlorophyllien et les infra-rouges très calorifiques sont réfléchis dans le tube à décharge, c'est la lampe à vapeur de sodium basse pression de plus en plus utilisée dans l'éclairage des voies publiques; elle détient le record de l'efficacité lumineuse, possède un excellent rendement avec une faible consommation, une très longue durée de vie; malgré son ballast et son retard à l'allumage, elle convient parfaitement aux éclairages permanets. Quant aux lampes dites froides, elles ne sont pas nécessairement achlorophylliennes mais ont prouvé le bien fondé de leur appellation dans les devantures de patissiers, etc...

Nos conceptions, en matière d'éclairage de grottes aménagées, se précisent. Les cheminements et les sites qui nécessitent des éclairages permanents devraien être équipés de lampes achlorophylliennes de type vapeur de sodium basse pression. Les concrétions et autres curiosités doivent être équipées de lampes dites froides, ou d'un système intermittent à allumage rapide, intervenat seulement pendant les visites.

Les fabricants devraient être consultés plus fréquemment sur le choix du matériel, compte tenu des impératifs dégagés cidessus. Mais il est bien évident qu'aucune installation nouvelle ne peut être mise en place sans qu'au préalable ait été éliminé, par un traitement approprié –le problème a été maintes fois exposé devant vous–, la végétation existante car autrement on maintiendrait une corrosion par fermentation.

Nous avons essayé de vous montrer, dans le peu de temps qui nous était imparti, comment devait être entrepris l'aménagement d'une grotte touristique. De toute évidence, les impératifs esthétiques ne sont pas les seuls à prendre en considération. Dans certaines situations la conservation l'emporte.

CAUMARTIN Victor 60 rue Delpéch- 80000 Amiens. France Tel. 22 95 36 32

1476

The Tourist Caves of China

Zhang Shouyue
Karst Research Group, Institute of Geology, Academia Sinica

RESUM

Atès que les coves es troben entre els fenòmens càrstics més rellevants, en aquest treball hi seran tractats com a elements de la naturalesa de gran importància per al fenomen turístic.

La Xina posseeix una extensa varietat de zones càrstiques situades en emplaçaments molt diferents, tan geològicament com climàtica. La Xina és una de les zones càrstiques clàssiques de la Terra. Les roques carbonatades cobreixen més d'una cinquena part del seu terreny i s'estenen en una superfície que supera els 1.250.000 Km^2.

Són més de 50 les coves obertes al públic, proveïdes de senders i d'il-luminació elèctrica.

A cada cova hi trobareu una llista tabulada amb la seva localització, nom, longitud o àrea, carreteres d'accés i amb els principals trets que la conformen en el seu aspecte geològic i espeleològic.

L'acondicionament de noves cavitats i una millor documentació dels guies són potser dos dels problemes que més ens interessa solucionar dins del món de les coves turístiques.

RESUMEN

Ya que las cuevas están entre los fenómenos kárticos más importantes, en este trabajo serán tratadas como objetos de la Naturaleza de gran importancia para el turismo.

China posee una variedad de zonas kársticas situadas en localidades muy diferentes tanto geológica como climáticamente. Es una de las zonas kársticas clásicas del mundo. Las rocas carbonatadas cubren más de una quinta parte del terreno y se extienden en una superficie superior a los 1.250.000 km^2.

Hay más de 50 cuevas abiertas al público en China. Provistas de senderos e iluminación eléctrica.

La localización, nombre, longitud, o área, carreteras de acceso, rasgos característicos en el aspectos espeleológico y geológico, se dan en forma de lista tabulada para cada cueva.

El desarrollo previsto para las nuevas cavidades y la mejora de las explicaciones del guía son los problemas más importantes en el campo de las cuevas turísticas.

SUMMARY

Since caves belong among the most important karst phenomena, they will be treated in this paper as objects of nature very important for tourism.

China possesses a variety of karst areas situated within many different geological and climatic setting. It is one of the classical karst regions in the world. Carbonate rocks cover over one fifth of the country and crop out over more than 1.250.000 sq. km.

There are more than 50 caves open to the public in China. They are equipped with trails and electric lights.

The location, name, length or area, access routes, distinctive features on speleology and geological setting on each cave are listed in tabular form.

The proposed development of new caves and qualitative improvement of the guide's explanations are the most important problems in the field of tourist cave.

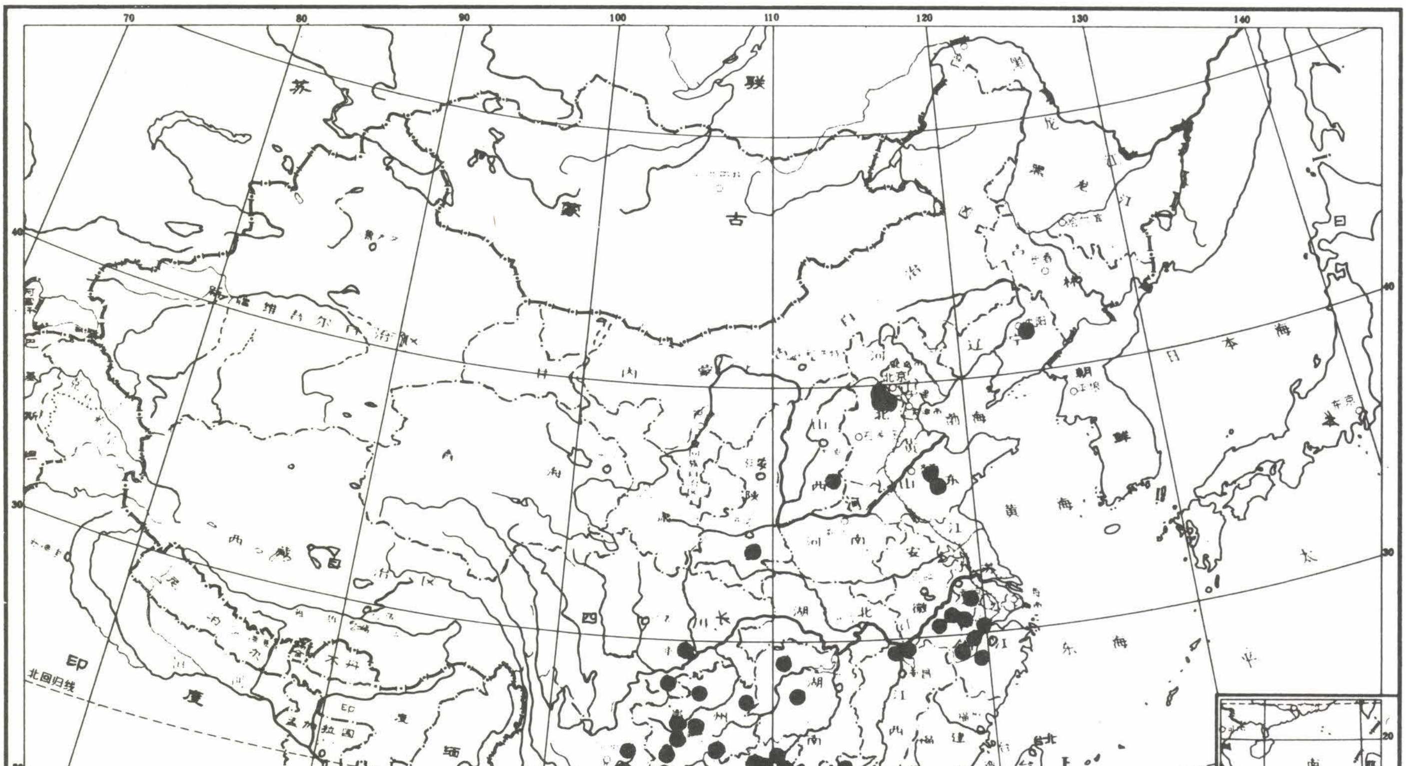


Fig. 1. The show cave locations of China

China possesses a veriety of karst areas situated within many different geological and climatic setting. It is one of the classical karst regions in the world. Carbonate rocks cover over one fifth of the country and crop out over more than 1.250.000 sq. km.

There is a large number of caves, it is believed that they amount to tens of thousands of them, but so far, only several handred caves have been registered.

From an economic and practical point of view, karst areas are generally poorly suited for agricultural purposes.

As tourist attractions, however, karst landforms, karst springs and speleologic phenomena are areas of exceptional interest.

Since caves belong to one of the most important karst phenomena, they will be treated in this paper as objects of nature very important for tourism.

There are more than 50 caves open to the public in China. They are equipped with trails and electric lights.

County and Province. Name of Cave	Length or Area	Lighting	Guide Provided	Access Routes to City	Distinctive Features on Speleology	Geological Setting
Benxi, Liaoning Water Cave	3.132 m.	electric	yes	railway	underground river	Ordovician, ls.
Fangshan, Beijin Yunshui Cave	570 m.	electric	yes	railway, air route	speleothems	Sinian, dolo.
Zhoukoudien (Choukoutien)		none	yes	idem	Mammalian and Sinanthropus fossils	Ordovician, ls.
Shifo Cave	above 2.000 m.	electric	yes	idem	speleothems, moon milk	Ordovician, ls. and dolo.
Zibo, Shandong Chaoyang Cave	1.300 m.	electric	yes	railway	speleothems	Ordovician, ls.
Yiyuan, Shandong	unknown	electric	yes	highway	idem	idem
Yixing, Jiangsu Shanjuan Cave	410 m.	electric	yes	highway, waterway	underground river, 300 m. long	Triassic, ls.
Zhanggong Cave	3.000 sq.m	electric	yes	idem	speleothems	idem
Linggu Cave	2.413 sq.m	electric	yes	idem	idem	idem
Hangzhou, Zhejiang Yaolin Cave	1.000 m.	electric	yes	railway, air route, and waterway	speleothems and underground river	Carboniferous, ls.
Jiande, Zhejiang Lingqi Caves	550 m.	electric	yes	railway, highway, waterway	water cave, wind cave and shift, 120 m. deep	Carboniferous, ls. and dolo.
Jinhua, Zhejiang Shuanglong Cave	150 m.	electric	yes	railway	underground river	Carboniferous, ls.
Binghu Cave		electric	yes	railway	shift, 45 m deep, underground water fall, 15 m high	idem
Chaozhen Cave	140 m.	electric	no	railway	speleothems	Permian, ls.
Huzhou, Zhejiang Huanglong Cave	unknown	unknown	unknown	highway, waterway	speleothems	unknown
Shuitai, Anhui Penglai Cave	above 3.000 m.	electric	yes	highway	speleothems, underground river	Ordovician, ls.
Jingxin, Anhui Guany in Cave	unknown	electric	yes	highway	speleothems	unknown
Jiujiang, Jiangxi Yongquan Cave	1.600 m.	electric	yes	railway, waterway	underground river	Triassic, ls.
Pengze, Jiangxi Longgong Cave	3.000 m.	electric	yes	highway, waterway	underground river, speleothems	Cambrian, ls. and dolo.
Lengshuijiang, Hunan Boyue Cave	2.500 m.	electric	yes	railway	speleothems, rimstone 1.5-2.0 m. high	Carboniferous, ls.
Cili, Hunan Huanglong Cave	unknown	electric	yes	railway, highway	speleothems	unknown
Zhaoqing, Guangdong Qixing Caves	small	electric or none	yes or no	highway, waterway	speleothems, underground river	Carboniferous, ls.
Lechang, Guangdong Gufo Cave	570 m.	electric	yes	railway	speleothems	Devonian, ls.
Yingde, Guangdong Baojing Cave	450 m.	electric	yes	railway, waterway	speleothems	Carboniferous, ls.
Liuzhou, Guangxi Bailian Cave	975 m.	electric	yes	idem	cave museum	idem
Dule Cave	above 500 m.	electric	yes	idem	speleothems	idem
Guilin, Guangxi Qixing Cave	1.700 m.	electric	yes	railway, air, route, waterway	speleothems	Devonian, ls.
Ludi Cave	240 m.	electric	yes	idem	idem	idem
Chuanshan Cave	518 m.	electric	yes	idem	idem	idem
Nanning, Guangxi Yiling Cave	1.100 m.	electric	yes	idem	idem	idem
Xingwen, Sichuan Tianquan Cave	above 3.400 m.	electric	yes	highway	speleothems, large underground room, largest collapse doline 176 m. deep and 505 m. in diameter	Permian, ls.
Dushan, Guizhou Shenxian Cave	4.965 m.	electric	yes	railway, highway	speleothems, underground river	Devonian, dolo.
Guiyang, Guizhou	550 m.	electric	yes	railway, air route	speleothems	Triassic, ls.
Anshun, Guizhou Long Cave	550 m.	electric	yes	highway, railway	underground river, speleothems	idem
Zhenning, Guizhou Xiniu Cave	407 m.	electric	yes	highway	speleothems, underground lake	Triassic, dolo.
Zhijin, Guizhou Daji Cave	above 2.600 m.	electric	yes	highway	speleothems, gigantic stalagmite 30-40 m. high	Triassic, ls.
Tongren, Guizhou Jiulong Cave	1.700 m.	electric	yes	highway	speleothems, large underground room, gigantic stalagmite 20-40 m. high	Cambrian, ls.
Lunan, Yunnan Zhiyun Cave	310 m.	none	no	highway	speleothems	Permian, ls.
Qujing, Yunnan	unknown	electric	yes	railway	speleothems	unknown
Licheng, Shānxi	idem	electric	yes	highway	speleothems	idem
Zuoshui, Shǎnxi Foye Cave	idem	unknown	unknown	highway	speleothems	Ordowician, ls.

The location, name, length or area, access routes, distinctive features on speleology and geological setting on each cave are listed in tabular form.

The show cave locations of China may be seen in the figure 1.

The proposed development of new caves and qualitative improvement of the guide's explanations are the most important problems in the field of tourist cave.

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Address of the author:
Zhang Shouyue, Karst Research Group, Institute of Geology, Academia Sinica, P.O. Box 634, Beijing, China.

15157

Tskaltubo Cave-the unique monument of the Nature

V.M. Dzhishkariani
Vakhushti Institute of Geography
The Academy of Sciences of the Georgian SSR, Tbilisi, USSR

RESUM

Aquest treball presenta els resultats de l'estudi realitzat a la cova de Tskaltubo durant els anys 1984-1985 pels espeleòlegs de l'Institut de Geòrgia Vakhushti.

Es varen efectuar estudis espeleomorfològics, mineralògics, geofísics, microclimàtics, hidrològics i hidroquímics, així com una topografia a gran escala, dins del projecte en curs d'habilitar la cova al turisme i a la investigació científica. La cavitat es troba bellament decorada amb formacions calcàries com helictites, perles, helicmites, «gours», etc. Els especiaslistes de l'Institut Vakhushti de Geografia, en col·laboració amb l'Institut de Geologia, Mineria i Mecànica i les escoles d'Enginyeria Hidràulica i Topogràfica de la Universitat estatal de Tbilisi han efectuat les recomanacions pertinents de cara a l'acondicionament de la cova i rodalies.

RESUMEN

Este trabajo presenta los resultados obtenidos en el estudio de la cueva de Tskaltubo durante 1984-85 por los espeleólogos del Instituto de Georgia Vakhushti.

Se efectuaron estudios espeleomorfológicos, mineralógicos, geofísicos, microclimáticos, hidrológicos e hidroquímicos, así como una topografía a gran escala dentro del proyecto de habilitar la cueva al turismo y a la investigación científica. La cavidad se halla ricamente decorada con formaciones calcáreas como helictitas, perlas, helicmitas, gours, etc. Los especialistas del Instituto de Geogragía Vakhushti en colaboración con el Instituto de Geología, Minería y Mecánica y las escuelas de Ingeniería Hidráulica y Topográfica de la Universidad Estatal de Tbilisi han efectuado las recomendaciones pertinentes para el acondicionamiento de la cueva y sus alrededores.

SUMMARY

The results of the Tskaltubo cave study during 1984-1985 by the speleologists of the Vakhushti Institute of Geography are given in the paper.

The speleomorphological, mineralogical, geophysical, microclimatic, hydrological, hydrogeological and hydrochemical investigations as well as the large scale instrumental survey to make up the project for the cave use for tourism and scientific observations were carried out. The cave is richly decorated with a variety of calcite formations such as excentric helictites, pearls, heligmites, gours, etc, etc. The specialists of the Vakhushti Institute of Geogrphi in collaboration with the Institutes of Geology, Mining and mechanics, the Hydraulic Engineering and land Reclamation Tbilisi State University worked out the recommendations for arrangement of the cave and its vicinities.

14125

Les grottes de Castellana: problèmes connexes à l'exploitation touristique et influence sur l'économie locale.

Vicenzo Manghisi
Instituto Italiano di Speleologia – Castellana-Grotte.

RESUM

Després d'una ressenya sobre l'exploració de les coves i d'una breu descripció de la cavitat, l'autor examina els problemes inherents a la preservació de la integritat de les coves de Castellana, deguts al considerable fluxe turístic que enregistren: manteniment d'infraestructures, enllumenat i proliferació d'algues, presència de visitants i perturbacions microclimàtiques, projects de millores i solucions tècniques per a la protecció ambiental.

A continuació, l'autor posa en evidència l'enorme importància de les coves de Castellana per l'economia local: actualment el nombre anual de visitants és de l'ordre de 400.000 persones.

RESUMEN

Después de una reseña sobre la exploración y una breve descripción de la cavidad, el Autor examina los problemas que conciernen a la integridad de las cuevas de Castellana, debidos al considerable flujo turístico: mantenimiento de las infraestructuras, alumbramiento y profileración de algas, presencia de visitantes y perturbaciones microclimáticas, proyecto de mejoras y soluciones técnicas para la protección ambiental.

A continuación, se pone en evidencia la enorme importancia de las Cuevas de Castellana para la economía local: actualmente el número anual de visitantes alcanza las 400.000 personas.

RESUMÉ

Après un aperçu sur la découverte et une brève description de la cavité, l'Auteur examine les problèmes qui concernent l'intégrité des Grottes de Castellana par rapport au considérable flux touristique: entretien des infrastructures, éclairage et prolifération des algues, présence de visiteurs et perturbations microclimatiques, projet d'amélioration et solutions techniques pour la protection de l'ambiante.

Ensuite on met en évidence l'énorme importance des Grottes de Castellana pour l'économie locale; actuellement le nombre annuel des visiteurs atteint les 400.000 personnes.

14160

Issledovanie peščery sof omar v Efiolii

Исследование пещеры соФ омар в ЭФиолии

T Kiknadze V Kiselev A Klimčuk K Rakviašvili
Т. Киннадзе, в. Киселев, А. Климчун, К. Ранвиашвили
АнадемиЯ Наун СССР

RESUM
Estudi de la cova de Sof Omar d'Etiòpia

Aquest treball està dedicat als resultats de l'estudi efectuat per espeleòlegs i carstòlegs soviètics a la cova de Sof Omar (Etiòpia) els anys 1983-1985. Les expedicions foren fetes a petició del govern d'Etiòpia i organitzades per l'Acadàmia de Ciències de l'URSS. L'objectiu d'aquestes expedicions fou la de dur a terme un estudi científic complet de la més gran de les cavitats del continent africà de cara a la viabilitat de la seva explotació turística. Els espeleòlegs soviètics han estudiat les característiques geològiques i mineralògiques dels materials així com la hidrologia i bioquímica del riu subterrani Webb, el qual ha format un espaiós laberint al llarg del seu curs. També s'ha dut a terme una topografia geodèsica a gran escala de la cavitat i s'han triat els recorreguts subterranis més aptes pels turistes, incloent aquelles recomanaciones que han de fer possible la utilització correcta de la cavitat i rodalies.

RESUMEN
Estudio de la cueva de Sof Omar en Etiopía.

El trabajo está dedicado a los resultados del estudio efectuado por espeleólogos y karstólogos soviéticos en la cueva de Sof Omar, Etiopía en 1983-1985. Las expediciones fueron invitadas por el gobierno de Etiopía y organizadas por la Academia de Ciencias de la URSS. La finalidad de las expediciones fue efectuar un estudio científico completo de la mayor cavidad africana de cara a dar recomendaciones para su utilización es vistas al turismo. Los espeleólogos soviéticos han estudiado la geología y mineralogía de los materiales, hidrología y geoquímica del río subterráneo Webb, que ha formado un espacioso laberinto a lo largo de su curso, llevando a cabo una topografía geodésica a gran escala de la cavidad, eligiendo los recorridos subterráneos para los turistas y efectuando recomendaciones detalladas para la utilización de la cavidad y los aledaños.

SUMMARY
Study of Sof Omar Cave in Ethiopia.

The paper is devoted to the results of study made by the soviet speleologists and karstologistis in Sof Omar Cave, Ethiopia in 1983-1985. The expeditions were invited by the government of Ethiopia and organized by the Academy of Sciencies of the USSr. The aim of the expeditions was to make thorough scientific study of the largest African cave with a view to give recommendations for its use for the purpose of tourism. The soviet speleologists have studied geology and mineralogy of rocks, hydrology and geochemistry of the subterranean river Webb, which formed the spacious labyrinth along its course, carried out large scale geodetic survey of the cave, marked out subterranean routes for tourists and worked out detailed recommendations for the use of cave and the surrounding country.

Пещера Соф Омар, крупнейшая на африканском континенте, находится в южной провинции Эфиопии-Бале, в 500 км юго-восточнее от Аддис-Абебы и в 140 км восточнее Гобы, центра провинции (рис. 1).

Пещера образована рекой Веб, берущей начало в горах Бале на высотах свыше 4000 м, в 120 км от пещеры. Долина р. Веб врезана в плато до глубины 130 м, местами описывая меандры. Сквозь шейку одного из меандр река выработала пещеру, оставив сухой часть своего прежнего русла. Проделав под землей путь длиной около 1200 м, река вновь появляется на поверхность в узком каньоне.

Пещера Соф Омар издавна известна местному населению. Она почитается как святое место у мусульман Галла и Оромо. По преданию пещера была жилищем святого человека Омара и впоследствии его имя стало названием деревни и пещеры. Она и сейчас служит местом паломничества мусульман.

Первое документальное свидетельство о пещере Соф Омар дано Дональдсоном-Смитом (1897). В 1913 и 1938 гг. пещеру посетили итальянцы. Позже важные исследования провели здесь британские спелеологи Эрик Робсон и Крис Клепхем, на основе которых были опубликованы популярные брошюры (К. Клепхем, Э. Робсон, 1967) и научная статья (Э. Робсон, 1967). После этого проф. Т. Монод и доктор В. Мортон исследовали фауну в пещере (1972). Большую работу по изучению пещеры Соф Омар и некоторых других пещер Эфиопии выполнила Британская спелеологическая экспедиция в 1972 году; составлено подробное описание пещеры, охарактеризованы вторичные отложения, намечены основные фазы развития полости (1973). Пещера Соф Омар упоминается также в небольшой статье В. Мортона (1976), посвященной спелеологическим открытиям в других районах Эфиопии.

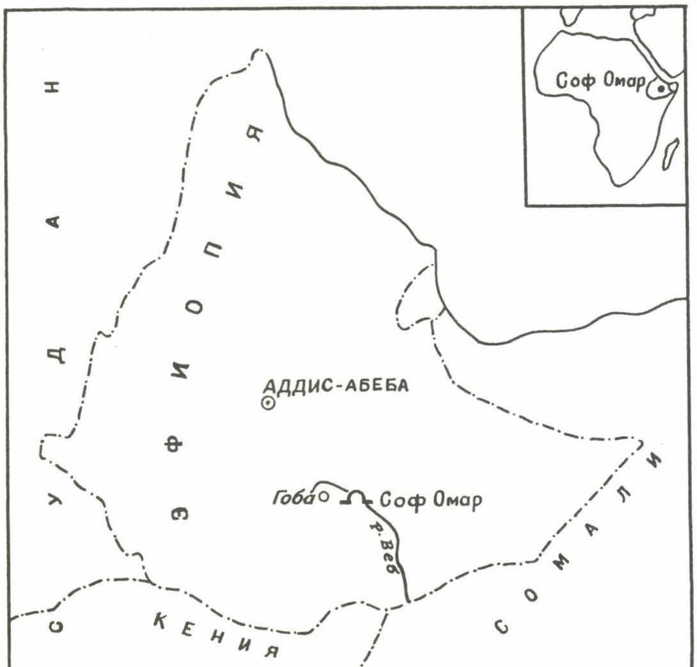

Рис. 1. Расположение пещеры Соф Омар.

По просьбе правительства Эфиопии, наметившего благоустройство пещеры Соф Омар для целей туризма, пещеру дважды (1983 и 1985 гг.) исследовала экспедиция советских спелеологов, организованная Академией наук СССР. Результаты этих исследований и даются кратко в настоящем докладе.

Морфология пещеры

Пещера Соф Омар представляет собой систему крупных и малых проходов, залов, галерей (рис. 2 - составлен по материалам британской - 1973 г. и советской-1985, спелеологических экспедиций), развитых субгоризонтально. Стержнем пещерного лабиринта является Речной проход, по которому в настоящее время протекает, по общему направлению СЗ - ЮВ, р. Веб. Речной проход представляет собой крупную галерею шириной и вертикальными стенами высотой 10-50 м. В верхней части (по отношению к течению реки) пещеры к Речному проходу примыкают крупные галереи. Слева расположена система Айю Мако, образуя обширное пространство с колоннами. Справа к Речному проходу под разными углами выходят также крупные галереи. Ниже по течению реки все ходы выклиниваются на Речной проход и его впечатляющий прямолинейный участок длиной около 250 м (Сафари Страйт) ведет к средней части пещеры, в конце образуя огромный купол высотой 50 метров от русла реки. Здесь примерно параллельно Речному проходу протягиваются две крупные галереи, Молоссидей и Рейлвей, являющиеся старыми руслами реки. В месте примыкания к Речному проходу они образуют огромный и прекрасный "архитектурный" ансамбль, называемый залом Колонн.

Еще ниже по течению, вдоль левой стороны Речного прохода тянется обвальная зона, образованная огромным провалом (Шейкхолл) в потолке крупного зала. Большие глыбы базальта и известняка блокируют все проходы по периметру Шейкхолла и загромождают русло реки, образуя Большие пороги.

В нижней части пещеры выделяется сложный лабиринт - Холука с большими галереями Флинтотоун, Мудвелл, Грейт Холл, а справа от речного прохода располагается система Клепхема. Все они ориентированы в целом поперечно к реке и соединены многочисленными галереями и ходами. Вблизи Грейт Холла река выходит на поверхность и протекает по каньону с вертикальной стеной слева, изубилующей живописными "окнами" на одном уровне. Крупные галереи и залы системы Клепхема ориентированы в целом параллельно речному проходу и каньону, вдоль крупного разлома. Их морфология сильно осложнена глыбовыми обвальными накоплениями.

Суммарная длина всех ходов пещеры Соф Омар составляет 15,5 км. Она является длинейшей карстовой пещерой Африканского континента. Общий объем пещерной системы, подсчитанная ориентировочно, превышает 1 млн.м^3, чем она входит в разряд крупнейших полостей в мировом масштабе.

Следует отметить также необычно большое количество входов у пещеры Соф Омар, их 42.

Разница высот по Речному проходу от Айю Мако до Холуки около 15 м. Амплитуда пещеры, т.е. разница высот между крайними верхней и нижней точками пещеры составляет 60 м.

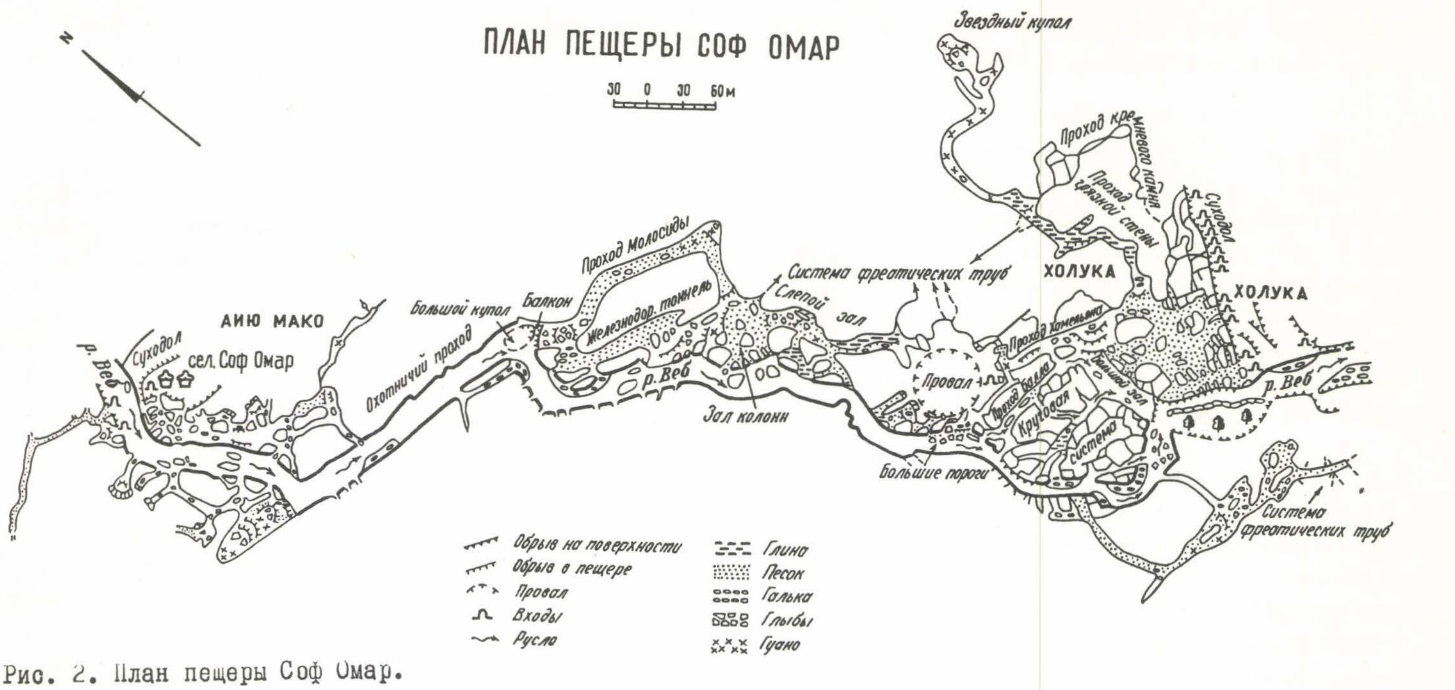

Рис. 2. План пещеры Соф Омар.

Форма поперечных сечений ходов пещеры отражает фреатические и последующие ведозные условия формирования и контролируется структурно-литологическими и гидродинамическими факторами. В формировании некоторых ходов и залов, особенно крупных, большую роль играют плоскости напластования, которыми подчеркнут прямоугольный облик поперечных сечений (Речной проход, некоторые участки зала Колонн, Флинстоун и др.). Форма ряда каналов, оформированных основным потоком реки и ныне оставленных водой, близка к горизонтально ориентированному овалу (Рейлвей, Молосидей и др.). Морфология подавляющего большинства ходов средних и малых размеров, образующих лабиринты в средней и нижней частях пещеры, определяется вертикальными тектоническими трещинами. Напластование и в этих случаях оказывается на форме, вместе с литологическими свойствами пород определяя детали скульптуры. Заложение ходов контролируется тектоническими трещинами преобладающих систем 20-200° и 110-290°. В нижней части пещеры становится важным также направления 80-260°.

Большинство неровностей поперечного сечения ходов, представляющих как-бы изысканные скульптурные украшения, созданы в результате неравномерного коррозионно-эрозионного воздействия движущейся воды на слоистые известняки. Характерными являются вертикально ориентированные углубления в стенах, образующие беспрерывные ряды и оформированные на одном или нескольких уровнях по многочисленным литогенетическим внутрипластовым трещинам.

В нижней части пещерной системы часто встречаются эворзионные котлы-мармиты, глубиной 1-1,5 м, иногда достигая в поперечнике 2-3 м. Почти повсеместно на стенах пещеры оставлены характерные небольшие углубления, образованные потоками воды.

Различные эрозионные формы образуются в заполнителе пещер: глине, песке, оцементированной гальке. Особенно впечатляющи каньоны, образованные в результате эрозионного размыва периодическими потоками в галереях системы Клепхема. Они достигают 3-4 м в ширину и глубину.

В целом, морфология большинства проходов и залов свидетельствуют об их формировании во фреатических условиях с последующим наложенным вадозным воздействием.

Геологические условия

Геологическое строение территории пещеры довольно простое, хотя и своеобразное. На докембрийском кристаллическом основании залегают осадочные породы позднепалеозойского и раннемелового возраста. На них расположена т.н. Антальская известняковая формация. Она перекрыта покровом базальтов неоген-четвертичного возраста. Долиной р. Веб вскрыты эти базальты, мощность которых здесь около 20 м, а также верхняя часть Антальской формации, представленной сверху вниз песчанниками, толстослоистыми песчанистыми известняками, глинистыми сланцами и известняками.

В геологическом разрезе окрестной территории, составленном нами, вырисовываются некоторые отрезки истории ее геологического развития, характеризуемые разной степенью доломитизации известняков, их разной песчанитостью и содержанием ископаемой фауны, изменением структурно-текстурных свойств карбонатных пород и т.д. В верхней части разреза, в контактной с базальтовым покровом зоне также отчетливо наблюдается постепенное изменение степени метаморфизации известняков. Отмеченные различия вместе с хорошо выраженной слоистостью и трещиноватостью создают условия для образования в пещере разнообразных колонн, украшенных фигурными основаниями и капителями, полок, террас и т.д. Вмещающие пещеру известняки в основном пелитоморфной структуры, часто с включениями ромбоэдров доломита и фрагментов спелетов микро-фауны. Мощность отдельных слоев колеблется в пределах 2-5 м. Известняки белого, серого и розового цвета, плотные, слабо подверженные выветриванию внутри полости.

Тектоника района спокойная, породы залегают почти горизонтально. Тектонические трещины пронизывают один или несколько слоев, реже - всю толщу.

Гидрологические условия

Современная гидрологическая ситуация в пещере Соф Омар полностью определяется климатическими особенностями района: сезон малых дождей продолжается с конца марта по июнь, сезон больших дождей - с конца августа до начала ноября. В сухие периоды уровень р. Веб сильно понижается и в пещере появляются широкие галечные берега и броды глубиной до 1 м. С началом дождей уровень воды в реке резко повышается, иногда до 7 м, и она заполняет боковые ходы и прилегающие залы.

Температура воды р. Веб в пещере колеблется в пределах 20,0 -

- 23,0^0 (май, 1983г.; март-апрель 1985 г), Минерализация воды плавно нарастает вниз по течению от 300,8 и до 375,7 мг/л.

Микроклимат

Температура воздуха в пещере Соф Омар подвержена суточным колебанием в пределах 20,0-23,6^0. Ее зависимость от наружной температуры возрастает в Холуке, где имеются многочисленные входы разной экспозиции. Наблюдается некоторое повышение температуры воздуха в местах скопления свежего гуано. В разных участках полости различных интенсивность воздушной циркуляции. Воздух пещеры характеризуется низкой относительной влажностью и повышенным содержанием углекислого газа, что также связано с окислительными процессами в накоплениях гуано.

Вторичные отложения

В пещере Соф Омар большое распространение имеют водные механические отложения. Современная хорошо окатанная галька базальта образовалась в результате размыва древних конгломератов в пещере. Во многих местах имеются песчаные наносы, состоящие преимущественно из мелких обломков известняка, зерек, рудных и нерудных минералов. Песчаные отложения пещеры Соф Омар хорошо отражают минералогический состав пород в бассейне р. Веб. Пещера является ловушкой и накопителем тяжелых и акцессорных минералов.

В некоторых галереях (Мудвелл в системе Холука, Блаинд вблизи зала Колонн) развиты мощные отложения глины, а в зонах временных затоплений образована глинистая корка, при рассыхании растрескивающаяся на полигональные блоки (микротакыры).

В пещере встречаются древесные наносы в виде крупных древесных стволов часто заклиненных поперек проходов на разных уровнях вплоть до самых высоких.

Гравитационные отложения также широко распространены в пещере. Крупные глыбы известняков песчаников и базальтов провально-гравитационного происхождения блокируют многие галереи на периферии пещерной системы. Огромный провал Шеикхолл на поверхности, фиксируется в пещере серией крупных глыбовых завалов. Обширные скопления обвально-гравитационного глыбового материала имеются в системе Айю-Мако, в зоне зала Колонн, в районе Большого Купола, в системах Холука и Клепхема. Термо-гравитационные отложения представлены мелкими обломками вмещающей породы, чаще всего в виде чешуйчатых отслоений.

Хемогенные отложения в связи бронированностью известняков базальтами и отсутствии вертикальной циркуляции подземных вод весьма редки. В галерее Римстоун развиты гуры, обнаружены также нитевидные гипсовые кристаллы - антодиты, образующиеся в результате выхода поровых вод из породы в условиях аэрации.

Органогенные отложения представлены гуано, образующим значительные скопления в начале галереи Сафари, в зале Колонн, в Грейт Холле в зале Астродом и в некоторых небольших проходах.

Флора и Фауна

В пещере Соф Омар встречаются, хотя редко, бесцветные грибы и крохотные цветы. Из постоянных обитателей пещеры следует отметить рукокрылых. Здесь живут целые колонии летучих мышей, среди которых отмечены 9 видов. Встречаются также паукообразные, кузнечики, жуки насекомые, внесенные в пещеру водным потоком. По реке в пещеру заплывают рыбы.

...

Нами инструментально закартированы предполагаемые подземные и поверхностные туристские трассы в масштабе соответственно 1:200 и 1:1000.

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PROTECCIÓ DE CAVITATS I RESERVES SUBTERRÀNIES
PROTECCION DE CAVIDADES Y RESERVAS SUBTERRANEAS
PROTECTION AND SUBTERRANEAN RESERVE CAVITIES

14226

Škocjanske Jame – exposé des motifs pous l'enregistrement dans la liste du patrimoine mondiale (UNESCO)

France Habe
Albin Debevec

RESUM

La comisió per a la protecció del carst i les cavitats habilitades de l'U.I.S. ja havia posat una especial atenció, en els congressos de Sheffield i Bowling Green, a les Coves de Škocjan, molt conegudes arreu del món i que tenen, des del punt de vista geològic, morfològic, hidrològic, climatològic, florístic i arqueològic, un interès indiscutible.

Aquest treball ens mostra, a grans trets, totes les seves característiques i l'esforc/ d'autoritats administratives i polítiques, així com de les organitzacions científiques, espeleològiques i turístiques perquè aquesta cova sigui inscrita a la llista del Patrimoni Mundial. De la mateixa manera, la Comissió fa una crida al Congrés Internacional d'Espeleologia de Barcelona perquè s'adhereixi a aquesta proposta en les seves conclusions finals, ja que aquesta decisió farà que es dediqui una major atenció a la depuració del riu Reka-Timavo.

RESUMEN

La Comisión para la protección del karst y las cavidades acondicionadas de la UIS ya había prestado una especial atención en los cogresos de Sheffield y Bowling Green a las Cuevas de Škocjan. Son conocidos mundialmente e incomparables desde el punto de vista geológico, morfológico, hidrológico, climatológico y florístico y arqueológico.

Este comunicado muestra en rasgos generales todas las características y el esfuerzo de las autoridades administrativas y políticas, así como de las organizaciones científicas, espeleológicas y turísticas para que esta cueva sea inscrita en la lista del Patrimonio mundial. Al mismo tiempo, la Comisión apela al Congreso Internacional de Espeleología de Barcelona, para que mantenga esta propuesta en sus conclusiones finales ya que esta decisión estimulará las atenciones particulares para la purificación del rio Reka-Timavo.

RESUME

La Commission pour la protection du karst et pour les grottes aménagées del l'UIS avait déjà aux congrès de Sheffield et Bowling Green consacré un soin particulier aux Grottes de Škocjan, bien connues dans le mode, lesquelles son dans le point gélogique, morhologique, hydrologique, climatologique et floristique et archéologique aussi sans comparaison.

La communication montre dans les traits généraux toutes les caractéristiques et l'effort des autorités administratives et politiques, bien que des organisations scientifiques, spéléologiques et touristiques pour l'enregistrement de cette grotte dans la liste du patrimoine mondial. En même temps la Comission fait appel au Congrès international de spéléologie de Barcelone de soutenir cette proposition dans ses conclusions finales car cette décision fera naître les soins particuliers pour la purification de la rivière Reka-Timavo.

Les Grottes de Škocjan, 1,5 km longues et 200 m profondes, présentent le plus grand phénomène naturel du Karst classique lequel est devenu célebrè par les premières déscriptions, ainsi donnant lieu aux nombreux termes professionels internationaux. De cette région origine le terme professionel Kras (Karst en allmand, Carso en italien) pour les phènomènes qui étaient décrits pour la première fois dans la región autour de Trieste. Cet objet intéressant sera montré à la fin de la communication par quelques diapositives.

Škocjanske jame, comme le phénomène mondial karstique, étaient toujours le souci de la Commission pour la protection du karst auprès de l'UIS laquelle a accentué l'importante de ces grottes dans les conclusions des Congrès en Sheffield en 1977 et en Bowling Green en 1981. Au 160-anniversaire du dévelopment de l'aménagament des grotes, sur l'initiative de l'UIS, était organisé le Symposium sur la protection du karst démontrant de nouveau que le Karst classique et les Škocjanske jame présentent un phénomènes dans la cadre mondial qui a donné l'initiative au développement de la science spéléologique. Comme monument naturel et culturel Škocjanske jame sont tellement importantes qu'il faut les protéger et le plus tôt possible achever la ceremonie pour l'enregistrement dans la liste du patrimoine mondiale auprès de l'UNESCO.

Au point de vue *morphologique* la region de 20 ha protégées, s'étendant entre l'entrée dans les grottes avec le canyon superficiel de Gornje Vreme, pont naturel entre Velika et Mala dolina jusqu'au canyon souterrain avec les murs verticaux de plus de 100 m, présente un vrai phénomène spéléologique mondial.

Au point de vue *hydrologique* la rivière Reka présente le seul cours superficiel dans le Karst classique. Le problème de pollution de cette rivière regarde trois communes où s'écoule Reka. Dans les dernières années la collaboration entre les institutions professionelles pour l'assainissement de l'eau a été organisé.

Au point de vue *climatique* les Škocjanske jame sont un singularité à cause de sa structure morphologique. Pendant l'hiver la grotte se refroidit à cause de sa forme convecte. L'eau dans la grotte est plus chaude alors le bruyard apparaît. Dans les grandes dolines d'éffondrement l'inversion climatique apparaît donnant lieu à circulation d'air spécifique.

Même la vie souterraine dans les grottes et dans les dolines d'éffondrement présente une spécialité *botanique*. Nos botanistes ont constaté que à cause de zonalité verticale dans la région de Škocjanske jame il y a 250 plantes phanérogames et 25 cryprogames. On y trouve les représentants de la flore autochtone ilyrienne, méditerranéenne, panonienne et baltique. On y trouve aussi dels relictes glaciales charactéristiques, comme par example Primula auricula.

Škocjanske jame sont intéressantes aussi au point de vue *archéologique* car il y a plusieurs nécropoles préhistoriques. Škocjan avec le karst de Divača présente un vrai paradis pour les trouvailles préhistoriques. Dans le système souterrain de Škocjanske jame sont les plus importantes les grottes Tominčeva jama et Roška špilja. Dans Tominčeva jama succèdent les strata culturelles du Moyen Age, l'antiquité l'age de fer et de bronze jusqu'au énéolitique. Ainsi la grotte est la plus grande site préhistorique du Karst.

De tout ce qu'on a dit il est évident que l'importance de Škocjanske jame est très variée: scientifique, recherche, pédagogique, pour les études, démonstrative, culturelle et recréative. C'est aussi refleté dans les mots que le bien connu spéléologue français Norbert Casteret a écrit dans l'album: «Dans la Grotte de Postojna on y voit tou ce que le coeur désire, tandis que les grottes de Škocjan n'ont pas de comparaison dans le monde.»

Toutes ces qualités d'objectes souterrains étaient connues depuis l'antiquité sous le nom Timavus. L'intérêt extraordinaire pour les Škocjanske jame étair provoqué par l'exploration du spéléologue de Vienne Adolf Schimdil. La vraie importance les grottes ont obtenu dans les oeuvres célèbres sur le Karst. En 1894 E.A. Martel dans Les Abîmes et le spéléologue de Vienne Franz Kraus dans Höhlen Kunde out prouvé que la nouvelle branche scientifique – spéléologie – était née en étudiant les phénomènes karstiques sur le Karst classique.

Les grands efforts pour l'aménagement de ce monde souterrain singulier son refletés dans les efforts des générations où, à part de nombreux spéléologues, les habitants de de region, courageux et intrépides, de Škocjanke jame penvent être divisées en cinq périodes. La plus vieille est présentée par la construction de la première voie turistique ont grands mérites. Les 160 années de l'aménagement touristique dans Velika dolina à la suggestion de conseiller à la diète Tominc de Sežana en 1823. La deuxième période commence en 1850 avec l'exploration de la Reka souterraine, organisée par le spéléologue de Vienne A. Schmidl et I. Rudolf avec les mineurs d'Idrija. Ils ont découvert la Salle de Schmidl, Grotte de Tomìnc et Mahorčič et ils ont traversé par le bateau de Velika dolina jusqu'au «Port de canots» au commencement de la galerie de Rudolf.

La troisiène période arrive 33 ans plus tard quand on a fondé à Trieste la première séction spéléologique «Küstenland». Les trois pionniers courageux – A. Hanke, J. Marinitsch et F. Müller – avec l'aide des habitants du village ont exploré entre 1884 et 1892 la rivière souterraine jusqu'au sifon dans le Lac mort. La Séction a reçu les grottes et a commencé d'aménager les voies touristiques jusqu'au canal de Hanke. En 1904 les indigènes ont découvert 60 m au-dessus le Lac de Müller les Cavernes silencieuses bien decorées.

La quatrième période du développement touristique tombe dans le temps quand le Karst classique appartenait à l'Italie. Società Alpina delle Giulie dirigeait les grottes jusqu'au 1945. En 1933 on a construit 90 m long tunnel artificiel lequel conduit le touriste de la doline d'éffondrement Globočak jusqu'au Paradis bien decoré. Pour la continuation de la voie à travers le canyon avec la rivière bourdonnante au-dessous, on a construit le fameux pont de Hanke 40 m au-dessus de l'eau et on a creusé dans le mur la voie jusqu'à la salle de Schmidl toujours à cette altitude. Cette voie vertigineuse était décrite dans l'oeuvre Höhlenkunde par le secrétaire générale de l'UIS Hubert Trimmel comme «les routes audacieuses au-dessus la fleuve bourdonnante» (1968, 253).

La cinquième période tombre dans le temps après la deuxième guerre mondiale quand les grottes appartenaient à Yougoslavie. Avec l'électrification en 1959 le souterrain immense de Škocjan recevait sa vraie valeur en montrant les beautés inattendues. On a refait les routes et organisé le service de guides.

A la base de tou ce qu'on a dit nous puvons constater que le système des Grottes de Škocjan et ses environs presentent un phénomène kasrtique unique dans le monde, et ainsi l'idée de classifier les grottes dans la liste du patrimoine mondiale auprès de l'UNESCO est tout à fait compétente.

14223

Le rapport de la Commission pour la protection du Karst et les grottes aménagées

Dr. France Habe.
Département de la protection, Commission pour la protection et l'exploitation et le tourisme.

RESUM

Aquesta comunicació comprèn l'informe del treball de la Comissió des del 8.è Congrès, facilitant el resum per a la protecció del món càrstic, epigeu i hipogeu, basat en tot el que s'ha escrit al respecte i els treballs personals. Malgrat els precs, la Comissió no ha rebut informes sobre les mesures preses per a la protecció del medi ambient dels països membres de l'U.I.S.

Amb els propis mitjans i la col·laboració del Secretariat de l'U.I.S. la Comissió ha organitzat els simpòsiums internationals per a la protecció del carst i de les cavitats subterrànies, a Postojna el 1981 i la Lipica el 1983.

Des del Congrés Internacional d'Olomouc (CSSS) es cataloguen tots els informes referents a les coves habilitades que hi ha en tot el món.

RESUMEN

La comunicación comprende el informe del trabajo de la Comisión desde el 8.º Congreso, facilitando el resumen para la protección del mundo kárstico, epigeo e hipogeo, basado sobre la literatura y el trabajo personal. A pesar de los ruegos, la Comisión no ha recibido informes sobre las condiciones de la protección del medio ambiente en los países miembros de la UIS.

Con sus medios y la colaboración del Secretariado de la UIS, la Comisión ha organizado los simposiums internacionales para la protección del karst y las cavidades, en Postojna el 1981 y en Lipica el 1983.

Desde el Congreso Internacional de Olomouc (CSSS) se catalogan los informes sobre las nuevas cuevas acondicionadas en el mundo.

RESUME

La communication comprend le rapport du travail de la Commission depuis le 8è Congrès, en donnant le résumé sur la protection du monde karstique et son souterrain basant sur la littérature et engagement personel. Malgré les appels la Commission n'a pas reçu des rapports sur les conditions de la protection de l'environment dans les pays, membres de l'UIS.

D'après ses pouvoirs et avec la collaboration du Secrétariat de l'UIS la Commission a organisé les symposiums internationales pour la protection du karst et les grottes à Postojna en 1981 et à Lipica en 1983.

Dès le congrès international à Olomouc (ČSSS) on colectionne les renseignements sur les grottes aménagées dans le monde. Au congrés de Barcelone nous pouvons présenter aux membres du congrès le catalogue imprimé des grottes aménagées du monde.

Dans l'origine le Département de la protection avait dans son cadre la sous-commission pour les problèmes scientifiques de la protection des grottes, présidée par Prof.V.Caumartin. Au 8ème Congrès à Bowling Green en 1981 dans le cadre de notre commission on a organisé la Commission spéciale pour les grottes aménagées, présidée par M. Russel Gurnee des États Unis.

Dès 1975, l'année proclamée pour la protection des grottes, le soin particulier était consacré à l'entendement général pour la protection des grottes. A Bowling Green déjà à la séance de conclusion du Congrès on a reçu la résolution pour la protection des grottes. On a accentué que les grottes présentent l'importance scientifique, culturelle et touristique pour l'humanité et que cettes valeurs sont menacées à cause de pollution de l'environment, de l'activité dans les mines et par les autres activités. C'est pourquoi le 8ème Congrès a fait appel à tous les membres de l'UIS de protéger cette richesse singulière du monde souterrain.

Maintenant 5 ans sont passés et il faut donner la réponse comment les membres de l'UIS ont executé la résolution. Il est évident que à cause de différents systèmes politiques et économiques des pays, membres de l'UIS, le lois pour la protection de l'environment diffèrent aussi. En général les lois pour la protection de l'environment devraient assurer l'equilibre entre les besoins de l'homme et conservation primaire de l'environment karstique. Ces mesures de protection sont visibles dans les publications, dans le Bulletin de l'UIS, dans Die Höhle et dans les autres journaux et publications spéléologiques lesquels recevait notre commission.

Dans le monde il y a beaucoup d'examples de pollution et même de déstruction de grottes à cause de l'urbanisation et industrialisation augmentants. Pour l'empêcher dans plusieurs pays, membres de l'UIS, ont organisé les symposia et l'on a publié les problèmes de la protection du karst dans les journaux.

Sans doute à la première place c'est l'Autriche où dans le journal spéléologique Die Höhle les articles spéciaux étaient consacrés à la protection des grottes. Malheureusement même dans ce pays karstique la reglémentation des mesures de protection est dispersée dans les departements divers. Dans les dernières années la Fédération des spéléologues d'Autriche organise les action de nettoyage des grottes à la jour de «la grotte prope» organisé dans le même terme que le jour international de la protection des grottes au commencement de juin chaque année. En 1981 la Fédération des spéléologues autrichiens a publié les mesures uniformes pour la protection des grottes dans le cadre de Bundesdenkmalamt. Le rôle de protection était transmis aux pays particuliers. De ce point de vue le pays de Salzburg est modèle ayant publié le 1èr Octobre, 1985 nouvelle loi sur les grottes. On a reglementé avec cette loi les normes de la protection de grottes, expéditions spéléologiques, la visite des spéléologues étrangers, guides dans les grottes, grottes aménagées et sa protection et contrôle.

A part des mesures différentes de la protection dans plusieurs pays d'Europe –Italie, France, Hongrie, Allemagne et dans les autres– je veux mentionner l'intervention de l'UIS à cause du travail dans la carrière près de Bat Caves, Kuala Lumpur, Malaysia. Un cas spécial de pollution présente la rivière Reka menaçant les grottes celèbres Škocjanske jame près de Divača en Karst classique. C'est pourquoi on a organisé le symposium pour la protection du karst, de Škocjanske jame spécialement, en Octobre 1982. Beaucoup de spécialistes ont montré au symposium les résultats de ses recherches dans la région de Škocjanske jame et alentours. Les plus importants résultats étaient publiés dans 16 points dans le Bulletin de l'UIS et dans la revue Die Höhle. On a accentué que le Karst classique avec Škocjanske jame est un monument naturel et culturel qui devrait être protegé par un décret spécial. Les participants ont suggeré d'inscrire la région de Škocjanske jame dans la liste du patrimoine culturel et naturel mondial auprès de l'UNESCO. Grâce aux efforts de l'administration de Škocjanske jame, du gouvernement yougoslave, de l'Institution pour la protection de l'héritage naturel et culturel de la Slovénie et aussi du secrétaire général de l'UIS la proposition avec documentation volumineuse (photos et texte) a été présentée à l'UNESCO à Paris. Il faut mentionner les lluttes pour la protection de Tara en Yougoslavie, laquelle était déjà acceptée dans le patrimoine mondial près de l'UNESCO mais était menacée à cause de la construction prévue pour l'hydroenergie. Pour le moment la rivière la plus propre, s'écoulant dans le gorge suavage avec le canyon, profond de plus de 1.000 m, est sauvée jusqu'en en 2.000. Tara présente à part du Lac de Plitvice et Parc national du Triglav dans les Alpes Juliennes un des objets karstiques les plus attractifs dans la Yougoslavie. Pendant la lutte pour la protection l'on a montré comme il est nuisible que nous n'ayons pas de loi de protection uniforme pour tout le pays et ainsi la décision pour la protection est en proie à la merci de six républiques, chacune taillant le destin de la nature karstique.

Ainsi nous avons dans le Karst dinarique quelques rivières qui peuvent être classifiées dans la première ou dans la deuxième classe. C'est pourquoi je propose de nouveau d'accepter à la conclusion du Congrès les résolutions, déjà acceptées au Congrès antérieur que tous les pays, membres de l'UIS, fassent la carte de distribution du karst et de sa pollution. De ce point de vue il faut donner la reconnaissance à l'Autriche qui a déjà commencé comme la première.

De la litérature et autres publications il est évident que dans beaucoup de pays, membres de l'UIS, on a publié différents brochures, prospectus et feuilles volantes, en Allemagne de l'Ouest, par example. Dans ce point de vue il faut mentionner surtout l'iniciative des spéléologues français. Fédération français de spéléologie a publié en 1982 les brochures Protegeons les nos cavernes, en s'adressant non seulement aux spéléologues mais aussi aux autorités locales, aux propriétaires des grottes et au public en général pour protéger la surface et sous-terre karstique. La brochure illustre avec le texte et les photos toutes les agressions sur les principes de la protection spéléologique et karstique. Les règles les plus importantes sont publiées en anglais, allemand et espagnol. La brochure devrait devenir le modèle de propagande pour tous les 44 membres de l'UIS, combattant pour la protection du karst et de grottes. Mais il faudrait ajouter pour chaque pays la carte de pollution à la fin du livret.

Il serait urgent que la Commission pour la protection du karst près de l'UIS recevrait au moins une fois par an le rapport de la

Commission de chaque pays sur les problèmes de la protection. L'importance spéciale présenterait une telle information des pays de l'Est et des autres continents d'où nous n'avons que des notices très rares ou pas du tout sur la protection du karst.

Departement de la protection comprend aussi la Commission pour les grottes aménagées, présidée par M.Russell Gurnee, représentant des États Unis. Je veux accentuer seulement que l'idée pour la publication du livre sur les grottes aménagées date de 1975 déjà et que notre commission, beaucoup aidée par le secrétaire générale Dr. Hubert Trimmel a composé le résume approximatif sur les grottes aménagées dans le monde. Je suppose que pour la période du dernier Congrès à Bowling Green fera le rapport M.R.Gurnee. Autant que je sais la brochure des grottes aménagées au monde est en train d'être préparée dans le cadre de Verband Österreichischer Höhlenforscher de Vienne.

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Potential Sites for Underground Wilderness in the United States

George N. Huppert
Associate Profesor, Department of Geography University of Wisconsin.

RESUM

En els darrers anys, als Estats Units, s'ha desvetllat un interès creixent per a establir reserves subterrànies segons les prescripcions del decret de reserves del 1964 o bé del decret de 1975 sobre les reserves de l'est. Sembla imminent l'estabilment de coves, l'única finalitat de les quals seria la de constituir-se com a reserves hidràuliques. L'elecció de coves amb aquesta finalitat no serà empresa fàcil. Una cova d'aquestes característiques, a més d'ajustar-se a les normes del decret, haurà de sotmetre's a un llarg procés de reconeixement i a l'oposició d'algunes forces. L'autor ens presenta aquí i segons el seu punt de vista, un nombre considerable de coves que reuneixen els requisits per a ésser candidates a aquesta designació. La relació de coves s'ha dut a terme només en estats federals. A més, els decrets anteriorment esmentats fan referència tant sols a aquestes zones.

D'altra banda, la llista no fa només referència a les coves aptes per a constituir-se en reserves. De tota manera, ben segur que les coves comptaran amb el vist-i-plau de la majoria d'espeleòlegs experimentats.

RESUMEN

En los últimos años, en los Estados Unidos ha cobrado ímpetu el interés en establecer una reserva subterránea según los preceptos del decreto de reservas de 1964, o bien el decreto de 1975 de la reserva del Este. Parece inminente el establecimiento de una cueva específica como reserva. La selección de una cueva para esta finalidad no va a ser empresa fácil. La cueva, además de tener que cumplir las normas del decreto, deberá poder sobrevivir a un largo proceso de revisión y a la tensión de fuerzas opuestas. El autor presenta aquí, según su punto de vista una cantidad de excelentes candidatos para la designación. La lista se ha efectuado solamente en países federales; también los decretos arriba mencionados se refieren exclusivamente a estas zonas. Además, la lista no solamente es exclusiva de las cuevas que pueden ser elegidas para reservas, sino que además las cuevas de la lista serán, probablemente elogiadas por la mayoría de espeleólogos expertos.

SUMMARY

Interest in the establishment of an underground wilderness in the United States under the precepts of the 1964 Wilderness Act or the 1975 Eastern Wilderness Act has gained momentum in recent years. Establishment of a specific cave as a wilderness seems imminent. Selection of a cave for this designation will not be simple. Not only will the cave have to meet the standards of the Acts, it will have to survive a lengthy review process and the strength of opposing forces.

Presented here, in this author's view, are a number of prime candidates for designation. The list is only made up of caves on federal government lands as the above Acts only apply to those lands. In addition, the list is not all-inclusive of the caves that might be eligible for wilderness, but the caves listed would probably be placed high by most knowledgeable speleologists.

Introduction

The concept of an underground wilderness in the United States has been formalized in the work of a number of authors (Watson and Smith 1971; Smith and Watson 1979; Huppert and Wheeler 1985). The strictures of the 1964 Wilderness Act (P. L. 88-577) or the 1975 Eastern Wilderness Act (P. L. 93-622) will define the criteria for caves to be selected for the National Wilderness Preservation System. Those strictures are noted as follows in the 1964 Act (Section 2. (c):

A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpared condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

The 1975 Act is similar in nature but it was specifically intented for federal lands east of the 100th meridian which may not meet the high standards of quality required by the 1964 Act.

While there is still considerable resistance to the idea of an underground wilderness it seems that there is no legal or practical barrier to designating a cave as wilderness. The opposition has come from various sources which have been outlined in previous works (Huppert and Wheeler, 1985).

We are at a point where we can ask which federally managed caves are suitable candidates for wilderness status. There are tens of thousands of caves in the United States. The state of Missouri, for example, has well over four thousand. Many caves are on federal lands, especially those in the western United States. Many are already de facto wilderness due to their size, isolation, difficulty, or lack of publicity; some are even located on designated surface wilderness areas.

Candidates for wilderness designation

Of the technically suitable caves on federal land a number stand out as exemplary. The caves listed below were selected on how well they seem to fit the intent of the Wilderness Act, including their isolation, unmarred beauty, challenge, and natural significance. The author has also not visited every cave on this admittedly subjective list but their reputation alone allows their inclusion. Figure 1 shows the location of each cave mentioned in the text with a number keyed to the text.

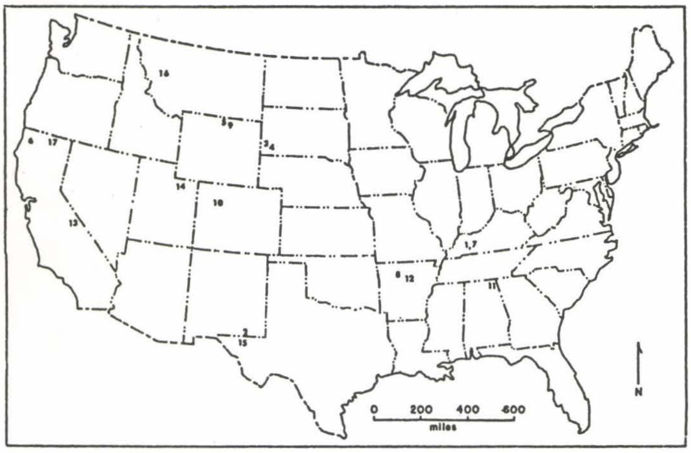

Figure 1: Proposed underground wilderness areas referred to in the text

1. Mammoth Cave - Flint Ridge System, Kentucky

Any listing such as this must include the World's longest known cave. The surface area of the park covers more than 50,000 acres which is managed by the National Park Service. The mandate for wilderness protection can be interpreted to be given in the National Park Service Organic Act of 1916 (P. L. 64-235). Therefore, it would seem that it would only take a change in status and management goals to bring about an underground wilderness. However, a prolonged attempt since the early 1960s to enact such designation has yet to be successful.

Difficulties have arisen in the form of opposition from local commercial interests, resistance within the park service, the question of whether caves can legally be wilderness, the «purity» of the surface above the cave as wilderness, and even resistance from some whitin the speleological community. The effort has had some success in the removal of some surface structures above the cave and the resolution of some of the difficulties presented by the opposition.

Mammoth Cave was selected as a World Heritage Site in October of 1981. This recognition by the World conservation community should be enhanced by its preservation as wilderness.

2. Carlsbad Caverns, New Mexico

Located in southeastern New Mexico, Carlsbad Caverns National Park is noted for its large rooms and extensive deposits of speleothems. The surface area of the park covers over 47,000 acres and includes are more than forty caves within its boundaries. However the premier attraction is the over twenty mile long Carlsbad Caverns itself. Designation of the more than seventeen miles of undeveloped cave as wilderness would seem easier here than at Mammoth Cave due to the less intense human impact on the surface and the lower level of commercial activity near the cave.

3. Jewel Cave, South Dakota

The entrance to Jewel Cave is in a relatively small national monument in the Black Hills of South Dakota. Beyond that entrance lies more than seventy-one miles of passage, making Jewel Cave the third or fourth longest in the world. This fact coupled with the minimal surface development and outside commercial interests would make this cave an ideal underground wilderness.

4. Wind Cave, South Dakota

Wind Cave is also located in the Black Hills of South Dakota only a few miles east of Jewel Cave. The national park is over 28,000 acres in area of which only about a thousand acres are developed. This forty-one mile long cave is another on the «World Class» list which should be included in the National Wilderness Preservation System.

5. Bighorn-Horsethief System, Montana-Wyoming

This system is believed to be over ten miles long. It straddles the state line between Montana and Wyoming. It is also administered by federal government agencies, the Bureau of Land Management and the National Park Service. In addition, the Crow Indian Nation has laid claims to portions of the system. The system is not commercialized and access to the entrances is moderately difficult. This would be an ideal underground wilderness if the matter of jurisdiction of the surface lands is settled.

6. Bigfoot-Meatgrinder System, California

This more than ten mile long system is over one thousand feet deep and has the added advantage of being located in the Marble Mountains Wilderness in northern California. This fine cave would seem to be the easiest to designate as underground wilderness. It would only require recognition of its significance by the proper authorities and a specific wilderness management plan.

7. Whigpistle Cave, Kentucky

While located within the boundaries of Mammoth Cave National Park this twenty mile long cave has yet to be connected to its larger neighbor. Designation of Whigpistle Cave should not stir up the high level of controversy that the attempt for a Mammoth Cave wilderness did.

8. Fitton (Beauty) Cave, Arkansas

This is an uncommercialized cave located on the lands of the Buffalo National River in northern Arkansas. It is managed by the National Park Service. This eight mile long cave is well suited for wilderness designation and attempts to do so should not create great opposition.

9. Great Ex(pectations) Cave, Wyoming

While one of the shortest caves on this list with about six miles of mapped passage, Great Ex Cave is perhaps one of the most challenging caves in the United States. Tight, narrow passages, cold rushing water and over a thousand feet of depth present a formidable fest for the hardiest cavers.

10. Groaning Cave, Colorado

This ten mile long cave (5 1/2 miles mapped) is in northwestern Colorado in the White River National Forest. Its challenge, size and potencial merit its consideration for underground wilderness.

The above federally managed caves already have some form of protection. Permit systems, gates, or commercial development prevent easy access. While these caves may be considered de facto wilderness, it takes more than access limitations to create a wilderness. A complete wilderness management plan must be drafted, enacted, and enforced.

Perhaps noticeable by its absence on the list of wilderness candidates is Cave Creek Cave in the Daniel Boone National Forest, Kentucky. This cave was proposed for wilderness status in 1983, an action which attracted much support and opposition. The Forest Service rejected the proposal, perhaps correctly. Partial flooding of the cave by an artificial lake and private inholdings on the surface are the major objections to the designation.

It has been stated that this list is subjective; however, the author feels that most of the caves selected would be highly rated on any such list. Other suitable caves on federal land do come to mind for an extended list. Examples of such caves are Russell Cave, Alabama (11), Blanchard Springs Caverns, Arkansas (12), Lilburn Cave, California (13), Big Brush Creek, Utah (14), and the many caves of the Guadalupe Mountains (15). The caves in the Bob Marshal Wilderness (16) and in Lava Beds National Park, California (17) are already in designated surface wilderness areas and may be suitable for underground wilderness.

A long fought effort may soon yield results. It seems likely that one of the above mentioned caves will become the first desigated underground wilderness in the United States.

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Ochrana Karstovych Peščer V Gruzii

Охрана Карстовых Пещер в Грузии

K Rakvišvili

Киазо РанвЬишвили

Совет слелеологии АН
Грузинсной ССР, Тбилисри

RESUM

La protecció de les caves càrstiques està estretament relacionada amb problemes de caire científic i d'altres de tipus organitzatiu.

La vessant científica va aparellada a les complexes investigacions dutes a terme en regions càrstiques i a les cavitats. Investigacions sobre la natura dels materials, tectònica, fissures, hidrologia, l'aigua i el règim climàtic, els dipòsits de les coves, flora i fauna, així com el seu interès respecte diversos factors naturals i antropogenètics.

L'èxit en aquesta tasca de protecció de les coves depèn de les condicions de protecció global de la natura del país així com de la pròpia iniciativa dels espeleòlegs.

Les mesures de protecció de les coves, en cada cas particular, cal que es desenvolupin en consonància mab els aspectes inherents a la seva utilització. A la URSS, la protecció de la natura és una qüestió prioritària d'abast nacional. A Geòrgia són molt nombroses les coves càrstiques i el govern de la República posa especial interès en la protecció d'aquests monuments únics en el seu gènere.

Aquest article conté informació sobre els mètodes, formes d'organització i condicions de protecció de les coves càrstiques de Geòrgia.

RESUMEN

La protección de las cuevas kàrsticas está estrechamente relacionada con problemas científicos y de organización.

La parte científica incluye las complejas investigaciones de las regiones kársticas y de las cavidades, la naturaleza de los materiales, tectónica, fisuras, hidrología, el agua y el régimen climático, los depósitos de cuevas, flora y fauna, así como su disposición hacia diversos factores naturales y antropogenéticos.

El éxito de la protección de las cuevas depende de las condiciones de protección de la naturaleza, en general, del país, y de la iniciativa de los espeleólogos.

Las medidas de protección de cuevas en cada caso particular, deben desarrollarse de acuerdo con los aspectos de su utilización. En la URSS, la protección de la naturaleza es un problema de importancia nacional. Hay muchas cuevas kársticas en Georgia y el Gobierno de la República presta mucha atención a la protección de estos monumentos únicos. El artículo contiene información sobre métodos, organización y condiciones de protección de las cuevas kársticas en Georgia.

SUMMARY

The protection of karst caves is closely connected with scientific and organization problems.

The scientific part includes the complex investigations of karst regions and caves, the nature of rocks, tectonics, fissures, hydrology, the water and climatic regime, cave deposits, flora and fauna as well as their disposition to various natural and anthropogenic factors.

The successful protection of caves depends upon the conditions of nature protection, in general, in the country and on the initiative of speleologists.

The measures of caves protection in every particular case, must be carried out in accordance with the aspects of their use. In the USSR the protection of nature is a problem of national importance. There is a lot of karst caves in Georgia and the Goverment of Republic pays much attention to the protection of these unique monuments. The article contains information about methods, organization and conditions of protection of karst caves in Georgia.

Охрана природы и ее отдельных памятников имеет жизненно-важное значение для каждой страны. Правительства многих государств принимают энергичные меры для сохранения в чистоте окружающей среды, воды, воздуха, для воспроизводства лесов, сохранения и умножения редких видов флоры и фауны.

Особого подхода требует к себе проблема охраны карстовых форм, так как невозможно восстановить благоприятные условия для использования, красоту и привлекательность подземного мира, созданные за тысячелетия. Правда, предлагают метод искусственного ускоренного роста разноцветных натечных форм в пещере (Шопов, 1983), но мы никакими методами и расходами не создадим ничего лучше и гармоничнее, чем создала сама Природа.

Общеизвестна также важность информации, предоставляемой карстовой пещерой ученым - геологам, геоморфологам, гидрогеологам, гидрологам, палеобиологам, зоологам и ботаникам, археологам, историкам, медикам, искусствоведам и др.

Пещеры играли большую роль в жизни древнего человека, являясь для них жильем, убежищем, творческой мастерской и т.д. По мере развития научного прогресса возросли возможности использования подземных полостей. В то же время деятельность человека сильно влияет или может повлиять в будущем как на интенсивность карстового процесса, так и на само существование в первозданном виде уникальной подземной красоты.

Антропогенный фактор в этих обоих случаях отрицателен, ибо ускорение закарстования территории мешает ее хозяйственному освоению, а загрязнение, повреждение и уничтожение пещер лишает нас одного из существенных природных богатств.

Пещеры Кавказа упоминаются в литературных источниках еще с античного времени, а спелеология, как наука, в Грузии насчитывает всего 60 лет. В 1925 году около г.Кутаиси, в Западной Грузии, Петре Чабукиани обнаружил карстовую пещеру Сатаплиа и всю свою жизнь посвятил ее изучению и охране.

С 1958 г. дело изучения пещер взяла на себя Академия наук Грузинской ССР, создав координационный Совет спелеологии при президиуме Академии и лабораторию спелеологии-карстологии в Институте географии им.Вахушти Багратиони. Началось планомерное исследование карстовых районов, покорение глубоких вертикальных пропастей, обводненных пещер. В настоящее время в Грузии известно более 1000 карстовых пещер, многие из которых входят в список крупнейших полостей мира.

Комплексные исследования карстовых районов и пещер дали возможность выявить закономерности развития карста и зафиксировать наиболее важные объекты карстосферы*, как подземные, так и поверхностные, требующие углубленного изучения с целью разработки соответствующих охранных мероприятий.

Основной причиной загрязнения повреждения или уничтожения карстовых пещер является сам человек и его деятельность. Отдельные путешественники или группы неорганизованных туристов ломают красивые натечные формы, выносят из пещеры или тут же бросают, портят кристаллические обрамления прозрачных озерков, наносят большой вред пещерной флоре и фауне, древним рисункам, копают культурные слои и т.д. Часто немалый ущерб наносится пещерам, при отсутствии высокой сознательности и контроли, туристами, спортивными и исследовательскими группами.

*Термин впервые применен проф.Л.Маруашвили (1970).

Сохранности пещер угрожает взрывные работы проводимые в ее окрестностях, горнодобывающие работы над пещерой, уничтожение растительного и почвенного покрова (рубка леса, интенсивная пастьба скота, сельскохозяйственная обработка склонов и др.)-вызывающие ускорение карстового процесса и ослабление устойчивости пород, использование пещер, колодцев и шахт для закачки жидких промышленных отходов, твердоко мусора и т.п.

Охране карстовых пещер должно уделяться постоянное, неослабляющее внимание. Посредством прессы, радио и телевидения, лекций и бесед среди населения и руководящих работников разных организаций проводится пропаганда значения пещер и их охраны. Закрываются и берутся под охраной наиболее значительные пещеры. Устанавливается строгий контроль за соблюдением правил посещения пещер, эксплуатационных норм, а также осторожности при работах по благоустройству.

Все проекты строительного, селскохозяйственного, горнодобывающего и т.п. освоения карстового района или участка должны быть согласованы с карстологическими и спелеологическими учреждениями.

Во избежании повреждения пещер такими природными явлениями, как гравитация, землетрясение и наводнение, следует провести укрепительные и водоотводные мероприятия, устроить стационарные наблюдения в пещерах.

Охрана пещер должна соответствовать и их использованию, т.е. следует умело комбинировать их охрану с аспектами использования (Раквиашвили, 1983). Для каждой пещеры и других карстовых форм, выявленных в стране, определяется степень значимости и аспект использования - туризм, спелеотерапия, склад-холодильник, научные исследования, лаборатория, добыча полезных ископаемых, водоснабжение и т.д. -а однотипные, с точки зрения их использования, объединяются в группы-категории (Яначик, 1977).

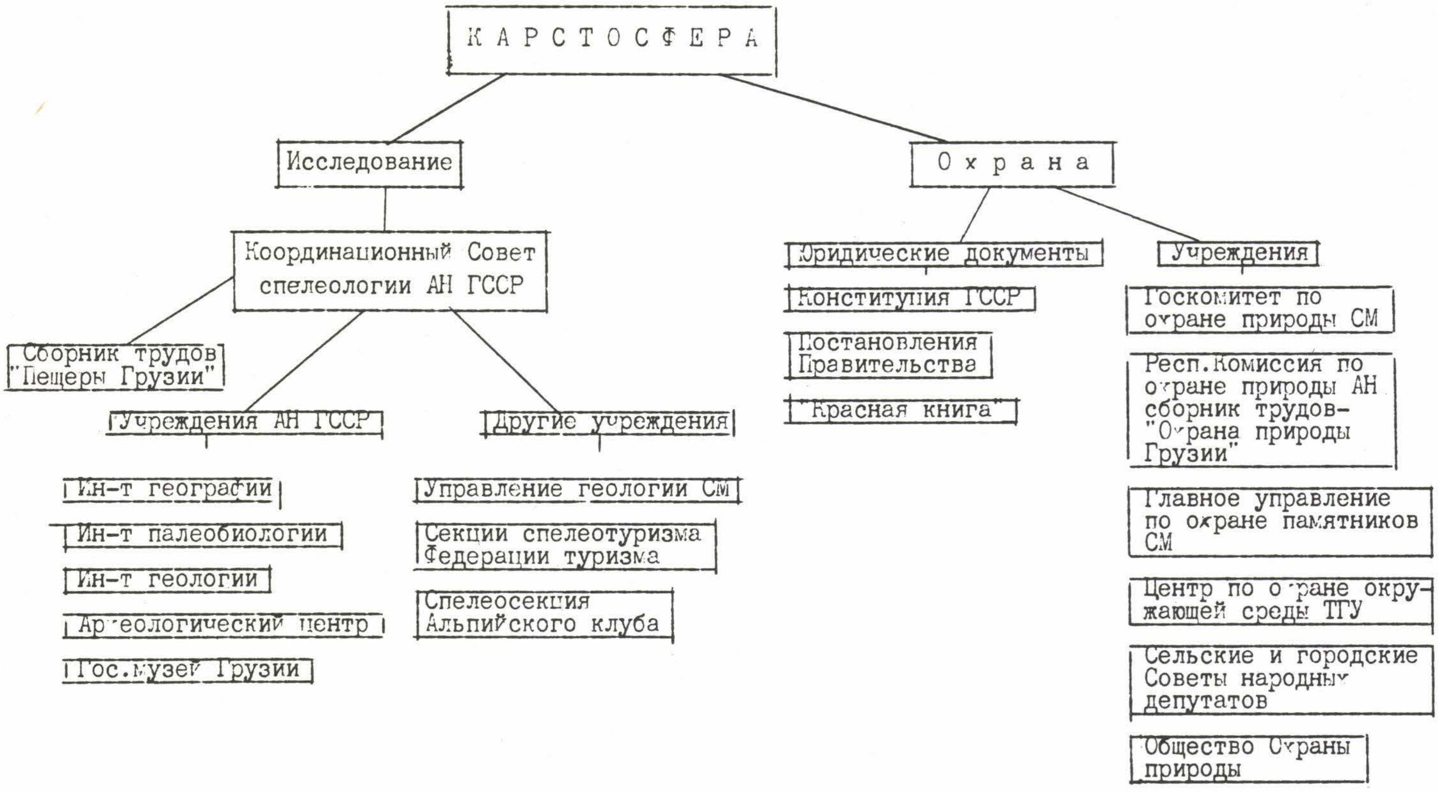
Согласно Конституции Грузинской ССР все организации и граждане объязаны заботится об охране природы Республики. Вопрос охраны карстовых пещер приобрел особую важность за последние 30 лет с открытием в Грузии множества огромных полостей, и эта важность подчеркнута несколькими специальными правительственными Постановлениями. Некоторые значительные карстовые формы внесены в "Красную книгу".

Охрану карстовых пещер проводили разные организации - Управление заповедников, Совет по туризму и др. В 1978 г. было создано Главное научно-производственное управление по охране и использованию памятников истории культуры и природы Грузии. Вместе с тем забота об охране пещер возложена на местных органах власти - городских и сельских Советов народных депутатов.

Основную роль в скорейшей организации охраны вновь открытых пещер играют спелеологи, их изучавшие и впервые отметившие значимость объекта. Примером служит прекрасная Цхалтубская пещера в Западной Грузии, исследованная спелеологами Института географии в 1964 г. Пещера тут же была закрыта и взята под охрану государства. Из сказанного следует вывод, что чем больше высококвалифицированных спелеологов в стране, тем надежнее будут охраняться пещеры.

Необходима также и широкая сеть природоохранных, спелеологических карстологических учреждений, групп, клубов и головная организация, руководящая всеми работами по охране пещер и ответственная за своевременное и качественное выполнение этих работ.

В заключение приводим схему основной структуры охраны природы и исследования карста и пещер в Грузии.



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ESPELEOTERAPIA
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SPELEOTHERAPY

14288

In Heilhöhlen behandelte Patienten im Spiegel einer repräsentativen psychologischen Untersuchung

Dr. Pais Ella - Dr. Fodor István

RESUM

A dues coves d'Hongria, localitzades a diferents indrets del país i d'estructures geològiques diferents, però amb característiques climàtiques similars, es varen investigar les condicions i possibilitats de tractar malalties físiques i somàtiques de diversos grups.

El nostre objectiu consistia en descobrir la proporció de casos asmàtics d'origen psíquic i fisiològic, així com l'efecte de les coves en els pacients que hi eren tractats.

Com que vàrem acordar una aproximació psicològica es va utilitzar el test MMPI.

RESUMEN

En dos cuevas de Hungría, localizadas en diferentes partes del país y con diferentes estructuras geológicas pero con características climáticas similares, se investigaron las condiciones y posibilidades de tratar las enfermedades físicas y somáticas en diversos grupos.

Nuestro objeto fue encontrar la proporción de casos asmáticos de origen psíquico y fisiológico, así como el efecto de las cuevas en los pacientes tratados en ellas.

Ya que decidimos una aproximación psicológica se utilizó el test MMPI.

SUMMARY

The conditions and possibilities of treating both psychic and somatic diseases were investigated in several groups and in two Hungarian caves located in different parts of the country and with different geological structures but similar climatic features. Our purpose was to find out the proportion of asthmatic cases of psychological origin and of physiological origin, as well as the effect of the caves on the patients treated there.

Since we decided on a psychological approach, the MMPI test was used.

Auszug des Referats

Es wurden die Bedingungen und Möglichkeiten des Heilungsprozesses psychischer und somathischer Krankheiten in zwei voneinander ferner liegenden Höhlen in mehreren Gruppen geprüft, die neben ihren geologisch abweichenden strukturellen Gegebenheiten doch ähniliches Klima haben.

Die eine Höhle ist in Abaliget, die am südlichen Teil Ungarns /östliche Länge 18°7', nördliche Breite 46°8'/ am Mecseker Karst 207 m über dem Meer liegt. Aufgrund bioklimatologischer Parameter ist die Lufttemperatur der ein kühles Gefühl hervorrufenden Höhle am Aufenthaltsort der Kranken 11 C°, der Feuchtigkeitsgehalt 98-99 %. Der Kalcium-Ion-Gehalt der Luft ist 60 mg/l, der Magnesium-Ion-Gehalt ist durchschnittlich 75 mg/l; aus bakterologischem Aspekt ist die Höhle steril, die Luftströmung schwach, und der Luftraum ist nicht zügig. Die Höhle wird seit 1959 in erster Linie von an chronischer Bronchitis und Asthma bronchiale leidenden Patienten besucht. In der letzten Zeit dient aber diese Höhle hauptsächlich zur Rehabilitationsbehandlung von Bergleuten.

Die andere Heilhöhle ist die Tapolcaer Seehöhle, deren geographische Koordinaten sind: 130 m über dem Meer, 46°53' N. 17°27' E. Diese Höhle ist ein Teil des in sarmatischem Kalkstein herausgebildeten Systems. Früher ist durch einen Teil der Höhle ein Warmwasser –Höhlenbach geflossen, der das Klima der ganzen Höhle in die Richtung der sog. Komfort– Zone verschoben hat.

Ihre bioklimatologischen Parameter zeigen aber grosse Ähnlichkeit mit der Abaligeter Höhle.

In beiden Höhlen werden seit längerer Zeit speläotherapische Behandlungen geführt.

Seit dem Anfang der 50-er Jahre hat sich die Anzahl der Erkrankungen erhöht, die einen psychischen Hintergrund haben. So bedeutet die Behandlung, die Heilung der körperlichen Symptome, die auf psychischem Grund entstehen, für die Forschung eine interessante Frage. Nach der Fachliteratur ist das Asthma bronchiale eine der psychosomathischen Krankheiten. Es kommt die Frage hervor, wie diese Höhlen, deren Eigenschaften und Parameter angegeben wurden, auf die Krankheiten wirken, die nicht definiert somathische Ursache haben. In unserer Forschung versuchen wir es nachzufolgen, welche Unterschiede die mit Höhlentherapie behandelten Patienten in der Hinsicht gewisser Personlichkeitszüge im Vergleich zur Population zeigen, die im Krankenhaus behandelt wurden. Antwort wird auch auf die Frage gesucht, wie die Höhle als eine von Reizen freie, geschlossene Struktur auf die Patienten wirkt.

Als Untersuchungsmethode haben wir mit dem MMPI psychologischen Test gearbeitet, der von Hathaway und McKinley zusammengestellt wurde und in der klinischen Praxis gut anzuwenden ist. Der Test ist für Ausfilterung von psychisch kranken Personen geeignet, aber er ist auch auf Signalisierung von Devianzen, auf Untersuchung de Wirksamkeit des therapischen Prozesses und auf Objektivierung der Änderungen, die im Zustand der Person erfolgen anzuwenden.

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Speleo Philately - The Human Aspect

J.P. van der Pas

RESUM

(L'espeleo-filatèlia, en la seva definició més senzilla, podríem dir que consisteix en col·leccionar segells referents a cavitats. Però no tot queda reduït als segells i mata-segells, ja que l'afeccionat valora també les emissions del primer dia i postals especials dedicades a temes relacionats amb les coves.)

De les pintures de coves, podem deduir-ne l'autor i què pretenen representar; però probablement l'artista no va ésser cap espeleòleg, como la major part de nosaltres, si bé va haver de resoldre el primer problema espeleològic: l'abasència de llum.

Hem fet un repàs i l'única persona que hem pogut trobar en els segells ha estat Emile Racovitza, potser l'únic professional dins del camp de l'espeleologia que ha merescut aquest honor.

RESUMEN

(La espeleo-filatelia en su definición más sencilla es la colección de sellos relativos a cavidades. Pero hay algo más que solamente sellos o matasellos, sobres de emisiones de primer día y postales especiales de temas relacionados con cuevas.)

Empezamos por el verdadero principio, las pinturas de cuevas de las que solamente podemos deducir quién las pudo haber creado y qué quieren representar. Probablemente el artista no fué un espeleólogo como la mayoría de nosotros, pero a pesar de ello tuvo que resolver el primer problema espeleológico: la luz.

Sin embargo, de todas las personas a las que se ha pasado revista, Emile Racovitza puede ser considerado como el único profesional en el campo de la espeleología, que ha merecido el honor de figurar en los sellos.

SUMMARY

(Speleo-philately in its most simple form is the collecting of stamps depicting a cave. But there is more than just stamps cancellations, first day covers and special postcards with cave-related subjects.)

We start at the real beginning, the cave paintings, where we can only guess who made them and who might be depicted. Probably the artist was not a caver like most of us, but still he tackled the first problem in caving: light.

Of all people discussed, however, only Emile Racovitza can be considered as professional in the field of speleology AND honoured as such on stamps.

Nowadays virtually the whole story of speleology can be shown on stamps: caves, karst, bats, etc. The caves are of course the most spectacular stamps to view. This lecture however will deal with persons depicted on philatelitical items and their relationship with caves or speleology.

If we start at the very beginning, the pre-historic cave paintings, we do not find names and faces. But somebody left his *«hand-prints»* (Spain, 1967, 1.50 ptas). We will not know who this man was who found his way in the dark, but maybe in the future science will develop techniques to identify him.

Later we find names, often of scientists, interested in all phenomenons they couldn't explain. In those days they seldom specialised, but studied every curiosity. And several of them wondered about caves, the origin of caves and even cave-life.

It seems all known people at the beginning of written history could be cave-related. Maybe they visited caves only once, but found it important enough to make reports which last up till now.

Some names? *Aristoteles* (384-322 B.C.) (Greece, 1978, 2d), had different idea's as Plato about underground waterflows, but his own idea's about the origin of stalagtites.

Who didn't read *Homer* (700 B.C.) (Greece, 1954, 300d), who's *Ulyssus* sailed virtually from cave to cave, (Greece, 1983, 20d). Later investigations showed many of the caves really exist, so somebody must have seen them.

The more we investigate, the more names we find. But be aware, none of these persons are really cavers or speleologists. For each of them it's just a sideline: a cave for hiding, living, or part of a geological or even more universal study.

Avicenna (980-1037) (Poland, 1952, 75gr), best known as a medic, did already remarkable observations on dripstone. In the middle ages we meet *Agricola* (1494-1555) (D.D.R., 1955, 10p) who publishes in a book in 1546 already a cave-plan. *Palissy* (1510-1590) (France, 1957, 12f) used as early as 1575 stalagtites in his lectures.

Niels Stensen publishes in 1671 his «Grotto Letters» in which he describes and discusses ice-caves.

Yoritomo on the contrary, a Japanese warrior (1147-1199) saved his life after a lost battle by hiding in a cave (Japan, 1982, 60y).

Also *Muhammed,* founder of the Islam, saved his life thanks to a cave. Muhammed is never depicted on a stamp, but symbolically the cave is (Irak, 1970, 15f).

Spallanzani (1729-1799) (Italy, 1979, 17OL) discovered bats could fly without using their eyes, although he couldn't know about echolocation. *Cuvier* (1796-1832) (France, 1969, 50c), studying also cavebiology, however didn't believe the findings of Spallanzani.

In later times we find Dr. *Joseph Pawan* (1887-1957) (Trinidad

& Tobago, 1975, 30c) who proved bats as rabies carriers. Probably to the disadvantage of vampires, but to the help of several harmless species.

Alexander von Humboldt, 1869-1959, mining engineer and later global explorer (Venezuela, 1969, 50c) visited many caves and often was the first to give a good description. So he reported the Guacharo Cave and the famous echo-locating bird, Steatornis Caripensis. And who never heard about the writer *Jules Verne?* (1828-1905) (Monaco, 1955, 10fr). In virtually all his books caves are used. And Samuel Clemens, better know as *Mark Twain?* 1835- 1910. In his book about Tom Sawyer a real cave is used. This cave is now named after him, «Mark Twain Cave», (Romania, 1960, 20b).

Two real scientists we meet in France, *Abbé Breuill,* 1877-1961, (France, 1977, 1fr) and *Père Teilhard de Chardin,* 1881-1955, (France, 1981, 1.40fr). Breuill is one of the first ones to prove (or convince) that the cave paintings are real and very old. He becomes a recognized expert in this field. Teilhard de Chardin looks and searches for the human origin by digging in caves. World famous are his discoveries in the Chinese Chou-Kou-Tien Caves.

In the 19th century several people start to work in Central Europe on a professional level.

Herman Otto (1836-1914) (Hungary, 1960, 60f), paleaonthropologist, becomes one of the founders of Hungarian speleology.

Jovan Cvijic, hydrologist, (1865-1927) (Jugoslavia, 1970, 0.50d), does karst research in Jugoslavia.

Emil Racovitza, speleobiologist (1868-1947) (Romania, 1958, 1.20L), starts one of the first underground biological laboratories and creates a complete organisation for biospeleology.

Very often explorers and discoverers find caves, as in Australia. *John Oxley,* surveyor-general, (Australia, 1976, 18c) discovers the Wellington Caves.

Captain *Charles Sturt* (1795-1869) (Australia, 1930, 1½) writes the first report on the Wellington Caves, based on descriptions by his expedition member *Hamilton Hume* (Australia, 1976, 18c).

Major *Thomas Mitchell* (1830) (Australia, 1946, 2½d) is the first one to find bones in Wellington Caves of the extinct Diprotodon.

Burke & Wills (1860-1861) (1983, Australia, 30c), explorers, discover many caves during their expedition, the first to cross Australia from South to North. They reached their goal, but perished during the return.

In later years Sir *William Edgeworth David,* geologist, (Australia, 1968, 5c) investigates also caves.

Now to some very «prominent» cavers. As it turns out some American presidents surveyed and explored caves. As president *Thomas Jefferson,* depicted on many U.S.A. stamps. He made one of the first American cave-maps (Madison Cave, around 1781). During later excavations in a saltpeter-cave some bones were found, and Jefferson recognized these as important, while Cuvier (mentioned before), named them as belonging to the Megalonyx jeffersonii (1804).

During the civil war in the U.S.A. many caves were explored not for the sake of the cave, but for the deposits of guano (the droppings of bats) which was badly needed for the manufacturing of gunpowder. Several other presidents, as *George Washington* and *James Madison,* worked in caves.

Both Washington and Jefferson were trained surveyors. The amount of stamps depicting them is overwhelming.

Another American, *Daniel Boone,* (U.S.A., 1972, 6c) escaped Indians via a cave. This is now the «Daniel Boone Cave».

An American explorer, *J.W. Powell* (1869), (U.S.A., 1969, 6c), professional geologist, discovered many caves during his Colorado River expeditions.

Then, finally, we are coming to some modern cave explorers.

Cesare Battisti (1875-1916), (Italy, 1966, 40L) is considered as the «father» of caving in the Trento area and one of the promotors of speleology in Italy.

A Laibach (Yugoslavia) stamp shows a still more or less *unknown caver.* (Laibach, 1945, 5c). The picture is taken in 1934 by Hafner during an expedition in Krizna Jama. Andrej Krajc (YU) recently checked all names of members on this trip and reduced the depicted person to four names.

Haroun Tazieff (1952), (North Korea, 1980, 30w), vulcanologist and explorer, took part in the first Pierre Saint Martin cave explorations. However, after a tragic accident during this expedition he returned to his primary fields, the study of vulcanoes.

Not a picture, only his name on a Spanish stamp: *Tito Bustillo* (1968). (Spain, 1975, 12pta). He discovered a cave now famous for it's fine cave-paintings. Shortly after this discovery he was killed in a climbing accident and in his honor the cave was named «Tito Bustillo Cave».

Not many cavers will be depicted during their lifetime, but it happened to *Vagn Bjerre Christensen!* (Barbados, 1977, $1).

This stamp, taken by his brother Jorgen Bjerre in the Harrisons Cave during an expedition in March 1971, shows a formation at station nr. 12 at the overlook at the Great Hall.

Not depicted on a stamp, but on a Maximum Card (a maximum card is a postal item, card, with a picture very similar to the stamp attached to it), Mrs. *Ioana Lascu* (1978). (Rumania, 3,40L).

Rumania issued in 1978 a beautiful set of cave-stamps, based on slides taken by her husband, Christian Lascu. Careful examination shows the card and the stamp are the same picture, only the lady is removed from the stamp!

On another kind of postal item (stationary), now a cancellation, we see the name of a very well-known French caver: *Ferdnand Petzl.* This cancellation is used on the mail of his cave-equipment producing firm. Petzl is well known from the Gouffre-Berger expeditions he organized (1953, 1954 & 1956). During these a world depth record was set.

Note & Resumé:
This article is certainly not complete. In modern philately not only stamps count, but also cancellations, covers etc. These are not used for this article. Also will further investigations bring many more names. The old problem: where to draw a line who is still interesting and who not.
From the stamps only Emil Racovitza can be considered as a true speleologist.
On the cancellations only Ferdnand Petzl is a professional.

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Cave Book Publishing In The U.S.A.

Richard A. Watson Editor' Cave books
Cave Research Foundation

RESUM

La publicació de llibres que versen sobre coves a EEUU durant als darrers 40 anys ha anat a càrrec, en gran part, d'empreses privades, en col·laboració amb la Societat Nacional d'Espeleologia, l'empresa NSS Grottos, la Inspecció Geològica Estatal, la Fundació per la investigació de coves i d'editors independents. L'historial de com s'han anat desenvolupant aquestes publicacions ja està començat i hi trobareu la situació actual de la publicació de llibres sobre les coves d'EEUU Mentre que els editors de llibres més importants d'EEUU publiquen molts pocs llibres sobre espeleología, els mitjans amb què compta la comunitat espeleològica pròpiament dita, són suficients per a publicar, no només els relativament escassos llibres manuscrits sobre les coves d'EEUU, sinó també articles, traduccions i reedicions de llibres antics de coves.

RESUMEN

La publicación de libros sobre cuevas en U.S.A durante los últimos 40 años ha sido debida en gran parte a empresas individuales en cooperación con la Sociedad Nacional de Espeleología, la individual NSS Grottos, State Geological Surveys, la Cave Research Foundation y editores independientes. La historia y desarrollo de esta publicación está esbozada y se describe la situación actual de la publicación de libros sobre cuevas en U.S.A. Mientras los editores de libros más importantes en U.S.A. publican muy pocos libros sobre cuevas los medios de la comunidad de espeleología propiamente dicha son adecuados para publicar no solamente los relativamente escasos libros manuscritos sobre cuevas en U.S.A., sinó también para publicar conjuntos de artículos, traducciones y reediciones de libros antiguos sobre cuevas.

SUMMARY

The publishing of cave books in the U.S.A. during the last 40 years has been largely due to individual enterprise in cooperation with National Speleological Society, individual NSS Grottos, state Geological Surveys, the Cave Research Foundation, and independent publishing houses. The history and development of this publishing is outlined, ant the present status of cave book publishing in the U.S.A. is described. While major trade book publishers in the U.S.A. publish very few cave books, resources in the speleological community itself are adequate not only for publishing the relatively few new book manuscripts written on caves in the U.S.A., but also for publishing collections of articles, traNslations, and reprints of old cave books.

Publishing books of specialized interest has never been easy. The initial costs of editing, typsetting, proof reading, page makeup, printing, binding are the same whether the edition is 500 or 500,000 copies. This makes is hard for small presses. Distribution is very expensive for small publishers because almost all orders are individual. Advertising other than through classified columns in specialized newsletters is much too expensive. And every copy sent out for review represents a high relative cost. Finally, there are royalties to be paid to authors, often such a small total sum for small editions that some authors forego payment, partly because they are so pleased that their books are published at all.

I have not mentioned salaries of editors and other members of publishing houses, for in fact there are few direct labor costs for most cave books published in the U.S.A. Almost all these books are published by non-profit groups such as state geological surveys, university presses, the National Speleological Society and its local grottos, the Cave Research Foundation, and individuals. If salary costs had to be figured in, there would be very few cave books published anywhere.

Big trade publishers do publish some cave books, such as *The Longest Cave* by Roger W. Brucker and Richard A. Watson (New York: Alfred A. Knopf, 1976). Knopf did a minimal, break-even first printing of 7;500 copies, and the book sold only about 12,500 copies through 1985 when it was allowed to go out of print because it had sold only 300 to 500 copies a year during the previous several years. Even here there was a personal element, because if Barbara Bristol, the book's editor at Knopf, had no kept an eye on it, the book would have been dropped several years earlier than it was. What I am leading to is this: You will agree that 300 to 500 copies a year is a big sale for a specialized press, and just because of this, Southern Illinois University Press is immediately coming out with a reprint of *The Longest Cave.* But if Knopf were to publish the sequel, *The Three-Hundred Mile Cave,* which is highly unlikely, the minimal break-even first printing in 1986 would have to be 10,000 or even 12,500 copies. It is because it took Knopf 10 years to sell taht many copies of *The Longest Cave* that it is not interested in *The Three-Hundred Mile Cave.*

I have not surveyed the market systematically, but trade publishers have published only about two dozen of the several hundred cave books that have appeared in the U.S.A. since 1945. Half of these have been books on cave art. Of the other 12 that I have in mind, one is social history, one poetry, one a guide to caves one cave scienec adventure, two how to cave, two novels, and four exploration. These 12 books were printend in hardback, and only two of them remain in print in paperback editions. I do not know of any cave book scheduled by a trade publisher at the present time.

During this 40-year period, state geological surveys have published as many as 50 cave books, counting field guides as well as cave surveys. Geological survey presses continue to be open to the publication of scientific studies of caves, and several are in press at the present time. University presses have also published as many as 50 cave books in the last 40 years, counting those having to do with cave archeology.

This leaves as many as 200 cave books and again let me say taht this is my impression as editor, collector, and close observer of the cave book scene, I have not done a detailed survey that have been published by specialized presses, the National Speleological Society and its grottos, the cave Research Foundation, and individuals.

Publication by individuals consists mostly of the issuing of their theses or dissertations as books, and ofer their work as local cave historians. They also publish general scientific studies of given caves or cave regions. I am not counting the history booklets or guidebooks for every commercial cave in the U.S.A., but most of there are also individual efforts.

The National Speleological Society and its grottos have published as many as 100 books, many of them guidebooks. The NS has published more than a dozen annual volumes extracted from the *NSS News* titled *Speleo Digest*, and several books on cave science. NSS grottos publish historical and scientific compilations on local caves and cave areas, and also cave surveys.

The Cave Research Foundation and individuals affiliated with it have been involved in the publishing of about 100 books. If one counts CRF annual reports, CRF has published about 50 books on its own. Then CRF members were instrumental in the Johnson Reprint Corporation's reprinting of five classics in speleology, and in editing 15 cave books in the Speleologia series of the very small Zephyrys Press. CRF organized its own publishing house in 1980, Cave Books, an effort I describe below.

This rough survey implies something about the economics of publishing cave books, and this is what I am most interested in discussing here. Almost nobody makes money publishing cave books, and that includes the big trade publishers ant the authors of the few cave books they publish. On the other hand, almost nobody loses money publishing cave books.

Let's look first at a cave book published recently by a big trade publisher. *Trapped!,* the story of Floyd Collins' death in Sand Cave by Robert K. Murray and Roger W. Brucker, was published in hardback in New York by G.P. Putnam's Sons in 1979. The book sold for $ 12.50. Of the first printing of 7,500 copies, about 5,000 were sold, and it was remaindered within the year. The Cave Research Foundation bought the remaining 2,500 copies ans still has some for sale. University Press of Kentucky contracted for a paperback reprint of the book which is still in print. We can assume that Putnam's did not lose money on the book, but the could not have earned much, for the profit margin in publishing is one of the lowest of any business, some say as little as 5 %. The authors were paid a $ 15,000 advance on royalties, minus 10 % or $ 1,500 for their agent, and that is all they made off the book. Writing *Trapped!* took several years, altrough not full-time. One conclusion is that it is a good thing the two authors don't have to live on their earnings from writing cave books, because $ 6,750 does not go very far. We have been trying to place another cave book with New York publishers since 1979 with no succes, although by cave books standards, *Trapped!* had a fine initial sale. Putnam's decision to dump the book may have had little to do with its actual potential. Big trade publishers push only a few of the books they publish.

In state geological surveys and in university presses, some people make money from publishing cave books, but no directly. Almost always, individual cavers working for these organizations make special efforts to get them to publish cave books, but these people are on salaries and receive none of the income from the sale of the cave books.

In the only case I know of my own where an individual was employed by publishers specifically to edit cave books, the financial motive again, to say the least, was not uppermost. I was editor of the Johnson Reprint Corporation Classics in Speleology series and of the Zaphyrus Press Speleologia Series mentioned above, producing a total of 20 books over a period of 10 years. My total cash earnings from this work was about $ 300. In effect, I contributed my editorial services.

Such voluntary work contributed by individuals supports the publishinf of cave books by the National Speleological Society, its grottos, and the Cave Research Foundation. This work is a labor of love. My summing up at this point is that most cave books in the U.S.A. are published largely through the volunteer contributions of hundreds of individuals. They contribute because they want to see cave books published, and if they did not contribute their services, as many as 200 of the cave books published since 1945 would never have seen the light of day.

Except for the two dozen or so cave books published by big trade publishers in New York, then, there are no real profits in publishing cave books in the U.S.A. The net receipts that do show in the book publishing efforts ot the National Speleological Society and the Cave Research Foundation would be wiped out many times over if the total real costs of publishing the books had to be paid. And even received profits are small. CRF's Cave Books, with 24 titles in print, published three books in 1985 (one annual report, one classic reprint, and one original cave exploration), has about broken even during the last five years. About all we do is recover the operating capital necessary to finance the publishing of more cave books.

I want to conclude this paper by marking a positive contribution to the publishing of cave books everywhere. I am extremely optimistic about the prospects for publishing cave books. With computerized typesetting and new printing techniques, individuals and groups making small investments can become publishers themeselves. They can even own much of the equipment needed to provide photo-ready pages for publishing. New printing and binding techniques continue to decrease the cost of producing the books. It is possible today for determined individuals or groups to do almost all of it themselves.

It does take money, but not as much as you might think. Suppose you want to publish two to four cave books a year (after all, there are not a large number of manuscripts available). Here is how we did it in the Cave Research Foundation. In 1980, we wrote to about 60 of the 300 active members of CRF asking for contributions to establish a Cave Books publishing affiliate of CRF. Thirty of those people responded with contributions totalling nearly $ 11,000. We had set a goal of $ 10,000.

Here is what you can do with $ 10,000 in 1986. It is enough to publish at least one and perhaps two books a year. A typical cave book might be 176 pages long and published in an edition of 1,000 to 1,500 copies. In the CRF operation, Cave Books pays for typesetting and book design, but in fact people exist in CRF who could do the typesething themselves by typing onto a disk or a tape through a word processer. And there are people in CRF who could do page makeup and book designing. But these are big jobs, and no one so far has found the time to contribute them.

So we negotiate with someone like Allan Kornblum of Toothpaste Press, who is one of the best book designers in the U.S.A. Together we choose a typesetter, he makes up the pages and designs the book, and then together we choose a printer.

It costs a lot of money to do small-print runs. In the U.S.A. in 1986, it will cost $ 6,000 to $ 8,000 to publish an edition of 1,000 copies of a 176-page cave book. Oh, of course you could do it for less. You could get cheaper typesetting that would look cheap, and you could cut costs by not using acid-free papaer, and by having glued bindings rather than sewn signatures. But if you are doing this because you love fine cave books, then you'll produce the best physical books you can.

Then you'll hope to sell enough copies in six months or a year to get your initial investment back so you can publish the next book that you've begun work on. That's the way the Cave Research Foundation operates Cave Books. To keep publishing a book or two a year, all we have to do is break even. But we also hope to make a bit of money for CRF in the long run.

I said that nobody really makes any money publishing cave books. This is because there are so many hidden costs that never come to the surface because of the immense amount of volunteer labor contributed to the production of cave books in the U.S.A. It's just not commercial, as the demise of two efforts to establish profit-making cave book publishingt houses has shown. Speleobooks in the U.S.A. and The Stalactite Press in Canada barely got underway before excessive costs forced them to stop publishing.

So despite the understandable caution and disinterest of commercial publishers, the publishing of cave books has flourished since 1945. Such specialized publishing will never be big businnes, and it will never be centralized. This is as well, because none of the publishing situations I describe here could ever handle the publishing of more than small editions of a few cave books a year. The big trade publishers will continue to take a cave book every two or three years, but most cave books will be published through the individual efforts of cave book lovers like you and me. I prefer it that way. Cavers are very individualistic, and cave books are not for everybody. The variety that is now available is very exciting and satisfying. With a little ingenuity, a modest amount of money, and a lot of time, anybody who wants to publish a cave book can do so.

La spéléo-philatélie au service de la spéléologie

Jacques Chabert
Spéléo-Club de Paris (Club alpin français)

RESUM

L'espeleo-filatèlia va néixer l'any 1960 amb la publicació d'un article de P. Strinati i V. Aellen a les Rassegna Speleologica Italiana. Més endavant aquesta nova disciplina va ésser reglamentada i compta, actualment, amb un butlletí editat per Jan Paul Van der Pas (Països Baixos), passant d'aquesta manera a ocupar el lloc que mereix al costat d'altres disciplines culturals del món de les cavernes (història, literatura, cinema de ficció, art, etc.).

Tractant-se d'una activitat eminentment internacional, l'espeleo-filatèlia ha permès d'assabentar a molta gent de cavitats i regions càrstiques desconegudes. Element d'avaluació de la importància de les coves en el patrimoni turístic dels estats, contribueix a la divulgació d'una imatge més assequible de l'espeleologia. L'autor intenta cridar l'atenció dels espeleòlegs envers l'interès que pot arribar a desvetllar l'emissió de segells postals en els respectius països.

RESUMEN

La espeleo-filatelia nació en 1960 con la publicación de un artículo de P. Strinati y V. Aellen en las Rassegna Speleologica Italiana. Después esta disciplina fué estructurada y dispone actualmente de un boletín editado por Jean Paul Van der Pas (Pays-Bas). En lo sucesivo ocupa un lugar al lado de tres diversas disciplinas culturales del mundo de las cavernas historia, literatura, cine de ficción, artes, etc...

Actividad esencialmente internacional; la espeleo-filatelia ha permitido descubrir cavidades y regiones kársticas desconocidas. Elemento de evaluación de la importancia de las cuevas en el patrimonio turístico de los Estados, contribuye a divulgar una cierta imagen real de la espeleología. El autor quiere llamar la atención de los espeleólogos sobre el interés que puede eventualmente presentar la emisión de sellos-postal en sus paises.

RÉSUMÉ

La spéléo-philatélie est née en 1960 avec la publication d'un article de P. Strinati et V. Aellen dans les Rassegna Speleologica Italiana. Depuis cette discipline s'est structurée et dispose actuellement d'un bulletin édité par Jan Paul Van der Pas (Pays-Bas). Elle occupe désormais une place aux côtés des diverses autres approches culturelles du monde des cavernes histoire, littérature, cinéma de fiction, arts, etc.

Activité essentiellement internationale; la spéléo-philatélie a permis la découverte de cavités et de régions karstiques méconnues. Elémént d'évaluation de l'importance des grottes dans le patrimoine touristique des Etats, elle contribue à divulguer una certaine image de la spéléologie. L'auteur veut attirer l'attention des spéléologues sur l'intérêt que peut éventuellement présenter l'émission de timbres-poste dans leur pays.

Cet article a pour but d'attirer l'attention du public spéléologique sur une activité actuellement limitée à quelques dizaines de personnes dans le monde entier, la *spéléo-philatélie*.

Cette discipline a consisté à l'origine à collectionner les timbres représentant l'intérieur ou l'extérieur des cavernes. C'est le parti pris par Villy Aellen et Pierre Strinati dans l'article très documenté qu'ils firent paraître dans *Rassegna Speleologica Italiana* en 1960 et qui est généralement considéré comme marquant la naissance de la spéléo-philatélie en tant que telle. Depuis le sujet s'est très largement étendu, chacun pouvant choisir sa collection selon ses intérêts propres... ou ses moyens financiers. On peut y englober les minéraux des cavernes, les animaux souterrains (notamment les chauves-souris...), les ponts naturels, les spéléologues et autres découvreurs de grottes, les paysages karstiques, les cavités artificielles ou les cavernes imaginaires (dans la littérature et les arts), la préhistoire et la paléntologie souterraines, l'art rupestre, voire même l'alpinisme quand les timbres montrent des techniques utilisées sous terre.

Par ailleurs certains spéléo-philatélistes ne se sont pas limités aux seuls timbre-poste, mais ont agrandi le champ de leurs investigations aux autres domaines de collection: les enveloppes «Premier Jour» (First Day Cover), aux «entiers postaux», aux maxicartes, etc, mais surtout aux flammes d'oblitération beaucoup plus nombreuses dans certains pays (la France, par exemple) que les timbres, et souvent beaucoup plus difficiles à trouver, ce qui, chez le collectionneur né, exacerbe le goût de la recherche.

En dehors de ses caractéristiques étroitement philatéliques, cette activité constitue un moyen très anecdotique, mais efficace de connaissance du monde souterrain à l'échelon planétire. Car les cas ne sont pas rares où les administrations postales ont précédé la communauté spéléologique internationale et ont ainsi permis de découvrir des cavités méconnues ou totalement ignorées. On pourrait citer, entre autres, les grottes des îles du Pacifique (Niue, Tonga, Pitcairn,...) ou du désert du Kalahari (Botswana). Les spéléo-philatélistes ne se contentent pas d'acquérir les vignettes postales pour les enfermer dans leurs précieux albums; ils ont toujours cherché à obtenir le plus de renseignements possibles sur les sujets représentés. C'est ainsi que de véritables études ont été menées pour tirer au clair certains points obscurs. Des spéléo-philatélistes ont même été amenés à entreprendre des voyages pour vérifier des informations sur place. Nous pensons en particulier à William Halliday visitant la grotte de Mangapwani à Zanzibar, mais cet exemple n'est pas unique.

Actuellement, grâce aux efforts constants de Jan Paul Van der Pas (Vauwerhofweg 3, 6333 CB Schimmert, Pays-Bas), les spéléo-philatélistes disposent, depuis 1981, d'un organe de diffusion périodique, *The Speleo Stamp Collector,* dans lequel les collectionneurs sont avertis de la sortie de toutes les nouveautés. Y sont publiés des articles sur les divers sites et sujets représentés sur des objets postaux. Un texte de Jan Paul Van der Pas paru dans ce bulletin en mars 1984 (N° 15) retrace l'historique de cette discipline en donnant les noms de ceux qui, des Britanniques Kay et Ray Mansfield à l'Allemand Johan Van Soeren, en passant par les Australiens Ross Ellis et Elery Hamilton Smith ou l'Italienne Anna Potenza, en ont marqué le développement. Et bien d'autres noms devraient être ajoutés à la sélection présentée ici.

Vers l'émission de timbres-poste

La philatélie peut-être utilisée comme un moyen de divulguer une certaine image de marque de la spéléologie auprès d'un large public à l'intérieur d'un pays donné. Certains spéléologues sont parvenus à faire éditer des timbres chez eux; d'autres encore, il faut aussi le dire, ont échoué dans leur tentative... Parmi les réussites, citons la belle série sur le 30ème anniversaire de la Sociedad Espeleologica de Cuba (1970) où se devine l'influence de Antonio Nuñez Jimenez et, non loin de là, les timbres vénézuéliens sur la Cueva de Guácharo et les gouffres du plateau de Sarisariñama, succès redevable à Eugenio de Bellard Pietri (1981).

Actuellement les spéléologues français regroupés autour de Lucien Gratté, rédacteur de *Spelunca*, organe de la Fédération française de spéléologie, s'efforcent de conveinae les P.T.T. d'émettre un timbre en l'honneur de Edouard-Alfred Martel (1859-1938), le grand pionnier de la spéléologie. Mais la partie n'est pas gagnée d'avance.

Signalons qu'une telle initiative ne peut s'inscrire que dans le cadre d'une politique souhaitée par l'ensemble des spéléologues du pays concerné. Parfois les soucis de protection du patrimoine souterrain peuvent faire prévaloir la discrétion.

Pour une commission «Spéléologie et Culture» au sein de l'U.I.S.

Pour ce 9ème congrès international de spéléologie, les quelques communications se rapportant à des thèmes divers dont le dénominateur commun est l'homme dans ses activités culturelles liées au monde des cavernes, se retrouveront sans doute classées dans la section «Documentation». Mais réduire par exemple l'histoire de la spéléologie à son aspect «documentaire», c'est la mutiler de plusieurs de ses composantes. En tout cas ce n'est pas un moyen de stimuler les recherches dans ce domaine à un moment où, ayant largement dépassé le siècle d'existence officieuse, le mouvement spéléologique a besoin de cette mémoire vivante que constitue le travail des historiens avant que ne disparaissent des données essentielles.

Il serait donc souhaitable qu'au sein de l'Union internationale de spéléologie una commission spécialisée soit créée qui prenne en compte tous ces aspects actuellement marginaux, ou plus précisément marginalisés: l'histoire, comme nous le disions plus haut, mais aussi les autres sciences humaines, la littérature, le cinéma de fiction, les arts en général, les collections (bibliophilie, philatélie,...), etc. Le titre de cette commission pourrait être «Spéléologie et Culture». Quelle que soit la dénomination retenue, il y a là tout un vaste domaine multiforme dont l'essor pourrait profiter à l'ensemble de la collectivité spéléologique.

Illustration:
Un projet de timbre pour E.-A. Martel. Dessin de Vianney-Jalin.

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*** Cet article est dédié à la mémoire de Wayne Russell, pionnier de la spéléo-philatélie, mort en plongée dans le Jacob's Well, Texas, le 26 février 1984.

El «Centre de documentació Espeleològica». Principals característiques i sistemàtica de treball, com exemple pràctic d'organització espeleobibliogràfica

Montserrat Ubach i Tarrés
Jordi Lloret i Prieto
«Centre de Documentació Espeleològica» (Barcelona) (1)

RESUM

S'exposen les particularitats més significatives del C. D. E. i de la seva sistemàtica de treball, com exemple pràctic d'activitat i organització documental i bibliogràfica.

Definició del C. D. E. Objectius bàsics i addicionals. Serveis complementaris. Membres fundadors i intersociabilitat. Estructura i responsabilitat dels seus membres. Idioma de la «Bibliografia Espeleològica Hispànica». Relació amb la Unió Internacional d'Espeleologia i de la Federació Espanyola d'Espeleologia. Sistemàtica a seguir en cada número de la revista. Principals activitats desenvolupades pel C. D. E.

En els 5 números de B. E. H. corresponents al període 1978-1982 s'han publicat 3.119 referències bibliogràfiques amb el seu corresponent resum, ordenades i classificades, mentre que prop de 1.500 estan actualment en preparació per ésser incloses en els pròxims números (1983-1985).

RESUMEN

Se exponen las particularidades más significativas del C. D. E. y de su sistemática de trabajo, como ejemplo práctico de actividad y organización documental y bibliográfica.

Definición del C. D. E. Objetivos básicos y adicionales. Servicios complementarios. Miembros fundadores e intersociabilidad. Estructura y responsabilidad de sus miembros. Idioma de «Bibliografia Espeleológica Hispànica». Relación con la Unión internacional de Espeleología y la Federación Española de Espelología. Sistemática a seguir en cada número de la revista. Principales actividades desarrolladas por el C. D. E.

En los 5 números de B. E. H. correspondientes al período 1978-1982 se han publicado 3.119 referencias bibliográficas con su correspondiente resumen, ordenadas y clasificadas, mientras que cerca de 1.500 se encuentran actualmente en preparación para ser incluídas en los próximos números (1983-1985).

SUMMARY

The most important particularities of the C. D. E. and its working methods are being explanied, as an example of activity and documentary and bibliographical organization.

Definition of the C. D. E. Basic and additional objetives. Additional services. Founders and participants. Structure and responsability of its members. Language of the «Hispanic speleological bibliography». Relation with the International Union of Speleology and the Spanish Federation of Speleology. System to be followed for each magazine number. Main activites developed by the C. D. E.

In the 5 numbers of B. E. H corresponding to the 1978-1982 period, 3.119 bibliographical articles have been published with the corresponding summary, while 1.500 are being prepared and will be enclosed in the next numbers (1983-1985).

El Centre de Documentació Espeleològica Definició

El C. D. E. és una entitat legalment constituïda el 1979 sota la legislació espanyola aleshores vigent, posteriorment inscrita en la «Direcció General d'Associacions i fundacions de la Generalitat de Catalunya». Sense caràcter lucratiu, compta solament com a únics recursos econòmics amb els que procedeixen de les seves activitats i de la lliure aportació dels seus membres. Aquests recursos es dediquen íntegrament a la BIBLIOGRAFIA ESPELEOLÒGICA HISPÀNICA, a altres publicacions de possible interès i als serveis que ofereix, propis d'un Centre de Documentació.

Objectiu Bàsic

Recopilació, ordenació y difusió de la BIBLIOGRAFIA ESPELEOLÒGICA HISPÀNICA. Es definiex com a tal el conjunt de publicacions editades a Espanya i les estrangeres referides a la nostra espeleologia i carst, independentment de la forma de presentació escrita (llibres, revistes, notes de premsa, etc.) i interès potencial.

La difusió d'aquesta compilació ordenada es realitza per dos camins diferents, pero complementaris:

– Edició anual d'una revista, BIBLIOGRAFIA ESPELEOLÒGICA HISPÀNICA, que recull, per anualitats vençudes, aquesta bibliografia, en forma de fitxes normalitzades i classificades, acompanyades cada una d'elles d'un breu resum del contingut dels treballs a què corresponen.

– Subministrament, prèvia comanda, de fotocòpies dels articles inventariats i publicats a la B.E. H.

Altres objectius addicionals

Publicació aperiòdica, mitjançant la SÈRIE DE DIVULGACIÓ–2.000 de:

– Treballs d'interès espeleològic global, realitzats per entitats o particulars sense capacitat editoria pròpia.

– Traduccions d'obres estrangeres.

– Reedicions de publicacions esgotades, etc.

Això serveix també, almenys teòricament, com a sistema d'autofinançament

El C. D. E., però, no està actualment en condicions d'oferir resolucions de consultes relatives a bibliografia anterior al seu primer any de compilació (1978); a documentació inèdita o aliena al seu camp d'actuació, ni informació espeleològica general, que en aquest cas concret correspondria a altres organitzacions espeleològiques: Federació, Escoles, etc.

Serveis complementaris

El C. D. E. es coordina amb la comissió de Bibliografia de la U. I. S. i forma part de la seva xarxa de Biblioteques nacionals. Amb la d'Àustria, França, Suïssa, Alemanya, Itàlia, Japó, E. U. A. Bèlgica, Veneçuela i Iugoslàvia, ofereix un servei de fotocòpies a nivell internacional.

Membres fundadors i intersociabilitat

El C. D. E. va ser creat a finals del 1978 per espeleòlegs de diferents clubs barcelonins, davant la preocupació comú pels següents aspectes:

– Importància de la Comunicació en qualsevol faceta humana, incloent l'espeleologia i disciplines afins.

– Paper rellevant que juga en ella la Bibliografia.

– Ingent i desordenat volum de dades que comprèn, amb marcada tendència e incrementarse.

– I, conseqüentment, l'interès de la seva classificació i difusió organitzada. Tot això va fer veure la necessitat d'un servei d'ordenació y divulgació bibliogràfica a nivell de tot l'Estat Espanyol.

l'òrgan gestor, coordinador i directiu de l'Entitat. No obstant, per a millorar la seva tasca i perquè el C. D. E. integrés tots aquells espeleòlegs identificats amb el tema bibliogràfic, es va organitzar el treball entre una xarxa de col.laboradors de tot l'estat: Amb ells es mantenen esporàdicament entrevistes consultives (especialment en les primeres fases de creació i consolidació estructural) i d'allò que fa referència a les seves respectives responsabilitats.

Estructura i responsabilitats

– El conjunt dels seus membres fundadors, als que, en general i per abreujar, anomenarem «CDE» 0 «Consell de Redacció» i que assumeix les funcions de:

. Manteniment de l'Organització, coordinació i direcció.

. Contactes amb l'UIS, FEE, l'Administració i Clubs.

. Administració i altres aspectes auxiliars i d'ordre intern.

. Confecció dels inventaris bibliogràfics per anualitats.

. Organització i control de la xarxa de corresponsals i demés col.laboradors, per a l'ampliació dels inventaris i altres tasques.

. Confecció de la major part de fitxes bibliogràfiques i correcció de las aliener.

. Ordenació i classificació de les mateixes

. Redacció, mecanografia, compaginació, edició, financiació i distribució de B. E. H.

. Manteniment, ampliació i ordenació del fons bibliogràfic.

. Manteniment del Servei de Fotocòpies, nacional i internacional

. Coordinació de bescanvis estrangers, subscritors, compradors, etc.

. Altres aspectes secundaris.

– Els corresponsals, que constitueixen la principal punta de llança perifèrica i que es responsabilitzen, en els seus corresponents àmbits geogràfics o especialitats de:

. Cumplimentació dels inventaris bibliogràfics que un cop l'any els hi tramet C. D. E. per la seva ampliació.

. Obtenció i tramesa de publicacions que el CDE, no havent pogut obtenir-les directament de l'editor o per altres mitjans, els hi sol.liciti.

. Confecció, en alguns casos, de fitxes bibliogràfiques.

. Proporcionar al CDE les notes de premsa de temàtica espeleològica que vagin apareixent als periòdics locals o regionals, així com articles publicats a revistes no especialitzades.

. Representació del C. D. E. en els seus respectius ambients o zones.

. Col.laboració en altres aspectes quan s'els hi sol.licita.

Addicionalment, cal esmentar la descentralització de BESCANVIS amb grups estrangers a càrrec, actualment, del corresponsal del CDE a Madrid.

– Assessors: Personalitats de reconeguda rellevància dins l'espeleologia científica o aplicada espanyola, a les que es consulta en determinades conjuntures.

– Col·laboradors habituals: Corrector de Català, Conseller jurídic, algún col.laborador destacat i autors de fitxes aliens al «Consell de Redacció».

– Particulars i entitats col.laboradores: en general, subministradores de publicacions al fons bibliogràfic.

Idioma de la B. E. H

L'idioma oficial de Bibliografia Espeleòlogica Hispànica és el català. No obstant, el fet que, si bé editat a Catalunya a iniciatives d'espeleòlegs catalans, vingui a resoldre un problema d'informació existent enllà de les nostres fronteres i que també, en part, degui la seva aparició a la col.laboració d'espeleòlegs de tot l'Estat Espanyol, ha portat a adoptar les següentes mides de bilingüisme en el seu contingut:

– Acompanyar tots el textos generals en català (editorial, tìtols, índexs, etc), de les seves corresponents traduccions en castellà.

– Publicar els resums bibliogràfics en el mateix idioma en el qual s'hagin escrit els treballs a què fan referència: castellà, català, gallec, euskera, etc. Els idiomes estrangers es resumeixen en castellà.

– Incloure, addicionalment, al català i al castellà, traduccions a l'anglès i al francès en apartats determinats de la revista, com per exemple les informacions que fan referència al Servei de Fotocopies.

Relació amb la Unió Internacional d'Espeleologia i la Federació Española

Segons amb L'U. I. S., el CDE va passar a ésser, des del moment de la seva creació, la representació oficial espanyola de la Comissió de Bibliografia de la Unió internacional d'Espeleologia. Quant a la seva relació amb la Federació Espanyola d'Espeleologia cal destacar dues importants en la seva trajectòria:

1. Col.laboració de la FEE amb el CDE des del moment de la publicació del n.º 1 de Bibliografia Espeleològica Hispànica (1978), patrocinant la seva distribució gratuïta a tots els grups federats de l'Estat Espanyol.

Aquesta col.laboració, que s'ha anat mantenint al llarg dels anys, s'oficialitza el gener del 1983.

2. Acord CDE-FEE (17.1.83). En un document distribuït en el n.º 4 de BEH, s'estableixen, entre d'altres, els següents punts:

. El CDE passa a ser l'ASSESSORIA BIBLIOGRÀFICA de la F. E. E. i a la vegada, el seu portaveu davant l'UISS en allò que fa referència als temes documentals.

. El CDE, nascut independent, manté la seva identitat i autonomia i la FEE no intervé en el seu funcionament intern.

. La FEE garanteix que continuarà patrocinant la distribució gratuïta de Bibliografia Espeleològica Hispànica a tots els grups espeleològics federats i a les seves corresponents federacions.

Sistemàtica de treball en la confecció de cada número de BEH

– Recepció de publicacions i registre d'entrada a la Biblioteca, segons els següents criteris:

. Les ja incloses en anteriors números de BEH

. Les que no procedeix el seu inventari (estrangeres sense referència a Espanya o espanyoles sense contingut espeleològic).

. Les que han de ser inventariadas i publicades en el proper o pròxims números de BEH, tot incloent-hi aquelles d'anys anteriors omeses en el seu moment.

– Confecció a primers d'any, d'una RELACIÓ DE PUBLICACIONS APAREGUDES L'ANY ANTERIOR, classificades per origen editorial (catalanes, resta d'Espanya i estrangers).

– Distribució d'aquesta RELACIÓ entre la xarxa de Corresponsals, els quals disposaran d'un termini de varies mesos per a tornar-la al CDE, després d'haver-hi afegit les publicacions que no hi figurin i que ells coneguin i puguin obtenir.

Mentrestant, el CDE ja ha iniciat l'extensió manual de les FITXES BIBLIOGRÀFIQUES corresponents als articles que contenen les publicacions entrades a la Biblioteca, segons un formulari estandaritzat que recull, bàsicament:

. REFERÈNCIA BIBLIOGRÀFICA ajustada a una estricta normativa.

. RESUM, totalment objectiu i amb un contingut correcte i raonable en funció de les característiques de l'article en qüestio.

– Recepció de les «Relacions de publicacions» ja complimentades pels Corresponsals o altres fonts. Obtenció de les publicacions indicades pels Corresponsals que no apareixien en la relació i constant manteniment de la mateixa.

Segueixen els treballs de redacció de FITXES i control de les que es reben confeccionades per col·laboradors aliens al «Consell de Redacció», per a procedir, sincrònicament a:

. Correció lingüística de les fitxes realitzades a mà.

. Extensió mecanogràfica i correcció.

. Classificació temàtica i subtemàtica, segons els apartats i subapartats en què el CDE ha dividit tot aquest potencial bibliogràfic.

– Ja en l'últim terç de l'any, es procedeix a «tancar» el procés d'admissió de noves FITXES. Es realitza la seva classificació definitiva i, una vegada finalitzat tot el procés mecanografiat de les fitxes, s'afectuen els darrers passos:

. Confecció i correció dels ÍNDEXS (TEMÀTIC, ALFABÈTIC D'AUTORS, ALFABÈTIC DE PUBLICACIONS, GEOGRÀFIC I GENERAL).

. Compaginació de les fitxes mecanografiades i de la resta del contingut de la revista.

. Fotocòpies de l'original reduït, distribució entre els membres del «Consell de Redacció» i última correció abans d'entregar a impremta.

. S'entrega a impremta l'original acabat, a punt de ser reproduït pel sistema «offset».

. Distribució de la revista.

Activitats desenvolupades

El punt de partida del CDE es situa en la bibliografia corresponent al 1978. Amb cinc números de BIBLIOGRAFIA ESPELEOLÒGICA HISPÀNICA fins ara publicats, s'abraça fins el 1982. Actualment (desembre 1985) es troben en preparació dos números nous, corresponents a 1983 i 1984. A partir de gener de 1986, d'acord amb la planificació descrita, hauran d'iniciar-se treballs de la bibliografia de 1985.

El balanç d'aquests cinc números apareguts, incloent les omissions recollides en cada un dels apartats «Publicacions no resenyades en anteriors números de B. E. H.» és el següent:

1978: 644 articles
1979: 860 articles
1980: 575 articles
1981: 585 articles
1982: 455 articles

A part de la seva activitat en allò que fa referència al Servei de fotocòpies, cal citar les següents tasques desenvolupades pel C. D. E.:

. Publicació del llibre, traduït al castellà, «La Espeleología Vertical» de Mike Meredith.

. Atenció a més de 1/2 centenar de consultes espeleològiques satisfetes per un teòricament inexistent Servei d'informació general.

. Presència en determinats actes intersocials.

. Organització d'activitats relatives al camp de la documentació con el «Cicle de Conferències sobre la Historia de l'Espeleologia Catalana» dins del marc del Primer Congrés Català d'Espeleologia», etc.

(1) Representació espanyola de la Comissió de Bibliografia de la Unió Internacional d'Espeleologia. Assessoria Bibliogràfica de la Federació Espanyola d'Espeleologia.

CAVITATS, EXPLORACIONS, CADASTRE
CAVIDADES, EXPLORACIONES, CATASTRO
CAVITIES, EXPLORATION, CENSUS

15185

International Speleological expeditions in Yugoslavia, in 1984 and 1985

Mladen Garašić

RESUM

L'expedició internacional «Kamensko 84» va ser organitzada a Croàcia (Iugoslàvia) el 1984. En ells hi van participar espeleògis de Gran Bretanya, França, EE.UU. i Iugoslàvia. Resultats: 31 noves cavitats amb un total de 7 Km. de recorregut, 11 sifons bussats amb una longitud de 1.800 m., 4,5 hores de filmació, etc. Responsable: M. Garašić, Dr. i T. Kovačević, ing. dipl.

L'expedició internacional «Durmitor 85», organitzada també a Iugoslàvia, hi van participar espeleòlegs de Gran Bretanya, França, Polònia i Iugoslàvia. Resultats: 21 noves cavitats, l'avenc més profund de Iugoslàvia, de 898 m. i d'altres de 605 m., 464 m., 461 m., etc. Alguns encara continuen. Responsables: M. Liešević, Dr. i M. Garašić, Dr.

S'explicarà com es duen a terme les expedicions espeleològiques a les zones càrstiques iugoslaves, on adreçar-se per a obtenir la informació necessària (permissos, mapes, guies), etc.

RESUMEN

La expedición internacional «Kamensko 84» fue organizada en Yugoslavia (Croacia) en 1984. En ella participaron espeleólogos de Gran Bretaña, Francia, EEUU y Yugoslavia. Resultados: 31 nuevas cavidades con 7 km. de recorrido, 11 sifones buceados con una longitud total de 1.800 m., 4,5 horas de filmación, etc. Responsable: M. Garašić, Dr. y T. Kovačesić, ing. dipl.

La expedición internacional «Durmitor 85» fue organizada en Yugoslavia en 1985 y en ella participaron espeleólogos de Gran Bretaña, Francia, Polonia y Yugoslavia. Resultados: 21 nuevas cavidades, la cima más profunda de Yugoslavia, con 898 metros y otras con 605 metros, 464 m., 461 m., etc. Muchas de ellas continúan. Responsables: M. Lješević, Dr. y M. Garašić, Dr.

Se explicará como pueden realizarse expediciones espeológicas en las zonas kársticas yugoslavas, con direcciones a las que escribir para obtener la información necesaria (permisos, mapas, guías, etc.).

SUMMARY

In 1984 in Yugoslavia (Croatia) it was organised international speleological expedition «Kamensko 84» with members from Great Britain, France, USA and Yugoslavia. Results: 31 new cases, 11 dived syphons total length 1800 meters, 7 km of caves, 4,5 hours of film material etc. Leader: M. Garašić, dr. T. Kovačeví, dipl. ing.

In 1985 in Yugoslavia (Crna Gora) it was organised international speleoelogical expedition «Durmitor 85» with members from Great Britain, France, Poland and Yugoslavia. Results: 21 new caves, the deepest cave in Yugoslavia 898 meters, than 605 meter, 464, 461 etc. Deep caves is going on. Leaders: M. Leješević, dr. and M. Garašić, dr.

It will be described how the strangers can make speleological explorations in Yugoslavian Karst area, with addresses on which they can write to get informations for that (permissions, maps, guide, etc).

In the last years, speleological activity in the whole world was very notable, because of the hasty progress of projecting, constructing and workmanship of the caving equipment. Better communications among some speleological societies and the better speleological knowledge of the individuals and caving clubs also caused that significant speleological activity.

Some «speleological nations», which have allready explored their territories, have organized speleological expeditions in the distant and atractive regions, particulary tropic southamerican, centralamerican, african and asian countries, where they explore unknown underground. Most of the countries have very poorly developed speleology, thus foreign cavers can have real researching work.

In Europe, the situation is different. We can say that the most of the karst areas in Europe are profoundly researched, so we can hardly find longer of deeper speleological objects (caves and pits). It is a well known fact that the most speleological expeditions, from other countries, are organized in Spain, Austria, Italy, Greece and Turkey, where speleologist look for deep, long and atractive caves. In personal contacts with these cavers I came to a conclusion that they were interested for the foreignspelunkers researches, but those expeditions are, sometimes, spontaneously organized so they had more damage than usefulness.

In Yugoslavia that situation is regulated with the Science Researches Law from 1972, 1976, and 1979, in which are also regulated the foreign speleological expeditions in Yuyoslavia. Yugoslavia is a classical karst country. We have here developed Dinara Karst System, in which over 15.000 caves and shafts are explored, and we have also very strong and developed speleological organization. We presume that only 35 % of Yugoslav karst area is explored. Obviously it is a target of foreign spelunkers, but following the Science Researches Law, they must ask the permission from the proper authorities, they must address the speleological organization in charge of particular republic (there are six of them in Yugoslavia), and they have to take with them a certain number of yugoslav cavers –guides.

Yugoslav cavers have, so far, organized relatively small number of expeditions in other countries, because they have many unexplored regions in their own country. Let us mention some of the expeditions with yugoslav members and organisations: 1971. Madagascar, 1975, Austria, 1976. Switzerland, 1977. Great Britain, 1979. New Guinea, 1980. Indonesia, 1981. USA, 1982. France, 1983. Marocco, 1984. Algeria.

Figure 1. Official sign for International speleologial expedition «Kamensko 84».

To show the possibilities of the speleological researches in Yugoslavia, members of Society for researching, surveying and photography of karst phenomena (DISKF) from Zagreb organized in 1984. *International Speleological Expedition «Kamensko 84», on the territory of Croatia (Lika, Kordun, Gorsky kotar) The cavers from Great Britain, France and USA also took part in this expedition. During twelve days of researches, 31 caves and shafts were found and explored, over 7,5 km of cave channels were surveyed, 11 syphons were dived through (the deepest among them was 44 metres deep), over 4,5 hours of 16 mm film was filmed etc. Leader of the expedition was dr Mladen Garašić, and egg. Tihomir Kovačević was organizing leader. Except some technical data, validity of this expedition was because of mutual field work that created friendship that is valuable for further researches. The foreign cavers were amazed by untouched nature and unexplored terrains of yugoslav karst (which is situated in Europe –thus there is no need for large trip expenses for european cavers). After getting all necessary permissions, foreign cavers will find real speleological «El Dorado» –large number of caves in the relatively small terrain.*

Figure 2. Official sign for International speleological expedition «Kamensko 84».

In August 1985. cavers from Zagreb (DISKF), Nikšić, Belgrade, Pazin, Sarajevo, Valjevo, Ribnica, etc. organized the Second International Speleological Expedition «Durmitor 85», *on the territory of Crna Gora (Monte Negro), on the mountain Durmitor. The speleologists from Great Britain, France and Poland also took part in this expedition. On that occasion 21 caves and shafts were explored, 897,5 m was the deepest among them (and wasn't explored all the way through), following the caves of 605,464 and 461 metres. Leader of this expedition was dr Milutin Lješević, and dr. Mladen Garašić was deputy leader. On the mountain Durmitor we confirmed the assumption that we can expect not only numerous but also deep speleological objects in Yugoslavia.*

All the foreign cavers, participants of the «Kamensko 84» and «Durmitor 85» expeditions, stated that they would come again in Yugoslavia, on further researches. Unfortunatelly, the activity of some foreign spelunkers who come to research yugoslav caves and shafts «illegaly» is very well known to yugoslav cavers. That way, they risk to lose all their equipment, according to the yugoslav law. For example 1984. cavers from Poland were on the Mount Durmitor, in 1984. and 1985 cavers from Czechoslovakia were on the mount Biokovo, 1985. Hungarian cavers were on the island Brač and so on. Some of them repeated *the caves that were allready explored –they didn't know it. If they have consulted domestic cavers they would be provided with all neccessary informations and with all permissions (licences) for their researchings.*

Figure 3. Official sign for International speleological expedition «Durmitor 85».

All the speleologist who wish to organize expeditions in Yugoslavia can address some of the speleological organizations in Yugoslavia (in charge of particular republic), or they can address personaly the author of this article (M.G. Nova Ves 73 a, YU –41000 Zagreb) who will give them all the necessary details. It is necessary to send all the necessary details at least few months before the expedition (name of the participants, date and the terrain where the expedition will hold, target of the expedition, etc.).

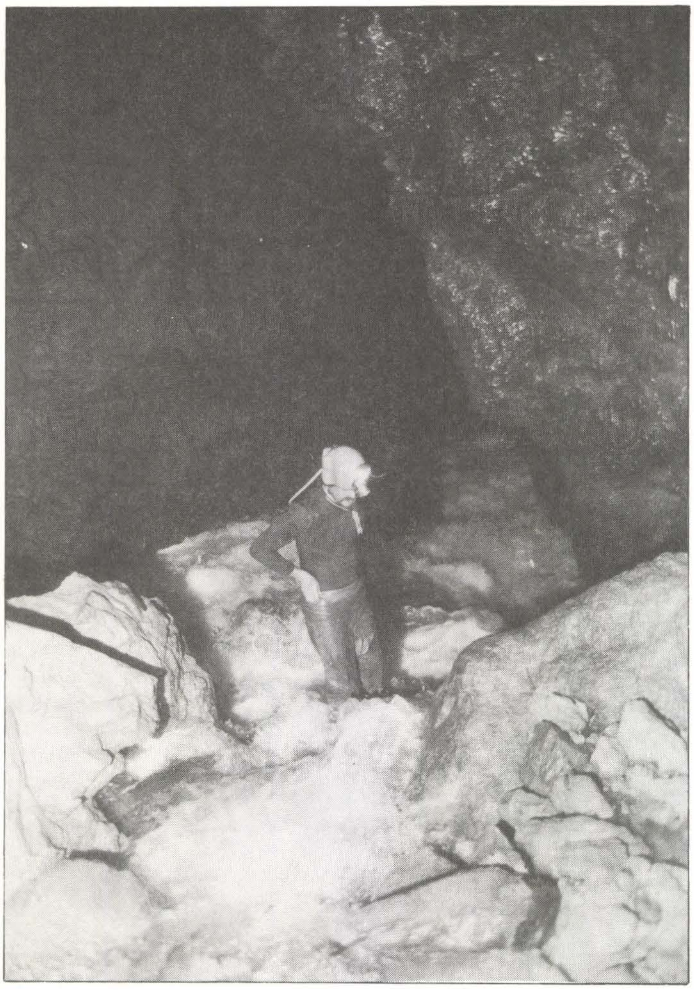

Figure 4. In two International speleological expeditions 52 caves and shafts were explored. Plenty of them are with strong water flows.

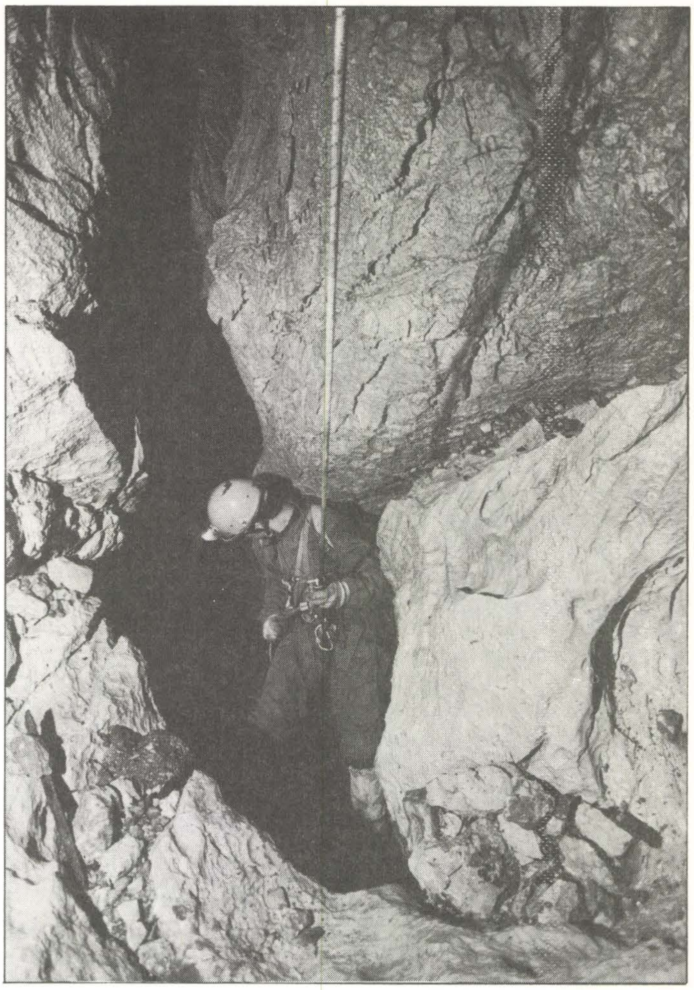

Figure 5. The deepest shaft found on these expeditions is 897,5 metres deep called Jamana na Vjetrenim brdima, on Durmitor, and potential are 1750 metres of depth.

Conclusión

In Yugoslavia it is possible to organize the speleological expeditions *after getting all the necessary permissions* for the researches on the particular terrain. In that expeditions it is necessary to have the yugoslav members guides.

Following the Yugoslav Law, foreign cavers found in researchings on yugoslav terrain, without licence, would lose all their equipment and would accept consequences according the Law. It is also refers to all *divings* in the caves by the sea shores, by the lake shores, by the river banks etc.

During 1984. and 1985. expeditions «Kamensko 84» and «Durmitor 85» were organized. They had international character, so the foreign cavers could see the advantages of mutual work and also could see yugoslav speleological capability. On that ocassions, 52 caves and shafts were explored (new caves). 897, 5 metres was the deepest, near ten kilometres was the longest, 11 siphons were dived through, films were filmed etc. On these expeditions participated the cavers from Great Britain, France, USA, Poland and Yugoslavia.

Only with organized work we can hit the target – explore as much caves and shafts as we can, no matter in which country, with remark that work must be useful and getable to all interested speleological organizations.

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15133

Recent cave exploration in Western Canada

Charles J. Yonge
Alberta Speleological Society, Canada

RESUM

Han estat nombroses les coves càrstiques explorades a la zona muntanyosa del Canadà occidental durant els darrers anys. Hi ha hagut descobriments significatius que han fet que la longitud total explorada siguin de l'ordre d'alguns centenars de quilòmetres, a més de confirmar la sospita de què resten encara molts sistemes de cavitats per descobrir en les zones calcàries interposades.

A l'illa de Vancouver, ha estat possible d'accedir a les zones càrstiques, gràcies a les carreteres que, per al transport de la fusta s'han anat obrint en zones molt apartades. A les Montanyes Rocoses, l'helicòpter ha demostrat ésser una eina insubstituïble per a apropar-se al carst més allunyat de la xarxa de carreteres, sobretot a aquelles zones on els arbusts i la vegetació així como un relleu abrupte dificulten enormement la tasca d'aproximació.

El que poden donar de sí les grans coves del Canadà és considerable, tant en el què respecta a la seva profunditat como en el seu recorregut. Les noves exploracions preveuen profunditats superiors a 1 km. i recorreguts de varis kms. amb exploracions addicionals. Actualment el sistema més profund descobert al Canadà és el dÁrctomys Cave, amb 552 m. i el que compta amb un major recorregut el de Castleguard Cave que quasi arriba als 20 kms.

RESUMEN

Numerosas nuevas zonas kársticas han sido investigadas en la zona montañosa de Canadá occidental en los últimos años. Las zonas con significativos descubrimientos de cuevas han alcanzado un nivel por encima de los centenares de kms. a parte de sugerir que muchos sistemas de cavidades han quedado aún por descubrir en las zonas calizas interpuestas.

En la Isla de Vancouver, las zonas kársticas han sido accesibles gracias a que las carreteras madereras se han abierto en zonas remotas. En las Montañas Rocosas el helicóptero ha demostrado ser insustituible para alcanzar el karst en zonas lejanas a la red de carreteras, especialmente donde los arbustos y vegetación y el terreno escarpado dificultan la aproximación.

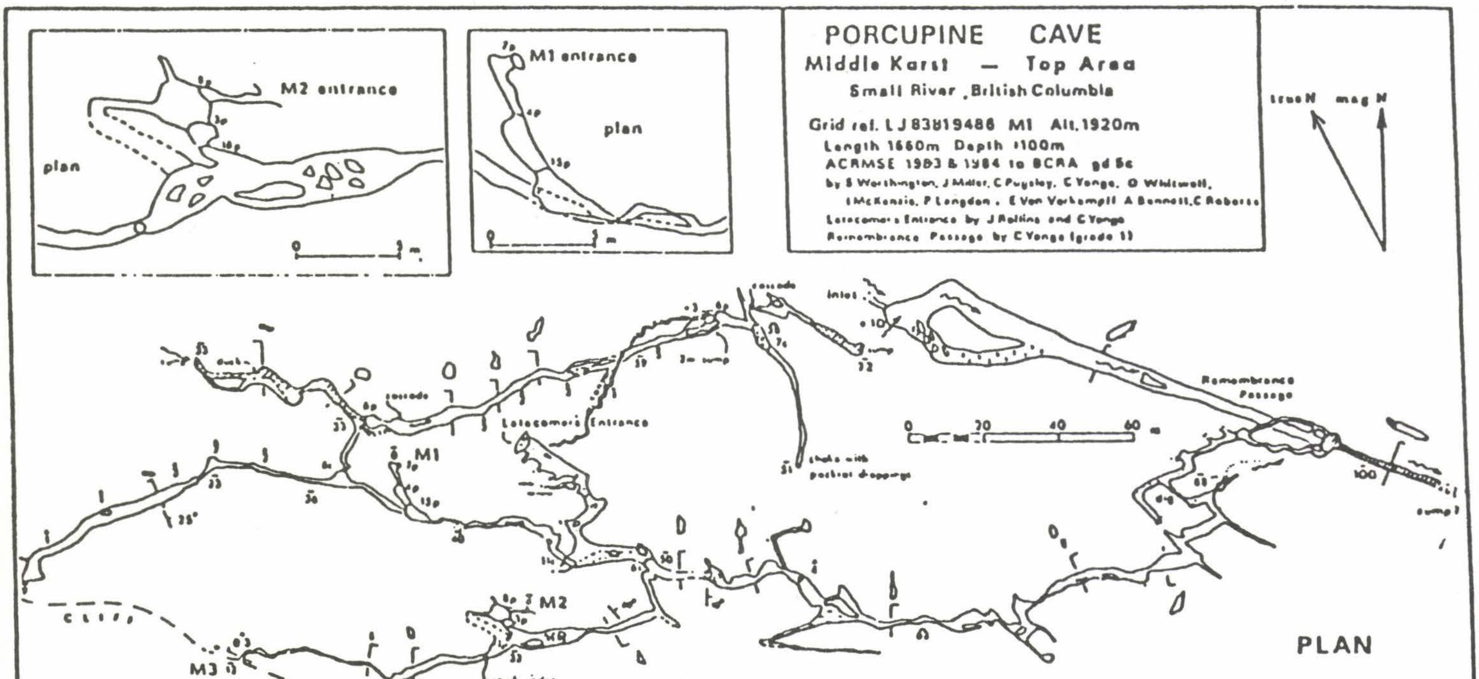
El potencial de grandes cuevas en el Canadá occidental es considerable, tanto para profundidad como recorrido y los nuevos descubrimientos prevén profundidades por encima de 1 km. y desarrollos de varios kms. con exploraciones adicionales. Actualmente el sistema más profundo descubierto en Canadá es Arctomys Cave con 552 m. y el de mayor recorrido Castleguard Cave, muy poco por debajo de los 20 km.

SUMMARY

A number of new karst areas have been investigated in the mountainous areas of Western Canada in recent years. The areas in which significant cave discoveries have been made range up to hundreds of km. apart suggesting that many cave systems remain to be found in the intervening limestone regions.

On Vancouver Island, karst areas have become accessible as logging roads have been extended into remote areas. In the Rocky Mountains, the helicopter has proved invaluable in reaching karst that lies far away from road systems, particularly where difficult bush and steep terrain need to be negotiated.

The potential for large caves in Western Canada is considerable in both depth and length and the new discoveries promise depths in excess of 1 km. and lengths of several kms. with further exploration. Presently the deepest system found in Canada is Arctomys cave at 522 and the longest, Castleguard Cave as just under 20 km.



Although a number of new karst areas have been investigated in Western Canada, this paper describes four regions, three in the Canadian rockies and one on Vancouver Island. The discussion focuses on the major caves developed in these karst areas.

1. Arch Cave and Glory'Ole, Vancouver Island, BC

These caves are each in excess of 300 m. deep and contain a few kilometres of passage (see figs 1 & 2). They are formed in Triassic to Jurassic limestones and marbles which are intruded by middle to late Jurrasic granites and granodiorites. Triassic volcanics, are also present.

Cave passage, where it is horizontal or dipping, appears to be developed on volcanic horizons. These sections end abruptly in pitches from 10 m. to 50 m. in length with ample evidence of piracy, particularly in the case of Arch Hole. The irregular length of pitches coupled with multiple piracy events in the region of Arch Hole suggest a high degree of local faulting. Glory'Ole, over one kilometre away appears considerably less affected. However, in the lower sections of Glory'Ole, vertical intrusives force the streamway to cult to the left and right in a somewhat geometrical pattern.

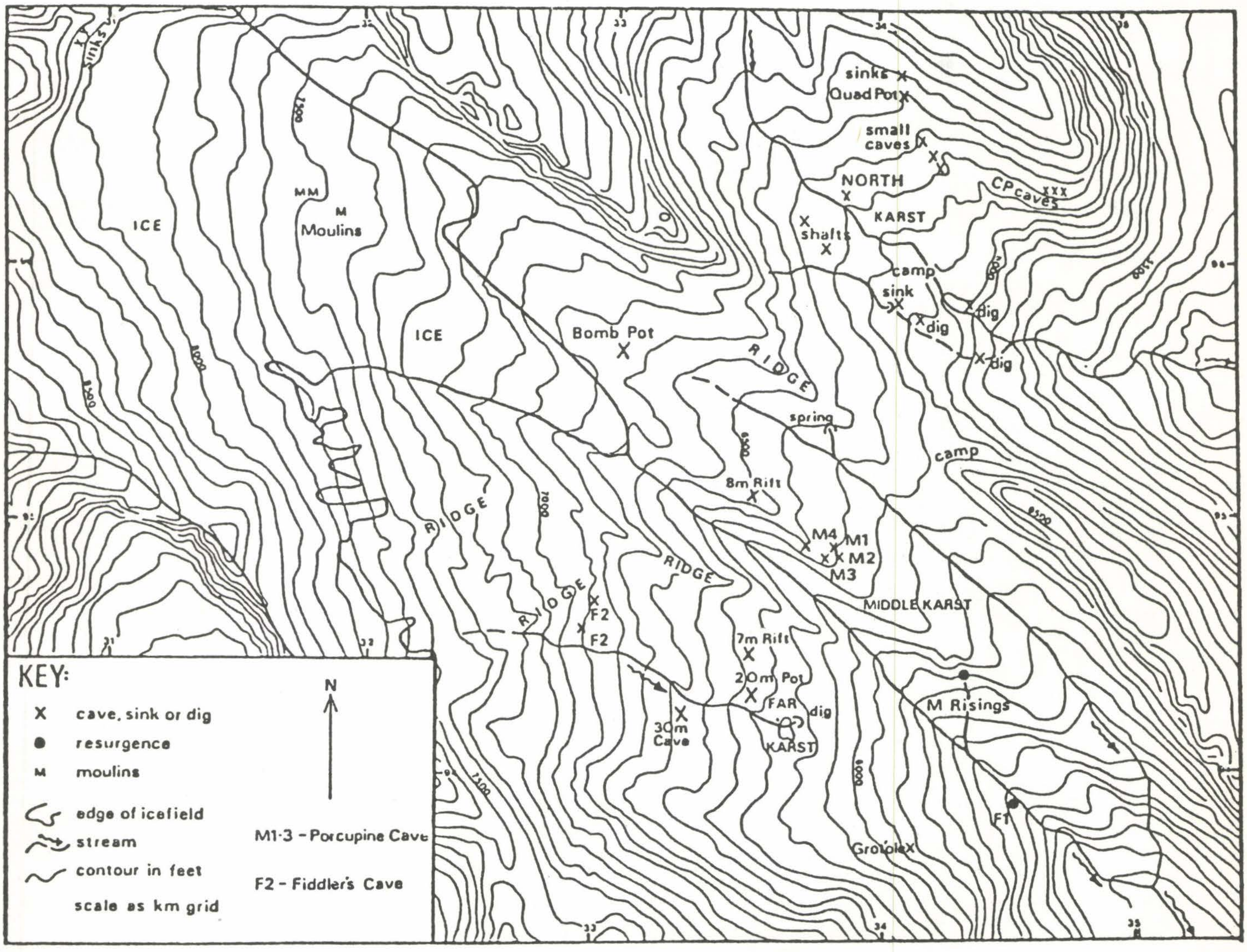
Glory'Ole approaches the upstream siphon in Arch Hole although the connection has not been proved. The deeper reaches of Arch Hole show a considerable amount of phreatic development even though it is presently perched some 600 m. above fjord-type lakes that contain likely spring outlets fro the cave system. The phreatic network is not obviously affected by intrusive/volcanic activity although it is presently partially active. A ramp (Cannon Ball Crawl) contains a superbly sorted range of spherical pebbles that span from 15 cm. in diameter to sand-size over a vertical rise of 30 m. Clearly tremendous hydraulic gradients were available and may have been present as the 1 km-thick ice-sheet melted back eastwards towards the mainland during the Wisconsin. The present high precipitation in this coastal region probably account for the paraphreatic conditions that exist now.

2. Dezaiko Cave, Central BC

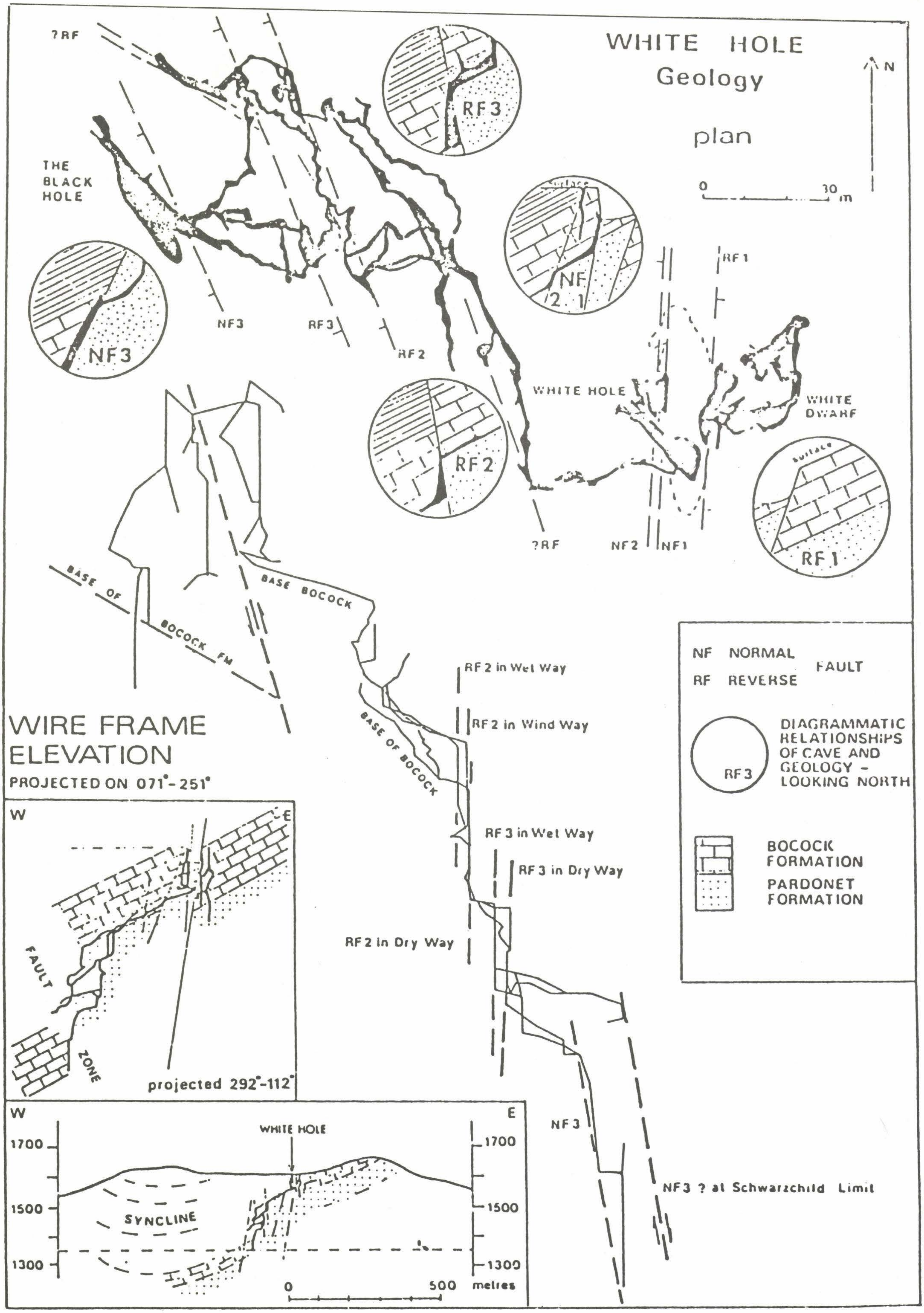
Dezaiko Cave is formed in thinly-bedded precambrian limestones and dolomites that are regularly interbedded with thin units of quartzite and Shales. The area is characterised by a faulted plateau of around 2.000 m. in altitude that contains many sinks and is drained by a few large resurgences with flow-rates up to several cumecs. Dezaiko Cave, for example, appears to drain more than 8 km. to one of these major resurgences suggesting the presence of a few fairly well-integrated subterranian drainage systems.

The region is highly glaciated and one portion presently supports a remnant glacial sheet several kilometres in extent. Hundreds of small post-glacial sinks exist on the freshly glaciated surface and their streams are temporally supported by either by small areas of moraine or geologically on the impermeable beds.

Dezaiko Cave appears to be one such sink, although parts of the upper reaches do seem to be old with large breakdown chambers and relatively massive redissolved speleothems. Otherwise the system is rather simple with essentially one canyon



Topography and cave locations, Top Area, Small River.



WHITE HOLE
Geology
plan
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30 m
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THE BLACK HOLE
NF3
RF3
RF2
RF1
NF 2 1
WHITE HOLE
WHITE DWARF
?RF
NF2
NF1
surface
WIRE FRAME ELEVATION
PROJECTED ON 071°-251°
BASE OF BOCOCK FM
BASE BOCOCK
BASE OF BOCOCK
RF 2 in Wet Way
RF 2 in Wind Way
RF 3 in Wet Way
RF 3 in Dry Way
RF 2 in Dry Way
NF 3
NF 3 ? at Schwarzchild Limit
NF NORMAL
RF REVERSE
FAULT
DIAGRAMMATIC RELATIONSHIPS OF CAVE AND GEOLOGY - LOOKING NORTH
BOCOCK FORMATION
PARDONET FORMATION
W
E
FAULT
ZONE
projected 292°-112°
WHITE HOLE
SYNCLINE
1700
1500
1300
0
500 metres

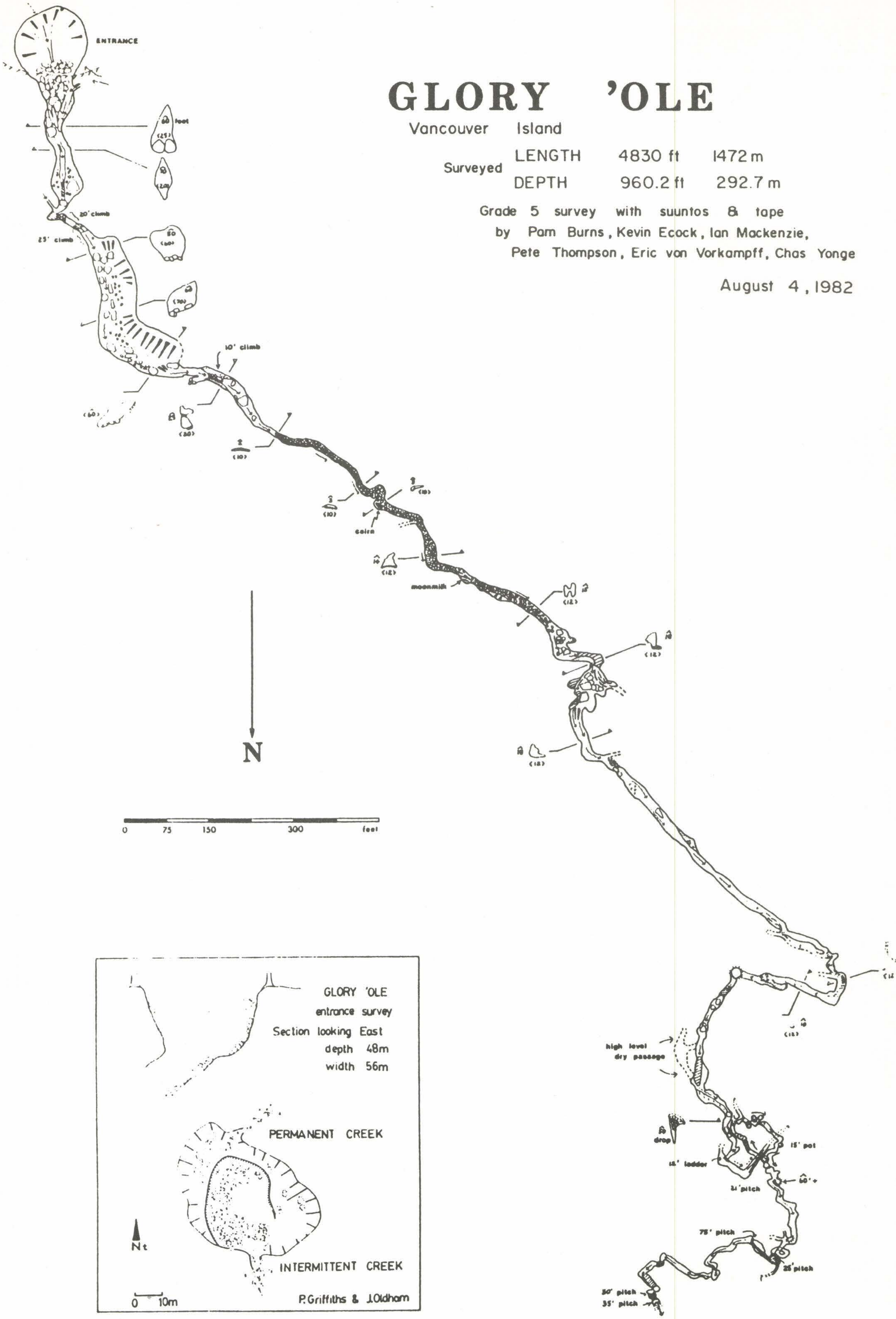
GLORY 'OLE

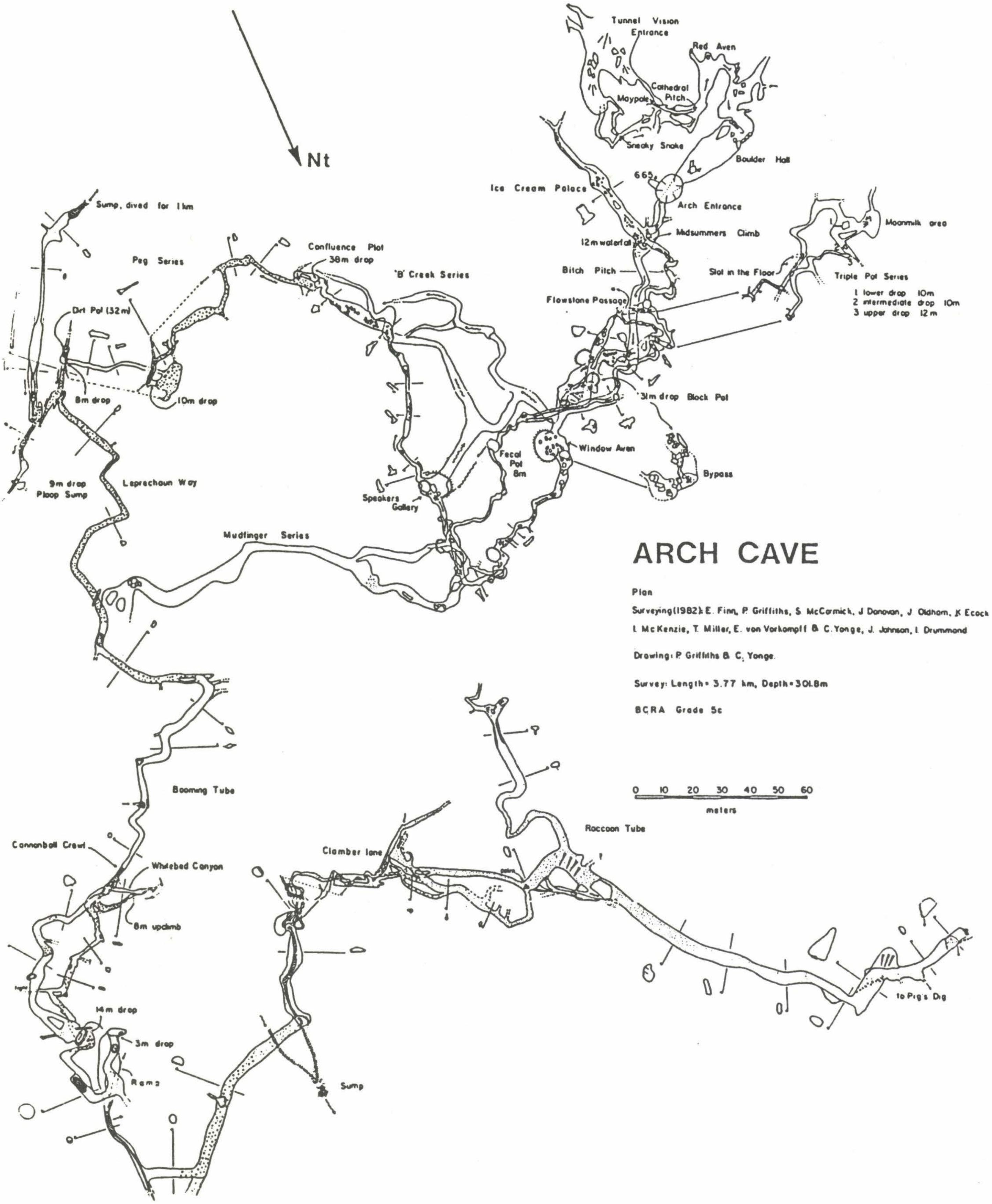
Vancouver Island

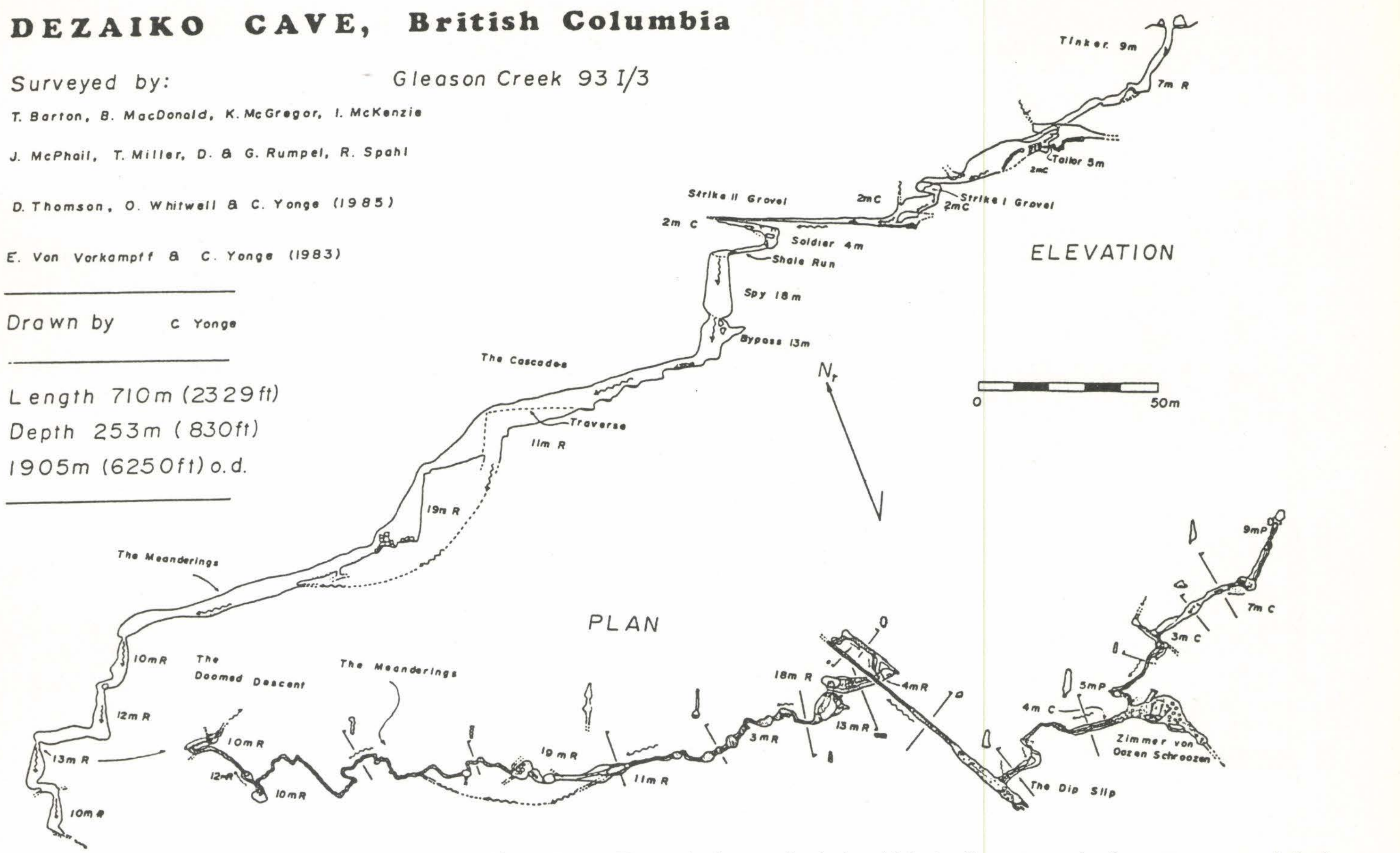
Surveyed LENGTH 4830 ft 1472 m
DEPTH 960.2 ft 292.7 m

Grade 5 survey with suuntos & tape
by Pam Burns, Kevin Ecock, Ian Mackenzie,
Pete Thompson, Eric von Vorkampff, Chas Yonge

August 4, 1982




Nt
Tunnel Vision Entrance
Red Aven
Cathedral Pitch
Maypole
Snecky Snake
Boulder Hall
Ice Cream Palace
665
Arch Entrance
Midsummers Climb
12m waterfall
Bitch Pitch
Slot in the Floor
Moonmilk area
Triple Pot Series
1 lower drop 10m
2 intermediate drop 10m
3 upper drop 12m
Flowstone Passage
31m drop Block Pot
Window Aven
Bypass
Fecal Pot 8m
Sump, dived for 1km
Peg Series
Confluence Plot
38m drop
'B' Creek Series
Dirt Pot (32m)
8m drop
10m drop
9m drop
Ploop Sump
Leprechaun Way
Speakers Gallery
Mudfinger Series
ARCH CAVE
Plan
Surveying(1982): E. Finn, P. Griffiths, S. McCormick, J. Donovan, J. Oldham, K. Ecock
I. McKenzie, T. Miller, E. von Vorkampff & C. Yonge, J. Johnson, I. Drummond
Drawing: P. Griffiths & C. Yonge.
Survey: Length = 3.77 km, Depth = 301.8m
BCRA Grade 5c
0 10 20 30 40 50 60
meters
Booming Tube
Raccoon Tube
Cannonball Crawl
Whitebed Canyon
Clamber lane
8m upclimb
14m drop
3m drop
Rams
Sump
to Pig's Dig



passage interspersed with pitches from 4 to 19 m. long. The canyon is lost in one place (Strike II grovel) where faulting in the thin limestone units has caused them to pinch out forcing the drainage along strike. In the vicinity of the cave across a deep valley, a massive shaft exposed at a scarp face suggests that preglacial cave development has taken place.

3. Porcupine Cave, Small River, Mount Robson, BC

This cave and others are formed in a limestone synclinorium some 60 km. in diameter that centres on Mount Robson. One of these caves on the east side of the synclinorium is over 0.5 km. deep and is the deepest cave in Canada and the USA. The limestone unit known as the Mural and is of Lower Cambrian age. The Mural is sandwiched between Gog quartzites and is split into two by a shale member; the impermeable units provide a distinct geological control on cave development.

The Small River area lies to the east of Mount Robson and represents the greatest exposure of the Mural Limestone. A remnant ice sheet has melted back to reveal a classic glacial karst region with sinks (including moulin sinks) and two large springs associated with the two split portions of the Mural limestone. Both springs appear in a canyon which itself may well have developed beneath the ice sheet when it was more extensive. Some caves have been noted below these springs in the wall of the canyon. The canyon presently carries a heavy stream from the ice sheet.

Porcupine Cave is developed updip and to the west the spring associated with the upper Mural member. Both cave and spring have essentially formed on the middle shale unit. The passages running from the cliff line appear to be glacial stream sinks abandoned as the ice sheet melted back. The heavy stream now running in the cave represents an active sink point under the glacier possibly fed by moulin sinks. The lower portions of the cave are vadose canyons starting at nick-points. The height of the canyons lowers at down-stream points as wide low passages are developed on the shale. Three 30 m. shaft systems punch down into the canyons from the alpine meadows above where a well-drained karst is observed. This cave system does not seem to be particularly old but other caves in the area suggest that preglacial development has taken place.

4. White Hole, Mount Bocock, BC

White Hole is the main sink point in a polje 4 km. long by 1 km. wide. The polje has been formed in the eastern limb of a syncline of Triassic shales, limestones and sanstones aligned to the regional folding. Streams are supported on the upper, impermeable sandstones of the Fernie Formation before sinking into the Bocock-Pardonnet Formation.

White Hole commences where several faults intersect and appears, after punching some 250 m. down thorugh the various limestone units, to travel thereafter 25 km. along the regional strike NNW to springs in the Peace River system some 1.000 m. lower.

The cave has been explored to -253 m. with little lateral extent in a series of active and abandoned shafts to a paraphreatic silt choke and this appears to be the preglacial portion of the cave. Behind the active sink, The White Dwarf Series represents one fossil sink; others are also apparent in the vicinity. Some massive flowstone has been found at or in the fossil sinks indicating a high degree of cave development perglacially. The glaciers retreated from this area only 5.000 to 10.000 years ago, however, the thick peats that have formed in the polje deliver a highly agressive water to the caves. Karst pavements are well-developed on uncovered bedrock surfaces in the polje basin.

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Recent developments in Castleguard Cave

Jon Rollins and Chaz Yonge
Alberta Speleological Society, Canada

RESUM

Els viatges anuals a Castleguard han centrat sempre l'atenció als espeleòlegs de tot el món. La seva localització, sota dels Columbia Icefields i la seva gran longitud, juntament anb les crues condicions hivernals de la superfície fan de Castleguard una experiència espeleològica sense precedents. El tap de gel originari que marcava la fi del sistema principal va ésser descobert l'any 1973. En els darrers anys s'han descobert cinc taps més de gel que obstrueixen algunes galeries secundàries i les esperances de trobar una segona entrada, com se sospitava, arran dels tubs de vent existents, han disminuït. En els últims quatre anys la cova ha vist augmentada la seva longitud en un 50 %, la cual cosa fa que arribi pràcticament als 20 km. La major part de les noves galeries s'han descobert a la capçalera, la qual cosa confirma la naturalesa dendrítica de la cova. No s'ha vist encara tot, ni molt menys, doncs no s'ha treballat encara l'extens sistema jovenil que hom sap que es troba sota dels Castleguards Meadows.

RESUMEN

*Los viajes anuales a Castleguard han actuado como un foco de atención de espeleólogos, a nivel internacional. Su situación bajo los Columbia Icefields y su gran longitud combinada con las condiciones de invierno áspero en la superficie hacen de Castleguard una experiencia espeleológica única. El tapón de hielo originario que marcaba el final del sistema principal fué descubierto en 1973. En los últimos años se han descubierto 5 tapones de hielo, que bloquean galerías secundarias y las esperanzas de encontrar una segunda entrada como sugieren los efectos del chimney-wind*han disminuido. Los últimos 4 años han visto añadir un 50 % más a la longitud total de la cueva, llevándola a prácticamente 20 km. Se han encontrado la mayor parte de las nuevas galerías hacia la cabecera, corroborando la natualeza dendrítica de la cueva. Hay todavía un gran potencial de desarrollo de la cueva hacia un vasto sistema juvenil que se sabe que está debajo de los Castleguard Meadows.*

SUMMARY

The annual Castleguard trips have acted as a focus of attention for cavers internationally. Its position under the Columbia Icefields and its great length combined with the harsh winter surface conditions make Castleguard a unique caving experience.

The original ice plug marking the end of the main cave system was discovered in 1973. In recent years five other ice plugs have been discovered blocking subsidiary passages and hopes of finding a second entrance, as suggested by chimney-wind effects, have diminished. The last four years have seen a 50 % addition to the total length of the cave making it just of 20 km. Most of the new passage found has been in the headward reaches emphasising the cave's dendritic nature. There is still great potential for extending the cave via a large juvenile system that is known to underlie Castleguard Meadows.

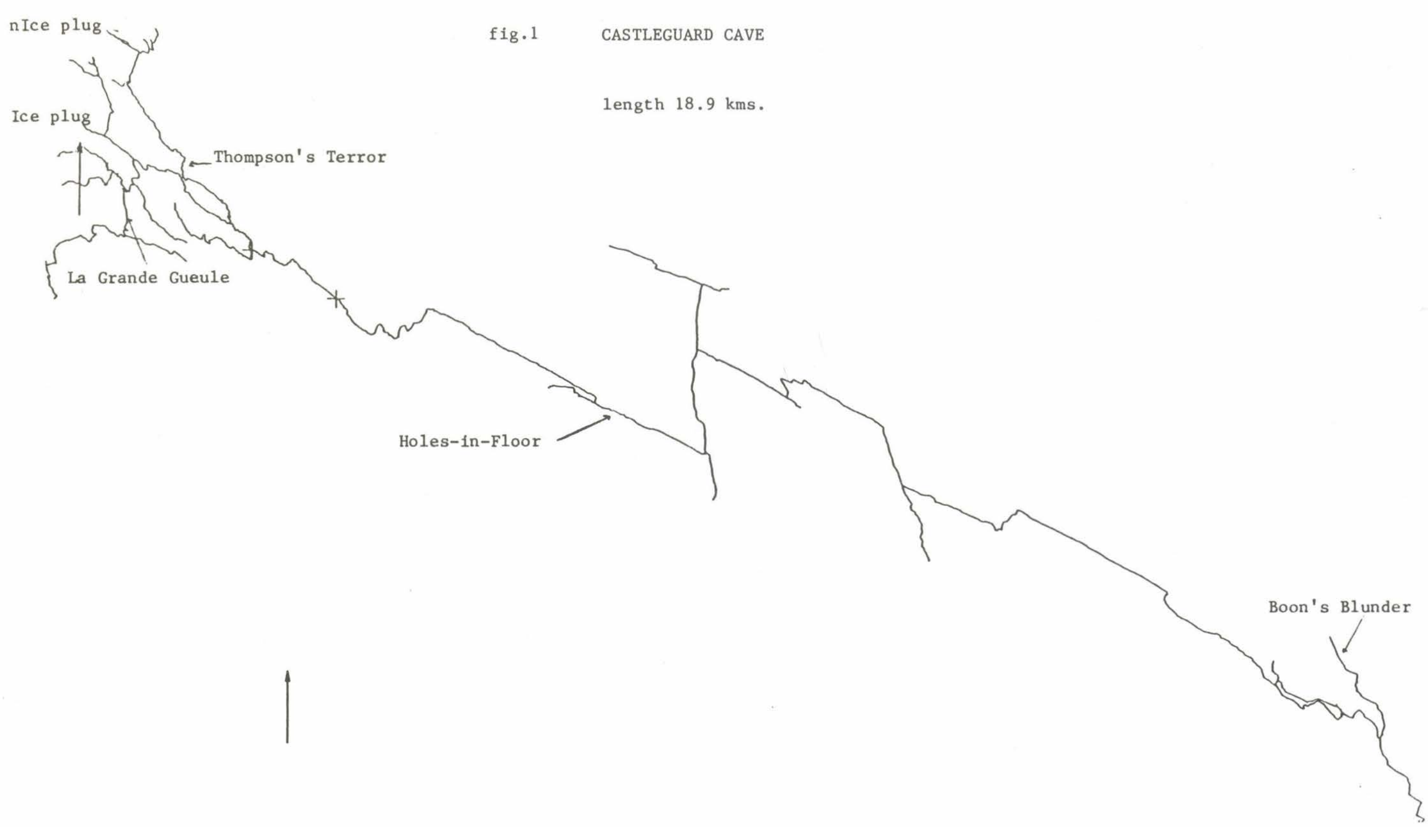

fig.1 CASTLEGUARD CAVE

length 18.9 kms.

In the past few years exploration in Castleguard Cave has become increasingly difficult as points of exploration have been pushed further from the enterance. Since the early 70's following the discovery of an ice plug in the upper reaches of the system where it extends under the Columbia Icefield, the general feeling was that the cave was more or less finished. This however was to prove far from true as numerous discoveries in the dendritic headward complex have extended the cave to its present length of 19 kms.

In 1979 a 25 m shaft was traversed by Quebec cavers close to the Ice Plug leading to a kilometer of new passage, the Boulevard du Quebec, but of major interest were a number of pitches in this section. If these could penetrate to a lower system (Castleguard II) that feeds the Big Spring located 300 m below the cave entrance, then a major extension to the cave might be possible. The deepest of the pitches known as La Grande Gueule eventualy sumped at 139 m possibly halfway to Castleguard II, another, Ooley Gooley Pit was a blind 75 m single drop. There are still draughting leads to be explored in this section of the cave.

The other major lead was Thompson's Terror, a large continuing fissure passage which because of difficult and loose traverses was initialy abandoned further exploration being regarded as unjustified. In 1983 however exploration ironically previous exploration had terminated at the last climb after which nearly a kilometer of very pleasant passage was mapped terminating in another beautiful ice plug the nice Plug, around which were several smaller passages also culminating in ice. Like the main ice plug the ice was opaque and coarsely crystalline with the same composition as ice samples taken high up on the Columbia Icefield. There is little doubt that this is ice from the base of the icefield that has been extruded into the passage and according to data on the distance ice will extrude into rock cavities it seems unlikely that there in more than 30 to 40 meters of cave passage beyond the ice front. Since the original ice plug was discovered in 1970 six other small passages terminating in ice have been found deliniating the extent of the dendritic headward system. The main ice plug has not changed by more than one to two centimeters during the past nine years reflecting the great stability of cave environments. No surface ice-front would change as little as this in a year.

New passage is still being found closer to the entrance, a lead near the Holes in The Floor went for half a kilometer before pinching out. Boon's Blunder also yielded new if low passage but no way round the sump was found. Essentially the complex of passages there comprise a braided drainage emanating from the sump; an excellent diving prospect for the future. In 1984 a cave radio was taken underground in an effort to locate the position and depth of the end of the cave under the Columbia Icefield. Based on a tentative cave «height» of 300 m and entrance elevation of 2016m, the ice plug is some 200 m below the surface. Due to poor surface conditions, a full scale blizzard, there were rendezvous problems and the results were not conlusive but tone contact was made and seemed to indicate that the end of the cave is in the same general area as shown by the survey indicating that there were no grave errors in cave mapping. However from the strength of the signal, the distance the signal could be heard over, and the lack of nulls it seems that the end of the cave is deeper than the supposed 200 m or that the ice adversley effects radio transmissions.

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«The Alto Ribeira Region: a photographic approach on the speleological potencial and its importance as a world-wide patrimony».

Mario Roberto Guitti Peixoto

RESUM

La intenció d'aquest assaig és la de presentar-vos una de les regions calcàries més representatives del S.O. del país i una de les més importants de Sud-amèrica. Mitjançant un àudio-visual i una exposició impresa, aquest treball pretén mostrar-vos una aproximació fotogràfica a una regió com aquesta, que compta amb 170 cavitats enregistrades, un nombre estadísticament prou significatiu, si tenim en compte les futures perspectives de descobrir noves coves i nous avencs.

Situades al sud de l'estat de São Paulo, el seu potencial espeleològic radica en coves com les de Santana, Arcias, Casa de Pedra i els nombrosos avencs, tots ells de gran bellesa i caracteritzats per la seva gran extensió, rica decoració, amplitud de llurs entrades i variada fauna subterrània.

RESUMEN

El propósito de este ensayo es presentar una de las regiones calizas más representativas del sudoeste del país y una de las más importantes de Sudamèrica. Mediante un audio-visual y una exposición impresa este trabajo pretende mostrar una aproximación fotográfica a una región como ésta en la que se han registrado 170 cavidades, un número estadísticamente significativo teniendo en cuenta las futuras perspectivas de descubrir nuevas cuevas y simas.

Situadas en el Sur del Estado de São Paulo, su infinito potencial lo representan cuevas como Santana, Arcias, Casa de Pedra y numerosas simas en las que se resumen su belleza y riqueza caracterizada por su extensión, decoración, fauna subterránea y amplitud de sus entradas.

SUMMARY

The purpose is presents an essay about the most representative limestone region of the Southwest of the country and one of most important of South America. Throughout an audio-visual and a print exposition the worke intends show the photographic approach on a region like this, where has 170 caves registred, a significant sthatistic taking into account the perspectives of new caves and potholes.

Situated in the South of the State of São Paulo, its infinite potential is representated by caves like Santana, Areias, Casa de Pedra and innumerables pothols, resuming beanty and richen characterized by the extension, adornment, underground fauna and the height of the entrances.

New discovered Gypsum Caves in Poland

Bronisław, W., Wołoszyn, Krzysztof, P. Wołoszyn and Sławomir Wiraszka

Intitute of Systematic and Experimental Zoology, Polish Academy of Sciences, Kraków and Polish Society of Earth Sciences, Kraków Branch

RESUM

A Nida Though (al sud de Kielce a la Polònia Central) s'hi troben uns dipòsits de guix del Miocè. Els fenòmens càrstics d'aquesta regió han estat descrits per Flis (1954). També han estat ja descrites 14 coves per Kowalski (1954). Són coves relativament petites. La més llarga, anomenada «Skorocicka», té 280 m. de longitud. Més recentment s'han descobert 15 coves més en unes exploracions empreses pels autors: el 1978 (BWW) i, més tard, l'agost i el setembre de 1985 (KPW i SW). La longitud total de les galeries descobertes per nosaltres és superior als 200 m. El descobriment més interessant va ser l'efectuat a Skorocice Valley, on vàrem trobar la regió més antiga del Skorocicka Cave System. La nova cova té una longitud aproximada d'uns 50 m.

Aquesta és l'única zona càrstica de guix que hi ha a Polònia. Els fenòmens càrstics, així com la flora xeròfil-la i la fauna d'aquesta regió, han fet que esdevingui una de les més interessants de Polònia.

RESUMEN

En el Nida Though (Sur de Kielce en Polonia Central) existen depósitos de yeso del Mioceno. Los fenómenos kársticos de esta región fueron previamente descritos por Flis (1954) y también fueron descritas 14 cuevas por Kowalski (1954). Las cuevas son relativamente pequeñas, la más larga llamada «Skorocicka» tiene 280 m. de longitud. Recientemente se han descubierto 15 cuevas durante algunas expediciones emprendidas por los autores: en 1978 (BWW) y más tarde en Agosto y Septiembre de 1985 (KPW y SW). La longitud total de todas las galerías descubiertas por nosotros es superior a 200 m. El descubrimiento más interesante fue efectuado en Skorocice Valley, donde encontramos la parte más antigua de Skorocicka Cave System. La nueva cueva tiene aproximadamente 50 m. de longitud.

Esta es la única zona kárstica en yesos en Polonia. Los fenómenos kársticos y también la flora xerófila y la fauna de esta región la convierten en una de las más interesantes de Polonia.

SUMMARY

In the Nida Trough (South of Kielce in Central Poland) there are gypsum deposits of Miocene age. The karst phenomenons of this region were described previously by Flis (1954), and also 14 caves was described by Kowalski (1954). The caves are relatively small, the largest one, named «Skorocicka» is 280 m. long. Recently 15 new caves were discovered during some expeditions undertaken by the authors: in 1978 (BWW), and later in August an September of 1985 (KPW and SW). The total lenght of all new corridors discovered by us is more that 200 m. The most interesting discovery was made in Skorocice Valley, where we found the oldest part of the Skorocicka Cave System. The new cave is about 50 m. long.

This is the only one gypsum karst region in Poland. The karst phenomenons and also the xerophil flora and fauna of this region make it to one of the most interesting in Poland.

Introduction:

In the Southern part of Central Poland, within the triangle determined by the localities: Pińczów, Busko Zdrój and Wiślica there is an interesting cavernous area.

This is the only locality of Poland of well developed gypsum karst phenomenons.

About 30 caves are known form this area, but half of them was recently discovered, and this new discovered caves are the subject of the present paper.

Geography:

The geographical centre of the studied area, called Nida Trough lies 50° 25' N, and 20° 45' E.

Busko Zdrój, the main town of this region lies about 50 km south of Kielce and about 80 km north-east of Kraków.

Gypsum karst:

In the miocene sediments filling up the Nida Trough there are large deposits of gypsum. The relief and features of the outcrops of the gypsum formation were studied previously by several sciencists, and karst phenomenons of this region were described in details by Flis (1954), and also 14 caves were described by Kowalski (1954).

The caves are relatively small. The largest one, named «Skorocicka» is 280 m. long.

More recently 15 caves were discovered during some expeditions undertaken by the authors. At July 19th, 1977 B. W. Wołoszyn found three caves near Marzecin (see fig. 1), and later, in August and September of 1985 K.P. Wołoszyn and S. Wiraszka discovered twelve new caves. During the two last expeditions all new caves were mapped and described by the junior authors.

A list of new discovered caves is as follow:

The most interesting discovery was made in «Skorocicka» Valley. The middle part of this Valley forms small but scenic canyon with gypsum rocks (see fig. 2).

In the left wall of the canyon there is «Skorocicka» Cave System. The feature of this cave is the work of running water. It forms a single gallery, about 200 m. long, with live stream on its bottom, and some openings to surface. In short distance from the north entrance of main gallery there are two chambers: «Górna» (Upper), and «Komora Dzwonów» (Bell's Chamber). The last also with live stream. Both had in the past connection with the main gallery. About 30 m. north of Bell's Chamber, in different rock, we found a new cave. This cave, named by us «Stara» (Old) (see fig. 2 and 3) althrough having a separate entrance, is a part of the «Skorocicka» Cave System. The new cave takes its name («Old») from the fact that its passages form the oldest part of the Underground bed's of Skorocicki Stream. The entrance passage to the cave is very narrow but after some meters it comes to the main passage, about 30 m. long with some short secondary corridors and two sinkhole-like connections with the live stream.

Cave's name	No. of the Cave[1]	Location	Total lenght in m
1. Stara/Old Cave/	15	Skorocice Valley	50
2. Szczelina w Skorocicach	16	Skorocice Valley	5
3. Schoronisko Trójkatne	17	Skoricice Valley	2.5
4. Maly Tunel	18	Skorocice Valley	5
5. Slomiany Tunel	19	Skorocice Valley	7
6. Jaskinia w Gackach	20	Gacki-Wola Gorna	30
7. Zydowska	21	Marzecin	10
8. Schoranisko Male	22	Marzecin	6
9. Schoronisko Stolowe	23	Marzecin	4
10. Mysia Nora	24	Marzecin	6
11. Dwie Studnie	25	Siesławice	30
12. Dziupla	26	Siesławice	9
13. Południowa	27	Siesławice	15
14. Połnocna	28	Siesławice	20
15. W Sładkowie Malym	29	Sładków Maly	4

(1) Following of Kowalski Catalogue 1954.

The total length of the new cave is about 50 m.

The Gacki and Siesławice are two another areas where more important discovery was made.

In Gacki we found 30 m. long small size tunnel (cave no. 20) opened on both ends, and probably filled up by water temporary (Fig. 4A). In the second area at Siesławice we found three longer caves (figs. 4B and 5): «Dwie Studnie» (Two sinkholes) -30 m. long, «Południowa» (Southern) -15 m. long, and «Połnocna» (Northern) -20 m long.

The Skorocicka Valley is at present a protected area. The karst phenomenons and also the xerophil flora and fauna of this region make it to one of the most interesting in Poland.

Caves:	Previously known Existing	Previously known Destroyed	New discovered
Number of caves	11	4	15
Total lenght in m.	363	105	204(2)

(2) + 15 m long new corridor in previously known Latanice Cave

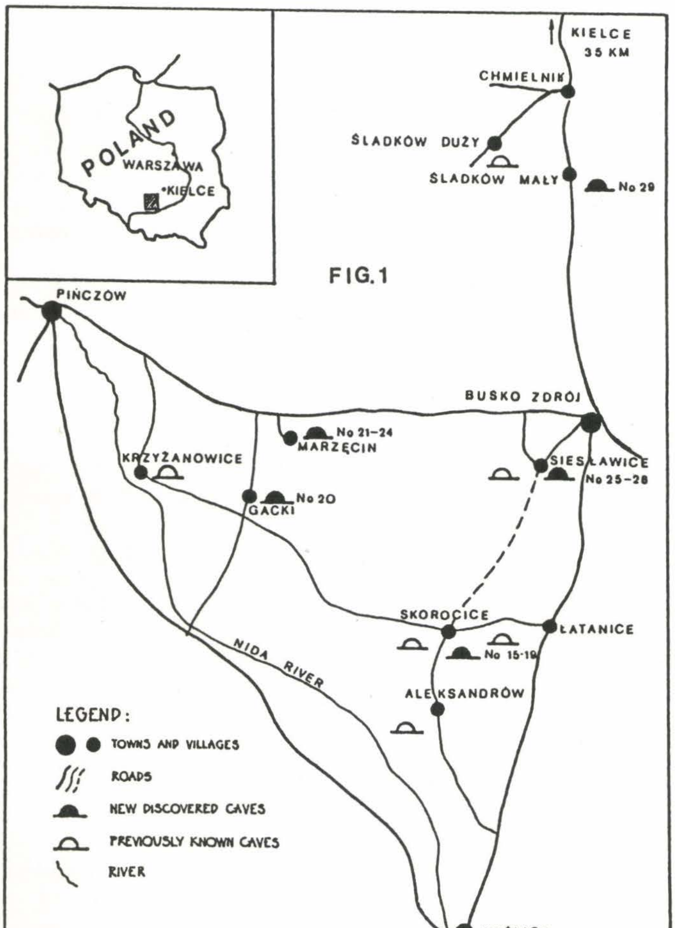

Fig. 1. General location of discussed sites.

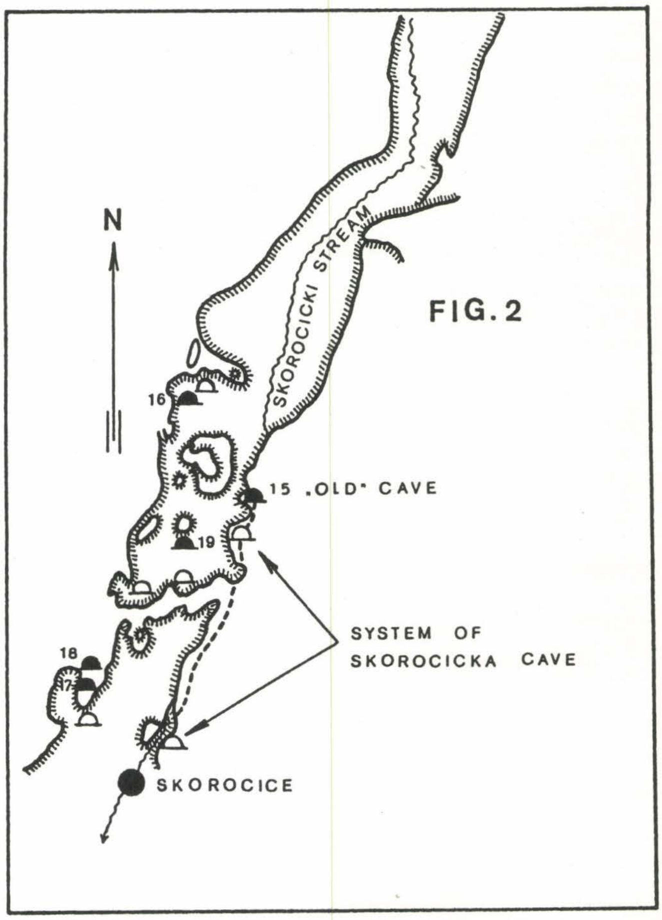

Fig. 2. The Middle part of Skorocicka Valley.
Explication as in fig. 1. The numbers following the black symbols are the numbers of the new discovered caves (see tabl. 1).

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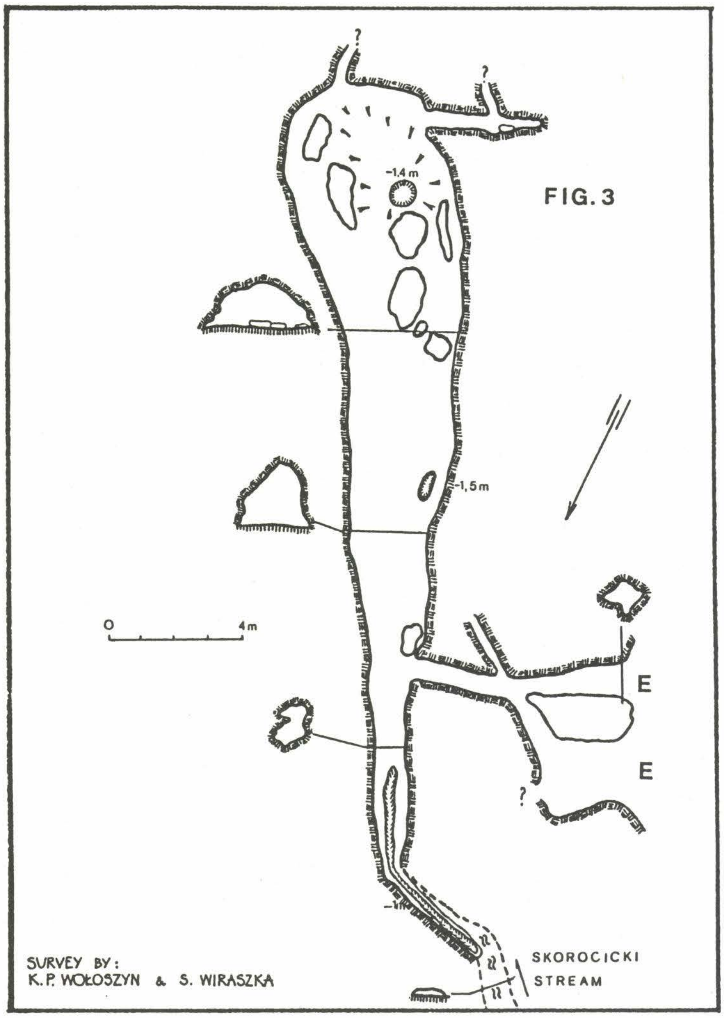
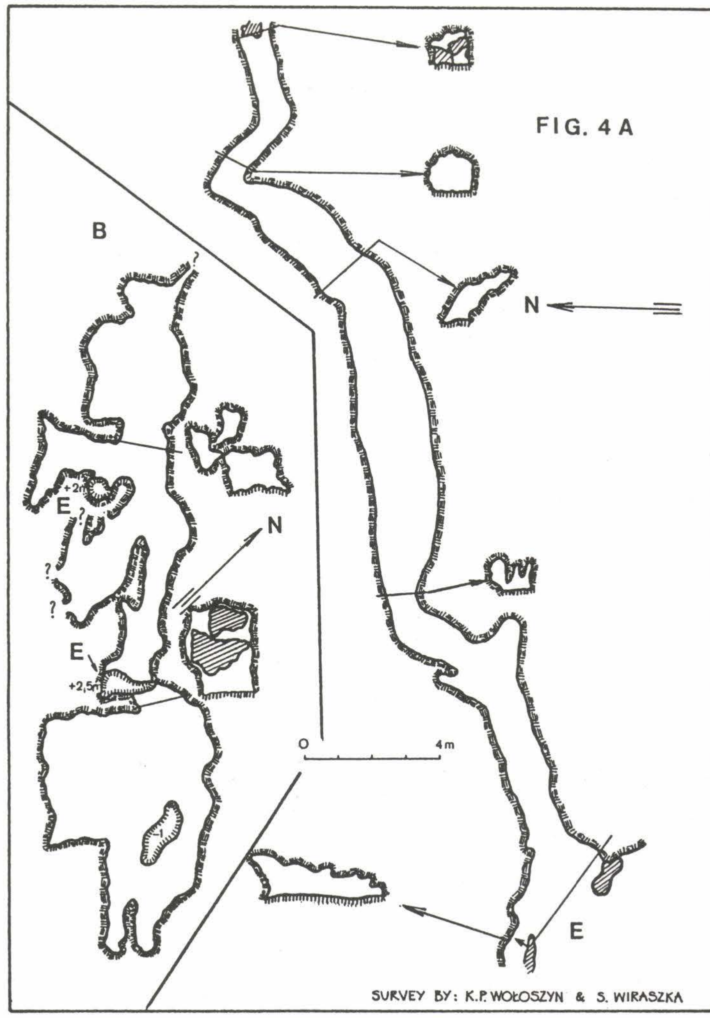




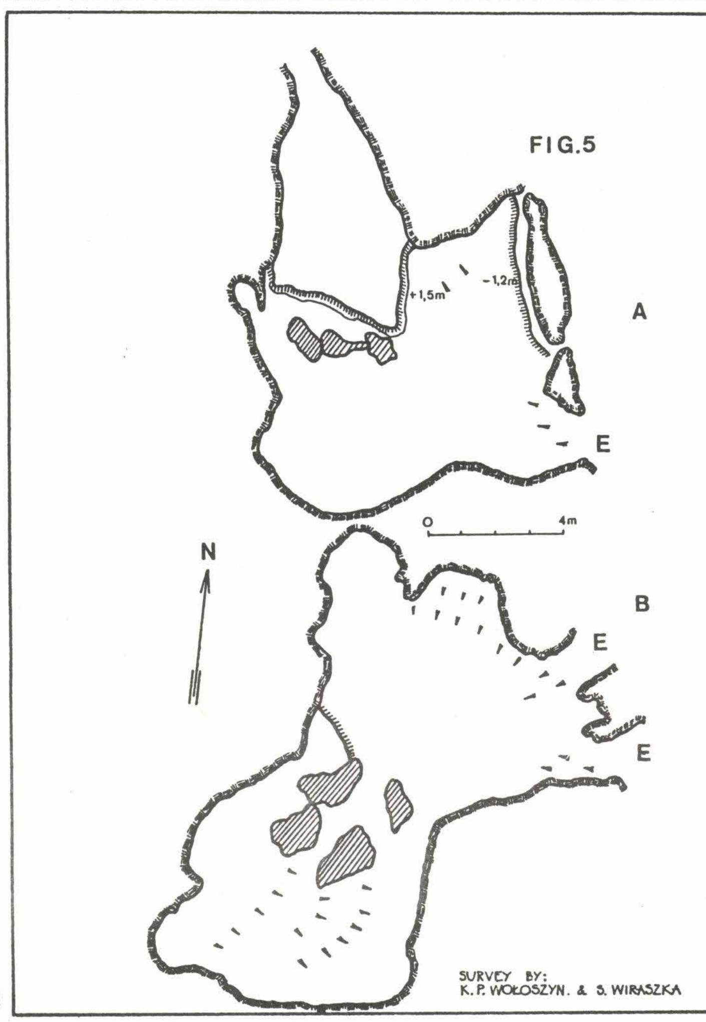


Fig. 3. The «Stara» (Old) Cave in Skorocice Valley. E-entrances.
Fig. 4A. W Gackach (In Gacki) Cave, near Gacki.
Fig. 4B. «Dwie Studnie» (Two sinkholes) Cave at Siesławice.
Fig. 5A. «Północna» (Northern) Cave at Siesławice.
Fig. 5B. «Południowa» (Southern) Cave at Siesławice.

Califronia Caverns - The Cave at Cave City

Peter and Ann Bosted

RESUM

Algunes parts d'aquesta cova van ésser explorades pels primers buscadors d'or els dies de la «febre de l'or» a Califòrnia, que les van saquejar barroerament; malgrat tot, exploracions més recents han descobert més d'un quilòmetre de galeries primitives amb una gran varietat d'interessants espeleotemes. La cova, la més llarga de l'àrea de California's Mother Lode, presenta una gran diversitat. Tot i que avui se'n fa un ús comercial, s'han donat facilitats a espeleòlegs per a procedir a estudis biològics i hidrològics de la cavitat i no es descarta la possibilitat de futures exploracions.

RESUMEN

Algunas partes de esta cueva fueron exploradas por los primeros buscadores de oro en los días de la Fiebre del Oro en California. Estas partes fueron saqueadas duramente, pero exploraciones recientes han descubierto más de 1 km. de galerías primitivas que poseen variedad de interesantes espeleotemas. Hay también mayor diversidad en el desarrollo de esta cueva, la más larga en el área de California's Mother Lode. Actualmente utilizada como cueva comercial, se han dado oportunidades a espeleólogos para hacer estudios biológicos, hidrológicos, así como para futuras exploraciones.

SUMMARY

Parts of this cave were explored by the early gold miners in the Gold Rush days in California. These sections were heavily vandalized, but recent explorations have covered over 1 km over pristine passages containing a variety of interesting speleothems. There is also much diversity in the passage development in this cave, the largest in California's Mother Lode area. Presently run as a commerical cave, opportunities have been made available for speleologists to make biological and hydrological studies, and as well as further explorations.

Cave City is located in a large limestone outcrop near McKinney Creek, almost in the center of Calaveras County, California. This is in the heart of the Mother Lode area, where gold was discovered in the foothills of the Sierra mountains in 1849. After the first big discovery of gold at Setter Creek, only 50 miles away, the gold rush was on. Numerous claims were established, and a mining settlement grew up not far from the cave. The wagon trail from Murphys to Moke Hill ant the famous Big Trees also passed close by. In October 1850, a miner named Captain Taylor and his friends were supposed to have been engaging in target practice in back of his cabin. When Taylor went to move the target back further for an additional challange, he stumbled upon a small entrance. After moving a few rocks, he and his friends crawled about thirty feet and found most of what was then called the «Great Cave», or «Mammoth Cave» of Cave City. As gold claims in the area were doing very well, the town grew quickly, until by 1853 Cave City boasted over 1000 settlers, a church, a public school and a cemetary.

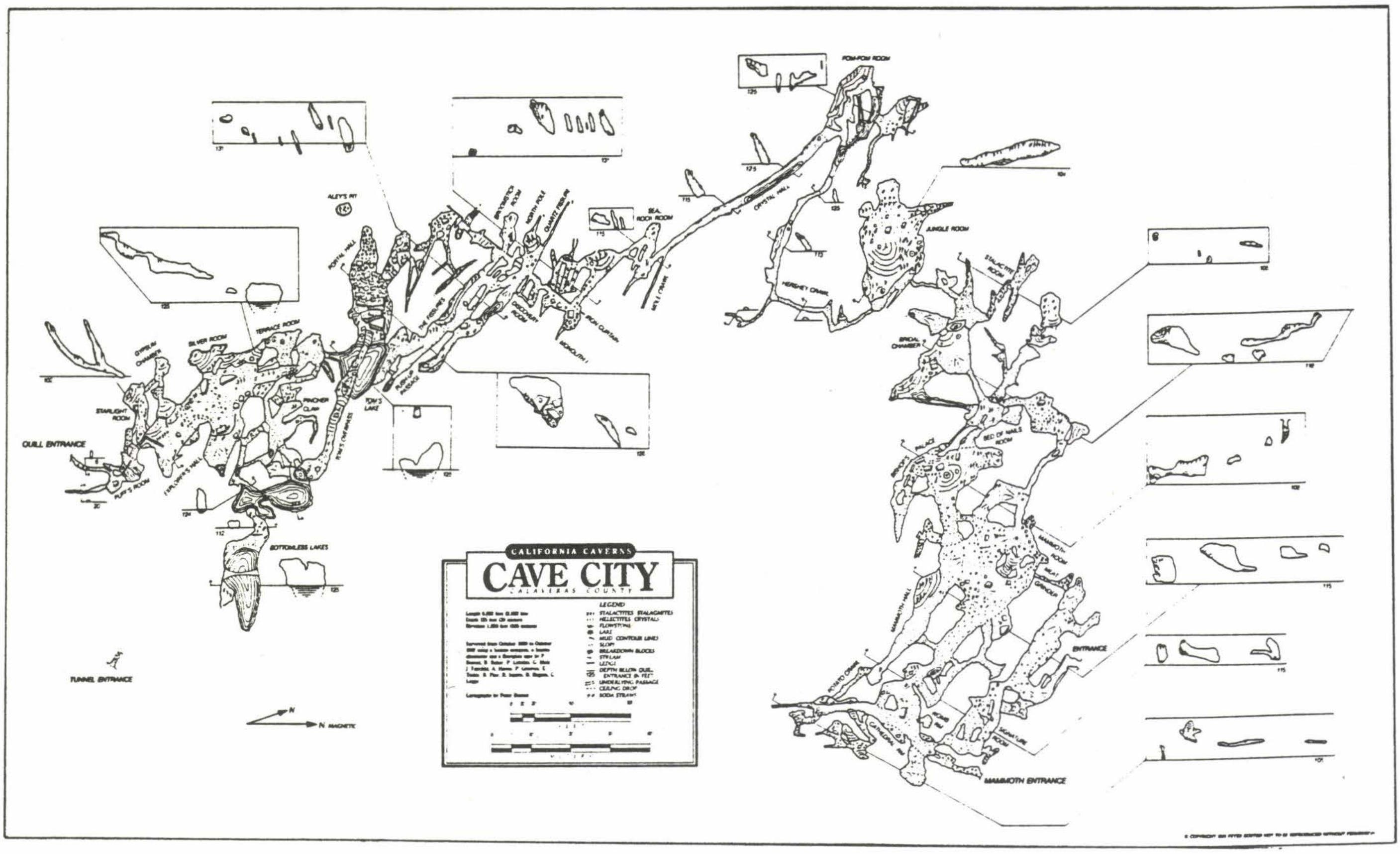
With the growth of the town, interest in the cave as a tourist attraction grew also, and in late 1853 W. McGee and H. P. Angell claimed the cave and erected a posh hotel near its entrance. They decided to commercialize the cave, the first such venture in the state. They excavated the entrance section to make it more easily passable, installed a door, and built wooden walkways in parts of the cave. Kerosene lamps were sometimes placed to help the tourists view the many wonders, with the visitors generally also carrying candles.

Most early descriptions glorify the abundance of formations, including columns stretching from floor to ceiling, delicate crystals, and large stalagtites that «rang like an organ». A great white cascade of flowstone was called The Cataract, and the Bishop's Palace was described as being resplendent with stalagtites. Lakes similar to the ones present today are also mentioned Although somemention is made of their levels varying daily with the tides, nothing is said of the yearly flooding that occurs now, after the Debris Dam was built in 1910 on McKinney Creek to prevent mining tailings from poluting downstream water supplies. Unfortunatly, it was the custom in those days to not only leave ones mark in the «Signaiture Room», near the entrance, but to also take out souvenirs of ones visit, often by the armload.

In the mean time, Cave City continued to flourish. The cave and hotel were boutht by a Mr. J. B. Smith in 1855. He continued to run tours and to build up the hotel as a center for gracious entertainment, including lavish balls and illegal gambling. The hotel burned down on April 30, 1858, only days before the major social event of the season, the May Ball. This was the heyday for Cave City. By 1860 the claims had begun to lose their luster, and were gradually abandoned. By the mid «60»s, the town had dwindled to a third of its former size, and by 1876 only the house of George and Johanna Nichols remained. They had taken over the cave guiding operation sometime in the interim. George («The Greek») was a colorful character, supossedly friendly and jovial, but also rumored to be a member of the notorius Murietta Gang, which terrorized the area. Cave City had always a reputation for violence, in contrast to nearby El Dorado (now Mountain Ranch). Many Chinamen and Mexicans lived there, and numerous are the accounts of attacks and murders in the newspapers of the day.

By the 1880's, activity in the area had definitly quieted down. No major extensions to the cave seem to have been found, but some archeological work was done at nearby Cave of the Catacombs, where hundreds of prehistoric skeletons were removed. After George's death in the mid 1880's, his wife continued to manage the operation. When she became too old, it was taken over by Byrnes. The Nichols house was torn down in 1933 to make way for a barn. Around this time there was a renewed interest in gold mining by people made desperate by the depression. Although the cave continued to be visited, vandalism had robbed it of its former glory

A new era was ushered in when Cave of the Quill's was discovered by Tom Aley and Ken Miller in 1962. Ken was a part-time caretaker for the property, and Tom also lived there at times. After digging open Quill Cave, they soon descended the twenty and sixty foot drops over glistening flowstone to find themselves in what is now called Explored's Hall. They explored the Bottomless Lakes, and crossed Tom's Lake to go as far the North Pole. The cave was, and still is, very delicate, with many fragile crystals and much boxworks growing on the walls. The ubiquitous mud made it difficult to preserve the purity of the many flowstone areas, so it was decided to gate the cave in 1963 to help protect it. To help prevent vandalism, Miller spread the word that sticks of dynamite were wired to the gate. This strategy was 100 % effective. Tom aslo made another significant discovery in October 1965: a very tight and awkward crawl near the Bridal Chamber led to a beautiful and untarnished room, the Jungle Room. Today this room is the main attraction of the «walk-through» tours. It's sad to think that the entire «historic» part of



the cave must have one looked like this! To protect his discovery, Tom blocked off the crawlway with mud, and only a very few people rediscovered it prior to the purchase or the cave property in 1979 by the Fairchild family.

The Fairchilds quickly rediscovered the Jungle Room and began leading «wild cave tours» asfar as that room in 1980. Also in 1980 they were able to dig throught a constriction near the Iron Curtain in Cave of the Quills and discovered the Middle Earth section. They were amazed at the quartz crystals growing on the walls, the beauty of the Seal Rock Room, and how wet and muddy the cave became when they pushed on towards the jungle Room. Feeling a good breeze, they made several trips to what is now called the Hershey Crawl and were finally able, on October 25, 1980, to get a very small caver throught to connect Cave of the Quills with the historic Mammoth Cave section. Subsequent blasting in several places has now made it possible to walk into the Jungle Room with street clothes on, and to negociate the Hershey Craul with relative ease. Bridges across the lakes and ladders in the Quill section make it possible to do a through trip with no special equipment other than a helmet, light, and coveralls.

Bob Baker, Paul Lukshin, and I (Peter) asked for permission to map the Quill part of the cave in 1980. Our progress was slow at first, but gradually we developed the techniques necessary for surveying in extremely muddy conditions, which occur in more than half of the cave due to the annual flooding. Bob and I went on almost all of the eighteen survey trips, with various friends helping out from time to time. It wasn't until late 1983 that we had mapped just about every known nook and cranny, including all of the Historic Section and several tight crawlways and passages that have seen very little other human traffic.

The cave is located near the southern end of a four mile long, half mile wide deposit of recrystalized limestone and dolomite that strikes at N45W and dips at about 65 degrees NE. The area near the cave is highly dissected, exposing barren cracks, crevices, and fragments of phreatic tubes, in places resembling kluftkarren. The marble is interbedded with metavolcanic and metasedimentary rocks of the Calaveras formation. The hanging wall portion of the lens contains coarse grained, withe to bluish grey limestone, while fine grained dolomitic limestone dominates the central and footwall portions. Dykes of schist up to several feet thick can be found throughout, as exemplified by the Iron Wall that cuts across the middle of the cave. Its name comes from its high iron content, which noticably distorts compass readings. Much of the passage development has been strongly joint controlled, as can been seen by examining the modern cave map, especically in the Middle Earth section. Several joint axes can be discerned in addition to the main one. Most of the cave has been formed by phreatic development on one horizontal level, making the large rooms found in the a good deal of the cave. Development continues today with the annual rising and falling of the lake levels, witch are approximatly the same from one end of the cave to the other. Even at low water, the Bottomless Lake is known to be over 100 feet deep, so that undoubtedly more passage remains to be found if the water table were ever to be lowered.

The sections of the cave that were not ruined by early explorers remain beautifully decorated today. In addition to large flowstone cascades, boxwork, crystals, and helectites are common throughout most of the Quill and Middle Earth sections. Extensive rows of stalagtites can be found in some areas, as well as pure white shields. With the luck, these features will be preserved for future generations to enjoy. We would like to thank the Fairchild family for of their gracious hospitality, and for all their friendly help on inumerable occassions.

The 1984 Chiquibul Expedition

RESUM

Aquest projecte va ésser concebut, originàriament, per la National Geographic Society per a investigar la formació del carst i l'arqueologia Maia establerta al seu interior, d'una extensa zona càrstica de les muntanyes de Belize. En el projecte es varen topografiar 23 Km. de galeries (de més de 110 m. d'amplària) inclosa la Belize Chamber, la més gran de l'hemisferi occidental.

Es van efectuar importants descobriments, alguns dels quals posaven en evidència el descens maia a pous de 150 m. També va ésser descoberta una nova espècie de cranc cec cavernícola, integrant d'una rica fauna cavernícola. El primer vertebrat fòssil citat de Belize fou trobat encaixat en una «colada».

S'analitzà la hidroquímica, el sòl i la roca d'una àrea que no havia estat encara estudiada.

A la superfície foren examinats i identificats embassaments i monticles d'origen maia, així com terrases agrícoles.

RESUMEN

Este proyecto fue consolidado originariamente por la National Geographic Society para investigar la formación del Karst y la arqueología Maya que se encontraba en su interior, de una extensa zona kárstica de las montañas de Belize. En el proyecto se topografió 23 km. de galerías (por encima de 110 m. de anchura) incluyendo la Belize Chamber, la mayor en el hemisferio occidental.

Se efectuaron importantes descubrimientos incluyendo la evidencia del descenso Maya en pozos de 150 m. Fue descubierta una nueva especie de cangrejo ciego cavernícola, parte de una rica fauna cavernícola. El primer vertebrado fósil citado de Belize fue encontrado encajado en una «colada».

Se analizaron la hidroquímica, el suelo y la roca de un área que permanecía sin estudiar.

Terrazas agrícolas, posibles embalses y montículos de origen Maya fueron citados en la superficie.

SUMMARY

This project was founded primarily by the National Geographic Society to investigate formation of, and Mayan archeology in, a extensive karst of the Belizean highlands. The project surveyed 23 kilometers of passage (up to 110 meters wide), including the Belize Chamber, largest in the western hemisphere.

Important archeological discoveries were made, including evidence of maya descent into 150 meter pits. A new species of blind cave crab was discovered, part a rich spelean biota. The first reported vertebrate fossil from Belize was found encased in flowstone.

Hydrochemistry, soil, and rock were analyzed from an area previously unstudied.

Agricultural terraces, possible dams, and mounds of Mayan origin were recorded on the surface.

The Chiquibul Cavern System lies in the Vaca Plateau of west- central Belize, Central America. Although extensively populated by the Maya until about 900 A.D., it has been essentially uninhabited since then except for sporadic logging and chicle gathering. Study of the caves began with the author's solo reconnaissance in 1982. A subsequent application for funding was acepted by the National Geographic Society in 1983, followed by smaller contributions from the National Speleological Society, the Explorers Club, and several scientific companies. Rope was donated by Pigeon Mountain Industries.

Sustained exploration and research began in March, 1984, with the location of suitable basecamp sites and the discovery of several major caves. In the following two months, 16 men and women explored, surveyed, and catalogued the geohydrology and archeology of the caverns.

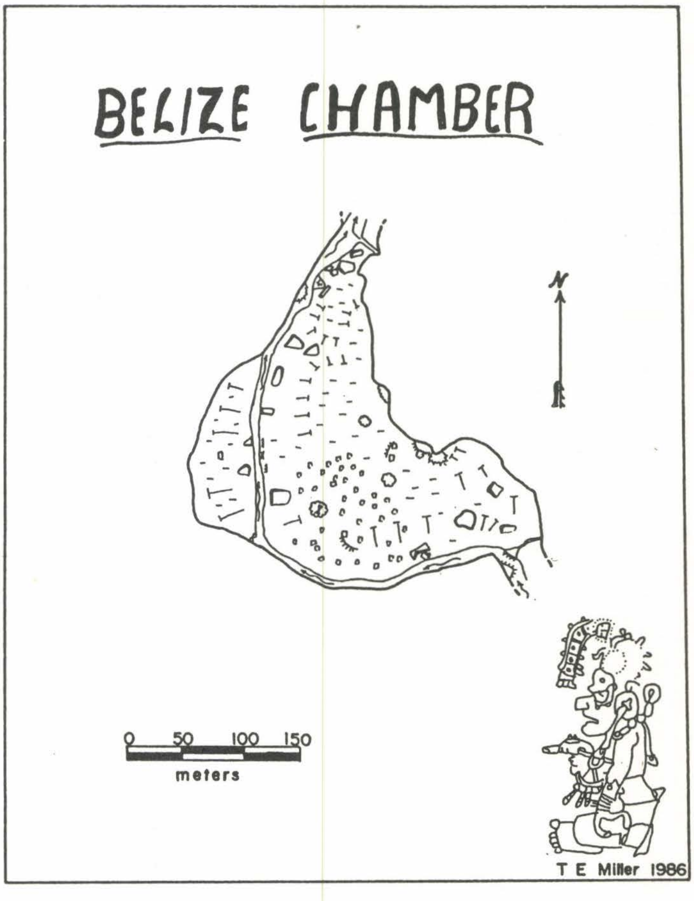
The Chiquibul is located in the rainshadow of the Maya Mountains with rainfall in the 150-200 cm/year range. It is covered weith rainforest typical of the seasonal wet-dry tropics.

Geology

The karst of the area is formed on Cretaceous carbonates bordering the Maya Mountains of Belize. These mountains are composed of higher-lying Paleozoic meta-sediments and Triassic intrusives. The Chiquibul River originates on these rocks and flows westward to sink into the carbonates. Three major types of karst have developed: a fluviokarst lies to the north in the Vaca Plateau, and a highly dissected «cockpit karst» to the south. Both are bordered on the east by karst topography extensively alluviated by clastics from the mountains.

The Caverns

By the end of May, 1984, 23 km of cavern passage had been surveyed. Widths occasionally exceeded 100 meters, with enormous rooms. The Belize Chamber (Figure 1) was found to be the largest room in the Western Hemisphere. The largest cave, Actun Tunkul, was mapped to over 11 km, longest in Central America. The Chiquibul Cave System to over 11 km, longest in



Central America. The Chiquibul Cave System occurs in two discrete sections (Figure 2). That closest to the presently active river ponor demontrates the tendency of the river to progressively change its sinkpoint with time in an upstream direction. This has resulted in a complex plan of vertical and lateral subsurface migration. The second section farther downstream has had primarily vertical development, with passage heights often exceeding 30 meters.

Although enormous surface shafts to 150 meters occur in bedded limestone of the area, nearly all the explored passage was in massively brecciated limestone.

Hydrology

The Chiquibul Cave System integrates water derived from the holokarst above the cave with invading allogenic runoff from the Maya Mountains. Both water types are strongly influenced by seasonal responses. Declining dry season base flow contrasts markedly with the high discharge floor pulses of the summer and fall wet season.

Cave waters of diffuse-flow origin were found to be saturated with respect to calcite and dolomite and had surprisingly high mean total hardnesses of nearly 300 mg/L (as $Ca\ Co_3$). A solute removal rate of 150 m^3/km^2/year was estimated. The high degree of saturation may be related to the enormous quantities of speleothems and travertine deposited in the caves. Stalagmites of 30 m height and columns of 20m width were frequently encountered, and the majority of the collapse breakdown in the caves was of old calcite precipitates.

Archeology

The majority of the Maya artifacts recvered from the caves aparently dete from the late Classic to Post-Classic (600-1000 A.D.).

Most of the large quantity of items were ceramics (including 1000's of sherds and occasional whole painted vessels), but lithics, shell, and human and animal bone was also recovered. Numerous walls, platforms, and terraces (33 in one chamber alone) were encountered. Although the Maya did not inhabit the caves, they routinely visited them to collect water for ceremonial purposes. One such vessel was found still Collecting dripwater. Nearly buried under a meter-high stalagmite that had grown on it. Evidence was also located of the descent of the Maya using ladders an ledges into the 150 meter-deep shaft of Nohoch Ch'en.

A tentative conclusion was that the cave artifacts suggested a negligible presence of the elite element of Maya society, and instead highlighted the importante of the caves in their folk religion.

No surface complexes are known in the immediate vicinity, but hundreds of agricultural terraces and several stone mounds ans platforms were discovered.

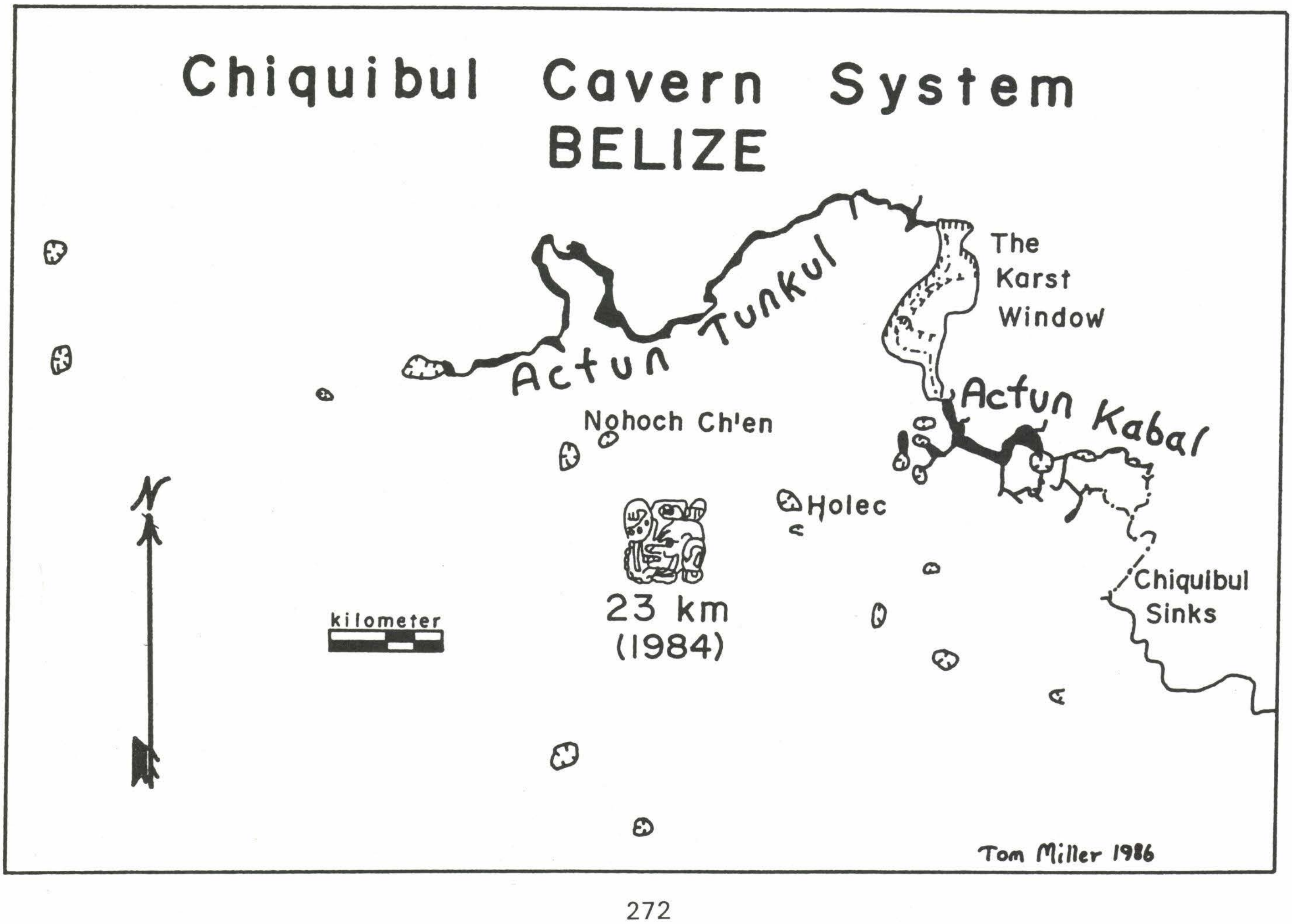
Miscellaneous Discoveries

Numerous troglobitic, eyelesscabs were found in the caves and were identified as a new species. A fossil mandible was found in flowstones and tentative analysis indicates a new species of deer.

Summary

The 1984 Chiquibul Expedition explored over 40 km^2 of rainforest once inhabited by the Maya, and surveyed 23 km of some the world's largest cave passage. Soil, water, and rock samples were analyzed from a previously unstudied area. It was the first expedition to study the Mayan archeology of an entire cave system.

With renewal of the National Geographic funding, a second expedition has returned to finish exploration of the cave system in 1986.



15234

Classification and characteristics of the caves in east China

Huang Yunlin, Lin Junshu, Zhang Yaoguang
Institute of Geography, Academia Sinica, Beijing, China.

RESUM

El paisatge càrstic de la Xina Oriental es caracteritza pels aspectes transicionals del «Fenglin» del sud de Xina fins als turons carstificats i valls seques del nord. L'àrea estudiada es troba localitzada entre els 25° y els 36° latitud nord. Les zones naturals han sofert diversos canvis, cap al nord o cap al sud, en vàries ocasions abans del Cenozoic. Les anàlisis de sediments ens indiquen que el paleoclima va sofrir freqüents fluctuacions. El desenvolupament càrstic va experimentar 6 marcades etapas.

Es possible de diferenciar tres regions càrstiques (incloent algunes subregions) a partir de la diferenciació de les zones paleogeogràfiques, el canvi de límit nord de «leterite» reticular i el límit sud de loess de les roques carbonatades de Xiasu i els moviments neotectònics.

RESUMEN

El paisaje kárstico en China Oriental se caracteriza por los aspectos transicionales de Fenglin en el Sur de China, hasta las colinas karstificadas y valles secos en el Norte. El área estudiada está localizada desde 25.° hasta 36.° N y las zonas naturales han cambiado hacia el Norte o hacia el Sur varias veces antes del Cenozoico. Los análisis de sedimentos sugieren que el paleoclima sufrió frecuentes fluctuaciones. El desarrollo kárstico experimentó 6 marcadas etapas.

Según la diferenciación de las zonas paleogeográficas, el cambio del límite Norte de leterite reticulado y el límite Sur del loess del Xiasu rocas carbonatadas y movimiento neotectónico, tres regiones kársticas incluyendo algunas subregiones pueden ser clasificadas.

SUMMARY

The karst landscape in East China is characterized by the transitional features of the Fenglin in the south China to the karstified hills and dry valleys in the north. The studied area is located in 25.° to 36.° N and natural zones have been shifted northward or southward several times sinces Cenozoic. The sedimental analyses suggest the palaeoclimate was fluctuated frequently. Karst development have experienced 6 strong stages.

According to the differentiation of paleogeographical zones, the shifting of the north boundary of reticulated leterite and the south border of Xiasu loess, carbonate rocks and neotectonic movement, three karst regions including several subregions can be classified.

Introduction

There are thousands of caves in East China where the carbonate rocks cover an area of over 243,000 km^2 (Fig. 1). The characteristics of the karst landforms and caves in East China is different from that of South China and that of North China. More and more attention has currently been given to the karst landforms and the speleothems of caves in East China. In the past few years, more than 20 famous and typical caves in this part of China have been investigated by the authors (Table 1). According to the study of these caves and of other caves in East China, the authors have given a classification of the caves in East China, related to the origin, morphology and volume respectively.

Physical geography

The studied area lies mainly in the central part of East China, i.e. E113°-121° long and N27-33° lat. This region is usually lower than 1500 m a.s.l. From south to north, the annual mean temperature goes down from 20° C to 12° C and the annual mean precipitation, from 1.700 mm to 700 mm. In the southern part of this region, the vegetation is tropical monsoon rainforest in local sites and subtropical evergreen trees in whole region, and the soil is lateritic soil or yellow soil. In the northern part, the vegetation is mixed forest and evergreen trees, and the soil is leaching brown earth. Topographically, it is usually a very broken region. There are lower mountains, hills, small basins, aluvial fans, plains and deltas in this region. Three large rivers, the Yangtze River and its tributaries, the Huaihe River and the Qiantangjiang River, and several small rivers flow through this region.

Geological fundament

In tectonics, the northern part of this region is of the North China Platform (craton) and the southern part, of the Yangtze Subplatform or the Huaxia Belt of Fold (Cathysia). As Fig. 1 has shown, carbonate rocks are scattered in East China. These carbonate rocks are of Precambrian (Sinian), Cambrian, Ordovician, Carboniferous period, Permian and earlytrias. In many

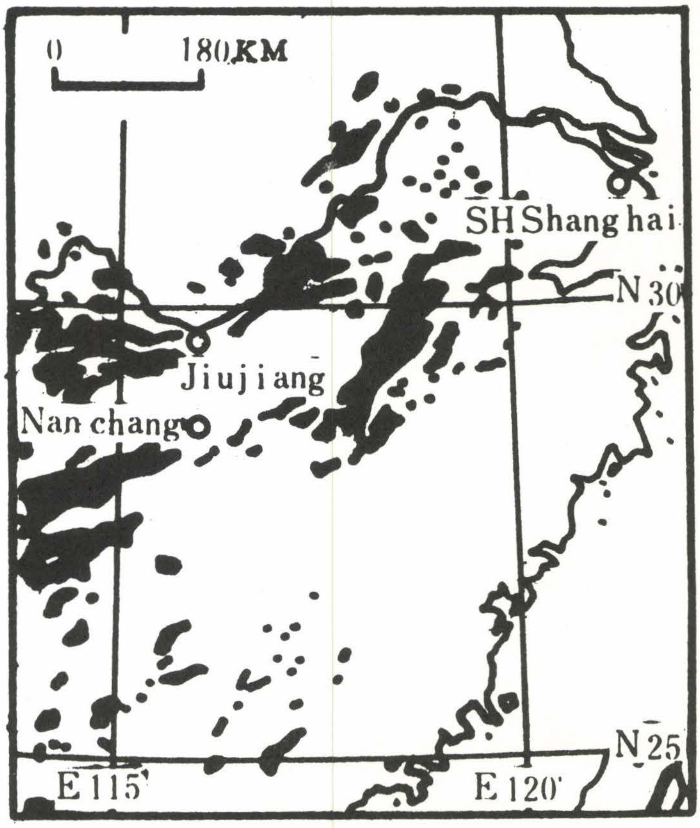


Fig. 1 Distribution of Carbonate Rocks in Central Part of East China

places, the carbonate rocks are not pure limestone. It is usually interbeded with non-carbonate rocks. This has made the caves in East China several special features. The neotectonic movements in East China are frequent, in some places. Faults, Folds and joints can frequently be seen in most places of East China. The structures play important roles in the development of caves in East China.

Classification and characteristics

We give three kinds of classification here for the caves in East China, according to their origin, morphology and volume respectively.

1. Cave classification with respect to its origin

This is shown in Table 1. A cave is usually composed of several different passages, some of which are formed by pure corrosion and others of which are formed by not only the corrosion but also the erosion or collapse. According to the intensity of corrosion, erosion and collapse of a cave and their proportion, five types of caves can be classified in East China. Pure corrosion caves are usually very small and have only one chamber. Pebbles are seldom found in such a cave. Some caves of this type are developed in layer of limestone. These caves are rich in various kinds of corrosional shapes on the walls and tops. The typical caves include Shanjuan Cave in the region near by Lake Taihu, Beishan Cave, Jinxian Cave in region of midstream of the Yangtze River, etc. Others are developed in layer of dolomite. These caves are lack of speleothems and corrosion shapes, except those potholes. The typical cave of this kind is Xianren Cave of Wannian County, eastern Jiangxi Province. The corrosion and erosion caves are commomly distributed in East China. Some passages of these caves are mainly formed by erosion, with erosional forms, rather than corrosional forms. Thick detrital deposits of pebbles, sands and clay can be found in some places in these caves. Also, in some caves, owing to the strong erosion, the detrital deposits collapsed and remain a thin coat with detrital cyclothems on the walls. On the cave bottom, small detrital cone can be found in some places. There are some notches on the walls. Some of them are formed by corrosion and others are formed by erosion. For example, there are 9 parallel notches (side-troughs) on the cave wall of Longquan Cave in southern Anhui Province, with about 30 metres high. It show 9 times of slow and intermittent uplifts in this region. The notches are also found in Nielong Cave of western Jiangxi Province and Linggu Cave of the region near by Lake Taihu. There are 4-5 parallel notches in these caves on the wall. The third type of the cave is corrosion and collapse cave. The typical cave of this type in East China is Hongyang Cave of Fenyi County, western Jiangxi Province. The length that can be enterd by us in this cave is about 220 meters. In the end of this cave, there is a karst pit, which is very narrow. Many stalactite-like rock pandents can be found on the wall. Near the end of this cave, Many fragment of limestone with corrosional scallops on the surface, are gradually collapsed from the top and develped on the bottom. A stonepillar in 10 meters diameter has been formed in the entrance of this cave. We can outline the development process of this cave as follows. First, strong corrosion of underground water; then, uplifted and became a dry cave; at last, fragments of limestone collapse gradually from the top in some places and speleothems are formed. The fourth type is erosion and corrosion caves. These caves are developed in the Cambrian striped thin argillaceous limestone interbeded with shale, such as the Longgong Cave of Pengze County, near by

Table 1 Some famous and typical caves in East China

Type	Name	Location	Length (m)
Pure corrosion a.limestone	Jinxian	Ruichang County, weatern Jiangxi	less than 40
	Beishan	id.	less than 50
	Kaihuashiba	Kaihua County, southern Zhejiang	less than 20
	Yongshan	Luping County, eastern Jiangxi	less than 60
	Shanjuan	Yixing County, southern Jiangsu	more than 180
b. dolomite	Xianren	Wannian County, eastern Jiangxi	more than 35
Corrosion and erosion	Nielong	Pingxiang City, weatern Jiangxi	more than 4000
	Longquan	Xuancheng County, southern Anhui	more than 2000
	Linggu	Yixing County, southern Jiangsu	more than 1200
Corrosion and collapse	Hongyang	Fenyi County, weatern Jiangxi	more than 220
Erosion and Corrosion	Longgong	Pengze County, northern Jiangxi	more than 2000
	Jiushan	Fengyang County, northern Anhui	more than 1000
Collapse and corrosion	Yaolin	Tonglu County, northern Zhejiang	965
	Hongyuan	Luping City, eastern Jiangxi	more than 150
	Changgong	Yixing County	more than 100

Table 2 Morphological classification of caves in East China

Type	Name of typical caves
1. Mono-storey	
A. vertical or high angle inclined	Shizi (Jihjiang City), etc.
B. horizontal or low-angle inclined	
a. single corridor	Kaihuashiba, Yongshan,
b. single chamber	Jinxian, Xianren
c. corridors and chambers (alternated)	Longgong, Jiuashan
d. branched	Linggu
2. Multi-storey	
A. deep pit connected	Bianyan (Tonglu County)
B. short pit or ponor connected	
C. short inclined passage connected	
a. corrosion	Shanjuan
b. collapse	Changgong
D. interstratified bed collapse	Yaolin

the middle-reach of Yangtze River and the Jiushan Cave of Fengyang County, northern Anhui Province. There are subsurface streams in these two caves. The Longgong Cave is more than 2 Km in length. There are several big chambers in these caves, but speleothems are not well-developed. Much more clay deposits with some layers of pebbles or sands and, in some places, the collapsed blocks of limestone can be found on the bottom. Except from some big potholes, other corrosional shapes are seldom found. The fifth type is collapse and corrosion caves. These caves are formed in horizontal or low-angle inclined limestone layer with competent faults and joints. For example, the Yaolin Cave of this type is formed under the control of the fault along the axis of a anticline. These caves are usually multi-storey caves. There is a subsurface stream in the lowest storey of the cave. Other storeies of the cave are dry passages. Because in these caves the interstratified bed is very thin and broken, large-extent collapse happened in the later stage of development process. In some places, interstratified bed between two storeies is completely collapsed. There are a lot of speleothems in these caves, which are very big and with much clay. In the first chamber of Yaolin Cave, the stone-pillar is 5 or 6 meter in diameter. The stalagmits in this cave are with valied beautiful shapes. The rimestone dams, curtains, cave flags, small cave pearls, cave shields, stalactites, and the potholes, flow marks, rock pandents can be found in some places of this cave. The cave-top troughs are well-developed in the third chamber of Yaolin Cave. Collapse sinks, Pits, collapse blocks of limestone and thick layer of detrital depostis suggest that it is a large-extent collapse cave. The Hongyuan Cave of Luping County, eastern Jiangxi Province is another large-extent collapse cave in East China. In many aspects, it is like Yaolin Cave. But, the rimestone in this cave is much bigger than that in Yaolin Cave. Each rimestone dam is about 50 cm. thick and with a deep hole. The largest hole as surrounded by rimestone dams is about 6 m. long, 2 m. wide and 1.5 m. deep. The Changgong Cave is also a large-extent collapse cave in East China. It has a karst window and a deep inclined well formed by collapse. These three caves are located in the eastern part of East China, with a same tectonic condition.

2. Cave classification with respect to its morphology

This is shown in Table 2. It is difficult to classify caves according to their morphology, because it is related to a three dimention space concept. For this reason, we first divided caves into two types: (1). Mono-storey caves; (2). Multi-storey caves. We subdivided the mono-storey caves into (1)A. Vertical or high-angle inclined caves; (1)B. low-angle inclined or horizontal caves. The latter is further subdivided into (1)Ba. Single corridor caves; (1)Bb. Single chamber caves; (1)Bc. chambers and corridors alternated caves (with few branches); (1)Bd. Branched caves. We divided the multi-storey caves into (2)A. Deep Karst pit connected caves; (2)B. Short pit or ponor connected caves; (2)C. Short inclined passage connected caves; (2)D. interstratified bed collapsed caves. Then, according to their plane morphology, we subdivided them into several subtypes. The pure corrosion caves are usually the single corridor, single chamber or short inclined corrosional passage connected caves. The corrosion and erosion caves are usually the chambers and corridors alternated caves or the pit or ponor connected caves. The Hong-yang Cave which is a corrosion and collapse cave is a multistorey cave connected by a deep karst pit with its underground stream (low storey). The erosion and corrosion caves, such as the Longgong Cave and jiushan Cave are chambers and corridors alternated cave, with a subsurface stream. The collapse and corrosion caves are the short pit or ponor connected, the short collapse passage connected, and the interstratified bed collapse caves. Besides, the Linggu Cave which is a corrosion and erosion cave near by the Lake Taihu is a branched cave.

3. Cave classification with respect to its volume

We give a relative classification of length, width and highness to the caves of East China here:

(1). Lenght

a. short cave, less than 100 meters;
b. middle-length cave, from 100 m tó 500 m;
c. long cave, from 500 m to 1500 m;
d. very long cave, more than 1500 m.

(2). Width

a. very narrow cave, less than 1.5 m;
b. narrow cave, from 1.5 m to 5 m;
c. middle-width cave, from 5 m to 20 m;
d. wide cave, from 20 m to 50 m;
e. very wide cave, more than 50 m.

(3). Highness

a. very low cave, less than 1.5 m;
b. low cave, from 1.5 m to 5 m;
c. middle-highness cave, from 5 m to 15 m;
d. high cave, from 15 m to 30 m;
e. very high cave, more than 30 m.

The Yaolin Cave, Longgong Cave, Nielong Cave and Longquan Cave are four largest caves in East China. For example, the area of Yaolin Cave is 27,890 m^2 and the volume of this cave its 426,680 m^3 (after Zhou Xuanshen, 1981).

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The classification and characteristics of the cave; in east China

Huang Yulin, Lin Junshu and Zhang Yaoguang
Institute of Geography, Academia Sinica

RESUM

D'acord amb el seu origen geomorfològic, la seva forma i els seus sediments, les cavitats de l'Est de Xina s'han classificat en cinc tipus diferents.

És evident que els diferents tipus de cavitats tenen les seves pròpies característiques geomorfològiques. Per exemple, la cova Longguan excavada en roca calcària pura del Triàsic inferior és molt rica en formes de dissolució i espeleotemes. A les seves parets s'han pogut establir fins 9 nivells diferents, a uns 30 m. d'altura, la qual cosa reflexa 9 episodis d'elevació neotectònica lenta a la regió. A Jiangxi Oest hi ha gran quantitat de cavitats amb formacions abundants. A la cova Hongyan s'ha format un pilar de 10 m. de diàmetre. Al NO de Jiangxi, Zhejiang Oest i Jiangshu Meridional, hi ha cavitats perfectament desenvolupades, algunes de les quals, com les coves Yaolin, Hongyuan i Zhanggona s'han engrandit a causa d'enfonsaments. Les formacions que podem trobar en aquestes coves són d'una mida considerable, de tipus diferents i amb molt de fang.

Hom també discuteix algunes possibles relacions entre les característiques de les coves i el relleu.

RESUMEN

De acuerdo con su origen geomorfológico, sus formas y sus sedimentos, las cavidades del Este de China se han clasificado en cinco tipos diferentes.

Es evidente que los diferentes tipos de cavidades tienen sus propias características geomorfológicas. Por ejemplo, la cueva Longguan, situada en calizas puras del Triásico inferior es rica en formas de disolución y espeleotemas. En ella se han descubierto 9 niveles en las paredes a unos 30 m. de altura, lo que refleja 9 episodios de elevación neotectónica lenta de la región. Existen gran cantidad de cavidades con abundantes formaciones en Jiangxi Oeste. En la cueva Hongyan se ha formado un pilar de 10 m. de diámetro. En el noreste de Jiangxi Zhejiang Oeste y Jiangshu Meridional, existen cavidades bien desarrolladas, algunas como las cuevas Yaolin, Hongyuan y Zhanggona, engrandecidas por los hundimientos. Las formaciones en dichas cuevas son grandes, de varios tipos y con mucho barro.

También se discuten algunas relaciones entre las características de las cuevas y el relieve.

SUMMARY

According to the geomorphological origin, forms and sediments of caves in East China, five types of caves have been classified.

It is obvious that the different patterns of caves have their own geomorphological characteristics. For example, the Longguan cave developed in the lower Triassic pure limestone is rich in solutional features and speleothems. Nine parallel sidetroughs on the walls about 30 m high have been discovered in the cave, that reflects 9 times slow and intermittent neotectonic uplifting in this region. There are lot of caves with aboundant speleothems in the West Jiangxi. A stone pillar 10 m in diameter has been formed in the Hongyan cave. In the northeastern Jiangxi, Western Zhejiang and Southern Ji Jiangshu Provinces, there are many well developed caves, some of which such as the Yaolin cave, Hongyuan cave and Zhanggone are further enlarged by the collapses. Speleothems in the caves are very large, various shapes and with much clay.

Some relations between the characteristics of caves and the landform have been discussed.

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Expéditions spéléologiques françaises en équateur

Eric de Valicourt

RESUM

Des del 1982 s'han realitzat quatre expedicions franceses (SSPPC- Pau HSN-Lyon) a aquest petit país de l'Amèrica del Sud. Aquestes expedicions han encetat un catàleg espeleològic de l'Equador –unes 300 cavitats– de les quals han esta explorades una quarentena, la qual cosa suposa uns 20 km. de topografies. Aquesta recerca ha posat en evidència l'existència d'una sèrie de carsts d'extensió reduïda a la Costa (Cova de Barberanos, 200 m.), de pseudocarsts, sovint de naturalesa volcànica, a la serra i a l'orient (a la vessant amazònica dels Andes), de carsts molt més estesos a la zona calcària cretàcica o juràssica. Al Nord, el carst d'Archidona, les coves més importants del qual són la cova de San Bernardo, 2.460 la d'Eturco-Uctu, 2.060 m., a la part central. La regió de Nera (captació del riu Puyo, 300 m.) i, finalment, al sud, la serralada de Cutucu amb la cova de Shimpiz, 2.223 m. A més, en aquest treball, hi consta també l'historial de totes les expedicions efectuades a aquest país i una relació de les cavitats més importants.

RESUMEN

Desde 1982 se han realizado cuatro expediciones francesas (SSPPC-Pau-HSN-Lyon) en este pequeño país de América del Sur. Estas expediciones han iniciado un catálogo espelelógico del Ecuador (unas 300 cavidades) de la que han sido exploradas una cuarentena, lo que supone unos 20 km. de topografías. Estas investigaciones nos muestran pequeños karsts en la Costa (Cueva de Barberanes, 200 m.), pseudo-karsts a menudo volcánicos en la Sierra y en el Oriente (en la vertiente amazónica de en los Andes), varios karsts mucho más extendidos en calizo cretácico o jurásico. Al Norte, el karst de Archidona cuyas cuevas más importantes son la Cueva de San Bernardo, 2.460 m. y Eturco-Uctu, 2.060 m., en el centro, la región de Mera (Captación del Rio-Puyo, 300 m.) y finalmente al Sur, la cordillera de Cutucu (Shimpiz, 2.223 m.). Además añadimos igualmente el historial de todas las expediciones en este país y la lista de las principales cavidades.

RESUME:

Depuis 1982, quatre expéditions françaises (SSPPO-Pau et HSN-Lyon) ont eu lieu dans ce petit pays d'Amérique du Sud. Ces expéditions ont commencé un inventaire spéléologique d l'Equateur (environ 300 cavités) et en ont exploré une quarantaine, représentant environ 20 kilomètres de topographies. Ces recherches font apparaitre de petits karsts sur la Costa (Cueva de Balears, 200 m.), de pseudo-Kants souvent volcaniques dans la Sierra et dans l'Orientée (versant amazonien des Andes) plusieurs Karsts beaucoup plus étendus dans un calcaire crétacé ou jurassique: Au Nord, le karst d'archidona dont les deux plus grandes cavités son la Cueva de San Bernardo, 2.460 m. et Eturco-Uctu, 2.060 m., au centre, la région de Mera (Captage du Rio Puyo, 300 m.) et enfin, au sud, la cordillère de Cutucu (Shimpiz, 2.223 m.). En outre, sont fournis également l'historique de toutes les expéditions dans ce pays et la liste des principales cavités.

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Las Grandes Cavidades de Cantabria

José León García
Plenario F. E. E.

RESUM

S'actualitzen fins 1-1-86 els recorreguts i les profunditats de coves i avencs d'entre els 2.000 i 3.000 m. o els –200 i –300 m., respectivament, i se situen referint el terme municipal, poble més proper, coordenades, etc., que són dades freqüentement publicades amb errors. Es dóna preferència al nom original de la cavitat, que no és sempre el mateix que el que hom utilitza dins el món espeleològic, mentre que els noms estrangers han estat substituïts per noms autòctons, d'acord amb el grup espeleològic que els va descobrir. S'afegeix sempre el nom dels grups que han treballat a cada cavitat.

Aquest és el resum d'un treball més ampli que en aquests moments està pràcticament enllestit i que inclou totes les cavitats càntabres que superen els 1.000 m. i els –100 m.

RESUMEN

Se actualizan hasta el 1.1.86 los recorridos y profundidades de las cuevas y simas entre los 2.000 y 3.000 m. o bien –200 y –300 m. respectivamente. Se sitúan dando el distrito municipal, pueblo, coordenadas, etc. de cada uno de los que frecuentemente se publicaron con errores. Se da preferencia al nombre original de la cavidad, que no es siempre el mismo que se usa en el mundo espeleológico, y los nombres extranjeros han sido substituidos normalmente por nombres del lugar con el acuerdo del grupo espeleológico que les dio el nombre. Se añade siempre el nombre de los grupos que han trabajado en cada cavidad.

Este es el resumen de un trabajo más amplio que ya está prácticamente acabado y que incluye todas las cavidades cántabras que superan los 1.000 y –100 m.

SUMMARY

As well as bringing up to date 1-I-86 the lengths and depths of the caves and pot-holes between 2.000 and 3.000 m. or –200 and –300 m. respectively, these follows the municipal district, village, co-ordinates, etc. of each one, which are details often published with mistakes. The original name of the cave, which is not always the same as the one used in the speleological world is preferred, and the foreign names have been substituted, normally by place-names, with the agreement of the caving group which named them. The caving groups which have worked in each cave are also included.

This is a summary of a large work, which is practically finished, including all the cantabrian caves bigger than 1.000 and –100 m.

Colaboradores

La realización de un trabajo como éste no hubiera sido posible sin la colaboración entusiasta de un cierto número de personas que, a riesgo de alguna omisión, tengo el deber de citar. Mi agradecimiento especial a Luis A. JORDE por su apoyo material y moral. Vaya mi agradecimiento igualmente para A. ALGUERO (ECTor), J.B. ANDRES (SESCEV), L. AZCONA, E.BAJET (ASCh), P.R. BILBAO (GESCAT), R. BOHIGAS (SAEC), A. BONACHERA, B. BOUCHARD (SCCh), E. BOYER (SCMJC), T. CANALES, J. COLINA (SCC), D. DIEZ (GAES), J. M.ª ESCACHX (ENEOJE), R. FERNANDEZ (GELL), V. FERNANDEZ (SESS), P. GALAY (SEV),

M.ª A. GARCIA, P. GUENEAU (ARES), N. HERRERO (SEII), P. IBERSON (AUSS), R. ITURRALDE, J. LAVIN, L. LLATA (SEL), J.L. MEMBRADO (ECG), J.T. MOLINERO (GELL), A.L. MOYANO (UEV), J.M. DEL MORAL (AER), Ph. MORVERAND (SGCAF), R. ORTIZ, J.M.ª PICO, A. PINTO (GEPUSCIATICA), C. PUCH (STD), P. SMITH (MUSS) y E. TORRES (SCC).

Entidades Espeleológicas Aludidas

AAEET Grupo A.A.E.E.T. (Valls, Tarragona).
ACEM Agrupación Cient. Excurs. Mataró (Mataró, Barcelona).
AER Asociación Espeleológica Ramaliega (Ramales, Cantabria).
AM Alpina de Millau (France).
ARES Ass. Rech. et d'Expl. Sout. (Dijon, France).
ASCh Ass. Spel. Charentaise (France).
BB Bielsko-Biala (Polska).
BT Bath Troglodytes (United Kingdom).
CAF Club Alpin Français.
CAS Club Actividades Subterráneas (Bilbao).
CASAPM Com. Act. Subt. de Asoc. Polaca de Mont. (Warszawa, Polska).
CASTAR C.A.S.T.A.R. (Lille, France).
*CEA*Centro Espeleológico de Aragón (Zaragoza).
CEG C. E. de Grácia (Barcelona).
CNEOJE Camp. Nac. Esp. Org. Juv. Española (Ramales, Cantabria).
DS Dijon-Spéléo (Dijon, France).
ECG Espeleo Club de Grácia (Barcelona).
ECS Espeleo Club de Sabadell (Barcelona).
ECSalou Espeleo club de Salou (Tarragona).
ECT Espeleo Club de Tarragona (Salou, Tarragona).
ECTor Espeleo Club de Tortosa (Tortosa, Tarragona).
ECV Espeleo Club de Varsovia (Polska).
ENEOJE Esc. Nac. Espeleología, Org. Juv. Española (Barcelona).
EREAEC Agrup. Excurs. de Catalunya (Barcelona).
ERECEC Equip Rec. Esp. del Centre Exc. Catalunya (Barcelona).
FJS Frente de Juventudes de Santander.
GAES Grupo de Actividades Espeleológicas (Bilbao).
GEC Grupo Espeleología Comando (Valencia).
GECant Grupo de Espeleología Cántabro (Santander).
GEE Grupo Espeleológico Esparta (Baracaldo, Vizcaya).
GELL Grupo Espeleología La Lastrilla (Castro Urdiales, Cantabria).
GEM Grupo Espeleología Montañés (Santander).
GEPUSCIATICA Grupo Esp. Perduraremos Un Siglo... (Santander).
GEQ Grupo Espeleología Querneto (Madrid).
GESCAT Gr. Esp. Santander del Club Alpino Tajahierro (Santander).
GESCECart Centro Excursionista de Cartagena (Murcia).
GESCMB Gr. Expl. Subt. del Club Montañés Barcelonés (Barcelona).
GESL Grupo Espeleología Santa Lucía (Santander).
GET Grupo Espeleológico Torca (Laredo, Cantabria).
GEV Grupo Espeleológico Vizcaíno (Bilbao).
GEVS Grupo Esp. Vallisoletano Spelaeus (Valladolid).
GFB Guardia de Franco de Bilbao.
GGG Grupo Geográfico de Gràcia (Barcelona).
GIE Grupo Investigaciones Espeleológicas (Barcelona).
GIM Grupo Ilicitano de Montaña (Elche, Alicante).
GJE Grupo Juvenil de Espeleología (Santander).
GL Grupo de Límpias (Límpias, Cantabria).
GPCS Grupo Proyección Cultural de Santander.,
GSL Groupe Spéléo Lombrics (Loos, France).
LUSS Lancaster Univ. Spel. Soc. (Lancaster, United Kingdom).
MJCM M. J. C. Montbard (France).
MUSS Manchester Univ. Spel. Soc. (Manchester, United Kingdom).
NPC Northern Pennine Club (Lancaster, United Kingdom).
OUCC Oxford Univ. Cave Club (United Kingdom).
SAEC Soc. Activ. Espeleológicas de Cantabria (Santander).
SAGA Spel. Arbeits Gr. Aachen (R.F. Alemana).
SCAV Speleo Club Alpino Valenciano (Valencia).
SCC Speleo Club Cántabro (Santander).
SCCh Spéléo-Club de Chablis (France).
SCD Spéléo-Club de Dijon (France).
SCMJC Spéléo-Club Maison Jeunes Culture (Rodez, France).
SCP Spéléo-Club de Paris (France).
SCS Spéléo-Club de la Seine (France).
SECEM Sec. Esp. del Centre Exc. Montserrat (Manresa, Barcelona).
SECS Soc. Esp. Cabezón de la Sal (Cantabria).
SEG Sec. d'Espeleologia Gelera (Barcelona).
SEII Sección Esp. Ingenieros Industriales (Madrid).
SEL Soc. Espeleología Lenar (Santander).
SESCEV Sec. Expl. Subt. del Centro Exc. de Valencia.
SESP S.E.S. Puigmal (Barcelona).
SESS Sección Esp. Seminario Sautuola (Santander).
SGCAF Spéléologues Grenoblois du Club Alpin Français (Grenoble, France).
SIRE Unión Excursionista de Cataluña (Barcelona).
SIS Sec. d'Invest. Subt. del Centre Exc. Terrassa (Barcelona).
SKM Speleoklub Morsky PTTK (Gdynia, Polska).
SMCC Shepton Mallet Caving Club (United Kingdom).
SEV Societat Espeleológica de Valencia (Valencia).
SSB Soc. Spél. de Bourgogne (Dijon, France).
STCEV Secció Talps Centre Exc. del Vallés (Sabadell, Barcelona).
UEV Unión Espeleológica Vallesoletana (Valladolid)
STD Grupo Espeleología Standard (Madrid).
ULSA Univ. of Lees S.A. (United Kingdom).
UP Univ. de Paris (France).
WCC Wessex Cave Club (United Kingdom).

Interpretación y consideraciones

Comienza cada ficha con un número que determina su posición en orden al desarrollo o desnivel de la cavidad cuyo valor se sitúa al lado.

Normalmente, el nombre va precedido de la abreviatura C., S. o T. para definir cueva, sima o torca. En primer lugar figura el «nombre principal», en cuya elección ha prevalecido siempre el asignado por los lugareños, si existe y hemos llegado a él. El sinónimo (sin.) más usado, cuando le hay, se da a continuación.

Al lugar (l.) de ubicación, le sigue la Entidad Colectiva (ec.) o Singular (es.) de Población a que pertenece oficial o tradicionalmente el terreno en que está enclavada la cavidad, con indicación de la categoría (aldea, caserío, lugar, barrio, concejo, mancomunidad, villa, etc.). Luego figura el término municipal (t.m.) en que se encuadra la entidad.

Las entidades espeleológicas (ee.) que han participado en la exploración o estudio de la cavidad figuran en orden cronológico, sin distinción alguna de la importancia de su aportación. Los guiones indican expediciones conjuntas. Se han omitido intencionadamente las actuaciones personales, que tanto han significado, de C. Mugnier, J.-P. Combredet, etc.

Por último, se da la situación, en coordenadas (coord.), de la mayor parte de las cavidades. El meridiano de referencia puede ser el de Madrid (M) o el de Greenwich (G), cuando no se hayan empleado UTM o Lambert (L).

Por razones obvias, no es posible citar la documentación consultada, su extensión supondría un trabajo más amplio quizá, que el presente. Quiero señalar que se intentó llegar a toda la información, publicada o no, sobre cavidades cántabras, y prácticamente se consiguió. Esto no excluye que pueda existir algún error u omisión que, si es comunicado, se tendría encuentra para futuras actualizaciones.

Cavidades no inventariadas

Se relacionan aquí una serie de cavidades cuya incorporación a este trabajo no ha sido posible por falta de garantías respecto a sus medidas o ante el riesgo de duplicar una misma cavidad.

Estas son: *S. Alpina* (–100, Arredondo/Soba), *C. del Aspio* (> 1.000, Ruesga), *S. de la Bartola* (> 1.000, Reocin), *C. de las Brujas* (1.500, Henerías), *Pozo del Castillo* (–293, Cillorigo-Castro), *Pozo del Compromiso* (–180, Cillorigo-Castro), *S. del Cordón de las Sierras* (–200, Soba), *Sima E.C.G. n.º 2* (–102, Arredondo), *S.G.C. 11* (–105, Soba), *Pozo del Hasta Luego* (–166, Cillorigo-Castro), *S. del Hornijal de la Mosqueta* (–150, Soba), *S. Jean-Pierre* (–100, Arredondo/Soba), *S. de las Losas* (> –100, Soba), *C. de la Mora* (1075, Cillorigo-Castro), *C. de Peines II* (> 1.000, Castro Urdiales), *S. Portillo el Hornijo* (–130, Soba), *C. de El Salín* (> 1.000, Val de San Vicente), *C. Surgencia 1* (1.200, Liendo), *S. del Torno* (–150, Soba).

Las grandes cavidades de Cantabria
Desarrollos (Rango: 2.000 a 3.000 m, -200 a -300 m.)

36 *2.852 m. LA CUEVONA,* l. Vinueva, es. lugar de Quijas, t.m. *Reocín,* ee. SESS, coord. (UTM) X409050 Y4800450 Z70 m.

37 *2.750 m. S. DE LA CALACA,* sin. LLC 2, l. Llana La Cueva, es. lugar de Aja, t.m. *Soba, ee. SEII.*

38 2.526 m. S. DEL HOYON, *sin. VT-4, l. El Hoyón (Alisas), ec. Bustablado, t.m.* Arredondo, *ee. ECTor-AAEET, coord. (UTM) X447555 Y4793330 Z571 m.*

39 2.500 m. C. DEL COVERON, *sin. n.º 2, l. Hoyo del Mortiro, es. lugar de Riba, t.m.* Ruesga, *ee. SESS, MUSS, coord. (UTM) X454310 Y4793780 Z300 m.*

40 2.300 m. S. DEL ROZACARIN, *sin. S. Hoyuhigal, l. prau de Rozacarin, t.m.* Rionansa, *ee. SCC, coord. (UTM) X384790 Y4792568 Z196 m.*

41 2.157 m. C. DEL POZO DEL INFIERNO, *sin. PÑ-11-206, l. Coto del Infierno, t.m.* Peñarrubia, *ee. STCEV, ECS, coord.(M) X0º56'44"O Y43º16'32" Z310 m.*

42 2.050 m. LAS FUENTES DEL GANDARA, *l. nacimiento del río Gándara, es. lugar de Lavín, t.m.* Soba, *ee. SCD, SCP, coord. (UTM) X452850 Y4782700 Z600 m.*

43 2.027 m. C. DE LACUERRE, *l. LaCuerre, t.m.* Rionansa, *ee. SCC, coord. (UTM) 4 bocas X385250 Y4795009 Z468, X385258 Y4794967 Z465, X385176 Y4794981 Z470, X484998 Y4794985 Z474 m.*

44 2.014 m. C. DE CUDON, *es. lugar de Cudón, t.m.* Miengo, *ee. SESS, coord. (UTM) X418190 Y4807705 Z38 m.*

Desniveles

34 *–297 m. RED T. DEL COTERON-C. CUBIO DE REÑADA-T. DE AZPILICUETA.* Ver *desarrollos (n.º 4).*

35 –293 m. S. DE LA CUEVONA, *sin. La Arenosa, l. Prao Janroi, t.m.* San Felices de Buelna, *ee. GJE, SESS, NPC, ECT, ECG, coord. (UTM) X413450 Y4793800 Z475 m.*

36 –280 m. S. DEL BLOQUE, *sin. LL5, l. La Llusa, es. lugar de Aja, t.m.* Soba, *ee. SSB, SEII.*

37 –277 m. S. GARMA CIEGA 19, *sin. GC 19, l. lapiaz de Garma Ciega, es. lugar Astrana/Aja, t.m.* Soba, *ee. SSB (?), SEII.*

38 276 *(–216, + 60)* m., C. DE LA CANAL DEL EMBUDO, *sin. Gully Cave, l. collado de Liordes, es. lugar de Espinama, t.m.* Camaleño, *ee. WCC, coord. (M) X1º 08' 20"0 Y43º 09' 04" Z1640 m.*

39 –275 m., COMPLEJO JAPEROSA-PEGOYUS, *sin. GC 10-12-17-23-24-26-28-30, l. lapiaz de Garma Ciega, es. Astrana/Aja, t.m.* Soba, *ee. SSB (?) SEII.*

40 –268 m., T. LARGA, *sin. C-17 y C-18, l. Cantos de la Liebre, es. Aldea de Calseca, t.m.* Ruesga, *ee. SESCEV, SCAV, coord. (M) X0º 01' 46"E Y43º 14' 50" Z1150 m.*

41 –266 m., S. GRANDE DE LA PORRA, *l. ladera norte Alto de la Porra, ec. Bustablado, t.m.* Arredondo, *ee. SCD, coord. (UTM) X446775 Y4788950 Z1074 m.*

42 260 *(–130, + 130) m., C. FRESCA.* Ver *desarrollos* (n.º 9).

43 *–260 m., S. DEL POZO NEGRO,* sin. CA 2, l. Peña Lavalle, es. lugar de Arredondo, t.m. *Arredondo,* ee. SGCAF, coord. (UTM) X448740 Y4789850 Z815 m.

44 *257* (–185, + 72) m., SUMIDERO DE MONTICUEVA. *Ver* desarrollos *(n.º 17).*

45 –254 m. T. DE LOS HAYEDOS, *sin LR-100 l. La Rasa, es. lugar de Astrana/Aja, t.m.* Soba, *ee. SEII.*

46 –254 m., S. LEVANTADA, *l. monte Mullir, t.m.* Voto, *ee. GET, SEL, coord. (UTM) X455260 Y4795990 Z718 m.*

47 –248 m., S. DEL PAPO, *l. La Muela, ec. Bustablado, t.m.* Arredondo, *ee. SCD, coord. (M) X0º 01' 10"E Y43º 15' 16" Z890 m.*

48 –247 m., SISTEMA BUHO-SUMIDERO. *Ver* desarrollos *(n.º 25).*

49 244 *(–84, + 160)* m., C. DE LA CAÑUELA. *Ver* desarrollos *(n.º 11).*

50 –243 m., S. DEL COTO, *sin. sima 277, es. aldea de Calseca, t.m.* Ruesga, *ee. SCD, coord. (M) X0º 00'17" E Y 43º 15' 20" Z860 m.*

51 –240 m., S. CANAL DE LAYA 47, *sin. CL-47, l Canal de Laya, ec. Bustablado, t.m.* Arredondo, *ee. ECG, coord. (UTM) X444295 Y4790800 Z835 m.*

52 –240 m., SIMA 320, *l. Cantispuela, es. lugar de San Pedro, t.m.* Soba, *ee. SSB.*

53 –235 m., T. DEL CAÑON, *l. Cantispuela, es. lugar de San Pedro, t.m.* Soba, *ee. SSB, coord. (M) X0º 06'30" E Y43º 14' 55" Z1144 m.*

54 –230 m., C. LA MARNIOSA. *Ver* desarrollos *(n.º 34).*

55 –228 m., S. TONIO, *sin. CA 31, l. Buzulucueva, es. lugar de Aredondo, t.m.* Arredondo, *eec. SGCAF, coord. (UTM) X449220 Y4790605 Z725 m.*

56 –225 m., SISTEMA AGUA SOPLADORES *ver* desarrollos *(n.º 14).*

57 –224 m., S. DE LA TORMENTA, *sin. CA 28, 1. Peña Lavalle, es. aldea de Asón, t.m.* Arredondo, *ee. SGCAF, coord. (UTM) X448700 Y4789860 Z814 m.*

58 –217 m., POZO CUADRANGULAR, *sin. Pozo Castin, l. Peña Lavalle, es. Val de Asón, t.m.* Arredondo, *ee. SCD, SEG-ERE-SIS-ECG, SGCAF, coord. (UTM) X449150 Y4789220 Z1020 m.*

59 –215 m., T. REGATO CALERO I, *sin. RN-37, 1. Regato Calero, es. lugar de Ojébar, t.m.* Rasines, *ee. GAES, coord. (UTM) X468290 Y4792477 Z465 m.*

60 –210 m., S. DE LA LLUSA, *sin. LL. 1, l. La Llusa, es. lugar de Aja, t.m.* Soba, *ee. SSB, ARES, SEII, coord. (M) X0º 07' 02"E Y43º 14' 08" Z1200 m.*

61 –209 m., T. DE LA YUSA, *sin. n.º 135, l. Cabañas del Mortero, es. aldea de Calseca, t.m.* Ruesga, *ee. GESCMB, SES-CEV, coord. (M) X0º 01' 18"E Y43º 15' 00" Z910 m.*

62 –208 m., SIMAS DE LLANA LA CUEVA 5-9-10-11, *sin. LL C 5-9-10-11, l. Llana la Cueva, es. lugar de Aja, t.m.* Soba, *ee. SEII.*

63 –203 m., S. BUSTABLADO 21, *sin. BU-21, l. Haza de Bernallán, ec. Bustablado. t.m.* Arredondo, *ee. ECG, SCD, coord. (UTM) X445115 Y4790145 Z935 m.*

64 –200 m., SIMA JO.38 *l. Jou Oscuro, es. lugar de Espinama, t.m.* Camaleño, *ee. ASCh.*

65 –200 m., S. PICON DEL FRAILE 3, *sin. PF 3, l. Picón del Fraile, ec. mancomunidad Cañedo-Valcaba, t.m.* Soba, *ee. GSL-SCP.*

Ecología
Defensa del Valle Kárstico del Arlanza

por Juan Antonio Bonilla Serrano

RESUM

Per mitjà de l'exposició dels diversos aspectes geogràfics, geològics, hidrològics, hidrogeològics, morfològics, tectònics, climàtics, edafològics, etològics, arqueològics, florístics, faunístics i paisatgístics que incideixen en l'existència del Valle del Arlanza (Burgos, comunitat autònoma de Castella-Lleó) volem fer veure la inconveniència de construir un embassament que ho anegaria tot, destruiria indrets d'interès arqueològic i monumental, alteraria el microclima zonal, anihilaria una fauna en gran part protegida, alteraria la xarxa subterrània i destruiria també, parcialment, un dels més grans savinars del món. Es recomana, doncs, la protecció i conservació d'aquest paratge, declarant-lo Parc Natural Nacional.

RESUMEN

Se trata, mediante la exposición de los variados aspectos geográficos, geológicos, hidrológicos, hidrogeológicos, morfológicos, tectónicos, climáticos, edafológicos, etológicos, arqueológicos, florísticos, faunísticos y paisajísticos que existen e inciden en la existencia del Valle del Arlanza (Burgos. Comunidad Autónoma de Castilla-León. España) la inconveniencia de construir un embalse que lo anegaría, destruyendo sitios de interés arqueológico y monumental, así como la alteración del microclima zonal, aniquilación de una fauna mayoritariamente protegida, alteración de la red subálvea, así como también la destrucción parcial de uno de los mayores sabinares del mundo recomendando la protección y conservación del lugar bajo la declaración de Parque Natural Nacional.

SUMMARY

We are going to show the inconvenience of building a dam on the river Arlanza by means of revealing the different geographical, geological, hydrological, hydrogeological, morphological, tectonical, climatic, edaphological, ethological, archaeological aspects and also taking into account the flora, the fauna and landscape that exist and affect the natural life of the River Arlanza Valley (Burgos, Autonomous Region of Castile and Leon, Spain).

This dam would flood a part of the Valley, ruinning some places of great archaeological and monumental value, as well as altering the zonal microclimate, distroying a mostly protected fauna, changing the underground network of the riverbed and also leading to the partial destruction of one of the biggest sabine growing areas in the world,

In consequence of that it is highly recommended to protect and to preserve this zone, proclaiming it «National Wildlife Refuge».

Preámbulo

Es en el día 26 de Julio de 1929 donde y en el archivo de la extinguida Comisión para el estudio de Obras Públicas aparece un informe sobre la impermeabilidad del vaso donde se pensaba localizar el embalse y que no era otro que el Valle del Arlanza. En Noviembre de 1934 se realizaron 150 ml. de taladros que dieron como resultado el conocer un accidente tectónico en las inmediaciones del Monasterio de San Pedro de Arlanza y que en el supuesto del llenado del vaso una amplia zona de rocas muy fisuradas quedarían anegadas. En el año 1935 se aprobaron los presupuestos para la realización de 525 ml. de taladros y que no se pudieron llevar a efecto en su totalidad debido a la contienda civil del 36-39. Es en 1943 donde se retoman iniciativas preparando un trabajo sobre la viabilidad del proyecto fijándose la situación de la presa a la altura del hito km. 18 de la carretera de Salas de los Infantes a Palencia C-110 y con una altura de muro de 45 mts. En Noviembre de 1965 se inician los trabajos de removición de tierras donde apoyar el blondín. El 10 de Junio de 1966 en un informe se dice «... es imposible establecer en este terreno la presa de gravedad proyectada...». En agosto de 1967 se presenta un nuevo proyecto y así hasta el momento presente en que merced a los movimientos de ecologistas, ecólogos, Colegios de profesionales, Ministerio de Cultura y otros se ha logrado parar la catástrofe que iba a suponer la construcción del embalse y que afectaría a la flora y fauna, a restos arqueológicos importantes, al microclima y a aspectos económicos difíciles de evaluar y cuantificar.

Situación geográfica

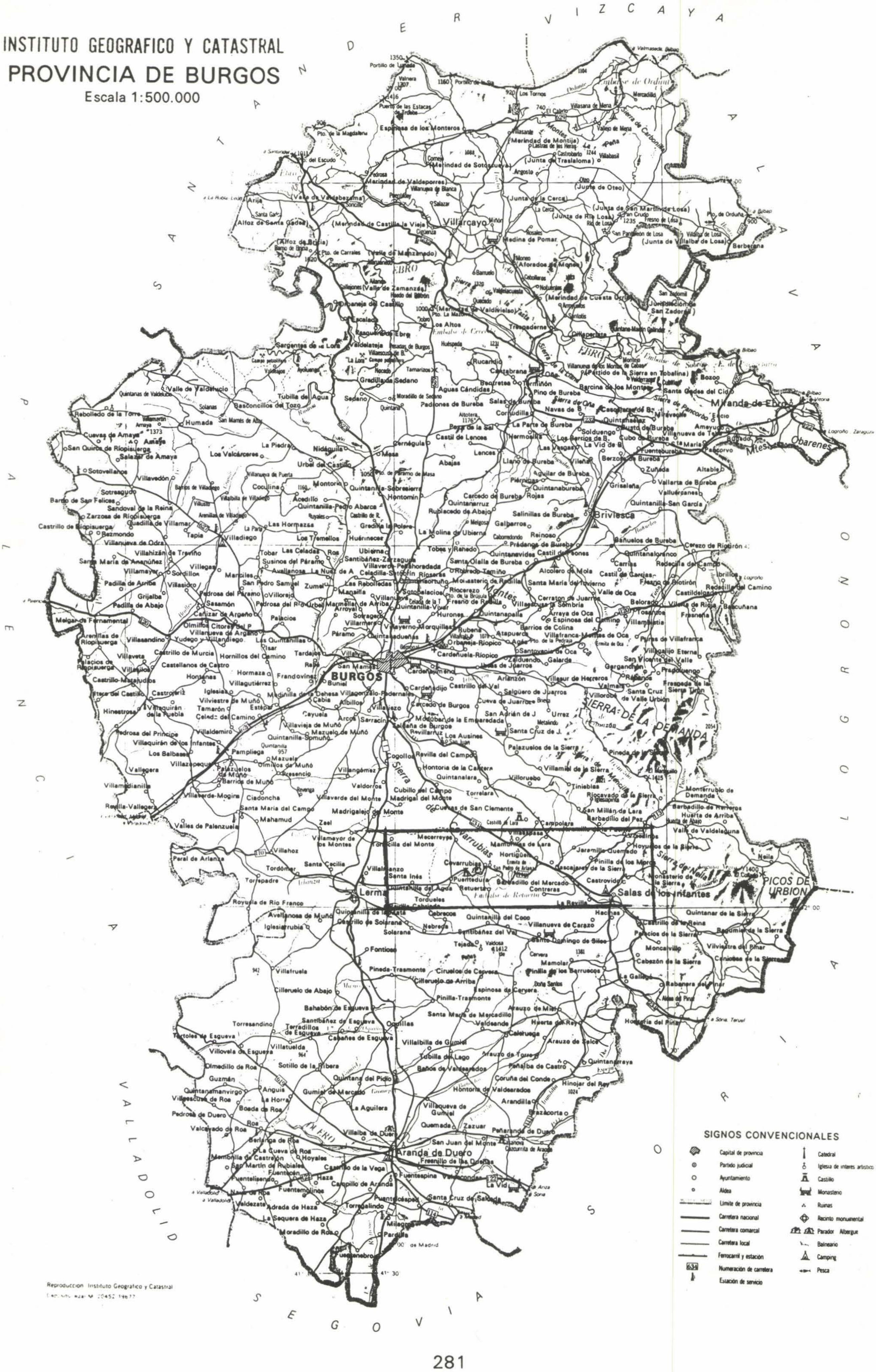
El Valle del Arlanza, se halla situado en la Provincia de Burgos (España) perteneciente a la Comunidad Autónoma de Castilla-León, al SE de la capital y entre los 0º-7º de longitud E y los 42º-06 y los 41º-59 de latitud N.

Se halla recorrido en toda su longitud y le presta el nombre a su vez, por el río Arlanza de 150 kms. de recorrido y que naciendo en la sierra de Neila –Sistema Ibérico desemboca en el Arlazón para a su vez hacerlo en el Pisuerga y finalmente en el Duero. El Valle del Arlanza tiene 26 kms. de desarrollo y prácticamente en toda su geografía está atravesado por la carretera comarcal C-110 de Salas de los Infantes a Palencia.

La Provincia de Burgos, que se halla dividida en dos grandes áreas, la Altiplanicie y los Páramos, es en aquélla, el altiplano, a donde pertenece la zona que nos ocupa, tierras de transición entre el Sistema Ibérico y la gran cuenca sedimentaria del río Duero. La altura máxima se sitúa en el alto de San Carlos (Peña Carazo) con 1.465 mts. y las mínimas en Hortiguela con 914 mts. en la cabecera del Valle y Retuerta con 900 mts. que era el lugar elegido para situar la presa.

Las tierras del Valle, pertenecen a los municipios de Cascajares, Hortiguela, Contreras, Monasterio de San Pedro, Retuerta y Covarrubias. Los municipios que quedarían anegados serían los de Cascajares, Hortiguela y Retuerta.

INSTITUTO GEOGRAFICO Y CATASTRAL
PROVINCIA DE BURGOS
Escala 1:500.000



Reproducción Instituto Geográfico y Catastral
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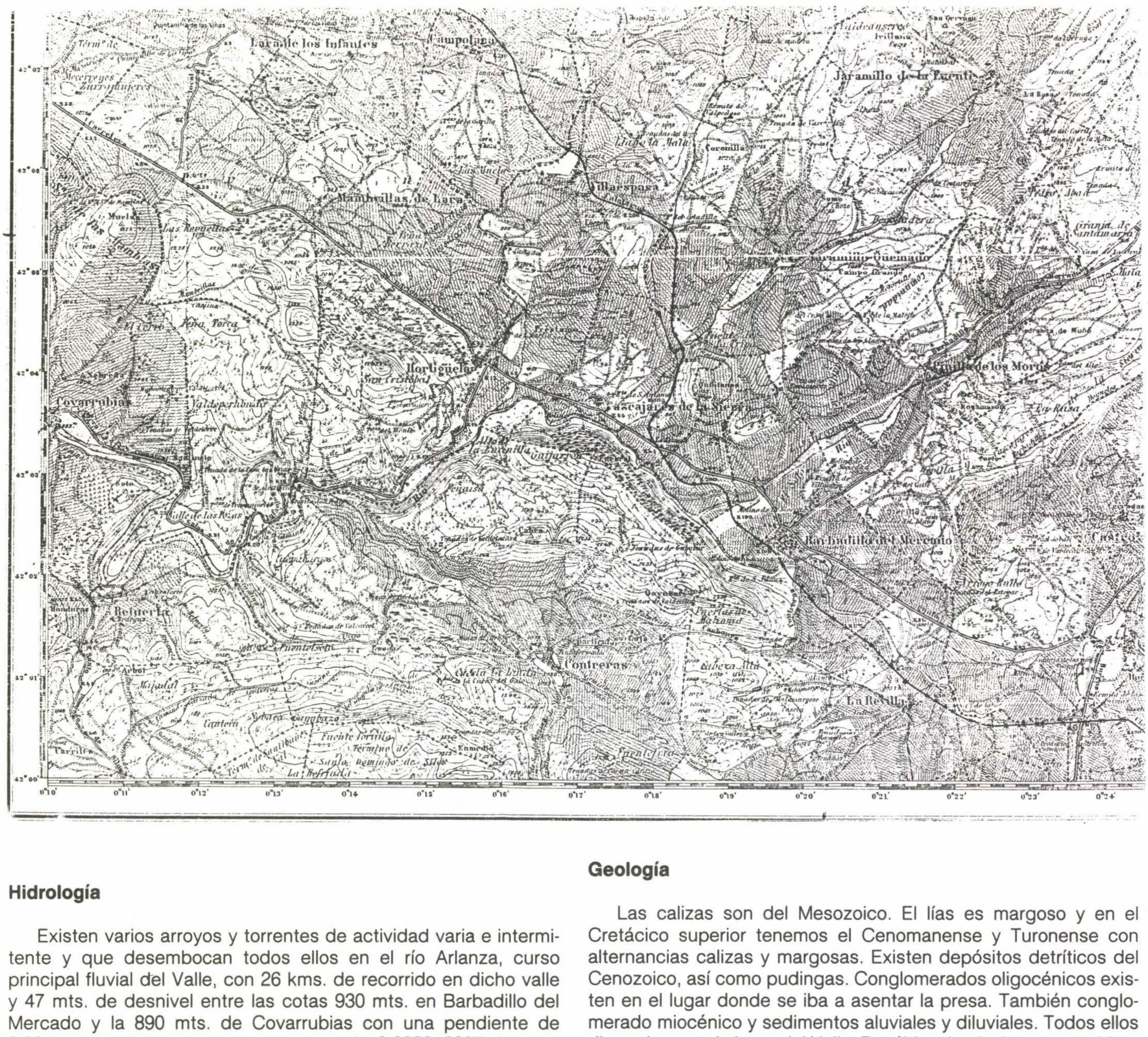

Hidrología

Existen varios arroyos y torrentes de actividad varia e intermitente y que desembocan todos ellos en el río Arlanza, curso principal fluvial del Valle, con 26 kms. de recorrido en dicho valle y 47 mts. de desnivel entre las cotas 930 mts. en Barbadillo del Mercado y la 890 mts. de Covarrubias con una pendiente de 0,0954° y medida en tanto por ciento de 0,000016667 % curso muy meandrizado, que nos da en una medida lineal de 8 kms 24 kms. de recorrido.

Pertenece a una red hidrográfica inadaptada a la estructura morfológica. Es una red sobreimpuesta por la tectónica regional que pliega y fractura la zona, discurriendo en materiales oligocénicos y posteriormente en calizas del Cretácico, con abundancias en terrazas fluviales de aluvión.

Climatología

Dadas las dimensiones del Valle, las diferencias climáticas son muy pequeñas. Podemos hablar de un microclima con temperaturas medias al año 10-11 grados y con oscilaciones entre máxima y mínima de 11 grados C.

La duración media del período de heladas es de 7 meses. La pluviometría media anual es de 800 mm. a 600 mm. y el tipo de clima es el del mediterráneo templado.

Dada la meandrización del Valle y su dirección E-W se producen zonas de umbría y soleadas que inciden en su microclima. Las corrientes de aire son ascendentes por el día, siendo descendentes –por involución térmica– por las noches, produciéndose en el estío tormentas de una cierta intensidad.

Geología

Las calizas son del Mesozoico. El lías es margoso y en el Cretácico superior tenemos el Cenomanense y Turonense con alternancias calizas y margosas. Existen depósitos detríticos del Cenozoico, así como pudingas. Conglomerados oligocénicos existen en el lugar donde se iba a asentar la presa. También conglomerado miocénico y sedimentos aluviales y diluviales. Todos ellos discordantes a lo largo del Valle. Por último las facies son wealdense y utrilla.

Morfología

La Zona que nos ocupa, se halla situada dentro del sector occidental de la Sierra de la Demanda (Sistema Ibérico) y establece su contacto entre el afloramiento paleozoico de aquélla y la cuenca terciaria de Castilla la Vieja perteneciente a la gran cuenca miocénica del Duero.

Las unidades de relieve se agrupan en tres conjuntos:

A/.– Unidades de relieve plegado al S. de la Sierra de las Mamblas. Son el sinclinal recorrido por el río Mataviejas, la bóveda anticlinal del Alto del Medio y el sinclinal de Covarrubias, la bóveda anticlinal de San Pedro de Arlanza y la propia Sierra de las Mamblas.

B/.– En el extremo oriental caracterizado por formas de relieve inverso. De sur a norte, tenemos la combe de Carazo, el sinclinal colgado de Peña Carazo, la combe de Contreras, el sinclinal colgado del Gayubar y la combe de Quintanilla de las Viñas.

C./– La tercera unidad de relieve, viene marcada por los vallejos generados por el curso principal fluvial –río Arlanza– que discurre por su centro.

Las calizas están muy karstificadas, que dan origen a una rica red subálvea, freática y vadosa, con un importante acuífero en el sinclinal de Covarrubias y a la formación de cavidades de las cuales tenemos censadas unas cuarenta de recorrido más bien pequeño, siendo las principales las 12 de San Pedro de Arlanza, 7 en Contreras, 7 en Hortiguela, 2 en Retuerta, 4 en Covarrubias, 2 en Barbadillo del Mercado, 2 en La Revilla y una en Revilla del Campo.

Tectónica

Es fundamentalmente Alpídica, con grandes pliegues de cobertera. La litología es heterogénea en las formaciones cretácicas y jurásicas. La orientación NW-SE de los plegamientos concuerdan con el macizo paleozoico, aunque se observa una cierta discordancia de la cobertera con respecto al zócalo en las fases orogénicas terciarias con variaciones en la dirección de los pliegues.

Arqueología

Se han encontrado restos del Musteriense en la cueva de San Pelayo, al lado de San Pedro de Arlanza. En la cueva Riscos de Estillín, apareció un taller de sílex y cerámicas del bronce así como también el bronce aparece en la cueva La Mina. En las terrazas fluviales aparecen diversos talleres de sílex y el lugar donde se pensaba situar la presa aparecieron restos de «pebbetouls».

Castros celtas se han hallado en La Muela (Sierra de las Mamblas) San Carlos en la Peña de Carazo y Peña Cervera en la Sierra de Cervera, así como otro probable en Quintanilla de las Viñas. El Monasterio de San Pedro de Arlanza, se halla situado encima de una basílica visigótica, que a su vez está encima de un templo romano y quizás esté construído sobre un lugar sagrado celta. Es de reseñar la importancia que tiene dicho Monasterio para la historia de Castilla, por ser ordenada su construcción por el Conde Fernán González primer Conde soberano de la antigua Bardulia habiendo reposado sus restos y los de su esposa D.ª Sancha hasta fechas recientes en que fueron trasladados a la Colegiata de Covarrubias.

Se han localizado varios asentamientos romanos y una calzada romana que discurría aproximadamente por donde en la actualidad va la C-110 de Covarrubias a Barbadillo del Mercado.

Flora

En el supuesto de construirse el embalse, 114.000 pies de árboles desaparecerían, de ellos 31,968 chopos, 6.793 olmos, 5.307 robles, 17.406 fresnos, 3.182 manzanos, 213 ciruelos, 1.064 cerezos, y guindos, 10 melocotoneros, 19 membrilleros, 2.579 almendros, 363 nogales y 45.070 enebros y sabinas.

De especial importancia son las especies de sabina Alvar y Quercus Furticosa, éste último un arbusto muy raro en Europa y en vías de desaparición.

El sotobosque, está formado mayoritariamente por tomillos, espliego, ceballos en forma de arbusto, coscoja y pastizales espontáneos, dándonos el perfil del suelo una medida que va desde pocos a 30 cms. lo que, naturalmente, condiciona la existencia de las especies reseñadas.

La zona se sitúa en la frontera entre las provincias o regiones mediterranea y atlántica, con predominio de las especies mediterráneas.

Fauna

Se han contabilizado hasta la fecha 255 especies de vertebrados. En aves son 70 las especies catalogadas, de las cuales 25 rapaces y muy importante la colonia de buitre leonado, formada por más-menos un centenar de parejas. Los mamíferos dan 35 especies. De invertebrados no se tiene hecho un inventario.

Zona de embalse

El embalse ocuparía 804 Has. más 579 Has. de extraembalse, lo que da un total de 1.384 Has. El volumen de agua embalsada hubiera sido del orden de 134 Hm^3– y su superficie de 11,30 kms^2–.

Edafología

Los suelos en general son pobres con un nivel de humificación de pocos a 30 cms. debido fundamentalmente a la existencia de especies de hoja perenne, que da un bajo porcentaje en el reciclaje de materia orgánica.

El hidromorfismo se manifiesta principalmente en las zonas próximas al río Arlanza, como consecuencia de una deficiente estructura y una capa freática elevada. Hay abundancia de rañas y suelos áridos, siendo los más ricos de éstos los situados en las terrazas fluviales por lo general.

Etología

El embalse anegaría a las poblaciones de Retuerta, Hortiguela y Cascajares de la Sierra, con una destrucción de 218 viviendas y el Monasterio de San Pedro de Arlanza desaparecería.

El tipo de construcción principal son casas de piedra de sillería con mezcla de cantos rodados y muy pocas de adobe. Las vigas son de roble y el entarimado algunas veces de enebro. Son pueblos típicamente castellanos en su estructura urbana, ganaderos y labradores. En ganado abunda la oveja y cabra y poco bovino y caballar. Ricos en historia pasada y pobres en la presente.

Conclusiones

Dadas las riquezas que alberga el Valle del Arlanza, especies florales casi únicas en España, especies animales –unas protegidas y en vías de extinción– muy ricas en vertebrados, monumentos importantes para la historia e identidad de los castellanos, posible alteración de la red freática y destrucción de cavidades con restos arqueológicos y un paisaje excepcional en cuanto a belleza se refiere además de otras consideraciones como los afectados que resultarían los ecosistemas del Valle y del río Arlanza, hacen recomendable el abandono de la idea del embalse y la declaración en su lugar de Parque Natural Nacional.

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JOSE ANTONIO ABASOLO. Vías Romanas en la Provincia de Burgos.

Las grandes cavidades de Cantabria
(Rango: >3.000 m., >-300 m.)

RESUM

S'actualizen fins el 1.1.86 els recorreguts i les profunditats de coves i avencs que superen els 3.000 m., o els –300 m., respectivament, i se situen referint el terme municipal, poble més proper, coordenadas, etc., de cadascun, que són dades freqüentment publicades amb errors. Es dóna preferència al nom original de la cavitat, que no sempre és el mateix que el que hom utilitza dins el món espeleològic, mentre que els noms estrangers han estat subsituïts, normalment, per noms autòctons, d'acord amb el grup espeleològic que els va descobrir. S'afegeix sempre el nom dels grups que han treballat a cada cavitat.

Aquest és el resum d'un treball més ampli que en aquests moments està pràcticamente enllestit i que inclou totes les cavitats càntabres que superen els 1.000 i els –100 m.

RESUMEN

Se actualizan hasta el 1-1-86 los recorridos y profundiades de las cuevas y simas que superan los 3.000 m., o –300 m., respectivamente, y se sitúan dando el término municipal, pueblo más cercano, coordenadas, etc. de cada una, que son datos frecuentemente publicados con errores. Se da preferencia al nombre original de la cavidad, que no es siempre el mismo que se usa en el mundo espeleológico, y los nombres extranjeros han sido substituidos normalmente por nombres del lugar con el acuerdo del grupo espeleológico que les dio el nombre. Se añade siempre el nombre de los grupos que han trabajado en cada cavidad.

Este es el resumen de un trabajo más amplio que ya está prácticamente acabado y que incluye todas las cavidades cántabras que superan los 1.000 y –100 m.

SUMMARY

As well as bringing up to date 1-1-86 the lenghts and depths of the caves and pot-holes which exceed 3.000 m. or –300 m. respectively, these follows the municipal district, village, co-ordinates, etc. of each one, which are details often published with mistakes. The original name of the cave, which is not always the same as the one used in the speleological world is prefered, and the foreign names have been substituted, normally by place-names, with the agreement of the caving group which namet them. The caving groups which have worked in each cave are also included.

This is a summary of a large work, which is practically finished, including all the cantabrian caves bigger than 1.000 and –100 m.

Desarrollos

1. *53.000 m. RED DEL RIO SILENCIO,* sin. T. Caballos-C.S. Escobal-T. de la Canal-Joyu Hondo II, El Hoyón-La Miés-Santa Cruz-Las Rebolligas-Santa Cruz., es. Torcollano-Helguera-Santa Cruz-Ojebar-Santa Cruz, respect., t.m. *Rasines,* ee. GL, GEV, SCMJC-GAES-SESS-CAS-CET, coord. (UMT) X470768 Y4791610 Z550 m., X466090 Y4794260 Z58 m., X467860 Y4794225 Z193 m., X469600 Y4793500 Z160 m., X467255 Y4793925 Z180 m., respect.

2. *28700 m. S. DEL CUETO-C. COVENTOSA-CUVERA,* sin. n.º 136-7-63 respect., l. valle del rio Asón, es. aldeas de Socueva-Asón-Asón respect., t.m. *Aredondo,* ee. GJE, SCD, SGCAF, sCP, coord, (M) XO.º 03'47"E Y43.º15'11" Z980m., XO.º04' 42"E Y43º15'08" Z285 m., XO.º04'49"E Y43.º15'09" Z168 m., respect.

3. *20.000 m. C. DEL NACIMIENTO,* sin. C. del Agua, l. valle del rio Urdón, es. lugar de Bejes, t.m. *Cillorigo-Castro,* ee. LUSS-SEII, coord. (M) XO.º59'30"0 Y43.º14'50" Z480 m.

4. *19.000 m. RED T. DEL COTERON-C. CUBIO DE REÑADA-T. DE AZPILICUETA,* sin. sistema de La vega Sur, l. La Vega, es. lugar de Matienzo, t.m. *Ruesga,* ee. SESS-GJE-AER, MUSS, coord. (UTM) X451250 Y4795390 Z370 m., X450450 Y4595770 Z180 m., X450400 Y4794980 Z475 m., respect.

5. *15.650 m. C. DE UZUECA,* sin. n.º 107, l. Riaño, es. lugar de Riaño, t.m. *Solórzano,* ee. MUSS, coord. (UTM) X451950 Y4800020 Z175 m.

6. *15.000 m. RED DE HOYO GRANDE,* sin. T. Hoyo Grande-Sumideros del Saco n.º 2, l. Los Apartados, ec. concejo de San Martín, es. lugar de Hazas, t.m. *Soba,* ee. SCD, SCP, SCCh, coord. (M) XO.º03'35"E Y43.º13'00" Z1210 m., XO.º04'00"E Y43.º12'50" Z1180 m., respect.

7. *14.500 m. C. DEL SOPLAO,* sin. T. Juñoso-T. Ancha, l. minas de La Florida, t.m. *Rionansa,* ee. SCC, coord. (UTM) X387444 Y4794924 Z475 m., X387640 Y4794884 Z517 m., respect.

8. *13.500 m. C. DE RESCAÑO,* sin. C. de Udías, es. barrio de Cobijón, t.m. *Udías,* ee. SESS, OUCC, CQ, GEM, coord. (UTM) X399825 Y479980 Z109 m.

9. *12.000 m. C. FRESCA,* sin. n.º 30, l. La casería, ec. concejo de San Martín, es. lugar de Hazas, t.m. *Soba,* ee.SCD, coord. (M) XO.º05'12"E Y43.13'16" Z408 m.

10. *9.226 m. SISTEMA S. DE GARMA CIEGA-SUMIDERO DE CELLAGUA,* l. lapiaz de Garma Ciega y Cellagua, respect., es. lugar de Aja, respect. t.m. *Soba,* ee. SSB, SKM, CASAPM-ECV, ERE-SMCC-OUCC, GESCAT, SEII, ECG-GIM-GESCEC art, ARES-CASTAR, coord. (M) XO.º07'15"E Y43.º14'00" Z1115 m., XO.º07'-30"E Y43.º13'45" Z960 m., respect.

11. *8.965 m. C. DE LA CAÑUELA,* sin. n.º 84, l. Garmalloso, ec. Bustablado, t.m. *Arredondo,* ee. SCD, SESS, coord. (M) XO.º03'59"E Y43.º16'29" Z267 m.

12. *8.250 m. SISTEMA T. DEL SEDO-LA CUEVONA-T. DE OÑITE,* sin. sistema del Risco, l. El sedo-Cubillas-Ozana, respect., es. lugar de Matienza, t.m. *Ruesga,* ee. SESS-GJE-AER, MUSS, coord. (UTM) X453300 Y4796040 Z196 m., X452920 Y4796200 Z175 m., X454410 Y4795110 Z254 m., respect.

13. *8.000 m. SISTEMA DE MORTERO DE ASTRANA,* sin. T. del Mortero, ec. concejo de San Martín, es. lugar de Astrana, t.m. *Sons,* ee. SSB-SCD, SSB-FJS-SCP, GESCMB (?), SECEM, CEA, SCP-UP-GSL, coord. (M) Mortero: XO.º06'50"E Y43.º12'32" Z720 m., Leonorna: XO.º07'18"E Y43.º12'36" Z743m., Cubieja: XOº07'04"E Y43º12'57" Z814 m., Cuesta Cuivo: XOº07'02"E Y43º12'59" Z838 m., fisura lapiaz: XO.º07'03"E Y43.º13'02" Z860 m.

14. *7.010 m. SISTEMA AGUA-SOPLADORES,* sin. n.º 32 y 45, ec. concejo de San Martín, es. lugar de Hazas, t.m. *Soba,* ee. SCD, SSB, SCP, SESS, coord. (M) XO.º04'40"E Y43.º13'50" Z600 m., XO.º02'57"E Y43.º14'05" Z825 M. RESPECT.

15. *6.750 m. C. DE LA CULLALVERA,* es. y t.m. *Ramales de la Victoria,* ee. GPCS, CNEOJE, SCD, GESCMB, SESSAER, coord. (UTM) X462920 Y4789530 Z90 m.

16. *6.500 m., C. DE LA LASTRILLA,* sin. C. del Sangazo, es.

lugar de Sámaro, t.m. *Castro Urdiales*, ee. GJE. OUCC, GELL-SESS-GEE, coord. (UTM) X479375 Y4801050 Z40 m.

17. *5.850 m., SUMIDERO DE MONTICUEVA*, l. Montes del Infierno, t.m. *Voto*, ee. SEII, GESCAT.

18. *5.700 m., SIMA 56*, l. Andara, ec. concejo «Los 5 Hermanos» (Bejes-Cabañes-Colio-Pendes-Lebeña), t.m. *Cillorigo-Castro*, ee. LUSS-SEII, coord. (M) X1.º02'25"O Y43.º12'45" Z1950 m.

19. *5.500, C. DEL TOBAZO*, sin. C. del Agua, l. El Tobazo, es. lugar de Villaescusa de Ebro, t.m. *Valderredible*, ee. GEVS, coord. (M) XO.º08'22"O Y42.º49'15" Z880 m.

20. *55.473 m., C. DEL LINAR*, sin. La busta-s. Palombal, es. lugar de La Busta, t.m. *Alfoz de Lloredo*, ee. SECS, GJE, SESS, GESCAT, SEL, coord. (UTM) X404400 Y4800625 Z95 m., X404240 Y4800990 Z237 m., respect.

21. *5.000 m., C. FRANÇOIS*, l. El Alveo, ec. concejo de San Martín, es. lugar de Hazas, t.m. *Soba*, ee. SGCAF, coord (UTM) X449000 Y4786000 Z1150 m.

22. *4.700 m., T. DEL MOSTAJO*, sin. n.º 71, l. Cubija, es. lugar de Matienzo, t.m. *Ruesga*, ee. MUSS, coord. (UTM) X450350 Y4796990 Z312 m.

23. *4.550 m., RED DE CARRILLO*, sin. S. del Mirlo, l. ladera norte del Carrillo, es. Valdició, t.m. *Soba*, ee. SCD, coord. (M) XO.º02'03"E Y43.º12'52" Z1405 m.

24. *4.500 m., C. DE RIAÑO*, sin n.º 105, l. Riaño, es. lugar de Riaño, t.m. *Solórzano*, ee. MUSS, cor. (UTM) X451910 Y4800440 Z175 m.

25. *4.392 m., SISTEMA BUHO-SUMIDERO*, sin. n.º 31 y 28, respect., l. el Dobra, es. lugar de Puente viesgo, t.m. *Puente Viesgo*, ee. GGG-GIE, ECG, coord. (UTM) X418760 Y4794190 Z420 m., X419005 Y4794290 Z400 m., respect.

26. *4.376 m., C. HONDA*, sin. C. de Hoz de Marrón, l. sierra de Breñas, t.m. *Ampuero*, ee. GJE, GIE, SCC, GEM, SELI, coord. (G) X3.º26'52" Y43.º20'15" Z180 m.

27. *4.290 m., C. DE LA HAZA*, Sin. n.º 40, l. Hoyo grande, ec. concejo de San Martín, es. lugar de Hazas, t.m. *Soba*, ee. SCD, SCCH, coord. (M) XO.º03'30"E Y43.º13'00" Z1240 m.

28. *3.800 m., C. LLUEVA*, sin. n.º 114, l. Llueva, t.m. *Voto*, ee. MUSS, coord. (UTM) X454680 Y4798390 Z147 m.

29. *3.616 m., C. DE LOS TOCINOS*, sin. G-1, l. depresión de Tocinos, t.m. *Guriezo*, ee. GJE, SESS, SEII, coord. (UTM) X470490 Y4798794 Z285 m.

30. *3.408 m., T. DE SOLVIEJO-T. DEL RAYO DE SOL*, sin. Suviejo y n.º 123, repest., es. casería de Secadura, t.m. *Voto*, ee. SESS, GET, MUSS, coord. (UTM) X454860 Y4800130 Z185 m., X454670 Y4799900 Z155 m., respect.

31. *3.200 m., T. DE LOS TORNILLOS*, sin, RN-30, l. Las Rebolligas, es. lugar de Ojebar, t.m. *Rasines*, ee. GAES, coord. (UTM) X469690 Y4793520 Z178 m.

32. *3.126 m., T. DE CARCABAS I*, sin. RN-75, l. casa de los Cirizuelos, es. lugar de Ojebar, t.m. *Rasines*, GAES-SCMJC-CAS, coord. (UTM) X469422 Y4791845 Z444 m.

33. *3.113 m., C. DE RIOCUEVA-T. DE LOS CAÑAOS*, sin. Recueva, l. Riocueva, es. lugares de Hoznayo y Villaverde de Pontones, respect., t.m. de *Entrambasaguas* y *Ribamontan al Monte*, respect., ee. GJE, GESL, SESS, GEC ant, coord. (UTM) X443350 Y4805780 Z30m., X443670 Y4805945 Z61 m., respect.

34. *3.000 m., C. LA MARNIOSA*, sin. n.º 19, l. valle de Sobra, t.m. *Tresviso*, ee. LUSS coord. (M) X1.º01'20"O Y43.º15'12".

35. *3.000 m., C. DE LOS PEINES*, sin. C. de la Peña, l. Momeñe, es. lugar de Sámano, t.m. *Castro Urdiales*, ee. OUCC, GELL, SESS. coord. (UTM) X481635 Y4799650 Z85 m.

Desniveles

1. *–1.169 m., SIMA 56*. Ver en *desarrollos* (n.º18).

2. *–831 m., S. BLOQUES DELICIOSOS*, sin. Dosse's Deligth, l. norte Pico del Moro, es. lugar de Bejes, t.m. *Cillorigo-Castro*, ee. LUSS, coord. (M) X1.º02'18"O Y43.º12'48" Z1690 m.

3. *–825 m., SISTEMA S. DE GARMA CIEGA-SUMIDERO DE CELLAGUA*. Ver en *desarrollos* (n.º10).

4. *–815 m., S. DEL CUETO-C. CONVENTOSA-CUVERA*. Ver *desarrollos* (n.º2).

5. *–792 m., S. TERE*. Ver en *desarrollos* (n.º 72)

6. *–723 m., S. DEL FLORERO*. Ver en *desarrollos* (n o50).

7. *648*(–635, +13)*m., SISTEMA SARA*, l. depresión de Sara, es. lugar de Bejes, t.m. *Gillorigo-Castro*, ee. LUSS-SEII, coord. (M) X1.º01'10"0 Y43.º12'30" Z1870 m.

8. *–608 m., COMPLEJO TORRE ALTAIZ-JOU DE LLOROZA*, sin. 119-M2-125, l. collado de Fuente Escondida, es. lugar de Espinama, t.m. *Camaleño*, ee. ASCh, coord. (M) X1.º08'10" Y43.º09'50" Z2090 m., X1.º08'16"O Y43.º09'50" Z2060 m., X1.º08'-14"O Y43.º9'50" Z20451 m., respect.

9. *–589 m., S. DE LAS PASADAS*, sin. LM-1, l. collado de Las Pasadas, es. Calseca/Bustablado, t.m. *Ruesga/Aredondo*, ee. SCD-MJCM, ECG, coord (UTM) X444835 Y4789810 Z925 m.

10. *552*(–530, +22)*m.,SISTEMA DEL MORTERO DE ASTRANA*. Ver *desarrollos* (n.º13).

11. *–505 m., MORTERON II DEL HOYO SALZOSO*, sin. sumidero del Hoyo Salzoso, l. Hoyo Salzoso, es. lugar de San pedro, t.m. *Soba*, ee. SCD, SSB, SEG-ERE-SIS-EGG, coord. (M) X0.º07'-16"E Y43.º14'48" Z880 m.

12. *–492 m., RED DEL RIO SILENCIO*. Ver *desarrollos* (n.º1).

13. *475* (–460, +15)*m., T. DE CORRALES DEL TRILLO*, sin. L 31, l. Peña del Trillo, ec. mancomunidad Cañedo-Valcaba, t.m. *Soba*, ee. GSL-SCP, STD, coord. (M) X0.º05'06"E Y43.º09'46" Z1320 m.

14. *–458 m., T. LA MUELA 7*, sin. LM-7, l. La Muela, Calseca/ Bustablado, t.m. *Ruesga/Arredondo*, ee. ECG, coord. (UTM) X444900 Y4789820 Z920 m.

15. *–435 m., RED DE HOYO GRANDE*. Ver *desarrollos* (n.º 6).

16. *–418 m., C. DE LA HAZA*. Ver *desarrollos* (n.º 27).

17. *–405 m., T. DEL HOYO MEDIO*. Ver *desarrollos* (n.º 66)

18. *–402 M., S. DE LA HORCADA VERDE*, sin. L 12, l. prox. al pico San Carlos, es. lugar de Espinama, t.m. *Camaleño*, ee. ASCh, coord. (M) X1º08'45"O Y43º09'51" Z2190 m.

19. *+400 m ., C DEL NACIMIENTO*. Ver *desarrollos* (nº 3).

20. *–369 m., EL MORTERON*, sin. Morterón del Hoyo Salzoso, l. Hoyo Salzoso, es. lugar de San Pedro, t.m. *Soba*, SCD, SSB, ARES, CIE-SESP-CEG, coord. (M) XOº07'41" E Y43º14'34" Z 890 m.

21. *–351 m., T. DEL HOYON II*, sin. RN-51, l. El Hoyón, es. aldea de Torcollano, t.m. *Rasines*, ee. GAES, coord. (UTM) X470768 Y4791655 Z550 m.

22. *–349m., T. DEL CARLISTA*, sin. R-87, VI-56, l. Peñas de Ranero, t.m. *Carranza* (Vizcaya)-*Ramales de la Victoria* (Cantabria), ee. GEV, ULSA, coord. (UTM) X468465 Y4790150 Z700 m.

23. *–334 m., T. DEL CALERO DEL AGUA*, sin. RN-142, l. Calero del Agua, es.- lugar de Ojebar, t.m. *Rasines*, ee. GAES, coord. (UTM) X468735 Y4791145 Z585 m.

24. *–327 m., S. PROCELOSA*, sin. LLC 1, l. pico Tejes, es. lugar de Aja, t.m. *Soba*, ee. SEII, coord. (M) XOº07'26" E Y43º14'03" Z1115 m.

25. *–319m., S. DE LAS FALSAS ESPERANZAS*, l. prox. a Sierra Redonda, es. lugar de San Pendro, t.m. *Soba*, ee. SEII.

26. *–319 m., S. T. DE LA RASA 98*, sin. LR-98, l. La Rasa, es. lugar de Astrana/ Aja, t.m. *Soba*, ee. SEII.

27. *–318 m/S. MAZARRASA*, l. la Casa Blanca, ec. concejo «Los 5 Hermanos» (Bejes-Cabañes-Colio-Lebeña-Pendes), t.m. *Cillorigo-Castro*, ee. LUSS, coord. (M) X1º01'30" O Y43º12'45" Z1810 m.

28. *–313 m., T. BOULDEROSA*, l. Pico del Moro, es. lugar de Bejes, t.m. *Cillerigo-Castro*, ee. LUSS-SEII, coord. (M) X1.01'30" O Y43º12'45ú Z1820 m.

29. *–313 m., S. DEL HOYON*. Ver *desarrollos* (nº 38).

30. *–312 m., S. DEL TURBON*, sin. 305, l. Alto de la Porra, ec. de Bustablado, t.m. *Arredondo*, ee. SCD, coord. (M) XOº01'59" E Y43º14'50" Z1095 m.

31. *–310 m., T. DE CARCABAS I*. Ver *dessarrollos* (nº 32).

32. *–303 m., T. REGATO CALERO II*. Ver *desarrollos* (nº 71).

33. *–300 m., TORCON DE LAYA*, sin. CL 11-12, l. Canal de Laya, ec. Bustablado, t.m. *Arredondo*, ee. ECG, coord. (UTM) X444480 Y4790875 Z785 m.

Las grandes cavidades de Cantabria (Rango: 1.000 a 2.000 m., −100 a −200 m.)

RESUM

S'actualitzen fins 1.1.86 els recorreguts i les profunditats de coves i avencs d'entre 1.000 a 2.000 m., o de −100 a −200 m., respectivament, i se situen referint el terme municipal, poble més proper, coordenades, etc. de cadascun, que són dades freqüentment publicades amb errors. Es dóna preferència al nom original de la cavitat, que no sempre és el mateix que el que hom utilitza dins el món espeleològic, mentre que els noms estrangers han estat substituïts normalment, per noms autòctons, d'acord amb el grup espeleològic que els va descobrir. S'afegeix sempre el nom dels grups que han treballat a cada cavitat.

Aquest és el resum d'un treball més ampli que en aquest moments està pràcticament enllestit i que inclou totes les cavitats càntabres que superen els 1.000 i els −100 m.

RESUMEN

Se actualizan hasta el 1.1.86 los recorridos y profundidades de las cuevas y simas entre 1.000 y 2.000 m., o −100 y −200 m. respectivamente, y se sitúan dando el término municipal, pueblo más cercano, coordenadas, etc. de cada una, que son datos frecuentemente publicados con errores. Se da preferencia al nombre original de la cavidad que no es siempre el mismo que se usa en el mundo espeleológico, y los nombres extranjeros han sido substituidos normalmente por nombres del lugar con el acuerdo del grupo espeleológico que les dio el nombre. Se añade siempre el nombre de los grupos que han trabajado en cada cavidad.

Este es el resumen de un trabajo más amplio que ya está prácticamente acabado y que incluye todas las cavidades cántabras que superan los 1.000 y −100 m.

SUMMARY

As well as bringing up to date 1-I-86 the lengths and depths of the caves and pot-holes between 1.000 and 2.000 m., or −100 and −200 m respectively, these follows the municipal district, village, co-ordinates, etc. of each one, which are details often published with mistakes. The original name of the cave, which is not always the same as the one used in the speleological world is preferred, and the foreign names have been substituted, normally by place-names, with the agreement of caving grup wich named them. The caving groups which have worked in each cave are also included.

This is a summary of a large work, which is practically finished, including all the cantabrian caves bigger than 1.000 and −100 m.

Desarrollos

45. *1.900 m., C. DEL AGUA,* sin. c. de El Molino, l. La Vega, es. lugar de Matienzo, t.m. *Ruesga,* ee. SESS, GESCMB, MUSS, coord.(UTM) X451610 Y4796220 Z165 m.

46. *1.850 m., C. DE ROGERIA,* sin. c. del Calero, l. Rogería, es. lugar de Oreña, t.m. *Alfoz de Lloredo,* ee. SESS, coord.(UTM) X408600 Y4805300 Z50 m.

47. *1.725 m., CUEVAMUR,* sin. c. del Muro, l. Muro del Eco, es. aldea de La Pared, t.m. *Ramales de la Victoria,* ee. CNEOJE, GJE, AER, SIRE-EREAEC, SESCEV, SESS, coord.(UTM) X463850 Y4787850 Z320 m.

48. *1.724 m., C. DE CHIVOS MUERTOS,* sin. n.º 133, es. lugar de Valdició, t.m. *Soba,* ee. GESCMB, SAEC, coord.(UTM) X442700 Y4785725 Z550 m.

49. *1.645 m., C. DEL RIO MUNIO,* 1. Rolacias, es. aldea de Asón, t.m. *Arredondo,* ee. SCD, SGCAF (?), coord.(UTM) X448135 Y4787290 Z805 m.

50. *1.600 m., S. DEL FLORERO,* sin. T 169, l. Pico del Moro, es. lugar de Bejes, t.m. *Cillorigo-Castro,* ee. LUSS-SEII, coord.(M) X1º02'19"O Y43º12'25" Z1800 m.

51. *1.500 m., C. DE CODISERA,* sin. c. de Coquisera, l. monte Beralta, es. lugar de Matienzo, t.m. *Ruesga,* ee. SESS, MUSS, coord.(UTM) X453370 Y4794300 Z450 m.

52. *1.500 m., C. DE COTERA,* sin. c. de los Valles, l. Valle, Perelada, es. lugar de Oreña, t.m. *Alfoz de Lloredo,* ee. SESS, SEL, coord.(UTM) X406550 Y4804500 Z80 m

53. *1.500 m., C. DEL COBACHO,* sin. c. de Iseca Nueva, l. el Covacho, es. barrio de Iseca Nueva, t.m. *Liendo,* ee. OUCC, SESS, BT, GELL, coord.(UTM) X469900 Y4803550 Z40 m.

54. *1.500 m., POZO SINIESTRO 2,* sin. PS-2, l. Reguleñes, es. lugar de Sámano, t.m. *Castro Urdiales,* ee. GELL, coord.(UTM) X478050 Y4801385 Z200 m.

55. *1.458 m., C. DEL HOYO DE LA FUENTE II,* sin. 56-G, l. Peña San José, es. barrio de Llaguno, t.m. *Guriezo,* ee. GEE, coord. (L) X631975 Y986850 Z322 m.

56. *1.435 m., C. DE SANTIAGO CANO,* sin. c. de El Regato, l. Fresnedo, es. caserío de Fresnedo, t.m. *Solórzano,* ee. SCC, coord.(UTM) X454400 Y4802100 Z220 m.

57. *1.250 m., T. DE LA CABAÑA,* sin. Torcón de la Vera Negra, l. La Vega, es. lugar de Matienzo, t.m. *Ruesga,* ee. MUSS, coord.(UTM) X450490 Y4795180 Z433 m.

58. *1.250 m., C. DEL MOLINO,* sin. c. del Cartero, l. crta. Arredondo-Bustablado, t.m. *Arredondo,* ee. SCD, ECTor-AAEET, coord. (UTM) X448570 Y4792380 Z218 m.

59. *1.240 m., C. DE LAS CANALES,* 1. Las Canales, t.m. *Soba,* ee. SGCAF, SCD, coord. (M) XOº05'53"E Y43º13'22" Z700 m.

60. *1.211 m., SISTEMA DE CONCHA,* sin. c. de Rupicos-Tijeras, es. aldea de Pando, t.m. *Ruiloba,* ee. ACEM, SESS, coord. (M) X0º34'43"O Y43º22'45" Z45 m., XOº34'50" Y43º23'00" Z35 m., respect.

61. *1.200 m., C. DE LA CUBILLA,* sin. c. la Penilla, l. La Cubilla, es. lugar de Sámano, t.m. *Castro Urdiales,* ee. OUCC, GELL-SESS, coord.(UTM) X477650 Y4801200 Z169 m.

62. *1.200 m., C. DE JUAN GOMEZ,* sin. cuevas de Sámano, l. Hoz, es. lugar de Sámano, t.m. *Castro Urdiales,* ee. OUCC(?), GELL, coord.(UTM) X480325 Y4801775 Z100 m.

63. *1.170 m., MORTERO DEL CRUCERO,* 1. collado de El Crucero, es. lugar de San Pedro, t.m. *Soba,* ee. SEG-GESCECart., coord.(M) X0º07'50"E Y43º14'07" Z1035 m.

64. *1.108 m., T. DE LOS CASTAÑOS DE DOÑA LUISA,* sin. RN-48, l. monte de Valseca, es. aldea de Santa Cruz, t.m. *Rasines,* ee. GAES, coord.(UTM) X467680 Y4792400 Z257 m.

65. *1.100 m., S.-C. DE CANTULAGATA,* t.m. *Rionansa,* ee. SCC, coord.(UTM) X386480 Y4791285 Z530 m.

66. *1.077 m., T. DEL HOYO MEDIO,* sin. RN-82, l. Alto de las Minas, es. aldea de Torcollano, t.m. *Rasines,* ee. SCMJC-AM-GAES, coord.(UTM) X471180 Y4791705 Z562 m.

67. *1.059 m., SUMIDERO DE LAS PALOMAS,* sin. DO.28, t.m. *San Felices de Buelna/Torrelavega,* ee. ECSalou, ECG, coord.(UTM) X415540 Y4795400 Z330 m.

68. *1.041 m., SUMIDERO DEL REJULLO,* sin. Cueva 4, l. de-

presión de Rejullo, t.m. *Guriezo,* ee. SEII, coord. (UTM) X470515 Y4798560 Z270 m.

69. *1.031 m., C. DE LA PRIMAVERA,* 1. barranco de la Sota, es. lugar de Valdició, t.m. *Soba,* ee. SCD, GEC, coord.(M) X0º02'-25"E Y43º13'40" Z1075 m.

70. *1.000 m., C. DE ONCE PUERTAS,* sin. RN-9, l. Rocillo de Abajo, es. aldea de Rocillo, t.m. *Rasines,* ee. GAES, coord.(M) X0º15'46" Y43º19'16" Z50 m.

71. *1.000 m., T. REGATO CALERO II,* sin RN-103, l. Regato Calero, es. lugar de Ojébar, t.m. *Rasines,* ee. GAES, coord.(UTM) X468200 Y4791705 Z445 m.

72. *1.000 m., S. TERE,*sin. 2.24, l. depresión de Sara, es. lugar de Bejes, t.m. *Cillorigo-Castro,* ee. LUSS, coord. (M) X1º01'00"O Y43º12'20" Z1850 m.

Desniveles

66 *–196 M., S. GRANDE,* sin. s. Palomar, l. Los Machucos, ec. Bustablado, t. m. *Arredondo,* ee. SCD, coord. (M) XO.º 02'32"E Y43.º15'58" Z650 m.

67 *–190 m., S. DEL OSO CAIDO,* l. Majada de la Llama, es. lugar de Bejes, t. m. *Cillorigo-Castro,* ee. LUSS, coord. (M) X1º-00'25"O Y43º13'15" Z1550 m.

68 *190 m., S. SLM 30,* es. barrio de Linto, t. m *Miera,* ee. GES-CAT.

69 *–185 m., T. MEXICANA,* 1. El Alveo, ec. concejo de San Martin, es. lugar de Hazas, t. m. *Soba,* ee. SGCAF.

70 *–182 m., S. CANAL DE LAYA 1,* sin. CL-1, l. Canal de Laya, ec. Bustablado, t. m. *Arredondo,* ee. GGG-GIE, ECG, coord. (UTM) X444215 Y4790830 Z845 m.

71 *–180 m., RED DE CARRILLO.* Ver *desarrollos* (n.º 23).

72 *–180 m., SIMA 55,* 1. Pico de Moro, es. lugar de Bejes, t. m. *Cillorigo-Castro,* ee. LUSS, coord. (M) X1.º02'35"O Y43º12'47" Z1900 m.

73 *–180 m., SIMA D11,* 1. Cabaña Verónica, es. lugar de Espinama, t. m. *Camaleño,* ee. ASCh.

74 *–176 m., T. DE CORDANCAS,* l. Cotero de Mingo Alvarez, es. lugar de Cicera t. m. *Peñarrubia,* ee. ECS, SESS.

75 *–173 m., S. DEL SOMBRERO,* sin. MCH 10, l. Cellagua, es. lugar de Aja, t. m. *Soba,* ee. SSB, SEG-GES art, SIII, coord. (M) XOº.07'23"E Y43.º13'49" Z1035 m.

76 *–170 m., S. DE TRES AVARILLAS,* sin. Hoyo Tres Avarillas, l. El Jorcón, es. lugar de Linares, t. m. *Peñarrubia,* ee. SCS-SCD, coord. (M) XO.º52'05"O Y43.º17'15" Z820 m.

77 *–168 m., T. CANAL DE LAYA 6,* sin CL-6, l. Canal de Laya, ec. Bustablado, t. m. *Arredondo,* ee. ECG, coord. (UTM) X444215 Y4790675 Z840 m.

78 *–166 m., S. CA 9,* 1. Peña Lavalle, es. Lugar de Arredondo, t. m. *Arredondo,* ee. SAGA-SGCAF, coord. (UTM) X448600 Y4789700 Z850 m.

79 *–162 m., S. MILLADERO 13,* sin. M-13, l. monte Milladero, es. lugar de Sámano, t. m. *Castro Urdiales,* ee. GELL, coord. (UTM) X478950 Y481770 Z290 m.

80 *–160 m., T. DE LA CABAÑA.* Ver *desarrollos* (n.º 57).

81 *–160 m., S. DS-400,* 1. Rolacía, es. lugar de Valdició, t. m. *Soba,* ee. DS, coord. (M) X0º02'53"E Y43º13'53" Z1010 m.

82 *–160 m., T. HOYO DE LA ESPINA I,* sin. CC-1-91, l. Hoyo de la Espina, es. lugar de Bejes, t. m. *Cillorigo-Castro,* ee. GJE, STCEV, ECS, coord. (M) XO.º57'50"O Y34.º14'10" Z1060 m.

83 *–160 m., T. LA SIMA,* sin. n.º 49, l.La Brenía, ec. mancomunidad de los lugares de Cañedo y Valcaba, t. m. *Soba,* ee. SCD, GESCMB

84 *–158 m., T. TRES AGÜELAS,* sin. n.º 3, l. cotero de Mingo Alvarez, es. lugar de Cicera, t. m. *Peñarrubia,* ee. SESS.

85 *–157 m., MORTERO DE CELLAGUA,* sin. MCH 0, l. Cellagua, es. lugar de Aja, t. m. *Soba,* ee. SSB, STD, SEG-GESCEC art, coord. (M) XO.º7'33"E Y43.º13'41" Z970 m.

86 *–156 m., T. DE LA LANCHERA,* 1. Cotero de Mingo Alvarez, es. lugar de Cicera, t. m. *Peñarrubia,* ee. GJE, SESS, coord. (M) XO.º50'55"O Y43.º12'05" Z1270 m.

87 *–155 m., SISTEMA GARMA CIEGA 5-6-9... AGUA,* sin. GC 5-6-9-...Agua, l. lapiaz de Garma Ciega, es. lugar Astrana/Aja, t. m. *Soba,* ee. SEII.

88 *–152 m., T. BUSTABLADO 45,* sin. BU-45, l. Llano de Mojabarcas, ec. Bustablado, t. m. *Arredondo,* ee. ECG, coord. (M) XO.º00'38"E Y43.º16'10" Z930 m.

89 *–152 m., SIMA 212,,* l. El Mullir, ee. t. m. *Voto* MUSS, coord. (UTM) X455390 Y4795770 Z720 m.

90 *–151 m., C. DE LA CULLALVERA.* Ver *desarrollos* (n.º 15).

91 *–151 m., TORCASUMIZAS,* sin. Torcas Humizas I, l. monte del Moro, es. aldea de Guardamino, t. m. *Ramales de la Victoria,* ee. AER-GFB, OUCC (?), GEE, SESS, coord. (UTM) X463980 Y4790080 Z250 m.

92 *–150 m., S. GRANDE DE BRENAS,* sin. s. de Brenas, l. ladera norte sierra de Brenas, es. barrio de Arriba, t. m. *Riotuerto,* ee. GJE (?), GEPUSCIATICA, coord. (UTM), X444545 Y4796575 Z575 m.

93 *–150 m., S. DE LA LLUSA 2,* sin. LL.2, l. La Llusa, es. lugar de Aja, t. m. *Soba,* ee. SSB, SEII (?).

94 *–150 m., S. DE LA LLUSA 6,* sin. LL. 6, l. La Llusa, es. lugar de Aja, t. m. *Soba,* ee. SSB, SEII (?), coord. (M) XO.º07'02"E Y43.º14'08" Z1200 m.

95 *–150 m., C. DEL SOPLAO.* Ver *desarrollos* (n.º 7).

96 *–150 m., S. TAPADA,* sin. sima 291, l. La Muela, ec. Bustablado, t. m. *Arredondo,* ee. SESP, SCD, coord. (M) XO.º00'37"E Y43.º15'30" Z935 m.

97 *–150 m., C. DEL TRONCO,* sin. C. de la Palanca, l. monte Milladero, es. lugar de Sámano, t. m. *Castro Urdiales,* ee. GELL, coord. (UTM) X478675 Y4801860 Z245 m.

98 *–149 m., S.-C. DE CANTULAGATA.* Ver *desarrollos* (n.º 65).

99 *–146 m., TORCADO. 10,* t. m. *San Felices de Buelna,* ee. ECG, coord. (UTM) X416450 Y4795150 Z455 m.

100 *–146 m., SIMA JO. 1,* 1.ladera este del Pico San Carlos, es. lugar de Espinama, t. m. *Camaleño,* ee. ASCh, coord. (M) X1.º08'30"O Y43.º09'45" Z2250 m.

101 *–145 m., T. EL CALERO,* 1. El Calero, t. m. *Rionansa,* ee. SCC, coord. (UTM) X381372 Y4793088 Z310 m.

102 *–142 m., SIMA CH-72,* es. lugar de San Pedro, t. m. *Soba,* ee. SCCh, coord. (UTM) X454500 Y4788500 Z1000 m.

103 *–142 m., S. DEL OJAL,* sin. Boutonnière, l. Peña Lavalle, es. aldea de Socueva, t. m. *Arredondo,* ee. SCD, coord. (M) XOº.º03'47"E Y43.º15'11" Z980 m.

104 *–140 m., C. DE EL LINAR.* Ver *desarrollos* (n.º 20).

105 *–140 m., S. DE LA LUNA LLENA,* sin. A-32, l. Peña Monteros, es. lugar de La Busta/Cóbreces, t. m. *Alfoz de Lloredo,* ee. SEL, coord. (UTM) X401495 Y4801490 Z312 m.

106 *–140 m., POZOS SIMONES,* sin. n.º 43-44-45, es. lugar de Quintana, t. m. *Soba,* ee. SCD, GESCMB.

107 *–140 m., T. DE YUSA,* sin. n.º 116, l. Hoyo de Yusa, t. m. *Ruesga,* ee. MUSS, coord. (UTM) X454670 Y4796230 Z720 m.

108 *–139 m., SIMA K 5,* 1. ladera este del Pico San Carlos, es. lugar de Espinama, t. m. *Camaleño,* ee. ASCh, coord. (M) X1.º08'20"O Y43.º.09'50" Z2109 m.

109 *–136 m., T. CANAL DE LAYA 82,* sin. CL-82, l. Canal de Laya, ec. Bustablado, t. m. *Arredondo,* ee. ECG, coord. (UTM) X444445 Y4790495 Z862 m.

110 *–135 m., SIMA 472,* 1. La Vega, es. lugar de Matienzo, t. m. *Ruesga,* ee. MUSS, coord. (UTM) X451820 Y4794270 Z570 m.

111 *–135 m., T. DEL HAYA DE LA MATILLA,* 1. Peñaventosa, ec. mancomunidad Lebeña/Bedoya, t. m. *Cillorigo-Castro,* ee. CJE, SESS, coord. (M) XO.º54'00"O Y43.º12'09" Z1070 m.

112 *–132 m., T. VALLINES,* 1. Puerto de Quión, es. lugares Colio-Pendes, t. m. *Cillorigo-Castro,* ee. ECS, coord. (M) XO.º57'-46"O Y43.º14'00" Z1000 m.

113 *–131 m., S. ALTO DE TEJUELO, 8,* sin. AT-8, l. Alto de Tejuelo, ec. Bustablado, t. m. *Arredondo,* ee. GGG, ECG, coord. (UTM) X444325 Y4789935 Z932 m.

114 *–130 m., SIMA CAF 63,* 1. Peñas Rocias, es. lugar de San Pedro, t. m. *Soba, ee. CAF.*

115 –130 m., T. DE GRAÑAYA, *1. Carrizoso, es. lugar de Linares, t. m.* Peñarrubia, *ee. SCS-SCP-SCD, coord. (M) XO.º52'-47"O Y43.º17'27" Z760 m.*

116 –130 m., S. DE LLANA LA CUEVA 13, *1. prox. al Mazo*

Chico, ec. Concejo de San Martín, es. lugar de Astrana, t. m. Soba, *ee. CEA (?), SEII.*

117 –130 m., TORCA 361, *1. alto de la Porra, ec. Bustablado, t. m.* Arredondo, *ee. SCD, coord. (M) XO.°01'40"E Y43.°15'00" Z1065 m.*

118 –127 m., S. DEL PASTOR, *1. Valle de Helguerón, t. m.* Soba *(?), ee. DS.*

119 –126 m., SIMA CH-67, *1.Peñas Rocias, ec. lugar de San Pedro, t. m.* Soba, *ee. SCCh, coord. (UTM) X453900 Y4788850 Z1130 m.*

120 –126 m., S. DEL CUETO, *sin. AR-2-23, l. monte de la Azuela, t. m.* Arredondo, *ee. SCD-FJS, GESCMB, coord. (UTM) X449400 Y4793600 Z700 m.*

121 –125 m., S. DE LA ESQUINA, *sin. Coin, l. lapiaz de Garma Ciega, es. lugar Astrana/Aja, t. m.* Soba *ee. SSB.*

122 –125 m., S. LUSA 9, *sin. L9, l. Peña de Lusa, ec. mancomunidad Cañedo-Valcaba, t. m.* Soba *ee. GSL.*

123 –125 m., SIMA PR-211, *1. prox. a Sierra Redonda, es. lugar de San Pedro, t. m.* Soba, *ee. BB.*

124 –124 m., S. DE LA VALLEJONA, *l. Cuesta de Pelea, es. lugar de Bejes, t. m.* Cillorigo-Castro, *ee. ENEOJE, coord. (M) XO.°55'55"O Y43.°13'55" Z1200 m.*

125 –123 m., C. DE LA PRIMAVERA. *Ver* desarrollos *(n.° 69).*

126 –120 m., T. DE LOS GUIAS, *sin. AL-10-10, l. monte Barbecha, es. lugar de la Busta, t. m.* Alfoz de Lloredo, *ee. SESS, coord. (UTM) X404090 Y4801050 Z250 m.*

127 –120 m., S. DE LOS RELLANOS, *sin. n.° 47, l. La Vega, es. lugar de Matienzo, t. m.* Ruesga, *ee, GESCMB, coord. (UTM) X450380 Y4795500 Z290 m.*

128 120 (–80, +40) m., S. DEL ROZACARIN. *Ver* desarrollos *n.°40).*

129 –119 m., T. CANAL DE LAYA 21, *sin. CL-21, l. Canal de Laya, ec. Bustablado, t. m.* Arredondo, *ee. ECG, coord. (UTM) X444165 Y4790265 Z885 m.*

130 –119 m., SISTEMA GARMA CIEGA 18-21, *sin. GC 18-21, l. lapiaz de Garma Ciega, es. Astrana/Aja, t. m.* Soba, *ee. SEII.*

131 –118 m., S. BROMISTA, *sin. T 225, t. m.* Tresviso, *ee. LUSS, coord (M) X1.°01'28" Y43.°14'28" Z1380 m.*

132 –118 m., SIMA CAF 56, *1. Sierra Redonda, es. lugar de San Pedro, t. m.* Soba *ee. SGCAF, SEII.*

133 –118 m., SISTEMA GARMA CIEGA 14-15, *sin. GC 14-15, l. lapiaz de Garma Ciega, es. Astrana/Aja, t. m.* Soba *, ee. SSB (?), SEII.*

134 –118 m., T. DE LA LASTRILLA, *sin n.° 427, l. La Vega, es. lugar de Matienzo, t. m.* Ruesga,ob es. MUSS, coord. (UTM) X449480 Y4796600 Z362 m.

135 *–118 m., T. DE LA YUSA II,* sin. C-14, l. cabaña del Mortero, es. aldea de Calseca, t. m. *Ruesga*, ee. SESCEV, coord. (M) X0.°01'18"E Y43.°15'00" Z910.

136 *–117 m., T. DEL MOSTAJO.* Ver *desarrollos* (n.° 22).

137 *–115 m., SIMA A 10,* 1. Hoyos Negros, es. lugar de Espinama, t. m. *Camaleño*, ee. ASCh.

138 *–115 m., S. HORNIJO SUR-5,* sin. HS-5, l. Hornijo, es. lugar de San Pedro, t. m. *Soba* ee. SESS, coord. (M) XO.°09'05" Y43.°14'07" Z1180 m.

139 *–115 m., T. LA MUELA 16,* sin. LM-16, l. depresión de la Ranchá, es. lugar de Calseca, t. m. *Ruesga,* ee. ECG, coord. (UTM) X444645 Y4789595 Z865 m.

140 *–115 m., S. RACHO,* sin CA 15, l. Peña Lavalle, es. lugar de Arredondo, t. m. *Arredondo,* ee. SGCAF, coord. (UTM) X448950 Y4789525 Z935 m.

141 *–112 m., MORTERO DEL CRUCERO I.* Ver *desarrollos* (n.°63).

142 *–112 m., S. SEPTRIN,* 1. norte Pico del Moro, es. lugar de Bejes, t. m *Cillorigo-Castro,* ee. LUSS, coord. (M) X1.°02'10"O Y43.°12'59" Z1650 m.

143 *–111 m., RED T. DE SOLVIEJO-T DEL RAYO DE SOL.* ver *desarrollos* (n.° 30).

144 *–110 m., SIMA 409,* 1. El Mullir, t. m. *Ruesga,* ee. MUSS, coord. (UTM) X455630 Y4795539 Z678 m.

145 *–110 m., S. DEL TEJO I,* sin. 6-G, l. Pico Ricardo, es. barrio de Llaguno, t. m. *Guriezo,* ee. GEE, coord. (L) X633900 Y965560 Z452 m.

146 *–108 m., C. FRANÇOIS.* Ver *desarrollos* (n.° 21).

147 *–108 m., TORCA 336,* 1. alto de la Porra, ec. Bustablado, t. m. *Arredondo,* ee. SCD, coord, (M) XO.°01'51"E Y43.°15'03" Z1025 m.

148 *–107 m., T. DE CELLARON,* sin. n.° 109, l.Cellarón, t. m. *Voto* ee. MUSS, coord. (UTM) X455230 Y4799090 Z282 m.

149 *–107 m., T. DEL TOMAREDO GRANDE,* l. Las Hoyas, t. m. *Villaescusa* , ee. GJE, SESS, coord. (M) XO.°09'25"O Y43.°21'48" Z230 m.

150 *–105 m., C. DEL JABALI,* sin. c. de Puntapeña, l. alto de la Granja es. lugar de Sámano, t. m. *Castro Urdiales,* ee. OUCC, GELL, coord. (UTM) X477390 Y4800780 Z327 m.

151 *+105 m., C. DE LA LASTRILLA.* Ver *desarrollos* (n.° 16).

152 *–105 m., T. DEL PERRO,* sin. t. del Bermejo, l. y es. aldea de Santa Cruz, t. m. *Rasines,* ee. GAES, coord (M) XO.°16'45"E Y43.°18'01" Z220 m.

153 *–105 m., T. DEL TOMAREDO CHICO,* 1. Las Hoyas, t. m. *Villaescusa* ee. GJE, SESS, coord. (M) XO.°09'25"O Y43.°21'48" Z230 m.

154 *–105 m., LA TORCONA,* sin. Torconal, l. Granja de Santa Eulalia, es. lugar de la Busta, t. m. *Alfoz de Lloredo,* ee. SESS, SEL, coord. (UTM) X403895 Y4801160 Z270 m.

155 *–104 m., T. DEL CEBAL,* 1.El Cebal, t. m. *Rionansa,* ee. SCC, coord. (UTM) X381781 Y4793778 Z188 m.

156 *–104 m., S. LUSA 4-4 bis-5,* sin. L 4-4 bis-5, l. Peña de Lusa, ec. mancomunidad Cañedo-Valcaba, t. m. *Soba,* ee. GSL-SCP.

157 *–104 m., SISTEMA DE LA NEVERA,* sin T 102-103-104, l. depresión de Sara, es. lugar de Bejes, t. m. *Cillorigo-Castro,* ee. LUSS-SEII, coord. (M) X1°02'27") Y43.°12'23" Z1950 m.

158 *–103 m., T. CANAL DE LAYA 56,* sin. CL-56, l. Canal de Laya, ec. Bustablado, t. m. *Arredondo,* ee. ECG, coord. (UTM) X444145 Y4790800 Z805 m.

159 *–103 m., T. DE LOS GARAMICIOS,* sin. Garamicios I, l. Los Garamicios, es. lugar de Bejes, t. m. *Cillorigo-Castro,* ee. ECS, coord. (M) XO.°57'44"0 Y43.°14'49" Z1080 m.

160 *–103 m., S. RN-130,* l. El Extremedo, es. lugar de Ojébar, t. m. *Rasines,* ee. GAES, coord. (UTM) X467947 Y4793500 Z425 m.

161 *–102 m. HOYO DE LLANECES,* sin. El Río Seco, l. LLaneces, es. lugar de Arredondo, t. m. *Arredondo,* ee. SSB, SCD, coord. (M) X0.°05'57"E Y43.°16'53" Z360 m.

162 *–101 m., S. DE LA RASA,* sin. LR-1, l. La Rasa, es. lugar de Astrana/Aja, t. m. *Soba,* ee. SSN, SEII.

163 *–100 m., SIMA A7,* 1. Hoyos Negros, es. lugar de Espinama, t. m. *Camaleño,* ee. ASCh.

164 *–100 m., C. DE CODISERA.* Ver *desarrollos* (n.° 51).

165 *–100 m., T. LAS CORBERAS,* sin. RN-31, l. Hoyo La Canal, es. aldea de Torcollano, t. m. *Rasines,* ee. GAES, coord, (UTM) X469485 Y4792307 Z373 m.

166 *–100 m., S. LUSA 33-34,* sin. L 33-34, l. Peña de Lusa, ec. mancomunidad Cañedo-Valcaba, t. m. *Soba* ee. GSL.

167 *–100 m., T. DE LA RASA 54 Y 110,* sin. LR 54-110, l. La Rasa, es. lugar de Astrana/Aja, t. m. *Soba,* ee. SEII.

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Estudio preliminar sobre una cavidad de gran desarrollo en Sierra Salvada: la Sima SI-44

Diputación Foral de Alava
Consejo de Cultura
Grupo Espeleológico Alavés

RESUM

La boca de l'avenc SI-44 s'obre a l'extrem E. de Sierra Salvada i va ésser descoberta per membres del Grupo Espeleológico Alavés el març de 1983. Es tracta d'un gran col·lector hídric, les galeries del qual s'estenen sota una superficie de 7 km^2., travessant en sentit E.-W. tot el flanc S. de la serra.

L'actual poligonal entrada – fons supera els 9 km. de longitud, per a un desnivell de 230 m. El desenvolupament total de les gàleries explorades (1985) és de 27 km., cosa que situa aquesta cavitat entre les principals xarxes subterrànies de la península.

Les característiques morfològiques de l'avenc, coincideixen amb les d'altres importants cavitats de la serra: zones de meandres actius fortament corroïts, que alternen amb pisos inactius i galeries caòtiques de gran magnitud on predominen els procesos clàstics, abundància de dipòsits de sorra i argila i minsa representació de les formes reconstructives.

RESUMEN

La sima SI-44 abre su boca en el extremo E. de sierra Salvada y fue descubierta por miembros del Grupo Espeleológico Alavés en marzo de 1983. Se trata de un gran colector hídrico, cuyas galerías se desarrollan bajo una superficie de 7 km^2., atravesando en sentido E. -W. todo el flanco S. de la sierra.

La actual poligonal entrada-fondo supera los 9 km. de longitud, para un desnivel de 230 m. . El desarrollo total de galerías exploradas (1985), es de 27 km., lo que sitúa a esta cavidad entre las principales redes subterráneas de la península.

Las características morfológicas de la sima, coinciden con las de otras importantes cavidades de la sierra: zonas de meandros activos fuertemente corrosionados, que alternan con pisos inactivos y galerías caóticas de gran magnitud, donde predominan los procesos clásticos; abundancia de depósitos arcillo-arenosos y escasa representación de las formas reconstructivas.

SUMMARY

The SI-44 chasm opens its mouth at the extreme East of the Salvada range and was discovered by members of the Alaves Speleological Group in march 1983. The chasm is a big hidro-collector wich galleries extend under a surface of 7 Km. 2. Acrossing in an East to West direction all the range's South flank.

The actual poligonal depht entrance surpasses 9 km. in length, for a slope of 230 meters. The total development of the explored galleries (1985) is 27 Km. which places this cavity among the most important subterranean systems in the Peninsula.

The morphological characteristics of this chasm, are coincident with those the other range important cavities: active meanders heavily corrosioned, which are alternated witch inactive seams or levels with chaotic gread sized galleries where clastic processes are predominant; great amount of sand-clay deposits and a small amount of reconstructive forms.

HISTÒRIA I LLEGENDES
HISTORIAS Y LEYENDAS
HISTORYS AND LEGENDS

15202

Inventory of folk narratives connected with caves in the county of Västernorrland, N. Sweden.

Rabbe Sjöberg,
University of Umeà, Sweden.

RESUM

Per encàrrec del consell de govern de Västernorrland, l'autor ha topografiat les cavitats de la regió. Aquesta zona, amb una superfície de 21.780 Km². es troba situada a la part NE de Suècia, entre els 62 i 64 graus de latitud nord.

Si bé l'objectiu primordial d'aquest estudi era el de valorar l'interès que podien tenir les cavitats de cara a la conservació de la natura, també es va tenir present el seu possible interès etnològic. Tant és així, que de 300 cavitats, 42 eren citades en narracions populars (NP). Aquestes NP foren classificades en cinc grups, d'acord amb els criteris d'Aarne i Thompson i situades en un mapa per a observar la seva distribució regional.

Es va poder constatar que les NP eren típiques d'una regió que abans havia estat habitada per una població essencialment agrícola i dedicada a la cacera, amenaçada durant segles, tant des de l'est com de l'oest, per enemics estrangers.

Malauradament, les NP són poc abundats si les comparem, per exemple, amb les que es coneixen al Sud de França; no obstant, reflecteixen les necessitats bàsiques de la població del Nord de Suècia durant els segles XVII al XIX, sovint amenaçada per bandolers i potències estrangeres.

RESUMEN

Por encargo del consejo de gobierno de Västernorrland, el autor ha topografiado las cavidades de la región. La zona, con un área de 21.780 km². está situada en la parte NE de Suecia, entre los 62 y los 64 grados de latitud Norte.

Si bien el objetivo primordial de la investigación era valorar la importancia de las cavidades para la conservación de la naturaleza, también se tuvo en cuenta su posible interés etnológico.

Así, de 300 cavidades, 42 guardaban relación con narraciones populares (NP). Estas NP fueron clasificadas en 5 grupos de acuerdo con las investigaciones de Aarne y Thompson, y situadas en un mapa para observar su distribución regional.

Se constató que las NP eran típicas de una región que fué dominada por una población agrícola y cazadora amenazada durante siglos desde el Este y el Oeste por enemigos extranjeros. Desgraciadamente las NP son poco abundantes si las comparamos con las del Sur de Suecia. Sin embargo reflejan las necesidades básicas de la población del Norte de Suecia durante los siglos XVIII al XIX, salud y paz, a menudo amenazada por forajidos y potencias extranjeras.

SUMMARY

On commision of the county council of Västernorrland the caves in the region have been surveyed by the author. The county with an area of 21.780 km² is situated in the NE parts of Sweden, between the 62th and the 64th N. lat.

The main purpose of the survey was to value the caves for nature conservation, but ethnological aspects should be considered.

Thus, out of 300 caves, 42 caves in the region were associated with folk narratives (FN). These FN were divided into 5 classes according to a classification of FN, based on Aarne & Thompson and plotted on a map to show the regional distribution of the FN.

The FN were found to be typical for a region once dominated by a farming and hunting population which was for centuries threatened by foreign enemies from the east and the west. Unfortunately, the flora of FN is poor compared with that of southern Sweden. However, the FN do reflect the dominant needs of a population in northern Sweden during the 17th to 19th century -peace and health, as threatened by outlows and foreign troops.

Introduction.

On commision of the county council of Västernorrland the caves in the county have been surveyed by the author. The county with an area of 21,780 km² is situated in the NE parts of Sweden, between 62-64° N. lat. The main purpose of the inventory was to value the caves for nature conservancy, but ethnological aspects of the caves should be considered. Thus, the folk narratives (FN) were divided into a classification based on a more general classification of folktales (Aarne & Thompson, 1961).

The FN in the county were found to be typical for a region which once was dominated by a hunting and farming population and which during centuries was threatened by enemies from both the east and the west.

Geomorphological background.

To the east the region is bourdered by the Bothnian Bay.

The topography is very broken, and for Sweden exceptionally high mountains reach all the way down to the coast. Four fairly big rivers cross the region in NW-SE direction. Due to glaciations and postglacial higher stages of the Baltic Sea these river-valleys are separated by mountaineouse forested areas. The bedrock is dominated by old metamorphic geosyncline sediments cut through by granites and Jothnian rocks as dolerite, young feltsparrich red granites and anorthosites. The eastern parts of the region up to 285 m.a.s. was covered by the sea when ice from the last glaciation left the region about 10,000 years B.P.

Culture-historical background.

When the ice melted man entered the region is small hunting comunities, using the waste inland for hunting and the rivers and the lakes for fishing. Agriculture became established early in the fertile coastal soils and about 4,000 years B.P. coastal farming comunities also became established in the region.

In medieval times the river-valleys were inhabited by farmers and in the 13th century the first Christian churches were built in the inland. The large forests were still used only by trappers and hunters. By the beginning of the 17th century the fertile soils around the lakes and the rich grasses in parts of the forests were being used fir the summer-grazing of the cattle in small shielings (Sw. fäbod) way off from the farms along the coasts and in the river valleys. Young girls followed the cattle and watched them in these shielings.

In their isolation they presumed that they were surrounded by lots of supernatural beings. In the following centuries woodcutters started their work in the forests as well as char-coal burners. Even these people presumed that thet were surrounded by supernatural being, who sometimes lived in caves –if indeed the wood-cutter or the settler himself did not live or stay in a cave.

Communications have always been troublesome in the area. In late medieval times we know that a «road» from the capital of Stockholm –far in the south–followed the Bothnian coast. This road was not prepared for wheel– carriges until the beginning of the 17th century. From the outlets of the rivers Indalsälven and Ljungan in the south-east a peregrine-road started which led to the shrine of St. Olof in the cathedral of Nidaros (Trondheim) in norway. Travelling was difficoult in summertime, thus most travelling was done on sledges in the winter. In the remote forests and wild mountains travellers were afraid of robbers who were supposed to live in caves ready to plunder both the travellers and the people in the farmsteads.

The region was located between two waring arch-enemies of the Swedish crown. To the west was the county of Jämtland, which in the 17th century belonged to Norway and Denmark, while to the east, across the Bothnian Sea, was Russia. During the wars the inhabitants often searched for shelter in the caves or hid their treasures in caves. Officers and soldiers who deserted from the armies of bothsides often hid in caves. The last war from which we can date an FN was in 1809. This was also the last war in which Swedish troups fought on Swedish ground.

Classification of cave-narratives

Most of the FN connected with the caves in the region were either previously collected in different folkloristic archives in Sweden, found in books on local history, or were told to me during my interviews with people in the research areas. My purpose was to find out; 1, was there a geological truth in the specific FN or not? In other words, was there a real cave connected with the FN, or not. 2, was the cave big enough to have been inhabited and therefor was it possible to find any «black-earth» or fire-place in the cave, which at least could prove that the cave had been used by man? Finally; 3, was there any regional pattern in the distribution of the different FN?

The cave-narratives were classified according to a classification constructed by Westerdahl (1982) and inspired by the general classification of folktales by Aarne & Thompson (1961). The classification is seen in table 1.

Results

A total of 42 caves in the county were associated with FN. Six of these caves were not found during the field work. The distribution of FN, according to the classification, can be seen in fig, 1 and table 2.

CLASSIFICATION OF FOLK NARRATIVES CONNECTED WITH CAVES IN SWEDEN

1. OUTLAWS.
   - a. «Twelve man in the forest». (migration tale).
   - b. Local robber, theaves, smugglers a.s.o.
   - c. General robber-cave, hinted at in local geographic name.
2. HAUNTS, DWELLINGS
   - a. For a craftsman, shoemaker, tailor a.s.o.
   - b. For devine services.
   - c. For settlers (during the first year /–s).
   - d. Beat hibernating dens.
3. WAR-INCIDENTS
   - a. Refuge for local people.
   - b. Refuge for cattle, food, valuables.
   - c. Refuge for deserter (Swedish or foreign).
   - d. «Snapphane»* cave.
   - e. Cave associated with the rebel Nils Dacke**.
4. SUPERNATURAL BEINGS
   - a. Dwelling for a siren of the woods (Sw.skogsrå
   - b. Dwelling for trolls.
   - c. Dwelling for giants.
   - d. Dwelling for local fairy folks (Sw. vittra).
5. ON THE MORPHOLOGY AND CONTENT OF THE CAVE
   - a. Continuing tunnel.
   - b. The cave ends in another cave.
   - c. And iron-gate stops the passage through.
   - d. Breakdown stops the passage through.
   - e. Secret covered entrance.
   - f. Secret entrance below water.
   - g. Hiding place for troll-gold a.s.o.
   - h. Culture layer in the cave.
   - i. Site of...

NUMBERS OF CAVES CONNECTED TO DIFFERENT TYPES OF FOLK NARRATIVES

I. OUTLAWS

Class	A	B	C
Nr. of	2	11	1

II HAUNTS, DWELLINGS

Class	A	B	C	D
Nr. of	4	3	3	2

III WAR-INCIDENTS

Class	A	B	C	D	E	F
Nr. of	7	1	1	–	–	–

IV SUPERNATURAL BEINGS

Class	A	B	C	D
Nr. of	–	2	1	–

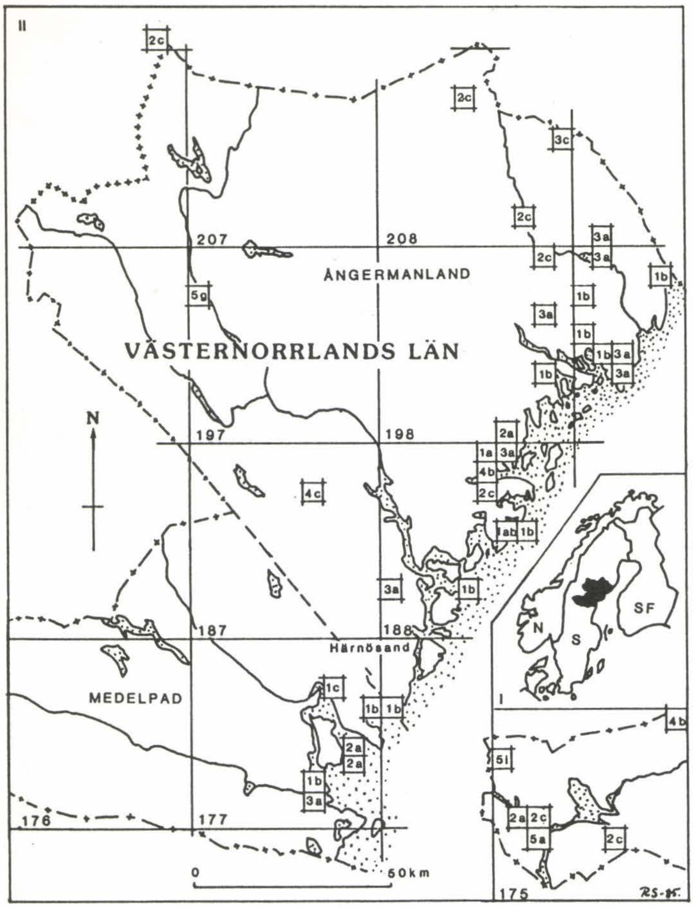
V. MORPHOLOGY AND CONTENT

Class	A	B	C	D	E	F	G	H	I
Nr. of	1	–	–	–	–	–	1	(7)	1

NOTES:

* «Snapphane» was a man in a Swedish gerilla in the 17th century supported by Denmark.

** Nils Dacke was a patriot fighting the new king in the 16th century.



As can be read in table 2 the most common type of FN is that about lokal robbers and smugglers. These FN are common in the more inhabited areas and along the old road from the Capital of Sweden up north along the coast. Most of these FN can be dated back to the 16th and 17th centuries according to several indirect evidence. In many cases these tales have over the years become confused with very old migration-tales.

Another common FN is about how the local people hid in caves and crevices during the raids of the Russian galleys during the wars of 1721 and 1809, when most of the villages and towns along the coast were burnt. These Russian raids have become a «tradition-dominant» in the coastal parts of the research-area. A common theme in these FN is that a child was born during the refuge in the cave and the informant had once been told about this by his/her mother/father who were supposed to have been ancestors of this child. Another theme is that about the silver from the churches in the region which was supposed to have been hidden in caves, and has since then never been found.

Surprisingly few supernatural beings seams to have lived in this region, according to the FN. further south in Sweden this theme is quite common and in the county to the north of survey, several caves seems to have been inhabited by the local fairy folks called «vittra». The «vittra» was the dominant supernatural being in the belief of the people staying in the mountain shielings during the summer.

By the distribution of the different FN (Fig.1) one can see how most of the FN are connected to the early inhabited coastal parts of the region. In the wast, and for long time waste, forested inland very few caves connected with FN are found, except for in the very SW parts of the region. The explanation to this exeption is that this special area is situated close to one of the oldest cultural regions in N. Sweden, the county of Jämtland.

What about the geological evidence in support of the FN? The caves connected with robbers mostly are big enough for a hide-away. Most probably the robbers did not actually live in the caves, but they were perfect hide-aways before and after a robbery.

As many as four caves are mentioned as dwellings. The reason seems to be that the fishermen hid in small caves on the islands along the coast when they were cought by bad weather. In only one case is it quite clear that a cave volontarily has been chosen as a dwelling in modern time. That was a wood-cutter who intermittantly lived in a cave between 1872 and 1875.

Most of the caves and the crevisses connected with war-incidents are big enough to be used as hiding-places and in many cases charcoal is found on the bottom of these caves. This is not a proof of the FN, but a good indication that the cave has been used by man.

Not surprisingly one of the biggest caves in the region is the only one connected with giants. The entrance of this cave is 15 m high and it can be seen from far away. According to the FN trolls have lived in only two caves in the region and in both cases the trolls seem to have been replaced by robbers during the political unstable 16th and 17th centuries.

Conclusions

Folk narratives (FN) are associated with caves all around the world. The types of FN clearly reflects the dominant belief and the historiacal cultural and political situation of the region. In the researched region, the county of Västernorrland in northern Sweden, it is quite clear from the FN that the region in former days was a border country both in political and cultural aspects. The flora of FN is very poor compared to that of southern Sweden, and the different FN reflect the dominant needs of the population –peace and health, as threatened by outlaws and foreign soldiers.

Acknowledgements

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La grotte «Labyrinthe» de Gortyne en Crete

*Anna Petrochilou**
Spéléologue

RESUM

El laberint de Creta al qual es refereix l'antiga mitologia grega, hom considera que es troba a tres llocs diferents de l'illa: Knossos, la cova de Gortis i la cova d'Agias Paraskevi Scotinou.

Els tres llocs justifiquen plenament el per què d'aquesta denominació. En aquest comunicat es fa referéncia a:

1) Opinions dels antics grecs i d'altres savis posteriors d'altres indrets que s'han preocupat per a localitzar el vertader emplaçament del laberint de Creta

2) Informació diversa sobre la cova laberint de Gortynos, després d'exhaustives investigacions, cartografies i altres estudis sobre la mateixa

3) Conclusions que hem tret arrel d'aquestes investigacions a què acabem de referir-nos, en relació amb altres estudis que s'han fet fins avui dia. La major part d'aquests estudis coincideixen en afirmar que la cova havia estat una antiga pedrera d'on s'havien extret les pedres que haurien de servir per a construir les antigues ciutats de Gortis i Knossos. Altres estudiosos, en canvi, han considerat que es tracta d'una cova natural, amb diversos recorreguts que segueixen, alhora, diverses direccions. Queda d'aquesta manera justificada la relació amb l'antiga mitologia grega quan fa referència a Theseus, Ariadne i Minotauros.

RESUMEN

El laberinto de Creta a que se refiere la antigua mitología griega se considera que se encuentra en tres lugares diferentes de la isla: Knossos, la cueva de Gortis y la cueva de Agias Paraskevi Scotinou.

Los tres lugares justifican la razón de este título.

En nuestro comunicado se hace referencia:

1) Opiniones de antiguos griegos y posteriores sabios extranjeros, que se han preocupado por el verdadero emplazamiento del Laberinto de Creta.

2) Informes de la Cueva: Laberinto, Gortynos, después de investigaciones, cartografías y estudios detallados.

3) Conclusiones sobre las mencionadas investigaciones, en relación con cualificaciones que los estudiosos han dado hasta el presente. La mayoría de ellos lo han caracterizado como una cantera de piedra, con la que fueron construidas las antiguas ciudades de Gortis y Knossos. Otros la han caracterizado como una cueva natural con varios recorridos hacia diferentes direcciones. Queda así justificada la relación con la antigua Mitología Griega que menciona Theseus, Ariadne y Minotauros.

SUMMARY

The Labyrinth of Crete, which has been connected with Greek Mythology, has been situated by the Ancient Greek and foreign scientists into three diferent areas: Knossos, the Cave of Gortis, and the Cave Agias Paraskevi Scotinou. All the three areas mentioned above require presuppositions justifying the claming of this title.

In our announcement, we include:

1) Opinions of different Greek and foreign specialized scientists, who have dealt with it at various times.

2) Description orf the Cave «Labyrinth» of Gortis, after a specified investigation, Mapping and study.

3) Aspects and conclusions, which took place in our above investigation, according to the characterisms which the investigators have given us so far. It was characterized, by some of them, as a stone-quarry from whose stones the Ancient city Gortis and Knossos were built, and by some others, as a natural Cave with a lot of passages and crossings which has been connected with the Ancient Greek mythology and also with Theseus, Ariadne, and the Minotaur.

LIEU ET MYTHOLOGIE

Le «Labyrinthe» de Crête, qui est lié à la mythologie ancienne, a, depuis des centaines d'années, préoccupé de nombreux scientifiques grecs et étrangers, en particulier à propos des questions qui concernent son site et sa création. Il a été situé dans trois endroits différents: à Cnossos, dans la grotte de Gortyne et dans la grotte d'Aghia Paraskevi Scotinou. Tous ces sites sont suffisamment justifiables. Diodore le Sicilien raconte, à propos du Labyrinthe de Cnossos, que Dédale, au cours de sa route vers l'Egypte, fut émerveillé par la construction artistique du Labyrinthe et, qu'à son retour à Cnossos, il fit construire un Labyrinthe similaire pour Minos, le Roi de Crête.

PLINE dit que sa dimension est d'environ cent fois la taille du Labyrinthe égyptien et *SAVARY* mentionne que le Labyrinthe de Cnossos était déjà démoli au temps de Pline.

TZETZES quant à lui dit que le Labyrinthe était une prison de laquelle personne ne pouvait s'échapper à cause du fait que ses innombrables circonvolutions étaient semblables à la coquille d'un escargot.

POCOCKE croit que le Palais de Minos n'était pas autre chose que le Labyrinthe. CLAUDIN distingue le Labyrinthe de Gortyne du Labyrinthe de Cnossos, en écrivant que «le Labyrinthe de Gortyne était la résidence permanente du Minotaure». CLAUDIUS CLAUDIANUS est du même avis (voir De Sexto Consulatu Honorii, 4ème-5ème siècle ap. J.-C.).

CEDRENUS ajoute: «Le Minotaure s'est caché dans les profondeurs d'une grotte aux cent circonvolutions».

MALLALAS (5ème siècle ap. J.C.) dit, entre autres choses, que Minos a donné l'ordre à Thésée de tuer le Minotaure, fils de sa femme Pasiphae et de Taurus le Maniaque, dans l'espoir que Thésée serait tué lui-même. L'amour anormal de Pasiphaé pour Taurus avait été créé par le Dieu Poséidon, de cette façon Minos pouvait être puni pour ne pas avoir sacrifié le taureau qu'il avait promis à Poséidon. Le Minotaure avait l'habitude de vivre dans les profondeurs d'un grotte horrifiante et complexe appelée «Labyrinthe». Ariane, la fille de Minos, donna une corde et un épée à son bien-aimé Thésée afin de le sauver. Àprès un combat mortel, Thésée tua le Minotaure et, à l'aide de la corde, il réussit à sortir de la grotte en vainqueur.

LITHGOW confond le Labyrinthe de Cnossos avec celui de Gortyne.

Caracteristiques de la formation du Labyrinthe de Gortyne

Le Labyrinthe de Gortyne a été caractérisé par certains comme une mine de pierre avec laquelle ont été construites les cités anciennes de Gortyne et de Cnossos. D'autres croyaient que la grotte avait été ouverte naturellement.

Au cours de leur visite dans cet endroit, les scientifiques BELON (1553), THENET (1575), BAROZZI (1577), RADZIVIL et QUERINI (1583), COCKERELL et SONNINI (1779) et SIEBER (1818) l'on déterminée comme étant une mine de pierre et ZUALLARDO 1586, BOSCHINI 1650, POCOCKE 1739. Dans un discours qu'il a donné au cours du Meeting des physiciens allemands à Venise en 1832 au sujet du Labyrinthe de Crête, OSTIN DE PROCKESH dit que la grotte est située sous Gortyne et il pense que c'était autrefois un cimetière qui a été découvert durant les années du règne égyptien. F. FRAULIN (1845) qui a étudié la région de la grotte et, géologiquemement, la cave elle-même, déclare: «On monte d'abord sur des marnes grisâtres qui renferment un grand amas de gypse minéral, peu fréquent dans l'île, puis on arrive sur des bancs de calcaire grossier et jaunâtre, au milieu desquels se trouve l'entrée. Au-dessus de l'entrée un banc de calcaire grossier et blanchâtre, avec des empreintes de coquillages marins. La colline est formée par d'autres calcaires grossiers plus ou moins durs et, de son sommet, on voit qu'elle fait partie de la terrasse tertiaire placée au devant des basses pentes du Psiloriti, dont elle est souvent séparée par des vallons.

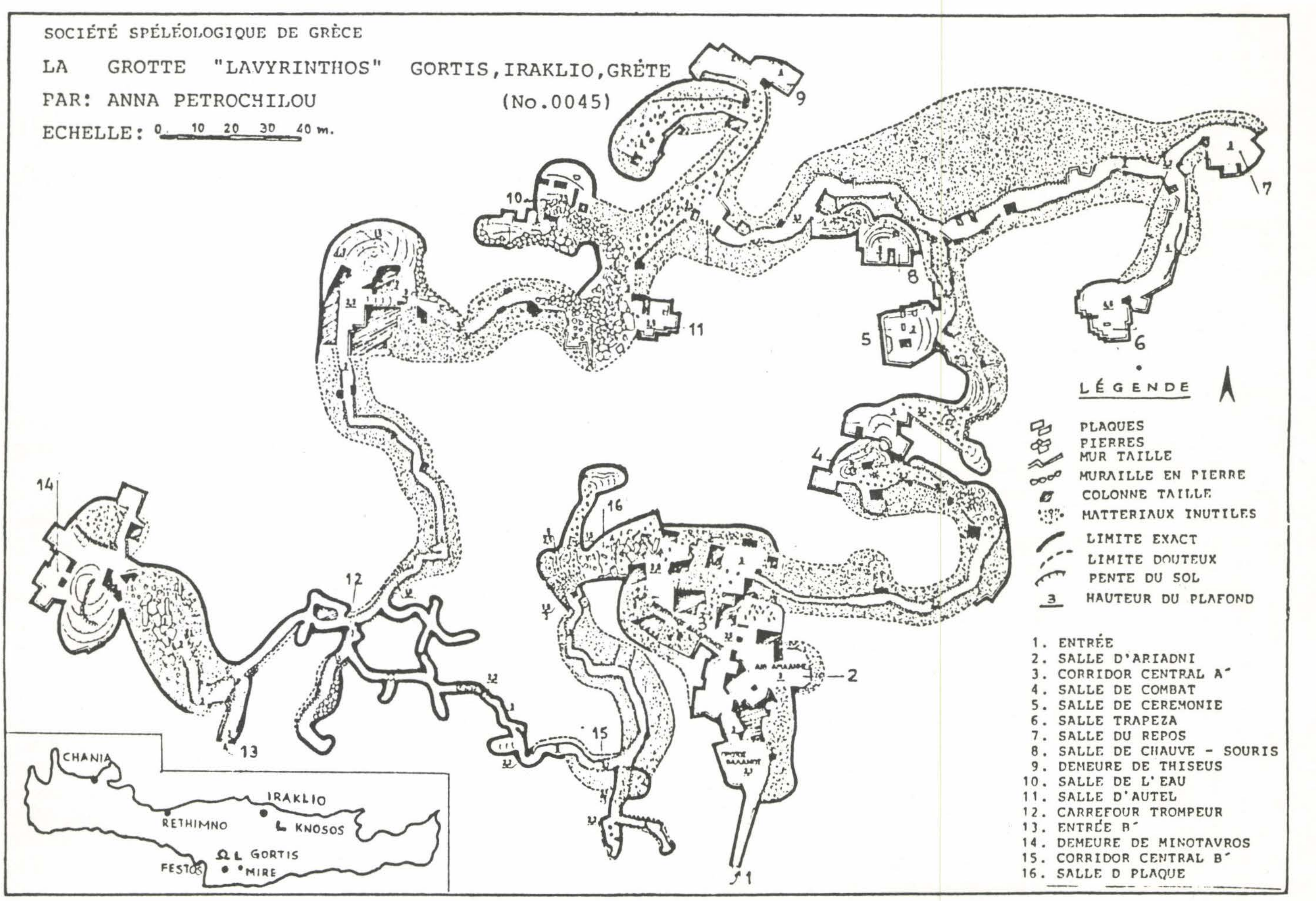
L'entrée du Labyrinthe, practiquée dans des bancs de calcaire grossier un peu sableux et jaunâtre, est surmontée immédiatement par un banc de calcaire sableux, grossier et jaunâtre, avec des empreintes de coquillages, suivi de plusieurs autres variés dans leur grain»...

Le sommet de la colline est formé par des calcaires grossiers et jaunâtres, tantôt durs en lits minces, et tantôt en partie grenus, avec de petits cailloux talqueux, en bancs assez épais».

...«Les salles ont leurs parois bien taillées qui sont généralement fort sèches. La roche est un calcaire grossier et jaunâtre renfermant des grains de sable dont la stratification d'abord assez distincte, l'est beaucoup moins dans des parties profondes, où les bancs d'abord peu épais le deviennent beaucoup plus».

Et il conclut: «Toutefois, s'il est vrai que l'on ne trouve pas, dans les collines de maciguo et de calcaire gris qui dominent Gortyne, de bonnes pierres de taille, il n'est past exact que l'église soit construite avec la pierre ordinaire du Labyrinthe, car c'est un calcaire grossier et jaunâtre avec des grains pisolithiques que je n'y ai pas rencontrés». Et il ajoute: «Il serait encore important..., et de vérifier l'origine naturelle ou artificielle du fameux Labyrinthe de Gortyne».

Pour continueeer, nous mentionnons, par ordre chronologique de leurs visites, les scientifiques qui croient que le Labyrinthe de Gortyne est une grotte naturelle dont les petites salles ont été agrandies il y a quelques siècles par d'excellents artistes qui ont également surélévé le plafond en enlevant ses couches de pierres qui étaient placées horizontalement le long l'épaisseur de la montagne. Ils ont mis au jour une partie des parois verticales et mis de côté la plupart des pierres qui gênaient le passage. Ces scientifiques étaient: RANDOLPH (1687), TOURNEFORT (1700), MAIHOWS (1750), SAVARY (1779), FABREGUETTES (1834), SCOTT (1834). Finalement P. FAURE (1958) place le Labyrinthe mythique dans le site d'Aghia Paraskevi à Scotinou près d'Héraclion, appuyant son point de vue sur les découvertes qu'il a faites lui-même et sur les trouvailles des fouilles conduites par EVANS, PENTLEBURY et DAVARAS ainsi que sur les formations de stalagmites qu'ils y ont trouvées, qui rappellent une des formes humaines qui ont été améliorées par l'homme. Il est aussi établi qu'il existe même une stalagmite qui a la forme d'un animal à quatre pattes et qui, probablement, représente le Minotaure. A part ces découvertes, la grotte d'Aghia Paraskevi est ouverte en étages successifs, divisés en sections par des formations de stalagmites, créant ainsi des couloirs complexes.



Cartographie

La reproductiones sur carte d'un plan de la grotte «Labyrinthe» a été enterprise par COCKERELL et SIEBER. La carte de COCKERELL, publiée en 1820, est incomplète. La carte de SIEBER, publiée en 1821 est meilleure. Sur sa carte, SIEBER emploie des noms de sa propre invention pour désigner les différentes sections de la grotte, la plupart d'entre eux ayant été inspirés de la Mythologie grecque ancienne et ayant une relation avec Thésée, Ariane et le Minotaure. Nous avons conservé et complété ces noms.

Site de la grotte

La grotte Labyrinthe de Gortyne est située au sud-ouest des contreforts du Mont Ida (montagne du Psiloritis en langage usuel), à une hauteur de 413 m. Pour l'atteindre, il faut partir d'Héraclion vers le village de Kastelli, en empruntant une route asphaltéete de 57 kms de long qui est prolongée par un chemin de terre de 3.800 m de long qui mène jusqu'à l'entrée de la grotte.

Selon le Professeur N. Symeonides «la pierre qui couvre la région du Labyrinthe date de l'époque mésomiocénique et contient, par alternances régulières, des couches d'argile d'eau douce grise et verdâtre, avec quelques sections d'asbestes datant aussi de l'époque mésomiocénique. Les plâtres qui existent au nord du village de Kastelli datent également de l'âge mésomiocénique».

La grotte

Les couches de pierres, dans lesquelles la grotte est ouverte, sont totalement horizontales et consiste en une sorte de pierre que nous avons déjà mentionnée plus haut. Dans de nombreuses parties du sol il existe des plaques qui se sont détachées du plafond et qui sont tellement symétriques qu'elles donnent l'impression d'avoir été faites par l'homme. Ces couches de pierres horizontales ont créé la cavité presque entièrement horizontale de la grotte, avec quelques déviations.

Ses parties accessibles ont une surface de 8.900 m^2. La longueur de ses couloirs complexes est de 2.470 m. Les grecs anciens ont tiré avantage de certaines de la plupart des sections favorables de la grotte, creusant artistiquement ces sections en salles de formes et de dimensions différentes. Jusqu'à présent nous n'avons pas d'indications quant à l'utilisation de ces pièces. Elles étaient peut-être utilisées pour des activités diverses, en tant que lieux de culte et de mystères, ou d'amusement, de rencontre, etc... La recherche archéologique répondra à ces questions. Toutes les salles sont reliées entre elles par des couloirs étroits ou plus larges, dont les parois creusées ont été renforcées par endroits avec des pierres enfoncées qui retiennent les matériaux inutiles mis à jour au cours du creusement des parois. Ces matériaux couvrent de larges parties de la grotte et restent inaccessibles encore de nos jours. Il existe aussi des colonnes sculptées qui supportent le plafond.

La supposition que la grotte est une mine de pierres souterraines, avec lesquelles les cités anciennes voisines de Gortyne et de Cnossos ont été construites, n'est vraisemblablement pas correcte pour les principales raisons suivantes:

1) Ainsi que nous l'avons déjà mentionné, la grotte est complexe dans sa forme et couvre une large région.
2) La plupart de ses salles sculptées sont à une grande distance de l'entrée et à une grande distance l'une de l'autre.
3) Par les étroits passages existant dans la grotte, et qui ont des parois de pierre et un sol irrégulier dont la largeur dans certains endroits est de seulement 1 – 1,5 m, il n'aurait pas été possible de déplacer vers l'entrée de la grotte les grandes et lourdes pierres naturelles et sculptées, en particulier si l'on considère qu'à cette époque les hommes n'avaient à leur disposition que des outils primitifs pour les aider à soulever les choses.
4) L'entrée de la grotte est à une distance d'une heure de la cité ancienne de Gortyne sur une pente plutôt escarpée et sauvage du Mont Ida, à 220 m de hauteur et sans route pour y accéder. Comment pouvait-il alors être possible, à cette époque, dans de telles circonstances primitives, de déplacer de grandes et lourdes pierres quant TOURNEFORT dit: «Il était même difficile pour un homme d'atteindre l'entrée à dos de cheval»?
5) Puisque la colline entière où la grotte est ouverte, ainsi que toute la région de Gortyne, est couverte par la même sorte de couche de pierre, il aurait été logique pour nous de conclure en disant que les matériaux de construction, pour n'importe quel besoin d'édification de l'époque, auraient été plus faciles à trouver et à prendre directement dans la région de Gortyne, cette solution étant plus facile et plus économique.

Conclusions

Le Labyrinthe de Gortyne que nous avons prouvé être une grotte ouverte naturellement et techniquement améliorée par l'homme, et qu'il soit le Labyrinthe mentionné dans la Mythologie grecque ancienne ou pas, est d'une grande importance au niveau international, à la fois à cause de sa vaste région et de sa formation sur des couches horizontales de pierres, et aussi à cause de l'admirable élaboration artistique de certaines de ses sections par les hommes d'un âge lointain, dans des conditions qui, même aujourd'hui, seraient considérées comme diffiiciles et dangereuses pour la santé humaine.

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Contributo alla conoscenza di Salvatore Ravecca (XVII sec.), precursore della speleologia scientifica

*Matteo Barbagelata**
Centre Studi per l'Ecologia del Quaternario

RESUM

Aquest article versa sobre la personalitat i el treball de Salvatore Ravecca (o Raveca), considerat per Michele Gortani com el precursor de l'espeleologia científica.

La primera part descriu la seva breu vida escolar, basant-se en l'escassa informació que se'n té i ressalta el fet que encara no s'ha investigat a fons la seva vida.

La segona part s'inicia amb una aproximació històrica dels moments que van envoltar la seva vida escolar (finals del 1.500 i principis del 1.600), intentant subratllar el caràcter científic de les seves observacions naturalístiques sobre els fenòmens càrstics de la Ligúria occidental (Itàlia), i en particular, la seva intuïció respecte a la relación existent entre la sorgència marina d'aigua dolça de Cadimare i les cavitats que s'obren, aproximadament, a 7 km. d'aquesta ciutat en un promontori situat a la part oriental del golf de La Spezia.

RESUMEN

El comunicado ilustra el carácter y el trabajo de Salvatore Ravecca (o Raveca), considerado por Michele Gortani como el precursor de la espeleología científica.

La primera parte describe la breve vida escolar, basada en la escasísima información que poseemos, resaltando también el hecho de que todavía no se ha investigado a fondo sobre su vida.

La segunda parte, se inicia en las consideraciones históricas en las cuales vivió el escolar (finales del 1.500, principios del 1.600), se intenta subrayar el carácter científico de sus observaciones naturalísticas sobre los fenómenos kársticos de Liguria occidental (Italia), particularmente su intuición sobre el enlace existente entre la surgencia marina de agua dulce de Cadimare, y las cavidades abiertas aproximadamente a siete kms. de distancia de esta ciudad, en el promontorio oriental del Golfo de La Spezia.

SUMMARY

The report illustrates the character and work of Salvatore Ravecca (or Raveca), considered by Michele Gortani as the forerunner of scientific speleology.

The first part describes the scholar's short life, based on the extremely scarse information we have, also keeping in mind the fact that no exhaustive research on his life has ever been carried out yet.

The second part, starting from historical considerations on the period when the scholar lived (end of 1.500, beginning of 1.600), intends to underline the scientific character of his naturalistic observations on the karst phenomena of Eastern Ligury (Italy), particularly his intuition of the link existing between the Cadimare sea spring of fresh water and the cavities opening nearly seven kilometes far from that site, in the Western promontory of the Gulf of La Spezia.

Le scarse notizie in nostro possesso non ci permettono di avere una chiara immagine dello studioso secentesco. Pur tuttavia si riesce palesemente a scorgere una personalità ricca di intuito che tende ad avvicinarsi sempre più a considerazioni prive di pregiudizi, considerazioni basate sú osservazioni in sito.

La ricerca di queste poche notizie è stata effettuata da Ubaldo Mazzini, storico locale, che l'ha raccolta e ordinata in un articolo apparso nel 1919 sul Giornale Storico della Lunigiana. Da questo si può desumere con una certa sicurezza che il Ravecca nasce il 26 dicembre del 1582 presso un piccolo gruppo di case detto Vissegi (o Visseglì) poco sopra alla località La Foce, nel comune della Spezia (Liguria orientale), da umile famiglia. Diviene dottore in legge a dal 1607 al 1608 tiene a Marinasco l'ufficio di vice curato. Si occupa di scienze storiche e umanistiche scrivendo la biografia di Bartolomeo Facio, umanista locale del XV secolo, che purtroppo non sarà pubblicata. Si dedica anche alla poesia, lasciandoci un solo piccolo elogio in tre versi che dice:

Praebuit inde suum recitantibus aula tenorem.
Blaxia Pontificis Romani et Caesaris olim.
Quae fuit hospitium variis domus inclyta factis

Sembra sia stato composto in occasione dell'apertura di un teatro da parte della famiglia Biassa che pare avesse ospitato nel propio palazzo l'imperatore Carlo V e i pontefici Clemente VII e Paolo III. Ma purtroppo, vista la misera quantità di scritti pervenutici, è assai arduo valutare il livello della sua poetica.

Una delle più attendibili note che riconoscono il Ravecca come personaggio di eccelsa erudizione è quella lasciataci da Antonio Maria (1601-1662) discendente diretto della famiglia Ravecca, nota apposta al margine dell'atto di nascita di Salvatore, che dice: «Salvator infrascriptus litterarum humanarum maxime poetices eruditissimus juris doctor et presbiter factus obijt aetatis suae trigesimo tertio maximo cum Populi ac Spediae merore ob opus imperfectum ab eodem relictum rerum gestarum a Bartolomeo Faccio spediensi serenissimae Genuensis Reipublicae a secretis, quod opus typis edidisset nisi morte preventus ad altiorum contemplationem evocatus eset».

Lo studioso, considerando la data di sepoltura riportata nel libro dei morti della Pieve di Santo Stefano, sarebbe morto nel luglio del 1612, quindi alla giovane età di ventinove anni. Sempre dal libro dei morti si desume che la sua fine non è per morte improvvisa, ma in seguito a lunga malattia.

Dovendo discutere l'opera del Ravecca, a questo punto è essenziale esaminare il suo discorso intorno all'idrologia sotterranea del promontorio occidentale del Golfo della Spezia. Per giudicarlo è indispensabile riportarlo nella sua veste integrale, considerato anche il fatto che è proprio da questo, dall'autore comunicate oralmente ad Ippolito Landinelli che ce lo ha tramandato sotto forma di manoscritto, che dipende l'attribuire allo studioso il titolo di precursore della speleologia scientifica.

Si riporta quindi, in una forma un po' più leggibile (si è sistemata una punteggiatura più idonea), como segue: «E» da sapere che tutto quel territorio si divide in due sorti di terreno: uno che volgarmente chiamano morto, per sua natura leggiero ma denso e senza spiracoli ovvero siti concavi e sotterranei; e l'altro vivo, tutto cavernoso e adorno di pietre vive nominate tuffi, di grotte e fontane, in modo abbellite solamente dalla natura che con le vaghe e deliziose colature d'acque rendeno non poco gusto a chi col benefizio del lume si diletta vagheggiarle entro le viscere più intime di quei monti. Tale è la Bocca Lupara, caverna sotto un monte che cammina gran spazio, e più basso nello stesso luogo un'altra amenissima fontana che nel supremoliminare ha inscritte queste parole: Nympharum domus; ambedue le quali stillano acqua limpidissima e freschissima e danno agevole comodità di andare a piano sotterra, di calare a scendere per molto spazio e di vedere la varietà di quei luoghi cavernosi e sotterranei, oltre a tante altre simili che per brevità si tralasciano.

Dalla parte adunque del terreno vivo, scendendo, per le viscere ascoste della terra, impetuosamente detto fiume al mare, è necessario che abbia il suo principio cinque o sei miglia e forse più dal suo fine e che scorrendo da quei luoghi cavernosi e sotteranei tanto maggiormente cresca, quanto che dalle diverse scaturigini d'acqua e molto più dalle abbondanti pioggie è riempito. E per prova di questa congetturata verità si può addurre che in tempo di pioggia e gran venti, mentre il fiume più è rapido e furioso, passando sopra Carpena verso Rimaggiore e stando ivi con le orecchie attente vicino a terra, si sente romoreggiare in maniera sotto a piedi nel profondo delle terrestri viscere, che probabilmente fa credere passarvi qualche fiume. Oltrechè la moltitudine delle cavernose e spesse fontane che derivano in diverse valli vicine a' monti per mezzo de' quali si è detto che passa il fiume sotterraneo, ciò dimostrano con le vene d'acqua che como per condotti vanno naturalmente penetrando per quei tuffi, onde se ne arguisce la prima causa dallo stesso fiume e massime che in abbondanza di pioggie egualmente ingrossano data la proporzione e si turbano le acque di esse fontane, come e per pioggia e per venti giunge quella del fiume torbida al mare.

Potrebbe anco essere che siccome ordinariamente quella bocca di spelonca detta Zigori, vicino a S. Benedetto del Montale, ha, per quanto si congettura da molti segni, corrispondenza colla sprugora nominata di Maggiola, che è questa in fine del piano della Spezia, così metre straordinariamente dalla piena dell'acqua viene accresciuta detta bocca di Zegori possi facilmente, per luoghi sotteranei, somministrar acqua, legnami e cose simili che essa va ingorgando al detto fiume che poi vicino a Marola sotto la nouva fortezza di S. Geronimo scarica nella marina. E ciò si può vedere perchè la sprugora di Maggiola non è atta a ricevere tanta materia e per la strettezza delli meati che la conducono e per l'ampiezza delle circonvicine caverne sufficienti a capire essa materia e maggiori cose; sicchè non è se non da tener per fermo ch'essendo tutti quei luoghi, como s'è detto, cavernosi, di tanti rivoli, scaturigini e torrenti sotterranei sia causato esso fiume scaricato poi dalla propria natura di quei luoghi a mezzo del mare».

El discorso si può schematizzare nel seguente modo:

1. Distinzione e descrizione geomorfologica del territrio;
2. Escursione in alcune cavità dell'area carsica con osservazione dei fenomeni relativi in esse presenti;
3. Ipotesi circa la genesi di un corso idrico sotterraneo che termina in mare;
4. Prima giustificazione dell'ipotesi basata su osservazioni indirette del corso idrico sotterraneo tramite mezzo acustico;
5. Seconda giustificazione dell'ipotesi basata sulla constatazione dell'esistenza di numerose cavità presenti in sito, che costituirebbero condotti naturali, e l'interconnessione che esisterebbe fra le sorgenti carsiche e l'esutore marino più evidente;
6. Ipotesi circa l'idrografia sotterranea del succitato corso idrico;
7. Proposizione conclusiva che ribadisce le ipotesi sulla genesi e l'idrografia de corso idrico.

Si nota dunque che il momento teorico inserito nella dialettica del metodo sperimentale, tenderebbe ad essere suffragato dalla verifica scientificamente valida, ma non riesce a per questo resta evidente che le ipotesi, basate indiscutibilmente su belle intuizioni, sono giutificate ma non teorizzabili.

Pagie manoscritte da Ippolito Landinelli sulle quali appare il discorso di Salvatore Ravecca intorno all'idrologia sotterranea del promontorio occidentale del golfo della Spezia.

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= Nimpharum Domus:
ambedue le quali stillano acqua limpidissima, e
freschissima, e danno agevole comodità di
andare a piano sotterra, di calare, e ascendere
per molti spazio, e di vedere la varietà di quei
luoghi cavernosi, e sotterranei, oltre a tante
altre simili, che per brevità si tralasciano.
Dalla parte dunque del terreno vivo stenden-
dosi per le viscere nascoste della terra im-
petuosamente detto fiume al mare è ne-
cessario, che abbia il suo principio, 5. o 6.
miglia, e forse più dal suo fine, e che scor-
rendo in quei luoghi cavernosi, e sotterranei
tanto maggiormente creschino, quanto che
dalle diverse scaturigini d'acqua, e molto
più dalle abbondanti piaggie è riempiuto
e per prova di questa congetturata verità
si può addurre, che in tempo di pioggia,
e gran venti, mentre il fiume più è rapi-
do, e furioso, passando sopra Carpena
verso Rimaggiore, e stando ivi con le orec-
chie attente vicino a terra si sente ro-

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fino alla Trava in alto, sebbene non è molta acqua
rigonfia, e bolle quando per spirano venti di mare
Ma circa l'origine, e proprietà di queste acque,
ho giudicato sia bene, che io trascriva qui un
ingegnoso discorso, che vi ha fatto sopra il Dottor
Ravecca di quella terra persona che come ho
detto si diletta di belle lettere, ed è molto mio
ambrevole, che comincia così =
È da sapere che tutto quel territorio si divi-
de in due sorti di terreno, uno che volgarmente
chiamano morto per sua natura leggiero, ma denso,
e senza spiraroli, ovvero siti concavi, e sotterra-
nei, e l'altro vivo tutto cavernoso, e adorno di
pietre vive nominate tuffi, de grotte, e formate
in modo abbellir solamente dalla madre na-
tura, che con le vaghe, e delizziose colature di
acque rendono non poco gusto a chi con benefizio
del lume si diletta vagheggiarle entro le
viscere più interne di quei monti, tale è la
bocca Lugara, e più basso nello stesso luogo
un'altra amenissima fontana, che nel supre-
mo liminare ha inscritte queste parole. =

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moreggiare in maniera [illegible] a piedi nel pro-
fondo delle terrestri viscere che probabilmente
fa credere passarvi qualche fiume, oltrecchè
la moltitudine delle caverne, e spesse fonta-
ne che derivano in diverse valli vicine a
monti per mezzo de quali si è detto, cha-
[illegible] [illegible] sotterraneo, ciò dimostrano
[illegible] [illegible] d'acqua che sono per condotti con-
[illegible] [illegible] sotterranei per quei tuffi —
[illegible] [illegible] [illegible] la prima [illegible] dello
[illegible] fiume e [illegible] [illegible] [illegible]
[illegible] [illegible] egualmente [illegible], [illegible]
la [illegible] [illegible] turbano le acque di
[illegible] [illegible] [illegible] [illegible], e [illegible]
[illegible] [illegible] del fiume torbido nel mare,
[illegible] [illegible] essere [illegible] [illegible] ordinaria-
mente nella bocca di spelonca detta Zegori
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] si [illegible] [illegible] [illegible] cor-
rispondenza con la Sprugora nominata
di Maggiola [illegible] [illegible] [illegible] [illegible]
della Sprugola [illegible] [illegible] [illegible]

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dalla piena delle acque viene accresciuta
detta bocca di Zegori, possi facilmente per
luoghi sotterranei somministrar acqua, le-
gnami, e cose simili, che essa va ingorgando
al detto fiume, che poi vicino a Marola
sotto la nuova fortezza di S. Geronimo
scarica nella marina, e ciò si può vedere
perche la sprugora di Maggiola non è
atta a ricevere tanta materia, e per la
strettezza delli meati che la conducono e
per l'ampiezza delle circonvicina caverna
sufficienti a capire essa materia, e mag-
giori cose; sicche [illegible] non da tener
per fermo, che essendo tutti quei luoghi
a mezzo il mare, ma di tutte le parti
della Liguria, o per avventura della Tos-
cana niuna è che pareggi il territorio di
Massa, e di Carrara, anzi le due terre stes-
se, peroché nessuna cosa si può vedere
nè più amena, nè più vaga nè delizziosa di
queste.
Di Massa fa menzione il Petrarca

TOPOGRAFIA, FOTOGRAFIA I REPRESENTACIÓ

TOPOGRAFIA, FOTOGRAFIA Y REPRESENTACION

TOPOGRAPHY, PHOTOGRAPHY AND REPRESENTATION

15228

Vorschläge und Gedanken Zur Digitalisierung von Daten Über Raumformen und Höhleninhalt

Günter Stummer
Wien

RESUM

En aquest treball s'examinen una sèrie d'idees i propostes per a la computerització d'informacions sobre les formes dels recintes i de les galeries de les cavitats, dipòsits i altres dades de treballs científics així com la seva conexió i correspondència directes amb les dades de les topografies. D'aquesta manera hom podria disposar d'una sèrie de dades d'interès de forma clara i ràpida per a qualsevol tipus de consulta.

RESUMEN

En este trabajo se examinan ideas y propuestas para computerización de informaciones sobre formas de recintos de galerías de cavidades, depósitos de cuevas y datos de trabajos científicos y su conexión y correspondencia directas con los datos de las topografías. De este modo los datos estarían disponibles de forma clara y rápida para cualquier tipo de consulta.

SUMMARY

This paper is a description of thougts and proposals to compute all informations about de figures of cave passages, cave deposits and dates of scientific works and connect and store them directly together with the cave survey data. By this way the dates could be avaiable very fast and clearly arranged for all kinds of questions.

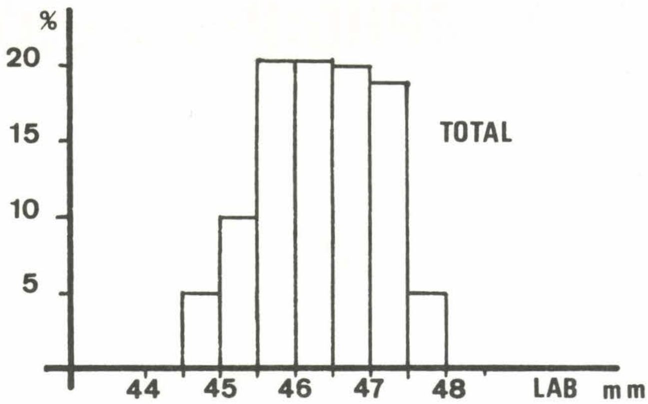
A. Einleitung

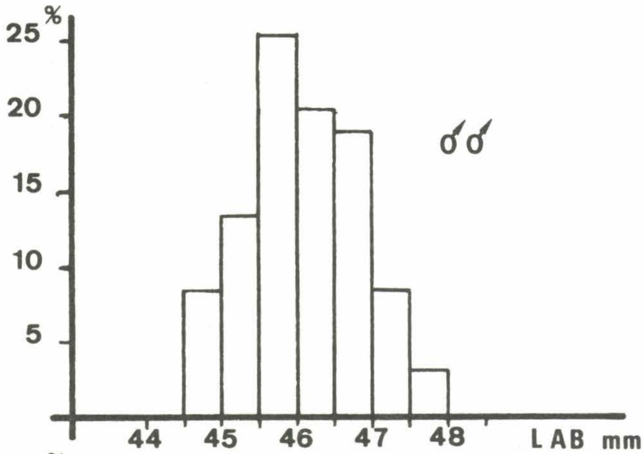
Grundsätzlich sind derzeit alle Informationen über Raumausformung und Höhleninhalt in drei Dokumenten enthalten, in graphischer Form am Höhlenplan, in verbaler Form in Raumbeschreibungen und Berichten und letztlich auf Fotos. Bei kleineren Höhlen wird diese Art der Informationsdokumentation völlig ausreichen, sich einen Gesamtüberblick über die Höhle zu verschaffen. Bei großen Höhlensystemen wird es jedoch überaus schwierig, die graphisch und verbal vorliegenden Informationen überhaupt noch zusammenschauend zu überblicken und hisichtlich bestimmter Fragestellungen Aussagen zu treffen. Dies vor allem schon deshalb, weil es bei derart großen Höhlen kaum mehr eine Einzelperon gibt, die aus eigener Anschauung alle Höhlenteile kennt, weil sich die Erforschung über Jahrzehnte entreckt und were bei solchen Höhlen in der Regel auch die vertikale Darstellung (Aufriß oder Längsschnitt) fehlt oder nur sehr schematisch vorliegt. Es wurden daher in den letzen Jahren immer wieder Überlegungen angestellt, diesen Mangel an raschem und übersichtlichem Zugriff auf die Informationen über Raumausformung und Höhleninhalt zu verbessern. Einen solchen Ansatz haben etwa KASPEREK, PAVUZA und TRAINDL (1985) mit einem Fomular gesetzt, auf dem in geordneter und übersichtlicher Weise bereits vorgegebene Stichwörter zum Höhleninhalt und zur Raumform angekreuzt werden können. Dieses Formular wird derzeit in einigen Höhlen getestet und stellt sicherlich einen wertvollen Beitrag für einen nutzungsorientierten Zugriff auf diese Informationen dar. Dadurch erfolgt auch bereits ein erster Schritt zur Aufbereitung verbaler Informationen.

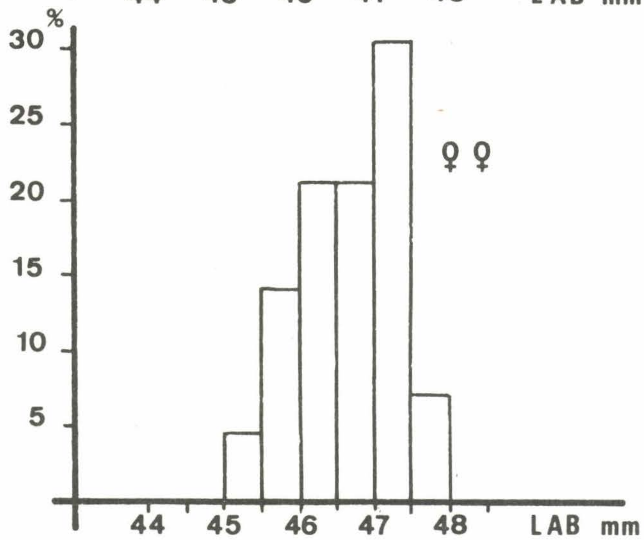
Ein wesentlicher Schritt, nämlich die Raumbezogenheit all dieser Informationen, wie sie auf graphischem Weg am Höhlenplan in durchaus zufriedenstellender Weise realisiert ist, ist damit jedoch noch nicht vollzogen. Eine solche Lageverortung macht aber den Einsatz der Datenverarbeitung und den räumlichen Bezug der Informationen zueinander erst möglich und sinnvoll. Dadurch stünden diese Informationen rasch, verknüpfbar und übersichtlich zur Verfügung.

B. Erfassbare informationen

Als eindeutiger Lagebezug der einzelnen Informationen innerhalb einer Höhle kann nur der Vermessungszug herangezogen werden. Es ist daher sinnvoll, alle erwünschten und erhebbaren Informationen direkt in Form geeigneter Codierungen an die Vermessungsdaten zu knüpfen und mit diesen abzuspeichern. Dies scheint umso leichter realisierbar, als die Meßdaten riesiger Höhlensysteme heute in zunehmendem Maß ohnehin bereits mit Computereinsatz bearbeitet werden und es daher vorwiegend um eine möglichst rationelle Erhebung und Aufbereitung der Informationen geht. Dadurch stünden die einzelnen Informationen nicht nur zueinander in einem exakten (der Vermessungsgenauigkeit entsprechenden) Lagebezug, sondern auch, soferne die Höhle exakt eingemessen ist, mit der Oberfläche. Die einzelnen Informationen über Höhleninhalt und Raumform ließen sich daher durch Nutzung der Punktkoordinaten und Codierung der Information digitalisieren und wären damit einer EDV-Bearbeitung zugänglich. Allerdings bedarf es vorest einer genauen Analyse, welche Informationen dafür in Frage kommen und welche auch weiterhin ausschilieβlich dem Höhlenplan vorbehalten bleiben können. Sinnvoll erschiene dies nur bei solchen, die zur Durchführung von Aussagen einer übergeordneten Zusammenschau bedürfen. So ist in diesem Zu-







sammenhang sicherlich die Frage berechtigt, ob etwa die Codierung der Sedimente, wie es auf Abbildung 1 dargestellt ist, sinnvoll ist oder ob in diesem Fall nicht eine zusammenfassende, verbale Charakterisierung optimaler ist. Grundsätzlich könen zwei Gruppen von Informationserhebungen unterschieden werden:

1. Informationen, die schon bisher auf guten Höhlenplänen und in Raumbeschreibungen enthalten waren. Diese Informationen müßten direkt vom Vermessungsteam miterhoben werden, da eine nachträgliche Rekonstruktion des Meßzuges in der Höhle in der Regel zu aufwendig wäre. Für eine derartige Erhebung müßte als Grundvoraussetzung gelten, daß sie vom Vermessungsteam ohne bedeutenden Zeitaufwand und ohne wesentliche, zusätzlich Schulung im Zuge der eigentlichen Vermessung durchgeführt werden kann. Als Lössung käme ein Formular (Abb.1) in Frage, auf dem neben den herkömmlichen Meßdaten (Länge, Neigung, Richtung) alle wünschenwerten Informationen (auf den Vermessungspunkt oder Zug bezogen) ebenfalls nur mehr angekreuzt werden müßten. Dabei könnten die zu erhebenden Informationen auf dem Formular durch jene Signaturen gekennzeichnet werden, wie sie auch auf dem Höhlenplan verwendet werden und daher dem Planzeichner geläufig sind. Soferne ein guter Höhlenplan vorliegt wäre es sicherlich auch vorstellbar, daß diese Informationen vom jeweiligen Bearbeiter und Kenner des Höhlenabschnittes an Hand seiner Aufzeichnungen auch nachträglich eingetragen werden, da die Handhabung solcher Formulare in der Höhle oft unzweckmäßig ist.

Abb. 1 FORMBLATT ZUR ERFASSUNG VON INFORMATIONEN ÜBER DEN HÖHLENINHALT UND DEN ZUGVERLAUF IM RAUM

vom Vermessungspunkt	bis Vermessungspunkt	Länge	Neigung	Richtung	Positionsangabe der Information	Feinsedimente	Blockwerk	Siphon	stehendes Gewässer	fließendes Gewässer	Eis	Versturz	offene Fortsetzung	unbefahrbar eng	Profil aufgenommen	Zug verläuft entlang linker Begrenzungswand	Zug verläuft entlang rechter Begrenzungswand	Zug verläuft an der Höhlendecke (oben)	Zug verläuft an der Höhlensohle (unten)	Zug verläuft von der linken zur rechten Wand	Zug verläuft von der rechten zur linken Wand	Zug verläuft von der Decke zur Sohle	Zug verläuft von der Sohle zur Decke	Zug verläuft in Gangmitte	Zug verläuft senkrecht zur Raumachse	Sternvisur (weder in Raumachse noch quer dazu)
VON	BIS	L	N	R	POS	INFORMATIONEN										ZUGVERLAUF IM RAUM										
												V	?	=	P	L	R	O	U	←	→	↓	↑	•	+	X
1	2	19,0	+02	037	1 - 8,0										X					✓		✓				
					1 - 10,0								X													
					1 - 2		X																			
					2 - 0,0			X																		
4	5	20,0	00	330	4 - 6,0										X					✓				✓		
					4 - 12,0				X																	
					4 - 5	X																				
					5 - 0,0							X														

Die zutreffenden Informationen über den Höhleninhalt und den Zugverlauf im Raum werden angekreuzt und können kombiniert werden.

BEISPIELE

In welcher Form diese Informationen schließlich zusammen mit den Meßdaten gespeichert und durch ein zweckmäßiges Programm den gewünschten Fragestellunge wieder zugänglich gemacht werden, kann dem EDV-Fachmann überlassen werden.

Folgende Informationen könnten etwa auf diese Weise an den einzelnen Vermessungspunkt oder Zug geknüpft werden (auch als Grundlage für topographische Höhlenpläne):

a. Profile, die nicht nur hinsichtlich ihrer in Abschnitt C beschriebenen Lage sondern auch ihrer Form mit einem in Abbildung 2 vorgeschlagenen Formblatt digitalisiert werden könen. Dadurch ergäbe sich die Möglichkeit der Berechnung der Querschnitte oder einer eventuellen generalisierten Zuordnung zu «Profiltypen». Derartige Profilangaben sind in vereinfachter Form, allerdings nur bei jedem Vermessungspunkt, auch heute bereits für laufende Programme zur räumlichen Darstellung von Höhlen erforderlich.

b. Höhleninhalt (Sedimente, Eis, stehendes und fließendes Wasser (mit Fließrichtung als Vektor), Verstürze, Verlehmungszonen, Siphone u.s.w.).

c. Offen Fortsetzungen (eine derartige Erfassung könnte durchaus für die Planung weiter Forschungen Aussagekraft besitzen).

d. Informationen über den Zugverlauf im Raum (auf diese Weise könnten nicht raumbestimmende Meßstrecken bei statistischen Auswertungen unterdrückt werden).

e. Nicht unerwähnt soll in diesem Zusammenhang bleiben, daß etwa auch der Materialbedarf von vertikalen Strecken mit abgespeichert werden könnte, sodaß etwa rasch eine Materialliste zusammengestellt werden kann.

2. Informationen, die nur sporadisch im Zuge spezieller Untersuchungsprogramme und meist mit spezieller wissenschaftlicher Zielsetzung erfolgen. Da derartige wissenschaftliche Untersu-

chungen in den seltensten Fällen Hand in Hand mit der Vermessung durchgeführt werden, müssen diese Informationen nachträglich durch Rekonstruktion des Meßzuges in der Höhle in einen Lagebezug gebracht werden.

Folgende Informationen könnten etwa auf diese Weise an den einzelnen Vermessungspunkt oder Zug geknüpft werden (auch als Grundlage für thematische Höhlenpläne):

a. Tektonische Linieamente (z.B. Fallen und Streichen von Schichten).
b. Fundstellen, soferne ausreichendes Datenmaterial vorliegt (z.B.: Tierfunde, Knochenfunde, Bohnerzfundstellen u.s.w.).
c. Klimadaten (z.B.: Temperatur, CO_2 - Gehalt, Windrichtung (als Vektor) und Windstärke u.s.w.).
d. Analysendaten (z.B.: Wassertemperatur, Härte, chemische Werte u.s.w.).
e. Ritzzeichnungen oder Felsmalereien u.s.w.

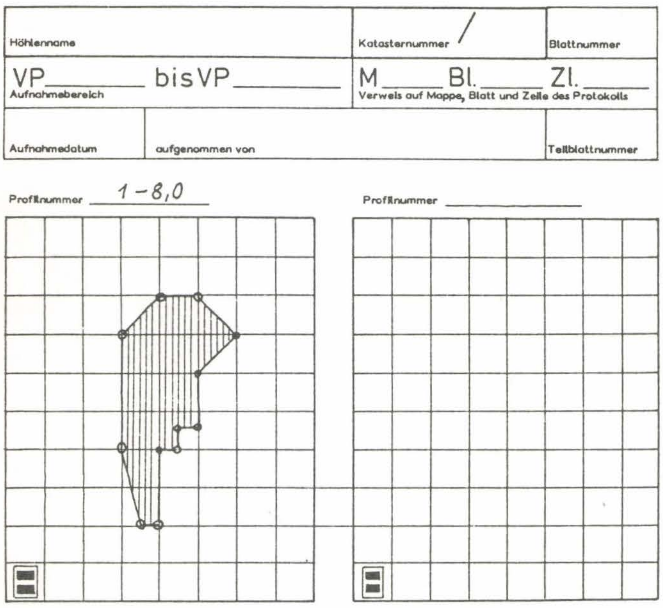


Abb. 2 : FORMBLATT ZUR AUFNAHME VON PROFILEN

Der Raster entspricht einer Fläche von 8x10m. Durch Einsetzen eines für den Computer lesbaren Faktors im unteren linken Kästchen (z.B.: 2 = 16x20m) ist die Fläche variabel gestaltbar. Durch Angabe der Profileckpunkte ist das Profil digitalisierbar und planimetrierbar.

C. Vorschlag für die festlegung des lagebezuges der daten

Der Raumbezug dieser Daten kann dadurch erfolgen, daß zur jeweiligen Nummer des Vermessungspunktes, durch Bindestrich getrennt, in Zugrichtung die Entfernung (mit Kommastelle) gesetzt wird, soferne es sich um eine Information handelt, die punktförmig beschrieben werden kann (z.B.: Profillage). Gilt die Information für den gesamten Meßzug (z.B.: gleichbleibendes Profil, gleichbleibendes Sediment), so wird als räumlicher Bezug die Meßstrecke selbst (keine Kommastellen) angegeben. Soferne die Raumbegrenzung nicht allzu weit entfernt vom Polygonzug verläuft, können seitliche Distanzen unberücksichtigt bleiben, sonst müßte die Information durch einen Hilfszug eingebunden werden. Die Koordinaten der jeweiligen Information ergeben sich dadurch daß man zur Berechnung zwar die Richtung und die Neigung des Zuges nimmt, anstelle der Länge jedoch die Entfernungsangabe hinter dem Bindestrich verwendet. Der Bindestrich ist deshalb anzuwenden, um eine klare Unterscheidung zwischen dem Schrägstrich bei Verwendung der von HELLER (1983) vorgeschlagenen Punktbezeichnung durch Serien und Stationen zu gewährleisten.

Die hier vorgestellte Art der Verortung von Informationen wurde erstmals von MAIS und STUMMER für Profile in der Leitnerhöhle bei Salla (Österreichisches Höhlenverzeichnis 2781/1) angewendet (STUMMER 1975).

z.B.:

1-1,0 = Code/Sand (1m von VP1 Richtung VP2)
1-2,5 = Code/Schutt
1-4,8 = Code/Sand
1-2 = Code/Sand (Sand von VP1 bis VP2)
1-4,5 = Profil (4,5m von VP1 Richtung VP2)
1-2 = Profil (gleichbleibend von VP1 bis VP2)

Ist gleichzeitig jeder Vermessungspunkt selbst durch ein geeignetes System, etwa nach Serien und Stationen (HELLER 1983) oder durch Zuordnung zu Blättern und Zeilen (STUMMER 1980), eindeutig für die ganze Höhle festgelegt, so gilt dies auch für die erfaßten Informationen. Erfolgt gleichzeitig die Errechnung der Koordinaten in einem übergeordneten System, etwa dem Bundesmeldenetz, so stehen diese Informationen auch mit allen in gleicher Weise erhobenen Punkten der Oberfläche in direktem Raumbezug.

D. Praktische anwendungsmöglichkeiten

Die einmal mit den Meßdaten mitgespeicherten Informationen stehen in dieser Form eigentlich allen Fragestellungen offen. Es seien hier nur stichwortartig einige derzeit bereits anstehende Fragestellungen und Möglichkeiten aufgezählt:

1. Berechnung des Höhlenvolumens an Hand ausreichend vieler Profile, wie dies in ähnlicher Form etwa JAKOPIN (1981) beschrieben hat.
2. Überprüfung, ob Profilformen in irgendeinem Zusammenhang mit der Neigung von Höhlengängen stehen.
3. Typisierung von Profilformen an Hand einer genügend großen Anzahl von aufgenommen Profilen.
4. Überprüfung der Lagezuordnung von Verstürzen, Siphonen oder Verlehmungszonen, Fließrichtung der Wässer.
5. Rasche un übersichtliche Information über offene Fortsetzungen (wobei auch der Grund für das Offenlassen der Fortsetzung angegeben werden kann, z.B. Mateiralmangel).
6. Ausplotten des Grundrißpolygons mit verschiedenen, einzelnen Profiltypen zugeordneten Signaturen.
7. Korrelation ausgewählter Informationen mit der Oberfläche.
8. Exaktere Richtungs- und Neigungsstatistiken, wie sie HENNE (1983) beschrieben hat, durch Unterdrückung von nicht raumrelevanten Vermessungszügen.
9. Verbesserung räumlich perspektivische Darstellungen an Hand größerer Informationsbestände (Profile).

E. Schlussbetrachtungen

Die hier niedergelegten Gedanken bedeuten sicherlich einen entsprechenden Mehraufwand bei der topographischen Erfassung der Höhlen. Versuche in dieser Richtung müssen daher neben der Verfeinerung der Methoden auch das Aufwand-Nutzen-Verhältnis Verhaltris und die praktische Anwendbarkeit klären. Die Realisierung solcher Überlegungen hängt sicherlich nicht nur vom guten Willen der Höhlenforscher, sondern auch vom Zugang zu entsprechenden EDV-Anlagen ab. Da dieser Zugang sowohl zur Hardware als auch zur Software in den kommenden Jahren immer leichter wird, können auf dem Gebiet der angewandten Nutzung der Computertechnologie nie früh genug entsprechende Überlegungen angestellt und vor allem ausreichend Erfahrungen gesammelt werden. Darüberhinaus sind derartige Gedanken immer in größerem Zusammenhang zu sehen. So ist etwa bereits durch die Bindung zukünftiger «Höhlenatlanten» an das Österreichische Bundesmeldenetz über derartige Höhlen ein Suchgitter gelegt worden, das bei entsprechender Verdichtung möglicherweise auch mit der erforderlichen Genauigkeit als Lagebindung herangezogen werden könnte.

All diese Überlegungen zur stärken Nutzung der Vorteile des EDV-Einsatzes müssen jedoch immer vor dem Hintergrund gretroffen werden, daß dieses Hilfsmittel nicht als ausschließlicher Ersatz für bewährte Dokumentationsmittel sondern nur als zusätzliche

Verbesserung des Zuganges zu den Informationen eingesetz werden. Darüberhinaus müssen alle Gedanken von Peter HENNE, wie er sie beim Seminar für Speläotographie und EDV-unterstützte Höhlendokumentation (Wien 1985) dargelegt hat, etwa die Probleme der Datensicherung oder seine Forderung, als Endstadium der Datenspeicherung letzlich wiederum nur Papier zu verwenden, mitberücksichtigt werden. Es ist zu hoffen, daβ dieser Beitrag zu einer entsprechend regen Diskussion und zu Versuchen in dieser Richtung anregt.

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Making Three Dimensional Cave Models

Peter and Ann Bosted

RESUM

Molt sovint es fa difícil de descriure la compleixat de les cavitats, com és el cas de les que es troben a Califòrnia, utilitza les tècniques cartogràfiques clàssiques. És per això que he enllestit un mètode per a construir models tridimensionals de coves, utilitzant filferro, argila i altres materials. Aquí exposo els mètodes de construcció i alguns models de posibles representacions.

RESUMEN

A menudo es difícil describir la complejidad de las cavidades como las que se encuentran en California, utilizando las técnicas cartográficas clásicas. Por ello he puesto a punto un método para construir modelos tridimensionales utilizando alambres, arcillas y otros materiales. Se trata aquí de los métodos de construcción y se expondrán modelos de representaciones.

SUMMARY

It is often difficut to portray the complexities of mazelike caves such as those found in California using standard cartographic techniques. I have therefore worked out a method for making three dimensional models using wires, clays, and other materials. Methods of construction will be discussed, and pictures of models both completed and in progress will be shown.

What is the best method of portraying a complicated cave maze that is easy to visualize, acurate and inexpensive? Cartographers are continually struggling with this problem using colors and overlays in addition to the more standard floorplans, profiles and cross-sections. Skilled artists make three dimensional drawings while computer users generate programs to portray caves on graphics display terminals.

When faced with the problem of creating a visual portrayal of a rather unusual cave, we explored various alternatives to the pen and paper solution. We experimented briefly with cut-away block type maps (such as the well-known map of Carlsbad) and wished we had the air-brush skills that were used in the rendering of Mammoth Cave. Even if we could draw that well, considerable visualization skills are needed for the observer to correctly interpret such renderings.

It became obvious that if were to create a 3-D rendering of the cave, we would have to work in three dimensions. We decided that the easiest would be to make a clay model. For our first attempt we chose a small 100m long cave, Music Hall, which follows two steeply dipping fissures – one to the South East and ther other to the West. We used wire to set the shape of the cave (following the survey lines quite closely) and then covered the shape with wet modelling clay. Unfortunately, when it dried big cracks developped and we had to use more liquid lay to fill in the ugly lines. After making the model, we realised that by using a clay which hardened after drying, we were also limiting the option to extend the model should more passage be discovered in the cave.

We then decided to experiment with plastacene and were so encouraged by the ease of modelling in this medium that we were able to build a model of a complicated 1500m long cave (Soldiers) by learning as we went along. Aside from discovering unsuspected modelling skills, we learned a lot about the cave and were able to make modifications easily when visits to the cave showed complexities in the maze of passages to different than we had remembered.

The basic approach was to represent the cave passages using plastacene molded over pieces of wire. While this does not permit details of what is inside a given passage to be shown, it effectively shows the relationships of the rooms and passages to each other.

If you have any desire to create a 3-D map, the first step would be to obtain a survey and map of the cave you wish to model. Make a plan view of the cave on the same scale you will be using to make the model. You could xerox or stat the map larger or smaller to save re-drawing. Most surveys show the depth of passages below (or above) the main entrance. You should find the lowest point of the cave and then convert these «elevation» levels into feet (or meters) ABOVE the lowest point of the cave. Write these elevation levels nex to the passages at selected intervals. The intervals can be greater if the passage is very flat. For pits it is helpful to have profiles on hand.

Once the coordinates of every point are known, the next step is to make a wire outline of the cave. Starting with the main passages, bend stiff wire so that it follows the center of the passage (as shown on the plan view) and changes in elevation according to the elevation levels. When the wire reaches a natural stopping place (at a pit or low point in the cave) bend it down vertically towards the base board ant cut it about a quarter inch longer. Later this non-cave part of the wire will act as a «leg» to support your model. It is important to plan these «legs» ahead of time so that your model will be evenly supported. We built 8 such legs into the Soldier's model.

The wires that do not end up as legs can be «tied off» to other main passages at convenient junctions using tape, solder or glue (we used plastic electrical tape and epoxy). You can minimize the amount of gluing or welding by clever planning and doing some doubling back at strategic spots where the passage is reasonably large. Thinner, more flexible wire can be used for smaller passages, but be caferul not to have too long a span of thin wire or it will sag.

Having made the grid, it is now time to put on the plastacene. Different colors can be used to good effect. Simply roll out cylinders of plastacene equal to the scaled-down size of the cave passage and squeeze them over the wires. Use the cross sections from the survey to get the passage shapes modeled as accurately as possible. In big rooms, inserting toothpicks or bits of wire can help keep features such as narrow ceiling channels from sagging.

Mounting the model on a base is essential, but easy. Simply figure out where the «legs» should be and drill small holes for them. Once in, the legs tend to stay there and they will help preserve the sape of the cave. You may find that some legs can be cut off without causing the model to collapse. We used black paper to cover the base and enhance the contrast with the off-white plastacene.

Next, the rooms and major passages should be labeled. We used titles mounted on the end of toothpicks as signposts. These are easly pushed into the plastacene. If you want to view or photograph the model from a different angle, these labels can be easly rotated. A legend with the cave name, north arrow, and scale can be glued onto the base plate. We made a plexiglass case to protect our model from dust and accidental bumps.

We found that making a model of our cave did not take much longer than it would to carefully produce plan and profile views of the cave. Although the model cannot be copied as a map can, in many applications it can be viewed by a large number of people, such as if it is a commercial cave. It can also be a use to scientists wishing to better see, for example, the relationships of passages to joints, or the sequences of passage formation.

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El arte y la Técnica de la Fotografía Espeleológica

Mario Roberto Guitti Peixoto

RESUM

Tot i que el medi ambient subterrani constitueix per sí sol un focus d'indubtable interès, la seva pura i simple documentació resulta freda si la comparem amb les possibilitats que ens depara la fotografia. Una tècnica depurada, una bona composició i una correcta utilizació dels diferents tipus de llum han d'unir-se a la creativitat per a l'obtenció d'uns resultats estèticament refinats i valuosos des del punt de vista artístic. L'agressivitat del medi comporta un apropament a un estil de fotoperiodisme geogràfic en el qual la utilizació del color pretén mostrar les formes i els colors que romanien ocults dins la foscor.

Aquest treball pretén explicar molts dels aspectes de la fotografia subterrània, com ho són l'elecció i la utilització de l'equip l'ús de fonts de llum artificials (flashos elèctrics, llums de carbur, etc.), sistemes per a procedir a fer la fotografía (flashos múltiples, cèl·lula fotoelèctrica), el macro, el factor «aigua» i, sobretot, la fotografia en condicions extremes: *la logística i la selecció de sistemes lleugers per a exploracions molt difícils, verticals i de tipus «alpí».*

RESUMEN

A pesar de que el medio ambiente subterráneo constituye por sí mismo un elemento de interés, su pura y simple documentación es una forma pasiva de la utilización de la fotografía. El cuidado de las técnicas, la composición y los diferentes tipos de luces deben unirse a la creatividad para producir un resultado estéticamente refinado y valioso desde el punto de vista artístico. La agresividad del medio ambiente conduce a un acercamiento al estilo del fotoperiodismo geográfico en el que el uso adecuado del color pretende mostrar las formas y colores de los elementos que siempre habían permanecido ocultos en la oscuridad.

Este trabajo pretende explicar muchos aspectos de la fotografía subterránea, tales como la elección y el uso del equipo, fuentes de luz artificiales (flashes eléctricos, lámparas de carburo, etc.) y sistemas de disparo (flashes múltiples y célula fotoeléctrica), el macro, el factor «agua» y, principalmente, la fotografía en condiciones extremas: *la logística y la selección de sistemas ligeros para exploraciones muy difíciles, verticales y de tipo «alpino».*

SUMMARY

In spite of the underground environment constituye by itself an element of interest, its pure and simple documentation is a passive form of the utilization of photography. The consideration for the techniques and the use of the composition and the light sources must join to the creativity to produce a work esthetically refined and astistically remarkable. The wild environment leads the geographical photojournalism approach in which the use of the color craft exhibit the hue and shape of the elements hide forever in the dark.

This work seems to explain many aspects of the cave photography such as the choice and the use of the equipment, articifial lighting sources (electronic flashs, carbide lamp, etc) and lighting sistens (multi-flash and slave-cell photography), the close-up factor «water» and, mainly, the photography under extremes conditions: *the logistics and the selection of a light-weight sistems very difficult incursions as well as the vertical and «alpine» explorations.*

No obstante el mundo subterŕaneo constituir por sí solo un elemento de interés, su documentación pura y simple es una forma pasiva de utilización de la fotografía. La consideración por las técnicas y el aprovechamiento de la composición y de las fuentes de luz debe unirse a la creatividad para engendrar un trabajo de estética refinada y artísticamente marcante. El ambiente hostil, sea interno cuanto externo, es el punto central de un trabajo de fotojornalismo geográfico donde el uso del color apunta las formas y matices de elementos ocultos para siempre en la oscuridad.

En se pensando en fotografía adentro de las cuevas es necesario que la persona interesada posea conocimientos suficientes de las técnicas básicas del esporte. Entonces el primer paso es la elección del equipo fotográfico tomando en cuenta dos aspectos: La presencia del agua y el terreno accidentado en que nos deslocamos. Las cámaras deben ser escogidas en función de la resistencia de sus cuerpos, tipo del visor y operación (automática o manual). Los visores tipo Reflex son los preferidos y las cámaras de operación manual (no electrónicas) son ideales por la facilidad de uso siendo menos sujeta a daños de orden interno en el caso de colisión y variación de temperatura y humedad. La lectura del exposímetro se torna innecesaria, pues el control de la exposición es hecha en función del flash electrónico, preestableciendo una velocidad de sincronismo. Las lentes con frecuencia más utilizadas son las gran-angulares y macro. Lentes como la 20, 24, 28 y 35 mm son útiles en la mejor parte de las situaciones y ambientes. Distancias focales menores, como por ejemplo 16 y 8 mm, son usadas en situaciones especiales donde la exageración del efecto realza el tamaño del salón o galería. La potencia del flash y las dimensiones de las salas determinan la elección de la luminosidad de la lente, siendo las más luminosas (1.4 – 1.8) preferidas desde que su construcción en función de la abertura máxima no afecte la definición.

La necesidad de una mayor profundidad de campo y el trabajo con distancias relativamente pequeñas no exigen la elección de una lente macro muy luminosa. Las Micro-Nikkor 55 mm f/3.5 y f/2.8 poseen altísima definición y fueron usadas en todo los trabajos que yo hice en closeup.

Los teleobjetivos tienen su uso muy restricto dada la poca luminosidad, la pequeña profundidad de campo y la distancia asunto-cámara que impide una mayor aproximación del flash para una iluminación adecuada – a no ser con cables extensores y un auxiliar usando la fuente.

Todo el equipo de registro (cámaras, lentes, películas) más el equipo adicional como flashes electrónicos, trípode, cables extensores y disparadores, células fotoeléctricas, superficie reflectora y material de limpieza deben ser alojados en recipients estancados y rígidos – el «Tupperware» se presta muy bien a esto – y acomodados en mochila adecuada y de uso sencillo (modelo dividido en dos compartimientos por ziper), forrado por un saco de plástico grueso. La protección contra colisión y la impermeábilidad son los dos factores principales en la elección y transporte del equipo fotográfico.

La complementación más correcta y práctica al equipo tradicional la de fotografía submarina. La impermeabilidad, la resistencia de su construcción y el tamaño reducido (un poco mayor que las tradicionales «view finder») hacen del sistema Nikonos la única opción para trabajos extremos. Cajas estancadas tipo Ikelite son desaconsejadas debido al volumen y peso adicionales, reducidos en actividades submarinas

La fuente de luz utilizada en la espeleofoto es el flash electrónico. La compacidad y rápida recarga hace de él la primera opción en términos de fuente luminosa. La cualidad de color de la luz de un flash electrónico es aproximada a los padrones de iluminación a luz del día. Flashes combinan con toda película balanceada para esta luz (daylight film). Con el pasar de los años la cualidad de color de la unidad del flash se cambia y el resultado general tiende a azular – o que también puede suceder con unidades de distintos fabricantes cuando usados en una misma foto. La solución seria el uso de un filtro «caliente» como el Kodak Wratten 81A o Kodak Color Compesating CCL0Y, sobre el falsh o sobre la lente. La niebla puede ocasionar el tono azul de la foto, siendo que el filtro ultra-violeta tendrá corta lo bien como proteger la lente de colisión y arañazo. Normalmente no es necesaria la correción de la exposición para estos filtros.

La elección del flash electrónico debe recaer sobre aquellos que poseen operación automática y manual. La unidad automática posee un sensor que mide la luz reflejada del asunto y determina la intensidad necesaria para exponer correctamente la película con una abertura de diafragma prefijada. Hay también un límite máximo y mínimo en los cuales la distancia asunto-flash debe si quedar para que no haga superexposición si ultrapassados. Esos límites son fijados por la relación abertura-sensibilidad. Aplicaciones prácticas de automatismo del flash son frecuentes en macrofotografía, como por ejemplo, delicados espeleotemas y pequeños animales.

En el modo manual cada vez que el flash es disparado emite su máxima capacidad de luz, de duración fija, normalmente 1/1.000. Una vez que la luz es constante, es necesario una corrección del diafragma para toda variación de distancia. Las unidades de alta potencia son así usadas en ambientes largos, como salones y galerías, donde la poca reflexión de las paredes vuelve impreciso el modo automático y el trabajo con iluminación indirecta.

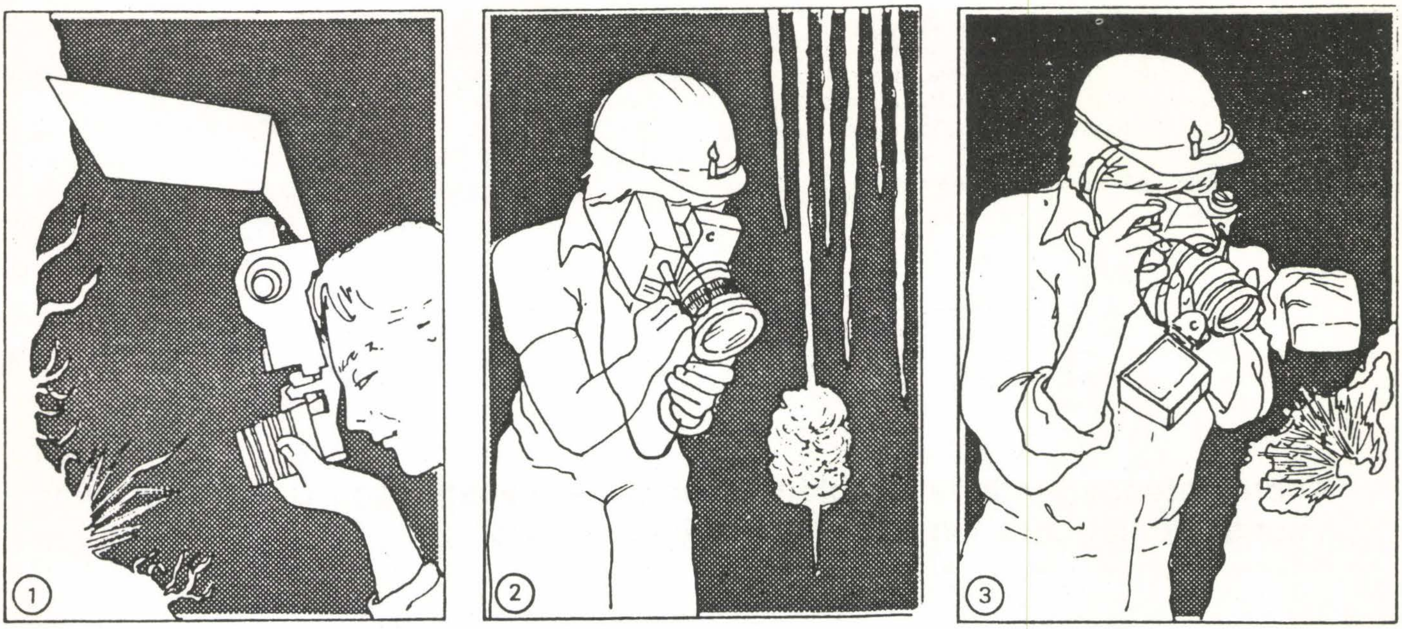
Al escoger un flash debemos observar también el tipo de alimentación. Fuentes de 6 Voltios de algunos modelos Frata y Metz tienen sus inconvenientes, dados los cuidados del nivel de la solución y a la frecuente recarga en corriente alterna, además será necesario llevarlos en el cuerpo através de alza. Muchos de los flashes de alta potencia trabajan con fuentes alcalinas de 1,5 V, iguales a los de las pequeñas unidades, ofreciendo energía suficiente y reducido volumen.

En las galerías de ríos subterraneos, como de la Cueva de Ouro Grosso y de la Cueva Santana, en el Vale do Bethary/ Iporanga (SP), donde la turbulencia de las aguas y la ausencia de un local seguro para la preparación del equipo, restringen el material común , los flashes submarinos son extremadamente eficaces. Con todo los controles y encajes vedados por «O-ring», son también ejemplos de la ligereza, compacidad, potencia, resistencia y facilidad de uso. Las cámaras Nikonos II y III (modelos como la IV-A y la V son electrónicas) y los flashes Sunpak Marine 28 y 32, el Toshiba TM-II o el Nikon SB 102 (con sensor automático) pueden componer un conjunto ideal para las situaciones extremas en exploraciones de cuevas.

Para esta aplicación las lentes para las cámaras Nikonos son limitadas a W-Nikkor 35 mm f/2.5 y Nikkor 80 mm f/4, pues las UW-Nikkor 15 mm f/2.8, 20 mm f/2.8 y 28 mm. f/35 fueran desarrolladas exclusivamente para la utilización abajo del agua; fuera de ella 35 mm funciona como una gran-angular, su campo cubre perfectamente las galerías del río encontradas.

En cuevas, las largas dimensiones y la baja reflexión de los ambientes requieren una compensación (un punto o más, abierta), haciendo con que el número guía dado por el fabricante no sea fiable. O qué hacer en circunstancias tan particulares?

Podemos ir hasta una cueva de fácil acceso y que tenga reunidas galerías de río y salones con paredes claras y oscuras. Con la cámara apoyada en un trípode a un distancia determinada, por ejemplo 5 metros, en un salón de pared clara vamos hacer una serie de exposiciones con una determinada película. Ektachrome 64/EPR, en aumentos sucesivos de 1/2 punto desde f/2.8 hasta f/16 (o f/22 si Ud. usa un flash potente con una película sensible). Después del revelado escogeremos la mejor exposición, f/4, y vamos a multiplicar por 5, obteniendo así el número guia 20 para esta película y mediciones en metros, Ese procedimiento debe ser hecho para toda las películas que se pretenda usar (200, 400, etc) bien como para salones de paredes obscuras y galerías de río, con flash en media carga y carga total. Hay una manera de calcularse el número guía de una película de otra sensibilidad desde un número guía ya obtenido: $NG2 = NG1 \times \sqrt{sens2/sens1}$, a donde NG1 es el número guía determinado, NG2 el número guía a determinar, sens1 la sensibilidad en ASA de la película de NG1 y sens2 la sensibilidad en ASA de la película de NG1 y sens2 la sensibilidad en ASA de la película NG2. Entonces, si usamos ahora una película de 400 ASA tenemos: $NG2 = 20 \times 400/64 = 20 \times 6,25 = 20 \times 2,5$; $NG2 = 50$.



1– El uso de la luz indirecta;
2– El uso del ring flash;
3– El uso de un par de flashes de baja potencia uno de ellos cubierto con un pañuelo.

Fotografiando salones debemos observar los reflejos y sombras, que pueden ser aprovechados por el posicionamiento del flash para realzar formas y detalles. La iluminación se vuelve más homogénea si usamos más de un flash, obteniendo así mejor profundidad en la composición. Para esto recurrimos a la fotocélula que puede disparar uno o más flashes sin el auxilio de cables extensores, cuando la unidad principal es accionada.

Con arreglos más elaborados de iluminación, la exposición correcta es muchas veces difícil de determinar sin un gran consumo de tiempo y pruebas. Los exposímetros de flash (flash meter) tienen su aplicación en este tipo de foto. Con el asunto encuadrado y los flashes instalados (en el modo manual), disparamos el flash principal con el flash meter junto a la cámara. En muchos aparejos la abertura correcta es obtenida por lectura digital directa. Disparando dos o más veces se puede obtener más luz para salones anchos y de mucha profundidad, bien como una mayor profundidad de campo; el flash meter tiene la capacidad de medir los disparos acumulados.

En la ausencia de flashes podemos recurrir a la «pintura» para producir una foto de un gran salón. Con la cámara posicionada en un trípode y el obturador en «B», es posible hacer varios disparos en distancias fijas en el área a ser fotografíada. El fotógrafo debe cuidar para que la lente sea cubierta con una tapa negra con cautela, pues el trayecto del auxiliar con el flash (la llama del casco) puede ser expuesto en la foto. Hay la posibilidad de un único disparo en un sector del salón dando destaque a una área de unafoto predominantemente negra. Es muy importante al abrir y cerrar el obturador usar un cable disparador largo para que la cámara no tiemble no el fotógrafo se aproxime mucho a ella con su iluminación de acetileno, perjudicando la exposicion.

Con frecuencia los problemas técnicos encontrados en la fotografía close-up recomiendan el flash electrónico como fuente de iluminación auxiliar. En espeleología este tipo de foto no existiría sin él.

La lente macro nos dará una posibilidad de aplicaciones hasta las proporciones de 1:1. Para mayores proporciones es recomendable el fuelle. Unidades pequeñas y de baja potencia son ideales para el close-up y en la mayoría de los casos son usadas en los pares. La disposición del par favorece el control de los efectos de iluminación, principalmente cuando queremos disminuir el efecto de sombras duras con el flash secundario. Uno de los flashes puede predominar en cuanto el otro está cubierto por un pañuelo o filtro difusor.

Cuando trabajamos más próximos de un tema esto quiere decir que vamos a tener que reducir la duración del disparo. Una buena alternativa es trabajar con luz indirecta, reflejada en una superficie blanca. Para espeleotemas que poseen aspecto retorcido o espiralado y las flores de aragonita, las dos con coloración blanca, o que refleje mucha luz, es recomendado el flash electrónico angular que ofrece una total iluminación frontal, evitando sombras confusas. Este flash forma sombras centrales suaves pues la luz es disparada oblicuamente desde el área alrededor de la lente.

Para exponer correctamente la película utilizaremos el modo automático en cualquiera de las tres disposiciones relacionadas. Si el flash posse un sensor móbil es ideal colgarlo en la lente – hay accesorios especiales que se adaptan en la rosca del filtro. Siendo la profundidad de campo el mayor problema, debemos optar por la menor abertura de uno de los dos modos automáticos de la unidad y quedar atento para no ultrapasar la distancia mínima asunto-flash.

Escoger la película adecuada necesita que sepamos la naturaleza del trabajo a ser desarrollado y qúe haga un buen senso técnico para la selección de las marcas y sensibilidades. Aquí están algunas sugerencias:

El Ektachrome 64 es una buena película para uso general en espeleología, poseyendo contraste normal y baja granulación, pero tiene una leve tendencia al azul. El Ektachrome 100 tiene una respuesta más neutra con baja granulación. Los Ektachromes 200 y 400 son los más indicados para salones grandes y galerías, tomándose en cuenta la alta granulación. El Kodachrome 25 es una película de bajísisma granulación, ideal para el close-up. La poca latitud y un mayor contraste vuelven su exposición más crítica y algunos detalles de sombra muy oscuros. el Kodachrome 64 es también una excelente película de grano fino y muy buena cuando un fuerte contraste es necesario. El Vericolor III tipo S es una película de sensibilidad mediana (160 ASA) y de gran latitud y poder de resolución para una película negativa. Podemos usarla para ampliaciones de alta calidad.

Conclusión.

Gran parte de mi trabajo fue desarrollado en el Vale do Alto Ribeira, en el sur del Estado de Sao Paulo, Brasil, en el decurso de los últimos cuatro años. El potencial y la cantidad de cuevas y simas de la zona ofrecen el desarrollo de exploraciones espeleológicas y de la fotografía subterránea. Este artículo cubre la parte básica de ese trabajo. Las aplicaciones especiales y la organización y logística de la fotografía en expediciones son algunos de los puntos que parten desde ahí. Lo que es muy importante es mucha práctica, pues solamente ella dará condiciones para el dominio de las técnicas que permite registrar las maravillas de ese universo interior.

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Koordinatengebundene Teilblätter zur Grossmasstäbigen Darstellung von Hönhlensystemen-Idee und derzeitige Realisierung,

Günter Stummer
Wien

RESUM

El treball descriu el sistema de mapes separats dels grans sistemes subterranis, en fulls amb les mateixes seccions de mapa. Les noves seccions es fixen ara en coordenades rectangulars Gauss-krüger.

Amb aquest sistema és possible realitzar un treball de conexió («Atles Subterrani») de les grans àrees muntanyoses.

Amb aquesta finalitat l'«Institut für Höhlenforschung» de Viena va dur a terme un estudi geodèsic i els primers sistemes de cavitats austríacs ja s'han dibuixant amb aquest nou mètode. Aquest treball ens posa al corrent de la situació actual d'aquests estudis.

RESUMEN

El trabajo describe el sistema de mapas separados de grandes sistemas subterráneos, en hojas con las mismas secciones de mapa. Las nuevas secciones se fijan ahora en coordenadas rectangulares Gauss-Krüger. Por este sistema es posible realizar un trabajo de conexión «Atlas Subterráneo» de las grandes áreas montañosas.

Para esta finalidad el «Institut für Höhlenforschung» de Viena efectuó mucho trabajo geodésico y los primeros sistemas de cavidades austríacos ya se han dibujado por el nuevo método. El trabajo refleja la situación actual.

SUMMARY

The paper describes the system of dividing maps of giant cave systems into sheets with the same map-sections. The mew sections are now fixed to the rectangular Gauß-Krüger-coordinates. By this way, a network of «Subterranean Atlas» over great mountain-areas ist possible.

For this purpose a lot of geodetic work was done by the «Institu für Höhlenforschung» in Vienna an the first austrian cave-systems are now drawn in the new system. The paper gives a view of the present position.

Die Probleme der Plandarstellung großer Höhlensysteme, die Einordnung derartiger Systeme in die Oberflächentopographie sowie der wachsende EDV-Einsatz in der Speläotopographie und Höhlendokumentation machten die Einführung eines exakten und auch übergeordnet anwendbaren «Lagebezugssystemes» erforderlich.

Früheren Überlegungen folgend, realisierte der Autor die Gedanken, auch die «Unterirdische Welt» in Form von großmaßstäbigen «Kartenwerken» kartographisch darzustellen, im «Atlas der Dachsteinmammuthöhle 1: 1000» und legte in dieser Veröffentlichung auch den historischen Werdegang dieser Überlegungen dar (STUMMER 1980).

Grundgedanke derartiger «Atlaswerke» ist es, riesige Höhlen, deren Darstellung in einem aussagekräftigen Maßstab übliche Planformate sprengen würde, in gleichogroße, einheitliche Kartenblätter (Teilblätter) zu zerlegen und diese Blätter durch ein strenges Bezeichnungssystem zueinander in Bezug zu setzen. Dabei wurde als größtes, noch handliches Format das Format Din A3 angesehen, woraus sich ein rechteckiger Blattschnitt ergab, der eine Fläche von 125 × 175 Meter im Maßstab 1:500 abdeckte (Abb. 1). Dieses neue System wurde im Gegensatz zur bisherigen Methode, einfach immer Planstücke anzuschließen (Teilplansystem), als «Teilblattsystem» definiert.

Neben vielen Vorteilen, etwa daß ein derartiges Kartenwerk durch Ergänzen oder Neuanlegen von Teilblättern rasch auf den letzten Stand gebracht werden kann, wurden in der Literatur (STUMMER 1980) auch viele Nachteile aufgezählt, die jedoch zum größten Teil durch entsprechende Manipulationen wiederum ausgeglichen werden können. Der größte Nachteil dieses Systems jedoch war der, daß sich der Blattschnitt an lokalen Koordinaten orientierte, wobei meist als Koordinatenursprung der Höhleneingang herangezogen wurde. Damit stand zwar ein in sich geschlossenes Kartenwerk zur Verfügung, dieses hatte jedoch keinerlei Lagebezug zu übergeordneten Koordinaten-systemen und konnte nicht einfach in andere kartographische Unterlagen übernommen werden. In Ermangelung geeigneter, zugänglicher Systeme, wurde jedoch das «Modell Mammuthöhle» sehr rasch auch auf andere Höhlensysteme übernommen. Zahlreiche andere Höhlen, etwa die Raucherkarhöhle (Österreichisches Höhlenverzeichnis Nr. 1626/55) oder die Hüttstatthöhle (Österreichisches Höhlenverzeichnis

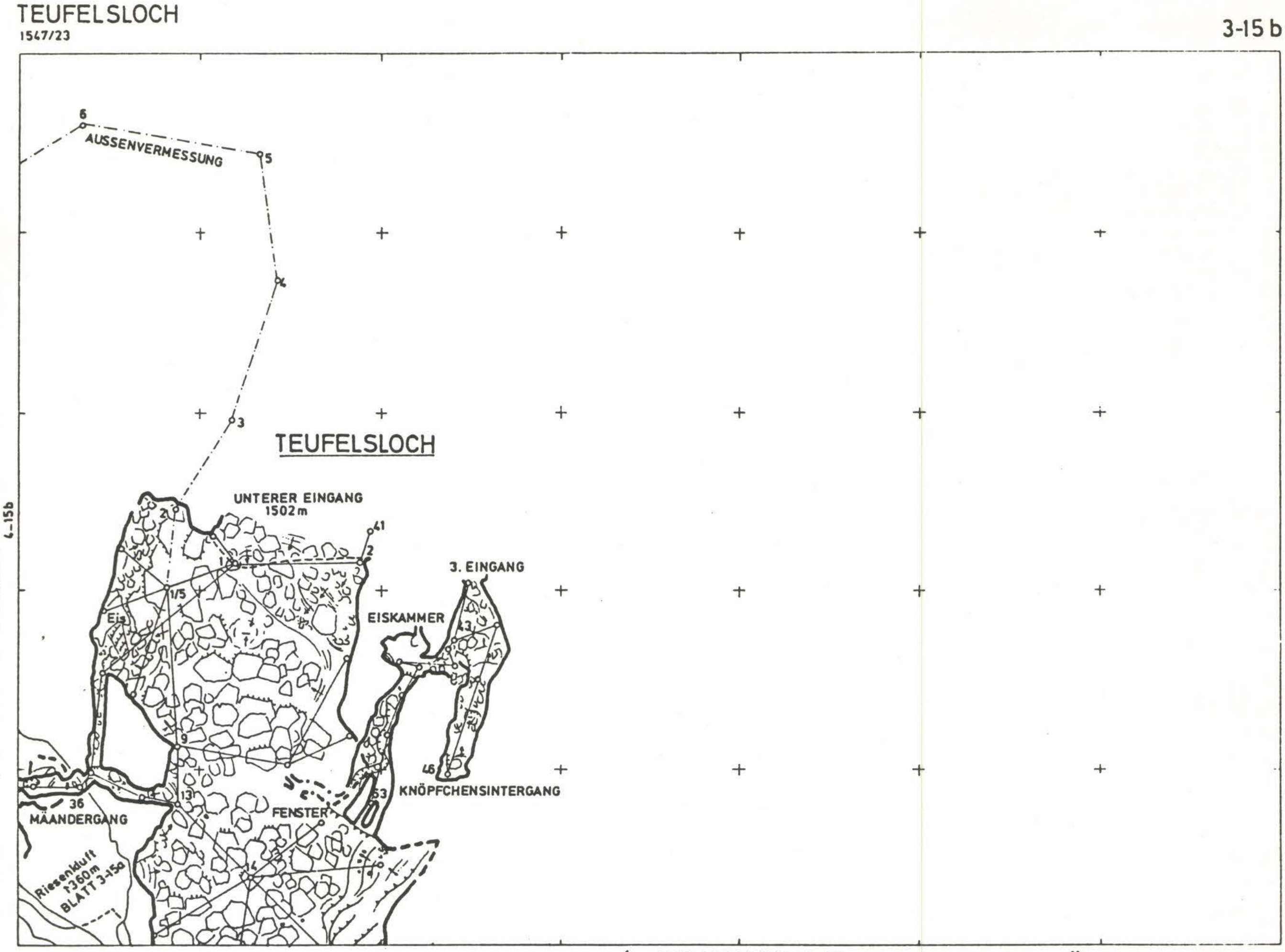


Abb. 1: TEILBLATT DES "ATLAS DER DACHSTEIN-MAMMUTHÖHLE". Der Teilblatt-Ausschnitt deckt noch eine Fläche von 125x175m ab

VOM TRIANGULIERUNGSBLATT ZUM HÖHLENTEILBLATT

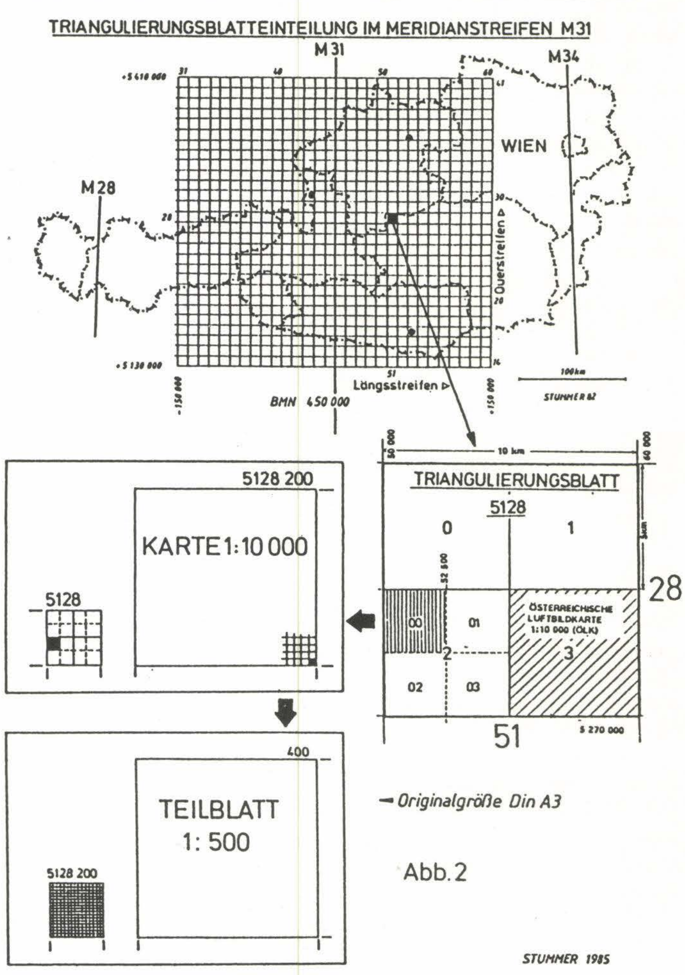


Abb. 2

Nr. 1624/28) wurden nach diesem System in der Folge bearbeitet. Eine kurze Zusammenfassung der im rechtechkigen Teilblatt-System bearbeitenen Höhlen gibt STUMMER (1981).

Das Projekt des Bundesamtes für Eich- und Vermessungswesen, die Österreichische Karte 1:50 000 mit einem aufgedruckten, modifizzierten Gauβ-Krüger-Koordinatennetz (Bundesmeldenetz-BMN) zu versehen, eröffnete neue Aspekte bei der Erstellung speläologischer Pläne und der Lageangabe von Punkten un Flächen in Österreich. Bereits am Beginn dieses Projektes hat der Autor im Rahmen seiner Tätigkeit im Institut für Höhlenforschung am Naturhistorischen Museum Wien begonnen, die neuen Möglichkeiten für die Höhlenkunde zu testen und anzuwenden und hat die gewonnen neuen Überlegungen jeweils in Veröffentlichungen vorgestlellt (STUMMER 1982, 1983, 1984), die hier nun zusammengefaβt werden.

Für die lagemäβige Zuordnung von Flächen (z.B. Teilblätter) oder Punkten (z.B. Höhleneingänge) in digitalisierter und daher EDV-gerechter Form kommen in Österreich derzeit drei Systeme in Frage. Das Gauβ-Krüger-Koordinatensystem, wie es in der Geodäsie in Anwendung stehen. Die Y-Achse (West-Ostachse) wird dabie vom Äquator dargestellt, als X-Achse (Nord-Südachse) werden in Österreich die Meridiane 28, 31 und 34 östlich von Ferro herangezogen. Die Y-Werte (Rechstswerte) dieser Hauptmeridiane besitzen daher in diesem System immer den Wert «O», wobei die Werte westlich des jeweiligen Meridians immer negativ, östlich jedoch positiv sind. Die Militärkoordinaten, wie sie auf der Österreichischen Militärkarte (ÖMK) durch violetten Aufdruck angegeben sind, stellen ein modifiziertes Gauβ-Krüger-System dar, auf das allerdings hier nicht eingegangen wird, da diese Karte nur für den Dienstgebrauch freigegeben ist. Für die praktische Speläologie ist jedoch die nun neu herausgegebene Österreichische Karte 1:50 000 mit schwarz aufgedrucktem Bundesmeldenetz (BMN) von gröβter Bedeutung, von der bisher 56 Blätter (Stand Jänner 1986) erschienen sind. Auch die Österreichische Karte 1:25 OOOV ist mit dem Bundesmeldenetz ausgestattet, sodaβ für die Erstel-

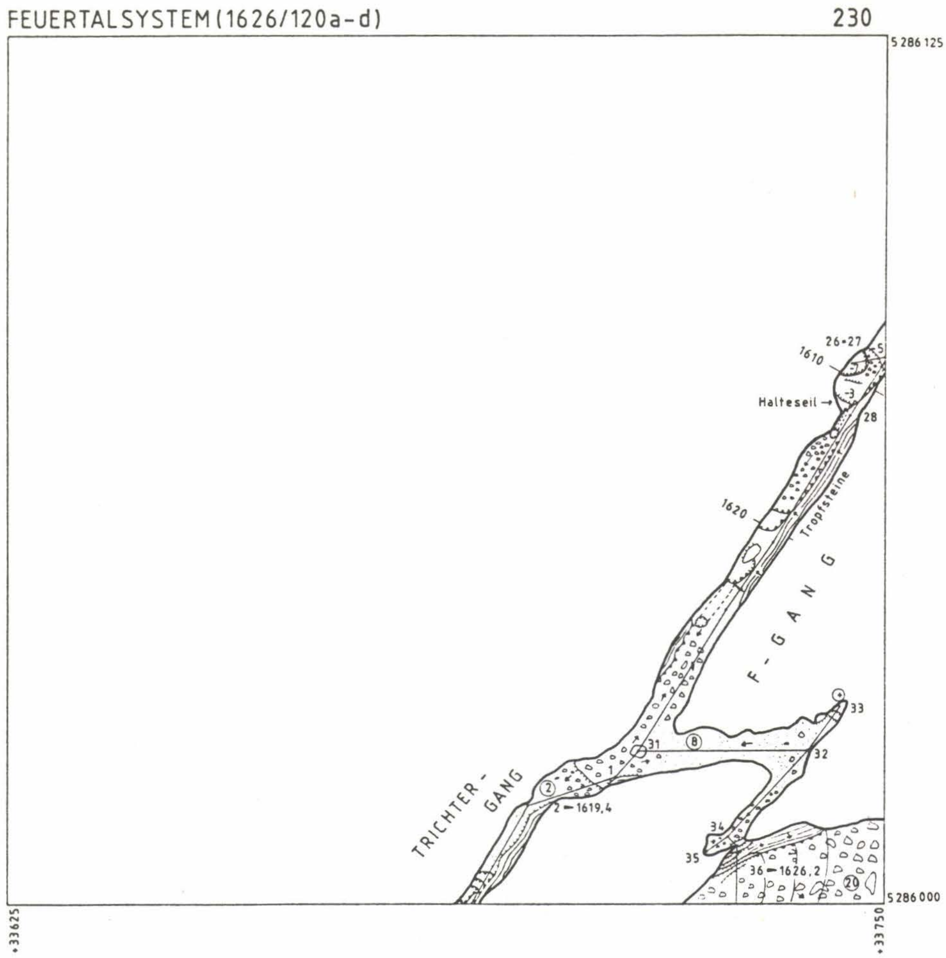


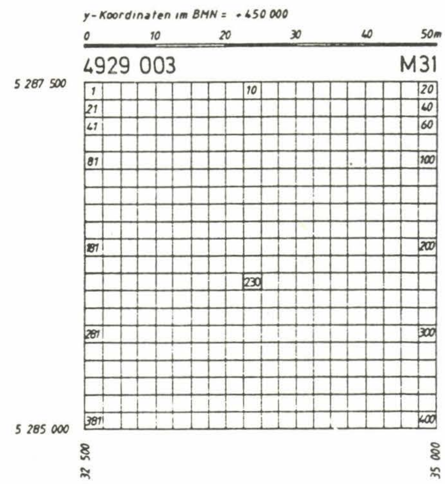
Abb. 3

FEUERTAL-ATLAS

Das Teilblatt ist bereits im Gauß-Krüger-koordinatensystem geschnitten. Angege= ben sind die geodätische Koordinaten, der Meridianstreifen M31, die Umrech= nungszahl für das Bundesmeldenetz und die Blattbezeichnung 4929 003.
Die Blattbezeichnung bedeutet:

Triangulierungsblatt	4929
Ausschnitt Luftbildkarte	0
Ausschnitt Katastralmappen= blatt	03

Die Lage des Teilblattes 230 innerhalb des 2,5x2,5km abdeckenden Blatt= schnittrahmens ist graphisch dargestellt.



lung von «Hölenverlaufskarten» und für Kartierungsaufgaben auch ein größerer Maßstab zur Verfügung steht.

Beim Bundesmeldenetz handelt es sich um ein modifiziertes Gauß-Krüger-System, bei dem dem Meridian 28 der Wert 150 000, dem Meridian 31 der Wert 450 000 und dem Meridian 34 der Wert 750 000 zugeordnet wurde. Dadurch sind alle Y-Werte (Rechtswerte) nur mehr durch positive Zahlen ausgewiesen. Die X-Werte (Hochwerte) sind bei allen drei beschriebenen Systemen ident, wobei lediglich beim Bundesmeldenetz die erste Zahl 5 weggelassen wurde, da sie für ganz Österreich gilt.

Für die Höhlendokumentation in Österreich und für alle daraus resultierenden Aufgabestellungen wurde nun auf das zivile Bundesmeldenetz zurückgegriffen.

Aufbauend auf diesen Voraussetzungen wurde vom Autor ein stufenweise geschachteltes System entwickelt (Abb. 2).

Vom 10 × 10 km abdeckenden, im Bundesmeldenetz geschnittenen Triangulierungsblatt und der bereits vorgegebenen Teilung und Benennung in jeweils 4 Luftbildkarten (5 × 5 km) bezw. in 16 Katastralmappenblätter (2,5 × 2,5 km) ausgehend, wurden nun die letzteren Ausschnitte zur Herstellung von 2,5 × 2,5 km großen «Karst- und höhlenkundlichen Arbeitskarten» im Maßstab 1:10 000 herangezogen. Diese quadratischen Karten sind an ihren Eckpunkten durch geodätische Koordinaten gekennzeichnet, wobei am Kartenrand jeweils die Gliederung des Triangulierungsblattes, der Meridianstreifen und die daraus resultierende Umrechnungszahl für den Rechtswert im Bundesmeldenetz angegeben sind. Damit sind diesen Karten sowohl die geodätischen als auch die Bundesmeldenetz-Koordinaten entnehmbar.

Diese Arbeitskarten können zur Erstellung von «Höhlenverlaufskarten», bei denen vor allem große Höhlensysteme, entsprechend dem Maßstab meist als schwarze Konturen, in ihrer Gesamtausdehnung, ihrer Lage zur Oberflächentopographie und in ihrem Lagebezug zu benachbarten Höhlen dargestellt werden, Verwendung finden.

Diese Arbeitskarten stellen aber gleichzeitig auch den neuen Blattschnittrahmen für die Darstellung der Höhlensysteme im Teilblattsystem dar. Zu diesem Zweck wird eine Arbeitskarte von 2,5 × 2,5 km in weitere 400 quadratische Teilblätter zerlegt. Ein derartiges, ins Gauß-Krüger-Koordinatensystem eingebettetes Höhlenteilblatt umfaßt nun eine Fläche von 125 × 125 m, erhält seine Bezeichnung durch die Kennziffern der Arbeitskarte (die sich aus der Nummer des Triangulierungsblattes, der Luftbildkarte und des Katastralmappenblattes zusammensetzt) und einer fortlaufenden Zahl von 1-400 und eignet sich bestens zur Darstellung des Höhlenausschnittes im Maßstab 1:500. Am Blattrand wird auch graphisch auf die Lage des Teilblattes innerhalb des 2,5 × 2,5 km großen Blattschnittrahmens hingewiesen (Abb.3).

Dieses System erfüllt nun alle an ein Kartenwerk gestellte Anforderungen. Es ist in ein übergeordnetes Koordinatennetz integriert, bei Kenntnis des Systems sind die Bezeichnungen der Nachbarblätter ableitbar und es ist eine nahtlose Ausweitung der Teilblätter über ganze Gebirgsstöcke möglich.

Die Darstellung in diesem System erfordert allerdings eine exakte, oberirdische Einmessung der Höhleneingänge. Dieser Entwicklung hat das Institut für Höhlenforschung Rechnung getragen und führt daher mit einer modernen geodätischen Ausrüstung diese Arbeiten gemeinsam mit den dort forschenden Gruppen durch.

Die bisher bei der praktischen Anwendung gewonnen Erkenntnisse und Ergebnisse haben gezeigt, daß sich dieses hirarchisch geordnete System besonders gut bewährt. So sind etwa entsprechende Vorarbeiten bereits im Steinernen Meer und im Höllengebirge (Hochleckengebiet) durchgeführt worden. Die Raucherkarhöhle und die Hüttstatthöhle wurden eingemessen, sodaß nun die bereits im alten Blattschnitt bestehenden Atlanten ins Gauß-Krügersystem integriert sind und auf den nach lokalen Koordinaten geschnittenen Teilblättern nun auch die Gauß-Krüger-Koordinaten angerissen werden können. Das Feuertalsystem (Österreichisches Höhlenverzeichnis 1626/120) die Höhlen westlich der Hüttstatt (Totes Gebirge) sind jedoch bereits nach dem neuen Blattschnitt dargestellt. Ein engmaschiges, besonders dichtes Vermessungsnetz auf der Tauplitz (Traweng, Schachtzone, Grub-

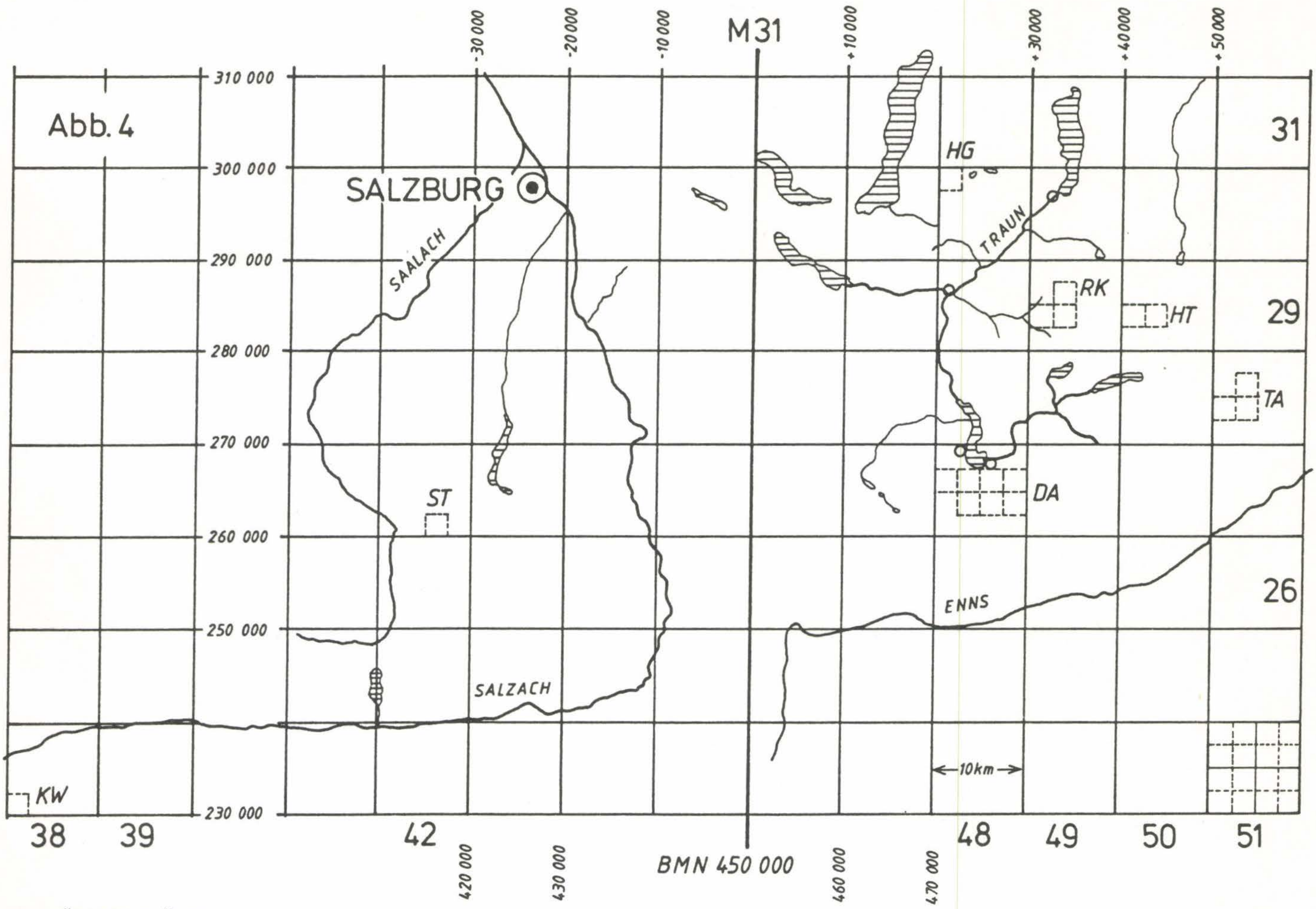


Abb.4 ÜBERSICHT ÜBER DIE ERSTELLTEN ARBEITSKARTEN
es bedeutet:
ST = Steinernes Meer
HG = Höllengebirge
RK = Raucherkarhöhle und Feuertal
HT = Hüttstatthöhle
TA = Tauplitz, Schachtzone, Grubstein
DA = Dachstein-Hirlatz

Angegeben sind ferner die Zonen- und Kolonnenziffern der Triangulierungsblätter sowie am oberen Rand die geodätischen, am unteren Rand die dazugehörigen Bundesmelde-Koordinaten

groβräumige und systematische Höhlendokumentation. Für welche Gebiete bereits Arbeitskarten erstellt und entsprechende geodätische Vorarbeiten durchgeführt worden sind, zeigt Abb.4.

Mit dieser absoluten Einordnung in das Bundesmeldenetz und stein) schafft dort bereits die Voraussetzung für eine optimale, in die Teilung eines Triangulierungsblattes ist darüber hinaus sichergestellt, daβ einerseits alle höhlenkundlichen Unterlagen in bestehende staatliche Systeme nahtlos übernommen werden können (z.B. in die Raumplanungsunterlagen), andererseits alle staatlichen Unterlagen (z.B. Luftbildkarte, ÖK 50 und 25V mit BMN u.s.w.) für den Höhlenforscher übergangslos nutzbar sind.

Daβ sich das hier vorgestelte System der Höhlendokumentation in jene Überlegungen einfügt, die in anderen Fachbereichen im Zuge des EDV-Einsatzes angestellt werden, zeigt der Aufsatz von WONKA (1984), der für die kartographische Darstellung der Bevölkerungsdichte 250 × 250 m groβe Flächen im Bundesmeldenetz vorschlägt und anwendet.

Die Nutzung des Bundesmeldenetzes für die Lageangabe von Punkten (Höhleneingänge) und zum Schnitt der Teilblätter wird in Zukunft eine übergangslose Integration speläologischer Datenbestände in bereits bestehende geowissenschaftliche Datenbanken ermöglichen.

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ESPELEOLOGIA TÈCNICA
ESPELEOLOGÍA TÉCNICA
SPELEOLOGIE THECNIQUE
THECNICAL SPELEOLOGY

TÈCNICA I MATERIAL
TÉCNICA Y MATERIAL
THECNICAL AND MATERIAL

1820

Research of Properties of Ropes

Ferdinand Šmikmátor
Czech Speleological Society, Commsission for Equipment

RESUM

Un dels problemes de caire tècnic que sovint se sol presentar és la qüestió de la fiabilidat que mereixen les cordes utilitzades en activitats espeleològiques. Hom constata una tendència cap a la millora de las seves propietats mecàniques, situació que no sol anar acompanyada d'una utilització apropiada a l'hora de fer-ne les proves corresponents. Els mètodes de prova que s'utilitzen normalment tenen un valor limitat des del punt de vista de l'espeleologia esportiva; a més, la utilització pràctica d'aquests resultats és, certament, qüestionable.

Els espeleòlegs txecs estan provant nous procediments, més perfeccionats, per a l'estudi dels processos a què es troben sotmeses les cordes en la seva utilització pràctica. No és casualitat que aquesta iniciativa provingui de Txecoslovàquia, ja que els espeleòlegs txecs es veuen ogligats a utilitzar cordes d'escalada de producció nacional, les quals no compleixen les normes que la U.I.S. estableix per a les cordes d'espeleologia. Els primers resultats d'aquestes proves semblen indicar que el treball de l'equip de la Comissió d'Equipament de la C.S.S. contribuirà a un millor coneixement de les propietats de les cordes i a una millor seguretat en la pràctica de l'espeleologia vertical.

RESUMEN

Uno de los problemas más importantes de tipo técnico es la cuestión de fiabilidad de las cuerdas que se utilizan. Las cuerdas muestran tendencias hacia la mejora de las propiedades mecánicas. Esta situación no va acompañada de una utilización apropiada de los procedimientos de prueba. Los métodos de prueba que se usan normalmente sólo tienen un valor limitado desde el punto de vista de la espeleología deportiva. Además la utilización práctica de los resultados es cuestionable.

Los espeleólogos checos tratan de iniciar procedimientos perfeccionados para estudiar los procesos que se dan en las cuerdas sometidas a la utilización práctica. No es por casualidad que esta iniciatiava proviene de Checoslovaquia, puesto que los espeleólogos checos se ven obligados a utilizar cuerdas de escalada de producción local, las propiedades de las cuales no cumplen las normas de la U.I.S. para cuerdas de espeleología. Los primeros resultados ya dan la seguridad de que el trabajo del equipo de la Comisión de Equipamiento de la C.S.S. contribuirá a un conocimiento más profundo de las cuerdas y a la seguridad práctica de la espeleología vertical.

SUMMARY

One of the most important technical problems is a question of reliability of ropes beeing used. The ropes exhibit trend towards improvement of mechanical properties. This situation is not accompanied by appropriate use of testing procedures, Testing methods, currently in use, do have only a limited information value from the viewpoint of practical caver. More over practical use of results is questionable.

Czechoslovak cavers are attempting to initialize improved procedures to study processes occuring in the ropes under practical use. It is not by a chance that this initiative comes from Czechoslovakia because Czech cavers are forced to use mountain climbing ropes of local production properties of which do not conform to UIS Standarts for Caving Ropes. Some first results give certainty that the work of team of Commission for Equipment of CSS will contribute to more thorough knowledge of ropes and safer practice of vertical caving.

One of the most important problems of vertical caving is a question of reliability of ropes beeing used. We witness rapid development of completely new types of ropes during latest years. The ropes exhibit trend towards improvement of mechanical and utilization properties. This situation is not accompanied by appropriate use of testing procedures that would comply with contemporary requirements and available testing technology. Testing methods, currently in use, do have only a limited information value from the viewpoint of practical caver as fare as rope stress, fatique and degradation concernes. Moreover, practiacal use of results is questionable.

Czechoslovak cavers are attampting to initialize improved procedures to study processes occuring in the ropes under practical use. They reached already several notable international successes in this country as well as abroad. Yet they are forced to use mountain climbing ropes of local production, properties of which do not conform to UIS Standards for Caving Ropes. Obviously the Commisson for Equipment of Czech Speleological Society could not remain indifferent to such situation. The main problem is that the cavers do not know how safe of unsafe they are on the rope that is available in this country / tensile strenght of about 15.000 N and elongation at 80 kg about 5 %. To solve

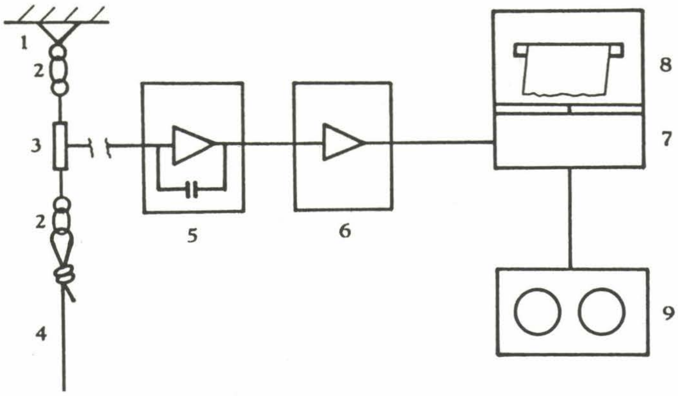

Figure 1. Block diagram of instruments were used during the first stage of project.
1. *anchor point*
2. *carabiner*
3. *strain gauge-type 9321 SN 57634, KIAG SWISS*
4. *rope*
5. *charge amplifier-type 5001, KIAG SWISS*
6. *galvo amplifier-type 5211 A, KIAG SWISS*
7. *power supply-type 3-143, Bell a Howell, U.S.A.*
8. *recordingoscilograph-type 5-130, Bell a Howell, U.S.A.*
9. *recorder-type CR 3000. 7 1/2, Bell a Howell, U.S.A.*

this important problem a volunteer team of members of various profession was established. This team will attempt to contribute considerably to better knowledge and understanding of deterioration processes in ropes. The basic requirement is an optimal simulation of actual performance of ropes in caves. The whole project was devided into following steps:

1. Measurement of forces in ropes during actual climbing
2. Mathematical analysis of results
3. Creating special programme for digitally controled testing machines and for suggesting suitable simulation on mechanical cycling machines
4. Performing fatique tests of various types of ropes under various conditions
5. Interpreting results

Until now we have succeded to finish the first task and partialy the fourth one. Measurements made were based on analysis of existing variations of techniques. Measurement instrumentation comprised piezoelectric tension sensor with neccessary amplifiers, ultraviolet oscilograph and instrumentation tape recorder –analog type. Measurement were recorded both on paper and on magnetic tape. Recorded data from tape can be digitalized and mathematically evaluated on a computer. Based o this evaluation as well as on statistical evaluation of techniques beeng currently used in Czech Speleological Society a universal equivalent model of actual loading of rope in caving conditions.

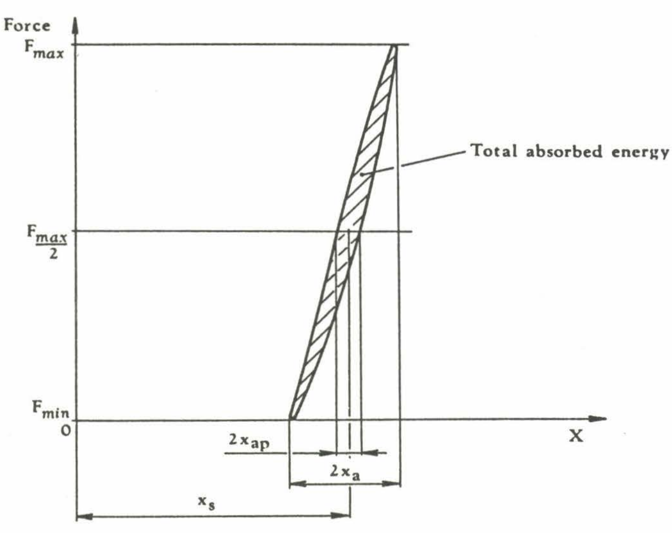

Figure 2. Diagram of graphic record with interpretation of used quantities.

In the course of time the original scheme turned out to be unrealistic because of the limited possiblities of an amateur team. Integration of all the courses of loading of the rope into one curve was not only impossible but also useless. That is why further research directed at getting acquainted in detail with mechanical properties and fatique characteristics of Czechoslovak ropes. It is necessary to note in advance that at the time of our experiments there were no international standard conditions at our disposal, so that the tests were realized according to the possibilities of the test device. This means that the results have a limited information value and must be corrected so they are in keeping with international practice.

Main interest was directed at a study of fatique behaviour of the ropes during a great number of loading cycles, which we consider to be one of the most important factors determining their reliability. Though it was a laboratory test we aimed at a most advantageous compromise between simulation of the real situation and possibilities of the test machine. We used the MTS device with programmed course of load force. The 11 mm rope sample was clasped between two Al– alloy rollers that were fixed in the jaws of the test machine. Active length of sample was 54 mm. The rope was loaded with static force of 800 N / thus we simulated weight of the «international caver»/. Then the sample was strained by

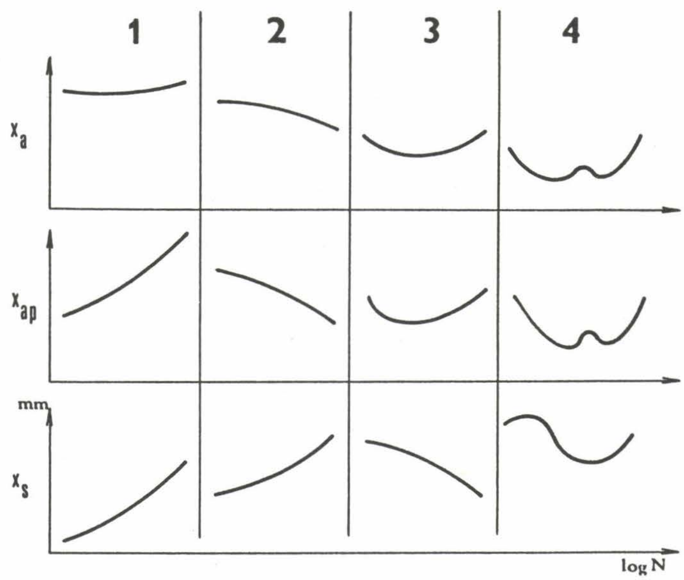

Figure 3. Behaviour of quantities during the whole test-see figure 4.

force of 800 ± 800 N with a sinusoidal course with frequency of 0,2 Hz. Because of lack of time the tests were finished after 50.000 cycles. For the tests and evaluation of their results we used the methodology usual in metal studies. The following table shows the results of a typical test.

The data were recorded digitally and graphically with a plotter. The whole data set can be divided into 4 characteristic groups see fig. 4, which shows the development of the changes in quantities. It holds during the whole experiment that the acting force is constant and the quantities x_a, x_{ap} and x_s are functions of log N.

Cyclic elastic properties of the rope $-x_a$

X_a is proportionate to the Young elasticity coefficient. Generally we can say that its value changes with the number of cycles. It will be the object of further experiments to verify to that extent this conclusion is correct, because behaviour of the rope differs from that of metal and the change observed may be due to the interaction of the inner fibre bundles or to the changes in microvolumes of

Number of cycles N	Total amplitude of deformation x_a/mm/	Amplitude of plastic deform. x_{ap}/mm/	Medium plastic deformation x_s/mm/	log N
1	5,20	0.50	15,30	0.000
2	5,18	0,58	15,54	0,301
3	5,20	0,65	16,40	0,477
50	4,80	0,55	16,86	1,699
100	4,75	0,50	17,10	2,000
200	4,60	0,46	17,54	2,301
600	4,60	0,48	16,72	2,778
1.000	4,50	0,44	16,60	3,000
1.500	4,70	0,46	16,34	3,176
31.000	3,80	0,30	20,40	4,491
32.000	3,45	0,22	22,00	4,505
34.000	3,75	0,25	21,60	4,531
35.000	3,80	0,25	21,00	4,544
37.000	3,50	0,22	22,40	4,574
50.000	3,80	0,26	22,94	4,699

macromolecules. Generally it can be inferred from the graph that with increasing number of cycles the x_a value decreases, e.g. with growing time of using the rope loses elasticity -it becomes more static and its ability to absorbe shock energy decreases.

Cyclic plastic properties of the rope $-x_{ap}$

The graph shows that with increasing number of cycles this quantity decreases. During the first three cycles the rope stretches considerably, then the contraction sets in, which can be explained as deformation strangthening of material. This quantity also influences the absorbtion ability of the rope and its mechanical properties.

Creep characteristics of the rope $-x_s$

If the x_s –value increases with the increasing number of cycles, the rope creeps. According to the graph the creep processes in the rope take place between the 1 st and 200 th cycle, the rope recovers between the 600 th and 1.500 th cycle and it generally continues to creep after a great number of cycles/ from the 31.000 th cycle on/.

Interpretation of results

- With the quantity x_s increasing the x_a and x_{ap} values fall, e.g. deformation ability of material decreases, the rope strengthens.

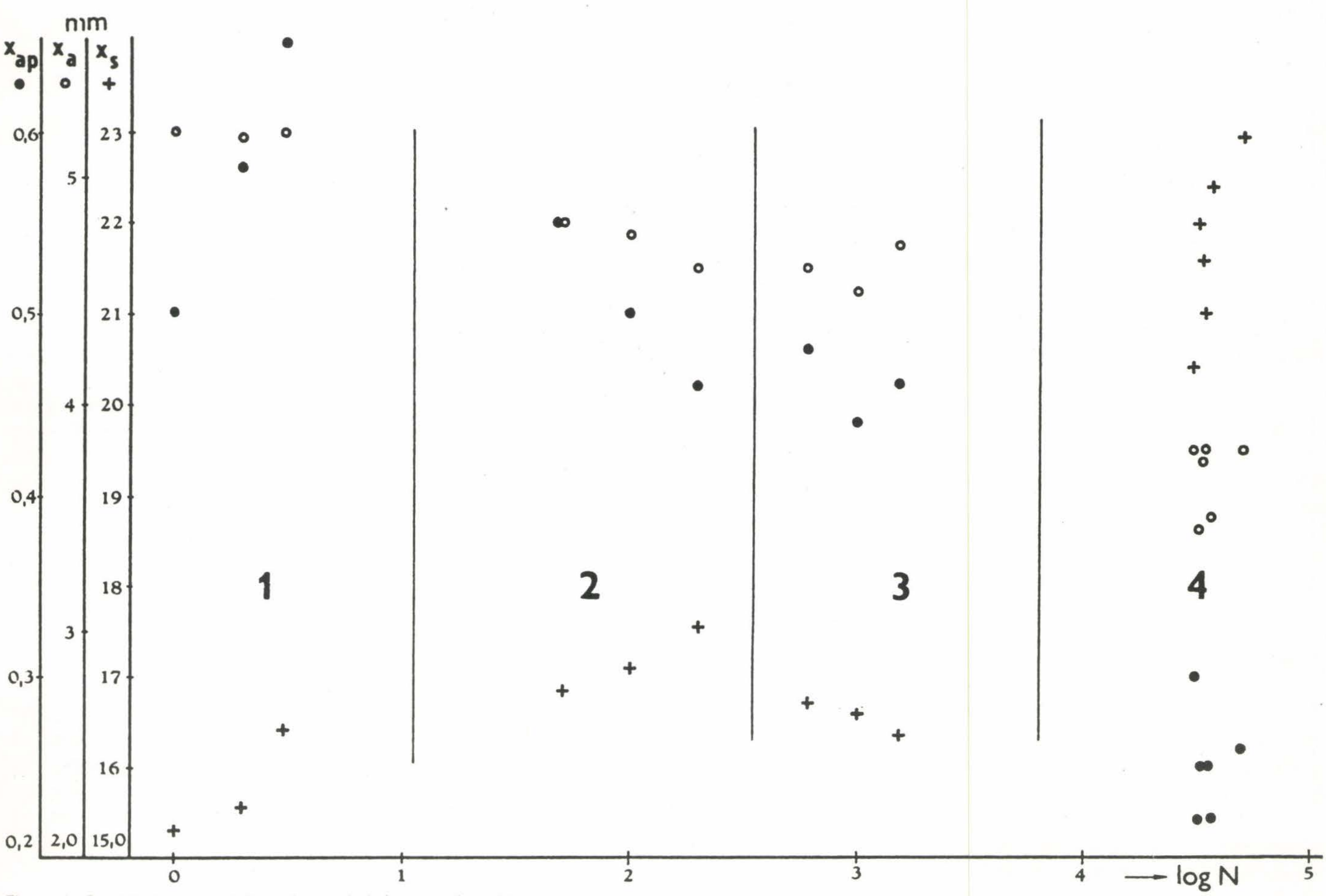

Figure 4. Graphical representation of recorded data-see the table.

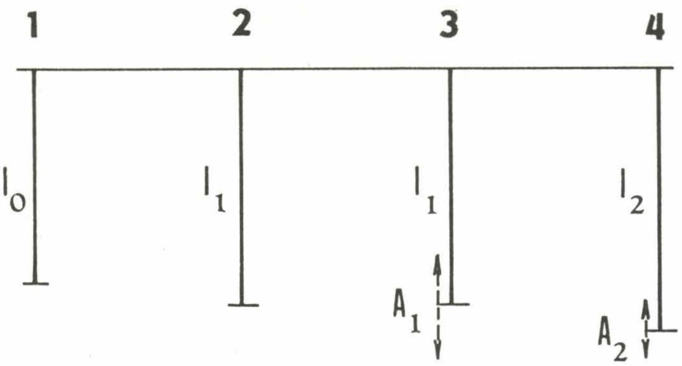

Figure 5. Objective scheme of change of mechanical properties during the loading
Case 1. Sample of rope without loading 1_0-lenght nominal
Case 2. Sample under the static loading only /800 N/ $1_1 > 1_0$
Case 3. Sample under the cyclic loading / N = 1/ –beginning of the test
A_1 –initial amplitude
Case 4. Sample under the cyclic loading / N = 5.10^4 / –finish of the test
A_2 resulting amplitude –$A_2 < A_1$
1_2 resulting length of sample –$1_2 > 1_1$

- At the beginning of loading the stretch of the rope is low and the amplitude of oscillation is big, but with the increasing number of cycles the rope stretches and the amplitude of oscillation gets smaller /see fig. 5/.
- All the changes in the characteristics of the rope begin to manifest themselves significantly only after a great number of cycles /N 10^4 which corresponds to about 0,5 hour of caver's uninterrupted movement on the rope.
- Strengthening of the rope is caused by a cyclic creep at an almost constant temperature. The consequence is a decrease in the values of x_a and x_{ap}.
- After completion of a test the sample was tough, after 12 hours it recovered its original elasticity.

Conclusion

The first preliminary results of a long-term experiment indicate that in agreement with the results of international research works the tested samples of Czechoslovak rope can bear the long-term exertion usual in SRT, at the same time it is necessary to take into account its disavantages and use it with maximum responsibility to achieve the highest safety possible. It is evident that the telling value of the laboratory experiment is relative. The method described is part of an extensive long-term project, which concerns it self with a complex research of all connected problems. Cooperation with foreign renowned associations will be necessary to give as well-founded information as possible on the possibilities and limitations of the ropes tested to Czechoslovak cavers.

Prospects of further work

- A detailed study and analysis of the acquired knowledge.
- A reappraisal of the methods employed for the experiment.
- An evaluation of the problems from the viewpoint of specialists in macromolecular chemistry and fibre production.
- Consultation with colleagues of foreign bodies /BCRA, NSS, etc./ which pursue these problems, and incorporation of our contribution into the international context, and, if need be, correction of the used methodology in order to unify the international practice.

We belive this interdisciplinary project shall contribute to more thorough knowledge of caving rope and of it's behaviour. This should contribute to safer vertical caving.

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Ascenders and Descenders: Insights into the variations

Gary D. Storrick
National Speleological Society

RESUM

El descens i l'ascens mitjançant rappel i prusiks són tècniques bàsiques d'espeleòlegs i d'escaladors, les quals han rebut, últimament, molta atenció per part dels grups de rescat convencionals. Durant els anys 60 i 70 els espeleòlegs han perfeccionat les seves tècniques, de tal manera, que la major part de les operacions verticals ha deixat de ser complicats exercicis i s'han convertit en pura rutina. Aquest desenvolupament tècnic ha anat també acompanyat d'una millora significativa en el disseny del material.

La col·lecció de l'autor inclou més de 100 davalladors i 50 bloquejadors europeus i nord-americans dels darrers 25 anys. Aquest treball estudia alguns d'aquests aparells ressaltant els seus avantatges i inconvenients. Al final, i citant alguns exemples dels fabricants de material de rescat més habituals, l'autor recalca la conveniència d'estudiar atentament els dissenys anteriors abans d'intentar millorar-los.

RESUMEN

El descenso y ascenso mediante rappel y prusiks son técnicas básicas de espeleólogos y escaladores, habiendo recibido recientemente mucha atención en los grupos de rescate convencionales. Durante los años 60 y 70 los espeleólogos han perfeccionado sus técnicas de tal modo que la mayor parte de las operaciones verticales ya no son complicados ejercicios, sino que se han convertido en pura rutina. Este desarrollo técnico se ha visto acompañado del correspondiente avance en el diseño del material.

La colección del autor incluye más de 100 descendedores y 50 bloqueadores europeos y norteamericanos de los últimos 25 años. Esta comunicación estudia algunos de estos aparatos resaltando sus ventajas e inconvenientes. Al final, citando ejemplos de los fabricantes de material de rescate más habituales, el autor recalca la importancia que tiene el estudiar atentamente los diseños anteriores antes de intentar mejorarlos.

SUMMARY

Rappelling and Prusiking are essential techniques for the serious caver and climber, and have recently recieved considerable attention in conventional rescue circles as well. In the 1960's and 1970's cavers have refined their techniques to the point that most vertical situations have become routine excises rather than the challenges they once were. This refinement in technique accompanied a corresponding improvement in equipment design.

The author's collection includes over 100 descender and 50 ascender types spanning the past 25 years of North American and European development. This paper considers several of these devices and examines their desirable features and their flaws. Finally, citing examples from the current «rescue rappel equipment» manufacturers, the author emphasises the importance of studying the works of others before attempting to improve the state of the art.

Ascenders

Thrun (1971) subdivides ascenders into knots consisting entirely of rope, semi-mechanical knots, and mechanical ascenders. Devices from the latter category are prefered for most serious vertical caving due to the improved efficiency obtained when employed in the more sophisticated climbing systems such as the Cuddington 3-phase, frog, or ropewalker. Consequently this paper will consider only mechanical ascenders.

The design of a mechanical ascender involves consideration of several parameters. The designer must achieve an acceptable compromise between size, weigth, safety, security, complexity, efficiency, speed of rope attachment, and ease of movement. Cost must also be considered, but unfortunately most people overemphasise this factor. Successful ascender designs generally fall into one of two categories. The first category, «grasp type» ascenders, includes those devices designed to be predominantly operated by the hands. Examples are the Jumar, Petzl Expedition, and CMI 5000 series ascenders. The second category includes devices designed to be operated without manual intervention such as the Gibbs, Lewis and Brew ascenders. For lack of a better term the author refers to these by their early North American designation, «climbing cams».

Most grasp type ascenders have several design features in common. In the typical implementation the ascender consists of a pivoting cam attached to a frame, which also serves as a handle. Slings connecting the ascender to the climber are attached to the frame. This arrangement necessitates the use of a toothed cam if the ascender is not to slip under load (Thrun, 1971). The frame is open on one side to allow easy rope attachment by manually opening the cam to its full open position. A safety catch is normally provided to insure the cam does not open inadvertently and release the main climbing rope. Most come in distinct left and right handed versions.

The extreme versatility of grasp type ascenders can be traced directly to the ease of attachment and removal. Any good design should insure that these operations can be performed quickly and smoothly, one handed and with either hand; however, the device must not come off the rope accidentally. The Jumar is perhaps the premier example of this class of ascenders. The placement of the safety catch allows easy release with the middle finger (particularly with the older, pre-1978 safety catch design) and the cam can then be opened easily with the thumb (or, if the ascender is held in the opposite hand, the forefinger). The Petzl, with the safety mounted on the cam, can also be operated ambidextrously but the motion is more awkward and the strong safety catch spring impedes the motion. The CMI 5000 series has similar problems. Finally, the Clog has a thumb actuated safety catch which is easily released, but the cam can only be opened if the ascender is held in the opposite hand.

Some less popular designs deviate from the configuration described above. The Bonaiti utilizes an untoothed lever action cam which requires a complex pivoting frame arrangement which appears to lack the strength of a solid frame. The Petzl shunt uses a novel class 2 lever arrangement for its smooth cam, but is a special purpose device for double ropes.

Several manufacturers have exchanged some ease in operability for a reduction in size and weight. Petzl, Clog, and CMI all introduced ascender models of this type.

Climbing cams typically consist of a cam which pivots in a U-shaped sheet metal shell. An example of a state of the art climbing cam design would be the Gibbs ascender. The climber's slings attach directly to the cam, resulting in a class 1 lever arrangement which eliminates the need for a toothed cam. There is usually no need for spring loading the cam in climbing applications, although spring loading has applications in hauling and rescue. Gibbs provides a spring loaded model where the spring loading is easily disengaged if not required. Since the hands are not required for operation, climbing cams may be operated directly to the climber's feet. Such ropewalking systems are very fast and efficient on free drops. The primary disadvantage of these ascenders is the time required for attachment to and removal from the main line. Consequently the climbing systems normally employed lack the versatility of those used with grasp type ascenders. In 1981 the author purchased a Kantyu ascender which can be described as an open-sided Gibbs. It was too small for use on standard North American ropes, but the design concept appeared sound and promised a significant improvement in attachment and removal speed. In 1984 the author made a similar device based on the Gibbs. It performed well on an expedition to Huautla, Mexico and elsewhere, and so was described at the 1984 National Speleological Society convention. To date no manufacturer has followed by introducing a similar device on a large scale.

Descenders

There have been a tremendous number of descender types marketed, reflecting not only a large design diversity but also substantial experimentation attempting to improve standard designs. This variety makers classification difficult. The author prefers to classify descenders based on the geometry of the rope path through the device rather than the morphology of the device. This is motivated by the observation that in most devices the perpendicular forces required to create friction between the rope and the device are generated by bending the main line rather than squeezing. Even racks and J-bars, which utilize squeezing to some degree, rely on a curved rope path for most of their friction. Squeeze brakes (which rely only on squeezing) have not achieved widespread ppularity due to safety and control problems. Nevertheless, they are easily included in the author's classification since their straight rope path is distinctive. Figure 1 illustrates one such classification with the class names based on typical examples. Of course the class names and the exact delineation of the boundaries between classes are not important since the classes grade into each other.

Important descender design considerations include size, weight, safety, heat dissipation, spin, friction provided and controllability. The first four are primarily functions of materials and dimension. The remaining three are heavily influenced by the rope path geometry.

Spin is generated by asymetries in the rappel equipment. The major contributer, laid rope, has fallen into disfavor in favor of braided (usually kernmantle) ropes. Consequently spin is now mainly a function of descender rope path geometry. The only rope path geometries providing complete angular symmetry and hence no spin contribution are planar ones. Important device examples are the rappel rack and the bobbin, perhaps the two most popular devices for serious cavers. Devices which lack a planar rope path will have varying degrees of spin depending on the exact rope path geometry. In some devices the geometry

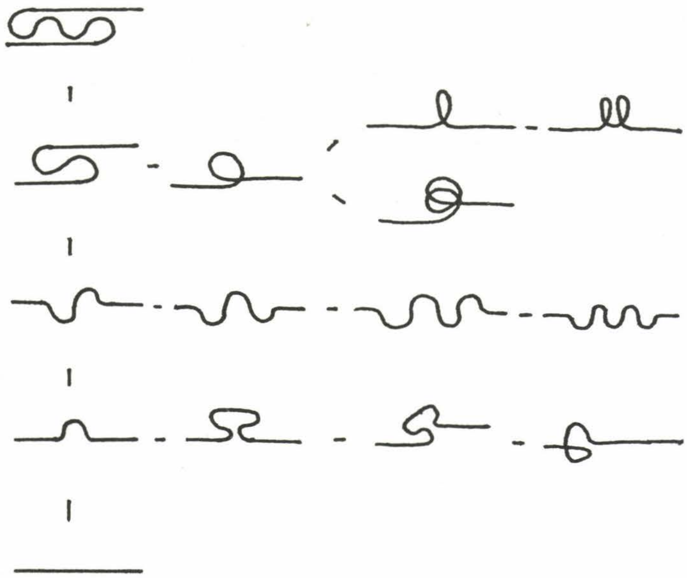

Figure 1: The author's method of classifying descenders based on rope path geometry. Small dashes illustrate some classes which grade into each other. Classes can be named based on a typical representative device. First column: Squeeze brakes. Second column (top to bottom): Brake Bar, Longhorn A, Longhorn B, Figure Eight. Third Column: Rack 2, Rack 3, Rack 4, Rack 5. Fourth column: Bobbin, Horizontal Spool 1, (left branch) Horizontal Spool 2, (right branch) Vertical Spool 1, Vertical Spool 2. Fifth Column: J-bar.

can be subdivided into two parts whose opposite spin contributions tend to cancel. The endless figure eight variations employ this spin reduction technique. Finally, designs with high angular assymmetry usually have high spin, as seen in the Hobbs, Peck, and Patten's hooks.

Friction is related to the total angular curvature Θ by the familiar snubbing formula $F = T(1-e^{-\eta\Theta})$ where F is the friction provided by the device, T is the rope tension above the caver, and μ is the coefficient of friction. Once again rope path geometry is the important factor. Increasing Θ increases the friction, as anyone who has added a wrap to a rappel spool understands. Since μ is essentially fixed by the materials and environment (eg., wet, muddy) the key to obtaining proper friction from a device lies in proper selection of Θ.

This finally brings up the subject of controllability. Unfortunately for the designer, there is a great variation in both cavers and environmental conditions and hence no optimum choice for Θ exists. A descender providing adequate friction for a 40 kg. female caver rappelling on a sandy rope may prove completely uncontrollable for a 100 kg. male carrying a 60 kg. expedition duffel on a new, clean rope. Therefore a variable friction device is highly desirable and at times almost essential. Both incrementally variable and continuously variable friction devices have been successfully introduced. The whaletail is a well known example of the former and has become popular in Australia. The brake bar rack provides continuously variable friction and is the device of choice in North America. Unfortunately, both these devices are larger and heavier than popular constant friction devices such as the figure eight and bobbin, and as a result are unlikely to completely replace them. Selection of a device is always a compromise.

Current Trends

The author has seen little in the way of significant new designs for either ascenders or descenders in many years. The basic grasp type ascender, the climbing cam, the rappel rack, the whaletail, the figure eight, the bobbin, etc. all date from before 1970. Improvements have been made in the area of material selection, manufacturing and quality control, but most recent improvements in device geometry consist of small changes to existing designs. Perhaps we have nearly achieved the optimum device designs possible.

Recently there has been an increase in interest in rappelling among rescue squads in North America and a corresponding large increase in the number of descenders marketed. Most of the devices that deviate from the most popular designs merely duplicate ideas which were tried unsuccessfully fifteen or more years ago. The Forrest roperider is essentially a rappel spool minus the rope guides. Another manufacturer has introduced a device which is very similar to squeeze brake designs abandoned years ago for safety reasons. The sidewinder is merely a slightly distorted longhorn. The tracson tries to combine an ascender and descender into one device, an idea generally abandoned long ago due to the difficulty of achieving good performance in either application. The author feels that had the manufactures of these devices researched the history of vertical technology, none of these devices would have been introduced. Their commercial success remains to be seen, but unless a substantial yet vertically uninformed market is found the author suspects that most of them are probably destined to fail commercially. History shows the original devices failed because they lacked the necessary combination of attributes that cavers/climbers/rescuers desired. Innovation is important if vertical technology is to progress, but the successful manufacturer will most likely be the one who thoroughly understands the basic principles of ascender and descender design and markets a proven product.

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Single Rope (Vertical Caving) Techniques in America A Survey of Current Practices and Equipment

David McClurg
Carlsbad, New Mexico
Former Chairman, Vertical Section,
U.S National Speleological Society

RESUM

Aquest treball descriu les tècniques de l'espeleologia vertical (SRT) i l'equip utilitzat normalment pels espeleòlegs nord-americans tal i com s'han anat desenvolupant, específicament, per a molts dels pous profunds (de 50 m. fins a 300 m. , o més) i en els extensos sistemes de rius subterranis que hom pot trobar a U.S. i a Mèxic. Els sistemes d'ascens que s'hi descriuen inclouen Gibbs, Ropewalker amb bloquejadors flotants, el sistema Jumar Mitchel i el sistema amb caixa gosset, Texas o Inchworm Jumar sistem i escales-electró. Els sistemes de descens que es descriuen inclouen un harness millor davallador del tipus vuit o rappel rack, i shunt. Amb el material d'ascens i descens esmentats, l'equip inclou cordes estàtiques d'espeleologia, de baixa elasticitat i d'una excel·lent resistència a l'abrasió, així com eslingues fetes amb membranes tubulars de 25 mm. i perló de 6-8 mm. Tots els sistemes verticals i l'equip corresponent seran exposats i es faran demostracions.

RESUMEN

Este trabajo relaciona las técnicas de la espeleología vertical (SRT) y el equipo usado normalmente por los espeleólogos americanos, tal como se han desarrollado específicamente para los muchos pozos profundos (50 hasta 300 m. o más) y los extensos sistemas de ríos subterráneos en los U.S. y Méjico. Los sistemas de ascenso descritos incluyen Gibbs, Ropewalker con bloqueadores flotantes, el sistema Jumar Mitchel y el sistema con caja gosset, Texas o Inchworm Jumar sistem y escaleras de cable. Los sistemas de descenso descritos comprenden un harness más descendedor de tipo ocho o rappel rack, y shunt. Junto al material de ascensión y descenso que acabamos de mencionar, el equipo incluye cuerdas estáticas de espeleología, de baja elasticidad y excelente resistencia a la abrasión, así como eslingas hechas de membranas tubulares de 25 mm. y perlón de 6-8 mm. Todos los sistemas verticales y equipo serán expuestos y se haran demostraciones.

SUMMARS

This paper surveys the highly-developed SRT (vertical caving) techniques and equipemnt currently in use by American cavers. Over the past 25 years, American SRT techniques have proven themselves safe, simple, and versatile. They have enabled American cavers to explore both the deep free-fall pits (50 to 300+m), as well as the complex multi-pit cave systems of the United States and Mexico. Because of their versatility, these techniques have also proven useful for smaller pits in conventional caves.

Ascending systems covered in this paper include 1) The Mitchell Jumar System witch chest box, 2) The Texas Jumar System (field-convertible from the Mitchell) and 3) The Gibbs Ropewalker with both ascedners floating. A descending system is described consisting of a rappel rack (or figure eight descender for shorter drops) with a sewn seat harness and a spelean shunt. Integral to American SRT techniques are static caving ropes with excellent abrasion resistance, high strength, low stretch, freedom from spin, and relatively low cost. All vertical systems and equipment will be displayed and demonstrated.

25 Years of Development and Field Use

Over the past 25 years, American caverns have developed a style of vertical caving (SRT) that has proven itsef to be safe, simple, and versatile. It has allowed them to penetrate many new or previously unexplored pits and cave systems in the U.S., Mexico and other countries.

Most American SRT systems can be said to have begun with a couple of carabiner brake bars for rappelling and Prusik slings of 3/8 inch (9mm) sisal rope for climbing out. The cable ladder was also widely used for short (10 or 20m) climbs, and occasionaly even for longer ones too. Rope for many years was mainly the old standby, three-strand Goldline. It spun you around horribly and had to be knotted together for really deep pits. Lather the first kernmantle ropes came into use and eventually today's superb quality static caving ropes were introduced.

During their two and a half decades of development and field use, American SRT systems have achieved an enviable safety record. These systems are simple to use and, although American caverns frequently must fabricate at least part of their vertical rigs themselves (because commercial versions are not generally available), they are also relatively simple to assemble. Moreover, they are multipurpose and have shown their value under a wide variety of different caving conditions. Main SRT Areas. Among the caving areas where American SRT techniques are wildey used are the:

Deep pits of the southeastern United States, Mexico, and other parts of the U.S.

O Complex multi-pit cave systems of Mexico.

O Smaller pits of other North American caves.

Deep Pits of TAG Country and Mexico

Tag Country. In the three southeastern states of Tennessee, Alabama, and Georgia, is a vertical caver's paradise known as TAG Country. Concentrated here are an estimated thousand or more pits. As a rule, the best krown of these are open-air free-fall pits that bottom out at 45 to 60 m. but a few, like these below, are among the wonderful exceptions that prove the rule.

Fantastic Pit, Ellison's Cave (Georgia)	155m
Increible Pit, Ellison's Cave	134m
Surprise Pit, Fern Cave (Alabama)	133m
Mystey Falls Cave (Tennesse)	96m
Mega Well (Alabama)	94m

Rigging. Many of the open-air pits are completely free after a few meters of contact with the wall at the top. Trees are abundant in this part of the country, so the 11m abrasionresistant rope is often tied off a meter to two up on the trunk of a tree. If possible, a tree rigth at the lip of the pit is chosen. Usually, the rope hangs free all the way to the bottom. A protective pad of denim material often the leg of and old pair of blue jeans, is tied at the top lip to guard against rope abrasion. Because the rope is rigged high on the tree, it is usually relatively easy to get off the rope when completing the ascent.

Safety Jumar. If the lip is difficult, many cavers routinely carry an extra ascender, a Safety Jumar, with a short three or four step etrier atatched. This is useful not only for negotiating lips and overhangs, but for crossing knots in the main line and as a general safety aid.

The safety Jumar is similar, at least inconcept to the cow tail used by European cavers. In use, it is often left attached to the seat sling and stuffed in a pocket or inside a shirt so as to be handy for emergencies.

Many of the popular TAG country caves are reasonably accessible: within 3 or 4 kilometers of a road. Carrying vertical gear and 60 to 90 m of 11mm rope, although accompanied by some expected grumbling, is not too difficult and is accepted as part of the game.

Mexican Pits. A good number of the deep pits in Mexico are similar to the open air pits in TAG Country-but much deeper.

For example, the free fall depths from the usual rigging points of three of the best known are:

El Sotano 410m
Sotano de las Golandrinas 334m
Hoya de las Guaguas 202m

The hike to Mexican pits is generally much longer and more difficult than to Tag Country caves. Because of the hot humid weather, Winter or Spring become the seasons of choice for a visit when feasible. In the early and mid 1960's, when Mexican pit caving was in its infancy, local Indian bearers and burros were often hired to carry equipment. Today, many back country trails have been made into roads. Some deep pits, such as Golandrinas, can now be reached with a four-wheel drive vehicle instead of the death march formely required.

SRT Systems for Deep Pits

Descending. American systems for deep pits work equally as well in any pit ranging from 15 to 350m and more. The key to doing really deep pits is a sewn seat harness (used by 87 %[1]) to provide a secure, comfortable resting position. A sewn seat harness is considered better since it is fail-safe should one section break. To this seat harness, a rappel rack (preferred by 96 %) is attached with a high strength locking carabiner. A Spelean Shunt, made of a Gibbs ascender with a carabiner attached to provide release leverage, is used by many American cavers. However, its uns is by no means universal.

Ascending. To ascend pits from as short as 15 or 20m to the very deepest, either the Gibbs ropewalker or the Mitchell Jumar system are the overwhelming choice (95 %) of American vertical cavers. Altho quite different in configuration, both actually operate very similarly. Your body remains nearly upright, close to the rope. You literally walk up the rope. The seat harness provides the rest position required by all but the strongest cavers, in reasonable safety and comfort.

[1] This percentage and others cited below are from a January 1986 survey of NSS verticalSection memebers.

The choice between Gibbs Ropewalker and Mitchell Jumar systems is largely personal. The ropewalker is more popular now (57 % to 34 % for the Mitchell). But 11 % of Vertical Section members surveyed have both systems. Gibbs for long drops, Mitchell for multi-drops or where water hazards, climibing, other technical problems exist. A jumar is easier to put on the line. You can in fact do it with one had. A Gibbs always requires two hands. But you have to move Jumars up the rope, whereas, Gibbs travel along with you without attention.

Rigging. Rigging deep Mexican pits often follows TAG Country practice, except that good trees in the rigth position at the entrance are sometimes harder to find. Bolts are used when necessary, but natural anchors are preferred here as this is the standard practice by most American SRT cavers. This means large secure breakdown blocks, stalagmites, columns, flakes, and the like.

Shorter Drops. For shorter pits up to 15 or 20m, particularey if in contact with the wall, the ligther weigth figure 8 descender (37 %) often replaces the rappel rack for descending. For coming back up, the Texas Sit/Stand system, or less frequently Prusik knots, replaces the ropewalker or Mitchell.

Note that the Mitchell is especially versatile, since it can be easily converted to the Texas configuration. A Sit/Stand system excells for short against-the-wall drops or where you need to keep away from the rope-as when forced to climb in a waterfall

Multi-Pit Systems

Mexican Cave Systems. Besides being known for its deep freefall pits, Mexico has now become justly famous for its world class cave systems. At least two (Sistema Huautla and Nita Nanta) have now passed the 1.000m depth mark. Most are characterized by a series of drops, as many as 30 or 40, each requiring a separate rope. Many of these drops are relatively short (5 to 20m). However, the higher sections of these complex systems sometimes will have deeper pits like the 75 and 90m pits of the Nita Sa/Nita Zan section of Sistema Nita Nanta, es just one of numerous examples.

Mexican River Caves. Many of these systems have active river passages, and even in the dry season, requiere full wetsuits for the many swims and waterfall drops. Sumidero Santa Elena, for example has more swims (52) than roped drops (30).

For these caves, many cavers prefer the Mitchell Jumar systems because it's easier to put on and take off the line.

Also it can be converted to the Texas Sit/Stand for short drops, particularly, waterfall drops. Getting on a rope, especially when standing or seimming in a pool of last moving water, is much easier with Jumars than with Gibbs, where the bottom ascender is on your foot down under the water.

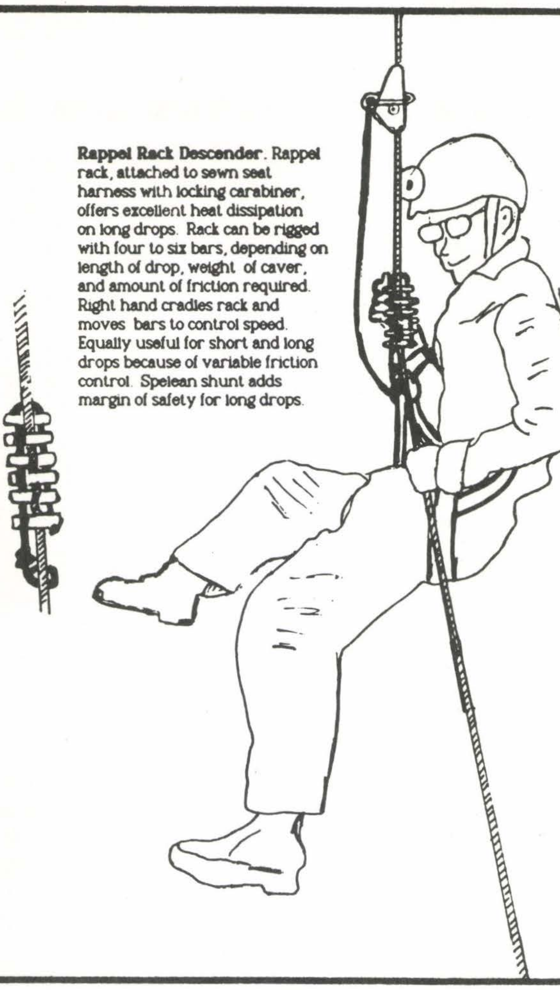
Rigging. Rigging all the ropes needed for the multiple pitches in these complex systems tends to follow, at least in principle, the American preference for natural anchors. But the harsh realities of deep river caving call for setting bolts and an occasional piton whenever a natural anchor is not readily at hand.

Carrying the extra weigth of 11mm rope (compared to smaller diameter ropes) in the multiple lengths needed has led some American cavers to recommend careful use of the newe 10mm abrasion resistant American SRT ropes instead. So far the newer ropes haven't had enough field use for a proper evaluation But the hope is there that the 10mm will work out.

Trends. All vertical cavers, and Americans are no exception, dream of ligther ropes and equipment, like 10mm rope.

As for other equipment, specific improvements will surely be made, at least incrementally. However, it should not be forgotten that many new designs in the U.S. are the work of individual cavers. The size of the American caving market is relatively small. For example, the number of cavers on the US is smaller than in Britain, even thougth the poulation of the US is some five times greater. Manufactures of caving equipment need other markets like sports, mountaineering, rescue, or fire departments to survive.

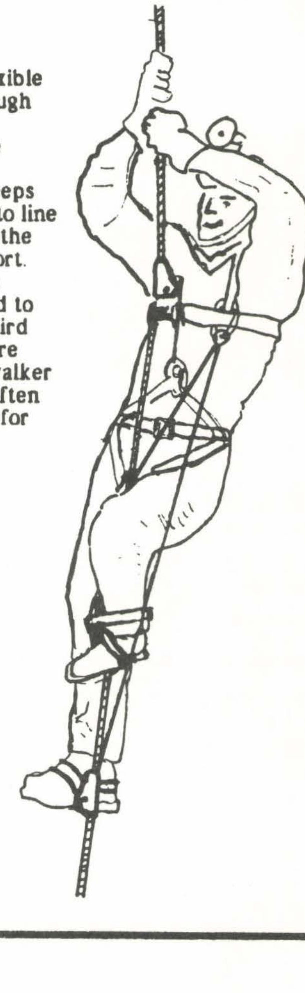
Portions of this paper are derived from the author's book *The Adventure of Caving,* Copyright 1986 by D&J Press.



Rappel Rack Descender. Rappel rack, attached to sewn seat harness with locking carabiner, offers excellent heat dissipation on long drops. Rack can be rigged with four to six bars, depending on length of drop, weight of caver, and amount of friction required. Right hand cradles rack and moves bars to control speed. Equally useful for short and long drops because of variable friction control. Spelean shunt adds margin of safety for long drops.

Mitchell Jumar System. Chest box keeps caver close to line so she literally walks up the rope. Both main line and top Jumar sling go through separate channels in box. Safety loops on boots keep Jumar slings securely attached. Sling from top Jumar to seat harness provides resting position. Sling from bottom Jumar to seat harness keeps ascender close to hand. Often a third ascender (omitted here for clarity) is attached to main line near box.

Texas Sit/Stand System. Upper Jumar goes to seat harness, lower goes to one or both feet, depending on type of sling used. Position of caver away from line is good for waterfall ascents, but cuts efficiency, because you have to raise yourself back up and into the line during each cycle. Best for short drops and waterfall pitches.



Gibbs Ropewalker. Flexible bungey cord routed through pulley on chest harness, floats both foot and knee ascenders for maximum efficiency. Chest box keeps caver upright and close to line enabling him to walk up the rope with mimimum effort. Top Gibbs (frequently a Spelean Shunt) connected to seat harness provides third point on line and a secure resting position. Rope-walker is system chosen most often by American SRT cavers for very long drops.

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Tests and practical experiences with Czechoslovak climbing ropes, used in speleology

Gustáv Stibrányi
Technical Commission of Slovak Speleological Society

RESUM

Les proves efectuades amb més deteniment incidiren sobre cordes d'escalada de la marca JUTA, utilitzades en espeleologia. Aquestes cordes sofreixen un elevat grau de degradació a causa del temps, l'aigua, el fang de les cavitats, la manipulació, l'abrasió i la pressió dels nusos. Si es guarden adequadament, preferentment en habitacions seques i fosques i a una temperatura de 15-20.° C. no s'observa una disminució de la seva resistència.

Les proves dinàmiques van posar de relleu que les cordes utilitzades tenen una millor capacitat que no pas les noves per a absorvir l'energia cinètica.

Les cordes de 11 mm. ∅ són satisfactòries per al seu ús en espeleologia, tècnica corda sola, durant molt de temps i càrrega intensiva.

No és recomanable l'ús de les cordes de 9 mm. ∅ per a espeleologia tècnica corda sola.

RESUMEN

La prueba efectuada fue la más extensiva en cuerdas de escalada de la marca JUTA, utilizadas en espeleología. Estas sufren un alto grado de degradación por influencia del tiempo, el agua, el barro de las cavidades, la manipulación, abrasión y la presión de los nudos. Si se almacena adecuadamente, preferentemente en habitaciones secas y oscuras y a 15-20.° C. de temperatura, no hay disminución de la fortaleza.

Las pruebas dinámicas mostraron que las cuerdas usadas tienen mejor capacidad que las nuevas para absorber la energía cinética.

Las cuerdas de 11 mm ∅ son satisfactorias para su uso en espeleología técnica sólo cuerda, durante mucho tiempo y carga intensiva.

No se recomienda el uso de las cuerdas de 9 mm ∅ para espeleología técnica sólo cuerda.

SUMMARY

The testing performed was the most extensive one at climbing ropes of JUTA mark, used in caving. There is a high degree of degradation of them, by influence of weather, water, cave-mud, manipulation, abrasion and knot-loading. There is no decrease of strength if there is proper storing, prefferably in a dark dry room, and at 15.°-20.·o C temperature.

Dynamic tests showed the ropes have better ability to absorb the kinetic energy after being used than the new ones.

The ropes of ∅ 11 mm are sastifactory for use in SRT caving for long time and at intensive loading, too.

Ropes of ∅ 9 mm are not recomended for use in SRT caving.

Introduction:

By the estimate some 12 to 15 thousand people hang up their lives on climbing ropes of JUTA mark more or less often. Over 7 thousand mountaineers and cave-men use the ropes in their activities in Czechoslovakia alone. Besides, these ones used by fire-men and in the industry too.

It's not a secret that the mountaineers and cave-men from the surrounding countries /Hungary, East Germany, Poland/ buy these either for sport or for any other purpose, often making their livings on ropes.

The JUTA climbing ropes of ∅ 11 mm are the most advisable ones for SRT in speleology among the ropes made in socialist countries. These realities and also a lot of rope tests and experiences publicated in world's speleoliterature by well-known personalities in last years inspired the Technical Comission of Slovak Speleological Society to know deeper the JUTA properties.

The tests felt into 2 main parts:

1. To follow + measure the change of some properties: Static strength, weight, flexibility, elongation when 80 kg loaded, ability to absorb a water, it all after used in different cave conditions.

2. To follow some dynamic properties of ropes. Their ability to absorb the kinetic energy developed by falling a human body and degradation of the property after use of ropes in general caving. To find a steel-mass of wight, truelly simulating that of a human body, and to find the shockforce growth at FF 2 in falling to different lenght of ropes.

It was impossible to compare the Czechoslovak ropes with the world marks, because of financial limitations. The price of tests on amateur basis was still rather high.

I can mention, as interesting, we had 20 pieces of ropes in tests of different lenght with length total of 1197 meters and we climbed 29410 meters on them in real cave conditions. It was all registered what happend with ropes during the tests.

Ropes of JUTA mark:

Czechoslovak climbing ropes are made of polyamid fibre of commercial mark CHEMLONKORD® manufactured in the national enterprise CHEMLON Humenné on the polymerization base of 6-caprolactam. Their fineness is 1880 dtex f 272 (1700 den), strength is 794 mN/tex (9 p/den) and elongation is 18,5 ± 2 %. This polyamide cord is final processed in the national enterprise JUTA Dvůr Králové nad Labem on rope in factory Bolatice. The ropes are manufactured with 11 mm diameter, of 30, 40, 45 and 60 meters legths, and 9 mm diameter (like half ropes) in lengths of 45 and 80 meters. The Czechoslovak standard disapproves sale of the climbing ropes of other lengths, or drum coiled, as standard elswhere.

Properties stated by producer:

∅ 11 mm – static strength 14700 N, elongation 18,5 %, weight 75 gr/m.

∅ 9 mm – static strength 11760 N, elongation 18,5 %, weight 65 gr/m.

Both kinds of these ropes are manufactured in two types which are not distinguished at sale.

Unused ropes 15. - 16. 3. 1983								15. - 21. 5. 1984						21. 1. 1986												
Evidence No.	Diameter in mm.	Date of produce	Weight per m.	Elongation at 80 kg	Knottest	Breaking strength the weakest sample	Average breaking strength in N.	Number of use	Number of climbers	Number of washings	Degree of use in tm/m.	Breaking strength the weakest sample	Average breaking strength in N.	Number of use	Number of climbers	Number of washings	Degree of use in tm/m.	Weight per m. dry	Weight per m. wet	Elongation at 80 kg	Knottest	Breaking strength the weakest sample	Average breaking strength in N.	Breaking strength the weakest sample wet	Average breaking strength in N. wet	Use conditions
8	9	28. 9. 1982	68,5	5,2	8	15250	15870	5	14	2	0,99	80 % 12200	85 % 13620	14	44	5	3,01	70,1	1,33 93,5	4,6	22	89 % 13620	87 % 13810	71 % 10850	75 % 11910	Permanent in water
9	9	2. 9. 1982	67,5	5,3	6	14700	15200	5	20	1	1,3	88 % 12950	91 % 13890	13	45	4	2,96	66,5	1,33 89	5,3	22	77 % 11350	81 % 12260			Only one end hung
10	11	24. 8. 1982	78,8	3,1	9	25000	25350	9	42	3	1,62	72 % 18140	78 % 19680	21	91	8	4,68	81,6	1,36 111,2	2,6	27	57 % 14200	63 % 15890	61 % 15580	67 % 17126	Generally used
11	9	13.12. 1982	65,2	5,3	6	11900	13380	4	22	2	1,45	102 % 12120	99 % 13230	11	50	4	3,41	67,4	1,26 84,9	3,8	30	83 % 9940	79 % 10550	78 % 9300	72 % 9613	Generally used
12	11	7.12. 1982	72,7	2,7	8	21650	22880	2	8	1	0,54	70 % 15130	73 % 16620	5	49	2	2,94	83,5	1,3 108,6	1,6	55	68 % 14750	66 % 15242			Permanent muddy
13	11	11.12. 1982	72,3	2,7	8	21300	23060	4	12	1	0,74	94 % 19940	91 % 20910	9	37	2	2,77	80,3		2,1	37	79 % 16900	83 % 19120			Stored dry
15	8	1.12. 1982	49,2	3,1	6	11800	12050					72 % 8470	75 % 9090													Left in atmospher.
16	8	1.12. 1982	51,2	3,1	6	11800	12050					71 % 8410	76 % 9140	1	10	2	0,66	53,7		3,1		65 % 7670	69 % 8290			Permanent muddy
17	8	1.12. 1982	50,7	3,1	6	11800	12050					68 % 7990	74 % 8910	5	24	2	1,56	53,6		3,6	26	73 % 8670	75 % 9080	70 % 8250	74 % 8930	Permanent in water
0	8	1.12. 1982	48,8	3,1	6	11800	12050					94 % 11130	102 % 12340							3	6	101 % 11950	104 % 12570			Unused
Ropes used in dynamic tests														23. 11. 1986												
18	9	26. 8. 1983												8	35	2	2,07									
19	9	26. 8. 1983				12700	13560							16	65	3	3,93									
20	11	30. 8. 1983												14	55	5	3,7									
21	11	30. 8. 1983				21500	22950							14	43	3	2,91									

Table 1 –Results of static tests

The ropes of ø 11 mm have a gently twisted core of 21 strands and the mantle is of 23 strands, 2 of which are different in colour (control strands). The ropes with coloured mantle (Photo 1, rope No. 1, Table 1, rope Ev. No. 10), red or blue, are more free in knit that's why there are more flexible and don't twist like the white ones (Photo 1, rope No. 2, Table 1, ropes Ev. No. 12, 13, 20 and 21) which are tougher. –See Table 1, knottest 21 Jan 1986.

The structure of the ø 9 mm rope, higher quality (Photo 1, rope N.º 3, Table 1, rope Ev. No. 8), is finer. The core is double, of 2 knitted elements, from 25 strands (13 + 12). The mantle is from 32 strands, from which 1 is coloured (the control one). The control strand of 9 mm diameter and 80 m length ropes is distinguished in colour for every half of the rope (usually blue and red). The other kind of ø 9 mm rope (Photo 1, rope No. 4, Table 1, ropes Ev. No. 9, 11, 18 and 19) has also the double core but from 2 disproportionally knitted elements of 20 strands (12 + 8) + 1 free strand in the core. The mantle is knitted of 24 strands, one from which is control. The difference between these ropes results from different production technologies (different knitting-mach.).

The industrial ropes (Photo 1, rope No. 5, table 1, ropes Ev. No. 15, 16, 17 and 0) are in Bolatice's factory JUTA made from the same material and on the same machinery like the climbing ones. That's why it is possible to compare the processes of degradation in industrial and climbing ropes. We were choosing them because of more appropriate price.

Static tests:

Were based on the strength of knotted rope at measurements. It's a real image of the strength in practical use. All the samples were knotted by right eight-figure knots at static measurements (Photo 2) which are stronger than the left ones (Right eight-figure knot is when the loaded arm curves top, at the outer side of the knot). The samples were torn by velocity of 25 mm/min. at static tests.

Explanatory notes for Table 1:

– Knottability based on «TISO» principle.

– All unused ropes were measured after stabilization. It means after 24 hours of wetting in water, followed by 9 days drying.

– Average strength is always the arithmetic mean from 6 samples. If unused ropes, it is of 5-13 samples.

– The percentage always concerns the rope unused. For example: The weakest sample to the weakes, the average strength of unused rope.

– The degree of use stated in tonmeters per 1 meter of rope. For example: If a group of 3 members used 68 meters from 80 meters long rope for descendind and for climbing of 60 meters deep pit, then the degree of use will be 0.204 tm/m.

$$k = \frac{lx.m.n}{l} = \frac{68.\ 0.08.3}{80} = 0{,}204\ \text{tm/m}$$

k – degree of use in tonmeters per 1 meter of rope
lx – length real of the rope used
m – weight of cave-man 80 kg = 0,08 t (constant)
n – number of cave-men
l – length total of used rope

Anomalies in the Table 1:

– The rope Ev. No. 9 was always used only from one end ①. There was a bond knot at the other end ② sometimes, but it was never loaded. The statc strength of singled ends is:

① – the weakest sample 11350 (77 %), average strength 11736 (77 %)

② – the weakest sample 12120 (82 %), average strength 12793 (84 %)

– There is a considerable strength difference between ropes Ev. No. 9 and Ev. No. 11, which are of same construction. The weakest sample of the rope Ev. No. 11, which are of same construction. The weakest sample of the rope. Ev. No. 11 is weaker by 19 %. It's possible to explain it here by poorer quality of the half-finished product from which was made or eventually, by improper storage.

– The difference in weight between ropes Ev. No. 9 and Ev. No. 11 is not explained. The eror in measurements is disclosed. The drying was going on, for 9 days with other ropes.

– The higher strength of the wet rope Ev. No. 10 treated on 21 Jan 1986 could be caused by its short wetting (6 hours). The other wet samples were torn after 3 days of wetting.

– The rope Ev. No. 17 disclosed from testing in 21 May 1984 from safety reasons.

– Growing strength of the rope Ev. No. 0 is caused by proper storing. It was stored in dark and dry room of constant temperature (15 – 20°C).

Dynamic tests:

What concerns the methods comparable we regret to say that: The rope ∅ 11 mm could not stand even 1 fall UIAA. The rope ∅ 9 mm stands perphas 1 fall UIAA and perphaps 1 from 2 samples may stand 2 falls (The UIAA tests were performed by the rope producer).

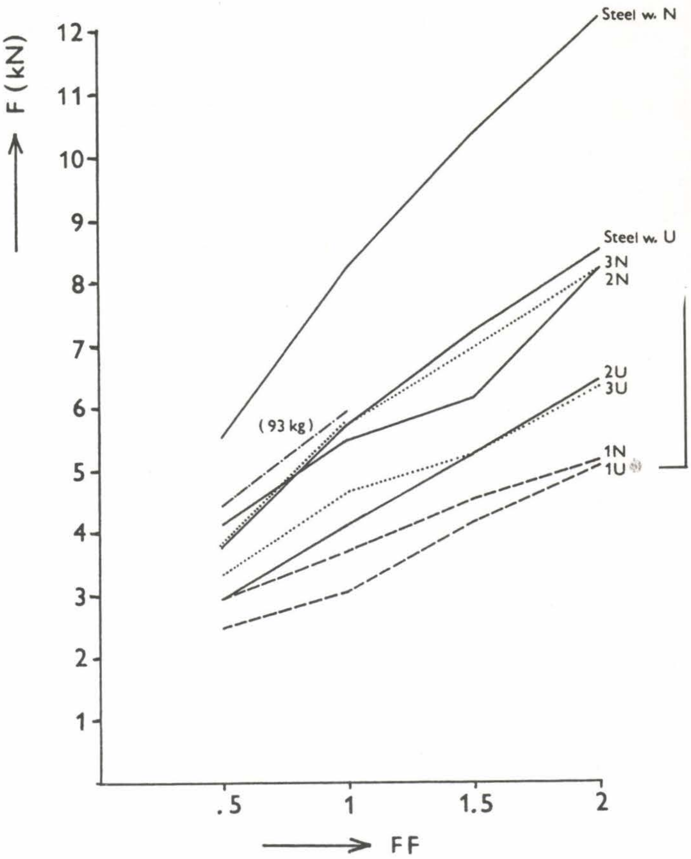
The concept of dynamic tests was as follows:

We bought 240 meters of ropes of ∅ 9 mm and 240 meters of ropes of ∅ 11 mm with the same date of production (the identical half-product) and we divided them into two halves. We used the first half for general speleology actions and we punctually registrated all the happenings about them. The second half underwent dynamic testing on 3 Dec 1983 and 14 Jan 1984, as follows:

We measured the shockforce at fall of a human body of 3 weight categories (60,8 kg, 80,8 kg and 85,5 kg) into 1 meter long sample of rope at fall-factor (FF) 0,5; 1; 1,5 and 2. Every trial was repeated 5 times. Measured were 60 real falls into the rope of ∅ 9 mm, and other 60 falls into the rope of ∅1 mm. We must have stopped the measurements at 93 kg because already

Fall-factor	m - body or steelweigh N - new rope U - used rope	Shock force in N.							
		Rope ∅ 9 mm				Rope ∅ 11 mm			
		1. weigh cat.	2. weight cat.	Steel weight	3. weight cat.	1. weight cat.	2. weight cat.	Steel weight	3. weight cat.
FF 0,5	m N	60,8 2932	80,8 4147	82 5510	85,5 3760	63 3367	83 4021	82 7427	85 4273
	m U	63,5 2491	80,8 2940	81 3722	88 3309	62 3120	81,75 3760	81 4761	88,3 3879
FF 1	m N	60,8 3709	80,8 5494	82 8234	85,5 5735	63 4693	83 5491	82 10624	85 5891
	m U	63,5 3059	80,8 4121	81 5727	88 4712	62 3862	81,75 4722	81 6718	88,3 4920
FF 1,5	m N	60,8 4538	80,8 6164	82 10375	85,5 6946	63 5475	83 7304	82 12596	85 7515
	m U	63,5 4169	80,8 5284	81 7230	88 5237	62 4705	81,75 5650	81 9549	88,3 5756
FF 2	m N	60,8 5124	80,8 8235	82 12265	85,5 8266	63 6332	83 8521	82 15944	85 8187
	m U	63,5 5066	81,75 6442	81 8518	88 6366	62 5312	81,75 6881	81 11110	88,3 6828
Control measurements with tied knots.									
FF 1,5	m N							81 14793	
	m U							81 11820	
FF 2	m N		81,75 7918						88,3 8752
	m U		81,75 7715			was broke		81 14715	88,3 8704
Multiplicity of shockforcegrowth at FF 2 - new rope -									
Peak forces FF 2		5557	8670	12265	8384	6432	9514	16348	8626
Multiple No.		9,32	10,9	15,2	10	10,4	11,7	20,3	10,3
Multiplicity of shockforcegrowth at FF 2 - used rope -									
Peak forces FF 2		5398	6577	8590	6474	5413	7083	11271	7049
Multiple No.		8,7	8,2	10,8	7,5	8,9	8,8	14,2	8,1

Table 2 –Results of dynamic tests –average values



Graph 1 –Growth of shockforces versus FF in 3 (body) weight categories, and with one steel-block weight category. Rope of ∅ 9 mm.

at FF 1 the shockforce reached 6160 N and the voluntary «jumper» refused to continiue. We made 3 measurements also with steel-block weight 82 kg. Whole cycle was repeated (the cycle of the measurements) after two years (23 Nov and 14 Dec 1985) with the same persons on the first half of the ropes, which went through general use in speleology. This part of tests was led by Jozef Filas from Technical Academy in Košice.

Measurements conditions:

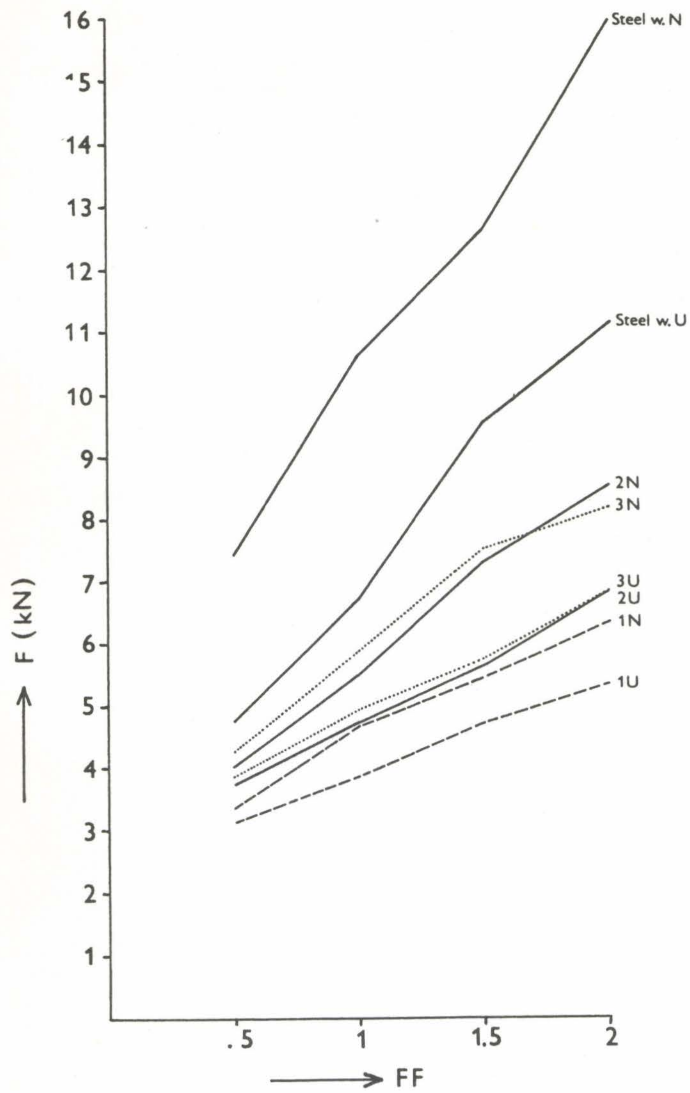
A load cell was fixed by a Maillon Rapide 7 GO and by 1 meter long steel rod of 30 X 6 mm on one ferroconcrete post of portal crane in the hall CÚ of Cement factory Turňa nad Bodvou. This fixation approximately gave us the static unit as in caving conditions.

The cave-man was fixed to the load cell by 1 meter long sample of the rope also with the Maillon 7 GO (by karabiners Walter 3000 with lock nut, in 1985). Measuring sample, two eight-figure knots including, was 1 meter long ± 2 % after static load by jumping person (steel-block). One knot was always L.H. and tightened from previous trial. Second, R.H. eight-figure knot was tightened only with static load (weight) either of a man or steel-block. The lenght tolerance was strictly adhered to. Measuring sample was connected to central anchorage of the cave-man's sit-harness. This one was united with chest-harness and with independent life-rope in case of failing measuring chain. A control of fall height was made by measuring-tape. A jumping man jumped alone on preliminary signal of the oscillograph attendant (Photo 3). Recording tape rate of ocsillograph was set to 16 m/sec – 50 m/sec.

In Table 2 and Graphs 1 and 2 only averaged values are given. The details results are too extensive for this report.

Perceivings at dynamic tests.

The most important perceiving in the second circle is the finding that there are lower shockforces in used ropes occuring. Though calculating the force losses would be greater when knots tighted up on less flexible used ropes, higher shockforces for the



Graph 2 –Growth of shockforces versus FF in 3 (body) weight categories, and with one steel-block weight category. Rope of ⌀ 11 mm.

second series were expected. After the finding we performed some control measurements on samples with both knots tightened (samples part 1 fall FF 2). These measurements showed us to that in the used ropes are smaller shockforces!

In the future we shall measure decreases in shockforce with ⌀ 11 mm rope.

Two samples raptured at forces of 10243 and 10648 M, when dynamic testing the samples of new ⌀ 9 mm ropes with steel-block weight 82 kg. In the 2nd series we measured the shockforce of only 8805 N at the measurements with the same rope but used, and no sample raptured!

We took 4 samples for static breaking strength measurements after rapturing the samples of new rope by forces 10243 and 10648 N. The average static breaking strength was 13560 N. It must be realised that the rope shall rapture at about 25 % lesser value of the dynamic loading.

In dynamic tests sit-harneses of Czechoslovak construction, type KOMBI were used. The experiences with sit-harness type Petzl C 15 CROLL were so painful it's not possible to imagine anybody could survire more falls FF 2.

The fall is less painful when sit-harness is faster tightened on body.

It's very necessary to take into consideration the numbers form lower part of Table 2 with multiplicity of shockforce growth at FF 2 as compared with the mass of a cave-man. Especially at buying your personal equipment (helmets etc.). It's multiple number near 10 for new rope. It means if you have a helmet of 2 kg on your head so it will be like 20 kg at falling FF 2 into 1 meter rope only, and you can well break your neck. It's necessary to have a lighter equipment (Petzl Ecrin 900 gr.).

We must be very careful at jumps. There was 9510 N max. force measured at falling of human body, but the dynamic tests were not «kamikaze - kind» (like said one critic). That could be very interesting subject for psychology too. The jumpers quickly altered situations of shock, stress and selfcontrol at falls FF 1,5 and 2. Hardly anybody can achieve it and that's why I want to mention the names Peter Perlík from group Jasov and Peter Tar from group J. Majku.It would be worthwhile for every cave-man to give it a try, and to learn from the experiences to exercise more caution when caving.

Discussion.

The static tests lack some those criterions that are suggestive of a rope performance. The author is aware of some shortages, e. g. small number of samples, improperly balanced rope usage, the sampling chronology.

There are some financial, but also time, and organizatory problems, which are in amateur conditions so difficult to estimate. Despite the shortages the level of losses in properties or, eventually, of property change, come clearly visible, due to precise life-keeping in particular.

The degree of use mentioned, though it is by no means an exhaustive one, in the sense we introduced, and with an integrity of multi-factorial attitude, may be a more explanatory one. From among the important degradation factors, i. e. number of use, number of washings, degree of use, watter, cave-mud, etc., derive-albe are the relations which, post computer-processed, could be indicative of degree of wear of rope, all without any need for expensive, complicated, practical testings.

Also dynamic testing shoved some defficiences, mainly due

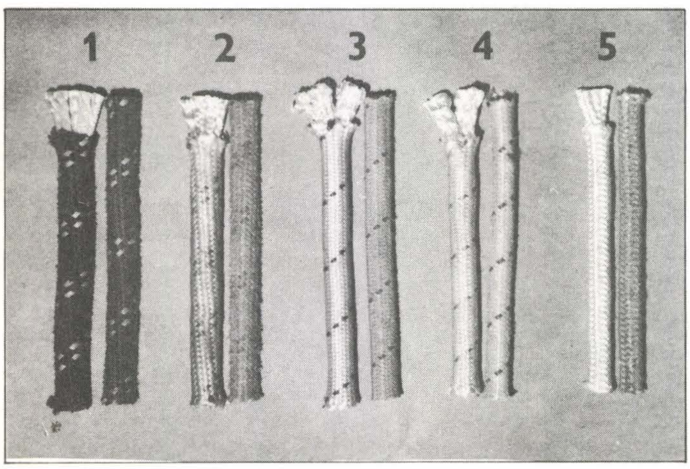


Photo 1 –Ropes of JUTA mark

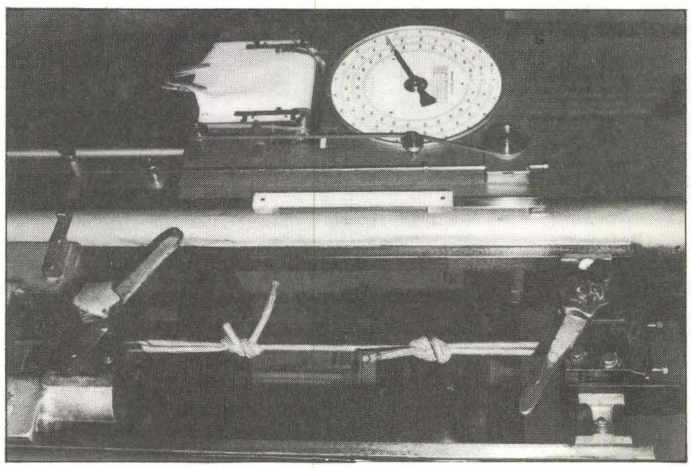


Photo 2 –Static tearing of rope sample to subjective approaches to knotting and to rope jump techniques. The number of measurements taken disables plotting sufficiently balanced force growth curves. Nevertheless, we can at least have some hint on the problem, and, though approximately at least, we are able to state the steel-block weight simulating a human body weight of 80 kg. See Table 3.

	∅ 9 mm	∅ 11 mm
New rope	57 kg	43 kg
Used rope	61 kg	55 kg

Table 3 –Steel-block weigth simulating a human body weight of 80 kg (in text)

Because of only a simple series measurements performed, the data of Table 4 are only of informative nature.

Used rope	Steel weight 52,2 kg						
Ev.No. 11	Rope length	1 m	1,5	2	2,5	3	3,5
∅ 9 mm	Force FF 2	6889	7514	7827	8140	9079	8140

Table 4 –Increase of shockforces at steel-block weight of 52,2 kg, FF2; 09 mm used rope, as dependant on the rope length.

Conclusion.

The testing perfomed was the most extensive one at climbing ropes of JUTA mark, used in caving. There is a high degree of degradation of them, by influence of weather, water, cave-mud, manipulation, abrasion and knot-loading. There is no decrease of strength if there is proper storing, prefferably in dark and dry room, and at 15°-20°C temperature.

Dynamic tests shoved the ropes have better ability to absorb the kinetic energy after being used than the new ones.

The ropes of ∅ 11 mm are satisfactory for use in SRT caving for long time and at intensive loading, too.

Ropes of ∅ 9 mm are not recomended for use in SRT caving.

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Photo 3 –Preparation for fall FF 2 jump

Photo 4 –The hundreds of samples destroyed during the tests.

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The «Tunel de la Atlantida» (Lanzarote). Exploration Methodology.

J. Bedoya, J.L. Fernández, J.L. García, L. Lapido, F. Lucero, J. Medina, F. Molinero, L. Ortega, C. Portilla, F. Seguro.
Asociación Deportivo-Cultural S.T.D.

RESUM

Durant el mes d'agost de 1984 i de 1985 la secció d'immersió espeleològica del grup S.T.D. dugué a terme l'exploració del Túnel de l'Atlàntida. La màxima longitud aconseguida fou de 1.750 m, lloc on la cavitat es troba a 60/70 m. de profunditat.
En aquest treball expliquem la tècnica i el material utilitzat en aquesta exploració.

RESUMEN

En el mes de agosto de 1984 y 1985 la sección de espeleobuceo del grupo S.T.D. llevó a cabo la exploración del Túnel de la Atlántida. La máxima longuitud alcanzada fue de 1.750 m. en donde la cavidad tiene de 60/70 m. de profundidad.
En esta comunicación explicamos la técnica y materiales empleados en esta exploración.

SUMMARY

During August 1984 and 1985 the speleodiving section of the S.T.D. group, carried out the exploration of the Tunel de la Atlantida. The maximun length reached was 1.750 m. where the cave has 60/70 m. depth.
In this communication we explain the tecnic and materials employed in this exploration.

Introduction

The «Túnel de la Atlántida» is located in the Jameo del Agua (UTM coordenates 28RFT527264, Army Geographical service map n.° 48-35 (1080).

This cave form part of a long lavic tube whose total length is larger than 7 km. The tube begins at the base of the «Volcan de la Corona» and it goes toward the sea leaving in his way more than twenty downfalls (jameos) some of them of particular beauty (Jameo del Agua, Cueva de los Verdes).

From the Jameo del Agua to the known end there is 1.570 m. of submerged cave of which 1.270 m. go below the marine bed.

The exploration of this cave began in 1972 when Guerra brothers reached 370 m. length. In February of 1981 an Italian expedition reached 410 m. Six months later Standard Group (now S.T.D.) came to 820 m. of lineal run.

In 1983 a German-Northamerican group carried out the «Jameos del Agua International Expedition». The new mark obtained by them fixed cave record in 1.370 m.

One year later, S.T.D. Association came to Jameo del Agua to study the fauna of the cave in colabortion with the Natural Sciences Museum of Madrid.

Last year, S.T.D. came one more time to this cave to advance further in the cave exploration. They reached 1.570 m. length and 60 m. deep.

Material

The principal technical difficulties that this cave present, consist essentially in the absence of ligth, great periods of permanency under water and the progressive deep increment that reach his higher point at the further distance known.

The great times of immersion oblige to consider light absence and air supply as two related problems. First, lack of light was palliated using lanterns with reduced size and weight. This lanterns have two hours of autonomy each, and four were carried by each Speleodiver. Diving bottles of 15 l. and 300 Kg/cm^2 were used for air supply. The bottles were joined in tandems of four. Int his way each diver disposed of 18 m^3 of air, which permited to move int into the cave with a large safety margin.

It was intended, within the possible, that bottles migth be total independent to control possible damages.

We had propulsors vehicles to advance in stalled pieces.

To avoid the danger that a long descompression present, we have designed and made a receptacle similar to a bubble where water absence allow a dry and relatively comfortable environment to the divers.

Other current diving and surface support material were used.

Exploration methodology

A submersed cave exploration need a method to reach the higher efficiency with a minimun of risk.

After a general program was established, a detailed working plan was prepared everyday for the next day immersion.

The first few immersions were devoted to two works simultaneously. One of them was to examine the guide cord installation and to install a bottle each 200 m. These bottles were prepared to prevent unusual air spend. They were deposited at 200, 400, 600 and 800 metres.

The other was the installation of the descompression «bubble». This was a spherical structure constituted by seventeen stell tube pieces that were fitted under water. The «bubble» was open of the bottom in order to let the divers pass. Water proof was attained by mean of a plastic which was attached to the metallic structure by a nylon net.

Water absence provoked an ascendent force of 4000 Kg. aproximatly. To strike back this force we had to anchor the structure to the soil and roof.

Under the «bubble» air and oxygen bottles were deposited to descompression.

Seven days later the exploration began. The 1370 first metres were effected with propulsors vehicles. In this way, diver air consumption was low. In this part of the tunnel, guide cord had been installed at 820 m. by S.T.D. in 1981, and by the «Jameos del Agua International Expedition» from 820 to 1370 m. in 1983. Our guide cord had a mark each ten metres which gave to divers enough information to know at any time were he was. This installation was made in 100 m. pieces and the cord was carried in a little bag. Meanwhile one diver tied an auxiliary cord to the substrate, the other one tied guide cord to that.

From 1.370 m. to 1.570 m. the tunnel was unexplored and a new cord was necessary. This was finer than 1981 and without location marks. The mode of installation was by means of a turning reel with 200 m. of cord.

As a safety basic role, air consumption was apportie in a third part to advance, another third to return and the rest as safety margin.

Descompression

Cave morphology and the last exploration point distance, had conjetured more than five hours of descompression, according to American descompression tables. This was too much time under water implicating a cold incident to divers. The solution was to search for low descompression time and minimed under water permanence.

First objetive was obtained employing oxigen at 6 m. and 3 m. descompession pauses. We have also employed a microcomputer (ITT-XTRA) to calculate «in situ» descompression times by means of an adecuate mathematical model (the employed to obtain the French Professional tables).

The methodology employed was:

Maximal times were assigned to surpass a series of deep points in cave known zones, datas already possesed through the preparatories immersions (30 and 50 m. deep).

It considered three exploration times cases with 60 m. maximal depth. Lastly It was assigned a maximal time to 33 m. point and first descompression pause arrive. Divers should not surpass the stablished maximal times and they should adjust their immersion to any of the three exploration times cases.

Divers should note the time employed to reach 33 and 50 m. depth, the time that they stayed deeper than 50 m., the maximal depth value and the time they employed to arrive to 33 m. and first descompression pause in the return way.

A support group waited the exploration equip at 120 m., 25 m. depth to gather exploration data.

These data were introduced in the microcomputer and descompression pauses times were obtained.

Afterwards, support equip gave descompression values to the exploration equip.

Exploration immersion length was 7 hours and 50 minutes. 2,20 hours were employed in the exploration, 3 hours under water descompression and 2,30 hours into «bubble» descompression.

Discussion

Due to the length and deepness reached in this cave would better to used gases mix. In this way descompression times should be disminished.

It verified that exploration efficacy at distant points goes in safety detriment because guide cord with no location marks and his installation may have less substrate attachs.

Lastly it was verified that descompression «bubble» is needed to next exploration immersions is this cave because a long time can provoke cold incidents. A similar function can attain if constant volume rubber suits were employed.

The cave dimmensions remain without considerable changes in all the explorated run, and cave end is still unknown.

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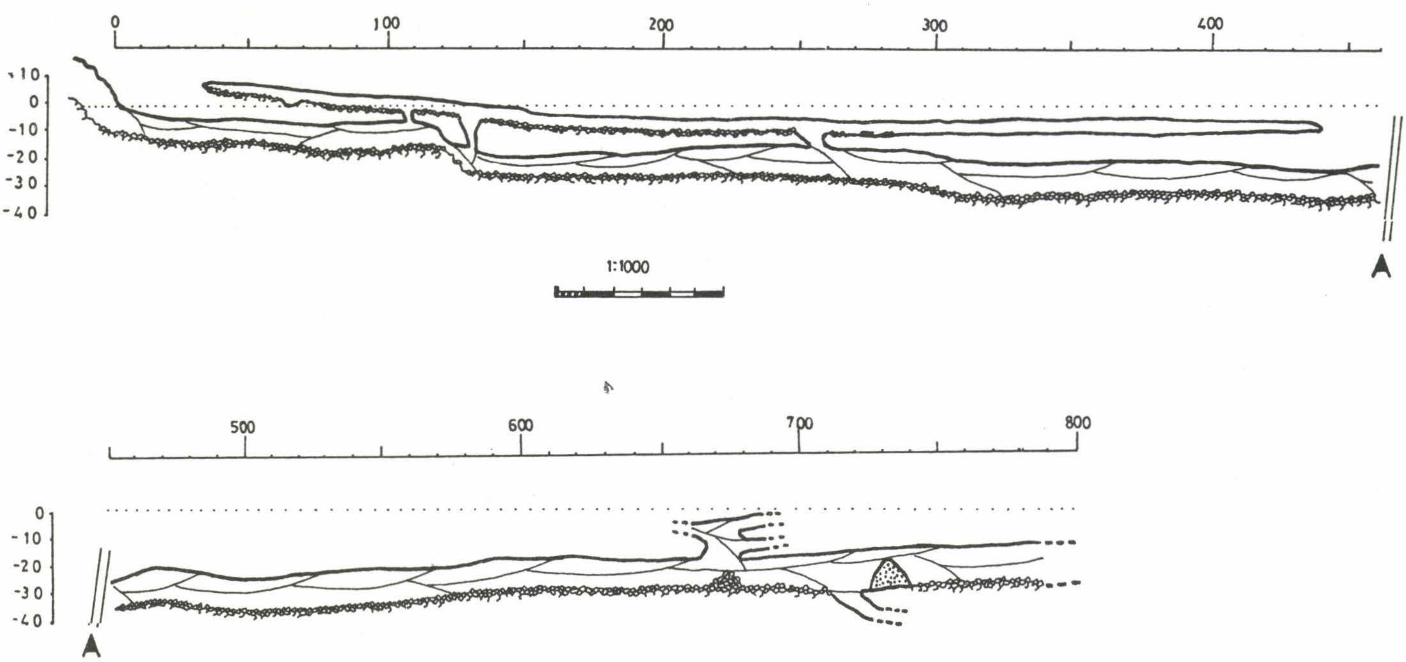

Topography of the «Tunel de la Atlantida» to 790 m. length.