NINGALOO UNDERGROUND CONFERENCE PROCEEDINGS

Proceedings of the 30th Australian Speleological Federation Conference Exmouth 21st – 26th June 2015. Edited by Dr Tim Moulds WASG.

The organising committee acknowledges with gratitude all the sponsors and supporters who have made such an invaluable contribution to this conference

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Appendix F Slides from YTIVARG - There, and back again. Sump II, JF-4 Kazad-Dum, Junee-Florentine Karst, Tasmania

Note: All unattributed photos in this publication are by Ross Anderson CLINC.

Frontispiece – Yardie Creek, Western Side of Cape Range by Ross Anderson CLINC

Editorial and Introduction

Tim Moulds
Western Australian Speleological Group Inc.

The 30th Conference of the Australian Speleological Federation was held in Exmouth, Western Australia from 21st – 26th June 2015. The conference was very well attended with delegates from across Australia coming together for a week of great presentations, socialising, fun and caving.

The presentations were all of excellent quality starting with an introduction to the Cape Range's unique subterranean fauna by Dr Bill Humphreys from the Western Australian Museum. Other highlights included a history of cave discovery and exploration on the Range by Darren Brooks and the in depth investigation of calcite straws on concrete by Garry K Smith. Several workshops also passed on valuable skills to conference participants such as building a DistoX during a fun afternoon in the Exmouth Shire Hall.

The field trip to Yardie Creek and the west side of the Range was very popular to explore some of the rockholes to see the stygobitic fish *Milyeringa veritas*.

A big thankyou for all who attended the conference, especially those who presented papers and then provided a written report to make these proceedings possible.

Organising committee members

Convener and local expert & organiser	Darren Brooks
Secretary, caving trip co-ordinator	Greg Thomas
Treasurer, registration	Fran Head
Program and proceedings	Tim Moulds
Bar Manager	Ida Newton
Speleo Sports	Ian Collette
Photographic competition	Ross Anderson
Website	Dave London (not at conference)
Committee:	Jackie Brooks, Dene Buckley, John Cugley, Rob Susac

Speleosports Report

Greg Thomas
Western Australian Speleological Group Inc.

The Speleosports was held at a local playground on Thursday afternoon, 25th June.

Each team of 4 had to do a compass reading and distance measurement or estimate by pacing between two set points, before proceeding to the main obstacle course which had been constructed amongst the playground equipment. First the "cave gate" had to be opened while lying under some spaghetti speleothems and using a large selection of keys. Each team member then clipped onto a rope which was followed maze like through the playground with numerous pasta and spaghetti speleothems to be avoided and a water hazard going up the slide.

At the “flying fox” platform more speleothem pasta limited the tread area with over and under exuberance during launch leading to some poor outcomes for the speleothems. From here one party member had to pass through a series of hanging car tyres and then a different party member had to harness up and climb a few metres up a wire rope ladder and swap out a self-locking karabiner.

Base times were adjusted with penalties for inaccurate survey measurements, damage to speleothems and loss of party members in the crevasse. (One team lost two members who dropped off the flying fox into the “crevasse”. Surviving party members were penalised for time spent in the Coroner’s Court).

Placing	Team name	Members	Base Time	Time with Penalties
1	Flying Orange	Aimee, Tim, Asha, Brett	7:07	9:17
2	Hillbillies	Ros, Grant, Lara, Rod	8:00	10:53
3	Blind Eels	Kim, Janine, Rob, Barb	8:05	11:22
4	Nameless Team	Andrew, Fiona, Luana, Danny	8:59	11:44
5	Spunky Speleos	Dominique, Garry, Brian, David	8:25	11:54
6	Blind Gudgeons	Rod, Westy, Alan, Jim	10:00	15:10
7	Christmas Trees	Cathie, Sarah, Jay, Janice	11:36	15:48
8	Fantastic 4	Weidi, Cindy, Lisa, Rob	13:25	80 days

(all unattributed photos by Ross Anderson)

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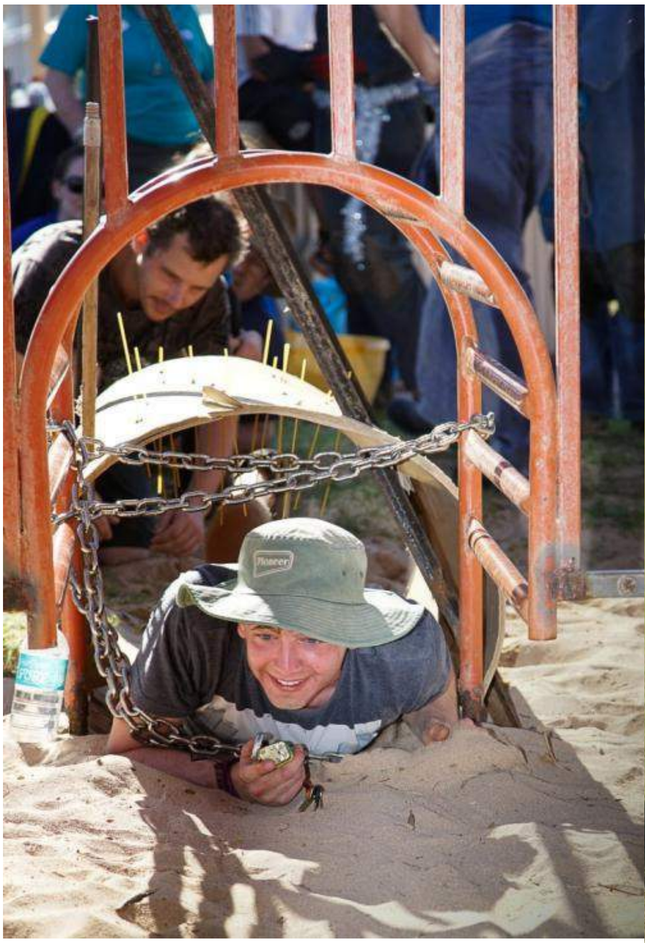


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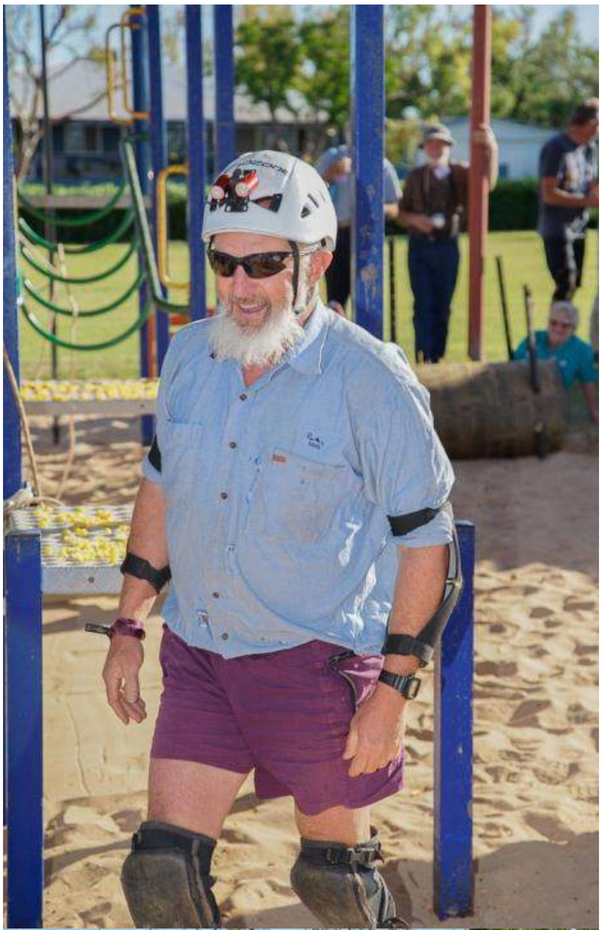


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The dashing Ross Anderson (Photo Greg Thomas)

Janine McKinnon in action on the ropes course (Photo Greg Thomas)

Al Warild shows how its done (Photo Greg Thomas)








Photos of the Conference Dinner and Presenters (All photos Ross Anderson)

Papers and Abstracts from the Ningaloo Underground Conference 2015.

The following papers, presentations and abstracts are arranged alphabetically by Author name, apart from the keynote address, which follows immediately.

Post Conference Caving on the Range (Photo Ross Anderson)

Keynote address

Cape Range caves changed understanding of Australian biogeography – rainforest and tethyan troglobionts

Dr Bill (W.F.) Humphreys

Western Australian Museum, 49 Kew Street, Welshpool, WA 6106; Australian Centre for Evolutionary Biology and Biodiversity and School of Biological Sciences, University of Adelaide, SA 5005; School of Animal Biology, University of Western Australia, Nedlands, WA 6907

In 1987 I was invited by Brian Vine to participate in a caving trip to Cape Range, an invitation that profoundly changed both my research and ultimately our understanding of the biogeography of Australia. This is that story. Brian had been making observations on a micro-whipscorpion in C18 and C106 following a visit there by Jackie Lowry in 1984. At the time no micro-whipscorpion had been described in Australia and their presence in arid Cape Range was incongruous as they typically inhabit rainforests. This short trip led to a series of expeditions (1988–1990) and the recognition of a diverse relictual rainforest fauna in Range caves. The work was extended to the coastal plain (1993) and opened up a completely different horizon. There, seawater intrudes below the fresh groundwater forming an anchialine ecosystem that contains aquatic species, mostly crustaceans, being members of higher taxa (Class, Order, etc.) comprising the tethyan assemblage, many being found for the first time outside the Atlantic Ocean. The techniques developed on Cape Range were extended to other karst regions (Barrow Island, Kimberley Devonian reefs, Christmas Island) identifying regionally distinct subterranean faunas on each and anchialine faunas on two.

However, the biggest surprise came when the techniques were extended to long emergent western Australian plateau. These non-karst areas mostly lack caves and the subterranean realm was accessed by boreholes yielding a great diversity of both terrestrial and aquatic troglobites. Mostly, each species occurs in only a small area, including 100 or so species of blind diving beetles, more species than occur on the surface. Despite this there is a total change in the subterranean fauna between the Pilbara and the Yilgarn, the cause of which is not apparent. A common theme arising from this more intensive research is the wet forest origin of many of the lineages now living as troglobionts in this now arid area, isolated underground by increasing in the Mid- to Late Tertiary.

The invitation to join Brian has led to 1000s of new species being discovered, numerous higher order taxa new to Australia and even the Southern Hemisphere. Australia, rather than being a troglobite poor continent, is vying for top rank in the global troglobiont stakes, a far cry from the poverty of the subterranean fauna so recently argued *to be the result of aridity*. The caver community has made a pivotal contribution to the development of these studies which themselves have been instrumental in raising awareness for the protection for subterranean fauna and karst landscapes.

A Micro-whipscorpion (Schizomid) from Papillion Cave (Photo Tim Moulds)

Recent advances in digital media and the conservation and interpretation of caves

Ross Anderson
Cavers Leeuwin Inc.

Digital Photography is a rapidly changing form of communication. In the early 2000's a 5 megapixel camera was considered high resolution, exposure latitude of 7 stops was considered wide. Lens technology is moving equally quickly.

The amount of detail able to be recorded in a single exposure is amazing.

What do you do with all that information?

Today's professionals typically have >5 software packages to store process and present their images.

Being able to take thousands of images in a weekend is easy, being able to put these images to some sort of use is another consideration altogether.

What does this mean for caves and karst? Metadata, cave locations, composite images, artificial lighting, 360's, VT's, 3D, online, interactive media, options, options, options....

This presentation will present a limited statement of what can be done to capture, process and present images of caves and karst today and pose the question for us all: What are you doing with your images?

The Cape Range (Photo Ross Anderson)

The Ningaloo World Heritage Area – an introduction

Heather Barnes
Department of Parks and Wildlife

An introduction to the Ningaloo World Heritage area and the Cape Range National Park.

The slides for this presentation are provided in Appendix A.

An introduction to Cape Range caving and (very brief and very basic) geology

Darren Brooks
Western Australian Speleological Group Inc.

The Cape Range karst consists mainly of three types of limestone. The uppermost, and thinnest layer, the white Trealla Limestone, is mostly dissolved and eroded away. Some significant patches occur on the flanks of the range and it does contain some small caves. It is a hard, crystalline limestone tending to fracture into sharp shards and caves in this limestone are small and difficult.

The layer below is Tulki Limestone. This is the layer that will most interest cavers as it is the main cave-bearing limestone. Again, it is a hard crystalline limestone that shades from white in the uppermost layers to pinkish in the lower regions. It varies from about 50 to 100 metres thick. The caves in this limestone are mainly vertical shafts, occasionally with crawlway sized and, less occasionally, with walking dimension tunnels leading off for generally short distances. There are a few exceptions to this rule. Wanderers Delight has been surveyed to nearly 7 kilometres length along a multi-level and multi-branching network of crawlway passages. Chambers of standing height and higher give regular relief to sore necks and knees. Good knee and elbow pads are a must for serious explorers in the Capes caves. Many tiny leads remain to be explored in Wanderers Delight but these are season-dependent due to long-term standing water pools. The remaining leads are many but are also very small and difficult.

Some of the caves require a degree of technical expertise in vertical techniques although many are simple shafts consisting of a single pitch. Conversely, some of the caves require several pitches to be negotiated and as most of the caves are in the national park, there are virtually no fixed artificial anchors and all caves must be negotiated via temporary rigging, eg tape and cord slings, tricams etc.

The third main layer of limestone is the Mandu Calcarenite. This limestone can be seen in the lower regions of the gorges, particularly along Shothole Canyon, where high exposures of it are easily accessed from the nearby road. It is a whitish, chalky and relatively soft limestone.

A keen eye will easily spot fossils of shells and echinoids in all the limestones.

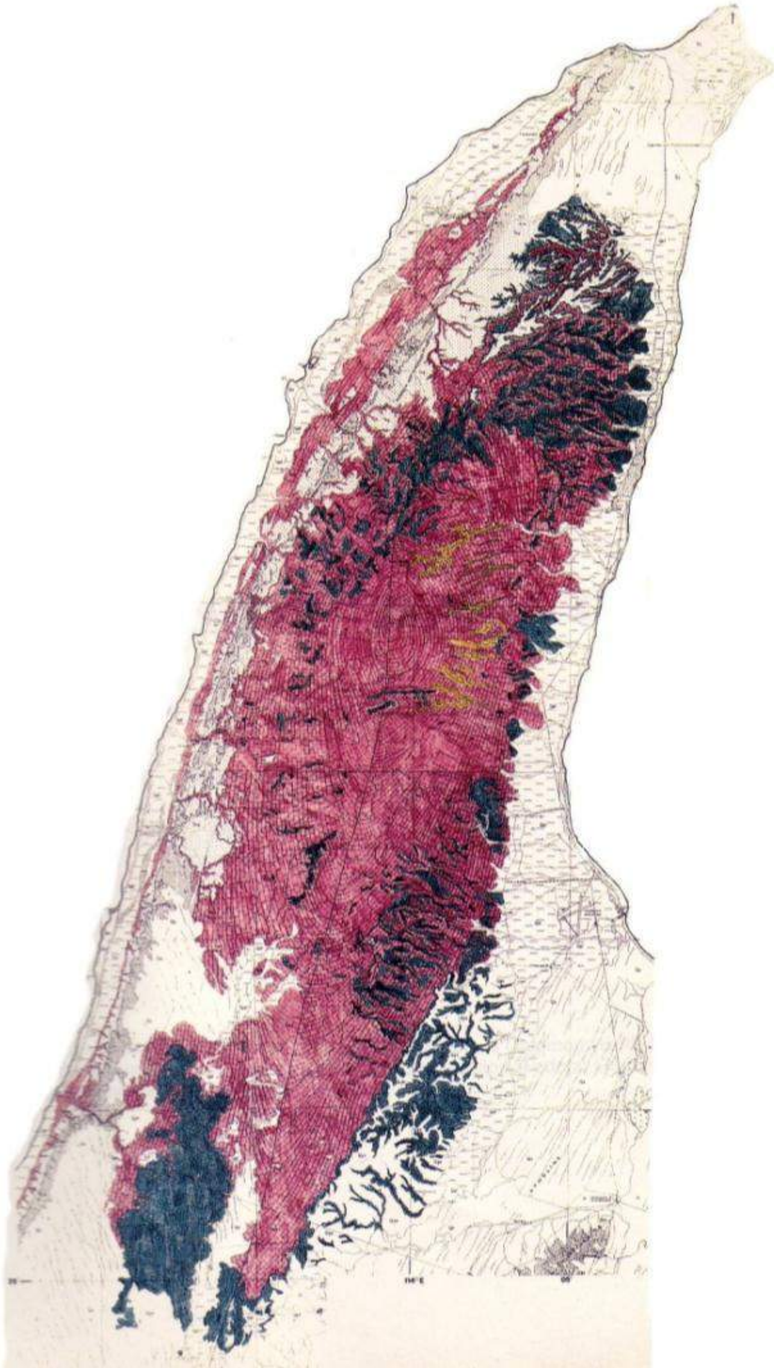
In the deeper caves the temperatures are generally up around the 27°-29°C mark. If wearing knee and elbow pads, it is generally more comfortable to explore in shorts and t-shirt. The temperature, coupled with the high humidity, makes the cave environment a taxing, tropical adventure and caving in overalls could potentially assist in causing heat exhaustion. Frequent rest breaks and cool water are recommended on the longer trips. If overalls are preferred then the lightweight version are all that is required.

Many areas of the range have had little visitation and there is always a very good chance that keen walkers will find new, unexplored features. When walking in the ranges, the locals generally wear shorts coupled with sturdy canvas gaiters. Gaiters, useful not only for protection from the fangs of venomous snakes, are wonderful for warding off the spikes of the ever-present spinifex. This spiky grass can be a real torment to tender legs.

The caves are rightly famous for their wonderful and varied array of troglofauna and stygofauna. They can be observed in the deeper caves where the humidity and temperature are fairly constant, and in some of the caves that contain water. Schizomids, millipedes, crickets, spiders, fish, eels, all blind, are commonly spotted during cave visitation.

There are many rock-shelter type caves on the western flank of the Cape Range. Many of these were used by the Jinigudira, the original indigenous inhabitants. A cave in Mandu Mandu Gorge returned a date of approximately 34,000 years BP and furnished 22 shell beads and many hundreds of stone artefacts.

Slide 1 Intro page. Photo of Paul Brooks on spur north of Badjirrajirra gorge.



Slide 2 The exposed areas of native limestone.

Trealla Limestone is depicted in dark green. This limestone is the uppermost member of the three main limestones. It occurs patchily in some higher areas of the range but particularly most strongly on the northeastern side in the region of the Exmouth townsite. It is a white, crystalline limestone which doesn't seem to offer much in the way of actual caves, although there is one feature near the town that is exclusively in this limestone.

Coloured in pink we can see the middle layer and main cave-bearing Tulki Limestone. Although depicted in pink, and in fact often found in its pink form, it does grade from pink in the lower portions to white in the upper region. During the field trips this will be the limestone that bears the caves the conference participants will be caving in.

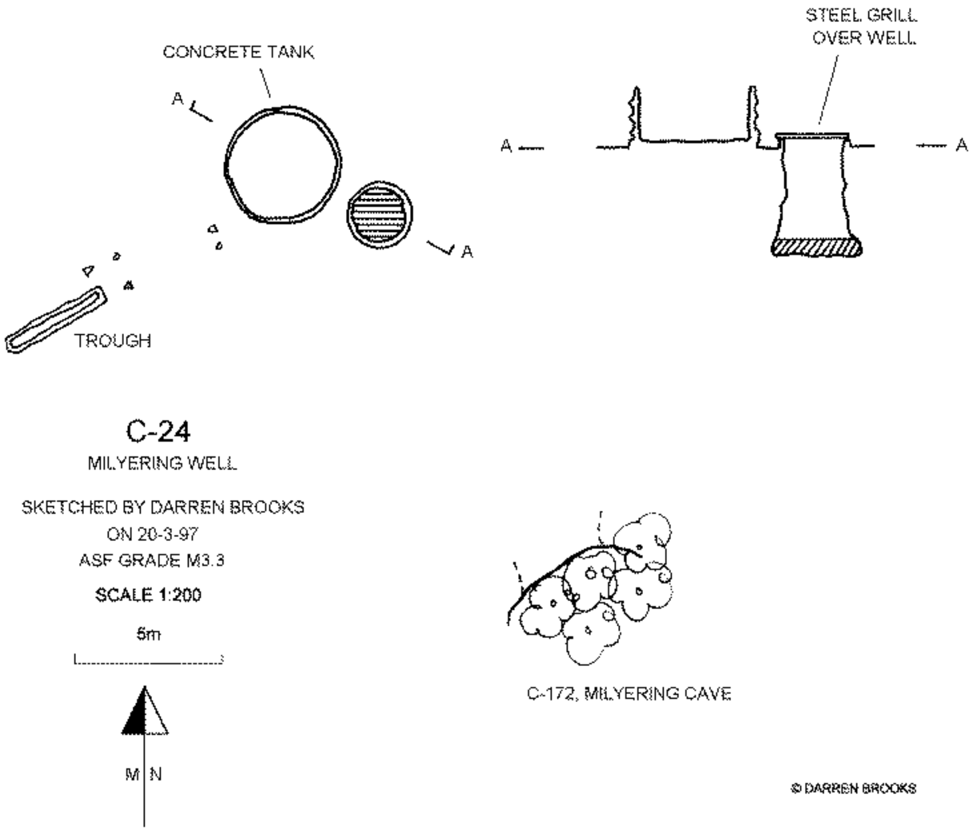
In yellow we can see the outcroppings of the Mandu Calcarenite. This soft, marly limestone is very thick but is only found in the lowest accessible areas in the bottom of the deeper gorges. The best place to view this limestone in Shothole Canyon.

Slide 3 Map depicting the distribution of the caves and karst features. The distribution of the features can clearly be seen to mainly follow the faulting of the limestone running from southwest to northeast. A smattering of small caves are found on the coastal plains.

Slide 4 A typical karst feature as would be seen on the Cape Range. This feature and the nearby cave is in the Tulki Limestone.

Slide 5 Mandu Calcarenite, Shothole Canyon.

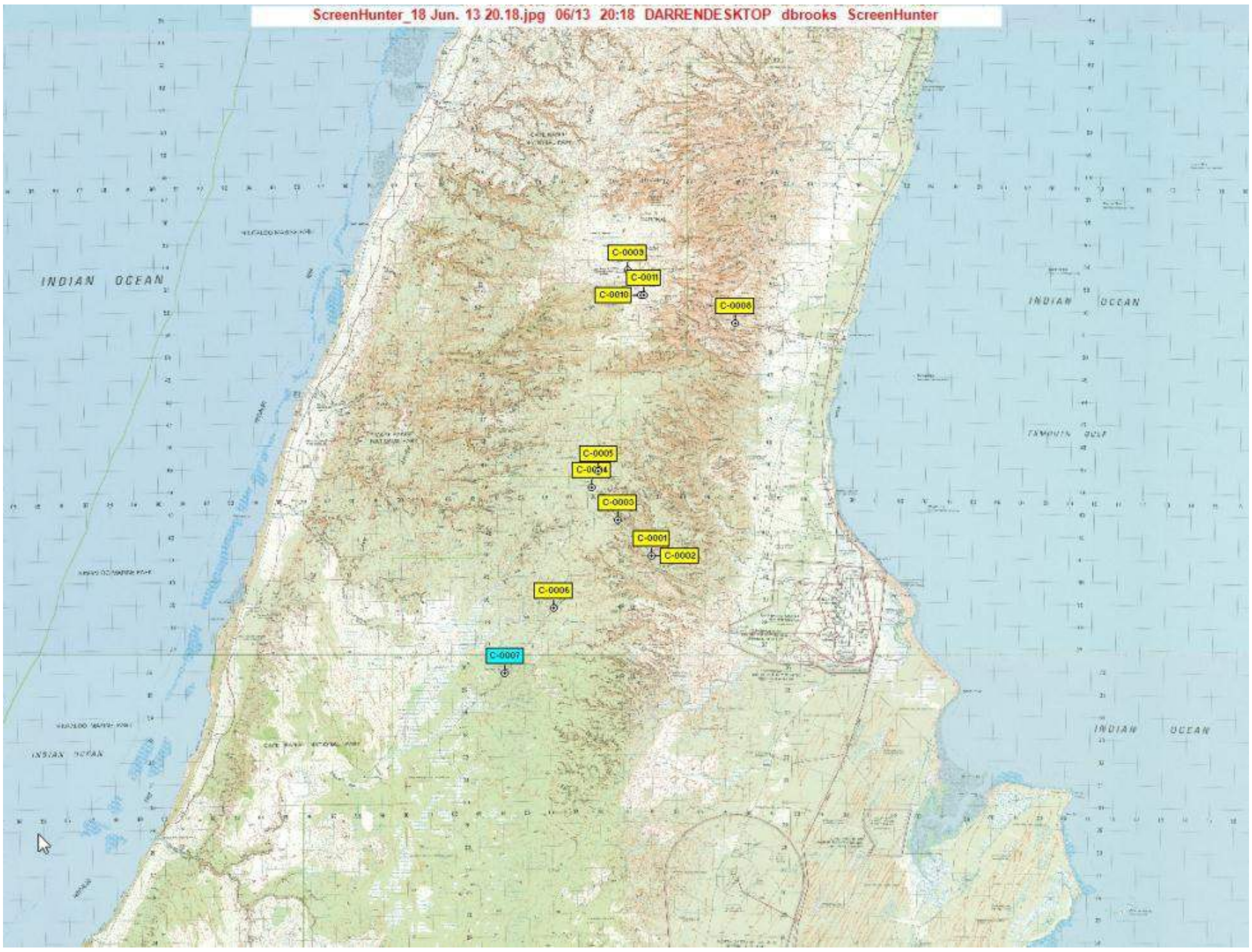
Slide 6 The first 'well' recorded investigation into the Cape Range karst occurred back in 1945 when blind fish were recorded in a well on the west coast. Although this generated some interest at the time the cape was still so remote that it was quite a few years before further investigations took place. In more recent times the Milyering Well was numbered as C-24. It was, in fact, dug in that particular place because there was a small cave nearby known to contain a reasonable supply of water.



Slide 7 Map of Milyering Well.

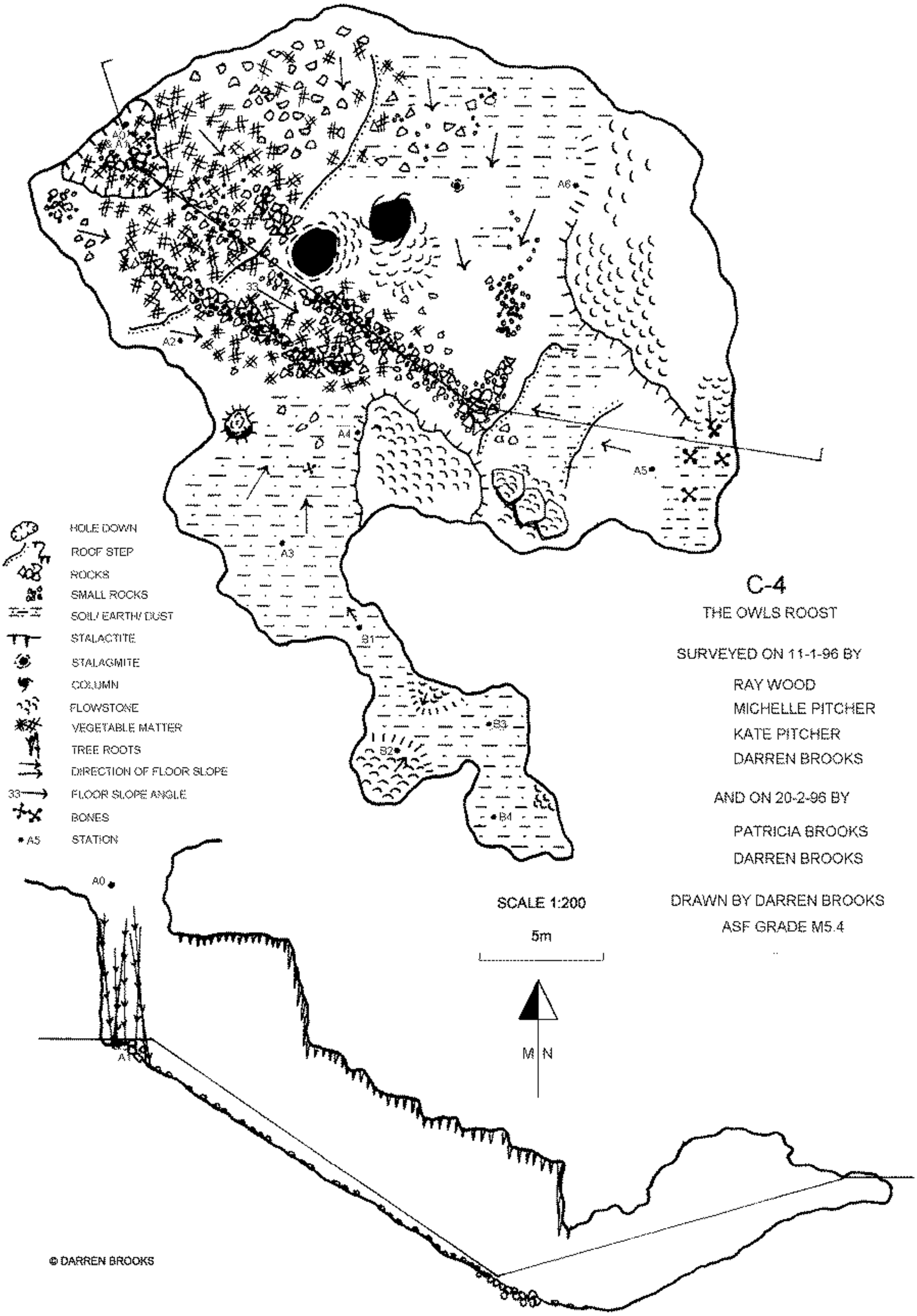
Slide 8 Brooks and Humphreys peer into the murky depths of Milyering Well.

Slide 9 Mylroie and Humphreys take selfies. Probably the first time anyone has ever had their selfie photo-bombed by a blind fish.



Slide 10 The first investigations into the caves of the area undertaken by real 'speleos' was back in 1962. David L. Cook and Tim Fry headed north from Perth for a very short trip to search for the rumoured caves reported by drillers and construction crew that worked on the roads and drill rigs of Western Australian Petroleum (WAPET). The roads were made back in the mid-fifties so it still took some time for cavers to reach the area. Naturally enough the first recorded features were all next to the road and are still easy to spot today. And some of the caves they found were quite exciting finds, for example, The Owl Roost. The modern incarnation of the features they numbered are seen here as C-1 to C-11.

As an aside, Peter Cawthorn and Paul Symons visited later in the same year, explored several caves and collected blind fish from Kubura Well on the east coast. Exmouth townsite now abuts very close to Kubura Well but of course back then there was no town at all. Unfortunately it seems he left no clear record of most of his discoveries.



Slide 11 Map of C-4, The Owl Roost.

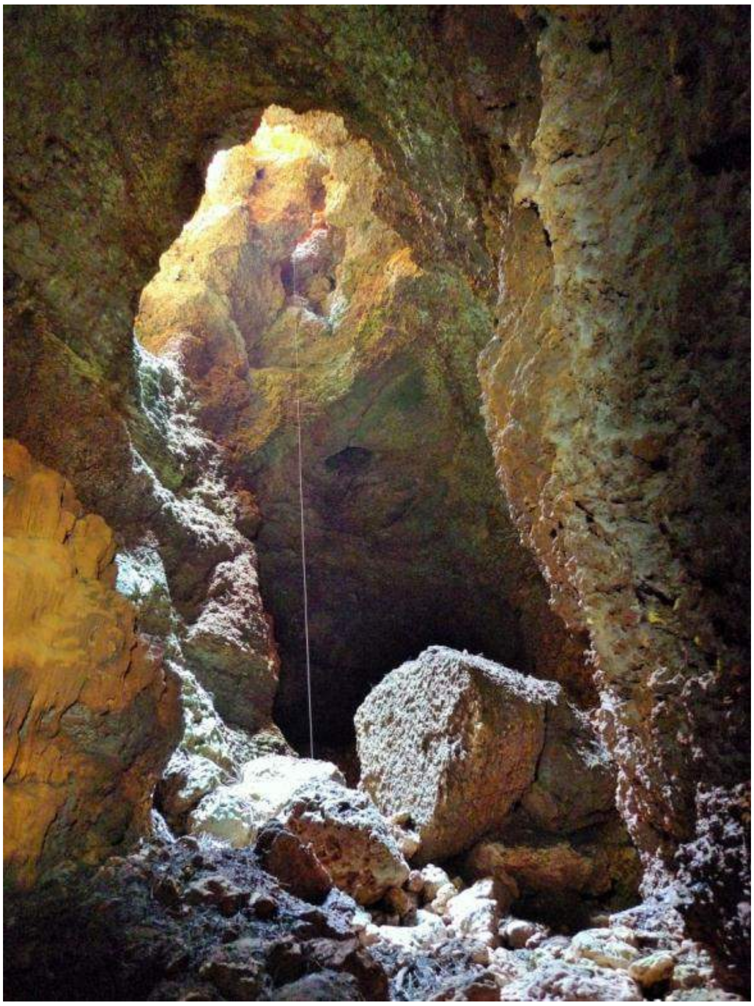
Slide 12 Entrance to The Owl Roost.

Slide 13 Steve West striking a rather stunning pose in the entrance of The Owl Roost.

Slide 14 Large column in The Owl Roost.

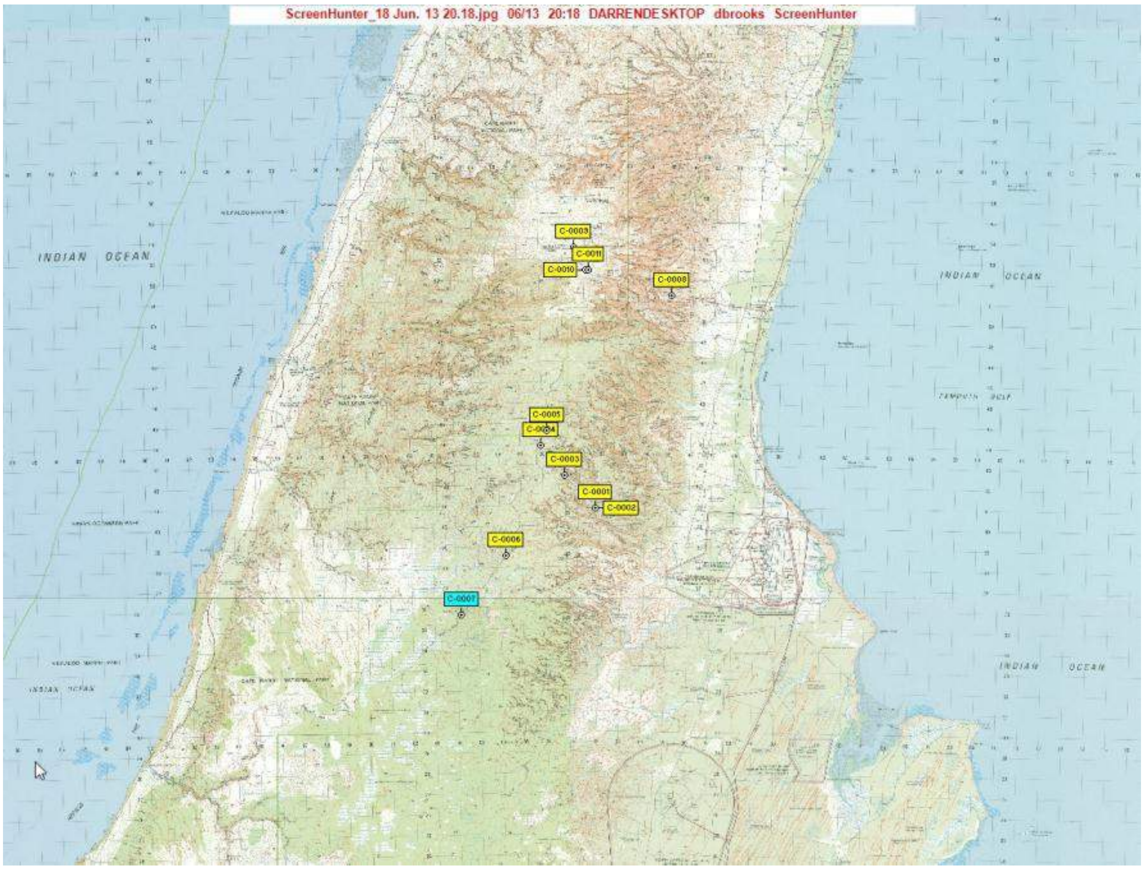
Slide 15 C-18 Dry Swallet. One of the caves discovered and explored by Cawthorn and Symons.

Slide 16 Entrance to Dry Swallet.

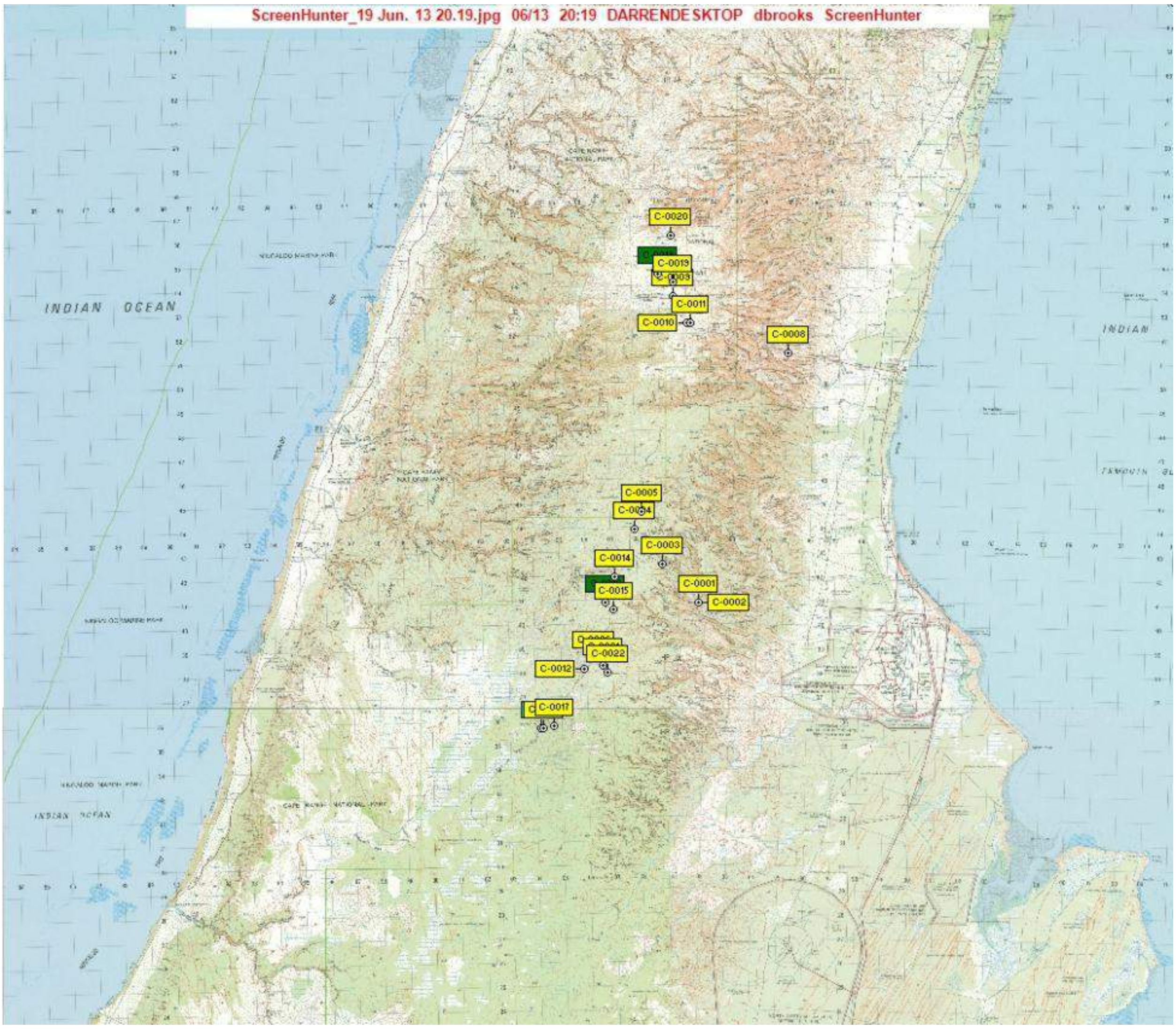


Slide 17 Entrance of Dry Swallet.

Slide 18 Cave fauna. Blind millipedes on mudbank in Dry Swallet.



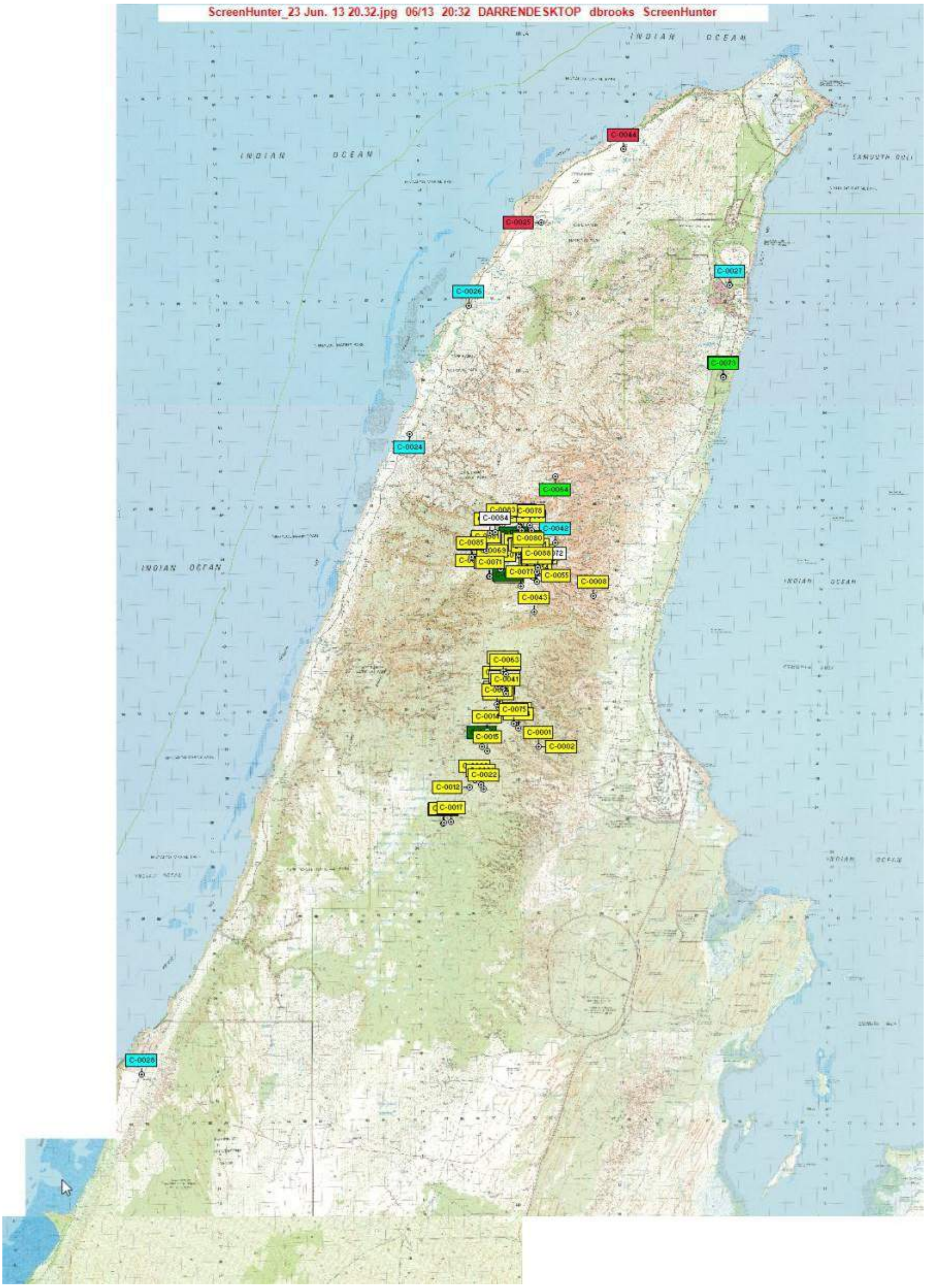
Slide 19 Refresh of Cook and Fry explorations.



Slide 20 In 1965 George W Kendrick, of the WA Museum, visited the Cape Range. The trip was particularly interested in collecting bones from the caves. They made a large collection from The Owl Roost. Their contributions to the record include C-21, Monajee Cave, where a small bone from a thylacine was collected and they noted several fragment of shells from the genus' Melo and Syrinx, shells typically used by aboriginal women for the transport of water. Monajee is the name 'conch shells used as utensils'.

Slide 21 Truncated stalactite in Monajee Cave.

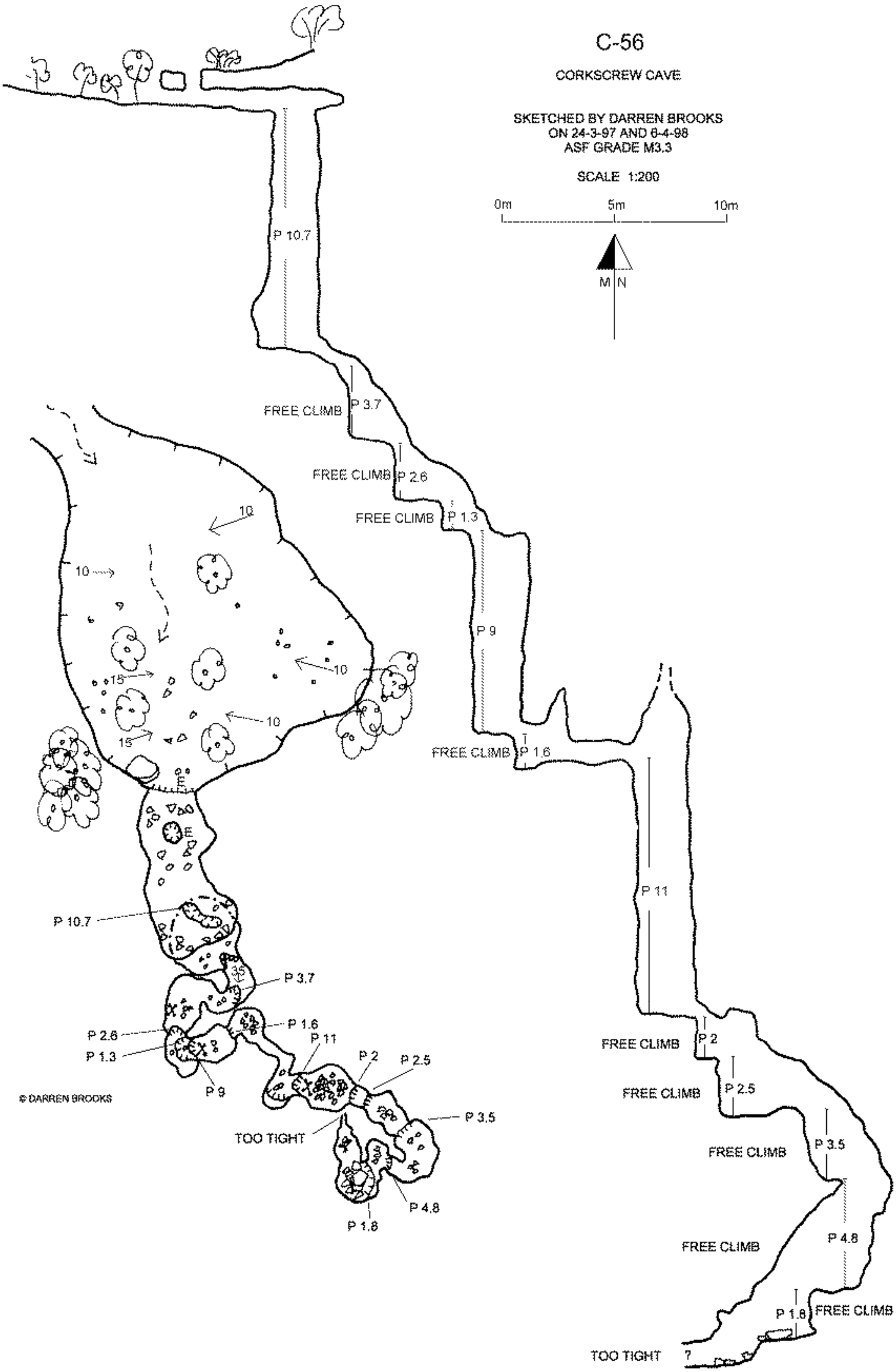
Slide 22 Roots from fig tree in Monajee Cave.



Slide 23 Bridge and Scott, with contributions from Janicke. In 1968 Peter Bridge led an expedition to the range to try and smash the Australian cave depth record. Needless to say, they didn't succeed in this indeavour. Steven Janicke was on this trip, along with several other WASG members.

Janicke returned in 1971 to continue exploration with a few new finds and explorations.

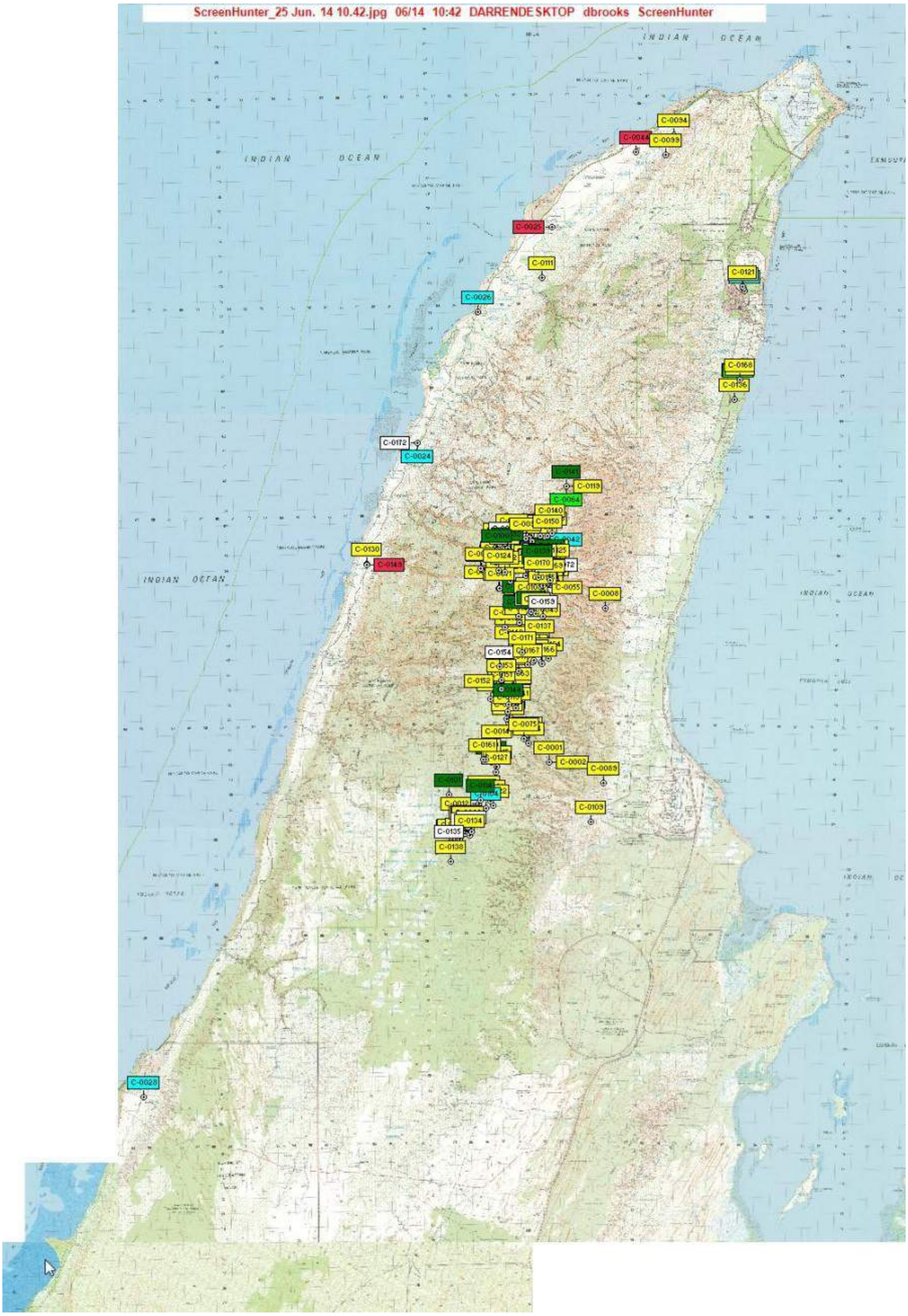
The big contributor in this era was Roger M. Scott, who led a team of 9 participants which, although not discovering a lot of new features, did actually start to organise the systematic location and recording of many of the known features.



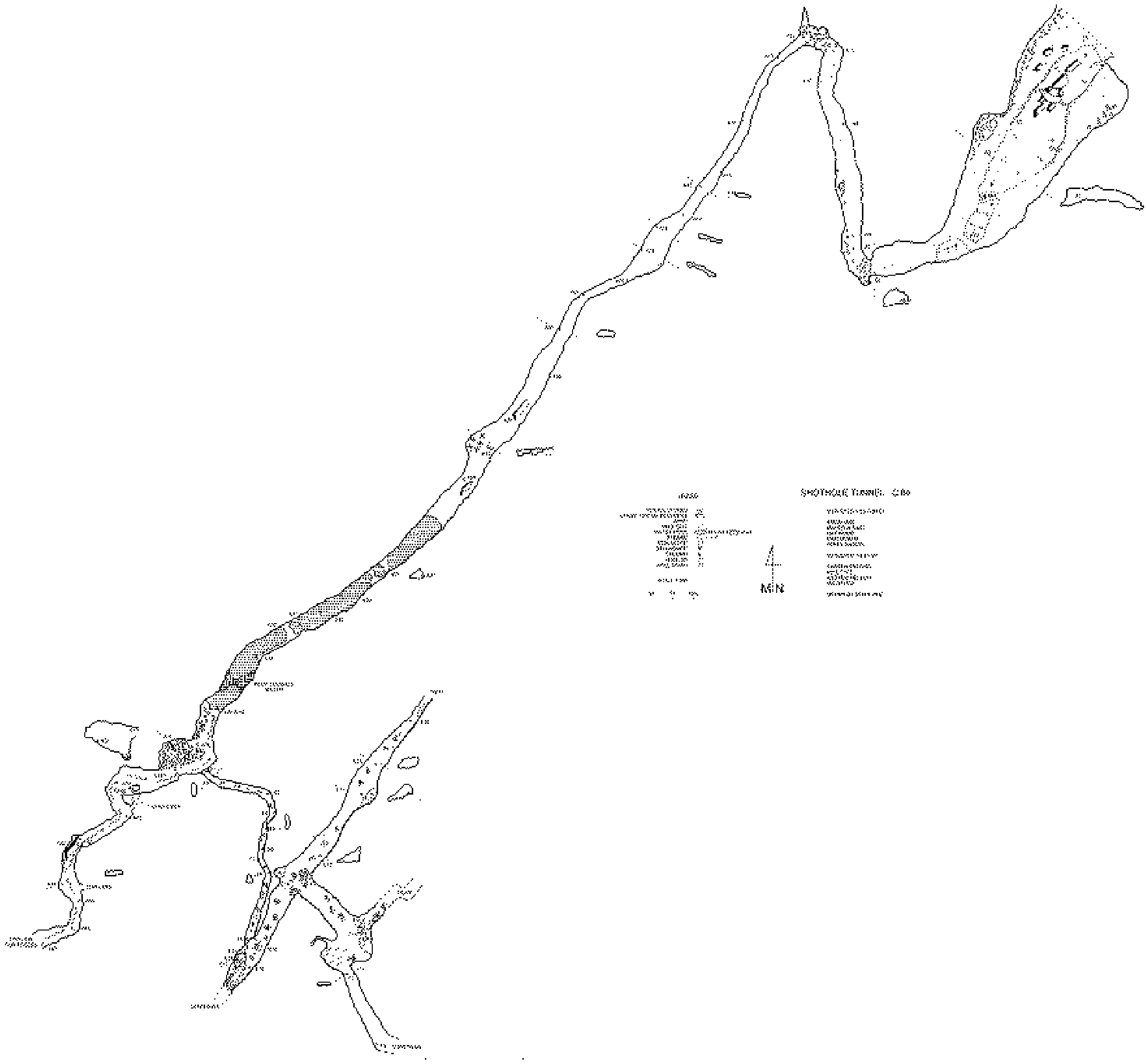
Slide 24 C-56 Corkscrew Cave. One of the finds of Scott expedition and one of the caves to be visited during the field trips.

Slide 25 Entrance to Corkscrew Cave.

Slide 26 Entrance to Corkscrew Cave demonstrating proximity to road.



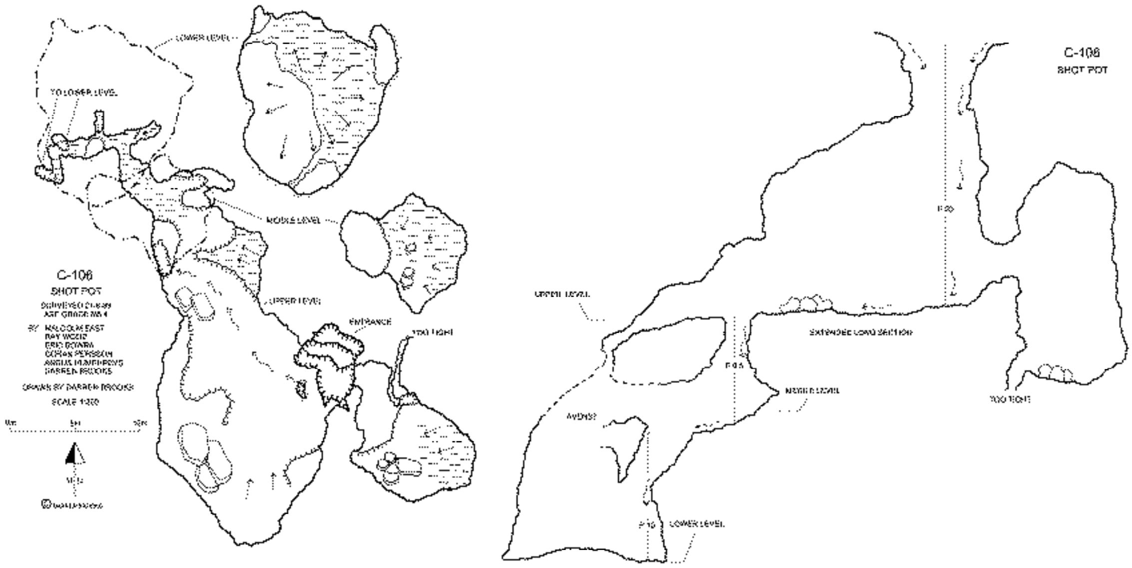
Slide 27 The Vine Period. Brian Vine instituted a program of systematic identification and exploration of as many of the known and of as many new caves as possible. He introduced many locals to the joys of caving in their own backyard and also entertained cavers and investigators from Perth and further afield. He made a great many significant discoveries and it was his observations of cave fauna that, in part, led to later investigations into the troglobitic denizens of the caves.



Slide 28 One of Brian's great and significant discoveries, Shothole Tunnel, the first resurgence cave known on the cape.

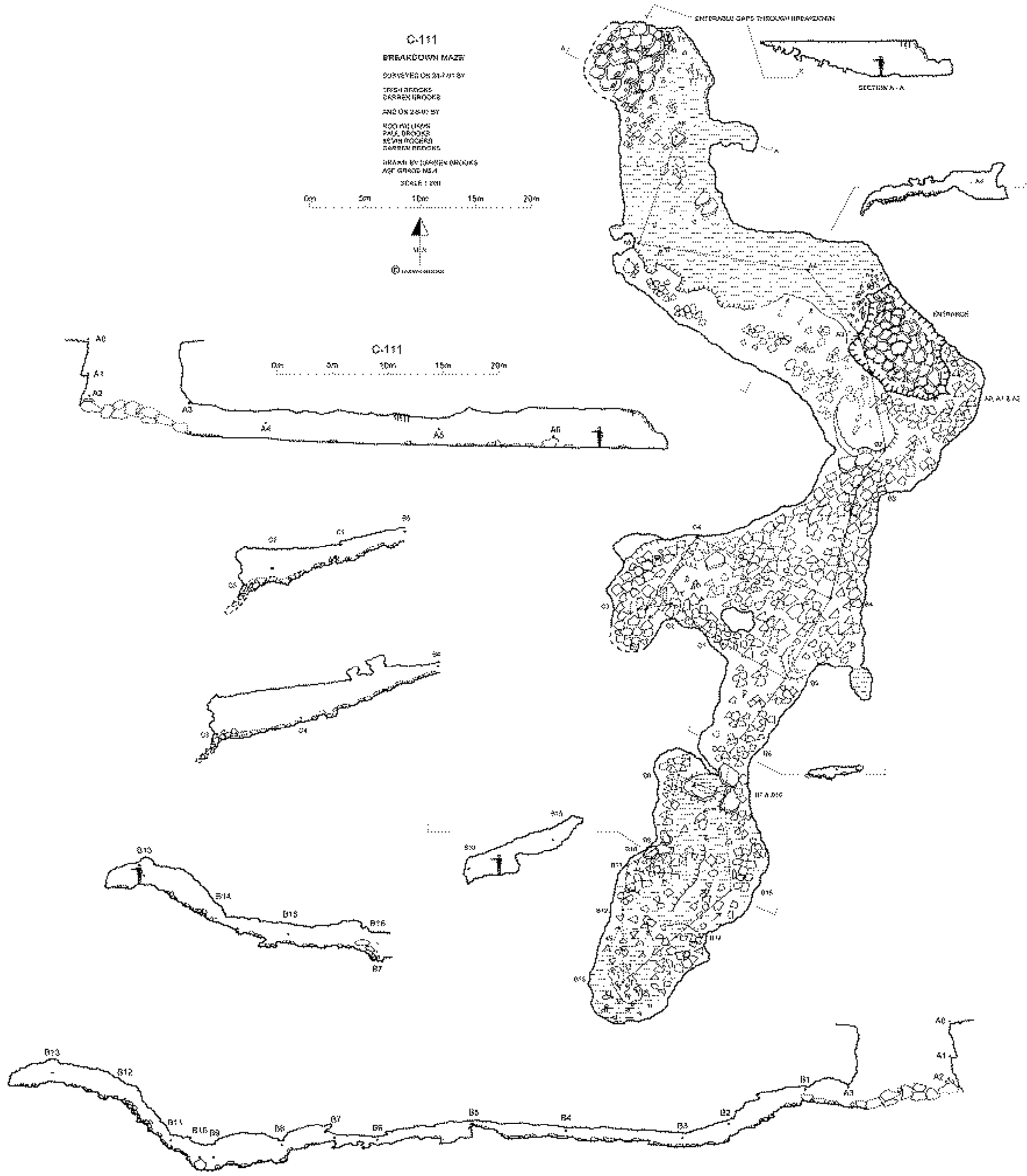
Slide 29 The resultant carnage after a trip into Shothole Tunnel.

Slide 30 Our own Tim Moulds graces the entrance to Shothole Tunnel.

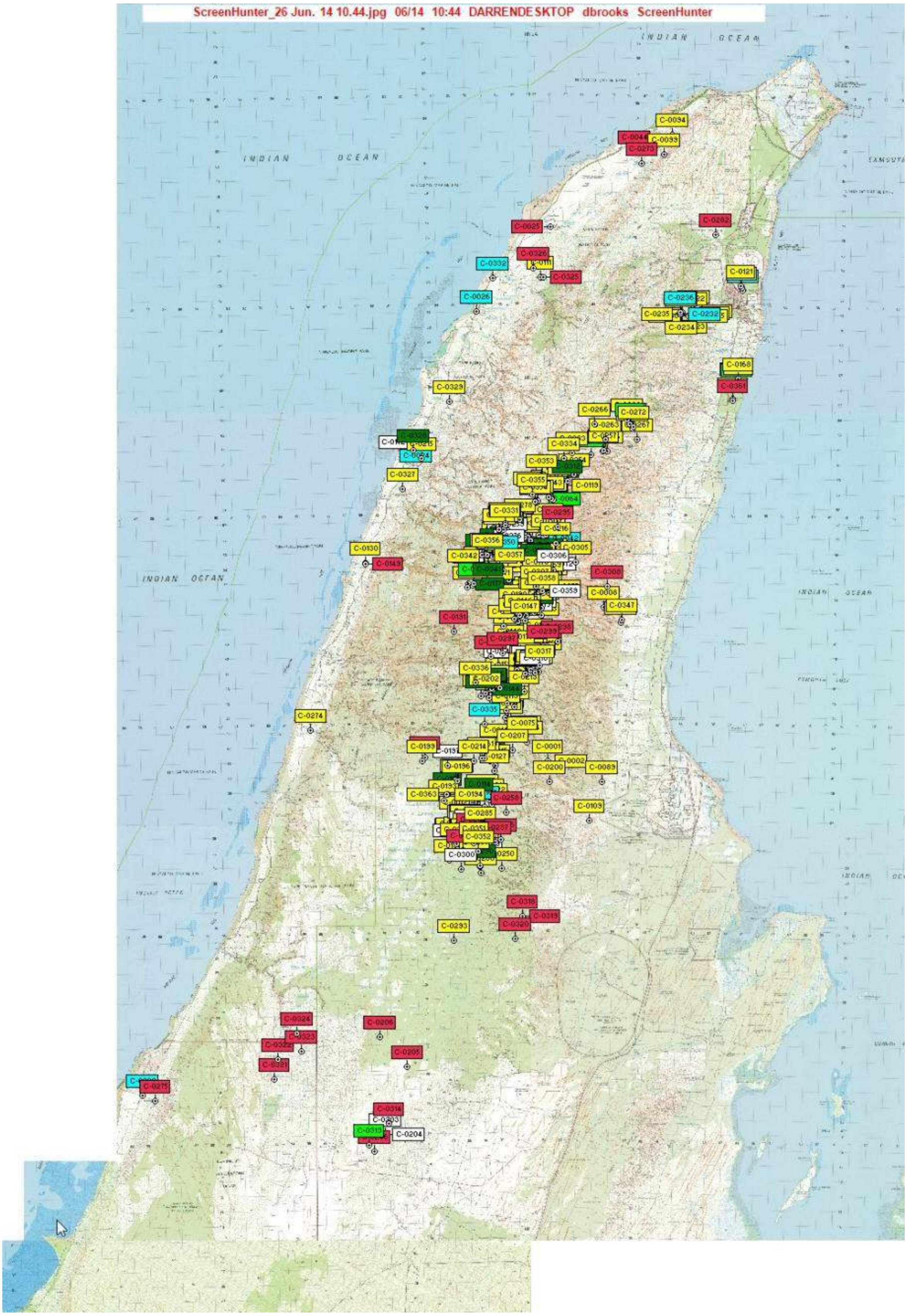


Slide 31 C-106, Shot Pot. Another of Brian's most significant finds, and the location of many of this troglofauna observations.

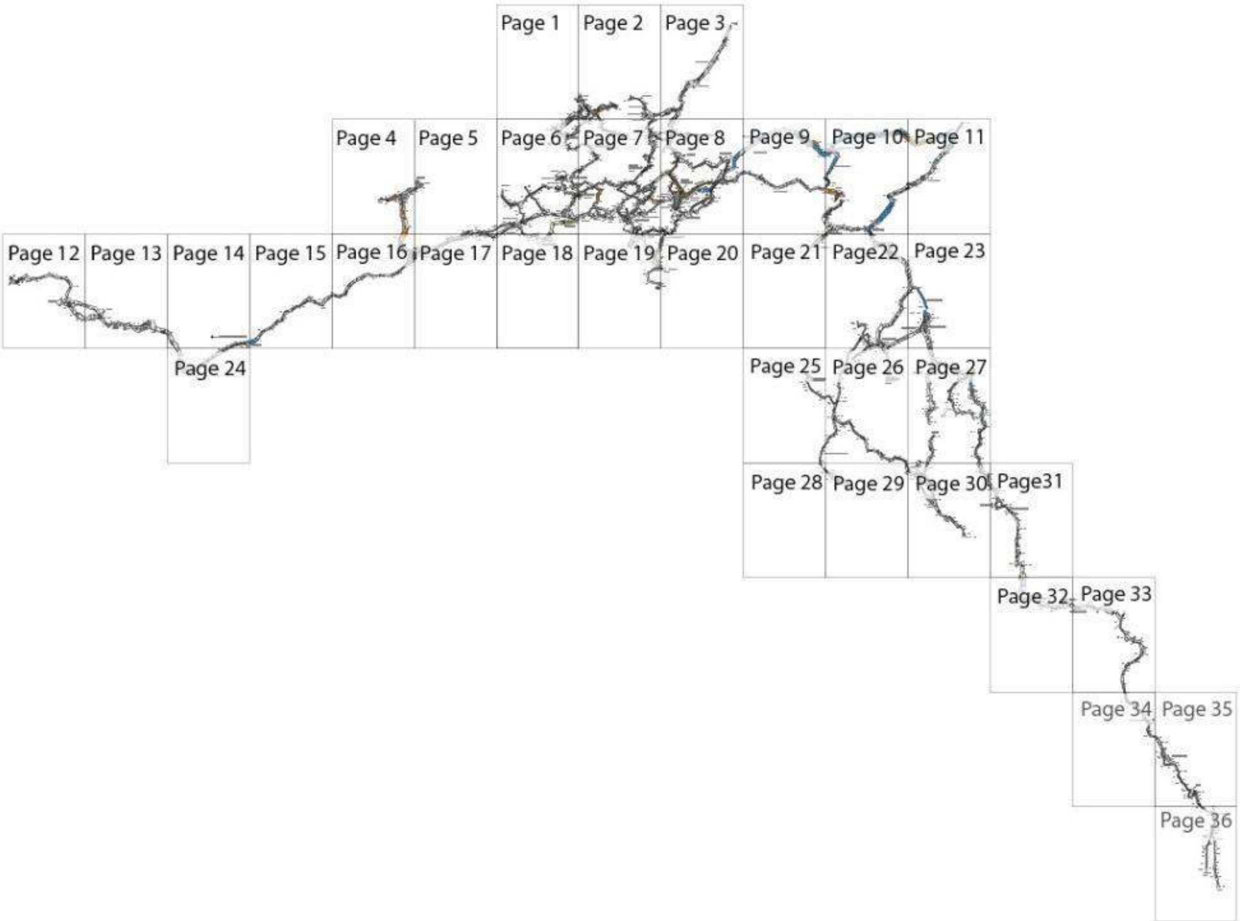
Slide 32 Entrance to Shot Pot.



Slide 33 C-111 Breakdown Maze. Another significant fauna cave, this one located on the western coastal plain.



Slide 34 The East Period. An overlap of the Vine Period, Malcolm East was the first to put his budding computer skills to use and create a transferable electronic database of the caves and karst features. The East Period includes the 1987 WASG and 1988 WA Museum expeditions whereby the numbers of new features discovered increased dramatically, particularly due to the use of very good quality aerial photos coupled with a high magnification stereoscope.



Slide 35 In 1987 Malcolm's colleague, Ray Wood, discovered Wanderers Delight, the first really long and challenging cave in the area. In the first two years of exploration they and others surveyed over three kilometres of mostly low, crawly tunnels.

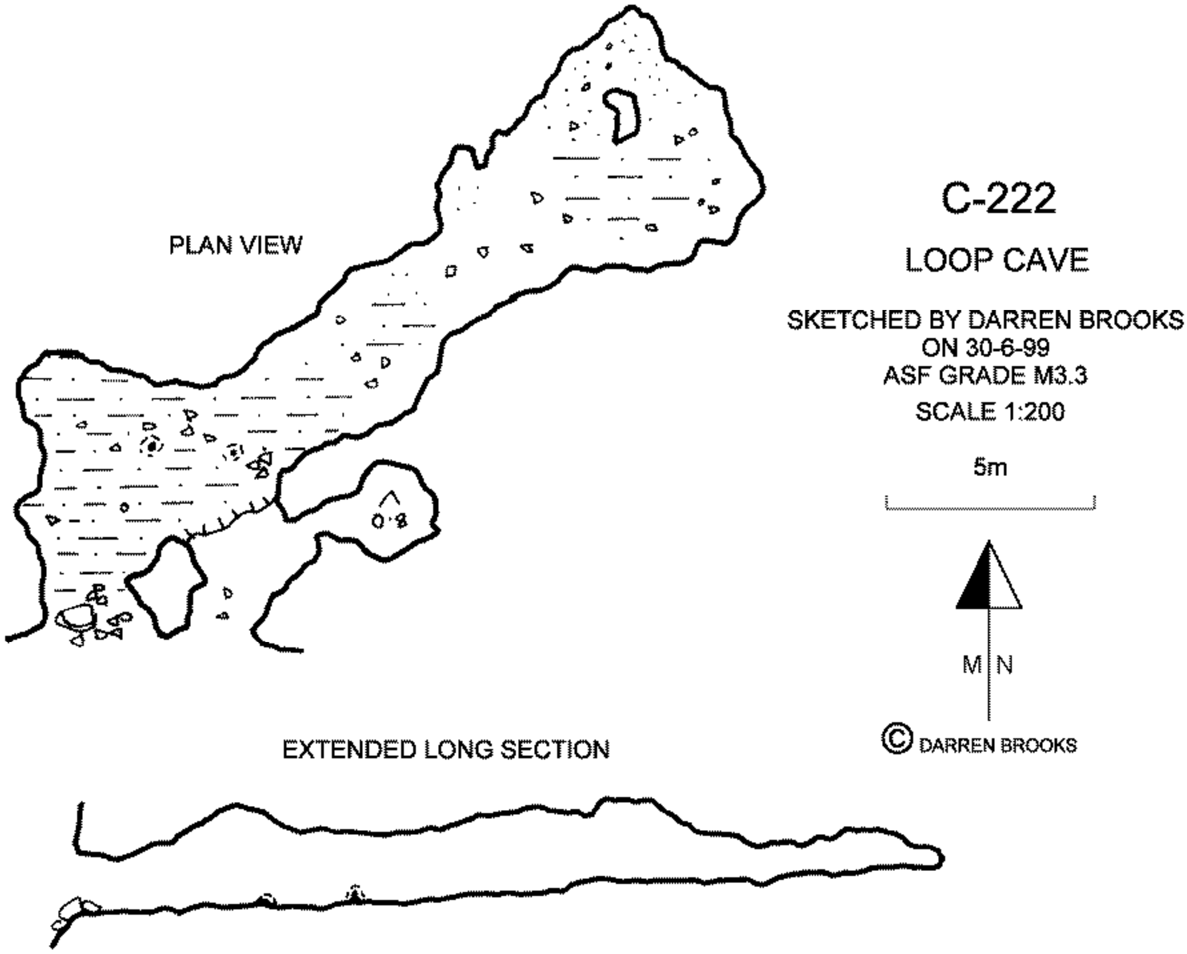
Slide 36 Greg Thomas gives a cheery salute before entering Wanderers Delight.

Slide 37 Typical passage in Wanderers Delight, delightfully adorned by my wife, Jackie.

Slide 38 Canal section in Wanderers Delight.

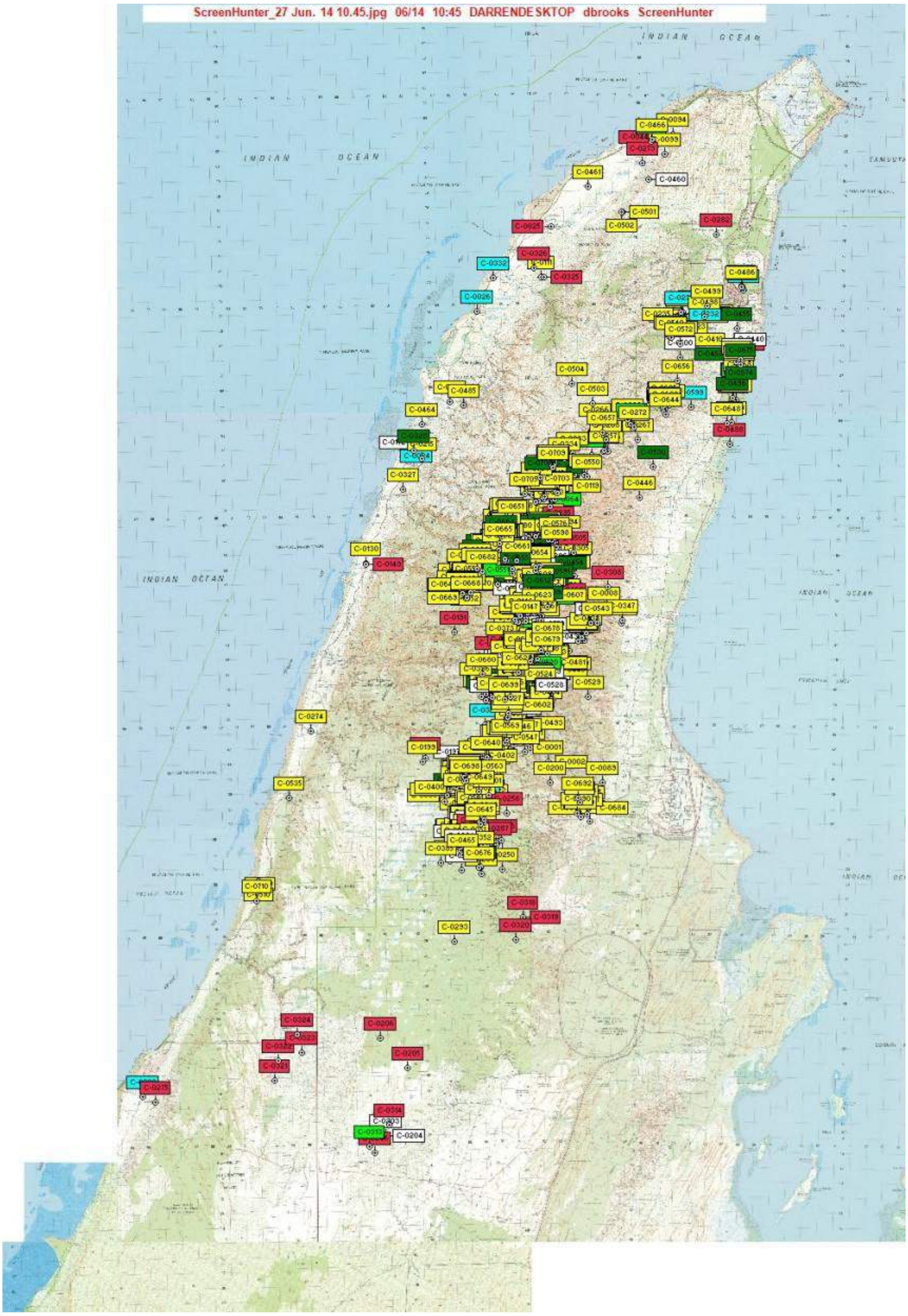
Slide 39 Pineapple Junction in Wanderers Delight.

Slide 40 Fossils abound in the caves and Urchin Chamber in Wanderers Delight is no exception.

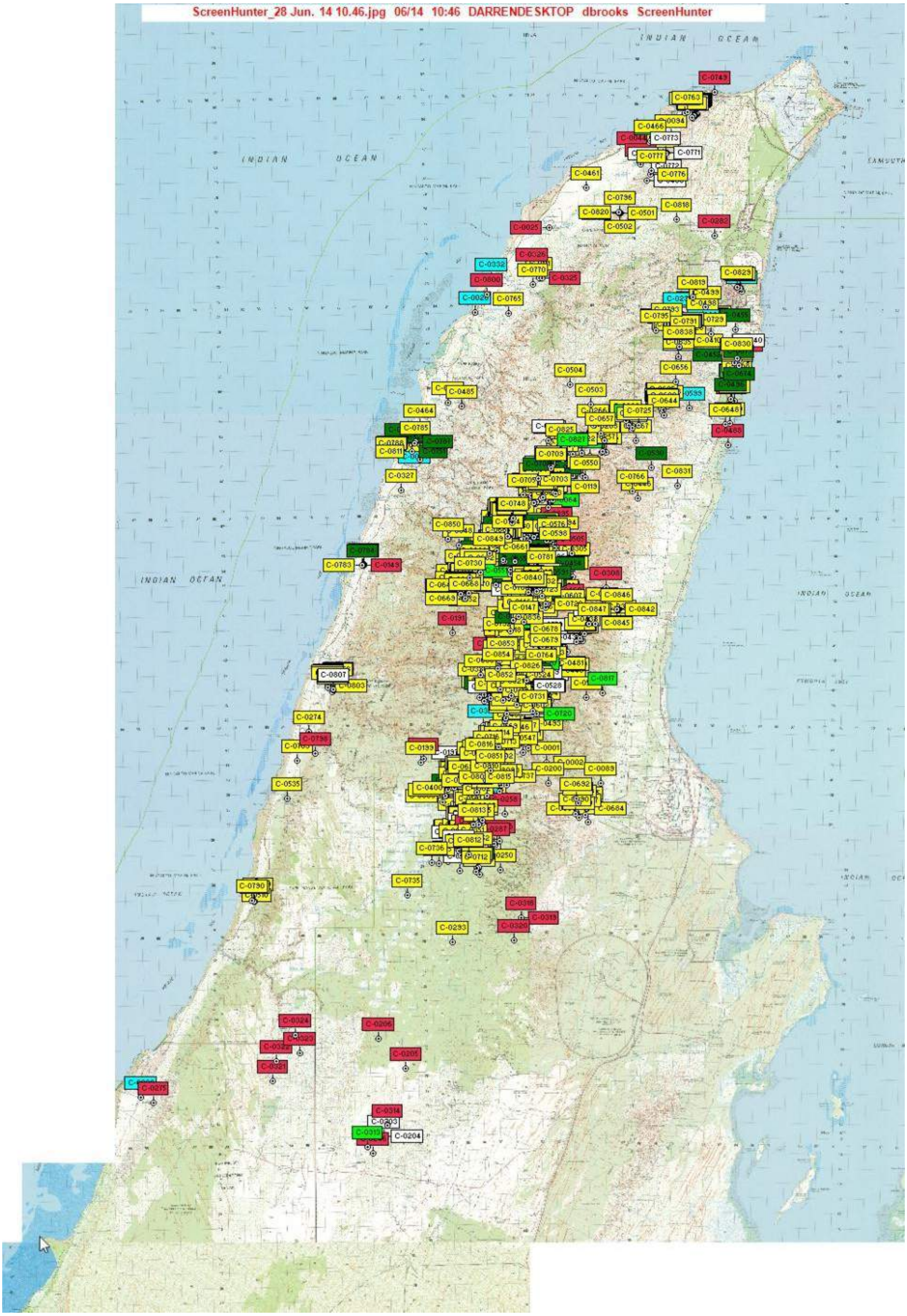


Slide 41 C-222 Loop Cave, a small but significant fauna cave located in the foothills west of Exmouth townsite.

Slide 42 Bill Humphreys, accompanied by John and Joan Mylroie, on one of his many forays into Loop Cave searching for the elusive blind millipede *Stygiochiropus isolatus*.



Slide 43 The Research Period. The WA Museum expeditions to Cape Range lent a new focus to karst investigations. Whereas the earlier expeditions were mostly, but not always, about discovery and exploration, this new era was more focused on systematic recording of karst features along with collection of cave fauna, plus delving into other, deeper, areas of cave science. Irrespective of the new focus though, the karst feature numbers climbed higher and higher from a couple of hundred in 1988 to over 700 in the year 2000.



Slide 44 The years 2000-2015 saw a continuation of the Research Period and the growth of newly allocated numbers to over 850, and the number continues to rise.

Slide 45 To complete our journey through time, a shot of probably the best decorated cave known on the range, C-127.

The Threat to Cliefden Caves

Ian Curtis and Denis Marsh
Orange Speleological Society

Preliminary

First. It is very fitting that I should be giving this talk here, in this area of world importance, where a fragile reef ecosystem is recognised and so passionately defended. We feel the same about the Belubula Valley and the Cliefden Caves which are currently under threat from a proposed new dam.

Heather* on Monday spoke of the 'Big 5' of Ningaloo: the whale sharks; the dugongs; the dolphins; the turtles and the rays. We, too, have our Big 5: Fossil Hill and Trilobite Hill (Ordovician fossil sites); over 60 highly decorated caves, including rare blue stals.; a thermal spring; rare tufa dams; and (endangered) bat species habitat and maternity sites.

And second. The ASF and local clubs seem constantly to be fighting ecological (and even ideological) threats. Remember Colong? The Bathurst/Orange Growth Centre? Timor? Well, over in NSW the latest in this list is the threat to build a dam on the Belubula River which will significantly impact the valley and the caves.

Introduction

Who am I? I am currently the President of the Orange Speleological Society. Over there sits Denis Marsh, our Vice President. We (OSS) are heading the ASF campaign to protect these caves. We are in constant touch with Nic White, whom most of you will know, the main man in the Karst Conservation side of our organisation.

Where are these caves? About five hours west of Sydney on the western side of the Great Divide. Who are OSS? We are a small club - the furthest Western club in NSW. Our club was formed in 1955 and is a foundation member of the ASF. We have a long, close link to these caves.

In March I was invited to Sydney to speak at the Trades Hall with several others. Keynote speaker that night was Tim Flannery. That's right - ***that*** Tim Flannery. Tim spoke on the importance of caves and what we can learn from them. Others spoke on fossils and water. My brief was to speak on the local perspective. I began by talking of Orange's reputation as a wine and food centre. I pointed out that Angullong wines came from a caving property - two of their wines being called Taplow Maze and Fossil Hill. Few outside the speleological and scientific communities knew of these caves. I pointed out that these caves are on private land and land owners have concerns about insurance, trespass and safety. Their farms are their livelihoods.

I gave a brief history of the limestone - the first found in NSW - 200 years ago last month. I talked of the Rothereys who took up land grants in the 1830s and lived here till the early 20th century, early exploration of the caves, the link of the caves to the local Wiradjuri people (scar trees, Malongulli, Burrumbarangal - caves with indigenous names), and the Dunhill family, who have farmed this land for four generations. My point: **The caves have been in the hands of only two families for nearly two centuries.**

I spoke of OSS's link to Cliefden. In 1960 we were invited by Anthony Dunhill's grandfather to manage the caves. This access control has meant that the caves are extraordinarily well cared for. Entry to the caves is permitted to ASF clubs and to visiting researchers. Many of you here will have visited our caves and know the ropes.

So, where has this dam proposal come from?

The Millenium Drought was the catalyst for additional water storage in our area. Our area, the Central West, traditionally is the last to go into drought in NSW but those years were very dry. Local councils tried a variety of measures to collect water: water harvesting; using grey water differently; raising the local Suma Park dam wall and starting (since completed) a river pipeline to Orange from the Macquarie River.

State Water NSW began looking at a dam and were encouraged to do so by water users - local mines (Cadia), farmers and lucerne growers at Canowindra - and local politicians.

National Party policy is to dam rivers. This dam is politically driven. The National Party is comfortably in power locally in both Federal and State seats and they are very influential on local councils. John Cobb, Federal MP for Calare, has been under strong pressure to do something about providing employment for local businesses which are closing down. Electrolux in Orange is slated to close in just over twelve months with the loss of 800 jobs. Simplot, Downer EDI (Bathurst), the Wallerawang Power Station - all are closing or shedding jobs. John Cobb argues this dam will provide employment and attract new industry (code for mines) to the area.

So, who is opposed to this dam?

NSW Labor (under Luke Foley) and the Greens, the union movement and all environment groups: the National Conservation Council; the Inland Rivers Network; the Central West Environment Group; the Environmentally Concerned Citizens of Orange; and, of course, us.

Let me read out from the handout sheet we give to local politicians. This is a double-sided A4 sheet with a series of points under five headings: ***What is wrong with the Needles site for a dam? What will be lost if the dam is built? Why aren't these caves better known? Does the Belubula need another dam?*** and ***What are the alternatives to a dam?***

It finishes with two statements: **This Needles Gap dam is not the answer to our water security** and **Dams do not create water, they simply prevent rivers flowing.**

So, what *will* be lost if this dam is built?

- Extensive, highly decorated cave systems, including rare blue stal. formations. (There are over 60 caves at Cliefden.)
- World-renowned fossil sites. Fossil Hill, Trilobite Hill and much of the highly fossiliferous Cliefden caves limestone will be inundated.
- An important national geoheritage site. This is the first Ordovician limestone found in NSW and it contains examples of some of the earliest shell beds in the geological record and earliest rugose corals known.
- Caves, ranked by NPWS as ***'highly significant'*** with **the highest number of internationally significant values** for any cave area outside the National Parks estate in NSW.
- The thermal spring - one of only three associated with karst in NSW.
- The rare tufa dams (calcite dams) on Davys Creek. These are the largest and most extensive in NSW.
- Cultural heritage sites - indigenous and early colonial.
- An important scientific research site for universities, scientists and local schools. More than 50 papers (including international papers) have been published on this area and the caves. Two academic studies (on bats and geomorphology) are currently in progress.
- Endangered bat species habitat and bat maternity sites.
- Large areas of productive river flat agricultural land, of high value, on several properties. There is no net benefit in losing productive land upstream to irrigate land downstream.
- A significant area of remnant riparian vegetation and wildlife corridor in an otherwise cleared landscape.
- A number of rare and/or endemic invertebrate species and their habitat: Syncarida, ***Cavernaspides Cliefdenensis***; Cliefden Pinwheel Snail, ***Elsothera belubula*** et. al.

What have *we* (OSS) done?

Practical things.

A Cliefden cave mapping project has begun and several NSW speleo clubs are working in the area. This has been organised through us and the NSW Speleo Council.

A bat study has begun.

A Geomorphology study is in progress.

Written things.

A submission (followed by a two hour interview) has been presented to State Water NSW. This was considered by us and Nic White as being of the utmost importance.

Newspaper articles have been published.

Political things.

Politicians have been interviewed - local State and Federal Members, Greens Upper House MP Jeremy Buckingham, local councillors.

Questions have been submitted and asked in State Parliament.

Media things.

The 7.30 NSW Report you've just seen was initiated. Interviews have been broadcast on local TV. Meetings have been addressed.

In all of this there have been two significant dates: the 9th of February 2015, when the Water Security Report was released, naming Cranky Rock as the preferred dam site in the upper Lachlan (though not ruling out The Needles) and 28th March 2015, when the Liberal/National government was returned at the State election, albeit with a lessened majority.

First, a few comments on the **Water Security Report for the Regions** (the 220 pages of it).

This report prioritised four sites/proposals for water storage:

#1 Build a dam at Cranky Rock on the Belubula - an 87m high wall; to hold 700 GL; to cost $768.5m.

#2 Build a dam on the Abercrombie above Wyangalah - to hold 700 GL; to cost $785 m.

#3 Build a dam at The Needles on the Belubula - to hold 700 GL, with a 102m high wall, 480m long; to cost $665.3 m.

#4 Raise Wyangalah Dam wall 20m; to cost $592 m.

The ***in situ*** investigation has begun and is due for completion in March 2016.

Some Points:

- Is inundation of Cliefden (caves, karst, fossil sites, hot spring, tufa dams) ruled out? NO.
- Will a dam at Cranky Rock, further downstream from the caves, save the caves? NO. Much uncertainty here because figures seem pretty rubbery.
- Could The Needles - third choice - be chosen? YES. This site is $100 million cheaper than the two preferred options and in difficult economic times …
- Who will own the water, which must be sold at full cost? GOOD QUESTION.
- Who is this dam for? MINING.
- Will a dam ever be full? ALMOST NEVER.
- Are these the final costs? NO. The costs shift. An original projected cost of $150m was given. Cranky Rock costing is $665 million and includes roads, land clearing, vegetation offsets, fish ways, land acquisition, and 10% profits. Not included are tunnels and diversion structures, gates and mechanical equipment, site security, sheds etc, decommissioning of downstream lakes/storages, electrical works. **It is not fanciful to cost this dam at $1 billion.**

Here is Nic White's take on this proposal. I work this, as often as I can, into conversations (written and oral) with interested parties.

'Cavers object to a dam which will flood and affect the Cliefden Caves. NSW taxpayers should not pay for a dam on a river system which already has dams which are seldom full due to insufficient rainfall and overcommitted water rights to downstream users which will have the effect of damaging karst values, flood nesting trees used by forest bats, birds and arboreal animals.'

So, is there any good news?

YES.

- Ian Houshold's Hydrogenesis study is progressing well.
- The Cliefden Caves mapping project, driven by Phil Maynard [SUSS] and Bruce Howlett [OSS] is coming along nicely.
- Meredith Brainwood's bat study has identified the caves as a bat 'hot spot', with at last count, 18 species identified. Meredith is currently writing up her findings for presentation at the Linnean Society symposium in Bathurst in early September.

What is still to do?

We need to pursue indigenous links.

We need to chase up some scientific studies.

We need to get back to State Water to see where they are up to.

Will We Win?

Ah, the Crystal Ball! I'm quietly confident. There are many elections to come and many millions of dollars to find in who-knows-what economic future. State Labor and the Greens are opposed to building this dam.

All this information (in greater detail) can be found in **Caves Australia** Nos. 198, 199 and 200.

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Strain Gauges in Caves

David Dicker and Bob Kershaw
Illawarra Speleological Society

Abstract

Since Lloyd Robinson began work on the Augusta Jewel Cave in Western Australia in the 1960's, he and members of Illawarra Speleological Society have placed rock movement strain gauges in numerous caves around Australia. It is only recently that the data has been given to ISS and a summary of the locations and readings are provided.

The strain gauge is a gauge for measuring the movement of rocks in cave. The movement may be due to earthquake or movement of the cave rocks over time. There are two metal welding rods or glass rods placed in adjacent rocks to measure the gap between the rods. Measurements taken over time show either a movement apart or getting closer or no movement.

The gauges are measured with automotive feeler gauges used to measure the gap of the spark plug points used in petrol vehicles. It is best if they are measured using the same set of gauges to maintain accuracy but this may not be able to be undertaken in the future.

Introduction

Since Lloyd Robinson began work on the Augusta Jewel Cave in Western Australia in the 1960s', he and members of Illawarra Speleological Society have placed rock movement strain gauges in numerous caves around Australia. It is only recently that the data has been given to ISS and a summary of the locations and readings are given below.

What is a strain gauge?

The strain gauge is a gauge for measuring the movement of rocks in cave. The movement maybe due to earthquake or movement of the cave rocks over time. There are two metal welding rods or glass rods placed in adjacent rocks to measure the gap between the rods. Measurements taken over time show either a movement apart or getting closer or no movement.

How are they measured?

The gauges are measured with automotive feeler gauges used to measure the gap of the spark plug points used in Petrol vehicles. It is best if they are measured using the same set of gauges to maintain accuracy but this may not be able to be undertaken in the future.

Caves with Strain Gauges

Augusta Jewel Cave

After Lloyd's contract finished in June 1960 he installed 3 stations in AJC for his own interest. Later communications with Peter Bell from Western Australia suggests that Bell made a few more readings of the gauges.

Table 1 Club Straw Platform rock pile is a glass gauge in line

Date Measured	Imperial	Metric
June 1960	0.051"	1.2954mm
Mid 1968	0.054"	1.3716mm
5/02/1970	0.055"	1.3970mm
18/12/1975	0.057"	1.4478mm

Date Measured	Imperial	Metric
May 1979		1.5303mm
12/05/1986	0.0635"	1.6129mm
11/11/1988	0.066"	1.6764mm
10/01/1991	0.070"	1.7780mm
sept 1991		1.6510mm
Dec 1991		1.5621mm
Feb 1992		1.6129mm
March 1992		1.6129mm

Table 2 Playford's Cut Through. This cut through is a glass type gauge in a right hand crack in wall at cut though set in line with a nil **gap to start with.**

Date Measured	Measurement
June 1960	nil
Mid 1968	nil
5/02/1970	nil
18/12/1975	nil
May 1979	nil
12/05/1986	0.01
11/11/1988	nil
10/01/1991	nil
sept 1991	nil
Dec 1991	nil
Feb 1992	nil
March 1992	nil

Easter Cave

In Easter Cave there are 4 gauges and number 4 is a glass type gauge.

Table 3 Easter Cave Strain Gauges with Peter Henley (?)

Strain Gauge	Date Measured	Measurement
no 1	25-1-1968	0.020"
	24-8-1968	0.015"
	29-5-1979	0.02"
	13-5-1986	0.02"
	10-11-1988	0.020"
	6-5-1995	0.0195"
no2	25-1-1968	0.0215"
	24-8-1968	0.022"
	16-12-1975	0.021"
	29-5-1979	0.021"
	13-5-1986	
	10-11-1988	0.022"
no3	25-1-1968	0.020"
	24-8-1968	0.016"
	16-12-1975	
	29-5-1979	0.02"
	13-5-1986	
	10-11-1988	
	6-5-1995	0.018"
no4	25-1-1968	0.000"
	24-8-1968	0.000"
	16-12-1975	0.000"
	29-5-1979	glass has bow
	13-5-1986	firmly together

Strain Gauge	Date Measured	Measurement
	10-11-1988	no gap
	6-5-1995	intact under pressure

Table 4 White Canopy Station is a floor crack near a white canopy in bye with glass and is flat in line with a Nil gap **initially**

Date Measured	Imperial	Metric
June 1960	nil	
Mid 1968	nil	
5/02/1970	nil	
18/12/1975	nil	
May 1979	0.0015"	0.0381mm
12/05/1986	0.003"	0.0762mm
11/11/1988	0.002"	0.0508mm
10/01/1991	0.002"	0.0508mm
sept 1991	0.0025”	
Dec 1991		0.0635mm
Feb 1992		0.0635mm
March 1992		0.0635mm

Tuglow Main Cave

Table 5 Tuglow Main Cave. Large Bridge type slippery slopey rock approximately centre of the two gauges.

Strain Gauge	Measurement Date	Measurement (Imperial)
top gauge	3/12/1977	
	22/04/1978	0.017"

	14/03/1982	0.016"
bottom gauge	3/12/1977	0.065"
	22/04/1978	0.067"
	14/03/1982	0.0695"

Wyanbene Cave

These were installed by Lloyd Robinson on 18th November 1978 and numbered 1,2 and 3. No 1 is between "loose" roof and large boulder on the downstream side of the "Lavatory Pan" No2 is in a large crack on lower side of rockpile chamber and No3 is between roof and large "chock" boulder, half way up rockpile chamber. These are near the entrance to the Gunbarrel Aven area of the main passage.

Table 6 Wyanbene Cave Strain Gauges

Strain Gauge	Date Measured	Measurement
no 1	18-11-1978	0.031"
	10-11-1979	0.029"
	20/12/1981	0.033"
	6-2-1982	0.033"
	20-2-1983	0.033"
	18-9-1983	0.034"
	13-1-1996	0.028"
	22-9-2007	0.0275"
no 2	10-011-1979	rod + 0.0015" tight
	20-12-1981	spacer + 0.0015"
		rod length = 5.2575"
no 3	10-11-1979	rod length = 2.3855"

Jenolan Caves - J46

The strain gauge was installed by Lloyd Robinson, Kevin Hanrahan, David Dicker and possibly Chris Edwards. Normally we installed the gauges in an inconspicuous spot, but the location in J46 was ideal for measuring movement. As far as I know, it was never subsequently checked, ISS was heavily involved in the Kimberley at the time, so our energies were directed elsewhere.

Cliefden Main Cave

Location is on Right hand side of track immediately before entering the main chamber. There is a crack and the top part of the gauge is cemented in a hole drilled in the roof and the bottom part is cemented in a hole drilled through the moving slab.

Table 7 Cliefden Main Cave

Date Measured	Measurement
12-8-1978	0.029"
15-4-2006	0.0295"

Figure 1 Gerrard Collins and David Dicker measuring the gap in the Cliefden Main Cave gauge

Kimberley region Gauges

Table 8 Kimberley Strain Gauges

Cave	Gauge Type	Date Measured	Measurement	Notes
Network Cave	influx gauge	12/06/1991	3.763m	with steel tape measure
		14/06/1992	3.763m	but closed 0.5mm 11 days later!
		6-7-1993	3.763m	

		8-6-1995	3.763m	
Cathederal Cave **Mimbi**		19-6-1991	2.620m	twist in tape
		14-6-1992	2.621m	
		1-7-1993	2.621m	
		8-6-1995	2.621m	
Cave Springs	top gauge	12-6-1980	0.020"	
		7-6-1991	0.019"	

Napier Range

There are photos of these gauge locations but no other data.

Bibliography

Lloyd Robinson various personal notes and letters

ISS trip reports

Illawarra Speleological Society Inc. Newsletter June 2006 Page 6

The slides for this presentation are provided in Appendix B.

"Getting Lucky - whilst caving"

Brian Evans
Illawarra Speleological Society

Fortune favours the prepared.

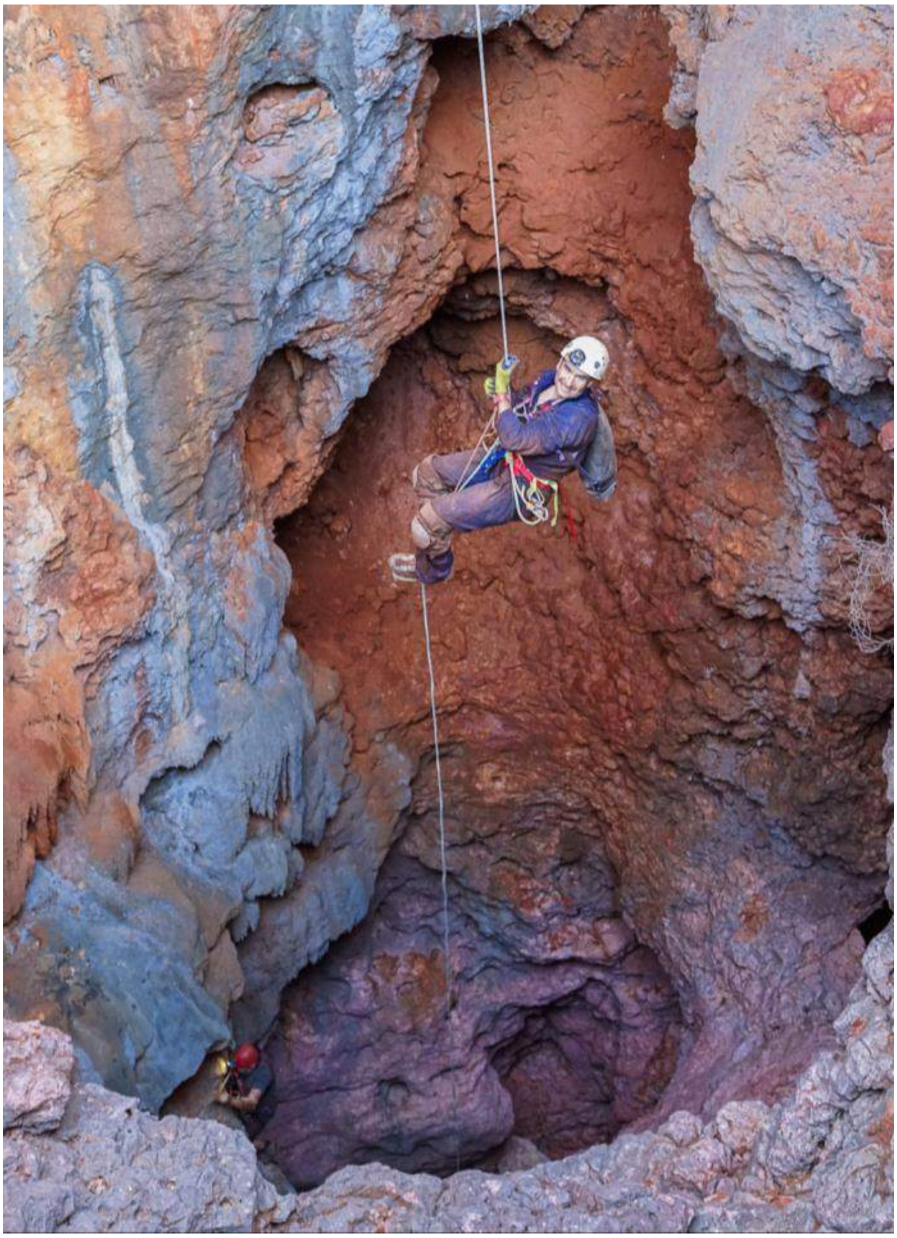
Fortune also favours the brave.

Many of us know that we've been lucky while caving, or in our other activities. We also know that we've been prepared, and been brave.

This discussion aims to prepare a simple graphic organiser for cavers to increase the number of 'lucky' cavers, especially for those with more youthful 'bravery' and less experience to draw 'preparedness' from.

While accidents are extremely (and fortunately) rare in caving, they need to be - rescue, and even self-rescue are extremely difficult, even in simple, trade-route caves; it is in all of our interests to make sure that accidents get even more rare…

The slides for this presentation are provided in Appendix C.



The Jenolan Show Cave Survey – an update on progress.

Dr Julia M. James
Sydney Speleological Society

jjam5907@usyd.edu.au

The Jenolan Caves Survey Project began in the late 1980's and this presentation is a companion to that given at the ASF conferences in 2009 and 2013. At Trogalong, 2013 the title for my Jenolan Caves Survey Project was "The Jenolan Show Cave Survey – publish or perish." The project aim was to produce a survey, which could be used by others for management and research. This talk will detail the further problems encountered as the group strives to get the survey ready as a publication available to speleologists and managers. In 2012 the decision was made that the survey should be published in hard or soft copy. The survey has been drawn at a scale of 1:200 and if reduced to 1:500 it can be published both as a poster and a folio of A3 sheets. Jenolan Show Caves have numerous areas with passages overlying those below; the two methods of presentation of these areas have been used. As final drafts have been prepared and checked problems have been noted, for example sections of the dive survey being of doubtful accuracy, have been re-surveyed. The representation of the many Jenolan Show Cave tours has required special thought; the earlier version will be shown and compared with the latest presentation of a cave tour. The survey in its unpublished form has had many uses for management and these will be presented. A 3D video presentation of the Jenolan karst and the cave system prepared for the International Show Caves Association (ISCA) Congress held at Jenolan in November will be shown.

The Nullarbor Caves and ASF conferences – Memories from the 1970's

Roz Hart
Western Australian Speleological Society – previous member

A history talk about the old ASF conferences and associated field trips to the Nullarbor Plain.

Workshop - International Congress of Speleology, Sydney, July 2017

Denis Marsh and Cathie Plowman
Orange Speleological Society and Northern Caverneers

The organisation of the 17th International Congress of Speleology to be held in Sydney in 2017 on behalf of the UIS. The workshop will cover an outline of where we are at with the organisation and where we are headed. Also where we need additional resources for assisting with the organisation with the view to encouraging/recruiting volunteers.

By the time we have the ACKMA and ASF conferences in 2015, the 2017 international congress will be just over two years away.

The 2017 conference will include the following field excursions:

1) Wednesday mid-week trip on Wednesday 26 July. The focus will be on Jenolan Caves. The mid-week excursion is not part of the conference registration fee, but a separate fee.

2) Pre and post congress excursions. To date we have the following excursions being planned:
    a. Queensland:
        i. Chillagoe. Pre and post congress trips from Cairns. Being coordinated by Paul Osbourne (CCC).
        ii. Undara Lava Tubes. Possible only at this stage. Being investigated by Paul Osbourne.
    b. New South Wales:
        i. Jenolan. Garry Smith interested. But assistance needed. Possibly coming from Brian Evans (ISS).
        ii. Cliefden Caves. Pre or post congress, being coordinated by Denis Marsh (OSS).
        iii. Wombeyan Caves. Pre and post congress caving.
        iv. Yarangobilly. Pre or post congress, being coordinated by MSS.
        v. Bus trip touring southern show cave areas, karst sites and scenic sites. Pre congress. Being coordinated by Grace Matts (SSS).
    c. Victoria:
        i. Buchan. Pre or post congress, based at Homeleigh.
    d. South Australia:
        i. Naracoorte.
        ii. Nullarbor caving.
    e. Western Australia:
        i. Kimberley. Pre and/or post congress trip.
    f. Tasmania
        i. No specific trips are being offered at this stage (due to winter weather conditions).
    g. New Zealand
        i. Trips are being offered on both the North Island and South Island. Being coordinated by NZSS.

3) Non-caving excursions pre or post congress:
    a. Highlights of Sydney.
    b. Uluru/Alice Springs. Still to be investigated.
    c. Museum of Old and New Art Hobart (MONA),

4) Non-caving day excursions during congress: Options can include: Parramatta, Tall Ships sail on Sydney Harbour, Blue Mountains.

A history of the Cape Range

Rogé Kemp
Shire of Exmouth

A brief history of the Cape Range, and town of Exmouth.

The slides for this presentation are provided in Appendix D.

Darren Brooks driving on the range (Photo Ross Anderson)

The biggest cave in the world – A photographic tour

Rob MacCracken
Western Australian Speleological Group

This presentation will provide a photographic tour of two of the largest cave systems in the world including a brief discussion of the formation and development of Hang Son Doong (Mountain River Cave) Phong Nha-Kẻ Bàng National Park, Vietnam.

Perseverance Pays (or why being stubborn can sometimes be useful). IB-232 D'Entrecasteaux River Third Sink, (into IB-14 Exit Cave), Ida Bay Karst, Tasmania.

Janine McKinnon
Southern Tasmanian Caverneers

The D'Entrecasteaux River sinks and resurges twice before its third sink into Marble Hill. It then reappears in D'Entrecasteaux Passage inside Exit Cave. The sump had never been dived. There is 250m direct line between the sump and the reappearance. Was this to be a straightforward exploration?

The slides for this presentation are provided in Appendix E.

YTIVARG - There, and back again. Sump II, JF-4 Kazad-Dum, Junee-Florentine Karst, Tasmania.

Janine McKinnon
Southern Tasmanian Caverneers

Kazad-Dum Cave terminates in a sump at -267 m. Only two attempts have previously been made to push this sump; the results were inconclusive. What does it take to get diving gear to this remote location? What was found?

The slides for this presentation are provided in Appendix F.

Speleothem climate reconstruction

Fiona McRobie
The University of Western Australia

My PhD research uses cave data from the Kimberley, and elsewhere in the world, to try to understand how the Australian monsoon changed since the last Ice Age some 22,000 years ago. My talk will briefly cover some topics relating to cave data and past climates: why we care about past climates, what are some of the questions waiting to be resolved about the Australian monsoon, and how I – as a mathematician – try to find answers from wiggly lines created from speleothems.

Archaeological research in the Eneabba area

Carly Monks[1,2]; presented with additional information by Fran Head[2]

[1]School of Social Sciences, University of Western Australia

[2] WA Speleological Group

Carly Monks
The University of Western Australia

Abstract

The caves of the coastal plain north of Perth, like those of the Leeuwin-Naturaliste region, provide excellent opportunities for archaeologists to better understand the ways in which Aboriginal people used the land and its resources. The remains of fires, animal bones, and artefacts are often not preserved outside of the caves, making the caves important resources for this research. The purpose of the archaeological research trip to 6E-30 was to excavate a couple of small test pits within the cave to look for stone artefacts and bones, so that we can begin to understand how Aboriginal people were using these sites and the surrounding environments over the last 5,000–10,000 years. This presentation details the initial search for suitable sites, the excavation, and the results to date.

Paper

Carly is a PhD candidate at the University of Western Australia who was referred to WASG for advice by one of her supervisors, Joe Dortch.

As an aside, Joe's father Charlie Dortch is an internationally renowned archaeologist, an American who settled in WA and worked at the WA Museum; he is known here primarily for his work on Devil's Lair cave in Margaret River, where human occupation has now been dated to nearly 50,000 years ago. Joe Dortch shared in his father's interests and work and completed his PhD at UWA, where he went on to become an Associate Professor and is currently a Research Fellow. He has overseen research projects investigating archaeological evidence for fauna extinctions in the Late Pleistocene; past Aboriginal burning and landscape management in south-western Australia; and sampling archaeological sites for ancient DNA extraction and analysis. He has also consulted widely to communities and industry.

Both Joe and Carly were keen to extend the cave-related research from the Leeuwin-Naturaliste region to the caves of the coastal plain north of Perth. (I for one was surprised to learn how little had been done in this region: some small-scale work on fossil fauna, but no investigation of, for example, the ways in which Aboriginal people used the land and its resources.) So Carly came to a WASG meeting at the start of 2014 to explain what she was looking for; she joined the club, and on Anzac Day weekend a few of us (Ian Collette, Ian McCann, Brett Wiltshire and myself) accompanied her on a trip to the Eneabba area (fig. 1) to look at possible 'rock shelter' type sites likely to have been occupied or used in the past by Aboriginal people.

We started our 'quest' at Stockyard Gully, a steep-sided gully leading into a well-known stream cave system. The name no doubt derives from the relative ease of penning cattle overnight in the gully while droving on a nearby stock route. Carly had visited this site previously and noted some minor rock shelters high on the gully slopes which she felt could have been used as shelter from the midday heat and to watch for wildlife (fig. 2). These were duly photographed and measured, and the remainder of the Stockyard cave system investigated, before we enjoyed a recreational interlude abseiling into ANU cave to admire the view of the heavily pierced roof.

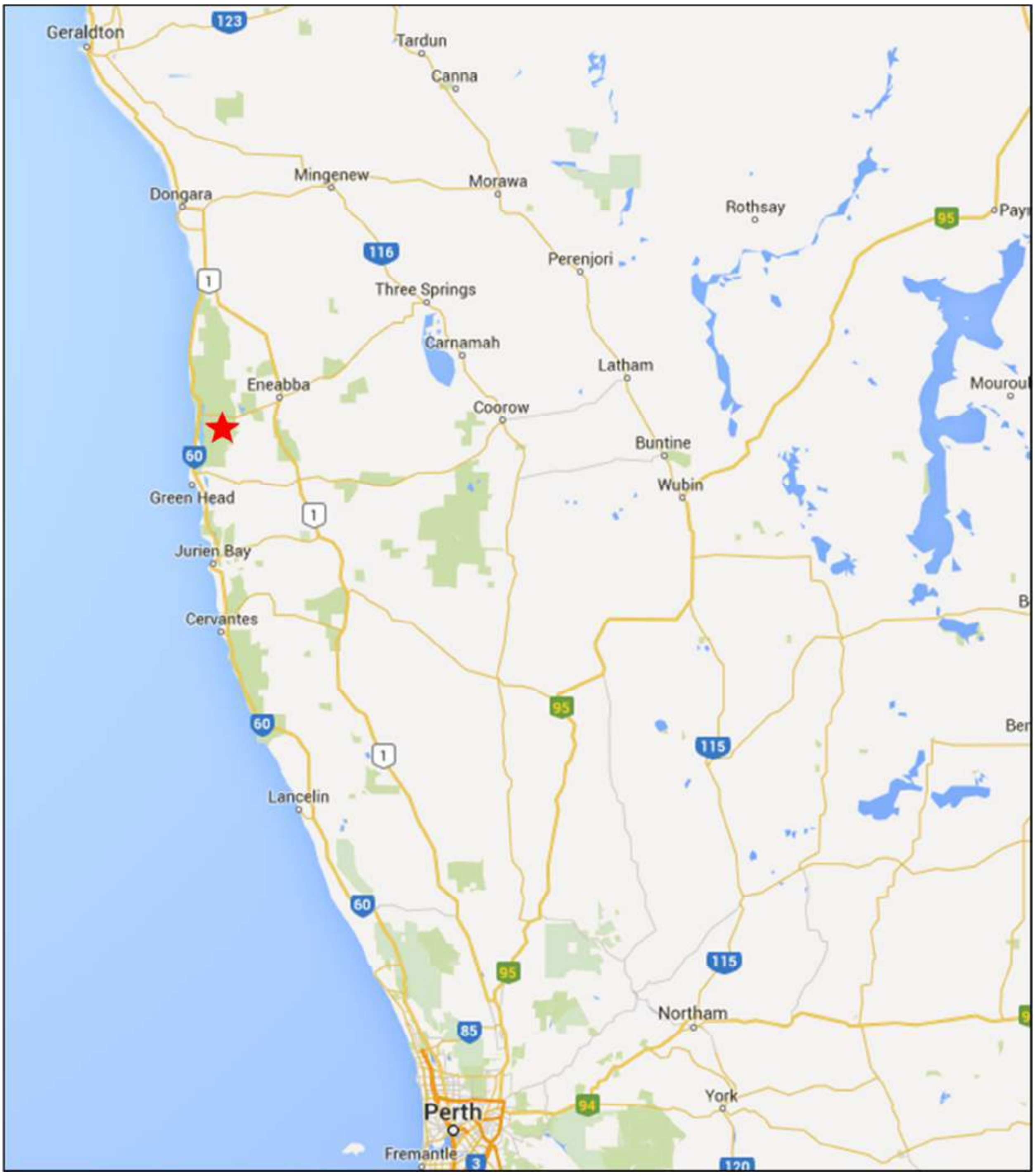


Figure 1: General location map, with the research area starred in red

We then undertook a cross-country circuit to check the numerous features to the north. These were all relatively shallow dolines into which one could walk, most with an obvious area of exposed rock and a number of blocked shafts but no entry. A couple, however, had a chamber or rock shelter, as noted below.

E-12, Seismic Cave or Facts-of-Life Cave, was the most likely prospect from today's caves. A boulder-filled doline slopes steeply down at one side into a fairly considerable rock shelter (fig. 3). Carly and Brett seemed unconcerned by the ferocious bees hanging off the overhang (fig. 4) and spent quite some time measuring and photographing in the sandy floor of the cave. Ian Collette and I were not game to brave them; Ian McCann was moving into the cave but beat a hasty retreat when he heard the bees fire up.

Figure 2: Carly Monks taking measurements in a rock shelter above Stockyard Gully. Image Ian McCann

On Saturday we headed for E-30 Drip Cave, where we clearly hit the jackpot from Carly's point of view. This is a wide rock shelter (fig. 5) with a large, flat covered area (fig. 6), dropping several metres to a chamber in near-darkness at the back. Evidence shows that it has been used by random campers/drinkers over a considerable period – not to mention goats, bees and swallows. There are also many deposits of small bones, several of which appear to be from owl roosts, including some tiny bones cemented on to the rock surface (fig. 7). Many measurements and photos were taken.

Carly's next task was to request permission for a dig from the Department of Aboriginal Affairs and the Department of Parks and Wildlife, which naturally took some time, but by late October she was ready to begin fieldwork. The rest of this report is given in Carly's words.

The purpose of the archaeological research trip to E-12 and E-30 was to excavate a couple of small test pits within the caves to look for stone artefacts and bones, so that we can begin to understand how Aboriginal people were using these sites and the surrounding environments over the last 5,000–10,000 years.

The research trip involved a large team including archaeologists and archaeology students from UWA and Curtin University[3], and Amangu Traditional Owners Thomas Cameron and Buddy Edwards. Some people joined us for the whole trip, but most just helped out where they could, for a few days between other commitments. We planned to dig test pits at the two caves, E-12 and E-30, which had been visited earlier in the year and showed the most promise as archaeological sites.

Unfortunately, this plan hit a snag on the first fieldwork day, when we reached E-12 only to find that the bees at the entrance had increased in number and ferocity since the previous visit. The decision was made not to attempt fieldwork at E-12 on this trip, so we trudged back to the cars… only to find we had staked the sidewall of a tyre. With our spirits as deflated as our tyre, we ended the first day on a bit of a low note. Fingers and toes crossed for the following day we tried to boost our moods with a discussion of the many ways in which the other cave, E-30, would be better.

Figure 3: Exterior view of E-12. Image Ian McCann

Figure 4: An earlier composite interior shot of E-12, showing clearly the descent route past the feral bees' nests. Image Paul Hosie

Figure 5: External view of E-30 from its broad doline

Thankfully, we were right. Our first test pit in E-30 was positioned in the northern end of the entrance; about four metres back from the dripline in an area with smoke staining on the roof (fig. 9). It was flat, dry, and just out of the reach of the afternoon sun: all the hallmarks of a good spot to make a fire. We strung out a small test pit (1 m^2), and started to dig… and before we'd even removed three buckets of sediment (mostly comprised of goat hair, goat manure, and goat bone), we'd found our first artefact. It's not an exaggeration to say that this small quartz flake buoyed everyone's spirits (particularly mine) instantly: we had an Aboriginal site!

Figure 6: Internal view of E-30 showing the extensive sandy floor, with (at the centre) the passage down to the inner chamber. Image Ian McCann

Over the next few days, the finds kept coming. We soon found a hearth pit, full of ash, charcoal, emu eggshell and bone. Three more hearths followed in quick succession, along with many artefacts made from a variety of stone types – quartz, basalt, silcrete, chert and limestone. The graffiti on the northern wall was photographed and recorded (fig. 10), and Thomas and Buddy told us about their uncles, who had lived rough in the area in the 1930s and 1940s, making use of caves like E-30 during harsh weather. Both Thomas and Buddy were very happy with the excavations, and would like to give E-30 an Amangu name reflecting its use by Aboriginal people. They are currently discussing possible names with senior Amangu elders.

Figure 7: Tiny bones cemented on to a vertical rock surface. Image Ian McCann

Later in the first week, Alex Baynes joined us to lend his expertise. He and Tess (a PhD candidate at Curtin) began to sort through small samples of the bone to collect tiny fragments for ancient DNA analysis (fig. 11). Tess will analyse these samples later in 2015, to search for traces of some of the species that are more difficult to identify.

The weekend of 1 and 2 November was particularly busy, with more people able to join the research team. This gave us an opportunity to open a second 1 m^2 test pit in a different part of the cave. Test Pit 2 was positioned towards to rear of the front chamber, next to a shallow channel created by water erosion. Joe began the excavation, and within moments he had uncovered a small fragment of marine shell!

We were joined over the weekend by WASG member Danny Wilkinson, who was quickly co-opted into helping with the excavations, as well as the survey of the front chamber. The finds kept coming, including complete mandibles of kangaroos and possums. Danny, Alex, and others identified several bones and partial skeletons within the cave, including the jaw of a dingo pup and most of a fox.

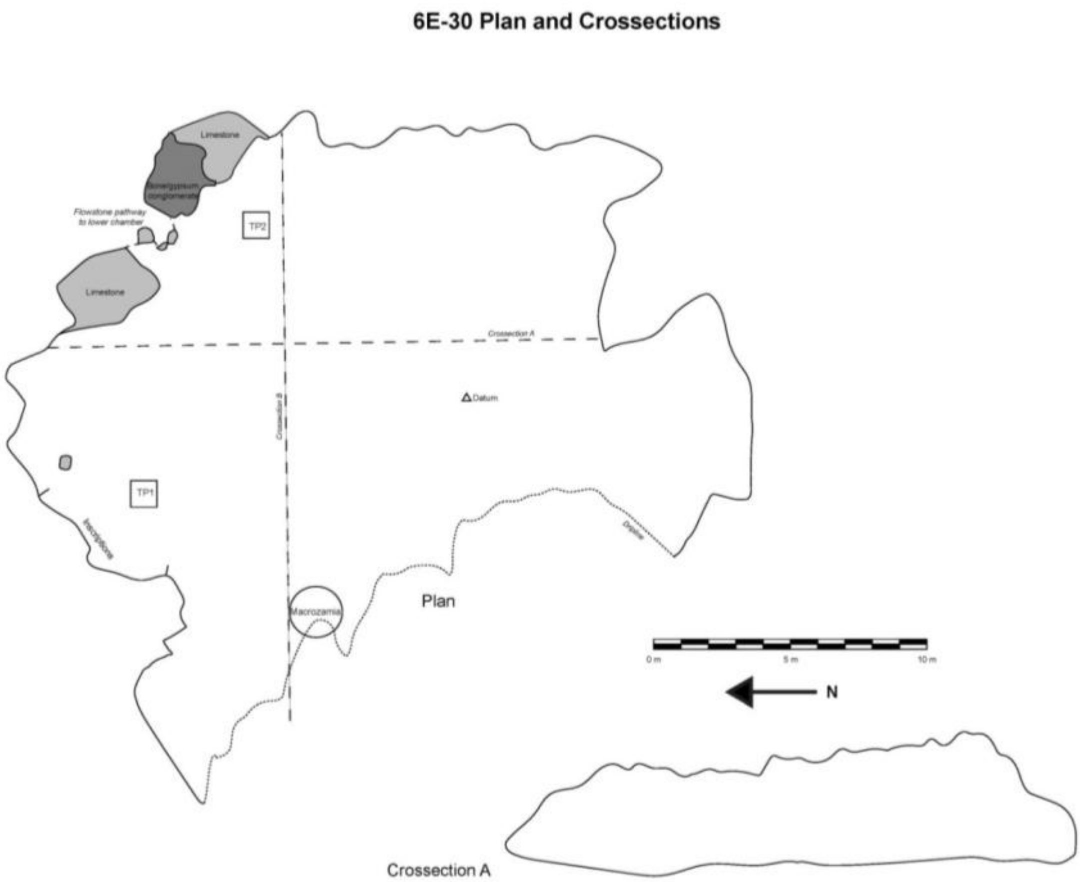


Figure 8: Carly's plan of the front chamber of E-30, showing the locations of the test pits

Figure 9: Test Pit 1, with a detail of one of the hearths. All images not otherwise credited are by Carly

Early in the second week, we reached our maximum depth of 1.5 metres in the first test pit and closed it off. We placed green plastic along the base and walls of the pit, and backfilled. The excavation of the second test pit continued for the rest of the week with a steady stream of bone and artefacts being noted. We reached a depth of 1.5 metres on our last afternoon, and finished backfilling in the late afternoon.

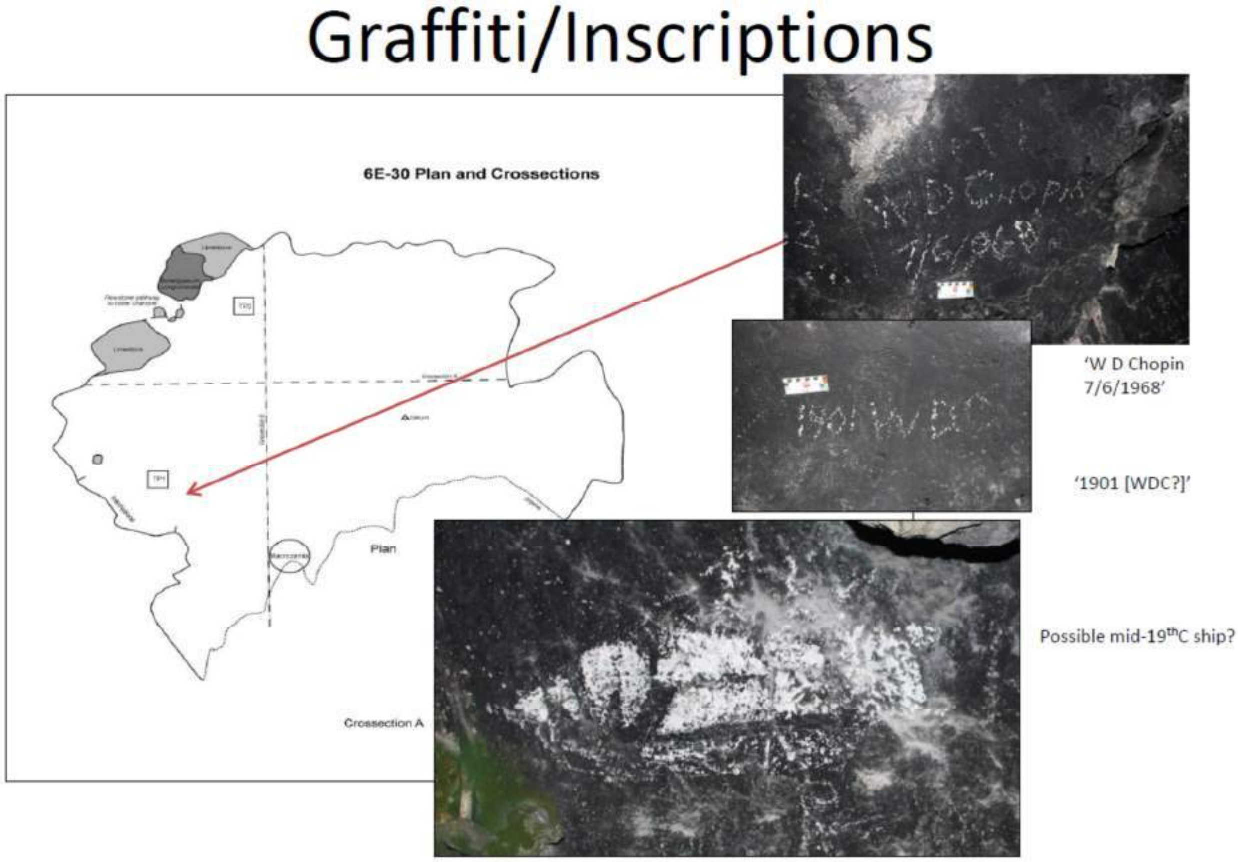


Figure 10: Details and location of the inscriptions

Overall, the trip was a resounding success, with the site showing excellent archaeological and palaeontological potential. The material brought back from the cave (fig. 13) will be cleaned, sorted and analysed this year. Carbon-14 dates will be available after mid-year, but the deposit is estimated to be up to 7,000 years old, covering the period from the establishment of the modern coastline up to the historic era. The many thousands of bones and artefacts show evidence of Aboriginal use of a wide range of resources, including marine resources, and I have high hopes that they will provide insights into how Aboriginal people occupied the coastal plain, and how they altered the plant and animal communities.

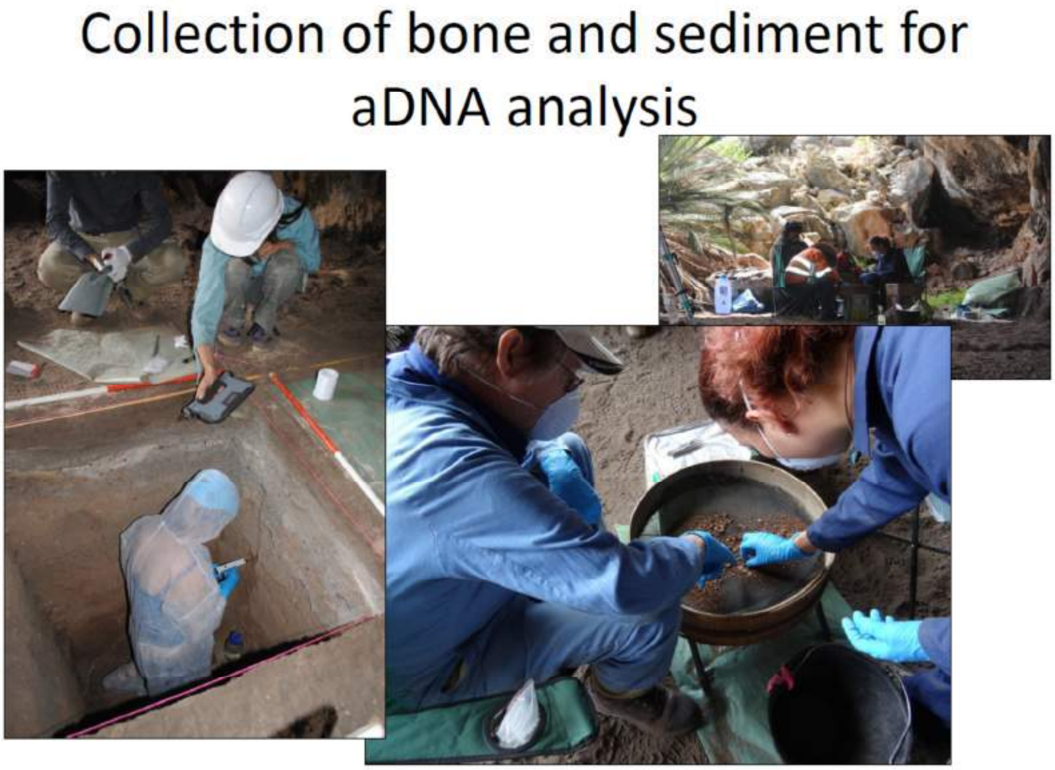


Figure 11: Collecting bone and sediment for ancient DNA analysis: plant (pollen) DNA is sought in addition to animal DNA. Tess Cole from Curtin University (in the pit) wears a full painter's suit while taking samples to prevent contamination by current human DNA (skin flakes, etc). Other researchers record temperature and humidity for a further PhD project to establish the kind of site where ancient DNA is best preserved, and the best way extract it. Amangu TO Thomas Cameron, seen in the top right picture, is very engaged with cultural projects, and currently aims to have the old people's stories recorded on Mingenew Station, where he works.

Figure 12: Test Pit 2, where many of the larger bones were found

Postscript: as you know, PhD research funding is quite limited. Last year's field work used almost all the funds available to me from my university and other sources. As a result, Joe Dortch and I have decided to try something a little different: we've turned to crowdfunding in a bid to raise money for a second field trip and radiocarbon dating. We launched the campaign in mid-May and have already had an excellent response[4].

Figure 13: A sample of the finds from E-30

References

UWA: Carly Monks (PhD candidate, WASG), Joe Dortch (PhD supervisor), Rebecca Stewart, Rebecca Foote, Shannon Henderson, Callum Forsey, Andrew Horn, Tania Phillips, Jacquie Brisbout, Daniel Monks; **Amangu Traditional Owners:** Thomas Cameron, Buddy Edwards; **WA Museum:** Alex Baynes, Cassia Piper; **Curtin University:** Tess Cole, Mike Bunce; **WASG:** Danny Wilkinson

In fact, by the time the campaign closed on 26 June 2015 it had raised $5825 from a total goal of $6800, which means that the next phase of the research will definitely be going ahead. Excerpts from the crowdfunding 'bid' are included as an Appendix to this paper.

Appendix: The crowdfunding bid

How nature and nurture created biodiversity in south-western Australia

Carly Monks

Our ecosystems are in danger

Over millions of years, extraordinary biodiversity evolved in Australia. And over many thousands of years, Aboriginal Australians met all of their food needs from our rich environments. But when Europeans arrived, more than 50 bird and mammal species disappeared within two centuries. Today, an astonishing 1700 species are at risk of extinction.

Foxes and cats are the main threats, but their effects are far worse where fire regimes have changed and land has been cleared. Our project proposes to understand the impact of humans on the environment before Europeans came to Australia. With this knowledge, we can identify the best ways to promote environments that protect native wildlife.

Exploring the past helps us plan for the future

Before Europeans came to Australia, Aboriginal people had developed sophisticated practices for managing their food supply, through social controls and through burning the landscape. Our aim is to determine whether these practices impacted the native fauna. We focus on the area between Jurien Bay and Leeman on the Western Australian coast, where cave environments preserve archaeological and palaeontological remains in the form of campfire ash beds, stone tools, and animal bones. The mega-diverse vegetation around these caves is the famous *kwongan*, harbouring thousands of endemic plants and unique animals like the honey possum, the only mammal that lives entirely on nectar. By identifying changes in animal species from their bones and DNA preserved in their bones, and the changes in human activity, we can understand how people hunted certain species and what impact hunting had. We can also understand the impacts of burning, by studying records of environmental change. Many animals require environmental conditions that can be altered by firing, so change in these conditions can be ascertained by studying changes in animal populations over time.

Your support is vital

In the first year of our project, 2014, we worked with local Aboriginal custodians and excavated a sample from a cave deposit that is full of animal bone and cultural material. We now hope to excavate at another cave nearby, to provide a "control" site where hunting was not a factor. But due to the time we had to devote to exploring the rich remains from the first site, we have few funds left to test the control site. We seek funding to return to the field and complete our study.

Join us!

Our largest expense is the engagement of two Aboriginal Traditional Owners, who represent the Amangu people who speak for the Country on which this research is undertaken. $2400 will be used to cover their employment, daily travel and accommodation expenses.

We're also expecting to transport, house and feed four researchers and students. We're seeking funding for vehicle fuel - $250, food - $450, and accommodation - $450.

Radiocarbon dating is an expensive and essential part of archaeological research. To answer our research questions, we need to be confident of the timing of changes and events. Radiocarbon dating is undertaken at dedicated laboratories, and costs about $650 per date. We would like to date 4 to 6 samples within the site to establish a chronology of change through time. Any funds raised beyond the target costs will be used to pay for additional dates, and other laboratory costs associated with analysis of the excavated material.

Workshop – Build a Disto X2

Kevin Moore
Sydney University Speleological Society

This is a workshop to construct and calibrate a new DistoX, based on the Leica X310. Kevin will supply one set of the necessary tools, so if anyone wants to build their own at the conference, they will be available. You will need to supply your own Disto X310, a non-magnetic LiPo battery, and the DistoX circuit board.

A preliminary survey of the invertebrate fauna of the Gunung Mulu World Heritage karst area, Sarawak, Malaysia.

Dr Timothy Moulds[1,2], Jay Anderson[3], Ross Anderson[3] and Patrick Nykiel[2]*
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Abstract

The Gunung Mulu World Heritage Area (Mulu) is situated in the north eastern corner of Sarawak , Malaysia on the Island of Borneo, adjacent to the South China Sea. The area was prescribed as a national Park in 1974 and is the largest national park in Sarawak covering an area of 528 km^2 . The area contains significant karstic limestone, with some of the world's largest caves by volume known from the area.

In 2012 a team of Australian speleologists undertook a preliminary survey of the invertebrate biodiversity of eight caves within Mulu. The caves were a mix of tourist, adventure and wild caves within the park. Invertebrates were recorded from a mixture of different microhabitats found within the caves and reference specimens from each cave were collected and preserved for future study.

The aims of the study were to:

1. Document the biodiversity of the caves.
2. Provide a photo inventory of species recorded.
3. Compare the invertebrate diversity and abundance between different cave zones and microhabitats.
4. Compare the invertebrate diversity and abundance between caves used for different tourism purposes.

The survey recorded over 19,000 specimens using a combination of collection and observation of species that presently represents 100 different morpho-species, from 28 orders and 9 classes. The number of morpho-species is expected to increase with additional sampling. Forty different species have been photo-inventoried thus far.

Preliminary analysis of data has shown no discernible differences in invertebrate diversity or abundance between tourist caves and wild caves. Observed differences in invertebrate populations are related to microhabitat variability and availability within sampled caves, with greater invertebrate abundance related to bird and bat guano deposits. Longer term sampling and research will be required to provide a greater understanding of species diversity and patterns of abundance throughout the Mulu karst.

Introduction

The Gunung Mulu World Heritage Area (Mulu) is situated in the north eastern corner of Sarawak , Malaysia on the Island of Borneo, adjacent to the South China Sea The area was prescribed as a national Park in 1974 and is the largest national park in Sarawak covering an area of 528 km2. Gunung Mulu World Heritage Area contains significant karst and associated subterranean fauna. Although substantial research was undertaken on the bio-speleological values, this was more than 30 years ago and much has changed in regard to our knowledge of such fauna especially within tropical settings.

Aims of the preliminary survey

The current preliminary survey aims to provide a basis for future biological surveys in Mulu by building upon the only other substantial biospeleological survey undertaken in the area by Chapman (1982). The current preliminary survey aims to provide an initial overview of the invertebrate fauna in the cave systems near the Park Headquarters and predominately in those used as tourist caves and adventure caves. The primary survey aims were to:

- Preliminary overview of the biodiversity and initial insights into the cave ecosystems as a baseline and starting-point for future ecosystem studies of the cave systems.
- Provide a photo inventory of species recorded.
- Compare the invertebrate diversity and abundance between different cave zones and microhabitats.

- Compare the invertebrate diversity and abundance between caves used for different tourism purposes.
- Provide management strategies to facilitate fauna survival and mitigate threats.
- Provide recommendations for future works to compliment the findings of the current study.
- Preparation of recommendations for further cave biodiversity studies, potentially focusing on sustainable cave management and adequate tourism development

Methods

Surveys for subterranean fauna may use many different techniques according to the type of fauna being targeted and the amount of time available for the survey. Due to the very limited amount of time available for the current preliminary survey it was decided to use active hand searching (hand foraging) to enable a wide variety of different habitats, and caves to be surveyed quickly and detect the majority of species present within. The caves sampled are shown in Figure 1. The majority of caves sampled during the current biospeleological survey were not sampled as part of Chapman's survey, with much of his sampling concentrating on the Clearwater System and other associated caves, as well as more remote caves further to the north (Chapman 1982). Green Cave, Deer Cave and Deer Water Cave were common to both surveys, albeit in differing sampling intensities.

Each cave was sampled in the Entrance Zone, Twilight Zone and Dark Zone with a selection of the main microhabitats sampled from each zone. The following microhabitats were identified as occurring within the Mulu caves; Fresh guano, Old guano, Massive guano, Damp sediment, Dry Sediment, Walls/Speleothem, and Streamway/Water pools.

In each light zone of a cave the overall site was photographed and the location on existing cave maps was recorded to facilitate repeat sampling in the future. Each sampling site was then assessed for the presence of microhabitats, with each microhabitat identified in the site sampled for 20 minutes each. The abundance of each species was recorded using a combination of collection of voucher specimens (maximum of five specimens per morpho-species per cave) for future identification and observation of total species abundance within each microhabitat. The location of any cave infrastructure, such as paths or lighting was also recorded. The intensity of sampling varied between caves, as a function of accessibility, diversity of microhabitats, time available for the survey, availability of guides to facilitate access to some caves and other stochastic factors.

Material collected was placed in 70% ethanol for preservation, and sorted using a Premiere (20x - 40x) stereomicroscope. Specimens were identified to lowest practical taxonomic level using the resources available at the time of the survey in Mulu. Preliminary identification of material was identified by Dr Timothy Moulds. All material collected remains the property of the Republic of Malaysia, and has been kept by the Sarawak Department of Forestry office in Mulu NP.

Results

The survey recorded over 19,000 specimens using a combination of collection and observation of species abundance that presently represents 93 different morpho-species, from 25 orders and 8 classes. The number of morpho-species is expected to increase with additional sampling and further identification effort. Forty different species have been photo-inventoried thus far.

The spider *Heteropoda* sp. (Sparassidae) was the most widespread species found in all caves sampled, followed by the millipede sp. A, Opilione Phalangodidae? sp.A, Lepidoptera: *Tinea*? sp. and Araneae: Pholcidae sp. A that were recorded in six of the seven caves comprehensively surveyed (excluding Clearwater Cave and Deer Water Caves). The majority of species (44.6%) were recorded from a single cave, with very few species recorded from five or more of the caves surveyed. The most diverse order was Coleoptera with 13 species recorded, followed by Araneae (10 spp.), Isopoda (10 spp.), Diptera and Hemiptera (9 spp. each) and Diplopoda (8 spp.). Eleven orders are represented by single species

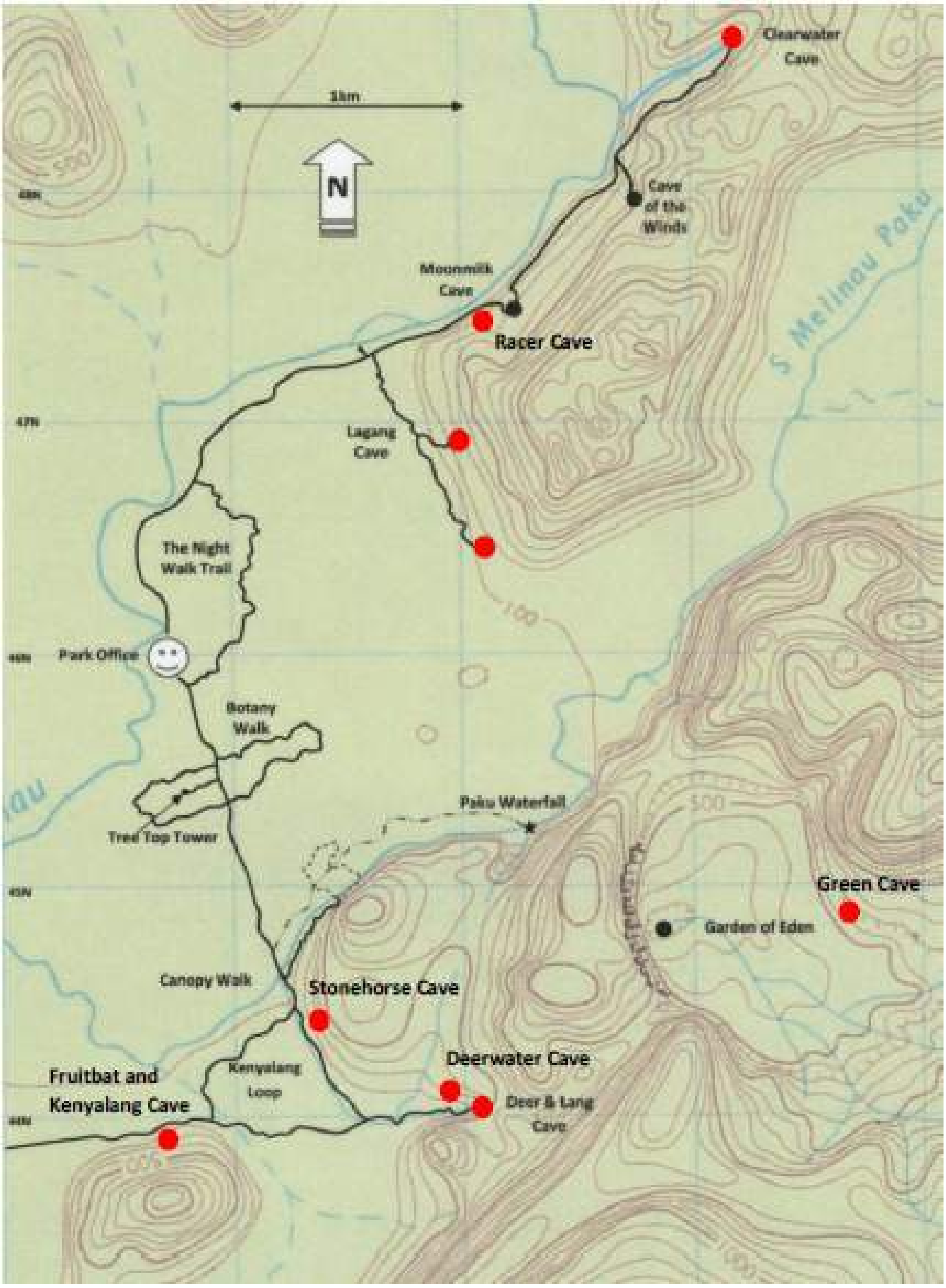

Figure 1. Locations of caves sampled for invertebrates within Mulu

PATN Analysis

The data were analysed used for similarity using PATN (version 3.12, Blatant Fabrications Pty. Ltd. 2009). Data were analysed using Bray and Curtis association, and nearest neighbour fusion algorithm. The PATN analysis by total diversity and abundance for each cave shows Racer, Lagang and Stonehorse Caves to contain very similar invertebrate assemblages and are also similar to both Kenyalang and Fruit Bat Caves. Green Cave and Deer Cave are the most dissimilar in their invertebrates assemblages (Figure 2).

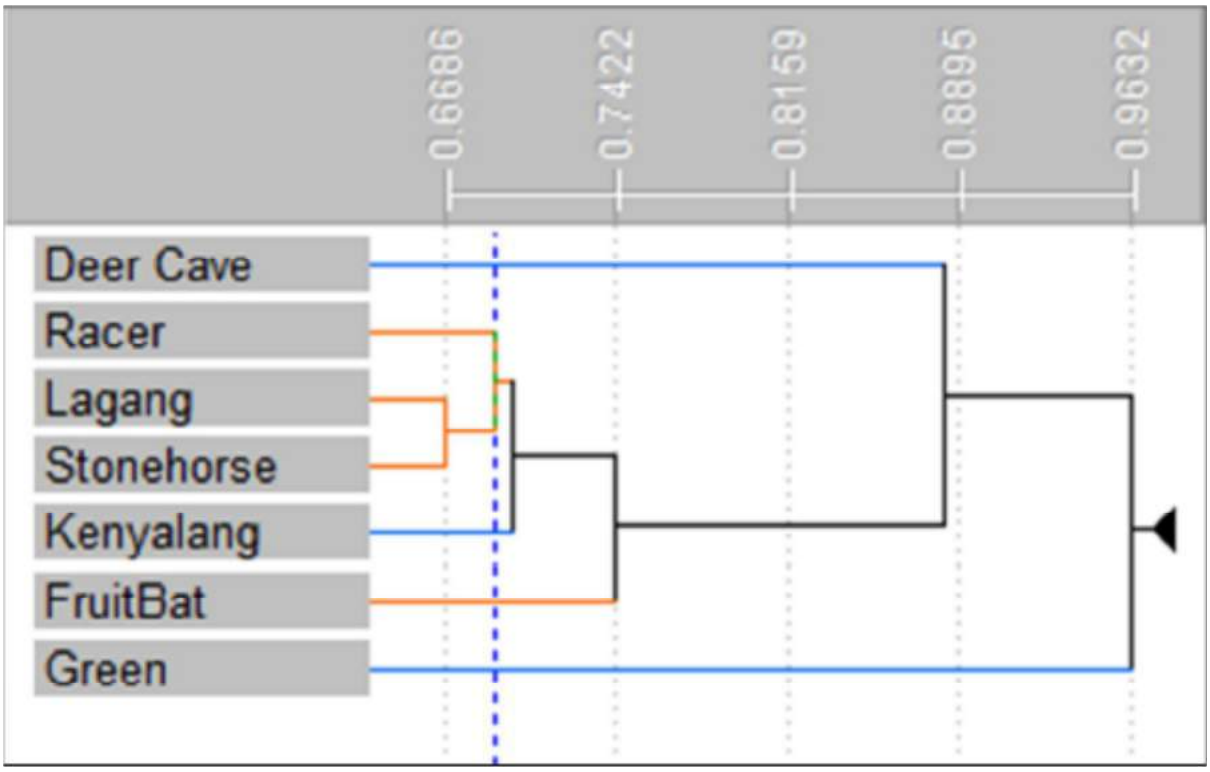

Figure 2. Column fusion dendogram nearest neighbour by cave

Management implications

The currently available data provide an insight into the diversity of subterranean faun in the Mulu caves. In the future this will provide a greater understanding of localised distribution within the karst system and eventually at a localised cave scale.

The current data do not enable a meaningful interpretation of cave invertebrate biodiversity as it relates to specific cave use for tourism, adventure caving or wild caving, however, it is readily apparent to the author that existing cave usage is not impacting upon the subterranean fauna observed in Mulu.

The author notes that the cave infrastructure within Mulu is of a very high world standard and promotes minimal impacts to both cave habitats and cave invertebrates generally. The Mulu Park staff provide excellent visitor education and supervision prior to and during cave tours eliminating predicable and avoidable impacts to the caves.

Concluding Remarks

The diversity of the Mulu karst area is very high and contains numerous obligate subterranean species, although the exact number is still currently unknown. The majority of species collected during the current survey appear to match those recorded by Chapman (1982), however, several previously unknown species were recorded. Further, more detailed identification will be required prior to confirmation. The patterns of diversity between the caves examined is complex with no obvious patterns evident from similarity analysis, although it would appear that caves are showing similarity based upon presence of similar micro-habitat rather than similarity of light zones. The Deer Cave, due to its complete dominance by massive guano piles appears to make it distinctly different in invertebrate composition to caves with far less guano such as Stonehorse or Langang Cave. It is currently unknown whether there exists any difference in invertebrate composition between the different limestone blocks such as Fruit Bat/ Kenyalang to Deer Cave/ Green Cave to Lagang/ Clearwater local areas of Mulu. The caves do show some level of association (Figure 15) but the strength of the current analysis is weak and further data, and identification of existing collected specimens may alter the results significantly. The determination of this will require far greater knowledge of both specific cave diversity and will invariably be linked to the geological history and karst geomorphology of Mulu.

The Mulu karst most certainly contains endemic species, although the exact number is currently hard to determine as many of the invertebrate identifications are still incomplete, for both Mulu and other karst areas in Borneo and South East Asia. Some of the invertebrate diversity found in Deer Cave could possibly be endemic, including the 'Hairy earwig' *Arixenia esau* that is associated with the naked bat species *Cheiromeles torquatus,* although this is more likely associated with the endemicity of the bat host rather than the cave itself. Much of the other specialised invertebrate fauna recorded by Chapman (1982) was found to occur in other karst areas in Borneo, Java and Sulawesi.

The present study has provided a preliminary investigation of the invertebrate diversity across nine different caves within the Gunung Mulu World Heritage Area. This study compliments and builds upon the only other broad scale cave invertebrate diversity study of Mulu by Chapman (1982) and provides a modern context for future research in Mulu. The patterns of diversity are complex in Mulu, invariably due to the very high diversity of species, the large number of microhabitats present within caves, the multitude of energy inputs and the systems and the geomorphological history of the area. It will take considerable further effort to start to unravel these complexities but it should prove very rewarding as Mulu is undoubtedly a premier site of world cave tropical cave invertebrate diversity and provides a superb opportunity to investigate evolutionary processes in such a setting.

References

Chapman, P. 1982: The invertebrate fauna of the caves of Gunung Mulu National Park. *Sarawak Museum Journal* 51: 1-17

Flank Margin Cave Development and Tectonic Uplift, Cape Range, Australia

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The caves on the paleo sea cliffs on the east and west sides of Cape Range, and the caves found in the deep gorges draining Cape Range, are flank margin caves when the caves are located in the Tulki or overlying limestones. The Mandu Formation contains primarily tafoni. The flank margin caves at high elevations are very old, concurrent with the uplift and initial subaerial exposure of Cape Range. As uplift is thought to have ended in the Pliocene, even the lower elevation flank margin caves are likely Late Miocene in age.

The flank margin caves in the Cape Range gorges and valleys developed as a result of complex interplay between tectonic uplift, and Miocene glacioeustasy. Some of the caves may have developed while folding was still occurring, and their original speleogenetic position altered as a result.

OzKarst Workshop

Graham Pilkington
Cave Exploration Group (South Australia)

No abstract provided

The Cave Animal of the Year

Cathie Plowman and Tim Moulds
Northern Caverneers and Western Australian Speleological Group

At the International Congress of Speleology held at Brno in 2013, we attended a session presented by Ms Barbel Vogel from the German Speleological Federation on the Cave Animal of the Year program in Germany. This is linked to the German 'Nature of the Year' program which includes over 40 different species and habitat including: Tree of the Year, Poisonous Plant of the Year, Dragonfly of the Year, Rock of the Year etc.

Cave Animal of the Year has a home page which is linked to Nature of the Year pages. As a result, cave animals are included in childrens magazines, school calendars and a variety of print media from garden club journals to daily newspapers. In her presentation, Ms Vogel reported that with a small budget the Cave Animal of the Year is an easy way to reach cavers and the public.

Cave Animal of the Year (Germany) has included the genus *Niphargus* (2009), the Herald Moth *Scoliopteryx libatrix* (2010), *Myotis myotis* (2011, the International Year of Bats), the Large Cave Spider *Meta menardi* (2012) and the fungus gnat *Speolepta leptogaster* (2013).

In 2011, the first European Cave Animal of the Year was declared and Ms Vogel's presentation in Brno raised the suggestion of a world-wide initiative with speleological federations from countries and continents coming together and choosing an order or family.

The presenters of this session wish to discuss the idea of Cave Animal of the Year Australia or Australasia and are raising it via sessions at the 2015 ACKMA and ASF conferences. The 2017 International Congress of Speleology in Sydney gives us an opportunity to perhaps launch an Australasian Cave Animal of the Year.

Calcite Straw Stalactites Growing From Concrete Structures

Garry K. Smith
Newcastle Hunter Valley Speleological Society

Abstract

The growth rates and corresponding drip rates of four stalactite straws derived from a concrete structure were studied over a ten month period. Factors which influence straw growth, including the chemical reactions and solution pH are examined.

The major influencing factors determining calcite deposition, were identified as the supply continuity of solution and the drip rate. Too fast a drip rate and there was insufficient time for deposition at the tip of the straw, too slow and the straw tip calcifies over or just dried up and stopped growing. A constant drip rate of one drop per eleven minutes produced the fastest growth of two millimetres per day. No detectable growth occurred when the solution drip rate was approximately one per minute or faster.

Minute calcite rafts were observed on the solution drop surface. Their sporadic movement around the drop surface aided by air movement and internal solution pulses, caused some rafts to be pushed onto the straw's outer surface adding to deposition. Rafts can influence the thickness and irregularities of a straw's outside diameter.

Concrete-derived calcite straw stalactites are essentially the same composition and in many respects mimic the shapes and forms of speleothems in limestone caves, however the chemical reaction which allows calcite to be deposited under concrete structures, is usually very different. The solution pH influences which chemical reaction/s are occurring at a particular time to deposit the calcite. This can also have a bearing on the deposition rate. Of the three main reactions, two rely on absorption of CO_2 from the atmosphere for calcite deposition to occur, as opposed to cave straws (speleothems) where deposition occurs due to degassing of CO_2 from solution. The third reaction appears to only occur in very old concrete and is essentially the same as the reaction occurring in limestone caves.

A search of literature failed to find a suitable term encompassing the various concrete or mortar derived secondary deposits growing from man made structures, consisting primarily of calcite. The term 'speleothem' by definition can only be used to describe, stalactites, straws, stalagmites, flowstone, etc, which were created in a cave. Hence, for the purposes of this paper the term **'Calthemite'** is used to encompass the various decorations mimicking speleothems, derived from cement or lime used in construction. The reasoning behind the introduction of this term is discussed in this paper.

Introduction

A layperson observing straws growing from a concrete structure could at a glance compare them to those growing in limestone caves. Given the right conditions, calthemite straws growing from concrete can grow at amazing rates, many hundreds of times faster than limestone cave straws (speleothems). This study looks at the relationship between the growth in straw length and the solution drip rates. Several other influencing factors are considered, including air movement, atmospheric humidity, temperature, atmospheric CO_2 concentration, solution pH and chemical reactions.

There are many chemical reactions occurring within curing concrete and later in its degradation. For the purpose of this study the latter reactions relating to the secondary deposition of calcite are considered. A number of previously published papers look at growth rates of concrete derived straws, such as Allison (1923) and Ver Steeg (1932), whom may have incorrectly concluded that calcite deposition at their study sites, was due to degassing. Later literature by Diamond (1976), Macleod et al. (1990), Borrows (2006a; 2007) and Maekawa et al. (2009), look more closely at the chemistry of concrete and indicate there may be more than one chemical reaction occurring at one time. These later authors conclude that the chemical reactions causing deposition of calcite is due to absorption of CO_2 into solution at the site of deposition.

Given my extensive interest in caves and speleothems, I was fascinated by the appearance of calcite straws at a nearby shopping centre. This interest quickly grew into a quest to know more. What are concrete derived deposits called? What growth rate is possible for a straw? What chemical reaction is occurring when concrete derived straws are created? What determines or influences concrete derived straw growth rate?

A new concrete building constructed in Belmont NSW, during 2008 (now 6 years old) included a partly underground carpark with supermarket area above. Straw stalactites began growing within months of the building being completed. Solution water originates from a minute hole in poorly constructed roof guttering, which trapped rainwater and leaked a constant flow onto the concrete structure. The slow trickle of water then found its way into the concrete structure, following micro cracks and voids, picking up calcium along its path until it emerged from cracks in the carpark ceiling. These drip sites are where the stalactite straws are growing.

Although the stalactites were in a difficult physical location to undertake measurements, due to vehicle movements, the constant supply of solution water all year round, made it ideal for a study of growth rates [Fig. 1]. The aim was to identify the main influencing factors determining growth rate of calthemite straws and identify which chemical reaction is responsible for the deposition of calcite at the study site.

Methodology

A metal ruler was used to measure the length of the stalactites and a digital photo taken of each measurement for verification at a later date. The time of day, temperature, humidity, solution pH and drip rate were all recorded. This was quite time consuming when measuring a very slow drip rate. Temperature and humidity were recorded from a meteorological bureau weather app, which had hourly readings for Belmont NSW. This was found to be consistently within a couple of degrees of a hand held thermometer.

The wind direction and strength was not recorded as the underside of the building was generally sheltered from southerly and easterly prevailing breezes, however vehicle movements did create significant air movement past the straws.

Figure 1. Location of straw stalactite on roof above supermarket carpark.

Figure 2. Measuring stalactites with an engineering metal ruler graduated in 0.5mm increments.

The straw's length and diameter were measure at the very tip by photographing a precision metal engineering ruler (calibrated in 0.5mm increments) next to the straw and at the same distance from the camera lens to eliminate parallax error. The digital photo was then enlarged to measure the exact outside diameter of the straw tip to within ± 0.15mm, using the ruler scale (Figures 2 & 9). This method allowed measurement of the fragile straw without physical contact.

Drip solution pH at each straw tip, was measured using 'universal pH indicator' paper (± 0.5 pH units). The chemistry of the solution water was not analysed nor the degree of calcite saturation which may be influenced by the path and flow rate of seepage water through the concrete. As an additional check, fresh rainwater at the study site was tested with 'universal pH indicator' paper and found to be pH7 - neutral.

To determine if vehicle exhaust was significantly aiding calcite deposition, the atmosphere at the study site was tested for CO_2 with a Dräger tube meter. The colorimetric tubes used, could measure a CO_2 range between 0.1 to 1.2 % by volume. Measured air samples sucked through the tubes during several occasions did not detect a measurable quantity of CO_2 despite significant vehicle movements.

Chemical reactions creating 'Calthemites' formations on concrete structures

Calthemites in the majority of cases, are created by different chemical reactions than those forming speleothems in limestone caves. A simplistic explanation of the different chemical process occurring to deposit calcite is:

- Speleothems are created when solution water degasses CO_2, resulting in calcite deposition,
- Calthemites are created when atmospheric CO_2 is absorbed into solution water, resulting in calcite deposition.

Before looking at the calthemite chemical reactions, it is prudent to delve a little into what makes up concrete.

The key component of concrete is cement. The mineral composition of ordinary Portland cement paste (cement + water) is roughly 70% C-S-H* gels, 20% portlandite ($Ca(OH)_2$), 7% aluminates and sulpho-aluminates and 3% unhydrated material (Diamond, 1976). There are a number of chemical reactions involved in the hydration of the calcium silicate, aluminate, and aluminoferrite minerals that cause cement mixed with water to go hard or set (also referred to as cure) (Borrows, 2006a, 2007; Macleod, et al., 1990). For the purposes of this paper only the calcium reactions are detailed. Several chemical reactions may be occurring simultaneously at a specific location and the solution pH, (by definition, pH is a measure of the hydrogen ion concentration in solution) has an influence on which reaction/s are occurring (Maekawa, et al., 2009). Refer to [Fig. 3]

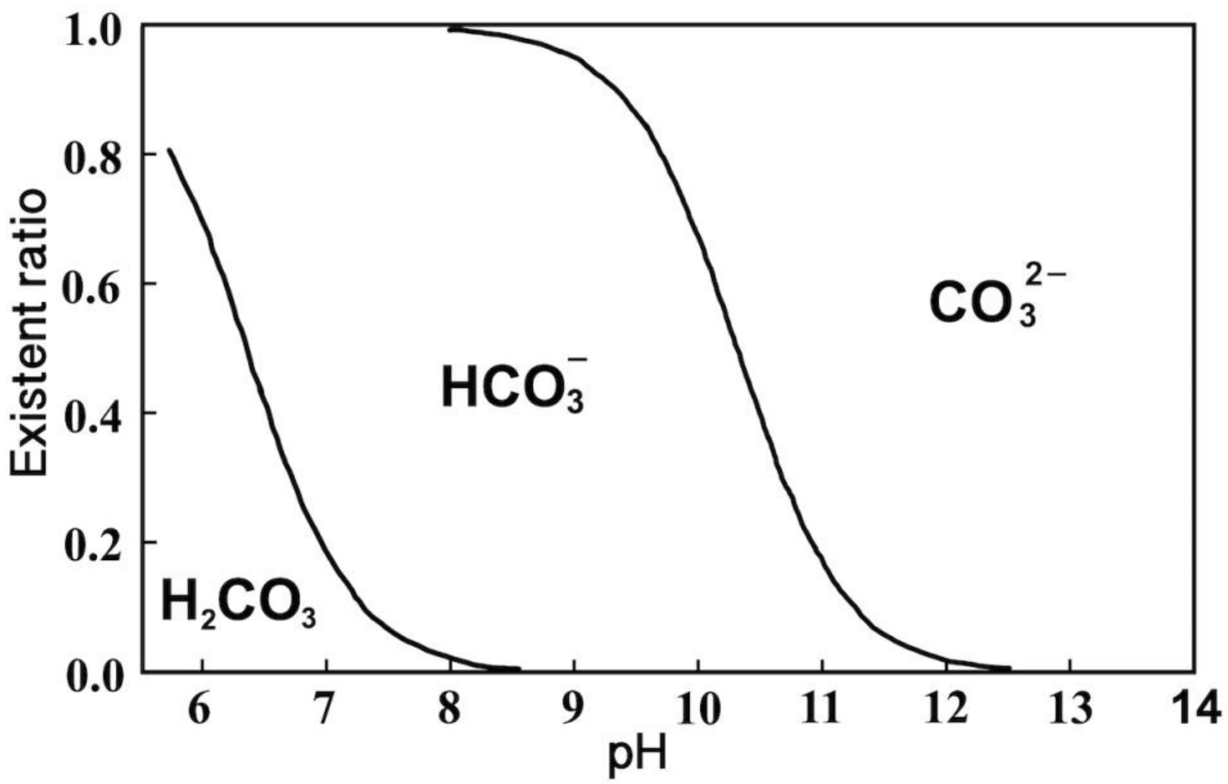

Figure 3. Relationship between equilibrium of Carbonic Acid and pH in solution. Carbonic Acid includes both carbonates and bicarbonates. Graph after Maekawa et al. 2009.

To make concrete, aggregate and sand (which play no part in the chemical reaction), is mixed with cement. When water is added to the mix, it readily reacts with the calcium oxide in the cement to form $Ca(OH)_2$ (calcium hydroxide), which is the 20% portlandite component of cement paste [Eqn. 1]. The chemical reaction is:

$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$ [1]**

Calcium hydroxide solution (lime water) is alkaline, typically pH 7-12. (Maekawa, et. al. 2009). Any carbon dioxide (CO_2) trapped in the mix will readily react with the calcium hydroxide solution to precipitate calcium carbonate ($CaCO_3$) within the concrete structure [Eqn.2]. This overall reaction has been generally termed as “concrete carbonation” (Ho and Lewis, 1987; Papadakis, et. al., 1989, 1991, 1992). The chemical reaction is:

$Ca(OH)_2(aq) + CO_2 (g) \rightarrow CaCO_3(s) + H_2O(l)$ [2]

Equation [2] is the overall reaction, however in practice the process is more complex and better described by equations 2a and 2b.

$Ca(OH)_2(aq) + CO_2 (g) \rightarrow Ca(HCO_3)_2(aq) + H_2O(l)$ [2a]

$Ca(HCO_3)_2(aq) + H_2O(l) + CO_2 (g) \rightarrow CaCO_3(s) + H_2O(l)$ [2b]

Reaction [2] occurs within the concrete matrix until all the available free CO_2 in the mixture is used up. Concrete exposed to the atmosphere containing more CO_2 will allow the 2nd reaction to continue to a shallow depth (often just a few millimetres) from the surface after which atmospheric CO_2 is unable to penetrate and carry on reaction [Eqn. 2] (Ishida and Maekawa, 2000; Borrows, 2006a;). Hence, in set concrete there remains some free calcium hydroxide within its structure.

If rain or other seepage water can penetrate set concrete micro cracks or micropores it will readily carry the calcium hydroxide solution to the edge of the concrete. When it comes into contact with air the chemical reaction [Eqn.2] will takes place. Carbon dioxide in the air reacts with the calcium hydroxide solution and precipitates calcium carbonate to create calthemite straws**.**

Calcium hydroxide is about 200 times more soluble in water than calcite (Sefton 1988), which explains why solution pH is so high and calthemite straws grow faster than speleothem straws in limestone caves.

To complicate the issue there is a period when the presence of potassium and sodium in new concrete, will support a higher solution alkalinity of about pH 13.2 – 13.4, (Ekström, 2001). As a consequence the dominant ion present in new concrete will be CO_3^{2-} (Maekawa, et al., 2009), and the chemical reaction [Eqn. 3] is most likely occurring. The source of the Ca^{2+} being the calcium component of the C-S-H* cement paste gels.

$Ca^{2+}(aq) + CO_3^{2-} (aq) \rightarrow CaCO_3(s)$ [3]

It is highly likely that reaction [Eqn. 3] is creating the calthemites at Belmont as the solution drops on the straws remained at pH13 throughout the study.

When the content of potassium and sodium starts to decline in the solution water, the pH falls to about 12.5, while the $Ca(OH)_2$ content starts to rise as Equation [2] becomes more active (Ekström, T, 2001). When the solution pH falls below pH 10, the dominant carbonate species will be HCO_3^- ion [Refer to Fig.3] (Pourbaix, 1974; Maekawa et al., 2009) and Equation [2] will become dominant in the deposition of calcite to create calthemites. As time passes, the available calcium hydroxide will gradually leach from the cement paste and the pH will fall even further. Below approximately pH 6.5, $H_2CO_3^-$ becomes the dominant species (Maekawa, et. al., 2009), and reaction [Eqn. 4] is mainly occurring

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Foot note

*In cement chemistry a shorthand notation is used to represent complex compounds, e.g. C, calcium oxide; S, silica; H, hydrate; A, alumina. ** (aq) denotes a species in aqueous solution.

Thus solution water emerging from stalactites growing on concrete structures as a result of reaction [Eqn. 4] is very similar to the classic degassing reaction creating speleothems in caves [Eqn. 6]. However, there is no timescale indicated and it could well be that the timespan required to leach all the $Ca(OH)_2$ from the seepage path is over tens or hundreds of years. As previously mentioned there are many factors which play a part in the overall process including: rainfall, porosity of the concrete, rate of seepage, etc. Given that if the solution water found alternative paths through new cracks or micro pores in old concrete, then this could unlock new sources of $Ca(OH)_2$, thus reverting the dominant reaction back to Equation [2].

$2HCO_3^-(aq)+Ca^{2+}(aq) \rightarrow CaCO_3(s) + H_2O(l) + CO_2(g)$ [4]

At the study site, atmospheric CO_2 is ≈0.04% where the rainwater collects in the building roof gutter. It diffuses into the rainwater (to form a weak carbonic acid) with no additional CO_2 from other sources. For reaction [4] to occur at the study site, this weak carbonic acid solution would have to enter the concrete and slowly dissolve calcium from its structure. Given the low calcium ion (Ca^{2+}) carrying capacity of this solution, it is highly unlikely that equation [4] reaction is involved in calthemite deposition at the present study site. An additional check on rainwater at the study site returned a value of pH 7 (i.e. neutral).

As previously mentioned, properly laid concrete and mortar are not very porous and the carbonation reaction [2] occurs mainly in the surface layers often to just a few millimetres deep. Borrows (2006a and 2006b) describes a very simple test using phenolphthalein solution (a pH indicator) to determine the depth of the carbonation layer in freshly broken old concrete, which can be used to determine the age of concrete.

Bear in mind that the strength of the concrete, 'cement to water ratio' and the compaction when being laid down, all play a part in the overall porosity of cured concrete (Lees, 1992). Capillary porosity, gel pores, air voids and micro cracks may allow some water seepage through the concrete structure to facilitate the movement of calcium hydroxide to the concrete surface, and subsequent deposition of calcite.

All the chemical reactions involving calcium are reversible and dependent on the dominant carbonate species, availability of water and pH, so at any one time there may be several reactions occurring at a greater or lesser extent and all of the above mentioned reactions are reversible. Within a concrete structure there will be a water pressure gradient and the leaching process creates calcium concentration gradients in layers between the concrete surface and its core. These layers affect the chemical equilibrium of the hydration products calcium hydroxide, calcium aluminium hydrates and calcium aluminium iron hydrate. It is a very complex process due to the many chemical reactions involved.

As a comparison, the insert text box detail the chemical reactions [Eqns. 5 and 6] which create speleothems in limestone and other carbonate rock caves.

The chemical reaction which creates speleothems in caves.

Limestone cave speleothems are created by a different chemical reaction than that which creates concrete derived straws and other calthomite decorations.

Rainwater percolating through surface soil, absorbs carbon dioxide and becomes slightly acidic (carbonic acid). This weak acid is able to dissolve calcite from the carbonate bedrock (e.g. limestone or marble) and transport it in solution as calcium bicarbonate. The chemical formula for this reaction is:

$CaCO_3(s) + H_2O(l) + CO_2(aq) \rightarrow Ca(HCO_3)_2(aq)$ [5]

This solution travels through the voids in the bedrock until it reaches an exposed surface. If this is on the cave roof it will begin to create a stalactite straw. When the solution comes into contact with cave air, degassing occurs and CO_2 is released, thus reducing the solutions acidity and calcium carbonate is precipitated out of solution to create speleothems. The chemical reaction is the reverse of that which initially dissolved the Calcium Carbonate into the solution. The reaction is:

$Ca(HCO_3)_2(aq) \rightarrow CaCO_3(s) + H_2O(l) + CO_2(g)$ [6]

The growth rates of stalactites in natural limestone caves has been well documented by repeated measurements in well-known caves. Data show that stalactites in caves never grow much over 2 millimetres a year and may average only a little more than a tenth of a millimetre per year. (Moore and Sullivan. 1997). However, James (2003) says that under ideal condition cave soda straws can grow in the order of centimetres per year.

pH of Solution (Drip Water)

Maekawa et al. (2009) demonstrate that calculations can determine, "the relationship between the pH value in solution and the ratio of carbonic acid, bicarbonate ion and carbonate ion. In the high pH range, carbonic ions are dominant, whereas carbonic hydroxide ions increase under lower pH conditions". [Fig. 3]

"Free" carbonic acid is H_2CO_3 but this is really a hypothetical species as carbonic acid is always in aqueous solution, where the pH determines which of the ions (H_2CO_3, HCO_3^-, CO_3^{2-}) is the dominant species. On the far right of Figure [3] the graph shows CO_3^{2-} as the dominant ion at a high solution pH, thus Equation [3] reaction is dominant. The center portion of Figure [3] is HCO_3^-, which indicates Equation [2] reaction is dominant. The lower left is H_2CO_3 indicates Equation [4] reaction is dominant. i.e (At solution pH11 there is approximately 17% HCO_3^-, [Eqn. 2] reaction and 83% CO_3^{2-} [Eqn. 3] reaction)

At the study site, approximately 10 straw drips were measured on a regular basis with 'universal pH indicator' (this included some not being monitored for length) and all were pH 13 throughout the study. Hence [Eqn.3] is creating the calthemites at the study site. Note; It is not advisable to have the drip solution come in contact with bare skin as a pH of between 11 and 14 is considered a strong alkaline solution and can cause burns.

A Swedish lab study of leach water found that new concrete produced highly alkaline solutions (pH 13.3) and decreased to about 12.5 after some time. This is because the first leaching removes potassium and sodium, which created the stronger alkaline solution (Ekström, T. 2001).

Straws under study

Over a period of 10 months the growth rates of four straw stalactites were documented. The growth rates of the fastest and slowest 'active' straws (with a constant supply of seepage solution), varied considerably.

The straw stalactite No. 1, [Fig. 4] had the best calcite deposition rate and consistently grew in length throughout the study. There were a few periods between measurements, when this stalactite grew an average of 0.714mm/day in a 14 day period and 0.875mm/day in a 16 day period, however 1mm/day growth rate was more common. In one measurement period this straw grew at an average rate of 2mm per day. On the 237th day of the study, it was noted that the end of straw No.1 had been broken off – cause unknown. Hence the growth rate for this straw had to be re-recommenced at the following reading date, then continued till the end of the study.

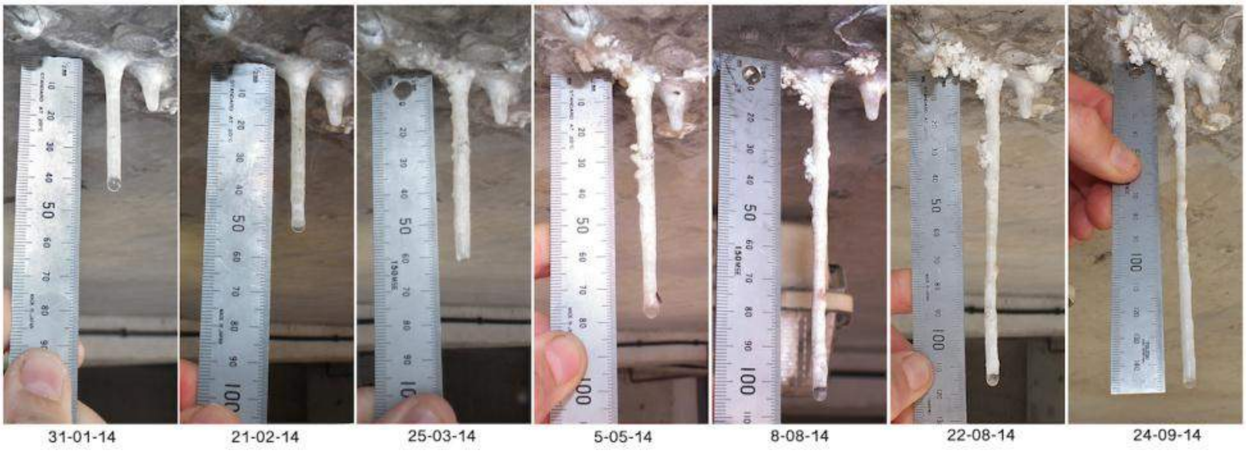

Figure 4. Growth of stalactite straw No.1. The sequence above shows the growth of 104mm in 237 days. When there was only one drip every 11 minutes, this straw grew an incredible 2mm per day. Note that the small straw on the right of straw No.1 has calcified over and not grown at all during measurement period. The date below each image relates to date of measurement recording.

Two of the straws (No.2 and No.3) had periods of sporadic activity before completely drying up just 2 months into the study, and no growth recorded thereafter. Other straws began growing at a fast rate just a few centimetres away from the now dormant straws. [Fig. 5a and 5b]. This indicates that the solution originally flowing to No.2 and No.3 had found another path to escape from the concrete.

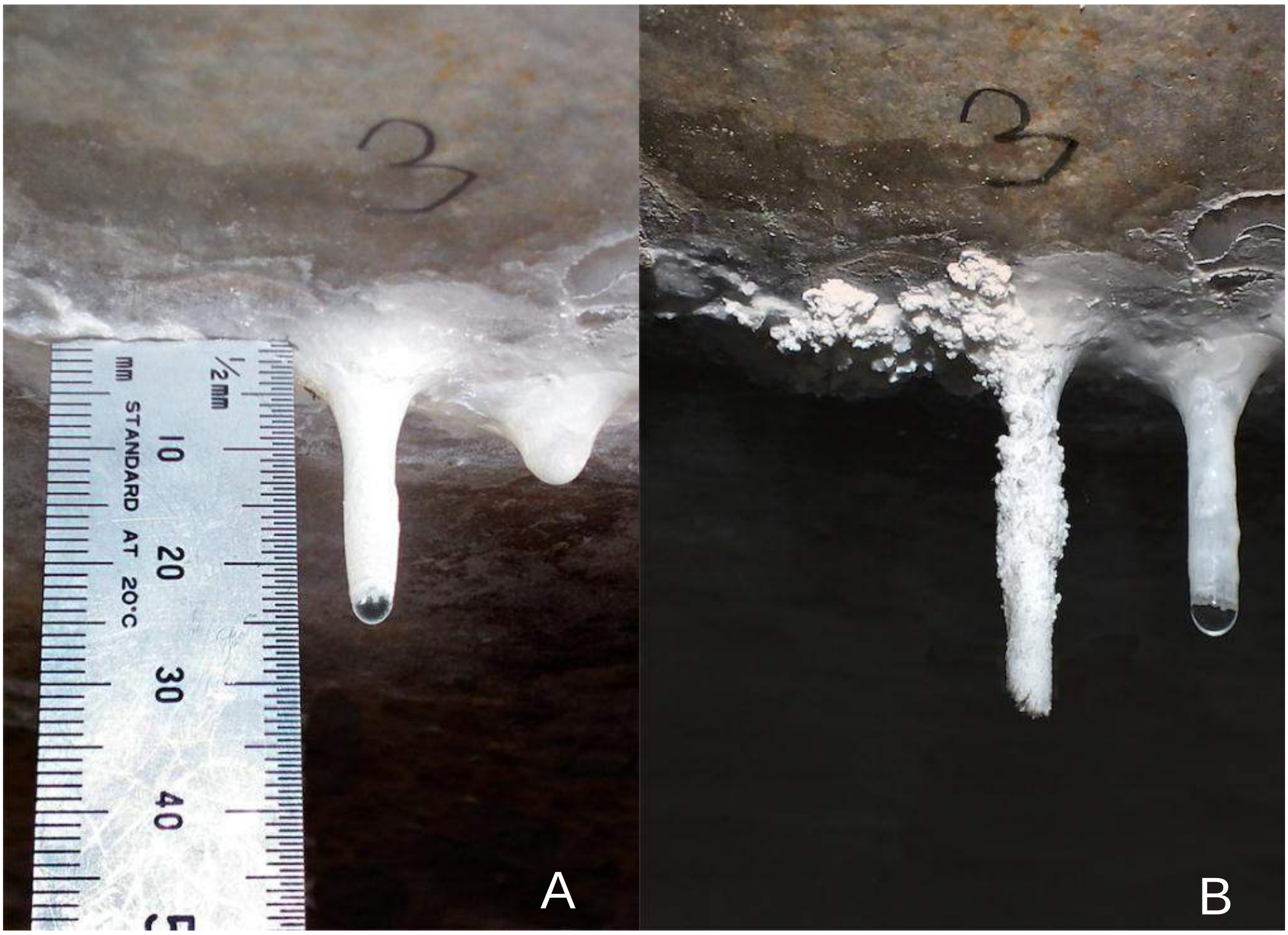

Figure 5a. Straw No.3 on the far left was dripping at the start of the study. The beginning of a small straw next to it is completely dry and calcified over.

Figure 5b. Two months after starting study, straw No.3 has dried up completely and the previously dormant straw next to it has become very active and is **growing** rapidly.

Straw No.4 began growing about the time of starting the study. During the third month into the study it was decided to record data from this straw, which consistently remained very active. This straw has been very useful in identifying the limitation on growth rate, which is associated with fast dripping seepage solution.

Growth and Drip Rates of Straws

Analysis of the data indicate almost no deposition occurs at the straw's tip when solution drip rate is approximately one or more drops per minute.

When the drip rate was slower than one drip per minute, deposition begins to occur at the straw tip and an increase in length resulted. For drip rates between 8 to 17 minutes, the corresponding growth rates was generally over 1mm per day. [Fig. 6]

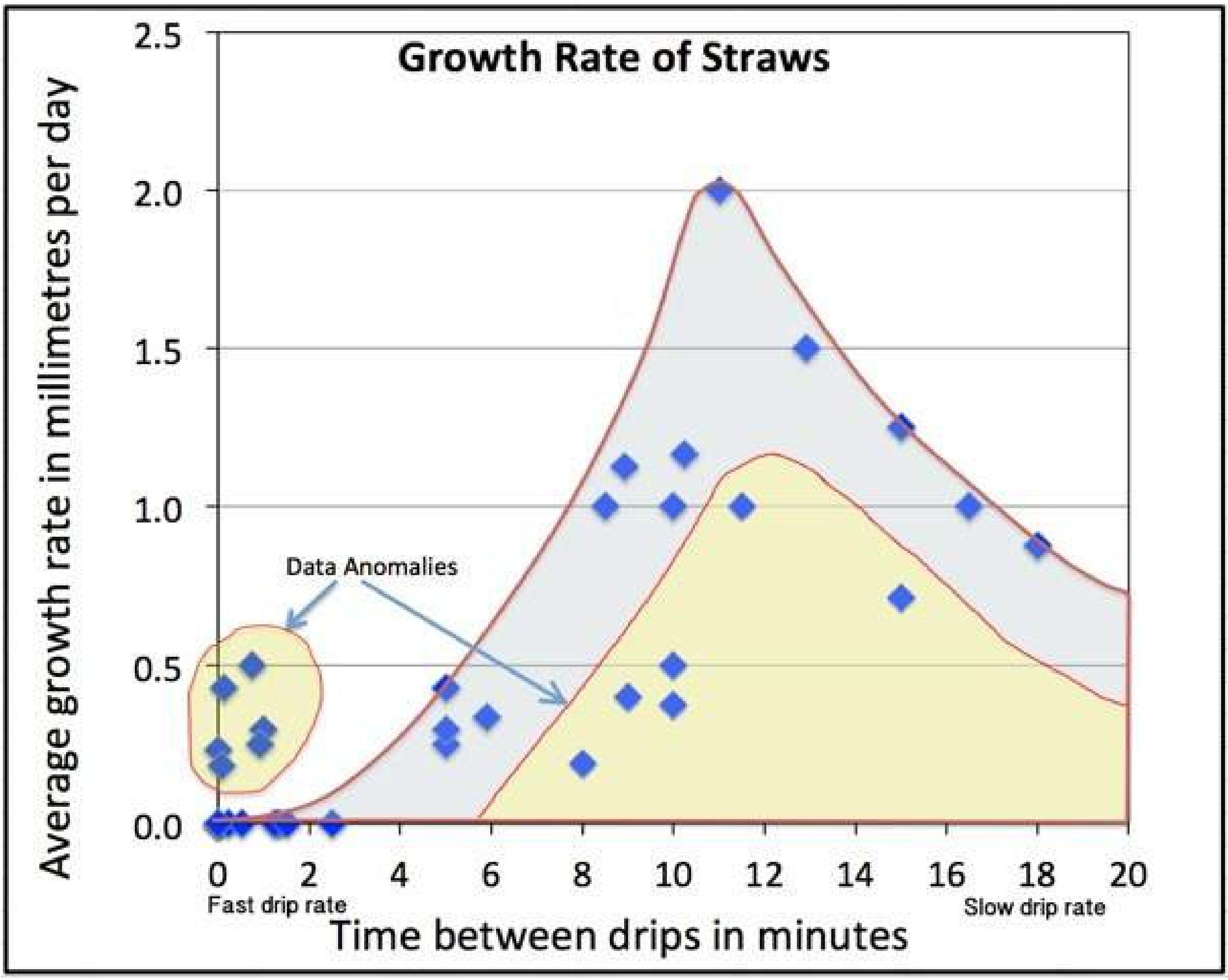

Figure 6. Plotted points showing straw average growth rates between periods of data recording, measured in millimetres per day in conjunction with solution drip rate in minutes. Note, the 'Data Anomalies', which occur when drip rate changes dramatically between recording periods.

The most rapid growth rate of 2 mm per day, occurred when the drip rate was one drop every 11 minutes.

The growth rates of the studied straws, was taken to be the increase in length between data collection periods, divided by the number of days elapsed. The drip rate was timed when each length measurement was recorded. Unfortunately it was beyond the scope of this study to continuously monitor the drip rate, which may well have varied between measurement periods. As Allison (1923) observed, "*one can hardly expect to secure uniformity in results from stalactites and stalagmites growing under diverse conditions*."

The relationship between the growth rate of straws and their drip rate is shown in Figure 6. Closer analysis of data points outside the bell curve, labelled as 'data anomalies', revealed that these growth rates were during periods when the drip rates had changed dramatically from a slow drip rate at the previous reading to a fast drip rate at the time of data recording. The reverse is the case for the data points in the shaded section beneath the bell-shaped curve. Because there were large drip rate variations influencing each data point labelled as 'data anomaly', they should not be considered as a true representation of growth rate relating to drip rate (Fig.6)

Mechanism for Calcite Deposition as a Straw

Many factors influence the porosity and cracking of concrete, including water to cement ratio, mineral additions and curing history (Ekström, 2001; Khokhar, 2010). The driving mechanism for water flow through the concrete matrix is surface tension, capillary and gravitational forces, which combine to pull the solution through the concrete cracks and micro pores (Macleod, et al., 1990; Maekawa, et al., 2009). As water travels through the concrete structure, it leaches out calcium ions and calcium hydroxide.

When the first mineral-laden drop of water comes into contact with the atmosphere, it absorbs CO_2 and calcite is deposited in a thin ring around the base of the drip where it is attached to the supporting structure. Each subsequent drop deposits more calcite onto the previously deposited ring of crystals. Eventually, these rings form a very narrow (4 mm), hollow tube often referred to as a "soda straw" stalactite.

On straw No.1, microscopic calcite rafts were continually forming on the surface of the suspended solution drop. [Figures 7 and 8]. A long period between drips (≈ 5 minutes or more), was sufficient time for absorbed CO_2 to cause calcite to precipitate out of solution and form microscopic rafts (up to 0.5mm across).

Figure 7. - Drip with latticework of calcite rafts forming on very slow dripping straw (≈ >12 minutes between drops) on a day with no wind or car movements.

Figure 8. - Calcite rafts are broken up and moving around drip surface quite fast due to lots of air movement

During periods of almost no air movement when the drip rate was very slow (i.e. ≈ >12 minutes between drips), calcite rafts were seen to form a latticework pattern over the drop surface [Figure 7]. A random injection of water from the straw tube would shatter this lattice work into small rafts [Figure 8]. Similar observations were reported by Allison (1923). Any additional pulse of water into the drop, caused rafts to be thrust upward, spinning toward the straw rim where occasionally they attached to the straw's outer surface. Often these minute rafts would remain attach to the straw rim when the drop eventually fell. This observation has not been recorded in any other papers obtained in literature searches.

On days with greater air movement due to vehicles and/or atmospheric wind, calcite rafts on straw No.1, would be turbulently spinning around the surface of the solution drop. The spinning direction of rafts could change in seconds from horizontally around the drop to an almost vertical orbit of the drop or a total direction reversal. A 34 second video was recorded of calcite rafts whirling around the surface of the straw drop. On occasions violent spinning would shear some calcite rafts from the drop's surface water tension and push them up onto the outer surface of the straw where rafts would stay attached in a film of solution. This could partly explain some bumps and irregularities in diameter down the length of straws. The sheared off micro rafts are allowing a film of solution to be drawn several millimetres further up the outside of the straw and complete the cementing of micro rafts to the straw's outside surface.

Allison (1923) studied straws growing from a concreted section of a coal mine roof in Pennsylvania, noted that; “The increase in diameter is effected partly by the creeping of the lime solution up over the rim of the stalactite and partly by the lime solution percolating from the inside of the tube outward through small channels in the stalactite wall”. There is no doubt that this mechanism is also occurring on the calthemites straws growing at the study site, as the active straws retained a thin film of moisture over much of their outer surface.

At the study site the solution drop diameter averaged between 4mm - 4.3mm. Straws with slower drip rates of approximately 15 minutes or more had a slightly larger straw drop diameter (up to 5mm diameter) and created a corresponding diameter straw [Fig. 9]. This may be due to the increased time for precipitation to occur when the drop is slowly growing in size and the diameter is slightly larger when the solution drop is partly formed, due to surface tension having less weight to hold up. Once the drop grows too heavy for the surface tension to hold the weight of solution, it begins to lengthen and stretch (reducing in diameter at the attachment point on the end of the straw) until the weight is too much for the surface tension to support and the drip falls. Consequently, it is the drop diameter, which determines the diameter of the straw (Ver Steeg, 1932), regardless of the length of stalactite.

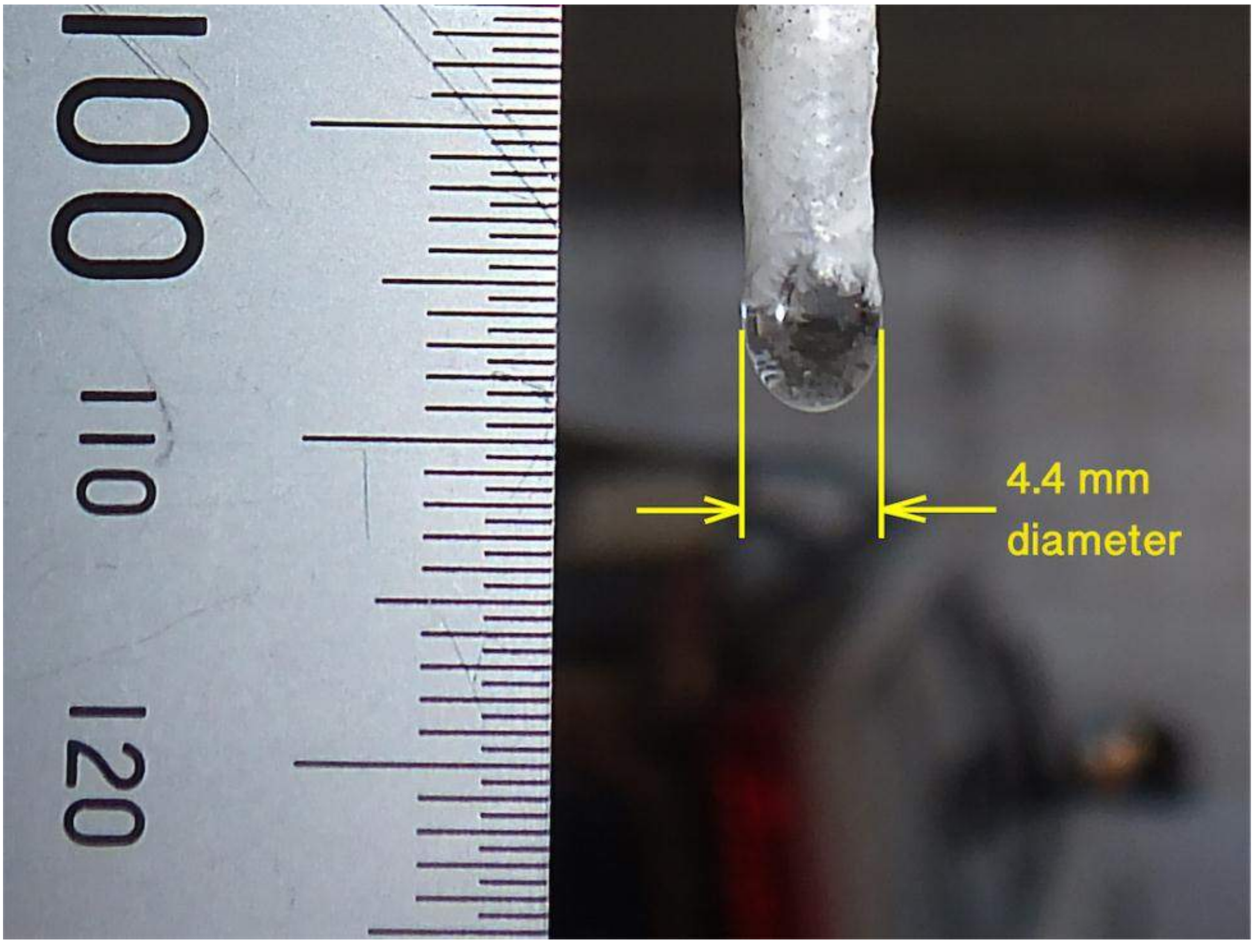

Figure 9. Method of measuring the straw diameter at the growth rim is by photographing a 0.5 calibrated engineering ruler next to the straw, at the same optical distance to the camera. The diameter of the straw can then be remotely measured from the digital image without the need to physically contact the fragile straw rim.

Ver Steeg, (1932) points out that the rate of vertical growth of stalactites, in the early stages of development during his study of above ground stalactites, compare closely with those studied by Allison (1923) of stalactites growing from concrete in a mine tunnel. Ver Steeg expected the aboveground stalactites to grow faster in conditions with lower relative humidity, increased air circulation and higher air temperatures, resulting in more evaporation than is typically experienced underground. However, Ver Steeg's recorded growth rates were very similar to Allison's.

The straws growth data recorded in the Belmont site study when related to atmospheric temperature and humidity confirmed Ver Steeg's observations that evaporation of solution had very little influence on the calcite deposition/growth rate at the straw tip.

Comparison of macro photos taken just a day apart, showed growth of calcite crystals was lengthening the straw in addition to attachment of microscopic rafts from the surface of the drop.

On fast dripping straws, no calcite rafts were visible to the naked eye, nor macro photography images. Atmospheric CO_2 could not diffuse quickly enough into the drop for deposition to occur at the straw rim nor to form visible micro rafts. Hence the calcium being transported in solution to the straw tip was remaining in solution and falling to the ground where depositing occurred as a stalagmite beneath the drip point. [Fig. 10]

Figure 10. Stalagmite about 8mm high, growing under one of the fast dripping straws.

Stalagmite Growth

While the aim of this study was primarily to look at the growth rate of straw stalactites, it was noted that the growth of stalagmites below the fast dripping stalactites (more than 1 drop per minute) was far greater than the slow dripping stalactites. These stalagmites are broad in diameter (approx. 150mm diameter) and the tallest was just 15mm high. Vehicle tyres and pedestrian traffic constantly pass over the damp stalagmites resulting in mechanical abrasion and dispersal of the calcite laden water from the drip site. This reduces the full potential for stalagmite growth. As a consequence it would have been pointless to consider studying the growth of these stalagmites over a period of time.

Calthemites containing other trace elements

Calthemites stained various colours by elements such as iron or copper are commonly observed under manmade concrete structures. Steel bars are used in concrete structures as reinforcing to add tensile strength to concrete. The drawback is that if water penetrates the set concrete and changes the pH balance around the reinforcing bars, it may facilitate oxidation of the steel. The resulting iron oxide, expands and cracks the concrete. Also the iron oxide can be leached out with the same solution seepage water which creates the calthemites. Hence the predominately white calcite, will be stained orange [Fig. 11].

Figure 11. Orange coloured Calthemite formation containing traces of iron from reinforcing bars within the concrete. This example is at the study site.

Copper pipes passing through or near concrete – while less susceptible to oxidation, can produce a green or blue copper oxide which discolours calthemites [Fig. 12].

Figure 12. Aqua coloured Calthemite formations containing traces of copper, deposited in conjunction with calcite. This example is at an underground carpark, 0.5km from the study site.

Terminology Discussion

The author had much deliberation as to whether the calcite soda straws and other formations (secondary deposits) associated with concrete or mortar, should be classed as 'speleothems' or possibly 'concrete speleothems'. References in notable publications define the term 'speleothem' as encompassing all secondary mineral deposits formed within a cave, most commonly **calcite**, however may be **aragonite** or **vaterite** or other secondary mineral. Therefore all cave straws, stalactites, shawls, flowstone, coral, stalagmites etc, which occur in caves are classed as speleothems. The formal definition of "speleothem" as introduced by Moore (1954) is derived from the Greek words *spēlaion* ‘cave’ + *théma* ‘deposit’.

Borrows, (2007) refers to the term ‘urban dripstone’ which implies that concrete derived secondary deposits only occur in the urban environment. However, they occur in many location away from the urban environment wherever there is concrete or mortar.

Hill and Forti, (1997) refer to “non-cave stalactites which derive their calcium carbonate from concrete”, “formations under concrete structures” and “deposits in the outside world, while not speleothems in the strict sense, nevertheless mimic the forms taken by speleothems.” While all these descriptions get the message across, they became quite cumbersome to use on a constant basis.

An extensive search of available literature failed to identify an existing term which encompassed the varied forms of secondary calcite deposits mimicking speleothems and growing under man-made concrete structures. A simple term which covers all concrete and mortar–derived secondary deposits regardless of the formation shape, would reduce the need for lengthy roundabout description.

Therefore the term **‘calthemite’** or plural **‘calthemites’**, is proposed to encompass the varied secondary deposits derived from man made structures, consisting primarily of calcite and may contain other trace elements such as iron, copper, zinc etc. or minerals e.g. gypsum. The word ‘calthemite’ being derived from the Latin *calx* (genitive *calcis*) “lime” + Latin < Greek *théma*, “deposit” meaning ‘something laid down’, (also Medieval Latin *thema,* “deposit”) and the Latin –ita < Greek -itēs – used as a suffix indicating a mineral or rock.

In coming to a decision for an all-encompassing term, many combinations of Latin and Greek words were considered. Among them were; efflorescence, concretions, limonite, calcrete and caliche to name a few, however these words are currently in use to describe specific geological forms of calcite and as such could not be used.

Conclusion

The growth rate of calthemite straws can vary considerably due to a wide range of chemical and physical conditions. The most influential factors are the continuity of saturated seepage solution and drip rate. Evaporation of solution due to atmospheric conditions, had no detectable affect on calcite deposition. The formation of calcite rafts on the drop surface, can influence the outside diameter of a calthemite straw.

Calthemites can grow much faster than cave speleothems. At the study site one calthemite straw achieved an average growth rates of 2mm per day over two days, when there was 11 minutes between drips. Too fast a drip rate, results in very little or no growth and too slow a drip rate caused the straw to calcify over and block up.

Given the number of variables which affect calcite deposition (growth of straws), it is almost impossible to predict the exact age of a calthemite straw by measuring its length or solution drip rate at a particular time.

The solution creating the calthemites at the study site is pH 13. This indicates that the predominant chemical reaction creating the calthemites is, $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$ and to a lesser extent $Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$. Deposition of calcite occurs in both these chemical reactions when atmospheric CO_2 diffuses into the drip solution.

While outside the scope of this study, it can be assumed that straws at other sites may achieve greater deposition rates at faster drip rate, if the atmosphere in contact with the solution, contained a higher concentrations of CO_2. Also a longer seepage path through concrete may allow solution water to leach a higher concentration of calcium ions and calcium hydroxide and carry it to the deposition site.

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Nullarbor Cave Diving

Kim and Karen Woodcock
Western Australia Speleological Group

An overview of cave diving on the Nullarbor.

Risk – A philosophical approach

David Wools-Cobb
Northern Caverneers

We've all been asked at some time or other "isn't caving dangerous and risky?", and no doubt many cavers have a stock answer to this question. Risk is often seen as a bad thing, however I think the opposite. I aim to stimulate your thinking and relate this to what we REALLY do when we go caving.

The definition of risk- according to Oxford Advanced Learner's Dictionary (1)

Risk: A situation involving exposure to danger:

The possibility that something unpleasant or unwelcome will happen:

A possibility of harm or damage against which something is insured:

Expose (someone or something valued) to danger, harm, or loss:

Expose oneself to the possibility of something unpleasant occurring:

However I like the following phrase which relates to caving type activities:

At one's (own) risk: *Taking responsibility for one's own safety or possessions.*

We will return to that later.

I have no doubt most cavers have been asked when someone finds out you're a caver: "Isn't caving dangerous?" I'm sure we all have some sort of answer to that.

My stock answer to the danger of caving questions is "YES, caving is very dangerous, because I have to drive in a car to the cave". Maybe some think that's facetious, but think about it, do these people ever consider the relative risk in their everyday lives?

I'm a careful driver of big solid four wheel drive, in good condition with airbags around me and lots of high-tech crumple zones, driving along at 110km/hr.; I have total control of my immediate environment. However I have no control over someone coming towards me at the same speed: none what-so-ever, and this driver has an enormous influence over how safely we pass. I find that pretty scary.

Most 'accidents' in life are not really accidents, they are human error whilst driving a car.

We blame a wet road, alcohol, speed, inattention, and call them road accidents: these are still human error. We or someone else chooses NOT to drive to the conditions, or to consume alcohol.

Where-as, in the bush or in a cave we have control over the majority of risks.

The chances of some things happening outside our control, like the roof falling in for instance, are infinitesimal.

I consider risk or danger is NOT a bad thing. If anything, I see it as a good thing, but I will explain further later.

Let's look at one of the great adventurers to influence Australia: Captain James Cook.

Much of the globe was unchartered or poorly chartered when Cook set off on his first of three voyages, ultimately aiming for the Pacific in 1768. Cook's seamanship, exceptional surveying skills and cartography, courage and ability to lead men in adverse conditions achieved a tremendous additional to our knowledge of the planet. These three trips, into the unknown required incredible planning. Most would know that scurvy (caused by the lack of vitamin C) was a major issue for all sailors at the time. Cook is renowned for insisting on adequate fruit intake and ensuring such supplies were replenished on his voyages. The risk of such voyages was huge; relatively small wooden ships, unknown territory and extremes of weather just to name a few. Clearly by managing most of the risks of his voyages well his expeditions contributed greatly to the knowledge of the world. (2)

Another risk manager that clearly stands out is Ernest Shackleton, particularly his 1914 expedition on the Endurance to Antarctica. Shackleton had considerable Antarctic experience already and had learned much from Scott, Amundsen and others. He was known as a great organizer and leader of men and understood the risks involved in such an expedition.

In brief, his ship was trapped in ice flows for 281 days before it was crushed and sank. All 28 men sailed their life boats to Elephant Island which was the first land they had been on for 16 months. A small group then sailed the 800 miles to South Georgia Island and finally Shackleton lead 2 others over quite treacherous mountain ranges some 17 miles to a whaling station, with the top priority of rescuing the men they had left behind. All 28 men survived. In a hostile environment that he had no control over, Shackleton's planning and decision making involved great leadership, with an incredible result. (3)

Contrast this with the climbing of Mt Everest. Until about 1990 Everest was the domain of the experienced, well equipped expeditioner. However about 1990 commercial operators commenced taking "tourists" albeit wealthy, fit & motivated individuals climbing the mountain. The death rate soared for ten years as a percentage of climbers (for both Sherpa and 'expeditioners'), however it then dropped in the next decade. (4)

Factors like the weather, the terrain, the altitude did not change: these are risk factors that no climber or company has any influence over.

The reasons are most likely for a halving of the death rate are:

1. Standards being set by companies (it's not a good look if your death rate is higher than other competing companies)
2. Better gear and gear technology
3. Increased use of Oxygen and better delivery systems
4. Understanding weather patterns and improved forecasting
5. Perhaps fixed bolts, although these have been used for some time

My point is that Climbing Everest would be considered by most to be a risky undertaking, but it took some time for commercial companies to "manage' that risk more adequately.

No matter what is done to manage risks, climbers on Everest will still die. There will always be risks like the recent avalanche into base camp that climbers, Sherpas and companies cannot 'manage' or predict.

Why have I mentioned these feats? Because good planning, an appreciation of the risks than you can control or minimize goes a long way to a successful outcome- everyone returning home safe.

Some would have said the undertakings of Cook, Shackleton, the Apollo missions and similar were too dangerous, too risky. But by pushing our boundaries and striving to manage known risks human kind has massively extended our knowledge. Climbing Everest was once seen as an ultimate goal for mankind; it has now become a personal, life goal for a number of people, however with over 4000 having been to the top now, its specialness is diminishing and many are questioning why a majority of deaths are the Sherpas. In the views of some, the commercialization of Everest has resulted in more risks to the Sherpas who are invariably in the advanced parties setting up camps, fixed ropes and crevasse crossings. (5)

Earlier I mention risk or danger as being a good thing: Risk or potential danger forces you to plan.

It is how you assess the risk, and what you do about it that determines your safety. Experienced cavers are inherently risk managers.

The awareness of risk or danger causes an experienced caver to PLAN and MANAGE their trip to minimize this risk. PREPARATION is the most important part of any activity. NO risk can be totally eliminated, but good planning is far more likely to result in us all returning home safe. Returning home safe should be the paramount aim of every caving activity. Completing a survey or exploring that side passage should never take greater priority than returning safe. I personally have seen the excitement of finding a huge new passage at midnight after 15 hours caving over-ride the safely getting home principal. The leader was so caught up on adrenaline he compromised his own and the party's safety. (6)

I believe it a reasonable assumption that very few experienced cavers will have looked at the Australian Speleological Federation (ASF) Cave Safety Guidelines, or Risk Management Policy in say, the last two years?

These Guidelines and Policies are predominantly for those new to caving, and external interests like Land Managers and Insurance companies. They demonstrate that our National Caving Body, ASF has standards. However the mere existence of Policies and standards does nothing to manage risk. It's what YOU as a caver actually DO to manage the risks that matters.

An experienced caver should know and appreciate the risks involved in a caving activity. They may not follow all guidelines to the letter, because risks vary depending on the area and all risks are relative.

For instance: the need to have a sleeping bag outside the cave is not necessarily appropriate. In northern climates hypothermia is often not an issue even at night, in Tasmania often your car is nearby with warm clothes.

Risk and the perception of danger is associated with fear. But why? Part of human nature is to fear the unknown, and society seems to have an irrational fear of the unknown. Any different activity outside general society's comfort zone is judged by some as too dangerous to undertake.

Many of the general public are highly critical of 'adventurers', often because of the sensational news when a rescue is undertaken with the resultant cost. This is not always balanced by the successes featured in publications like National Geographic and Australian Geographic and Wild Magazine.

No-one complains about the costs of rescuing victims of car crashes.

As opposed to this irrational fear, for those involved in an activity, the rational approach is to assess the risks and manage what risks involved.

Caving is outside most people's comfort zone, but well within ours.

We cavers need to continually manage our risks: asking ourselves "can I do this safely"? is there a safer way? As I'm sure all would appreciate, the consequences of an adverse event requiring an extraction or even self-rescue can be enormous. Most extractions from a cave are extremely difficult and in fact sometimes impossible. So it is not just the risk of an adverse event we must consider but then the consequences such an adverse event.

For instance: carrying a first aid kit does nothing to manage the actual risk of an accident, but it may help manage the result. Carrying a climbing tape may make that climb much safer.

Now let's examine the concept of a **team** and **leadership** whilst caving.

I see no problem with asking for help from someone else in the party.

One view may be: "he's just an old fart caver….he is passed it." Maybe before entering the cave this caver's fitness and ability should have been assessed? But he's here in the cave, and asking for help.

In caving the team shares the risk. By assisting, this risk is lowered for the whole party. If someone is not comfortable, like doing a climb, and assistance of rigging a tape means no adverse event, then we all return safely.

Contrast this with a party member who needs assistance on most of the challenges- the leader should have assessed this before-hand and recommended more training, perhaps fitness. Most leadership positions enable the exclusion of someone who may add risk to the group.

We all must have confidence and competence but not be blasé due to our familiarity with the cave environment.

The leader does not necessarily lead from the front, but is usually the most experienced member of a party, based on their knowledge and skills. I believe this person's people skills are just as important; a good leader keeps a close eye on the rest of the party.

Many caving club trips have no specific leader- joint decisions are made by consensus; with no major risks beyond what the party members are familiar with; there may be little need for a leader, but with increased risks a leader becomes more important.

Each member of a party is responsible for the whole group's risk management. A caver should never be offended if someone wishes to check their harness or how a rope is rigged: it has to be right.

I am concerned about society's more recent approach to risk, particularly the advent of what some of us call the 'cotton wool' approach.

We've seen the advent of increased insurance premiums and the insistence of risk management tools for most business activities and across much of society. But the problem I have with some of this development is that such standards are sometimes being written by people who don't understand the risks, often over-state them and sometimes in their insistence on certain actions actually increase the risk. The other aspect is the "dumbing down' of risk management so we're all treated like idiots.

It could be argued that catering for the lowest intellect is social engineering directly against Darwinian principles, that is, even the most stupid survives and can take litigation. We now have a plethora of rules and regulations catering for people's stupidity and lack of common sense. Instead of dealing with the isolated problem, legislators ensure we all suffer with more regulations.

Examples that I have noted:

1. I've now twice seen at the bottom of a set of stairs signage stating: "Mind the step".
2. Recently on a building re-fit I was forced to install tactile mats on a floor of an area leading into a non-public part of the business. This actually increased the trip hazard for the staff.
3. Some time ago the travel insurance I obtained for a caving expedition is the USA stated I would NOT be covered if climbing with a rope: frankly I consider free climbing to involve much greater risk!

The Tasmanian environmental group Karstcare conduct working bees in caves. Many of these caves are managed by the National Parks Service, however they both lack the resources and often the skills and knowledge to do this type of work. Such managers concentrate much of their efforts on Job Safety Assessments (JSA), managing the risks, and rightfully so, however sometimes I'm very amused at being presented a JSA with some actions that actually increase the risk, (such as recommending steel cap boots standing in freezing cold water),because the person in head office has not truly understood the environment or even what the job entails. (7) Cavers are comfortable working in a cave environment, and because of our experience and skill set, we can work more safely than non-cavers.

Earlier I mentioned in relationship to the definition of risk the phrase:

At one's (own) risk: *Taking responsibility for one's own safety or possessions.*

That is the crux of it- individual responsibility. It is your planning and preparation and assessment of risk that is the critical factor in determining a good outcome. It is not standards and guidelines from external bodies- these are important, however it is what YOU do that matters.

The ASF Safety Guidelines specifically state, *"Risks can be reduced to acceptable levels but never eliminated. The way to minimise risks is to undertake caving with an attitude of self-reliance, responsibility and preparedness. In practical terms this means careful planning, competent organisation, appropriate provisioning and thorough training."* (8)(9)

We cannot risk manage for every contingency.

For instance: a lightning strike…..but it has happened.

A group of cavers reported being struck while holding a metal tape in Luddington's Cave USA, whilst surveying. The passage was given the name Lightning Bolt as a result of the incident. (10)

Conclusion

Risk is not a bad thing; it adds to the adventure of caving. It is part of what makes it so special. Going where no human being has been before is quite an incredible feeling, seeing something beautiful that nature has produced for the first time is so exciting. I have argued that risk is actually a good thing. By considering the dangers involved and managing them, a caver is far more likely to have a successful trip and return home safe.

Our legislators and insurance companies have got it wrong; the principle of individual responsibility seems to have been abandoned. Certainly those new to an activity such as caving need education and training in their approach and techniques to ensure safety, however the management of risk is still up to the individual. Risk management starts with you. You cannot abdicate it to other people, the rest of the group or external authorities.

Many risks are not within your control. If such risks are also outside your comfort zone, then don't do it!

I wish to leave you with one final phrase: No matter how well prepared you are, sometimes…

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(1) Oxford Advanced Learner's Dictionary: Risk
(2) Captain Cook Society web page
(3) Shackleton E: "South" the last Antarctic Expedition of Shackleton and the Endurance 1919
(4) Jenkins M: National Geographic June 2103
(5) www.alanarnette.com/blog (collation of Everest death statistics)
(6) Lechuguilla expedition Nov 2004 personal experience
(7) Parks & Wildlife Service Tasmania, pers. com. (Gunn Plains Karstcare JSA June 2008)
(8) Risk Management Policy Jan 2007 ASF
(9) Safety Guidelines April 2011 version ASF
(10) National Speleological Society (USA) News: lightning search.

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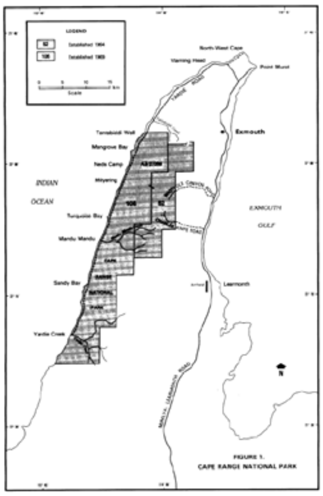
Chairperson for day	21st Sunday	Monday 22nd Greg Thomas	Tuesday 23rd Tim Moulds	Wednesday 24th Darren Brooks	Thursday 25th Ross Anderson	Friday 26th Ian Collette
8.30 AM				Field Trip	ASF council meeting	Norm Poulter OAM - Unusual Caves of Australia
9:00 AM		Official opening - Shire President Turk Shales and conference convenor Darren Brooks	Cathie Plowman and Tim Moulds - Cave Animal of the Year			
9:30 AM		opening speaker - Darren Brooks Cape Range Caving and geology intro	Tim Moulds - Mulu Caves, An invertebrate survey, Borneo			Graham Pilkington - WORKSHOP on Ozkarst
10:00 AM		Keynote speaker - Dr. Bill Humphreys - Cape Range caves changed understanding of Australian biogeography – rainforest and tethyan troglobionts	Rob McCracken - Hang Son Doong Vietnam			
10:30 AM			Ross Anderson - Digital media and the conservation and interpretation of caves			
11:00 AM		**Morning tea**	**Morning tea**		**Morning tea**	**Morning tea**
11:30 AM		Roge Kemp - Exmouth/Cape Range History	Janine McKinnon - YTIVARG There, and back again. (Cave Diving)		Ian Curtis - Save Cliefden Caves	Graham Pilkington - WORKSHOP on Ozkarst
12:00 PM		Heather Barnes DPaW - Cape Range World Heritage and NP listing	Kim and Karen Woodcock - Nullarbor Cave Diving		David Dicker and Bob Kershaw - Strain gauges in caves	
12:30 PM		John Mylroie - Flank Margin Cave Development and Tectonic Uplift, Cape Range, Australia	Janine McKinnon - Perseverance Pays (or why being stubborn can sometimes be useful). Cave Diving		Garry K Smith - Calcite Straws on concrete	
1:00 PM		**Lunch**	**Lunch**		**Lunch**	**Lunch**
1:30 PM		**Lunch**	**Lunch**		**Lunch**	**ASF council meeting**
2:00 PM	Registration / ASF EXEC meeting	Fiona McRobie - Speleothem dating in northern Australia	David Wools-Cobb - Assessing risk in caving		**Speleo sports**	
2:30 PM		Julia James - The Jenolan Show Cave Survey - the latest.	Brian Evans - Getting Lucky Underground			
3:00 PM		Carly Monks - Archaeological research in southern WA caves	Roz Hart - Nullarbor Caving and ASF conferences - Memories of the 1970's			
3:30 PM		**Afternoon tea**	**Afternoon tea**		**Afternoon tea**	**Afternoon tea**
4:00 PM		Kevin Moore - Disto X2 Conversion Workshop	Denis Marsh and Cathie Plowman - UIS Conference organisation and Pre and Post Conference Caving Workshop		**Speleo sports**	**ASF council meeting**
4:30 PM						
5:00 PM						
5:30 PM						
6:00 PM						
	Welcome BBQ - meat and greet		SRT Competition 7.00 - 9pm	Photo Session - Open to the Public 7.30 - 9.00pm	Quiz night - 7pm	Cavers Dinner 6.30pm Potshot Hotel

Appendix A -The Ningaloo World Heritage Area – an introduction

NINGALOO COAST
WORLD HERITAGE

By Heather Barnes

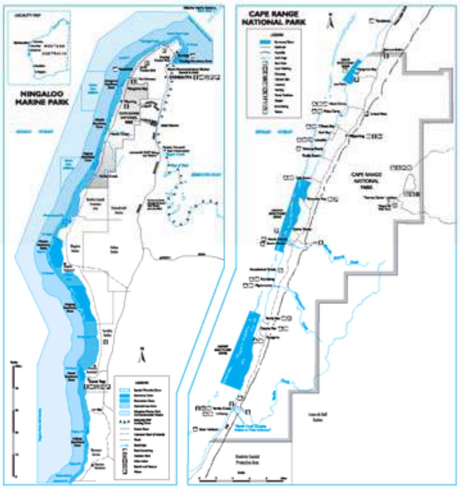
Conservation Estate History



- Conservation significance of the area both marine and terrestrial recognised in the early 60's
- Original proposal by shire of Exmouth in 1964 for 13424 ha as a C class reserve
- Shire then proposed an addition in 1968, south to Yardie Creek and up to Tantabiddi well – up to 50 000 ha
- Status changed to NP in 1974
- At this point the EPA through a Conservation through reserves committee recommended further extensions to the NP, the declaration of a "marine" national Park (Ningaloo), and the declaration of a series of island reserve in the gulf.
- Things quietened down for a little while with the islands being declared but no uptake of the Marine Park or NP extensions.

NINGALOO COAST
WORLD HERITAGE

Marine Park History



- Change of legislation in 1984 allowed the declaration of marine parks
- In 1987 the Ningaloo Marine Park was declared (both state and Federal waters) from Bundegi to Amherst Point.
- In 2005 and into 2006 the extension to the Ningaloo Marine Park to the south was undertaken and the inclusion of the waters around the Muirons was incorporated.
- Sanctuary increase from 10-33%

NINGALOO COAST
WORLD HERITAGE

World Heritage

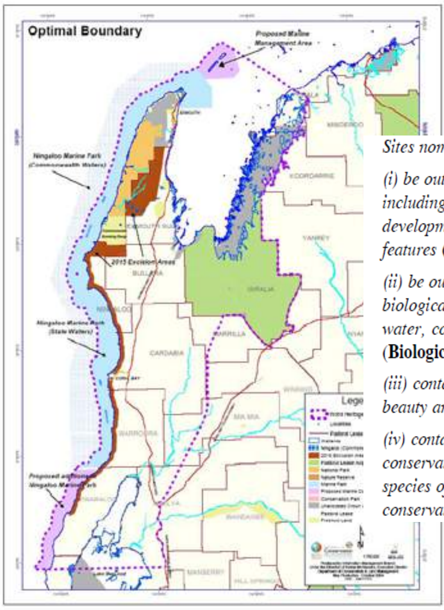
United Nations Educational, Scientific and Cultural Organization

World Heritage

- World Heritage began in 1972 by **UNESCO** developing the “World Heritage Convention”
- High Political and public interest in the areas as a result of the proposed Maud’s landing development
- State labour government ecotourism strategy released in 2001 identified an action to seek to have the area listed.
- Cabinet endorsed and agreed to this in 2003 and this was endorsed by the federal government
- WH consultative committee was formed (03/04) and liaised with key stakeholders and began researching the proposal and the WH listing process

NINGALOO COAST
WORLD HERITAGE

Figure 24. Map showing Optimal Boundary for the proposed World Heritage nomination.



- World Heritage Consultative committee came up with a series of preferred options (12 in fact). Preference was 2.5 million Ha in 2004

Sites nominated should therefore:

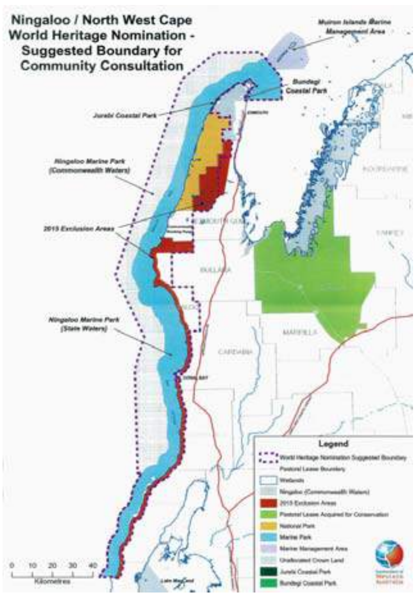
(i) be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of land forms, or significant geomorphic or physiographic features (**Geoevolutionary history**); *or*

(ii) be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals (**Biological evolution**); *or*

(iii) contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance (**Superlative beauty**); *or*

(iv) contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation (***Biological diversity***).

NINGALOO COAST WORLD HERITAGE



- Eventual proposal put forward in 2010 of 708 000 hectares based on ongoing consultation

- Eventually considered and inscribed by the international World Heritage Committee in **June 2011.**

NINGALOO COAST WORLD HERITAGE

- The final outcome was the listing only of those areas that were either existing conservation estate or managed by the federal government. (defence lands) total area of 604 000ha.
- Finally inscribed **June 24 2011**
- 15%Terrestrial and 85% Marine

4 YEAR ANNIVERSARY - THIS MONTH !

NINGALOO COAST WORLD HERITAGE

World Heritage Natural Criteria

- (vii) contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance; ✓
- (viii) be outstanding examples representing major stages of earth's history ✗
- (ix) be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals ✗
- (x) contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation. ✓

NINGALOO COAST WORLD HERITAGE

What is World Heritage?

World Heritage listing is the highest global recognition of the importance of a site.

World Heritage listing:

- recognises the significance of the Ningaloo Coast at an international level as one of the world's best examples of natural heritage
- creates an obligation to ensure the World Heritage values of the area are conserved
- creates the requirement for development proposals that are likely to significantly affect World Heritage values to be referred to the Australian Government under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).*

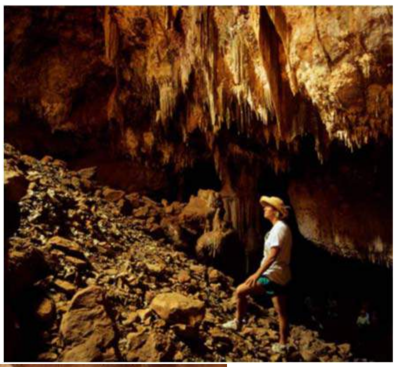
NINGALOO COAST
WORLD HERITAGE


Mega Marine Life

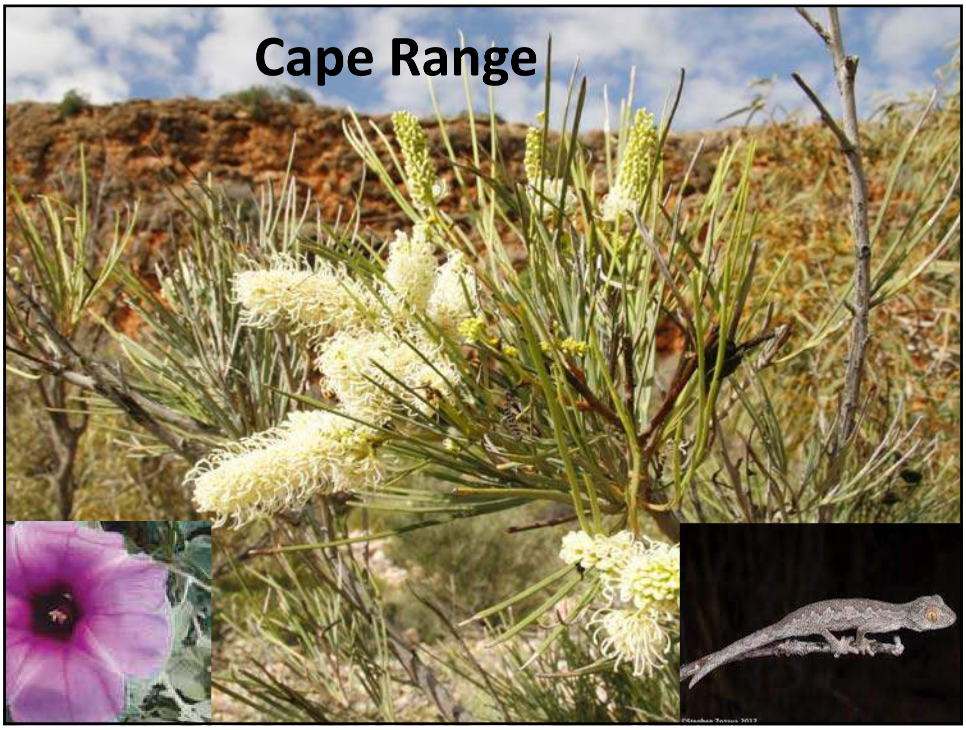

Ningaloo Reef & Deep Sea

Turtle nesting

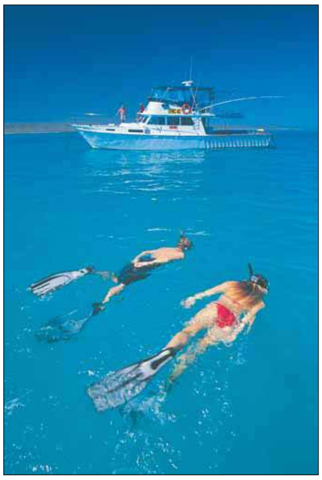
Cape Range Karst System



NINGALOO COAST
WORLD HERITAGE



Benefits of being placed on the World Heritage List



- World Heritage listing acknowledges the significance of a place at the international level. With this comes a commitment at the local, state and national levels to manage the property for present and future generations.
- With World Heritage listing, the EPBC Act applies to new developments that are likely to significantly affect World Heritage values.
- In Australia, World Heritage places are strongly promoted and many have received increased tourism investment.

NINGALOO COAST
WORLD HERITAGE

Managing the Ningaloo Coast World Heritage Area

- Existing management programs (DPaW, Exmouth Shire, Defence) continue
- Development of a NCWHA Committee
- Potential funding for special projects
    - Feral Animal Control
    - World Heritage Officer

Questions?

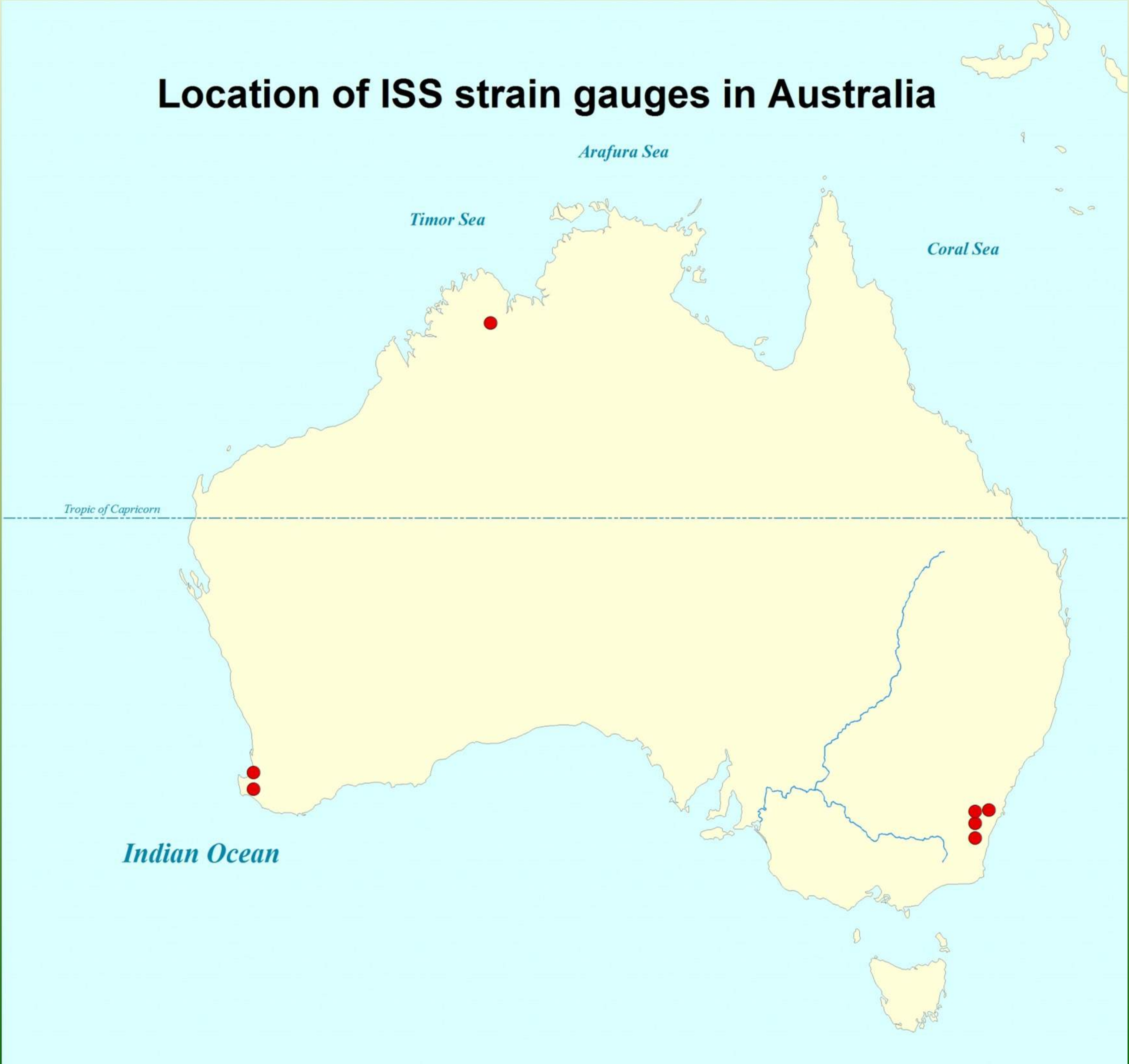
Appendix B - Strain Gauges in Caves

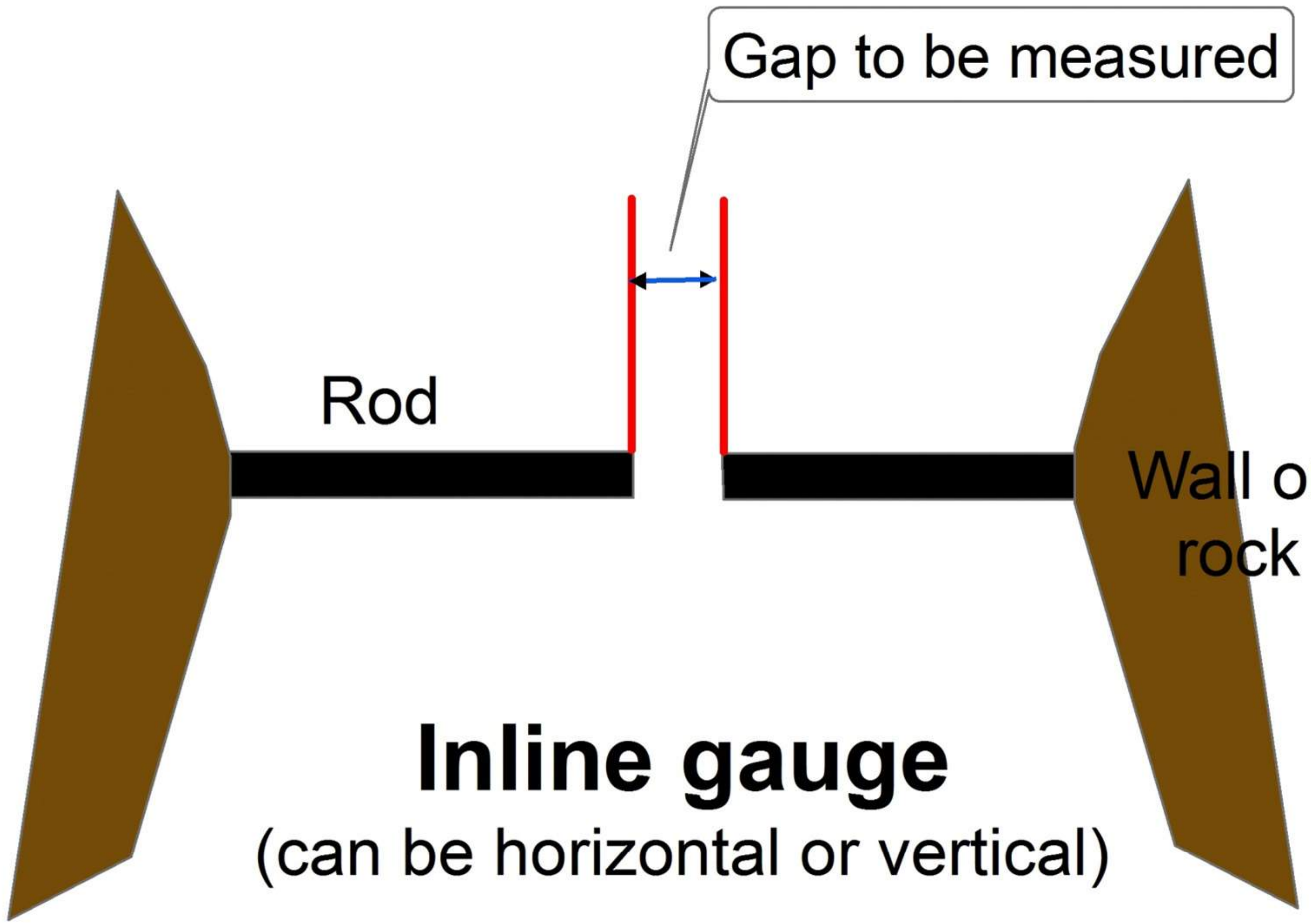
Strain Gauges

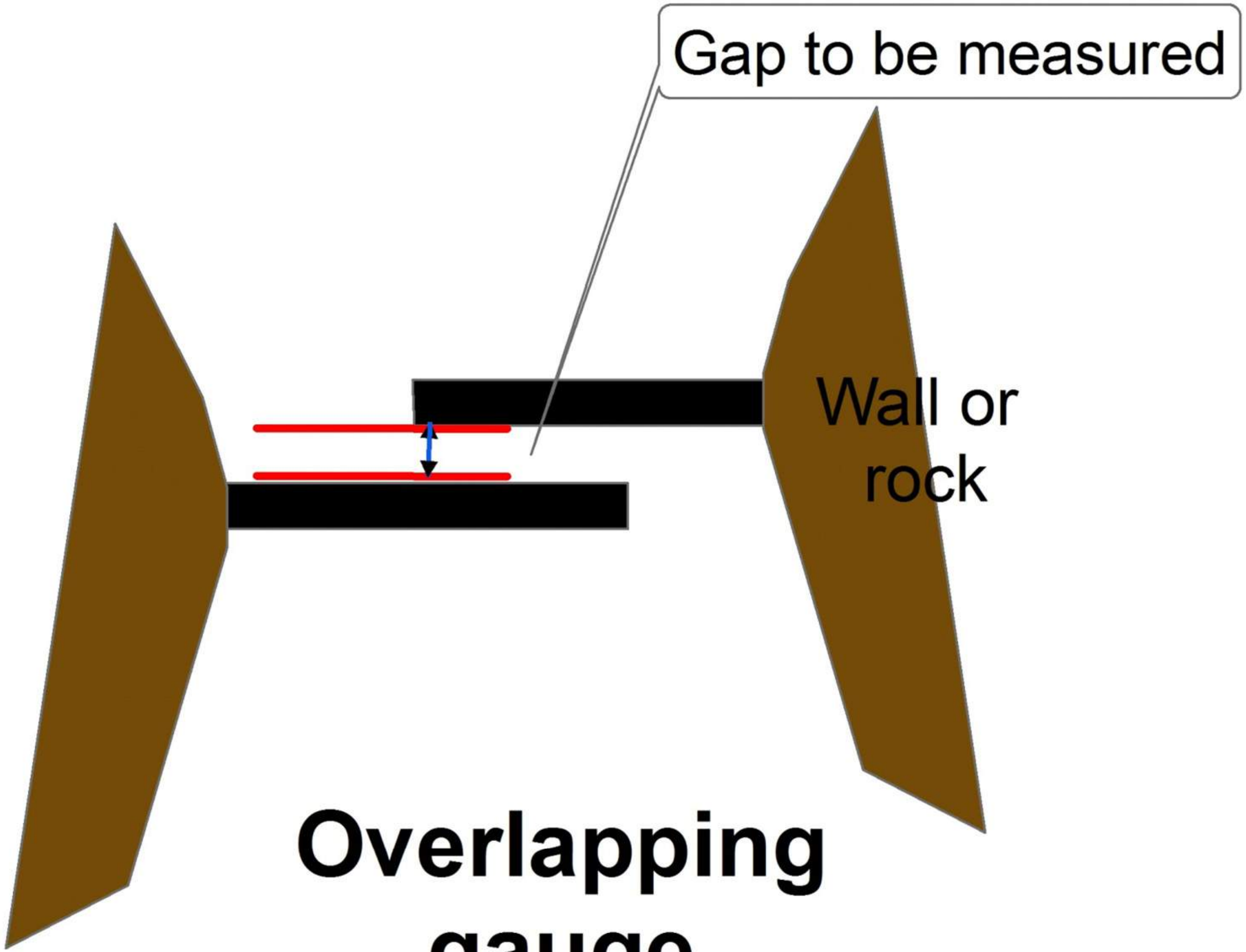
By Bob Kershaw
Illawarra Speleological Society Inc

Ningaloo Underground
30th ASF Conference
Exmouth, Western Australia
21-26 June 2015

Location of ISS strain gauges in Australia




Gap to be measured
Rod
Wall or rock
Inline gauge
(can be horizontal or vertical)

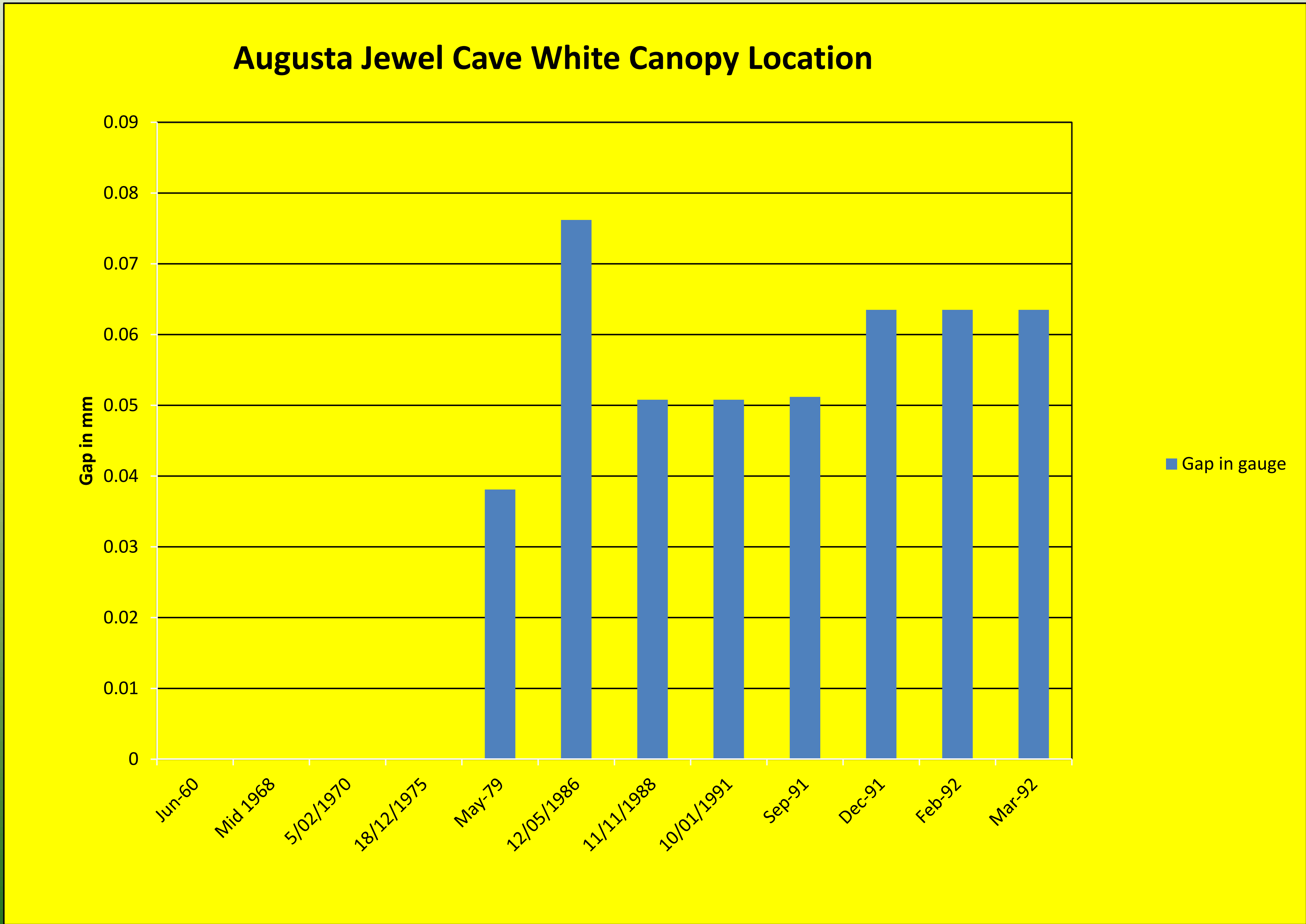


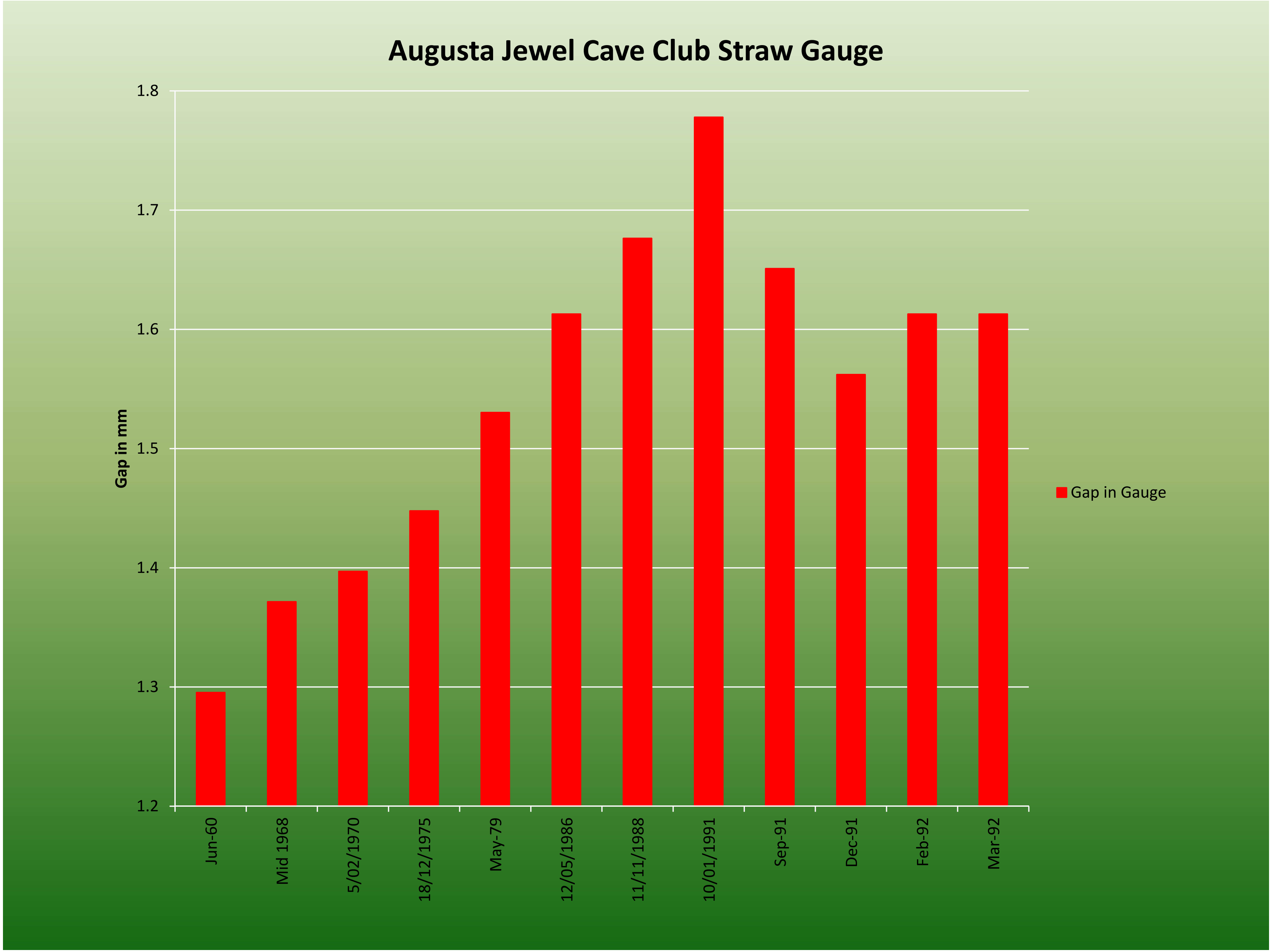
Overlapping gauge


J46

Playfords Cut
Augusta Jewel Cave


010
008
004
THICKNESS GAUGE


Augusta Jewel Cave White Canopy Location
Gap in mm
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jun-60
Mid 1968
5/02/1970
18/12/1975
May-79
12/05/1986
11/11/1988
10/01/1991
Sep-91
Dec-91
Feb-92
Mar-92
Gap in gauge



Augusta Jewel Cave Club Straw Gauge
Gap in mm
1.8
1.7
1.6
1.5
1.4
1.3
1.2
Jun-60
Mid 1968
5/02/1970
18/12/1975
May-79
12/05/1986
11/11/1988
10/01/1991
Sep-91
Dec-91
Feb-92
Mar-92
Gap in Gauge

Conclusions

- **The data shows that there has been no movement in the rocks in the eastern States although the no1 gauge in Wyanbene has fluctuated.**

- **The north of Western Australia is stable.**

- **The fluctuations in the Augusta Jewel Cave are interesting but since the** *Augusta Margaret River Tourism Association* **do not want their data published, we cannot tell it there is any cyclic movements of rocks in the cave.**

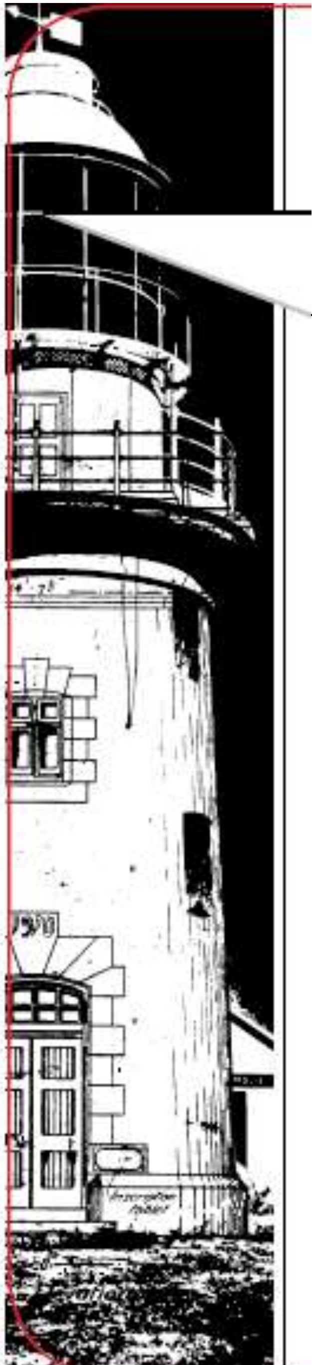
- **Why is there is movement in the rocks in the SW of WA?**
- **Maybe it is the younger calcarenite rocks that move**

- **But since the last readings were taken many years ago we cannot really draw noteworthy conclusions.**
- **And I don't have the data on Yanchep to comment!**

Appendix C - “Getting Lucky - whilst caving”


I'm safe. I'm lucky
I'm confident. I'm prepared.
My team is prepared I have plan B, C ...
We're maintaining good decisions - food, rest, water, warmth.
I'm watching.
I'm listening.
I'm thinking.
Risks today?
Temperature?
Flood? Delay?
Rockfall? Anchors?
Time constraints?
I'm listening.
I communicate.
Where/when do we re-group?
What happens when one does not show?
Who is doing what?
We all know the plan... and its changes.
My gear is good.
I know it's working.
I know its limits.
It's suitable for today.
I'm familiar with the techniques and limitations of its use.
My body is good for the job today.
The safety margin is OK.
I'm in shape, enough.
I'm listening to it.
Who is responsible
... for MY safety?
... for my team's safety?
We're all alert and responsible for each other.
ILLAWARRA SPELEOLOGICAL SOCIETY Inc

Appendix D - A history of the Cape Range

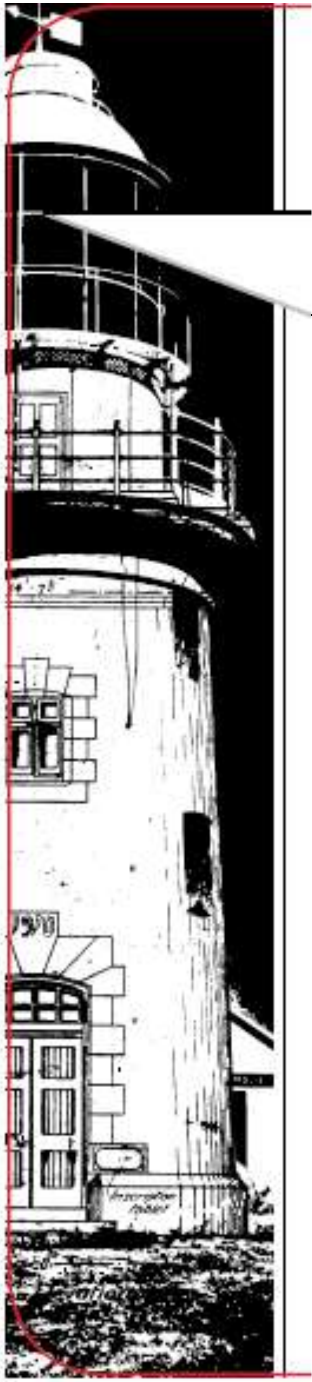


History of Cape Range and Exmouth

Where exploring and passion go hand in hand

Rogé Kempe – Executive Manager
Community Engagement

Shire of Exmouth

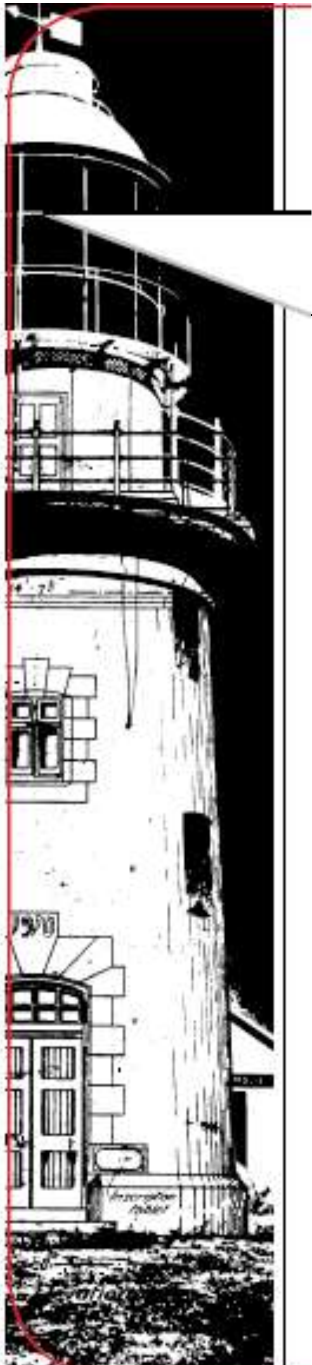


Providing you a Sense of Place

1. More than 35,000 years of Human History

2. Who are the people of the Cape; what is this Place?

3. What about the Future?



YOU DON’T REALLY WANT TO BE HERE..!!

You are too excited!

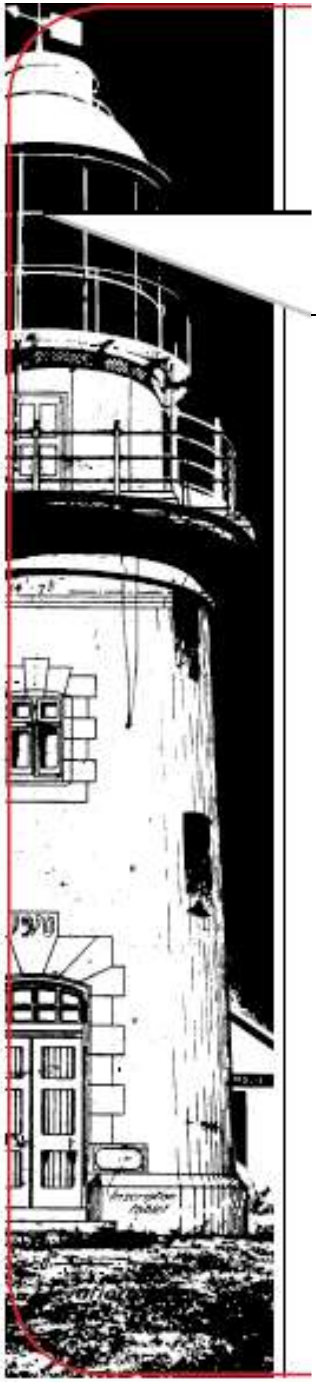
You want to go out and explore…

Get your hands dirty

See what is out there

Be amazed by the unknown

You are like so many people before you!



More than 35,000 years of Human history

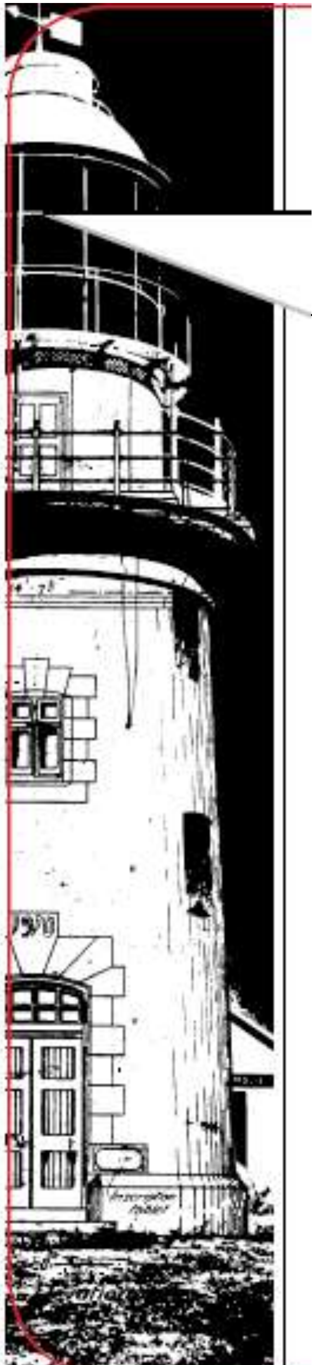
The region provides the earliest evidence of human ornamentation found in Australia.

Shell beads discovered at Mandu Mandu Creek rock shelter at Cape Range have been dated to more than 32,000 years before present time.

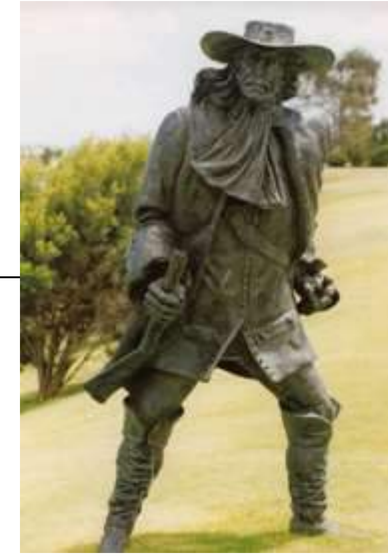
How the Cape was ‘found’

1618
Dutch Sailor Haevik Claeszoon van Hillegom records the first sighting of Northwest Cape on June 24.

This Wednesday it will be 397 years ago!



We are on the Map!

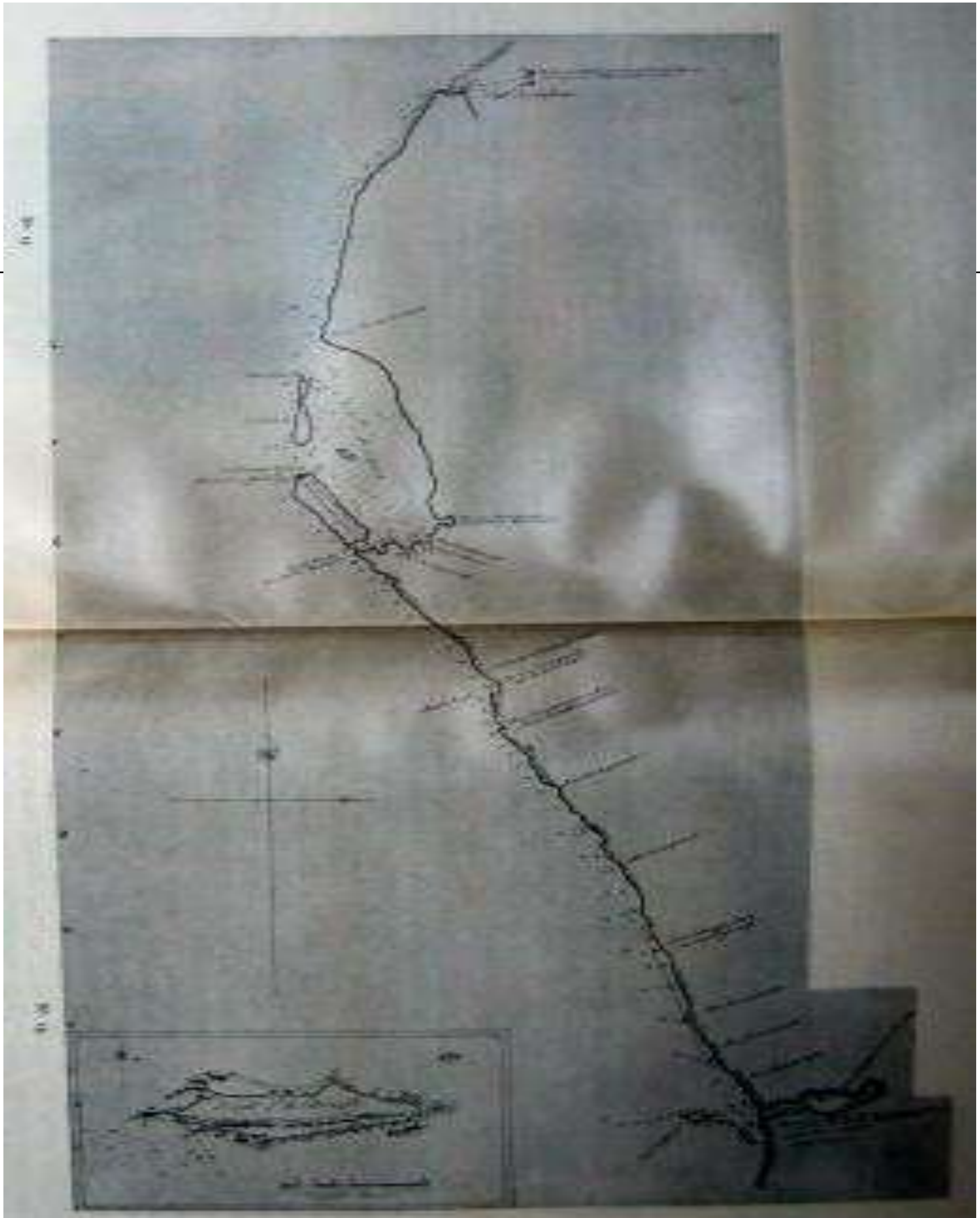


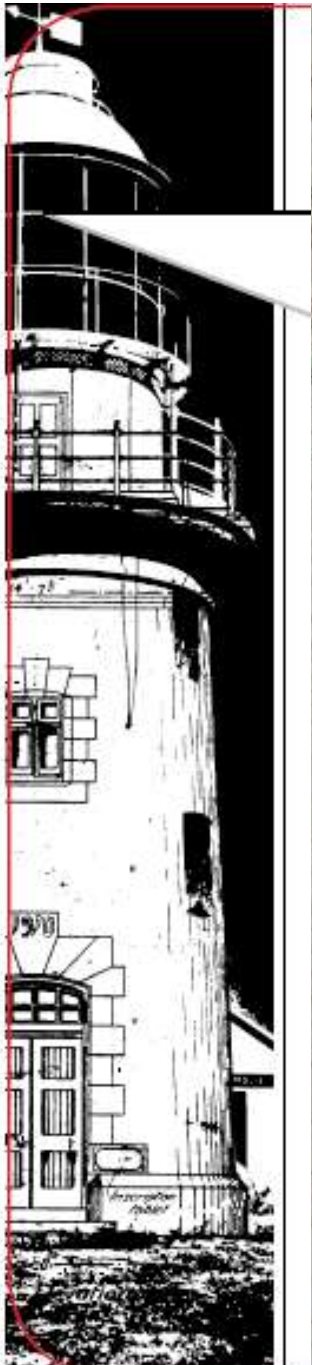
1696

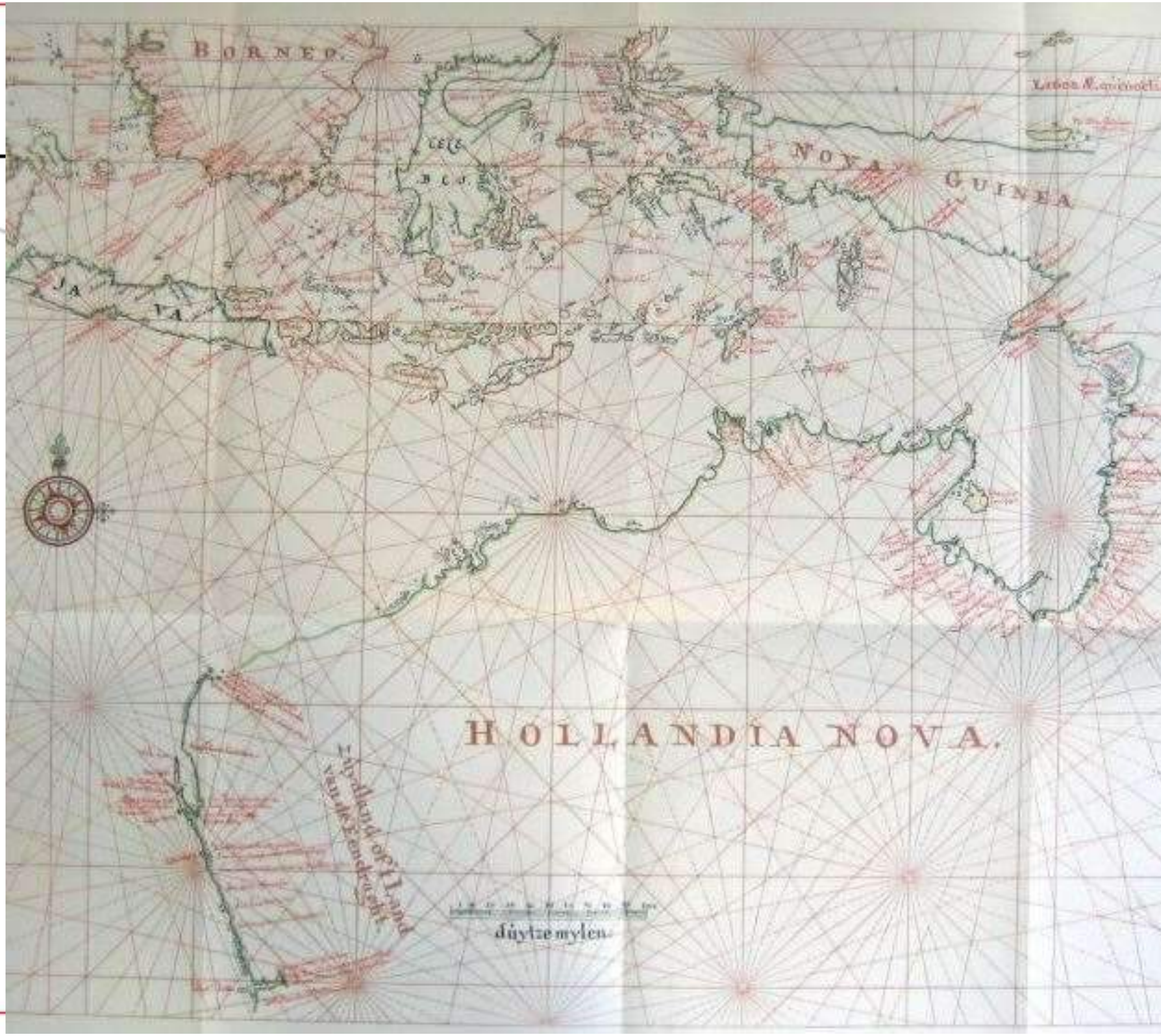
Willem de Vlamingh charts Vlamingh Head

Well, amongst all other things he did, like:
Discovering and naming Swan River & Rottnest Island

and also ‘doing the dishes’ at Dirk Hartog island near Shark Bay





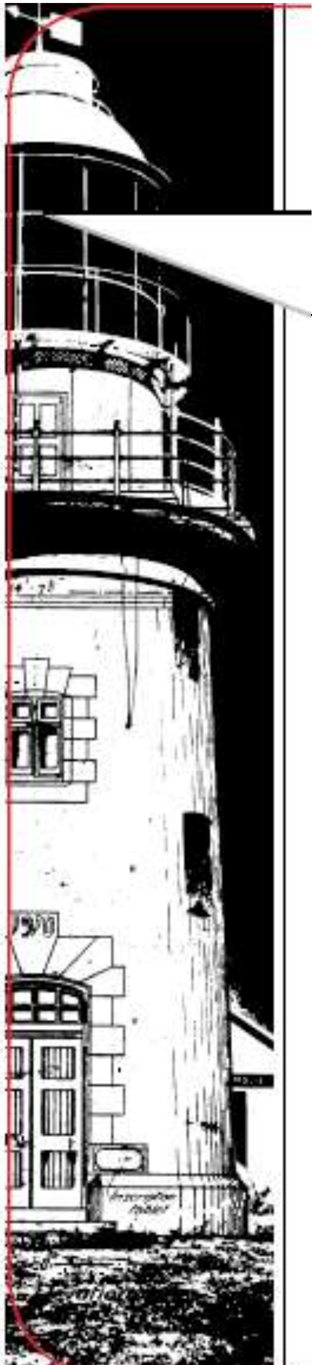

BORNEO.
NOVA GUINEA
JA VA
HOLLANDIA NOVA.
duytze mylen.

It’s getting busy; we are getting more names!

1801
Nicholas Baudin names **Cape Murat** on the northwest tip of the Cape and **Muiron Islands**

1811
The Rapid (an American 3 masted wooden vessel) was wrecked near **Point Cloates**

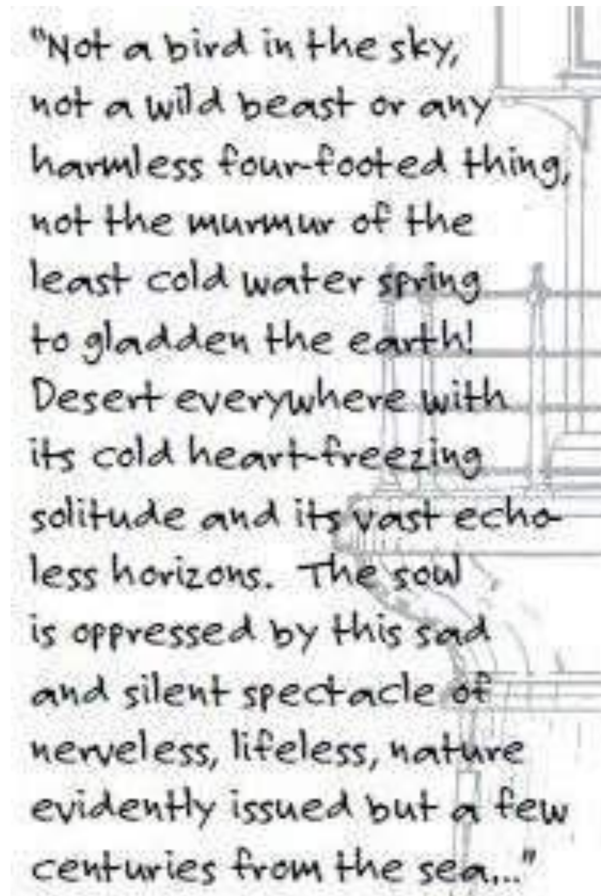
1818
Philip Parker King surveys the Cape and names **Exmouth Gulf** after the ‘noble and gallant Count’ in England; also **Bay of Rest**.



....but they are not getting this Place !!!

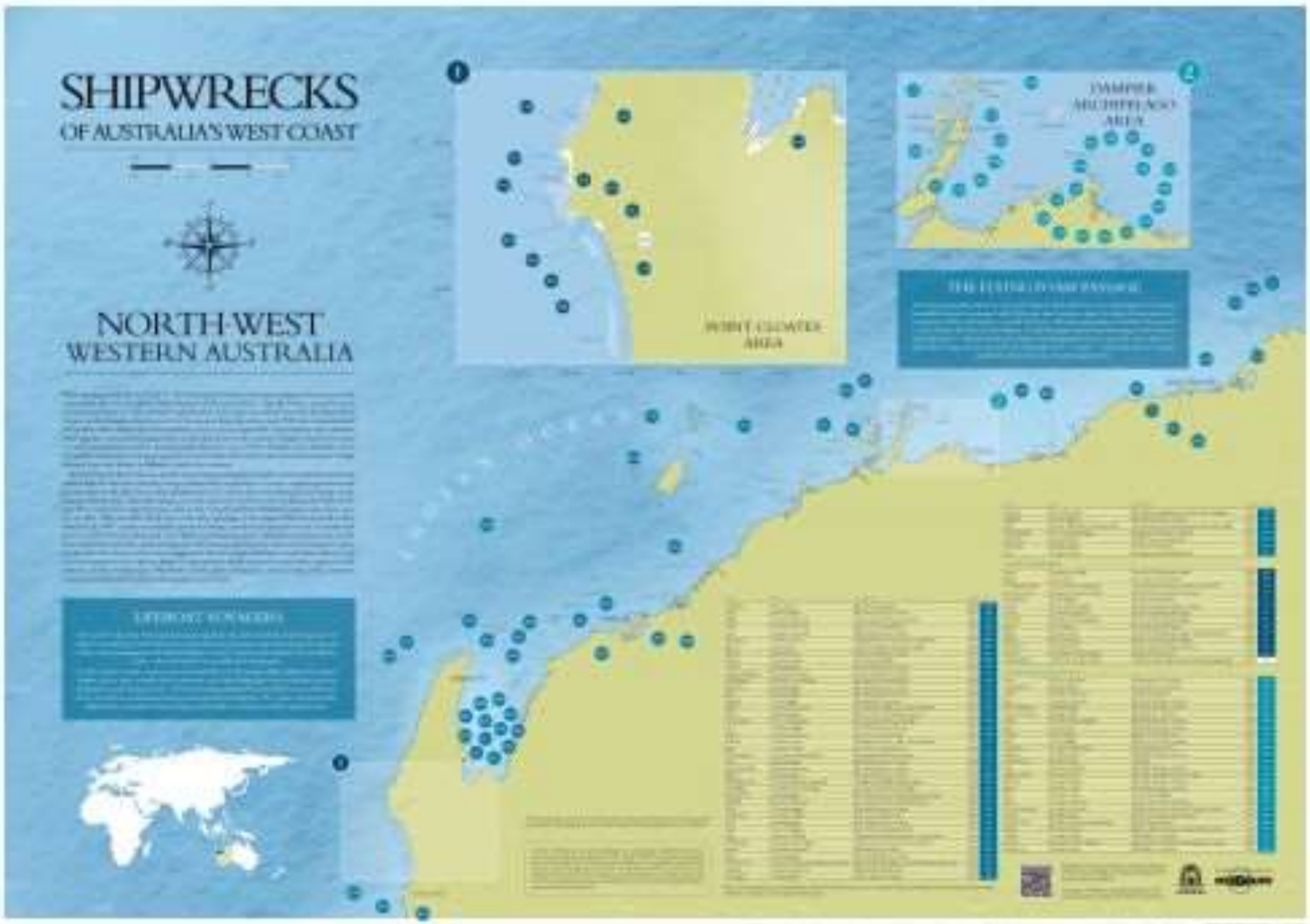
1818

French vessel Uranie visits North West Cape



French artist, Jacques Arago from the vessel *Uranie* commenting on this coastline in 1818

….and some just never made it!



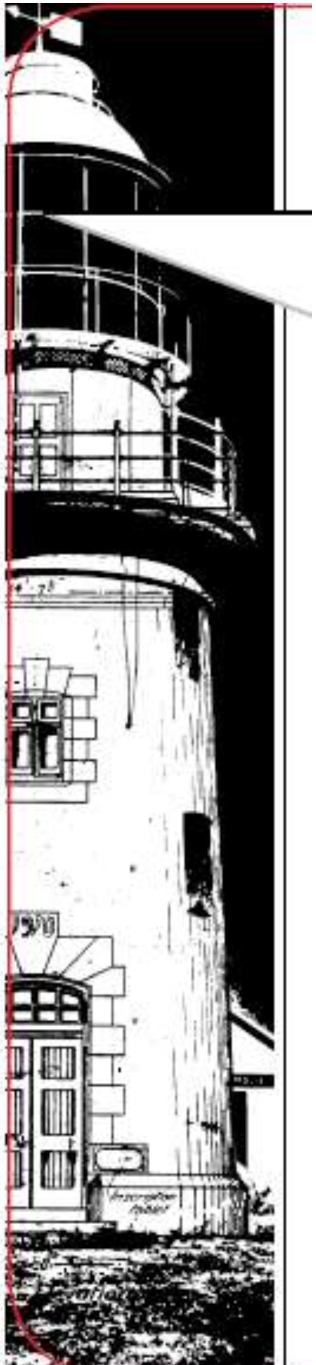
People start moving into the area!

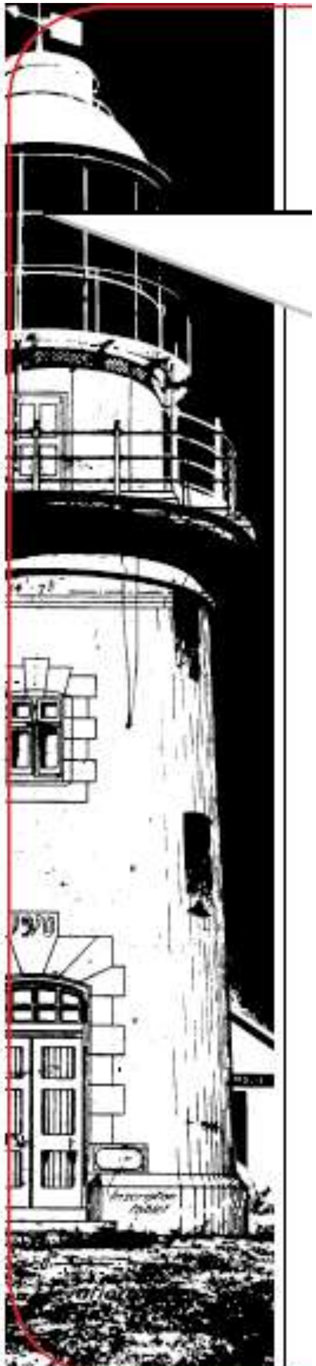
1870-1912 Pearling and Pastoral Settlement

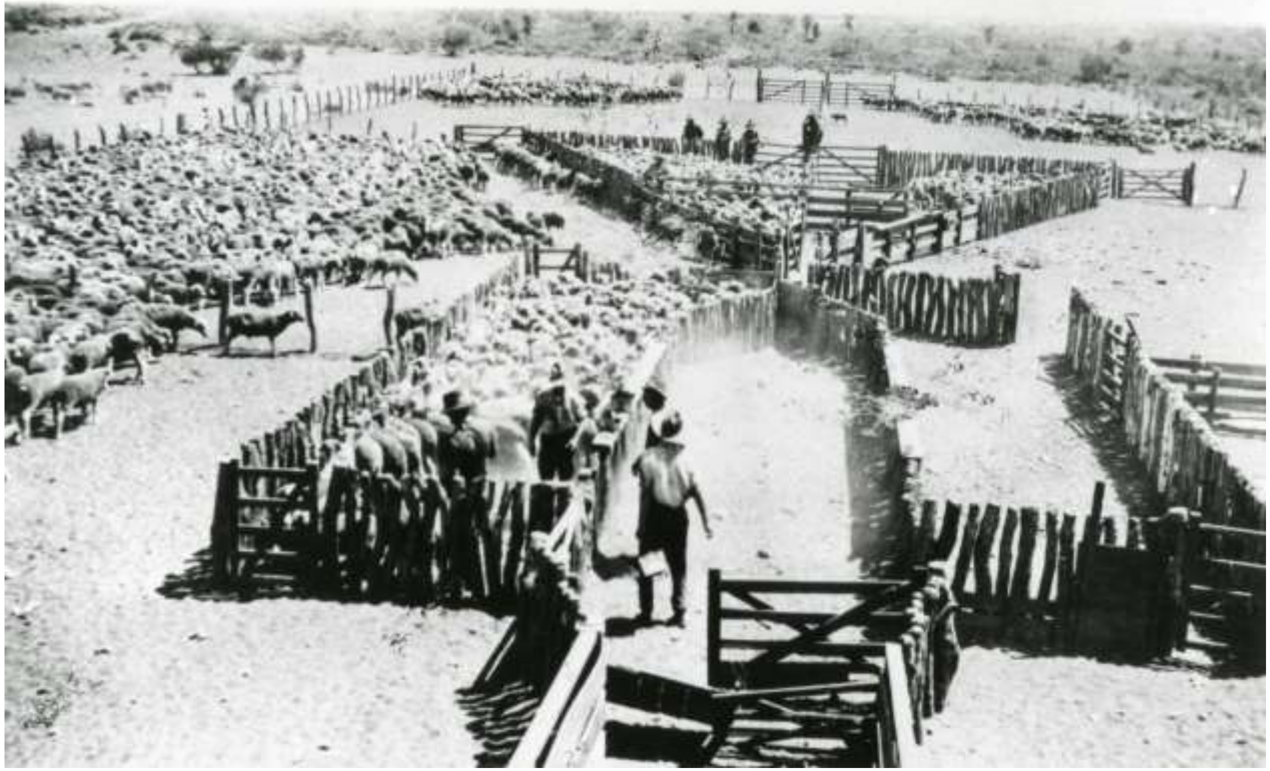
Thomas Carter (a famous ornithologist) acquired the first pastoral leases on the North West Cape in 1891;

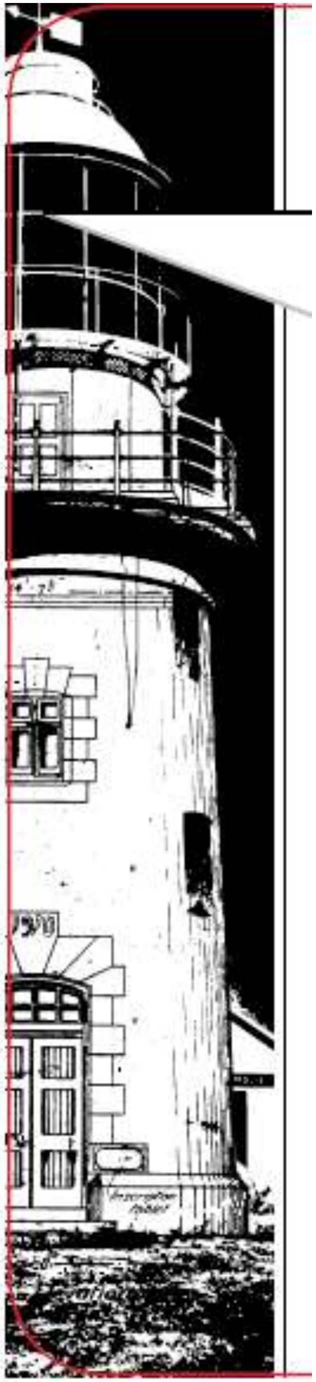
Carved them up 20 years later, thus creating Ningaloo, Exmouth and Yardie stations

Pearling Luggers move into the Exmouth Gulf area from the north.





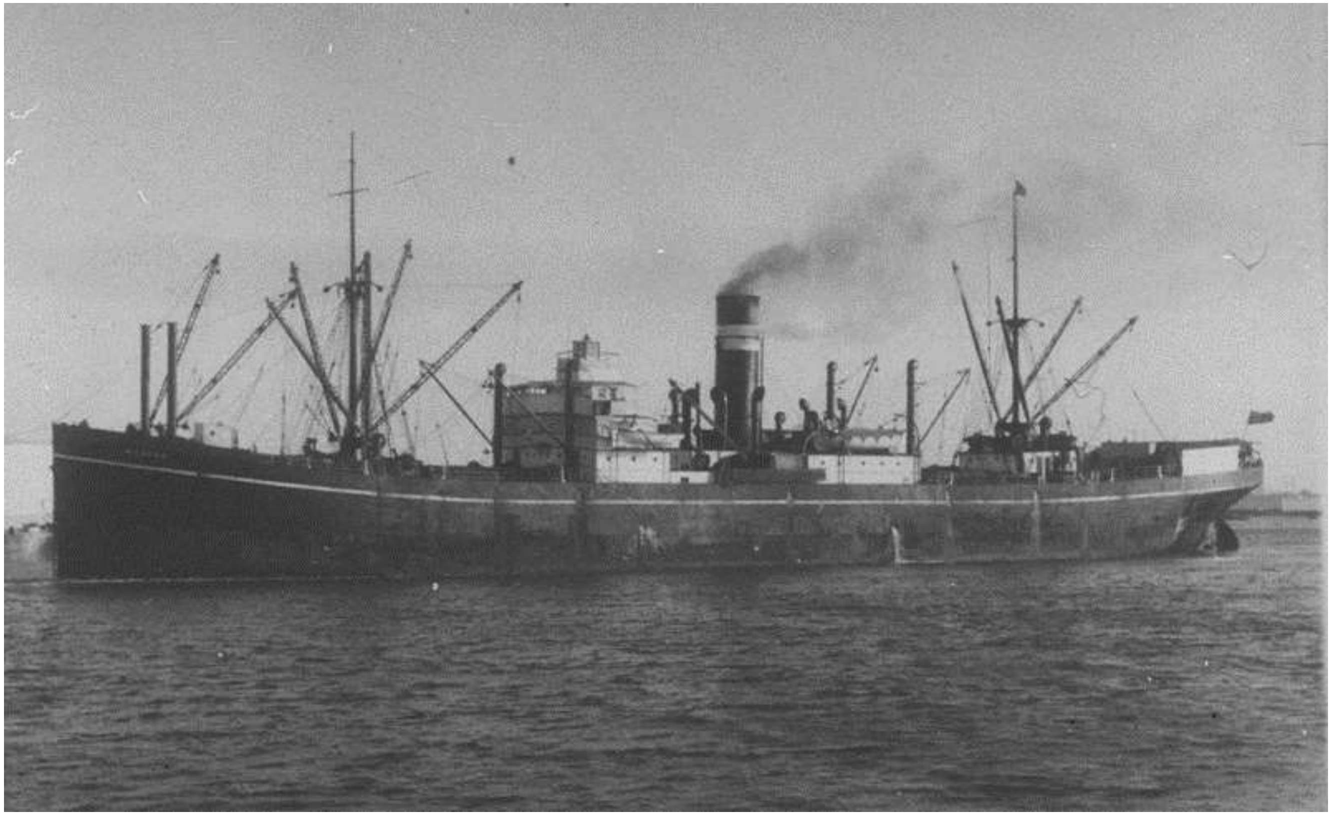


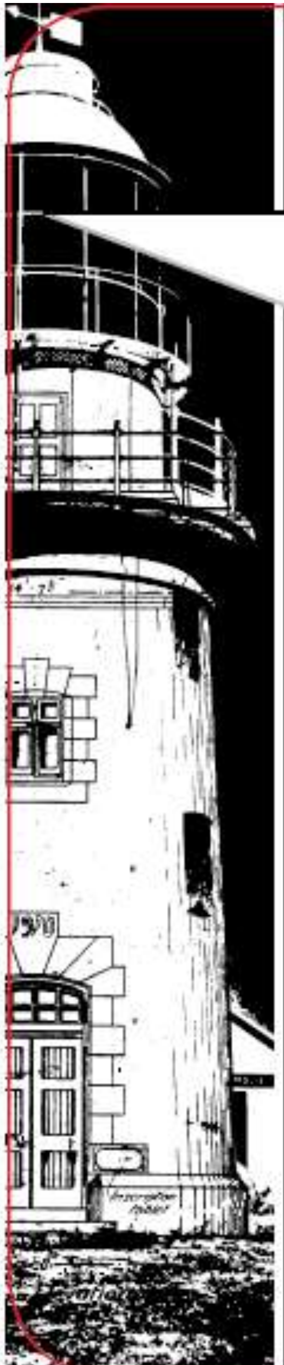


Lighting up the North West Cape

1912

The Lighthouse born out of disaster.





War comes to the Cape

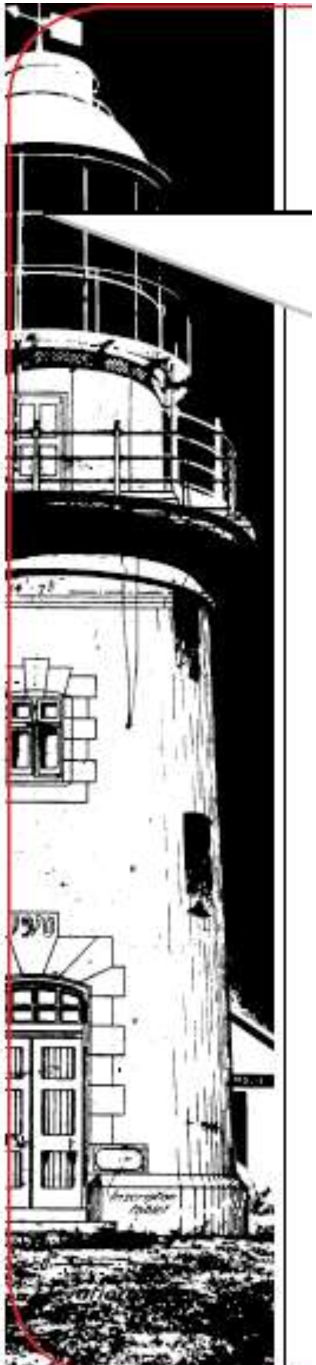
1942

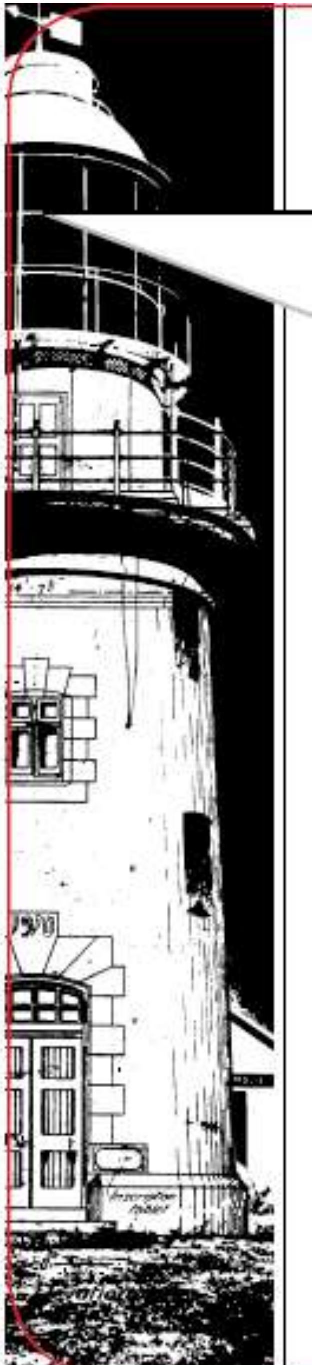
Operation Potshot Commences

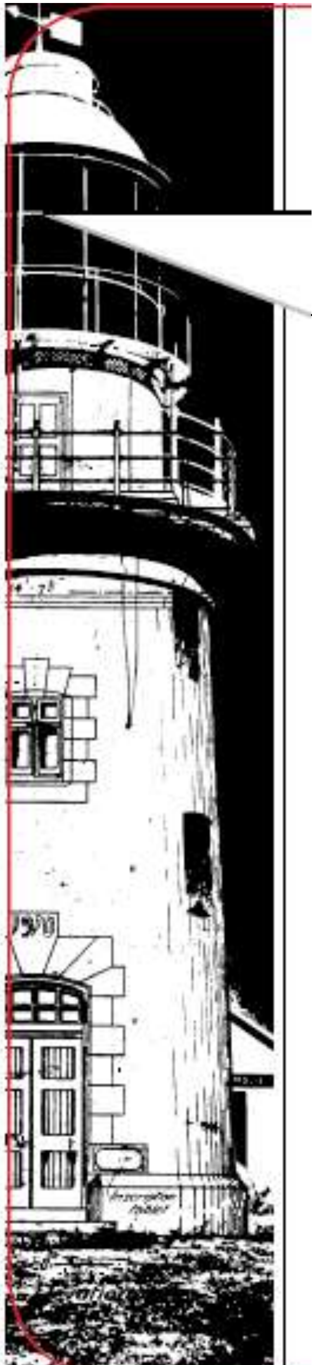
Airstrips, radars, anti-aircraft guns and servicing/fuel for submarines

Radar station at Vlamingh Head was built.

Operating Jaywick (Krait)







First Mainland Oil strike!

1953 -Rough Range struck oil.

DAILY NEWS

Vol. LXXI, No. 24,536 — Perth, WA, Friday, December 4, 1953 — Price 3d.

THE DAY

OIL FOUND IN WA

OIL — very high-grade crude oil in what appears to be commercial quantities — has been found at Exmouth Gulf. This was officially announced in San Francisco today by the headquarters office of Standard Oil of California.

The announcement said that West Australian Petroleum Ltd. had been testing oil showings in sand at 3605ft. to 3620 ft. at Rough Range No. 1 — the company's first wildcat. In a 25-hour test, oil rushed through a quarter-inch pipe at the rate of 20 barrels an hour. This is roughly 700gal. an hour — about average for a new well.

This announcement — giving credence to a spate of rumours over the past three weeks — has had a terrific impact on Australian stock exchanges. Ampol Exploration shares (Ampol holds a 20 per cent interest in WA Petroleum) jumped overnight as much as 39/- (Perth) and 102/- (Melbourne).

Premier Hawke was jubilant at the news. "This is great news, particularly for Western Australia," he said. "The future developments could play a tremendous part in the State's progress." Later, he told the Legislative Assembly that action would be taken to ensure that the State and its people would get substantial benefit from the discovery.

He said that Mines Minister Kelly and his departmental officers had closely considered the State's position. They had studied law practices current in the Canadian Province of Alberta, where big oil discoveries had been made.

The text of the Standard Oil Co. announcement was: "Oil showings in Australia. At Rough Range Number One, its first wildcat, West Australian Petroleum Limited has been testing oil showings in sand at 3605 to 3620 feet.

"Perforation tests showed a very waxy, high-grade crude oil which flowed for 25 hours at the rate of 20 barrels per hour through a one-quarter inch bottom hole choke.

"This announcement is made today by California Texas Corporation, which holds an 80 per cent interest in West Australian Petroleum. A 20 per cent interest is held by the Australian firm, Ampol.

"The discovery appears to be the first commercial quantities of crude oil ever found on the continent of Australia. It has been made by an affiliated company in which Standard Oil of California has an interest.

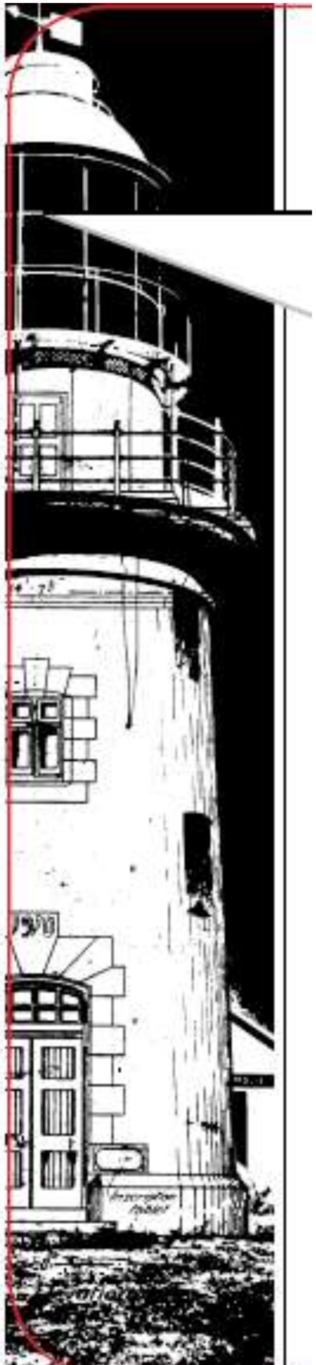
Long-Term Concession

"The discovery well, Rough Range No. 1 is an exploratory venture of West Australian Petroleum Ltd., drilled to begin testing of more than 300,000 square miles held under long-term concession from the State of Western Australia.

Oil Shares Rocket In All Capitals

AMPOL Exploration shares jumped 39/- up to 56/- when Perth Stock Exchange opened at 11.30 a.m. today. In Adelaide the oil shares jumped

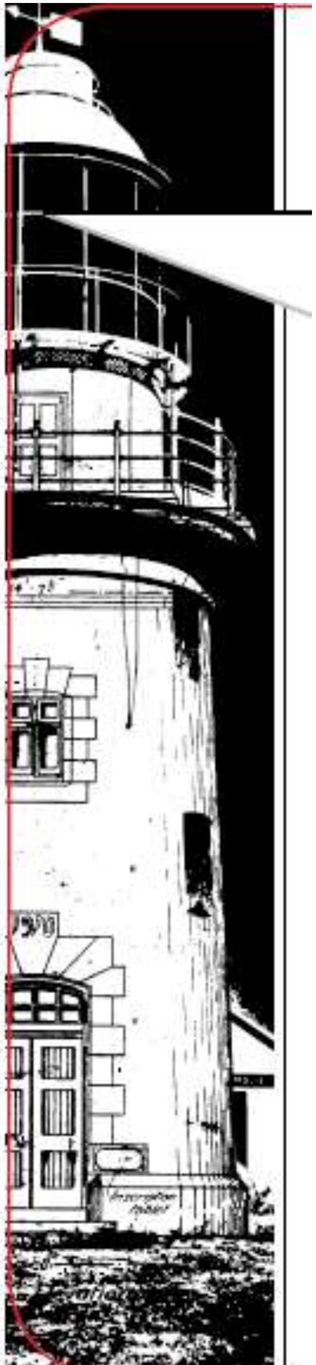
This Is It

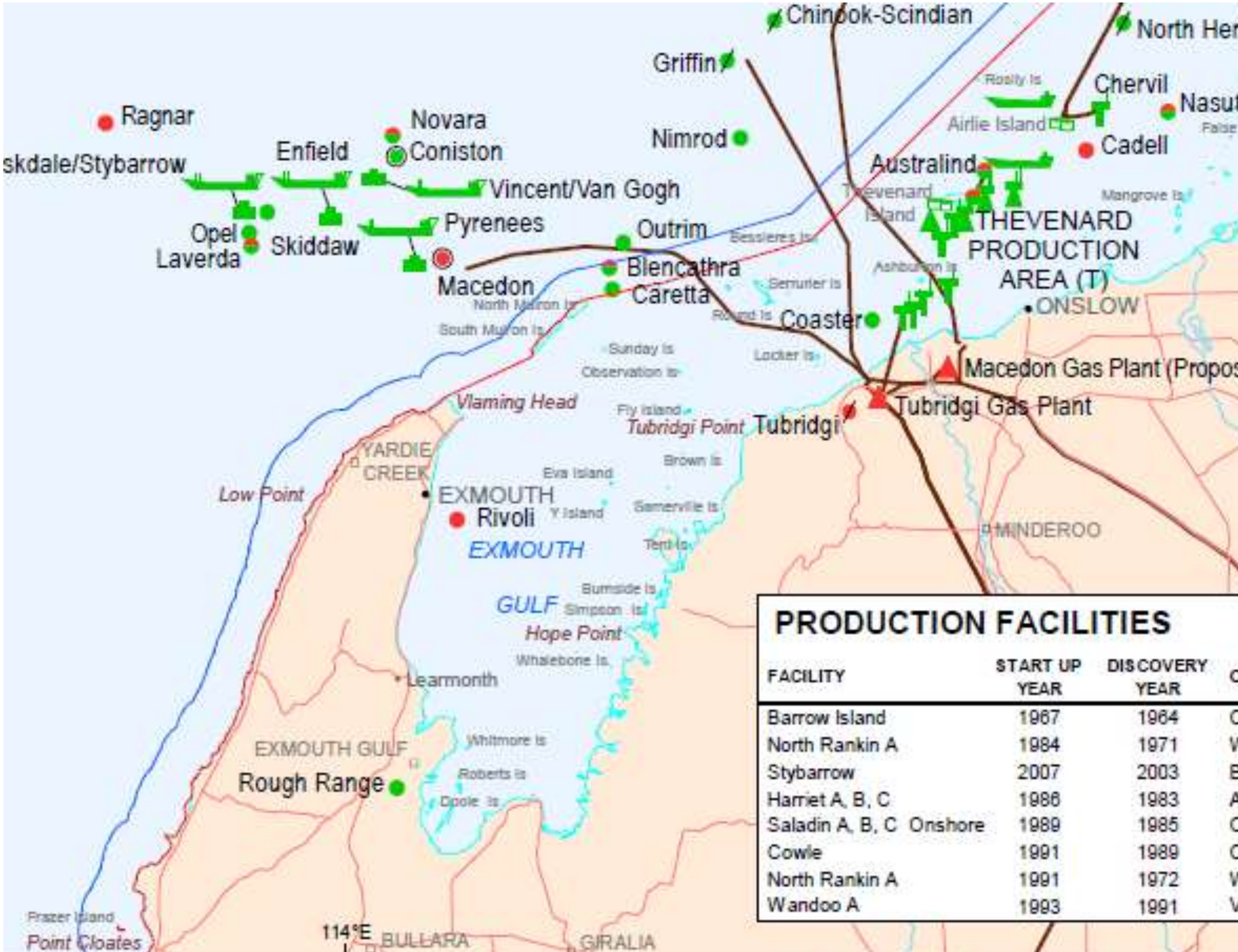


BLACK AND YELLOW GOLD

The discovery of oil at Exmouth Gulf is certainly the most important development in this State — indeed in all Australia — in this century.

Its importance has been ranked above that of the discovery of gold in the second half of the last century, but only history will prove whether or not this high claim is justified.

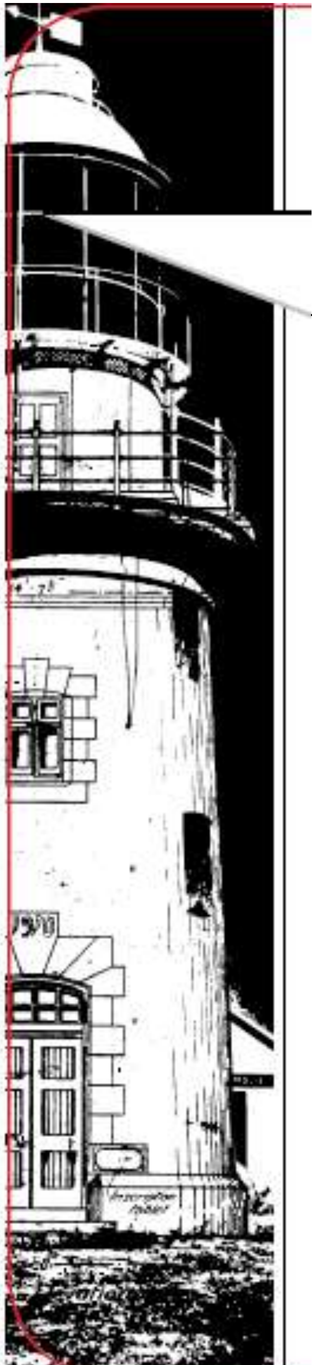




PRODUCTION FACILITIES

FACILITY	START UP YEAR	DISCOVERY YEAR	OP
Barrow Island	1967	1964	Ch
North Rankin A	1984	1971	W
Stybarrow	2007	2003	BH
Harriet A, B, C	1986	1983	Ap
Saladin A, B, C Onshore	1989	1985	Ch
Cowle	1991	1989	Ch
North Rankin A	1991	1972	W
Wandoo A	1993	1991	Ve

Date: 20 August 2014



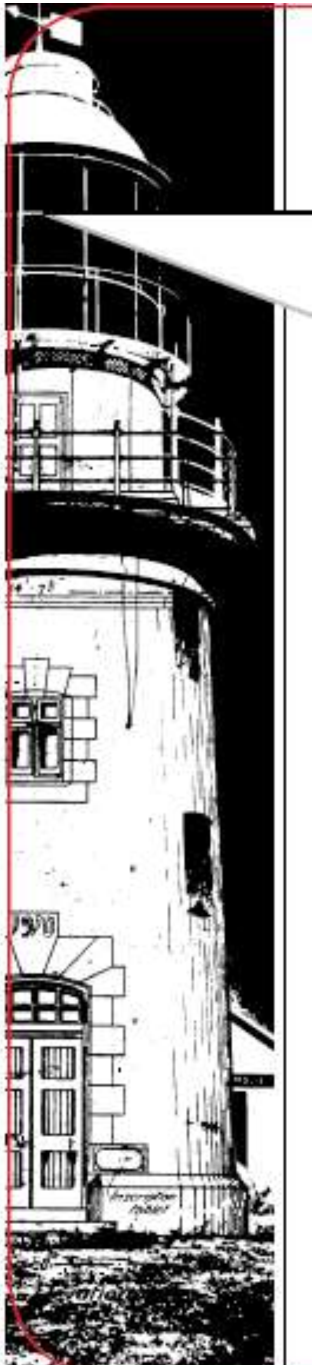
The Birth of a Town

1963

agreement was reached between the Australian and USA Governments to establish a VLF Communications Station at NW Cape.

The town of Exmouth was created to support this facility.

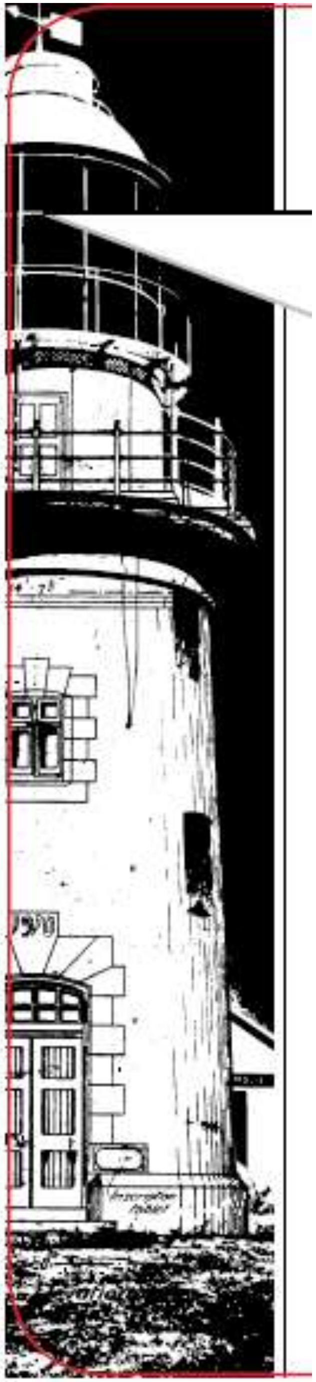
Both were officially opened in **1967**.

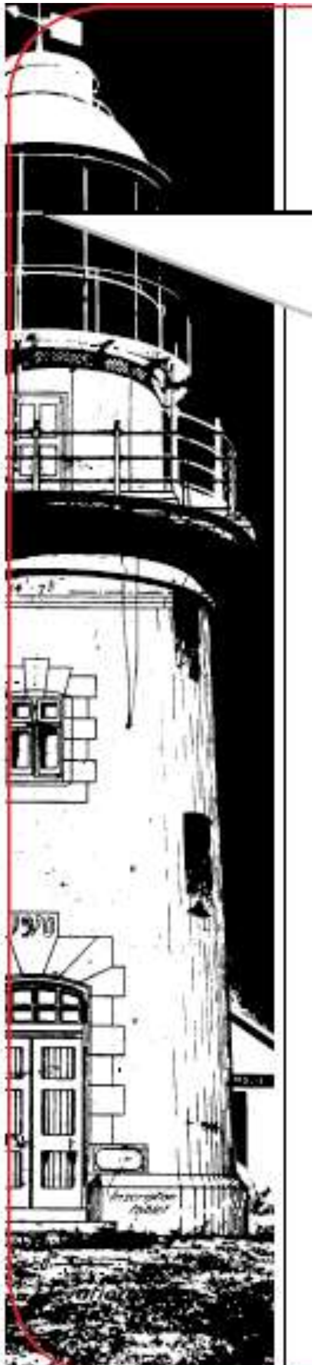


On the main road to Exmouth, 1963.

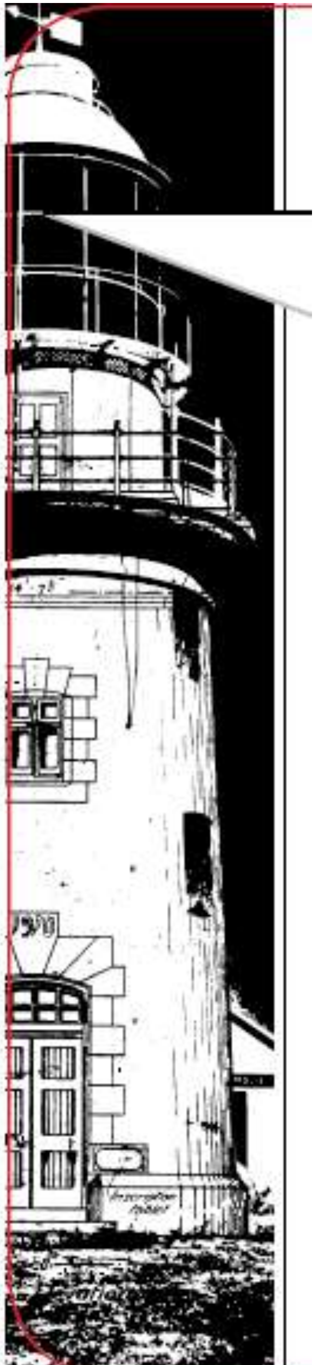
"You are to go to the world's most remote capital city. Then go another 700 miles (1100 km) or so north, and build a technological and engineering marvel. Oh, by the way, you will need to build a town, roads, a power station and a pier. And did I mention the heat and the cyclones?"

Brian Humphreys in "Calls to the Deep"

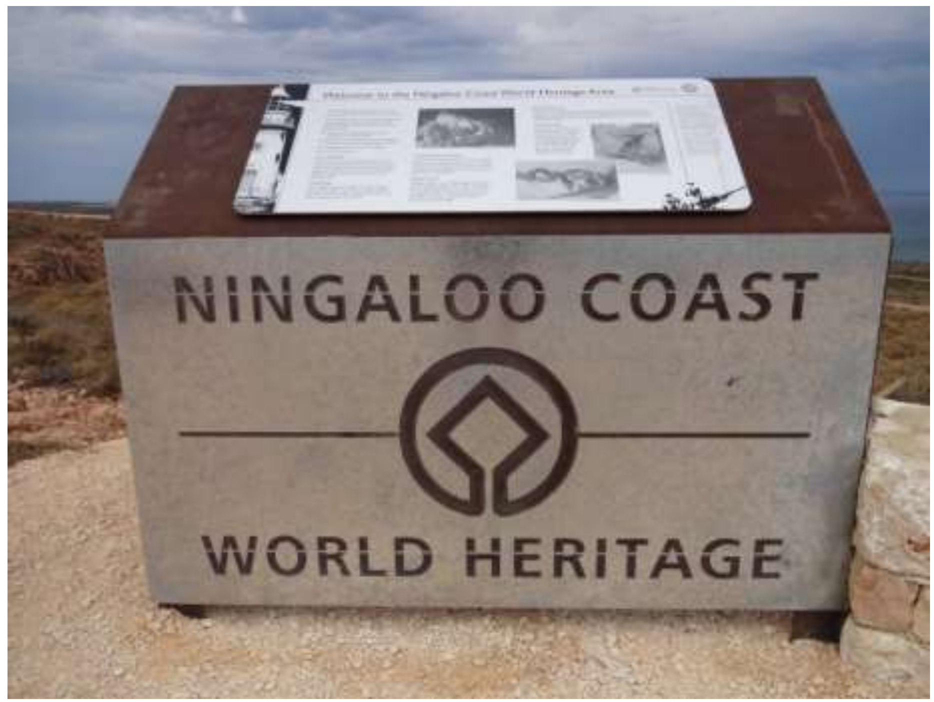





Today...



More Recently……..!!!!!



Exmouth today

2,5000 people, and still many of the old pioneers from the 60ies

Many arrive here as a tourist and never leave, or come for a short term job and stay

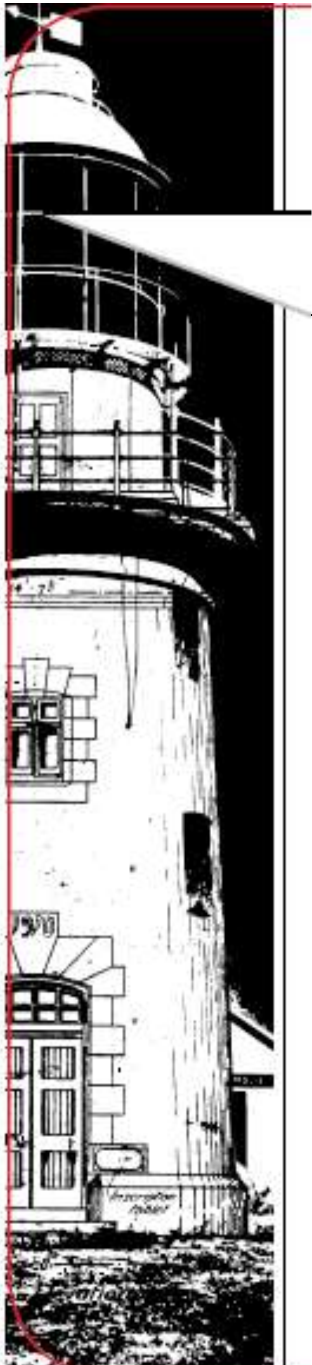
Tourists explore the natural wonders

What would I ask of you…?!

Please show **Respect** for this land's rich cultural and environmental values

How can **Young People** benefit from your conference and your future activities, knowledge and skills?

Be curious and let our community know what you discover – how about a **Community Newsletter**?

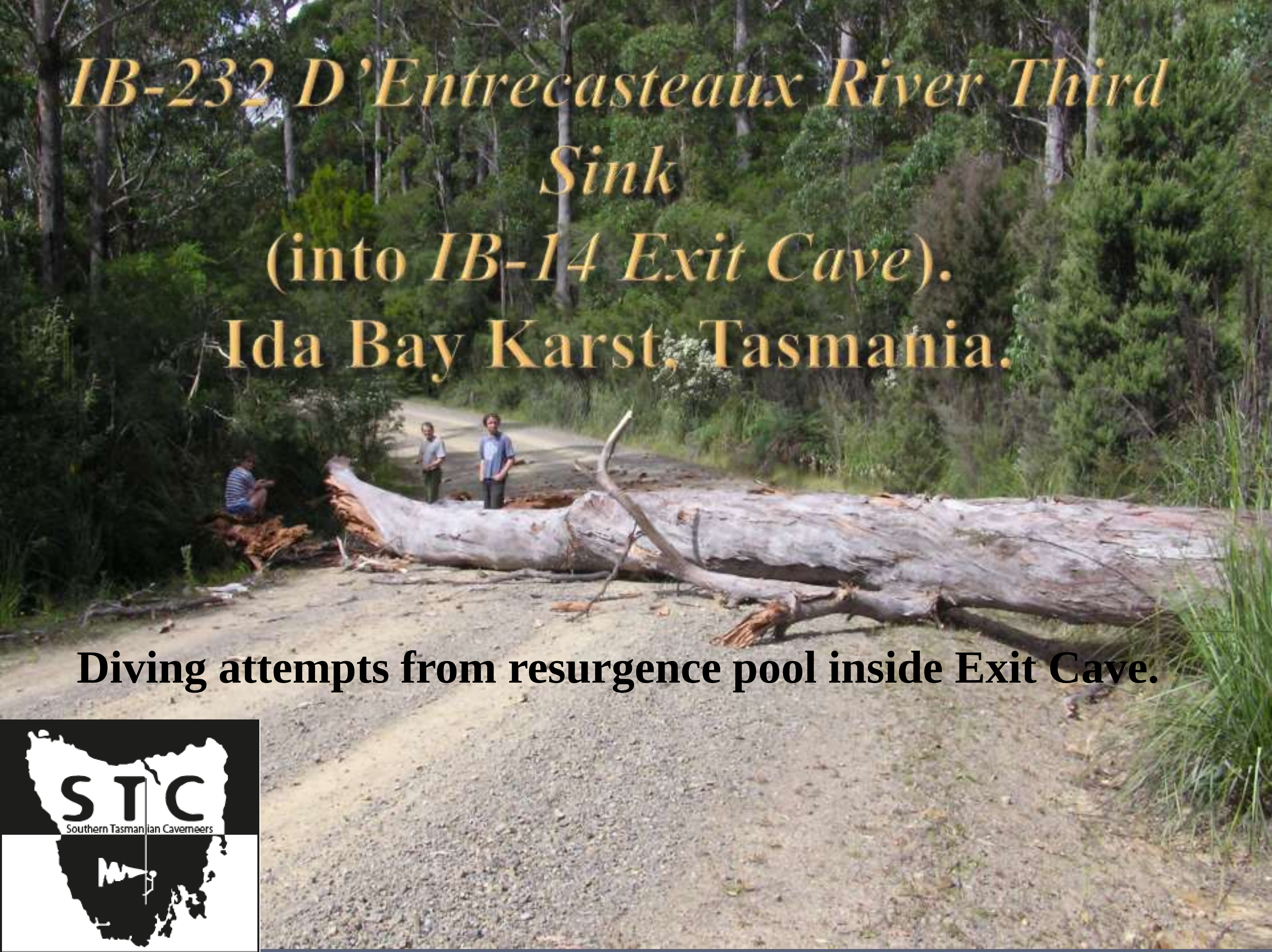


What holds the Future?

Let’s hear it from young people from Exmouth

Appendix E - Perseverance Pays (or why being stubborn can sometimes be useful). IB-232 D'Entrecasteaux River Third Sink, (into IB-14 Exit Cave), Ida Bay Karst, Tasmania.

IB-232 D'Entrecasteaux River Third Sink
(into *IB-14 Exit Cave*).
Ida Bay Karst, Tasmania.



Diving attempts from resurgence pool inside Exit Cave.

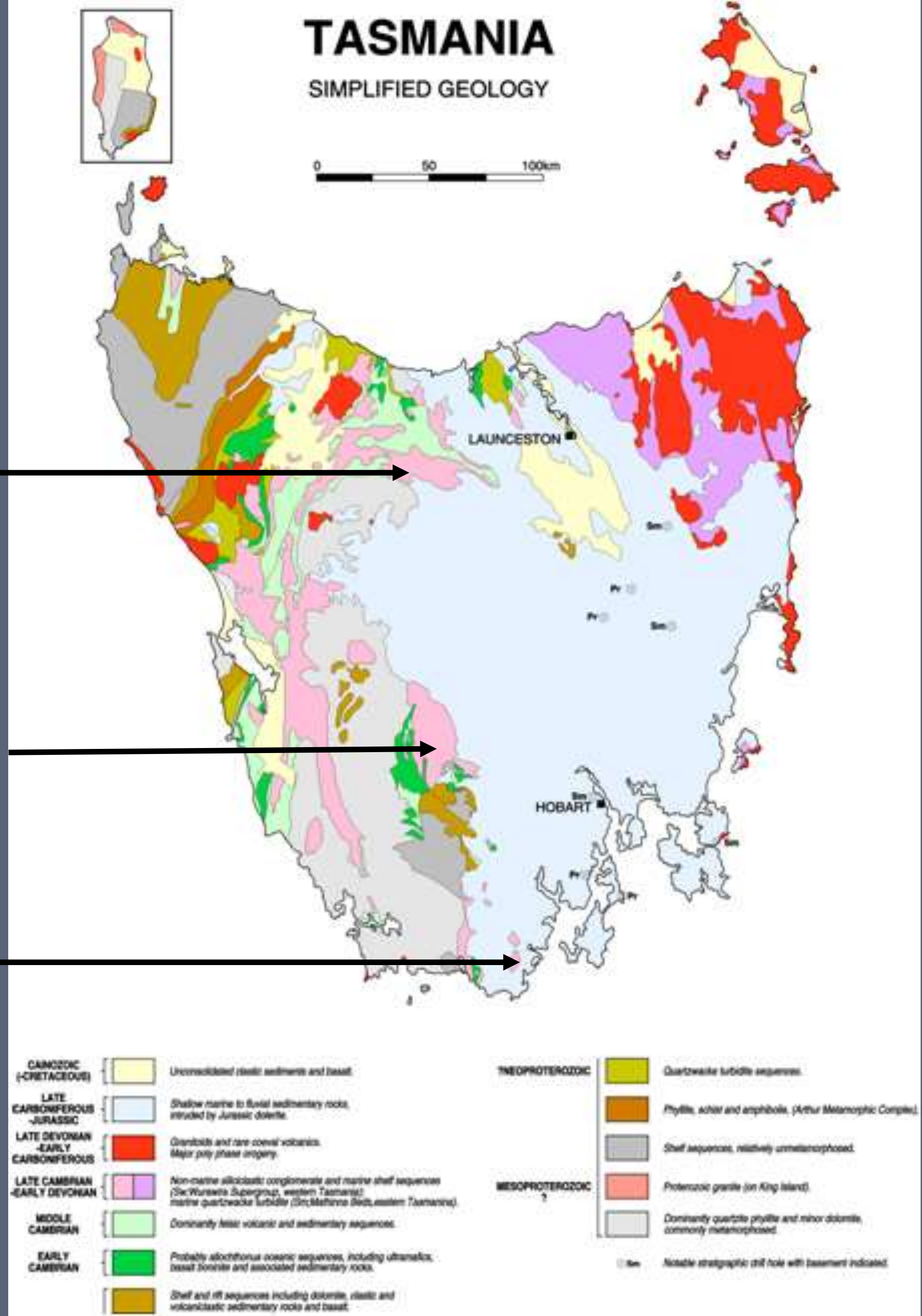
Southern Tasmanian Caverneers

Karst Areas

MC Mole Creek

JF Junee Florentine

IB Ida Bay



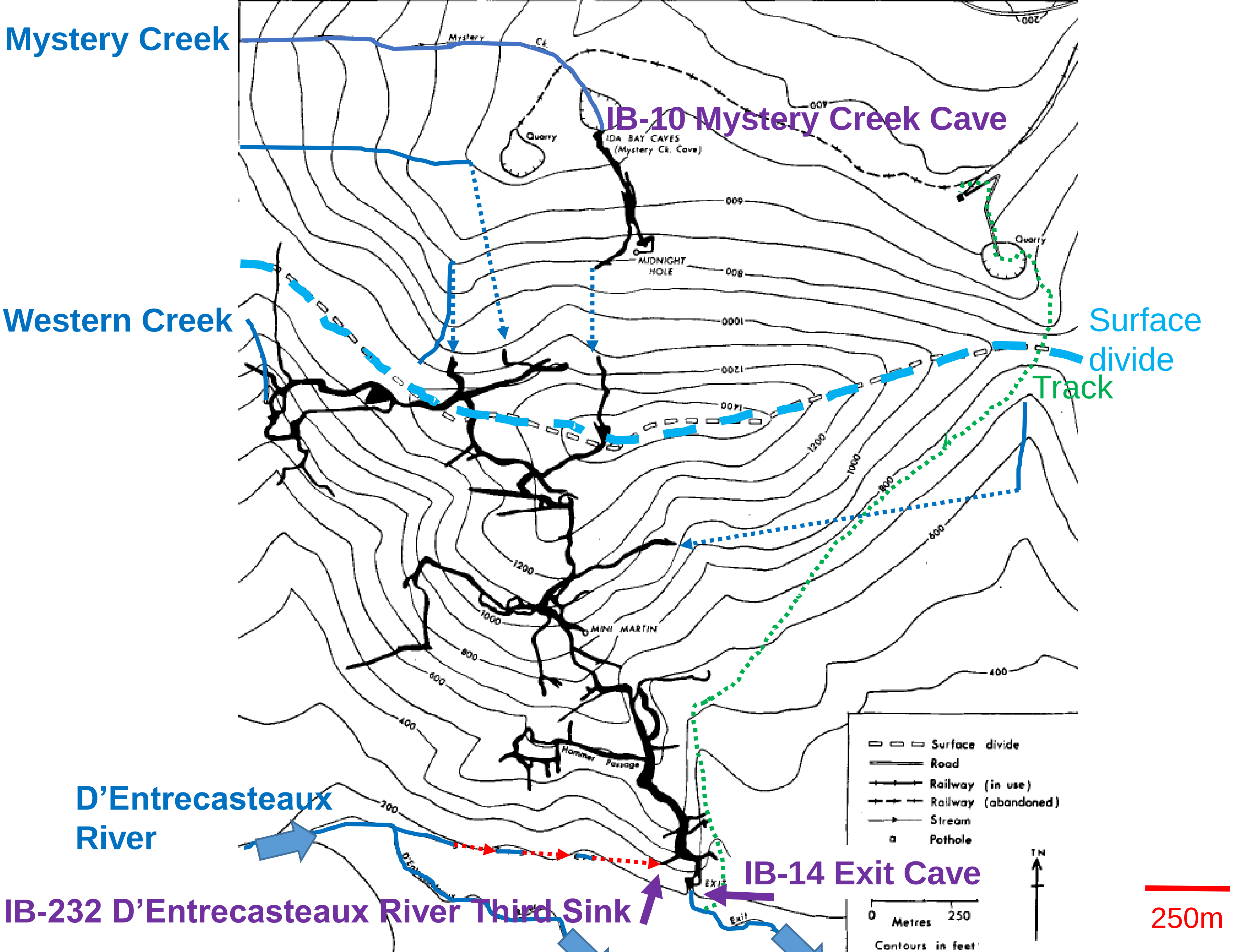
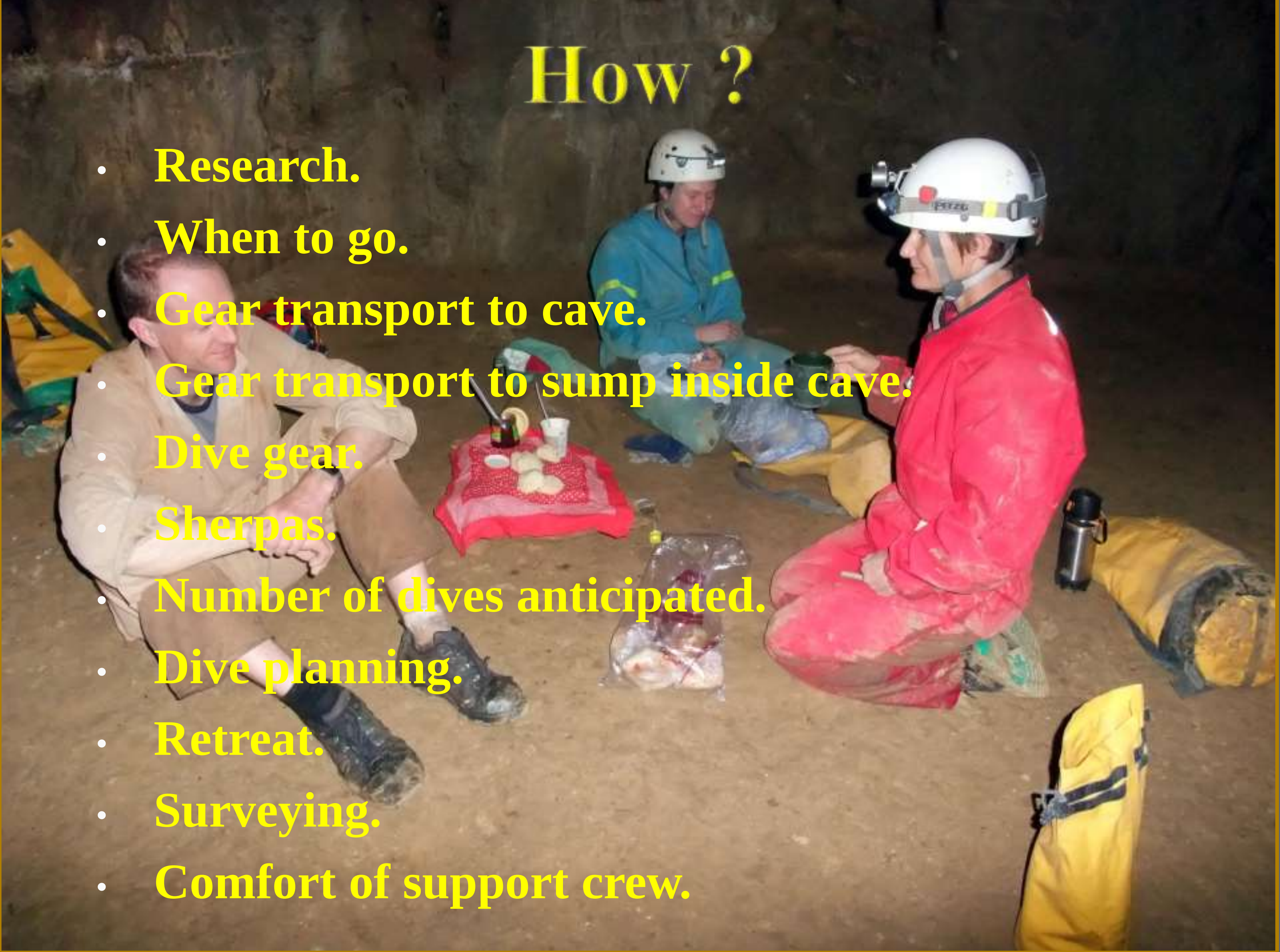


Figure 2. Main cave systems Ida Bay in relation to surface topography.


How ?
Research.
When to go.
Gear transport to cave.
Gear transport to sump inside cave.
Dive gear.
Sherpas.
Number of dives anticipated.
Dive planning.
Retreat.
Surveying.
Comfort of support crew.


Trip one - frustration and disappointment

D’Entrecasteaux Passage, Exit Cave


Trip two - the other end
The main passage named Sign of the Times (SOTT)

SUCCESS

FINALLY

Trip Four - exploration & surveying.

Exit Cave

The Ball Room, Exit Cave

The Ball Room, Exit Cave

The Ball Room, Exit Cave


Trip five - continuation of exploration & surveying

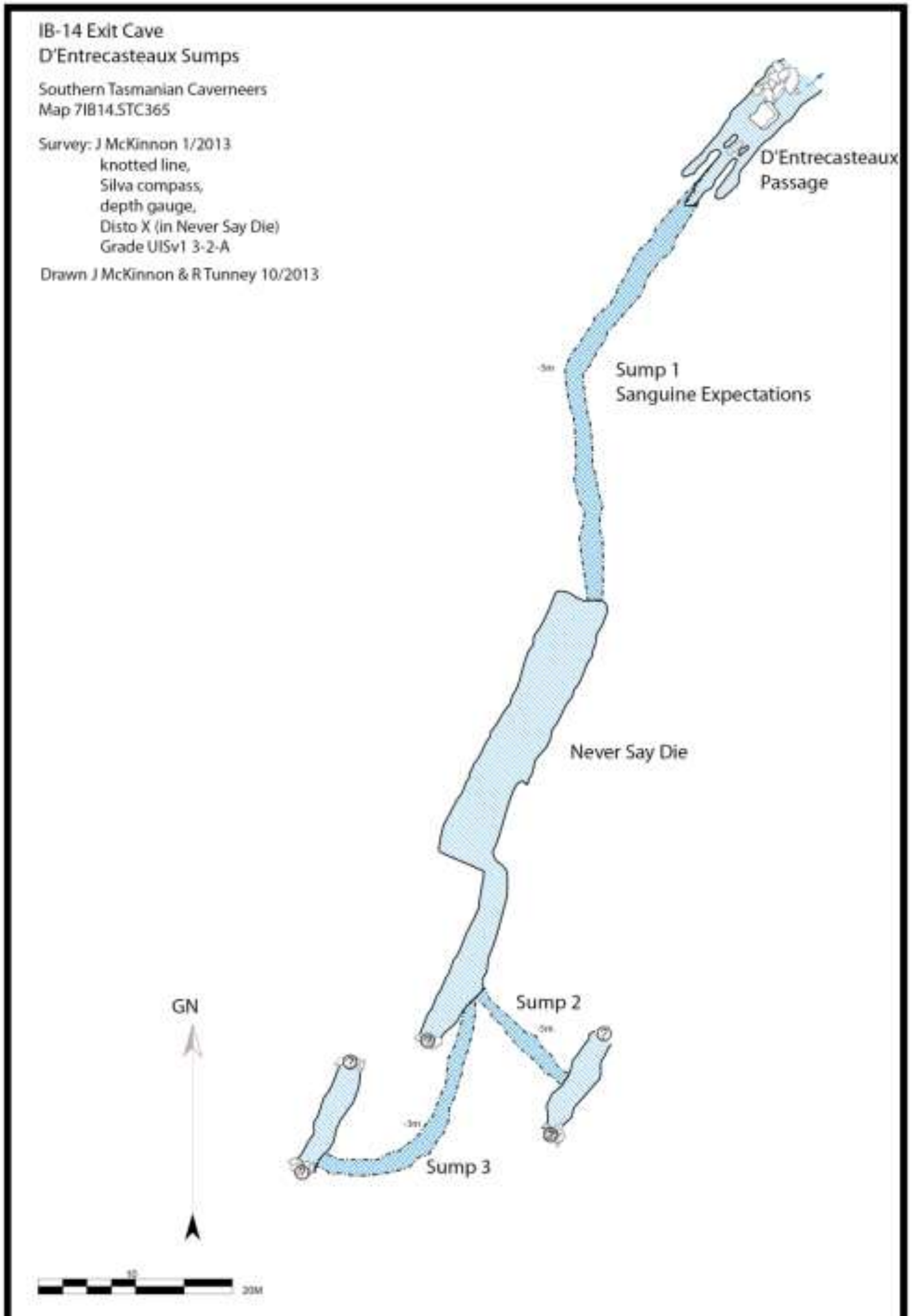
Dives.

- Found sump II.
- Explored beyond - large swimming passage to rockpile.
- Explored beyond - crawling, very muddy passage (usually sump).
- Surveyed sump II to start.
- Found sump III.
- Explored beyond - swimming to rockpile both ends of passage.
- Looked for bypass of rockpiles.
- Surveyed from sump III.

Surveying.

- Solo.
- Poor visibility.
- Some time constraints.
- Instruments:

1. Never Say Die (chamber) - Disto X (laser distance measure with electronic compass and clinometer).
2. IB232 to rockpile- Disto X
3. Elsewhere - depth gauge, knotted line and compass. Line plot only.

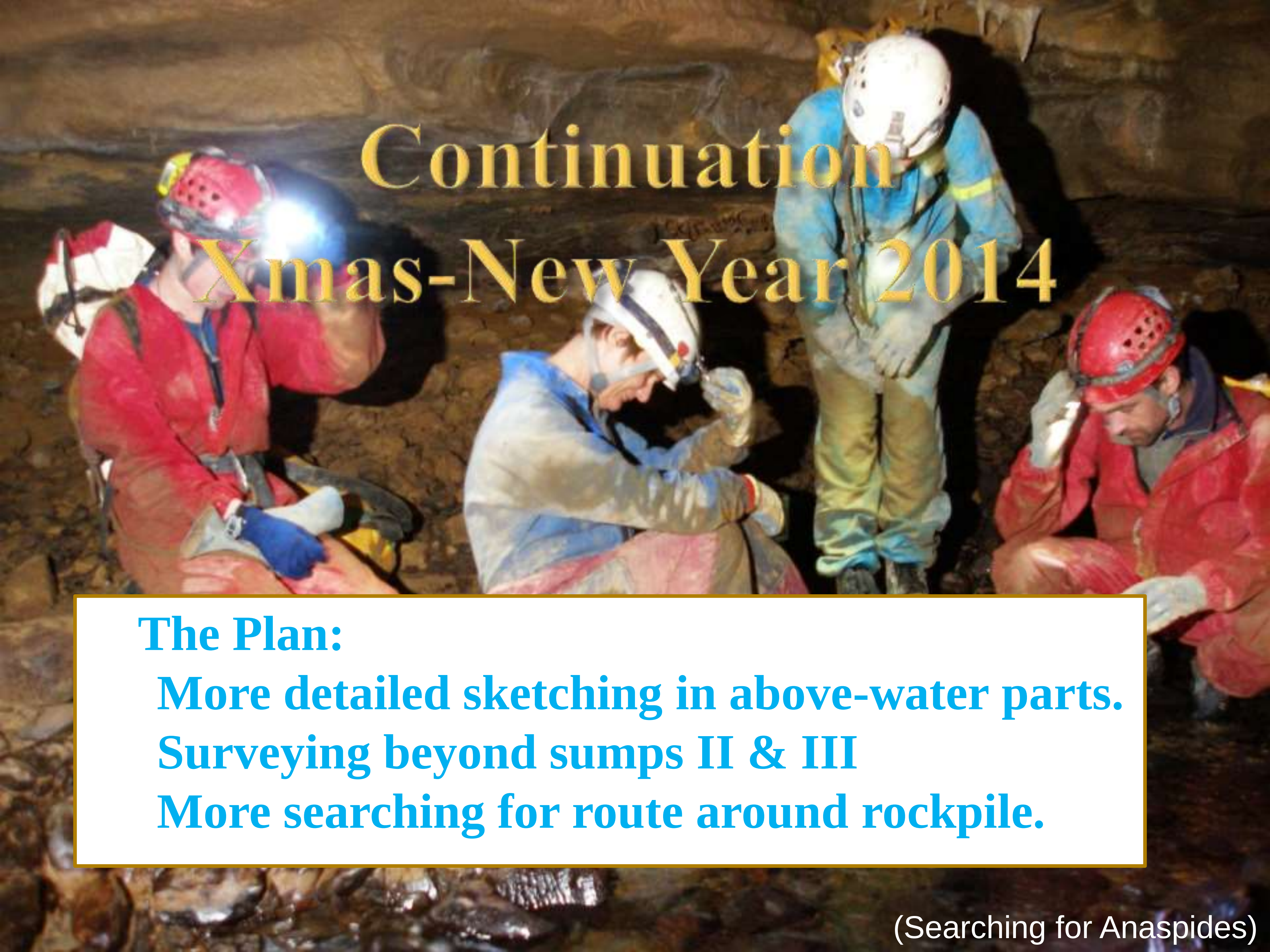

IB-14 Exit Cave
D'Entrecasteaux Sumps
Southern Tasmanian Caverneers
Map 7IB14.STC365
Survey: J McKinnon 1/2013
knotted line,
Silva compass,
depth gauge,
Disto X (in Never Say Die)
Grade UISv1 3-2-A
Drawn J McKinnon & R Tunney 10/2013
D'Entrecasteaux
Passage
Sump 1
Sanguine Expectations
Never Say Die
GN
Sump 2
Sump 3


IB86
Slip-In
IB232
IB161
Bobs
Hole
IB87
Drop-In
IB-14
Exit Cave
IB191


The Last Straw
Waddenlensplosh
Wigwomwoom
Lost Squeeze
Conference Concourse
The Bermuda Triangle
Hard Mans Way
Broken Column Chamber
The Beach
Eastern Grand Fissure
Mystery Creek Extension
Kellars Squeeze
Western Grand Fissure
Southern Passage
Great Expectations Tributary
The Dig
Wooly Jumper Room
Eastern Passage
Little Grunt Streamway
Gumboot Gallery
Inner Base Camp
Edies Treasure
Western Arthurs
Wall of Despair
Western Passage
Angels Lair
Dribble Loop
Devils Stovepipe
The Ballroom
Colonades
Hammer Passage
Edies Trash
D'Entrecasteaux Sump
Balls & Udder
Wind Tunnel
Grid North
MGA94
Exit Cave - Draft A3 wall detail map
26th January 2015
STC
Southern Tasmanian Caveneers
0
125
250
500
Metres
1:5500 when printed at A3

Overview:

- Six trips
- Four dive trips
- Permanent line laid into SE entrance
- Exploration line left in-situ
- 150m passage surveyed
- Connection not made
- Leads poor but not exhausted


Continuation
Xmas-New Year 2014
The Plan:
More detailed sketching in above-water parts.
Surveying beyond sumps II & III
More searching for route around rockpile.
(Searching for Anaspides)

What actually happened

I gained a dive/exploration/surveying buddy, which was good

We had NO sherpas, and two divers' worth of gear, which wasn't good

We found the way through the rockpile to SOTT on the first day

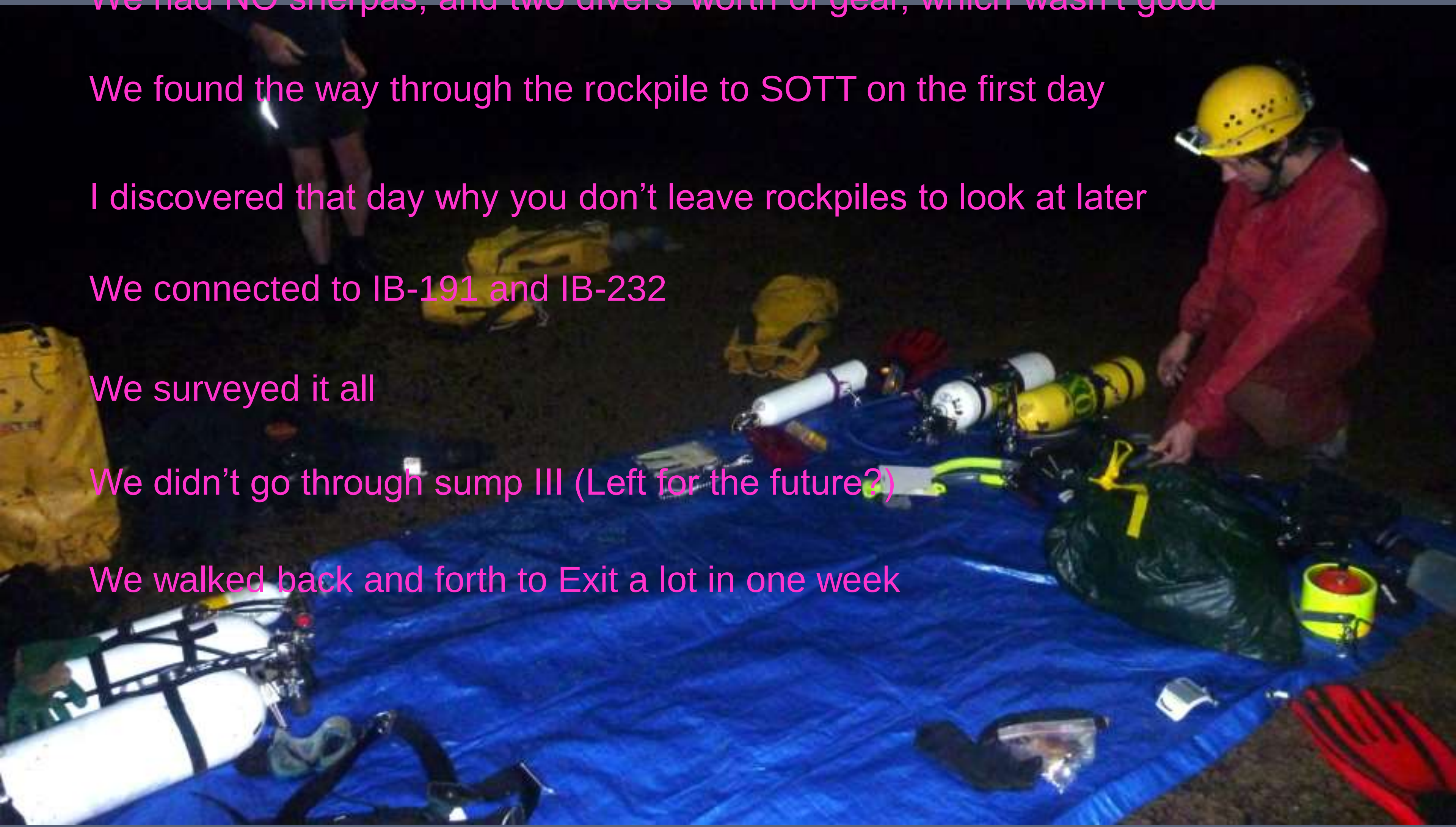
I discovered that day why you don't leave rockpiles to look at later

We connected to IB-191 and IB-232

We surveyed it all

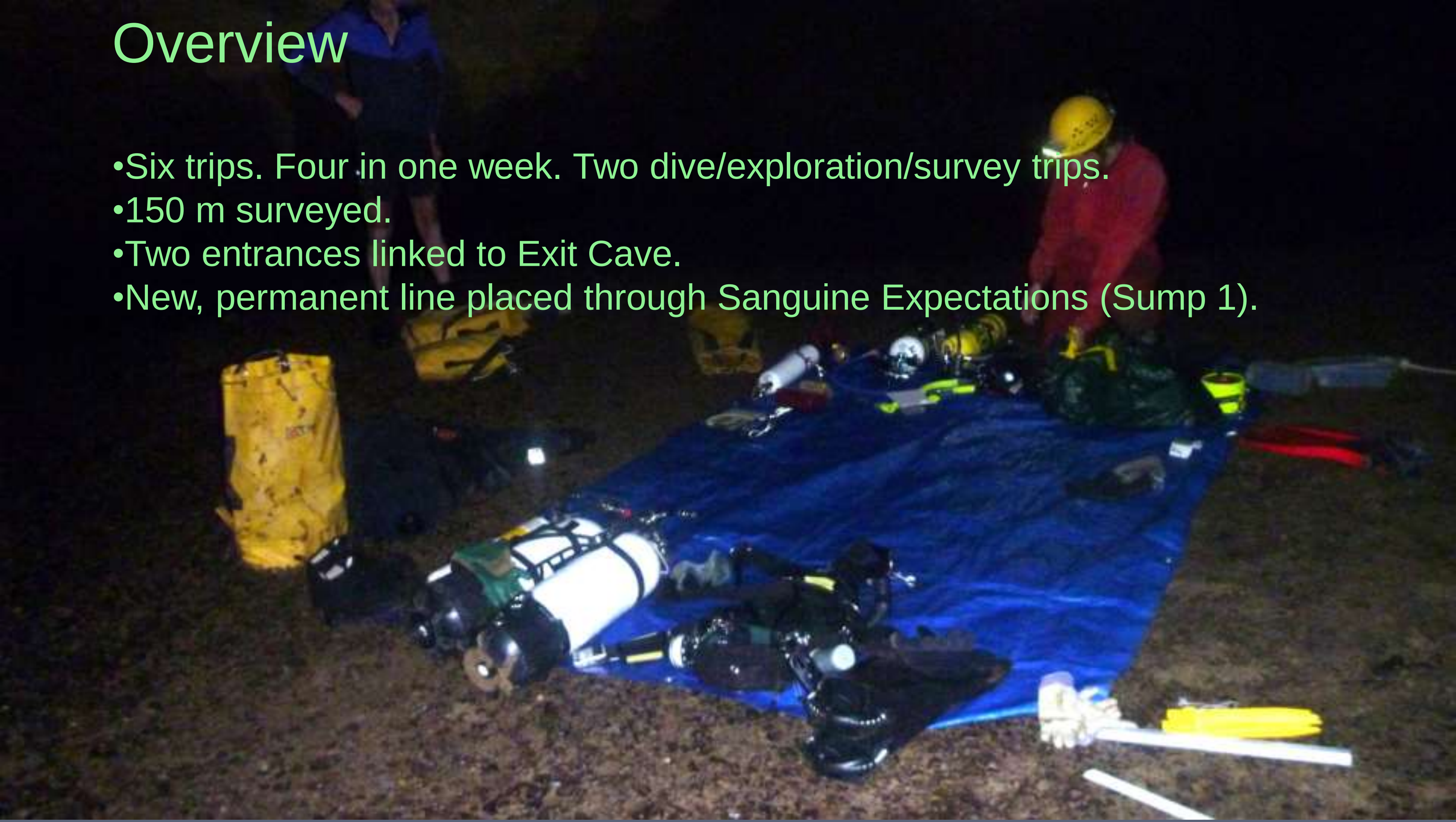
We didn't go through sump III (Left for the future?)

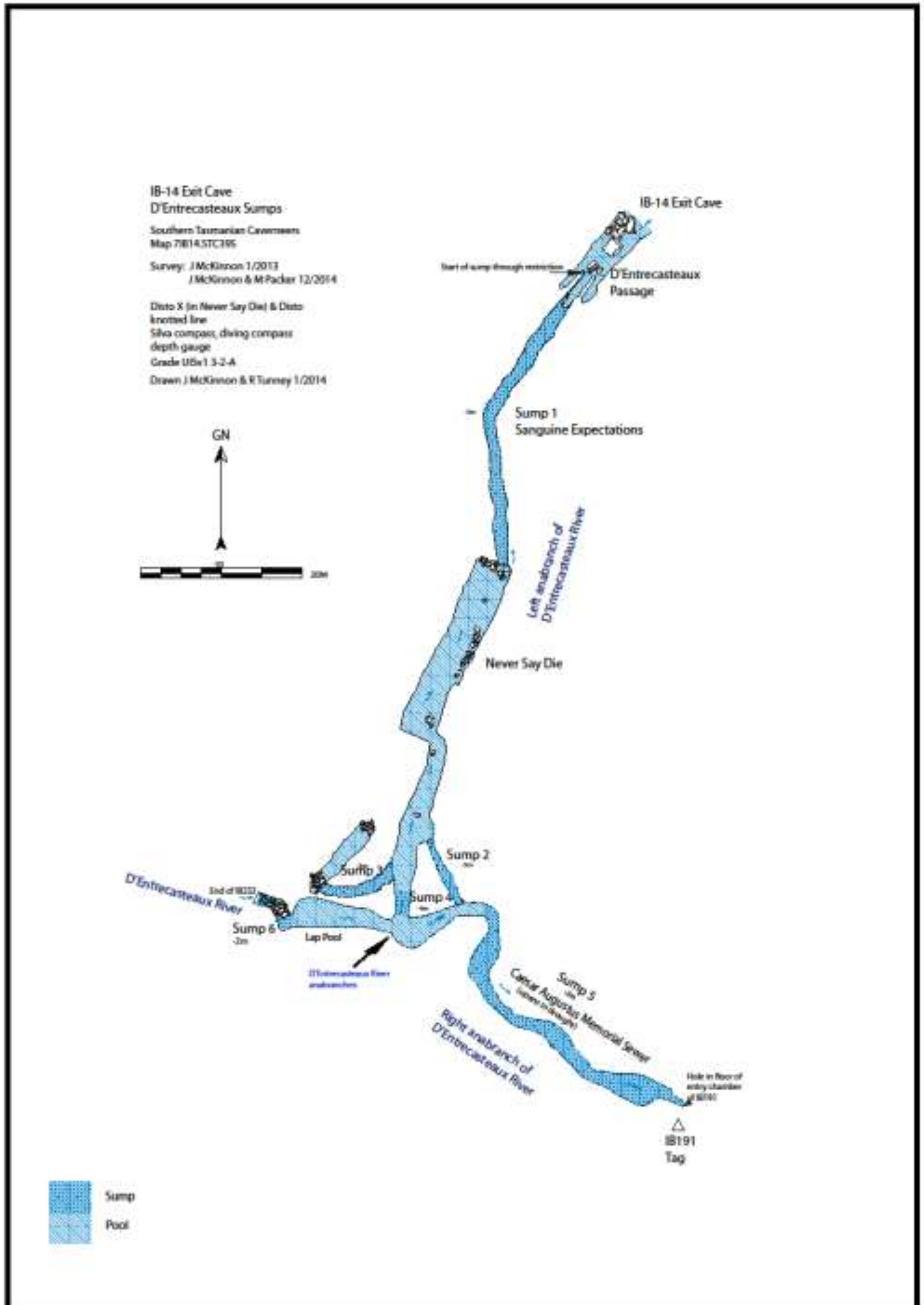
We walked back and forth to Exit a lot in one week

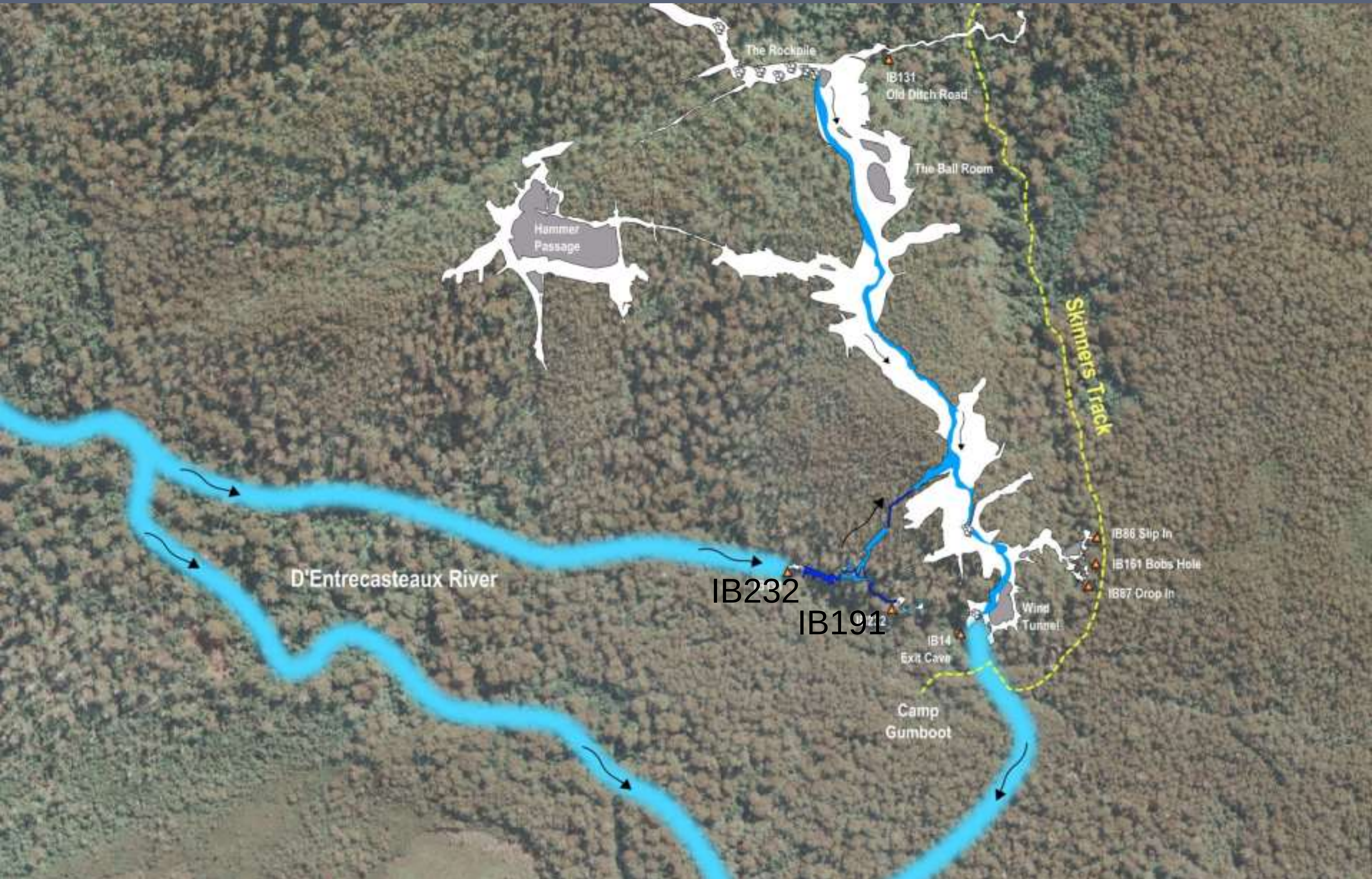


Overview

•Six trips. Four in one week. Two dive/exploration/survey trips.
•150 m surveyed.
•Two entrances linked to Exit Cave.
•New, permanent line placed through Sanguine Expectations (Sump 1).




IB-14 Exit Cave
D'Entrecasteaux Sumps
Southern Tasmanian Caverneers
Map 7IB14.STC395
Survey: J McKinnon 1/2013
J McKinnon & M Packer 12/2014
Disto X (in Never Say Die) & Disto
knotted line
Silva compass, diving compass
depth gauge
Grade UISx1 3-2-A
Drawn J McKinnon & R Tunney 1/2014
GN
IB-14 Exit Cave
D'Entrecasteaux Passage
Sump 1
Sanguine Expectations
Left anabranch of D'Entrecasteaux River
Never Say Die
Sump 2
Sump 3
Sump 4
D'Entrecasteaux River
Sump 6
-2m
Lap Pool
Sump 5
Caesar Augustus Memorial Sewer
Right anabranch of D'Entrecasteaux River
IB191
Tag
Sump
Pool


The Rockpile
IB131
Old Ditch Road
The Ball Room
Hammer
Passage
Skinners Track
D'Entrecasteaux River
IB232
IB191
IB86 Slip In
IB161 Bobs Hole
IB87 Drop In
Wind
Tunnel
IB14
Exit Cave
Camp
Gumboot

Results

The end of D'Entrecasteaux Passage in *IB-14 Exit Cave* has been linked to both *IB-191* and *IB-232 D'Entrecasteaux River Third Sink*.

The D'Entrecasteau River Anabranch has been found to anabranch while underground. One anabranch flows into D'Entrecasteaux Passage, the other anabranch flows through *IB-191* and resurges in the rockpile at the entrance to *IB-14 Exit Cave*.

Special thanks to:
Ric Tunney
Michael Packer

Thanks to:
Chris Coxson
Johnathan Esling
Mark Euston
Alan Jackson
Fraser Johnston
Pierre-Dominique Putallaz
Laura Putallaz
Amy Robertson
Ian Stewart

Photo credits:
Johnathan Esling
Fraser Johnston
Janine McKinnon
Ric Tunney

STC
Southern Tasmanian Caverneers

D'Entrecasteaux Passage, Exit Cave

Appendix F - YTIVARG - There, and back again. Sump II, JF-4 Kazad-Dum, Junee-Florentine Karst, Tasmania.

YTIVARG – There, and back again

STC
Southern Tasmanian Caverneers

Exploration in:

Sump II, *JF-4 Khazad-Dum*

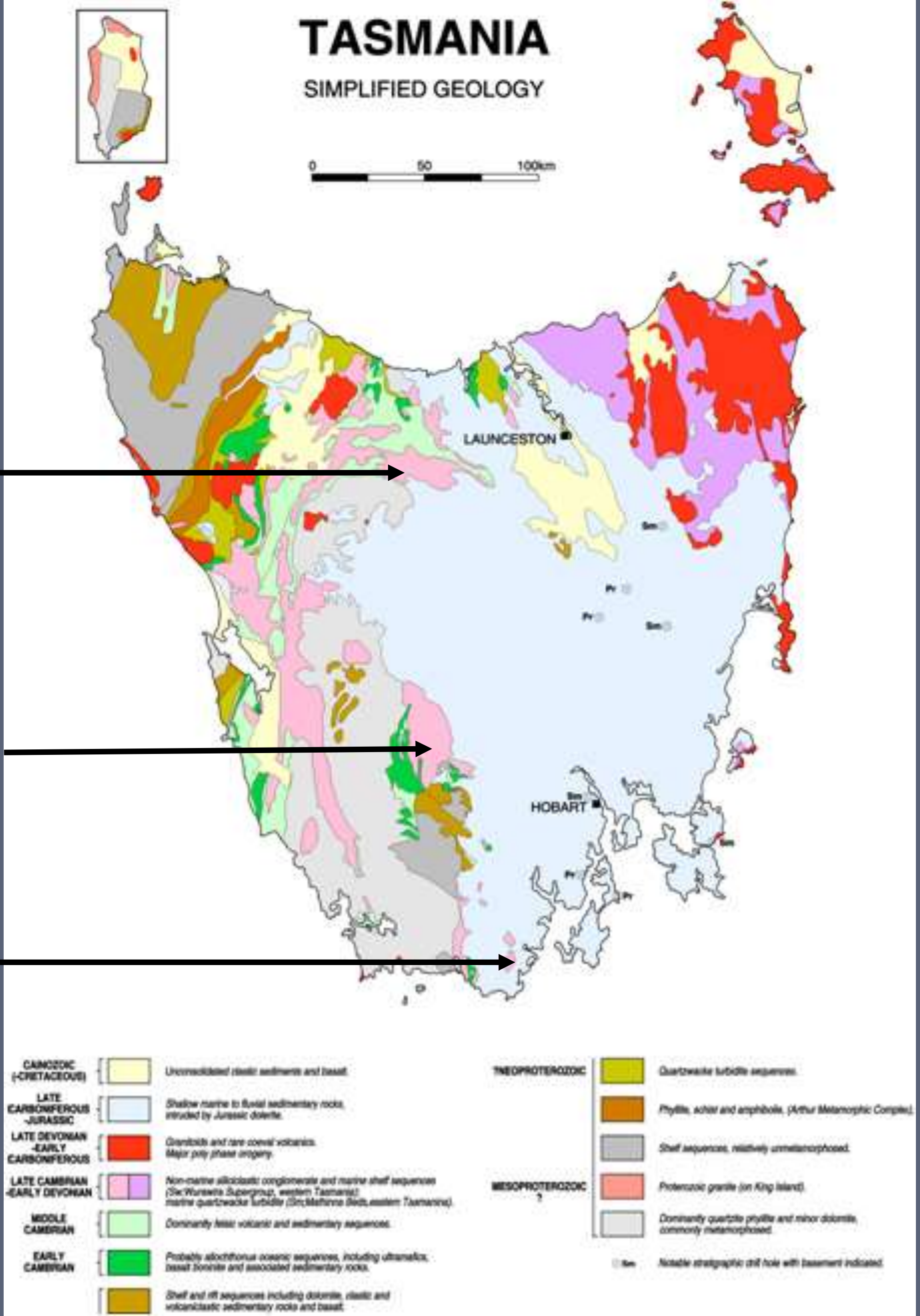
Junee-Florentine Karst, Tasmania.

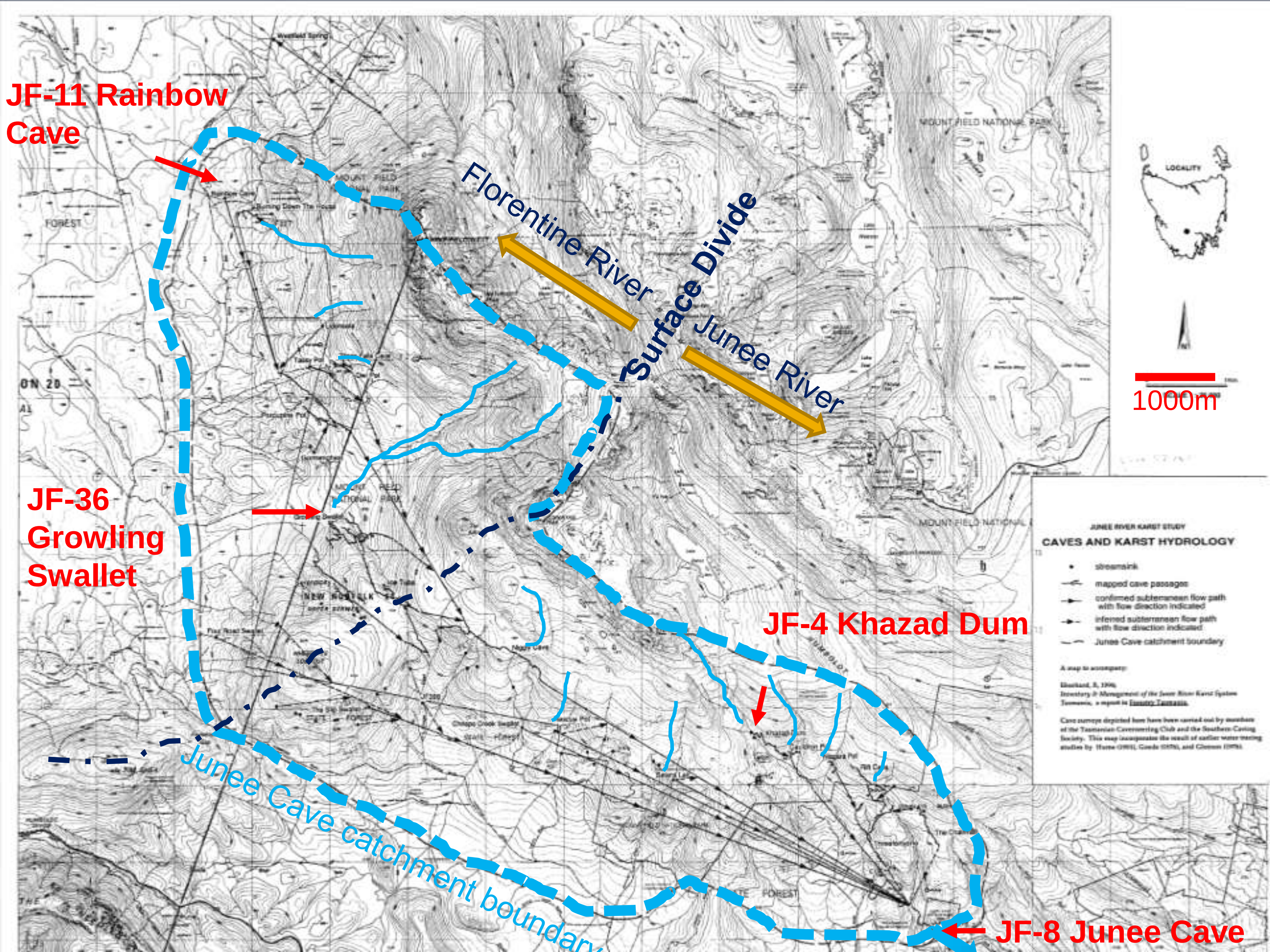
Major Karst Areas

MC Mole Creek

JF Junee Florentine

IB Ida Bay




JF-11 Rainbow Cave
Florentine River
Surface Divide
Junee River
1000m
JF-36 Growling Swallet
JF-4 Khazad Dum
Junee Cave catchment boundary
JF-8 Junee Cave
MOUNT FIELD NATIONAL PARK
LOCALITY
JUNEE RIVER KARST STUDY
CAVES AND KARST HYDROLOGY
streamsink
mapped cave passages
confirmed subterranean flow path with flow direction indicated
inferred subterranean flow path with flow direction indicated
Junee Cave catchment boundary
A map to accompany:

Cauldron Pot

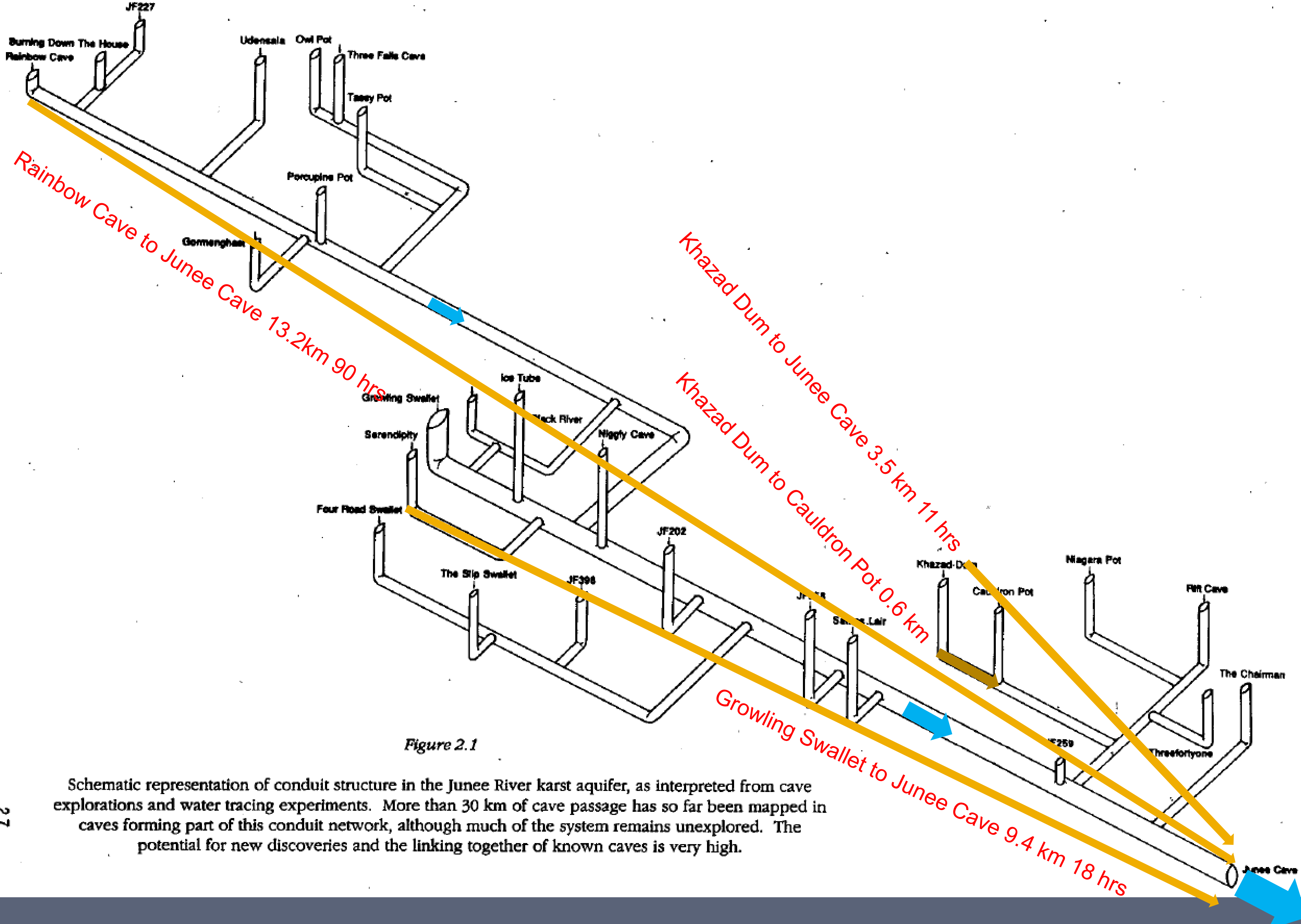


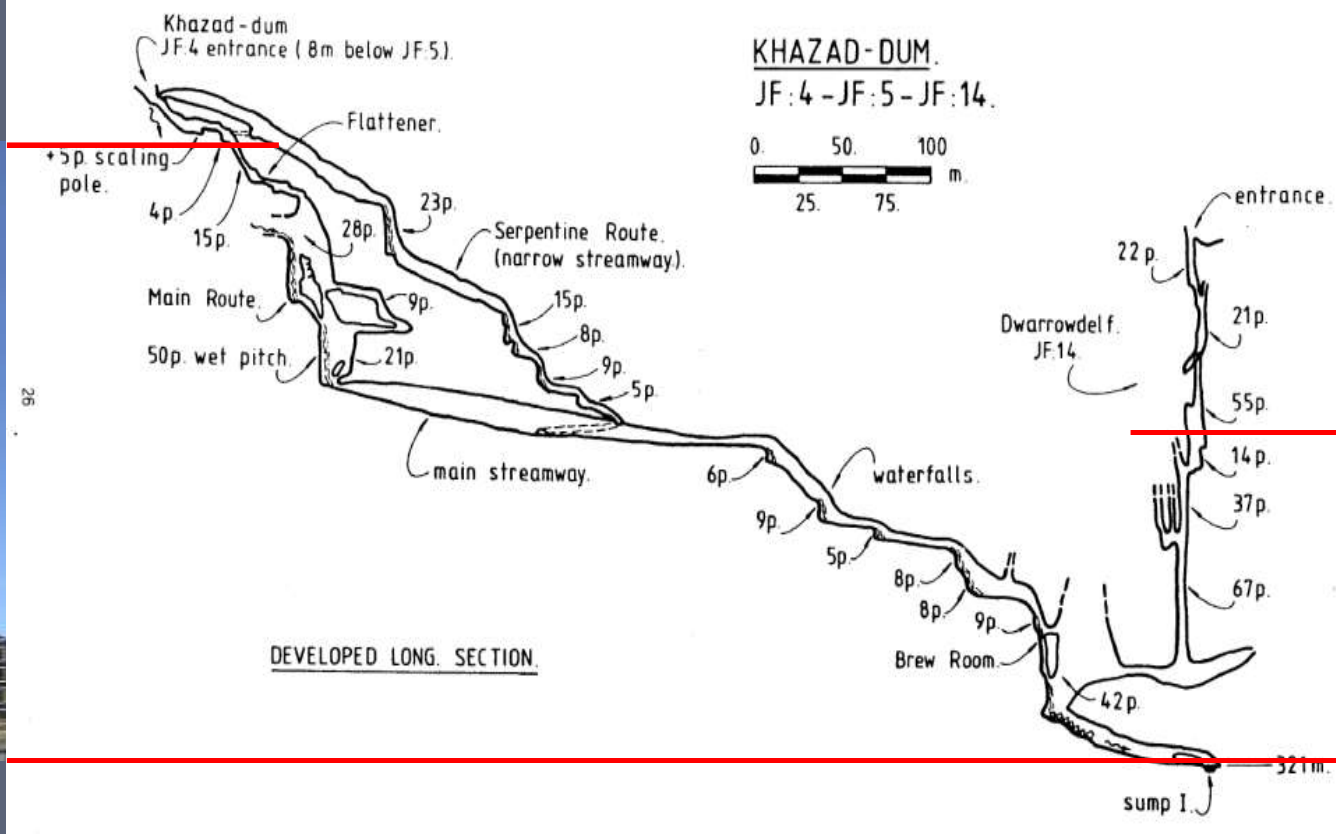
Figure 2.1

Schematic representation of conduit structure in the Junee River karst aquifer, as interpreted from cave explorations and water tracing experiments. More than 30 km of cave passage has so far been mapped in caves forming part of this conduit network, although much of the system remains unexplored. The potential for new discoveries and the linking together of known caves is very high.


Sump II,
JF-4 Khazad-Dum

Why?

- Add 50m to cave system depth.
- Open lead.
- Because it’s there.



Eureka Tower Melbourne 298m (Tallest building to roof in Australia)

JF-4 Khazad Dum extended section

Central Park Perth 226m to roof

How?

- **Research.**

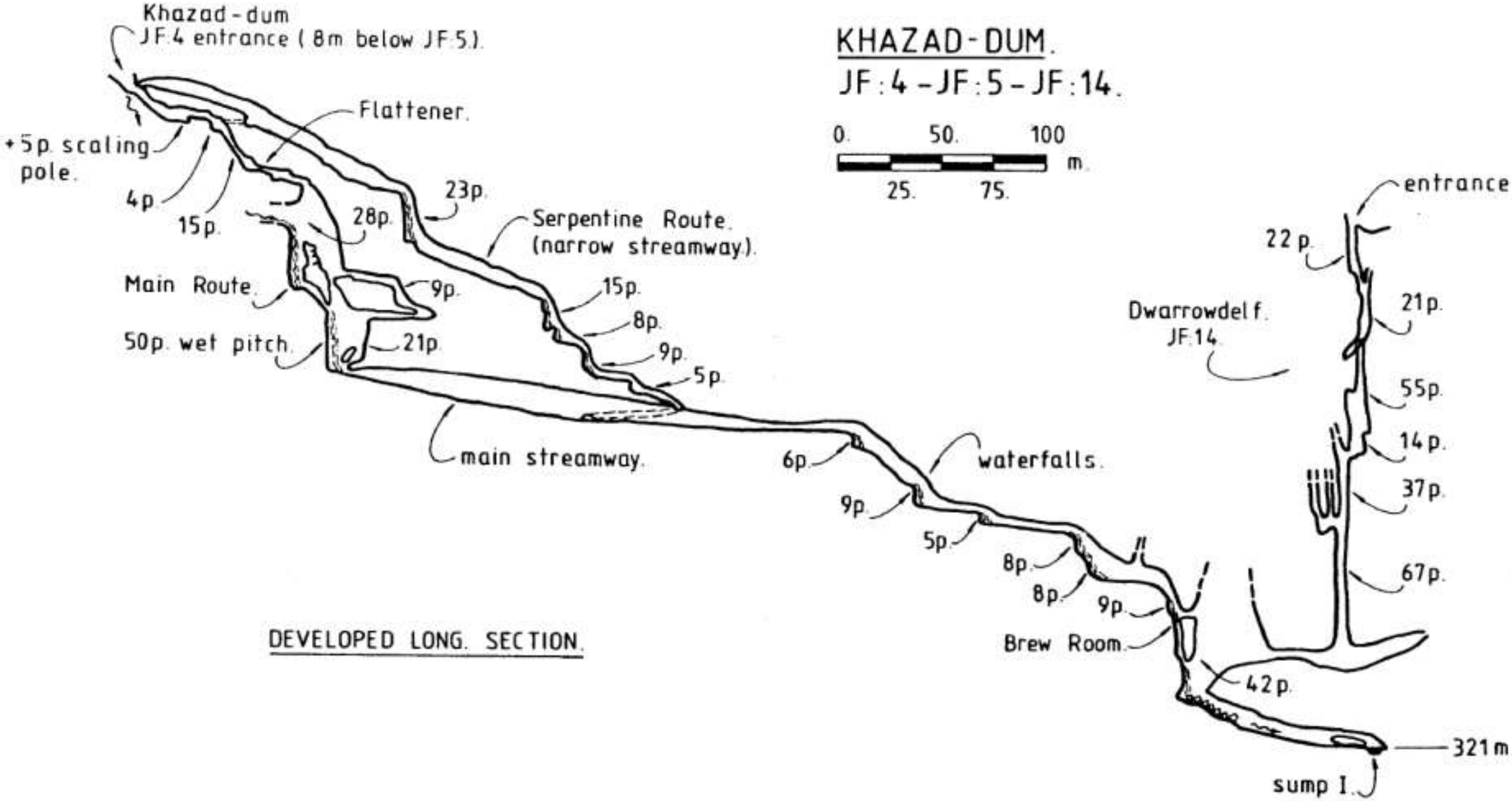
Previous dives

- 1987. Phil Hill. 1 dive. 7 minutes. N direction along rift. Too narrow after 35m.

- 2005. Stefan Eberhard. 1 trip/2 dives. SW direction.
- He "…*continued on through small horizontal passage …The passage curved to the right and appeared to be trending upwards slightly at my furthest point,.. i.e. it's still going .*"

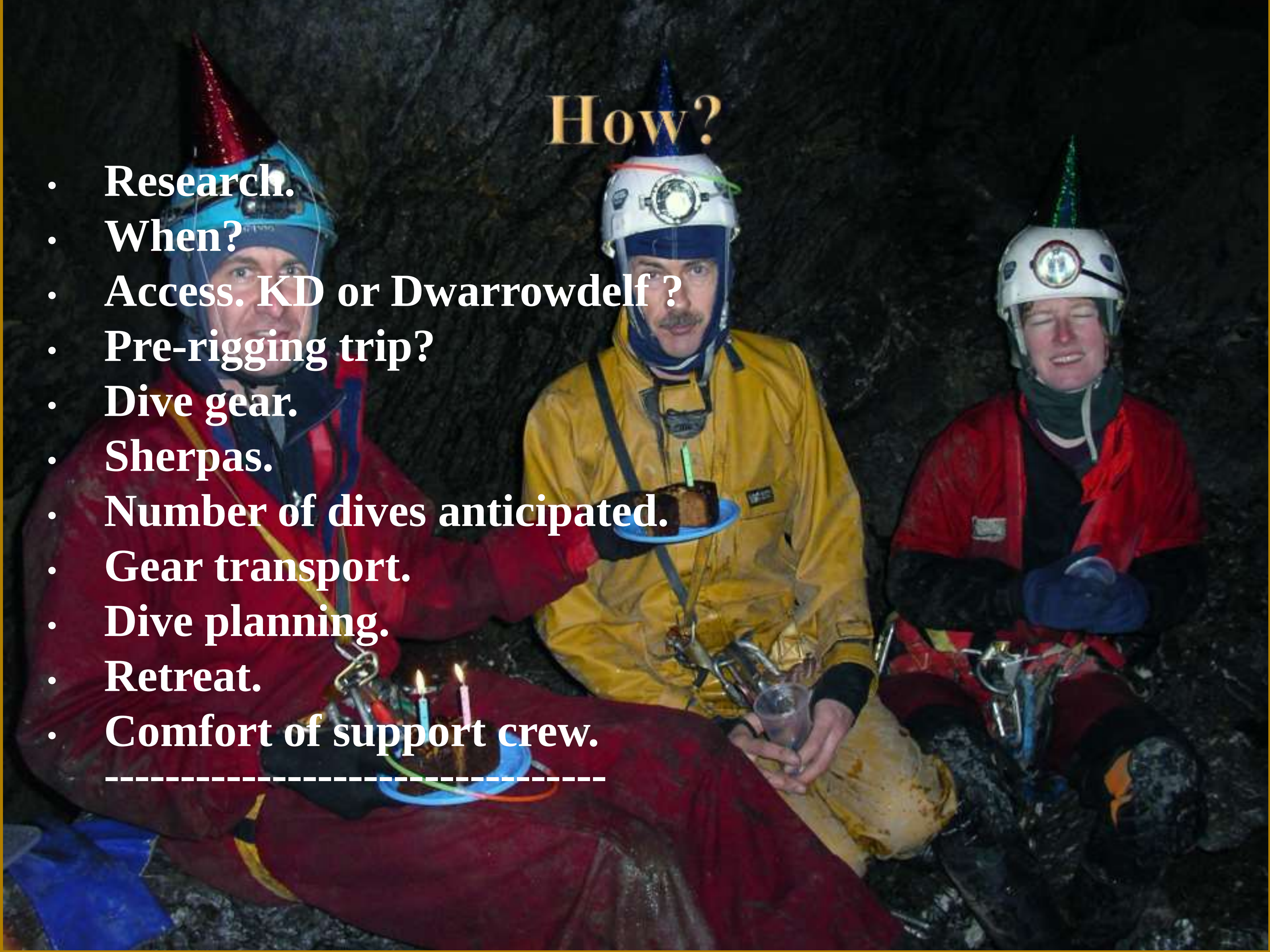
How?

- **Research.**
- **When?**
- **Access - KD or Dwarrowdelf ?**


KHAZAD-DUM.
JF:4 - JF:5 - JF:14.
0. 50. 100
25. 75. m.
Khazad-dum
JF:4 entrance (8m below JF:5).
+5p. scaling pole.
4p.
15p.
Flattener.
28p.
23p.
Serpentine Route.
(narrow streamway).
Main Route.
9p.
50p. wet pitch.
21p.
15p.
8p.
9p.
5p.
main streamway.
6p.
waterfalls.
9p.
5p.
8p.
8p.
9p.
Brew Room.
42p.
321m.
sump I.
Dwarrowdelf.
JF:14.
entrance.
22p.
21p.
55p.
14p.
37p.
67p.
DEVELOPED LONG. SECTION.

Dwarrowdelf access

- pitches - 22m, 21m, 55m, 14m, 37m, 67m
- then 20m handline
- then along about 100m of crawls and restrictions.



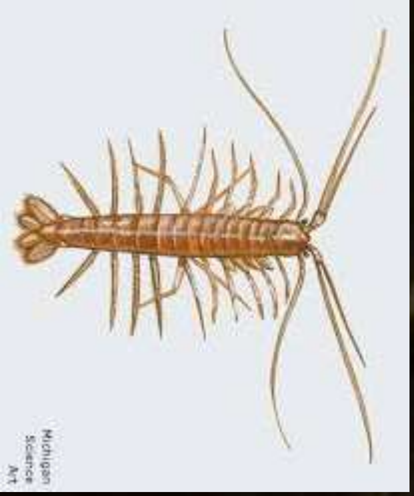
How?

- **Research.**
- **When?**
- **Access. KD or Dwarrowdelf ?**
- **Pre-rigging trip?**
- **Dive gear.**
- **Sherpas.**
- **Number of dives anticipated.**
- **Gear transport.**
- **Dive planning.**
- **Retreat.**
- **Comfort of support crew.**


Dive trip 1

Dive 1

- Pool depth 17m.
- Line buried in deep silt but intact.
- Small passage (0.5m H X 1.5m W) going SW.
- Reached end of Stefan's exploration.
- Water temperature: 6ºC.
- Numerous white *Anaspides tasmanie*



Anaspides tasmanie

Dive 2

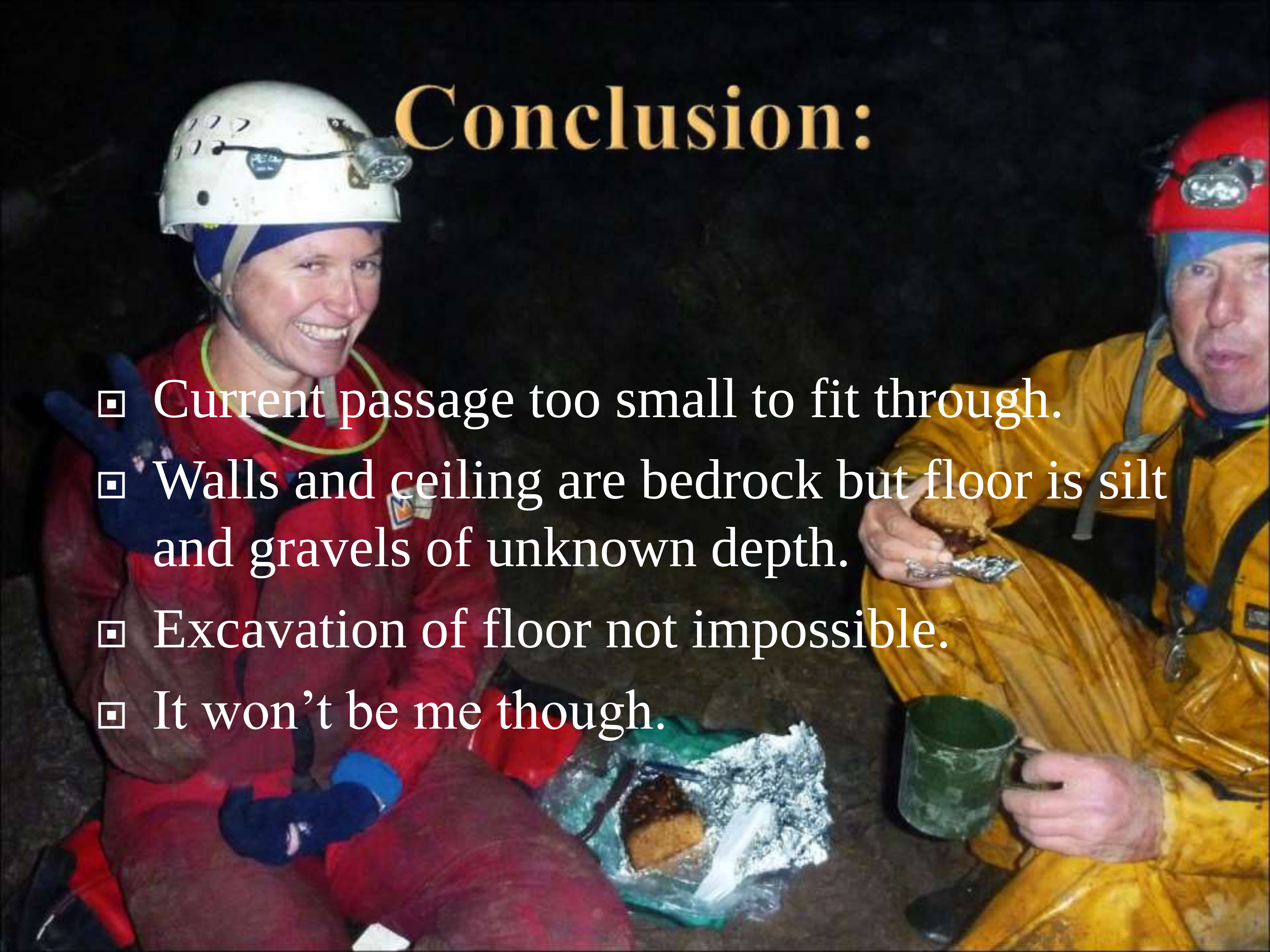
- Visibility in pool cleared to 0.5m again, visibility in side passage still zero.
- Added 7 metres new line.
- Passage tending upward at 45 degrees, narrowing significantly, and lowering.
- Dive time: 25 minutes.

Dive trip 2

- One week later.
- Tanks refilled. Drysuit, undersuit, delicate gear carried in again.
- Heavy rain during the week.

Dive 3

- Visibility 15 cm.
- Gained 5 m more.
- Unable to fit head through restriction.
- Started systematic search of pool.
- No other leads found.
- Dive time: 30 minutes



Conclusion:

- Current passage too small to fit through.
- Walls and ceiling are bedrock but floor is silt and gravels of unknown depth.
- Excavation of floor not impossible.
- It won’t be me though.

Surveying - why not?

- Exploration line did not have knots.
- 6ºC water temperature limits dive time per dive. Extra dives required.
- Inflow, high silt dive. Very short survey time per dive.
- Skills and fitness required of sherpas limits available sherpas for multiple survey trips.
- Cave does not “go”.


Overview
•4 trips - 1 Rigging, 2 dive, 1 de-rigging
•40 kgs of dive gear to sump and return once
•25 kgs of dive gear did the trip twice
•Approx. 12m new cave gained

Special thanks to:
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Thanks to:
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Chris Coxson
Andreas Klocker
Ken Murrey
Jane Pulford

Photo credits:
Janine McKinnon
Jane Pulford
Ric Tunney
Chris Coxson

STC
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The troglobitic spider *Bengalla bertmaini* in Papillon Cave, Cape Range (Tim Moulds)