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FRONT COVER: Nettlebed Cave, New Zealand

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EDITORIAL

Steve Bourne

Between Journal 108 and this Journal 109, I advised President Dale Calnin that I would be stepping down as Publication Officer at the AGM to be held In Margaret River in May. The time required to produce a quality journal and the time I seem to have available now no longer match. It is time for someone else to take the role on and build on the tradition of ACKMA journals. I doubt it is very common for an organisation with the longevity of ACKMA to have only ever had 2 people publish their journal; Kent Henderson produced an amazing 82 and my tally will stop at 28.

In Journal 108, I reproduced Scott Hocknull's article from the Australian Age of Dinosaurs magazine, maintaining their format as requested. This seemed to work quite well so I have used the same methodology for Mary Traye's article; her Field Guide used for the post UIS Congress excursion. Mary has quite a deal of experiencing in producing newsletters and field guides and it seemed a pity to pull it a part just for the sake of a different format. And its much quicker to do as well!

John Brush alerted me to a couple of nice articles on Thailand and Xe Bang Fei Cave in Laos when he visited Naracoorte last August. He put me in contact with the author Terry Bolger and the Xe Bang Fei Cave article is printed in this journal. The Thailand Caves article will appear in the next journal. I had not heard of Xe Bang Fei Cave prior to seeing this article but its strange how things work out. One of the participants in the post IUS congress excursion Liz Reed and I hosted, Augusto Auler, said he was arranging a trip to Vietnam and Laos in 2018. Plans have fallen into place very nicely and I am joining Augusto and his friends for a 3 week caving trip into Vietnam and Laos which includes Xe Bang Fei and Son Doong Caves. It is a fair chance there will be an article for the new Publication Officer from this trip!

John Brush and Marjorie Coggan have been travelling again and John has kindly provided two articles. One is on a visit to Höllgrotten, Switzerland and, as usual, John has given a nice overview of the tour and the management of the site. For anyone who travels and writes up a cave visit for the ACKMA Journal, take a look at how John does it.

John is chairman of the IUS Commission on Volcanic Caves and has written a piece promoting the Vulcanospeleology Symposium to be held this year in Northern California. One day I would love to attend one of these events but unfortunately in wont be this year.

A group of ACKMA members; David Gillieson, Andy Spate, Ann Augusteyn, Jodie Anderson and Scott Melton, have produced a guide survey. The purpose is to identify the level of training provided to cave guides and opportunities for this to be improved, possibly with ACKMA playing a role in this. All guides and managers are encouraged to complete this survey. as an incentive, ACKMA is offering registration fees for the Margaret River ACKMA conference. you will need to prioritise this as entries close 28 February.

Nicholas White brought my attention to a cave-monitoring website; www.cave-monitoring.org. The website was developed following the 2nd International Workshop of Cave Monitoring in Innsbruck, Austria. It is a web-based database of sites where cave monitoring has taken place for at least one year, and is intended as a platform to improve and coordinate research activities in the fields of cave meteorology, karst and speleothem science, and subterranean ecology. If you would like to add your site to the map, you will find a template that is quick and easy to complete under the Submit tab. The authors of the site report, "*we are not intending to have a data repository on the website, but merely provide some basic information and contact details should you wish to have access to the data.*" Already there are quite a few entries for Australian cave sites.

Andy Spate put out a call for ACKMA members to review the draft Management Plan for the Nullarbor Parks. A few members provided some comments and submissions were made on behalf of ACKMA and other caving groups that I am aware of. For me, the plan was far less than what constitutes a good management plan. It lacked consultation in preparation of the draft, omitted many important values in the description of the Nullarbor and had a series of objectives under four themes, without priorities and critically, who was actually taking responsibility for the actions. Then there is the small point that the plan stops at the border. Maybe one day two state governments can work together for the better management of this great landscape.

New Karst Ranger at Mole Creek

We have a new posting in Tasmania – Chris McMonagle is the new Karst Ranger at Mole Creek. He comes to Mole Creek with 16 years' experience in conservation estate management, having worked as a park ranger at Iron Range and Lawn Hill National Parks in North Queensland. He also spent 9 months as a wildlife ranger in Mt Isa which involved flying fox mitigation and managing crocodiles in the Gulf of Carpentaria. He has been the Senior Ranger in the Shark Bay World Heritage Area in Western Australia for the past 11 years and moved to Tasmania in September with his family.

Chris is looking forward to the new challenges involved with managing karst and its associated stakeholders. His responsibilities do not include the operation of the show caves but instead focus on the management of the regions 'wild caves', as well as places like Devils Gullet, Central Plateau Conservation Area and the Walls of Jerusalem National Park.

Whilst he does not have a great karst background, other than the Hamelin Pool stromatolites, he has always had a keen interest in karst - having visited most of Australia's show caves at some stage in his life, not to mention assisting in the management of the Riversleigh WHA and its associated karst landscapes for several years. He is being eased into his new position by such people as Rolan Eberhard, Cathy Plowman, Deb Hunter and myself. And doubtless others.

He has recently joined ACKMA as a member and is planning to attend the next conference in Margaret River in 2018.

I was hoping to have some news on Deborah Carden's replacement at Naracoorte and Tantanoola. I know a few that applied who have been advised the vacancy was being withdrawn and will be "redesigned to better fit our needs". I was surprised when I read the original role description as it didn't include any requirement for cave and karst knowledge. I hope this will be addressed with the new role.

The Margaret River team is busy preparing for the May conference. They need your registrations and abstract submissions. Without people and papers there cant be a conference!

PRESIDENT'S REPORT

Dale Calnin

I begin this report by acknowledging a well-known and much loved ACKMA identity for his marvellous contribution to the organisation and to cave and karst management internationally.

Recently I informed ACKMA membership that Steve Bourne would be standing down as Publications Officer with effect from the next AGM to be held at Margaret River in May 2018.

A surprise indeed but given Steve's high profile professional life combined with many research interests it was not totally unexpected.

During the shock of Steve's announcement and wondering how on earth are we going to fill such a massive void, I reflected on the amazing contribution that Steve has made to ACKMA. As well as Steve's extraordinary six years as probably the most effective President that ACKMA has had, he has put in an outstanding seven years as the Publications Officer producing a very high-quality Journal.

Steve will always be a highly valued leader and mentor within ACKMA. As much as we would all love to see him continue in the Publications Officer role we now need to honour his decision, thank him for this remarkable contribution and, somehow find a new ACKMA Editor. So, what a fantastic opportunity for one of our members to step up and continue the great work of our past editors.

It was great news to hear of Jodie Anderson's appointment as the new General Manager of Jenolan Caves Reserve Trust. Jodie is a much valued ACKMA committee member and her impressive communication and leadership skills hold her in good stead to lead a very successful career at Jenolan. Congratulations Jodie and on behalf of ACKMA we wish you every success.

In early November, East Gippsland District Manager Will McCutcheon and I hosted the Parks Victoria's state-wide Cave and Karst Advisory Group at the Buchan Caves Reserve. The committee, which is made up of Parks Victoria representatives and well known caving identities from various backgrounds, takes a keen interest in the management, conservation and recreational use of caves and karst landscapes.

Parks Victoria manages such landscapes in the Buchan area and stretching up the Snowy River towards the Alps, around the Glenelg River and through the Port Campbell National Park, amongst others. It was a great opportunity for the group to be part of the local Cave and Karst management scene at Buchan which is a jointly managed park with traditional owners, the Gunaikurnai people.

More recently I had the pleasure in helping to facilitate the new casual guide training at the Buchan. A couple of very enjoyable days spent with staff commencing their cave guiding careers as they prepare for the busy summer holiday period and the influx of visitors ahead.

The count-down has certainly begun towards our next ACKMA Conference in the Margaret River Region, Western Australia in 2018. Congratulations to conference Convener Mark Delane and his team for putting together an exciting conference program, promising another wonderful opportunity to learn and network with fellow contemporaries - one not to miss.

As we approach our next AGM, I am keen to pass on the baton of the ACKMA Presidency. I welcome anyone who is interested to take on the role to please let me or the committee know.

As the summer period rapidly approaches I offer on behalf of the ACKMA Executive committee all members the very best for Christmas and a happy and safe New Year. I look forward to another progressive year in 2018 and to continue the good work that you do in cave and karst.

Parks Victoria's Cave and Karst Advisory Group

Photo: Dale Calnin

ECOTOURISM DEVELOPMENT at XE BANG FAI CAVE, LAOS

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Introduction

Xe Bang Fai Cave in Hin Nam No National Protected Area (NPA) is a world class cave with great potential for ecotourism. Hin Nam No NPA encompasses part of a limestone karst area in Khammouane Province in central Laos, adjacent to the border with Vietnam (Figure 1). The Xe Bang Fai river has cut a 6.4 kilometre (km) underground course through the limestone mountain, creating one of the largest active river cave passages in the world. The active river passage averages 76 metres (m) in width and 53 m in height, with a maximum width of 200 m and a maximum height of 120 m. In addition to the size of the cave passages, the cave is superbly decorated with speleothems, including many large and beautiful stalagmites, flowstone draperies, gour pools and cave pearls (Pollack et al. 2009).

Exploration and Mapping of the Cave

The first recorded traverse of the river passage though the cave was led by the French explorer Paul Macey in the year 1905. The next recorded exploration and first detailed survey of the cave was by a team of French cave explorers in 1995, after which the area was closed to foreigners for 10 years. A team of North American cave explorers visited the cave in 2008, and documented the cave to a high standard with 'state of the art' surveying and photographic equipment (Pollack et al. 2009). The North American team returned to the cave in early 2015 to finish the exploration and mapping of the cave in collaboration with the Hin Nam No Project, a German development cooperation project with the Lao government. A map of the cave, with 14.7 km of passage in total, is presented in Figure 2. In early 2016, the exploration and survey of a nearby cave, called Tham Nguen, led to a connection, bringing the total length of the Xe Bang Fai Cave system to 16 km.

1. Map showing the karst areas of Laos and Hin Nam No NPA in central Laos, adjacent to the border with Vietnam.

Ecotourism Development of the Cave

Although the ecotourism potential of the cave has long been recognized, its remote location, difficult access, a lack of services, and low human resource capacity in the area has limited that potential. Ecotourism to the cave began about 10 years ago with a few small groups of kayakers, cavers and other adventurers. The ecotourism company '*Green Discovery Laos'* has offered adventure tours to the cave during this period. Photographs of the large cave passages and speleothem formations from the first North American expedition were published on the National Geographic website in 2008, revealing the splendours of the cave to the world. A complete magazine article with more pictures and a detailed map of the cave was published soon after (Pollack et al. 2009). More recently, a book on Xe Bang Fai Cave resulted from the 2008 and 2015 North American expeditions (Bunnell and Kambesis, 2016). French cavers also published a magazine article on the cave, including a map and pictures (Mouret et al. 2010). These articles, photographs and maps have contributed substantially to raising awareness of the significance of Xe Bang Fai cave, and to increasing interest in ecotourism visitation to the cave. The cave was designated as a tourism site by Khammouane Province in 2010.

Since 2011, the Hin Nam No Project has assisted with conservation and ecotourism development of the cave using a co-management approach involving the local villagers. The Hin Nam No Project has provided skills development training to the villagers for providing services to tourists, including village cave guides and village guesthouse and homestay options for accommodation. Project supported developments to facilitate tourism to the cave while minimizing its impacts include constructing defined walkways to the cave entrance and along an upper balcony passage, and building wooden boats for touring the main river passage. In the meantime the Lao government has been working to upgrade the road access to the area.

The villagers now offer guided cave tours of a downstream section of the river passage and an upper balcony passage that overlooks the river passage (see Figure 3). From the downstream entrance to the cave, visitors are taken along the active river passage by boat to a point about 1.75 km into the cave where a major rockfall and rapids obstructs further navigation. On the way back downstream the boats stop on the left bank of the river passage and the visitors are guided on a walk up the balcony passage to a balcony overlooking the active river passage near the downstream cave entrance. This trip allows visitors to see many of the outstanding features of the cave, such as the large river passage, large and beautiful stalagmites and flowstone draperies, bats and swiftlets roosting in the ceiling near the cave entrance, and the spectacular view out the entrance from inside the cave.

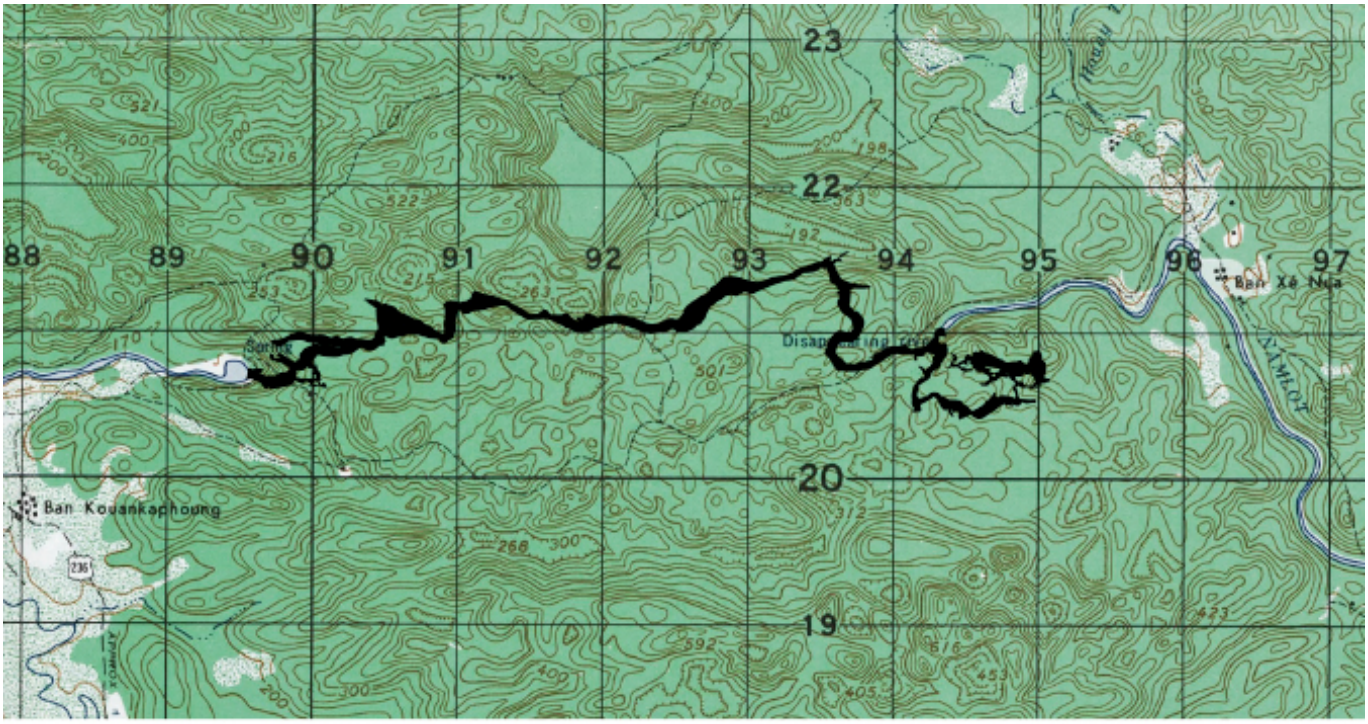

Figure 2. Map of Xe Bang Fai Cave overlaid on a topographic map with a 1km grid.

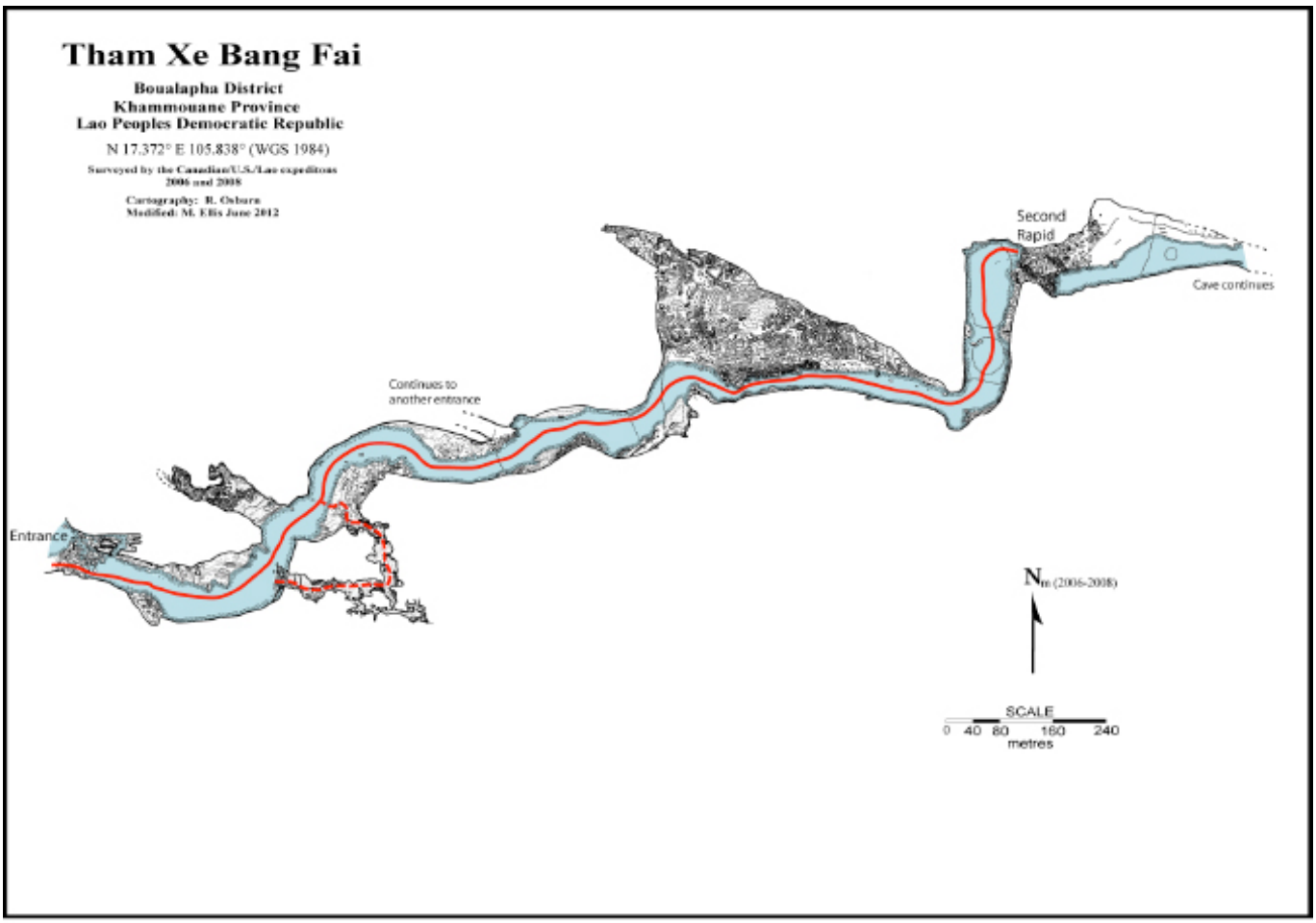

Figure 3. Map showing the downstream section of Xe Bang Fai Cave with the boat route indicated by the solid line along the river and the balcony walk indicated by the dashed line.

Adventure-seeking visitors with a good level of physical fitness and agility can kayak all the way through the active river passage (and back) using inflatable or hard shell kayaks (see Figure 2). The kayaks must be portaged around three major rockfall / rapids in the downstream section of the cave, and a further five rapids in the upper section of the cave must be portaged going in the upstream direction, but can be 'run' when kayaking downstream. As long as the kayakers stay on the river or close to the riverbank and near the water level they have minimal impact on the cave passage or speleothem formations. This trip is offered on a commercial basis by Green Discovery Laos, or can be organized with village guides if you have your own kayaks and equipment. Improved access to the river upstream of the cave now allows a two-day kayak trip through the upper karst valley and downstream through the cave.

Publicity about the cave, along with improved access and services has resulted in a rapid increase in visitor numbers in recent years, as shown in Table 1. The cave can only be visited for tourism during the dry season, from November to May.

Table 1. Visitor numbers to the Xe Bang Fai Cave in recent years.

Dry Season (years)	Number of Visitors
2011-2012	93
2012-2013	332
2013-2014	465
2014-2015	1743
2015-2016	2781

For the 2015-2016 dry season, the visitor number comprises 2391 Lao nationals and 390 foreigners (14% of the total). It is good to see that Lao people are enjoying and appreciating the cave, and there is still plenty of potential for foreign visitor numbers to increase. Revenue from cave tours is shared between the local villagers and Hin Nam No NPA in a benefit sharing arrangement. The ecotourism service providers in the nearby village earned a seasonal average of $255 each for providing tourism services, which is a 20% increase in their average annual household income.

World Heritage and Ecotourism at Xe Bang Fai Cave

The Lao government has recently placed Hin Nam No NPA on the World Heritage tentative list, a first step towards the nomination of Hin Nam No as a UNESCO Natural World Heritage site, under criteria for geoheritage (criterion viii) and biodiversity (criterion x). Xe Bang Fai cave is the most significant and distinctive geomorphic feature in Hin Nam No NPA. Thus, it would be one of the key features for claiming the outstanding universal value of Hin Nam No under criterion viii. In addition, the biodiversity and endemic species living in the cave contribute significantly to the overall biodiversity of Hin Nam No, which would be the basis of claiming outstanding universal value under criterion x. On the other hand, the Xe Bang Fai Cave is the most prominent tourist attraction in Hin Nam No, and is seen as a promising source of income for the sustainable financing and management of Hin Nam No NPA, and for improving the livelihoods of the local villagers.

Listing a property as a Natural World Heritage site requires that it be deemed of outstanding universal value, and meet strict conditions of integrity, which is defined as a measure of the wholeness and intactness of the natural heritage and its attributes. Therefore, a careful balance is required between the infrastructure required to facilitate tourism to the cave and the need to minimize alteration or disturbance to the natural features and environment in and around the cave (Williams 2008). In a World Heritage site, this balance must err on the side of precaution and conservation. These principles have been used to guide the ecotourism development of the cave, so as to preserve the integrity, and not to jeopardize the possible listing of Hin Nam No as Laos' first Natural World Heritage site (Bolger 2013). The prospective listing of Hin Nam No as a UNESCO Natural World Heritage site will enhance the profile as well as the management of the NPA, including the cave.

Acknowledgements

The project 'Integrated Nature Conservation and Sustainable Resource Management in the Hin Nam No Region' (or the 'Hin Nam No Project'), a German development cooperation project with the Lao government provided financial and technical support for much of the work reported here. We thank Hin Nam No project staff (Joost Foppes, Ronny Dobbelsteijn, Ms Vanhxay, Mr Khamphao, Mr Bounlong), local guides from Nongping village (Mr Songka, Mr Sak, Mr Phong, Mr Lop, Mr Sai, Mr Nuch), and members of the North American expeditions (John Pollack, Bob Osburn, Patricia Kambesis, Aaron Addison, David Sawatzky, Dave Bunnell, Kevin Stanway, Phil Whitfield).

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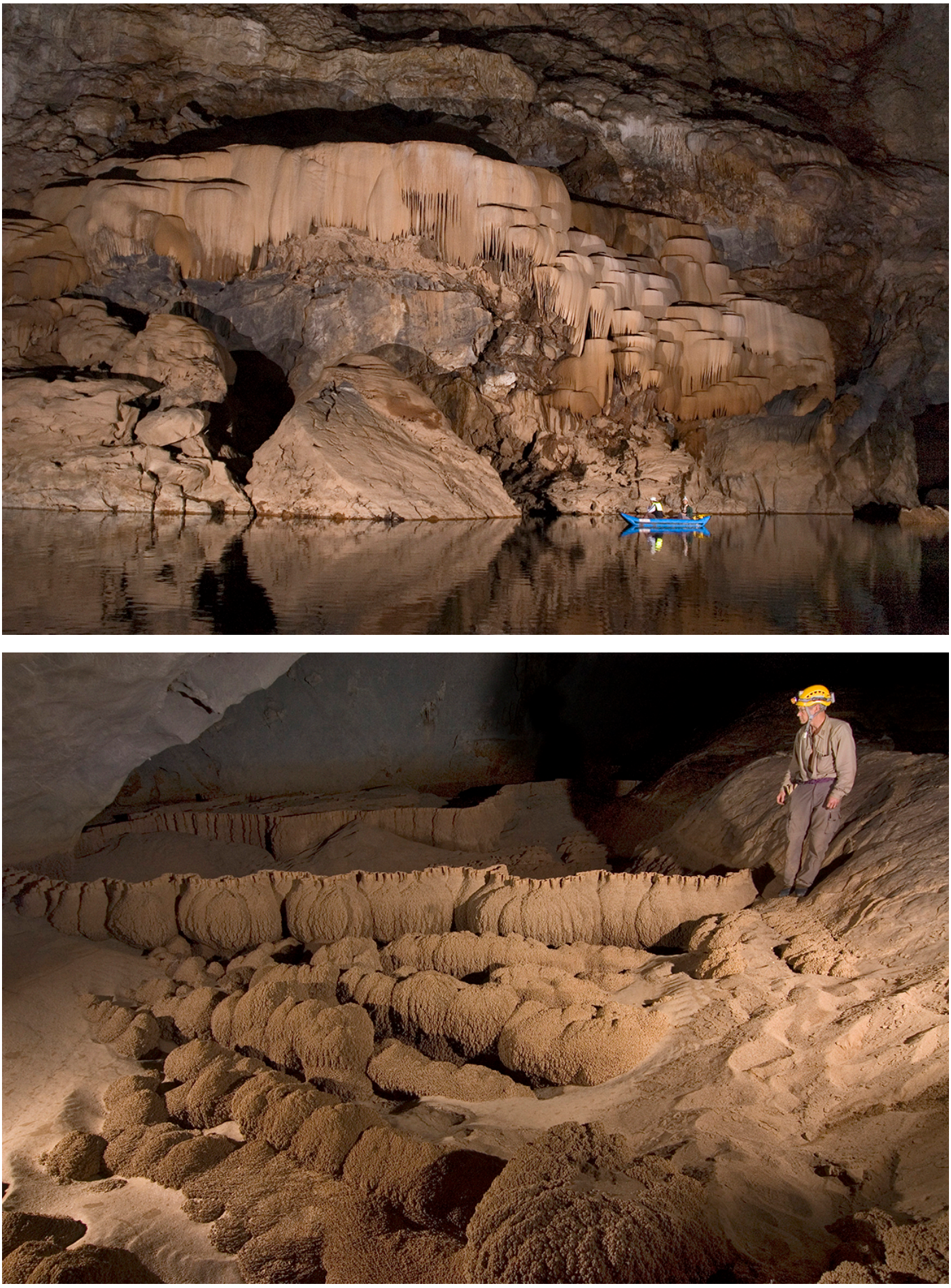
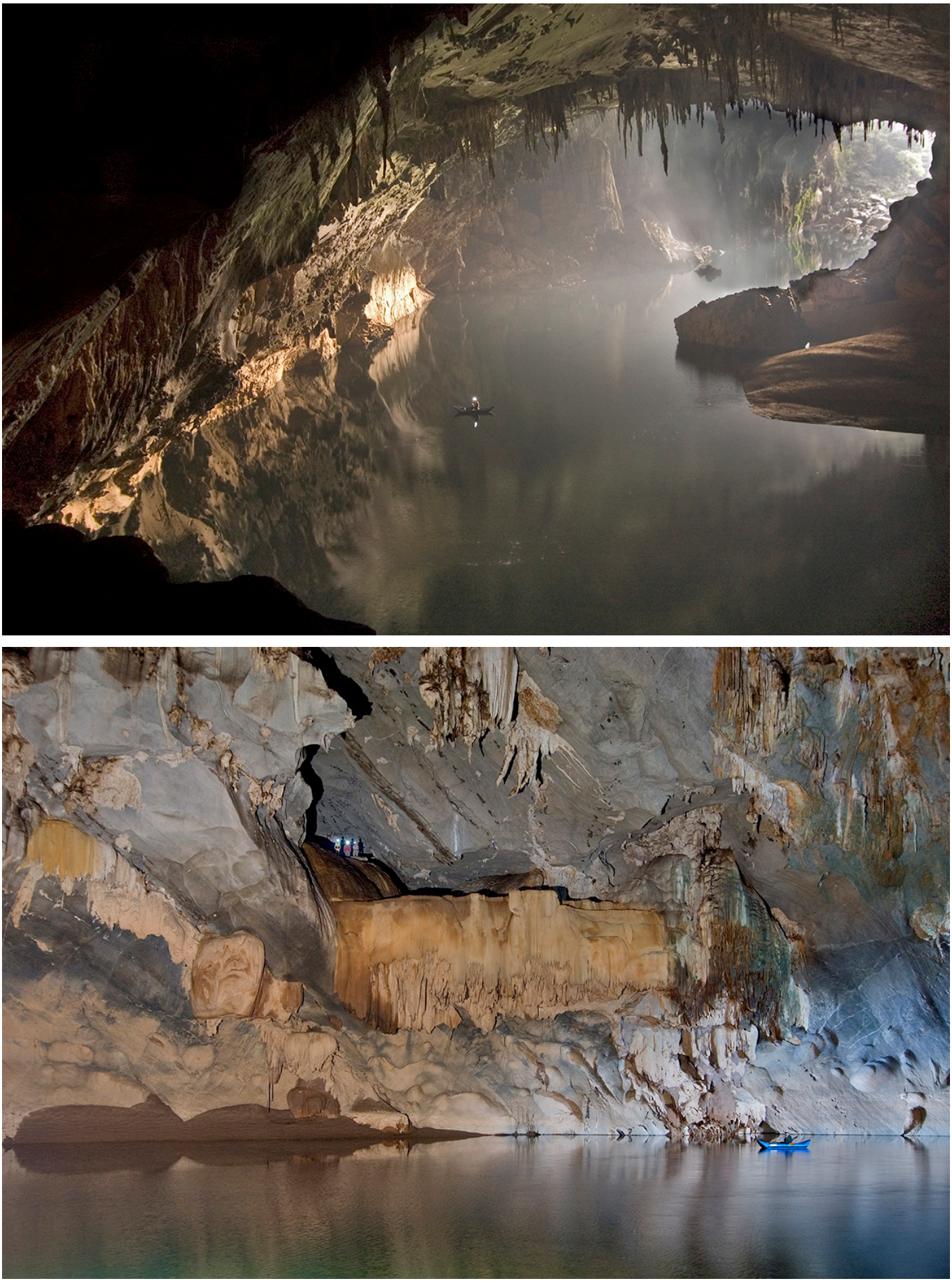


Top: This spectacular series of rimstone terraces is one of the many scenic views enjoyed by visitors in the downstream section of the cave
Bottom: Phil Whitfield with the Dragon Eggs, seen by visitors in the Balcony Passage
Photos: Dave Bunnell



Top: The view towards the downstream entrance from the end of the Balcony Passage, which visitors explore on foot. From here they must retrace their steps.
Bottom: Cavers in the passage above the Dragon Balcony, in a view 180 degrees from that above.
Photos: Dave Bunnell

A TRIP to HELL in SWITZERLAND

John Brush
Canberra Speleological Society Inc

An opportunity to visit Höllgrotten ("Hell Grottoes") in Switzerland arose for Marjorie Coggan and me in September 2017. The small show cave operation is located just outside the town of Baar, about 40km south of Zurich. Despite the name, the two caves open to the public are very interesting and nothing untoward happened during our visit but there was one aspect of the caves' management that made us wonder if satanic forces are at work.

The Höllgrotten area is unusual in that there is no limestone in the immediate area, and the caves formed as cavities in tufa that was being deposited on the flanks of a valley. In other words, they have formed by accretion, rather than by solution, which is normally the case for karstic caves. According to information on the Höllgrotten website, the Lorze Valley was carved out by glacial meltwaters towards the end of the last Ice Age. Later, percolating ground water several kilometres away dissolved calcium carbonate from limestone fragments in glacial moraines and subsequently precipitated it as tufa at springs on the lower slopes of the valley, forming a number of voids in the process. The tufa deposit is around 200 metres long, 50 metres thick and around 40 metres high, all deposited in as little as a few thousand years - either 3000, 5500 to 8500, or perhaps 10,000 years, depending on whether you believe interpretative signs in the caves or various pieces of information on the Höllgrotten website. Regardless of which figure is correct, the grottoes are VERY young for caves in carbonate rock!

Accretion caves are not at all common in Australia and the best example I can think of is in the Ravine Karst area in the Kosciuszko National Park in New South Wales where calcium carbonate from thinly bedded and impure limestones has been redeposited further downslope, generally over cliffs of sandstone and shale, creating a number of cavities, the largest of which (Milk Shanty Cave) is about 15 metres long and 2-3 metres wide and high.

Entrance to the Upper Höllgrotten Cave
Photo: John Brush

At Höllgrotten it is a short uphill walk, with an elevation gain of about 40 metres, from the ticket kiosk to the entrance of the upper cave. Although guided tours for groups of up to 12 people are available, Höllgrotten is essentially a self-guiding experience. Entry is gained by presenting the cave ticket to a barcode scanner at the entrance turnstile. From there the show cave route meanders down through the cave, continues through an artificial tunnel dug in 1917 and then, after a few metres on the surface, enters the lower cave. The exit point from the lower cave is at the base of the hill close to the ticket kiosk.

The cave is open from 9.00am to 5.00pm every day from 1 April to 31 October. The ticket price is currently 12CHF (about $17).

The upper cave was discovered during quarrying operations in 1863. The tufa was in demand as a construction material as it

The Coral Canyon.
Photo: from the Höllgrotten Website and taken by Flavio Heggli/ Daniel Christen.

The Green Beard, a particularly luxuriant growth of lampenflora. Photo: John Brush.

Calcite encrusted electrical cable Photo: John Brush

was light, porous and easy to cut and was used, among other things, for lining railway tunnels. Fortunately, quarrying was halted in 1885 to protect the cave. At about the same time, there were concerns that several 'lakes' in the cave were impeding access, so Josef Leonz Schmid, a local Councillor and son of the original discover, decided to drain them by digging a tunnel through to the surface. Two years later, in 1887, the cave officially opened for public inspections. Further grottoes were discovered in 1892 and in 1902 and Schmid purchased neighbouring plots of land to ensure he would be able to link up all the grottos and preserve the cave system for posterity. Today, the caves - as well as the surrounding land and a nearby restaurant - are still owned by the Schmid family through a trust set up in 1942.

Coloured lights display in the Enchanted Castle. Photo: John Brush.

From the upper entrance, the show cave trail meanders through a series of small chambers with evocative names like the Root Grotto, the Bear Grotto, the Green Beard, the Coral Canyon, the Enchanted Castle and the Fairy-tale Grotto, all seemingly at odds with the name of the cave. As to be expected in a cave that was formed by calcite deposition, there is no lack of speleothem development. Stalactites, draperies, stalagmites and flowstones are common. Botryoidal coral-like growths predominate in some grottoes and, as they most likely formed underwater, are indicators of where those drained lakes once were. Tree roots, mostly calcified, can be seen in several places and the rapid rate of calcite deposition can be gauged from the coating of some electrical cables.

Throughout the caves there are internally-illuminated interpretative signs with detailed explanations in German and English. Some also have accompanying diagrams. We thought the signs significantly enhanced the visitor experience.

It is difficult to avoid noticing the LED light fittings in the Enchanted Castle.
Photo: John Brush

Botryoidal coral-like speleothems above a small pool.
Photo: John Brush

In 2012, the caves were entirely relit using, as the Höllgrotten Website states *"cutting edge LED technology, affording the very first opportunity for visitors to enjoy a proper view of the stone's vast range of shapes and colours in all their subtlety".* There is one place in the cave (the Enchanted Castle) where coloured lights are used. The room, which has a shallow pool about 3 metres long and 2 metres wide is bathed in white light but soon after visitors enter, the lights go through a sequence of orange, reds and purple followed by blues and greens. I can't say I am much of a fan of coloured lights in caves but this did strike me as being pretty spectacular. Perhaps my brain is rotting?

In general the cave lighting has been done quite aesthetically but the emphasis seems to have been on what the lights were illuminating rather than what they were attached to.

It is also a pity that the rewiring project was not seen as an opportunity to also install cutting edge motion detectors and timers so that passages are only illuminated while visitors are present. We gained the impression that all the lights are switched on first thing in the morning and not switched off until after closing time. The result is that the cave's range of colours includes a lot from the green part of the spectrum. Lampenflora is everywhere and seriously detracts from the aesthetic qualities of the cave. Patches of black (dead algae) might suggest attempts are sometimes made to control the lampenflora but it is more likely that they result from the seasonal nature of the caves' operations – the caves are closed for 5 months over winter during which time the lights are presumably switched off and the lampenflora would die off.

Management has attempted to turn this lampenflora negative into a positive by highlighting one particularly luxuriant area (a lampenforest?) and naming it the Green Beard. The accompanying interpretative sign blandly states that "the 'green beard' growing over the tufa is the result of artificial illumination" and by doing so perhaps gives the impression to visitors that nothing can be done about it. Why can't the operators implement an integrated lampenflora control strategy?

In conclusion, the small show cave operation is well worth a visit, despite the lampenflora, as the mode of formation of the caves is unusual and their is a good range of attractive decoration.

The Crocodile.
Photo: from the Höllgrotten Website and taken by Flavio Heggli/ Daniel Christen.

View of the tufa deposit/ cliff from the track between the upper and lower caves.
Photo by Marjorie Coggan.

THE 18TH INTERNATIONAL SYMPOSIUM on VULCANOSPELEOLOGY is COMING

John Brush
Chairman, IUS Commission on Volcanic Caves

Crystal Cave in Winter.
Photo: Dave Bunnell

The next International Symposium on Vulcanospeleology (ISV) will take place 21-26 July 2018 in Northern California in and around the Lava Beds National Monument.

The Symposium will include presentations, cave and surface field excursions and a range of social activities over 5-6 days. The symposium is open to anyone, but especially to those with an interest in lava caves, volcanoes and volcanic terrains. ISV participants are usually a friendly mix of cavers, cave scientists and cave managers from all over the world. The last international meeting, held in Hawaii in February 2016, attracted 80 participants. There were 13 Australian participants, many of whom are ACKMA members.

The 2018 Symposium will be a great opportunity for ACKMA members to explore some of the most extensive lava tubes in the western region of the United States. Lava Beds National Monument is a land of turmoil, both geological and historical. Over the last half-million years, volcanic eruptions on the Medicine Lake shield volcano have created a rugged landscape dotted with diverse volcanic features. More than 400 caves as well as Native American rock art sites, historic battlefields and camp-sites, and a high desert wilderness experience await you!

Most caves in the National Monument area are wild, however some have been modified to facilitate visitor access with stairways or ladders and marked trails. One cave (Mushpot) near the National Monument Visitor Centre has been lit and contains exhibits.

The Lava Beds area is relatively remote and with little by way of public transport, the organisers have suggested that people rent a car to get to the area. Lava Beds is about 6-7 hours' drive from either San Francisco (California) or Portland (Oregon). The closest major airport (Reno, Nevada) is about 4 hours' drive away. There is also limited accommodation in the immediate area but the organisers have pre-reserved a range of options (from camping to ensuite rooms) at two motels within easy daily driving distance of the National Monument and one of these (Winema Lodge) will be the venue for presentations and also where meals will be served.

Please visit the Symposium Website (http://18ivslavabeds.com/) for more detailed information and to register.

Valentine Cave.
Photo: Dave Bunnell

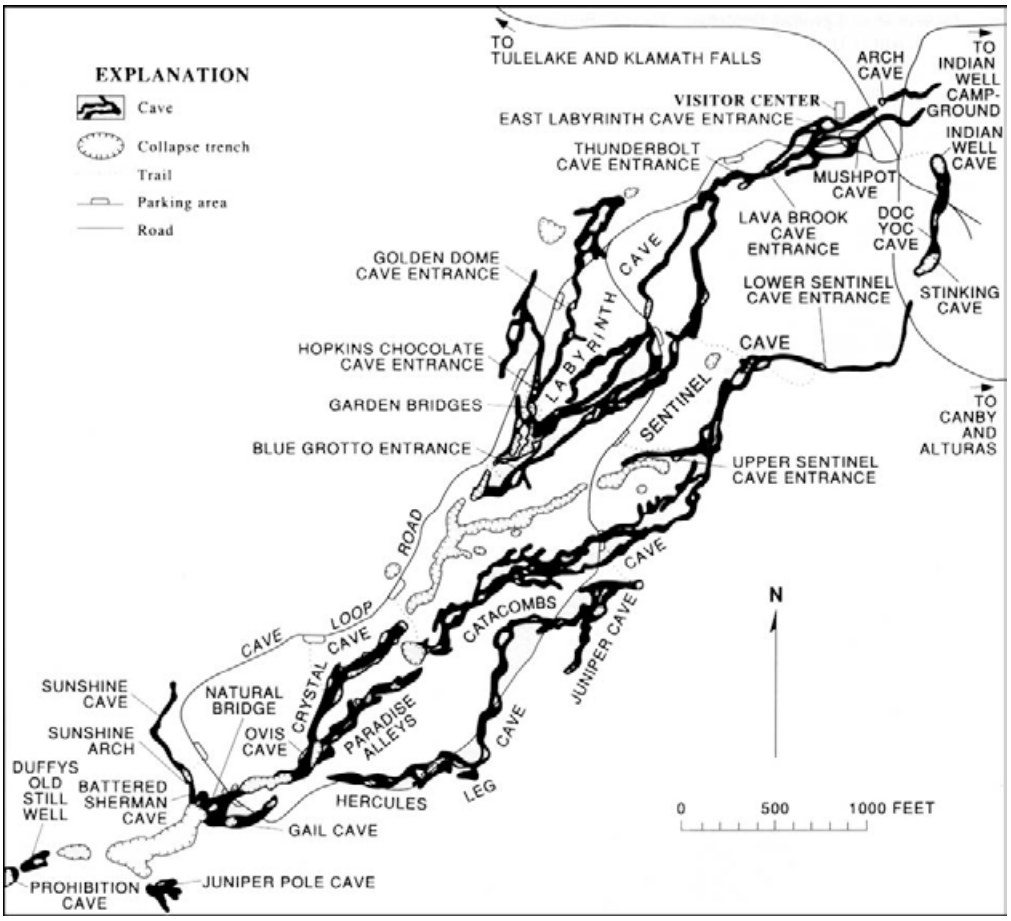
A classic lava tube passage at Lava Beds National Monument.
Photo: Dave Bunnell

The IUS Commission on Volcanic Caves – Background

An international group focussing on lava caves was established in the 1970s and became known as the Commission on Volcanic Caves in 1993 after being granted full Commission status by the International Union of Speleology – IUS – (or Union Internationale de Spéléologie – UIS). The first International Symposium on Vulcanospeleology was held in Hawaii in 1972 and since 1998, the symposiums have been held every two years. Locations of recent symposiums include Hawaii, Ecuador (Galapagos Islands), Korea, Jordan, Australia, Mexico, Portugal (Azores), Mexico, Iceland and Spain (Canary Islands). The Commission also meets every four years at IUS Congresses, such the one held at Penrith NSW in July 2017.

The principal objective of the Commission is to advance the scientific exploration, study, and preservation of caves and related features in volcanic rock throughout the world. It seeks to bring together all persons, organisations, and agencies with interests in volcanic caves, their features and their environments. Its members include leading vulcanospeleologists from around the world, cave microbiologists, cavers and cave managers.

IUS is the international body for speleology and caving. It was founded in 1965 and currently has around 60 member countries - its voting members consist of a delegate from each member country. This delegate represents the member country's cavers and speleologists, rather than its national body(s). An elected Bureau runs the affairs of the IUS between the General Assembly meetings held at the International Congresses but the actual speleological 'work' of the IUS is done by the members of its Commissions – such as the one on Volcanic Caves – and Working Groups, which are open to anyone who is interested.



Lava features in the vicinity of the Lava Beds National Monument Visitor Centre (from US Geological Survey Bulletin 1673: Selected Caves and Lava Tube Systems in and near Lava Beds National Monument, California (1990).

A BRIEF INTRODUCTION TO SPELEOLOGY

Lana Little

The show caves at Chillagoe are managed by the Queensland Parks and Wildlife Service (QPWS), and the tours are conducted by QPWS Ranger-guides. In the interests of best-practice resource management, visitor engagement and safety, and staff development, QPWS supports local management in the bid to maintain a very high standard of guiding.

To this end, QPWS engaged ACKMA's Andy Spate to develop and present a guide's workshop at Chillagoe, held 4-6 December 2017. During these three days, eight Chillagoe Ranger-guides had the opportunity to acquire new information and clarify or refine existing knowledge during class room and field-based activities. Andy encouraged questions throughout, allowing participants to focus either broadly or on very specific details. The on-site rambles through the three caves used for guided tours were especially well received, with each guide having the chance to develop a deeper appreciation of features which may have seemed commonplace beforehand.

Three days may seem more than 'brief', but Andy insists that it is no more than a peep around the door into the complex, dynamic and enthralling world of karst and caves. Nonetheless, the range of topics was vast, including geomorphology, climate, biology, palaeontology, fire, human impacts and the management implications of them all. The handbook Andy prepared provides many excellent illustrations, a bibliography and a list for further reading. The accompanying slideshow of karst and pseudokarst from around Australia and around the world had the audience engrossed.

Andy's workshop built upon a grounding in local karst and cave geology which was delivered to the guides by Chillagoe geologist John Nethery earlier in the year. It's also not the first time that Andy has travelled to Queensland to undertake similar Guide Schools – one was held at Chillagoe in 1994, and Rockhampton in 2001. QPWS had supported the attendance of 2 Chillagoe Rangers at the Rockhampton workshop, but due to staff turnover, there remains only one current guide who previously had the privilege of a face-to-face *'Andy Sez'* session.

Ranger-in-Charge Mick Cockburn commented that the Rangers had guiding experience ranging from 1 to 15 years, and Andy was able to share knowledge very effectively with them all. He made the further point that the Rangers all perform general duties as well as sharing a guiding roster and it was important for them to recognise and appreciate the special values and relationships that exist in karstic terrain, as they go about their routine tasks.

The handbooks provided to each participant were retained as resource material and Andy, as always, has indicated his willingness to respond to emailed queries into the future. ACKMA's journals, conference papers and other material are also invaluable to the Ranger whose curiosity and appetite for answers to all things cave and karst has been whetted by Andy's "Brief Introduction to Speleology".

Andy Spate, third from right, with workshop participants in Trezkin Cave
Photo: Doug Davidson

CAVE GUIDING SURVEY for all PRACTITIONERS

David Gillieson, Andy Spate, Ann Augusteyn, Jodie Anderson, Scott Melton

Mission: To ensure guided cave tours in Australasia are of the highest quality in delivery and content.

Objectives

- Content: Improve the accuracy of information delivered by cave guides
- Delivery: Ensure delivery of interpretation engages the visitor.

To achieve these objectives we need to establish what methods and resources are used currently to train cave guides and what additional resources and training procedures are needed to fill the gaps. We hope that managers and guides will share their views and reach out to any cave operations that are not members of ACKMA in the interest of preserving our amazing natural resource and engaging the public in an increasingly competitive world.

Scope: ACKMA members

RESEARCH INTO CURRENT CAVE GUIDE TRAINING IN AUSTRALASIA

1. Initial training. Please circle.

- ✳ Trainee observes experienced guides on tour. Yes No
- ✳ Trainee inspects cave without supervision. Yes No
- ✳ Trainee is given a tour manual Yes No

✳ If yes do contents of the manual include

- ✳ Scientific information about the cave, geology, geomorphology Yes No
- ✳ Cave fauna, flora and fossils Yes No
- ✳ Surface fauna and flora Yes No
- ✳ Social and cultural history Yes No
- ✳ Is training given in visitor risk management Yes No

How is this delivered? Please give details.....

.....

- ✳ What additional training aids or tools are used? Please circle.

Videos Reference books Fliers Documentaries

Other .....

- ✳ Is any training in tour delivery and visitor engagement given? Yes No

Please give details.....

2. Guide initial appraisal

- ✳ Is an initial assessment check list used? Yes No
- ✳ Who assesses the trainee ? Please circle Management senior guide colleague
- ✳ Does the trainee answer a written assessment? Yes No

3. Ongoing guide appraisal

- Does the cave site provide ongoing appraisal at regular intervals? Yes No

Please supply details .....

- What external guide appraisals are used? Please circle:

Trip adviser guest comment book emails anecdotal visitor reports.

4. Professional development

Are guides given off-site professional development opportunities ? Please give details. Eg

Opportunity ACKMA conference Location Te Anau,NZ How is it funded ? Self
Opportunity ..... Location..... How is it funded .....
Opportunity ..... Location..... How is it funded .....
Opportunity ..... Location..... How is it funded .....

Are internal on site professional development opportunities offered? Please give details

Guest lecturer/workshop on-site .....
Internal staff workshop.....
Staff think tank on site.....
On line activities.....

5A. Guide accreditation. Manager's response only

Are guides offered opportunity for external accreditation?
Please give details: Name of accreditation, level, funding method.
.....
.....
.....
Please list benefits and outcomes of external accreditation for staff.
.....
.....

5B. Guide accreditation Guide response only
What guiding accreditation have you undertaken?
Name of accreditation..... What level..... How long ago?.....
Funding.....
Has this accreditation helped in your career development?.
Provide details.....
Would you be interested in a National Certificate Level 111 in Cave Guiding?.....
Would you be prepared to do a course on line?.....
How would you fund this course?.....
What topics would you like to see included in a cave guide course?.....
.....

IDENTIFICATION OF GAPS IN GUIDE TRAINING

1. Managers

What resources and assistance do you need to ensure you are delivering guided cave tours of the highest quality in delivery and content?

.....

.....

.....

.....

.....

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2. Cave Guides

What resources, tool kit and assistance do you need to ensure you are delivering guided cave tours of the highest quality in delivery and content?

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3.Managers and Guides

How can ACKMA assist in filling these gaps to improve cave guiding standards?

.....

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.....

Thank you for completing this survey. Please supply your name and contact details so that we can contact you with regard to the outcomes of the survey and any proposals to assist with cave guide training.

Name ..... Email.....

ART and MUSIC in TASMANIAN CAVES

Cathie Plowman

For more than 20 years there has been an artist-in-residence program in Tasmanian national parks and reserves, provided by a partnership between Arts Tasmania and the Parks and Wildlife Service. Residencies range between four and eight weeks and offer opportunities for artists to immerse themselves within the environment, to experiment and develop new ideas. The provision of on-site accommodation enables artists to live within the reserve for extended periods of time away from their usual environments.

Over the past 20 years artists participating in the program have worked with varied media that have included writing, painting, sound, textile and fibre. To see more, have a look at these websites:

https://tasmanianartsguide.com.au/online-exhibition/arts-in-parks

http://www.arts.tas.gov.au/funding/programs/residencies

In 2016-17 two artists had residencies, one at Hastings Caves and the other at Mole Creek Caves.

Hobart artist Janelle Mendham has felt drawn back to Hastings Caves since a visit there with her parents 20 years ago. Her work at Hastings Caves was entwined with the theme 'Return to Earth' and Janelle likens entering a cave to entering the body of the Earth.

Janelle has developed three tranches of work in response to her experiences at Hastings Caves.

An exhibition called *Inner Topographies*, which was an installation of drawings, visual diaries and a book of short stories written in response to the cave. The drawings were done by impregnating the paper with solution-based water, Janelle's response to the development of the cave by water seeping into the rock. This exhibition was shown at the Moonah Arts Centre in Hobart in late 2016. A 'mini-exhibition' was also prepared for the staff at Hastings Caves so that they could see what Janelle was developing from the information and stories that staff were contributing. Janelle is very grateful for the time and input the staff gave her, taking her to nearby caves and sharing their stories.

Darkness and aloneness were integral to a work called *Dark Cave* which was a quiet, performance reading event in Newdegate Cave. Janelle describes Dark Cave as 'one of the most powerful and beautiful artworks that I've made'.

The third event is an exhibition due to open on 5 April 2018 at the Rosny Gallery, in Hobart. This is called *The Shape of Space* and is a response to the empty space of the cave.

As part of the exhibition, Janelle is endeavouring to communicate the immense age of the rock - 650 million years. Dolomite rock formed aeons ago when a single-celled organism was the only life on Earth. How do you comprehend and convey that amount of time? Janelle is developing a 7.5 metre 'map' to try. Hobart geomorphologist and ACKMA member Chris Sharples is helping Janelle with the story of the Hastings dolomite.

Emily Sheppard was drawn to caves as part of her journey playing violin and viola and singing in resonate spaces. This has included playing in Tasmanian locations that include the disused silos on Maria Island, the Table Cape Lighthouse, the Alexander Battery at Sandy Bay and the Hobart Rivulet tunnels.

A part-time player with the Tasmanian Symphony Orchestra Emily was successful in obtaining residencies at both Hastings Caves and Mole Creek Caves in 2017.

At Mole Creek, Emily had a week in July, followed by another in September and spent three hours each day in Marakoopa Cave playing music during two cave tours and, for 1.5 hours between these tours, alone in the cave with its silence, working with the acoustics of the cave and developing music, using viola, violin and voice. She strives to create a single, homogenous sound between her voice and instrument, the cave acoustic assisting in the blend.

Alone in the house at King Solomons Cave at night, sometimes as snow fell outside, Emily experimented with her ideas, practiced and recorded her pieces. She says that she is grateful for the time that she spent with the cave guides, learning about the cave from them and incorporating this into her music.

While the Mole Creek residency was as a solo musician, the Hastings Caves residency was with musician Anne Norman from Hobart. Anne plays a shakuhachi, which is a traditional Japanese flute, made from bamboo. The duo shared a two-week residency in September 2017, which culminated in a performance in Newdegate Cave. The one-hour performance featured music inspired by caves and was attended by 100 people. Titles of pieces included Moonmilk, Cave Guides and Memory Places; the latter piece honouring the Indigenous people of the Hastings Caves area.

Looking back on her residencies, Emily feels that four weeks was somewhat ambitious to write, compose, notate, practise and develop a performance, but that there is a lot more scope for developing music in caves and sharing this with the wider community. She continues to collaborate with Anne Norman and other musicians developing sound in resonate spaces. Emily is part-way through an environmental science degree.

While on tour with a chamber music group in central Queensland earlier in the year, Emily linked up with long-time ACKMA member Dianne Vavryn who kindly took her to Chandelier Cave near Rockhampton where she enjoyed playing her instruments.

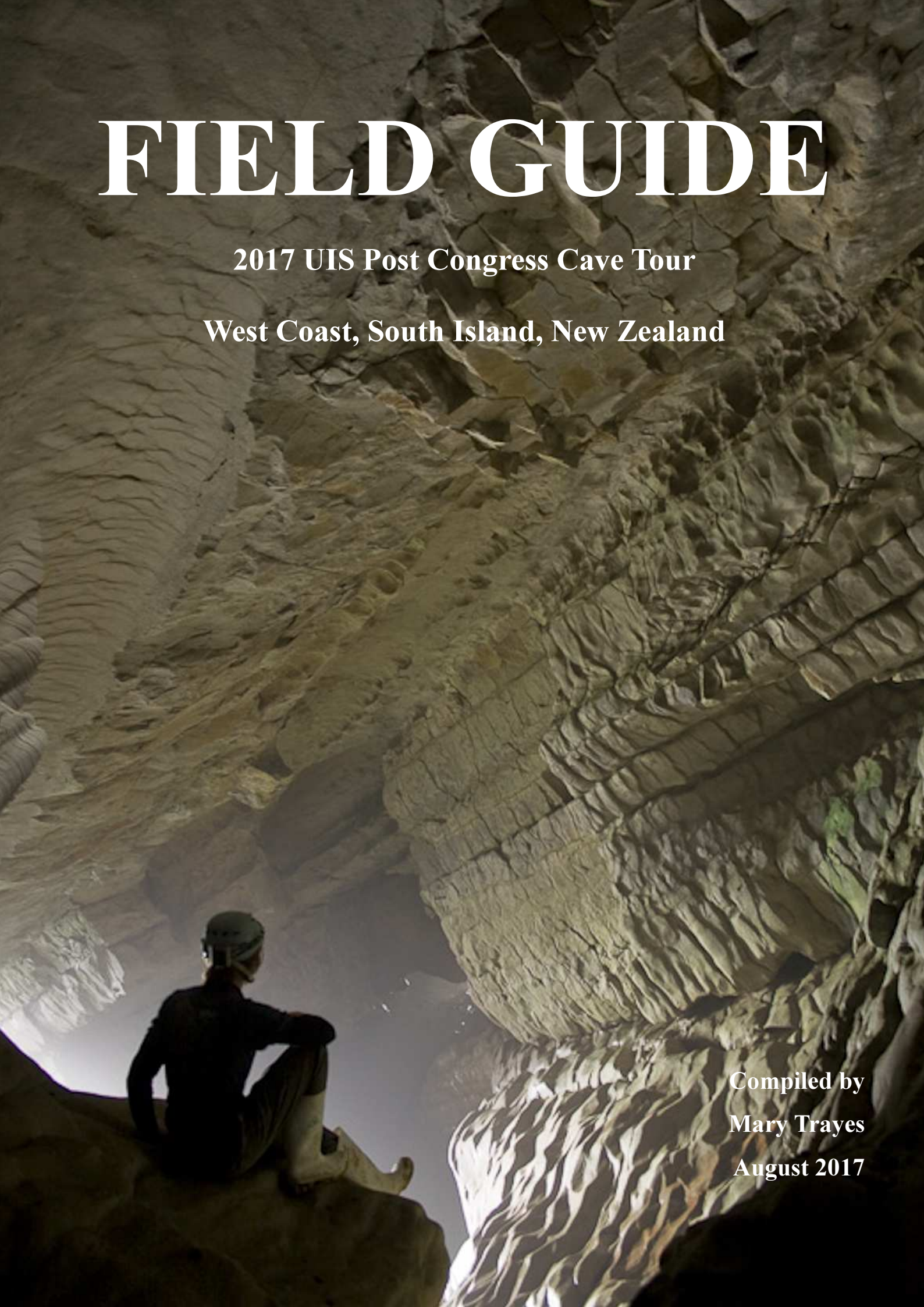
In preparing this article, I have felt humbled talking to both Janelle and Emily and trying to understand more about their work. As cave managers and advocates we have barely scratched the surface in reaching out for new ways in which to link the community with caves. The sold-out performance in Newdegate Caves says that the public is more than keen.

My thanks to Beth Russell at Hastings Caves, artist Janelle Mendham, musician Emily Sheppard and Wendy Morrow at Arts Tasmania for their kind assistance with this article.

FIELD GUIDE

2017 UIS Post Congress Cave Tour

West Coast, South Island, New Zealand



Compiled by
Mary Trayes

August 2017

FIELD GUIDE

2017 UIS Post Congress Cave Tour

West Coast, South Island, New Zealand

Introduction

This publication has been compiled from a variety of reports with the aim of giving those coming to the West Coast after the Sydney UIS Congress, July 2017, a 'good taste' of what the coast has to offer. We look forward to taking you around our cave and karst areas, and answering your questions.

The information which follows has been designed to ensure there is something for everyone with a mix of karst geology, cave exploration history, cave science and specific information about the caves which are on the itinerary. Not to mention a little local information. The maps presented vary in type, depending on what has been published for any given area and what was available to the compiler.

Our region is large and there are many more caves than it will be possible to visit on such a short tour but your tour organisers are hoping many of you will come back ……. for more.

It should be noted that as it is winter in New Zealand, and the West Coast has a wet climate, it may not be possible to visit all caves on your itinerary. Flooding has the potential to be an issue at both Bullock Creek and Castle Hill.

Mary Trayes

Alice Shanks, organiser

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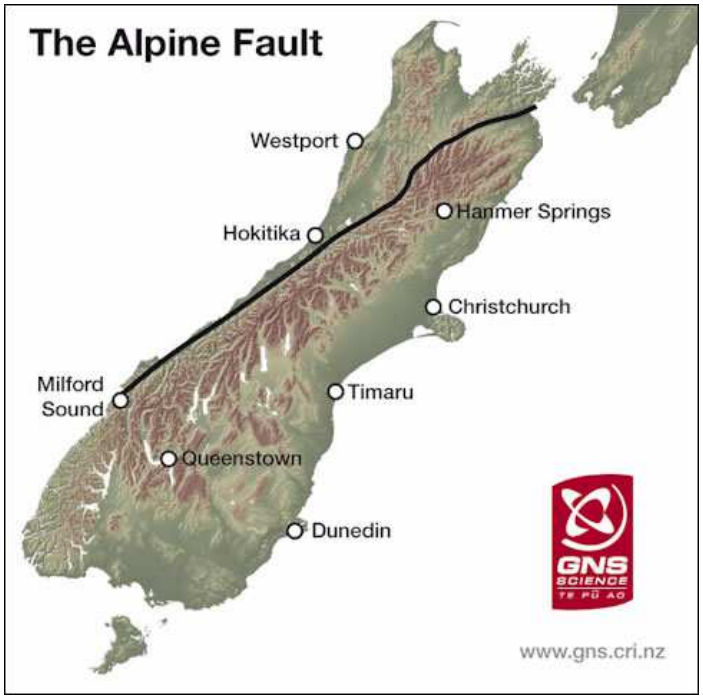
Front page photograph
Te Ana Puta's second sea cave entrance, Point Elizabeth
Nic Barth, 2010

Photograph at right
"Come caving with us, we will light your way……."
Metro Cave, G Thomas, 2015

West Coast Karst Overview

Map of the West Coast (lighter green) showing the main towns of Westport, Greymouth and Hokitika. The coastline is 600kms in length from Kahurangi Point in the north to Awarua Point in the south.



Map showing the Alpine Fault in relation to the West Coast. Karst areas on the West Coast are all to the west (left) of the fault which denotes the boundary between the Australasian Plate (to west) and the Pacific Plate (to east).

On the West Coast of the South Island all karst areas lie west of the Alpine Fault and apart from one small area of Paleozoic limestone (late Cambrian – Ordovician Mt Arthur Group), which has been metamorphosed to marble, this karst is formed from mid Tertiary aged limestones. A small area of fossiliferous Paleozoic Limestone near Reefton (Devonian Reefton Group) is significant to New Zealand's geochronological history, but not karst forming.

The Alpine Fault is a major New Zealand geological feature which marks the convergence of two active continental plates, the Pacific Plate and the Australasian Plate. Convergence at the boundary between these two plates began around 50 million years ago and continues to this day, with movement on the fault being dextral-reverse, i.e. there is both horizontal slip (northward) and vertical uplift (forming today's Southern Alps). Scientists estimate that the next Alpine Fault earthquake—the probability is quite high in our lifetime) - will generate sufficient energy (Moment Magnitude 8+) to cause 1 - 3m of uplift and 7 - 8m of horizontal movement in the central Southern Alps area.

Over the Tertiary period strike-slip movement has separated large blocks of rock which used to be continuous across the fault. The Red Hills ultramafic area in South Westland and the allied Dun Mountain ultramafic area near Nelson are now 480 kilometres apart while the marbles of Mt Arthur are linked to the many marble remnants found throughout Fiordland.

During the Oligocene period (37 – 25Mya) almost all of New Zealand was under the sea and large beds of carbonate sediments were laid down, blanketing the older sediments and Paleozoic basement rocks. Those carbonate sediments began to surface in Miocene times (about 20 million years ago), along with some of the strata below, as a result of tectonic uplift and dropping sea levels. Much of the uplift has been along the Alpine Fault (since around 9Mya) but there has also been uplift along other NE – SW trending faults further west, which have formed the Paparoa Ranges.

Currently the mountains in and around Mt Cook are "growing" at 10mm per year. But they also eroding at much the same rate so that on the coastal shelf there are large depths of recently eroded sediments, plus earlier glacial gravels, overlying large areas of carbonate rocks.

As the non-marine coal-bearing sediments under the carbonate rocks have the potential to contain gas and oil, much of the coastal shelf off the West Coast was explored by petroleum companies in the 1960-70's using seismic reflecting methods. The limestones in particular are good seismic reflectors and have contributed greatly to our current understanding of West Coast bathymetry.

The 600 kilometre coastal strip from Kahurangi Point in the north to Big Bay in the south, otherwise known as the "West Coast," is underpinned by some of New Zealand's oldest rocks. These basement rocks are Paleozoic remnants from proto-New Zealand, when this country, along with eastern Australia and Antarctica, formed the southwest segment of Gondwanaland.

Basement (oldest) rocks on the West Coast are either Ordovician metasediments (sandstones and mudstones known as greywacke) or Devonian plutonic rocks (granites). Both have eroded down over time as well as being metamorphosed, the greywackes becoming indurated and the granites changing to gneiss.

Extensive outcrops of the granitoid basement rocks, from which overlying sediments, including limestones, have been eroded, can be found in the Paparoa and Victoria Ranges and large outcrops of Greenland Group greywackes can be found at Ross and Waiuta. Small areas of both types of basement rock can also be found along the coast.

The only Paleozoic karst found on the West Coast is a small area at Springs Junction. Here the Sluice Box Limestone formation forms the southern-most known outlier of the Ordovician Mt Arthur Group.

In some places mid-Tertiary limestones lie unconformably over basement rocks – for instance pockets of Oligocene age Takaka Limestone in Kahurangi National Park rest on an ancient peneplain formed of Karamea Granites – but in most places there other Mesozoic – early Tertiary sediments in between.

These include breccias (mid Cretaceous Hawkes Crag Breccia), coal measures (late Cretaceous Paparoa Coal Measures and Eocene Brunner Coal Measures), sandstones (Eocene Island Sandstone:) and mudstones (early Oligocene Kaiata Mudstone). The Oligocene Limestones are in turn topped in many places by various Miocene formations such as the Welsh Formation (calcareous mudstones and limestones) and Stillwater Mudstone (often known as Blue Bottom or simply "papa").

The final cap which lies over much of the lowland West Coast landscape, is a layer of Pliocene non-marine gravels (Old Man Formation) and Quaternary glacial gravels. In many places relatively recent Tectonic activity has uplifted the beaches to form raised beaches or terraces behind the present coastline. In some places gravels on these terraces lie directly over limestone, e.g. at Darkies Terrace, Point Elizabeth. Sluicing these gravels for gold was difficult due to the propensity for water to drain away underground from dams and water-races.

With the exception of a very small area of strongly foramineral late Paleocene limestone in South Westland (the Abbey Limestone Formation at Abbey Rocks, south of the Paringa River), the remaining limestones of the West Coast region have all been formed during the Oligocene period between 37 and 25 million years ago. They are all considered to be sufficiently similar in age and structure to be placed in the one group, the Nile Group.

Outcrops of Nile Group limestones increase from south to north as the gap between the coast and the Alpine Fault widens, i.e. there is far more limestone and consequently more karst and caves north of the Taramakau River than south.

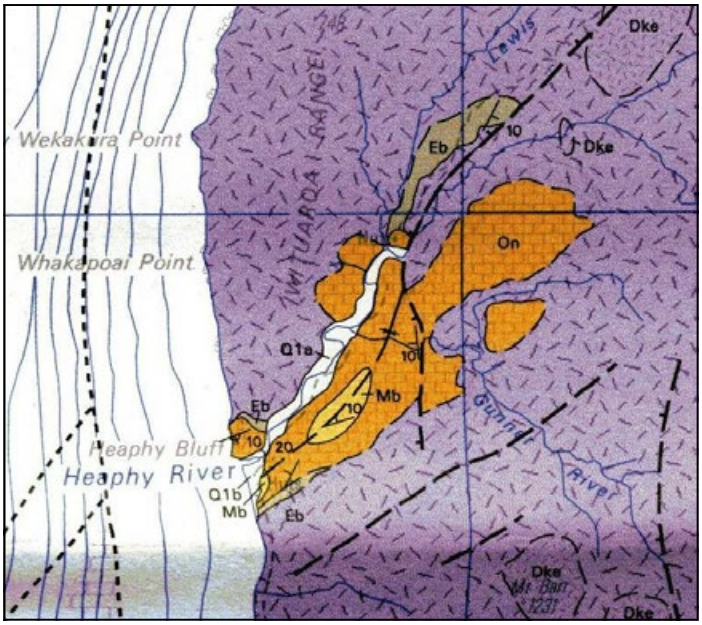
In fact there is a large gap between the Taramakau and Paringa Rivers with only two minor outcrops of limestone, at Ross and Mt Camelback. From Paringa south most of the limestone is found along the coast and on offshore islands, the last being Brig Rock off the mouth of Milford Sound.

North of the Taramakau the best karst and caves are formed in Potikohua Limestone which is found, in varying thicknesses, from Fox River to the Punakaiki River. It overlies a less calcareous, more sandy formation, the Tiropahi Limestone. Potikohua Limestone is formed from a hard white flaggy polyzoan biosparite which averages 90% CaCO3. About half the karst and caves in Potikohua Limestone are in Paparoa National Park.

All the other formations are more variable, often with muddier bands grading down to actual mudstone, and of variable thickness. The Tarapuhi Limestone Member, which forms the Point Elizabeth area, is the best ranked (highest $CaCO_3$) of the Cobden Limestone Formation while well decorated caves can be found in Takaka Limestone (Megamania), Stony Creek Limestone (Honeycomb), and in the unnamed formation at Jackson's Bay (Serendipity).

On the West Coast karst development is best amongst higher ranked limestones where there has been sufficient water flow. For instance in the capture of Bullock Creek waters to Cave Creek South through the Potikohua Limestone Xanadu Cave system and the capture of Cave Creek North waters to Fox River through the Armageddon - Babylon - Fox River Cave system .

In contrast karst formation in the muddier, lower ranked formations is often hindered by poor drainage resulting in small, muddy caves, sumped passages and tomos without ongoing leads, all typical features of the Cobden Limestone, Tiropahi Limestone, Matiri and Welsh Formations. The development of the large Honeycomb Cave in the moderately ranked Stoney Creek Limestone has been much facilitated by the high rainfall and strong drainage patterns of the area (Oparara River and in-cave streams).



The above extract from the Nelson Geological Map 1:250, 000 is about 15kms square. Takaka Limestone (On, orange) and other sediments overlay granite basement (purple) . There is considerable karst development with a number of caves on both sides of the syncline.

The photographs at right were both taken in Megamania Cave, currently New Zealand's 5th longest at 15,077m. Set in heavy West Coast bush, the cave was found in 1994 by air reconnaissance.. Photos: N Barth, 2010

Inangahua Junction Area

INTRODUCTION

At Inangahua Junction karst can be found either side of the Buller River. Known caves are mostly on the south side, the highway down the valley giving more ready access. Access to the north side is more difficult and there is still scope for finding more caves. A major earthquake in 1968 caused major damage . to the karst , the epicentre being on the north side.

GEOLOGY

Formation: Whitecliffs Formation (part of calcareous sediments, Tertiary Nile Group)

Distribution: Limestone scarps between headwaters of McMurray Creek and northern boundary of mapped area near Pensini Creek and surrounding area; single outcrop in Landing Creek.

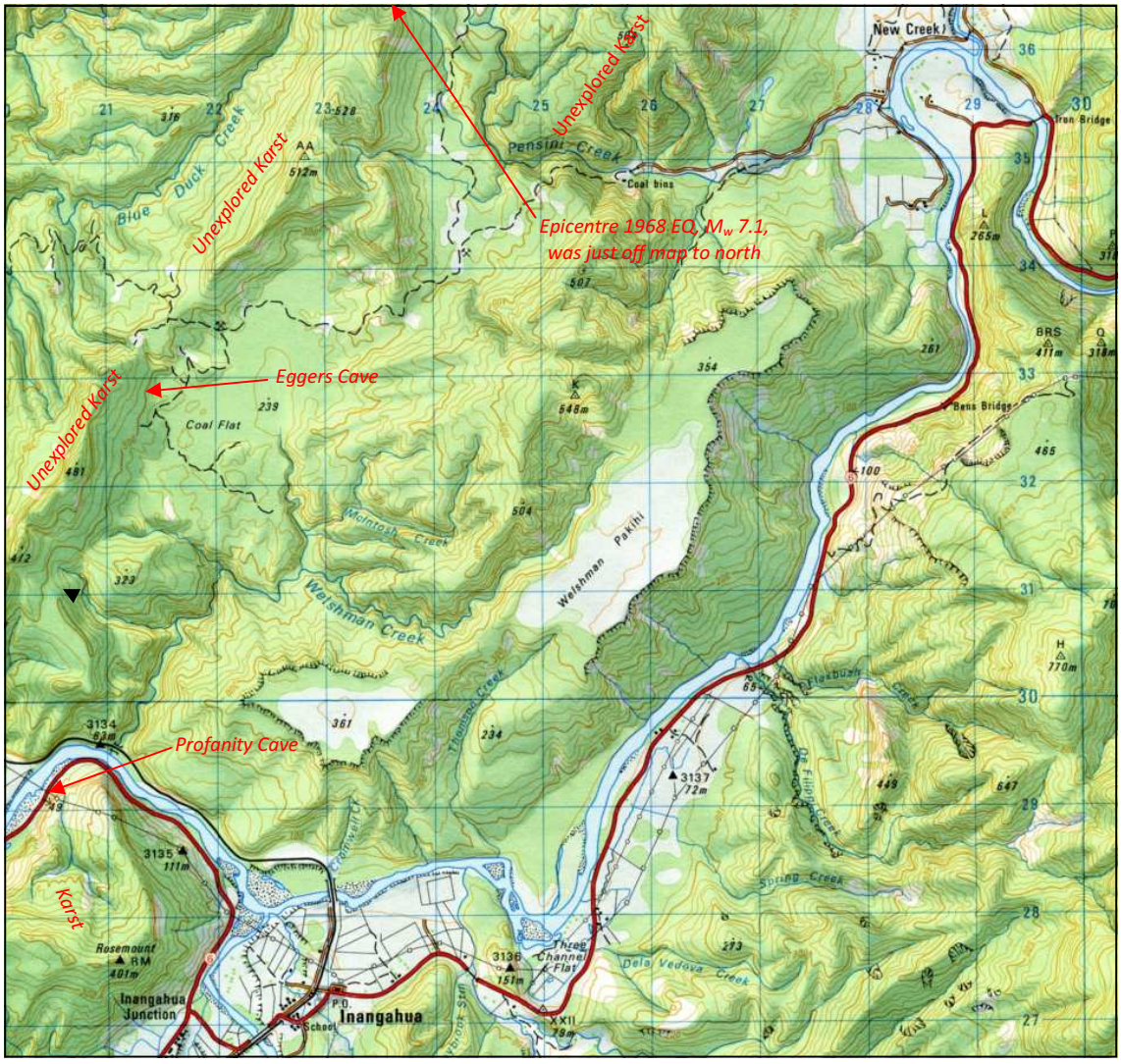
Description: sandy conglomeratic limestone (basal part near Whitecliffs), massive sandy micaceous limestone, and interbedded muddy limestone and calcareous mudstone; boulders of flaggy organic limestone and muddy limestone seen beneath Berlins Bluff; conformably overlies Kaiata Formation. *Thickness:* 60-360m.

Age: Whaingaroan to Waitakian (possibly to lower Otaian).

Depositional Enviroment: Marine, middle to outer shelf; rapid sedimentation.

Reference: Handbook to NZ Buller – Lyell Geological Map, Sheets S31 & 32, 1:63,360, Simon Nathan, DSIR, 1978

At left: The "Whitecliffs" looking eastwards from the roadside. The resurgence entrance of Profanity Cave is at the bottom of the cliffs underneath the power lines. Photo: M Trayes, 2006



Extract about 10km square from NZ Topo Map, Sheet L29, Inangahua 1:50,000, 1979

Whitecliffs Formation Limestone runs in a curve from south to north across the Buller River.

About 3kms further east there is another smaller band of karst abounding the Inangahua Fault (east side).

THE CAVES

The Inangahua Junction area has a number of caves in the White-cliffs Formation which extends both south and north of the Buller River along a syncline. Some of the caves were explored as far back as the 1870's by goldminers and prospectors. A major earthquake in 1968 on the Inangahua Fault affected a number of caves in the area, Eggers being the closest known cave to the epicentre.

Locals told cavers who explored the area in the 1970's that the area has never been quite the same since, some caves now being 'lost' including Golden Cave, the underground passages of which were staked out by goldminers early in 1879 (see more below). Today the Inangahua area is less well visited by cavers than other parts of the West Coast due to its remoteness from town centres, although a highway passes right through the area.

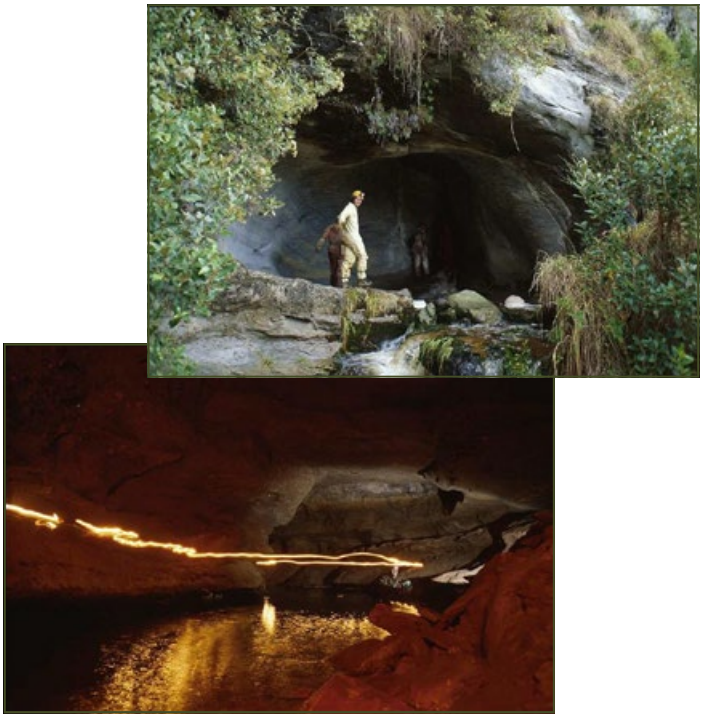
Eggers Cave is on the north side of the Buller River, west of the Iron Bridge (near Lyell) and is an easy, but interesting stream cave with several entrances. Eggers is a 'bit off the beaten track" but has been known of for many years, originally being called Coal Flat Cave. However of recent years it's become known as Eggers' Cave, Egger being the name of a bulldozer driver who almost drove 'over it' when the area was being logged about 30 years ago.

Being an 'easy' cave (despite being both remote and unmapped) Eggers Cave is popular with scientists. In 2002 –'03 DOC staff collected freshwater snails from the cave which were identified in 2008 as a new species, *Opacuincola permutata Haase* and in 2016 a new species of Carabid Beetle from the cave was added to the latest update of the Catalogue of New Zealand Carabidae. In 2005 cavers assisted a PhD student, with a DOC permit to collect stalagmite cores for climate change research, in his work at the cave.

References

T.E. Whittaker: High Resolution Speleothem-Based Paleoclimate Records from New Zealand Reveal Reveal Robust Teleconnection to North Atlantic During MIS 1-4: Ph D Thesis, Uni. of Waikato, 2008

A. Larochelle: Taxonomic Supplement (2001 to 2015) to the Catalogue of N.Z. Carabidae (Insecta Coleoptera): University of Nebraska - Lincoln, 2016



Two views of Eggers Cave, the lower one showing the stream running through the cave. Photos: M Rodgers

Profanity Cave is on the south side of the Buller River just west of Inangahua Junction. It is a large cave with streamway which resurges from the toe of the high 'Whitecliffs' bluffs. The cave was described by CCG caver Steve Wilkinson in the 1970's as *"An arduous cave, not fully explored. Has quite a variation of formation, the best being possibly 3.2 km from the entrance. Sports a varied cross-section of passages, wet, clean and wet, muddy, rocky, sandy etc. Part way in a 'lake' passage adds to the sport, especially for non-swimmers."*

In July 1980 the cave was the site of a major cave rescue when 3 cavers were trapped by rising floodwaters after torrential rain. Searchers dug out an old entrance, which bypassed the flooded section to find the cavers alive. It was surmised that the old entrance had collapsed as a result of the 1968 earthquake.

Reference

S. Wilkinson: Inangahua Prospects: NZ Speleological Bulletin, Vol. 5, No.88, May 1974

Profanity Cave resurgence is just off the highway at the base of the Whitecliffs, Inangahua Junction Photo: M Trayes, 2006

Westport Times, Volume XII, Issue 1644, 26 November 1878

DISCOVERY OF LIMESTONE CAVE AT THE WHITE CLIFFS, BULLER ROAD.

GOLD FOUND IN CREEK RUNNING THROUGH THE CAVE

Mr Warden Broad, who on Friday returned from the Lyell, brought the news that a day or two since Mr Reuben Waite's nephews went out to the claim of Knopp and another, who are working in a creek about two miles from Waite's Accommodation House, in the lime-stone ranges to the right of the Buller Road. This creek disappears through a hole, and it has previously been a mere matter of conjec-ture where it again found an outlet. The young Waite's ventured to get down the crevice through which the creek disappears, and to their astonishment found themselves in a spacious limestone cavern hung with stalactites and arched like a cathedral dome. They lit up some grass as a torch, and they say the sight was grand in the extreme. The creek forms a pretty water fall into the cavern, and then flows onward until it finds an outlet in the cascade at the White Ciiffs, near the boundary of the Buller and Inangahu Counties. Following up their discovery the explorers prospected the bed of the bed of the creek as it runs through the cavern, and found payable gold in it. They purpose making a track up the range, and opening the entrance to the cave so that tourists may visit this great natural curiosity.

Paparoas Area

INTRODUCTION

The Paparoas are a range of mountains lying west of the Southern Alps between the Buller and Grey Rivers. A significant area of karst exists on the coast side of the range, most of it on the western limb of the Barrytown Syncline. High limestone cliffs denote the western margin of the limestone (the Punakaiki Anticline) and parallel the coast from the Nile River in the north to the Punakaiki River in the south.

A number of rivers flow west from the main divide of the Paparoas (essentially basement rocks with some older sediments) to reach the sea. The rivers have all cut down through the limestone anticline to form gorges (i.e. river flows are antecedent to the downcutting). There are also many other karst features including caves, karren, grykes, stream capture and polje.

The karst south of the Tiropahi River to the Punakaiki River is managed as part of Paparoa National Park and the rest (apart from an outlier of the National Park around the Metro Cave) is lower ranked conservation land, some of it having been logged in the past. The recent review of the Park's management plan recommended that all the karst become part of the Park but this has not been actioned yet.

As the whole of the karst is too large for a single map, for the purposes of this Field Guide the Paparoas Karst has been subdivided into the Charleston and Punakaiki Areas (the Fox River Area not being part of the planned tour). Generally the geology is the same but as there are some interesting differences between the two areas, the geology is outlined for both.

A. Charleston Karst

GEOLOGY

Most of the karst-forming limestone in the Charleston area is Potikohua Limestone overlying Tiropahi Limestone. Only a few small caves are known from the Tiropahi Limestone where it outcrops along the coast (Pahuatane). Caves are known from the high quality Waitakere Limestone but around Charleston and at Cape Foulwind much of it has been quarried for farm lime and cement production.

Waitakere Limestone **ne (Nathan 1974), 6-20m**

Description: White light grey algal limestone, locally with thin bands of mudstone or quartz sand: highly calcareous (averages 94% $CaCO_3$); petrographically and algal biosparite (Folk 1959); occurs mainly north of the Nile River, south of which it appears to grade laterally into the lower part of the Tiropahi Limestone; conformable on the underlying Little Totara Sand.
Age: Lower Whaingaroan
Depositional Environment: shallow marine clear-water conditions (probably shoal within the zone of light).

Tiropahi Limestone **nt (Nathan 1974), 15- 180m**

Description: Massive white or light brown muddy limestone, locally sandy; extensively burrowed; $CaCO_3$ averages 68%; petrographically an impure foraminiferal biomicrite (Folk 1959); thickens southwards, conformably overlies the Waitakere Limestone.
Age: Lower Whaingaroan to Duntroonian
Depositional Environment: Middle to outer shelf, possibly shallowing towards the north

Potikohua Limestone **np (Nathan 1974), 60 – 105m**

Description: Hard, white, flaggy, polyzoan limestone; $CaCO_3$ averages 90%; petrographically a polyzoan biosparite (Folk 1959); conformably overlies the Tiropahi Limestone.
Age: Duntroonian to Waitakian
Depositional Environment: Shallow marine, open water but with a little clastic material.

Reference: S Nathan: Handbook to Geological Map Foulwind & Charleston, Sheets S23 & 30, 1:63.360, DSIR, 1975

* *see a more detailed description with Punakaiki Karst, p. 10*

The cave in Tiropahi Limestone which was exposed during roadworks to re-align the highway at Pahuatane in 2009. The works were stopped thanks to due diligence by locals and West Coast cavers. Photo: F McDonald, Limestone Creek

Above: Bluffs of white Potikohua Limestone on the north side of the Nile River not far from the road end. Photo: M Trayes, 2007

Extract from LINZ BS20 Charleston topo map showing Charleston Area with roads, key cave and karst features. Map is approx. 9 x 8 kms.

THE CAVES

Via the Nile River

A number of caves can be found in the Nile River area, the largest being the **Metro** (or Ananui/Nile River Caves). The block of karst in which the cave is located forms an outlier of Paparoa National Park. A local tourist operator has a concession to take commercial tours into the cave. The Metro has been gated since 1972 to protect the cave and control visitor numbers.

The Metro is on the north bank of the Nile River near the top end of the Nile River Gorge. The cave has been formed by the underground capture of Ananui Creek, a true right tributary of the Nile. The stream has carved its way down through the Potikohua Limestone to the contact below with the Tiropahi Limstone, forming about 8 km of cave passage in an area about 600m long and 100m high.

The cave has formed on or about the contact between the two limestones with the Potikohua being overlain by the late Miocene – early Pliocene O'Keefe Formation (part of the Blue Bottom Group), (fine grained, muddy sandstone). Topping this off again are glacial gravels (Addison Formation) dated back to the interglacial period before last or about 200,000 thousand years ago. As the cave could not have formed before these gravels were uplifted, this also gives a maximum age for the cave.

The Metro has gone through six formative stages before reaching its present state. The stages were linked with the rate at which the Nile River cut down through the limestone to form its gorge.

As the baseline to which the Ananui Creek had to sink kept changing, the creek too had to readjust, both in its route through the cave, and at the point where it submerged. Each submergence moved progressively back up the creek leaving previous entrances stranded. The earliest resurgence was at today's gated Triclops Entrance, which is now 37m above the river), whilst today's large main entrance, which was the location of the second last main submergence, now only receives water if the present main submergence overflows.

The progressive abandonment of the older passages by active streams has allowed sediment deposition and speleothem formation but this process has not proceeded at an even pace, given the climatic and sea-level changes linked to the last two glaciations. Sediments vary from large rounded boulders to thick beds of fine sand and silt. Many excellent white speleothems, formed from the Potikohua Limestone are found in the cave and a large number of sub-fossil bones have also been recorded from the cave's sediments.

Reference: P. Crossley, P. Millener, C. Pugsley, P. Williams: Metro Cave - A Survey of Scientific & Scenic Resources: edited P. Williams, Professor of Geography, Uni. of Auckland, 1980.

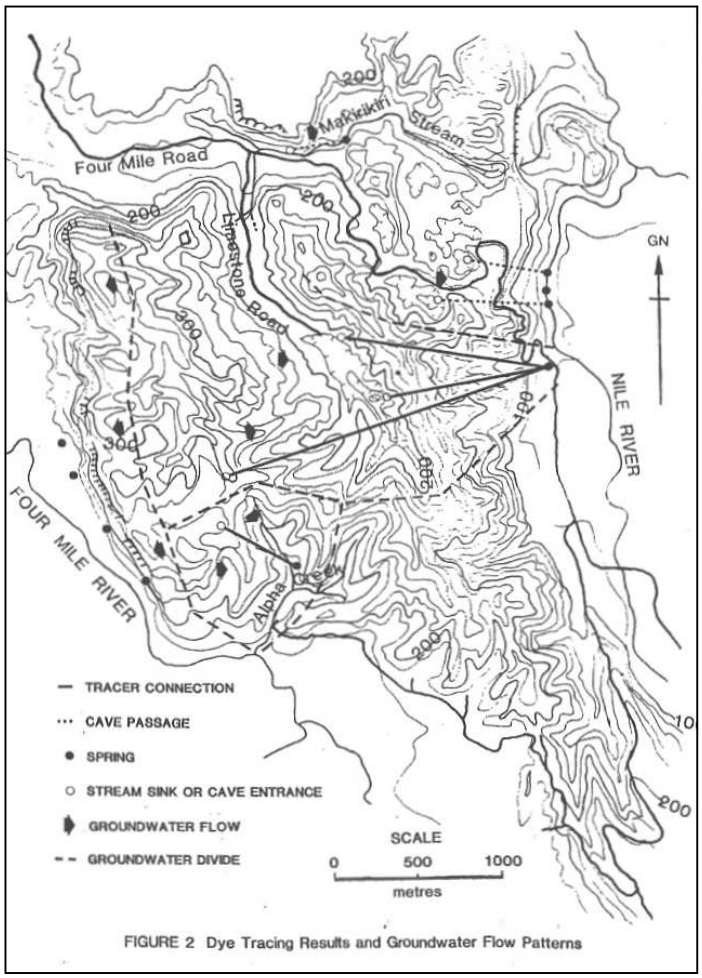
The Metro Cave was surveyed in the early 1960's by Greymouth cavers led by Malcolm Laird., who had earlier taken up caving whilst doing a geology degree at the University of Auckland. When he got a job with the NZ Geological Survey at Greymouth he began taking young West Coasters caving including trips to the Metro. As part of his job Malcolm also compiled the Punakaiki Geological Map

Via Four Mile Road

Four Mile Road, a former logging road gives access into the karst between the Nile and Tiropahi Rivers. The many caves in this block are popular with recreational cavers and there is still scope for more finds in the thick bush. In recent years there has been a push by cave divers* to try and connect some of the resurgences along the Nile River, and a couple of its tributaries, with caves above. Cavers are hoping that this block of karst will soon be added to Paparoa National Park because of the quality and quantity of caves.

* N. Thorpe, West Coast Cave Diving: NZB, Vol. 11. No. 210, pp.195-197, December 2015

Cavers preparing to dive the Winchhead Resurgence in 2015. Photo: T Crisp



Map showing underground drainage in the Four Mile Road—Alpha Creek area from Scott Crawford's Karst Hydrology of the Alpha Creek Area and Potential Impacts of Quarrying. Report to Milburn NZ Ltd (1990).

The **Hole in the Wall (**or Hill) is a large natural arch located in Makirikiri Creek, a tributary of the Nile River (see map). The arch has been formed by the gradual eroding of a large block of Potikohua Limestone, and is the only one known from the Paparoa Karst. Access is via Four Mile Road then a rough walking track which skirts a very large doline before dropping down into the creek where the large arch spans the full width of the creek. There are also a number of caves in this area.

Hollywood Cave is off the same foot track which gives access to the Hole in the Wall. As its name suggest Hollywood has both "glam and glitter" however besides being well decorated this cave is also quite fragile. In consequence the one entrance has been gated to regulate the number of those visiting and protect the cave. The entrance series is a narrow and time-consuming rift, which eventually opens into the decorated parts of the cave. Hollywood Cave was found in 1984 by Buller Caving Group cavers. A survey was then done by Canterbury and Buller Caving Club cavers and the map published in 1994.

As the name suggests**, Golf Course Cave** has many holes to contend with, making it quite a 'sporty 'cave. Access to the cave from Four Mile Road is via an old logging road (Limestone Road) which is becoming overgrown, then a rough bush track. If water levels in the cave are down ,and the body is agile, it's possible to get through all the holes without getting wet, but one never quite knows with this cave until the day.

Buller Caving Group members explored the cave thoroughly in the 1980's but did not publish a map so most people complete the through trip without realizing how extensive the cave is. Canterbury Caving Group members are currently surveying the cave with plans to publish a map soon.

Taken in the upper levels of Hollywood Caves on a joint trip by Sydney and West Coast cavers in 2002. Photo: A. Pryke, SUSS

B. Punakaiki Karst

GEOLOGY

Distribution: The formation crops out on both limbs of the Barrytown Syncline.

Description: Hard, white, flaggy, polyzoan limestone, locally sandy. Petrographically it is a polyzoan biosparite (Folk 1959). It is highly variable in thickness, reaching a maximum of 600m south of the Pororari River on the east limb of the Barrytown Syncline, and thins rapidly to the southwest to less than 18m in the headwaters of Lawson Creek. At Dolomite Point a horizon of phosphatic nodules and quartz granules up to 1 cm in diameter divides the 44 m thick limestone almost equally into a lower thicker-bedded non-platy limestone and an upper stylobedded platy limestone. The hiatus represented by this horizon has not been recognised elsewhere in the region, and it may be only of local significance. More rapid weathering of softer layers in the platy limestone have accentuated the bedding to form the well known Pancake Rocks.

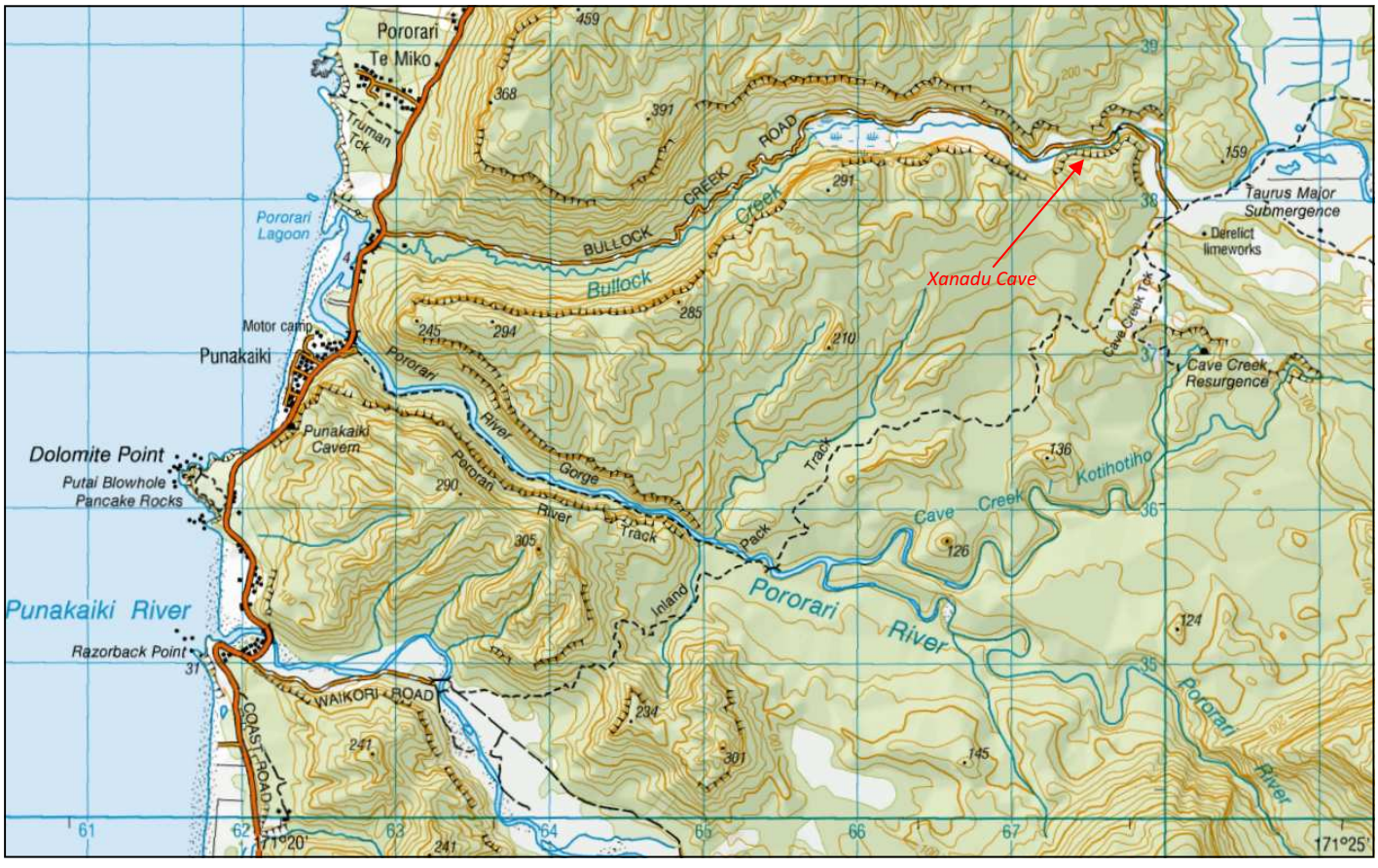
Stratigraphic Relations: In the northwest the formation rests conformably on or interdigitates with Tiropahi Limestone. In the coastal area south of Hatters Bay, Potikohua Limestone rests in most areas apparently conformably on and with transition over a few decimetres into Island Sandstone (e.g., on the road-side immediately north of the Pancake Rocks). However, a local discordance of 10° between these two formations (Fig. 12) is visible in the lower gorge of Bullock Creek and the basal few centimetres of the Potikohua Limestone contain phosphatic nodules and quartz pebbles up to 1 cm.

Age: Lower Whaingaroan to Waitakian on microfossil evidence.

Environment of Deposition: Transgressive deposits, inner shelf (locally) to outer shelf (Anderson 1984).

Reference: M. Laird: Handbook to the Punakaiki Geological Map, 1:63,360, DSIR, 1988

Potikohua Limestone in the south side of Bullock Creek near the entrance to Cairns Catacombs. Note the dry creek bed and gently dipping limestone. Photo. M Trayes, 2008



Extract from NZ Topo Maps (online) of the Punakaiki—Bullock Creek Area showing key cave and karst features. Map is approx. 9 x 5.5 kms

CAVE & KARST FEATURES

The **Bullock Creek Cave System** is a significant caves and karst system with Bullock Creek being one of the of the six streams which have cut down through the limestone belt which runs parallel to the coast between Punakaiki and Charleston. About 3kms up the Bullock Creek road the gently dipping limestone reaches creek level and as it sinks karst features such as caves and sinkholes begin to appear. These continue right back to the syncline where a calcareous, muddy sandstone (Welsh Formation) begins to overlie the Potikohua Limestone.

In places gravels overlie all other formations still on the valley floor and these are the remains of the last interglacial deposition, the Waites Formation, in this area. The bed of Bullock Creek itself contains many medium to small sized granite boulders eroded from the main Paparoa Range and washed down the creek by the high rainfall in the area. Granite pebbles act as an effective grinding agents within the caves, adding to the rate at which solution passages are formed.

A key feature of the Bullock Creek drainage is the capture of most of its water, which comes off the main Paparoa range, by an underground system of passages to the Cave Creek South - Pororari River catchment. In fine weather the bed of Bullock Creek below the main sinks (Taurus Major) is often dry but when it rains heavily (not uncommon) the main sinks overflow and water travels on down the creek to find its way into other sinkholes in the bed of the creek) and into the many fissures and cave entrances on the south side of the creek. If it rains for long enough, the other sinks and caves all fill as well so the creek begins to flow on down, filling the swamp and then on down to the sea.

This stream capture has been caused by a landslide which came off the north side of the valley about 45,000 years ago. This dammed the creek and raised the creek bed. Creek waters then began to find their way southward through a network of floodwater maze passages (the present Xanadu Cave system) to emerge through a number of springs in the upper reaches of Cave Creek South.

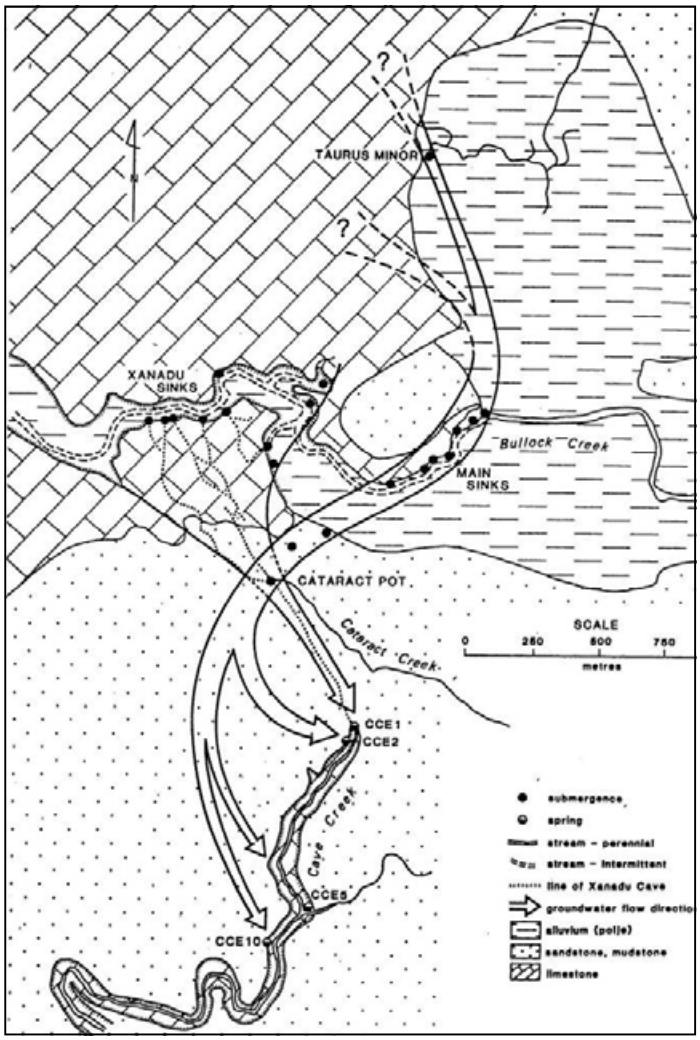
Since European times this natural change to the drainage has been further changed by both grazing and logging of the area upstream of the main sinks (Taurus Major). This includes a system of drains having been dug on the north side of the creek about 50 years ago.

Anecdotal evidence points to the sinks flowing more often due to the affects of deforestation, causing more frequent flooding of the caves and swamp downstream. Whilst these effects are difficult to quantify, at least one cave was highly impacted in the early 1970's, its speleothems being covered in mud.

It's unclear yet what the effects the cessation of grazing (about 10 years ago) will be for this large wetland area, but DOC have closed the drains off, and are allowing the cleared area to revegetate naturally. Although not technically a 'polje' this shallow depression area where Bullock Creek crosses the Barrytown Syncline, acts in very similar fashion, and is often referred to as such.

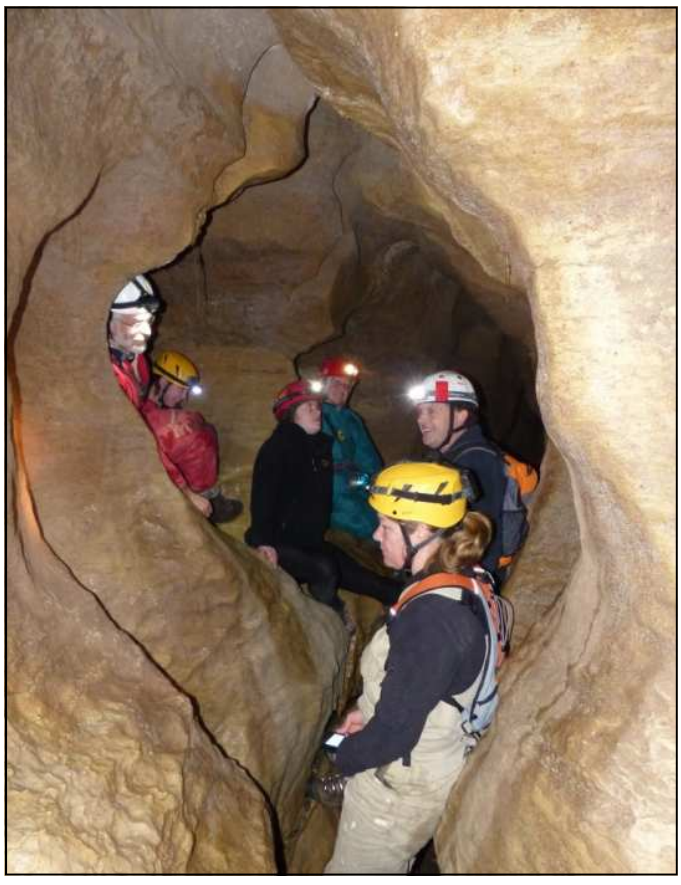
In 1989 a major study was made of the Bullock Creek karst hydrology by Scott Crawford., a student at the University of Auckland. Whilst cavers had long since suspected that the captured waters resurged into Cave Creek South, it took a comprehensive study using dye tracing and measurement of aquifer recharge (water level monitoring, rain gauges) to prove this without doubt.

Reference[i] S. Crawford: The Hydrological Behaviour of a High Flooding Frequency Karst System in New Zealand: Geography Dept., University of Auckland, 1989



Above : Diagram from Crawford, 1989 re Bullock Creek stream capture

Below: Cavers in the Keyhole Passage, Xanadu Cave, 2015 Photo: G Thomas



The triangular area between Dolomite Point and the Coast Road at Punakaiki is generally known as the **Punakaiki Pancake Rocks.** The rock strata see here is Potikohua Limestone and an overlying layer of Waites Formation gravels. The limestone contains no Mg_2CO_3 component despite the name "dolomite," a fact which continually misleads visitors and locals alike.

Close scrutiny of a rock stack out at the Pancake Rocks will reveal that they are formed from two types of limestone: non-platy and platy. The contact point can generally be distinguished from a layer containing quartz granules and phosphatic nodules. The non platy lower section of the stacks has normal limestone bedding similar to the strata found in the Xanadu Caves system at Bullock Creek. The upper platy layer with its "pancaking effect" is more unusual and over the years there have been many attempts to explain how this has come about. The following is derived from the 1999 GNS "Guide to the Pancake Rocks" and is the generally accepted explanation for the pancaking effect.

"The origin of the mudstone bands, referred to here as seams, has been the subject of much scientific interest. It was popular belief that this type of layering limestones formed at the time of deposition. However, geologists now consider a secondary process is responsible. When sediments are buried and compacted by the enormous load of overlying material, grains of shell material and silt are forced against each other.

At their points of contact where the pressure is concentrated, the calcite in the shell fragments is least stable and begins to pass into solution. For reasons still unclear these sites of solution eventually merge to form an irregular boundary (styolite), oriented approximately perpendicular to the axis of pressure. As permeating solutions continue to carry dissolved calcite away, insoluble minerals are left as a residue, in time becoming concentrated along the boundary to form a seam of mudstone.

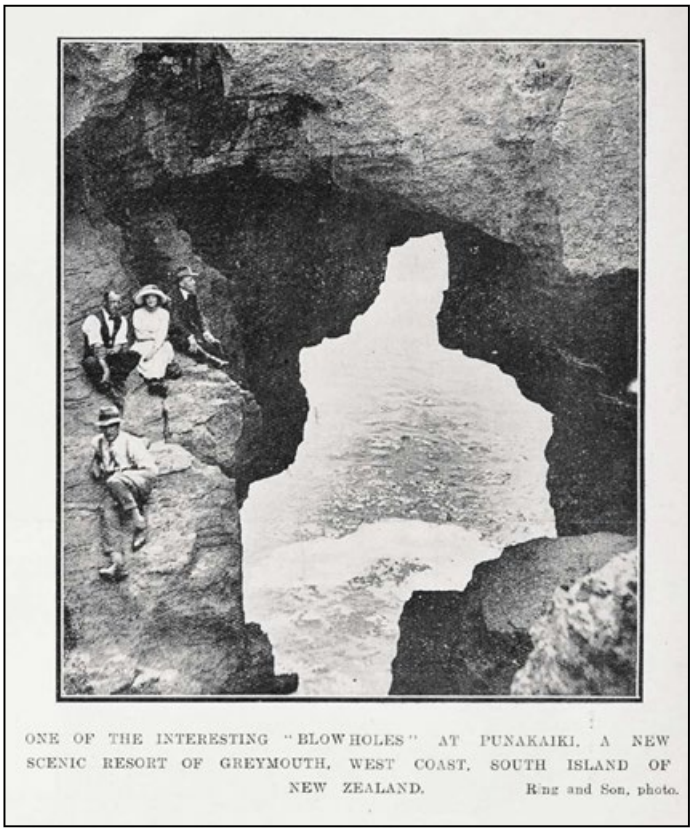
This type of layering, found in limestones worldwide, is known as stylobedding. In the Pancake Rocks the seams forming the stylobedding are more or less parallel to the original sedimentary bedding. However, in limestones from other parts of the world, the seams cut across bedding demonstrating that the stylobedding formed sometime after deposition, by a secondary process."

The constant battering of the sea and prevailing south-westerlies fronts off the Tasman combine to weather the mudstone layers more quickly than the limestone ones, leaving the limestone more sharply profiled. The same elements, combined with a rainfall of 2500mm per year, are also continuously eroding the whole area from the coast back to the road.

At the Pancake Rocks, the many tomos, caves, blowholes and rock arches are an attraction for thousands of visitors every year. The infrastructure is checked annually for corrosion and the rocks for erosion by GNS scientists who have predicted that 'one day' the land bridge near the big pool will collapse.

There are plans to improve the various services needed to meet visitor demand at the Pancake Rocks (toilets, cafes, Information centre, more car-parks etc) but this is no easy task in this karst environment, especially as the sea caves behind the big pool probably reach back as far as the road, and at least one hole - a 4m deep grike - has opened up under the present Visitor Centre since it was opened in 1987.

Reference: G Coates & M Laird: Guide to the Pancake Rocks, Punakaiki: GNS Science, 1999. Order online for $5 at http://shop.gns.cri.nz/is_70/



ONE OF THE INTERESTING "BLOW HOLES" AT PUNAKAIKI, A NEW SCENIC RESORT OF GREYMOUTH, WEST COAST, SOUTH ISLAND OF NEW ZEALAND. Ring and Son, photo.

Proof that the Punakaiki Pancake Rocks have long been popular. Photo: Auckland Weekly News, AWNS, 23rd February 1922

The same young men who explored and mapped the Bullock Creek Caves in the early 1970's also conquered this rock, known locally as the 'Punakaiki Overhang.' See a photo of their climb in the Punakaiki Tavern. Photo: M Trayes, 2006

Greymouth Area

GEOLOGY *[The following is an extract only from the four detailed pages about this strata in the map handbook]*

Nile Group (Nathan 1974)

Cobden Limestone nc (McKay 1877)

Distribution: As a result of the southwest plunge of the Brunner Anticline, the Cobden Limestone crops out in a horseshoe shape extending from Greymouth in the northwest to lower Stillwater Creek in the north centre of the district. It forms narrow steep escarpments and wider dip slopes, the latter being up to 2 km wide south of Greymouth where dips average c. 15°, but less than 0.5 km wide on the northwest sides of Card and Stillwater creeks where dips progressively increase northeastwards from 18° to 50°. To the southwest along the axis of the Brunner Anticline, it crops out in small inliers west of Marsden (632486) and in Fireball Creek (612447).

Apart from the area from which it has been eroded in the core of the anticline in the north, the Cobden Limestone underlies almost the whole of the Kumara-Moana district northwest of the Hohonu Fault. Only in the area of the Kawhaka-1 well is it absent, probably as a result of Late Miocene uplift and erosion.

Two small areas of outcrop lie within the Hohonu Fault zone at Deep Creek, Hohonu, and at Knoll Point on the south side of Lake Brunner.

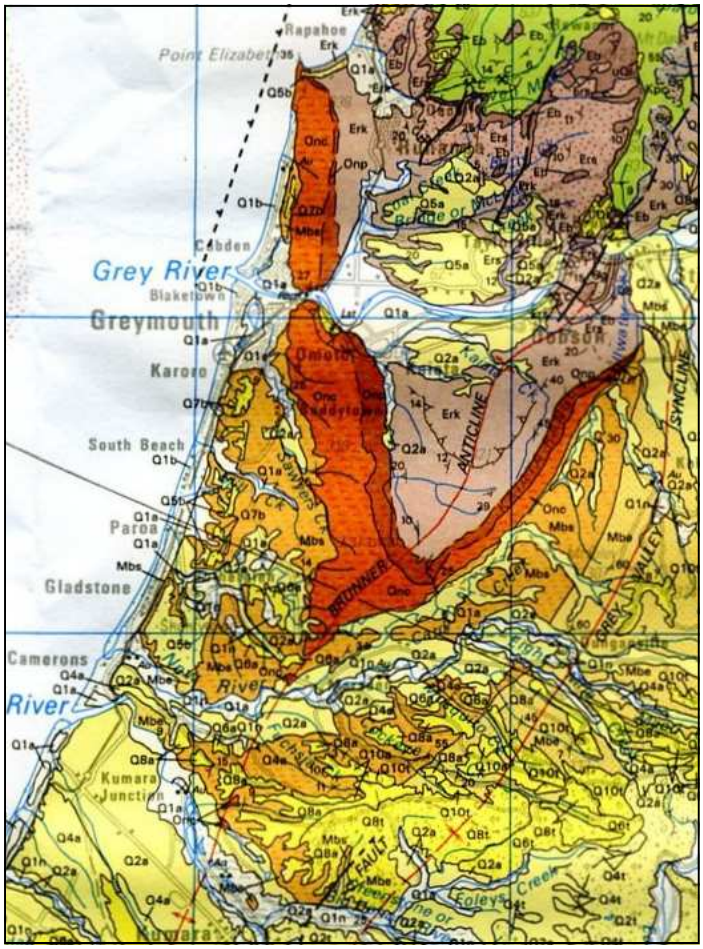
Because of both its extent and the lithological contrast between it and the overlying sediments, it forms an excellent seismic reflector for structural interpretation, except along the very steeply dipping west limb of the Grey Valley Syncline. ……

In the Greymouth area, where the Cobden Limestone is 370m thick, it is muddy throughout, apart from glauconitic bands which allow its separation (Nathan, 1978) into three members, the Ngarimu and Tarapuhi Limestone Members, and at the top, the Puketahi Mudstone Member. …….

Environments of Deposition: The prevalence of limestone throughout the Kumara –Moana district, as indeed over the West Coast as a whole, reflect the culmination of the Paleogene marine transgression over eastern peneplaned areas not reached earlier. In the west, deposition was mainly in an outer shelf to upper bathyal environment, rather deeper in the Greymouth area in the north. Inner shelf environment prevailed in the west.

Age: Age data are few but taken as a whole the age range for the Cobden Limestone is from late Whaingaroan to early Waitakian.

Reference: R.P Suggate, T.E. Waight: Geology of the Kumara – Moana Area, GNS, 1999



Extract from 1999 Kumara - Moana Geology Map showing the Cobden Limestone as 'nc' in bright orange. The small area just across the Taramakau River from Kumara has the best karst development for the Cobden LS.

Stalagmites 'retrieved' from blasting at Cobden Quarry in 1999. The smaller one is at Melbourne University for dating, the 'double' one is on display at Shantytown. Photo: M Trayes, 2013

CAVES

Karst development is widespread in the Cobden Limestone but most caves found to date are muddy and smaller than those of the Potikohua Limestone. The outlier out at Cape Terrace where the limestone is higher grade, has the best karst features including a stream capture from Fireball Creek to Tansey Creek.

Te Ana Puta is a sea-cum-solution cave at the Point Elizabeth end of the Rapahoe Range (also known as the Twelve Apostles). The cave has formed in the Tarapuhi Limestone Member of the Cobden Limestone Formation, and runs for about 1km along under the Point Elizabeth Walkway.

The sea entrances into the cave have been known of for many years, being noted on a 1911 Geological Map of the area, but it wasn't until the 1990's that the cave was fully explored and mapped by local cavers. As the sea entrances are impossible to enter other than at spring low tide with very calm sea conditions, initial exploration concentrated on finding a tomo entrance seen from inside the cave.

Finding it took nearly 5 months of 'flax bashing' during which time other tomos were also found, all enabling further exploration without having to worry about sea conditions. However those exploring the cave soon realised that the state of the tide was important because a key passage, which links the sea caves area with the further parts of the cave (the "The Lakes"), is in fact tidal.

As a general rule, through trips in this cave are best done at mid to low tide but for those wanting to see - and hear! – the effect of big south-westerly rollers slamming into a cliff face, the best time to visit the Second Sea Cave entrance is around high tide. On such visits it should be noted that the sudden changes in air pressure can be hard on the ears. And cause other odd effects ……..

The **Grey River Gorge** with associated cave and karst features is at the south end (Greymouth) end of the Rapahoe Range. The river has cut down through the limestone on the western limb of the Brunner Anticline to form a gorge which in early days of the town, came right down to the water on both sides.

Bridge building (four to date) has been made difficult over the years by the depth of the gorge. When the present road bridge was being built in the early 1970's, engineers drilled down over 50m trying to find a stable base for the piles. In doing so they went right through the limestone into caves in some places. They also found that the river bottom was very uneven so that all the piles had to be custom made of different lengths.

In developing the town as a port in the early days, quarrying on both sides of the river has destroyed a number of caves and tomos. However some still remain including two small caves, two large resurgences and many tomos and grikes. In the 1990's further quarrying on the south side exposed a repository of bones which were noticed by a local man. When investigated by palaeontologists in 1998 they turned out to be those of the extinct New Zealand Snipe, a valuable find.

Recent research points to at least six caves having been quarried away on the Cobden side of the river between 1877 and 2005. Today the remnants of the last cave uncovered (1999) can still be seen in the top corner of the quarry and some of the speleothems which were retrieved are on show at the West Coast Gem & Mineral Club's Hall at Shantytown *(see photograph on previous page).*

References:

T.H. Worthy, C.M. Miskelly, R. A. Ching, Taxonomy of North and South Island snipe (Aves: Scolopacidae: Coenocorypha), with analysis of a remarkable collection of snipe bones from Greymouth, New Zealand, 2002, New Zealand Journal of Zoology 29: 231-244.

Point Elizabeth at left with Te Ana Puta's sea cave entrances mid-photograph. Photo: P Caffyn, 2013

Castle Hill Area

GEOLOGY

Abstract (from the paper referenced below)

A basin analysis of the Oligocene Porter Group rocks in Castle Hill Basin, Canterbury, was completed. The Porter Group contains the Coleridge Formation which comprises a lower sandstone unit and an upper micritic limestone unit, and the Thomas Formation which consists of biosparite limestone and interbedded tuffs. Basin analysis provided evidence that the Coleridge Formation lower sandstone unit was deposited in an inner shelf setting based upon its moderate sorting, large grain size range, laterally continuous geometry and lack of bedforms due to intense bioturbation. The upper micritic limestone is a mid shelf deposit composed of micrite and minor clastic grains. Provenance analysis has classified the lower sandstone unit as a quartz arenite. Both metamorphic and plutonic source areas are likely for the sandstone, along with reworked grains from underlying Formations based on QFL, SEM-CL, heavy mineral and glauconite analysis. The Thomas Formation limestone is a typical New Zealand cool water biosparite deposited on the inner shelf as a result of storms and debris flows, with the upper cross-bedded limestone lithofacies being reworked by currents in shallow water. Petrographic data showing multiple stages of diagenesis at the upper contact of the Thomas Formation provides evidence for a major tectonic event. The interbedded tuffs are a result of basaltic marine volcanism on the inner to mid shelf. The tuffs are reworked and deposited by turbidity current, debris flow and storms. Analysis of a dike within the Thomas Formation volcanics showed a weakly alkaline geochemical signature that is indicative of volcanism related to extension.

A regional synthesis compared the Porter Group rocks in Castle Hill Basin with Oligocene rocks in North Canterbury, West Coast and North Otago. Oligocene quartz-rich sandstones are found in Castle Hill Basin, Harper Valley, Avoca and Culverden while micritic limestone is found on the East Coast from Marlborough to Otago. Oligocene basaltic volcanics interbedded with limestone and karst unconformities are found in Castle Hill Basin, Culverden and Otago. Normal faulting may be responsible for thickness variations and several regional karst unconformities in the eastern South Island. Plate reconstructions based on sea floor magnetic anomalies also suggests the New Zealand region was tectonically active during the Oligocene. Mounting evidence, including Eocene-Oligocene faulting and volcanism in the South Island, suggests that New Zealand may not be best described as a passive margin during the Early-Mid Tertiary.

Paper Reference:

L.M. Congdon**:** Basin Analysis of the Porter Group, Castle Hill Basin, Canterbury: Implications for Oligocene Tectonics in New Zealand: University of Canterbury. Geological Sciences, 2003: http://ir.canterbury.ac.nz/handle/10092/1488

Other References:

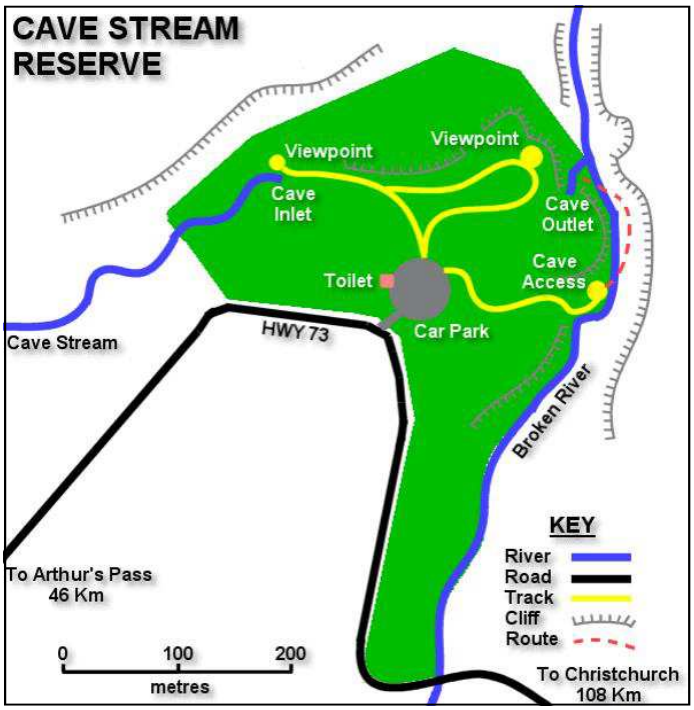
N. Reznichenko: A Field Guide to the Geology of the Castle Hill Basin: Geological Sciences, University of Canterbury, 2012

S.C. Cox, D.J.A. Barrell (compilers): Geology of the Aoraki Area: Handbook & 1:250,000 Map, GNS Science, 2007

Looking down Cave Stream toward the northern part of Castle Hill Basin. The stream sinks underground for 600m just left of centre photo. [Photo: A Shanks]

CAVES

One moderate size stream cave and several smaller ones can be found in the limestone at Castle Hill Basin, the main streams being Cave Stream, Broken River and the Thomas River**.** The other main karst features are the many limestone boulders both in the southern part of the Basin at the Castle Hill Conservation Area and up above the cave in Cave Stream Reserve. A number of walks link these. Tracks in both reserves are used by walkers and rockclimbers.



Broken River or Cave Stream Cave is located in the high county at Castle Hill Basin on the main highway between the West Coast and Christchurch. The karst parts of the basin are in two main areas with that on the south side nearer Castle Hill Station being popular with rockclimbers and walkers. On the northern side where Cave Stream goes underground to exit into the Broken River, there are futher walking tracks and more boulders.

The cave is about 600m long and a relatively easy trip if conditions are good – low water, summer temperatures. However it can become impassable in spring thaw conditions or heavy rainfall events, and the cold water can lead to inexperienced cavers rapidly becoming hypothermic. There have been at least three deaths in the cave due to people ignoring good advice and undertaking the trip without adequate gear. The high country climate, proximity to a main road and open access make this cave a risky venture at times. On the other hand it can be a fun cave if you pick the right day, have warm clothing and good lights, and do the trip upstream (recommended).

Maori, particularly the Waitaha people, have long had links to the wider Castle Hill Basin. Evidence of Māori occupation in the Cave Stream area includes rock-art, artefacts and signs of seasonal camps.

References

Cave Stream Scenic Reserve: http://www.doc.govt.nz/parks-and-recreation/places-to-go/canterbury/places/cave-stream-scenic-reserve/

Cave Stream Scenic Reserve: http://www.arthurspass.com/pdf/cave_stream.pdf

Cave Stream SAR Callout, Saturday June 21: NZSS Tomo Times, No. 160, August 2003

Above left: Cave Stream Cave submergence

Above right: Resurgence of Cave Stream into the Broken River

Below: the writing on the sign as you enter the cave……. a reminder that caves in the area were used by Maori people - the 'Waitaha' - in pre-European times

Map above courtesy of http://www.arthurspass.com/index.php?page=169

Photos this page: M Trayes, 2013

Inner Topographies and Red Chair Library installations at the Moonah Art Centre. The viewer is invited to become part of the Hastings Caves experience by sitting in the red chair and reading stories from the cave that are held in the Inner Topographies artist book. In the background are some of Janelle's drawings from the caves.

Photo: Peter Mathew