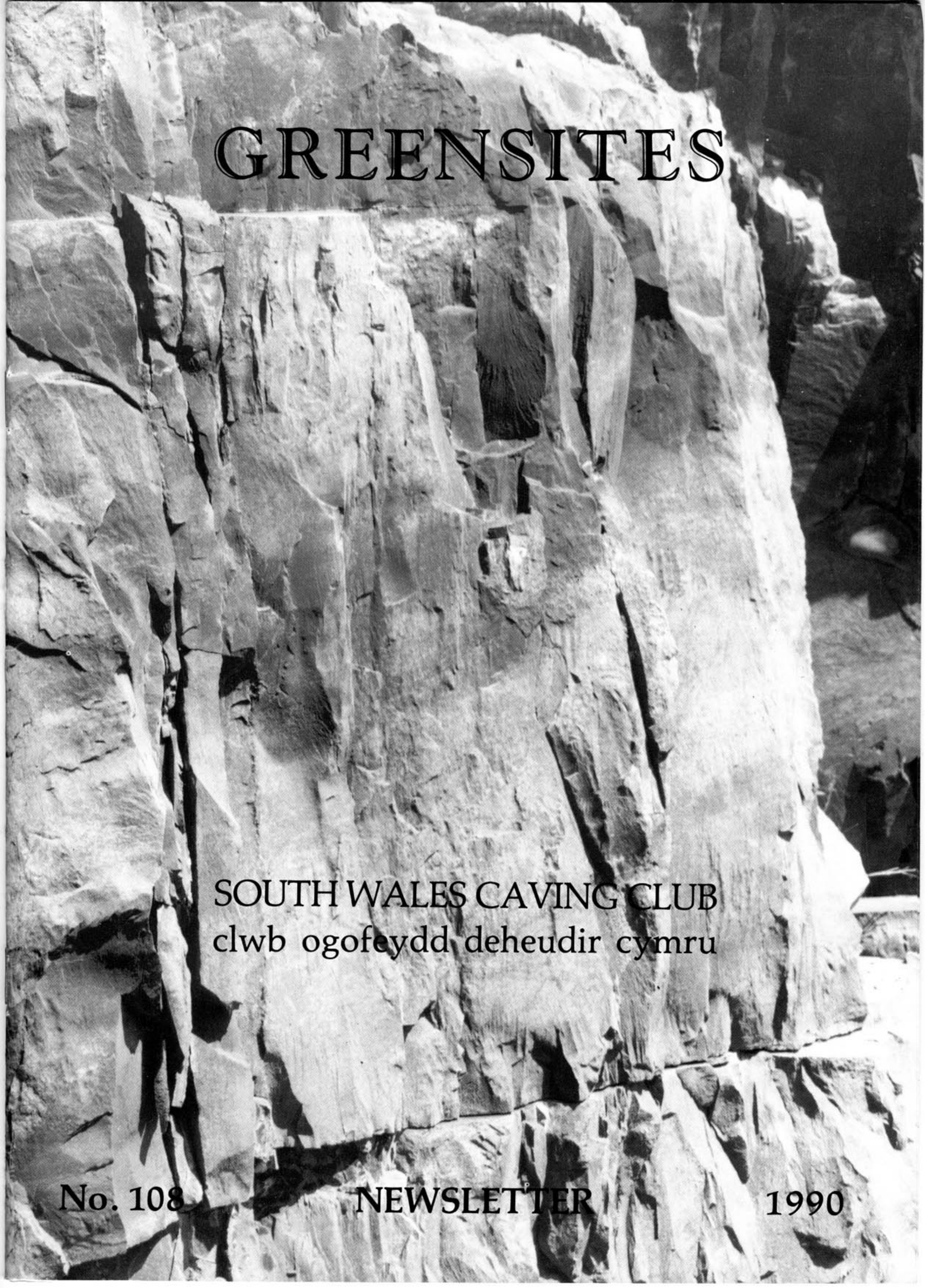


GREENSITES

SOUTH WALES CAVING CLUB
clwb ogofeydd deheudir cymru

No. 108 NEWSLETTER 1990

CONTENTS

Preface

THIS publication contains most of the papers, discussion and conclusions of a meeting held at the Copper Beech in December 1989. The purpose of that gathering was to review and explore ways and means of detecting cave passages. In particular we were concerned with finding digging sites not associated with any obvious cave features, such as sinks and risings. Hence the name Project Greensites.

Many aspects of cave detection were discussed on that December day. It is hoped that what is recorded here is a reasonably accurate account of what transpired. There are bound to be some inaccuracies which if reported can be put right in a later publication.

The problem of editing has been that the discussion was free ranging and the contributions were enthusiastic. This made difficulties for those recording and trying to make sense of what was said.

Our main thanks must be to the contributors — Colin Fairbairn, Keith Ball, Ray Woods, Malcolm Herbert and Rob Drayton. Without their efforts we would not have had a basis from which to develop Project Greensites.

Thanks are due to Jem Rowland for editing the discussion on remote sensing, Alan Woods and Dave Holder for recording the events on the day. To Dave again for arranging and correcting the transcription, as far as was possible, of the original tapes. To Clare Jones for the final typing and to Annie Peskett for final editing and blending pictures with script.

Read these proceedings with an open mind. In that way some of the apparently ridiculous comments can be turned into sublime thoughts and actions. Look on them as a primer to you own personal brainstorming and let us have more wild thoughts and considered ideas.

Clive Jones

Introduction

Good morning. Welcome.

A couple of weeks ago someone gave me a book called effective communication. In it I read that under no circumstance do you start a meeting, symposium or workshop with a joke. That is unless you think that you are a stand up comic. You may or may not have heard the story of the great white hunter. He was in Africa and he came across a dead elephant. A huge dead elephant with a little pygmy seated on it.

"Did you kill that elephant" he asked the pygmy.

"Yes" was the reply.

"I'm amazed" said the hunter, "I've got the latest in elephant guns, I've been hunting all the week and killed nothing. Did you kill that elephant with your club?"

"Yes" said the pygmy.

"How big is your club"

"At the last count we had 250 members"

That is what today is all about. We have some big caves to find and a lot of intelligent people in the club to give us the expertise we need to find them.

The problem has been that many of us in the past went about looking for caves in the wrong way. We dug only at sinks, risings and collapses. A classic example was Waun Fignen Felin. Here we dug a deep shaft following the main sink. We found a few miserable collapsed chambers. All the time we suspected that nearby there was a disguised way in. Our suspicions were reinforced when Ffynnon Ddu 2 was found because the new entrance, and many other places, were close to the surface. These passages were but a short dig from daylight. There was no indication of their presence on the surface. What we are here to do today is to devise ways of locating these close to surface caves. Can we dream up a spy glass which enables us to look at the surface and show us what lies beneath? (Demonstation). There are many situations to consider.

Tunnel Cave top, found by radio location from inside, was only 60 feet from the surface. Steeple Aven may be closer. How many more are there like this?

Then we have numerous kinds of holes in the Dan-yr-Ogof dry valley. Most of the ones were dug seem to be blocked for a long way. Some may not be — how do we differentiate? Is there another Pwll Dwfn or better still a hole that goes somewhere? Then there are cave entrances blocked by drift or scree on sides of active and dry valleys (e.g. Ffnnon Ddu top entrance). Many types of cave entrances are probably blocked with drift.

At the Dan-yr-Ogof conference it was suggested that we set up a think-tank project to produce ideas to help us locate these hidden passages. At the first meeting of interested people it was decided to pursue five avenues of thought. These were geophysics, chemistry, biology, distance observations and dowsing. There may be others, such as geo-bio-poetry or speliofizziology. Let us not disregard anything.

Today's format will be presentations, each followed by a discussion. During the lunch break there will be a demonstration of satellite mapping.

When the presentations are completed we will have a general discussion. This will be followed by group discussion on the five topics. Each group will report back to the meeting. After a wider ranging discussion we should be able to come up with a plan of action.

At one time this club had a reputation for the numerous gadgets and devices which we built. We were once called the "clockwork cavers." We are now in the age of electronics, bioscience and clever chemistry. If the same spirit is about then we can build the present day equivalents of the clockworks of the past. If we cannot build we can beg and borrow. We can even, perhaps, raise funds to support research projects. Do not let costs or magnitude of resources hinder our thinking today.

Clive Jones

Detecting Cavities Using Geophysical Methods

INTRODUCTION

The objective was originally to find Ogof Ffynnon Ddu 2 type entrances without going underground. This has been expanded to passages down to 10 metre depth to give more of a digging challenge. If we look at other limestone rocks in a similar situation can we find the hidden passage with any degree of certainty?

Geophysical methods are generally non-intrusive using measurements of the physical properties of the earth. Examples of these properties are resistivity, gravity and velocity of elastic waves.

METHODS OF CAVITY DETECTION IN GENERAL

Table 1 gives a rating for the usefulness of various geophysical methods in cavity detection. There is no method that is judged excellent and therefore to be universally applied. This table has been extracted from a Report by the Geological Society Engineering Group Working Party on Engineering Geophysics. This group was set up in 1982 with representatives from academia, government bodies and industry. Its report was published in 1988. No method was deemed to be excellent that would work in every situation. Field trials are always required.

TABLE 1

USEFULNESS OF METHODS FOR CAVITY DETECTION

1. SEISMIC

Refraction 1
Reflection 2
Cross-hole 3

2. ELECTRICAL

Resistivity sounding 2
Induced Polarisation 0
Electromagnetic and Resistivity profiling 3

3. OTHER

Radar 3
Gravity 2
Magnetic 2

1 = limited use .... 4 = excellent method

A brief description of the various methods follows.

1. SEISMIC

These methods utilise the propogation of waves through the earth. This propogation depends on the elastic properties of the rocks.

1.1 Refraction.

This technique involves the recording of the primary or compressional (P) wave travelling both directly through surface layers and refracted along underlying layers of higher seismic velocity. The energy source for shallow investigations is normally a heavy hammer blow with the ground movement recorded by a number of geophone stations. The output from the geophones is recorded on an engineering seismiograph which enables several blows at each station to be stacked together to enhance the signal.

If a returning wave passes through a cavity, especially air filled, its travel time will be delayed.

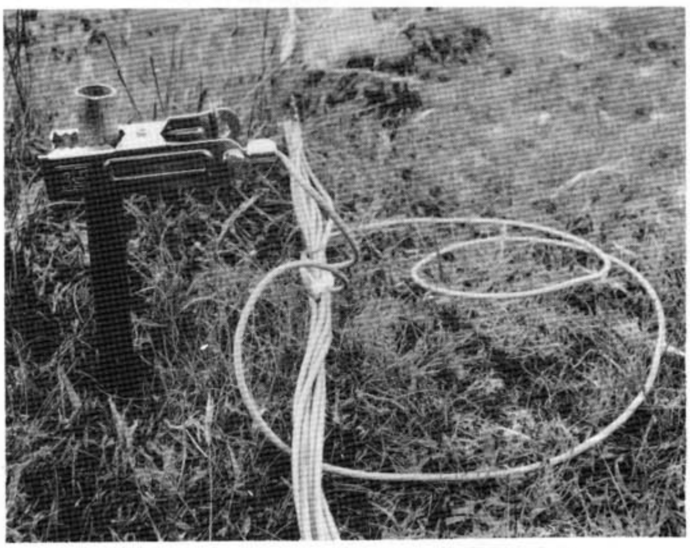
Interpretation of the results will not be unambiguous as delays may also be introduced by irregular weathering of the near surface rocks or varying depth of soil. A close spacing of 1 or 2 metres for the geophone stations is also required to make sure travel paths pass through the cavity. Refraction survey traversing will be slow.

1.2 Reflection

Reflected rather than refracted waves are utilised. The equipment and survey method is similar. A cavity should produce a strong reflection of energy especially if it is air filled due to a large change in both density and velocity at the interface.

Very shallow reflection work is often unsuccessful due to the interference of direct and refracted waves. A badly weathered and highly fractured near surface attenuates and scatters the energy.

A further drawback is that specialised computer processing is generally requires to achieve the necessary



The electrode as being used on the resistivity testing.

Pant Maur: Rob Evans taking gravity measurements. *Photo by Colin Fairburn*

signal to noise ratio. Seismic reflection is the most used of any geophysical method especially for hydrocarbon exploration, and its interpretation is generally the most easily believable.

1.3 Cross-hole

This technique invloves making travel time and amplitude measurements of seismic waves from one borehole to another. Tomographic methods are used to map areas of low velocity between the boreholes which may be associated with cavities. Obviously not applicable to our situation.

2. ELECTRICAL

2.1 Resistivity

All resistivity methods employ an artificial source of current which is introduced into the ground through two electrodes. The procedure then is to measure potentials at other electrodes in the vicinity of the current flow. The current is noted and therefore an effective or apparent resistivity of the subsurface can be determined. Various configurations of electrodes can be used.

Depth sounding — A number of measurements are taken with the use of a fixed centre and an expanding spread. For the location of voids this can only be applied where the width to depth ratio is large. More localised voids are only likely to produce significant anomalies if the sounding is centred over a void and there are associated anomalous moisture conditions. This type of sounding is frequently necessary in order to establish the proper electrode spacing for the lateral search.

Traversing — The array of electrodes is determined by the cavity size relative to depth ratio and the resistivity contrast which determine the amplitude of the resistivity anomaly. The array is then moved along the traverse line. The field procedure is relatively fast compared to the depth sounding but does not give as much detail.

The void will show as an increase in resistance. The anomaly being greater for air filled rather than water or clay filled voids.

With all resistivity methods the main problem occurs if the overburden material is inhomogenous giving a high background noise level. Thinning of clay over limestone may produce apparent resistivity variations which could be misinterpreted as air filled cavities conversely anomalies associated with patches of thick clay could indirectly indicate the presence of cavities. Survey equipment can be assembled cheaply.

2.2 Induced Polarisation

This method was not considered relevant to cavity detection.

2.3 Electromagnetic

The technique of ground conductivity surveying gives similar results to resistivity traversing and for the depth range down to 30 metres is quicker. It has therefore largely replaced conventional resistivity traversing in the commercial world.

A transmitter coil energised with an alternating current is placed on or above the ground surface and a receiver coil is located up to 40 metres he time varying magnetic field arising from the A/C in the transmitter coil induces very small currents in the earth. These currents generate a secondary magnetic field which is sensed together with the primary field by the receiver coil. The intercoil spacing and operating frequency are chosen so that the ratio of the secondary to primary magnetic field is linearly proportional to the ground conductivity.

A direct reading of conductivity is obtained and with a spacing of 5 or 10 metres between readings several kilometres of traverse can be covered in a day. It may be necessary to take readings with varying coil spacing to cover cavities at any depth down to 10m. If a cavity is encountered a low conductivity reading would be expected. As with resistivity there may be interpretation problems if varying thickness of clay is encountered.

3. OTHER METHODS

3.1 Radar

Continuous electromagnetic subsurface probing by ground impulse radar techniques is a relatively new tool in the geophysics armoury.

It utilises downward looking short wavelength radar pulses. Impulses are partially reflected at conductivity boundaries. It is a very high resolution method, using 10-200 MHz generally, but with low penetration. This is generally down to 20m in low conductivity materials such as sand, gravel, rock and water. This is reduced to a few metres or less in conductive soils as clays, silts or soils with saline or contaminated pore water. It has been reported to have seen down much deeper in limestone in Japan and has been used to measure the thickness.

Problems are likely to arise with a fractures sub-surface due to asttenuation and scattering of the radar energy. Clay content in the soil will also reduce depth of penetration. Computer processing of the data may be required but the type of equipment used to locate buried pipes may give a real time display.

Pant Maur: The magnetometer crew — Bob Saunders and Jamie.

3.2 Gravity

Measurements involve the precise determination of the earth's gravitational attraction using a sensitive spring balance called a gravimeter. Corrections have to be applied to the readings to take into account instrument drift, earth tide latitude, station elevation and terrain corrections. The resulting Boguer anomaly is interpreted as a varying bedrock topography.

The recent development of micro-gravity meters which can be read to 1 or 2 microgal has encouraged the use of gravity for cavity detection. Gravity lows will be seen over voids and they will be larger for air filled rather than water or sediments filled cavities.

The worst problem is the correction of the terrain effect. It needs an estimate of the amount of material present above and absent below an assumed flat surface through the measuring station. Density estimates are also required. Each measuring station which might have to be at 1 metre centres needs to be levelled to within a few centimetres and quiet conditions are necessary.

A bad site with variable topography and variable near surface densities might produce 25-80 microgals of difficult to reduce error. This level of noise may swamp the anomaly caused by a cavity of 2 metre diameter at 2 to 3 metre depth.

3.3 Magnetic

This involves the measurement of local variations in the magnetic field of the earth caused by local differences in magnetisation of the subsurface. A proton precession magnetometer is normally used these days. The instrument depends on the measurement of the free precession frequency of the protons which have originally been polarised in a direction approximately normal to the direction of the earths field.

For cavity detection, the void has to be filled with a magnetised material. The great advantage is that it is quick and easy, but not generally applicable to our problems.

CONCLUSIONS

Table 2 shows the conclusions of the Working Party as to the location of solution voids in limestone.

Electromagnetic traversing seems the best method and it is also fast and easy. Other methods also have some merit in certain circumstances. As we have a number of test sites available as many methods as possible should be tried.

TABLE 2

LOCATION OF SOLUTION VOIDS IN LIMESTONE

TYPE CAVE	SIZE/DEPTH DEPTH/DIAMETER	RECOMMENDED METHOD
(cylinder)	<2:1, <30m depth	E M TRAVERSING
	<30m depth	CROSSHOLE SHOOTING
CAVERN (sphere)	>1, <10m cover	E R or E M TRAVERSING
		RADAR
	>1, >10m cover	GRAVITY
		CROSSHOLE SHOOTING
SAND FILLED	<5m depth	RADAR
CLAY FILLED	<2.1. <30m depth	E M TRAVERSING
		MAGNETIC

Universities are always looking for MSc projects and I think a number would be interested in helping us evaluate geophysical methods for locating our cavities.

Colin Fairburn

BIBLIOGRAPHY

Applied Geophysics by W M Telford *et al.*

Quarterly Journal of Engineering Geology. 1988, Vol 21. pp 207-271. Report by the Geological Society Engineering Group Working Party.

Detection of abandoned coal mine workings and underground voids by microgravity. D Beiller. Mining Engineering. April 1989 pp 245-247.

High Resolution Sounding using Ground Probing Radar. J L Davis & A P Annan. Geoscience Canada. Vol 13, No 3, September 1989.

Examples of Geolectric Surveys. 1959, L S Palmer, Vol 6, Part A, Proceedings of the Institution of Electrical Engineers.

DISCUSSION

K.B. Do you need boreholes or could you use adjoining cave passages or quarry faces for seismic tomography?

C.F. The geophones would have to be attached to the cave passage or quarry face but the technique could be used. Specialised software for computer processing would be required for topography.

B.R. Up to what distances can electrodes be separated for resistivity measurenments?

C.F. I'm not an expert on this but there are various configurations of electrodes used with separations out to about 100 metres.

C.J. Would you use resistivity to confirm your digging rather than looking for new sites?

C.F. No, the method has been used to look at large cavities in the past such as Lamb Leer in 1938 but it can be used for ground traversing. The problem is that to find small voids the measuring positions need to be closely spaced. Detailed surveying of a digging site is probably more reliable than ground traversing for small cavities.

Unknown. You mention depth limitations for resistivity, can you look down to depth of 100 metres?

C.F. Yes, if the cavity was large enough.

N.G. On the electromagnetic side there's the "active" method that you were describing but there are also "passive" systems using VLF transmissions. The Americans and Russians have enormous transmitters for submarine navigation. A friend at Camborne School of Mines suggests we could use this making measurements at a walking pace. The equipment has been developed for commercial use and is available now.

R.S. Another parameter which, if we could measure it, might indicate the presence of caves is the variation of electric field gradient above the ground. Normally, this has a value of about 300 volts/metre. To measure it you need a special type of voltmeter which doesn't draw any current. This is a very difficult thing to measure. Caves are said to emit air which is ionized. This ought to modify the electric field gradient and could provide an indication of cavernous limestone.

GEOPHYSICAL GROUP RECOMMENDATIONS

Resistivity — Stuart France has read the papers and reckons that using today's technology for the equipment described by 'Palmer' it could be built for a few tens of pounds.

E-M Traversing — Obtain a trial hopefully using equipment from a University or BGS.

VLF Tellurics — Obtain more knowledge of the method from Camborne School of Mines and BGS Look at the possibility of building our own equipment.

Magnetometer — Bob Saunders to try out a magnetometer around Pant Mawr pot.

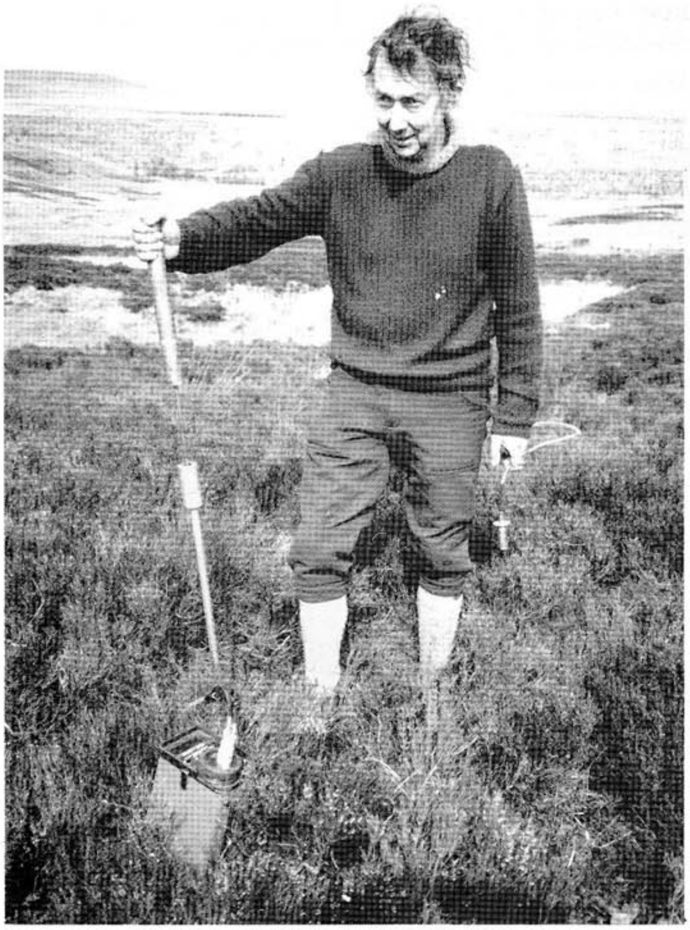
Gravity — A trial survey with BGS gravimeter around Pant Mawr.

Radar __ We look for a trial using either BGS or Cambridge consultants' equipment and perhaps British Coal.It was thought that Universities may be interested in MSc or Honours projects to help investigate the different methods considered.

Gas Geochemistry as a Means of Locating Near Surface Cavities (a brief review)

The gases occupying the pore spaces of soils have a composition which is usually markedly different from that of the atmosphere. Usually the soil gas has a higher carbon dioxide content and a complementary lower oxygen level. Other gaseous compounds which are often higher in the soil gas phase include radon, methane and other light hydrocarbons (C1-C5), various organo-sulphur compounds, helium and a host of other gases and volatile compounds at trace and ultra-trace level. The presence of a ventilated cavity near to the soil will tend to perturb the content of these compounds, which will tend to a composition more like that of the atmosphere. Therefore soils which would normally contain a few percent of carbon dioxide would have the concentration reduced towards the 0.03% level typically found in the atmosphere, where as oxygen would increase towards the 20.7% usually found in the air.

Traditionally soil gas geochemical methods have been applied to the detection of buried mineral deposits. However more recently, attempts at locating mined galleries and shafts in a variety of rock-types have been made and although not totally successful are sufficiently so that further work can be recommended. For further reading see Sibley and Grainger (1988a,b).



Pant Maur: Keith Ball sampling for Radon.

Photo by Colin Fairburn

Peachley et al. (1985) have however shown that other near surface features, and even land usage can have a profound effect on the composition of soil gases and therefore great care must be taken in the location of sampling points, so that like would be compared with like. For example soils under tree cover can give substantially lower carbon dioxide levels than under grassland, and soils underlain by different compositions of glacial drift may give different concentrations of a wide variety of gases. These authors have carried out tests in the Penwyllt area and showed that typically the ranges of carbon dioxide in soils (at the time of the experiment) were 0.0-0.3% for soils over limestone and thin (<0.5m) drift; 0.4-1.0% over thick Old Red Sanstone derived Glacial Drift; and 0.0-0.6% over Basal Grit Drift. Quite naturally other near surface features may present different soil types and patterns referable to e.g. dolines, shafts etc., but these may in any case be appropriate targets.

A novel approach has been described by Gregory and Durrance (1985) who injected helium into a cave passage at Buckfastleigh (Devon) and were able to map out the distribution of the helium some time later in soils overlying the known and possible cave passages. They concluded that the helium distribution revealed the presence of a boulder choke and infilled shaft that formerly connected the cave to the surface.

Of the gases the most practicable to determine are carbon dioxide and oxygen, and maybe radon although the latter requires specialised equipment. Both carbon dioxide and oxygen may be determined quickly and accurately using simple volumetric equipment. The Orsat Stack-gas Analyser is particularly appropriate as it is cheap, sufficiently sensitive, portable, and free of electronics. Ball et al. (1983) describe the use of this equipment in the search for buried mineral deposits and describe the construction of a suitable probe to extract the soil gases from a suitable depth.

T K Ball

C.J. What about radon and this device?

K.B. Well radon we have already dealt with and I haven't thought more on that.

C.J. OK, there are a lot of things there. Could you make a plan of action of that and are there enough people around to do the things?

K.B. Yes we have already figured the number of people to find some more data on this. I think that obviously in the New Year we will need to have a test area, and clearly for ionised air we would need to look at cave entrances first of all to see whether it is simply a function of the cave entrance rather than the cave air. That is important.

C.J. Are you prepared to lead the group and keep it going and get more people into it?

K.B. Yes, sure.

Chemical Group Discussion

CHEMICAL GROUP THOUGHTS AND RECOMMENDATIONS

K.B. We roughly divided the problems into three groups apart from what has already been spoken about. We have decided we would look firstly at intrinsic gases. Those are the ones that are in caves already or could reasonably be expected to dilute what was in the soils. Apart from carbon dioxide, oxygen and radon levels, we have come up with the possibility of detecting the ionisation of air associated with caves. Cross fertilisation with the Geophysical group resulted in the suggestion that probably there is an ionisation detection of the kind used in gas and liquid chromatographs which might be useful. The method of approach would be to try one of the ionisers that are available and then simply work on methods of detecting indoors firstly and then to experiment in cave entrances after that. Moisture in cave air might be a useful perameter to go for and in my experience the best way of detecting moisture in gases, initially at least, would be to use instruments like Draeger tubes, which are specifically designed for the detection of moistures in gases, in fairly dry passages. Finally we came down to animal sniffing but we couldn't really think of any animals that could sniff out caves.

Secondly methods of injection: here we either put things in to cave atmosphere and then try and detect them from the surface or put them into potential input areas and attempt detection from inside the cave. We like the idea of pheromones. Fungus spores can be taken to the stage where they can be detected using a microscope. This doesn't involve any growing or culturing, simply look at the spores.

Finally there were the light gases. Another one which came apart from helium and methane which we have already dismissed was hydrogen, a nice active one again, but very low toxicity. This is very important we feel. One should be able to detect it using an ionisation detector. We cast around for other things and the possibility of using pHs which are easily determined in the field, simply to detect different soil types, which may relate to drift filled holes was suggested. Then we went wild and thought between us that there are such things as drills which use air pressure. These are rotary percussion drills. In the centre of the stem the chippings are blown out using compressed air. If on drilling these chippings stop coming out it might appear that that one has found a hole. We will just leave it at that. That is fairly costly, most of the others I think could be done readily enough.

C.J. May I start the discussion by saying that Charles George wanted to take this approach many years ago when we were looking for Ffynnon Ddu 2. He was not as sophisticated as Keith. His idea was to burn kippers on Ffynnon Ddu 1, as an in draught. Then he intended to have the hounds from the local hunt seek out the smells.

J.R. I'd like to make a comment. The way that we know that we we're digging in the right spot for Ffynnon Ddu 2 was that the underground party let off a bang and we first of all felt it. I had a pick and removed some subsoil and smoke and smell came out.

C.J. It may be worth talking to one of the companies who produce pheromones. They may recommend a pheromone and an insect, which is easy to handle, as a means of cave detection.

K.B. Perhaps we should talk to Mick Day as well on this one.

Plant Species as Indicators of Caves

INCREASED SURFACE DRAINAGE

A shallow cave system may exert an influence on surface plant growth through improved surface drainage. On acidic soil this would favour the growth of heather dominated vegetation or in heavily sheep grazed areas, dry sheeps fescue-common bent grassland. On calcareous soils species rich grasslands with abundant thyme, eyebright, sheeps fescue etc. might form. Such communities are, however, very common on shallow soils over solid rock and on natural screes and are unlikely to prove useful as indicators.

ALTERED AIR MOVEMENTS AND COMPOSITION IN FISSURED AREAS TO AND FROM CAVE SYSTEMS

Many plants respond to changes in temperature and humidity. Air leaking from caves in the winter is likely to warm and moisten plants. A number of liverwort and moss species are known to be susceptible to low winter temperatures and dry conditions. These are described as Atlantic species (Radcliffe D A 1968), since they are confined in the main to the western seaboard of Europe, where winters are relatively mild and humid. Block screes in dolines with an abundance of species such as *Scapania gracilis* may be worth further investigation, as too may be sites for the hay scented fern (*Dryopteris aemula*). The liverwort Jubula hutchinsiae is very frost sensitive and in Mid Wales is confined to springs which never freeze, even in the most severe winter. Clearly such water has to rise from great depth and though at present this liverwort is only known from a handful of Mid Wales sites, where none are likely to be associated with caves, it may yet prove useful.

Less is known of the tolerance of many other species. It is, however, recognised that many species with their headquarters in the Mediterranean achieve their greatest penetration north and westward in Britain on limestone. Some are ever more confined to the coast as you travel northwards, suggesting an intolerance of low winter temperatures, e.g. gromwell (*Lithospermum officinale*), wild madder (*Rubia peregrina*) and ivy broomrape (*Orobanche hederea*). Unexpected inland populations may be worth investigation.

A number of widespread species such as bracken (*Pteridium aquilinum*) and lady fern (*Athyrium filix-femina*) are sensitive to late spring frosts. In a year providing such conditions the gentle upwelling of warm air from caves may protect the plants from frost damage.

Alteration in carbon dioxide levels in air passing through caves may affect plants, (Woodward F I, 1988). Annuals in particular are known to respond to increased carbon dioxide by producing fewer breathing pores or stomata. If air exiting from fissures in the winter is richer in carbon dioxide than normal atmospheric air this may be reflected in fewer stomata in the leaves of biennials or winter annuals such as bitter cress (*Cardamine flexuosa*), herb robert (*Geranium robertianum*) or rockcress (*Arabis hirsuta*) growing in dolines.

Amelioration of acidic precipitaion from mists, rain and dry impaction may be expected in sheltered dolines. This effect may be enhanced if the hollow is regularly flooded with air naturally scrubbed of NOx, SOx etc. by its passage through a cave. Sensitive species such as lichens may reflect these less polluted conditions. Species of rock tripe (Umbillicaria) survive in a few dolines on Mynydd Llangynidr. Their presence here was previously attributed to the dolines providing a refuge from moorland fires. This may not be the whole story.

R G Woods

REFERENCES

Ratcliffe, D A (1969) An ecological account of Atlantic bryophytes in the British Isles. New Phytologist 67, 365-439

Woodward, F I (1988) The response of stomata to changes in atmospheric levels of carbon dioxide. Plants Today 1, 132-135.

Perring, F H and Walters, S M (eds.)(1976) Atlas of the British Flora. E P Publishing, Wakefield.

Photo by Clive Jones

The biology group find the right ferns at Engine House Dig.

Biological Methods

My first response to being asked to do this was, "Oh good God". I couldn't begin to imagine what one would say. Then I thought it would be a good academic exercise. I'll ask a few people. They all looked at me as if I was daft when I asked various questions. When you come to think about it really, to use the plants and animals is just one step again removed from the cave passageways and the way they influence the physical environment because, after all, the plants and the animals are only going to be responding to the gases we have already been told about, the drainage and the mineral composition. So they have really got to be very good at picking up these parameters if they are going to be useful at all, otherwise it is going to be a real fag for example trying to determine the amount of carbon dioxide through the plant. It's obviously much easier to measure directly. So you can see there are big problems. If you use animals, for example like bats and species of moths which regularly hibernate in holes, I suspect we are a damn sight better at spoting the holes than they are so they are not going to tell us much about holes we know nothing about, but I will come onto that at the end anyway. Let's have a look at the shape of the problem. I am very much an amateur in all these areas. We know from the archaeologists that you can use plants to spot disturbances in the ground. Differences in soil structure form crop marks. They have known about them for years. Where you have a nice even crop of wheat and somebody has dug a hole a thousand years ago, chances are, given the right conditions you can still spot the hole that was dug because slight changes in soil drainage or nutrients status are revealed in the degree of colouration of the crop. Unfortunately few known caves lie under even field crops. Most are in semi-wild places and you soon realise this is a non-starter because of the tremendous effect of the variations of topography on the natural vegetation. You are never going to spot, I don't think, even in a clump of bracken, the likelihood of even a shallow cave passageway underneath the ground — principally because of the differences of soil depth in this sort of terrain. You would have to grind the whole place down fairly smooth with even soil depth, sow it down with all one species of plant and you then might be able to pick out where the caves are. I think you know it is a bit of a non-starter even for caves like Little Neath, where you have got a fair number of fields which are agriculturally approved.

I have had a look at the air photographs which we have got of this area and there is absolutely no trace of anything in the fields to pick out these caves as they pass through this agricultural area. There is a fairly uniform green looking field. If there were to be a response then the supposition is that you might find plants which enjoy slightly drier conditions than normal — an advantage to mountain cats-ear, the little mouse-eared hawkweed, thyme or any grasses which tolerate dry conditions. They may pick out areas where there is increased drainage due to the close proximity of cave passageways under the surface. So what are we left with. Well the sorts of processes that were described by Keith, our last speaker, the differences in carbon dioxide levels or oxygen levels emenating from cave systems. These might be picked up by plants in, for example, a big doline like this one on the edge of Pant Mawr. If there is a large cave system in the particular case, and I don't think we know of any cave systems associated, but maybe if there were a cave systems which was venting through the bottom and the sides of the dolines, then changes in carbon dioxide levels, humidity or temperature might be reflected in the floor to some extent. So what are the sort of species we should be looking for? There is a range of lower plant species, mosses and liverworts in particular, which are called Atlantic species which are fairly sensitive to winter cold. They are confined to the western seaboard of Europe. There are about 60 — 80 of them. Typically they are found in places like the Canaries, the Pacific islands and so on, but in this country they survive up the west coast where there are rarely ever any frosts. With air venting out of cave systems in the winter it tends to be warmer than surrounding areas and if it was sufficiently warm to prevent frost formation in amongst the boulders then you might expect to find species like this liverwort, occuring in amongst those boulder fields. It might occur east in Wales, more so than you would normally expect to find it. The liverwort *Scapania gracilis* is about the only Atlantic species which I think you are likely to find in Mid Brecknock, for example, because all the other species are even more sensitive and tend to occur further west and there are no records this far east than Wales. Another very sensitive one is this leafy liverwort Jubula hytchinsiae which appears, as far as I am aware, to be confined to strong springs in valley bottoms, which clearly never freeze. This plant cannot tolerate freezing at all. It probably colonised the country and was fairly wide spread during the Atlantic period when we know the climate was milder and wetter and has since retreated back so that it now survives in resurgences from deep water bodies which even in the winters of 1947 and 1963 never froze. Again I suspect that this is, in the main, of a great deal of interest because it is much easier to stick a thermometer down rather than worry how you are going to identify a liverwort. But nevertheless we know of a number of sites for this particular species, though none immediately I suspect will warrant further investigation because I cannot think of any on or close to the limestone; they all are on the Old Red Sandstone. As far as the higher plants are concerned there are a few species which mostly occur around the Mediterranean but which creep round the southern coasts of Wales. We don't really know why, we think it might be winter cold. It doesn't seem to be actual frost, it may well be day degrees of warmth. They need to have a growing season of a certain length in order to survive and flower. The ivy broomwade is one of them. It is suspected that where it occurs inland on limestone, big concentrations of it might indicate airways which may tend to be a bit warmer than others and as a result could indicate caves. One of the most common plants which is frost sensitive is the bracken and a picture taken in June of this year not far from my house in North Brecknock, where we have had some wicked late frosts, looks like an autumn shot but is in fact a shot taken about three or four weeks after the fronds had emerged. Bracken rarely colonises the hill tops because of its susceptability to frost. Again the sheltered dolines which support interesting isolated populations of bracken might be worth looking at with a temperature probe just to see if there is a significant temperature difference. There is another quite common fern which is also frost sensitive, the lady fern. I grow a range of these because there are a lot of interesting garden forms which the Victorians collected in the wild. Every year they get blitzed by late frosts. But looking amongst boulders, screen etc. you might find a find a high altitude population. There is another fern called the hay scented fern which looks not unlike this but instead of the fronds each curving down at the edges it tends to curve up at the edges. It is called hay scented fern because it does smell of hay but only when you have it in a herbarian press for a couple of years. The furthest site that we have got in Wales is around the entrances to the Dolaucothi gold mines. It is an easy fern to overlook especially if you are not anticipating finding it, but it is another species which might just be encouraged to grow due to a warmth from cave systems.

The other response which has recently come to the forefront in the botanical world is response to carbon dioxide levels. We are also interested in the Greenhouse Effect clearly and in looking for ways to try and assess past concentrations of carbon dioxide. It's proved quite interesting to look at herbarium specimens of plants collected 200 years ago and compare the number of stomata - breathing holes, in the leaves with that same species of plants grown today. As the carbon dioxide levels go up it is known in the main that plants respond by producing fewer stomata. They don't need the same number because obviously they get more carbon dioxide in, in a smaller area of holes in the leaves. For most of the perennial plants it looks like we have reached saturated level with carbon dioxide. If you increase the carbon dioxide levels any more then they don't seem to respond by producing extra stomata. But annual plants still seem to be responding, so I think if you were to consider that these cave systems vent from the inside out during the winter months you have obviously got to look for a group of annual plants which tend to develop during the winter months. I suspect there is a small group of winter annuals which it might be worth looking at. The herb robert is one of them. There is a hairy rock cress and some of the other cresses — bitter cress etc. They develop leaf rosettes over the winter, flower in the summer months, die off in the height of the summer drought, set the seed and the seed grows in the autumn. So you have got these plants growing through the winter and by looking at the number of stomata on them you may get some impression as to whether the carbon dioxide levels have been elevated or reduced. The suspicion is that it reduces in air flowing through a cave system. But then again it might be a lot easier to actually measure the carbon dioxide. However if it is a variable then the plants sitting there day and night might better reflect extreme levels which otherwise might have been expensive and time consuming to detect. Getting into even greater heights of fantasy now — rock tripe is a lichen species. Look at the distribution maps of rock tripe species and they are common through Scotland and the north of England into North Wales and then there is a big gap in Mid Wales. And then they turn up again in Exmoor and Dartmoor. I have been searching for these damn things in Mid Wales and I finally found one or two populations. They all seem to be surviving in hollows in big boulder fields. For a long while I suspected it might be because of wide spread fires in the past in this part of the world. They are very sensitive to fires. They easily get burnt off. They seem to be very poor colonisers and past atmospheric pollution almost certainly has taken its toll. Even today I suspect that the levels of sulphur dioxide might be too high in parts of Mid Wales for these things to survive. But having said that we have one or two isolated populations sitting in the bottom of dolines. It's rather interesting to suspect that it's winter levels of sulphur dioxide which in the main seem to cause the problems and if they are receiving air which has passed through cave systems it may have sulphur dioxide scrubbed out of it. Also solid particles would be removed. We find now that the lichens in some of the FC trials using open top air chambers from which pollutants have been scrubbed are surviving remarkably well in areas where hardly any species of lichens survive at all. So it may well be that cave systems could be acting as scrubbers by permitting the growth of these species. Having said that I'm going to get a little bit narked if every population of my rock track suddenly has a bunch of cavers descending on it, digging a great hole in the bottom there, so I think I might be a bit reluctant to reveal where these are. That's about the long and short of the plant side.

The animal side. Well you all now are aware of caves and hibernating bats. I suppose the lesser horseshoe bat offers about the best scope. Greater and lesser horseshoe bats can easily be detected using bat detectors. But I think its very unlikely that they are using caves that we're totally unaware of. They tend to use very large entrance holes — large enough for us to crawl in. I don't think we know of any caves, the entrances of which have had to be seriously dug which supported at the time a lot of bats. But then the trouble is of course they could well be using the systems we know nothing about or do not even suspect. But we are now in a position where we know enough, I think, about bat numbers to know that there aren't probably large numbers of lesser horseshoe bats which aren't accounted for. Well having said that we shall have to see the results of some of the recent ringing work. Other bats such as Daubenton's certainly make use of small crevices. There is one case of a bat watcher just standing on a roadside bank and a bat flew past him and just disappeared down a rabbit hole beside him. We never really suspected that they used rabbit holes. So quite clearly the bats may be making use of voids underground that we haven't suspected, though they may be very small voids and I suspect that following bats is not going to be the answer. Nor is following moths such as the herald moth or tissue moth which regularly hibernate down caves, even if there were a technique to follow and locate them. That's all I have been able to come up with on the biological side. Not a great deal but one or two ideas perhaps.

Ray Woods

DISCUSSION

C.J. Thank you very much. May I make two comments. The first concerns the fern you've mentioned. I have noticed them in certain holes in the Dan-yr-Ogof dry valley. The second is that the rising in front of Porth-yr-Ogof has a great deal of lush vegetation which I've not seen anywhere else in the Neath Valley.

R.W. What I need to know is whether we can identify a number of holes which we know are connected up to cave systems. Then I can have a poke down them and identify the plants. That's the big problem at the moment — the experimental conditions.

J.R. From the dry summer we've just had, do you expect to see moisture stress in uniform areas of vegetation where those happen to be above an infilled cave entrance?

R.W. I think you possibly might but I think the problem is likely to be differential, that they are likely to show it first, and then gradually all the turf would turn dry. That's really the zone that effects the plants in terms of the hole in the soil or the rock. But it may well be that they are influenced first. On the other hand you could argue that maybe dew formation at night, by drawing more air through may make them more moist. The one thing with ventilating Dan-yr-Ogof which we were worried about was that formations might dry out. But in fact the reverse happened and it got wetter through the summer because it's much cooler down in there and there was condensation by air being pushed through the system.

J.R. There is likely to be a difference one way or the other, whether you can detect it or not is another matter.

R.W. And whether the natural year on year variations will hide most things. It only needs one hard winter to wipe out all those frost sensitive species I have been talking about as they are all sensitive to temperature. That might well override all these other factors created by caves.

C.J. I'm not so sure, because the harder the winter the stronger the draught is.

A.W. You were talking about really positive biological signs i.e. cave plants you associate with caves. Is there any possibility that there is going to be certain plants that you are not going to get near caves but generally widespread over the area?

R.W. Again the only influence I can foresee would be this drought effect, but in limestone areas just the depth of soil really tends to affect the distribution. If the soils are uniform then it might be possible to detect caves. The soils are so variable in thickness that any cave effect is likely to be masked.

Remote Sensing, GIS and DTM's for Cave Studies

INTRODUCTION

Most of the techniques discussed in this workshop are concerned with measuring and observing from a distance, but these days remote sensing is generally taken to mean the use of scanners operating in the visible and infra-red parts of the electromagnetic spectrum, and carried in platforms at some height above the earth's surface. Most remote sensing is done from orbiting satellites, but data from airborne platforms would probably be of more value in cave studies.

An extremely important product of the growth in remote sensing has been the development of data management systems known as Geo-Information Systems, which organise many types of data as well as remotely sensed data, and facillitate a wide range of analyses. One layer of data that is present in almost every GIS is concerned with the topography of the earth's surface and is known as a Digital Terrain Model.

REMOTE SENSING

Scanning instruments are carried on a variety of orbiting and geo-stationary satellites. They work in visible light, infra-red and the thermal infra-red regions. They are not cameras, but the digital information they collect can be processed to give pictures of the earth's surface which can be interpreted by non-specialists. Alternatively, the digital data can be interpreted directly, which is a more powerful technique, and is the most efficient way of obtaining the numerical information needed in environmental studies.

Various families of satellites are in orbit, from 900km to 3500km altitude, giving a wide range of precision (resolution) and size of image. The lower satellites (higher resolution) pass over the same point on the ground many times a year, but because of the frequent occurrence of cloud and haze, the number of useful images is reduced to just a few a year. Nevertheless, sufficient images of South Wales have been collected to allow you to monitor changes occurring at any location over a period of time. Studies of cave systems and their associated surface environment would require the use of the finest resolution scanners e.g those carried on the SPOT and Landsat 5 satellites from which relatively few images of South Wales have been acquired to date.

Imagery can also be acquired from sensors carried in aircraft, giving much finer definition of ground features. This would seem to be the best option for cave studies, but the cost of commissioning flights would be very high. My recommendation would be to put up a proposal to Natural Environment Research Council for a project which acquired imagery as part of their annual airborne remote sensing campaign. Alternatively it may be possible to persuade a commercial organisation to extend a flight to include the sites of interest. Model aircraft have also been used successfully for carrying various types of camera and scanners.

ACQUIRING THE IMAGES

The most important satellites for land-based studies (Landsat, SPOT) are now organised on a commercial basis and imagery has to be bought from their archive or ordered specially. However, the Remote Sensing Unit UWCC holds an archive of imagery covering the whole of Wales on a number of dates, which could be made available for the project.

INTERPRETING THE DATA

The simplest (and cheapest) method of extracting information from a satellite image is to make a visual interpretation of a photographic product. These can be viewed just like an aerial photograph, with details being inspected and measurements being taken as part of a desk study, needing no special equipment. The choice of product is crucial though, and you would need advice to guide you in the selection of the best imagery for your particular project.

The real benefits of remote sensing emerge when the imagery is processed digitally. This is carried out interactively at a computer-based machine known as an image processor. Using the image processor, the image is firstly cleaned up and then enhanced, to bring out the features of particular interest. It is possible to bring out very subtle features in the landscape, but the processing would be done as a joint activity, with a cave expert and an image processing expert working together at the computer terminal.

Similar image processing techniques can be used for data from other sensors such as hand-held thermal imaging cameras, ground penetrating radar and so on.

CLASSIFICATION

Using numerical techniques, it is possible to create maps distinguishing, for instance, very subtle changes in vegetation species, health and vigour of vegetation, influence of soil conditions, areas of wet or dry ground, geology and so on. It is possible to overlay conventional map grids, administrative boundaries etc. to create a product tailored to your needs, which can then be printed. Preferably, image classifications should be stored in a Geo-Information System, together with a variety of other data of interest.

The usual classification procedure is based on the discrimination of surface features by virtue of their characteristic reflectance in a number of wavelengths. For a caving study these characteristics could be found using hand-held radiometers in the field, or they could be obtained from the image data itself, if suitable training locations can be identified in the image.

DIGITAL TERRAIN MODELS

Digital Terrain Models are numeric representations of the topography, which can be stored as a spatial data base, and interpreted using data base or image processing techniques. They may contain simply elevation data as a grid of spot heights (Digital Elevation Models) or they may contain elevation data stored as contour lines, along with other linear features such as roads and rivers (Digital Terrain Models).

They may be analysed to give lengths and areas of features, and estimates of topographic parameters such as elevation, slope, aspect, curvature, ruggedness etc. They can form the basis for Geo-Information Systems and numeric models of many environmental processes. The Remote Sensing Unit leases DEM's of most of South Wales from the Ordnance Survey, and could make them available for the project.

GEO-INFORMATION SYSTEMS

Geo-information systems are computer-based data management systems containing a wide variety of environmental or geographic data, all organised on a spatial basis. In addition to providing a conventional data analysis they are linked to image processing systems which enable users to interpret their data visually and to prepare results in the form of maps and diagrams. Current trends are for numerical models of the environment to be based on GIS.

They are data bases in which data are organised to maintain their correct spacial relationships. Data may be quantitative, e.g. environmental factors such as topography and climate, or they may be numeric codes for attributes, such as the type of vegetation. Information may be stored in respect of points, lines or areas. A cave for instance could be represented as a series of National Grid coordinates, with an elevation value for the roof and floor of the cave at each point and a value to represent its width, together with an attribute to say whether or not it was carrying a stream at that point.

Analyses that may be carried out include arithmetic operations (e.g. calculating the gradient of the ground surface) or spatial (e.g. drawing cross-sections) or logical (e.g. finding which areas have a certain vegetation cover and are also within 100 metres of a cave passage).

GIS provide an ideal way in which to store all of the data from surface and underground surveys, and from existing maps. Simply assembling all of the available data into one data base will prove beneficial, but the greatest benefits will come from variety of analyses that will then be possible, and the ease in which they can be carried out. I strongly recommend the setting up of a GIS for the study as soon as possible.

CONCLUSIONS

Remotely sensed data from satellites are available, and may provide data of interest to cave studies if the spatial resolution is sufficiently fine. Data from airborne scanners are likely to be more useful, but would have to be specially acquired.

The project will yield large quantities of data, of many different types and formats. It is strongly recommended that the data are assembled in a Geo-Information System, based on a Digital Elevation Model of the study area, which will permit a wide range of spatial analyses to be made. Facillities for handling, displaying and analysing data using image processors and Geo-Information Systems are available from the Remote Sensing Unit of the University of Wales College of Cardiff, which can also provide imagery and the digital elevation data.

Robert Drayton, University Wales College of Cardiff.

DISCUSSION

The discussion opened on the question of processing remotely-sensed images to detect temperature differences, for example warm air emerging from shakeholes and crevices on high ground in winter. The required spatial resolution rules out the use of satellites (which are too far away); an aircraft equipped with a thermal scanner would be more appropriate. A cheaper alternative, that could more easily allow comparison of results obtained over a period of time, is to use a thermal imaging camera to look along the surface and to detect plumes of emerging warm air; in this case reference markers need to be placed on the ground to allow accurate positioning and hence easier comparison, and other processing, of successive images.

Detecting these relatively small differences from ambient temperature requires equipment that responds to the 'far' infra-red. Such equipment is expensive and is inherently poor in terms of spatial resolution. Could we use something to magnify the effect of the temperature difference? Green foliage, including grass, responds to stress in ways that alter its reflective properties in the 'near' infra-red. This is a region of the spectrum to which infra-red photographic film can respond. Plant stress that can alter the infra-red reflectance can result from insufficient water, or from low temperature; even relatively small changes in temperature or soil moisture lead to changes in reflectance. A conventional camera and infra-red film (probably false-colour infra-red film) may be able to record such changes, which are then detected by image processing techniques applied to the transparencies. The camera could be mounted in an aircraft or could even be used from one hillside to photograph another.

Problems could arise where there is considerable diversity of plant species in the area of interest. In this case a possible refinement would be to apply image processing to sequential photography of a given area. This may show, for example, areas in which a given species appears less early than in others, or perhaps suffers moisture stress earlier or later than in the surrounding area. Factors that can confuse the results include disturbance of the ground by man, even in the distant past, and the activities of sheep. It was suggested that to investigate the effectiveness of infra-red photography and subsequent image processing, we should apply it to a known site.

The discussion then turned to the use of spatial databases as a means of processing and correlating various different forms of information about an area of interest. A spatial database can be thought of as an 'image' of an area of ground, except that instead of being made up of various levels of light intensity as in a conventional image, the image is made up of different information such as: the height of the ground, its temperature, its moisture content, its geology, type of vegetation, sheep population, and so on. Each type of information forms an 'image' of the area of ground that can be viewed with, and processed by, an image processor in just the way that it processes conventional optical images. As Rob Drayton indicated in his talk and demonstration, the image processor is able to combine and correlate multiple images. It is possible, therefore, to look for correlations between surface features and all other available information about an area of ground; this could include the survey of any known caves and the results from geophysical surveys (with impulse radar, resistivity, etc.).

It was suggested that an application be made for the NERC (Natural Environment Research Council) aircraft to overfly our area of interest at a fairly low level to produce a videotape of the surface features. This tape could be fed to the image processor for correlation with other available information, as described previously. A low level flight could also carry thermal imaging and near infra-red cameras. It was pointed out that model aircraft were often used for similar purposes.

Clive concluded that all these techniques could be combined to produce a pair of cave-detecting spectacles.

Jem Rowland

Dowsing

Dowsing is an ancient art, much older than any technique which has been described here today. Unfortunately I do not have the benefit that other speakers have had as the effects they describe can be backed up by science. The most I can do is to describe various methods of dowsing, then ask you to relate any of your experiences of it to see if we can put together a series of experiments to prove if it has any real value or whether it is hocus pocus. There is no way we can, at this stage, devise experiments to explain the phenomenon if it works.

There appear to be three kinds of equipment for dowsing.

These are sticks, wires and pendulums. The sticks are usually hazel and two configurations are used at the club. Some people use a Y section of hazel cut from a tree. This is what most traditional dowsers use. Others take two bits of straight hazel and tie them together at one end to make a V. Purists in SWCC swear that the tie must be old detonator wire. In both cases (Y and V) the sticks are held in the palm of the hands. Tension is put into them using thumbs and fingers. When the dowser passes over what he or she is looking for the sticks react. They either jump up and down or they move up at the start of a passage and down when the passsage is crossed. Some dowsers interpret the reactions in other ways. They reckon that the distance between the two reactions is a function of the depth of what they have detected.

Hendy de France in his book on dowsing claims that there are four reactions on detecting underground streams. The two inner reactions are directly over the stream and represent its width. The two outer reactions are used to determine depth. Half the distance between the two outer reactions is an indication of depth.

The method I prefer is the wire method. This is probably the easiest to use. In this two pieces of this pipe of wire are bent into right angles. Each of these detectors is now held loosely in a fist so that one part is in the fist and the part at 90o points horizontally forward. They must be held so that they can swing. This is best done with bent arms. You now walk forward trying to keep the wires or tubes parallel and pointing forward. Walk fairly slowly and when you come to be over cave passage they will cross and when you leave the passage they will uncross. I find copper pipe the best material for this form of dowsing.

In both the sticks and wire methods I have described a traversing technique. The passage is crossed and reactions are obtained at the edges. Some dowsers are then capable of following these edges and tracing passages along their length.

The pendulum method is new to me as I've only seen it in a book. The pendulum dowsers claim to be able to detect anything to which they set their minds. The pendulum rotates anti-clockwise when over the lode and clockwise when it is not. Some of the pendulum proponents use it to test the quality of food and even to diagnose ailments. They claim to be able to find minerals by dowsing maps.

There are innumerable tales of dowsing successes but as yet no real evidence of caves being discovered as a result of this art. Two projects are underway in the club to try to prove or disprove the use of dowsing for finding caves. The first is the grid, set up by Stuart France, over Pant Mawr. Any dowser can obtain a copy of the grid from the club and then mark in his or her deductions as to the whereabouts of the cave.

The second experiment is a dig near Waun-Fignen Felin. At least 3 people have dowsed a cave going from the west side of the bog towards Sinc-y-Giedd. In what was thought to be the dowsed passage there were a number of very small depressions. One of them near the passage edge was chosen for a dig. We've gone down about 10 feet. The east side of the dig is solid rock and the rest is large slabs of solid which seem to have broken up as if collapsing into a hole lower down. Time will tell — if we can get enough people to help us dig it.

The cavers in the Forest of Dean are keen on dowsing and they also work with a local dowser. Apparently people at Chepstow Race Course were attempting to locate water. One possibility was Otter Hole water and this they failed to find, even after a radio location. The dowser located the water, recommended a site to drill and she was correct to within 10 feet.

Malcolm Herbert

DOWSING DISCUSSION

A.W. Has Stuart France deduced anything so far from the Pant Mawr experiment?

C.J. The results are more interesting than we thought they would be. It would be wrong to reveal results at this stage as we require a lot more people to dowse the grid.

M.H. The intersting thing about dowsing is that a lot of us seem to get exactly the same results in the same place. Both Clive and I dowsed the same passages out of the sink in the fault at Waun Fignen Felin without having seen each others results.

C.J. Is this bulls eye or bullshit?

N.G. Despite all the hilarity about this dowsing I once saw a real live demonstration of it in Cornwall. The house I was staying in had a gas leak in the garden. The gas board turned up in their Land Rover. Two old guys got out and one of them had a pair of dowsing rods. He wandered around the garden, located the leak, dug a hole and there it was. I spoke to this guy afterwards and he asked me to put coins in the flower beds, all over the place. He found every one of them. You then start to believe.

M.H. Some people have traced the drains at the club.

N.G. Yes, but their location is known.

C.F. I've traced water pipes for companies. We used to mend the club water supply by finding the pipes using dowsing. Finding cave may be another thing.

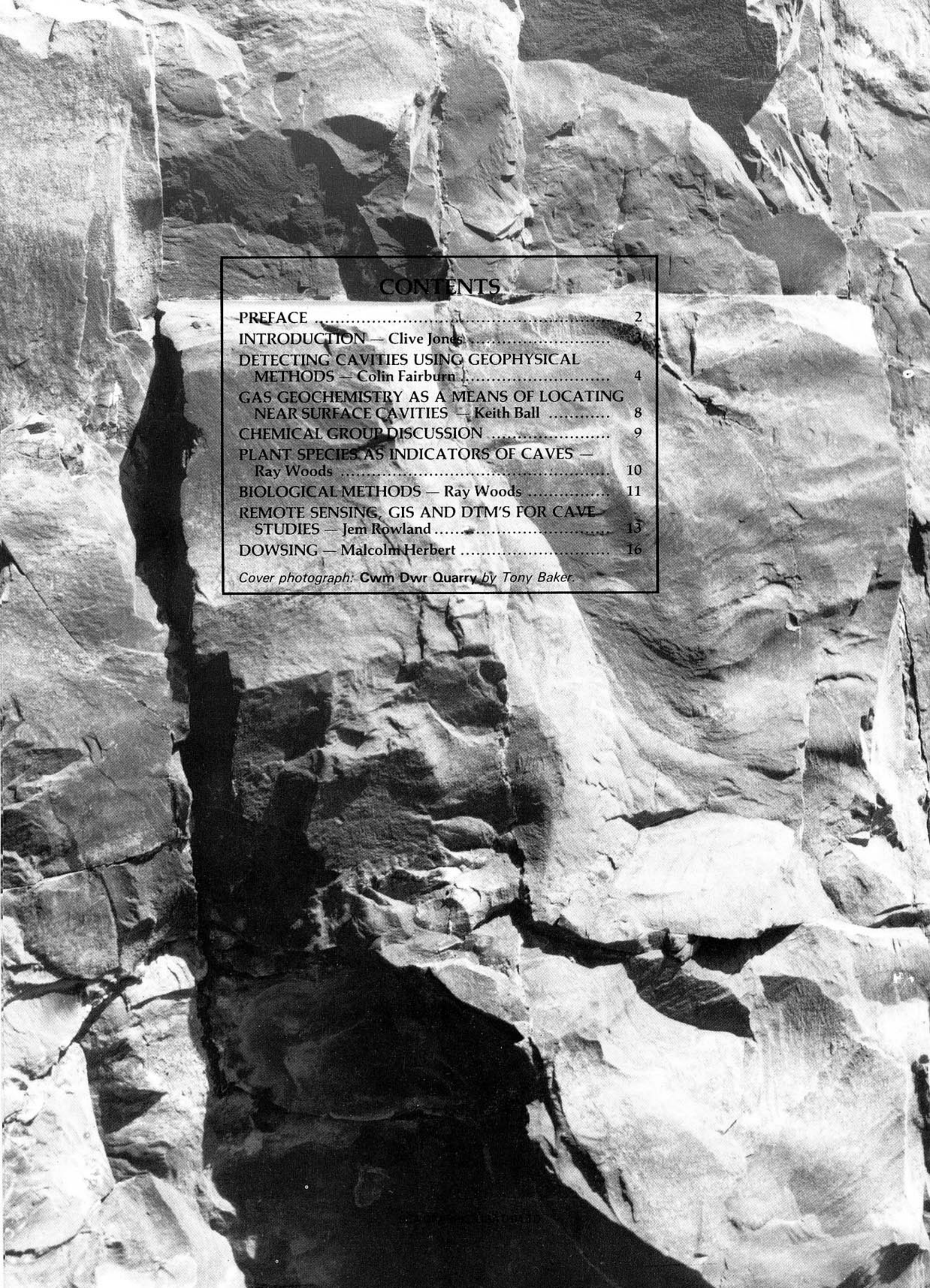
B.F. Well I worked with an outfit who paid a dowser to help them. We were working on a job where our excavator driver was an absolute maniac and he kept digging up everything. The limit came whan he dug up a cable TV line. We had now to know where everything was before we let this guy and his digger loose again. The dowser turned up and he used the copper rod technique. Instead of holding them loosely in his hand he dropped them into little cylinders. He could sort out what he was detecting by using different materials for the cylinders. He had a 75% success rate and saved us a lot of time and money.

K.B. A general comment. I used to get a large number of letters from people who called themselves dowsers. They tended to sit at maps and dangle pendulums. I used to file them under N for nutcases. They were consistantly wrong. We had things like diamonds under granite and nickel in impossible places. There were also things that may have been possible.

M.H. OK. Keith has brought us back to earth with a bump. What we must stop doing is reminiscing after a few beers and get down to some serious experimentation.

EXTRACT FROM A LETTER RECEIVED FROM ANNE BELL

We have heard it was said that in the surface location of the Otter Hole sump, dowsing succeeded where the radio location device failed. This is not true. A local dowser did locate the streamway, but she was not confident about pinpointing the sump because she felt her strength was in finding running water. The precise position for drilling the borehole was found by radio location. John Elliot placed the transmitter in the cave and took bearings and measurements to locate the centre of the sump. Andy and I were the surface party. When the borehole was drilled it did intercept the sump. This is recorded in SWCC Newsletter 101, pp 26-27 1986.



CONTENTS

Cover photograph: **Cwm Dwr Quarry** *by Tony Baker.*