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Volume 5

Symposium 5: Applied Speleology
Symposium 6: Mapping & Techniques

International Union of Speleology / Swiss Speleological Society

The Swiss Speleological Society

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Applied Speleology

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Mapping & Techniques

La Chaux-de-Fonds, Switzerland, 10-17.08.1997

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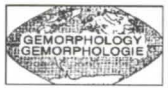

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Oil and gas drilling in cave and karst areas

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Abstract

Karst lands pose a unique set of problems for the oil and gas industry and for the cave and karst environments. Land management agencies have been working together with the industry to develop acceptable practices for drilling and operation in karst lands. Their mutual goal is to minimize the potential of encountering those problems and to reduce the impacts of oil and gas drilling to caves and karst lands. This paper discusses the basic approach and procedures to achieve this goal.

Resumen

La tierra de karst plantea una rerie de problemas para la Industria de Petroleo y Gas uni como tambiza para las cuevas y el medio ambiente de la misua. Agencia de managemente de la tierra han estado trabajando en conjunto con la industria de patroleo y gas para desarrollar practicio accptables de perforacion y operacidar en karst. La metar de ambo es minimizar en la posible esta problemas al enfrentarlos y redusar los impacto, de las paiforacionas de Petroleo y Gas a las cueva y a la tierra de karst. El presente truta la propuesta basica y procedimientus para alcanzar esta meta.

The Background

The United States Bureau of Land Management (BLM) is a part of the United States Department of the Interior. The BLM is an agency entrusted with the management of more than 270 million acres of the nation's public lands. Management is based on the principle of multiple use and sustained yield of our nation's resources within a framework of environmental responsibility and scientific technology. BLM recognizes that it must manage for future generations as well as for present needs. It's mission is to find a balance between developing public land resources and protecting natural resources. In southeast New Mexico, the Carlsbad Field Office must balance developing oil and gas resources with the protection of cave and karst lands and water resources associated with them.

The risks to industry can include excessive loss of drilling fluids, loss of tools and equipment down hole, down-time while fishing for tools, and expense for extensive cementing programs. In extreme instances the loss of drilling rigs and equipment due to the collapse of shallow cave passages add to the risks to public health and safety.

The potential hazards to the cave/karst resources result from contaminants such as lost drilling fluids (which sometimes contain chemicals) and cements, as well as hydrocarbons from spills or leaks from well casings, storage tanks, mud pits, pipelines, and production facilities that may enter into the cave/karst systems.

This contamination could result in pollution of groundwater and aquatic and atmospheric habitats of caves, causing a die-off of cave life. Additionally, cementing operations could affect portions of underground drainage systems by restricting groundwater flow and introducing pollutants into karst systems. This could alter the quality and quantity of water reaching springs and resurgences.

Other possible impacts are vented or escaped gases, such as natural gas or hydrogen sulfide, collecting in sinkholes and caves. These gases can cause a die-off of plant and animal life that use the special habitat created by the microclimate of the cave entrances or sinkhole. In the extreme, the buildup of these gases has the potential to cause underground explosions and/or asphyxiation of plant, animal, and possibly human life.

During the development of the Carlsbad Office Resource Management Plan (RMP), an agency/industry work group was convened to address the problems and possible solutions of oil and gas drilling in cave and karst areas. The results of this work group were:

1. The recognition of the mutual goal to isolate cave environments from the affects of oil and gas operations
2. Development of criteria to initiate protection measures.
3. Development of specific mitigative measures that could be applied.

The Carlsbad RMP and Lease Notice

The Carlsbad RMP was approved in 1988 with a decision that protection requirements for caves would be applied on a case-by-case basis at the Application for Permit to Drill (APD) stage instead of blanket stipulations. Additionally, mitigations and procedures for cave protection during oil and gas drilling operations would be developed by a joint BLM/Industry Task Force, and would be implemented where determined feasible.

After the approval of the Carlsbad RMP, a Cave/Karst Lease Notice and map was issued for all leases in potential cave or karst occurrence areas. The purpose of the notice was to inform potential lessees that the BLM may implement cave protection measures by requiring conditions of approval on APDs. The lease notice informed lessees that due to the sensitive nature of the cave and karst systems of this area, special measures may be required to protect them. Those measures could include a change in drilling operations, special casing and cementing programs, or modifications in surface activities.

The Task Force

The BML/ Industry Task Force was reconvened in early 1991 to develop the more technical aspects of drilling, casing, cementing, and production operations in cave and karst areas. This was largely due to the development of the Dark Canyon Environmental Impact Statement (EIS) resulting from interest in drilling wells in the area of Lechuguilla Cave. The Cave and Karst Task force was composed of members from the oil and gas industry, government agencies, academia, and the private sector.

The Task Force was responsible for developing field procedures to resolve concerns over drilling wells in the area of Lechuguilla Cave. A second goal was to address the concerns of drilling in cave and karst areas throughout the area, specifically in the cave- bearing limestone and gypsum karst areas. Members of the Task Force were asked to represent their particular interest by providing technical information, while working to reach agreement and resolution of the concerns addressed by the Task Force.

Task Force Findings

The Task Force came to early consensus that a procedure was needed for dealing with proposals for oil and gas well drilling which was applicable in all situations. A three step process was developed: 1) Detection of Cave or Karst Features 2) Avoidance of those Features 3) Mitigation of Impacts to Cave or Karst Resources that can not be Avoided

Detection indicates where possible avoidance measures might be needed and would make avoidance measures more effective. Detection and avoidance measures combine to reduce the chances of needing mitigation measures. However, noting is certain until the well is actually drilled.

Detection

The Task Force's Geologic Subcommittee identified basic methods of detecting subsurface voids. These methods ranged from very simple methods such as field examinations to very sophisticated geophysical methods. These methods were evaluated to determine reasonableness and cost effectiveness. Some of the methods identified were: field examinations and cave exploration, aerial photographs (both color and black and white), lineament surveys, natural potential surveys, electro- telluric survey, and high resolution seismic survey.

Avoidance

Avoidance of cave and karst features can be accomplished in two basic ways. The first is a long range approach involving BLM's planning system. Areas identified as having significant cave or karst resources can be established as "no drilling areas" through the planning process. Drilling restrictions for these areas could include no surface occupancy stipulations and no leasing.

A second method of avoidance in areas that are already leased is relocating a proposed drilling location or right-of-way to reduce the possibility of conflict with caves or karst features. The decision to move a location, with certain constraints, can be a condition of approval of an APD. This method of avoidance would be used in conjunction with site- specific detection methods, such as field examinations or lineament surveys.

Another method of avoidance may be directional drilling. Lateral moves of the original surface location greater than 100 meters may require the operator to drill a directional well in order to hit the original downhole target. The directional portion of the well is typically below any cave or karst resource concerns.

Mitigation

There may be instances when the drilling of oil and gas wells would be in conflict with cave or karst management, even after detection and avoidance measures have been conducted. The third step in the process is the mitigation of impacts to caves/karst resources that can not be avoided.

Downhole impacts would occur first during the drilling process and are immediate impacts. After completion of each well, another series of impacts potentially could occur as a result of casing deterioration. These future impacts are potentially long term and relate to the escape of hydrocarbons from the drill hole into surrounding formations. In porous rock, the hydrocarbons could migrate, contaminating groundwater and/or the water quality in the caves. This could impact the growth of speleothems, cave microclimates, and cave biota. In a worst-case situation, human life could be endangered by escaping gaseous hydrocarbons from a well into the cave environment.

The Task Force's Drilling and casing subcommittee addressed impacts of drilling, casing, and cementing and the impacts of casing failure by developing procedures which would best isolate the drilling, casing, and cementing operations from cave environments. These procedures were developed for use in the limestone areas near Lechuguilla Cave and were not specifically considered for use in the gypsum karst area. The recommendations of the Task Force formed the basis for drilling conditions of approval and mitigations developed in the Dark Canyon EIS. Following their submission of recommendations, the Task Force was disbanded.

The Drilling Guide, the Resource Management Plan Amendment

Based on the recommendations of the Task Force, an **Interim Guide for Oil and Gas Drilling and Operations in Cave and Karst Areas** was developed. It's intent was to assist the oil and gas industry in protecting sensitive cave/karst resources including karst ground water recharge areas, cave biota, recreational, and scientific uses while enjoying the development of their lease. It was meant to fully define and help resolve the potential conflicts associated with drilling and production operations in cave/karst areas that can have adverse effects on both industry and cave/karst resources. The guide established a set of procedures for the detection and avoidance of cave /karst features, and the mitigation of drilling and production actions in the event that those features are encountered. The following is taken from the Guide:

Surface Mitigations

To minimize potential problems due to **reserve pit spills or leakage**, the BLM may require the following actions: (1) The use of a closed system or steel tanks; (2) The use of a modified "V" pit, constructed all in cut material with extra heavy pit liners that are not broken during reclamation. (3) Relocation of pits; (4) Berms around the pits sufficient to contain any spills.

To minimize the potential problems due to **leaking tanks or pipelines**, the BLM may require:

1) Berming around storage tanks sufficient to contain any spills;
2) Leak detection systems for pipelines;
3) Permanent liners in storage tank areas;
4) Differential pressure shut-off valves;
5) Corrosion-inhibiting coatings and cathodic protection.

To minimize the potential problem of **vented or escaping gases** the BLM may require:

1). The use of stock tank vapor recovery systems.
2). Flaring, rather than venting of gas, to better disperse the gases and eliminate possible gas ignitions.

Subsurface Mitigation

Mitigative measures to be implemented while drilling in high potential cave zones and lost circulation zones encompass every aspect of the drilling and completion process. These include drilling methods, casing setting depths, drilling fluids and additives and cementing programs. Every effort should be made to use applicable mitigative measures in determining the most feasible technologies available for safely drilling and completing oil and/or gas wells in cave and karst areas.

Rotary Drilling Techniques

Rotary drilling techniques should employ the use of either fresh water mud or compressed air as a circulating medium. Fresh water is more commonly used due to its affordability and availability. Compressed air is less frequently used because of its increased equipment cost and the relative unavailable equipment in some areas. Both water and air can transport cuttings to the surface, or can indicate lost circulation in varying degrees of severity when some of the cuttings do not make it back to the surface.

When drilling with fresh water, non-toxic additives such as bentonite (gel), cellophane flakes or other non-toxic non-organic constituents can be introduced into the system to combat lost circulation zones. Viscous pills, (also known as "sweeps"), which are typically composed of the same non-toxic non-organic materials as those listed above may need to be pumped down hole to build a bridge across severe lost circulation zone(s). Sweeps may also be pumped prior to running casing to condition the borehole for cementing operations. Fresh water resources which are often found in caves will not be contaminated by fresh water mud or compressed air. Brine water- based drilling mud should not be used since it has a higher density than fresh water. This could exacerbate lost circulation problems. The saline mud would also pollute fresh water zones.

When drilling with fresh water mud, the operator should consider using larger than normal size jet nozzles in the drilling bit. This reduces the hydrodynamic force exerted by the mud on the relatively fragile rock formations or strata. In the event that a major void is encountered while drilling, a downhole camera may be used to determine the significance of the void.

Casing selection and cementing practices are two of the most fundamental elements in the drilling and completion of a well. If successful, the well will produce trouble-free for several years and be simple to plug and abandon at the end of its productive life. The casing and cement must also maintain their integrity for several decades after the well has been plugged and abandoned to continue protecting cave resources.

All casing should meet the highest standards. The cave protection string should be set at least one hundred feet below the last known cave bearing stratum as limited by the uppermost hydrocarbon bearing zone. This will give the cave zone an extra measure of protection by providing a positive cement-to-casing and cement-to-borehole bond around the shoe of the casing.

Casing and cementing programs

Casing and cementing programs for the surface and intermediate portions of a directionally drilled well are similar to casing and cementing programs in a vertical well.

The casing should be cemented in place using the following method: If a large void or severe lost circulation zone is encountered, isolation from above and below, rather than complete cement coverage of these zones, could be employed. This can be accomplished by using stage cementing equipment, external casing packers, cement baskets, and one-inch remedial cementing techniques.

This procedure is as follows: Tie back the cement as high as possible on the primary cement job, at least to the bottom of the deepest known lost circulation zone. Strategically position flexible cement retaining devices (i.e. cement baskets) or an external casing packer/stage cementing tool arrangement immediately above the top(s) of the lost circulation zone(s). A cement evaluation tool such as a temperature survey or bond log is required to evaluate the primary cement job and to identify the gaps in the primary cement job prior to proceeding with remedial cementing techniques. Remedial cementing operations would involve running one-inch pipe with a "muleshoe" joint on the end into the annular space between the casing and the borehole. The one-inch pipe can puncture the canvas component of upper cementing basket(s) and penetrate to a depth where other cement basket(s) have been positioned. A cement slurry can then be pumped down the one-inch pipe in consecutive stages above each cementing basket at depth. If a multiple- stage cement job is chosen, the external casing packer could be actuated to provide a bridge, and the pumping of the second stage could then commence. This technique could provide isolation of the lost circulation zone(s), but would leave substantial "gaps" in cement coverage across the zone(s). For this reason, the next casing string to be run below the cave occurrence zone should be cemented to allow the top of the cement to be tied back above all gap zones. This provides additional protection against potential fluid migration from any brine or hydrocarbon bearing formations below. (See Illustration 1)

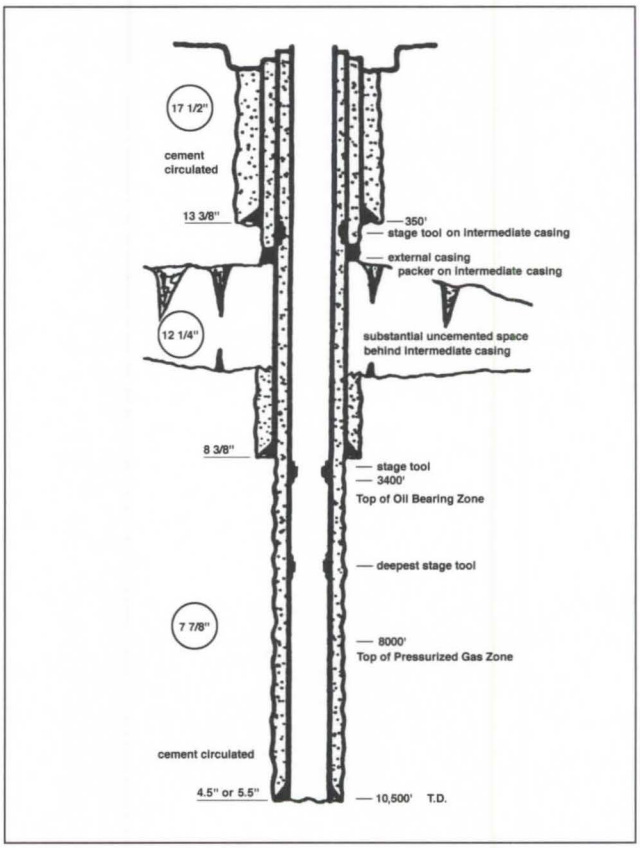

Illustration 1 : Casing and cementing in lost circulation zones

Economical assessement of speleoresource and cave protection

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Résumé

Les imperfections de la législation ukrainienne sur l'environnement et l'absence d'une méthode d'évaluation de la valeur des « ressources spéléologiques » empêchaient la mise sur pieds de mesures efficaces pour la protection et l'utilisation rationnelle des cavernes. En avril 1995, le cabinet ministériel d'Ukraine a reconnu notre liste technique de prix des ressources spéléologiques, qui donne une estimation des dommages potentiels aux ressources spéléologiques, géologiques et hydologiques. Une telle méthode d'estimation a permis d'estimer la valeur des sédiments des cavernes et des spéléothèmes en fonction de leurs caractérisitiques, de leur abondance, de la possibilité de les restaurer, de leur forme et dimension, du degré de pollution, etc. Une méthode analogue a été dévelppée pour estimer les dommages liés aux activités humaines dans les régions karstiques, mais jusqu'ici elle n'a pas encore été reconnue officiellement.

Extended abstract

Imperfection of the legislation and lack of legal framework for the reglementation of natural features prevents the realisation of effective protection and rational use of geological, karstic, speleological and hydrologic features. Up to recently, speleoresources were completely excluded from any juridical protection. So far damages have been quite unsignificant because of the difficulty to access to caves and to very restricted profit-toursim in them.

The necessity to set up rigid and unequivocal measures of protection of each karstic feature is motivated by the fact that they enclose much information, are unique, not renewed and vulnerable.

In Ukraine, the only way to build up such a framework consists in estimating the value -price- of speleoresources. Such an estimation provides a basis for: a) the calculation of economic sanctions -fine- with respect to damage; b) assessing the potential financial resource of a region or a state as a whole.

For the first time, the Cabinet of Ministers of Ukraine accepted such a resolution for speleoresources (Resolution No 239, April 3rd, 1995). It is then assumed that every damage or destruction diminishes the potential value of karst, speleological, geological and hydrologic natural objects.

The estimated objects are: speleothems of all genetic kinds, karst waters, pollution of underground and surface forms. The lack of preceeding similar estimation and because of inflation the values are given in « minimum salary » units.

The following table gives an outlook of the speleological features considered. The value is given in length, surface or volume units.

The resolution takes into account additional estethical, fragility, general harmony parameters. Rarity is important as well. Damages of walls and ceiling of caves, caused by inscriptions, drawings, solid items, etc. are estimated separately.

Special quotations are used for pollution (mechanical, biological-bacterial, chemical, radiating, thermal), for unauthorised visits of caves, infringement of live conditions of troglophils and troglobionts.

Beside this resolution we developed a similar technique for the calculation of the losses caused by anthropogenic (technogenic) activities on karst. So far it is not officially accepted. The total sum of potential deficits is determined by the possible costs of : a) pollution of underground waters and change of their quality; b) loss of material in soluble condition (carbonates, gypsums, salts); c) cost of water owing to hidrodystrophia in the karst hydrogeological system; d) cost of technical and other structures, losing functional value due to human impact on karst; e) cost of structures and objects, directly injured; f) loss of land surface due to collapse, landslide and erosion processes.

Rate

for calculating the damage caused to natural objects (speleological, geological and hydrological objects)

Kind of object	Estimation of damage (parts of min. salary)
Karst-speleological objects	
Slactites, stalagmites, stalagnates (for 1 cm^3)	
a) growing	2.5
b) not growing, relicts	3.5
Dripstone crusts (for 1 cm^2)	
a) growing	2.0
b) not growing, relicts	3.0
Water-carbonate sediments (for one dm^3)	1.5
Gypsum crystals, needles and other similar formations	
a) For separate detached ones (for each cm of length)	
- growing	3.0
- not growing, relicts	4.0
b) For bushes, other formations (for one square dm) :	
- growing	2.0
- not growing, relicts	3.0
Monocrystals of a gypsum, calcite and other minerals (for one dm^3)	2.0
Clay-polymineral stalactites of gypsum caves (for one centimetre of length)	1.5
Clay-dripstone (beanlike) crusts (for one dm^2)	2.0
Clay-mineral sediments (for one dm^2)	2.0
Archaeological, paleontol. artefacts (for one dm^3)	3.0
Damage of walls, ceiling (for one dm^2)	2.0
Pollution of caves	
a) mechanical :	
for each left thing, bottle, synthetic container and other	0.3
for each cm^3 of an extraneous inert material brought into a cave	0.2
b) chemical :	
left in open kind chemical reagents (for each 100 grammes of substance)	0.3
c) biological :	
(organic, bacterial) for each 100 grammes of organic substance	0.5
Pollution of caves (cont.)	
d) pollution of underground atmosphere by fulfilled gases ecologically of dirty	
sources (springs) of illumination and heating :	
in each hour of a working source	0.1
for each smoked cigarette or any other kind of tobacco products	0.2
e) thermal pollution :	
for each subsequent degree on Celsius (increase or reduction) from usual for given cave of a temperature level (at each 100 m^3 of underground air)	0.2
f) radiating pollution :	
for each unit over extreme allowable doze	5.0
Unauthorised visiting of a cave (for each person)	1.0
Surface karst-speleological formations	
Damage of valuable karry, primary and secondary crystal formations (for one dm^2)	0.5
Fulfilling of sinkholes, ponors, downturns without sanction of natureprotection organs (for 10 m^2)	3.0
Pollution of sinkholes (for one m^3 of material)	4.0
Geological objects	
Damage at geological exposures, cuts (for one m^2)	3.0
Damage at geomorphological features (dm^2)	5.0
Hydrologic objects	
Damage to waterfall (for 0.5 meters of height or one meter of width)	20.0
Damage reservoir (for 0.1 hectare)	30.0
Damage of bogs (for 0.1 hectare)	30.0
Destruction of bogs (for 0.1 hectare)	50.0

Addition N 1 to Resolution N 293 from April, 3, 1995 of Cabinet of Ministers of Ukraine

Potabilité de l'eau du Karst de Tsanfleuron

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Abstract

Nowadays, it is common to extol the virtues of protecting the underground water in the Karstic massifs. Since 1988, the source of Glarey located in the municipality of Conthey (County of Valais-Switzerland) has been the object of constant investigation. The main problems encountered are basically due to bacteriological contamination and numerous occurrences of cloudy water. Although there is no doubt the clarity of laws , regulations and directives it seems that the application of these various regulations is another matter.

The problem of Tsanfleuron is a complicated case involving regional tourism interests, the limits of communal responsibility, politics, the options of the cantonal agencies responsible for environmental protection issues, geology and location of the water supply areas, etc.

Résumé

De nos jours, il est un lieu commun de prôner la protection des eaux souterraines dans les massifs karstiques. La source de Glarey sise sur le territoire de la commune de Conthey (VS-CH) fait l'objet d'études suivies depuis 1988. Les principaux problèmes rencontrés sont fondamentalement dus à des contaminations bactériologiques et à de nombreuses périodes de troubles des eaux.

Si la clarté des lois, ordonnances et directives concernant la protection des eaux souterraines ne fait aucun doute, il semblerait que l'application de ces différents textes en soit tout autre.

Le problème de Tsanfleuron est un cas complexe mélangeant les intérêts touristiques de la région, les problèmes de limites intercommunales, la politique, les options des responsables cantonaux en matière de protection de l'environnement, la géologie et l'emplacement des zones d'apport etc...

1. Introduction

Désireuse de faire face à la consommation en eau potable de sa population, la commune de Conthey entreprend depuis 1988 une série d'études visant à capter la source dite de Glarey, du nom du petit hameau voisin.

Du fait de la bonne connaissance de la région, le bureau de l'auteur est mandaté pour l'étude des zones de protection et des problèmes annexes au captage de cette source.

Dans le cadre de ces études, la circulation des eaux souterraines dans les zones karstiques allait faire ressortir toute sa complexité. Les aires d'alimentation étant déjà occupées par un alpage, des aménagements touristiques, des terrains d'exercice militaires et des surfaces très prisées par les amateurs de 4x4, il a fallu faire preuve de diplomatie envers tous ces groupements concernés par les retombées de l'établissement des zones de protection. Malgré la connaissance de notre rapport du 14 novembre 1989, le Service de la Protection de l'Environnement du canton du Valais autorise la construction d'une cabane qui débutera en 1992. Cette dernière située en pleine zone S2 demandera la construction d'une route de chantier qui traversera de grandes surfaces de lapiaz collecteurs qui alimentent le captage.

Comme vous pourrez le constater, la masse des problèmes soulevés ne faciliteront pas la protection des eaux souterraines du Massif des Diablerets.

L'intime mélange entre la spéléologie, la géologie, l'hydrogéologie et les intérêts privés vont faire de la source de Glarey un exercice de style dans le domaine de la spéléologie appliquée.

2. La source

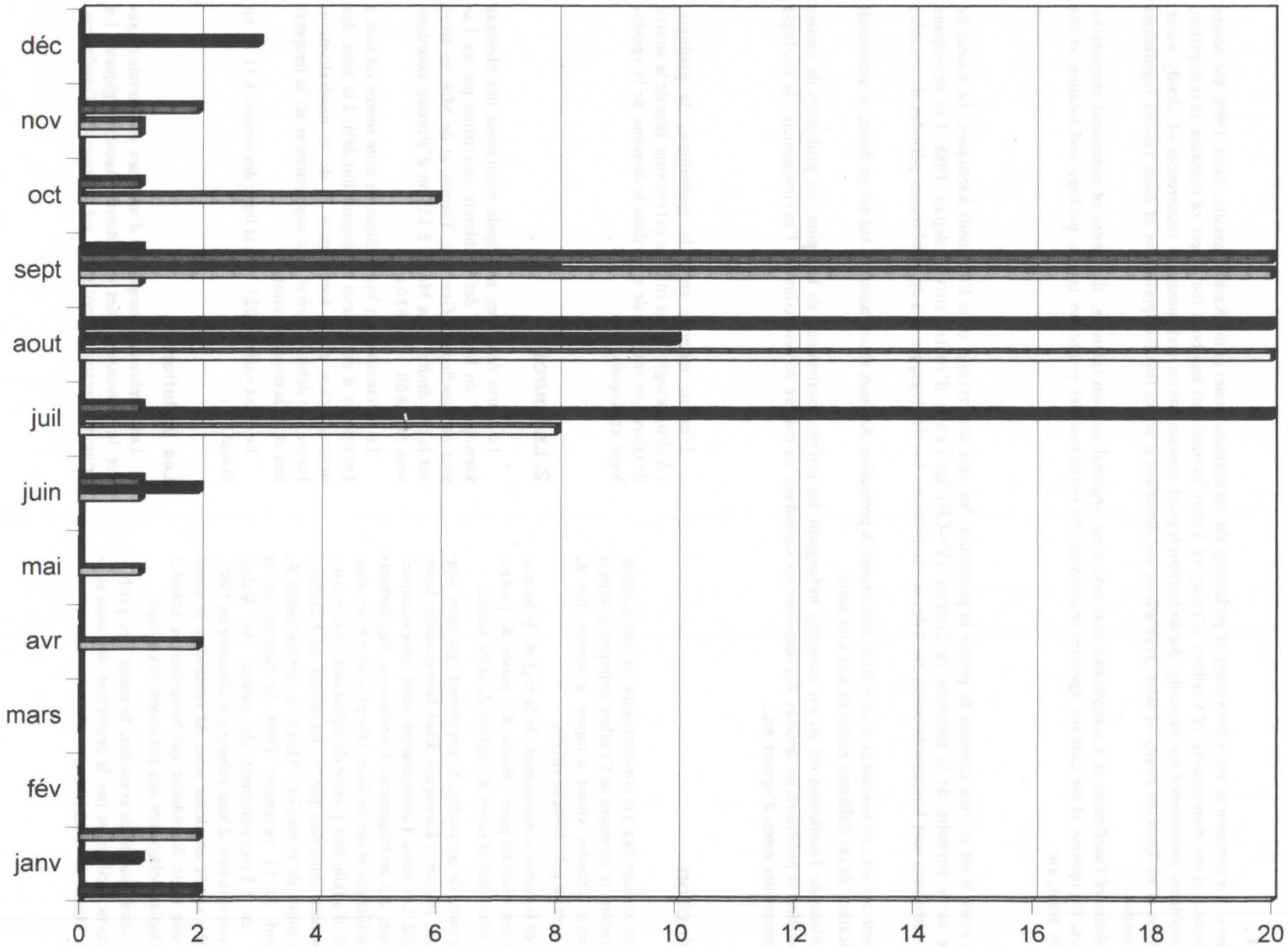
La source de Glarey, principale exsurgence des plateaux karstiques du Massif des Diablerets constitués par les Lapiaz de Tsanfleuron, Genièvre, Tsaréin, et de Mié, se situe sur la rive droite de la Morge à 1550m d'altitude coordonnées 589'660 / 128'650 m.

Le fonctionnement hydraulique de cette source est tout à fait typique d'une source karstique : fort débit à la fonte des neiges, baisse de la température et de la minéralisation. Baisse des débits en hiver avec augmentation de la température et de la minéralisation.

Le débit varie de 225 l/s à la fonte des neiges, à 11 l/s en étiage.

Les pollutions

Les nombreuses campagnes d'analyses ont permis de sérier la provenance des pollutions bactériologiques. Le principal vecteur de pollution est l'alpage de Tsanfleuron.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Centre et Musée de Spéléologie
SOURCE DE GLAREY
présence de coliformes

En effet, cet alpage, contrairement aux directives en vigueur, pratique l'épandage de lisier par tous les temps et nous avons pu constater l'effet traceur du lisier en de nombreuses fois. Les analyses serrées, parfois deux dans la même journée, ont permis de démontrer dans le détail le fonctionnement de ces pollutions.

Durant les grandes chaleurs, la source présente une eau trouble. Cette turbidité est principalement due à la remobilisation par la fonte de la glace des lambeaux de moraines interstratifiées dans cette dernière.

Pour faire face à ces différents problèmes, la commune de Conthey filtre et traite l'eau aux U.V. avant sa consommation.

Il semblerait, de par nos différentes observations ainsi que par la situation en profondeur de l'aquifère Urgonien, qu'un captage définitif dans ce dernier permettrait un allégement notable des frais de traitement des eaux de la source.

Les risques

Les principaux foyers à risques situés dans les zones d'alimentations de la source sont très bien connus à l'heure actuelle. Il s'agit, par ordre décroissant d'importance, de l'alpage de Tsanfleuron, des surfaces pâturables, de l'exploitation touristique du glacier de Tsanfleuron et da la cabane de Prarochet.

Il semblerait que les pollutions d'origine fécale, quoique bien connues, ne soient pas uniquement en cause. En effet, le risque de pollutions par hydrocarbures ou autres produits toxiques est bien réel. En plus du trafic des ratraks, bus des neiges, et atterrissage sur glacier des avions, les produits d'entretien des remontées mécaniques apportent également son lot de désagrément. La création de routes d'accès sur le Karst de Tsanfleuron, la découverte en zone de protection d'un estagnon contenant du perchloréthylène, stigmatisent le risque potentiel réel de pollution par des produits toxiques de l'eau de la source.

3. La géologie des aquifères

Les calcaires Urgonien et Priabonien (Nummulitique) forment les principaux aquifères de la source. Les horizons imperméables dominants sont représentés, quant à eux, par le Barrémien schisteux, les grès nummulitiques et les schistes à Globigérines.

Les surfaces drainantes de l'exokarst montrent leurs formes typiques depuis la route du Col du Sanetsch jusqu'à la bordure du glacier de Tsanfleuron. L'intense fracturation de ces calcaires permet un drainage de direction SW-NE au début et NW-SE pour terminer.

Les explorations spéléologiques de ces différents karsts ont confirmé la quasi absence de karsts noyés. L'existence de quelques galeries siphonnantes ne nous permet pas de tenir compte de réserves importantes dans l'aquifère Priabonien. Lors de nos travaux, nous avons pu constater l'étiage marqué de cet aquifère qui a atteint la valeur de seuil de 0 l/s. Par contre, l'aquifère Urgonien présentait un débit de l'ordre de 10 l/s au minimum. La coupe géologique laisse subodorer la présence d'un aquifère notable au niveau du pli couché affectant l'Urgonien encapuchonné dans les schistes du Barrémien.

Les différentes températures relevées à l'étiage dans les eaux des collecteurs nous permettent d'approcher la profondeur à laquelle se situent les aquifère. Pour le Priabonien, la température de l'eau atteint 1,4°C. En admettant une température annuelle moyenne de 1,13°C selon la formule d'Utinger, et un gradient géothermique de 3°C/100m, la zone à micro-fissures productrice d'eau se trouverait entre 30 et 40 m de profondeur. Pour l'Urgonien, dont la température de l'eau à l'étiage atteint 3.9°C, la profondeur de la zone à micro-fissures, seule zone productrice en étiage, se situerait entre 150 et 200 m.

4. Limite or not limite

Lors des travaux de recherches entrepris sous les cascades de la Contheysanne, il a été possible de mettre à jour les deux exutoires temporaires des deux aquifères, Priabonien et Urgonien. Le premier a pu être topographié sur une cinquantaine de mètres de développement (PAHUD & DONZE 1990). Le second n'a pas pu être dégagé totalement et l'eau de celui-ci sourd au travers des alluvions tapissant le fond de la fouille.

Lors de ces travaux, l'eau de la source pérenne de Glarey était devenue boueuse, ce qui nous a permis d'affirmer que nous avions touché un regard donnant sur les eaux souterraines transitant en direction de cette source. Le problème des pertes polluantes du torrent de la Morge avait déjà été mis en exergue lors d'un essai de traçage (BESSE & UDRY 1988).

Nous avions touché du doigt le collecteur des karsts du Massif des Diablerets. Les problèmes allaient surgir. La commune de Savièse estimait que les travaux avaient été effectués sur son territoire. La commune de Conthey estimait quant à elle que les travaux avaient été effectués sur le sien. Les recherches sont arrêtées assez longtemps pour que les débits augmentent avec le redoux, rendant impossible toute suite, réduisant ainsi les efforts de Conthey à zéro. Pour les uns la cascade de gauche fait office de limite, pour les autres c'est la cascade de droite.

Vient ensuite la guerre des géomètres pour définir exactement le passage de la limite intercommunale. Aujourd'hui, 7 ans après, le problème de cette fameuse limite n'est pas encore tranché et les travaux du captage sont toujours bloqués.

Si l'on avait tenu compte du cas de jurisprudence posé par deux chutes se trouvant quelque 200 mètres en amont, et o_ la limite intercommunale se situe entre ces deux chutes, on aurait pu régler le cas de Glarey de manière beaucoup plus efficace et nettement moins coûteuse. Dans ce cas, la commune de Conthey pouvait terminer tranquillement son captage.

5. Les solutions

Le problème juridique réglé, il ne restait plus qu'à faire respecter les zones de protection et capter cette source de la manière la plus judicieuse qu'il soit.

Le pourtour de la doline du Sex Rouge est correctement clôturé. Le bétail ne pâture plus dans cette zone. Le problème des pollutions provenant de cette aire d'alimentation est pratiquement résolu.

Les écoulements dans les ponors situés au NE de l'alpage de Tsanfleuron devraient être contrôlés. La totalité des grandes pollutions bactériennes seraient ainsi maîtrisées.

Le captage devrait être réalisé par galerie drainant sélectivement les eaux de l'aquifère Urgonien. La création d'un tel ouvrage devrait permettre d'obtenir une eau libre de tous germes fécaux et plus limpide. L'effet de stockage dans cette formation calcaire permettrait une disparition des germes accidentels ainsi qu'une sédimentation d'une partie des particules fines.

L'efficacité de l'évacuation des déchets organiques et des eaux grises des cabanes du Yéti-Palace et de Prarochet devrait être contrôlée sérieusement par le service de l'environnement concerné.

A notre humble avis, les solutions apportées ci-dessus permettraient à la commune de Conthey de jouir d'une véritable eau issue des montagnes mais pas un cloaque où la qualité de l'eau se rapproche plus à certaines périodes des liquides circulant dans un collecteur d'égout.

6. Une conclusion qui tarde à venir

La résolution des problèmes techniques est nettement moins compliquée que les labyrinthes des palais de justice.

Depuis 1990, des professeurs de droit s'acharnent sur l'apparent épineux problème de la source de Glarey.

Il semblerait que d'après l'arsenal des lois déjà en vigueur depuis fort longtemps, les problèmes inhérents à cette source devraient déjà être réglés quelques mois après le début de cette affaire.

La limite intercommunale doit être déterminée par les géomètres, en tenant compte du cas de jurisprudence des chutes supérieures du torrent de la Contheysanne.

La commune de Conthey étant sur son territoire les travaux de captage doivent démarrer selon la mise à l'enquête officielle de 1988.

Parallèlement les travaux de protection des eaux souterraines de la source.

Les voies de la justice à l'instar des voies des eaux souterraines sont parfois impénétrable.

Aujourd'hui, nous pouvons vous donner une dernière information : la commune de Savièse à été déboutée au tribunal cantonal. Cette commune peut encore faire recours au tribunal fédéral.

S'agit-il du dernier épisode avant la mise en chantier du captage, ou d'une simple suite de ce long chemin du combat pour l'eau ?

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The dynamics of the karstic features of Sprimont (Belgium) and its consequences on the land-use planning Preliminary note

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Abstract

The Department of Physical Geography of the University of Liege (Belgium) was in charge of updating the physical factors of the regional land management map for Sprimont, a karstic municipality of Belgium. The influence of floods, karst processes, landslides, and other physical factors were evaluated.

The karst features and karst-related events have been mapped three times with accuracy in this area during the last century (in 1898, 1971 and 1996). The data provided the basis for a study of the rates and dynamics of the karst processes and permitted the forecasting of hazards on a secular basis.

A map of karstic areas, karst features and karst dynamics was prepared. Some systematic trends of the evolution of karst features were noted. A map of risks and land-use constraints was derived from the first map and from the observed trends. Rules were induced from these data and were proposed to control building and other activities in clearly defined areas.

Résumé: La dynamique des processus karstiques à Sprimont (Belgique) et ses conséquences sur la planification d'aménagement du territoire. Note préliminaire.

Le Département de Géographie physique de l'Université de Liège a été chargé d'établir les facteurs physiques susceptibles d'influencer le plan d'aménagement de Sprimont, une commune karstique de Belgique. L'influence des inondations, des phénomènes karstiques, des glissements de terrain et d'autres facteurs physiques a été prise en considération.

Les phénomènes karstiques ont été cartographiés, à Sprimont, en 1898 puis en 1971 et enfin en 1996. Ceci a permis d'évaluer la vitesse de certains processus et d'établir, sur une base séculaire, une prospective des risques.

Une carte des zones karstiques, des phénomènes karstiques et de la dynamique du karst fut élaborée. Une carte des risques et des contraintes en fut dérivée. Des règles de sécurité en ont été déduites et ont été élaborées en un projet de décret régissant les activités de construction et de génie civil dans des secteurs karstiques définis.

Introduction

The updating of the management plans

In the Walloon region (Southern Belgium), the land management is ruled by plans, schemes and regulations. Land-use planning divides the territory into land-use zones.

It was recently decided to update the management plans, and firstly the criteria of these plans. These criteria include physical ones and human ones.

The Physical Geography Department of the University of Liege was in charge to carry on "the restatement of the criteria of a right management with regards to physical constraints". The task had to be carried out in the municipality of Sprimont, considered as typical and set as such as test-place.

The municipality of Sprimont

Sprimont is a municipality of some 74 km^2 in the folded area of Southern Belgium : the so-called Ardennes, in the broad meaning of this term. The area was folded by Hercynian movements, and the municipality territory includes Devonian and Carboniferous (= Mississippian) formations with thin remnants of a Post-Hercynian, Tertiary cover.

The morphology is typically Appalachian : the ridges consist of Devonian sandstones levelled by an old peneplain, and the valleys are hollowed out in Devonian and Carboniferous limestones.

Mapping the natural constraints

The natural constraints considered and mapped included flood hazard, slopes (including rockfall and slide hazard, influence on motorized cultivation, solar energy balance...), karst, protection of water catchment zones, sewage constraints, soil fertility, etc... A general map was presented including all the contraints. In the present paper, we shall deal with the karst hazard map only.

Karst features of Sprimont

Present-day morphology of the Sprimont syncline

The structural geology of Sprimont is complex; we shall here consider only the Carboniferous Limestone syncline crossing the built-up center of the municipality. This syncline is edged on both sides (north and south) by Devonian sandstone anticlines, between which it is depressed, and shelters a dry valley.

The dry valley is pitted by dolines and swallowholes. All the streamlets are intermittent or episodic. Some swallowholes are cave entrances, but more caves are scattered on the steep slopes of the valley. The main resurgence, "le Trou Bleu" (The Blue Hole), lies in the alluvial plain of the Ourthe valley and is the outlet of almost all the valley waters, however some resurgences have been detected in the bottom of the Ourthe bed.

Recent history of the karst landscape

The drainage is presently disorganized, no stream flows in the axis of the valley, and the few streamlets of the tributary dales run only during a few days after the rainfalls (MICHEL, 1971).

The synclinal valley was carefully studied and mapped in 1898 by E. MARTEL, E. VAN DEN BROECK and E. RAHIR. They published a map and a detailed description of the karstic features of the valley (E. VAN DEN BROECK, E. MARTEL, and E. RAHIR, 1910). In two different sites they referred to "ancient sinkholes

downward the present ones". During a second visit to the region, in 1909, they noted that "as in most swallowhole areas changes had occured in the interval" (p. 1401 and p. 1411).

Later on, between 1960 and 1970, one of us (C.E.) noted a lot of new modifications and suggested to map the valley anew. The changes appeared to be drastic on an unpublished survey in 1971. At least three swallowholes had moved backward by 400 m or more, and among 22 holes, 8 had moved in the same direction, on a mean distance of 270 m (MICHEL, 1971).

In 1995 one of us (V.M.) revisiting the region, noted new changes in the last 24 years.

The swallowholes move normally upwards along the valley axis. But when man blocks an inlet, waters run downwards and can open or re-open a lower sink. The result is then visible on the map as a recent swallowhole situated downward of an older one. This is an exception. The rule is the move upward, i.e. up-stream.

Stating and mapping karst constraints

The map here presented (Fig. 1) is the result of three successive surveys (1898, 1971, 1995).

The purpose of the concerned work was to find out a methodology to identify the physical constraints important for a good land-use planning (EK & GRIMBÉRIEUX, 1985; MICHEL, 1996; PISSART & CLOSSON, 1996).

With this aim in sight, a first descriptive map of the present situation has first been drawn from aerial photographs and field observations in 1995. This map was then compared to the two older ones. The resulting figure is presented in this paper (Fig. 1).

From the compilation of all present and past field data, we derived a map called *Karst-related constraints*. On this map were distinguished :

1. Non building areas, at least 30 diameter around the dolines;

2. Restricted building areas, at least 60 m diameter around the dolines, and, around the swallowholes, extended to 100 m upstream;

3. Karstic substratum areas where a lot of activities are restricted.

This map was eventually combined with the other constraint-maps to produce a *Synthetic map of physical constraints*.

The analysis of these maps by the Direction Générale de l'Aménagement du territoire lead to a new article in the Walloon Code of Land Management :

"Article 46 : When activities or works are to be carried out in an area prone to karst hazard, the works or activities can be forbidden or submitted to special requirement to protect people and the environment".

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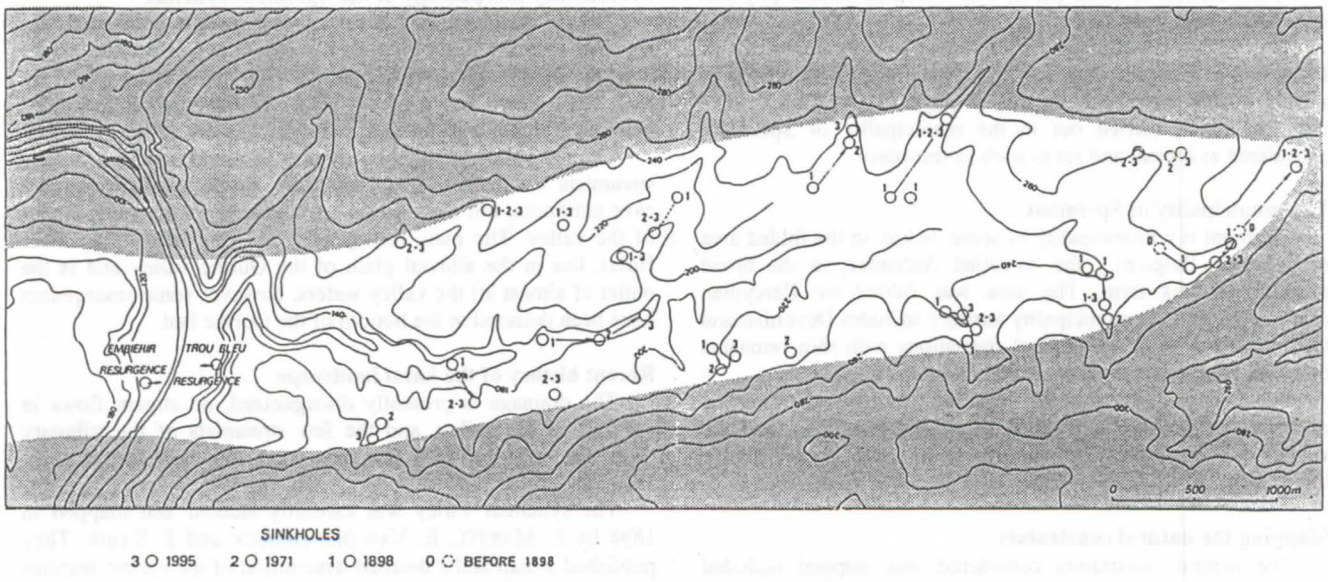

Figure 1: Sprimont carboniferous syncline: evolution of sinkholes between 1898 and 1995.

Cango Cave, Western Cape Province, South Africa a speleo-bureaucratic Report

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Abstract

Cango Cave, South Africa's leading show cave, has been mismanaged for two centuries. This paper describes the lengthy and continuing bureaucracy involved among the various vested interests in the process of securing a more appropriate management structure.

Sommario

La Grotta Cango, che e' la piu' importante grotta naturale aperta al pubblico in Sud Africa, da due secoli soffre le conseguenze di una cattiva amministrazione. Questo rapporto, nell' ambito di un processo che si prefigge di garantire una struttura gestionale piu' adeguata, descrive il ruolo, tra i tanti interessi particolari, di una burocrazia lenta e continua.

Cango Cave, a low energy cave in the Swartberg foothills 27 km. north of Oudtshoorn, is South Africa's leading show cave, receiving up to 250000 annual visitors who will probably spend about R4 million at the Cave and more in the nearby town. The legal owner of the Cave hase always been the; State. In 1921 control and management of the Cave were transferred, for reasons of administrative convenience, to the Oudtshoorn Municipality; but Province was required to approve the entrance fees and expenditure of the-profits. The initiative for any change and expenditure of money comes from the municipality. Province merely approves or disapproves. It was, and still is, State and Provincial policy that Congo Cave is a NATIONAL asset which shall be conserved, and that the Municipal policy has always been from the Cave. Despite this the municipality shall not make a profit that the Cave is a LOCAL asset which shall be exploited for the Municipal benefit a policy which has succeeded very well, to the detriment of the Cave which is but a shadow of its former glory. In particular, little or nothing has been returned to the Cave during the past three decades for research, development and maintenance.

In my PhD thesis I shewed that the Cave had never been well managed, and identified the reasons for this mismanagement. I concluded by making recommendations in principle for future better management viz. That control and management should be transferred to an independent board of trustees, that a Cave Manager with a degree in the earth sciences and knowledge of speleology should be appointed, that he should be required to balance the conflicting demands of presentation and preservation, and that an environmental impact assessment should be commissioned with a view to a long-term management plan1.

The bureaucratic developments since then must be read in conjunction with the simultaneous political changes in South Africa. In April 1994 the State became controlled by the African

National Congress (ANC). However, the Western Cape Province remained under the control of the National Party (NP). There is therefore antagonism between central, and Western Cape Provincial, governments. The Oudtshoorn Municipality for years was controlled by the NP. Following the recent political changes, there was a hung council in Oudtshoorn, followed in 1996 by ANC control.

In 1989 the old Oudtshoorn Council created the Cango Cave Scientific Advisory Committee, which coincidentally held its first meeting on 5 October 1994, immediately after publication of my thesis. The Town Clerk was so abusive about the content of the thesis that his remarks were reported in the local newspaper2. This was the start of much continuing publicity in the newspapers, magazines, radio and television.

The Committee resolved to invite proposals and tenders for, "*a comprehensive study of the environment and visitor impact...(which) must provide the basis for a scientifically-based management policy . . .3*" Of the seven proposals received, five were invited to make presentations to the Committee on 6 October 1995. The two which are relevant to this report are the those of University of the Orange Free State (UOFS) which quoted R776497 or R207336, and of the University of Cape Town (UCT) which quoted R176677 negotiable. Most of the UOFS proposal, and the discussion afterwards, was in Afrikaans. The voting was 1 for UCT, and 4 for UOFS. I subsequently discovered that the UOFS, which presented first, had been reduced to R157936, and was awarded the contract on the basis of lowest price. The UCT was not recalled and invited to lower its price. In other words, the tender process had been converted into an auction at which the favoured bidder knew the prices quoted by the competitors.

The South African Spelaeological Association (Cape Section) was so concerned about this meeting that it had the UOFS proposal translated into English. That, and that from the UCT, were sent to Australia for independent opinions of experts involved in show cave management. Both confirmed that the proposal of the UOFS was seriously wanting, and that that of the UCT was far superior. In particular the UCT had the services of an internationally known karst geomorphologist.

I then requested, and was granted, two meetings with the Acting Chief Director of Local Government - the Provincial Department which is required to supervise local authority affairs. The second meeting, on 24 January 1996, was also attended by the Chief Director of Nature Conservation and, from Oudtshoorn, by the (ANC) Mayor, Town Recreation Portfolio Committee, and the Cave hanager. While discussing the meeting of the Scientific Advisory Committee of 6 October 1995, I used the phrase «*procedural irregularity*».The Chief Director of Nature Conservation used the word "*corruption*". The only contribution which the Mayor had to make was to accuse ne of "*racism*"! The Acting Chief Director of Local Government referred the matter to the Auditor-General who is currently investigating all the financial affairs of Cango Cave.

An unexpected development occurred in February 1996 when the Chairman of the Oudtshoorn Ratepayers' Association found a crate of speleothems in a Municipal store. He then went to the Police.

Station and laid a charge of malicious damage to property against municipal officials4. This allesation will never come to Court because it is impossible to prove from where, in which cave, and when, the speleothems were removed.

Another statutory authority involved in Cango Cave is the National Monuments Council (NMC). Cango Cave was declared a National monument in 1938, and re-declared, in the light of the 1972 and 1975 extensions, on 4 August 19955. In terms of the National Monuments Act, it is illegal to alter a National Monument without the consent of the NMC. Despite this a cell 'phone repeater station and antenna were erected above the Cave entrance early in 19966. Following a complaint by an official of the NMC to the Oudtshoorn police, the offending construction was removed! and prosecution may follow.

Another Government department which has an interest in Cango Cave is Water Affairs and Forestry. The effluent from the Cave mouth building is pumped to a series of inefficient oxidation ponds on the hill above the Cave entrance. From thence raw, untreated and unfiltered, sewage drains straight into the aquifer. This is illegal in terms of the relevant legislation.

Despite these inadequate arrangements for sewage disposal, the Oudtshoorn municipality in March 1996 announced plans to build a 44 bed luxury hotel and conference centre at the Cave entrance7, even though it may conflict with other development plans for the Swartberg foothills8. In August 1996 it announced further plans to drive three artificial entrances into the show cave9. This was motivated on the believed need to ventilate the Cave to reduce the pCO2, and to introduce one-way traffic which would halve the wear and tear on the Cave. This was rejected by the Scientific Advisory Committee which was not convinced that the high pCO2 is responsible for the deterioration of the speleothems, and which concluded that one-way traffic would double the numbers of visitors in unit time!

Meanwhile the UOFS researchers are continuing their investigations which have been downgraded to a vague "scientific study". Their report is due to be tabled at a meeting of the Scientific Advisory Committee on 31 January 1997.

The conclusion which I draw from all these bureaucratic manoeuvres is that Province is well aware that all is not well in the state of Cango, but that it does not know what do about it. One compromise would be to transfer control and management of the Cave to the National Parks Board, while leaving the trading at the Cave in the hands of the Oudtshoorn locals. This would ensure long-term sound environmental management of the Cave without adversely affecting the financial interests of the Oudtshoorn business community.

This is NOT an exercise in academic speleology. The dominant industry in Oudtshoorn is tourism, all of which is dependent on the Cave which attracts visitors to the town. If a long-term and environmentally acceptable management structure is not very soon imposed on the Cave, it will continue to deteriorate rapidly to the point where it no longer attracts visitors to Oudtshoorn.

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Problèmes liés à la mise en valeur touristique d'un site karstique. Le cas du karst de Tsanfleuron (VS, Suisse)

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Abstract

This paper analyses the positive and negative impacts of four types of touristical activities developped in the Tsanfleuron Region (Switzerland), on the water quality and on the landscape modifications of this glacio-karstic site. The studied activities are skiing, walking, didactical tourism and motorized sports. It appears that numerous illegal constructions increase the negative impacts of these activities (water quality degradation, soil erosion, landscape degradation). Different measures of protection should be taken to prevent the quick degradation of the environment.

Introduction

Le site glacio-karstique de Tsanfleuron forme un vaste plateau incliné sur le flanc normal de la nappe des Diablerets. Il est occupé dans sa partie amont par le glacier de Tsanfleuron. Le karst lui-même est constitué de deux zones séparées par les crêtes morainiques du Petit Age Glaciaire. A l'amont, le karst est fortement moutonné par l'abrasion glaciaire; à l'aval, les lapiés sont acérés. Ces lapiés se prolongent au sud par deux autres zones karstiques, les *Lapis de Mié* et les *Lapis du Genièvre*, au pied desquels s'écoulent deux émergences karstiques, la source de la Lizerne et la source de Glarey.

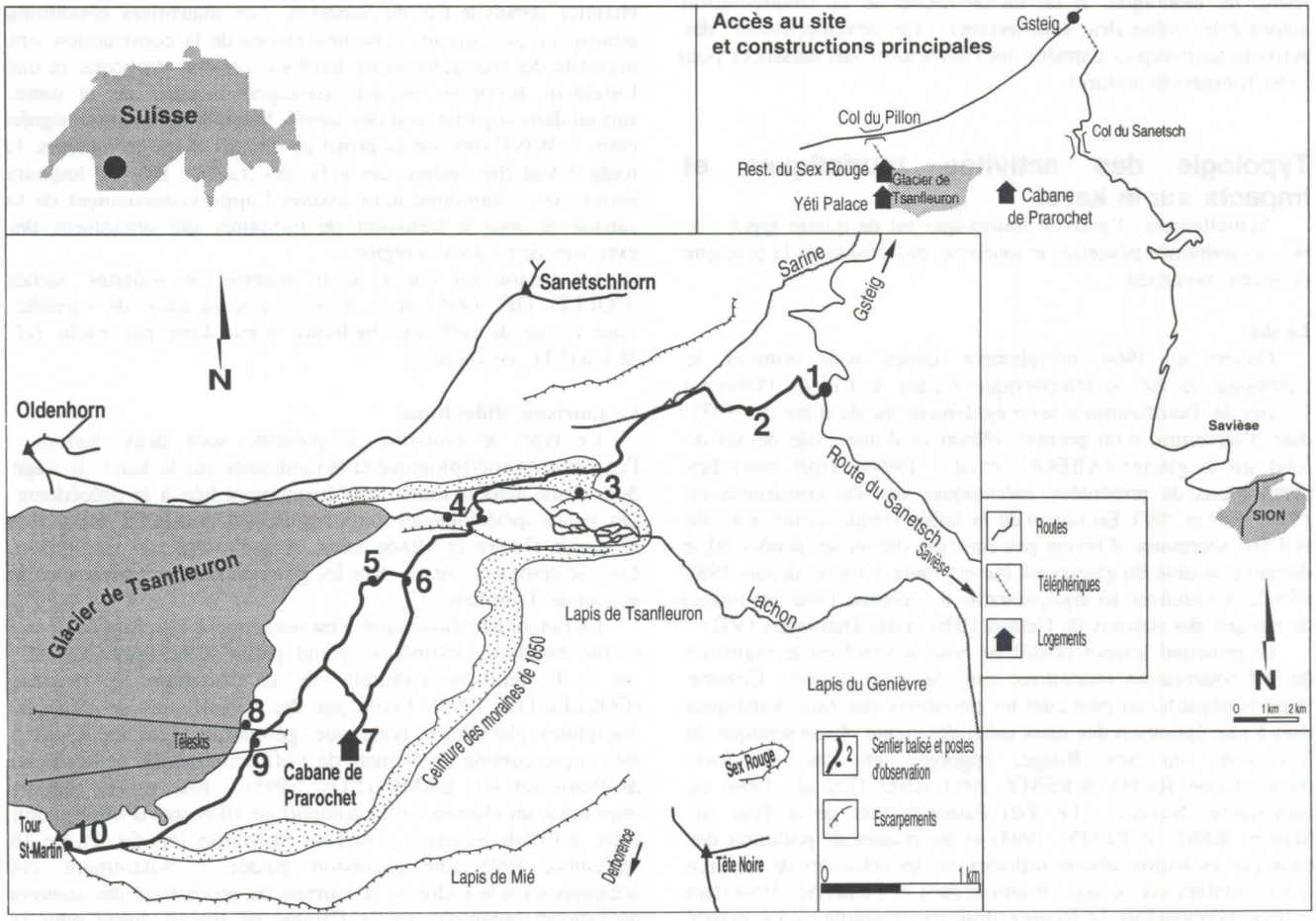

Fig. 1 Situation de la zone d'étude

La valeur scientifique du karst de Tsanfleuron

Le site glacio-karstique de Tsanfleuron intéresse les scientifiques depuis les années 50, notamment en raison de la richesse en réseaux souterrains et de la possibilité d'étudier les relations entre l'hydrologie glaciaire et les processus karstiques.

Ainsi, suite aux travaux pionniers de CORBEL (1957), MAIRE (1976) étudie en détail les différentes unités karstiques de la région et propose une typologie des karsts de montagne. Dans son ouvrage de synthèse sur la montagne calcaire (MAIRE, 1990), il étudie également les variations du chimisme des eaux traversant le karst. Depuis le début des années 70, des glaciologues observent et modélisent les relations entre la glace basale du glacier de Tsanfleuron et les processus karstiques sur le bedrock calcaire (cf. par ex. HALLET *et al.*, 1978, LEMMENS *et al.*, 1982, SOUCHEZ & LEMMENS, 1985, SHARP *et al.*, 1989, 1990). Dès les années 70, de nombreuses expéditions

spéléologiques ont permis de démêler l'écheveau des réseaux souterrains (BERCLAZ, 1977). Elles sont à la base de travaux de spéléologie appliquée à la recherche hydrogéologique (cf. par ex. MASOTTI, 1990, 1991, MASOTTI, ce volume).

En raison de la diversité des formes et des processus, le site de Tsanfleuron offre également un cadre didactique idéal pour les étudiants en sciences naturelles : les travaux de diplôme se sont ainsi multipliés ces dernières années. On peut citer, pour montrer la diversité des approches et des origines universitaires, les études de GARDAZ (1992), REYNARD (1992), TÄUFER (1993) et LAMBOTTE (1995).

Le développement touristique de la région

Malgré sa haute valeur scientifique, ce karst est resté pendant longtemps inconnu du grand public. Il faut y voir pour cause principale la difficulté d'accès, la route du Col du Sanetsch (cf. fig. 1) étant sans issue vers le nord. A partir du barrage du Sanetsch, le col se limite à un sentier muletier sur la flanc bernois. La pénétration du tourisme s'est faite depuis le col du Pillon, par la pratique du ski d'été dès la fin des années 70, puis du ski d'hiver dès les années 80. Parallèlement, des visites de grottes étaient organisées par des spéléologues professionnels durant la saison estivale. Au début des années 90, la fréquentation a fortement augmenté avec la construction d'un refuge de montagne. Il en est de même de la fréquentation automobile (véhicules tout-terrain). Ce développement des activités touristiques entraîne inévitablement des nuisances pour l'environnement naturel.

Typologie des activités touristiques et impacts sur le karst

Actuellement, l'activité touristique est de quatre types : le ski, la randonnée pédestre, le tourisme didactique et la pratique de sports motorisés.

Le ski

Ouvert en 1964, initialement conçu pour admirer le panorama en été, le téléphérique reliant le Col du Pillon au Glacier de Tsanfleuron a servi également au ski d'été dès 1971, date d'ouverture d'un premier téleski et d'une piste de ski de fond sur la glacier (ABEGG *et al.*, 1994). Trois nouvelles installations de remontées mécaniques ont été construites en 1977, 1983 et 1993. En raison de la faible fréquentation estivale et d'une succession d'hivers peu enneigés durant les années 80, le domaine skiable du glacier est ouvert toute l'année depuis 1988 afin de rentabiliser les équipements. Il constitue l'une des images de marque des stations de Gstaad (BE) et des Diablerets (VD).

Le principal impact positif de cette activité est le maintien de la fréquentation touristique dans ces deux stations. Comme impacts négatifs, on peut citer les pollutions des eaux karstiques dues à une épuration des eaux usées déficiente (fosse septique du Restaurant du Sex Rouge, engorgée en cas de forte fréquentation; REMY & REMY, 1993, ABEGG *et al.*, 1994) ou inexistante (Buvette « Le Yéti Palace », près de la Tour St-Martin; REMY & REMY, 1993) et les risques de pollution des eaux par les hydrocarbures utilisées par les véhicules de damage et les installations de ski. Un article paru le 17 janvier 1994 dans le quotidien vaudois *24 Heures* titrait par exemple : « Le massif des Diablerets distille une flotte douteuse ». Les équipes de ski s'entraînant sur le glacier utilisent parfois du sel pour durcir la neige (REMY & REMY, 1993), ce qui peut également provoquer une pollution des eaux karstiques.

En raison du retrait continu du glacier, les pilônes inférieurs de deux téleskis se sont retrouvés sur la roche (cf. fig. 1). Afin de les sceller avec du béton, la Société des Téléphériques des Diablerets a construit en automne 1996 une route illégale depuis le côté valaisan, avec l'accord du Président de la Commune de Savièse, sur le territoire de laquelle est situé le lapiaz (cf. *Journal de Genève,* 10 octobre 1996). Cette construction a été dénoncée par l'Etat du Valais, sur injonction de la Commune de Conthey, propriétaire de l'émergence karstique de Glarey qu'elle capte pour son approvisionnement en eau potable. Cette route carrossable a nécessité le démantèlement d'une partie de la moraine historique de 1850 (cf. fig. 1), dont les matériaux ont été utilisés pour combler les « marches d'escaliers » du karst en banquettes structurales récemment déglacé. L'impact visuel négatif est majeur. Comme le soulignait dans cet article l'hydrogéologue et cinéaste Gérald Favre, c'est un « joyau de la géologie alpine et de la glaciologie suisse » qui a été démoli.

Un projet de rénovation des installations de remontées mécaniques du glacier est en cours. Il prévoit notamment la construction de buvettes sur le glacier lui-même.

La randonnée pédestre

Ce type d'activité était très limité avant la construction du refuge de Prarochet, propriété du Ski-club de Savièse, inauguré le 15 août 1993. Depuis cette date, la fréquentation estivale est en nette augmentation. Elle constitue un atout indéniable pour le développement touristique du versant valaisan, dénué de domaine skiable équipé. La toute nouvelle Société de développement de Savièse, créée en 1994, mise d'ailleurs sur le développement du tourisme de randonnée pédestre, dans une perspective de promotion du tourisme doux.

Mais ce développement a aussi ses effets négatifs. La construction du refuge a nécessité l'ouverture d'une route de chantier depuis le Col du Sanetsch. Les mauvaises conditions atmosphériques durant certaines phases de la construction ont nécessité des changements de tracé sur certains tronçons et ont fortement accrû les impacts paysagers négatifs de la route, surtout dans la partie aval des lapiés. Selon la convention signée entre le WWF (opposé au projet au départ) et les promoteurs, la route devait être détruite dès la fin des travaux. Elle est toujours entretenue, notamment pour assurer l'approvisionnement de la cabane et pour le transport de militaires qui organisent des exercices de tir dans la région.

La cabane est munie d'un système de toilettes sèches (COLLECTIF, 1995), mais n'épure pas les eaux de vaisselle. Tout risque de pollution hydrique n'est donc pas exclu (cf. MASOTTI, ce volume).

Le tourisme didactique

Ce type de tourisme se présente sous deux formes : l'exploration spéléologique et la randonnée sur le karst. Il s'agit donc d'une activité touristique étroitement liée à la précédente. Les visites spéléologiques sont organisées depuis la fin des années 80 par le Centre et Musée suisse de spéléologie de Chamoson. Elles se déroulent autant dans les galeries karstiques que sous le glacier de Tsanfleuron.

La randonnée didactique s'est notamment développée depuis qu'une brochure destinée au grand public a été éditée en 1995 par la Commission culturelle de la Commune de Savièse (COLLECTIF, 1995). Ecrite par des scientifiques de plusieurs disciplines (glaciologie, botanique, géomorphologie, etc.), elle a été conçue comme un élément de l'offre touristique de la cabane de Prarochet (cf. LAMBOTTE, 1995). Elle est le support imprimé à un chemin balisé comportant 10 postes d'observation entre le Col du Sanetsch et la Tour St-Martin (cf. fig. 1). Le 16 septembre 1995, une excursion guidée a notamment été organisée dans le cadre de la journée de promotion des sentiers géologiques organisée par le Groupe de travail suisse pour la protection des géotopes (STRASSER *et al.*, 1995) à l'occasion de l'Année européenne pour la nature.

Ces activités ont deux impacts positifs principaux : le développement touristique du versant valaisan et la formation du grand public aux problèmes de gestion de l'environnement liés au karst. Pour autant qu'elles restent dans certaines limites, elles n'ont pas d'impacts négatifs sur le karst.

La pratique des sports motorisés

Ils sont de deux types : la dépose d'avions et d'hélicoptères (autorisée sur le glacier de Tsanfleuron) et les « rallyes » en

véhicules tout-terrain. La dépose d'avion provoque essentiellement des impacts sonores. Les eaux karstiques pourraient être polluées en cas d'accident. Par contre, le transport par véhicules 4x4, assez intense car l'aspect désertique du lapiaz donne aux chauffeurs un sentiment de liberté difficile à trouver ailleurs dans la région, est autrement plus dommageable. En plus des risques de pollution des eaux, le passage des véhicules provoque une érosion des maigres sols présents dans la partie basse du karst (près de la route du col). Cette activité est pratiquée presque essentiellement par les indigènes des deux versants (Valais et Vaud).

Synthèse et perspectives

La figure 2 résume les différents impacts. Il apparaît clairement que le développement touristique des deux régions (Gstaad/Diablerets depuis une trentaine d'années et Sanetsch depuis un peu plus de 5 ans) s'accompagne d'une série d'impacts négatifs dont les plus importants sont la pollution des eaux (MASOTTI, ce volume) et la dégradation rapide du paysage (en 1991, les téléskis et les deux restaurants du glacier étaient les seules constructions). Les infractions aux lois fédérales sur l'aménagement du territoire (LAT) et sur la protection des eaux (LEaux) sont nombreuses (systèmes d'épuration des eaux usées insuffisants, constructions illégales).

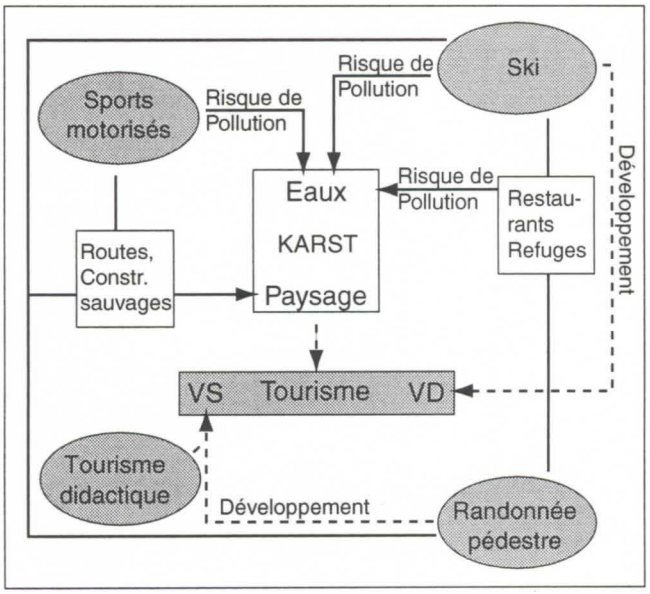

Fig. 2 Impacts des activités touristiques sur le karst de Tsanfleuron. Les flèches en trait plein représentent les impacts négatifs; les flèches en pointillés représentent les impacts positifs.

Afin de minimiser ces dégradations, trois actions sont urgentes :

- La marge proglaciaire du Glacier de Tsanfleuron est l'une des régions sélectionnées dans le cadre de l'*Inventaire des marges glaciaires et des plaines inondables alpines (IGLES)*, mené sous les auspices de l'Office fédéral de l'environnement, des forêts et du paysage (OFEFP), en vertu de la Loi fédérale sur la protection de la nature et du paysage (LPN) (KÜTTEL *et al*., 1995). Sa mise sous protection permettrait d'être beaucoup plus restrictifs concernant les aménagements dans la zone de transition entre la langue glaciaire et le karst (zone récemment déglacée depuis 1850).
- Cette mise sous protection est toutefois limitée dans l'espace. Une protection de l'ensemble du site glacio-karstique, motivée par son intérêt scientifique et paysager majeur, serait nécessaire dans le cadre des procédures de protection des géotopes d'importance cantonale, voire nationale.
- Plus globalement, l'adoption d'un plan d'aménagement coordonné de toute la région du Sanetsch par la Commune de Savièse permettrait d'assurer le développement touristique à long terme. C'est ce à quoi s'attelle la Société de développement de Savièse.

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La mine de cuivre de Zinal dans le Val d'Anniviers

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Abstract

Zinal's Cooper Mine's corridors extend as far as 500 meters under the high mountain pasture of La Lé. The Mine was first explored in 1857, before being actively mined between 1900 and 1902.

The resort of Zinal has decided to develop the Mine and to open it to the public. This underground attraction will be inaugurated during the International Congress of Speleology's field-study trip.

Résumé

La mine de cuivre de Zinal, dans le Val d'Anniviers, étend ses galeries sur plus de 500 mètres sous l'alpage de la Lé. Cette mine qui avait connu de modestes recherches en 1857, voit une période d'extraction plus importante de 1900 à 1902.

Aujourd'hui, la station de Zinal, après moultes études, a décidé d'aménager la mine pour le public. Si la chance nous sourit, cette attraction souterraine sera inaugurée durant l'excursion de spéléologie appliquée du congrès international de spéléologie.

Introduction

Suite aux recommandations de Monsieur Norbert Jungsten de l'Office des Monuments Historiques du canton du Valais, nous avons eu la chance de pouvoir mettre à l'épreuve nos connaissances en matière minière et touristique.

Le 31 août 1995, Madame Tarchini de l'office du tourisme de Zinal, Monsieur Bellwald du musée du Lötschental de Kippel, Monsieur Jungsten et votre narrateur, se rendaient à l'ancienne mine de cuivre au sud du plateau de la Lé à Zinal, dans le Val d'Anniviers (fig.1), afin de se rendre compte de la possibilité d'ouvrir ce site au tourisme.

Il découlait de cette visite une série de travaux d'approche qui ont duré de 1995 à 1997. Ces travaux concernaient autant la sécurité des galeries que les différents scénarios de visite de la mine.

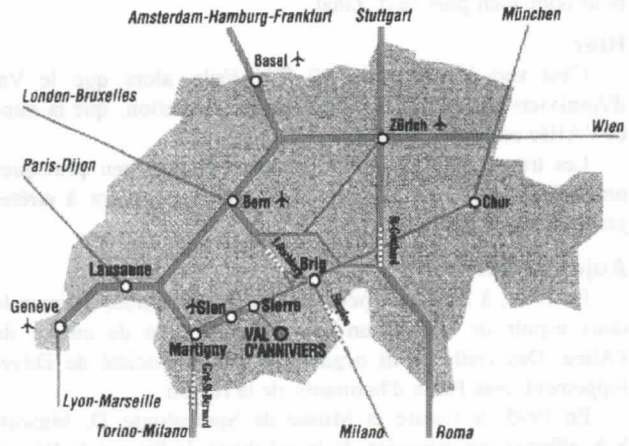

Fig.1 : Situation de Zinal et du val d'Anniviers en Suisse.

La topographie

Le seul document en notre possession est le relevé effectué en 1943 par la célèbre équipe de spéléologues, Amoudruz, Verdan et Dumont. Cette topographie étant incomplète, nous décidions de la terminer et de la contrôler.

Ce travail fut réalisé le 10 octobre 1995, avec, la plupart du temps, une eau glacée jusqu'à mi-cuisses. Gérald Favre et Jean-François Crittin furent les valeureux topographes de ce nouveau relevé qui présente un développement d'environ 530 mètres.

Cet important travail nous servira de base pour bons nombres d'études.

La présence de gaz indésirables

Les analyses ont été accomplies directement sur place à l'aide d'un appareil électronique utilisé par la mine de sel de Bex et qui permet d'obtenir immédiatement des résultats.

Le méthane

A première vue, il semble inutile d'essayer de déceler la présence de méthane dans des formations géologiques n'appartenant pas au Carbonifère. Notre expérience dans différentes mines nous pousse à la prudence la plus élémentaire. En effet, il n'est pas rare de voir le méthane migrer dans les fissures des roches ne comportant pas de niveaux charbonneux, et provoquer de nombreux accidents. Dans le cas d'une future exploitation touristique, on ne peut pas se permettre d'allégations approximatives. Il est préférable de se baser sur des analyses réelles.

La présence de méthane (CH_4) a été décelée en infimes proportions (<0.001%) dans l'atmosphère de la galerie 3, qui est la plus profonde de la mine. Cette présence est certainement imputable au pourrissement des étais, au début de la partie effondrée. Il ne s'agit pas de concentrations dangereuses. Le méthane est dangereux à partir de 6% de concentration dans l'air des galeries et détonne à la moindre étincelle. On donne à ce mélange le nom de grisou.

Afin d'offrir le maximum de sécurité, des contrôles de routine seront effectués durant l'exploitation touristique de la mine.

Oxygène

Lorsque la teneur en oxygène baisse en galerie, l'homme ressent une gêne à partir de 15%. La flamme d'une bougie ou d'une lampe à pétrole s'éteint à 17%.

Les résultats des analyses effectuées en continu dans les galeries montrent une variation de la teneur en oxygène de 17.9 à 18.1%.

La même remarque que pour le méthane sera prise en considération, les contrôles de routine seront envisagés.

Stabilité des galeries

Les tronçons qui présentent une instabilité locale apparaissent au premier coup d'oeil. En effet, les débris rocheux provenant des ruptures d'équilibre de la voûte jonchent le sol de la galerie à ces endroits.

Nous ne nous sommes pas basés uniquement sur ces observations mais nous avons également effectué des détections de zones de décollement, par martèlement des pieds droits et de la voûte.

En règle générale, la stabilité de l'enveloppe des galeries est assez bonne. Les galeries d'entrées présentent des zones de résistance médiocre. Cette situation est due principalement aux phénomènes de gel et dégel dans les micros-fissures de la roche.

Lors de nos relevés, nous avons également observé des zones instables dans la paroi qui domine l'accès à la mine. Malgré le caractère aérien de ces dangers, nous les avons quand même fait figurer dans ce chapitre. L'assainissement de la paroi est à entreprendre avec l'aide des guides locaux.

Dans le cadre de la future exploitation touristique, les visiteurs seront impérativement équipés de casques afin de se prémunir contre tout danger de chutes de pierres non prévisibles. On profitera des contrôles de routine de la teneur en gaz de la mine pour effectuer une analyse rapide de l'évolution de l'équilibre de l'enveloppe rocheuse. Une mine ouverte au public reste toujours une mine.

Il sera intéressant de rétablir un chantier d'étayage à l'ancienne mode dans les parties peu stables de la mine, apportant ainsi un pôle d'intérêt supplémentaire.

L'eau dans les galeries

La présence d'eau dans les galeries est principalement imputable aux eaux météoriques ainsi qu'aux percolations parasites d'une cascade extérieure.

Les fissures au sol étant colmatées et empêchant une évacuation naturelle de l'eau, il serait intéressant de rétablir l'ancien système d'exhaure qui serait mû par une source d'énergie moderne tel que panneaux solaires par exemple.

Seule la grande galerie qui présente un intérêt particulier sera assainie par ce système de pompage. A l'endroit le plus bas de la galerie, on creusera un puisard servant à la récolte des eaux parasites ainsi qu'à l'installation de la partie aspirante de la pompe. Nous avions pensé établir un diaphragme de Plexiglas avec drainage à chaque fenêtre de la mine; cette installation empêcherait l'eau de percoler à l'intérieur des galeries. Ce système inesthétique empêcherait une grande partie de la ventilation naturelle de la mine; cette possibilité est donc à écarter.

La canalisation d'évacuation rejettera l'eau près de l'entrée principale de la mine, apportant une agréable fraîcheur visuelle aux touristes épuisés par la montée du chemin. Une affiche mentionnant "eau non potable" sera apposée à côté de la sortie d'eau.

Les principaux buts

Faire revivre, à Zinal, l'industrie minière du cuivre du début du siècle à l'aide d'un musée didactique actif.

Permettre à chacun de vivre, durant une demi-journée, la passionnante aventure des mineurs dans les Alpes, en participant de manière active à leurs travaux.

Faire comprendre les mécanismes de la formation de la chaîne alpine, dans une région qui abrite les sommets les plus prestigieux des Alpes.

Telles seront les cibles principales à atteindre pour faire de cette attraction un pôle d'intérêts pour tout un chacun, élèves des écoles ainsi que touristes.

Un brin d'histoire

Avant-hier

Le cuivre, contenu tout d'abord dans les laves volcaniques basiques, est disséminé dans la pâte visqueuse et brûlante des roches en fusion. Ce magma va, en s'élevant dans la croûte terrestre, se refroidir lentement au sein des roches superficielles déjà consolidées.

Le télescopage titanesque entre l'Afrique et l'Europe, dont les Alpes demeurent le témoignage grandiose et muet, va mettre en route un nouveau phénomène, le métamorphisme.

Ce cuivre qui somnolait depuis des millions d'années va, par l'augmentation de la pression et de la température dues à ce choc, être emporté par les circulations hydrothermales qui vont migrer vers la surface.

Ce minerai ne sera pas composé uniquement de cuivre pur. Seront également associés le fer et le soufre, pour composer ce que l'on appelle de la chalcopyrite, de symbole chimique $CuFeS_2$. Des fragments de ce minerai seront concentrés par place dans le solde du matériel hydrothermal qui va former, en se solidifiant, la gangue, composée principalement de quartz.

Depuis ce jour, le minerai, après un long et lent voyage, va refléter le soleil de cuivre d'une région exceptionnelle qui aura pour nom, bien plus tard, Zinal.

Hier

C'est vers le début du 20 ^{ème} siècle, alors que le Val d'Anniviers enregistre un maximum de population, que la mine de l'Allée connaît son apogée.

Les travaux d'exploitation et de traitement peu pratiques ont obligé la Société des Mines du Val d'Anniviers à arrêter graduellement l'affaire en 1903.

Aujourd'hui

En 1994, à Zinal, un petit groupe de personnes caresse le doux espoir de réaliser un musée de la mine de cuivre de l'Allée. Des visites sont organisées par la Société de Développement avec l'aide d'habitants de la région.

En 1995, le Centre et Musée de Spéléologie D. Masotti S.A. effectue une expertise de la salubrité de l'air et de l'équilibre des galeries. La topographie du site souterrain est également complétée.

En 1996, sous la houlette de Messieurs Serge Melly et Norbert Jungsten, un comité d'étude et de réalisation du Musée de la Mine de Cuivre de l'Allée pose les premières pierres de cet intéressant édifice.

Demain

L'hôte de la station de Zinal se verra proposer un intéressant programme:

A partir de l'été 1997

Une visite didactique de la mine de l'Allée, avec, sur le trajet d'accès, d'intéressants panneaux qui lui expliqueront la formation de la chaîne des Alpes. Il apprendra que les sommets prestigieux tels que le Besso, le Zinalrothorn, l'Ober-Gabelhorn, la Dent Blanche etc... appartiennent à la partie septentrionale de l'Afrique. Cette intéressante promenade lui fera découvrir les mille et un secrets de la naissance fascinante de ces vagues de pierre gigantesques que sont les Alpes. La visite de la mine, couronnera cette initiation historique en le faisant plonger dans le cœur de l'histoire des hommes et du cuivre.

A partir de 1998

S'essayer au métier de mineur en passant une demi-journée à l'Allée, dans la galerie d'initiation de Sainte-Barbe, en travaillant aux différents chantiers de l'exploitation minière. Il terminera cette demi-journée de travail en ayant la possibilité de faire fondre soi-même le minerai extrait, en touchant un petit lingot de cuivre en souvenir de Zinal, et surtout, se voir remettre un diplôme de mineur de l'Allée avec sa photographie en tenue de circonstance, tout en dégustant un met à la mode 1900.

Le scénario de visite retenu

Nous avons retenu à la lettre le principe discuté lors de la séance de l'Association des Musées Suisses à Vevey en 1996, c'est-à-dire créer une émotion chez le visiteur tout en lui inculquant les messages ressortant de l'exposition.

Nous nous bornerons à décrire ci-dessous le résumé du scénario prévu pour la visite touristique de la mine de la Lé. La numérotation des paragraphes correspond au plan (fig.2).

1) Après s'être acquitté de son droit d'accès, à la petite cabane à côté de l'entrée de la mine, le promeneur pourra :
2) Voir de près les premiers signes témoignant de la présence du cuivre dans le massif rocheux. Il apprendra les gestes et le coup d'œil du prospecteur.
3) Les techniques d'avancement de l'époque, restes de culots, etc... lui seront expliqués à l'aide de supports didactiques et de traces témoins visibles sur place.
4) Des schémas simplificateurs sur panneaux couleur cuivre montreront le constat du terrible accident entre les deux continents que sont l'Europe et l'Afrique. A ce moment, le visiteur comprendra que les roches qui l'entourent proviennent du fond d'un ancien océan vibrant d'activités volcaniques.
5) Les mécanismes de la minéralisation des filons seront traités également sur panneaux et en situations réelles.
6) La tragédie d'un éboulement sera reconstituée avec bruitages.
7) Le filon s'amenuise.
8) On retrouve la chalcopyrite dans la roche même.
9) A un détour de la galerie, le visiteur confronté, jusque- là, à l'univers statique des panneaux didactiques, verra sa raison remise en question. En effet les bruits de voix et le martèlement des burins l'amèneront vers le front d'attaque d'une galerie. Là, la lumière vacillante des lampes à acétylène, des mannequins, par la gestuelle, montreront la technique de perforation de la roche.
10) Quelques pas plus loin, une sonnerie de trompe indiquera au visiteur qu'il peut appuyer sur la manivelle de l'exploseur afin de déclencher lui-même le coup de mine. Il sentira vibrer le sol lors de l'explosion. Quelques secondes plus tard le pouillant envahira la galerie (effet fumigène des discothèques).
11) A l'avancement 2 mannequins posent des rails pour les wagonnets.
12) Un chantier d'étayage sera visible, et l'oreille attentive captera les grincements du bois sous la poussée du rocher.
13) Un éclaté d'une pompe d'époque montrera le mécanisme du pompage de l'eau des galeries ainsi que de leur ventilation.
14) Le bruit métallique du matériel roulant sur d'étroits rails nous meurtrira les tympans.
15) La teneur en cuivre baisse de plus en plus; on ne se donne plus la peine de ressortir le marin on le dépose dans d'anciennes amorces de galeries.
16) Le minerai n'est plus assez riche en cuivre, la mine est fermée; on demande au visiteur de sortir et de rendre son équipement de mineur
17) Panneau explicitant la ventilation naturelle et artificielle de la mine
18) Un four servant au grillage, élimination du fer et du soufre de la chalcopyrite, montrera les différentes opérations de concentration du cuivre.
19) Un mannequin à l'air fâché résumera les problèmes avec les pâtres.
20) A coté de la cabane de réception, une vitrine contenant des objets en cuivre vous fera parcourir le chemin de l'utilisation de ce métal connu en Egypte depuis le cinquième millénaire av. J-C. Eventuellement souvenirs en cuivre.

Estimation du coût de la réalisation

L'estimation du prix de cette réalisation basée sur les prix à la construction de 1996 se monte à 325'000.-CHF. Une grande partie pourrait être financée par des crédits LIM, encouragement pour les régions de montagne, ces crédits sont calculés sans intérêts, et par des sociétés à buts culturelles, Société de Développement, la commune d'Ayer. Une autre partie serait à trouver parmi les donateurs potentiels divers.

Inauguration durant le congrès 97

Au vu de ce qui précède, nouveau pôle d'attraction pour le Val d'Anniviers, possibilité de développement futur du premier Centre Suisse du Cuivre, ouverture de la première mine de cuivre active ouverte au tourisme technique etc... Il semblerait que le financement d'un tel projet ne soit pas une aventure financière trop risquée.

Par contre, cette aventure humaine, au sens noble du terme, offrirait à la région de Zinal des possibilités d'offres sur le plan du travail, qui ne seraient peut-être pas négligeables.

En plus de l'offre touristique actuelle, il se pourrait bien que le cuivre et tout ce qui gravite autour attire un nombre supplémentaire de visiteurs dans la Station.

L'inauguration de la première étape, la mine de l'Allée, durant le congrès mondial de spéléologie, permettrait à Zinal de se faire encore mieux connaître sur le plan international.

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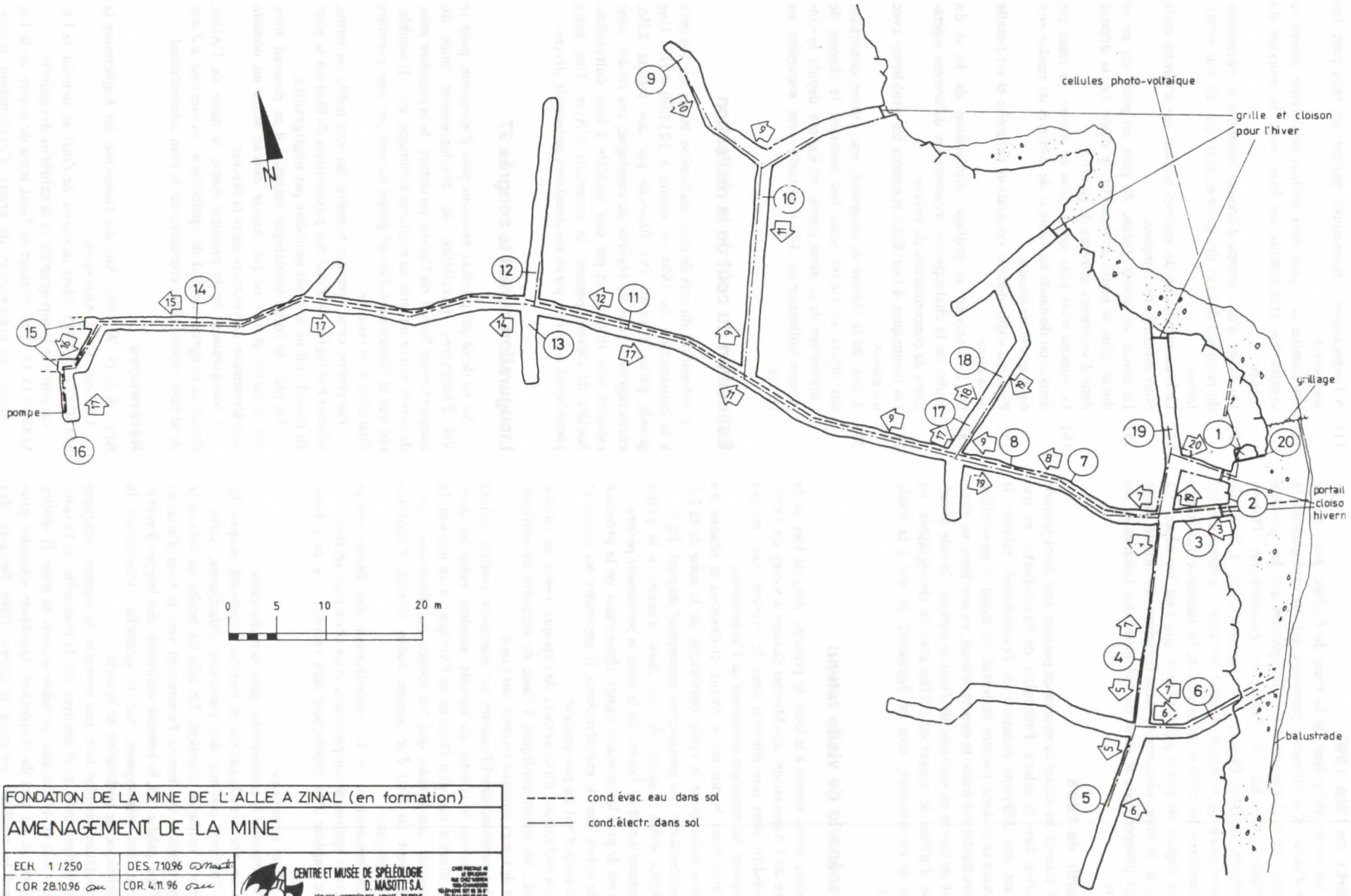
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FONDATION DE LA MINE DE L' ALLE A ZINAL (en formation)
AMENAGEMENT DE LA MINE
ECH. 1 / 250
DES. 7.10.96
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COR. 4.11.96
CENTRE ET MUSÉE DE SPÉLÉOLOGIE
D. MASOTTI S.A.
GÉOLOGIE · HYDROGÉOLOGIE · MINAGE · TOURISME
cond. évac. eau dans sol
cond. électr. dans sol

FIG 2

Musée suisse de spéléologie an 4

par Daniel Masotti
Musée Suisse de Spéléologie, case postale 46, CH-1955 Chamoson, Suisse
Bureau d'études D. Masotti SA, section de spéléologie appliquée, Rue chez Moren, CH-1955 Chamoson, Suisse

Abstract

The Swiss Museum of Speleology opened on 5th March 1994, The following account, as the perfect chef would say, provides you with the recipe for creating such an establishment. The difficulties encountered are given the same amount of attention as the successes. What is most interesting is that not only is the international congress being held in Switzerland this year but 1997 also marks the tenth anniversary of the opening of the Applied Speleology Centre in Chamoson in the Valais.

The three professional speleologist who work full-time at the Centre and the museum all declare having the same aim : they want people to discover speleology so that they will like it and from this liking will grow respect. Many applied speleology classes are organised and given by the author of this report within the setting of the museum. Any speleologists who would like to turn their passion into their job should not fail to read this report.

Résumé

Le Musée Suisse de Spéléologie a ouvert ses portes le 5 mars 1994. L'exposé qui fait suite, donne en parfait chef de cuisine la recette amenant à la concrétisation d'un tel édifice. Les difficultés sont traitées au même titre que les réussites. Faits intéressants, si 1997 porte le congrès international en Suisse, cette année voit également le dixième anniversaire de l'ouverture du Centre de Spéléologie appliquée à Chamoson en Valais.

Les 3 spéléologues professionnels qui oeuvrent à temps complet au sein du Centre et du Musée clament tous la même profession de foi, faire découvrir pour faire aimer et faire aimer pour faire respecter. De nombreux cours de spéléologie appliquée sont organisés et donnés par l'auteur de cette communication dans le cadre du musée. Spéléologues qui désirez faire de votre passion votre job, ne ratez pas la lecture de cette communication.

1. Introduction

Le principal moteur de la création du musée de spéléologie a été le didactisme. En effet entendre parler de la spéléologie dans la presse uniquement par le biais des accidents souterrains et de rares exploits, ne convenait pas du tout à mon envie de partager une passion avec les gens susceptibles d'être intéressés par le milieu souterrain.

Les fausses idées, induites par le mystérieux fonctionnement des eaux souterraines et des sources, devaient être combattues également. Le respect de l'eau, pour moi, devait obligatoirement passer par la possibilité pour le commun des mortels d'approcher les différentes techniques de l'hydrogéologie au travers d'expositions didactiques.

Il va sans dire que toutes ces démarches, jusqu'à leurs aboutissements, et dans le fonctionnement pratique du musée, sont guidées par l'éthique la plus élémentaire en matière de spéléologie appliquée. La célèbre phrase de Jacques Morier-Genoud, président en 1987 de la Ligue Suisse pour la Protection de la Nature : « Faire connaître pour faire aimer, faire aimer pour protéger », tel est le but que vise chaque spéléologue de notre institut, conscient de la fragilité du monde souterrain.

Pour construire une exposition permanente, il faut à la base avoir de la monnaie, ce qui n'était en tout cas pas mon cas. On ne peut que rarement créer un musée en maîtrisant parfaitement les aléas de la finance, de l'architecture, du didactisme et des voies d'accès à la reconnaissance mondiale en matière muséologique. Et pourtant, comme dit le proverbe « à cœur vaillant rien d'impossible » la réalisation de notre but a été grandement aidée par l'amitié.

Environ 17 ans après la réalisation des premières épures, l'idée de création d'un musée de spéléologie sous forme institutionnelle prend forme de manière plus précise. Une équipe dynamique formée de Messieurs Charles-Marie Crittin, avocat, Pascal Udry, technicien et Daniel Masotti, géotechnicien, se met en devoir de réaliser l'irréalisable, construire et exploiter le Musée Suisse de Spéléologie dans un petit village (fig.1) décentré par rapport à l'axe routier principal et qui n'abrite aucune caverne célèbre.

2. La recherche du financement

La réalisation de l'ouvrage est devisé à 1'000'000.- CHF. L'argent, nerf de la guerre nous fait cruellement défaut et nous sommes obligés de mettre en jeu mon habitation privée ainsi que mon laboratoire, qui abrite depuis 1987 les activités du Centre de Spéléologie Appliquée. A ces conditions, la banque Raiffeisen de Chamoson veut bien se lancer dans cette aventure à condition que nous obtenions des Crédits LIM. La demande

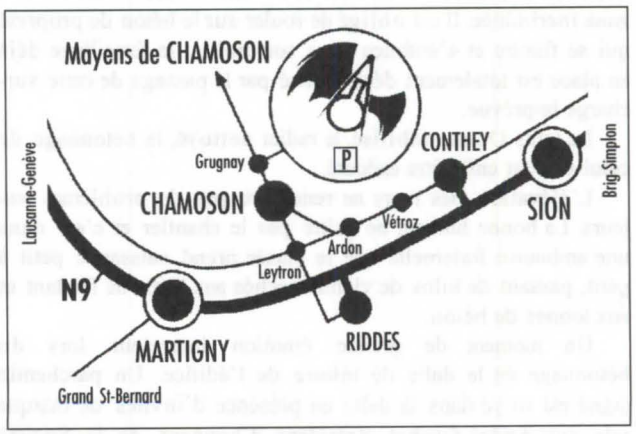


Fig. 1 Situation du Musée Suisse de Spéléologie

d'obtention de ces crédits sans intérêts d'aide à l'investissement en région de montagne, date de 1989 et nous recevons une réponse positive en 1993 seulement. La grande aventure peut enfin démarrer.

3. La construction du musée

Etant dessinateur-architecte de première formation, il m'a été aisé d'établir les premiers plans au 1/100 des projets, présentés en 1986 au Président Central d'alors, Monsieur René Scherrer, et du dossier de la mise à l'enquête publique du dossier du musée.

Le manque de temps dû à une surcharge de travail dans les secteurs géologie et hydrogéologie ne m'a pas permis de continuer le suivi du dossier de construction. L'architecte Marcel Disner étant pressenti pour la suite du travail, c'est celui-ci qui dirigera la construction du musée.

Durant les travaux de fouilles, nous découvrons une petite source d'un débit assez régulier d'environ 1 dl/sec. La dureté élevée de cette eau permet la réalisation de petits gours à la sortie de la conduite d'évacuation. Devant cette aubaine, nous ne résistons pas à la tentation de restituer cette eau sous forme de petite source artificielle, qui sera équipée plus tard d'un matériel sophistiqué servant à observer le débit, l'évolution de la dureté de l'eau, sa température, etc. Toutes ces données seront retransmises par satellite vers un PC, en démonstration dans le laboratoire de didactique du musée. Mais ceci est encore de la musique d'avenir.

La mauvaise portance du sol de fondation ne permet pas une construction conventionnelle. Les premiers problèmes pointent à l'horizon et le bureau d'ingénieur Tournier et Blanc de Sion nous propose la solution de construire notre musée sur un radier renforcé. La spéléologie sera à l'abri dans un bunker, ce qui permettra en cas de conflit mondial de sauvegarder les biens culturels du milieu souterrain. Il est autorisé de faire un peu d'humour même dans les cas extrêmes, car ce dernier aléa va nous augmenter le coût de construction, et nous savons pertinemment que nous ne pourrons pas redemander une réévaluation du projet auprès des crédits LIM. La décision de continuer les travaux est prise, car, ''au point o_ l'on en est, on ne peut plus s'arrêter'' clame tout haut le conseil d'administration.

Le ferraillage du radier est terminé lorsque le talus Ouest, talus beaucoup trop raide selon Masotti qui peint toujours le diable sur la muraille, aux dires de l'entreprise de maçonnerie Hubert et Hervé Crittin, glisse et s'écroule sur le radier qui était prêt à être bétonné. Le camion-grappin dépêché sur les lieux afin d'évacuer la terre éboulée n'arrive pas à atteindre la zone incriminée. Il est obligé de rouler sur le béton de propreté qui se fissure et s'enfonce sous son poids; le ferraillage déjà en place est totalement désorganisé par le passage de cette surcharge imprévue.

Le talus Ouest stabilisé, le radier nettoyé, le bétonnage de celui-ci peut enfin être exécuté.

L'élévation des murs ne rencontre pas de problèmes majeurs. La bonne humeur ne quitte pas le chantier et c'est dans une ambiance fraternelle que le musée prend naissance petit à petit, passant de kilos de viande séchée aux litres de fendant et aux tonnes de béton.

Un moment de grande émotion intervient lors du bétonnage de la dalle de toiture de l'édifice. Un parchemin signé est noyé dans la dalle en présence d'invités de marque tels que André Grobet, Président d'honneur de la Société Suisse de Spéléologie, Christian Costa, Président du Groupe de Spéléologie Rhodanien accompagné de nombreux spéléos, quelques notables de la région, et de toutes les personnes travaillant sur le chantier. Suivant la tradition des bâtisseurs de cathédrales, un repas de fête est organisé en l'honneur des travailleurs. Certains apprennent le portugais, d'autres le français, et c'est tard dans la nuit que se terminent ces premières grandes festivités.

4. La recherche des objets

La décoration et l'aménagement du musée touche à sa fin. Nous sommes au début du mois de février 1994 et les seuls objets à disposition résident en ma collection privée. Devant les exhortations de la banque, je décide d'ouvrir et d'inaugurer le musée le 5 mars. Nos décorateurs en chef, Charles-Albert Lathion et Jean-François Crittin ''crient au fou''. Il faut beaucoup plus de temps pour mener à bien les travaux de finition, mais l'argent commence à manquer.

Mon bâton de pèlerin en main, je commence le périlleux voyage de la collecte des objets manquants. De nombreux kilomètres m'amènent quelquefois à glaner des objets qui tiendraient dans une boîte d'allumettes et seraient facilement envoyés par courrier postal, mais le contact avec les donateurs reste le moyen le plus sûr de marquer le respect dû à ces sympathiques personnes. J'ai remué le ciel et la terre de France et de Suisse pour trouver des chauves-souris empaillées, et c'est tout près finalement que je les ai trouvées, à Brigue en Valais.

Nous avions besoin de mannequins afin de mettre en scène des ambiances d'évolutions spéléologiques, et c'est avec un regard envieux que mes collaborateurs me regardaient partir à la chasse dans les arrières boutiques des grands magasins. Les contacts avec les décoratrices et décorateurs ont toujours été très enrichissants. Les donateurs potentiels réalisent leurs dons une fois le musée ouvert ; la qualité de ce temple des eaux souterraines et de la spéléologie, pour reprendre la phrase de la journaliste Catherine Killé, encourage ceux-ci.

Nous nous sommes également approchés de la Société Suisse de Spéléologie afin de savoir si les membres étaient prêts à collaborer sainement à un développement du musée, institution qui défend l'éthique et la science du milieu souterrain, la spéléologie.

5. La consécration

La date du 5 mars 1994 restera longtemps gravée dans les coeurs des personnes qui ont participé à l'élaboration du musée. Le Président Central de la Société Suisse de Spéléologie, Monsieur Jean-Claude Lalou, écrit : '' en faisant connaître intelligemment ce que l'on aime, on participe de la meilleure manière à sa protection. Longue vie pour cela au Musée et bravo à ses réalisateurs.'' De nombreux spéléos sont présents et le fendant coule à flots durant ce week-end mémorable.

Nous ne désirons pas nous arrêter en si bon chemin et nous formulons la demande d'entrée au sein de l'Association Valaisanne des Musées Locaux. Celle-ci nous répond par l'affirmative. La prochaine demande est plus ambitieuse, être accepté comme membre dans la très cotée Association des Musées Suisses. Là encore, nous faisons mouche. Suite à la visite de l'expert de cette dernière association, lequel nous suggère de faire la demande directement au sein des seins des musées internationaux, l'ICOM, International Council Of Museums, nous accepte parmi tant de musées prestigieux que notre modestie en chancelle.

Il aura fallu 9 mois au musée, depuis son inauguration officielle jusqu'à sa reconnaissance internationale.

La fin de l'année 1995 voit la modification de la raison sociale « Centre et Musée de Spéléologie D. Masotti SA », en « Fondation du Musée Suisse de Spéléologie », d'une part, et « Centre de Spéléologie Appliquée D. Masotti SA » d'autre part. Un conseil de Fondation est formé, par Messieurs le Professeur Willi Aellen, Jean-Jacques Miserez, Charles-Marie Crittin, Pierre Cattin, Gérald Favre, Pascal Udry, Denis Gigandet, André Putallaz et votre narrateur.

Lors de l'Assemblée des Délégués de la Société Suisse de Spéléologie en 1996 à Chamoson, la visite du Musée Suisse de Spéléologie avait été le passage obligé de la journée.

Les 16, 17, 18 et 19 avril 1997 notre musée a participé aux cérémonies de remises des prix du ''1997 European Museum of the Year Award'' au Musée Olympique à Lausanne. Notre musée avait été sélectionné parmi une centaine de musées européens. Afin de garder la primeur des résultats pour les lecteurs des Actes du congrès, je me permets d'infliger à notre ami Pierre-Yves Jeannin, de par un retard obligé du retour de ma communication, un suspens à peine supportable.

C'est avec un très grand plaisir que nous avons appris que bon nombre d'organisateurs d'excursions de notre congrès 97 passeront par le relais obligé des spéléologues amateurs de bons vins et de bonne chère.

En ce début d'année 1997, l'avenir financier semble être un peu moins morose. En effet, il semblerait que mon épouse et moi-même ne serions plus obligés de subventionner en partie le musée par nos salaires. Le canton du Valais ainsi que la commune de Chamoson nous propose une aide matérielle bienvenue. L'aide en matière culturelle de la Loterie Romande assainit une partie de la lourde dette contractée pour la construction du musée.

6. Le fonctionnement du musée

Depuis son inauguration, le musée a toujours été ouvert toute l'année, tous les jours sauf le lundi, de 9h00 à 12h00 et de 14h00 à 17h30. Sur demande, il a toujours été possible de le visiter les heures et jours non ouvrables.

Le travail des week-ends est rendu possible par la présence à tour de rôle de notre collaborateur, Jean-François, et de votre narrateur. Le manque de finances ne nous permettant pas d'engager de guides supplémentaires, l'exercice de fin d'année se solde pour moi, à chaque fois, par un nombre important d'heures supplémentaires gratuites, entre 4 à 5 mois.

Si vous désirez essayer vivre de votre passion il faudra peut-être passer par les joies du travail, sept jours sur sept et en moyenne 14 heures par jour. Si vous êtes fortuné au départ, les choses seront éventuellement plus faciles.

Des classes de Romandie profitent couramment de nos cours type ''Connaissance des roches et des grottes'' qui se déroulent sur une semaine, nourri logé, pour un montant dérisoire.

Des techniciens communaux suivent également nos cours du soir d'initiation à la géologie, à l'hydrogéologie, à la géotechnique etc...

La publicité est le grand moteur de la réussite d'un musée, mais malheureusement elle coûte très cher. Il faut trouver une solution pour intéresser les médias à nos activités et de cette manière mettre sur pied des campagnes publicitaires qui ménagent un porte-monnaie déjà en mauvaise posture. Des expositions mensuelles sous forme d'invité du mois prennent forme, et les journaux locaux s'y intéressent. On parle du musée, les visiteurs affluent, et les banquiers retrouvent le sourire, et notre taux d'adrénaline redescend.

Fin 96 je n'arrive plus à m'occuper à la fois du musée et de mon bureau technique. Jean-François Crittin, notre collaborateur de toujours prend la relève, et mon épouse Sophie le remplace les jours ou il ne peut pas être présent. L'activité de mon bureau redémarre et c'est avec une courte accalmie au niveau du stress que nous avons commencé l'année 97. Accalmie de courte durée, car la surcharge de travail nous amène un manque de contact avec la presse qui a pour corollaire une nette diminution des entrées, et par conséquent un accès de mauvaise humeur des banquiers et une reprise des aigreurs d'estomac, maux de cœur, essoufflements, insomnies etc...

Les efforts d'imagination de notre ami Charles-Marie pour échapper à la catastrophe semblent nous amener une bouffée d'air frais. Serions-nous hors du labyrinthe ?

En guise de conclusions

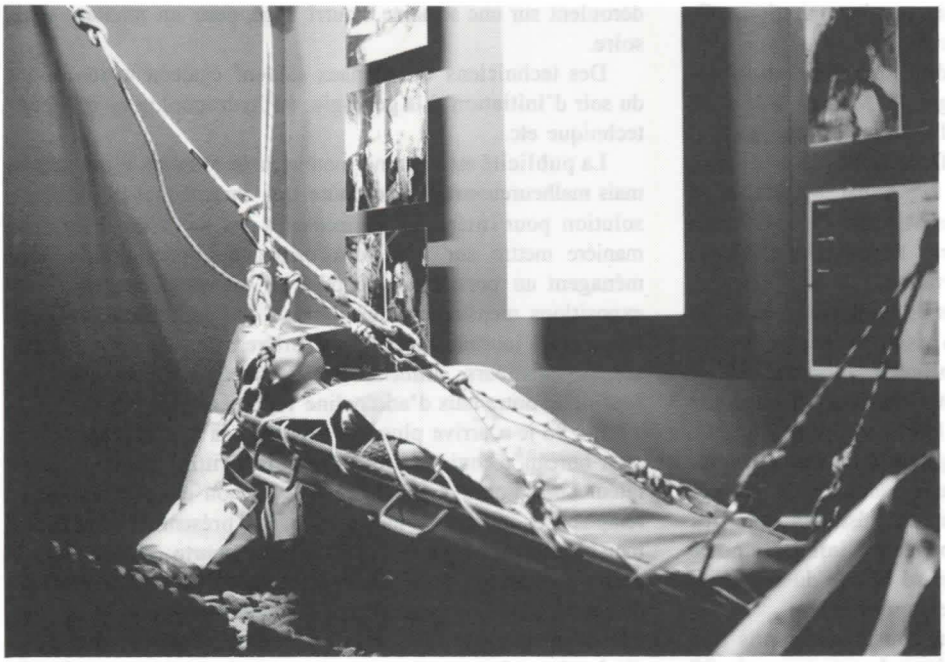
Pour faire démarrer une affaire telle que celle-ci, il vous faut quelques solides amis dont un au moins est avocat expérimenté dans le domaine des transactions financières, et qui surtout, travaille gratuitement, par amitié. Le reste va presque tout seul : n'importe quel spéléo émérite arrivera à monter une exposition didactique sur sa passion.

Une bonne dose de folie est très certainement nécessaire, voire obligatoire. Il faut surtout être persuadé de la parole du sage qui dit que ''lorsque l'on aime, on ne compte pas''.

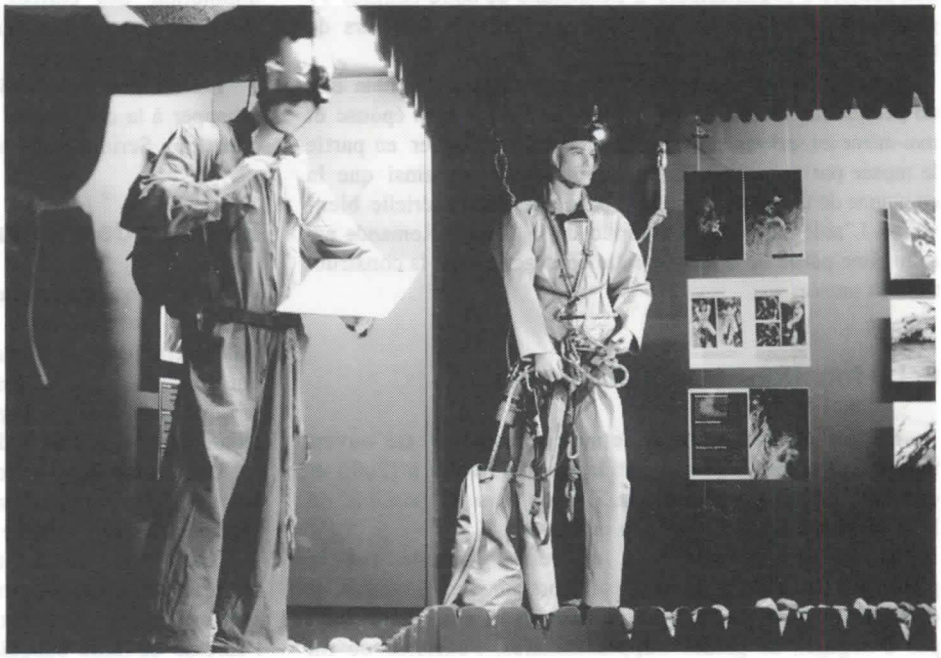
Je m'adresse enfin à mes frères spéléologues, afin de les rassurer : en ce qui concerne les fortunes faites sur le dos de la spéléologie, je ne peux que leur donner, sur demande, l'adresse de notre banquier, mais qu'ils se dépêchent avant qu'il ne devienne fou, car lui n'est pas un spéléologue.

''Tout homme qui dirige, qui fait quelque chose, a contre lui ceux qui voudraient faire la même chose, ceux qui font précisément le contraire, et surtout la grande armée des gens beaucoup plus sévères, qui ne font rien''.

J. Clarétie



Une exposition dynamique, le secteur dévolu au secours en caverne



Spéléologie d'hier et d'aujourd'hui

Notre premier don, la marineuse de l'entreprise Dénériaz

Akakor Project: psychological support

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Abstract

This report discusses the psychological aspects tied to cave diving as an absolute experience and also as an element of synergy and development of the concept of science as a sovereign human activity. It therefore analyzes the psychology of the cave diver and closely examines issues having to do with fear, its characteristics and manifestations. It examines fear of the dark and finally collective comfort, an indispensable element in cave diving. It also presents the results of the first psychological support program of the Bonito 95 Expedition /AKAKOR PROJECT, which was divided into preparatory and operative phases. It discusses methods, actions and motivations and concludes with several psychotherapy elements.

Cave diving

Current knowledge of human physiology, the high level of reliability of diving equipment and an improvement in exploratory techniques have transformed cave diving from being a merely hazardous adventure to an absolute experience in which elements from different fields, functioning in total synergy, not only satisfy the legitimate curiosity of Homo sapiens of exploring the unknown, but also help them acquire more information and developments that amplify the concept of science as a sovereign human activity.

Cave diving psychology

Rituals, magical rites, collective dramatizations, symbolism and myths have been a source of consolation to humans since the dawn of humanity and still today. Humans have used them in an attempt to channel their fears. They have striven to dominate their fears through the comfort of collective support, to avert them through a sublimation of legends, and to alleviate them by resorting to supernatural credence. These fears are of the unknown, of the destructive forces of nature, of being separated, of being alone during adverse events and also in the face of death, that incontestable event that ends one's existence in this world.

Primitive humans developed a series of complex and apparently irrational and absurd behaviors that permitted them to use collective support to control their most profound anxieties and to help conquer their fear of destruction and annihilation.

Without this collective support, humans have to deal with their fears alone. They find themselves face to face with their own mortality and resultant anguish, a solitary encounter that is often impossible to bear. It could therefore be said that the profound differences in the way adults handle anxiety and adversity are the complex result of constitutional, ontogenetic and cultural factors. In fact, anxiety seldom emerges unexpectedly, independently from the person's environment.

Humans are capable of recognizing personality traits and conditionings they have experienced in the past, and at any point in their lives they may attempt to break away from their dominion.

Fear: Characteristics and manifestation

Fear is an element of cave diving. It mainly appears during the explorative phase or in highly dangerous situations. Fear is a correct alarm signal that warns us when it would be better to interrupt a dive or a progression without a precise reason. Therefore, one should never ignore its warnings. Fear is prevalently considered a reprehensible sentiment and is therefore categorically refused by most. We, however, must use it as a complement to our explorations. Many accidents occur when fears are not heeded. Fear must be recognized and controlled, so it can help us.

Not all fears are disorganizing and harmful; as a matter of fact, Mother Nature has allowed us to interpret a series of stimuli as danger signals and to react promptly, thereby correctly orienting the action and removing us from the danger that is threatening us. In terms of biological evolution, fear has a positive function that is indispensable for survival.

Fear is an emotion that affects each person to a different extent and often leaves indelible traces in his mind. These traces can emerge again in a more or less dramatic way, both consciously and through dreams.

Fear is an emotion that can create huge problems of adaptation. In extreme cases, it can lead to the death of the person. Phobias caused by fears whose origin we have often forgotten can block normal functioning in the life of normal people. They force people to limit their freedom of movement and thought and to perform ceremonies that are utterly useless on a practical level but considered reassuring and essential for their physical and psychological well-being. Besides realistic fears, there are also imaginary fears that proliferate in the folds of each person's subjectivity, altering the perception of reality and hindering action.

Fear of the dark

Fear of the dark is considered an innate anxiety that makes its appearance when the nervous system develops.

The dark itself does not initially cause fear: people fear what might happen in the dark. The possibility of orienting oneself is drastically reduced in the dark, and the unknown increases. Stimuli become ambiguous, difficult to interpret and make perception uncertain and frightening.

Human sight is less keen than that of many animals. Therefore, humans are more defenseless than other mammals. Moreover, the absence of light and precise perceptive references fuel a person's imagination, which has free reign to mix reality with fantasy more easily.

The dark therefore frightens people due to the "objective" and "subjective" dangers. Most probably, "objective" dangers of the night, which have accumulated over centuries, have induced humans to fill the dark with "subjective" dangers. Therefore, fear "in" the dark has evolved to become the more specific fear "of" the dark.

Collective comfort

Due to its high social and technological organization, human society permits relatively isolated individuals to survive. Nevertheless, these people suffer great psychological distress. Due to isolation, the expressive potential of these people is impaired by the ancestral fear of being alone, which is strongly rooted in each of us as a harbinger of death. The macroscopic differences in the way adults handle anxiety are in fact a collection of inbred factors and numerous situations experienced personally or observed in others.

Each moment experienced is the inexorable mathematical result of many other moments (conscious or unconscious) that have preceded it and, contemporaneously, it becomes the point of departure for other significant moments of our life. It is therefore necessary and indispensable to learn as much as possible about the person's background when planning and preparing strategies that take into account emotional aspects to provide support, reinforcement and consolidation of people (SPELEOLOGIST - CAVE DIVER) who operate in particular and often hostile environments and under extreme physical and psychological conditions.

Akakor Project: Psychological support

After evaluating the complexity of cave diving and the importance of the person's psychological, emotional and relational aspects that influence and condition endeavors and results, we decided to use and interact with other disciplines and/or sciences such as psychology. For this reason, we added a person who is an expert in psychology to the expedition group.

Akakor Project

Psychology in the expedition

Psychological support to the expedition group first took place as follows:

A. Preparatory Phase

1. Identification and selection of the person on the basis of emotional competence
2. Reinforcement and consolidation of expedition objectives through meetings and work groups.

B. Operative Phase

1. Group support

A. Verification and possible reinforcement action towards expedition objectives.
B. Observations and actions on dynamics within the group.
C. Support to individuals during a crisis.

Methods and motivation

Methods used to develop this experience are:

A. Support to group dynamics concerning reconfirmation/ exclusion of group members
B. Work on motivation
C. Work on awareness of task
D. Work on roles
E. Work on expedition objectives, with integration of specific and subjective difficulties.

Research

Aside from the research mainly done by the Brazilian group on the psycho-physiological reactions of people who work in hypogean settings and after an in-depth psychological study in cooperation with an Italian psychologist and psychologists from the University of Sao Paolo (Brazil) that primarily observed aspects of emotional reactions, we have now decided to carry out an experiment on the therapeutic value of several special "hypogean" environments whose characteristics may be used to trigger or amplify particular emotions.

On the basis of several psychoanalytical concepts and the theory of the importance of the influence of the environment, which is considered a system that comprehends and interacts with humans and can modify them, we are preparing studies to verify how therapeutic it may be to use these emotions, sensations, impressions, fears and anxieties deriving from the experience of "being inside". By reliving childhood experiences, we aim to understand the hidden and traumatic aspects of a person and to transform them into positive elements of change. These aspects, of course, are of strictly psychological pertinence. We are certainly not asking the speleologist to take the place of the psychologist. In this project the adequately trained speleologist will allow this emotional process to occur, ensuring safety and transmitting an empathetic ability to understand, share, respect and help the group that is experiencing these particular conditions.

Akakor project: Bonito '95 expedition

This grand expedition is a great experience under all aspects. One hundred people are directly involved, including speleologists, cave divers, geologists, biologists, doctors, hyperbaric experts, nutritionists, psychologists, documentary film-makers, guides, etc. The thirty-day expedition was an enormous success on a human, professional, explorative and scientific level. Eleven thousand hours of research by experts from different fields produced impressive results such as the discovery of 34 new grottos (with relative mapping and geological study); 6 new karst springs and underwater grottos, which were explored, mapped and recorded; the discovery of an unknown fish species (Cascudo Albino) that was classified and given to the University of Campinas; and nine courses and meetings having a technical/scientific theme. All this was made possible through the efforts of the people and institutes involved in this project. Reconnaissance flights, deep sea diving, journeys through the equatorial forest, and the exploration of unknown grottos fully satisfied the adventurous aspects of the project.

Dynamics of physical characteristics of the atmosphere in speleotherapy chambers

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Abstract

The atmosphere in isolated (closed) speleotherapy chambers, made of whole natural sylvinite blocks, brought from the Upper Kama deposit, and lined with pressed sylvinite tiles, have been investigated. Long-duration uninterrupted and parallel measurements of physical characteristics in the atmosphere of isolated (closed) speleochambers made it possible, to reveal the rather obviously expressed 24-hourly dynamics of such properties as, first of all, the concentration of light aeroions and that of respirable fractions of aerosol.

The extremums of aeroion and aerosol concentrations, in comparison with the same parameters of troposphere, are shifted in time and, besides, apart from the season and duration of the experiments, the inverse interaction between the concentrations of light aeroions and the aerosol is obviously seen. As for the troposphere, the said interaction is directly proportional.

1. Introduction

The speleoclimatic effect of the microclimate in chambers, made of natural sylvinite, is defined, to a considerable extent, by both their aeroion and aerosol content. The difference of physical and chemical processes, taking place in the atmosphere of isolated (closed) chambers, from those in the troposphere, is predominated by the presence of some weak ionizing radiation.

The physical and chemical processes going on in isolated (closed) chambers are leading both to the increase of light aeroions concentration and respirable aerosols of potassium salts and that is causing an additional medical and preventive affect.

2. The Contents

In order to investigate experimentally the physics of the processes taking place in the atmosphere contacting with natural salts, laboratory models of on-surface speleotherapy chambers were designed and constructed: one was made of whole blocks, taken from the sylvinite bed of the working mine, where in the layer the average contents of

NaCl was 59.8% and KCl - 35.8%. The second one was lined with pressed sylvinite tiles of different chemical composition.

The method of the experiment consisted of conducting continuous in time parallel measurements of the atmosphere parameters in an isolated (closed) chamber, including such parameters as temperature, pressure, relative humidity. The concentration of light aeroions, having the mobility of

$$(0{,}1 - 2{,}5) \cdot 10^{-4}\ m^2/(V \cdot s)$$

quantitative aerosol concentrations of different spectra has also been measured.

On the basis of the data, obtained during the first experiment, held on the 17 - 19 October 1995, the 24-hourly dynamics of light aeroions and aerosol concentrations were revealed (Fig. 1a). The second experiment, held on the 31 October - 2 November 1995, confirmed the 24- hourly changeability of the major medical characteristics of speleochambers atmosphere (Fig. 1b). The dynamics of aeroions and aerosol concentrations, obtained on the basis of experimental data of 23-27 April, 1996, is represented in Fig. 1c.

From the comparisons, presented in the three given figures (Fig.1a, Fig.1b, Fig.1c) one can see, that the natural changes of light aeroions and aerosol concentrations are having maximums and minimums, coinciding in time. Thus, the well-known 24-hourly dynamics of physical and chemical properties of atmospheric air for the troposphere is observed in the air environment of the isolated (closed) speleochambers, but, nevertheless, there is a number of revealed distinguishing peculiarities.

Thus, the 24-hourly motion of light aeroions concentration is characterized by only one maximum in the late morning hours. As for the troposphere the maximums are observed in early morning hours and in the second half of the day (SMIRNOFF, 1992). In the 24-hourly dynamics of aerosol particles concentrations the maximum is reached in the second half of the day, whereas in the troposphere, the maximum value is recorded in the morning hours (IVLYEV, 1982).

Considerable differences in fluctuations of average concentration values is observed, e.c, the maximum concentration of positive aeroions is 4020 cm^{-3}, whereas the minimum one is 50 cm^{-3}. As for the negative aeroions it is 3900 cm^{-3} and 60 cm^{-3} respectively. The average quantitative concentration of aerosol, having the size of 0.3-2.0 μm, is fluctuating from 435'000 up to 3500 particles per litre of the air.

The concentrations of light aeroions and aerosol are interconnected, but unlike in the troposphere, their fluctuations are asynchronous, that is, the negative correlation is obviously traced.

The average quantitative concentration of aerosol is increasing within a 3-day period, reaching its maximum, and then it is considerably decreasing, whereas the concentration of aeroions is successively increasing.

The aeroionic regime, estimated by the concentration of light ions, is characterized by the presence of bipolar ions, more often the coefficient of unipolarity being 1.2-1.5, but some periods with the negative ion predomination are observed, as well.

The aerosol regime, estimated by the average quantitative particle concentration, having the size of 0.3-10.0 μm, is characterized by the fact, that the overwhelming quantity is presented by particles, having the size of 0.3 -0.4 μm.

The histograms of the dispersed aerosol composition in isolated (closed) chambers show that despite the dynamics of general concentration, the contribution of different fractions

into the total number of aerosol particles is constant enough and is expressed as follows:

- for fractions of 0.3-0.4 μm - it is 58-63%;
- for fractions of 0.4-0.5 μm - it is 26-33%;
- for fractions of 0.5-1.0 μm - it is 8-15%;

In the course of the experiments it was ascertained that in conditions of on-surface speleochambers, the usual feature, typical of the subsurface sylvinite chambers, is preserved, that is, the stability of the relative humidity indicator, (in the air of the chamber it is 48-45%, whereas in the atmosphere air, the said indicator of relative humidity is having the fluctuaion of 64-78%.

The carried out duplicate tests with the established regularities of the 24-hourly dynamics of light aeroions and aerosol concentrations are confirmed with sufficient degree of approximation. The seasonable meteorologic parameters are inconsiderably affecting the character of the curves: the experimental data given in Fig. 1a and 1b, are made in autumn, as for the results shown in Fig.1c they are made in spring, correspondingly. The unipolarity coefficient, estimated by the concentration of light aeroions, is fluctuating within the wide limits in autumn, that is, from 0.2 - 30. Nevertheless, the greater part is represented by the periods when the unipolarity coefficient is equal to 1.2-1.8. In spring - the relationship between the concentrations of positive and negative light aeroions is more constant and is equal to 1.2-1.5, and the periods, when the negative aeroions are predominant, begin to appear.

3. Discussion of the results

The differences of dynamics of the atmosphere physical characteristics in isolated (closed) on-surface speleochambers may be explained by the fact that the air environment in the said represents an unstable thermodynamic system, interacting both with the external environment and the internal sylvinite surface, bearing a number of specific properties and higher radiation ability, first of all.

The asynchronic character of the formation dynamics of aeroion and aerosol composition in sylvinite chambers is explained by the fact that the bipolar light aeroions activate the coagulation processes of halogen micro-particles, constantly generated by the inner chamber surfaces.

4. Conclusions

The dynamics of light aeroions and aerosol concentrations in the atmosphere of isolated (closed) sylvinite chambers, both the 24-hourly one and the 3 and 5 days ones, has obviously expressed regularities and considerably differs from the changes of the indicated characteristics in the troposphere. The interconnection between the light aeroions and aerosol concentrations in isolated (closed) sylvinite chambers has clear negative correlation.

Within a time span of 24 hours, an increase (growth) of light aeroion concentration as well as the total aerosol concentration is observed. Meanwhile the latter is considerably decreasing after having reached its maximum on the 3rd day.

The studies of the dynamics of physical characteristics in isolated (closed) speleochambers makes it possible to make a more exact and accurate estimation of the atmosphere quality and to develop efficient methods of air control, purification and treatment.

It is to notice that the dynamics of size spectra formation and the particles mobility formation, their thermal and temporary stability, the influence of gas and aerosol agents on their genesis (origin), that defines the hygienic and medical - preventive properties of the atmosphere in sylvinite chambers.

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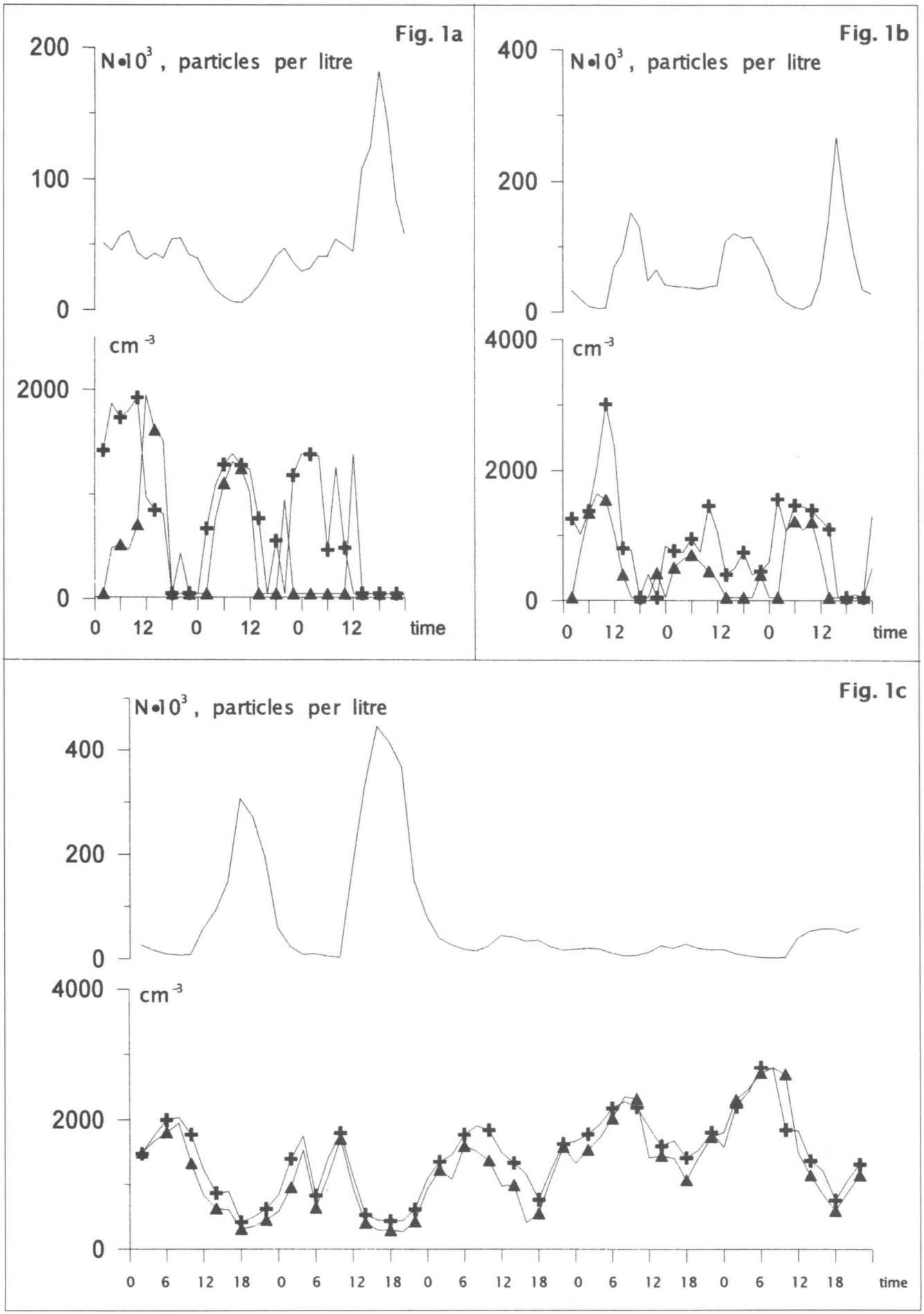

Fig.1. Experimental dynamic ion and aerosol characteristics of atmosphere in an isolated chamber.

Study of the cave's environment as an instrument in Environmental Education and how this study is carried out in Brazil

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Abstract

This paper is divided into two parts. In the first one, the common use of the expression *Educação Ambiental* (Environmental Education) is discussed due to the generic application of this term by the cavers and environmentalists without any uniformism about it. The authors make a proposition about a standardisation of the use of this term. In the second part the authors present a methodology concerning the approach of environmental studies, mainly dealing with students of high schools and junior high school, using specialists as teachers as well as text books, especially in cave environment. The authors make also a warning: the touristic activities carried out in units under preservation (called *Turismo Ecológico*) don't fit the orientations established for the „Plan of Handling" of each one of them.

Résumé

Le présent travail est divisé en deux parties. La première traite de l'utilisation, parfois inappropriée, de certaines expressions comme "Éducation Environnementale" par exemple, par les spéléologues et les environnementalistes. Les auteurs suggèrent alors une standardisation de l'emploi de ce type de vocabulaire. Dans la seconde partie, une technique d'approche et d'étude de l'environnement est présentée, impliquant principalement des élèves du primaire et du secondaire ainsi que des spécialistes dans le domaine des cavernes notamment. Cependant, les activités développées par des unités de préservation appelées "Tourisme Ecologique" ne semblent pas convenir aux directives établies par la constitution Brésilienne.

Introduction

Environmental Education is a term very often used nowadays. A term that confers an air of seriousness to all activity in that it is used. But do all the people using it really know what it means? Do activities of Environmental Education really correspond to its meaning?

The Environmental Education term has been used very often to call activities as to study and to experience special preserved environments (including caves), often with schools, aiming to put the individual into a close contact with Nature. For us Environment Education is something a little bit more complex. It also involves the formation of an individual: his character, citizenship, behaviour in the society, respect of rights and duties of each person, respect of the environment and respect of life.

In the ecological aspect of the Environmental Education, an environment cannot be considered alone. Every ecosystem is in relationship with many others and is part of an immense flow of energy; of one single history: the history of the Earth. An environment cannot be understood by learning only its relief, flora or fauna. It can be understood only when its origins are known, its previous and current dynamics of evolution, its relation to the many environments that surround it, the beings that inhabit it, the relations of interdependence between them and the environment, the history of the region, the human occupation, the societies that depend on it and the future consequences of the human interventions. Therefore, the analysis of an environment does not only depend on Earth sciences, but also of an interdisciplinary work that involves History, Mathematics, Philosophy, Politics and so on. The detail assessment of the behaviour of a preserved environment imply for example to have a certain conscience of our consumption exaggerations of electric energy, water, foods etc. that happens in the cities!

The use of very generic terms, as Environmental Education, for the denomination of activities ranging from cave study to ecological conscience can therefore causes mistakes.

Therefore we consider the use of the term Environmental Education inexact and inadequate, when identified to activities carried out in caves and other environments, natural or not. As a language standardisation we suggest the use of the terms "Environmental Study" and "Ecological Tourism", depending on the activity these terms cover.

Environmental Study: a technique of ambient studies

The Environmental Education, as global formation of the individual uses some techniques of environmental studies in order to understand the environment as a whole. We consider that the term "Environmental Study" describes the ecological activities in relation with Environmental Education and carried out in caves or in other environments. This implies a transfer of specific knowledge in Earth sciences from teacher to student.

Environmental Studies must take into account the transmition of information and the specific knowledge needed to understand concepts and long processes. In the same way, the ecosystem must be interpreted, not alone, but as part of a structure belonging to a wider context, up to Earth System. Environmental Study can then be carried out, taking into account not only the scientific information but also the formation of the individual in physical, ethics, social aspects, etc., In this case, Environmental study becomes close to the objectives of the Environmental Education, as it will be discussed later.

In the search of effectiveness in learning, we adopted the *Construtivismo de Piaget* method, where the supplied information has to be minimum to start, and where the persons can construct a net of logical reasoning based on their own observations.

An experience during a trip into a cave

Cave environment seems to be sufficiently adequate to carry out Environmental Studies in an Environmental Education context. It provides a way to experience an unknown and well defined situation needed to develop basic characteristics of the formation of the personality that any citizen and human being have to develop: spirit of adventure, friendship, understanding, patience and, the most important, respect of other members of the group. It has to be observed that the experience in caves makes possible the development of the individual personality inside the group, through mutual aid between participants in adverse situations (crossing rivers, bridges, and so on) leading to a certain degree of solidarity. Each person have the feeling to be part of the group.

Another aspect to be evaluated is the stimulation, guided by the monitor, of unusual sensitivity to the environment. Due to the light absence of cave environment other senses than vision have to be stimulated in order to get a "sensation" of danger.

It is important to stand out that the efficiency of such experiences for the development of the physical and psychological personality, depends much on the monitor capacity to get a perception of the profile of each individual. Based on this perception, the monitor will determine the ways, the rhythm of the trekking, the degree of attention needed for each individual, appropriate experiences and so on.

The interdisciplinarity and the Environmental Study

The job of specialists of different areas related to environmental matters is effective when a cooperative work can be set up, without hierarchizations of knowledge and without preconceptions. This allows that the every faces of that multiple field arise in rich questions (MORAES 1994). This way to do, joining performance of professionals would permit to reach some goals: update of the knowledge, magnifying of theoretical horizons, better conceptual instrumentalization, stimulation of the philosophic reflection, etc. This is necessary to the development of the environmental research in each area, before any elaboration of interdisciplinary work.

Topics that can be explored in an Environmental study in caves

Many different aspects can be approached in such a study. Let us consider the example of the caves in the PETAR - PARQUE ESTADUAL TURÍSTICO DO ALTO RIBEIRA (TOURIST STATE PARK OT HIGHT RIBEIRA), located near the city of Iporanga, State of São Paulo, Brazil. An ideal arrangement for these trips, would be the inclusion of two monitors for each group of 8 the 10 persons, foreground a geologist and a biologist. The first one will deal with origin of the caves and their relation to adjacent rocks and speleothem formation. The second one will deal with all the life aspects and their relations to inside and outside parts of the caves.

Aspects of the Geology

Working cave origins with groups of any age is not an easy task. This is due to the fact that, to approach such a subject, a certain background about the evolution of our planet is required. Starting from the internal structure of the Earth, passing through the various types of rocks, until theories about origins of caves (AYUB and DEHIRA 1995). All along these steps, the *constructivism concept of Piaget* have to be used. Beyond caves origins, one approaches the genesis of speleothems. At each step, it is essential that the monitor geologist incites the participants to reconstruct the "geologic history" in order to let people verify by theirselves their understanding of the subject.

On the contrary to common sense, Geology is not an abstract science, and anyone should be able to understand the processes involved. Meanwhile for certain concepts the monitor geologist have to take care to adjust its language in order to make it accessible to the persons. Using this way, the participants have the feeling to get a good understanding of the processes of the nature.

Aspects of the Biology

The subjects related to Biology mainly belong to Zoology Botany and Ecology. Although having close relations, these subjects are generally treated separately, in opposition to the idea of interdisciplinarity and construction of wider concepts. We estimate that this should be treated as integrated parts of one single whole, leading at the end to the same common environment for caves and Ecosystem.

Along these developments, subjects as human, animal and vegetal physiology, genetics, evolution and animal behaviour, etc. can be discussed.

Ecological Tourism

The term Ecological Tourism can be applied to the overdeveloped activities carried out in preserved environments, including caves, that do not make use of the principles described above. Participants of any age aiming to have a contact with the pure and simple nature, without any formal necessity of transmission of knowledge are accepted and the role of the monitors is then purely technical.

However, it is important to stand out that if these activities are developed using the principles of an ambient experience or study, even under an informal way, it can be admitted that the Ecological Tourism really contributes to the formation of individuals towards the meaning of an Environmental Education. If not practiced this way, we can then talk about conventional tourism and we can argue that companies or institutions doing this way inadequately use preserved areas. The use of conservation units for aims that not fit in ambient principles, or in the effective Plans of Handling should be discussed further in the future.

Conclusions

An adequate use of the term Environment Education and the proposition of new terms like Study of the Ambient, Ambient Experience and Ecological Tourism are presented here in order to clarify the terminology commonly used by the many institutions, Ambiental entities, ONGs (Not Governemental Organisations) and private companies working in that topic.

Through an adequate questioning and the suggestions that comes out during Ambient studies, it is aimed to transmit awareness of nature preservation. For this it is necessary to use professional competences for leading groups and of a rational control, not only in the way used to operate these activities, but, also, of the results effectively reached by them.

We can however consider that if Ecological Tourism is practiced using the principles of an ambient experience or study, even using an informal way, it can contribute to the formation of individuals towards the meaning of an Environmental Education. This can be obtained despite the short time of living together because of the very intense relationships that appear and that permit to acquire wider and permanent knowledge. Therefore, the responsibility of any guide, monitor or educator is important because participants will probably come back alone into such places. Furthermore, it is also certain that, these persons will relate the experience they lived, spreading out, not only the learned technical knowledge, but, also, the ambient „way of thinking" acquired through the living together with these monitors and "ambiental" guides.

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Humans and Animals have Rights do Caves ?

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Abstract

Jenolan Caves is one of Australia's outstanding tourist destinations, boasting a spectacular but fragile natural environment and a rich cultural heritage. Increasing visitation is likely to have serious adverse environmental and social consequences unless it is carefully managed.

As part of the planning process for the Jenolan Caves Reserve, the Reserve Trust has recently completed a study of its social and environmental carrying capacity. The project involved specialist input from cave and visitor management experts from around Australia and around the world.

The outcome is a Visitor Impact Management (VIM) system which is becoming the basis for Jenolan's future.

VIM involves the identification and use of indicators to monitor key social and environmental factors. The results of the monitoring process are used as input to management decision making.

The outcome is a world first for tourism-based resource impact management in a major karst (cave) area.

Introduction

The Jenolan Caves Reserve Trust manages three land areas that support impounded karst terrains geographically named Jenolan Caves, Wombeyan Caves and Abercrombie Caves. While the three locations are well known tourist destinations it is Jenolan Caves, New South Wales Australia (Fig A) and its environs that have the most intensive use of both the natural, cultural and built resources. Because of such intensive use the Jenolan Caves Reserve Plan of management (1989) raises the question of the caves having a carrying capacity.

The concept of natural resources having a carrying capacity is well established in the agriculture industry but the idea of a natural area having too many humans using it is a notion that has been thought of as having no logic, particularly in the Australian context. It has been suggested that some of the ancient civilisations such as the Incas may have exhausted their resources or populated beyond the carrying capacity of suitable land. "There are times and places when we believe whole civilisations collapsed and we don't know why," says Newman. Here we can say that phosphorus is one thing they should have been worried about" Cohen 1995. This reflects loss of soil nutrients and depletion of the basic food chain could limit substainable capacity but it also raises the question of the complexity of understanding the dynamics of capacity.

Aley (1975) published a paper, Caves, Cows and Carrying Capacity in which he discusses the concept of caves having a carrying capacity and if there is a basis for making such assumptions. The question of the caves at Jenolan having a carrying capacity as raised by the Plan of Management proposes the introduction of the Limits of Acceptable Change (LAC) a system devised by Stanky and others (1985).

In a report to the Jenolan Caves Reserve Trust (1992) the Karst Resources Manager defined issues relating to a carrying capacity and emphasised that they were divided into two categories, environmental and social as was first suggested by Van Cleave (1975). The Trust adopted then endorsed a maximum day visitation for Jenolan as proposed in the Plan of Management. It also recognised that the issue of traffic and the Grand Arch raised in the report and the Plan of Management should be investigated.

During 1994 a study was undertaken by Colston Hunt Budd and Twiney Consultants to look at the future visitor access to Jenolan Caves. Environmental and economic issues in the study showed that there was a need to understand future visitor numbers and constraints before a final decision could be made regarding access.

In response to this the Trust initiated a study to understand the principles to make informed and substantiated management decisions as to the carrying capacity of The Jenolan Reserve. Manidis Roberts Consultants were engaged to carry out the study. This study involved an initial three day workshop held at Jenolan. Participants of the workshop were selected from various Australian and International organisations and included:

- Cave Managers
- Land Managers
- Karst Scientists
- Biologists
- Recreational Specialists
- Social Geographers
- Tourism Professionals

Following the conclusion of the workshop and the study the Jenolan Caves Reserve Trust resolved that a Visitor Impact Management system should be implemented for Jenolan Reserve. This system is to be based upon an environmental and social monitoring program, which incorporaties those parameters as defined by the study.

The environmental monitoring program

The monitoring program is divided into 4 management units:

- unit.1. Developed above ground areas
- unit.2. Developed caves
- unit.3. Low density surface areas
- unit.4. Other Caves.

Management Unit 1

Issue	Method of monitoring
A. Air quality	Analysis
B. Hazards	Modelling Maintain incident reporting
C. Hydrological; physical, Chemical, Biological	Historical Records, Stream gauging, Water quality studies, Biological studies.

Management Unit 2

Issue	Method of Monitoring
A. Un-natural cave desiccation.	Temperature, Evaperation, Humidity. Presence of indicator organisms at base- line levels.
B. CO_2	Drager , in-situ infra red grab sample and continues sample
C. Lint and other organ compounds	Lint collection stations (UV light microscopic identification and densitometer).
D. Water quality	Based upon an adquate characterisation study
E. Water quantity	Based upon an adquate characterisation study
F. Lampen flora	Detailed records of treatment of each site.
G. Poor lighting design placement and control	A good inspection light meter
H. Effects of cave cleaning	Turbity monitoring, UV photophgrapy of speleothems with patinas, microscopic surface identification
I. Sediment	Based upon an adquate characterisation study

Management Unit 3

Issue	Method of Monitoring
A. Reduction in Habitat diversity	% ground cover, Air photo and ground patrol assessment. Trapping baiting and ground patrol assessment.
B. Water quality downstream of roads and Jenolan Caves Reserve	Water quality sampling methods.
C. Reduced infiltration	% natural vegetation/introduced species in catchment

Managment Unit 4

Issue	Method of Monitoring
A. Physical damage by cavers, divers and adventure cavers (Accidental and deliberate).	Inspection and photo monitoring.
B. Fauna Impacts	Population surveys.
C. Disruption of natural processes	Based upon an adquate characterisation study
D. Researcher impact	Collecting standards. Report and review

Methodology

The hydrological study will be based on information gathered at several recording points on the Reserve. Information gathered is water levels, electrical conductivity, temperature, pH, rainfall, flow measurements, water quality and turbidity.

Track monitoring has been carried out using a Trust designed profiler and infra-red movement counters. Early indications are that track design, development and management are lacking and will required better planning before visitor related impacts can be assessed.

Calibrated syringes adapted for use as evaporation meters have been installed and while data is being taken experimentation is concentrated on the precision of the devices to allow elimination of instrument error.

Evaporation Meters (Piche evaporimeters)

The design (Sutton, L. J. 1945)of the evaopmeters involves the recording of water lost/gained through the litmus paper which is clipped onto an upside down syringe. This water loss indicates either one of the following or a combination of:

- Barometric influences
- Air movement
- Human presence
- Airesol content.

With the continual recording of water losses/gains, the data recorded can be analysed as to the sources of moisture, air and people movements. It must be noted that all data recorded

by the different instrumentation will be correlated, thus providing a combined result that emphasises the human impacts upon and within the cave.

The evapometers have been hung straitified to give maxium information near the tracks along two line transects that run North-South, East-West.

Evaporation Dishes

Calibrated dishes containing water have been placed along the transect lines, to complement the evapometers. Results will be recorded as per the evapometers.

Temperature Probes

These probes are connected to a datalogger that record the air temperature at 30 minute intervals. Numerous temperature probes have been positioned at various distances from pathways. Results received from the data logger will be correlated with weather, visitor numbers through the cave and tour times. The correlation of these results will be recorded over time and all trends will be analysed in relation to evapometer water losses/gains.

Dust Sampling

The use of reflective glass plates will allow for the analysis of dust collectic through microscopic and photographic processes. The methodology of dust collection is to repeat a method used in dust free manufaucturing process and to give comparitive data to be compared with other work as there may be problems in the method or collection devices for example dishes that have raised edges.

Humidity Probes

Located along both transects the humidity probes will record data on 30 minute intervals. As with the temperature probes this information will be related to weather, visitor numbers and tour times.

Invertebrate Quadrants

Quadrants, 25cm by 25cm, will be analysed for invertebrates on 5 metre intervals along the transect lines. These studies will record what species are found and their population densities. The studies will be conducted on a regular interval, allowing for seasonal and weather changes. Again, the results from these studies will be analysed in relation to all other recorded data. This study is in its infant stages and will have to be further investigated by an entomologist with relevant experience.

Air Flow

The air flow will be recorded through the use of specially designed probes that act as anemometers. Set up will follow the same guidelines as the temperature and humidity probes.

Conclusions

The combination of all these results will allow human impacts within the cave to be identified and the extent of these impacts. With this knowledge the Karst Resources department, through statistical analysis and smaller studies, will be able to relate the results to other caves within the cave system.

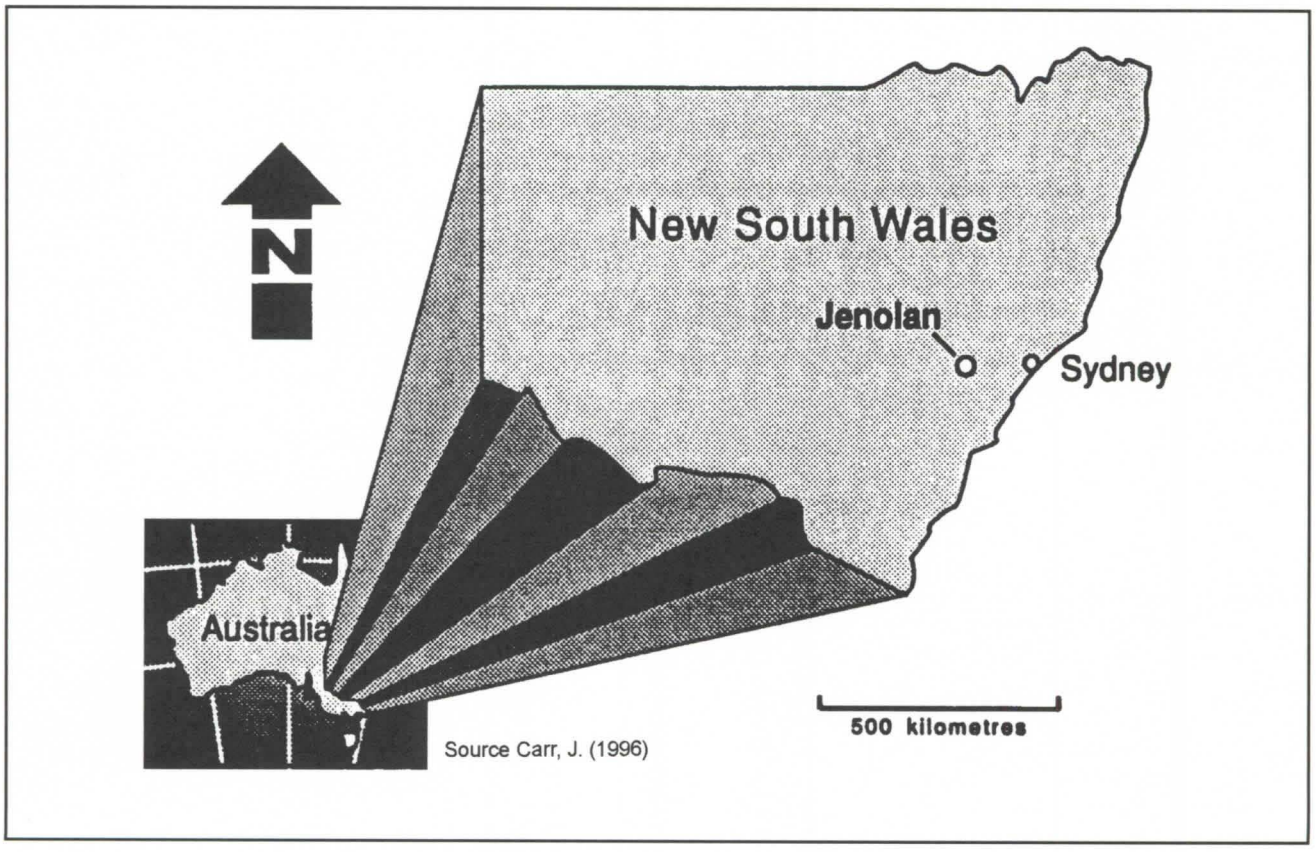

Figure 1. Location Jenolan Caves – Australia

The next phase of this progect is known as S.E.M. (Social and Environmental Monitoring) and involved the appointment of a committe of specialists to oversee and stear the project. This will allow for the best use of resources, current knowledge, and correlation wth other like research to be utilised.

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The Threat to Caves of the Human Dust Source

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Abstract

New methods have been developed to monitor dust deposition in caves. Observations in Jenolan Caves, N.S.W. Australia and Ngilgi Cave, Western Australia, show the widespread nature of dust deposition. Dust sources have been localised, the most important is the human visitor. The quantities of dust deposited are compared with other soiling rates and show the magnitude of the threat to caves. In a tourist cave, measurements of dust deposition showed that 3000 visitors in 25 days deposited a total dust deposition causing 0.7% loss of reflectivity (about 18 mg m–2 of dust). This amount of dust in other situations with white surfaces would be classified as "dirty" by critical observers. Cavers in wild caves are thought to have individual dust source magnitudes that are orders of magnitude higher than those measured in tourist caves.

Introduction

This is a preliminary report on part of the material being prepared for a thesis.

Dust in Caves

For more than 100 years, Jenolan Caves have been used as show caves. Although they were the first caves to use electric lighting, (first trials in 1880), a variety of sources of dust and smoke have caused visual degradation of the speleothems. In 1955 steam cleaning was tried, and since then water cleaning has become part of the regular maintenance of the caves, Bonwick & Ellis (1985). The continuing need for cleaning has prompted study of the processes of dust deposition in the caves. In 1979 an instrument was developed to evaluate the optical absorption of dust films deposited on glass sample plates left in the caves. In 1993 the project was revived as a study of climate, dust and carbon dioxide in Jenolan Caves, Michie (1995). Additional study has been conducted in Ngilgi Cave, Western Australia, which has an environment quite unlike that of the Jenolan Caves. The problem of lint and lint management in caves has been addressed by Jablonsky et al (1994)

The Human Dust Source

There is increasing awareness that there is a dust cloud associated with each person. Wallace (1996) reviewed indoor dust, and discusses this personal cloud. Skin flakes, hair and textile fibres represent less than 10% of the mass of this dust, the nature of the rest of the dust depends on the nature of the dust in the atmosphere in which the people spend most of their time. The concentration of dust in the personal dust cloud is associated with the level of activity. Thatcher & Layton (1995) attributed elevated dust levels in the presence of people to re-entrainment of dust that was deposited on floors, but it is apparent from this study of dust in caves that the people themselves are a source of dust, and that re-entrainment in well managed caves is a lesser problem.

Method

Air flow patterns about groups of people standing in caves were investigated using titanium tetrachloride as an air tracer by the technique described by Halbert & Michie (1971).

Dust in the cave was measured by two methods:

1. Airborne dust was measured with a TSI aero-dynamic particle sizer, which was operated in the caves on three occasions at four sites. Measurements were made before, during and for more than an hour after tours.

2. Settling dust was sampled on 70 mm Petri dishes, at 140 sites in Jenolan Caves, and later on six sites in Ngilgi Cave and were measured in situ on monthly visits with a purpose built optical densitometer. After the dishes had been exposed for times as long as two years they were removed from the caves and were photographed with a Kodak DCS-200 digital camera. The data were then subjected to image analysis with Optimas 5.1a software, mainly to evaluate the proportion of fibres in the dust.

While the dust was being sampled, measurements of the cave climate were made to analyse the patterns of air movement into and within the caves, and to determine the sections of the caves which had natural circulations that could carry outdoor dust into the cave.

Results

Although the results of the Jenolan dust deposition measurement have not yet been fully analysed, it is already obvious, in many deep cave situations, that the quantity of dust deposited depends on the number of visitors, and that the other sources of dust are negligible.

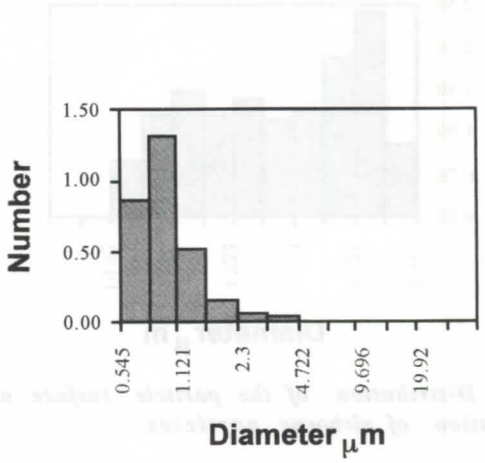

Figure 1 Distribution of the number concentration of airborne particles.

In Ngilgi Cave, the dust deposition in the cave at six sites over a period of twenty five days, with the passage of 3000 visitors, was measured to have caused an average density of 0.7 % optical transmission loss, (equivalent to about 18 mg m–2 of dust). This rate of deposition is similar to those rates measured at Jenolan.

The measurement of the airborne dust with the aerodynamic particle sizer showed a wide range of particle sizes, ranging from less than 0.3 μm to greater than 30 μm. The instrument measures the particles by their response to acceleration in air, and calculates the equivalent size of spheres with density 1.0 g cm–3 that would settle in the air at the same rates.

The measurements of one of the airborne dust samples are shown in Figures 1, 2 and 3.

Figure 1 shows that the greatest number of particles have a diameter of about one micrometre.

Figure 2 shows the same data plotted as a distribution of mass. As a particle of twice the diameter has eight times the mass, the distribution looks quite different. The majority of the mass of the dust is in particles about ten micrometres in diameter. The ability for a particle of dust to obscure a surface and change its apparent colour, is proportional to the surface area of the particle, and so the data may be plotted a third way, as a distribution of particle surface area. This is shown in Figure 3.

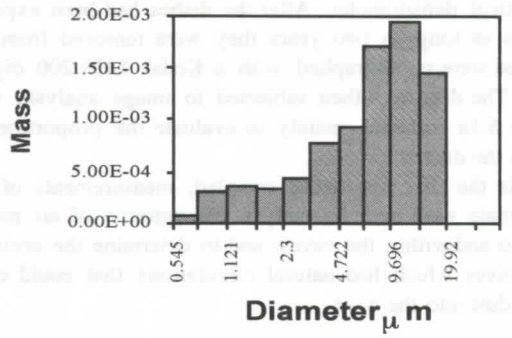

Figure 2 Distribution of the mass concentration of airborne particles..

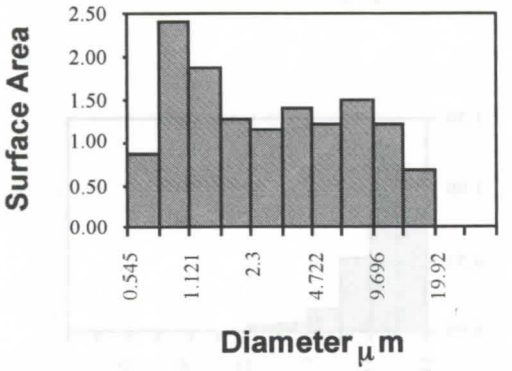

Figure 3 Distribution of the particle surface area concentration of airborne particles.

The influence of the visitors on air flow in the caves was a major mechanism for dust dispersal. Extensive convection currents develop, driven by the body heat of the people, with velocity as high as 1 m s^{-1} above the party. See Figure 4. The velocity reduces as the air flows away from the heat source and on the far side of the cave may be about 0.01 m s^{-1}. The cave lighting system further contributes to the circulation of the air in the cave, and the dispersion of the dust through the air.

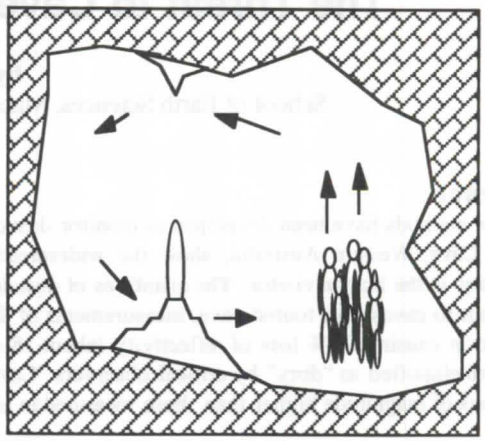

Figure 4 The pattern of air movement about a party of visitors in a cave

Discussion

The phenomenon of people being sources of dust, probably depends on the almost universal habit of wearing clothes made of textile materials. The textured fibrous surface and the continual movement the bodies of people appears to provide an efficient transfer mechanism for dust to be entrapped from a dusty environment. An equilibrium exists between the concentration of dust in the environment and the quantity of dust in the personal dust plume. The same mechanism releases dust, and in a low dust environment makes people into a net source of dust. There is also a personal source of skin flakes and hair and the textile source of the clothing that is worn. It appears that more than 90 % of the dust released by people has been previously captured elsewhere. The problem of release in caves might be prevented by wearing freshly washed clothes and using "air showers" with vigorous agitation of the clothing to accelerate the approach to an equilibrium with clean air before entering the cave. High dust levels outside caves present a problem if this dust is allowed to be adsorbed and then carried into the caves.

The settling rates of unit density particles in air are given by BARON & WILLEKE (1993) and are shown in Table 1. Notice that, for example, a one micrometre particle takes eight hours to settle one metre through the air.

The wide range of diameters of the particles and the even wider range of settling rates mean that some particles will remain suspended in the air for days, and some will settle out in seconds.

The circulation of air, and the dust that is released by the tour parties as they move through a cave cause the dust to be evenly mixed through the air in the cave. Measurements of dust deposition at a site 20 metres from the nearest track were not significantly less than measurements at a site 1.5 metres from the track.

In the USA, lint has been described as a problem in caves, Jablonsky et al (1994). It appears that this is another perspective of the problem that is being examined here. To determine the part that fibres play in cave dust, image analysis was conducted on photographs of dust on the sampling dishes. Figure 5 shows a photograph of a dust deposit on one of the sampling dishes. Individual fibres are visible, but only large particles or aggregations of particles have exceeded the pixel density threshold so that they appear on the photograph.

The images showed that in Jenolan Caves the proportion of fibre in the dust was less 10 % of the total weight, confir-

ming a value that Wallace (1996) had quoted for fibre, dander and hair in the personal dust cloud. Most textile fibres are larger than 10 μm in diameter and hair from humans is usually more than 30 μm in diameter. The aerodynamic diameter of a cylinder is approximately equal to its diameter so that the aerodynamic size of hair or fibre is about the same as its diameter. The fibrous component of the dust will settle more quickly than the finer component of the dust, which being greater in surface area is most responsible for visual degradation. However, fibres have a major dimension which may be greater than 10 mm. This makes them much more visible, particularly when suspended in air. On surfaces, the small mineral particles adhere to the surface, causing it to reflect light differently but without being individually visible. The fibres do not conform to the solid surface and so can be seen as a fibrous mat overlying the greater mass of invisible fine particles. So the lint seen in caves may be an indicator of a much greater quantity of fine particulate material.

Table 1

Particle Diameter μm	Settling Velocity m s^{-1}
0.1	8.8×10^{-7}
1	3.48×10^{-5}
10	3.06×10^{-3}
100	2.61×10^{-1}

The intensity of the dust source depends of the activity of the people. Vigorous body movement near the aerodynamic particle sizer gave dramatic increases in particle count rates. Tourists on hard, clean surfaces walking slowly on level tracks produce a low rate of cave soiling.

Wild caving, with vigorous activity, and muddy clothes is expected to be thousands of times more potent as a dust source. At times clouds of dust from active cavers are visible in torch light. The only data that have been collected on this subject are from a section of cave that is only accessed by wild cavers. The sampled dust had much more coarse particle content. Because of the very much lower numbers of wild cavers than tour visitors, the total effect of personal dust in wild caves is less likely to be as noticeable as it is in tourist caves.

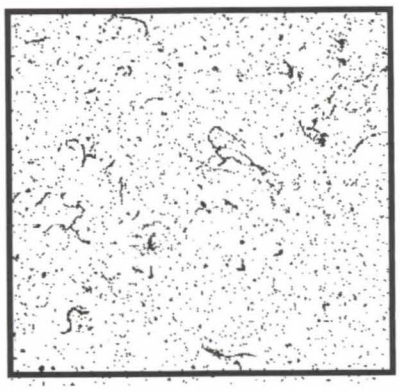

Figure 5 Digital image of a 10 mm square on a sample dish after thresholding

Air flow from outside introduces dust into the caves. This often is not so obvious as human introduced dust, as those parts of a cave subject to outside air flow are often subject to an unsaturated atmosphere and may have evaporation influenced speleothems, the crusty surfaces of which may contain advected dust as part of their natural composition.

Nazaroff et al (1989) measured dust deposition in museums in USA. Outdoor dust was considered the major problem. Under a variety of conditions, ranging from best practice air treatment and flow control to no artificial ventilation, they measured deposition rates that ranged from 266 x 10–6 μg m–2 s–1 to 98 x 10–3 μg m–2 s–1. It is encouraging that the measurements in Ngilgi Cave, which has dusty floors and no dust management program, is less (8.3 x 10–3μg m–2 s–1) than a public building which doubtless has regular cleaning.

These levels of dustfall are almost imperceptible, but as the dust accumulates it dulls the surface on which it falls, Ngilgi Cave in 25 days acquired a dust film dense enough to be noticed if there was not already a dust film over everything. Hancock et al (1976) using critical observers and white surfaces, found a threshold of dust coverage of 0.7 % of surface area to be considered "dirty".

Conclusion

There is a personal cloud of dust particles associated with each person and their clothing. This cloud absorbs dust in dusty environments and releases it, together with personal organic dust and textile dust, in cleaner environments. This process is a major threat to tourist caves.

The measurement method of sampling dustfall on glass plates has proved sensitive and efficient.

To preserve caves it is necessary to first know the use to which the caves will be put. If the use of the cave will cause dust deposition that exceeds a threshold of 0.7 % in a chosen time period then it should be considered to protect the cave by constructing pathways that enable management of the dust problem. Failure to manage the dust may result in the dust being cemented into speleothems by depositional processes. The effect of dust is not just aesthetic, the organic component of the dust provides nutrients for micro-organisms such as moulds and fungi and influences the food chain of the cave's biota.

Existing tourist caves should address the almost imperceptible rate of loss of cave quality that occurs with use, by measuring the soiling of the cave, and if necessary, modifying management practice by improving tracks, improving drainage and setting the cave up for regular cleaning by water sprays.

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Causes of poverty and methods for shaking off poverty in karst areas of South China

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Abstract

A rural population of 20'000'000 people lives below the poverty line in karst areas of Southern China (personal income of less than 440 yuan RMB per year). 10'000'000 of them can hardly obtain sufficient drinking water. Besides the high growth rate of the population, the specific features of the Nature are the main causes of poverty: 1. The wet season does not coincide with farming one (time for sowing seeds, planting and growth of crops); rainfall are very unevenly distributed over the year. 2. Because of the presence of karst features, rainfall infiltrates quickly into the ground and turns into karst groundwater. 3. Because of serious leakage or easy rainwater infiltration conditions are bad for reservoir construction and then water consumption of farmland in karst area is usually much higher than in non-karst areas. 4. Over lumbering and deforestation, heavy rainfall and karst features make 70% of total water volume which is drained away very quickly. 5. Soil impoverishment, scattered cultivated lands, water losses, soil erosion, frequent drought and floods disasters produce a great negative impact on agriculture production.

The following proposal may be taken as basic principles: 1. Consideration of small karstic drainage areas as units for harnessing. 2. To use comprehensive methods, such as engineering and biological engineering measures to extract karst groundwater and effectively improve soil quality and further, to popularize eco-agriculture. 3. To exploit natural resources and to set up rural enterprises accordingly to the local conditions.

As frequently found in South China three types of karst geological environment have been considered: peak-cluster moutains, peak-forest plains and basin in plateaus. This paper presents some cases where these methods have been applied in order to present concrete conepts of development and managment for various types of karst geological environments.

1. Introduction

In China karst has broad expanse and covers up to 3 millions square kilometers in total. Bare karst covers about 0.9 million square kilometers. A population of 100 millions people is living on bare karst areas of Southwest China, i.e. Guangxi, Yunnan, Guizhou and the parts of Sichuan, Hunan, Hubei and Guangdong provinces. On a surface area of 0.54 million square kilometers 35 millions residents of minority nationalities and 34 millions of rural residents are living below the poverty line having an annual income of less than 440 Yuan (US$48) and an annual grain consumption of 200 kilograms per capita. According to the state's anti-poverty program 592 poverty-stricken counties with 80 millions poor peasents have to be helped in order to ease poverty in seven years (1993 to 2000). Of them, 162 counties and 20 millions poor peasants are located in the karst areas of Southwest China. Ten millions residents have even not sufficiently drinking water. The arduous task of Chinese karstologists is to harness and to develop karst areas comprehensively in order to help residents to ease poverty.

2. Analysis on the causes of poverty

Karst areas of South China are rich in mineral, water and waterpower potential, sunlight and heat resources. The annual average temperature ranges between 17°C and 22°C, the precipitation from 1200 to 2000 mm and the frost-free period is between 280 and 360 days long, so that most of these areas yield three crops a year. These areas, however, are being in poverty since a long time. Besides human-induced factors, such as the continued growth rate of the population and extensive cultivation, special natural features of the landscape are the main causes of poverty. In other words, the difficulties of developing and using water resources and the poor and scattered land resources are the principal factors restraining local economic development.

2.1 Serious lack of irrigation water and reservoir, canal leakage

1). Because of mosoon climate, rainfalls occur very differently depending on the season. During the wet season from April to June the cumulated rainfall reaches up to 50% of the total annual one. There is much less rainfall during the crop growth period between July and October, which often results in serious drought during fall.

2). The double-layered surface and subsurface karst structure is responsible for the underdevelopment of the surface water system. Rainfall rapidly penetrates into ground and forms underground rivers. About 70% of the annual rainfall is therefore drained away and can't be utilized efficiently.

3). Because of intensely developed karst features at the surface and and because of serious leakage, some experiences, such as building dams and channels to divert water for irrigation can't be sucessfully applied in karst areas. For example, in Guangxi karst areas 92 of 262 main reservoirs or channels and half of smaller reservoirs have trouble with leakage.

4). The leakage from farm fields is also serious. In general, $2m^3$ of water are needed to produce 1 kg rice in non-karst areas, only 1 m^3 in non-karst areas with good irrigation condition, and up to 5 m^3 in karst areas.

5). Overlumbering of forest reduces the water retaining capacity of soil and increases the infiltration of rainfall. As a result, some springs, brooks and streams are dried up. For example, 230 springs or brooks have dried up in Yuanyang County, Hubei Province. Among the 364 small streams in Guangxi, 146 showed a decrease in discharge of 1/3, 102 of 1/2, and 21 streams completely dried up.

6). Because of the heterogeneity of karst development and deep buried karst water, it is difficult to prospect for planting karst water.

2.2 Impoverished and scattered farmland, serious desertification

1). As cabonate rocks are rich in calcium and magnesium and have a low content of silicate, the process of soil formation is very long. It takes about 2500 or 7000 years to form a 1 cm thick soil layer. Karst areas are therefore characterized by bare rock, and thin, scattered cultivated land. Poljes or valleys with relatively continuous farmland often suffer from drought and waterfloods disasters. The limited drainage capacity of karst conduits often induce waterfloods in poljes during the wet season. On the contrary, rainfall infiltrates deep into karst conduits during the dry season.

2). Deforestation and use of waste land lead to water loss and soil erosion. For instance, in Guizhou Province, areas subject to desertification have been estimated to one fifth of the total territory in 1965. They covered one third in 1984. The desertification goes on at a rate of 624 km^2/year and the area has doubled in 25 years. Some 6.6 millions tons of soil are lost each year. In Guangxi Zhuang Autonomous Region, water loss and soil erosion destroys fertile farmland of 100'000 mu each year, namely, about 1.75 million tons of nitrogen, phosphor and potassium are drained away from the soils. This corresponds to 5250 millions of kg of grain lost in a year.

3. Successful experiences in harnessing typical karst environments

3.1 Guiding principles for harnessing karst environment and shaking off poverty

The following principles will help to limit the poverty in karst areas: to use small drainage area or systems as units of management; to use comprehensive engineering and biological engineering measures to collect karst water and to improve soil quality effectively; to popularize eco-agriculture; to exploit natural resources and to expand rural enterprises according to local conditions. More concrete, this can be summurized aas follow:

1). To build dams in conduits and to construct reservoirs in poljes or uvalas; to drill wells; to build underground reservoirs for exploiting and utilizing surface and ground water resources, as well as to use limited concentrative farmland to establish high yielded grain bases.

2). To adjust the cultivation plan of crops according to the geological conditions, to popularize eco-agriculture, to develop special local products, to plant trees in order to recover the destroyed ecological environment.

3). Based on local conditions, to exploit minerals, potential water-power, animal and plant resources, to develop rural enterprises and to expand courtyard economy.

3.2 Some cases and patterns for harnessing and developing

(1) Peak-cluster moutain areas

The method for developing and harnessing constists in building dams in karst conduits at higher site and planting trees on slopes; irrigating the fields in poljes; growing industrial forest; generating electricity power with cascade hydroelectric stations; exploiting local resources; developing rural enterprises. This will lead to shake off poverty and to get richer.

No.1 case Luota Town, Longshan County, Hunan Province

The following measures have been undertaken: Building of a dam in a suitable conduit at high level, construction of reservoirs in uvalas; building of channels for irrigating farmland in low poljes or uvalas; growing medical herbs, such as eucommia. On slopes cascade hydroelectric stations have been built; local coal resources exploited and enterprises have been set up, changing farmlands located on steep slopes into forest exploitations.

As a result, the economic impact has been that, from 1985 to 1994, the gross industrial and agricultural output value of the whole town grew from 240'000 Yuan RMB income (80 Yuan RMB per capita) to 1.45 million Yuan RMB (570 Yuan RMB respectively). Bumper harvests have been gathered in for several years running and the green hill and blue water have recovered their original looks.

No.2 case Daqinping, Yuanzhou City, Hunan Province

The following measures have been undertaken: Selection of uvalas and caves at high elevation in order to build dams in caves and construct combined surface-underground reservoirs; and channeling water into the terraces farmlands.

During the construction of Maoeryan reservoir 1.49 million Yuan RMB have been invested and 22'300 labourers were used. Therefore the total investment has been 1.95 million Yuan RMB (about 25 Yuan RMB per mu farmland). The completion of the reservoir provided water to thousands of farmlands for irrigation. Then the local residents have been lifted out of water shortage. In 1992, the grain output was increased by 1567 tons i.e. the output value reached 920'000 Yuan RMB, and in 1993, 1076 tons corresponding to 1'060'000 Yuan RMB respectively.

(2) Peak-forest Plain areas

In this region the way to develop agriculture and to catch water has been to use underground spaces to make storage and adjustment of water volume; to drill and to dig wells in order to withdraw local underground water; to prevent and control seepage, to teach the way to economize water; to adjust overall arrangement of cultivation and to set up the crop base with high and stable yields.

No.1 case Laibin County, Guangxi Zhuang Autonomous Region

The measures used have been: to dig and drill wells to withdraw water; to harness leakage of reservoirs; to adopt sprinkling irrigation in order to economize water resources; to adjust the overall arrangement of cultivation and to popularize new techniques, such as covering fields by using plastic films, to preserve soil moisture; and to plant quick-growing trees, such as eucalyptus and so on.

Economic efficiency: The cost of exploiting local karst underground water for irrigation has been about 20 ~ 40 Yuan RMB per mu, i.e. less than that of catching water from the Hongshuihe River. The rice production has been increased to 118 kg per mu, and sugarcane rised from 2 ~ 3 tons to 4 ~ 6 tons per mu. Eucalyptus grew up of more than 3 meters in 2 years. Multiple cultivation index has been increased by 0.6.

No.2 case State Jinggang Farm, Nannin, Guangxi Zhuang Autonomous Region

The measures used have been: exploration of karst groundwater and setting up of motor-pumped wells and spray irrigation system.

Economic efficiency: Three thousands mu farmlands have been irrigated and six thousand local residents have been got rid of lack of water. From 1955 to 1978, the state farms had a deficit of more than 14 millions Yuan RMB in total. Since this adequate water supply have been used, the net profit was 3 million Yuan RMB in 1980 - 1981 and almost 3 million Yuan RMB in 1982.

(3) Plateau karst basin

The ideal development pattern is to build underground dams in suitable locations; to rise groundwater levels; to set up irrigation systems; to expand industrial crops in line with local conditions.

Case: Chaoba Basin, Mongzhi County, Yunnan Province

The study on feasibility and the prospecting for the construction of a underground reservoir in Chaoba Basin is in progress. Recently, the distant outlet of Nandong cave have been used as water resource for irrigating farmlands in the basin. The denivellation between them ranges from 200 to 300 meters. The local degree of self-sufficiency in grain is now below 50 percent. Once the underground dam in Moshigou site will be successfully completed, the groundwater level in the basin will rise up of some 100m ~ 200 m and the local underground water resources will reach 128'000 m^3/day. As a result, crops with high and stable yields will be set up and the areas will be used for planting tobacco. It is estimated that the annunal profit will reach 10 millions Yuan RMB.

3.3 Potential benefit of the types mentioned

The above-mentioned cases for harnessing and developing karst environment are not only of remarkable economic profit, but also of practical significance for other sites with similar conditions. In the peak-forest plain areas of Guangxi, there are 10 millions mu cultivated land with natural conditions similar to those in Laibin County and Jinggang State Farm. The problem of agricultural drought can be resolved by setting up motor-pumped well and spray irrigation systems, by building dams in suitable caves to fill up uvala reservoirs. The drilling of irrigation wells may also provide irrigation water for the 20.86 millions mu of cultivated land that are distributed in the hill depressions or uvalas of the peak cluster mountain areas of Guizhou Province. The environment setting of the farmland of 1.3 million mu in karst basins in Yunnan Province is similar to that of Mongzhi basin. The construction of underground reservoirs to utilize local groundwater resources, and an adequate information about eco-agriculture would allow to develop this region as well.

Due to different geological conditions, the heterogeneous distribution of karst water, the geochemical setting of soil and rock, the type, distribution and storage law of mineral resources vary from place to place. Moreover, it is difficult to search for karst water and to determine the location of karstic caves and fissures. The successful rate of drilling wells is only 30 ~ 40 percent so far. Therefore, harnessing karst mountain regions to shake off poverty means a lot of scientific work: delineation of karst drainage systems as harnessing unit, classification of various types of morphological features, setting up a managment concept, and popularizing experiences, etc. This appears to be the only way to develop resources and to harness environment in order to help the rural residents to ease poverty in karst mountaineous regions.

The data presented in this paper are a summary of the results obtained at the Institute of Karst Geology and the related department or units. The author hereby expresses his thanks to them.

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Une solution intégrée pour le traitement spéléométrique
Le logiciel HADES-2000

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Abstract
The HADES-2000 program is a modular application written for operating-systems MS DOS and Windows 95. The principal subject of this communication is the MS DOS version of the program. The purposes of HADES-2000 includes the processing of caving topography and the management of caves databases. The speleological surveying software which offers everything needed by the modern surveyor: matricial minus-squared compensation method, 2D and 3D multiples representations, 3D Modeller and geological statistics. Particularly suited for medium complexes and synthesis, HADES allows 9 typs of topographic-courses and generates 3D views with hidden-faces and is able to export all work in AutoCAD and TOPOROBOT formats. The central processor, used for SYLVIA, uses the TAILLARD method and integrates support of theodolites and tacheometers.
This communication presents MS DOS and Windows 95 versions of the HADES-2000 software.
Keywords: 3D-diagrams, matrix operations, 3D-geometry, karstology, Lux-calculated images, software, topography.

Résumé
Le logiciel HADES-2000 est une application modulaire qui fonctionne sur compatibles PC sous systèmes d'exploitation MS DOS et Windows 95. La communication portera essentiellement sur la version 1.50 pour MS DOS. Architecturé autour d'un code de calcul de topographie générale, HADES est un logiciel de topographie spéléologique qui offre la totalité de ce qu'attend le topographe moderne: méthode de compensation automatique, différentes représentations 2D et 3D, procédés d'archivage, modélisation 3D, préparation des épures et des plans, statistiques spéléométriques. Particulièrement adapté aux réseaux de moyenne importance et aux synthèses, HADES admet 9 types de cheminements et génère des vues 3D en volume, et est capable d'exporter aux formats TOPOROBOT (fichiers Text) et AutoCAD. Le code de calcul est un module utilisé également par SYLVIA, un logiciel de topographie forestière de ma conception. Il travaille suivant la méthode de TAILLARD et intègre le support des instruments de topographie générale.
La communication traitera des fonctionnalités générales des deux versions de HADES-2000.
Mots clefs: Blocs-diagrammes, calcul matriciel, géométrie 3D, image de synthèse, karst, logiciel, topographie.

1. Présentation générale du logiciel

Le logiciel HADES-2000 est une application texte/graphiques qui fonctionne sur plates-formes MS DOS, y compris sur petits systèmes à base de 80286. Les pré-requis matériels sont les suivants:
- Processeur 16 bits 80 286 et supérieur (486 recommandé pour le code de calcul)
- Disque dur
- Ecran VGA couleur.

Une version Windows 95 existe également; elle nécessite les spécifications de ce système d'exploitation mais est beaucoup plus conviviale et performante que son homologue DOS.

1.10. Modules de HADES-2000

Le progiciel HADES est constitué de plusieurs programmes indépendants regroupé autour d'un code de calcul utilisé également par un logiciel de génie civil et un programme de topographie forestière en cours de développement.
Les modules principaux du logiciel sont les suivants:

1.11. Programme P2000: Code de calcul

Noyau du logiciel, P2000 est un code de calcul polyvalent qui peut être lancé par un autre module (généralement le programme P2002) ou bien directement. Le procédé utilisé est la méthode des moindres carrés (développée par Eric TAILLARD) avec des variantes dans le calcul de répartition sur les séries. P2000 effectue également le calcul des contours simplifiés des galeries. Le calcul matriciel intervient dans la résolution d'un système linéaire et utilise le procédé de factorisation de Cholesky en raison de la précision de cette méthode, particulièrement adaptée à l'inversion des systèmes à déterminant symétrique. Le résultat du traitement effectué par ce module est d'une part une note de synthèse au format texte, d'autre part l'écriture des résultats dans les fichiers de données eux-mêmes.

1.12. Programme P2002: Acquisition des carnets de terrain

Ce module, spécifique à HADES-2000, est l'utilitaire de gestion des dossiers topographiques. C'est par lui que passent toutes les phases d'acquisition de données et c'est le seul programme, en dehors du code de calcul, qui peut écrire sur les fichiers. P2002 comporte de nombreuses boîtes de dialogue et de sélection. Le système de menus est architecturé suivant la chronologie de traitement d'un dossier: création, sélection et modification de dossiers, traitement d es cheminements dans une autre section de menu, utilitaires d'exportation et d'archivage lancés par un sous-menu, etc... Chaque dossier comprend un fichier de paramètres et récapitulations et autant de fichiers que de cheminements. Cette organisation est le résultat d'un choix personnel et présente l'avantage de ne pas nécessiter de moteur de bases de données ou de code

spécialisé pour traiter les données. En effet, le code de calcul n'a pas à faire une recherche préalable pour construire la matrice d'assemblage ni de faire une réindexation sur tout le dossier en cas d'insertion ou de suppression de stations. Les deux inconvénients de cette méthode résident dans la structuration du dossier en petits fichiers et la forte segmentation du réseau: il est ici obligatoire de définir un "noeud" (extrémité de cheminement) à chaque départ ou intersection.
P2002 supporte la totalité des instruments usuels de topographie spéléologique et accepte 3 unités: degré, grade et millième d'arc ainsi que le travail au topofil. Les paramètres utilisés pour le calcul sont les suivants:
- Numéro des noeuds de départ et d'arrivée. Très importants, ces paramètres définissent la table d'assemblage du réseau et la continuité de la numérotation doit être impérative. HADES-2000 demande beaucoup de méthode.
- Unités des instruments de mesure d'angle (degré, grade, millième d'arc)
- Termes de correction d'erreur systématique à appliquer pour les deux angles
- Facteur de correction d'erreur de mesure des longueurs (voisin de 1; ne doit pas être nul)
- Position du zéro du clinomètre (zénithal ou horizontal)
- Déclinaison magnétique
- Taux de précision absolus des trois instruments (Δl/l; ces valeurs ne doivent pas être nulles)

L'ordre d'introduction des cheminements est sans importance mais il est absolument nécessaire de respecter la connexité du réseau (il doit être possible d'atteindre un point quelconque du réseau à partir de l'entrée).
Différents types de cheminements peuvent être déclarés dans les catégories suivantes:

Cheminements à ne pas prendre en compte pour le calcul du développement:
- 1. Cheminements Fxxxx Déclaration de points fixes
- 2. Cheminements Sxxxx Cheminements spéciaux pour positionnement de profils et liaisons de surface

Cheminements à prendre en compte pour le calcul du développement des parties naturelles:
- 3. Cheminements Bxxxx Cheminements ordinaires en galerie fossile
- 4. Cheminements Vxxxx Cheminements en galerie active parcourue par un ruisseau permanent
- 5. Cheminements Cxxxx Cheminements en galerie pouvant être ennoyée complètement par temps de crue
- 6. Cheminements Wxxxx Cheminements en siphon

Cheminements à prendre en compte pour le calcul du développement des parties artificielles:
- 7. Cheminements Axxxx Cheminements en galerie artificielle
- 8. Cheminements Mxxxx Cheminements en filon minier

Cheminements servant au calcul du modèle de surface:
- 9. Cheminements Pxxxx Cheminements de profil en travers de massif, orientés suivant la plus grande pente.

Les préfixes ci-dessus servent pour la ventilation du développement des différentes parties d'une topographie et sont utilisés par les grapheurs pour la visualisation en couleurs du réseau.
L'entrée des données topographiques proprement dites se fait dans un tableur graphique semblable à Quattro-Pro DOS. Ce tableur est prévu pour permettre une saisie rapide des points topométriques et demande, pour chaque point, la longueur, l'azimut, la pente, la largeur à droite, la largeur à gauche, la hauteur au-desssus du point, la hauteur de la station et enfin un court commentaire. Il fonctionne exactement comme le tableur Quattro-Pro, dont il s'est inspiré en partie, et possède les fonctions attendues d'un tel outil de saisie: édition, saisie rapide, insertion et suppression de stations, sauvegardes, rappel des données, contrôle de cohérence intégré et surtout une fonction de visualisation en plan (à droite) et en coupe développée avec contours. Il est possible de suivre en temps réel les différentes visées avec leurs paramètres.

1.13. Programme P2103: Grapheur tridimensionnel

Ce module intègre les fonctions graphiques nécessaires aux représentations des cavités: vue en projections, vues 3D en volumes, histogrammes des directions. Les fonctions de prévisualisation, communes à P2103 et 3DFRAME, distinguent 9 types de cheminements définis dans le module P2002. La fonctionnalité la plus spectaculaire est la prévisualisation tridimensionnelle des volumes des cavités: cette fonction faire tourner la topographie dans l'espace (voir ci après).
Au niveau du graphisme papier, P2103 génère du code HPGL 1 destiné aux traceurs. Un contrôleur de tracé différé du domaine public interprète ce code pour les imprimantes (100 modèles environ). Une procédure du grapheur permet la sortie **à l'échelle désirée** des vues en plan et des projections (méthode des mosaïques), avec mise en place de cotes, de numéros de noeuds et de textes.
L'exportation vers des programmes de DAO n'est pas en reste puisque P2103 intègre 4 méthodes d'exportation vers AutoCAD (format DXF et DXF 3D faces pleines) avec préparation automatique des couches.

1.14. Programme 3DFRAME: Modeleur 3D

3DFRAME regroupe toutes les fonctions nécessaires à l'élaboration des blocs-diagrammes en volume des cavités. La méthode de modélisation des galeries retenue est un procédé basé sur une fonction de 4 variables qui retourne un profil en travers-type à section hexagonale. Les solides générés sont des segments de tubes (un par visée) délimités par 12 triangles pleins et sont sauvegardés aux formats interne, DXF 3D, HPGL, POVRay et RAW. Le résultat peut être sauvegardé aux formats pré-cités ou bien imprimé par l'utilitaire de tracé par zones commun à tous les programmes.
Le programme 3DFRAME est la passerelle vers l'imagerie de synthèse et intègre un générateur de code P.O.V. 2,20 dont le résultat est interprété par le renderer PovRay pour aboutir à une image 3D réaliste et/ou à des animations 3D.

1.20. Bases du programme - Bibliothèques communes - Méthodes générales

Le logiciel HADES-2000 est en fait un ensemble de bibliothèques communes à divers modules et même à d'autres programmes développés hors du cadre spéléologique (exemples: Calcul des portiques par la méthode des déplacements).

1.21. Utilitaires de menus et contrôles "maison" DOS (interface utilisateur)

Un programme MS DOS, à la différence d'un logiciel Macintosh ou Windows, doit être créé de toutes pièces, y compris les éléments de l'interface homme-machine (fenêtres, menus, masques de saisie et autres). Une série de 8 contrôles de base a été créée et utilise un code réduit: il s'agit du cadre, du menu PopUp, de l'éditeur de champ, du tableur, de la boîte "Cases à cocher", de la boîte à liste, du menu en barre et enfin du groupe de boutons-radio. La combinaison de ces 8 éléments forme la totalité de l'interface utilisateur de HADES-2000. Son inconvénient majeur est le non-support de la souris, mais son avantage majeur réside dans sa simplicité. Le système d'aide est intégré sous la forme d'une stratégie de description exhaustive des menus et l'inclusion d'une barre d'état au bas de l'écran.

1.21. Visualisateur graphique 3D

Commun aux programmes 3DFRAME et P2103, ainsi qu'à un programme de génie civil , le visualisateur 3D permet de visualiser en 9 couleurs (les 9 types de cheminements évoqués plus haut) et de faire tourner la topographie en perspective parallèle. Le visualisateur 3D génère un fichier intermédiaire pour le gestionnaire de tracés.

1.22. Gestionnaire de tracés

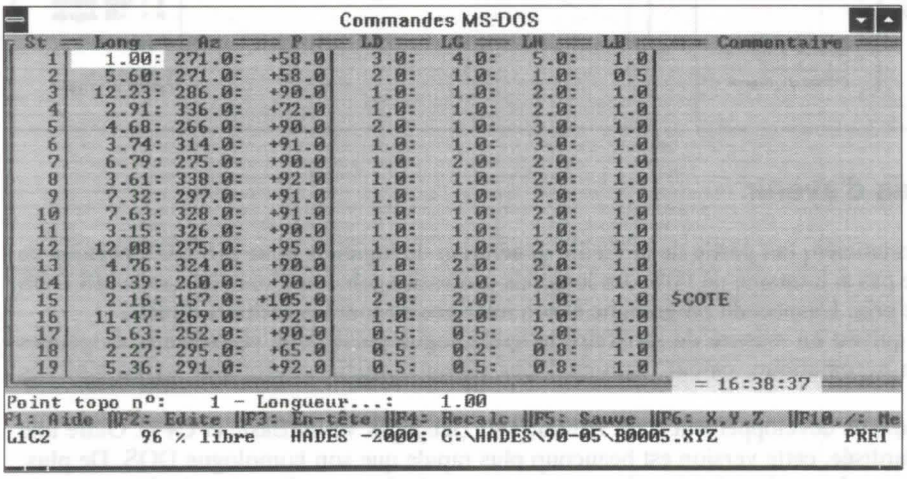
Cette bibliothèque intégrée reçoit les fichiers générés par le Visualisateur 3D et possède une routine pour tracer les projections orthonormales (Filtres XY, YZ et XZ); elle fractionne le dessin en autant de pavés que nécessaire et il est possible de redéfinir l'échelle à tout moment. Bien entendu, cette bibliothèque inclut une fonction de détourage. Le gestionnaire de tracés ne tient pas compte de la nature des différents cheminements et génère du code HPGL I.

1.23. Contrôleur de tracé différé

Il s'agit ici d'un logiciel du domaine public qui supplée les tables traçantes. Appelé par le gestionnaire de tracés et le générateur d'histogrammes de P2103, il supporte 100 imprimantes usuelles et la nouvelle version inclut la couleur. Le résultat des sorties est très satisfaisant, même sur des matricielles, et concurrence les traceurs électrostatiques.

2. Travaux générés par HADES-2000: Etude d'un dossier en images

Fig. 1 et 2: Tableur: Saisie et contrôle graphique des points d'une série.



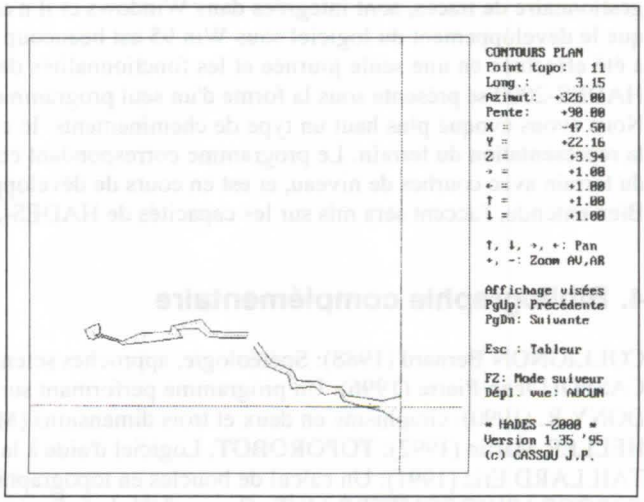
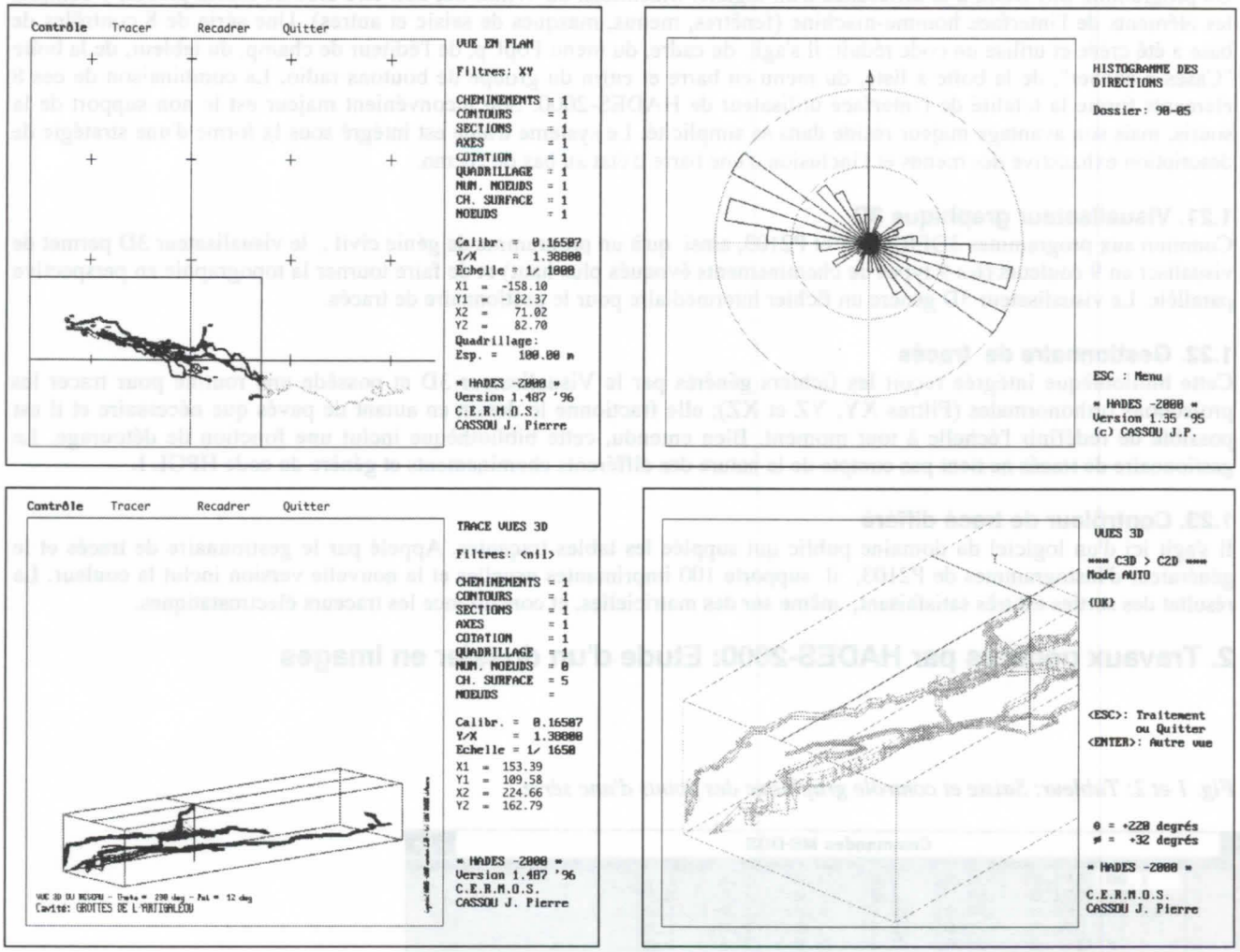


Fig. 3, 4, 5 et 6: Module graphique : Histogramme des directions et vue en plan, Contrôle Vue 3D et tracé 3D



3. Conclusion et perspectives d'avenir

HADES-2000, conçu par un non-informaticien, fait partie de la vieille génération de logiciels pour MS DOS puisque ce projet a été lancé en 1989 à une époque pas si lointaine où 90% des logiciels professionnels fonctionnaient sous MS DOS 3,30 et où les Macintosh étaient hors de prix. L'aspect du programme et son interface en sont les héritiers directs.
Cependant, il s'agit d'une application qui est en mesure de satisfaire le spéléologue puisqu'elle répond aux exigences modernes du spéléologue: 3D, dessin automatique, calcul rationnel des réseaux, saisie confortable et possibilités d'échanges.
Une version de HADES-2000 est en cours de développement sous Windows 95 (langages VisualBasic et C++). Outre une interface entièrement refondue et standardisée, cette version est beaucoup plus rapide que son homologue DOS. De plus, de très nombreuses fonctions, notamment la gestion des imprimantes et surtout la fameuse fonction de détourage du gestionnaire de tracés, sont intégrées dans Windows et il n'est pas nécessaire de les reprogrammer. C'est pour cette raison que le développement du logiciel sous Win 95 est beaucoup plus rapide: à titre d'exemple, la réécriture du code de calcul a été effectuée en une seule journée et les fonctionnalités de P2002 étaient prêtes en deux semaines. La version finale de HADES-2000 se présente sous la forme d'un seul programme et inclut un module de D.A.O. orienté spéléographie.
Nous avons évoqué plus haut un type de cheminements: le cheminement "P", destiné au calcul du modèle de surface pour la représentation du terrain. Le programme correspondant établit à partir de ces cheminements un modèle tridimensionnel du terrain avec courbes de niveau, et est en cours de développement.
Bien entendu, l'accent sera mis sur les capacités de HADES-2000 à gérer les grands réseaux complexes.

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SURVEX - Cave Surveying Software

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Survex is multi-platform, freeware, cave-surveying software. It has been designed, rather than simply written, and is based on a certain philosophy. This article explains how the software came to be, its intended purpose, what it can do at the time of writing (early 1997), and the direction of future developments.

Philosophy

Survex was started in 1989 by Olly Betts and Wookey. Like most survey software it was driven by a particular surveying project - Cambridge University Caving Club's explorations in Austria. However, unlike most survey software we spent about a year looking at the pros and cons of existing software, working out features that would be useful and appropriate, and algorithms that would be effective and scale to the available computing power, before writing any code.

We didn't want to produce something that would only be useful for the sort of surveying we were doing. We wanted something that would be useful for many sorts of surveying, on different computing platforms, in different countries and languages. We were particularly concerned that the data-processing engine had a sound mathematical basis, and that the data formats reduced transcription errors, and preserved the original data as faithfully as possible, i.e. you enter the data just as it is written down in the notebook. Another important criterion was to ensure there were no artificial limits to what could be processed, and that other features could be added later as surveying methods and computing power changed. Limits would only be imposed by the available memory or speed on the processing computer.

We also wanted to get away from the sorts of restrictions common in survey software at the time:

- Inability to enter data in an arbitrary order (You had to add data so the new survey legs were always connected to one previously entered).
- Connections between surveys involved changing the data - either changing the end names of the surveys to be the same, or adding a zero-length leg to join them.
- Limits on station name length, number of stations, number of unconnected traverses etc.
- You could only process one cave at a time.
- Cave viewers were slow and cumbersome
- Inflexible data entry and data organisation

A side effect of producing this software was that it would help to reduce the amount of data lost through incompatibility, and improve survey software generally by combining the efforts of various programmers. Back in the 1980's many cavers wrote their own survey software for their own projects. This resulted in an enormous duplication of programming effort, and a great deal of data recorded in very specific formats. Most of this software was not publicly released so the data could not be used by anyone else, or kept in a library of cave data in any useful way. If the Survex became widely used it would help to standardise the format that survey data was kept in, and being flexible in its import it should encourage people using other less capable pieces of software to move their data to Survex.

Of course Survex would only be widely used if it was free, and significantly better than existing software.

By making the software free, and the source freely available this should mean that other programmers could help to improve Survex functionality where it didn't do something they wanted, rather than everyone writing the same code over and over again for many different survey programs.

The name, by the way, comes from 'SURVey EXcellence'. It also sounds a bit like a famous operating system and a part of the female anatomy, just to amuse us.

History

The result of the deliberations were a number of basic design decisions:

The basic input would be ASCII text files with a very general format. We decided not to write a specific data entry editor, as it would be very time-consuming, and impossible to please everyone, but just to let people use their own favourite text editors. A data-entry editor/checker for Survex could always be added if there was sufficient demand.

These files would be a data-stream containing the data itself and commands expressing such things as names for surveys, variances of measurements, style and ordering of data, fixed points, units in use, etc. To facilitate import of data all the special characters (e.g. end-of-line, decimal separator, permitted station name characters, omitted-field) were specifiable.

A mechanism was required to ensure that problems did not occur because something was specified for one section of data, and not those following it, but the surveyor forgot to 'turn it off' -e.g. an instrument calibration). For this each section of data could be wrapped into a section. These sections normally correspond to surveys, but it is up to the user exactly how things are arranged. Any settings within a section are reset at the end of the section back to the previous settings in force before that section started. This allows settings to be applied to one leg, a few legs, a survey, part of a cave, a whole cave etc.

A very important concept was that of station naming. In order to allow very large datasets to be processed the simple 'every station must have a unique name' method was not sufficient. Nor did it reflect the way that caves are normally surveyed. Surveyors generally just number their stations 1,2,3,4... and then, when entering the data, say that station 1 on survey 'Big Chamber' is the same as station 47 on the previous 'Long Passage' survey. Survex preserves this naming, making the names in each section independent from the others, but allowing connections to be made within the hierarchy. This means that two caves can easily be processed even if they have the same station names within them. Also the sections can be used to separate all the data in one area from that in an

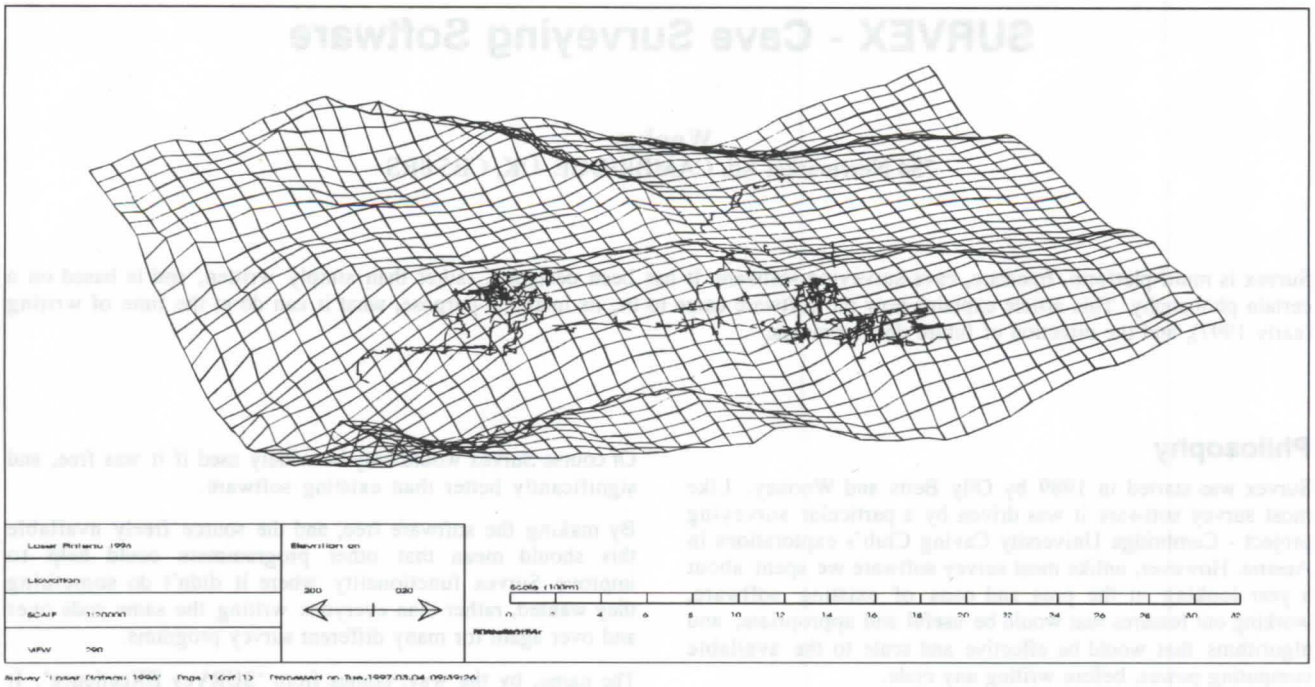

Figure 1 - Survex Printer output: Caves and surface of Loser Plateau, Totes Gebirge, Austria

adjacent area, or to separate surface data from underground data. It is up to the user how the system is used - but it is very powerful.

Of course, if you only have a simple cave, or prefer to use the 'AB01' type numbering then you don't need to use any of the above features and can simply enter the data.

History

Programming actually started in 1990, and has nearly all been done by Olly. The early releases were used by CUCC until the first public release (v0.21) in 1992. Since then development has been continuous with more features steadily being added, and the stability increasing. Wookey runs the user group and web pages.

Versions for DOS, UNIX and RISCOS are available. The DOS versions come in both 286 and DJGPP (extended memory) variants. The 286 version is limited to the DOS 640K of memory, but will work on any PC. The DJGPP version allows full use of the memory in 386 or better PCs, including virtual disk memory. Both can be run from within Windows as well as from DOS. In fact Survex is best used with some sort of shell (such as Explorer, File Manager or Norton Commander) that allows you to associate its commands with file extensions, then just double click on .SVX files to process them, or .3D files to view them (for example). Under Windows 95 setting up the right-button menus to give these options works particularly well.

The code could be compiled for other operating systems with a bit of work, as it is designed throughout not to be platform specific. Only the graphics for a new system require significant programming. Unfortunately the absence of a command-line interface on the Mac makes it difficult to produce a Mac version at this time.

Current Status

After 6 years development we are on version 0.71. This comment, made when Survex was 3 years old in the BCRA Cave Surveying Group Journal 'Compass Points' (Issue 1) is still true:

> *"We now have something that can be used by anyone to process their own data. It's not 'finished' by any means (version 1.0 is still at least a year away)."*

However it is true to say that it is a lot more finished and capable now than it was then.

Future Developments

Survex development continues, as available spare time allows. It is about to get a major update to the .3D plotfile structure to make it include much more than the final position data and station names. This will allow much more control within the cave viewer of what is displayed and what is not, highlighting of large closure errors, dynamic display of individual surveys etc.

A windowing front-end will also be added to allow a native Windows version and Mac version. It should also make Survex easier to use.

There are also other utilities available which can be used in conjunction with Survex. Mike McCombe has written 'Speleogen', which takes a processed Survex centreline, surface data grid, and LRUD (Left, Right, Up, Down) data, combines them with a preview, and writes out the result on multiple layers into a DXF file for import to CAD software. This is being further developed to output VRML data for viewing in a browser. This software is for Windows (all versions) only.

We already have demonstration software for taking a drawn-up picture and stretching it around the skeleton to fit any adjustments made for loop closure. We also have software called Tunnel written by Julian Todd which allows cross-sections to be specified with arbitrary spatial relationships to the skeleton, and then the whole is rendered into a 3d solid and displayed as VRML. This is written in Java and so should be very portable. These developments will eventually become part of the Survex package.

Other items on the do-list:

- Blunder detection for finding and correcting gross errors.
- Surface generation from DEM or spreadsheet data.
- GPS co-ordinate system support.
- Automatic plot grid/graticule generation.
- Translation to more languages, and of the documentation.
- Implement specifiable output units (currently metres/degrees).
- Implement 'percent' units for clinos.
- Implement Topofil format
- Finish implementing data formats where the lines are not all the same, e.g. the stations are on different lines to the survey leg info. e.g:

  <stn1>
  <tape> <compass> <clino>
  <stn2> etc.

Where to get a copy

On the Net:

Webpages: http://www.chaos.org.uk/survex/SVXHome.htm

FTP: ftp://ftp.chaos.org.uk/pub/survex/

Email: mailto:wookey@aleph1.co.uk

The Website has links to current and past versions to download, latest documentation, Survex User Group info, and details of the software. This is the best place to get up-to-date information.

You can also get a copy from the author at the address at the top of the paper. Please send a formatted floppy and stamped self-addressed envelope, or international reply coupon. Most floppy types and sizes can be catered for, but DOS 3.5" is easiest.

Summary of features

Here is the latest info about Survex, giving a list of current facilities:

Distinguishing features:

- It's free!
- Multi-platform (from lowly 8086 PCs to UNIX systems)
- Language support for all program text, errors, data files: English, French, German, Spanish, Catalan, Portuguese, Italian, US English. Support for other languages is simple to add.
- Unlimited survey hierarchy for organising data by survey, route, cave, area, country, planet.
- Versatile data input, so data from other software, spreadsheets, computers or countries can be used. Item order can be specified, and unneeded items or everything at the end of a line can be ignored.
- Fast processing of survey data. e.g. 5400 stations, 40km of data with 91 loops, takes 21 seconds on DX2/66 PC
- Survey viewer is panned, spun and zoomed with the mouse, as if you grab the cave and 'wave it about'.
- Source code freely available, and others encouraged to add features.

Data processing:

- Cave complexity limited only by available memory
- Hierarchical survey station naming. Each name level normally has up to 12 characters, but more or less can be specified if required.
- Include files allow 'projects' for survey data management. A survey, or collection of surveys, can be included in many different projects.
- Data input can be in arbitrary order - all the data is read in before the network is checked for connectivity. If part of the network is not connected to a fixed point then the rest of the network is processed, and the 'hanging' stations are reported. If no fixed point is given then one is invented at 0,0,0
- Network reduction by least squares. Standard errors calculated for each leg. The errors in loop closures are reported in the .ERR file. The horizontal and vertical components are given separately, which can often distinguish between compass or clino errors.
- Survex 'command file' allows automation of complex processing tasks, by allowing the Survex commands you want to give to be kept in a file. Command line options to specify case-sensitivity in station names, bracketing to stop setting 'escaping' into adjacent data, force conversion of plumbs to 'UP/'DOWN', set .3D plotfile output to ASCII format for manual editing, read filenames containing odd characters, specify length of station names that is compared when matching them.
- Data can be partially processed, loops closed, and then more data processed which will not move the existing stations. This is useful for adding a loop to an existing map without re-drawing.
- On completion the overall length, adjusted length, North-South, East-West & Up-Down extents, horizontal & vertical component lengths, number of stations, loops, independent traverses, time taken, and node structure of the cave is reported and saved in a .INF file. The positions of the stations go into the .POS file, the plot data into the 3D file, and the traverse closure error info into the .ERR file.
- You can put in as many fixed points as you need. E.g. for entrances, map benchmarks, GPS fixes etc. A fixed point can occur more than once in a dataset, so long as it is in the same place in all instances. Unused fixed points (i.e. ones with no survey data connected to them) are listed at the end of processing.
- Diving data format (depth gauge) supported.
- Plumbed legs entered as UP or DOWN are not adjusted by Clino calibration. LEVEL (where a water surface or other level was used) is treated the same.
- All instruments (e.g. tape, compass, clino, topofil, depth gauge) have optional scale & zero corrections.
- Magnetic deviation separately specifiable to compass calibration.
- Free-text input with user-definable symbols, so you can choose the separator, decimal point, command prefix etc.

This aids import from other programs, spreadsheet data, foreign languages etc.

- Wide range of input units: metres, feet, degrees, mils, grads.
- Each measurement can have its Standard Deviation specified separately (for specifying the 'grade' of a section, or giving special treatment to an odd or suspicious measurement, or radiolocation).
- Network processing saves memory by extensive reduction of parallel traverses & 'lollipops', and delta-star transformations. The network is also split at articulation points for separate processing, improving speed and memory use.
- Simple EXTEND program to make extended elevations from processed data. Legs are simply flattened to one side, starting from the highest 1-node. This program will be made smarter and more interactive, but despite its simplicity it is quite handy so we include it 'as is' for now.
- DIFFPOS, a utility to check if the positions of stations within two datasets are the same to a specified accuracy.
- Import/export from/to HTO cave data transfer format We will be supporting future data exchange standards that emerge.

Printer support:

- Multi-page printouts (for big plots on small printers) . After setting the scale the number of pages required is reported. You can then either confirm the print or change the scale. Any arbitrary selection of pages can be printed.
- Plots can be done at any rotation or tilt angle.
- Selective plotting of legs, stations, names and border.
- Corner registration marks are automatically printed on multi-page printouts, so they can be correctly assembled. If borders are enabled then dashed 'cutting lines' are drawn to allow accurate removal of the border prior to sticking the pages back together.
- All printer settings are kept in the PRINT.INI text file. This is where you specify the output channel, correction scaling for your printer, and special control codes it needs, default paper size etc. Printer definitions for new printers can easily be added.
- Printer output can be set (in PRINT.INI) to a port (eg LPT1, COM2), or a filename, or can be piped to another command under UNIX.
- The cave can be set spinning for demonstration and visualisation purposes.
- 8, 9 and 24 pin dot matrix (Epson, IBM Proprinter, and compatibles) , and Canon BJ series.
- Actual printout scaling can be set for your dot matrix printer, to correct for inaccuracies in printers.
- PCL - i.e. all deskjets, laserjets and compatibles. 300, 150 & 75 DPI resolutions.
- Postscript. Font, font size, and line widths are specifiable.
- HPGL driver - for various pen plotters. Origin can be in the centre or bottom left corner, as required by printer/plotter.
- All plots are time and date stamped, and page numbered for later identification, as well as showing the generating Survex filename, scale and view direction.
- The scale bar auto adjusts to print at sensible labelling and resolution, whilst fitting the page. The maximum length is kept reasonable on HPGL plots to reduce plotting time on large sheets.

Graphics:

- Very effective cave visualisation by keeping refresh times as high as possible and using bank-switching for smooth cave rotation and movement.
- On-screen scale bar, direction of view indicator and tilt indicator. Smooth plan/elevation transition on higher-performance displays.
- Display of legs, stations, station names are all switchable. Name display automatically turns off when moving the cave, for smoother update. Can be forced to stay on during movement if required. Names are automatically selected for display dynamically so that they are not overlapping. All names can be turned on if required.
- Sense of mouse controls can be swapped so you either move the viewpoint or the cave - whichever suits you.
- Multiple plot files can be read in and displayed in different colours - e.g. for cave/surface distinction.
- 'Reset' facility if you lost the cave off the edge of the screen somewhere!
- DOS graphics support for VGA, EGA, CGA, Hercules, 8514a, et al. New DJGPP version has SVGA support.
- Acorn RISC OS at various resolutions. Triple bank switching for extra-smooth display, if you have enough memory. ARM-coded display makes caverot particularly fast on this platform.
- X-Windows support
- Extended elevations are automatically locked flat as 'rotation' is meaningless.

Summary

Survex is very powerful cave survey software. It is still actively developing into a complete cave visualisation package. It does not have a nice windows and menus interface yet, as we are concentrating on what it can do, not what it looks like. This means that it isn't as easy to get to learn as some software, but you won't find that it can't cope with your data. It is particularly good for large complicated cave systems, or areas where you need to see the relationships between multiple cave systems. Putting existing data into it should be easy.

We welcome input from other surveyors on what features they need in Survex, or improvements to the way existing features work. We also encourage people to add their own functionality and send the code back to us for inclusion in the main code. This makes Survex a collaborative project amongst cave surveyors, and I must thank the many who have helped translate, test and improve it so far.

I hope that some more of you will try it after reading this paper.

Simulation of cave hydrological systems using modern computer software: Practical case studies from the UK

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Abstract
Simulation of the characteristics of a karst conduit system can provide insights into possible passage configurations based on input and output waveforms. This has been well known since Ashton's work in the mid 1960s, the most common parameters of interest being flow, total hardness and pH, observed at the sinks and resurgences, and within caves. Modern software, e.g. the MS Excel spreadsheet, now allows simulation of streams and cave characteristics to be performed using personal computers, without the need for extensive programming. The simple simulation described is capable of extension using more complex time-dependent coefficients to produce a model which must both represent best practice in hydrological modelling and predict parameters which conform with observed parameters to a high degree of statistical confidence. The incorporation of artificial intelligence to predict passage configurations will be discussed.

1. Introduction

The principles of simulation of stream flow are well-known, and modelling computations were undertaken before the general availability of electronic computers (e.g. GROVER & HARRINGTON, 1943). ASHTON (1965; 1966; 1967) described how flow, total hardness and pH, at sinks, in the cave, and at resurgences could be used to provide insights into possible passage configurations. In the 1960s, however, it was necessary to use a main-frame computer and considerable programming skills (WILCOCK, 1968) to make a reliable computer model of a hydrological system. With more frequent access to computers it has become possible to employ complex techniques of simulation such as the kriging and Monte Carlo methods (MARSILY, 1986). Kriging is a method for optimising the estimation of values for parameters which are distributed in space and measured at a network of points, for example the hydrogeological parameters transmissivity of an aquifer, piezometric head, and concentrations of solutes. The method is not limited to simple point estimations, but can also be used to obtain an estimation of the variance, i.e. the confidence interval of the estimation. The Monte Carlo simulation method for a stochastic process generates a large number of probabilistic realisations of a variable, and then statistically analyses the ensemble in terms of expected value, variance, histogram and distribution function. Various other numerical solutions have been employed such as finite differences, finite elements, large linear systems of equations, and the transport equation. The use of a numerical model involves data collection, choice of parameters such as size of mesh and time step, calibration of the model, and prediction using the model. Common computer programs for groundwater modelling include well characteristics, solute analytical models, and formation modelling in two and three dimensions (OKO, 1994).

It is now possible to use personal computers in an interactive fashion to simulate streams and cave characteristics using standard software, such as the Excel spreadsheet package of Microsoft Office. Far from being just an accounting aid, a modern spreadsheet package allows the use of colour graphics, a wide range of charts, the representation of time series, formulae for evaluation at run time, logical decisions, buttons for the execution of complex macros written in a language such as Visual Basic, and facilities for importing hydrological data from other packages, such as word processors and databases. This paper describes a numerically-based stream and cave hydrograph model, which although simple in its original configuration, with constant coefficients and a fixed time granularity, is capable of extension to use variable coefficients and time granularities, all without significant effort in programming.

2. Previous modelling of karst features

The waveforms of input and output for cave hydrological systems have proved fascinating to cave scientists since at least the beginning of the 20th Century. The first successful recorded use of artificial flood pulses to give information on a cave system was by the Yorkshire Geological Society (HOWARTH, 1902; DWERRYHOUSE, 1905). These investigators raised the level of Malham Tarn, and then flooded the Tarn Sinks by releasing the dam boards. The resulting flood pulses proved normal flow connection to Aire Head Springs, and a flood connection to Malham Cove. A summary of early cave hydrological work is given by Myers (1953). However, the use of the flood pulse technique as a serious method for the investigation of the dynamic characteristics of a cave system only received attention in the early 1960s. Ashton first propounded his classic theory for the pulse hydrology of caves in 1965 (ASHTON, 1965; 1966) and went on to develop the theory, which was used to analyse the results of the University of Leeds Hydrological Survey Expedition to Jamaica 1963 (ASHTON, 1967). A notable success of the method was the prediction of the form of the Kingsdale Master Cave, later confirmed by exploration.

Some more recent examples of modelling applied to karst features include delineation of spring catchment areas and investigation of hydrographs (HOBBS & SMART, 1989), simulation of karst water level changes (CSEPREGI & LORBERER, 1989), schematic hydrological diagrams (GUNN, 1991; HARDWICK & GUNN, 1995), flow switching (BOTTRELL & GUNN, 1991), network flow modelling of selective enlargement of competing flowpaths (GROVES & HOWARD, 1991; 1994), and simulation of cave formation processes (SHEN ET AL., 1993; SHI, 1993).

3. Proposed use of a spreadsheet

A typical computerised spreadsheet is an array of cells containing data, located in named columns and rows. Entries

may be data, references or formulae. When a reference is used in a formula, it is treated as an *address*, and the *contents* of that other cell are returned as data to the cell containing the reference. Alternatively, complex formulae may be used to return the results of arithmetical or logical calculations operating on the values in a number of other cells. This completes the basic specification of a spreadsheet, and its typical use is in adding columns of figures, and in tabulating both alphanumeric and numerical data to form a simple database, such as a list of names, addresses and telephone numbers. In this form, spreadsheet software has been available since the 1970s.

However, modern spreadsheets are much more than simple accounting or tabulation aids. Colour graphics may be used, a wide range of interactive charts may be generated, instructions to the user may be listed in text boxes, and buttons placed which cause complex programs to be executed. Complex macros may be written in a high-level language such as Visual Basic, data may be imported from an integrated word processor or database, graphics may be imported from clip art or draw/paint packages, and printouts generated of any area of formulae, data or charts, with cell boundaries removed if desired. Several sheets may be interlinked, and the whole becomes an applications package embodying many features of hypermedia. Finally, a novel use is that spreadsheets may be used for investigating time series, using complex formulae embodying logical relationships which are not evaluated until run time, and it is particularly with time series simulation that this article is concerned.

4. A hydrological simulation of rainfall, a stream and associated water storages and transports

If the spreadsheet is to be used to simulate rainfall, a stream and associated water storages and transports, the data model is represented as a *graph*, i.e. a series of *nodes* connected by *edges*. Both nodes and edges are *objects*, i.e. entities which have both data and intelligence. In the hydrological simulation the nodes are reservoirs which store water, and these are indicated by circles. The edges are processes which distribute water in the percentage proportions (fixed or variable) given on the output edges, with some variable time delay. It is possible to have recursive edges, applicable for the reservoir nodes, where the contents of the reservoir in the next time period is partially a function of the contents of the same reservoir in the previous time period, and partially a function of other inputs. There will be outputs from the reservoirs even if there are no inputs, which explains why a stream continues to flow even if there has been no rainfall, getting most of its low-level flow from the storage reservoirs. The recursive edges are indicated by circular arcs with arrows, and each reservoir effectively has a memory of its own previous state with a delay of one time period in the current time granularity. A spreadsheet is normally used as a combinational machine, where cells are evaluated in a dendritic fashion, the outputs (cell evaluations) are a direct function of the inputs at a point in time (i.e. of other cell values), and no circular linkages are allowed (these produce the error message 'Cannot resolve circular references'). But in the simulation described the spreadsheet has been used in a novel fashion as a sequential machine, with some time relationships. Since there may still be no circular linkages, successive rows of the spreadsheet are used for successive time periods in the current time granularity. Furthermore, the time relationships are not restricted to invariant formulae for the functions of previous variables, but may embody some logical tests which are evaluated continuously. This is just what is required for a simulation where the soil storage may become saturated, for example, new cave streams may be activated as flood levels increase, or the transmission or feedback parameters change with time.

Excel is a registered trademark of the Microsoft Corporation, Redmond, WA, USA, to which full acknowledgement is given.

As an illustration of the type of expressions which have to be entered, consider a possible formula for Infiltration. For simplicity constant transmission or feedback coefficients will be employed, although as explained above these can easily be modelled to change with time. Infiltration is conditional on whether the soil can hold any more water (i.e. has not reached the soil maximum storage). A conditional formula IF is available, followed by two parts, the THEN part for use when the condition is TRUE, and the second ELSE part for use when it is FALSE. IF statements may be nested to give very complex constructions, that is the THEN and ELSE parts may themselves be IF statements:

=IF((H1<=H3),0,(IF((H3+G4*0.65<=H1),G4*0.65,H1—H3)))

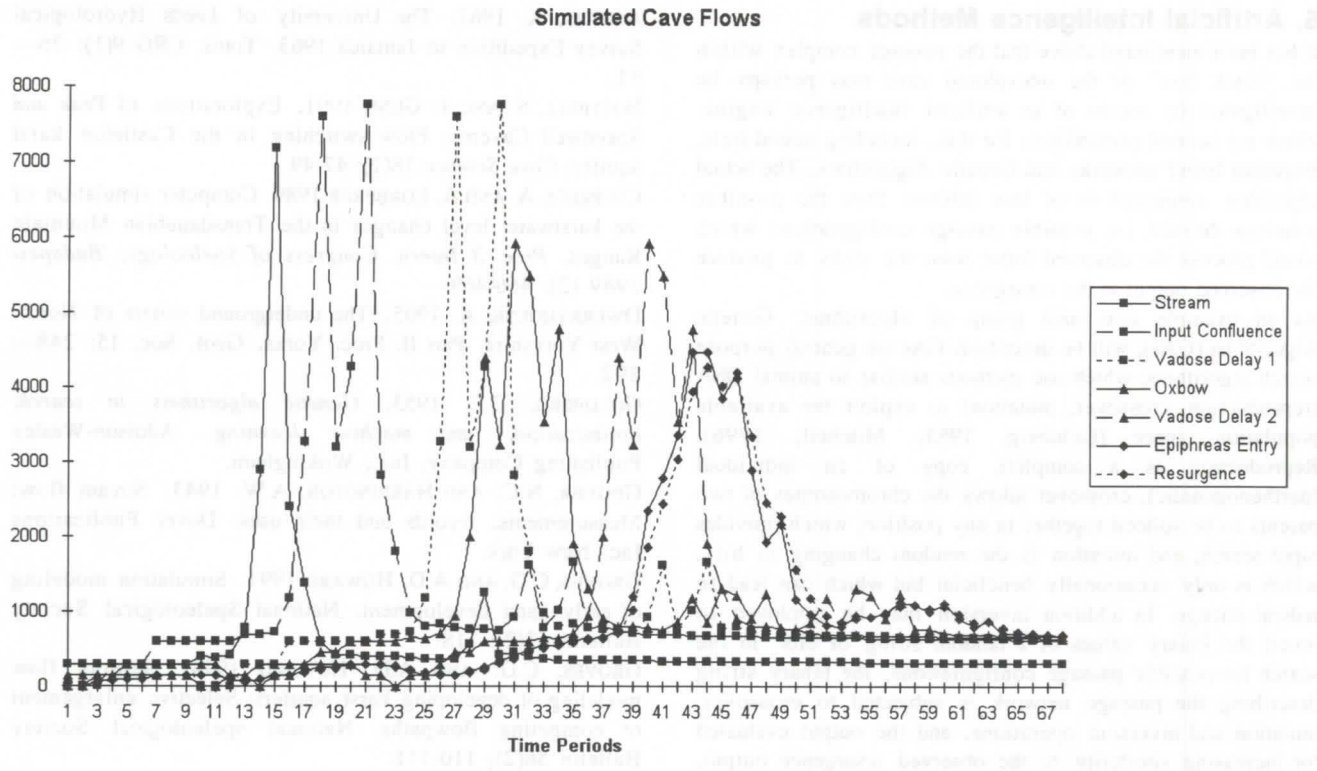
Given that soil storages are entered in column H and surface storages in column G, this statement says for row 4 of the sheet (i.e. time period 4):

IF the soil maximum (stored in the absolute cell H1) is less than or equal to the desired soil storage from the previous time period (i.e. from a relative cell in the previous row)
THEN Return 0 Infiltration
ELSE IF (the Soil Storage from the previous time period) + (Surface Storage for the current period * 0.65) is less than or equal to the soil maximum storage
THEN Return Infiltration as (Surface Storage for the current period * 0.65)
ELSE Return Infiltration as (soil maximum storage— Soil Storage for the previous time period)

Excel is also capable of generating many types of chart without the necessity for programming. It is only necessary to select the range of cells for which a chart is required, and to manipulate the type of chart, axes, legends, titles and labels as required using menus. A typical example of what is achievable is illustrated in the Figure below for the final cave simulation.

5. Extension of the modelling principles to the hydrological simulation of sinks, vadose passages, phreatic domains and resurgence for a cave system

The spreadsheet may be used to extend the model to simulate the sinks, vadose passages, phreatic domains and resurgence of a cave system being affected by a flood pulse input from a rainfall event. The data model is generally linear for a simple through cave system.



Multiple line graph generated on-line for the simulation of a simple cave system involving input generator, first vadose delay, passage complexor, second vadose delay, output complexor and exponential follower.

In the graph of the data model, the nodes (reservoirs) are the initial input rainfall channelled into a surface stream, the input junction (where the input streams join underground), the input to the oxbow complex, the epiphreatic domains, and the resurgence, all represented by circles. The edges (processes) are the input generator (representing sinking streams of different volumes and passage lengths which join underground), the first vadose delay, a passage complexor (representing a pattern of oxbow passages which branch, have different lengths, then rejoin), the second vadose delay, an output complexor (representing a pattern of passages of different lengths which feed the common phreatic domains), and an exponential follower simulating the action of the epiphreatic domains, all represented by edges.

The initial input employed is the stream simulation which has been described above. The next task is to simulate the effect of several sinks with different stream volumes and passage lengths which join at the input junction underground. The effect is to produce a multi-peaked input resulting from the superimposition of several single input peaks of different heights and timings. This is referred to as the *input generator* in this article.

The first vadose delay representing a single passage from the input junction onwards may be simulated by a simple delay of a number of lines in the spreadsheet.

The cave stream now arrives at a series of passage junctions, oxbows and flood-activated passages where the flood pulse waveform is progressively modified. In some cases the stream will divide into two streams, of different volumes depending on the relative sizes of their respective passages. In other cases the division will only occur if a specific flood level has been reached, when an overflow passage activates. Each of the active passages may further subdivide in a dendritic fashion, and then some passages will rejoin. This division and rejoining after different passage lengths have been traversed is termed the *passage complexor* in this paper, and it may be simulated in terms of logical formulae with passage weights and activation levels which are suitable for later manipulation by an artificial intelligence engine, such as a neural net or genetic algorithm. By examining the components of the resultant bit string some insight into possible passage configurations may be gained.

After the passage complexor there is a second vadose delay representing a single passage between the oxbows and the phreatic domains, which may be simulated by a simple delay of a number of lines in the spreadsheet.

The cave stream now divides again into several passages which enter the phreatic domains separately. When the flood pulse from one of these component passages reaches the phreatic domains, it will be transmitted immediately to the resurgence, a single pulse at the second vadose delay thus producing multiple pulses at the resurgence. This situation is equivalent to the passage complexor, and is referred to in this paper as the *output complexor*.

Finally, there is the effect of backing-up of flood water at the phreatic domains entrance to be simulated. Initially the phreatic domains cannot transmit the increased flow, so the water backs up until the increased pressure is sufficient for the new volume of water to be forced through the restricted passages of the phreatic domains. This can be simulated by a simple exponential rise in level, the difference between the old and new water levels at the phreatic domains entrance being referred to as the *epiphreatic domains*. As the flood subsides, a similar exponential decay will occur. This mechanism is referred to in this paper as an *exponential follower*.

6. Artificial Intelligence Methods

It has been mentioned above that the passage complex within the "black box" of the unexplored cave may perhaps be investigated by means of an artificial intelligence engine. There are several possibilities for this, including neural nets, Bayesian belief networks and Genetic Algorithms. The actual algorithm employed is of less interest than the possible solutions derived, i.e. possible passage configurations which would process the observed input from the sinks to produce the observed output at the resurgence.

As an example one such group of algorithms, Genetic Algorithms (GAs), will be described. GAs are general purpose search algorithms, which use methods similar to animal DNA (reproduction, crossover, mutation) to exploit the available population space (Goldberg, 1953; Mitchell, 1996). Reproduction is a complete copy of an individual (parthenogenetic), crossover allows the chromosomes of two parents to be spliced together in any position, which provides rapid search, and mutation is the random changing of bits, which is only occasionally beneficial but which can lead to radical change. In addition inversion may be employed to invert the binary values of a random string of bits. In the search for possible passage configurations, the binary string describing the passage network is subjected to crossover, mutation and inversion operations, and the output evaluated for increasing similarity to the observed resurgence output. An example of GAs being used to control the Usk Reservoir in the Swansea Valley, UK is given by Peggs et al. (1995). The evaluation of GAs for the analysis of passage networks is work in progress by the author.

7. Conclusions

It has been shown that modern spreadsheet software can satisfy many of the requirements for cave hydrological simulation. This can be achieved with a minimum of programming. The spreadsheet implementation of the model allows on-line updating of the equations and charts during a simulation, and "what if" experiments with different passage configurations and different flood activation levels may be carried out, until the generated output approximates to what is observed in the field.

The ultimate aim is a degree of artificial intelligence, using neural nets, genetic algorithms or other techniques, where the computer will adjust its model of the cave system inside the "black box" automatically until given inputs generate outputs which approximate to reality. Observing the formulae and passage generators/complexors which then exist in the model may give some insight into possible cave passage configurations in unexplored systems.

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Das SPELIS-System der Bibliothek des Verbandes der deutschen Höhlen- und Karstforscher

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Zusammenfassung

Das SPELIS-System der Verbandsbibliothek ist der erste Versuch, ein einheitliches System zu Erfassung speläologischer Literatur in Deutschland zu schaffen. Dies geschieht mittels eines auf spezielle bibliothekarische Erfordernisse zugeschnittenen Datenbanksystems mit einheitlicher Struktur, Systematischen und Geographischen Thesauri. Die Eingabe hat nach **international üblichen bibliothekarischen Regeln** zu erfolgen. Die Einführung dieser Datenbank und vor allen Dingen die Schulung der bibliographischen Regeln sind die besonderen Schwerpunkte dieser Arbeit.

Abstract

The SPELIS-System of the Library of the German speleological Association is the first attempt to create a homogeneous system of recording speleological literature in Germany. This task is realized by a special Database with homogeneous structure, classed catalogue and geographical thesaurus. The input has to be effected according to usual library rules. The special aspects of this work are the introduction of the a/m database and the teaching of the cataloging rules.

1. Geschichte der Verbands - Bibliothek

Die Verbandsbibliothek wurde 1955 gleichzeitig mit unserer Verbandsgründung ins Leben gerufen. Die ersten Jahre befand sie sich in den Räumen des HHV Laichingen. Zu jener Zeit wurde schon der Versuch unternommen, durch Schriftentausch die Bestände zu erweitern (A.A., 1959). Umzug der Bibliothek in das neue Vereinshaus des HHV (A.A., 1959). Jahre später wurde die Bibliothek von Dr. F. Laaber betreut und in seiner Wohnung untergebracht.

Erst ab 1980 wurde die Verbandsbibliothek wieder aktiver betreut. Die Höhlenforscher B. Kliebhan, P. Schneider, D.W. Zygowski und andere brachten den Bestand der Bibliothek nach Münzenberg (KLIEBHAN & ZYGOWSKI, 1980). In den nächsten Jahren nahm der Bestand durch den intensivierten Schriftentausch und vermehrten Zukauf von Höhlenliteratur stark zu (KLIEBHAN, 1988). Mit der Zeit wurde die Titelaufnahme und Recherche nach Literatur mittels Karteikarte zu aufwendig, und B. Kliebhan beschloß, diese Aufgabe in Zukunft mit einem Computer und einer Datenbank zu erledigen (KLIEBHAN, unveröff.). Nach fast 10 Jahren des Sammelns und Erfassens kündigten sich Raumprobleme an, und es wurde ein neuer Standort gesucht.

E. Hammerschmidt und der Autor erreichten durch intensives Bemühen, daß die Bibliothek zur Dechenhöhle in Iserlohn umziehen konnte. Die Besitzer der Höhle hatten ausreichende Räumlichkeiten für die Bibliothek zugesagt. Seit Januar 1991 ist die Bibliothek in Iserlohn an der Dechenhöhle beheimatet. Durch die Intervention des Autors konnten der Erwerbungsetat deutlich erhöht und der Schriftentausch noch einmal gesteigert werden. Das führte zu einem erneuten Anwachsen der Bestände. Es kam 1994 ein weiterer kleinerer Bibliotheksraum hinzu. Der Bestand bis zum Jahr 1996 erstreckt sich auf ca. 120 Regalmeter. Das sind derzeit etwa 1400 Monographien, über 570 Zeitschriften u. Reihen, ca. 1800 Sonderdrucke sowie zahlreiche Kongreßakten, Bibliographien und einige Nachläße.

2. Entwicklung der Bibliographien in Deutschland von 1959 - 1985

Auf der Jahreshauptversammlung in Schellenberg 1959 wurde die Herausgabe einer „**Bibliographie zur Karst- und Höhlenkunde in Deutschland**" beschlossen. Diese Bibliographie sollte mit dem laufenden Jahr beginnen und jährlich erscheinen (HELLER & BINDER, 1959). Dieses erste Heft für 1959 enthielt 91 Titelzitate und hatte einen Umfang von 10 S. Gleichzeitig damit wurde eine neue Serie des Verbandes begründet, „Kleine Schriften zur Karst- und Höhlenkunde". Die Bibliographien erschienen in den folgenden Jahren in steter Folge und endeten 1971 mit dem Heft 14 der „Kleinen Schriften". In diesen 13 Jahren wurden 12 Bibliographien von verschiedenen Bearbeitern mit insgesamt 1980 Titeln veröffentlicht.

In der folgenden Zeit wurde neben dem Format (bisher A5, jetzt A4) auch der Publikationszeitraum auf 2 Jahre erweitert. Die neuen „**Bibliographien zur Karst- und Höhlenkunde in der Bundesrepublik Deutschland**" (Bearb. T. Rathgeber) wurden der neuen Zeit angepaßt. Der Verzeichnungszeitraum begann 1970 (!); die erste Bibliographie der „zweiten Generation" erschien 1985 mit 1020 Titeln und endete mit einer Lücke von 1978 - 79 (RATHGEBER, 1986). Insgesamt wurden in den 3 erschienenen Bibliographien 3560 Zitate veröffentlicht.

Das vorläufig letzte Kapitel der Bibliographien begann 1980 mit der Herausgabe der „**Bibliographie zur Karst- und Höhlenkunde in Deutschland**" durch D.W. Zygowski. Es erschienen ebenfalls nur 3 Hefte für den Zeitraum 1980 - 85 (ZYGOWSKI, 1988). Die Anzahl der Titel belief sich auf 4130. Seither ist leider keine weitere Bibliographie mehr erschienen.

3. Die Datenbankentwicklung

Der erste Versuch, die neue zukunftsweisende EDV - Technik in die Verbandsbibliothek einzuführen, reicht bis in das Jahr 1985 zurück. B. Kliebhan versuchte, die anfallenden bibliothekarischen Aufnahmen auf einem PC und einer Datenbanksoftware namens dBASE (Vers. II + III) zu bearbeiten. Die Strukturen dieser beiden Datenbanken für Zeitschriften u. Reihen sowie für Monographien, Sonderdrucke u.ä. waren sehr knapp gefasst. Bei einem PC mit einer Festplatte von 20 MB Speicherplatz sicherlich zu verstehen (KLIEBHAN, unveröff.). Bis zum Jahre 1990 umfaßte der Bestand etwa 2500 Titelaufnahmen für den Alphabetischen Katalog und ca. 450 Zeitschriften.

In den nächsten Jahren hat der Autor versucht, mit erweiterten Strukturen und verschiedenen selbstgeschriebenen dBASE - Programmen gegen die Unzulänglichkeiten dieser Software anzukämpfen. Die Datenein- und ausgabe funktionierte noch akzeptabel. Die Literaturrecherche war mit dem vorhandenen System nicht befriedigend zu lösen. Das gab die Datenbanksprache von dBASE nicht her.

Im Jahre 1993 entdeckte der Autor auf der CEBIT in Hannover eine für die Bibliotheksarbeit hervorragend geeignete Software: Diese professionell geschriebene Software **VCH Biblio** bietet wesentliche Vorteile gegenüber dem bisher benutzten dBASE - Standard. Das Programm in der aktuellen Version 3.0 ist komplett ausgestattet, die Datenbankstruktur leicht und selbständig den eigenen Bedürfnissen anzupassen. Die 2 implementierten Recherchearten erlauben eine Index- und eine Volltextsuche. Die Suche ist über alle Felder und mit allen logischen Operatoren möglich und läßt keine Wünsche offen. Es ist sogar eine Syntaxprüfung eingebaut. Die bis zu 127 Datenbankfelder sind alle in der Länge variabel. Pro Datensatz dürfen bis zu 30.000 Zeichen eingegeben werden. Es ist sogar die Einbettung von Grafiken oder anderen Objekten vorgesehen.

Es gibt zusätzlich spezielle Feldtypen wie z.B. Autoren, Titel, Schlagwort, Zeitschr. und Signatur. Die besonderen Datentypen erlauben z.B. die wahlweise Nachstellung von Vornamen im Autorenfeld oder mehrere Schlagwörter in einem Feld, die einzeln in den Index abgelegt werden und somit recherchierbar sind. Diese Datenbank ist dokumentenorientiert, d.h. es gibt für jede Dokumentenart (Monographie, Aufsatz, Serie, Dissertation etc.) eine eigene Eingabemaske. Es sind bis zu 20 solcher Dokumententypen möglich. Aus einem gemeinsamen Feldvorrat können nur die für den jeweiligen Dokumententyp benötigten Felder ausgewählt werden. Die Software erleichtert die Erstellung von formatierten Literaturlisten. Literatureinträge können auf dem Bildschirm angesehen und in verschiedenen Ausgabeformaten gedruckt werden (Fig. 1). Das erleichtert die Anpassung an verschiedenste Zitierregeln. Die Ausgabe ist auch direkt in etliche bekannte Textprogramme wie WordStar, MS-Word u. a. möglich. Besonders interessant sind noch einige zusätzliche Features wie z.B.: ein hierarchischer Thesaurus, eine Stopwortliste, eine Dublettenprüfung und ein Importmodul für viele Online-Datenbanken wie CAS ONLINE, Medline, BIOSIS, Derwent, dBASE, ASCII usw (Kreutzer & Krohn, 1995).

4. Das SPELIS-System

Das SPELIS-System ist der erste Versuch, in Deutschland ein EDV-gestütztes Erfassungs- und Erschließungssystem für Höhlenliteratur auf Basis international anerkannter bibliothekarischer Regeln zu schaffen.

Dieses System gliedert sich in 2 sich ergänzende Teilbereiche:

A. Die bibliothekarischen Grundlagen

Die bisher benutzten bibliothekarischen Regeln in der Verbandsbibliothek und den Bibliographien waren so verschieden wie ihre jeweiligen Bearbeiter. Da es keine gemeinsamen Regeln oder Absprachen gab, wurde oftmals sehr willkürlich mit schwierigen Titeln verfahren. Allein schon der Umgang mit „Anonyma" und die Einführung von „Autorenkoll." als Ersatz für eine sorgfältigere Titelaufnahme zeigt das ganze Dilemma (Rathgeber, 1976 ff.). Es wurden in der Titelaufnahme z.B. Herausgeber mit Autoren gleichgesetzt! Dazu kam, daß die Bibliographien mit großer zeitlicher Verzögerung erschienen!

Die geographische Aufschlüsselung außerhalb Deutschlands war viel zu ungenau, einzelne Länder konnten nicht recherchiert werden. Erst . B. Kliebhan hat 1986 die bisher benutzte Systematik in System- und Geographiedeskriptor unterteilt (KLIEBHAN, 1988). Somit ließen sich die Suchkriterien besser an die EDV anpassen. Der Autor fügte 1993 die recherchierbaren Datenbankfelder „Höhlennamen" und „Katasternummern" hinzu. Diese Neuerungen wurden beim jährlichen Katalogdruck der Verbandsbibliothek berücksichtigt (HOFFMANN, 1992 ff.).

Der nächste entscheidende Schritt mußte nun sein, der Problematik der uneinheitlichen Titelaufnahmen endgültig mit einem festen Regelwerk zu begegnen. Nach Beratung mit Fachleuten der Universitätsbibliothek Dortmund und der Diplombibliothekarin J. Krüger kam der Autor zu der Überzeugung, daß die DIN 1505 die richtige Wahl sei. In dieser DIN sind alle Vorteile eines solchen Regelwerkes vereint: Die relativ leichte Anwendbarkeit auch für bibliothekarische „Laien" und die Übereinstimmung mit internationalen Katalogisierungsregeln.

Die DIN ist aus den „RAK, Regeln zur Alphabetischen Katalogisierung" abgeleitet. Diese Regeln sind von der IFLA (International Federation of Library Associations) anerkannt und zudem seit ihrer Entwicklung EDV-tauglich. Das grundlegende Prinzip der RAK lautet: „Weglassungen sind möglich, Änderungen dagegen nicht. Zwar kann bei verschiedenen Bibliotheken und innerhalb eines Gesamtkataloges die Ausführlichkeit der einzelnen Titelaufnahmen ... unterschiedlich sein, nicht jedoch die Ansetzungsform der Namen und Sachtitel, die festgelegte Reihenfolge der Teile der Titelaufnahme mit deren einleitenden Zeichen sowie die Ordnung der Titel" (Regeln f. d. alphabet. Katalogisierung, 1980).

Somit ist die DIN 1505 das bindende Bibliotheks- und Bibliographieregelwerk der Verbandsbibliothek. Diese Vorgehensweise erleichtert die Arbeit in einer Gruppe, die mit geringer personeller Decke versucht, eine solche in Deutschland einmalige Spezialbibliothek zu betreuen.

B. Die EDV-gestützte Umsetzung

Sie wird erreicht mittels der schon oben besprochenen Bibliothekssoftware. Die Dokumententypen wurden für die am häufigsten vorkommenden Dokumentenarten entwickelt. Es gibt Typen für Monographien, Aufsätze, Serien, Dissertationen usw. Die Felder und die Reihenfolge wurden bibliographischen Erfordernissen und der DIN 1505 angepaßt. Die vielen kurzen Eingabefelder machen das System leicht bedienbar (Fig. 2). Dadurch können Fehler vermieden und Deskriptionszeichen in der Ausgabeformatierung automatisch eingefügt werden. Es ist auch möglich, die Reihenfolge von z.B. Zeitschrift, Band, Heft, Jahr und Seitenzahl individuell an vorgeschriebene Zitierformen anzupassen. Häufig sich wiederholende Einträge können aus dem vorherigen Datensatz feldweise übernommen werden. Zudem erleichtert eine BASIC - Makrosprache die Eingabe von Daten aus selbstentwickelten Modulen.

Das System besteht derzeitig aus 2 Datenbanken und 2 Projekten:

- dem Alphabetischen Katalog, in dem alle Monographien, Sonderdrucke und ausgewertete Zeitschriftenaufsätze enthalten sind

- dem Zeitschriften- und Reihenkatalog, in dem alle

Zeitschriften und Reihen der Verbandsbibliothek mit dem jeweiligen Bestand erfaßt sind

- der retrospektiven Aufnahme aller alten Bibliographien

- der Entwicklung einer neuen Form der Bibliographie durch den Arbeitskreis „Spel. Dokumentation"

5. Erfahrungen aus Schulung und Anwendung

Der Arbeitskreis „Spel. Dokumentation" besteht seit Nov. 1994 und hat sich nun zur inzwischen 3. Arbeitstagung getroffen. Die Benutzung des Datenbanksystems und dessen spezielle Gegebenheiten waren für die beteiligten Personen mit Computerkenntnissen kein größeres Problem. Sie hatten i.d.R. schon mit ähnlichen Systemen gearbeitet. Deshalb war die Schulung an einer solchen Datenbank nicht schwerer als die Einführung sogenannter „Standardprogramme" wie MS-Word oder Excel.

Die Umsetzung der bibliothekarischen Regeln erwies sich als wesentlich schwieriger, da viele Teilnehmer eben doch nur vage Kenntnisse über korrekte Titelaufnahmen besaßen. Bisher hatten sie nur mit „eigenen" oder nicht schriftlich fixierten Regeln zu tun. Die spezifische bibliothekarische Sprache führte anfangs auch zu Irritationen. Der Autor hat eine Sammlung von Beispielen für Titelaufnahmen zusammengestellt. Die wissenschaftl. bibliothekarische Literatur bietet darüberhinaus auch eine Reihe solcher Stoffsammlungen. Die nahe Verwandtschaft aller dieser Regeln erleichtert die Übertragung von Beispielen der RAK zur DIN 1505. Mit diesen Hilfsmitteln ist es möglich, auch bibliothekarischen „Laien" die Titelaufnahme nach festen Regeln nahe zu bringen.

Die Einteilung der zu verzeichnenden Literatur in verschiedene Dokumententypen birgt gewisse Vorteile: Es lassen sich anhand der Stoffsammlungen in kritischen Fällen immer wieder Analogien zu bereits hier vorliegenden oder zu selbsterstellten Titelaufnahmen herstellen. Das System der Dokumententypen erleichtert außerdem das Bearbeiten der entsprechenden Titelaufnahme, da immer nur die wirklich notwendigen Felder in der Eingabemaske erscheinen. Diese lassen sich dann auch noch über entsprechende Makros aus selbsterstellten Eingabemodulen mit Werten auffüllen oder aus dem vorherigen Datensatz übernehmen. Zusätzlich ist es hilfreich, aus dem Register z.B. die Abkürzungen von Zeitschriftentiteln o.ä. zu ermitteln und direkt in die Titelaufnahme zu übernehmen.

Ausgehend von der Zielsetzung, daß das hier vorgestellte und inzwischen bewährte SPELIS-System bundesweit bei der Erfassung von höhlenspezifischer Literatur eingesetzt wird, bleibt anzustreben, daß sich weitere Höhlenvereine und einzelne Höhlenforscher diesem Projekt anschließen.

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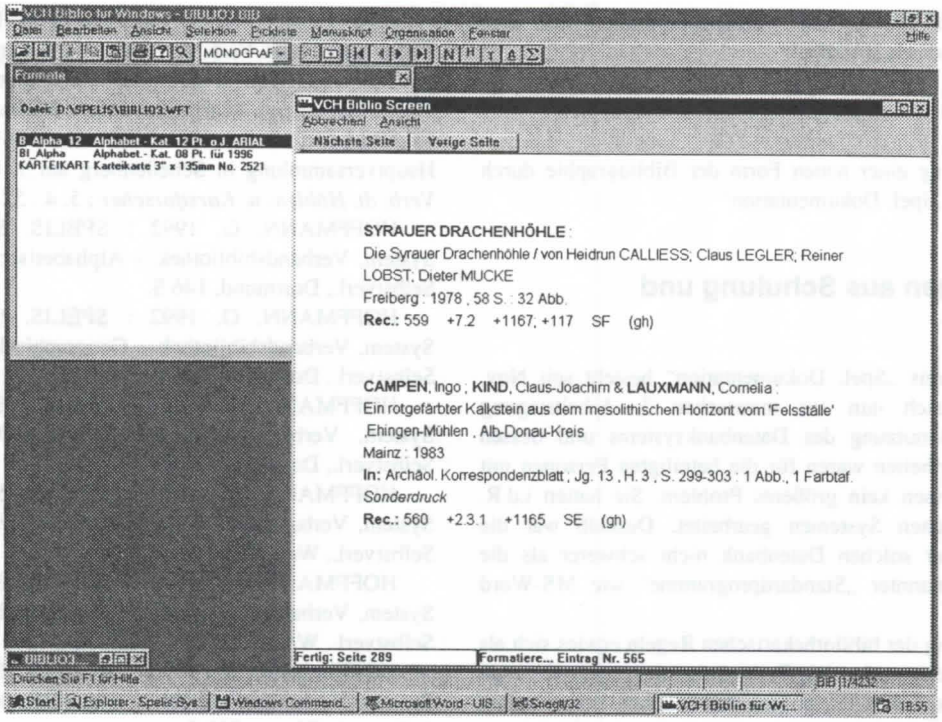
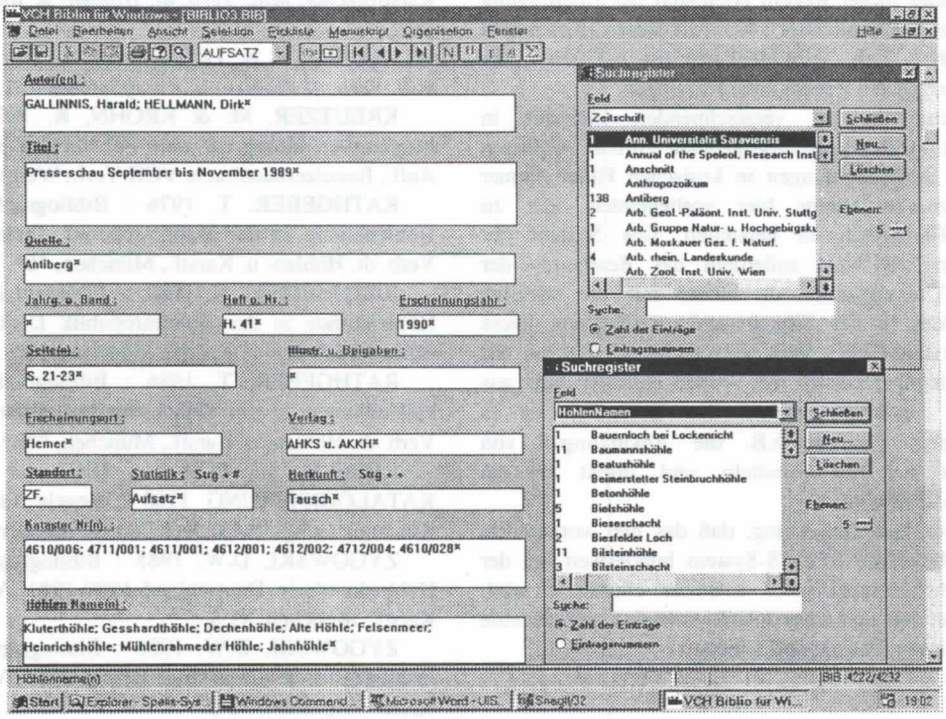


Figur 1 : VCH Biblio Bildschirm mit Format- und Ausgabefenster



Figur 2 : VCH Biblio Bildschirm mit Eingabemaske für Aufsatz u.2 Registerfenster

The Cave Register of the Speleological Association of Slovenia

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Summary

The Speleological Association of Slovenia, the association of all the caving clubs in the Republic of Slovenia, manages the Cave Register. The Cave Register is a collection of data on all known underground karstic phenomena for the entire territory of Slovenia. Documenting work on the caves which being explored from the beginning of this century was organised in a systematic way in 1938, when the basis for the actual Cave Register was set. Today the Cave Register collects 64 data on each cave in the standardised form as well as all additional material concerning each cave. Every cave has its register number as an identification code. Documenting is organised according to the geographical co-ordinates of the cave entrances in order to achieve that all neighbouring caves in an area are put together in the documentation. This makes arranging of the documentation more demanding but it meets better the needs of the users. The database with some basic data in the electronic media is also available. The minimum criteria for registering a cave is 10 m of length of a passage penetrable by man. There are nearly 7000 registered caves in Slovenia. The Cave Register is mostly used by the caving clubs, the number of external users is on the increase.

1. Introduction

The Cave Register of the Speleological Association of Slovenia (Jamarska zveza Slovenije) is a collection of documentation on all Karst caves in the Republic of Slovenia. Slovenia is a new European country which came into being in 1991 with the break-up of Yugoslavia. It is relatively small, covering only 20,256 km^2, but about 44% of this area is composed of carbonate rocks, belonging to two large systems, the Alps and the Dinara, which meet in Slovenia. The Cave Register is managed by the Speleological Association of Slovenia and is a record of the caving activities of all its member clubs, as well as of the activities of other explorers of the Slovenian Karst. The purpose of this text is to present the Cave Register and its organisation; a brief history of the Cave Register, and its functions, users and activities are described below.

2. A brief history of the Cave Register

Slovenia is a small, young country, but it has a long and rich caving history. Similarly, the history of the documentation of discovered caves is very long and rich. The first known documentation of a Karst cave in the area of present-day Slovenia is from the seventeenth century, when Johann Weichard Valvasor published the first cave map, a map of the Podpeška jama pri Dobrepolju (Podpeč Cave near Dobrepolje) (KRANJC, 1977).

The late eighteenth and early nineteenth centuries saw the beginnings of scientific interest in the Slovenian Karst, while modern Slovenian caving begins with the foundation of caving clubs Anthron in 1889 and the Cave Exploration Society of Ljubljana (Društvo za raziskovanje jam Ljubljana) in 1910, the oldest still active caving club in Slovenia. From the outset, Slovenian cavers understood the importance of the documentation of field caving activities. The members of the Cave Exploration Society of Ljubljana immediately began drawing maps of the discovered caves, describing them and recording their biological, hydrological, and geological aspects and other observations. The oldest map preserved in the Cave Register is the map of the Marjanščica cave dating from 1911. Between 1911 and 1914, a number of other maps and descriptions of caves were made.

World War I interrupted the activity of the Cave Exploration Society of Ljubljana, but its members continued their caving activities, exploring the caves and potholes of the hinterland of the Isonzo Front for the Austrian-Hungarian army. Over 100 descriptions and maps drawn in 1916 and 1917 are still preserved in the Cave Register (SIMIĆ, 1994).

After World War I, the exploratory activity of the Cave Exploration Society of Ljubljana intensified, and all caving expeditions were documented on special standardised forms. Since the number of these forms grew quickly, in 1938 Alfred Šerko attached a register number to each newly documented cave as an identification mark. The Gaüss-Kruger co-ordinate system began to be used for determining the location of cave entrances, and still remains in use today. Alfred Šerko thus organised the collected cave forms into an orderly documentary collection, laying the foundations of the modern Cave Register. Until the beginning of World War II the register comprised documentation on 848 caves (ŠUŠTERŠIČ, 1981).

Between both World Wars, the south-western part of Slovenia, the most interesting for caving, became part of Italy. The Italian Speleological Institute (Instituto Italiano di Speleologia) in Postojna maintained the National Cave Register, which also contained information on caves in the south-western part of Slovenia. There is no proved connection between this register and that maintained by the Cave Exploration Society of Ljubljana.

It is interesting that during World War II the occupying Nazi German authorities attempted to confiscate the Cave Register of the Cave Exploration Society of Ljubljana, but its members kept it hidden throughout the war (HADŽI, J. 1961). The Nazi plan for the defence of the Adriatic coast against an Allied invasion thus had to be made solely on the basis of published information on caves and on information from the National Cave Register maintained by the Italian Speleological Institute.

After World War II, the Cave Register became active again, and documentation started arriving from newly-formed caving clubs all over Slovenia. With the foundation of the Speleological Association of Slovenia, an association of all the Slovenian caving clubs, the Cave Register of the Cave Exploration Society of Ljubljana became the Cave Register of the Speleological Association of Slovenia. The year 1952 was an important milestone for the development of the Cave Register, as its twin register, now maintained by the Carst Research Institute at the Slovenian Academy of Sciences and Arts, was founded. The war which followed Slovenia's declaration of independence again endangered the Cave Register, and because of the danger of its destruction it had to be dispersed to several places, which made its continued operation impossible for more than half a year.

3. Functions and users of the Cave Register

Because of its historical development, the Cave Register today is a documentation centre, keeping information on all caves in Slovenia. It operates as a commission of the Speleological Association of Slovenia, but in line with tradition is still managed by the Cave Exploration Society of Ljubljana. The main users of the Cave Register are cavers, who in Slovenia are mainly organised in caving clubs which are members of the Speleological Association of Slovenia. The main function of the register is a documentation service for the exploratory caving activities of these clubs. Its other functions are connected with other users, i.e. experts in research institutions in the fields of karst sciences, geology, archaeology, biology and ecology, state administrative bodies responsible for nature protection, teachers who prepare school activities, pupils and students, and many others. From the Cave Register these users can obtain the information on caves that they need in their scientific and educational work. It is particularly important that the register provides the Ministry of the Environment and Physical Planning with information on the vulnerability of caves which is needed for their protection.

4. Cave Register activities

In view of the above functions, the activities of the Cave Register are as follows: (1) collection of information on caves, (2) arranging and processing of information on caves in the written documents collection and in the computer database, (3) dissemination of information on caves, (4) training of cavers in cave documentation, (5) development of documentation activity in caving.

4.1. Collection of information on caves

The Cave Register collects all documentation on caves, from descriptions and maps, though newspaper and scientific articles, to photographs. The basis of the documentation of each cave consists of two standardised forms. In the A Form, 64 pieces of information on each new cave are collected. This information is divided into several sections: basic identification information on the cave (name, entrance co-ordinates, registration number, municipality, accessibility, map section with cave locations, type, dimensions, club which registered it, and similar); a description of the cave, including its history; information on certain characteristics of the cave (geological, hydrographic, meteorological, biological, archaeological and economic); other information (history of the exploration of the cave, equipment necessary for its exploration, bibliography, names of explorers and reporters, and similar); and the cave map. B Form is intended for additional information on known caves. Both forms are open-ended and decisions on the extent and detail of information are left to the person filling in the form. This manner of information collection is adapted to very different levels of contributor knowledge.

Collection of information is the most important Cave Register activity, therefore we try to obtain as much documentation as possible from caving clubs. The number of the received documentation varies from year to year. Between 1990 and 1995, for example, we collected an average of 640 documents on caves each year. Slovenian cavers contributed 90% of the documentation. The Cave Register evaluates the documentation received yearly, and the caving clubs which contribute the most documents or documentation on particularly important caves are rewarded with sets of compasses and clinometers for surveying caves. This manner of encouraging competition and rewarding the best caving clubs has proved to be very effective, and the number of documents received has increased.

4.2. Arranging and processing of information on caves

The first step in the arranging of the documentation received involves determining whether it refers to known or new caves. The main criterion for the registration of a new cave in the Cave Register is the cave size: it has to have at least ten metres of negotiable passages. This applies to both dry and flooded passages (siphons). Only exceptionally may a smaller cave be registered. Each new cave receives a registration number as its main identification marking. Between 1990 and 1995, 651 new caves were registered, or 130 new caves a year on average (VERŠA, 1995). At the moment, 6923 Slovenian caves are registered in the Cave Register.

The Cave Register receives documentation on caves in written form, therefore the main document collection consists of written documents. In the basic document collection, documentation on each cave in inserted in a special folder. These are arranged according to a geographic principle, i.e. by the Gauss-Kruger co-ordinates of cave entrances. Slovenia was divided into 35 columns five kilometres wide, and the documentation on caves within a column is arranged from south to north. This principle means that caves in the archive are arranged in a similar way to the actual caves. This arrangement is demanding for those who manage it, but it best meets the needs of the users. Cavers often need information on all the caves in an area, and a register arranged according to a geographic principle can supply answers to such requests very quickly, since all the relevant caves can be found in the documentation in just one or two columns. It is estimated that the whole register contains about 30,000 different written documents.

Ten years ago, on the initiative of and in co-operation with the twin register at the Carst Research Institute at the Slovenian Academy of Sciences and Arts, we designed a computer database for caves. It contains 24 basic information categories on caves and enables queries to be made on all this information in accordance with various criteria. It is designed in the DBase format, with queries processed through a Clipper application.

The quality of documents on caves is very varied and depends on those who wrote them. They were mainly contributed by cavers with no special expertise in the field of karst studies and geology, so we can generally say that they do not have the quality of

scientific documentation. Our efforts towards better quality are oriented particularly towards better identification information, i.e. reliable entrance co-ordinates, descriptions of cave access, and good cave maps.

Information organised in the Cave Register affords interesting analyses. The average depth of Slovenian caves is 25.2 m, and the average length 71.5 m; 89.5% of them are up to 100 m deep, and 97% up to 100 m long. The average altitude of cave entrances is 784.7 m. The distribution of cave-entrance altitudes shows that the biggest group of caves, 21.6%, have entrances at altitudes between 500 and 600 m (Brenčič, 1995). In Slovenia there are four registered caves with depths of over 1000 m (Čehi II at 1370 m, Črnelsko brezno at 1198 m, Vandima at 1182 m, and the Molička peč system at 1130 m), while the Postojna cave system is the longest with a total length of 19,555 m.

4.3. Dissemination of information on caves

The Cave Register is managed by two people on a voluntary basis, it can therefore be open to users for only two hours a week. Since Slovenia is so small, the register is visited by cavers from all parts of the country. Cavers, who are the most important users of the Cave Register, most often search for information on known caves in the area they explore, on caves suitable for caving courses, on caves suitable for photography or promising in terms of further exploration or scuba-diving, and similar. In providing information, we advocate the principle of mutuality, meaning that information from the Cave Register may be used by those caving clubs who also contribute documentation. In addition to access to written documentation, caving clubs can also be provided with the computer database of caves.

The Cave Register also provides caving clubs with other materials needed for the documentation of cave exploration. We provide them with topographic maps at the scale of 1:10,000 and 1:5,000, which are the basis for determining locations, and with standardised forms. We also lend cave surveying equipment and assist in buying literature.

The needs of other Cave Register users described above, which arise from time to time, are managed according to individual agreements.

4.4. Education of cavers and the development of documentation activity in caving

The Cave Register provides education for cavers in the field of cave documentation and the management of caving club registers. Occasionally we organise short one-day courses with lectures on surveying and drawing caves, participate in caving courses organised by caving clubs, publish articles on individual topics regarding the operation of the Cave Register in the bulletin Naše jame (Our Caves), and, during working hours, provide consultation regarding particular problems.

Cave documentation needs to be constantly improved and adapted to new information technologies and the needs of users. In future, the Cave Register will intensify its presence in the nature preservation information system at state level. We will start to collect more detailed information on the condition and vulnerability of Slovenian caves for the needs of the Ministry of the Environment and Physical Planning.

5. Conclusion

In our work on the Cave Register we face a number of problems, particularly because of the low funding allocated to the Cave Register by the state. The flow of funds is also irregular, since the financing of the Cave Register is not systematised.

Caving clubs which are members of the Speleological Association of Slovenia are statutorily obliged to submit documentation on their cave exploration, but many of them do not fulfil this duty. With the opening of Slovenia to foreign cavers we face the new problem of certain foreigners who explore our caves but do not deem it necessary to send the documentation on their discoveries to the Cave Register and thus make it available to us. Such visitors are not welcome in Slovenia.

There are a few other open and unsolved problems concerning the Cave Register, yet the Cave Register still plays an important role in servicing and encouraging the exploratory activity of Slovenian caving clubs and in the provision of information on caves to other users. The advantage of the Cave Register lies in the fact that it contains information on caves throughout Slovenia and that said information is contributed and used by all Slovenian cavers. The principle of free flow of information on caves guaranteed by the Cave Register is its basic quality and orientation, and this will continue to be the case in the future.

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Demonstration of Cave Database System

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Abstract

A live demonstration of the "Australian Karst Index" relational Cave Database System which currently uses around 500 fields. This system is being used as a pilot to test cave/karst database principles being developed by the UIS Informatics Commission. It is designed so that clubs can update data for theit local cave area and periodically consoliodate it to the national database, with exact locations removed if necessary, leaving only a coarse location. All aspects are up for discussion during the Congress.

Cave Database Structure

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Abstract

A diagram of the physical table structure of the present stage of the "Australian Karst Index" relational cave/karst database system. Entities covered include cave/karst features, references, maps, people, organisations, areas, fields, subjects.

Karst Data Interchange

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Abstract

A draft proposal for a standard method of exchanging cave/karst data between dissimilar databases.

Accidents spéléologique en France de 1985 à 1995

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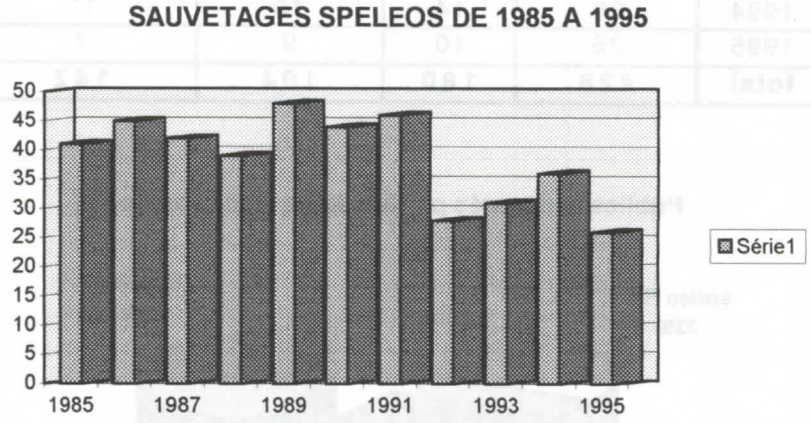
Préambule : Cette analyse porte sur 11 années. Elle est tirée d'un travail réalisé début 1996 par C. Dodelin (Conseiller Technique National du Spéléo Secours Français) pour la Fédération Française de Spéléologie afin d'apporter des éléments statistiques pour une meilleure PREVENTION auprès de tous les usagers du Monde Souterrain. Il est possible de varier le contenu du message et les moyens de prévention auprès des différents publics en tenant compte de l'origine des victimes et des types d'accidents propres à chacune d'elles.

Les sauvetages souterrains en France

Nous prenons en compte ici les accidents qui ont donné lieu à une opération de secours. Ce sont les événements qui ont fait l'objet de l'activation du « PLAN D'URGENCE » par les Préfets concernés.

Sur ces 11 années nous avons enregistré 426 sauvetages, ce qui fait une moyenne annuelle entre 38 à 39 sauvetages. Les interventions sont en régression depuis 1992. Malgré cette diminution la spéléologie est victime de la publicité faite par les médias dès qu'une opération de secours dépasse les 24 heures. Ce fut le cas en 1996 avec les sauvetages du G. Berger en juillet, à la Dent de Crolles en novembre, à l'aven Jean Nouveau en décembre.



Les causes de la diminution des accidents

Les actions de prévention et d'information de la fédération vis à vis de tous les publics en partenariat avec les administrations et les fabricants de matériel ont pour effet :

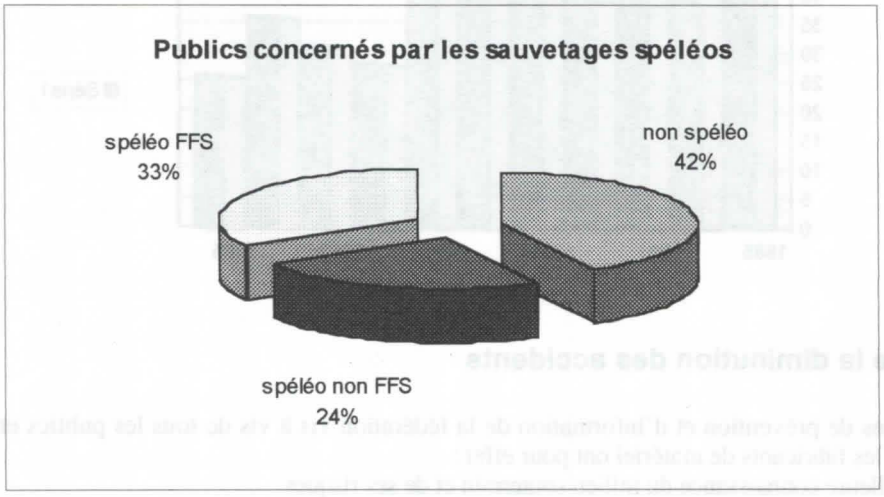
- une meilleure connaissance du milieu souterrain et de ses risques
- une amélioration des techniques de progression
- une meilleure qualité et fiabilité du matériel utilisé
- une meilleure performance des vêtements et de leur protection contre l'eau et le froid
- une prise en compte des besoins physiologiques (diététique, contrôle de l'effort,..)
- une recherche permanente par toutes les commissions : médicale, enseignement, secours, plongée, expéditions internationales, scientifique,... sur des thèmes variés avec notamment : recherche sur les gaz d'explosif, les micro charges, les harnais, les techniques de repérages, la médicalisation, la civière plongée pour siphon, les techniques de progression classique, les techniques secours, résistance des noeuds, étude sur les poulies, ...
- un enseignement adapté dans les différents stages. (les stages touchent 1 spéléo sur 4 chaque année).
- une formation et qualification des spéléos qui assurent l'encadrement qu'ils soient bénévoles ou professionnels.
- une diffusion de l'information par les revues nationales (spelunca, karstologia), les bulletins de liaison des commissions et des structures fédérales, les bulletins et publications de clubs,...

La compétence accrue de certaines équipes leur donne une plus grande autonomie ; ce qui évite bon nombre d'accident et permet parfois des autosecours sans l'intervention d'équipes de sauvetages. En l'espace de 11 ans nous avons enregistré 258 autosecours concernant des spéléos blessés sous terre et qui sont sortis aidés par les spéléos constituant l'équipe d'exploration. Il y a en moyenne 23 à 24 autosecours par an.

Repartition selon l'origine des victimes

« LES NON SPELEOS » : sont des personnes étrangères au « milieu spéléo ». On y trouvent des randonneurs, skieurs, promeneurs, aventuriers non avertis des risques en milieu souterrain, les enfants qui par jeu s'aventurent sous terre, des plongeurs de mer,...
« LES SPELEOS NON FFS » qui ont une pratique régulière de la spéléo mais en dehors des structures fédérales. On y trouve également les spéléologues étrangers venus faire la visite d'une classique en France.
« LES SPELEOS FFS » sont des spéléologues qui appartiennent à la Fédération Française de Spéléologie, qu'ils soient en club ou individuel (pendant ces 11 années leur effectif oscillait entre 7400 et 7800 licenciés).

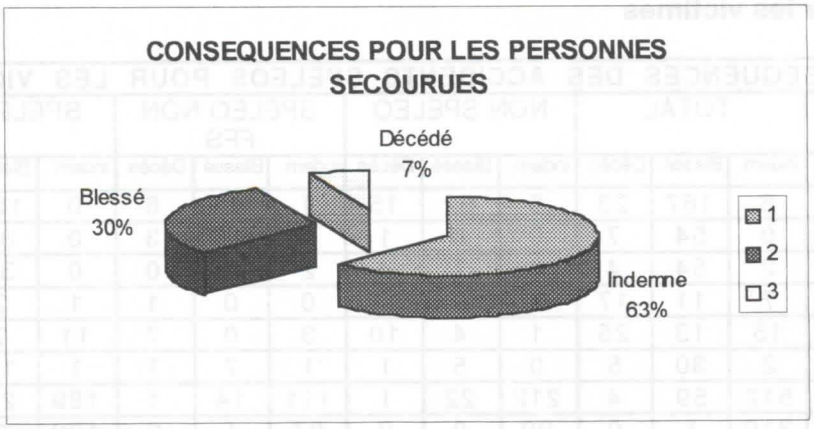
SAUVETAGES SPELEOLOGIQUES DE 1985 A 1995				
Années	**Sauvetages**	**non spéléo**	**spéléo non FFS**	**spéléo FFS**
1985	41	15	10	16
1986	45	17	8	20
1987	42	13	13	16
1988	39	26	3	10
1989	48	18	13	17
1990	44	21	10	13
1991	46	26	7	13
1992	28	8	8	12
1993	31	12	13	6
1994	36	14	10	12
1995	26	10	9	7
total	**426**	**180**	**104**	**142**



Les évenements souterrains

Avec la prise en compte des accidents ayant mobilisé des équipes de secours, les autosecours, les retards et alertes diverses, nous appréhendons un nombre d'événements plus important. L'analyse des causes de ces événements et des conséquences pour les victimes est plus significative de la pratique spéléo et de ses risques.
L'analyse porte donc sur 740 événements ayant concerné 1352 victimes.

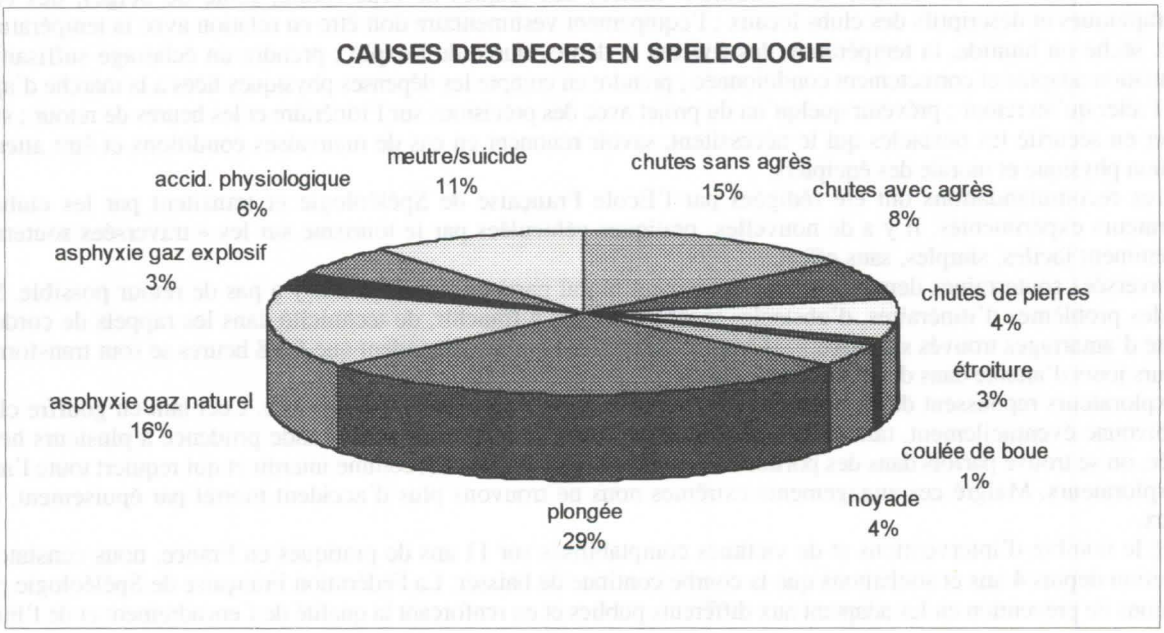
EVENEMENTS SOUTERRAINS DE 1985 A 1995								
PUBLIC	**EVENEMENT**	**SAUVETAGE**	**AUTO SECOURS**	**FAUSSE-ALERTE**	**VICTIME**	**INDEMNE**	**BLESSE**	**DECEDE**
non spéléo	**218**	180		38	**474**	314	117	43
spéléo non FFS	**168**	104	14	50	**304**	215	69	20
spéléo FFS	**354**	142	154	58	**574**	325	223	26
total	**740**	**426**	**168**	**146**	**1352**	**854**	**409**	**89**



Les causes d'accidents en spéléologie

Les accidents mortels ont des causes différenciés selon les publics concernés. Le tableau ci dessous établi année par année : les causes par publics. Les accidents mortels touchent plus les non spéléos (près de la moitié).
Ce sont les chutes qui sont les principales causes de décès (chutes avec ou sans agrès + meurtres et suicides) 34%, suivi par les accidents de plongée : 29%. Viennent après les asphyxies : 19% qui touchent plus les non spéléos.

CAUSES DES EVENEMENTS AVEC DECES				
Causes	**total**	**non spéléo**	**spéléo non FFS**	**spéléo FFS**
chutes sans agrès	**13**	5	6	2
chutes avec agrès	**7**	1	3	3
chutes de pierres	**4**	4		
étroiture	**3**	1	1	1
coulée de boue	**1**			1
noyade	**4**		1	3
plongée	**25**	10	7	8
asphyxie gaz naturel	**14**	11		3
asphyxie gaz explosif	**3**		1	2
accid. physiologique	**5**	1	1	3
meutre/suicide	**10**	10		
total	**89**	**43**	**20**	**26**



Conséquences pour les victimes

CAUSES ET CONSEQUENCES DES ACCIDENTS SPELEOS POUR LES VICTIMES												
CAUSES	TOTAL			NON SPELEO			SPELEO NON FFS			SPELEO FFS		
	indem.	Blessé	Décès	indem.	Blessé	Décès	indem.	Blessé	Décès	indem.	Blessé	Décès
Chutes sans agrès	6	187	23	5	62	15	1	19	6	0	106	2
Chutes avec agrès	0	54	7	0	8	1	0	16	3	0	30	3
Chutes de pierres	2	54	4	0	7	4	2	12	0	0	35	0
Asphyxies	7	11	17	6	9	11	0	0	1	1	2	5
Plongée	15	13	25	1	4	10	3	0	7	11	9	8
Physiologique	2	30	5	0	5	1	1	7	1	1	18	3
Blocages	512	59	4	212	22	1	111	14	1	189	23	2
Fausses alertes/retard	310	1	0	90	0	0	97	1	0	123	0	0
Noyades	0	0	4	0	0	0	0	0	1	0	0	3
TOTAL	**854**	**409**	**89**	**314**	**117**	**43**	**215**	**69**	**20**	**325**	**223**	**26**

Les conséquences les plus graves pour les victimes proviennent des chutes surtout pour les non-spéléos (chutes sans agrès). Pour les pratiquants, les chutes avec agrès proviennent davantage d'erreurs techniques ou de négligences plutôt que de défaillance du matériel. Les ruptures d'amarrage (15) ou de corde (1) sont liés à des erreurs humaines ou à la vétusté de certains d'entre eux.
En deuxième cause viennent les accidents de plongée avec des accidents de décompression (17), des égarements (9), panne d'air (4). La fréquentation des siphons par des plongeurs non spéléos occasionnent des accidents plus graves du fait de techniques non adaptées au milieu souterrain.

Les asphyxies ont touché 31 personnes par des gaz naturels souvent liés à des feux allumés par des visiteurs non spéléos. Le tristement célèbre accident en Normandie (de juin 1995) a fait 9 victimes dont certaines également du côté des sauveteurs.
Les blocages sont le plus souvent sans conséquences graves pour les victimes sachant que l'intervention des secours met fin à des situations qui auraient pu avoir des conséquences dramatiques liées au froid, l'eau, le manque de nourriture ou le stress pour bon nombre de cas. Ils sont liés pour certains à l'égarement (104) et des problèmes d'éclairage (32), à des crues (248), à des erreurs ou incapacité technique (55), à des épuisements (53). Dans les causes naturelles, si l'on excepte les crues dont certaines pourraient être évitées, on trouve des éboulements ou trémies (25) et des étroitures (24). Ce sont ces derniers cas qui ont les conséquences les plus graves pour les victimes.

Enseignement et prévention

La pratique de la spéléo demande une préparation physique, morale et technique. Les recommandations d'antan sont toujours valables : réaliser une exploration correspondant aux possibilités de l'équipe ; se prémunir des risques objectifs par une connaissance du terrain, des conditions météo, des risques de crue (pluie, fonte de neige), des éléments topographiques et descriptifs des clubs locaux ; l'équipement vestimentaire doit être en relation avec la température de la cavité, sèche ou humide, la température des rivières et débits, durée de l'explo ; prendre un éclairage suffisant et une alimentation adaptée et correctement conditionnée ; prendre en compte les dépenses physiques liées à la marche d'approche tant à l'aller qu'au retour ; prévenir quelqu'un du projet avec des précisions sur l'itinéraire et les heures de retour ; sur place équiper en sécurité les obstacles qui le nécessitent, savoir renoncer en cas de mauvaises conditions et être attentif à la condition physique et morale des équipiers.
D'autres recommandations ont été rédigées par l'Ecole Française de Spéléologie et transitent par les clubs et les explorateurs expérimentés. Il y a de nouvelles pratiques véhiculées par le tourisme sur les « traversées souterraines » apparemment faciles, simples, sans effort,....
Les traversées souterraines demandent un engagement moral particulier puisqu'il n'y a pas de retour possible. Se pose alors des problèmes d'itinéraires, d'obstacles incontournables à franchir, de technicité dans les rappels de cordes et de fiabilité d'amarrages trouvés sur place,... . Certaines traversées qui ne demandent que 5 à 8 heures se sont transformées en plusieurs jours d'attente dans des conditions précaires.
Les explorateurs repoussent de plus en plus loin les limites en profondeur et en distance. Ceci tant en gouffre classique avec bivouac éventuellement, tant en siphon. Même si l'on a un réflexe de plus grande prudence à plusieurs heures de l'entrée, on se trouve parfois dans des portions de cavité où tout accident est comme interdit et qui requiert toute l'attention des explorateurs. Malgré ces engagements extrêmes nous ne trouvons plus d'accident mortel par épuisement, et c'est heureux.
Malgré le nombre d'interventions et de victimes comptabilisés sur 11 ans de pratiques en France, nous constatons leur diminution depuis 4 ans et souhaitons que la courbe continue de baisser. La Fédération Française de Spéléologie poursuit les actions de prévention en les adaptant aux différents publics et en renforçant la qualité de l'encadrement et de l'initiation.

Höhlenrettung in der Schweiz

von Martin Jordi
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Abstract
The beginning of organized rescue in Switzerland will be described. The development of the Schwarzer stretcher is pointed out. The lecture also shows the present structure of the Swiss SPELEO-SECOURS and the collaboration with the air rescue (REGA). Finally, some special exercises and operations are presented.

Zusammenfassung
Rückblick auf die Anfänge der organisierten Höhlenrettung in der Schweiz. Die Entwicklung und Erprobung der Schwarzer-Bahre. Der Aufbau der SPELEO-SECOURS SCHWEIZ und ihre Zusammenarbeit mit der Schweizerischen Rettungsflugwacht (REGA). Vorstellung einiger ausgewählter Übungen und Einsätze.

1. Die Entwicklung der organisierten Höhlenrettung in der Schweiz

Die Anfänge der organisierten Höhlenrettung in der Schweiz liegen in den frühen Siebzigerjahren. Vorher basierte das Höhlenrettungswesen auf vereinzelten und regionalen Anstrengungen, teilweise in Zusammenarbeit mit SAC-Rettungskolonnen, Feuerwehr oder Polizei. 1973 wurde die Rettungskommission der SGH gegründet, ihr erster Präsident war Richard Burnell. In seiner Amtszeit wurden mehrere grosse, gesamtschweizerische Rettungsübungen durchgeführt mit dem Hauptziel, die Leute aus den verschiedenen Gegenden der Schweiz miteinander bekanntzumachen und Rettungstechniken kennenzulernen und weiterzuentwickeln. Auf organisatorischer Ebene wurde versucht, die Schweiz in Regionen mit je einer Rettungskolonne aufzuteilen, die den bestehenden Gebieten bezüglich Clubs und Forschungsgebieten Rechnung trugen (Abbildung 1).

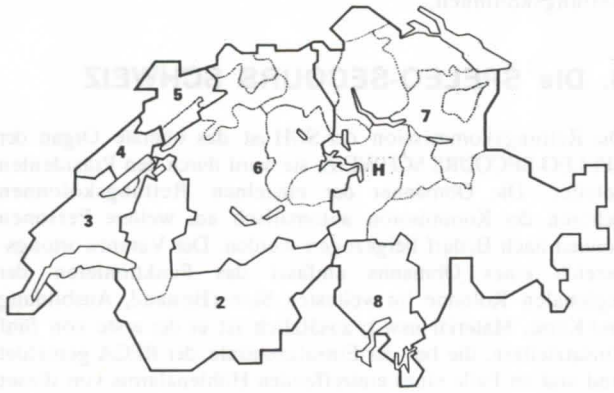

Abbildung 1: Geographische Aufteilung der Höhlenrettungskolonnen in der Schweiz
2 Wallis, Freiburg, Waadt Ost
3 Genf, Waadt West
4 Neuenburg
5 Jura und Berner Jura
6 Deutschschweiz West
7 Deutschschweiz Ost
8 Tessin
H Hölloch ***(nach Moeschler, 1988)***

Die neue Schwarzer-Bahre führte ab 1976 zu einer ganzen Reihe von Neu- und Weiterentwicklungen in der Höhlenrettungstechnik, insbesondere in den Bereichen Transport und Medizin. Seit 1978 erfolgt die Alarmauslösung zentral über die Nummer der Schweizerischen Rettungsflugwacht (REGA). 1979 übernahm Olivier Moeschler das Präsidium der Kommission. Als Arzt und Mitarbeiter der REGA verfügte er über wichtige Kenntnisse und Beziehungen zu andern Rettungsorganisationen. So konnte 1981 ein Vertrag zwischen der SSS/SGH und der REGA abgeschlossen werden, in dem sich die beiden Partner verpflichten, bei Höhlenrettungen zusammenzuarbeiten. Damit erreichte die SGH einen ähnlichen Status wie der Schweizer Alpenclub (SAC) bei Bergunfällen. Die regionalen Rettungskolonnen wurden weiter ausgebaut und einheitlich strukturiert, regionale Rettungskurse lösten sich im Jahresturnus mit dem Zentralrettungskurs ab. 1987 wechselte das Präsidium der Rettungskommission zu Rémy Wenger. Bereits 1988 konnte das "Handbuch für Höhlenretter" (MOESCHLER *et al.*, 1988) und ein Jahr später das "Handbuch für Einsatzleiter" (MOESCHLER *et al.*, 1989) herausgegeben werden; damit verfügte die SPELEO-SECOURS SCHWEIZ auch über einheitliche, zweisprachige Ausbildungs- und Einsatzunterlagen. Fortschritte in der Kommunikation, vor allem durch die Entwicklung mehrerer drahtloser Speläofone, und die Ausbildung und Aufstellung von Spezialisten-Gruppen (Höhlentaucher, Spreng- und Pumpfachleute) bildeten weitere Schwerpunkte in den letzten Jahren. Die Zusammenarbeit mit andern Rettungsdiensten wurde kontinuierlich gepflegt und weiter ausgebaut; insbesondere beim SAC und bei der REGA ist die SPELEO-SECOURS SCHWEIZ inzwischen als Partner und bei Höhlenunfällen als die zuständige Rettungsorganisation anerkannt.

2. Entwicklung und Erprobung der Schwarzer-Bahre

Im Rahmen der neugegründeten regionalen Rettungskolonnen plante 1976 die *Speleo-Secours Bern-Interlaken-Basel* (später: Region 6) im Juni einen Rettungskurs im *Hugoschacht* im Stockhorngebiet (Simmental / Berner Oberland). Eine Rekognoszierung mit einem Zivilschutz-Rettungsbrett endete bereits bei der ersten scharfen Kurve im engen Teil unterhalb des zweiten Schachtes im *Canyongang*; die Bahre war selbst leer nicht durch-zubringen. Auf der Heimfahrt von dieser Tour nahm die Idee einer neuen Höhlenrettungsbahre undeutlich Gestalt an. Bei einem Vortraining in Ostermundigen bei Bern wurden Ende Mai zwei Bahren-Prototypen vorgestellt: Durch den Medizinstudenten Andreas Gerber eine Art verbessertes und verstärktes

Schwedenbrett und durch den Schreiner und Bootsbauer Hans Schwarzer eine zweiteilige, knickbare Mumienschale aus Polyester (Abbildung 2). An der Übung im *Hugoschacht* erlebten beide Geräte ihren ersten Einsatz, wobei vor allem die Bahre von Hans Schwarzer aufgrund ihrer Knickbarkeit einen Patiententransport um Kurven erlaubte, die bisher mit keiner einzigen bekannten Trage passierbar waren; auch der gute Schutz des Verletzten und die leichte Handhabung beim Vertikaltransport versetzten sowohl Retter wie auch Figurant in Begeisterung.

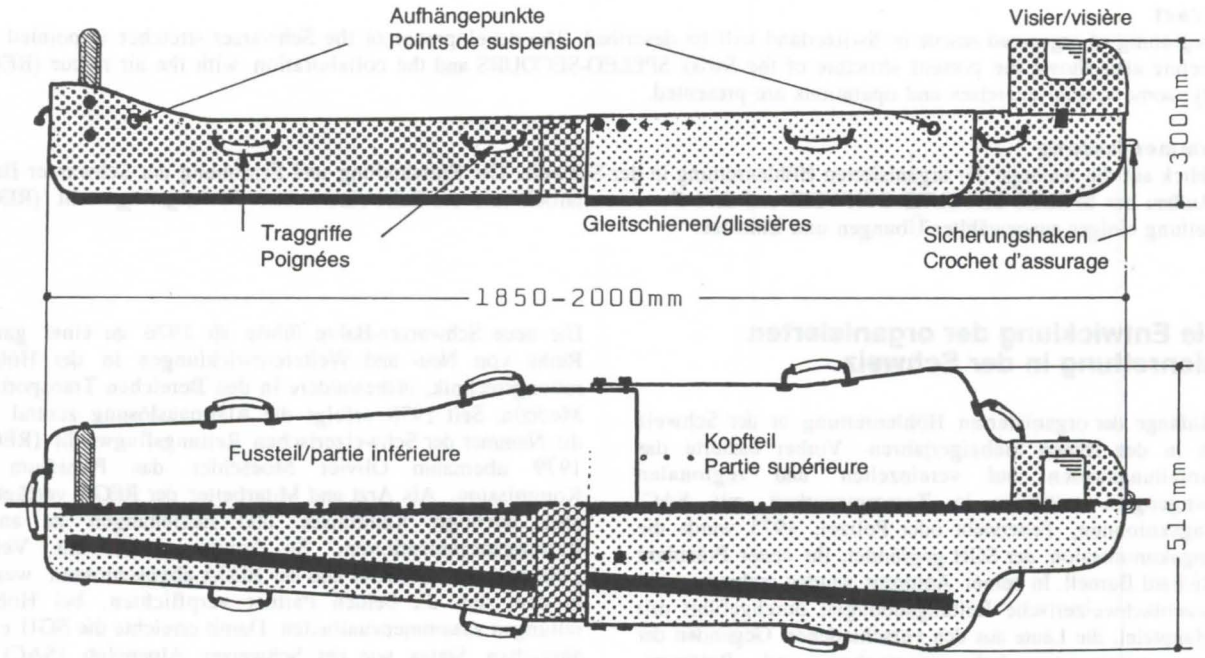

Abbildung 2: Die Schwarzer-Bahre, Serienmodell 1977-1983 (aus Probst, 1982)

Weitere Übungseinsätze in verschiedenen Schweizer Höhlen und eine Demonstration anlässlich des 7. UIS-Kongresses in Sheffield im September 1977 zeigten die Überlegenheit der Schwarzer-Bahre gegenüber andern Höhlentragen deutlich. Ein Exemplar wurde sogar vierteilig gebaut: Die zusätzliche Längsteilung macht einen Transport der leeren Bahre auch durch extreme Engstellen möglich. Am Ende des gleichen Jahres musste die Trage leider auch zur ersten Bergung eingesetzt werden: Ausgerechnet der angehende Arzt Andreas Gerber, der sich auf Hypothermie beim Bergsteigen und in der Höhlenforschung spezialisiert hatte und darüber seine Doktorarbeit verfasste, starb an Weihnachten 1977 beim Ausstieg aus dem Hochwasser führenden *Faustloch* an Unterkühlung.

In den folgenden Jahren wurden alle Rettungskolonnen der SPELEO-SECOURS SCHWEIZ mit der Schwarzer-Bahre ausgerüstet. 1981 wurde die Bahre erstmals samt Patienten mittels Zweikomponenten-Polyurethanschaum in einem passend zugeschweissten Polyäthylensack körpergenau ausgeschäumt, ein Verfahren, dass sich seither als Kälteschutz und für das Wohlbefinden mehrfach bewährt hat. Seit dem Rettungkurs 1982 der Region 6 in der *Beatushöhle* sind die notwendigen Massnahmen bekannt, damit der Verletzte auf der schwimmfähigen Bahre geschützt durch Wasserfälle und Seen transportiert werden kann. Im *Stalactite* erschien im Rahmen eines Berichtes über die Höhlenrettung auch ein Artikel über die Schwarzer-Bahre (PROBST, 1982).

Hans Schwarzer verbesserte 1983 seine Konstruktion in mehreren Punkten. Die wesentlichste Änderung ist die Längenverstellung, die nun mit einem separaten Fussteil vorgenommen wird und nicht mehr wie ursprünglich an der Knickstelle zwischen den beiden Hauptteilen. Weitere Verbesserungen wurden durch die Rettungskommission angeregt, so unter anderem die Schienung von Beinbrüchen mittels Extension. Das Gerät gehört heute zur Standardausrüstung aller Rettungskolonnen.

3. Die SPELEO-SECOURS SCHWEIZ

Die Rettungskommission der SGH ist das oberste Organ der SPELEO-SECOURS SCHWEIZ; sie wird durch den Präsidenten geleitet. Die Obmänner der einzelnen Rettungskolonnen gehören der Kommission automatisch an, weitere Personen können nach Bedarf beigezogen werden. Der Verantwortungsbereich eines Obmanns umfasst das Funktionieren der regionalen Kolonne im weitesten Sinn (Bestand, Ausbildung und Kurse, Material usw.); zusätzlich ist er der erste von fünf Einsatzleitern, die bei der Einsatzzentrale der REGA gemeldet sind und im Falle eines eintreffenden Höhlenalarms von dieser angerufen werden. Pro Region sind rund zwanzig Retter auf der Alarmliste aufgeführt. Zusätzlich stehen für die ganze Schweiz eine Verstärkungskolonne und eine Tauchrettungskolonne zur Verfügung. Auch Adresslisten für medizinische und technische Spezialisten gehören zu den Unterlagen der Einsatzleiter. Der Zusammenarbeitsvertrag mit der REGA bietet uns eine ständig professionell betreute Alarmzentrale, einen Versicherungsschutz für alle aufgebotenen Höhlenretter, Helikopter-Transportmöglichkeiten, Unterstützung bei der Kommunikation und in der Logistik und zum Schluss eine Übernahme des Inkassos.

Die SPELEO-SECOURS SCHWEIZ deckt das ganze schweizerische Gebiet ab mit Ausnahme des *Nidlenlochs* (Hinterweissenstein / Kanton Solothurn), für das die Rettungskolonne der SAC-Sektion Weissenstein zuständig ist.

4. Ausgewählte Übungen und Einsätze

1952 erregten Höhlen und ihre Gefahren vermutlich erstmals in der Schweiz die Aufmerksamkeit einer breiteren Öffentlichkeit: Eine vierköpfige Forschergruppe mit Alfred Bögli blieb wegen Hochwasser während zehn Tagen im *Hölloch* im Muotathal eingeschlossen. 1969 verunfallte ein Mitglied der AGH im Hochsystem des *Göttergangs*, einem abgelegenen und schwer zugänglichen Gebiet des *Höllochs*. Die Rettungsaktion dauerte fast vier Tage; der offene Unterschenkelbruch des Verletzten musste in der Höhle mehrmals versorgt werden. Aufgrund der gemachten Erfahrungen und der speziellen Situation in diesem riesigen Höhlensystem entwickelten die Rettungsorganisation der AGH und die mit ihr kooperierende Rettungsstation Mythen des SAC eine spezielle Doktrin: In mehreren Depots in der Höhle ist auch medizinisches Material gelagert, und die Höhlenforscher erhalten unter ärztlicher Leitung eine Ausbildung, die über die Kenntnisse eines Samariterkurses hinausgeht.

Der erste Kurs der neugegründeten Rettungskommission der SGH fand im November 1974 in Fornet statt; rund vierzig Leute waren an der Übung im *Creux d'Entier* - einer "rüden Schachthöhle", wie sich ein Kritiker des Grossanlasses äusserte - beteiligt. Ein Jahr später nahmen am Rettungskurs im gleichen Gebiet bereits hundert (!) Personen teil, die auf drei Höhlen verteilt werden mussten...

Um die Anerkennung ihrer Kompetenz bei Höhlenunfällen mussten die Mitglieder der Höhlenrettungskolonnen anfänglich hart ringen. Fälle wie 1971 in den *Grottes de Naye*, wo die örtlichen Speläologen nach einem Unfall nicht einmal orientiert wurden und sich Polizei und SAC-Rettungsleute bei der Bergung des Verletzten sehr schwer taten, sind zwar selten; dafür liegen die Dispute über Stiefel und Karbidbeleuchtung mit älteren Mitgliedern der SAC-Rettungskolonne Weissenstein im *Nidlenloch* noch gar nicht so lange zurück und sind legendär.

Zur bisher grössten Rettungsaktion der SPELEO-SECOURS SCHWEIZ kam es im Oktober 1981 *im Réseau des Sieben Hengste* (Region Hohgant / Berner Oberland), wo ein belgischer Höhlenforscher im *Réseau du Gypse* im Gebiet *Les Coucouillères* - über fünf Stunden vom Eingang entfernt - einen Oberschenkelbruch erlitt. Nach der ärztlichen Versorgung musste der Verletzte durch mehrere Engstellen ohne Bahre transportiert und zum Schluss durch den 125 m hohen Eingangsschacht des *Manneken Pis / Z 49* aufgezogen werden. Die Aktion dauerte 65 Stunden; im Einsatz standen mehr als 50 Retter, davon etwa die Hälfte belgische Kollegen und zwei Ärzte.

Auch die Suche nach vermissten bzw. eingeschlossenen Höhlentauchern führte zweimal zu Grosseinsätzen. In der *Beatushöhle* konnte im Februar 1987 der Vermisste erst nach zwanzig Stunden Suche unverletzt zwischen mehreren Syphons gefunden werden; an der zweitägigen Aktion waren 37 Retter beteiligt, davon sieben Taucher und zwei Ärzte. Im *Lauiloch* im Muotathal wurden im Oktober 1994 zwei von drei Tauchern einer Höhlenforschergruppe hinter einem temporären Syphon im *Zick-Zack-Gang* eingeschlossen. Überaus mühsam gestaltete sich für die Einsatzleitung die Suche nach geeigneten Höhlentauchern. Nach fast dreissig Stunden konnte mit den Eingeschlossenen Kontakt aufgenommen und ihnen das zum Zurücktauchen nötige Material gebracht werden. Die ganze Aktion dauerte 40 Stunden, beteiligt waren 37 Retter, davon sieben Taucher.

Der Einsatz verbesserter Kommunikationsmittel in Höhlen setzte in der Schweiz nach 1977 ein; Michael Andrée baute Ende der Siebzigerjahre ein Speläofon, dessen Grundprinzip (Einkoppeln von modulierten VLF-Wellen in den Boden bzw. Fels) er am UIS-Kongress in Grossbritannien kennengelernt hatte. Eine leistungsfähigere Ausführung mit einer tauchfesten Höhlenstation entstand in den Achtzigerjahren unter der Federführung von Edouard Marmillod und ist nun Bestandteil des gesamtschweizerischen Rettungsmaterials. Parallel dazu wurde ein einfaches und robustes Ein-Draht-Telefon (Monofon) beschafft, über das heute mehrere Regionen verfügen. Die fortschrittlichste Lösung ist momentan der AGH-Funk der Hölloch-Rettungsorganisation: Felix Ziegler hat mit seiner Gruppe ein Speläofon entwickelt und gebaut, dessen automatische Aussenstation einen Relaisbetrieb mittels VHF-Sprechfunkgeräten ermöglicht; es konnten Sprechfunkverbindungen durch 800 m Felsüberdeckung und Morsetelegrafieverbindungen durch mehr als 1400 m hergestellt werden (HURNI, 1995).

Während sich bisher die Einsätze der SPELEO-SECOURS SCHWEIZ vorwiegend auf die Rettung oder Bergung von Höhlenforscherkollegen und einigen Höhlentouristen beschränkte und die aktiven Speläologen deshalb leicht zur Mitarbeit motiviert werden konnten, werden in Zukunft wohl auch vermehrt Aussenstehende von Höhlenunfällen betroffen sein: Im September 1996 stürzte im Rahmen eines Höhlentrekkings in einer innerhalb der SGH nicht bekannten Höhle (*Edis Loch*, Entlebuch / Kanton Luzern) ein dreizehnjähriger Junge fast dreissig Meter tief in einen engen Schacht. Wie durch ein Wunder wurde er nur leicht verletzt und konnte von einer Höhlenrettungskolonne aus seiner ungemütlichen Lage befreit werden. Das aufkommende Canyoning wird innerhalb der SGH durch eine spezielle Arbeitsgruppe betreut, und bereits wurden mehrere Schlucht-Rettungsübungen, teilweise in Zusammenarbeit mit dem SAC, durchgeführt.

5. Epilog

Der Autor möchte sich zum Schluss bei all den vielen nicht namentlich erwähnten Höhlenforschern entschuldigen, deren wichtigen Beitrag zur Höhlenrettung er entweder vergessen hat oder gar nicht kennt; gerade sie sind es, die die SPELEO-SECOURS SCHWEIZ so effizient und unbürokratisch machen!

Allein von 1983 bis 1995 hat die Schweizer Höhlenrettung 43 Einsätze durchgeführt; 11 Mal konnten konnten Verletzte gerettet werden, 14 Mal waren es tödliche Unfälle. Beim Schreiben dieser Zeilen wurden viele Erinnerungen wach an verunglückte Freunde und Höhlenkollegen, die sich meist auch im Höhlenrettungswesen stark engagiert hatten. Ihrem Andenken sei dieser Artikel gewidmet.

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Histoplasmosis

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National School of High Mountain and Speleology of the Mexican Red Cross, Luis Vives 200. México D.F. 11510.

Abstract

Histoplasmosis, a little known disease. Histoplasmosis is the motive of an investigation of the National School of High Mountain and Speleology of the Mexican Red Cross in the tourist caves of Mexico. The National Society of the Red Cross not only provides underground assistance but also performs in the preventive labor field. This project will be conducted, within our possibilities as to identify health problems and safety questions related to people confined in caves as a high priority. In this sense, we have detected as a health problem the presence of a microscopic mushroom defined as *Histoplasma capsulatum* that provokes a disease known as histoplasmosis the one which alters in a virulent way the human organization. We consider that a preventive attitude according to the criteria of this investigation can influence a reduction of histoplasmosis among the caves visitors. Therefore we focus the primary interest of this study to the caves destined tourism in bulk, where the visitors ignore the existence of this pathology, the one which is frequently confused by non specialties physicians with the sintomatology of respiratory tract ailment causing through a wrong treatment an aggravation of the patient's condition.

At the Mexican Red Cross we consider convenient to provide the caves explorers with enough information about histoplasmosis and make clear that the disease exists and cannot be ignored. They must know that an effective treatment is available. At present we know for sure that there is no way to guarantee to cave visitors explorations without the risks of histoplasmosis. Tourist must face the fact that an exposition to mushroom may occur in any hole or crevasse. We suppose that in all the caves in which inhabit bats there are colonies of *Histoplasma capsulatum*. Physicians it is classified as an occupational disease that affects: mines workers and engineers, archeologists and speleologists. These physicians will define such case as work accident.

Investigation plan

The first phase of the investigation intends to detect the devastation of the mushroom *Histoplasma capsulatum* in the Mexican tourist caves with the support of the Tourism Secretariat and the National Diagnosis Institute and Epidemiological Reference of the Health Secretariat.

Conception de la civière étanche

J. Michel
30, rue Clément Janin 21000 Dijon

Abstract

The Speleo Secours Français has been perfecting a waterproof stretcher. A diver team from Dijon has been working on this prototype for several years. There's more and more exploration behind sumps by the cavers. So there is a statistical risk of accident with a pathology which prohibits the immersion and the cold. Then it's important to do research on a waterproof canvas escape chute. In other respects, on the international market, we don't find a stretcher that is really suitable for this in a similar situation.
The manufacturing takes into account the former tests and experiences. We have tried this stretcher within the security rules for divers and with the agreement from a doctor. The victim is put into a waterproof stretcher fixed onto a metallic framework. This framework also holds the bottles.

Résumé

Mise au point par le Spéléo Secours Français, une équipe de plongeurs Dijonnais travaille sur ce prototype depuis plusieurs années. La recherche sur un sac étanche d'évacuation est justifiée par le développement des explorations post-siphon par les spéléologues, d'où un risque statistique d'accident et d'éventualité d'une pathologie interdisant l'immersion et le froid. Par ailleurs, il n'existe sur le marché international aucun matériel adapté aux exigences de ce type d'intervention.
Sa fabrication tient évidemment compte des conceptions antérieures et de l'expérience acquise dans les différentes manipulations, en respectant impérativement pour la victime et l'équipe d'intervention les règles de sécurité inhérentes à la pratique de la plongée souterraine, et en ne tentant l'évacuation qu'en parfait accord avec le médecin traitant. Le blessé est transporté dans un sac étanche de forme sarcophage fixé sur un cadre métallique qui sert également de support aux bouteilles.

Prototype N^0 III

La recherche sur le sac étanche est justifiée par le développement des explorations post-siphon, d'où un risque statistique d'accident et d'éventualité d'une pathologie interdisant l'immersion et le froid.
La mise au point de cet équipement devient donc vitale et urgente.

Par ailleurs, il n'existe sur le marché international aucun matériel adapté aux exigences de ce type d'intervention.
Par conséquent, il n'y a actuellement aucune possibilité pour sortir un blessé de cette situation.
Cet avis fait l'unanimité, des éventuels sauveteurs concernés par ces sauvetages:
(Spéléos-Plongeurs / Pompiers / Gendarmes / Société de sauvetages en mer / Marine Nationale Fédération des plongeurs subaquatiques FFESSM).

Le Spéléo Secours Français (SSF) à donc pris en charge depuis plusieurs années la réalisation d'un prototype dont le modèle N^{0}3 est en cours de réalisation.

Sa fabrication tient évidemment compte des conceptions antérieures et de l'expérience acquise dans les différentes manipulations depuis plus de dix ans.

On peut même imaginer une étendue des possibilités d'intervention pour le sac étanche:
- Sauvetage en mer pour des victimes bloquées dans un navire retourné
- Personnes immobilisées par une brusque montée des eaux (sous-sol)
- Crue et/ou inondation piégeant des individus (tunnel)
- Evacuation en milieu aquatique (canyon)

Partenaires techniques :
SUBCHANDLERS / SCUBAPRO / EXPE / LICATEX / PLONGESPA

Financement :
SPELEO SECOURS FRANCAIS / COMMISSION. SECOURS DU CDS 21.

Réalisation :
SPELEO SECOURS FRANCAIS. J. Michel, 30, rue Clément Janin 21000 Dijon

Cahier des charges pour la réalisation d'une civière "plongee"

Doctrine :

Respecter impérativement pour la victime et l'équipe d'intervention les règles de sécurité inhérentes à la pratique de la plongée souterraine.
Ne tenter l'évacuation qu'en parfait accord avec le médecin traitant.

Etat de la victime après médicalisation :

Fracture immobilisée d'un membre supérieur.
Traumatisme facial.
Fractures du bassin avec plaies.
Suspicion d'hémorragie interne.
Fractures de côtes et pneumotorax.
Respiration normale.
Eventuellement non plongeur.
Bon état psychologique.

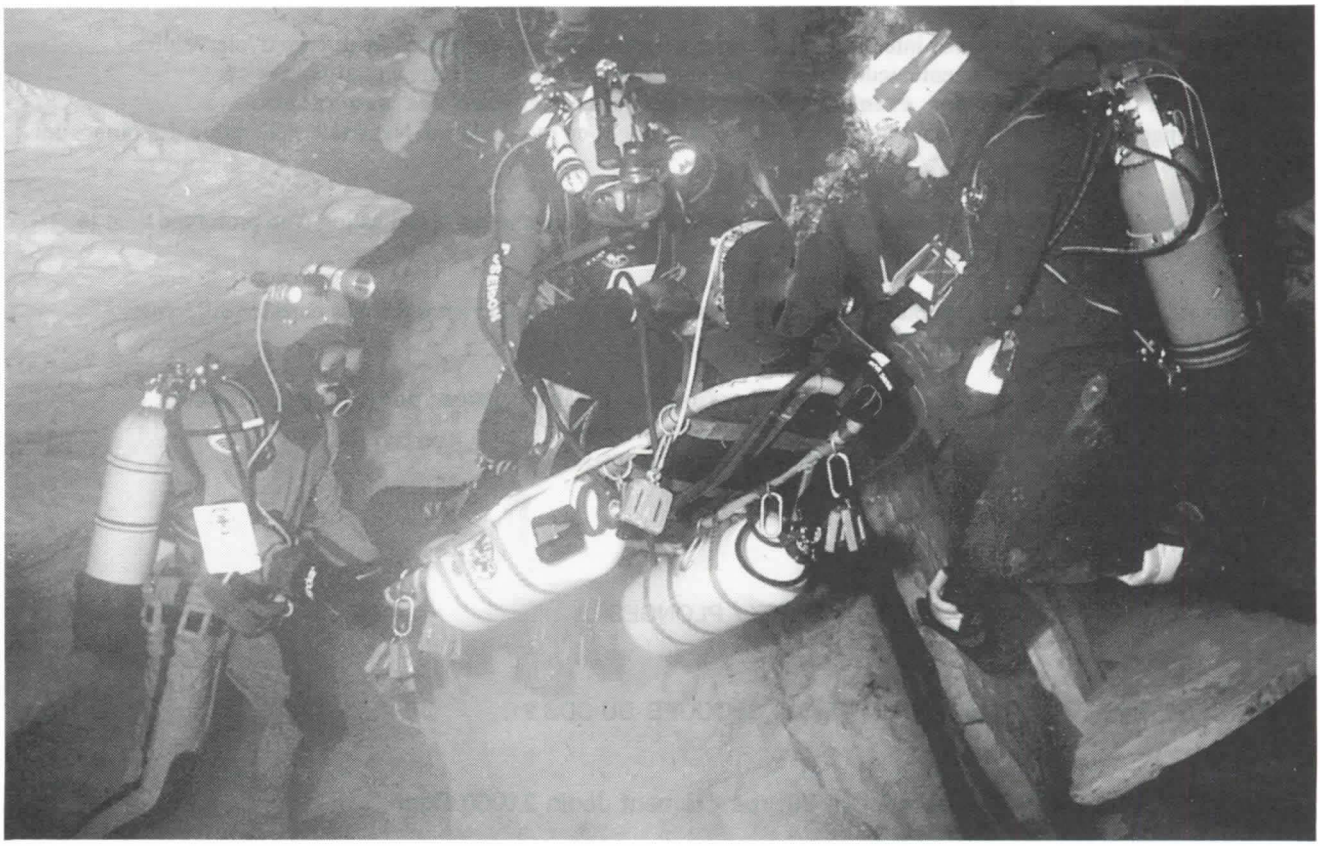
Profil du siphon :

Longueur : 200 m environ.
Profondeur : -5 m à -10 m en moyenne, court passage à -20 m.
Pas d'étroiture.
Visibilité moyenne.
Peu de courant.
Bien équipé.

Mise en oeuvre :

L'ensemble de cet équipement doit faire partie d'un lot entièrement autonome et ne pas dépendre de matériel appartenant aux sauveteurs.

- Organiser et entrainer une équipe minimum de six plongeurs (4+2)
- Anticiper l'évolution du matériel et de son maniement
- Assurer la maintenance de la totalité du matériel
- Maintenir en état d'alerte les moyens humains et matériel
- Diffuser et transmettre l'information et la formation



Description sommaire du matériel et de son utilisation

- Le blessé, après médicalisation et sur avis du médecin, est transporté dans un sac étanche de forme sarcophage avec deux bras...

- La victime est préalablement vêtue d'un vêtement de protection en deux parties séparables recto & verso. Ce vêtement est réalisé avec un garnissage en quallofil, peu sensible à l'humidité et possédant d'exellentes propriétés isothermiques. Pour compléter ce duvet, la victime est équipée d'un gilet chauffant alimenté par une batterie au plomb étanche de 12v.

- Les dimensions du sac permettent éventuellement d'installer un blessé avec une coque plastique ou dans un matelas à dépression (coquille) en cas de fractures multiples.

- L'étanchéité du cou est assuré par une collerette en latex, les gants sont solidaires des manchettes. En cas d'immobilisation d'un membre supérieur fracturé, la manche est roulée.

- La fermeture principale fait le tour du sac (sauf les épaules) permettant ainsi une ouverture quasi intégrale et une mise en place du blessé selon les principes traditionnels du secourisme.
  Deux fermetures étanches sur chaque épaule renforcent l'ouverture de la civière.

- Le blessé respire sans embout dans un masque facial Aga (Divator MKII), connecté à un manifold branché sur les premiers étages des deux bouteilles de 15l, ce montage permet grâce à une vanne deux voies l'équilibrage sur chaque bloc et la double sécurité.
- Ce système équipe également les accompagnateurs.

- Le sac étanche repose sur un cadre métallique où il est fixé par des sangles. Ce cadre sert également de support aux bouteilles pour la respiration du blessé (2x15l), et aux bouteilles d'équilibrage (2x3l).

- La structure est recouverte par un jeu de plaques en Macrolon.

- L'extrémité supérieure de la civière est sensiblement coudée, afin de relever légèrement la tête du blessé et de lui assurer une position plus confortable pour la respiration (il est installé sur le dos).

- L'ensemble du support (28 kg) se décompose en quatre parties. Un jeu de bretelles amovibles sur chaque élément facilite le portage fond de gouffre. L'alimentation en air est quadruplée par mesure de sécurité et toutes les arrivées au masque sont munies de raccords rapides avec clapets anti-retour permettant de larguer rapidement si nécessaire le masque et de couper l'air automatiquement. Des manomètres submersibles permettent le contrôle permanent de toutes les bouteilles.

- Une procédure d'urgence a été testée avec succès, pour passer la victime sur un détendeur classique dans un premier temps, et pour l'équiper d'un masque traditionnel dans un second temps.

- L'équilibrage de l'ensemble est réalisé pour le lestage, par des plombs larguables accrochés à la demande sur le bâti, et pour l'allégement, par insuflation d'air (2 direct-systèmes) dans un balast en latex compartimenté et fixé par des sangles sous le support. Les plombs sont également utilisés pour lester si besoin les conteneurs de matériel lors du passage aller du siphon.

- L'équipe d'accompagnement, composée de quatre plongeurs parfaitement entraînés, communique sous l'eau grace à un système de transmission utilisant la technologie superhétérodyne. Cette communication est tout à fait indispensable pour assurer une bonne coordination de la progression, en particulier dans des conditions de visibilité médiocres voir nulles...

- La victime est équipée d'un cardio-fréquencemètres afin d'avoir un indicateur permettant un minimum de surveillance de l'état médical du bléssé.

L'équipe d'assistance aux victimes lors des secours spéléologiques

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Abstract

The medical commission of the French Federation of Speleology (F.F.S.) and the French Speleo-Assistance (Spéléo-Secours Français, S. S.F.) works for some years on the development of very specialist teams to do victim's assistance. There are some notes about this notion.

Résumé

La commission médicale de la Fédération Française de Spéléologie et le Spéléo-Secours Français développent, depuis quelques années, la création d'équipes très spécialisées dans l'assistance aux victimes d'accidents en spéléologie. Composées de spéléologues de très bon niveau technique, elles doivent rejoindre rapidement la victime. Leur formation spécifique et le matériel dont elles disposent leur permettent alors d'enchaîner un certain nombre d'actions:

- déplacement de la victime et mise en situation de sécurité et de confort, sans aggraver les lésions préexistantes,
- premiers soins et examen du blessé, appréciation de son état, et transmission rapide de toute ces informations sous forme fiable permettant une prise de décision de l'équipe médicale, et le choix des meilleurs moyens à mettre en oeuvre,
- assistance du médecin, si il est amené à intervenir,
- soutien logistique du blessé et de l'équipe médicale tout au long de l'évacuation.

Naissance d'un concept

Organiser un secours en milieu souterrain, à plus forte raison spéléologique, nécessite de mettre en oeuvre des équipes spécialisées ayant chacune une tâche précise à accomplir. Ainsi vont se succéder dans la cavité, selon les problèmes rencontrés, des équipes de reconnaissance, de téléphonie, d'équipement, de désobstruction, de brancardage, de soutien logistique, voire même de plongeurs.

Durant les années 70, et à l'instar des Services d'Assistance Médicale d'Urgence (S.A.M.U.), la prise en charge médicale des victimes sur les lieux mêmes de l'accident, c'est à dire sous terre, s'est fort heureusement développée. Et les médecins sont souvent intervenus entourés d'une certaine assistance pour transporter leur matériel, voire pour les aider dans leurs gestes. Cette dernière tâche était d'ailleurs généralement dévolue aux quelques spéléos membres de professions paramédicales: infirmiers, ambulanciers, kinésithérapeute, manipulateurs d'électroradiologie...

Depuis la fin des années 80, l'idée d'une équipe dont la mission spécifique serait en fait l'assistance directe de la victime s'est imposée dans l'esprit de responsables du Spéléo-Secours français et de la Commission Médicale. Bien formée, elle pourrait aussi assurer, si nécessaire, et cette fois ci de façon moins aléatoire, l'assistance au médecin.

A la base de ce concept: quelques constatations simples:

- L'assistance médicale vraie, c'est à dire un médecin et des moyens d'action adaptés, n'arrive souvent que tardivement après le déclenchement du secours auprès de la victime (rareté des médecins à la fois facilement disponibles, proches du lieu de l'accident, compétents en secours et encore bien entraînés en spéléologie; renseignements sur la victime, son état, l'accident lui-même, pas toujours fiables et rendant donc le choix des moyens parfois difficile voire empirique). Or le délai moyen d'intervention des premiers sauveteurs, c'est a dire l'entrée dans la cavité après l'accident, est déjà de 4h30 (statistiques S.S.F. 89-93) . Pourquoi perdre encore du temps avant de s'occuper efficacement de la victime et ne pas en profiter également pour collecter et transmettre un maximum d'informations fiables sur son état réel ?
- Dans un nombre non négligeable de cas cette assistance médicale semble injustifiée: dans les mêmes statistiques 59% des personnes secourues sont indemnes, 10% sont malheureusement décédées, seules 31% sont considérées blessées, dont certaines sans intervention médicale indispensable: on relève en effet dans cette population 45% de contusions, 20% d'épuisements de degrés divers, 5% de malaises, et seulement 30% de fractures. Par contre l'apport d'une aide physique, physiologique (alimentation, repos, chaleur) et psychologique (notion très importante de l'assistance) est souvent indispensable.

Les débuts

Après plusieurs années de gestation, le premier stage de formation des cadres de ces équipes eut lieu en 1991. Lui et les suivants furent un véritable laboratoire pour cette méthode, dont voici quelques conclusions.

L'équipe d'assistance au blessé est relativement nombreuse. Six membres minimum, car ils emportent un matériel relativement important, ils devront mener plusieurs actions de front, et parfois déplacer la victime dans des situation très difficiles et acrobatiques. Tous sont des spéléos aguerris pouvant se déplacer rapidement sur tout type

d'équipements (jonction avec la victime la plus rapide possible dés sa localisation). Ils sont entraînés à leur mission avec l'aide des médecins intervenants habituellement avec eux, que ce soit pour les gestes paramédicaux (petits soins, attelles,...), que pour les déplacements, l'examen d'un blessé, son conditionnement ou l'aide aux gestes médicaux. Parallèlement et à l'occasion des exercices ils connaissent parfaitement et entretiennent leurs lots de matériel.

Leur matériel, justement: une fois engagés dans le secours, ils sont totalement autonomes, et devront assurer pour un temps l'intendance de la victime et parfois du médecin. Ils emportent donc vivres, réchauds, eau et produits pour la purifier. Ils disposent également de matériel paramédical (minerves, attelles...), de matériel pour déplacer le blessé (bâches), le réchauffer (heat-pack), l'isoler du froid (doudoune spéciale blessé, matelas gonflable, couvertures de survie..), de l'humidité, parfois de matériel d'examen, en tout cas toujours de fiches d'examen et de tout autre moyen pour renvoyer vers la surface des informations fiables. Par contre, ils ne prennent pas le matériel proprement médical.

L'équipe d'assistance aux victimes: son rôle tout au long du déroulement d'un secours spéléologique

C'est, par définition, l'équipe qui part en priorité, dés que la victime est localisée. Elle doit progresser très rapidement sur les équipements existants, pas toujours prévus pour le passage d'une équipe "lourde", pas toujours judicieusement installés. Mais elle doit passer rapidement, avant tout "rééquipement" qui prendrait du temps, et, malgré tout, en sécurité C'est dire toute l'importance qu'il y a a s'assurer du très bon niveau technique des spéléos qui vont la composer et qui doivent sécuriser très rapidement les zones à risques avant de s'y engager..

Arrivée le plus rapidement possible auprès de la victime, une partie de l'équipe réalise un examen immédiat de la victime, des lésions les plus évidentes (conscience, fractures) ou des suspicions les plus graves (rachis cervical) et de sa situation. Si cette dernière n'est ni de sécurité ni de confort, un déplacement primaire sera réalisé avec des moyens paramédicaux si nécessaires (minerves...) vers un emplacement préparé par l'autre partie de l'équipe et appelé "point chaud".

Dans ce "point chaud" habituellement constitué de couvertures de survie installées sous forme de tente, suffisamment spacieux pour la victime et une ou deux personnes, chauffé à plus de 20°C par les lampes à acétylène, celle ci est déshabillée et mise en tenue sèche. Un examen complet est alors réalisé, très analytique, comparé au premier examen, consigné par écrit, et envoyé immédiatement, par tout moyen disponible (estafette, téléphone) au médecin susceptible d'intervenir. Cet examen, parfois décrié par certains confrères car non effectué par un médecin, est une phase essentielle si on souhaite gagner du temps dans la mise en oeuvre du secours, et adapter au mieux les moyens à la situation. Il ne s'agit pas, pour des non médecins, de faire un diagnostic, mais de décrire en termes simples ce qu'ils constatent, grande fonction par grande fonction, région par région, guidés généralement par une fiche d'examen: conscience, pouls, respiration, présence de douleurs, de plaies, de déformations, etc Le médecin aura donc des éléments pour juger de l'utilité ou non de son action et des moyens à mettre en oeuvre, et cela d'autant plus sûrement qu'il connaîtra les compétences des équipiers et aura participé à leur formation.

Si cela est possible, la ou les victimes pourront se réchauffer, se reposer, s'alimenter, et cela résoudra la majorité des cas rencontrés, sans intervention plus lourde nécessaire.

Si une médicalisation est indispensable, un ou plusieurs membres de l'équipe doivent pouvoir assurer d'assistance au médecin" pour tous ses gestes techniques. Là encore, une bonne formation est requise. Le mieux étant qu'elle ait été réalisée avec le ou les médecins les plus susceptibles d'intervenir avec le groupe.

Enfin, l'évacuation commence. Les passages difficiles ont été aménagés, voire élargis. L'action de l'équipe ne s'arrête pas. Ils assurent toujours l'intendance de la victime et de l'équipe médicale si il y a lieu. De plus, ayant pris la précaution de reconditionner parfaitement leur matériel, ils se tiennent prêts à réinstaller un point chaud s'il le fallait. En conséquence, il ne faut pas, pendant cette phase, que la direction des secours les oriente vers d'autres actions. En cas de coup dur, blessé et médecin pourraient se retrouver "en chemise". Equipe d'assistance ils sont., équipe d'assistance ils restent, du début à la fin du sauvetage.

Conclusion

Actuellement, quelques équipes sont déjà bien structurées et opérationnelles, certaines ont déjà été mises à contribution. Ces débuts sont prometteurs. N'en doutons pas, les quelques idées simples exposées ici vont faire leur chemin, et, progressivement, les massifs spéléologiques franc,ais seront couverts par ces groupes d'intervention.

Mais je ne peux conclure en passant sous silence certaines réticences liées à la crainte d'un désengagement du corps médical, d'une "demédicalisation" des secours. Je pense véritablement que cette crainte est injustifiée. Bien au contraire nous allons pouvoir mieux adapter la prise en charge médicale, en moyens et en personnels, aux vrais besoins des victimes, et cela est un réel progrès.

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Epidemic dangers in the caves of Middle Asia

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Abstract

A microbiological study of the Kupp-Koutan-2 and Tash-Yurak caves (Kugitangtow ridge, Turkmenistan) showed that pathogenic and conventional pathogenic microorganicms found in the caves could be dangerous for humans. *Staphylococcus, Enterobacteria, Penicillus, Aspergillus, Nanizzia*-like from Gymenoascaceae fungi were isolated from sediment samples and air. The most dangerous places are connected with subentrance sediments consisting of organic dust where the main part is faeces of animals. Deep parts of caves are safe. However, we have discoveried a pollution by enterobacteria near the cavers base existing for a long time. Also we have discovered that a group of 6 cavers increase the concentration of microorganisms in the air by three times because the dry dust and the spores rise to the air very easily.

Аннотация

Микробиологическое обследование пещер Кап-Кутан-2 и Таш-Юрак (хр.Кугитангтау, Туркменистан) показало, что встречающиеся там патогенные и условно-патогенные виды бактерий и микромицетов могут представлять опасность для человека. Среди таких организмов были выделены *Staphylococcus, Enterobacter, Penicillus, Aspergillus*, гименоасковые грибы близкие к *Nanizzia*. Отмечено, что места наибольшей опасности связанны с привходовыми отложениями рыхлой органической пыли, значительная часть которой представлена сухой фекальной массой грызунов и копытных. Объемы и отложения глубинного карста в достаточной степени стерильны от условно патогенных организмов, исключая районы длительно существующих подземных стоянок, где было выявлено загрязнение бактериями кишечной группы. Было также установлено, что передвижение группы из 6 человек по рыхлым органическим отложениям увеличивают микробную обсемененность воздуха в 3 раза из-за того, что сухая пыль и споры легко поднимаются в воздух.

The caves of Kugitangtow ridge were studied for pathogenic and conventional pathogenic species of microorganisms contained in different kinds of the sediments and in the caves' air.

We think that the caves of Kugitangtow ridge is an ideal model of other Middle Asian Caves, because they contain all main elements of underground landscapes typical for Asian regions: sediments connected with bats, porcupines, gnawers, unguligraders etc., and also the deep part of the caves contain mineral sediments only.

We worked with samples of sediments which were studied by cultural technique on Levin (for enterobacteria) [3], Chapeck (for micromycetes) [2], blood agar (for hemolythic bacteria) [3], egg yolk salt agar (for pathogenic coccus) [3] and beef-extract agar (for summary saprothrophic bacteria) media. The air was studied by Kokhs sediment method [3] during our expedition in the caves. Incubation was fulfilled between 24°C and 35°C.

As a result of studies the **Table 1** was made.

samples	sum of saprophytes bacreria	sum of saprophytes fungi	sum of conventional enterobacteria	pathogenic enterobacteria	Staphylococcus	hemolyth. bacteria	pathogenic fungi
Organic sediments near entrance of Kupp-Koutan Cave	$1 * 10^7$	$1,8 * 10^4$	$8 * 10^3$	$0,3 * 10^3$	++	NO	++
Organic sediments near entrance of Tash-Yurak Cave	$9 * 10^6$	$0,5 * 10^4$	$1,2 * 10^3$	NO	NO	$1,5 * 10^3$	++
Flood mineral sediments in Snezhny Korolevy Chamber	$3,2 * 10^6$	$5,1 * 10^5$	$7 * 10^3$	NO	+	$2 * 10^3$	NO
Flood mineral sediments in Skazka Chamber near cavers base	$2,4 * 10^6$	$3 * 10^4$	$5 * 10^4$	$5,5 * 10^3$	++	$4 * 10^3$	NO
Red-color ocher from Snezhny Korolevy Chamber	$7,6 * 10^6$	$1,2 * 10^5$	NO	NO	NO	$0,5 * 10^3$	NO
Faeces of bats from Ozerny Khod Passage	?	?	?	?	?	?	+++

Table 1: Concentration of microorganisms in the organic sediments and in the clay (CFU - colony forming units/gr)

It's necessary to give some explanations:

Pathogenic enterobacteria. This is a type of organisms isolated by classic medical techniques and biochemical tests. Pathogenic enterobacteria were distinguished as forming the uncoloured colonia on media with lactose, eosine and methilthioninchloride. On the other hand natural microflora is painted in blue or red colours [3]. We didn't study our cultures in medical-biological tests.

Pathogenic fungi. Fungi were studied in pure culture and also by microscopy in samples. Identification was made by morphology of reproductive organs. We have found many species of fungi which could be an agent of infection and allergy. *Aspergillus flavus, Aspergillus fumigatus*-like, *Penicillum faniculesum, Penicillus purpurogenum, Aspergullus sp., Penicillus sp.* are isolated from samples of sediments. Also we have discovered *Gymenoascaceae* fungi like *Nanizzia* which could cause dermatomycosis infection. There were some cases of dermatomycosis in caver groups after expeditions [Korshunov, pers. comm]. Characteristic for this infection is the fall of skin density. *Hystoplasma capsulata* as one of the most dangerous microorganisms wasn't found in the caves yet.

Hemolythical bacteria. Those are bacteria having ability of growth in blood media and forming hemolysis zones in agar.

Staphylococcus. The discovery of many Staphylococcus in the caves [1] is a real fact. We also have found them in sediments samples and air. 95% of those bacteria are *Staphylococcus albus*-like organisms. However, the conclusion about their pathogenic property is rather doubtful. We suppose that we usually find a free-living form in the caves.

It's evidently that subentrance chambers containing the organic matter of gnawer's and unguligrader's faeces are the most dangerous parts of the caves. Moderate dry conditions and a variety of organic substrates are a reason for the high stability of saponoze infection agents and other epidemic infectiones types. A big role in the support of infection agents lifecycle is played by the zoological factor. The subentrance parts are the environment for animals (mainly gnawers) which can be the natural reserve for some infections. And also, the most part of carriers is dwelling in the similar environment. As an example, we have calculated a quantity of mites which are carriers of Human Return Typhus (*Ornithodorus sp.*). In the subentrance chambers of Tash-Yurak Cave we could calculate about 2-3 mites/m^2. In the part of this cave where organic sediments are absent we have calculated 1 mite/10 m^2 and less. In the deep parts of other caves *Ornithodorus* mites were not found.

We studied also caves' air in the subentrance chamber (with organic sediments) and in the Baobab Chamber (with mineral sediments mainly) "before" and "after" the pass of group of 6 cavers. It was discovered that concentration of microorganisms in the air had become three times higher (**Table 2**).

The point of tests	The sum of saprothrophic bacteria	The sum of enterobacteria	The sum of Staphylococcus	The sum of micromycetes
Subentrance chamber of Kupp-Koutan Cave "before" cavers	$4,5 * 10^3$	NO	NO	$8 * 10$
Subentrance chamber of Kupp-Koutan Cave "afterwards" cavers	$1,2 * 10^4$	NO	$0,7 * 10$	$3,1 * 10^2$
Baobab Chamber of Kupp-Koutan Cave "before" cavers	$3,2 * 10^2$	NO	NO	$0,3 * 10$
Baobab Chamber of Kupp-Koutan Cave "afterwards" cavers	$9,8 * 10^2$	NO	NO	$0,7 * 10$

Table 2: Concentration of microorganisms in the cave's air (CFU - conoly forming units/m^3)

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Geophysically predicted and discovered large cave emptinesses in Siberia

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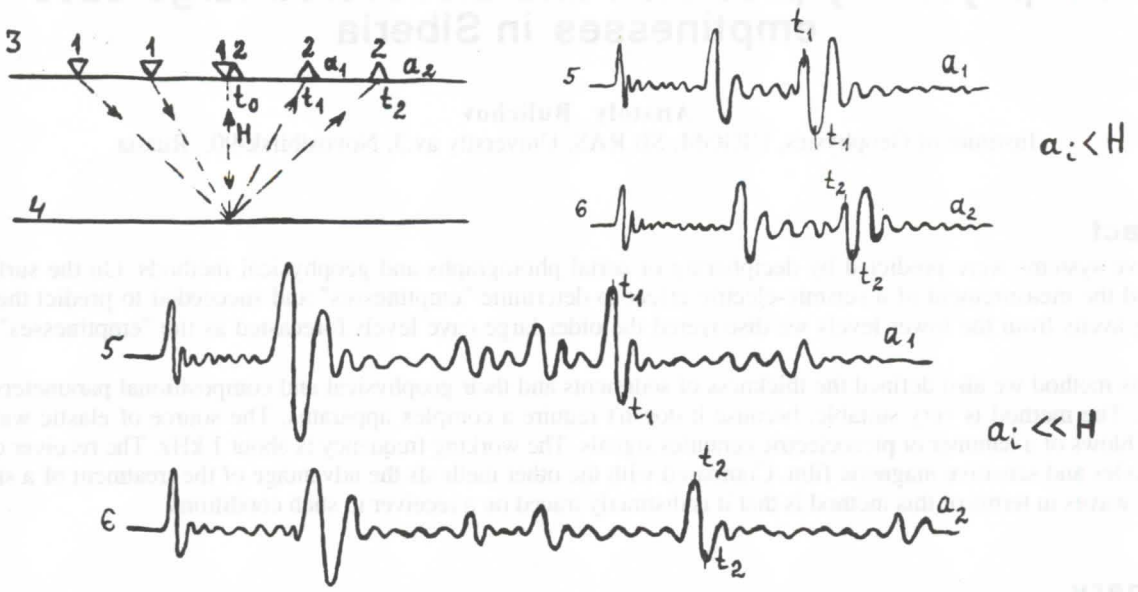
Abstract
Huge cave systems were predicted by deciphering of aerial photographs and geophysical methods. On the surface we organized the measurement of a seismic-electric effect to determine "emptinesses" and succeeded to predict them. By climbing avens from the lower levels we discovered the older large cave levels forecasted as the "emptinesses" on the surface.
Using this method we also defined the thickness of sediments and their geophysical and compositional parameters inside the cave. The method is very suitable, because it doesn't require a complex apparatus. The source of elastic waves are repeated blows of a hammer or piezoelectric ceramics signals. The working frequency is about 1 kHz. The receiver consists of electrodes and sensitive magnetic film. Compared with the other methods the advantage of the treatment of a signal of reflected waves in terms of this method is that it is distinctly traced on a receiver in such conditions.

Summary
On the surface, the method of seismic-electric effect made it possible to outline the emptinesses in karst massifs, if the depth of a frontier between the covering rocks and the emptinesses doesn't exceed 15-20 m and if the frontier is harsh and legible. Measurements were carried out in Altai karst massifs (Seminsky range, Altaiskaya and Kektash caves) and East Sayan massifs (Great Oreshnaya cave).
The same method, successfully tested in cave conditions, allowed to determine the thickness of clayey-sand, clayey-lime sediments covering the limestone or dolomite basement in galleries. The method may be useful for specialists studying the sedimentary covers in caves. For the first time, the method was applied by the author in field conditions on reflected waves.

1. Introduction
Since 1978 we investigate the wonderful karst massifs of Siberia (BULICHOV, 1990). In mountainous Altai we succeeded, by deciphering of aerial photographs, to determine the most promising points of new cave entrances, which later were opened. Usually we looked for fault intersections and opened caves such as the Soan-technical (-240), Duet (-100) and many others (BULICHOV, 1989a). In the lower levels we studied cracks and faults to reach the upper unknown cave levels. So, large horizontal galleries were discovered in Altaiskaya cave (BULICHOV, 1989b), in Kektash cave, which is the deepest in Siberia (-350m), and in Great Oreshnaya (length 50km, NSU and Sibirskaya systems) (BULICHOV, 1988) and in other caves. But to get there we had to climb up 40-130 m of sheer or hanging walls using artificial bolts, pitons, stoppers, platforms, climbing stairs and serious mountain skill (BULICHOV, 1989c). Often only the ceiling was found. That is why we wished to know how to recognize the emptinesses by some additional method to find be sure to find other levels. Thus, the attempts to reveal the emptinesses with acoustical and seismic-electric methods were made. The latter method was more preferable as far as the first entries of waves were more legible and strong (BULICHOV, 1996).

2. Seismic-electric effect
The seismic-electric effect (SEE) is the appearance of the difference of potentials or electric field tension between two points where the gradient of pressure exists in moisture-saturated porous rocks along elastic wave propagation (BULICHOV, 1980). SEE nature relates to electric-kinetic phenomena in binary electric layers on the solid/liquid interface (PARHOMENKO, 1978). The SEE value depends on elastic affect intensity and rock parameters such as porosity, permeability, electric resistance, x (potential value), liquid phase composition, temperature, concentration and others (BULICHOV, 1982). Lots of successful experiments were made for various rocks in laboratory conditions on guided waves to study the properties of SEE and the ways to use it in geological practice (BULICHOV, 1983).

3.Field measurement of SEE
For the first time a SEE experiment was carried out on the reflected waves in field conditions. The technique is not complex (figure 1): any spare of apparatus may be changed by manual instruments and/or any procedure may be fulfilled manually. This makes the method attractive for studies inside of caves. Block 1 is represented by power bimorph piezoelectric ceramic source, several batteries and electric transformer or simply by repeated blows of a heavy hammer.



1- block-generator of elastic wave impulses
2 - block-register of electric field
3 - surface
4 - reflecting frontier
a_1 , a_2 - distances between source and receiver in different positions (method of common depth point)
H - thickness of layer
t_o - time of signal arrival in case of straight seismic ray
t_1, t_2 - times of reflected waves sinphases axes for a_1 and a_2 positions
5, 6 - examples of SEE signals on oscillograph sweep

Figure 1 : SEE experiment technique

The block 2 consists of two electrodes, electric amplifier and refined registering device with sensitive magnetic film or portable oscillograph (if dynamo used or benzine electric-generator on surface used). To divide the guided and reflected signals we chose a_i < H and H >= 2λ, where λ is the wave length. Elastic waves frequencies were 500 - 1000 Hz depending on the depth of the frontier 4 and sedimentary cover parameters. Amplitudes of SEE were 40- 200 mkV. From figure 1 follows:

$$H = \frac{1}{2}\sqrt{\frac{a_2^2 t_1^2 - a_1^2 t_2^2}{t_2^2 - t_1^2}}$$

$$v = \frac{1}{t_1}\sqrt{\frac{a_2^2 t_1^2 - a_1^2 t_2^2}{t_2^2 - t_1^2} + a_1^2}$$

where v is the wave velocity.
The method works only in case of a legible, harsh and strong reflecting frontier (densities of rocks in layers should differ clearly). In moisture-saturated rocks and soils the SEE signal was obviously more clear than the acoustical one, so it was more convenient for treatment. It is caused by the formation of integral SEE amplitude along the acoustical wave propagation (BULICHOV,1983). The method may work at greater depths by increasing the elastic affect intensity. In our case only the depths of 15-20m were reached. For greater depths it is necessary to use heavier hammer or higher electric tension on the input.

4. Results of SEE field measurements in caves

On the surface we made the measurements using the piezoelectric ceramic source. In 1988, the experiments were carried out on the plateau near Oreshnaya cave. At the depths of 10-12m the emptinesses were predicted but no entrances were found. From the lower storeys a 90 m aven was climbed upwards. So we reached these emptinesses and discovered three great systems "Lotos", "Strem", and "Sibirskaya". Large emptinesses were predicted on the plateau above the Altaiskaya cave at the depths of 10-20 m in five places. Three of them were later reached (the upper parts of huge shafts, figure 2), and two (above "Old river" and "Ali-baba") have not been recovered yet. Not far from the Altaiskaya cave large emptinesses were predicted but remained unrecovered yet.

Special experiments were organized in 1995 in Altaiskaya cave (figure 2) discovered by the authors and investigated for several years (the exact map is published here for the first time). We tried to determine the thickness of sedimentary covers in galleries.

A heavy hammer was used as a source of elastic waves. We hammered many times on a hard plate situated on a layer surface. For the block-register of electric field we used 10 light silver-zinc batteries, each of them having 4,5V outlet. To compare the resulting intensity of acoustical field we also used the piezoelectric ceramic source with the mentioned batteries on the input. The signal was faint but possible to be registered. Later we could use a more powerful bimorph piezoelectric ceramic source of acoustical waves. The main frequency was about 1000 Hz. For example, the determined thickness of clayey and clayey-sandy deposits on the second cave level "Old river" was 5-6 m in different places, in grotto "Tube" it was 9m, on the third level in gallery "Camel" clayey deposits with limestone inclusions reached 2.5 m, in grotto "Sphinx" 4 m, etc. We verified the precision of the method on an artificial model in laboratory conditions. Examinations were sufficiently successful.

5.Conclusion

First steps have been made to conduct SEE experiment in karst massifs. We would like to improve the block-register (record, reproduction). More measurements on Seminsky and Sumultinsky ranges are planned. The SEE method may be useful for geologists and archeologists researching caves deposits. Elaboration of borehole geoacoustics and SEE investigations of carbonic oil collectors and deep karst stratums is proposed. Finally I'd like to appretiate the help in work and advises of V.Z.Koksharov - UIGGM geoacoustics department leader.

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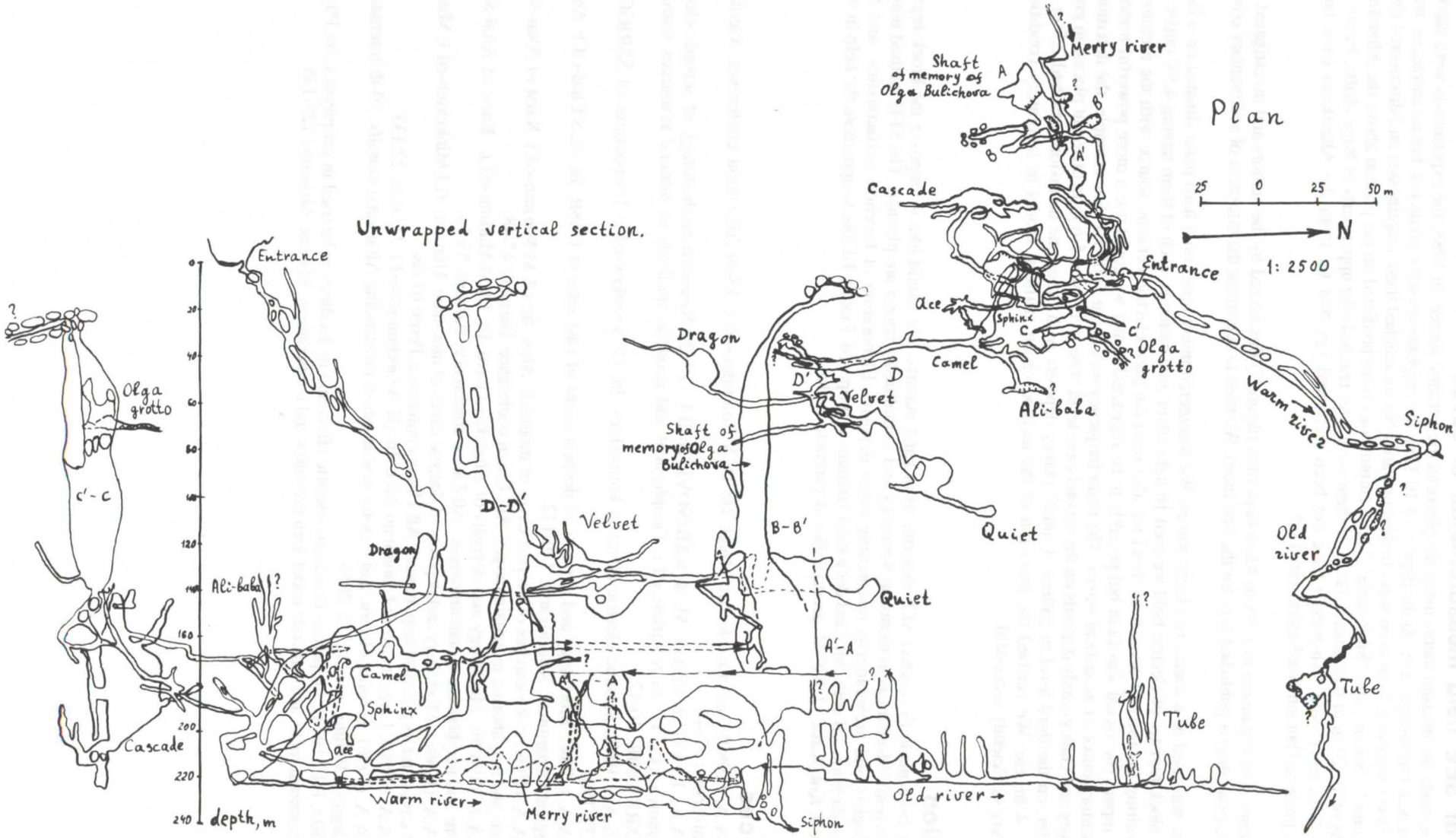

Figure 2 : One of our objects - cave Altaiskaya (maped by A.Bulichov, "Cascade-Adventure" Novosibirsk Club leader), L=4460m,-240m on 1996 year

Automatic ignition for carbide lamps

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Abstract

The carbide lamp comes up to cave and caving requirements. The only weakness is the ignition system. The piezoelectric ignitor is a simple and reliable unit, but can't secure caving with carbide lamp safely especially in difficult cave conditions with strong draughts, rains, waterfalls etc.

For increasing caving safety a carbide lamp with automatic ignition is proposed. The illumination sensor controls the carbide as well as the electric lamps. Nearly ten years exploitation of the carbide lamps with automatic ignition in various cave's conditions have shown that the electronic unit is reliable and caving is save .

1. Introduction

Electric spark arisen in consequence of high voltage discharge is widely used for carbide lamps ignition. The high voltage is produced by piezoelectric or electronic converters.

The piezoelectric converters are reliable, unfastidious, and power supply is not required. A single spark is produced for a working cycle. The electric converters are more complicated, more expensive, a power supply is needed, but the ignition reliability is higher because of the high frequency rate of the sparks. Acetylene and air mix into the discharge chamber and ignition is possible even with a weak spark (not more than 1 mJ). I think the only inconvenience is the manual ignition control. At difficult cave conditions (strong draught, rain etc.) an exploration with carbide lamps is not impossible and an electric lamp is necessary. The flame burning during external situations (climbing etc.) will be able to cause accidents. Evidently manually controlled ignition of the carbide lamp is not effective for difficult caving and is frequently replaced with an electric lamp. The use of the electric converter makes it possible to automate the ignition process. The carbide lamp efficiency and the service life of a battery is increased. In this case caving safety is higher and caving may be mainly realized with carbide illumination.

The idea of the automatic ignition was born in 1987 due to an unsuccessful experience with a piezoelectric ignitor. The first carbide lamp with automatic ignition had been built the same year. However, various models of the automatic ignition carbide lamp were equipped with tubular metal gas jets. Electric discharge was realized between an open high voltage electrode and the tip of the jet. Such carbide lamps operate in various cave conditions occuring during the vertical wet caving. But an open high voltage electrode is potential dangerous especially in damp environment. This defect has been eliminated by 1995 in the carbide lamp using a ceramic jet.

2. The idea of the automatic ignition using ceramic jet

The eramic jet is a ideal unit for the carbide lamp. It provides a powerful flame, has high reliability and easy replacement. But using automatic ignition in this case is not easy. Such a jet is bigger than the tubular one. The arrangement of the discharger electrodes above a jet (GANTER, 1989) is unreliable and dangerous. Using of an added, automatically ignited tubular metal jet with low gas consumption for lighting the main torch is not comfortable.

I think that the gas ignition scheme through the jet is the best (see figure 1). The high voltage electrode in this case is inside of the jet and discharge is realized through the gas channel to the lamp's body.

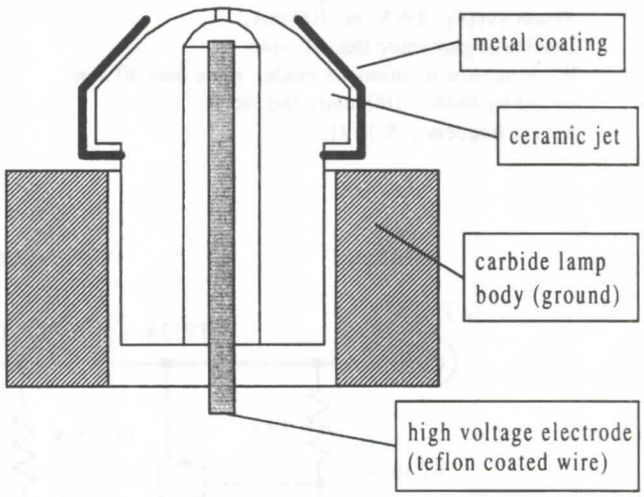

Figure 1 : Arrangement of the carbide lamp elements

The high voltage electrode is protected from environmental forces and is inaccessible for users. Decreasing of the discharge distance can be achieved by metallization of the top jet surface.

This scheme may evoke the next question: will the gas ignite or not? After all, pure acetylene rises from the jet. Gas-dynamic analysis shows that the gas-air mixture exists in an outlying area. This mixture is first ignited and later lights the main flow. For thin moving flow ignition a stronger spark is needed. Experimental investigations have shown that the spark energy has to be more than 5 mJ if the gas consumption is 14-16 liters per hour.

3. Electric scheme description

Very hard demands are made for the cave electronic equipments. There are 100% humidity, sharp environmental temperature changing, low voltage and economic power supply, compactness, lightweight. High voltage electronics make the demands harder.

Single-stage high-voltage converters, used in the automobile industry, have low quality and can't be made as compact and economic devices. Usually such units use double-stage converters. The first stage increases the voltage from the battery level to 100-200 V, charging an accumulation capacitor. The

second stage discharges the capacitor through a primary high voltage transformer's winding. The output voltage on the secondary winding may reach a few tens kilovolt. The distance between electrodes of the discharger in the carbide lamp with ceramic jet is more than 5 mm. It is in accordance with the voltage requested from the converter, approximately 20 kV. It is not recommended to use an accumulation capacitor charge voltage higher than 300 V, because special pulsed high voltage capacitors have large dimensions, but a compact capacitor can be damaged during discharge through thermal destruction of the capacitor's isolation. That is why the additional increase of the output voltage is achieved with the aid of a second stage of the converter. For achievement of the second stage work efficiency a fast thyristor is used. Because such elements need high operational current, an additional control unit is applied. With the unit parameters choice repetition frequency and discharge voltage are tuned. The scheme of the automatic ignitor is represented on the figure 2. The main parameters are:

Power supply: 3-6 V, 60-100 mA;
Discharge gap: more than 10 mm;
Working time (continuous mode): more than 30 min;
(stand-by mode): 100 hours and more;
Sparks frequency: 5-15 Hz;

The scheme is easy in tuning, steady and may be reproducible as a serial product.

4.Conclusion

The design of the automatic ignition carbide lamp with ceramic jet has been considered. In the design for increasing ignitor protection from environmental forces and exploitation safety, the high voltage electrode is placed inside of the jet. The ignitor scheme is made for serial production conditions. Since 1995 almost 60 carbide lamps have been made. Tests carrying out in the various caves demonstrated the capacity for work of the carbide lamp and caving safety.

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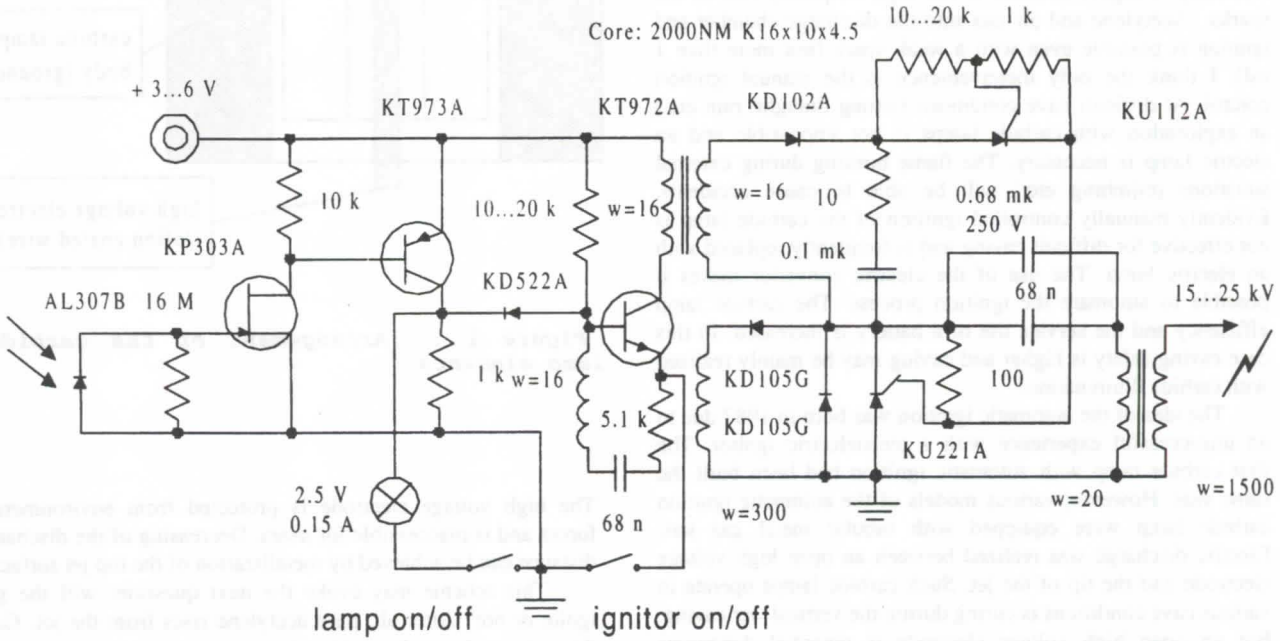

Figure 2 : Scheme of the automatic ignitor

An impulse generator for the ground penetrating radar

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Abstract

In the latest time, ground penetrating radars (GPR) are widely used for search and analysis of varied underground objects of natural and artificial origins. Caves and cavities can also be found and investigated with the GPR's aid. The Impulse generator is the key unit which determines GPR's parameters: depth of penetrating, accuracy etc.

Serial power drift diodes are used for generation step voltage with nanosecond rise time. A few kilowatts peak power and a frequency repetition near 20 kHz with portable power supplies have been achieved. Such generators can be used in the simple GPR for cave-finding applications.

1. Introduction

In recent time an electromagnetic sensing technique by the ground penetrating radars (GPR) are widely used for engineering geophysics tasks (DANIELS et al., 1988). GPR utilize a burst of electromagnetic energy pulses sent into the ground from a transmitter antenna located on the surface. Subsurface structures, such as bedding, cementation, changes in moisture and clay content, cavities, voids, fractures, intrusions, man-made objects and many other interfaces showing a contrast in dielectric properties cause some of the pulse energy to be reflected back to the surface, while the rest of the energy continues to penetrate deeper. The reflected pulse energy is picked up by a receiver antenna on the surface. These signals are then processed and plotted in a distance versus time-depth display. Thus, as the radar antenna is slowly towed across the surface, a continuous cross-sectional "picture" of subsurface conditions is generated. GPR can be used for mapping geologic strata, aquifers, aquicludes, voids, shallow bedrock units and fractures, site clearance for drilling, mapping utilities, locating underground storage tanks, archaeology etc.

The depth of penetrating is dependent on the conditions found at each site. Electromagnetic pulse launched by GPR are attenuated (absorbed or scattered) by certain properties of the site's soil; the most important of which is the electrical conductivity of the material. Generally, better overall penetrating is achieved in dry sandy soils; reduced penetrating is achieved in moist, clay or conductive soils. Considerable depth may be attained in saturated sands or through lake water if the specific conductance of the water is low. Radar penetrating is excellent in massive dry materials such as granite, limestone, and concrete.

GPR operating abilities are dependent on the impulse transmitter (pulser), antennas, receiving electronics and the data processing algorithm used. A pulser for engineering geophysics applications has to generate kilowatt impulses with a duration from 1 to 10 nanoseconds at a repetition rate of more than 10 kHz.

High power impulse generation possibilities by drift diodes are considered and a simple pulser for portable GPR for various caves and voids location is proposed.

2. Power nanosecond pulse generation

High power nanosecond pulses are mainly generated with various gas-filled or vacuum electric switches. However, amplitude and shape unstability, low repetition rate and efficiency create obstacles to use these devices in the GPR. Semiconductor devices, such as step-recovery diodes, avalanche diodes and transistors, generate step voltage only ten's volt per unit. Frequently this power level is not enough for engineering geophysics applications.

A new effect for powering high voltage nanosecond impulse generation was discovered in 1983 (HREHOV et al., 1983). This effect is similar to the other one used in step-recovery diodes, but applicable to power drift diodes. It is called a step-recovery drift-diodes effect. Peak power more than 1.6 megawatt (10 Ohm loading) with 2 nanosecond rise time was achieved with using step-recovery drift diodes (BRYLEVSKY et al., 1988). The step-recovery effect in drift diodes may be observed only with satisfaction of the specific conditions. Because charge carriers mobility in the drift diodes are low, straight direction currents through p-n junctions are not constant, but short. Moreover, for drift diodes with a long life time of the charge carrier, the straight direction current time has to be as short as possible, but no more than 500 nanosecond. If the diode has a short life time of the charge carrier (approximately 500 nanoseconds) the straight direction current time is limited with the p-n junction overheating and may be more than 10 microseconds (HREHOV et. al., 1984). The best results may be obtained with special diodes, but I have no information about manufacturing such devices at presence time.

There are many serially produced diodes that may be used as step-recovery drift-diode (ZIENKO, 1984). Differences of serially made diodes from ideal ones cause a pulse shape distortion and efficiency decreasing. This defects may be eliminated by carrying out the following conditions (BELKIN et al., 1992): a) straight direction current time and charge brought into the diode base region have to be as small as possible; and b) back direction current time has to be more than ten times smaller in comparison with straight direction current time.

3. Impulse generator based on drift step-recovery diodes

Earlier drift diodes are used as sharpener of a step voltage generated with power semiconductor switchers (e.g. modulator thyristor) (ZIENKO, 1984; HREHOV et al., 1986; KARDO-SYSOEV & CHASHNIKOV, 1986). Schemes using a thyristor as active element are optimal as step voltage former if the pulse duration is longesr than its rise time. If pulse duration and rise time are comparable, thyristor generators have a low efficiency. Energy losses deal with thyristor switching losses and dissipation energy into the

drift diode. Low efficiency and comparatively slow work limit the impulse repetition rate.

BRYLEVSKY et al. (1988) have proposed to use intermediate inductance energy accumulators. Energy transmission from the inductance accumulator to loading was realized with step recovery drift diodes. In this case losses determined earlier decreased, efficiency increased and the impulse voltage amplitude of the generator significantly exceeded the power supply voltage. Impulse voltage near 1300 Volt with 2 nanosecond rise time on the 50-Ohm loading was formed with the generator using 50 Volt power supply. The scheme's efficiency was more than 20 per cent with a 20 kHz repetition rate. The generator was used switching two powerful bipolar transistors (V_{CE} = 70 V, I_C = 20 A, f_1 > 90 MHz) assembly connected with Darlington's scheme. Commutation currents were at several tens of amperes and control currents were a few amperes.

BELKIN et al. (1992) have proposed a scheme decision with one single active commutator. Current reverse through the drift diode was provided with a saturation core transformer. The Capacitor connected sequentially with the secondary winding of the transformer and the drift diode was charging when the commutator was switched on. Thus straight direction current through the p-n-junction of the diode was realized. Further, the capacitor fast discharged through the low inductance of the transformer's saturated secondary winding and the drift diode. Because the charges accumulated within the capacitor and those passed through the diode are approximately equal, the diode recovered when the capacitor discharged. When the diode recovered, due to the self-induction effect on the loading resistance connected in parallel with the diode a nanosecond pulse was generated. The impulse voltage of 700-1000 Volt with a 1-1.5 nanosecond rise time on the 50-Ohm loading was formed with the generator using a 100-150 Volt power supply. Repetition rate was 50 kHz and efficiency was near 50 per cent. A power pulse bipolar transistor (V_{CE} = 150 V, I_{CM} = 25 A, P_{TOT} = 450 W) was used as commutator. The capacitor's discharge time was approximately 100 nanoseconds.

As a result of the described schemes, analysis nanosecond pulse generators have been made and tested. The principle of operation is explained in figure 1. During the time t_1 when the commutator S1 is switched on, energy is accumulating in the primary winding of the transformer TV1. Due to the self-induction effect when the commutator S1 is switching off, the capacitor C1, connected to the secondary winding of TV1, is charging. Time t_2 after commutator S2 is switching on and capacitor C1 during the time t_3 fast discharges through primary winding of transformer with saturation core TV2. Further processes, described earlier, are occuring.

Output circuit parameters of the generator are tuned so that the transformer's TV2 core saturation has been placed at the moment when the capacitor C2 charges. Interval duration t_3 does not influence the impulse forming. This time has to be enough for the full capacitor C2 discharge. Unit efficiency will be maximal if C1 and C2 capacitances will be approximately equal.

The impulse generator's scheme is represented in figure 2. An N-channel enhancement mode field-effect power transistor BUK456-100A (V_{DS} = 100 V, I_{DM} > 130 A, tr < 60 ns) was used as commutator S1. For the capacitor C2 discharge a fast-switching N-channel insulated gate bipolar power transistor (V_{CE} = 800 V, I_{CM} = 50 A, tr = 45 ns) was selected.

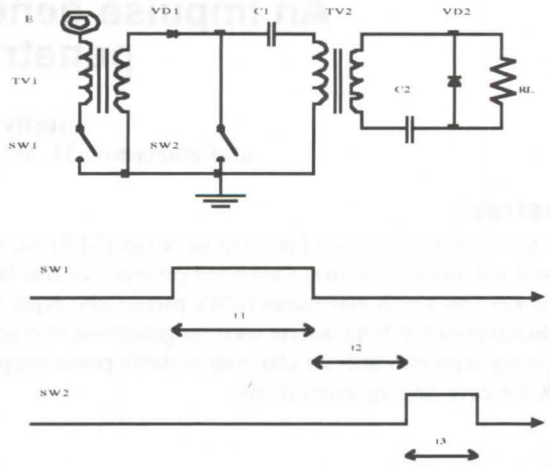

Figure 1 : Operation principle of the impulse generator based on step-recovery drift diode

The Commutator's control unit was realized on fast TTL logic elements. The control voltage for the transistors has to have amplitudes from 5 to 30 Volts. This volume is higher than standard fast TTL signals level. Level conversion was made on fast middle-power switching n-p-n transistors (V_{CE} = 60 V, I_C = 1 A, f1 > 200 MHz, R_{CE}(on) < 2 Ohm) with transformer loading that provided galvanic outcome between control unit and output stage of the generator.

The charge voltage of the capacitor C1 was set with time interval t_1 changing, varying from 100 to 500 nanoseconds.

4. Discussions

During this work the following results have been achieved:

Impulse with peak amplitude of 500 V and 2 nanosecond rise time (12 nanosecond full pulse duration) was achieved on the 50 Ohm loading with a 50 Volt power supply.

Time intervals were: $t_1 = t_2$ = 2000 nanoseconds, t_3 = 300 nanoseconds. A pulse generation cycle was less than 5000 nanoseconds. So this repetition rate may be increased to 100 kHz without characteristics deterioration by transistors heat mode providing.

Impulse amplitude changing was not accompanied with shape distortion.

Power consumption was less than 4 W with 8 kHz pulse repetition rate.

The generator efficiency was approximately 2.5 per cent. This value is much smaller than the results achieved earlier. The scheme analysis shows that the main losses deal with non-optimal choice of the output circuit parameters and element types. So in the model ferrites with smaller than prototype magnetic permeability and non-impulse capacitor types were used.

The potential possibilities of the scheme are much better than represented results. Parameters may be improved with control unit modernization and more through nominals selection.

The main merit of the design is better safety due to the absence of external high voltage circuits. Impulse parameters may be stabilized with time duration t1 operation.

Simplicity and control convenience make it possible to use the generator as a transmitter of cheap impulse GPR for engineering geophysics.

Conclusion

A powerful nanosecond pulse generator controlled by standard fast TTL signals has been considered. Due to scheme simplicity the generator can be actually made in home conditions. It can be designed as impulse generator for different application by a selection of few elements without the electric scheme changing. The impulse generator can be applied in the cheap portable GPR for finding caves.

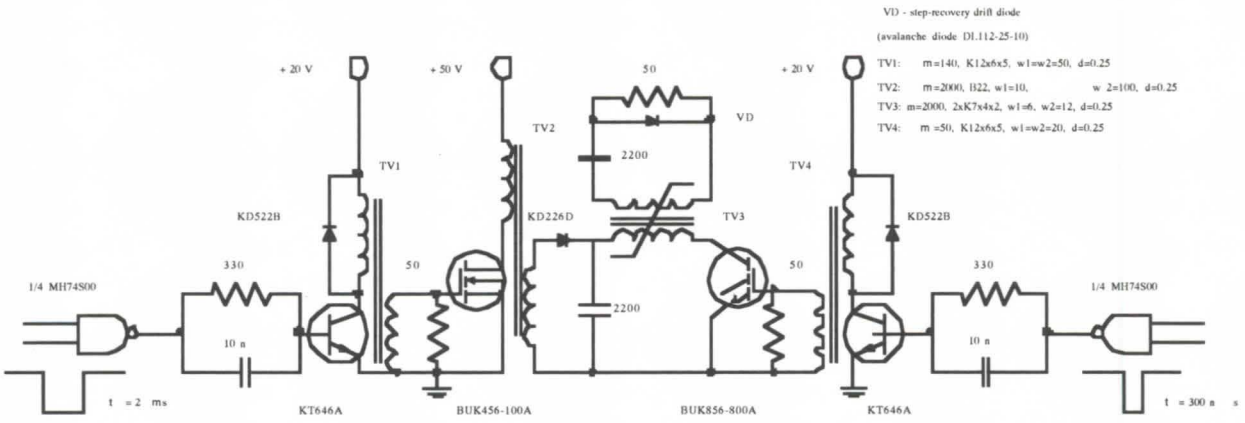

Figure 2 : Scheme of the impulse generator based on step-recovery drift-diode

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16 mois d'enregistrement dans la Luire

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Abstract :

The Luirographe can record automatically parameters such as the water height in a karstic network. Placed at the beginning of April 1995, at -200 meters, it recorded for the first time the Luire swelling, which lasted two days. The cave of the Luire is situated in the massif of Vercors, with an hydrogeological basin of 230 km². The Vercors is a forest of middle mountain within the French Prealps of the North. The Luire swelling principaly exits when there are very big nival spate accentued by important rainfalls and by a southern wind. Such event arrives only every other year on average. The difference between the high and low level of karst floods can reach the impressive height of 475 meters, the most important known in the world. It is the difference between altitude of saturated zone where there is the continuous spring of Arbois and the temporary emergence of the Luire, known up to -451 meters, and they are 20 kilometres apart. The paper proposes to present the sytem called Luirographe, then to study the results given by the measurement equipement until April 1995.

Résumé :

Le Luirographe permet l'enregistrement automatique de grandeurs, telle que la hauteur d'eau dans un réseau karstique. Placé début Avril 95 à -200 mètres dans le réseau de la Luire, il enregistra pour la première fois une crue. Une multitude de crues internes, difficilement observable, a pu aussi être enregistrée. Les crevaisons de la Luire sont spectaculaires de part leur puissance de débit qui atteint 40m^3/s, leur rareté et leur irrégularité en moyenne une fois tous les deux ans pendant un ou deux jours seulement. La Luire est située dans le Vercors, massif de moyenne montagne des Préalpes Française du Nord. Son bassin d'alimentation typique des karst montagnards couvre une superficie de 230 km². En plus de la Luire, les sources d'Arbois et Bournillon, distantes l'une de l'autre de 1 km et 20 m plus hautes, sont les principales exsurgences de ce bassin. Par de violentes crues, le karst se noie sur une hauteur impressionnante de 475 mètres. Cette hauteur correspond à la différence d'altitude entre la source pérenne d'Arbois et la Luire (connue jusqu'à -451 mètres) éloignées de 20 kilomètres. Le débit des plus grosses crues atteint, avec les trois exsurgences, 160 m^3/s. Après une présentation générale du système appelé Luirographe, l'article propose d'analyser les résultats fournis par le Luirographe placé depuis Avril 1995.

1. Introduction

Dès les années 1953/54 germe l'idée parmi les membres du GSV de créer un système qui puisse nous renseigner sur les niveaux d'eau dans la cavité. Le premier prototype est mécanique. Ce capteur ne permet de renseigner que sur l'absence ou la présence d'eau en un point donné. Ce prototype est surnommé Luirographe, par Claude Pommier. Il n'a pas vraiment fonctionné, puis il tombe aux oubliettes. Quelques prototypes succédèrent, mais sans grand résultat. L'idée du Luirographe est lancée sous forme de projet de fin d'année en Licence Ingénierie Electrique à la faculté de Belfort. Le cahier des charges est élaboré ainsi que le schéma général. Des capteurs, une mémoire centrale, un microcontrôleur pouvant gérer jusqu'à huit paramètres différents et sur une durée d'une semaine à un an, sont enfermés dans une boite étanche contenant en plus l'alimentation (piles standards). Le concept des réalisations précédentes avait pour faiblesse une ligne électrique qui les reliait à la surface pour l'alimentation et la transmission des données et qui, dès les premières crues était arrachée. Cette centrale autonome pallie à cet inconvénient. Il suffit donc de placer cette centrale dans un endroit stratégique de la Luire et d'aller ponctuellement la chercher afin de récupérer les données. Une fois l'enregistrement effectué, un programme informatique recueille les données enregistrées et les transcrit sous forme de courbes. La centrale permet une acquisition des données avec une précision inférieure à 1%.

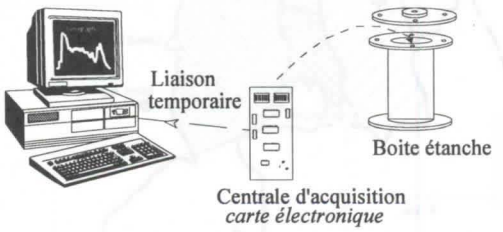


Figure 1 : Schéma général de la centrale d'acquisition.

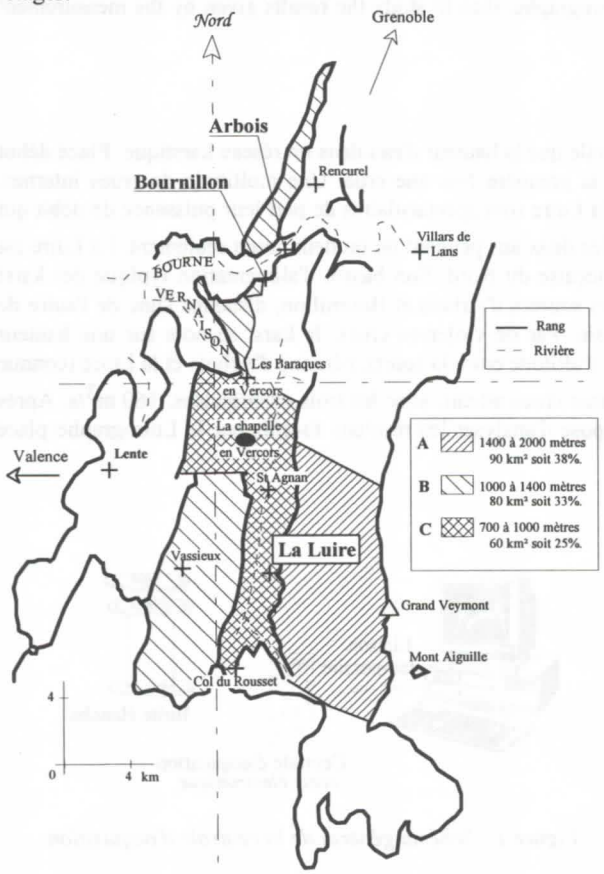
2. Présentation géographique et géologique

Le Vercors, massif des Préalpes du Nord est divisé administrativement par les départements de la Drôme et de l'Isère. Son étendue géographique est limitée par de hautes falaises le détachant nettement des autres massifs l'environnant. La Bourne, principal cours d'eau du massif, délimite le Vercors Nord du Vercors Sud.

La grotte de la Luire et son bassin d'alimentation se développent essentiellement dans le Vercors Sud; ses principales résurgences, le Bournillon et Arbois, se jettent dans la Bourne collectant la majeur partie des eaux. Avec environ 230 km² étagés sur plusieurs niveaux, ce bassin représente le système hydrogéologique le plus important du Vercors, et le troisième de France par son puissant débit moyen de 7,8 m^3/s.

Le trait caractéristique de cet ensemble est une mise en charge impressionnante de 475 mètres par rapport aux sources pérennes d'Arbois; elle doit être la plus importante connue dans le monde. Il arrive lors de violents orages que le réseau soit entièrement noyé et que l'eau ressorte par le porche d'entrée. Le débit peut alors atteindre 40 m^3/s. Un tel événement arrive très irrégulièrement en moyenne tous les deux ans.

La grotte de la Luire se développe essentiellement dans les calcaires à faciès urgonien [Delanoy, Garnier]. Les dernières explorations, en progressant de façon notable sous les plateaux, ont permis d'atteindre un nouveau type de calcaire (Hauterivien). Des fossiles d'oursins et de belemnites y ont été retrouvés. Ces calcaires reposent sur un niveau imperméable des assises marno-calcaires de l'Hauterivien. Tout le réseau est creusé principalement en régime noyé et l'ensemble des galeries connues se développent parallèlement au synclinal, sur plusieurs étages.



Fugure 2 : Situation géographique, et répartition par tranche d'altitude du plateau d'alimentation.

La répartition du bassin d'alimentation, figure **2**, typique des karst montagnards, présente des possibilités de stockage à différents niveaux. Le stockage nival est un trait caractéristique du régime, par exemple une augmentation de la température et une pluie printanière créent de violentes crues, conditions obtenues le 22 Avril 1995. De plus, la rapidité de l'infiltration et l'évapotranspiration n'est pas la même dans la zone C, que dans la zone A. La zone C est caractérisée par des lapiaz, la zone A par un couvert forestier et des prairies. Les précipitations n'ont pas la même ampleur suivant les zones du bassin d'alimentation. Une météorologie locale sur chacun de ces plateaux doit être étudiée pour comprendre le fonctionnement exact du système. Nous nous contenterons dans un premier temps de la station météorologique de la Chapelle en Vercors.

3. Mise en charge

Le système étudié est constitué de plateaux d'alimentation, de la Luire et de deux résurgences principales. Toutes les précipitations, neiges et pluies sont recueillies par les plateaux d'alimentation. Cette eau est évacuée principalement par la source d'Arbois, source pérenne, et par Bournillon résurgence temporaire. Ce karst est constitué d'une multitude de galeries convergeant des plateaux vers les résurgences d'Arbois et de Bournillon. La Luire peut être considérée comme un regard dans ce karst et permet de connaître en ce point le niveau piezomètrique.

Lors de précipitations, l'eau est évacuée vers les résurgences et sature progressivement le réseau. Chaque galerie est équivalente à une perte de charge, due à un parcours sinueux ou à un rétrécissement par exemple. Ces pertes de charge créent une montée de l'eau dans le réseau, toute l'eau ne peut pas être évacuée par les résurgences. Si ses précipitations sont importantes la mise en charge atteint 475 mètres, c'est à dire la différence d'altitude entre la Luire et la résurgence d'Arbois, la Luire crève.

4. Résultats et premières analyses

Différentes crues ont été enregistrées pendant ces 16 mois. Durant l'automne de violentes crues internes au réseau sont observées. Pendant le printemps 1995 la fonte progressive de la neige noie le réseau pendant plusieurs semaines. On observe aussi, pendant la fonte de la neige, des oscillations journalières expliquées par le gel et le dégel de la couche neigeuse.

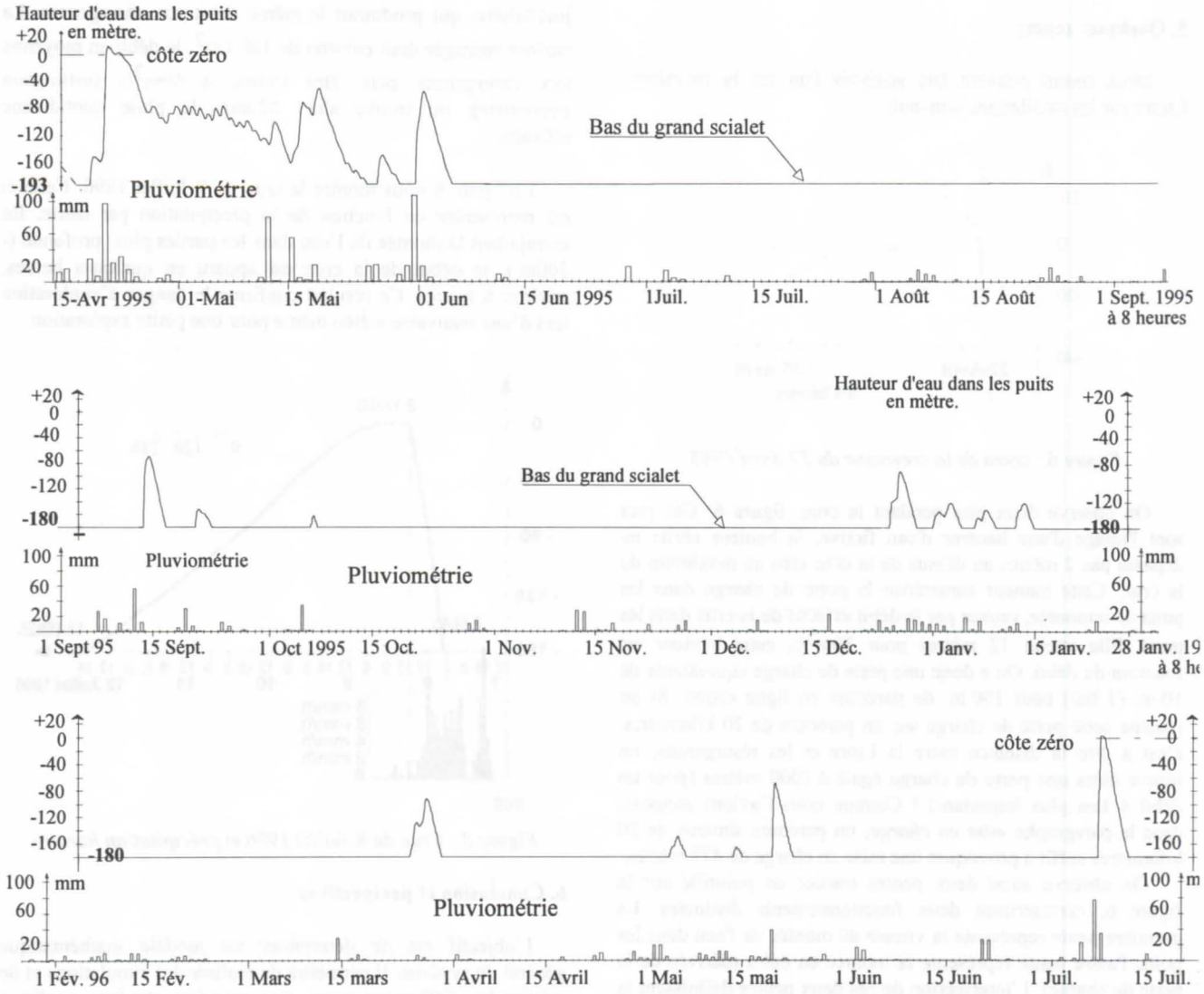


Figure 3 : Relevé de la hauteur d'eau dans la cavité en fonction de la pluviomètrie..

En 16 mois deux crevaisons ont eu lieu, la première crevaison, estimée à 30m^3/s, s'est produite le 22 Avril 1995. Elle a été provoquée par une augmentation de la température et une forte pluie sur une épaisse couche de neige. La seconde crue a eu lieu le 8 Juillet 1996 et dura 20 heures, estimée à 10m^3/s suite à une pluie intense de 24 heures. La figure 5 montre le nombres de crues en fonction des mois, une crue au mois de juillet n'avait jamais été observée. Au total 18 crues ont été observée en 45 ans.

La figure 4 représente la remontée maximale d'eau dans les puits en fonction de la pluviométrie, il existe une relation linéaire entre ces deux grandeurs. Cette courbe sera affinée par un nombre de points plus important et par l'installation d'un Luirographe dans les réseaux plus profond.

D'une façon générale, la vitesse de montée est plus rapide que celle de la descente. Ceci est dû à la saturation rapide des gros conduits lors de la montée et à l'écoulement progressif des micro-fissures lors de la descente. La vitesse de montée maximale enregistrée a atteint 30m/h.

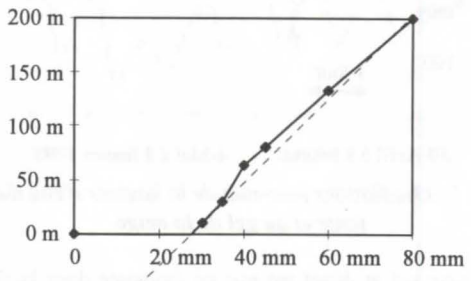


Figure 4 : Hauteur maximale d'eau dans les puits en fonction d'une précipitation.

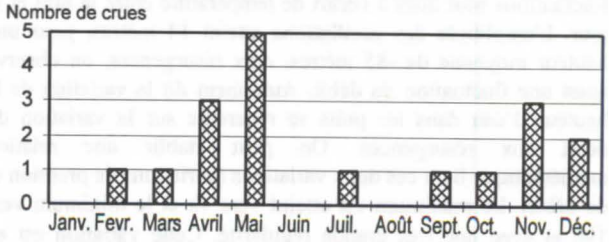


Figure 5 : Nombres de crues par mois observées entre 1951 et 1996.

5. Quelques zooms

Deux zooms peuvent être analysés l'un sur la crevaison, l'autre sur les oscillations jour-nuit.

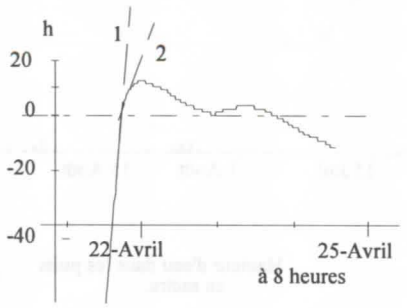


Figure 6 : zoom de la crevaison du 22 Avril 1995.

On observe deux pics pendant la crue, figure 6. Ces pics sont l'image d'une hauteur d'eau fictive, la hauteur réelle ne dépassa pas 2 mètres au dessus de la cote zéro au maximum de la crue. Cette hauteur caractérise la perte de charge dans les puits de remontée, causée par le débit effectif de la crue dans les puits. Elle atteint 12 mètres pour $30m^3/s$, cette hauteur est fonction du débit. On a donc une perte de charge équivalente de 10 m. (1 bar) pour 190 m. de parcours en ligne droite. Si on ramène cette perte de charge sur un parcours de 20 kilomètres, c'est à dire la distance entre la Luire et les résurgences, on trouve alors une perte de charge égale à 1000 mètres (pour un débit 4 fois plus important) ! Comme nous l'avions supposé, dans le paragraphe *mise en charge*, un parcours sinueux de 20 kilomètres suffit à provoquer une mise en charge de 475 mètres.

On observe aussi deux pentes tracées en pointillé sur la figure 6, caractérisant deux fonctionnements distinctes. La première pente représente la vitesse de montée de l'eau dans les puits, l'autre pente représente la montée en débit (dérivée de la perte de charge). L'intersection de ces deux pentes définissent la cote zéro de la Luire.

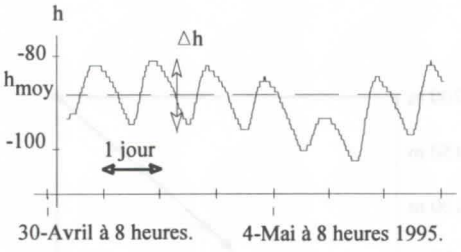


Figure 7 : Oscillations jour-nuit de la hauteur d'eau dues à la fonte et au gel de la neige.

Le cycle gel et dégel est mis en évidence dans la figure 7. L'eau est à une hauteur moyenne de -85 mètres où s'ajoute une fluctuation. Cette hauteur moyenne est entretenue par la fonte régulière occasionnée par la température moyenne jour-nuit. Les fluctuations sont dues à l'écart de température entre la nuit et le jour. L'amplitude des oscillations atteint 14 mètres, pour une hauteur moyenne de -85 mètres. Aux résurgences, on observe aussi une fluctuation du débit. Autrement dit la variation de la hauteur d'eau dans les puits se répercute sur la variation du débit aux résurgences. On peut établir une relation mathématique liant ces deux variations (variations de pression et de débit). Le maximum est atteint vers 4h et le minimum vers 19h et avec une très grande régularité. Cette variation est en déphasage avec la fonte réelle sur le plateau d'environ une douzaine d'heures. On peut calculer la pluie équivalente journalière, qui produirait le même débit aux résurgences. La surface enneigée était environ de 100 km^2, le débit en moyenne aux résurgences peut être estimé à $60m^3/s$ (estimation pessimiste), on trouve alors 52 mm de pluie quotidienne efficace.

La figure 8 nous montre la crue du 8 Juillet 1996. Celle-ci est représentée en fonction de la précipitation par heure. En extrapolant la montée de l'eau dans les parties plus profonde (-300m.), le début de la crue est apparu en quelques heures, environ 6 heures. Ce résultat confirme le danger d'exploration lors d'une mauvaise météo même pour une petite exploration.

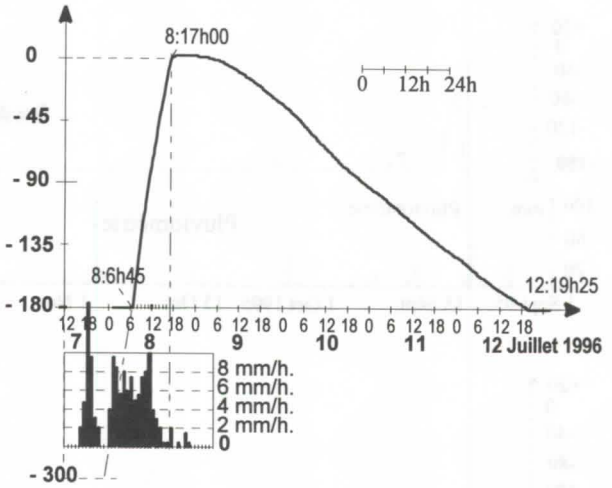


Figure 8 : Crue du 8 Juillet 1996 et précipitation horaire.

6. Conclusion et perspectives

L'objectif est de déterminer un modèle mathématique général du système. Il permettra de réaliser des simulations et de prédire les différentes crues. Ces premiers résultats confirme l'intérêt du Luirographe.

Pour tout renseignement complémentaire me contacter.

Remerciements

Je remercie le Groupe Spéléologique Valentinois (GSV) pour son aide financière et pour son soutien logistique et moral. Je remercie la faculté de Belfort et l'Institut Génie Energétique (IGE) pour leur aide technique et leur confiance, et enfin je remercie toutes les personnes ayant participé au projet qui n'aurait pas vu le jour sans elles.

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L'Atlas du Karst Wallon : un outil pour une gestion intégrée des régions calcaires de Wallonie (Belgique)

Par C. De Broyer, G. Thys, JP. Bartholeyns et G. Michel
Commission Wallonne d'Etude et de Protection des Sites Souterrains, av. Rodin, 21, 1050 Bruxelles - Belgique.

Abstract
The management of land in karst regions involves specific elements : nature conservation, underground waters protection, effects of underground dissolution on infrastructure and buildings and the exploitation of quarrying.

Therefore, the ministery of environment and natural ressources of Wallonia has asked the Wallonian Committee for Protection of the Underground Sites, to carry out an inventory of the karstic sites of Wallonia. This inventory, containing more than 3800 karstic sites, 648 quarryings and 695 water wells, is almost finished today. Each site is described briefly, and put back in its geographical and geological context.

Furthermore, this study gives general guidelines for the development of conservation of nature matters in karst regions, for the protection of underground waters and more specific protection options for remarquable undergroud sites.

Résumé.
L'aménagement du territoire en région karstique doit tenir compte de plusieurs éléments spécifiques : la conservation de la nature, la protection des eaux souterraines, l'incidence du sous-sol sur l'habitat et les infrastructures diverses et l'exploitation des carrières.

Dans ce cadre, le Ministère des Ressources Naturelles et de l'Environnement en Région Wallonne a chargé la CWEPSS de dresser un inventaire cartographique et descriptif des sites karstiques et des « rivières » souterraines de Wallonie.
Cet inventaire, qui comprend plus de 3800 sites karstiques, 648 carrières calcaires et 695 captages, est aujourd'hui en passe d'être terminé. Il présente chaque phénomène et le replace dans son cadre géographique afin de ne pas l'isoler artificiellement des autres sites karstiques proches ou des activités en surface.

En outre, des règles générales pour l'aménagement des différentes régions karstiques ainsi que pour la protection de certains sites souterrains remarquables y sont suggérées.

Introduction

Motivés à l'origine par la volonté de protéger le milieu souterrain karstique, les promoteurs de l'Atlas du Karst Wallon ont vite réalisé qu'il était impossible de protéger efficacement et à long terme les sites souterrains sans les placer dans leur contexte géographique et économique et sans avoir un certain contrôle sur l'ensemble des activités qui ont un impact réel ou potentiel sur le milieu karstique. La protection d'un site exceptionnel, par son contenu biologique ou ses caractéristiques géologiques et hydrologiques, est irréalisable si elle ne se conçoit pas dans une zone plus vaste. Il faut en effet prendre en compte le fait que le karst est un système ouvert, dans lequel les circulations d'eaux souterraines mettent en contact des sites pouvant être relativement éloignés. C'est par l'intégration de ces relations dans la définition d'un mode et d'une zone de protection adéquate qu'il faut envisager la conservation du milieu souterrain.
Afin de tenir compte des particularités du milieu karstique liées à sa perméabilité en grand, la Commission Wallonne d'Etude et de Protection des Sites Souterrains a conçu cet atlas qui couvre l'ensemble des régions caractérisées par un sous-sol carbonaté en Belgique et dès lors sujettes aux phénomènes de karstification.

Présentation de l'Atlas et méthodologie

L'Atlas du Karst Wallon est un inventaire cartographique et descriptif, organisé en banque de données, de tous les sites karstiques et des rivières souterraines de Wallonie. Plus d'un quart de cette région du sud de la Belgique est constitué de roches carbonatées (calcaires et craies) où se développent des phénomènes karstiques.

Concrètement, l'AKWA est constitué de 156 cartes au 1/10.000è (publiées au 1/25.000è) qui indiquent le *contexte géologique et hydrologique* (terrains calcaires et dolomitiques, pendage, failles, bassins versants et bassins hydrogéologiques, circulations d'eau souterraine), les *données karstiques et spéléologiques* (sites karstiques: entrées de grottes et réseaux souterrains, pertes et résurgences, dolines et dépressions paléokarstiques, abris-sous-roche), les *données d'intérêt économique* (captages d'eau et carrières, abandonnées ou exploitées, en terrain calcaire) et enfin des *éléments intéressant directement la conservation de la nature et l'aménagement du territoire*: les zones de protection existantes (réserves naturelles, sites classés, sites archéologiques,...) et les zones dont la protection est revendiquée.

Dans la phase de réalisation des cartes, sont regroupées les informations géologiques les plus récentes et les plus complètes sur les affleurements calcaires. Un dépouillement systématique des données bibliographiques et une collaboration avec les administrations, les bureaux d'études, les associations d'environnement et les clubs spéléo actifs en région calcaire ont permis de rassembler un ensemble de données souvent inédites sur les phénomènes karstiques.
Sur base de ces informations et en tirant des enseignements complémentaires de l'analyse d'anciennes cartes topographiques et de photographies aériennes, une prospection systématique et un état des lieux actualisé des sites sont réalisés sur le terrain.

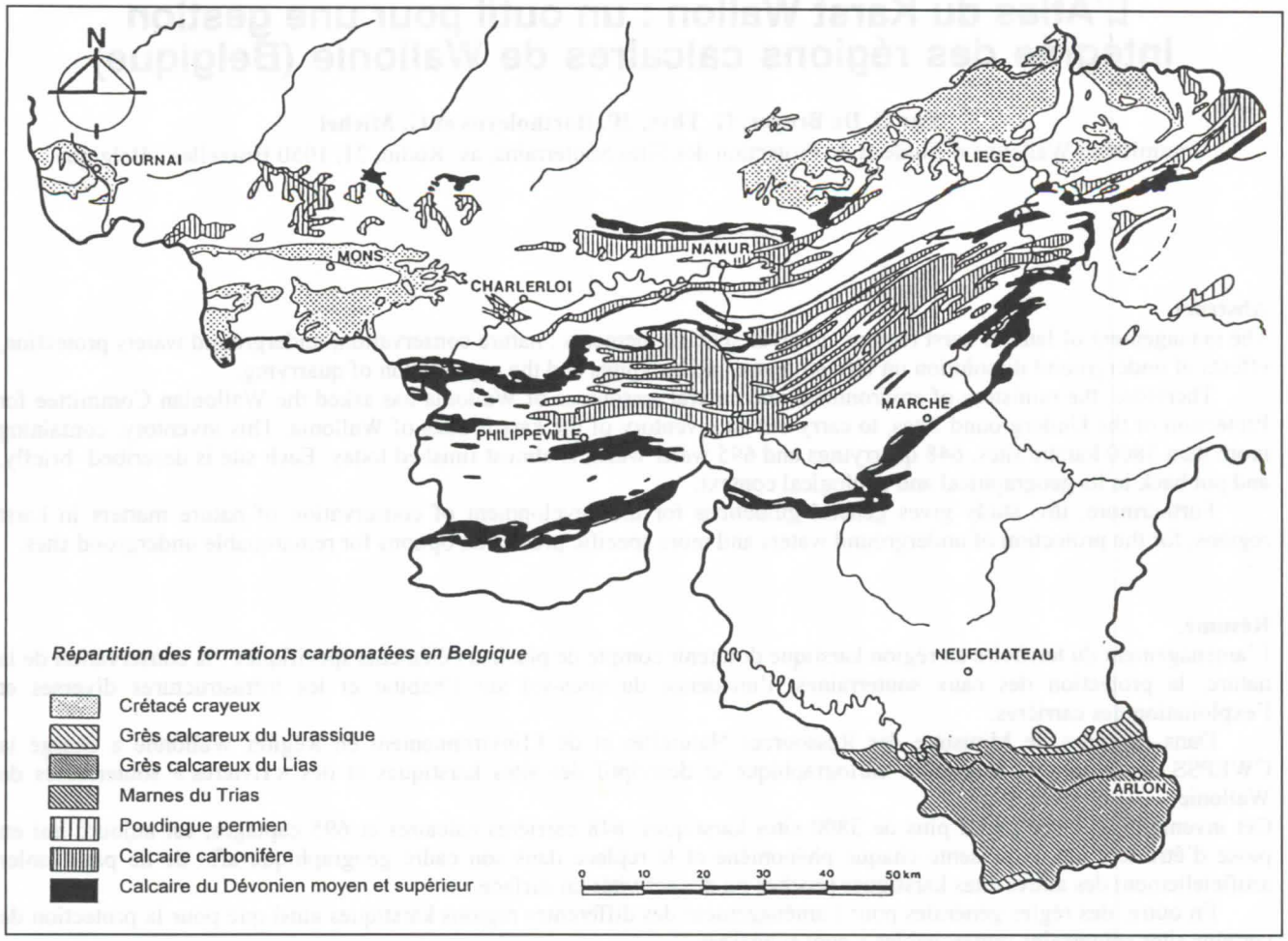

Figure 1. Affleurements carbonatés de Wallonie (d'après C. Ek). L'ensemble des ces zones ont été inventoriées dans le cadre de l'Atlas du Karst Wallon.

Cette phase de terrain a permis de répertorier de très nombreux sites karstiques inédits et de systématiser l'information pour chaque phénomène sur le schéma suivant : la localisation précise du phénomène (système de coordonnées Lambert), le type de site, sa description, son environnement hydrogéologique, son intérêt scientifique, socio-économique, touristique, paysager, ou même sportif, les références bibliographiques, ainsi qu'un état des lieux (pollutions, destructions, menaces,...) et l'affectation du site dans les plans d'aménagement du territoire.

La réalisation de l'Atlas du Karst Wallon a été rendue possible grâce au travail en commun , aux avis et aux renseignements qui ont été fournis tant par les spéléologues de terrain, que par les scientifiques qui ont participé à l'interprétation de certaines observations.
Une telle collaboration entre deux milieux qui trop souvent s'ignorent devrait être généralisée dans le cadre d'études et d'inventaires sur le milieu souterrain.

En plus d'une localisation et d'une description sommaire, chaque site repris dans l'inventaire est lié à une base de données de références bibliographiques précises permettant aux utilisateurs de l'atlas de mener des recherches plus approfondies sur une cavité en particulier.
En outre, des mesures de protection et, le cas échéant, d'assainissement sont proposées pour tous les sites et ensembles remarquables.

Enfin, un texte introductif général émet des propositions pour une meilleure gestion de l'environnement en région calcaire et présente les méthodes utilisées, la bibliographie (4225 références), les index des sites recensés et des introductions par thème sur la géologie et l'hydrogéologie des calcaires, l'exploitation des aquifères karstiques et leur protection, l'intérêt biologique, spéléologique, archéologique et touristique du milieu souterrain karstique.

Province	Cavités	Abris	Pertes	Résurgences	Dolines	Puits naturels	Sites détruits	Total
Namur	621	52	325	145	329		41	1513
Liège	405	36	227	92	294		134	1188
Luxembourg	156	12	99	176	69		30	542
Hainaut	65	22	65	114	90	186	46	588
Total Wallonie	1247	122	716	527	782	186	251	3831

Figure 2. Nombre de sites karstiques inventoriés par province dans l'Atlas du Karst Wallon (situation au 1/12/1996)

Etat d'avancement et couverture de l'AKWA :
Cette vaste étude, en cours depuis 1990, touche à sa fin. Cet inventaire est à notre connaissance unique en Europe. Il est à la fois précis (cartographie au 1/10.000 et inventaire systématique de l'ensemble des phénomènes karstiques) et il couvre tout le territoire Wallon caractérisé par des affleurements calcaires (soit plus de 5.000 km²) pour donner une vue globale du karst à l'échelle de la région.

Structuré par province pour des raisons de faisabilité, le premier atlas est publié et diffusé à partir du mois de mars 1997. Il couvre l'ensemble des bandes calcaires de la province de Liège (voir figure 4).

En plus des phénomènes karstiques et dans le but de globaliser les informations sur le sous-sol, sur sa gestion et son exploitation, l'atlas du karst comprend également un inventaire des carrières et des captages avec leur localisation précise, leur description, la nature des terrains, les volumes captés, un état des lieux actualisé...
Pour l'ensemble de la Wallonie, l'Atlas localise et décrit 640 carrières et anciennes carrières calcaires et 695 captages situés en terrain calcaire. Une attention particulière a été portée à l'état des lieux des carrières et anciennes carrières qui sont des sites privilégiés pour le développement de décharges sauvages ou même parfois autorisées.

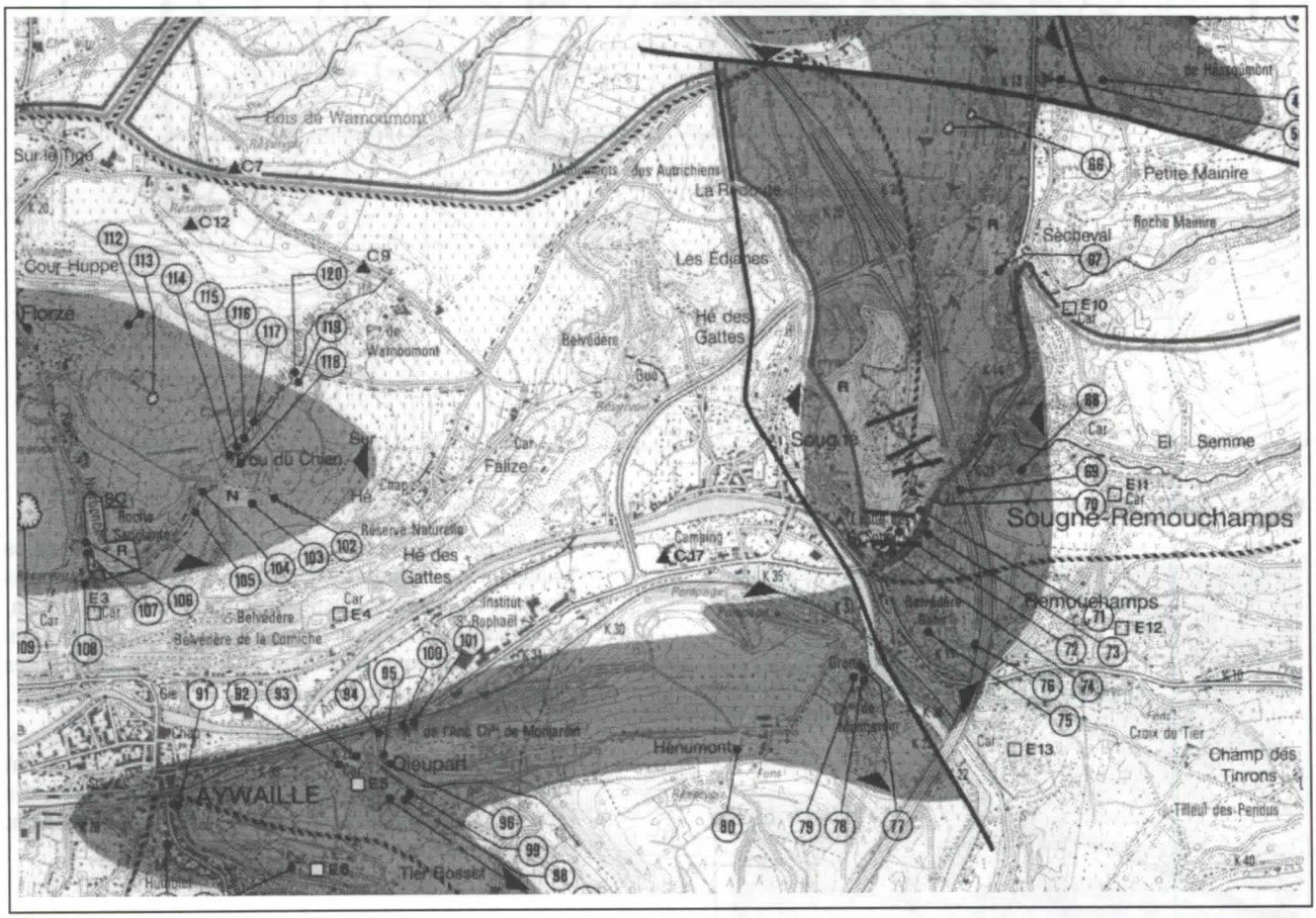

Figure 3. Extrait de l'Atlas du Karst Wallon (1/25.000). Inventaire des sites de la région de Remouchamps (province de Liège)

Usages de l'Atlas et applications futures

Cet outil de référence, dont les données sont informatisées, est destiné à être diffusé, avec une promotion adéquate, vers tous les acteurs de l'environnement: pouvoirs publics à tous les niveaux, populations locales des régions concernées, sociétés de distribution d'eau, associations de protection de la nature et de défense de l'environnement, associations socio-culturelles, associations de spéléologues, institutions scientifiques et bureaux d'études.
Cet inventaire a été conçu en particulier pour les applications suivantes :

- Permettre de mieux prendre en compte les particularités des régions calcaires dans les plans d'aménagement et notamment de tenir compte de la vulnérabilité des aquifères karstiques et d'attribuer un statut adéquat aux sites souterrains remarquables. L'Atlas apporte concrètement des éléments d'information utiles aux décisions d'affectation du sol ainsi qu'aux études d'incidence dans les régions karstiques
- Localiser les cavités importantes et les zones présentant des risques d'instabilité liés au karst, afin d'éviter que de grandes infrastructures ne s'y développent. Ces informations indiquent la forte probabilité de trouver un terrain de fondation de mauvaise qualité, entraînant toujours des majorations des coûts de construction, voire des difficultés techniques insurmontables.
- Focaliser l'attention sur la présence de sites karstiques dans la périphérie et dans les zones d'extension de carrières, afin de protéger les plus remarquables et permettre une meilleure planification des projets d'extraction, ceci afin d'éviter peut-être des conflits d'intérêts.

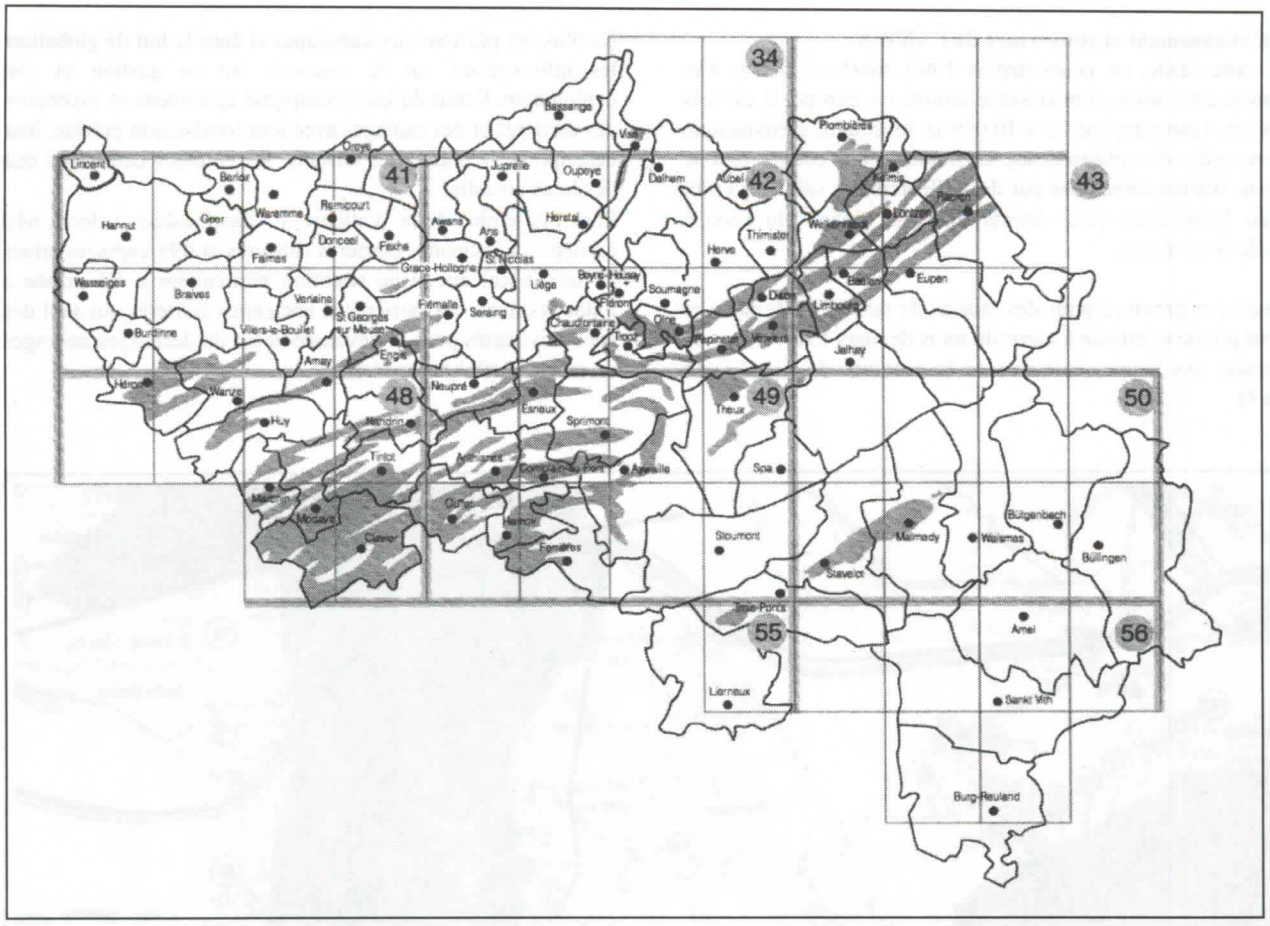

Figure 4. Bandes calcaires et étendue de l'inventaire des sites karstiques de la province de Liège (1/600.000).

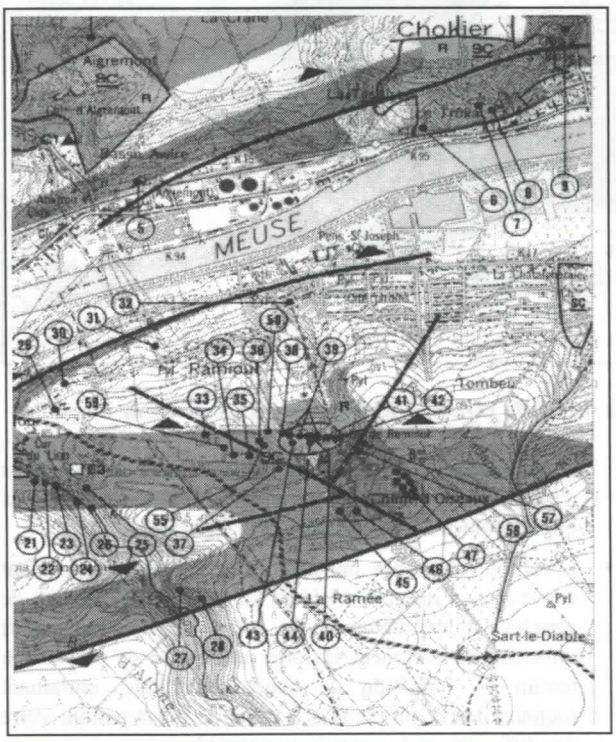

Figure 5. La grotte de Ramioul, ainsi que les sites alentours présentant un grand intérêt archéologique et biologique. Il faut en tenir compte dans les plans d'aménagement futurs, et notamment dans les projets d'extension de la carrière.

- Inventorier les points d'absorption, les circulations souterraines, les informations hydrologiques principales ainsi que les captages karstiques et des points de pollution, constituant des éléments concrets et directement utiles à la protection des eaux karstiques et à la détermination des zones de protection des captages.
- Délimiter précisément les zones et les sites intéressants, qui méritent la mise en réserve naturelle, en justifiant l'intérêt spécifique des sites considérés. Sur ces bases, des propositions plus détaillées avec axes de gestion pourront être élaborées.

Conclusion

L'Atlas du Karst Wallon veut être, à sa mesure, un instrument privilégié de conservation et de gestion des régions calcaires de Wallonie et, en particulier, de leurs sites karstiques, de leurs paysages typiques et de leurs eaux souterraines. En provoquant la prise en considération systématique par les pouvoirs publics des valeurs et du caractère spécifique des régions karstiques, il peut et doit contribuer à une gestion plus rationnelle du territoire wallon.

Ce type d'approche pourrait sans doute être utilement appliqué dans d'autres régions d'Europe.

Progetto Monte Cucco di Didattica Ambientale: i fenomeni carsici e l'educazione scolastica naturalistica

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Abstract

For more than 10 years, Costacciaro and the carstic region of Monte Cucco (Umbria, Italia) holds the main project of environmental education of the Appenine, with more than 7000 participants. The project grew out of an accordance with the Environmental Miniostry, the Region of Umbria, the community of Costacciaro, the education board of Perugia and the CENS.

The aim is to use the natural phenomenons (and also the caves) that are present in the carstic regions to improve the knowledge about Nature, and especially the sensibilisation to problems connected with the water supplies. Bear in mind that, on the Italian peninsula, the available water is bound to 80 % to the interiors of the carstic regions of the Appenine.

The participants are children and teachers of the primary, the secondary and of the High School.

Riassunto

Da più di 10 anni Costacciaro e l'area carsica del Monte Cucco (Umbria, Italia) è teatro del principale progetto di didattica ambientale dell'Appennino, con oltre 7000 partecipanti. Il Progetto nasce da un accordo fra Ministero dell'Ambiente, Regione dell'Umbria, Comune di Costacciaro, Provveditorato agli Studi di Perugia e CENS.

Lo scopo è di utilizzare i fenomeni naturali presenti nelle aree carsiche, non escluse le grotte, per promuovere, in generale, la conoscenza naturalistica e, in particolare, la sensibilizzazione sui problemi legati alle risorse idriche. Si tenga presente che nell'Italia peninsulare il patrimonio idrico disponibile è legato per l'80% alle acque raccolte all'interno dei territori calcarei appenninici.

Partecipano alunni e docenti delle Scuole Elementari (primarie), Scuole Medie Inferiori e Scuola Medie Superiori.

1. Valutazione analitica e finalità

Il Progetto Monte Cucco nasce dalla convinzione che il problema della salvaguardia e valorizzazione dell'ambiente naturale passa prima di tutto attraverso la conoscenza diretta e intima del valore e del significato del patrimonio naturalistico che sta intorno a noi, vicino al luogo dove risiediamo, a portata di mano.

E tanto prima si attua questa conoscenza tanto più efficace è l'azione educativa che ne consegue: dopo la scuola primaria tutto diventa più difficile, poco praticabile, per la desensibilizzazione che i mezzi di comunicazione di massa producono, indisturbati, nei giovani, sottoposti giornalmente a dosi massicce di input televisivi. L'azione pedagogica è molto più incisiva negli alunni dei corsi elementari, la cui sensibilità, curiosità e interesse speculativo è ancora indiscutibile. Ciò non esclude la partecipazione di alunni di Scuole Medie e Medie Superiori, specie se accompagnata da una incisica, continuata e organica azione dei docenti.

L'impegno del CENS, della Regione dell'Umbria, del Comune di Costacciaro, del Provveditorato agli Studi di Perugia e del Ministero dell'Ambiente nel voler promuovere l'educazione naturalistica - intesa come fattore di crescita globale, tanto culturale, quanto civile, che sentimentale - si basa anche sulla constatazione che il Fenomeno Naturale di per sé è uno strumento didattico perfetto; possiede infatti la rigorosità scientifica abbinata alla spettacolarità, al gusto dell'avventura e del mistero, alla sollecitazione prorompente dei sensi, tanto da colpire la fantasia e, al tempo stesso, la ragione.

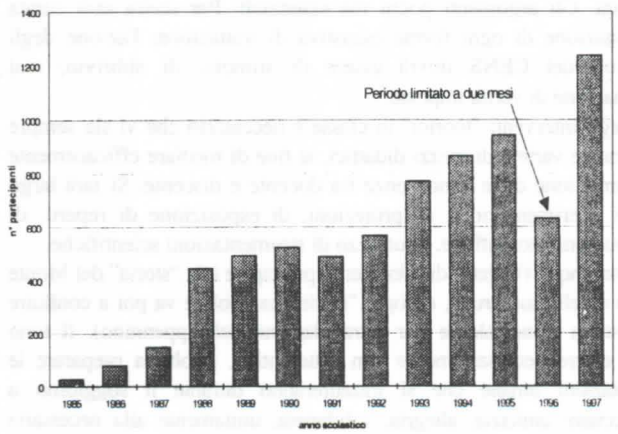

Figura 1: Partecipanti al Progetto M.Cucco nel periodo 85-97

Al di fuori di ogni valenza ambientalistica, il Fenomeno Naturale è un "quid" che integra molteplici componenti, tutte volte allo sviluppo delle capacità di osservazione, di critica, di interpretazione. Il risultato finale è l'affermazione delle potenzialità raziocinanti e del metodo scientifico, sia come fatto culturale che come strutturazione comportamentale.

Inoltre il Fenomeno Naturale è anche, come già affermato, a portata di mano, fuori dall'uscio di casa o della scuola, fra le pieghe dell'orizzonte quotidiano. Il Fenomeno Naturale non costa nulla ed è perfetto!

E queste peculiarità dell'elemento-natura cadono a proposito nel contingente. Infatti il problema dell'insegnamento nelle scuole si pone anche come contrapposizione all' "educazione", se così si può chiamare, quotidiana e martellante somministrata dai grandi e piccoli schermi, i quali, fra l'altro, propinano con grande profusione di mezzi spettacolari programmi tanto allettanti quanto poveri di contenuti culturali e formativi.

In aggiunta i fenomeni carsici e le aree che li contengono hanno aspetti fortemente stimolanti, molto più di altri aspetti naturalistici, per il senso di grande mistero e di straordinaria avventura che emanano. La suggestione prodotta dagli ambienti sotterranei è un veicolo di grande efficacia per creare un produttivo rapporto fra docenti e discenti. Anche gli aspetti tecnici legati alla progressione sotterranea (vincere il buio con mezzi illuminanti appropriati, l'uso di attrezzi come corde o piccole scale, affidarsi alle imbracature, agli attrezzi per la discesa e la risalita) contribuiscono a rendere proficua e gratificante l'azione educatrice, che parimenti agisce come fattore di riscoperta del corpo e delle sue funzioni motorie.

Anno	Alun.	Inseg.	Genit.	Tot.	Clas.	Plessi
1985	21	4	1	**26**	1	1
1986	69	6	3	**78**	4	2
1987	123	13	13	**149**	7	5
1988	393	18	35	**446**	15	10
1989	423	23	46	**492**	18	11
1990	450	37	37	**524**	23	14
1991	410	51	28	**489**	31	19
1992	487	57	22	**566**	38	24
1993	626	97	48	**771**	40	26
1994	721	107	38	**866**	45	28
1995	791	123	28	**942**	51	32
1996	536	82	13	**631**	38	18
1997	1001	148	33	**1182**	69	40
Totale	**6051**	**766**	**345**	**7162**	**380**	**230**

Figura 2: Partecipanti al Progetto Monte Cucco nel periodo 1985-1997

2. Metodi

Il Progetto Monte Cucco di Didattica Ambientale è riconosciuto come "tempo scuola" dal Ministero della Pubblica Istruzione e come Centro di Esperienza del Progetto INFEA (Informazione e Educazione ambientale) dal Ministero dell'Ambiente. Ciò permette di effettuare delle azioni educative e conoscitive lungo tutto il periodo scolastico, tanto in classe, come sul terreno, quanto con corsi residenziali a Costacciaro.

Il Progetto Monte Cucco consiste in una proposta di Corsi Integrativi di Didattica Ambientale (C.I.D.A.), ricordando ancora una volta che con tale denominazione si intende un'azione didattica in cui il Fenomeno Naturale è uno strumento di formazione *COMPLESSIVA* della personalità degli allievi. Per *INTEGRATIVI* si intende che questi corsi debbono andare ad aggiungersi a precedenti e/o contestuali azioni didattiche svolte dagli stessi Insegnanti nell'ambito dei normali corsi scolastici, azioni ovviamente rivolte all'approfondimento delle Scienze della Terra e dei loro riflessi antropici.

Gli operatori del CENS agiscono come "strumenti" nelle mani degli Insegnanti, i quali determinano i programmi complessivi, sia nei contenuti che nelle modalità di esecuzione. *GLI OPERATORI DEL CENS NON SOSTITUISCONO GLI INSEGNANTI NEL LORO RUOLO ISTITUZIONALE.* Gli Insegnanti rimangono il punto di riferimento fondamentale e sulla base delle loro indicazioni viene modulato il programma dei C.I.D.A., sia nella scelta delle argomentazioni guida, sia nell'individuazione dell'intensità e dell'approfondimento dell'azione docente. Anche il linguaggio, parlato e strumentale, necessariamente coerente con il livello di preparazione raggiunto dagli allievi, è suggerito dagli Insegnanti. Preferenzialmente ci si indirizza verso le scuole elementari e medie, ma ciò non toglie che programmi similari possano essere rivolti - fatte le dovute modifiche di linguaggio, approfondimento e intensità - anche a studenti delle scuole medie superiori.

Considerato che gran parte del lavoro didattico si svolge sul terreno, in montagna, lungo sentieri e torrenti , all'interno di grotte, è consigliabile che il numero degli alunni partecipanti sia limitato (al massimo 30). Solo così si garantisce un rapporto creativo e proficuo fra docenti e alunni, nonché un alto livello di controllo e sicurezza.

3. Strutturazione dei corsi

Per ogni Anno Scolastico i C.I.D.A. vengono articolati nelle quattro seguenti fasi:

a) *PIANIFICAZIONE* preliminare dell'azione educativa sulla base delle indicazioni del Corpo Docente della Scuola interessata; in caso di corsi triennali la programmazione viene predefinita a partire dalla terza classe fino alla quinta classe;

b) *PREPARAZIONE* preventiva degli alunni nelle proprie classi, ad opera degli incaricati del CENS, con conversazioni, audiovisivi, materiale dimostrativo, poster, cartelloni, dimostrazioni sperimentali;

c) *SOGGIORNO* di studio a Costacciaro di durata adeguata al tipo di programma scelto; la sede logistica del CENS funziona come base per le diverse escursioni programmate, nonché come struttura dove svolgere le attività di impostazione teorico-descrittiva, rielaborazione e socializzazione, animazione;

d) *SINTESI* del lavoro svolto, analisi finale delle azioni didattiche, verifica dei risultati, elaborazione e diffusione della relazione critica finale (a cura degli Insegnanti).

3.a. Pianificazione

Dopo l'invio (entro il mese di novembre) da parte del Provveditorato agli Studi a tutte le scuole della Provincia di una circolare esplicativa, sulla base delle richieste pervenute (entro il 15 novembre) e delle indicazioni del Provveditorato agli Studi e della Regione dell'Umbria vengono individuate le Scuole che parteciperanno al Progetto. Il CENS interviene successivamente al fine di definire i contenuti e il programma degli interventi in classe e del soggiorno a Costacciaro (entro dicembre).

3.b. Preparazione

E' di fondamentale importanza svolgere alcune azioni didattiche preliminari, in classe, curate dal personale del CENS tanto nell'esposizione degli argomenti quanto nel reperimento dei mezzi esplicativi necessari. Con tali azioni ci si prefigge di dare le notizie di base per preparare e sensibilizzare ad un creativo rapporto con il Mondo Naturale montano. Il soggiorno a Monte Cucco, anche per questa ragione, non deve risultare una semplice escursione, ma piuttosto un fatto incisivo di crescita culturale e civile.

Il linguaggio, soprattutto in questa fase, dovrà essere lineare, semplice, tale comunque da non creare barriere fra operatori del CENS e alunni. Gli argomenti pochi ma essenziali. Per scelta sarà curata l'eliminazione di ogni forma esaustiva di trattazione: l'azione degli operatori del CENS dovrà essere di stimolo, di abbrivio, mai affermazione di verità imposte.

Negli interventi "teorici" in classe è necessario che vi sia sempre una grande varietà di mezzi didattici, al fine di mediare efficacemente la trasmissione delle conoscenze fra docente e discente. Si farà largo uso di sperimentazioni, di proiezioni, di esposizione di reperti, di ricostruzioni geografiche, di utilizzo di strumentazioni scientifiche.

Comunque l'oggetto di riferimento principale è la "storia" del Monte Cucco e delle sue grotte, ed ogni "storia" particolare va poi a confluire sulla storia principale (e per estrapolazione dell'Appennino). Il tono dovrà essere necessariamente non cattedratico, rivolto a preparare le connotazioni umane che si instaureranno durante il soggiorno a Costacciaro: amicizia, allegria, solidarietà, unitamente alla necessaria disciplina che impone il vivere in collettività.

3.c. Soggiorno

Il contatto diretto con l'Ambiente naturale deve produrre l'insegnamento più radicato e liberatorio. E' l'avvicinarsi al Mondo Naturale la spinta all'analisi autonoma: in questa fase il ruolo degli Insegnanti e del personale del CENS è di gestire tecnicamente gli itinerari e la progressione tecnica, nonché di stimolare, sostenere, consolidare e inquadrare le ricerche personali dei singoli discenti. A tal fine il Progetto Monte Cucco richiede necessariamente una fase residenziale con base nella sede logistica del CENS a Costacciaro (qualificato come Casa per Ferie e Centro Vacanze) ed escursioni lungo i principali itinerari del Massiccio del Cucco.

Ogni momento della permanenza presso il CENS, anche se dedicato al gioco o alla ricreazione, è una indiretta integrazione di quanto raggiunto durante le escursioni. Alcuni interventi in aula (proiezione di audiovisivi, sperimentazioni o dimostrazioni) vanno a completare quanto visto e commentato durante le escursioni.

Gli allievi devono curare la sistemazione dei propri bagagli e dei propri letti. Collaboreranno inoltre alla gestione generale del soggiorno con un impegno significativo soprattutto sul piano dei principi etici comportamentali e non certo per l'entità quantitativa del lavoro.

3.d. Sintesi

Al termine dell'esperienza, è richiesta agli insegnanti la rielaborazione di quanto portato avanti dal personale del CENS durante le escursioni e le lezioni teoriche. Si richiede anche una relazione per verificare l'efficacia dell'azione educativa.

4. Risultati

Nei 13 anni di attività al Progetto Monte Cucco, prima nell'ambito del Centro Nazionale di Speleologia e poi del Borgo Didattico (struttura operativa che dal 1996 ha sostituito il CNS), hanno aderito 7162 partecipanti, fra alunni e insegnanti (si veda Fig. 1 e Fig. 2). C'è stata una flessione solo nel 1996 a seguito dei problemi nati per l'eliminazione del gestore CAI che hanno fatto contrarre il periodo di effettuazione del Progetto a soli due mesi. Ma ora il trend positivo è di nuovo in atto ed è prevedibile che nei prossimi anni, anche a seguito dell'ampliamento del territorio di riferimento, si manifesti una continua espansione.

In base a verifiche effettuate si è accertato che gli alunni e gli insegnati che hanno preso parte al Progetto costituiscono un nucleo consistente di cittadini capace di incidere molto positivamente nel campo della cultura ambientale dell'Umbria, regione che si pone all'avanguardia nel campo della conservazione e della valorizzazione dell'ambiente montano appenninico. E' altrettanto vero che i partecipanti al Progetto sono una garanzia per la prosecuzione delle ricerche e degli studi sul carsismo.

Dal Progetto prende corpo anche l'attività di maggior spessore del Parco del Monte Cucco, il Parco delle Grotte, i cui progetti principali sono tutti strettamente collegati con la Didattica Ambientale (Centro Documentazione e Accoglienza di Costacciaro, Centro Escursionistico a Pian delle Macinare, valorizzazione didattica della Grotta di Monte Cucco).

Contribution à l'étude de l'évolution du matériel spéléologique en France vue à travers la commercialisation

par **Jacques Chabert**
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Abstract

A preliminary study on the evolution of caving techniques in France through the commercialisation of caving equipment.

The development of caving in France after World War II has been accompanied by a growing commercialisation of caving products. Commercial catalogues which are generally thrown away prove to be an invaluable source of historical information on the appearance of new techniques as well as the disappearance of out-of-date techniques. The author proposes a preliminary study of some of these documents.

Résumé

Le développement de la pratique spéléologique en France après la Seconde Guerre mondiale s'est accompagnée d'une commercialisation sans cesse accrue du matériel d'exploration souterraine. Les catalogues des commerçants, que l'on jette généralement après usage, ont pris au fil des ans valeur de documents historiques. A travers eux on peut replacer dans le temps l'apparition des techniques nouvelles ainsi que, ce qui est tout aussi intéressant, la disparition des anciennes. Il est proposé ici un premier dépouillement de ces documents pour servir à l'histoire de notre discipline.

En France le matériel spéléologique fait à l'heure actuelle l'objet d'un commerce apparemment florissant. l)es industriels—dont la dynamique entreprise Petzl est le porte-drapeau -- et des distributeurs se sont intéressés depuis quelques années à ce marché en extension.

Notre propos n'est pas ici de présenter une histoire de la commercialisation de la spéléologie en France, ni de nous lancer dans ce que les Anglo-Saxons appellent la *business history*. l'histoire des entreprises, une discipline qui a, du reste, été longtemps négligée par les chercheurs français. Ce survol hâtif ne représente qu'un embryon d'une étude à mener sur l'évolution du matériel et de sa commercialisation et il laisse dans l'ombre bien dcs aspects de cette activité.

Plus modestement. nous tenterons, à travers la pratique d'une entreprise de vente de materiel de plein air ayant joué en la matière un rôle pionnier, de situer dans le temps la mise sur le marché du matériel d'exploration souterraine, d'en cerner quelques caractéristiques et de suivre en conséquence l'évolution des techniques. Pour mener à bien cette brave étude, nous avons procédé au dépouillement des catalogues de cette maison depuis leur apparition au lendemain de la Seconde Guerre mondiale jusqu'au milieu des années 1970, époque qui marqua le début de l'ère de l'industrialisation. D'autres entreprises de production et de diffusion mériteraient qu'on s'intéresse à leur histoire—nous en croiserons certaines au fil des pages de ces catalogues. Mais aucune firme commerciale ne présentait la même ancienneté.

Une entreprise pionnière

Tous les Parisiens adeptes des sports de nature—et donc les spéléologues— connaissent Au Vieux Campeur, magasin aux multiples boutiques, situé en plein coeur de la capitale, à deux pas de la Sorbonne, le centre historique de l'université. La direction en est demeurée résolument familiale et en 1979, c'est à son fils, JacquesYves, dit Jacky, que Roger de Rorthays passe les rênes d'une entreprise prospère, "mariage heureux du scoutisme et de la bosse du commerce"—qu'il avait fondée en 1941.

La véritable réussite du Vieux Campeur est d'avoir su créer un état d'esprit très spécifique et de fidéliser son public. Le client qui sait y trouver du matériel de qualité vient également y chercher des conseils, voire y échanger des points de vue avec un vendeur qui, comme lui, est un pratiquant du même sport. C'est cette connivence avec la clientèle dans une «ambiance ineffable, très rétro, presque ringarde», à mille lieues des centres commerciaux impersonnels, qui a permis au magasin de résister aux attaques de ses concurrents, notamment à celles des grandes surfaces. La pratique des prix fixes, qui fut, quant à elle, pratiquée dès le début, rappelle la méthode qu'instaura Boucicaut au Bon Marché à la fin du siècle dernier et qui fut une des clés de son fabuleux succès.

En feuilletant les catalogues

Dans cette stratégie commerciale, le catalogue a loué un rôle de plus en plus important au fil des ans, alors que, son volume augmentant sans œsse, ce document devenait «à une véritable encyclopédie de la vie en plein air», comme «le Vieux» le proclame lui-même. Le catalogue actuel, entièrement en couleurs, composé à Massy, compte des centaines de pages et plusieurs fascicules saisonniers spécialises.

Bien que conscient de la valeur historique des catalogues anciens, le magasin lui-même a vu parfois sa vigilanœ prise en défaut dans la conservation de œ patrimoine. L'edition doté de 1978, distribué à plusieurs milliers d'exemplaires, n'existe plus dans ses collections qu'à un seul exemplaire. Quant au catalogue d'hiver 1960, il a tout bonnement disparu

La première livraison consultable dans les collections du magasin remonte à 1947 et ne comporte que quatre pages ronéotypées. Cette annce-là, la France se remet lentement du traumatisme de la Seconde Guerre mondiale. Les citadins à qui le Front Populaire a, en 1936, accordé les congés payés, prennent goût aux activités de plein air, un désir de nature dont saura profiter le magasin. Dès le départ Roger de Rorthays adopte un ton de complicité avec ses clients dont la maison ne se départira jamais. Certes le matériel de spéléologie est totalement absent du catalogue de cette année. Mais notre discipline n'est pas oubliée, le supplément «librairie» proposant trois livres de spéléologie, *Histoires au-dessous de tout* de Norbert Casteret, *La spéléologie, alpinisme à l'envers* de Pierre Weité et *Spéléologie,* le manuel technique du président du Speléo-club alpin de Paris, Henry P. Guérin.

Rien de neuf de 1947 à 1956... Néanmoins, en 1949, pour s'éclairer, le spéléologue aurait pu acheter une petite lampe frontale alimentée directement sur une pile plate toute nue, rien d'autre. Pour le reste, ayant à sa disposition le seul équipement d'alpinisme, il se verra contraint de fabriquer lui-même son équipement dans son atelier, œ dont il ne se privera pas, comme nous le savons, ou faire appel à plus bricoleur que lui, dans une économie plus proche du troc que du commerce proprement dit.

Les cordes

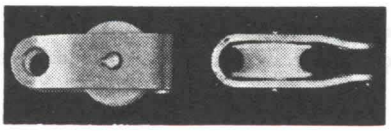
A défaut de matériel spécifique, intéressons-nous quelque temps aux cordes, un article que les speléos partagent au moins en partie avec les alpinistes et qui illustre bien les mutations techniques intervenues. On les voit arriver dans le catalogue en 1949. A cette

La cheville Spitroc est soigneusement décrite: «0 8 mm, à expansion, à tête auto-foreuse, s'emploie avec des boulons de même calibre, recule les limites de l'impossible. Très sûre» avec son fixecheville à main (le mot «tamponnoir», courant à présent, n'est pas encore utilisé) avec poignée de protection, pesant 590 g.

Et l'année suivante, 1968, qui verra les étudiants défiler dans le quartier latin, là-même où s'ouvre le magasin, le mot «spéléologie» s'étale pour la première fois sur la page de couverture du catalogue. Mais le choix proposé ne correspond pas encore à ce que le magasin avait espéré. Voilà ce qu'on pouvait lire cette année-là dans le catalogue: «De nombreux obstacles sont sans arrêt sous nos pas, difficulté de trouver certains objets, qui les fabriquent. Bien souvent nous tombons sur de petits artisans, qui préfèrent en toute franchise vendre directement à leurs petits copains sans payer beaucoup de taxes, que de nous faire des factures à nous-mêmes.»

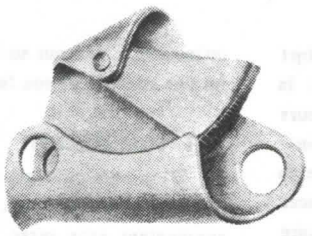
Ces plaintes mettent en lumière les limites de l'instrument utilisé pour retracer l'histoire des techniques spéléologiques. Chez les spéléologues français, l'introduction du monde du commerce dans l'univers spéléologique ne se fera que progressivement et avec réticence. Outre le marché réduit que représente la spéléologie, sans doute faut-il voir là également la manifestation de l'esprit volontiers libertaire du spéléologue, attitude qui s'exprimait sur le plan du matériel par la généralisation du troc et du bricolage. Il faut croire que ces pratiques se sont prolongées quelque temps puisqu'on retrouve ce même «pavé», quasiment inchangé dans les catalogues suivants. En 1974, le magasin n'hésite pas à manifester son exaspération devant des pratiques commerciales jugées douteuses. «Les fabncants sont rares et souvent pour des raisons de légalité il ne nous est pas possible de travailler avec eux. De plus certains de ces fabriquants (sic) "pas

40041. **Poulie Dressler,** corps en métal léger, poulie en nylon. Possibilité de mettre sur une corde sans en avoir l'extrémité.

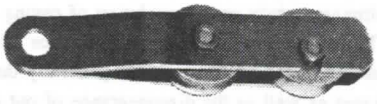


Utilisations : manœuvres de corde et tyrolienne. Utilisée avec le frein, elle permet une assurance efficace, peut servir de palan. Très utile dans un sauvetage. **20,—**

40046. **Poignée de frein Dressler.** Corps forgé en métal léger, avec un patin mobile dentelé en forme de spirale assurant un freinage correspondant exactement à la tension de la corde. Trou de fixation du mousqueton, pour le relier soit à une poulie, soit au baudrier dans le cas de l'auto-assurance ... **38,50**



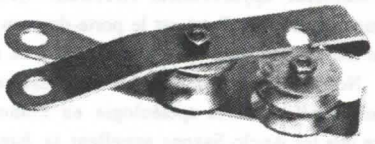
Descendeurs Dressler. Constitués de deux poulies fixes en métal léger montées sur deux bras latéraux en tôle d'aluminium, font suivre à la corde un tracé en S qui sans échauffement ni usure permettent



de contrôler facilement soit sa propre descente (dans le cas d'être relié directement au baudrier), soit la descente d'un blessé ou d'une charge en reliant le descendeur au point d'accrochage de la corde. Se pose sur une corde sans enfilage du fait du bras latéral ouvrant.

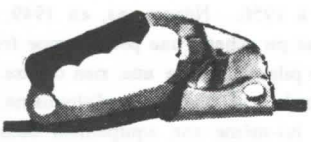
40042. Pour corde simple, modèle à deux poulies .... **40,—**

40043. Pour corde double, modèle à quatre poulies .... **60,—**



Le materiel de progression sur corde. Cattalogue 1970

40075. **Poignée d'ascension Petzl.** Poignée dont la technique est inspirée du bloqueur Dressler, avec adjonction d'un cliquet de



sécurité, d'une poignée anatomique, et d'un support de cordelette pour le pied.
La paire ..... **179,—**

C'est en 1973 que les clients du Vieux Campeur découvrent pour la première fois le nom de Petzl.

entièrement blancs" cherchent à distribuer leurs produits par des canaux fiscalement pas très "blancs" non plus et dans ces cas specifiques nous préférons nous abstenir. Cependant nous sommes persuadés que "les spéléos" seront les perdants de cette suite de "combines"»...

L'avènement de la spéléologie alpine et le début de l'industrialisation

Mais rien désormais n'arrêtera le développement du rayon spéléo. En 1968, à côté du portrait de Claude Gendron, le spécialiste spéléo du magasin, deux produits typiquement spéléologiques apparaissent en photographie, le «fixe-cheville» et la lampe frontale.

En 1970, date de l'avènement de la spéléologie alpine, sont mis en vente les premiers éléments permettant de se déplacer sur corde fixe, fabriqués à l'époque par Bruno Dressler, membre du Speléo-club de Paris et de Dijon, les descendeurs simple et double, à réas fixes, la poignée de frein et la poulie En 1971 s'ajoute la poulie Dressler à deux bras amovibles, ainsi que les combinaisons «réalisées par la firme Herribery en fibre polyamide 66 enduit PVC double face».

Dans le domaine de l'éclairage, la lampe mixte acetylene-électricité est un article qui connaîtra un grand succès. C'est celle mise au point par Marcel Tourbin, comme nous l'apprendrons dès l'annnée suivante, qui est propose. Il vient concurrencer les bricolages des spéléos dont il n'est, semble-t-il, qu'une ingenieuse adaptation artisanale.

En 1972. les nouveautés comprennent la poulie autobloquante, le descendeur Dressler à cliquet de sécurité, le shunt Petzl, «sorte de système de freinage, mais surtout d'auto-assurance». Pour la première fois est imprimé dans le catalogue le nom de ce spéléologue grenoblois, Fernand Petzl. principal compagnon des explorations de Pierre Chevalier à la Dent de Crolles, qui deviendra l'industriel le

époque le chanvre règne en maître. «Chanvre d'Italie, est-il précisé, à longs brins, témoignée, avec fil de sécurité en coton». On en offre six diamètres différents depuis la cordelle de 6 mm - résistance 280 kg, poids au mètre 28 g.—pour rappel de secours et anneaux, jusqu'à la corde d'«attache» de 12 mm—résistance 1600 kg, poids 109 g. Cette même année le nylon fait son apparition sous la forme d'une «corde tressée imputrescible» de 5 et 8,5 mm. Mais il faudra attendre sept ans (1954) pour que le catalogue présente une véritable corde nylon d'un diamètre de 10,5 mm et d'une résistance de 1750 kg. IJn an plus tard il s'enrichit avec l'arrivée de la «corde perlon câblée trois torons Bergeil Matterhow», un produit allemand proposé en trois diamètres, 6, 8 et 10 mm. En 1960, les cordes de chanvre n'ont pas disparu, mais la concurrence des matériaux synthétiques s'organise. Le nom de la marque Joanny est mentionné pour la première fois, mais l'année suivante à la rubrique cordes de chanvre qui persiste il est précisé «fabrication Bessoneau»

Il est vrai que, depuis plusieurs années déjà, les spéléologues qui évoluent en milieu constamment humide, n'utilisent plus les cordes de chanvre. Mais ce n'est qu'en 1964 que le Vieux Campeur inscrit dans son catalogue une «corde de spéléologue, fabrication CDS, cordeau trois torons, diamètre 8 mm, poids au mètre 40 g. Résistance statique 1000 kg. Coloris blanc.» Son prix de 1.80 F le mètre la met bien au-dessous de la corde dynamique de diamètre à peu près équivalent vendu 2.80 F.

Enfin en 1967, les cordes de chanvre s'effacent pour ne rester que sous la forme d'une cordelette de 6 mm auxquels, nous dit le magasin, certains restent fidèles notamment pour le prussik. Quatre ans plus tard on assiste à leur dispariton totale qu'accompagne un requiem où le distributeur dit adieu à cette «vieille compagne» «reléguée au musée des vieilles choses».

Catalogue 1968. Pour la première fois, le mot «spéléologie» apparaît sur la couverture.

En 1971, une rubrique «cordes de spéléologie» est ouverte avec deux cordes de diamètre 10 mm, de marque Everest et Mammouth (sic). L'année suivante, elle se grossira d'une corde Fussener qui n'y restera qu'un an. En 1978. on assiste à une véritable explosion de l'offre avec seize cordes au catalogue (Everest, Joanny, Petzl Beal, Interalp Spéleo TSA, Mammut). Nous sommes entrés dans l'ère industrielle.

Claude **GENDRON**

Chef du rayon spéléologie, Claude Gendron meurt en plongée dans une grotte de l'Yonne en 1972. Catalogue 1970.

Les premières années de la «spéléo»

C'est en 1957 que la rubrique «Maténel spéléo» est créée. Pendant plus de dix ans ce sont les même trois articles qu'on y voit, pratiquement inchangés. Tout d'abord une échelle spéléo, en longueur de dix mètres, (puis dès 1958 en longueur de cinq mètres également) «fil galvanise, diamètre 2,7 mm; barreaux dural, diamètre 12-14, comportant 34 à 36 barreaux au pas de 29 cm». Et deux accessoires, le câble attache-échelle (le Vieux Campeur n'utilisera le terme d'élingue qu'en 1968) long de 2 ou 4 mètres, et des «anneaux italiens dits mousquetons spéléo, résistance 400 kg).»

A cet inventaire un peu court, vient s'ajouter en 1966 l'échelle spéléo P.A. (Pierre Allain) entièrement inox, mais qui présente la particularité de posséder des barreaux de Rilsan «de forme rationnelle permettant de les avoir bien en main. Extrémité et centre barreaux phosphorescents permettant un repérage facile en cas de panne de lumière». On sait que ce produit industriel élaboré, nettement plus cher que l'échelle ordinaire (en 1967, 110 F le train de dix mètres contre 70 F pour le modèle classique), plus volumineux et arrivant trop tard quelques années avant l'avènement de la spéléologie alpine, n'a pas connu le succès escompté.

Entre temps, perdu dans les profondeurs d'un catalogue de plus en plus épais, on pouvait repérer en 1963, entre les casquettes et les bonnets, un «casque plastique coloris blanc, souple et léger, pour alpinisme et speléo». Mais l'année suivante on le cherche en vain... Il n'y est plus.

Les difficiles débuts de la commercialisation

1967 représente une date importante. Le rayon speléo «est en cours de prendre une importance considérable à la demande de nombreux clients et de deux de nos vendeurs, mordus par cette activité». L'un d'eux n'est autre que Claude Gendron, adepte de la plongée souterraine, qui disparaîtra tragiquement dans un siphon de la grotte de l'Entonnoir à Saint-Moré (Yonne) en 1972. Si les sempiternelles échelles et leurs amicaux italiens restent fidèles au poste, un supplément ronéotypé énumère une liste complémentaire où l'on trouve l'éclairage acétylène avec lampe frontale adaptable, tuyau de raccordement et carbure en boîte de 1 et 5 kg, la combinaison Méryl fort enduit de plastique («étanche aux cascades») et des gants de protection «en plastique moulé et intérieur Jersey, coloris jaune».

plus dynamique et le plus inventif. Ses productions dépasseront le cadre étroit de la spéléologie et connaîtront un succès mondial.

L'annce suivante, une photographie nous montre la «poignée d'ascension Petzl, dont la technique est inspirée du bloqueur Dressler avec adjonction d'un cliquet de sécurité d'une poignée anatomique et d'un support de cordelette pour le pied».

En 1975 le magasin semble avoir réussi à contourner l'obstacle que dressaient devant son expansion les pratiques «souterraines» des petits ateliers semi-professionnels. «Nous sommes heureux, annonce-t-il, de [...] présenter un rayon complet», constitué en majorité d'articles "spéciaux" Vieux Campeur que nous avons fait fabriquer, avec nos idées et vos suggestions». Parmi ces produits maison qui voient le jour cette année-là, signalons les sacs spéléo cylindriques «Scialet» et «Igue», «diamètre une échelle, hauteur 4 échelles». Après les combinaisons, dont l'offre s'élargit, viennent la pontonnière «Gournier» et les gants spéléo en chlorure de polyvinyle. Cette année-là, dans le matériel de progression sur corde (poulie, descendeurs, bloqueur), le nom de Petzl se substitue à celui de Dressler qui disparaît dcfinitivernent. Marcel Tourbin propose des lampes à monter sur casque à acétylène ou électrique (modèles tous deux baptisés Ardèche) et mixte (modèles Margénaz ou Foussoubie) que vient concurrencer l'éclairage mixte des établissements Petzl.

1976 verra à la fois de nouveaux produits, le bloqueur américain Gibbs, la maillon à vis delta, les baudriers cuissards signés Petzl et Marbach. Le nom de Georges Marbach, un des grands explorateurs souterrains de sa génération, promoteur en France de la «spéléologie alpine». apparaît en 1976, année qui semble marquer une étape d'un intéressant itinéraire personnel dont le récit reste à écrire.

En 1977 Petzl poursuit ses innovations en ajoutant à sa gamme un éclairage mixte «livré avec boîtier porte-pile» qui bénéficie d'un «allumage piézo-rotatif», mais perd son réflecteur.

Pour conclure

Nous arrêtons là, abruptement, le dépouillement des pages spéléologiques des catalogues du Vieux Campeur. Il nous a permis d'assister, au milieu des annees 1970, à la naissance d'une ère nouvelle. Pour les équipements le plus courants, les stratégies commerciales et industrielles ont définitivement pris le pas sur le système D. La spéléologie est devenue une activité sportive pratiquée par un public suffisamment large pour soutenir tout un secteur d'activités professionnelles. Plutôt que de verser dans la nostalgie qui ne peut manquer de faire surface à la lecture de ces vieux documents, vestiges de temps révolus, voyons le bon côté des choses. L'exploration des grottes et des gouffres y aura gagné des outils plus performants et plus sûrs. Ces mutations auront contribué, à leur manière, à une meilleure connaissance du sous-sol de nos karsts.

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L'auteur tient à remercier Jacques -Yves de Rorthays et Francine Delrieu qui lui ont facilité l'accès aux collections du Vieux Campeur

343001. **Eclairage mixte** acétylène-électricité. Cette lampe mixte est à notre connaissance la plus au point actuellement. Dimensions extérieures : largeur 95 mm, hauteur 95 mm, épaisseur 60 mm.

L'éclairage frontal électrique est équipé d'un interrupteur étanche aux cascades. Diamètre du réflecteur, 45 mm.

L'éclairage à acétylène est équipé d'un allumeur automatique électrique. Bec livré avec débit 21 litres. Réflecteur inoxydable de 45 mm de ∅. Fixation de l'ensemble sur une platine d'aluminium reliée au casque par trois pattes. L'ensemble est livré avec le fil électrique et le tuyau à acétylène de départ. Un modèle vraiment sympathique ne pesant que 160 g ..... **70,—**

L 'éclairage mixte mis au point par Marcel Tourbin marque une étape vers l 'industrialisation du matériel spéléologique. Catalogue 1971.

Laboratorio prove Materiali di Costacciaro: ricerche preliminari sugli attacchi con collante chimico

di Francesco Salvatori,
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Abstract

Following laboratory tests with force gauges, several anchors, constituting of a steel bar with type M winding and anchored to the rock with different 2 component glues, have been subject to extraction tests. As a standard rock material blocks of white Carrara marble was used.

The role of the borehole surface is shown, and the cohesion forces as a function of the glue type and the elapsed time is calculated. It is shown that, using the same type of glue, the values of the cohesion forces are independent of the dimensions of the borehole, the diameter of the steel bar, and of the depth of immersion of the bar into the glue. The hardening time of the different glues is always the same, whereas the cohesion forces (σ_t) are different.

1. Standard di riferimento e condizioni sperimentali

Per supporti rocciosi standard sono stati utilizzati dei blocchetti di Marmo Bianco Carrara (MBC) - una roccia nota per le sue elevate caratteristiche di omogeneità - delle dimensioni di 15x15x12 cm.

I collanti presi in considerazione sono stati i seguenti: *HILTI HY 150, SARATOGA FORTE PRESA, SPIT DERRINGER, FISCHER C 700, FISCHER C 235, WURTH WIT C 100.*

Per tasselli sono state utilizzate delle barre di acciaio ad altissima resistenza (12.9), di vario diametro ma sempre con filettatura tipo M. In tal modo si è potuto ottenere degli ancoraggi:

a) di varia lunghezza e diametro ma con architettura standardizzata e riproducibile,
b) con resistenza tanto elevata da determinare, ad estrazione, la crisi e la rottura del collante senza che far intervenire la rottura della barra.

In sintesi le condizioni sperimentali standard sono state le seguenti:

COLLANTI: *HILTI HY 150, SARATOGA FORTE PRESA, SPIT DERRIGER, FISCHER C700, FISCHER C235, WURTH WIT C100*
MARMO BIANCO CARRARA
BARRE FILETTATE M ACCIAIO 12.9
TRAPANO BOSCH CON PUNTE A FONDO CONICO
TEMPERATURA AMBIENTE 15° C

Ogni dato riportato è stato ottenuto facendo la media dei risultati di almeno tre test uguali così concepiti: calcolo di F_{rc} (forza di rottura ad estrazione in kgp) nella macchina dinamometrica, producendo sollecitazioni via via crescenti, fino al cedimento dell'ancoraggio per estrazione della barra.

2. Superficie di taglio S_t

Per comprendere il meccanismo di tenuta degli ancoraggi a collante chimico si tenga presente che, ad estrazione, la rottura del sistema-ancoraggio si manifesta con l'estrazione della barra dal cemento chimico, lasciando un foro profondo quanto la parte immersa nel collante e con diametro massimo pari al diametro della barra misurato sulla parte esterna dei filetti.

La parte di barra estratta si presenta come un cilindro di superficie uniforme, con i filetti riempiti di collante. In fig. 1 è riportato con una linea tratteggiata il profilo della superficie di distacco. Non c'è alcuna adesione fra collante e metallo tanto che la barra, dopo l'indurimento del collante, può essere svitata: ciò che produce la tenuta del tassello nel foro è l'incastro che si determina fra filetti della vite e i conseguenti filetti del collante. Parimenti non ha alcun effetto di tenuta il contatto fra il fondo della barra e il collante.

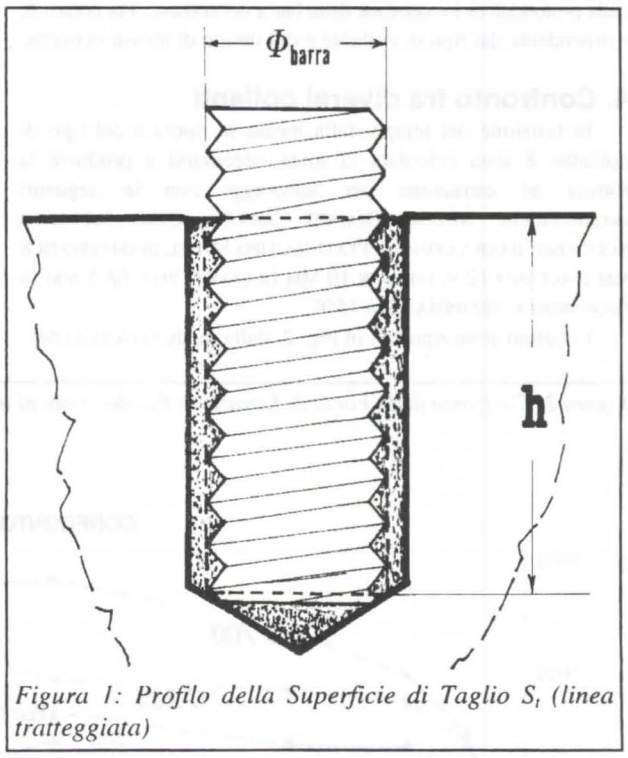

Figura 1: Profilo della Superficie di Taglio S_t (linea tratteggiata)

Dalle prove effettuate dunque risulta che la superficie effettiva di tenuta, definita come Superficie di Taglio S_t , è pari alla superficie laterale di un cilindro di altezza h e diametro ϕ_{barra} (vedi fig. 1). Detta superficie ha una misura pari a:

$$S_t = \pi \cdot \phi_{barra} \cdot h$$

Il valore di S_t è dunque l'elemento caratterizzante della tenuta dell'ancoraggio e per barre di diametro compreso fra 8-12 mm (quelle sperimentate) il passo dei filetti non sembra influenzare la resistenza ad estrazione dell'ancoraggio. Si può affermare infatti con una ragionevole certezza che la forza F_{rc} necessaria per produrre la rottura è direttamente proporzionale alla S_t e, quindi, un ancoraggio chimico è tanto più resistente quanto maggiore è il diametro della barra e quanto più questa è immersa nel collante.

Questa è la conclusione di maggior rilievo prodotta dalle ricerche effettuate, dalla quale discendono tutte le altre che qui di seguito esponiamo.

3. Sforzo di coesione σ_t

Se c'è proporzionalità diretta fra Superficie di Taglio S_t e Carico di Rottura ad Estrazione F_{rc} di una barra filettata immersa nel collante, allora è possibile calcolare il valore della forza di rottura all'estrazione in kgp per ogni unità di superficie coinvolta nella coesione. Detta forza unitaria è definita come Sforzo di Coesione σ_t (kgp/mm^2):

$$\sigma_t = F_{rc} / S_t$$

Dato che F_{rc} è espressa in kgp ed S_t in mm^2, σ_t corrisponde al numero di kgp tenuti sino alla rottura da ogni mm^2 della superficie di taglio.

Come già detto in precedenza, lo Sforzo di Coesione è indipendente dalle dimensioni del foro, dal diametro della barra e dalla profondità di immersione della barra nel collante. Per contro σ_t è dipendente dal tipo di collante e dal tempo di messa in opera.

4. Confronto fra diversi collanti

In funzione del tempo dalla messa in opera e del tipo di collante, è stata calcolata la forza necessaria a produrre la rottura ad estrazione per ancoraggi con le seguenti caratteristiche: MARMO BIANCO CARRARA COME SUPPORTO ROCCIOSO, BARRA CON FILETTATURA TIPO M DEL DIAMETRO DI 8 MM E ACCIAIO 12.9, FORO DI 10 MM DI DIAMETRO E 68.5 MM DI PROFONDITÀ, TEMPERATURA 15°C.

I risultati sono riportati in Fig. 2, dalla quale si ricava che:

a) dopo appena 30 minuti dalla messa in opera la tenuta di tutti i sistemi è comunque superiore o pari ai 2000 kgp;
b) i collanti esaminati si dividono in due categorie:
Fischer 235, Fischer 700 e Wurth con $\sigma_t = 3{,}3$ kgp/mm^2; Spit, Saratoga e Hilti con $\sigma_t = 2{,}4$ kgp/mm^2;
c) per tutti i tipi di collante la tenuta massima si ottiene dopo 72 ore dalla messa in opera; oltre questo tempo la tenuta si stabilizza sul valore massimo.

5. Accorgimenti e precauzioni

Per ottenere il massimo della resa occorre evitare che:
a) il collante sia scaduto,
b) la barra non sia posta al centro del foro,
c) il foro e la barra abbiano lo stesso diametro,
d) il foro sia sporco e bagnato.

Con temperature inferiori ai 15°C il tempo ottimale di presa si allunga: tanto più la temperatura dell'ambiente è bassa tanto più tempo occorre perché si verifichi la massima tenuta.

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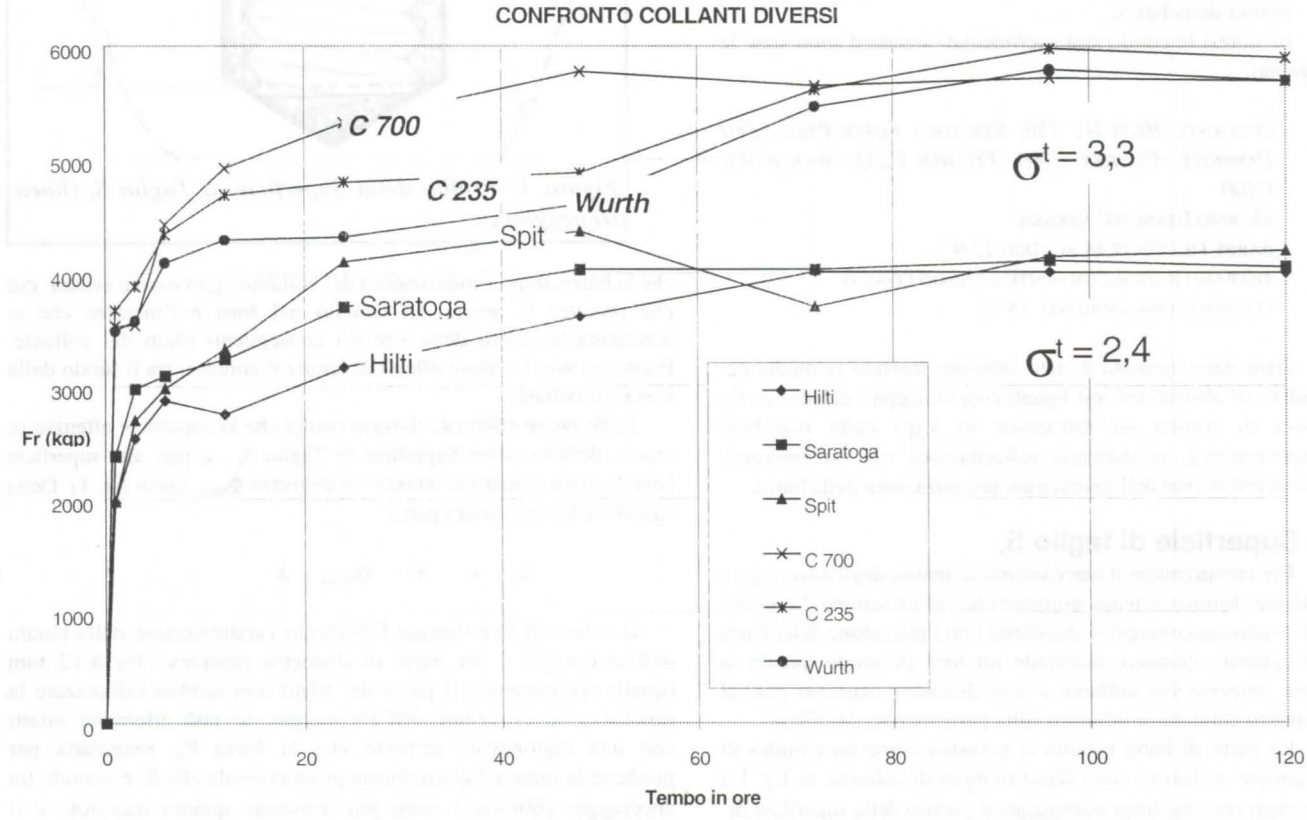
Figura 2: Confronto della Forza di Estrazione F_{rc}, dei tempi di indurimento e dello Sforzo di Coesione σ_t per diversi collanti



Laboratorio prove materiali di Costacciaro: confronto fra ancoraggi artificiali ad espansione e a collante chimico

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Abstract

In order to compare the strength (against extraction and shear), different types of anchors have been subject to rupture tests with the aid of a force gauge. The comparison has been made with chemical and machanical anchors with comparable dimensions and boring energies.

1. Standard di riferimento e condizioni sperimentali

Gli ancoraggi prescelti sono tali da essere comparabili nelle dimensioni, restando diversi nell'aspetto e nelle modalità di adesione o coesione alla parete interna del foro.

I tasselli sottoposti confronto sono:

a) *Barra M+ (chimico): acciaio 12.9 con filettatura modificata (5 spire/cm) e dimensioni 10 x 80 mm,*
b) *Barra M (chimico): acciaio 12.9 con filettatura tipo M (9 spire/ cm) e dimensioni 10 x 80 mm,*
c) *Raumer Superstar (chimico): acciaio inox con superficie zigrinata e dimensioni 10 x 80,*
d) *Golfare (chimico): acciaio 8.8 con filettatura tipo M e con dimensioni 14 x 100 mm,*
e) *Cassin (chimico): acciaio (caratteristiche indefinite) sezione trasversale ellittica con scannellatura oblique e dimensioni massime 12 x 110 mm,*
f) *Petzl Collinox 25 kn (chimico): acciaio inox sezione trasversale circolare con scannellature oblique e dimensioni 10 x 70 mm,*
g) *Spit MF 10 (espansione meccanica): con bullone acciaio 12.9 con filettatura tipo M e diametro 10 mm,*
h) *Fix Hilti HSA 10 (espansione meccanica): con filettatura tipo M e dimensioni 10 x 70 mm.*

Per supporti rocciosi standard sono stati utilizzati dei blocchetti delle dimensioni di 15x15x12 cm di Marmo Bianco Carrara (MBC), una roccia nota per le sue elevate caratteristiche di omogeneità. Il collante utilizzato è l'*Hilti HY 150.*

In sintesi le condizioni sperimentali standard sono state le seguenti:

Marmo Bianco Carrara
Tasselli come sopra indicato
Foro di dimensioni opportune
Collante Hilti HY 150
Tempo di indurimento 72 ore
Temperatura 15°C
Ad estrazione attacco su anello simmetrico
A taglio attacco su piastra acciaio spessore 5 mm.

Per ottenere la rottura ad estrazione la macchina dinamometrica ha sollecitato l'ancoraggio con forze via via crescenti e di direzione coincidente con l'asse del tassello.

Per ottenere il cedimento a taglio il banco dinamometrico ha applicato all'ancoraggio forze via via crescenti con direzione ortogonale rispetto all'asse del tassello.

I dati riportati sono la media dei valori ottenuti in almeno tre test uguali.

La rottura ad estrazione per i "chimici" avviene per estrazione del tassello dopo il cedimento della Superficie di Taglio S_t. Fa eccezione il Golfare, che cede per rottura dell'occhiello, e il Cassin, che cede per flessione della barra lungo la sezione trasversale posta sotto l'occhiello. Il cedimento a estrazione dei tasselli ad espansione si verifica per lo scorrimento dei tasselli all'interno del foro.

A taglio il cedimento avviene per tranciamento della barra oppure, come nel caso del Cassin e del Petzl, per flessione ed estrazione della barra.

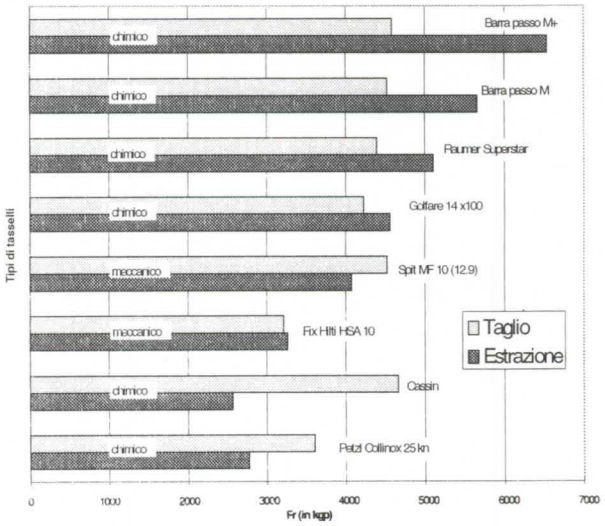
2. Risultati e conclusioni

Quanto ottenuto dall'analisi sperimentale è riportato in Fig. 1. Se ne ricava che i tasselli "chimici" con superficie filettata o zigrinata garantiscono una tenuta superiore o uguale rispetto ai classici Spit autoperforanti e ai Fix per i quali occorre il trapano (questi ultimi, come noto, con tenuta inferiore agli Spit).

La filettatura tipo M garantisce la tenuta più elevata. Se tale filettatura viene modificata a 5 spire/cm, l'ancoraggio acquista una resistenza superiore.

I tasselli "chimici" con scannellature oblique (Cassin e Petzl) sono quelli che mostrano minor resistenza alla rottura, sia ad estrazione che a taglio. Il tassello Collinox della Petzl è l'ancoraggio che ha il peggior rapporto qualità/prezzo.

Figura 1: Confronto fra ancoraggi chimici e meccanici



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Velký Traverz
The superlong Tyrolean

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Turna nad Bodvou 328, 044 02 Slovak Republik

The idea of bridging the Zadielska tiesnava (Zadiel Gorge) by means of a plaited rope and climbing across is not new. I can't remember exactly when it was mentioned for the first time, but it must be at least 12 years that it has occurred to us from time to time, like an almost unrealizable dream. During the past few years it seemed to us that we would never be able to do it, as we constantly met with the peremptory and persistent resistence of environmentalists.

It is no wonder. The Zadiel Gorge is a morphological and botanical jewel of the Slovensky kras (Slovak Karst). It is situated in the Eastern part of the karst territory and it is named after a small village, Zadiel, which is tucked in front of the valley. The gorge is over 3 km long. Vertical walls, sometimes even overhanging rock walls rise above the torrent of Blatnica to a height of 400 m. The edges of the plateau are 400 to 800 meters apart. Access to the gorge from the South is only 1 km from the state road E571 Kosice - Roznava. The turnoff is at the 406th km. Another possible access is from the West, along the valley of Cremosna (it is less frequently used). Despite the narrow and relatively good-quality road leading through the gorge, automobiles are prohibited and strictly monitored throughout the year. The Zadiel Gorge, being a National Natural Reservate, is protected by the law of the Slovac Republic. Since 1954 the highest degree of nature preservation has been applied to it.

Yet dreams are here to come true. In a poem J. Langston Hughes says:

Hold fast to dreams,
for when dreams die,
life is a broken winged bird,
that cannot fly.

Perhaps a factor was a prepared International Speleological Congress, or maybe some people loyally dedicated to speleology in top government positions, but most likely, properly used arguments helped us, after long preparation, to get an exception to the law in order to implement this project.

Prior to starting arrangements of any formalities, it was necessary to answer several principal technical questions:

1. Connecting the two edges of the gorge
2. A rope for bridging
3. Deep slack of a rope-climber resulting from a long lenght of plaited synthetic rope and its relatively great elongation.
4. Suitable anchorage by means of tensionless knots.
5. Measuring the forces on the anchorage.

1. To draw a rope with a weight of 70 kg to the other side of the 800 m gorge as the bird flies, is not a simple task. It is obvious that it must be done in several stages. In our case it seems realistic to do it in three phases.

The first phase is a cord 1.3 mm in diameter, with a weight of more than 1 kg and a strenght of 750 N. To transport the cord along the surface is practically impossible because of high tree cover which literally forms a tunnel with a tree canopy at a height of 20 m above the torrent in the summer months.

To transport the cord by means of a helicopter, motor hang-glider, flight model, or even by a specially constructed rocket missile is possible, but from our speleotechnical point of view, not very congenial. We consider using a specially constructed ballistic missile which would transport the clew of cord to the other side.

The next phase is to draw over a thicker 12.5 kg cord with a 5 mm diameter and strenght of 5 kN by means of the first cord. The last phase uses the latter to draw over a rope with a diameter of 12 mm. The above listed tasks require technical equipment constructed especially for this purpose (as light as possible).

2. Bringing over the rope itself is a separate chapter. Numerous discussions among the experts about the most suitable parameters for the rope required for this project were, in the end, always directed and restricted within the framework of material and technological possibilities of the producer. Fortunately, the manager of technical development for the rope producer is a veritable expert and, as well, he is sufficiently infected with "the virus" of Velky Traverz. He spent many hours pattering a suitable rope, mastering continual plaiting and making various adaptations of already existing ropes. He finally managed to get the closest thing to the required parameters of the rope, which are as follows: the rope length 850 m in one piece, the rope diameter 12 mm, specific weight 85 gr, the rope strength 30 kN and elongation at a loading of 10 kN - max 7 %. At the time of finishing this paper there was one more result of the sample test available, the diagram of which is covered by Figures No. 1 and No. 2 in Supplement, however, we also recieved telephone information which proved the existence of another, even better sample.

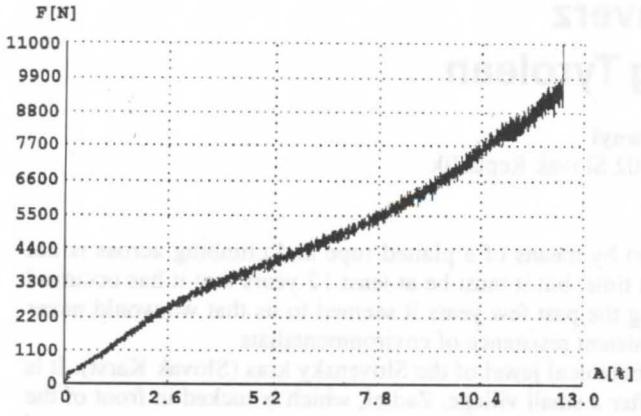

Figure No. 1

F - force in N
A - elongation in %

d - 11.4 mm
W - 87.54 g/m
AH - 12.60 %

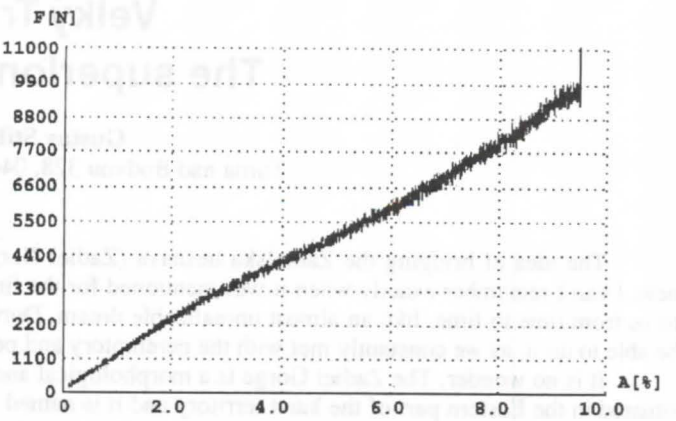

Figure No. 2

Rope as Fig. No. 1 - heat treated

F - force in N
A - elongation in %

d - 11.4 mm
W - 85.5 g/m
AH - 9.45 %

3. A long length of a horizontally tightened rope between two edges of the gorge causes great problems which must be solved. The common safety requirement is the slack of a climber at a depth which is a minimum 10 % of the lenght of a tightened rope. Provided that the tightened rope is totally horizontal, the calculated rope weight is 66 kg and the climber´s weight is 90 kg (total 156 kg), the forces are three times higher than those that can be expected at the anchorage. 10 % slack of a climber on such a long bridging can cause several problems. The large angle of the rope behind the anchorage which causes a steep descent on a really long section, requires lowering by an auxilliary rope or braking on the carrying cable which can be dangerous. Likewise, climbing up to the anchoring on the other side with a high ascent can cause

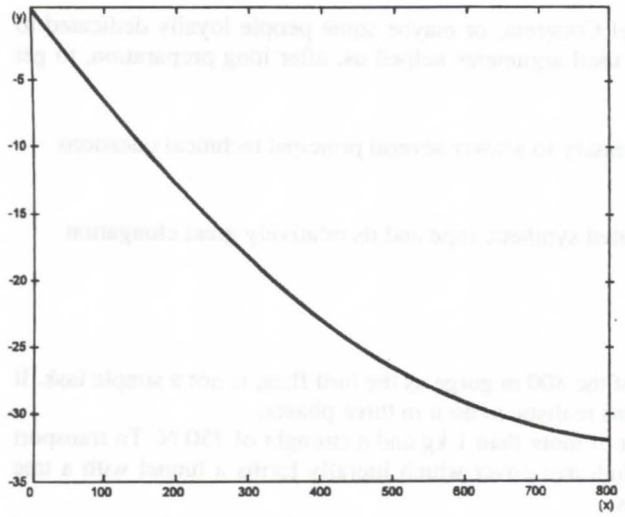

Figure No. 3

Computer simulation - tighted rope itself

x - rope lenght in meters
y - rope slack in meters

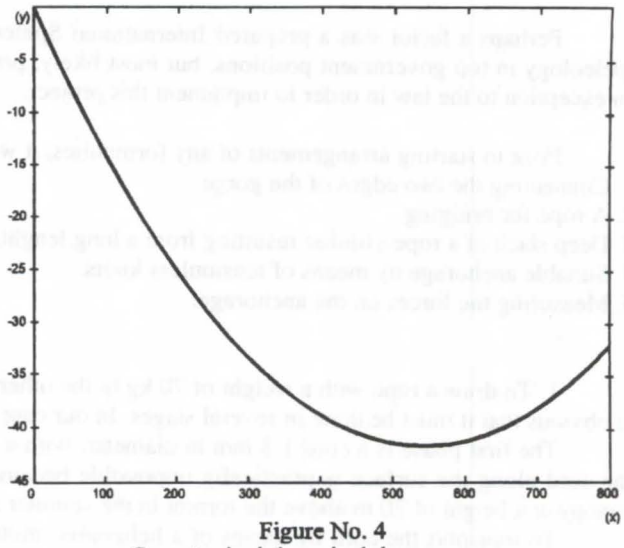

Figure No. 4

Computer simulation - loaded rope

x - rope lenght in meters
y - rope slack in meters

problems for the climber and can at least affect the duration and comfort of climbing.

Safeguarding using a safety rope proved to be a similar problem. In practice it is common to construct longer Tyroleans of two ropes with a separate anchorage. However, in our case, installing two ropes could cause almost irresolvable practical problems during installation itself, as well as during anchoring, tightening and climbing.

There is nothing left but to use one rope, to ensure maximum security and comfort for the man who will climb.

If we consider using a rope with a safety coefficient of 3, which is a sufficiently high level, it will be possible to tighten our rope to the value of forces in the anchorage which is 10 kN. This represents more than the double value compared with the assumed force at the slack of 80 metres (which is 10%, according to the common rule).

We took two approaches to solve the problems of force relations in the anchorage, depending on the slack:

The first was to set simple functions to a computer, with the basic requirement that the rope pre-stress will be continuously checked and adjusted, so that forces in the anchorage will permanently have a value of 10 kN. The computer drew a curve of the tightened rope itself, with a such prestress (Figure No. 3) and also the curve of the rope loaded with a climber with the weight 80 kg (Figure No. 4).

The second method was to calculate the force parameters using common mathematical methods, at several chosen parameters of the depth of the slack. The results of these calculations differ significantly from the results of the simple computer simulation. They assume more than double slack, compared with the results shown in Figure No. 3 and No. 4.

Finally, relations between compared values are not linear, which results from more factors, but mainly from the rope elasticity. Therefore, the values obtained by merely theoretical calculations can differ and will differ from the values measured in practice. That is why we decided no to publish them for the time being. They will be processed in details and published along with the results of the experiment in the proceedings covering this event.

4. Today it is generally known that if a knot is tied in a rope, the rope strenght will practically decrease by half. Thus, a knot in the rope for Velky Traverz was excluded at the conception of the idea itself. The only possible way of anchoring is by means of a tensionless knots. Only a friction drum winch with a suitably selected gear enables anchoring by means of a tensionless knot and simultaneously change pre-stress in rope using the simplest possibility.

Fortunately, a large of choices of yacht winches are available with various epicyclic gears and for various rope diameters. These winches enable us to anchor, stress and release the rope with losses of up to 5% of the rope strenghth. They are elegantly constructed, light, strong and, importantly, they can be used under practically any conditions.

Another possibility is to construct a special winch with an electric drive with the possibility to be powered from either a power station or from a battery source. The drive of the winch drums can be done by a ratchet wheel and the braking can be ensured either by means of a brake drum (band brake or shoe brake), or, in order to achieve higher safety, by means of a worm gear unit. Such a winch with an electric drive can be interconnected by means of electronic measuring nad, forces in the traverse can be checked automatically in a selected mode.

5. Nowadays, precise measurements even in exteriors do not present any difficulties. There are many systems and even more producers of various equipment. Choosing the most suitable measurement is only a question of finances.

In our case, along with common criteria for choosing a suitable measurement, like volume, weight and preciseness, there were also requirements connected with an independent power source, waterproofness, and simple installation. Digital crane scales produced by a renowned producer, with mesurement of up to 2.5 tons and a declared deviation of +- 5 kg, but with an actual deviation of +- 1 kg (according to tests done by the State Testing Laboratory) proved to be the best choice.

The five above mentioned and partly described problems of our project are only the basic ones. There are many other problems and issues which affect practical implementation of the superlong tyrolean. We have to take into account water soaking the rope from possible rain. Also, gusts of wind on the wet rope must be considered. The surface area of the 800 m long rope is almost 7 m^2 (if we consider the rounding-off coefficient), which is quite a large area. It is necessary to consider the possibility of rescue, i.e., two people being on the rope simultaneously and, possibly, their common descend on the rope to the bottom of the gorge or their possible lowering by means of releasing the ends by adding auxiliary ropes. We don't know exactly what will be created by longitudinal waving in the rope resulting from the effects of rhytmical climbing or regular gusts of circulating air. These and other tiny details demand hundreds of hours of precious time, of which there is never enough.

If you noticed this contribution and are interested in these problems, do not hesitate to register immediately. Velky Traverz, the superlong tyrolean, is a practical part of the international Workshop on Tyrolean Traverses, which is a follow-up event to the 12th International Congress of Speleology, and it will take place in Kosice from 21st to 25th of August, 1997.

VELKY
TRAVERZ

Foreign cavers coming to Turkey: Our respective relations

by Ender Usuloglu
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Abstract

Historically, speleological activities in Turkey have been initiated by one man, Temucin Aygen, with the great help from foreign cavers who have been interested in Turkey's karstic areas. There were some interested Turkish people though who were limited to only helping foreign cavers, mainly sorting logistical problems.
Starting in early 1980's and especially towards the end of the decade, Turkish cavers increasingly became more experienced, technically well built and active, which has increased a hot debate to what extent foreign cavers should come to Turkey, are they following the prodecures and ethics of caving, etc?
Turkish cavers are getting more and more organized among themselves. There is Turkish Cavers Union which has been organized voluntarily and de facto. Sooner or later, it will become legalized.
There are laws, ways of application for caving and a caving organization to consult in Turkey for foreign cavers.

Turkish caving history and foreign cavers

If you look briefly to caving history in Turkey, serious expeditions start about in 1950's. These were biospeleogical expeditions done by foreigners. In mid-1960's, Temucin Aygen, aware of the potential of Turkey, invited cavers to explore the hidden under-world of Anatolia. Although Turkish Speleological Society was established in 1964, together with Temucin Aygen, there were only limited Turkish people interested in this strange business. However, caving became popular almost 20-25 years later. At those times, people considered only crazy foreigners can go into black holes and return covered full of mud.
With increasing expeditions, very important explorations have been accomplished: Dumanly-Kembos system (1966), Altynbesik Düdensuyu (1967), Düdencik (1967), the Turkish depth record till 1989, Pynargozu resurgence (1970) one of the tallest caves in the world and the longest cave in Turkey, Tilkiler Düdeni (1976-80), the second longest cave in Turkey are some examples of foreign expeditions. With these expeditions and contributions from foreign cavers, the interest in caving in Turkey slowly but surely grew. Within this sense, we are grateful to foreign cavers. Out of the little group of Temucin Aygen, students formed in 1973 the first speleological society in the Bogazici University. Lack of equipment and experience, they had to rely on foreigners as well. In 1979, expedition to Cimiyayla with Emperial College from England was, I believe, one of the turning points of the Turkish caving history. Now equipped and experienced, it gave the necessary momentum for longer and deeper Turkish expeditions.
Starting from 1981, Dupnisa cave, Sorkun, Kapakly, Dongelyany, Topmeydany, Cykrykkapy and Ilgarini sinkholes have found their places in the deepest and longest ranking of Turkey. Desire to break the Turkish depth record has been realised in 1989 in Cukurpynar sinkhole (-394 m, -824m, -1037 m, -1190 m respectively) with the help of Temucin Aygen. While Turkish cavers are busy with their own expeditions, foreign cavers keep coming to Turkey from everywhere: Checzks, Hungarians, French, English, Spanish etc. There were also joint-expeditions, but its amount continued to decrease. Since both parties were busy with carrying their own expeditions, the contacts were on exchanging letter basis. Among the Turkish cavers, there was also a lack of communication and a mild to strong competition.

I believe, breaking the Turkish depth record solely by Turkish cavers was again one of the important turning points in the history. It led to the conglomeration of Turkish cavers, especially with the firm ground established at the first Speleological Syposium held in May 1990 and with a small convention in Istanbul afterwards, where hot debates about foreign cavers were held. In the decade that we are in, there are more than 10 clubs and societies dealing with caves and caving. The number may seem strange and little, especially compared to Europe. But we can easily say that this is just the beginning and building of caving culture in Turkey.
At the moment, in spring 1997, out of the first ten deepest caves, eight of them have been discovered by Turkish cavers. Self-sufficiency, creation of culture, communication and better relations among Turkish cavers inevitably fires the question of our relations with foreign cavers.

Current relations with foreign cavers

Becoming more and more professional in caving and starting to be the owner of our caves led to strain the relations with foreigners. Conflict of interest is becoming more and more apparent. Once, used to come with no restrictions or not following the prodecures, foreign cavers now have to understand the current conjuncture of Turkish caving.
If you look at the caving groups coming to Turkey, most of them are coming for sportive activities and to find a cave(s) that will carry them to world caving literature. Most of them has the minimum of scientific activities which we consider as drawing maps and writing reports. Interestingly enough, we do not receive these documents that are produced, or we get them years after, when foreigners don't want to be confronted with problems when they are coming to Turkey for the second time .
We believe that there are caving ethics that should be applicable to any caving activities wherever they are held. But whatever the reason might be, some foreign cavers seem to forgot these ethics in Turkey. There were some examples that we had to protest to their related associations. As Turkish cavers we are in line with caving ethics so far and we wish the same thing for foreign cavers.
There are Turkish laws concerning caves and cave life which bind foreign cavers to follow prodecure(s) for caving

activities in Turkey. However these laws weren't applicable in practical sense because no one seemed to need these laws until today. Below you will find the details of these laws.
Foreigners still tend to see Turkey as third world country. We have to admit that as Turkey, we have our own contribution to this perception. As Turkish cavers we are trying hard to break this perception and we would like to see the same attitude from foreign cavers.
Last but not least, foreign cavers now claim that Turkish cavers have no unified organization where they could apply when they come to Turkey.
In November 1994, Turkish cavers had their second speleological symposium, held in Ankara. I believe, one of the most important part of the symposium was the declaration of "Turkish Cavers Union" by BUMAK and MAD (speleogical association established by Temucin Aygen in 1964). Later, the number of attendees to the meetings clearly shows that though it is very hard, Turkish cavers are becoming more and more unified.

Turkish Cavers Union

Definition

A voluntary working national caving organization established by the related associations, university clubs and by contribution from related clerical people of the governmental organizations

Purpose

- Provide coordination and flow of information between attendees.
- On behalf of attendees, be a spokesman and representative for caving, conservation and caving related problems in Turkey.
- On behalf of attendees, be representative for the foreign caving federations and groups that are active in Turkey. Follow and coordinate international caving expeditions in Turkey.
- Inform local and international associations about caving codes and procedures, lobby for caves and caving codes and procedures in the governmental organizations. In the long-term, work on law that will enable the protection of caves.
- To support, organize and establish nation-wide rescue caving team.
- To encourage and if possible to support scientific caving publications and reports of caving expeditions.

Attendees

- Speleological Society of Bogazici University and Cave Research Association, Ankara
- Speleological Society of Zonguldak University and Speleological Society of Hacettepe University
- Center for Hidrokarst studies, Hacettepe University and Caving department of state organization for minerals research (M.T.A.)
- Speleological Society of Ege University and Speleological Society of Ankara University

At the moment, within the Union, there are three working groups. The Standardization group works for a common terminology and standards of caving reports and mapping. The Rescue group is working on the establishment of the team, and on a handbook for rescue techniques. The Documentation and Publication group primarily copes with the gathering of bibliography of caves and related activities. The fourth one which is the coordination of foreign and local caving activities in Turkey is on the way.
We believe that running such an organization until it becomes legal is really hard but we are doing our best. We can say that Turkish Cavers Union is the right address for foreign cavers who will be conducting expeditions in Turkey.

Turkish laws concerning caves and cave conservation

1. State approach to caves and conservation

In Turkey, since caves and caving are relatively new subjects to the people, media and state, there are no caving or cave conservation laws that sets the rules directly. Before 1993, there has been no approach or interest for the codes of caving and cave conservation. Unified cavers have stopped so many activities that were going to ruin a cave life or the cave itself. Ikigöz resurgence in Catalca, Istanbul, has been saved from a cement plant to be destroyed totally. Tuluntas cave near newly built highway of Ankara was also saved from destruction. A discovered cave near the construction of a highway of Izmir is another example. In early 1990's, caving and caves became mediatic thanks to latest discoveries. This has attracted the attention of the government of that time. The Ministry of Tourism invited foreign cavers to some caves in the south. The main reason, however, wasn't the concern of cave conservation but how to attract tourists and make money.
As Turkish cavers, we have tried so hard to convince the ministry that caving is dangerous and unique outdoor activity which needs experienced team and quite a bit of equipment. And we also added that foreign cavers are not type of tourists that are going to spend so much money because their accomodation is tent and they even bring their own food from their own countries. We are not quite sure to what extend we have convinced our state but one thing is sure: that we have opened the door of the long way to caves and caving law in Turkey.
Under the organization of Ministry of Tourism, with the collaboration of the High Board of Conservation of Natural and Cultural Habitat, members of BUMAK and MAD had set up a committee. At the end of the meetings of the committee, practically nothing happened. But now, at least we have a door in the state to knock on.

2. Laws As of 20th of February 1984

Turkey has accepted the BERN agreement with 84/7601 code of the Council of Ministries. The first part of the Bern agreement indicates the protection of wild flora and fauna and their environment. Also, Law 3386, Law 2863 and Law 2872 concerns with the protection and conservation of natural and cultural habitat of Turkey both overground and underground which covers cave(s) and cave flora and fauna.
The 9th rule of the Law 2863 indicates and explains the circumstances in which one has to have a permission from the High Board of Conservation of Natural and Cultural Habitat. Clearly, foreign cavers who are coming or carrying out an expedition in Turkey have to get an permission from this board.
As we have explained above, there are no direct laws concerning caves. One of the main and long-term activity of Turkish Cavers Union will be drafting the codes for caves and cave life conservation in Turkey.

What do the Turkish Cavers expect from foreign cavers?

a. Expeditions

As Turkey, we always welcome any scientific activity or expedition which will be benefited by the concerned science worldwide and in Turkey. However, we do not accept caving expeditions carried for sportive activities, and we don't call writing a report and drawing maps scientific. Therefore, we regret foreign sportive caving activities for the sake of deepest and longest records because as Turkish cavers, we are already doing that.

We would like to share our caves for scientific purposes but not for sportive ones, unless Turkish cavers benefit from these activities and if foreign cavers follow the ways of application for expedition and caving ethics.

b. Reports and ethics

After an expedition carried in Turkey, not all foreign cavers/groups tend to send their reports. When they are confronted with problems or after years pass, they are sending their reports.

Another problem we confront is ethical isssues. We do not know the driving factors but some groups tend to forget about caving ethics.

As rule of thumb, as Turkish Cavers we would like foreign cavers to send their reports within six months after their expeditions to related Turkish caving groups or organizations. And of course, please follow the caving ethics while you are in Turkey.

How to apply for an caving expedition?

Either contact the Turkish Cavers Union or related any Turkish caving group or contact a Turkish Embassy nearby at least six months before the expedition for the permission, explaning your expedition in details. This time is necessary because Turkish Embassy will consult the Ministry of Foreign Affairs who in return will contact the H.Board of Conservation of Natural and Cultural Habitat.

Addresses

-Turkish Cavers Union, P.K. 670 06445 Yenisehir, Ankara, Turkey.

-Speleological Society of Bogazici University, Bogazici University Bebek 80815, Istanbul, Turkey.

-Cave Research Association, P.K. 670 06445 Yenisehir, Ankara, Turkey.

-Internet; There are WWW pages, E-Mail for Turkish caving groups.

Toporobot

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Cave Modeling and Visualisation

The Toporobot approach to cave surveying will be explained in a multimedia presentation. Concepts of spatial information systems will be illustrated using "LimeLight", the new version of this widely used software.

Toporobot, developed in Switzerland over the last 25 years, offers the cave cartographer an encompassing system to model and visualise complex caves. LimeLight packages sophisticated methods for error analysis and 3D graphics into an easy to use application for the Macintosh. It has assisted many cavers in the surveys of major caves and accompanied many expeditions worldwide.

With its emphasis on morphological structure, Toporobot enables cave surveyors greater expressiveness than other approaches because caves are modeled as sets of passages, each approximated as a tube. This requires cavers to start viewing their data in a different way: as the basis of a spatial model.

The presentation will close with an outlook on cave information systems that integrate diverse information (geological, geographical, historical, organisational bibliographical, etc) on electronic networks.

Höhlenmodellierung und Visualisierung

In einer Multimediapräsentation wird Höhlentopographen die Toporobot-Methode zur Höhlenvermessung vorgestellt. Anhand von LimeLight, der neuen Version des weitverbreiteten Programms, werden Konzepte eines räumlichen Informationssystems illustriert.

Toporobot, seit 25 Jahren entwickelt, offeriert sich dem Höhlenkartographen als ein umfassendes System zur Modellierung und Visualisierung komplexer Höhlen. LimeLight verpackt ausgefeilte Verfahren zur Fehleranalyse und 3D-Graphik in einer leicht zu beherrschenden Macintosh-Applikation. Es bewährte sich bei der Vermessung zahlreicher Höhlensysteme und begleitete Expeditionen weltweit.

Der Toporobot-Ansatz ermöglicht dem Höhlentopographen grössere Expressivität als andere Methoden: Höhlen werden als Sätze von Gängen modelliert, die als Röhren angenähert werden. Dies bedingt ein Umdenken beim Vermessen: die Messdaten bilden die Grundlage für ein räumliches Modell.

Das Referat schliesst mit einem Ausblick auf Höhleninformationssysteme, welche verschiedenste Daten (geologische, geographische, historische, organisatorische, bibliographische) auf elektronischen Netzwerken integrieren können.

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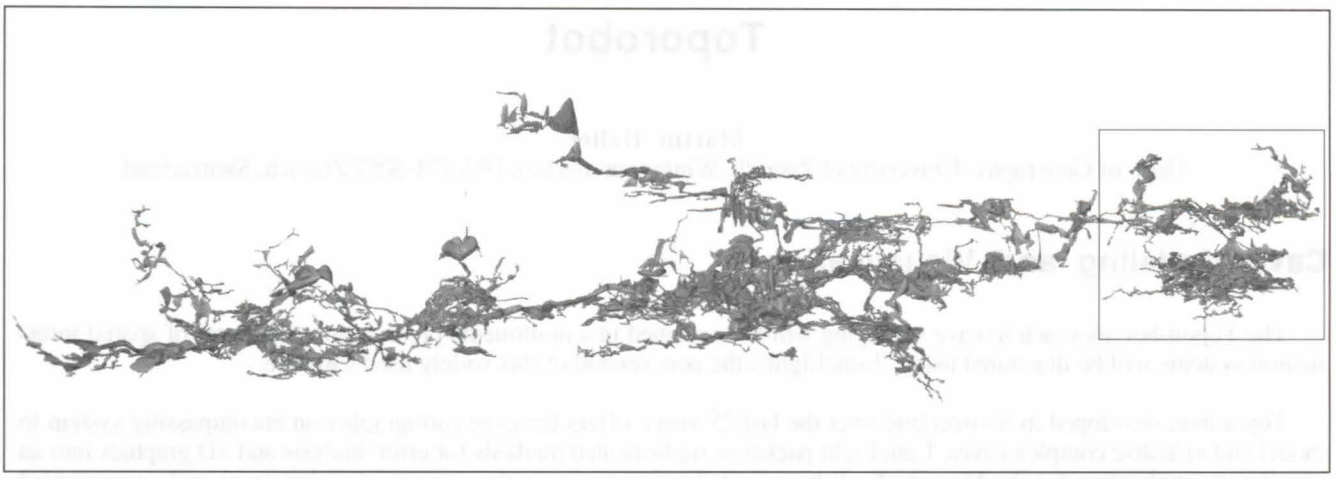
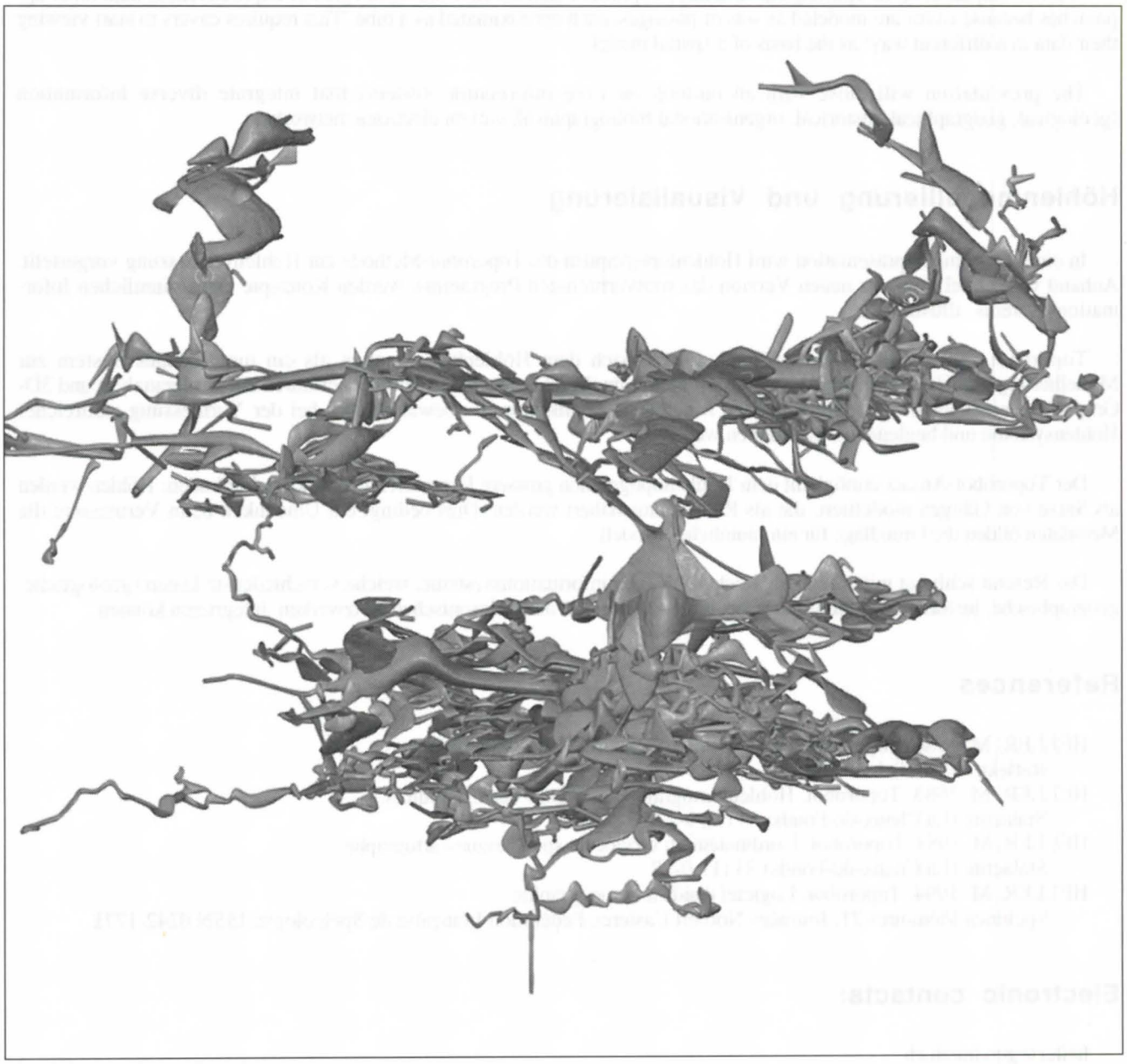


3D overview (S-N) of Lechuguilla Cave, New Mexico, USA – Toporobot by Martin Heller



Lechuguilla Cave, New Mexico, USA – 3D-view of the Far East – Toporobot by Martin Heller

The Making of the „Caver's Living Dictionary"

by Attila Kósa
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Abstract

The making of a dictionary of speleological terms was started in 1965 and it has never been really concluded. The start was an English-Hungarian version in 1966, then a Hungarian-English-German-French-Russian version was published in 1989 for the UIS Congress. After that point the computer came into the picture and an English-French-German-Hungarian version was published in 1995–this time available from any language to any of the other.

During the thirty years of the editing it has been realized that such a dictionary (as any other) can not ever be „completed" but it must be made mobile, „living". The paper presents the editing, the published stages, explains the size of the volume, the choice of words and the way of making the dictionary „alive".

Stage One: the Sixties

The author (mother tongue Hungarian) started to read English language speleological publications, books and periodicals in the late fifties. Soon he realized that neither his English teacher nor the dictionaries were good enough to solve some riddles. Some words were not there in the dictionaries (to begin with *karst* and *speleology* and not to mention *spelunking* or *domepit, swallet etc.*) or the common meaning of the word was something else (a *pothole* is not necessarily a discontinuity of road pavement, but a vertical cave in England, a *grotto* is a caving club in the USA etc.) Some other words carried more than one or indefinite meanings and some things had more than one names.

Years passing a little vocabulary was developing of solved riddles. The sources of the solutions were glossaries, books with pictures, correspondence and personal contacts. When it contained more than two hundred (217) entries it was decided by the author that it was worth to publish it as others might welcome the collection of words collected through almost a decade. As the modern ways of copying were not yet available the dictionary was typed in as many carbon copies that fitted into the typewriter and distributed to some people to be reviewed in 1967. In spite of a general favorable opinion there was no way to publish it at that time and the whole thing went dormant for twenty years.

Stage Two: the Eighties

The Hungarian Speleological Society organized the 10th International Congress of Speleology in 1989. It seemed to be a good practical idea to „resurrect" the speleological dictionary so that it would be available for the organizers and guests as well. It was decided that it be published in a Hungarian to English, German, French and Russian version. 1989 wasn't yet really the age of the computer in eastern Europe, thus the dictionary was typed and printed in some 300 copies with about 160 entries. A number of copies is still available now, eight years later.

Stage Tree: the Nineties

In the beginning of the decade the author started to use a computer and the idea to computerize the dictionary came soon after. The database part of an early version of the MS WORKS seemed to be good to handle the job and the existing entries were typed into it in a tricky way to make the entries available to any language to any other. Except Russian, because of character difficulties.

Using later versions of the MS WORKS and WORD for WINDOWS 6.0 the final form of the dictionary was developed in 1994 and it seemed to be too good to keep it in secret.

Publication

The conditions since the sixties had not improved in 1995. The only way of financing proved to be that the author foots the bill. That means a small number of copies, that means Xerox techniques. Have 25-30 copies printed, sell them (forget about profit) and finance the next edition from the income. In the meantime mistakes can be corrected, words can be added and the opinions of the readers can be considered. The next edition will be better. A dictionary printed in more than a minimal number of copies can not be corrected until the stock is gone, but the method of printing a small number, makes the dictionary „breath", it becomes the *„Caver's Living Dictionary"*.

Four editions have been completed since 1995, three of them in 30-30 copies that have been sold and a special edition in 250 copies–this time printed–to be distributed to the participants of two conferences in Hungary in 1996.

The Choice of Entries and Languages

As it has been mentioned primarily words of caving missing from common dictionaries or listed with a different meaning were entered to the „Living Dictionary". These are the special terms of caving, caving gear and techniques, cave science as well as the terms of closely related sciences, geology in the first row. There were debates about such common words as *cave* or *bat*, but finally they were included as e.g. *water* and *level* etc. were not. There is a book, the Glossary of Hydrology, a comprehensive work, 1800 pages (English only), sold at 130 GBP. The publishers can not sell it, the readers can not buy it. With the modest stock of entries on the fifty pages of the concise Living Dictionary it can be produced and sold.

The dictionary the author is talking about contains terms of four languages and as it was produced in Hungary, one of them is Hungarian. This column may not be very important anywhere else in the world but it can be easily replaced with the terms of any other language of local or global interest, because it is computerized.

It seems to be a quite natural purpose to make the „ultimate" dictionary of speleology with lots of pictures. It is however hard to imagine, what the size of this book would be, what languages would it include, its financing and marketing etc. The solution will be probably not a book at all, but a *computer file* (and probably not under MS WORKS any longer) or a *compact disk* showing pictures that identify the meaning of dubious terms.

The Editing and the „life" of the Dictionary

The dictionary was edited by a single person in the sixties, by an all Hungarian team in the eighties and by an international team of widely known experts–representing each of the languages–in the nineties. The „team" of editors seems to be widening as active persons who are interested in the subject join with corrections, additions, suggestions and occasionally with completed works and problems of publication to be solved.

About one hundred copies of the four editions of the dictionary have been sold in Hungary and England in two years, other one hundred and fifty copies were distributed to the participants from about thirty countries in two congresses in Hungary.

Contributors to continue the work are most welcome.

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Typical arrangement of terms in MS WORKS Dbase

aragonite	aragonite (f)	Aragonit (r)	aragonit
aragonite	aragonite (f)	Knöpfchensinter (r)	aragonit
aragonite	aragonite (f)	Traubensinter (r)	aragonit
archeological dig	fouille (f) archéologique	Grabung (e)	ásatás
ascender	bloqueur (m)	Klettergerät (s)	mászógép
ascender	bloqueur (m)	Steigklemme (e)	mászógép

Typical arrangement of terms in WORD for WINDOWS 7.0–the published form

aragonite	aragonite (f)	Aragonit (r) Knöpfchensinter (r) Traubensinter (r)	aragonit
archeological dig	fouille (f) archéologique	Grabung (e)	ásatás
ascender	bloqueur (m)	Klettergerät (s) Steigklemme (e)	mászógép

The cave and its place in mediaeval bulgarian paintings

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Zusammenfassung

Es sind zahlreiche Beweise für die Rolle der Naturhöhlen im religiösen Leben der Bulgaren im 12. - 14. Jahrhundert erhalten. In den Felsen im Tal von Iskar und Russenski Lom sind kleine Naturhöhlen in grosser Menge vorhanden. Dort haben die Einsiedlermönche ihre Unterkunft gefunden. Sie haben die Naturhöhlen nicht nur in Wohnungen, sondern auch in Klosterkomplexe mit Kirchen und Kapellen verwandelt. In ihnen sind einige der schönsten und überaus interessanten Wandmalereien erhalten. Neben traditionell religiösen Themen kann man auch Szenen aus dem Mönchsleben als Höhlenbewohner betrachten, sowie auch die Höhlen selbst.

There is an abundance of caves of different origins in Bulgaria. They are situated in several regions predominantly: on the right bank of the Danube and alongside the rivers falling into it, as well as alongside the seashore's rocks. These caves, as shown by the archaeological investigations, have been known and used from the Paleolithic onwards. In cases when their situation and dimensions were appropriate, the caves served as shelves and places of habitation. An important part of them were venerated as cult places as well. Very impressive are the plenty of small and shallow caves and shelves around the village of Tzarevetz, Vratza District (North–Western Bulgaria – fig. 1). In the soft limestone walls there are incised more than 3000 drawings and inscriptions. As a whole their study is forthcoming, but certainly in these small caves rituals have been performed and drawings with magic purposes incised, without a break from very ancient times till recently. (ХАНДЖИЙСКИ, 1985; ОВЧАРОВ, 1982 – fig. 1)

Fig. 1 Graffiti from cave No 13 near Tzarevetz

Another cave complex is situated near the village of Karlukovo, alongside the Iskur river too, famous with its paleolithic material (МИКОВ, 1936; ПОПОВ, 1920; DZHAMBAZOV, 1981). A new element should be added to the usage of these caves with abundant archaeological material – the rock niches and shallow caves, transformed to habitations of monks-hermits. In these dwellings the anachorets spent their life in desolution, devoted to the Christian religion with the desire to come closer to God through life full of deprivations. The hermits have escaped from the official church and civil life in order to meditate in solitude and to be in touch with God, undisturbed by anyone.

In the valley of Roussenski Lom (Central North Bulgaria) there is a lot of caves, used by the monks as cells . Their graffiti show the beginning of this hermit-dwelling in XII C. (ВАСИЛИЕВ, 1946; АНДРЕЕВ, 1975). The numerous caves were gradually inhabited by anachorets, but soon the suitable caves became unsufficient because of the wide spreading of hesihasm and the connected with it enlarging of the hermits number. According to hesihasm it is necessary to live in a definite way in this world in order to get into Paradise in the other world. This is namely the hermit's life, far from life's temptations, in complete silence and strict fasting. As the time went on, the monks began to improve the caves by additional reorganisation and cutting in order to form churches and form the caves. In Ioakim I's Vita (the Patriarch of Turnovo, Bulgarian capital, 1235–1246) it is underlined, that after he had become a monk in Mount Athos, he came back to Danube and cut cells with a small church in the village of Krassen (СНЕГАРОВ, 1954; АНГЕЛОВ, 1962). The monk colony was occupied not only with a holy way of life, but as well with book – and enlightened activities and thus deeply impressed the Bulgarian Tzar Ivan Asen II (1212–1242). As a result he granted a significant amount of gold in order the monks to change the separate small caves and niches to a real monastery complex. The rooms were transformed to churches, covered with frescoes, which are among the best and most interesting ones (GRABAR, 1925; IB., 1954; FILOV, 1930; МАВРОДИНОВ, 1946; ВАСИЛИЕВ, 1953; VELMANS, 1965; BOSCHKOV, 1974; МАВРОДИНОВ, 1988). It is not possible to describe in short the magnificent images of Christ and Virgin, the scenes from their life, scenes and separate images from saints' Vitae.

Alongside both banks of the same river Roussenski Lom near the village of Ivanovo 5 more churches with wall paintings have been cut, dated from the first half of XIII C., but some of them belong even to XV C. One of them, known as The

Fig. 2 Tzar Ivan Alexander with the rock with cave church and its chapel. Ivanovo, the Church, XIV C.

Church, is devoted to the Virgin (МАВРОДИНОВА, 1988). The church donor is represented in the murals and this is the Tzar Ivan Alexander (1331–1371). The image is not very well preserved (ВАСИЛИЕВ, 1960 – fig 2), but the most interesting moment is, that the Tzar holds in his hand a rock with schematically represented church of Virgin and its chapel. Undoubtfully the painter tried to show what could be seen from outside of the rock, namely the outlets, formed as a door of the church.

Fig. 3 Unknown woman – church donor of the Demolished Church, XI–XIII C.

One more church in the complex is dated to the same time – the so called Demolished Church with another image of a rock church. An unknown woman – church donor holds in her stretched out hands a rock piece with the interior of the church and even with the decorative scheme in 7 registers (fig. 3). One can see the good outlines of scenes, a frieze with medallions with saints and other registers with images. Later, because of the strong cutting, the rock and especially the ceiling fell to the floor. The outlet of this cave was very wide, not closed with a wall and the paintings could be observed from outside. From the painting is obvious that the paintings covered not only the walls, but the ceiling as well. Usually in Bulgarian mediaeval churches the paintings begin from the floor with a decorative plinth, after which followed 3 – rarely 4 layers with standing saints and scenes from the Vitae of Saints and images down to the waist in medallions, and on the ceiling-scenes from Saints Vitae and Biblical subject-matters. Such is the case with the image of the woman-church donor and the representated decorative scheme in the interior of the church. Both representations of donors are rather unusual. In both cases the donors hold in their hands not buildings, but rocks with caves, transformed to churches and decorated with murals.

There exist another unusual subject-matters in the cave churches near Ivanovo. The only one get and not very good black-and-white photo is not very clear. But nevertheless the rocks can be seen very well, closed in white outline, with two caves left and right. (fig. 4) Both of them have triangular outlets. The left one is additionally outlined with a dark line, while its interior is light, with the image of a seated monk, turned to the right, with a book in the hands, very schematically represented dress and a monk hat with sharp top, a beard and moustache. The right cave is outlined by a thin line, the entrance has an irregular form and outline, approximately like a triangular, bigger than the former one. Again in the interior a figure of a monk is depicted turned to the left, but unfortunately very badly preserved, excerpt for the monk cap with a grey hair hanging out and an outline of a low chair, the monk seated.

Fig. 4 Caves-cells of hermits in Ivanovo.

Fig. 5 The mural of Bachkovo Monastery with the Dormition of St. Ephraim Syrin, XVI C.

Both caves are drawn separately from the rest of paintings in the chapel. Another scene on its walls with big dimensions is from Vita of St. Atanasius, namely the Vigio over his body, the dessert and the monks-hermits, as well as mountains with caves and monks in them. This fresco repeats similar images from other places, for instance Bachkovo Monastery (ЧАВРЪКОВ, 1978; БОЖКОВ, 1981 – fig. 5) and separate icons (CHATZIDAKIS, 1974, fig. 6) illustrating the Dormition of St. Ephraim Syrin, from later times – XIV–XVI CC.

Fig. 6 The Dormition of St. Ephraim Syrin. Icon from XV C.

So up to now the earliest images of caves in Bulgarian mediaeval painting are from XII–XIV CC. They illustrate their usage as places, remote from the civil world and very suitable for religious meditation, holy places suitable for building of the House of God. Their cutting, intially and later, and improving, is a result of the activities of the hermits, the Bulgarian kings and pious rich church donors.

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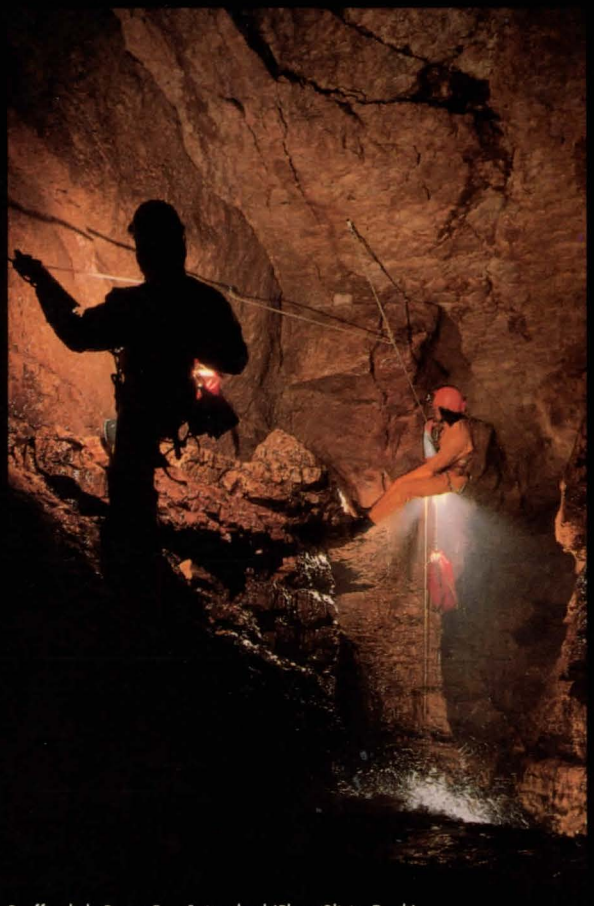
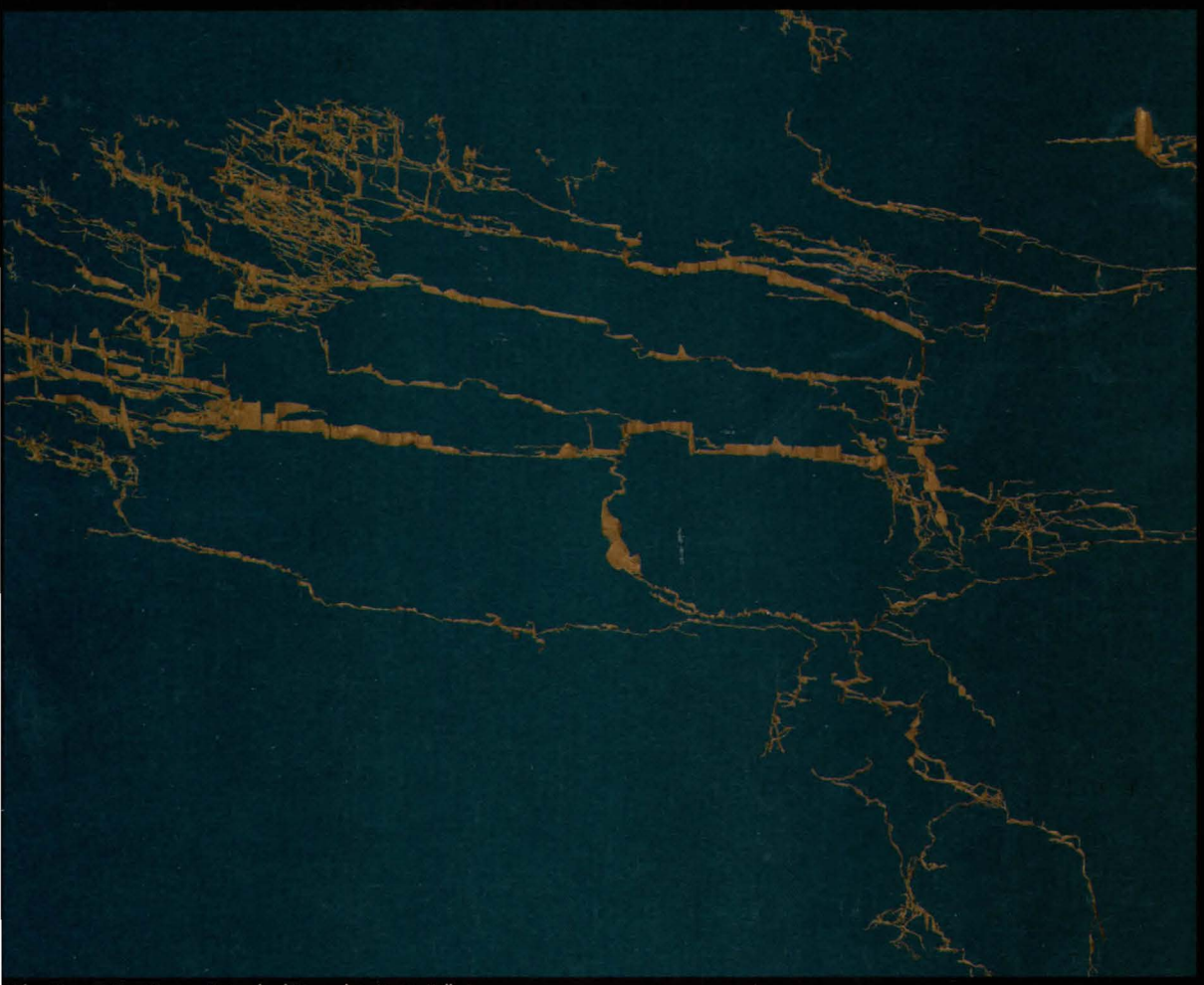
Pollution in a Jura cave, Switzerland (Photo Pascal Huguenin)



Gouffre de la Rouge-Eau, Switzerland (Photo Olivier Trueb)



Sieben Hengste Cave System, Switzerland (Toporobot, Martin Heller)