Caves, Craters & Critters

Proceedings of the 26th Biennial Conference of the Australian Speleological Federation

6th -12th January 2007

Edited by Graham Pilkington and Athol Jackson

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And a special thank you

for 2 trophies donated by Ivo Tadic.

to the many others who have assisted with information, advice and support throughout the planning and to all those that assisted with everyday tasks.

and to our sponsors

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District Council of Grant

Scout Outdoor Centre

City of Mount Gambier
BLUE LAKE CITY

Past Presidents Present

Back row: **Ken Lance** 1979-82**,** **Warren Peck** 1961-62**,** **John Dunkley** 1983-85 2002-04**, Elery Hamilton-Smith** 1960 1963-65 1971-74**, Nicholas White** 1975-78

Front row: **Lloyd Robinson** 1986-92**,** **Jay Anderson** 2005-06**,** **Miles Pierce** 1993-94

1956 veterans: Bob Sexton, Christine Warner, Elery Hamilton-Smith, and Noel Mollet.

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Caves, Craters and Critters

held at Mount Gambier, South Australia
6 January to 12 January 2007

Proceedings of the 26th Biennial Conference of the Australian Speleological Federation Inc.

Celebrating 50 years of Federation

DVD produced by: **Athol Jackson**

Cover photographs
Blackberry Cave, Naracoorte, by Athol Jackson
Blue Lake volcanic crater, Mt Gambier, courtesy of City of Mount Gambier
Ningbing Scutigeromorph, by Paul Hosie

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Presentations at the 26th Biennial Australian Speleological Federation Mt Gambier 6-12 January 2007

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KEYNOTE

ADDRESS

Looking Back: Gains and Losses

Elery Hamilton-Smith
Antique Speleologist

1966 Nullarbor Expedition

South Australia has a long speleological heritage

- Grey, Angas, Burr and others 1840
- Edward Snell 1850
- Father Tenison Woods 1856-67
- Reddan, Mason, Leitch and others 1890s-1930s
- Samuel Bedford 1930s
- Woolf & Watson 1930s
- Hale and Tindale 1930s
- J Maitland Thomson, MacRitchie 1930s-1960s

"Modern" Speleology

- 1946 Tasmania
  – Warren Carey and the Caverneers
- New South Wales
  – The bushwalker tradition
  – SUSS, then SSS and others.
- South Australia, which now leads to CEGSA and my personal narrative

The New Elizabethans and Rover Scouts

- It all started on 4th-6th June 1954

The first caving trip to Corrells Cave, Curramulka, 4-6th June 1954.

Back Row: Graham Chinner, Elery Hamilton-Smith; Centre Row: Cecil Giles, David Pegum, John David Taylor Front: Noel Mollet (Photograph: N. Mollet)

Over the next 12 months, this group grew rapidly, recruiting other Rover Scouts, friends, bushwalkers and others.

The things we gained . . .

- Fun, fellowship and a wonderful new interest
- A sense of new confidence and of safety in this new pursuit
- Freedom and spontaneity in caving
- New Friends – including landowners
- Respect and support from the museum and from academics

And also . . .

- Getting to know Captain Thomson
- Learning technical expertise from each other and other inquiries
- Developing greater environmental understanding
- The opportunity for inquiry and research
- Visiting remarkable places across the State

Some vital strategies

- A focus on proper recording and documentation
- Many things due to the remarkable Alan Hill, e.g.
  - Cave Numbering
  - Understanding cave processes in soft rock
  - A greatly enriched vocabulary
  - Receiving gifts from the Queen and others

So, on 19th April 1955

The Cave Exploration Group of South Australia was inaugurated.

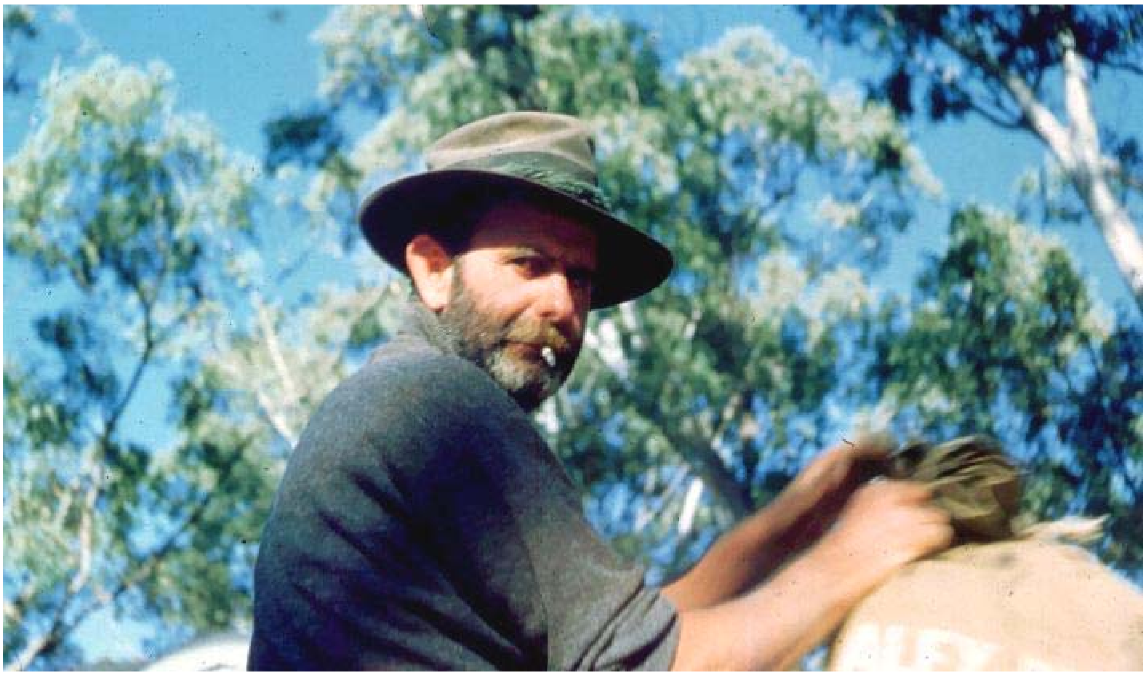
Many other things followed but in particular . . .

- Hosting the Inaugural Conference of the Australian Speleological Federation
- Two Nullarbor Expeditions

The 1954 Nullarbor Expedition, led by Arnold (Burly) Wright, standing in front of driver's door
(Photograph by courtesy Peter Wright)

Now for the compulsory pikkies

The great Captain J. Maitland Thomson



Captain J. Maitland Thomson (Photograph Ken Peake-Jones)

And the 1956 Expedition . . .

The 1956 Expedition camped at Weebubbie Cave (Photograph Hamilton-Smith)

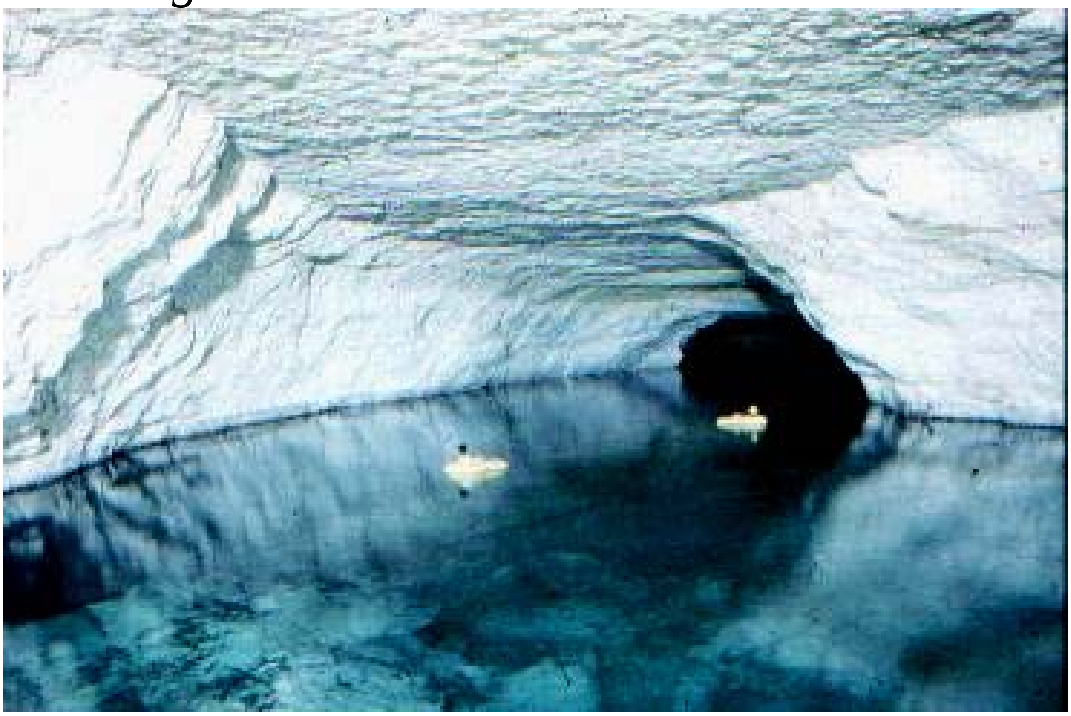
1 p4

Coordination Team for the 1956 Expedition: Stan (driver), John McQuie (surveyor), Gordon Bowen (radio operator), Jonathon Coles (‘Advertiser’ Newspaper) and Elery Hamilton-Smith.
(Photographer anon.)

Bob Sexton surveying in Warbla Cave (Photograph Hamilton-Smith)

The great Joe Jennings in White Wells cave, saying a few appropriate words about the fact that his camera tripod has just collapsed for the umteenth time! (Photograph Hamilton-Smith)

The Photographic Challenge . . .



1 p6

- The last photograph, taken with the help of the Megaflash, brings us to the photographic challenge of the Nullarbor caves
- So, the Nullarbor became the focal point of experiments with the so-called Diprotodon – a lamp which blew magnesium powder through a flame

Various diprotodons . . .

- Invented and used in Europe & North America in the 19^{th} century
- Introduced to Australia by Charles Kerry
- Commercially manufactured by Baker and Rouse under the brand Austral
- Used on the Nullarbor by HG Watson who in turn passed it on to Maitland Thomson

The 1950s and other elaborations

- Henry Fairlie Cunninghame built several for the 1956 Expedition, each powered with a meteorological balloon
- Alan Hill used high density magnesium powder
- Norm Poulter used canned gas

Most importantly, there have been wonderful discoveries

- The Koonalda (and later many other) archaeological sites
- The Victoria Cave and many other fossil sites
- The cave invertebrates, especially at Cape Range
- The use of intra-red imagery at the Bat Cave

Close co-operation between cavers and scientists

- Particularly fostered by Tindale and by Jennings

Then, organisationally . . .

- The ASF Handbook and Karst Data Base
- The development of cave diving and in particular the training program

As a brief digression, two of my most significant and highly valued personal decisions have been to take that first journey to Curramulka and to proceed with the notion of the Federation and everything that has arisen from that . . .

Including

- Growing national and then international co-operation
- The Australian Bat Banding Scheme and eventually, the inauguration of the Australasian Bat Society
- A progressively holistic approach to Cave and then Karst Conservation
- A systematic strategy for improving quality of cave and karst management, and again, the eventual establishment of the Australasian Cave and Karst Management Association
- And now, a broad commitment to international programs in heightening environmental awareness, protection and conservation

But, what have we lost?

- The spontaneity and freedom of just simply going caving
- Including the freedom to just explore new discoveries without impediment
- The uselessness and cost of most “risk management”
- The growing complexity of ensuring protection

Most importantly . .

- We have certainly lost many valued friends, including the late Alan Hill, Norman Tindale and others
- So, let me pay tribute to the many people who walked along the road with us and whose memory now helps to sustain us.

The Gambier Karst Province

Ken G Grimes & Susan Q White

The Gambier Karst Province is an extensive area of Tertiary marine limestone and overlying Quaternary dune limestone in south-eastern South Australia and western Victoria. These are "soft rock" limestones: youthful, weakly-consolidated porous calcarenites (sandy limestones) that are quite distinct from the classical "hard rock" limestones of the east coast, and other parts of Australia.

The caves in the Quaternary dune fields are syngenetic with the initial early cementation of the limestone, but those in the Tertiary limestones postdate that cementation.

The caves in both limestones are characterized by cap rock effects, solution pipes, extensive low horizontal phreatic mazes and abundant collapse modification. They are locally well-decorated, especially with straws and moonmilk, which the ongoing collapse tends to destroy leaving many bare fractured walls.

The Tertiary limestones differ in showing good joint control on their passage orientation. Beside the gorge of the Glenelg River there are linear, stream caves. Near the coast there are extensive large flooded systems which formed during the lower sea levels of the glacial periods. Tank Cave has 6 km of flooded shallow horizontal passage and The Shaft extends to a water depth of 120m. The cenotes, large water-filled collapse dolines, are unique(?) within Australia. There are large springs rising from flooded caves at the coast and offshore.

The syngenetic caves in the dune limestone can be horizontally extensive but have little depth. The largest tend to be at the edges of the dunes - adjacent to the sea that existed when the dunes formed, and also to the later swamps. We use the term "flank margin caves" for the irregular chambers that formed where sea water mixed with fresh water at the old coast, and "swamp margin" for the later modifications by acidic swamp waters eating into the edge of the dunes. Both tend to be low-roofed horizontal crawly mazes alternating with rubble-filled domes rising towards the surface.

2 one page

The Karst features of the SW Nullarbor – Mardabilla Plain & adjacent localities

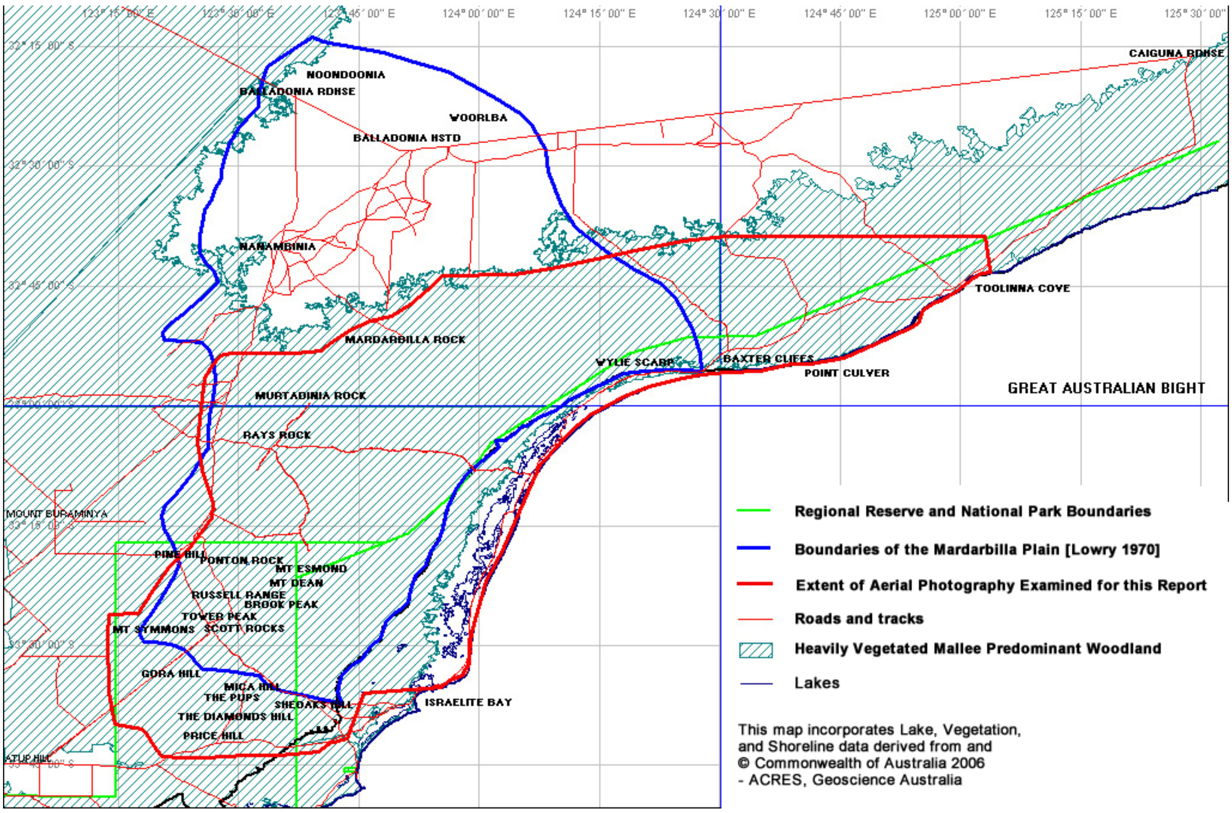
Paul Devine

Abstract

The Southwest portion of the Nullarbor is an area known as the Mardabilla Plain. The vegetated area consisting of the southern half of the Mardabilla Plain and an adjacent portion of the Hampton table land comprises an area of circa 7000km² and is typified by gently, undulating karst terrain, isolated outcrops of basement rock in the western half, but also by dense vegetation. As a result of the latter, it has received only limited karst exploration or documentation. Prior to 2005 only 50 features appear in records [KIDSA] for this area, and $^1/_3$ of these have never been visited on the ground. A far higher number of features for this area has been eluded by the previous work and discoveries of both David Lowry and Joe Jennings. By using remote sensing it has been possible to locate a very large number of new karst features. A systematic stereoscopic study of the area was completed using modern aerial photography. This was then compared on Google Earth imagery. As a result over 1000 new defined karst features have been located. These new features consist of collapse and erosion dolines, with a smaller number likely to access shallow caves.

Introduction

The Southwest Portion of the Nullarbor is named the Mardabilla Plain [Lowry 1970] after Mardabilla Rock. The area detailed in this report circa 7000 km²

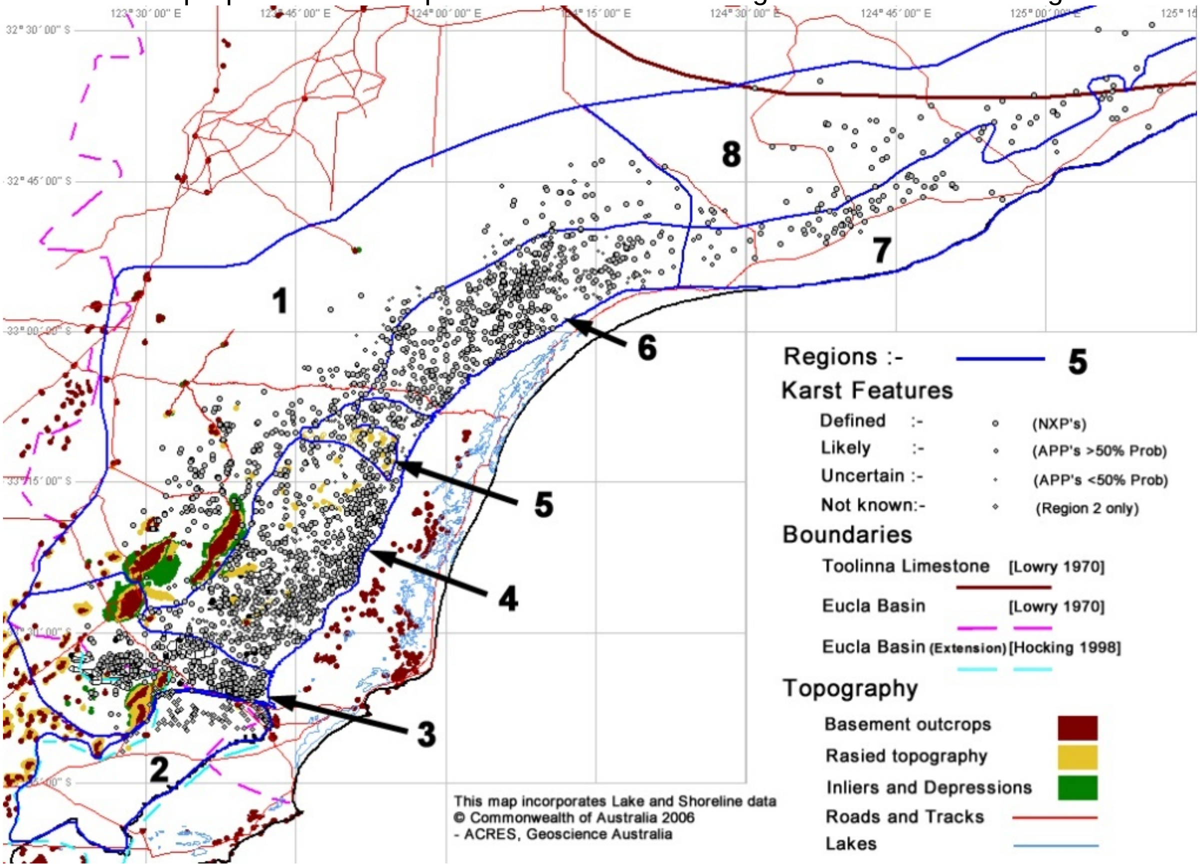


(Figure 1) comprises of the vegetated zones to the East and South of Mardabilla Rock lying principally in the southern portion of the Mardabilla Plain. It overlaps three 250 thou map sheets, the SW portion of the Culver SI51-04 map sheet, the southern portion of the Balladonia SI51-03 map sheet and the Malcolm map sheet SI51-07. By systematically searching this area stereoscopically using Air Photos, I have located an extensive number of new Karst features referred to herein collectively as MPF's - Mardabilla Plain Features, and identified individually as NXP Numbers or APP (Air Photo Point) Numbers.

The Karst features of the SW Nullarbor – Mardabilla Plain & adjacent localities
Paul Devine

Regional Setting

For the purposes of this report I have divided the vegetated zone into 8 Regions



(Figure 2) which are defined by surface topography, feature type and occurrence.

The setting for the MPF's is they lie within the area formed principally of Toolinna limestone [Lowry 1970]. This area is bounded along its southern margin in the east by the Baxter Cliffs, the Wylie Scarp in the SE and Precambrian basement in the West and SW. The general height of the Plain in this region is between 60m adjacent to the Baxter Cliffs in the east and increasing in height to around 150m in the West and SW.

There is also a corresponding increase in outcropping bedrock strata in the southern and western parts. This increase in bedrock outcropping is also shown clearly on the wave cut platform of the Israelite Plain.

The bedrock outcrops that break the surface of the Mardabilla Plain lie chiefly within Region 1 the western portion, and are described [Doepel 1969] as being principally two types. NNE trending Metasediments, that form the prominent peaks of the Mt Ragged/Russell Range and Brook Peak/Mt Esmond range, along with the lower Hills forming the Mica to Price Hill group.

(Figure 3)

The second type composed of granite & gneiss forms the more numerous but subdued relief outcrops. Examples include Rays, Ponton, Scott, Murtadinia, and Mardabilla Rocks to name a few.

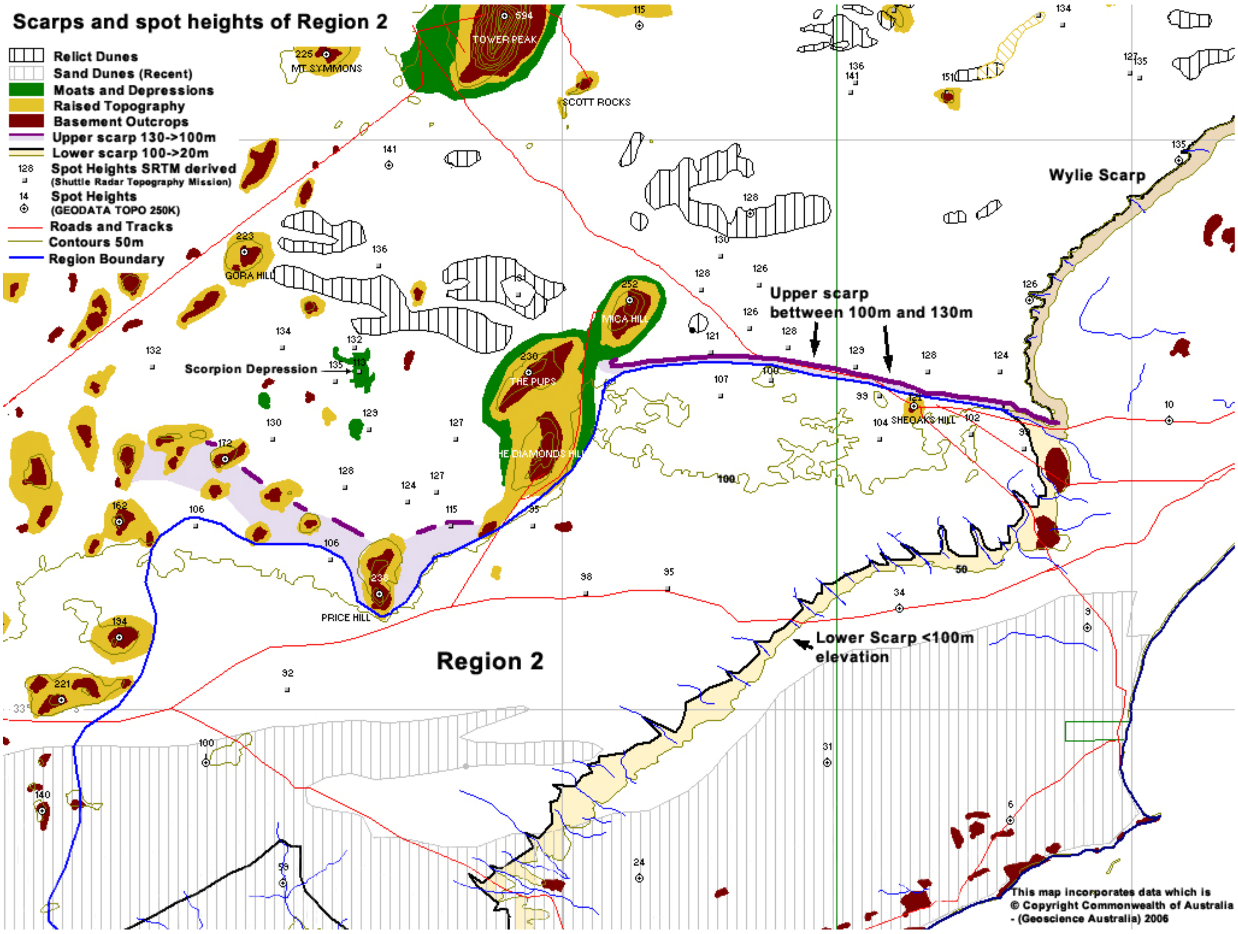
Mardarbilla Rock and shallow moat

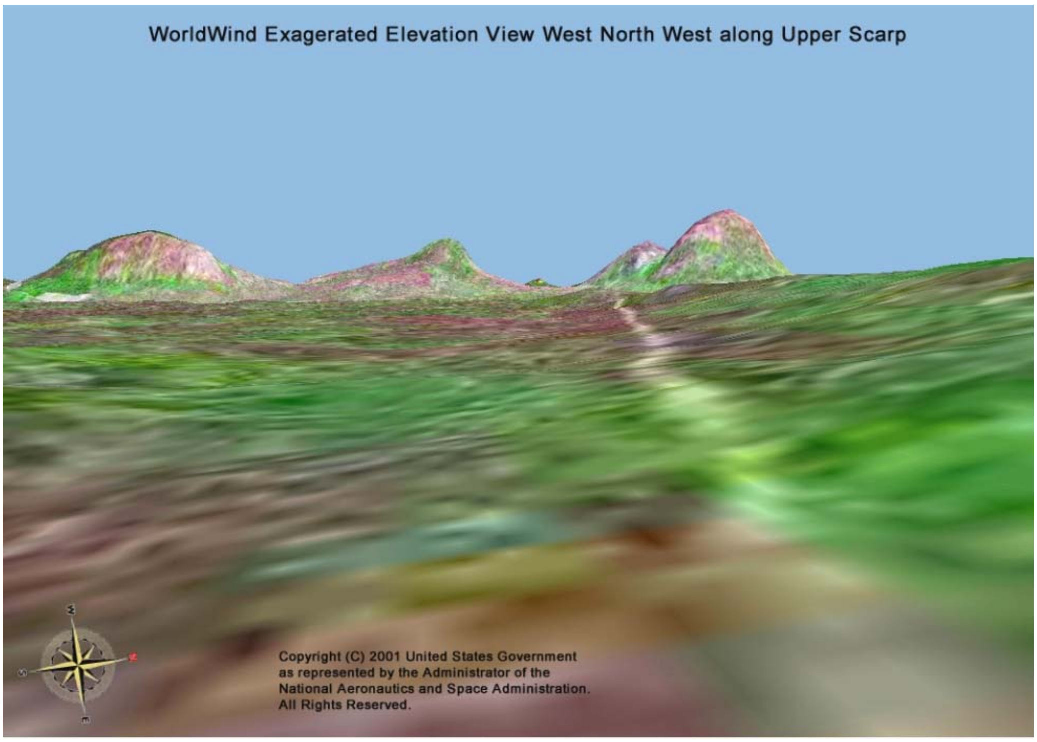
The elevated ranges and to a lesser extent a number of the granitic outcrops have depressions or “moats” surrounding their base. The bases of these moats are generally 6-10m lower than the surrounding plain [Lowry 1970]. Region 1 is typified by a thicker layer of calcareous soil cover. Lineation in vegetation is not reflected in surface relief. Surface relief is typically flat with only minor undulations in areas away from inliers and outcrops, and a scattering of more widely dispersed shallow flats.

To the SE of Mica Hill is an area mostly excised by Lowry [Lowry 1970] but now included as part of the Eucla Basin [Hocking 1994]. This area - Region 2 is bound by two identifiable scarps.

The lower is the southern end, and more indistinct extension of the Wylie Scarp [Lowry 1970], being formed by the sea level incursion which created the Israelite plain. This lower portion of the Wylie Scarp starts to the SE of Sheoaks Hill and it has a maximum height less than 100m. Compared to the main portion of the higher >125m elevation section of the Wylie Scarp to the north, this southern portion has a more rounded, deeply incised form reflecting a loss or reduction of the near surface indurated layer present on the Mardabilla Plain.

The second scarp is a low perpendicular scarp running WNW toward Mica Hill from the southern end of the higher portion of the Wylie scarp near Sheoaks Hill. The Mardabilla Plain ends at the top of this upper scarp where there is a drop in elevation of around 25m. The drop in elevation trends Southwest along the base of the Mica to Price Hill outcrops, then it trends WNW again becoming irregular and ill-defined in amongst more numerous bedrock outcroppings on the Eastern side of Balladonia Road. This higher scarp near Sheoaks hill is suggested to represent the northward limit of an incursion of a higher sea level at around 15-20m below the level of the Mardabilla plain. This is at a height above current sea level of approx 110-105m in this area. The area to the south of this higher scarp is uniformly undulating at an average close to 95m in elevation.


Scarps and spot heights of Region 2
Relict Dunes
Sand Dunes (Recent)
Moats and Depressions
Raised Topography
Basement Outcrops
Upper scarp 130->100m
Lower scarp 100->20m
Spot Heights SRTM derived
(Shuttle Radar Topography Mission)
Spot Heights
(GEODATA TOPO 250K)
Roads and Tracks
Contours 50m
Region Boundary
TOWER PEAK
MT SYMMONS
SCOTT ROCKS
GURA HILL
MICA HILL
Scorpion Depression
THE PUPS
THE DIAMONDS HILL
PRICE HILL
SHEOAKS HILL
Wylie Scarp
Upper scarp
betweeen 100m and 130m
Lower Scarp <100m
elevation
Region 2
This map incorporates data which is
© Copyright Commonwealth of Australia
- (Geoscience Australia) 2006


WorldWind Exagerated Elevation View West North West along Upper Scarp
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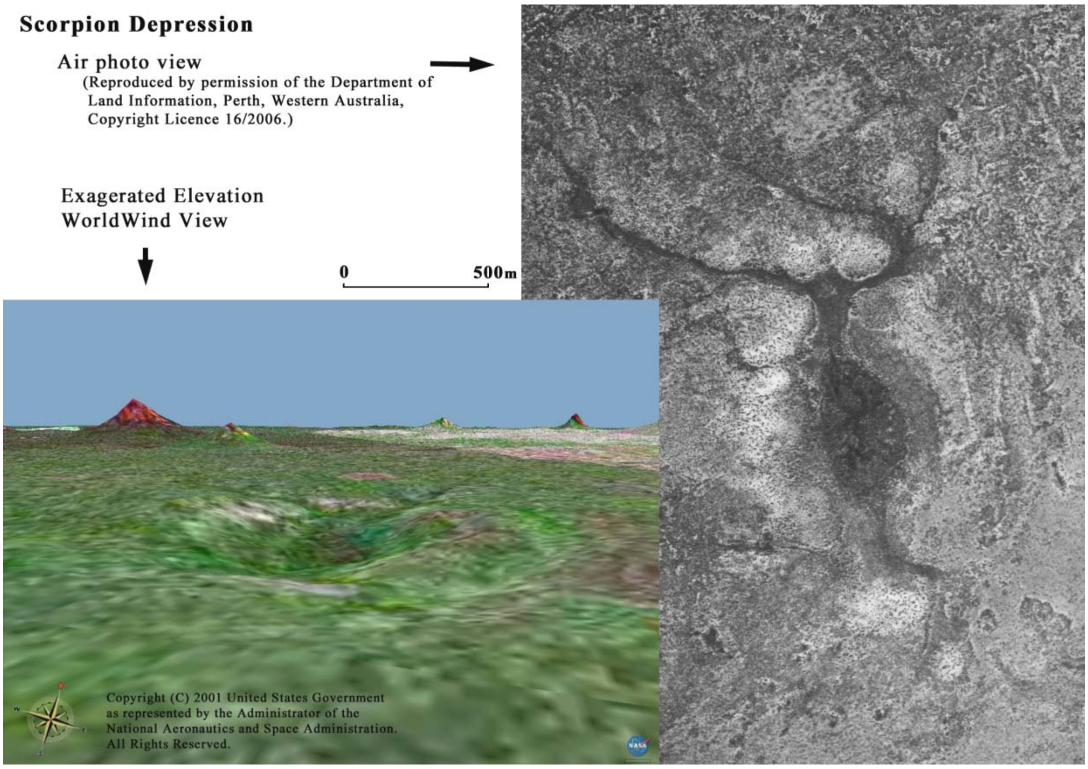
The area immediately to the north of this low E-W scarp in Region 3, shows an irregular surface, limited visual jointing control, and large areas of remnant dunes that appear mostly weathered and not well defined at ground level. In the western part there are at least two large enclosed depressions which drop more than 15m below the level of the Plain. The larger scorpion like shaped depression is 1400x750m and between 20-25m deep.



To the east of Mt Dean in Region 4, the Plain shows prominent parallel joint controlled shallow corridors.

These corridors are separated by low rises differing in elevation by only 3m increasing to approx 6m in the numerous shallow flats that are generally oriented but not limited to the corridor structures. Lineated corridors become less defined in the north of Region 4 but lineation is still strongly expressed in vegetation. Region 4 has a uniform structure expressed in its surface excepting isolated limestone knolls that protrude up from the surface in the region of 10-20m. A number of these knolls are tentatively suggested to define close to surface rises in bedrock strata that do not outcrop.

The Karst features of the SW Nullarbor – Mardabilla Plain & adjacent localities
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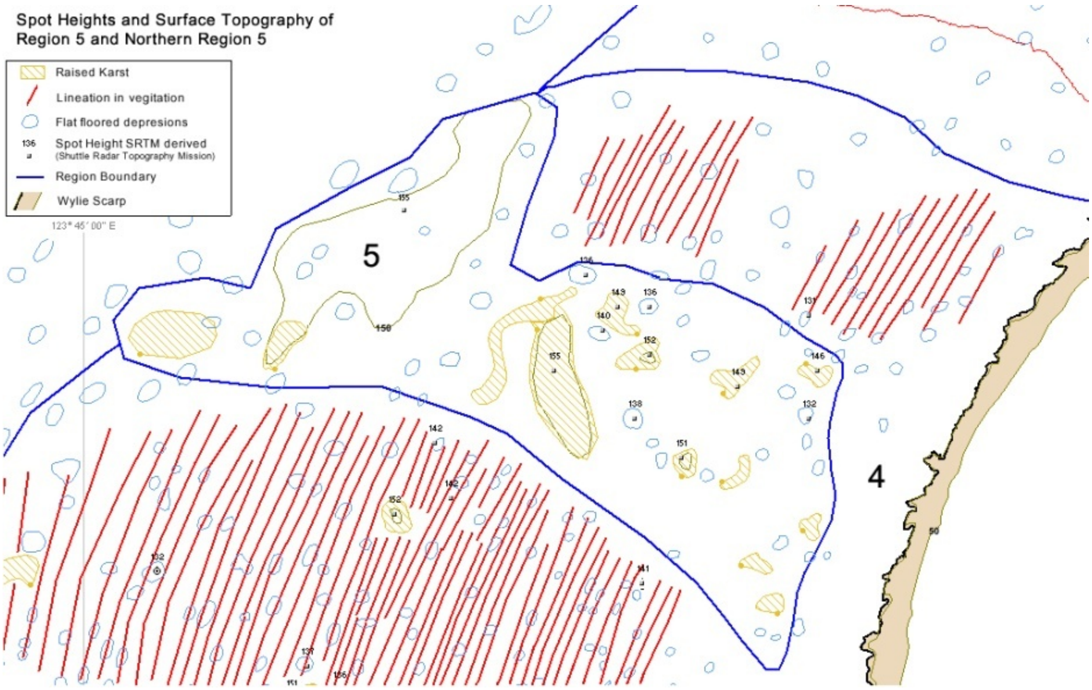
Crest of Wylie Scarp at north end of Region 4

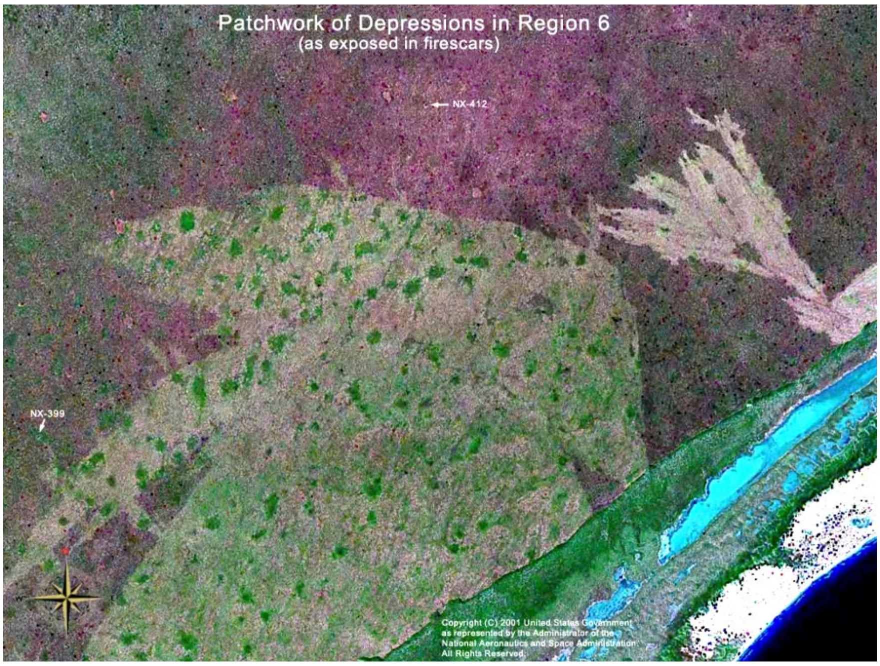
The scarp to the east shows a structure of a hard surface cap overlying layers of friable weathered limestone.

At a Point approx 45 km to the north of Sheoaks hill in Region 5, the level of the plain rises by approx 10m and the strongly lineated surface evident to the south disappears replaced with a more random patchwork of depressions surrounded by higher ground



The difference in elevation between the depressions and the rises increases to 10-16m.

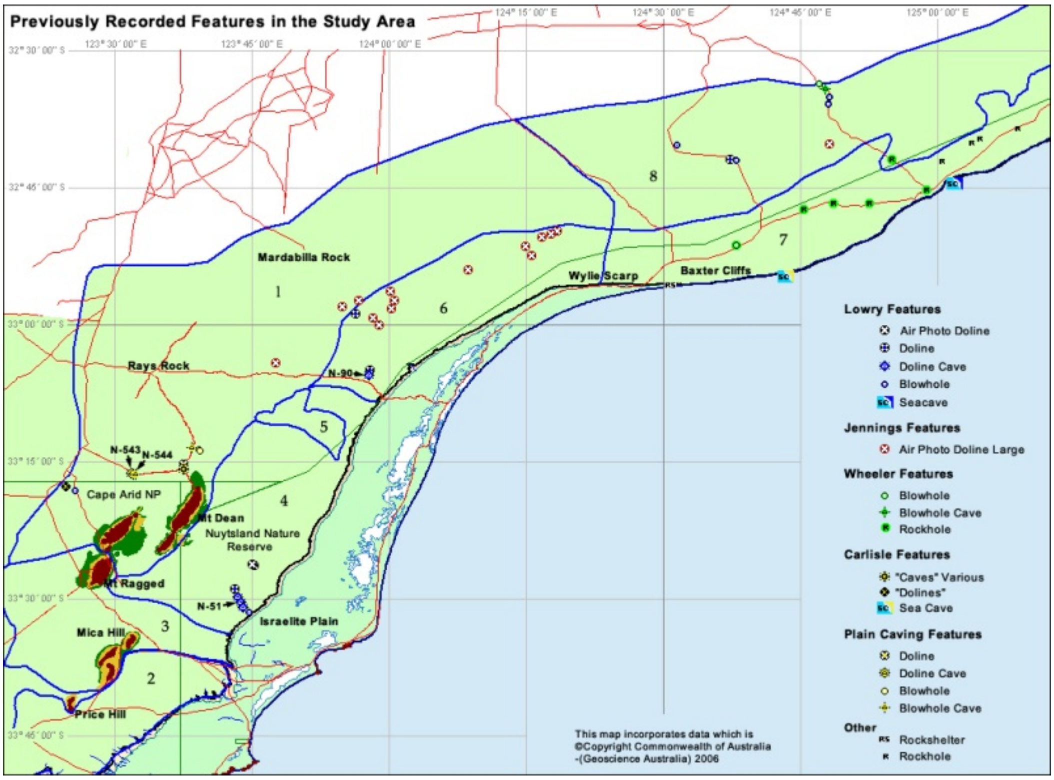
The area adjacent to the Wylie scarp the SE of Mardabilla Rock in Region 6, has an undulating terrain between a more random patchwork of large rounded donga like depressions



(Figure 11). Surface lineation is more subdued and for the most part is not expressed in surface relief. Further east in Region 7 toward the Baxter cliffs and beyond there is an increase in near coast sand dunes, and a change to an eroded more exposed karst surface along with a reduction in elevation close to the coast. This more exposed karst consists of a patchwork of limestone ridges and flats with lineal joint control. Both Regions 7 & 8 lie outside the Mardabilla plain. The less eroded karst further from the coast Region 8 is similar to the NE of region 1, having an increased surface soil cover than the coastal regions and an a patchwork of shallow bare flats.

Previous Features

In the area studied there are roughly 65 historical and described karst features (this does not include 8 records mostly of rockholes occurring in granite).



The Karst features of the SW Nullarbor – Mardabilla Plain & adjacent localities

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David Lowry recorded 13 features:- Gecko Cave - N-51 [ABC] that has an approximate 13m of passage, 5 other dolines [BC], 3 with shallow caves to approx 10m N-86, N-87, N-90, 2 without caves[BC] N-88, N-89 he also recorded 5 blowholes [C] N-318, NX-749, NX-750, NX-759, NX-760. He also mentions a number of other features were visited in the area, most of these were evidently not described. He did however, describe one doline Lowry Point-87[B], in the vicinity of NX-402, and he also circled 2 features on 1960 photography [B], these correspond to NXP-1005 and APP-A6/5177-02.

Joe Jennings whilst examining 1960 series air photos noted 17 features [C]. They are NX-396 – NX-412. To date it appears none of these features have been visited.

Harry Wheeler recorded 11 features [C]:- 4 blowholes including one cave, one doline with holes and 6 rockholes N-1149 to N-1152 and N-1155.

John Carlisle eludes to a number of features [C], one is NX-223 a sea cave. He mentions (NX-186 [C]) there are dolines in country east of road between Juranda RH and Pine Hill, and he also mentions (NX-282 [C]) that a number of caves exist in the vicinity near Kangawarie Rockhole. These are likely to also be included in around 8 features visited by members of Plane Caving[D] in the mid 1990's in this locality. Three of these features include N-543, to N-545 and access the longest recorded caves in the entire search area of this report at 35, 120, and 30m respectively [C].

One feature NX-374, a rock shelter in the Wylie Scarp is noted by Alex Baynes[CE].

A far higher number of features should exist in this area as indicated by the number of features located on the traverses completed by David Lowry.

The existence of these karst features is noted in statements David Lowry makes:- "East of Mt Ragged the surface of the plateau is broken by numerous craters 5 to 20 feet deep. Caused by the collapse of kankar crust into shallow caves." [Lowry 1970] and also "The air photos* indicate scores of other shallow dolines in the vicinity (of Gecko Cave) distributed along joints trending in a NE direction" [Lowry 1966].

**1960's Malcolm SI51-07 Aerial photography was 1:50000 scale, Balladonia along with the rest of the Nullarbor was a much lower resolution 1:83000 scale.*

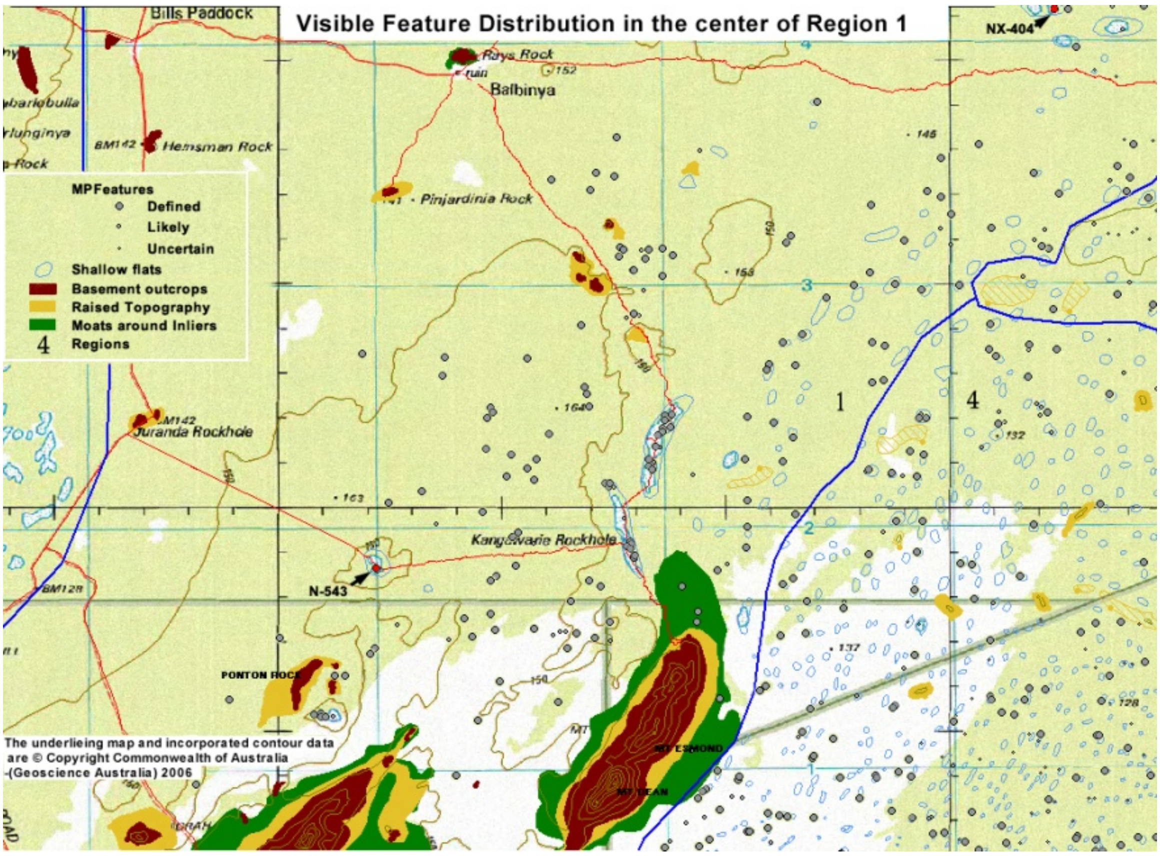
Data reference: [A] [Lowry 1966], [B] [Lowry 1964], [C] [KIDSA 2006], [D] [Norton 2004], [E] [Baynes 1987].

Methods

I made a detailed examination of the region using 1:50000 1990 series Black & White aerial photography, and followed this up by a further re-examination and recording of accurate positions for new MPF's by using Mosaiced & ortho-rectified SkyView imagery [LANDGATE 2003] along with Google Earth as hi resolution cover became available.

MPF Features

To date I have located roughly 1600 more clearly defined MP features along with around 1000 spurious possibilities APP's (Air Photo Points). The majority of the visible MPF's are more concentrated in the more eroded areas adjacent to the Scarp where jointing is most prominent and the karst surface is more relict.



Visible features in Region 1 are overall less well defined. Defined features are commonly associated with bare shallow flats or areas adjacent to knolls of outcropping basement. The greatest concentration of visible features in Region 1 is in and adjacent to the flats near Kangawarie Rockhole. Within the moat areas surrounding basement outcrops, although a number of shallow drainage channels exist, there are only 3 visible dolines present. These 3 are in the moat of the Brook Peak/Mt Esmond range.

South of the 2nd perpendicular scarp in Region 2 there is a change to a surface with a scattered pattern of randomly sized enclosed donga like depressions (Figure 15). This change is also accompanied by the absence of clearly defined collapse and degraded dolines. A number of vague shallow apparent subsurface draining, smaller depressions are present often associated with the donga like enclosures. The presence of surface outcrops of limestone along Fisheries Road to the east of Price Hill, the occurrence of donga like enclosed depressions, and the presence of these smaller possible erosion dolines suggests cavity development cannot be ruled out for this southern plain.

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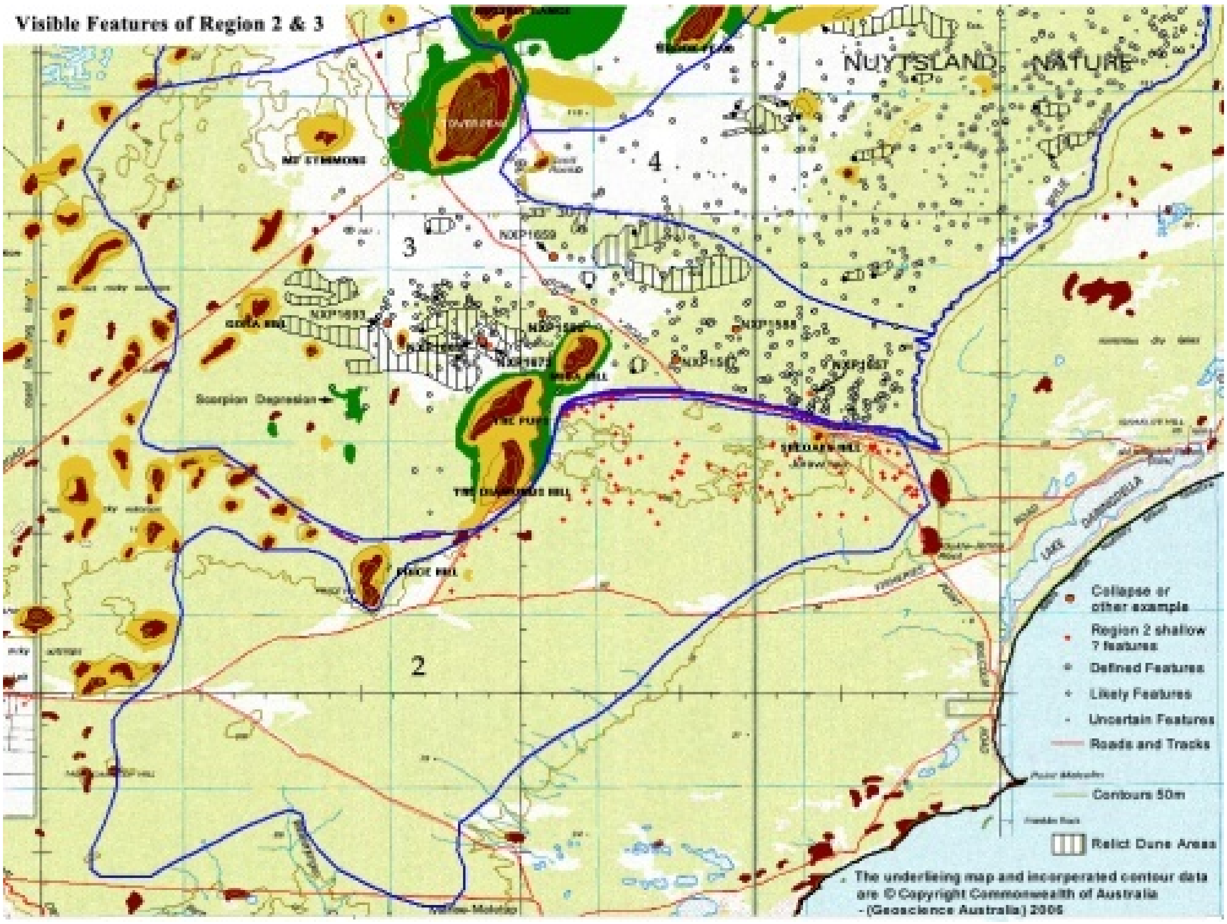


To the North of the 2nd scarp in Region 3 visible features appear more degraded.

Selection of Visible Features from Region 3

NXP-1669
Doline
Highly Degraded
typical in west

(bare after
second fire)

NXP-1657
Doline
Degraded
typical in east

(still vegetated
after one fire)

NXP-1590
Doline
exhibiting more
recent erosion

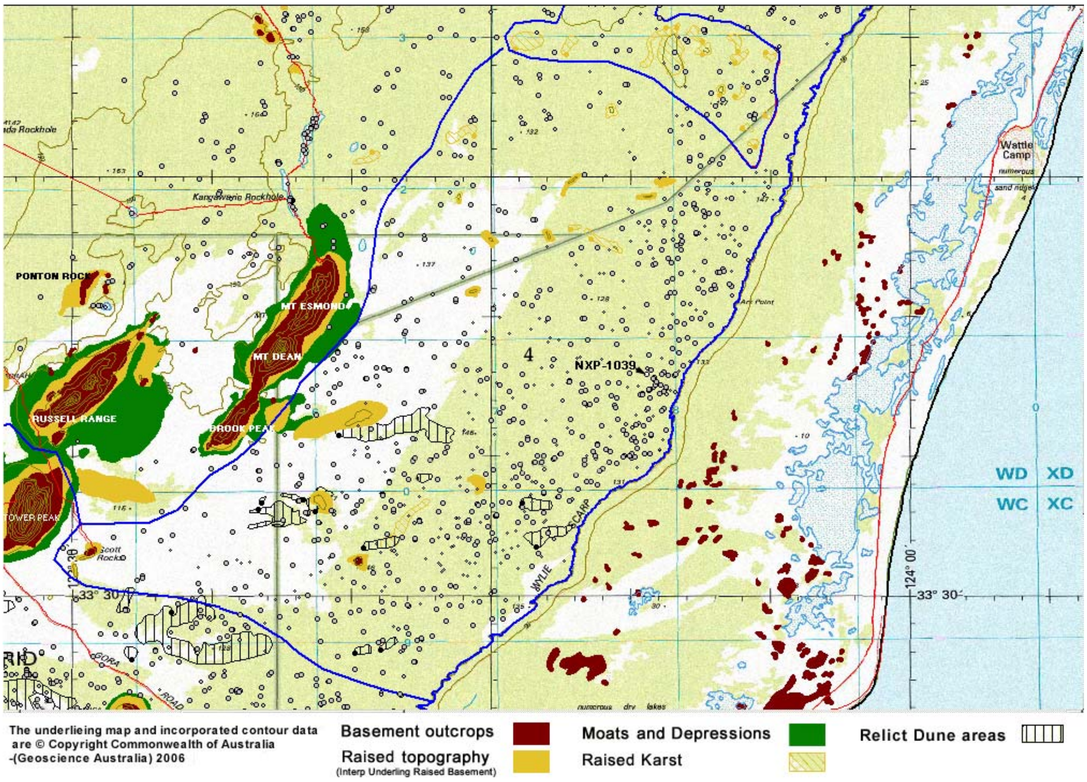
NXP-1673
Doline
with more
recent erosion

0 100m

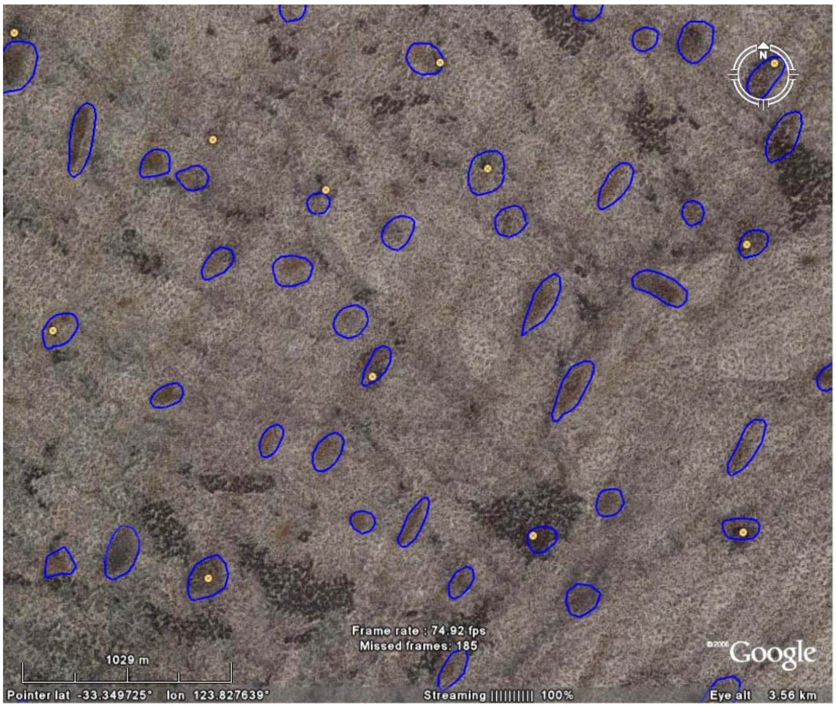
Collapse process is overall less prominent, and only a low percentage appear to exhibit recent erosion or collapse activity eg NXP-1587,1588. Degradation of features increases in the west and southwest. Of which there are a few exceptions such as NXP-1590 and NXP-1673.

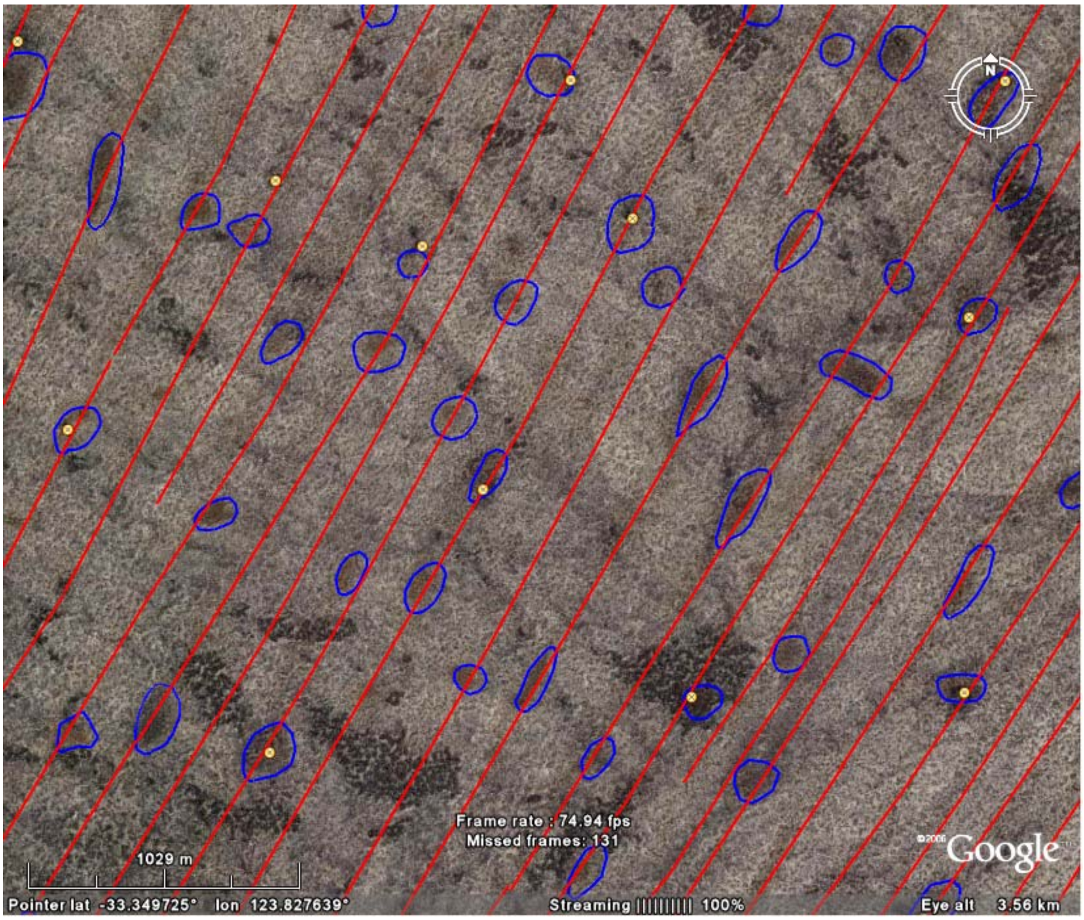
Visible features in the joint controlled Region 4 lie in the area that Lowry defined as the region of Gecko Caves.

Visible Features in Region 4

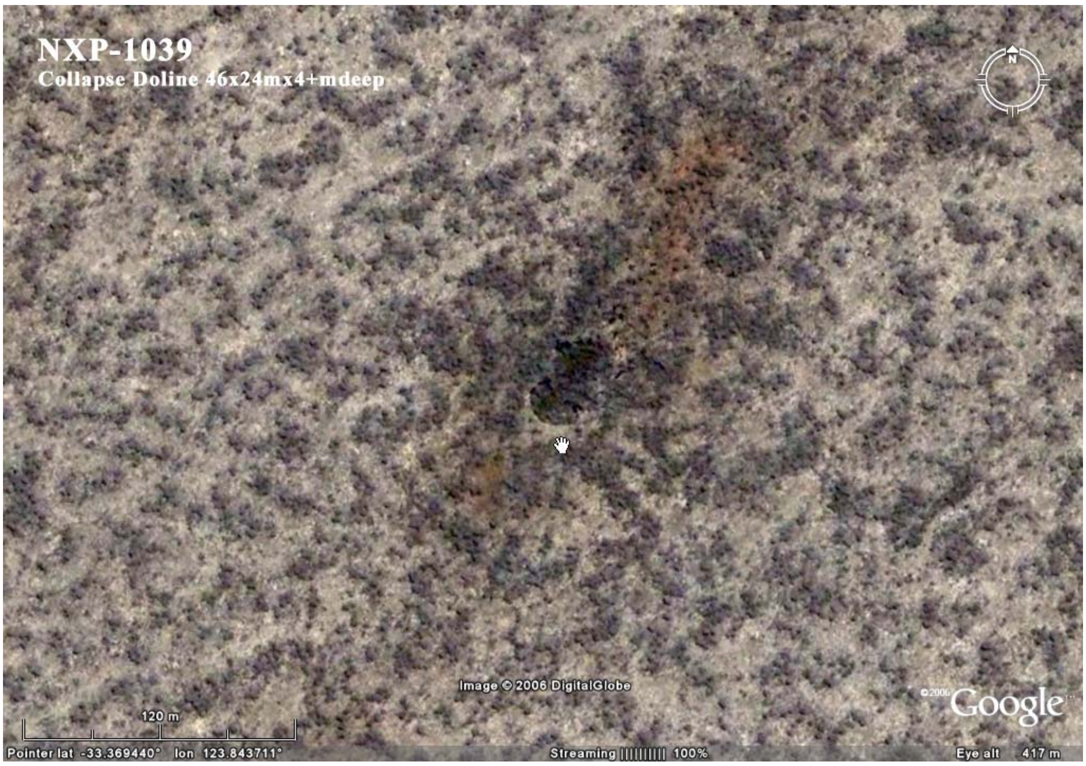


The MPF's in this region are commonly found on the peripheries of shallow flats whilst their location on the edges of these flats appears random, there is a clear association with the central trends of the corridors.



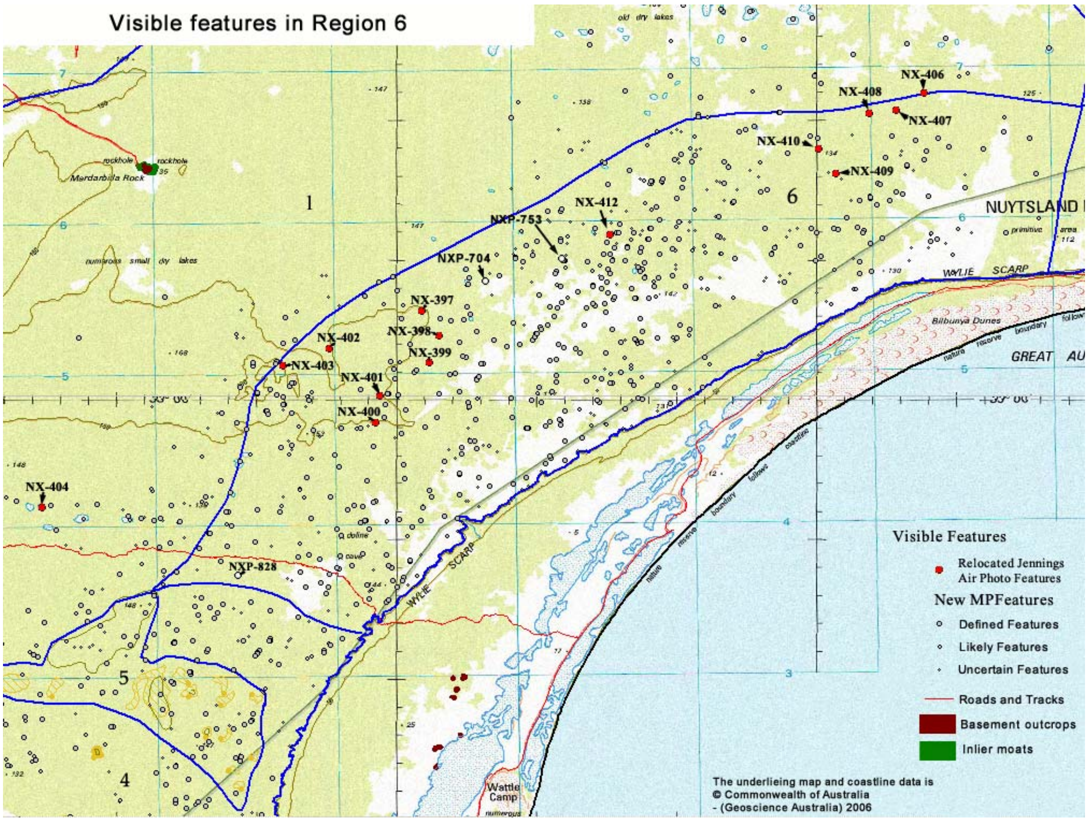


A lack of frequent prominent erosion surrounding features seems to suggest a shallower soil cover in depressed areas. Visible features in this region exhibit a range of from recent collapse such as in NXP-1039 to degraded collapse and various stages of sedimentation.

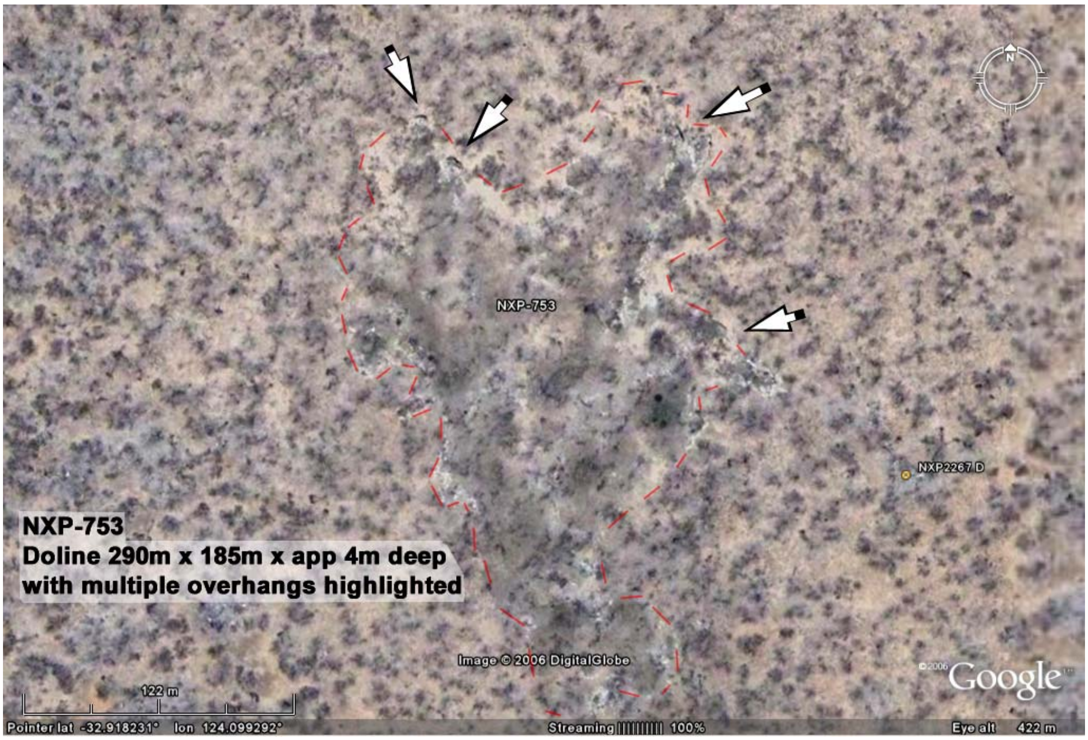


In Region 5 the area of greater relief, visible features consisting of multiple collapses are more locally concentrated in a patchwork of larger depressions.

Within the features visible in Region 6 there is a high number of widely distributed well defined collapse features. A large number are complex features.

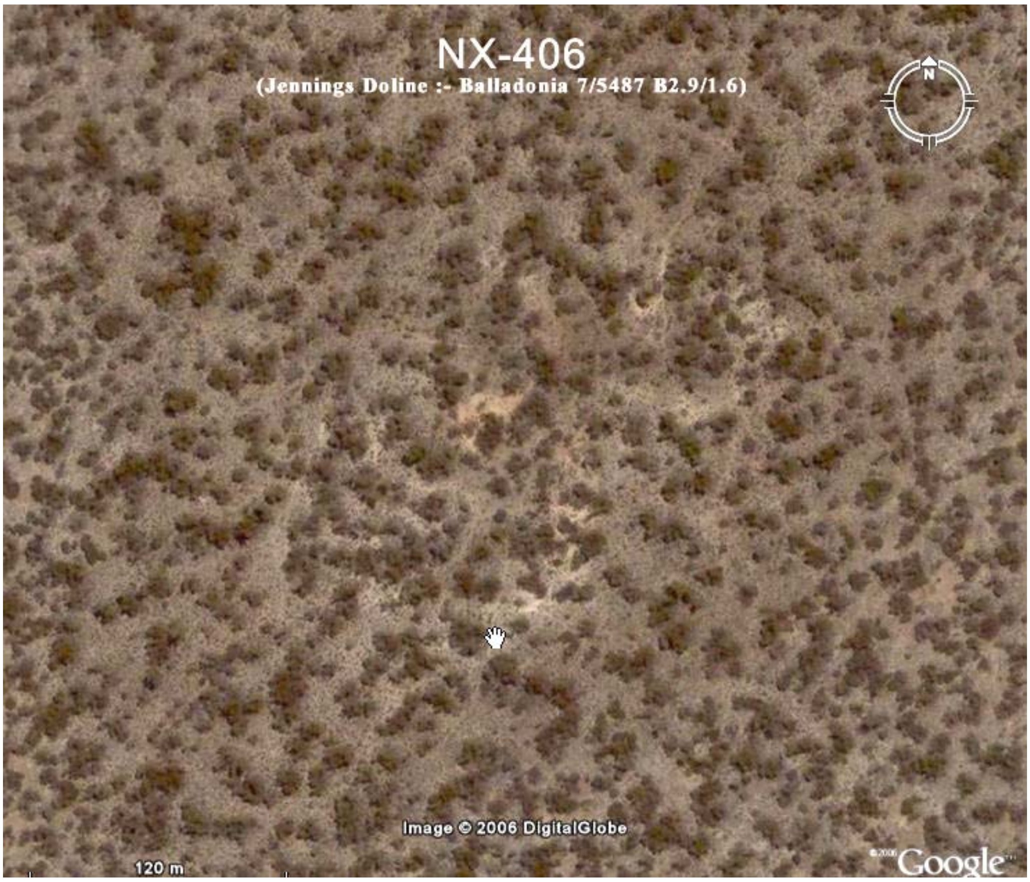


The largest feature which highlights this complexity is NXP-753 a feature 290x185m by and estimated minimum of 4m deep. This complex has at least 4 separate overhang areas with likely entrances.



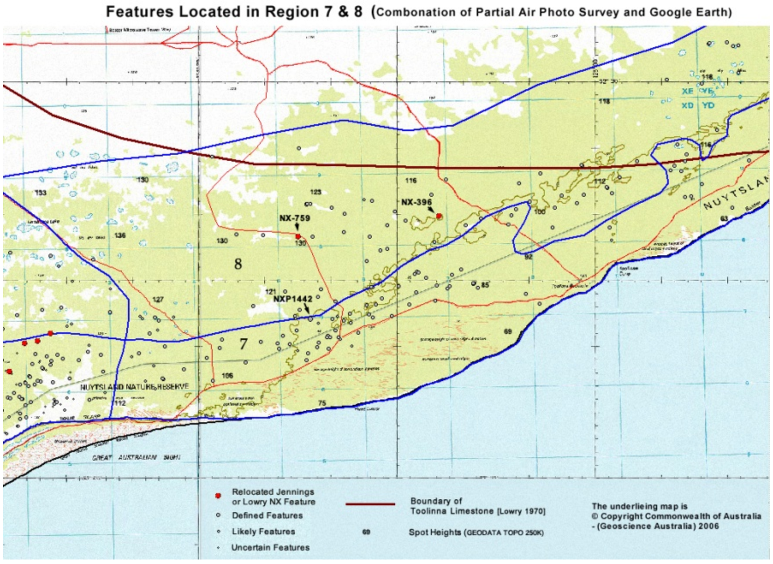
The Karst features of the SW Nullarbor – Mardabilla Plain & adjacent localities
Paul Devine

Within Region 6 there is again an association with the peripheries of enclosed donga like flats. Although the karst surface topography does not display prominent lineal corridor control in vertical relief or vegetation, patterns of feature locations and structure still suggest a strong correlation between jointing and feature location on a 32/122° $^{+}$/- 5° cross-jointing trend. There is an appearance of large erosion features such as NX-399 (200x150x5), NXP-828 (200x120x4m), NX-400, NXP-704, NX-412, suggesting an increase in soil thickness associated with the enclosed donga like depressions. A general increase in soil cover away from the coast in the NE of this area is reflected by the large highly degraded erosion dolines which form NX-410, 408 (210x150x3), 407, 406 (170x100x3)



Further east and north, well defined features become less frequent, less pronounced, and collapse appears to be largely absent.

Features Located in Region 7 & 8 (Combonation of Partial Air Photo Survey and Google Earth)

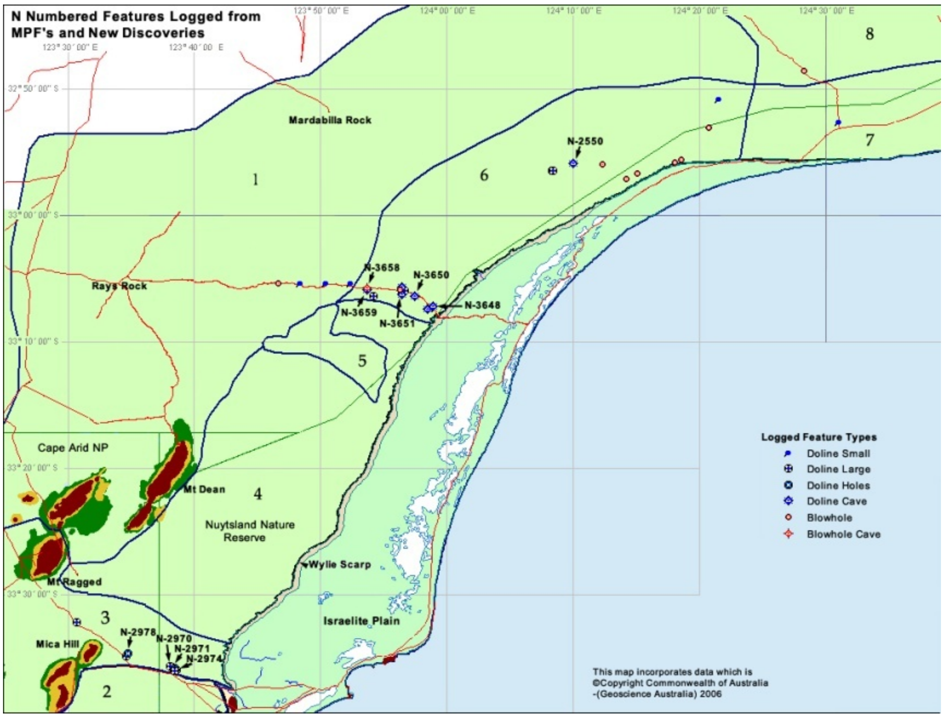


Visible features in Region 7 are more degraded in the exposed karst of the coastal strip but they show more detail from the northern margin. In Region 8 visible features appear predominantly as soil erosion dolines. The most pronounced erosion doline in this area is Jennings NX-396.

The only exception to the apparent lack of collapse in Region 7 & 8 is the 20m diameter NXP-1442.

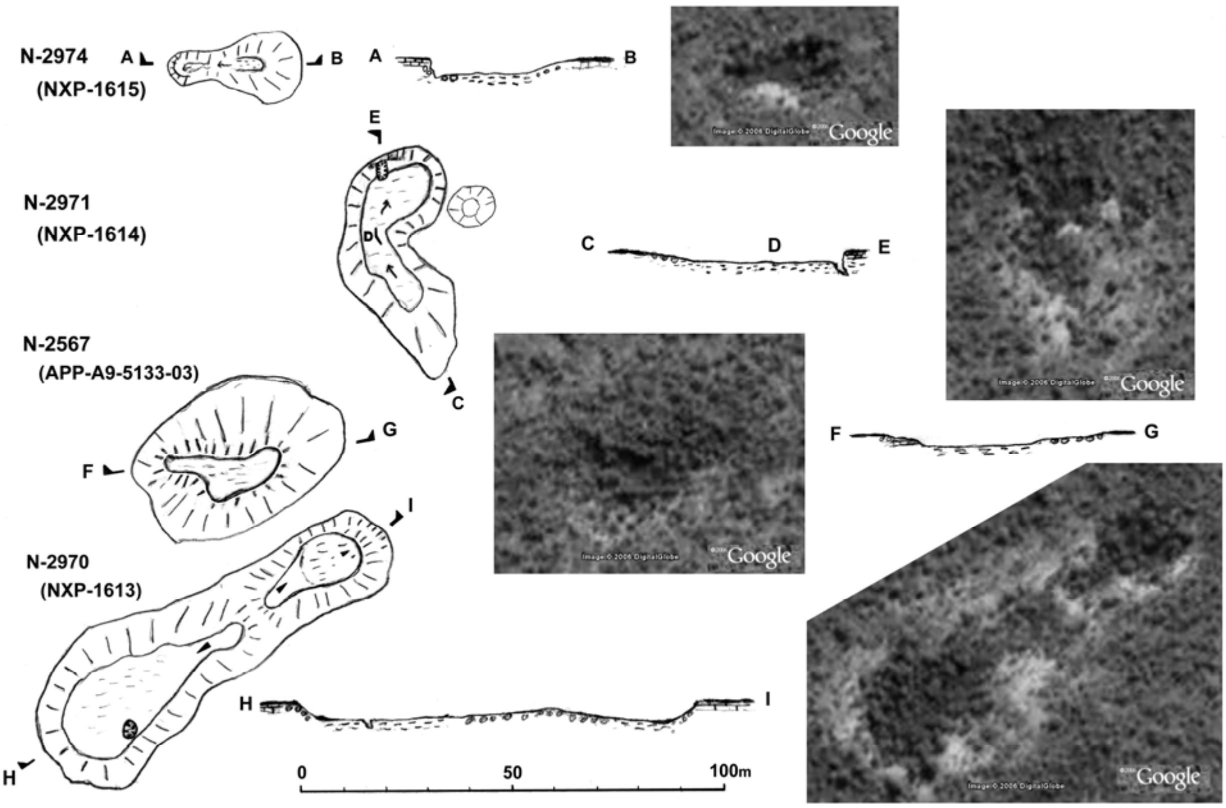
Visited Features

To date I have visited the locations of 26 MPF's. 22 of these were actual features. In the process an additional 20 features were located which I had not recorded on Air photos or Google Earth, making a total of 42 new features visited in the study area.



In Region 3, 10 MPF’s have been visited [Devine 2006], the 10 features located consisted of mostly degraded large dolines which ranged in depth between 2 to 4m; 3 dolines showed signs of recent activity; 2 were reactivation sinks N-2970 (NXP-1613), N-2971 (NXP-1614); and the other N-2978 (NXP-1587) had areas of recent collapse and (not entered) shallow development.

Examples of Visited Features in Region 3



In Region 6, 11 MPF’s were visited resulting in 10 features, along with an extra 14 features not seen via remote sensing. New features located consist primarily of blowholes (14) and smaller dolines (4). The 3 MPF’s visited in the NE of Region 6 [Devine 2005], consist of collapse dolines to 6m in depth with associated shallow caves although none of the features at the time were fully explored. The general form is collapse of surface limestone containing limited residual kankar into voids in underlying friable layers.

N-2550 (APP-B14/5175-09)
Chocolate Wattled Cave

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Paul Devine

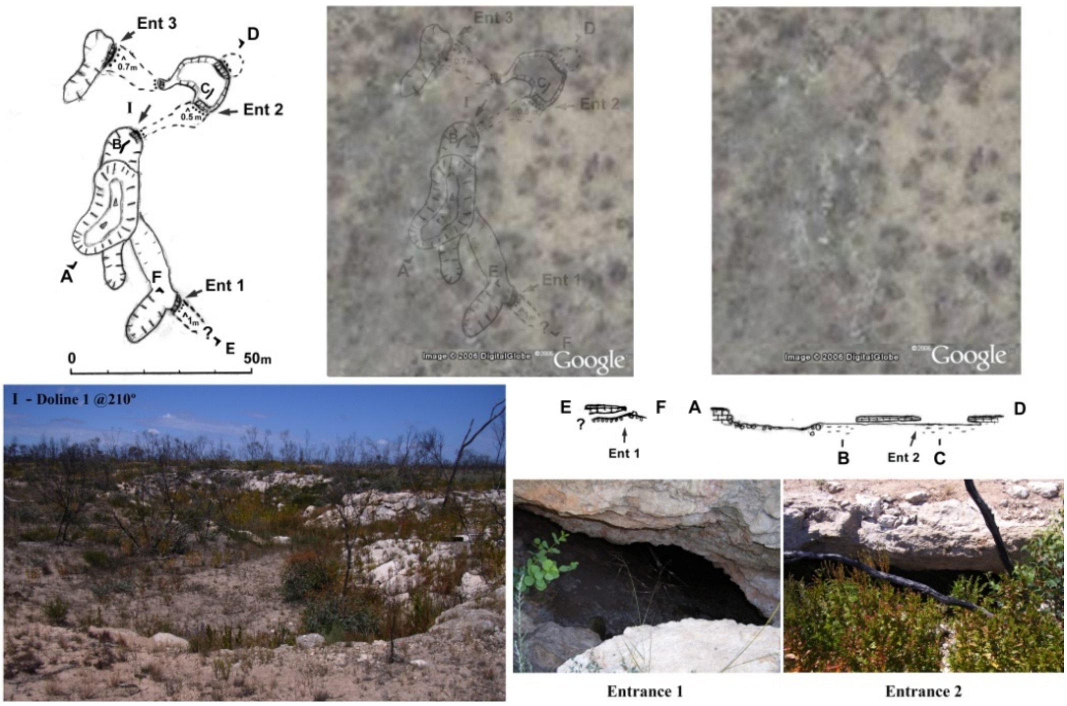
MPF’s visited in the SW of Region 6 consist primarily of collapse dolines, many are complex, nearly all have associated overhang caves in friable limestone.

One example was visited N-3657 (NXP828) of a large highly degraded (non active) doline N-3657 appears to be similar to a number of the larger Jennings Air Photo Dolines e.g. NX406-8, which are located further north. It was found to be 4.8m deep with the steepest side being <45º in the west. Off Google Earth the extent of erosion is roughly 195m x 120m.

N-3657 (NXP-828)
Large Degraded Erosion Doline

The only feature examined which was definitely noted as being formed solely beneath a kankar cap was located amid the same prominent corridor structure in which N-90 lies, 1.4km to the NNE. N-3650 consists of a collapse complex with multiple shallow flattener entrances under a layer of brecciated and nodular Kankar.

N-3650 - (NXP-2388) Doline shallow cave complex



The Karst features of the SW Nullarbor – Mardabilla Plain & adjacent localities
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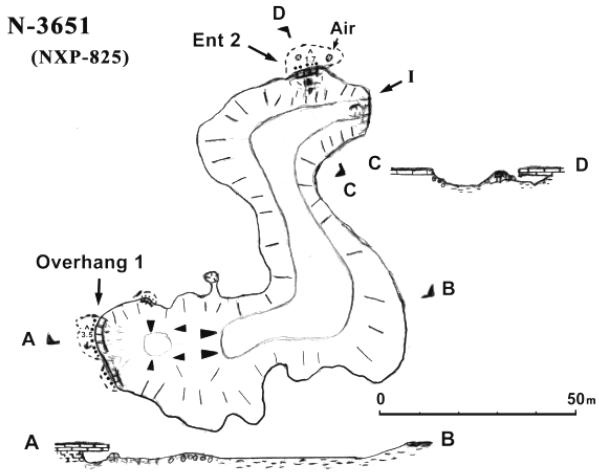
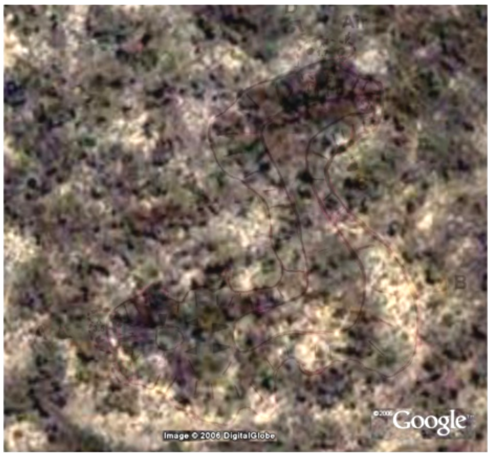
Most caves or entrances of examined MPF's appear to lack internal air movement unless it is caused by external sources, as with N-3650 where there are 2 connecting entrances. The only exception was in the north overhang cave of N-3651 (NXP-825) where exhaling air was present in floor sinks possibly indicating a further more significant extension to this system.



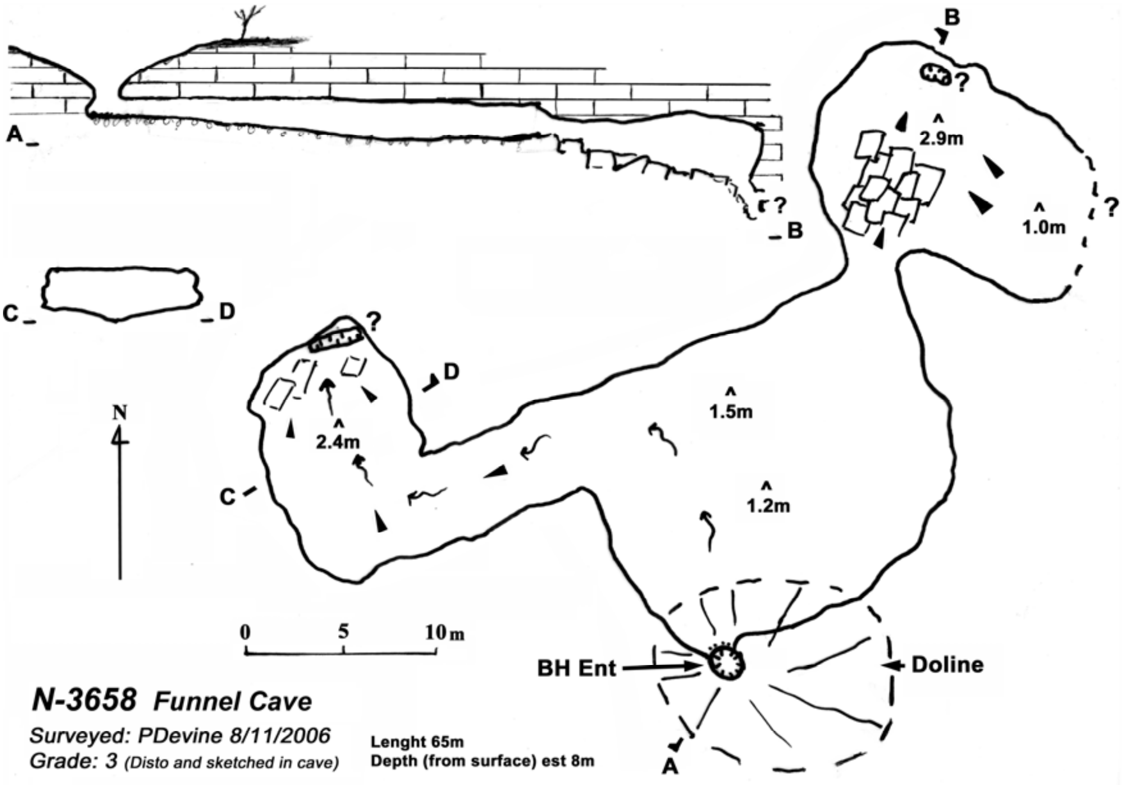


Overhangs extended up to 30m as read by disto from entrance of the still unexplored N-3659 (APP-A2/5254-07), and were found up to 25m in width.

3 p18

N-3648 (NXP-2561).

The largest cave explored was N-3658 Funnel Cave



The cave is entered via a conical blowhole, with 34m of passage measurable from the entrance and another 30m of side passage mostly 5-8m wide and 1.5-2.5m in height. There are three remaining leads, two are down to possible lower development.

Conclusions

The low number of previously recorded features in this area reflects more the difficulties in locating and in accessing the area due to the thick vegetation, not the lack of karst development.

Larger numerous surface features are concentrated in the more coastal regions of the Mardabilla Plain. Features appear to many differing stages of collapse, sedimentation and finally reactivation.

The region of shallow karst development for this area can be substantially extended.

The lithological relationship by which Lowry defined Gecko Type caves as to developing beneath a harder kankar cap is questioned, as it restricts the regional inclusion of similar shallow features developed by the same process of cavity development in friable layers beneath a non kankar layer. Whether the surface layer shows a presence or absence of kankar, or limestone, or shows a combination of both seems not as relevant as cavern form, process and possible levels of initiating development.

Lastly a further examination of these features is needed to establish the full subsurface extent for these systems, and hopefully reveal the level of precursor development.

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Acknowledgements

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Walli Cave Entrance Micro-organisms

Jill Rowling

Abstract

The entrances of Piano Cave and Bone Cave at Walli (NSW) were examined to see whether the colours of the coatings were due to minerals or organisms. Both mineral and biological coatings were found. Some of the orange colours are due to the rapid precipitation of calcium carbonate (white) together with either reddish clays or red algae, or both. The dark greens and blacks are colonies of a green algae, which appears emerald green under the microscope. A pale green colour can occur where this algae co-exists with rapidly precipitated calcium carbonate such as moonmilk, and may persist as microscopic emerald-coloured speckles a few millimetres into the precipitate, presumably according to the ambient light levels and the substrate porosity. A purple colour resulted from a reddish mineral substrate (carbonate-cemented clays) with microscopic colonies of emerald-green algae. Bryophytes also develop in the shaded parts of cave entrances, usually away from the most direct sunlight. Some organisms form a blue-green colour, coating moist speleothems where there is sufficient filtered ambient light. Two types of filamental blue-green organisms were observed under the microscope, and may be a symbiosis of fungus and cyanobacteria.

Introduction

Walli Caves (NSW) are located on private grazing property about 215 km west of Sydney. During a cave aragonite study, samples were obtained of the Cliefden Caves Limestone at the surface at Walli (Rowling 2004), some of which had surface coatings. It was apparent that some of the colours seen were a thin coating of calcium carbonate containing a biological colouring agent which was initially thought to be a red algae. A few years after collection, the surface samples were scraped to obtain some of the mainly white and pale orange coatings. The sample was sent to Dr Brett Neilan who heads the University of New South Wales School of Biotechnology and Biomolecular Sciences, where it was examined by students and staff at the School. Dr Neilan later commented that the material was “indeed a cyanobacterium ...most closely related to nitrogen-fixing filamentous species” and that one match of the material’s DNA was to a bacterium found in deep sea sediment. No fungus was detected in the sample, as it was old, however fresh samples might be more useful.

When a trip to Walli Caves was organised by Sydney Speleological Society in July 2006, this was seen as an opportunity to further study the coatings near cave entrances. Piano Cave and Bone Cave were chosen due to their ease of access and having been previously described and studied (Wilkinson 1892, Frank 1974).

Aims

The aim was to visit Piano Cave and Bone cave which have interesting coatings near the entrance with a biological component rather than the purely mineralogical components previously examined by Rowling (2004). It was hoped to identify what was the cause of the colour seen.

Materials and Methods

There are no particular restrictions on sampling imposed by the land owner. Permission to sample was obtained by personal communication to Peter Wellings of the Sydney Speleological Society and the trip leader. Samples were to be taken of the different types present, based on appearance. The caves chosen are relatively close to the camp site, and have a good representative collection of coloured coatings apparently due to micro-organism colonies. A steel blade was used to scrape the samples into new ziplock polyethylene bags, aiming to obtain about 1 g of material (about a heaped teaspoonful). Samples were to be taken from areas while preserving the natural appearance of the site, and photos were taken of the sampled areas. Part of each sample was transferred to a microscope slide for viewing, describing, and scanning.

Piano Cave observations

Piano Cave was visited on Saturday 8th July 2006 with members of Sydney Speleological Society including Ernie Byrnes, Larry Zanker and Steven Zanker and Jill Rowling. The weather was rather cold but the cave was warm and humid, typical for Walli. The group spent some time in the cave, mainly looking at historical signatures; Jill looked at some of the geomorphological features such as ceiling canyons and some evidence that warm water had risen into the cave from sumps and springs (Figure 1 map, GR 029 038). She suspects a peculiar crystalline calcite coating on a bedrock pendant in one chamber to be an original crystal lining, possibly dating to a thermal period of the cave's development. This calcite was previously described in Rowling (2004) (map GR 045 086, WA12/5).

Sampling was done by Jill (with Steven Zanker) on the way out, just outside the old gate, where it is dim but dark enough to need a light (map, Figure 1). Samples are discussed below.

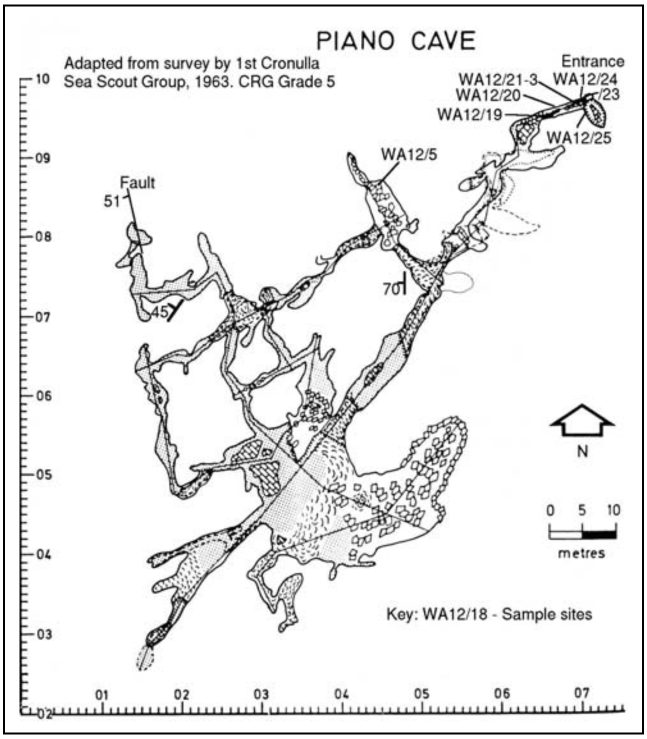

Figure 1: Piano Cave (plan): Sampled sites (Map based on Frank 1974).

Samples and Discussion - Piano Cave

Sample WA12/19

A reddish coating on stalactites and other speleothems just outside and south of the old cave gate and in the twilight zone is mainly mineral, comprising calcite and clays.

Sample WA12/20

A white coating on the otherwise black limestone bedrock of the entrance tunnel just outside and North East of the old cave gate, at about head height and in the twilight zone comprises minerals resembling gypsum and barite, characteristic of Walli as mentioned in Rowling (2004).

Sample WA12/21

The dark green stalactitic coating in a sheltered ceiling corner near the cave entrance (Figure 2) appears to be a mixture of green algae and bryophytes on a substrate of calcite moonmilk. The algae colonies occur throughout the moonmilk, indicating some light penetrates the porous material. The moonmilk holds water, which in turn supports the algae. Moonmilk is a particularly fine form of mainly calcium carbonate, often with a fibrous "thatch" structure due to biological activity. It can be made of needle-form calcite ("lublinite"), sometimes with small quantities of aragonite and vaterite, and is usually fairly quickly precipitated leading to a small crystal size.

Figure 2: Piano Cave: Sample site WA12/21, 22, 23 with various coloured coatings.

Sample WA12/22

The pinkish band between the green and grey areas appears to be mainly mineral, comprising a creamy white crystalline coating (probably calcite) over moonmilk. This is possibly a mixture of calcite, small quantities of aragonite and vaterite as it has an anomalous colour with UV (purple and green-white with afterglow), with underlying brown to reddish sediment (possibly illite cemented with calcite). A small amount of green material appears to be green algae (Figure 2).

Sample WA12/23

The blue-grey-green coatings near the North wall of the cave entrance is a fine grained mineral (probably calcite) coated with green algae, filamentous organisms and bryophytes. The filamentous organisms favour the finer grained material and appear to develop around the grains, presumably as they are sheltered. Some of the clear mineral grains have a high refractive index; at Walli this is commonly gypsum or barite.

Sample WA12/24

This sample appears purplish from a distance, comprising reddish coloured flakes and chips which are layered pink and green coatings on speleothems on the North wall of the cave entrance. The purple-colouring appears to be an optical effect caused by green algal colonies developing on porous reddish layered sediments, mainly calcite with clays. The algal colonies have typically developed between the mineral grains. The reddish outer layer appears to be calcite; below this is a layer of emerald green algal colonies. Below that is clear columnar calcite, then porous reddish material (possibly clays), a white layer (moonmilk) and more clays.

Sample WA12/25

The sheltered area near the cave entrance exposed intermittently to daylight is colonised by several organisms including bryophytes, green algae and two types of light grey-green filamentous bacteria forming coralloid shapes on the wall. The substrate is moonmilk and cave sediment comprising calcite and clays. Under the microscope, the green algae forms emerald-green spherical colonies. The filamentous material takes two forms. One form is easily visible under a microscope at 50x, and forms grey-green filaments 1 to 2 mm long and about 0.03 mm diameter, comprising emerald green interior filaments coated with a silvery exterior (possibly calcite), and glow weakly green under UV light. It is thought that these are calcite-coated bacterial threads (Figures 3 and 6). The other filamentous form is about an order of magnitude finer, hard to see under 70x magnification, and comprises a network of short filaments which can re-join forming green-grey threads a little like fungal hyphae. It is assumed that the second form is a different species to the first form. Possibly the colony is a symbiosis of cyanobacteria and a fungus. A purple fluorescence seen under UV light was thought to be caused by moonmilk.

Figure 3: Filamentous micro-organisms and bryophyte, Piano Cave entrance, scanned.

Bone Cave observations

Jill visited Bone Cave accompanied by Larry Zanker on Sunday 9th July 2006, a sunny, cold day and much warmer inside the small cave (Figure 4). The lower area of the cave had mildly elevated CO_2. Part of the ceiling has an interesting inverted canyon shape, reminiscent of past warm spring activity. The twilight area has coloured deposits (plant and mineral) on the walls. Four samples of coatings were taken, including some like white concrete, also pale green, blue-green and black coatings. The samples were all taken from the hanging wall inside the cave entrance, where the light is dimmer and a torch is needed (Figure 5).

Figure 4: Entrance, Bone Cave, with Kurrajong tree which drops leaves and nuts into the cave.

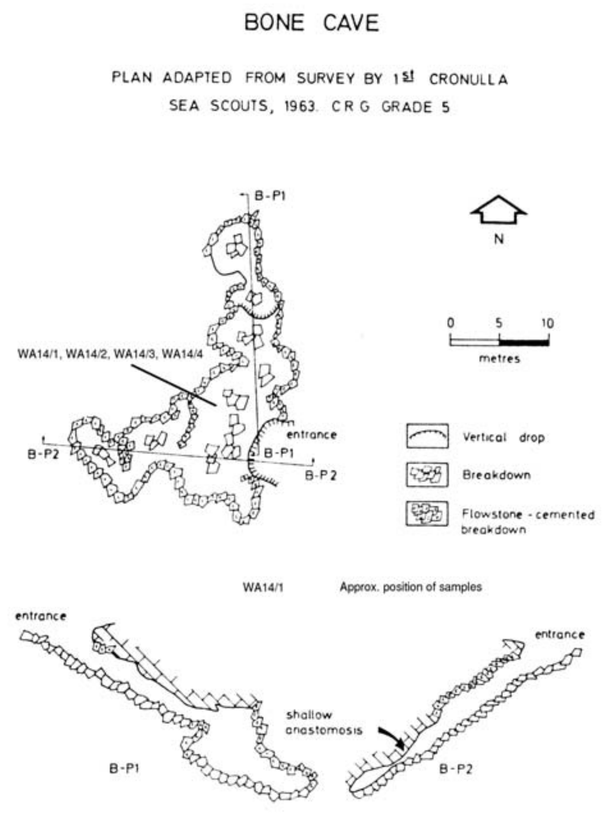

Figure 5: Bone Cave: Sampled sites (Map based on Frank 1974).

Samples and Discussion - Bone Cave

Sample WA14/1

The white concrete-like coralloids are mainly mineral (for example, calcite, huntite, aragonite and gypsum) with occasional spherical colonies of green algae buried in between the grains. Anomalous colours under long-wave UV light (yellow-white and purple with greenish afterglow) suggest mineral components are mainly calcite with some moonmilk (needle-form calcite possibly with trace aragonite and vaterite) and possibly some huntite. The presence of algae was surprising since the material did not look obviously green.

Figure 6: Filamentous micro-organisms, two types, on sediment from Bone Cave (scanned). Grains are about 1 mm diameter.

Sample WA14/2

The sample comprised blue-green “fluff” developed over a tan-coloured soft sediment. The soft crumbly sediment substrate is composed of calcite, clays and some organic material. The blue-grey-green fluffy material comprises two different types of organisms which have developed on the sediment. The organisms may be two types of cyanobacteria or a bacterium and a fungus, and are similar to the types observed in sample WA12/25, comprising a larger filamentous form (cyanobacteria) which can be seen on low power, and a very fine mesh networking form (possibly a fungus) which is seen under high power. The second type forms a three dimensional network (Figure 6). Under long wave UV light, the fluffy material fluoresced slightly purple.

Sample WA14/3

This dark green sample comprises mainly dark emerald green (to black) colonies of green algae, coating tan-coloured cave sediments. The layered sediment comprises reddish clays, clear columnar calcite crystals and possibly some small quantities of aragonite (or a paramorph of calcite after aragonite). The green algal colonies coat the sediment grains and lie between the crystals.

Sample WA14/4

The sample comprises scrapings of the light green material from coralloids. The mineral component appears to be calcite with some moonmilk (needle-form calcite, possibly trace aragonite and vaterite) and possibly some huntite based on the long wave UV response (glows purplish and white with a short, green afterglow). The biological component is made of small emerald-green colonies of algae amongst the grains.

Conclusions

Many of the reddish brown colours seen near cave entrances are due to a thin covering of clear and white calcite over cave sediments including calcite and reddish clays. White coatings and soft deposits may be moonmilk, mainly calcite and possibly small quantities of aragonite or vaterite, often with an organic component. The light green coatings on the white deposits are small emerald green colonies of green algae developed on clear calcite and white "moonmilk" (mixture of possibly calcite and small quantities of aragonite). The shade of green is determined by the density of colonies. Dark green coatings are usually dense colonies of green algae (emerald green under the microscope). Black coatings near the cave entrance are usually dense colonies of algae. These are usually black to emerald green under the microscope, suggesting possibly two different species. The blue-green and grey-green coatings are dense colonies of at least two different species, possibly cyanobacteria and fungus. One (bacterium) type forms long filaments which are apparently coated with calcite, and the other (fungal) type forms a fine mesh of thinner green filaments, also possibly with a calcite coating. Bryophytes colonise the lighter areas, where they compete with cyanobacteria, fungus and algae, depending on available light, soil and water.

Acknowledgements

Particular thanks are given to Dr. Brett Neilan and students at the University of New South Wales School of Biological and Biomolecular Sciences for their insight into the types of micro-organisms to be encountered near cave entrances. Thanks are given to members of the Sydney Speleological Society for enthusiastically supporting the trip.

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Appendix

Summary of Samples

Table 1 lists the sampled material.

Table 2 suggests the composition of the sampled material.

Sample No.	Cave	Location	General Appearance
WA12/19	Piano	Dark/twilight zone, map GR 067 095	Reddish coating on speleothems
WA12/20	Piano	twilight zone, map GR 068 096	White coating on bedrock
WA12/21	Piano	sheltered zone, ceiling, map GR 070 096	Green coating on white powder
WA12/22	Piano	sheltered zone, ceiling, map GR 070 096	Pinkish powder
WA12/23	Piano	sheltered zone, ceiling, map GR 070 096 & sheltered zone, map GR 072 097	Blue-green powder
WA12/24	Piano	sheltered zone, ceiling, map GR 071 097	Reddish flakes
WA12/25	Piano	entrance wall, map GR 071 095	Green and grey fluff
WA14/1	Bone	Hanging wall, base of rubble pile	White powder
WA14/2	Bone	Hanging wall, base of rubble pile	Blue-green fluff
WA14/3	Bone	Hanging wall, base of rubble pile	Dark green material
WA14/4	Bone	Hanging wall, base of rubble pile	Light green material

Table 1: Samples from the entrances of Piano Cave and Bone Cave, Walli Caves.

Sample No.	Suggested mineral components	Suggested biological components
WA12/19	calcite, clays	-
WA12/20	gypsum, barite	-
WA12/21	"lublinite" calcite, trace aragonite, vaterite	Green algae and actinomycetes (in moonmilk)
WA12/22	"lublinite" calcite, clays	actinomycetes (in moonmilk)
WA12/23	"lublinite" calcite, trace gypsum or barite	filamentous cyanobacteria
WA12/24	calcite, clays	green algae
WA12/25	"lublinite" calcite	filamentous cyanobacteria, fungus, bryophytes, green algae
WA14/1	"lublinite" calcite, trace aragonite, vaterite, huntite	green algae
WA14/2	"lublinite" calcite, clays	filamentous cyanobacteria, fungus
WA14/3	calcite, clays, trace aragonite	green algae
WA14/4	"lublinite" calcite, trace aragonite, vaterite, huntite	green algae

Table 2: Estimated composition of samples.

Walli Cave Entrance Micro-organisms

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A trip to Walli Caves organised by Sydney Speleological Society in July 2006 was an opportunity to further examine the coatings near cave entrances.

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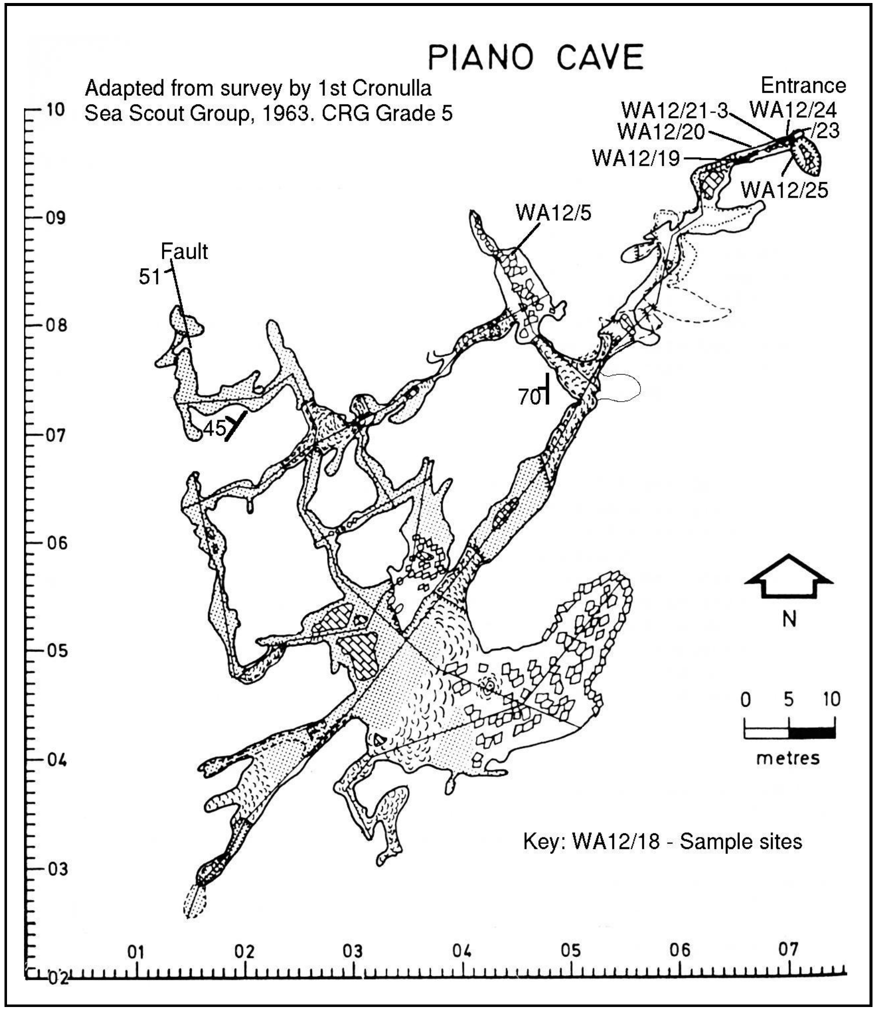

Figure 1: Piano Cave (plan): Sampled sites (Map based on Frank 1974).

Samples and discussion - Piano Cave

Sample WA12/19

A reddish coating on stalactites and other speleothems just outside and south of the old cave gate and in the twilight zone is mainly mineral, comprising calcite and clays. The red may be either humic acids or iron oxides (or both).

Figure 2: Sample WA12/19.

Sample WA12/20

A white coating on the otherwise black limestone bedrock of the entrance tunnel just outside and North East of the old cave gate, at about head height and in the twilight zone comprises minerals resembling gypsum and barite, characteristic of Walli (Rowling 2004).

Figure 3: Sample WA12/20.

Sample WA12/21

Figure 4: Looking towards Piano Cave entrance.

A dark green stalactitic coating in a sheltered ceiling corner near the cave entrance appears to be a mixture of green algae and bryophytes (mosses and liverworts) on a moonmilk substrate (often needle-form calcite, trace aragonite and vaterite). Algal colonies occur throughout the moonmilk, indicating some light penetrates the porous material. The moonmilk holds water, which in turn supports the algae.

Figure 5: Piano Cave: Samples WA12/21, 22, 23 with coloured coatings.

Sample WA12/22

The pinkish band between the green and grey areas appears to be mainly mineral, comprising a creamy white crystalline coating (probably calcite) over moonmilk. This is possibly a mixture of calcite, small quantities of aragonite and vaterite as it has an anomolous colour with UV (purple and green-white with afterglow), with underlying brown to reddish sediment (possibly clays cemented with calcite). A small amount of green material appears to be green algae.

Figure 6: Coloured coatings, Piano Cave.

Sample WA12/23

The blue-grey-green coatings near the North wall of the cave entrance comprise a fine grained mineral (probably calcite) coated with green algae, filamentous organisms and bryophytes. The filamentous organisms favour the finer grained material and appear to develop around the grains, presumably as they are sheltered. Some of the clear mineral grains have a high refractive index; at Walli this is commonly gypsum or barite.

Sample WA12/24

This sample appears purplish from a distance, comprising reddish coloured flakes and chips which are pink and green layers on speleothems on the North wall of the cave entrance. The purple-colouring appears to be an optical effect caused by tiny green algal colonies developing on porous reddish layered sediments, mainly calcite with clays. The algae typically grows between the mineral grains. The reddish outer layer appears to be calcite; below this is a layer of emerald green algal colonies. Below that is clear columnar calcite, then porous reddish material (possibly clays), a white layer (moonmilk) and more clays.

Sample WA12/25

Figure 7: Sample WA12/25.

Several organisms form green cave coral shapes on the wall near the entrance, intermittently exposed to daylight: bryophytes, green algae and two types of microscopic, light grey-green filamentous organisms. The substrate is moonmilk and cave sediment (calcite and clays).

Under the microscope, green algae forms emerald-green spherical colonies. The filamentous material takes two forms.

Grey-green filaments are visible under the microscope at 50x. They are 1 to 2 mm long and about 0.03 mm diameter, comprising emerald green inner filaments with a silvery outer coating (possibly calcite), and glow weakly green under UV light. They may be calcite-coated bacterial threads (Figure 8).

Figure 8: Sample WA12/25.

The other filamentous form is about an order of magnitude finer, hard to see under 70x magnification, and comprises a network of short, grey-green filaments which re-join, resembling fungal hyphae.

Possibly the whole colony is a symbiosis of cyanobacteria and a fungus.

A purple fluorescence seen under UV light was thought to be caused by moonmilk.

Bone Cave observations

Jill visited Bone Cave accompanied by Larry Zanker on Sunday 9th July 2006, a sunny, cold day and much warmer inside the small cave (Figure 9). The entrance area was littered with Kurrajong leaves and nuts.

Figure 9: Entrance, Bone Cave, with Kurrajong tree.

The lower area of the cave had mildly elevated CO_2. Part of the ceiling has an interesting inverted canyon shape, reminiscent of past warm spring activity. The twilight area has coloured deposits (plant and mineral) on the walls. Four samples of coatings were taken, including some like white concrete, also pale green, blue-green and black coatings. The samples were all taken from the hanging wall inside the cave entrance, where the light is dimmer and a torch is needed (Figure 10).

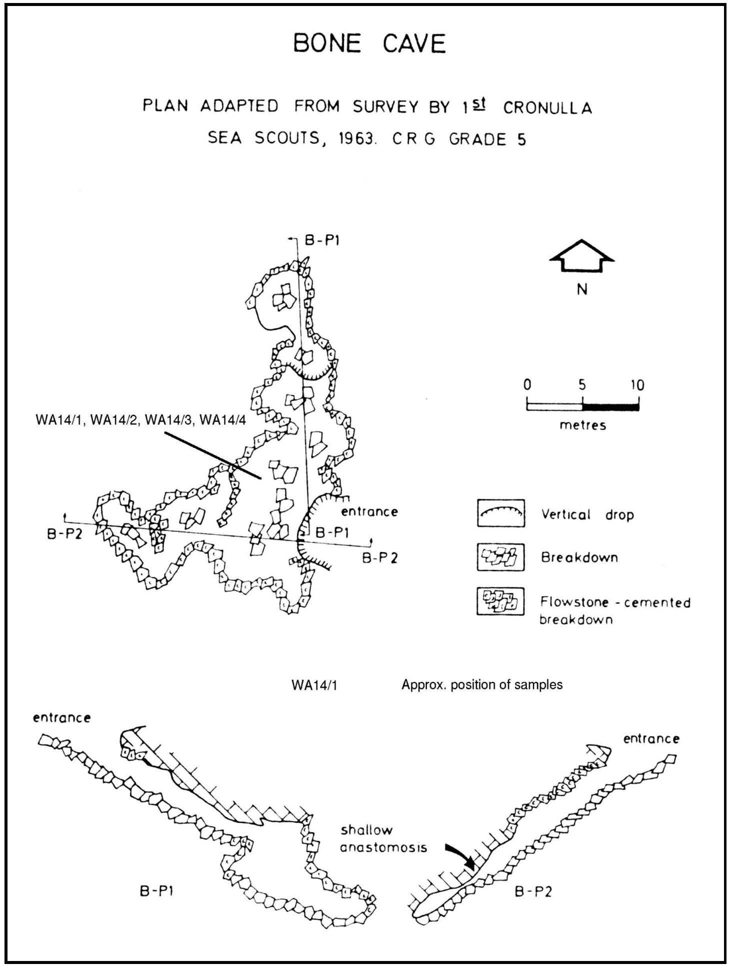

Figure 10: Bone Cave sampled sites (Map based on Frank 1974).

Samples and discussion - Bone Cave

Figure 11: Coloured deposits on the hanging wall, Bone Cave.

Sample WA14/1

Figure 12: Sample WA14/1.

Concrete-like white coralloids are mainly mineral with occasional spherical colonies of green algae between the grains. Anomalous colours under long-wave UV light (yellow-white and purple with greenish afterglow) suggest mainly calcite with moonmilk (mostly needle-form calcite) & possibly huntite.

Sample WA14/2

Blue-grey-green “fluff” has developed over a tan-coloured sediment of calcite, clays and organic material. Two different types of organisms are present, similar to WA12/25, namely a larger filamentous form (cyanobacteria) which can be seen on low power, and a very fine mesh form (possibly fungus), visible only under high power (Figure 13). Under long wave UV light, the fluff fluoresced slightly purple so it may have a carbonate coating such as calcite or vaterite.

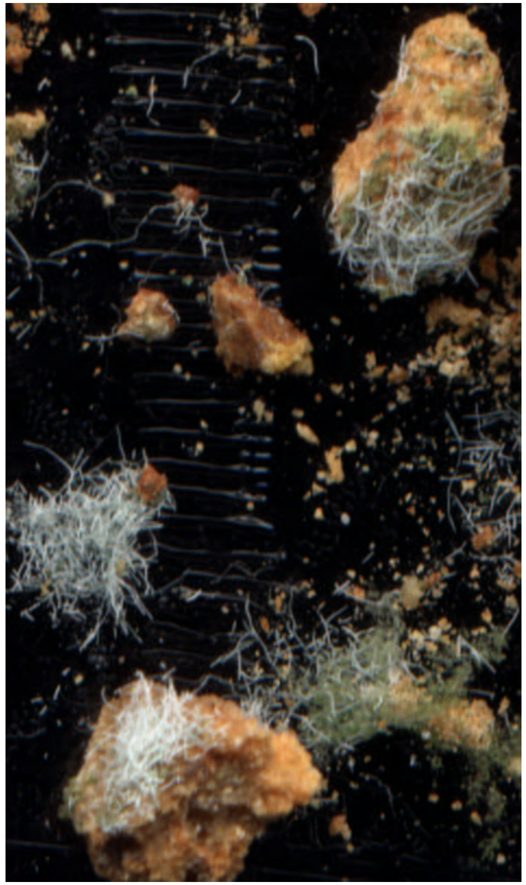

Figure 13: WA14/2.

Sample WA14/3

This dark green sample comprises mainly dark emerald green (to black) colonies of green algae, coating tan-coloured cave sediments. The layered sediment comprises reddish clays, clear columnar calcite crystals and possibly some aragonite (or a paramorph of calcite after aragonite). The green algal colonies coat the sediment grains and lie between the crystals.

Sample WA14/4

The sample comprises scrapings of the light green material from coralloids. The mineral component appears to be calcite grains, moonmilk and possibly some huntite based on the long wave UV response (glows purplish and white with a short, green afterglow). The biological component is made of small emerald-green colonies of algae amongst the grains.

Figure 14: Sample WA14/4.

Conclusions

Some reddish-brown colours seen near cave entrances at Walli are due to a thin covering of clear and white calcite over cave sediments including calcite and reddish clays. Purplish colours result from an optical effect of emerald-green algae colonies on reddish-brown sediment. White coatings and soft deposits may be moonmilk, mainly calcite with possibly small quantities of aragonite or vaterite, often with an organic component. The light green coatings on the white deposits are small emerald green colonies of green algae developed on clear calcite and white moonmilk.

Figure 15: Coloured coatings, Bone Cave.

The shade of green is determined by the density of colonies.

Dark green coatings are usually dense colonies of green algae (emerald green under the microscope).

Black coatings near the cave entrance are usually dense colonies of green algae, black to emerald green under the microscope, suggesting possibly two different species.

Figure 16: Coloured coatings, Bone Cave.

The blue-green and grey-green coatings are dense colonies of at least two different species, possibly cyanobacteria and fungus. One (bacterium) type forms long filaments which are apparently coated with calcite, and the other (fungal) type forms a fine mesh of thinner green filaments, also possibly with a calcite coating.

Bryophytes colonise the lighter areas, where they compete with other organisms, depending on available light, soil and water.

Figure 17: Coloured coatings, Bone Cave.

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Wilkinson, C. S. (1892), 'Description of the Belubula Caves, Parish of Malongulli, Co. Bathurst', *Records of the Geological Survey of N.S.W.* **III**(1), 1–5, plates I–III.

Acknowledgements

Particular thanks are given to Brett Neilan and students at the University of New South Wales School of Biological and Biomolecular Sciences for their insight into the types of microorganisms to be encountered near cave entrances.

Thanks are given to members of the Sydney Speleological Society for enthusiastically supporting the trip.

Sea caves or Flank margin caves: do we understand cave formation at Tantanoola and Taragal?

Susan White, John Mylroi & Joan Mylroi

Sea Caves or Flank Margin Caves

Do we understand cave formation in coastal areas?

Susan White (Latrobe University, Bundoora),
John Mylroie & Joan Mylroie
(Mississippi State University)

Acknowledgements

Ken Grimes
Nicholas White

Sea Caves or Coastal Caves

What is the difference?

- **Sea caves** are formed by the MECHANICAL action of the sea
- **Coastal caves** occur on or near the coast and may have several mechanisms of formation.

Background

- Marine water is saturated in $CaCO_2$
- $CaCO_2$ does not usually dissolve in sea water
- Sea Caves form by mechanical action of the sea
- Many coastal caves are not sea caves

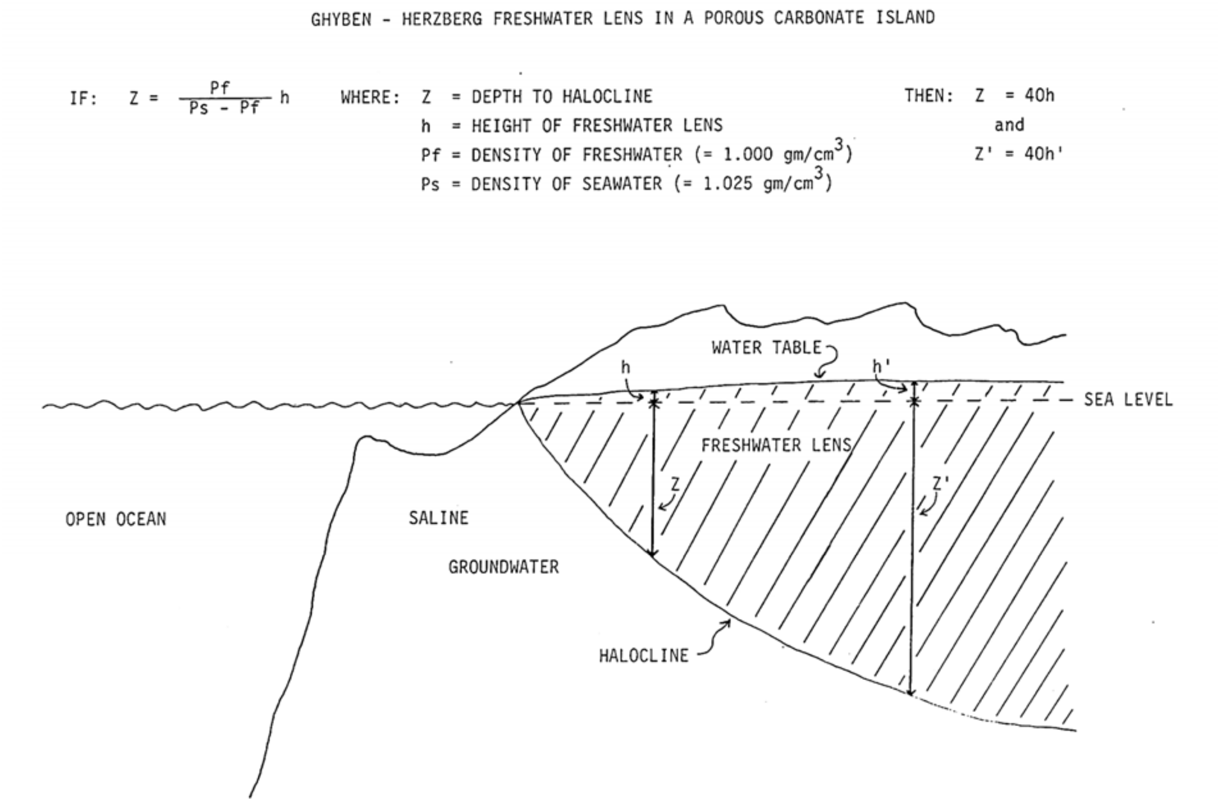
Flank Margin Caves

- Many caves are formed in a flank margin setting
- Based on Bahamas & Pacific island eg Marianas, studies over last 25 years.
- Now can be applied to continental settings such as south coast of Australia.

Carbonate Island Karst Model, CIKM

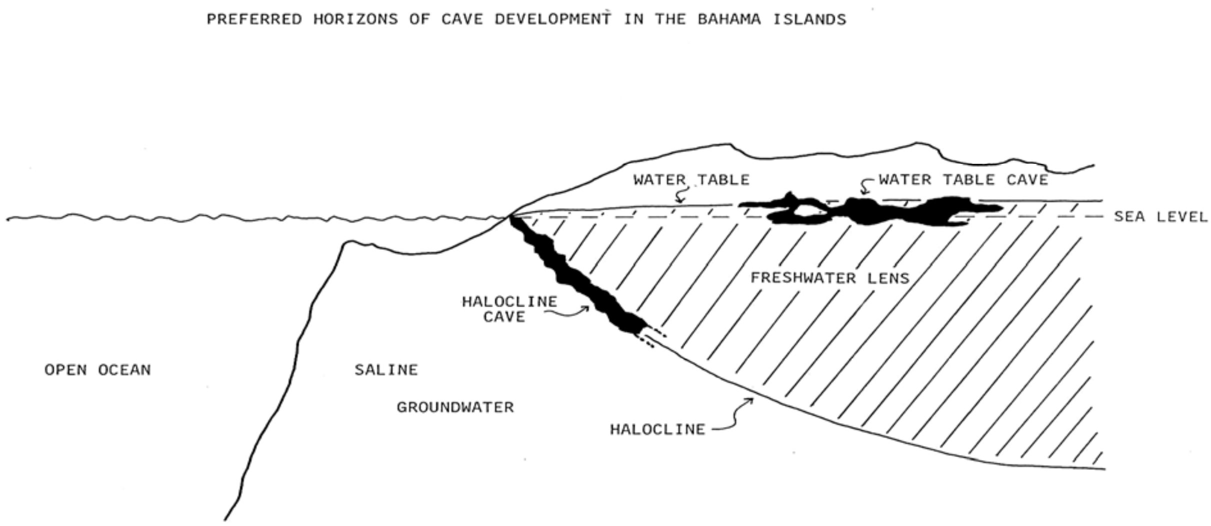
1: Fresh Water/Salt Water Mixing
2: Glacioeustasy
3: Local & Regional Tectonics
4: Simple Carbonate – Carbonate Cover – Composite Islands – Complex Islands
5: Relationship to continental margin coasts

Sea caves or Flank margin caves: do we understand cave formation at Tantanoola and Taragal? *Susan White, John Mylroi & Joan Mylroi*.



Mixing dissolution occurs at the vadose/phreatic water contact and at the fresh/marine water contact

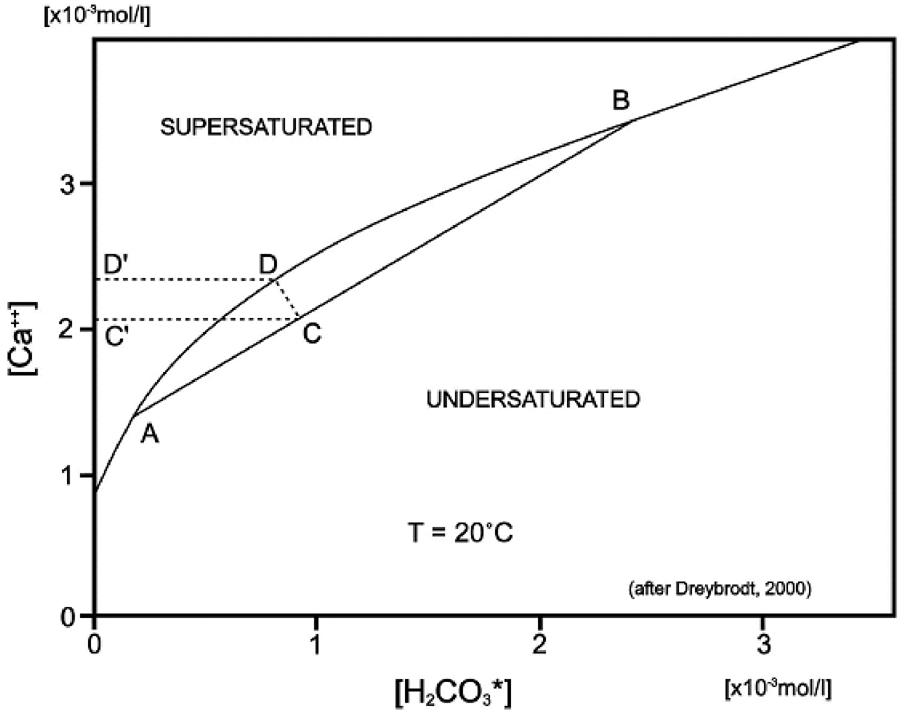
Preferred places of Cave Development in flank margin situation.



Cave Production: Making a "Flank Margin

Superposition of the vadose/phreatic and fresh/marine mixing zones at the lens margin means cave development is favoured at the lens margin, under the flank of the land. Hence the name "Flank Margin Cave".

5 p2


[x10⁻³mol/l]
SUPERSATURATED
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B
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D
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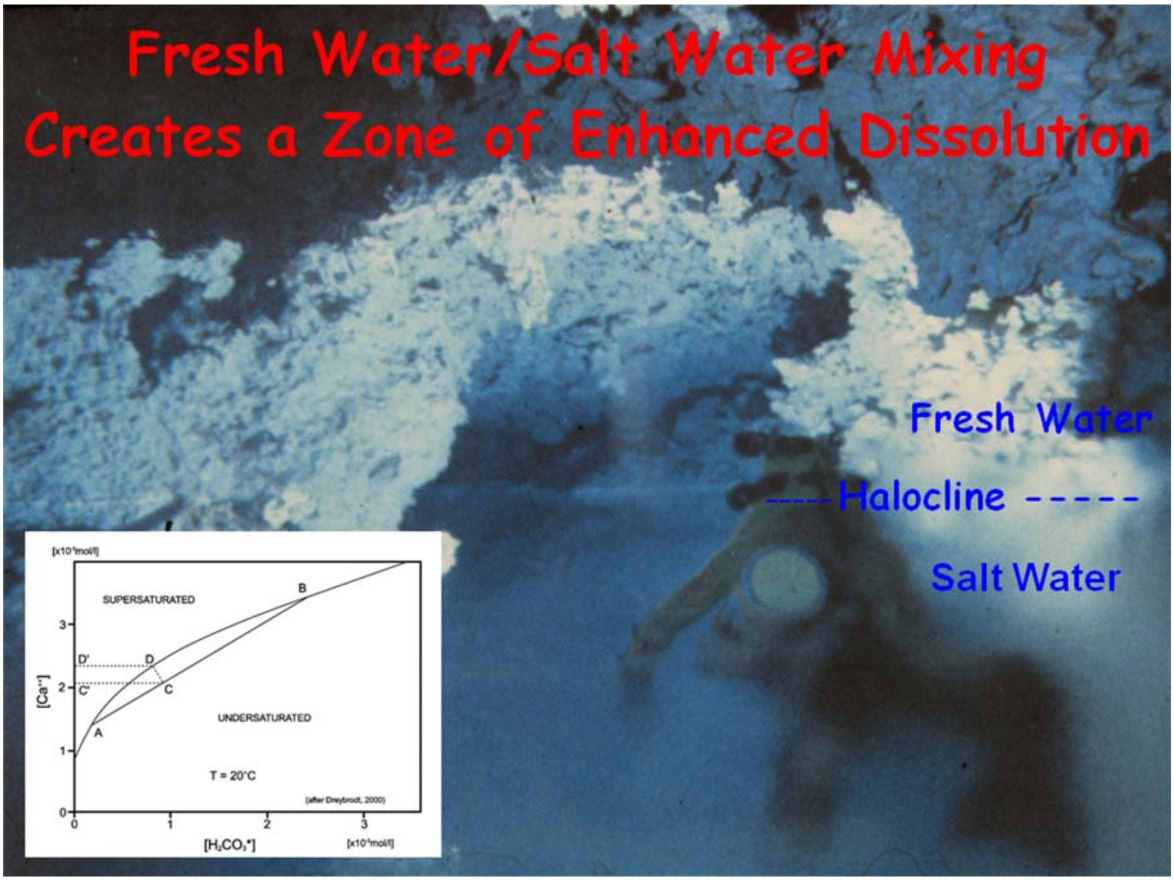
[H₂CO₃*]
[x10⁻³mol/l]


Fresh Water/Salt Water Mixing
Creates a Zone of Enhanced Dissolution
Fresh Water
---- Halocline -----
Salt Water
SUPERSATURATED
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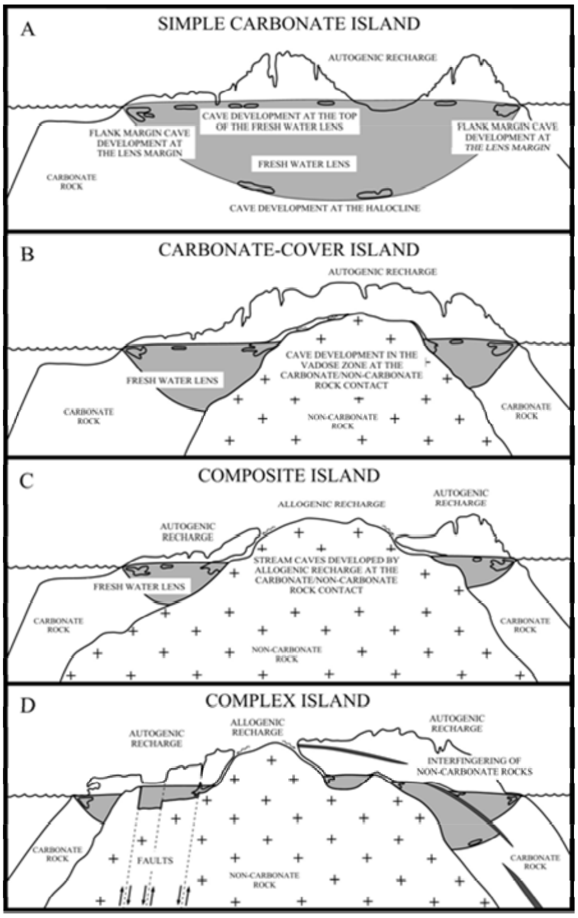
T = 20˚C

Sea caves or Flank margin caves: do we understand cave formation at Tantanoola and Taragal? *Susan White, John Mylroi & Joan Mylroi*.



No non-carbonate rock influence on island hydrology.
BAHAMAS
Non-carbonate rocks under a carbonate veneer. The lens is partitioned.
BERMUDA (sea level low)

Carbonate and non-carbonate rocks exposed. Allogenic recharge occurs.
BARBADOS
Faulting, folding and facies relationships create complex lens configurations.
SAIPAN

The Gambier Karst Province is an extensive area of Tertiary marine limestone and overlying Quaternary dune limestone in south eastern South Australia and western Victoria. These are "soft rock" limestones: youthful, weakly-consolidated porous calcarenites (sandy limestones) that are quite distinct from the classical "hard rock" limestones of the east coast, and other parts of Australia.

The caves in the Quaternary dune fields are syngenetic with the initial early cementation of the limestone, but those in the Tertiary limestones postdate that cementation.

The caves in both limestones are characterized by cap rock effects, solution pipes, extensive low horizontal phreatic mazes and abundant collapse modification. They are locally well-decorated, especially with straws and moonmilk, which the ongoing collapse tends to destroy leaving many bare fractured walls.

The Tertiary limestones differ in showing good joint control on their passage orientation. Beside the gorge of the Glenelg River there are linear, stream caves. Near the coast there are extensive large flooded systems which formed during the lower sea levels of the glacial periods. Tank Cave has 6 km of flooded shallow horizontal passage and The Shaft extends to a water depth of 120m. The cenotes, large water-filled collapse dolines, are unique(?) within Australia. There are large springs rising from flooded caves at the coast and offshore.

The syngenetic caves in the dune limestone can be horizontally extensive but have little depth. The largest tend to be at the edges of the dunes - adjacent to the sea that existed when the dunes formed, and also to the later swamps. We use the term "flank margin caves" for the irregular chambers that formed where sea water mixed with fresh water at the old coast, and "swamp margin" for the later modifications by acidic swamp waters eating into the edge of the dunes. Both tend to be low-roofed horizontal crawly mazes alternating with rubble-filled domes rising towards the surface.

Travertine deposits cut by fluvial erosion at Mole Creek, Tasmania

Henry Shannon

In Croesus Cave at Mole Creek, there are sections where wall, ceiling and even floor elements are cut in travertine formations which must have been deposited in airspace but which have later been eroded under fluvial conditions. These field relations imply substantial changes in streambed level, from lower than present to some 2m higher before returning to present. Higher ceiling cuts in the cave imply the process has happened more than once. The rise in streambed level and subsequent ceiling cut is attributable to an input pulse of gravel that makes sense as a response to soil mantle instability, likely to have been triggered by glacial/periglacial extremes, and that the travertine deposition occurs through the remainder of a glacial/interglacial cycle. The situation in Croesus Cave contrasts with that in neighbouring Lynds Cave in that the 2m cut level is absent in Lynds. Since Kansas Creek is responsible for both caves and switches from one cave to the other periodically, it is thought that the last change from Croesus to Lynds occurred at least one extra cycle back and certain features of the associated flowstone surfaces, indicating relative age, are discussed.

Slide 1

Re-solution of flowstone examples

- In certain caves at Mole Creek there are travertine masses which must have formed in subaerial situations, which have been eroded later under riverine conditions. This means there has been a sustained change from the general rule of erosional downcutting to that of sediment buildup. A datum is provided to test ideas of what constitutes old-looking flowstone.

Slide 2

Travertine deposits cut by fluvial erosion at Mole Creek, Tasmania

Henry Shannon

Slide 3

Fluvial incut in older travertine with scalloping with 2 generations of later canopy formation

Slide 4

Slide 5

Travertine deposits cut by fluvial erosion at Mole Creek, Tasmania
Henry Shannon

Slide 6

Travertine shelf is undercut, and there has been no growth since which would have been shown by a fringe of stalactites

Slide 7

Slide 8

This undercut surface is 15 m above present creek level

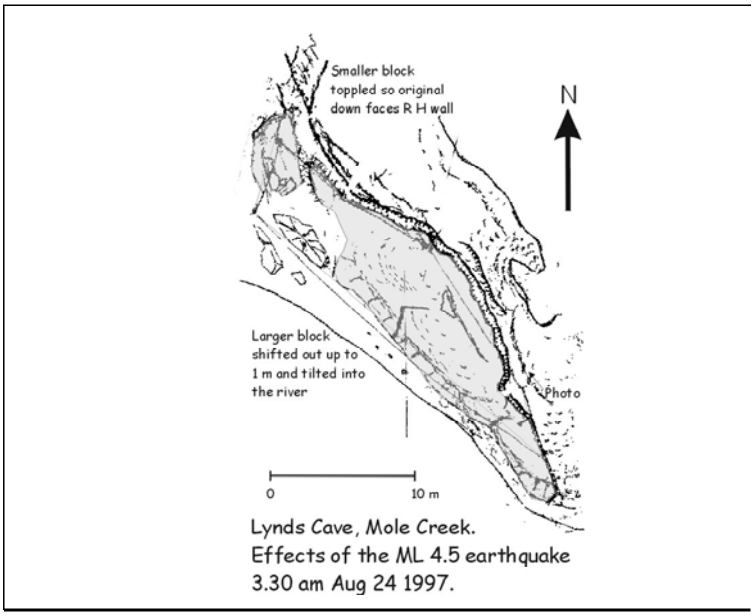
Travertine deposits cut by fluvial erosion at Mole Creek, Tasmania

Henry Shannon

Slide 9

Slide 10

Slide 11

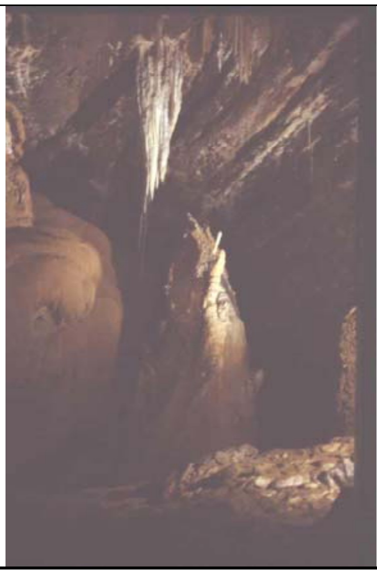


6 p4

Travertine deposits cut by fluvial erosion at Mole Creek, Tasmania
Henry Shannon

Slide 12

Slide 13



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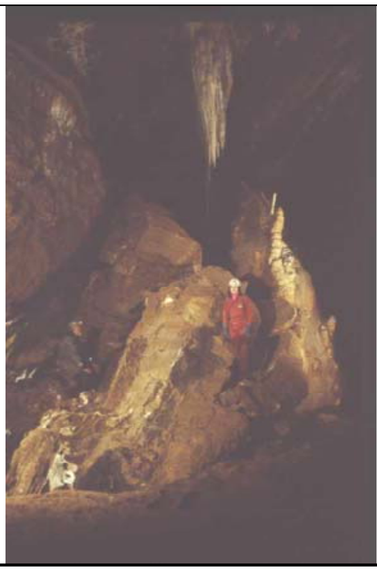

Cave Porosity and Permeability: A Technique for the Comparison of Differing Karst Areas

Susan Q White and John Webb

The understanding of karst groundwater flow and karst hydrogeological concepts and the relationship of both porosity and permeability in karst are often poorly understood. The high variability of karst areas make comparison between areas difficult. Confusing and contradictory terminology has not helped.

Worthington (1991) developed morphometric techniques relating to porosity and permeability measurement in carbonate aquifers which enhance understanding of conduit development in the aquifers. Consequently these techniques are useful tools for the comparison of the karstification of different areas.

Concepts such as conduit density and porosity can assist in determining the karstification of an area. Cave porosity is the percentage volume of the karstic rock occupied by mapped cave. It represents only part of secondary porosity, which also includes smaller fissures. Conduit density is defined as the total length of conduits within a unit volume of rock (karst aquifer). These values are always underestimates as they will always be increased by further exploration and mapping and they are a rather coarse measure of karstification. However, they enable comparison between areas in a way that has been previously difficult.

Australia has been described as having limited caves and karst (Jennings, 1967; Jennings, 1975). However more systematic exploration has significantly extended the karst estate. The problem remains in developing methods for valid comparison of karst areas with vastly different characteristics. Comparison of several Australian karst areas and some international well-known karst areas will illustrate this technique as a useful comparative tool.

7 one page

Lake speleothems of the Nullarbor

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Abstract

Subaqueous speleothems occur in several cave lakes on the Nullarbor Plain, Western Australia. Samples from two cave diving expeditions in 2001 and 2005 were examined. The subaqueous speleothems include structures resembling helictites, shields and pool crystal. The unusual speleothem structures include highly porous helictites, and some speleothems may be precipitated around organic structures. Small flakes on the surface of the speleothems resemble microbial veils. The material was sourced from Tommy Grahams Cave and Mullamullang Cave (Grotto Lake, White Lake, Lake Sh'bula and Gurgle Lake). Analysis indicates calcite, magnesian calcite, aragonite, hydromagnesite, gypsum and other minerals. According to the divers, these deposits occur in the cave lakes at depths of less than 6 m, typically between 1 to 2 m and may be associated with haloclines. The variety of deposits, including aragonite helictites, suggests a seepage source within the highly porous Nullarbor Limestone bedrock containing ions of magnesium and sulphate.

Introduction

After separate expeditions to Mullamullang Cave and Tommy Grahams Cave on the Nullarbor Plain (Western Australia) in 2001 and 2005, cave divers Paul Hosie, Ken Smith and Stuart McGregor photographed and reported several types of subaqueous speleothem in the caves' lakes and sent me some samples for analysis. The 2001 material was analysed during 2001 and 2002, and presented at the ASF's "Under WAy" conference in Bunbury, WA in January 2003 (Rowling 2004*b*). This article summarises those results and describes new material from the divers' 2005 expedition. Although the latter requires more XRD analysis for positive mineral identification, several chemical and physical tests were used to estimate that their mineral components were similar to those of the 2001 expedition.

Apart from pool crystal, subaqueous speleothems are not often reported in the world's caves. Subaqueous helictites have been reported from Lechuguilla Cave, USA and other places (Hill & Forti 1997). The Nullarbor divers' samples include shapes resembling porous helictites, small cave shields and dense pool crystal. It is intriguing as to how these speleothems came to be deposited underwater, in cave lakes, deep in the dark zone. Some samples are fine-grained, suggesting a relatively rapid rate of deposition. Other material is quite coarse grained and may be of considerable age.

Materials and Methods

All samples were supplied by the cave divers. Specimens 6N37poolF and 6N37shbula were prepared by Jill at the University of Sydney, Electron Microscope Unit and photographed and examined at the Geosciences Department. The XRD work on specimens 6N37poolF and 6N37shbula was done by Jill at the Electron Microscope Unit at the University of Sydney using a 3kW Siemens Kristalloflex 710D X-Ray generator coupled with a Siemens D5000 Diffractometer and a small computer. The generator was operated at 40kV, 40mA, with a copper target. Slits used, in order: 1 mm at source, 1 mm, 0.2 mm, 0.6 mm (at receiver). The monochromator was a graphite crystal ($2d = 0.2708$ nm) for Cu $K\alpha$ radiation. $K\beta$ filters were nickel, 12 μm thickness. Scans were made from 2 to 70 2θ in 28 minutes (2.4° per minute).

Chemical tests of the samples used a drop of 32% HCl on about 250mg of crushed sample to indicate whether carbonate was present. Reddish precipitates were most likely clays and oxides, and white crystalline precipitates most likely non-carbonate components such as gypsum. Slowly-dissolving grains may be dolomite (summary, Table 2). Crystal shape was observed under the microscope. Physical tests include observation of crystal cleavage, and observation of the response to the specimen with long wavelength ultraviolet light. The cleavage of calcite and aragonite is distinct, calcite having the typical rhombohedral cleavage and aragonite tending to cleave straight across the needles. Under UV light, cave calcite often glows green due to organic molecules in the crystal structure, whereas cave aragonite often has a poor UV response as organics are usually excluded from the crystal structure.

Samples sent to the Australian Museum were examined by Ross Pogson, curator of minerals, using XRD on new equipment. David Colchester had kindly prepared the samples for X-ray (Ross Pogson, pers. comm).

Results

Ross Pogson commented that major minerals noted in XRD were calcite and aragonite (and gypsum, in one sample).

The tests using optical, HCl and physical mineral properties had indicated calcite, aragonite, possibly huntite or hydromagnesite, possibly magnesian calcite and a non-carbonate component such as gypsum.

A summary of the samples and their mineral constituents is given in Appendix, Tables 1 and 3.

Observations: speleothem forms, based on samples

The divers report that these samples were found underwater in relatively still lakes, and it is assumed these are the conditions under which they were deposited. Seepage and direct precipitation of carbonate are significant. Gravity-influenced deposits include large raft cones, formed from the sinking of cave rafts under a drip point, reported from Tommy Grahams Cave (Stu McGregor, pers. comm.).

Subaqueous helictites, heligmites and pseudo-helictites

Introduction

Helictites are seepage speleothems, usually with one or more central canals and a tendency to develop worm-like structures. Heligmites are simply helictites which develop upwards from a flat or sloping surface. Pseudo-helictites are speleothems resembling helictites, but which may have another origin such as a carbonate coating over a fungal thread. Subaqueous helictites are not often reported. The Nullarbor subaqueous helictites are relatively large and porous, and take several forms: worm-like, shrub-like and conical. Instead of a seepage into an air-filled chamber, these speleothems are most likely formed by a seepage of mineralised water from within the porous limestone to a pool, with a higher concentration of minerals in the seep compared to that in the pool.

Mullamullang Cave, Pool Fingers, sample 6N37PoolF

Pool Fingers were named by Paul Hosie and described as a type of subaqueous helictite with cylindrical symmetry Rowling (2004*b*). They are mostly composed of calcite, with some aragonite, hydromagnesite and magnesian calcite, minor gypsum, halite and celestite (XRD). A fibrous crystalline core is surrounded by hydromagnesite powder, ray-fan aragonite crystals and isolated gypsum crystals. An outer yellowish coating with 3-sided crystals terminations (magnesian calcite) includes some biological component such as microbial veils. The helictite’s tip appears to be its growth point, developing by fracturing along the sides near the tip, similar to the model presented by silica gardens.

Lake Sh’bula “Shbulatites”, sample 6N37shbula

“Shbulatites” were named by Paul Hosie and described as a subaqueous helictite from Mullamullang Cave with triangular symmetry (Rowling 2004*b*). They are composed of aragonite, calcite, crystobalite, magnesian calcite, gypsum and hydromagnesite, with huntite and trace halite (XRD). The interior of the specimen is similar to “Pool Fingers”, but the exterior has a curious triangular symmetry with square lobes.

The material is very similar to "6N37PoolF" in structure, with a tendency to form flat plates instead of cylinders. The central core appears to be aragonite. Outer yellow and white coating is most likely high magnesian calcite (yellow) and calcite. Chalky material is probably gypsum, hydromagnesite and huntite. Dark specks on outer surface may be bat guano. The sample is from hypersaline water, hence some halite. Crystobalite peak is large in XRD and may explain why the specimen was hard to cut.

Grotto Lake helictites, sample 6N37PHGL1

This yellowish lump vaguely resembles a large helictite, 100 mm long x 50 mm diameter, tapering to a point with a crumbly prickly coating and irregular lumpy branches (Figures 1 & 2). Paul Hosie commented this occurred as a "horizontal layer growing upwards on the edge of the rocks." Like other samples, the outer yellow coating has shrunk and cracked since collection, indicating that it originally had a high water content. This outer coating is very fine grained and is most likely gypsum and magnesian calcite. The structure is very porous, with numerous holes in the outer surface. Dried organic material (possibly microbial veils) is present around pores in the structure, suggesting that water coming through the pores may contain some nutrient (possibly may be sulfur-cycle bacteria as per Contos (2000)).

The prickly surface resembles partially etched and recrystallised aragonite, with needle crystal aggregates forming spheroidal clusters. Fine hairlike crystals similar to "lublinite" (needle-fibre calcite) or gypsum are also present in the structure.

In the porous base of the helictites is a white powder resembling huntite or hydromagnesite, and radiating needle crystal masses with isolated areas of more solid crystal resembling calcite. More dense regions are possibly dolomite (clear rhombs seen).

The tip resembles that of a "normal" helictite. Pores near tip are crystal-lined rounded cavities containing remnant clusters of "microbial veils" and "lublinite" hairs, as a thatch. Dried flakes, assumed to be microbial veils are delicate, translucent grey with a metallic lustre under polarised light.

Figure 1: Side view, cut helictite 6N37PHGL1, about 80 mm long.

Figure 2: Base view, 6N37PHGL1, about 60 mm wide.

Figure 3: Helictite 6N37PHGL2, base, about 23 mm wide.

Figure 4: Helictite 6N37ken2, base, about 25 mm wide.

Figure 5: Grotto Lake fibrous aggregate, about 20 mm wide.

Figure 6: Grotto Lake coralloid, about 17 mm wide.

Grotto Lake flattened helictites, sample 6N37PHGL2

These are white to pinkish, oriented nodules typically 70 mm x 30 mm x 20 mm and superficially resembling helictites with a branching form, including some flattened shapes (Figure 3). Paul Hosie reported that these "blobs had developed on a crystal substrate".

Under the microscope, one sees a multi-layered structure. The outer yellow layer is cracked (dehydrated?) and pores can be seen. Some of the outer surface vaguely resembles scales (like proto-dolomite or hydromagnesite). Other surface crystals resemble clear dolomite. Fine dark threads seen on the surface may be organic or fungal.

The flattened parts are composed of two halves with a gap inside; the cylindrical parts have a low density centre and multiple canals appear in broken section. A multi-branched specimen indicates that branches can re-join. This structure is composed of very fine crystals compared to the Lake Sh'bula or 6N37KEN3 samples.

Discussion: They may be pseudo-helictites, formed around organic sheets or microbial veils. Alternatively they may be conventional helictites, but the open structure and high porosity allows the branches to re-join. The flattened structures may have developed along a crack, like a cave shield. Interestingly, the Lake Sh'bula specimen 6N37shbula also features flattened areas. The finer crystal size suggests the helictite developed faster than the other samples.

Lake Sh'bula helictites, sample 6N37ken2

The samples comprise a few lumps of soft material, pale brown to yellow to white, about 50 mm x 90 mm x 60 mm, forming a somewhat crenulated, irregular folded shape with a white crystalline inner section (Figure 4). Diver Ken Smith mentioned the substrate was a "large rock covered in white crust", and the "speleothems occur in lines at 1.7m depth associated with a yellow band on surrounding rock. Yellow band is extensive in this part of the cave, is 0.2m high, horizontal, possibly a specific chemical layer in the water."

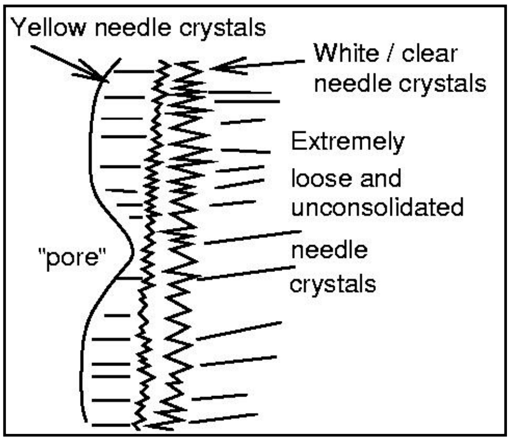

Figure 7: Sketch of pore cross section, sample 6N37ken2

Under the microscope, the outside of the speleothem has a soft crumbly yellow crystalline coating, about 2 mm thick, which has shrunk and cracked since collection. The tips of crenulations have multiple pores (canals). Directly below the yellow coating is a white crystalline region (at the base of the pores, Figure 7). Within this white region are aragonite needle crystals, based on cleavage; some look partially recrystallised. The white crystals radiate from a denser central region which may include calcite and has hollow channels in it. This is a very open structure. Loose hard cores in the structure are surrounded by aragonite needles. The overall shape is formed by many spherulites.

Another piece from this sample comprises parallel plates of the same material, with an inner low density part filled with fairly loose aragonite needles (Figure 8).

Discussion: The divers' notes say that these occur in lines, "at depth of 1.7m" and are "associated with a yellow band on surrounding rock" and that the band is "0.2 m high". This may infer a halocline of stratified mineralised water. The yellow band could be dolomitic, organic, or gypsum – it has very little reaction with HCl. The parallel plate example suggests that this structure develops along the top edges of subaqueous cave shields.

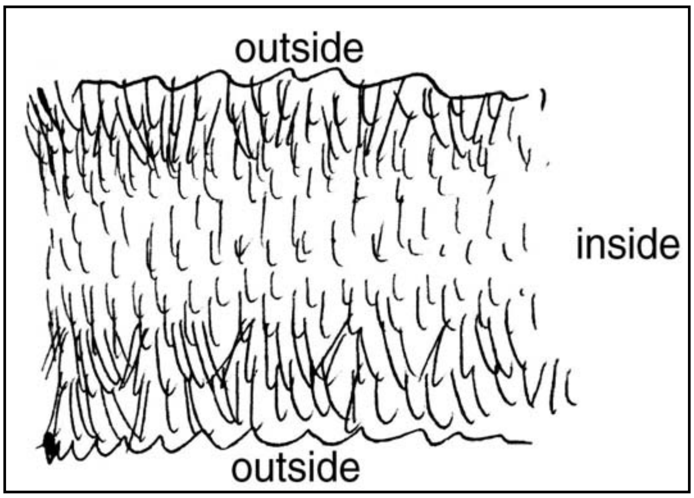

Figure 8: Sketch of structure, sample 6N37ken2

Subaqueous cave coral and related forms

Grotto Lake subaqueous popcorn and coralloids, sample 6N37PHGL3

The samples comprise two types of lumps and crumbly bits, mostly white (Figures 5 & 6).

Fibrous aggregates:

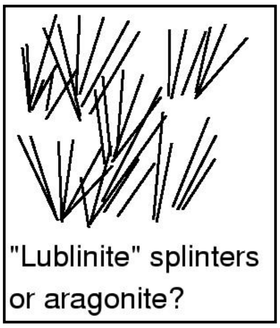

Figure 9: Sketch of growth habit, fibrous aggregate 6N37PHGL3

These are porous aggregates with a radial fibrous to oriented fibrous appearance (Figure 9), typically 40 mm x 40 mm x 30 mm, and are a mixture of calcite and aragonite, based on cleavage. The surface is somewhat flattened e.g. by corrosion, and recrystallised to calcite, with numerous surface pores. Individual crystals are coated with finer crystals and possibly microbial veils. Material appears to be "lublinite" calcite and aragonite based on cleavage.

Coralloids: These form crystalline hemispheres with a yellowish coating, typically 20 mm x 20 mm x 10 mm. Four pieces were examined. The general structure comprises a central core of linear yellow aragonite surrounded by clear radiating aragonite. Some samples have an inner layer of yellow material. The radiating area may contain clear crystalline balls of possibly calcite or dolomite. The outer coating is a very fine yellow or yellow-brown crystalline material with pores, aragonite aggregates and possibly microbial veils. The inner and outer yellow material has shrunk and cracked since collection.

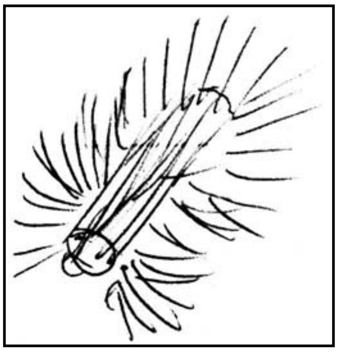

Figure 10: Sketch, coralloid growth habit, sample 6N37PHGL3.

Below the yellow coating is a soft white layer of radiating aragonite crystals and possibly "lublinite". (Figures 10 and 11).

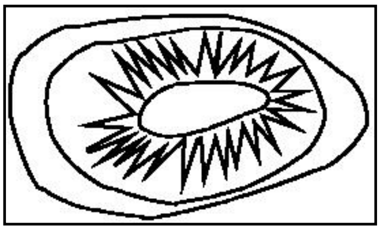

Figure 11: Sketch, coralloid growth habit.

Gurgle Lake coralloids, sample 6N37PHGL7

These creamy yellow nodules are about 40 mm x 30 mm x 20 mm with concentric layers. A soft core is surrounded by harder layers and a powdery and crumbly surface (Figure 12).

The outermost layer is yellowish, fairly thin, and shiny in areas. It has cracked (shrunk since collection) to expose a white powdery layer just below it. Occasional whisker-like crystals may be "lublinite".

Below the yellow layer is a porous white layer of radiating needle crystals (aragonite, based on cleavage) forming a layered structure, with some layers harder than others.

The innermost area is crumbly, powdery and soft, possibly recrystallised, with isolated needle crystals and resembles the interior of a subaerial "cave turnip". The

Figure 12: Gurgle Lake coralloid, about 17 mm wide.

needle crystals are coated. Small remnant dark shiny microbial veils are visible. A soft white powdery region apparently contains hydromagnesite with aragonite needles.

Pool crystal, crusts and rafts

Grotto Lake over-coated cave rafts or crusts, sample 6N37PHGL4

These samples are soft and crumbly, coloured white, cream, yellow and brown, and are mostly a flat shape. Typical sizes are 10 mm x 20 mm and are possibly over-coated calcite or aragonite rafts or crusts (Figure 13).

Under the microscope, randomly-oriented fine needle crystals have cemented together to form a soft crust. One side, possibly the up-side, is porous and its yellow and brown surface appears cracked or shrunk. Other parts of the sample resemble pool crystal (i.e. an overgrowth) with small hemispheroidal aggregates which may be aragonite.

It is not clear whether these are sunken rafts or crusts; the flatter samples resemble rafts and the curved ones resemble crusts. Both appear to be over-coated with aragonite, so possibly they originated from the water's surface and have since sunk to the bottom of the lake.

Figure 13: Fragment of Grotto Lake cave raft, about 16 mm wide.

Grotto Lake pool crystal, sample 6N37PHGL5

This bowl-shaped lump of pool crystal is rounded and crystalline, with a layered clay and carbonate substrate. Its approximate dimensions are 110 mm x 130 mm x 50 mm (Figure 14).

The laminated clay substrate is composed of both crystalline carbonate sediment, clays and other materials (possibly bat guano, quartz, hydromagnesite). Crystalline carbonate septa or veins separate areas of sediment and cut through the layers.

Figure 14: Grotto Lake pool crystal with sediment substrate, cut, about 100 mm long.

The area between the clay and the pool crystal has a gradual transition from loose brown sediment, then brown carbonate-cemented clays, white laminated carbonate, and hemispheroidal carbonate aggregates (aragonite cement).

The outer crystal coating is a white and yellow mixture of fibrous, needle-shaped radiating aggregates (possibly aragonite) and massive material (possibly calcite).

Discussion: This appears to be a conventional pool crystal deposit on sediment. The aragonite isomorph may be influenced by calcite crystal poisoners in the substrate (e.g. Mg in hydromagnesite) and ions in the water (e.g. SO_4^{2-}). Carbonate septa in the substrate suggest that the lake and the clay may have dried out at some period, cracked, and was later cemented forming a type of boxwork.

Lake Sh'bula crust, sample 6N37ken1

A white crystalline coating on a brown clayey substrate has formed a shard with a smooth clay substrate, darker cemented layer and a white prickly crystalline surface. The sampled piece is 80 mm x 50 mm x 10 mm (Figure 15). Diver Ken Smith noted that this deposit occurred at a depth about 1 m as a white crust flaking from the tops of large submerged rocks about 1 m diameter. They are common in shallow water and a similar white crust is common on rocks above water.

Under the microscope, the soft porous brown laminated crystalline substrate has small interlocking grains and contains some aragonite crystals. The substrate becomes less porous closer to the white crystal area. The white area is porous and is composed of needle to columnar crystals, terminated across the flats of the needles. It appears to be a mixture of calcite, aragonite and lublinite variety of calcite. The aragonite needles terminate as "church steeples", etched and partially redissolved with some (calcite) cement.

Discussion: It is unclear whether this is a subaqueous or subaerial deposit as it is reported from both above and below water around the lake. As it is apparently flaking from the tops of submerged rocks, this suggests the deposit is related to the surface of the lake, rather like cave rafts. If it can deposit as aragonite at times, there is something present in the water preventing calcite from depositing. Possibilities include SO_4 concentration, Mg, or both.

Figure 15: Lake Sh'bula crust with porous substrate, about 10 mm thick.

Tommy Grahams Cave: Massive pool crystal, sample 6N56SMTG1

This rock was found loose in the sediment of the lake in Tommy Grahams Cave by diver Stu McGregor, and measures about 300 mm x 100 mm x 100 mm (Figures 18, 19). One side is limestone, the other side is a subaqueous speleothem, partially eroded. The eroded area contains lots of needle crystals, originally greenish and full of water, and since sunken in. The divers report that the walls of the lake are covered with a similar pool crystal.

Under the microscope, highly porous pale orange Nullarbor Limestone contains sand-sized grains, including brown and sparkly "dolomite" shells (bioclasts). One area of porous bedrock has little micrite, with only the larger bioclasts remaining. The limestone is coated with a dense white cement layer, 5 mm thick, and very fine-grained. The white layer merges with a pale olive aragonite layer, 10 mm thick, featuring typical aragonite ray-fan needles, developed from clusters on the white cement layer. The pale olive layer is surmounted by clusters of hard, dense aragonite 40 mm thick. This is a massive deposit featuring larger and longer aragonite crystal blades compared to the pale olive layer. Crystal aggregates form bundles (columns) of about 10 to 20 mm diameter. The base of these aggregates contains a white powder similar to hydromagnesite. A white powder terminates this layer (also possibly hydromagnesite). This layer has split horizontally (across the needles), possibly by specimen shrinkage. Part of this layer was exposed to the lake water where it had developed a solution notch, indicating that at times the water is aggressive to aragonite.

Outer layers: The outer layers are complex, with several different types of coatings and textures. The porous outer surface appears to be recrystallised with indistinct crystals, skeletal needle crystals, sugary coatings and small hemispheres. A surface brownish patch has little round holes in it: it may have once housed microorganisms. Some aragonite crystals are skeletal, others are complete.

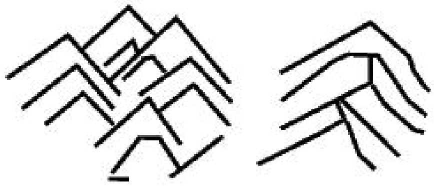

Figure 16: Sketches, cube corners and en-echelon crystals.

En-echelon cube-corner crystals resemble dolomite (Figure 16) and are opalescent usually the result of multiple fine layers.

In the corrosion notch, small white and black grains are lodged between long loose needle crystals, thought to be hydromagnesite and bat guano respectively. Surface irregularities like blunt spikes appear to be coatings over filaments or over original bedrock bioclasts. In this case, a soft porous core is coated with harder external layers and could be described as pseudo-helictites (Figure 17).

Discussion: This material appears to have been deposited underwater as aragonite, possibly at a particular depth where mineralised groundwater in the limestone meets the lake water in Tommy Grahams Cave. The general form could be described as aragonite pool crystal. The outer surface of the material may have housed microbial veils, and the chemistry appears to have at times favoured the deposition of a variety of minerals on the surface such as calcite, dolomite and gypsum. Judging by the massive aragonite of the main structure, this deposit may be very old, and has broken off the main deposit due to structural failure of the soft porous underlying bedrock.

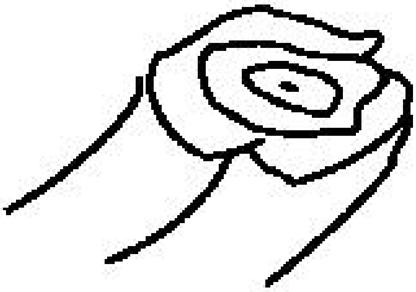

Figure 17: Sketch, pseudo-helictite.

Figure 18: Pool crystal, Tommy Grahams Cave, photo by Stuart McGregor.

Figure 19: Pool crystal, Tommy Grahams Cave. Cut surface, about 125 mm wide.

Figure 20: Subaqueous cave shield, about 40 mm wide, after brushing.

Figure 21: Cave shield interior, about 40 mm wide.

Cave shields and related forms

Grotto Lake cave shield, sample 6N37PHGL6

This small hollow crystalline "shell" is a small cave shield measuring about 40 mm x 20 mm x a few mm and is a brown/tan colour. The specimen was cleaned with a dry brush to remove a clay coating as it had been packed with sample 6N37PHGL5 (Figures 20, 21).

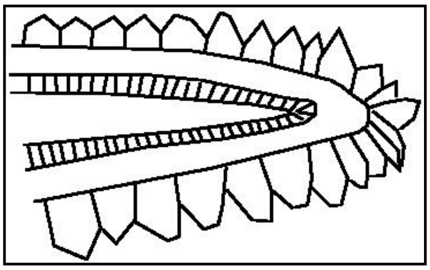

Figure 22: Symmetrical ridge development.

Under the microscope, the "shell" outer surface has a rough surface caused by neat pyramids (crystal terminations). A sparkly appearance when rotating the specimen is caused by the alignment of numerous 3-sided crystal terminations, possibly en-echelon calcite similar to "Bizarre forms" (Folk, Chafetz & Tiezzi 1985). Crystal terminations are aligned in approx. 10 mm-wide arrays of the specimen faces, resulting in reflective lines (rows) at some angles. This material covers the outer surface of the speleothem, especially around the edge of the plates. At a broken edge, the pale coloured corner has spiky crystals on the inside, forming part of the shell. The C-axis is 90° outwards from the "shell" (Figure 22). The two halves of the shell are cemented by a seam with an interesting edge (Figure 23) and a small hole. Symmetrical ridge development either side of the edge for a few mm of length infers they are developed together. A dimple in the base of the structure leads to a tepee shape (Figure 24).

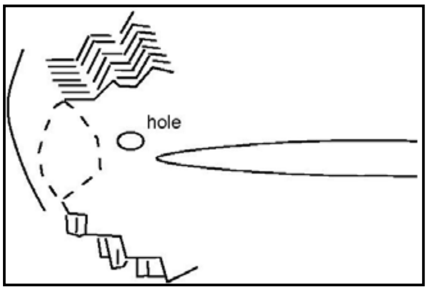

Figure 23: Sketch: area close to edge.

The outer material may be aragonite, based on surface crystal cleavage and low UV response, but could also be calcite or dolomite. The inner fill may be magnesian calcite as it seems to have a calcite cleavage. The inside is partly filled with crystal, including one long crystal oriented horizontally (parallel to plates) and may be dolomite or Mg-calcite.

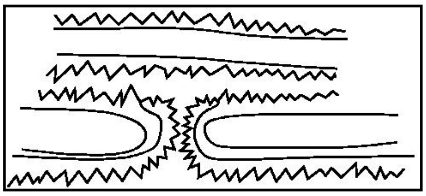

Figure 24: Sketch of dimple.

Discussion: Assuming this is a conventional cave shield, developed underwater, it appears to have developed a little like a helictite with a slot rather than a capillary tube. The edge seems to be the main region of growth. Imagine a small capillary tube around the edge, similar to that depicted in Figure 23, like the central canal of a conventional helictite only connected to the substrate at both ends.

Such a structure may originate from a small crack in the substrate. Like conventional helictites, this small tube can be slightly dissolved by the fluid in the substrate, however instead of breaking open at one end like conventional helictites, it breaks open along the outer edge of a short segment of the tube due to the alignment of crystallites and the thickness of the inner wall. Where the tube opens, carbonate precipitates. Additionally, calcite can glide / cleave without breaking. If the pressure of crystal growth inside the shield is sufficiently high, the material may glide apart while still precipitating carbonate. This would result in symmetrical crystal development at the edge and develop a cave shield.

A slight green afterglow with long-wave UV suggests that the main material is calcite with very little organic material (organics make the calcite afterglow a brighter green). If the en-echelon material is calcite, it may be like the sides of ribbon helictites (Rowling 1998).

Figure 25: End of flat speleothem 6N37ken3, about 54 mm wide.

Lake Sh'bula flat speleothem: cave shield or coating? Sample 6N37ken3

This flat, pale coloured speleothem is about 55 mm x 25 mm x 10 mm (Figure 25) with soft prickly outer coating and has formed in two halves like a cave shield. Diver Ken Smith noted that the "substrate was large rock. Area covers several metres. All rocks at this depth (2.8 m) appear to have this cover. This sample is part of a flake which is cemented to the base rock."

Under the microscope, the surface appears to be recrystallised aragonite. On some needle crystal tips is a loose, shiny coating (microbial veil?) which resembles a thin dry dark snail trail under crossed polars and is easily disturbed. The needles are a little coarser than 6N37ken2 and radiate as spherulites from the median plane of this "shield" (Figure 26). The spherulite nucleation points is a white and powdery substance resembling hydromagnesite and the whole structure is highly porous.

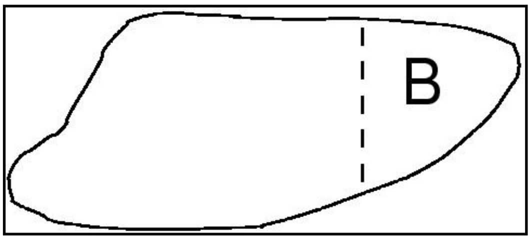

Figure 26: Sketch of pieces, flat speleothem 6N37ken3.

What is it? It may be part of a cave shield, developed around a crack on the base rock, out of which has come hydromagnesite around which aragonite has deposited. The porous structure may continue to develop as long as the underlying crack continues to seep. Alternatively, it may be an aragonite coating over a microbial veil containing hydromagnesite. The porous structure may eventually thicken and become engulfed by pool crystal.

Discussions

Helictites, heligmites and pseudo-helictites

Subaerial helictites have a large variety of shapes and sizes, as do the subaqueous Nullarbor lake helictites. The samples are mainly heligmites, that is, they developed upward from a substrate (typically from boulders or from pool crystal).

The finger-shaped forms typically have a central canal (or set of them), supprounded by radially-oriented carbonate crystals such as calcite or aragonite. Pores near the tip are connected to the central canals through less dense mats of needle crystals. The outer surface may be coated with magnesium calcite, dolomite or gypsum. Development is from the tip.

There is a branching form, where the branches may join up, forming a structure consisting of both cylindrical and flattened shapes. The cylindrical parts have cylindrical central canals, and the flattened parts have a slot-shaped central canal (similar to a cave shield). These structures are enigmatic; they may have both helictite and cave shield structures, or they may be developed around organic filaments and microbial veils. Microbial veils (also known as snot-tites) have been recorded from Nullarbor cave lakes (Contos 2000). Several samples have what appears to be remnant microbial veils attached to their surfaces.

Cave coral and related forms

Conventional cave coral is a subaerial speleothem, with a film of mineralised water on the surface. Growth is near the area of maximum air movement, where CO_2 exchange is highest. Cross-sections of a coralloid show the growth layers. A particular sub-type is the cave popcorn and coralloid, usually made of aragonite, and developing along the lines of aragonite "shrubs", filling in the spaces, as it were.

In the case of the Nullarbor cave lake coral, the material appears to be alternating calcite and aragonite, with hydromagnesite supplying calcite-poisoning Mg. Development is like that of subaerial cave popcorn and coralloids, only larger and less dense. Some of the forms resemble helictites, but sectioning reveals them to be overcoated acicular spheroids (i.e. cave aragonite).

A similar form has been recorded from a marine (coral reef) setting, where aragonite "mamelons" partially fill cavities in the reef (Ginsburg & James 1976).

Pool crystal, crusts and rafts

These are more conventional, and are often reported from caves. Pool crystal often lines the sides of standing pools of mineralised water. In the case of the Nullarbor pool crystal, it occurs at specific depths, possibly corresponding to particular layers in the rock or to a depth at which CO_2 exchange is optimal, or may simply follow the lake levels. Divers report haloclines in the lakes although there are no reports correlating pool crystal with haloclines. The usual polymorph deposited is calcite, whereas the Nullarbor cave samples appear to be aragonite (Tommy Grahams Cave) with hydromagnesite and gypsum, suggesting crystal poisoning by Mg and SO_4 leaching from the bedrock.

Cave rafts are relatively common, caused by the out gassing of CO_2 from the surface of the lake to an air filled chamber. This allows carbonates to precipitate. What is unusual in the raft samples is the crystal polymorph, which is normally calcite but in the samples they appear to be aragonite. One possibility is the rafts precipitated as calcite, but were later overgrown with aragonite after they sunk.

Crusts are also common in caves. The divers reported a crust (6n37ken1) which occurs both above and below water, flaking off the rocks. The sample is most likely formed at the water's surface, dependent on the lake level, and is a simple carbonate coating formed on the rocks by mineralised water. The flaking is most likely due to the clay in the substrate expanding and contracting with water level. They appear to be a mixture of carbonates, including calcite and aragonite.

Cave shields and related forms

There appear to be two types of cave shield-like speleothems. One type is a relatively conventional cave shield, comprising two halves like a bivalve, hollow inside, and with a fine linear capillary along the edge. Growth appears to be by pressure-gliding along cleavage planes, with the edge crystals oriented such that they form a mirror image of each other about the two halves. In many respects, cave shields resemble helictites with the direction of growth at 90 degrees to the central canal instead of at one end.

The other type of cave shield (if it is one) is a porous, loose structure forming a blade or plate, with a powdery core (possibly hydromagnesite) surrounded by acicular carbonate crystals such as aragonite. The divers reported that these developed on the surface of some of the pool crystal. One possibility is they have developed over particular cracks in the substrate, from which mineralised water seeps, allowing the development of a shield. Another possibility is they develop around microbial veils, as a simple coating, although in that case one would expect a more random structure.

Possibly the less dense structure develops where there is water to support the speleothem's weight, and the growth habit of aragonite promotes a less dense form than does calcite.

Conclusions

A variety of subaqueous speleothems occur in some cave lakes on the Nullarbor Plain. The following conditions may lead to the deposition of carbonate speleothems on rocks in a cave lake:

- The limestone and dolomite rocks in the lake should be porous.
- The concentration of HCO_3 in the rock pore water should be higher than that in the lake.
- The exchange of CO_2 between the rock water and the lake water allows CO_2 to escape from the rock water to the lake water (or dissolve in it).
- The rocks may be conducting highly mineralised groundwater to the lakes. As some of the speleothems were reported from isolated rocks, possibly the rocks are dissolving.
- The actual form (helictite, shield, pool crystal etc) depends on the physical conditions during deposition.

- The mineral species deposited depends on the chemistry during deposition. For example, aragonite may deposit instead of calcite if there are sufficient calcite crystal poisoners present (Mg, sulphate and Mn are the most common).
- Dedolomitisation of the bedrock may be the source of Mg present in the speleothems.

Acknowledgements

Many thanks are given to Ross Pogson, Curator of Minerals at the Australian Museum, Sydney, for the XRD analysis of samples. David Colchester (Australian Museum) kindly prepared the museum samples for analysis. Thanks are also given to Ross for allowing me to reproduce his comments for this article.

Most samples from Mullamullang Cave were collected by Paul Hosie. Samples 6N37ken1...3 were collected by Ken Smith. Sample 6N56SMTG1 was collected by Stuart McGregor from the lake in Tommy Grahams Cave.

Bulk intact specimen 6N56SMTG1 was photographed by Stuart McGregor. All other specimens were prepared, photographed, scanned and examined by Jill at Thornleigh.

For specimens 6N37poolF and 6N37shbula, micro-photography, preparation, XRD work and spectral analysis was done by Jill using equipment at the Geosciences Department and the Electron Microscope Unit at the University of Sydney under the supervision of Drs A. Osborne and T. Hubble as part of a study on cave aragonite (Rowling 2004*a*).

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Appendices

Summary of Samples

Most samples are from Mullamullang Cave (on private property) and collected by Paul Hosie and Ken Smith. Stu McGregor collected the sample from Tommy Grahams Cave. Details are as indicated in Table 1. Sample numbers are based on the divers’ sample numbers (1, 2, 3, etc) but with additional information such as cave ID and collector. Sample depth was recorded by the divers’ depth gauges.

Sample No.	Cave	Lake	Description	Collector	Date	Depth
6N37poolF	Mullamullang	White	"Pool Fingers" helictites	Paul Hosie	Jan. 2001	
6N37shbula	Mullamullang	Sh'bula	Small "Sh'bulatite" helictite	Paul Hosie	Jan. 2001	
6N37PHGL1	Mullamullang	Grotto	Large lumpy helictite	Paul Hosie	13/01/2005	-1.7 m
6N37PHGL2	Mullamullang	Grotto	Branching flattened helictites.	Paul Hosie	13/01/2005	-3.5>-6 m
6N37PHGL3	Mullamullang	Grotto	Radial fibrous aggregates and crystal hemispheres	Paul Hosie	13/01/2005	-3.5>-6 m
6N37PHGL4	Mullamullang	Grotto	Coated calcite rafts.	Paul Hosie	13/01/2005	-3.5>-6 m
6N37PHGL5	Mullamullang	Grotto	Bowl-shaped radial fibrous precipitate, clay substrate.	Paul Hosie	13/01/2005	-3.5>-6 m
6N37PHGL6	Mullamullang	Grotto	Small cave shield.	Paul Hosie	13/01/2005	-3.5>-6 m
6N37PHGL7	Mullamullang	Gurgle	Pebble-sized layered nodule.	Paul Hosie	13/01/2005	
6N37ken1	Mullamullang	Sh'bula	Rough crystalline shard with clay substrate.	Ken Smith	13/01/2005	-1 m
6N37ken2	Mullamullang	Sh'bula	Soft, crystal-cored lumps.	Ken Smith	13/01/2005	-1.7 m
6N37ken3	Mullamullang	Sh'bula	Flat prickly piece.	Ken Smith	13/01/2005	-2.8 m
6N56SMTG1	Tommy Grahams	Lake	Thick fibrous sedimentary deposit.	Stuart McGregor	2004	

Table 1: Summary of samples

Tests using HCl

32% HCl was applied to a small sample of the material and the resulting reaction observed for effervescence indicating carbonate, any residue, and any coloured material. Table 2 shows the results.

Sample No.	Carbonate	Clear residue	Coloured residue	Comments
6N37poolF	High	Small	-	
6N37shbula	High	-	-	
6N37PHGL1	High	-	-	May be calcite
6N37PHGL2	High	-	-	Slowly dissolving grains may be dolomitic
6N37PHGL3	High	small	-	"""
6N37PHGL4	High	-	Yellow grains	"""
6N37PHGL5	High	-	Small brown grains	"""
6N37PHGL6	High	-	Small brown grains	"""
6N37PHGL7	High	-	Small yellow grains	"""
6N37ken1 (substrate)	Medium	-	Brown	Clayey
6N37ken1 (crystal)	High	-	-	Slowly dissolving grains may be dolomitic
6N37ken2 white needles	High	-	-	"""
6N37ken2 yellow coating	Low	-	Yellow grains	Possibly gypsum residue
6N37ken3	High	-	Yellow grains	""
6N56SMTG1	High	-	-	Slowly dissolving grains may be dolomitic.

Table 2: Tests using HCl 32%

Sample mineral constituents

Most samples discussed in this paper have been estimated using physical properties only, and are compared with the few samples analysed with XRD.

Sample No.	Calcite	Aragonite	Magnesian calcite	Gypsum	Hydro-magnesite	Other
From XRD						
6N37poolF	major	minor	minor	minor	minor	minor celestite & halite
6N37shbula	major	major	major	major	major	major crystobalite, minor huntite, trace halite.
6N37PHGLx	major	major	-	-	-	
6N37PHGL2	major	major	-	major	-	
6N37kenx	major	major	-	-	-	
Estimated only						
6N37PHGL1	high	medium	-	-	medium	
6N37PHGL2	high	high	high	high	high	crystobalite, huntite
6N37PHGL3 (fibrous)	medium	high	low	low	low	
6N37PHGL3 (shells)	medium	high	medium	low	low	dolomitic
6N37PHGL4	high	high	medium	medium	low	
6N37PHGL5	high	high	medium	-	low	minor clays
6N37PHGL6	high	low	high	-	-	minor clays, dolomite
6N37PHGL7	medium	medium	medium	medium	high	
6N37ken1 (substrate)	low	medium	-	-	-	clays
6N37ken1 (crystal)	medium	high	medium	-	medium	dolomite
6N37ken2 white needles	medium	high	medium	-	-	
6N37ken2 yellow coating	low	low	medium	high	low	
6N37ken3	medium	medium	medium	medium	medium	
6N56SMTG1	low	high	medium	-	low	dolomite

Table 3: Mineral constituents.

Lake Speleothems of the Nullarbor

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Introduction

In 2001 and 2005, cave divers Paul Hosie, Ken Smith and Stuart McGregor photographed and collected subaqueous speleothems in the lakes of Mullamullang Cave and Tommy Grahams Cave on the Nullarbor Plain (WA). An analysis of the 2001 material was presented at the ASF's "Under WAy" conference in Bunbury, WA in January 2003 (Rowling 2004).

This presentation describes material from the divers' 2005 expeditions, comprising pool crystal, helictites and a cave shield. Several chemical and physical tests were used to estimate the mineral components, and recent XRD analysis by the Australian Museum has confirmed some of these.

The divers’ samples include shapes resembling porous helictites, small cave shields and dense pool crystal. Pool crystal is fairly common, but subaqueous helictites and cave shields are not. Subaqueous helictites have been reported from Lechuguilla Cave, USA and other places (Hill & Forti 1997).

It is intriguing as to how these speleothems came to be deposited underwater, in cave lakes, deep in the dark zone.

Some samples are fine-grained, suggesting a relatively rapid rate of deposition. Other material is quite coarse grained and may be of considerable age.

Materials and methods

All samples were supplied by the cave divers. Most samples are from Mullamullang Cave (on private property) and collected by Paul Hosie and Ken Smith. Stu McGregor collected the sample from Tommy Grahams Cave.

Dilute HCl was used to indicated presence of carbonate. Physical tests include observation of crystal shape and cleavage, and response to long wavelength ultraviolet light.

X-Ray diffraction was used to determine the mineral content of some specimens (pers. comm, Ross Pogson, curator of minerals at the Australian Museum).

Results

The HCl, UV, cleavage and optical tests suggested calcite, aragonite, possibly huntite or hydromagnesite, possibly magnesian calcite and a non-carbonate component such as gypsum.

XRD indicates major minerals were calcite and aragonite (and gypsum, in one sample) (Ross Pogson, pers. comm.)

The divers reported that these samples were found underwater in relatively still lakes, and it is assumed these are the conditions under which they were deposited.

Subaqueous helictites and heligmites

Helictites are seepage speleothems, usually with one or more central canals and a tendency to develop worm-like structures.

Heligmites are simply helictites which develop upwards from a flat or sloping surface.

Subaqueous helictites are not often reported. The Nullarbor subaqueous helictites are relatively large and porous, and take several forms: worm-like, shrub-like and conical. Instead of a seepage into an air-filled chamber, these speleothems are most likely formed by a seepage of mineralised water from within the porous limestone to a pool of water.

Grotto Lake tapered helictites

sample 6N37PHGL1

This yellowish lump resembles a large porous tapered helictite with a crumbly prickly coating resembling aragonite, irregular lumpy branches (Figure 1) and fine hairlike crystals similar to "lublinite" (needle-fibre calcite). It forms from a "horizontal layer growing upwards on the edge of the rocks." (Paul Hosie, pers. comm.) Dried organic material on the surface may be from bacteria (Contos 2000).

Figure 1: Cut helictite 6N37PHGL1, about 80 mm long and 60 mm wide.

Grotto Lake flattened helictites

These white to pinkish, oriented nodules resemble branching helictites with some flattened shapes (Figure 2, sample 6N37PHGL2). Crystal size is very small and helictite branches can re-join. Paul Hosie reported they "had developed on a crystal substrate". The porous outer yellow layer is cracked (dehydrated?) and surface crystals resemble clear dolomite. Fine dark threads seen on the surface may be organic or fungal.

Figure 2: Base of Grotto Lake helictite 6N37PHGL2, about 23 mm wide.

Lake Sh’bula helictites, sample 6N37KEN2

The samples comprise a few lumps of soft porous material, pale brown to yellow to white, about forming a somewhat crenulated, irregular folded shape comprising a soft outer yellow crystalline coating (possibly gypsum) with a white crystalline inner section. Diver Ken Smith mentioned the substrate was a “large rock covered in white crust”, and the “speleothems occur in lines at 1.7 m depth associated with a yellow band on surrounding rock. Yellow band is extensive in this part of the cave, is 0.2 m high, horizontal, possibly a specific chemical layer in the water.”

Figure 3: Base view of Lake Sh'bula subaqueous helictites 6N37KEN2, about 25 mm wide.

The outer tips have multiple pores (canals). Directly below the yellow coating is a white crystalline region (at the base of the pores). Within this white region are aragonite needles radiating from a denser central region which has hollow channels in it. The overall shape is formed by many spherulites.

Another piece from this sample comprises parallel plates of the same material, with an inner low density part filled with fairly loose aragonite needles. Possibly the parallel plate structure develops along the top edges of subaqueous cave shields.

Subaqueous cave coral and related forms

Grotto Lake popcorn and coralloids, sample 6N37PHGL3

Fibrous aggregates: These appear to be a mixture of calcite and aragonite (Figure 4). The porous surface is flattened and recrystallised (calcite). Individual crystals are coated with finer crystals and possibly microbial veils.

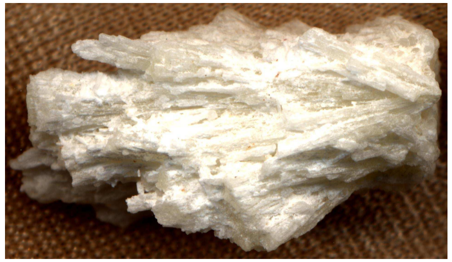

Figure 4: Grotto Lake fibrous aggregate, about 40 mm long.

Coralloids: These form crystalline hemispheres with a yellowish coating, typically 20 mm diameter (Figure 5). The general structure comprises a central core of linear yellow aragonite surrounded by clear radiating aragonite, with clear crystalline (calcite) balls. The outer coating is a very fine yellow brown porous crystal with aragonite aggregates and possibly microbial veils. Some samples have an inner layer of yellow material (possibly gypsum). The inner and outer yellow material has shrunk and cracked since collection. Below the yellow coating is a soft white layer of radiating aragonite crystals and possibly “lublinite” calcite.

Figure 5: Grotto Lake coralloid, about 17 mm wide.

Gurgle Lake coralloids, sample 6N37PHGL7

These creamy yellow nodules are about 40 mm x 30 mm x 20 mm with concentric layers (Figure 6).

The outermost layer is yellowish, fairly thin, and shiny in areas. It has cracked (shrunk since collection) to expose a white powdery layer just below it. Occasional whisker-like crystals may be “lublinite”. Small remnant dark shiny microbial veils are visible.

Below the yellow layer are porous white layers of radiating aragonite crystals, with some layers harder than others.

The innermost area is crumbly, powdery and soft, possibly recrystallised, and may include some hydromagnesite, with isolated coated aragonite crystals and resembles the interior of a subaerial “cave turnip”.

Figure 6: Gurgle Lake coralloid, about 17 mm wide.

Pool crystal, crusts and rafts

Grotto Lake over-coated cave rafts or crusts, sample 6N37PHGL4

These samples are soft and crumbly, coloured white, cream, yellow and brown, and are mostly a flat shape. Typical sizes are 10 mm x 20 mm and are possibly over-coated calcite or aragonite rafts or crusts (Figure 7).

Under the microscope, randomly-oriented fine needle crystals have cemented together to form a soft crust. One side, possibly the up-side, is porous and its yellow and brown surface appears cracked or shrunk. Other parts of the sample resembles pool crystal (i.e. an overgrowth) with small hemispheroidal aggregates which may be aragonite.

It is not clear whether these are sunken rafts or crusts; the flatter samples resemble rafts and the curved ones resemble crusts. Both appear to be over-coated with aragonite, so possibly they originated from the water's surface and have since sunk to the bottom of the lake.

Figure 7: Grotto Lake cave raft fragment, about 16 mm wide.

Grotto Lake pool crystal

sample 6N37PHGL5

This bowl-shaped lump of pool crystal has a layered clay and carbonate substrate (Figure 8).

The laminated clay substrate is composed of both crystalline carbonate sediment, reddish clays and other materials (possibly bat guano, quartz, hydromagnesite). Crystalline carbonate septa or veins separate areas of sediment and cut through the layers, resembling a boxwork.

Between the brown clay and the white pool crystal is a gradual transition from loose sediment, carbonate-cemented clays, laminated carbonate, then radiating aragonite aggregates.

The outer crystal coating is a mixture of white and yellow fibrous, needle-shaped radiating aggregates and massive material (possibly calcite, aragonite and gypsum).

Figure 8: Grotto Lake pool crystal, cut, about 100 mm long.

Apart from the aragonite isomorph, this appears to be a conventional pool crystal deposit on sediment. Carbonate septa in the substrate suggest that the lake may have dried and the clay shrunk and cracked. Septa may have then deposited either subaerially or subaqueously, possibly coincidentally with the lowest layers of pool crystal.

Lake Sh’bula crust, sample 6N37KEN1

A white crystalline coating on a brown clayey substrate forming a shard with a dense cemented layer and a white prickly crystalline surface (Figure 9). Diver Ken Smith noted that this deposit occured at a depth about 1 m as a white crust flaking from the tops of large submerged rocks about 1 m diameter. They are common in shallow water and a similar white crust is common on rocks above water.

Under the microscope, the soft porous brown laminated crystalline substrate has small interlocking grains and contains some aragonite crystals, becoming more dense in the transition to the white area. The white area is porous and is composed of needle to columnar crystals, terminated across the flats of the needles. It appears to be a mixture of calcite, aragonite and lublinite variety of calcite. The aragonite needles terminate as “church steeples”, etched and partially redissolved with some (calcite) cement.

It is unclear whether this is a subaqueous or subaerial deposit as it is reported from both above and below water around the lake. As it is apparently flaking from the tops of submerged rocks, this suggests the deposit is related to the surface of the lake, rather like cave rafts.

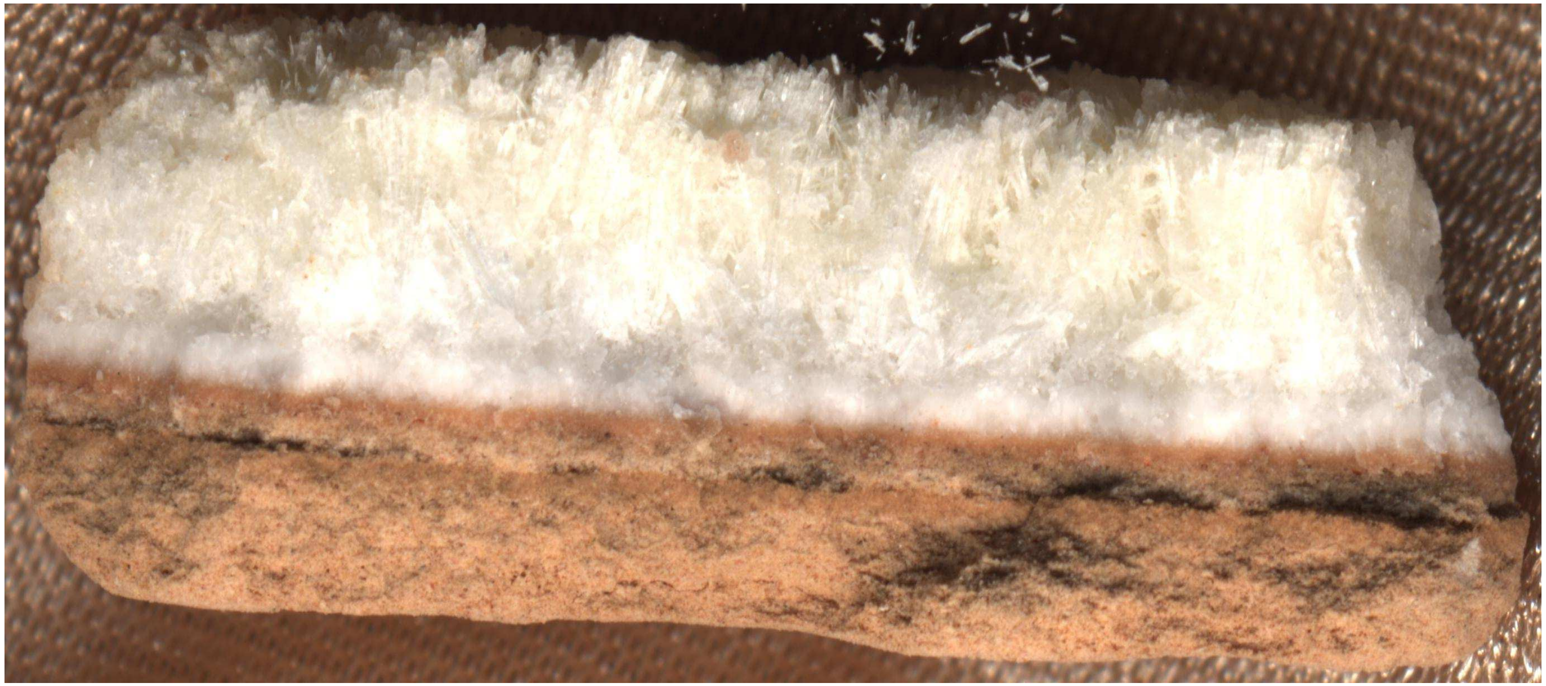

Figure 9: Lake Sh’bula crust is about 10 mm thick.

Tommy Grahams Cave: Massive pool crystal, sample 6N56SMTG1

This rock was found loose in the sediment of the lake in Tommy Grahams Cave by diver Stu McGregor (Figures 11, 10). One side is limestone, the other side is pool crystal, partially eroded. The eroded area contains lots of delicate needle crystals, originally greenish and full of water, and since sunken in. The divers report that the walls of the lake are covered with a similar pool crystal.

Under the microscope, highly porous pale orange Nullarbor Limestone with sand-sized grains is coated with a fine-grained, dense white cement layer, 5 mm thick, which merges with a pale olive aragonite layer, 10 mm thick featuring typical aragonite ray-fan needles, developed from clusters on the white cement layer. The pale olive layer is surmounted by clusters of aragonite forming a hard, dense layer 40 mm thick.

Figure 10: Pool crystal, Tommy Grahams Cave. Cut surface, 125 mm wide.

This is a massive deposit featuring larger and longer aragonite crystal blades compared to the pale olive layer, and is terminated by a white powder (possibly hydromagnesite). Part of the massive layer was exposed to the lake water where it had developed a solution notch, indicating that at times the water is agressive to aragonite. The porous outer layers are complex, with several different types of coatings and textures.

Figure 11: Pool crystal, Tommy Grahams Cave, photo by Stuart McGregor. 50c coin for scale.

This material appears to have been deposited underwater as aragonite, possibly at a particular depth where mineralised groundwater in the limestone meets the lake water in Tommy Grahams Cave. The general form could be described as aragonite pool crystal. The outer surface of the material may have housed microbial veils, and the chemistry appears to have at times favoured the deposition of a variety of minerals on the surface such as calcite, dolomite and gypsum. Judging by the massive aragonite of the main structure, this deposit may be very old, and has broken off the main deposit due to structural failure of the soft porous underlying bedrock.

Cave shields and related forms

Grotto Lake cave shield, sample 6N37PHGL6

This small hollow crystalline “shell” is a small brown/tan cave shield about 40 mm x 20 mm x a few mm.

Figure 12: Subaqueous cave shield, about 40 mm wide, after brushing.

The “shell” outer surface has a rough surface caused by neat pyramids (crystal terminations).

A sparkly appearance when rotating the specimen is caused by the alignment of numerous 3-sided crystal terminations, possibly en-echelon calcite similar to “Bizarre forms” (Folk, Chafetz & Tiezzi 1985). Crystal terminations on the specimen faces are aligned in arrays up to 10 mm wide, resulting in reflective lines (rows) at some angles. This material covers the outer surface of the speleothem, especially around the edge of the plates. At a broken edge, the pale coloured corner has spiky crystals on the inside (Figure 13).

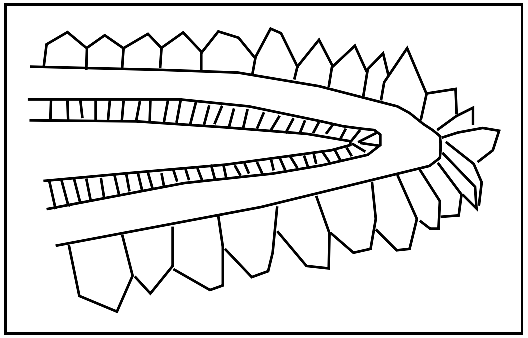

Figure 13: Symmetrical ridge development

The two halves of the shell are cemented by a seam with a symmetrical edge (Figure 14) and a small hole.

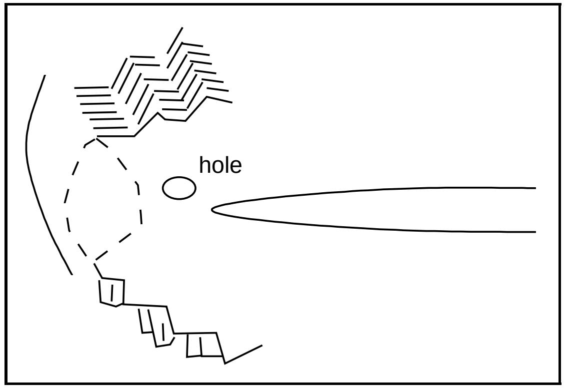

Figure 14: Sketch: area close to edge

A dimple in the base of the structure leads to a tepee shape.

This appears to be a conventional cave shield, only developed underwater. Development may begin like a helictite, only with a capillary slot rather than a capillary tube. The edge seems to be the main region of growth. Imagine a small capillary tube around the edge, similar to that depicted in Figure 14, like the central canal of a conventional helictite only connected to the substrate at both ends.

Figure 15: Cave shield interior, about 40 mm wide

Such a structure may originate from a small crack in the substrate. Like conventional helictites, this small tube can be slightly dissolved by the water in the substrate, however instead of breaking open at one end like conventional helictites, it breaks open along the outer edge of the crack. Growth may continue in this way due to the alignment of crystallites and the thickness of the inner wall. Where the tube opens, carbonate precipitates. Additionally, calcite can glide / cleave without breaking. If the pressure of crystal growth inside the shield is sufficiently high, the material may glide apart while still precipitating carbonate. This would result in symmetrical crystal development at the edge and develop a cave shield.

Lake Sh’bula flat speleothem: cave shield or coating? Sample 6N37KEN3

Figure 16: Cross-section of flat speleothem 6N37KEN3, about 54 mm wide.

This flat, porous speleothem has a soft prickly outer coating and has formed in two halves like a cave shield. Diver Ken Smith described its growth habit as “part of a flake . . . cemented to the base rock.”

All rocks at the 2.8 m depth had this cover, which covered several square metres.

Under the microscope, the surface appears to be recrystallised aragonite, with occasional loose, shiny fragments (dried microbial veil?), easily disturbed. The needles radiate from the median plane of the speleothem (Figure 16) which contains a white powder resembling hydromagnesite.

Discussions

Helictites and heligmites

Subaqueous helictites from the Nullarbor cave lakes are mainly heligmites, as the divers noted they developed upward from a substrate (typically from boulders or from pool crystal).

Finger-shaped forms typically have a central canal (or set of them), supprounded by radially-oriented carbonate crystals such as calcite or aragonite. Pores near the tip (growth point) are connected to the central canals through less dense mats of needle crystals. The outer surface is coated with materials such as magnesian calcite, dolomite or gypsum.

In **branching forms**, the branches may join up, forming a structure consisting of both cylindrical and flattened shapes. The cylindrical parts have cylindrical central canals, and the flattened parts have a slot-shaped central canal, similar to a cave shield.

Microbial veils (also known as snot-tites) have been recorded from Nullarbor cave lakes (Contos 2000). Several samples have what appears to be remnant microbial veils attached to their surfaces.

Cave coral and related forms

Conventional cave coral is a layered subaerial speleothem, formed by a film of mineralised water on the surface. Growth is near the area of maximum air movement, where CO_2 exchange is highest. Sub-types include cave popcorn and coralloids, usually made of aragonite, and developing along the lines of aragonite “shrubs”.

Nullarbor cave lake coral appears to be alternating calcite and aragonite. Development is larger and less dense than subaerial cave popcorn and coralloids.

Similar structures have been previously reported from a marine (coral reef) setting as aragonite “mamelons” (Ginsburg & James 1976).

Pool crystal, crusts and rafts

These are conventional, often reported from caves. The Nullarbor **pool crystal** occurs at specific depths, corresponding to either particular layers in the rock, or a halocline. The usual subaerial polymorph deposited is calcite, whereas the Nullarbor lake samples appear to be mainly aragonite (Tommy Grahams Cave) and calcite with other minerals, suggesting crystal poisoning by Mg and SO_4 leaching from the bedrock.

Cave rafts are caused by the outgasing of CO_2 from the surface of a lake to an air filled chamber, allowing carbonates to precipitate at the water-air interface. What is unusual in the raft samples is the crystal polymorph, which is normally calcite but in the samples they appear to be aragonite. One possibility is the rafts precipitated as calcite, but were later overgrown with aragonite after they sunk.

The divers report a **crust** which occurs both above and below water, flaking off the rocks. This is most likely formed at the water's surface, dependent on the lake level, and is a simple carbonate coating formed on the rocks by CO_2 outgasing from mineralised water. The flaking is most likely due to the clay in the substrate expanding and contracting with water level. They appear to be a mixture of carbonates, including calcite and aragonite.

Cave shields

Two types of cave shield were identified:

1. A relatively conventional cave shield, comprising two halves like a bivalve, hollow inside, and with a fine linear capillary along the edge. Growth appears to be by pressure-gliding along cleavage planes, with the edge crystals oriented such that they form a mirror image of each other about the two halves. Cave shields resemble helictites with the direction of growth at 90° to the central canal.

2. A porous structure forming a blade with a powdery core (possibly hydromagnesite) surrounded by acicular carbonate e.g. aragonite. The divers report they develop on pool crystal. Perhaps cracks in the substrate seep mineralised water along with calcite crystal poisoners. The less dense aragonite structure may develop where water supports the speleothem's weight.

Conclusions

A variety of subaqueous speleothems occur in some cave lakes on the Nullarbor Plain. Conditions leading to the deposition of carbonate speleothems on rocks in a cave lake may include:

- Porous bedrock (limestone and dolomite) in the lake area.
- Higher concentration of HCO_3 in the rock pore water than that of the lakes.
- Exchange of CO_2 between the rock pore water and the lake water allows CO_2 to escape from the rock pore water, thus precipitating carbonate.
- The rocks may be conducting highly mineralised groundwater to the lakes. As some of the speleothems were reported from isolated rocks, possibly the rocks are dissolving.

- The actual form (helictite, shield, pool crystal etc) depends on the physical conditions during deposition.
- The mineral species deposited depends on the chemistry during deposition. For example, aragonite may deposit instead of calcite if there are sufficient calcite crystal poisoners present (Mg, sulfate and Mn are the most common).
- Two possible sources of Mg and SO_4 are: Dedolomitisation of the bedrock (including pyritic decomposition) and the prevailing winds carrying seaspray to the area.

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Thanks also to Stu McGregor for the lovely photograph of “The Thing” from the lake in Tommy Grahams Cave.

The Glenelg River Karst Area

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Abstract

The Glenelg River karst area lies within the Gambier Karst Province, along the Glenelg River and its immediate environs. It has been known as a caving area for many years but its known caves are restricted. It forms part of a composite karst area on the coastal plains of the Gambier Karst Province. The influence of the incised Glenelg River on surface and underground water flows and the tectonic activity of the faults along the escarpment to the east of the river, has resulted in a significantly different karst landscape to the drowned cenote karst to the west. Within the Glenelg River karst there are known two sub-areas: the escarpment and the immediately adjacent incised Glenelg River karst area which, include several poorly defined cave documentation areas used by the VSA and CEGSA (Matthews, 1985): a small part of the lower southeast of South Australia (L) just to the west of S.A./Victoria border, known as Dry Creek, including areas of pine forest and farmland nearby, and in Victoria, the Glenelg (G), Drik Drik (DD) and poorly documented areas between the fault escarpment and the Glenelg River. Although formed in the Tertiary limestones, like Naracoorte, the karst landscape evolution is very different. This paper will look at the landscape development of the karst through the Pleistocene, compare it to what happened in Naracoorte and discuss potential for further discoveries.

Introduction

The Glenelg River karst area lies within the Gambier Karst Province (White, 2005), along the Glenelg River and its immediate environs (Figure 1). Although the Glenelg River has its headwaters in the non-limestone areas to the east, downstream from Casterton it flows through predominantly limestone terrain.

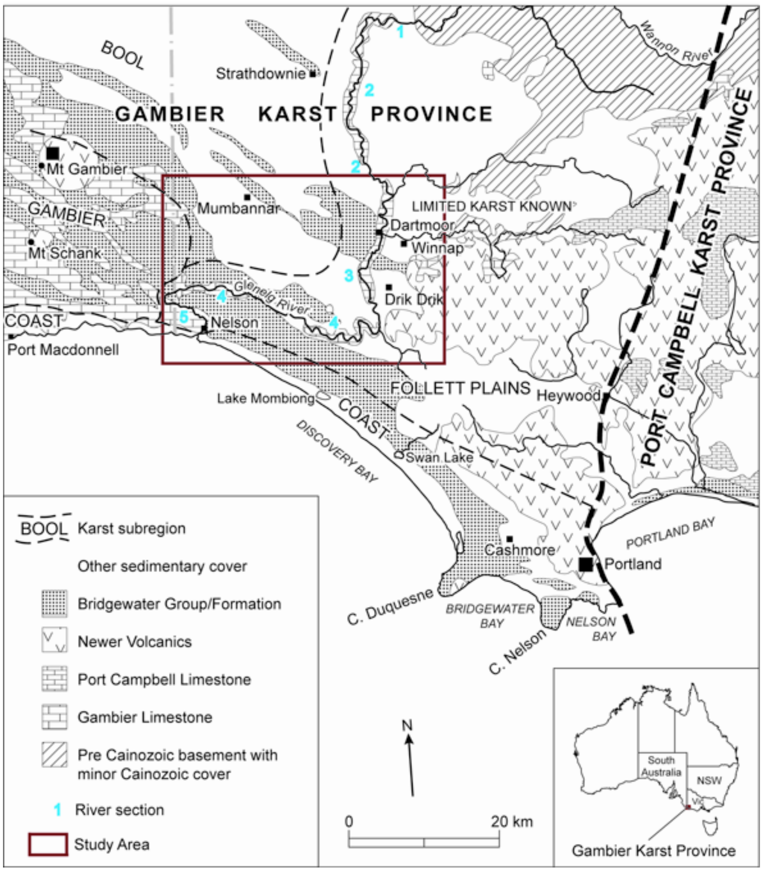

Figure 1: Glenelg River karst area: location map (White, 2005)

The karst forms part of a composite karst area on the coastal plains of the Gambier Karst Province (Grimes et al., 1995; Marker, 1975). The influence of the incised Glenelg River on surface and underground water flows and the tectonic activity of the faults along the escarpment to the east of the river has resulted in a significantly different karst landscape to the drowned cenote karst to the west and the Naracoorte karst to the north. Within the Glenelg River karst there are two sub-areas: the escarpment and the incised Glenelg River karst area.

The Glenelg River karst area includes several poorly defined cave documentation areas used by the VSA and CEGSA (Matthews, 1985): a small part of the lower southeast of South Australia (L) just to the west of S.A./Victoria border, known as Dry Creek, including areas of pine forest and farmland nearby, and in Victoria, the Glenelg (G), Drik Drik (DD) and poorly documented areas between the fault escarpment and the Glenelg River. The Follett Plain north and east of the Kanawinka Escarpment contains dune karst in Bridgewater Group aeolianites, but is not regarded as part of the Glenelg River karst area (Figure 1).

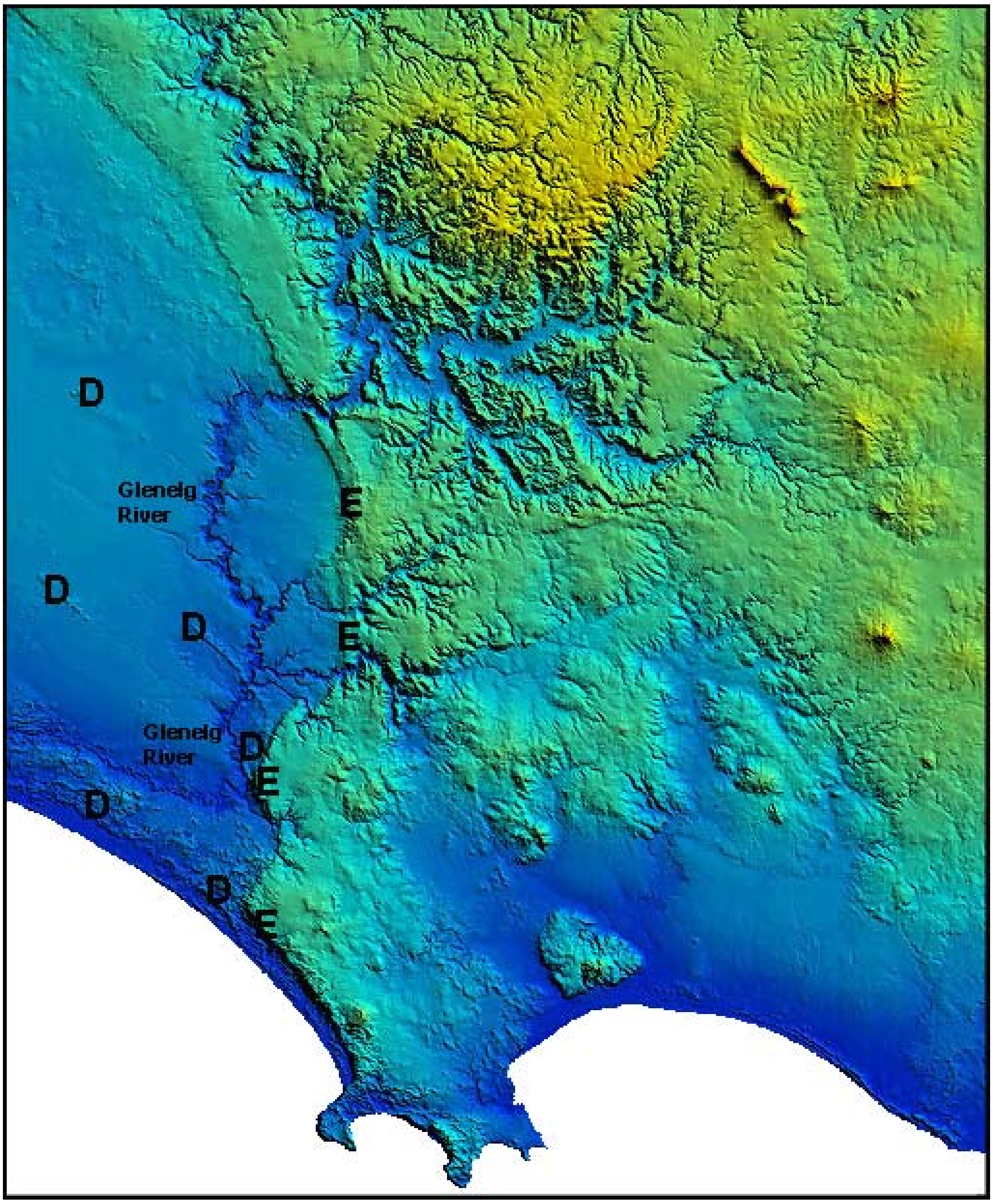

Figure 2: Digital Terrain Model showing the escarpments and dune relationships: 100 m grid cell interval digital elevation model derived from 1:25,000 topographic contours and spot heights, (after Primary Industry Research, Victoria, Bendigo). D = Dune ridge; E = Escarpment.

Geology

Within the Glenelg River area karst has developed in both Gambier Limestone and overlying Pleistocene Bridgewater Group. The main karst host rock in this area is the marine Oligo-Miocene Gambier Limestone. Pleistocene Bridgewater Group dune ridges overlie Tertiary limestones and form most of the surface outcrop. The Bridgewater Group here is low in quartz (0.6% to 5%) compared to other sites, e.g. Bats Ridge near Portland where up to 28% quartz is present (White, 1984). The stratigraphy of the Oligo-Miocene limestones in western Victoria has been the subject of some confusion and discussion (Abele et al., 1988; Gallagher et al., 1999) but the limestones outcropping along the Glenelg River are now clearly identified as Upper Gambier Limestone (Dickinson et al., 2001). East of the fault escarpment, Gambier Limestone grades laterally into non-karstic Gellibrand Marl, which is disconformably overlain by the younger Port Campbell Limestone. No outcrop of Gambier Limestone is known east of the escarpment. The Gambier Limestone and its equivalents were gently folded prior to the deposition of the Pliocene limestones and the folding is exposed in the cliffs of the Glenelg River gorge (Dickinson et al., 2001).

Pliocene basalts (between 2.2 and 2.4 Ma in age) (Aziz-Ur-Rahman and McDougall, 1972) have blanketed and infilled an erosional surface developed on the Tertiary limestone plateau to the southeast of Dartmoor and Drik Drik. The flows are ~10 m thick, depending on the underlying surface, and have been extensively weathered to thick clay rich soils.

The area has been subsequently subjected to tectonic uplift and warping and is dominated by a reactivated series of faults: the Kanawinka, Weecurra, Drik Drik, Jones Ridge, Kentbruck and Swan Lake-Bridgewater Faults, which separate the Glenelg River area from the Early Cretaceous sediments to the east. The faults form the western boundaries of elevated fault blocks tilted to the northeast, and are not topographically part of the Glenelg River karst area, except for a small area at Drik Drik, south of Dartmoor (Figure 2).

The joint directions in Gambier Limestone in the Glenelg River karst area are generally north/northwest and less commonly, at right angles to this, and these conjugate joint patterns have influenced cave development very strongly in the major cave areas close to the Glenelg River. However, in areas closer to the faults, e.g. on Jones Ridge, the jointing patterns are not as regular.

Surface Landforms and Processes

The dominant surface landforms of the area are the Glenelg River and the fault escarpments, apart from which the area has a subdued relief with dunes on the coastal plains. The interplay of soluble lithologies, a large perennial river, tectonic activity along the Kanawinka/Weecurra/Jones Ridge escarpment and the Pleistocene dunes covering the area, has resulted in a complex surface geomorphology. The escarpments represent old coastal cliffs 0.25 to 2 km east of the faults themselves.

The dunes are oblique to the escarpment and climb it in some places e.g. Jones Ridge where the large doline of DD 4 exposes climbing Bridgewater Group dunes with distinctive cross bedding, that overlie colluvium containing basalt fragments (Figure 3).

Except for the Glenelg River and its a few small tributary streams, the plains have a minimal and poorly developed surface drainage that generally is only significant during periods of high rainfall and runoff. Curran's Creek is a well defined but short perennial surface stream incised into a small gorge on the north bank of the river and is strongly influenced by the dominant northwest striking joint pattern as are most of the tributaries in this area. Most tributaries are very short and unnamed, and are perched above current river levels descending via steep knickpoints to the present river level. The larger creeks may have been previous main channels of the Glenelg River, e.g. Moleside Creek.

Much of the drainage of the area is underground. Some surface drainage has been disrupted by underground capture to form dry valleys, which carry water only during irregular periods of high flow, e.g. Dry Creek. Features such as Runaway Hole (G 43) have predominantly dry channels, which collect and funnel water underground in times of high surface flow and act as a point source recharge for the groundwater.

The Glenelg River is the largest perennial river in the western Otway Basin. Its headwaters are outside the karst area in the wetter higher altitude areas of the southern Grampians, and the river maintains a permanent flow to the sea. The Glenelg has a deep narrow valley and has cut an impressive 30 m deep gorge into the Gambier Limestone with steep cliffs incised in the southern section. The gorge is not continuous and the cliffs vary from near vertical to more gently sloping bluffs. In the gorge walls, the sub-horizontal limestone has been differentially eroded along bedding planes. The river has a complex drainage pattern, which has been modified since the Late Tertiary (Boutakoff, 1963) and is further complicated by the influence of karst ground water flow. River flow levels are maintained by the combination of relatively high rainfall in the catchment, and discharge into the river from underground streams and lateral groundwater flow.

The westerly flowing stretch of the Glenelg River downstream from Keegan's Bend is parallel to the dunes of the Bulley Range, indicating that these dunes were present when this section of the gorge was incised. The deposition of these dunes and the diversion of the river are therefore probably linked and probably occurred when sea level was below ~30 m to 40 m above present sea level.

The relatively soft limestone outcrops in the Gambier Karst Province do not develop extensive surface solutional microfeatures. Very little karren is present and in most areas, sub-soil karren is poorly developed. However, larger surface karst features, which include a wide range of solutional pans, hollows and dolines, are similar to those found further north and may be polygenetic although enigmatic (Grimes, 1996; Grimes et al., 1999). Solutional dolines, many undocumented, are widespread, e.g. G 48D and G 53D, and are also concentrated along the escarpment. They are generally conical in shape but vary greatly in depth from 1 m to 5 m. The numerous small pans and hollows scattered across the Glenelg River karst. Large elongated basin-shaped dolines, up to 500 m across and up to 10 m deep, occur in the dune ranges south of the Glenelg River and west of Moleside Creek. These dolines are predominantly solution-modified dune swales and usually have soil floors. A few contain "runaway holes", which funnel surface water underground during periods of high runoff.

At Drik Drik a group of seven dolines occurs as a spectacular set of nested solutional dolines. Some of these are nested into larger dolines in Bridgewater Group limestone on a bench half way down the escarpment. The dolines are generally blind and exhibit inverted-cone morphology.

Collapse dolines are concentrated close to the escarpment. DD 4 has a large collapse doline 26 m deep and ~20 m in diameter with near vertical cliffs (Figure 3) (Foster and McEachern, 1929). This doline contains the entrance of DD 4 and is formed in Bridgewater Group climbing dunes and has collapsed into the underlying Gambier Limestone. The collapse dolines do not extend below water table to form cenotes.

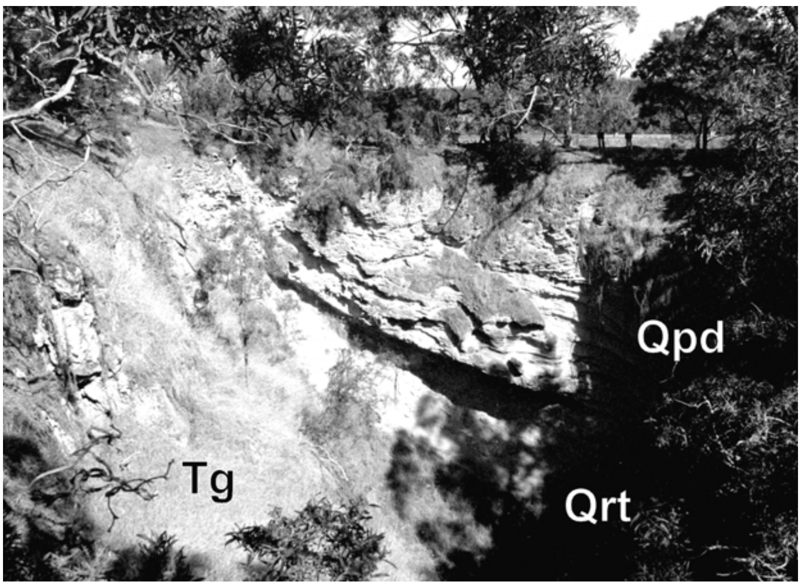

Figure 3: Climbing dunes overlying colluvium on the escarpment, DD 4; Gambier Limestone (Tg) under Talus deposit (Qrt) under Bridgewater Group dune limestone (Qpd) (Photo: K. Grimes)

Underground Features

Although over 100 features, including 67 caves, are known from the Glenelg River karst area, this reflects an incomplete knowledge of the area. Caves are concentrated in two areas, along the Glenelg River and along the escarpment at Drik Drik, and there is a paucity of known caves elsewhere. Whether the distribution and numbers of caves is an artefact of exploration or not is unclear, but current exploration indicates that more caves exist.

Most caves, including all of the larger ones, have the majority of passages developed within the Gambier Limestone. Entrances, especially solution pipes and passages connected to the surface, often pass through the overlying Bridgewater Group.

The caves occupy six general positions in the landscape:

Caves with entrances close to river level, i.e. within 1 m of the level of the present river or a tributary such as Curran's Creek, e.g. Curran's Creek Cave (G 4) (Figure 5). These often contain perennial streams.

High level caves close to the river; at 10 to 15 m above present river level with entrances in the cliffs, Amphitheatre Cave (G 2) (Figure 4).

High level caves which are not close to the river, e.g. McEachern's Death Trap (G 49) (Figure 6). These are positioned at the same level as the other high level caves, but are over 1 km from the river and are more modified by collapse and sediment infill.

DD 4, a complex two-level branchwork cave that contains an underground tributary of the Glenelg River flowing towards the Glenelg River from the higher elevation area of the Jones Ridge escarpment. This cave is atypical for the area.

Small syngenetic caves developed in Bridgewater Group aeolianites, e.g. DD 7. These often have solution pipe entrances, e.g. G 10 (Figure 9) or "Runaway" holes and dolines on the flatter plains away from the river, e.g. G 48D.

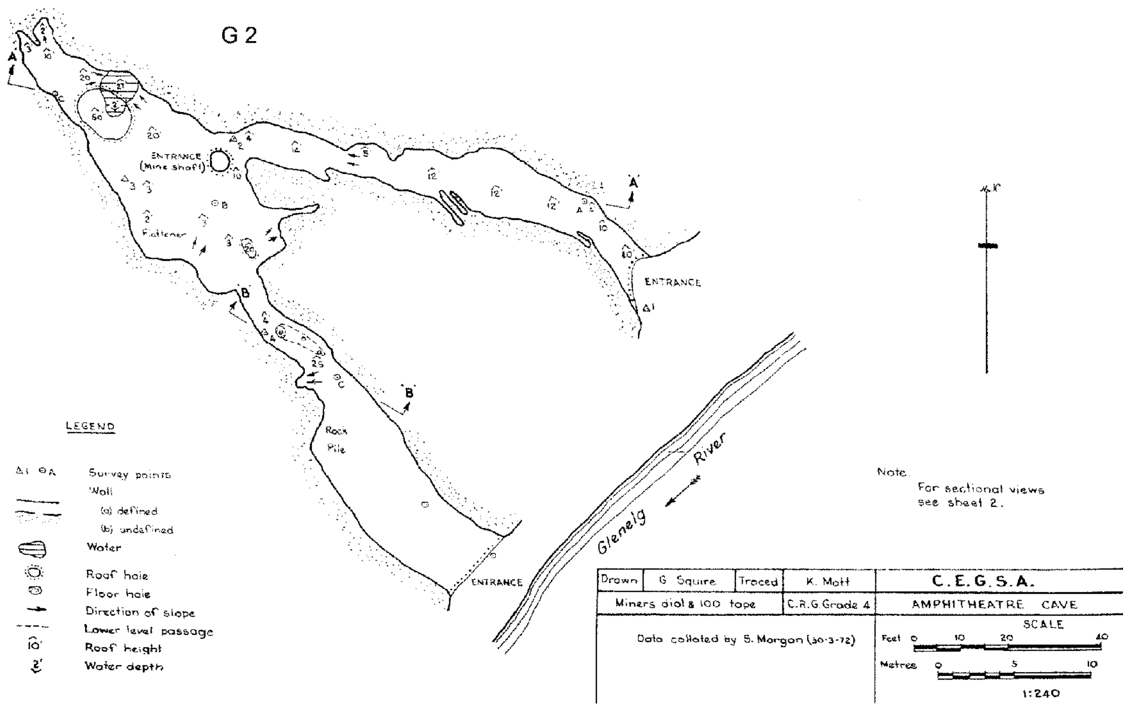

Figure 4 Map: Amphitheatre Cave (G 2) (after CEGSA map 3G2 CEG2, 1974)

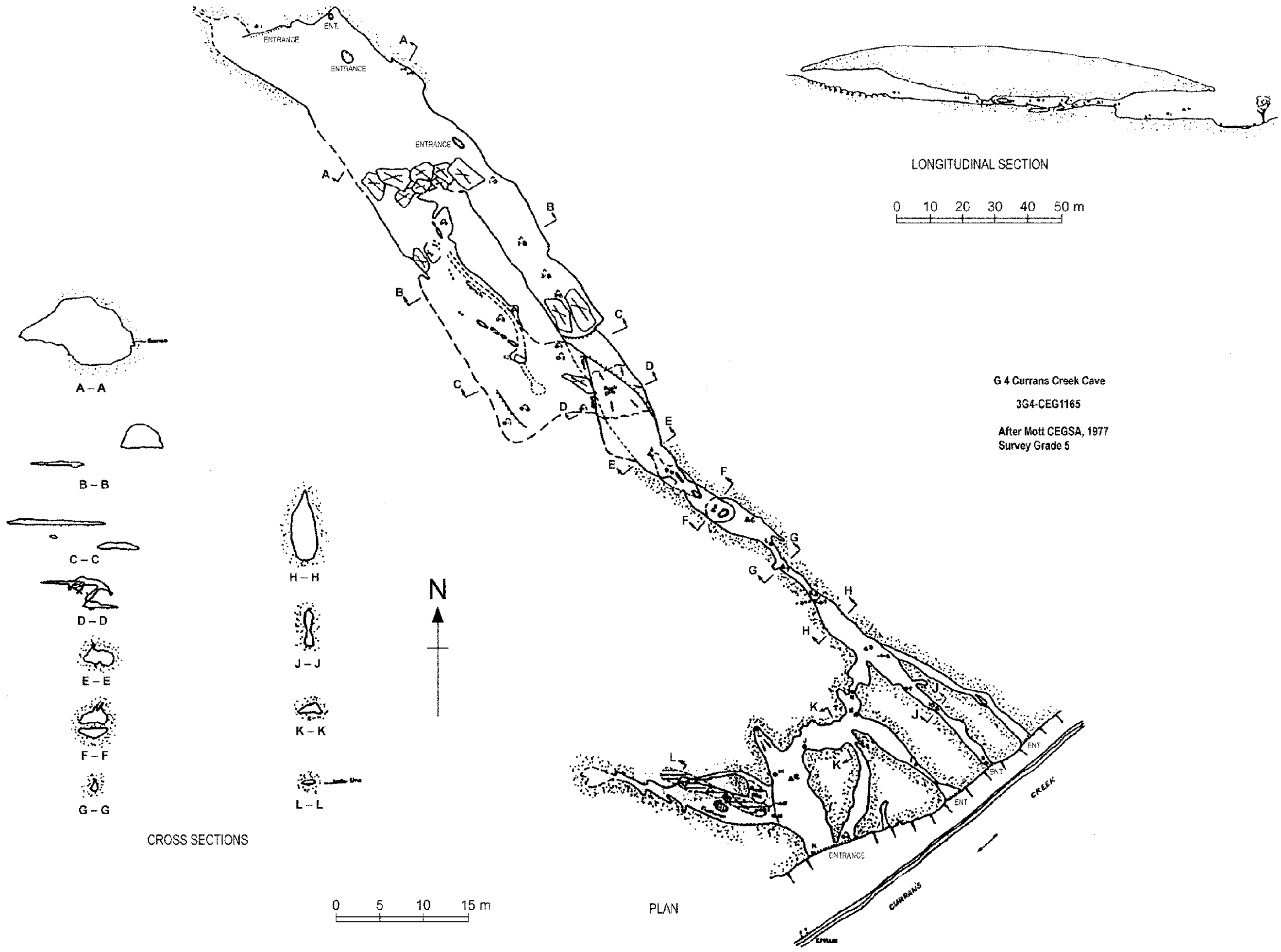

Figure 5 Map: Curran's Creek Cave (G 4) (after CEGSA map 3G4 CEG1, 1974)

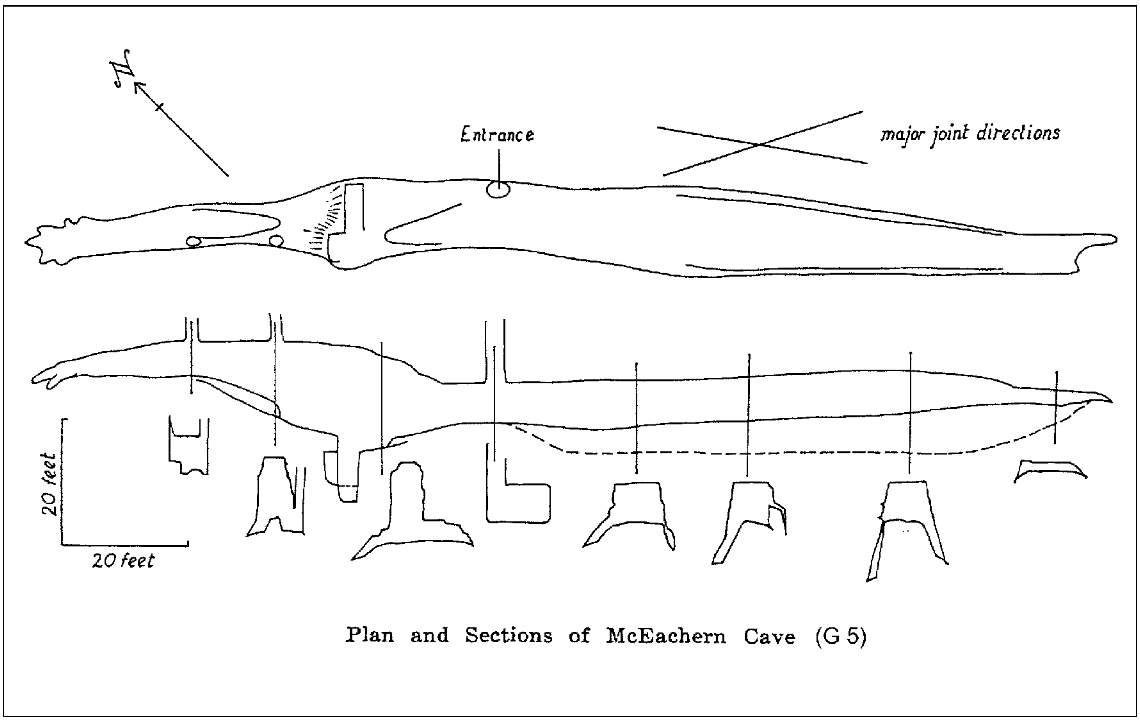

Figure 6 Map: McEachern's Cave (G 5) (after Ollier, 1964, M. Pierce, pers. comm., 1978)

The caves are predominantly simple, short single passages, i.e. single conduit caves. There are few multilevel or branchwork caves and no cave of the complexity of the maze caves observed at Naracoorte. Caves vary in length from a few metres, e.g. Hand Cave (L 3), to ~2 km (DD 4). Most cave passages are narrow, high rifts with near vertical walls, e.g. Princess Margaret Rose Tourist Cave (PMR) (G 6). Both phreatic and vadose passage shape are evident and many show evidence of phreatic initiation as either a subcircular or elliptical tube in the ceiling, e.g. PMR (G 6). However, vadose entrenchment occurs especially in the caves containing flowing streams. Surface weathering on the cave walls commonly obscures distinctive and diagnostic phreatic or vadose wall features. The influence of the predominant regional joint patterns on cave passage orientation is marked (Figures 7 & 8).

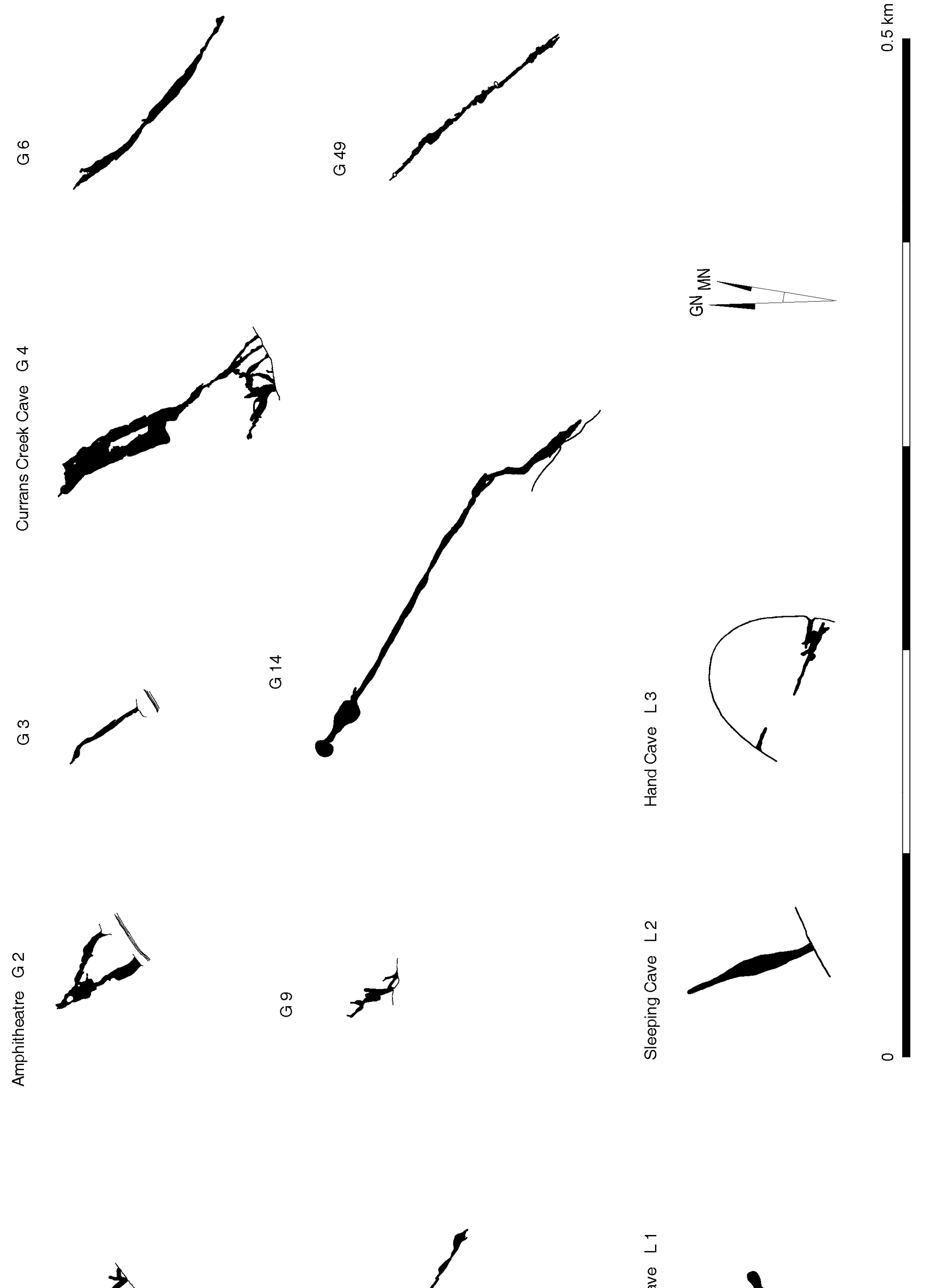

Figure 7: Cave orientations as passage outlines (after CEGSA and VSA maps)

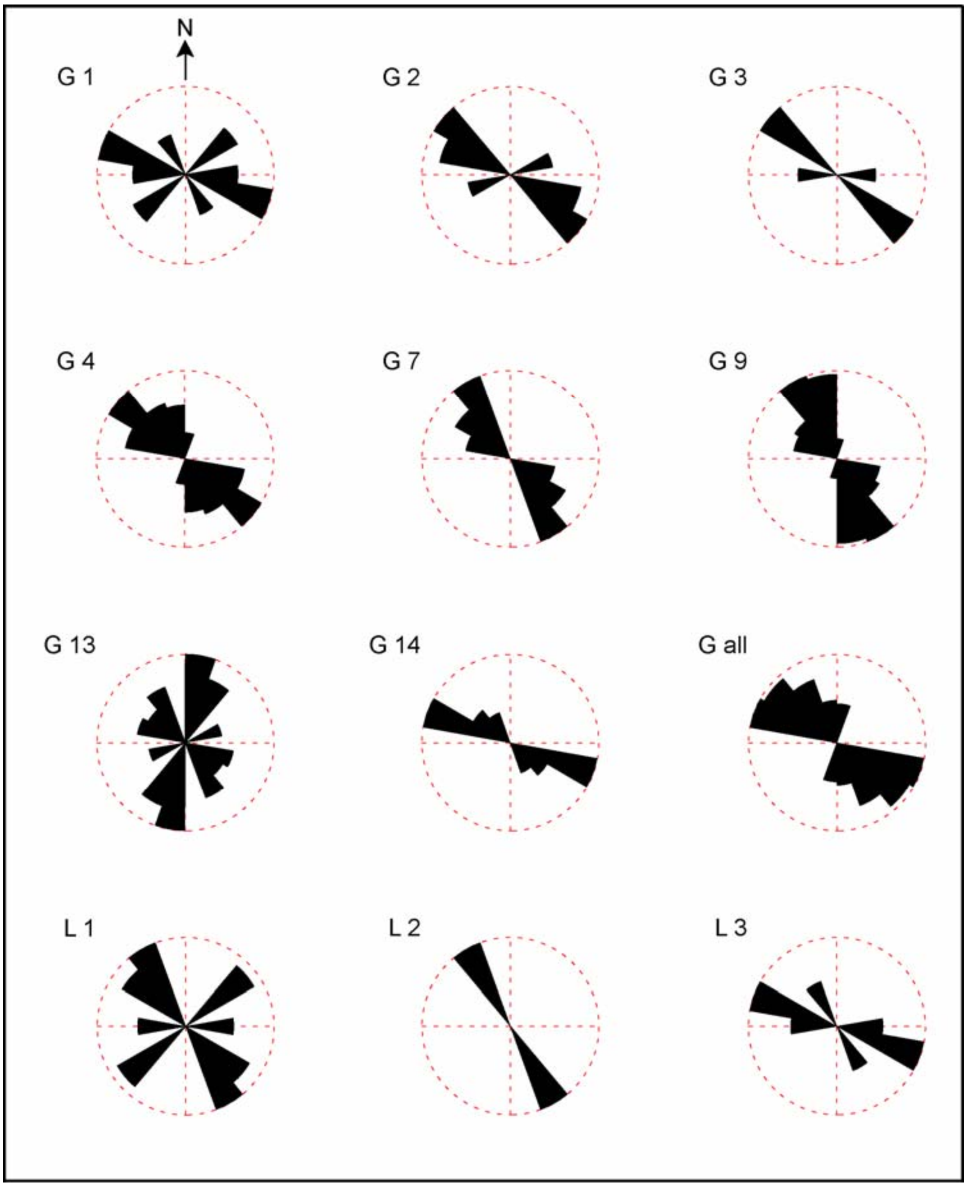

Figure 8: Passage Direction Roses, Glenelg River karst area (data from CEGSA and VSA maps)

Some passages have been modified by collapse, but the rubble piles found in many caves are generally small and collapse is not as important in cave modification as at Naracoorte.

Although a number of caves in the Glenelg River karst area contain water, this represents flowing streams and not groundwater pools.

Five entrance types are found: artificially modified entrances, e.g. PMR (G 6), solution pipes, e.g. G 10, collapse, e.g. DD 4 and horizontal “cave” type entrances, which can be subdivided into cave crawl and fissure types, e.g. DD 8 and McLennan's Punt Cave (G 14) respectively. In common with the Naracoorte area, many caves have more than one entrance and more than one entrance type. The most common entrance type is the fissure entrance especially along the river cliffs. These vary from tight vertical fissures to large fissures on the river cliffs. Vertical and smooth sided cylindrical tubes (solution pipes) penetrate from the surface and may intersect cave passages. They occur singly, e.g. G10 (Figure 9) or in multiples, e.g. Curran’s Creek Cave (G 4), and typically have a thin, cemented rim, but are not associated with rhizomorphs. Solution pipes are characteristic of highly permeable limestones and are formed by focussed vertical flow of undersaturated meteoric water (Grimes, 2004; Lauritzen and Lundberg, 2000). In the Glenelg River karst area, solution tubes have always developed where Bridgewater Group aeolianites overlie the Gambier Limestone. They never act as the initial sink for a sinking stream. Solution pipes have a close association with fossil deposits, e.g. McEachern’s Cave (G 5) and McEachern’s Death Trap (G 49) as a significant pitfall linking the caves to the surface and enabling surface sediment and fauna to enter caves. Most have surface sediment at their base, often as sand cones. Solution pipes completely blocked with sediment are present in several caves, e.g. McEachern's Cave (G 5), McEachern's Death Trap (G 49), and these have probably been open entrances in the past.

Figure 9: Solution Pipe entrance, G 10 (Photo: R. Frank)

The main wall and ceiling solutional features present are horizontal grooves (notches), pendants and non-directional and large symmetrical scallops. Ceilings with bell holes and avens are found in specific caves only, e.g. DD 4, but are not a common feature in most caves in the area. The notches are either waterline notches or lithologically controlled and multiple waterline notches occurring in some caves, e.g. McEachern's Death Trap (G 49) probably correlate with base level stillstands during downcutting of the river, and may therefore correlate with particular sea levels (Kos, 2001), assuming minimal tectonic movement in the area over the Mid to Late Pleistocene period.

The caves in the Glenelg River karst area, except for DD 4, are significantly smaller, with more uniform passage dimensions, than those at Naracoorte and there are no large maze caves. The two branchwork caves, Amphitheatre Cave (G 2) and Curran's Creek Cave (G 4) are not distinctively different from the single conduit caves. Although collapse has modified passages in the Glenelg River karst area, the uniformity in passage dimensions is at least partly because there is no large collapse chambers. For example, the Princess Margaret Rose Tourist Cave (G 6) and G 3 contain an area of collapse but no large collapse passage occurs. The breakdown material in the caves has typically not been removed by solution. Caves in the Glenelg River karst area do not extend as far below the surface as at Naracoorte. There is only one cave over 20 m below the surface (DD 4), and this is also significantly longer than all other caves in the area; at 2000 m in length it is almost an order of magnitude longer than the next largest cave (Curran's Creek Cave, G 4) at 250 m in length.

Most caves do not contain extensive clastic sediments, as past or present streams have removed sediment relatively rapidly. However, extensive unconsolidated clastic sediments containing Pleistocene bone material are found in a few caves in the Glenelg River karst area: Amphitheatre Cave (G 2), McEachern's Cave (G 5), McEachern's Death Trap (G 49) (Baird, 1986; Hope and Wilkinson, 1982; Kos, 2001; Link, 1967; Wakefield, 1967).

Speleothem development in most caves is limited, with a few exceptions, e.g. Princess Margaret Rose Tourist Cave (G 6) and DD 4.

Cavern development and speleogenesis

The main process involved in cavern development in the Glenelg River karst area is dissolution. Solutional modification, especially vadose entrenchment, has continued to alter the caves after they were drained because underground streams are present in several. Collapse has occurred after the initial solutional development but it is significantly less important than at Naracoorte.

The caves were initially developed as phreatic conduits and later modification occurred as the river incised into the landscape in response to the lowering sea levels, the subsequent water table lowering and the draining of phreatic conduits. These passages may have been flooded again at times of high sea levels, and this high water level may be partially responsible for the solutional features on the walls of the caves. As they drained, the caves modified by entrenchment rather than collapse, so rift-shaped passages are common rather than collapse domes. Vadose canyons are present in those caves with streams, e.g. McLennan's Punt Cave (G 14). Other caves have been left as drained rifts, e.g. PMR (G 6). As the river has very few surface tributaries, these vadose fissure caves are significant contributing tributaries down stream from Moleside Creek. Many caves continue to contain at least seasonal flowing water, e.g. McLennan's Punt Cave (G 14).

Collapse features, including breakdown rock piles and domed ceilings, are less common in the area than at Naracoorte and no large collapse chambers of the dimensions found at Naracoorte occur. The vertical elliptical shape of the phreatic conduits is such that the removal of buoyancy support when the caves drained did not lead to collapse in most caves (E. L. White and W. B. White, 1969). In the few cases of major collapse, e.g. Curran's Creek Cave (G 4), it appears to be the result of beam failure of the roof.

The two isolated caves, McEachern's Cave (G 5) and McEachern's Death Trap (G 49), in the Bulley Ranges south of the river. show more collapse than other caves in the area indicating that the draining of the cave post dated significant cave development, as they are not current stream caves. Both have solution pipe entrances and contain significant Late Pleistocene fossil deposits (Kos, 2001; Wakefield, 1969).

Landscape History

The Gambier Limestone accumulated in the near-shore shallow water Gambier Embayment of the Otway Basin during the Oligocene and Miocene (Holdgate and Gallagher, 2003). Coastal barrier conditions occurred across southeastern Australia (Warne, 2002). The karst landscape developed in several stages which are presented graphically in Figure 10.

In the Glenelg River karst area the caves are significantly less complex than at Naracoorte. All but three caves are single conduits and there are no maze caves. The single conduit caves are mostly linear and less than 100 m in length. The two main karst areas at Glenelg River formed at different times. At Drik Drik karstification occurred at similar times to the formation of karst at Naracoorte (between 1.1 Ma and 400 ka), whereas the caves along the Glenelg River lower reaches and the Bulley Ranges developed no earlier than the 400 ka (δ^{18}O stage 11) stillstand.

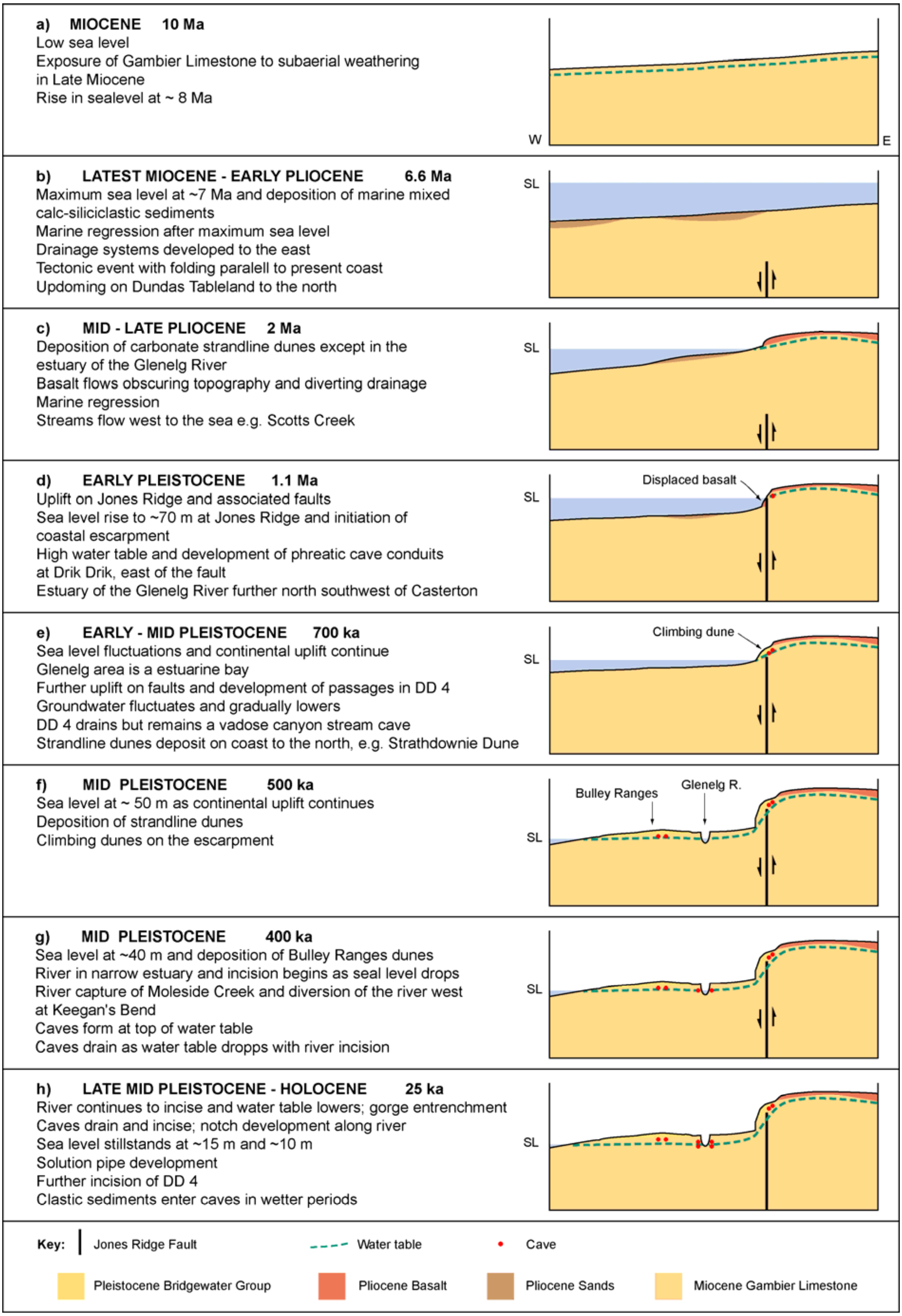

Figure 10: Landscape evolution stages, Glenelg River karst area

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Volcanic Caves of Western Victoria

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Abstract

The Western District Volcanic Province extends from Melbourne across to the Mount Gambier area and has been erupting basalt lavas for at least the last 5 million years. Lava caves have formed in several areas across the region, but the best concentrations are in the ~30,000 year-old lavas from Mt. Eccles and Mt. Napier.

There are a variety of volcanic caves, including large feeder tubes that are responsible for the long lava flows (60 km in the case of a flow from Mt Rouse), but also smaller but more complex shallow subcrustal lava caves and one example of a still-open volcanic vent or large hornito.

Lava tubes form in two main ways. The first is by the roofing of narrow surface lava channels, which happens in several ways. This type tends to form linear and simply-branching or anastomosing tubes. The second way is by draining from beneath the crust of a set of spreading lava lobes near the leading edge of a lava flow - these tend to form more complex mazes of shallow, low-roofed chambers and passages, but over time they may evolve by solidification of the more stagnant areas and erosional enlargement of the fastest moving routes to form simpler linear tubes that are difficult to distinguish from the roofed channels.

Both types of tube contain liquid lava flowing beneath a solid crust. At the end of the eruption some of that lava drains out to leave empty caves, but most tubes remain filled with solidified lava. Many lava caves end at solid undrained lava "sumps".

The Western District Volcanic Province

The Western District Volcanic Province of western Victoria (previously known as the Newer Volcanics Province) is one of the world's larger volcanic plains, and has formed by a succession of eruptions and basaltic lava flows over the last five million years. The isolated volcanoes near Mount Gambier are a western outlier of the Province (Figure 1). Eruptions have continued up to quite recent times and further eruptions could occur in the geological future. Current dating suggests that the youngest volcano may be Mount Schank, south of Mount Gambier, which erupted 5,000 years ago. The flows associated with these younger eruptions show better lava caves and surface features than those of the older volcanics. None-the-less, a few of the caves are in flows several million years old.

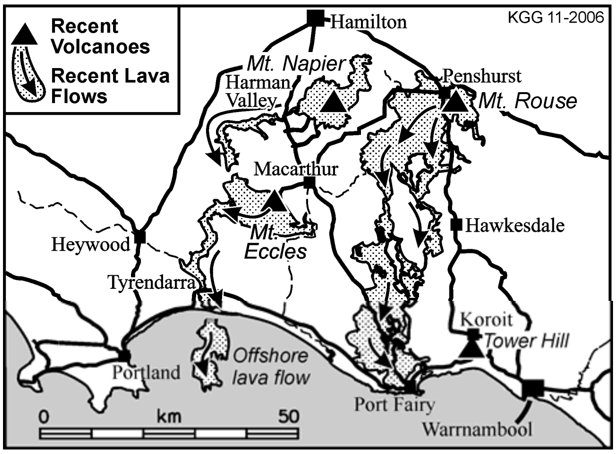

Figure 1.

Western District Volcanic Province & caves.

Lava tubes and other volcanic caves are scattered across the province (Figure 1), but the majority of them are in the western area where they are associated with two of the younger eruptions in the region - Mt Eccles and Mt Napier (Webb & others, 1982, Grimes & Watson, 1995, Grimes, 2008).

Surface landforms

The volcanics are dominantly built up from basalt lava flows, but there are numerous small volcanic cones built by explosive activity, as well as larger maar lakes formed by major explosions (Price & others, 2003; Joyce & Webb, 2003).

The older volcanoes of the region have degraded features, and thick lateritised soils, which make their recognition difficult. By contrast, the flows from the younger eruptions have only minimal soil development and rough undulating surfaces known as stony rises. Isotope dating suggests that these are all less than 500,000 years old.

The best modern model for the nature of vulcanism in this region is provided by the Hawaiian volcanoes. There we see broad lava shields built up by successive flows of very fluid basaltic lava spreading out from a central crater or fissure. In the crater area we see lava pools with fountains jetting into the sky and building local small cones of welded spatter or loose scoria. The long lava flows are seen to be fed either by surface channels, or underground by lava tubes.

Local examples of lava shields are the lower slopes of Mount Napier and the lava fields surrounding Mount Eccles. However, in Victoria we also have slightly more explosive eruptions which build larger scoria cones; and the maar lakes (eg. Tower Hill), which are large but shallow craters formed by major steam-driven explosions where rising magma intersected water-saturated limestone. At Mount Eccles a line of scoria cones running southeast from the main crater could have formed along a fissure eruption.

Lava flows:

Basaltic lava is a hot (1100°C) liquid that can flow readily. There are two main forms of basaltic lava flow, which grade into each other. *Pahoehoe* lava is the most liquid form - characterised by the formation of thin smooth skins that become wrinkled (hence its alternative name of 'ropy lava'). Pahoehoe lavas advance as a succession of lobes, each of which develops a skin, is inflated by the liquid pressure within, then ruptures at one or more points to release liquid lava to form new lobes (Figure 4).

As pahoehoe loses gas and cools it becomes frothy and stiffer. The surface tends to crack, twist and break into angular, often spiny, blocks to form what is called *aa* or 'blocky' lava.

Behind the advancing lava front solidification of stagnant areas restricts lava movement either to narrow surface channels, or internally in lava tubes beneath a surface crust. Overflow from the surface channels builds up levee banks of thin sheets or spatter. Larger flows across a levee can feed lateral lava lobes with small internal lava tubes. A major breach of a levee may result in a large side flow, fed by its own channel, and the original channel may be abandoned. Good examples of lava channels (locally referred to as 'canals') occur at Mount Eccles. A number of shallow lava tubes are known in flows that have run off to the sides from these channels (Figure 14; Grimes, 1995 & 2008).

Lava tubes provide good insulation for the hot lava flowing within them. This allows the formation of very long flows such as the 50km Tyrendarra Flow from Mount Eccles, which extends offshore across the continental shelf (which was dry at the time), and the older 60km flow from Mount Rouse, which may also extend offshore (Figure 2).

When a lava flow follows a valley, as in the Harman Valley flow from Mt. Napier and the Tyrendarra flow from Mount Eccles, it disrupts the drainage. Twin lateral streams may run down each side of the original valley. Swamps or lakes will form where the flow enters the valley, and where tributary valleys have been dammed by the flow.

Formation of Volcanic Caves

Lava tubes form in basaltic lava flows by two main processes (Peterson & others, 1994; Halliday, 2004)> One is by the roofing over of surface lava channels. Figure 3 gives details of the three ways of doing this. Later overflows through sky-lights may thicken the tube's roof from above. On many cases linings plastered on the walls, or collapse modifications, make it hard to distinguish the three modes.

The other way of making lava caves by the draining of still molten material from beneath the solidified crust of a flow. Figure 4 illustrates the formation of these subcrustal lava caves. In its simplest form, drainage of lava from beneath high areas on the crusted surface will form simple isolated chambers. Complex nests of advancing lava lobes create equally complex patterns of active tubes and chambers which can later drain to form open caves (Figure 4, steps 1, 2 & 3a). Lava lobes can be stacked vertically as well as advance forwards so that a complex three-dimensional pattern of branching tubes can form. As lava continues to flow through these complex systems they will evolve by erosion and solidification to form larger, more streamlined, linear tube systems that act as “feeder tubes” to carry hot lava to the advancing lava front (Figure 4, steps 3b & 4). If sufficiently evolved, these linear tubes can converge on the form of the, generally larger, linear tubes formed by roofing of surface lava channels. Thus the genesis of many large lava caves remains difficult to deduce.

The long lava flows in the region would all have been fed by large cylindrical lava tubes; but only parts of these would have drained at the end of the eruption to form open caves. Many lava caves end at solid undrained lava “sumps".

Features found in Volcanic Caves

The lava caves contain a distinctive suite of lava structures or “decorations”, some of which are illustrated in Figures 7-11.

The level of lava within the tubes tends to fluctuate during the course of the eruption, and so we find thin linings plastered onto the walls and roofs, and ‘tide-marks’ are indicated by solidified linings, benches or shelves on the sides of the tubes (Figure 11). Some shelves can reach right across a passage to form a false floor (Figure 8).

The thin wall linings can rupture, peel back and curve over to form draperies and scrolls. Some linings are smooth, but others have a sharp hackly surface which may be due to the bursting of many small gas bubbles (Figure 10). Rafted slabs floating on a flow surface may leave grooves and striations on the semi-solid wall linings. Lava “hands” of semi-solid lava can be squeezed out through cracks or holes in the lining.

Small round-tipped lava stalactites, (lavacicles, lava drips) form where molten lava has dripped from the roof (Figure 10). Lava ribs form where lava dribbled down the walls of the cave, or where the whole lining has sagged and wrinkled. If the floor was already solid (unusual) drips of lava from the ceiling can build up lava stalagmites (Figure 9).

The floor of the tube is often flat or slightly arched; being the surface of the last flow of lava through it. If a lava flow within a tube forms a solid crust, and then drains away from beneath it, we get a tube-in-tube effect with a thin false-floor bridging the tunnel. Small lava mounds, or tumuli, may be heaved up by pressure from below. In some caves the crusted floor has buckled and broken into a jumble of heaved up plates, or cracked into a mosaic of jostling plates with rounded or upturned edges. Material falling from the roof may be rafted some distance downstream and may end up welded into the floor, or piled up in ‘log jams’.

The Volcanic Caves

The two main cave areas and some selected caves are described here. Additional descriptions and maps appear in the ASF conference guidebook (Grimes, 2007).

Mount Eccles Area

The main volcano has a deep steep-walled elongate crater which contains Lake Surprise. Current studies on sediments within the crater lake suggest an age of about 33,000 years for the Mt Eccles eruption. The crater wall has been breached at its north-western end by a large lava channel (or “canal” as they are called locally). A line of smaller spatter and scoria cones and craters extends to the southeast from the main crater.

The longer and more complicated caves known at Mount Eccles are associated with the South Canal (Figure 14). These caves are generally formed in the levee banks on the sides of the canal and would have fed small lateral lava lobes or sheets when the canal overflowed. Some are simple linear feeder tubes, but many have branching forms and complexes of low broad chambers which suggest draining from beneath the solidified roof of a series of flow lobes (see Figure 4 and Grimes, 1995, 2008).

3H-8: The Shaft, Mt Eccles

This is the still-open vent of a small volcano (Ollier 1964a). A shaft in the bottom of a funnel shaped crater in a small spatter cone opens up below into a single large elongated chamber with rubble floor. It contains moss-covered lava stalactites. See Figure 12.

3H-9: Tunnel Cave, Mt Eccles

This well-known cave is found beside the walking track at the start of the canal. It is a typical lava tube, 60m long, with “railway tunnel” dimensions and shape (Ollier 1964a). The flat floor is the top of a solidified lava pool. As you walk into the cave the roof becomes lower and eventually reaches the floor. The tube would originally have continued but is now blocked by solid lava (Figure 13). Features of interest are the lava bench on the left side near the entrance, and further in there are lava drips, a ropy lava floor and a sagged wall lining that has opened up a gap behind it. Johnson & others (1968) documented the progressive change in the biology as light decreased away from the entrance.

3H-10: Natural Bridge (Gothic Cave), Mt Eccles

From the crater near the southeast quarry a small lava channel runs off to the south-west. At its SW end, part of the lava channel has been roofed over to form a short 36m section of cave. The pointed, ‘gothic’ roof of this cave suggests that it was roofed by levee overgrowth (Figure 5 & 3c). The contorted layers visible in its walls would be linings that were built up and then slumped while still hot. Towards the NE end, the east wall has scrape marks formed when the lining was still soft. For a detailed description and map see Grimes (2002b).

3H-51: North Pole Cave, Mt Eccles

This complex system is a set of small interconnected lava tubes running away from the canal (Figure 14 and see detailed map in Grimes & Watson, 1995). There are some good lava features, including sharp aa floors and a photogenic root chamber at the far end. The name refers to a magnetic rock found at an obvious survey point.

3H-70: Carmichael Cave, Mt. Eccles

A complex 605m lava tube system leading away from the canal (Figure 14 and see detailed map and description in Grimes 2002a). It has many small tunnels alternating with low broad chambers. A lower level at the far end has a larger, partly collapsed, chamber. There are many good lava formations, including lava 'turds', drips (Figure 10), floors and an invasive lava lobe (Figure 15). This is an excellent example of a “drained lobe” style of subcrustal lava cave (Grimes, 2008).

The Wallacedale Tumuli.

A Tumulus is a steep-sided mound of lava crust that has been pushed up above the lava surface. The solidified crust above the liquid core of a lava flow generally forms irregular mounded surfaces known as Stony Rises. However, in a few places, the movement is localised to small “soft spots” in the crust which are pushed up to form discrete steep-sided mounds the size of a house rising above a relatively flat surface. While stony rises are a common feature, steep-sided tumuli are rare, and the tumuli seen in the Harman Valley flow are the best examples in Australia (Ollier, 1964b).

Mt Napier

Mount Napier (Figure 2) is a composite volcano with a broad, timbered, lava shield capped by a steeper, bare, scoria cone formed by explosive activity at the end of the eruption (Whitehead, 1991). There are a few small lava caves on the shield. The lava shield flooded the pre-existing Harman Valley, damming the creek to form a major swamp on the upstream (eastern) side, and flowing down the valley as a long linear flow that finally is lost beneath the Condah Swamp (which was dammed up by a lava flow from Mt Eccles). This long flow was fed by lava tubes, drained remnants of which can be entered at the Byaduk Caves, near the head of the valley, and elsewhere. Lavas also flowed down several other, smaller, valleys such as Scotts Creek at Byaduk township.

For a long time the eruption was thought to have been a bit over 8,000 years old, based on a “minimum age” radiocarbon date from peat material in the swamp dammed by the flow. However, more recently, Stone and others (1997) used isotopes generated by cosmic radiation hitting the lava surface at the Byaduk Caves to deduce an age of 32,000 years.

The Byaduk Caves

This lava flow, which came from Mount Napier, is the same one as that seen from the Harman Valley Lookout. It was fed by large lava tubes. In the Byaduk Caves area collapse of parts of the main feeder tube has exposed the largest and most spectacular lava tubes, arches and collapse dolines in the region (Ollier & Brown, 1964, 1965; Grimes & Watson, 1995; Grimes, 2007). The largest tunnels are up to 18 m wide and 10 m high, but not very long (maximum 200m) as they terminate in lava sumps. There are also some smaller but more complicated subcrustal caves, and a multilevel system (3H-33).

3H-11,12: Harman Caves, Byaduk

This is typical of the large "feeder tubes in the area. It is a large lava tube that has been extensively modified by collapse, and is separated into two parts by a large collapse doline. However, some relicts of the original form, including ropy lava floors, can still be seen (Map 16, Grimes, 1998). The connection from H11 to H12 is hard to find and initially a tight squeeze through rubble.

The small surface “blister” beside the track to the western lookout, called Turtle Cave (3H90), is a shallow “drained-lobe” cave on the surface of the flow (c.f. Figure 4). It has some nice lava drips on the ceiling.

3H-33: The Theatre, Byaduk

This multi-level system is the most interesting and complex cave at Byaduk (Figure 17). The upper level is branching crawlways. The middle level is several descending chambers connected by lava cascades that leads to “The Stage”. This faces into a large collapse dome (The Theatre) with sharp low-level crawlways exiting in two directions. The eastern crawl and "cheese-grater" squeeze opens into a short large tube with ropy lava floor (Figure 18). The western section has good examples of lava "tide-marks" (Figures 8 &11) and ends in a tight "high-friction" crawl. The cave has formed by lava rising from the lowest tube to build a surface mound that partly solidified, and then drained back to the lower level to leave the upper passages.

3H-74, 106, 108: Chocolate Surprise Cave (and neighbours). Byaduk

These three caves occur in a stacked set of thin, 1-3m, lava flows exposed in the wall of a large collapse doline (Figure 19). The elongated doline formed over a deeper large feeder tube (up to 25 m wide and 15 m high in the Church Arch (3H-16) at its western end) and the thin flows may have been fed by overflows from the feeder tube, or through roof windows. The three shallow caves comprise low-roofed branching passages and chambers very similar to those found beside the channel at Mount Eccles (Figure 14). In the lowest cave (H-74) there are intrusive lava lobes that may have entered through roof holes from the overlying lava flow. Likewise, in the next highest cave (H-108) a lava fall drops a metre to a short section of lower-level passage that might be in the same flow as H-74.

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Figures

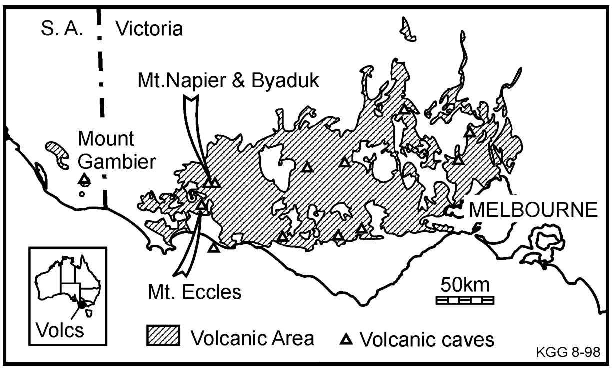


Figure 2.

Recent lava flows in western Victoria.

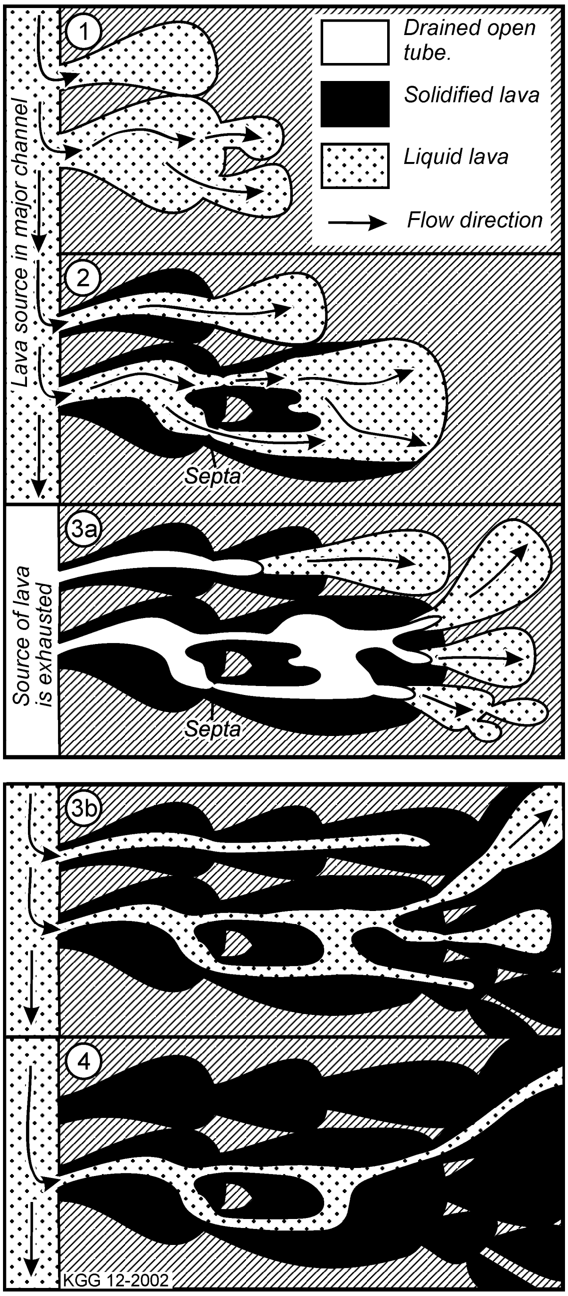


Figure 4:

Stages in the formation of lava tubes by draining of lava lobes.

Step 1: Thinly crusted lobes of lava expand by breakouts through ruptures and budding of further lobes.

Step 2: Stagnant areas of the older lobes solidify, but flow from the source keeps the feeder conduits liquid.

Step 3a: If the source flow ceases some of the conduits may drain to form air-filled cavities.

Steps 3b and 4 indicate the further evolution into more linear feeder tubes as lava continues to flow through the system.

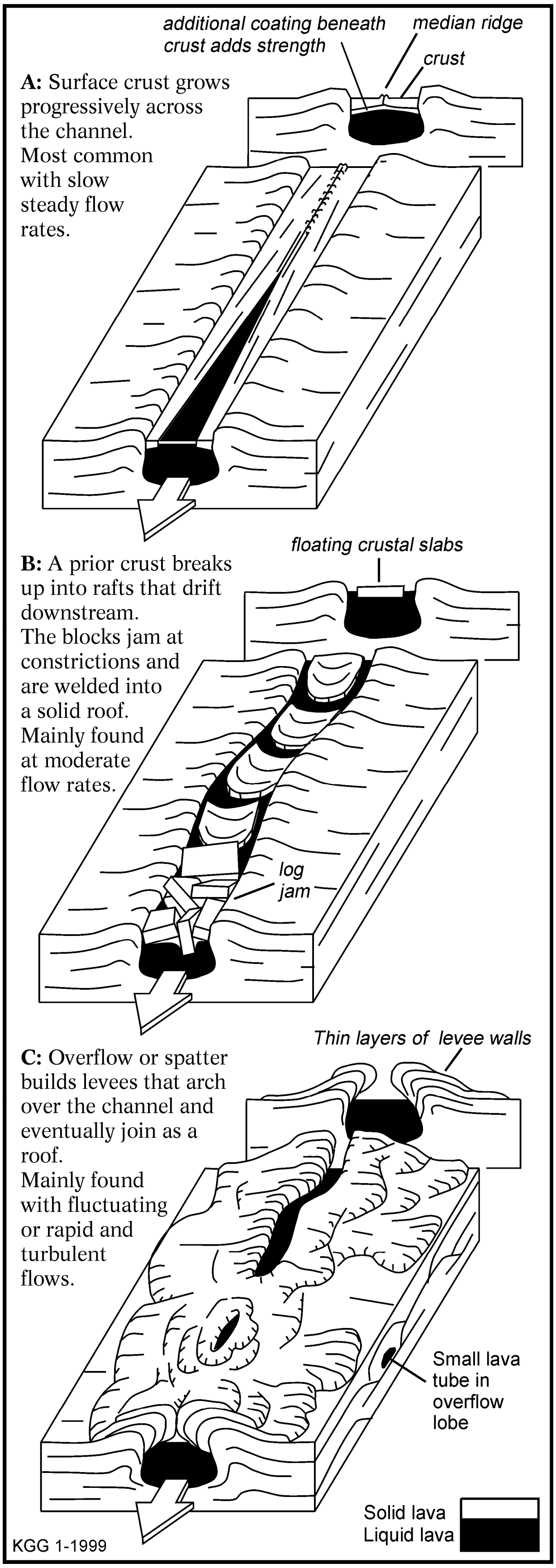


Figure 3.

Three ways to make a lava tube by roofing a lava channel.

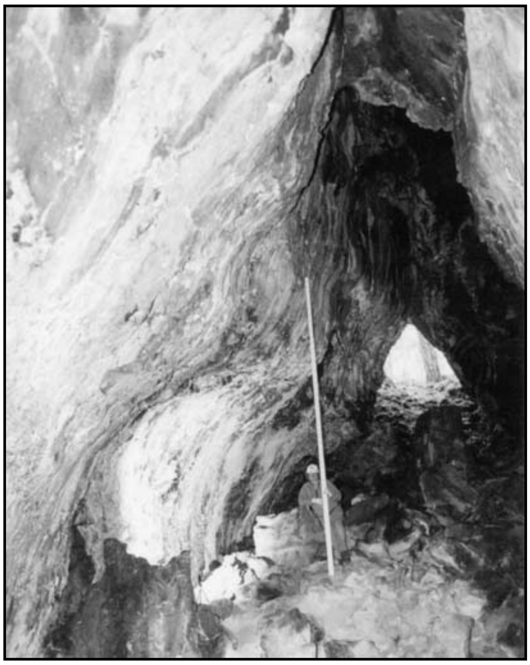


Figure 5.

The ceiling of Natural Bridge (3H-10), Mt. Eccles has a "Gothic" cross-section that suggests it formed by levee overgrowth, as shown in Figure 3c.

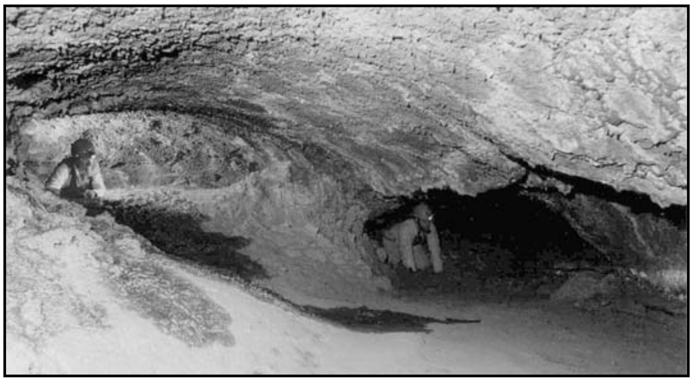


Figure 6.

Caves formed by draining of lava lobes tend to have low broad chambers and passages (see Figure 4). Carmichael Cave, 3H-70, Mt Eccles.

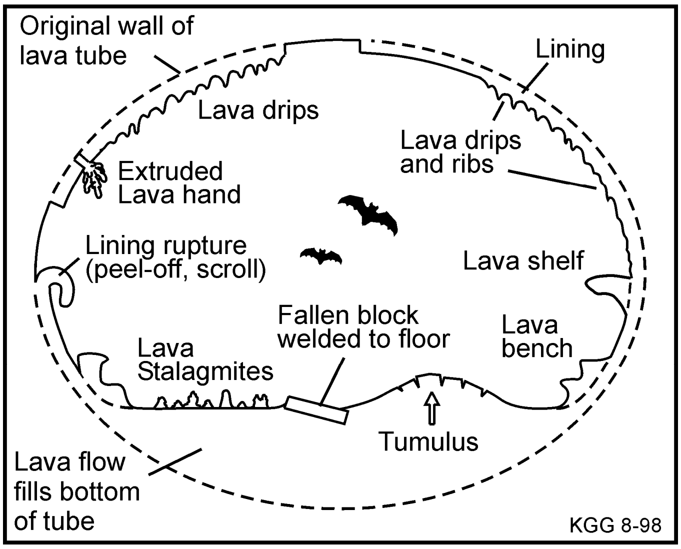


Figure 7.

Formations found in lava tubes.

Figure 8.

Lava shelf, which bridges across the passage behind the caver. 3H-33, Byaduk.

Figure 9.

A lava stalagmite built up of coalesced droplets of viscous lava. The fine spikes may have formed from liquid lava pushed out through small holes by the expanding gas within the lava (see Allred & Allred, 1998). Scale in cm.

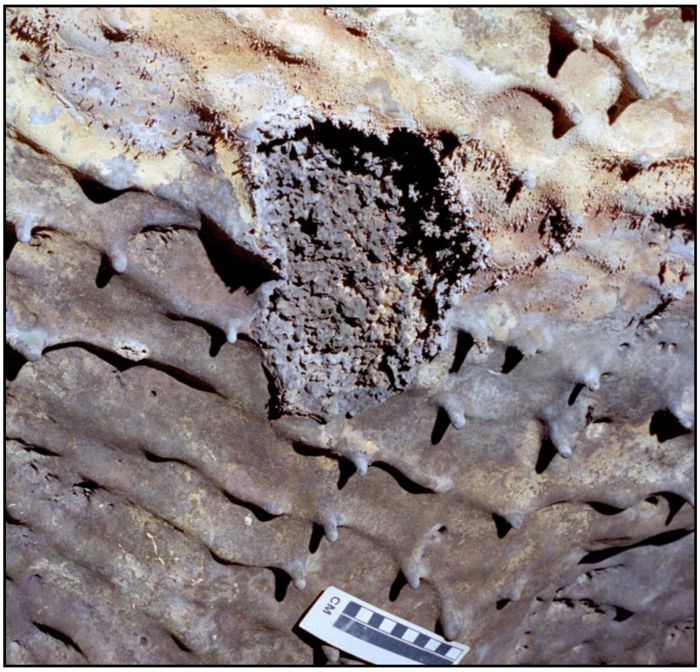


Figure 10.

Lava drips and a hackly burst section of lining on the ceiling of 3H-70, Mt Eccles.

Figure 11.

Lava dip (tide-mark) on a roof pendant. 3H-33, Byaduk.

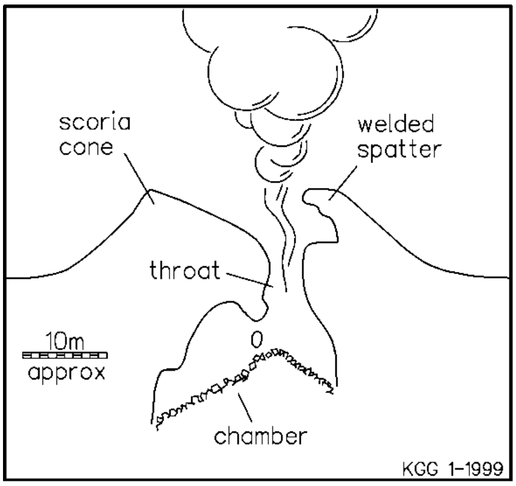


Figure 12.

The Shaft (3H-8), Mt Eccles.

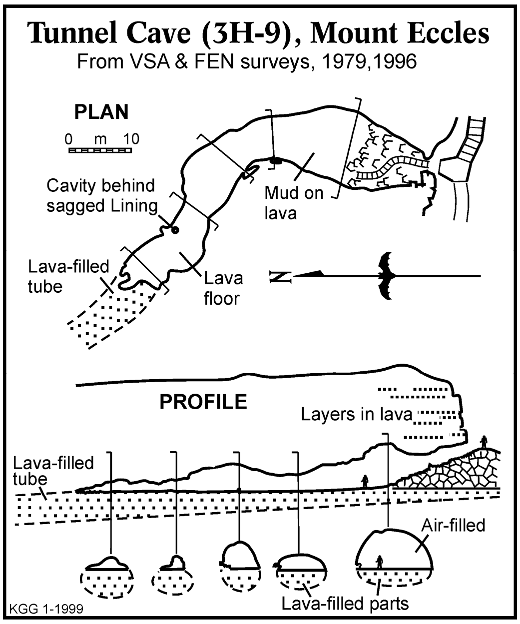


Figure 13.
Tunnel Cave.

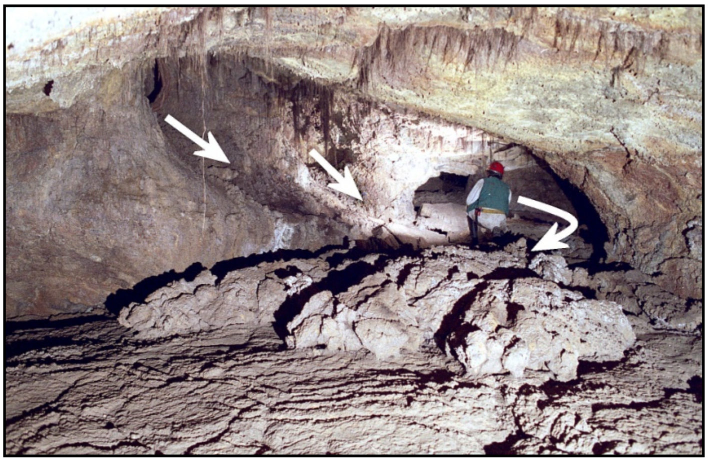


Figure 15.
An aa lava flow has invaded the lower level of Carmichael Cave. Arrows indicate its entry points from a higher level.

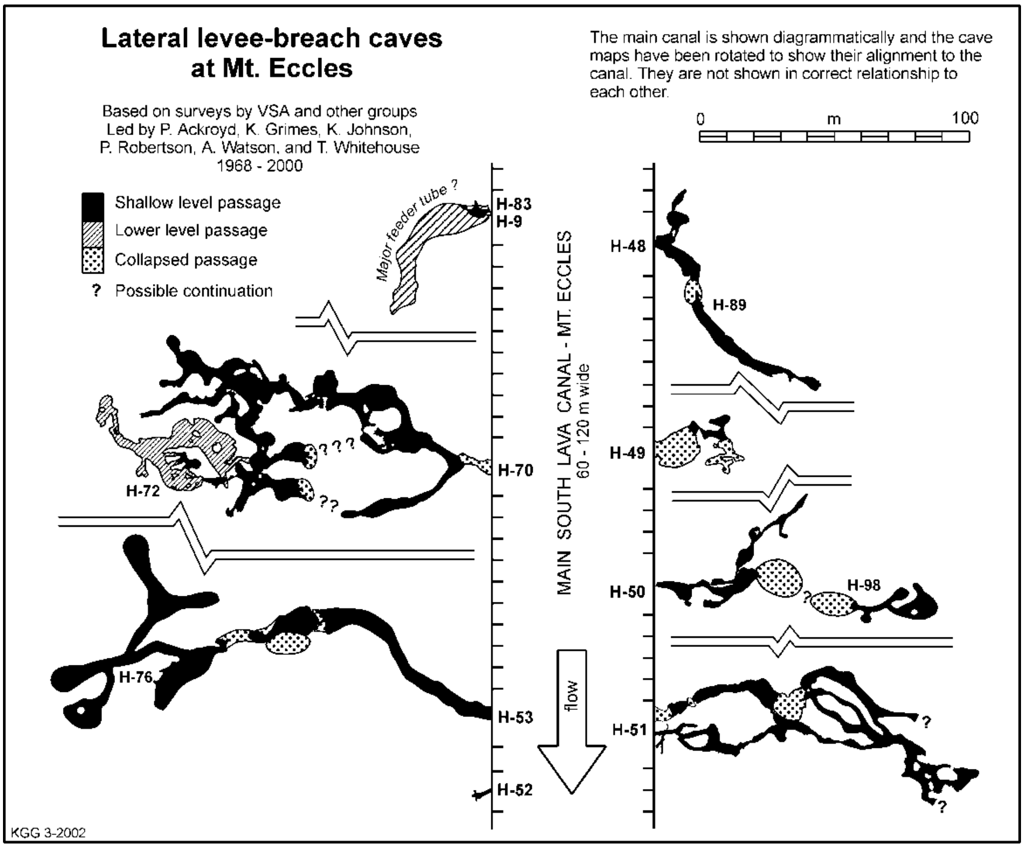


Figure 14.
Lava caves on the sides of the South Canal at Mt. Eccles.

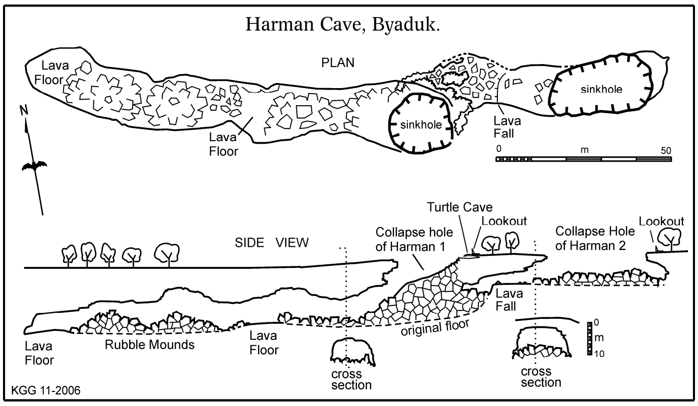


Figure 16.

Harman Cave is a large lava tube with considerable collapse modification.

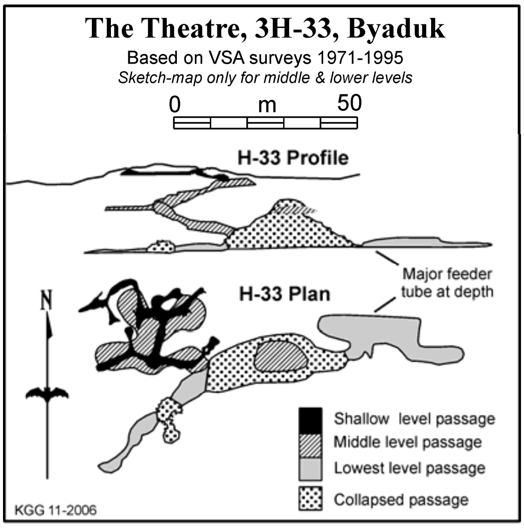


Figure 17.

The Theatre is a multilevel system.

Figure 18.

Feeder tube with a fairly jagged ropy lava floor, at the end of 3H-33, Byaduk.

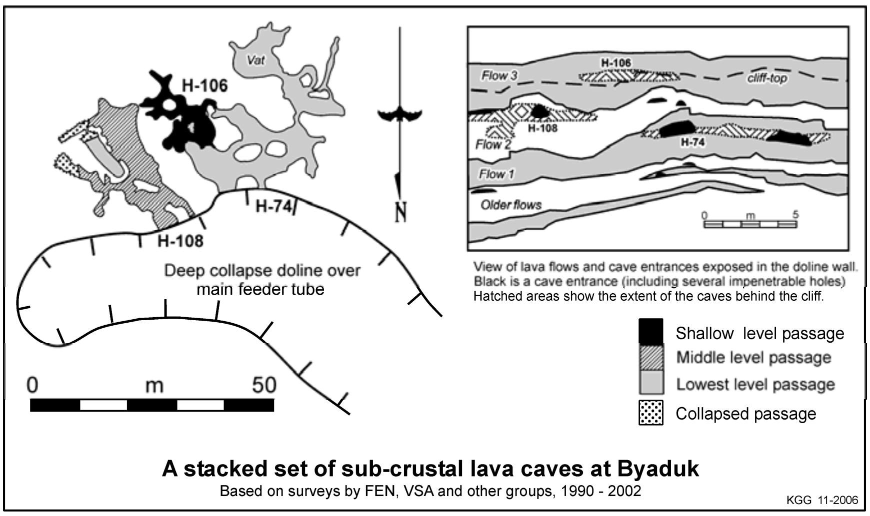


Figure 19.

3H-74, 106 and 108 form an interesting set of stacked lava caves.

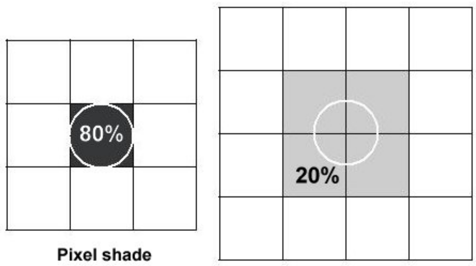
Improving Karst Data Using Google Earth

Graham Pilkington

Google Earth is a free interactive internet software package that supplies images of satellite data in near true-colour with a pixel resolution varying from about 20m down to about 0.2m. The pixel size is variable across Australia but is supplied as strips of pixel data usually north-south or east-west. These strips have been adjusted for image distortion so that a nearly consistent scale is presented. The strips have been merged together where they overlap to present a scaled map image.

In this talk I will use the Nullarbor for examples of how Google Earth can be used.

What has to be remembered at all times is that each pixel is the average colour and intensity over that pixel coverage area (blended across pixels to make the display smoother). This means that the pixel colour depends on where the edges of the pixel fall. For instance, if a horizontal black hole surrounded by white rock is the size of a pixel and the pixel is exactly over the hole, then the pixel will be 80% black and the adjacent pixels white. However, if the pixels bisect the hole, then those pixels will be only 20% black and spread over four times the area.

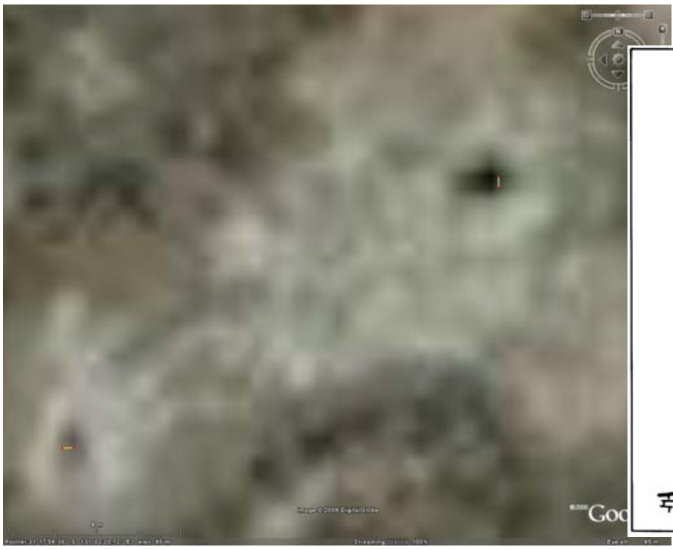


Pixel shade
over a black circle of pixel diameter in a white backgound

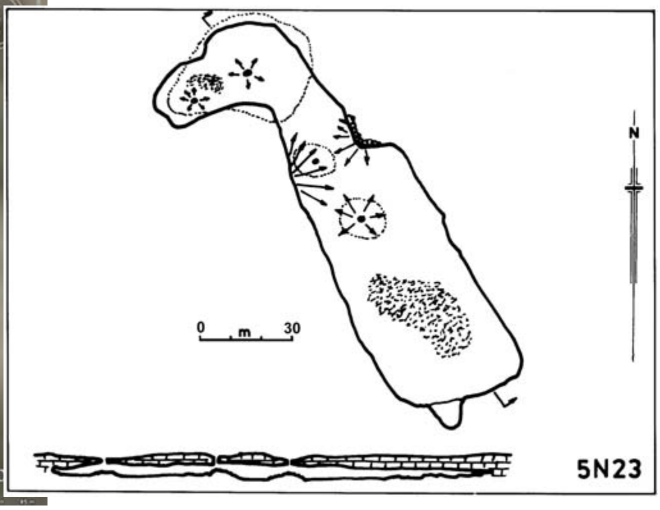
If the pixel size is greater than the size of the object being looked for, then it's a waste of time looking at the image because background "noise" will swamp the image. However, such objects as blowholes inside larger dolines can be estimated on the assumption that the doline is the result of the presence of a blowhole. To check the pixel size in an area, zoom in so that individual pixels can be seen, then measure with the Google scale bar. The satellite images are upgraded occasionally, hence large-sized pixel areas need to be checked up on periodically to see if better data are now available.

My first example of how Google Earth can be used is by looking at Jimmies Cave, 5N-23.

According to the Nullarbor Caving Atlas of 1986, its given location was accurate to ±100m and it also has an ASF grade 2 map made by Joe Jennings in 1957.



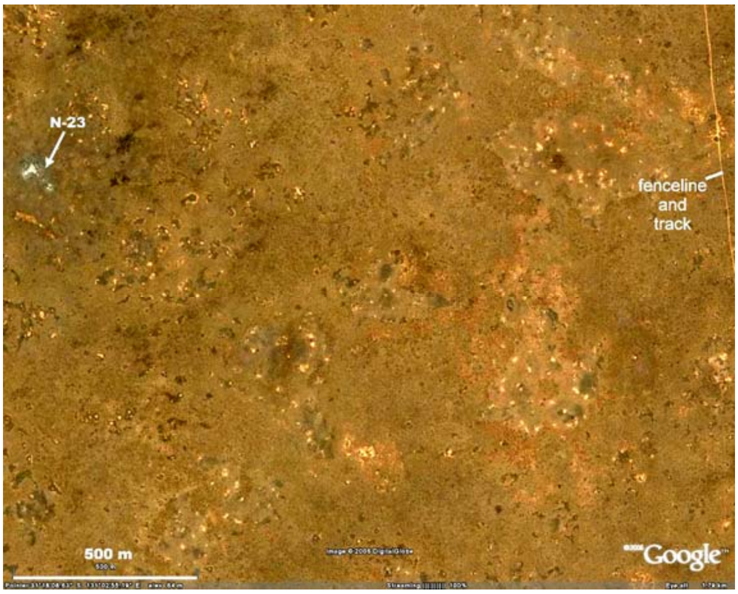
Google image of northern entrances of N-23 illustrating a pixel size of 0.6m



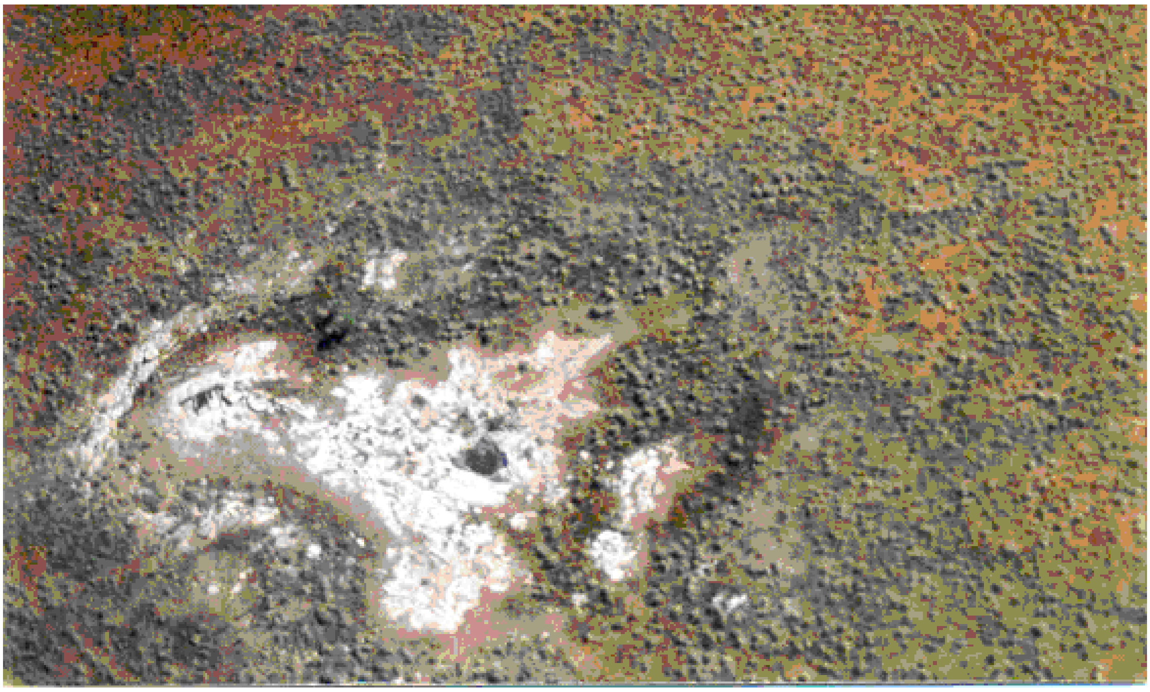
1957 simplified Jennings map of N-23

The satellite coverage of the N-23 Atlas location does not give any indication of the 4 dolines shown on the map. It does show the many forays by people searching the site for the cave!

The CEGSA Records location is: "1.2km south of number-6 gate take the right-hand track. Cave is on the right after 2.4km". Without knowing which gate in number 6, it is difficult to determine if the given location agrees with this, but it is 2.4km along a track west of a fence and 100m north of this which does fit part of the description. Using Google Earth to expand the range of the search, a patch of exposed rock 2km to the north can be seen that closely matches the pattern and size expected from the cave map.



On closer inspection, we can see that this feature is just north of a 2.4km long track coming from the north-south fence and that the track takes off from a point 1.2km south of another fence – probably the location of number 6 gate. No known feature is within 2km of this new location. Zooming in on the feature, 4 possible blowholes in small dolines can be located and measured.



N-23 from an aircraft ©Max G Meth

N-23 overlay of dolines as measured from the satellite image and from the map

Because the Jennings cave map has surface dolines and blowholes plotted on it, the surface map can be overlaid onto the satellite image. Adjusting the map to match the satellite image by rotating 3° west (magnetic north was about 3° east when the survey was made) and enlarging the scale by 13% gives a very close fit: This means that Google Earth was used to improve the orientation and accuracy of a cave map!

To establish accurate locations for the cave entrances from the satellite data, we need some way to calibrate the Google Earth locations. This can be determined by assuming that the Global Positioning System is accurate to within 5m on the Nullarbor after the deliberate errors were removed in May 2000. Such an assumption is validated by the research done by others on GPS location accuracy and by the repeated re-readings made at specific points over the Nullarbor over the last few years by many people using different GPS units. N-23 has no known accurate GPS readings within its satellite strip but we can get an estimate from the adjacent strip.

Table 1 gives the locations of features read off GPS units and measured from Google Earth on the same image strip. It is vital to use the same strip and to keep away from the merged edges in obtaining good calibration figures.

TABLE 1

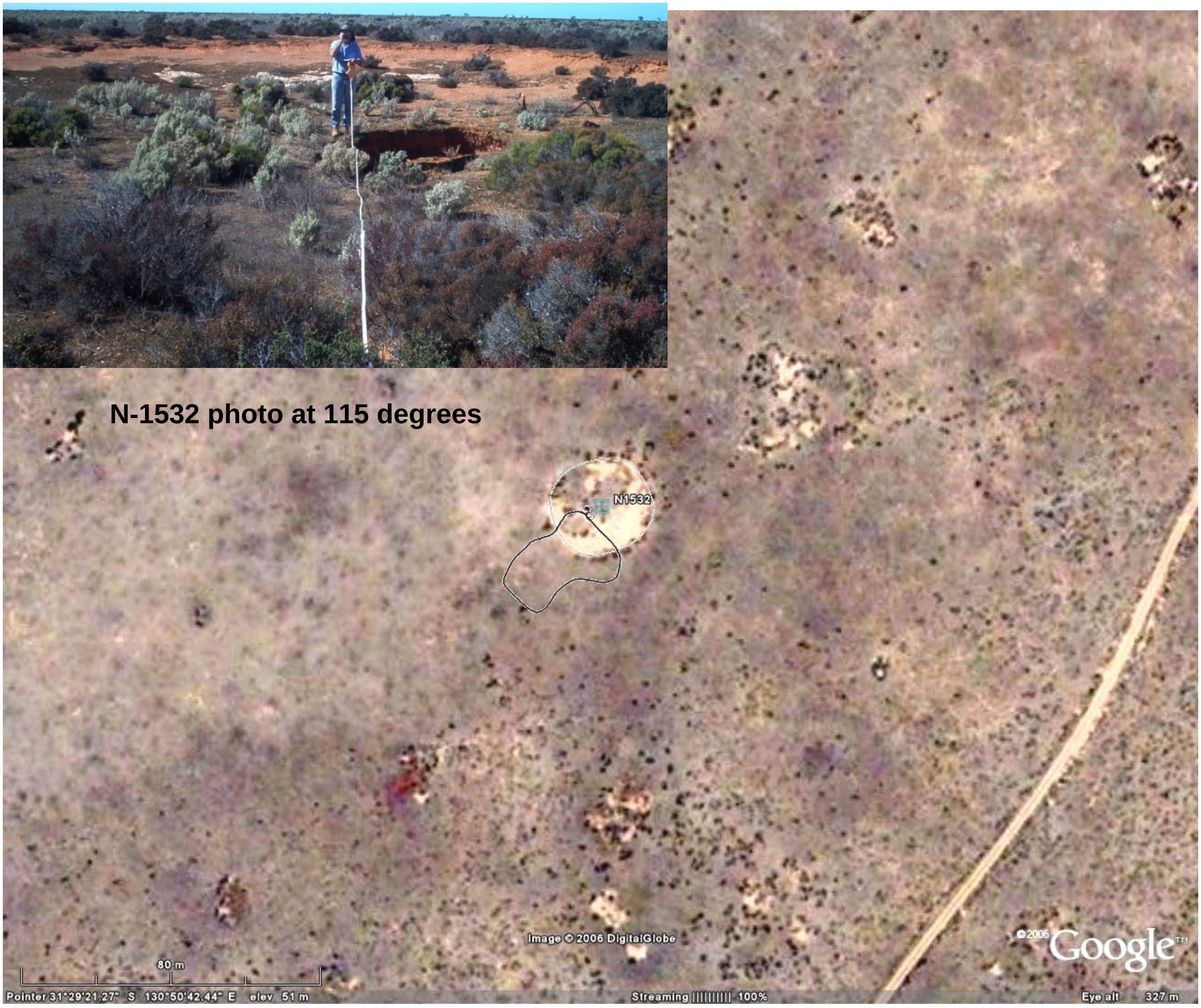
			Google Earth location						Datum WGS 84				difference	
Area	**#**	**Where**	**lat**	**min**	**sec**	**long**	**min**	**sec**	**sat E**	**sat N**	**GPS E**	**GPS N**	**E**	**N**
N	14	centre	31	25	29.60	130	59	29.56	689295	6521580	689302	6521582	7	2
N	61	blowhole	31	25	12.05	130	58	25.89	687623	6522151	687632	6522155	9	4
										correction to satellite location			**8**	**3**
N	1532	blowhole	31	29	21.27	130	50	42.44	675252	6514689	675259	6514699	7	10
N	1528	blowhole	31	29	0.64	130	48	48.38	672256	6515375	672263	6515387	7	12
N	1529	blowhole	31	28	42.93	130	48	39.70	672036	6515924	672040	6515937	4	13
N	121	centre	31	31	9.67	130	46	1.61	667791	6511475	667798	6511491	7	16
										correction to satellite location			**6**	**13**
N	2046	blowhole	31	9	11.81	127	53	30.04	394359	6552870	394365	6552879	6	9
N	83	tag	31	9	12.09	127	57	33.46	400804	6552924	400817	6552932	13	8
N	1306	blowhole	31	9	16.57	127	58	28.87	402273	6552800	402282	6552812	9	12
N	2181	blowhole	31	11	30.79	127	48	32.46	386526	6548509	386528	6548509	2	0
N	1779	blowhole	31	13	8.74	127	58	46.00	402792	6545656	402798	6545653	6	-3
										correction to satellite location			**7**	**5**
N	131	blowhole	31	41	30.73	127	56	57.87	400433	6493226	400427	6493234	-6	8
N	192	blowhole	31	43	33.42	127	54	17.66	396253	6489406	396252	6489413	-1	7
N	739	rockhole	31	43	53.03	127	50	9.46	389727	6488735	389726	6488740	-1	5
										correction to satellite location			**-3**	**7**

From this table we can estimate that the best N-23 adjustment to the Google Earth location is to add 7m in easting and 5m in northing to end up with the location of each blowhole to within about 5m without having to go to the bother of actually travelling out there.

Following are some examples of map overlays and ground photos:

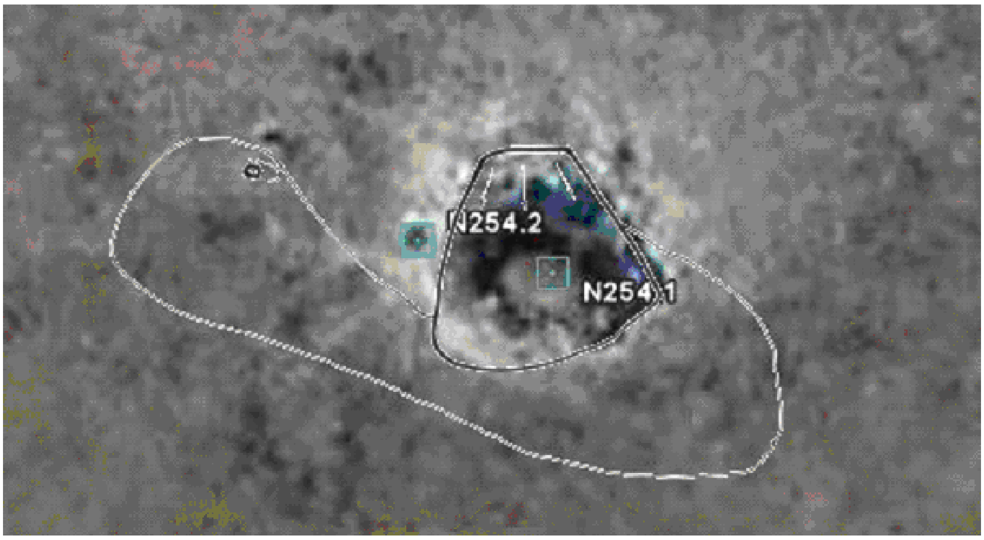
N-213 satellite image with doline outline

N-213 photo at 190 degrees



N-1532 photo at 115 degrees

In the case of N-254, by comparing the map and satellite image it was found that the ATLAS had the north arrow pointing south! A few other maps where also shown to have an incorrect orientation and Google Earth has been used to correct them. With N-254 both the doline shape and the blowhole entrance could be used but in most cases an accurate doline outline is required. Many cave maps neglect the surface component and just show the survey of the underground part of a cave. These cannot be checked for orientation unless they have more than one entrance (or are not South Australian caves but have rivers flowing into them!).

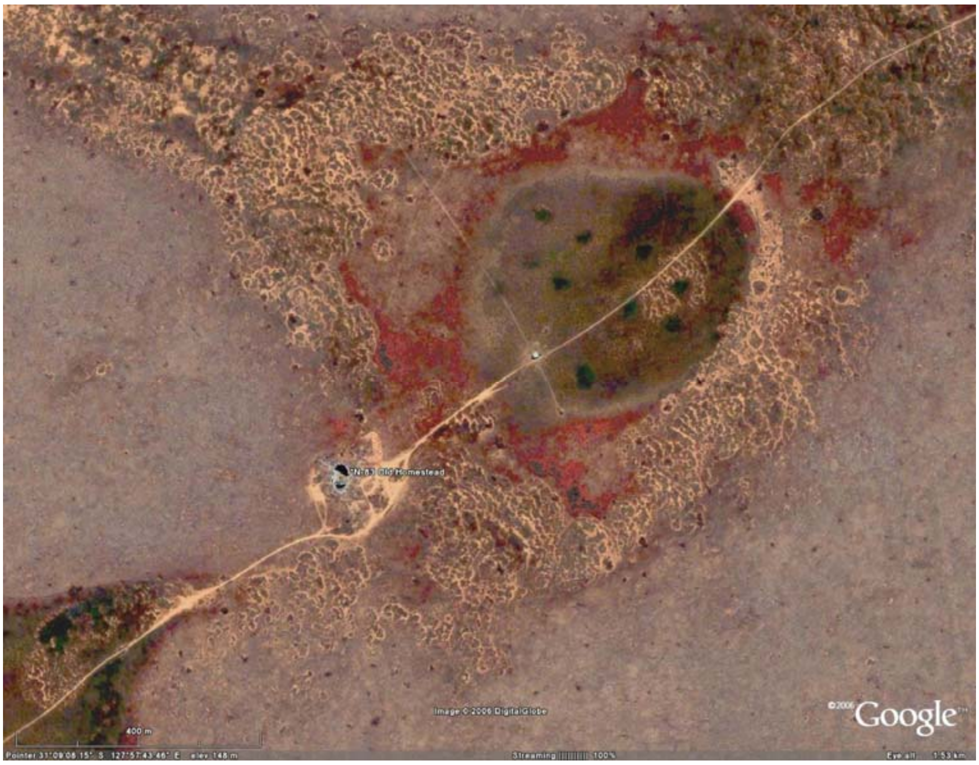


N-254 satellite image with corrected map overlay

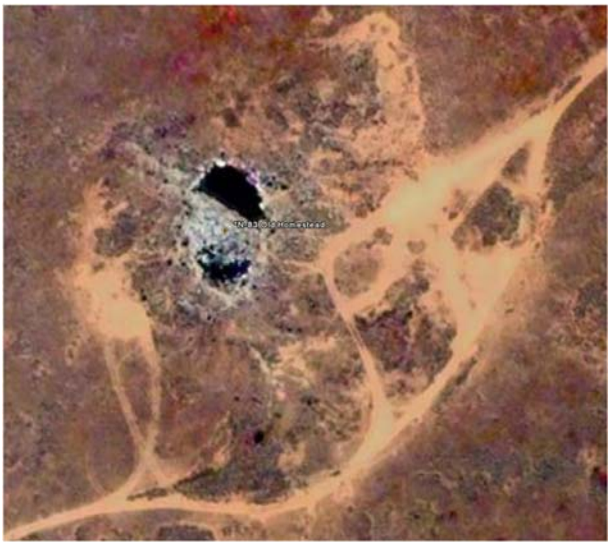
Gross scale errors are also easily fixed by reference to Google Earth. A good example is N-22, Knowles Cave. The map of the southern lobe of N-280 was grossly in error.

N-22, N-280, N871 Google image and 1986 ATLAS map

An example of more complex Google Earth use is given by the Old Homestead Cave (N-83) area:



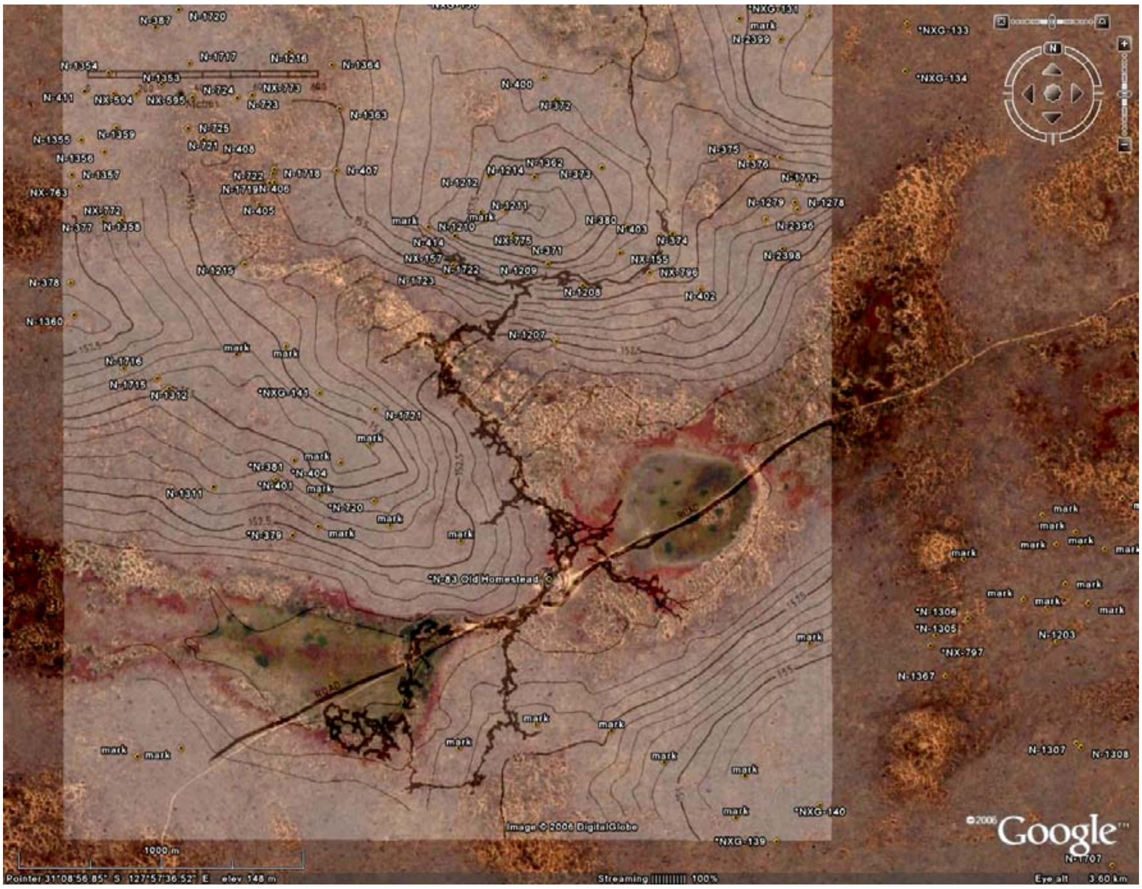
N-83 entrance and hut site



N-83 entrance and hut site

The image illustrates the quality of the satellite image by looking at the track definition. You can see the 2x1m toilet to the south of the hut and even where the chicken wire was removed from the area east of the track to the toilet. This image also shows that Nullarbor tracks are more ephemeral than most people thought: the main road from Mundrabilla to Forrest, used several times a week, passed just south of the hut site, looping around the debris of the original collapsed hut; part of this can still be seen but has vanished since 1986 when the site was cleaned up and the current track put back into operation.

The final image shows a composite of satellite image, feature location markers, cave map (as of 1991), and land-surface contours (at 0.25m, this is the Nullarbor!). It illustrates the close match between cave passage and topography 70m above it.



Summary of what Google Earth can be used for:

- Establish feature location as accurately as on site GPS (after calibration using GPS).
- Measure the relative positions of features as accurate as of twice the pixel size – typically 1m – over distances of kilometres.
- Measure the size and shape of large surface features such as dolines, more accurately and more detailed than most ground surveys, and in less time, while not having to spend valuable field time doing it. However, field data is usually needed to complete the surface map.
- Measure the size of small surface features, such as blowholes, when no field data is available and the pixel size is adequate. Eg in the N-23 zoomed-in image shown earlier, the most northern entrance blowhole can be measured as about 2x1.5m and the smaller one at no more than 0.5m diameter.
- Correctly align maps to true north.
- Uncover and possibly eliminate gross mapping errors.
- Improve map scales and orientation where estimated distances and/or bearings were used, especially for surface features and caves with more than one entrance.
- See what tracks are available for close approach and to determine the best way to get to a feature to avoid problems such as bluebush, dense scrub, cliffs and creeks.
- Locate large previously unknown features, allowing a more accurate determination of feature spatial density and type as well as new caves to explore.

Notes:

"ATLAS" refers to "The CEGSA Nullarbor Caving Atlas, 1986".

N-23 was named "Jimmy's Cave" in 1952 (after Jimmy Scott, who discovered it in 1937), not "Jimmies Cave" as is now used.

Relict Palaeorivers of the Western Nullarbor and their associated Karst Features

Paul Devine

Abstract

The more northern portion of the Nullarbor shows evidence of a number of relict palaeoriver systems. These systems have been known for many years, along with approx 41 karst features that are in close proximity to one of the main systems near Haig. Statistical relationship between 2 caves of deeper origin and these palaeoriver regions along with the location of new closely related, shallow karst features prompted a closer examination of the 2 main palaeorivers in WA. This has resulted in the location of a large number of previously unrecorded karst features. Features examined appear similar in form and origin to previously recorded features.

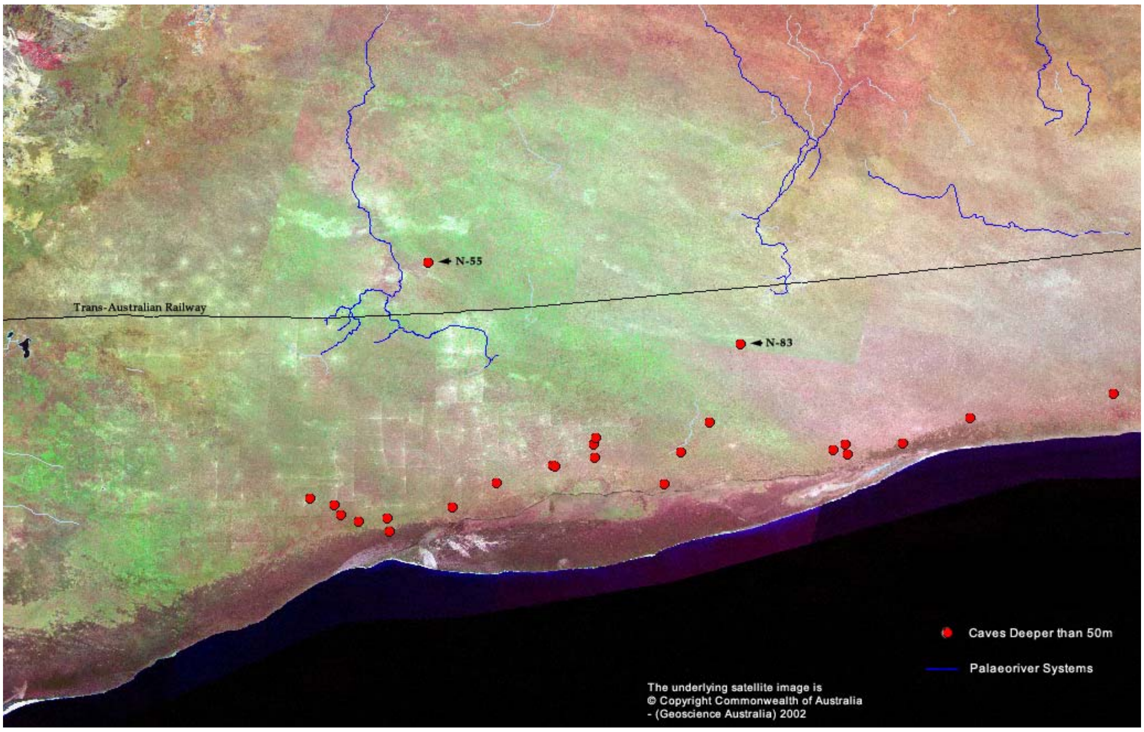


Figure 1 Deeper cave distribution on the Nullarbor - 50m or deeper

Introduction

All known deep caves on the Nullarbor occur well south of the Trans continental Railroad.

Reasons for this were postulated by Jennings, due to rainfall gradient, [Lowry& Jennings 1974] and counter postulated by [Benbow & Hayball 1992] to be a lack of upward stopping or previous stable water table levels. In the WA portion of the Nullarbor only two known exceptions to the southern trend of deep cave distribution are known, one is Old Homestead Cave (N-83), and the other, the only known deep cave north of the Rail, Haig Cave (N-55).

Haig Cave's formation and origins are not fully explained. While there is no direct link, its proximity to or possible relationship with one of the Nullarbor's largest relict palaeoriver systems has not been examined or explained. These ideas if nothing else provided the impetus for a broader examination of the areas associated with the two main relict palaeorivers in the WA portion of the Nullarbor the Haig and Forrest systems.

Background

Modern river systems that do have periodic flood flows to the peripheries of the Nullarbor do not extend far onto the Plain, instead they form lakes such as Lake Boonderoo. This particular lake fills from the Raeside palaeodrainage system that only flows during major flood events through Ponton Creek to the western edge of the Nullarbor.

Relict Palaeorivers of the Western Nullarbor and their associated Karst Features

Paul Devine

The outlying palaeorivers that surrounded the Nullarbor and flowed into the Eucla basin during its earlier stages of formation are thought to have been largely inactive post the emergence of the Plain during the middle Miocene [Van de Graaff et al 1977].

Figure 2 rivers wide and external inc active

Since the 1960's sections of relict palaeorivers have been recognised on the Nullarbor Karst.

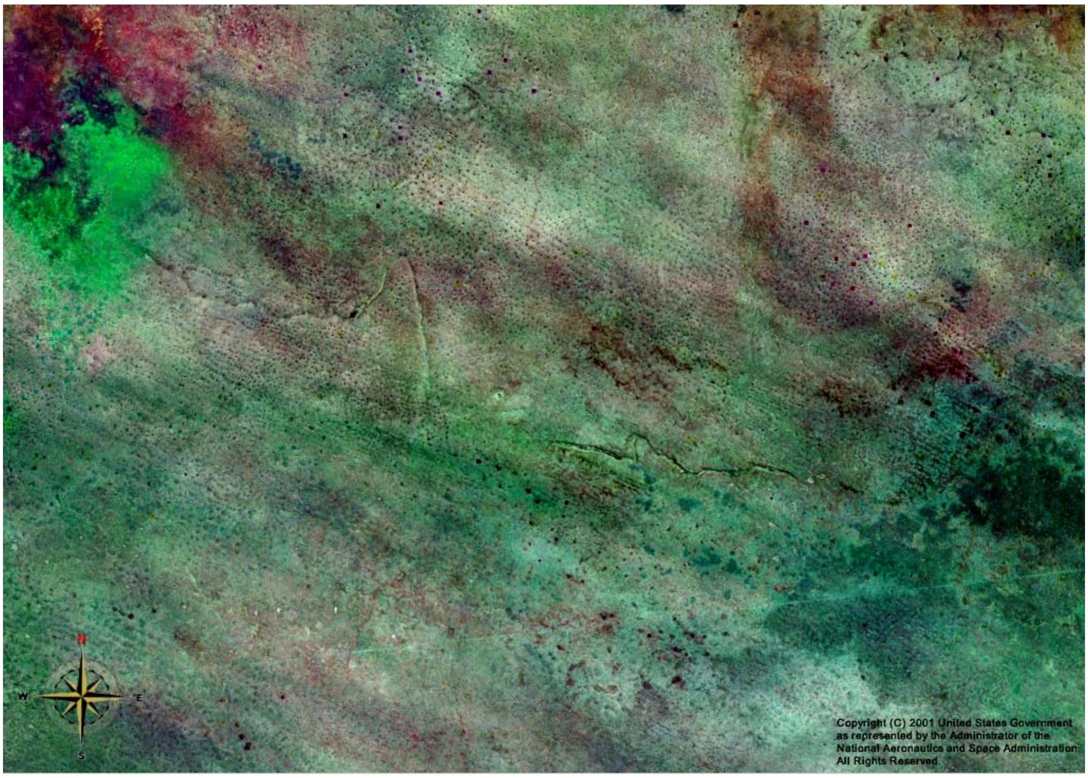


Figure 3 The Dip World Wind Satellite View

Relict Palaeorivers of the Western Nullarbor and their associated Karst Features

Paul Devine

"The Dip" first described by Joe Jennings [Jennings 1967] is a system approx 130km long originating in WA and ending near Cook in SA.

Forrest and Haig palaeoriver systems were noted and described by David Lowry [Lowry 1970] along with small fragments of river near Naretha.

Several smaller systems have been noted in the eastern portion of the Nullarbor [Jennings and Lowry 1974] and [Benbow et al 1995b].

The link or continuity between the Nullarbor systems and the inactive palaeodrainage systems lying outside the plain is noted by Jennings and Lowry [Lowry & Jennings 1974] for the Haig, Forrest, and one east of Cook

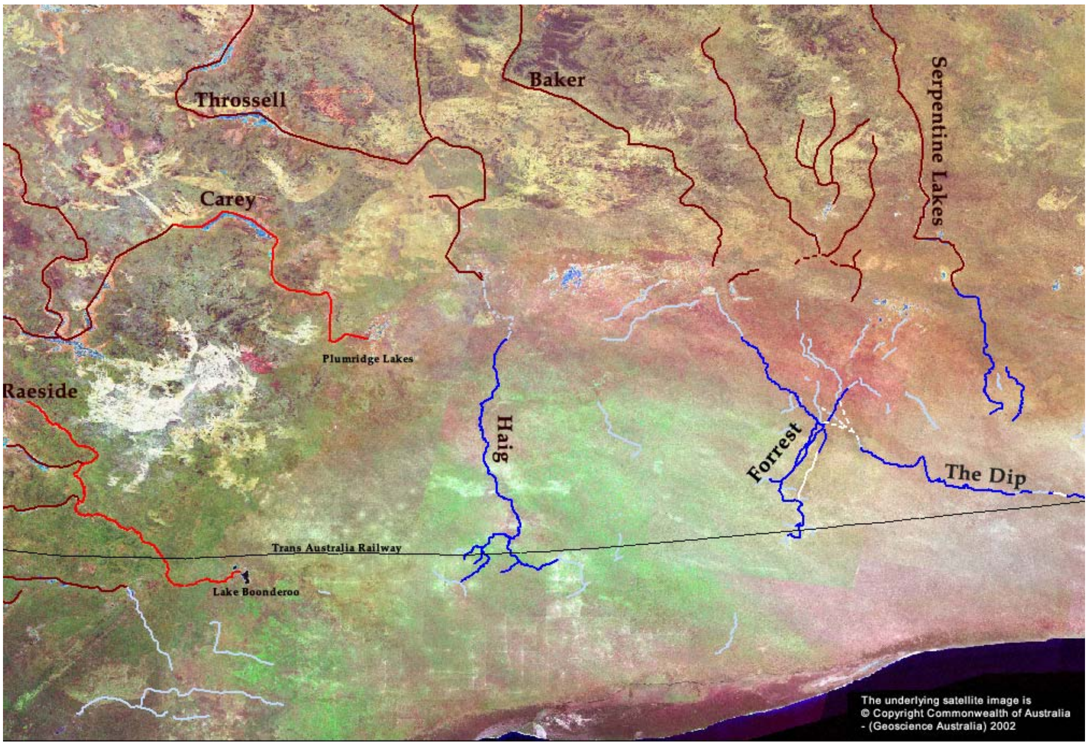


Figure 4 Nullarbor Palaeorivers and links to External Palaeodrainage

The two western ones correspond to the Throssell, and the Baker palaeodrainage systems. Beard [Beard 1973] also proposed a link with the Carey system to Haig palaeoriver.

More recently for sections of a paleoriver north of the Dip in South Australia, a continuous link has been shown to the Serpentine Lakes palaeodrainage system to the north [Benbow et al 1995a].

Flows of the palaeoriver systems on the Nullarbor that deposited sediments are said to have occurred in a number of stages, the first at the period at emergence of the Plain and later more sporadic flows during the Pliocene [Benbow et al 1995a]. These later flows during wetter periods in the Pliocene are evidenced by clays and sediments associated with palaeochannels in SA and at Haig in WA [Benbow et al 1995a,b]. It is also suggested that a period of greater precipitation in the Late Pliocene occurred at a similar time to the deposition of red-brown karst breccias and calcite speleothems [Benbow et al 1995a]. It appears there are a number of stages of calcite deposition [Geode et al 1990]. The most recent initial results of U-Pb dating of one stage of Nullarbor calcites, at 4.1-3.8my [Woodhead et al 2006] starts to provide a link for the timing of a period of greater precipitation and possible palaeoriver flow.

Both of the major palaeoriver systems in Western Australia, the Forrest and the Haig, are largely south trending and they both break into a series of distributaries at their southern ends. These southward trends are associated with large areas of remnant surface cover [Lowry 1970].

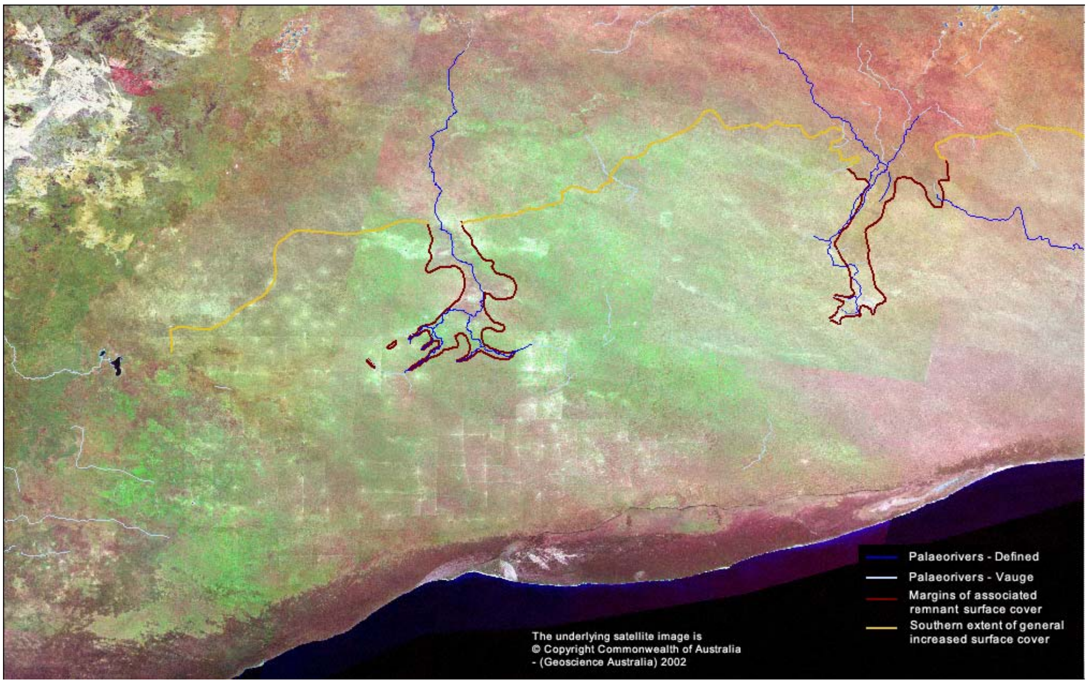


Figure 5 Belts of soil cover surrounding Nullarbor Palaeoriver Regions

In the case of the Haig palaeoriver this consists of deep calcareous soil underlain by calcretes that can vary up to several metres in thickness [Lowry 1970]. The remnant surface cover is associated with widespread vegetation consisting predominantly of Myall. Throughout the margins of the lower Haig Palaeoriver Region in areas were soil has been deflated large surface expanses of oolitic calcrete are exposed.

Figure 6 Haig Palaeoriver veiw of associated belt of vegetation

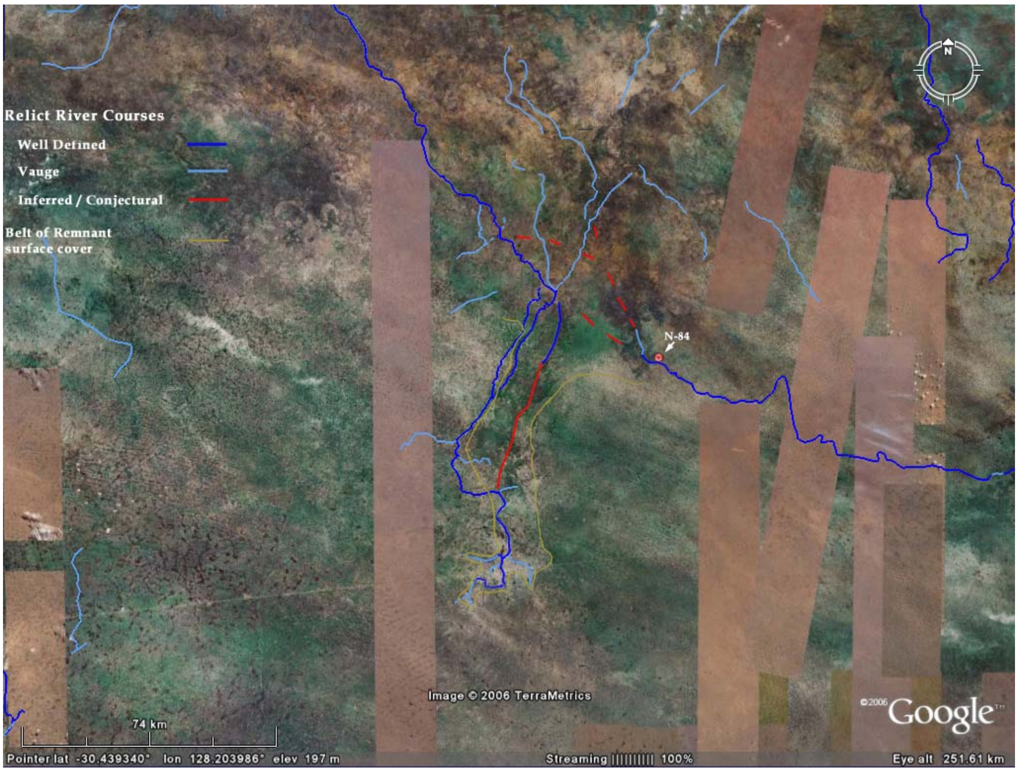


Figure 7 Visible Palaeorivers Complex in the Forrest and Dip System

The Forrest palaeoriver suggests a number of various stages, like the Haig river further west, the Forrest river is surrounded by the belt of remnant soil cover. In the case of Forrest this was deposited in an earlier stage as the river later broke from this area and deviated west and rejoining the belt further south [Lowry 1970]. Although the Forrest palaeoriver has a raised area of remnant surface deposits, it however mostly lacks the pronounced vegetation cover that is present at the Haig region. The upper portion of the Forrest Palaeoriver appears complex and multi-channelled. It is likely that The Dip, which becomes discernable from a point near Decoration Cave (N-84), is an easterly flow from one of the stages of the Forrest palaeoriver. Like sections of other palaeorivers the link for this system is no longer well defined.

Palaeoriver courses have undoubtedly undergone substantial post flow modification such as solution modification [Lowry& Jennings 1974] and deflation [Lowry 1970]. Overall the development of the relict river systems on the Nullarbor appears complex and multi staged.

The area of remnant surface cover surrounding the palaeorivers is referred to as the Haig & Forrest PRRegions (Palaeoriver Regions) respectively in this article.

Previous Features

Prior to 1998 in the Haig PRRegion, 36 karst features were listed in CEGSA records. Comprising of 26 N number allocated features and 10 unallocated NX features. Subsequent relocation of NX numbers during trips to the area made between 1998 and 2003 along with further research has shown that approximately 41 features (Table 1) were visited or recorded by cavers prior to 1998.

Table 1: - List of features in records prior to 1998 for the Haig Palaeoriver Region

Number	*Located by*	*Date*	*Recorded by*	*Date Rec*	*Reference*
N-55	Eileen Fletcher? (Pilot) AJ Carlisle (on ground)	1937	Harry Wheeler David Lowry	1958 1965	KIDSA2006 Lowry1965
N-*1551*, *N-1655*, *N-1658* *N-2515*, *N-2517*, NX-81	AJ Carlisle		Harry Wheeler	1958	KIDSA2006 &Devine2003
N-1552, N-1553, N-2139	AJ Carlisle		Max Meth		KIDSA2006
N-141, N-142, *N-2238*	Joe Jennings	1964	David Lowry	1965	Lowry1965
N-2237, *N-2238* [1]	Joe Jennings	1964			Meth1997
N-143, *N-1554*, *N-1657* *N-2138*	David Lowry	1965	David Lowry	1965	Lowry1965
N-540, N-541	?		Max Meth		KIDSA2006
N-496 to N-517	Plane Caving	1990			KIDSA2006

[1] ***N-2238 was circled by Lowry on Air Photos.*** ***Numbers in italics were listed as NX prior to 1998***

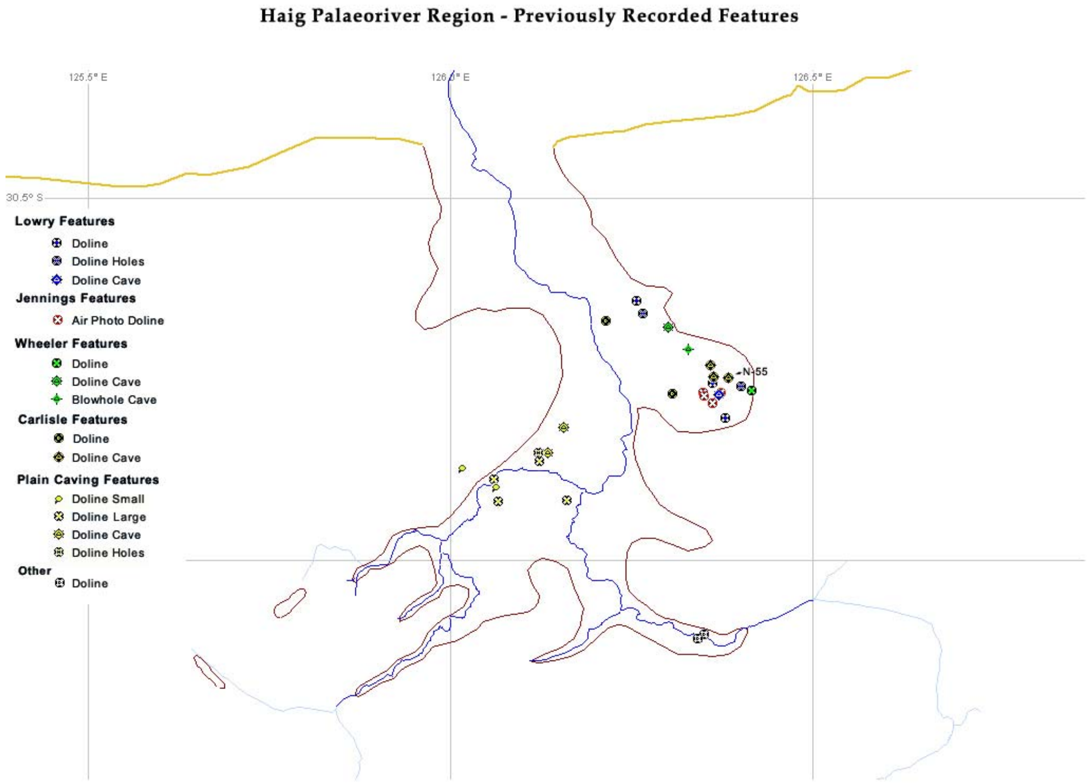


Figure 8 Map of Previous Features in the HaigPRRegion

Most of the previously recorded features are scattered throughout the Haig PRRegion

A higher number is indicated by the description of several of these dolines as breakaways* by local pastoralists, who refer to them as being numerous.

*(These "breakaways" as coined by the locals differ completely in their formation from the true cliff-line breakaways occurring elsewhere – including the breakaways described by Lowry which lie further north on the margin between the Nyanga and Carlisle Plains [Lowry 1970]. Instead of simple process of mechanical undercutting and erosion away from a cliff-line, these pseudo-breakaway features are formed by slumping, shallow collapse and effects of drainage into the clifflines and the associated underlying cavities)

New Observations

In early 1999 new 1:50 000 scale air photos became available and I purchased photography covering the Balgair region. 30 features were initially identified off these photos, (N-1604 to 1611, N-1613, N-1629 to 1631, N-1634 to 1636, NXP-26 to 32, NXP-36, NXP-96 to103). Of which nineteen are located on the banks of the Haig relict palaeoriver (N-1604 to 1610, NXP-26 to 32, NXP-96 to103). A further examination of the additional air photos has allowed me to define around 200 larger surface features in the Haig PRRegion.

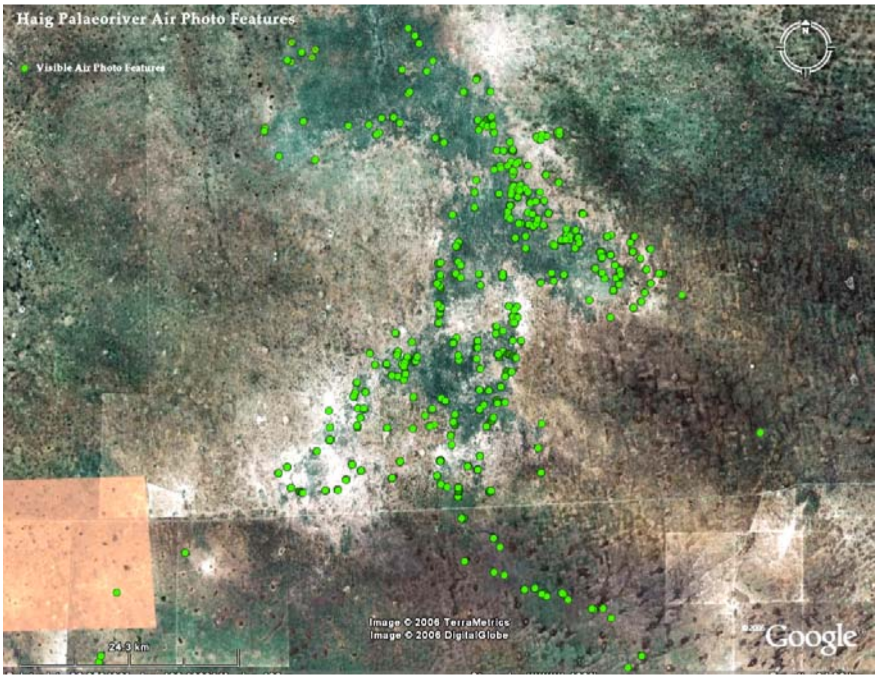


Figure 9 New Visible AirPhoto Featuresof the HaigPRRegion

By enlarge most of these features are visible due to the greater depth of surface cover in this region. It is the surface expression of cover erosion or cover collapse into underlying cavities that stands out in sharp contrast to the surrounding landscape.

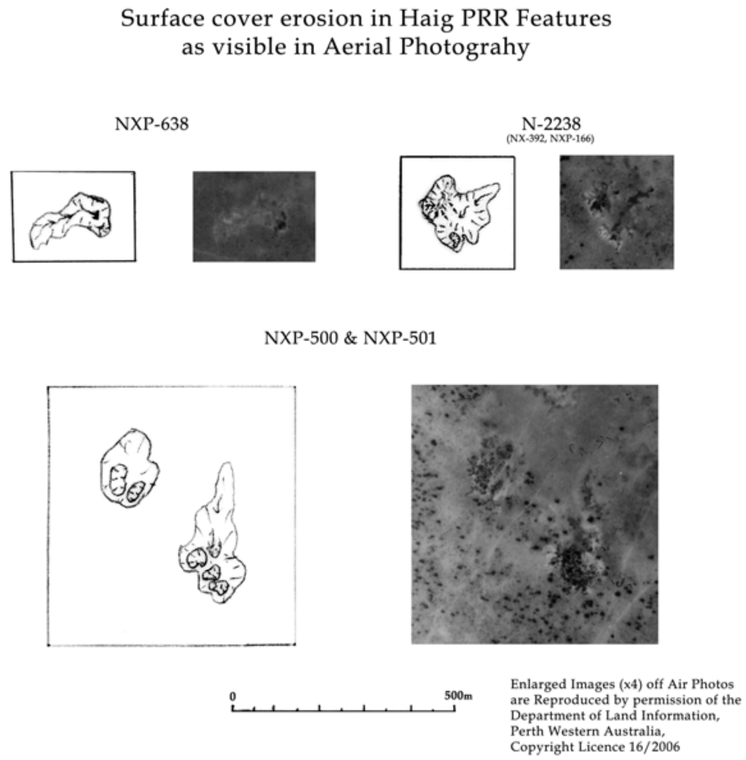


Figure 10 Surface cover erosion of HaigPR Features as visible in Air Photos

This is what highlights these features easily stereoscopically in aerial photography.

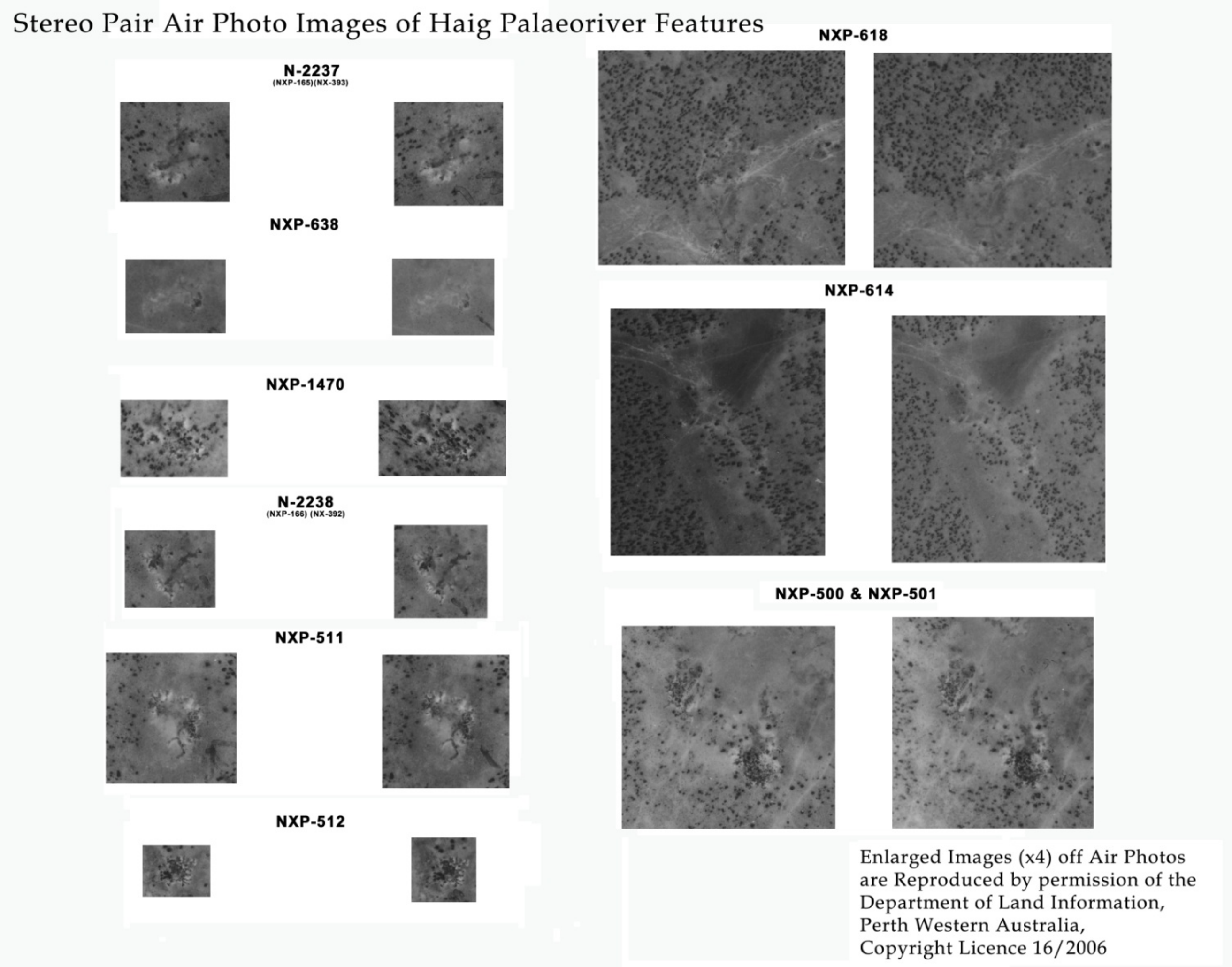


Figure 11 Stereoscopic images of HaigPRRegion features

The cover erosion dolines appear to be in various stages of formation, from sharply incised steep sided erosion dolines to more subdued degraded dolines eg similar to N-143.

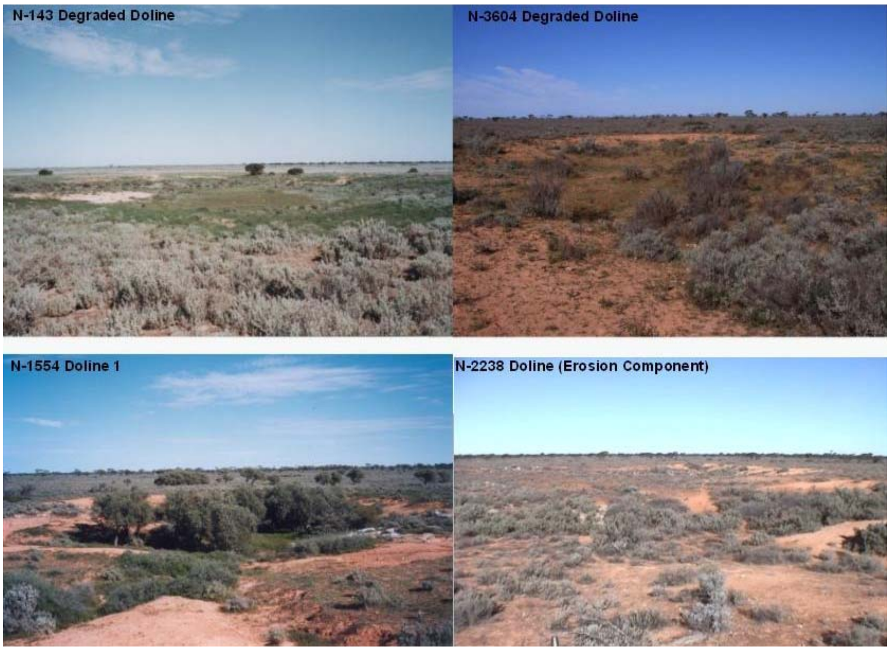


Figure 12 N-143 & Examples of Erosion Dolines

These features do not occur on raised areas of ground like that of Haig Cave instead they tend to occur in broader areas of lower relief. Only a small number of the 200 have been visited to date

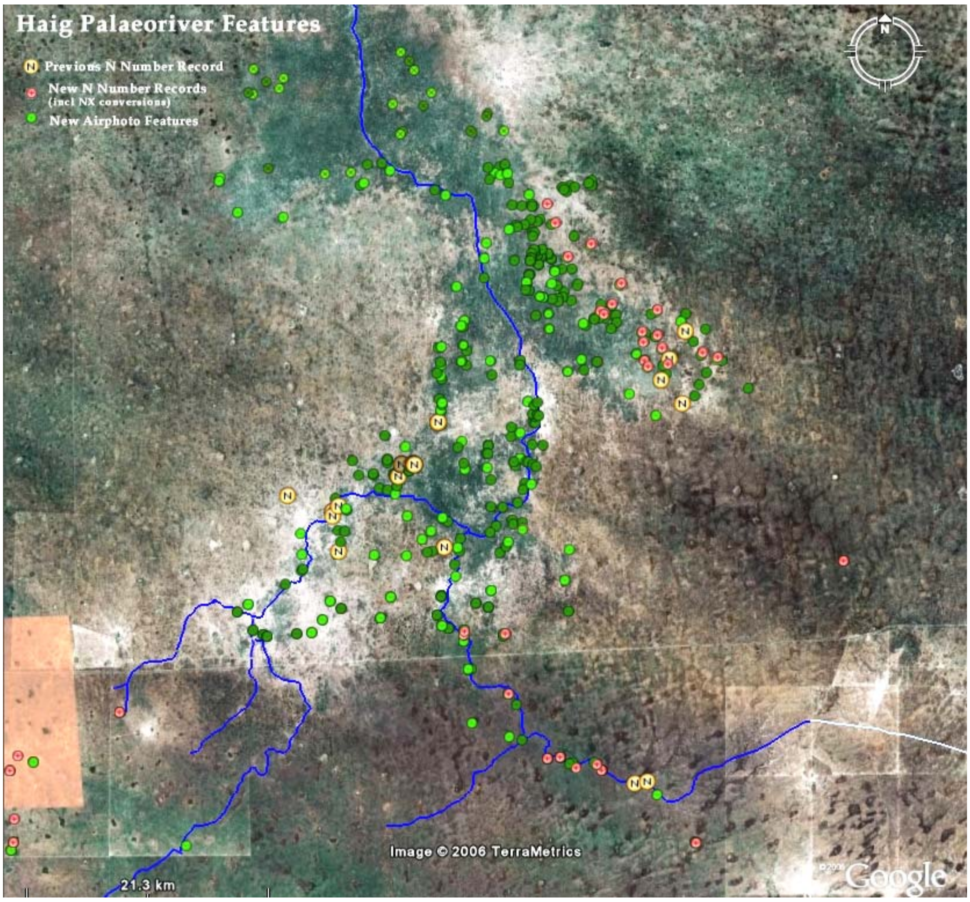


Figure 13 Features of the HPRRegion showing New visited and Previous N Features

Blowhole entrance to shallow collapse : N-2639

Slot entrance to shallow collapse : N-2642

Slumping Collapse : N-2238

Degraded Collapse area in N-2642

Figure 14 Examples of Stages of Process

Relict Palaeorivers of the Western Nullarbor and their associated Karst Features

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The features to the west of Haig Cave (N-55) show the cause of the cover erosion to be the widespread upward shallow stopping collapse of underlying limestone.

Again there are many examples of various stages of process often present at the same location

Stages found include:

- Blowholes, slots (enlarged joint controlled entrances), and small collapse entrances, leading to shallow rockpile chambers, N-2637 – 2640 complex.
- Areas of exposed shallow surface slumping & collapse (N-2641).
- Highly degraded slumping or collapse, showing substantial modification of exposed limestone N-2642.

In this area large rounded cavities are evidenced in walls below ground and shows a number of different infill types including rarer massive gypsum occurring in nearer surface cavities, dark red brown, green-grey, or grey-white clays in cavities of varying depth.

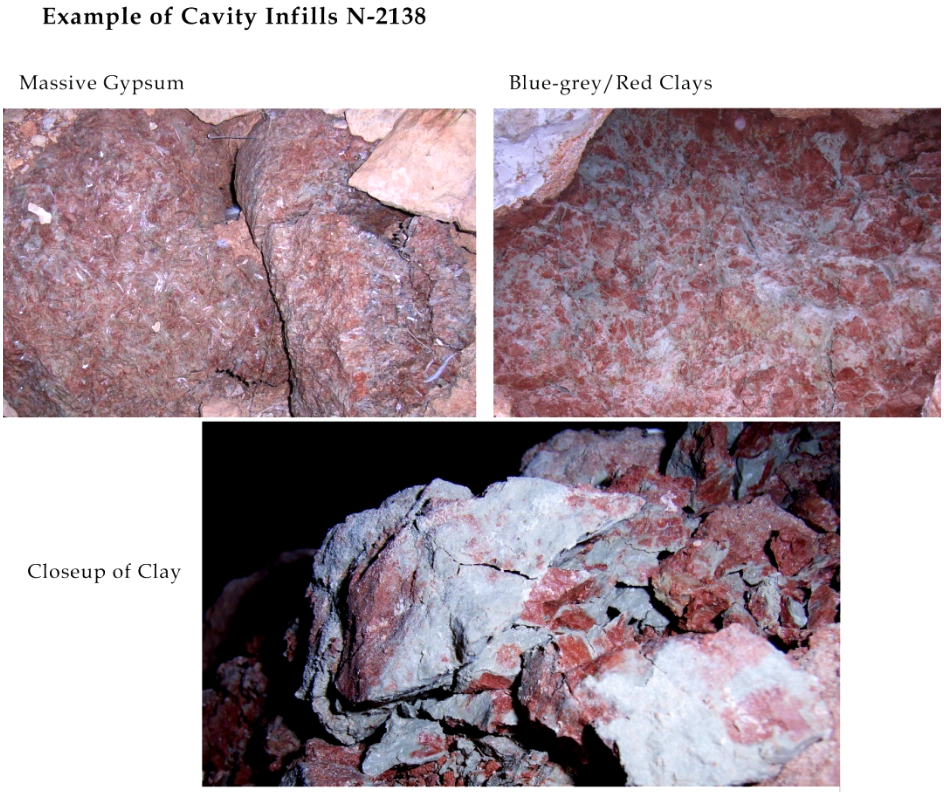

Figure 15 N-2138 Examples of Cavity infill types

This cavitation and infilling has created areas below the surface which in places are inherently unstable. An example is in N-142 where roof slabs have been noted having more clay content than limestone. Although no direct evidence has been found, it appears the collapse development originates from a relatively shallow level. Precursor development observed has been limited to minor shallow phreatics and enlarged cavitation. In features visited to date the level of precursor development is obscured by the nature of the widespread near surface collapse development.

These features by enlarge fit with the Lowry 1970 observation in regards to, - "N141 - N143, dolines formed by clay washing down joint openings in Nullarbor limestone. To cavities formed by solution when the water table was close to the surface, or vadose enlargement of cavities filled with clay."

To the north of Family Dam there is a trend for features to be more concentrated on the margins of the Haig PRRegion. To the south of Family Dam the palaeoriver splits into distributaries. From this point and to the southeast a high proportion of the features are located on the edges of the river channel with a number appearing to drain or divert modern localised flood water flow.

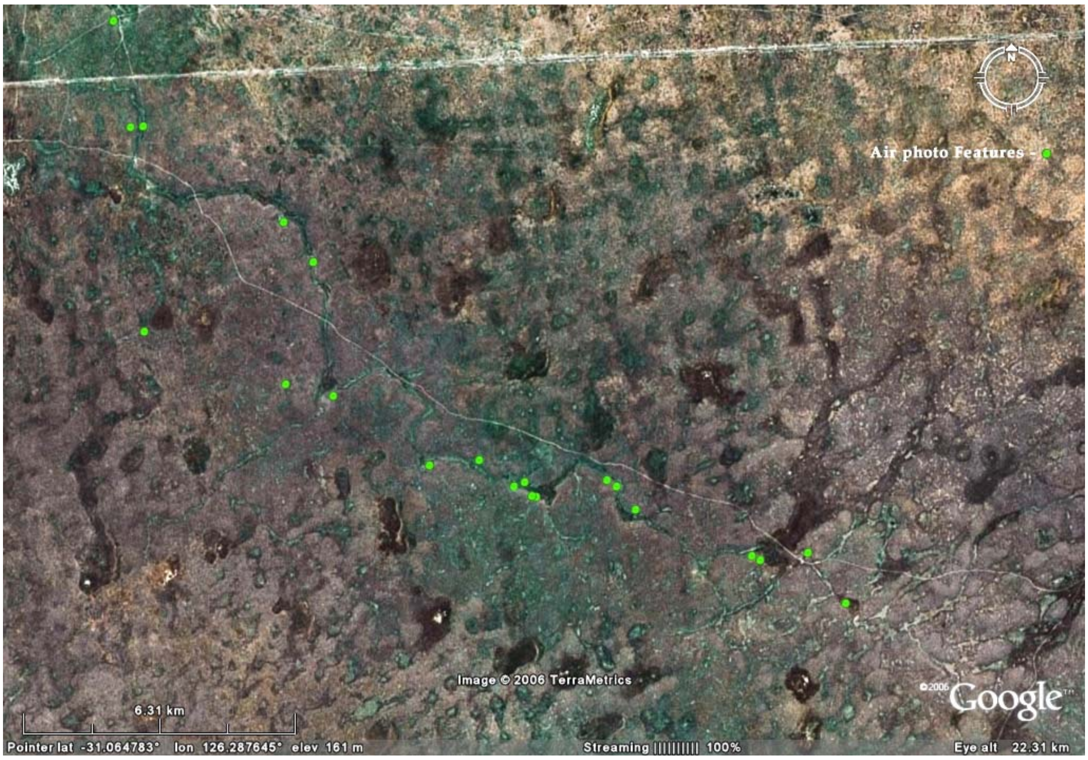

Figure 16 Features along the SE HPRiver Distributary

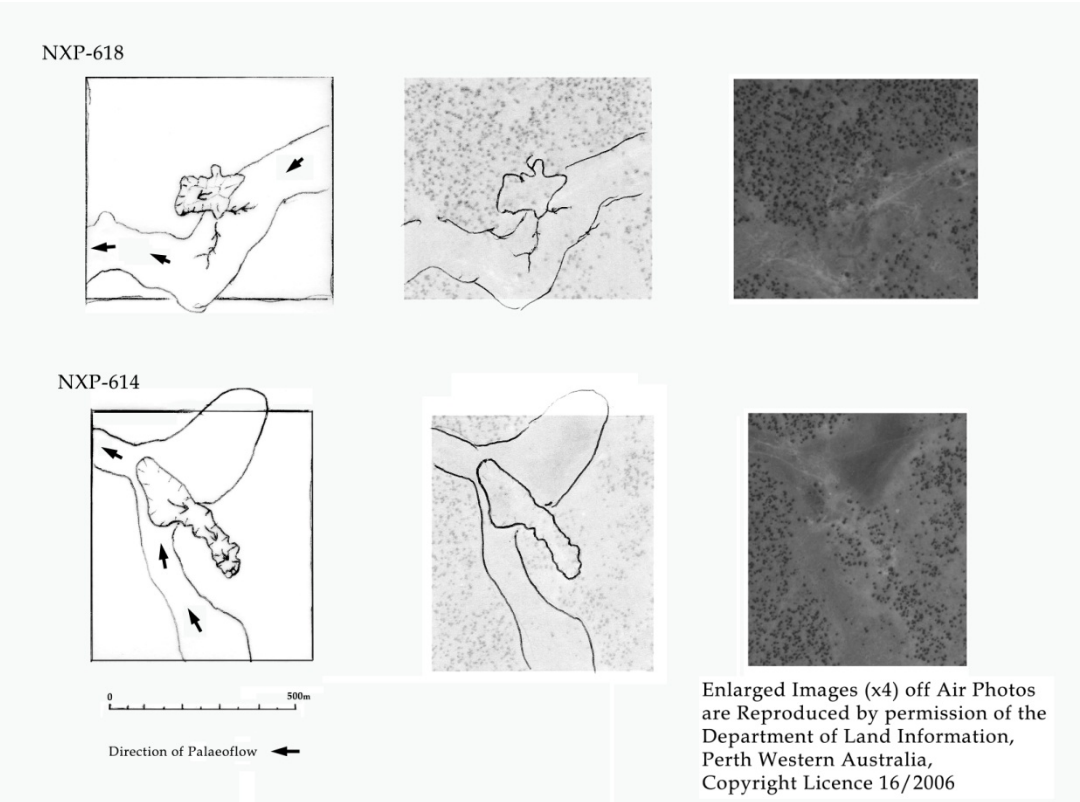

Figure 17 Examples of River Channel draining features

NXP-614 is a case where drainage of modern localised flood flow appears to be predominantly from the west. This is in a reverse direction to that of the original palaeoflow.

Features visited further along the south eastern Haig distributary, access within these surface collapses is confined to the layer of oolitic and rubble calcrete cover with only minor outcrops of underlying limestone present. The surface features show no indication of the form of cavity development in the underlying limestone.

Figure 18 River Draining Feature N-1607 D@210º
& **Figure 19 River Draining Feature N-1608 D@50°**

In the area of the Western Haig distributary the surface mostly lacks the broader surface calcretes, instead only isolated patches are evident. In this area, only one shallow degraded surface collapse is present: N-2999.

Although a number of caves located nearby (N1536, N1611, N1612, N-1596) are more indicative of substantial shallow cavity development in both their size and subsurface collapse development, at depths accessible up to 14m.

To date I have only completed a detailed search of approximately two thirds of the Forrest PRRegion, but from this it is apparent there are far fewer large surface karst features, as only two have been located so far.

Figure 20 SW HPR Distributary Feature - Shallow degraded collapse N-2999D@65º

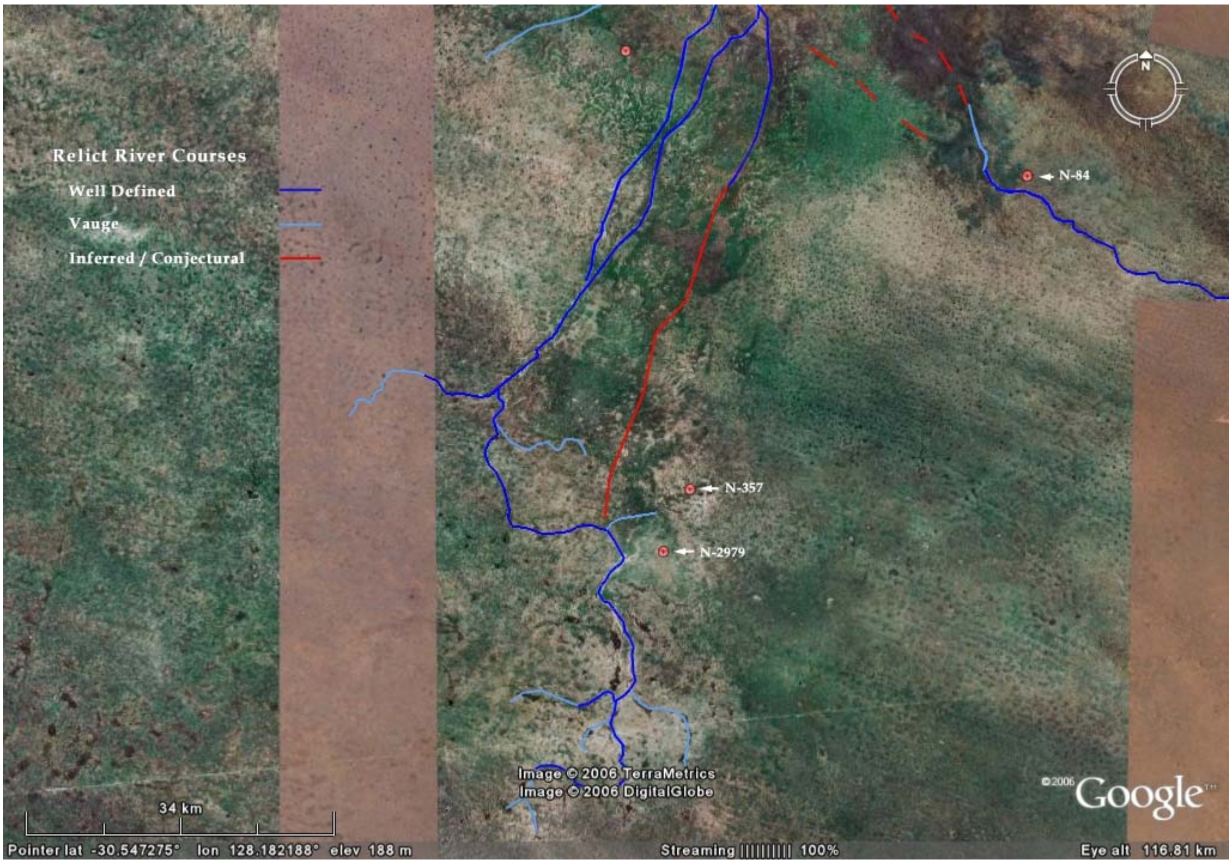

Figure 21 Forrest PRRegion and the two visible features N-357 and N-2979

Relict Palaeorivers of the Western Nullarbor and their associated Karst Features
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Figure 22 N-2979 D1@30º Doline comlex with multiple slots & holes

One was known previously N-357, and one is new N-2979. N-357 appears to be a shallow collapse occurring in the base of a shallow E-W corridor on the eastern margin of the Forrest PRRegion and it differs substantially to the other feature N-2979 which is a complex of shallow dolines and holes where the deepest access is only 3m.

Areas studied outside and further removed from the Palaeoriver systems within the Loongana and Forrest Map sheets, do show a number of vague shallower surface features on Air Photos. They are numerous, but appear to be more random and much more widely scattered. A number visited show the cause to be shallow soil erosion areas around blowholes. These blowholes eg. N-3606 (NXP-559), and N-3607 (APP-L12/5032-04) seem to access more typical doming structures developed over “vuggy” macro-cavity layers with limited lateral extent. Visible surface collapse appears largely absent and the only exception located to date is N-2455 (NXP-177). This collapse does access a cave with more extensive shallow cavity development with approx 340m of shallow passage at depths to the surface of no greater than 8m [Devine 2007].

Conclusions

The depth of surface cover causes an enhanced size of surface doline expressions for the features located within the Haig PRRegion and is the reason these features are easily observed in Aerial Photography.

The underlying cause of these surface features appears to be areas of localised shallow collapse.

Areas of surface and underlying collapse appears to be more restricted to within, or in close proximity to the Haig PRRegion and its distributaries.

The Forrest system does not appear to have the same underlying karst development as the Haig system, or it could simply lack current surface activity.

Areas adjacent to the western portion of the Dip exhibit no easily recognisable features on Aerial Photography.

The areas examined are limited to the lower reaches of the Haig and Forrest systems and the western end of Dip, therefore a further examination of the palaeoriver regions both in Western and

South Australian Nullarbor is needed to show if the Haig system features are an isolated occurrence.

Finally the link between historical shallow water table levels seems to be supported by the widespread development of shallow karst features in the Haig region. Although further investigation of features shown in this report is needed to lead to direct evidence of the level of precursor development for these caves.

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Acknowledgements

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ForestrySA Cave Management System

Trevor Wynniat

Many people in this region saw caves & sinkholes as nuisance value holes in the ground. They were often filled in or used as rubbish dumps which created the potential to pollute groundwater. Those on Forest Reserves were no exception – often filled with original vegetation when cleared, planted right up to or through.

Background

- 1996 - With the inception of a Community Forestry Section, the author was appointed to a Ranger position – interested in caves, but didn't know much about their locations.
- Became aware of location of dive sites & some regularly-visited dry caves.
- Over a period of time as logging machinery & mechanical treatments became bigger, caving people contacted Forestry SA saying we have damaged or destroyed a cave – eg through chopper rolling or harvesting contractors who had stood logs into entrances etc.
- Began to erect danger / warning signs at selected sites.
- 1999/2000 – started fencing using post & rail (200 x 50 treated timber) and included elongated versions of our warning signs.
- Could then see a need to get karst features onto some sort of database.
- 1999 – Tracee Perry was appointed to the Community Forestry Section as a Project Officer, so one project was to come up with how to capture information on a database.
- Project involved local caving / CEGSA gurus Fred Aslin and Kevin Mott also with Peter Mackenzie (GIS) who also has interest in caves.
- Of about 500 CEGSA-numbered cave sites throughout the Lower South East, there are about 130 in Forest Reserves.
- Information Collected:
    - L Number (L being LSE) if already numbered
    - Sensitivity
    - If site needs fencing
    - Gating
    - Rubbish
    - Dimensions
    - Comments, eg doline, cave, etc, if visited by public, etc.
    - Popular name
    - Alternative names
    - Actual name
    - If cave has a thin roof
    - Special features, ie formations, etc
    - GPS coordinates
    - Photo
- During this process were found approx 100 more karst features (900 or 1000 series)
- Data-loaded this into GIS system developed by P Mackenzie

Procedure

- o When we log on, we see red dots, representing karst features, plus L numbers
- o Hot-linked, so when we click on dots it will bring up a photo, plus site information
- o Our Sales Division see forest compartments on the GIS system coloured in red - indicating Exclusion Zones - and will need to see the Forester (Troy) or myself. This may result in a site visit with the Logging Coordinator, Contractor CF and possibly the operations coordinator to agree about a buffer zone regarding treatment and safety if the cave area has a thin roof, etc
- o In the meantime we have gated about 12 sites, including 4 out of 7 diving sites
- o EMS & Buffer Zone guidelines were developed – the cave info already collected complement the system well
- o Continue to put new features on system as they're often found & identified in Hazard / Incident Reports
- o 2005 – formation of ForestrySA caving / cave management group, which consisted of myself, Troy (a Forester), Grant Pearce & Peter Mackenzie, with advice from local CEGSA people when needed
- o We look at new discoveries & what to do with them - eg if sand holes we GPS and photograph them, put on the database & fill hole. Another example is Hells Hole Quarry - how to make it secure in the short term eg standardising fencing (post & cable?)
- o Developed "Significant Site Record Form" (on Standard Forms)
- o Where to from here? There will always be opportunities for continuous improvement, eg -
    - Establishing Buffer Zones around caves (eg Wandilo Siding)
    - Establishing buffers along drainage lines / creek lines at (eg Claypans Everglades)
    - Should be an easy way to capture such improvements on FMS system!
    - Need to capture other hazards (eg, wells at Myora / Caroline)
    - Need to develop a "Significant Site" on-ground marking system to include heritage (European & Indigenous), rare plants, etc (looked at Ezy Drive marker post system).

King Solomons Cave

David Wools-Cobb

- Located in Mole Creek Karst National Park (MKCNP) Tasmania
- Discovered 1906/7
- Opened as tourist cave 1908
- Lit by acetylene
- 1 main chamber, 2 passages leading off
- Extended in December 1928, electrified with generator soon after?
- Gazetted a cave reserve 1939
- Connected to main electrical grid system about 1953
- ? New electrical system upgrade 110 volts 1970's
- Electrical system replace with 12v 1983
- Low intensity system with C-bus control July 2004 (Kell)

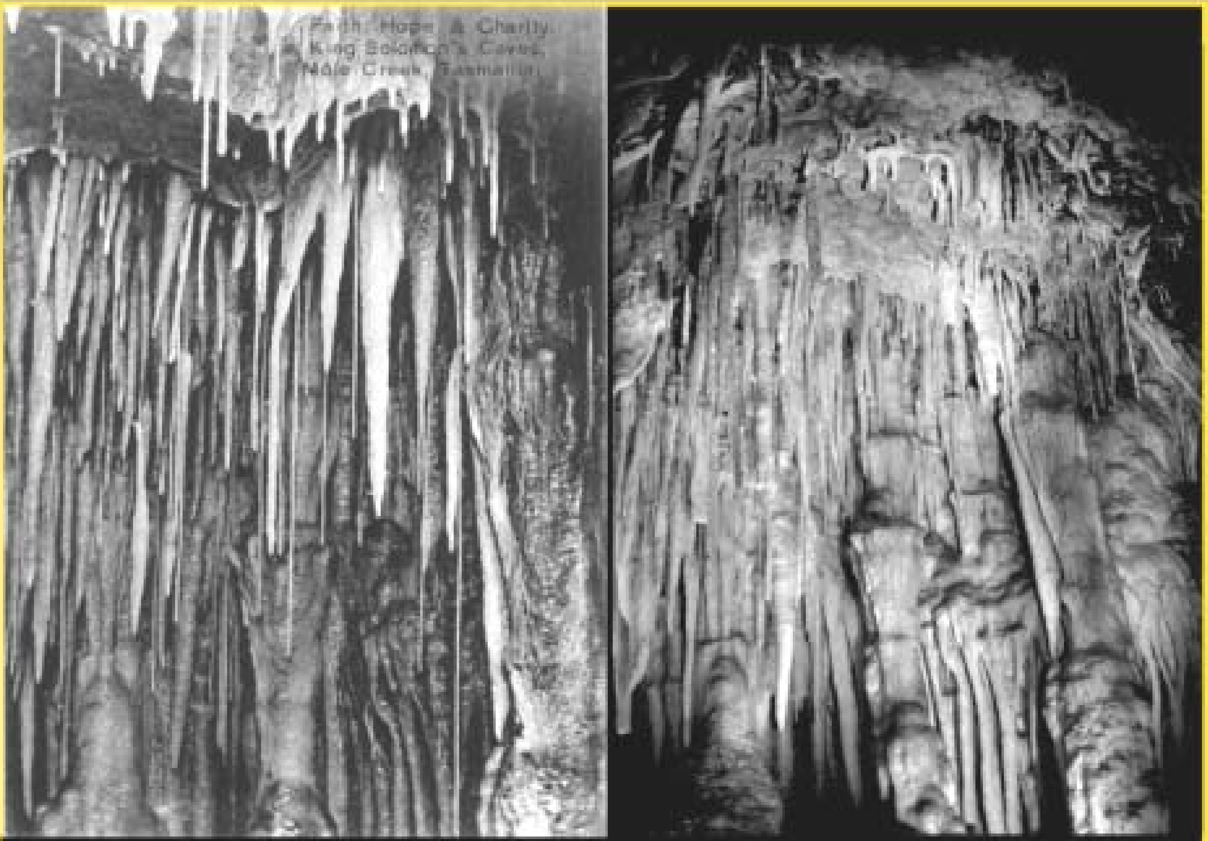
Photographer Stephen Spurling 3 1896-1962

- Ambitious in travels & what photographed
- Claimed first to use dry plate method in Tasmania
- Possibly magnesium flash method
- Willing to climb for the right angle and squeeze through to non-tourist section

Relocate specific sites within cave Re-photograph
Compare to determine changes over past approx 98 years
Consider any patterns to changes/damage

Method

- Digitalising originals
- Printing for locating in cave
- Location of features
- Attempting to determine angle of view & lighting
- Digitally photograph
- "Layer" beside original
- Analyse changes

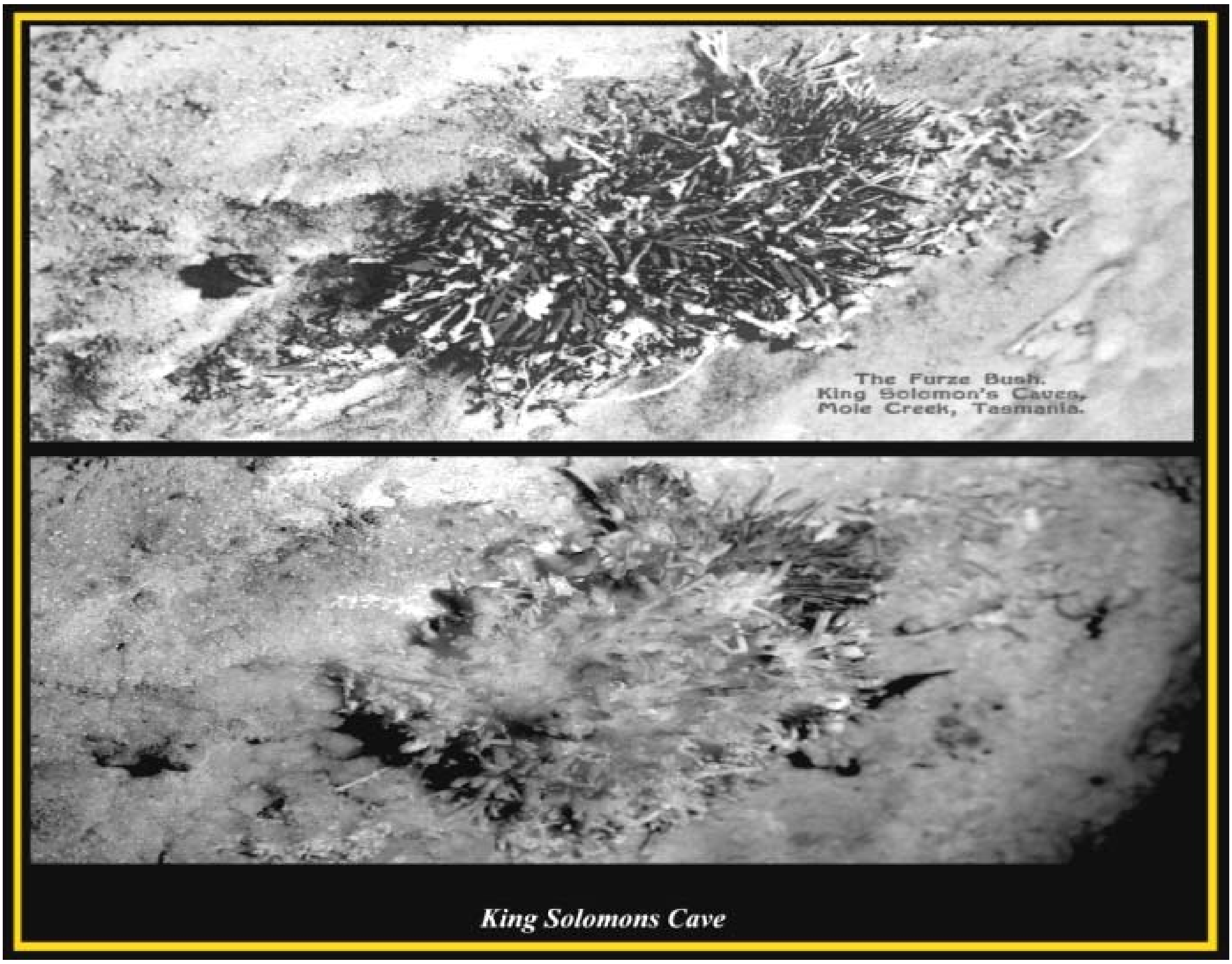


King Solomons Cave

King Solomons Cave

Problems

- Names of features change
- Difficulty in locating many sites
- Duplication of light, angle
- Access to some photo points
- Accuracy of background information (references vary)



Observations

- Floor lowered in many places
- Speleothem damage due to
  - Development
  - Light positioning
  - Protect tourists
  - Carelessness
  - Deliberate – souveniring?

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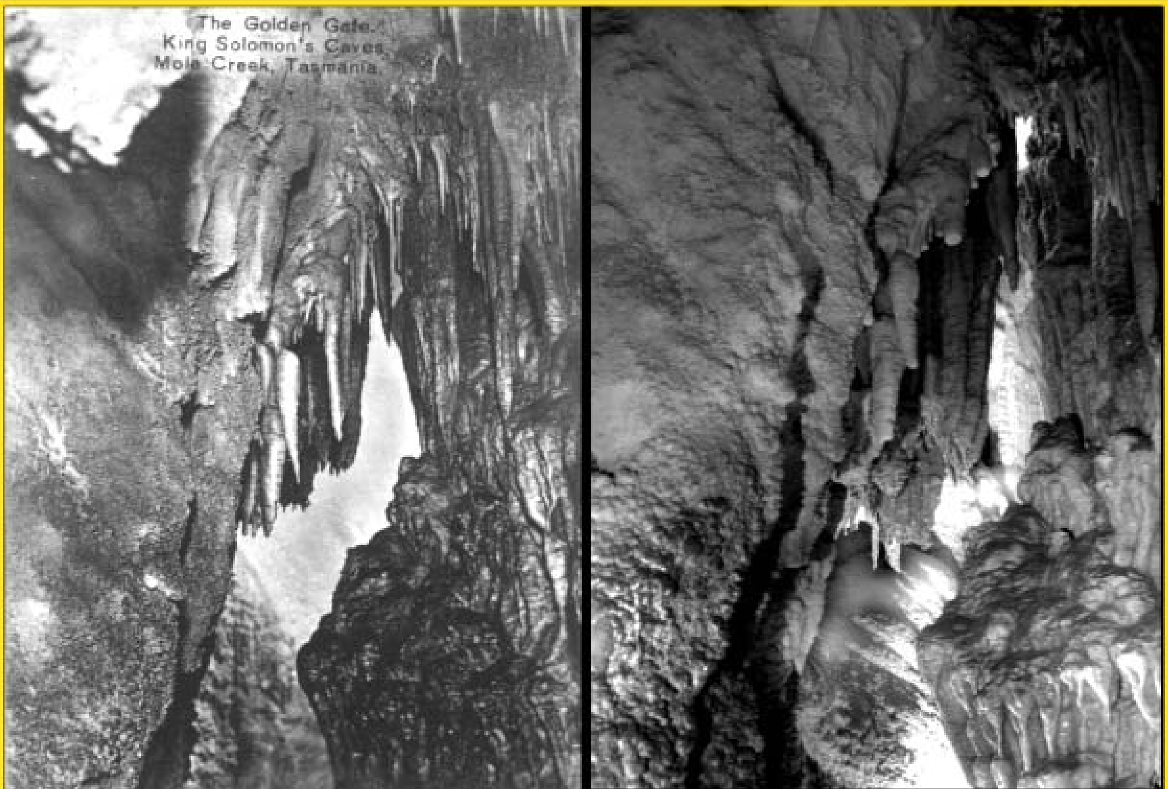
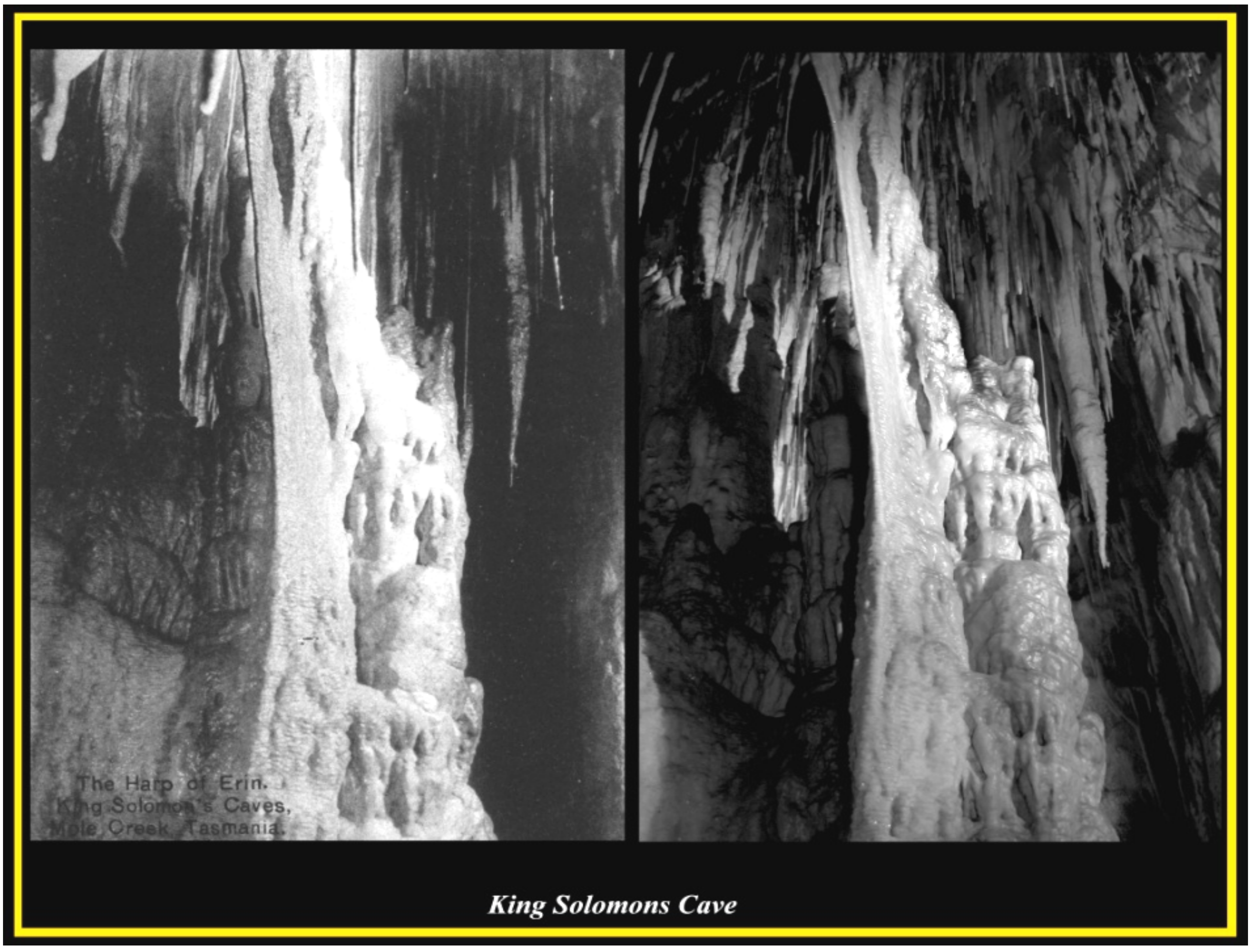
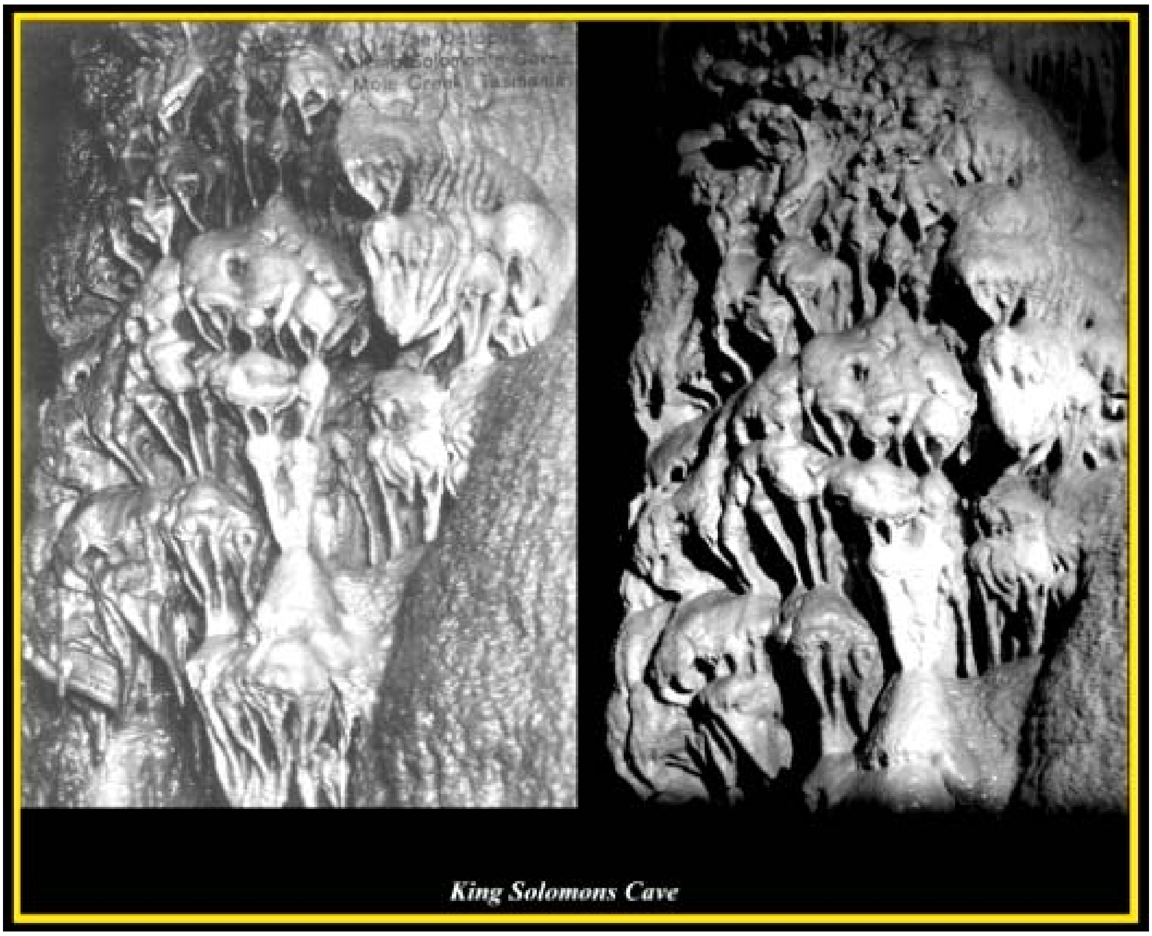
King Solomons Cave

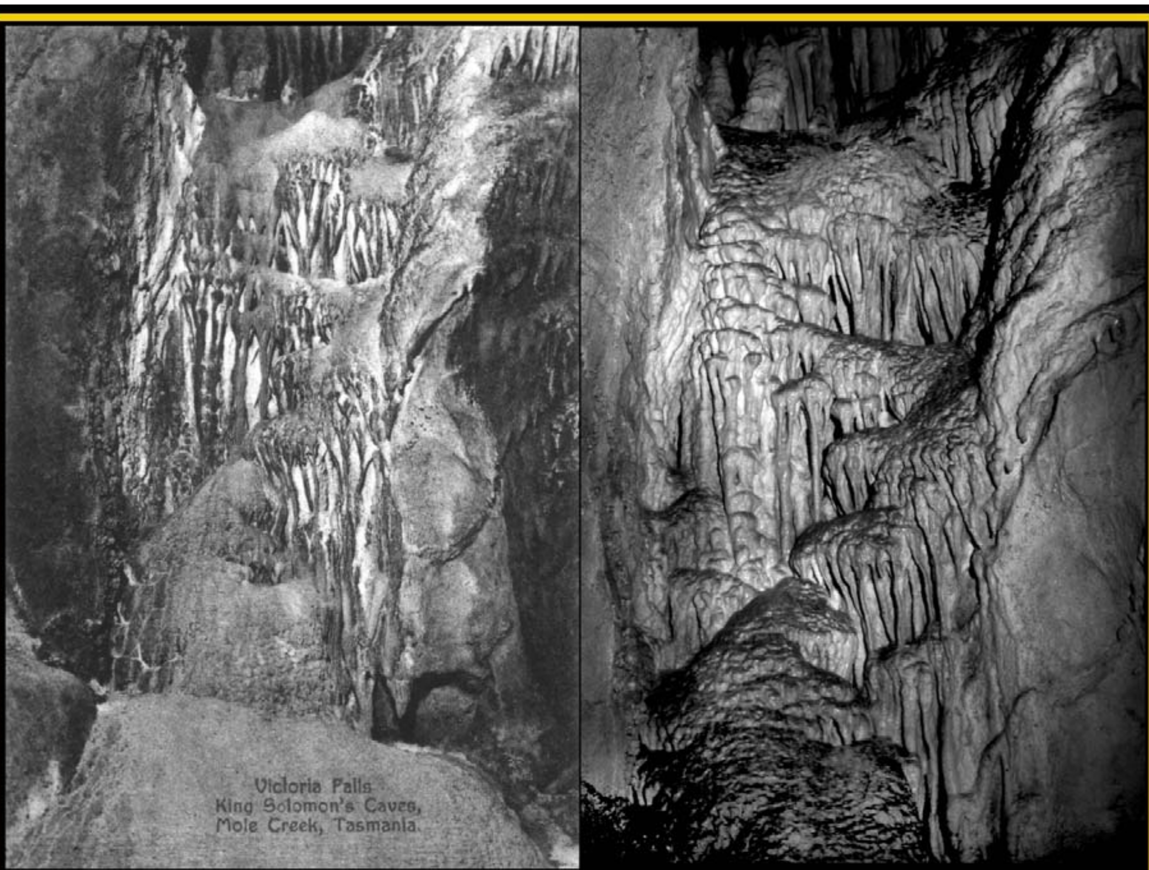


King Solomons Cave


The Harp of Erin.
King Solomon's Caves,
Mole Creek, Tasmania.
King Solomons Cave


Mole Creek Tasmania
King Solomons Cave

King Solomons Cave



King Solomons Cave

Acknowledgements

- Michael Simco, Ulverstone - Historical postcard collector
- Paul Flood MCKNP Tourist Cave Manager - access & assistance with photography
- Stephen Blanden – historical search
- Nic Hogarth – historical cross references
- Chester Shaw, retired Park Ranger MCKNP

References

- Haygarth: National Library of Australia newsletter Sept 2004
- Chris Long: Tasmanian Photographers 1840-1940
- Terry & Evans: "To the Westward", Thematic history Meander Valley 2004
- Examiner Newspaper 14/9/1908
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Celebrating Planet Earth

UNESCO GEOPARKS

Susan White

The recent initiative by UNESCO to establish a worldwide Network of Global Geoparks has important implications for Australia, especially western Victoria and south eastern SA.

The Geological Society of Australia and various state government departments have been documenting geological sites of conservation and heritage value for over 30 years.

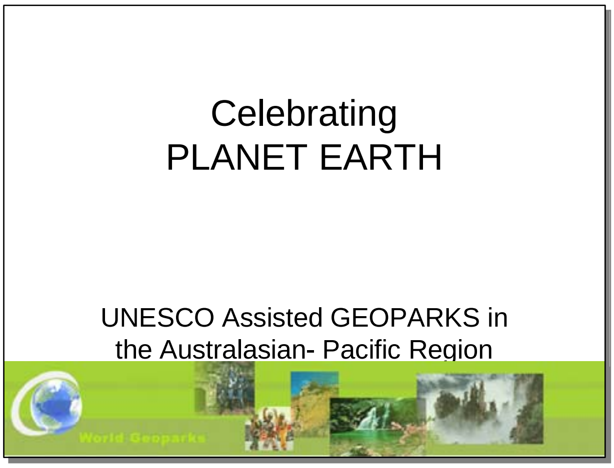
The Geopark Network aims to promote geological sites for geotourism, education and research. The Geopark model most likely to be effective in Australia is a 'Grass-roots' approach where local communities in conjunction with different levels of government take responsibility for their own region. Comparison with some of the European Geoparks Network provides useful examples. An informal network of people interested in forming Geoparks in Australia and the South Pacific has been formed.

A formal application for a Global Geopark is currently underway for the region known as the Kanawinka Geopark, extending across the South Australian and Victorian borders. This Geopark is concerned predominantly with the volcanic landscapes of the Western District Volcanic Province and its geological context.

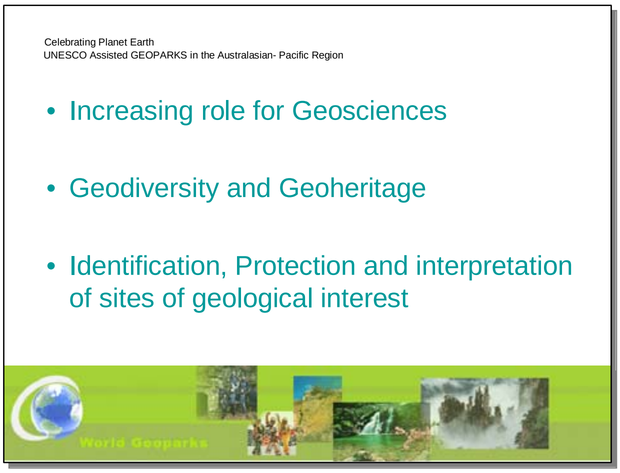
This presentation will outline aspects of the proposed Kanawinka Geopark. The area proposed, extends from Colac and Red Rock to the coast of South Australia past Millicent and North to Nigretta and Wannon Falls and the base of the Grampians. This area has significant volcanic caves and associated karst areas and is of interest to both CEGSA and VSA. Since 1998 the local Government bodies of this region commenced operation of the Volcanoes Discovery Trail Committee to promote the region and link geology with tourism.

Important aspects of Geoparks are the links between the geology and the people, their stories, culture and history that build into a sustainable source of geotourism, bring jobs to rural and indigenous people and in turn help protect sites of importance and promote geoheritage complementing the work of the interested non government and government organizations.

Celebrating Planet Earth UNESCO GEOPARKS *Susan White*



Slide 1



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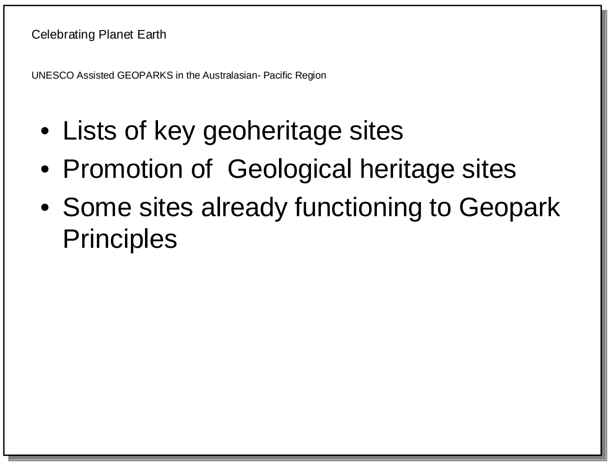

Slide 3

Slide 4

Slide 5

Slide 6

Celebrating Planet Earth
UNESCO Assisted GEOPARKS in the Australasian- Pacific Region

What is a Geopark?

•A territory with well-defined limits that has a large enough surface area for it to serve local economic development.

•It comprises a certain number of geological heritage sites (on any scale) or a mosaic of geological entities of special scientific importance, rarity or beauty, representative of an area and its geological history, events or processes.

•It may not solely be of geological significance but also of archaeological, ecological, historical or cultural value.

World Geoparks

Slide 7

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UNESCO Assisted GEOPARKS in the Australasian- Pacific Region

To Qualify:

According to UNESCO, for a Geopark to qualify it needs to have:

- *A management plan designed to foster socio-economic development that is sustainable (most likely to be based on geotourism).*
- *Demonstrate methods for conserving and enhancing geological heritage and provide means for teaching geoscientific disciplines and broader environmental issues.*
- *Joint-proposals submitted by public authorities, local communities and private interests acting together, which demonstrate the best practices with respect to Earth heritage conservation and its integration into sustainable development strategies.*

World Geoparks

Slide 8

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UNESCO Assisted GEOPARKS in the Australasian- Pacific Region

Geoparks foster

- **Employment**
- **Protection**
- **Heritage**
- **Education**
- **Tourism**
- **Fun**

World Geoparks

Slide 9

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UNESCO Assisted GEOPARKS in the Australasian- Pacific Region

- Since 2003 Dr Sue Turner has been forging the Asia Pacific and informal Oz Geopark Network
- Support from Tourism Commission of SA
- Tourism Vic, Museums, Academics
- Geological Society of Australia Inc.
- National Trust

World Geoparks

Slide 10

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UNESCO Assisted GEOPARKS in the Australasian- Pacific Region

Australia has two areas very close to applying for Geopark Status:

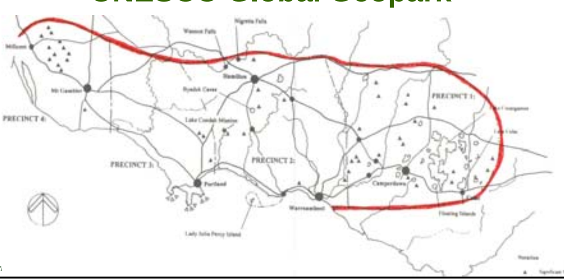
- Flinders Ranges
- **KANAWINKA GEOPARK.**

Western Plains of Victoria and South East South Australia

World Geoparks

Slide 11

Australia's
First Proposed
UNESCO Global Geopark



Slide 12

Four precincts:

- Lakes and Wetlands (Camperdown and Colac)
- Cones and Falls (Hamilton and Warrnambool)
- Coast and Caves (Portland and Nelson)
- Craters and Limestone (Mount Gambier District)

Victoria and South Australia

Slide 13

Precinct 1: Lakes and Wetlands (Camperdown and Colac)

- Lake Bullen-Merri
- Mt Noorat
- Red Rock
- Mt Elephant
- Lake Purrumbete
- Lake Gnotuk
- Stony Rises

- Lake Bookar
- Lake Cundare
- Mount Leura
- Mount Sugarloaf
- Lake Keilambete
- Lake Tooliorook
- Skipton Cave

Slide 14

Precinct 2: Cones and Falls (Hamilton and Warrnambool)

- Mt Eccles
- Tower Hill
- Mt Rouse
- Byaduk Caves
- Wannon and Nigretta Falls
- Mt Napier

- Mount Hamilton
- Mount Warrnambool
- Mount Shadwell

Slide 15

Precinct 3: Coast and Caves (Portland and Nelson)

- Lady Julia Percy Island
- Cape Bridgewater
- Bats Ridge
- Cape Nelson
- Cape Grant

- Mt Richmond
- Lake Condah
- Cape Sir William Grant

Slide 16

Precinct 4: Craters and Limestone (Mount Gambier District)

- Mount Gambier (Blue Lake)
- Mount Schanck
- Lake Leake
- Mount Burr
- Lake Edward
- Mount Muirhead
- Mount Graham

Slide 17

Volcanoes Discovery Trail Committee was formed including representatives from:

- Local Government of Victoria and South Australia

(annual funding provided from the Shires of Southern Grampians, Corangamite, & Glenelg in Victoria and in South Australia: Mount Gambier City Council, Grant District Council and Wattle Range Council)

- Regional and Local Tourism Associations,
- Department of Environment and Heritage, SA
- Parks Victoria
- Greater Green Triangle Area Consultative Committee

Victoria and South Australia

Slide 18

International Significance: 6 sites
(4 Vic)
National Significance: 18 sites
(all Vic plus SA ones)
State Significance: 8 sites
(many more than this!)
Regional Significance: 25 sites
(many more than this!)
Heaps of local sites!

The Volcanic Plains of Western Victoria and South Eastern South Australia include the following specific features:

- International Significance: 6 sites
- National Significance: 18 sites
- State Significance: 8 sites
- Regional Significance: 25 sites

Slide 19

The main associated cultural features of importance include:

- Floating Islands Reserve
- Ramsar Lakes of Western Victoria
- Geothermal Energy - Portland
- Aboriginal Cultural Heritage
- Stone Walls

Slide 20

Australia's Kanawinka Geopark

- Meetings held in Mount Gambier and Hamilton in December 2005
- Overwhelming support for Geopark Application
- Application and Strategy will be ready for public comment in late August 2006 before sending to UNESCO for assessment in November.

Slide 21

Issues for ASF

- Has issues for us as it includes caves & karst
- Geoparks people here don't understand ASF or its structures and roles
- Cannot be ignored
- Useful public relations and getting our message out there!

LIVING ON KARST!

Slide 22

Australia's Kanawinka Geopark

After public meeting in Mount Gambier
Photo courtesy Dr Sue Turner

Dr Turner, Graham Arkinstall and Joane Mcknight at Mount Leura in December 2005
Photo Courtesy Camperdown Chronicle

Slide 23

Australia's Kanawinka Geopark

Not just Volcanics but also grasslands, lakes, caves, wetlands, homesteads, gardens, towns, villages, culture, heritage, legends, history and exploration, stone walls, soldier settlement and much much more……

EDUCATION, PROMOTION AND PROTECTION

Slide 24

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UNESCO Assisted GEOPARKS in the Australasian-Pacific Region

IN SUMARY

The important aspects of Geoparks are the links between the geology and the people, their stories, culture and history that build into a sustainable source of geotourism, bring jobs to rural and indigenous people and in turn help protect sites of importance and promote geoheritage complementing the work of the Geological Society and Government Bodies..

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Australia's Kanawinka Geopark

Celebrating Planet Earth
UNESCO Assisted GEOPARKS in the Australasian-Pacific Region

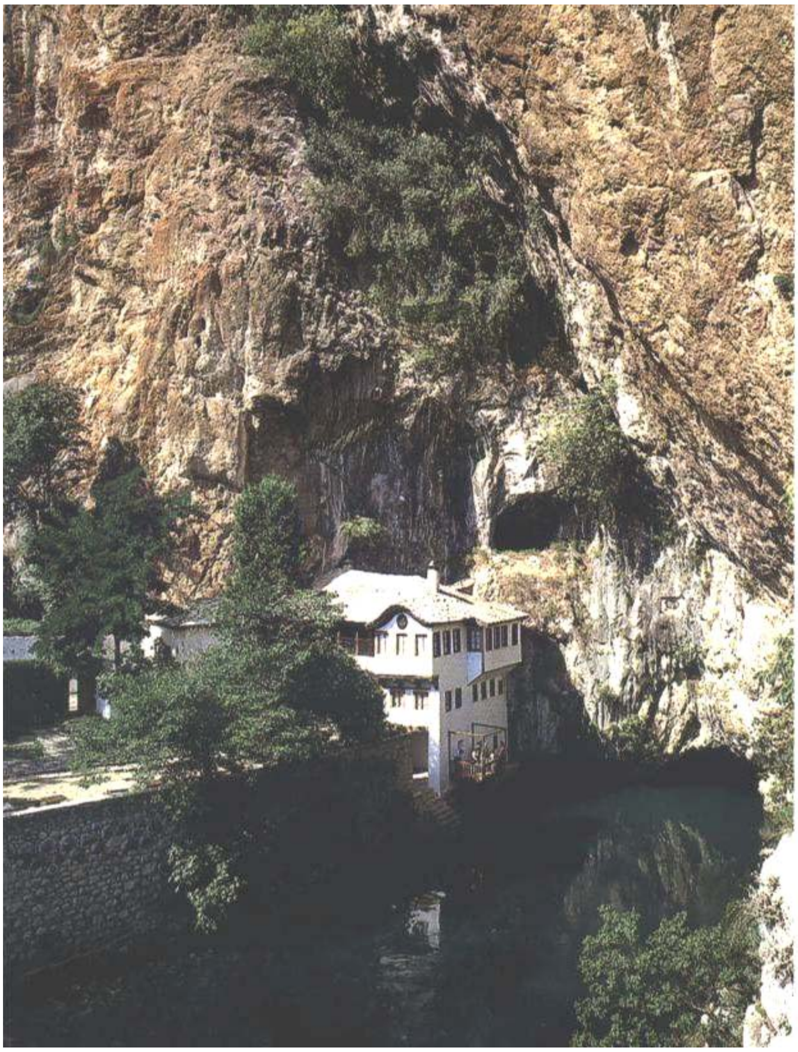
THANK YOU
to Dr Susan Turner
UNESCO Advisory Group of Experts for Global Geoparks
for support and valuable guidance.
Photos from Volcanoes Discovery Photo Libary

Joane McKnight
Chair
Volcanoes Discovery Trail Cross Regional Committee
Joane_McKnight@msn.com

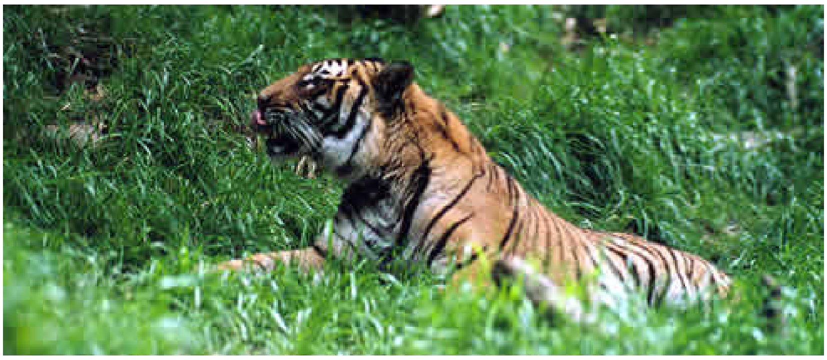
Slide 26

The World scene in Cave Conservation

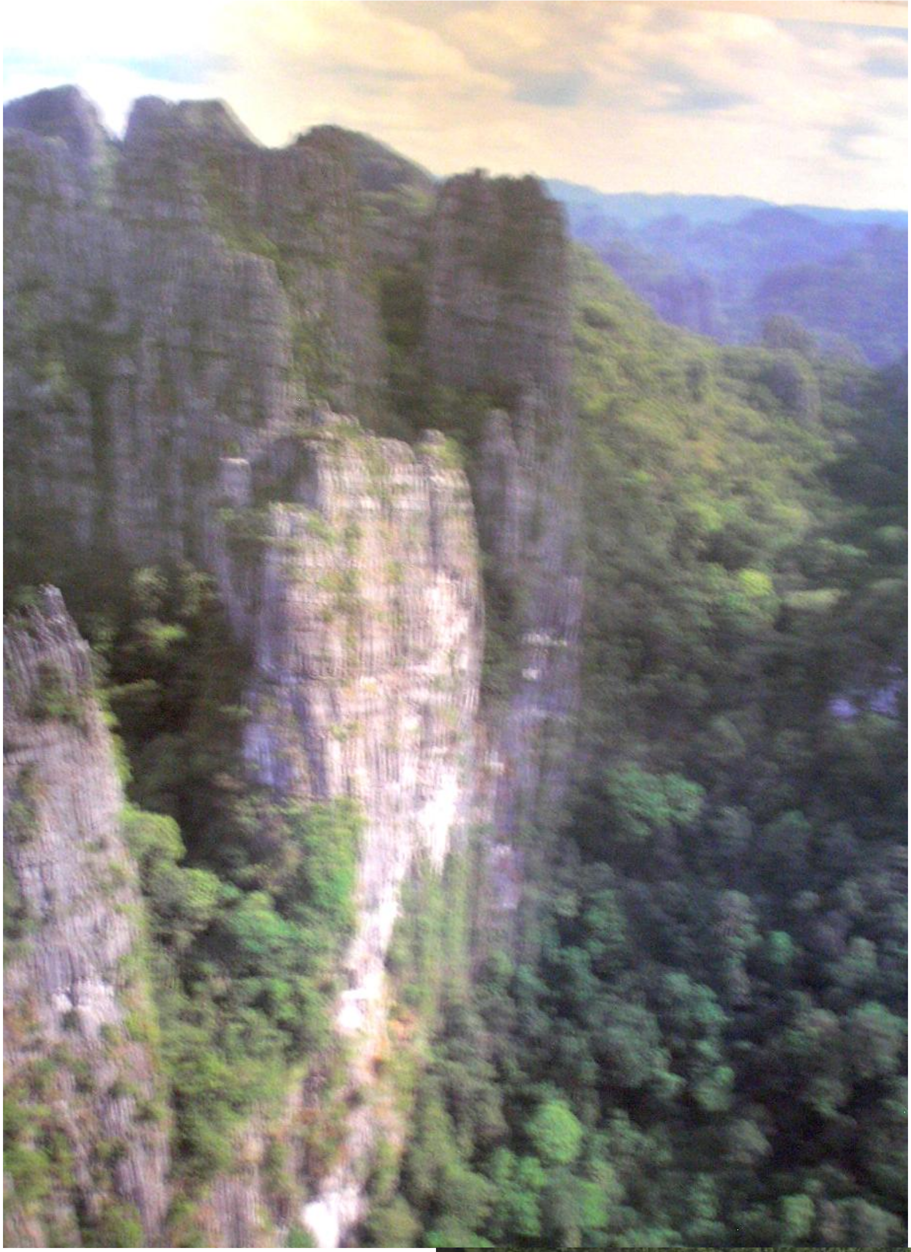
Elery Hamilton Smith



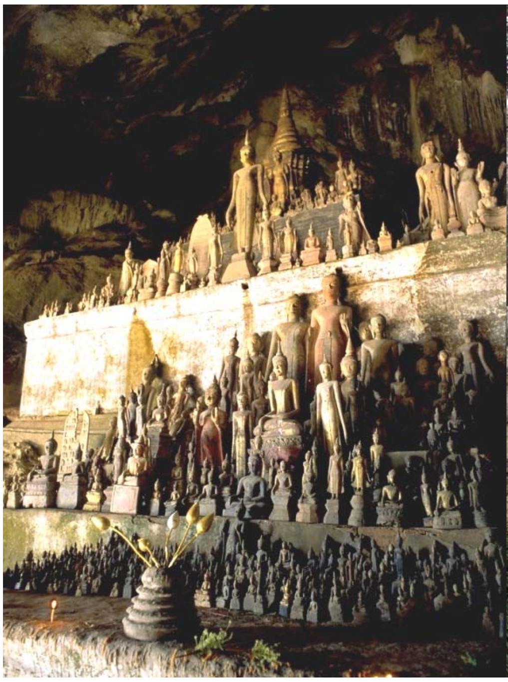
16 p1



Deer Cave, in Gunung Mulu WHA, Sarawak (Photograph J. Wooldridge)



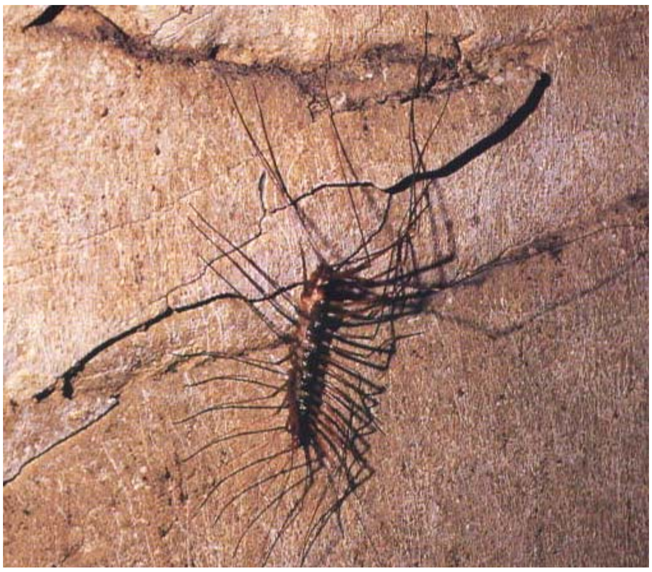
16 p4



The part of the ritualized arrangement of cave bear skulls by the Neanderthal in Piatra Altarului, Romania (Lascu et al, *Piatra Altarului)*

The fossil deposit in Victoria Fossil Cave, Naracoorte (Photograph Hamilton-Smith)

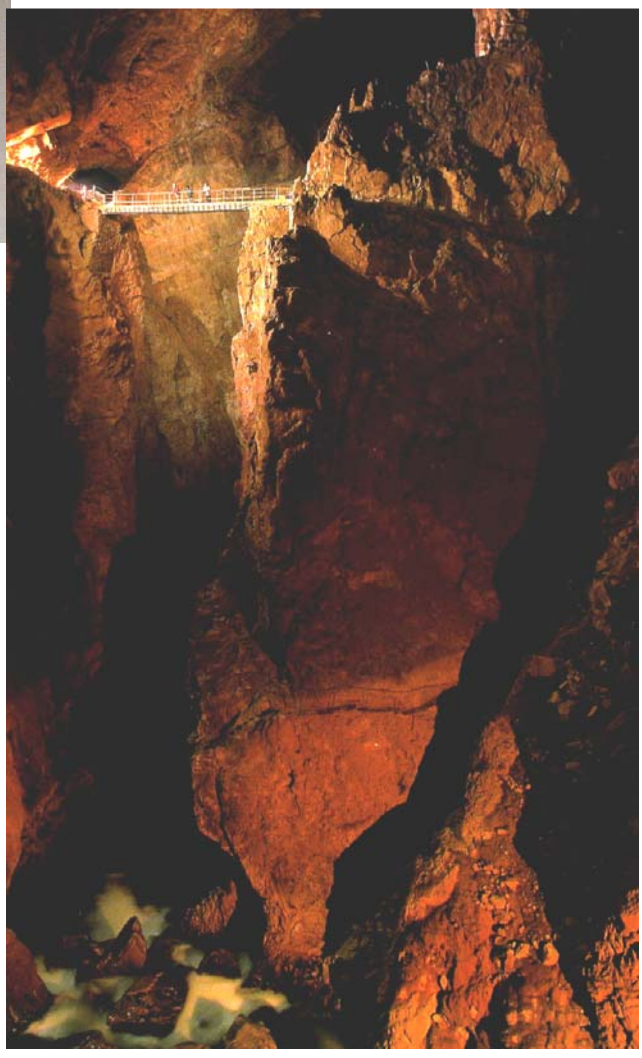
The Plitvice Lakes, each held by dams of limestone travertine (Photograph Hamilton-Smith**)**

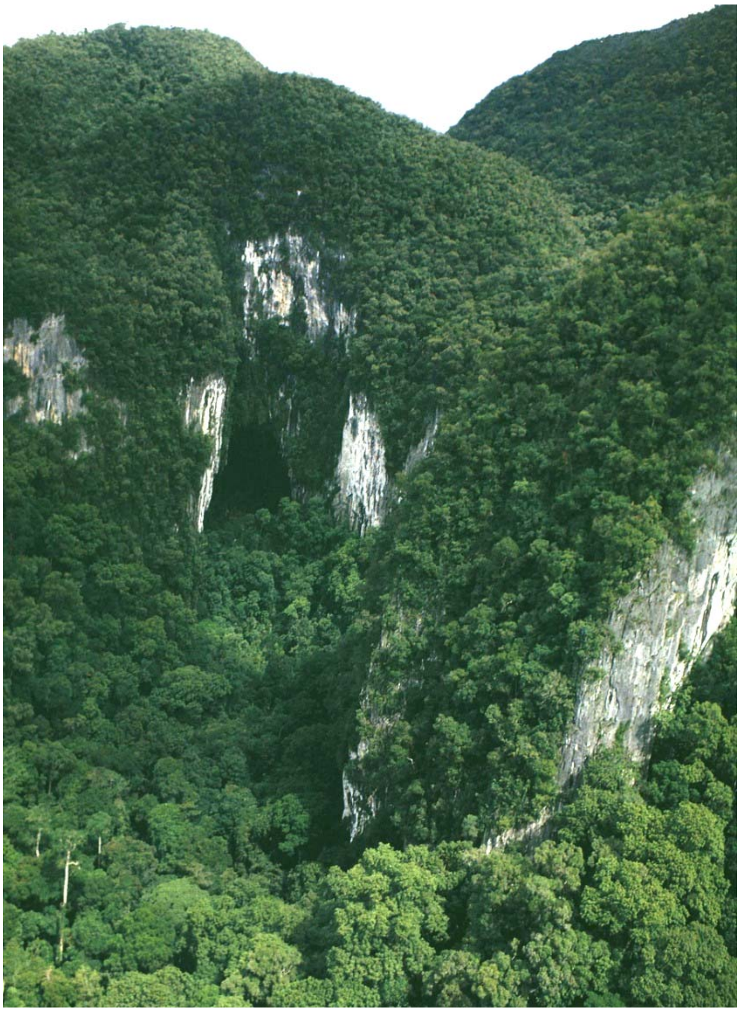


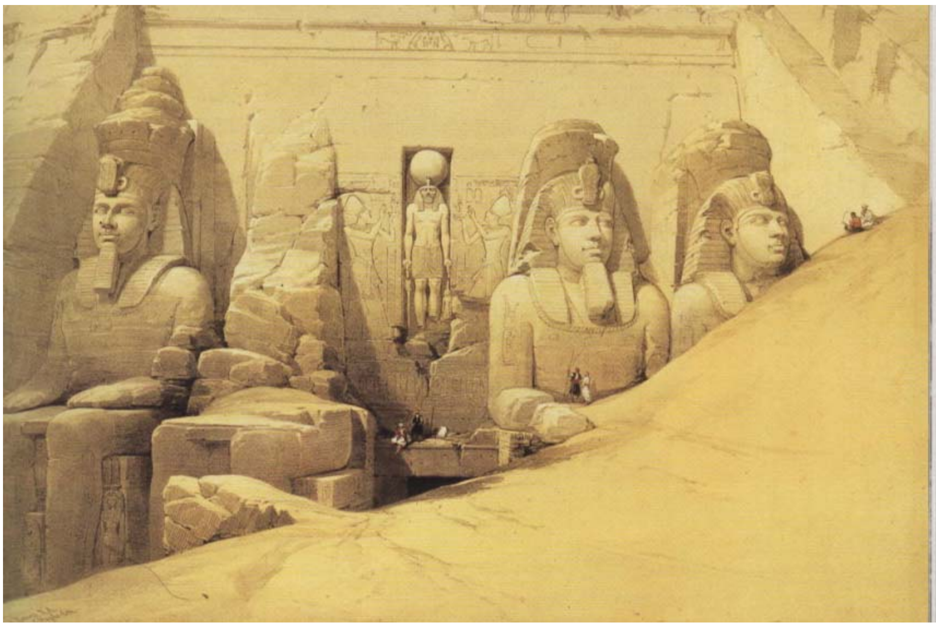
Scutigeromorph Centipede in a cave at Gunung Mulu (from Meredith et al, *Giant Caves of Borneo*)

The immense bat flight (*Chaerephon plicata*) from Deer Cave, Gunung Mulu (Photograph Hamilton-Smith)

The Hanke Bridge in Skocjanske Cave, Slovenia







Saving the monuments of Abu Simbel from being lost beneath the waters of the Aswan Dam was a key inspiration for the establishment of the World Heritage Convention (Illustration after engraving by Roberts 1846)

16 p8

The ASF: some visions of the future

Jay Anderson

Members can have the opportunity to assist in developing the future of YOUR organisation. Where is the ASF going? What is your vision for the ASF? Where do you see the ASF in the future and what will it all look like? The ASF President would like to raise the issue of organisational identity and provide members with an opportunity to be involved in future planning. This presentation will examine some options and seek suggestions from members for the future of the ASF.

Australia's peak Cave-related organisation

- **Who are we?**
- **Where have we come from**
- **Where are we going**
- **How will we get there…**

A two way street

I'll share some questions & ideas

- Seeking your input & thoughts & ideas
- This conference celebrates our 50th Anniversary
- In keynote presentation - Elery outlined where we came from and who we are

BUT – where are we really going???

Quick Revision

- formed – 1956.
- National Federation of clubs, organisations & individuals.
- involved in the exploration, documentation, & protection of caves & karst.
- incorporated in ACT - 1984.
- Predominantly members →through State "clubs"
- Membership varies – about 26 member groups which constitutes between 800-1000 individual members

The aims of the ASF

(a) to safeguard & protect the natural environment, specifically the cave & karst environment of Australia;

(b) to:

-- gather & disseminate information,

-- develop & promote policies,

-- foster & publish research,

& provide education & advice to the Australian community on conserving Australia's karst resources;

(c) to bring together & represent persons interested in caves & karst in Australia & the attainment of the Federation's aims; and

(d) to foster speleology in all of its aspects.

What does the ASF "have"?

- Logo, members, constitution, executive
- Annual Council Meeting to provide decisions and direction to the Executive Directors of the ASF
- A biannual CONFERENCE – here we are…& published papers of aspects of speleology
- Publications – Caves Australia, Helictite
- A number of site specific karst publications & books
- Guidance to members on Leadership, Codes of Ethics, Risk Management…
- Representatives on karst advisory committee's
- Insurance……

The Environmental Fund

According to our Constitution –

- A public fund to be called "The Australian Speleological Federation **Gift Fund**"
- specific purpose → supporting the environmental objectives/purposes of ASF
- to receive all gifts of money or property for this purpose

You'll have heard → moving into the future →a land acquisition that will entail responsibilities too.

What does the ASF "DO"?

- Caving of course!!
- As per the aims – education, advice on all aspects of speleology
- Contributes to knowledge of caves and karst
- Involved in karst management
- Representatives on Government advisory committee's
- Submissions re management plans & Government policy

The majority of these activities may occur at a State level through State corporate members – eg majority of karst documentation occurs through club trips.

The way other groups operate

A couple of examples of organisations I deal with……

- EDO – WA – a volunteer board of management however grants & fundraising support a small team of paid staff
- APEN – volunteer management committee & a paid secretariat position

The way other Speleo groups operate

- NSS – USA – The Board of Directors are volunteers however….there is a number of office "staff".
- FFS - French Federation of Speleology: significant Government support to provide a staff of 5 & they own their premises.

Any room for improvement or changes?

- Are we growing?
- How do we represent ourselves to public, land managers etc…
- Large administration burden at both a National and State level
- Many admin tasks outstanding
- Lack of collaboration on projects, trips or management issues
- Significant amount of member fees goes to Insurance
- Large number of ways of doing things like data management, training, trip organisation

Other considerations

- Lack of volunteers to fill key positions
- Shortage of TIME to do things,
  (related to being volunteers & active with many things including personal lives...)
- Lack of $$ for key projects

Perhaps

The ASF could:

- Assist in providing standard documentation packages to clubs – leadership, training, trip organisation – anything else?
- Address the admin burden by seeking a paid position. Allowing members to focus on aims of organisation
- Gather EG documents & central database store – facilitate time saving & individual preparatory work

What about our organisational IDENTITY

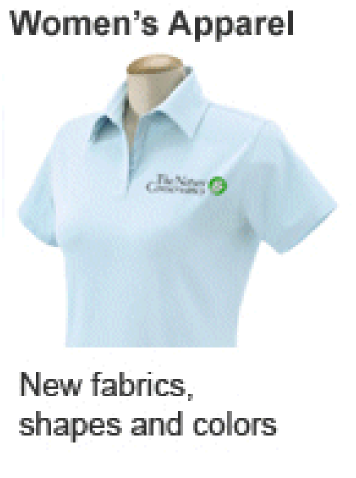
Think about this…..

- At a National Level – do other Organisations know who we are? What we do?
- At a State Level – what involvement does the ASF have? Some States have a speleological council.
- Do the State clubs get involved with local or State Environmental groups?
- Is the ASF involved with any collaboration or partnerships with national environmental organisations?
- Do our members ALL know who the ASF is and what we are and do??
- Is it a positive image?

SPECIFIC EXAMPLES from other Environmental Organisations

- A) The Nature Conservancy
- B) WWF – panda bear….
- C) United Nations Environment Programme
- D) The Wilderness Society

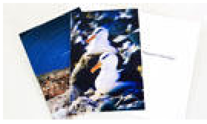
Their Ways → raise profile & fundraise



- The Nature Conservancy

GREETING CARDS

- WWF – World Wildlife Fund for Nature



Wildlife Works & the United Nations Environment Programme

UNEP Items

17 p4

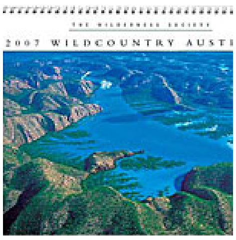
The ASF: some visions of the future ***Jay Anderson***

Image: Kangaroo-Lizard-Butterfly-Kangaroo Paw

Price: $31.00 *Plus shipping*
Plus surcharge for XXL t-shirts

Click the image to see a larger preview.

The Wilderness Society



Calendars
Diary
Online Shop

What other Cavers & Speleos have

NSS –

- Numerous t-shirts,
- stickers,

FFS -.

- Badges, Key rings
- Boxer shorts
- Tie-pins, Lighters
- Bags (small and big ones

Do we have any products that are used to <u>promote the ASF</u>?

1. Would you wear an ASF T-Shirt?
2. Do you think -ASF sticker → appropriate way to “get our name out there”?
3. Does the ASF need a special brochure on the organisation?
4. What does the ASF need to do to raise its profile in the community?

The ASF: some visions of the future *Jay Anderson*

Could this be on
an ASF T-Shirt?

Or Perhaps this could be on
an ASF T-Shirt?

Uniquely Australian
& cave related…...

Future

- Could the ASF benefit from a Funded position – ASF administrator ??
- Do we need to do Presentations to Govt agencies & local community organisations – who we are & what we do?
- Should we seek Funding - resources for displays, publications
- Is there a need for ASF related merchandise?
- Do members want any specific items with ASF logo on it………. ideas?
- Would you support a $ membership levy – extraordinary projects?

Any other suggestions??

Where to from here?

- Concerned or Interested? talk to me this week
- There may be opportunities for delegates → raise issue in Council General Business
- You →GO back to your club and seek further input on the role of the ASF.
- The executive will seek further feedback from members → in the future.

We need a DIRECTION and a PLAN for where we are going as an organisation.

WILL <u>YOU</u> BE involved??…………THANK YOU

The ASF's Karst Index Database – Under the Bonnet

Michael Lake

Abstract

The Australian Speleological Federation's Karst Index Database is a database of caves, maps, areas, organisations and people and is accessible on the Internet at http://www.caves.org.au. Updating has started in NSW by SUSS and in Victoria by VSA and to date there have been several hundred updates.

This paper will cover the technology that underlies the ASF's server and the KID, details on why we have two KIDs, the user and system documentation, installation and maintenance, inbuilt testing suites, source code management, backup and security. Future work will be suggested.

Introduction

The ASF's Karst Index Database (KID) contains information on 6600 caves and karst features, 2400 cave maps, 192 organisations, 1308 persons, references to 925 articles and covers 355 caving areas in Australia. Most of this information is accessible to anyone via a guest login.

Data on scientific items that may be in the caves, exact location information and some other information is restricted. For cavers or researchers that wish access to this information, a KID Access Group exists and application should be made to them. Details of this are on the ASF's web site.

The first read-only KID was written by a professional programmer engaged by the ASF in 2000 and went online in January 2001 as a read-only system. The programmer was contracted again over the period 2003 – 2005 to extend the functionality to include updating. The updating project took a long time to finish as the database itself together with the updating procedures required were quite complex. Because of this complexity the scope of the updating was reduced during the course of the contract to include updating of caves, areas, maps, organisations and people but not updating of articles.

Updating has started in NSW by SUSS and in Victoria by VSA and to date there have been several hundred updates.

The ASF KID Software Licence

The ASF's KID software is released under the GNU General Public License (GPL) [1]. One of the requirements of the ASF specification to the programmer was that the software used in the KID was open source and the KID code would be released under the GPL. This means that the ASF did not need to purchase any software or software licences and we can use other people's high quality, open source code in our KID. Because the KID software is released under the GPL it's also available for other speleological groups and individuals to use and hopefully contribute to it.

A number of overseas groups have already downloaded the software or expressed interest in our code: the Database Commission of the Portuguese Speleological Federation, the Swedish Speleological Federation and a Russian Speleological Society.

The data stored in the database of course remains the property of the ASF and contributing clubs and is not subject to the GPL.

Summary of the KID Functionality

The following is a brief summary of the functionality of the KID user interface.

Searching: Searching for caves, cave maps, other maps, information on cave areas, organisations, people and articles related to caves.

Updating: Updating of caves, maps, cave areas, organisations and people via a web based interface. Checking of these updates via a *peer-review* process by other updaters for that cave area is done to minimise mistakes. Only after the checking step has accepted the data does it become visible to others viewing the data.

The history of changes can be viewed showing what was changed by who and when. In addition to activity reports for each updating organisation per month. Note however that this is simple sum of the insertions, deletions and changes made per month so no great emphasis should be placed on the value.

Documentation: Tutorials to assist updaters in using the KID are available on the documentation page in PDF format. This format was chosen for the tutorial so that they could be printed and used in training.

An Administration Page: This includes a web-based interface for adding new updaters and setting their access levels. Access levels are quite fine grained: you can set the cave area, the individual cave fields they can read or write to, and the entities they can update such as caves, maps, areas, orgs or people.

The administration page also allows administrators to view any of the KID tables directly and view an audit trail of any update. From this page one can also view extensive and detailed documentation in HTML format of all the Perl modules that were developed or used in the KID.

The ASF Server

The KID runs on a virtual server which is running a Debian GNU/Linux distribution. A virtual server is an operating system hosted by a physical computer which runs multiple operating systems simultaneously. At the hosting provider the real, physical machine is running RedHat Enterprise Linux in a large data centre.

The ASF "owns" one of these virtual servers which is running our Debian Linux. Other organisations might own and run other virtual servers on the same physical machine. Each one is fully independent and appears as a separate server. Users or programs running under one virtual server cannot see or access the memory or files on another virtual server. We also have root access to our own virtual server which means that we have full control over our server; we can install any software we wish such as web servers and databases, add users and control access. The ASF uses a virtual server as this is much cheaper than a stand alone server.

Although we use a Debian Linux distribution, with minor changes to the installation procedure the KID will install and run under any other Linux distribution or UNIX system such as Apple's OSX.

The Web Server

The web server is the application that sends web pages from caves.org.au to a user's web browser and accepts web forms submitted by a user's browser. We are using the most popular web server in the world, Apache (http://www.apache.org). This versatile, high-performance web server is used by about 60 % of all web sites in the world [2]. It features a modular design and supports dynamic selection of extension modules at runtime. Some of its strong points are its security, range of possible customization, dynamic adjustment of the number of server processes, and a huge range of available modules including many authentication mechanisms, access control, caching and many more.

Whenever you attempt to access a web page in the KID, the Apache web server checks the KID database to see if you should have access to that page. If a username and password is required it will ask you for one. If you send an incorrect response or you shouldn't have access to that page, it will send back to you a short page telling you that the "server could not verify that you are authorized to access the document requested" and denying access. If your request for a page is accepted by the web server, it is passed to a programme (a Perl script) which will query the database, get the results back, format them into a nice web page and pass them back to the web server to be sent back to your browser.

The Programming Language

Next is the programming language. The KID uses Perl (http://www.perl.org) and it's these Perl programs that do most of the work. The Perl programs generate the web pages that are sent to the user when a user visits the KID website, take a users query and send it to the database and get the data back. They take that data and transform it into nicely formatted web pages and then hands the pages to the web server which then sends the page back to the user.

Perl is widely used for CGI scripts although the choice of this language more reflects the programmer's preference and what was mature and available in 2000 when the KID was first commissioned. Other programmers that tendered for the project would have used PHP, which was also widely used in 2000, or Java. Today Ruby or Python would be strong contenders. In hindsight Perl was an excellent choice; it has been very stable as it's a mature language, it runs fast, and we have been able to use the same language for the many command line scripts developed to support the KID. In contrast PHP has evolved considerably in the last several years and we would have had to do significant coding changes to keep up-to-date.

Thousands of small modules have been developed for Perl over many years and these can be used instead of writing your own routines (http://www.cpan.org). They are open source, well written and free. We are using modules that provide: authentication and authorization, reading config files and parsing command line arguments, interfaces for Perl to access databases, comma separated values manipulation routines, SQL parsing and processing, routines for processing CSV files, interfaces for RSA and MD5 encryption, parsing and extracting information from HTML documents, APIs to the client side of various protocols such as email, ftp etc., persistence for Perl data structures, template processing and routines to produce PDF.

One very useful Perl module that we are using is "Template Toolkit" (http://www.template-toolkit.org). This neatly separates the HTML code for the user interface from the Perl code of the business logic and makes for a cleaner and more easily maintained site.

The Perl programming language has in our case a close connection with the web server. Our version of Apache has been compiled with mod_perl which embeds a copy of the Perl language interpreter into the Apache Web server (http://perl.apache.org). This, together with intelligent caching, results in a considerable speed increase of the Perl scripts. It can produce anywhere from a 400 % to 2000 % speed increase on sites using Perl scripts, and is used on many large script-based web sites like http://slashdot.org.

We are not using any web application development frameworks. These are very popular today, particularly the Model-View-Controller approach. Examples include Ruby-on-Rails, Turbogears for Python, Catalyst for Perl and several others. At the time the KID was started these either didn't exist or were just being developed. They can certainly speed up development and provide an excellent separation of the database, the HTML presentation layer and the business logic of the application. If the KID were being started today we would consider using such frameworks.

The Database

At the lowest level of the KID is the database that stores the data on the caves, maps, organisations, people and cave areas. The database the KID uses is MySQL (http://www.mysql.com). MySQL is a fast, lightweight and full-featured database which is also reasonably easy to administer. This database also stores the user access privileges of the users such as the guest user and the updaters from various clubs. There are over 500 fields structured into 74 tables. Most of these are the same as the draft table schemas and database fields published by the Informatics Commission of the International Union of Speleology [3].

Two KIDs

There are actually two Karst Index Databases; a production one and another one used for testing and development. They have separate code bases and backend databases. The KID accessed at http://www.caves.org.au/kid uses the production code and the production database and is the one used by guests using the ASF KID and by updaters updating the KID. The KID at http://www.caves.org.au:8080/kid uses the development code base and a development database (the :8080 means Apache is serving the pages from port 8080 instead of the default port 80). It is used by programmers for testing code changes on the database. If a coding mistake is made in development of new features it will not affect the production server. It is also used by updaters as a "play" database where they can familiarise themselves with the updating system without worrying about making incorrect changes to the production database. Guests can also access the test KID.

At some point in time a decision is made to release the development version to production. This is usually when sufficient changes have been made to the development KID and it is deemed stable and there are no known bugs. When this occurs the current production system is moved away and the development system is put in its place. The system is given a quick final test and the web server is restarted. During this brief time the web site may be down for a few seconds.

You can find the software version listed on the Help page. The software version of the production KID is always an even number, e.g. version 1.32, and the version of the development KID is always an odd number, e.g. 1.33.

User Documentation

On the documentation page at http://www.caves.org.au/kid/doc are two sections: "Documents for Updaters" and "ASF KID Specifications".

The "Documents for Updaters" section consists of a general introduction and a series of tutorials on how to update people, caves, add new areas and organisations and a description of access control. These are in PDF format so they can be printed out and referred to easily. The PDF documents are written using LaTeX – a high level typesetting language which is designed for the production of high quality technical documents [4,5]. A LaTeX document is written in plain text with markup that describes bold face, italics, tables, lists etc. This plain text is then compiled into PDF output. LaTeX is very nice to use; it is mature and produces output of the the highest typographic quality.

The "ASF KID Specifications" section contains complete documentation in HTML format for all the database fields used in the KID and the database table schemas. These HTML pages are produced on-the-fly from the KID database itself. The advantage of this is if the database is changed, this part of the documentation is automatically updated. These fields and their definitions are based on the field definitions defined by the Informatics Commission of the International Union of Speleology, of which the ASF is a member.

System Documentation

Detailed installation and maintenance documentation is available in HTML format on the software page at http://www.caves.org.au/kid/docs/software. This describes how to install the KID, how to make updates and releases and general maintenance of the system.

For every Perl module that the programmer has written the object classes and methods are documented in the module code itself. The system has scripts which generate HTML formatted documentation from the module documentation in a standard format for all modules. Other third party Perl modules which we have used also have their HTML documentation in the same format on that page.

Inbuilt Regression Testing

The KID also has some inbuilt regression tests available to test that code changes have not broken the system. Before a code change the output pages of several searches can be saved. After code changes the search pages afterwards are compared to the ones before. If changes to the search pages are not expected the test suite should report that the files match.

Regression testing is also used to check the CSV (comma separated variable) upload functionality which allows a user to upload bulk cave updates. This is essential for testing the bulk uploading as there are many errors that can occur in a bulk file generated or edited outside of the KID system. For instance in a CSV upload a record in the file may have unbalanced quotes, a field may be missing or an extra field may have been inserted. For each possible error that could occur is a test file with that error. During the test validation each of these files is loaded and the test suite should flag an error.

Source Code Management

All the KID software is managed by a SCM (Source Code Management) system. We are using Subversion (http://subversion.tigris.org) which is rapidly becoming the most widely used SCM in the open-source world. It is a "work-alike" replacement for the older SCM system called CVS.

A SCM system allows provides several benefits; it allows many developers to work collaboratively on the same code, tracks which changes have been made by which developers, tracks history of changes and it allows one to revert to any previous version. For instance, I can work on the KID code on my laptop whilst on the train for a few days and later connect to the ASF server and commit my changes to the test KID.

Backups

Backups of the data and the KID software are critical in case there is a hardware problem with our server. I have setup a backup script that runs automatically as a cron job at about 4 am Sydney time each week. This sends a copy of the current data and software to a site in the United States (kindly provided by the Informatics Commission of the IUS). Also included with the software and data is documentation to assist a System Administrator in a recovery procedure.

The following is done each time the backup script runs:

1. Backup files more than 6 months old are removed so the server will not fill up.
2. The current KID software is copied to a backup directory if no current backup file exists.
3. The latest installation guides and disaster recovery documents are also copied to the backup directory.
4. The Update Home Page is replaced with a temporary page preventing new updates and checkouts. The script needs to stop and restart the web server as the Update Home Page will be cached in memory. This may result in the ASF Web site being "down" for a few seconds.
5. A dump of the entire database is performed, compressed and placed in the backup directory.
6. The Update Home Page is restored.
7. Logs of the above operations are written to the backup directory.
8. A checksum is generated for the backup files.
9. The script then securely copies all these backup files to the remote servers.
10. Finally an email is sent to the KID System Administrator to indicate if the backup was successful or not.

An example of the email that the KID System Administrator receives is below.

> Subject: ASF KID Backup successful
> From: kid@www.caves.org.au
> To: mikel@speleonics.com.au
> Date: 1 Jan 2007 04:00:44 +1100
>
> Hi
>
> The KID backup script at caves.org.au successfully made a backup of database kid on 2007.01.01. There is a checksum asf-kid-data-v1.32-2007.01.01.cksum with the data file that can be used to check that data transfer was successful.
>
> Admin, caves.org.au

Security

There are two main security concerns for the ASF server. First the KID contains some sensitive information such as records of aboriginal remains in some caves or, in the future, exact location information. We would not like this information to be stolen. Secondly is that we don't wish the server to be compromised and a trojan installed or an extra login account created. Such trojaned servers are referred to by crackers as being "0wned". They can be used to mount subsequent attacks against other servers such as government or military sites.

Security was considered by the web programmer during the coding stages and a number of measures taken in the KID code. For instance, all user input into the KID is filtered to guard against SQL injection attacks. Additionally the following policies are adhered to on the ASF server:

- Minimal services are run on the ASF Server.
- The server is kept up-to-date with security patches.
- Intrusion detection systems are used. These compute multiple checksums for important files on a system.

- All login access is via secure shell version two and the use of public/private keys.

Future Directions

Generate Information for use on PDAs

Already work has started to generate summary information for all caves in an area for use on PDAs by updaters. The idea is that an updater could request the KID to generate summary information, similar to the simple and standard search format, but for all caves in an area and not just a small range of caves. This data would be zipped into a single file which the updater could download and transfer to their PDA. There would be no logo or large headings as the format would be designed to be used on the small screens of PDAs. Such information would be useful in the field, particularly if exact location information was included.

Karst Index Books in PDF Format

The last hard copy version of the KID was the "Australian Karst Index 1985" [6]. The cost of publishing today would preclude such a publication, however, one could produce of PDF book of karst features for a State. They would be similar in format and layout for each State, thus forming a collectable series, and could be produced every six months.

Internationalisation

The software currently uses the English language. Future versions of the software should be internationalised so that it can be easily adapted by other countries. The KID already has excellent separation of the Perl code from the HTML markup so redesigning the user interface for other speleo groups is not too difficult. However there are areas of code such as error messages which will present some problems, especially for countries that use non Latin character sets.

The Next Generation KID

Software ages fast and the KID is no exception. There are already technologies that would be useful in the KID such as AJAX (Asynchronous Javascript and XML) and it's likely that we will wish to add some GIS capabilities and connectivity to other databases in the near future. Also as updaters from more clubs use the KID they will develop ideas on how the software and the updating process could be improved. New ideas can't be implemented as soon as users would like as we have limited funds and volunteer time, however we should certainly think about how and in what direction the KID will evolve – or what we will replace it with.

References

[1] GNU General Public Licence, http://www.gnu.org/licenses/licenses.html

[2] Netcraft, http://news.netcraft.com

[3] Informatics Commission of the International Union of Speleology, http://www.uisic.uis-speleo.org

[4] LaTeX Project Site, http://www.latex-project.org

[5] LaTeX Wikipedia entry, http://en.wikipedia.org/wiki/LaTeX

[6] Australian Speleological Federation Inc., "Australian Karst Index 1985", Edited by Peter G. Matthews ISBN 0 9588857 0 2

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ASF's Karst Index Database

— Under the Bonnet —

Michael Lake

26th Biennial ASF Conference
January 2007, Mt. Gambier SA

Outline

This paper will cover the technology that underlies the ASF's server and the KID, details on why we have two KIDs, the documentation, development and testing, backup and security. Future work will be suggested.

The ASF KID

The ASF's KID contains information on 6600 caves and karst features, 2400 cave maps, 192 organisations, 1308 persons, references to 925 articles and covers 355 caving areas in Australia. It is accessible at http://www.caves.org.au

The KID was written by a professional programmer engaged by the ASF in 2000. It went online in January 2001 as a read-only system. The programmer was contracted again over the period 2003 – 2005 to add updating ability.

Updating has started in NSW by SUSS and in Victoria by VSA.

The Software Licence

The ASF's KID software is released under the GNU General Public License (GPL).

A number of overseas groups have already downloaded the software or expressed interest in our code; the Database Commission of the Portuguese Speleological Federation, the Swedish Speleological Federation and a Russian Speleological Society.

The data stored in the database of course remains the property of the ASF and contributing clubs and is not subject to the GPL.

Examples of the KID

Saved web pages of KID Interface:

- Searches
- Updating
- Documentation
- Administration

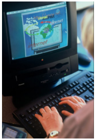
The ASF Server

The ASF Server is a virtual server running Debian GNU/Linux.

A virtual server is an operating system hosted by a physical computer which runs multiple operating systems simultaneously. At the hosting provider the real, physical machine is running RedHat Enterprise Linux in a large data centre.

How Web pages are Delivered

A simple static web page request e.g.
http://www.caves.org.au/calendar.htm



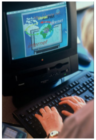
Apache Web Server

Web Pages on Disk
`calendar.htm`

User requests a web page, web server looks for the page.

How Web pages are Delivered

A simple static web page request e.g.
http://www.caves.org.au/calendar.htm



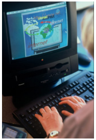
Apache Web Server

Web Pages on Disk
`calendar.htm`

Web server reads the web page & sents it back to the user.

How Web pages are Delivered

A request for a dynamic page e.g.
http://www.caves.org.au/kid/search/top10



Apache Web Server

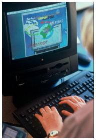
Perl Programs e.g. `top10`

MySQL Database

User requests a web page ...

How Web pages are Delivered

A request for a dynamic page e.g.
http://www.caves.org.au/kid/search/top10



Apache Web Server

Perl Programs e.g. `top10`

MySQL Database

Web pages are sent back to user . . .

The Web Server

We are using the most popular server in the world, Apache (http://www.apache.org). This versatile, high-performance web server is used by about 63% of all web sites in the world.

It features a modular design and supports dynamic selection of extension modules at runtime. Some of its strong points are its security, range of possible customization, dynamic adjustment of the number of server processes, and a huge range of available modules including many authentication mechanisms, access control, caching and many more.

The Perl Programs

The KID uses Perl (http://www.perl.org) and it's these perl programs that do most of the work.

Perl programs generate the web pages that are sent to the user when a user visits the KID website, takes a users query and sends it to the database, gets back lots of data and turns it into nicely formatted web pages and then hands the pages to the web server to send back to the user.

The choice of this language reflects the programmers preference and what was mature and available in 2000 when the KID was first commissioned. Alternatives might have been PHP or Java. Today Ruby or Python would be strong contenders.

Perl Modules

Perl has thousands of small modules that can be used instead of writing your own routines. They are open source, well written and free. We are using modules that provide:

- Authentication and authorization
- Reading config files and parsing command line arguments
- Interfaces for Perl to access databases
- Comma separated values manipulation routines
- SQL parsing and processing
- Routines for processing CSV files
- Interfaces for RSA and MD5 encryption
- Parsing and extracting information from HTML documents
- APIs to the client side of various protocols i.e. email, ftp etc
- Persistence for Perl data structures
- Template processing
- Routines to produce PDF

among others.

Perl Modules

All of those Perl modules are released under an open source licence so we can use them in the KID at no charge. Thanks to the following authors of those modules:

- Abhijit Menon-Sen
- Andy Lester
- Tim Bunce
- Jochen Wiedmann
- Jeff Zucker
- Gisle Aas
- Steve Peters
- Rick Welykochy

and many more.

Important Perl & Apache Modules

To provide separation of the business logic from the user interface we are using a Perl module called Template Toolkit (http://www.template-toolkit.org). This neatly separates the HTML code from the Perl code, making it easier to program, and makes for a cleaner and more easily maintained site.

The other important module we are using is an Apache module `mod_perl`. This integrates Perl into the Apache web server! It can produce anywhere from a 400% to 2000% speed increase on sites using perl scripts, and is used on many large script-based web sites like http://slashdot.org.

The Database

The database used is MySQL (http://www.mysql.com). This is a fast, lightweight and full-featured database which is also reasonably easy to administer.

The database stores the data on the caves, maps, organisations, people and cave areas in tables.

Also stores the user access privileges of the users such as the guest user and the updaters from various clubs.

There are over 500 fields structured into 74 tables. Most of these are the same as the draft database fields and tables published by the Informatics Commission of the IUS.

The Database

```
$ mysql -e "desc PE0000" kid
+---------------------------+-------------+------+-----+---------+-------+
| Field                     | Type        | Null | Key | Default | Extra |
+---------------------------+-------------+------+-----+---------+-------+
| person_id                 | varchar(10) | NO   | PRI |         |       |
| surname                   | varchar(30) | YES  |     | NULL    |       |
| usual_first_name          | varchar(20) | YES  |     | NULL    |       |
| middle_initial            | varchar(5)  | YES  |     | NULL    |       |
| initials_for_given_names  | varchar(10) | YES  |     | NULL    |       |
| title                     | varchar(20) | YES  |     | NULL    |       |
| address_line_1            | varchar(50) | YES  |     | NULL    |       |
| address_line_2            | varchar(50) | YES  |     | NULL    |       |
| address_line_3            | varchar(50) | YES  |     | NULL    |       |
| address_line_4            | varchar(50) | YES  |     | NULL    |       |
| city_or_suburb            | varchar(25) | YES  |     | NULL    |       |
| state_code                | char(2)     | YES  |     | NULL    |       |
| postcode                  | varchar(12) | YES  |     | NULL    |       |
| country_name              | varchar(25) | YES  |     | NULL    |       |
| country_code              | char(2)     | YES  |     | NULL    |       |
| email_address             | varchar(30) | YES  |     | NULL    |       |
| phone_numbers_prefix      | varchar(15) | YES  |     | NULL    |       |
| home_phone_number         | varchar(18) | YES  |     | NULL    |       |
| work_phone_number         | varchar(18) | YES  |     | NULL    |       |
| mobile_phone_number       | varchar(18) | YES  |     | NULL    |       |
| fax_phone_number          | varchar(18) | YES  |     | NULL    |       |
| pager_phone_user_number   | varchar(20) | YES  |     | NULL    |       |
| organisation_code_1       | char(3)     | YES  |     | NULL    |       |
| organisation_code_2       | char(3)     | YES  |     | NULL    |       |
| organisation_code_3       | char(3)     | YES  |     | NULL    |       |
+---------------------------+-------------+------+-----+---------+-------+
25 rows in set (0.00 sec)
```

Two KIDs

There are two Karst Index Databases;

Production: http://www.caves.org.au/kid
Development: http://www.caves.org.au:8080/kid

They have separate code bases and backend databases.

The development one is used by myself for new code development and testing and by updaters as a “play area” for practice in updating.

We try not to break the production one.

Documents for Updaters

The documentation page is at http://www.caves.org.au/kid/doc
There are two sections: “Documents for Updaters” and “ASF KID Specifications”.

Documents for Updaters consists of a general introduction and a series of tutorials on how to update caves, people, areas and organisations. These are in PDF format so they can be printed out and referred to easily.

The PDF documents are written using LaTeX – a high level typesetting language which is designed for the production of high quality, technical documents.

ASF KID Specifications

The ASF KID Specifications section is the complete documentation in HTML format for all the database fields used in the KID and the database table schemas.

These HTML pages are produced on-the-fly from the KID database itself. The advantage of this is if the database is changed, this part of the documentation is automatically updated.

These fields and their definitions are based on the field definitions defined by the Informatics Commission of the International Union of Speleology, of which the ASF is a member.

Example: Cave and Karst Definitions

System Documentation

Detailed installation and maintenance documentation is available in HTML format on the software page at http://www.caves.org.au/kid/docs/software. This describes how to install the KID, how to maintain a KID installation, and how to make updates and releases.

For every Perl module that the programmer has written the object classes and methods are documented in the module code itself. The system has scripts which generate HTML formatted documentation from the module documentation in a standard format for all modules. Other third party Perl modules which we have used also have their HTML documentation in the same format on that page.

Source Code Management System

All KID software is managed by a Source Code Management system: Subversion http://subversion.tigris.org

A SCM system allows allows many developers to work collaboratively on the same code, tracks the history of changes including which changes have been made by which developers and allows one to revert to any previous version.

I can work on the KID code on my laptop whilst on the train and later connect to the ASF server and commit my changes. The SCM system knows exactly what files I have changed and where.

Inbuilt Regression Testing

The KID also has some inbuilt regression tests available to test that code changes have not broken the system.

Before a code change the output pages of several searches can be saved. After code changes the search pages afterwards are compared to the ones before. If changes to the search pages are not expected the test suite should report that the files match.

Inbuilt Regression Testing

The CSV (comma separated variable) upload functionality allows a user to upload bulk cave updates.

There are many errors that could occur in a bulk file generated or edited outside of the KID system. For instance in a CSV upload from a spreadsheet a record in the file may have unbalanced quotes, a field may be missing or an extra field may have been inserted.

For each possible error that could occur is a test file with that error deliberately inserted. During the test each of these test files is loaded and the test suite should flag an error.

Backups

Regular backups of the data and the KID software are critical!

A backup script runs automatically as a cron job at about 4 am Sydney time each week. This sends a copy of the current software and data to a site in the US (kindly provided by the Informatics Commission of the IUS).

Also included with the software and data is documentation to assist a System Administrator in a recovery procedure.

Backups

The following is done each time the backup script runs:

1. The current KID software is copied to a backup directory.
2. A dump of the entire database is performed, the data is compressed and placed in the backup directory.
3. Logs of the above operations are written to the backup directory.
4. A checksum is generated for the backup files.
5. All these backup files are copied to remote servers.
6. An email is sent to the KID System Administrator to indicate if the backup was successful or not.

Backups

```
Subject: ASF KID Backup Successfull
From: kid@www.caves.org.au
To: mikel@speleonics.com.au
Date: 1 Jan 2007 04:00:44 +1100

Hi

The KID backup script /home/kid/bin/backup_asfkid at
caves.org.au successfully made a backup of database
kid on 2007.01.01.  There is a checksum
asf-kid-data-v1.32-2007.01.01.cksum with the data file
that can be used to check that data transfer was
successful.

Admin, caves.org.au
```

Security

Two main security concerns for the ASF server:

- The KID contains sensitive information such as records of aboriginal remains in caves or, in the future, exact location information.
- We don't want the server to be compromised and a trojan installed or an extra login account created. Such trojaned servers are referred to by crackers as being '0wned'. They can be used to mount subsequent attacks against other servers such as government or military sites.

Security

Security was considered by the web programmer during the coding stages and a number of measures taken in the KID code. For instance, all user input into the KID is filtered to guard against SQL injection attacks.

Additionally the following policies are adhered to:

- Minimal services are run on the ASF Server.
- The server is kept up-to-date with security patches.
- Intrusion detection systems are used. These compute multiple checksums for important files on a system.
- All login access is via secure shell version 2 and the use of public/private keys.

Future Work

- Generate summary information for all caves in an area for use on PDAs by updaters
- Production of State-based Karst Index Books in PDF format
- Internationalisation
- The Next Generation KID

References

- ASF "Australian Karst Index 1985", Edited by Peter G. Matthews ISBN 0 9588857 0 2
- The ASF Karst Index Database http://www.caves.org.au
- GNU General Public Licence http://www.gnu.org/licenses/licenses.html
- Informatics Commission of the Union International de Spéléologie http://www.uisic.uis-speleo.org
- LaTeX Project Site http://www.latex-project.org

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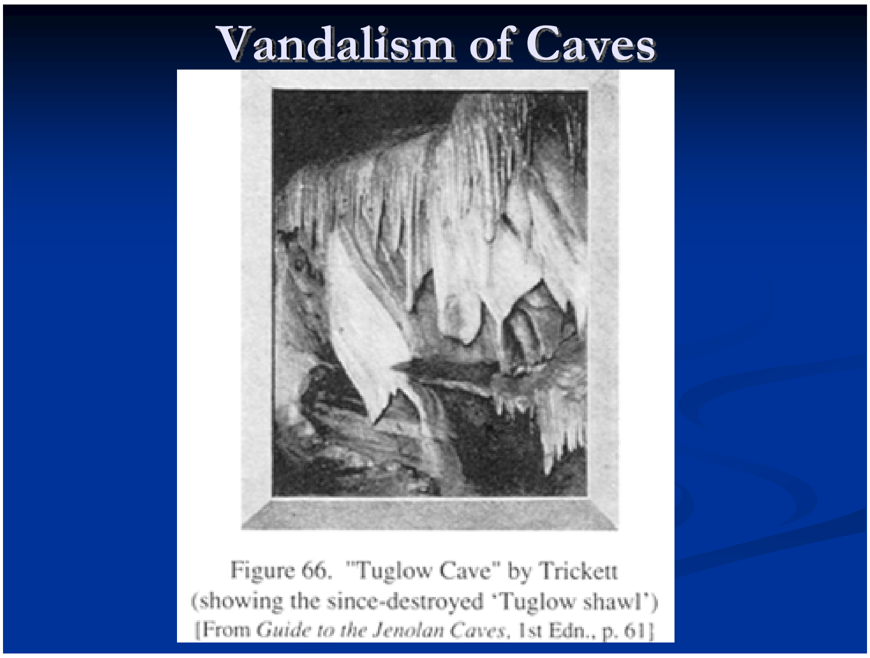
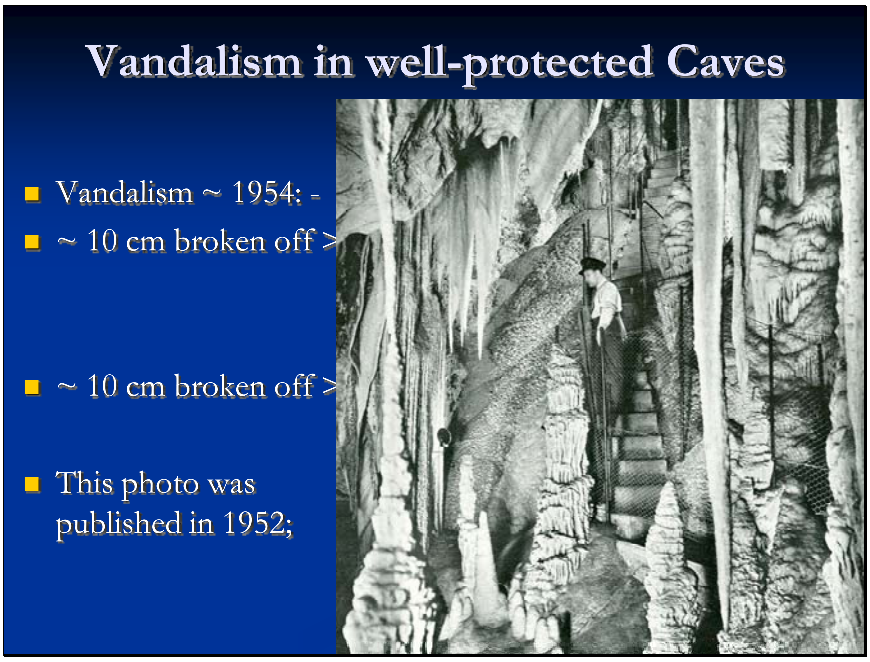
Non-Entry Inspections to Conserve Tourist Caves

Warren Peck

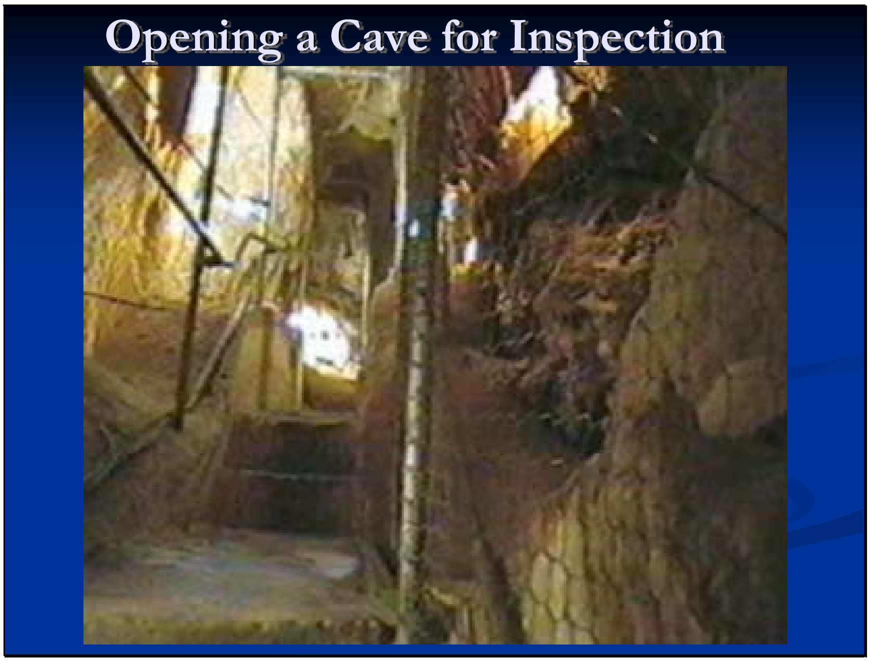
There are sections of Australian operating metal mines where human access is not permitted, yet mining continues using remote-controlled machinery overseen by remote-sensing techniques from a nearby tunnel or alcove in the mine. If applied to tourist caves, these techniques would permit visitors to experience the full ambience of a delicately-ornamented cave without actually entering it. Whilst this concept is particularly applicable to previously undeveloped caves, thus avoiding the wholesale cave damage involved in the construction of paths and installation of lights, it is also applicable in caves already open to the public eg. a vandal-prone section of a tourist cave.

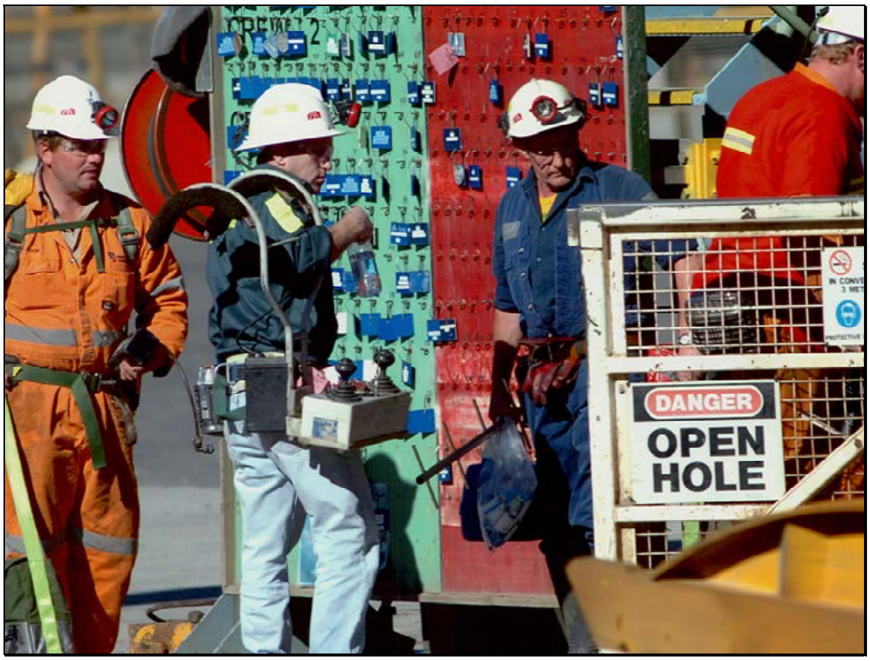

Vandalism of Caves
Figure 66. "Tuglow Cave" by Trickett
(showing the since-destroyed 'Tuglow shawl')
[From Guide to the Jenolan Caves, 1st Edn., p. 61]

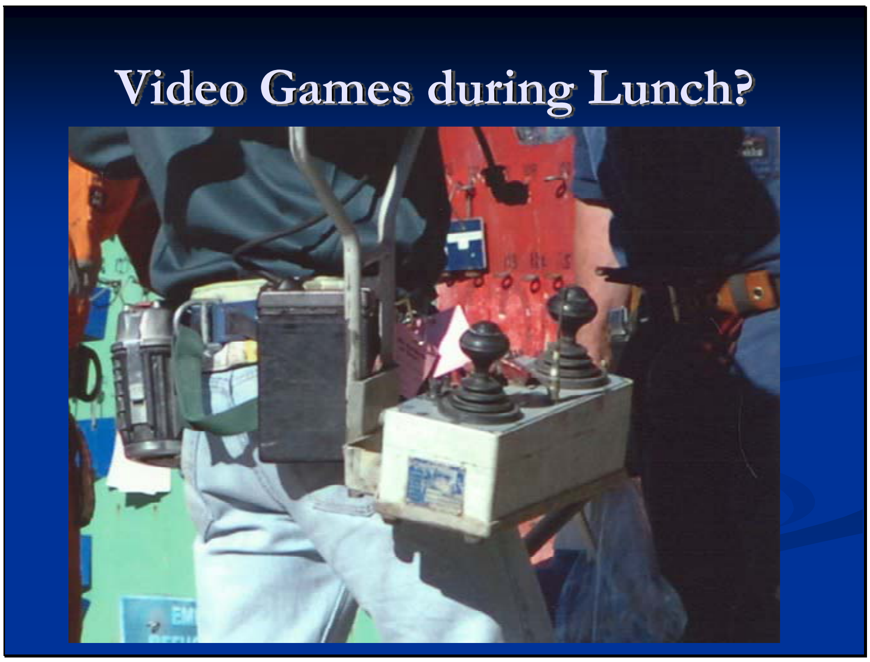

Vandalism in well-protected Caves
Vandalism ~ 1954: -
~ 10 cm broken off >
~ 10 cm broken off >
This photo was published in 1952;

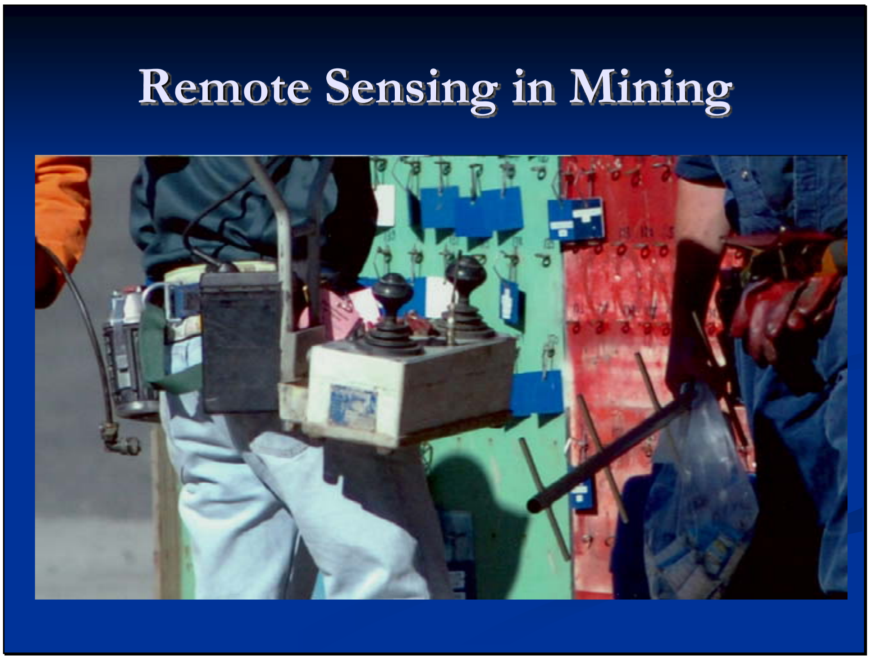

Destroyed after 80 yrs of Tours
1905
1952

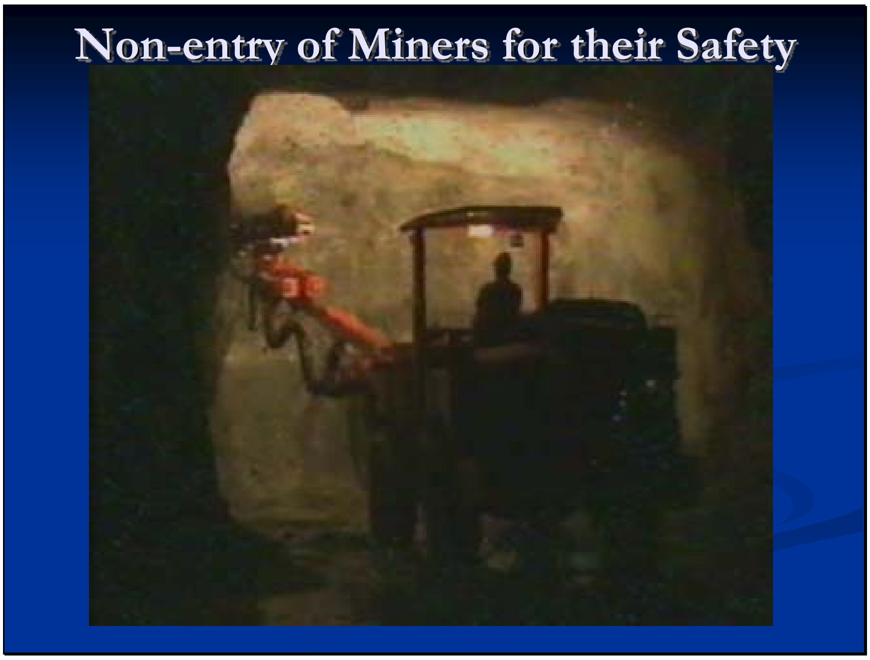
19 p2

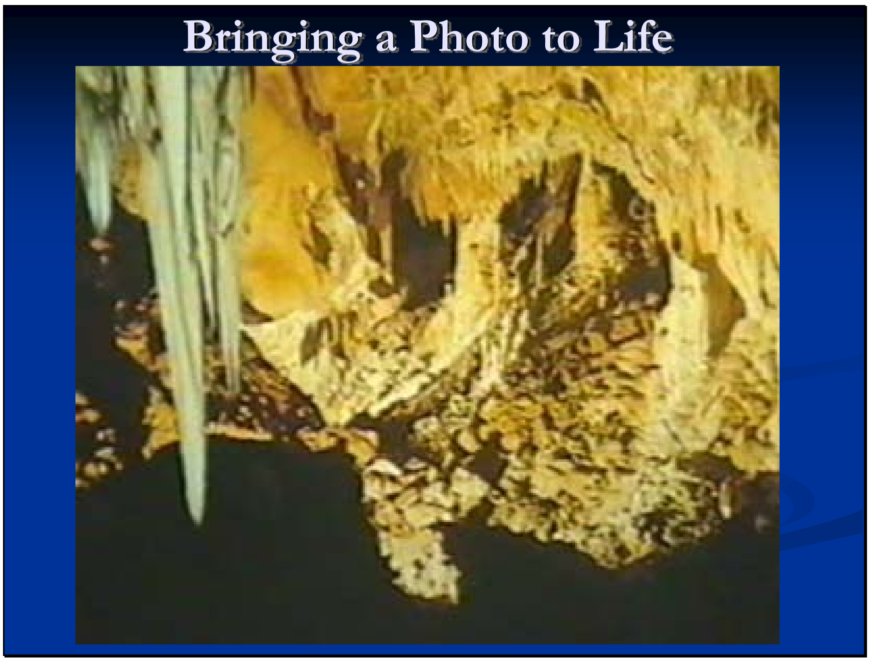

Opening a Cave for Inspection


DANGER
OPEN
HOLE


Video Games during Lunch?


Remote Sensing in Mining


Non-entry of Miners for their Safety


Bringing a Photo to Life

Even amateur Video has Ambience

The Concept – Non-entry of the General Public into easily damaged caverns; no new caves opened

How could it be done?

- Make a movie in a few days (compact digital camera with 12 volt halogen lamps powered by rechargeable batteries and at least one speleo / ranger / presenter in-frame for scale) ; or
- Closed circuit TV (hard to justify the expense).

Where does the General Public View it?

- In a nearby cave or arch with plenty of space,
- or in a theatrette (suits visitors with disabilities)
- or sell copies for home viewing.

The Exploration Component of a Cave Management Plan

Patricia E. Seiser, <u>Ross Anderson</u> & Jay Anderson

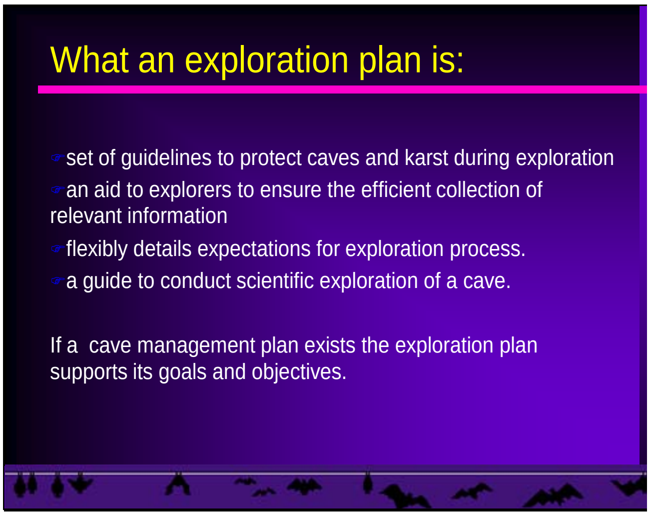
Exploration activities are often overlooked in the development of management plans for caves, yet exploration can have a significant impact on a cave's environ. In addition, knowledge derived from exploration is a key component in the conservation and protection of caves. Few cave management plans can be considered complete without addressing cave exploration activities. Exploration management plans are not plans for how an expedition is to be run, rather they address policies and procedures for both in-cave and surface activities associated with exploration. Exploration management plans must address competency requirements of participants, ranging from necessary caving skills to required skill levels for surveying and inventory activities. Plans need to address a variety of activities including: survey procedures, the establishment of trails, and photo documentation. In addition to in-cave activities, plans must address surface activities including data management and cartography. It is important that all plans are region appropriate. Exploration can be a powerful tool in the conservation and protection caves, but only as long as it is conducted in a manner that conserves the cave and provides data and results to support conservation/protection efforts.

Slide 1

Introduce Self:

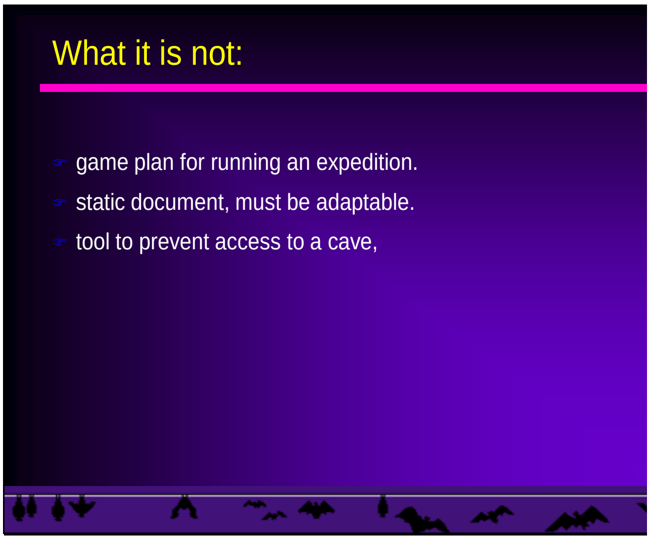
- Most caving has been surveying.

Slide 2



- Quick overview of what will be covered.
- Many ideas may be "controversial". Many of these things have evolved over time.
- The idea is to point out need for changes and to provide food for thought.

Slide 3



RPP

- Oh and then someone else can survey what we found.
- accuracy isn't that important.
- sketching to scale isn't that important.

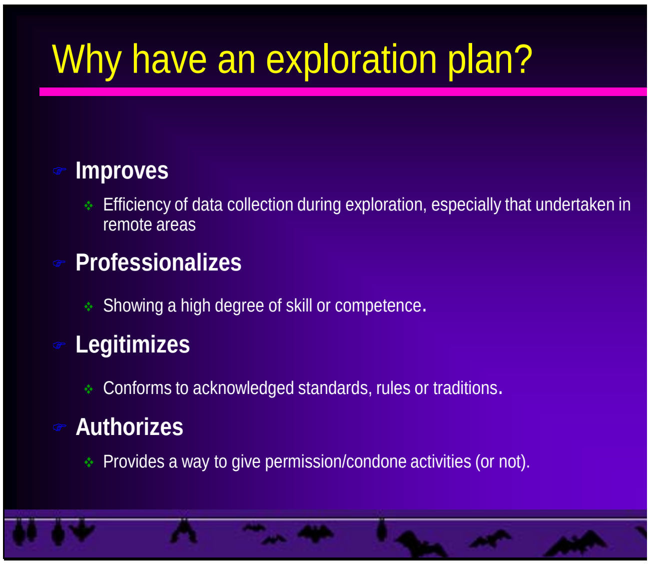
SAYG

- Survey accuracy and sketch quality has become very important.
- Quality of survey has become a standard throughout much of the caving community, particularly in projects.

DNE

- evolving survey practices, heightened awareness among the average caver.

Slide 4



- Survey once viewed as a pretty basic activity -- just set a few stations and sketch the passage. How much thought is required - especially for station setters and instrument readers?
- But….survey activities can impact the cave, both during the survey and in the future.
- Responsible survey practices can lead to greater protection to the cave.
- Survey techniques to be discussed, after running through a few basic definitions.

Slide 5

An exploration plan…

- addresses surface and subsurface exploration.
- details activities to occur during the exploration process and follow-up activities.
- addresses access policies related to exploration.

- A quick review of these definitions.

Slide 6

Putting together a exploration plan

Skill sets for exploration

Required caving skills:

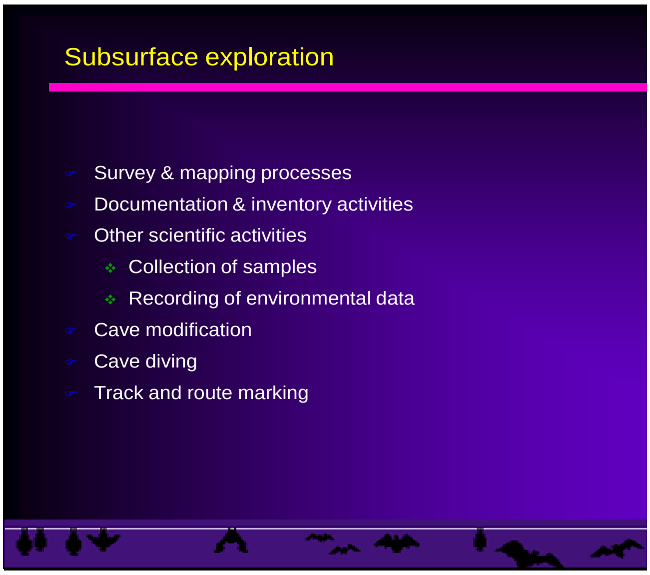
- basic horizontal skills
- vertical skills
- survey/sketching experience
- documentation skills
- minimal impact caving, track/ route marking techniques
- navigation skills

- First of all let's be honest:
- We all go into caves, so we ALL impact them!

Slide 7

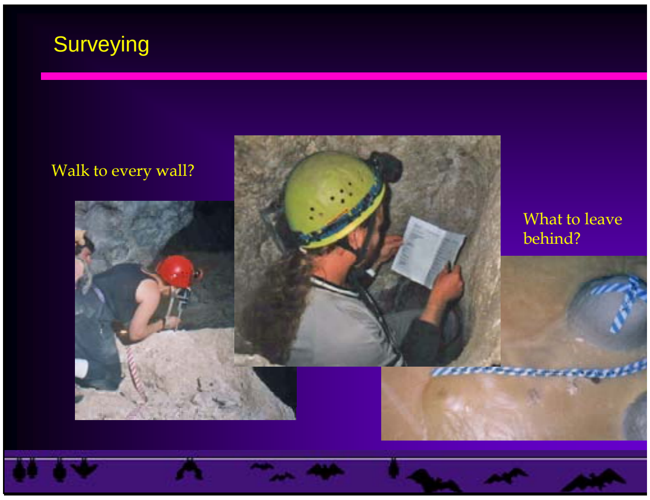
Are they Competent?

Slide 8

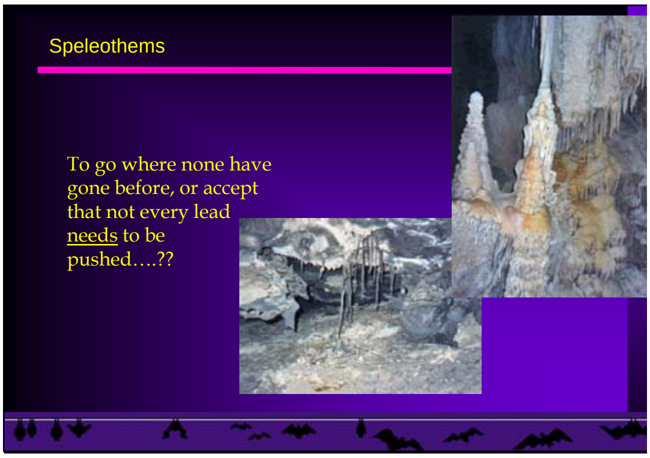


Impact is….

Slide 9



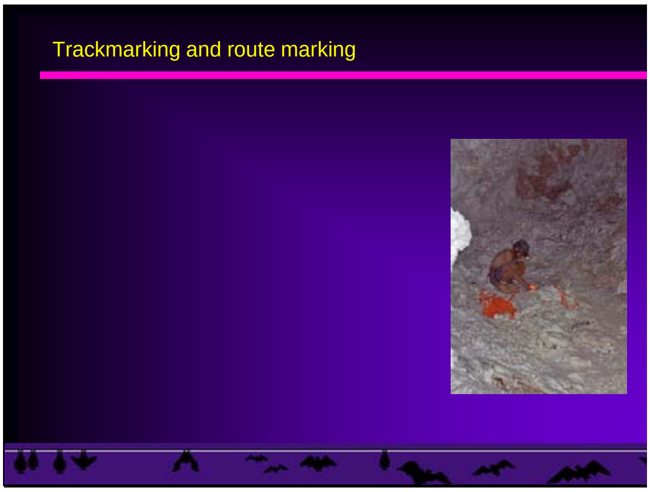
Slide 10



Slide 11

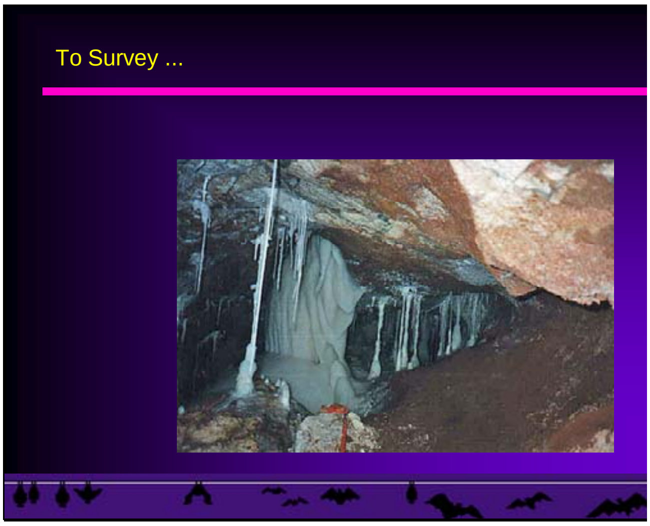
Slide 12

Slide 13



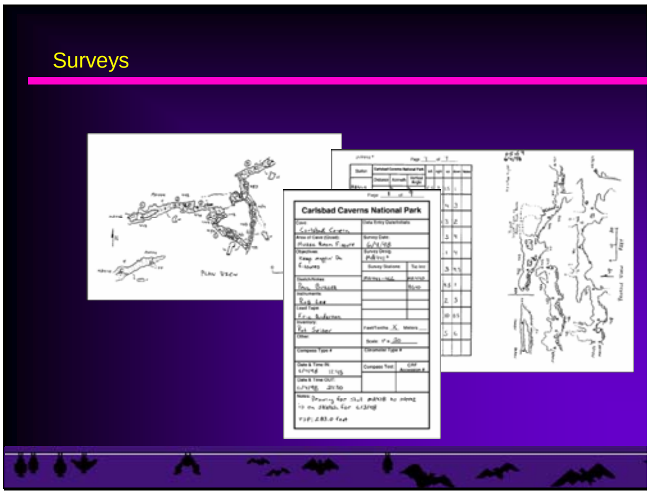
Slide 14

Slide 15



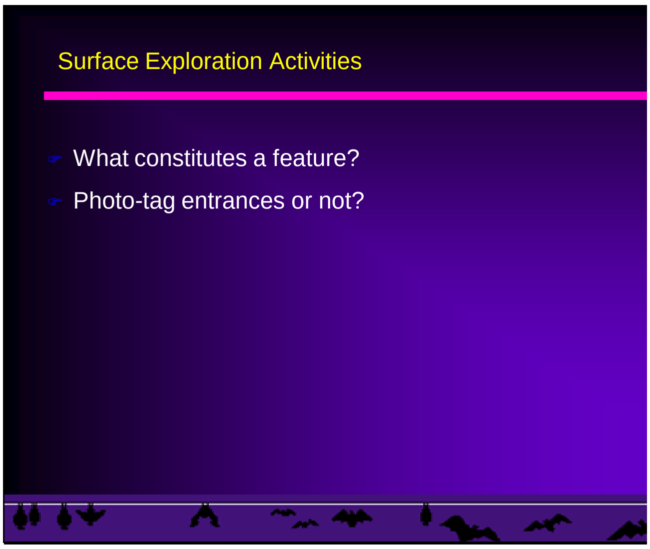
Slide 16

Slide 17



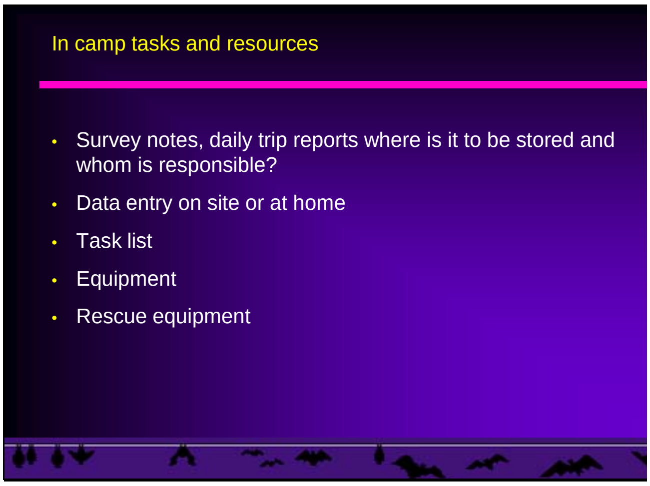
Slide 18

Slide 19

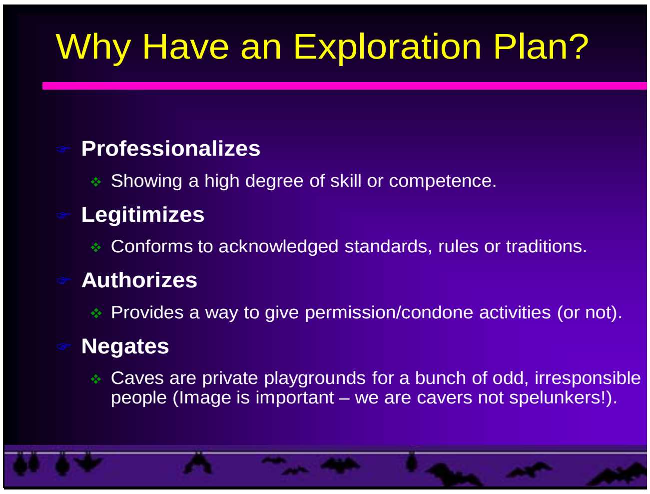


- Preservation is…
- Ideal cave preservation is to close off a cave, never enter it (but this rarely if ever is going to happen!)

Slide 20



Slide 21



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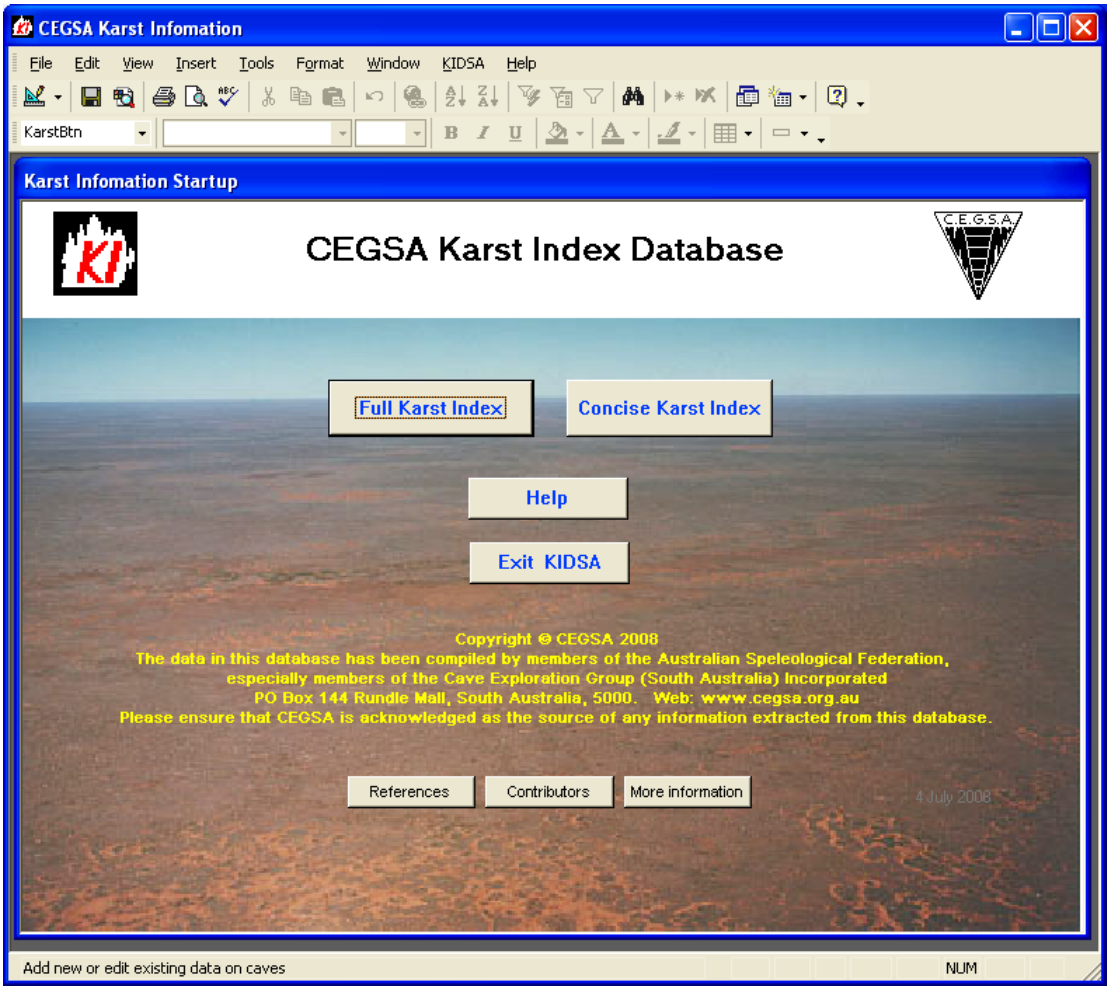
- Responsible survey practices can lead to greater protection to the cave.
- Survey techniques to be discussed, after running through a few basic definitions.

Slide 22

Summary of the Karst Index Database (KIDSA) of the Cave Exploration Group (South Australia)

Graham Pilkington

The ASF has a Karst Index Database (the KID) that is designed to be online and available to everyone – so why did CEGSA create its own version?

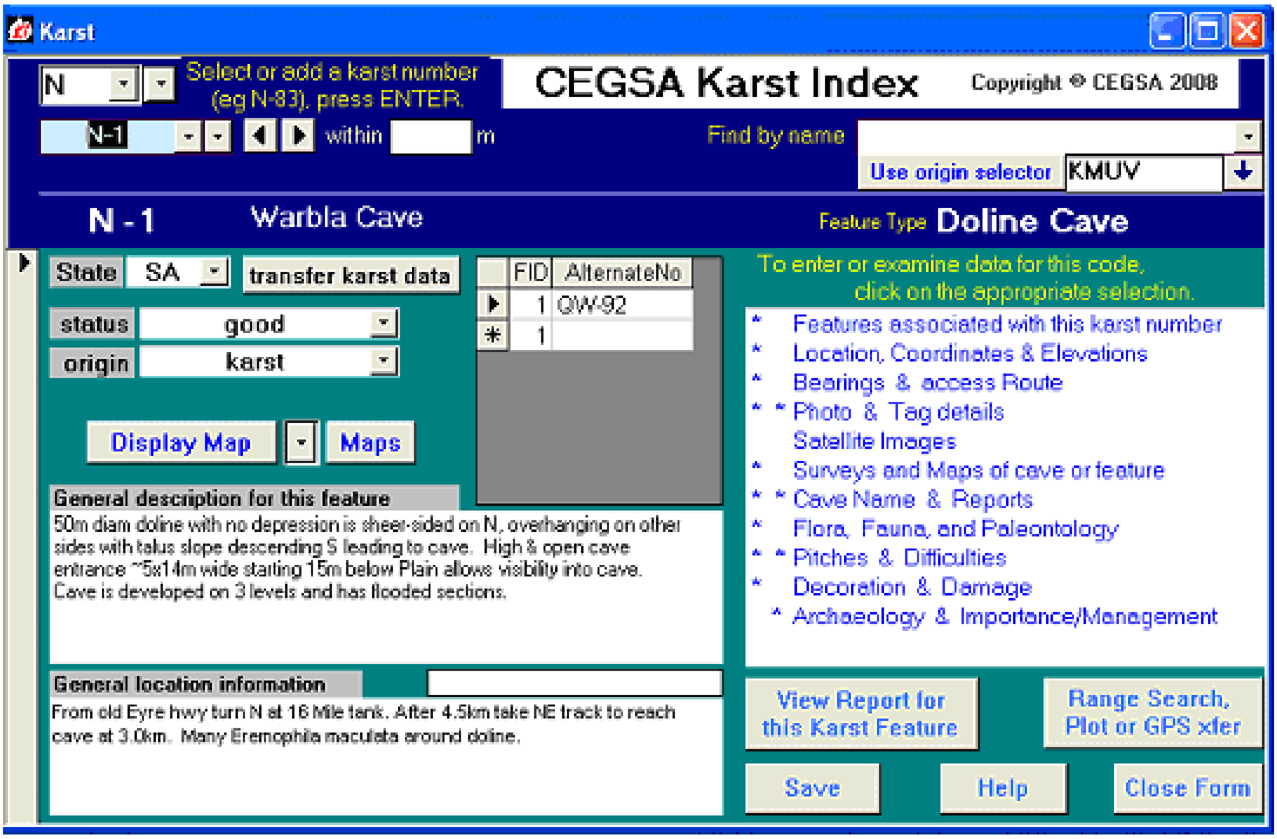


Because KIDSA:

- Was initiated before there was an electronic ASF KID. The karst feature documentation handled by CEGSA had become too large to handle manually. Storing data away was not the problem – it was making use of it. There was also the problem of making backup copies – this is much cheaper, easier, and quicker to do in electronic format. Also, electronic copies can be distributed and used in research without having to read each piece of paper.
- Matches the way that CEGSA handles karst data – an expanded version of the ASF standard. CEGSA has its own method of documenting karst features which does not quite correspond with the ASF's scheme. The main reason for this is that not all surface features are given their own code as per the ASF. In SA we have many occurrences of shallow chambers or slots with multiple small entrances. The same as often occurs in tower karst. Other States appear to have handled this problem by ignoring it (as we once did). We number the major entrance as per the ASF then allocate a "feature identifier" or FID to each surface feature. The FID is noted as a "dot" after the code: eg 5U-1.1 (the main one being ".1" and implied if absent)
- Evolves rapidly to suit our needs. For instance adding satellite images.

- Has a user interface that better suits the way that we use our karst data. KIDSA is organized to extract data not just by karst code but by other attributes. For instance, if it lies close to a specified location or other feature. The interface allows for retrieval of the actual data as well as an index to it.
- Has been expanded to hold more data types while eliminating those we do not use. South Australian karst will never need some data descriptions that are needed for other types of karst – these fields have been removed rather than always have them blank and occupying valuable screen space. However, we have added fields to handle the extra information that we require, such as for our photographs.
- Is evolving to hold the actual data – a Karst Database. Instead of just telling you where to get the data you want (a KID), we are adding the actual data into the database. For instance, instead of listing all available photographs, the photos can be displayed. The same goes for cave maps.
- Is designed for field use whereas the KID is designed for home use. Access to the data is useful if doing research, including planning a caving trip. But what if you are out on a trip and discover an unexpected karst feature? Because KIDSA can be taken with you, all that's needed is to enter the location and it will list all known features in your vicinity from which you can determine if it is known and the access and gear requirements.
- Can be installed on a PC whereas KID is only available via the internet.
- Has been seamlessly interfaced with other software such as Global Positioning Systems (GPS) and Graphical Information Systems (GIS). KIDSA can upload locations into your GPS together with pertinent information such as accuracy of location and feature type.

As an example screen, clicking on "**Full Karst Index**" and selecting region "N" gives:



Specific data topics for the feature can be accessed by selecting something on the right-hand side tagged with a "*". No * means no data has been recorded in KIDSA (the tagging is automated).

Cave Rescue in the USA and Canada

Ross Anderson

Introduction

- Recent Travels offered the opportunity to attend both British Columbia Cave Rescue (BCCR) and National Cave Rescue Commission (NCRC) rescue courses in Canada and the US.
- This presentation will outline courses and how the organizations operate but will not go into detailed analysis or comparison of techniques taught.
- Other cave rescue organizations exist in both countries but Jay and I only had the opportunity to attend courses presented by these organizations.

Canada – British Columbia Cave Rescue (BCCR)

- formed 1984
- rescue and training service of organized caving in British Columbia
- recognized by the Provincial (State) Emergency Program (PEP) as the lead agency in cave rescue, providing specialized personnel and equipment for cave rescue emergencies
- on callout by the Royal Canadian Mounted Police (R.C.M.P.) or the PEP Emergency Coordination Centre.

Environment

Canadian caves range in temperature from 0- 9°C.
Caving requires equipment for cold and wet conditions.

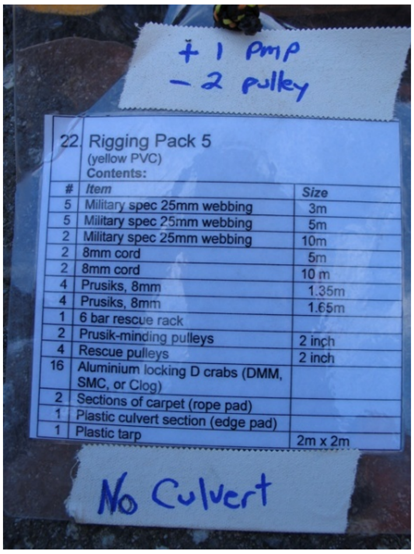
Caves in Canada are very hard, and rescue practice is undertaken in cave. Generally rescue exercises are undertaken in "sacrificial" caves that have little restriction of public access and exhibit significant visitor impacts.

Rescue equipment and property

- BCCR has three rescue gear caches one on Vancouver Island, and secondary caches in Kamloops and Prince George.
- Each cache contains several bags of pre-sorted equipment for quick deployment.
- Equipment bags include: Initial response equipment (first aid and patient management equipment), rigging packs, rope packs, medical packs, communications equipment

Rescue co-ordination and procedures

Courses and Training



+ 1 pmp
– 2 pulley

22. Rigging Pack 5
(yellow PVC)
Contents:

#	Item	Size
5	Military spec 25mm webbing	3m
5	Military spec 25mm webbing	5m
2	Military spec 25mm webbing	10m
2	8mm cord	5m
2	8mm cord	10 m
4	Prusiks, 8mm	1.35m
4	Prusiks, 8mm	1.65m
1	6 bar rescue rack	
2	Prusik-minding pulleys	2 inch
4	Rescue pulleys	2 inch
16	Aluminium locking D crabs (DMM, SMC, or Clog)	
2	Sections of carpet (rope pad)	
1	Plastic culvert section (edge pad)	
1	Plastic tarp	2m x 2m

No Culvert

<u>Cave Companion Rescue course -</u> weekend rescue courses held annually.
Include hands-on practice with:

- Basic first-aid, planning and preparing for a cave trip
- basic SRT rope skills (ascending / descending)
- equipment & safety considerations
- raising & lowering systems
- team approach to cave rescue
- mock cave rescue scenario

course fee of $75.00 ($40.00 for persons affiliated with a recognized caving group or SAR group)

<u>Weeklong Cave Rescue seminar</u>

- Introduction, BC rescue organizations, caving accidents and incidents
- Medical, First aid, planning, packaging and basic patient transport
- Rigging theory and practice
- High angle rigging and practice
- Major search and rescue organization, incident command system
- Communications
- Underground horizontal and vertical stretcher handling practice

Course cost $120, provides course notes and use of BCCR rescue equipment.

National Speleological Society
National Cave Rescue Commission (NSS – NCRC)

- established 1979
- NSS representative on cave rescue training and operations.
- Volunteer group developed primarily to train and track US cave rescue resources
- NOT a functional cave rescue team, NCRC trains rescuers, but doesn't conduct rescues – limits liability.

NCRC Aims
General NCRC stuff
NCRC courses

<u>Weekend Cave rescue orientation course</u>

Course includes many elements of the weeklong seminar does not include vertical rescue

- Cave environment
- Equipment and patient packaging and planning
- First aid equipment, medical and psychological considerations
- Communications and documentation
- Incident command system
- Search and rescue
- Bad air, water - special situations
- Practical rescue practice and considerations

Course fee: $35US, notebook $10US

Summary

BCCR
www.cancaver.ca/bccr/
NSS – NCRC
NCRC.info
www.caves.org

Speleo volunteers and karst environments: A summary of some useful tools and techniques from USA speleo colleagues

Jay Anderson

Whilst on a recent trip to the USA, the author was able to attend both the NSS Convention and the National Cave and Karst Conservancy forum. It was noted that many cave and karst managers in USA utilise speleological volunteers extensively in aspects of cave and karst management. Some of these techniques may be of interest to Australian cavers. The use of cave exploration and surveying standards in cave management plans is presented (thanks to Pat Seiser of NCKRI). The NSS has a database that records speleo volunteer time on speleological projects and in performing a number of activites - the importance of "Volunteer Value". Many National Parks are utilising cavers and their knowledge of caves to perform comprehensive cave inventory's. A number of these useful tools will be presented. The author was also able to participate in a biological inventory. A useful tool for undertaking records of subterranean fauna will also be presented.

<u>**Speleo Volunteers & Karst Environments**</u>

A summary – some useful tools & techniques from USA speleo colleagues

Speleo volunteers and karst environments: A summary of some useful tools and techniques from USA speleo colleagues *Jay Anderson*

Presentation Summary

- Background – importance of caves & karst systems
- Volunteer Value
- Exploration, surveying & cave management
- Inventory's
- Eg – biological inventory
- Cave Rescue – preplanning for situations

CAVES or the whole KARST SYSTEM?

- So what do you do when you go "caving"??
- Common to focus on "finding caves" or "surveying caves"
- The need to document aspects →components of whole karst system…..
- Aspects to consider in addition to maps/surveys

<u>Not just about Caves & recreation</u>

2: Volunteer Value

- ***cavers → willing to donate time/effort →wide range of cave related activities.***
- ***Cavers will spend countless hours above & below ground working to:***
  - improve,
  - conserve,
  - better understand karst systems.

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Speleo volunteers and karst environments: A summary of some useful tools and techniques from USA speleo colleagues *Jay Anderson*

Sometimes this volunteer work is officially recognized & applauded

Cavers usually do the work just for the opportunity to :

- explore,
- understand &
- protect the unknown.

NSS & USDA Forest Service Agreement - 1998

- Background: Federal Government proposed "user fees" to help overcome budget deficits.
- Cavers → TO pay fee to Gov't to locate, explore & map caves on Gov't lands.
- agreement → defined value of volunteer work cavers donated →Government.
- The monetary value of the volunteer work negated paying user fees.

Agreement covered:

- <u>"Salaries"</u> –Volunteer labour - hourly rate.
- <u>Volunteer Hours</u> –Travel & work time.
- <u>Supplies & Equipment</u>
- <u>Professional Services</u>
- <u>Mileage</u>
- <u>Preparation and Documentation</u>

Rationale:

- Assign $$ values →volunteer work

Add up & keep records…….

- Documentation → Assist in cave management proposals & karst protection battles.
- Volunteer Value Report Sheet #1 NSS

Document Volunteer Value →all cave projects:

- cartography,
- inventory,
- photo documentation,
- science,
- survey,
- administration, preparation and report filing
- restoration, maintenance, clean-up, and in-cave work.

3: Exploration & cave management

- knowledge →exploration is a key component in the conservation & protection of caves
- exploration → can have a significant impact on a cave's environment.
- Need for cavers and Cave Managers to be aware
- Minimal impact techniques required.

Speleo volunteers and karst environments: A summary of some useful tools and techniques from USA speleo colleagues *Jay Anderson*

Things to consider:

- policies & procedures - in-cave & surface activities
- Skills of participants-
- necessary caving skills to
- required skills -- surveying & inventory activities
- the establishment of trails/tracks in cave/surface
- Need for photo documentation.
- Survey procedures & standards:
- data management & cartography.

4: Inventory & Karst Assessment

- Aim – to gather environmental data to assist in management decisions
- Knowledge of the environment → vital for decision making.
- Databases →detail landforms, geology, soil, hydrology, flora & fauna

Many approaches to inventory

- Rapid techniques – checklists
- Detailed observations and measurements

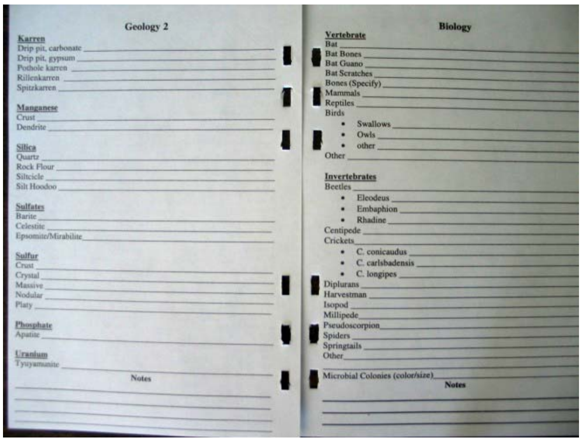
Options for Inventory:

- As you SURVEY & explore a cave
- As a special PROJECT – ie cave already surveyed – but need > INFO.

EG – Many National Parks & BLM lands

- Undertaken by 4th person in survey team
- Specific documents to complete
- Data linked to location of survey point
- Comprehensive data → storage considerations

5: Eg – Biological Inventory



Geology 2

Karren
Drip pit, carbonate
Drip pit, gypsum
Pothole karren
Rillenkarren
Spitzkarren

Manganese
Crust
Dendrite

Silica
Quartz
Rock Flour
Siltcicle
Silt Hoodoo

Sulfates
Barite
Celestite
Epsomite/Mirabilite

Sulfur
Crust
Crystal
Massive
Nodular
Platy

Phosphate
Apatite

Uranium
Tyuyamunite

Notes

Biology

Vertebrate
Bat
Bat Bones
Bat Guano
Bat Scratches
Bones (Specify)
Mammals
Reptiles
Birds
- Swallows
- Owls
- other

Other

Invertebrates
Beetles
- Eleodeus
- Embaphion
- Rhadine

Centipede
Crickets
- C. conicaudus
- C. carlsbadensis
- C. longipes

Diplurans
Harvestman
Isopod
Millipede
Pseudoscorpion
Spiders
Springtails
Other

Microbial Colonies (color/size)

Notes

- **Importance of collecting information**

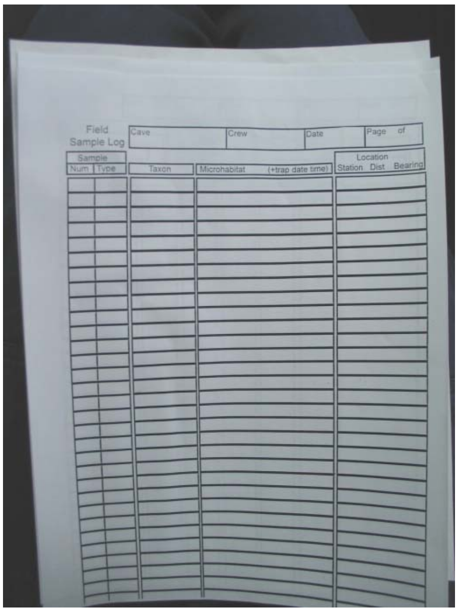
  Subterranean …….
  - Fauna
  - Habitats

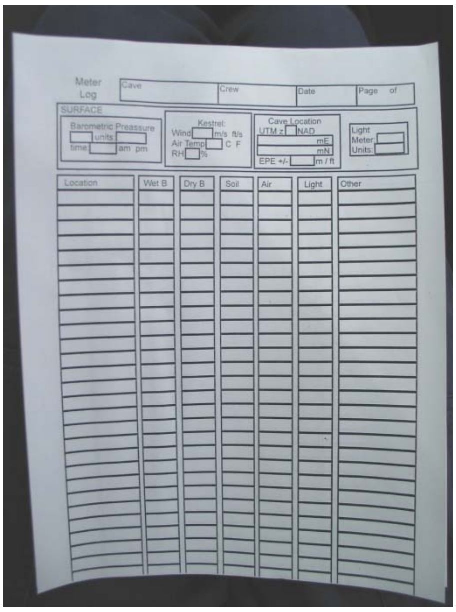
- ***Important to Not just "collect" specimens….***
- ***Visual observation & recording***
  – Photomonitoring
  – Documenting fauna seen → on a "log"
  – Record location → on a cave map
  – Collect selected fauna → later identification
  – Some cavers have specialist biological knowledge

Speleo volunteers and karst environments: A summary of some useful tools and techniques from USA speleo colleagues ***Jay Anderson***

Eg → Supporting Environmental data collected

- *Temperature – air, soil, water*
- *Humidity*
- *CO2*
- *Water Salinity/pH*
- *Also – site description - height of site, location in cave.*





6: Cave Rescue

- Situation preplanning – Incidents & Accidents
- Cavers → cave rescue training & cave rescue

Develop

- specific cave rescue preplan
- appropriate equipment.

EG – To consider

Search and Rescue Plans

- Overall Action Plan
- Guidelines For Entering Cave
- Pre-plan goals map.
- Rescue Pre-plan
- Communications
- Rescue Operations
- Rigging Plan & Rationales, Anchors
- Patient Packaging & Litter Procedures
- Underground Team Guidelines

Speleo volunteers and karst environments: A summary of some useful tools and techniques from USA speleo colleagues *Jay Anderson*

We have many example & comprehensive documents from Carlsbad

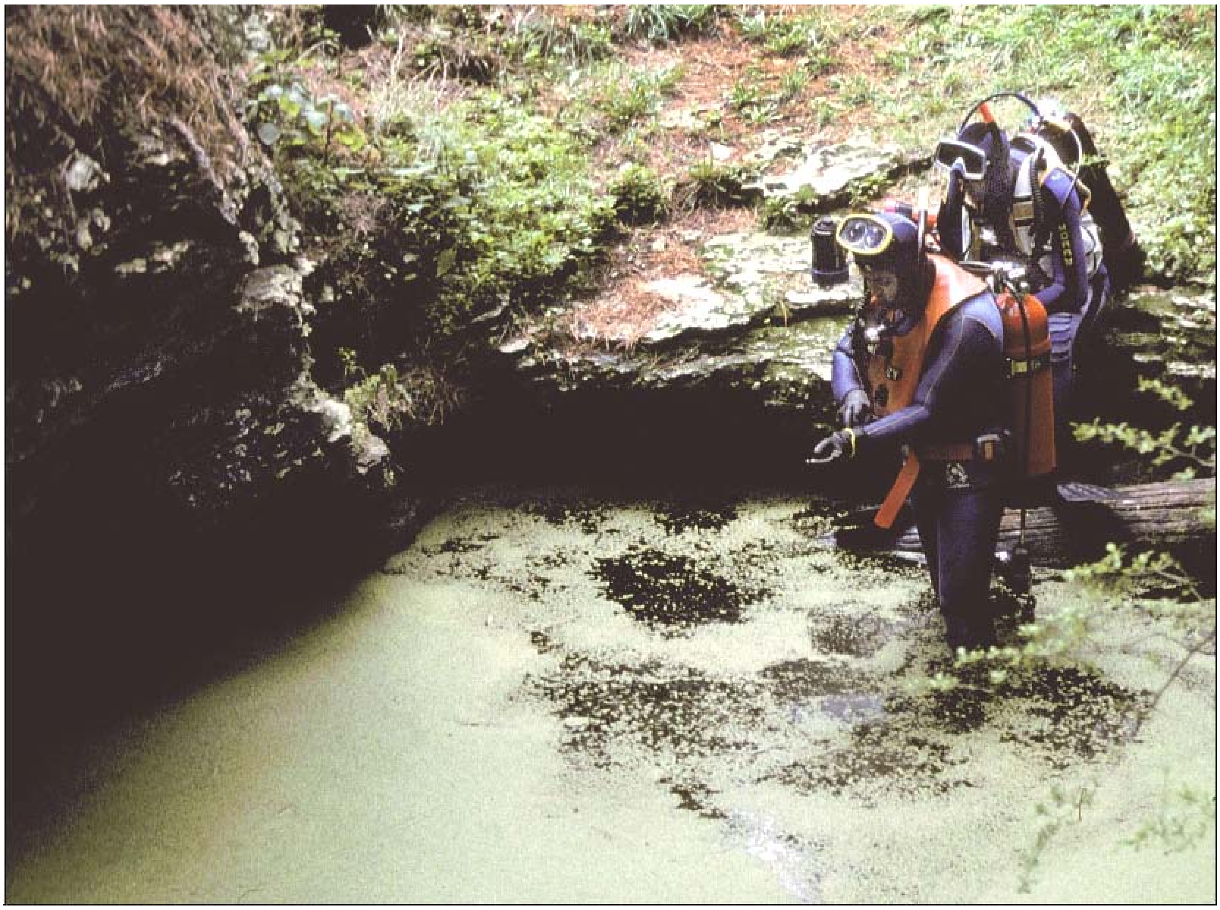
Summary

- Karst environments are important systems
- Need →holistic & specialist management
- Gathering of information through exploration → IMP.
- Information on values & threats → assist in management plans & decisions
- Cavers, Speleologists play a key role

Hope you found these examples useful to consider in your activities*……*

A Brief History of South Australian Cave Diving

Peter Horne



(Photo courtesy R&D Keller/ANT Photo Library)

Abstract

It has only been during the past 50 years or so that the waterfilled sections of our caves have begun to surrender some of their secrets. Before the advent of reliable and affordable underwater breathing and lighting equipment, cave explorers were naturally blocked when they encountered subterranean pools and lakes, and the cold and mysterious realm beneath the water's surface was only briefly visited by a handful of brave and adventurous souls who used innovative and often extremely dangerous techniques to push just that little bit further.

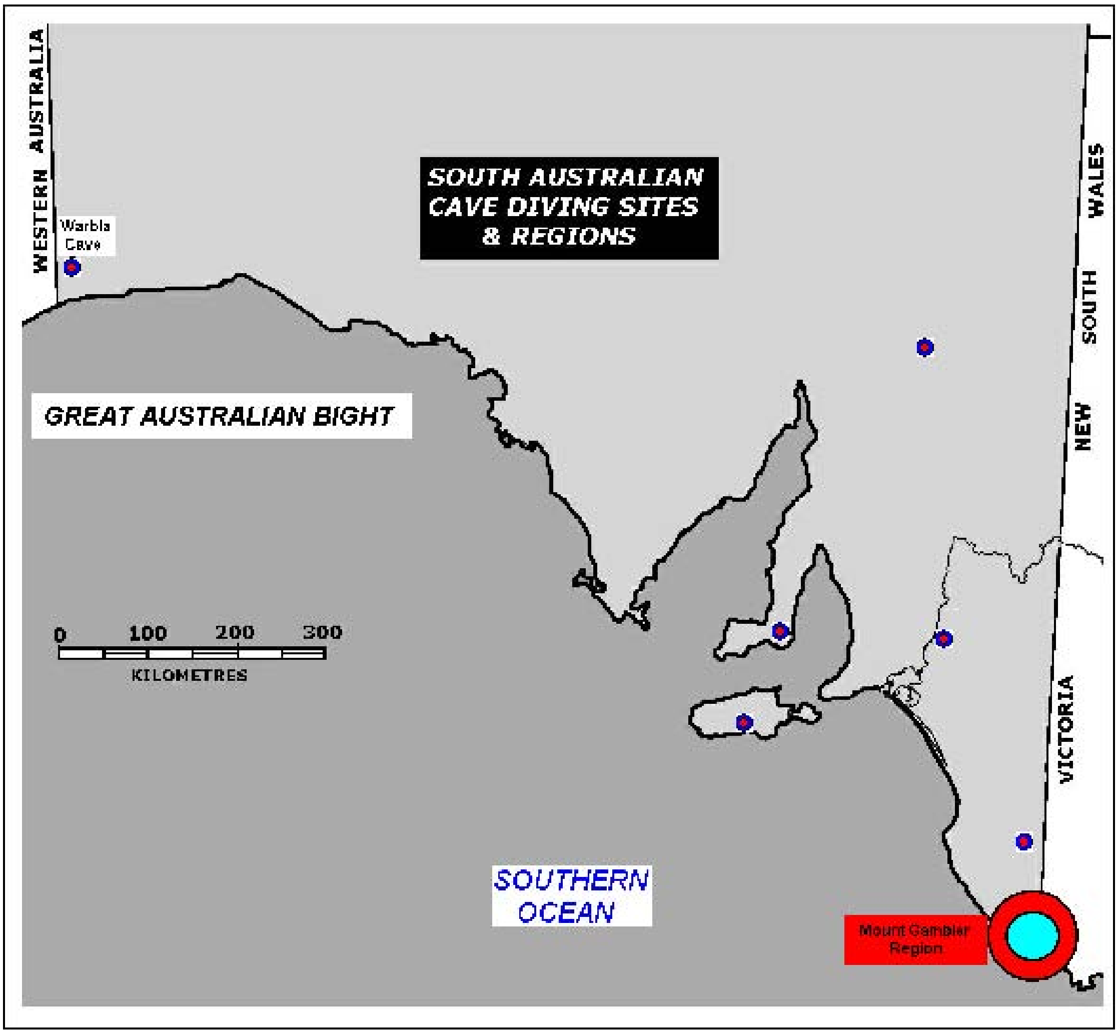
With the opening-up of underwater exploration for recreational purposes after World War II (mainly thanks to the development of the Aqua-Lung by Jacques-Yves Cousteau and Emile Gagnan), cavers and divers were quick to realize that they now had a means by which they could finally visit the vast and mysterious "silent world" of the waterfilled caves, a realm which was just crying out to be explored. It was here, at the unique interface between the atmosphere and the subaquatic realm, that the activity known as "cave diving" came into its own.

This paper is intended to serve as a basic record of many of those early explorations and discoveries by Australian cave divers, and includes information about other related aspects as well.

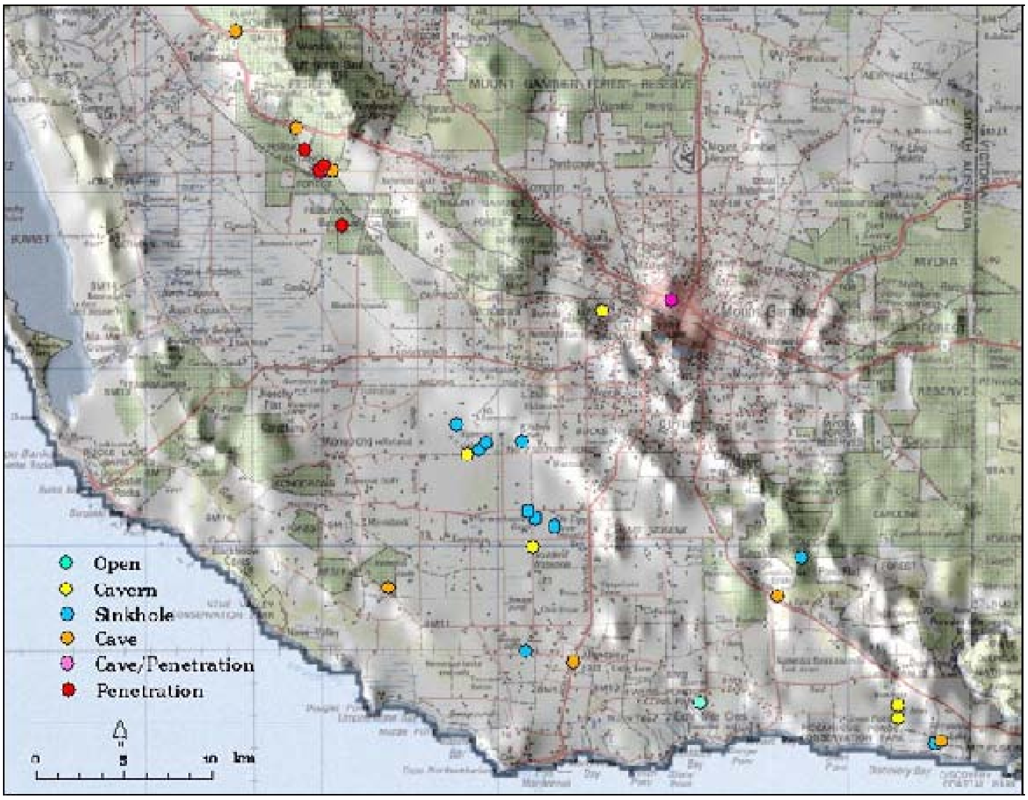
The First Explorations

The world's first known cave dive took place in France in March 1878, some 74 years before Australian cave diving commenced, when Nello Ottonelli dived in the Fountaine de Vaucluse (The Fountain of Vaucluse) to a depth of some 23 metres. No doubt other undocumented paddles were undertaken after that first effort, and in 1922 Norbert Casteret undertook the first successful traverse of two sumped passages in the Grotte de Montespan. In 1936 Graham Balcombe performed the first known British cave dive in Swildons Cave, and ten years after that, Jacques-Yves Cousteau was lucky to survive after he and his dive buddy Frederic Dumas became entangled in their surface-supplied 'safety rope' at a depth of 60 metres whilst under the influence of nitrogen narcosis in the Fountain of Vaucluse.

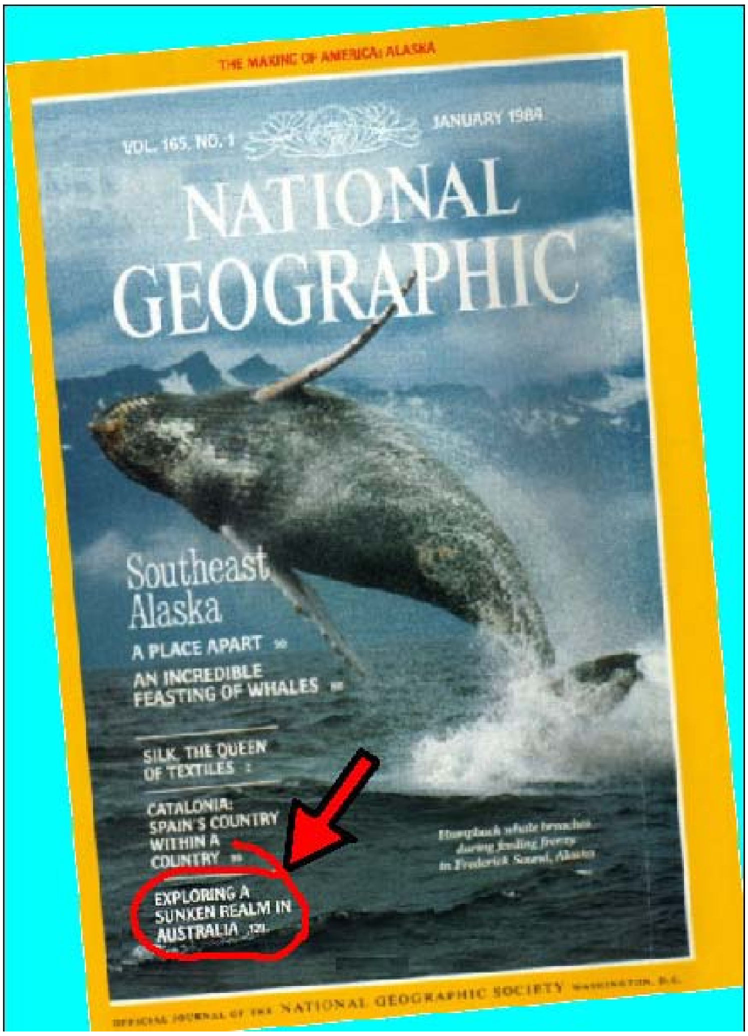
Unfortunately, early records about Australia's first cave dives are very scarce, but the first Australian cave dives known to the author reportedly took place in 1952 at the Imperial Sumps of Jenolan Caves in New South Wales, when Ben Nurse and Denis Burke undertook a series of well-publicized dives using airpumps and hoses. This groundbreaking work coincided with the first known cave dive in the United States the same year, when an unnamed Floridian diver explored a cave called Jugg Hole. Some six years later in early 1958, Bill and Bob Kunert and Jim Palmer performed a pioneering dive at Buchan in Victoria between Royal and Federal caves (often dry but a sump on this occasion), and in May that year John Driscoll and Peter Matthews also continued exploration in Sub-Aqua Cave using oxygen rebreathers and very primitive and bulky rubber dry-suits. In June 1959, John and Peter turned their attention to Dalley's Sinkhole, around the same time that a small number of divers first began to visit Mount Gambier's better-known, more readily-accessible sinkholes.



While South Australia covers a rather large area, more than 99 percent of cave diving activities occur in the extreme south-eastern corner of the state, in the dozens of 'wet' caves and sinkholes which are to be found in the Tertiary limestone of the region.



The general distribution of the major caves and sinkholes showing how many major features follow ancient sand dunes and joints in a NW-SE trend, roughly paralleling the modern-day coastline (graphics courtesy Heike Apps).



The region has long been known internationally for its cave diving sites, as this National Geographic magazine from January 1984 indicates.

Detailed records about Mount Gambier's early diving explorations are especially scarce for this period, but thanks to the memories of a number of earlier divers and cavers, and especially the records of the Cave Exploration Group South Australia (CEGSA) Inc., it is at least known that many pioneering sinkhole dives had been undertaken by the end of the 1950s, including some of the first dives in Kilsbys Hole, Little Blue Lake and Ten-Eighty Sinkhole by Adelaide divers including Peter Girdler and Barry Fowler.

With the realization in the late 1950s/early '60s that Mount Gambier's sinkholes were a divers' paradise came a steady influx of visitors from all around the country, and a number of local divers, in particular Lawrence Arthur "Snow" Raggatt and Philip "Mick" Potter, became almost legendary figures as they discovered and explored one site after another during those early days. Mick and Snow also probably spent more time than anyone else searching for and exploring new sites, even going so far as to fly over the area to spot sinkholes and caves from the air, and they were among the first people to develop local cave diving techniques and to manufacture and import a range of international diving gear.

Compared with the vast range and quality of gear available today, the equipment that these early cave divers needed to obtain, build or modify was quite extraordinary; for example Doug and Sandy Haig bought some ex-Navy Porpoise scuba cylinders in 1959 or thereabouts, and like many other divers they shipped large containers of compressed air to Mount Gambier from C.I.G. (Commonwealth Industrial Gases) in Adelaide so they could decant them without needing a compressor. Snowy's first tank was a 32 cubic-foot steel Porpoise, and he then got twin 28 cubic-foot steel tanks from T.D. Preece (Sydney) with a Sea Hornet regulator. These cylinders consisted of old ex-Army "buffer" cylinders which were originally used to cushion the recoil from big guns! No harness was available for the tanks – the cylinders were simply wired together and supported by a strap worn around the waist, so that the bottles floated up behind him.

Snow Raggatt as a spearo, late 1950s/early 1960s (courtesy Steve Raggatt)

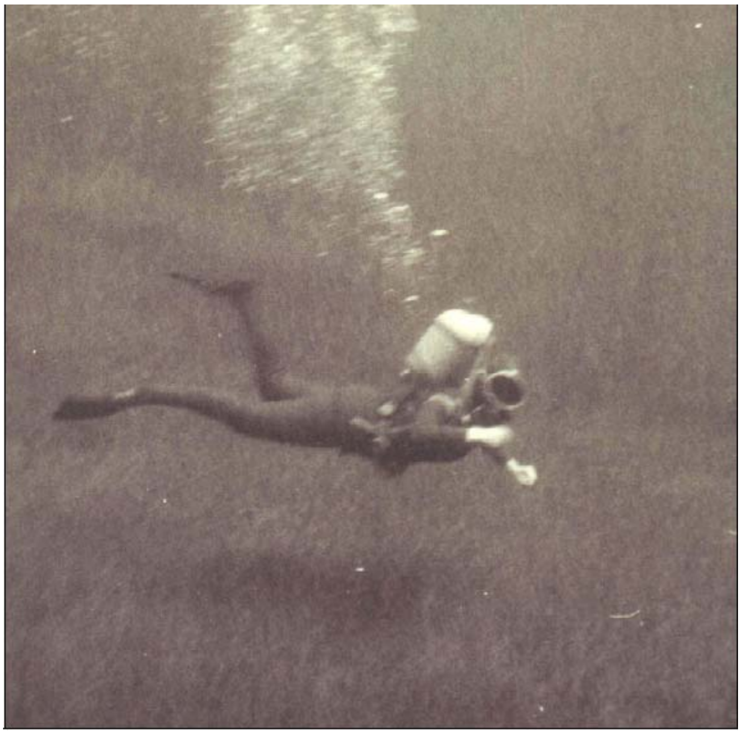
During a lengthy tape-recorded interview by Peter Stace in 1982 as well as during subsequent discussions with the author in the 1980s, Snow explained that he first became interested in diving by watching Italian frogmen during World War II. He later experimented with an old Army gas-mask in the River Murray near Tailem Bend, which at first his younger brother wore while Snow manually blew air down the tube; this of course wasn't very successful, and they later used a number of small air compressors which eventually saw them reaching a depth of about 6 metres! Snow met his future wife, Jean, in New Zealand during a visit to that fair country, and along with all the other members of Snow's family, Jean was to become an avid scuba diver in the early 1960s. Snow later became a long-haul truck driver in Mount Gambier for Kain & Shelton Transport.

Like many divers of that era (including the author, unfortunately!), Snow began his in-water hobby as a keen spearfisherman, but he was put off of that activity when he saw the incredible wastage of fish after some spearfishing competitions on Kangaroo Island where excess (and unfortunately dead) fish were simply dumped into the sea. Snow's first logged scuba dive took place on May 17, 1962, when he explored Mount Gambier's then crystal-clear Valley Lake to a depth of about 90 feet (i.e. 27 metres); however, he also felt that he might have done some earlier diving which had not been recorded.

Snow Raggatt performing what he believed was probably his first dive, at Port MacDonnell around 1959 (photo courtesy Snow, Jean and Steve Raggatt, 2005; digitally cleaned-up by the author, 2006).

Snow's first sinkhole dive took place on 18 November 1962, in Ten-Eighty Sinkhole on Barnoolut Estate (the sinkhole was then also called Simpson's Hole) which was followed soon afterwards by a dive in The Bullock Hole, and within the next year or so Snow dived in many of the area's sinkholes with members of his family (including Paul and Judy, who even at the age of around 12, dived to 36 metres with Snow) as well as Mick Potter. They were also involved in the building of the jetty at Piccaninnie Ponds with the Mount Gambier Spearfishing and Skindiving Club a couple of years later.

As diving in the sinkholes became more popular once Piccaninnie Ponds became more widely known, Snow established a dive shop in Mount Gambier which he ran with Jean, and sometimes there would be up to 200 people visiting them over a long weekend as well as heaps of sleeping bodies all over the floor in their home! To cater for the vast lack of knowledge or understanding of the risks of sinkhole diving, Snow, along with Mick and the club, ran the first training courses in Ewens Ponds, and there is no doubt that it was largely through their safety-consciousness and innovativeness that risks were minimized as much as possible in that era.



Snow wearing twin scuba cylinders in Ewens Ponds, early 1960s (courtesy Mick Potter and Snow, Jean & Steve Raggatt, 2004).

Jean and Snow Raggatt representing their shop and club at a display, circa 1964 (courtesy Steve, Jean and Snow Raggatt, 2004; digitally cleaned-up by the author, 2006).

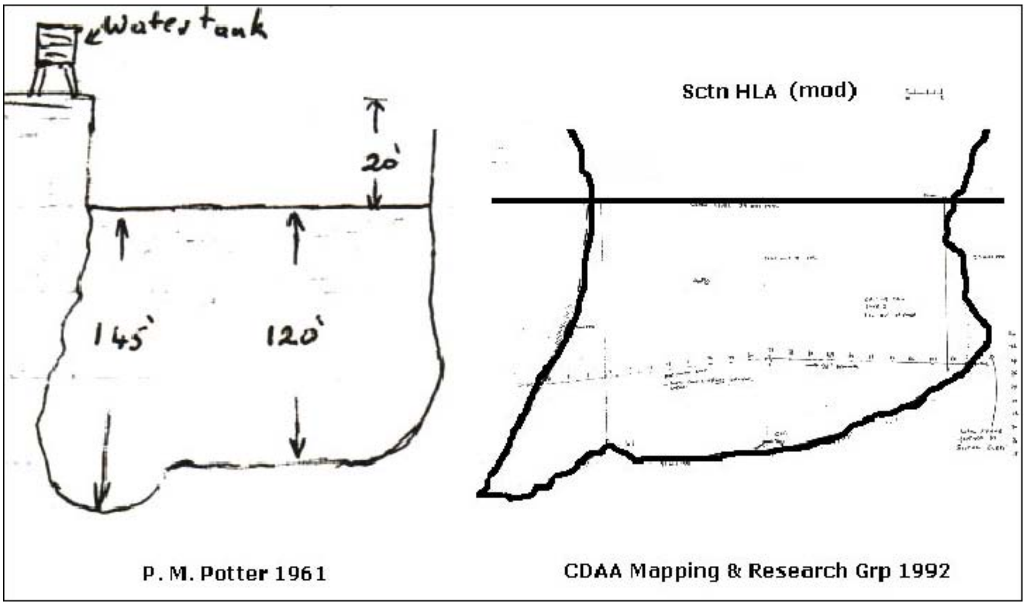
Mick Potter got his twin Porpoise cylinders in 1961 and also used the decanting technique to refill them. He dived on moored boats to clear fouled propellers and also dived in the Glenelg River; his regulator was a single-hosed Porpoise Sportsman and he had to stick his tongue into the mouthpiece to stop it from free-flowing. And like many other divers, Mick also at first used a very uncomfortable dry suit called a Dunlop Aquafort which caused painful blood-blistering at depth because it had no inflation system to compensate for the crushing effects of the surrounding water pressure. After enduring this for some months, Mick bought a new Sea Bee wetsuit (very possibly the first in the country), and later gear was to include a 72 cubic-foot steel bottle, two twin-hose Heinke Merlin regulators of “exceptional quality for the day”, and twin 50 cubic-foot aluminium cylinders which were especially made up for him (pers. comm. Mick Potter, 2004).

Mick Potter with his dry-suit and at the jetty at Piccaninnie Ponds. The wetsuit was the first US Divers suit (made in France) and the Rolleiflex camera (worth $6,000 at that time!) was in a Hanns Hass housing imported from Norway in late 1963 or early 1964. The weights and weightbelt were made at a club meeting, and the twin aluminium cylinders were evidently the first 3000psi aluminium units used in Australia by civilians, having been imported from France by the Australian Navy (courtesy Snow, Jean & Steve Raggatt, and Mick Potter, 2004; digitally cleaned-up by the author, 2006).

Mick was also one of the very few early divers with the foresight to keep a log of his dives and to also make sketches of some of the places he visited, and back in the mid-1980s he graciously provided a copy of this document to Peter Stace and the author for historical storage. The first deep dive he recorded took place on 13 December 1961 with Dave Burchell in Little Blue Lake; Mick was grossly overweighted and crash-dived to about 10 metres before he luckily managed to halt his descent. He surfaced and made buoyancy corrections before descending again, this time to 36 metres. Then on 23 February 1962, in the company of local pro diver Bob Pulford, Mick explored a small pond called Donovan’s, and he then decided to advertise for the formation of the Mount Gambier Spearfishing and Skindiving Club which came into being on 14 March 1962. The following month during Easter, an Adelaide-based CEGSA group explored several caves in the region and formally classified the sinkholes then called Devil’s Punchbowl and The Sisters (Devil’s Punchbowl is now The Black Hole). They also had some unnamed divers with them who explored three sinkholes – One Tree (a.k.a. Wurwurkooloo), Ela Elap and Kilsby’s. These were the first (known) recorded dives in these features.


Comparative shots of Mount Gambier's famous Blue Lake (left) and Little Blue Lake in the late 1990s (by the author and Alex Wyschnja respectively).


Water level comparisons in Little Blue Lake – around 1961/62 (courtesy Graham Went, 1982) and in early 2007 (by the author).



The first known underwater map of a sinkhole, incidentally also of the Little Blue Lake by Mick Potter, based on his first dive; nearly 40 years later and after many dozens of more careful mapping dives, the 'formal' CDAA survey by the author and many others looks disturbingly similar (was it worth the effort and expense?!)

Much of Mick's home-made or modified equipment was of quite a high standard as far as durability was concerned: small torches were made from kitchen sink and petrol pipe fittings and copper pipe, and most used 5 x 1.5 volt batteries. Even back then they had large 12-volt spotlights which were powered by surface-supplied car batteries to explore such places as the Cathedral in Piccaninnie Ponds. Weightbelts were often modified ex-Army belts, the buckles being of a two-ring design with another loop for "quick-release", and the heavy lead weights were home-made, with the molten lead being poured into round tins which had a bar of stainless steel stuck through so that the weights could be slid onto the belts and pinned into place. Eventually Mick and other local club members made their own quick-release wire buckles, and the club often got together to make gear such as camera housings and torches (one of Mick's first camera cases in fact consisted of an old pump-type fire extinguisher which had the ends cut off, a glass port installed and push-bike handlebars attached for handgrips!). Other types of gear included depth gauges which were probably only accurate to within around 10-20%, and Mick also did all of his own valve modifications and servicing.

Dave Burchell established Adelaide's first major dive shop, Adelaide Skin Diving Centre, in Compton Street in the early 1960s, and this is where the ASDC stayed until it finally ceased trading in the late 1990s. Perhaps the shop's most celebrated feature was its unique 22-foot-deep training tank, which Dave manufactured from a scrap metal tube he found in Port Adelaide (pers. comm. Dave Burchell, 2005). Who knows how many people were inspired (like the author) to take up scuba diving after staring in fascination at the divers who were blowing bubbles and waving to them underwater, just beyond the green glass of those windows? The inset photo above shows Dave being assisted from the ocean after performing the State's first "Para-Scuba" jump at Port Noarlunga, where he parachuted into the ocean and then descended to a mini-submarine which brought him to shore! Despite losing his right leg in a train accident during his youth (and not from a shark attack!), Dave lived his life to the full and achieved many remarkable goals (photos courtesy Dave and Ona Burchell, 2004).

ASDC's much-loved bright yellow training tank; divers practicing buddy-breathing techniques can be seen through the front window. The right shot was taken from inside the tank looking out the very same window by the author as he was testing his brand new Praktica camera housing one bright sunny day in 1975 – the fellow in the centre is Paul Lunn, who took over the shop from Dave Burchell, and he was accompanied at that time by Phil Booth (right) and a happy fellow wearing an Underwater Explorers Club T-shirt.

"Spearos" of the early 1960s, with spearguns and drysuits – note the reel on the gun (courtesy Bob Cunningham, 2005).

Over the border in Victoria during Christmas in 1960, John Driscoll discovered a significant amount of new cave using a hookah in Scrubby Creek Cave, and several Western Australian Speleological Group (WASG) divers also undertook the first preliminary assessment of the underwater regions of Weebubbie and Cocklebiddy caves on the Nullarbor Plains sometime around 1961-1963, although the silty conditions they encountered ironically prompted the report that Cocklebiddy apparently "didn't go"!

Back in the Mount Gambier region, divers from the Sub Aqua Speleological Society of Victoria (SASSV) including Ron Addison, Lorraine Newman, Ed Steet, Peter Robertson, Les Grant, John Noonan, Bill Kunert and Elery Hamilton-Smith explored a number of the larger sinkholes including

Piccaninnie Ponds which was first dived around 1961 (pers. comm. Ron Addison 2006), although it had long been known about and fished for its eels by the landowner, Max Holloway, who kept a small boat in the ponds long before it was dived.

Pioneering Mount Gambier divers Ron Addison and Dave Warnes, early 1960s (courtesy Ron and Dave in 2006 and 2004 respectively).

Preparing for an early dive in Little Blue Lake, early 1960s – note the redundant dual-tank system and the upside-down configuration which allowed for easy access to the tank valves (courtesy Ron Addison, 2006).

Some general views beneath the surface of Little Blue Lake, 1981-2005
(courtesy Mark Nielsen and Neil Vincent).

Aerial view of the First and Second ponds at Ewens Ponds, mid-1960s
(courtesy Valerie Taylor, mid-1980s).


The landing at Ewens Ponds as it first appeared to the author in 1976 (left), and as the same area looked in the early 1960s (photos by the author and Mick Potter).

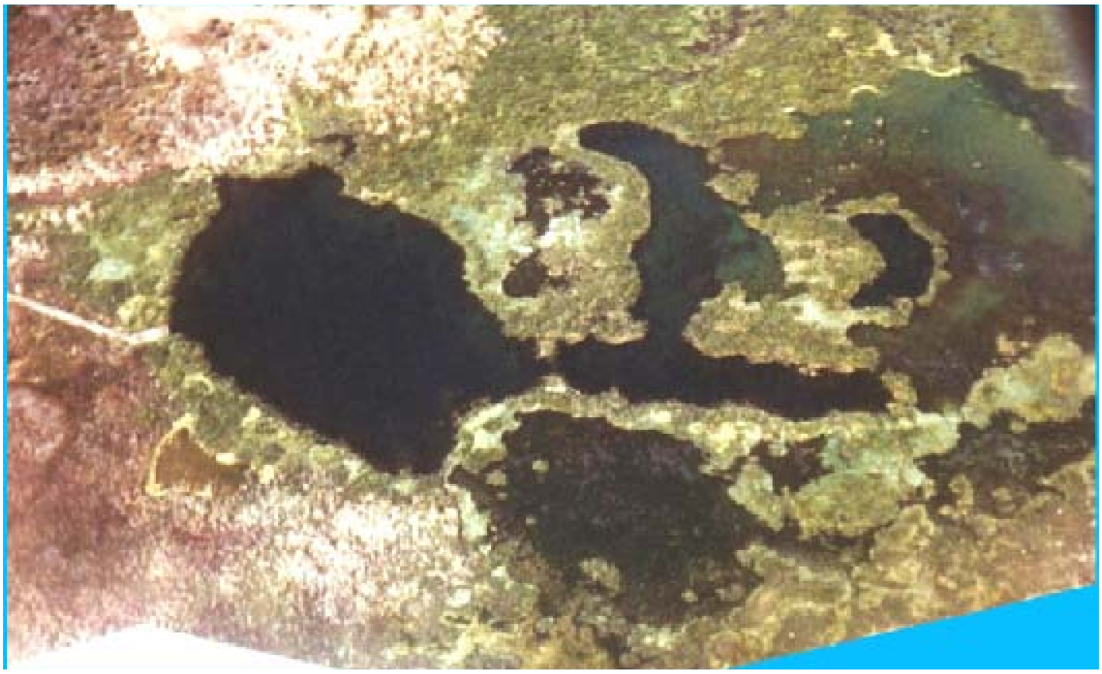
One of the more popular sinkhole dives of the region, One Tree Sinkhole, with its One Tree! The first known dives here took place in April 1962 (courtesy Alex Wyschnja, 2005).

A view of the lake surface at One Tree (courtesy Alex Wyschnja).

Ela Elap sinkhole, 1980s (courtesy Phil Argy, 1990s).

In mid-1962, hearing of Mick's involvement with diving, some duck-shooters and eel fishermen told him (more as a word of caution than their actual interest in the feature itself) about this waterfilled "bottomless chasm" near the Victorian border which allegedly swallowed a floating tree-trunk and even an entire fence! Mick and Snow located the area from the air, and in the winter of 1962, accompanied by about nine snorkellers from the club, Mick explored Piccaninnie's Chasm with scuba for the first time.

Aerial view of the Piccaninnie Ponds swamps as they appeared in the early 1960s (courtesy Steve, Jean and Snow Raggatt, 2006).

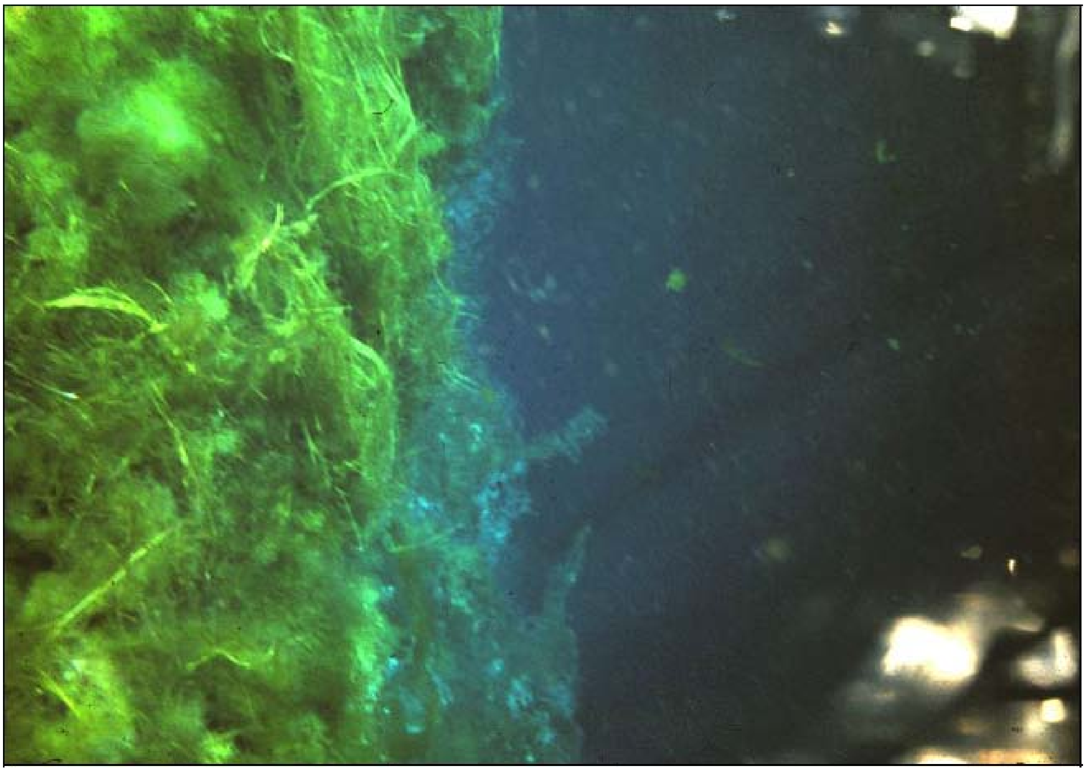


Piccaninnie Ponds from the air, mid-1960s (courtesy Valerie Taylor, 1980s).

Comparative views of divers' access to Piccaninnie Ponds: Mark Nielsen (with the Puddles Kambrook Reel) in 1980 (above), and Ron Addison's mob around 1960 (below) – photos by the author and Ron Addison. We have never had it so good!

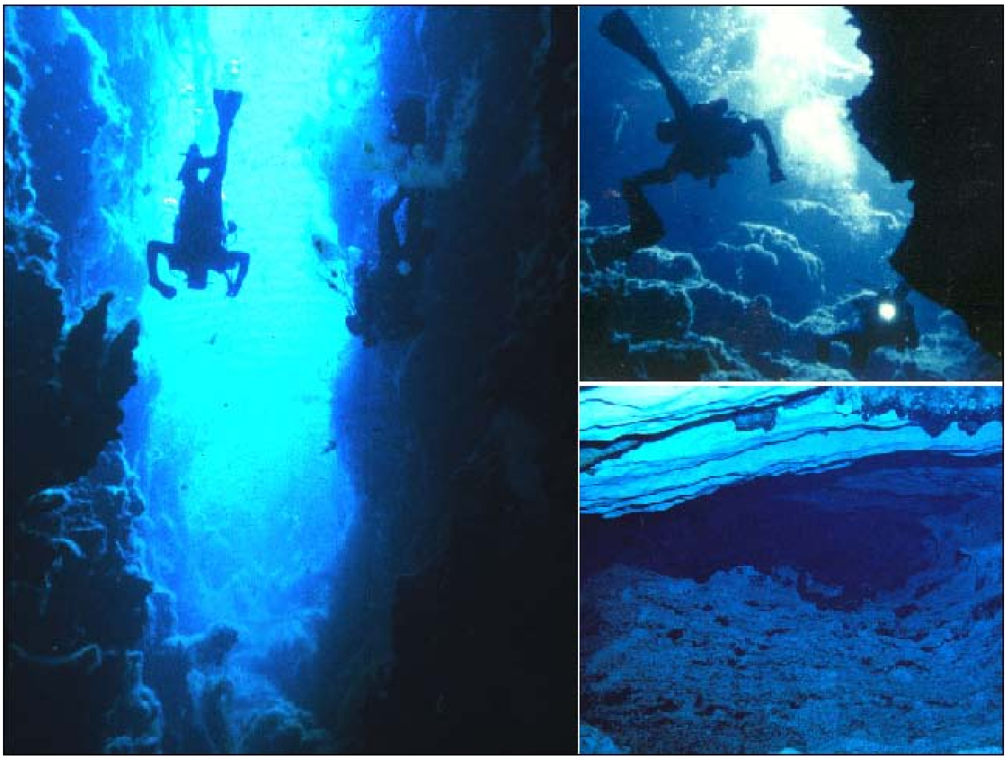
Mick Potter performed a number of other deep dives in Piccaninnie Ponds without incident until 27 January 1964, when he and Brian Rodger were almost killed when they lost contact with their vertical safety rope whilst ascending through near zero-visibility water at a depth of 235 feet in a confined area of the Dog Leg tunnel. As a result of this experience Mick developed a guideline reel which consisted of an open coil of line wrapped around an old cable drum with a stick poked through it. This allowed him to feed out and tie off line as required, thus avoiding the problems of line-traps and snagging around corners which were frequently caused by surface-fed ropes. Similar guideline systems were also developed independently overseas, and this innovation of a manageable and continuous line to the surface proved to be one of the most important safety techniques ever developed for cave diving.

Swimming through the Reed Curtain separating the First Pond from the awesome Chasm (photo by the author).



The spectacular "bottomless" Chasm a diver first sees after swimming through the Reed Curtain – even seasoned spearfishermen have been known to take a few extra breaths here to ensure they don't plummet out of sight! The limestone Teeth jutting out from the wall are at a depth of about 16 metres (photo by the author, 1977).

The author shooting some video in the very picturesque Chasm (courtesy David Kellett, mid-1990s).



Some general views in the Chasm, and (bottom right) looking down The Dog Leg (photos by the author and Andrew Cox, mid-1980s).


Mick Potter with his twin-hose regulator and the "safety rope" which nearly caused his demise in the early 1960s (courtesy Mick Potter, 1980s).



Three other popular sinkholes – The Sisters, Ten-Eighty and The Black Hole (photos by the author and Andrew Cox, 1980s).

Another spectacular Barnoolut Estate sinkhole – The Bullock Hole (photos by the author, mid-1980s).

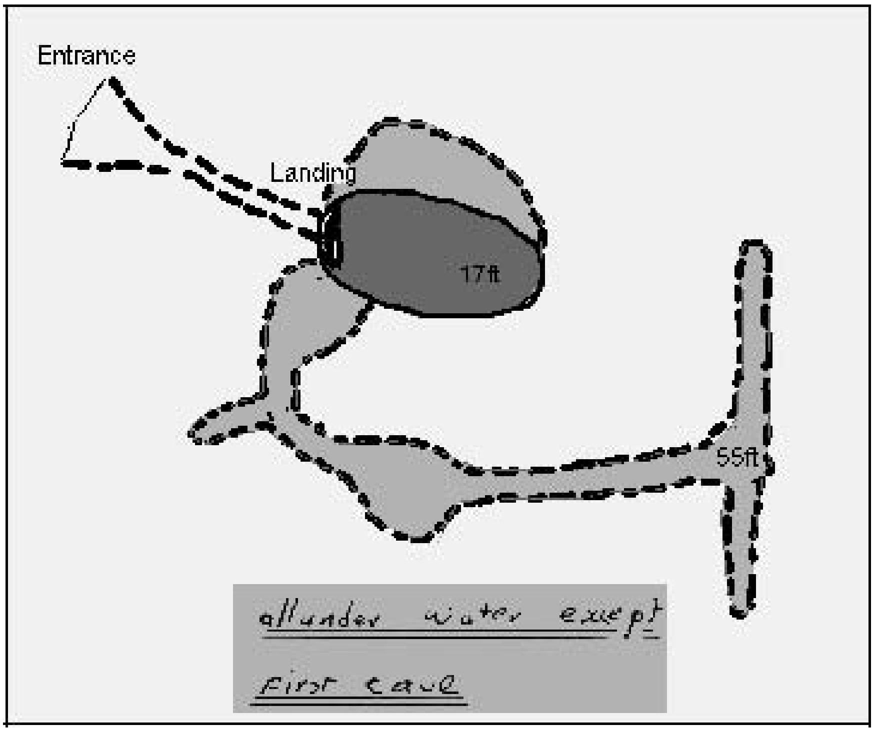
Mick first used this reel system just a few months after his Piccaninnie Ponds experience in a true waterfilled cave passage in Engelbrechts Cave, in the heart of the City of Mount Gambier itself. On 4 April 1964, in the company of Dave Burchell, John Lees and Ross Curnow, he dragged his scuba gear down the glass-and-rubble slope in the then rubbish-filled sinkhole to the eastern-side lake to investigate, as he wrote in his logbook, "… a new maze of caves for the City Council. (The) Council flood-lit the cave for us – big publicity. Bottom of cave is 80 feet below ground level, water depth 17 feet, entered cave on right hand side of water, followed tunnel, turned left (and) entered underwater cave. Followed tunnel, came to T-shaped bend, turned to left, followed along tunnel for about 20 feet then turned back (and) followed line out in pitch blackness. Used drum on safety line for first time". From this dive Mick drew up a representative sketch-map of the cave; years later it was realized by other cave divers that had his team merely gone to the ceiling and checked out some of the gaps between the boulders at their furthest penetration they would probably have discovered the large air chamber there as well. It also seems especially ironic that as a result of those early explorations, the newspapers felt that there was no tourism potential in what is today one of Mount Gambier's most important tourist drawcards!

The Border Watch, Tuesday, April 7, 1964—7

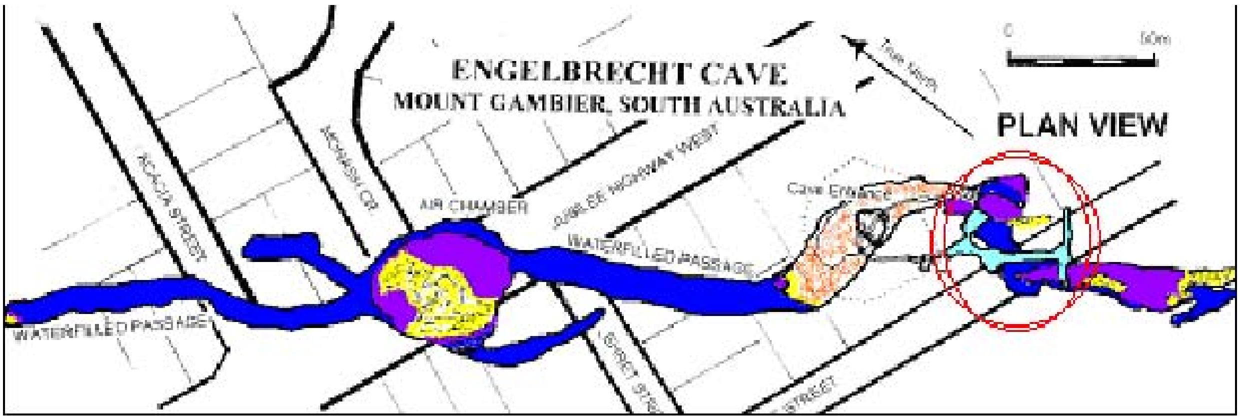
TOURIST POTENTIAL NOT IN THIS CAVE

The four divers, who explored Engelbrecht Cave on Saturday, have a "breather" in the main chamber of the cave. They are Ross Curnow (left), David Burchell, John Lees, aand Mick Potter. On the ledge above the water with his back to the camera is Craig Roeger, son of the Town Clerk (Mr. D. H. M. Roeger) who assisted in the exploration. (Picture by Ray Fowler).

ENGELBRECHT CAVE does not appear to have any potential for development as a tourist attraction, although its underwater features impressed four divers who explored it on Saturday.



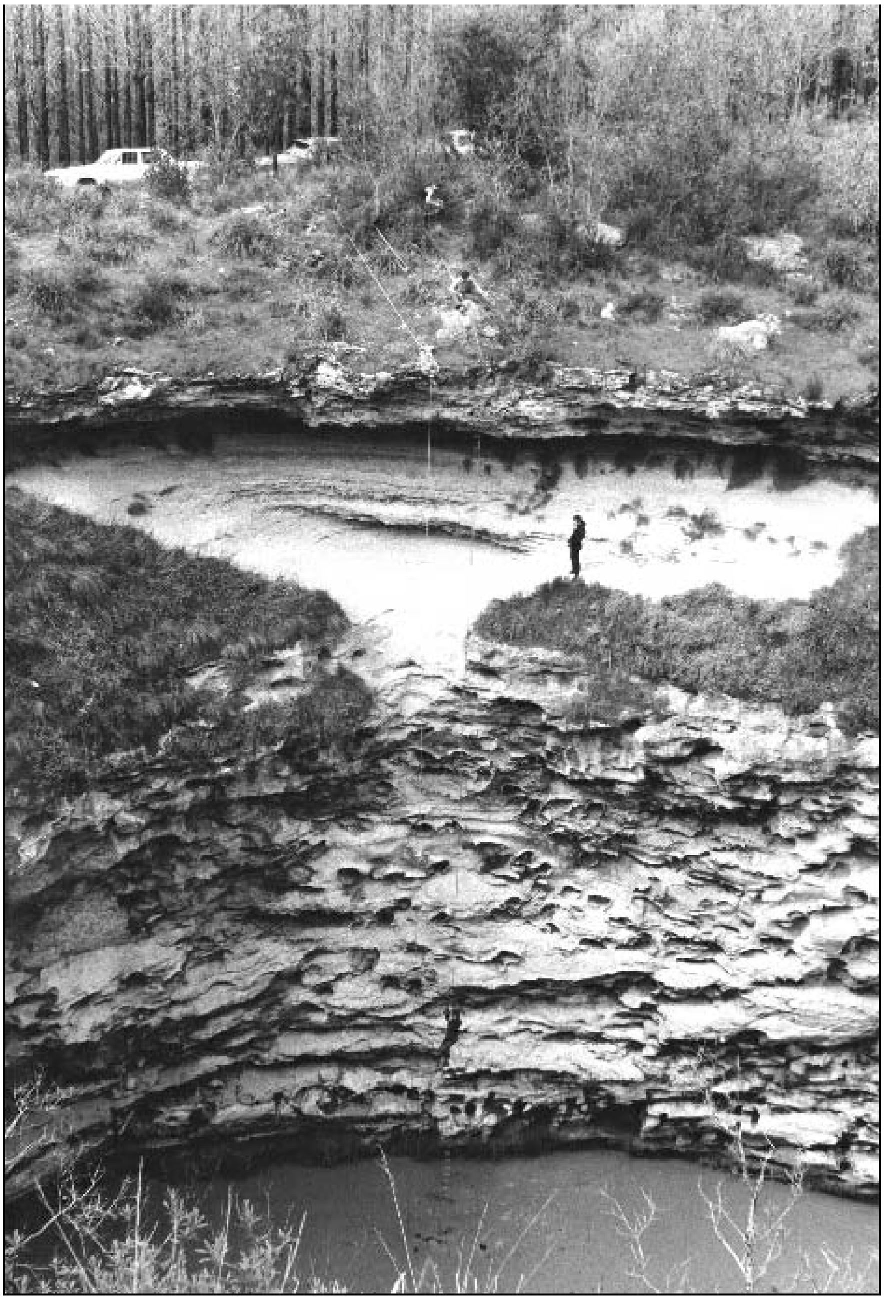
Tracing from Mick Potter's sketch of the Eastern Side of Engelbrechts Cave as it appeared in his personal logbook.



The relationship between Mick Potter's sketch and the cave as it is currently known, with his drawing circled in red.

Mick Potter and Snow Raggatt performed dozens of initial underwater explorations together and had many exciting adventures during those early days, including the time in July 1963 that a club member (who would no doubt be somewhat embarrassed if his name was published here) decided to 'visit' Snow and his friends while they were diving in the awesome Hells Hole on a cold and rainy day. Arriving at the top of the 30-metre high overhang, Martin (whoops!) put on his wetsuit and weightbelt and decided to climb down the greasy, slippery knotted rope by hand, without any kind of safety rope.

About one second after he swung onto the rope, Martin no doubt fleetingly experienced a sense of freedom followed by sheer terror during his brief free-fall to the lake below, just missing Snowy by less than two metres before burying himself in the mud at the bottom some 5 metres below the surface. Fortunately he wasn't too stunned to get back to the surface, where he, like the others, was pulled out of the hole on the same greasy rope with a lot of difficulty!



Hells Hole (courtesy Mark Nielsen, circa 1980).

Rubber boat in Hells Hole, circa 1960s (courtesy Ron Addison).

The locals explored many other features between 1963 and 1964, one dive of which involved a preliminary exploration by Bob Pulford in Bungalow Bay Cave in July 1964 (CEGSA Records). The popularity of the pastime also quickly escalated when Piccaninnie Ponds started to be made known to the general diving fraternity, and around 1965 many new divers were becoming involved. Snowy, Mick and the club managed to keep 'Pics' quiet for about 3 years until a group from Adelaide started to talk about what they had been shown in confidence, and it was mainly because of this that Mick and the club then started to teach people how to safely dive, taking them into Ewens Ponds before letting them know where the better (read "deeper"!) dive sites were located.

During this time there were fortunately no fatalities although there were a number of close calls including some decompression injuries and one instance when Jean Raggatt found an unconscious diver (actually the same unfortunate individual who fell into Hells Hole) hovering at a depth of about 10 metres in The Chasm at Piccaninnie Ponds after he passed out from hyperventilation (luckily Jean was able to get him to the surface and back to dry land where he was successfully resuscitated). Another scary incident was the time that a scuba cylinder plummeted some 25 metres down the entrance tube of McKays Shaft, striking Snow's sister a glancing blow on her hip. The first fatal accident occurred in April 1969, shortly after Mick broke away from the club and Snowy had sold the only compressor in the Mount (details of this and later accidents are covered later in this presentation).


McKay's Shaft (courtesy Mark Nielsen, 1980s).

Elery Hamilton-Smith also recently recounted the story of a four year old girl who was a very competent and capable swimmer for her age, being taken by her father to Piccaninnie Ponds in those early days, whereupon she was fitted with a small hand-made facemask and then taken on scuba into the Dog Leg to a depth of 180 feet! Surfacing safely later, she excitedly took off her mask and exclaimed "Wow! That was the best swim EVER!". Now THOSE were the days of REAL adventure! (pers. comm. Elery Hamilton-Smith during the ASF Conference, Jan.2007). Several years later, probably in 1964 (although no records have been located to date), local diver Jock Huxtable performed what is thought to have been the first (solo) dive to about 20 metres depth in The Shaft at Allendale East.

Entrance to The Shaft (during the 1984 CDAA mapping project), and Valerie and Ron Taylor climbing in sometime around 1965 (courtesy Valerie Taylor, 1980s).

While Mount Gambier was becoming known as the "Mecca" of South Australian cave diving, other work occasionally took place elsewhere in the State. One such widely-publicised project involved the first underwater exploration of Narrina Lake Cave during the Easter break of 1967, when a combined CEGSA/South Australian Museum group of researchers and surveyors comprising Peter Robertson, Doug Seton and Alan Waldron explored this shallow, very muddy cave (pers. comm. Grant Gartrell and Peter Robertson, 2005). The divers were linked to a rope fed out from the surface, and they used karabiners to slip along the line. They checked a lead along a 1-1.5m high passage for several minutes before the rope became hard to pull through; Peter explained that when he looked back, he found they had lost almost all visibility due to mud being stirred up, so they decided to abort the dive. However when they signalled for the rope to be held tight by the surface party so they could pull themselves out, the signal was not understood and each pull only resulted in more rope being fed out! The rope also went across to the side of the passage to an area where it was too narrow to pass through, and it was only through the cool-headed efforts of the lead diver, who very gently eased the rope out of the inaccessible flattener and pulled in all the slack (thus allowing the other divers to have a tight rope to follow back to the surface) that the State's first cave diving accident was not a triple-fatality in the Flinders Ranges.

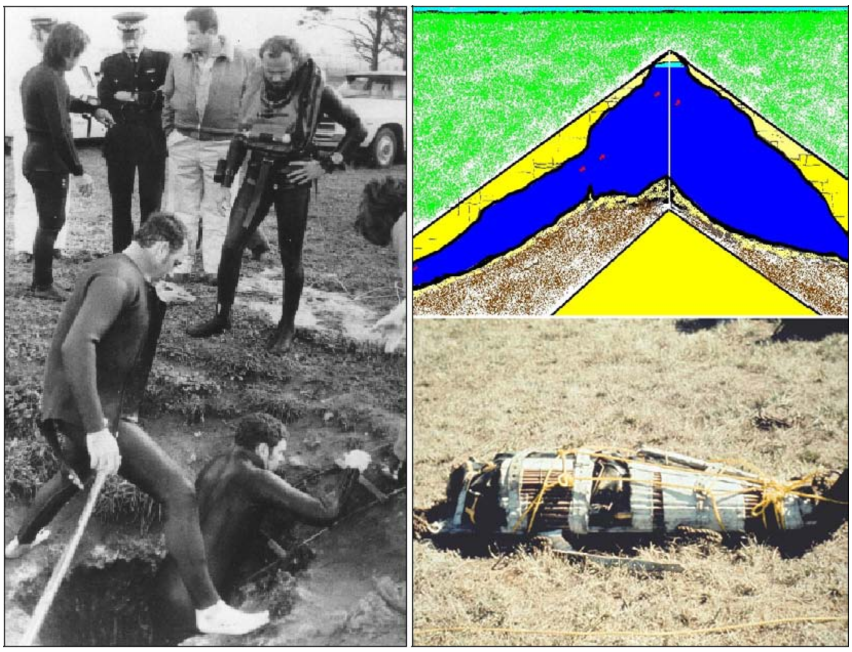
Although such cave explorations were rare occurrences during those early days, there were still those even then who wanted to utilize their underwater skills to benefit mankind in a more general way. Not a lot is known about scientific cave diving of that era but Graham McKenzie and Brian Brawley were certainly among the first South Australian cave divers to put their skills to use in this manner. Graham was in fact the first person to recognise the potential value of the fossil beds in "The Green Waterhole Cave" (Fossil Cave as it is known today); he passed a small quantity of collected bones to Fred W. Aslin who subsequently coordinated further dives involving Graham and Brian during the next five or six years with Dr Brian Daily of the S.A. Museum, with the January 1968 collection including six sets of skulls and jaws of the extinct marsupial Sthenurus sp. Brian also undertook additional bone-collecting dives between 1968 and 1974, and as a result most of the more obvious and important material was collected and preserved.

Between 1965 and 1968 the large number of extremely inexperienced and untrained people visiting the deep and silt-prone features of the Mount Gambier area without knowledge about such dangers as nitrogen narcosis, decompression sickness, buoyancy changes caused by compression, hypothermia, or even the simplest of safety lines made many more experienced people believe that it was only a matter of time before someone's luck ran out. The chances of an accident occurring were also increasing as people tended to discard the use of twin, small cylinders in favour of larger-volume, single tanks; contents gauges were few and far between (and basically mainly of the “needle-gauge” variety); and buoyancy vests, when used at all, were basically modified inflatable life jackets of the “horse-collar variety” (divers often removed their weightbelts at depth as their wetsuits compressed and they became less buoyant – it wasn’t until the mid-1970s that anything approaching a true “buoyancy-compensator device” with a scuba-fed inflator system first came onto the Australian market).

Many divers also tended to rely on their old faithful ‘J-valve reserve’ mechanisms too much, the same way they did when they were catching crays in the open ocean. Consequently, in April 1969, these fears proved to be well-founded, when two novice divers drowned together at a depth of approximately 60 metres in Kilsbys Hole. The sinkhole was subsequently closed to divers and later taken over by the Defence Department for secret development tests, and after all the hoo-ha had died down a few months later, sinkhole diving activities in the region returned more or less to normal ... but unfortunately, the next two accident-free years were really just “the quiet before the storm”.

In January 1970, the focus on Australia’s cave diving areas swung away to the hot, waterless Nullarbor Desert to the State’s west, when caver Ian Lewis first snorkelled in Weebubbie Cave with an underwater torch, thereupon discovering a massive sump which sparked his desire to take up diving (so that he could return and explore it properly) and commencing a decade of record-breaking discoveries under the Nullarbor. Two years later in 1972, Ian led the first “Nullarbor Cave Diving Expedition” which included such folk as Dave and Tamsin Warnes, Ron Doughton (from Sydney, with his wife and a compressor) and Mike Turner. Phil Prust and Bob Turnbull explored Weebubbie Cave underwater for the first time and Phil also discovered the first 150 metres or so of the enormous underwater passage in Cocklebiddy Cave during this trip.

Back in the Mount Gambier area, the period 1970-1974 was an especially bad time for the cave diving community (not to mention the families and property managers who were also directly involved), when eight divers perished in a number of closely-spaced accidents over just a 16-month period. The first case, in January 1972, involved a young man who ran out of air after following a friend into a low, silty passage with very little air in his cylinder and without a guideline to follow out of the silted-out cave; nine months later in October, a group of three perished together in Alleyn’s Cave after similarly swimming into an enclosed side-cavern through an extremely low and silty duck-under without a safety line; and finally just seven months later in May 1973, a group of four Sydney-based divers died in The Shaft (reportedly the worst civilian multiple-fatality in the world at that time) as a result of diving far deeper than their experience and equipment safely allowed – again, without a continuous guideline to the surface. This last case was by far the most dramatic in the media’s eyes, especially since it took more than seven months before the victims’ bodies could be located and retrieved by members of Adelaide’s Police Underwater Recovery Squad.



The Shaft, 1973 (courtesy Sgt. Marty Harnath, S.A. Police, 1979).

Ponds out of bounds

Piccaninny Ponds, east of Port MacDonnell, in the South-East, have been declared out of bounds to swimmers, campers and divers by the director of the SA National Parks Commission (Mr. R. G. Lyons).

Mr. Lyons said last night the area would remain out of bounds until

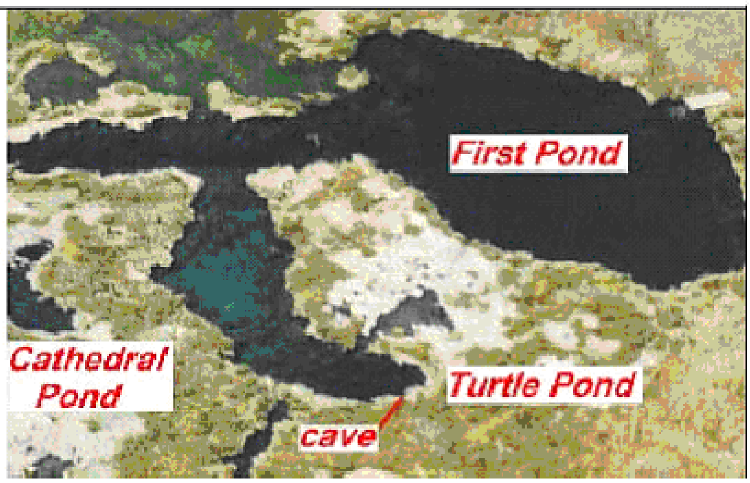
Lyle Kelly, 3?, of Hampton, Melbourne, had been scuba diving in one of the ponds with a friend when he got into difficulties and was unable to return to the surface.

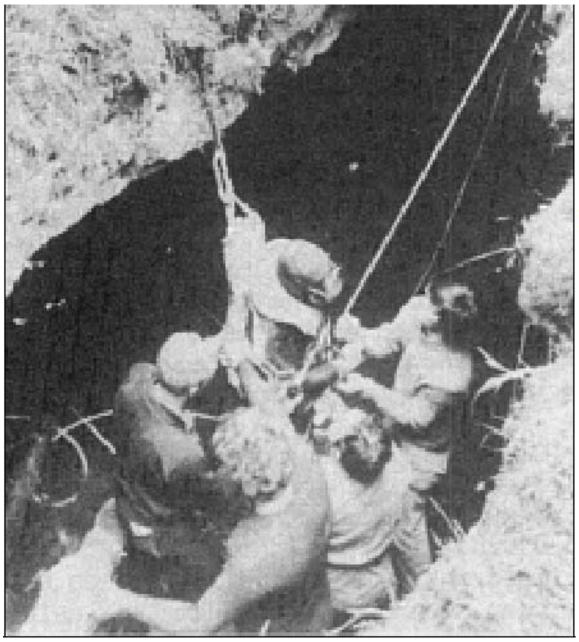
His body was recovered on Saturday evening by local scuba divers.

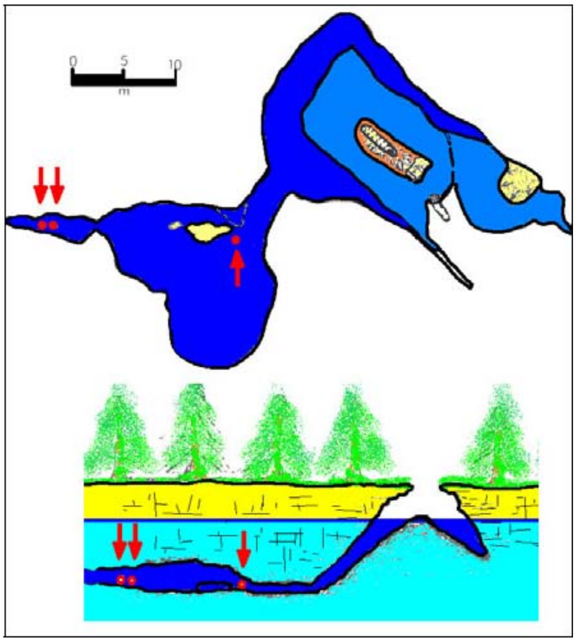
Mr. Lyons said he had instructed the park ranger in the area to erect a notice at the entrance to the ponds declaring the area out of bounds.

He wanted to talk to scuba divers and other bodies connected with water safety, to try to find some way to allow people to enjoy the ponds safely.

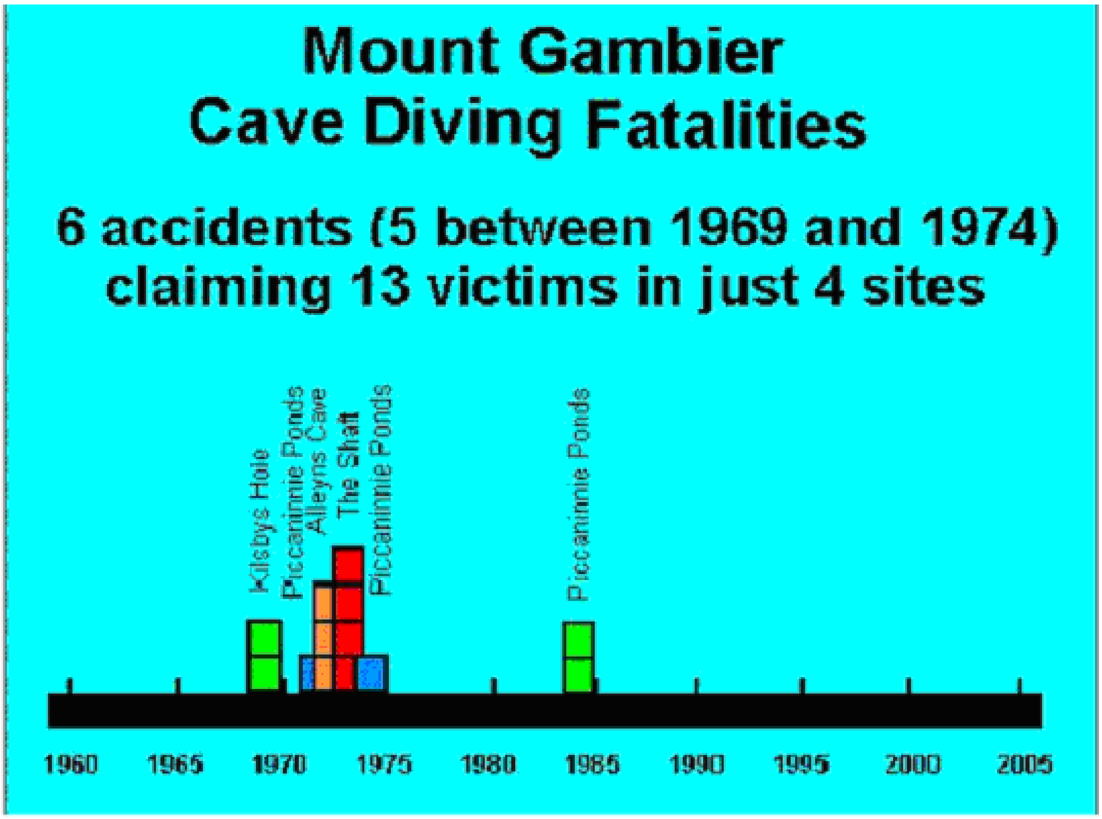
He said he understood Mr. Kelly had little experience in the use of scuba gear, and that he had only recently bought

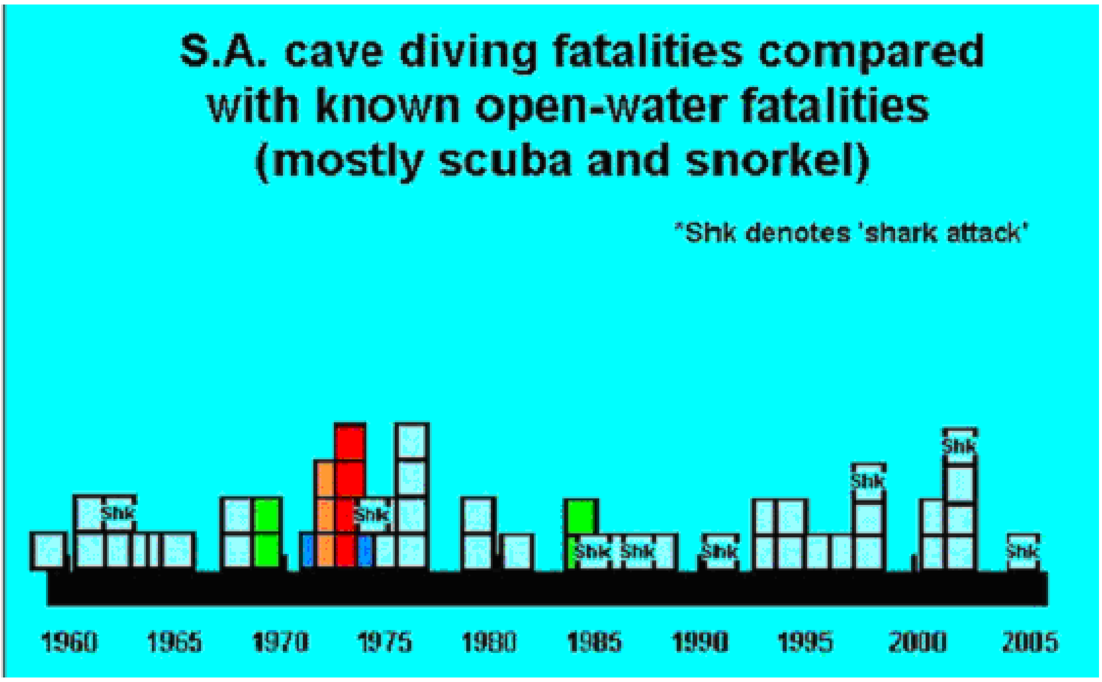




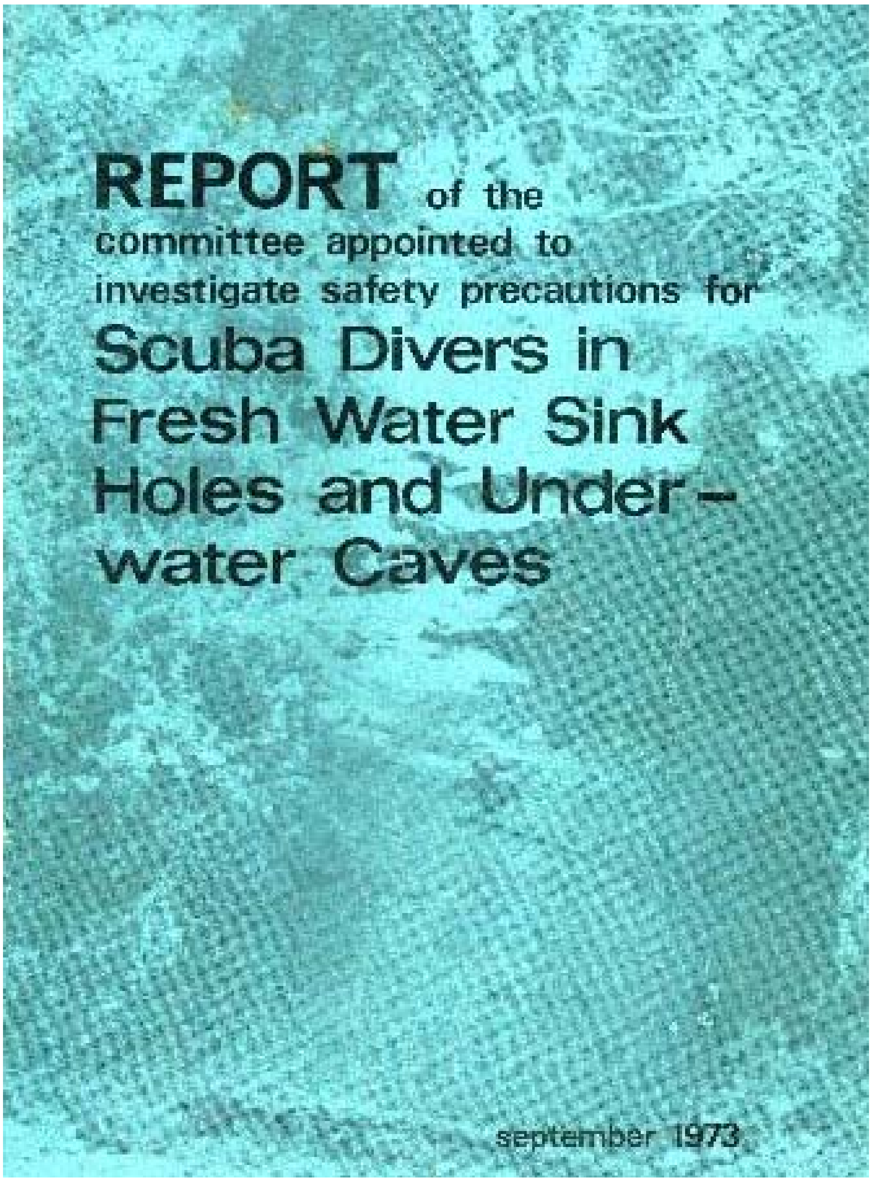


Alleyn's ("Death") Cave (courtesy The News, 1979).





The public and political response to this accident was considerable and drawn-out; understandable, perhaps, in view of the fact that it wasn't until some 11 months had passed before the last victim's body was removed from the cave. Because of the public outcry surrounding these accidents and calls from certain quarters for the total banning of all cave diving activities, the Government decided to form "The Committee Appointed To Investigate Safety Precautions for Scuba Divers In Fresh Water Sink Holes and Underwater Caves" which (fortunately for the cave diving community) was very well-represented by divers in the form of Dave Burchell, Peter Christopher (President of the Underwater Explorers Club of S.A.) and Bob Pulford (diving representative for the Mount Gambier Spearfishing and Skindiving Club). The Committee also comprised the Chairman (and Deputy Commissioner of Police), Mr L.D. Draper, the Chief Ranger of Department of Environment and Conservation (Mr G.C. Cornwall) and the Secretary of the Department of Marine and Harbors (Mr R.J. Wight).


REPORT of the committee appointed to investigate safety precautions for Scuba Divers in Fresh Water Sink Holes and Under-water Caves

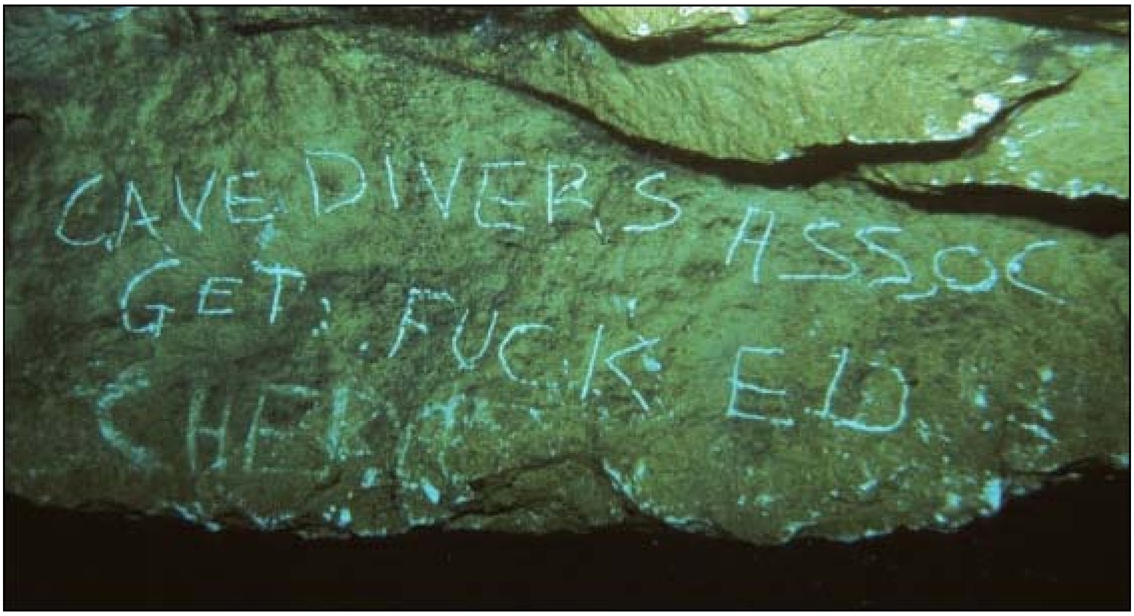
september 1973

Public opinion was sought and considered by this Committee and the fact that some members of the cave diving community (notably members of FAUI, the Federation of Australian Underwater Instructors) were prepared to try self-regulation was favourably considered; in fact on page 16 of the Committee's report they noted that "…While at Mt. Gambier in the course of its enquiry informal discussions were held with people both resident at and visiting Mt. Gambier and who had a common interest in diving in sink-holes and underwater caves. The obvious concern of these people was that action would be taken to close off holes and caves or in some way destroy them …suggestion (was) made that a united body would, apart from other benefits, give opportunity for standardization of education and qualifications. Interested persons called a meeting at that time and the Cave Divers Association of Australia was formed, with an interim Committee. That Committee called a meeting of the proposed Association in September, 1973 … "

cave divers association of australia

They also stated in the report that " … As a Committee we are optimistic that the activity of the Cave Divers Association with Australia-wide interests coordinated, would go far towards solving many of the problems associated with sink-hole and underwater cave diving … we are of the opinion that while a chance exists for achievement of greater underwater cave diving safety by the employment of virtually voluntary remedies, legislative control of the sport should be deferred". The Committee also went so far as to recommend that "… the cave known as either "S86" or the "Death Cave" situated in Pine Forest F 5.1 (Block 7) Hundred of Hindmarsh be sealed in a manner that preserves its physical condition but prevents access, e.g. an iron grille". Such awareness of the value of cave conservation was largely the result of representations by many prominent members of the caving community and this recommendation was very commendable, considering the public feelings about the drownings.

The first Committee of the Cave Divers Association of Australia was comprised of Eddie Gertners (President), Alan Day (Vice-President), Frank McGuire (Secretary), Laurie Kristoff (Treasurer) and Committee members David Warnes, Neil Tindal, Roger Townley and Russel Pope, but unfortunately there was widespread resentment within the general diving community when divers realised that they would need to fit into the self-appointed CDAA's ideas of what constituted a good, safe cave diver rather than being members of an already-established dive club, etc. Consequently some divers unfortunately used the cave environment itself to express their feelings about the situation!



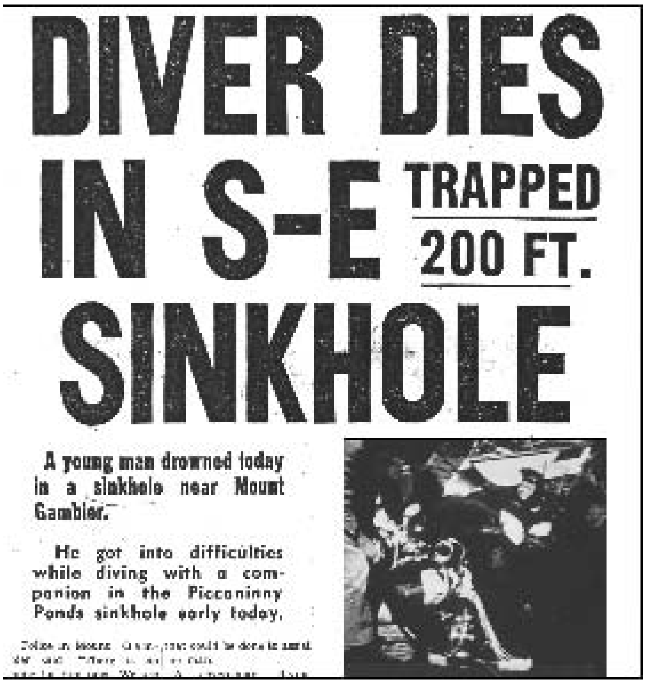
A "message" for the newly-formed CDAA at around 10 metres in Allendale Sinkhole!

Even as the CDAA was getting its act into gear during 1973 and 1974, cave diving activities continued to blossom elsewhere around the country. Ron Allum and Al Grundy performed a number of dives in such places as Jenolan, Bungonia, Wyanbene and Cliefden in New South Wales, and Ron (and later, Ian Lewis) investigated some sumps in Yarrangobilly. Also around this time Ian explored 50 metres of virgin underwater passage in a cave near the Glenelg River using a hand-held scuba cylinder, as well as Town Cave at Curramulka on the Yorke Peninsula with Phil Prust assisting from the surface.

In the mid-1970s a series of complex dives was also commenced under the Nullarbor by a number of groups from southern and western Australia. In January 1974, Ian Lewis led the "Second Nullarbor Cave Diving Expedition", and he and Keith Dekkers, assisted by about 30 other cavers from around Australia, dived every known wet cave except Moonera Tank during that trip. They were the first into Koonalda, Winbirra, Pannikin Plain, Nurina, Mullamullang, Murra-El-Elevyn and Tommy Graham's caves (discovering the first air chamber in Tommy's, with Keith almost reaching the second air chamber), and they eventually totalled some 1.3km of virgin underwater passage all up.

Then in mid-1974 or thereabouts, Phil Prust, Peter Chesson, Denis Whatt and others explored Tommy's again and found the second air chamber, and also discovered about 350m of new passage in Weebubbie Cave. Around May that year Ian dived S102 and the Henschke Quarry caves near Naracoorte, and also around this time he checked out Coobowie Corner Cave on the Yorke Peninsula with Terry Reardon (which the author dived and mapped some 10 years later in August 1985, being unaware of this earlier exploration). They also dived Lake Hamilton Homestead Cave near Sheringa on the southern Eyre Peninsula.

Tasmania entered the cave diving picture sometime around 1974 as well, when Bill Kinnear and others reportedly discovered 400 metres of submerged passage in Kubla Khan Cave without reaching the end. Back in Mount Gambier, yet another drowning in Piccaninnie Ponds in December 1974 created renewed community concern which was fortunately quickly quelled when it was realised that the victim was not diving within the CDAA's (or National Parks') safety guidelines. This was the last fatality for 10 years until April 1984, when two young men died in Piccaninnie Ponds in what was to be the final accident of the 20th Century.


DIVER DIES IN S-E SINKHOLE

TRAPPED 200 FT.

A young man drowned today in a sinkhole near Mount Gambier.

He got into difficulties while diving with a companion in the Picconinny Ponds sinkhole early today.

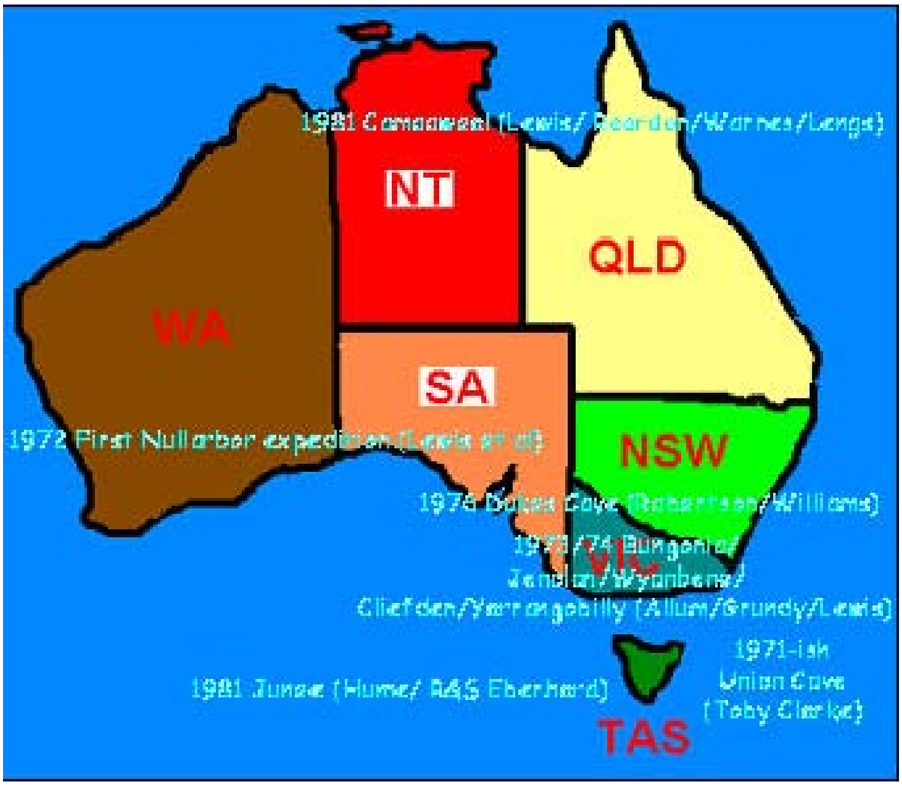
Headline from the December 1974 Piccaninnie Ponds tragedy

These photos of the 1984 double-fatality, whilst unpleasant to view, are nevertheless an important training aid for cave divers to better understand the need to properly manage guidelines during their dives, demonstrating why it is so essential to minimize or remove all potential snagging and entanglement points (courtesy S.A. Police, 1984).

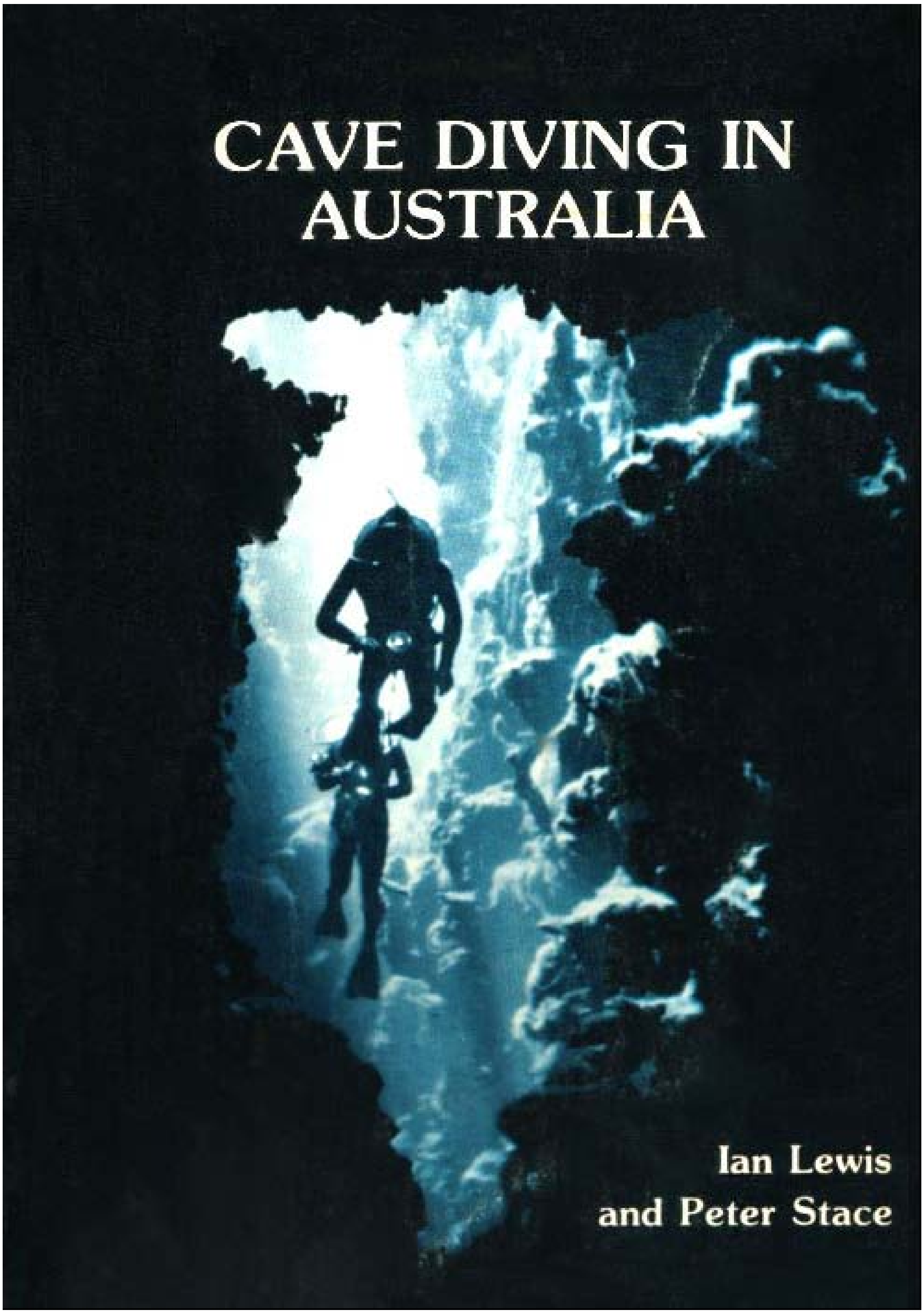
In 1975 Ian Lewis published his comprehensive “South Australian Cave Reference Book” (Occasional Paper Number 5 for CEGSA) detailing all of the caves known in South Australia at that time, and during the period 1975-1979 numerous Nullarbor discoveries dominated the Australian cave diving scene.

In August 1975, Hugh Morrison, Simon Jones and Keith Dekkers made a world-record push to the 550-metre mark in Cocklebiddy Cave and also pushed Tommy’s to the final rockpile which they explored until the top portion collapsed, and in May the following year Hugh and Dick Beilby, as members of a large combined South Australia/Western Australian team, discovered Cocklebiddy’s First Rockpile air chamber at the one-kilometre point, and also went about 100m on from the far side. Phil Prust, Dave Warnes and others also explored Murra-El-Elevyn around this time and found the first air chamber in that cave (pers. comm. Phil Prust, 1980s), and also some time in 1976 Peter Robertson and Lou Williams penetrated Dukes Cave in Victoria for a short distance before they were stopped by a restriction.

In early to mid-April 1977, Phil Prust, Peter Stace, Ron Allum and Al and Jo Grundy et al found another 350m in Cocklebiddy (totalling 1,520 kilometres) and they also further explored and surveyed Tommy Graham’s, Weebubbie and Murra-El-Elevyn caves using RDF equipment which was reportedly designed by Ron Allum. Later in 1977, Hugh Morrison, Simon Jones and Steve Sinclair undertook a 7-hour multi-cylinder dive to around 2100 metres in Cocklebiddy, and as Hugh explained to the author in a letter in March 1992, it was during this dive that he “…first used a sledge which Simon made from PVC tubing”.

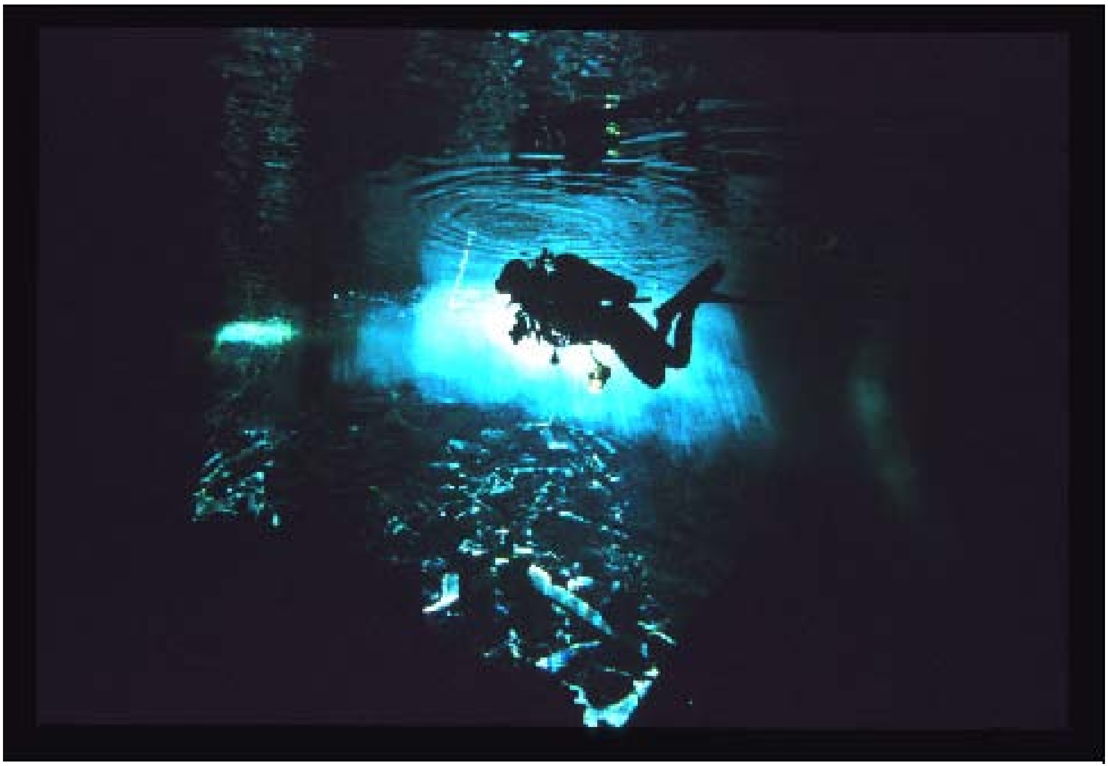


In early 1978 South Australian cave divers Peter Stace, Phil Prust and Ron Allum continued from earlier Tasmanian explorers and discovered more than 1.4 kilometres of arduous, dirty and very cold (4-6°C) passage in a number of different cave systems, especially in Kubla Khan, where a major breakthrough occurred. Also that year, Ron and Phil returned to Cocklebiddy and added yet another 300m or so to this enormous cave. In addition, Peter Stace and Ian Lewis checked out a number of “new” sinkholes in the Mount Gambier area including Woolwash Cave, Rubbish Cave, Horse and Cart Sinkhole and Tea Tree Sinkhole, for potential dive sites for CDAA-qualified divers, and Ian and Peter spent much of their dive-time undertaking and drawing-up the first reasonably accurate surveys of the known popular sinkholes and caves of the region for their ground-breaking book, “Cave Diving In Australia”, which they published in 1980.

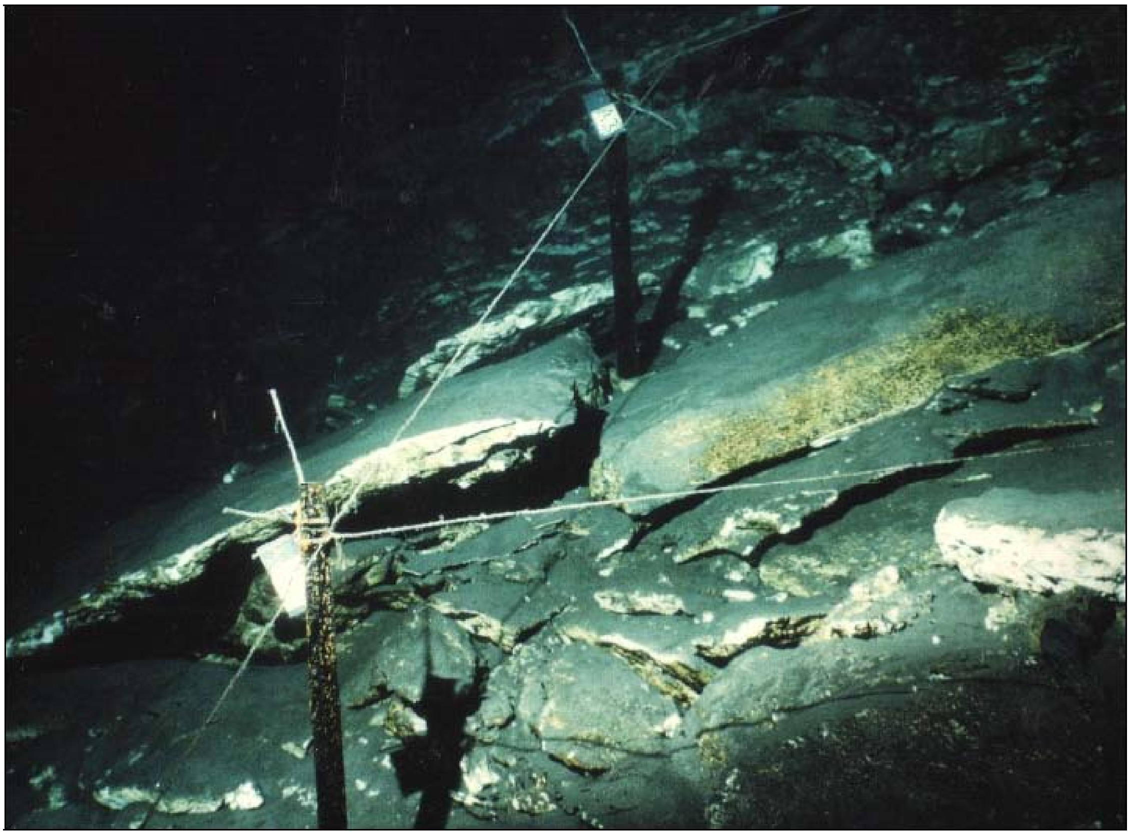


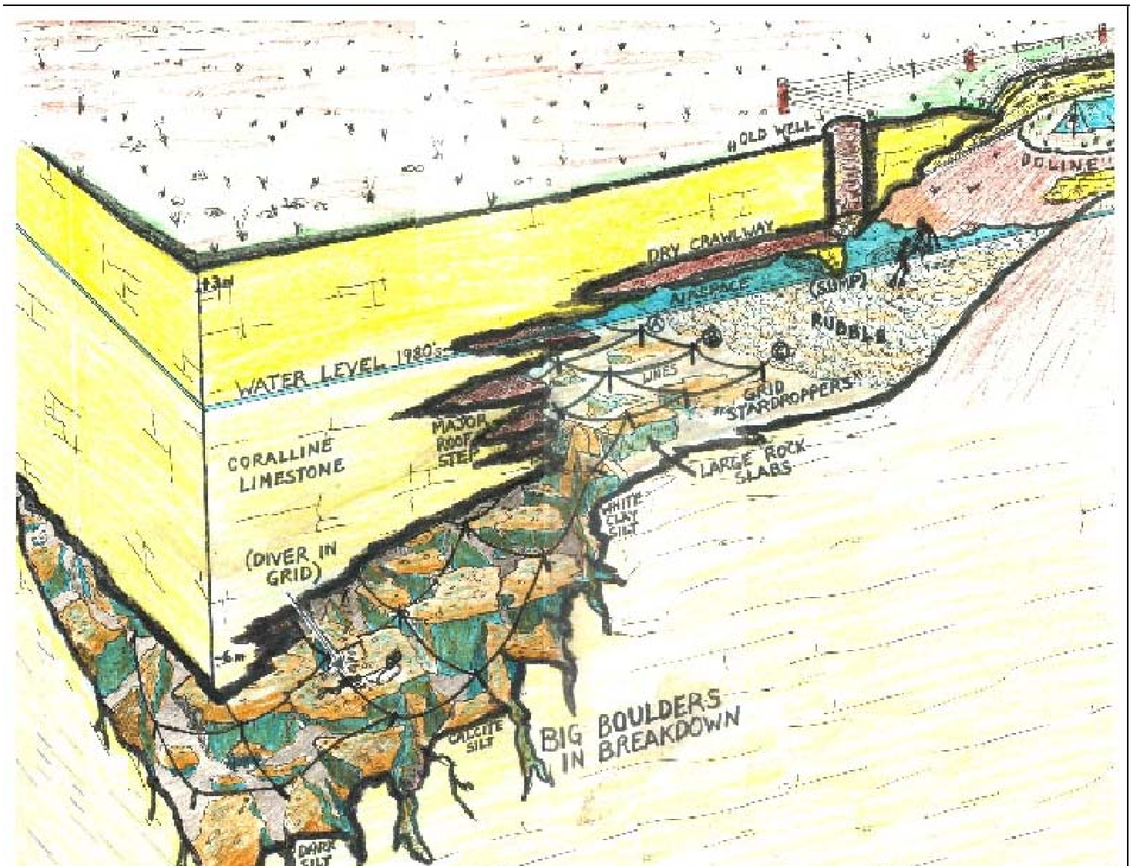
In early 1979, Hugh Morrison was involved in yet another Cocklebiddy push, this time using much more sophisticated sleds which could hold 15 scuba cylinders; they also ran a telephone cable out to the First Rockpile and reached a penetration distance of some 3,150 metres. Meanwhile back in Mount Gambier again, Robin and Martin Garrad, Clive Mills, Richard Stanton, Keith Evans, Peter Rogers and Jenny Hiscock, working with Flinders University's palaeontologist Dr Rod Wells, set up a complex star-dropper survey grid in Fossil Cave, and they subsequently recovered hundreds of important bones of extinct Australian animals.

Fossil Cave as it appeared in 1979 (photo by the author).



Just inside the entrance lake (courtesy Andrew Cox, mid-1980s). The star-dropper grid (courtesy Mark Nielsen, 1986).





3D perspective cutaway sketch showing the general layout of Fossil Cave and the survey grid (by the author, not to scale!)

During this period there were also a number of other important explorations and discoveries in the Mount Gambier area; the Eastern Side of Engelbrechts Cave was revisited for the first time since 1964 and more thoroughly explored by Phil Prust, Peter Stace and Ron Allum (resulting in the discovery of the large air chamber there – the first such feature ever found in a Mount Gambier water filled cave), and in May, the unstable, silty and very restrictive Western Side's entry lake was pushed by Ron Allum, who surfaced soon afterwards, reporting that he couldn't see a thing, but also that apparently it "went"! Phil and Peter were also the first to discover the 100m-long main passage on the Western Side but they didn't look up, and it was during a later dive by Ian Lewis and Terry Reardon that they discovered the large air chamber there, along with the other flooded passages leading off from it. The horrible northwestern extension of The Swimthrough and the underwater regions of The Three Sisters were also explored for the first time by members of this group during this period; these were the first dives since the cave had been sealed in the 1960s as a result of extensive pollution which had been caused by a local abattoir in days gone by!

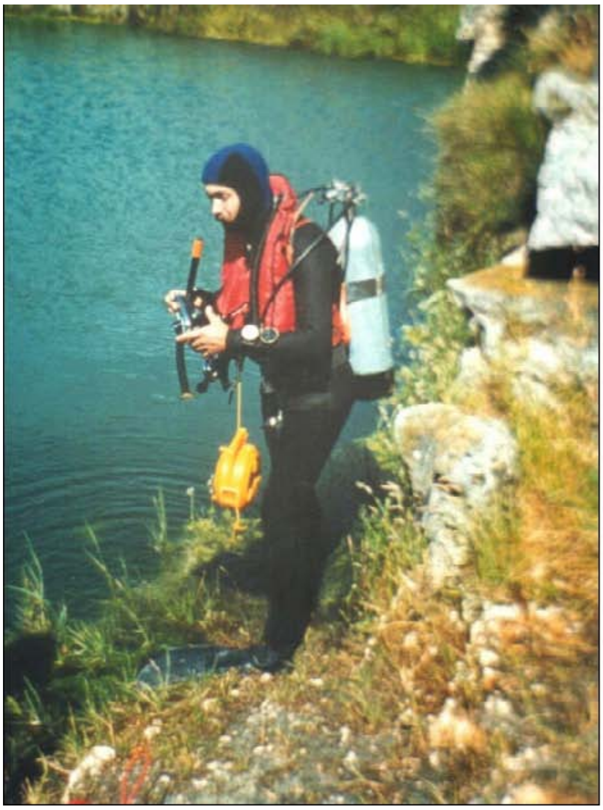
At the end of the 1970s a number of significant discoveries were made in the Jenolan Caves system by a team including Ron Allum, Phil Prust, Ian Lewis, Terry Reardon, Robin Garrad, Jenny Hiscock and Peter Rogers, with many of these occurring in Mammoth Cave (Ice Pick and Slug Lake), Imperial Cave and "Sump 7", which was reportedly "very nasty, silty and with nil flow", while in Tasmania, Frank Salt and Peter Cover discovered a major air chamber and passages in Union Cave and also explored My Cave. Around the same time Stuart Nicholas, Nick Hume and Rolan and Stefan Eberhard undertook a number of explorations in the Junee-Florentine Master (Cave) System. And cave and sinkhole diving in the Mount Gambier region was once again becoming a very popular pastime.

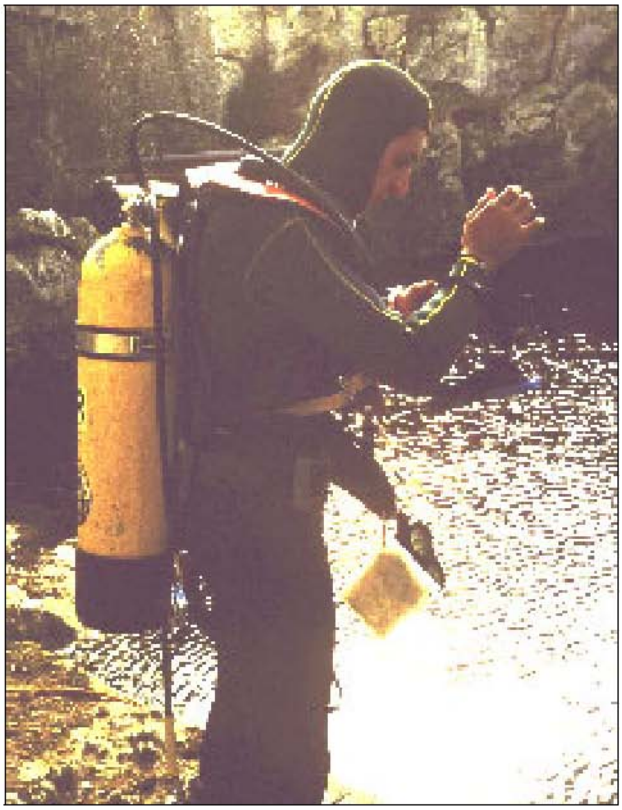
The 1980s – An Explosion of Research and Exploration Activities.

With the commencement of the 1980s came a flood of innovative new diving technologies including better-quality buoyancy systems and more powerful and reliable underwater lighting equipment (especially in America), and cave diving explorations continued not only in South Australia and the Nullarbor but in other States as well. However the vast majority of Australian cave diving activities still occurred within a 30-kilometre radius of Mount Gambier.

Typical gear of this era consisted of a 5mm or 7mm neoprene wetsuit and hood, a heavy weightbelt, a single 72 cubic-foot steel or 88 c/ft aluminium compressed-air scuba cylinder (the author also used a "slingshot Y-valve" configuration on one cylinder so that two regulators could be attached separately), a main regulator and an "octopus" regulator on a tether or neck-strap (in the author's case again, also with a nylon stocking fitted across the mouthpiece to keep silt and rubbish out!) as well as a scuba-feed hose and tank contents/depth gauges, and divers also often carried a large (often home-made) lead-acid battery pack and hand-held torch (the more flashy ones being of the sliding test-tube variety, but most were fixed-beam monsters). Although Fenzy-style inflatable buoyancy vests were all the rage in the mid-1970s, cave divers soon learnt about their limitations in cave environments (they were not good for holding a diver's body in a horizontal position), and back-pack or jacket-style buoyancy systems then became more popular, as did other brands and styles of 'horse-collar' vests (with their CO_2 cartridges removed and plugged, and the neck regions wrapped in tape to minimize upper-body lift when the vest was inflated).

The first inflatable dry suits also began to enter the cave diving scene around this time, and helmet-mounted lights (although long used by cavers and divers in Europe) were first introduced in the Mount Gambier region by the author in 1983 as a simple "hands-free" underwater research and surveying light source after pinching the idea from visiting French cave divers! Such ugly-looking contraptions initially evoked cries of derision from some of our more respected "old-time cave divers", as these early versions were little more than simple low-powered reference lights; the more powerful "standard" helmet-mounted systems which were to later adorn cave divers' heads only came into being several years later, almost as an adjunct to the concept of twin-independent scuba cylinders.





The author and Mark Nielsen demonstrating some of the typical sinkhole-diving gear of the late 1970s at Ela Elap sinkhole: modified Kambrook electric cord reels used as guideline reels, horse-collars vests (again somewhat modified) and single cylinders with J-valve reserve mechanisms were still in common use.

During this period, the author became interested in underwater cave mapping and research work, and in 1980 he collected a range of water samples at various depths from a variety of sinkholes and caves to enable them to be assessed for contaminants such as nitrates and pesticides. Then on 26 January 1981, he stumbled upon some unusual centipede-like animals during a visit to Fossil Cave, so he collected a few and took them to Wolfgang Zeidler, the Curator of Marine Invertebrates at the S.A. Museum (just seeing the jaw-dropping shocked look on Wolfgang's face when he was presented with living specimens of a supposedly 200-million-year extinct beastie was well worth the effort of bringing them back to Adelaide!). Wolfgang went on to formally describe and document the creatures which turned out to be a rare type of crustacean known as a syncarid (species Koonunga crenarum as named by Wolfgang), and this simple discovery proved that even basic investigations into the underwater speleological world had not yet been undertaken properly to that time.

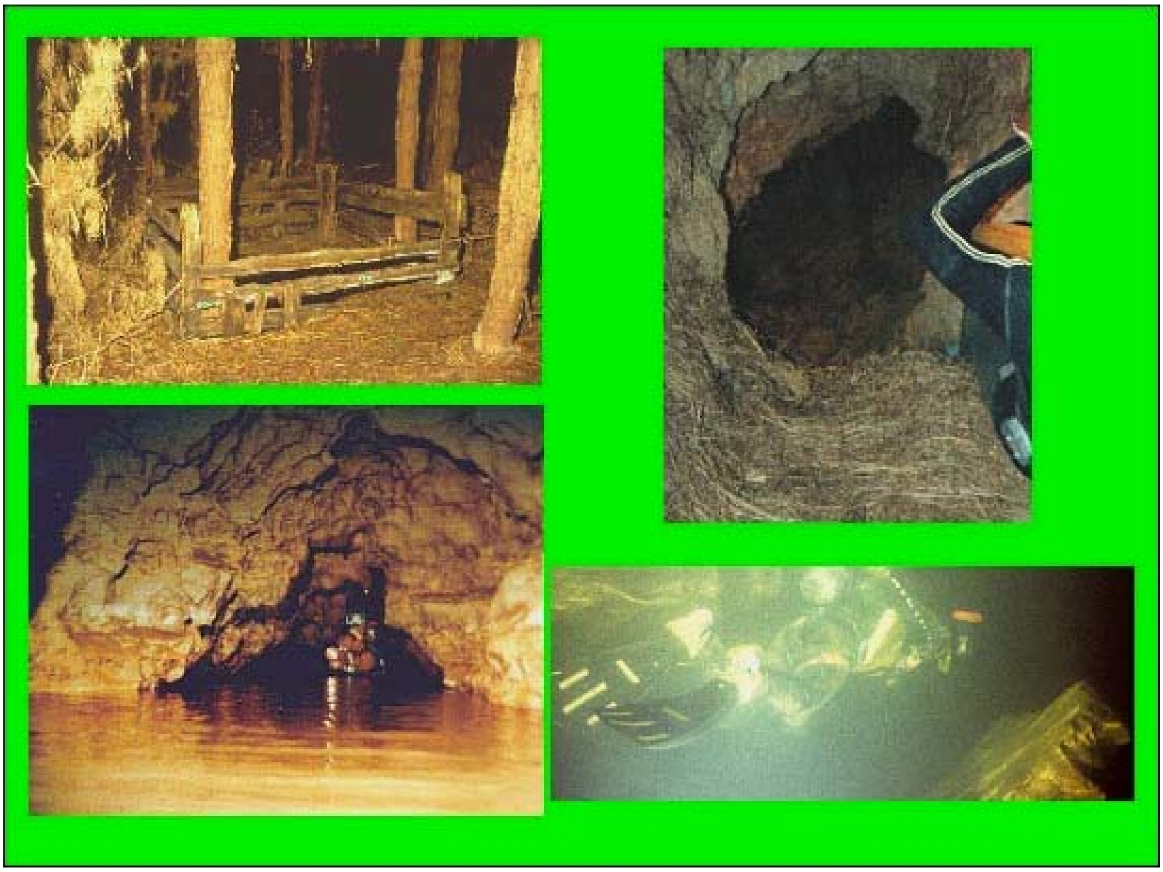
Syncarid found in many of Mount Gambier's caves and sinkholes (courtesy Michael Hammer).

Inspired by this discovery, the author decided to continue along the research line by collecting information about everything unusual that he found in the caves and sinkholes he was exploring around the Mount Gambier region. One area which he especially felt needed greater understanding was the general underwater environment of the sinkholes, so in March 1981 he and Mark Nielsen commenced a year-long, 3-monthly study of the temperature structures of four of the larger sinkholes, One Tree, Ela Elap, Ten-Eighty and The Black Hole. This project resulted in some very interesting findings, and also confirmed that Ela Elap at around 11 degrees Centigrade was indeed the coldest known waterfilled feature in the Mount Gambier area (most of the others were around 14-15°C, although Little Blue Lake went down to 12°C on one occasion; even the 'notoriously-cold' Ewens Ponds and Piccaninnie Ponds hover around the relatively-comfortable 15-16°C mark).

The author recording temperature readings of 11 degrees C at the bottom of Ela Elap while a dive buddy illuminates his slate; a few years later the author put some very basic "Aquaflash" torches on a canoe helmet so that he could write in the dark and read mercury thermometers etc. without needing such additional lighting assistance (courtesy Mark Nielsen, 1981).

The same month that the author and Mark Nielsen commenced the water temperature study of the sinkholes they also explored a feature known as 5L179 near Hells Hole, initially finding a chamber with potential leads running off. Over the course of the next couple of years various rock-shifting efforts enabled the author and others to negotiate one obstacle after another until finally in January 1984, a small, circular lake was seen at the bottom of a narrow vertical fissure, some 30 metres below the ground surface. The author dived this lake in July 1984 using a waist-mounted 16 cubic foot scuba cylinder which allowed him to spider-crawl down the fissure with both hands free before dropping the final two metres into the water, and investigation of this lake revealed a 4m deep flooded passage which contained spectacular white "hanging drapes" of something like the bacterial colonies found in underwater passages in various Nullarbor caves along its 20-metre length. Later in September that year the author also took Dr Keith Walker of Adelaide University's Zoology Department to some of the larger sinkholes where they collected and identified a variety of important and unique specimens.

In February 1981, Nick Hume and Stuart Nicholas undertook their initial exploration of Wolf Hole in Tasmania, and also around that time Pannikin Plain Cave was explored to about 400 metres by Ron Allum, Terry Reardon and Peter Rogers before shortly afterwards being pushed to about 600m (to near a rockpile) by Phil Prust, Jenny Hiscock and Russell Kitt. Far North Queensland's Camooweal area was also visited and assessed for the first time in 1981, when Ian Lewis, Dave Warnes, Terry Reardon and Karl Lengs undertook the first dives in the caves in this area; unfortunately they were not able to make any major discoveries at that time. Around October to December, Nick Hume and Rolan and Stefan Eberhard undertook further major explorations in the Junee system in Tasmania, and during early January 1982, the author accompanied Peter Stace in a check of various features around the Mount Gambier area.



The rediscovery of “144” and the subsequent first explorations of the water-and-airfilled passages underneath a young pine forest (courtesy Peter Stace, Mark Nielsen and Andrew Cox, 1980s).

A number of discoveries were made but the most significant of that trip was what they called “One Forty-Four” or “The Airport Cave” (later known as Sheather’s Cave after a former landowner). This quite extensive horizontally-developed phreatic cave system ended up producing more than half a kilometre of virgin passage (including some interesting sumps!), and it was a totally unexpected discovery considering its location in the relatively thin limestone near Mount Gambier’s aerodrome. This once again showed that there were undoubtedly still many other major Mount Gambier cave systems still awaiting discovery! Within the next few months the author and Peter Stace also undertook the first-ever mapping dives at a number of other little-known sites, including Benara Sinkhole and Bungalow Bay Cave.

‘Best-perspective’ view of “Kambrook-reel-kid Puddles” during early explorations in “One Forty-Four” (courtesy Mark Nielsen).

A Brief History of South Australian Cave Diving ***Peter Horne***

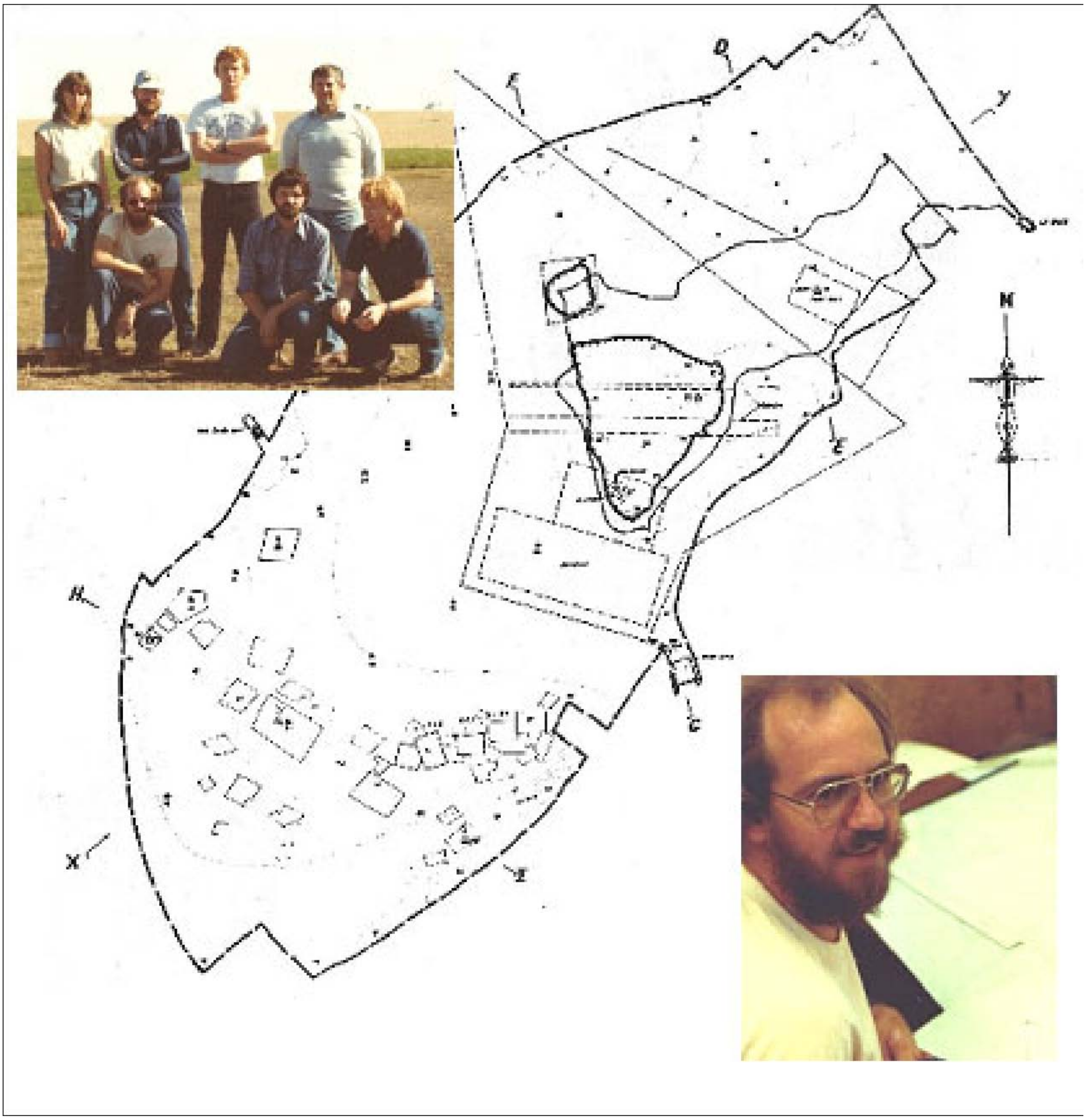
In March 1982, Glen Netherwood, Peter Ackroyd and Alex Kariko used British-style side-mounts and surface-fed lines to explore a very tight, silty sump in M-4 Cave, and in September Hugh Morrison led another combined SA/WA team to Cocklebiddy Cave, resulting in the discovery of Toad Hall, which was explored to the lake on its far side – an extra 500 metres, to a world-record penetration distance of 4,100 metres. Also that year Chris Brown pushed from the 600 metre point to 780m in Pannikin Plain Cave with Phil Prust (using triple cylinders) and found an air chamber; Phil also made a major discovery in Murra-El-Elevyn (with Chris, Ron Allum and Peter Rogers) resulting in a 300% increase in known cave passage.

Around this period Ian Lewis also pushed the small cave in the Third Pond at Ewens to a depth of around 20 metres, where a fierce outflow and very tight flattener passage at an “interesting cross-jointed aquifer outlet” prevented further exploration (Ian’s words as related here don’t really indicate how difficult it was to squeeze along the restriction with his hand-held scuba tank flapping behind him and his mask pushed so hard against his face that he thought his eyeballs were going to pop out!). Also in December 1982, the author and Mark Nielsen checked out a number of nasty little features including The Bullock Head Cave, where the joys of swimming through rolls of rusting wire and rotting garbage really need to be experienced to be appreciated!

(left photo) The author and Peter Stace after a duckweed-covered grovel in Sinkhole 5L145, (courtesy Barbara Stace) and (right photo) Enjoying the thrill of sliding through the rubbish in Bullock Head Cave – one reason why the author is also known as Peter “Puddles”! (courtesy Mark Nielsen)

Ah, there’s nothing quite like the security offered by the modified Kambrook electric-cord reel and a powerful 12-watt Dacor UL-700 torch! (courtesy Mark Nielsen).

More formalised cave research appeared on the scene in Mount Gambier in early 1983, when Peter Stace, Robin Garrad, Jenny Hiscock and the author formed the core of the CDAA Research Group (the brainchild of Peter Stace), which became a formal subcommittee of the CDAA in March. This rather hurriedly-formed group undertook the first major underwater mapping and general assessment of an Australian sinkhole at Kilsbys Hole over a period of just two weekends, and this also served to re-open access doors which had been closed since the 1969 dual-fatality there.



The Kilsbys Hole mapping team, a draft of the final map and project coordinator Peter Stace caught off-guard by the author (bottom right).

The Kilsbys Hole research party (L to R) – Peter Girdler, Ian Lewis (the one with the cute yellow ducky-fins!), Robin Garrad, Martin Garrad, Jenny Hiscock and Peter Stace or Phil Prust (one or the other!) Note all of the floating support platforms and other gear which covered the lake's surface during those years (photo by the author, 1983).

Back at Dalley's Sinkhole in April 1983, Glen Netherwood and Peter Ackroyd explored a 14m sump and discovered a large cavern, and from April to July Nick Hume, Stefan Eberhard and others explored the Junee system again, along with Welcome Stranger.

Between March and August, the author in the company of Mark Nielsen and Andrew Cox undertook a range of explorations in various "fissure caves" and other features in the Mount Gambier area, and during these grovels one chance photo happened to highlight an unusual wall feature which nobody in our party realized was an ancient petroglyph which may have been as old as 20,000 or more years. Soon afterwards the author took various petroglyph experts around the caves of the South East and a number were found to contain these rare and important archaeological artefacts which some believe were carved by the very ancient "Tasmanoid" people, the predecessors of today's Aboriginal people who subsequently settled Australia (pers. comm. Dr Neil Draper, Aboriginal Heritage Unit, Dept. for the Environment circa 1985).

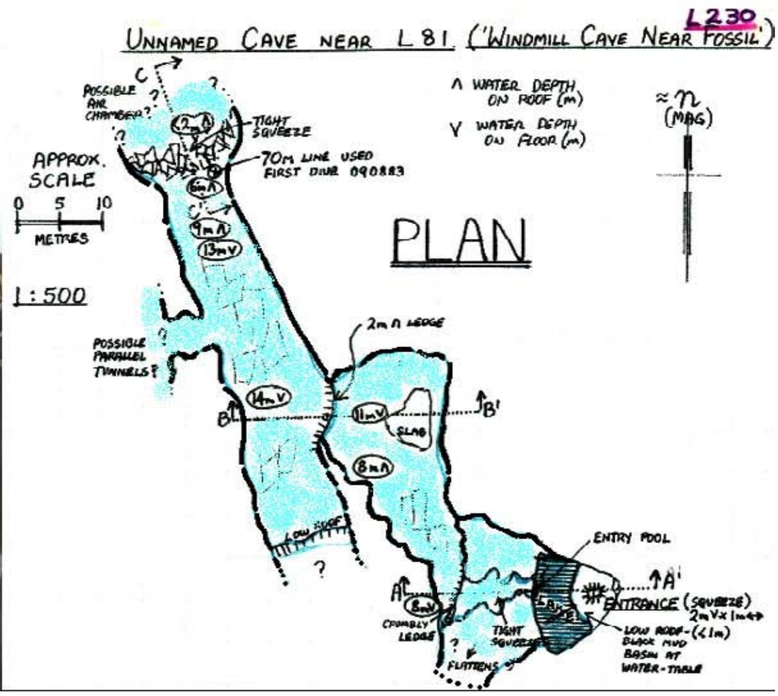
Site of the discovery of the first major “petroglyph” wall markings in 1983; an accidental finding which occurred while the author (the diver with the yellow reel) and Andrew “Grovel” Cox were investigating a small deep pool of water there (courtesy Tony Hambling/Rino Dell’Antonio).

Close view of the most significant petroglyph, which was fortunately not disturbed by the bulk of the author groveling underneath! (courtesy Rino Dell’Antonio/Andrew Cox/Tony Hambling).

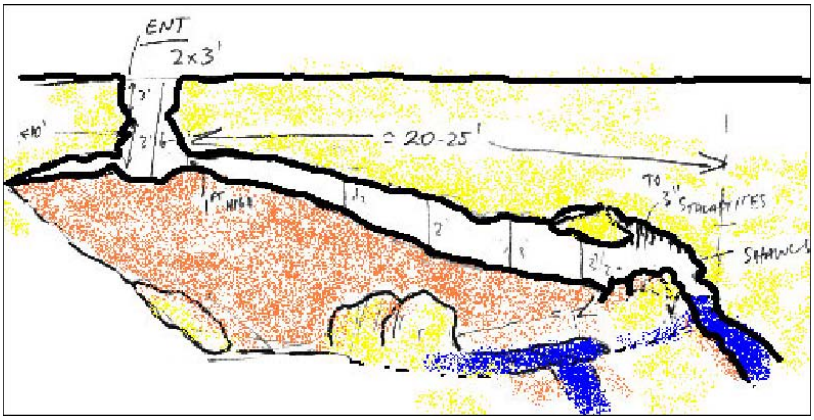
Other petroglyphs discovered by the author and colleagues in another Mount Gambier Cave (courtesy Richard Harris).

One of Mount Gambier's most important cave explorations took place early in the evening of 9 August 1983. While following up rumoured early dives mentioned by Peter Stace and others over the years, and under a dead-quiet, star-filled sky, the author and Mark Nielsen dragged their dive gear across a paddock to a forbidding little hole hidden underneath a large overturned concrete tank which almost covered it. Pulling the planks of wood away they carefully squeezed through the narrow gap and one by one stepped the metre or so down to a ledge before stepping the final metre down to the floor of the cave. One at a time, they squatted under the entrance so they could get into their tanks before sliding sideways through the 30cm-high gap into the shallow pool further in … they were completely unaware that they would shortly be sitting in that same (now-muddy) puddle, staring silently at each other in abject amazement – not through shock caused by the dripping-wet cow-poo and mud in which they were covered, but as a result of realising that they had just explored one of the most awesome and picturesque flooded passages they had ever seen, after bumping their way through what they had earlier believed to be just another unlikely muddy grovel in a narrow and unstable submerged rockpile! Thus "Tank Cave" (as the author unfortunately rather boringly named it) entered the cave-diving arena.

Although "the windmill cave" had long been rumoured to be some kind of dive, nobody had ever reported finding the 100 metres of so of spectacularly-clear and completely unmarked passage that the author and Mark had just explored, and Mark returned a few weeks later with another diver to explore further. Unfortunately with the limited access and poor lighting gear of that time, no further explorations were made after that second dive, and attempts to lease the paddock to enable the digging-out and stabilizing of the entrance were unsuccessful. The author then moved on to his many other projects and passed on the discovery to Phil Prust, Chris Brown and Paul Arbon a couple of years later for their "possible interest" in pursuing the difficult access arrangements, in the mistaken belief that the cave did not really have much potential anyway (hundreds of much more thorough explorations since that time subsequently resulted in the discovery and surveying of more than 7 kilometres of spectacular waterfilled passages which run under virtually the entire paddock)!



The original entrance to Tank Cave (photo by Mark Nielsen, during the second trip there) and the first sketch by the author from the first dive.



Author's sketch of the original entrance showing the ceiling just a foot (30cm) above Tank Cave's muddy, cow-poo-covered floor.

One of the hundreds of fascinating and very beautiful passages in Tank Cave (courtesy Neil Vincent, 2006).

A Brief History of South Australian Cave Diving *Peter Horne*

European-style cave diving techniques and philosophies reached South Australia in September 1983, when French divers Francis and Eric Le Guen (assisted by Veronique Borel, Jerome Krowicki and Sylvie Goutiere) visited the Mount Gambier area before heading out to Cocklebiddy Cave to set a new world penetration record of 6,000 metres there. Prior to this visit no Australian teams had ever considered the exploration of Cocklebiddy in a competitive light, and considering the hospitality which was extended to them by Adelaidian cave divers many people were extremely offended by the way in which the French subsequently boasted about how they had "broken the Australian record" when it had never been a competition in the eyes of the locals.

1983 French "Nullarbor Expedition":
(l-r) Eric Le Guen, Veronique Borel, Sylvie Goutiere, Jerome Krowicki (sitting) and Francis Le Guen (*People* magazine 5 Dec 1983)

Consequently, just over a month later, a large Australian team including Ron Allum, Peter Rogers and Hugh Morrison broke the French (and thus the world) record when Hugh used a single cylinder to squeeze some 240 metres further along a very narrow and silty passage – an astounding display of courage, considering the fact he was alone, with no backup cylinder … and 6 kilometres from the entrance!! During that trip Chris Brown and Phil Prust also pushed Pannikin Plain Cave to 1,070m and explored 130m or so of a lower section of Warbla Cave; they also explored Warbla's second air chamber for the first time during that trip.

In October and November 1983, Stefan Eberhard, Nick Hume and Peter Clover undertook exploratory dives in the Trowutta Arch and Kubla Khan systems in Tasmania, including making a thru-dive in Kubla Khan, and between March and June 1984 a lot of other Tasmanian progress occurred including further major explorations in Union Cave by Rolan and Stefan Eberhard, more Junee explorations by Nick Hume and Attila Vrana, and Rolan Eberhard's pushes in Pendant Pot/Growling Swallet where he penetrated a 15m tunnel which joined the systems together.

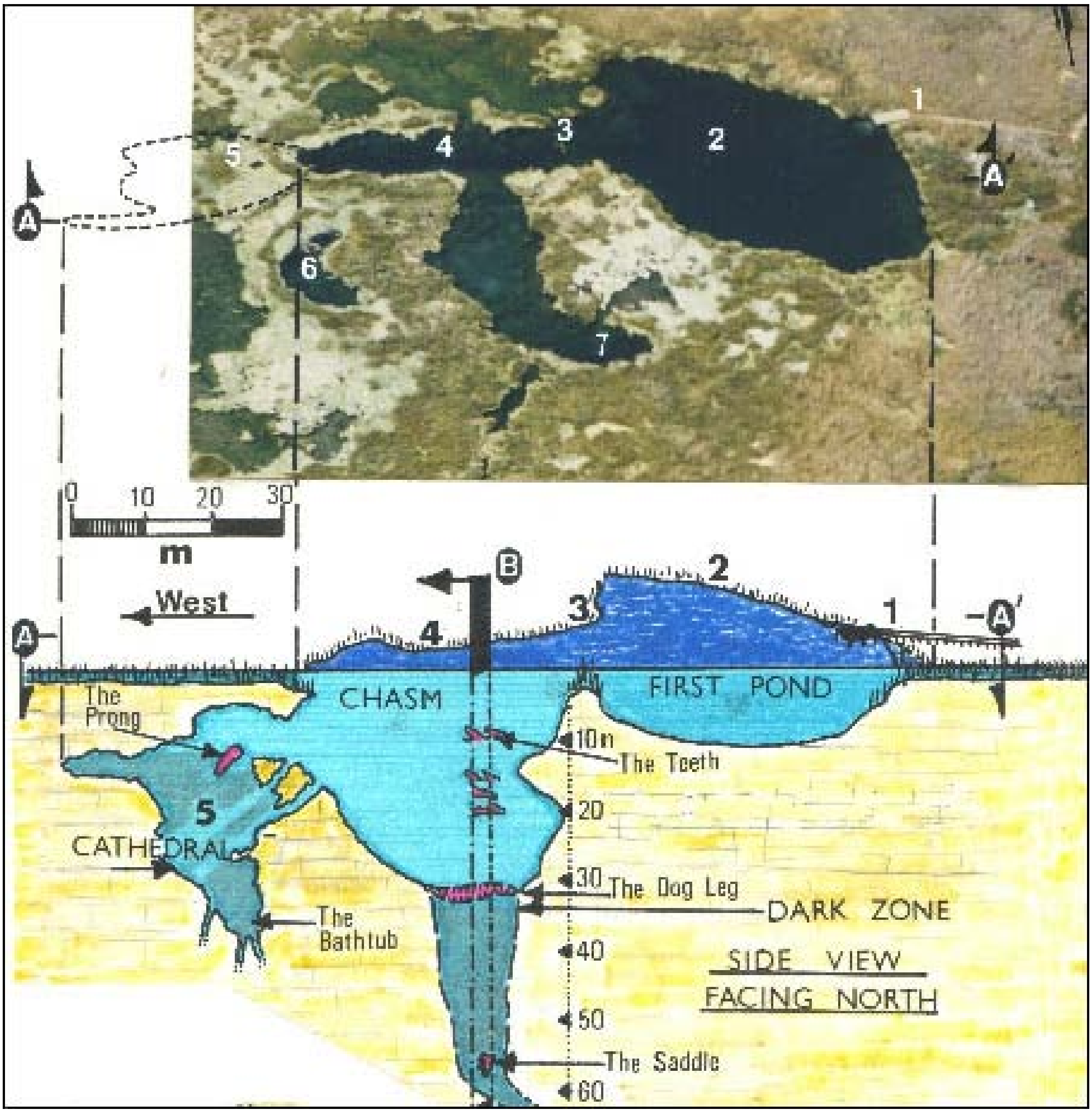
In early 1984 local Mount Gambier crop-duster pilot and diver Peter Blackmore, in the company of Phil Earl and Danny Quintel, discovered Iddlebiddy Cave – a flooded single-passage system some 250 metres in length (unfortunately the discoverers chose to keep its location a secret for many years; it was accidentally found by the author later through a bizarre coincidence involving a forestry worker). Later some skull fragments from a young person, possibly aboriginal, were found in the flooded entrance chamber, making this the first waterfilled cave in the area known to contain human remains. In February, after months of negotiations, the first survey of The Shaft commenced; the dive team was selected by the author, Peter Stace and Phil Prust, and this project also served to open the door to more general access to this site for the first time in 10 years (with the much-appreciated support of the landowners, Mr and Mrs Viv and Jean Ashby, and their son Robert).

Photo showing the relatively high water level in The Shaft during the 1984 project – the surveyors including Chris Brown (left), Andrew Cox and the author (with the funny hat) were all able to very comfortably utilize the ledge (which is these days several metres above the water) to prepare for their dives with the other team members (courtesy Paul Arbon, 1984).

The wonderful Ashby family – Betty Jean, Robert, Trevor and Bertram 'Viv'; sadly Jean and Viv are now deceased (courtesy the Ashbys, 1980s).

In April 1984, the sixth tragic diving accident occurred (in Piccaninnie Ponds yet again), involving two divers who drowned at about 60 metres after becoming entangled in their line in the Dog Leg. The fact that they broke several key rules (not the least of which was one diver's total lack of cave diving qualifications) again highlighted the importance of the CDAA's role in cave diving issues, and fortunately for the diving community the "killer sinkholes" outcry of yesteryear was not repeated this time. This accident also appeared to have been largely caused by the guideline becoming snagged in a non-standard waist-mounted snap-hook which could not be disentangled by divers affected by nitrogen narcosis and in zero-visibility conditions.

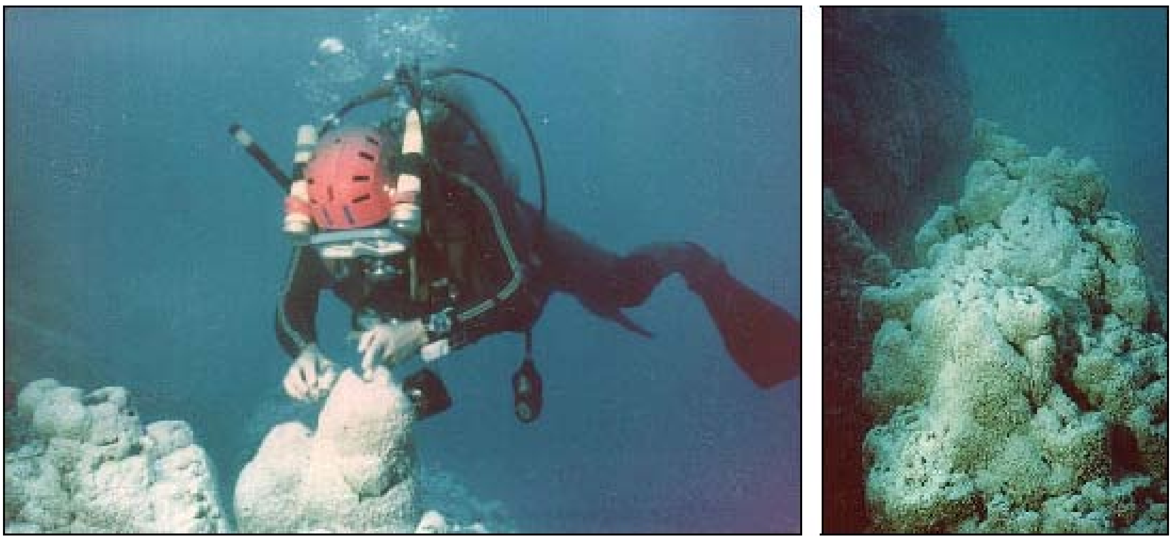
In May 1984, Chris Brown reported finding an interesting passage of about 40m penetration behind the rockpile in The Pines with Paul Arbon, and in August Chris and Paul, along with Phil Prust, checked out the many virgin side-tunnels past the 720m mark in Pannikin Plain cave. Then in November, the author commenced the CDAA's Piccaninnie Ponds Research Project, when the first lines were laid in the cave system. This project resulted in the production of a high-quality map of The Cathedral and main Chasm areas of this famous feature.



Combined photo/cutaway sketch representation of the main Piccaninnie Ponds system, based on the CDAA Research Group's mapping project which the author coordinated there in 1984 (sketch by the author, photo courtesy Andrew "Grovel" Cox, 1983).

In January 1985, after many months of planning and hot on the heals of the 'Pics Project', the author commenced the Blue Lake Research Project – a week-long effort involving divers and scientists from such institutions as the S.A. Museum and the University of Adelaide, and the first of several such studies over the next few years. This project also provided the impetus for the author to invent a system of standardising underwater visibility observations, using a Secchi Disk – a simple but effective tool in many other underwater visibility applications. Although Blue Lake is a dormant volcano and not a karst feature, it nevertheless contains flora and fauna which is also found in many caves, as well as many other unique features such as enormous stromatolites – some of which sadly had to be sacrificed in the name of science!…

The Blue Lake is a very beautiful place in summer; the blue colour is actually a physical characteristic of the water itself and is replaced at around the 16m point by a foggy grey “mist” comprising small planktonic forms. In the above photos Wolfgang Zeidler passes a plankton net to the author and a diver holds a Secchi disk which when used with a fibreglass tape attached, served as an excellent horizontal-visibility indicator. In the shallows, it was never any clearer than around 20-25 metres, but at depths of around the 50 metre mark it dramatically improved and by 75m it could have been as much as 100m visibility, although it was too dark there to use the disk technique (the illumination across the flat, grey bottom of the lake looks very similar to a full moon on a white sandy beach at midnight). Photos by the author, Andrew Cox and Mark Nielsen.



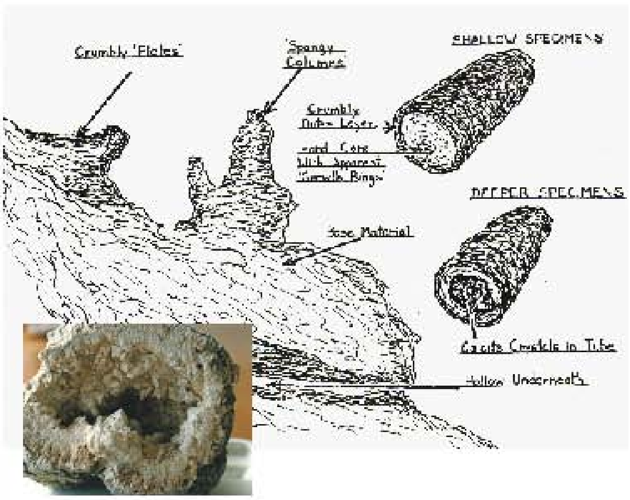
The author sampling a portion of the amazing “stromatolites” which were discovered in Blue Lake in 1985 (courtesy Mark Nielsen/Andrew Cox).

World first discovery in Blue Lake?

Editorial

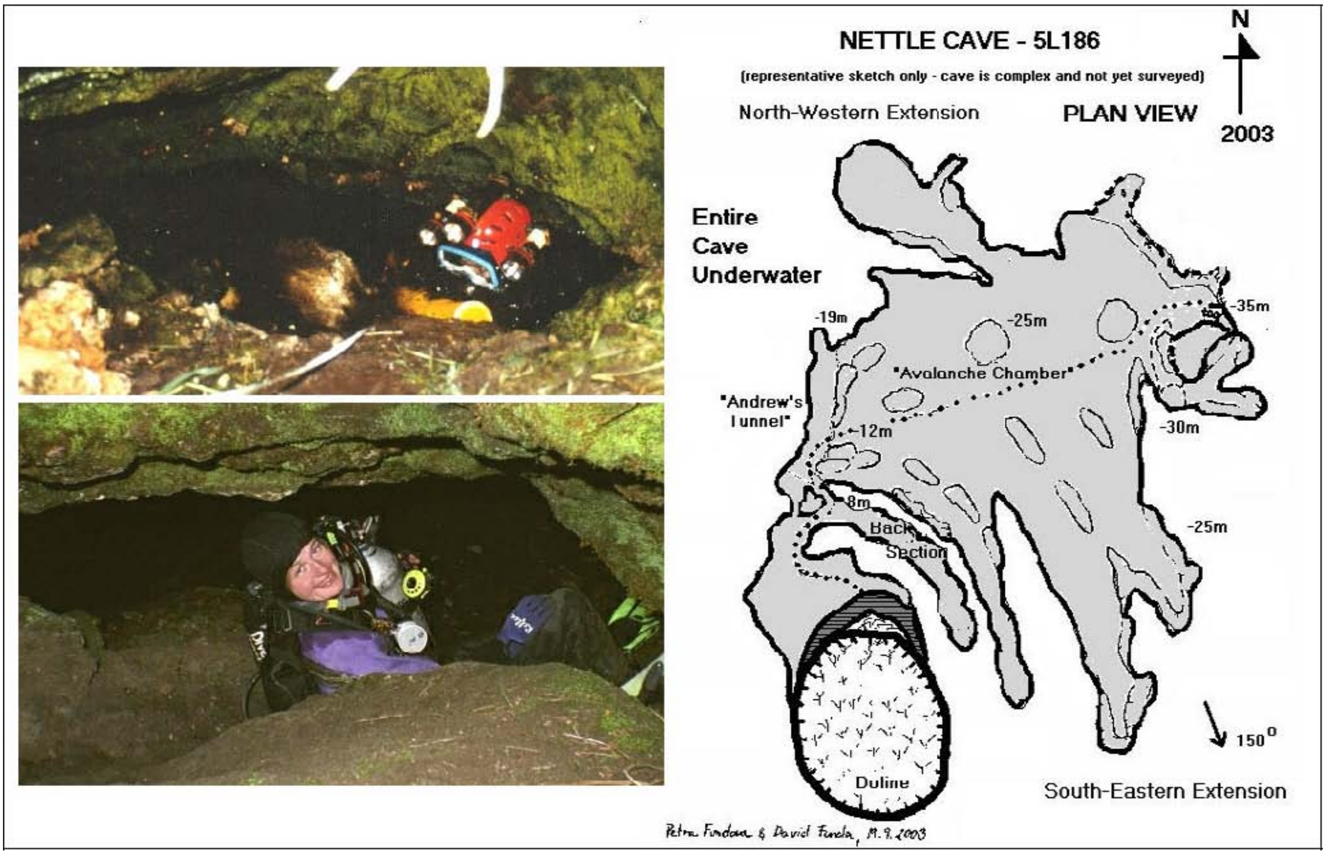
Divers make a find

300 acres burnt




TYPICAL "BLUE LAKE" WALL PROFILE
Warm surface water in summer (22°C)
20 metres visibility
Colder, grey, low-visibility plankton layer
(13-16°C, 3-5 metres)
Gloomy, colder & clearer water
(12°C, 30+-metres visibility)
20 metre high sheer limestone cliff
Gently-sloping grey, grainy-silt bottom
and golfball-like freshwater sponges
with accompanying hydroids

A few months after the completion of the January 1985 Blue Lake study, the author used one of Ian Lewis's small hand-held scuba cylinders to squeeze into an unnamed hole across the road from The Pines, reaching a maximum depth of just eight metres where a small silty restriction was found. This feature would later be called Stinging Nettle Cave and it would be pushed to around 30 metres deep by David Funda and Petra Fundova in 2003.



The author using a small hand-held cylinder to check out Stinging Nettle Cave in 1985 (top left) and the same restriction during one of Petra Fundova's dives in 2003 – what a difference a 2m water-level drop can make! (courtesy Dennis Tham and David and Petra Funda, 2003).

In October, Stuart Nicholas and Nick Hume explored the Coelacanth Extension in Tassy, and between November 1985 and June 1986 Nick also undertook more explorations in Pendant Pot and Mainline Sump.

In May 1986, the CDAA commenced its Engelbrechts Cave Mapping Project which was coordinated by Andrew Cox, and the following month Peter Ackroyd explored Confession Sump in Dukes Cave for some 18m to a restriction at a depth of six metres. He also re-opened a small hole in Whale Cave and explored 14m of nasty passage without fins, using only a small hand-held scuba cylinder. In August Chris Brown, Paul Arbon and Dennis Thamm organised the first sled-push party to visit Cocklebiddy Cave's Toad Hall since 1983 (and the fourth ever); it was also the smallest expedition to that point, and most of the known side tunnels were explored.

A typical Cocklebiddy Cave sled dive
(courtesy Ken Smith and Chris Brown, and the 1995 Toad Hall expedition team).

The author noting compass bearings and tape measurements in the Eastern Side air chamber at Engelbrechts Cave (courtesy Mark Nielsen, 1982).

In October 1986, the author formed a new research-oriented cave diving body, the South Australian Underwater Speleological Society (SAUSS) Inc. with a group of scientific and diving friends and associates, and the Society commenced the detailed mapping and study of a number of sites including more work in Fossil Cave, Gouldens Hole, The Pines, Blue Lake, Allendale Sinkhole and Ten-Eighty Sinkhole. Also in October the author participated in an exploration and assessment study of all known major drains and headsprings along the Mount Gambier coastal area with Lands Department's environmental officer, Mark Watson; these visits revealed that most sites required urgent protective measures to be taken. The following month the author and Chris Brown undertook an exploratory and mapping dive in Alleyn's Cave to assist with later access planning and negotiations; other divers involved in that project included Dennis Thamm and Richard Megaw.

SAUSS Project Number 1, in Fossil Cave, carrying on from where the original Flinders Uni teams left off in 1979 (photos by the author).

The main chamber of Fossil Cave, looking out; the boulders and a large portion of the line-grid can be seen in this photo (courtesy Ian Ploenges, 1986).

Flinders Uni researcher Cate Newton spreads the bones out to dry before transporting them back to Adelaide. One particularly stressful moment involved a large German Shepherd which a tourist brought down into the sinkhole while these 30,000 year old bones were all exposed! (photo by the author, 1986).

The author and Greg Bulling after a bone-recovery dive in Ten-Eighty Sinkhole, during which some important fossil material was retrieved including a Diprotodon femur (courtesy Peter Ginnane, 1986).

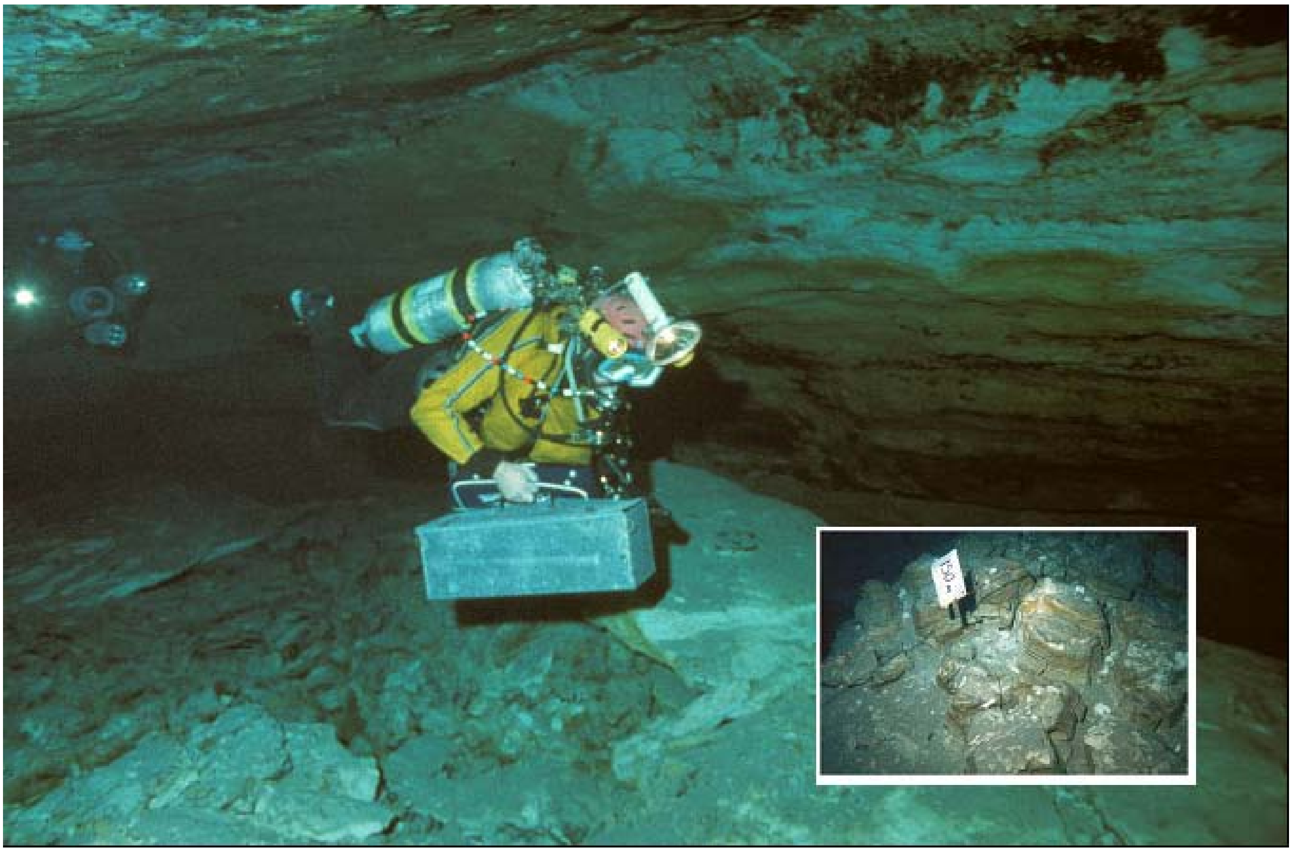
First light for this monster bone in many thousands of years!

The next event of significance known to the author occurred in Pannikin Plain Cave in September 1987, when Ron Allum and Chris Brown made yet another major discovery of 600 metres of virgin passage. Peter Rogers and Andrew Wight also discovered the Oval Room and several hundred metres beyond, to near the end of Mega Chamber. Three months later in December, Chris and Peter extended the cave for another 250m and found a collapse with a major lead beyond Mega Chamber. The author was also busy again during this period; in September he worked with Mia Thurgate to re-assess the coastal springs which he had visited the previous year with Mark Watson, and other features including Woolwash Cave were also assessed. Then in December renowned biologist Dr Thomas Iliffe from the Bermuda Biological Station for Research visited Mount Gambier, and with the assistance of the author and his associates Tom visited a number of important biological sites and collected a variety of rare troglobitic life-forms which he scientifically described back home later.

SAUSS projects ranged over a number of areas and subjects, as indicated by these photos (top left clockwise) – Tony Carlisle contemplating videography in The Black Hole, Chris Hales collecting water samples, the author after another survey dive and the survey tool jokingly called the Nielsenometer by the author after Mark Nielsen, who designed and built the unwieldy contraption! (courtesy various people).

In September 1988, Andrew Cox, Ian Lewis and Peter Blackmore undertook the first official CDAA assessment of Iddlebiddy Cave, and two months later the “Pannikin Plain Cave Diving Expedition” was organized by Andrew and Liz Wight. This was the first professionally-sponsored, hi-tech scooter-assisted cave diving expedition in Australia, and the team comprised lead divers Phil Prust, Ron Allum, Chris Brown, Paul Arbon, Peter Rogers, Rob Palmer (U.K.) and Wes and Terri Skiles (U.S.A.).

This exceptionally-skilled team pushed the cave to its known end ... and barely escaped from being entombed after a major collapse of the entrance during a flash-flood! This was also the first occasion when water and speleothem sampling of flooded Nullarbor caves commenced on a large scale, a project which was later to continue under the leadership of Dr Julia James (Sydney University). Two months later in November 1988, a combined team of CDAA and SAUSS divers including Andrew Cox, Greg Bulling, Tony Carlisle (video cameraman) and the author performed a research dive in Iddlebiddy Cave, and recommended that the site be opened to small parties of divers on an occasional basis.

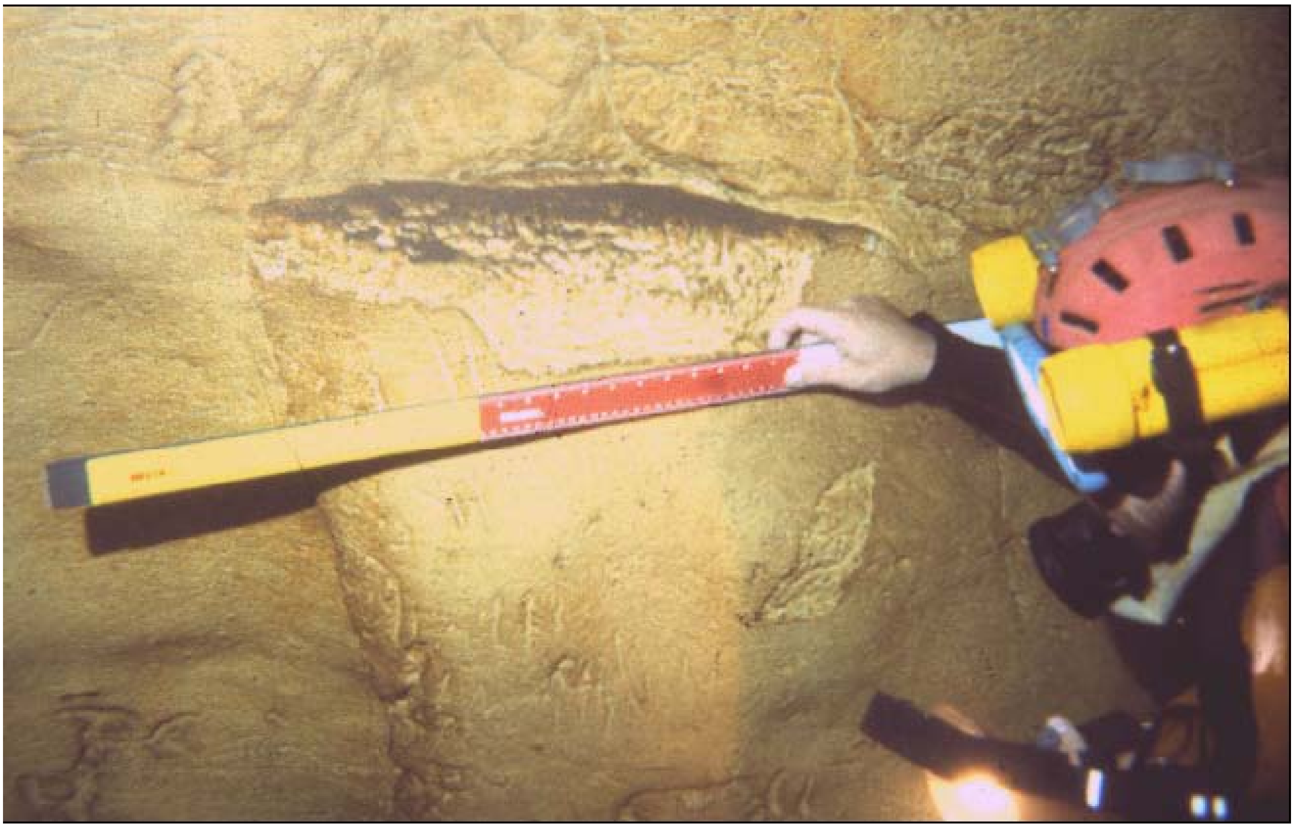


The author carrying a Fossil Cave "bone basket" through Iddlebiddy Cave; the basket was an ideal container for the sediment corers (one of which can be seen through the basket’s mesh in the photo) along with several large and very fragile glass bottles which were used to collect water samples for pesticide checks (courtesy Greg Bulling).

The following month the author coordinated a CDAA research project involving the assessment of the major sinkholes on Barnoolut, when about a dozen keen divers recorded the physical aspects of Bullock Hole, Ten-Eighty and The Black Hole prior to the re-establishment of regular diving activities after a two-year closure of the property. Also around this period, at Wellington Cave (Limekilns or McCavity Cave) in New South Wales, following reported efforts by earlier cavers during low-water under drought conditions, divers Simon McCartney, Keir Vaughan-Taylor and others explored the main waterfilled chamber of this impressive feature for the first time (pers. comm. Ernie Holland, Jenolan Caves, 1990s).

In May 1989 after a failed attempt several years earlier, Chris Brown and Phil Prust revisited Tank Cave and finally broke through into some of the major extensions, commencing the dives that would result in the discovery of several thousand metres of virgin passage in the next year or so (this project is still going on and to date has involved several dozen divers). In September, with groundwater pollution in the Mount Gambier area becoming topical because of a new copper-chrome-arsenate (CCA) plant being proposed, the author set up a short-term CDAA subcommittee called the “Water Quality Assessment Directorate” which involved the input of Ian Lewis, Maurice Parry and others. One high-nitrate site was located, but fortunately no significant detrimental discoveries were made.

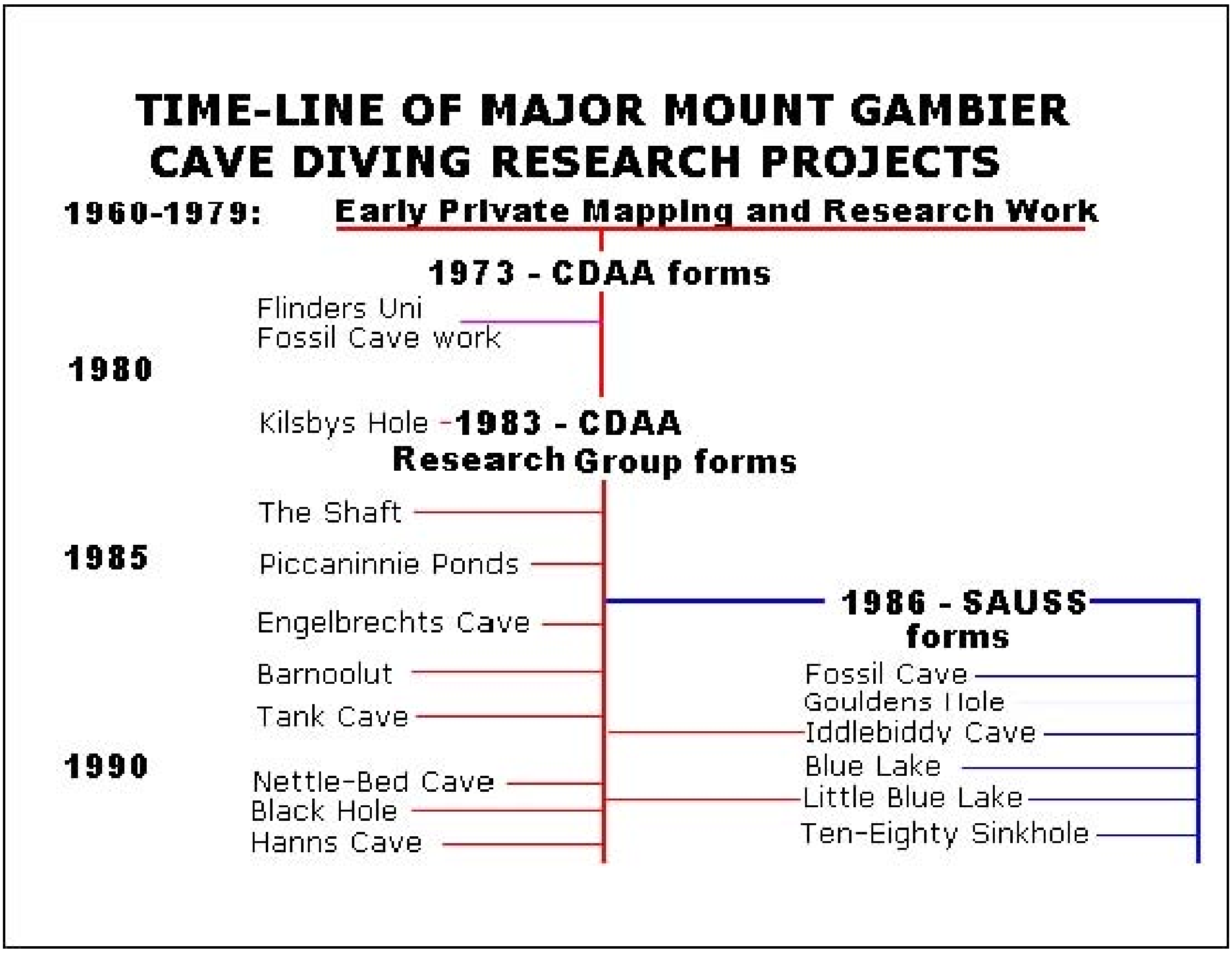
In January 1990, the CDAA Mapping and Research Group commenced its ninth research project, namely the exploration, mapping and scientific assessment of a new feature called Nettle-Bed Cave, around the same time that the Little Blue Lake mapping project also finally got off the ground after some five years in the planning. Nettle-Bed was discovered by Adelaide diver Grant Pearce (with the assistance of Chris Murphy) after he had removed some rocks at the other end of Mud Hole's collapse doline. The site exhibited possible human wall scratchings underwater along with probable mega faunal markings, and the presence of abalone and limpet "tucker" shells in the cave also indicated that considerable community and Aboriginal consultation and research planning was needed before recreational cave divers were able to safely gain access.



Suspected human markings in Nettle-Bed Cave (courtesy Grant Pearce).

The following month the author accompanied noted American cave diving researcher Jeff Bozanic to the "Bone Room" in Ten-Eighty Sinkhole, and in March 1990 Tony Carlisle and Greg Bulling produced an excellent videotape of Warbla Cave, enabling those who could never go there to see its underwater beauties for the first time. In April the following year, Tony and Greg also coordinated the first major videotaping and research/surveying dive to Cocklebiddy Cave's Toad Hall, using improved underwater tank/video sleds (this was the 5th team ever to visit Toad Hall). Later in 1990, the author worked with Andrew Cox (the Manager of the CDAA's Research Group) to undertake a series of exploratory dives in the sinkholes on Barnoolut Estate to determine which features might have been worth including in the CDAA's general access list, but unfortunately nothing was found to be suitable for recreational divers although some interesting scientific aspects and sites were identified.

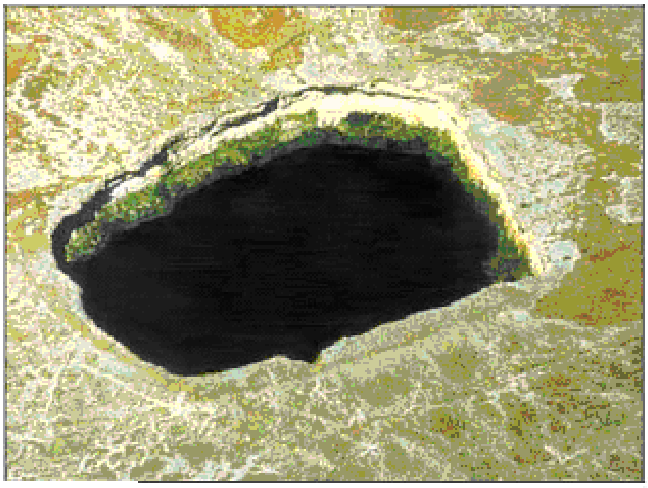
In the middle of 1991 the author assisted Mark Nielsen with the SAUSS mapping project he was running in Ten-Eighty Sinkhole, and in November Peter Ackroyd explored the Prayer Pool in Dukes Cave for several metres after abseiling directly into the water whilst wearing dive gear. This was found to be about 6m deep and some 18 metres penetration distance (sounds strangely familiar!).

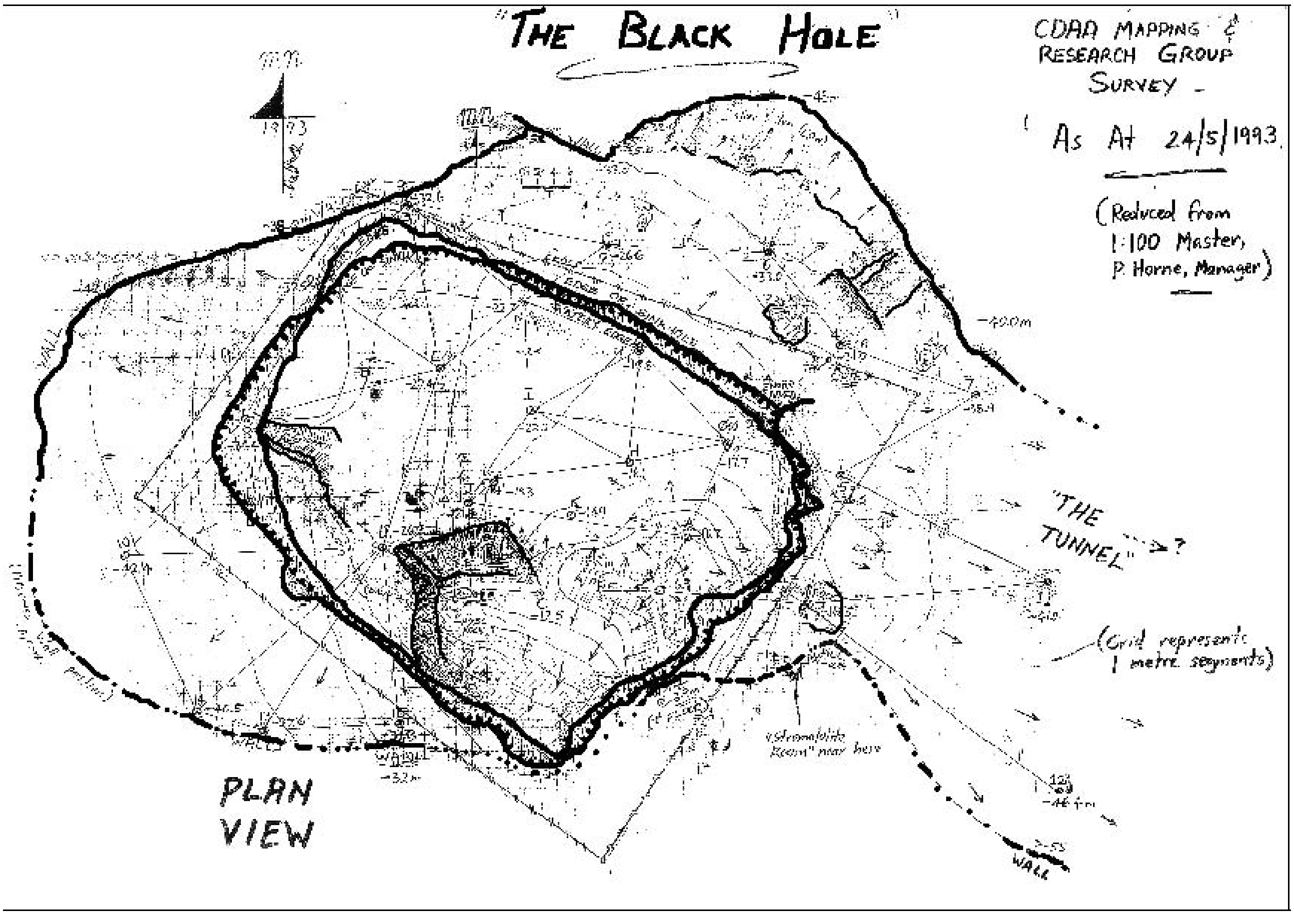


In 1992 a team of some of Australia's most experienced deep cave divers including Ron Allum, Chris Brown and Phil Prust dived to the 87 metre point, around 200 metres in from the entrance, in the Big Tunnel of The Shaft with world famous U.S. cave diving pioneer, Irby Sheck Exley, and years later other deep teams (again including Chris and Phil) would explore the very deepest regions of this awesome cave to around 125 metres on the opposite side of what was long believed to be the deep end and it is tragic that Sheck was to perish just two years after his Shaft visit without having known of these later discoveries.

The mighty Black Hole began to reveal its true nature in 1994 during the first stages of a detailed exploration and surveying project in the sinkhole; the study was coordinated by the author and only stopped when the property changed hands and the site was closed (and the air divers were working at depths approaching 50 metres). And in 1995, two new sites, Hanns Cave and Bakers Cave, were opened up to the general Mount Gambier cave diving community. The same year Chris Brown broke the world record in Cocklebiddy Cave yet again by reaching the apparent "real end" of the cave … but who can know for sure?

Various Black Hole photos by the author, Andrew Cox and Alex Wyschnja.





The Future

There have been many truly spectacular underwater cave discoveries during the past few years. With thousands of caves now known to exist on the Nullarbor alone, there is a great deal of fascinating speleology to be undertaken in this vast country of ours.

As prominent Western Australian cave diver Paul Hosie mentioned in a report dated March 2004, "after the last of the 'great' cave diving expeditions to push Cocklebiddy Cave occurred in 1994, things seemed to quiet down a little. We stood back and looked on in awe at the achievements of the Americans at places like Wakulla Springs, as well as the extensive flooded cave systems of Mexico … although cave diving still continued in New South Wales and South Eastern Australia, many subsequent visits to the Nullarbor revealed little in the way of exploration or new passages. Had it all been done? Was there nothing left to do but follow line?? Recent discoveries and a new generation of cave diving explorers are showing that exploration of Australia's awesome Nullarbor Plain has only just begun…".

In 1997, Paul, with fellow cave divers Andy Nelson, Craig Challen and Karl Hall dived all of the known wet caves of the Nullarbor and later realised that there were many other diveable caves in the region. Their first breakthrough occurred in Nurina Cave on the Roe Plains, where some 150 metres of virgin underwater passage was explored. To explore this cave, the divers were required to adopt "…sidemount techniques and all the team members learnt underwater surveying skills in order to map the new passages they had found". The cave was subsequently explored to more than 700 metres, with many underwater leads still to be explored. Later in September 2000, while the divers were surveying the main line through Warbla Cave during an expedition coordinated by the Sydney Speleological Society (SUSS), a small low flattener passage was noted high on a wall about 300 metres into the cave; further investigations eventually led to "Lost Lake", revealing to the group that in fact "…there was still a lot of work to be done on the Nullarbor, and all involved now had 'the Exploration Bug'!!".

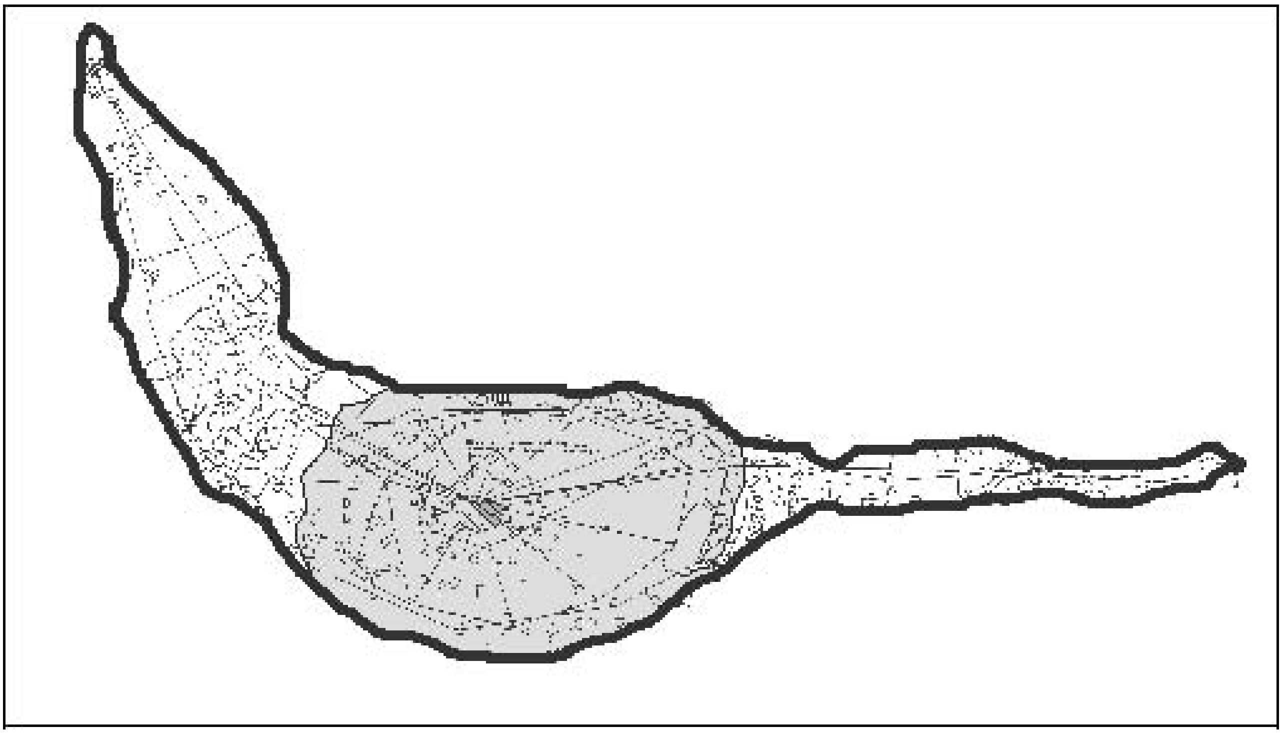
A lot has happened in the Nullarbor during the last few years in relation to the astounding mega-kilometre discoveries there of such places as Olwolgin and Burnabbie Caves on the Roe Plains, and there was also a major rekindling of the Exploration Bug in Mount Gambier during 2003 and 2004 as well when visiting Czech academics/cave divers David Funda and Petra Fundova bravely pushed many of the "question-mark" areas in numerous Mount Gambier caves and discovered among other places everything extending beyond the Dark Room in The Pines (notably the CCR – the "Crazy Czech Room" or "Closed Circuit Rebreather") and the deeper, side-mount-only regions of Stinging Nettle Cave across the road from The Pines. And even as this paper was being prepared, the author was aware of yet more spectacular caves which have only just been discovered by such people as Paul Hosie, Dr Richard "Harry" Harris and Ken Smith et al in the Kimberley (Western Australia) and Camooweal, etc.

It is, indeed, really very much 'early days' for cave diving in Australia!

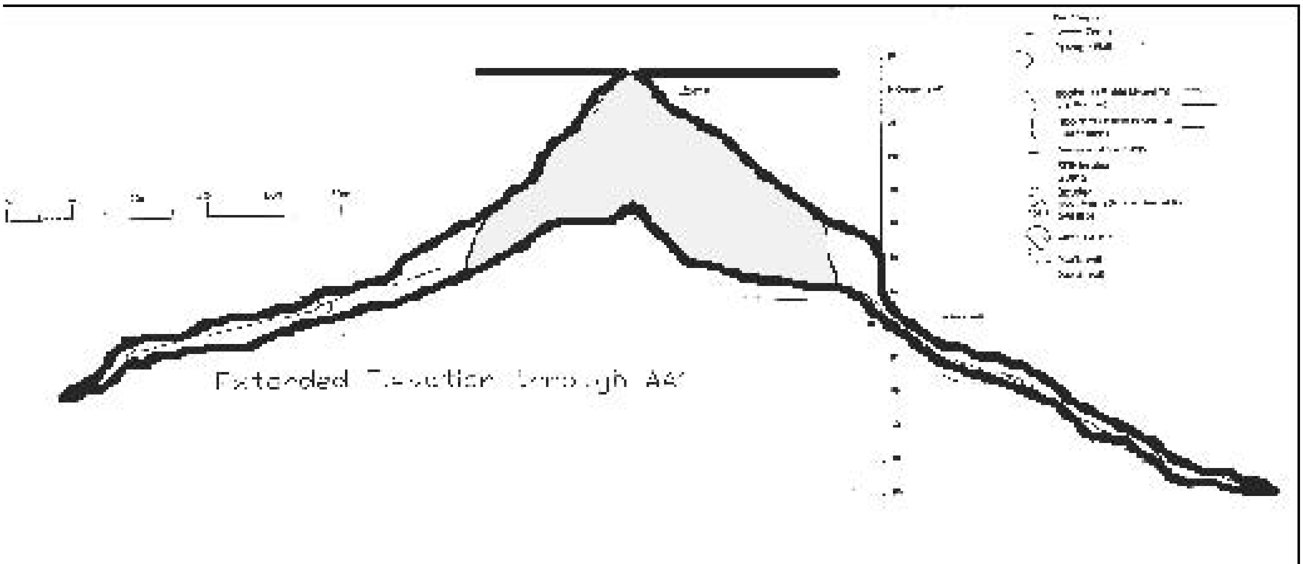
The Pines in the mid-1980s (by the author) and the original squeeze at the end of the Dark Room in 2003 which led to a large area of new cave including the CCR (courtesy Dave & Petra Funda).

Petra Fundova, Ken Smith, Carlo Virgili and David Funda during the weekend that the Dark Room restriction collapsed, opening up the area to everyone (photo by the author).

Recent maps of the final exploration and survey of the deepest accessible regions of The Shaft, undertaken using trimix between the mid-1990s and 2006 (with special thanks to Tim Payne and Chris Brown, ASF Cave Diving Group).



PLAN VIEW



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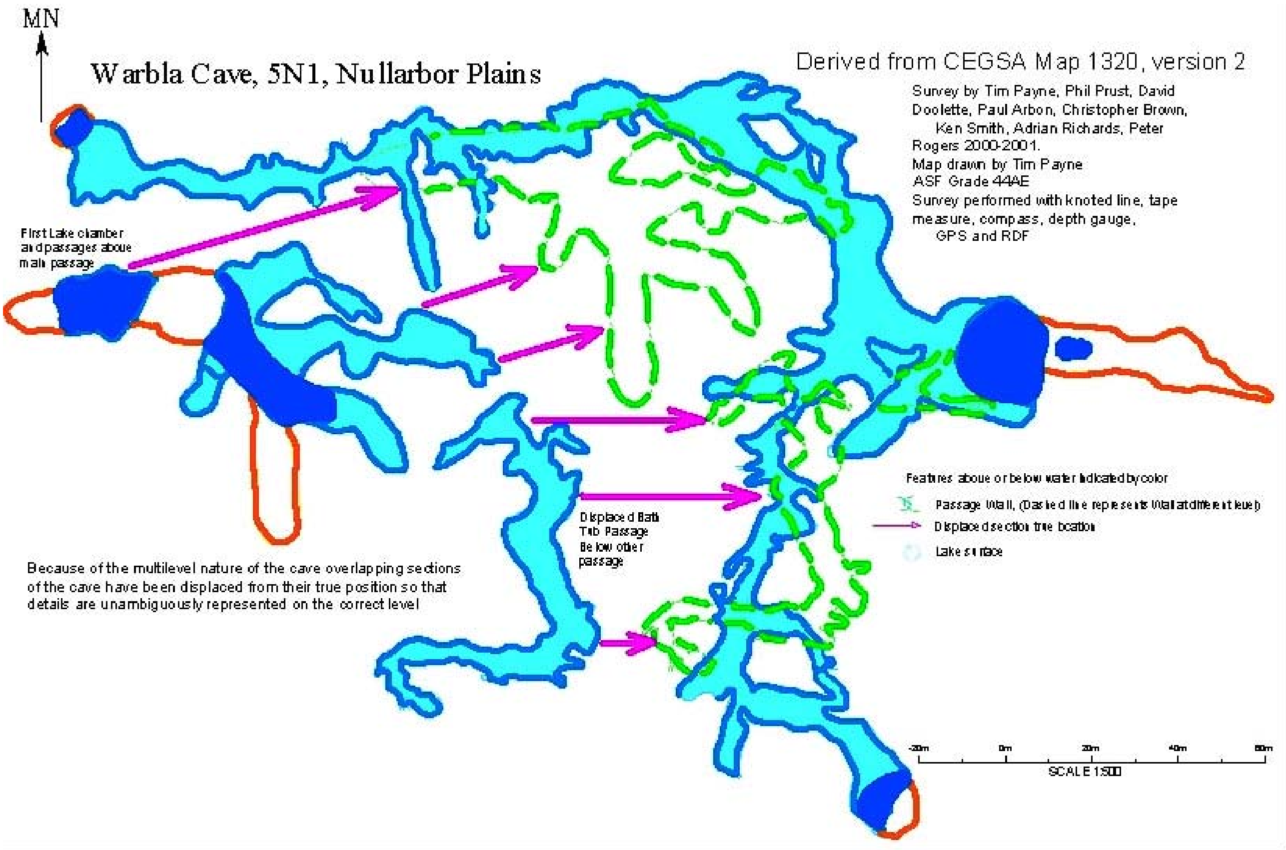

Another recent and very detailed map by Tim Payne and colleagues.
This time of Warbla Cave on the Nullarbor (again, with thanks to Tim).

Acknowledgements

This necessarily-brief historical summary was produced from a huge amount of much more detailed personal information which was kindly provided to the author by many dozens of people, particularly Dave Warnes, Peter Stace, Mick Potter, Snow Raggatt, Phil Prust, Ian Lewis, Peter Girdler, Chris Brown, Paul Arbon, Bob Cunningham, Doug Haig and Bob Pulford (South Australia); Andrew & Liz Wight and Al Grundy (New South Wales); Stuart Nicholas, Nick Hume and Stefan Eberhard (Tasmania); Peter Robinson, Ron Addison, Peter Ackroyd and Chris Edwards (Victoria); and Paul Hosie and Hugh Morrison (Western Australia). Many others helped to pioneer cave diving in South Australia, and it is only because of the unfortunate lack of published records that the contributions of other early underwater adventurers are not so widely known or acknowledged. It is the author's hope that this paper and presentation will help to serve as a starting point in this regard.

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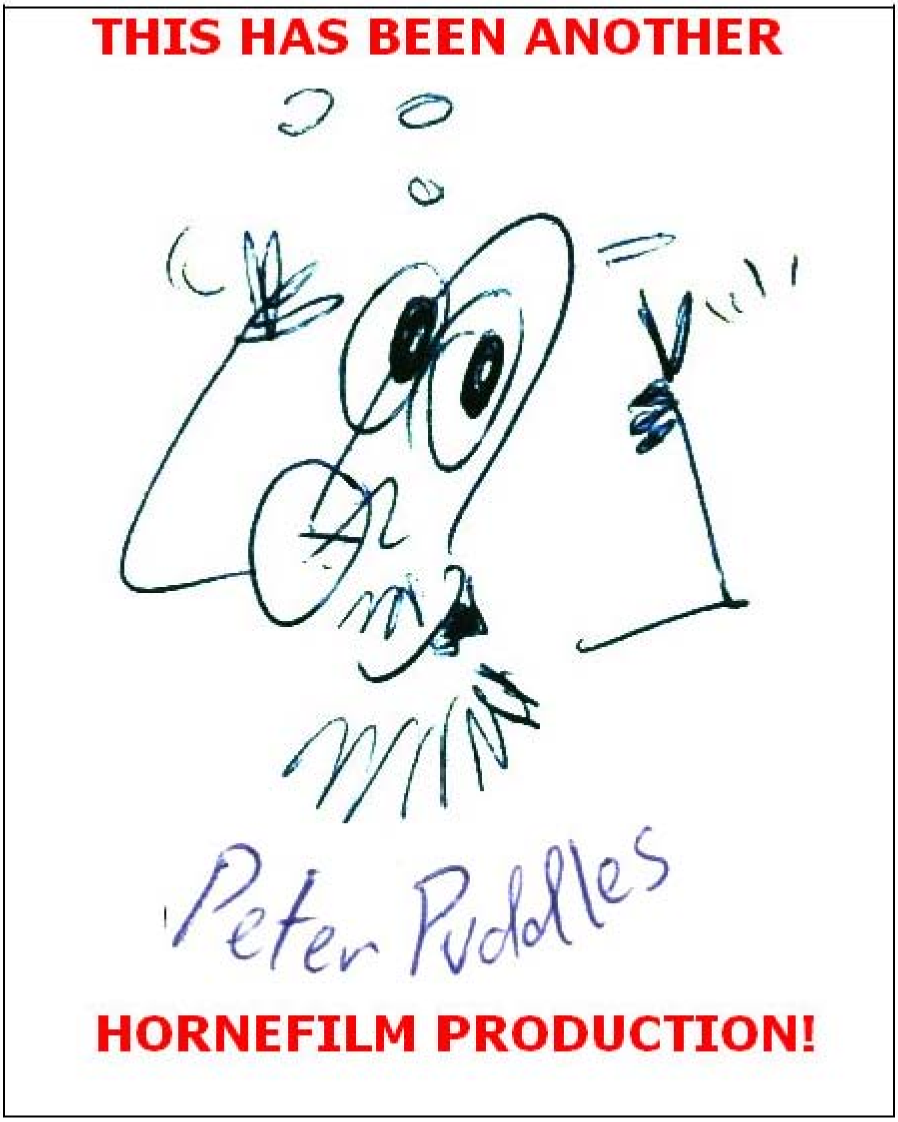
Many thanks to Ken Smith for his help and for providing access to his slide-scanning equipment, and to all those whose photos were used ... and a very special thank-you to Steve, Jean and Snow Raggatt, Dave & Ona Burchell and Ron & Lorraine Addison for their help with historical information and photos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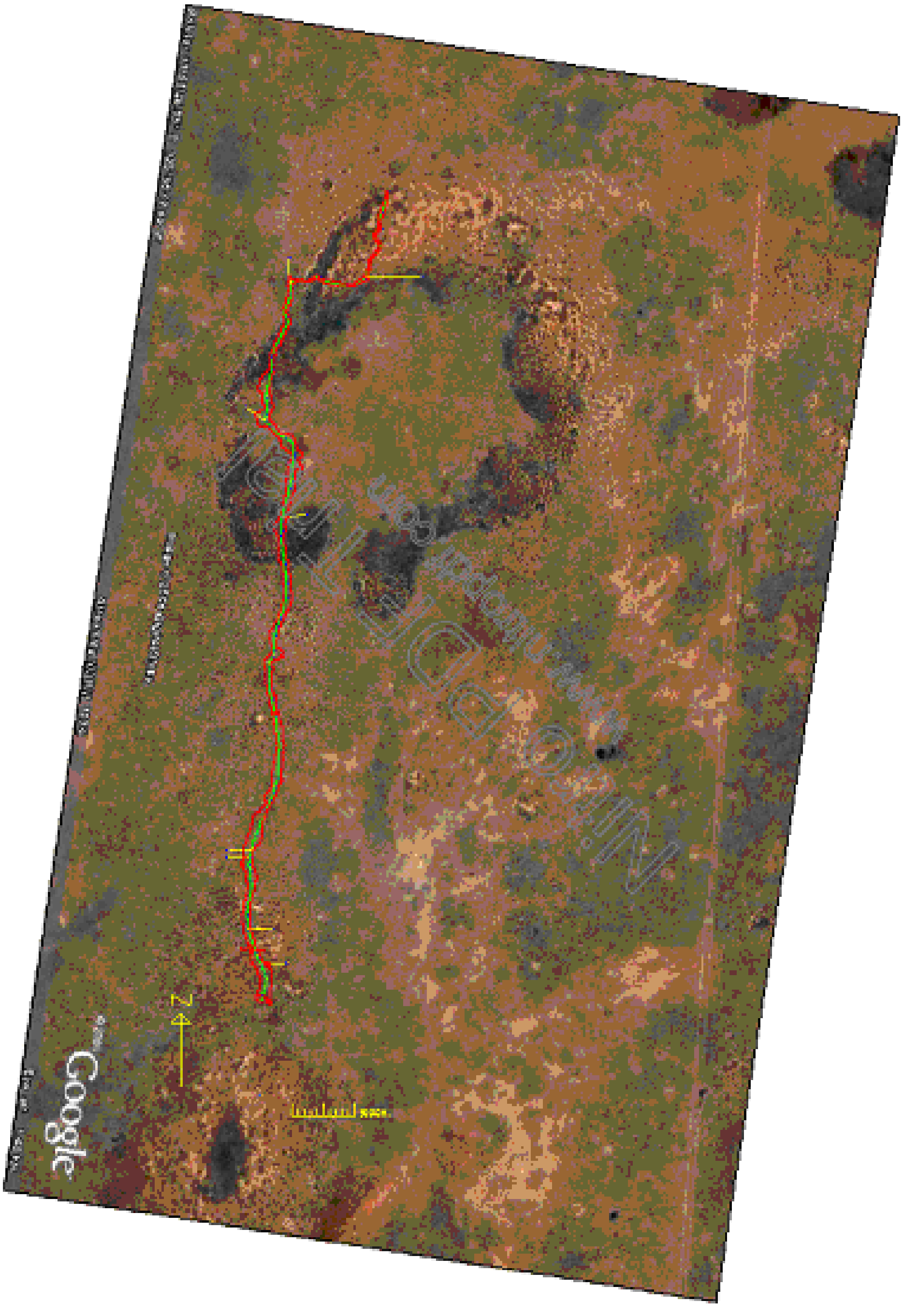
Cocklebiddy, old and new techniques together

Tim Payne

There was a time that Cocklebiddy was considered the Everest of cave diving, but those days have passed and visits to Toad Hall, the dry chamber nearly 4km into the cave are now relatively routine. But despite the ease with which Toad Hall can now be reached few trips have managed to repeat the feats of the early explorers who explored the third sump. This year three divers using techniques and equipment resurrected from the early explorers made it to Toad Hall with enough gear to camp and conduct a series of dives in the third sump allowing them to complete a map of the sump.



Preliminary overlay of the 3rd sump of Cocklebiddy which was mapped during the trip, and which is draped over Google Earth imagery.

This talk discussed the techniques and the modifications to the equipment which made this trip possible as well as the findings and map that was produced.

25 one page

Cave Diving on the Roe Plain
Burnabbie Cave 2006

Paul Hosie

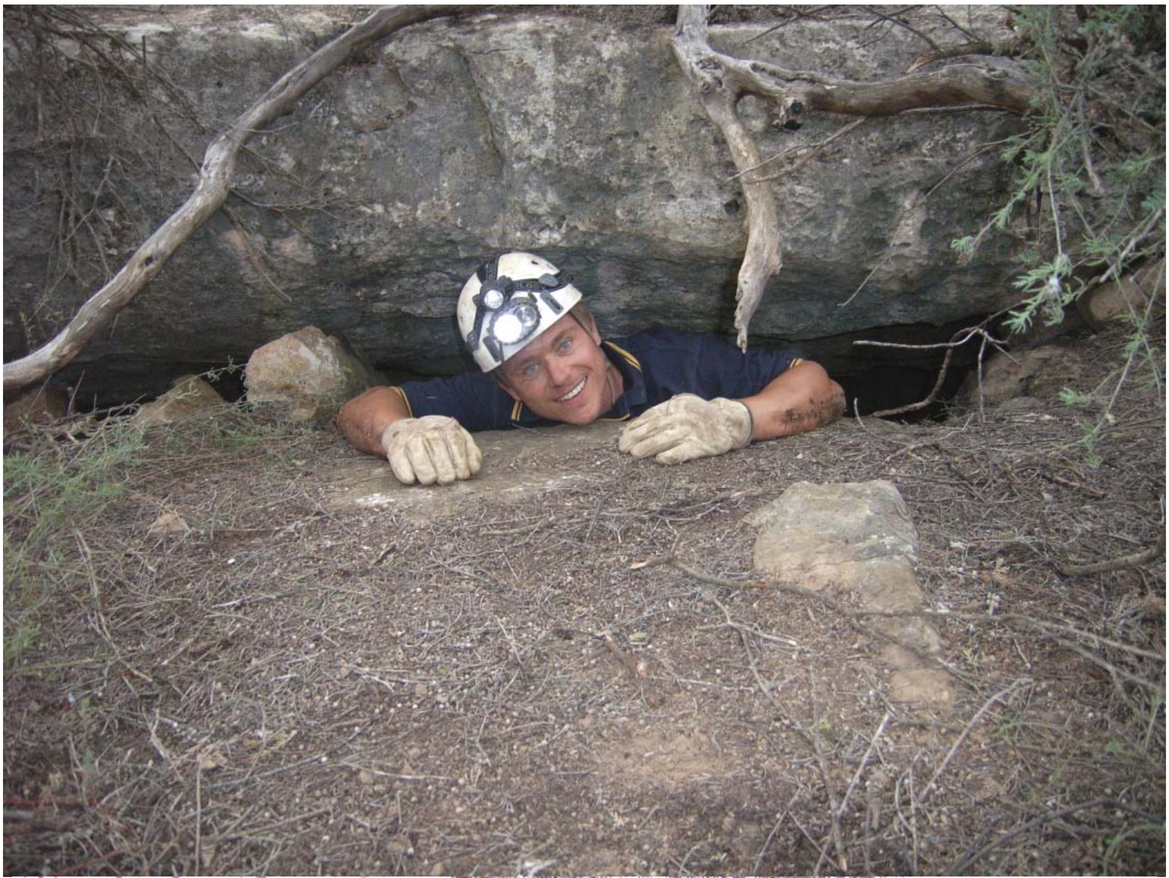
The Roe Plains of the Nullarbor hold some incredibly complicated cave systems. Fortunately for some ‘special’ cavers, most of them are full of hyper-saline, crystal clear water! Burnabbie Cave is undoubtedly the current King of the Roe Plain caves with over 2.2km of surveyed passages, most of it underwater, but there are some large half submerged chambers which are rich troglobitic fauna habitats.

With difficult cave diving penetrations of over 900m from the entrance, exploration and mapping of the cave was continued by WASG members Alan Polini and Paul Hosie during the period 30 Oct – 04 Nov 2006. Preparations for this trip included modification of closed circuit rebreathing equipment into an ‘off-mount configuration’ and familiarisation with them beforehand. The first dive was done together on open circuit scuba to suss out the ten restrictions between the entrance and the end of the cave to see whether the rebreathers would fit through or not. Staged bailout cylinders were also dropped off 500m into the cave to serve as safety backup for the rest of the week’s diving.

The rebreathers worked beautifully and allowed the cave divers to safely travel to the end of the cave where normal scuba cylinders were used to explore and map the many new passages there. By the week’s end, over 500m of new passages had been added to the map, making Burnabbie the 4th longest diveable cave so far discovered in Australia. As usually happens on exploration trips like this, the last dive turned out to be the most revealing with a whole new section of tunnels discovered in the most unexpected area of the cave.

Between dives, Alan and Paul also walked to over twenty karst features spotted from aerial photos and provided by Paul Devine. Most were blind dolines, but three were identified as caves and one even went down to the water level. Without doubt, there is plenty more discoveries to be made on the beautiful Roe Plains. If you like bushwalking and exploration, contact Paul Hosie about the next planned trip.

Much more remains to be done and it is planned to return to continue the exploration and mapping efforts in April 2007.

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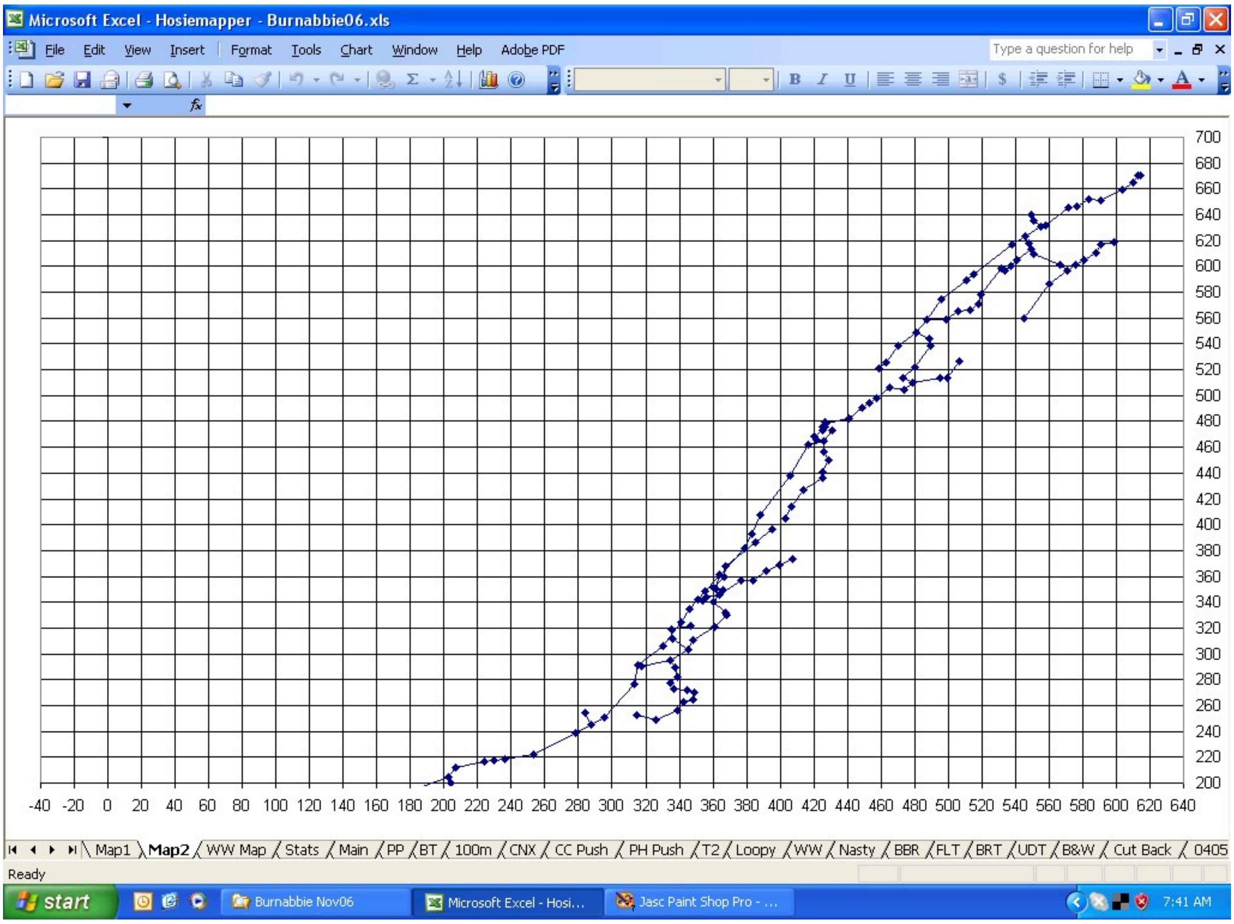
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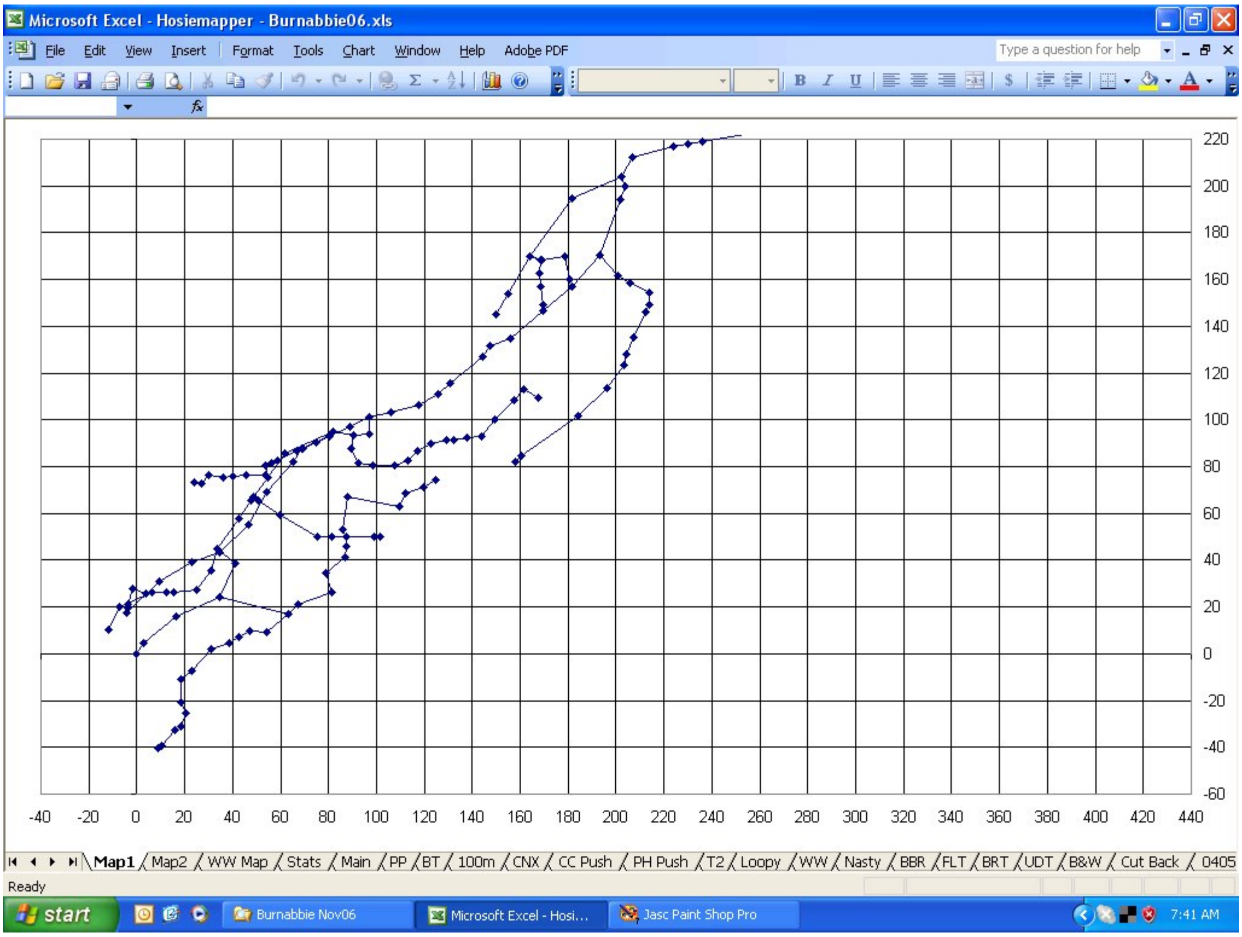
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Karst on Pungalina Station, Northern Territory

Nicholas White, Paul Brooker, Daryl Carr

VSA has now conducted two very productive trips to explore the caves and karst on Pungalina Station, NT. Pungalina Station is situated close to the Gulf of Carpentaria on the Calvert River and operates high quality safari tours. VSA became aware of caves from cave photographs in promotional material for these safaris. Enquiries led to organising an expedition during June 2005 to explore and study the karst.

The caves are in the Pre-Cambrian Karns Creek Dolomite (~ 1.3 billion years old) that contains fossil stromatolites. To date we have discovered and explored over 25 caves and features.

Totem Pole Cave (PUN-7) was known to the owners and when surveyed turned out to be over 1 kilometre in length and to contain a maternity colony of ghost bats. Other discoveries followed such as Ballroom Cave (PUN-11), an extensive, well decorated multi-entrance cave with a large population of orange horseshoe bats. The follow-up trip in June 2006 was nearly cancelled because of flooding during the wet season and wet conditions constrained extensive exploration, but resulted in more detailed exploration near Totem Pole Cave. Careful track-marking was done in both Ballroom Cave and Totem Pole Cave to constrain the effects of small tourist parties and to avoid bat roost areas. A lot of biological collecting was undertaken as well as some bat bone collecting to confirm the identity of the bats.

VSA is planning further trips to the area to examine the numerous possibilities, evident from aerial reconnaissance

27 one page

Large Caves Discovered on Flores (Indonesia) July – August 2006

Garry K. Smith

Abstract

In July -August 2006, a group of five Australians and one Indonesian set out on a five-week palaeoclimatology research expedition to the island of Flores, eastern Indonesia. The project involves the study of speleothem growth and composition to determine past changes in the regional climate. These data will be related to human habitation, with the added bonus of possible links to the demise of the recently discovered human skeleton named *Homo floresiensis* ("the Hobbit"). Our goal was to visit caves in the area near the town of Ruteng to locate and collect samples of suitable speleothems which could yield useful palaeoclimate data.

The extent of the cave systems around Ruteng was not fully known other than through brief descriptions by previous researchers of non-caving background. In total, our group visited five major caves including the now-famous Liang Bua (Hobbit Cave), which in 2004 yielded the most significant paleoanthropology find in decades. To our amazement we discovered and surveyed a large extension to this cave.

Another cave (Liang Luar) was known by the locals to be approximately 100 metres long. A route past a rockpile choke revealed extensive passage and huge, well-decorated chambers, which was far beyond our wildest expectations. To date, this cave has been mapped to just over 1.6 km with much more to be surveyed. It is hoped that a future expedition planned for 2007 will enable the survey of this cave system to be completed.

This paper deals primarily with the access logistics, survey difficulties of Liang Luar cave and description of the five major caves we visited.

Introduction

In July–August 2006, a group of five Australians and one Indonesian set out on a five-week research expedition to the island of Flores in eastern Indonesia. Among the group were three scientists (Dr. Mike Gagan, Dr. Russell Drysdale, Dr. Linda Ayliffe) a senior technician (Bambang Suwargadi) and two cavers (Neil Anderson, Garry Smith). Our Indonesian colleague, Bambang, is employed by the Research and Development Centre for Geotechnology, Indonesian Institute of Sciences (LIPI), which is the Indonesian equivalent of the Australian CSIRO. Nic Severino joined our group for several days and assisted in part of the Liang Luar survey.

Left to Right – Linda, Neil, Garry, Mike, Russell and Bambang at the entrance arch to Liang Bua.

The recent discovery of a complete human skeleton measuring just one metre tall and dated at around 18,000 years old, has been heralded as the most significant paleoanthropology find in decades. The skeleton, named *Homo floresiensis* ("the Hobbit"), was found by an Australian – Indonesian team led by Professor Mike Morewood (University of New England), while excavating a 6 m deep pit in Liang Bua cave on the island of Flores. The discovery has sparked much debate and inspired our research project, which is led by Dr. Mike Gagan of the Research School of Earth Sciences at the Australian National University.

Mike was instrumental in applying for and gaining funding from the Australian Research Council *Discovery* grants scheme to study the region's palaeoclimatology. The research involves reconstructing the history of monsoon rainfall extremes, abrupt climate shifts, and catastrophic volcanic eruptions. The information contained within speleothems could yield many secrets of the events which have shaped the history of human habitation in Indonesia, as well as the weather conditions which influenced habitation in Northern Australia. There was a need in this specific project to collect some stalagmites for full laboratory analysis. The majority of the samples gathered were specimens found already broken in the cave from natural causes. However, in cases where a specimen needed to be collected, the group used unobtrusive "mini-drill-holes" to investigate the quality of the stalagmite material, and ensure it was worthy of collection. Only a few essential specimens in out-of the way parts of the cave were collected.

Mike and Bambang after a long day underground.

Logistics of the expedition.

- Special permits were obtained from the Indonesian Institute of Sciences before visiting the karst area. This took a considerable amount of effort on the part of Mike, Bambang, Heather Scott-Gagan and Joan Cowley. Flights to Flores via Jakarta were very limited, so our group opted for an island hop approach to reduce waiting time.
- A considerable amount of sampling and caving equipment had to be transported from Australia. This added greatly to the bulk and weight of equipment manhandled on and off each mode of transport. The excess-luggage cost was quite expensive.
- In addition to the government permits, we had to seek permission from the local authorities and each of the cave property owners. Many thanks go to Bambang for being so methodical in gaining all these approvals.
- Westerners are not common in remote locations in Indonesia, so at times the language barrier added to the complexity of organizing accommodation, meals, supplies, etc. Bambang's interpretive skills were much appreciated. Our operational base was set up at a motel in the town of Ruteng nestled high in the mountains of central Flores. The backdrop of several extinct volcanic mountains occurs to the south while rich green rice paddies covered ridges and valleys stretch as far as the eye can see to the north.
- On the first trip to the karst area we had hired Toyota Kijang 1.8L petrol wagons. These proved to have inadequate ground clearance as they kept bottoming out on the rough road. Also they had to be pushed up the steep sections a number of times on the way back to Ruteng. It became very obvious after the first trip over the 11.5 km of rough, steep and narrow winding road, that these vehicles would not serve our purposes for the many trips required.

  On the next occasion Bambang organized a Mitsubishi Colt diesel truck which is generally used by villagers as a people carrier. This form of transport, while adequate for the task, did have limitations with comfort and exhaust fumes. It was also prone to mechanical problems due to the age and repair of the vehicle. These included brake failure with air in the hydraulics, fuel blockages, tyre puncture and a front wheel bearing which collapsed on the way down the mountain. I

Mitsubishi Colt diesel truck

will say that the full-time mechanic who travelled with the truck did know how to carry out running repairs. The average time to travel from Ruteng to the karst area was 1 hour 15 minutes to cover the 11.5 km, provided there were no mechanical problems. This gives a good indication of the condition of the steep single lane road which snaked its way down the mountain past countless small villages.

The five major caves entered are now discussed.

1. Liang Galang, which in Indonesian means 'Bathtub Cave'.

The entrance to this cave is at an elevation of approximately 548 m ASL and is below a small NE facing limestone cliff overlooking a river valley of rice paddy fields. There are two spacious entrances with a sloping earth and flowstone floor leading toward the back of a large chamber measuring approximately 20 metres long by 20 metres high. At the bottom of the entrance slope and still within the twilight zone there are a couple of very large impressive rimstone dam basins which were dry at the time of our visit. No doubt they would be very spectacular when full of water and they are certainly the reason for the cave's name. The earth floor slopes to the left of the basins and into a dark zone along a short distance of high ceiling passage. It could be argued that this was just part of the one chamber. At the end of the sloping floor in the dark zone, there is a small drainage point at floor level which is impassable. High above there is a chance for further exploration with a well-decorated passage visible. This would take some rigging with scaling poles and ladders.


The impressive rimstone dams in Liang Galang

2. Liang Neki, which in Indonesian means 'Bad Cave'

The cave is approximately 13.5 kilometres by road from Ruteng and takes two hours by vehicle due to the state of the road. There is a bamboo platform in the cave entrance, which is used by a local family as shelter.


Bamboo platform in entrance of Liang Neki

From the entrance a spacious passage with dusty earth floor slopes steeply down to a restriction then opens up again into large passage with damp mud floor. Once through the restriction the humidity increases considerably. A number of echo location Waled birds were sighted in this area of the cave. They make an unusual clicking sound while flying around the cave.

There are a couple of small drops in the sloping floor, the last one being the largest at about three metres. From here the cave opens into a large chamber with a steeply sloping floor at the far end. From the back of the chamber it is possible to proceed in three directions. To the left a very steep mud slope leads to an active stream passage which can be followed for some distance. Straight ahead continues on a considerable distance through several chambers with high sections and the lower passage eventually turns into a muddy crawl. To the far right there is a 1.5 metre climb through a keyhole and then down about 2.5 metres into a well decorated chamber. This chamber was found to have foul air with a very low concentration of oxygen and high carbon dioxide.

The extent of this cave was not fully explored.

3. Liang Bua, which in Indonesian means 'Fruit Cave'. This cave has been nicknamed the 'Hobbit Cave' after the discovery of the *Homo floresiensis* skeleton in 2004.


Bambang looks from the Liang Bua balcony toward the entrance.

The entrance is at an elevation of approximately 562 m ASL and is below a small NE facing limestone cliff overlooking a river valley of rice paddy fields. The entrance is approximately 170 metres to the NW of Liang Galang**.**

The entrance chamber of Liang Bua measures 51 metres long, averages 13 metres high and 27 metres from the entrance overhang to back wall. This chamber is very impressive with a number of seven metre long stalactites hanging in the middle of the chamber. They are bent and twisted as if being pulled toward the daylight. Directly below the stalactites is a 2 m diameter x 2 m tall stalagmite. The back of the entrance chamber to the left, a steep slope leads up through some rocks to an impressive stalagmite at the rear of a balcony overlooking the chamber. Behind the stalagmite there is a short section of passage leading off to a small chamber with some good decoration. From the base of the 5.4 m high balcony a laser distometer was used to obtain a 19.6 m measurement from floor to the top of an aven.


Mike is dwarfed by the immense size of Liang Bua entrance chamber.

To the far left of the main entrance chamber and at the base of the balcony slope there are a couple of holes between boulders which lead into a 23 metre pitch at an incline of 60°. At the base of this pit there is a sloping dirt and rubble floor leading into an impressive chamber 23 x 24 x 5.4 metres high. It is predominantly an earth (mud) floor with drainage toward a stream sink at the NE wall. The ceiling is covered in many stalactites. To the NW there are a number of stalagmites scattered up a flowstone slope. This slope leads to a small chamber located 12.4 metres below the concrete entrance path.

A number of Horseshoe bats and Waled birds were sighted in this chamber. The Waled bird has echo location ability and can be heard making an unusual loud clicking sound as it flies around in total darkness. The birds look similar to a swallow with jet black feathers.

4. Liang Luar, which in Indonesian means 'Mist Cave'. The entrance is at an elevation of approximately 550 m ASL.

The entrance, measuring approximately 1 metre x 1.5 metres, is at the base of a 20 metre cliff. It has the appearance of a typical out-flow cave and there are signs that in periods of very heavy rainfall a small amount of water would flow from the entrance. The first hundred metres of cave is an easy walkthrough meandering passage with tacky mud underfoot. At this point the passage is blocked by a boulder choke which must be climbed to a height of 5.5 metres. A route past the rocks leads down to more passage at the same elevation as before the choke. Here the full width of passage floor quickly turns to gooey mud up to knee deep with a few centimetres of water over the top and the roof height reduces to just 0.7 metres. This chamber has been named "Kabangan Kerbau" meaning Buffalo Wallow. The only sign that anyone had ever passed the boulder choke was one set of small bare footprints leading along the passage and a little way into the mud before retreating. No other sign of human entry was sighted past this point.

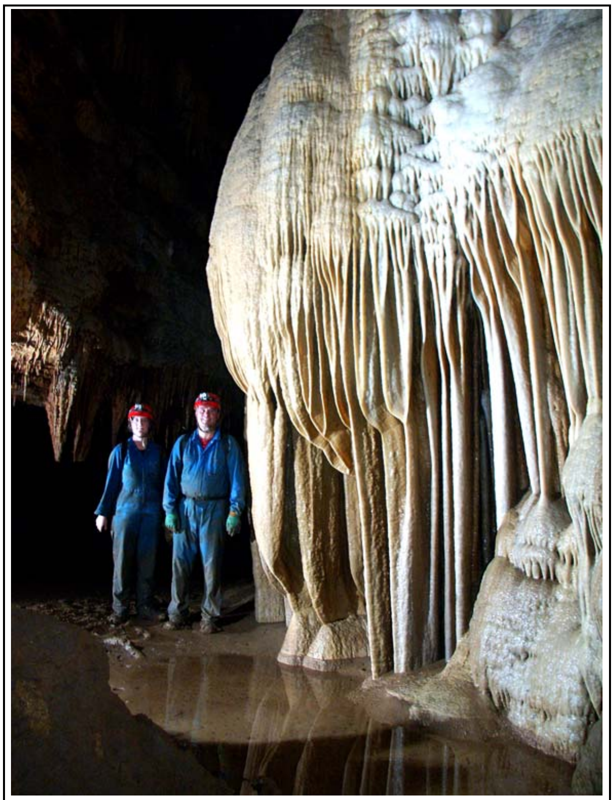
Nick next to Cadi Prambanan

From the large mud pool, another hundred metres of low passage before the cave opens up to large chambers with excellent decoration. Several active stalagmites approximately 7 metres tall mark the start of a dramatic transformation from small passage into large halls and spacious caverns. These beautiful large speleothems ranging in colour from deep orange through to pure white, are truly nature's masterpieces. They have been named "Cadi Prambanan" after a temple of the same name.

There are two small stream sinks encountered in the main passage before a huge chamber is encountered at about 0.5 km into the cave. This chamber, named "Raksasa Ruang" (meaning Huge Hall), is approximately 90 metres long x 50 wide x 30 high. There are some massive boulders strewn across the chamber which make navigation a little difficult. It was calculated that there is approximately 50 metres of solid rock above this chamber to the surface.

After climbing over the large boulders one descends a slope leading to passage at an elevation not much above the earlier passage. There are a number of sections of excellent speleothems.

After descending about 4 metres a stream sink is encountered between rocks. The passage becomes a rather large and meandering railway tunnel shape, 10 to 14 metres high and the same in width. There are typically 2 to 3 metre banks of damp clay on either side of the passage and a stream valley snaking down the middle. Caving at this point becomes more of an underground bushwalk. At about the 1 km mark a huge stream sink is encountered. It has not been explored yet,



Linda and Mike at the far end of Raksasa Ruang.

Spectacular decoration at 1.3km into Liang Luar

Russell and Garry at 1.4km into Liang Luar

but a distometer reading measured it to be at least 19.7 metres deep. This can be skirted around by a tricky climb on the right side.

At about the 1.2 km mark a large deep pool can be skirted around on the left side by climbing up between several large columns. Another 260 metres further on another large pool of water is encountered at the base of a 4 metre waterfall. This can be free-climbed with some difficulty.

A short distance above the waterfall the cave splits into two passages. The high passage narrows down through a well-decorated area before opening up into large dry passage again. The lower passage leading off steeply to the left is obviously a resurgence which wells up in times of high rainfall, then overflows into the main passage and over the waterfall.

Continuing along the high passage past lots of excellent decoration the cave continues to meander. There are in places large channels in the earth floor leading into stream sinks. It was possible to make long sightings up to 72.5 metre with the laser distometer during the survey of this section.

At the 1.6 km mark the survey was terminated due to lack of time. The cave however was explored for a further several hundred metres past a tight squeeze and back into large passage. Eventually the passage splits into two of approximately equal size. Hopefully the rest of the cave can be explored and surveyed during the next visit in 2007.

The whole mountain above Liang Luar is cultivated by the local population to grow coffee, pineapples, sweet potato, bananas and rice. The cave system is fed by many surface streams leading into about 10 major dolines with associated sinkhole caves which have yet to be fully explored. Indications are that the sinkhole caves are not venting the Liang Luar cave atmosphere and will all pass

Russell up to his knees in Liang Luar mud.

through sumps before entering Liang Luar. Within Liang Luar there are at least 7 stream sinks which feed to a lower cave system, as yet unexplored. These stream sinks generally prevent water from flowing out the main entrance through which we entered the cave. The active efflux of the cave system is not known at this point in time.

5. Liang Padut is located approximately 200 metres to the west and approximately 50 metres higher in elevation than the entrance of Liang Luar. It was rumoured to be part of the same system as Liang Luar. However, we found no evidence to support this.

Liang Padut main chamber

The cave has a very large collapse doline entrance and has acted as a resurgence at some point in the cave development. There is a steep sloping entrance, 35 m long at -37° into a large chamber measuring 37 metres long by 21 metres wide and 12 metres high. A small shaft leads up from one side of the main chamber and comes out at the top of the main entrance slope on the right side. The large chamber is very well decorated with white speleothems.

Cave Surveying

The Liang Bua and Liang Luar caves were surveyed using a Leica (Disto Classic a) laser distometer, Suunto inclinometer and baseplate magnetic compass.

Flashing red LEDs which snapped onto the terminals of small PP3 batteries (9V) were used as survey station markers. These were extremely good as they could easily be seen over distances of 80 metres and eliminated the need for a person to stand at designated survey stations. For difficult survey stations a blob of mud was used to stick the flashers to the cave walls.

Distances greater than 60 metres usually required someone to hold a brightly coloured pack as a target for the laser distometer. Despite the distometer being accurate to the millimetre (0.001 metres) the survey data was only recorded to the nearest 0.01 metres.

Surveying in Liang Luar was made very difficult in places due to the quantity of gooey mud, particularly some low awkward sightings. Keeping the survey pad clean was very difficult during some periods when surveying on my own, while scribing and taking readings.

Discoveries so far.

The oldest animal bone collected from the lower chamber of Liang Bua has been dated to about 90,000 years. This date is very exciting as it indicates that the big "mud-mound" may contain a wealth of very old bone material. Future paleontology expeditions are planned and may yield a wealth of knowledge about the prehistoric past.

A stalagmite nicknamed "Big Boy" which was sampled from Liang Luar has been dated at its base as being 25,000 years old. Two more stalagmites were “mini-drilled” near the bases and the calcite powders extracted from these holes have now been dated to 40,000 years old. This is fantastic because it means that they grew from just prior to the last glacial maximum right through to the present. There is virtually no information about the climate during the last ice age in Indonesia, so this is a real find.

From the scientist’s point of view, perhaps the most exciting discovery is a date from a short-core extracted from a collapsed flowstone that has yielded an age of 200,000 years. The flowstone is 1.5 m thick, and the date is from 0.5 m depth, so it is possible that the entire flowstone could be as old as 600,000 years. If this longevity proves to be the case, the flowstone will give the team a record-breaking history of past climate in the tropics.

Future discoveries.

Given the remote nature of the Miocene limestone karst area, there is considerable scope for more discoveries. The locals know the whereabouts of the caves but do not have the equipment, lighting or caving knowledge required to undertake exploration. Given the need to put food on the table through agricultural farming, there is not much time nor inclination for most locals to explore caves. There were a few exceptions with a couple of entrepreneurial Indonesians wanting to learn more about the caves with the view of opening them up for tourism. Since most locals and cave owners are very poor, the commercialization of the caves without putting in place lots of preservation infrastructure would certainly be a disaster. The making of a quick dollar would rule over preservation of such wondrous natural beauty.

A few events which occurred during the expedition.

1. When entering the 23 metre pitch below the main chamber of Liang Bua for the first time, I encountered a large boulder 600 to 700 mm diameter (probably weighing half a tonne). The boulder appeared to be wedged between the walls of the pitch but moved slightly when my foot was placed on it. On close inspection I noticed that it was just balancing on a smaller rock which was jammed. I locked off on the abseil rope and retrieved the trailing rope hanging below. The large balancing rock only took a little nudge and it went crashing down the pitch with a tremendous rumble and smashed into many bits.

More than 20 children flock into Liang Neki with a one LED torch between them.

This was very lucky as the abseil rope could have easily pushed on this loose boulder and brought it down upon me. I continued the abseil to the bottom and was amazed at the size of the huge chamber which lay before me. The floor was mainly tacky mud, but there was a high section which contained a number of large stalagmites.

Flowstone and dripcones merge and erode away over thousands of years as the silt banks change shape.

2. In Liang Neki after gaining permission to enter, we trogged up and headed in with a cast of many children and adults in tow. Only one local child had a torch with a single LED globe. The rest were relying on the light from our head torches. It was quite comical with our group of researchers dressed in overalls, helmets, headlights, solid boots and huge packs of equipment. The locals had shorts, tee-shirts, thongs or bare feet, no helmet or light. After following us a long way into the cave, the children went back out, led by the child with the single LED torch.

3. In Liang Neki I climbed through a small keyhole leading to a well decorated chamber. The 2.5 metre climb down was rather tricky as tacky mud covered all the solid rock. I entered and was followed by Russell. In the middle of the chamber was a pile of large rocks with 2 metre deep holes between. As I was crossing, a lump of mud broke off the rock, sending me crashing down onto my right knee and left me half dangling between the boulders. The pain was excruciating so I did not move for a couple of minutes hoping it would subside and that no permanent damage had been done to my knee. Then I started feeling very dizzy and said to Russell there was high CO_2 and I had to get up. He helped me up and I stood on the far side of the chamber. That was the last I remember until I heard Russell calling me. I believe I had passed out and thankfully Russell was there to stop me from falling back into the pile of rocks. A check was made of the air at knee level and sure enough the cigarette lighter would not work. There was less than 14% oxygen and probably at least 6% CO_2.

4. The Liang Luar owner took us to another cave on the ridge a few hundred metres to the east of Liang Luar. A trail of children followed. Not far away another doline was located and we walked down into the bottom of the depression. The last 3 metres was a small climb over some rocks and the cave owner followed me down. I scrambled around with a small torch looking for any possible leads. There were some nice decorations but no large passages leading off. Everyone else was still further up the doline slope when there came a tremendous amount of screaming from a small child. Then a few loud swear words from Russell. The cave owner listened for a moment and clasped his hands together and crouched under a rock as if to pray. I was totally bewildered when he beckoned to me to crouch under the rock, turn off my head torch and also pray. OK this is weird, sounds like someone up the top is dying and he wants me to prey. After another 5 minutes he looks up and points at a mass of large flying insects swirling around the cave entrance and covering the ceiling above us. Then it struck me, they were huge stinging wasps and the nest was some 5 metres above me. We waited some 20 minutes while the whirling mass subsided and they retreated back into their hive. Then we both crept back up the slope and out of the doline.

   Eventually we met up with the others. There was Russell with 2 stings, Linda with 2, Mike with 4, Bambang with 1, a couple of the kids had been stung and

Garry K Smith next to Cadi Prambanan in Liang Luar

Pious (land owner) in the unnamed cave with wasps at the entrance had totally bolted from the scene. It was obvious that the pain was very intense and huge welts had formed around the stings on each victim. Thankfully, the cave owner had known what to do and we missed out on the painful experience.

5. One evening, while standing at the curb waiting for the vehicles to take us to a restaurant, I fell down to my waist through a gap in the pavement which covered the drainage system (sewerage). It was quiet a shock to be standing on two feet then totally falling. The feeling of a sharp object running up my leg as I fell, had me thinking that I had split my leg right open for its full length. Luckily the reinforcing bar which protruded from the broken concrete had been bent downward and my long pants had taken most of the abrasion impact. My foot was soaked with water and stunk of sewerage when I climbed back out the hole.


Footpaths have many holes

Acknowledgements.

I would like to thank Mike Gagan and Russell Drysdale for their helpful reviews of this paper. Also thankyou to Neil Anderson and Nic Severino for assistance in exploration and surveying the Liang Luar cave. Mike, Russell, Linda and Bambang provided valuable organisation of the field logistics and academic expertise, which assisted greatly in interpreting the geology of the area. Our group worked well as a coherent team in the field which made the whole expedition a pleasurable experience. Financial support for the expedition was provided by an Australian Research Council *Discovery* grant (DP0663274) to Mike Gagan (ANU) and Wahyoe Hantoro (LIPI).

Caving and Cave Diving in Vanuatu

Richard Harris

Introduction

I arrived in Vanuatu to live for 2 years in January 2004, and this paper serves to summarise my caving activities there. I came as a doctor to work with AusAid at the Vila Central Hospital, but I was also drawn by amazing tales of caving and cave diving. Cave reports/updates have been archived with the ASF and CEGSA for anyone planning a trip to Vanuatu. Also check my website on www.divedoc.net

Geography and Geology

Vanuatu (formerly the New Hebrides prior to independence in 1980), consists of a Y shaped archipelago of some 83 islands extending 1176km north-south, supporting a population of over 200,000. It lies on the edge of the Pacific tectonic plate. The first islands of Vanuatu were pushed up from the ocean floor 22 million years ago (Espiritu Santo, Malekula and the Torres group), and the most recent less than 5 million years ago. The islands continue to increase in size due to slow ongoing uplift together with the formation of fringing coral reefs. Hence most of the islands are volcanic in origin but many are coral atolls and hence limestone in nature. In general, the limestone forms a series of terraces, each marking successive still-stands of sea level; caves often occur at the interface between terraces. The largest limestone area is on Espiritu Santo where the eastern half of the island consists of an uplifted block 60km long by 25km wide.

Culture and Land Access

It seems that caving anywhere in the world revolves around problems of obtaining permission to access the sites, and Vanuatu is no exception. The country is divided into 6 provinces and any major expedition should start with a courtesy call to the secretary of the appropriate provincial office. The secretary will simply make a note of your visit and nothing further will come of it, however, in the event that any “issues” arise with the landowners, this will put you in good stead. Every village has a chief and some areas have a paramount chief. You need to ask permission from the chief when you arrive in any area, to access the caves you are interested in. A gift like a big bag of rice or tins of beef/fish will go a long way to smooth the negotiations. Soccer balls, pens and papers etc for the local school and kids are a good idea. Equally importantly, you must also get permission from the actual kastom landowner of the site. This is where you will inevitably come unstuck from time to time, as it is often in dispute who the rightful landowner is. Your mere presence and questions may cause these issues to come to the surface and some disputes or even violence can follow. It is impossible to work this all out as an outsider, so my advice is to be (incredibly) patient, ask permission from as many people as possible, try and verify that you have spoken to all the right people and after doing all that; be prepared to walk away if it doesn’t feel right.

Payment for access can be tricky. If you walk in looking like you are part of a major expedition, seem desperate to get into the caves, and start waving Vatu around, it will cost you an arm and a leg and will spoil it for all those that follow. Try and find out what the going rate is from the local expatriates and again, be prepared to walk away if the price is too high. Otherwise you will pay double the next day. We paid Vt1000 per day per porter for carrying heavy equipment plus providing them with food and some small gifts for the village. The chief or “bigman” may want a few thousand extra for himself. Ask if it is OK to film or take photos before you do so, or you might end up paying for that too.

The Sites

I was aware of 2 main islands containing caves before I arrived. On the island of Efate (home to the capital Pt Vila) there are well-documented caves in the tourist guidebooks. To the north, the island of Espiritu Santo (home to the well known shipwreck the SS Coolidge) has been visited by cave divers from the CDAA starting in 1996 after the discovery of water filled caves in the south central part of the island.

After arriving, it became clear from discussions with many local NiVanuatu people that caves abound on virtually all the islands and so the possibilities for exploration seemed endless. However, it requires significant time here to learn about and then find the sites, let alone organize an expedition to explore or dive them. For example I heard from several local sources about a cave in the hills near Pt Vila where boys would carve their initials on bamboo sticks, throw the sticks into a deep cave and then run about 1 mile to the coast and find their sticks washing around in the surf! Such stories can make a cave diver's heart miss a beat and so I searched the area extensively for the alleged cave without success (I found a number of dry caves along the way). However I strongly suspect the cave may have existed but has perhaps been lost during a large earthquake several years before.

The object of this report is twofold. Firstly to propose a numbering system for the caves of Vanuatu that future cavers might add to, and secondly to document the tiny proportion of Vanuatu's caves that I visited. Where possible I made a rough survey of the features, took photos and recorded a GPS reference point (in WGS 84). The GPS points for the caves whilst not published here are archived with the Cave Exploration Group of South Australia (CEGSA) and with the ASF.

Cave Numbering System, Vanuatu

I could find no record of a cave numbering system here in Vanuatu, or with the Australian Speleological Federation (ASF) or Union Internationale de Spéléologie (UIS). Hence I have used the following for my own records, and put it forward for use by those that will follow. This has been ratified by the UIS and the ASF. It is based on that in use and recommended by the ASF.

1.	Country Code	VU	
2.	Province Code	Sanma	2
	[Region]	Penama	3
		Malampa	4
		Shefa	5
		Tafea	6
		Torba	7
3.	Island Code	Torres Is	TS
	[Area]	Banks Is	BK
		Espiritu Santo	ES
		Ambae	AM
		Maewo	MA
		Pentecost	PC
		Malakula	MK
		Ambrym	AB
		Epi	EP
		Shepherd Is	SH
		Efate	EF
		Erromango	EM
		Tanna	TA
		Futuna	FU
		Anatom	AT
4.	Cave number	numeric identifier	

E.g. Clearwater Cave, Efate Island VU-5EF0002 [ASF code would be VU5EF-2 Editor]

Should a cave lie on an island not listed, it will be referred to the nearest listed island. Similarly for sea caves. In all other respects the numbering code should try and conform to the system outlined by the ASF in its document entitled "ASF Cave and Karst Numbering Code".

Cave Features in Vanuatu.

Collapse dolines and cenotes, phreatic passage, lava tubes and sea caves all exist on these islands. Large speleothems and cave decorations appear to be uncommon but a healthy bat and other fauna population exists in many of the sites. Tall coralline limestone escarpments veer across the landscape in many areas and dry caves can often be found at their bases, however most of these features have been quite small to date. In other areas, river resurgences like that of the Sarakata River on Espiritu Santo, may give rise to extremely long phreatic passage. Coastal blue holes in many of the islands hold the promise of significant caves also.

A small selection of cave features and some of the exploration were discussed during the presentation.

The Caves of Efate Island

9 caves were described on the main island of Efate.

The Caves of Espiritu Santo

This island appears to hold the greatest potential for significant finds. The eastern half of the island is uplifted limestone. A drive along the eastern coast shows numerous crystal-clear streams and small blue holes by the roadside. But at this time the best finds have been those associated with the tributaries of the Sarakata River, which empties into the Segond Channel just west of Luganville.

In Luganville, an expatriate Frenchman named Rufino Pineda is a fantastic source of knowledge of the caves and geography of Santo. Any expedition to Santo should begin with a phone call to this very helpful man. In August 2005, 2 French cave explorers (Bernard and Josiane Lips) spent 5 weeks exploring the caves of Espiritu Santo, in preparation for a very large French biodiversity study occurring in 2006. In November 2005, French cave diver Franck Brehier further searched for diveable (in particular anchialine) caves. Bernard and Josiane Lips were kind enough to share this information with me, and I have a full translated copy of their report.

The Sarakata resurgence cave and the caves on Mt Hope Station nearby (2ES10-2ES32) were first brought to cavers' attention by Russell Donavan, the expatriate leaseholder of the Mt Hope cattle property. It was his original intention to develop one of the sites as a tourist site, offering the adventure of a "duck through" of the short sump in 2ES15. With the help of local cave diver and dive operator Kevin Green (the first person to dive many of these sites), a group of CDAA cave divers came to explore the cave and discovered many more as part of the same system. These explorations occurred between 1996 and 2000. In addition to these caves, approximately 55 other caves are described on Espiritu Santo including the Sarakata Resurgence.

<u>The Sarakata Resurgence.</u> The exact history of the exploration of this site has been difficult to pin down. It was first dived in early 1997 and then again later in that year. I think another expedition occurred in 1999 and possibly again in 2000. The groups contained different members but instrumental in the exploration were Steve Sturgeon (WA) who coordinated much of the exploration. Unfortunately I have been unable to obtain any maps of these dives, and accounts describe a total distance of approximately 1700m, terminating in a breakdown room with only a very narrow way forward (if at all).

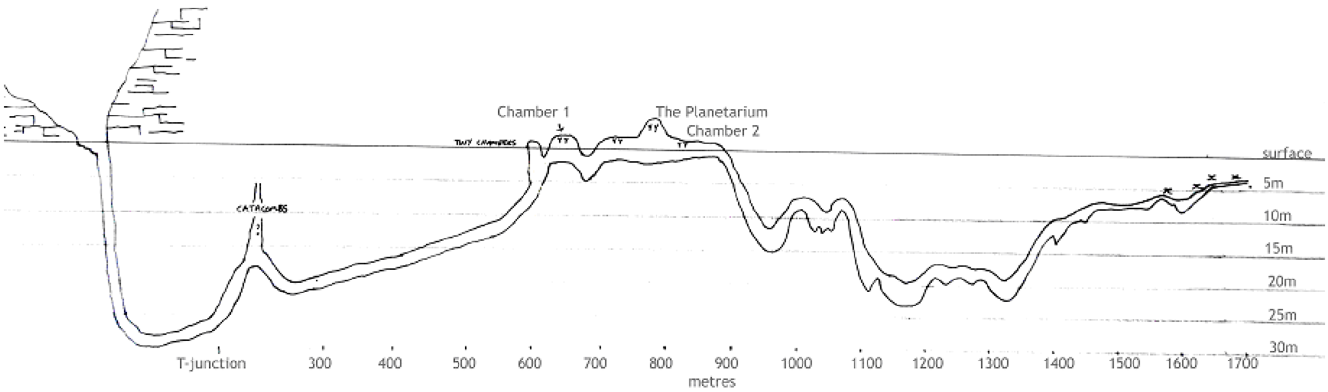
I first dived the site in March 2005. It involves a difficult one-hour hike through the dense jungle and into a steep gorge (only 830m as the crow flies according to the GPS) carrying dive gear. The resurgence pool lies in a north south direction and is approximately 40m long. The water wells up at the base of a cliff, and at this point divers drop straight down to the gravel at 18m then to 30m depth. The cave entrance lies before you and flow in the early section is considerable. A number of masks have been lost in this section! Visibility improves as you enter the cave but in the wet season can be 2-4m with a water temperature of 22 Celsius. The water is drinkable. The resurgence pool contains numerous species of colourful tropical fish and freshwater prawns (Nowra). Further into the cave no life was seen in the fast flowing water except and occasional eel (Namari) and small shrimp.

The cave continues at a consistent 29-30m depth until the first air chamber at approximately 400m in, after which the depth is more in the 15-20m mark. The final 100m of the 3rd sump is 5-7m. 2 large side tunnels have been marked and partially dived in the final sump ("Whim-a-way" and "Green Lane"). There remains enormous potential for exploration in this system.

Partially mapped to 1700m penetration. Full report on www.divedoc.net

Acknowledgements

My thanks for all those who gave me information about their exploration and discoveries, especially the cavers who have explored and mapped the tributaries of the Sarakata River on Espiritu Santo, including Kevin Green, Steve Sturgeon, Gary Bush, Gary Barclay, Linda Claridge, Dave Walton, Warrick McDonald, Tony Davis, Craig Challen, Paul Hosie, Dave Warren. Apologies to any of the original explorers who have been forgotten or overlooked. Thanks to the French cavers Bernard and Josiane Lips, and Franck Brehier for allowing me to include their hard won information. To Barry Holland and Kevin Green from Aquamarine in Santo for all their help and for sponsoring the cave diving exploration. Thanks to Clare Sulis in Pt Vila for her many hours of work in translating the work of Bernard and Josiane Lips…I hope it is accurate! A special thank you to the people of Vanuatu who allowed me explore their beautiful land.



VU 2ES0033 Sarakata Resurgence (section view)
R Harris, B Holland, K Green, S Pittaway, J Currie 2005

ASF 3.2 to end of first chamber
ASF 2.1 after first chamber

29 p5

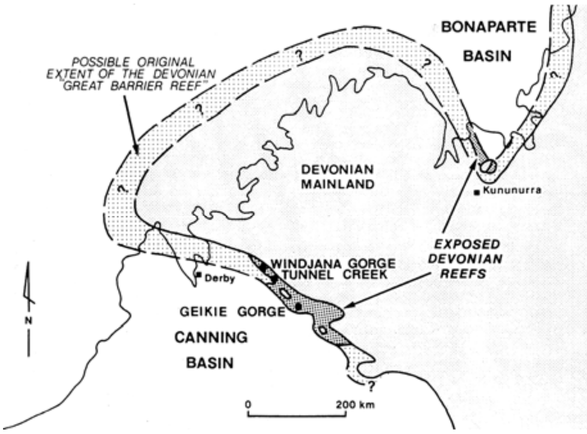
29 p6

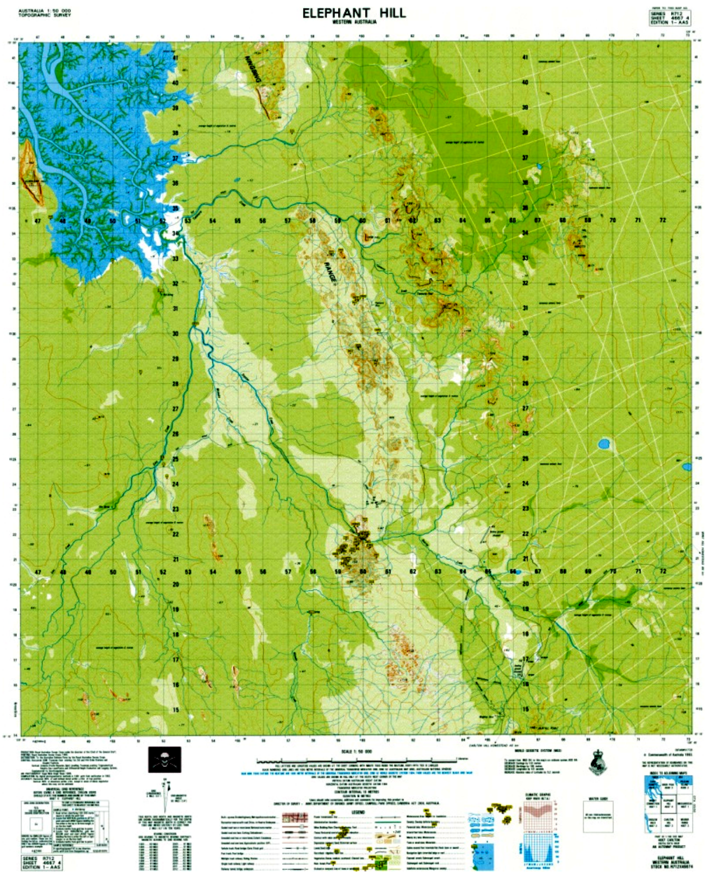
Karst of the Ningbing Range

***John Cugley* WASG**

This presentation will discuss the Nungbing Ranges including the location, climate and access. The geological history and mode of formation of the unit and associated karst blocks will also be discussed. Previous numbering of features during SRGWA trips and current record keeping will be presented along with major discoveries. The long term surveying and exploration aspirations for the BFC and Southern Ningbings will also be presented. Associated fauna of the area including bats, snakes and invertebrates will also be shown. The presentation will conclude with a discussion of minimal impact caving and pertinent conservation issues of the area.

So where are the Ningbings? 300km east of BROOME.

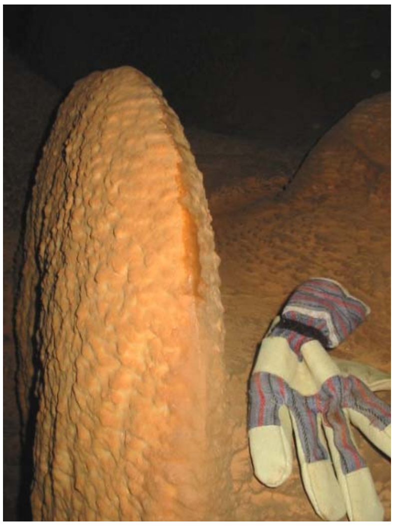




Getting Out

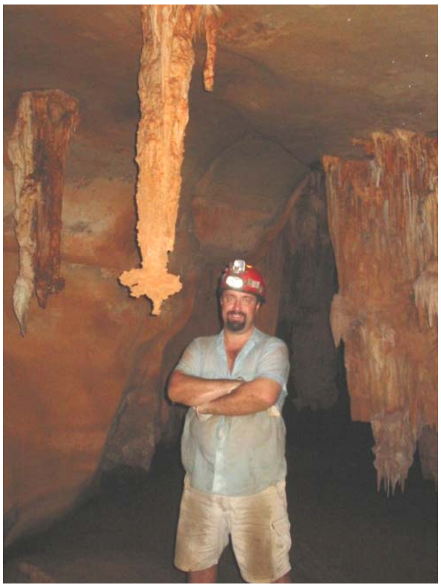
30 p2

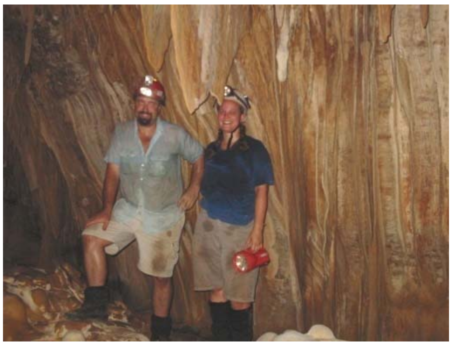
KNI 49 on left **KNI 80** on right

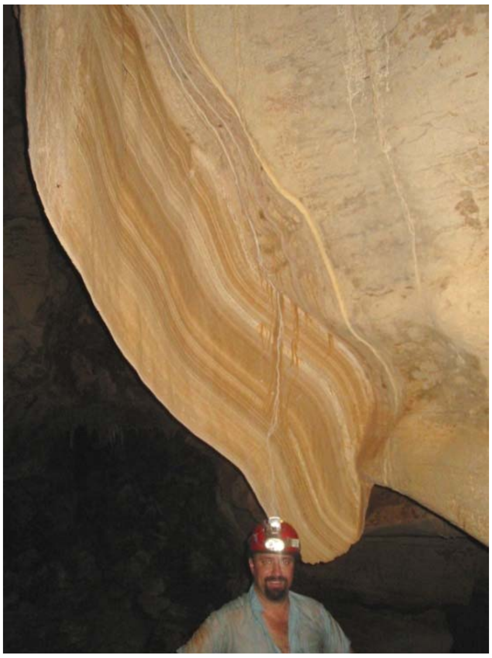


30 p3

KNI 77





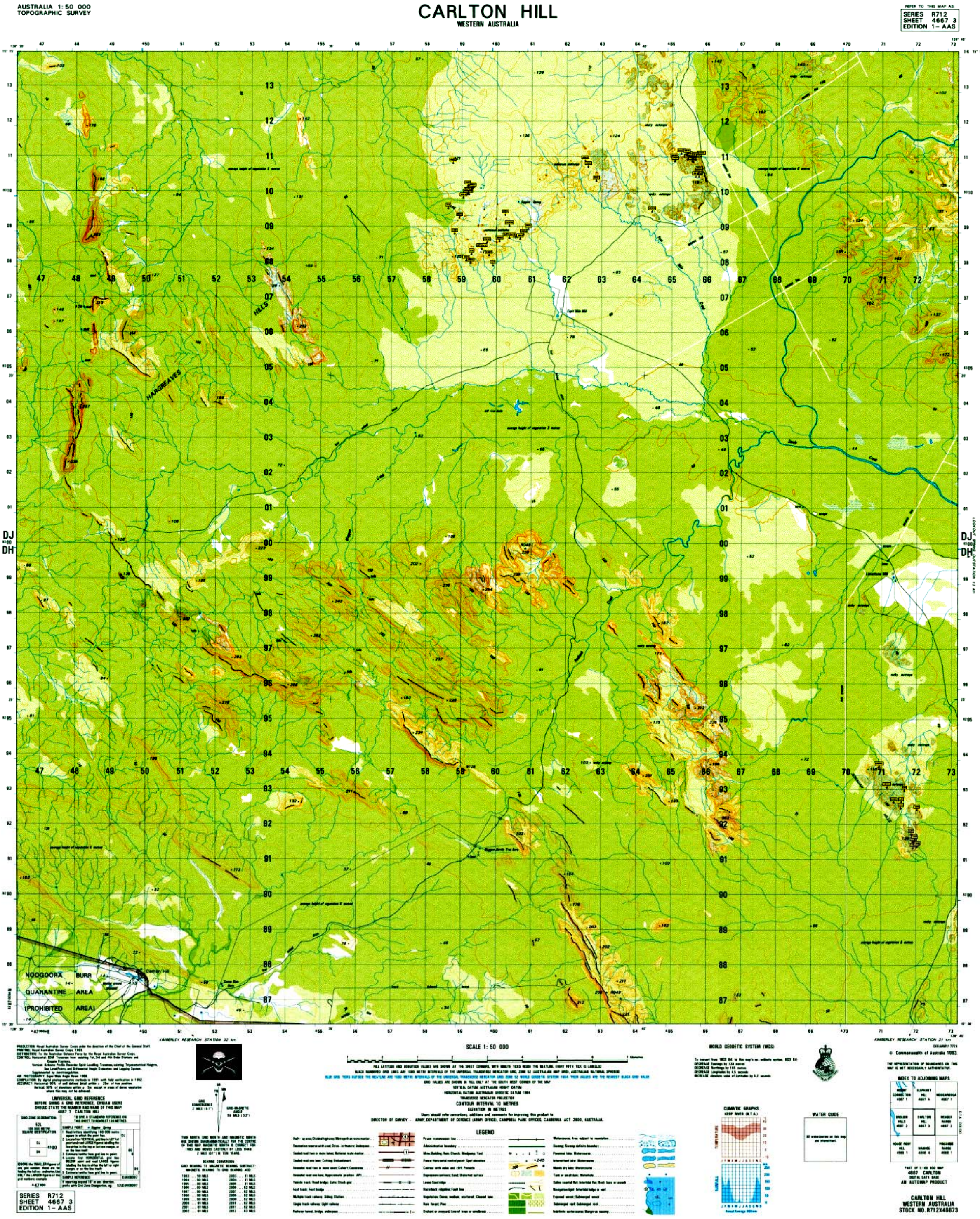


KNI 44 below

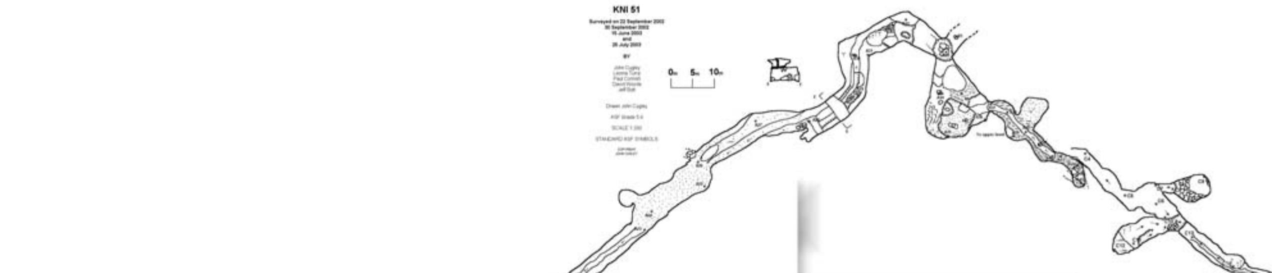
30 p4

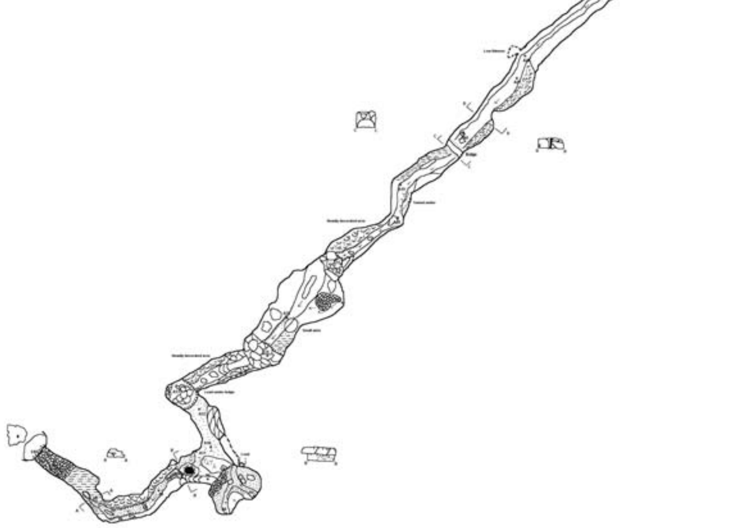
Fauna

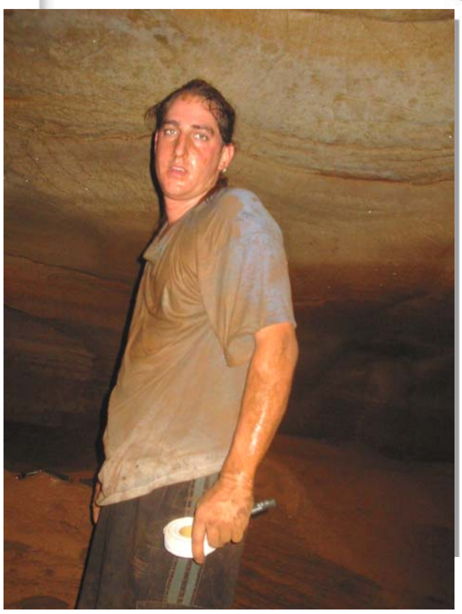
SOUTHERN AREA



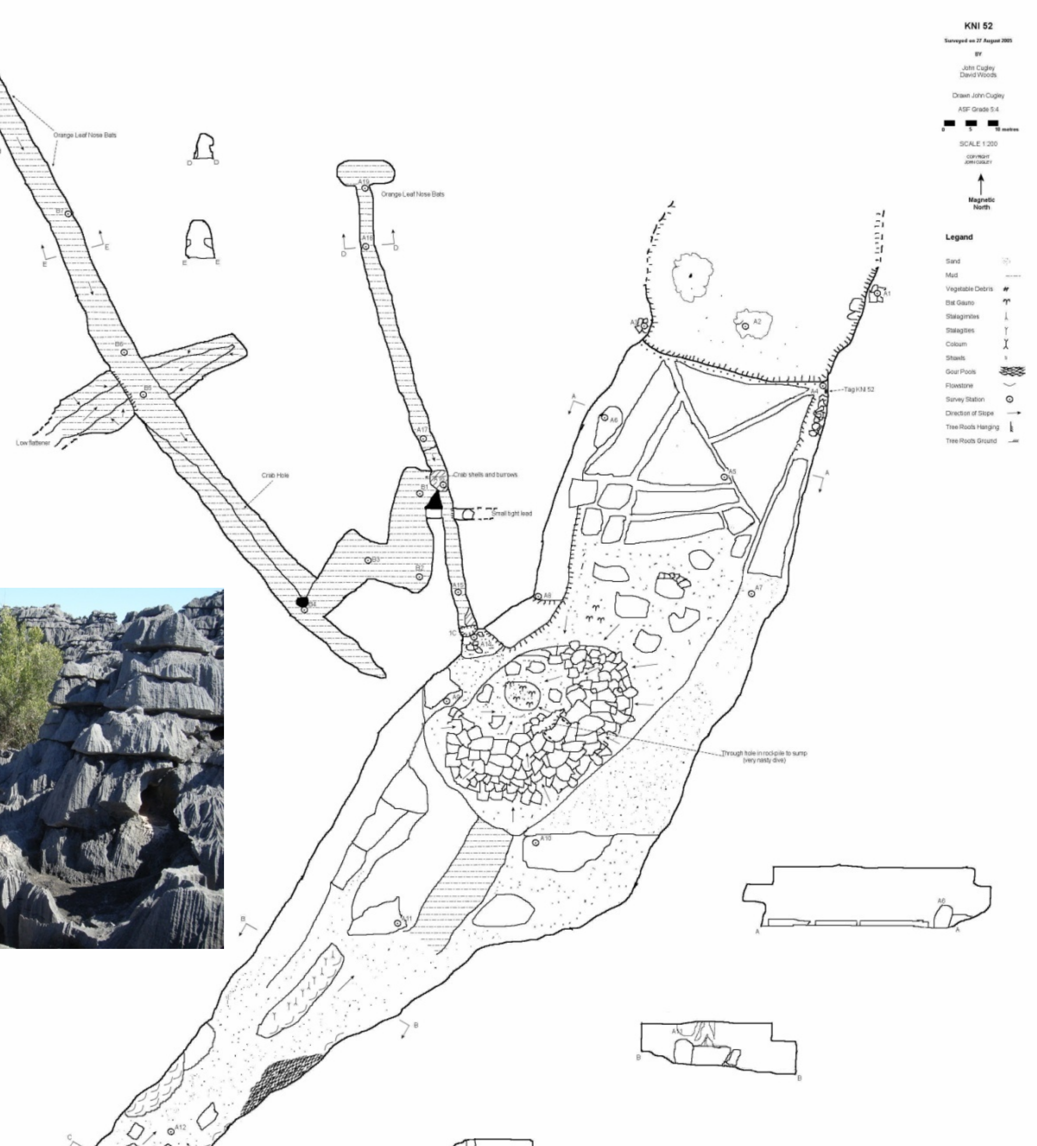
KNI 51







KNI 52


KNI 52
Surveyed on 27 August 2005
BY
John Cugley
David Woods
Drawn John Cugley
ASF Grade 5:4
0 5 10 metres
SCALE 1:200
COPYRIGHT
JOHN CUGLEY
Magnetic
North
Legand
Sand
Mud
Vegetable Debris
Bat Gauno
Stalagimites
Stalagties
Coloum
Shawls
Gour Pools
Flowstone
Survey Station
Direction of Slope
Tree Roots Hanging
Tree Roots Ground
Sump 0.7 deep
Bat skeletons in mud
Orange Leaf Nose Bats
Low flattener
Crab Hole
Crab shells and burrows
Small tight lead
Tag KNI 52
Through hole in rockpile to sump (very nasty dive)
Wallaby droppings

KNI 88

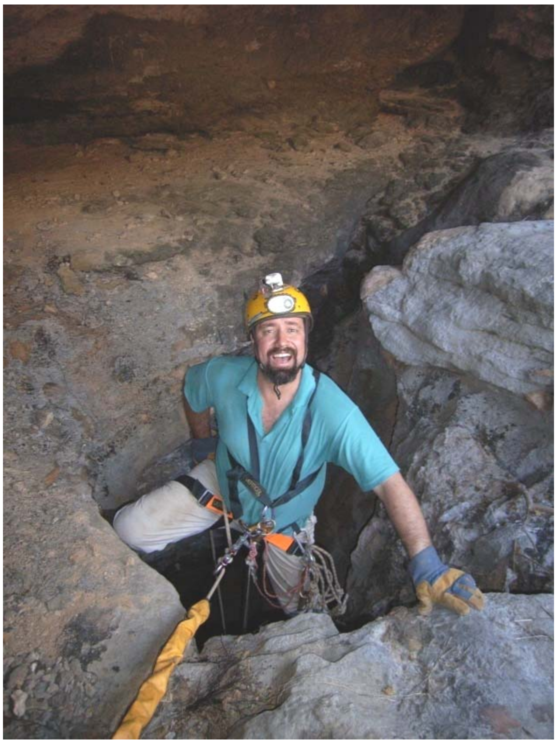


Photo Credits

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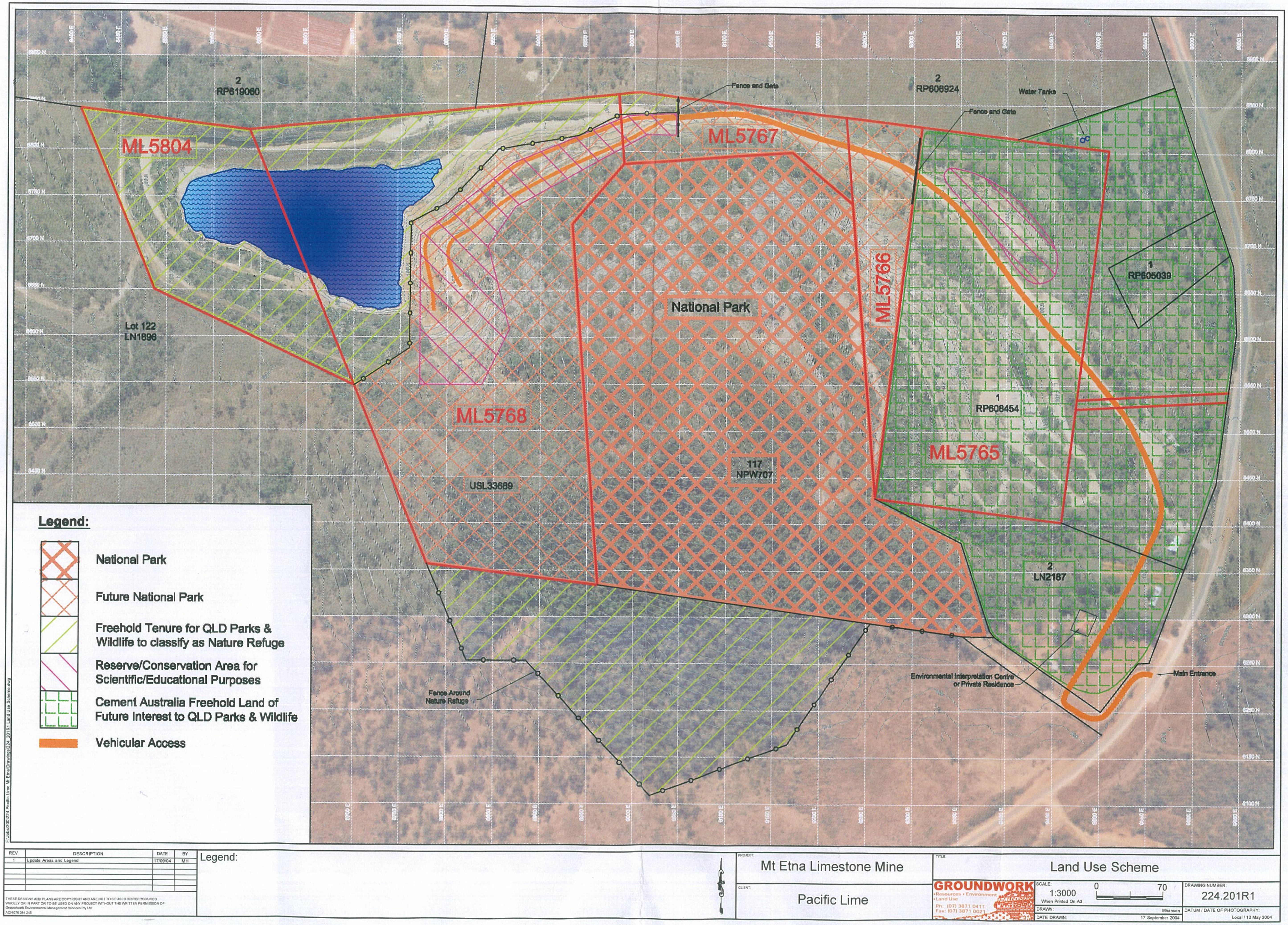
2
RP619060
2
RP608924
Fence and Gate
Fence and Gate
Water Tanks
ML5804
ML5767
ML5766
ML5768
ML5765
National Park
Lot 122
LN1896
1
RP605039
1
RP608454
117
NPW707
USL33689
2
LN2187
Environmental Interpretation Centre
or Private Residence
Main Entrance
Fence Around
Nature Refuge
Legend:
National Park
Future National Park
Freehold Tenure for QLD Parks &
Wildlife to classify as Nature Refuge
Reserve/Conservation Area for
Scientific/Educational Purposes
Cement Australia Freehold Land of
Future Interest to QLD Parks & Wildlife
Vehicular Access
Legend:
Mt Etna Limestone Mine
Pacific Lime
Land Use Scheme
GROUNDWORK
1:3000
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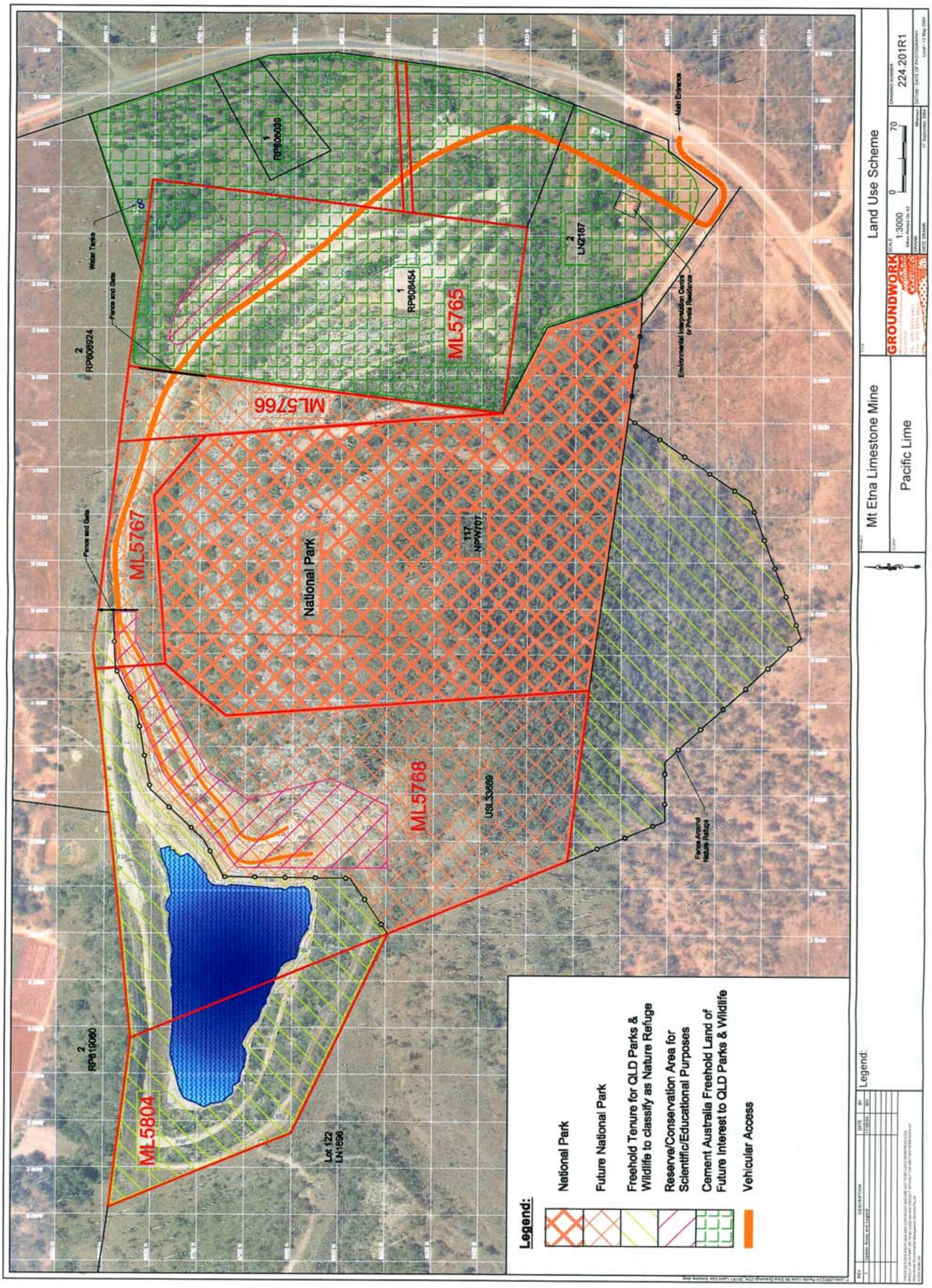
70
224.201R1
17 September 2004
Local / 12 May 2004

Mt Etna Recent ASF management opportunities

Nicholas White



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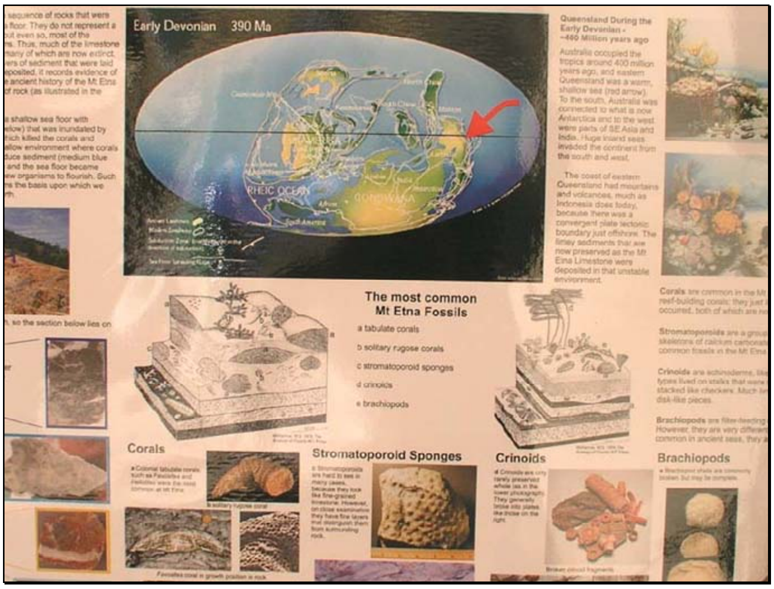

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Slide 16

Slide 17

Slide 18

World Rock Art

Robert Bednarik

Convener/CEO, International Federation of Rock Art Organisations (IFRAO)
auraweb@hotmail.com

Australia is distinguished not only by possessing the largest concentration of rock art, but also by being the only country that has continuing broad access to ethnographic interpretation of rock art by its traditional custodians. Moreover, Australia has the largest organisation of rock art researchers, the premier scientific journal in the field, and the largest academic congress in the discipline. This presentation explains the reasons for some of these factors, and it offers an overview of the huge corpus of Australian rock art. The major regional concentrations of it are introduced, with special attention given to the cave art of Australia, which is the world's second-largest body of this particular phenomenon. Some attention is also given to the time periods the rock art belongs to, to the methodology of estimating the age of rock art, to the issue of its interpretation, and to the questions of its preservation and protection. The presentation closes with a brief synopsis of the current campaigns to protect rock art in Australia.

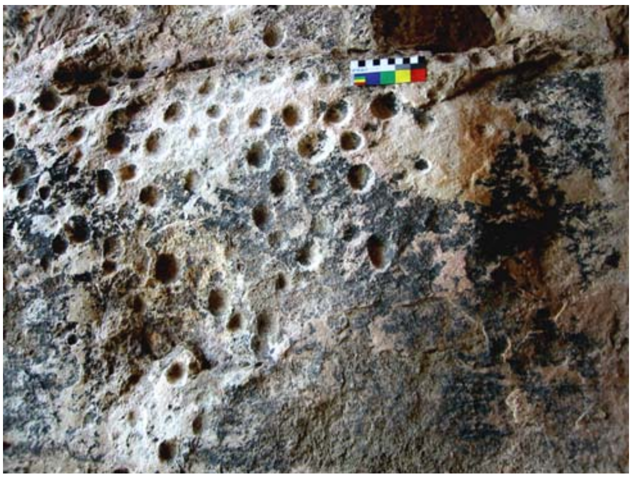
The world's major rock art regions are defined and described, and the long history of their study is briefly reviewed. It is demonstrated, however, that the proper scientific study of world rock art is a very recent phenomenon, having been initiated only in the last few decades. Rock art research remains an embryonic science that is only now being developed through an international network of research organisations.

A brief review

Rock art is a global phenomenon occurring in nearly all countries. It constitutes the major component of the surviving cultural evidence of pre-historic people, accounting for some 99% of all palaeoart in the world today. It is therefore the most outstanding part of humanity's early cultural heritage, providing a rich source of information about the conceptual reality of the ancients, and about the cognitive evolution of our species.

The oldest known rock art dates from the Lower Palaeolithic period, the most recent from the 20th century. This presentation addressed the great diversity of what has survived on the rocks, continent by continent.

NOTE: The presentation was verbal; text not available.



Rio Siguas valley, southern Peru

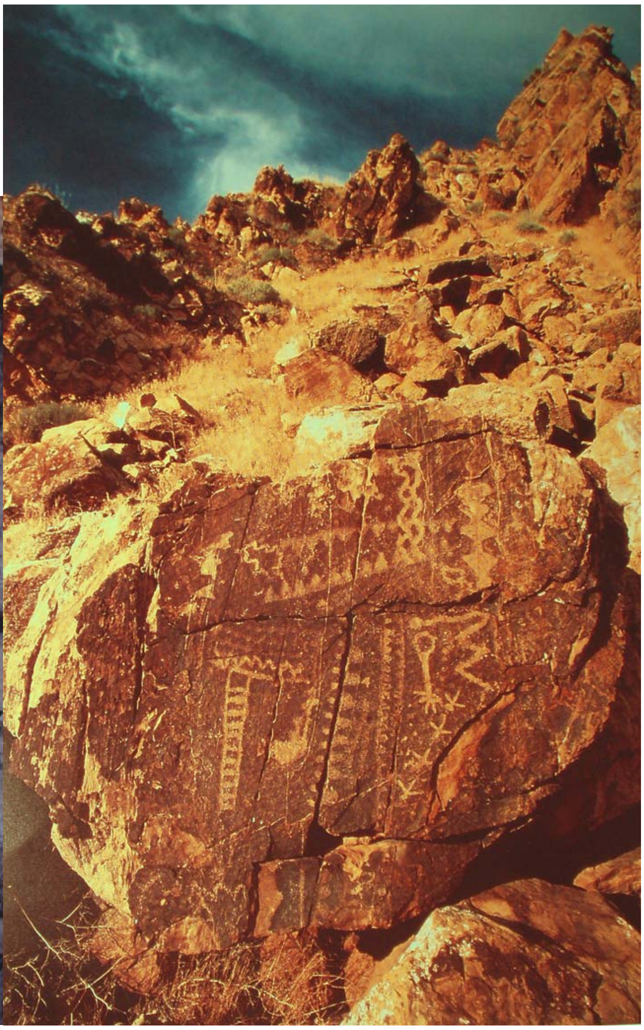
Rio Siguas valley, southern Peru

Toro Muerto, Arequipa, Peru

El Buey, Mizque valley, central Bolivia

Noreste tradition, Piaui, Brazil

Para,lower Amazon, Brazil



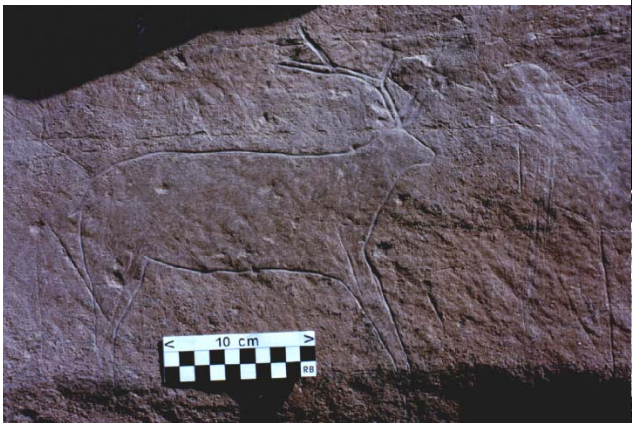
Cerro Blanco, Sonora Desert, northern Mexico

Hispaniola cave art, Caribbean

Barrier Canyon, Utah, USA

Three Kings Site, Uinta County, Utah, USA

Atlatl Butte, Carbon County, Utah, USA

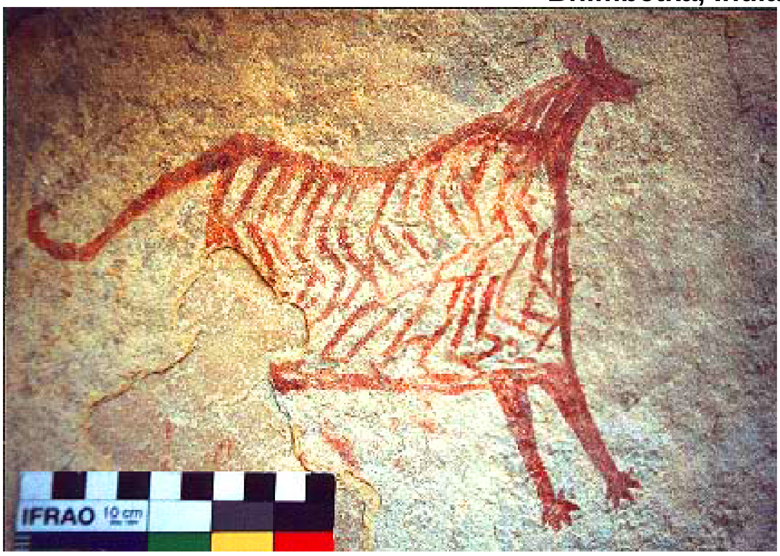


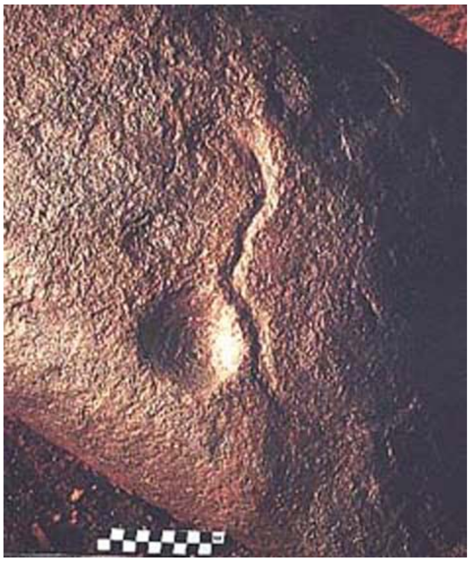
Shishkino, Lena River, central Siberia

Helanshan, Ningxia Province, NW China

Cliff paintings at Huashan, Ming River, Guangxi Zhuang Province , southern China, extending to 40m height

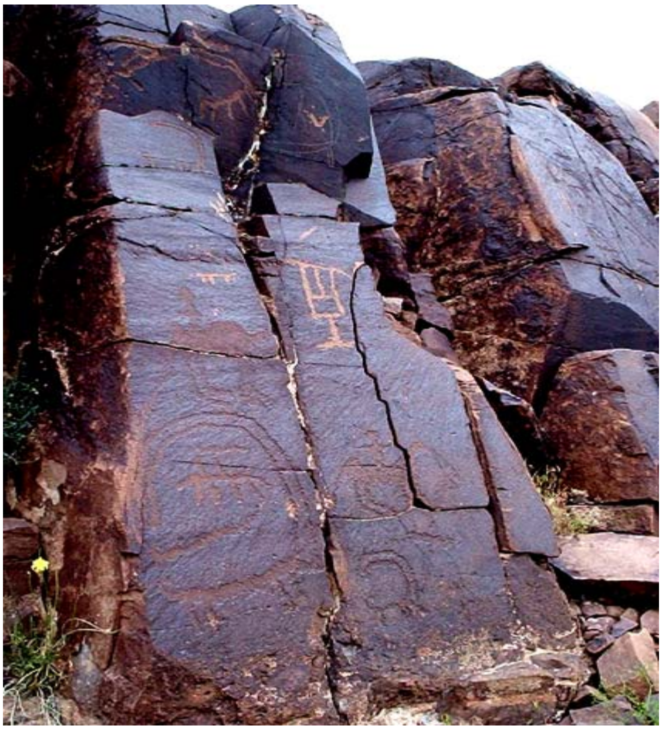
Bhimbetka, India





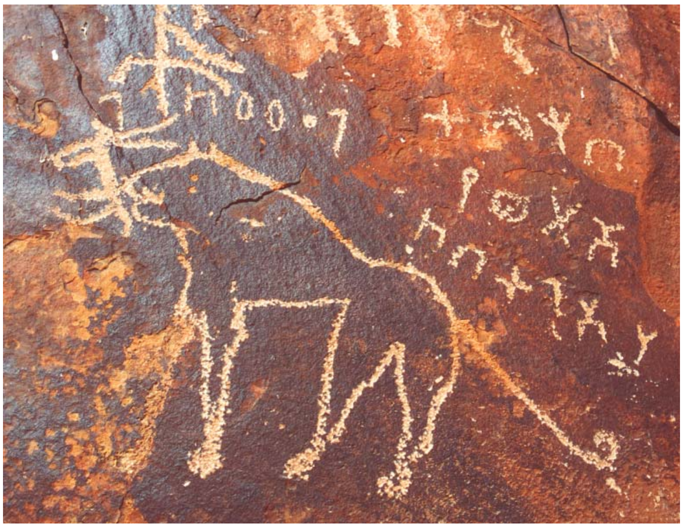
Mesolithic, ~8,000 years **Acheulian, ~200,000 years**

Central India, Bhopal region, Madhya Pradesh



Qom region, Iran

Al ‘Usayla, central Saudi Arabia



Yatib, Arabia

Hima, Najran region, Arabia

Acacus region, Libyan Sahara

Tahilahi, Sahara

Chariot, Tassili, Algeria

Horatio Rockshelter, South Africa

Tandjiesberg, South Africa

Penascosa, Portugal

CAVE ART

Lascaux, France

Lascaux, France

Baume Latrone, France, probably Aurignacian, >30,000 years BP

The proper scientific study of world rock art is a very recent phenomenon, having been initiated only in the last few decades. Rock art research remains an embryonic science that is only now being developed through an international network of research organisations.

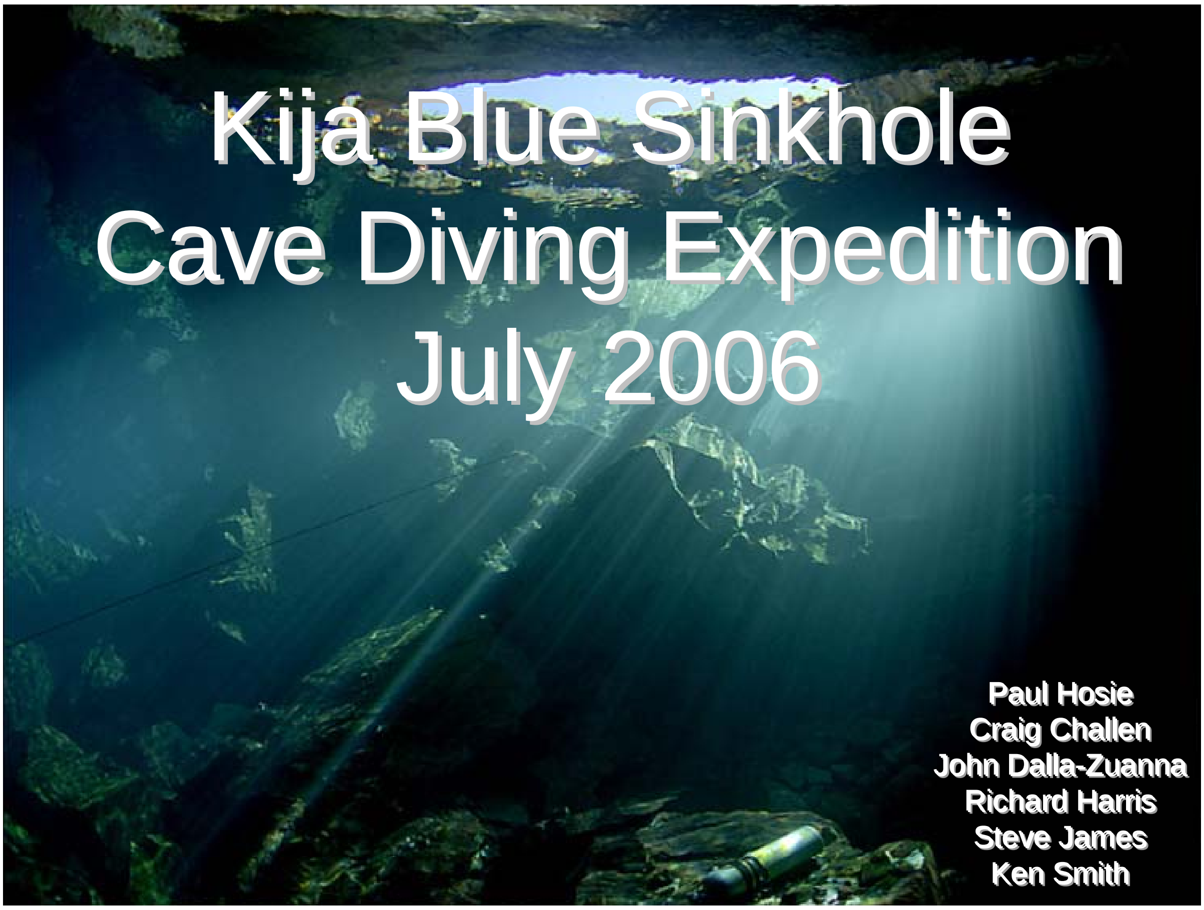
Chauvet Cave, France Aurignacian 32,000 years BP

32 p12

An expanded version is on the DVD PowerPoint slide show

Kimberley Cave Diving

Paul Hosie & Ken Smith




VH-SYC

26th Biennial Conference
Celebrating 50 years of the ASF
Caves Critters and Craters, Mt Gambier 2007

Marie Choi
Conference Co-ordinator

Well after two years of planning and 12 months of frenzied organising the 50th Anniversary conference has come and gone. If you didn't attend, you don't know what you missed.

So what were the highlights of the conference? Well it had the highest number of attendees for an ASF Conference -151 to be exact. I hear it raised the most money ever at a caver's dinner auction. It had some of the oldest and youngest attendees ever. Of the four 1956 veterans, three were CEGSA members - these were Elery Hamilton-Smith, Bob Sexton and Noel Mollet.

The conference also brought out a number of other old-timers, some of whom hadn't been to a conference since 1965; that's a long time between drinks. Overall, the conference received mainly positive feedback – that it was very family friendly, and that the range of activities and presentations suited all tastes and interests from the scientific to the creative.

No conference can work well without its support team and the people behind the scenes. Besides all the work that went on prior to the event, there was much to do before people arrived. Athol Jackson, Chris Gibbons, Kevin Mott, Adam Branford, Monica Burt and myself worked hard for two days before the event setting up the venue, organising food and electronic equipment. We also had a number of interstate cavers who turned up early and were "recruited" into helping to set up. Most notable of these were Chris Gillard (NSW), Greg Leader and Ian Farhall (Vic). Then there were June and George MacLucas who arrived to set up the Art Show with help from Sam and Geoff Aslin. The Art Show seems to get bigger each time and many local artists were represented.

Our first hiccup came with the Cold Room at the function centre. It had broken down before we arrived and they were still waiting for the repair guy when we got there. Thanks to Vilma at the Racecourse - she kept chasing them up so it was running by the time the first lot of food arrived.

Then hiccup number 2 - Damian Grindley found Stan Flavel broken down on the side of the road on the morning that the conference opened - with our T-Shirts, mugs and half the programs. Damian and Amanda unloaded their car and put the conference gear in to get it to us ASAP while Stan got his car repaired.

Although some were recruited to help us, having quite a few conference attendees turn up days early also created some problems at Willow Vale Caravan Park where most people were staying, as the place was virtually booked out and some major shuffling had to happen. But in the end it was all sorted out, even with all the extra people who turned up at the last minute. Willow Vale was a little overcrowded but the atmosphere was pretty good and relaxed and many people were impressed with the owners' hospitality.

Another group who require a special mention were the volunteers that took care of feeding the hordes at lunchtime and during tea breaks. We had decided to include lunch in the cost of the conference to keep everyone together and ensure things ran on time but it was a big job - mostly the washing up after each break. These volunteers included Monica Burt, Sam Aslin, Christy and Dannielle Thomas, Julie Mott and Sharon Dykes. They were our conference angels; so much so that I went out and found halos for them all - all except Christy because if you ever stay at the farm at Avenue she can be a little devil - so she got the bright red devil's hat complete with horns and tail. Anyway they did an extraordinary job and it was probably the most physically demanding of all.

Then there was Adam Branford who ran numerous errands, organised some equipment and kept some of our attendees entertained on a number of caving trips. He was also an entertaining bus driver for our Naracoorte field day trip.

Athol and Stan took control of the presentations, ensuring it all ran smoothly. I have to wonder just what equipment Athol doesn't have - he brought so much down from Adelaide. It included PA systems, projectors, TVs, video and DVD players, printers, computers, cabinets, display boards, screens - you name it he had it.

Damian of course took care of his special project of wines along with numerous other jobs including dobbing me in to the local media for an interview when I had just woken up from a quick nap. But the wine was really his baby. It proved so popular he had to have another 12 cases shipped to the Mount. Tim Payne put together an SRT race along with an SRT obstacle course that proved a bit challenging.

Day one was registration day. There were a number of self-guided adventure caves available for those who turned up early along with some snorkelling at Ewens Ponds. We also had a number of very late registrations, and people went about setting up all sorts of displays. We then had a welcome BBQ after which Andy Eavis, President of the International Union of Speleology, presented a viewing of the BBC's "Planet Earth Caves".

Day two saw the official opening with Elery as the keynote speaker and then the presentations began. Later that afternoon we had the official opening of the Speleo Art Show and there was a great range of artistic styles presented ranging from sketches, sculptures and paintings. Unfortunately the only work Brigid was able to submit this time were the logos that she had designed for the conference which impressed a lot of people. After the Art Show opening, Andy Eavis gave an excellent 3D slide show of impressive caves from around the world.

On day three were more presentations with the day having a strong cave diving contingent. Peter Horne even managed to make it between work and ill health so he could present a history of CDDA and cave diving. One of the activities that proved successful was a limestone sculpting workshop run by local artist Ivo Tadic. Some of the participants came back wanting that to be run at all conferences. These proud new sculptors put their handiwork on display during the conference and a number of them even managed to sell their creations - possibly some future artists in our midst.

We also had another group of budding artists who paid $5 for a plywood bat (flying type, not cricket type) that they could paint or decorate. These artists ranged from 2yrs to 50yrs plus, with the majority being 12 and under. They even decided to put on their own little art show and covered the place with signs announcing their Bat Art exhibition. The Bat Art proved so popular that we were cutting them out of cardboard for the kids to do.

The evening ended with a Speleo Quiz with about 10 teams entered. The Quiz included a range of serious scientific, general knowledge, historical and funny story questions. Did you know that Dick Smith (Dick Smith Electronics) was once a member of a NSW caving club, or that Steve Bourne, Manager of Naracoorte Caves, had a previous job as a Sheep Shearer? What I'm trying to work out though is even though the judges (Damian Grindley and John Dunkley) were open to some bribery, how did my table (the one with all the kids on it) manage not to win when we had most of the answers? The winners ended up being a mixed team of Tasmanians, NSW and Western Australians I believe.

Day four again was full of presentations and the ASF Council meeting. Other than that, the most significant event that was developing before our eyes was a young romance budding between 4 year olds Merrin Grindley and Mitchell Payne. These two little love birds were often seen running hand in hand towards the large sprinklers, on the very hot days we were having, ignoring Amanda's and Pams calls not to get wet. Could this be the start of a new caving dynasty, the joining of two prominent CEGSA families? Stay tuned - you never know what may happen over the next 20 years - maybe the big event at the 70th anniversary conference will be a caver's wedding!!!!!!!

Day five saw the field trip at Naracoorte. Poor Steve and the staff at the caves. It was a stinking hot day of about 38°C and even though there were a few hiccups, the day was a big hit. Cavers were made most welcome. Steve and his team had to manage his normal busy Xmas holiday visitors and then to have 140+ cavers turn up for the day was a big ask with tours and talks through all of the Show Caves and a number of wild cave tours available. Although only a few of the group who went to Brown Snake Cave managed to get through that tight entrance, of course Damian had to stay on the surface and entertain those that couldn't get in.

Everyone met back at Wirreanda for a relaxed BBQ dinner and even the staff at Naracoorte got to relax for half an hour. Then as it began to darken, most people headed to the Bat Cave with their wine and beer to view the bats flying out. Mind you there is a bit of a concern that the drought is impacting on the bats. If you saw the Advertiser article from early January when Steve went in to do some maintenance on the Bat Cave cameras, he came across a large number of dead bat pups. Anyway we headed back to Mt Gambier at around 10pm with Adam's bus picking up a number of stragglers. The ride back was very entertaining and if Adam ever wants a career change he should consider being a Bus Tour driver.

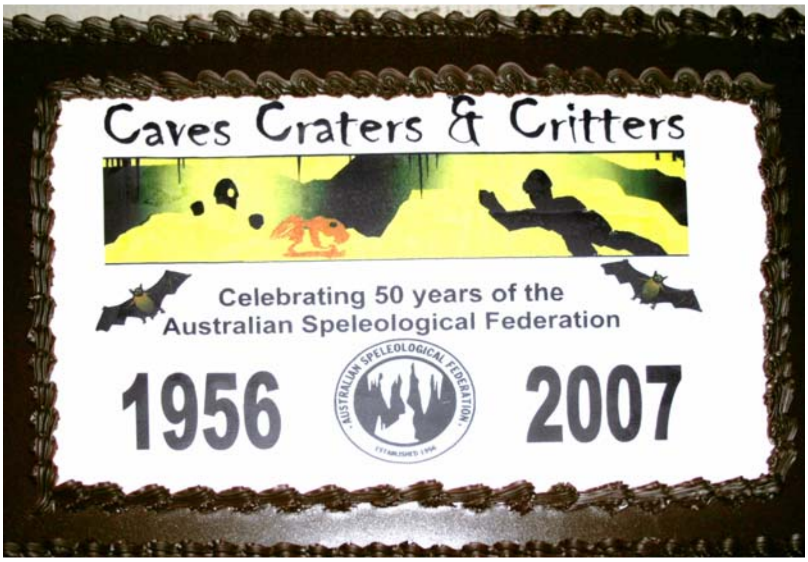
By Thursday Chris and I were exhausted but there was little time to rest as we had to organise a number items for Friday. One of those was green jelly for the Speleo Sports. We ended up buying every packet of green jelly in Mt Gambier along with plain gelatine. We spent the afternoon making gallons of the stuff. We also had a heap of BBQ items left, so Thursday night saw a free BBQ dinner for those who wanted it. A number of Videos and DVDs were also presented.

Well Friday was the last day - there were a few presentations but the big events for the day were Speleo Sports and SRT races. Stan and I set up the Speleo Sports utilising the winner's area of the race course. We wound about 300 metres of cheap rope around, over, and through various gates, fences, and steps as well as through a detergent-covered tarp tunnel and then the tarp-covered paddle pool full of green jelly and ice. Yes, I said ice because we left the lids down on the eskies - when we put them in the fridge a lot of the jelly didn't set. We also placed a key in the pool which the teams had to retrieve. Teams of four had to move through the course while connected to ropes and carrying an egg. Damian and Stan assisted many of the teams at the paddle pool by diving on top of participants once they started looking for the keys in the pool, to make sure they got low enough to find the key...

There were a number of teams ranging from adults to kids and a couple of mixed teams. One of the funniest sights was when Pam Payne and her 2 young ones were in the event with a friend and young Mitchell kept deciding he wanted to run off (I think he was looking for Merrin) and she had to chase him down. He's fast for a little tacker. The competition was at an end when Stan was duly dumped in the jelly pool and bombarded with the leftover eggs. Of course I missed that because I was setting up for the Dinner and I'm not sure what Damian's excuse was.

The dinner was great, and three people rang up and booked-in the night before for that. The caterers were great and the meal was excellent so if you ever want to cater something in the Mount, I highly recommend Posh Nosh and their prices are reasonable. We decorated the tables with candles and black and gold Helium balloons. I have to say Adam looked really funny when he rolled up with his car full of 150 balloons.

There were the usual speeches as well as the auction in which Andy Spate was the Auctioneer. He did a great job but you had to be careful as scratching your nose was considered a bid for some. As mentioned, it was the most money raised at a conference dinner and probably the biggest one ever. There were a number of characters at the dinner. Motty of course was in fine form with his white overalls, Hagrid Wig and drinking helmet with flashing bats.



We even had a great birthday cake. I got the same people who made the CEGSA 50th birthday cake make this one. It had the conference logos along with the ASF logo and bats on it. I have to mention a grateful Thankyou to Harry's wife who caught him as he backed out of the driveway to remind him that he was to bring the cake to the Dinner from Adelaide on Friday, because like many males he's a bit forgetful when it comes to things like that. Anyway the dinner wound up well after midnight and so the 50th anniversary came to an end (well for some - I still had a post conference trip to do.)

All in all it was a very successful event and a great celebration of the ASF's first 50 years. We were told by many that we had raised the bar for conferences. I believe we succeeded in our goals of making it an interesting, diverse and fun event. We wanted to try and have activities and events that appealed to a broad range of our young and old members and make it as cost-affordable as possible and I think we did that. However, I think I can safely say the next time it's CEGSA's turn to host the conference there's quite a few people who will be hiding, because its "bloody hard work!".

Congratulations and thank you to all involved in helping out. Hopefully I haven't forgotten anyone. Also Special Mention and thanks to our sponsors: SA Department Of Tourism; SA Department of Environment and Heritage and their respective Ministers; Scout Outdoor Centre; City of Mount Gambier; Limestone Coast Tourism; District of Grant; and Willow Vale Caravan Park.

For those from CEGSA who didn't make it, you missed a great time and if you didn't get a T-shirt, I have a few left in L, XL, and XXL at $30 each.

Speleo Art / Down Under

5th International Cave Art Exhibition

June MacLucas

In January this year the 5th International Cave Art Exhibition, "Speleo Art / Down Under", took place as part of the 26th Biennial Conference of the Australian Speleological Federation, held at Mount Gambier in the south eastern corner of South Australia. The Conference was held at the Mt. Gambier Race Course and the Speleo Art Exhibition was opened by world leading rock art specialist Robert Bednarik of Melbourne, Victoria.

Speleo Art / Down Under is modelled on the criteria of the International Society of Speleological Art (ISSA). The exhibition opening, plus gallery setup, has become an important social event for all who attend the conference. As well as attracting international and national Speleo artists, an invitation is extended to local well-known artists living in the local area of each conference.

In all, 14 artists took part. 6 were from overseas - Ceris Jones, Jane Foale and Robin Gray from Great Britain, Ian Ellis Chandler from Spain, Carolina Shrewsbury and Rosemary Balister both from the USA. Our Australian representatives include four Speleo artists - Eve Taylor from Yanchep National Park in Western Australia, Garry Smith the well-known caver and cave photographer from New South Wales, Geoff Aslin - caver, artist, writer and local historian of the Mount Gambier area and June MacLucas, artist and Speleo Art / Down Under coordinator from Adelaide, South Australia.

Without doubt the highlight of the exhibition were the five local artists from Mount Gambier who included three well-known limestone sculptors- Robert Miles, Dagny Strand, and Ivo Tadic, while artist Anne Miles presented two Water Colour paintings of fossilised shells and Kelvin Smibert displayed a large collection of ancient Aboriginal engravings reworked onto large sheets of fibre glass.

These images by Smibert included life-size replicas of Aboriginal petroglyphs from the early Holocene age found in local Paroong Cave. These petroglyphs (called Karake-style art) include circles with internal designs up to a metre in diameter, incised to depths of up to 40mm (Bednarik *et al* 2003:3). Smibert's work is interesting in that he works from photographs and carefully reworks the images life-size onto large sheets of fibre glass. This presentation offered a great opportunity for viewers to walk amongst the engravings, as all the twenty or more Aboriginal caves in the area are gated and locked, and require special permission to enter.

The Art Exhibition was highly successful exhibiting 97 pieces of art work. From this, 19 pieces of displayed works were sold with a further 13 sales made from the bargain table (works shown at previous Speleo/Art exhibitions). In all 32 artworks were sold.

As part of the conference it was organised for speleo artists to take part in local sculptor Ivo Tadic's very successful five hour limestone sculptural workshop. All participants were so involved in completing their work with the help of Ivo, that for several hours all were so engrossed that no one spoke a word. The final artistic and creative standard of our first attempt at sculpture was rewarded with the sale of two of the students' works and all who attended, including me, purchased several limestone blocks to work on at home at some later date.

At this stage the Speleo Art / Down Under Art Exhibitions will be put on hold, but arrangements are in place for several Art Workshops at the next 27th Biennial Conference to be held at Sale in Victoria.

Photographic Competition

A photographic competition was held during the conference for ASF members. It consisted of seven categories with both open and novice divisions in each. Prizes were awarded in each division with an overall winner and a popular choice winner for the print entries.

Eleven members entered the competition with a total of 152 images submitted.

The judges were Barbara Styles (Adelaide Eastern Suburbs Camera Club), Keith Seidel (Australian Photographic Society judge) and Athol Jackson of CEGSA to keep them informed of the physical and technical difficulties of underground photography.

The following are the winners and commendations.

Water and Light

Entrances / Karst Features

Open Div

First Place
Richard (Harry) Harris---Water and Light

Commendations
Ross Anderson------------Cold Start
Garry K Smith--------------Chambers Pillar
Garry K Smith--------------Entrance to Liang Bua (print)

Novice Div

First Place
Kym Hosie-------------------Twilight at Stockyard Tunnel (print)

Twilight at Stockyard Tunnel

High and Dry

Passages / Chambers

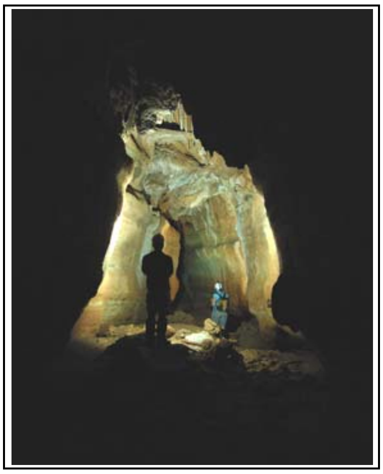
Open Div

First Place
Ross Anderson-----------High and Dry

Commendations
Richard (Harry) Harris---In the Rough
Garry K Smith-------------Serpentine Cave Meanders
Garry K Smith-------------Croesus Cave (print)
Ken Smith------------------Decorated Chamber 2

Novice Div

First Place
Kym Hosie-----------------Exploring the Ningbings (print)



Exploring the Ningbings

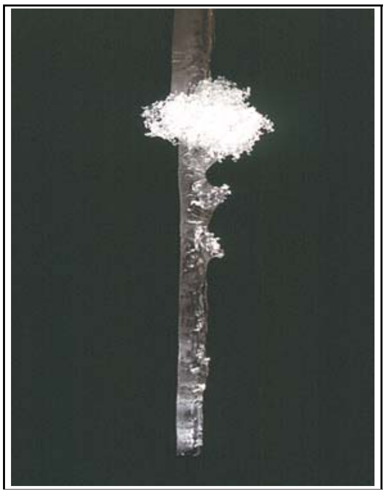
PHOTOGRAPHIC COMPETITION ***Athol Jackson***

Cave Decoration

Open Div

First Place
Norman Poulter-------Halite crystals on Halite Straw (slide)

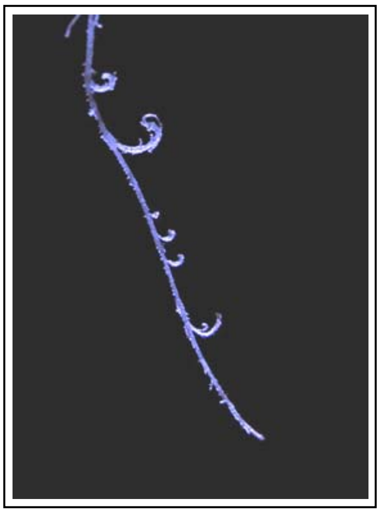
Commendations
Garry Smith------------Silk Shop – Kubla Khan
Garry K Smith---------Helictite – Gengus Khan
Norman Poulter-------Halite and Calcite Decoration (slide)



Halite Crystals on Halite Straw

Novice Div

First Place
Paul Hosie-------------Halite Whorls (print)



Halite Whorls

Scientific

Open Div

First Place
Garry K Smith----------Hickmania Troglodyte Cave Spider (print)

Commendations
Ross Anderson--------Ostracoding

Hickmania Troglodyte Cave Spider

Novice Div

First Place
Paul Hosie--------------Ningbing Scutigeromorph (print)

Ningbing Scutigeromorph

PHOTOGRAPHIC COMPETITION

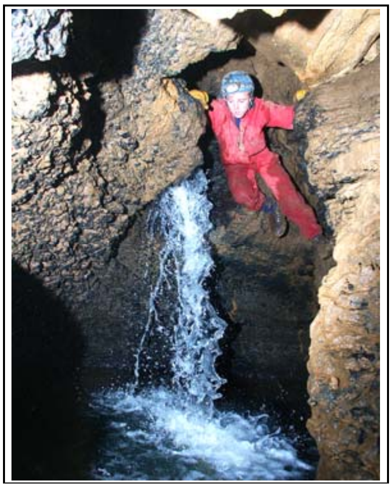
Athol Jackson

Cavers in Action

Open Div

First Place
Garry K Smith---------Andrew in Emperor Cave

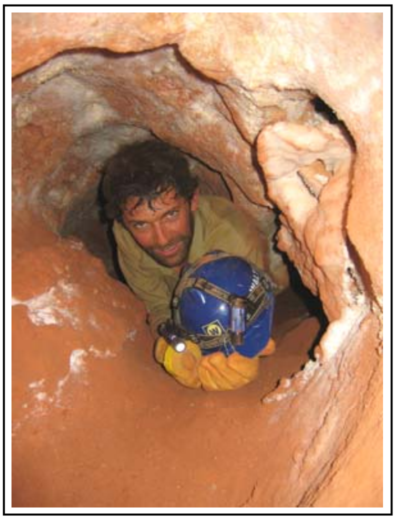
Commendation
Ross Anderson--------Dropping the Pot



Andrew in Emperor Cave

Novice Div

First Place
Paul Hosie--------------Ripley in Ezam (print)



Ripley in Ezam

Cave Diving

Open Div

First Place
Richard (Harry) Harris---Inner Space

Inner Space

Freeform

Open Div

Commendation
Ross Anderson------------Once Upon a Drain

Overall of Show

Garry Smith-----------------Hickmania Troglodyte Cave Spider (print)

See previous page for photo.

Peoples Choice Print

Paul Hosie-------------------NingBing Scutigeromorph

See previous page for photo.

Athol Jackson.
(Photo Competition Coordinator)

Sinkhole / Cenote Field Trips – Mount Gambier to the Coast

Ian Lewis

The Gambier Karst Province is more-or-less centred around the volcano and City of Mount Gambier. The better karst pavement exposures and large cenotes are to the southeast and southwest of the mountain, extending to the coastline and the region's biggest karst discharge spring at Ewens Ponds. Altogether, the limestone region forms approximately 30% of the recently UNESCO-declared Kanawinka Global Geopark which also covers the "new volcanics" region across western Victoria and the Mount Gambier and Mount Burr volcanic complexes in South Australia.

There is so much to see and we only had a day to show it! Rather than trying to cover everything, two separate day tours commenced at Mount Gambier and ended at Ewens Ponds on the coast, taking our speleo-guests via opposite paths through the karst field (see diagram) down the groundwater catchment and across these landscape components –

- stranded pleisocene dune ranges which were once former coastlines
- pine forests and irrigated farmland
- cenote locations
- remnant native vegetation and areas of clearance
- karst plain and soil stripping
- groundwater, diving and pollution sites
- quarrying and gas wells
- volcanic intrusions
- the coastal karst springs

Tour 1 – the south-western route

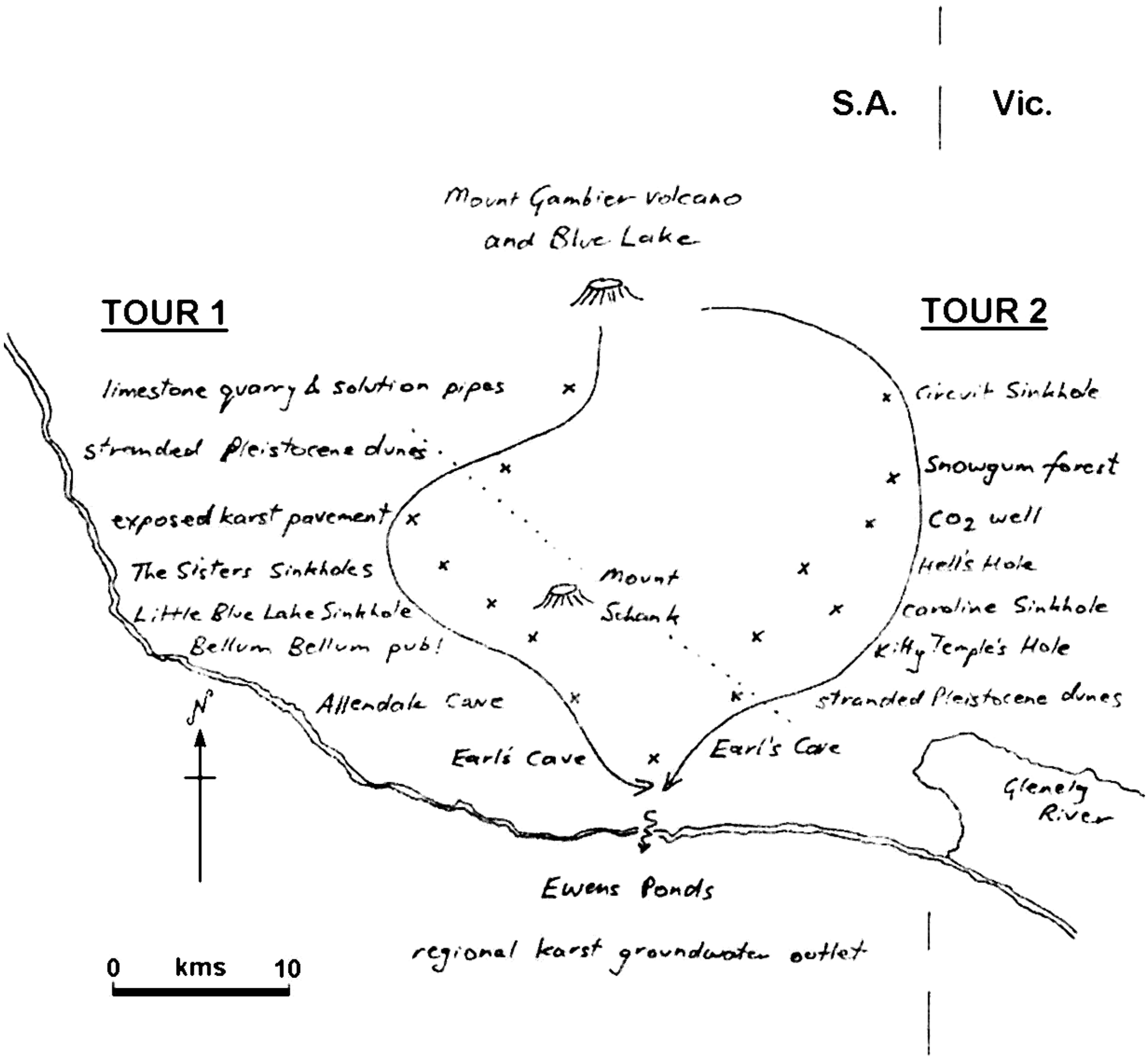
Moorak Quarry – Gambier limestone, extensive piping and volcanic soil cover
Burleigh and Caveton stranded dunes
Little Blue Sinkhole – cenote alignments, public access issues, blue-green algae blooms
Gouldens Hole - cut stock access ramp, wall exposures of strata and spongework
The Sisters – double cenote, rubbish dumping issues
Karst pavement - exposure, karren, and microkarst, remnant Stringybark cover
Mt Schank – volcano and crater, interpretive signs, adjacent scoria quarry
Allendale Cave – middle of the road diversion and collapse history
Earls Cave – issues of pollution and dumping directly into the water table
Ewens Ponds – renowned triple doline spring-system with drainage channel cut to the sea

Tour 2 - the south-eastern route

Circuit Sinkhole – large dry doline rehabilitated in a rubbish removal programme
Pine forests and the most westerly Snowgum remnant from past climates
Carba Well – 2500m deep CO2 reservoir possibly linked to volcanogenic karst processes
Caroline Sinkhole – rehabilitated site with viewing platform and charcoal ledge sites
Hells Hole – giant cenote breaching stranded dune 30m into limestone and dark lake
Kitty Temples Hole – early settlers pub and horse-change site of dubious reputation large-scale pivot irrigation systems drawing from unconfined and deep confined aquifers
Earls Cave – see Tour 1 description
Ewens Ponds – see Tour 1 description

Kevin Mott and Ken Grimes took Tour 1 while Ian Lewis took Tour 2. It was a great enjoyment and privilege to show everyone our sheet karst field with its issues which contrast with eastern state mountain karst mini-regions. Our audience were engaged, appreciative, interested and provided much discussion. And personally, I was delighted to be "trapped" in my ute with Henry Shannon for 4 hours talking about all this non-stop. It was the best way for Henry and I to catch up after too many years!

ASF Gambier Karst Tours



Attendees of the 26th ASF Conference

Summary 151 people:

			Home State of registered attendees	
103	registered full	(2 were 1956 vets)	6	ACT
2	registered 2-day		35	NSW
13	registered 1-day		2	Qld
11	registered children		27	SA
4	1956 veteran		12	Tas
7	1-day guests		22	Vic
10	dinner-only	(2 were 1956 vets)	22	WA
6	volunteer	(1 was registered full)		

attendee		**duration**	**home State**	**affiliations given**
Jay	**Anderson**	all conference	WA	WASG & SRGWA
Ross	**Anderson**	all conference	WA	WASG & SRGWA
Fred	**Aslin**	dinner only	SA	CEGSA
Geoff	**Aslin**	all conference	SA	
Jeanette	**Aslin**	dinner only	SA	
Samantha	**Aslin**	volunteer	SA	
Erica	**Baddeley**	all conference	Vic	VSA
Glenn	**Baddeley**	all conference	Vic	VSA
Serena	**Benjamin**	all conference	Tas	STC
Anna-Eugenia	**Binnie**	all conference	NSW	
Ian	**Binnie**	all conference	NSW	HCG
Steve	**Bourne**	guest	SA	DEH SA
Sarah	**Boyle**	dinner only		
Chris	**Bradley**	all conference	ACT	NUCC & CSS
Christopher	**Bradley**	child	ACT	NUCC & CSS
Adam	**Branford**	all conference	SA	CEGSA
Tony	**Bresnan**	1-day	WA	
Vicki	**Bresnan**	all conference	WA	SRGWA
Darren	**Brooks**	all conference	WA	WASG
Cathy	**Brown**	all conference	ACT	HCG & CSS
Grace	**Bunton**	all conference	Tas	STC
Kathy	**Bunton**	all conference	Tas	STC
Steven	**Bunton**	all conference	Tas	STC
Monica	**Burt**	volunteer		
Dave	**Butler**	all conference	Tas	NC
Allan	**Butt**	dinner only		
Daryl	**Butt**	dinner only		
Rita	**Butt**	dinner only		
Daryl	**Carr**	all conference	Vic	VSA
Alan	**Caton**	all conference	NSW	RSS
Marie	**Choi**	all conference	SA	CEGSA
Sandra	**Chrystall**	1-day	NSW	OSS
Ian	**Collett**	all conference	WA	WASG
Brian	**Combley**	all conference	WA	Clinc
Joan	**Crabb**	all conference	NSW	HCG
John	**Cugley**	all conference	WA	WASG
Ian	**Curtis**	all conference	NSW	OSS
Paul	**Devine**	all conference	WA	SRGWA & CEGSA
Wesley	**Devine**	child	WA	SRGWA & CEGSA
Bruce	**Downes**	all conference	Vic	CCV
Jeanette	**Dunkley**	all conference	ACT	CSS
John	**Dunkley**	all conference	ACT	HCG
Chris	**Dunne**	all conference	Qld	HCG

Attendees of the 26th ASF Conference

Peter	**Dykes**	all conference	NSW	CWCG
Sharon	**Dykes**	conference, volunteer	NSW	
Andy	**Evais**	guest		IUS
Lilian	**Evais**	guest		
Ian	**Farhall**	1-day	Vic	CCV
	Farhall	1-day	Vic	CCV
	Farhall	1-day	Vic	CCV
Dave	**Fielder**	1-day	SA	CDAA
Stan	**Flavel**	all conference	SA	CEGSA
Chris	**Gibbons**	all conference	SA	CEGSA
Chris	**Gillard**	all conference	NSW	RSS
Andrea	**Gordon**	1-day	SA	CDAA
Adam	**Griffith**	1-day	NSW	OSS
Glen	**Griffith**	all conference	NSW	OSS
Helena	**Griffith**	1-day	NSW	OSS
Ken	**Grimes**	all conference	Vic	CEGSA & VSA
Amanda	**Grindley**	all conference	SA	CEGSA
Damian	**Grindley**	all conference	SA	CEGSA
Damon	**Grindley**	child	SA	CEGSA
Suzanne	**Hall**	all conference	WA	SRGWA & WASG
Elery	**Hamilton-Smith**	all - 1956 vet	Vic	CEGSA & VSA
Richard	**Harris**	all conference	SA	CEGSA
Fran	**Head**	all conference	WA	WASG
Alistair	**Hodgson**	child	Tas	
Kathy	**Hodgson**	all conference	Tas	
Darren	**Holloway**	2-days	Vic	ASF
Kym	**Hosie**	all conference	WA	WASG
Paul	**Hosie**	all conference	WA	WASG
Grant	**Humphries**	guest	SA	
Deb	**Hunter**	all conference	Tas	MCCC & CCV
Kerrin	**Huxley**	2-days	Vic	ASF
Yvonne	**Ingeme**	all conference	Vic	VSA
Athol	**Jackson**	all conference	SA	CEGSA
Margaret	**James**	all conference	Vic	VSA
Robert	**Kershaw**	all conference	NSW	ISS
Bryce	**Kraehenbuehl**	1-day + dinner	SA	CEGSA
Janine	**Kraehenbuehl**	1-day + dinner	SA	CEGSA
Peter	**Kraehenbuehl**	all conference	SA	CEGSA
Tara	**Kraehenbuehl**	1-day + dinner	SA	CEGSA
Mike	**Lake**	all conference	NSW	SUSS
Ken	**Lance**	all conference	WA	WASG
Brigid	**Larkin**	all conference	SA	
Greg	**Leeder**	all conference	Vic	CCV
Ian	**Lewis**	all conference	Vic	CEGSA & CDAA
Ian	**Lutherborrow**	all conference	NSW	HCG
George	**MacLucas**	all conference	SA	CEGSA
June	**MacLucas**	all conference	SA	CEGSA
Angus	**Macoun**	all conference	NSW	CASM & RSS
Rhys	**Maddern-Wellington**	all conference	Vic	VSA
Denis	**Marsh**	all conference	NSW	OSS
Grace	**Matts**	all conference	NSW	SSS & ASF
Elysha	**McCabe**	child	NSW	HCG & SSS
Megan	**McCabe**	all conference	NSW	HCG & SSS
Natasha	**McCabe**	child	NSW	HCG & SSS
Shannon	**McCabe**	child	NSW	HCG & SSS
Stephen	**McCabe**	all conference	NSW	HCG & SSS
Iain	**McCulloch**	all conference	ACT	NUCC & ANURSES
Ann-Marie	**Meredith**	all conference	WA	WASG

Attendees of the 26th ASF Conference

Greg	**Middleton**	all conference	Tas	STC & SSS
Noel	**Mollet**	dinner only; 1956 vet	SA	CEGSA
Cynthia	**Mollet**	dinner only	SA	CEGSA
Julie	**Mott**	volunteer	SA	CEGSA
Kevin	**Mott**	all conference	SA	CEGSA
Mitchel	**Payne**	child	SA	CEGSA
Pam	**Payne**	all conference	SA	CEGSA
Tim	**Payne**	all conference	SA	CEGSA
Warren	**Peck**	guest		
Miles	**Pierce**	all conference	Vic	VSA
Rhonwen	**Pierce**	all conference	Vic	VSA
Graham	**Pilkington**	all conference	SA	CEGSA
Cathy	**Plowman**	all conference	Tas	NC
Norman	**Poulter**	all conference	WA	SRGWA
Liz	**Reed**	guest	Vic	
Chris	**Riley**	all conference	NSW	
	Riley	all conference	NSW	
	Riley	child	NSW	
	Riley	child	NSW	
	Riley	child	NSW	
Trace	**Robins**	all conference	WA	Clinc
Dorothy	**Robinson**	all conference	NSW	ISS
Lloyd	**Robinson**	all conference	NSW	ISS
Jill	**Rowling**	all conference	NSW	SUSS & SSS
Bob	**Sexton**	dinner only; 1956 vet	SA	CEGSA
Henry	**Shannon**	all conference	Tas	NC & SUSS
Mara	**Silins**	all conference	Vic	VSA
Neville	**Skinner**	all conference	SA	CEGSA
Gary	**Smith**	all conference	NSW	NHVSS
Ken	**Smith**	all conference	SA	CEGSA
Andy	**Spate**	all conference	ACT	CSS & ASF
Mae	**Steele**	guest	SA	
Jackie	**Tapper**	all conference	WA	WASG
Eve	**Taylor**	all conference	WA	SRGWA
John	**Taylor**	all conference	NSW	KSS
Cristy	**Thomas**	volunteer	SA	
Danielle	**Thomas**	volunteer	SA	
Bruce	**Waddington**	all conference	NSW	HCG
Philippa	**Wall**	all conference	Qld	HCG
Christine	**Warner**	all - 1956 vet	NSW	
Bev	**Watterson**	dinner only	WA	Clinc
David	**Watterson**	all conference	WA	Clinc
Nickolas	**White**	all conference	Vic	VSA & CCV
Susan	**White**	all conference	Vic	VSA & CCV
Bridget	**Wilkinson**	1-day	SA	CEGSA
Michael	**Winn**	all conference	WA	Clinc
David	**Wools-Cobb**	all conference	Tas	NC
Jessica	**Wools-Cobb**	all conference	Tas	NC
Trevor	**Wynniat**	all conference	SA	ForestrySA
Reto	**Zollinger**	all conference	Vic	WASG & CEGSA

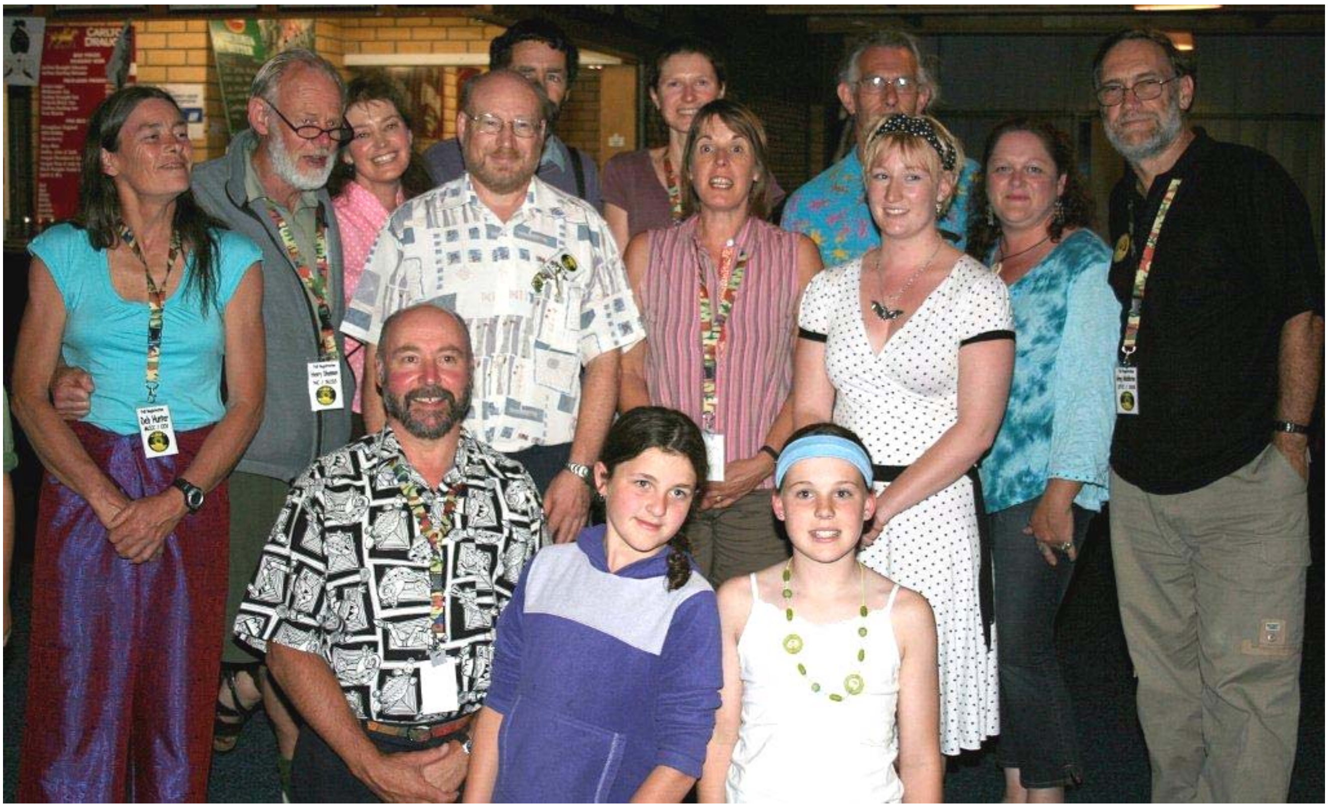
Attendees of the 26th ASF Conference

Australian Capital Territory

New South Wales

Attendees of the 26th ASF Conference

South Australia



Tasmania

Attendees of the 26th ASF Conference

Victoria

Western Australia

Conference Registration Form

26th Biennial Conference of the Australian Speleological Federation

Celebrating 50 years of Federation!

6 January to 12 January 2007

www.caves.org.au

Caves, Craters and Critters

ASF ABN 15 169 919 964

Hosted by:

Caves Exploration Group South Australia inc

One application per applicant!

Name: (Mr/Mrs/Ms/Dr) ....Club or Affiliation: ....

Address:...

Postal Address: (If different to the above) ....

Phone Number: (h) .... (w) .... (fax) ....

(M): ....Email:..

Please where required

1. Your arrival Date: Saturday 6th January: ❑ Other specify) ....

2. Registration details: (* Includes one set of proceedings either CD or hard copy!)

ASF member: *(All member categories)* Early payment by 30 September*	@ $180.00 @ $160.00	$ $
ASF Members attending their first conference or Fulltime students Early payment 30 September*	@ $130.00 @ N/A	$ $
All others *(Non ASF members)* Early payment by 30 September	@ $200.00 @ $180.00	$ $
'First' 1956 ASF conference registered attendees	Complimentary	$
Single day registrations (include trips except Naracoorte or satchel\mug).	@ $40.00	
Single day registration Naracoorte Wed 10th. Includes BBQ Dinner, Does not include satchel\mug)	@ $60.00	
Children under 10 (no proceedings, satchel etc)	@ $50.00	
	SubTotal	$

* Please provide my copy of proceedings on: Paper: ❑ **OR** CD: ❑

Two adult families - deduct $50 from registration fee if you only wish for one conference bag which contains 1 proceedings, field guide, mug.

3. Extra Copies of Proceedings:

Paper @ $25.00 including postage within Australia	$
CD @ $15.00 including postage within Australia	$
Add extra $10 for overseas postage	$
Sub Total	$

4. Presentions:

I wish to present a: Paper (Name of paper): .... Poster presentation: ....

Name of author/presenter:...

Time required: Short (15 min): ❑ Medium (30min): ❑ Long (45 min): ❑

Presentations must arrive by 1 December 2006. Please send your presentation\paper to the address below.

5. Accommodation option 1:

Willow Vale Caravan Park – Share bunkhouse and cabin – per person. FULL REGISTRATION PEOPLE ONLY

- Cost: $110 per person for the week. (BYO linen or sleeping bag)
- 1km from the function centre.
- Limited number of share 'bunk' accommodation. Book early & don't be disappointed!
- Note: 12 double beds available for couples. Couples please indicate if you require a double bed.
- Swimming pool

Full stay @$110.00	**Sub Total**	**$**
Double bed (for couples)	**Yes** ❑ (please tick)	

6. Accommodation option 2:
Willow Vale Caravan Park - Camping Full Registration Bookings have priority

- Unpowered site $15 per night per person or $50 per person or the week
- Powered site $20 per night per person or$75 per person for the week
- Showers\toilets: use of main block, Kitchen and laundry area available
- Swimming pool

Unpowered site (Price Per Person) **@$50.00for week or $15 per night x number of nights ( )**	**Sub Total**	**$**
Powered site (Price Per Person) **@$75.00 for week or $20 per night x number of nights ( )**	**Sub Total**	**$**

7. Accommodation option 3:
Mount Gambier Race Course - Camping - tent or small caravan

- Camping fee: $20 per night per person. Tent or small caravan permitted.
- Power: All sites power available.
- Showers available: 3 male and 2 female showers
- Toilets: Lots of male & female toilets.
- Kitchen: Use of on course kitchen facilities available.

Site @$20.00 per night x number of nights ( )	**Sub Total**	**$**

For those requiring only a few nights accommodation, or, other types of accommodation a list will be available on the website of recommended sites/ hotels etc.

Accommodation will be allocated on a first come first serve basis. The earlier you register the better your chance of being accommodated according to your wishes. *No guarantees on what you get*! Accommodation is also available in the area but is limited and is likely to be much more expensive.
Conference time is *'peak'* holiday season, book early!

8. Meals:

Meals	**Dates required**	**Sub Total $**
Morning & afternoon teas included in fee	N\A	N/A
Optional breakfast variety of cereals, toast and spreads, fruit Juices tea and coffee @ $25	Full conference dates	$
Lunches included in fee	N\A	N/A
Dinners not included, discounts on local cafes etc will be available	N\A	$
	Sub Total	**$**

9. Dietary Considerations and Allergies to Food:
Vegetarian meal required: ☐ Vegan meal required: ☐
Other special meal requirements including food allergies: ....

10. Cavers'Dinner - *Celebrating 50 years of ASF!*

Mount Gambier Race Course Function Centre (Friday 12th January) @ $30 per head *Please see dietary consideration & allergies above!*	**Sub Total**	**$**
'First' 1956 ASF conference registered attendees	**Sub Total**	**Free**

11. Merchandise:

Item	**Size & Number Required**	**Sub Total $**
Polo t-Shirts with front pocket @ $30 each	XS: S: M: L: XL:	$
ASF Anniversary red wine @ $10 per bottle		$
ASF Anniversary port wine @ $15 per bottle		$
Conference mugs @ $10 each		$
Extra Conference satchel @ $15 each		
	Sub Total	**$**

12. Fieldtrips, activities & events: conference/post conference

Snorkelling at Ewen ponds free. BYO Wet Suit, or hire @ $10 BYO mask, snorkel fins, or hire $15 per person	$	
Reflection tour of sinkholes and caves: Hear the gruesome history of the many cave diving mishaps $5 per person	$	
Limestone Sculpting Workshops $50 Per Person all materials supplied	$	
Wooden Bat decorating sessions, paint and decorate your own wooden bat great for young and old $5 per bat.	$	
5th Speleo Art Exhibition	Free entry	
	Sub Total	**$**

*** Naracoorte field trip:** includes all tours & presentations, includes transport, BBQ dinner & lunch

13. Medical conditions:
Do you have a medical condition that we should be aware of:..

14 Payment:
Early payment will result in a generous discount on registration only. See item 2.

I am making a deposit payment and will pay balance *before* 1 December 2006	❑	See item 2.
I am making a full payment now. (Full payment due *before* 1 December 2006.	❑	

If you are not an ASF member, by registering for this conference you will receive a complimentary ASF membership for the duration of the conference 6 January to 12 January 2007

Method of payment:

Cheque: ❑

Bank Cheque: ❑

Postal order: ❑

Send payment and papers to:

Cave Exploration Group South Australia
PO Box 144, Rundle Mall,
Adelaide SA 5000

Total Payable: *(Full payment)*	**$**
Deposit: *(Minimum deposit = registration!)*	**$**
Balance: *(By 1 December 2006)*	**$**

Our 50th Anniversary sponsored by

Naracoorte DEC

Government of South Australia
Department for Environment and Heritage

South Australia. A brilliant blend.

Willow Vale Caravan Park

Mount Gambier, SA

Scout Outdoor Centre

City of Mount Gambier
BLUE LAKE CITY

District Council of Grant

Enquiries: Marie Choi of CEGSA
mariechoi@adam.com.au **Mobile: 0429 696 299**

Register now to avoid disappointment.

ASF Celebrating 50 years of Federation!