

Issue 18



COMPASS POINTS

December 1997



BCRA

Geology for Surveyors Survey Data Archiving

Viewing Stereo Pairs

CSG constitution

Magnetic Field Variation

COMPASS POINTS INFO

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The CAVE SURVEYING GROUP of the BCRA.

OBJECTIVES OF THE GROUP

The group aims, by means of a regular Journal, other publications and meetings, to disseminate information about, and develop new techniques for, cave surveying.

BCRA ADMINISTRATOR

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DATA PROTECTION ACT (1984)

Exemption from registration under the Act is claimed under the provision for mailing lists (exemption 6). This requires that consent is obtained for storage of the data, and for each disclosure. Subscribers' names and addresses will be stored on computer and disclosed in an address list, available to subscribers. You must inform us if you do not consent to this.

COMPASS POINTS LOGO

courtesy of Doug Dotson, Speleotechnologies.

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Editorial

This issue was completed at the Autumn CSG field meet at South Wales Caving Club. We did an experiment to try and separate out the factors of people and instruments in compass calibrations, which is something I have wanted to do for years. Many Thanx to Brian Clipstone for setting out the course and to the attendees for testing themselves. The results will be presented in the next issue. We also did some DIY differential GPS testing to further Iain Miller's research in this area. This will also appear in a future issue.

AGM at BCRA conference

We held our AGM at the BCRA conference. It wasn't very exciting, but we did discuss a number of things and chart the year ahead for CSG.

Agenda:

Voting for the Committee: The committee remains the same:
Wookey (Chairman/Editor), Andrew Atkinson

(Treasurer/Secretary/Web Editor), Pete Grant (Publicity/Meets Organiser), Olly Betts (Technical Editor).

Ratifying the Constitution: In fact it wasn't ratified as various people pointed out problems with it as it stood. See later for the gory details.

Data Archiving discussion: The preliminary document was discussed and agreed with a small amendment. It is published in this issue.

Pricing Policy: It was agreed that the CSG will continue to disseminate cave surveying information to its members at the minimum possible cost, including electronic publishing on the web. We agreed to try and keep annual membership below a fiver. Should the group decide that it needs to raise additional funds for further projects (such as data archiving) then the method of fund raising would need to be agreed in advance.

SNIPPETS

UK cave co-ordinates

Allan Richardson

Does anyone already have a list of cave locations in a computer somewhere for any of the UK caving areas? If so, Allan would like to hear from you, as he doesn't want to have to type them all in himself.

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Survey Software for Psions

Psion handhelds are pretty popular in this country. It would be really useful to many people, especially those on expeditions to far-flung places, if there was some survey software for this device. Does anyone know of such a thing, existing or under development? If so contact Andy Atkinson (contact details in masthead).

UIS Working Group on Survey Symbols

This working group is a result of the "International Meetings on Subterranean Topography" that began to verify and standardise the existing conventional signs. This work is in full progress, and we've been faced with many other linked problems, such as:

- the use of computer Software to draw plans (CAD programs)
- standardise the line thicknesses
- choose a standard set of colours (in view of the progress of computer plans)
- try to establish a worldwide standard of precision and accuracy.

This will be done as a working group within the UIS Informatics Commission and in close liaison with the International Geographical Union and other institutions.

The aim of the working group is to establish a set of international standards in order to make maps readable for everybody.

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The UK representative on this Working Party is Andrew Atkinson. If anyone has opinions or information on the above topics, see that he gets to hear about it before it's too late.

LETTERS

John Hollman

Found and read your publications on the Internet. Terrific.

RE instrument lighting:

I solo survey small caves and have used this method for years:

Cyalume makes or used to make a 3" long chemical lightstick (green). My Suuntos are attached back-to-back with duct tape.

They hang with a neck loop of 1/8" parachute cord threaded through a neck pad of 1/2" tubular webbing.

A keeper cord for the lightstick, a 6" long loop of 1/16" diameter bungy cord is attached to the Suuntos' attachment rings.

It's a simple matter to hold up the lightstick to the appropriate side of the instrument with the same hand that holds the instruments, with no magnetic anomalies.

Another lightstick is kept handy for station marking. The little plastic extrusion at the end can often be 'jammed' into rock ceilings. Duct-taping a ten-penny nail to the end allows it to be stood up in dirt floors.

For a few bucks one can spend a day surveying.

I have used up a box of these sticks I bought last year in B.C., and can no longer find a source -- anybody has one please let me know. Bob and Bob (WV, USA) no longer carries them.

Jon M. Hollman, NSS, Manitou Springs, Colorado, USA.

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Surveying and the role of Geological Data

Dr. A.R.Farrant, Dept of Geography, University of Bristol

Geological information is rarely portrayed on surveys. Although the role of geology in determining the plan and style of cave formation is often acknowledged, few surveys record this crucial information. This is primarily because most cavers are unfamiliar with basic geological knowledge or feel that the inclusion of geological data on surveys is irrelevant. However, much information can be usefully added onto a survey with a little extra time and effort, and greatly enhances the use of a survey. Several types of data can be included without more than a basic understanding of geology or cave geomorphology. These can be divided into three categories, flow indicators, passage morphology and geological structures. These will be examined in turn.

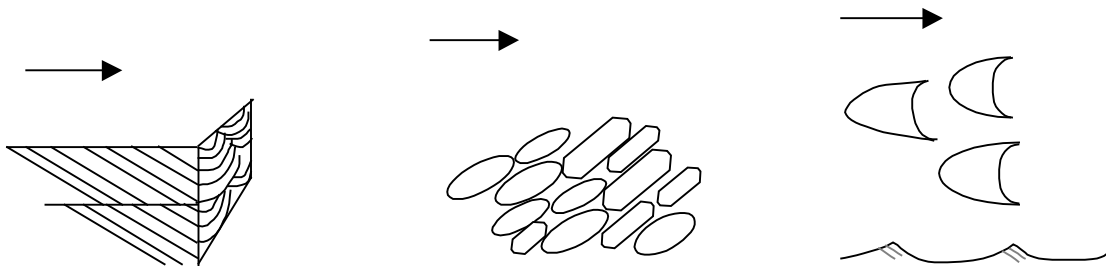
Flow indicators.

Several methods can be used to determine the direction of water flow in abandoned 'fossil' passages. Determination of flow direction is critically important in understanding how cave functioned, especially in horizontal passages or phreatic passages where flow direction may not be immediately obvious. Scallops are the most common flow indicator and generally provide a reliable guide to flow direction. Furthermore, they can also be used as a flow velocity indicator. Scallops are asymmetrical solutional depressions etched into the limestone between usually between 0.5 cm - 1 m across (Fig. 1). The steep face of the scallop always lies on the upstream side, hence by examining a large (> 20) number of scallops, flow direction can be established. When recording flow direction, care should be taken to note scallop directions over a relatively wide area to eliminate the possibility of recording anomalous flow in eddies. The size of scallops gives an indication of flow velocity; the smaller the scallop, the faster the flow. Thus in a fast turbulent vadose stream, scallops will tend to be elongate, unidirectional and small (0.5-5 cm). In slower flowing phreatic passages, scallops will be much larger (10-100 cm) less asymmetric and more irregular, often merging into wall pockets.



Fig. 1 *Cross section through a scallop, with flow direction.*

Another method of looking at flow direction is examining structures commonly preserved in undisturbed cave sediments. Alas, in many caves, mud banks and sandy floors have too often been trampled and disturbed. Adequate taping is needed at an early stage to preserve these highly delicate features. Several indicators can be used to determine flow direction such as cross-bedding, imbrication and ripple marks. These are sketched below (Fig 2).



A. Cross bedding.
Occurs in sandy sediment.

B. Imbrication
Occurs in gravel deposits

C. Ripple marks
Occurs on sand/silt.

Fig. 2 *Flow indicators in cave sediments.*

Cross bedding is best developed in fine sandy sediment and can be observed where a section has been cut into a sediment bank. However, care must be taken as the type of structure seen will depend on the orientation of the section

with respect to the flow direction. The clearest cross bedding will usually be seen in a section parallel with passage orientation.

Ripple marks are common on sandy-silty floors, and like scallops, the steep lee side of the ripple is on the upstream side. Imbrication is the orientation of gravels in the direction of flow. Platy clasts such as shales and thinly bedded sandstone are easily aligned in the direction of flow. The clasts generally dip upstream. With a little practice, these observations can be made within a few minutes and easily added to the survey notes.

An example where flow indicators provided an important insight to understanding the evolution of a cave system is in Ogof Draenen. From a simple examination of the survey, it appears that Gilwern Passage is an inlet to the Beyond a Choke streamway. However, ripple marks, scalloping and cross bedding all indicate flow to the north. Similar evidence from Megadrive indicates a southward flow (Simms et al., 1995).

Passage morphology.

Passages can be divided into three basic types, vadose, phreatic and paragenetic. An accurate, well drawn cross section through a passage, with the relative vadose or phreatic portions marked is invaluable. An example is shown below (Fig. 3).

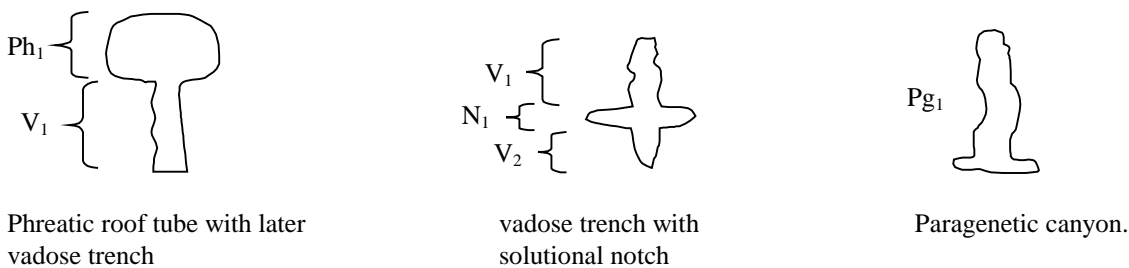


Fig. 3. Cross section through several passages showing each phase of development.

Vadose passages are characterised by trench shaped passages, which are often well scalloped and fretted. Phreatic passages are often more rounded in profile, have generally smoother walls. Paragenetic passages are the most difficult to recognise and are less common. In shape they often resemble vadose passages, yet have a phreatic sculpture. They are formed by sediment infilling a phreatic passage such that the floor becomes armoured with a sediment cover, and thus solution can only proceed upwards. Characteristic features of paragenetic passage include a phreatic canyon passages, parasitic half tubes etched on the passage walls and roof and evidence of a previous total sediment fill. Many of the passages in the upper series in Ogof Ffynnon Ddu show characteristic paragenetic canyons (e.g. between Selenite Tunnel and Cross Rift). The choked caves exposed in Eldon Hill Quarry, Derbyshire are another superb example, many of which are still infilled with gravel.

Geological structures.

Perhaps the simplest thing to measure while surveying is the dip of the rock. The dip is the maximum slope of a bedding, while the strike is an imaginary line at right angles to the dip (Fig. 4). This can be done with a clinometer on a convenient bedding plane and takes only a moment. Many passages are oriented either down dip or along strike. Joints and fault lines are also important in determining potential flow routes and can be easily marked on a survey. Joints are fractures in the rock with little or no evidence of movement, and are often infilled with calcite. Faults are less common, but usually more obvious, being marked by a zone of shattered rock often several metres wide and heavily veined with calcite. As a fault is a plane where rocks have moved in relation to each other, individual beds are not continuous across the fault. A good example is the Hall Fault, exposed at the base of the 40' pitch in GB Cavern. This is marked by a thick zone of shattered heavily veined rock, dipping at an angle of 40° which determines the location of the pitch.

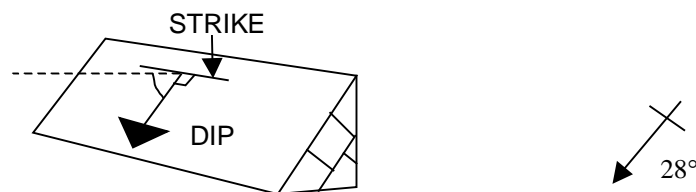


Fig. 4 Dip and strike as measured on a bedding plane.

Folds can also be marked, if they are small and prominent enough to be marked on a survey. Large scale folds can be picked out if enough dip measurement are taken throughout the cave system. Two basic types occur - anticlines and synclines (Fig 5). Many small examples can be seen in the walls of the Swildons streamway below the old 40' pot and in G.B. On a larger scale the position of anticlines and synclines in OFD determines the location of many of the inlets. This is shown in the OFD Chapter in Limestones and Cave of Wales (Smart and Christopher, 1989).

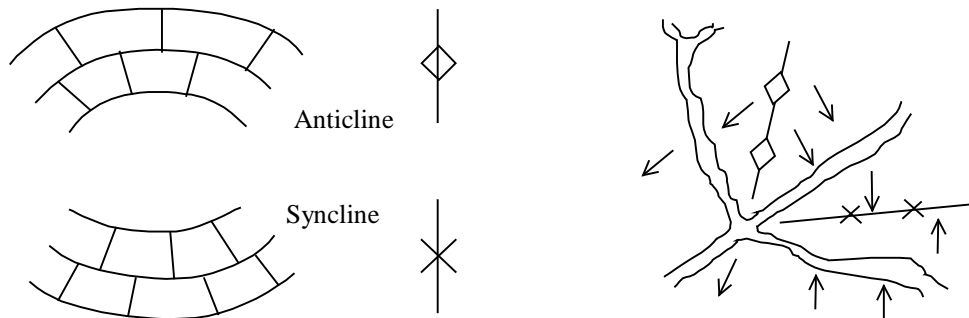


Fig. 5. Basic fold types; Plan of cave with dip arrows, anticlines and synclines marked.

Other features

Many other observations can be easily noted on surveys. Abrupt changes in passage shape, size or orientation usually have a geological or geomorphological control, and if significant, should be noted. Major changes in roof elevation at junctions are especially important as they often provide evidence of the relative age of each passage. Similarly, changes in rock type, the presence of shale bands or a particular marker horizon should be noted. Which, if any of these observations will depend on the cave being surveyed. For example, in Ogor Draenen, three rock units can be easily distinguished, even by the non-geologist and their location noted. The presence of non-limestone boulders in chokes is another easily identifiable feature which can be noted on a survey.

Conclusion

Much information about caves and how they functioned can be obtained from relatively few easily observed features. However, very little of this information is ever marked on cave surveys. Furthermore, most of these observations can be recorded on a normal surveying trip without spending much time and with only a little practice. I hope that anyone involved with surveying a new cave will consider the geological aspect and plot the relevant data - it makes the geological interpretation a lot easier!

Geological data symbols

Phreatic flow direction		Vadose flow direction	
Dip, direction and angle		Anticlinal axis	
Joint		Synclinal axis	
	J	Fault	
			F

Cave Surveying Data Archiving

Andy Atkinson

At one of the early meetings of the CSG concern was raised about the amount of surveying data that had been lost in the past, and the amount of work that was

being undertaken to reproduce these surveys. The question was how to reduce the loss of this survey data in the future.

Proposal

Most survey data is kept by the original surveyors. This is usually the only record of the original data and the usual way for it to get lost is for the person concerned to retire from caving and forget about the data that is in their loft, but there is also the potential for loss through fire etc (e.g. UBSS hold a vast quantity of data in the library which burned down in 1981 - on this occasion luck was on their side and no data was lost, but this may not always be the case).

With this in mind, the best way to protect data is to set up a second (and ideally a third) storage place. This however, immediately comes in conflict with clubs protecting the data that they have collected, usually to sell in order to recover the costs of the surveying, and to fund further surveying exercises. The other problems are where and how to store the data, the cost of the place, and the copying of the data which although small per unit, totals to a very large quantity of data across the country.

Protection of the data

To overcome the problem of clubs and individuals not wanting to divulge their survey data to another outside source, I propose that the group (i.e. CSG, BCRA or another body set up for the purpose) that ends up holding the data, holds it under proscribed conditions, listed below, as categories 1-5. We need to define some terms here: The provider is the person, group or club that hands over the data/survey and specifies the category that it is held under. They must be entitled to do this, and thus will normally be the original surveyors/surveying club. The author is the original surveyor(s)/drawer(s)/club which may be different from the provider. The holding body is the organisation charged with maintaining the archive. The user is anyone wishing to access the archive.

- 1) **Public domain** The data is stored and is free to any user for any purpose. The original author should be credited.
- 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.
- 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)
- 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 enquires will be referred to the provider.
- 5) **Secret** The data will be stored, however no record will be available publicly. 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.

Note that different types of data can be kept under different categories. Typically the survey data itself might be category 4, whilst the completed survey is category 2 or 3. There will also be the facility for providers to record what information that they hold but do not or cannot (i.e. due to expense) give to the holding body. This should reduce duplication of work. Anyone wishing to send locations under Category 5 may also do so with the same conditions.

As this is a system to stop the loss of data the question must be asked what will happen to the data in Categories 3-5 when the authors are no longer in contact.

I propose that after an agreed period (e.g. 5 or 10 years) with no contact the holding organisation tries the last known contact address to warn them of the lapse. This information will also be published (with the exception of category 5) in

Compass Points or an equivalent journal. If no response is heard within two years, the data will move to the default Category, (1, 2 or 3) with the holding body becoming responsible for giving permission for category 3 data. This will be stipulated when the data is first transferred.

The category of the data and the default category can be changed by the club at any time.

Data for which the original provider contributed the entire cost of placing the data in the archive may withdraw the data. Were the holding body has contributed to the cost the data may only be withdrawn if this cost is reimbursed.

What Data to hold

Ideally this would be every form of data that goes with the Cave. In reality it is proposed that the following items be included.

- Where the data is held and by whom.
- Location
- Original data collected - Figures
Drawings
- Corrected centre line (This is intended for authors who want to keep their original data private)
- Drawn up survey.

It is hoped that this data will be held in computer format with the main archive being in microfiche.

Where to Hold the Data

This would be one of the hardest problems to solve. One of the first tasks is to find out what the potential storage space that will be needed. If it is excepted that the paper format of the data would not be accessible to the public, this would make the problem simpler. The computer data could be stored anywhere with it being accessible though the web.

There may be the possibility that Ordnance Survey or the British Geological Survey may be willing to help out, however the freedom for us to do as the caving world would prefer would be reduced and therefore it may make the scheme none viable. Also organisations aims change with time and in five years the project could just be dropped. There is always the Lottery (Ha Ha).

Control of the Holding Organisation

Each provider donating data would be a member so long as the data remains in possession of the Holding Body. A committee that is elected once a year will control the day to day running. Any proposals to change the protection of the data would be subject to a 75% majority, and a period of at least six months after the vote for data to be withdrawn.

Concluding Remarks

This is the initial proposal to reduce the loss of data. Criticism and suggestions are welcomed.

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CSG Constitution Update

Andrew Atkinson

After discussions at the AGM, and further feedback at the Autumn Field meet, these are the revised paragraphs of the CSG constitution published in CP17. These will be ratified

at a forthcoming BCRA council meeting. If you have any objections please make them known to the committee soon.

- 2.1 The Group shall be managed by a committee consisting of not less than two elected officers and any other members as shall be determined by a simple majority vote of paid-up members at a General Meeting of the Group. The committee may co-opt up to two additional members. All committee members (including co-opted members) must be Personal members of the BCRA.
- 2.3 The Group shall hold an Annual General Meeting in September of each year. Motions for discussion must be submitted to the secretary in writing by 30th July of the year and must be proposed and seconded by paid-up members of the Group. Notice of AGMs shall be made to all paid-up members giving at least 28 days' notice of date, venue and time. Notice shall be made in writing or by other equally or more reliable means available (e.g. personal delivery to the member or electronic mail) to their address most recently notified to the secretary. Non-receipt of notification shall not invalidate the meeting. Amendments to motions may be submitted in writing, or by other equally or more reliable means, available to the secretary to arrive to arrive no less than three days before the meeting and must be proposed and seconded by paid-up members of the Group. Motions 'from the floor' will not be permitted.
- 2.4 Extraordinary General Meetings shall be convened as required, upon unanimous vote of the committee or upon the presentation to the committee of a written motion signed by not less than ten paid-up members or 50% of the paid-up membership whichever is the least. EGMs may only discuss the motion proposed in the notice. Notice of EGMs shall be made to all paid-up members giving at least 28 days' notice of date, venue and time. Notice shall be made in writing or by other equally or more reliable means available (e.g. personal delivery to the member or electronic mail) to their address most recently notified to the secretary. Non-receipt of notification shall not invalidate the meeting. Amendments to motions may be submitted in writing, or by other equally or more reliable means available, to the secretary to arrive to arrive no less than three days before the meeting and must be proposed and seconded by paid-up members of the Group. Motions 'from the floor' will not be permitted.
- 3.1 The funds of the Group shall be placed in an account that shall have the title BCRA Cave Surveying Group. The account shall have no less than two signatories, including the Treasurer and Chairman of the Group.
- 4.1 Election to membership shall be as determined by the Group. Any matter of dispute shall be referred to the Council of the BCRA.
- 4.2 Termination of membership of the group shall be determined by a majority of the full committee, pending approval at a General meeting.
- 6.3 Council shall retain an overall control of the Group, and a right of access to all information held by the Group. Any decision Council may make regarding the Group shall be final, subject to ratification at the next General meeting of BCRA at which the Group may appeal against the decision.
- 6.4 In the event of the dissolution of the Group, its realised assets after discharge of all liabilities shall be handed to the BCRA. In other situations Council shall give due consideration to a request for the Group to retain its assets.

Viewing Stereo Pairs

Larry Fish

Several people have asked me for information on how to generate stereo line plots with a cave survey program. The COMPASS cave survey software manual has a chapter on generating stereo plots. Even though it comes from the COMPASS manual, the techniques will work with almost any cave survey program. I thought this topic might be of general interest, so I have included the following excerpt from the manual:

Making Stereo Pairs

Sometimes caves are so complicated that looking at a line plot can be very confusing. Line plots are two dimensional, but caves are three-dimensional. This means that you cannot tell from a line plot, which passages are far away and which passages are near. In fact, passages that appear to be close together can actually be hundreds of feet apart.

There is a relatively simple solution to this problem that allows you to see the whole three-dimensional structure of a cave on a line plot. The solution is to create stereo pairs from line plots. With stereo pairs you can view the cave in three dimensions and see exactly how the cave is constructed.

Human beings have three-dimensional vision. This is because their eyes are on the front of their heads and they are spaced a few inches apart.

As a result, each eye views the world from a slightly different angle.

The brain combines the image from each eye and forms a single three-dimensional view of the world. This is the way the old ViewMaster viewer works. Basically, you look at two different photographs taken from slightly different angles. Each eye sees a picture of the object from a different angle and your brain sees a three dimensional image. Cartographers use this technique with aerial photographs. As the plane flies over the land, it takes a picture of the same terrain from two different angles.

When you view these aerial photographs, the mountains and valleys appear three-dimensional.

Creating Stereo Plots

You can do the same thing with any cave survey program that allows you to rotate the plot. All you have to do is create two plots that view the cave from slightly different angles. If you view these plots through a stereoscope the cave will appear in three dimensions. Here are step-by-step instructions for creating stereo pairs:

1. To start with, pick a cave that is relatively simple. Profiles are the easiest to create and have the most dramatic 3-d effects.
2. When you view the plot, your eye will be fairly close to the page, so make the plot fairly small; no more than two or three inches across.
3. Make two plots on separate sheets of paper. Make sure that they are both profiles of the cave. The first plot can be from any angle. The second plot should be rotated about three to six degrees from the first.

In other words, after you have made the first plot, rotate the cave by about three to six degrees and plot it again. The rotation must be in the horizontal plane. This means that the cave should rotate in same plane that a record player turntable rotates. The bigger the angle, the stronger the stereo effect. However, don't over do it or your eyes won't be able to merge the images.

Once you have created the stereo pair, you will want to view it. Some people can view stereo pairs with the naked eye, but most people need a stereoscope for easy viewing.

Using a Stereoscope

A stereoscope is an optical instrument, which is used to view aerial photographs. It is also very useful for viewing stereo cave plots.

The stereoscope is similar to the View Master viewers sold in toy stores. The instrument is very simple; it consists of two magnifying lenses mounted in a frame so that each eye looks through one lens.

The frame usually has four legs, so that it can be positioned at a fixed distance above a stereo pair placed on a table.

Learning to use a stereoscope is a bit tricky, and most people require some practice before they can use it effectively. To see the 3-D effect, you have to look at one of the pairs with your left eye and the other pair with your right eye. The tricky part is that your eyes automatically focus on one point, not two. As a result, you have to retrain your eyes to see the 3-D effect.

When you look at an object that is close to your face, say the end of your nose, the line of sight of each eye converges at a sharp angle on that point. If you look at a distant point, the line of sight of each eye is nearly parallel. When you look at a stereo pair, your brain sees it as a nearby object and focuses your eyes on a single point, when what you really want is to have your eyes looking at two different points, one on each photograph. The trick then is to pretend that you are looking at a far away object when you look at the stereo pair. This makes the line of sight of each eye more parallel and allows each eye to focus on a different image.

The following is a step by step procedure for examining stereo pairs.

1. **Aligning.** Before you can view the stereo effect, you must align the stereo pair properly. The images must be placed so they are on the plane of rotation. In other words, the plots should be placed side-by-side.

Since each plot is a different image for each eye, the rotation must be along the same line as your eyes. If the orientation is wrong, the stereo effect will be completely lost.

2. **Converging.** The next step is to merge the two stereo plots into a single three-dimensional image in your brain. The easiest way to do this is to pick an easily identifiable landmark in the plot. It can be a passage, a station or anything that is easy to see. Locate the landmark on both plots and adjust the spacing between the plots until the two landmarks are about as far apart as your eyes. You may need to overlap the plots to get the landmarks in the proper position. Now place the stereo viewer over the plots so that the center of the lenses is directly over the image of each landmark.

Now look at the landmark through the stereo viewer. Close one eye and look at the landmark through the other. It should appear directly under that eye. If it doesn't, move the plot until it is in the correct position. Now do the same thing with the other eye.

When everything is correctly aligned, open both eyes, relax and pretend you are looking at a distant object. As you do this, you should see one image drift toward the other. The further into the distance you look, the closer the images will get. The goal is to put one image right on top of the other. You may need to move the plot slightly, either up and down or closer or farther apart. When everything is just right, something magic will happen! The images will seem to lock together and the whole scene will jump into three dimensions. After you get the scene in stereo, you can move the plots or the viewer to other parts of the picture to examine the cave. If part of the image is hidden under the other picture, curl the edge of the top plot up so that you can view that part of the bottom plot. If you lose the stereo effect, move the viewer back to the landmark and realign everything.

At first, you may have difficulty getting and maintaining the stereo effect, but with practice you will train your brain and eye muscles to maintain the stereo effect easily, even when you move the photographs around.

If you don't have a stereoscope, you may be able to get the effect with the naked eye. Just follow the instructions above and skip the part about the stereoscope. It is easier for a nearsighted person to view with the naked eye because they can get close to the plot and still focus on the image. If you are nearsighted, take off your glasses before viewing the plots. If you are not nearsighted, reading glasses or pair of magnifying lenses can help. The main thing is that you have to get your eyes fairly close to the page.

Hourly Variation of Magnetic Declination

Robert Thrun

Magnetic declination is the difference between true north and Magnetic North. There are both long-term and short-term changes in the Earth's magnetic field. The long-term, wide-area changes are predicted by models such as the International Geomagnetic Reference Field (IGRF). The values from these models are used for the values given on the bottom of topographic maps. Surveyors should be aware that the printed declination value may not be accurate for their time and place. A more accurate value may be got from a surface survey using landmarks on the topographic map.

The differences between individual magnetic compasses are another source of error in a cave survey. Some cave survey projects establish a compass correction by sighting between reference points, thus accounting for both declination and compass differences. Ultimately the limit of accuracy of a magnetic survey is established by the short-term variations in the Earth's magnetic field. Land surveyors have long been aware of this and use more accurate ways of measuring angles.

Measurements of the Earth's magnetic field are available on the Internet. The British Geological Survey has the Geomagnetism Information and Forecast Service at:

http://ub.nmh.ac.uk/gifs/on_line_gifs.html

The US Geological Survey has the National Geophysical Data Center at:

<http://www.ngdc.noaa.gov/seg/potfld> and
<ftp://ftp.ngdc.noaa.gov>

The British site will give a table of hourly means for a single day at one of three magnetic observatories. The US ftp site has all the data for a magnetic observatory, sometimes going back to 1901, in one huge file with a complicated format. Data at 1-minute intervals are available on CD-ROM in both countries. I requested 31 days of July 1997 hourly means from the UK Hartland

observatory at 50° 59.7' N, 355° 31.0' E.

Data were given for hours 0 to 23. I added half an hour to place the mean at the middle of the hour. I plotted the declination for the entire month to see if there were noisy and quiet days. I also overlaid all 31 days on one plot to see the reproducibility of the daily pattern. It should be noted that the data consist of hourly means, so there is some smoothing of instantaneous peaks.

The largest change in one day was 0.232°. The hourly variations are small enough so they are hidden by other errors. Those who calibrate a compass with reference points might want to do the calibrations at the same time of day. The variations will not swamp out accuracy gains from reading to better than half a degree, though other factors might. Perhaps we should record the time of the compass readings on our surveys.

There are quiet and noisy locations and years. The magnetic field varies with sunspot activity. I will leave it to others to look at the variations at other times and places.

