CAVE QUEENSLAND

22nd Biennial Conference – Australian Speleological Federation 1999
- Taking caving in to the next Century with Fun, Unity and Fellowship -

CONFERENCE PROCEEDINGS

John Toop Zoologist - Queensland Parks & Wildlife with a *Macroderma Gigas* (Ghost Bat) of the Mt Etna Caves National Park

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INTRODUCTION

The Australian Speleological Federation 22nd Biennial Conference was held 4 - 8 January 1999 at the Yeppoon Recreation Centre in Yeppoon, Queensland and hosted by Central Queensland Speleological Society.

The main goal of the 4-day Caving Conference, being the last of the 20TH Century, was to promote fun, fellowship and unity for those with an interest in preserving the unique natural beauty and scientific values of this fascinating geological feature for future generations. It featured oral presentations, slides, videos, workshops, caving activities, pre and post Conference caving trips and displays.

The Conference presented an outstanding schedule of sessions and presenters for both the education and research of caves and its environs. It also provided an excellent networking opportunity, including exhibitors, resource providers and activities.

A major topic for discussion was the Rehabilitation of Mt Etna presented by Kim Henley of Orica Explosives and Chris White, Manager of Pacific Lime. Another highlight was the Speleo-Art Display by artists from all over the world. See this in the section of Work & Play in the Conference Photos provided by Jeanette Sands.

Numerous individuals have contributed to these proceedings and without their efforts, the Conference would not have been a success. Thank you. On a final note, a special thank you goes to the Conference Convenor, Peter Berrill, for his continued support, guidance and leadership.

Debbie Roberts
Secretary CQSS

LIST OF PARTICIPANTS

Peter Berrill	CQSS
Arthur Clarke	STC
Evalt Crabb	HCG
Jim Doyle	Qld Museum
Chris Dunne	HCG
Ken Grimes	VSA
Kim Henley	ORICA
Clive Kavanagh	CQSS
Lanah Little	CCC
June MacLucas	CESGA
Angus Macoun	RSS
Norman Poulter	SRGWA
Henry Shannon	CHC
Garry Smith	NHVSS
John Toop	DoE
Chris White	PACIFIC LIME

LIST OF ATTENDEES

Glenn Baddeley	VSA
Peter Berrill	CQSS
Dianne Berrill	CQSS
Luke Berrill	CQSS
Nathan Berrill	CQSS
Ian Binnie	MUCG
Anna Binnie	MUCG
Rebecca Binnie	MUCG
Chris Bradley	CSS/NUCC
Lisa Bradley	CSS/NUCC
Cathy Brown	CC/HCG
Arthur Clarke	STC
Eval Crabb	HCG
Joan Crabb	HCG
Dave Dicker	ISS
Lani Draheim	NSWCRS/HCG/SSS
John Dunkley	CSS
Chris Dunne	HCG
Grant Farrell	CQSS
Phil Fleming	HCG
Marie Horvath	HCG
Ken Grimes	VSA
Kerry Hamilton	CQSS/CSS
Bruce Howlett	OSS
Doug Irvine	CCC
Clive Kavanagh	CQSS
Pascale Levacher	CQSS
Lanah Little	CCC
June MacLucas	CESGA
Angus Macoun	RSS
Rhys Maddern-Wellington	VSA
Erica Maggs	VSA
Andrew March	CTA
Janice March	CTA
Denis Marsh	OSS
Grace Matts	NSWCRS/HCG/SSS
Lloyd Mill	VSA
Faye Chapman	VSA
Mary McCabe	CQSS
Steve Morgan	CQSS
Mick Moylan	CCC
Robbie Moylan	CCC
Chris Norton	SUSS
Paul Osbourne	CCC
Norman Poulter	SRGWA
Chris Riley	NC
Debbie Roberts	CQSS
Ray Roberts	CQSS
Dorothy Robinson	ISS
Lloyd Robinson	ISS
Kath Rowsell	VSA/CCV
Noel Sands	CQSS
Jeanette Sands	CQSS
Amy Sands	CQSS
Aaron Sands	CQSS
Henry Shannon	NC
John Taylor	KSS
Leanne Thurling	CT
Mark Westhorp	CT
Sheryl Wolfenden	CQSS/CSS
Norm Pershouse	CQSS
Doreen Perhsoue	CQSS
John Toop	DoE
Pauline Toop	
Alan Toop	
Andrew Toop	
Dianne Vavryn	CQSS

LIST OF CHILDREN

Christopher Fleming	Rebecca Fleming
Samantha Fleming	Emma Moylan
Ariel Riley	Christopher Bradley

CONFERENCE PROCEEDINGS

OPENING ADDRESSES

Peter Berrill President ASF and CQSS

Welcome to Cave Queensland ASF 22nd Biennial Conference.

We don't apologise for the weather because this is Queensland, however we do appreciate your attendance and hope that it will not be too uncomfortable for you. The units are air-conditioned from 9pm for comfortable sleeping.

We have tried to arrange this Conference as a Caver's Conference by trying to remove some of the politics and replace it with fun, friendship and every day caving things. The papers received have been mixed and varied but, unfortunately, not very well supported by ASF members in general. Although the agenda is set, there is room for additional items. If you want to speak on some issue or run a workshop, please see one of the Conference Officials and we will try to make appropriate arrangements. The Officials are the ones standing....

We have arranged a number items of general interest such as photos, videos and slides on the Mitchell-Palmer expeditions and the Mt Etna Campaign and in particular, blockade news items. There are a number of photos of yester-year, of some now older members.

We have an International Speleo-Art Display. This initially started out with a small number of pieces but surprisingly has developed into a major International Speleo-Art Display with 41 pieces. Some pieces have been sent from as far away as the United Kingdom and Slovakia. All art is for sale. June MacLucas from CEGSA has attended specifically to display the art.

There is available for your use - a computer, photocopying, slide projector, over-head projector and general stationary etc. There is a display board for items of daily interest. There is a mobile phone for conference use and for emergency contact if needed. There are general rules for the Conference Centre which are detailed in your agenda booklet and I ask you all to read and abide by them. If you have any problems, please come and see, either, myself or one of the Officials.

Because this is Queensland, we have made available for your use sun block, insect repellent and vinegar. The vinegar is not for drinking, but to be taken with you when you go swimming. The reason is that there may be stingers in the water at this time of the year. We will keep you informed on this matter. We have a licensed bar which opens at 5 o'clock every day to late. CQSS have an arrangement where by no matter what we are doing as a club, 5 o'clock is Beer o'clock and all work and politicking ceases.

There are a number of items for sale - port wine which was produced in Roma district of Queensland, a number Bat Cleft T-shirts left over from when CQSS ran the tours, these are going cheap. If any body requires conference T-shirts we are happy to take your order and money!

Now to officially open the Conference - In considering who would be appropriate, CQSS took into account those who have given them the support at a time when it was most needed. Of course, I 'm talking about the Mt Etna Campaign days. It has been the rule to ask some local politician, Beaurocrat, Mayor etc to open such a Conference, however, during our time of need, we were cast out into to cold and virtually ostracised by them and the local communities, so we have decided to ask Cavers to officiate.

I would like now to introduce you to two people in particular, who for many years have given us their support and encouragement. One of them, during the campaign days and after and the other encouraging us in our exploration of the Mitchell-Palmer area of Cape York.

Lana Little is with the Department of Environment and is the District Ranger based at Chillagoe. CQSS first visited the Mitchell-Palmer area in 1989 and since then, Lana has given us overwhelming support and assistance both professionally and personally while at the same time not afraid to dish out a reprimand. She is a Caver at heart and places the preservation of caves and karst foremost. I will add that she sometimes is known to exaggerate the truth, so please, don't believe everything she says about CQSS.

Then we have John Toop, a past UQSS and CQSS member. John also works with the Department of Environment as a Senior Conservation Officer based here in Rockhampton and is the Zoologist, who in the mid-seventies carried out research into the Ghost Bat colony of Mt Etna. During the Direct Action Campaign, he was caught up in controversy due to being a member of CQSS, the organisation heading the campaign, as an employee of the Department of Environment and being the researcher who held an unpublished report regarding the importance of the caves systems of Mt Etna to the Ghost Bats. He has continued to support CQSS, even after Ministerial reprimands.

Please make welcome Lana Little and John Toop.

Yeppoon Recreational Centre - January 1999

OPENING ADDRESS

by John Toop

Mr President, fellow cavers, it is with great pleasure that I accept the honour, along with my colleague Lana Little, to officially open the 22nd Biennial Conference of the Australian Speleological Federation. The first time that this biennial event has been staged in Central Queensland.

To those of you who do not know us, I may say a few words by way of introduction.

We both employed by the Queensland Parks and Wildlife Service. Lana, a member of the Chillagoe Caving Club since 1984, is currently District Ranger at Chillagoe and has managed the caving areas of Chillagoe, Undarra and Mitchell-Palmer since 1988.

For myself a former member of the now disbanded University of Queensland Speleological Society since 1970, on graduation, I joined the Commonwealth National Parks and Wildlife Service in 1975 to work on the conservation of the cave dwelling bat colonies here in Central Queensland. This work was subsequently taken over, despite some State Government opposition by the Queensland Parks and Wildlife Service in 1980 and I have been with them ever since, working on management of bat colonies throughout Queensland.

I will not bore you with the times I have spent inspecting bat caves with Lana, let's just say, we both enjoy our caving and have both extensively, through Australian and overseas.

I take this opportunity to welcome fellow cavers to Central Queensland. Some of you will have been here before and for others it will be their first visit. Even for first timers however, the area will not be unknown. The Mt Etna are recognised by all Australian cavers.

For cave conservationists, this area is hallowed ground. It was here that a bitter, twenty-three year conservation battle was fought to conserve these caves and their associated bat colonies.

At first, the University of Queensland Speleological Society carried the conflict forward. The convenors of this Conference, the Central Queensland Speleological Society, in the final years, carried the fight to a successful conclusion.

During this time, I saw this controversy hurt a large number of people. I saw marriages break up, professions and businesses ruined and careers damaged. I saw the Rockhampton community and even the caving club split apart by conflicting ideologies. Even today, ten years after Mt Etna was declared a National Park with some 69% of the caves conserved, some of these rifts and bitterness still remain.

As we move toward the new millennium however, I see the process of healing slowly gaining ground on both sides. I see the anger of the conservation movement subsiding and on the other, I see the cement company, Pacific Lime sponsoring the Australian Bat Society Conference in Rockhampton last year and I see them becoming involved in cave conservation.

This climate of reconciliation, augers well for the future of this area. The theme of this Conference, "Taking Caving into the Next Century with Fun, Unity and Fellowship", I would suggest, will be achieved. A sense of unity in cave conservation and cave management is slowly gaining ground.

The fun and fellowship part of the equation - we will start on in earnest at five this afternoon, as the first stubbies are broached.

Before handing over this Official Opening to my colleague, Lana, I would like to personally thank the Central Queensland Speleological Society for their assistance to me over the years and in particular in light of our gathering here, I would like to congratulate them for organising this Conference. As part of a four-member Committee, who put the Australian Speleological Federation's Brisbane Conference together I can assure members here, that it is a soul-destroying task. It is a task however, that has to be faced in the future, by cavers, some of you here, if we are to create the unity which, is so required on the part of cavers, to ensure that our sport is not unduly hampered by unthinking, unworkable regulations in the future.

Ladies and Gentlemen - Lana Little, District Ranger, Chillagoe.

OPENING ADDRESS

By Lana Little

Caving means different things to different cavers - or more often, a number of different things to any one caver.

Let's look first at caving as an adventurous activity. A great many of us were probably first attracted to caving as a sport - a challenge, a lot of fun, great fellowship, and all in a novel and often very beautiful setting. We learnt and honed skills together, and developed a sense of unity amongst teams, caving groups and the greater fraternity of cavers.

We should acknowledge, though, that element of risk that we also found attractive. To us, it is an element of the challenge and attraction of the sport. But today's landowners and managers have come to realise their exposure to litigation and so has been born the ASF caving insurance policy. Running parallel with the search for appropriate insurance cover came the push for a cave trip leadership accreditation scheme, which has already become a reality in some ASF affiliated clubs.

From my professional perspective, given that a private land manager can demand and expect compliance with insurance and trip leadership conditions, in order to minimise his or her liability towards cavers on their property, I can accept that managers operating on behalf of Government Agencies are concerned about expecting any less. As many of you are aware, caving is set to become a Special Activity on Protected Areas, requiring a permit to be issued to an accredited leader. The ASF has been, and I'm sure will continue to be, heavily involved in the refinement of all such initiatives, to the ultimate benefit of the caver.

The other aspect of caving, apart from its recreational values, lies in its intrinsic scientific value. Caves are functioning laboratories where we may observe processes of biology, geomorphology and hydrology taking place - or at least evidence that it has done so!

Members of the CQSS - in particular Peter Berrill, Noel Sands, Clive Kavanagh, and in the past Andrew March, Craig Hardy and others have been deeply involved in research in my District, particularly the Mitchell-Palmer karst. Here their interests have centred upon the Ghost Bat and its habits, but they have been unfailing in their observations of all creatures, great and small.

John has already highlighted a local conservation issue, in his address concerning the Mt Etna campaign. The challenge of protecting our caving areas into the future is a real one. An aid towards this objective is the Queensland system of conservation agreements, binding private owner/managers and Government Conservation agencies in a land-title-based contract to ensure the long-term viability of both the resource and the caving activity. In all these contexts, we value conferences such as this to provide a forum for constructive discussion. It's these sort of progressive steps that will lead the way into the next century.

I join John in thanking the CQSS, both for their extensive efforts in caving and cave conservation in the past, and for the months of preparation that have gone before this conference today.

On behalf of John and myself, I hereby declare the 22nd conference of the Australian Speleological Federation officially open.

Australian Ethnoecology

By Jim Doyle Presented by Lana Little

What is Australian Ethnoecology?

Australian Ethnoecological research is a relatively old field of study, which is experiencing a degree of popularity once again in recent years. This field has been studied for at least forty thousand years in Australia, (only I don't think it was called Ethnoecology way back then, I think it was called survival,) but the principles were much the same. With a growing interest in indigenous studies there has been a resurgence of interest in Bush Foods and Bush Medicines. Most cities now boast a restaurant, which claims to serve "Bush Tucker", but it could be argued that the food served, has been modified so much that it no longer could be classified as a natural resource. Ethnoecology is basically, the study of indigenous peoples' uses of all natural resources for the purpose of aiding in subsistence and or survival. This in general terms means a study of Bush Foods, Bush Medicines, Survival Aids and Survival Analysis and how and why it is utilised. But the knowledge that can be gained from this field can be utilised in far more ways than just the obvious!

As a starting point though, we can say when talking about "Bush Tucker" we are referring to the natural resources that are utilised for the purpose of subsistence or survival. "Bush Medicine" we are referring to the natural resources that are utilised for maintaining good health and or the relief of sickness or ailments. "Bush Techniques/Survival Aids" refer to the natural resources that are utilised for the purpose of aiding subsistence or survival and "Survival Analysis" being the study of subsistence strategies. There have been many ethnoecological projects undertaken by different people and organisations in Australia in recent years but none would be possible without the knowledge of the Aboriginal people of Australia. Many Aboriginal communities have over the last few years endeavoured to record their own ethnoecological knowledge and many have resulted in small publications going to print. Most people would be familiar with Les Hiddins, AKA "The Bush Tucker Man". Each week he brought us an insight to the use of many of the resources used by aboriginal people and others but few would be aware of the contribution Mr Hiddins made to the Australian Defence Department in cataloguing the resources of Northern Australia.

There are many other people with an interest in bush tucker and other related fields of studies and have initiated a variety of different research projects over the past years. Many early explorers and Anthropologists noted resources used by aboriginal people during their journeys and some even applied this knowledge for their very survival. So we shouldn't forget the contribution they made to our current knowledge and understanding. It was not until our early explorers were exploring the country that any real effort was made to record the use of the natural resources by Aboriginals. Many of the explorers noticed how the Aboriginal people appeared to be in good health, when in many cases they themselves (the non-aboriginals) were sick. Consequently, many explorers began noting in their Journals information about resources used by Aboriginals, what was used, how it was prepared, how it was applied and whether it appeared to work.

In Australia, there appears to be many different uses of natural resources for medicinal purposes by the Australian Aboriginals. Some bush medicines were utilised for the purpose of contraception, childbirth, abortions, fertility, narcotics etc. With the year 2000 approaching rapidly, we as non-Aboriginals know very little about Aboriginal knowledge of medicinal resources eg. Bush Medicine, how it was used, what was used etc. There are a number of possible reasons for this:

Aboriginal people had no use for writing; therefore this knowledge was never documented until recently. Medicinal knowledge was normally only known to a few in the group and handed down as required.
Many of the treatments appear to have no medical reason for working (yet many did), so many non-Aboriginal people believed it was 'a ritual thing' rather than having any real value to science. Because of this belief, there wasn't a lot of interest in the subject and therefore the recording of this knowledge wasn't widespread by early non-Aboriginal people. Aboriginal people having been in this country for at least 40,000 years, and with their Gatherer/Hunter subsistence system, were required to relocate regularly so their use of medicinal resources was quite varied and in doing so were able to treat most illnesses before non-Aboriginal peoples arrival. With the arrival of non-Aboriginal people, there was a huge impact on the way that Aboriginal people utilised the natural resources. Non-Aboriginal people brought with them many new illnesses. They also brought the drugs used to treat the illnesses that arrived with non-Aboriginal people. Until contact with non-Aboriginal people, Aboriginal people had no way of directly boiling water. With the introduction of the 'Billycan', Aboriginal people were able to utilise a whole new range of resources.

By the mid 1800's, the so-called civilised world wanted to know everything about medical practices. This in part was due to the fact that Europeans were no longer of the mind that only Witches etc. could use natural resources for the treatment of sickness. The other reason is that after the American Civil War, medical practitioners of the time wanted to find ways of relieving the pain and suffering of the wounded.

Although humans have and many still do, exploited the natural resources for medicinal purposes for thousands of years, many cultural groups have a strong spiritual or social attachment or belief in the use of many of these resources. This is one area where science is just beginning to recognise when dealing with the subject matter. There wasn't any real scientific or serious study until perhaps Anthropologists began noting and recording the use of resources for medicinal purposes amongst indigenous people. This early work was mainly cataloguing the resources but invaluable all the same.

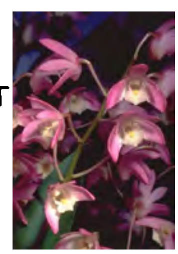
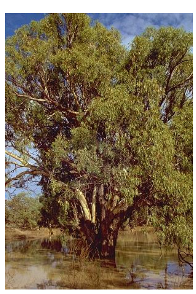
Survival analysis looks at how and why different people adopt different strategies to subsist and how we can use this knowledge to aid our own survival when we find ourselves in an unfavourable situation. Bush techniques cover such things as fish poisons, string making, fire starting, shelter construction, hunting techniques, tool manufacture etc. So what, if anything, would this sort of knowledge be of use to us in the current global environment. Well we know that most, if not all the resources that are used for medicinal purposes do contain trace elements and chemical properties that our modern drugs try to reproduce. The resources that are utilised for food have been found to contain high levels of Vitamins, Proteins, Carbohydrates and other nutrients, which are essential to our very survival. So, this as a scientific understanding of our environment is of immense benefit.

To Anthropologist and Archaeologist, this information is also of immense benefit because the information can tell us a great deal about the social structures, belief systems, survival strategies and how humans adapted to a change in circumstance or environment. Historians also can gain by this knowledge by understanding through the achieves of explorers, anthropologist, archaeologist and missionaries etc what their lives were like at a given time, how hard or how easy they found subsisting in the new land. People, who have an interest in pure survival, also gain from the hard data of what resources can be utilised for the purpose of survival because this very data tell us what you can eat, drink, or utilise. And finally, the Aboriginal people of Australia are given the opportunity to have their knowledge recorded and available for prosperity. This paper has only touched on a very fascinating area of study, which I believe has something for all in understanding the diversity of humankind.

Resources Found in the Rockhampton District

BE WARNED THAT MANY OF THE RESOURCES LISTED REQUIRE DETAILED KNOWLEDGE IN THE PREPERATATION AND ADMINISTRATION:
SOME PLANTS ARE TOXIC TO TOUCH AND SOME DEADLY



Scientific Names	*Common Names*
ACACIA HOLOSERICEA	FISH POISON TREE
AGARICUS CAMPESTRIS	FIELD MUSHROOM
AJUGA AUSTRALIS	AUSTRALIAN BUGLE
ALOCASIA MACRORRHIZAS	CUNJEVOI
ALPHITONIA EXCELSA	SOAP TREE
ARCHONTOPHOENIX ALEXANDRAE	ALEXANDRA PALM
AVICENNIA MARINA	GREY MANGROVE
BRACHYCHITON POPULNEUM	KURRAJONG, BOTTLE TREE
BRACHYCHITON RUPESTRIS	BOTTLE TREE
CAPPARIS ARBOREA	NATIVE POMEGRANATE
CAPPARIS CANESCENS	WILD ORANGE, ORANGEWOOD
CAPPARIS MITCHELLII	WILD ORANGE
CARALIA BRACHIATA	BILLABONG TREE
CASSYTHA FILFORMIS	DEVILS GUTS, DODDER LAURE
CASUARINA EQUISETIFOLIA	SHE OAK
CAYRATIA TRIFOLIA	WILD GRAPES
CHELODINA LONGICOLLIS	EASTERN SNAKE NECKED TURTLE
CHITON SP	CHITON
CISSUS HYPOGLAUCA	NATIVE GRAPE
CLERODENDRUM FLORIBUNDUM	LOLLY BUSH
COCOS NUCIFERA	COCONUT PALM
CYMBIDIUM CANALICULATUM	TREE ORCHID, BLACK ORCHID
CYPERUS ROTUNDUS	NUT GRASS, WILD ONION
DASYATIS	STINGRAY
DENDROBIUM SPECIOSUM	ROCK ORCHID, KING ORCHID DIOSCOREA
TRANSVERSA	LONG YAM
EICHHORNIA CRASSIPES	WATER HYACINTH
ELEOCHARIS DULCIS	SPIKE RUSH, WATER CHESTNUT
EMILA SONCHIFOLIA	THISTLE
ENCHYLAENA TOMENTOSA	RUBY SALTBUSH, RED BERRIES
ERTHRINA VESPERTILIO	BATWING CORAL TREE
EUCALYPTUS CAMMLDULENSIS	RED RIVER GUM
EUCALYPTUS MICROTHECA	RIVER GHOST GUM
EXCOECARIA AGALLOCHA	MILKY MANGROVE, POISON TREE
FICUS OPPOSITA	SANDPAPER FIG
FICUS PLATYPODA	NATIVE ROCK FIG
FICUS RACEMOSA	CLUSTER FIG
FICUS SP	FIG
FLAGELLARIA INDICA	SUPPLE JACK

GAHNIA ASPERA	SAW-EDGE
GREVILLEA PTERIDIFOLIA	GOLDEN GREVILLEA
GREWIA LATIFOLIA	GIANT EMU BERRIES
GREWIA RETUSIFOLIA	EMU BERRIES
HAKEA LOREA	
HAKEA SP	CORKWOOD TREE
HETEROPOGON TRILICEUS	GIANT SPEAR GRASS
HETEROPOGON TRITICEUS	GIANT SPEAR GRASS
HIBISCUS HETEROPHYLLUS	NATIVE ROSELLA, ROSELLA BUSH
HIMANTURA	
IPOMOEA PES-CAPRAE	GOATS FOOT
LANTANA CAMARA	LANTANA
LATES CALCARIFER	BARRAMUNDI
LIASIS FUSCUS	WATER PYTHON
LIVISTONA AUSTRALIS	CABBAGE TREE PALM
MACROZAMIA SP	ZAMIA PALM
MARSILEA DRUMMONDII	NARDOO
MELALEUCA LEUCADENDRON	PAPERBARK, TEA TREE
MYOPORUM SP	BOOBIALLA
OECOPHYLLA SMARAGDINA	GREEN ANTS
OPUNTIA SP	PRICKLY PEAR
PANULIRUS ORATUS	PAINTED CORAL CRAYFISH,
PASSIFLORA FOETIDA	BUSH PASSIONFRUIT
PLANCHONIA CAREYA	COCKY APPLE, NATIVE PEAR
PLEIOGYNIUM CERASIFERUM	BURDEKIN PLUM
PODOCARPUS ELATUS	PLUM PINE, BROWN PINE
POLMESODA COAXANS	MUD MUSSEL
PORTULACA OLERACAE	PIGWEED, PURSLANE
PSIDIUM GUAJAVA	GUAVA
PSYLLA EUCALYPTI	LERP SCALE
PTERIDIUM ESCULENTUM	BRACKEN FERN
PTEROCAULON SPHACELATUM	
SACCOSTREA SP	ROCK OYSTER
SANTALUM LANCEOLATUM	QUANDONG
SARCOSTEMMA AUSTRALE	CAUSTIC VINE
SCYLLA SERRATA	MUD CRAB
SECURINEGA MELANTHESOIDES	RAGAH
STERCULIA QUADRIFIDA	PEANUT TREE, MONKEY NUT TREE
TEPHROSEA PURPUREA	WILD INDIGO
TEREBRALIA SP	MUD WHELK
TEREDO SP	MANGROVE WORM
TRIGONA SP	NATIVE BEE / SUGAR BAG
VARANUS GOULDII	GOULDS GOANNA
VIGNA LANCEOLATA	MALOGA BEAN,
VIGNA RADIATA	GULAKA
XANTHORRHOEA PREISSII	BLACKBOY
XANTHORRHOEA SP	GRASSTREE, BLACKBOY
ZIZYPHUS MAURITIANA	CHINESE APPLE, INDIAN JUJUBE





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SHOULD SPELEOLOGICAL SOCIETIES AND THE ASF HAVE A POPULATION POLICY?

By Norman Poulter
Speleological Research Group Western Australia Inc

During June 1999, the world's population is expected to reach and then surpass 6 billion! Is this achievement something to be proud of - or a further sign that humanity's arrogance is overlooking the fact that is seriously overtaxing the planet's delicate ecosystem? Is this fact a result of recent calculations? No! It has been known since the early 1970's [or earlier] that the world's population would attain this figure somewhere around this period - and few at the time [or since] seemed interested in what the consequences could mean.

It took at least 100,000 years for global human population to reach two billion. In 1800, world population stood at 1 billion. Now, just on 200 years later, we are 6 times that number and poised to grow at an even faster rate unless fertility rates can be lowered. It took 130 years [1800-1930] for world population to grow from 1 to 2 billion but then a mere 30 years [1930-60] to increase by another billion. Since 1960, we have been increasing at the rate of almost a billion every ten years. But that ratio is set to change dramatically.

What has all this to do with speleology? Should we collectively "buy into" a potentially divisive debate that would be seen by many as being well outside the aims and objectives of a speleological society or federation? 1 believe we should, as, whether we like it or not, population pressures DO have an effect on caves and karst regions!

1 would hazard the guess that in none of the recent environmental "battles" fought on behalf of karst regions, has population pressure been cited as an argument against a particular proposal. Indeed, one of the most enduring arguments against destructive development, at least in regional areas, is the perceived greater benefit to be gained from increased tourism. Then, if the battle is miraculously successful - work often begins to curtail [or prevent] tourist development! Why? Because too many tourists can easily degrade or destroy the very features they go to marvel at!

Limestone is one of the most useful commodities exploited by modem humanity. It has either directly or indirectly played a part in the provision of all goods and services that we utilise in everyday life. Glass to paper - food to housing - steel to fuel.

Most, if not all our environmental problems are population driven - again, either directly or indirectly.

A short but incomplete summary could include:

- mining — Mt. Etna [Qld.], Colong, Yessabah [NSW] Exmouth [WA], Ida Bay [Tas.]
- forestry — Mole Creek, Junee/Florentine [Tas.]
- urbanisation — Yanchep/Wanneroo, Pinjarra/Mandurah [WA]
- agriculture — Nullarbor, Leeuwin-Naturaliste Ridge [WA], Naracoorte [SA] and Pike Creek [Qld.]
- tourism — virtually all karst areas.

Mining of Mt Etna Queensland 1999
Photo: Arthur Clarke

Now, while Australia's population has been increasing, membership of the ASF has declined. In 1965, I seem to remember that the ASF, through its associated societies, had a membership of about 800, higher than it did in early 1998 - although 1 hear that membership has recently risen to be close to 1000. However, at the same time, the popularity of eco-tourism [involving caves] and adventure caving has increased many times over since the introduction of those activities.

Many, many years ago on an ABC radio series by Dr. Paul Ehrlich where Australia's population was mentioned, he alluded to conclusions that could be drawn by various demographers [study of births, death, disease & conditions of life in communities] using the same statistics. He stated that in relation to food production, demographer "A" said, Australia [provided we stopped or curtailed food exports] could support a population of 30 million, while demographer "B" agreed, that due to our water resources, Australia could indeed support a population of 30 million - provided half of them lived in Tasmania! Now, Tasmania is currently struggling to support a population of half a million [despite former Premier Rundle's best efforts to double the population]. So what would they do with an extra 14.5 million people and where would they house them?

Australia's population currently stands at approximately 18.7 million but the Federal Government anticipates the population to "peak" [given the current trend in births, deaths and immigration] at or about 23,000,000 by 2020. Former Prime Minister Malcolm Fraser, is on record [with others] that we should aim [Indeed have a "duty" to aim] for 50,000,000 over much the same time span. This is in direct contrast to what the general public seem to prefer - that is, a lower population. Dr. Tim Flannery of "The Future Eaters" fame, is on record several times over saying that Australia should have a population of about 12,000,000 in order to maintain a sustainable environment. This call has been echoed to a slightly lower degree [9,000,000] by Professor Harry Recher [Environmental Management, Edith Cowan University].

In todays "politically correct' and "Hansonite climate", any voices raised [even on environmental grounds] objecting to Australia's directionless "policy" of limitless [population] growth, have been immediately branded racist or worse by religious, political, some ethnic and special interest groups, which includes the "immigration industry". I use the term immigration industry because that is what it has become, complete with lobbyists, specialist lawyers, consultants and publicity machines, feeding on people's fears, aspirations and prejudices but often supported by religious, ethnic and media groups. It is often a neat but vicious circle!

I would mention at this point, that due to the perceived isolation of Western Australia, from detailed information about current environmental issues on the eastern seaboard - and visa versa - this paper attempts to highlight problems existing in Western Australia, problems that quite probably mirror similar instances existing in the rest of Australia. 1 also think it fair to acknowledge my membership of "Australian's for an Ecologically Sustainable Population Inc." [AESP]

According to the Western Australian government, Perth's population of 1. 1 million will double within the next 16 years. The current Liberal Government seems quite proud of this forthcoming increase although such an event will place enormous strains on already scarce water and food resources, not forgetting such infrastructure as roads, transport, sewerage and energy. Conveniently forgotten in all this euphoria, is that the majority of Western Australia's lower coastal strip, is dune limestone - a very friable rock. Some years ago, it was fairly common knowledge amongst some domestic reticulation contractors, [45-50% of Perth households have their own bores], that drill holes often broke into subterranean cavities. Caves exist near central Perth and in the banks of the Swan River. This is not to suggest that some sections of Perth's older suburbs are about to collapse into the ground in the near future but - the possibility is there.

Where karst areas exist close to centres of population, pressure is being placed on those regions by urbanisation. As Perth urbanisation expands, especially to the north and south - extensive karst areas are being steadily encapsulated and sub-divided. The city of Wanneroo, which includes Yanchep, has extensive shallow and highly friable cavernous regions. Indeed, WASG and SRGWA were instrumental in postponing development in one Wanneroo region during early 1997. Postponed! The council only placed a 10 year moratorium on the proposal, after which it could well be resurrected. There were indications that the developers and council were not about to highlight the fact this was a known cavernous region - a risky undertaking in today's "public liability" and litigation-prone climate. I might add that the urban sprawl is less than 2km from this region. South in Mandurah, caves already exist within the city limits with more karst regions set for development in the medium-term. Urbanisation of karst areas brings its own problems and concerns as evidenced by the mad scramble for explanations that took place in Mt Gambier during 1997, when unexplained subterranean noises were heard, noises later attributed to "water-hammer" in pipes undergoing increased use due to maintenance work elsewhere in the district. Quite a humorous incident in hindsight - but a genuine cause for the "jitters" at the time.

Much of the water that supplies the Perth metropolitan area and Goldfields regions, now comes from underground sources [commonly referred to as "mounds"]. Due to the current fickle nature of the winter rains, the dams of the Darling Scarp are rarely capable of supplying the year-round demands expected of them. This has resulted in increased reliance on the little understood water mounds. To the north of Perth lies the Gnangara Mound, a mound that extends into the limestone regions of Wanneroo and Yanchep. As Perth's population has increased, so have the demands placed upon the Gnangara [and southerly Jandakot] Mound.

When inviting public comment into the proposed northerly extension of the Gnangara Mound during the early 1980's, the water authority estimated that they would lower the watertable in the Yanchep National Park region by half a metre - enough to dry out most of the [stream/lake] caves. Their solution to this "dilemma" was that the Department of Conservation and Land Management [CALM] should cut down half of the nearby pine plantation - a solution once flatly rejected by CALM. In more recent times, the Court Government announced plans to indeed remove half the trees in order to establish an enormous park. Work has yet to start. In the meantime, the caves of Yanchep are drying [the lake and stream in the tourist cave (Crystal) has all but disappeared] and the unique fauna therein placed at extreme risk.

As the water table drops, many of metropolitan Perth's surface lakes have been drying out, resulting in a loss of surface species and habitat for both resident and migratory water birds. During the latter part of last century and early this century, many lakes were simply filled in. In recent times, Councils resort to spring and summer pumping to keep the lakes "full'.

Western Australia's premier tourist region is the south-west, an area that includes the highly popular Leeuwin-Naturaliste Ridge, an area that currently receives about 1,000,000 visitors a year. The Ridge also contains some of the state's most spectacular caves such as Easter-Jewel, Crystal, Strongs and Labyrinth to name but a few. For more than 20 years, speculators have been trying to turn parts of the Ridge into another Surfer's Paradise - helped along by the development of the hotel, surfing and wine industries. The traditional dairy and forest industries are in decline. Areas that were once State Forest are now National Parks. Where once excessive groundwater extraction could possibly be blamed on the dairying activities, now it should be placed mainly at the feet of the burgeoning population of incoming residents, tourists and wine industry.

Although, to be fair, the region has also suffered from loss of "average" rainfall in recent years. Several caves have already suffered loss of water. The lakes of Jewel have disappeared while the lakes of Easter have dropped alarmingly. The stream in Strongs has all but disappeared, the root mats, so important to the troglobitic fauna, has dried and died in many sections. Is all this attributed to population increase or natural evolution? Other stream caves such as Crystal, Calgardup and Lake appear quite healthy with no apparent drop in water level or flow.

About 1.5 days drive north of Perth lies the town of Exmouth, near the tip of Cape Range peninsula [North West Cape], a karst area with important links to the Gondwana era. Exmouth was largely created to service the American naval communication base and nearby part-time RAAF base. Over the years, the agriculture, tourism and prawning industries gained a foothold.

Following the introduction of enhanced satellite technology, the Americans moved out of Exmouth - creating a huge employment vacuum. Rather than let the town "downsize" [electorally unpopular], proposals were canvassed to help maintain the town - increased tourism to the nearby Ningaloo Marine Park and Cape Range National Park were put forward, along with plans to quarry part of the Cape Range itself. The quarry has already figured in conservation issues within the ASF - at least one cave has already been damaged.

In the past, reliance on "technological fixes", is often cited as a means of accommodating increases in population. Advances in technology can be a double-edged sword. The "green revolution" only served to allow nations to over-extend their population at the expense of the environment. The new generation of genetically-engineered crops are more chemical-reliant than their predecessors [for yield] and have the ability to plunge user nations into deeper debt and environmental degradation without solving the underlying cause - overpopulation.

In a primary and secondary industry sense, one by-product of advances in technology is to create further unemployment through displacement of jobs. The tendency of transnational and local companies to relocate their operations into countries where safety and environmental laws are "softer" and labour costs and conditions lower does nothing to help Australian's burgeoning population either. In short, advanced technology is very good at putting people out of work - especially those on the lower socio-economic scale.

How is population increase encouraged in Australia?

1. lack of a population policy
2. immigration
3. tax incentives [child allowance]
4. sales tax on contraception/birth control items
5. political/business/media "boosting"
6. religious instruction.

What are some of the consequences of population increase?

a. less arable land
b. land degradation
c. water degradation and loss
d. loss of native species
e. social unrest.

Some impacts of population growth on Australian karst regions have been:

1. introduction of permit systems, fees or loss of access
2. degradation of caves, decoration, fauna [surface and troglobitic]
3. degradation of caves caused by inappropriate land management practices in [cave] catchments [which may be outside cave reserves] - siltation, deforestation
4. lowering of watertables due to pumping, irrigation etc.
5. surface and subsurface vandalism
6. creation of eco-tourisrn/adventure caving by non-speleological groups or expansion of existing organisations
7. increased crime - theft and vehicle break-ins - a small problem maybe but it occurs nonetheless
8. mining.

Humanity in general currently refuses to admit to, and limit its growth - contrast this with Australia's continued push to control the population of perceived "pest" species such as the kangaroo, dingo, wombat and fox, to name but a few! Are we just following the crowd by not admitting that we really have a human [population] problem as instead? We cannot shamelessly say that population increase is a "third-world problem", predator nations such as the USA, Japan and Australia consume resources at a higher per-capita rate than that of the third world, not only our own resources but the resources of other countries as well.

As has been said on numerous occasions in the recent past, many of our environmental problems will not be solved until we address and solve the population problem. Australia, right now, needs to enact a humane population [control] policy while there is still time for it to be socially and mutually acceptable. Australia should not bury its head in the sand until it becomes necessary to adopt "inhumane" measures such as those that have been imposed [legally or otherwise] in nations such as India, Singapore or China and certainly well before Nature enacts its own forms of population control. The ASF and its member societies should seize the initiative by formulating a population policy and lobbying the federal, state and local governments and media to enact one also. A small step has already been taken in this regard by Premier Carr of NSW who recently said, *"...... Australia must begin to think of itself as a country with a population problem. Let's throw away for all time the notion that Australia is an empty space, just waiting to be filled up. Our rivers, our soils, our vegetation won't allow that to happen without an enormous cost to us and those who come after us."* [Carr 1997] This was followed by Professors Ian Lowe of Griffith University, who said, *"If we are to be a civilised country in control of our destiny, we need to have a strategy for stabilising the human population." and "... a restraint on the clearing of small areas of bushland could be considered as treating a symptom, whereas having a population policy could be considered as treating the underlying cause."* [Lowe 1997]

The purpose of this paper was to stimulate discussion [without prejudice] and perhaps launch the ASF into the forefront of [specialist group] environmental thinking. I hope that I have done that without ruffling too many feathers. In concluding, I would quote a United States Cree Indian saying: ***"Only when the last tree has died, the last river has been poisoned and the last fish has been caught will we realise that we cannot eat money."***

POSTSCRIPT - This paper was submitted during September 1998 for inclusion in the conference papers, scheduled at that time for publication prior to the ASF Conference in January 1999. Events precluded publication, until after the Conference.

Since the time of writing, information released by the Australian Bureau of Statistics [ABS cat. #3101.0], showed that Australia's resident population for the year to March 31, 1998 grew by 1.2% [221,900] to 18.71 million. This in turn, represented a migration intake of 100,200, coupled with a natural increase of 121,700. The Bureau's "Population Projections 1997-2051" [ABS cat.#3222.0], revealed that even if Australia could get its net overseas migration down to 90,000 and fertility rate to 1.75 [it's currently higher than that] our resident population in 2051 would be 26.4 million and rising, more than 3 million higher than Immigration Minister Ruddock currently states. Prior to the 1998 election, the Labor Party implied that it favoured a population policy but it now seems to prefer an increase above the current 1.1%. If Australia's growth rose to 1.3%, our population would rise to 37 million by 2050.

To lend weight to my arguments listed above, I would urge readers to consult Mark O'Connor's book, "This Tired Brown Land".

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A Dichroic Caving Light

By Norman Poulter
Speleological Research Group Western Australia Inc.

Since the beginning of human evolution, man has been associated with caves. Caves first provided shelter and a place to record history. Exploration and mining added to man's list of caving abilities with the development of portable light sources. Initially these consisted of burning sticks but through the ages transcended into candles, carbide, magnesium and electric light.

While various types of carbide generators have proven to provide the greatest duration, its by-products have meant that its use is no longer acceptable in some caves or cave areas. Electric light has proved to be the most versatile. The designs are many and varied, as is their robustness, brilliance and endurance.

The most favoured lights in most Australian speleological circles are usually miner's lights [Oldham, MSA] or their speleological cousins [SpeleoTec, Petzl] although personal experimentation continually brings hi-bred lighting systems to the forefront. Indeed, that is apparently how the British speleological community developed the SpeleoTec lamp even though it bears a striking resemblance to the Oldham light in all respects with the exception of the type of battery used.

When first developed during the late 1800's, miner's lights used incandescent globes. These globes were reliable and produced a reasonable amount of useable light [with little heat as a by-product]. One major advantage the Oldham system of lighting had over most other light sources was the inclusion of a low powered "spare" globe. The 4-volt battery could commonly power the "main" globe for 10-15 hours while illuminating the "spare" for twice that time.

During the 1970's, quartz halogen globe became available. These globes produced more light for approximately the same energy consumption. The only disadvantage apart from their higher unit cost was that they could not be handled with bare hands, the oils from the hand could set up stresses in the quartz envelope that could cause premature failure of the globe. However, they provided a great improvement in illumination technology and there would be very few mining lights using the old technology globes today.

During the latter part of the 1970's or early 1980's, a new halogen globe evolved, but not for caving. It was the dichroic tungsten halogen globe, or dichroic for short. It still used the same lamp technology as its predecessor, but worked at higher voltages and had an inbuilt reflector that passed resultant heat out through the back of the reflector instead of passing it forward. Producing so much heat that it needed special heat-resistant socket and leads, a revolution in illuminated had been unleashed. But what use might they have in caves by cavers? For a start, they were energy-hungry and appeared too fragile. Shops, galleries and trendy homes loved them. Vast amounts of high brilliance but low-voltage lights that wouldn't cook the subject of attention. Then suddenly, almost overnight it seemed, at least in Western Australia, they started appearing in caves, especially big Nullarbor caves!

Enter the "Himee"! Up to 75 watts of energy-consuming brilliance! Put one of these alongside an Oldham and you immediately thought the [Oldham's] battery had suddenly gone flat!

The first "Himee" lights were built around small 12 volt motorcycle batteries, "gelcells" or Eveready " Big Jim", 6 volt dry-cell batteries. Modelled from cave diving lights seen on the Nullarbor, Mark Norton and Greg Perejuan of Plane Caving built six of the first-generation hand held "Himee" lights for video-taping on a Nullarbor caving trip during 1992 [Norton 1993]. Since that time, many different varieties of "Himee's" have been built by numerous cavers for personal and commercial adventure-caving use. Most "Himee" lights have been made using a 50mm diameter dichroic globe generally ranging from 50-75 watts. This usually means that battery duration is short, about 20-45 minutes. Experimentation has taken place using plastic lamp-houses but due to the operating temperature of dichroic lamps - interesting results have been forthcoming - in direct proportion to the amount of time that the light has been switched on!

This author first saw a "Himee" in action in a Leeuwin-Naturaliste [Ridge] cave during 1995. The illumination output was fantastic. Entire chambers could be lit up. Unfortunately, the weight of the unit gave a new meaning to the term "a short life but a merry one," [flat batteries seem heavier than "full" ones!]. After about 30-45 minutes the battery was flat - so it was back to using lights that somehow now seemed quite inadequate.

Safe in the knowledge that there were now 35mm diameter dichroic globes available and not liking the idea of caving with hand-held lights, 1 decided to try developing a more versatile helmet mounted version with longer battery life. 1 settled on a Thorn 12 volt x 12 watt [1 amp] open dichroic globe costing about $14.00. An insulated mounting socket cost about $14.00. I field-tested an uncompleted version during the latter part of 1996, using a lead-acid motorcycle and had a completed version ready for the 1996-97 SRGWA Nullarbor Expedition, powered by a 1.0 amphere-hour Dry-power 12SBIO "gelcell" [$55], that was worn on the waist in the same fashion as mining lights. I had incorporated an exposed 2.2-watt "low beam" beside the main lam-house. The dichroic globe can run for about 10 hours on a fully charged battery while the "low beam" can bum for about 54 hours [on a fresh battery]. A miniature 3-position switch, cable clamp, normal three core flex and a piece of heat-resisting glass completed the parts list. The lamp-house was custom-machined from brass and aluminium and its weight is comparable to an Oldham lamp-house.

Despite its low wattage and size in contrast to globes used in a "Himee", the resultant beam of my light is still quite impressive. It has been used for videotaping, and makes focusing a camera much easier. Very large Nullarbor chambers have been effectively illuminated. Following a few minor modifications, it is now my primary light source.

The disadvantages are many:

1. Dichroic lamps have high operating temperatures - mine is no different. I have measured my lamp-house temperature at 75 degrees Celsius meaning that once it has reached that peak, the lamp-house can only be comfortably handled with gloved hands.
2. Being custom-made and in dire need to dissipate heat, the lamp-house is not waterproof and the low-beam globe and switch require protection meaning that the entire assembly is not as robust as a miner's light lamp-house.
3. Medium duration "gelcell" batteries are more bulky and heavier than mining lights. I built my light around a 10a/h battery that is 150 x 100 x 90mm and weighs 4.1kg, as against 2kg for a similar duration Oldham. If you want to carry same-size "spare" on those extra long trips, you'll need a lot of staying power! The battery does not have rounded edges. Shorter duration "gelcells" would naturally be lighter, smaller and less expensive.
4. Unless all electric terminals are insulated, the system is not suitable for caves where the entire unit is likely to get wet.

So what are the advantages?

1. Discounting the cost of the custom-made lamp-house, dichroic light units are relatively cheap to construct, measured against commercial mining lights.
2. If 12-volt dichroic lights are used, recharging of the batteries can be done direct from a vehicle's alternator system or, inexpensive main operated trickle chargers can be employed.
3. Smaller, lower amphere-hour batteries can be used for shorter duration trips, thus saving on weight.
4. By using sealed gel-cells, the batteries can be transported on commercial airline without difficulty - in direct contrast with well-cell mining lights.
5. Probably the most important advantage of these lights is that they are very, very BRIGHT!

To conclude, despite the depressing weight of the battery, [that I use], the perceived fragility lamp-house and susceptibility to moisture, I feel that for in dry and moderately wet caves, the level of illumination far outweighs the disadvantages.

Materials -

Thorn 12V x 12V Watt [1amp] open dichroic globe [M64/FTA][GZ4] $14.00
Dry-power 12SB10'gelcell', 12V 10a/h battery - 4.1kg, 150 x 100 x 90mm $55.00
Radio spares [on-off-on] single pole miniature switch [344-710] $13.00
12 V 2.2 Watt miniature single contact bayonet globe
Single contact bayonet globe holder
Custom-made battery belt, kindly manufactured by Heather Jefferies and Wayne Tyson [SRGWA]

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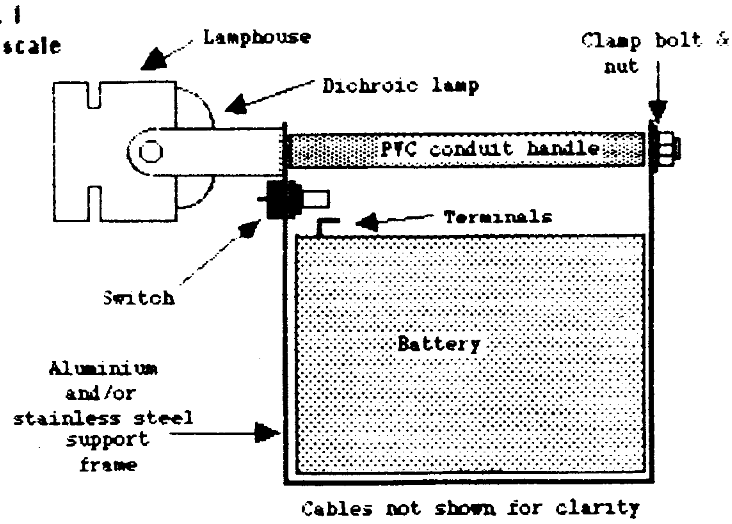
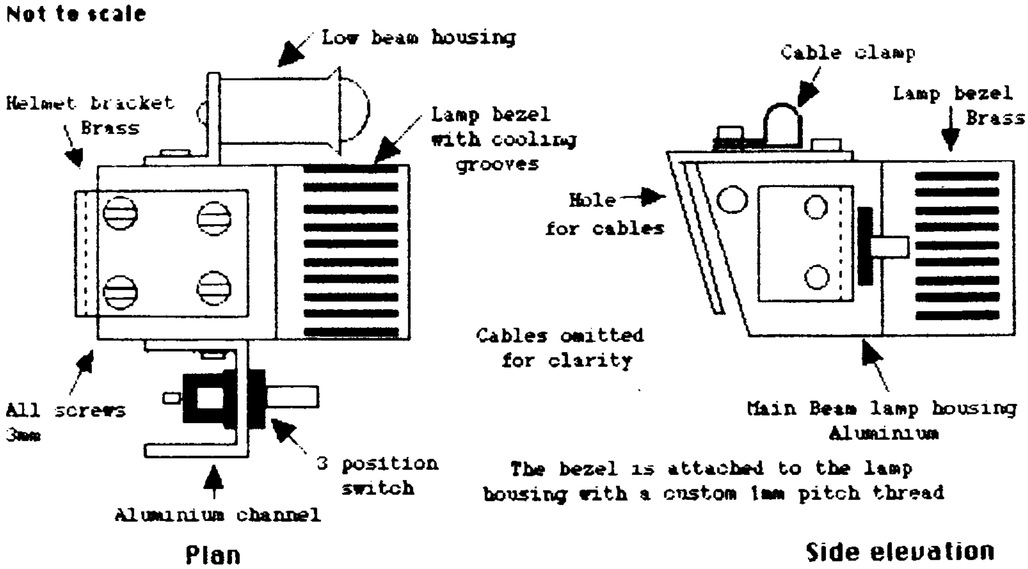
Dichroic Caving Lights

Fig. 1
Not to scale



"Himee" Light - after Mark Norton 1992

Fig. 2
Not to scale



Dichroic caving light - lamphouse

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The Caves of Christmas Island (Indian Ocean)

by Ken Grimes

Christmas Island is a tropical island (Latitude 10°30'S), in the Indian Ocean, northwest of Australia. In March - April of 1998 a group of six caver-scientists spent two and a half weeks on the island, doing a study of the island's caves and karst. The team involved Bill Humphreys and Stefan Eberhard, who studied the cave biology, Ken Grimes and Dan O'Toole, who looked at the geological hazards, and Andy Spate and Rauleigh Webb who looked at other hazards and cave and karst management in general (Grimes, 1998). This was done for Parks Australia North, so as to assist them in preparing a management plan for the National Park which now covers a large part of the island. Our job was made much easier by a set of unpublished cave maps and reports prepared in the 1960s by local cavers, such as David Powell and Roy Bishop; and also by maps and reports from a later cave expedition from West Australia in 1987 (Brooks, 1990).

The island is an old basaltic volcano with a limestone capping that is rising out of the Indian Ocean at a rate of 0.14mm per year and drifting north towards Indonesia at 8 cm per year. The interaction of uplift and a sequence of old sea-levels is a series of old shore-terraces cut into the steep and cliffy limestone sides of the island. The central plateau (about 200-250m ASL, with hills up to 360m ASL) is phosphate over a pinnacled epi-karst limestone surface, with the crest of the volcanic surface about 30-40m down. Phosphate mining has exposed the pinnacled sub-soil surface. I had expected a relatively soft porous limestone, similar to the Nullarbor (which is the same age) but the limestone is tight and hard. It is mostly a massive marine micritic calcarenite with scattered corals and partly recrystallised.

Most of the big caves are at sea level and entered from the base of the coastal cliffs. Higher up one finds uplifted systems that formed at past sea levels, and on the plateau there are some horizontal stream passages (see figure). The coastal cliffs which circle most of the island have strong notches cut at sea-level, and well-developed hackly phytokarst sculpturing of the rocks. In one place spring-fed streams running across the Shore Terrace have cut narrow canyons, known locally as The Dales.

Coastal Caves

The coastal caves are horizontal and lie at present sea level. They are typically entered by jumping off a boat and swimming into a low entrance in the sea cliff at low tide, and you continue wading or swimming in tidal water for much of their length (which is why most of the local cavers are also divers). The longest has 2.5 km of mapped passage, and many unexplored leads. Most of these caves have strong outflows of fresh water and submarine springs have been reported from depths as great as 200m.

These caves are horizontal joint-controlled passages with irregular, sharp, spongework walls. At intervals they are punctuated by massive rockpile chambers, and some entrances are via collapse dolines on the "Shore Terrace" (20-40m ASL). Some caves are dominantly collapse with little of the original passage visible. The caves have some very well decorated parts, but these are mostly difficult to reach. In places within the coastal caves one can feel cool fresh water floating on warm salt water, so I suspect salt/fresh-water mixing-corrosion is active and responsible for the extensive spongework sculpturing. Tidal mixing & flushing may also assist in the solution of the limestone.

The tight nature of the rock restricted the original passages to the joints, but spongework cavities are actively expanding from these.

The presence of drowned speleothems down to at least -6m in the main flooded passages suggests that the original cave development predates the present Holocene high-stand of the sea, and might date back to an earlier sea-level; most likely the 101-104 ka high-stand if we superimpose measured uplift rates on sea-level curves.

Several caves had irregular pockets of paleokarst breccias exposed in the walls; these are strongly cemented and very hard. Possibly they could date back to prior karstic events during the periods of low sea-level of the Pliocene, or even the late Miocene.

Plateau Caves

The few known plateau caves are different. Smaller, muddy, horizontal stream passages running at or not far above the limestone-volcanic contact, and entered via vertical shafts or collapse dolines. They show some joint-control, but it is partly obscured by a tendency to meander. These presumably feed water to the coastal caves (several kilometres away, and 200m down) as some of those have impressive water-spouts coming out of small holes in their ceilings (or out of a hole in a basalt wall in one case), but no connections have been found so-far. We found foul air (3% carbon dioxide with 17% oxygen) in all the plateau caves. This had not been reported before so perhaps it is just a seasonal thing - we were there at the end of the "wet" season, but it had been an unusually dry one.

Other Caves

There are also a couple of fissure caves, behind and parallel to cliff faces, that I suspect are at least partly the result of mass-movement. Most intriguing was a report by David Powell, held in the phosphate company records, that describes a sizeable cave near the edge of the plateau that had a stream and was formed mainly in basalt beneath the limestone. Unfortunately, the entrance was filled in some years ago, and is currently lost.

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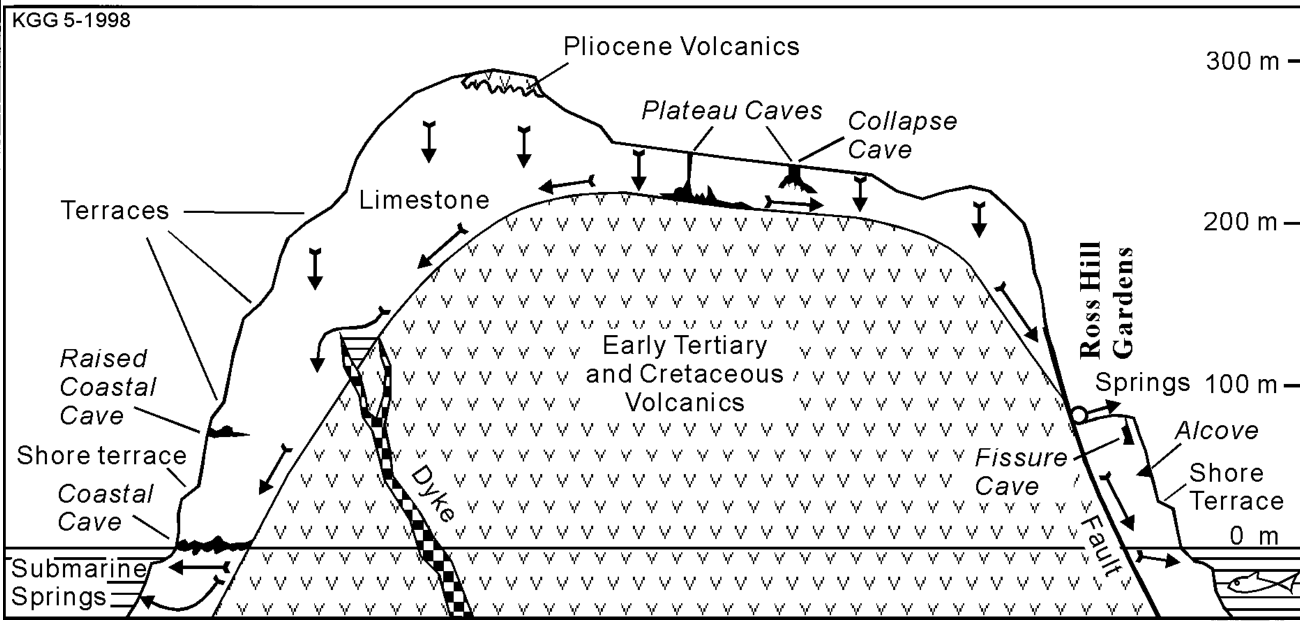
Ken Grimes - PO Box 362 Hamilton Vic 3300

Figure Caption:

Cross-section of Christmas Island (vertical scale exaggerated x10) showing water movement and location of typical cave types.



Christmas Island – Aerial View

Rockpool - Dolly Beach

OWL PELLET REMAINS IN NEWDEGATE CAVE (H-X7) SOUTHERN TASMANIA

By Arthur Clarke

Introduction:

Mammalian skeletal remains (commonly referred to as sub-fossil deposits) are frequently found in caves, particularly in those caves with vertical or sloping entrances and/or large rift entrances, where the caves act as pitfalls or "mammal traps", but may also contain skeletal remains of other vertebrates: reptiles, amphibians and birds. The skeletal bone pieces are usually whole pieces, though often dismembered and scattered, and the soft-boned skull fragments are often found close to or intact with their harder-boned mandibles (jawbones). Identification of this skeletal material is useful because it can provide an indication of the present day (and past) distribution of vertebrate species (including extinct species and macro-fauna) in any given locality. In some caves which have relatively large vertical or rift entrances, floor deposits in the entrance series of passages may contain the accumulated skeletal remains of small mammal species, mainly composed of whole bone pieces such as skulls, mandibles and leg bones; these accumulations often represent the remains of owl pellets.

Owls are known to roost in caves; as creatures of habit, they regularly roost in the same locations on sheltered ledges high up in avens, shafts or vertical rifts inside the darkened cave entrances. Owls tend to only use undisturbed cave sites that are not regularly frequented by other (human) cave visitors. While roosting in caves (and barns etc.), owls regurgitate "pellets" of indigestible material: "scrunched up" and whole (intact) bone pieces and fur, which over time form as small heaped piles or mounds on the cave floor directly beneath their roost (**Clarke, 1988**). Owls are included amongst the raptors: birds which prey on small mammals such as rodents and antechinus, as well as other smaller birds, frogs, lizards and some invertebrates, mainly spiders and large beetles. Some owls are known to prey on larger mammal species, usually immature species, including brushtail and ringtail possums, quolls and rabbits (**Hall, 1975; Hollands, 1991; Mooney, 1993**). Many of the owl pellet accumulations of small mammal bones in caves, represent the remains of past activity by owls that frequented caves and cave entrances, possibly many decades or even centuries ago (**Bowdler, 1984; Hall, 1975; Hollands, 1991; Wakefield, 1969**).

There are only three or four active owl roost sites in Tasmanian caves, known to the writer at time of presentation of this paper; all of these are located in forested karst areas of southern Tasmania: in the Cracroft, Ida Bay and Precipitous Bluff karst areas. However, there is evidence that caves have been previously used as owl roosting sites in several other caves in Tasmanian karst areas, including Bubs Hill, Hastings, Junee-Florentine, Mole Creek and Mount Weld (see Figure 1).

It is quite likely that there are other owl roost sites in Tasmanian caves and karst areas, particularly in the forested regions that owls, such as the Tasmanian Masked Owl (*Tyto novaehollandiae*), are known to frequent. One of these presumed past owl occupation sites includes Newdegate Cave (H-X7): the present tourist cave in the Hastings karst area of southern Tasmania, where the writer has been recently engaged in collating an inventory of the cave dwelling invertebrate species. Many of the small mammal bone fragments found in Newdegate Cave have been fractured or broken, probably subsequent to deposition.

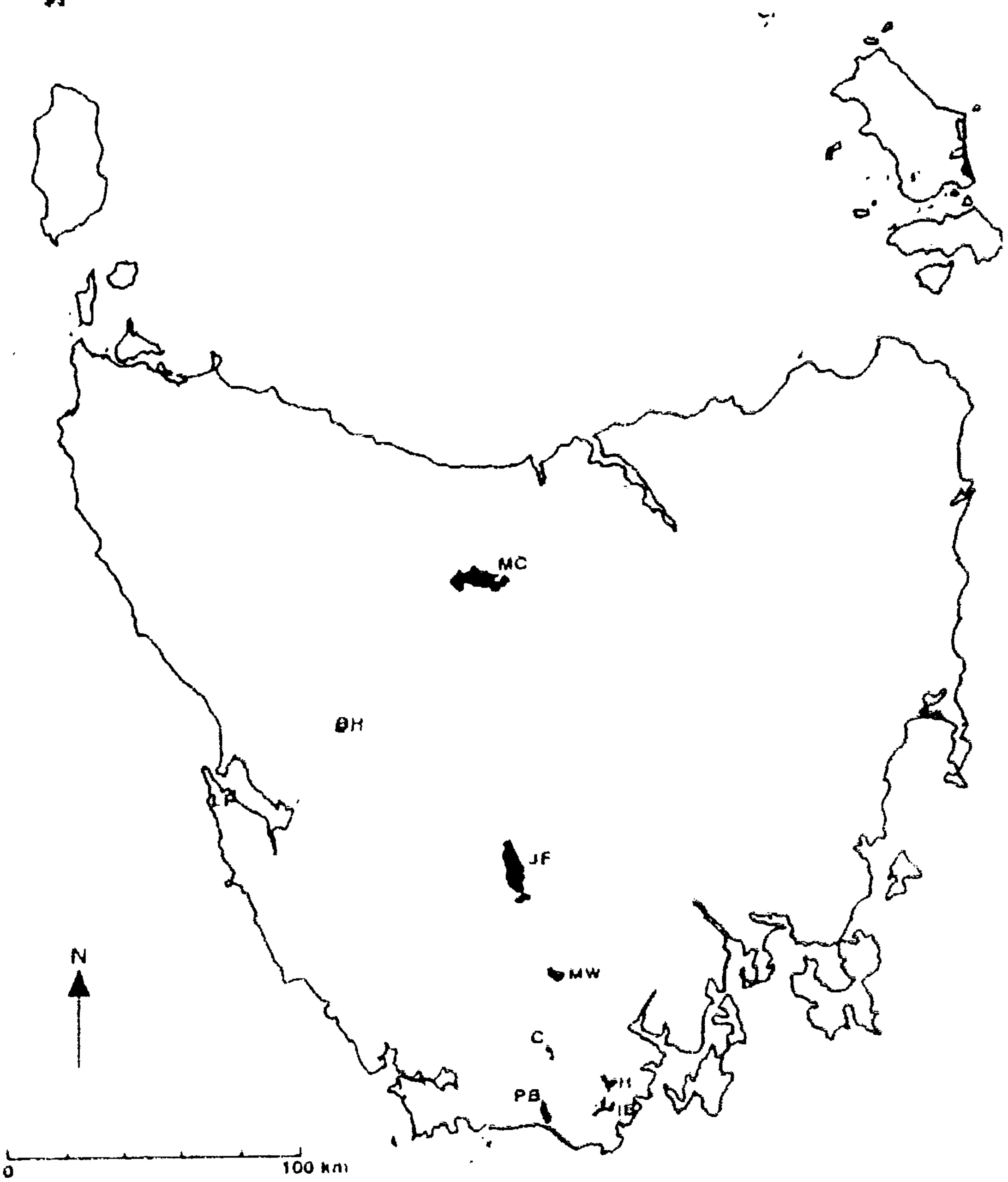


Figure 1: Map of Tasmania showing location of the eight karst areas with the records of caves containing owls or owl pellets (as discussed in this paper). The karst areas are shown by their respective ASF Cave Area codes: BH = Bubs Hill, C = Cracroft, H = Hastings, IB = Ida Bay, JF = Junee-Florentine, MC = Mole Creek, MW = Mount Weld and PB = Precipitous Bluff.

The formation of owl pellets:

The avian (bird) stomach consists of two parts: the first (top) stomach is a glandular organ with enzymes, where most initial digestion takes place; the second (bottom) stomach is a muscular organ, sometimes referred to as a gizzard. In fowls, this second stomach, which is sometimes referred to as the "crop", acts as a grinding organ to mash up the partly digested and softened seed grains, grit and other foodstuffs. In raptors, such as owls, this second stomach acts as a filter, holding back the insoluble food substances such as bone, teeth, claw-tips, fur, feathers, the chitinous exoskeletons of insects or spiders and sometimes cellulose (Hall, 1975; Mooney 1993).

Most animal species have the ability to selectively choose which parts of a food source they wish to consume. Many bird species, including some raptors, can use their beaks or claws to separate seeds from husks or flesh from bone, but owls can only roughly tear their prey apart and tend to swallow their prey food whole. During a breeding season, when there are young owl chicks in the nest, owls will often decapitate their prey and swallow the heads whole, bringing the remaining body back to the nest for the chicks (**Hollands, 1991**). Following initial digestion in the glandular stomach, the remaining indigestible foodstuffs including skull, mandibles (jawbones or dentaries) and other bone parts accumulate in this second filtering stomach (or gizzard) where it is compressed into the shape of the gizzard, coated in mucous and regurgitated as a pellet while the owl is roosting. Owls will usually regurgitate at least one pellet a day, sometimes two or more depending on the species, their prey foraging habits and success rate of prey capture. The *Tyto* species of owls usually only regurgitate a single pellet each day, regurgitated at their favourite roost place: their pellets tend to be highly compressed and are usually much more durable (**Hollands, 1991**).

The importance of cave sites:

In a forest habitat, the owl pellets are dispersed quite rapidly, by bacteria, insects, fungi and marauding scavengers including other mammals and birds. In caves, the pellets tend to be well preserved, possibly due in part to the presence of a moist calcareous environment. In dry caves where there are often less bacteria or insects compared to more moist cave environments and epigean (surface) habitats, the pellets may retain their shape for several months and the component parts including fur and feathers may remain unchanged for many years (**Hollands, 1991**). Over time, these single individual pellets found in caves may coalesce to form a large accumulation mound, which may represent a considerable period spanning several decades or centuries (**Clarke, 1988; Hall, 1975**) or many thousands of years (**Wakefield, 1969**). An owl pellet accumulation from Cave Bay Cave on Hunter Island in north-western Tasmania has been dated back to late Pleistocene times, *circa* 19,000 years BP (**Bowdler, 1984**).

Caves are important for several other reasons:

- They provide an excellent site for researchers (zoologists or speleologists) to study recent owl pellet remains or the long term older accumulations;
- The pellet sites can yield information of other animal species within the 1-2 kilometre foraging range of owl roosts, particularly extant (living) mammal species that may not have been seen during routine trappings or observations by zoologists (**Clarke, 1987b; 1988; Hall, 1975; Hollands, 1991; Mooney, 1993**);
- The deposits can provide information on the availability of prey food, food preferences or dietary selection over a given period of time (**Mooney, 1993**);
- Owl pellet deposits can provide records for extant mammal species that may be no longer known or recorded in that particular geographic area (**Hall, 1975; Mooney, 1993; Wakefield, 1969**);
- The larger or deeper (older) accumulations often contain records of extinct species, either from recent decades, last century or pre-European settlement (**Hall, 1975; Hollands, 1991**), or dating back to pre-historic times in the Pleistocene era (**Bowdler, 1984; Wakefield, 1969**);
- Older deposits may be important sites for age determination (using bone carbon or charcoal) for dating the occupation by owls in those caves (**Bowdler, 1984**);
- An analysis of the species types and food selection in the older deposits may also provide speculative or actual information relating to vegetation or climatic change over a period of time, plus the possible anthropological effects of aboriginal or European man on native fauna (**Bowdler, 1984; Wakefield, 1969**);

- The presence of larger disused or abandoned deposits at the base of avens or cave chambers may also be important as a geomorphic tool, providing a useful indicator to the likely presence of previous cave entrances that may have become subsequently blocked by surface tree fall, doline or cave entrance collapse or the more recent deposition of speleothems.

In the paper presented by Les Hall (to the 10th ASF Biennial Conference), where he compares his work in Marble Arch with the results of excavations in Pyramid Cave at Buchan **(Wakefield, 1969)**, Hall has identified some 23 mammals, based on his detailed excavation of owl pellet accumulations at Marble Arch, 60km southeast of Canberra **(Hall, 1975)**. A similar number of mammalian species were determined from the bone accumulation in Cave Bay Cave on Hunter Island (which is presumed to be a combined peregrine falcon deposit in Holocene times and an owl pellet accumulation during the Late Pleistocene); this latter deposit is dated 19,000 years BP **(Bowdler, 1984)**. In the more recent 1989 paper by Nick Mooney, where he details the past and present diet of the Tasmanian Masked Owl, he lists a total of 26 extant mammal species from 15 widely dispersed collection sites in northern, central and southern Tasmania **(Mooney, 1993)** .

Owls, owl pellets and accumulation deposits in Tasmanian karst areas and caves:

Three species of owls are known to frequent sandstone rock shelters and solution caves in Tasmania: the Southern Boobook or Mopoke (*Ninox novaeseelandiae*), the Barn Owl (*Tyto alba*) and the Tasmanian Masked Owl (*Tyto novaehollandiae*). The Boobooks use a range of habitats including forests, farmland trees and leafy suburban trees; Barn Owls tend to favour more open habitats, farmland and offshore islands, rather than more densely forested areas and/or open woodlands (which the Masked Owl prefers) where most Tasmanian caves are found **(Hollands, 1991)**. Similarly, Boobooks tend to be more insectivorous (insect eaters), in preference to predating on larger mammals such as rats and although known to frequent caves, they do not regularly roost in the same place. Barn Owls are rarely seen in Tasmania and although known to occasionally use caves in mainland Australia, their preferred diet is frogs, lizards, small birds and small rodents such as the introduced House Mouse, rather than the larger range of mammal species which the Masked Owls predate **[pers. comm., D. Hollands, 1998]**. Although the Tasmanian Masked Owl has a varied diet, studies of their pellets indicate that over 90% of their biomass prey food are mammal species **(Mooney, 1993)** and it is suggested that these owls are the likely source for most of the owl pellets found in Tasmanian caves **[pers. comm., N. Mooney,1998]**.

The writer has observed the presence of owls and/or their regurgitated pellets, plus a few accumulation mounds in a number of Tasmanian caves in several karst areas: Bubs Hill, Cracroft, Hastings, Ida Bay, Junee-Florentine, Mole Creek, Mount Weld and Precipitous Bluff (see Figure 1). The following list of these karst areas includes those caves which are still active owl pellet accumulation sites (marked by an asterisk "[*]") and sites from where mammal species have been collected or identified (denoted by the hash symbol "[#]"). The records of identified mammal species are listed in Table 1.

- BUBS HILL (western Tasmania): *WCOC Cave* (BH-3) [#]; *The Downpipe Connector* (BH-7) [#];
- CRACROFT (southwest Tasmania): *The Propylaeum* (C-17) and *Cemetery Shaft* [* / #] extension into *Wargata Mina* (C-1), formerly known as *Judds Cavern* - includes large (un-measured) accumulation mound under present day pellets;
- HASTINGS (southern Tasmania): *Newdegate Cave* (H-X7) [# see text below];
- IDA BAY (southern Tasmania): *Hooks Hole* (IB-26) [#] - non-active site with an ancient accumulation mound, approximately 1.0-1.2m wide and 35-40cm high; un-named cave (IB-32) [#];

March Fly Pot (IB-46) [#]; *Pseudocheirus* (IB-97) [?*?/#]; *Machete Pot* (IB-107) [*/#] - active pellet deposition above a small accumulation mound, 0.7-0.8m wide and 15-20cm high;

- JUNEE-FLORENTINE (southern Tasmania): *Owl Pot* (JF-221);
- MOLE CREEK (northern Tasmania): *Honeycomb Cave* (MC-84);
- MOUNT WELD (southwest Tasmania): *Arrakis* - top cave entrance (MW-X1) [#];
- PRECIPITOUS BLUFF (southern Tasmania): *Cueva Blanca* (PB-4); *Bauhaus* (PB-6); *Christmas Cavern* (PB-18) [*].

Small mammal species from owl pellet remains in Tasmanian caves:

The following analysis of mammal species in Table 1, represents the results of a brief examination by the writer of a number of owl pellet sites in Tasmanian caves, during bio-speleological studies over a period of 15 or more years. The list of ten positively identified mammal species (plus a few further possible unidentified species) is not intended to be an exhaustive list or comprehensive statement of all the mammals present at any given cave site and hence should be considered as largely incomplete.

The list merely represents a summary of my records of identification, based on a cursory examination and study of the mammalian remains in the surface scatter of a number of owl pellets, some of which were immediately above accumulation mounds.

All the mammals listed in Table 1 were identified from either skull or mandible (jawbone) remains. The earlier identifications were performed by Bob Green (the former Curator of Vertebrate Zoology at the Queen Victoria Museum in Launceston, Tasmania) and the more recent sub-fossil mammalian remains from Newdegate Cave (H-X7) were identified by the writer - based on a microscopic study of the anatomy and dentition of their mandibles and reference to **Green and Rainbird (1983)** [see Figure 2], plus some reference to **Hall (1975)** and **Triggs (1996)**.

Table 1: Identified mammals from owl pellet remains in Tasmanian caves

Common Name	Scientific name	Cave sites	Identification	Reference
Dusky Antechinus	*Antechinus swainsonii*	C-1 (C-17);	R.H. Green	Clarke, 1987a; 1987b
		H-X7;	A.K. Clarke	
		IB-26; IB-97; IB-107	R.H. Green	Clarke, 1987b;1988
		MW-X1	R.H. Green	Clarke, 1987b
Swamp Antechinus	*Antechinus minimus*	BH-3;BH-7;	R.H. Green	Clarke, 1989
		C-1 (C-17);	R.H. Green	Clarke, 1987a; 1987b
		H-X7	A.K. Clarke	
		IB-26	R.H. Green	Clarke, 1987b;1988
Unidentified dasyurid:	*Antechinus stuartii* (??)	H-X7	A.K. Clarke	
Unidentified dasyurid:	*Sminthopsis leucopus* (??)	H-X7	A.K. Clarke	
Little Pygmy Possum	*Cercatetus lepidus*	H-X7	A.K. Clarke	
Eastern Pygmy Possum	*Cercartetus nanus*	H-X7	A.K. Clarke	
Brown Rat	*Rattus norvegicus*	IB-32; IB-97; IB-107	R.H. Green	Clarke, 1987b;1988
		H-X7	A.K. Clarke	
Swamp Rat	*Rattus lutreolus*	BH-7;	R.H. Green	Clarke, 1989
		C-1 (C-17);	R.H. Green	Clarke, 1987a; 1987b
		H-X7	A.K. Clarke	
		IB-26	R.H. Green	Clarke, 1988

Broad-toothed Rat	*Mastacomys fuscus*	MW-X1; H-X7	R.H. Green A.K. Clarke	Clarke, 1987b
Long-tailed Mouse	*Pseudomys higginsi*	C-1 (C-17); H-X7	R.H. Green A.K. Clarke	Clarke, 1987a; 1987b
		IB-26; IB-46; IB-107	R.H. Green	Clarke, 1987b;1988
		MW-X1	R.H. Green	Clarke, 1987b
New Holland Mouse	*Pseudomys novaehollandiae*	BH-7;	R.H. Green	Clarke, 1989
		H-X7;	A.K. Clarke	
		IB-46	R.H. Green	Clarke, 1987b;1988
		MW-X1		Clarke, 1987b
Unidentified Muridae:		H-X7	A.K. Clarke	
Ringtail Possum	*Pseudocheirus pergerinus*	IB-97	R.H. Green	Clarke, 1987b;1988

Small mammal bones from owl pellet remains in Newdegate Cave:

Newdegate Cave (H-X7) is the present tourist cave in the Hastings karst area of southern Tasmania, 125km south of Hobart. In similarity with a number of the other Tasmanian caves where owl pellet remains have been found, Newdegate Cave has an entrance that would have been suitable for the flight of owls, to and fro from the cave. The reasonably sized 2.5-3.0 metre high, 2m wide horizontal entrance (now gated) leads down a short inclined staircase passage through massive speleothems and large calcite coated rock fragments, then flattens out to a gently sloping cave passage leading to the present spiral staircase above the first main large chamber that connects to the *Central Hall*. On the left hand side of the gently sloping passage the cave is floored with flowstone and cave coral, which slopes down to a flattened area with platelets of calcified mud, ancient gours and cave pearl deposits. During the recent rehabilitation efforts in Newdegate Cave, a wide scatter of predominantly fragmented mammalian bone remains were discovered on this short slope of flowstone and cave coral (see subsequent Figure 3).

Prior to the rehabilitation of Newdegate Cave, this slope of flowstone and cave coral, along with the mud platelets, gours with cave pearls, was previously covered by several layers of embedded clay and "blue-metal" gravels that abutted to the central concrete pathway. Consequently, most of the sub-fossil bone material is now coated with a thin layer of clay. Although some of this clay may have been washed down from the entrance or higher up in the cave, most of it appears to have been transported into the cave and inadvertently dumped on the top of the bone deposit and speleothems during earlier stages in the development of pathways into the tourist cave.

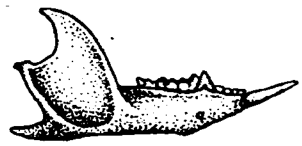
The bone site is appealing as an owl pellet deposit site because it lies beneath some short 3-4m high walls with small ledges that would probably have been suitable for roosting owls. Dominant amongst these sub-fossil skeletal mammalian remains, are the small "harder" or more resilient bones: leg bones, tiny vertebrae, rib-bones, mandibles and teeth, with rare occasional paper-thin fragments of cranial skull. Many of these bone pieces are damaged: broken and fragmented, possibly due to the dumping of clay and gravel overburden (but see concluding comments). In mid-November (1998), approximately 37 major bone pieces were collected along two half-metre transects, each containing five adjoining 10cm square grids with selective preference given to collecting the more easily identified material: 23 mandibles, 7 teeth and 7 leg bones. There were very few matching left and right mandibles of individual species beside each other in any one grid square so total species numbers to date have been determined from the individual mandibles and teeth (six murid incisors and one dasyurid *Antechinus* premolar) and only one of the seven leg bones has been identified.

It is an unknown oddity as to why the bone collection contained 17 left-hand side (LHS) mandibles, compared to only six right-hand side (RHS) mandibles. [Perhaps the reason is due to the fact that my major reference source in Green and Rainbird (1983) only depicted illustrations of RHS mandibles - see Figure 2.]

Dusky Antechinus
Antechinus swainsonii x 2
$I\frac{4}{3}, C\frac{1}{1}, P\frac{3}{3}, M\frac{4}{4}, = 46.$

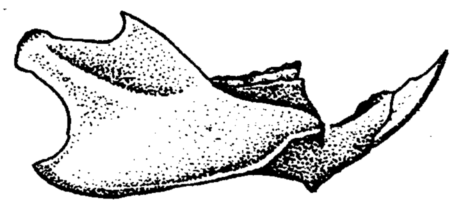
Swamp Antechinus
Antechinus minimus x 2
$I\frac{4}{3}, C\frac{1}{1}, P\frac{3}{3}, M\frac{4}{4}, = 46.$

Little Pygmy-possum
Cercartetus lepidus x 2
$I\frac{3}{1}, C\frac{1}{0}, P\frac{3}{4}, M\frac{4}{4}, = 40.$



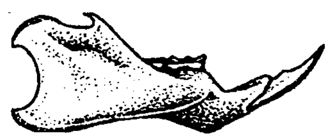
Eastern Pygmy-possum
Cercartetus nanus x 2
$I\frac{3}{1}, C\frac{1}{0}, P\frac{3}{4}, M\frac{3}{3}, = 36.$

Swamp Rat
Rattus lutreolus x 2
$I\frac{1}{1}, C\frac{0}{0}, P\frac{0}{0}, M\frac{3}{3}, = 16.$



Broad-toothed Rat
Mastacomys fuscus x 2
$I\frac{1}{1}, C\frac{0}{0}, P\frac{0}{0}, M\frac{3}{3}, = 16.$

New Holland Mouse
Pseudomys novaehollandiae x 2
$I\frac{1}{1}, C\frac{0}{0}, P\frac{0}{0}, M\frac{3}{3}, = 16.$



Long-tailed Mouse
Pseudomys higginsi x 2
$I\frac{1}{1}, C\frac{0}{0}, P\frac{0}{0}, M\frac{3}{3}, = 16.$

Figure 2: Diagram depicting the right-hand side (RHS) mandibles of the eight native mammal species found amongst the "presumed" owl pellet remains inside Newdegate Cave (H-X7) in the Hastings karst of southern Tasmania. The diagrams and captions for the depicted mandibles (drawn at twice the normal size of mature adult specimens) are taken from Green and Rainbird (1983). The captions include the respective dental formula for upper jaw (skull) and lower jaw (mandible) dentition: incisors (I), canines (C), pre-molars (P) and molars (M). (These diagrams are reproduced with kind permission from R.H. (Bob) Green and Judy Rainbird.) Note: The introduced Brown Rat species is not shown above.

Apart from the six unidentified leg bones, a preliminary analysis of the identified (ID) skeletal material from the "presumed" owl pellet remains in Newdegate Cave, indicates the presence of 31 individual specimens representing nine confirmed mammal species (see Figure 2) and possibly two other dasyurid species (as listed in Table 1). Details are as follows:

- Dusky Antechinus - 4 specimens: ID from 2 x LHS mandibles; 1 x RHS mandible; 1 x premolar tooth;
- Swamp Antechinus - 1 specimen: ID from 1 x LHS mandible;
- Unidentified dasyurid (antechinus), clustered "wrap around" teeth, with similar appearance to mainland species: Brown Antechinus - 1 x LHS mandible;
- Unidentified dasyurid, possibly White-footed Dunnart - 1 x RHS mandible fragment;
- Little Pygmy Possum - 2 specimens: ID from 1 x LHS mandible; 1 x RHS mandible;
- Eastern Pygmy Possum - 2 specimens: ID from 1 x LHS mandible; 1 x leg bone (humerus) with prominent flange;
- Brown Rat - 3 specimens: ID from 2 x LHS mandibles; 1 x RHS mandible
- Swamp Rat - 6 specimens: ID from 2 x LHS mandibles; 4 x incisor teeth;
- Broad-toothed Rat - 4 specimens: ID from 2 x LHS mandibles; 2 x incisor teeth;
- New Holland Mouse - 3 specimens: ID from 2 x LHS mandible; 1 x RHS mandible;
- Long-tailed Mouse - 4 specimens: ID from 3 x LHS mandibles; 1 x RHS mandible.

Concluding remarks on the small mammal bones and their fragmentation:

Many of the vertical caves in forested areas of Tasmania have been described as mammal traps, where the vertical entrances act as pitfall traps (Clarke, 1988); however these sub-fossil bone deposits are not restricted to caves with vertical entrances. The skeletal remains of small mammal species are often found in caves, particularly near entrances and those caves with narrow fissured or vertical entrances, where animals crawl in for shelter and become trapped or fall into the cave. Apart from owls, there are several mammal predators that use caves and these animals will introduce excreted bone matter into the cave. Based on her study of the older Holocene and Late Pleistocene deposits in Cave Bay Cave, Bowdler (1984) suggests such predators as native cats, Tasmanian Devils, Tasmanian Tiger (Thylacine) and perhaps even the Tasmanian Lion (*Thylocoleo carnifex*) may have used Tasmanian caves as habitation sites. However, many of their prey would have been larger species (compared to those expected from owl roost sites) and unlike the predominantly intact whole bones and skulls regurgitated by owls, the bones left by mammal predators would be chewed and broken.

The position of this small mammal bone site in Newdegate Cave (Figure 3) suggests that it is unlikely that these bones would have simply been washed in to the cave or be the result of animals that have fallen in or been trapped in entrance crevices. Since the bone deposit is located within the entrance passage series to the cave, it is more likely that the skeletal material could have been trampled on by early cave visitors or the labourers engaged in the construction works for establishing the site as a tourist cave.

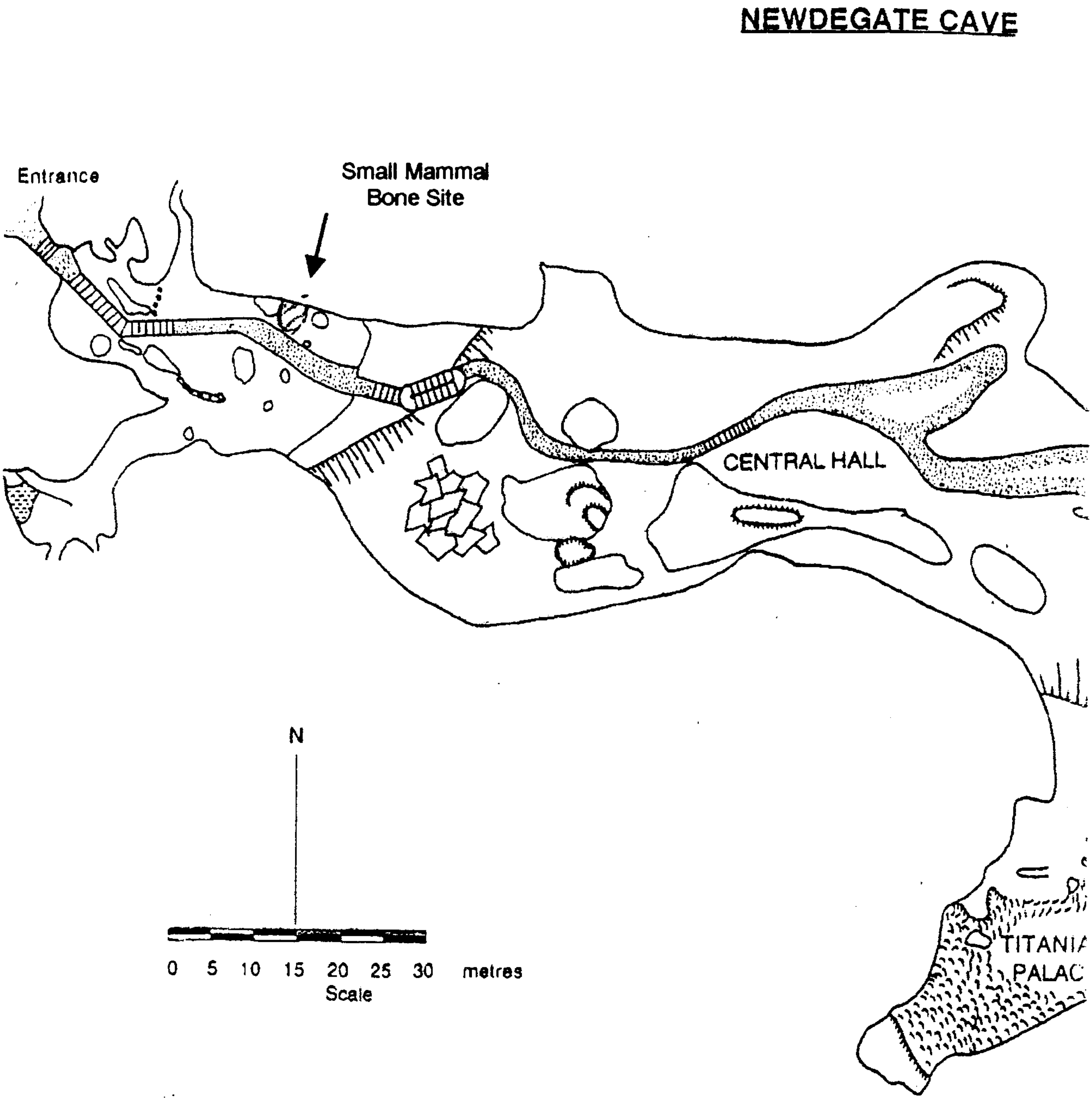


Figure 3: The entrance series of passages and chambers in Newdegate Cave (the present tourist cave in the Hastings karst area of southern Tasmania), showing location of the sub-fossil bone deposit of small mammal species, presumed to be derived from owl pellet remains of the Tasmanian Masked Owl: *Tyto novaehollandiae*. [Map is excerpted from the 1947 cave survey of Newdegate Cave by the former Tasmanian Caverneering Club.]

As previously mentioned, prior to the recent rehabilitation works in Newdegate Cave, this bone site was plastered by layers of compacted clay and blue metal which would have surely caused considerable breakage to the underlying bones. The above-mentioned predator factor could also have contributed to the breakage and fragmentation of bone, since predator species including brushtail possums and reptiles are known to use Tasmanian caves, they might scavenge on owl pellets and also be responsible for the scatter of pellets or small mounds.

However, despite the limited number of specimens collected from Newdegate Cave, the presence of small mammal species and the range of species present with the predominant ratio of rodents over dasyurids, all typify the results found in previous surveys of owl pellet sites conducted by Bowdler (1984) Hall (1975) and Mooney (1993). In most owl pellet deposits, there is a preponderance of rodent bones and although only a small sample was collected during this study, two-thirds of the 31 identified individuals belong to the five murid (rodent) species, which represent over half the total number of nine individual species here. Eight of the nine species (shown in Figure 2) are native species; the additional species: the introduced Brown Rat (*Rattus norvegicus*), may be due to the presence of nearby settlements along the Hastings Road or a legacy of the early pioneering loggers, millers and the tramway construction teams who camped in the foothills near the Hastings Caves Hill.

Assuming my identifications are correct, there are two final observations regarding the small mammal bone deposit in Newdegate Cave: the presence of the New Holland Mouse (*Pseudomys novaehollandiae*) and the Broad-toothed Rat (*Mastacomys fuscus*). The New Holland Mouse is generally only known from coastal lowlands and presently extant species in Tasmania have only been recorded in the far northeast and east coast, down to Freycinet Peninsula [pers. comm., R. Rose, 1998]. The Hastings Caves area abuts on to the Lune River plains which are only a few kilometres from the coast, so it is possible that if these bones in Newdegate Cave represent part of an older deposit, this rodent species may have had a wider distribution in the past. As shown in Table 1 (with reference to Figure 1), my records indicate that the New Holland Mouse has also been recorded in caves of the Mount Weld and Bubs Hill karsts: both of these areas are in excess of 40km from the sea and/or open lowland coastal plains. In his study of the Marble Arch deposit, 40km south of Braidwood (and a considerable distance from the NSW South Coast), Les Hall commented that the New Holland Mouse was only found in the older basal section of his excavated deposit, suggesting that this species had a much wider, more inland distribution in the past. Similarly, the present known distribution range for the Broad-toothed Rat in western Tasmania and alpine regions would suggest that these specimens in Newdegate Cave represent a considerable expansion of its known range. It is possibly further evidence to suggest that these bone remains are part of an older deposit, when species such as the Broad-toothed Rat had a wider distribution. Nick Mooney has also commented that some of the bones collected from his field studies of owl roost sites indicate that the Broad-toothed Rat has previously been found a lot further east and south of its present day habitat [pers. comm., N. Mooney,1998].

Acknowledgments:

I am indebted to Ian Houshold for the opportunity to conduct biospelelogy studies in Newdegate Cave and for the assistance given me by Hastings Caves rangers, particularly Roger Griffiths and Peter Price. I am very grateful to the support with identifications offered to me by R.H. (Bob) Green and also to Bob Green and Judy Rainbird for permitting me to reproduce their illustrations of the mandibles of the eight native species from Newdegate Cave, shown in Figure 2. I am also very grateful to the kind assistance of Nick Mooney including the loan of two valuable reference books, plus subsequent talks and email exchanges. Through Nick, I was also able to make phone contact with David Hollands and Barbara Triggs who both gave me valuable advice in regard to owls, their habits and owl pellet remains. I am also extremely grateful to Barbara for the prompt dispatch of her new book: "*Tracks, Scats and other Traces*". Thanks also go to Dr. Randy Rose in the School of Biological Sciences at the University of Tasmania for assistance with mammal species distribution records. Finally, I should also like to thank John and Jeanette Dunkley who forwarded me the copy of Les Hall's paper presented at the10th ASF Biennial Conference in Brisbane in December, 1974.

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GEOLOGY OF THE MT ETNA AREA

by C H C Shannon

Summary and Introduction

The section of the book, Mt Etna Caves titled "Geology of the Mt Etna area" contains valuable information and concepts that are not readily accessible since the book has been out of print for years. This paper is a modestly updated "rehash" of the 1970 version with some additional material from Morand (1993) dealing with other Devonian limestone bearing sequences in Central Queensland.

The Devonian age rocks including the limestone are confined to an inlier, so limestone bearing country stops abruptly where it goes under the cover of younger rocks. Within the inlier, the structure is anticlinal with the "nose" near Cammoo, and East limb through Mt Etna and a Northeast limb extending from Johanssens. There are complications: dykes of easily weathered andesite make for gaps in the outcrop and a set of north trending faults repeats the nose of the structure.

Once the true bedding had been deciphered, it was possible to subdivide the Mt Etna Limestone erecting local "informal" member divisions. It would seem that the base of the thin-bedded Mt Etna Trig Member is the base of Morand's Barmudoo Formation, with the limestone and below part of his Mt Holly Formation. The map was drawn as a "superficial deposits eliminated" and is not reliable where there is in fact extensive cover.

The speleogenesis for the caves is related to water collection on bare rock catchment and is independent of, and if anything, inhibited by any prior collection of water into streams on non-limestone catchment (almost essential for cave development in "ordinary Australian" cave complexes). Yet the caves in the Rockhampton bare karst occupy more of the limestone than is the case say, at Jenolan or Yarrangobilly. A probable solution is found in the earth sumps found in many of the caves (and presumably all if you could get down to them) which are considered to generate acid of "soil air" proportions, that is several percent carbon dioxide in contrast to ordinary cave rivers which are in equilibrium with ordinary atmospheric levels of carbon dioxide. The supersaturated nature of the spring water draining from the karst is supportive of this model.

The term barekarst is better than towerkarst for the Mt Etna district karsted outcrops, since they are only marginally and locally cliffed at the boundary with the unconsolidated deposits. It is the sloping bare rock surface that decides the character of the karst.

There are other karsts which share these features most notably Yessabah, NSW ; Fanning River, Q; also the Bullita complex, NT and the North Queensland karsts.

Here follows the original article as in *Mt Etna Caves:*

Introduction

The geological interest of Mt Etna centres on the karst phenomena, which includes the highest towerkarst hills and the most accessible examples of towerkarst landforms on the Australian continent. Also, the fossil fauna of the limestone is of longstanding interest to palaeontologists. Fossils collected from the foot of Mt Etna are of early Devonian age. This fauna is old for central or southern Queensland and serves to place an upper limit on the age of the underlying basement rocks.

The Devonian strata form an inlier surrounded by Permian volcanics (Berserker Beds) and Cainozoic sediments. The Devonian rocks apparently extend as far as Milman.

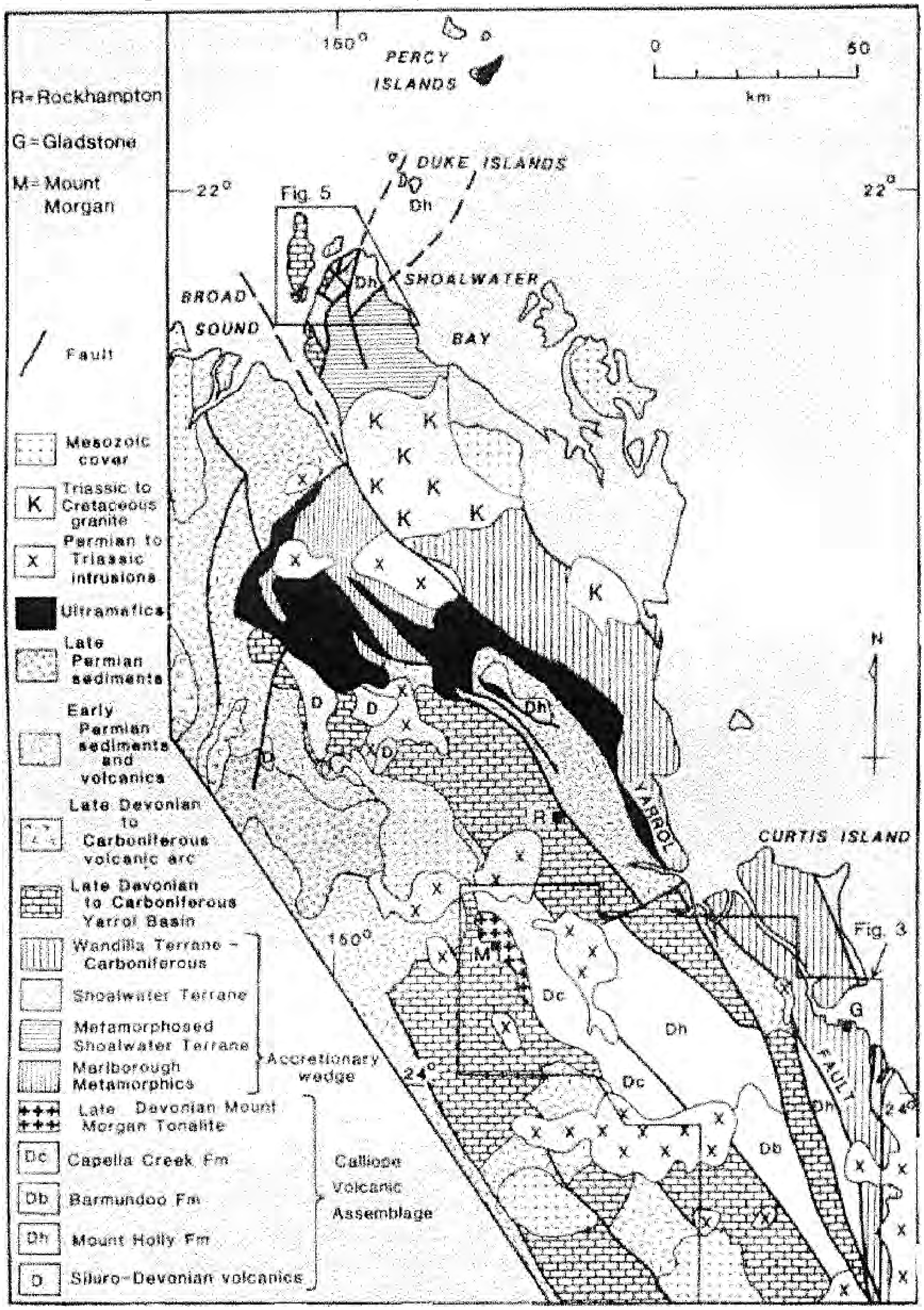
The structural problem of the Devonian rocks presented an impasse to refined work on the palaeoecology of the district. The recent solution to this problem makes possible tenable outlines for the stratigraphy and hydrology. Surface geomorphology has not yet been subject to intensive study.

Early work on the karst phenomena was not very profound, despite the popularity of the caves around the turn of the century. The first rigorous work pertaining to the caves was performed during the Second World War, when a map of six caves on Mt Etna was produced by 'Z Force' commandos under Captain S.W. Carey (later Professor). Further maps have been produced by UQSS members, but the majority of caves lack high-grade surveys at present. Speleogenesis of these caves is not directly comparable with the better known caves of temperate regions. Working hypotheses are set out, which serve to explain some of the differences.

Stratigraphy and petrology

The compilers of the most recently published map of the Mt Etna area recognise two major stratigraphic units in The Caves district. These are the Devonian Mt Etna Beds and the Permian Berserker Beds (see Rockhampton 1:250 000 geological map, provisional edition). A third unit is present which is older than the Mt Etna Beds.

The map following is from: Morand, V.J. (1993)



The sequence has its best exposure along the meridian of the Mt Etna trig. Station. The stratigraphic units are quite distinct, but dip information is scarce and so the thicknesses given below are approximations.

The sequence is as follows:

Pre-Devonian or Lower Devonian

Tufa Creek Beds', 100 foot minimum, base not exposed. Dark grey shales and massive greywacke; minor chert. The rocks in outcrop are indurated but lack slaty cleavage; though since the outcrops are close to igneous contacts both induration and lack of cleavage could be due to contact metamorphism. The rocks appear to be deep water turbidites belong to the pre-Devonian basement, but the bedding attitudes are close enough to those of the limestone to allow conformable sequence between the formations.

Igneous, age uncertain

'Pershouse Well Serpentinite', 700 foot maximum. Porphyritic green serpentinite, granular grey serpentinite, sheared grey and green serpentinite, calcite-magnesite-serpentine rock. (This last has a network of calcite veins making up to 80% of the rock with relict serpentine cores.) Gabbro dykes intrude the serpentinite. The contact of the serpentinite with the Tufa Creek Beds is presumably intrusive, but its contact with the Mt Etna Beds could either be intrusive or erosional on present evidence.

Lower to Middle? Devonian

Mt Etna Beds

3.1 'Bates Farmhouse Limestone', 100 metres. Organic limestone. The principal components are crinoid debris and stromatoporids; there are some chert nodules. A rich fauna of rugose and tabulate corals has been collected from this member, mostly from floaters.

3.2 'Speleo Camp Member', 17 metres. Reworked andesite tuff containing crinoid fossils, very coarse grained calcareous sandstone and limestone. Tabulate corals are common.

3.3 'Mt Etna Caves Limestone', 270 metres. Massive and organic limestone, some reef limestone with pink siltstone internal sediment, rare bedded limestone; sometimes with chert nodules. Most of the limestone lacks fossils, but crinoid ossicles occur in the lower part and tabulate corals and stromatoporoids occur in several beds.

3.4 'Mt Etna Trig Member', 170 metres. Laminated thin bedded siltstone, calcareous mudstone and dolomite. These sediments may represent a backreef facies transgressive over the limestone.

3.5 'Cammoo Member', 350 metres minimum. A poorly exposed unit thought to consist of andesite tuff and andesite.

Permian

4. Berserker Beds, mainly green rhyolite tuff and ignimbrite. They unconformably overlie the older rocks.

Structural geology

The structure of the Devonian rocks is difficult to determine because of the massive character of the limestone and poor outcrop conditions. The attitude of strata can, however, be determined from bedding in the limestone as defined by several criteria, which are mutually consistent. Places where bedding can be determined in the limestone are rare, but sufficient observations can be made to solve the structure. The rare thin bedded facies of the limestone has been most useful; in both surface and underground exposures, the bedding planes in this facies outcrop as etched pits and grooves in a system of parallel but unevenly spaced partings, usually about 5 cm but varying from 2-50 cm. The bedding planes are warped with low amplitude folds; wavelengths 5-100cm, amplitude a half cm to 10 cm, giving a "wavy" appearance. This peculiar appearance of bedding surfaces helps to distinguish them from the joint surfaces, which are strictly planar. It was also found that in this facies, the discoidal stromatoporoid and tabulate coral colonies were in growth position, lying flat on the bedding plane. Further dip measurements taken on stromatoporoid colonies, and also dips taken on internal sediment filling reef cavities have proven to be compatible with measurements from the thin-bedded limestone facies.

The new dip information clashed with the earlier "inclined bed" interpretation of the structure, particularly in the Johannsen's Caves area. The author developed an hypothesis of anticlinal structure to account for the 'aberrant' sequence of dips, and this hypothesis was confirmed when a continuation of the limestone beds about a kilometre long were traced through the adjacent area of poor outcrop. Details of the structure have been worked out by air photo interpretation and field work

The basic structure of the Mt Etna Beds is an anticline, with its axis trending WNW and plunging to SSE. It is complicated by a set of cross faults trending N 10 degrees E. The NW limb is apparently attenuated along an axial thrust fault, although this observed thinning of the unit may be a depositional feature of the limestone. The valley between the limestone hills is occupied partly by igneous rock interpreted here as a large faulted dyke, with a number of smaller dykes not shown on the map. These intrusions cut across the limestone strata. Crystal or Limestone peak at the South end of Limestone Ridge is an upfaulted section of the anticlinal nose, while the Johannsen's section of Limestone Ridge contains part of the nose and the start of the NW limb. Mt Etna contains the exposed section of the southern limb of the limestone outcrop.

On Limestone Peak, in particular, there is much small scale folding which is considered to be due to crumpling of the limestone in the axis of the fold.

Geomorphology

The Mt Etna area appears to be an unique class of towerkarst with affinities to arid tropical towerkarsts such as at Chillagoe, Queensland or the West Kimberleys in Western Australia. The main feature in common with the described examples of arid tropical towerkarst is the pediment surrounding the residual limestone hills, but the hills of Mt Etna are conical with much talus around the base and have practically no cliffs. Normal dry towerkarst hills are cliffed in such a way that they become cylindrical or pointed spires, and are practically free of talus at the base. Mt Etna also lacks functioning resurgence caves at the foot of the residual hills which are present in the other areas mention.

The small scale surface solution features termed microkarst are splendidly developed on the limestone outcrop. The spectacular karrenfields cover large areas of bare rock pavement. Large scale solution grooves and aretes (rinnenkarren) are the dominant form, with secondary rillenkarren also common.

Grikes are not always obvious and are frequently rubble choked. Cave entrances are generally associated with either grikes or solution pipes. The vertical solution pipes can be large enough to be called dolines, though in origin and form they differ from the type form of humid karst areas. Several other forms are present, which appear to be unique to this area.

The residual hills generally have full outcrop of rock, or thin soil cover. The pediments have thick soil cover and there is little rock outcrop even in gully sections. Adjacent to the residual hills, there is generally hillwash cover.

Gours occur in the creek below a spring about 800 metres to the North of Mt Etna. This spring is considered to be the resurgence of the system, since deposition of travertine is to be expected only if the water was coming from the limestone.

Some of the oddities of Mt Etna can be explained in terms of base level changes. Fragments of the coastal erosion surface (about 70 metres) occur at the Mt Etna campsites and the caves probably developed as a normal towerkarst with resurgences at this level. The present base level is lower, and the karst spring has taken over the outflow function of Main Cave and Johannsens Caves.

Hydrology

The climate of the Mt Etna area has a large rainfall deficit (annual potential evapo-transpiration exceeding annual rainfall) and also a long dry season. In such climates, small permanent watercourses or strongly flowing springs are oddities likely to represent the effect of special geological conditions acting to retard direct run-off and evapo-transpiration. In the area of the reserves R444 and R272, about half the surface is hard catchment, either bare rock or very thin soil cover, and the run-off from these area is diverted deeply underground, where it is protected from evapo-transpiration and so gives local conditions favourable for permanent springs.

Rain falling on the limestone outcrop runs off the karrenfield areas like water from the roof of a house. The water drains from the surface into grikes, solution pipes or talus slopes and thence into the caves, either through their entrances or avens. The caves operate as conduits bringing water into the interior of the mountain. The cave watercourses can be followed down to an earth sump or an impenetrable hole. In normal weather, the earth sumps are flat areas of earth floors, with earth rich in organic matter and loosely packed. In storm conditions, some of the sumps become temporary lakes, but drainage through sump floors is quite rapid.

Beyond the sumps, the nature of the drainage is uncertain. Some shafts in Resurrection Cave reveal short sections of active streamway fed by water from Winding Stairway, and large water flows seen inside Johannsens Cave in floods would appear to come from the caves in the northern part of Limestone Ridge.

The water in most caves is collected in horizontal cave systems near the water table and it is considered that a similar "master cave" occurs here. The horizontal network of systems of Main Cave on Mt Etna and Johannsens may once have functioned as collection and discharge routes, and caves of similar form, but closer to the present water table may be expected to be active at present.

The manner of discharge of cave water has not been determined in full. Springs with karst characteristics have been found at Cammoo Park and to the North of Mt Etna. The karst spring North of Mt Etna appears to be the principal resurgence for the area.

This spring, according to local report, was permanent until the 1960s, when a dry spell set in. The spring is located on the NE limb of the anticline and the limestone is continuous between it and Johannsens caves.

The drainage of Mt Etna presents a difficulty, since the outcrop appears to be surrounded by impermeable barriers, but a link is possible through a concealed outcrop of limestone across the valley floor. No spring discharge has been observed around the rim of the limestone outcrop, at least in recent years (meaning late 1960s-early 1970s).

The rainfall on the hard catchment areas yields an average 360 acre feet per year which would yield in principle a flow of 0.5 cusecs. Naturally, there would be large evapo-transpiration losses to be subtracted from this figure, and some addition from water falling outside the limestone area.

The discharge of water from the caves can take various forms, none mutually exclusive. In dry conditions, the spring is inactive, the water being removed by percolation and transpiration. In "normal" years, there is a surplus which flows out at the spring. In extremely wet conditions, there is a direct discharge from the lower cave entrances (eg at Olsens caves in 1956, R. Semple pers.com.).

Speleogenesis and Cave Development

The caves of Mt Etna and Limestone Ridge are classifiable into two basic types; the rainwater inflow caves which are essentially vertical caves genetically related to their present function as the runoff collectors of the karrenfield areas; and the ramifying caves which possess general horizontal passage development, often with genetically related passage networks and also tributary avens which are essentially rainwater inflow caves connecting into the system. The ramifying caves are of composite development, being former water dispersion and discharge caves now modified towards rainwater inflow type. In addition to these two categories, a third type of cave is inferred which acts as a discharge route connecting to the resurgences. It may be entirely water-filled.

The rainwater inflow caves are the most common and characteristic cave type. The simplest forms are solution pipes which are transitional to surface solution pits. More commonly, these caves are joint-controlled and expand towards the base. The more important caves descend in steps to a terminal earth sump, collecting water from tributary avens as well as entrances. The stream bed occupies most of the cave floor, and the steps are made up of rubble slopes alternating with waterfalls. These caves generally follow vertical or near vertical joints; cross-sections are basically triangular and very tall. Where the controlling joint is inclined, the hanging wall is always eroded back more than the footwall. Occasionally, there are stretches of level earth-floored cave, even at high levels within the mountain, such as in Winding Stairway Cave.

The horizontal passages of the ramifying caves are generally floored with earth or guano but sometimes with bare rock. The passage cross-sections are of doorway proportions (height :width ration of 2.5 :1) with all the corners rounded off. Some of the smaller passages and squeezes depart from strict joint control and become gently winding in plan. Stream channels take up only part of the floor, but can become channels. Caverns tend to be larger than those in the rainwater inflow caves. Rockpiles occur where the caverns run up against the outside of the outcrop. The speleogenetic processes that operate at Mt Etna require discussion in some detail since they are all somewhat abnormal by comparison with the "standard" speleogenetic processes of temperate regions and have not been described before.

1. **Organic Decay Assisted Corrosion**

This process accounts for the aggressive character of water trickling through and over organic fill, even when the water has previously deposited travertine over limestone walls. It is considered that the decaying organic content of the cave material (typically rotted tree roots) is capable of generating fresh acid inside the cave itself. The fill acts as an acid-soaked sponge pressed against the limestone and direct corrosion by the re-acidulated water occurs in some sumps where lakes form during rain. More rarely, a flowing film of re-acidulated water cuts grooves in the cave wall. The acid-sponge process occurs in miniature in wall cups, which are hemispherical cups breached by a slot in the passage itself. They are found filled with organic debris (bark and bits of tree roots, or guano).

Water trickles through the accumulated matter during rain. Some of the cups have cut downwards as much as a metre. The principal site of attack, however, is the earth sump. The sumps have periods of infill and fill removal. Fill removal is general at present. Only in these parts of the caves are there much fresh limestone exposed. Rubble blocks, apparently, are dissolved here. The rubble slopes are also sites of solutional attack. The floor beneath the rubble is generally smoothly curved. Running water is able to shift earth particles, but does not actually abrade. The rubble shifts by mass wasting rather than by fluvial action. Modern cave earths are brown, friable and highly organic. In some caves older fill is exposed (eg Helms Deep). This fill is pink and highly calcareous and includes scattered bones and snail shells. In Carn Dum at least, this material apparently filled the cave at one time.

2. **Subaerial Chalky Weathering**

This form of attack breaks down the crystalline limestone to a soft, opaque "chalk". In it's fullest development, crusts form and flake off, the rock underneath becoming deeply etched and rotted. These crusts are most common in the higher parts of caverns. The process may be driven by humidity changes, possibly with actual solution and re-deposition of the calcium carbonate. Old flowstones are attacked more severely than limestone.

3. **Travertine deposition**

The main stream channels deposit travertine over any steep drop on their route to the earth sumps. Cave coral and flowstones are particularly common; other forms are generally superficial. Practically all the flowstones are fine grained without "sparkle" and with randomly oriented crystals. Resurrection Cave provides exceptions, with the "normal" coarsely crystalline-oriented crystal flowstones (ie c-axis perpendicular to growth lines). Some of the old corroded flowstones are coarsely crystalline with oriented crystals.

4. **Erosion**

The water flowing through the caves removes all the lime in solution, but also transports limestone dust and flakes and soil particles. Larger stones are shifted if at all by mass wasting processes.

5. **Direct solution by rainwater**

This occurs to a small degree near entrances.

6. **Corrosion assisted by bat excrement**

Assumed to occur in Bat Cleft where etching and rotting of rock is carried on to a greater than normal degree.

7. **Corrasion**

Some pebbles of siltstone acquire polish in splash cups. In the water chutes where corrasion would be most expected, chalky weathering and flaking of the limestone is a faster process. The flowing water hardens the chalky crust making it relatively resistant to corrasion.

The speleogenetic processes described above operate to a much smaller degree in temperate eastern Australia, but caves which bear some resemblance to those of Mt Etna, do occur. The small potholes on Viator Hill, Texas, Q (now flooded by Pike Creek Dam) and similar caves at Timor, NSW are examples. These caves are very small, basically vertical shafts, which are never developed on sufficient scale to divert much water underground.

At Timor, they generally have fig tree roots, and at Texas, fig trees probably grew there in the past. Normally these shafts are confined to level ground, typically ridge tops. At Buchan, Victoria, some dolines have enterable caves of a form somewhat like the Mt Etna caves. The common feature of all of these caves is the lack of concentrated creeks draining into them. They are all rainwater caves, not river caves.

Nevertheless, Mt Etna remains a puzzle in that it has the most cavernous limestone outcrop in Australia, yet the caves have developed in a dry subhumid climate which would be expected to inhibit cave development. Temperate rainwater caves occur as minor features in areas dominated by river caves. At Mt Etna, there are no river caves at all. The key factors allowing cave development at Mt Etna are the karrenfields, which provide a local hydrology which offsets the general dryness of the climate; and the vine forest vegetation, which send tree roots into the caves where they provide the acid necessary for the solution of the limestone.

The Chillagoe Caves resemble the ramifying type of the Mt Etna district, but without the modifications due to rejuvenation and without the rainwater inflow cave type. Water inlets are generally through daylight holes in domed caverns. In the Kimberleys, there are small caves of the Chillagoe type (ie Window Cave), but the larger caves are river caves. The humid tropical karst areas of New Guinea and New Caledonia appear to be river cave areas, but perhaps the Mt Etna type of rainwater inflow cave occurs as well.

Stalactite - Spring Cave
Chillagoe

Contrasts between river caves and rainwater inflow caves

River caves eg Yarrangobilly, NSW or Camooweal, Q	Inflow caves of Mt Etna
Typical cross sections are either flat lying ovals or composite of ovals on the top of the other	Cross-sections are generally tall triangles
Cave passages develop away from primary joints tending to meandering forms	Cave passages remain straight but the overhanging side wall is selectively eroded
Wall sculpture is characterised by directional forms, particularly scalloping and incut benches (which make up the oval elements in the cross-section)	Wall sculpture is generally non-directional; shallow dish-like hollows to a metre across are the most common
Stream sediments are well sorted, generally rounded gravels derived from the diverted surface creek, sand and bedded clay. The affinities are with alluvial deposits	Stream sediments are poorly sorted, generally angular blocks and chips of limestone with earth and vegetable matter as the matrix. Affinities are with the hill-wash(colluvium)
Flowing water is the main solution agent. The water of the underground river attacks the cave walls directly and the fill is practically inert, but the ceiling of the cave is sometimes attacked by water percolating through gravel infilled cavities. Vegetable matter is not normally present in quantity	The cave water generally deposits lime except where it is soaking through organic fill; the acid-sponge effect is the main agent of solution. The cave floor is attacked. The acid is supplied by decaying vegetable matter in place.

Contrasts between cave areas in temperate eastern Australia and Mt Etna

Yarrangobilly, Timor etc NSW	Mt Etna
Rainwater caves few, small and often not present at all	Rainwater caves dominant and river caves not present
Caves develop by diversion of surface creeks, generally on upland plateau or through creek beds. Inflow caves do not develop on steep slopes. Swallet development generally related to creeks starting outside the limestone terrain.	Inflow caves develop mainly on steep hillsides without prior concentration in gullies. There is no diversion underground of surface creeks. Inflow caves can develop entirely from the limestone catchment. Outside runoff does not seem very helpful.
The limestone outcrop generally has some soil cover except on steep cliffs and buttresses. Karren fields consist of "tombstones"(with rillenkarren)poking through the soil cover, generally on gentle slopes with associated bowl-shaped solution dolines.	Most of the limestone outcrop is bare rock pavement with very sharp pinnacles and rinnenkarren. Dolines are replaced by solution pipes and shafts. Where there is much soil cover, cave entrances are not much found.
Wet climate and microclimate favours cave development. Active cave development confined roughly to humid climate areas and active swallets to super-humid climate (Snowy Mountains). The drier caves of the central west are generally inactive.	The climate of Mt Etna appears to be drier than any of the NSW cave area. Rainfall is moderate but evaporation is very high. Pediments, characteristic of arid climate, are normal. The moister southern and western faces are often soil covered and lack entrances.

Yarrangobilly, Timor etc NSW	Mt Etna
Most caves contain permanent water.	All caves lack permanent water.
Subaerial chalky weathering of cave walls confined to development of a soft patina over fresh rock.	Chalky weathering causes deep etching of the rock, with the development of a layer 1.5 cm thick of altered powdery rock and also thin crusts over soft chalky rock. Buttresses inside the caves become "rotted". Flowstones are attacked more than limestone.
Flowstones generally coarsely crystalline, with c-axis oriented perpendicular to the growth lines; surfaces of active flowstone have waxy or sparkling appearance.	Flowstones generally finely crystalline, without obvious orientation of the crystals. Active flowstones have a "flat" finish

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FOUL AIR IN LIMESTONE CAVES AND ITS EFFECT ON CAVERS

By Garry K. Smith © 1998

INTRODUCTION

'Foul Air' is a life threatening hazard which speleologists may encounter in caves with relatively still atmospheres. Although not a significant problem in the majority of caves around the world, those containing concentrations of foul air may become death traps for cavers not familiar with the signs and symptoms of the gases involved.

'Foul Air', sometimes called 'Bad Air', is a cave atmosphere which has a noticeable abnormal physiological effect on humans. In limestone caves, 'foul air' can be described as containing greater than 0.5% carbon dioxide (CO_2) and/or lower than 18% oxygen (O_2) by volume. As a comparison, normal air contains approximately 0.03% CO_2 and 21% O_2 by volume. However there are some isolated caves which contain atmospheres influenced by other gases such as:- methane, ammonia, hydrogen sulfide or carbon monoxide, but these gases are generally rare in limestone caves.

An elevated CO_2 concentration is usually the most life threatening foul air scenario found within Australian limestone caves. This colourless, odourless and non-combustible gas is the body's regulator of the breathing function. In industry the maximum safe working level recommended for an 8 hour working day is 0.5% (5,000ppm by volume). A concentration of 10% or greater can cause respiratory paralysis and death within a few minutes.

To the novice caver the first encounter with foul air is often a frightening experience. Typically there is no smell or visual sign and the first physiological effects are increased pulse and breathing rates. Higher concentrations of CO_2 lead to clumsiness, severe headaches, dizziness and even death. Experienced foul air cavers can notice a dry acidic taste in their mouth, however the average caver may not notice this effect.

Strang and Mackenzie-Wood, (1990) state that, "Carbon Dioxide is regarded as a 'hot gas' due to its low thermal conductivity, heat is not conducted away as rapidly as in normal air so a person standing in it feels warm about his lower limbs".

TYPES OF FOUL AIR IN CAVES.

The Foul Air Types used below were first characterised by James (1977) and expanded upon by Halbert (1982) with the use of the Gibbs Triangle and the Cave Air Index.

1. In this scenario, "Foul Air Type 1", CO_2 is absorbed by the ground water as it passes through surface soil containing high concentrations of the gas, due to the decay of vegetation. Soil CO_2 contents can reach as high as 10 to 12%, however most values range between 0.15% and 0.65%. The resulting weak carbonic acid percolates through the rock strata and enters the cave system, usually taking part in the calcite deposition cycle. In this instance the addition of extra CO_2 to the cave atmosphere equally displaces O_2 and nitrogen (N_2) in direct proportion to which they constitute the atmosphere being displaced. See Table 2.

   Atmospheres consisting strictly of "Type 1" foul air, rarely exceed 1% CO_2. An example of this atmosphere could contain 1% CO_2 and 20.8% O_2.

   Halbert (1982), relates "Foul Air Type 1" cave atmosphere to the introduction of CO_2 into the cave atmosphere and all other components are diluted - the source of the CO_2 is immaterial. An atmosphere resulting from purely a type 1 process occurs quite slowly and it requires five percent CO_2 to reduce the O_2 level by one percent.

2. In the second scenario "Foul Air Type 2" the CO_2 is a by-product of organic and micro-organism metabolism or respiration by fauna such as bats or humans. In this instance the oxygen concentration is reduced in proportion to the increase in CO_2. The N_2 concentration stays constant. See Table 3.

   Halbert, (1982) "Foul Air Type 2" describes in great detail the relationship between consumption of O_2, and production of CO_2 in the metabolic process of living organisms. Essentially the volume ratio of CO_2 produced to O_2 consumed, called the "respiratory quotient" (RQ) is not constant and can vary between 0.7 and 1, depending on organic matter involved. ie. carbohydrates, fats or protein. If fats were utilised solely in the metabolic process the RQ = 0.7, and would result in a consumption of O_2 with a relatively smaller amount of CO_2 volume being produced in return.

3. In the third scenario, "Foul Air Type 3", cave atmosphere which has resulted from the introduction of other gasses, such as methane and nitrogen and the non-respiratory uptake of O_2 as well as CO_2 stripping by water. Another example is "stink damp" so named because it often contains hydrogen sulfide and the O_2 is significantly more depleted than in "Type 2". Foul air consisting strictly of "Type 3" are rare in caves and therefore is only dealt with briefly in this paper.

   Also falling into Halbert's third type is an atmosphere which has resulted from a combination of scenarios 1&2 with addition of another mechanism ("Foul Air Type 3"), which alters the gas concentrations.

James, (1977) recognised six sources of CO_2 in cave atmospheres,

a) evolution from cave waters
b) production from micro-organisms
c) respiration of plants and animals
d) Diffusion of gaseous CO_2 into the cave
e) Burning of hydrocarbons
f) Volcanic emission

Of these the first three are covered in scenarios 1&2. Not considered in this paper is source d) which is an external source of CO_2, generally of a sporadic nature and the last two don't have any real significance in Australian Caves.

INFLUENCING FACTORS IN CO_2 CONCENTRATION.

Even though CO_2 is 1.57 times heavier than nitrogen and 1.38 times heavier than O_2, it has a tendency to disperse in an isolated volume of air, due to molecular diffusion. In other words, a mixture of gasses will not separate into layers of various density gases if it is left for a long time in a still chamber. On the other hand, various gasses purged separately into a closed container will become uniformly mixed over a period of time.

A possible explanation of the high concentration of CO_2 in deep caves (with a relatively still atmosphere), is that CO_2 is being produced metabolically or entering the cave via ground water at a greater rate than the gas can disperse (by molecular diffusion) into the cave atmosphere, thus settling or remaining at the bottom of the cave because it is a dense gas. (Smith. G. K. 1997a)

'Foul air', is often encountered in pockets at the lower sections of deep caves where there are no active streams and air movement is minimal. Frequently there appears to be a definite boundary between 'good air' and 'foul air', with a noticeable elevation in CO_2 concentration being present. In caves containing 'foul air' the author has on numerous occasions experienced these invisible boundaries with a transition of less than one metre. Often there isn't a gradual transition in air quality as one might expect if dispersion of the gases were occurring at a relatively fast rate.

In Australia most of these atmospheres can be attributed to 'Foul Air Type 2', or a combination of (2+1) or (2+3), however the CO_2 is being introduced into a relatively still cave atmosphere and molecular diffusion is insufficient to disperse the gas with an even gradient over the vertical range of the cave.

This build up in CO_2 concentration is more prevalent in deep caves, however it can still be found in some shallow caves with a vertical range of less than 10 metres. A very still cave atmosphere may allow CO_2 to sink to (or remain at its origin in) the deepest part of the cave and displace O_2 and N_2. This allows CO_2 to build up to a higher concentration, at the lowest point. An example of this would be Suicide Hole Cave at Crawney Pass N.S.W, which has a vertical range of approximately 6 metres and contains a high concentration of CO_2 in the bottom two metres of cave passages. The CO_2 can be attributed to a large number of fine tree roots in a passage just above the foul air.

An example of how CO_2 can be liberated and build up to high concentrations in the bottom of caves is suggested by Osborne, (1981), in a study of the 'CO2 Pit' in Gaden Cave - Wellington NSW Australia. Osborne surmises that the atmosphere is most likely due to degassing of the extensive bodies of still water in the underground lake system. This relates to a strictly foul air type 1, however Osborne conjectures that the test measurements indicate a type 2 foul air is also involved.

Indications are that the gas is being introduced into the cave atmosphere at a greater rate than it can disperse by molecular diffusion, thus a very definite boundary occurs. In the 'CO2 Pit', the boundary between good breathable air and life threatening foul air is often less than 0.4 metre. Recent discussions with divers undertaking mapping and photographic projects indicate that the extensive underground lakes are well known for their acidity and constant production of calcite rafts. This strongly supports the theory put forward by Osborne, that the majority of the foul air in the 'CO2 Pit' is due to Type 1 with the addition of some Type 2.

James & Dyson (1981) found at Bungonia, NSW Australia, that "CO_2 is encountered at a threshold and below the threshold it appeared to be relatively homogeneously mixed". While "......caves with flowing streams which terminated in sumps showed a pronounced CO_2 gradient, increasing with depth". Drum Cave generally followed this pattern, however during bat maternity season, an inverted gradient was observed even when the stream flowed.

The bats respiration and micro-organisms in the guano were concluded to be the major sources of CO_2, and were responsible for the highest recordings in the cave, (measured in the entrance series chamber). The CO_2 concentration was observed to decrease down the cave toward the terminal sump. They conclude that "in general, CO_2 is located in the cave close to the source of its production".

Another factor was highlighted with a study of Grill Cave at Bungonia. This cave is known to regularly contain foul air (which has a short transition distance between good air and hazardous foul air), the relative depth from the surface, (of the interface), varies considerably with climatic change and correlates with highs and lows in atmospheric pressure. The high atmospheric pressure compressing the gasses, thus pushing the interface deeper into the cave and the reverse with atmospheric lows. This can be greatly enhanced by passage dimensions and volume capacities of chambers within a cave system. (Smith G. K., 1998).

Temperature changes outside caves also have an effect on the concentration of foul air. Jennings, et al. (1972) give the example of caves at Bungonia where the average underground temperature is 17.75°C. During summer the above ground air temperature rarely drops below this temperature, hence the cold, dense air remains in the lower levels without circulating. However during winter the caves "breathe". The warmer air rises, thus causing an expansion of the CO_2 regions with a reduction in CO_2 concentration.

Floods are also known to reduce high concentrations of 'foul air' as the influx of large volumes of fresh water absorb CO_2 from the cave atmosphere and transport it away. O_2 is also liberated from the fresh water into the cave atmosphere. Floods also carry into the cave, fresh organic matter which micro-organisms feed on to rapidly increase CO_2 once the water flow has subsided. Micro-organisms can increase CO_2 concentration in the cave atmosphere by several percent over a 48 hour period. (James and Dyson, 1981)

Foul air will not build up in caves with two entrances at different elevations, as temperature gradients cause a flow through affect which flushes the cave atmosphere. Active stream-ways in caves also dissipate any build up of foul air. See Figure 1.

CALCULATING GAS CONCENTRATIONS IN A CAVE ATMOSPHERE.

In dry air the total pressure (of a mixture of gases) is equal to the sum of their partial pressures. In simplified terms, the atmospheric or barometric pressure of dry air is equal to pNitrogen (pN_2) + pOxygen (pO_2) + pRare Gases (pRG) + pCarbon Dioxide (pCO_2).
However since a great majority of cave atmospheres contain high humidity, the water vapour component should be included in the equation.
Barometric Pressure = $pN_2 + pO_2 + pRG + pCO_2 + pH_2O$.

Halbert (1982) uses the Cave Air Index (CAI) to characterise gas mixtures found in caves on a dry atmosphere basis. The water vapour component in the calculation, slightly changes the concentrations of CO_2 and O_2, but does not affect the arguments derived from the data. Essentially the water vapour constitutes about 0.5% by volume of a saturated cave atmosphere at 20°C and conversely in a dry atmosphere it would be 0%.

For simplicity cave atmospheres may be considered to consist of O_2, CO_2, and a Residue Fraction (RF) made up of rare gases, N_2 and water vapour (H_2O).

Table 1. *Cave air scenario and* **correlation with "Foul Air Type" & Cave Air Index.**

Foul Air Type *(after Halbert 1982)*	Possible Mixes	Cave Air Index
1		$4 \leq CAI \leq 5$
1+2 combination	1+3	$1 \leq CAI < 4$
2	2+1, 2+3, 1+3	$0.75 \leq CAI < 1$
2+3 combination	1+3	$0 < CAI < 0.75$
3		$CAI = 0$

$$\text{Cave Air Index} = \frac{CO_2 \text{ Concentration}}{21 - O_2 \text{ Concentration}}$$

INTERPRETING FOUL AIR.

The theoretical "Foul Air Type 3", where CAI = 0, is rarely known to exist in caves. In general cave atmospheres with CAI of < 0.75 are regarded as falling into the Foul Air Type 3. This could be a mixture of "Foul Air Types" (3+1) or (3+2). Halbert (1982) gives the example of "Foul Air Type 3" atmospheres containing 1% CO_2, 17% O_2, and 82% RF and another with 4.5% CO_2, 10.5% O_2, and 85% RF. He points out that a low absolute O_2 concentration does not need to be present. However in practice "Foul Air Type 3" atmospheres likely to be encountered in caves will have low O_2. Also this type of foul air may have deceptively low CO_2.

At Bungonia Caves (N.S.W.) Australia, foul air accumulation by loss of CO_2 from saturated ground water is not the major source, but a contributing factor. CO_2 levels of up to 6% have been linked to micro-organisms (i.e. fungi and bacteria) which depend on the nutrition present in organic material leached down from the soil or washed into the caves by floods. These organisms produce CO_2 as a by-product of their digestion process. This mechanism was observed to correlate with the reduction in O_2 accompanied by the increase in CO_2 concentrations. This would suggest foul air Type 2 or a combination of 1 & 2. (Crawshaw. R. and Moleman, D, 1970), (Jennings. J. et al., 1972), (Smith., G, 1993)

Halbert (1982) suggests that some readings at Bungonia are a "Foul Air Type 3". They include atmospheres in Grill Cave with a composition of 1.4% CO_2, 12.0% O_2, 86.6% RF which gives a CAI of 0.16 and readings in Odyssey Cave of 2.8% CO_2, 14.5% O_2, 80.3% RF which gives a CAI of 0.43. James (1977) had previously speculated on the possible sources of "Type 3" foul air sometimes found at Bungonia. These include:- (1) Anaerobic bacterial action - nitrogen producing bacteria which have been identified in caves at Bungonia. (2) Removal of O_2 from the cave atmosphere by oxidation of inorganic or organic sediments.

In 1958 members of Sydney University Speleological Society (S.U.S.S) confirmed that readings of up to 13.5% CO_2 at Wellington and Molong Caves (N.S.W.) Australia, were at the expense of oxygen. ie. the sum of CO_2 and O_2 was constant and the percentage of inert gases was reasonably constant. They also concluded that this was probably due to organic decomposition. (Halbert., E. J. 1972). These CO_2 readings appear to be exceptionally high and one would wonder if another mechanism could be involved.

The answer could be in a later study of the 'CO2 Pit' in Gaden Cave - Wellington (N.S.W.) Australia, by Osborne (1981), when he surmises that the atmosphere is most likely due to degassing of the extensive underground lake system with some involvement of a type 2 foul air mechanism. As can be seen from the above, it is one thing to analyse samples of cave atmosphere to determine composition, however the real problem comes with the interpretation of this data to identify the source of the gases, especially if the source is not readily apparent. Calculation of the CAI, appears to be a very valuable tool to assist researchers in identification of foul air types and hence could assist in tracking down the source.

Examples of foul air, theoretical gas concentrations are given in Tables 2, 3 & 4.

Table 2, **Theoretical gas concentrations in cave atmosphere. Using scenario 1 with CAI = 4.**

Total CO_2 concentration in cave atmosphere	Total O_2 concentration in cave atmosphere	Total RF concentration in cave atmosphere
1%	20.75%	78.25%
2%	20.50%	77.50%
3%	20.25%	76.75%
4%	20.00%	76.00%
5%	19.75%	75.25%
6%	19.50%	74.50%
7%	19.25%	73.75%
8%	19.00%	73.00%
9%	18.75%	72.25%
10%	18.50%	71.50%
24%	15.00%	61.00%

Table 3. **Theoretical levels of gases in cave atmosphere, using a combination of scenario 1 & 2, resulting in CAI = 2.**

Total CO_2 concentration in cave atmosphere	Total O_2 concentration in cave atmosphere	Total RF concentration in cave atmosphere
1%	20.50%	78.50%
2%	20.00%	78.00%
3%	19.50%	77.50%
4%	19.00%	77.00%
5%	18.50%	76.50%
6%	18.00%	76.00%
7%	17.50%	75.50%
8%	17.00%	75.00%
9%	16.50%	74.50%
10%	16.00%	74.00%
12%	15.00%	73.00%

Table 4, **Theoretical levels of gases in cave atmosphere, Using scenario 2. with CAI = 1.**

Total CO_2 concentration in cave atmosphere	Total O_2 concentration in cave atmosphere	Total RF concentration in cave atmosphere
1%	20.00%	79.00%
2%	19.00%	79.00%
3%	18.00%	79.00%
4%	17.00%	79.00%
5%	16.00%	79.00%
6%	15.00%	79.00%
7%	14.00%	79.00%
8%	13.00%	79.00%
9%	12.00%	79.00%
10%	11.00%	79.00%
15%	6.00%	79.00%

EFFECT OF CO_2 ON HUMANS.

As each person's body has a slightly different reaction and tolerance to stressful situations the following symptoms are general, however nobody is immune to the dangers of CO_2.

Table 5. **Generally accepted physiological effects of CO_2 at various concentrations.**

Concentration	Comments
0.03%	Nothing happens as this is the normal carbon dioxide concentration in air.
0.5%	Lung ventilation increases by 5 percent. This is the maximum safe working level recommended for an 8 hour working day in industry (Australian Standard).
2.0%	Lung ventilation increases by 50 percent, headache after several hours exposure. Accumulation of carbon dioxide in the body after prolonged breathing of air containing around 2% or greater will disturb body function by causing the tissue fluids to become too acidic. This will result in loss of energy and feeling run-down even after leaving the cave. It may take the person up to several days in a good environment for the body metabolism to return to normal.
3.0%	Lung ventilation increases by 100 percent, panting after exertion. Symptoms may include:- headaches, dizziness and possible vision disturbance such as speckled stars.
5 - 10%	Violent panting and fatigue to the point of exhaustion merely from respiration & severe headache. Prolonged exposure at 5% could result in irreversible effects to health. Prolonged exposure at > 6% could result in unconsciousness and death.
10 - 15%	Intolerable panting, severe headaches and rapid exhaustion. Exposure for a few minutes will result in unconsciousness and suffocation without warning.
25% to 30%	Extremely high concentrations will cause coma and convulsions within one minute of exposure. Certain death.

(Strang. J., and Mackenzie-Wood. P., 1990), (Laboratory Safety Manual, 1992) (Osha Regulated Hazardous Substances, 1990), (Matherson, D., 1983). Long-term exposure to levels of between 0.5 and 1% as may be experienced by personnel on a submarine, is likely to increase calcium deposition in body tissues such as the kidney. (Matherson, D., 1983)

Exposure of between 1 and 2% CO_2, for some hours will result in acidosis, even if there is no lack of oxygen. This acid-based disturbance will occur in the human body when the increase in partial pressure of CO_2 (pCO_2) is greater than 44mm Hg. Acidemia will result and secondary mechanisms are initiated by the body that attempt to prevent drastic changes in pH and tend to return the pH toward normal. "Intracellular buffering, via red cell haemoglobin, phosphate, and protein, exchange intracellular sodium and potassium for the excess extracellular hydrogen ion. In addition, hypercapnia leads to an increase in renal hydrogen ion secretion and net acid excretion, as well as an increase in bicarbonate reclamation. Although this response begins early, the maximum effect takes several days." (Clinical Management of Poisoning & Drug Overdose, 1990). Prolonged breathing of air containing around 2% or greater will disturb body function by causing the tissue fluids to become too acidic. This will result in loss of energy and feeling run-down even after leaving the cave. It may take the person up to several days in a good environment for the body metabolism to return to normal.

The "Laboratory Safety Manual (1992)", quotes 0.5% CO_2 as the `Threshold Limit Value Time Waited Average' (TLVTWA). This is the concentration to which a person may be exposed, 8 hours a day, 5 days a week, without harm. The manual also quotes 5% $CO_2$ and above as being `Immediately Dangerous To Life and Health' (IDLH). This is the concentration that will cause irreversible physiological effects after 30 minutes exposure.

One must be mindful that the sight of bats in a cave does not necessarily mean that the atmosphere is suitable for humans. On several occasions the author has experienced laboured breathing in caves containing bats, however a simple Butane Cigarette lighter would fail to ignite and struck match head would only fizz before going out. The bats seemed to be undeterred by the low O_2 and high CO_2 content of the atmosphere. These observations are echoed by Hamilton-Smith, (1972) who states that, "..... the Bent-winged Bat is able to tolerate higher concentrations of gas (CO_2) than that acceptable to human beings."

EFFECTS OF O_2 DEFICIENCY ON HUMANS.

If we consider an atmosphere consisting of just N_2 and O_2, where the O_2 is at a lower concentration than the normal atmosphere, the human body would be effected in the manner shown in Table 6. (Laboratory Safety Manual, 1992)

Table 6. **Generally accepted physiological effects of reduced O_2 concentrations.**

O_2% by volume.	Symptoms (at sea level)
reduced from 21 to 14%	First perceptible signs with increased rate and volume of breathing, accelerated pulse rate and diminished ability to maintain attention.
between 14 to 10%	Consciousness continues, but judgment becomes faulty. Rapid fatigue following exertion. Emotions effected, in particularly ill temper is easily aroused.
10 to 6%	Can cause nausea and vomiting. Loss of ability to perform any vigorous movement or even move at all. Often the victim may not be aware that anything is wrong until collapsing and being unable to walk or crawl. This is followed by unconsciousness and death. Even if resuscitation is possible, there may be permanent brain damage.
below 6%	Gasping breath. Convulsive movements may occur. Breathing stops, but heart may continue beating for a few minutes - ultimately death.

(Laboratory Safety Manual, 1992), (Safe Handling of Compressed Gases, 1992), (Strang. J., and Mackenzie-Wood. P., 1990),

SHOULD WE BE LOOKING AT O_2 DEFICIENCIES AS LIFE THREATENING WHILE UNDERGROUND?

The partial answer to this question can be found in a paper by Field, (1992) which studied the use of a new fire extinguishing gas mixture, designed to be used in enclosed spaces. The gas called 'Inergen' consisted primarily of Argon and CO_2. It was designed to disperse and dilute oxygen to below 15% volume, so that there would be insufficient oxygen to support combustion. The research found that the addition of a small percentage of CO_2 was beneficial as it induced an immediate and sustained stimulus to increase breathing rates of persons caught in areas flooded with this gas mixture. It was the increase in CO_2 and to a much lesser extent the decreased O_2 which stimulated the respiratory response.

The report goes on to say that great majority of healthy people whether young or old, would not be limited by their ventilatory function during physical exertion at a work level when breathing air at sea level containing 3.1% CO_2 and 15% O_2, however many, particularly the elderly would experience mild-moderate breathlessness.

In an atmosphere containing 4.3% CO_2 and 12.4% O_2, the average healthy person with a reasonable level of physical fitness would be capable of less than half the maximum physical exertion they could normally attain breathing air. (Field, 1992). One thing lacking in this paper is any real mention of time scales of exposure to this concentration of CO_2 and O_2.

The data as listed in the Tables 6 above, indicates that very little difficulty is caused by short-term exposure to O_2 / N_2 mixtures down to about 10% O_2. In Tables 2, 3 & 4, it can be seen that at 8% CO_2 concentration (which is dangerous to humans), there is still sufficient oxygen to support life.

The Australian Standard (AS 2685-1986, P.7) 'Safe Working in Confined Space', states that entry to confined space shall not be permitted if oxygen deficiency is below 18%. This standard was revised in 1995 and the minimum concentration raised to "19.5 percent by volume under normal atmospheric pressure, equivalent to a partial pressure of oxygen (pO2) of 19.8kPa ...". it goes on to say that "an airborne concentration of a particular substance in the person's breathing zone, exposure to which, according to current knowledge, should not cause adverse health effects nor cause undue discomfort to nearly all persons." The criteria used is the Time-Weighted Average (TWA). "The average concentration of a particular substance when calculated over a normal eight-hour workday, for a five-day working week." (AS 2865-1995, P. 6-7). One could argue that this is a very conservative O_2 concentration, designed for the workplace to cater for people with a very wide range of physical fitness and ailments and the possible need to undertake continuous strenuous work over an 8 hour day.

One should note that it is simply not just the O_2 volume percent which is necessary for human respiration but the O_2 partial pressure. For instance the O_2 partial pressure decreases at higher altitude while the O_2 volume percent remains constant. An example of this is the partial pressure of O_2 at an altitude of 2,000 metres above sea level is 17.67kPa (176.7 millibar) and this is equivalent to breathing air in which the O_2 concentration has been reduced to 17.5%.

HOW THE HUMAN BODY GETS RID OF CO_2.

The human body under average conditions inhaling air which contains approximately 21% oxygen and 0.03% CO_2. The air breathed out of the lungs contains approximately 15% to 16.3% oxygen and about 4.5% CO_2. A person at rest inhales and exhales approximately 6 litres of air per minute but in times of stress, this may increase to more than 100 litres per minute.

The CO_2 level in the blood is an important stimulus to respiration. Nerve receptors in the aorta near the heart and in the carotid artery that goes to the brain, monitor changes in the CO_2 in the body. If the amount of CO_2 in the blood increases, both the rate and depth of breathing increases.

Changes in oxygen levels are also monitored, but the receptors are not as sensitive to changes in oxygen as to CO_2.

The exchange of the two gases (CO_2 and O_2) takes place in the lungs by diffusion across the walls of the air sacs (alveoli). Oxygen from inspired air diffuses across the lining of the air sacs and enters the circulation, while CO_2 moves in the opposite direction. Then the gases are transported between cells and the lung by the blood circulation.

The principle by which diffusion occurs dictates that a gas in high concentration will move to an area of relatively low concentration, until an equilibrium is reached. This enables CO_2 in the body at a higher concentration to diffuse to the inhaled air. (Smith. G. K., 1993 & 1997b).

SIMPLE TEST FOR FOUL AIR.

In the majority of foul air found in caves, the real danger is the CO_2 concentration which is the main trigger for the human body to increase the breathing rate. This is generally attributed to a Type 2 Foul Air or possibly a mixture of Types (2+1) or (2+3). Prolonged exposure to a concentration of just 6% CO_2 or more may be enough to cause suffocation.

In the majority of cases, if a person has any of the symptoms of elevated carbon dioxide, a simple 'naked flame test' will fail to ignite.

The 'naked flame test' can be undertaken by igniting a match or butane cigarette lighter or carrying a lit candle into suspected foul air. If the flame is extinguished, foul air is present. Where possible a butane cigarette lighter should be used to reduce unpleasant fumes emitted from matches burnt by people testing air quality in the confines of a cave. (Smith. G. K. 1997a)

Laboratory tests have proven that combustion of a match, candle or butane cigarette lighter will cease at about 14.5% to 15% concentration of oxygen. Twenty one percent (21%) being the oxygen concentration in normal atmosphere. Bearing in mind that humans on average breath out air containing between 15% - 16.3% oxygen and this is enough to revive a person using Expired Air Resuscitation (EAR). In fact humans can survive in an atmosphere containing 10% oxygen, so when the flame test just fails, the atmosphere still containing enough oxygen to survive. (Smith. G. K. 1997a)

CONCLUSION

In the majority of cave atmospheres an elevated CO_2 concentration, corresponds to a depletion of O_2. A high CO_2 concentration is the most life threatening situation encountered underground while a life threatening low O_2 concentration is rarely encountered. The majority of dangerous atmospheres in caves can be contributed to a combination of Type (2+1) & (2+3) Foul Air. This covers a considerable range of CO_2 to O_2 combinations, however when CO_2 is high so as to be dangerous to humans, there is generally not enough O_2 to support combustion.

The first signs of high CO_2 include increased heart and breathing rates, headaches, clumsiness, fatigue, anxiety and loss of energy

Without sophisticated measuring equipment, the best advice is if you or a member of your group experiences any of the common side effects of CO_2, carry out a simple flame test with a butane cigarette lighter. If the flame fails to ignite notify others in the party and the group should vacate the cave in a safe manner.

Carbon dioxide when treated with respect is no worse than the other dangers in caves. Despite the possible dangers, caving is still safer than driving a motor vehicle, which most of us take for granted. The best advice is, "If in doubt, get out".

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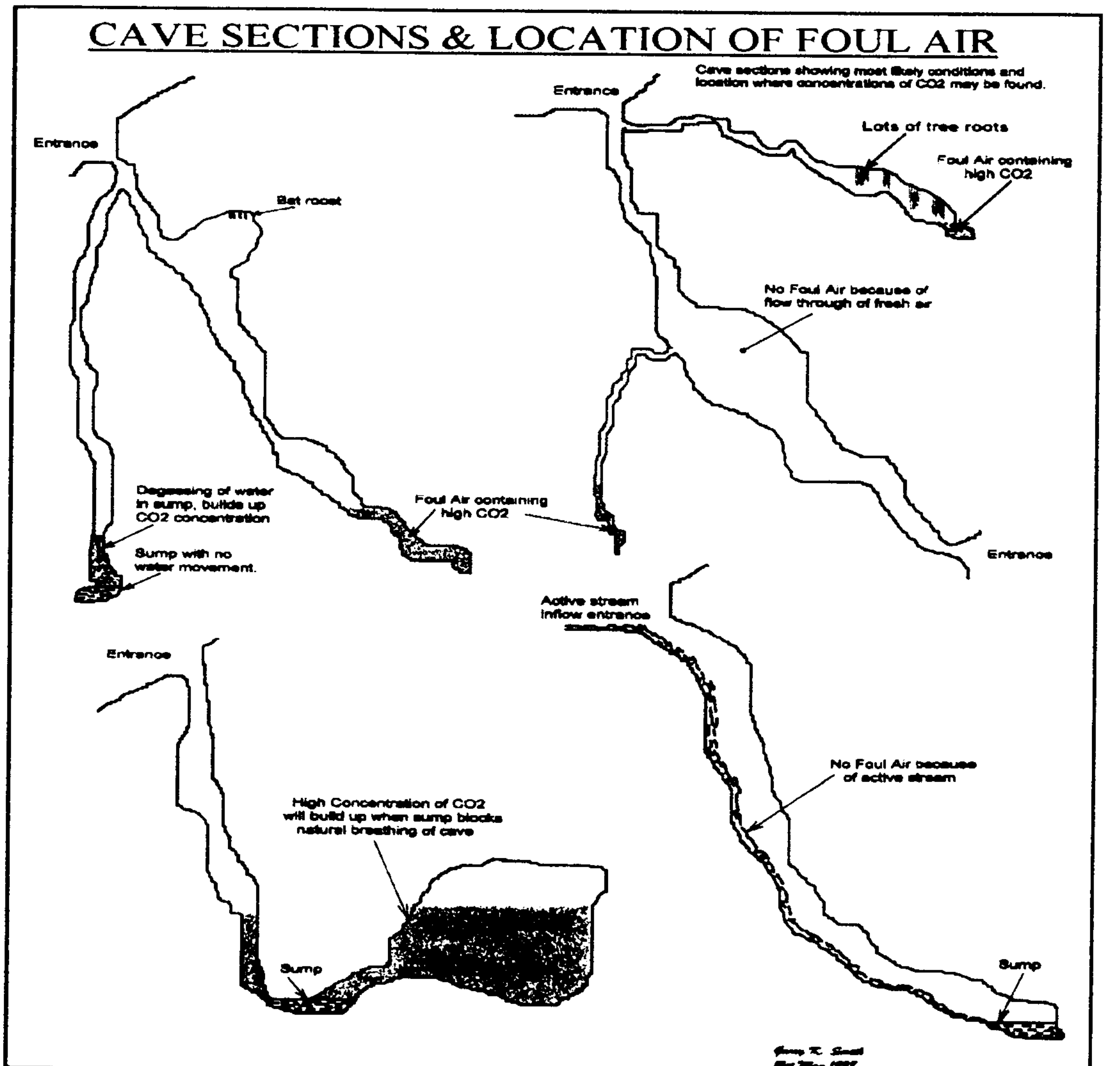

Figure 1.

GLOSSARY OF CAVING TERMS

By Garry K. Smith (August 1998) Presented by Angus Macoun

This list of words and their definitions covers many of the common and colloquial terms used by the Australian speleological fraternity.

Many words have been introduced into the English language over the last hundred years. Some because there was a need to describe a new item or process which was discovered. Some examples are Karabiner, Piton and Wetsuit. On other occasions a new word or group of words may be used to describe an action or new sport. Examples which spring to mind are Chimneying, Cave Diving, Prusiking and Abseiling. There are the words which are spelt differently, depending on which school you went to. A classic example would be Karabiner or Carabiner. The need to formalise the spelling and exact definition was recognised many years ago when J. Jennings first compiled a list of "Cave Terminology" in 1960. This limited list of definitions was later published in the 1968 Speleo Handbook, edited by P. Matthews.

A greatly increased glossary of terms by J. Jennings with the assistance of others, was published in the 1985 Australian Karst Index. These authors must be commended on such a comprehensive list of definitions for words in use up to that period.

The on-going evolution of words in common usage among the speleological fraternity has continued since that time. There are presently a number of slang and colloquial caving terms which have been used widely for many years. The exact definition of these words remain open for interpretation, as there appears to be no recent listing of their correct meaning!. I would hope that the list of terms I present for publication in the conference proceedings will be thought provoking and set the wheels in motion toward having some additional words officially recognised in the Speleological fraternity. No doubt the selection of words and some meanings will be controversial, but I make no apology for this as I am prepared to wear the flack, if any is due.

Getting back to the glossary of terms and meanings which I have listed, and how they were derived. A large number of publications and articles were used to cross reference the meanings of words because it was found that many definitions varied between publications. In general the publications listed (at the end of the glossary) were used as the main references because it was felt that they contained the most acceptable meanings. In all there were probably 30 publications and articles used to a much lesser extent. These have not been acknowledged as their contribution to the overall listing was very minor.

Many words used among speleologists varied in meaning to that in the common English language dictionary. They included quite a few colloquial terms not listed at all in dictionaries, therefore I wrote a new meaning which hopefully best described it. In general, few definitions have been duplicated word for word from any source as it was often found that a combination of descriptions best suited the meaning of a word. As an interest point, the origin (history) has been included after some word definitions.

Much deliberation over definitions of closely related words such as; shaft, pit, chimney, grike, fissure and cleft, made the compiling of this list fairly difficult.

For instance I quote a few meanings from the World Book Dictionary which is typical of many descriptions given, bearing in mind that each of these words have many meanings which also don't relate to caving.

1. **Chimneyed**. - having a chimney or chimneys.
2. **Chimney**. - A crack or opening in the rock, mountain, volcano, or other natural fissure, Synonym - **Cleft**.
3. **Cleft**. - A space or opening made by splitting; a deep cleft in the rock. Synonym - **fissure**.
4. **Fissure**. - A long, narrow opening, split or crack in rock. Synonym - **Cleft**.
5. **Pit.** - A natural hole in the ground. An open hole or excavation made in digging for some mineral deposit; such as coal; a **shaft**.
6. **Shaft**. - A passage that is like a well; long narrow space, a deep passage sunk in the earth.
7. **Grike**. - A crevice or chink; A ravine on the side of a hill.
8. **Crevice**. - A **fissure** or crack on or through the surface of something; cleft; chink.

After looking through many dictionaries, I was certainly very confused as they all seemed to be cross referencing to each other. But this did not solve the problems when relating these terms to caving.

I started looking back through the history of terms and determined that a PIT was used to catch animals. In other words there was no way out for the captured animal. This led me to come up with a definition which described a PIT as a vertical or near vertical shaft, without passages or chambers leading from it.

The definition of a SHAFT was handled in a similar manner. A shaft was typically dug by miners to ventilate a mine. This meant that it connected with other passages. Therefore I wrote a definition which included a vertical cavity or passage which has at least one passage or chamber leading from it.

A number of dictionaries referred to a CHIMNEY as a hole or crack open to the surface, however cavers referred to it as being a near vertical passage, which a caver can climb by applying pressure with their body to opposite rock faces. Therefore a CHIMNEY could fit into the description of a SHAFT or a PIT, except that it is smaller in width and able to be climbed by the act of chimneying. In the definition I have deliberately omitted any mention of open to the surface as a person can chimney in a chimney not open to the surface.

This leads me to another point. If a person can CHIMNEY in a CHIMNEY, then I needed to start including the uses of these words in a similar manner to that in a dictionary. Therefore I have included the different ways in which a word could be used. ie. As a **noun**, **verb** or **adjective**. I had to draw the line somewhere so a further break-up of verbs into transitive and intransitive has not been included for simplicity sake.

This document is not the sort of article that a person will sit down and read from front to back, but it will hopefully act as a reference document. There is the added advantage that bold text words which are closely related or are used in a definition may be cross references to compare meanings.

In conclusion, the publication of this glossary of caving terms, marks the culmination of 11 years research into the definition of words used by speleological people in Australia.

This glossary of terms was first published in the "NEWCAVES CHRONICLES". Volume No. 11, July 1998, the official publication of the "Newcastle and Hunter Valley Speleological Society", then revised and additional words included during August 1998 for publication in the proceedings of the Australian Speleological Federation's 22nd Biennial Conference January 1999.

It should be noted that only a limited selection of biological and geological - lava cave term have been included in this glossary. For a comprehensive list of these terms refer to previously published articles by Arthur Clarke, Stefan Eberhart, and Ken Grimes.

GLOSSARY OF CAVING TERMS

Common terminology and colloquial terms used throughout the speleological fraternity.

<u>**Authors note**</u> - A large number of publications and articles were used to cross reference the meanings of words because it was found that many definitions varied between publications. In general the reference publications listed (at the end of this glossary) were used as the main references because it was felt that they contained the most acceptable meanings. There are also quite a few words used among speleologists which vary in meaning to that in the common English language dictionary. They included many colloquial terms not listed at all, therefore a new meaning was written by the author. In general, very few definitions have been duplicated word for word from any source as it was often found that a combination of descriptions best suited the meaning of a word. As an interest point, the origin (history) has been included after some word definitions. The publication of this glossary of terms, marks the culmination of 11 years of research on the definition of words used by speleological people in Australia.

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Abbreviations Uses:-

adj. Adjective

Biol. Biology.

cf. confer (compare) with the following term which is similar but not identical.

Geol. Geology

n. noun

Syn. synonym - a word having the same or almost the same meaning as another.

v. verb.

AA. *n.* A surface type of solidified lava, characterised by broken lumps of material or very sharp prickly fragments. The rough texture is caused by movement of a partly solidified surface layer, prior to complete solidification, thus causing the surface to break into sharp fragments. Surface texture grades from '**pahoehoe**' to 'aa' lava. See **lava cave**.

ABSEIL. *v.* The act of lowering oneself down a cliff, pitch or steep slope on a fixed rope. The controlled descent is obtained by friction of rope on the body or passing the rope though a **karabiner** or other descending device. Derived from the German word '*abseilen*'.

According to W. Hutton "History of Derby" (1801), Abseiling was developed in the Middle Ages by jugglers in Germany who use to descend from church steeples for money. One such demonstration by a man called Chapman occurred in Oct. 1732. The rope was fixed at the top of All Saints Steeple and the other end at the base of Saint Michaels. This formed a very steep incline over a horizontal distance of 80 yards (73 metres). Chapman then slid down balanced over a wooden breast plate with a groove to fit the rope. To execute this balancing feat, he lay on his belly with arms and legs extended. During this 6 to 7 second act he fired a pistol and blew a trumpet. Although successful on this occasion he lost his life shortly after at Shewsbury.

ABSEIL CLEAR. *n.* A call for the person who has just **abseiled**, indicating to others above, that the rope is clear for the next person to descend. *cf.* **off-rope**.

ABSEIL ROPE. *n.* A rope on which a person is abseiling or a rope set up for abseilers to use. See **static rope**.

ABSEILER. *n.* The person undertaking an **abseil**.

ABSEILING. *n.* A call from an **abseiler** to a **belayer**. Indicating that the abseiler is beginning to descend.

ACTIVE CAVE. *n.* A cave with a streams flowing in it. *cf.* **live cave**. Antonym. of **dormant cave** or **dead cave**.

ACETYLENE LAMP. *n.* See **carbide lamp**.

ACETYLENE. *n.* Is a colourless flammable hydrocarbon gas C_2H_2. It is produced when water reacts with calcium carbide. Acetylene burnt in an oxygen deficient atmosphere has a smoky, but bright yellow flame. When burnt in a good air supply the flame is white. The by-products of combustion are **carbon dioxide** and water. See **carbide Lamp**.

AEOLIAN. (1) *adj.* Pertaining to or caused by the wind; wind-borne. (1) *n.* Landforms generated by the wind, or **sediments** transported by the wind. Derived from Æolus, the Latin God of the wind.

AEOLIANITE. *n.* A rock formed from **calcareous** dune sand, a dune **calcarenite**.

AEOLIAN CALCARENITE. *n.* **Calcareous** fine sand size particles which have become air-borne due to wind and are deposited as dunes, later to undergo consolidation and **diagenesis** to form dune **limestone**. Also see **calcarenite** and **Syngenetic Karst**.

ANCHOR. *n.* A secure object used to attach a person while operating a **safety line** or for attaching equipment such as ropes or ladders. *Syn.* **anchor point**

ANCHOR BOLT. *n.* A bolt used as an **anchor** point. See **bolt**.

ANCHOR POINT. *n.* Same as **anchor**.

ANGLES WING. *n.* Colloquial term for **curtain** or **shawl**.

ANTHODITE. *n.* A **speleothem** composed of gypsum or aragonite and forming needle-like crystal clusters eg. **gypsum flower**.

ARAGONITE. *n.* The second most common **polymorph** of calcium carbonate $CaCO_3$. Usually recrystallised to a needle-like shape.

ARCH. *n.* A carved structure supported on both sides. In speleological terms, a rock structure over a large **passage** or cavity with two or more entrances in which a person is always within sight of daylight. (during daylight hours) *Syn.* **natural arch**.

ARCHAEOLOGY. *n.* Scientific study of history from the remains of early human cultures. Especially prehistoric man, mostly by systematic excavation and description of remains and artefacts.

ARMCHAIR CAVER. *n.* Colloquial term for an experienced caver who is now incapable of caving or a person still able to, but has lost the urge to actually go caving. On the other hand they may spend much of their time writing or reading caving books and hours may be spent reminiscing over photographs from past trips.

ASCENDER. *n.* A mechanical device which grips the rope (usually with a cam operation) and allows a person to ascend a rope. *cf.* **prusik**.

ASF. Acronym for the Australian Speleological Federation's.

AVEN. *n.* A shaft which rises from a passage, sometimes leading to a passage above, but not open to the surface.

BAT. *n.* A mammal able to fly. Classified as *Chiroptera*, meaning `hand winged'. This order is further divided into two Suborders of *Microchiroptera* (meaning 'small hand wings') and *Megachiroptera.* (meaning 'large hand wings'). Many *Microchiropteras* are cave dwelling bats and have good eye sight which allows them to see in low light conditions, as well as sonar which allows them to navigate in total darkness. They can fly at great speed through tight twisted cave passages with astonishing accuracy. Most species roost in large colonies deep in caves during the day.

At dusk a mass exodus occurs as they leave the safety of the cave to feed on airborne insects during the night. The small cave dwelling bats should not be confused with their larger cousins, *Megachiroptera*, the fruit eating bats, otherwise known as flying foxes.

BED. *n.* A layer in a belt of sedimentary rock or unconsolidated sediment.

BEDDING-PLANE. *n.* The surface separating two beds of rock, often contains a layer of clay or shale between.

BEDDING-PLANE CAVE *n.* A cave developed along a **bedding-plane**, usually elongated in cross section.

BEDROCK. *n.* The solid mass of parent rock originally laid down - from which a cave or feature has been eroded by mechanical or chemical action. This term includes bedrock which has been transformed in crystalline structure due to heat (eg. **marble**) but does not include redeposited minerals (eg. **speleothems**).

BELAY. (1) *v.* To operate a **safety line**. (2) *v.* To secure (a person) at the end of a rope. (3) *v.* To secure (a rope) to a person or object. (4) *v.* To be made fast. (5) *n.* The set-up of a **safety line** through a belay device, secured to an anchor point. (6) *n.* The securing of a person or a safety rope to an anchor point.

BELAY BOLT. *n.* A bolt from which a belay is operated. *cf.* **bolt** and **belay**.

BELAYED. (1) *n.* The person being belayed. (2) *v.* Past tense of **belay**.

BELAYER. *n.* A person who is **belaying**.

BELAY-ROPE. *n.* The rope or **safety line** used to **belay**.

BELAYING. *v.* The act of one who or that which belays.

BELOW. *n.* A emergency call, warning of danger from falling object/s. Usually yelled by a person at top of the **pitch** to warn people below that an object has been dislodged and is falling toward them.

BLIND VALLEY. *n.* A valley which is closed abruptly at its lower end by a cliff or slope facing up the valley. There is usually a perennial or intermittent **stream sink** at its lower end, however it may be dry. *cf.* **half blind valley**.

BLOCK. *n.* A solid piece of stone larger than 3 metres across. *cf.* **boulder**.

BOOB TUBE. *n.* Colloquial term for a clear flexible tube about one metre long. Used like a straw to drink water from small crevices or inaccessible pools.

The original name was the *Super Syphon Sucker*, believed to be first utilised around 1973-74 by Jeffory Smith a Venturer Scout in the Kotara Unit (N.S.W). Jeffory used it extensively on bushwalking, caving and cross-country skiing trips and the use of such a tube spread widely among outdoor enthusiasts from there. Several name changes occurred over the next few years, however during the last 10 to 15 years the name Boob Tube has been most widely used. Some sources suggest that long drinking tubes were in use by some bushwalkers prior to 1973, however these reports are still to be confirmed.

BOLT. *n.* A high tensile steel bolt used as an **anchor** point to attach **rigging** for descending or ascending or **safety line**. The bolt locks into a drilled hole by one of the following methods; expansion of a threaded holder, chemical bonding, or by hammering into a slightly smaller hole. The latter being the least reliable anchor method.

BOLTING. *v.* The act of placing **anchor bolts** to assist in a climb.

BOULDER. *n.* - A piece of **rock** larger than a **cobble**. *cf.* block.

BOULDER CHOKE. *n.* A collapse of rock from floor to roof which makes further progress difficult or dangerous.

BREAK BAR. *n.* A **piton** hinged on a **karabiner** or a round bar on a **rappel** rack used to apply friction to a rope for **abseiling**.

BREAKDOWN. (1) *v.* A fall of **bedrock** from cave roof or wall under its own weight. (2) *n.* A pile of broken bedrock.

BREATHING, (relating to cave) *v.* Movement of air in and out of a cave due to changes in atmospheric pressure and/or temperature changes on the surface.

BRECCIA. *n.* Angular fragments of **rock** and/or fossils, often, but not necessarily cemented together or with a matrix of finer **sediment**.

BRECCIA - BONE. *n.* **Breccia** containing many bone fragments.

CALCARENITE. *n.* Soils and sedimentary rock with a sandy texture, which has become hardened or cemented together and is composed largely of **calcium carbonate** fragments which have formed by the mechanical breakage or abrasion of the parent rock. ie dune limestone. See **aeolian calcarenite**.

CALCAREOUS. *adj.* Containing **calcium carbonate**. From the latin word 'calcarius' meaning 'of lime'.

CALCAREOUS SEDIMENTS. *n.* Fragmented material, mainly composed of **calcium carbonate**, which has been deposited by water or air.

CALCIFY. *v.* To harden by the deposit of calcium salt. eg calcified animal remains or tree roots. *cf.* **calcification**.

CALCIFICATION. *n.* Process of becoming hard or calcified by being impregnated with calcium salts.

CALCITE. *n.* The most common **polymorph** of **calcium carbonate** ($CaCO_3$). The most common constituent of **stalactites**, **stalagmites**, **flowstone** etc. **Limestone**, **marble** and **chalk** consist largely of calcite.

CALCITE RAFT. *n.* A thin layer **speleothem** of **calcite** crystalline material which forms and floats on the surface of still **cave-pools**. Disturbance of the pool surface often sinks the rafts. This speleothem forms on the pool surface due to degassing of CO_2 from solution which causes saturation of solution and deposition of calcite at the surface. *cf.* **floe calcite**.

CALCIUM CARBONATE. *n.* The scientific name for a crystalline compound containing, calcium, carbon and oxygen in the proportions of $CaCO_3$. A **primary mineral**. Also see **limestone**, **marble**, **chalk**, **calcite**, **aragonite**, **vaterite**. *cf.* **dolomite**.

CALL. *n.* A specific verbal signal (usually yelled) by a caver to another, to indicate an action, intended action or possible danger. eg. **below**, **abseiling**, **falling**, **on-belay**, **climbing**, **that's me**, **up-rope**, **slack**, **safe**, **off-rope**, **abseil clear**.

CANYON. (1) *n.* A deep valley with steep to vertical sides. Frequently formed in **karst** by a river rising on impervious rocks outside the karst area.

(2) *n.* In caves - a deep, elongated cavity in the floor or roof of a cave formed by running water.

CARABINER. *n.* American spelling for **karabiner**.

CARBIDE. *n.* Calcium carbide, (CaC_2) is a grey substance prepared by heating lime. It was used extensively in early caving lamps. Water dripped onto the carbide pellets, reacts to produce **acetylene** gas which is burnt. The resulting naked flame emits a bright light.

CARBIDE LAMP. *n.* A type of cavers lamp, with a bright naked flame produced by burning acetylene gas. Also called **acetylene lamp**. See **acetylene** and **carbide**.

CARBONATE. (1) *n.* A salt of **carbonic acid** eg. **calcium carbonate** ($CaCO_3$). (2). *v.* To charge or impregnate with **carbon dioxide**.

CARBON DIOXIDE. *n.* (CO_2) A colourless, odourless and non-combustible gas which is 1.57 times denser (heavier) than air. A by-product of respiration and metabolism of living organisms. Normal air (above ground) contains approximately 0.03% CO_2, however '**foul air**' in caves has occasionally been known to contain lethal concentrations of up to 13.5% by volume.

CARBONIC ACID. *n.* (H_2CO_3) A weak acid produced when **carbon dioxide**, (CO_2) is dissolved in water. Usually present in ground water and is responsible for forming caves by dissolution of **calcium carbonate** rocks.

CAVE. *n.* A natural cavity in rock, large enough for a human to enter. The extent of a cave system which may have more than one entrance and consist of many chambers and passages. The term still applies if the cavity is totally filled with water.

If the cavity is filled with **sediment** or ice, (making it impenetrable), then qualification of the term is required.

cf. **active cave, dead cave, dormant cave, fault cave, fissure cave, glacial cave, grot-hole, ice cave, lava cave, limestone cave** and **live cave.**

CAVE CORAL *n.* Also called "**coralloids**". This type of speleothem has branching stems and nodular tips; often resembling marine coral. When cut in section, concentric growth rings can be seen. Location of the developing coralloids can considerably vary shape and size. They can form submersed in a pool (subaqueous) or high up on the cave wall or ceiling (subaerial).

CAVE ENTRANCE. *n.* The start of a cave, defined by the **dripline** or at a horizontal line across an entrance at the base of a **doline.** The starting point of a cave **survey**.

CAVE PEARL. *n.* A concentrically-banded concretion that usually form in shallow cave-pools. Cave pearls can be spherical, cylindrical, irregular, or even cubical. They can range in size from as small as a sand grain up to 15 cm in diameter or as big as a basket ball. A single pearl may sit in it's own "cup" or a group of pearls may congregate in a "nest". The nuclei around which the concentric rings of calcite crystals grow is generally foreign material such as a grain of sand. A cave pearl is sometimes incorrectly called an **oolite** or oolith (British). Refer to **splash cup**.

CAVE-PISOLITE. *n.* See **pisolite**. *cf.* **cave pearl**.

CAVE-POOL. *n.* (1) Any isolated body of water in a cave, although generally accepted as having a small surface area.

(2) A deep place in an underground stream, often formed by a **rimstone dam**. *cf.* **rimstone pool, sump** and **lake**.

CAVE SYSTEM. *n.* The whole known extent of interconnected caves and cavities underground, including those too small to enter, which have been proven to be atmospherically or hydrologically connected.

CAVER. *n.* A person who goes caving. (American, `spelunker').(British, 'Potholer') *Syn.* **speleologist**.

CAVERN. *n.* A very large chamber in a cave.

CAVERNOUS *adj.* (1) Full of caverns. (2) characteristic of a cavern.

CAVERNICOLE. *n.* An animal which normally lives in a cave for the whole or part of it's life cycle.

CAVERNICOLOUS. *v.* See **cavernicole**.

CAVES. *n.* Plural of **cave**. Usually implies two or more cave systems which don't have any known physical underground connection large enough for human passage.

CAVING. (1) *v.* The physical act of entering and exploring a cave or caves. (2) *n.* The sport of exploring caves and other aspects included in the term **speleology**. *Syn.* **spelunking**.

CHALK. *n.* A soft white limestone consisting of fossilised remains of very small water organisms.

CHAMBER. *n.* Any large cavity inside a cave system.

CHIMNEY. (1) *n.* The cavity between two relatively vertical and parallel faces of rock which can be climbed by a person applying pressure to the opposing rock surfaces. (2) *v.* To chimney - the act of climbing a chimney. - *Syn.* **chimneying**.

CHIMNEYING. *v.* The act of climbing two relatively vertical and parallel rock faces, by a person applying pressure with parts of their body to the opposing rock surfaces.

CHOCK-STONE. *n.* A stone which has become firmly wedged between two solid rock faces.

CHOKE. *n.* A blockage or constriction in a passage, usually of fallen boulders, clay, sand or surface vegetation washed into the cave.

CLAUSTROPHOBIA. *n.* A fear of being in enclosed or confined spaces.

CLEFT. *n.* A space, opening or passage made by the cracking or splitting of rock. *Syn.* **fissure**.

CLAY. *n.* See **sediments**.

CLIMB. (1) *v.* the act of climbing, to raise oneself - ascend. eg. ladder climb. (2) *v.* physically climbing on rock to ascend or descend. (3) *n.* a place where climbing is necessary to progress.

CLIMBER. *n* A person who is descending or ascending a **pitch** either on a **ladder** or climbing a very steep incline or near vertical face. For safety reasons a safety line is generally used. Sometimes the term climber is used to describe a person prusiking up a rope.

CLIMBING. (1) *n.* A call yelled by a **climber** to a **belayer** that they are starting to ascend. (2) *v.* the act of climbing, to raise oneself - ascend. Can also include descending a steep rock face by means of physical contact of a persons limbs.

CLINOMETER *n.* A surveying instrument used in caves to measure inclination angle of a **leg** in relation to the horizontal. Also used to measure the dip of a **bedding-plain**.

CLINT. *n.* Surface erosion forms of limestone with irregularly fretted shape. Characterised by cris-cross grooves. The French word *lapiez* is sometimes used for clints

CLOSED TRAVERSE. *n.* A **traverse** in which a series of survey **legs** are joined to form a loop traverse, thus reducing cumulative error in a cave survey.

COATING. *n.* A thin finely crystalline speleothem which covers another solid body or object.

COBBLE *n.* - A piece of rock ranging in size from tennis ball to football. *cf.* **pebble**, **boulder**

COLLAPSE DOLINE *n.* See **doline** - **collapse**.

COLUMN. *n.* A **speleothem** which joins from floor to ceiling, formed by the junction of a **stalactite** with it's counterpart **stalagmite**. *cf.* **travertine**.

CONULITE. *n.* A speleothem resembling a hollow tube or cone formed in mud, sand or other soft material as the result of water dripping in the one spot. The drill-hole is gradually lined by the deposition of calcite from solution. Erosion of the surrounding soft material may leave the crystalline cone free standing.

CORAL. *n.* See **cave coral**.

CORALLOIDS. *n.* See **cave coral**.

COW'S TAIL. *n.* A short but strong length of rope used as a safety line when crossing a **rebelay**.

CRAWL. *n.* A low passage negotiated by stooping or crawling on hands and knees.

CRUST. *n.* A thin layer/s of crystalline speleothem covering a **bedrock** or soft material (eg. clay or sand) which can be easily removed from its underlying material with little mechanical effort. Similar to a **coating** but more granular and porous.

CRYSTAL POOL. *n.* A pool, usually with little or no overflow and containing calcium deposits of well formed crystals.

CURRENT MARKING. *n.* Shallow hollows formed by **solution** involving turbulent flowing water and typically covering walls of stream passages in **karst** caves.

CURTAIN. *n.* A **speleothem** in the form of a wavy or folded sheet hanging from the wall or roof of a cave, often translucent with various shades and colours of growth bands. See **shawl** and **travertine**.

DARK ZONE. *n.* The part of the cave system which daylight does not reach, no matter how faint. *cf.* **twilight zone**.

DAYLIGHT HOLE. *n.* An opening in the roof of a cave which allows light to enter from the surface.

DEAD CAVE. *n.* A cave without streams, pools or drips of water. A more correct term to use would be **dormant cave**.

DECORATION. *n.* A general term encompassing all types of **Speleothem**.

DESCENDER. *n.* A mechanical device used for controlled descent of a **pitch** or steep slope. It works on the principle of applying friction on a fixed rope to obtaine controlled descent for the **abseiler**.

DIG. *n.* The site of past, present or future excavation, where cavers are hopeful of significantly increasing the known extent of a cave. Also a site of excavation to uncover archaeological artefacts or animal bones. See **archaeology**.

DIAGENESIS. *n.* Changes in the mineralogy, geochemistry, texture and fabric of a **sediment** after deposition.

DIKE. *n.* A mass of **igneous rock** intruded into a fissure in another rock. In some instances, igneous rock has entered pre-existing cave passages.

DIP. *n.* The angle of inclination of a bed of rock from the horizontal, measured in degrees. The true dip is the maximum angle of the **bedding-plane** at right angles to the **strike**. Lesser angles in other directions are apparent dips.

DIP, APPARENT. *n.* See dip.

DOG-TOOTH CRYSTAL or **DOG-TOOTH SPAR.** *n.* A variety of calcite crystals with acute shaped points.

DOLINE. *n.* A closed depression on the surface of a **karst** area, which drains run-off rain water to a single low point. A doline may or may not contain the entrance to a cave or pothole. The shape of the depression may vary considerably from one to another, however they often resemble the shape of a bowl, cone, cylinder or elongated shape, ranging in size from a few to many hundreds of metres.

DOLINE - COLLAPSE. *n.* A natural surface depression formed by the collapse of a cavity below.

DOLINE - SOLUTION. *n.* A natural surface depression formed by solution.

DOLOMITE. (1) *n.* A double **carbonate** mineral consisting of **calcium** and magnesium. $CaMg(CO_3)_2$.
(2) *n.* A rock consisting largely of dolomite. *cf.* **magnesite**.

DOME. *n.* A large hemispherical hollow in the roof of a cave formed by **breakdown**, often in mechanically weak rocks where bedding and/or joints play little, or no part in dominating the form.

DORMANT CAVE. *n.* A cave without streams, pools or drips of water. Antonym of **active cave** or **live cave**.

DRAPERY. *n.* A wavy or folded **speleothem** which hangs down from an inclined wall or ceiling and resembles a **curtain**.

DRIPHOLE. *n.* A hole in the cave floor, formed by dripping water.

DRIPLINE. *n.* A line on the ground at the **cave** entrance formed by water dripping from the rock above. A dripline defines the beginning of a cave survey. ie. start of cave.

DRIPSTONE. *n.* A general term for **speleothems** formed by falling drops. eg. **stalagmites**.

DUCK-UNDER. (1) *n.* A constriction in a passage where water is at or close to the cave roof for a short distance, which requires a caver to become (more or less) fully submersed for a brief period before continuing. (2) *v.* The act of going through a **duck-under**. Also see **trap**.

DUNE LIMESTONE. *n.* A limestone made from **aeolianite**.

DYNAMIC ROPE. *n.* A **kernmantle** rope manufactured with twisted core strands and has the ability to stretch sufficiently to break the fall of a rockclimber. Rarely used in caving.

EFFLUX. *n.* Point of outward drainage of water from a cave system or **karst** area. May or may not be large enough to allow passage of a caver. *cf.* **outflow cave** and **resurgence**.

ENTRANCE *n.* See **cave entrance**.

ENTRANCE ZONE. *n.* The interface between the surface and subterranean (underground) environments leading into the **twilight zone**. Occurring in an **entrance chamber**.

ENTRANCE CHAMBER. *n.* A **chamber** which begins at the cave entrance or a chamber connected to the entrance by a short passage, but still within the **twilight zone**.

EOLIAN. *n.* Same as **aeolian**..

EPIPHREATIC. *n.* Referring to fast moving water in the top of the **phreatic zone** or in the zone liable to be subject to flood part of the time. *cf.* **nothephreatic**.

EROSION. *n.* The wearing away of bedrock or sediments, by mechanical and/or chemical action, usually facilitated by wind, running water or other moving agent.

ESCARPMENT. *n.* A long, cliff-like ridge of rock, commonly formed by faulting or fracturing of the earth's crust or down-cutting of streams. A steep slope or drop of a precipitous line of cliff, thus terminating high land abruptly.

FALLING. *n.* An emergency call yelled by a **climber** who has fallen, thus warning **belayer** to expect the safety rope to become taught with full weight of climber.

FALSE FLOOR. *n.* Sometimes called a "flowstone benche". **Flowstone** once deposited on sediments, but now eroded away, leaving a false floor which may span between passage walls or project to form ledges along a wall. Thickness may range from a centimetre or two, up to several metres.

FAULT. *n.* A fracture in a continuous body of rock where one side has displaced relative to the other. Movement has occurred along the **fault plane**.

FAULT CAVE. *n.* A cave developed along a fault, by preferential dissolution and may include abrasion by solid particles carried by water.

FAULT PLANE. *n.* A plane along which movement of a fault has occurred.

FISSURE. *n.* An open crack in rock or occasionally soil. Not formed by solution weathering. *cf.* **grike**. *Syn.* **cleft**.

FISSURE CAVE. *n.* A narrow vertical **squeeze**, formed by the splitting of rock often developed along a **joint** but not always so. Mostly formed by solution however sometimes due to tension. Also see **cleft**.

FIXED LIGHTING. *n.* Electric lighting with permanent wiring, usually installed in **show caves**.

FLATTENER. *n.* A **passage** which is wide but very low, requiring a person to lay on their stomach to facilitate movement.

FLOE CALCITE. *n.* Thin flakes of calcite having originally formed on the surface of a pool. May either be floating as a **calcite raft** or have sunk to the bottom of pool, or laying across the base of a dry pool. *cf.* **pool deposit**

FLOWSTONE. *n.* A deposit of calcite formed by a thin film or trickle of **calcium** bearing water, flowing over walls or floors. *cf.* **travertine** and **speleothem**.

FLOWSTONE BENCH. *n.* See **false floor**.

FLUORESCEIN. *n.* A powerful but harmless organic dye used for **water tracing**. A reddish-yellow in colour which turns to a green **fluorescence** when added to water. It is detectable in very dilute **solutions**.

FLUOROMETER. *n.* The instrument used to measure the **fluorescence** in water when water tracing. *cf.* **fluorescein**.

FLUORESCENCE. *n.* The emission of visible light when exposed to radiation of different wave length. Often a fluorescent substance converts invisible, ultraviolet (UV) light into light of a visible colour. Fluorescence stops as soon as the incoming radiation causing it, is removed. In simplified terms the ultraviolet light is absorbed by the atoms of the fluorescent material and the electrons take on a higher energy level. The electrons then begin a spontaneous release of portion of this energy in the form of heat as the atoms collide with neighbouring atoms. The heat generated is not perceptible, however sufficient to reduce the level of energy which can be re-emitted as light. Since the emitted light has less energy it is transmitted at a longer wavelength than the original incoming ultraviolet.

Consequently the light produced may well be in the visible portion of the light spectrum. *cf.* **luminescence**.

FLUTE or FLUTING. *n.* See **solution flute**.

FORMATIONS. *n.* A colloquial term, incorrectly used to encompass all types of **speleothem**.

FOSSIL. *n.* The remains or traces of animals or plants preserved in rocks or **sediments**.

FOUL AIR. *n.* 'Foul Air', sometimes called 'Bad Air', is any atmosphere which has a noticeable abnormal physiological effect on humans. In **limestone** caves, 'foul air' can generally be described as containing greater than 0.5% **carbon dioxide** (CO_2) and/or lower than 18% oxygen (O_2) by volume. As a comparison, normal air (above ground) contains approximately 0.03% CO_2 and 21% O_2 by volume. However there are some isolated caves which contain atmospheres influenced by other gases such as:- methane, ammonia, hydrogen sulfide or carbon monoxide, but these gases are not common in limestone caves.

An elevated CO_2 concentration is usually the most life threatening foul air scenario found within limestone caves. This colourless, odourless and non-combustible gas is the body's regulator of the breathing function. Physiological signs of foul air include:- increased heart and breathing rate, headaches, clumsiness, dizziness, loss of energy, feeling hot and sweaty. (Note, that at high altitudes there is an increased physiological effect.)

Elevated concentration of CO_2 in limestone caves can be due to the mechanism by which **carbonate** deposition occurs and/or a by-product of micro-organism metabolism and/or respiration by fauna such as bats or humans.

FREE-CLIMB. *n.* (1) A very steep incline or near vertical rockface which a person is able to climb with relative ease without the need for climbing aids. (2) *v.* The act of climbing a near vertical face without the use of a safety line. This is a dangerous activity if the climber is high above the ground.

FREE-CLIMBING. *adj.* see **free-climb**.

FREE PITCH. *n.* A vertical pitch where the rope or ladder hangs away (free) from the wall for almost all of the pitch length. *cf.* **Overhang**.

FRIEND. *n.* A specific type of mechanical climbing device, used as an **anchor** point by wedging it into a crack or hole.

FROSTWORK. *n.* A **speleothem** consisting of fine needle like crystals in radiating clusters similar to a thistle plant or in its composite **stalagmite** form possessing spiny limbs like a fir tree. The term was first used by cave guides in Wind Cave, South Dakota USA, during the 1890's to describe speleothems which looked like ice (H_2O) frostwork.

GARDENING. Colloquial term. (1) *v.* The act of clearing loose rock or debris away from an **abseil** face or ladder climb for safety and in doing so reduce the risk of objects falling on other people. (2) *v.* Moving of loose material from a tight or awkward **passage** to increase accessibility.

GASTEROPOD. *n.* Same as **gastropod**.

GASTROPOD. *n.* One of a large class of aquatic and terrestrial molluscs including the snails, slugs, limpets and whelks etc., usually having a single piece spirally coiled shell (univalve) and a flattened muscular creeping organ which acts as a foot on which they move about. Sometimes spelt **gasteropod**.

GEOCHEMISTRY. *n.* The science dealing with the chemical composition and changes in composition of the earth, particularly the crust.

GEOLOGICAL TIME SCALE. *n.* An arbitrary chronological arrangement or sequence of geologic events. It is usually presented in the form of a chart showing the names of various time-stratigraphic, rock-stratigraphic or geological-time units, as currently understood. eg. The geologic time scales published by Holmes (1959), Kulp (1961) and Harland (1964).

GEOMORPHOLOGY. *n.* The scientific study of landforms and landscapes. The term usually applies to the origins and dynamic morphology (changing structure and form) of the earth's land surfaces, but it can also include the morphology of the seafloor The science has developed in two distinctive ways that must be integrated in order for the whole picture of landscapes to emerge.

'Historical geomorphology' relies on various chronological analyses, notably those provided by stratigraphic studies of the last 2 million years. 'Process geomorphology' analyses contemporary dynamic processes at work in landscapes. The mechanisms involved **weathering** and **erosion**

GIBBS. *n.* A type of **ascender** which grips the rope with a cam operated by the weight of the caver.

GLACIAL CAVE. *n.* A cave formed within or beneath a glacier. *cf.* **ice cave**.

GOUR. *n.* Synonymous with **rimstone dam**. Derived from the French, the term 'gour' is now widely used in Europe. It should not be confused with the same word used for surface erosion features in deserts. *cf.* **microgour**.

GRADE. *n.* The level of accuracy of a cave **survey** and resulting map, based on the precision of instruments used in the survey. Survey standards range from Grade 1 (a sketch from memory) to the most accurate Grade 9 (precision **theodolite** survey).

GRAVEL. *n.* See **sediments**.

GRID NORTH. *n.* The direction in which each grid line points toward the top of a grided map. In a sense it is an artificial north adopted by map makers, but for practical purposes may be regarded as **true north**. Each grid line, in effect points to a north of its own, whereas all true north lines (meridians) if produced would meet at the north pole.

GRIKE. *n.* A deep, narrow, near vertical slot with almost parallel sides, in a rock outcrop caused by **solution** along a **joint**. *cf.* **solution tube** and **fissure**.

GROT-HOLE. *n.* Colloquial term for a small insignificant **cave** with no possible leads, often tight and difficult to manoeuvre oneself in.

GROTTO. (1) *n.* A small to moderate size cave **chamber** which is richly decorated with **speleothems**. (2) *n.* A term used by U.S. cavers to describe a local caving club.

GROUND-TROG. *v.* The systematic searching of surface ground for cave entrances. Also ground-trogging. *cf.* **trog**.

GROUND-WATER. *n.* Water below a **watertable** such as a waterlogged zone in permeable rocks or soil.

GUANO. *n.* A large accumulation of bat excrement which may also consist partly of decomposing animal skeletal material and small fragments of rock particles. To a lesser extent in caves it may consist of bird droppings.

GYPSUM. *n.* $CaSO_4.2H_2O$; Hydrated calcium sulphate, the third most common cave mineral and the most common sulphate mineral in caves. Gypsum is a **primary mineral**.

GYPSUM FLOWER. *n.* A radiating cluster of gypsum crystals, simulating outward-curving flower petals. *cf.* **anthodite**.

HALF BLIND VALLEY. *n.* A **blind valley** which overflows to a surface stream when the flow of water entering the blind valley, exceeds the maximum capacity which the stream sink can accept. *cf.* **blind valley**.

HALL. *n.* A large **chamber** which is considerably longer than it is wider.

HANDLINE. *n.* A short strong rope used to assist cavers on an awkward or exposed climb or **traverse** (2).

HARNESS. *n.* An arrangement of webbing **tape** used to attach the lower body (seat harness) or upper body (chest harness) to **ascender** or **descender**.

HEAD LAMP. *n.* The main lighting source, mounted on a cavers helmet. In Australia this usually refers to an electric light source, with the location of the battery/s being irrelevant. In many other countries this term refers to a **carbide lamp**. *cf.* **Head lamp - auxiliary**.

HEAD LAMP - AUXILIARY. *n.* A secondary light source (usually a small torch) attached to a cavers **helmet** and used as a backup in the event of an emergency.

HELICTITE. *n.* A **speleothem** which often resembles the form of a twisted or worm-like shape and having appeared to defy gravity during its growth process.

HELIGMITE. *n.* A **helictite** that grows upward from the cave floor is sometimes called a "heligmite".

HELMET. *n.* A non metallic hat designed to protect the wearers head from bumps or impact from small objects dislodged from above. Miners helmets with chin strap and **head lamp** clip are often used, however other varieties with four point attachment are preferable.

HISTO. *n.* Abbreviation for **Histoplasmosis.**

HISTOPLASMOSIS. *n.* A fungal disease which initially affects human lungs and may spread to other organs if untreated. The fungus - Histoplasma capulatum, is an organism which grows in soil having a high nitrogen content, generally associated with **guano** of birds and bats. Spore is breathed in with airborne dust stirred up by the movement of cavers. The disease usually appears as a mild cold before complete recovery. Occasionally severe infections occur and if left untreated can lead to death.

Other names for this disease include:- "Histo", "cave disease", "cave fever", "Darling's disease", "Ohio Valley disease, "Tingo Maria fever", "reticuloendotheliosis" and "reticuloendothelial cytomycosis".

HORIZONTAL ANGLE. *n.* The difference in direction between two **survey** lines measured clockwise in a horizontal plane.

HUMIDITY. See **relative humidity.**

HYDROLOGY. *n.* The study of water and stream movements above and below ground.

HYDROSTATIC PRESSURE. *n.* Pressure due to a column (or head) of water.

HYPERTHERMIA. *n.* An extremely high body core temperature of 41°C (106°F) or above. Can result from a caver exposed to prolonged periods of over-exertion, combined with insufficient loss of generated body heat. In extreme cases may result in death.

HYPOTHERMIA. *n.* A dangerously low body core temperature - below 37°C. Commonly caused by prolonged immersion in cold water. May also be caused by cold air circulation past a caver wearing insufficient or damp clothing from perspiration or in contact with wet or cold surfaces over a period of time. Death will occur at or around 30°C core temperature.

ICE CAVE. *n.* A cave containing permanent ice and/or seasonal ice. *cf.* **glacial cave.**

IGNEOUS ROCK. *n.* Aggregate of interlocking silicate minerals formed by cooling and solidification of magma.

INFLOW CAVE. *n.* A **cave** into which a stream enters or has been known to enter, but can't be followed downstream to the surface.

INORGANIC. *n.*(1) Not having the organised structure of animal or vegetable life; not living. (2) The chemistry of compounds lacking carbon or containing it only in the form of carbonates, carbides, and most cyanides.

INVERTEBRATE. *n.* An animal without a backbone or spinal column.

JOINT. *n.* A natural division or gently curving crack, which bisects a **bedding-plane.** Separating two parts of a once continuous rock without relative movement along the **bedding-plane.**

JOINT PLAIN CAVE. *n.* A cave developed along a joint. Typically high in relation to width.

JUG-HANDLE. *n.* A small loop of rock shaped like a handle, used as an anchor point or hand hold to aid climbing.

JUMAR. *n.* A single rope ascending device with a simple finger - operated safety catch. *cf.* **ascender.**

KARABINER. *n.* A metallic link which incorporates a spring loaded gate allowing a quick and secure coupling. Often used in conjunction with other equipment when rock-climbing and abseiling. Also see **krab** and **carabiner.** Origin:- Shortened from the German word 'Karabinerhaken' which means carbine hook, that is, one used to attach a carbine rifle to a belt.

KARREN. *n.* The minor forms of karst due to solution of rock on the surface or underground. eg. **rillenkarren, rundkarren** and **spitzkarren.**

KARST. *n.* An area of terrain containing features which are formed by natural waters dissolving rock. In most cases these areas contain **caves**. Derived from the geographical name of a part of Slovenia. See **solution**.

KARST FEATURE. *n.* Any feature formed by natural waters dissolving rock above or below ground. eg **cave** and **karren**.

KARST HYDROLOGY. *n.* All scientific study of water chemistry and distribution, whether stationary or moving in a karst system, as well as the effects in relation to human activity.

KERNMANTLE ROPE. *n.* A generic term describing a type of synthetic rope with a plaited sheath surrounding a core. Approx. 70% of the ropes strength comes from the inner core, 30% comes from the outer protective sheath. Ropes have two classifications:- '**static**' which have parallel strands in the core and '**dynamic**' with twisted core strands. The word 'Kernmantle' is derived from the German word 'Kern' for a core and Old English word 'Mantle' for a sheath. The word 'Kernmantle' should not be confused with any particular brand of rope. Sometimes spelt 'Kernmantel' which may be linked to the Latin word '*mantellum*' or Old French word '*mantel*' meaning - loose sleeveless garment or cloak.

KEYHOLE. *n.*(1) A small **passage** or opening in a cave having a keyhole shaped cross section, round above and narrow below. (2) A short **squeeze** of generally oval shape, which is the only access to a large cave extension. Key-hole, implying unlocking of access to the rest of the cave.

KRAB. *n.* Colloquial term for **karabiner**. A steel or aluminium alloy snap-link used in rope work.

LABYRINTH. *n. Syn.* **maze cave**.

LADDER. *n.* The type used for caving is portable and flexible. They are usually consist of aluminium alloy rungs attached to galvanised steel or stainless steel wires.

LAKE. *n.* (1) A sizeable body of water above ground. (2) In caving terms, a deep body of relatively still water with a surface area upwards of several square metres. There may or may-not be underwater passages leading from the lake. *cf.* **cave-pool** and **sump**.

LAVA. (1) *n.* Molten rock that issues from an active volcano or through a fissure in the earth's crust. (2) *n.* Rock formed by the solidification of this substance. Lava surface types include '**pahoehoe**' and 'aa'.

LAVA CAVE. *n.* A cave formed in **lava**, usually as a result of a flow of liquid lava through a solidification mass, or by roofing over of an open channel. Small lava caves may form as gas blisters.

LAY. *n.* The way in which strands of rope or cable are twisted. eg. left hand lay (also called 'S' twist) and right hand lay ('Z' twist). In caving this term is rarely used due to the overwhelming support of synthetic **Kernmantle** ropes.

LEAD. *n.* A cave **passage** noticed but not yet explored.

LEADER. *n.* In caving, the person directing activities of a caving party and held responsible for the group's safety.

LEG. *n.* Part of a survey **traverse** between two consecutive **stations**.

LIGHT-WATER *n.* Water aerated with bubbles making it less dense, thus providing less buoyancy to a person and their equipment. Light-water usually occurs at the bottom of waterfalls, rapids or cascades. Swimming in a light-water pool directly beneath a waterfall can be very dangerous, as reduced buoyancy and downward force of water can hold or snag a person underwater.

LIMESTONE. *n.* A sedimentary rock composed mainly of **calcium carbonate** ($CaCO_3$). (Containing more than 50% $CaCO_3$). It usually originates from the accumulation of **calcareous** remains of marine life.

LIMESTONE CAVE. *n.* A **cave** formed in **limestone**.

LIMESTONE-OOLITIC. *n.* Composed of small spherical grains bonded together by a cement composed of **calcite**.

LITHIFICATION. *n.* Process by which unconsolidated rock-forming materials are converted into a consolidated or coherent state.

LIVE CAVE. *n* A cave containing a stream and/or active **speleothems**. *cf.* **active cave**. Antonym of **dormant cave** and **dead cave**.

LONGITUDINAL (or LONG) SECTION. *n* A scale drawing of a cave elevation, sectioned along the length of a cave passage or chamber, or combination of these, or along a survey traverse.

LUMINESCENT. *adj.* Pertaining to **luminescence**.

LUMINESCENCE. *n* An emission of light. The glowing of an object due to an increased energy level of it's atoms and without perceptible heat. The atoms can be excited by radiation, such as light or by electricity and is re-emitted at any wavelength, but is most familiar as visible light. Two forms of luminescence are "**fluorescence**" and "**phosphorescence**".

MAGNESITE. *n.* $MgCO_3$. The mineral - magnesium carbonate. Magnesite karst areas are rare, however several sites exist in Tasmania, one being at Keith River. Magnesite can also occur as crusts and as moonmilk in caves in **dolomite** rock.

MAGNETIC NORTH. *n.* The direction in which the needle of a compass points, differing in most places from **True North**. *cf.* MN. and **grid north**.

MARBLE. *n.* **Limestone** which has been recrystallised after being subjected to high temperatures as may occur in nature from surrounding volcanic action. The resulting marble is much harder than limestone and is able to be polished, making it much sought after for sculptures and architecture. Also see **metamorphism**.

MAZE CAVE. *n.* A complex network of connecting cave passages, often on two or more levels, forming a three dimensional maze.

MEANDER. *n.* A bend or semi-circular curve in an underground stream bed which has the same origins and looks similar to a meander in a surface stream.

MEANDER NICHE. *n.* A hemispherical recess or depression in a cave roof, formed by a stream meander. A stream meander in the cave roof.

METAMORPHIC. *adj.* Of or pertaining to **metamorphism**.

METAMORPHISM. *n* The process whereby rocks undergo physical or chemical change or both to achieve equilibrium with conditions other than those under which they were originally formed. Factors which may cause metamorphism are heat, pressure and chemically active fluids. Weathering is usually excluded from the meaning. eg. When **limestone** comes into contact with molten lava it undergoes metamorphism to form **marble** upon cooling.

MICROBOD. *n.* A colloquial term used to describe a child or an adult caver of small build - able to fit through narrow passages and seemingly able to dislocate their joints to negotiate tight corners.

MICROCLIMATE. *n* The climate (ie. temperature, humidity, air movement, etc.) of a restricted area or space. eg. of a cave or on a lesser scale of the space beneath stones in a cave.

MICROGOUR. *n.* A miniature rimstone dam with associated tiny pool, approximately 10mm wide and deep. They commonly occur in flowstone.

MINERAL *n.*- PRIMARY. A natural occurring homogeneous solid, of definite chemical composition and crystal structure. (eg. **calcium carbonate**., quartz, **gypsum**). Rocks may be comprised of several minerals (eg. granite or basalt), others composed of a single mineral (eg. **limestone** or **dolomite**).

- SECONDARY. A mineral originating from another mineral as a result of chemical change caused by atmospheric oxidation, carbonic acid and water. ie. **Speleothems** consisting of **calcite**, **aragonite** or **gypsum**.

MN. *n.* Abbreviation on maps for **Magnetic North**.

MOONMILK. *n.* A term used to describe, finely crystalline substances of varying compositions. Texture, not composition is implied by the term "moonmilk".

Most commonly composed of calcite which forms a soft white powder when dry and feels like cream cheese or cotton candy when moist.

MORPHOLOGY *.n.* The study of form and structure. (1) *Geological* - The study of the physical form of land or region. *cf.* **geomorphology** (2) *Biological* - The study of the form and structure of animals and plants, without regard to function.

NAPPY. *n.* A colloquial term for an abseiling **harness** worn around the hips and thighs.

NATURAL ARCH. *n.* An arch of rock formed by weathering alone, - without human intervention. *Syn.* **arch.**

NATURAL BRIDGE. *n.* A bridge of rock which spans a ravine or valley and is formed by erosion.

NOTHEPHREATIC. Referring to water moving slowly through cavities in the **phreatic zone**. *cf.* **epiphreatic.**

OFF-ROPE. *n.* A call from an **abseiler** or belayed **climber** to indicate that they have disconnected from the rope. *cf.* **abseil clear.**

ON-BELAY. *n.* A call made by the **belayer** (to a **climber**) that the set-up has been checked and they are ready to operate the manual **belay** system.

OOLITE. *n* A morphological term meaning a small spherical or subspherical, accretionary body consisting of two or more concentric rings. The overall size being smaller than 2 mm in diameter. Anything larger is called a **Pisolite.**

The body can be made of any material and not necessarily calcite. A rock may be said to possess an oolitic texture if it consists largely of oolites. In general the term **oolite** should <u>not</u> be used to describe a **cave pearl.**

British publications refer to a cave pearl as an "oolith" or if unpolished, included in the general term of "cave-pisolite" which covers all types of concretions formed of concentric layers. See **cave pearl.** *cf.* **pisolite.**

OUTFLOW CAVE. *n.* A cave from which a stream discharge flows or formerly did so, and which cannot be followed upstream to the surface. *cf.* **efflux** and **resurgence.**

OVERHANG. *n.* (1) A ledge or shelf of rock which projects past the rest of the rock face below. Includes a **rock shelter** or simple cave in which no part is in the **dark zone.** (2) *n.* part of an **abseil** (either above or below ground), where the **abseiler** is hanging free of the rock face. Specifically, once an abseiler has passed a projection of rock which makes it impossible for the abseiler's feet to touch the rock face without swinging on the rope. For a ladder climb the overhang is considered to be that section of a pitch where the ladder free hangs, clear of the rockface and for some distance.

PAHOEHOE. *n.* A type of **lava** in which the surface was relatively fluid just prior to complete solidifying and so formed smooth or porridge-like surfaces. Variants include wrinkled or 'ropy' surfaces, like thick flowing tar or pitch, and surfaces with small rounded knobs. Surface texture grades from 'pahoehoe' to 'aa' lava.

PALAEONTOLOGY. *n.* The study of bones and fossils.

PASSAGE. *n.* A cavity which is much longer than it is wide or high and may join larger cavities.

PEARL, CAVE. *n.* See **cave pearl.**

PEBBLE. *n.* - A rock between the approximate size of a golf ball and tennis ball. *cf.* **sediments** and **cobble.**

PENDANT. *n.* A smooth sculptured projection of **bedrock** suspended from the roof or wall of a cave. Formed by **erosion,** - not redeposited as a secondary mineral deposit. Not a **speleothem.**

PENDULITE. *n.* A kind of **stalactite** which is or has been partly submerged in cave water for some time and now has a growth of **dog-tooth crystal** over that part which was submerged, to give the appearance of a drumstick.

PERCOLATION WATER. *n.* Water which is moving downward through pores, cracks and tight fissures in the **vadose zone.** *Syn.* **seepage water.**

PERMEABLE. *adj.* having pores or openings that permit liquids or gases to pass through.

PERMEABILITY - PRIMARY. *n.* The property of rock or soil to allow passage of water or gas through the interconnecting pores in its grain structure.

PERMEABILITY - SECONDARY. *n.* The state of rock allowing water or gas to pass through **joints** and / or **bedding-planes**.

***pH* value.** *n.* A scale of values, ranging from 0-14, indicating the acidity or alkalinity of a **solution**; 7 is neutral, lower values from 7 to 0, show increasing acidity, and alkalinity increases from 7 to 14.

PHOSPHORESCENCE. *n.* Similar to **fluorescence**, however the emission of visible light continues after the removal of the original radiation light source. Also see **luminescence**.

PHREATIC DEVELOPMENT. *n.* Enlargement of existing joints and bedding planes by movement of water under pressure (ie with no free airspace).

PHREATIC WATER. *n.* Water in the **phreatic zone**.

PHREATIC ZONE. *n.* The level in the strata which is below the **watertable** and all cavities in the rock are filled with water.

PILLAR. *n.* A column of bedrock reaching from floor to roof, remaining after surrounding rock has been eroded away.

PINNACLE KARST. *n.* A tropical **karst** of near vertical sided spires. *cf* **Spitzkarren**.

PIPE. *n.* A tubular cavity in karst rock extending from its surface to a depth of a metre or more and often filled with **sediments** and/or **breccia** for some of its depth *cf.* **solution tube**, **fissure** and **grike**

PISOLITE. *n.* A morphological term meaning spherical or subspherical, accretionary body consisting of two or more concentric rings. The overall size being larger than 2 mm in diameter. The body can be made of any material and not necessarily calcite. *cf.* **cave pearl** and **oolite**.

PIT. *n.* A term used by cavers to describe a vertical or near vertical **shaft** and without **passage** or **chamber** leading from it. A pit often has a flat bottom of earth or rock fill. The entrance may be open to the surface or below ground in a cave. A pit is wider than a **chimney**. *cf.* **shaft**, **chimney** and **pothole**.

PITCH. *n.* A vertical or near vertical section of a cave where **ladders** or ropes are normally used for descent or ascent.

PITON. *n.* A metal peg hammered into cracks for an anchor. Although this was the original used, with environmental awareness of damage caused to the rock face, it's use as an anchor point has diminished considerably. These days it is used more as an abseiling device.

PLAN. *n.* A cave sketch or scaled map, showing details projected vertically onto a horizontal plane.

PLUNGE POOL. *n.* A pool, usually of large size and often containing **light-water**, occurring at the bottom of a waterfall or rapid. May be on the surface or underground. *cf* **swirlhole**.

POLYMORPHS. *n.* A substance (such as **calcite**) which has the ability to assume several crystalline forms.

POOL. *n.* Any small isolated body of water or a deep place in a stream. *cf.* **cave-pool**.

POOL DEPOSIT. *n.* (1) Any sediment which accumulates in a **cave-pool**. (2) Any **speleothem** precipitated in a cave-pool although usually of crystalline shape as well as structure. *cf.* **calcite raft**, **dog-tooth crystal** and **rimstone**.

POROSITY. *n.* (1) The property of rock or soil with small voids which may or may not be **permeable**. (2) porosity due to fractures and joints in rock. (3) porosity of a **karst** system due to conduits. *cf.* **permeability** and **percolation water**.

POTHOLE. *n.* An English speleological term. (1) A vertical or almost vertical **shaft** or **chimney**, open to the surface and requires **rigging** to enter. (2) a cave system containing multiple pitches requires the use of ropes or ladders to enter. *cf.* **pit**.

PRIMARY MINERAL. *n.* see **mineral - primary**

PRUSIK KNOT. *n.* A friction knot which grips on the fixed ascending rope when weight is applied and runs free along the rope when weight is removed. Used to ascend ropes, however it's possible to descent but rarely used this way because the method is very slow. The knot was first described by Dr. Karl Prusik in an Austrian Mountaineering Journal of 1931. Possibly first introduced to caving in 1952 by Bill Cuddington of Virginia, when he successfully rappelled and prusiked a 40 foot pit in Haynes Saltpeter Cave, West Virginia U.S.A.

PRUSIK SLING. *n.* A loop of rope tied to another rope with a prusik knot.

PRUSIKING. *v.* The modern day term refers to either ascending on a rope using **prusik knots** or **ascenders**.

QUATERNARY. *adv.* Of or pertaining to the youngest geological period covering approximately 1.8 million years to the present. - *n.* The quaternary period.

RADON. *n.* The heaviest known gas which is colourless, odourless and radioactive, (atomic no. 86, atomic weight 222 -most stable isotope). Formed by the radioactive decay of radium-226, formerly called 'niton'. symbol (Rn). Radon-222 was discovered in 1900 by the German chemist Friedrich Ernst Dorn (1848-1916).

Radon has a half-life of 3.8 days, decaying by the emission of alpha particles into an isotope of the element polonium. Small quantities of radon, formed by decay of uranium minerals, are found in rock and soil. Concentration of the gas, can collect in some caves and is believed to be a potential health hazard.

RAPPEL *v. Syn* **abseil**.

RAPPEL RACK. *n.* A mechanical **abseil** device, able to be set with variable degrees of friction to suit the weight of the **abseiler**.

RAFT. See **calcite raft**.

REBELAY. *n.* Any additional attachment points (after the initial anchor point) on a rope down a pitch. Rebelays are placed to avoid rub or wear points on a rope or to split a long pitch. Also used as a **redirection**. *cf.* **belay**.

REDIRECTION. *n.* A **rebelay** used to redirect a rope so that cavers, either abseiling, prusiking or climbing, avoid a dangerous hazard such as a waterfall.

RELATIVE HUMIDITY. *n.* Is the amount of water vapour that air actually contains at a certain temperature compared with the maximum amount it could contain at that temperature. Changes in relative humidity of a cave air, correlate to variations in atmospheric pressure, ingression of **ground-water** and variation in cave **temperature**. Expressed as a percentage, the relative humidity of saturated air, such as fog or cloud is 100%. Most caves have a high humidity.

RESURGENCE. *n.* The point at which a stream resurfaces like a large **spring**. This occurs when water of a surface stream disappearing into a **stream sink**, where upon it flows underground for some distance. The resurfacing point of this stream is the **resurgence**. The underground water stream may also originate from a combination of many small surface streams and seepage in a cave system, before resurfacing at the **resurgence**. *cf.* **spring**.

RHIZOMORPH. *n.* A **speleothem** originally formed around tree or plant roots, which may have long since decayed, but the calcareous deposit has preserved their shape and form. *cf.* **rootsicle**.

RIFT. *n.* A long, narrow, high and straight cave passage with development controlled by a relatively straight weakness in the rock. (eg. formed along a **fault** or **bedding plane**).

RIGGING. (1) *v.* The setting up of descending or ascending equipment. The term also includes a **belay** if required. (2) *n.* The equipment in total, required for an ascent or descent.

RILL. *n.* A small solution groove on the surface of exposed karst rock. *cf.* **rillenkarren, rundkarren, spitzkarren, solution flute**.

RILLENKARREN. *n.* Well developed solution flutes. Small linear hollows separated by narrow, sharp ribs, which run down the steepest line of slope on steeply inclined to vertical faces. Usually formed on the surface of karst bedrock exposed to the atmosphere.

cf. **rundkarren**, **spitzkarren**. *Syn.* **solution flute**.

RIMSTONE. *n.* A deposit precipitated from water flowing over the rim of a pool. *cf.* **speleothem**.

RIMSTONE DAM. *n.* A barrier of **calcium carbonate** or other precipitated deposit which obstructs a stream or pool. The ridge or dam formed is often curved convexly downstream. *Syn.* **gour**. *cf.* **travertine**.

RIMSTONE POOL. *n.* A **cave-pool** lined with a **rimstone dam**.

RISING. *n.* A natural flow of water from below ground, issuing from rock or soil, to the land surface or into a body of water. *Syn.* **spring**.

ROCK. *n.* A consolidated mass of mineral matter.

ROCK PENDANT. *n.* See **pendant**.

ROCK SHELTER. *n.* A rock overhang or simple cave which has been, or could be, used by humans for habitation or shelter from the elements.

ROCKHOLE. *n.* A hole in **karst** or non-karst surface rock, usually round in form and holding water after rain. Generally shallow if formed by weathering or chemical erosion, and can be deep if formed with the aid of running water.

ROCKPILE. *n.* A heap of rocks in a cave, usually conical or part-conical in shape and formed by local collapse or **breakdown**.

ROOF CRUST. *n.* A crust formed on the roof of a cave.

ROOF-SNIFFING. (1) *v.* Colloquial term for the act of edging oneself along a small water-filled passage, on your back with only sufficient airspace for eyes and nose. Also roof-sniff. (2) *n.* A place where a caver must roof-sniff.

ROOTSICLE. *n.* roots of trees or plants which grow into a cave cavity and become calcified. The roots and **speleothem** comprising the rootsicle. *cf.* **rhizomorph**.

RUNDKARREN. *n.* Surface karst solution feature consisting of rounded grooves, normally formed under soil, heavy litter or moss. *cf.* **spitzkarren** and **rillenkarren**.

SAFE. *n.* A call made by a person who has finished climbing (ascending or descending) to a another person who has been belaying, - to indicate that they are safe and that the belay rope is no longer required.

SAFETY LINE. *n.* A safety rope attached to a caver climbing a **ladder** or undertaking a difficult manoeuvre, and **belayed** by another person either above or below. *Syn.* **belay rope**.

SAND. *n.* See **sediments**.

SATURATED. (1) *adj* water logged (hydrology). (2) *adj.* The state of a **solution** which will hold no more solute (physical chemistry).

SCALING POLE. *n.* A lightweight pole, often constructed from short sections and assembled in situ to raise a **ladder** to a point inaccessible by **climbing** without the aid of **anchor bolting**.

SCALLOPS. *n.* See **solution scallops**.

SCROGGIN. *n.* An edible random mixture of nuts, dried fruit, rice crisps, unwrapped lollies, chocolate and edible seeds. The mixture is consumed by cavers, bushwalkers and other outdoor enthusiasts as a source of high energy food. It is made up to suit an individuals taste and requirements.

SEA CAVE. *n.* A **cave** in present-day or emerged sea cliffs, formed by wave action, or **solution** to sea water.

SECONDARY MINERAL. *n.* See **mineral - secondary**.

SECTION. *n.* A sketch or scale drawing of a **cave** in vertical plane, which shows floor, walls and roof, to represent the shape of cave **passage** or **chamber** at the section.

SEDIMENTS. *n.* Fragmentary material deposited by water or air.

Clay - The individual particles are too small to be seen with the naked eye. It becomes very sticky when wet. *cf.* **terra rossa**.

Silt - Very fine grit but the particles can be seen with the naked eye.

Sand - About beach size sand. (Approx. 1 - 2mm diameter).

Gravel - Rocks generally the size of small blue metal chips (smaller than a **pebble**), however may contain a mixture of smaller **sediments**. For descriptions of larger rock material which may fall into the category of sediments see:- **pebble**, **cobble**, **boulder** and **block**.

SEDIMENTARY ROCK. *n.* Rock formed from accumulation of sediment, which may consist of rock fragments of various sizes, remains or products of animal or plants, production of chemical action or of evaporation, or mixture of these. Stratification is the single most characteristic feature of sedimentary rocks.

SEEPAGE WATER. *n. Syn.* **percolation water**.

SELENITE. *n.* A coarsely-crystalline, transparent variety of **gypsum**; colourless when pure, but sometimes tinted brown or grey by impurities.

SELF-GUIDED CAVE. *n.* A **show cave** which is set up in a manner which allows visitors to guide themselves around marked tracks. Usually with explanatory literature and/or recorded messages and fixed lighting.

SHAFT. *n.* A vertical cavity or passage with approximately equal horizontal dimensions and much larger vertical dimension. A shaft has at least one **passage** or **chamber** leading from it. The entrance may be open to the surface or below ground in a cave. A shaft is wider than a **chimney**. *cf.* **pit** and **pothole**.

SHAWL. *n.* A triangular shaped **curtain**. Type of **speleothem**.

SHOW CAVE. *n.* A cave open to the public for guided or **self-guided** tours. Often with formed tracks and fixed lighting.

SINK. *n.* A place where a stream sinks. See **stream sink**.

SINKHOLE. *n.* A natural drainage hole or cavity in rock, worn by the action of water usually along a joint or fault. Often formed in a doline. (A word of American origin.)

SILT. *n.* See **sediments**.

SIPHON. *n.* A waterfilled passage of inverted 'U' profile. Water flows out of the siphon whenever the head of water feeding into the upstream side of the **trap** rises above that of the siphon passage.

SLACK. *n.* A **call** made by a person being **belayed**, to the person **belaying**. A request for extra slack in the **belay** line.

SLING. *n.* A loop of **rope** or **tape**.

SOLUTION. *n.* A homogeneous mixture formed by dissolving one or more substances, whether solid, liquid or gaseous, in another substance.

In **karst** areas, water containing **carbon dioxide** or other dilute acid in solution causes the chemical **erosion** of **carbonate** rock. The acidic water, erodes the bedrock (eg. **limestone**) when its ions go directly into solution without transformation and are carried away.

SOLUTION DOLINE. *n.* A **doline** formed by **solution** in **karst** rock and not modified by collapse.

SOLUTION FLUTE. *n.* A solution hollow running down the maximum slope of the rock, of uniform fingertip width and depth, with sharp ribs between each groove. Usually found on surface limestone due to weathering. *Syn.* **rillenkarren**.

SOLUTION PAN. *n.* A dish-shaped depression on flattish rock. Its sides may overhang and carry **solution flutes**. The bottom of the pan may have a cover of organic remains, silt, clay or rock fragments.

SOLUTION PIPE. *n.* See **pipe**.

SOLUTION RUNNEL. *n.* A solution hollow larger than a **solution flute**, running down the maximum slope of the rock and increasing in depth and width over its length. Thick ribs between neighbouring runnels may be sharp and carry **solution flutes**.

SOLUTION TUBE. *n.* A hole or small tunnel, formed in **calcium carbonate** or other **material** which has been created by the chemical action of water. Orientation is irrelevant. Larger in size and more round than a **grike**.

SOLUTION SCALLOPS. *n.* Current markings that intersect to form points and are due to the action of swirling water.

These shallow depressions in the rockface are most commonly found in solid **bedrock**.

SPELEOGEN. *n.* A **karst** cave feature formed in rock by **solution** or **erosion**. eg. **pendant** and **current markings**.

SPELEOLOGIST. *n.* A person who studies caves in any of the scientific aspects. *cf.* **speleology**.

SPELEOLOGY. *n.* The exploration, mapping, photography, description and scientific study of caves, subterranean environments and phenomena relating to karst terrains. Includes:- hydrology, geology, mineralogy, palaeontology etc. The term is often extended to include **ground-trogging**. *adj.* speleological.

SPELEOTHEM. *n.* A **secondary mineral** deposit formed within a cave, most commonly **calcite**. However may be **aragonite** or **vaterite** or other secondary mineral. The formal definition of the word "speleothem" as introduced by Moore (1954) and widely accepted (Greek *speleon*, a cave; *them*, deposit), does not exclude **stalactites** and **stalagmites** of ice and lava.

SPELUNKER. *n.* American name for a **caver**.

SPELUNKING. *v., n. Syn.* **caving**. *cf.* **spelunker**.

SPITZKARREN. *n.* Solution spikes. A **karst** feature which has developed in conjunction with bedding grikes, and due to erosion, sharp fluted spikes have formed on the upper faces,. This feature usually develops in steep to vertically dipping beds. Height may vary from 0.5 to 3 metres depending on limestone composition and climate. *cf.* **Pinnacle karst**, **rillenkarren** and **rundkarren**.

SPLASH CUP. (1) *n.* A shallow cavity in the top of a stalagmite caused by dripping water. (2) *n.* Any shallow depression caused by dripping water. *Syn.* **conulite**. *cf.* **driphole**.

SPONGEWORK. *n.* A complex of irregular, inter-connecting cavities intricately perforating the rock. Cavities may range in size from a few centimetres to more than a metre across.

SPRING. *n.* The natural source of ground water flowing upwards from rock or soil onto the land surface to form a small pool and/or stream. *cf.* **resurgence**.

SQUEEZE. (1) *n.* A small opening in a **cave** which is passable with effort. Also see:- **crawl** and **flattener**. (2) *v.* To wriggle or push through a small passage.

SRT. Acronym for 'Single Rope Technique' - includes **abseiling** and **prusiking**.

STALACTITE. *n.* A **secondary mineral** deposit (**speleothem**), hanging from the roof of a cave and often shaped like an icicle. Most commonly consisting of **calcium carbonate** which forms by seeping or dripping water depositing calcium carbonate out of **solution**. **Travertine** is the form of **limestone** which makes up this type of speleothem. However the term "stalactite" also includes formations of ice, lava and other deposited cave minerals.

STALACTITE STRAW. *n.* See **straw**.

STALAGMITE. *n.* A **secondary mineral** deposit (**speleothem**), which grows upward from the floor of a cave. Most commonly consisting of **calcium carbonate** which forms by dripping water depositing calcium carbonate out of solution. **Travertine** is the form of limestone which makes up this type of speleothem. However the term "stalagmite" also includes formations of ice, lava and other deposited cave minerals.

STATIC ROPE. *n.* A **kernmantle** rope manufactured with parallel core strands and has little stretch with the weight of a person abseiling or prusiking. This type of rope is not suitable for rockclimbing as the small amount of stretch would induce high shock loading on a person, when arresting a fall. Static ropes are mainly used by cavers. *cf.* **dynamic ropes**.

STATION. *n.* A main survey reference point, usually in a chain of such points used to survey a cave or surface feature.

STRAW. *n.* A hollow thin-walled **stalactite**, uniform in diameter over its whole length. Usually less than 7mm in diameter. Also see **speleothem**

STREAMBED. *n.* The ground over which a stream or flow of water is running or once did. The lowest path of a valley or cave passage formed or altered by water.

STREAM SINK *n.* A point at which a surface stream disappears into an underground drainage system, usually into an obvious **karst** feature. Often a depression containing a hole or number of holes into which the stream flows. May also percolate down through streambed **sediments**. See **sink** and **resurgence**.

STRIKE. *n.* The direction of a horizontal line through a **bedding-plane** in rocks inclined to the horizontal. On level ground it is along the direction in which inclined beds of rock outcrop. At right angles to the **dip**.

STROMATOLITE. *n.* A mound like structure of **calcareous sediments**, formed by fine layers of inorganic debris (eg sand grains) deposited on successive gum like mats produced by Cyanobacteria (formally known as Blue-Green Algae). Stromatolite fossils date back to the Archaean and Proterozoic eras, and their presence suggest the process of photosynthesis began at an early age in the development of life on earth. Excellent examples can be found in the **limestone** deposits of Brachina Gorge - Flinders Ranges South Australia. Also see **stromatolitic stalagmite**.

STROMATOLITIC STALAGMITES. *n.* A type of stalagmite found only near the **entrance** and **twilight zones** of some caves. This type of speleothem may have a lobster or crayback appearance which can be contributed to the growth of algae (often Cyanobacteria more commonly known as Blue-Green Algae) which has preferentially enhanced deposition of **calcite** on the light facing side of the **stalagmite**. In some locations such as through **arches**, the deposition of calcite on the stalagmites may be influenced by a constant air flow as well as algae. Thus the stalagmite is elongated in section and oriented toward the cave entrance. This type of stalagmite can be classed as both **speleothem** and stromatolite. Also see **stromatolite**.

SUBTERRANEAN. *n.* Pertaining to underground environments (in **karst**).

SUMP. (1) *n.* A pool of water completely filling a submerged passage as in a water **trap**. (2) *n.* The lowest point in part of a **cave system**, where water collects in a pool before draining or seeping away slowly. *cf.* **cave-pool** and **lake**.

SUPERSATURATED. *n.* Referring to water that has more **calcium carbonate** or other **karst** rock mineral in **solution** than the maximum corresponding to normal conditions.

SURVEY (cave). *n.* The measurement of distances and direction (compass bearing) between survey points (**station**) and noting of prominent cave features. Usually for the purpose of producing scaled drawings of cave plans and sections (cave map) from the measurements.

SURVEYING. (1) *n.* a branch of applied mathematics that teaches the art of accurately determining distances, direction and area of any portion (eg. cave) and delineating the whole on paper. (2). *v.* The act of doing a survey.

SWIRLHOLE. *n.* A more or less circular hole in rock of a present or past **streambed**, eroded by eddying water with or without the mechanical action of **sediments** up to the size of a **cobble**.

SYNGENETIC KARST. *n.* **Karst** developed in **aeolian calcarenite** when the development of **karst features** has taken place at the same time as the **lithification** of **calcareous** dune sand.

TAG. *n.* A small marker with a cave number marked on it. Usually made of corrosion resistant sheet metal (25mm square), with the number stamped on the face.

TAGGING. *v.* The act of fixing a tag (bearing the cave number) to the solid **rock**, tree or structure, near the **entrance** of a cave.

TAPE. (1) *n.* A flat or tubular webbing tape, usually made of nylon. Used to make **harnesses** and **slings**.

(2) *n.* A graduated tape measure, used in surveying. Tape materials presently available include; steel, plastic, wire-reinforced cloth, fiberglass and carbon fibre (kevlar).

TERRA ROSSA. *n.* Reddish clay soil developed on or around limestone.

TERRACE. *n.* A gently sloping series of **rimstone dams**.

THAT'S ME. *n.* A call from a **climber** to a **belayer** who is taking up the slack in the rope - indicating that the belayer is feeling the weight of the climber with no slack in the rope.

THEODOLITE. *n.* An accurate instrument used to measure horizontal and vertical angles by means of a small telescope. Used in cave surveying for **Grades** 7 to 9.

THROUGH CAVE. *n.* A cave which may be followed from entrance to exit along a stream course or passage which formerly carried a stream.

TOURI. *n.* A colloquial term used to describe a group of tourists at a commercially developed caving area. In other words those people who go on guided or **self-guided cave** tours where **fixed lighting** is provided to view the caves.

"Stay out of sight of the tourists (touri)", is usually one of the conditions attached to a caving permit, where the permit cave is in the vicinity of a commercial tour cave.

TOWERKARST. *n.* Residual **limestone** outcrops with very steep to overhanging lower slopes. Between the towers there may be alluvial plains or flat-floored depressions.

TRACE. *n.* A short length of woven wire fitted with interlocking rings fitted at each end and used to attach a flexible **ladder** or rope to an **anchor point**.

TRACER. (1). *n.* A substance introduced into surface or underground water. It is used to determine drainage connections and travel time.

(2). *n.* A material introduced into cave air to determine interconnecting chambers and tunnels.

TRAP. *n.* A place where a cave passage becomes completely full of water to the roof (usually for some distance) before rising above water to a siphon. *cf.* **duck-under** and **sump**.

TRAVERSE. (1). *n.* The commonest form of cave **survey** in which distance, direction and vertical angle between successive points are measured. A series of **legs** between **stations**.

(2). *n.* A way along ledges above the floor of a cave.

(3). *v.* To move along such a route.

TRAVERTINE. *n.* A form of dense, closely compacted **limestone** consisting mainly of banded layers. It is often coloured white or cream and consists mostly of $CaCO_3$ which is deposited from spring, river or lake water. *cf.* **Tufa**.

Specifically in caves, any **flowstone** or **dripstone** deposit consisting mostly of $CaCO_3$. ie. **Stalactite** and **stalagmite**.

The word travertine comes from an old Roman name *Tiburtinus* of Tibur (now Tivoli), a town in Italy where large deposits of travertine occur.

TROG. (1) *n.* Colloquial term for caver. Abbreviation for **troglodyte**. (2) *v.* Systematically searching the surface ground for cave entrances. - Same as **ground-trog**.

TROG-UP. *v.* Colloquial term. To get changed into suitable clothing and necessary equipment in readiness to go underground.

TROGGED-UP *n.* Past tense of **trog-up**. Attired in caving gear in readiness to go underground.

TROGLOBITE. *n.* An animal (**cavernicole**) living permanently in the **dark zone** of a **cave** and unable to live outside the cave environment.

TROGLODYTE. *n.* A human cave dweller.

TRUE NORTH. *n.* The direction to the geographical north pole from the position of the observer. *cf.* **grid north** and **magnetic north**.

TUBE. *n.* A smooth cave passage of nearly circular or elliptical section.

TUFA. *n.* A porous, light yellow crystalline limestone often with a spongy like appearance, deposited in solution from **spring** or surface water. **Calcium carbonate** which is deposited over twigs, dead leaves, moss and earth, builds up mounds or **terraces** in the above ground streams. Over time the vegetation decays, leaving the calcium carbonate with a spongy appearance. *cf.* **travertine**.

TUNNEL.(1) *n.* A nearly horizontal cave open to the surface at both ends, fairly straight and uniform in cross-section. Not necessarily in sight of daylight *cf.* **arch**. (2) *n.* A spacious cave **passage**, fairly straight and uniform in cross-section. (Not open to the surface.)

TWILIGHT ZONE. *n.* The outer part of a cave where daylight penetrates and gradually diminishes to zero light, Between the **entrance zone** and **dark zone**.

VADOSE DEVELOPMENT. *n.* The down-cutting action of a cave stream having a free airspace. Cave development due to water (vadose water) which descends freely and is not under hydrostatic pressure. The fast moving water carries rocks and grit which also cause mechanical erosion of the **bedrock**. A tell-tail sign of 'vadose development' is **scallop** markings in the bedrock, caused by running water.

VADOSE FLOW. *n.* Water flowing in a free surface stream, thus having no hydrostatic pressure.

VADOSE SEEPAGE. *n.* Syn. **percolation water**.

VADOSE WATER. *n.* Water in the **vadose zone**.

VADOSE ZONE. *n.* The zone where rock cavities are partly filled with air and through which water descends under gravity.

VATERITE. *n.* The least common form of **calcium carbonate** found in caves.

WALK-THROUGH. *n.* A **passage** with plenty of headroom where a caver can walk through without stooping or crawling.

WATER SINK. *n.* Either above or below ground. A place where flowing water sinks into an impassable passage.

WATERTABLE. *n.* The upper limit of the **phreatic zone**, or the level of saturation of the strata, (usually very localised in limestone terrain).

WATER TRACING. *n.* Determining the water connection point of a steam sink and its reappearance at the **efflux** or **resurgence**. See Tracer.

WATER TRAP. *n.* See **TRAP**.

WEATHERING. *n.* The processes of physical disintegration and/or chemical decomposition of solid rock materials at or near the earth's surface. Physical weathering breaks up rock without altering its composition, and chemical weathering decomposes rock by slowly altering its constituent minerals.

Weathering may alter the colour, texture, composition, or physical shape of rocks.

WET CAVE. *n.* A cave containing a **lake/s** and/or active stream with deep **pool/s**, which require wading or swimming to progress through the cave. The caver can expect to become very wet and possibly cold. The wearing of wetsuits may be advisable. This term also includes caves where inflatable rafts are used to cross a deep section of water.

WHALETAIL. *n.* A mechanical **descender** made from an aluminium block, designed to apply varying degrees of friction depending on the number of slots the **abseil rope** is passed through.

WINDOW. *n.* An irregular shaped hole through a thin rock wall, between cave **passages** or **chambers**.

ZONE, DARK. *n.* See **dark zone**.

ZONE ENTRANCE. *n.* See **entrance zone**.

ZONE, PHREATIC. *n.* See **phreatic zone**.

ZONE, TWILIGHT. *n.* See **twilight zone**.

ZONE, VADOSE. *n.* See **vadose zone**

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Shawls - Mitchell-Palmer
Unknown Cave

CLIEFDEN CAVES REVEGETATION PROJECT

Authors: Chris Dunne and Bruce Howlett © January 1999
Given by: Bruce Howlett

(This paper replaces that listed in the program as *Rehabilitation of Cliefden Caves* by Peter Dykes)

Background

Tree planting was the prompt for this project. Over the past decade, about eight separate plantings of trees (about 200 per site) have occurred on *Boonderoo* property, which is known to cavers as *Cliefden,* after the original property in the district. Several of these plantings have been done by members of member clubs of the NSW Speleological Council in co-operation with the owner of *Boonderoo,* Anthony Dunhill. However, none of them has been done with a specifically karst related outcome in mind.

Also in recent years, members of both the Federation and the Speleo Council have expressed the desire to obtain funding for cave and karst related activities, without the need to dip into their own pockets. Peter Dykes, Convenor of the Speleo Council's *Cave Numbering and Documentation Committee,* has long had an interest in obtaining grant funding to assist in the documentation of karst in NSW.

In 1995, the Speleo Council established a *Heritage Grants Committee,* convened by Chris Dunne, to pursue such applications. A proposal to seek a *Heritage Grant* from the NSW Heritage Council in 1995-96 was not pursued as, at that time, another organisation had already obtained a grant for a *Study of Carbonate Rocks in NSW.* Subsequently, the Heritage Grants scheme ceased and our applications have been directed to two newer schemes: the NSW Government's *Environmental Trusts* (ET) and the Commonwealth government's *Natural Heritage Trust* (NHT). These schemes have a strong focus on projects with environmental and vegetation outcomes.

In 1997 and 1998 we lodged ten applications under these schemes, eight with an emphasis on karst related vegetation. Projects mooted in these applications are seen as a means to piggy-back work on the wider documentation of karst areas. Two of our applications have been approved. For Cliefden, we were granted an amount of $5,000 in early 1998.

The Cliefden Context

This grant from the Environmental Trusts' *Rehabilitation and Restoration Trust* was to assist in the fencing out and revegetation of a significant karst outcrop at Cliefden, known as *The Island.* Cliefden Caves is an especially significant karst in the valley of the Belubula River, a tributary of the Lachlan River in the Murray-Darling Basin, in the Central West of NSW.

It covers parts of five adjoining pastoral properties, the main one being *Boonderoo* mentioned above. Cliefden lies within the Lachlan Karst Region for purposes of karst documentation and is formed in Ordovician limestone.

The limestone along the Belubula River was first reported by Surveyor George Evans in 1813. Although his visit coincided with a drought, he described the tree cover in the vicinity as *park-like* (ie. scattered woodland). The district was settled from the 1820s, with grazing of sheep, cattle, horse and goats being the main land use since that time.

During the late 1800s, the caves at Cliefden were a popular destination for the more adventurous in the region. As a result, some caves suffered severe impacts. In the 1950s, the area became popular with speleological groups. To alleviate problems between visiting groups, the then property owner Bruce Dunhill (Anthony's father) asked Orange Speleo Society (OSS) to instigate a system to control cavers and their access to the caves. This control evolved into the present system of permits and gated caves which has succeeded both in protecting the caves and in promoting good relations with all five property owners at Cliefden.

Grazing pressure and other human activity over 175 years have had profound impacts on the endemic flora of the region, especially the karst specific species and communities at Cliefden, which remain poorly conserved. A study undertaken in 1995 [?] for the Walli Limestone Landcare Group by Professor David Goldney and students from Charles Sturt University, in Bathurst, looked at different flora communities within the area. Whilst several species could be found in different communities, the study found there existed a karst specific community.

Fortunately, there are several small but significant remnant vegetation sites at Cliefden. These occur where the karst is steep and rugged so that they have been inaccessible to stock. The only other reasonably intact, karst specific flora communities in this region are thought to be those at Borenore Caves and a smaller site on a reserve adjoining the limestone quarry at Molong. However, these are both many kilometres to the north of Cliefden, and the species which make up those communities are somewhat different.

In consultation with owner Anthony Dunhill, the karst outcrop known as *The Island*, an area of about 15 hectares, was selected as a project site. It is significant within the Cliefden karst, and distinctive in that it is bounded on one side by the Belubula River and on three other sides by an alluvial flood plain. It is plainly a cutoff spur from a former river meander.

Island Cave is located at the foot of a steep bluff in the southwest corner of the outcrop and has four entrances. The cave is usually very dry and dusty, but becomes *active* following major rain events. There are several minor caves and karst features in the outcrop.

The existing vegetation consists of several kurrajongs and acacias in the southwest of the outcrop, native groundcovers and ferns amongst the rocky sites, and is otherwise dominated by briar, thistles and other introduced weed and grasses.

The outcrop was formerly fenced around, however, only 750 metres of this fence remains in good condition. A further 750 metres was in derelict condition and partially buried as a result of soil erosion from the slopes above.

Project Description

The aim of the *Cliefden Caves Vegetation Restoration and Rehabilitation Project* is to remove grazing stock from *The Island* and revegetate with locally endemic, karst specific species, thus recreating as closely as possible the natural plant community. The team co-ordinating the project comprises: Chris Dunne, Peter Dykes, Bruce Howlett and Denis Marsh.

The grant application included a budget of $10,000 for the project. The *Environmental Trusts'* contribution of $5,000 was to finance the purchase of fencing materials, the collection and propagation of seeds, and for tubes, stakes and tree guards to enable planting out.

The remaining $5,000 identified in the budget mainly covers *in kind* contribution of labour by members of Speleo Council member societies for the removal of derelict fencing, erection of new fencing, collection and propagation of seed, and the planting of seedlings, together with the property owner's *in kind* contribution of labour and the use of machinery, etc.

The initial phase of the project was removal of the derelict fencing, which was achieved by two one-day work trips, mostly by members from OSS. Although new fence-posts were placed, heavy rain during the Spring and the subsequent planting of a lucerne crop on the adjoining paddock over Summer made site access difficult. Consequently it was not possible to string wire and complete fencing during 1998. A joint trip by member clubs is planned for early February 1999 to complete this task.

Meanwhile, building on the earlier work of Goldney et al., Peter Dykes, who is a specialist in vegetation ecology, has carried out additional work to develop a *vegetation model* as a guide to our intended planting, ie. what species to place where, numbers and ratios of species, etc.

In this study, it was observed that natural community consists of scattered White Box and Kurrajong on the limestone itself, some Yellow Box on the margins and on the alluvium, and also occasional Cyprus Pine elsewhere on the karst. However, the major component of the karst specific community is the shrubs. Hop Bush (Dodoneae) and Quondong (Santalum) dominate. One species of Acacia is only found on *The Island*. Other species include: Clematis, Indigofera, Westringia, Cassia, Eremophilla and Hardenbergia (some species of which are locally and regionally rare).

OSS member Greg Lee, who has a background in horticulture, has made several visits to identify and collect suitable seed, which he is now propagating off site. Ultimately, it may be necessary to augment this with the purchase of some local nursery stock - there are two local nurseries within 15 kilometres of Cliefden.

The final phase of the work will be the planting of seedlings in Autumn 1999. This will again involve member clubs of the Speleo Council. Although this will mark the formal conclusion of the project in terms of the grant, it is expected that additional plantings will be carried out over several years. By this time we anticipate that earlier plantings will be regenerating naturally.

Project Outcomes

Although not mentioned in our grant application, the impetus for the project was that this was not to be just another tree planting exercise. This would be an attempt to recreate a natural ecosystem by reintroducing and protecting a poorly conserved, karst specific, flora community.

By revegetating in this manner, it is intended to recreate several natural processes, which may all interact and are not mutually exclusive:

- The increase in canopy and litter cover will reduce erosion and soil desiccation (ie. drying out), leading to an increase in soil moisture retention, and an increase in the amount and quality of water infiltrating the limestone.

- The increase in the amount of organic matter in the soil will enhance the CO_2 cycle so important to karst processes.

- The exclusion of stock will reduce (and even reverse) soil compaction, which, together with improved soil structure from increased organic matter in the soil, may reopen former infiltration channels into the karst.

If these processes can be successfully recreated, then it may be inferred that there will be positive effects flowing through to any underlying caves, such as rejuvenation of speleothems and the like. To this end, a monitoring program within *Island Cave* will assess likely effects over time.

Finally, Walli Limestone Landcare Group will be invited to inspect the site giving us the opportunity to raise its member's awareness of karst vegetation issues and the unique attributes of the karst environment.

Wider Sphere

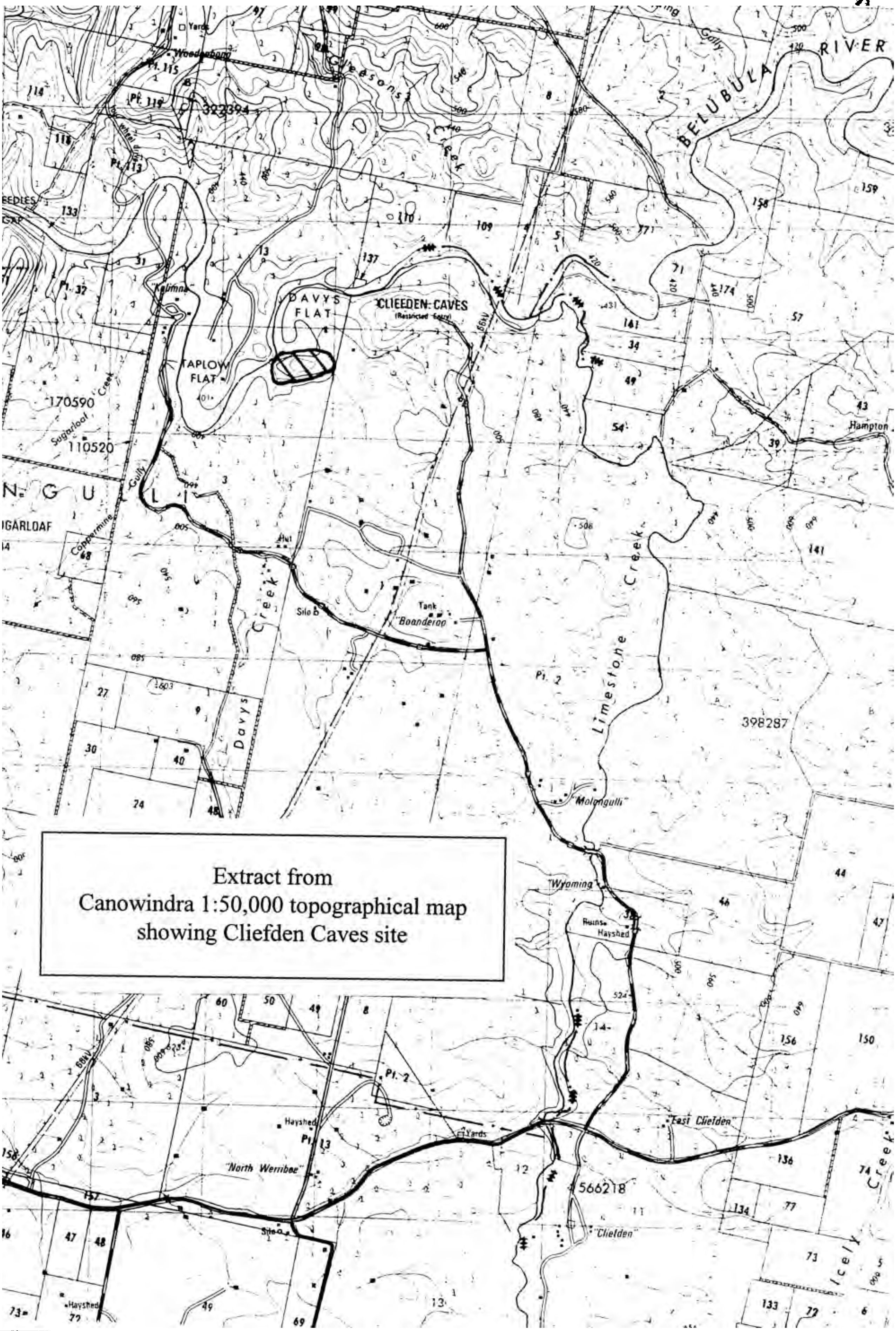
Our 1998 application to the Commonwealth government's *Natural Heritage Trust* (NHT) included the Cliefden project as a state government funded component of a larger karst vegetation and documentation project across the Lachlan Karst Region. *The Island* at Cliefden would have been highlighted as a *Demonstration Site* within the region to show the benefits and practicalities of restoring the natural karst specific ecosystem.

Our NHT application for the Lachlan Region and a similar one for the Blue Mountains Karst Region were unsuccessful.

However, our application for the Macquarie Region, well to the north of Cliefden, has recently won us a grant of $27,330. A *Demonstration Site* at Bakers Swamp in that region will be given similar treatment to the Cliefden site.

Acknowledgments:

- Anthony Dunhill and his family have made us welcome at Cliefden over many years and Anthony has been behind all eight plantings conducted on his property.
- OSS has staged some of these, particularly those near the cavers' hut.
- Chris Dunne, inspired by the two earliest plantings by *Men of the Trees*, initiated two of the major tree plantings (500 trees) which sparked the Cliefden project.
- Peter Dykes deserves credit for his conceptualisation of our several project grant applications and congratulations on our winning the two grants obtained.
- Peter's push and Chris's fine tuning of the applications and support also deserve credit, as do the contributions of several others.



Extract from
Canowindra 1:50,000 topographical map
showing Cliefden Caves site

ASF KNOWLEDGE MANAGEMENT

by Evalt Crabb January 1999

INTRODUCTION

Issues of intellectual property, copyright and financial enterprises have been subject to discussion recently in informal avenues within the Australian Speleological Federation. These discussions have lacked clarity because of confusion about the basic principles of copyright.
The intention of this paper is to define copyright in simple terms, then discuss how intellectual property can be most effectively managed. In view of the quantity of data collection and recording in our activity, there will be particular attention to copyright issues affecting cavers, caving clubs and ASF. At this time it is intended to use a narrative form - the hundreds of references can be made available on demand.

DEFINITION

The concept of copyright is quite simple. Copyright laws protect authors and publishers by giving them certain exclusive rights. These rights create a market for the products produced by authors and publishers and allow them to make a living, or at least gain some reward, from the use of their work. Unauthorised copying deprives authors and publishers of valuable income and reduces incentive to create new works.

Copyright is a type of property (or asset) which can be bought or sold, and is only different from tangible property such as a house or car in that it is not a physical entity. Hence the term 'intellectual property'. It is different to physical property in that it can often be duplicated easily without the knowledge of the owner.
Copyright is the exclusive right by law to produce copies, often involving payment of a fee, and to control an original literary, musical or artistic work, by the creator, for a specific number of years. In Australia as in many other countries, an author's copyright exists for 50 years after the author's death. Copying can only be done with the permission of the copyright owner or their exclusive licensee or agent.

The law of copyright in Australia is set out in the *Copyright Act 1968* (as amended). A 1984 amendment to the Act included in the definition of the term 'literary work' a table, or compilation, expressed in words, figures or symbols (whether or not in a visible form) and a computer program or compilation of computer programmes. Later amendments (up to July 1998) expand detail of electronic media rights and employed journalists' rights.

WHAT DOES COPYRIGHT PROTECT?

MORAL RIGHTS

Although pre-empted, there is not yet legislation in respect of Moral Rights. In brief: where the copyright of a work can be assigned or sold to another person, moral rights are personal to the artist and recognise the link between a creator and their work irrespective of ownership of the copyright.

Some of the proposed points in a Moral Code are:

- The artist should be attributed
- A work should not be falsely attributed
- An artist's decision to remain anonymous or use a pseudonym should be respected
- An artist's choice to have their name removed from a work should be respected
- Works should not be intentionally destroyed, mutilated, distorted or defaced
- Works should be maintained in good condition
- Artists should be consulted about alterations to their work
- Adaptations of a work should maintain the integrity of the original work
- An artist's work should not be trivialised.

For the purpose of this Code the term 'artists' refers to all creators, such as writers. The final details will not be known until the legislation is introduced.

REGISTRATION

There is no system of registration of copyright in Australia. Copyright protection does not depend on publication, a copyright notice or any other procedure - the protection is free and automatic. A work or other subject matter is protected from the time it is first written or recorded in some way, provided it has resulted from the creator's skill and effort and is not merely copied from another work. However, a compilation of non-original material may qualify for protection if the compilation is sufficiently distinctive. It is the compilation that attracts the copyright. Although the copyright notice is not required for protection in Australia it is advisable to place the notice on all copies because it indicates the work is protected and identifies the owner. The notice consists of the symbol © followed by the name of the copyright owner and the year of first publication.

Example: © Evalt Crabb 1999

NB. To avoid the possibility of a claim that a copy preceded yours it is desirable for a copy to be annotated with the actual date of completion. If the original work is stored as a computer file, the time and date are automatically recorded.

OWNERSHIP OF COPYRIGHT

The general rule is that the first owner of copyright in a work is its creator. The first owner of copyright in a film is usually its producer or investors. The first owner of copyright in a sound recording is usually its investor.

*Generally, the author of any "literary work" will hold copyright in that work (s35(2)). "Literary work" is used in a legal sense and refers not only to works of what would normally be regarded as literature, but in fact any written compilation of information. The term is expressly defined to include tabulated data (such as a cave survey) and computer programmes (such as the electronic Karst Index).

The "author" will be whoever had intellectual input in compiling that work. In the case of a survey, it will be all the people who participated in that survey. In the case of a cave map, it will be the person who translated the survey data into a map.

For cavers, there is one relevant exception to the above. Section 35(6) provides that a literary work made under the terms of employment by another person under a contract of service, then the employer owns the copyright. However, for most volunteer speleos, this exception is not likely to apply. The law differentiates between employment "under a contract of service" and engagement under a contract for the provision of services. In the first case, a relationship of employer/employee exists; the second case is that of an independent contractor engaged to perform services for someone. The following are some possible indicia of employment under a contract of service:

- the author is an "integral part" of the employer's business
- the employer's resorces are made available to the author to carry out the author's job
- the author does not use their own capital for the job
- the employer's remuneration is not affected by the success or failure of the activity being performed
- the employer deducts tax and superannuation contributions from the employee's salary.

So, if an employee of a karst management authority surveys a cave, then the employee will not own copyright and it will subsist with the management authority; however, if the management authority asks or engages a speleologist to survey a cave, copyright rests with the speleologist (subject to the provisions discussed below).

There are other exceptions in s35 that are unlikey to be relevant to cavers - relating to work under a contract of service for a newspaper, magazine or similar periodical; and commissioned portraiture (photographic, artistic or sculptural).

(The Copyright Amendment Bill 1997 introduced changes whereby copyright ownership is split between employed journalists and newspaper proprietors under s35(4). Employed journalists will own copyright for reproduction of the work for the purpose of inclusion in a book and photocopying, while newspaper proprietors will own copyright for all other purposes, including electronic publication. etc).

Another exception is provided by s176. Where a literary work is made "by, or under the direction or control of, the Commonwealth or the State", copyright subsists in the Commonwealth or State, as the case may be (henceforth referred to as "the Crown").

The legal result of this is not absolutely clear. In particular, does a requirement on a permit that "copies of any survey must be provided to management" mean that the survey was done "under the direction of" the Commonwealth or State? It would appear to be the case, that if the work was compelled to be done then it belongs to the Crown; however, if work is done voluntarily and then provided to the Crown, even if pursuant to a permit condition to provide any such voluntary work, then copyright nevertheless subsists in the author. Although Crown permission may be required to enter a cave, and activities in the cave may be regulated, the Crown is not exercising "control" over the production of the survey. It would only be doing so if it required the survey to be done, and dictated, for example, the grade of the survey, the instruments to be used and so forth; and also requiring the survey to be done.

Note that trip report forms which some Crown land managers require to be filled in as a condition of entry are probably Crown copyright as they are filled in at the direction of the Crown.

Since compulsory trip reports may be Crown copyright, cavers may wish to publish a different version of the trip report to that which is supplied under a permit condition, to avoid any doubt over the ownership of the material in that report. *

REWARDS FROM OWNERSHIP OF COPYRIGHT

The owner of copyright can gain reward from their endeavours in many ways.

- NON-CASH REWARDS
  The owner of copyright may permit general free use of the work, their only benefit being self-satisfaction, or prestige arising from correct attribution. This often occurs when the owner is attempting to influence other people or the general public.

- SELF-PUBLISHING
  The owner may choose to self-publish and sell the published work directly or indirectly to consumers, retaining all rights for the duration of the copyright. Or they may change the licensing status at any later time.

- BOOK PUBLISHING - ROYALTY BASIS
  The right to publish and sell the product may be assigned to a publisher, with a contract specifying conditions and limitations. This is the usual course for books, and the conditions may include sales only in a specified country, the format and construction of the book, and any time limitation.

  The owner (author) can assign the right to publish a book to one person; to translate into another language to a different publisher, or allow another to produce a dramatised version.

  Payment to the owner is usually on a royalty basis; for example, the author may receive 10% of the retail price of every book sold. Most contracts between publisher and author call for variations for different quantities of sales, or a variation of royalty between hard cover and paperback editions. It is usual for a publisher to pay some royalty in advance, then quarterly or six-monthly amounts depending on actual sales.

  Disputes often arise because the author must depend on the sales figures provided by the publisher, and also the growing trend to remaindering a book (from which the author gets no return) if it does not achieve high sales figures within a few months of launch.

  A new scenario is imminent. Hand-held reading devices are now being sold, usually with ten books stored electronically. It is possible to down load these books onto a computer to clear some space (and therefore become available for use by anyone else) and replace them with new books from the internet. Presumably a fee would be applicable. This has the potential to be a nightmare in author/publisher relationships because of a perceived threat to the authors' income potential.

- PUBLIC LENDING RIGHT

  Another source of income for authors and publishers is the Public Lending Right scheme.
  Australia is one of the few countries in the world with Public Lending Right legislation under which some authors and publishers receive from the public purse annual compensation for use of their books by Australian libraries - being able to borrow a book obviously diminishes sales.

However, it should be noted that not all authors or all publishers are funded in this way. Only those books, which are fairly widely distributed to libraries qualify. Each year the Australia Council, which administers the scheme, surveys a selected number of libraries throughout Australia. All titles of which 50 or more copies are found, to be held in libraries qualify for the Public Lending Right payment. Authors and publishers have to lodge separate claims for each title but the claim only needs to be made once - annual payments are automatic as long as a sufficient number of the title are held.

- THE CROWN AND COPYRIGHT

  The Crown is entitled under the Copyright Act to use any copyright work so long as the work is used for the services of the Crown. The Crown does not have to obtain the consent of the copyright owner, but it is required to notify the owner of the use of the material and to pay compensation as agreed upon by the Crown and the owner, or as fixed by the Copyright Tribunal.

- COPYRIGHT AGENCY LIMITED

  The Copyright Agency Limited was established in 1974 by the ASA, ABPA and the Australian Copyright Council to be a viable, central agency to collectively administer the copyright of authors and publishers in the volatile copying environment, representing authors and publishers.

It is the collecting society authorised by the Federal Attorney-General to administer the statutory licences as contained in the Copyright Act, and also offers/administers voluntary copying licences. It collects from government departments, educational institutions, corporations, associations, places of worship and information brokers. It is a **not-for-profit** company and distributes collected fees to its member authors and publishers. While its previous focus was print copying, it is now extending its services into electronic media.

- ASSIGNED RIGHTS

The owner of copyright can assign his or her rights, in whole or in part. Remuneration may be part of the agreement. This is the basis of sale of the right to publish freelance work. The work may be offered to a publisher (newspaper, magazine, etc) for first publication rights only. Variations might be:

- all rights
- first Australian rights
- one-time only rights
- English language only rights
- specific use rights, and others.

In the commercial world a written contract is used, which specifies the extent of the rights to publish and the remuneration, which is usually a "once-off" payment on publication - sometimes but not often on acceptance for publication.

Over the past few years there has been increasing conflict between authors and publishers re assigned rights due to greater use of electronic media. When a writer assigned a work it was expected that it were for print, and the fee was commensurate with circulation of the publication. But some publishers used the same work in electronic form and writers believed that they should receive additional payment.

The case of National Geographic best illustrates this conflict. Virtually all of the content - text and photos - of National Geographic is freelance work, on the basis outlined by Chris Norton "an independent contractor engaged under a contract for the provision of services... " and assignment of rights was "first world rights".

National Geographic recently compiled all past issues as a collection on 10 CD-ROMs. Writers regarded this as a new publication. The ultimate ruling was that: it was not a new use of the material but merely a different edition similar to, say, a large print version. As the reproduction was an exact facsimile including editorial and advertising material, National Geographic still held the copyright on the full layout of the magazine which included all of the assigned material. It has been stated that if the reproduction had been modified to display only some or all of the assigned material (without advertising, editorial content, an index, etc then there may have been a breach of assigned rights... Or the original contracts may have permitted an anthology...
The point here is that former processes for assignment of rights are now inadequate and while there is still much conflict, both writers' and publishers' organisations are trying to resolve the issues.

The assignment of rights is being breached quite clearly in another way. There are on-line services which "find" and reproduce (transmit) intellectual property for a fee without having the right to do so. In some cases these services have developed huge databases on particular subjects. Although action has been taken against a few of these services, they are often hard to detect and even harder to locate.

If an author or publisher wants to protect their income, they should be very cautious of e-publishing.

- LICENSING

There are two methods of payment for licensed use of copyright material; a "once-off" fee, or "per capita usage". There are also possible licensing limitations:

- *Partial assignment - so that the owner retains part only of the rights, for example, the author of a book may retain the rights to republish the book but assign the rights to make a movie or stage play based on the book.
- Exclusive licensing - the owner permits another person to exercise the rights, in whole or part, to the exclusion of anyone else, either indefinitely or for a specified period of time.
- Joint licensing - the owner permits another person to exercise the rights, in whole or part, either indefinitely or for a specified period of time, but maintaining the right to use those rights themselves or assign similar rights to others.
- Regional assignment or licensing - the owner assigns or licences rights to another person that are only exercisable within a particular part of Australia. *

An example of "once-off" fee is the marketing of computer software, whereby the user is licensed to use the work for their own use, but not dispose of it to another party nor copy, nor allow copies to be made for use by another party. Anyone who has purchased software would be familiar with the voluminous terms, conditions, limitations attached to the package.
An example of "per capita" licensing would be a training course package used by a licensed individual or organisation where a fee is payable for every participant in such a training course.

In both examples, the owner retains the copyright and also the exclusive right to amend the product.

- **INTELLECTUAL PROPERTY IN ASF**

There is a very wide range of intellectual property in respect of ASF and its parts; ownership, permitted or licensed use has never been clearly determined, although the above discussion does define automatic ownership.

- **INDIVIDUAL CAVERS**

  Copyright automatically belongs to any caver who reports on their experiences, observations or data collected.

  Where data is collected jointly, such as cave survey data, the copyright is owned jointly. The copyright in any drawn map rests with the person who drew the map (or jointly, if more than one person was the draughtsman). Individuals may, if they wish, permit the use of their work by clubs or ASF, with or without limitations, but copyright does not automatically flow to the club or ASF.

- **CAVING CLUBS**

  Non-incorporated clubs have no legal identity and therefore cannot own any property, including intellectual property. Any claims that "the club" owns copyright are invalid. An exception occurs where there is a formal Deed of Trust and Trustees appointed in accordance with the appropriate legislation. This was the situation with ASF prior to Incorporation.

  Incorporated clubs have a legal identity and may own property. Whether it is desirable for individuals to yield their rights to a club is outside the purpose of this paper.

  A common club function is the publication of newsletters, journals and sometimes occasional papers. The latter is usually the work of an individual who thus owns copyright. Copyright in serial publications is usually vested in the editor or publisher, unless claim to copyright is indicated for particular items.

- ASF

  Many documents are being produced and have been produced by or on behalf of ASF, and there has been preliminary discussion (admin. meeting 29/8/98) which tried to examine both ownership issues and marketability including archives and private papers as resources.

  The copyright in some publications is definitely vested in ASF. These are:

  - Australian Caver.
  - Speleo Handbook 1
  - Australian Karst Index (but not necessarily raw data used in compilation)
  - Various leaflets promoting caving or ASF
  - All policies, codes and guidelines
  - Administrative Handbook
  - (possibly) the qualifications, training and appointments material now in course of preparation.

  Marketing any of the products above is not for decision or recommendation by this author, but will no doubt be addressed elsewhere.

In view of the above, it is believed to be important to fully review the "ASF PUBLICATION POLICY & COPYRIGHT" (Dec. '72), as several anomalies exist.

Attention is drawn to clause 9 of that policy, which states that data collected by the ASF Commission on Bibliography be published as "Australian Speleological Abstracts" **and the copyright of that journal shall vest in the Sydney Speleological Society.**

FINAL COMMENTS

The above paper has dealt with issues of ownership of copyright with some comment on use of copyright material. But many questions are left unanswered. Below are further comments by Chris Norton:

- **WHAT IS ASF PROPERTY?**

What sort of material makes up ASF property? Is it anything done by ASF members in caves? Surely not - that would mean any club's maps, bulletins etc were ASF property. To this end, something should only be ASF's property if there is an agreement between the ASF members producing that property and ASF.

- **OWNERSHIP**

What should the terms of that agreement be? Should the members retain any rights over the property, or should it belong completely to ASF? Should this be determined on a case-by-case basis? What consideration should there be where someone assigns their intellectual property rights to ASF? One-off payment (which may be nominal)? 'Royalties' on any amounts earnt by ASF from the work?

Where someone retains partial intellectual property rights, what happens to any amounts received for use of that property? Should the individual and ASF share any profits? Should each party retain all the profits made by their own use/marketing of the property?
Where someone retains partial intellectual property rights, is the express permission of ASF and the person both required before any use is made of the property? Or is a clause granting full permission to be included in any agreement of assignment of property?

My preference is that all rights are handed over to ASF for an agreed sum. Whether or not this sum should represent "fair return" for the input of the individual is probably a matter for case-by-case analysis. How many tens of thousands does ASF propose to pay Krunchy, yourself et al for the work done on the Caving Leadership standards?!

USE BY ASF ORGANISATIONS

- On what terms should ASF clubs, members, speleo councils, commissions be able to use ASF property? Should an agreement be used? Should use be limited to ASF purposes only?
- Should members get a discount on standard licence fees for private (non-ASF) use of ASF material?

USE OF PROPERTY BY NON-ASF ORGANISATIONS

- Does ASF hand over all intellectual property rights (of the Exit survey), or merely grant a licence? My preference is ASF should always grant a licence or it will end up having to ask permission to use its own work!

- What should the terms of the licence be? A one-off payment is easier to enforce and less admin hassle. A 'pay per use' agreement may be more lucrative (particularly for training materials eg pay $x for each student).
- Should a licence be time-limited?
- Does a licensee have any rights to updates, new versions etc? For free? At a reduced rate? Can a licensee sub-licence?
- Should ASF be identified on all material used as the copyright holder/author?
- Is any liability accepted by ASF for eg whether the material complies with any relevant standards; loss in tort including negligence; damages in contract?
- Is liability limited to the purchase price?

PROTECTION/ENFORCEMENT

- What physical steps can be taken to protect AEF property? (eg printing of logos on each page of documents, maps; protection of computer files)
- What attitude would ASP take to the alteration of its material by a licensee for the licensee's purposes?
- What will the ASF's attitude be to any breach of agreement, either by its members or a licensee/assignee?*

*Sections enclosed in asterisks (pp. 2-3, 6, 7-8) copied from comments by Chris Norton (pers. com.)

Sources:

Australian Copyright Council
Australia Council for the Arts
Australian Society of Authors
Copyright Agency Limited
Style Manual (of the Australian Government Publishing Service)
PLR - Dept. Of The Arts and Administrative Services

MITCHELL-PALMER KARST EXPEDITIONS

By Clive Kavanagh

A CENTRAL QUEENSLAND SPELEOLOGICAL SOCIETY PROJECT

The name "Mitchell-Palmer Karst Expeditions" was chosen by CQSS when applying for funding from the Australian Heritage Commission to continue the exploration of the Mitchell-Palmer karst area. The original application was for three, two-week expeditions over a three year period. Fortunately, this application was successful. Prior to this, members of Central Queensland Speleological Society Inc (CQSS) as well as various other people conducted six trips, all at the individual participant's expense. The Mitchell-Palmer campsite is 1500kms by road from Rockhampton, home base to the CQSS members. Each trip required the expeditions to be completely self-sufficient, carrying everything that may possibly be needed for every eventuality. This meant food, drinking water, fuel, medical, caving and rescue equipment for a full two-week stay had to be transported to the area. The nearest town, Chillagoe, is over one hundred and thirty kilometres to the south-east.

The Australian Heritage Commission's National Estate Grants Program of 1995 had allocated CQSS $13500 over a three year period (1995, 1996, 1997). The Grant was to locate and record sites of the vulnerable Ghost Bat (*macroderma gigas)*, as well as explore and document pristine cave systems, record fossil sites and generally document the area.

How it all started -

Our trips to the Mitchell-Palmer area are a spin-off of the Mt. Etna campaign. CQSS had decided it would have to bring the campaign to a head. In order to do this we had to raise of the importance of the Mt-Etna caves. This was achieved by giving politicians and the media first hand experiences of caving.

For years, every spare movement of our time was spent taking these people on tourist type caving trips. The same caves and the same educational talk over and over. These trips were also used as a cover for some ***not so legal activities*** onto the Mining leases. The Cement Company soon became wise to our activities and photographed our every move. Long after the campaign had ended the company continued to intimidate us, documenting our every move near the Mt. Etna area. We became very tired of this. As a consequence, some members stopped caving altogether. We needed a new area to revive our caving spirit.

At the Tropicon Conference a copy of the Mitchell- Palmer Karst book, which had been just been released by the Chillagoe Caving Club, was purchased. This whet our appetite for a new venture and in June, 1989 CQSS conducted its first expedition to the Mitchell-Palmer area. Fortunately, as it turned out, this reconnoitre of the area did not include families, as, in very sobering form, we learnt of the harshness and unforgiving nature of the area. Winter temperatures consistently sit in the mid-thirties. Frivolously imparted information, by a person "knowledgeable" of the area saw members of the group, after a full days caving, walk sixteen kilometres back to camp on a track "you can do in 10 minutes by car".

In fact, the trip by car, the 16 kilometres took, at best, minimum of 45 minutes. Despite this very timely lesson, we were so taken with what we saw that, in the following eight years we returned to the area nine times.

Tom Robinson has this to say in his introductory comments in the Mitchell-Palmer book:

"***Because of the remoteness of the area exploration will take some time, but the rewards to the adventurous speleologist will be very satisfying The area, we hope, will remain a wilderness, offering the experience and the thrill of isolation resulting from exposure to a natural and often potentially dangerous environment.***"

We have found this to be very true.

Area description

The area is situated to the north-west of Chillagoe in Far North Queensland. It stretches from fifteen kilometers north of the Palmer River to six kilometers south of the Mitchell River, some 100kms in all. The towers are spread over three leasehold properties, Palmerville, Mount Mulgrave and Bellevue and lay in a band approximately 10kms wide with a north-south orientation.

The limestone towers of the Mitchell Palmer area, together with the exposed limestone from Rookwood to Almaden are part of the Chillagoe Formation, an exhumed reef complex.
The Mitchell-Palmer karst area consists of approximately 150 towers of tropical tower karst limestone encompassed in an area of some 1000 square kilometres. These towers vary in size and composition from low to high (approx. 150mts) and from relatively solid to heavily dissected. The caves contained within the towers tend not to develop much below plain level. They generally consist of large interconnected chambers with numerous openings to the surface. Speleothems consist mainly of flowstone, stalagmites, stalactites, rimpools and oolites. As yet, only one cave found has contained helictites.

Ghost Bats

Mist netting of the Ghost Bats at Big Mac Cave resulted in some of the bats having been DNA sampled and ear tagged. From the DNA testing it was determined that the Mitchell-Palmer colony are distinct from Ghost Bats from other sites.

So far, Big Mac Cave has proven to be the largest and most consistently used Ghost Bat site. Several other significant roost sites and numerous feed sites have also been located.

Macroderma gigas

These include, amongst others, Mac's Diner, Bat Mosque and Little Delight, the latter containing fourteen sites within the cave.

Feed site remnants have included Gekko tails, Sugar glider tails and Swiftlets wings. Spasmodic use of sites makes a true assessment of the population of the area very difficult, although sixty-three individuals were observed at Big Mac during one visit. Other bats frequenting the area include *Miniopterus Australis*, *diadema*, *semoni* and *Taphazous Georganus* with one cave housing approximately 200-300 of the latter making it a possible maternity site.

Swiftlets

The Northern Grey Swiftlet inhabits various caves in the Mitchell-Palmer area. Once on the wing , these birds must remain in flight, as they are unable to land anywhere except to cling to side of their nest. At one site, there are approximately 100 old nest sites. Large swiftlet guano piles are reasonably common. Their nest sites have been located deep within caves, beyond tight crawls and small entrances.

Flora

Areas on the scree slopes and saddles of the towers, as well as along the creek s of the area contain remnant rainforest vegetation. This is one of only two areas in Australia containing lemon scented iron barks. Black cymbidiums and Cooktown orchids are reasonably common.
Rubber vine tends to be quite prolific along the watercourses.

Fauna

Large native animals are reasonably uncommon at Mitchell-Palmer, seemingly restricted to the occasional kangaroo on the grassy plains, the odd dingo and snake. Rock wallabies are fairly common on the towers. Insect life, particularly in the caves is prolific. Feral animals observed to date have included pigs, cats and of course, cattle and horses.

Fossils

Fossil bearing rocks, collected from the area have been forwarded to Dr. Ralph Molner of the Queensland Museum and Mike Archer at the University of New South Wales.

The Queensland museum has acknowledged the significant contribution to the Museum collections of the samples so far deposited in so far as:

- They include large numbers of fossil bones
- They derive from a region of northern Queensland from which there are relatively few fossils in museum collections
- They represent a substantial cross-section of the terrestrial vertebrate fauna of the region at the time the deposits were laid down, and thus they;
- Have the potential of elucidating climatic and environmental changes in that region over the past several thousand years, in addition to which they also potentially;
- Can illuminate the bio-geographical relationships of the north Australian fauna to that of Papua New Guinea, which was recently (in geological terms), connected by land links to Cape York Peninsula.

Cultural sites:

Aboriginal art and occupation sites are common throughout the Mitchell-Palmer area. These consist of small numbers of prints to galleries containing hundreds of paintings and engravings. A 'spoked' wheel shaped engraving, infilled with coloured ochre was located on one of our earlier expeditions.

Several sites containing fragmented bone, shells and flaked stone tools have also been located. On our most recent trip, what we believe to be a fire stick was found lodged in a crevice at an art site. On the ground, at that particular site was found a large, clear quartz stone. As noted in the journal of the early explorer Ludwig Leichhardt, Aborigines quite often carried with them, clear quartz stones.
We speculate that paintings at Mordor man Cave, thought to be that of flying foxes, may be of Ghost Bats because of the disproportionately large ears

Cape York Peninsula Land Use Strategy (CYPLYS)

The Mitchell-Palmer limestone lays at the southern most boundary of the area being considered for its conservation value on Cape York Peninsula. CYPLUS is a joint initiative of the Queensland and Commonwealth Governments. The Mitchell-Palmer Karst and Palmer River crossing area has natural conservation significance because:

- It contains a diverse and representative tower karst system which has national geological significance;
- It contains fossil deposits and geological features important to understanding past regional climates and environments;
- It is a major habitat of nationally vulnerable Cave Swiftlet *(Collocalia spodiopygia chillagoensis)* and Ghost Bat *(Macroderma gigas)*, and roosting location of another two bats vulnerable or rare in Queensland;
- It is a major habitat of Godman's Rock Wallaby *(petrogale godmani)*, which is endemic to Cape York Peninsula;
- It supports deciduous vine thicket, which is a broad vegetation group rare on Cape York Peninsula, and nationally uncommon, and;
- The Palmer River contains the best exposures of the Palmerville Fault system, a major fault structure in North Queensland.

History of area:

The area is probably most famous for the Palmer River gold rush. Palmerville and Maytown sprang up to cater to the hoards of hopeful miners, both European and Chinese who swarmed onto the diggings. Several books have been written on the area and it's gold, showing the hardships faced by the intrepid hopefuls, not only against the elements, but also the local indigenous population. A "goat track" from Cooktown, through the notorious "Hell's Gate" pass was the original pathway to the riches of the goldfields. Officially thirteen million ounces of gold was extracted, although unofficially, the figure was most likely double this. Gold is still being extracted from the area and many relics of the bygone era remain.
Remnants of the old telegraph route still stand in various locations through out the area. Old decaying timber poles as well as perfectly preserved "Ericcson" cast iron poles, dot the landscape.

In recognition of the enduring work in the preservation of the Ghost Bat colony at Mitchell Palmer, CQSS has been nominated for a "Rolex Award for Enterprise." We received a special mention and were included in the 1996 edition of the Spirit of Enterprise for International Conservation Awards.

From this a French documentary filmmaker, Marathon Productions, approached us. Unfortunately, this led nowhere after we outlined the logistics and enormity of organising and getting to Mitchell Palmer. More recently we were mentioned in the Readers Digest / Taronga Park Zoo Environment Awards.

CQSS anticipates further expeditions to the Mitchell-Palmer, continuing to compile information and formulate a Conservation Plan for the preservation of the limestone towers and what is contained within.

Clive Kavanagh standing on a section of the Mitchell-Palmer Karst

One of Mitchell-Palmer Limestone Towers

SPELEO-ART AND INTERNATIONAL SOCIETY FOR SPELEOLOGICAL ART, LEEDS, UK

BRINGING TOGETHER SPELEO ARTISTS FROM AROUND THE WORLD WITH SPELEO ART DOWN UNDER

The founding of ISSA

Formally instigated through Carolina Brook, of Leeds, Gt Britain, by a desire to capture the magic of limestone formations in something other than photographs and to educate the public in general to the beauty and splendour of the world that lay beneath our feet.

Carolina with a group of like-minded artists/cavers met for their first workshop at the Caver's Fair, Yorkshire 1994 when the fraternity of ISSA - International Society for Speleological Arts was conceived. Four of those founding member's works, are shown in this exhibition, Carolina Brook, Robin Gray, Mark Lumley and Ceris Jones.

The founding of Speleo-Art

Also founded by Carolina Brook as an organisation for artists and interested people to promote and recognise speleo art as a serious art form in itself. "You get a chance to see the corners ignored in the intensity of exploration and science". (Carolina Brooks, ISSA Newsletter Vol 1 1995 p 4.)

SPELEO ART DOWN UNDER

Speleo Artists are few and far between but we are growing in numbers and working towards being seen and heard around the world by exhibiting with groups like SPELEO-ART and ISSA, INTERNATIONAL SOCIETY FOR SPELEOLOGICAL ART, both founded in England in the last few years.

In the 19th Century art cave fitted into the art scheme of things, it was sublime, picturesque, and grand. It had a power that matched the new age of steam driven machinery and the grandness of discoveries of the new far away lands. It was fashionable to portray huge refinery furnaces, awesome seascapes or sublime landscapes with huge gaping caves with great holes in the ground it fitted the critique of fashion.

There are many illustrations from this period of black and white superb engravings of caves from around the world but many of these images can only be found in dusty old books in libraries without any mention of the artist. In all but a few of the very famous, they are from unknown hands. Such is the fame of illustrators and the unknown artist.

Through the invention of photography last century, these illustrations that were for the most part carried out for scientific purposes, has all but ceased and unfortunately the 20th Century has remained virtually silent in this field of art.

Things are changing and now through the work of a few artists, speleo art can live again as it has never been seen before. ISSA and SPELEO-ART have gathered these few artists represented here and others together from around the world and given strength to their numbers and their purpose. By exhibiting speleo art whenever possible, be it at a Speleo Conference or exhibiting in an art gallery situation, it offers a chance to show the public the wonders that can be found beneath our feet.

Artists have the ability to record what others miss, * "you get a chance to see the corners ignored in the intensity of exploration and science". This then becomes a chance to educate the public that we must preserve our caves for the benefit of all of us now, as well as for the future generations.

This exhibition of speleo art work from cavers around the world shows a variety of work. It has been brought to you through Australian Speleological Federation and SPELEO-ART at individual artists expense. Please feel free to wonder around. All works are for sale, contact June MacLucas in Adelaide Tel: 08-8261-4180 or Peter Berrill, Rockhampton 074934-2870

*Carolina Brook, ISSA Newsletter Vol 1 1995 p 4.

Carolina Brook **Leeds, UK**

Born in 1956 in the UK. Went through art college intending to become a fashion designer but got caught up with speleology. Became concerned with conservation issues and public awareness of caves. ISSA was formed, then SpeleoArt to support and promote recognition of speleo art as an art form to bring about a greater awareness of the preservation of caves for the future.
To see and know more, artist or punter, please contact: carolina@caves.org.uk

Robin Gray **Cheddar, UK**

Robin Gray has been exhibiting since 1968 and has had in excess of 30 one-man shows while enjoying a highly successful teaching career as well as achieving a reputation as a leading pyrotechnician and international caver. Robin worked at developing a highly meticulous and academic realism based on Somerset landscapes and legends. He also built a reputation as an innovative abstract painter and colourists and cartoonist with many of his cartoons published in Australian CEGSA NEWS, SSS JOURNAL AND NARGAN.

Linda Heslop **British Columbia, Canada**

Linda is a professional artist and illustrator living in Victoria British Columbia Canada. Her depictions of caves and cavers has won her recognition world-wide.She has been published in numerous magazines for the past 15 years, and has illustrated a number of books, (see the fine examples of her work in "*Lechuguilla, Jewel of the Underground*", 1991) and has a collection of her art published as her own book entitled "*The Art of Caving*" 1996. She is varied in her subject matter producing logos, designs for t-shirts and art for television. Linda has received a fellowship in the NSS, was presented the Arts and Letters award, and has been recipient of numerous NSS Art Salon awards. If you wish to purchase *The Art of Caving* contact Linda at e-mail: linda.heslop@bbc.org

Ceris Jones **Lancs, UK**

Born in York 1956, studied Art & Design at various Colleges and from 1983 taught at Broughton High School, Preston. A founding member of ISSA is now the Secretary of the group. Ceris interests are mainly concerned with the body and in particular cavers, divers and cave divers where the human form undergoes an almost animal-like appearance when aids, attachments and breathing apparatus are added. "To go into the unknown holds feelings from obsession and apprehension to almost total terror, these feelings is what I try to capture".

June MacLucas **Adelaide, South Australia**

Born in Adelaide June has a Diploma of Art and a Bachelor of Fine Art. In 1989 she completed the largest charcoal drawings by one person ever to come from Australia, totalling 64 metres in length by 3.5 in height. The actual specifications of the convict built Ross Bridge, built in 1839 in Ross, Central Tasmania. The next few years were spent completing huge works taken from her own dreams by using the theories of Carl Jung and dream interpretation as well as his theory on the psychological transformation found in medieval alchemy.

With her interest still centred on the unconscious, it was a natural step to join her husband and friends and join CEGSA, Cave Exploration Group SA. Since then her style of work has completely changed, no longer the huge "audience participation of walk into" size works but rolls of paper, boxes, easel etc., are now taken into some of Australia's most beautiful show caves of the Blue Mountains, or some of the more remote caves of the Nullarbor. Left to get on with it, June enjoys the solitude and the challenge of drawing in caves using form and many layers of colour to portray her own emotional response.

In 1994-96 June coordinated and took part in INSIDE EARTH-CAVES BENEATH THE NULLARBOR touring exhibition to 5 leading Australian galleries in 4 different states. The exhibition included many of Australia's leading cave photographers, Norm Poulter, Kevin Mott, Ken Boland and Elery Hamilton Smith, who officially opened 4 of the exhibitions. Since then June has exhibited solo in various galleries including an exhibition held inside Abercrombie Cave NSW celebrating Australia Day 1998 when Elery launched his new book *Perceptions of Australian Caves in the 19th Century: The Visual Record, and Nineteenth Century Paintings, Drawings and Engravings of Australian Caves.* Pub. Through Helictite Vol.35 (1&2) price $20 contact E-mail elery@melb.alexia.net.au

Mark Lumley **Bath UK**

Mark has been involved with art for some time and has his own flourishing Art Design business. A caver for over 20 years Mark has been on caving expeditions to Spain, Austria, Mexico and the United States that included a trip to the famous Lechuguilla Cave system. The diver shown in his work here was painted from a small sketch carried out while diving, using plastic sketch pad and pencils on string.

Andrew Lawrence **Abercrombie NSW**

Born Newbury, Berkshire, England. In 1975-76 studied Fine Art at Bristol Polytechnics. From 1976-79 studied Multi Disciplinary Design at Stoke-on-Trent. Developed an interest in caving while at college and was founding member of Newbury and District Caving Club. Became an avid caver in Mendip, Wales, South Coast, the potholes of Yorkshire and Derbyshire, the river caves of Seranangh and Sligo in Ireland. Travelled extensively in early 1980 before settling in Australia in 1983. Set up a business as a freelance artist in Concord NSW until 1986 while still accepting commission based work, mainly utilising oils and acrylics. Exhibited in a variety of locations in the Sydney area.

In 1987 accepted the position as guide in Abercrombie Caves in order to pursue a strong interest in speleology as well as to be close to the Australian bush. Cave photographs and graphics have been used for numerous Abercrombie promotions and signage for the Self Arch Guided Cave Tour. Also received 1st prize in the heritage section of the Evans Arts Council photographic competition.

From 1994 to the present he is employed as manager of Abercrombie Caves while at the same time taking on the more challenging role of parenting. He still accepts a small amount of commissions annually, for inquiries contact Andrew Lawrence, Trunkey NSW 2795 Tel: (W)0263-68-8603, (H)0263-688685
Fax 0263-68-8634, e.mail abercrombie@jenolan.org.au

Ian Chandler **UK**

Ellis (Ian Chandler) MA.MCIOB.FIMBM Prof Emeritus of Building Technology

Ellis has been a caver for over 30 years and his work is based directly on his own caving experience. Using the 3rd dimensional form of sculpture, he often works from a specific trip taking in the effects of the environment, texture, and the dampness in the caves and uses it as a medium which he incorporated into the flow of his art work.

Frantisek Mihal **SLOVAKIA**

Mihal has been a caver for over 20 years and in 1972 took part in the discovery of Stratena Cave. He travels all over the country side on his bike or skis drawing wherever he can. Mihal has found that he has discovered Stratena Cave all over again, only this time in pencils and coloured chalk.

Bud Hogbin **UK**

Born in Derbyshire in 1942, studied at University of London Goldsmith's College 1961-64. From 1961-70 taught art and ceramics at various Adult Educations Centres. From 1970 taught age group, becoming Deputy Head in 1974 and in 1977 became Head Teacher of a large Infant/Nursery school. In 1975-76 gained a degree and in 1984 awarded a fellowship of the College of Preceptors. Since retiring in 1985, gained a Certificate in Art & Design, a Diploma in Fine Art and Honours Degree in Fine Art at the University of Hertfordshire.

The main sources of inspiration for my work are from the study of forms found in nature, birds, rocks, plants and patterns in landscape. Recently the focus of my work is on caves and geological structures of these internal spaces. I aim to portray the "cathedral" qualities within natural caverns and to depict the struggle of man to explore and conquer these phenomena.

Lucja Radwan **Austria**

Speleo artist from Austria. Member of the Austrian Artists Professional Association and a member of the St.Lucas Association of Artists (Antwerp -Vienna). Exhibiting since 1985 her work has been exhibited in Austria, Poland, Switzerland, Japan and Hungry. Essentially a water colourist the world she perceives is shown in a new and different light. She is continuously looking for hidden places and recesses; finding the beauty that is often unnoticed by an inattentive observer.

Restoration Blasting near Limestone Caves at Mt Etna Limestone Mine

By Kim Henley
Principal Blasting Specialist - Quarries and Construction
Orica Explosives
and
Chris White
Company Manager
Pacific Lime Pty Ltd

Introduction

The Pacific Lime Mt Etna mine is approximately 30 km north of Rockhampton Queensland. The limestone produced at the mine is the raw material for lime and cement manufacture. These products are used for building and construction, water purification, gold and base metals recovery, in road stabilisation, sugar milling and refining, and in a range of industrial processes.

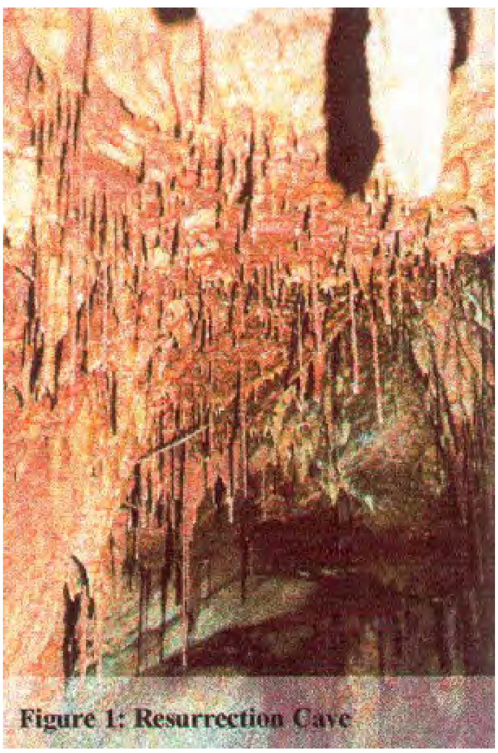


Figure 1: Resurrection Cave

Limestone deposits throughout the world are associated with the formation of caves, as natural weathering processes cause limestone to be dissolved by weak carbonic acid, formed by carbon dioxide mixing with water. Limestone is deposited in formations inside the cave when water flowing into the cave loses its carbon dioxide into the air, causing the dissolved solid to precipitate out of solution. This process takes many hundreds of years to produce large formations, with the rate of deposition usually around 1 cubic centimetre every 15 to 25 years.

The area around the Mt Etna mine has many caves containing a range of formations, and these caves are a well-known tourist attraction.

Blasting associated with the mining operations at Mt. Etna during the late 1960's inadvertently created an opening into a previously unknown cave at the site. This opening is the only entrance to the cave, which became know as Quarryman's or Resurrection Cave.

Resurrection Cave contains some of the most impressive formations in the area, including stalactites, shawls, straws, and helictites. Straws and helictites are among the most fragile of limestone cave formations, and take many hundreds of years to grow.

Background

During the late 1980's there was a prolonged dispute about further mining at Mt Etna. At the end of this period, it was decided that the future restoration of disturbed areas on Mt Etna should be determined by consultation between the company, community representatives and suitable experts and the Mt Etna Mine Rehabilitation Advisory Committee (MEMRAC) was formed.

The committee set out a range of trials and activities that culminated in the presentation of a Premier's Award for Environmental Excellence in 1996.

Apart from a range of different plant types and planting methods, the trials included a proposal to carry out blasting to remove some of the engineered appearance of the old mine workings. An initial blast was carried out in late 1994. The blast was successful in removing the engineered face and creating a planting medium but did not fully meet the expectations of the rehabilitation plan. This was because the blast was laid out like a normal production blast and produced a rather even slope and material size which contrasted with the natural topography of Mt Etna. The three years of extreme drought that followed also did not assist the successful establishment of vegetation cover on the area.

Following this experience it was decided to adopt a different approach to fulfil the objectives of the Mt Etna Rehabilitation Strategy. Blasting was still proposed for old mining faces to ensure that the north west slopes of Mt. Etna were suitable for re-establishment of flora and fauna. This time, however, the blast design used the existing slope of the mountain as a guide, to produce landform that is typical of the area.

There were 4 main priorities to the restoration blasting,

1. An effective slope with character as close as possible to the natural slope on the mountain.

2. Ensure that the structure and formations in the caves close to the blasting area were not damaged.

3. Ensure that the final slope was safe for replanting of flora.

4. Ensure airblast and flyrock from the blast was controlled.

Figure 2: Resurrection Cave Formations

The closest cave to the restoration blast was Resurrection Cave, which is well known as having the most spectacular limestone formations in the area. Ensuring that the cave and its formations were not damaged was a priority of the blast design process.

Two reclamation blasts were fired. The first was a test blast that was used to confirm that the design blasting parameters for the main blast would control airblast, vibration, and achieve a satisfactory final profile.

A comprehensive face survey and blast modelling were used to design the blasts and all charging parameters.

Community consultation during the lead up to the blast design process allowed local groups to have input to the blast design so that the blast could achieve all the objectives of the local stakeholders.

Community Consultation

A high level of community consultation and involvement had been a feature of the decision to proceed with this second restoration blast. This consultation, started by Pacific Lime, involved the MEMRAC team and other interest groups in agreeing on restoration objectives. The groups were:

- Local caving society
- National Parks and Wildlife Department
- Department of the Environment
- Mines Department

Orica Explosives' Blasting Specialist was briefed on the various requirements of the local interest groups, and was asked to provide a proposal for restoration blasting to achieve the objectives agreed during the community consultation process. The proposal was presented to the interested parties who accepted the proposal, and agreed to proceed with the restoration blast.

Restoration Blasting Objectives


Figure 3: Slope before Blasting

Environmental

Overall undisturbed slope on this side of Mt Etna is about 42 degrees. The overall slope of the existing mine benches is less than this, being between 40 and 30 degrees. However, the high slope angle of the bench faces discourages flora establishment and use of the area by fauna.

The objective of slope restoration was to return this part of the mine to a landform capable of ultimately sustaining the continued establishment of the native flora and fauna lifecycle. Restoration of the North West-facing slope of the old mine needed blasting of the existing benches to achieve a more natural landform.

Variation of the rehabilitated slope angle along the blasted area was a priority to ensure the final slope looked as natural as possible. Consistency of blast result was not desired, with large boulders needed to give fauna a habitat typical of the area.

Final slope variations were introduced by varying the energy in the blast.

Vibration Control

There are three caves near the restoration blast:

- Bat Cleft Cave - about 100m from the nearest end of the blasting area.
- Winding Staircase Cave - about 60 m from the blasting area.
- Resurrection Cave (also called Quarryman's Cave) - about 50 m from the blasting area.

Resurrection Cave is the only cave with significant limestone formations. Both Bat Cleft Cave and Winding Staircase Cave are solute cavities, and have no formations. The greatest possibility of damage was to Resurrection Cave where fragile formations were most likely to be damaged by vibrations from blasting.

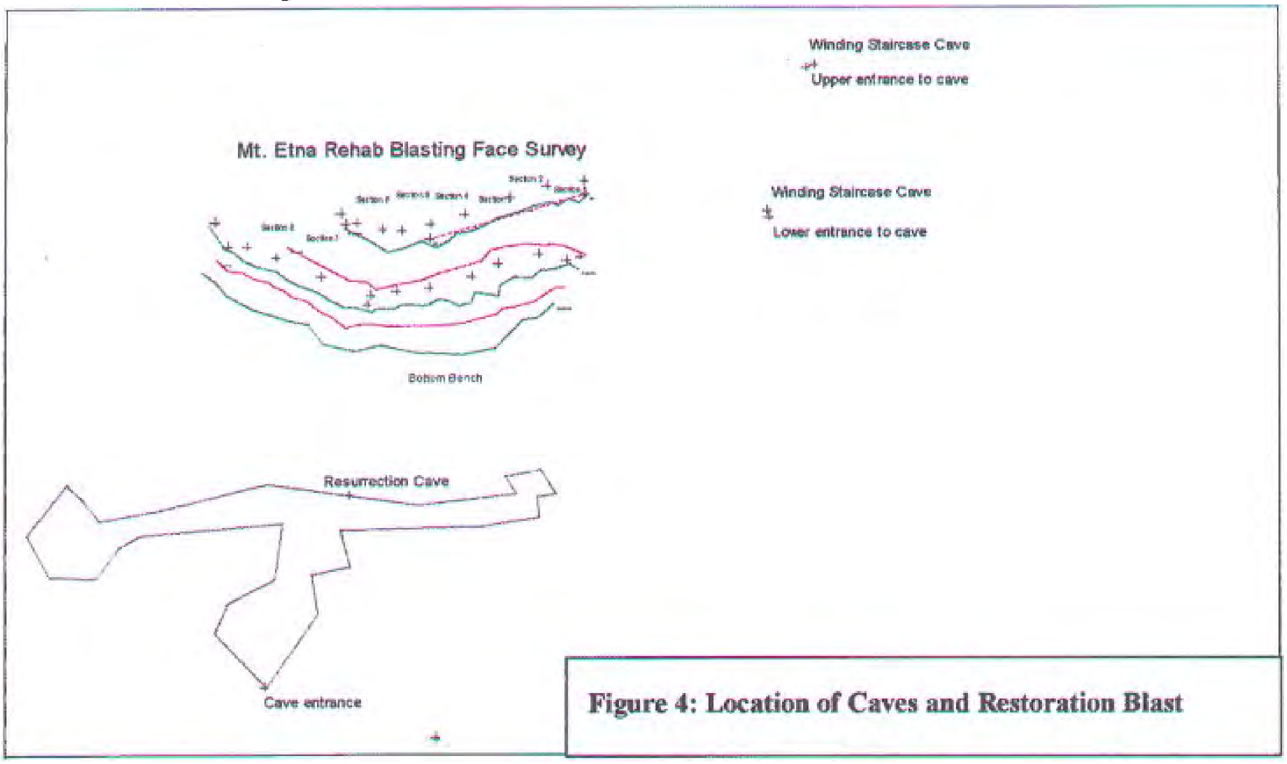


Figure 4: Location of Caves and Restoration Blast

Data collected during 1990 was used to develop a formula for predicting vibration from the restoration blasts. This general formula was established by the United States Bureau of Mines over many years and is recommended for use by the Australian Standards Association in AS2187 Part 2.

Using the data collected, the formula has the form:

$$V = 612 * \left(\frac{\sqrt{Q}}{R} \right)^{1.57}$$

where:

V = Peak Particle Velocity in mm/s
Q = 28 kg
R = 50 m

This predicted a maximum vibration at Resurrection Cave of 18 mm/s.

The vibration levels need to damage intact hard rock range from around 500 mm/s for softer types such as limestone, to around 2000 mm/s for very hard rocks such as dolerite.

In the late 1960's production blasting opened Resurrection Cave. Blasting at this time was aggressive and many blast holes were fired instantaneously. This frequently resulted in nearly 1 tonne of explosive being fired at any single instant.

The vibration levels likely to have been generated were calculated using the formula above, and predicted a ground vibration of 420 mm/s.

At these vibration levels, blasting was likely to have caused damage to the formations in the past. The photos taken by Peter Briggs show some stalactites in the cave that have been damaged, but it is not known whether this was caused by blasting. The fact that most of the formations, particularly fragile ones, are undamaged indicates that they have withstood considerable vibrations during blasting in the past. The predicted vibration from the restoration blast was 4% of the levels that the cave had already been subjected to during the previous blasting operations.

A photographic survey of Resurrection Cave was conducted to provide a record of the condition of the formations before the blast A re-survey after the blast showed that no formations were damaged by the restoration blast.

Slope Safety

Ensuring final slope safety was a priority, to allow for safe access for tree planting and watering during early establishment of the plants. Access to the muckpile was prohibited for 48 hours immediately after the blast to allow unstable voids in the rock pile to settle.

Unstable boulders produced from the blast were moved using an excavator to prevent them from rolling down the slope. This ensured the slope was safe for people accessing the slope from time to time.

Restoration Blasts

Two restoration blasts were planned. The first blast was used to test the blast design and blast outcomes on a small scale before committing to the larger main blast.

The test blast was located at the western end of No. 4 bench. The main blast was to include the remainder of No. 4 bench and a section of No. 5 bench

However, drilling difficulties on No. 5 bench indicated that the blast result on this bench would be difficult to predict, so this part of the blast was abandoned. Drilling on this bench intersected many voids and cracks in the limestone, causing loss of air pressure for flushing drill cuttings from the hole. Drilling air was also venting through cracks out of the face of the blast.

Charging these blast holes with explosives was going to be difficult, and likely to cause flyrock and airblast. Based on the hazard potential of blasting this bench, the quarry manager, Don Kime, decided that satisfactory restoration could be achieved by using an excavator and rock breaker.

Blasting Process

Face Survey

The first step of the blast design process was to determine the shape of the current faces. The face was surveyed using laser equipment to provide accurate information about the shape of the face to be used for the slope design. Sections through the blast area were used to develop a proposed blasting strategy for the slope.

Final Slope Design

The overall slope of the mountain was used to guide the design by placing on the plan lines at 40 degrees inclination Blast hole depths were calculated to produce a blast that breaks up the tall faces into shorter sections with blast rubble at the base to allow vegetation establishment.

The Orica Explosives blast simulation program Sabrex, backed up the author's extensive knowledge and experience in blasting to design a blast that proved very successful. The simulated sections from Sabrex are shown in Figure 5.

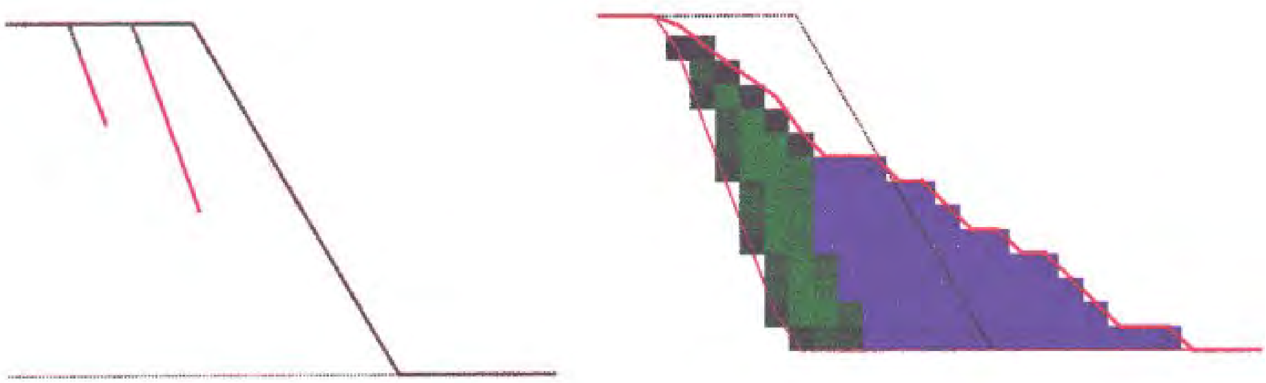


Figure 5: Blast Simulation of Typical Section

Test Blast

Drilling Conditions

Drilling of the test blast was made difficult by the numerous cracks and voids encountered. This frequently caused loss of return air and indicated that charging of the blast needed extreme caution to avoid overcharging causing flyrock and airblast.

Figure 6: Test Blast Location

Charging

Charging of the test blast was extremely difficult. Voids and cracks caused ANFO to be lost from the blast holes and consistent column rise was rarely achieved.

Layflat tube filled with stemming material was used to block the ends of blast holes and also to provide a bridge across voids part way up the holes.

Modifications to the planned blast charging design were made frequently to overcome these problems. Approximately 200 kg of explosive was used to charge the test blast.

Result

The test blast result was considered extremely successful by all whom witnessed the blast. No flyrock was produced, and noise and vibration was low.

The crest of the bench moved forwards slightly, then dropped to the bench below, producing a level section with fine material for tree planting, and a mix of fine and coarse fragmentation, plus large boulders.

Airblast at the nearest residence was 112 dB and no vibration was recorded.

At Winding Staircase Cave, airblast was 119 dB and vibration recorded as 35 mm/s, while at Resurrection Cave entrance 3.53 mm/s was recorded. However, both of these vibration monitors were not mounted effectively because of difficulties in positioning the mounts at both these locations.
More time was needed to overcome these difficulties than was originally allowed.

Figure 7: Test Blast Result

Main Blast

Drilling Conditions

Drilling conditions for the main blast were much better than the test blast. Few voids were encountered in the rock indicating that the rock was of higher quality and was likely to fragment easier than the test blast.

To ensure that fragmentation was not excessive, some modifications were made to the charging design to lower the powder factor, and encourage the creation of larger rocks.

Charging

Charging conditions for the main blast was good. Only 3 blast holes contained voids that needed special treatment.

Result

The blast was fired 5 minutes early due to the approach of a thunderstorm.

The top part of the bench lifted and dropped in a similar fashion to the test blast, but rock sizes produced were a more consistent than the test blast because fewer cracks and voids were encountered in the rock.

A few large boulders were produced near the start of the blast, and a good mixture of fine material was mixed with moderate sized rock.

Everyone interested in the blast outcome also considered this blast successful. A small section of the blast was fragmented but failed to move forwards due to the low powder factor in this area. This section was pushed forward by an excavator that to move the material into final position.

Airblast and vibration were as follows:

Bates Residence		Resurrection Cave		Winding Staircase Cave	
Vibration	Airblast	Vibration	Airblast	Vibration	Airblast
0	110.1 dBL	10.9 mm/s	N/R	6.1 mm/s	120.1 dBL

Impact of Main Blast on Caves

A photographic inspection of Resurrection Cave showed that no damage to formations had occurred in the cave.

Final Mechanical Treatment of the Slope

An excavator was be used to move a small amount of the material to ensure slope safety, and to achieve the desired final profile.

Main Blast Photos

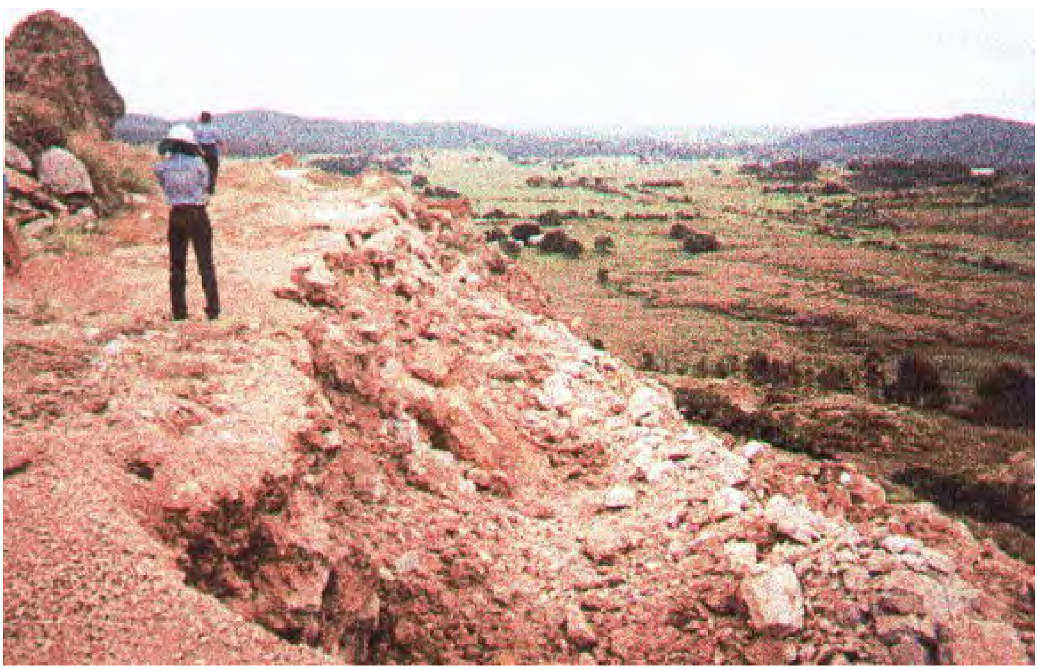


Figure 8: Main Rehabilitation Blast Photos

Figure 8: Main Rehabilitation Blast Photos

Conclusion

The reclamation blasts were fired and achieved all objectives. The blast moved only the top part of the face needed to achieve the final profile, which now matches the existing overall slope of the mountain.

Minimal vibration was recorded at Winding Staircase and Resurrection Caves and airblast was low. No damage was caused to the limestone formations in Resurrection Cave. Community groups expectations were met and all were pleased with the result.

One of the most important factors which lead to community support for the restoration blast was the mine's approach to the problem. Community groups had been involved in all aspects of the rehabilitation process leading up to the blast and their views of the blast outcomes were incorporated into the blast design.

The experience of the previous blast designed without proper consideration of rehabilitation objectives made the groups very wary of another blast. The assurances provided by the presenting the restoration blasting proposal to community for their approval satisfied their concerns about the outcome of the restoration blast.

HABITAT REQUIREMENTS, SURVIVAL STRATEGIES AND ECOLOGY OF THE GHOST BAT Macroderma gigas (DOBSON, MICROCHIROPTERA, MEGADERMATIDAE) IN CENTRAL COASTAL QUEENSLAND

By John Toop

Studies of the Macroderma gigas colony centred around the caves of Mt Etna Caves National Park Central Queensland, have identified the major habitat requirements and seasonal movements of the colony.

Overall the colony aggregates for a summer breeding season and disperses over a wide range during the cooler months.

At the beginning of spring, the pregnant females congregate in the warmest caves in the Caves area, finally giving birth over a period of one month, commencing mid October with the last young born by the end of November. There is no sexual segregation during parturition. Some males and immature females roost with the breeding females at all times. Birth caves at this time are initially rare, as only a few caves have reached an acceptable temperature. As the caves become warmer as summer progresses, the young may be shifted into a larger number of suitable nursery caves in the area.

Carried by their mothers initially, the young are later, left to roost at night in colonies in the nursing cave. The young commence flying on average at seven weeks with all young capable of flight at the end of January. At this time, the young accompany their mother during foraging and many 'doubles' of female and young were caught in the mist nets during February.

From mid summer, the numbers of adult bats slowly increases as the remainder of the males and one year old females join the bats already present in the area. Weaning is completed during March and mating then occurs through April. During the wet season in summer, early autumn J1, Johannsen's Cave becomes critical to the bat colony because it alone seems to offer dry roost sites.

After the wet season, numerous caves unsuitable during the wet are used as roosting sites before the onset of winter. At this time at the end of the mating season in May, sexual segregation can occur with predominantly males roosting in one cave and predominantly females in another.

With the onset of winter, the entire population again reassembles briefly in the warmest caves, finally dispersing during July. Some bats remain in the caves area during the winter, especially the pregnant females, and the warm caves used at this time are probably very important in relieving environmental stress on these females.

Seventy-five per cent of the population, however, disperses in small groups from the caves area and roosts in caves, rock shelters, overhangs and mines over a wide area. Animals from this colony have been caught during winter at distances of up to 20, 25, 35 and 50 km from the caves area and most probably the reports of single ghost bats further afield at Gladstone (90 km), Banana Range (130 km) and the foothills of the Blackdown Tableland (150 km) represent limits of dispersal of this colony. During this study a similar sized ghost bat colony at Cape Hillsborough (300 km) to the north has been kept under observation with at least 50% of its population being tagged and no interchange of colony members with the caves area colony has been detected.

In contrast to the 30-50 animals remaining in The Caves area, which invariably roost together, the dispersed groups are small with single and paired animals most frequently observed, the largest number being 12 bats located in an abandoned mine. This dispersal from the Caves area over a wider winter range is most probably in response to shortages in food supply during the cooler months.

With the commencement of spring, reassembly of the population commences in The Caves area and the population pattern cycles once again.

Microhabitat preference of the colony was initially difficult to determine. The ghost bat in the caves area roosts preferably in avens where warm air created by the bats can be trapped. Maximum/minimum thermometer readings at points below these roosts were invariably meaningless. To offset this problem, a remote infrared biological thermometer was purchased and two seasons data were obtained with this thermometer.

Ghost bats in central Queensland can warm an aven to 3°C to 4°C above ambient rock temperature with a very narrow preferred range of from 23°C to 26°C. Above this range the colony will cease aven roosting while below this range the colony will disperse to another site. At the lower preferred temperature, shifts can be to a site of similar temperature but of higher relative humidity. Initial difficulties in housing conditions for the captive colony at Taronga Park Zoo indicated that at below 70% relative humidity the ghost bat experiences difficulties such as wing membrane cracking so the preference for higher humidities can be readily understood.

Demographic studies were very successful with this colony because the entire population can be found at one site during the mating season and at the onset of winter. As a consequence, the entire population has been tagged over five years and the breeding, nursing and mating season could be precisely determined.

The population size of this colony fluctuates around 150 individuals with a 1:1 sex ratio, with 40-45 young being born each year. Both females and males commence breeding in their second year. Major mortality periods for the colony are at parturition for adult females, early nursing and weaning for young with older animals dropping from the population in winter.

Feeding studies have been carried out by identification of prey remains found in roost sites together with faecal analysis. In the forested coastal environment of central Queensland, the prey chosen is predominantly arboreal in keeping with the wing and sonar characteristics suggesting a gleaning bat. Identification of prey remains from roosts was usually to a species level while remains from faecal pellets could only be identified as of insect, mammal or bird origin because of the small size of the fragments.

During the warmer months the predominant prey are insects with large species such as grasshoppers *Valanga sp,* Rhinoceros beetles *Xylotrupes gideon,* Longicorn beetles *Agrionome spinicollis and* various species of cicadas and Tettigoniid grasshoppers forming the bulk of the remains found in roosts.

Although the majority of the beetle prey do not stridulate there is strong evidence that insect sounds attract ghost bat attacks. The Rhinoceros beetle *Xylotrupes gideon* feeds in large noisy groups in introduced poinciana trees at Olsen's Caves and invariably numbers of ghost bats will be present hawking back and forth from nearby roosts in the scrub feeding on these insects. Stridulating cicadas are heavily preyed on and the single call of a foraging ghost bat can silence calling cicadas over an area of a hectare in the scrub at the caves.

As the weather cools, the percentage of insect fragments in the dung decreases while the proportion of bird and mammal bones increases. Remains of feathers, rodent tails and bat wings from feeding roosts have identified 22 species of bird, 3 species of rodent and 3 species of bat preyed upon by Macroderma gigas with the owlet nightjar *Aegothelas cristatus,* little strike thrust *Colluricincla megarhyncha,* Lewin's honeyeater *Meliphaga lewini,* house mouse *Mus musculus* and sheath tailed *bat Taphozous georgianus* being the most common species taken.

Australian Owlet-Nightjar

The bulk of the bird remains are of scrub species; they and the bat remains are found in feeding roosts all through the caves area. Rodent remains, on the other hand, have only been collected in feeding roosts adjacent to cleared and preferably ploughed agricultural land where it is possible for the bat to hunt ground dwelling animals.

Bat remains under feeding roosts show a seasonal species diversity. The little bent-wing bat *Miniopterus australis* is mainly taken for only two weeks in mid January when the young bent-wing bats initially fly from the breeding cave Bat Cleft on Mt Etna. In contrast, the sheath tall bat *Taphozous georgianus* is largely taken during the colder months when easier prey is scarce. The horseshoe Bay *Rhinolophus megaphyllus* is very rarely taken with only three remains of kills having been found.

In contrast to desert colonies of ghost bats, ground dwelling prey is rarely taken. No reptile or ground dwelling frog kills have been recorded at all while ground dwelling arthropods are very scarce with a scorpion and a carabid beetle being recorded on only two occasions. Tree frogs are only rarely preyed upon with ten *Litoria caerulea* being collected under roosts surprisingly during the cooler months when prey is scarce. During the summer wet when these frogs are very common in the vine thickets, they are not preferred by the ghost bats.

During the course of this work, ghost bats were held for extended periods in captivity. A total of four pregnant females with four males have been held for six months through parturition and nursing to obtain growth records of the young during the phase of development when they are left high in the avens of the nursing cave and are consequently unobtainable.

The highlight of the captive animal studies was the close observation and recording of the birth of a ghost bat. The ease of handling of the animals allowing, even the close use of video equipment without detriment to either the adult or the young. Of the four young raised in captivity, one died from a broken wing but three survived and were successfully released with their mothers, back into the cave colony from where all have been recaptured over a period of years. One of these, a female, has since successfully bred in the wild.

In addition, two females and two males were held for a period of nine months through the mating season, however, both females failed to become pregnant and undoubtedly greater numbers of bats would have to be held to have a successful breeding colony.

Captive animals were held in a constant temperature room 8 m x 3 m with wire mesh on the ceiling for roosting. Adult females were found to require one baby rat per day to maintain weight and the bats rapidly adapted to eating segmented adult rats when rat breeding failed to keep pace with consumption.

Because of the insistence in feeding whole animals with the roughage contained (fur, elytra, feathers and bones, etc.) no difficulty with scouring was ever experienced with these captive animals. Probably because of the blood content of the food, the captive bats were never observed to drink, although water was available at all times.

The young born blind and essentially naked do not develop quickly. The ears prick after seven days and the eyes open at two weeks. At four weeks, the mothers finally leave the young roosting by themselves, and their weight at this time is at around 50 g. Pelage develops quickly and the young are capable of flight at the end of seven weeks, at around 70 g. Because of the intimidating size of the offered food, young did not successfully kill baby rats until 14 weeks old when their weight is around 90-100 g, although they would accept and eat segmented rat at 12 weeks old. All young were released before weaning so that their close association with their mothers would enable them to develop hunting skills to survive in the wild.

Behaviour patterns, mother young interactions, male young interactions and nursing female interactions with other young were recorded at this time.

Food preference tests revealed that baby rats and mice were preferred over any offered insect. Ghost bats also proved incapable of capturing birds (house sparrow *Passer domesticus)* when the lights were on in the room the birds proving capable of dodging all attack passes by the bats. Capture was immediate when the lights were extinguished, however, paralleling the situation in the wild where birds are taken from sleeping roosts in the scrub at night.

Capture of baby rats and mice, was usually carried out by the bats hovering momentarily overhead and then dropping vertically onto the prey. The wings envelope the animal trapping it on a small area of floor usually against a wall or in a comer where it was seized by the neck or head. Once seized the bat would fly back to the roost where the struggles of the prey would cease very quickly. The prey would then be consumed from the head with usually the hind legs and tail being discarded.

During eating the bats invariably used their wrist claws to hold the prey and indeed bat number 491 Zeus was captured with one wrist claw missing and this bat always had difficulty holding a baby rat during feeding.

Management strategies have been implemented at Mt Etna Caves National Park to maximise the survival of the ghost bat colony in the area. The main emphasis has been directed towards protecting the breeding aggregations during spring, summer and autumn. To this end, the major cave (J1 Johannsen's Cave) utilised by the ghost bat colony for parturition, nursing, wet season roosting and mating was closed to the public initially for the period of parturition and flightlessness of the young every breeding season.

The colony reacted in a favourable manner to this strategy, young mortality over this period has been reduced by over 50% and the colony has exhibited much reduced disturbance behaviour. In addition the colony for the first time dramatically increased its period of occupancy of the cave to include the colder months of winter.

Limited options would appear to exist to protect the bulk of the population during the winter months because the greater proportion of colony is dispersed over a wide area. Protection of the warm caves in the caves area utilised by the majority of the pregnant females during the winter would seem to offer the only useful strategy. Certainly, mortality has been recorded after disturbance at this time.

One such cave is located at Olsen's Caves and is adequately protected from interference at this time although in the future this cave could be developed for tourism.

In 1988 a large portion of the northern cavernous face of Mt Etna was obtained as part of Mt Etna Caves National Park. Unfortunately, E7 Speaking Tube on the western flank of Mt Etna was outside this section. This cave was an over wintering site and was deliberately destroyed by the mining company so it could not be used as a lever to extend the park.

The remaining warm sites are located on the Limestone Ridge section of Mt Etna Caves National Park. J1 Johannsens and J8 Ballroom. J8 Ballroom cave is freely accessible to the public at this time but the roost site is located in the bottom sections of the cave and is relatively free of disturbance.

J I Johannsens has only been utilised as a over wintering site since the cave was closed to the public for the spring and summer breeding. Its long term viability as an over wintering site was unknown, both with regard to environmental conditions and potential disturbance. To minimise the latter, the period of closure of J1 Johannsen's was extended to include the winter months for the protection of the pregnant females. This cave is now closed to the public from 1 June to 31 January.

Response from the bat colony has been very positive with females in residence through the winter.

This combination of management strategies has been successful in increasing the colony size in Central Queensland. Since the 1980s when the colony numbered around the 150 individuals the colony has increased to around 170 individuals.

For the future, as long as off park mortality factors (insecticide poisoning, entanglement in barbed wire fences etc) do not become limiting, the future of the Central Queensland colony would seem assured.

"THE KNEE BONE'S CONNECTED TO THE ... (BLOODY SIDE OF THE CAVE!)"

FOSSILS FROM MT ETNA AND BROKEN RIVER CAVES.

By Scott A. Hocknull

Abstract

Rich deposits of fossil bone have been recovered from a series of caves in the Mt Etna/ Limestone Ridge Caves and a cave in the Broken River. Presented here is a preliminary list of the animals that once inhabited both areas and what this tells us about past ecosystems in Queensland. The role of palaeontology and speleology will be discussed in the hope to provide adequate incentive and enthusiasm to all cavers so that any deposits they find don't go unnoticed.

Fossils collected from, the now extinct, Elephant Hole and Speaking Tube Caves, Mt Etna and Mini, Larynx and Ballroom Caves, Limestone Ridge have produced many wonderfully preserved fossils. Elephant Hole Cave is special for it has the most diverse fauna including; a new species of sugar glider, bilbies, Tassie devils, bandicoots, possums, lizards, frogs, snakes, dunnarts, antechinus, kangaroos (rock wallabies), ghost bats, bent-wing bats, snails and rodents. Speaking Tube Cave is breccia filled cave with animal smells, however, work has just begun on this site. Mini, Larynx and Ballroom Caves have produced some of the oldest material, including the same new species of sugar glider, and small marsupicarnivores. It does, however, contain a large cuscus, ring-tailed possums, lizards, rodents, a possible small marsupial lion, and large kangaroos. Dodgey's Cave, in the Broken River, has produced similar faunas to Mini Cave, including ring-tailed possums, rodents and sugar gliders. It has also preserved bilbies, ghost bats, bent-wing bats, bandicoots, phascogales, and large, possibly tassie devil teeth. There is a good record of Australia's recent past, preserved in the silt and breccia along the east-coast of Australia. The caves have acted like huge pit traps, in effect, producing fauna surveys that span many thousands of years.

INTRODUCTION

Fossils in Australia are characterised by being uncommon, fragmentary and badly preserved. Few sites comprise of complete skeletons and even fewer have entire ecosystems preserved within their sediments. The early history of palaeontology in Australia tended to focus on the biggest and best fossil specimens for scientific study and public display. Large animals, like the well known *Diprotodon* are found throughout Australia's recent fossil record and tell of times when the continent was much wetter and more diverse in numbers of species. Questions are then raised as to *what* were these marvelous beasts, *when* did they disappear and *why?*

The answers lie, not within the study of the largest animals themselves, but in the smaller, more "insignificant" members of the ecosystem.

The reasons for this are many-fold:

1. Smaller animals are effected by climatic change and are therefore good correlates for previous climatic regimes:
2. Small animals make up the largest proportion of faunas and can provide insights into the type of ecosystem operating at the time the larger "mega" fauna were around;
3. Where small animals are preserved, they are associated with larger animals and found in relatively high abundances and; finally,
4. Many of the small species have not gone extinct and therefore, provide substantial evidence for previous distributions (conservation in mind).

Where then do you find fossils of small animals? CAVES! Caves are the richest resources for small animal fossil faunas in the world. They act as natural pit-fall traps that collect animals brought into or those that fall into their cavernous interiors. Fine silt, either from bat and owl pellets or blown in or washed in from the exterior provide the anoxic conditions for fossil bone and shell preservation. Thus, within a single cave, fossils from a range of animals and plants can be found. For all the back-boned animals there are two ways of accumulation within caves:

1. Brought in as prey by bats, owls, snakes, frogs and some mammals; or
2. Pit-falls that collect any number of large and small vertebrate.

Snails, millipedes and beetles also preserve via guano from bats or the members of an internal ecosystem. Plant material is also preserved in cave deposits, as seed, pollen and rootlets. Each of the caves under the present study accumulated their deposits via a combination of these processes. The following paragraphs will describe two caves systems, one from the Broken River near Townsville and the other from Limestone Ridge and Mt Etna proper.

Elephant Hole Cave - Speaking Tube Cave - Mini Cave Larynx Cave - Ballroom Cave Limestone Ridge & Mt Etna - Rockhampton CEQ

Little fossil material has been collected from the fossil breccias of the Mt Etna region. The Queensland Museum holds collections from fissure deposits in the Marmor Quarry, near Marmor, cave breccias in Speaking Tube Cave (Mt Etna) and silt deposits from Elephant Hole Cave (Mt Etna). Most recently, Paul Tierney, Noel Sands and the author excavated small pieces from Mini, Larynx and Ballroom Caves (Limestone Ridge) with remarkable results.

The Fauna So Far....

Elephant Hole Cave (extinct)

The Specials:

Macrotis lagotis (Bilby): Two molars are unmistakably from *M lagotis*. The presence of the Bilby within the EHC deposit illustrates a close proximity to add areas sometime in Mt Etna's past. A mathematical prediction, using climate modelling, of former Bilby distribution by BIOCLIM produced a maximum distribution line very close to Rockhampton, and hence both records corroborate each other.

Petaurus sp. nov. (new species of sugar glider); many jaws and skeletal elements are attributable to this extinct and distinctive species. Fossils of this species have been found in EHC and MC and hence provide a faunistic link between the two sites - the significance of this will be discussed later.

Sarcophilus harrisi (Tasmanian Devil). Devil's are known from mainland Australia throughout it's recent past, however, few records are as high up the continent as Rockhampton.

SNAIL SHELL

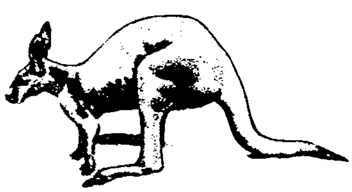
Although many people think the best thing for snails is to lightly marinate them, another application - being developed by Dr. John Stanisic at the Queensland Museum, for their shells is to study the affects of shell growth in relation to precipitation levels and climate fluctuations. Shell growth can be retarded when times are bad and accelerated in better times, therefore, by using the fossil shells and comparing them to modem shells that have experienced known environmental stress the past climates and precipitation fluctuates can be predicted.

Not so special, but significant:

Seeds
Molluscs (snails)
Frogs (3 species so far)
Lizards (dragons, skinks, geckos, snake-lizards, goannas)
Snakes (elapids (venomous), pythonids)
Rodents *(Rattus, Pseudomys, others)*
Bats (Macroderma gigas, Miniopsteris others)
Marsupial Mice *(Antechinus, Sminthopsis)*
Marsupial Cats *(Phascogale, Dasyurus)*
Bandicoots *(Perameles nasuta, Isoodon obesulus)* Rock Wallabies *(Petrogale)*
Kangaroos & Wallabies *(Macropus spp.)* Mountain Brushtail *(Trichosurus caninus)*

Mini Cave - Larynx Cave - Ballroom Cave

Molluscs (snails)
Ringtailed possum *(Pseudocheirus sp.) Cuscus (Strigocuscus sp.)*
Marsupial Mouse *Antechinus sp.*
Petaurus sp. nov.
?Marsupial lion tooth
Large kangaroo
Rodents
Skink



DODGEY'S CAVE, BROKEN RIVER

In 1995 a small party from the Queensland Museum discovered fossil bone breccia outside and within several caves in the Broken River region, west of Townsville, NEQ. One of the caves, Dodgey's Cave had the breccia and large samples of cave silt collected from it. From these collections several species have been identified, however, nothing has jumped out as being terribly spectacular - until recently.

The Specials:

Macrotis lagotis (Bilby): - From bone breccia. The presence of the bilby from this locality reiterates the interesting conclusions brought forward by the BIOCLIM data and the specimens found in EHC. The presence of bilbies so far from their present distribution also provides further evidence of a rapid reduction in range in recent times.

Macroderm gigas (Ghost Bat): - From silt floor. In mid 1998, the author discovered a skull of a Ghost bat, lying on the top of a silt slope within the first chamber of Dodgey's Cave. It is not fossilised and seems to be very recent in origin! Determining the age of the skull is near impossible, however, there are three factors that can be used to estimate the latest date.

1. The skull was found very near an excavation that commenced in 1995. If the skull has originated from reworking of the silt layers then the maximum age of the skull will be known when these bones are dated.
2. In spite of thorough surface searching within this chamber for skulls and teeth in 1995, large complete skulls like this one were not recovered.
3. Deposition within BR caves is rapid (wet cave system), therefore, if skull had been stationary for - even up to 10 years - calcium incrustation should be present. The fossil does not possess any of these characteristics.

There are therefore, two possibilities:

1. The animal has been deposited there in the last 5- 10 years or it has been reworked from previous deposits when calcium incrustation was not so active.
2. Another, confounding factor is that throughout the excavation the most common jaw element of a bat is the Ghost Bat.

The possible presence of a new locality for Ghost Bats within the Broken River region needs urgent attention.

Large marsupicarnivores -

There are many teeth and fragments of teeth that indicate the presence of large marsupial carnivores, unfortunately the bones and teeth are badly preserved and are identifiable. The closest possibility is the Tassie Devil.

Other beasties...

Silt accumulations (different ages)

Rufous Bettong
Marsupial Cat *Phascogale topoatafa Glider Petaurus sp.*
Brush-tailed possum *Trichosurus vulpecula Quoll Dasyurus sp.*
Antechinus, Sminthopsis.
Bats *(Miniopterus, Rhinolophus)*
Rattus, Pseudomys (rodents)
Dog/ Dingo *Canisfamiliaris*
Cane Toad *Bufo marinus*
Rock Wallaby *Petrogale*
Pythons
Venomous snakes
Frogs
Dragons, skinks, geckos, goannas.
Snails, millipedes, seeds, pollen.

Bone Breecia
(oldest material)
Rodents
Skinks, dragons, snakes
Antechinus
Bats
Ring-tailed possum
Brush-tailed possum
Rock Wallaby

PALAEOCLIMATES AND SIGNIFICANCE OF BOTH SITES.

The significance of each cave site has not been fully recognised so far. It won't be until dating of the caves is accomplished that the entire significance of the fossil faunas is known. What can be concluded so far is easiest represented in point form.

- Both cave systems preserve faunas of different ages (breccia vs silt) within each cave, therefore, it is possible to provide rough chronologies of the caves geological past. This will aid in understanding the formation of the fossil deposits and determine how they formed in the first place.
- Each cave system preserves large and diverse faunas, which will inevitably lead to better understandings of past ecosystems.
- The fossil faunas from Larynx, Ballroom and Mini cave are typically rainforest adapted species (e.g. ring-tails, cuscuses). The presence of the new species of sugar glider may suggest that it had it's origins in rainforest areas,
- The fossil fauna from Elephant Hole Cave suggests a different ecosystem of dry scherophyll (similar to today) (e.g. arid-adapted species). The presence of the sugar glider here is confusing, however, it may provide the vital 'link between the two faunas. Either the two faunas are different due to time (e.g. rainforest fauna being older = hard old breccia, than the arid-adapted fauna = soft young silt), or they are of similar ages with the ecosystem holding mostly arid-adapted species with pockets of rainforest. This will only be determined through close dating.

- The Broken River deposits seem to be dominated by arid-adapted species and therefore are indicative of very recent times. It may be that Dodgey's Cave preserving its arid-adapted faunas, are of similar age to that of Elephant Hole Cave.

THE FUTURE

There is still a significant portion of work ahead. More excavations are needed, with more finite excavation techniques. But most of all the need for firm dates is the one retarding factor in understanding the full extent of these cave systems. The lack of funding for dating and excavation has plagued palaeontology throughout it's entire history, however, this needs to change if the information used by biologists is going to be of any worth.

The Queensland Museum now has small samples from Chillagoe, Michell-Palmer, Hervey's Range, Broken River, Mt Etna, Limestone Ridge, Gore Cement Mills, Texas Caves, Ashford Caves and Riversleigh. Each of these sites provides a record of climatic fluctuations that pushed and pulled Australia's rainforests and woodlands apart. What we need to do now is to sythesise these pieces of information by good dating techniques and more thorough excavation. What is needed ... Time and Finance (typical).

Cavers are an integral part of the study of ancient faunas, stumbling across them where ever they go, however, little is reported to the relevant researchers in each field. The field guides that are kept by Caving Clubs and Societies are important to people (like myself in knowing the whereabouts of fossil deposits. This is not to encourage the collection of fossils from caves for personal or museum collections, it is to understand the full potential of cave systems and to mount proper, well organised, neat and very discrete digs with the combined help of all interested parties. Cavers and Palaeos must work together to develop a rapport that can benefit the public, science and our quest for knowledge as human beings. The present applications of the knowledge of our recent past is the ability to predict events in the future! Whether they be for *Homo sapiens* or for animals and plants we wish to conserve.

By Scott A Hocknull
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THE CHRISTMAS CREEK COMPROMISE

Presented by Peter Berrill

Compiled by John Kersey, Craig Kersey, Dwayne Kersey and John Wells
Resource Material supplied by Chillagoe Caving Club, Broken River Karst Index (Mick Goodwin), Department of Environment, Department of Mines, Greenloading Biostudies and David Mitchell Ltd.

The concept of this paper is to give details of the events, beginning in mid 1996, regarding the Christmas Creek Limestone area.

SUMMARY

The highly cavernous karst ridge became the proposed site of a major Limestone quarry. The mining company, David Mitchell Ltd had held a mining lease over approximately half the area sine 1983. (ML 1445). None of the cavers involved, (including Chillagoe Caving Club) knew of this.

It was learnt that the Company had not gained approval to mine this particular lease from the Queensland Department of Mines.

When an approach was made to this Department by the Townsville Caving Group, the ASF Conservation Commission, Peter Berrill and the Department of Environment, via Mick Goodwin, the Mines Department immediately ordered the Company to stop work.

The entire situation was looked at by the Caving Group. Many aspects were investigated and much discussion took place. The following being considered:

- The preservation of the outcrop it's caves , flora and fauna
- Maintaining access to the area through the grazing lease holder
- The commercial aspects of the situation ie local employment in the mine and proposed kiln operation.

As a result of this consideration, a Compromise Proposal was put to the Mining Company to relinquish the portion of the Lease over the main cavernous part of the outcrop and (with the support of the cavers) , extend the Lease in the opposite direction, over a portion of the outcrop which did not contain many (discovered, enterable) caves. Bearing in mind, that there already existed a considerable quarry and a large disturbed area in this section.

David Mitchell Ltd agreed to this proposal and further conditions regarding environmental studies. As a result, an agreeable situation now exists to the satisfaction of all parties.

PROFILE OF EVENTS WITH REGARD TO THE MINING OF LIMESTONE AT THE CHRISTMAS CREEK KARST AREA

Location - West from Townsville

The karst outcrop is situated approximately 40km south of Greenvale and 6km east of the Gregory Development Road. The karst occurs on the grazing lease property "Christmas Creek", owned by Mr Viv Keen. It is a single major karst outcrop in the area with two smaller outcrops occurring adjacent to the Gregory Development Road just south of the Christmas Creek property turn off.

There are a series of smaller karst formations that lie in an arc to the west and south from this point to south of the Clark River.

The two outcrops on the highway contain a few minor caves. The south-west arc has not been investigated. The Christmas Creek karst outcrop is approximately 1.8km long; 500m wide and up to 150m high. The majority of it is cavernous. Forty caves have been tagged with the potential to go well over 100. One major bat maternity cave exists with the potential for at least two more.

HISTORY

During the early 1970's, the area was explored by the now defunct Charters Towers Speleological Caving Club. Some 20 odd caves were tagged by them. Unfortunately, most of their records have been lost and the remaining member (currently active with the Townsville Caving Club (TCC), has a very bad memory! It is presumed that many of the caves were explored by various people while the Greenvale Mining Town was functional. Carlisle, Sheean and Fraser were regular cavers, but it appears that no records were kept.

During the mid to late 1970's, the northern end of the outcrop was mined for ballast for the Greenvale Rail Line. Two considerable sized quarries were developed and much loose rock was left behind. It is known that the lease had lapsed.

The Chillagoe Caving Club visited the area in March 1986 and recorded and tagged 19 caves. These are documented in the Broken River Karst Index.

In July 1993, three of the Kersey family and the previous CTSCC member, visited the area. This was the beginning of the Townsville Caving club. Mick Goodwin of CCC supplied TCC with the Broken River Karst Index. Exploration, tagging and surveying has continued in accordance with the ASF Standards. TCC now has about 30 members and is currently considering joining CCC as a sub-branch. About 6 people are prepared to meed the ASF Horizontal Cave Leader Accreditation Standards.

MINING

On the 5 May 1996, heavy mining machinery was seen moving down the old haul road put in by the 1970 Mining Company. Inquiries revealed that this Company, Calcium Products, a subsidiary of Mitchell Mining Ltd, held a lease over a substantial portion of the karst outcrop and were indeed planning to begin mining operations. See CCC map.

Further investigations revealed that the Lease ML 1445 at Christmas Creek had been granted in 1983 along with several other leases at Calcium near Townsville where the Company has lime burning kilns. ML 1455 had been granted without an individual EMOS or EIS. John Kersey made representation to the Department of Environment and work was immediately stopped in the area.

Access to the caves via the property owner, Viv Keen, has always been tentative. Viv is a 'hard man' and he had problems with unauthorised people on his property previously, so the cavers had to treat him carefully. Viv was approached for his attitude towards the mining. His position is that, he doesn't want the caves destroyed but due to the downturn in the cattle industry, any compensation he would receive from the mining would be very desirable. Hence, he would not appreciate the cavers stopping the mining. From that the cavers deduced that they would no longer be welcome on his property.

That situation was compounded by the question of access to the Broken River area (40km further west), as the properties are close and property owners talk to one another. If access was lost to Christmas Creek, it was most likely that access to Broken River would also be lost. The situation called for some lateral thinking:

- How to keep the property owner happy
- How to save the caves
- The mining company did not really come into the question except for the possibility, that if it stopped here, they may go elsewhere and the problem would not go away.

A compromise proposal was evolved. It was made quite clear to the Mining Company that unless they agreed to relinquish a major portion of ML 1455, they would lose the lot. A thorough examination of the northern end of the Tower was conducted by the cavers. Following the on-site inspections and discussions, the Mining Company agreed to the compromise proposal and sought (and gained) approval to remove the loose rock (ONLY) left from the previous operation. They were also instructed to commission a preliminary report on the environmental aspects of the area with particular attention to the caves and bat populations.

The preliminary study has been carried out by a NSW based company, Greenloading Biostudies. Alison Martin, the representative involved, conferred with Les Hall (University of Queensland), before coming to Christmas Creek. Particular attention was given to the listed caves.

THE FUTURE

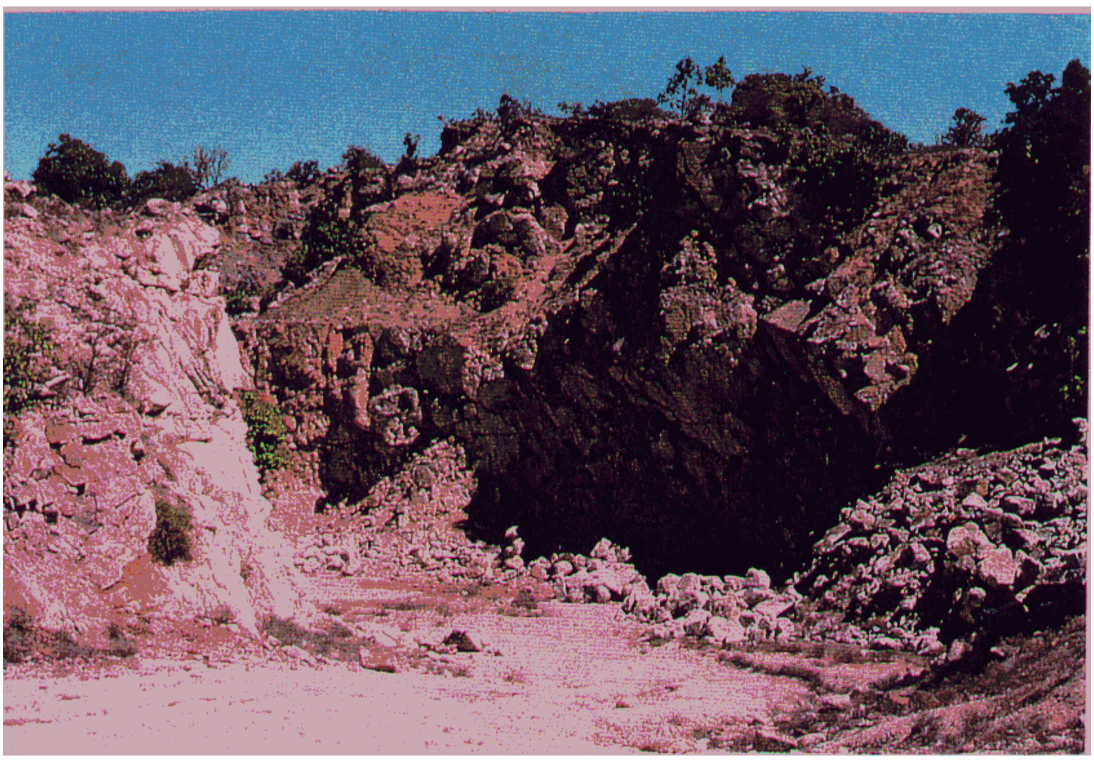
As this is the first bat maternity season since this began, it is vital that all possible data is gained now to determine the possibility of mining and if necessary, to restrict mining at time and or areas. TCC know of the sites listed but others may exist that have not been discovered, particularly, the southern end of 001 tower. A program of close monitoring will begin on the 19 October to determine:

(a) If there are any more maternity sites in this area;
(b) What is happening in known caves (whether they are maternity sites or not);
(c) To find other maternity sites in the southern end of 002 tower. This is less critical at the moment due to a greater distance from the proposed mining area and will depend on caving persons resources. It is believed that there is at least one more major maternity site in this area, from old reports;
(d) Inform relevant capable research persons of these findings and support them in a proper study of the bats during this season.

If mining is allowed to proceed, TCC will monitor the operations to ensure that they do the right thing. Now that the property owner has negotiated a satisfactory compensation agreement with the Mining Company, access (subject to normal terms and conditions), is assured and that goodwill will extend to other property owners in the area.

NB - Due to the size of John Kersey's presentation, we apologise that not all of his paper is presented in the proceedings. If anyone is interested in reading the full paper, please contact CQSS or John Kersey.

Looking in a north easterly direction across the former plant site of the earlier ballast rock operation - taken in 1993. The crushing plant and stockpiles of the current operation now occupy this area. On cessation of mining, revegetation will be encouraged.



Looking into the old ballast quarry from its entrance on the eastern side of the limestone ranges. Further mining will reduce the height of the main face and will remove some presently overhanging sections.

MEDIA RELEASE

By Peter Berrill

Cave Queensland Conference

Cave Queensland is the 22nd Biennial Conference of the Australian Speleological Federation and is being hosted by the Central Queensland Speleological Society, which is based in Rockhampton.

The venue is the Yeppoon Recreation Camp, 170 Matthew Flinders Drive Yeppoon and the Conference runs from 4th - 8th January.

The Conference is held every two years to bring together cavers from all over Australia to discuss matters relevant to caves and karst. Papers are presented on items such as sport caving, conservation and management issues, safety and all aspects of caves and caving in general.

A major topic for discussion will be the rehabilitation of Mt Etna, which recently was the centre of a rehabilitation blast. Rehabilitation blasting has been somewhat of a contentious issue throughout the caving community because it has never been tried previous to the Mt Etna blast.

A paper will be presented by Orica, the company carrying out the blasting and afterwards there will be an on-site inspection of the blast site. There have been thousands of trees planted as the next stage of the rehabilitation program.

There is also a Speleo-Art comprising some 41 pieces. These artists have sent their work from all over the world, 4 countries in fact, to be displayed at this conference. The artists are in fact, all cavers who have the desire to express their feelings of the world caves in art. It is believed to be the largest assemblage of speleo-art ever put on display.

After the conference there will be a week of post conference caving in the local area.

For more details or comment on the Conference you can contact the President, Peter Berrill of the Central Queensland Speleological Society. Peter is also the National President.

Phone 49 342870 or the Conference Mobile 014938187

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Livingstone Shire Council
Department of Environment
Keppel Coast Photographics

Jodi's Catering provided appetizing and nutritious meals throughout the Conference and especially the Cave Man's Dinner, which was a sensational seafood buffet - of which was thoroughly enjoyed by all.

ASF 22[ND] BIENNIAL CONFERENCE AWARDS

Presented by Peter Berrill - President ASF & CQSS

Awards Committee:

Current President: Peter Berrill

Past Presidents: Lloyd Robinson
John Dunkley
Miles Pierce

Nominations Received:

Edie Smith Award: Norm Poulter (SRGWA)

Henry Shannon (NC)

Certificate of Merit:

Dave Martin (Absent)
John Toop

CONFERENCE PHOTOS














Cave Man's Dinner

Seafood Delight

Dining Hall

Official Table

The Cave Man's Dinner Guests
















CREATURES