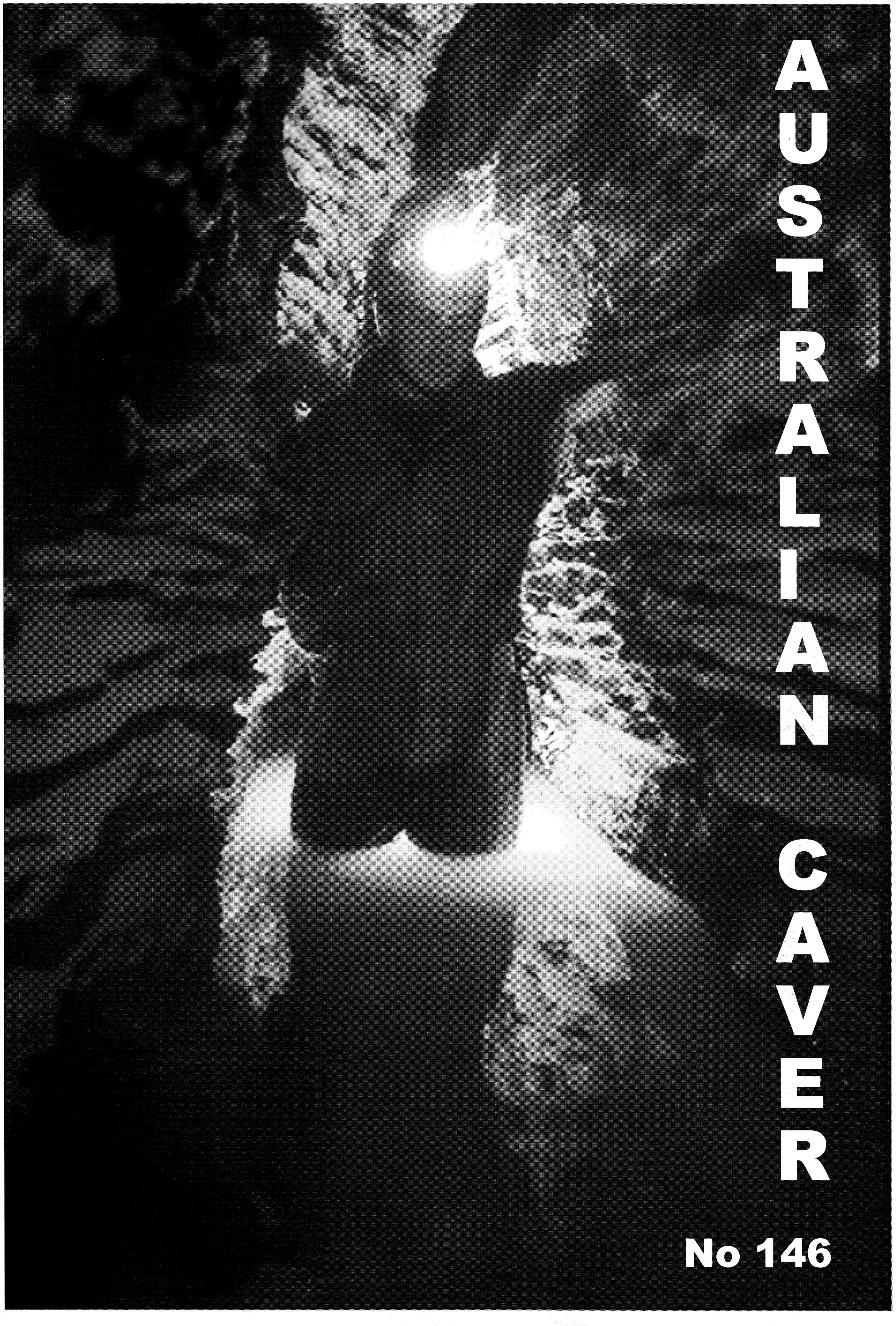

AUSTRALIAN CAVER

No 146

COMING EVENTS

6-8 March 6-8
Down to Earth – A speleological convention & workshop at Buchan, organised by Victorian Speleological Association.
Cost: about $45.
For details, enquire at vsa@werpie.net.au.

18 April
NSW Speleological Council meeting – Sydney, NSW
Details: Chris Dunne, PO Box 193, Westgate, NSW 2048. Ph. 02-9560-3060

15-16 May
Tree planting at Cliefden

26-27 June
Nav 99 – A rogaining-type event, N.S.W.

16 October
NSW Speleological Council meeting - Venue TBA

2001 January
23rd Biennial Conference of ASF, Sydney, NSW
Details: Angus Macoun, 02-9416-2588 or amacoun@eagles.com.au

2001 July
International Congress of Speleology, Brasilia, Brazil

Australian Caver Issue No 146
February 1999

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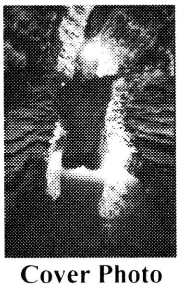
All contributions are welcome

The views expressed in the Australian caver are not necessarily the view of the Editor, or of the Australian Speleological federation Inc

Contents...



Cover Photo
Daniel Eberhard in
Loons Cave
(efflux entrance).
Ida Bay Tasmania
Photo by Stefan Eberhard

Editorial

I should have listened to Stuey...

A couple of years back, when I was thinking of offering my services to the ASF as Editor, I remember asking some advice from Australian caving guru Stuart Nicholas. I distinctly remember saying to him "Well, I've got the spare time to do it."

"Ha!" laughed Stuey "You may think you have the spare time!"

Hmmm...

I generally pride myself in being on time with things. This issue was supposed to be out in November, but it's already a few days into December, and I'm still working on it! What's gone wrong???

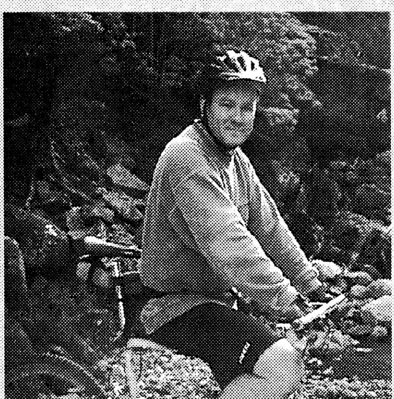
I'm afraid the answer is spare time – or lack of it. There have been a few changes in circumstances since I took the Australian Caver on, and I'm afraid I've run out of the spare time to do it any more! As a result – as hinted in my last editorial – this is to be my last one, and the ever-faithful Sherry Mayo will be taking over full time from now on.

Don't get me wrong, seeing each issue of Australian Caver finally come out in print is a enormously satisfying experience. I'm proud of all the issues I have done *(except for the first one maybe...)* It's just that they do take an enormous chunk of spare time to produce.

Thanks to everyone for the support and contributions, and don't forget...what you read is only made up of what the members put into it as the contributors!

As I ride off into the sunset, I wish Sherry the best of luck, and I'll catch you all later...

Dean Morgan
Ex-Editor...



PS: In case anyone is interested, please note my change of address too.

PPS: A special "thank you" goes out from me to Lucinda Coates for taking the time to send me that "special" Christmas card! Thanks Lucinda – you're a legend!

NEWS IN BRIEF

"One of the defining moments in my life was when I discovered caving in Belgium. I was a girl at high school. That's when I realised that you could actually do something more with your life than read books and watch television. What appealed to me was the attraction of the unknown in all sorts of different fields. I love learning and I love space."

Brigitte Muir, quoted in an interview with Christopher Bantick. Brigitte is the first Australian woman to climb Everest as well as the highest summits on each continent.

WORLD HERITAGE LISTING FOR JENOLAN?

In 1998 the Commonwealth and NSW Governments concluded an agreement nominating Greater Blue Mountains Area for World Heritage listing. Jenolan Caves Karst Conservation Reserve has been included in the nominated area. The nomination does not argue that the cave values *per se* are of World Heritage standard, but rather that the karst is an integral part of the whole Blue Mountains area. A decision is expected from the World Heritage Committee about December 1999.

For about 20 years ASF has been arguing that Jenolan Caves has values which meet the requirements for World Heritage listing, and this was included in consultant studies conducted by ASF in the 1980s. Speleologists have played a significant role in raising consciousness about cave values of this, our premier tourist cave area.

An Amplification.

In my article, "Analysis of a Caving Incident in Tasmania", regrettably, I omitted to properly acknowledge the source of the survey I included. Rolan Eberhard drew this survey (which I indicated was sourced from Australian Caver 115),; the data was collected by Rolan & Stefan Eberhard, Martyn Carnes & Trevor Wailes.

In addition, the accompanying quote by Rolan Eberhard came from Speleo Spiel 212. I would like to apologise to Rolan, Stefan, Martyn and Trevor for this omission.

Jeff Butt.

Karst Index Cave Database Update

Peter Matthews
ASF Documentation Commission
17/11/98

Testing of the Alpha version of the new Karst Index cave database software by VSA has been going well. The purpose of this Alpha testing is to check that the basic functionality is working OK in a real cave data environment by someone other than me.

It installed without problems (without help from me), and during the past few weeks while I had gone bush on annual leave from my paid job its preliminary workout revealed only a few minor bugs, and the need for better "getting started" information to help new users overcome the learning curve. It is currently getting a workout with some heavy-duty real cave/karst data entry to flush out any further weaknesses.

While that is going on, I am fixing up any Alpha version problems and preparing the Beta version for preliminary testing in each State of Australia, a more demanding situation on the software.

After that, and when the State Co-ordinators are satisfied that it is working OK for their requirements, the first general release will be made to clubs around Australia.

Press Conference

In October 1998 a press conference was organised in Bangkok by Dean Smart, an ex-patriate British caver currently employed by the Royal Forestry Department in an enviable capacity, finding and surveying caves and making recommendations on their management. Held in their conference room and chaired by the Director of the Thailand Research Foundation, the main purpose of the gathering was to promote two projects funded by the Foundation: a 6 million bat inventory of the karst and caves of Mae Hong Son province, and a preliminary survey of the karst resources of Thung Yai Naresuan, a World Heritage property west of Bangkok. Partly in recognition of the work done by Australian speleologists, ASF was represented by John Dunkley, who was invited to make a presentation to Nopparat Naksathit.

(see articles elsewhere)

ASF receives large National Heritage Trust grant

ASF (represented by the NSW Speleological Council) has received a grant of $27,330 under the National Heritage Trust funding scheme for 1998-99. The grant will enable us to extend our knowledge of karst and caves in the Macquarie River catchment area of central NSW. The program includes documenting karst areas with special reference to remnant vegetation, identifying priorities and developing strategies for rehabilitation, raising community awareness of the uniqueness of karst and karst-adapted vegetation, and preparing a regional Karst Management Strategy. As well, it will enable us to identify outcrops, caves and other features on topographic maps, to update the Karst Database and to conduct on-site demonstration. Several member clubs will be cooperating on the task: BMSC, CWCG, ECRC, HCG, MSS, OSS and RSS. Peter Dykes will coordinate the project. Peter will be conducting a workshop at the Queensland conference with a view to enthusing speleologists in other states to consider seeking NHT funding for worthwhile projects.

Letter to the Editor

EDITOR CALLS IT A DAY

Edition 146 of the Australian Caver will be Dean's last, *(sadly).*

For personal reasons, Dean has decided that he has done his bit for the cause. Tonight when I phoned to personally thank him, I could hear in the background, one of those reasons. A tiny voice talking to dad.

For whatever reason we, all of ASF, thank him for his effort and wish him well.

Dean volunteered for the job of Editor of the Australian Caver during a very turbulent period. We had not seen the magazine for about 18 months and the Federation was heading for disaster if the most important part of its communications was not restored. He had his first copy out in weeks and from the beginning, received favourable comments. The quality improved with each issue and its regularity soon returned to a quarterly journal. This was the result of Dean's commitment to the magazine. In order to ensure that the job was done, Dean retained complete control of all aspects of the magazine from editing through to posting. A mammoth task for just one person, but that's the way he preferred it.

At the May 30 Executive Meeting, the Executive, in consultation with Dean, decided to ease the load of the Editor by appointing a Manager for Australian Caver who would be responsible for the printing postage etc. leaving the Editor more time for editing. However, it appears that life has caught up with him and Dean has decided to ***'call it a day'*** as Editor.

Dean, I am sure that all of the Federation joins me in **sincerely** thanking you for restoring their Magazine.

"Thanks for a job well done".

Peter Berrill
President ASF

And the new Editor is...

While Dean was absent attending to paternal matters, Sherry Mayo edited Edition 143 of the Australian Caver for him.

Guess who our new editor is?

Commencing with the first edition in 1999, Sherry will be our new Editor.

Please give her your full support by submitting articles. *Sherry can be contacted at:-*

Home: (03) 9533 0437 Work: (03) 9545 2702 (office) and 9545 2675 (lab)

email: mayo@mst.csiro.au or scmayo@rsc.anu.edu.au

FAX: (03) 9544 1128

ASF's Membership and Financial Year

Response to Chris Dunne - by Garry K. Smith.

It is good to see that some (healthy) discussion has started on this subject. While I respect the comments put forward by Chris in Australian Cavers No. 145, there are a few points in his report which I do not agree with. Mind you, by questioning the comments of a person with years of experience on the ASF, I am probably sticking my neck on the chopping block with the axe ready to fall. However I am prepared to eat humble pie if proven wrong. So Chris, please don't take these comments as a personal attack.

1. Under the heading "Current Situation" in the article titled "ASF's Membership and Financial Year", Chris states, "Garry Smith has raised the issue of these two administrative years being out of sync with each other and suggested that ASF adopt the common Taxation Year for both." In the original article I actually say, "It seems to me that the 'Membership Year' and the due date for 'Membership Fees' should be the one and the same to save confusion." The ASF's Financial Year is not mentioned at all here. As readers would have noted in my previous article, the date of ASF's Financial Year (ending 31st August) is entirely different to that of the Due Date for Membership Fees. (Same as the end of Taxation Year - 30th June). The ASF's Membership Year currently ends on the 31st December.

2. Under the heading "Current Situation" Chris states, "by common practice, ASF's Financial Year is the calendar year, January-December." This implies that there is no question as to the date of the ASF's Financial Year. As Chris later admits in his article, the only date defined in the By-laws, is the Due-by Date for Membership Fees. In other words the ASF's Financial year is not defined. I am led to believe that the ASF financial books are tallied up on the 31st August and have been for many years. Therefore I would argue that the ASF Financial Year ends on the 31st August and starts on the 1st September.

3. Chris also states, "technically, all fees are due and payable from the 1st January each year; the amount of fees due is set out in the by-laws". I would have to disagree here, as the amount of fees is not documented anywhere in the ASF Constitution or By-Laws, only the Due By Date is stated. I would also question whether "technically" fees are due by the 1st January, as this is not written down anywhere in the Constitution or By-laws. The By-laws say that 'Membership Fees' are due by the 30th June.

4. Chris states, "you have 12 months to pay, ie. you are expected to pay during the current calendar year." I could find nothing about the 'calendar year' written in the ASF Constitution or By-Laws.

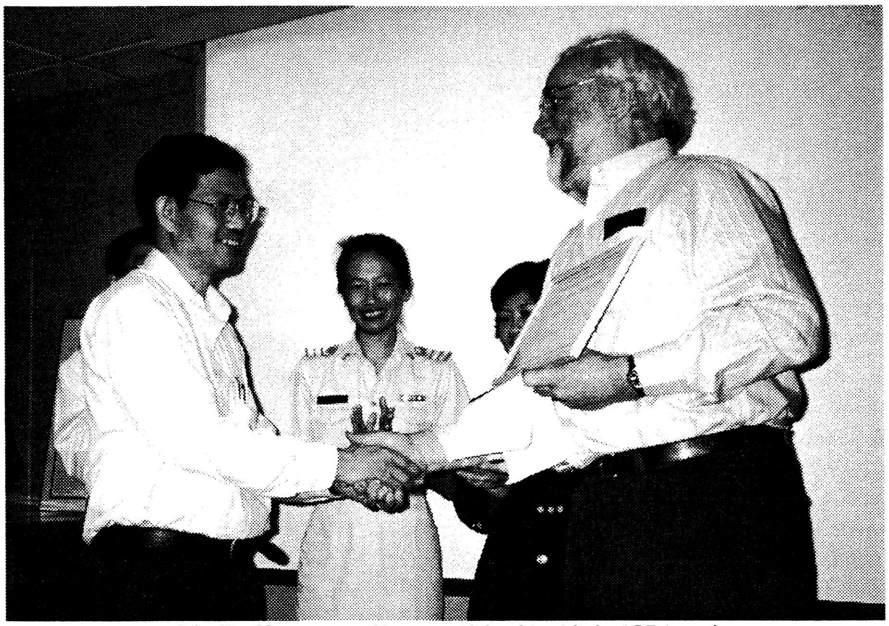
5. Chris states, "payment is due by 30th June or you incur a late fee (and lose entitlement to any pre-July discount". The 30th June is correct, however as was described at the last few ASF meetings, it was a DISCOUNT for paying early (before 30th June). The standard membership fee was due after 30th June. However the discount system was voted out at the ASF Meeting (April 1997) which coincided with the 21st Biennial Conference at Quorn SA. In other words, there is no more discount.

6. Chris states, "if you haven't paid by the end of December you are not a member for that year." Again I could not find this written down in the ASF Constitution or By-Laws. As Chris later states, ".... neither the By-law nor the ASF Constitution explicitly defined the ASF Membership Year - nowhere is the period covered by fees actually defined." If this confusion about dates is a wheel which comes around again and again, as Chris suggests, then it is about time the confusion is eliminated once and for all. If a simple solution is to make the Membership Year and the Due-by Date for payment of Membership Fees, one and the same. - I suggest that the 30th June would suit the majority of clubs. The fact that the ASF's
Financial Year begins on the 1st September and the financial statement is presented at the ASF's AGM during January should not affect the merger of the "Membership Year" and "Due-by Date of Membership Fees". This common date should also be linked in with the entitlement for the issues of Australian Caver.

I would think it a simple task to merge some dates as suggested and add all relevant dates to the ASF By-laws to eliminate further confusion. May I propose that our ASF Executive team or their appointed Ad-hoc Committee look at this possibility before the February 1999 meeting.

ASF makes Awards of Distinction to Speleologists in Thailand

At the last ASF Conference in Quorn in 1997 the Federation made an Award of Distinction to each of two residents of Thailand: John Spies, an ex-patriot Australian who has lived there for 20 years, and Nopparat (Nop) Naksathit, an employee of the Royal Forestry Department. Both had been of immeasurable assistance to the many Australian caving expeditions to Thailand between 1983 and 1997, Nop having led the 1996 Khlong Ngu & 1997 Thung Salaeng Luang Karst Expeditions. More importantly, both made an immense contribution to raising public consciousness about caves and karst, and securing official and high-level support for their conservation. They epitomise the difficulties faced by conservationists and land managers in a rapidly developing country which nevertheless has laid sound foundations for cave and karst management. Brett and Jason Moule (HCG) were able to arrange delivery of certificates and books earlier in 1998, but the opportunity to make a more formal presentation arose only recently, at a press conference in Bangkok.



John Dunkley presents Nopparat Naksathit with the ASF Award of Distinction in Bangkok, watched by Khun Suchata, Program Director of the Thailand Research Foundation

John Spies

An accomplished writer and photographer, John Spies has since 1985 operated the renowned Cave Lodge in Mae Hong Son province, in the far north-west of Thailand bordering Burma. This is the centre of one of South-East Asia's most significant karsts, more than 1,000 sq.km of limestone with the longest and deepest caves on the mainland of South-East Asia. Of very great value to archaeology, biology, tourism and recreation, the karst is impacted by shifting agricultural practices, newly developed sedentary cash cropping, and by a rapid increase in tourism. His established respect and the publicity flowing from his photography and articles enabled John to exercise a real influence on the conservation of the area, which has avoided the excesses of development evident in some other karsts of Thailand. His citation reads: ***"Awarded in grateful recognition of significant and lasting contributions to the preservation of the karst heritage of Thailand, specifically for dedication to the exploration, documentation and the promotion of sound management of caves and karst in Thailand, and for logistical assistance to the Australian speleological expeditions."***

Nopparat Naksathit

Nop has worked primarily in Kanchanaburi province, west of Bangkok. Here there are nearly a dozen contiguous national parks, wildlife sanctuaries, non-hunting reserves and two of Thailand's four World Heritage properties, Thung Yai Naresuan and Huai Kha Khaeng. All of these contain karst and caves and together this vast area is one of the world's great wilderness karsts: remote, difficult of access, heavily forested, almost uninhabited and largely unexplored for caves except on the more accessible margins. There are several long and truly impressive pristine river cave systems, some large, some comfortably sporting, and in 1992 an Australian expedition discovered the world's tallest column (or stalagmite, it's hard to say), measured at 61.5m. . Nop organised and led the 1996 Khlong Ngu Karst Expedition which included 7 Australian speleologists, the results of which helped establish the case for promulgating a Khlong Ngu National Park. Nop is the first non-Australian to receive an award from ASF . His citation reads: ***"For significant and lasting contributions to the preservation of the karst heritage of Thailand, specifically for dedication to the exploration, documentation and the promotion of sound management of caves and karst in national parks and reserves of Thailand."***

Yeppoon Conference and ASF Council Meeting

4th to 8th January 1999

Report by Chris Dunne

Yeppoon Recreation Camp at Yeppoon, on the Central Queensland coast near Rockhampton, was the venue for *Cave Queensland*, ASF's 22nd Biennial Conference and for ASF's 43rd Council Meeting.

Council Meeting:

Contrary to what some believe, ASF Conferences are not *gabfests* for speleo-politicians nor, for the most part, are Council meetings political events. Under ASF's 1990 Constitution, much of the government of the Federation is by the nine-member Executive, and President Peter Berrill is fortunate to have gathered about him a fairly professional team. Much of the debate over each and every Report, which has characterised Council meetings for decades, is now avoided by aggregating all the reports of the Executive, Commissions and Committees, and any major items of business into an *Annual Report*. General Secretary Peter Dykes had sent this to clubs in mid-November.

Flowing from some of these reports were the adoption by the Council of revisions to the *Cave Diving Code of Practice*, *Free Diving Code of Practice*, and the *Minimum Impact Caving Code*. There was also the lifting of the moratorium on *bolt laddering* (now covered by the *MICC*), and revision of the *Cave Safety Guidelines* in respect of foul air (which the Executive is to finalise in conjunction with Cave Safety Convenor Mike Lake).

Minor amendments to the Constitution will enable the Federation to seek registration as an *Environmental Organisation*. This would improve our chances for gaining funding for our own administration. It is also a necessary step in moving towards the establishment of a *Foundation*, which has been proposed by Senior Vice-President John Dunkley and others as a means for ASF to receive tax-deductible donations (including bequests) and in the longer term to aid speleological endeavours through grants or loans.

New By-Laws on Roles and Responsibilities of Executive Officers and Roles and Responsibilities of Commissions were passed by the Executive. Also on the Commissions front, Ric Brown of WASG joins Rauleigh Webb as a Conservation Co-convenor in the West. Evalt Crabb's Codes & Guidelines Review Committee has been recast as a Commission. The Newsletter Commission has been renamed as the Journal Commission and a separate Publications Commission under Angus Macoun has been established.

The definition of *Family Membership* was adjusted to now include children of the family under 18 residing in the same household - you'd be surprised that the Federation now has a sizeable number of family memberships.

Two clubs were admitted as Corporate Members. Former member club, the University of New South Wales Speleological Society (UNSWSS) was readmitted. Canberra Troglodytes was also admitted.

Finally, elections for five members of the nine person Executive saw Peter Berrill returned as President. John Dunkley and Chris Riley were also returned. Keven Cocks (of South Australia) and Phil Lardner (from NSW) were elected. Outgoing were Arthur Clarke and Harry Nagle, although Arthur and Harry both remain as a Non-Executive Vice-Presidents.

The Conference:

Conference Papers ranged through ASF Knowledge Management (principally concerning copyright), Caver Population, Expeditions to Christmas Island and to Mitchell-Palmer, Cliefden Caves Vegetation Rehabilitation Project, Speleo Art, Foul Air, Geology of Mt Etna, Mt Etna Rehabilitation, Owl Pellet Remains in Newdegate Cave Tasmania and others.

An ASF Future Directions workshop (over two sessions) was facilitated by Membership Secretary Angus Macoun. Another workshop devoted to Cave Mapping was convened by Ken Grimes.

The Conference itself was punctuated by an afternoon visit to Mt Etna and Limestone Ridge National Park, about 20km north from Rockhampton, scene of the conservation battle which culminated in the late 1980s. An inspection of the mine rehabilitation works, to which CQSS is a consultant, was hosted by *Pacific Lime's* Rehabilitation Co-ordinator, Ian Herbert, and their Explosives Consultant Kim Henley (from Orica Explosives). On two evenings there were trips up the mountain to observe the evening emergence of 200,000 Little Bent Wing Bats. Later, courtesy of National Parks bat specialist John Toop, there was a close up viewing (even to touch for some) of several specimens of the larger Ghost Bat.

People honoured during the *Cavers Dinner* with *ASF Awards* were John Toop, Norm Poulter, Henry Shannon and Dave Martin. Norm was subsequently honoured in the Australia Day Honours with Membership of the Order of Australia.

On display throughout the Conference, courtesy of CEGSA's June MacLucas, was *Speleo Art - Down Under*, a collection of 44 pieces (mostly paintings and drawings) by artists from seven countries most of whom are members of the *International Society for Speleological Art*. All items were available for purchase and several were bought during the Conference and at an auction staged by CQSS's Kerry Hamilton during the *Cavers Dinner*. The bidding was so infectious, that bits of Kerry's attire were auctioned as well!

Special thanks go to members of CQSS who hosted the Conference and particularly to Debbie Roberts. Post Conference trips were on offer to Mt Etna, Broken River and Chillagoe.

A.S.F. Executive Contact List - 1999

Provided by Angus Macoun (ASF Membership Secretary)

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MACQUARIE KARST VEGETATION REHABILITATION PROJECT - Peter Dykes

Project Overview:

As you may by now be aware, the NSW Speleological Council, with the help of the Federation, has received a grant from the Commonwealth Government's Natural Heritage Trust (NHT) to undertake a documentation, vegetation survey and rehabilitation project over karst areas in the Macquarie Region of NSW. Briefly the project has the following Aims, Actions and Outcomes:

Aims:

- Raise awareness of the uniqueness of karst and karst adapted vegetation for groundwater sustainability.
- Quantify and prioritise karst areas in the region in respect of remnant vegetation in agricultural landscapes.
- Demonstrate strategies to rehabilitate karst related vegetation communities/habitat for long-term sustainability.
- Prepare a Regional Karst Management Strategy.

Actions:

- Field investigation to identify karst areas, conduct preliminary vegetation inventory and identify factors degrading the karst ecosystem in each area.
- Update the ASF national Karst Index Database.
- Prioritise areas by significance, needs and practicality for rehabilitation.
- By use of a Demonstration Site, highlight the importance of conserving, rehabilitating and protecting karst ecosystems.
- Prepare a Karst Management Strategy.

Outcomes:

- Preparation of a Karst Management Strategy for the region containing a profile of the region's karst, its vegetation type, an assessment of the factors degrading the karst and action plans for future management.
- Highlight the significance of karst through conserving and rehabilitating an important outcrop on private property.

The defined area is the upper region of the Macquarie River catchment which includes karst areas from Limekilns to Wellington and Ilford to Mudgee. The overall project coordinator is Peter Dykes, responsible to reporting to a special sub-committee of the NSW Speleological Council. Bruce Howlett and Evalt Crabb have agreed to assist by acting as regional coordinators for the for parts of the project. Chris Dunne is the project manager, responsible for liaison between the Federation and the NSW Department of Land and Water Conservation's funding branch, which coordinates NHT grant in this state.

While the project extends to some regeneration of remnant bushland over karst areas, evaluation of degradation factors and community workshopping, the main thrust as far as most caver participating are concerned, is the full documentation of all karst and its features within the region. The documentation process will use the techniques developed for the Australian Karst Index plus additional forms and methods developed by Peter Dykes as convenor of the Cave Numbering and Documentation Committee of the Speleo Council.

The project will lead to the investigation and exploration of many of those out of the way, little visited karst areas. There is a good chance of new discoveries being made and the opportunity will exist to explore caves rarely visited.

A general request is being made for NSW clubs to consider participating on one or more of the trips being planned by Bruce Howlett (OSS) and Evalt Crabb (HCG). Any assistance would certainly be appreciated and acknowledged in the final report of the project. Clubs and individual wishing to participate in any way with the project are welcome. Contact initially should be through Bruce and Evalt, although anyone wishing to help Peter with the vegetation survey work may contact him direct. The trip program, contact details and trip organisation details are listed below.

Trip Program:

6 – 7/2/99	Cliefden Caves	Bruce Howlett	Planning meeting.
20 – 21/2/99	Cumnock/Geurie	Peter Dykes	Documentation & Veg Survey
6 – 7/3/99	Bakers Swamp	Bruce Howlett	Documentation & Veg Survey
13 - 14/3/99	Portland	Evalt Crabb	Documentation & Veg Survey
2 – 5/4/99	Wellington	Bruce Howlett	Documentation & Veg Survey
10 - 11/4/99	Capertee Valley	Evalt Crabb	Documentation & Veg Survey
1 – 2/5/99	Kandos/Cudgegong	Evalt Crabb	Documentation & Veg Survey
15 – 16/5/99	Cliefden	Bruce Howlett	Tree Planting
29 - 30/5/99	Molong	Bruce Howlett	Documentation & Veg Survey
12 – 14/6/99	Mudgee/Queens Pinch/Apple Tree Flat	Evalt Crabb	Documentation & Veg Survey
26 – 27/6/99	Molong	Bruce Howlett	Documentation & Veg Survey
10 – 11/7/99	To be advised	Evalt Crabb	Documentation & Veg Survey
24 – 25/7/99	Dripstone	Bruce Howlett	Documentation & Veg Survey

Trip Coordinators:

Evalt Crabb	121 Hoxton Park Rd. Liverpool 2170 PO Box 154 LIVERPOOL BC 1871	H (02) 9607 2142 E-m evalt@cyber.net.au
Peter Dykes	C\- DLWC 62 Marshall St Cobar 2835 PO Box 307 COBAR 2835	H (02) 6836 1317 W (02) 6836 1575 F (02) 6836 2988 E-m dlwcwtcm@cobar.net.au
Rebecca Hayes	5 Todman Ave. West Pymble 2073 PO Box 447 CHURCH POINT 2105	H (02) 94491601 W (02) 9906 5436 E-m hayes@tig.com.au
Bruce Howlett	3 Miriyan Drive KELSO 2795	H (02) 6331 4627 W (02) 6332 8141

Trip Organisation:

The project has been split into two karst regions, each with a coordinator to organise trips. The coordinators will be responsible for undertaking the documentation component of the project:

Lithgow – Mudgee Region:

Coordinator:	Evalt Crabb
Coordinating Club	Highland Caving Group, PO Box 154, LIVERPOOL BC, 1871
Areas:	Apple Tree Flat, Capertee Valley, Cudgegong, Ilford, Kandos, Lue, Mudgee, Portland, Queens Pinch, Talbragar River

Macquarie Region:

Coordinator:	Bruce Howlett
Coordinating Club:	Orange Speleological Society, PO Box 752 ORANGE, 2800
Areas:	Bakers Swamp, Burran Burran, Campbells River, Cumnock, Dripstone, Geurie, Limekilns, Macquarie River, Molong, Stuart Town, Wellington

The vegetation survey component of the project will be undertaken by Peter Dykes and Rebecca Hayes. Except for the trip on 20 – 21/2/99 to Cumnock, no special trips are planned. Rather it is intended to hook into Evalt's and Bruce's trip program to undertake the vegetation work.

On the verandah at Cave Lodge - an interview with John Spies

Interview & Photo by John Dunkley

(John Spies left Australia 20 years ago to follow the then popular backpackers' overland route to Europe. He made it as far as Chiang Mai in the north of Thailand, from where he and Diu Wilaiwan Intikat operated a trekking service for some years. In 1985 they built a backpackers lodge perched in the remote and spectacular limestone mountains of Mae Hong Son province, nearly 900km north-west of Bangkok. The Lodge quickly became renowned among backpackers and a mecca for serious cavers. It is just a few hundred metres from Tham Lot, an impressively large, well decorated through river cave, then almost unknown but which has since become a major tourist attraction.)

John, you've lived in Thailand for some 20 years, you speak fluent Thai and Shan, and you've written many articles on the hill tribes and caves of Mae Hong Son province. What was it that first interested you in this particular area?
Well, originally it was the hill tribes and the prospects of trekking in a new area. My former wife Diu ran a trekking operation out of Chiang Mai. This area was very remote then, just one truck a day from Chiang Mai and Pai along the track built by the Japanese during the war. We didn't know anything about the caves. I remember one guy on top of a truck telling us about this cave I had to see – he said it had to Thailand's biggest. It turned out to be Tham Lot which is the one just down the road from here. I think it was the first one I showed you when we met in 1983.

The American archaeologist Chester Gorman conducted a dig in one of the caves in the 1960s when this area was very hard to reach. What was that all about?
I'm not sure why he came to Mae Hong Son province. He was looking for evidence of early agricultural communities, early stone-age cave dwelling people. He probably just saw it on a map and got information from Thais who said it was a good place to look for cave sites. Local villagers would have told him about the Spirit Caves (Tham Phi Man). He found two sites here, at Spirit Cave and at Banyan Valley Cave, and he would have walked to others. He found habitation going back 12,000 years, and this made it the oldest record known of agriculture. It's in the Guiness Book of Records but his conclusions are still a bit controversial.

I've heard there is a move to conduct another dig?
Yes, an Australian archaeologist Peter Graves is interested. There would be world-wide sponsorship interest.

Was much else known about the caves when you first started coming here?
There were no academic-type studies but locals had known for a long while. They would have been going through Tham Lot for a long while as you can see it's a through cave. For many others they would have known the entrance but been too intimidated to go inside. It's the hunters and gatherers who get to know about the caves, for example the honey-bee collectors along the cliff-lines.

Did the local people have any affinity with the caves?
They had a long history of using rock-shelters while hunting – that's still the case in the wet season. The dark zone was always intimidating. Not so long ago there were tigers and bears in there. Many of the local hill tribes started moving here only a few hundred years ago - they are not the same culture which produced the coffins, and they refer to the coffin sites as Tham Phi Man – Spirit caves.

Has that changed?
Not traditionally. Over the last 20 years or so there has been some casual looting in the coffin caves, but

only as a market developed for saleable items. Also they have proper lights now, batteries and torches. Some locals have been as far as the upper levels of Mae Lana Cave – that's 3 kilometres underground. They've also been through Pha Mon Cave, a similar distance. The villagers at Pang Kham (on the border of Burma) talked some time ago of how big and beautiful their cave was, they certainly go in there and have even installed some ladders.

Tham Lot seems to be the most publicised cave around here. What sort of cave is it? Did you have any influence on its management?
It's become a popular destination for both Thais and foreigners because it's accessible and has a variety of attractions – lots of decoration, the underground river, some coffins, the bird flight at dusk. Its Nature Education Centre draws people in also, and the Royal Family has taken an interest; Princess Sirindhon has been here twice and that has an influence. Working out management has not been easy – who had the ultimate authority? I just advise. I've taken Forestry Department people in and discussed problems of visitor impact. Forestry can't be too dictatorial. Ladders have been repaired and we've kept electricity out although kerosene lamps are still used. There's a marked trail in places, for instance in the large well decorated upper chamber. But some things are not so good, for example they were mixing cement in one of the rim pools. It wouldn't take too much to make Tham Lot a cave management showpiece for Thailand, but there are problems. It's a fairly rare example in Thailand of a facility overseen by the Royal Forestry Department but it's the locals who make the money.

So this has helped the local village economy, has it?
Oh, yes. It's a major source of income for the local village (Ban Tham – Cave Village). About 70 guides share the work in rotation, they charge about 100 baht (A$4-50) per group for a trip and they supply lamps. Increasing usage has meant there's now a concrete road to the village and cave. Then there are the people who sell food out the front, people who work for the Forestry Department spending their money locally. It all adds up. In fact some are doing so well that apparently they are neglecting their crops.

So there is something here for people other than just the French and Australian caving expeditions?
There's every level here. For the hard-core cavers there are long caves and vertical holes, several we know but are unexplored, some you need oxygen equipment. Then there are some pretty indestructible caves that we use for adventure caving, like Nam Lang and Waterfall Cave. For tourists there is Tham Lot. And of course there are the archaeological and coffin cave sites and some caves that are pretty important for biology, like the waterfall-climbing blind fish. There's also a great variety of forest – deciduous, evergreen and pine trees.

There seem to be 2 kinds of cave which have excited people the large, long river passages like Nam Lang cave, and the coffin sites. I gather you now know of 75 caves containing coffins. Where are they typically found and what are they like?
They are usually higher, drier caves, occasionally a high level in a stream cave but generally high on a hill, not very big or long. They're usually within an hour or so's walk of a present-day village which is probably on much the same site as it would have been hundreds of years ago, although it was a different culture which produced the coffin cave sites. The coffins are several metres long, the longest is 9 metres, and they're often stacked in tiers or jammed into rifts. They are mostly about 1,600 to 1,700 years old and were dated at Lucas Heights using the Accelerated Mass Spectrometry method.

In the last few years official interest in the caves seems to have increased considerably. What has brought this about?
I think I've had a significant role. When I first came here the caves were great adventure, the thing that attracts people like me to caving in the first place, without any great feel for conservation and the like. Then I remember when you first contacted me in 1982, your story about disappearing rivers on the maps and so on. So the Australian expeditions came over and were pretty obsessed – sitting around for 10 days talking about caves. I had exposure to the different expedition people, then the experts started coming. The blind fish we found on those early trips produced experts interested in taxonomy and DNA tests. The other thing that always intrigued me was the coffin sites. Who were these people who made them, who dragged them up hills and into caves? I could just walk in and out of them and there was no official interest.

I had already written articles on the hill tribes. Now I started writing about caves. Then I was asked by the Royal Forestry Department to go to a seminar on caves at Phayao. I got interested in the huge Khlong Ngu cave system down south in Kanchanaburi province, where the Australians had discovered the world's tallest column in 1992. The Khlong Ngu bordered on Thung Yai which was a World Heritage area, and I advised the authorities to secure it. Eventually we got a Khlong Ngu National Park. One day this will perhaps be one of the biggest attractions close to Bangkok.

That session we had with you and Elery in 1995 at Erawan National Park continued to spread the message to national parks people. There's definitely an expanding interest in the values and vulnerability of the caves and karst both in this area and throughout Thailand.

And what about the project being funded by the Thailand Research Foundation. What are its objectives?
"Exploration and Data Base" is the translation from Thai. It involves collating information from all sources – caving expeditions etc. It includes impacts, state of the ecosystem, the archaeological sites (both coffin and habitation caves), the geology of the area, location of old village sites, the state of the forest, its animal life, water quality work. There's also a sociological aspect – the history, attitudes and practices of the hill tribes and villagers. It's all going into a Geographical Information System and perhaps will be put on CD. It can be linked with the project being run by Dean Smart in Kanchanaburi province.

How have you been involved?
Well, I know where so many of the caves are. I've been able to employ a Research Assistant – Sally has a

degree in Environmental Science from the University of Wollongong and she's been here 6 months now. There's a lot of leg work, walking around the hills, talking to the locals, mapping all of the coffin sites in detail. We're finding new caves and more about the coffins all the time and we'll have very detailed information on most if not all of the coffin caves. We have now recognised more than 50 different styles of coffin head, for example.

So, what steps do you think are necessary to provide better protection and management of the caves? Is it just the coffin sites or are there other vulnerable caves?

They're all vulnerable but in different ways and on different levels. The project includes making recommendations about future management of the whole area. My job includes working out which caves are most important and most vulnerable because budgets and manpower will be limited. A few sites really jump in your face – the blind fish sites are extremely vulnerable, some could be protected, others will be very difficult because of the size of the catchment area e.g. Mac Lana Cave with its two species of blind fish sharing the streamways. This one needs swift action, maybe a gate and limited access. We need an educational program for villagers in catchment areas, focusing on maintenance of water quality. The upper level in Pha Mon cave, the area with the blue stalactites, needs a gate. There are several coffin sites requiring protection. We have had to be careful about publicising some of the sites, in order to protect them

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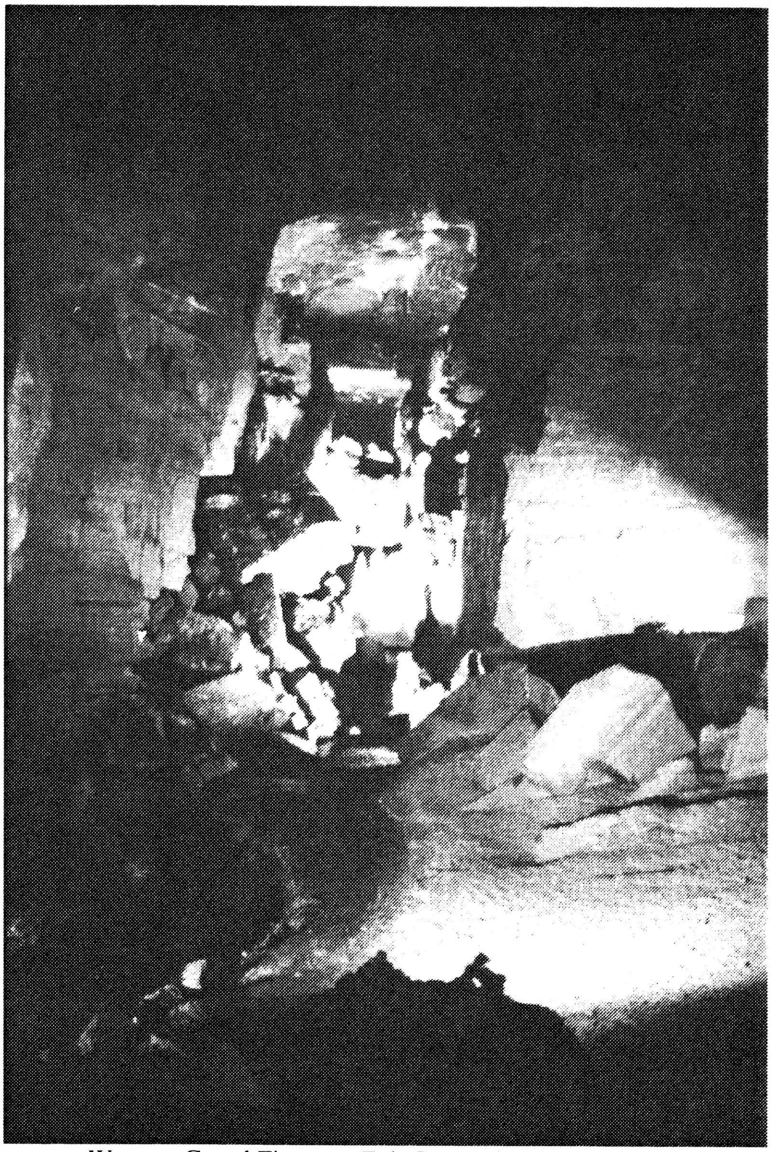
ASF documentation of caves in Tasmania: listing the cave areas of Tasmania, ASF Karst Index area codes and rock types.

Arthur Clarke

Introduction:

This paper provides a resume of cave documentation in Tasmania, followed with a summary list of 123 cave areas in Tasmania: 85 karst and 39 non-karst areas and their respective rock types. One area: Erith Island (EI) has caves recorded in two rock types: (limestone karst and non-karst granite), hence the apparent mathematical error above! There are probably more "known" cave areas (karst and non-karst) and additional "known" caves for which I have no records, along with the hundreds of caves yet to be discovered. The only cave areas included are those for which there are documented records of caves either on ASF Karst Index (K.I.) summary forms or in the records maintained by the ASF (Tasmanian) State Area Co-Ordinator.

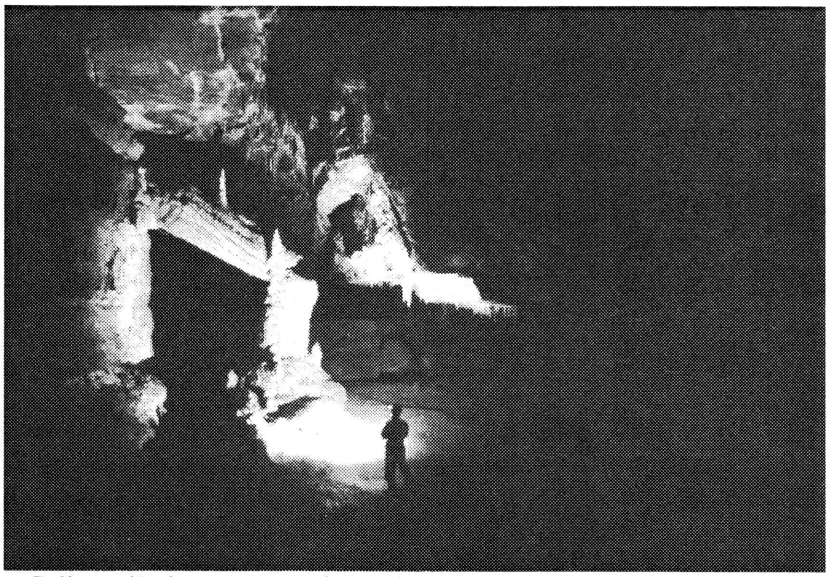


Western Grand Fissure – Exit Cave. Ida Bay, Tasmania
Photo by Stafan Eberhard

In 1978, the ASF (Tasmanian) State Cave Recorder (Albert Goede) listed 43 caving areas in Tasmania (with their letter codes), without distinguishing between karst or non-karst areas **(Goede, 1978b)**. Ten years later, Kevin Kiernan produced a numbered list of cave and karst areas in Tasmania, encompassing 106 carbonate rock areas (including karst) and 44 non-karst (parakarst and pseudokarst) cave areas **(Kiernan,**

1988). His listed pseudokarst areas include sea caves, boulder or landslip caves, weathering rockshelters, "other caves in rock" plus snow and ice caves. Kiernan only assigned area codes to all his number listed carbonate rock localities, and records the presence of caves in 45 of these 106 carbonate rock areas (and the presence of karst without caves in another 18 areas). "ASF (K.I.) Area Summary" forms have not been forwarded for a number of these (1988) listed cavernous karst and non-karst areas and in the absence of cave records (and "ASF Cave Summary" forms) for these areas, some have not been included in the present Tasmanian K.I. list of caving areas. Additional cavernous karst (carbonate rock) areas have been subsequently recorded by Kiernan **(1995)** and Sharples **(1997)**, but the K.I. documentation for these additional karst areas ("ASF Area Summary" forms) and their caves ("ASF Cave Summary" forms) has not yet been forwarded to the ASF Tasmanian State Area Co-Ordinator. In some instances, "new" ASF area codes have been assigned to the cavernous karst areas recorded by Kiernan **(1988; 1995)**: some of these new ASF K. I. area codes were assigned quite recently during compilation of cave fauna records from new or previously unrecorded cave areas **(Clarke, 1997)** and during the recent exploration and documentation of caves in NW and western Tasmania by the Savage River Caving Club **(Gray, 1998)**.

Caves in karst of Tasmania are predominantly solutional landforms found in three carbonate rock types: limestone, dolomite and magnesite. In chronological order (by geological age) the cavernous karst areas included in the accompanying list are: Pre-Cambrian Dolomite, Pre-Cambrian Magnesite, Pre-Cambrian Dolomitic Schist, Cambrian Dolomite, Cambrian Dolomitic Greywacke Turbidites, Ordovician Limestone, Permian Limestone, Tertiary Limestone and Pleistocene Limestone. The non-karst areas, described by Kiernan **(1988)** as pseudokarst features, include Pre-Cambrian Quartzite (and Pre-Cambrian Slate), Pre-Cambrian Metamorphics, Pre-Cambrian Conglomerate, Devonian Granite, Permian Mudstone, Triassic Sandstone, Jurassic Dolerite, Tertiary Basalt and Pleistocene (Glacial) Moraine deposits.



Collapsed column at start of "Skyline Traverse" in Mystery Creek Cave, Ida Bay, Tasmania - Photo by Stefan Eberhard

Although written from a Tasmanian perspective, the following sections relating to Karst Index area codes, documentation of caves (including naming of caves and number-tagging), plus assignation of ASF Map Numbers will have relevance to all Australian caving groups.

ASF Karst Index area codes and Cave Area names:

The ASF Karst Index area codes for cave areas in Australia can be up to three (3) alphabetic characters long, but in Tasmania these are only one or two letter character codes, followed by a "hyphen" and the cave number, e.g., H-214, IB-10 or JF-4. In each state or Territory of Australia, these letter codes for cave areas are preceded with the respective state "code number", e.g., "7" for Tasmania, "5" for South Australia, "3" for Victoria and "2" for NSW. (Using the Tasmanian examples above, those caves are more correctly referred to as 7H-214, 7IB-10 and 7JF-4.) More precise detail on area codes and cave area names can be located in the 1985 ASF Karst Index - in Section 16, titled: *"Cave and Karst Numbering Guide"* **(Matthews, 1985a)**.

In most parts of Australia, karst and non-karst areas are treated the same, however in some regional parts of NSW where there are caves in relatively widespread non-karst (or pseudokarst) areas, the area code assigned is often a three-letter (character) combination based on the letter coding prefix of the 250K (1:250,000) topographical map sheets. This practice is also now being deployed for identifying karst areas in the Northern Territory, so effectively one particular limestone karst can (and does) have two different area codes, based on the regional map area letter prefixes, for example in the Cutta Cutta karst area near Katherine, caves numbers are now prefixed by either "KAB" or "KAH" depending on which map sheet area the caves are located in.

The assigned Karst Index area codes generally follow on from those published in the ASF Karst Index **(Matthews, 1985a; 1985b)**, plus additional codes that have been assigned following discussion with cave explorers, caving clubs or those speleo persons who have given respective State Area Co-Ordinators any reports about "new" cave areas. In earlier times of ASF cave documentation (pre-1984), when the Karst Index was being updated for a printed format, there was probably more regular dialogue regarding cave area names with the "to-ing and fro-ing" of cave area and K.I. cave summary forms between the State Area Co-ordinators and Peter Matthews (the ASF National K.I. Co-ordinator). (Peter is still available for consultation on cave documentation issues, especially if they will have an impact on the national KI system.) However, the "making up" or assignation of area codes and names has always been the prerogative of the State Co-ordinator, following along the guidelines contained in Section 16 of the 1985 ASF Karst Index **(Matthews, 1985a)**. In the case of Tasmania, the respective Karst Index (State Area) Co-ordinators: formerly Albert Goede (as Cave Recorder), then Phil Jackson and now Arthur Clarke have assigned area codes for new karst and non-karst areas that were simply devised or arbitrarily "made-up", from the character initials of part or all of a local geographic or regional area name where the caves occur **(Clarke, 1997)**.

In some areas, the local name (and area code prefix) covers all the caves which fall in a broad geographic area, usually relating to one rock type. Some Tasmanian examples include: Hastings (H) and Mount Anne (MA) in Pre-Cambrian Dolomite; Ida Bay (IB), Junee-Florentine (JF) and Mole Creek (MC) in Ordovician (Gordon) Limestone; Western Arthurs (WA) in non-karst Pre-Cambrian Quartzite and Kent Group (three islands: Dover Island, North-east Island and Deal Island) where all caves occur in non-karst rock: Devonian Granite. In some other areas, particularly where non-karst caves occur, the same principle generally applies, though some of these broad geographic areas such as Hunter Island (HI) and smaller geographic areas such as Erith Island (EI) may include caves which occur in different rock types. [For example, on Hunter Island, there are caves recorded in Pre-Cambrian Slate and Pre-Cambrian Quartzite; on Erith Island there are caves in both Pleistocene Limestone and Devonian Granite.]

Assigning names for caves:

There are no hard and fast rules in regard to who gives a cave its name, but traditionally cave names are assigned by those cavers who either first discover or first explore a new cave, but sometimes subsequently by the person/s who are surveying the cave or drafting the cave survey or perhaps by whoever is the caving club's record keeper. As described by Albert Goede **(1978c; 1985)**, naming of caves serves several purposes: identification of site, particularly if a significant cave; as a description of the site, reflecting some of its attributes or peculiarities; and for commemoration - of historical events or prominent persons, preferably non-living persons, unless named after (past or) present day royalty. Some examples of commemorative cave names include "*Rescue Pot*" (7JF-201) in Junee-Florentine, "*Good Friday Cave*" (5F-6) in Flinders Ranges (South Australia) and "*Easter Cave*" (6AU-14) in Augusta (Western Australia) **(Goede, 1978c; 1985)**, plus "*King George V Cave*" (7H-214, formerly 7H-X6) at Hastings in Tasmania **(Clarke, 1998)**.

The recommended guidelines for naming of caves and cave features **(Goede, 1978c)** were formally adopted by ASF and are included in Section 15 of the *Australian Karst Index 1985*" **(Goede, 1985; Matthews, 1985b)**. Divided into two sections, these recommendations include three "procedural guidelines" and twenty "naming guidelines" that cavers should follow before assigning names, e.g., not using apostrophes in cave names.

The general practice used to be (and still should be) that proposed names for new caves are brought forward to the monthly business meeting of a caving club for acceptance and ratification before being published or formally placed on cave map surveys. This used to be done for two reasons: firstly to enable those naming a cave to check with their club's karst officer, records keeper and/or the State Area Co-ordinator, in order to determine that the name chosen had not been used anywhere else within that karst area and preferably not

Tasmanian Karst Officer (Ian Houshold) at start of Stringline Track in "Edies Treasure", Exit Cave, Tasmania - Photo by Stefan Eberhard elsewhere within that State area, i.e., in case of Tasmania, nowhere else within the "7" area. Secondly, since we (as caving clubs) are voluntary non-Government organisations that are assigning names to natural features of the world, all new cave names are supposed to be presented to the respective State or Territory "Nomenclature Board" for their consideration, approval or acceptance. This is usually mandatory and rarely objected to, particularly if the cave names follow the naming guidelines and are brought forward to the Nomenclature Board as part of the Minutes of Record of a caving club's business meeting **(Goede, 1978c; 1985; Matthews, 1985b)**. In the 1970's and early 1980's when the Tasmanian Caverneering Club (TCC), had Albert Goede as its (TCC)'s records keeper (and he was also the ASF State Cave Recorder for Tasmania), this process of formally adopting cave names was aided and abetted by the fact that Albert was a member of the Tasmanian Nomenclature Board.

Once published, it is often very difficult to change the records, so it is important that before assigning cave names (or cave numbers etc.), cavers and caving clubs should check with their club's Records Keeper of their respective State Area Co-Ordinators. Unfortunately, there are already published records for caves with the same name in Tasmania, in different karst areas. Some Tasmanian examples include: "*Quarry Cave*" which is "MC-21" at Mole Creek and "BH-205" at Bubs Hill **(Goede, 1978a)**, "*Honeycomb*" which is a multi-entranced cave "MC-44"/ "MC-84" etc. at Mole Creek and similarly as "R-210" at Redpa; plus "*Tree Root Cave*" in two areas: as "PB-33" at Precipitous Bluff and "GP-70" at Gunns Plains and "*Lyons Den*" is "H-205" at Hastings and "KR-9" in the "new" Keith River magnesite karst area. Similarly, in relation to incorrectly cited cave numbers, a map survey has been published for "*Dismal Hill Pot*" showing the cave number as "IB-130" (see *Speleo Spiel*, 238 - June 1988); this cave was number-tagged as "IB-128". More recently, a cave survey was published with the cave number ("IB-162") for an un-tagged (un-named) cave at Ida Bay (see *Bulletin of Syd. Uni. Speleo. Soc.*, Vol. 34 - 1994). [The Ida Bay caves that are tagged as "IB-130" and "IB-162" have been named as "*Gastropod Grotto*" and "*Chiton*" **(Clarke, 1998)**.]

<u>What to do when you find a new cave (or new entrance)</u>:

In most Tasmanian karst areas and many of the non-karst areas (and probably many mainland areas), there will be new caves or new entrances to known cave systems, plus unrecorded or unexplored caves. All cave exploration visits should be recorded, either by completing a trip report for publication or more importantly by number-tagging the cave entrance, then undertaking a cave survey (map) of the cave. In addition to a trip report and the documentation procedures, a "Cave Report" should be filled out and sent to the club's record keeper, who then fills out a Karst Index cave summary form and assigns a club map number to any cave survey or area plan. These "cave reports" should never be published; the reports should include details of the cave's location (not published) and the reports should remain available within the club records.

[An example of the layout of these "cave reports" is shown on page 13D-1 of the 1985 ASF Karst Index. The three "field" forms for trip leaders are collectively shown on pages 13D-1, 13E-1 and 13F-1 of the ASF Karst Index **(Matthews, 1985b)**. These forms are freely photocopyable for use by any cavers, caving clubs or club record keepers. Their instructions are shown up the left margin of each form. Members of VSA (Victorian Speleological Association) have used these forms extensively for many years.] When a possible new cave is located, members of caving clubs (and visitors from other clubs or interstate groups) should contact their ASF State Area Co-ordinator or their own club's Karst Officer to check on these procedures. Most caving clubs have their own Karst Officers or Records Keeper, who keep K.I. records of their club's cave exploration activity and can issue club members with cave numbers or tags, blank cave summary forms (if necessary) and assign respective (ASF) club map numbers to completed cave surveys or maps.

<u>Numbering (number-tagging) of cave entrances in Tasmania</u>:

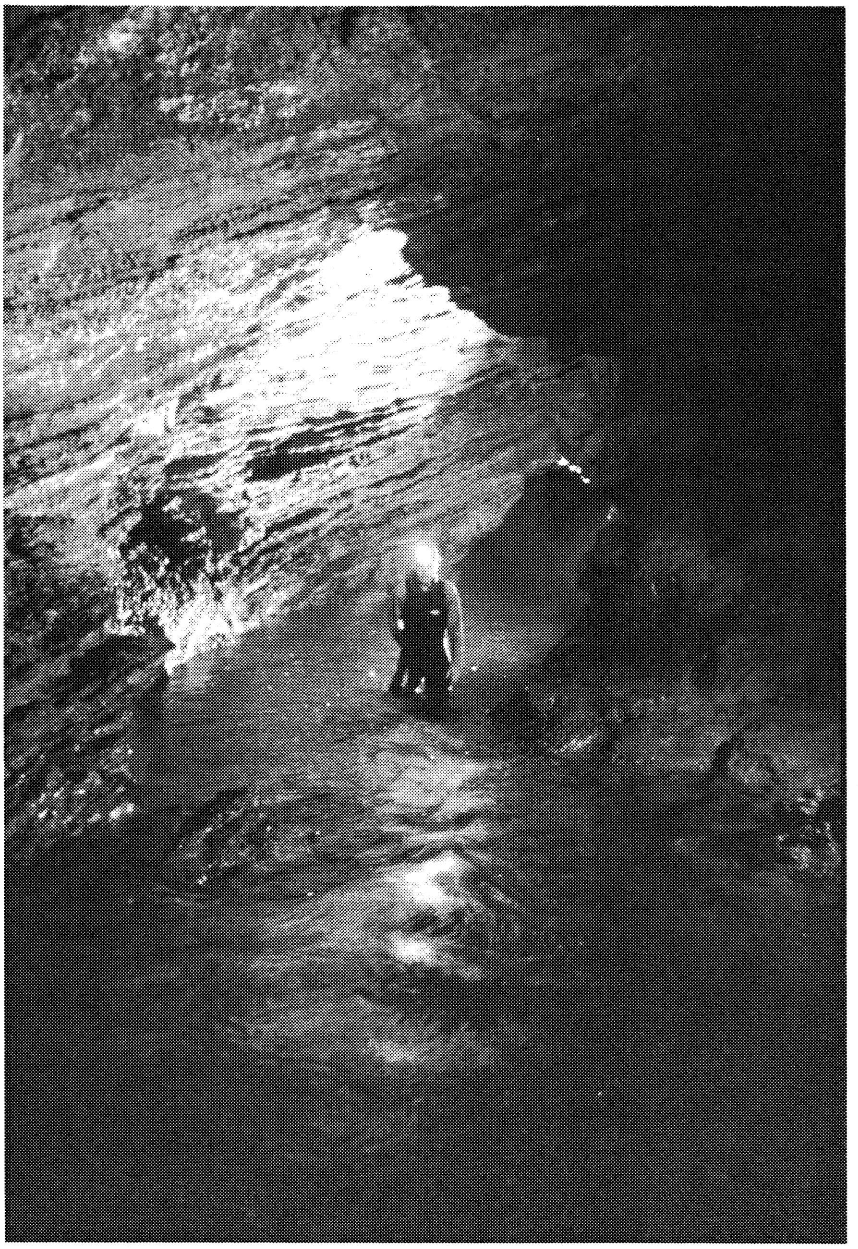
In most instances in Tasmania, where caves have been numbered, this has involved the placement of permanent number tags. However, there are exceptions. During their 1987 expedition to the Mt. Anne alpine karst area of SW Tasmania, a team of visiting Czechoslovakian cavers used paint to "number-tag" caves: assigning painted "MA-CS" numbers to 12 new cave entrances **(Tasler, 1989)**.

Most of the cave number tags used on Tasmanian caves have been small square, oblong or triangular shaped pieces or plates of aluminum or stainless steel, with the cave number (usually preceded by its one or two letter character "area code" prefix) punched into the metal surface. However, during exploration of the Mt. Anne karst area in SW Tasmania, a former TCC member (Nick Hume) stated that some cave entrances "exuding highly promising draughts", below the Annakananda doline at Mt. Anne, were simply tagged as "TCC#1 and TCC#2 etc." **(Hume, 1987)**. The cave number tags are usually affixed to rock near the cave entrance, using one or two short anchors: concrete nails, screws or masonry anchors; these are hammered into pre-drilled holes using a 6mm or 8mm masonry drill bit in a hand-operated drill or cordless percussion drill. As well as indicating the presence of a known or recorded cave, the number tags act as a reference point for cave surveys, a fixed point for overland survey traverses used to place a cave on a cave map or as position markers for locating caves with a GPS unit. (Number-tagging caves may also have important implications for cave conservation and search & rescue purposes, apart from assisting in determination of hydrological links between caves and/or location of likely new entrances to a known cave system.)

In the past, there has been an unfortunate practice of placing number tags on trees, twigs of wood or logs near the cave entrances, sometimes only "tied on" by wire or flagging tape; these tags tend to become lost as the bark grows over the tag, the tree falls over or the twigs and logs rot away. Number tags should be placed beside cave entrances, physically attached to the rock in an obvious position, preferably near to (or slightly above) the actual entry point into the cave; (see Section 16:8 of 1985 ASF K.I.) Care needs to be given to the actual placement position (on the flat rock or vertical wall), so that the cave number is obvious and does not become covered over with moss or overgrown by ferns and other cave entrance vegetation. When documenting the cave in a trip report or filling out a Karst Index cave summary form, it is important to record where the cave number tag is placed in relation to the cave entrance.

In earlier days, when the Tasmanian Caverneering Club (TCC) was the only caving club in Tasmania, all Tasmanian caves were simply number-tagged in consecutive order from number one ("1") onwards. Following the formation of the two breakaway caving groups, firstly Tasmanian Caverneering Club Northern Branch (TCCNB) - later becoming Northern Caverneers (NC), then secondly the Southern Caving Society (SCS), each of the three Tasmanian caving groups was assigned its own "block" of 100 numbers for number-tagging caves. The tag numbers were assigned according to club "seniority" with the oldest club (TCC) being given numbers 1 to 100; the second oldest club (TCCNB or NC) receiving numbers 101 to 200 and the most recent club (SCS) being assigned numbers: 201 to 300 **(Clarke, 1986; 1989)**. This (in part) explains the "apparent" anomaly in the Tasmanian Karst Index, where there is a gap in the sequence of cave numbers, or in the case where some karst or non-karst areas that were only explored by SCS, have cave numbers starting at "201" **(Clarke, 1989)**.

Today, this former practice has been disregarded and in any given area, new caves are simply numbered in consecutive order from one ("1") onwards. A superb example of the practice of cave documentation and number-tagging in Tasmania is contained in the recent publication by Savage River Caving Club **(Gray, 1998)**. Blocks of cave numbers (in running order) are still assigned by the Tasmanian State Area Co-ordinator to the various clubs that are working jointly or separately in one or more particular karst areas, e.g., in the Mole Creek area separate blocks of numbers have been allocated to both Northern Caverneers and Mole Creek Caving Club.



Daniel Eberhard in Junee Resurgance. Junee-Florentine, Tasmania
Photo by Stefan Eberhard

In instances where other visiting clubs are working (or exploring) new caves in areas that have been number-tagged by another "host" club, the visiting cavers should always contact the host club's Karst Officer or State Area Co-ordinator before placing new number tags. There have been instances where visiting cavers have been unfamiliar with cave numbering procedures in other states; for example when the SUSS (Sydney University Speleological Society) expedition to Mt. Anne in SW Tasmania took place, some of the formerly untagged caves with temporary "MA-X" numbers were formally tagged with permanent numbers. However, the first three of over twenty or so new "MA" number tags used by SUSS: "MA-1", "MA-2" and "MA-9" were applied to three of the known and named cave entrances with the same temporary "MA-X" numbers: "MA-X1", "MA-X2" and "MA-X9", instead of consecutively numbering these "MA-X" caves as MA-1, 2 and 3. Consequently, there is now another gap in the number sequence with six Mt. Anne (MA) cave numbers "MA-3" to "MA-8" not used.

<u>Un-numbered (un-tagged) caves</u>:

Sometimes its not practical to immediately number-tag a cave entrance. In situations where it is unlikely that the new cave will be number-tagged in the near future, the cave can be recorded by assigning a temporary "X-" number: the recognised method of defining a cave which has not been physically number-tagged (**Matthews, 1985a**). These consecutively assigned "X-" numbers are only ever used once, so when that particular cave is eventually physically tagged with a number, its previous "X-" number is recorded in the documentation (or trip report) with the number-tagged cave, but to avoid future confusion in the caving literature, that particular "X-" number is never re-assigned or used again. The "X-" number caves contained within the Tasmanian K.I. also include un-tagged, but named caves and unnamed caves that have been recorded in various publications, e.g., the list of known caves at Mole Creek included in a Tasmanian Parks, Wildlife and Heritage publication (**Kiernan, 1989**) and some caves in NW Tasmania recorded in a report to the Australian Heritage Commission detailing the karst geomorphology of Arthur-Pieman (Tarkine) region (**Sharples, 1997**).

Although most of the known or recorded un-numbered caves in Tasmania are referred to as un-tagged "X-" number caves, in his comprehensive study of caves in the Junee-Florentine karst (and a classification of karst sensitivity zones), Rolan Eberhard introduced another (non-ASF) system for some of the "new" caves, ascribing some of these un-numbered caves with "Z-" number prefixes (**Eberhard, 1994; 1996**).

Another risk for cavers when finding an apparently untagged cave is whether it already has a number assigned. There are two issues here:
(a) how do you distinguish a "new" cave from any surrounding caves when describing it to the Records Keeper so that he can tell whether it really is a new cave; and
(b) if you are tagging on the spot and are not familiar with all the other nearby numbered caves, you run the risk of double-numbering the cave - its original tag may have not been noticed, covered over by moss or other vegetation, "vandalised" off, or never put on in the first place. (In Tasmania, there are several recorded instances in the Mole Creek and Lorinna karst areas, where number tags have been deliberately removed from cave entrances.)
With an apparently new cave it's always better to refer to the records first before assigning a new number or physically tagging, (except by allocating an "X-number" of course) to avoid double numbering.

<u>Assigning ASF Map numbers to cave surveys or drawings and karst area maps</u>:

Ideally, prior to publication, all surveys or drawings of caves and cave location or karst area maps should be assigned with an ASF Map Number, using the procedure outlined in Section 17 of the ASF Karst Index (**Matthews, 1985b**) and an "ASF Map Summary Sheet" should be filled in. These map numbers and map summary sheets can be completed later on, but it is simpler and more efficient if done prior to publication of a map or survey, so that the ASF map number is included on the published map or survey. All ASF map numbers have a pre-defined component layout or structure, e.g., "7JF36.TCC169", being a map of Growling Swallet (JF-36) drawn by Trevor Wailes of (former) Tasmanian Caverneering Club (TCC) or "7BH.TCK3" - an area plan for the "Geomorphology of Bubs Hill", drawn by Ian Houshold of the former Tasmanian Cave and Karst Research Group (TCKRG).

Using the first JF-36 example (above), the component parts of ASF Map Number "7JF36.TCC169" are: "7" for the state of Tasmania; "J36" as the cave number (without hyphen); "." as a mandatory separator between cave number and source code; "TCC" as the original source code representing the club that has produced the survey; and "169" is the map sequence number allocated by TCC (the source organisation). This sequence number is usually simply one of a series of consecutive numbers assigned to all the successive maps or surveys that are produced by that club. In the second map number example given above (where the map relates to a general area, not a particular cave), this is indicated by the absence of a cave number - hence just "BH".

All ASF member clubs and other non-ASF clubs that regularly produce cave maps are allocated with a 3-letter source code or abbreviation (representing that club's initials, or part thereof) for assignation to ASF Map numbers to indicate the source of the map; map numbers are kept by each club. (The respective club source codes that were in use in 1984 are listed in Section 17A of the 1985 edition of the ASF Karst Index.) To date, there have been seven (7) source codes issued to Tasmanian caving clubs for ASF Map Numbers: in order of issue -"TCC" for Tasmanian Caverneering Club, "SCS" for Southern Caving Society, "NCA" for Northern Caverneers, "TCK" for Tasmanian Cave and Karst Research Group, "SRC" for Savage River Caving Club, "MCC" for Mole Creek Caving Club and "STC" for Southern Tasmanian Caverneers.

<u>An ordered list of Tasmanian karst and non-karst cave areas</u>:

The following list of ASF Karst Index area codes for Tasmanian karst and non-karst areas and their respective rock types, relates only to those areas for which there are published or documented ASF Karst Index records for number-tagged or un-numbered (untagged) caves.

AM: MOUNT AMOS - Devonian Granite.
AR: ACHERON RIVER - Pre-Cambrian Dolomite.
AS: MOUNT ARROWSMITH - Pre-Cambrian Metamorphics.
BB: BLACKMANS BAY - Permian Mudstone.
BH: BUBS HILL - Ordovician Limestone.
BI: BIRCH'S INLET - Triassic Sandstone.
BO: BLAKES OPENING - Pre-Cambrian Dolomite.
BP: BREAKNECK POINT - Pre-Cambrian Quartzite.
BR: BUTLER RIVULET - Ordovician Limestone.
C: CRACROFT - Ordovician Limestone.
CA: CARDIGAN RIVER - Ordovician Limestone.
CB: CAPE BARREN ISLAND - Pleistocene Limestone.
CC: COOK CREEK - Pre-Cambrian Dolomite.
CI: CRAGGY ISLAND - Devonian Granite.
CL: CRADLE LINK - Tertiary/Pleistocene Glacial Moraine deposits.

CP: MOUNT CRIPPS [Formerly "Mayday" (MY)] - Ordovician Limestone.
CR: CHEYNE RANGE - Pre-Cambrian Dolomite.
D: DEVONPORT - Tertiary Basalt.
DB: DUBBIL BARRIL - Ordovician Limestone.
DF: DODGES FERRY - Jurassic Dolerite.
DH: DON HEAD - Tertiary Basalt.
DL: DONALDSONS LANDING - Ordovician Limestone.
DR: DANTE RIVULET [Formerly "Lake Spicer" (LS)] - Ordovician Limestone.
DV: DAVEY RIVER - Ordovician Limestone.
DW: DE WITT ISLAND - Ordovician Limestone.
E: EUGENANA - Ordovician Limestone.
EH: EVERLASTING HILLS - Pre-Cambrian Dolomite.
EI: ERITH ISLAND - Pleistocene Limestone and Devonian Granite.
F: FRANKLIN RIVER - Ordovician Limestone.
FB: FOSSIL BLUFF - Tertiary Limestone.
FC: FRENCHMANS CAP - Pre-Cambrian Dolomitic Schist.
FG: FLOWERY GULLY - Ordovician Limestone.
FH: FOREST HILLS - Pre-Cambrian Dolomite.
FR: FRANCISTOWN - Triassic Sandstone.
G: GRAY - Permian Limestone.
GC: GOODWINS CREEK - Ordovician Limestone.
GI: GOAT ISLAND - (Deformed) Pre-Cambrian Conglomerate.
GP: GUNNS PLAINS - Ordovician Limestone.
GS: GORDON SPRENT - Ordovician Limestone.
H: HASTINGS - Pre-Cambrian Dolomite.
HA: HARDWOOD - Ordovician Limestone.
HI: HUNTER ISLAND - Pre-Cambrian Quartzite and Slate.
HO: HOWTH - Pre-Cambrian Conglomerate.
HR: HIGH ROCKY POINT - Pleistocene dune limestone and calcarenite.
HS: HAMPSHIRE - Ordovician Limestone.
IB: IDA BAY - Ordovician Limestone.
IG: ILE De GOLFE - Ordovician Limestone.
J: JANE RIVER - Pre-Cambrian Dolomite.
JB: JUBILEE RIDGE - Pre-Cambrian Dolomite.
JD: JUKES DARWIN - Ordovician Limestone.
JF: JUNEE FLORENTINE - Ordovician Limestone.
JH: JACOBS BOAT HARBOUR - Pre-Cambrian Quartzite.
JR: JULIUS RIVER - Pre-Cambrian Dolomite.
KG: KENT GROUP - Devonian Granite.
KI: KING ISLAND - Tertiary Limestone.
KR: KEITH RIVER - Pre-Cambrian Magnesite.
L: LOONGANA - Ordovician Limestone.
LA: LOWER ANDREW RIVER - Ordovician Limestone.
LB: LOUISA BAY - Pre-Cambrian schist.
LC: LONGBACK CREEK - Pre-Cambrian Dolomite.
LF: LIFFEY FALLS - Permian Mudstone.
LG: LOWER GORDON - Ordovician Limestone.
LH: LOWER HUSKISSON - Ordovician Limestone.
LL: LAKE LEA (Vale of Belvoir) - Ordovician Limestone.
LM: LOWER MAXWELL - Pre-Cambrian Dolomite.
LO: LORINNA - Ordovician Limestone.
LP: LIBERTY POINT - Triassic Sandstone.
LR: LANCELOT RIVULET - Pre-Cambrian Dolomite.
M: MOINA - Ordovician Limestone.
MA: MOUNT ANNE - Pre-Cambrian Dolomite.
MC: MOLE CREEK - Ordovician Limestone: 352 caves.
MF: MOUNT FAULKNER - Triassic Sandstone.
MG: MESA CREEK - GLEICHENIA CREEK - Tertiary/Pleistocene Glacial deposits.
MI: MARIA ISLAND - Permian Limestone.
MK: McKAYS PEAK - Pre-Cambrian Dolomite.
MM: MOUNT MUELLER - Cambrian Dolomite.
MN: MOONLIGHT CREEK - Permian Mudstone.
MQ: MACQUARIE ISLAND - Jurassic Dolerite.
MR: MOUNT RONALD CROSS - Pre-Cambrian Dolomite.
MU: MONTAGU - Pre-Cambrian Dolomite.
MW: MOUNT WELD - Pre-Cambrian Dolomite.
N: NELSON RIVER - Ordovician Limestone.
NC: NEWALL CREEK - Ordovician Limestone.
NL: NORTH LUNE - Ordovician Limestone.
NR: NICHOLLS RANGE - Ordovician Limestone.
OL: OLGA - Ordovician Limestone.
P: PRESTON - Tertiary Basalt.
PB: PRECIPITOUS BLUFF - Ordovician Limestone.
PP: (SOUTH of) PINDARS PEAK - Ordovician Limestone.
PS: PRIME SEAL ISLAND - Devonian Granite.
R: REDPA - Pre-Cambrian Dolomite.
RA: RANGA - Pleistocene Limestone.
RB: RISBYS BASIN - Ordovician Limestone.
RC: ROCKY CAPE - Pre-Cambrian Quartzite.
RI: ROCKY BOAT INLET - (Deformed) Cambrian Dolomitic Greywacke Turbidites.
RO: ROSS - Jurassic Dolerite.
RR: ROGER RIVER - Cambrian Dolomite.
S: SOUTHPORT - Permian Mudstone.
SB: SURPRISE BAY - Ordovician Limestone.
SC: SOUTH CAPE BAY - Triassic Sandstone.
SD: SCOTTSDALE - Devonian Granite.
SI: SISTERS BEACH - Pre-Cambrian Quartzite.
SP: SCOTTS PEAK - Pre-Cambrian Dolomite.
SR: SAVAGE RIVER- Pre-Cambrian Magnesite.
ST: STOODLEY - Pre-Cambrian Conglomerate.
SX: STYX RIVER - Pre-Cambrian Dolomite.
T: TROWUTTA - Pre-Cambrian Dolomite.
TC: TIMBS CREEK [Formerly "Savage River" (SR)] - Pre-Cambrian Dolomite.
TP: TASMAN PENINSULA - Permian Mudstone.
TS: TIM SHEA - Pre-Cambrian Dolomite.
UH: UPPER HUSKISSON - Ordovician Limestone.
UN: UPPER NATONE - Devonian Granite.

UW: UPPER WELD - Pre-Cambrian Dolomite.
VB: VARIETY BAY - Permian Mudstone.
VF: VANISHING FALLS - Ordovician Limestone.
W: WELD RIVER - Pre-Cambrian Dolomite.
WA: WESTERN ARTHURS - Pre-Cambrian Metamorphics.
WC: WHITE HAWK CREEK [Formerly "Brougham Creek" (BC)] - Ordovician Limestone.
WE: MOUNT WELLINGTON - Jurassic Dolerite.
WL: WILSON RIVER - Ordovician Limestone.
WM: WEST MAXWELL-ALGONKIAN - Pre-Cambrian Dolomite.
WR: WHYTE RIVER - Pre-Cambrian Dolomite.
WY: WAYATINAH - Jurassic Dolerite.

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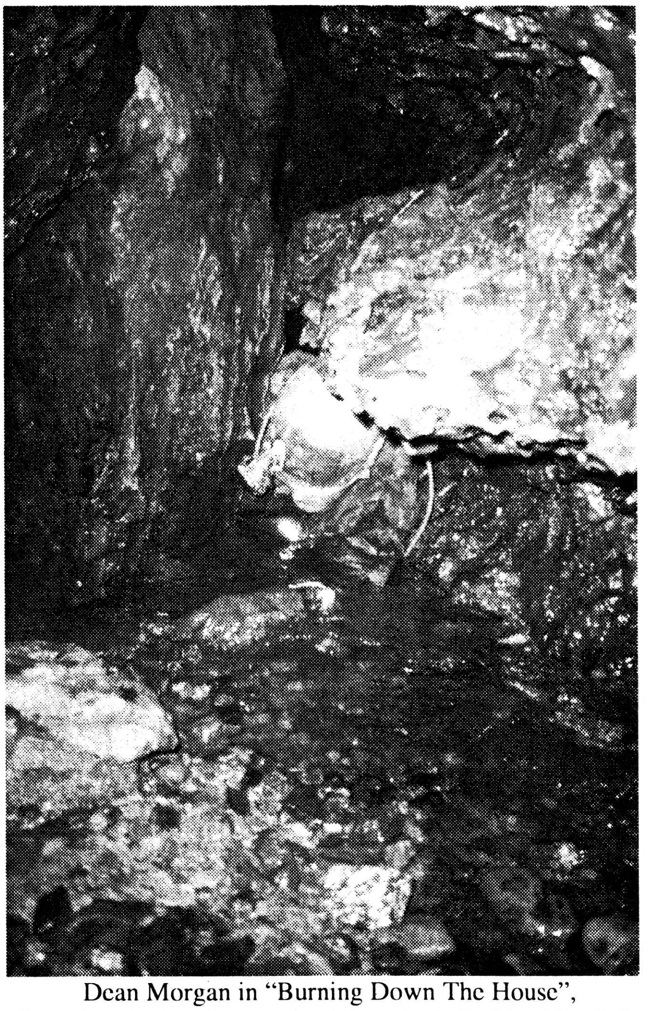


Dean Morgan in "Burning Down The House", Florentine Valley, Tasmania - Photo by John Hawkins-Salt

Long-life bolts-what are the options? Which is the best one?

Jeff Butt

Placing bolts in caves has an impact; so the ethically minded caver considers the options carefully, only placing bolts if suitable naturals can't be found, or if a bolt (or bolts) are needed to avoid some hazard (e.g. waterfall, dangerous rocks). However, in the past even so-called ethically minded cavers haven't necessarily thought about the long-term situation and have placed comparatively short lived bolts. It would be good to address this issue, so that we can be confident that any bolt placed will have a useful life of something like 20-50 years or even more!

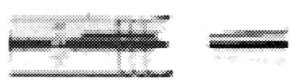
I found that I wanted to learn more about this subject, so did a bit of research on the subject. Note that I don't claim to be any sort of expert, but did think that others might also be interested in what I discovered. If anyone has more to tell, especially in relation to their own practical experiences etc., then I for one would be interested to hear from them (contact details at the end).

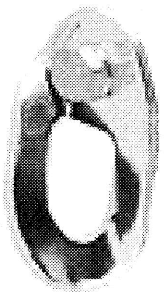
1. An historical Introduction-a Tasmanian perspective

The first "standard" for bolts used in Tasmanian caves was the large eye-bolts (made from 1/2" diameter galvanised rod), screwed into galvanised Loxin anchors (thin-walled expansion casings). These were installed in the 60's and early 70's for anchoring ladders. At that time, the only available welded and galvanised eye-bolts available were large in size (1/2" diameter, 5" long), and so the large diameter Loxins (requiring a 7/8" diameter hole, 2 & 1/2" deep) were chosen to suit. The hole was drilled by hand (with a star drill and a club hammer-watch your thumbs!), each bolt taking around 1-2 hours to drill and place, which was the major disadvantage. The following quote from Stuart Nicholas (1998), summarises this pretty well. *"Installing a bolt was something that one never undertook without some considerable search first for natural belays and anchor points. Bolting trips were a major source of Forward Programme entries as I recall but not too many people went on them after their first time . . . normally a choofer stove was to hand and someone made the tea/soup/coffee while others drilled, and swapped turn about. It was a welcome respite from the bone chilling cold when one's turn to drill came up!!!!"* The eye-bolt could be removed and regularly inspected, although the actual Loxin could not be accessed.

This bolting system has stood the test of time, many of these bolts still exist (e.g. in Midnight Hole, Khazad Dum, Niagara Pot) and are regularly used (when loaded they do flex somewhat, this is consistent with the fact that the captive nut into which the bolt is screwed resides in the bottom of the Loxin). Being large chunks of steel, they are long lasting and hard wearing (the one's in Midnight Hole have been used regularly for trips for over thirty years, although those on the last two pitches are now showing significant wear (~30-40 % worn through) due to the large number of pull-through trips). Apart from the placement (i.e. back from the edge of the pitch), in many respects this bolting system resembles some of the more robust systems that are in use today.

Sources of the eyebolts dried up in the mid-70's, which was the main reason for discontinuing their use, (Nicholas, 1998). About this time, with the advent of SRT (a faster way to cave), a faster method for installing bolts was called for. Cavers looked to rock-climbers to see what sort of bolts they were using. At the time rock-climbers were using the so called Australian Rock Bolt, or Carrot bolt (basically a 5/16" diameter, 2 & 1/2" long high tensile bolt with a head; the thread was ground to a partial square taper to make it pointy with ridges of thread between; the bolt was then generally pounded in with a hammer). Stuart Nicholas says *". . . these were fraught with hazard of course as you never knew what internal/structural damage you were doing to the bolt while it was being driven in. . . . always provoked some level of fear seeing the bolt head bend and twist as it was pounded with a hammer!!!!"* A keyhole style hanger (or a small wired chock or a sling) was used to attach a krab to the anchor. These bolts were comparatively short lived and many of the heads have rusted/broken off. Some can still be seen (e.g. top 2nd and 6th pitches in Dwarrowdelf, top of the big pitch in Three-forty-one, at the top of the third pitch in Mini-Martin). Indeed the one in Mini-Martin is still regularly used! Both rock-climbers and cavers moved on from these sorts of bolts in the 70's. New technology from overseas provided better (generally better due to ease and efficiency of installation, as opposed to strength and longevity!) options.



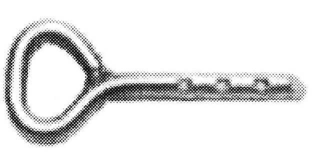


The defacto international standard bolt for caving then became the 8 mm self drilling bolt-casings, knows as "Spits" or "Terriers" or simply just "Bolts", as shown at right. The casing is 30 mm long, 12 mm diameter, has a toothed drilling end and is threaded internally to accept an 8 mm diameter bolt. A larger (10 mm) size Spit (15 mm diameter casing, 40 mm long, accepting a 10 mm diameter bolt) was also available but was rarely used in Tasmania. The casing is held in place by the spreading of the inner end against a metal cone compressed against the bottom of the hole. Such a bolt can be installed in 10-15 minutes by someone who knows what they are doing and so allowed pitches to be rigged quickly. When properly installed they have a shear strength of around 1400-2200 kg in good rock, 700 kg in soft rock-Warild (1988). The casings are made from steel but have a coating (i.e. plated steel) to prevent corrosion.

Of course, they still do corrode, the plating is damaged when installation occurs. Generally an Aluminium alloy hanger is fitted to the casing by a high tensile 8 mm diameter steel (Grade 8.8) bolt (a twist hanger is shown at left). Some cavers leave the hanger in-situ, others remove it and leave a plastic marker (so the spits can be found again) in it, others just remove the hanger and don't mark the casing (in which case, if another caver doesn't find the existing casing, they may install their own!). Leaving the hanger in situ enhances the corrosion potential of the anchor; Aluminium and steel in close proximity in a wet environment leads to electrochemical corrosion.

In relation to these self-drilling anchors, it is interesting to note that they are definitely out of flavour with the climbing fraternity, as evidenced by the following quote by Hirst (1998).*"The self drilling bolt set-up is about the worst system you can still buy . . . you wind up with about the weakest bolt on the market. These come in two sizes, Worthless (8 mm) and Lame (10 mm) . . . The small self-drive bolt is "officially" approved for caving and not for climbing. If you own such a kit, sell it to a caver."* Of course, rock-climbers generally use their bolts in a different way than cavers. For climbers, bolts are for protection; they are generally not loaded, but if/when they are the loading is generally a higher shock load transmitted through a fall on an attached dynamic rope. For cavers the bolt is statically loaded at a comparatively low level via abseiling and prussiking on an attached static rope.

Anyway, the fact is that these self-drilling bolts gradually decay and the integrity and safety of the anchor begins to diminish. Many of the spits in Tasmania have were installed in the heady days of the 70's or early 80's and so many of these have been installed for one to two decades. Some have had hangers left in them (to assist in relocation), these are more likely to be in a worst state due to electrochemical corrosion (see below). I have not heard of any failing (yet), but from experience overseas, this will gradually begin to occur. Incidentally, many of the original installations were done for speed, not safety and so often you will find a pitch-head equipped with a single bolt, the rope being tied back to another anchor. In these types of situations, if the bolt at the pitch head fails the consequences are more severe. (In the ideal world, two bolts would have been installed at the pitch-head for safety). Also, the 'speed' often meant that the casings weren't greased (as recommended) to prevent the ingress of water and the onset of corrosion.



So, very soon many of these ageing spits will need replacing. It would be good to replace them with some longer lived type of anchor. In addition, since the spits are often in the best position (w.r.t. rope hang), it would be good to re-use the existing location (if possible) for the replacement anchor.

There are several different contenders to use for replacing them. Cavers in different countries use different devices; often rock-climbers and cavers in the one area use different methods (of course, the bolts often serve different purposes). There is not an easy answer to the question: "What is the best system to use?" as the several possible systems each have their own good and bad points. I thought that I'd scan the literature (and Internet) to see what sorts of systems are in use about the place and present the information so that we can make a more informed decision about what is the best method to use.

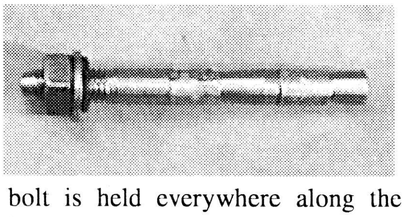
These days, the existence of high-powered portable drills means that a substantial hole can be drilled quite quickly, and as a result the bolts of this modern day era tend to me much more substantial (like the eye-bolts of old, those oldies did seem to do it properly!).

2. Some background

Prior to having a look around and seeing what sorts of bolts are in contemporary use, it is instructive to have a look at some basic concepts, to get a feel for some of the potential problems that a good bolting system will have to deal with.

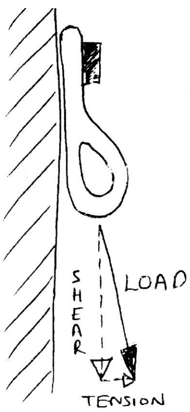
2.1 Types of bolts

Bolts can be divided up into two sorts by the methods used to fix them to the rock. Bolts can be either mechanically fixed (e.g. via expansion cone(s), expansion sleeve, compression ridges, or simply a friction fit) or chemically bonded (e.g. epoxy resin, commonly referred to as 'glue') to the surrounding rock. An example of a mechanically fixed bolt (expansion sleeve) is shown at right, whilst an example of a chemically fixed eyebolt is shown at left. Mechanically fixed bolts are the most appropriate for hard rock, whilst chemical bolts are best suited to soft rock. If a mechanically fixed bolt is used in soft rock, then it is only held in place by a comparatively small surface area (e.g. the flared area around a cone), if the rock fails in that area the bolt can come out. A



chemically fixed bolt is held everywhere along the glue-rock and bolt-glue interfaces, and thus is less likely to be affected by localised failure. Because of this large surface area of holding power, chemically set bolts have a very high pull-out strengths (which also means that it can be hard to remove them if you want to!). In fact properly prepared chemically fixed bolts are only limited by the quality of the surrounding rock. Chemically fixed rocks obviously will work well in hard rock as well. Sometimes mechanically fixed bolts are specially made so that they don't rely on a single mechanical fixing (e.g. a double expansion bolt), which makes them safer in soft rock than bolts with a single mechanical fixing.

2.2 Forces on bolts



The two main forces on bolts are an outwards force parallel to the rock (tension) and a breaking force perpendicular to the bolt (shear). If the tensile force is exceeded, the bolt will be pulled out of the rock. If the shear force is exceeded, the bolt will break off. When the "strength" of a bolt is quoted, people are usually talking about the shear strength. When a bolt is loaded in caving (or climbing applications), it is generally primarily loaded parallel to the rock surface, but there may also be a small outwards loading, as shown in the diagram opposite. (Sometimes, e.g. for a bolt in a roof, the loading might be primarily in tension, in which case a suitable hanger (ring) must be used!).

Component	Typical Strengths
10 mm diameter Stainless steel anchors	25-29 kN, Shear. 23-40 kN, Tensile (mechanically fixed bolts). 25-50 kN, Tensile (chemically fixed bolts).
10 mm diameter karabiner/maillon	Various (long axis, gate closed) in the ranges 18-32 kN (alloy), 22-45 kN (steel)
Static rope	Various in the range 18 kN (9 mm diameter)-30 kN (11 mm diameter)
Tape	Various in the range 11 kN (14 mm wide)-21 kN (26 mm wide)

In relation to strengths, it is worth keeping in mind that the anchor is only as strong as the weakest component in the system. Typical ratings of the various components normally used are shown in the adjacent Table. Modern day stainless steel bolts are generally the strongest parts of the anchor system; in the event of a fall the bolt will be the least likely component to fail.

2.3 Strength of limestone

A few physical properties of different rock types are shown in the table below. Limestone when compared to other types of rocks has a low hardness and will withstand less compressive force. Consequently limestone is generally regarded as a soft rock. The quality of the limestone in Tasmania can be quite variable, but most seems to be reasonably hard beneath the often weathered surface. The vast majority of bolts used in Tasmanian caves have been mechanically fixed ones.

For a given type of natural rock there can be a substantial variation in physical properties (see opposite Table), thus it can be difficult to make hard and fast rules about the types of bolts best suited to different types of rock. In general, the softer the rock, the beefier the bolts need to be for the same holding power. Shorter mechanically set bolts may be adequate for hard rock, but for softer rock, longer chemically set bolts are better suited.

Material	Density[1,2] (kg/m^3)	Hardness[1] (Mohrs Scale)	Load (kg) to cause a standard test cylinder to compressive failure.[3]
Concrete (anchor testing grade)	2700-3000		1800
Gypsum	2320	2	
Limestone	2680-2760	Calcite 3/Marble 3.5	400-2000
Dolomite	2840	3.5	
Sandstone	2140-2360		400-9000
Granite	2640-2760		1800-18000
Dolerite	2890		
Quartzite	2647	7	

Notes. 1 from CRC (1996)
2 from CRC (1997)
3 from Raleigh (1989)

2.4 Stresses placed on rock by bolts

When a bolt is placed in rock, stresses are placed upon the rock. For uniform rock, the so-called stress zone resembles a cone radiating outwards from the bottom of the hole to the surface of the rock, the radius of cone at the surface being about the depth of the hole. When a bolt is loaded, it will stress the rock in this cone of influence; a shorter bolt means a smaller volume of rock is stressed and thus it is less secure than a deeper bolt, where the stress can be spread over a larger volume. Expansion bolts further stress the rock by the deformation of the cone to hold the bolt within the rock. Chemical bolts do not have this added stress mechanism.

Because of the consequences of failure, it is advised that when bolts are used, a minimum of two are used. To ensure that the failure of one bolt doesn't affect the integrity of the backup bolt, it is desirable that the stress cones are not overlapped. Various statements are made about the minimum spacing, e.g. no closer than 20 hole diameters apart, or no closer than 25 cm to each other. I have seen a pitch bolted (not in Tasmania, I'm pleased to say) with two spits placed right next to each other, under 5 cm apart. In this case two spits are probably less secure than one alone!

Any rock that is weathered will be weaker near the surface, and so a deeper bolt will be more secure than a shallower bolt. Similarly, a bolt with some mechanical gripping will be more secure if the gripping is deeper in the hole. The standard spit has the gripping at the end of the hole, in the best possible position. Compression bolts (see below) grip the hole mid-way along the hole, where the rock could be weaker. A chemically set bolt grips the hole everywhere along the glue-rock interface.

2.5 Materials for bolts and hangers
Generally bolts are made from high tensile steel, or stainless steel. Hangers are made from the same materials, but can also be made from Aluminium alloys. Aluminium is weaker than steel, and so hangers made of it are thicker than those made from steel. For example, a Petzl twist hanger is about 4 mm thick, whereas an RP steel hanger is about 2 mm thick.

There are many different grades of steel and alloys used for different components. Steel components could be standard mild steel, or high tensile steel (Grade 8.8), or a so called austentitic stainless steel, (which comes in many different varieties; types, 303, 304, and 316 are common classes). Types 304 and 316 are commonly used in climbing protection (Law et al. (1992)), but 316 (commonly known as Marine Grade) has better corrosion resistance and a better choice than 304 in coastal environments.

Many of these modern alloys have been specially treated (e.g. through controlled heating and cooling processes such as tempering, annealing) when being made, and often again after being fabricated into the end products (e.g. some high strength karabiners). Any modifications (e.g. bending, hammering, drilling, grinding, welding) to the end product may modify the strength and/or corrosion properties of these, and so should be avoided as much as possible. If any modifications need to be done, then it is best to do them gently and avoid heat as much as possible, this may necessitate doing the work in small stages and quenching in between.

2.6 Corrosion
When two different metals (or grades of the same metal) are in contact, especially when moisture is involved there is a potential for electrochemical corrosion (i.e. galvanic coupling). A stainless steel expansion bolt might be fitted with components made from different grades of stainless steel. Aluminium alloy hangers are fitted with a high tensile steel bolt. Often components made of steel (e.g. bolt casing) are plated with another material (e.g. Cadmium or Zinc (i.e. galvanised)) to prevent/slow corrosion. So, any particular anchor can have a variety of metals in intimate contact. Ideally all components in an anchor will be made of the same material.

Sharp bends and deformities (e.g. crevices, welding dags) can encourage local corrosion. Thus it is good to avoid these by choosing well designed and well finished products, i.e. those with only large radius bends and free from welds; or if welded, well finished welds.

Stainless steel does still corrode, it just does it at a much slower rate than normal mild steel. In sea-water, where a mild steel will corrode at a rate of about a millimetre every six years, an austentitic stainless steel will corrode about a millimetre every 200 years. This corrosion can be greatly accelerated by galvanic coupling when two different grades remain in contact. Hellyer (1988) reports that in Thailand, on seeping limestone sea cliffs, (where climbing is popular), six year old stainless bolts have already begun to show visible signs of corrosion. There have been several failures causing several serious injuries.

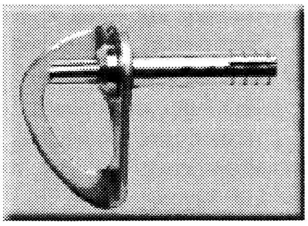
Obviously the corrosion potential in an inland Tasmanian cave will be a lot lower than by the sea in Thailand, but it is still present. Many existing spits have obviously rusted (exacerbated by them not being greased when installed?); and of course you can only examine the internal thread, not the remainder of casing. In some caves, hangers have been left in-situ for a more than a decade and anchor could be in a very bad condition (e.g. the hanger on the rebelay on the 55 p in JF371, was recently examined after 14 years residence, the hanger was very badly pitted, but both the bolt and thread in the casing appeared to be okay). Karabiners that have been left in a cave for 6 months can often show substantial surface corrosion. One way of minimising this corrosion potential is not to leave hangers installed in casings, but to instead to insert a greased and non-metallic plug, which prevents the ingress of moisture and also aids the relocation of the casing. (This is the current practise in Tasmania, the nylon bolt being fitted with a reflective marker.)

2.7 Thermal cycling
When on the surface, bolts can undergo large thermal cycling. This regular heating up and cooling down leads to thermal expansion and contraction of the bolt, which can lead to loosening the mechanical fixing and make the bolt subject to failure. Fortunately, apart from in the entrance region, the cave environment is very stable and so any sort of thermal cycling problem should be minimal.

3. The types of 'long-life' bolts used around the world
I don't claim this to be exhaustive, but it probably represents a reasonable assessment of the different types of long lasting bolts used around the world. Note, that I have excluded spits because of their relatively temporary nature and lower strengths. They (even if available in a stainless steel form) just don't measure up with many of the more substantial types of bolting hardware available around the world.

3.1 Mechanically set bolts
Most of the these types (and there are a multitude of different shapes, styles, sizes, materials, mechanisms) of bolts on the market have been designed for fastening things to concrete. Acceptable loads for the different types of bolts are carefully stipulated by Construction Codes for specific grades of concrete. The appropriate loads in natural rock aren't specified. These types of fasteners are most suited for use in hard rock. Some fasteners are more suitable for use as caving or climbing anchors than others. A few types have been specifically made for caving/climbing anchors.

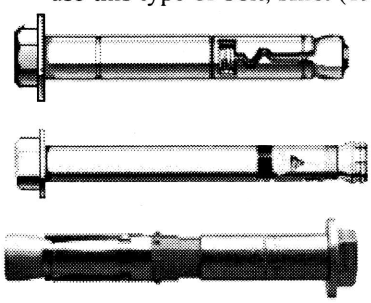
Fasteners used for permanent anchors in cliffs or caves are substantial pieces of metal (say 60-100 mm long, 10 to 12 mm diameter, made of stainless steel), with some sort of expansion mechanism to allow the bolt to be held firm in the rock.



When compared to a spit (see the scaled diagram left) there is no comparison!, the spit looks like a total safety compromise!

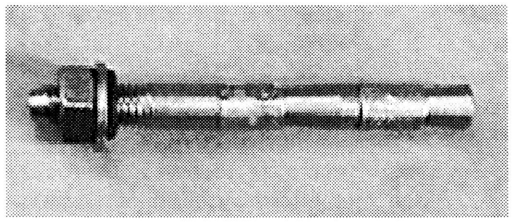
The mechanical fastening can be made by many different mechanisms; these are briefly described below:

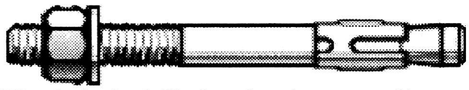
- **Sleeve:** have an outer sleeve (along the full length of the bolt, but sometimes this is in 2 parts) around the bolt and a cone at the end. Some types are fitted with a bolt, others are threaded to accept a nut. The standard Dynabolt is a very low technology example of this type of bolt and the holding power and security of a Dynabolt is low compared to some of the other types; some of which are designed to hold in concrete with cracks in it (e.g. the top of the three bolts shown below). For the higher tech. models (e.g. Rawl '5-piece' or equivalent), as the bolt is screwed into the cone the end of the sleeve deforms outwards to grip the rock. Further tightening causes a nylon compression ring between the two parts of the sleeve (e.g. as in the lower two of the three bolts pictured below) to deform and bind to the rock. For this particular example, the actual bolt and outer part of the sleeve is removable, but the bound portion of sleeve and cone isn't. Rock-climbers in the USA extensively use this type of bolt, Hirst (1998). For sleeve bolts, the diameter of the hole is greater than the diameter of the actual bolt to allow space for the sleeve, and the diameter of the hole must be selected to match the diameter of the bolt.



  Petzl (France) make a permanent anchor that instead of having a nut on the end has a captive hanger and a protruding pin, to set the bolt (expand the end) the pin is driven in. Once installed, it is not removable, hence the name. Presumably cavers and climbers in Europe use this bolt, but it is expensive.

- **Wedge:** are basically a solid stud, threaded on the outside end to take a nut, and machined into a wedge on the inside end to accept a small wrap around sleeve. When the nut is tightened, the wedge forces the sleeve to bind to the rock. Once they are in and the sleeve is deformed, that's it and they won't come out. However, if the hole is over-drilled (i.e. deeper than the bolt) by about two centimetres, then the actual bolt can be bashed in and the bolt hidden. Some bolts may have more than one wedge/sleeve pair, as shown in the lower example (made by Fixe in Spain). The hole is drilled to be the same diameter as the bolt, which gives the maximum shear strength in relation to hole size. Fixe double expansion bolts of this type have been used in the first stage of rebolting pitches in Ice Tube, Hawkins-Salt (1998a). Rock-climbers in New Zealand use wedge bolts (e.g. Hilti HSA or Ramset Tru-bolt) for hard rock, Newnham (1995); these models have good expansion reserves (see below).
- **Compression:** are split shaft studs which compress for a spring fit when pounded into drilled holes.

  The hole is drilled to be the same diameter as the bolt. Supposedly they are fairly strong when new, but lose their grip after about ten years. With the application of some force (e.g. through leverage) they are removable, or if the hole is over-drilled, they can be bashed in and hidden. Note that from the outside of the rock, wedge and compression bolts look the same. I haven't found evidence of the availability of these bolts, let alone availability in stainless steel. Various people, e.g. Child (1995), recommends against using them, except for alpine climbing when a quick and light bolt is required. Apparently a 1/4" diameter version (non-stainless steel) were very popular in the USA in the past, but these rusted badly and the grip weakened resulting in them readily failing (for this reason they are referred to as "coffin nails").

Collectively, Sleeve and Wedge mechanism bolts are known as Expansion Bolts. Law et. al (1992) talks at length about these, and divides them up into two types, deformation-controlled and load-controlled. The deformation-controlled type (e.g. spit) once in are in and cannot be tightened, they have no expansion reserves. The load-controlled type (e.g. Sleeve) have a reserve of expansion holding power, i.e. they can be nipped up to counter any changes in the rock (e.g. local failure). Note that these bolts have a specified torque that they should be tightened to. The long and short of it is that Deformation-controlled bolts are recommended against (another nail in the coffin of the spit), and only the Load-controlled expansion bolts that have a high expansion reserve are recommended.

The properties for all these types of bolts (in stainless steel) is summarised in the Table below.

Mechanism	Typical hole size required	Longevity and how limited.	Relative[1] Shear Strength	Relative[1] Tensile Strength	Expansion Reserve[2]	Removability
Sleeve	2 mm wider than bolt, 50-75 mm deep	?? years due to corrosion.	64 %	> 100 %	Medium-High	MOSTLY, the internal bolt and outer sleeve section can be removed.
Wedge	same diameter as bolt, 50-75 mm deep	?? years due to corrosion.	100 %	100 % (> for double wedge)	High	NO, but it can be bashed in if the hole is deep enough.
Compression	same diameter as bolt, 50-75 mm deep	?? years due to corrosion, but even less to spring fatigue?	100 %	< 100 %	None	YES, with force. Can also be bashed in if the hole is deep.
Note: 1 For a 10 mm diameter hole in the rock 2 For a good high tech. example						

A summary of the different types of stainless steel mechanically fixed bolts that are in use (or are available in outdoor gear shops) is shown in the Table below:

Brand name/origin	Mechanism	Typical Sizes Used Diameter	Length	Hole Diameter	Strength[1] Tensile (kN)	Shear (kN)	Notes/ Applications etc.
Petzl /France	Sleeve	12 mm		12 mm		25	Integral hanger
Coast /USA	Wedge	$^{3}/_{8}$"	$2^{1}/_{4}$-$3^{3}/_{4}$"	$^{3}/_{8}$"	24	18	MEC-Canada. Climbing.
Fixe /Spain	Twin wedge	10 mm	98 mm	10 mm	31	23	Several countries. Climbing, Caving
Rawl	Sleeve	10 mm 10 mm	65 mm 90 mm	10 mm 10 mm	32-37 38-40	23-28 25-34	USA-Climbing
Ramset Trubolt	Wedge	10 mm 12 mm	75 mm	10 mm 12 mm			Good expansion reserves. NZ-Climbing.
Hilti HSA	Wedge	10 mm 12 mm	75 mm	10 mm 12 mm	23 38	27 43	Good expansion reserves. NZ-Climbing.
Notes. 1 from Manufacturers specifications or Equipment Suppliers catalogues, unless otherwise shown							

3.2 Chemically set bolts

Chemically set bolts were initially designed to hold rock, or concrete together, e.g. at dam sites, road cuttings, in mines. With some adaptations, mainly to the shape of the fastener, this system has been adapted for use as caving or climbing anchors.

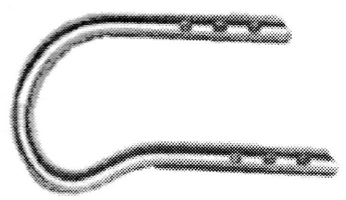
Again, as with the mechanically set bolts, chemically set bolts are substantial pieces of metal. There are two types of chemical set bolts; bolts which take a hanger and 'hangerless' bolts where the design results in a loop of steel protruding from the rock.

The chemical setting agent (the 'glue') is generally a two part epoxy resin, discussed below. Some of these resins will even set underwater whilst others are tolerant of a damp environment. The hole for the bolt has to be larger (2-4 mm in diameter, e.g. 10-12 mm hole for 8 mm bolt) than the bolt to allow an annular space for the resin. The cleanliness of the hole is paramount to the adhesion of the resin to the rock surface, all traces of dust/rock powder must be removed. The safety of glue-in bolts is critically dependant on the installation being done correctly. Some of the References at the end of this article go into much more detail about this, see CNCC (1998).

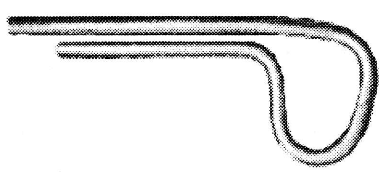
For the 'hangerless' variety, there is only one piece of metal, which means that the problem of galvanic corrosion doesn't occur. Also, for this variety of bolt, the surface is generally roughened, or deformed (e.g. with dimples), and/or the ends are bent to increase the bonding between the glue and the metal. In addition, the ends of glue-in bolts are generally sharpened/angled to assist in preventing air pockets forming around the bolts as the bolts are pushed into the glue. Hellyer (1998) reports that in the early days of chemically set bolts, there were several accidents due to failure of the resin to adhere to the smooth steel shafts of Staples. The thread on machine bolts and threaded rod allows the glue to get a better grip on these bolts, which are rotated as they are inserted to ensure good adhesion of the glue.

The bolt itself can have many different shapes and forms, the main ones are described below:

- **Staples:** are made out of 8 mm marine grade stainless steel (316) rod bent into a "U" shape such that the two straight ends or "legs" are parallel. Overall the U is about 90 mm long; with one leg about 10 mm shorter than the other. The long leg is embedded about 60 mm, the short 50 mm. The internal gap between the two legs is about 30 mm. One hole is needed for each leg; care must be taken to keep the holes parallel! The commercially produced version (as shown above) is shaped to give a nice position for an attached karabiner; in addition, the entrance to the bottom hole is shaped so that where the leg curves, it sits hard on the rock. The home-made version is generally just a straight "U", and so an attached karabiner is forced to rest against the rock-face. Home-made "U" anchors of this type have been used by local rock-climbers at a number of locations (e.g. Coles Bay, Fruehauf Quarry, Adamsfield), over the last 5 years. Two glues/systems (see below) have been used: the Hilti "HY-150" injection system, and a hand-mix/syringe system using "Megapoxy HT"; Parkyn (1988).

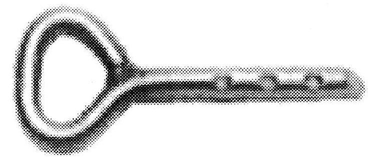


- **P Hanger:** This is basically a variant of the Staple ("U"), where both legs are placed in the same hole to give a "P" shape.

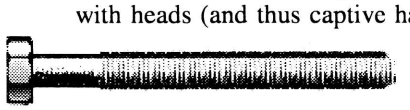


The DMM Eco-hanger (shown above) is made from a single piece of 8 mm marine grade stainless steel (316) rod, which is installed into a single massive (18 mm diameter, 100 mm deep) hole. This style of hanger is extensively used by the Caving fraternity in the UK, CNCC (1998).

- **Eyebolts:** are generally made out of 10 mm stainless steel (or bigger, e.g. the Petzl Batinox is made from 14 mm diameter rod). A single hole, 2 mm larger in diameter than the bolt shaft diameter is used. A few examples are shown here. Shapes for the eye vary, the closer the hanger sits to the rock surface, the less leverage and the stronger the anchor. Again, as with staples, some custom shaping of the hole allows the bottom of the eye to be recessed slightly, this prevents any rotational



force on the hanger, which would tend to twist the hanger out.
- **Bolts that take a hanger:** basically these are the glue-in equivalent of mechanically set bolts, but with an increased holding power in soft rock. Bolts with heads (and thus captive hangers) can be used, as can threaded rod. The only glue-in bolts that



the hanger can be removed is the headless variety (e.g. threaded rod). Stainless steel (316) machine bolts (10 mm by 120 mm) with captive stainless steel hangers were installed (in 1996) with Ramset 'Chemset' capsules on the second and third pitches of Slaughterhouse Pot by John Hawkins-Salt (1998b).

The properties for all these types of chemically set bolts (in stainless steel) is summarised in the Table below.

Type	Typical hole size required	Longevity and how limited.	Relative[1] Shear Strength[2]	Relative[1] Tensile Strength[3]	Removability	Volume[4] of resin (ml)
Staple ("U")	2 holes, 10 mm diameter, 50 mm & 60 mm deep.	Life of the resin.	100 %	69 %	NO	9
Eyebolt	2 mm wider than bolt, 70-100 mm deep	Life of the resin.	78 %	71 %	NO	9
"P" hanger	18 mm diameter, 100 mm deep	Life of the resin. (bolts in the UK have been in use for ~10 years to date)	100 %	100 %	YES, drill down the sides of the hanger (5 mm bit), and with a big bar through the eye rotate it out.	19
Machine Bolts	2 mm wider than bolt, 70-100 mm deep	Life of the resin, or corrosion.	78 %	71 %	NO	9
Threaded Rod	2 mm wider than bolt, 70-100 mm deep	Life of the resin, or corrosion.	78 %	71 %	NO	9

Notes:
1. For the normal sizes used, e.g. 10 mm rod for bolts/rod/eyebolts, 8 mm rod for staples/P hangers and for the maximum sizes shown in Column 2.
2. Based on the cross-sectional area of the bolt material.
3. Based on the surface area of the bolt material.
4. Assuming a wastage of 20 %.

A summary of the different types of stainless steel chemically fixed bolts that are in use (or are available in outdoor gear shops) is shown in the Table below:

Brand name/origin	Type	Typical Sizes Used Diameter	Length	Hole Diameter	Strength[1] Tensile (kN)	Shear (kN)	Notes /Applications etc.
DMM Eco-hanger/UK	P	2x8 mm	100 mm	18 mm	18-54[2]		Cavers in the UK and elsewhere
Fixe /Spain	Eyebolt	10 mm	100 mm	12 mm	36	40	Cavers
Home-made	U	2x8 mm	60 mm	2x12 mm 2x10 mm	18[3] 32[4]		Rock-climbers in several countries
Petzl	Eyebolt	10 mm 14 mm		12 mm 16 mm		25 50	France-cavers and climbers
Threaded Rod	rod	10 mm 10 mm	60 mm 115 mm	12 mm 12 mm	30 50	29 29	Rock-climbers
Machine Bolts	bolts	10 mm	120 mm	12 mm	~50	~29	Rock-climbers/cavers

Notes:
1 from Manufacturers specifications or Equipment Suppliers catalogues, unless otherwise shown
2 CNCC testing, range for pull-out of DMM bolts, for all types of hole preparations. Hanger deforms at 19 kN.
3 from Hellyer (1998), a single test.
4 Parkyn (1998), a single test. with two U anchors in series. Failure was ductile in nature.

3.3 Chemical Setting agents

Various different types of chemical setting agent (i.e. the 'glue') are used, the main ones being two part epoxy resin; the resin itself and a hardener. The resins available were designed for any number of industrial and construction applications, for example the insertion of steel reinforcement rods into concrete.

There are several different types of resin, e.g. Epoxy, Polyester, Urethane. Polyester resins (according to reports) are much easier to work with as they have a lower viscosity. However, manufacturers specifications show that Polyester resins are not as strong as the Epoxy resins.

Which is the correct resin to use for which rock type is the subject of much debate and is more often dictated by what is locally available. A summary of the different commonly available stronger resins, and who uses them is shown in the table below. Note that Hellyer (1998) reports that a large amount of research has been carried out by the UK National Caving Association (NCA), concentrating on resins suitable for limestone. Please note that some internationally distributing companies sell different products in different countries. Also, the use of proprietary brand names, (which often sound similar) can cause some confusion. The manufacturers specifications need to be carefully checked.

Resin Brand name/ type	**Made in/ Available from**	**Recommendations**	**"Rucksack" sport users**	**How available**
Exchem Resifix 3 Plus	Exchem, UK	Recommended by the UK National Caving Association (UK-NCA) for massive limestone. [Formerly Hilti C50 resin was recommended, but no longer is due to environmental concerns.]	Cavers in the UK [CNCC (1998)], Canada [Horne (1998)]	dispenser pack
Vivacity Megapoxy HT	Vivacity Engineering, NSW	Epoxy Resin. Australian Rock-climbers. Manufacturers claim this glue to be hydrophillic.	Rock climbers in Aust. [Parkyn (1988)]	bulk
Ramset Epoxy-Set	Ramset, Australia	Epoxy resin. Manufacturer recommends for concrete, solid brickwork and stone. Excellent resistance to alkali and moisture. Capsules can be used underwater.	Rock climbers in NZ [Newnham (1995)]	capsule or dispenser pack
Hilti HY 150	Hilti, Australia	Manufacturer recommends for concrete and hard natural stone. No problem with wet environments.	Some rock climbers in Aust. [Parkyn (1988)]	dispenser packs
Hilti HVU	Hilti, Australia	Styrene free Vinyl Urethane resin. Manufacturer recommends for concrete and hard natural stone.		sachets
Rawl Kemfix	Rawl, Australia	Manufacturer recommend for solid concrete and masonry materials.		capsule
Rawl Foil Fast	Rawl, Australia	Manufacturer recommends for concrete and other solid base materials.		dispenser packs

The life of the installed resin is somewhat open-ended or ill-defined. Many of the applications that cavers/climbers are using it are outside the normal commercial/industrial types of use. Resin in caves is not subject to ultra-violet light, but conditions are generally more humid. The longevity of the resin is an unknown; they certainly last a significant time; they may last 50 years. No one really knows, only time will tell. Some bolts installed by the NCA have been in use for ~10 years without showing any signs of old-age.

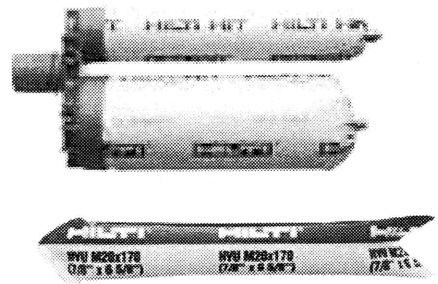
The resins generally have a low shelf life (some are 2 years, others 12 months), and so one needs to get fresh stock and use it quickly.

It is crucial for the resin and hardener to be properly mixed. Like most chemicals, the vapours and the material itself are dangerous (avoid breathing or skin contact or exposing to flame).

Once mixed the resins have a setting time that is primarily temperature dependant. Setting times are also dependent on the volume of resin used, i.e. shorter for greater volumes. Typical gelling times are, 20 minutes@20°C, 30 minutes@10°C, 1 hour@0°C and 5 hour@-5°C. Some manufactures recommend that temperatures be above 5°C for best results and that if used for lower temperature on-site testing be carried out.

Resin comes in either bulk packs (e.g. Expellable containers, or tins) or single shots. Some bulk

packs are designed for use in special dispensing guns which expel the resin and hardener from a the pack in the appropriate ratios and mix it via nozzle equipped with many spiral baffles. Between jobs you may need to replace the nozzle and you are set to go again. Often a colour change is used to indicate complete mixing. Other bulk resins come in tins/containers. This system is a Batch system, where you measure out the appropriate amount of resin and hardener, mix it, then dispense it via a caulking type gun/syringe etc. You have to use the entire mixed batch before it sets (typically 30 minutes). Single shot resin packs consist of resin and hardener in either a glass ampoule or foil



sachet. The ampoule or sachet (sachets don't fall out of downward pointing holes) is inserted into the hole. The stem of the bolt is then driven into the resin container and mixing is effected by rotating the bolt (e.g. via an attachment to a drill). This system can't be used for Staples; asymmetric hangers would be difficult to spin as well.

There are a variety of advantages/disadvantages between the Bulk and Single-Shot Systems, these are summarised in the table below.

System	Methods	Advantages	Disadvantages
Bulk (Gun Dispenser)	The resin is automatically mixed as it is injected into the hole. The hole is 2/3 rd's filled, from the back. The bolt is placed in and any excess resin is cleaned up as it exudes.	• The cartridge holds enough glue for many bolts. • Accurate dispensing ratio of resin and hardener. • Via the clear mixing nozzle, have a visible indication (colour change) of correct mixing. • Easy to take a sample of resin home to ensure it sets.	• Potentially messier. • Have to install a large number of bolts to make the best use of the larger amount of glue.
Bulk (Batch Mix)	Measure out resin and hardener, thoroughly mix it and transfer to an injection gun, then proceed as for the Dispenser Gun; however all the mixed resin needs to be used before it sets.	• The least expensive method. • Can mix as much resin as is required.	• Much messier and there is a lot more mucking around and potential for spilling etc. • Potentially more wastage of resin. • Potential for inaccurate ratios of resin/hardener.
Single-Shot (Ampoule or Sachet)	The ampoule is inserted into the hole, the stem of the bolt is inserted through the ampoule and rotated to mix the resin.	• Easy to do a single bolt at a time. • Can purchase a single shot of resin at a time, so it's up to date. • Less waste of resin. • Less potential for polluting the cave environment. • Accurate amounts of resin and hardener.	• Can't see how well the resin is mixing. • Resin is contaminated by Ampoule/Sachet debri. • More expensive.

Temperatures in Tasmanian caves being in the 4-14°C range means that gelling times will be 30-40 minutes. This is not a long period, especially if you have to move between pitches. As a result one needs to be well organised and spare mixing nozzles carried just in case. The quick thinkers will have realised that other anchors will have to be used for the installation process. Newly installed chemically bonded anchors are normally allowed ~ 24 hours before use.

Once installed, the resin sets harder than rock and is thus difficult to remove. The P hangers can be removed via drilling 5 mm holes along both sides of the stem and then by rotating the hanger via a bar through the eye. Some two part resins soften with heat (e.g. Araldite), and so it may be possible to use a blow torch or similar to heat the hanger and soften the glue, thus allowing it to be removed?? This is something that would need to be checked by practical testing.

3.4 Hangers and Anchor Systems.

All the Mechanically fixed bolts (presented in Section 3.1) and the non-hanger integral chemically fixed bolts (discussed in Section 3.2) need to have hangers affixed. Ideally these should be of the same material as the bolt, to minimise the potential for galvanic corrosion.

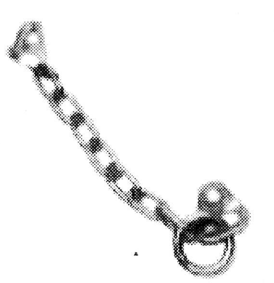
There are many good and strong hangers around, some come equipped with one or two stainless steel rings to facilitate pull-through style trips. Some are even available in environmental colours to make them blend in with the rock.

Systems with replaceable hangers have an obvious advantage in that if a hanger (or ring attached to it) becomes worn, it can be easily replaced. It should however be noted that stainless steel is very hard wearing. The large eyebolts in Midnight Hole have probably seen the most use of any bolt installed in a Tasmanian Cave. After over thirty years of trips (mostly pull-through trips), the mild steel eyebolts on the longer pitches are showing significant wear, about 30-40 % of the way through the 1/2" stock. The time is near to replace these, a hanger of the type shown above (captive ring, made from 10 mm diameter material) would be ideal. If the Loxin was in good condition, a 1/2" diameter bolt could be used to affix one of these hangers (with the hole enlarged) to the existing Loxin anchor as a short term solution.

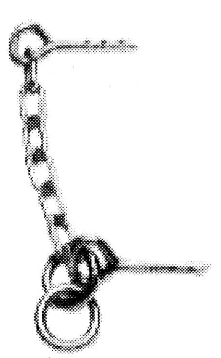
Most of these hangers are very strongly rated. The two Fixe hangers above right are rated at 40 kN (Twist hanger) and 26 kN (Flat hanger with Ring, itself rated at 40 kN).

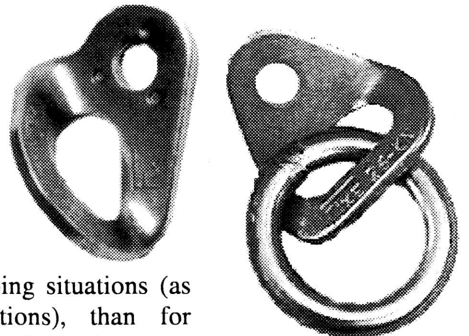
Nuts for any of the threaded bolts may loosen up with time, so it makes sense to use locking nuts (i.e. those with nylon inserts), or use some sort of proprietary Loc-tite material. Note that the outside end of the a threaded bolt is generally tapered to allow it to be tapped into the hole without burring the thread, and so it is not possible to simply burr the end of the bolt over to ensure the nut stays on.

When using artificial anchors the accepted practise is to use at least two, i.e. to never put ones faith in a single anchor. When installing anchors, often a pair are thus required. In the case of the hangerless variety, this generally means installing two bolts (no less than 20 hole diameters (e.g. 240 mm for 12 mm holes) apart!), and the rope is threaded through both. Note that the "eyes" should be oriented with due consideration to where the rope will lie and the direction of pull.



Some manufacturers make abseil stations, which include a pair of bolts, joined by a 25 cm long section of stainless steel chain (itself rated at 26 kN). Two examples are shown here, for both mechanically and chemically fixed bolts. These are probably more suited to





rock-climbing situations (as abseil stations), than for caving situations, however, the rope drag on a single ring will be less than that for two anchors.

3.5 Prices of Hardware.
This section has been removed to reduce the size of this article. Details are available from the author; Contact details at end.

4. The Best Option is????
To my way of thinking, the ideal bolt should:

- be absolutely secure,
- be well situated,
- be easily locatable (unlike some unmarked spits),
- be long lasting (i.e. corrosion resistant),
- be replaceable,
- cause minimal impact on the cave environment (e.g. no nasty chemicals being spilled during installation or leaching out afterwards) and the installer (e.g. no nasty fumes or dangerous chemicals),
- be reasonably priced (i.e. inexpensive over it's lifetime),
- be easily installed,
- and have a known history (i.e. records kept of the installation and periodic checking).

You can devise all sorts of rating schemes using the data above to try and work out which bolt is best, but to me it is not immediately obvious that any one method outshines the rest. However, there certainly is a case against continued use of the 8 mm spit in any cave that is going to have more than infrequent visitation.

Law et al. (1992) state that Glue-in bolts are at present the best answer to the all-round bolt; they are strongest in the widest range of rock and the integral stainless nature gives them high life expectancy.

In the UK, where they have significantly more cavers than here, the decision (based upon extensive research and testing by the NCA and the CNCC Technical Group) has been to go with the chemically fixed "P" hanger (DMM Eco hanger). Of all the glue-in bolts, the P hanger is the only one that is easily removable, which gives it the edge-i.e. it is replaceable when the time comes.

A comparison of all types of permanent anchors presented in this article is shown in the table below.

Type of bolt	Sleeve	Wedge	Comp-ression	"U"	Eye	"P"	Mach-ine bolt	Thread-ed Rod
Amount of drilling	SMALL-MEDIUM	SMALL	SMALL	MEDIUM (2 holes)	SMALL-MEDIUM	LARGE	SMALL-MEDIUM	SMALL-MEDIUM
Installation difficulty	LOW	LOW	LOW	HIGH	MEDIUM	HIGH	MEDIUM	MEDIUM
Biological Impact	LOW	LOW	LOW	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM
Tensile Strength	MEDIUM-HIGH	MEDIUM-HIGH	LOW-MEDIUM	HIGH	HIGH	HIGH	HIGH	HIGH
Shear Strength	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
Expected Long-evity	MEDIUM	MEDIUM	SHORT-MEDIUM	LONG	LONG	LONG	MEDIUM-LONG	MEDIUM-LONG
Replace-able hanger	YES	YES	YES	NO	NO	NO	NO	YES
Remove-ability	PART-IALLY	NO (but can bash in)	YES	NO	NO	YES	NO	NO
Cost per anchor	MEDIUM	LOW	??	MEDIUM-HIGH	MEDIUM	HIGH	MEDIUM	MEDIUM
Approp-riate for limestone	MEDIUM	MEDIUM-HIGH (if 2 wedges)	LOW	HIGH	HIGH	HIGH	HIGH	HIGH
Overall Rating	**GOOD**	**GOOD**	**POOR**	**GOOD**	**GOOD**	**GOOD**	**GOOD**	**GOOD**

5. The Next Steps??

To me the following seems a logical sequence to follow:

- Ensure our knowledge of the options is complete and accurate,
- Gain some practical* experience; preferably hold a practical workshop* where we get some "experts" (e.g. company representatives, people with considerable practical experience etc.) to come along and provide sound instruction to people likely to be involved in installing bolts, (this is one proposal I have suggested for the Down To Earth Conference the VSA are running early next year; however it could equally be held at an ASF conference, or as a special event somewhere that interested cavers can get to). [*For the chemically set bolts there are quite a few points that need to be strictly adhered to (no pun intended) in order to achieve a high quality result.]
- Have a trial of some of the different bolting systems in a couple of different caves,
- **Plan out** a rebolting program; targeting the more popular caves (e.g. for Tasmania) such as Midnight Hole, Khazad Dum, Dwarrowdelf etc.

Any feedback from out there would be appreciated, contact details below. Thanks for the time and considerable space!

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Acknowledgements:
Nearly all diagrams were taken from the Internet, see the various Web addresses below.

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Paul Cornish emerging from the free dive in Old Napier Downs Cave, Kimberley. WASG expedition 1998. Photo Stefan Eberhard.