Sustainable Mapping of Caves

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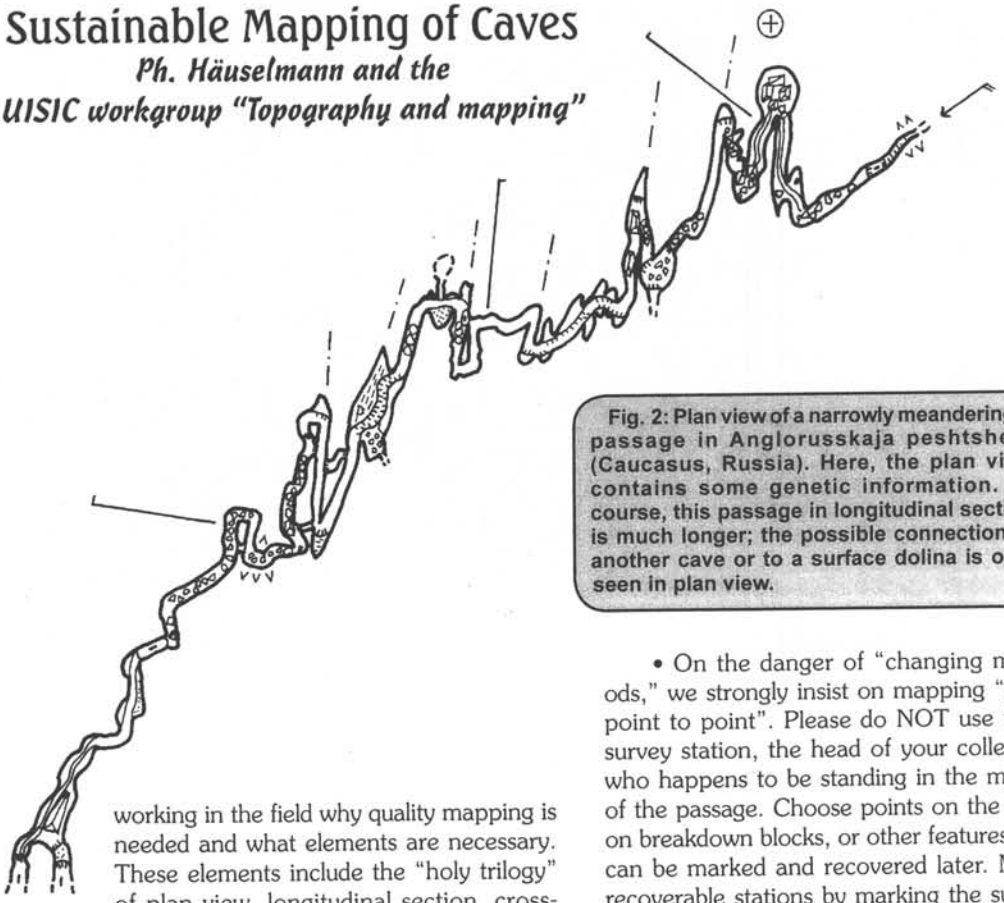


Fig. 2: Plan view of a narrowly meandering passage in Anglorusskaja peshtshera (Caucasus, Russia). Here, the plan view contains some genetic information. Of course, this passage in longitudinal section is much longer; the possible connection to another cave or to a surface dolina is only seen in plan view.

Introduction

The title of this communication may seem somewhat strange but anything that is of general interest today seems to have the word "sustainable" in the title. However, this is no joke: If we define "sustainable" as "minimizing impact and conserving the environment", sustainable mapping does exist. The scope of the present contribution is not to advocate the use of this or that (non-toxic) marker in mapping, but to show that mapping is sustainable only if it is well done. Otherwise, in some years, inevitably the cave will have to be remapped and this adds more impact on the fragile cave environment.

Experience has shown that remapping of caves is an ever-repeating issue. There are a number of reasons to remap caves: The original maps may be lost. Or if a map exists, the original data is lost or not available. Vertical control and/or a longitudinal profile is missing. The quality of the original survey may not be up to acceptable standards. What is even more disheartening is that despite the knowledge that a cave needs to be remapped, many speleologists are doing so but not including vertical control or a longitudinal profile. At some point in time the cave will need to be re-mapped yet again in order to include these important elements.

Often, remapping without including vertical control and profile occurs because the cavers involuntarily lack knowledge of what is needed and why. The aim of this paper is thus to inform the speleologist working in the field why quality mapping is needed and what elements are necessary. These elements include the "holy trilogy" of plan view, longitudinal section, cross-sections, and a written description. We, the team of mappers all over the world, hope that this article will be disseminated as widely as possible, to minimize future impacts of remapping projects and to maximize the amount of information than can be gleaned from mapping a cave, even to non-geologic speleologists.

Fig. 1 (facing page): Longitudinal section, horizontal cross-sections, and plan view of Stägeschacht ("Staircase shaft", Walop, Switzerland). The longitudinal section nicely shows that the cave mainly follows one single inclined fracture, moreover, it shows the bedding planes (and the folded structure of them in the top shaft). The longitudinal section contains two sites where it had been turned, once for showing that the fracture going down to "Verstürzte Hoffnung" is parallel to the one in the main shafts; and once so that plan view and longitudinal section are coherent.

The plan view of the lowermost, subhorizontal part has been expanded with the superposition of the horizontal sections. This way, the interrelation of all the passages up to the surface is shown as well as the direction of the guiding fault.

The basics of mapping

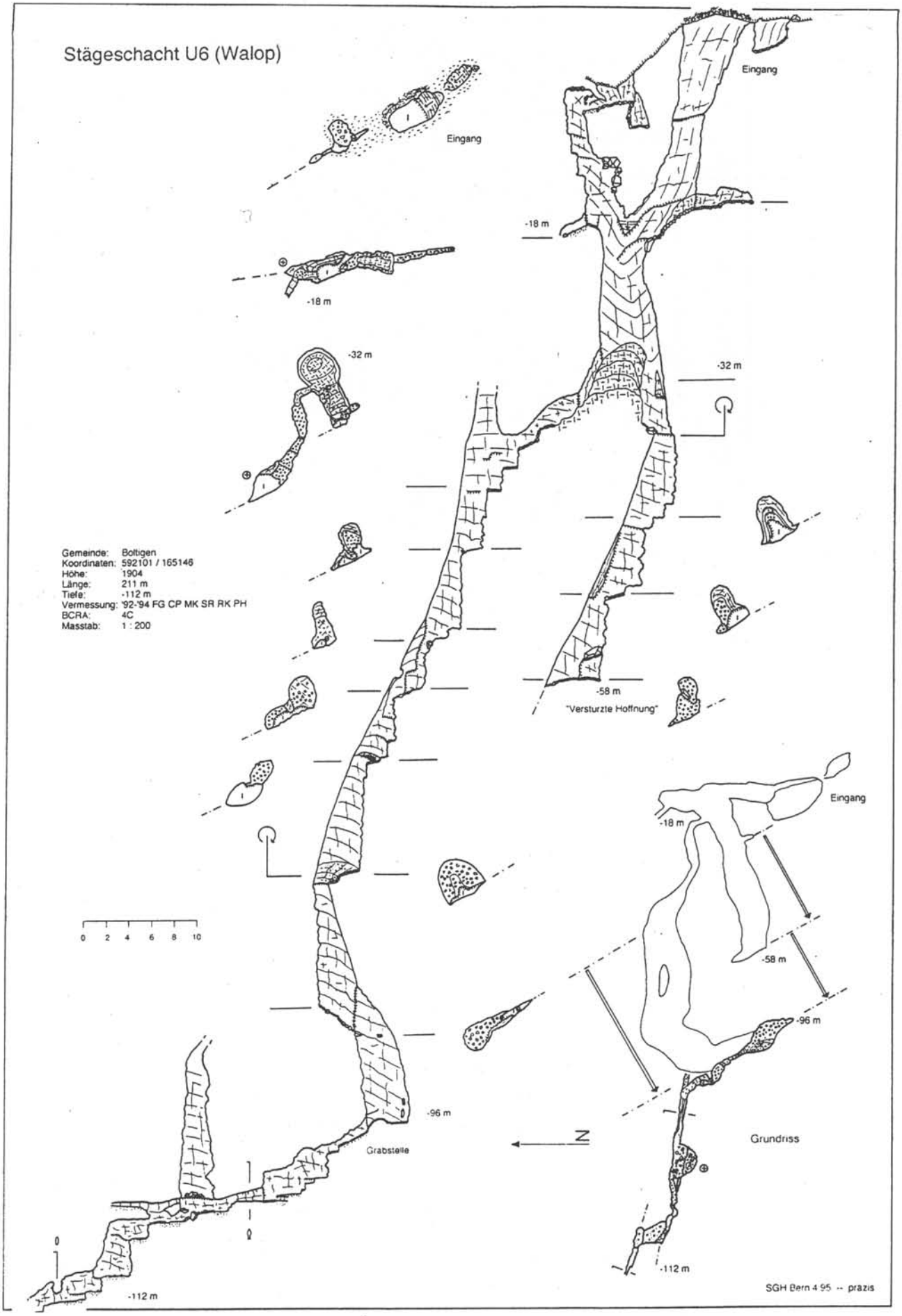
There are many different mapping styles in the world, some better than others. However, our point is not to promote a particular standard (this would be another article), but to remind cave surveyors that the fundamentals of cave mapping do not change. These include:

- Using well-maintained and functioning instruments, tapes, lasermeters etc., preferably ones checked for accuracy, for instance on a calibration course.
- Use only co-surveyors who know the importance of correct data collection, are experienced at reading instruments, and for whom you are aware of possible eye defects (dioptry, parallaxis, etc.).
- Be VERY aware of the danger of deviation by metallic objects (carbide generators, handrails in tourist caves, batteries, glasses) and light sources. It has been shown that even modern, lightweight LED lamps may cause substantial magnetic fields (some only when lighted)! Please check and re-check- often!
- On the danger of "changing methods," we strongly insist on mapping "from point to point". Please do NOT use for a survey station, the head of your colleague who happens to be standing in the middle of the passage. Choose points on the wall, on breakdown blocks, or other features that can be marked and recovered later. Make recoverable stations by marking the survey points (nail polish usually does the job very well, a small red dot being discreet and long-lasting; another method is a small, removable clip of reflector tape). Be sure to include the location of the station with respect to the left and right walls and the ceiling and the floor (this is the standard method for recording passage dimentions). The station can also be shown in cross sections, to help locate it in the future.

Since we are addressing methods: some surveyors will voluntarily round the dimension measurements to the nearest decimal (3.56 m giving 3.55 or even 3.6 m). Why? The critical measurements, which are the survey readings, are already done, so why decrease precision if it is not needed?

The location of survey stations seems to be a hot topic—some of the reviewers of this paper wanted to leave basically no mark within the cave (to preserve its natural state), while others wanted an easily visible, durable (and labeled) marking at least on bifurcations to allow future tie-ins. My personal preference is to have points that you only see if you search for them—but they are present and labeled on critical sites.

- Last but not least, make a detailed and accurate sketch. The importance of that is described below in the section "Why precisely drawn maps?". Some people draw the sketch to scale already in the cave (with the aid of protractors and scale), which lengthens the survey process, but helps to eliminate


Stägeschacht U6 (Walop)
Eingang
Eingang
-18 m
-18 m
-32 m
-32 m
Gemeinde: Boltigen
Koordinaten: 592101 / 165146
Höhe: 1904
Länge: 211 m
Tiefe: -112 m
Vermessung: '92-'94 FG CP MK SR RK PH
BCRA: 4C
Masstab: 1 : 200
-58 m
"Versturzte Hoffnung"
Eingang
-18 m
-58 m
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0 2 4 6 8 10
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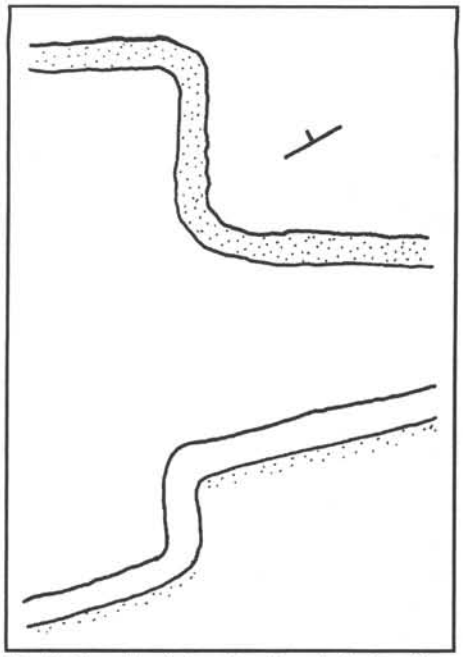

Fig. 3: Plan view (above) and projected section (below) of a hypothetical cave passage. The projection makes a shaftlike structure where in reality the passage gently dips away from the projection plane. It is evident from that figure that only longitudinal sections represent the true cave morphology

possible errors and increases accruacy.

Why the holy trinity?

The first question one might ask is why is it necessary to have more than only a plan view, especially for horizontal caves. The answer is simple: The Earth's surface is a two-dimensional object that can easily be represented on a map—and geographical, geological, or road maps are widespread. On the contrary, a cave (even if horizontal) is a truly three-dimensional object, and thus cannot be fully represented in a map; even in perfectly horizontal caves, the shape of the passage contains much valuable information that should not be neglected. Below, we present the advantages of all three necessary elements and what information they usually contain. Then, we indicate why it is much more useful to make accurate drawings instead of having a rough "exploratory sketch" or only the mapping data. In the end, we emphasize the importance of publicizing the maps and results.

Why a plan view?

• The first answer is the first motivation of anyone making a map: a plan view shows the orientation of the cave passage, illustrates its width, relationships with other passages, and shows passage details.

• More specifically for caves, it helps to get information about possible connections between separate caves in the same area. This is why it might prove very useful to also make maps for caves that are mainly vertical (and of which sometimes only a longitudinal section was made). The true extent of a cave in space may reveal that it is only a very short distance to the next (maybe more important) cave (Fig. 1). Surveys that are tied to surface bench marks show the relationship between surface features and cave features.

• A plan view offers little information about the genesis of the cave. However it can often give information that is related: for instance, if the cave follows a set of predominant fractures, or if the cave is very meandriform (Fig. 2).

• A plan view is informative for the sediments encountered in the cave and their location. Sometimes it is of great importance for finding a continuation to know the location of sediments and whether they may obstruct the main continuation. Such information is usually easily seen by cavers, but if it is not reported in the map, there will be no systematic search for continuations.

• The limitation of the plan view is that it does not show the shape of the passage, nor its vertical extent (the other two dimensions).

Why a longitudinal section, why cross sections?

• The first oppositional question to that might be why is it not sufficient to have a projected section. The answer is that a projected section hides some important information. Let us assume a S-N plane for projection, and a cave passage that falls first to the south (thus is represented "correctly" in the projection), before it turns west and continues with the same dip (Fig. 3). This portion will be represented resembling a vertical shaft. If now there are important changes in cross-section of this passage, then this cannot be seen: information is lost. A good mapper can construct a projection with the help of plan and longitudinal section, but it is much more difficult (or in case of changes in passage inclination impossible) to extract a longitudinal section out of a projection.

Projections are important for having the 3D-representation of the cave together with surface features. However, such projections are usually done with a computer, since the mapping data are processed with it in the first stage.

• Longitudinal sections can give insight on fracture guidances and bedding planes which cannot be seen with a plan view alone. An example is given in Fig. 1.

• Longitudinal sections can give comprehensive views of expected difficulties (pits, crawlways, waterfalls etc.) and can thus be useful for planning a next trip. They represent the total development of the passage to scale.

• The foremost and most important use of the longitudinal section is that it gives information about the caves genesis! All the fractures a plan view may give, all the sediment displayed, cannot give half of the information a longitudinal section does. Is the passage of phreatic genesis (i.e. a rounded tube)? Or is it a vadose meander? Or a superposition of both, a keyhole passage? Sure, all this information is contained also in the cross-sections, but the interrelation of these forms are of importance and best presented in a longitudinal section. A good example is presented in Fig. 4.

• Cross-sections are very important too: They give the shape of the actual passage, which is also very informative in terms of determining speleogenesis. In order to portray the important geologic features of the cave, all three views (map, longitudinal section, cross section) are needed.

Why a written description?

The answer is very simple: Did you ever try to draw a bat into your plan (to scale, of course)? Or the extent of possible flooding danger you observe on the cave walls? How do you represent your ideas about the cave's genesis?

The written description is an invaluable source of information that may be very important, not only scientifically, but for basic cavers: Equipment lists, flooding danger, types of rocks encountered, unstable breakdown, gypsum occurrences, biology and genesis... all these things cannot be represented graphically and have to be written down. Thus, the description is not a marginal text describing only the things you can see on the map yourself ("To the left, a passage leads to a shaft...") but all your important observations. And YES: Everyone can observe important things! Even you can do it!

Why precisely drawn maps and not only topographic data or sketches?

This is a very good question at first sight, because it is the precise drawing that takes most of the mapping time and which makes mapping so "boring." So why not only use a rough sketch? For scientific purposes, it is clear that an accurate drawing carries much more information. But also "normal cavers" can extract a lot of important information from a good drawing. Figure 5 shows an excerpt of a cave map. On the upper side, the original map. On the lower side, a possible "beautiful" map (I did this from my memory, so it might not be correct, even though the basic information remains). Where is the continuation of the large passage? Yes—at the lower right corner you may try to dig to find the BIG continuation. And—of course—you do not see that on the sketch.

In short: type of of passage form, as well as sediments and their position, coupled

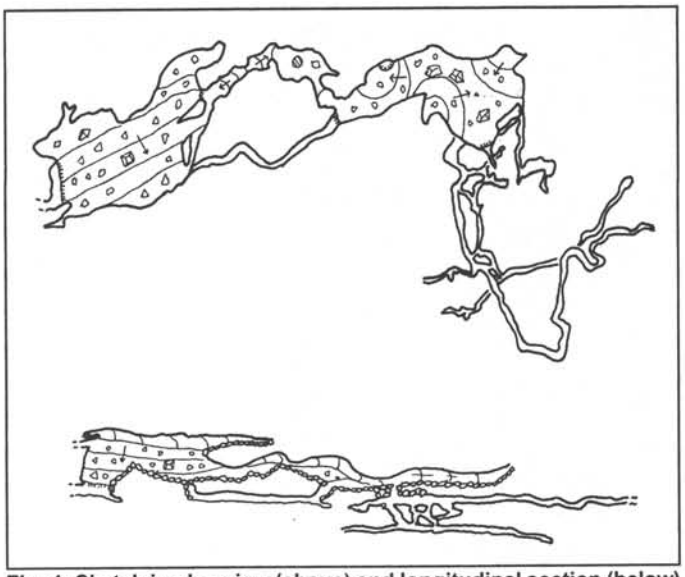

Fig. 4: Sketch in plan view (above) and longitudinal section (below) of the entrance part of Pestera Humpleu (Muntii Apuseni, Romania). Both of the sketches are of poor quality (so don't take them as examples). However, only in the longitudinal section, a genesis of the cave in three distinct phases can be seen. Do draw longitudinal sections also in horizontal caves!

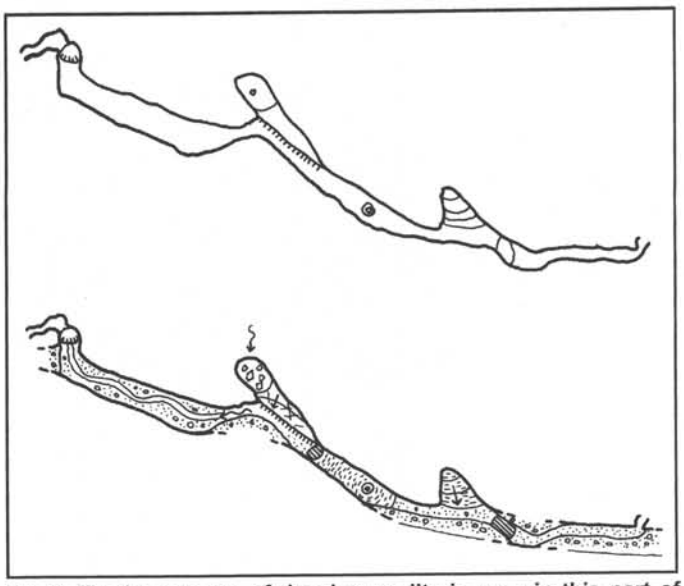

Fig. 5: The importance of drawing quality is seen in this part of a cave in Romania. The upper drawing is a sketch in plan view without major details; while the lower drawing represents the same passage with much more detail (please note that the details are from my memory and might not be real, however it is real that the big passage continues somewhere!). Only the precise drawing shows a possible continuation of the large passage which may lead to the main continuation of that superb cave.

with information about reduction or increase in passage size, gives important information for possible continuations. But these things are only visible in a precise sketch.

Besides: If you, bored instrument reader, wait for the drawer to end his endless pencil-scratching, what do you do (besides freezing)? Yes: you look for possible lateral passages. They exist, be assured—look for them, you'll find them! Another intelligent form of keeping warm is to take backsights to confirm the accuracy of the previous reading. Be ready for some surprises!

There might be a problem of scale for the map. This has to be addressed depending on the needs of the survey: a paleontological site might want a scale of 1:50 on a large sheet, while a big cave might be sufficiently mapped 1:500 in several atlas sheets. In Central Europe, we usually map 1:100 for very small caves, 1:200 for caves between 20 and 500 m, and 1:500 for larger caves. Try not to mix too many scales within the same cave area for the sake of comparison between the maps. Of course, if you know that your final map is 1:500, there is no need to take the survey to 1:50 precision - although you can do it. What you cannot do is to sketch with 1:500 precision in the cave and still draw a precise map on the scale 1:50 at home! So please think about this issue before beginning to map.

Why publicize?

You found an easy, beautiful, promising cave, and you've mapped it with great effort. You may be afraid that fellow cavers, wild spelunkers, or even trekking organizations may misuse the cave, so your reaction is to keep the cave secret. This is very understandable. The very negative point is that once you're no longer active, or the mapper had a row with his mother who subsequently burned all his maps (mind you, that is not a joke, I know such a case!) all the information is lost.

So this is to implore you: please publish your caves, your maps, your data! If publishing means a real danger to the cave, please put it (at least) into your national cave register. Several countries have registers which offer to keep the maps and data secret —use this possibility if you think it is needed. Please, do not throw away your great work by hiding it in your cupboard!

Keyword hiding: Even if you publicized your great work, it might be that the original data are to be introduced in a computer to get 3D images of the area and the surface in question. This last point might be very important in convincing a quarry manager NOT to blast where the cave is. Or, there may be new passages found (breakdown? - it needn't be that you didn't look well!). In both situations it is vital to have everything somewhere—either at your home, or in a club archive, or in a central register. Please do NOT throw away your field notes and sketches; even though dirty they might prevent another complete remapping for just the cases I described above. Keep them— they take up little space and future use might be tremendous!

A look into the future?

More and more, computers replace the traditional ink-pen drawings. In recent years, the use of drawing programs (such as Adobe Illustrator) are used to generate accurate and actually very nice maps. The advance of technology permits us to add colors to the maps (sand is brown, water is blue, or at least it should be). For persons interested in computer drawing, there is a website below where they'll find information and prepared libraries for Illustrator. Please keep in mind: The most durable archive form is still paper, which lasts between 20 and 500 years or even more, while CDs might be unreadable after only 2 years. So please: after having drawn by computer, print the map out for archive purposes! Save your work!

Some websites with more information

There are several websites that offer good information about mapping and mapping problems, techniques, and data. Four of the more useful are listed below:

www.sghbern.ch/hrh.html
- This is the site of the HRH (Siebenhengste, Switzerland) and there are many articles about mapping, errors, etc.

www.carto.net/neumann/caving/cave-symbols/
- cave mapping symbols of the UIS

www.sghbern.ch/surfaceSymbols/symbol1.html
- symbols proposed for geomorphological mapping

www.ngdc.noaa.gov/seg/geomag/jsp/declination.jsp
- to calculate the declination for any site on Earth

Thanks to all persons who gave input, corrections, suggestions, and who translated the article.