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Issue 34

COMPASS POINTS

BCRA

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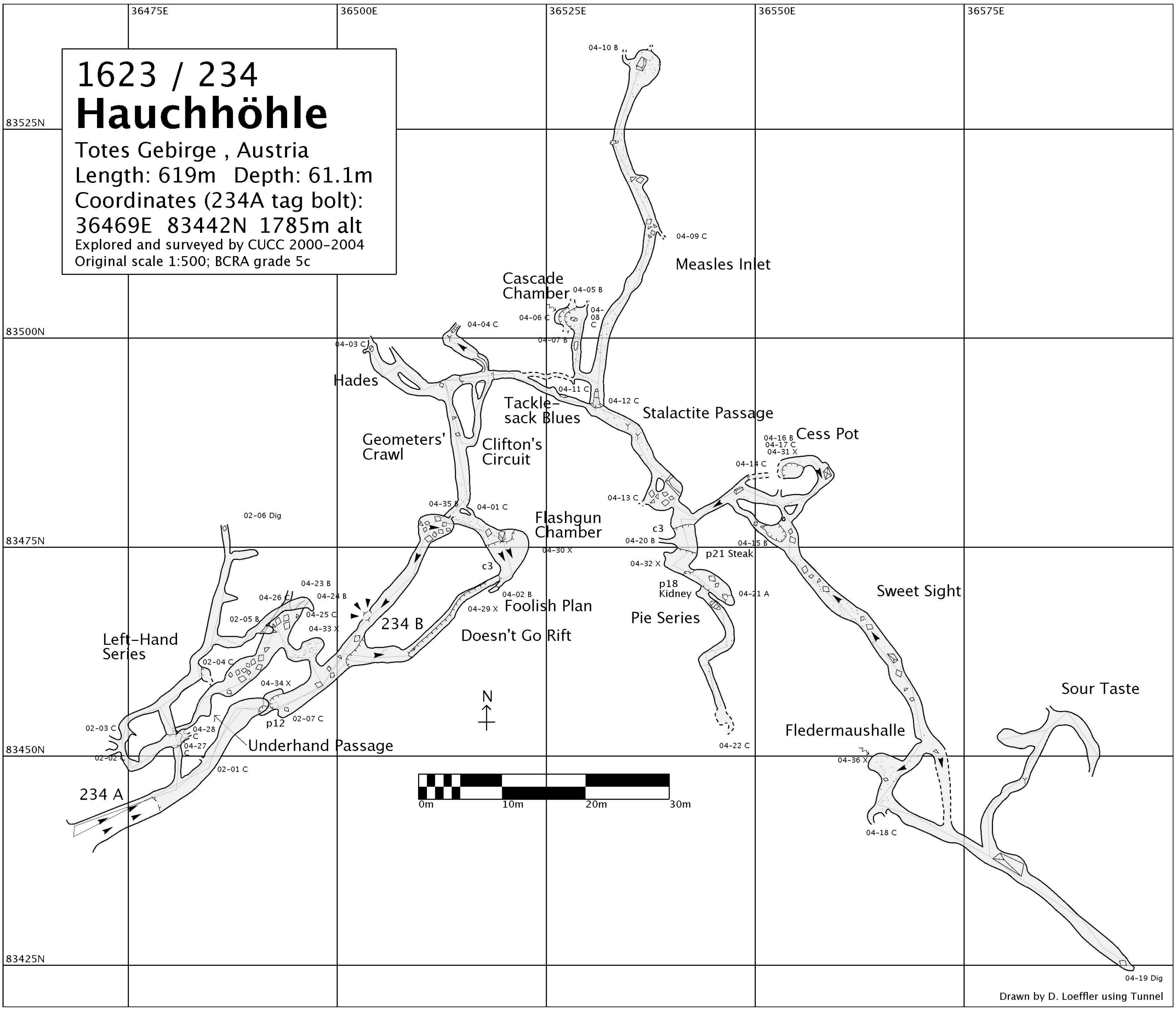

Methods for Performing Loop Closure

Survey Data Archiving Revisited

The Journal of the BCRA Cave Surveying Group

COMPASS POINTS INFORMATION

Compass Points is published three times yearly in March, July and November. The Cave Surveying Group is a Special Interest Group of the British Cave Research Association. Information sheets about the CSG are available by post or by e-mail. Please send an SAE or Post Office International Reply Coupon.

NOTES FOR CONTRIBUTORS

Articles can be on paper, but the preferred format is ASCII text files with paragraph breaks. If articles are particularly technical (i.e. contain lots of sums) then Latex, OpenOffice.org or Microsoft Word documents are probably best. We are able to cope with many other formats, but please check first. We can accept most common graphics formats, but vector graphic formats are much preferred to bit-mapped formats for diagrams. Photographs should be prints, or well-scanned photos supplied in any common bitmap format. It is the responsibility of contributing authors to clear copyright and acknowledgement matters for any material previously published elsewhere and to ensure that nothing in their submissions may be deemed libellous or defamatory.

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COMPASS POINTS LOGO

courtesy of Doug Dotson, Speleotechnologies.

CAVE SURVEYING MAILING LIST

The CSG runs an e-mail list for cave surveyors around the world. To join send a message containing the word 'subscribe' in the body text to `cave-surveying-request@survex.com`

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Cover image: Plan survey of Hauchhöhle, Totes Gebirge, Austria. Surveyed by Cambridge University Caving Club and drawn by David Loeffler using Tunnel, one of the survey drawing packages highlighted in the "Surveying Software Updates" section.

Editorial

At long last, here is the heavily delayed Compass Points issue 34 – so late that we have effectively missed two issues (and I am aware as I write these lines that it isn't really March any more...) As with earlier delays, subscriptions are number-of-issue-based rather than time-based – therefore you will receive the number of issues you have paid for.

The delay was caused initially by technical problems last Summer, though a total absence of material did not help matters. The technical problems have now been solved, and I should be able to stick more-or-less to the planned publication dates. Indeed, the changes within BCRA discussed in the Admin. section may require CSG to adhere more strictly to a time-based schedule in future. Of course, such plans are subject to there being a steady flow of suitable articles, so I once more urge anyone with a good story to tell to come forward and tell it.

CSG Admin

Changes in BCRA

As our British subscribers will no doubt be aware, there have recently been some changes in the role of BCRA following the formation of the British Caving Association (BCA). In essence, BCA has taken on many of the roles previously performed by the BCRA as the *de facto* national body for individual cavers. Henceforth, BCRA will be a body dedicated to cave science under the umbrella of BCA.

As a result of these changes, a BCRA held a Special General Meeting on 26th February 2005 to discuss the association's new role in the light of these changes, including that of its Special Interest Groups (SIGs). There followed a meeting of BCRA on 27th February. David Gibson reports that, at this meeting, council formally adopted a set of proposals regarding its SIGs. Specifically, BCRA Council re-affirmed the following:

1. BCRA continues to support the concept of SIGs as "groups of members with a common science interest" rather than as "member clubs".
2. BCRA continues to allow the SIGs to use the name "BCRA" in their title, subject to certain guarantees, as at present. These to include:
    - at least two SIG executive officers must be BCRA members (as at present);
    - financial control remains with BCRA (as at present);
    - full voting members of the SIG must be BCA or BCRA members.
3. From 1st January 2005 the members of a BCRA SIG must be individual members of BCA (DIM/CIM) or BCRA.
4. BCRA will investigate the possibility of providing similar services to the SIG members that it intends to provide to subscribers to Cave and Karst Science - i.e. centralised collection of subscriptions, centralised printing and centralised mailing services.
5. Since BCRA can now be more focussed as a science body, it will look at additional ways of supporting the work of the SIGs.
6. A means will be found whereby BCA "club officers" insurance can be applied to all SIG officers.
7. A means will be found whereby temporary PL insurance can be offered to participants in SIG events.
8. There shall continue to be a "non-member subscriber" status of SIG supporter.

In practice, these statements will probably make little difference to most readers of Compass Points. It has always been the case that membership of BCRA was a prerequisite for membership of CSG, whilst anyone can subscribe to Compass Points. CSG particularly welcomes point 4 above, and hopes that this proposal can indeed be put into practice. As for point 5, any thoughts readers may have regarding practical ways in which BCRA could help the work of the CSG will be gratefully received by the editor and passed on.

Snippets

Surveying Software Updates

In days gone by, Compass Points used to include a regular "Software Updates" section. This would describe in fine detail the latest and greatest new features in recent releases of various surveying software packages. This is a feature I would like to reintroduce.

In these days of much more widespread internet access, I see little point in reproducing detailed release notes in the pages of Compass Points. Instead, my intention is to keep track of developments in major software packages, and provide brief reports of the important changes that have been introduced when new versions are released. This will necessarily be based on information published by the authors since I have neither the time nor the resources to write detailed reviews of all the relevant software – though I welcome submissions from anyone who wishes to write such articles.

Below is the list of software packages I intend to keep track of, along with the basic details of the most recent release and the home page address. This list is based on that published in the BCRA Cave Surveying booklet in 2002, with the exception of Caveplot since the home page address as published no longer exists and I have been unable to locate a replacement. I have supplemented the list with three drawing packages, Carto, Therion and Tunnel, that are targeted towards creating final copies of surveys. I make no claim that this represents the definitive list of major cave surveying software packages currently under development and in wide use, and I invite suggestions for additions.

- Compass
Latest release: 1st December 2004
`http://www.fountainware.com/compass/`
- Survex
Latest release: version 1.0.34, 22nd January 2005
`http://www.survex.com/`
- TopoRobot
Latest release: version 9.1.4, 2nd January 2003
`http://www.geo.unizh.ch/~heller/toporobot/news.html`
- Walls
Latest release: version 2 B7, 10th March 2005
`http://www.utexas.edu/depts/tnhc/.www/tss/Walls/tsswalls.htm`
- Winkarst
Latest release: version 12.2
`http://www.resurgentsoftware.com/winkarst.html`
- Carto
Latest release: version 0.9.8, 3rd March 2005
`http://www.psc-cavers.org/carto/`
- Therion
Latest release: version 0.3.7, 16th March 2005
`http://therion.speleo.sk/`
- Tunnel
`http://www.goatchurch.org.uk/tunnelx/index.html`

Another Electronic Instrument Project

Mike McCombe

Compass Points 33 contained an article by Dave Edwards about the South Wales Caving Club project to build an electronic compass/clino unit, and the editorial asked whether there were any other similar projects out there.

As I'd reached an age where I find it increasingly difficult to use a conventional Suunto compass (try sighting uphill in poor light whilst wearing varifocal glasses), I started to develop a crude digital compass about three years ago. This was based around a Hall Effect sensor (made by Dinsmore) and a digital voltmeter chip. Although it had excellent resolution (i.e. better than 0.1°), measurements had very poor repeatability, apparently due to mechanical hysteresis in the sensor. With errors of up to 15° being quite common, I reckoned I could continue to do better with a traditional compass, despite my deteriorating eyesight and inherent incompetence!

Earlier this year I saw Dave Edward's article in the SWCC newsletter and also spoke to Brian Clipstone of SWCC on the phone. At the time, we were trying to survey our latest discoveries which, typically, are so tight and winding that it is often physically impossible to raise a compass to the eye. Having just given up work, I decided to have another go at developing a digital compass and clinometer based on more modern sensors and a PIC microcontroller. Given that we've chosen almost identical components and have obviously built upon the same set of application notes, our designs are probably very similar. The main differences I noted were:

1. Whereas the SWCC team have gone for surface mount and PCB construction, I don't have the facilities to do this at home so instead have gone for a less elegant "breadboard" style of construction using stripboard. As one or two components are only available as miniature surface mount packages, this has meant having to do some rather delicate bits of hand soldering!
2. I've included a RS-232 serial port. The end objective is to be able to use this to transfer survey measurements from the EEROM in the device into a PC, and to be able to adjust calibration or display options without having to reprogram the microcontroller. During development, the serial port is invaluable because I can use it to view or change memory locations whilst the program is running, or I can stream the sensor outputs straight to the PC. Using this, I can experiment with the algorithms in a high-level language (Java) with real sensor data. I then write a version of the code, still in Java, but using the same limited-precision integer arithmetic as the microcontroller, before finally writing the microPIC code.
3. I've not attempted to include self-calibration inside the unit. The current plan is to keep calibration coefficients in the EEROM but to do any large-scale or high precision number crunching on the PC and update via the serial port.
4. The unit has a 16 character × 2 row back-lit LCD display which can display text and symbols as well as digits.
5. It is built in a die-cast box with 4 mm acrylic windows for the display and laser. With a NATO-style 6-pin connector for external power and serial port, it's somewhat chunkier than the SWCC instrument though I still wouldn't rate it "cave-proof" !

The dual-axis clino works well and has the expected resolution. The magnetic sensors also seem to work well and produce plausible streams of digits through the microcontroller and out via the serial port. I still haven't decided how to make the adjustable mounting for the laser pointer. I've developed the compass software to produce both clino and compass displays, including all of the corrections for tilt. Calibration has proved to be a major challenge, as it is necessary to compensate for variations in electrical gain and offset between the three channels as well as the hard and soft magnetic effects of the surrounding components. Batteries in particular have proven to have pronounced magnetic effects. At the moment, I'm taking the easy option of powering the compass from an external battery on the end of a flying lead. This at least has the advantage that I could change batteries underground without having to open the box.

We've done one underground trial, surveying some new discoveries in OFD, where we've used it alongside the conventional Suunto instruments. It proved a huge success with the surveying team as it is very much quicker to use and overcomes all of the difficulties of not always being able to get one's head in the right position to take a sighting. The accuracy of the results was OK but suggested that I still have some work to do on the calibration – as expected. I've since added a feature which waits until the instrument stops moving, then averages a set of samples over about a second, before turning off the laser-pointer and displaying the result. This seems to make a big improvement in repeatability of the results.

Arthur Butcher Award

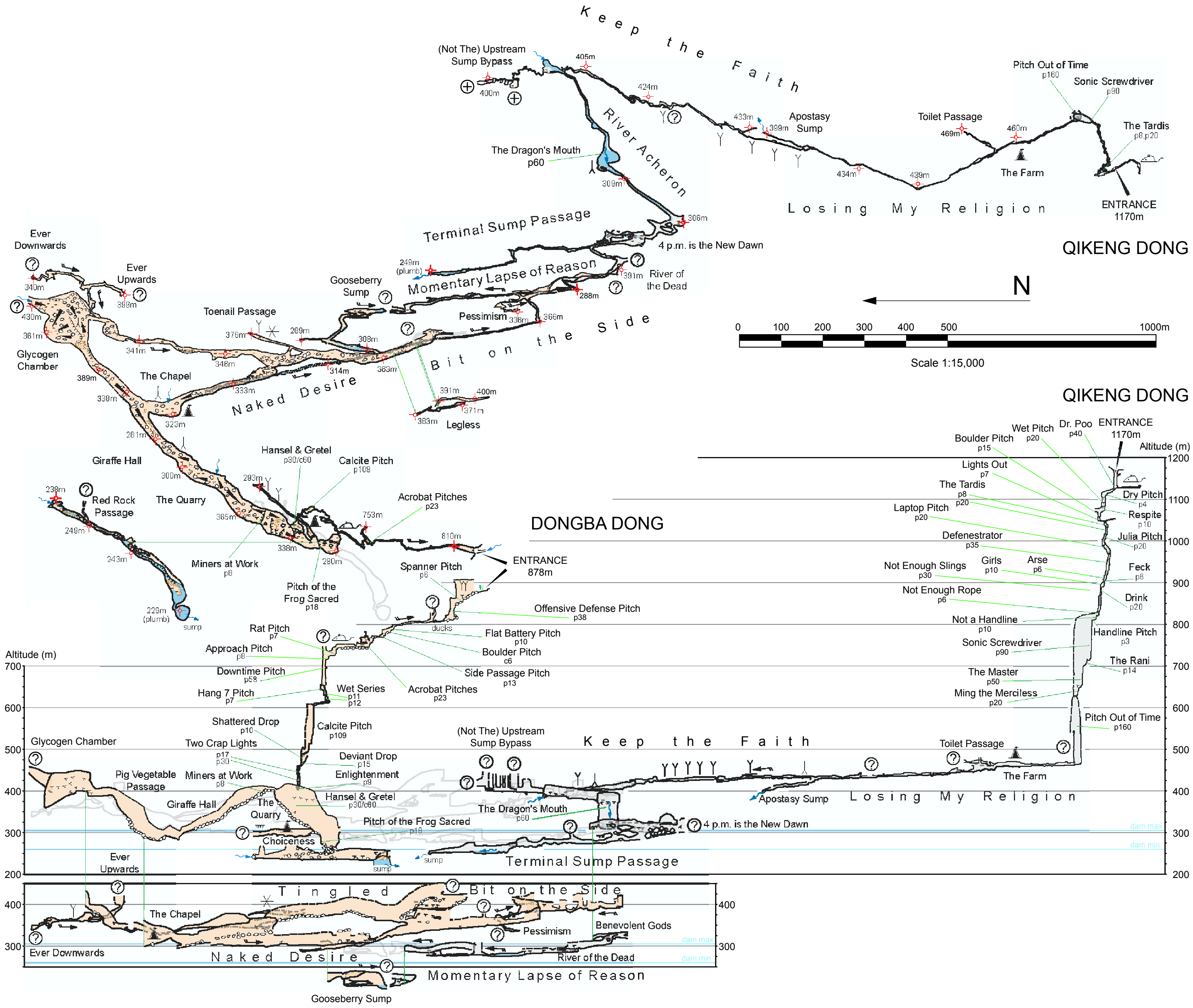
Each year, BCRA presents an award for, broadly speaking "excellence in cave surveying". The winner receives a cash prize of £100, a trophy that they keep for a year. The Award is judged and announced at the National Caving Conference.

The 2004 winners were Erin Lynch and Duncan Collis for excellent cartography and presentation of the Qikeng Dong & Dong Ba Dong surveys, as well as a huge amount of surveying in China over the last four years. The use of colour, the detail, cross-referencing, overview information and layout of the survey are exemplary. Their use of the Hong Meigui Cave Exploration Society website for interim publication of surveys and data was also commended.

An honourable mention went to Martin Green and Cambridge University Caving Club for the Steinbrückenhöhle survey (which would have won in a typical year) for excellent use of colour to distinguish levels in a very complex cave, and helping to develop state-of-the-art survey drawing software (Tunnel) in the process.

To be considered for the award, individuals or caving clubs must bring their work to the attention of the judges. For a cave survey, you can easily do this by displaying it on your club stand at the conference. If, however, you want other work to be considered - such as a report or publication on a surveying topic, or other more general achievements - then you should contact the judges in advance. Nominations should be sent to the conference manager by 1st September.

The 2005 conference will be held on 23rd-25th September at Churchill School, Winscombe in the Mendips. More details about the conference and the Arthur Butcher Award are available from the BCRA, or from the conference website at:
`http://hidden-earth.org.uk/`



A small version of the award-winning Qikeng Dong – Dong Ba survey

Problems with Silva Instruments

Ray Duffy

The Red Rose Cave and Pothole Club owns a number of Silva instruments, which are heavily used in the Easegill resurvey project. About a year ago, whilst recalibrating some of these instrument, I spotted a white object with approximate dimensions 15×8mm floating around in one of the compass capsules. I returned the capsule to Silva, including a covering letter asking if they could repair or replace the capsule as soon as possible, since it was in use every week. Their reply simply stated that the compass was out of warranty, noted the object floating around, and asked how I wished to have it disposed of. I am not sure of the law in this matter but, even if the compass was out of warranty, the fact that they supplied a faulty object means they should surely replace it free of charge since they admit it cannot repaired.

It has since transpired that the white object is the dial delaminating. I have received a verbal offer to replace the compass, though as yet none has been forthcoming.

I have previously had another problem with Silva instruments when the capsules started leaking their fluid. On that occasion, Silva admitted that the fluid dissolved the adhesive used to seal the capsules - a fairly basic error in manufacturing. I have also recently noticed that our Silva clinometer has almost dropped off its bearing and is hanging at a jaunty angle.

Needless to say the Red Rose will not be buying any further Silva instruments. Whilst I feel that Silva instruments are the easiest to use and clearest-reading instruments available, it has become apparent that are they simply not robust enough to survive the sort of rigours that real cave surveying entails.

Press Round-up

Illustrated Walls

Issue 183 of Descent contains an interesting article by Mark Passerby concerning the use of technology in a surveying project in the Raiders Valley area of West Virginia, USA. A similar article is available online [1].

Mark describes the problems of managing an ongoing surveying project of ever increasing complexity. Originally, they made use of the Compass software to process the line survey. Wall plots were generated and scanned, then morphed to fit the line survey. This approach proved adequate for creating a working survey. However, collecting together all the disparate sections to create a version for publication proved to be a considerable task, so a better solution was sought.

The surveying team aimed to move towards a "draw-as-you-go" solution, whereby a version of the survey that can easily be incorporated into the final published version can be produced soon after the data have been acquired. Such an approach allows the drawing workload to be spread more evenly over the lifetime of the project. Additionally, it provides motivation for those involved as they get to see an approximation to the finished version resulting from their labours earlier in the process.

Achieving this aim requires improvements in the quality and flexibility of the intermediate maps such that they can easily be incorporated into the whole. Passage outlines must be morphed and adjusted depending on nearby vectors, whilst text, symbols and cross-sections must be translated and scaled. The solution adopted uses the Walls cave surveying software, Adobe Illustrator for drawing detail, and the Scalable Vector Graphics format (SVG) to store the results. These elements are combined in a process that the author terms "roundtripping":

1. The line survey data is processed in Walls and exported in SVG format. The resulting file contains a number of predefined layers and tags in addition to the line survey.
2. The file is loaded into Illustrator, which is used to add complex information such as wall outlines, passage detail and formations. These data are put into the predefined layers. The combined data saved as another SVG image.
3. When more data are acquired, the most recent Illustrator file can be used in Walls as the basis for new additions. The existing data objects in the base file will be adjusted according to the line survey adjustments.
4. The resulting file is then opened in Illustrator, and the new details added, resulting in an updated map.

The final link in the chain is to acquire data in the cave in a format such that it can easily be included in this scheme. The team were loaned a ruggedised PC with an external battery (necessary for long surveying trips) for two months, which was carried around in a Peli case. The team found that, for efficient operations, it was essential that the person responsible for sketching had a good working knowledge of Illustrator. A fixed library of commonly used symbol also helped them to add detail on-the-fly. Since then, the team have invested in two "Panasonic Toughbooks" which are relatively cheap (less than £100 each) and are sufficiently powerful to run an older version of Illustrator.

The final survey has been made available in the form of a pdf map book, which is available on line [2]. A low resolution version can be viewed online, or the full version can be downloaded [3]. The flexible SVG format allows passages to be grouped by level, and displayed or hidden at the users request.

[1] Passerby, M. The Raders Valley project, online at: `http://www.cavediggers.com/techsurvey.pdf`

[2] Passerby, M. (2004). Zicafoose blowhole cave project PDF map book, online at: `http://www.cavediggers.com/zicmap.pdf`

[3] Zicafoose blowhole (scalable vector graphics working map), online at: `http://www.cavediggers.com/fullmap2.html`

Loop Adjustment Decisions

John Halleck

In this article, John Halleck discusses the advantages and applicability of two different methods for loop closure that are commonly used by cave surveying software.

A large proportion of modern cave surveying software closes loops using a "least squares" technique. However, it is important that users of such software should understand what that term implies, and the conditions under which its assumptions are valid. In addition, it is important to realise that there are other options available. The adjustment technique that a cave survey program uses is, to a large degree, a judgement call since there are a lot of competing factors. Also, some of the factors are different from those land surveyors must deal with. If they identify a "bad" point they will simply perform a re-survey and throw the old survey away, an option which is frequently unavailable to cave surveyors.

As a practical matter, almost any loop closure method will generally produce points that (in the absence of blunders) are similar. At the scale of a typical cave map, it would take a keen eye to tell the difference between the output of the various methods. If your goal is simply to choose a consistent method to allow you to draw the map, then, in practice, almost anything will suffice.

This article provides a very quick introduction to two classes of commonly used loop closure methods: loop oriented schemes, and the popular least squares methods. Note that the discussion is heavily simplified: you are advised to consult a standard surveying text for further details.

Loop Oriented methods

Before computers, actual surveyors (for entire country surveys) would perform loop analysis, and do the network adjustment by the method of "closing your best loops first". Some cave survey programs do this too. There are a number of techniques available in the literature to close a single loop, including "compass rule", "chain rule", "Bowditch's method", and "Barda's modification of Bowditch's method". Standard surveying texts cover many of them, and some (Barda's modification, for example) have been shown to be equivalent to least squares in many cases. Most of them are equivalent to some specific assumptions, generating some weightings of the shots in a least squares solution.

Loop oriented methods are not as intrinsically general or flexible as least squares, but do have some abilities that least squares does not. For example: there are well-known published formulae that, given a loop known to have an angular blunder, will give you the distance from each point to the likely blunder. There is another published procedure that can, in the same case, give you the direction from each point to the likely blunder. There are tried and true methods that deal with blunders in length.

There is a big difference between adjusting a single loop and adjusting a network. The most common method of extending loop oriented methods is called "best loops first". This involves just finding the loops with the best closure, and adjusting them first, and having adjustment of later loops not change any that have already been adjusted. This is not to say that all "loop oriented" programs all do this, but only that the method allows this. Loop oriented analysis of blunders is often covered in books on elementary survey network adjustments, along with least squares.

Least Squares

Least squares is a wonderful piece of mathematics invented by Gauss that produces the mathematically "most probable" model that would have produced the data you have recorded. It is the most general method of handling errors - any kind of network, and almost any kind of constraints (such as GPS'd points) can be thrown together meaningfully. As such, it is my method of choice if I have to choose. The method takes a linear system of network equations, and makes the following assumptions:

1. the errors are randomly distributed;
2. there are only random errors, and not systematic errors;
3. the probable error bounds on the measurements are known, and weightings have been produced based on these.

If the assumptions are met the result is the most probable values for the adjusted network. These locations are obtained by (in some sense) forming appropriately weighted averages based on the expected magnitude of the random errors. However, the method is computationally intensive. Hence it is the most commonly simplified of the methods, and most simplifications lead to it no longer having the original mathematical assurances. Surprisingly, least squares does about the best job around of identifying that there are problems, and discovering something of their nature (although the final error statistics are often not printed by cave survey programs because people seem not to want to wade through them....)

If there are "blunders" in the data (i.e. errors that are not remotely likely as random error) then assumption 2 is violated, and the naive adjustment would smear this error all over the survey. Now, in defence of least squares, the adjustment also produces error statistics. If the error statistics show serious problems, there are well known (studied since the 1800's) methods of addressing this. For example, new weights based on the error statistics could be obtained, and the adjustment performed again. Whilst such approaches might produce a perfectly acceptable map that is not far from what your intuitions lead you to expect, formally (academically) the result has lost some of the claim to be the "most probable" mathematical result. The mathematical problem is that the "random" errors model has been violated, thus one of the prime motivations for choosing this method has been compromised. In addition, such techniques approximately double the amount of programming required to get it all running. Again, this is not to say that all "least squares" oriented programs do everything the method allows, but only that the method allows this.

From the point of view of the geometer one of the problems is that least squares doesn't "know" about loops. Obviously, one could do a least squares adjustment to identify that there are problems, and then use the traditional loop oriented methods to identify them.

A step in setting up a least squares problem is to convert from the actual measurements (a non-linear problem) to something that least squares can handle (a linear problem). This is just the normal conversion from known uncertainties of the instruments and a distance, azimuth and dip, to a change in X, Y and Z, and an appropriate weight. This is an area where, surprisingly, lots of different cave surveying programs often make simplifying assumptions. (Converting the XYZs is the same, the weights are a matter of religious wars). The theoretically correct procedure is given in survey adjustment books, but lots of different simplifications are seen.

Back in the days before computers, surveying books often gave a number of ad-hoc simplified methods of weightings to keep the task tractable (such as "weight by number of shots", or "proportional to shot length".) In those same days, loop oriented methods were used instead of least squares. In mainline (non-cave) surveying publications, these other weightings have all but died out in any least squares programs.

Even within least squares there are lots of ways to go. To the best of my knowledge everyone in cave surveying performs least squares starting from the connectivity matrix, with a problem size related to the number of points. Some programs trim dead ends off to try to keep this number down, but the number of points remaining can easily be many thousands based on the cave surveys that I have seen.

This is but one of the methods of doing least squares for a survey. Another method involves forming the loops (outside of the least squares program), and setting up a problem matrix (or matrices) that have a size proportional to the number of independent loops. Since the number of independent loops is *usually* less than a hundred or so in a survey of thousands of shots, this has some advantages. This does, however, require that you then take the result of the least squares solution, and the original loops, and use these to compute the final locations of the points. For those wanting to read more, survey adjustment texts call the "usual" method "adjustment by observation", and the version using the loop constraints is called "adjustment by conditions." No matter which method is used, if it is correctly implemented, all solutions with the same shot weights will produce mathematically the same final results.

Regardless of which way the least squares the problem is set up, you can solve the system in a number of different ways. "Normal equations" are popular in survey circles, and "orthogonalization methods" have become popular amongst mathematicians in the last twenty years or so. It is also possible to compose the problem "bottom up" in terms of weighted averages, and a number of other formalisations exist. Finally, even if you have picked a method of set-up, and the method of solution (e.g. normal equations), there are many ways to solve such a system, from Helmet blocking (used by NGS, for example), to various decomposition methods, to various gradient or slope following methods, etc. Even *then,* one has a choice of various methods for the final numerical evaluation.

Conclusion

The bottom line is that choosing a loop closure method is not easy. All methods have good and bad points. After people do a lot of research into "their" method of choice, it becomes a religious war to get them to even look at other methods.

Further Reading

For further information on the subjects discussed in this article, consult the author's cave survey bibliography, which lists a number mainstream surveying books. It is available online at:
`http://www.cc.utah.edu/~nahaj/cave/survey/bibliography.html`

The Case for a National Cave Survey Data Archive

Harry Pearman

Long-time readers of Compass Points may recall past proposals for the establishment of an archive for original cave survey data. This subject has recently been considered by Harry Pearman, chairman of the William Pengelly Cave Studies Trust. This article outlines the case for such an archive, and presents an implementation proposal.

It is my belief that under the present set up, in say 50 years time, all current cave survey data will be lost. By survey data I mean stations, bearings centre lines etc. There will still be the original paper prints, looking a bit tatty no doubt. I visualise a different future where the data is preserved and widely available and there are all sorts of exciting methods of plotting it - 3D, rotation, colour, and also links to surface maps and GIS systems to integrate with other data collections. In order for this vision to become a reality, an archive of existing survey data is required. This article discusses the many reasons why such an archive is desirable, and addresses how it may be implemented.

The case for a national cave survey data archive

All significant British caves have been surveyed. Club librarians can usually turn up a plan of any given cave. However these paper plans have drawbacks:

- Often they are not supported by cross-sections or profiles and are thus limited to two dimensions.
- Often there is no link to the outside world; no surface topology.
- Paper is a biodegradeable medium, which, as well as compromising its long term future renders it an unsuitable medium to take down a cave,
- Prints are generally of a one-size-fits-all nature; the survey may have been shrunk from its optimum scale in order to fit onto a printed page, and become downgraded in the process.

End users' requirements

These vary with user.

- The surveyor will want his own copy marking the position of survey stations, showing the centre line and various relevant bits of narrative.
- An explorer or recreational caver requires a compacted print annotated with information on route finding, hazards and points where equipment will be needed.
- A hydrologist requires a stream map; a paleontologist a plan showing sediments; a geologist a section and so on.

Lack of integration

A survey is only one way of representing a cave.

- Many scientific observations are made and published in a variety of forms.
- There are also useful accounts of caves in many general publications.
- Currently there is no means of integrating this information and this might be a useful secondary role of a database once created.

Maintenance Problems

A paper plan is a static snapshot at a point in time, and can rapidly become dated since:-

- Subsequent discoveries may change the cave configuration.
- Two or more caves may become joined.
- Caves themselves are dynamic and may be enlarged or truncated by natural processes
- Accuracy and draughtsmanship may be improved.
- Survey standards can change and technology can radically alter the way surveys are plotted and represented.

The fate of survey data

Any modification requires reference back to the original survey data and herein lies a major problem, for it is likely to be unavailable. It seems to be the fate of most survey data to disappear:

- Early surveyors regarded the data as a discardable intermediate step towards producing a paper plot.
- Next of kin throw out surveying notebooks.
- PC disk crashes or upgrades can wipe-out data.
- Surveyors lose interest, or move or cease caving and dump the data.

For those who *are* interested in data conservation there is no organisation that they can turn to which will guarantee indefinite data storage.

The current position

For many British caves there is thus no longer any record of where the survey stations or centre line are, which must be a matter of regret for anyone who has spent hours grovelling with the end of a tape.

The upshot of all of this is that, although thousands of hours of effort have gone into cave surveying, nationally we enter the new millennium with a fragmented mass of survey plots which cannot readily be, validated or updated. At worst it means that if this generation does nothing to conserve the survey heritage then the next will have to commence a second survey.

This is why a national survey data archive is needed, and by this I mean the angles, distances and notes, not the plotted results. The archive would be a readily available cave by cave single source of aggregate survey and other data, to which ideally any caver/surveyor could contribute according to their knowledge and ability and which any interested person could use freely according to their need.

An implementation proposal

The two primary aims of the proposed data archiving scheme are:

1. To conserve cave survey data.
2. To improve access to cave survey data.

Outline scheme

An earlier outline scheme by the BCRA Cave Surveying Group [1] dealt with many of the practical issues and these ideas are carried forward here. In brief they are:

- Spreading the load of data collection and archiving by having a series of regional custodians.
- A system of grades of accessibility determined by the owners of the data ranging from *No Access* to *Public Domain*.
- Use of the World Wide Web as a public access medium.

The proposals differ in the content of the data to be held (summarised in Table 1) and the storage medium. In addition this proposal envisages a number of value adding enhancements to the data which will be expanded below.

Because of the high graphical content the original proposal a microfilm storage medium was proposed. However this raises issues of cost, shelf life, inability to update and difficulty of access. This proposal, by limiting the data to a value enhanced centre line, opens the way to a database solution which will be less expensive to maintain and more flexible.

Data included in 1999 CSG Archiving Proposal	*Included in current proposal?*
A) Current owner	Yes
B) Location of source data	Yes
Ci) Surveyors' Figures	No
Cii) Surveyors' Cross sections	No
Ciii) Surveyors' Drawings	No
D) Centre Line	Yes
E) Drawn up survey	No

Table 1: Scope of the current data archiving proposal compared with the earlier CSG proposal described in [1].

Preparatory work

It will be necessary to design a suitable database and to draft specifications of the associated functionality.

A pilot implementation

The initial suite of programs required comprises:

- A Database Update Function for direct amendment of the database.
- A Browser to locate rapidly the data for a given cave.
- A Housekeeping program to provide a check on the internal integrity of the database.

This would facilitate a system test for one area to include several caves and test all elements of the database and associated procedures.

Value added features

- All centre line data recorded to a common standard.
- Provision for a library of international cave survey standard symbols
- The inclusion of bibliographic references to published material on caves.
- Dynamic update capability to input change, and corrections.
- Input laundering including:
    - ➔ Back bearings converted to forward.
    - ➔ Potential traverse closure errors identified.
    - ➔ Conversion of imperial units to metric.
    - ➔ Centre line continuity checking
    - ➔ Text placement
    - ➔ Symbol placement
    - ➔ Calculation of a national grid ref. and altitude a.s.l.

  ...for each survey station.
- Specialist annotation (e.g. geology, hydrology) leading to specialist survey plots.
- Specialist supplementary notes.

Data classes

The following five classes are taken from the 1999 proposal and are updated in the light of the new proposal by means of footnotes.

1. **Public domain** - The data is stored and is free to any user for any purpose. The original author should be credited.

(This would be the same in the new proposal. To achieve this data-sets for individual caves would be abstracted using an ftp (file transfer protocol) , compressed and be made available for downloading via a web site. The end user would then need to provide an interface to their preferred plot program. N.B. The finished plots would lack the magnificent draughtsmanship of current published surveys but would be more informative, specialized and - dare one say – disposable.)

2. **Free Access** - The data is stored and is free for any user for any purpose. as long as the original author is credited. Profit may not be made but the costs of distribution may be recovered.

(This class has no equivalent here as the end user does the plotting. Instead a new class – ***Flawed*** *- is proposed which is the same as Class 1 but with a health warning that the data may not produce viable plots – for example there may be missing pages from survey notes, or bad closure errors.)*

3. **Limited Access** - The data is available to any user, but reproduction and use may only be carried out with the permission of the provider or holding body. Where to gain permission will accompany the data (i.e. the original author may pass permission to the holding body or provider.)

(This could be achieved by passwording access to the online data set holdings.)

4. **No Access** - The data may not be accessed by anyone, however a list of the fact that it exists will be published. Any further enquiries will be referred to the provider.

(A record of the existence of the data would be placed on the on-line pages.)

5. **Secret** - The data will be stored, however no record will be publicly available. Anyone asking about data about the cave, or entrances with the same location will be told "nothing known for that site". The authors will be informed of the request unless those asking request secrecy (i.e. secrecy can be reciprocal).

(No record would be placed in the on-line site.)

In addition to the above I proposes a sixth class - **Derivative**. This covers cases where the original survey data is lost but a public domain printed survey exists. Here a virtual centre line can be recreated from inspection of the printed source.

Rolling Out

Once a pilot scheme is operative it can be rolled out in a number of directions utilizing a rolling 3 year implementation plan. These are:

Administrative

Appointment of a National co-ordinator charged with the tasks of:

- Setting up regional co-ordinators and training them. (This could extend to foreign caves if desired).
- Monitoring regional plans and progress.
- Providing a good practice manual. This is to ensure consistent treatment of:
    - ➔ Backup
    - ➔ Security
    - ➔ Recovery
    - ➔ Special cases – e.g. Two caves become connected; traverses involving surface bearings; caves connected audibly or by smoke test; caves connected by diving; caves with multiple names.)

Access

- Provision of the Abstraction and web update utilities.
- Maintenance of a web site.

Data Collection

Transcription of every survey point and survey leg for every cave in a given region would be logistically impossible for a regional co-ordinator. The browse and update functions and miniatures of the database could be put out to surveyors, clubs etc., who might appreciate the laundering capability of the system and be prepared to carry out data entry for specific caves and would periodically send copies of their files to the regional co-ordinator.

Other delegated tasks could include the provision of specialist notation and bibliographic references.

This would require a merge utility to integrate distributed data with the regional collection.

Technology

It would be necessary to review the technology associated with the database from time to time to ensure that it did not disappear down a time warp. Specific enhancements are implicit in some of the roll out proposals specified above. Other enhancements which could be considered are:

- An improved browser from the one proposed here.
- Interfaces with some of the more popular plot systems.

A schematic diagram showing how the final scheme will function is shown in Figure 1.

In Summary

This article has proposed a viable implementation plan for a national cave survey data archive. It has been forwarded to the chairman of the BCA, which is the logical body to run such a scheme - it is to be hoped that they will pick up the proposal from here. In the meantime I have written a PowerPoint demonstrator for the proposal which doubles as a function specification of the Update utility and it is available free to any interested party. I have implemented the database in Access and am in the process of producing an interface with Survex. An example of the data stored in this database and how it might be used is provided in an appendix.

References

[1] Atkinson, A. (1999). Cave surveying data archiving proposal, *Compass Points*, 25, 14-16.

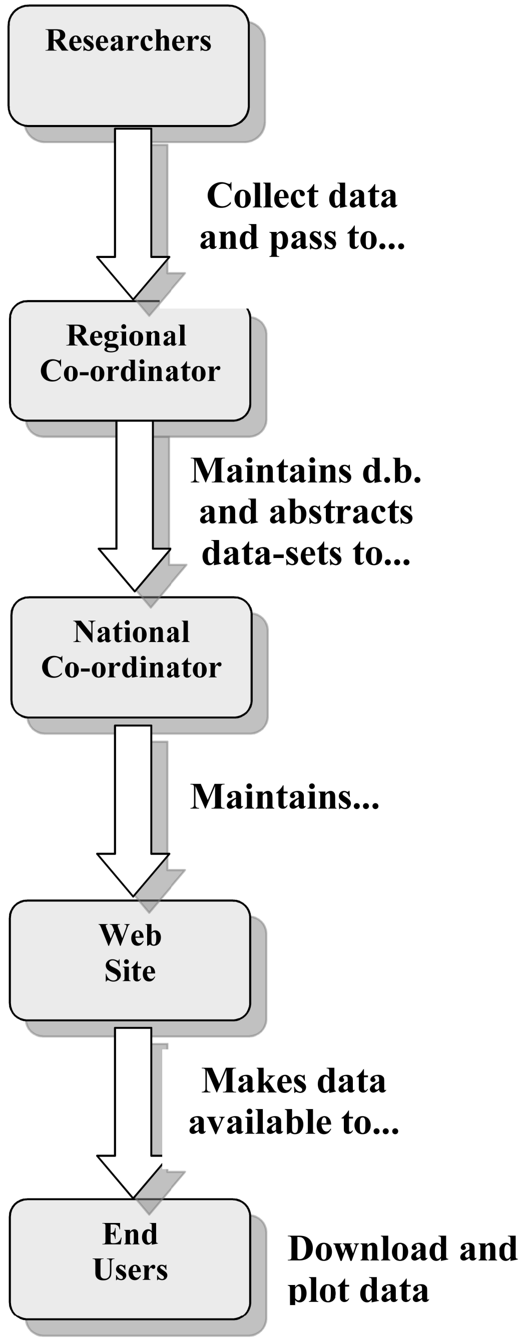


Figure 1: Schematic diagram of the proposed data archiving implementation.

Appendix: Example data

This appendix contains examples of the data stored in the database implementation for a fictitious cave called "Easy Cave". An illustration of how this relatively limited data could be used to derive simple, but useful, representations of the cave.

Serial	Leg	From	To	Bearing	Distance	Angle
1	1	1	2	010	1.00	00
2	2	2	3	010	1.00	00
3	3	3	4	010	1.00	00
4	4	4	5	010	1.00	00
5	5	5	6	010	1.00	00
6	6	6	7	010	1.00	00
7	7	7	8	010	1.00	00
8	8	8	9	010	1.00	00
9	9	9	10	010	1.00	00
10	10	10	11	010	1.00	00
11	11	11	12	010	1.00	00
12	12	12	13	020	1.00	+10
13	13	13	14	020	1.00	+10
14	14	14	15	020	1.00	+10
15	15	15	16	020	1.00	+10
16	16	16	17	020	1.00	+10
17	17	17	18	020	1.00	+10
18	18	18	19	020	1.00	+10
19	19	19	20	020	1.00	+10
20	20	20	21	020	1.00	+10
21	21	21	22	020	1.00	+10

Serial	Leg	From	To	Bearing	Distance	Angle
1	1	1	2	10	1	0
2	2	2	3	10	1	0
3	3	3	4	10	1	0
4	4	4	5	10	1	0
5	5	5	6	10	1	0
6	6	6	7	10	1	0
7	7	7	8	10	1	0
8	8	8	9	10	1	0
9	9	9	10	10	1	0
10	10	10	11	10	1	0
11	11	11	12	10	1	0
12	12	12	13	20	1	10
13	13	13	14	20	1	10
14	14	14	15	20	1	10
15	15	15	16	20	1	10
16	16	16	17	20	1	10
17	17	17	18	20	1	10
18	18	18	19	20	1	10
19	19	19	20	20	1	10
20	20	20	21	20	1	10
21	21	21	22	20	1	10

Figure 2: Line survey and passage dimension data for Easy Cave, such as might be derived from raw survey data. This simple data may be used to generate simple plans or elevations, without the need to store large quantities of graphical data.

```
Entrance,Stalactites,1,10,0
Stalactites,Mud_Bank,1,10,0
Mud_Bank,Hodgkins_Passage,1,10,0
Hodgkins_Passage,New_Extension,1,10,0
New_Extension,Waterways,1,10,0
Waterways,Loose_Roof,1,10,0
Loose_Roof,8,1,10,0
8,9,1,10,0
9,10,1,10,0
10,11,1,10,0
11,12,1,10,0
12,13,1,20,10
13,14,1,20,10
14,15,1,20,10
15,16,1,20,10
16,17,1,20,10
17,Helictites,1,20,10
Helictites,Low,1,20,10
Low,20,1,20,10
20,Curtains,1,20,10
Curtains,Dates,1,20,10
```

Figure 3: Line survey data with some stations renamed according to nearby features. This allows simple annotated plans/elevations to be produced.

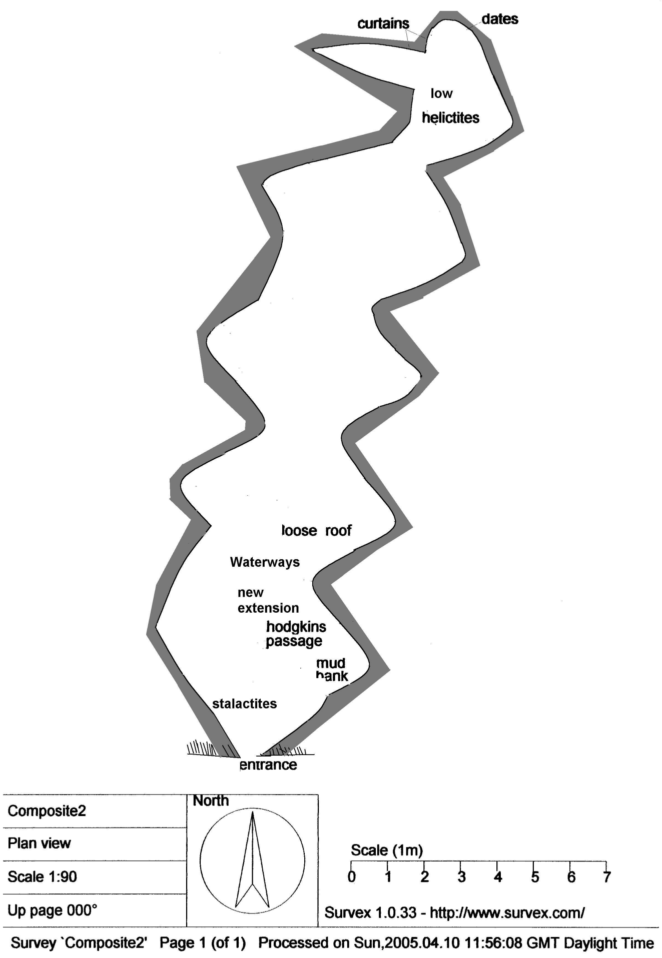


Figure 4: Example plan of Easy Cave, derived from the data in the database.