

*Journal of the*

# Australasian Cave and Karst Management Association





# The ACKMA Journal

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**FRONT COVER: Owen Griffiths (centre top) at the deep cave seen on Steve Bourne's third day caving on Madagascar. Note the Octopus (left) and Boabab (right) Trees above the cave entrance.**

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# POSITION VACANT — no later than May 2021??

## Journal Editor (unpaid)

### EDITORIAL

Welcome to the first digital-only edition of this Journal. This edition reports on a number of matters that are of an entirely conventional nature (as later described) but also on a number of matters that are unprecedented in the life of the Association (as they have been inflicted by the COVID-19 pandemic and the restrictions which it has applied to the movements and social lives of Australian citizens).

Before turning to the more usually expected matters concerning conventional content in this edition, it is appropriate to commence by recording the efforts of Jodie and Scott and others in planning and making the arrangements for the (now abandoned) Jenolan Conference. Hopefully, this present abandonment will be transmuted into a conference at Jenolan in 2024, as noted in the outcomes of the 31 May 2020 Annual General Meeting.

That AGM, the committee meeting held preceding it and that held subsequently to follow up on matters arising were conducted using Zoom, an internet technology with respect to which I suspect that most of us were entirely unfamiliar until the advent of the virus-dictated new reality of the world thrust upon us. I confess that I was particularly impressed by how well behaved the 36 members of the Association who Zoomed in to the AGM were. My past experiences of groups of cave enthusiasts over the years (including but by no means confined to the 2001 Wombeyan Conference; smaller groups of my own caving friends; and my return to an AGM at Naracoorte last year - after an absence of 17 years from ACKMA meetings) had all been rather more boisterous than the well-behaved “electronic mob” over whom Andy Spate presided on 31 May.

Matters of substance arising from these administrative processes are discussed elsewhere in this edition.

However, as is discussed in the report concerning the Association’s offer of data loggers to show cave sites, out of times of darkness it is sometimes possible to see and seize opportunities that might otherwise not ordinarily have arisen. The suggestion by Rauleigh Webb; acted upon enthusiastically by Andy, Dave Gillieson and Andy Baker; and readily endorsed by the outgoing committee is an example of a *carpe diem* opportunity.

Similarly, the pragmatic adoption of the zero-dollar fee regime for the Association’s current financial year is not only a recognition of the financial impact that the virus has imposed on employees at show cave sites (and, more generally in the community) but also provides a useful potential recruiting tool. I confess that I was quite struck, as I swiped right or left on my iPad screen to see

all those participating in the AGM (a swiping process with which I was only previously theoretically aware being happily, monogamously committed to Leanne for over a quarter of a century), by the very high percentage of the male participants whose beards were either grey or, like those of Andy and me, were white. I hope that the fee regime will permit a refreshment of membership and an influx of younger members (indeed, I secretly fantasise that such recruitment might uncover a replacement editor!).

I look forward to working with Ian Eddison, our new president (whose profile is also published later in this edition), over (**not more than**) the next three editions of this Journal. As I indicated in the March edition, I have **very, very, very reluctantly** agreed to continue for up to a further year beyond the two-year term as editor I accepted in order to support my friend, Andy, in his presidential role. If there is no emergence of a successor as editor for the Wellington AGM next year, it is necessary that I make it expressly clear that I will be walking away from this role at that time.

Finally, on administrative matters, I want to record my personal thanks to Andy for his support during his recent tenure as the Association’s president. Our interaction during these past two years of my editorship has been a high point of my friendship with him, a friendship that commenced more than 30 years ago at Yarrangobilly Caves over a Glad-bag full of tossed salad when I encountered him for the first time (in our then NPWS roles as Minister and Cave science officer).

To return to more mundane and conventional Journal matters, this edition leads off with yet another interesting travelogue from Steve Bourne - this time concerning his visit to south-western Madagascar. I note that he has speculated, toward the end of his article, on the possibility of a further visit to the area. Whilst the state of my ageing knees no longer legitimately permits any fantasies on my own part of emulating such journeys, I nonetheless look forward to future vicarious enjoyment of Steve's expeditions in this Journal (whether in my final three editions or at some later time).

Steve's contribution is accompanied by my own rambling discussion of my visit to La Roque St Christophe in the Dordogne region of France during January of this year. It is the second (and final) instalment of my writings concerning those of my cave-related fantasies that remained able to be fulfilled. Unfortunately, the pandemic-imposed shutdown on travel necessitated the abrupt cancellation of a trip to South America with my wife that had been planned for April this year. Thus, for the foreseeable future, my own cave-related travelogues must be put on hold.

## EDITORIAL continued

This putting on hold of travel has also impacted the proposed vulcanospeleology symposium on Sicily, an invitation for participation in which had been extended by John Brush in the March edition. Information on the postponed timing of this conference appears later.

Although the pandemic has, effectively, rendered the “Around the show caves” segment largely obsolete, Pete Chandler has provided a round-up of what has been happening (or not happening) in Waitomo for this edition.

The recent AGM confirmed the dates for the 2021 Guides’ School and Association AGM (with accompanying seminar on the impact of last summer’s bushfires on our cave and karst resources) to be held in Wellington, New South Wales, in May 2021. A poster for this appears on the back cover.

Finally, I record that I was surprised and humbled to be elected a Fellow of the Association at the AGM. The citation for my nomination is later reproduced and I ask you, dear readers, to note that the words are not mine, but are those of my friend Andy.

Stay well and stay safe.

**Tim Moore**

### NOTE THE DATES:

- **2021 - Wellington - Guides Training (3-5 May 2021), AGM (6 May 2021) & Fires Workshop (7 May 2021) see notice on the back cover**
- **2022 - Takaka, South Island, New Zealand (Full Conference)**
- **2023 - AGM Weekend: TBA - volunteer for location welcome**
- **2024 - Jenolan (Full Conference)**

### JOURNAL BACK COPIES

**If you would like to receive any of the back copies listed below, email my Associate, Ms Peta Dixon, at [peta.dixon@courts.nsw.gov.au](mailto:peta.dixon@courts.nsw.gov.au)**

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Issue	Month and Year	Copies
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No. 84	Sep-11	7
No. 85	Dec-11	Nil
No. 86	Mar-12	Nil
No. 87	Jun-12	6
No. 88	Sep-12	28
No. 89	Dec-12	9
No. 90	Mar-13	6
No. 91	Jun-13	Nil
No. 92	Sep-13	17
No. 93	Dec-13	1
No. 94	Mar-14	Nil
No. 95	Jun-14	4
No. 96	Sep-14	7
No. 97	Dec-14	51
No. 98	Mar-15	16
No. 99	Jun-15	7
No. 100	Sep-15	47
No. 101	Dec-15	19
No. 102	Mar-16	21
No. 103	Jun-16	11
No. 104	Sep-16	Nil
No. 105	Dec-16	41
No. 106	Mar-17	21
No. 108	Sep-17	1
No. 109	Dec-17	1
No. 110	Mar-18	1
No. 111	Jun-18	2
No. 112	Sep-18	7
No. 113	Dec-18	6
No. 114	Mar-19	2
No. 115	Jun-19	Nil



## **Meet Ian Eddison, ACKMA President**

Ian had a retail career, an advertising career and continues to enjoy his renewed caves' career.

From humble beginnings, Ian was dissuaded from finishing high school (completing Year 10 equivalent), encouraged to get work and bring in a wage to the household. His after school and holiday work in a department store led to a three-year retail management course and he completed this, along with TAFE at the same time. Ian's retail work included supervisory (from 18 years of age) and department management at Walton's and Myer, as well as store manager of Lowes Menswear stores.

His business understanding of consumers and market segments led him into sales in the advertising industry. Ian worked for Radio 2WS; the Sydney Morning Herald and also the Australian Jewish Press. Ian then worked with a specialist industrial advertising agency, McMonigal & Associates (account manager and media manager), attracting clients and managing their marketing of products from hot sprue bushings, rheostats - switchgear, hardware fittings and railway rolling stock.



He completed many short courses over the years and has a distinction in media planning.

Ian's love of the environment and scouting led him into volunteering in his spare time with his local council and NPWS in the Blue Mountains. In turn, this led to TAFE courses in bushland regeneration and an advanced certificate course in outdoor guiding. He was drawn away from the big lights of Sydney, gave up the entertainment allowance and company vehicle for casual work as a bush regenerator and cave guide. This period of time leads his wife, Anita (cave guide at Jenolan Caves), to refer to it as his mid-life crisis. Anita and Ian met in kindergarten in 1965, were engaged at 18 and married at the age of 21. They moved to Jenolan Caves with their children, Mitchell and Elise, in 1997 and have been involved in caves since. Ian began as a casual guide at Jenolan Caves in December 1996, was made a permanent team member in March the following year and remained until June 2011. Ian continued his study relevant to tourism and has many tourism-related certificate courses under his belt. In his time at Jenolan Caves, Ian wrote a paper \* on the Historic Gardens of Jenolan Caves in order to assist management with the background detail to fight for grant funding. He self-published The Flora and Fauna of the Jenolan Karst Conservation Reserve in order to provide quick reference species lists of the reserve for staff and management. As a keen bush regenerator, Ian held the role of Chairperson of Lithgow Oberon Landcare Association and represented Jenolan Caves and Landcare on the Steering Committee with NPWS and the CMA (catchment management authority), to target Jenolan's Sycamore Maple infestation.

After leaving Jenolan Caves, Ian juggled a few temporary positions, focused on supporting his father in his ailing years. He renovated a home in Bathurst. He considered himself retired by 2014. Remaining an ACKMA member, (Anita continued guiding at Jenolan Caves) some casual cave-guiding work at Wellington Caves in 2017 enticed him to work in caves again. Ian is now a permanent team member at Wellington Caves as the caves engagement officer. This also led to Ian being involved in Landcare again. He is on the committee of The Central Tablelands Landcare and is Vice Chair of Mid-Macquarie Landcare. Ian's work at Wellington Caves is varied, including planning interpretation, training team members, risk management, engaging with the scientific community - and Ian still regularly conducts cave tours.

**\* EDITOR'S NOTE: Ian's paper will appear in the September Journal**

# President's Report June 2020—the year ahead for ACKMA

## Ian Eddison

With all of the show caves in Australasia being closed due to COVID-19, the coming year (June 2020-May 2021) for ACKMA looked like we all could just hang up a sign, “Gone Caving”. But it turns out, of course, there is much work to be done!

First, to look back not far, to see the impact of drought, fire, flood, landslips and rock fall on different cave sites in Australasia. My wife Anita and I saw the new calendar year in with cave friends and, over that lovely evening, we got word that a little cottage at Jenolan had burnt down. This was where our friend at dinner had moved into as a new 1960s cottage when he was a toddler and, coincidentally, where we lived in the late 1990s. We quickly learned of the suffering of other cave friends and sites through different disasters. Some are suffering one incident after another and another. Little did any of us know that very soon a worldwide pandemic would affect us all.

Second, I have been included in ACKMA committee communications of late and I can assure you that those people behind the scenes of this organisation have been very diligent in putting forward their contributions. The new committee has changed little but the prospective additional input from new faces will be helpful and refreshing but the main strength is people who will continue to help.

Tim Moore, who has offered very kindly to continue for this year as editor, is a big blessing and Andy Spate may be standing down as president but is committed to continue gallantly to lead the way on environmental fronts associated with caves and karst through Australasia. I am sure you join me in being grateful and thankful for the work of Tim and Andy. All the committee, past, continued and new are your champions and we are in good hands into the new year.

So, what does the coming year hold for us?

We need to prepare for our part in promoting the International Year of Caves and Karst (IYCK) in 2021. It is an exciting opportunity to spotlight the many unique aspects of our caves and karst areas.

We are aware of and have concerns for two development applications under consideration. These are for a limestone quarry and for an abattoir on different karst areas, which will require due consideration of the possible impacts and our submissions in relation to those applications.

We all need to consider the structure of our tourism operations, staffing and meeting the demands of our respective markets in a safe manner for everyone due to COVID-19. I admired the team at Capricorn Caves who devised regular private tours in order to make the tour numbers small and keep the tourism flow before they had to shut down. It is time for managers of tourist caves to consider how they will operate in the future. Keeping our valued, highly trained staff safe and sharing the natural wonders

of our caves with the public in a safe manner is the prime focus for each of these operations. We should never have, but now certainly must not just “*Rack ‘em*”, “*stack ‘em*” ‘*n*’ “*stick ‘em*” in the hole! Managers of cave tour sites are forced to rethink how we conduct business in light of the threat of COVID-19, or any other contagious health risk, exacerbated by confining people.

All staff members need to think about how they can safely interpret caves and karst to the public and how the workplace can do this in the safest manner possible. The lessons are that teams of people in other industries have lost people, their staff, because they were in close proximity with each other, sharing surfaces and equipment. Even in our leisure pursuit of caving we must share those times together safely at some distance.

There are business lessons to be learned from the recent past. Theme park tourism operators as well as volcano speleology have had their guests suffer horrifically. Their staff and their businesses suffer as well. Astute managers may well have a ‘Business Disaster Plan’ in place which includes the threat of fire, flood, cyclone, earthquake, tragic accident or other regional factors that can cause an effect on their business. A business disaster plan is more about the business coping and recovering. Consider the demise of Virgin Australia most recently. It didn’t take long before it went into voluntary administration. Did they have a business disaster recovery plan that includes a planned response to the impact of a worldwide pandemic? Do you? Well, that needs to be included in future and, for now, managers of tourist cave sites need to plan how to minimise risk of exposure to such contagious diseases.

Despite the tragic circumstances of COVID-19 on our communities, our staff and businesses, there have been advantages. The caves have had a break from our impact upon them. I am sure some of you considered this. It was pointed out by our IT guru and Webmaster Rauleigh Webb that an opportunity existed to record the natural climatic conditions of our caves and their chambers during this shutdown in order to have a recorded benchmark free of any visitation. This idea has been enthusiastically endorsed by many and is something we should all consider for the cave sites where we are involved. I love the idea of turning a negative into a positive. What a way forward into the coming year!

I am humbled to have been asked to be your president. Thank you for your endorsement. I wish you all good health, fresh ideas in promoting caves and karst as well as productive science and sustainable business through the coming year.



# A visit to Madagascar

## Steve Bourne (story and photos)

I had previously been to Madagascar in 2015, to the western side of the island to a limestone area named Beanka (see ACMKA Journal 102 – March 2016) for a report on that trip). I thought Beanka took a long time to reach from Australia but it's not - compared to getting to Itampolo! To reach Itampolo from Naracoorte, it's a:

- four-hour drive to Adelaide and hotel overnight
- three-hour flight to Perth and then a five-hour wait
- eight-hour flight to Mauritius - I stayed there for four nights but an overnight stay is needed anyway
- three-hour flight to Antananarivo, capital of Madagascar, with an overnight stay
- one-and-a-half-hour flight to Tulear, with an overnight stay
- ox-cart ride to catch a boat and then a one-and-a-half-hour boat trip to Anakao
- four-hour drive to Itampolo, with an overnight stay and
- one-hour drive to a village and then a two-hour walk to the first cave!

The trip was a reconnaissance one to investigate some new caves located by local people, and to investigate a known swamp fossil site. Owen Griffiths coordinated the trip, with Julian Hume of the British Natural History Museum providing the scientific expertise, supported by Owen's local staff - Nicola, Bema, Roger, Tsivalo and Jary. A few more staff based at Besely participated but, unfortunately, I struggle to remember Malagasy names - they can be complicated. For example, Bema's name is actually Aldus Andriamamonjy and Tsivalo's full name is Tsilavo Hasina Rafeliasoia.

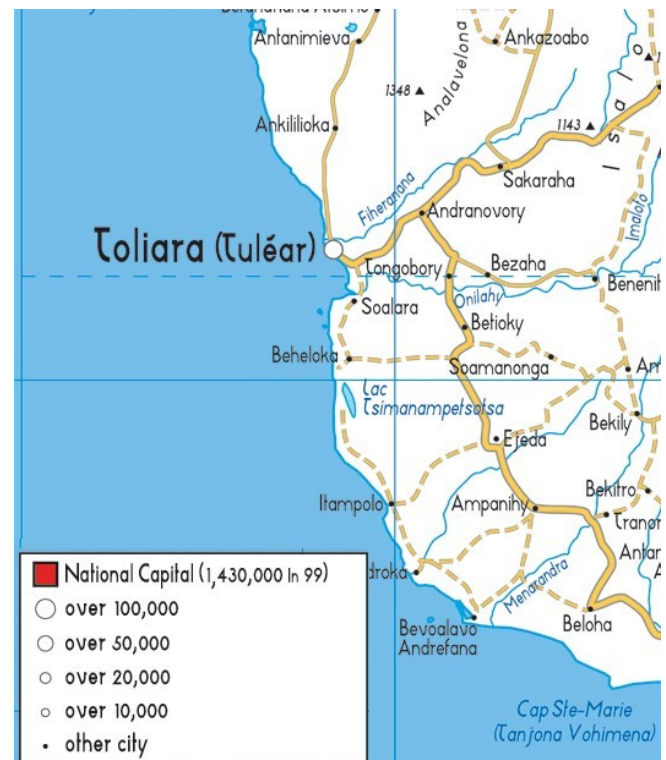
Owen operates Biodiversity Conservation Madagascar (BCM), which has established a series of nature reserves in the Mascarene Islands and on Madagascar. Besely is a reserve he has established about 20 kilometres south of Itampolo to protect Radiated Tortoises which we visited on this trip.

Owen and Julian had learnt about a swamp site near Itampolo on a previous trip to the Besely Reserve. Owen had his staff investigate possible cave sites in the region for our trip. A focus was a 20-metre deep sinkhole that had the remains of an extinct giant tortoise, *Aldabrachelys grandidieri*.

The sinkhole had only been entered by a local climbing a tree in the entrance. I was invited to attend to assist with the ropework for this and any other sinkholes we found.



Road map of Madagascar (above) and, marked in red, a close up below of the area to which we travelled. Note the lack of roads. Those that exist are generally of poor quality.





Whenever I tell anyone that I have been to Madagascar, the response is usually one of jealousy, with most people having visions of jungle and abundant wildlife. Unfortunately, this is not the case, as Madagascar has huge degraded areas with only isolated pockets of vegetation remaining. I understand the north is somewhat better, but the areas I have been to certainly do not reflect the perceptions created by David Attenborough's documentaries. It depends on the source of information, but Madagascar's population is 25-27 million and increasing rapidly in a land area a little larger than New South Wales. This places enormous pressure on the natural environment. Forest is being cleared for grazing land for zebu (cattle), with timber used for cooking or making charcoal. Hunting has had serious impacts on the local fauna in some areas exacerbating the problem. There are still pockets of vegetation where wildlife persist and NGOs such as Owen's BCM are doing what they can to preserve what is remaining.

I find the Madagascar capital, Antananarivo, unattractive and challenging. I stayed in the same hotel as my last trip, The Sakamanga, with Julian Hume and Nicola. This hotel is comfortable but once you step outside you are confronted by beggars and others pushing local crafts at you. I certainly don't blame them; these people are trying to eke out a living any way they can. I was pleased when we caught our flight to Tulear, which is also known as Toliara. We were advised the Air Madagascar flight to Tulear was delayed until 8.40 am from the scheduled 7.30 am departure when we landed at Antananarivo, which is apparently a regular occurrence. It may not seem too much, but it meant we could not catch the only daily boat to Anakao; hence, we had to book some overnight accommodation in Tulear. This turned out to be rather pleasant as we visited a family-owned arboretum that has been running for over 40 years. It contains over 900 local species of plants. We dined at their restaurant, which was a pleasant al fresco experience.

I had heard about the ox-cart ride to the boat, but wasn't quite ready for it. Wooden carts are pulled by two zebu to a depth of water suitable for the boats.



Animal welfare is non-existent and those transporting you are very demanding for tips for their services. Luggage is likewise transported via ox-cart separately from the passengers and I kept a close eye on my bags as I didn't want camera gear to go missing.

The boat ride cuts across a very wide bay, and takes about 60 to 90 minutes, depending on which boat you get. Apparently, the road route is at least nine hours from Tulear to Anakao, so the expense of 90,000 Ariary (~A\$35) for the boat trip was worthwhile. Locals travel at a much reduced rate. Owen had arranged for our drivers to meet us at Anakao so we quickly left for Itampolo. There is no road as such, just a defined sandy track. We managed to travel at between 40-60 kilometres per hour for most of the way, taking lunch at a halfway point called Ankilibory.



The Ankilibory track

Towards the end of the journey, a limestone escarpment loomed on our left, running parallel to the direction we were travelling on, the inland side. This escarpment of Tertiary limestone. It is known as the Mahafaly Plateau and rises from the coastal plain. I estimated it to be around 200 metres high. When we walked up this later, I decided it maybe a little higher than this.





Mid-afternoon, we arrived at Itampolo and settled into our bungalow-style hotel rooms. We did a quick visit to the swamp fossil site late in the afternoon to check on its condition. The site has been excavated by locals for many years. Locals sell the fossils of pygmy hippo, crocodile and Aepyornis elephant bird to the few hardy visitors that make it this far. Owen had paid the landowner a handsome sum (by local standards) to prevent further digging and it appeared this was working.

Caves were on the agenda for the following day - at last! We headed north from Itampolo, back along the route we took to get there, and then headed slightly inland to a small village. Coming from a wealthy, western country, it is difficult to fathom how these people manage in this landscape. Their dwellings are small, timber huts with a natural floor, with some having an internal timber platform. Cooking appeared to be done inside and I saw examples of fires burning inside the huts. A water supply was not obvious. A few sheep were housed in a small enclosure and chickens roamed throughout the village. Manioc is the staple diet, this being a starchy tuber that has a high cyanide content and requires careful preparation. Tapioca is its dried form - this will be more familiar to most.



Itampolo main street

The following morning we went to the swamp site again to check prospects for an excavation, which involved stripping down to underwear and plunging into the previously excavated holes. Although the swamp was dotted with holes, there was still plenty of unexcavated sediments. I located two bands of charcoal in one hole which I was able to trace into several others at one end of the swamp. It appears there is some reasonable stratigraphy at the site. The owner of the land showed us several other swamps on his land, which had few excavations in them. These appear to sit slightly higher in the landscape, so it seems likely these would have less bone material, as this would be concentrated in the lowest pool where animals became tethered to the waterhole in dry conditions.

Owen's staff had advised us that the first caves we were visiting were 'walk-in' caves and no gear was needed, but I suggested we take one 10-metre caving ladder and a 40-metre nylon rope as a handline just in case we had one of those awkward small drops. We engaged some local villagers to act as guides and to carry some of our equipment. I was concerned when we set off that the villagers were not carrying any water and it was already very warm. Around an hour into the walk, they stopped and lifted a small rock adjacent to the path, revealing a natural hole in the limestone. One of them picked up a dried baobab seed pod, tapped it against the ground to remove any dirt, and used this to scoop water out of the hole. I was gobsmacked by this. Several more times throughout the day, they stopped at these holes to take a drink; no need to carry water when you know where you can get a drink!



Despite heavy excavation of the swamp site, careful excavation could still yield important scientific information.



The route we took was through some reasonable quality spiny forest of amazing diversity. High plant diversity is usually associated with tropical areas but Madagascar's isolation from other land masses for many millions of years has seen flora and fauna evolve to forms not seen elsewhere.





One of the most bizarre vegetation types is *Didierea madagascariensis*, commonly called the Octopus Tree (above), with several species of Baobab trees, *Adansonia* sp., (at right) also seen in the area.

The first cave had a large, steeply sloping entrance. The scree slope was very loose, with every step dislodging rocks that tumbled down and down into the cave. I was tasked with checking for a way down and, about 15-20 metres below the natural ground surface, I called for the rope for a handline. I knotted this as I descended until I reached a vertical drop of approximately eight metres. The ladder would be useful! A nearby boulder was large enough to use as an anchor and the ladder was secured to a tape around this. The steep scree slope continued, with the handline essential to move safely. I ran out of rope just as I reached a second drop similar to the first and I could see the cave extended at least 30 metres further down from where I was. Out of rope and ladder on the first walk-in cave - not a great start.

There was no sign of large bone material and any animal that had fallen victim to this hellhole would surely have been smashed to pieces by the time it reached the bottom of the cave, however far down that was.

I did locate an area of small bone material protected under a large boulder, but nothing too exciting palaeontologically.

Our next cave was a walk of another hour or so, through forest that was more degraded. This cave has a skeleton and shell of the giant extinct tortoise, *Aldabrachelys grandidieri*.

There were other bones visible, including a lemur dentary tentatively identified as *Megladapsis*, informally known as koala lemur due to its form and habit deduced from its skeleton. This identification was confirmed later by local biologist, Steve Goodman, from photos.

The third cave for the day was a spectacular disappointment. The spectacular, gaping hole was clearly not a walk-in cave, confirmed by dropping a rock and waiting five seconds for it to hit the cave floor. That makes it around 125 metres deep!

We immediately felt a sense of disappointment because this cave was well beyond the equipment we had and skills of the people present!



Entrance to a "walk in" cave – the first we visited



The following day we returned to the second cave to more fully explore and Owen discovered a second side to the cave, which we hadn't noticed the previous day. What had appeared to be a one-sided sloping cave, as per our first cave, but smaller, was in fact a large, shallow cave with a collapsed doline covered in vegetation. This second side of the cave showed huge promise for a repeat visit and detailed study.

For those unaware, owls regurgitate pellets of bone and feather, fur and skin, depending on the prey, which accumulates over time, providing a record of what was living in the area (at least of what the owl likes to eat!). We carefully followed each other's tracks to minimise disturbance and photographed key localities within the chamber and the chamber itself.



Our third day's caving was closer to Itampolo (so only a short drive) but required more walking. This time, we parked at the base of the escarpment and walked to the top and around six kilometres to our target cave. On the way, we passed another large deep cave, five seconds deep like we had seen two days previous (see front cover photo).

It appeared to be something of a tourist site with seats and a worn path to and from it.

The cave we visited was an enormous collapse, 60 metres-plus in diameter, with

some sides 30 metres deep, and the shallow side from which we accessed the cave around four-to-five metres.

We almost missed this section of the cave. It will be a focus of a future expedition

I found a complete skeleton on the floor, initially identified as a lemur but later confirmed as a cat. I am not sure what species of cat though.

I did rig up the ladder, but it was just as easy to climb a tree growing near the cave wall. It was fun to watch the locals try a caving ladder.

They are so adept at rock-hopping and climbing trees and the cave walls, but looked really clumsy on the unfamiliar cable cave ladder.

We split up and searched various parts of this large cave. Owen found the plastron (shell breastplate) of the large tortoise, *Aldabrachelys grandidieri*, and a limb bone identified as *Mullerornis*, the smaller of the two species of elephant bird.



The cave had also been (and maybe still is) inhabited by owls, nature's great biological surveyors thanks to their eating habits.





I found a few teeth plus some limb bones of a hippo. This poor hippo was either a more terrestrial species not tied to water or hopelessly lost up on the karst plateau. The team also located a few lemur bones, including partially mummified specimens, so not too old.



An unerupted hippo tooth

We enjoyed lunch in the cool of the cave rather than the glaring heat of the plateau.



We walked on to a second cave which was an even larger doline, but with only a small amount of cave development around the edge. This cave was notable for the large amount of *Aepyornis* eggshell, clearly placed on rocks by people. How did the eggs get here? Were they laid or carried in by people? We found several pieces with small holes drilled in them, which Julian informed us meant they had been used for carrying water.



The cave development was limited to cavities in rockfall, so we crawled and squeezed between large boulders.



Once again, we found mummified remains but nothing that would warrant an excavation. By the time we finished here, it was very hot and we “only” had a six-kilometre walk across the bare landscape back to our vehicles.



Many of the caves had kestrels and the Malagasy endemic Vasa Parrot nesting. Vasa Parrots are the only black parrot in the world and are a striking sight screeching at a cave entrance.

There were aspects of the caves that reminded me of some parts of the Nullarbor karst. Once on top of the escarpment, the plateau was generally quite flat. When standing at a cave entrance, it was generally possible to discern that the cave entrance was in fact the lowest point in the immediate landscape, with very large, very shallow depressions feeding water to the low point to create the caves. Clearly the caves formed under different conditions from those the region experiences today.

We did a trip to the Beseley Reserve, 20 kilometres south of Itampolo, where a research centre is under construction. We walked several kilometres through the reserve and found several live tortoises, including 'pixies', which indicate they have been breeding. Unfortunately, we also found several dead, with no obvious cause of death. The Radiated Tortoise, *Astrochelys radiata*, is an endemic species in serious decline through loss of habitat; hunting for meat; and poaching for the pet markets (primarily in China. I understand).



A reconstructed *Aepyornis* egg at The Tulear Aboretum

We also visited a sinkhole the locals told us was named 'Vintany'. This has formed in much younger limestone than the Tertiary escarpment and plateau, with the upper section barely consolidated shells. Once a popular swimming hole, the site is now regarded as spiritually significant. The blue-green algae was enough to put me off from wanting to swim there.

Itampolo was a very long way to go from Australia for three days' caving, although I very much enjoyed the other sites we visited.

I enjoyed Itampolo; our accommodation was the best in town which meant it had flushing toilets and a 'shower' - a hose with a nozzle that you could get wet under.

A generator provided light in the rooms until the owner went to bed. The meals were outstanding. We generally ordered at breakfast and the owner would collect the fish or crayfish from local fishers as they walked along the beach. You can't beat this for fresh!

We left Itampolo at lunchtime Sunday and I arrived back in Naracoorte at lunchtime on Thursday. Despite this, I hope to go back again late in 2020 as the likelihood of finding new caves and new fossil sites is high.

Palaeontologists have been working on water-filled caves in Madagascar with some spectacular finds. Information on this is easily found on the internet, but I have not been able to locate too much about the dry caves we visited. I suspect many of these deep caves may not have been entered before, so there is an opportunity for suitably skilled cavers to do some deep cave exploration.



Beseley Reserve has been established to protect and establish a breeding population of Radiated Tortoises

The beach at Beseley was literally covered in *Aepyornis* egg shell. The theory is the birds migrated to the sandy beaches to lay their eggs, as the thick shell required intense heat to incubate.

The government has very strict regulations on taking *Aepyornis* eggs out of Madagascar but, despite this, reconstructed eggs are readily available for purchase in local markets. These are of variable quality and are generally manufactured from multiple eggs, but occasionally associated material enables a single egg to be reconstructed. Rarely, intact eggs are found, with one famous egg in possession of Sir David Attenborough.

# ACKMA Cave Climate Project

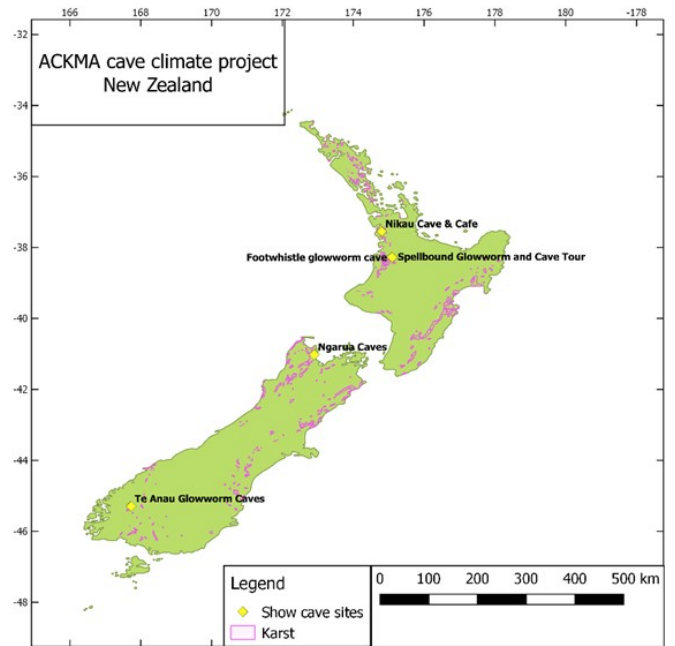
Andy Baker (University of New South Wales, Sydney), Andy Spate (Optimal Karst Management) and Dave Gillieson (University of Melbourne)

## Introduction

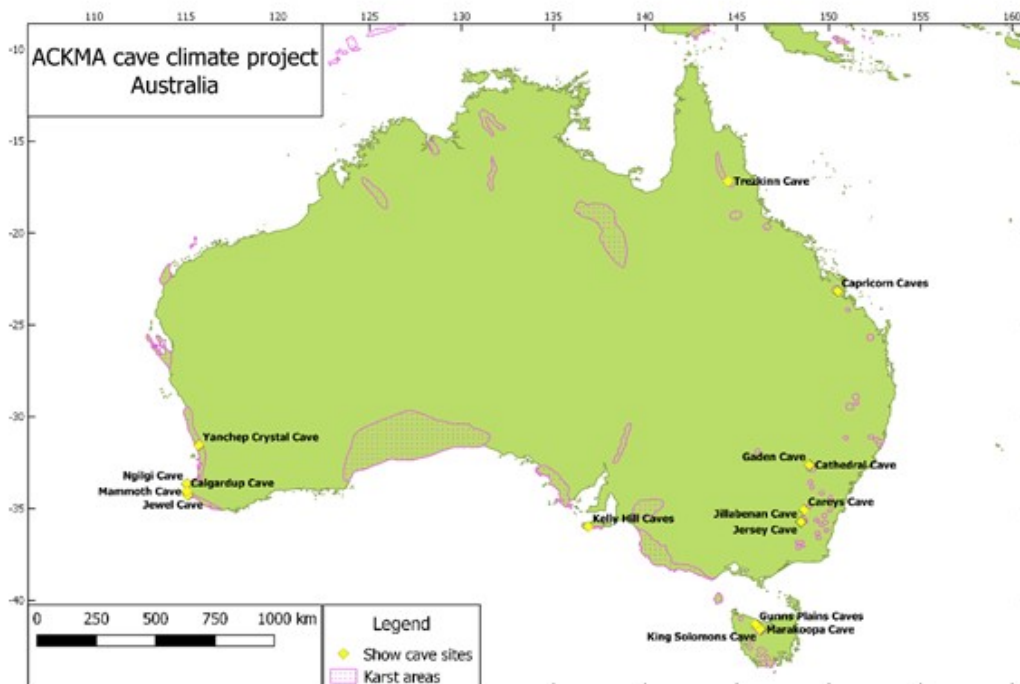
Not long after the COVID-19 virus closed Australian and New Zealand show caves, Rauleigh Webb came up with the brilliant idea that this might be an opportunity to establish baseline show cave climate conditions in the absence of visitors. This concept was rapidly taken up by your committee, which set aside up to \$8,000 for such a project. A subcommittee of Rauleigh, Peter Chandler, Andy Baker, Dave Gillieson and Andy Spate moved rapidly to put such a project in place. We purchased 50 Jaycar QP 6013 temperature and relative humidity loggers at a total cost of \$4,000 - one for outside and one for inside each cave. Because we made a bulk purchase, we received a discount of \$39 dollars off each unit! About \$450 has also been spent on postage and associated costs.



Andy Baker then calibrated them and sent them off to those sites that wished to participate across Australia and New Zealand. Sixteen sites have joined so far and have received a total of 42 loggers. We do have a few more loggers available - so please contact us if you'd like to be part of the project. We hope that each site will be able to record data for a significant period of time without visitors, but recognize that every site would like to get up and running again. Once tours recommence, the loggers will provide a fascinating set of data on how individual caves are responding to the seasons, to weather and to the varying number of visitors.



Participating sites as at early June 2020





## Caves and cave temperature fluctuations

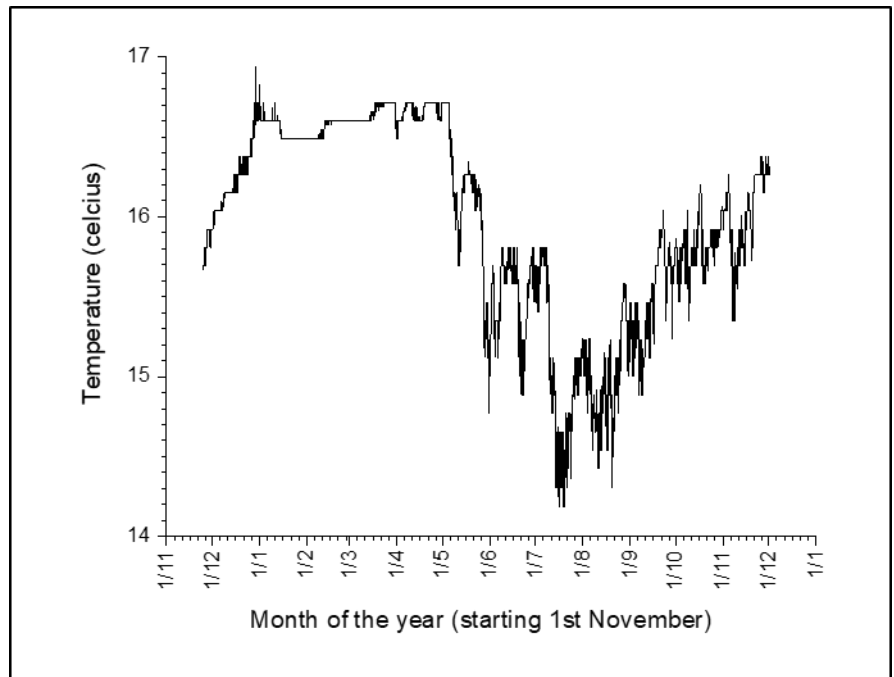
First, the science. The air temperature in a cave is due to two main processes. One is conduction of heat through the rock. The source of this heat is sunlight reaching the surface above the cave. Conduction is a slow process, with the heat signal getting smaller and delayed as heat is conducted from the heat source to the subsurface. Around ten metres underground, the rock will be warmest a couple of months after the hottest summer months.

The other process is the transport of heat (or advection). This is most commonly due to the movement of air. In caves, ventilation can introduce air with a different temperature. This is a fast process, as cave ventilation can change rapidly. In caves, we typically experience a cooling of the cave air temperature in winter. How fast this takes place will depend on how warm the cave air is relative to the outside air, and the morphology of the cave—e.g. does it have one or more large entrances. And the only other thing you need to remember is that warm air rises.

What do we expect to happen in caves? Something like the adjacent example.

In late autumn/early winter, cave air is likely to start to be warmer than outside air. Because warm air is more buoyant, it will leave the cave if it can, and will be replaced by colder air from outside that can sink in to replace it. You start to see some variability in cave temperatures and a cooling trend.

In summer, cave air is likely to be cooler than the outside air temperature. It is not buoyant and can get trapped in the cave. Now all the variability in cave air temperature is gone. The cave air will slowly equilibrate to the temperature of the heat conducted through the rock. The cave is warmest in late summer/early autumn, as it takes a few months after the summer for the rock temperature to reach maximum temperature.

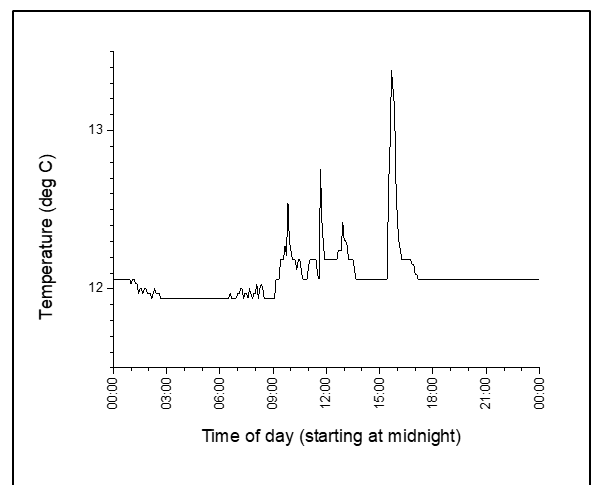


An example of seasonal temperature variation in a cave

As the air is not buoyant and trapped, there is minimal ventilation and carbon dioxide and other gases can build up.

Spring and autumn are intermediate periods. Around the equinoxes, caves might exchange air with the outside only at night, when the outside air is cooler, and not in the daytime. The exact time that a cave might start or stop exchanging air with the outside air will depend on the cave morphology (the number of entrances, how wide they are, etc) and the night-time temperatures (cold nights are needed to allow air to escape from the cave).

The loggers we have supplied record both temperature and relative humidity. Temperature is precise to 0.1 degrees centigrade. We have suggested programming the loggers to record every 10 minutes. This will allow you to understand how the cave temperature responds to natural processes (conductive heating and advective cooling, as described before) as well as any possible human influences (heating from body heat, lights, opening and closing doors, etc).



A day in the life of a cave

Now - if your cave ventilates, it will have started recently. The loggers will tell you about the extent of ventilation. You might see daily ventilation, with warm air leaving the cave every night, and cooler air replacing it. This tells you that you have a well-ventilated cave with good air exchange. Or, you might only see cooling every week or two, which would be when low pressure systems pass over you, and the lower pressure onto the cave atmosphere means some of that cave air can leak out. This cave would have less air exchange. Or you might see no variability at all, indicating a very stable cave atmosphere.

The second figure on the previous page shows the day in the life of one cave last October. In this relatively well-ventilated cave, you can see the air is cooler and temperature more variable in the pre-dawn, as the cave is ventilating overnight. Peaks in temperature can be seen during the daytime, as student groups go past the logger. The last temperature peak dissipates in less than three hours; this is termed the relaxation time and is a measure of how quickly the cave returns to equilibrium. As the day concludes, temperatures are stable as the cave hasn't ventilated all the day, and the temperature is slightly warmer as the rock temperatures are just starting to warm after the winter minimum temperatures.

The examples: the first example is one year of data col-

lected by the KSS Cave Studies Team from Deep Slide Cave, Yessabah. The second example was collected over one day on a UNSW Environmental Geophysics student field class to Wombeyan Caves in 2019.

**Credit:** Part of this text is based on that previously published by Andy Baker as 'Caves and climate' in the 60th Anniversary Edition of the Kempsey Speleological Society TROG Vol 54 No 5 (Nov 2018).

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## Election of Tim Moore as a Fellow of ACKMA

### Andy Spate

At the 31 May 2020 on-line AGM, Tim Moore was made a Fellow of our Association by adoption of a motion moved by Andy Spate and seconded by Kent Henderson. The AGM wholeheartedly supported the motion—the citation for which which read:

*Tim started his caving career as a teenager in caves such as Tuglow. As the 'cave man' in the NSW NPWS, I came to Tim's attention sometime early in his 'reign' as Minister for the Environment - we became friends very quickly. I took him and his staff through Eagles Nest at Yarrangobilly - despite the then Premier's intervention.*

*Tim has been involved in ACKMA almost from its inception. For most of those years he has been very much behind the scenes. But, and a very big but, he has contributed much to cave and karst management in NSW and, in more recent years as Editor of our Journal. His acceptance of this role*

*for another year is another example of his devotion to ACKMA.*

*Tim hosted two important meetings with the caving community in NSW. The first, in Sydney, was to discuss cave and karst management across NSW and a second one at Tallong, near Goulburn, to discuss cave management issues, and the possible extension of the limestone quarry, at Bungonia. Both meetings were well attended by both ACKMA and ASF members.*

*Most importantly, Minister Moore introduced legislation in NSW to recognize karst as an important part of our environment and to introduce the concept of karst conservation reserves - five of which now exist across NSW - Ashford, Jenolan, Wombeyan, Borenore and Abercrombie Caves. The legislation also introduced a 'strata title-like' system for protection and management of caves beneath private lands - as far as I am aware this has not been acted upon.*

*The downside of the Bill for this legislation was a phone call at 3.00 am from a Parliamentary draftsman seeking a definition of 'karst'!*



**Tim at the entrance to Croesus Cave near Mole Creek with his (now 40 year-old) twin daughters at the time he joined ACKMA**



# Fires, karst damage and cave management discussions at Yarrangobilly

**Andy Spate and John Brush**

**A. Bushfire - a very effective means of removing unsightly rillenkarrren from your limestone!**

“A” above was the subject line of an e-mail that John sent to me a few days ago after a visit to Yarrangobilly. The image he attached is fabulous, showing what fire can do to surficial karst forms (Figure 1). Figure 2 shows some undamaged rillenkarrren at Yarrangobilly. It was taken in a different part of the area and it is not known how well that site survived the recent fire.

I have previously written about fire and karst in both ANDYSEZ 44 and 45, and karren in 57. And elsewhere in our Journal about fire impacts. There is also a piece in Helictite - accessible from the ASF website (Holland E, 1994, The Effects of Fire on Soluble Rock Landscapes, Helictite, 32(1)3-90).

The fire must be ‘hot’ to start calcining (turning limestone to lime) - more than 600° C.

But over to John now for comments on his visit to Yarrangobilly (**Parts B and C**).



**Figure 1 (above) Rillenkarrren damage in the West Deep Creek area caused by the January 2020 bushfire.**

**Figure 2 Below) Rillenkarrren near Jillabanan Cave. Photo taken in 2013. It is not known how this site fared in the January 2020 bushfire.**



## **B. Cave cleaning and maintenance at Yarrangobilly**

Cave cleaning and Maintenance, that was the title of a brief article I had proposed to do for the Journal. I had envisaged a few words on cave cleaning accompanied by lots of photos of Yarrangobilly staff wielding scrubbing brushes, spray bottles and tweezers (used for lint picking). However, such is the nature of life in this COVID-19 world, that things do not always turn out as planned.

At the end of May 2020, I spent two days in the Yarrangobilly area, along with other members of the Kosciuszko Speleological Reference Group (KSRG). The KSRG is an advisory group for identifying, assessing and managing cave and karst issues across the seven (or eight, depending how you count them) karst areas in the Kosciuszko National Park. Complications arising from the January bushfires and COVID-19 restrictions meant that a normal meeting was not feasible. Instead, Bernadette Zanet (Yarrangobilly Caves Supervisor) and I discussed the possibility of convening a socially-distanced workshop and demonstration of cave-cleaning and maintenance techniques for Yarrangobilly staff.

Bernadette saw benefits in improving the knowledge and understanding of staff, especially among recent recruits, and in expanding and formalising the current cave-

cleaning activities, a large part of which has been a personal initiative of the remarkable Regina Roach.

At the time of writing, Yarrangobilly remains closed to the public, but some staff are rostered on each day to service Caves House, which has been fully occupied by workers associated with the Snowy 2.0 project, so there were already a few staff in the area. In addition, Bernadette juggled rosters to maximise staff participation in the workshop. As a result, it was a sizeable group that assembled outside the Yarrangobilly Visitor Centre for the initial discussions. Later in the day, the group continued discussions in appropriately spacious areas around and in South Glory and Jersey Caves.

It soon became clear that Yarrangobilly staff are passionate about the area; are very observant in their caves; and have a thirst for information on cave and karst issues and management strategies that extended well beyond mere cleaning and maintenance activities in caves. It also became apparent that some of the sites we had initially identified as being suitable for demonstrations were not large enough to accommodate the whole group safely at the one time. As a result, progress through the caves - and the intended program - was slower than anticipated. This meant there was less scrubbing, water spraying and lint picking than intended.

The intensity of the discussions also meant that nobody (including me!) remembered to pull out a camera and take a photo or two. Despite there being a lesser focus than envisaged on demonstrations of cleaning techniques, I believe the wide-ranging discussions addressed an apparent need and were beneficial in expanding the knowledge base of staff.

The following day, we were able to continue the discussions in a more informal manner during a walk through an area burnt in the January 2020 fire.

### **C. A walk across the blackened Yarrangobilly Karst**

The primary purpose of the walk was to provide KSRG members with an opportunity for examining the impacts on the caves, the karst and the vegetative cover of the January 2020 fire, which essentially burnt the whole of the Yarrangobilly karst area. It appears only a few small patches escaped.

As the Yarrangobilly area remains closed to the public, I acknowledge the assistance of NPWS in permitting KSRG members to visit the area. Obviously, there would have been advantages in visiting much earlier in the year, but that was not possible given public safety concerns and the COVID-19 travel restrictions.

On the walk, our party went from the Snowy Mountains Highway down to the Yarrangobilly River and back in an area some three to four kilometres north of the show caves area towards West Deep Creek Cave and beyond. Most of the area we covered was previously burnt, to a greater or lesser extent, during the fires in January 2003 and, before that, in 1966. Just two weeks after the January 2003 fire, Andy and I (and also Jess Spate and Marjorie Coggan) did a similar walk and photos taken at the time provided a useful basis for comparison. Even though the recent KSRG visit was nearly six months after the January 2020 fire and the bush (including blackberries!) was starting to bounce back, it possible to make some observations about the intensity and extent of the two fires - and the severity of damage inflicted on the limestone surface.

In 2003, a series of dry lightning strikes resulted in a string of fires in mountainous country extending from the Victorian Alps to well north of Canberra. In the Yarrangobilly area, which had remained unburnt for nearly 40 years, the fire was at its hottest in the Yarrangobilly Gorge area, in the show caves area and around Yarrangobilly village. However, much of the limestone, as well as the adjoining catchment areas to the east, was only lightly burnt. Some of this was due to low-intensity back-burning operations supervised by Andy and carried out by NSW RFS volunteers.

This time around, the fire was more widespread, and the bush appears to have been more evenly burnt than in 2003. The unburnt and very lightly burnt areas are smaller and less common than in the previous fire. On the other hand, I came away with the impression that the severity of the fire in the show cave area and along parts of the Yarrangobilly River Gorge was lower than in 2003.

That said, there have been significant impacts on some exposed limestone surfaces, especially where the rock was in close proximity to fallen logs that burnt. Large areas of outcrop are now white-coloured (Figure 3), resulting from obliteration of lichen and algae and by calcination. Where the heat was intense, rock fracturing and spalling is common (Figure 4). As noted above, the spalling has damaged surficial features, most notably rillenkarren.

Looking on the bright side, the temporary absence of undergrowth makes for easy walking and for finding or relocating natural and cultural features. Indeed, on our walk we came across several cave entrances, two mine shafts, the foundations of a hut near one of the mines, several artefacts associated with the mining and the remains of an old weir. The weir was used for karst hydrology studies by Dr Joe Jennings and was constructed in early 1975 by a team of volunteers that included both Andy and me. Even though I had passed very close to the site a number of times over the last decade or so, I had not noticed the weir through the thick undergrowth and had long assumed the weir and associated gabions had been removed. Perhaps it is now a good time to tidy up the site?

Once the Yarrangobilly karst reopens for public access, most likely sometime in spring, there will be a window of opportunity for easy surface investigations before the bush once again closes in. It will be a busy summer.



**Figure 3 (above) Regina Roach in an area of fire-damaged limestone**

**Figure 4 (below) Heavy spalling in close proximity to a burnt log.**





# La Roque St Christophe

**Tim Moore**

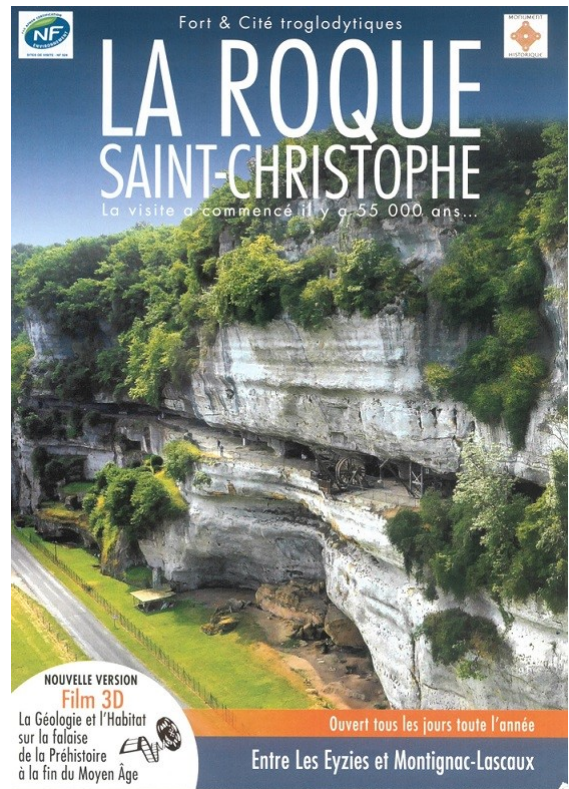
In the March edition of this Journal, I described visits in January this year that my teenage son, Luke, and I made to Neolithic cave art sites in France. Two of those cave art sites, Lascaux 4 and Grotte de Font-de-Gaume were in valley of the Vézère River, a tributary of the Dordogne. For our visit, I had also researched whether there were other locations in the Vézère valley that were cave sites which might be of interest to us.

As I noted in my earlier article, many of those that I had thought might be of interest were the subject of their fermeture annuelle, their annual winter shutdown. However, I discovered one unusual site, La Roque St Christophe, which proclaimed on the web that it was open every day of the year ([www.roque-st-christophe.com](http://www.roque-st-christophe.com)). As La Roque St Christophe was reasonably close to La Fissandie, the restored 18th-century farm outbuilding where we were to base ourselves, we decided to allow a day for a visit to this site.

On the appointed day, we set off in much the same fashion we had done during the previous week or so of wandering around the back roads of rural France, a process which had followed several seven or eight hour drives along sections of high-speed French autoroutes.

In our meandering along these B, C or D class roads, I had been faithfully and docilely following the instructions of the woman who lived in the dashboard and who gave driving directions in a Teutonic voice (reminiscent of the tone I imagined would have been used by a German concentration camp guard during WW2). Hitherto, she had guided us faithfully and accurately (at least for the very great part) since we had first been united with her in Geneva some three weeks and many thousand kilometres earlier.

On this day, however, as we tried to navigate the labyrinth of minor roads that lay between La Fissandie and



La Roque St Christophe, our guiding voice went feral, resulting in us finding ourselves, on two or three occasions, being instructed to follow roads that slowly tapered into nothing better than what, in Australian parlance, would be described as fire trails.

The reason for this, we later discovered, was that there had been a landslide several months earlier which had blocked the otherwise traditional and conventional tourist route leading from our abode to La Roque St Christophe. However, having had to retreat from several of these false starts, recourse to “cartographer Google” on my phone took us in the correct direction and delivered us accurately to our destination!

La Roque St Christophe is located close to the bank of the Vézère River some seven hundred metres to the west of the D706 regional road along a smaller offshoot, the D66.



**The location near the Vezere River**

An impressive limestone escarpment rises some 40 m or so from the lushly grassed (but narrow) floodplain with the D66 (following the river) being bordered by fenced paddocks containing contentedly grazing cows (the paddock on the river side being 60 m or so wide, with a similarly grassed but narrower paddock to our right to the base of the escarpment). The width of these paddocks gradually decreased as we drove toward the carpark.

During the last hundred metres or so, the road passed through a pinch point between a 3 m or so high limestone outcrop about half the size of a tennis court on our left (between us and waters of the Vézère) and the limestone of the escarpment immediately on our right. This forced the road to narrow to a single lane over this distance with no passing bay. Although, in the traffic circumstances in which we were visiting, this was unchallenging, I hesitated to think of the potential chaos in peak tourist season as the un-rectified landslide meant that this road was the only way in and out for this site.

As I observed in my March article, my son and I were travelling in the depths of European winter, which meant that, in this portion of the French countryside, there were frosts on the ground lasting until the middle of the day and the occasional remnant snowdrifts from a heavy fall which had occurred some weeks earlier.

We arrived at the carpark at La Roque St Christophe late in the morning. The carpark had been designed in anticipation of substantial tourist visitor numbers (we were

subsequently told at the visitor centre that there were frequently up to 500 people on site during peak summer holiday season in July/August of each year). The car park was clearly designed to cater for this with multiple tourist coach bays and spaces for several hundred cars. At the time of our arrival and departure, ours was the only vehicle to be seen. We had the site to ourselves!

There are three aspects of La Roque St Christophe that are of interest to a visitor. The first is the highly defensible physical layout of the two primary habitation gallery levels. The second is the history of human habitation of the site. Finally, there is what a visitor can now observe to give a (limited) glimpse of those past human activities.

The primary aspects of the site are two long horizontal galleries running some 50 or 60 m in the face of the escarpment. The lower of them is some 15 m above the floodplain while the upper gallery is about 10 m above that. The lower gallery is much longer than that above. These galleries are described in the visitor materials on-site as having been formed in the long past by glacial erosion. As later described in a little more detail, the galleries have been subject to human modification, modification (with two exceptions) largely confined to shaping out the back wall of the galleries. Although there has also been, during the first half of the last millennium, habitation at the floodplain level, this occurred for a comparatively short period in the overall history of habitation of the site.

The two galleries are generally some 3 m or so high at their outer lips tapering only slightly to be generally, 2.5 m high at the back wall. The main, lower gallery is some 8 to 10 m wide. Although the floor is somewhat uneven, it is not significantly so. The unevenness may have been addressed, at least during the more recent period of habitation, by earthen packing to create level floors in the various structures erected within the galleries (as later described).

I earlier noted that the site is highly defensible, a position immediately obvious upon arrival. A sloping ramp and stairs, some 50 m or so long, leads from the car park to the late 20th century Visitors' Centre (a building at which the entrance fee of €9.00 (€6.50 student) is collected and the usual postcards, trinkets and baubles are available to be purchased).



Looking west along the main gallery and the floodplain

Visitors pass through this Centre, exiting onto a narrow ledge only some 2 m or so wide. This ledge passes through a stone wall with a postern sentry gate, an opening only a metre or so wide. This gate was the first line of defence for the mediaeval inhabitants of the site. This gate is some five or 6 m below an element of the lower habitation gallery permitting defenders to rain rocks and other projectiles down on those who might seek to breach the gate.

Beyond the gate, for tourist access (and replicating the access of the 16th century), there is a wooden platform cantilevered out from the cliff face as the ledge leading from the small gateway has, by here, disappeared. For modern visitors, there is now a wooden stairway leading upward from this platform to the first gallery level. In the past, a similar but less sophisticatedly engineered stairway would also have been available to inhabitants.



In the very distant mists of history, footholds had been carved into the rock by much earlier inhabitants to enable them to climb to this lower habitation level. This physical approach layout meant that, until the advent of the (comparatively) modern siege weapons of the mediaeval era, the inhabitants of the site could reasonably regard themselves as living in an impregnable fortress.

There are, however, two significant human modifications to the site.

The first is that, originally, the lower gallery was not continuous. At a point where there was a slight bowing out of the face of the escarpment, past inhabitants have laboriously picked out a tunnel some eight or ten metres long, little more than a metre or so wide and 2 m high, to connect what had been, on the far past, two quite separate habitation spaces. No information exists as to when this construction might have occurred but it is to be inferred that metal tools would have been necessary for this construction activity to have taken place. However, the thus connected gallery further from the primary entrance had also been continuously used from earlier times as there were, apparently, hand and footholds in the rock face indicating that access had been available before the digging of the tunnel.

The second significant human modification to the site was the carving of a flight of stairs out of the rock at a less vertical element of the face between the two levels. This is now described on the tourist material as the “Grand Staircase”.

This access to the upper level is not presently used and there is no other general access to that upper level. The visitor experience is therefore confined to the main gallery level. However, the Grand Staircase can readily be observed (including a “very tasteful” plastic reproduction of a Neanderthal hominid looking out across the Vezere River from the upper level!).

I now turn to the habitation history of La Roque St Christophe. The material provided at the site is limited, but explains that there has been evidence of human habitation discovered showing occupancy of the terrace level was from approximately 50,000 years BCE or a little longer. There is no present physical manifestation of this occupancy able to be observed on the site although there are diorama elements in one section of the lower terrace reproducing what has been imagined to be a simulacrum representing aspects of that early habitation.

There were books in the Visitors’ Centre available for purchase, but the interpretive material concerning this aspect of the site past was limited to short elements of a well-produced audio visual display shown on a screen just outside the Visitors’ Centre as customers exited the site. Visitors were not encouraged in any fashion, to my recollection, to view this audio visual presentation before entering the site.

There was also a location toward the centre of the main terrace where a screen was also installed with a sign indicating that the audio visual presentation could also be



**The Grand Staircase with my son in the foreground and the “tasteful” Neanderthal statue at the upper end**

watched at that point. Unfortunately, this system was malfunctioning during our visit. As the audio visual presentation was informative of the habitation history (particularly that of the 15th and 16th centuries), it would have been quite helpful to have been able to view it at this point rather than on departure from the site.

Nonetheless, the evidence is that the site was inhabited continuously from those very early times until 1588 when it was sacked as part of the Wars of Religion then sweeping France. The Wars of Religion were caused by a theological dispute between the King of France, the Pope and the forces of the state supporting them (on one hand) and the Huguenots, a theologically less orthodox group who were Protestant followers of John Calvin and who were thus rejected by the Catholic Church.





As was made clear by the audio visual presentation and as could be seen from the remnant elements along the lower terrace, the development of habitation on the site during the 15th and 16th centuries was extensive and sophisticated. As a specific example, the workings visible on the rock outcrop at the pinch point on the access road demonstrate that a sophisticated guarding structure had been constructed for defensive purposes (see photograph at foot of previous page).



The audio visual presentation incorporated an artist's impressions of what the structures had looked like toward the end of the habitation period when it fell in 1588 (reproduced left from the site's web site).

In addition, the range of activities undertaken for the supply of food through a small on-site abattoir complex and by an on-site smithy provides testimony to a degree of sophistication in the habitation toward the end of its life as a settlement.

The remnant evidence of a small church which had been incorporated in the structures toward the middle of the lower terrace was a poignant reminder of the theological conflict which had ultimately led to the destruction of this settlement and its abandonment as a human habitation.

Finally, there were two reproductions of mechanical structures which had been used to raise supplies from the floodplain to the lower terrace. These reproduction structures, as the limited interpretive material on them explained, were authentic replicas reconstructed from historic records detailing how those materials had been raised during the final habitation period of the site.

The site was an unusual experience for us and certainly an interesting digression from the main purpose of our visit to the Dordogne region, being to go to Lascaux and Grotte de Font-de-Gaume.

However, I would not suggest that a visit to La Roque St Christophe would warrant, in itself, visiting this region.





# Elery Hamilton-Smith Award

Recognizing the most meritorious article published in the ACKMA journal over the previous two years

Awarded to:

**Mary Trayes**

**May 2020**

*Andy Spate*

**Andy Spate  
President**

*Tim Moore*

**Tim Moore  
Editor**

*Blenche Cave, Neraccorte, photography by Steve Bourne*

## The 2020 Elery Hamilton-Smith Award

The Elery Hamilton-Smith Award is presented to the author of the article adjudged by the Editor and Assistant Editor of this Journal to have made the most significant contribution in support of the aims of the Association during the prior two years. Although usually presented at the Association's biennial conference, Covid-19 meant that the 2020 award winner was revealed at the Zoom Annual General Meeting held at the end of May 2020.

My Assistant Editor, Tony Culberg, and I selected the article by Mary Trayes (in the March 2019 Journal) entitled "The Maori Heritage Caves at Redcliffs, Christchurch, New Zealand" as the outstanding article of the last two years. Not only was the article well written and comprehensively covering the topic of the preservation of, and recovery actions for, culturally significant caves in the Christchurch region after the serious damage caused by the 2011 earthquake but it also provided an insight into the necessity for culturally appropriate negotiation for such activities.

Kirsty Dixon prepared the certificate awarded to Mary to acknowledge receipt of this award. The certificate was unveiled (on-screen) during the AGM and posted to Mary after the meeting.

As the article noted, the Association has made an offer to Christchurch City Council to contribute \$1,000 toward the cost of appropriate interpretive signage when the location and terms of that can be agreed by the relevant Maori cultural custodians. Although that process may prove to be a lengthy one, your committee recently confirmed that that offer remains open to the Council.

**Tim Moore**



## 19TH INTERNATIONAL SYMPOSIUM ON VULCANOSPELEOLOGY

CATANIA ~~28th~~ AUGUST - ~~5th~~ SEPTEMBER ~~2020~~ **2021**



### ANNOUNCEMENT - POSTPONEMENT OF ISV19

Dear Vulcanospeleologists and Friends,

The Organizing Committee of the 19th International Symposium on Volcano Speleology, convened a video conference at the beginning of April and noted the spread of the COVID19 pandemic all over the world.

Events over the last month or two have changed the lives of millions of people for ever. Tens of thousands of people have died, millions of people have lost their jobs, and even if they still have a job, they may not be at work at present and may not be earning any income. Many businesses have closed, perhaps permanently.

It is general belief that even if Italy and particularly Sicily will exit from the most critical phase before the Northern Hemisphere Summer, it will be difficult for most participants to travel freely from their country of residence to Italy and vice versa. It is also understandable that those who have suffered economic damage from the pandemic will have greater difficulties facing the long journey to come to Catania.

In this global background, the preparation for ISV19 seems an activity of minor importance even to those who worked to organize it over the last two years.

The Organizing Committee had earlier decided to wait until the end of June 2020 to take a decision on cancellation or postponement of the Symposium but the evolution of the situation in the world, forced it to bring forward that decision in order to limit the economic impact on participants.

Therefore, the Organizing Committee, having also heard the opinion of the UIS Commission on Volcanic Caves, decided not to continue with the symposium scheduled for August-September of this year and to postpone it to the same period of the following year.

The 19<sup>th</sup> Symposium on Volcanic Caves thus will be held in Catania from August 28<sup>th</sup> 2021 to September 3<sup>rd</sup> 2021. The following excursion to Aeolian Island is scheduled from September 4<sup>th</sup> 2021 to September 9<sup>th</sup> 2021.

The Symposium organizers will send an email to all participants that are registered and pre-registered informing them of the postponement and also communicating how to request the return of any sums already paid. Unfortunately, they have to inform registrants that it is not possible to refund of 100% of the amount they have paid because of paypal/bank transfer commissions.

For those who wish, it will be possible not to request a refund and consider the amount already paid as the participation fee of the 2021 Symposium (no increase will be required).

The Organizing Committee is really sorry to have to communicate this news to you, but assures you that it will work to prepare an even more beautiful Symposium for 2021 Summer than that planned for this year. Your appointment with Catania and Sicily is only postponed for a year.

Sincerely  
on behalf of the ISV19 Organizing Committee



## OPINION: Wearing gloves in caves

Dave Wools-Cobb - President, Karstcare 'cavers caring for caves' and Member of Northern Cavers Inc; Savage River Caving Club and ACKMA.

It is well established that bare skin can leave acidic body oils, microbes, skin cells and other such debris on touched surfaces. The skin's surface typically has a pH of 4.5-6 (1). Limestone surfaces, being alkaline, are particularly susceptible to such acids and, over time, leave a terrible black mark on such surfaces (as exhibited in photos 1 & 2).

From my observation on ACKMA caving trips and exhibited in many photos in this Journal (including front covers of editions 102 & 117 editions chosen at random), I am very concerned about the apparent lack of awareness of the need to wear gloves whilst caving. I accept that, sometimes, gloves are removed for "aesthetic value" during photography.

Of course, this is a problem far beyond just activities of ACKMA members. However, as a Cave Management organisation, I feel we should set a better example of minimal impact caving.

Photos 1 & 2 are stark examples of a heavily visited cave after 'countless' contacts. I have observed many examples of such impacts in both 'wild' and show caves (but these are not something one would normally photograph). I believe any cave visitor should always mitigate against such problems. Gloved hands are viewed as a much more conservation-aware practice than bare hands. It is best to minimise any contact by your hands with a cave surface as, even with gloves, this can leave dirt or mud already 'picked up'.



Handmarks in Postnoja Cave near Postojna, southwestern Slovenia



Popularly visited caves can often have badly muddied spots in specific areas regularly used for a 'hand hold' whether using gloves or not. Sometimes surface contact is unavoidable; for support one can use an elbow, or just one gloved finger or the back of your gloved hand. Gloves that are well muddied can be washed if a pool is available and suitable.

For some cave visits, carrying a spare pair of gloves would be good practice. Obviously contact with cave surfaces occurs often whilst climbing, however one should always consider the impact and try to minimise this. My Karstcare volunteers spend countless hours cleaning up visitor impacts in both show caves and 'wild' caves.

Wearing gloves also aids in keeping your hands clean when expecting to use photographic equipment and protects your hands from rough surfaces. Perhaps, on a single day trip, this protection may not be thought important – however, on a multi-day expedition, gloves would be considered essential! Gloves also offer some protection from insect bites: there are some very nasty mites and fleas in caves regularly habited by animals (e.g. those in Western Australia's Kimberly region).

#### **Choice of gloves**

Cotton and other natural materials often shed lint, so are not considered suitable for use in a cave environment. Latex gloves are often thin, easily torn and very sweaty – again not very suitable. Latex gloves are often based on natural rubber that can shed proteins which can provide an unwanted nutrient source for cave biota. Some also have powders to help with sweating, another extraneous material that can be deposited in a cave. (Hildreth-Werker V & J 2006 )

Generally leather gloves and many synthetic materials are more robust, shed less material and protect hands well, particularly when using ropes and climbing tapes. In very wet environments, I have observed that many cavers wear a long sleeve plastic coated glove. I find these seem to develop holes and tears too readily and I am un-

sure how well the plastic coating lasts not to shed into the cave environment.

I have found 'riggers gloves' made from pig skin to be reasonably durable but harden uncomfortably if dried too quickly. The market is flooded with a huge variety of modern 'working gloves', some specialised to certain activities like 'anti-vibration' for chainsaw use and some coated with harder wearing materials. Many of these I find very suitable for caving; it is a matter of trying out several brands to see if they will be comfortable even when wet and that they are adequately durable to justify the cost.

I go through about six pairs of gloves a year: working with tools or chainsaws and going caving, but that's a small price to pay to both protect cave surfaces and my hands.

I have observed many cave guides, during their initial presentation to their clients, hand around a 'sacrificial' speleothem to visitors to satisfy their need to touch something. I believe this is good practice as it gives the guide an opportunity to educate as to why cave surfaces should not be touched.

Just as we currently often judge past practices as being poor regarding cave conservation, so too will we be judged poorly in the future.

I predict sometime in the future show cave managers will insist on some method of de-linting or clothes covering, shoe cleaning, hair nets and gloves. We must protect cave environments for future generations. Our tiny impact to the cave environment on each caving trip may not be much, however multiplied by many more cave visitors over many years results in outcomes such as that shown in photo 1.

#### **Reference**

1. <https://www.ncbi.nlm.nih.gov/pubmed/1848930>

**Hildreth-Werker V & J** 2006 Cave Conservation and Restoration. 433-435

## **Tau Caves of Fiji**

### **Kent Henderson**

In February 2020, my wife Rasyi and I undertook a 14 day cruise to Noumea, Vanuatu and Fiji – none of which we had visited before. Happily, we got back to Melbourne before the coronavirus really hit...

In Fiji, whilst berthed at Lautoka, I took a full day tour to the Fiji Zip Line and Tau Cave, which proved to be both very energetic and fascinating!

The limestone caves in Fiji have long been interwoven with Fijian culture. According to an article in the Fiji Times, the Oho ('occupied') Cave, near Tau village, was one of the first Fijian settlements – dating back 4000 years. In 'pre-European contact' times, tribal warfare was common – I had heard that Fijians were cannibals. The cave offered a secure, defensible site – where women and children could hide as necessary. It even came equipped with bats that were useful as an early-warning sign when intruders were approaching the cave. As the times became more peaceful, the Tau people moved their village out of the cave but, until modern times, the villagers maintained it as a 'refuge cave'.

Carbon dating of recent archaeological finds has indicated that Tau was one of the first places humans settled when they arrived in Fiji and clearly the cave would have made a great home for people newly arrived.



A view of Pacific islands as havens for karst does not immediately spring to mind and, indeed, the vast majority of the islands I visited, particularly Fiji, are volcanic in origin. The karst that does exist is largely situated at the 'top of mountains' forced up through volcanic uplift - and this is the case with the Tau caves located high in a mountainous area.

The principal tourist attraction is not, in fact, the caves but the zip line. There are 16 concurrent zip lines up to the cave and back. On the way up, significant rising stairways (a total of over 1000 steps) join the end of one zip line to the start of the next. The whole trip is not for the faint-hearted! The youngest in my 'group' was a 6 year old. Reputedly, the oldest to have done it was a 94 year old woman. I have to say that, after a few 'zips', one quickly gets the hang of it. That said, everyone was very glad to get to the top. Incidentally, the whole tour (including lunch back at the bottom) takes about 4 hours.



Zip line gear greets you at the entrance to the site

So, to the cave itself... There are three chambers in fact - all linked, of course. The Main Cave is huge - one of the largest in the South Pacific. Our guide explained that 'three Boeing 747 jets could fit inside' - an exaggeration, but... Main Cave has a huge chamber with a roof collapse, allowing considerable light in. The chamber is approximately 100 metres deep and 220 metres wide. The last Zip Line coming up the mountain finishes just outside the cave entrance; whence the group enters the spacious entrance area. There is talk of the Zip Line company developing zip lines inside the cave in the future. Oh dear...

One can do a separate tour just to the cave/s, involving proper caving - their *Abseil Tour*.

There is another leg of the cave that goes deep underground and, apparently, features expansive speleothem areas. Aside from a significant bat colony in the cave, it is also the repository of thousands of Swiftlet nests in the cave ceiling.

Three species of microbats are assumed to use the caves -- the Fijian Blossom Bat (*Notopteris macdonaldi*) - listed as vulnerable (Fiji represents the global population of this species); the Pacific Sheath-tail Bat (*Emballonura semicaudata*) - listed as critically endangered; and the Fijian Free-tailed Bat (*Tadarida bregullae*) - listed as endangered. Bat monitoring is intermittent, at best.

There is another cave/chamber just below the main cave. This Lower Cave (30 metres from top to bottom) is much smaller and round in shape. It too has a central 'skylight'. Below the Lower Cave is the third cave/chamber - Secret Cave. It is actually more of a cave passage, and is filled with speleothems. The Secret Cave leads into Hidden Valley; a section that apparently hasn't been fully explored but has at least six other chambers leading off it.

### Management?

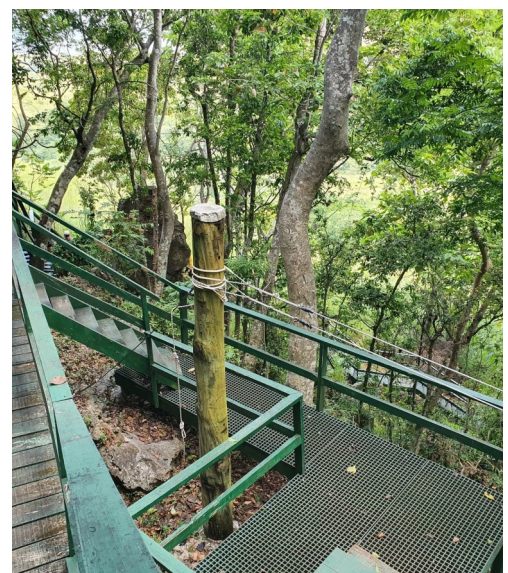
The infrastructure for the Zip Line (all wooden construction) and safely equipment is first rate and the guides clearly are highly trained. The infrastructure took over a year to complete with tours starting in 2008. The idea of zip lines in the caves themselves is of concern, particularly given the extra bat disturbance this would involve. However, there are no immediate plans, it would seem.

So, I would most certainly recommend the experience; it is a great deal of fun - with interesting karst scenery and a cave at the end! But it is not cheap. The Zip Line Tour is currently \$245 per person and the Abseil Tour inside the caves is \$165 per person. Full details are at: <http://www.zip-fiji.com/>



Walkway constructed through the karst leading to the cave entrance (above)

Zip line platform with tie-off post and zip line in the centre (below)



## “Around the show caves”

### Peter Chandler, Spellbound and Glowworm Cave tours, reports on “*Waitomo Caves in COVID-19 Lockdown at 20 May 2020*”

By government decree, between 25 March and 15 May 2020, Waitomo, the home of glowworm tourism, has been non-operational - with various companies adopting some additional days before and after.

On Saturday 21 March 2020, Prime Minister Jacinda Ardern asked people 70 years' old and older, and people with compromised immune systems, to stay at home as much as possible. She asked people who could work from home to do so and said people should limit travel within the country. The government also introduced a four-level alert system to help combat COVID-19.

Prime Minister Ardern said the country was at Level 2, which meant the risk of community transmission was growing. On the following Monday 23 March we moved to Level 3, essential travel only - getting people home and no large gatherings. At midnight on Wednesday 25 March, the New Zealand Government declared a state of emergency and put its five-million inhabitants into Level 4 lockdown. Many of the cave operators had shut down before this, as the social distancing rules were onerous.

Spellbound did its last tours on Sunday 22 March and Glowing Adventures had stopped earlier. The Waitomo Glowworm Cave did its last tours on 25 March.

Throughout this time, the Waitomo village was very quiet! Forestry operations were deemed non-essential in Level 4, so the weekday disruption of up to 100 heavy vehicle movements per day disappeared.

The Taharoa iron sand mining on the west coast remained open, as did the Graymont limestone quarry, their burnt lime is used for pH control in municipal water supplies. Farming operations continued as normal, so a certain number of stock, fertiliser and lime trucks continued to operate.

There is plenty of accommodation normally at Waitomo village, especially with some local people choosing to list their extra accommodation on Airbnb in recent years.

As far as we could tell, apart from private arrangements, there were only around 10 backpackers staying at Juno Hall; most took the mercy flights arranged by Germany over this time. At the Waitomo turnoff, Caves Motor Inn had people in for the Level 4 lockdown.

New Zealand reverted to Level 3 on 28 April, Kiwis seemingly excited about being able to order takeaways. The Waitomo general store and café was able to take advantage of this, having been open daily through Level 4 as a grocery shop (and takeaway coffees!).

Interestingly, cave operators have been slower to reopen, when we reverted to Level 2 on Thursday 14 May, than they were to close when Level 3 was imposed. This was undoubtedly due to the lack of visitors. There has now

been a campaign for domestic visitors to see their country, with this likely to ramp up over the summer. Level 2 meant restaurants and hairdressers could open, as could cave tours with appropriate anti-COVID-19 precautions.

Simon and Maria Hall of Kiwi Cave Rafting were first to open on the Friday, just for the weekend, for overseas travellers who had been locked down in New Zealand.

But no show caves opened last weekend. The Waitomo Glowworm Cave is about to open as this is written, perhaps 21 or 22 May. Their Discover Waitomo website advertises specials - adult prices down from \$55 to \$38 and children's prices lowered too. The legendary Black Water Rafting is likely to remain closed till Level 1, but weekly there are “tweaks” to the rules - today, 20 May, in New Zealand bars have opened again.

Ruakuri Cave tours will open sooner, but just three tours per day. Spellbound will open for weekends, plus as required from 29 May. Our guiding staff have accepted the change to casual contracts. Glowing Adventures reopened but just for groups - rather than free independent travellers. A three-hour adventure cave tour, for between two and eight people at a price of \$800.

Reported on television today was that \$9 billion was spent by Kiwis going overseas and around \$40 billion per annum income came into New Zealand from tourism. There will certainly need to be a change in mindset for Kiwis with some discretionary income to travel. Waitomo could be well-placed for this behind iconic destinations of Queenstown or the Bay of Islands.

I haven't mentioned Waitomo Adventures, with their Lost World Abseil, and the predominance of top-end international visitors - they hope to reopen in October. Cave World/Footwhistle Glowworm Cave remains uncertain about a reopening date, but for now have vacated their office space in the Old Post Office beside the Museum of Caves.

Bridget Mosely, director at the Museum, has cut back staffing levels. The 12-week government subsidy runs out on 9 June. This may unfortunately result in large numbers of redundancies or casualisation of cave staff. A second round of wage subsidies, for businesses with less than 50% of turnover from 10 May to 9 June is available, but some careful thought is required to decide whether to take advantage of this.

There has been some local uptake of the ACKMA-sponsored cave climate study. The largest operator (Glowworm, Ruakuri and Aranui caves) already monitors climate. However, the smaller operators will get some useful data, but time will tell whether the instruments are sensitive enough to measure human visitors in small numbers.

And right now, our fine and frosty May weather continues, the perfect opportunity to get out and look for undiscovered cave entrances in the cold morning air! Some underemployed cave guides have even been out on some energetic wild cave trips!



## Carbon Dioxide in Waitomo Glowworm Cave

**David Merritt**, Chair of Environmental Advisory Group, Waitomo Glowworm Cave and Associate Professor, School of Biological Sciences, The University of Queensland

**Shannon Corkill**, Environmental Manager, Discover Waitomo, Tourism Holdings Ltd

Waitomo Glowworm Cave (WGC) is unique in that it is visited by hundreds of thousands of people each year who visit to see cave wildlife - the glowworms. It is an iconic New Zealand tourist attraction, with many international visitors. "Discover Waitomo" also operates a walking tour and black-water rafting tours through Ruakuri Cave, where visitors also experience the beautiful cave formations and the glowworms. Aranui Cave offers visitors the chance to see some beautiful cave formations and a number of cave weta. The numbers of visitors began to reduce in March 2020 in response to the COVID-19 pandemic and the New Zealand Government announced a nationwide lockdown to begin on 26 March 2020. Discover Waitomo closed all sites and caves for visitation on the evening of 23 March. A small team of fewer than 20 employees continued to work remotely over the lockdown period.

The absence of visitors provided the unanticipated opportunity to study the cave environment when there are no visitors. It is probably more than 100 years since WGC has had such a long period without visitors. The environmental impacts of visitation are a significant component of cave management. Concerns go back to the 1970s, when Les Kermode of the Department of Scientific and Industrial Research pointed out that carbon dioxide (CO<sub>2</sub>) exhaled by visitors was potentially leading to speleothem corrosion in WGC (Kermode 1977). Since that time, the cave environment has been monitored, using increasingly sophisticated equipment, much of it under the guidance of Dr Chris de Freitas who led the scientific studies of cave microclimate. From this early start, microclimate data is now available on line and photographic glowworm monitoring allows remote assessment of the glowworm population. The Environmental Advisory Group meets twice a year to examine microclimate and management of the caves. The caves' environmental manager has responsibility for implementing the cave management plan. Currently, sensors detect airflow near the upper entrance, air temperature and humidity both inside and outside the cave, and river level and water temperature in the grotto. Carbon dioxide is monitored at two locations. The data is displayed in real-time in the cave manager's office and each day the likelihood of high levels of CO<sub>2</sub> is assessed, based on anticipated visitor numbers and the temperature profile through the day.

The temperature differential between outside and inside the cave plays an important role in clearing CO<sub>2</sub> because

WGC is a chimney-effect cave with air flowing either upward or downward, depending on the differential. On days when the external temperature crosses the cave's internal temperature (around 15°C), the airflow in the cave transitions between up- and down-flow with a stagnant period during the transitions. On days when the external temperature is close to the cave temperature, low airflow can lead to CO<sub>2</sub> build-up. In extreme cases, cave visits can be limited to prevent CO<sub>2</sub> reaching a specified action threshold of 2400 ppm. For context, levels from 250-400 ppm are normal outdoor levels, 400-1000 ppm are typical of indoor settings, and 2000-5000 ppm can start to affect people by producing drowsiness or a sense of stale air.

Another tool available to the cave manager is the status of the upper entrance door. When this automated door is open, air readily flows according to the temperature differential. However, the door is not kept open all of the time because the glowworms in the grotto can be dehydrated by dry air entering the cave. Consequently, cave environmental management aims to strike a balance between allowing airflow to flush visitor-produced CO<sub>2</sub> and limiting airflow to prevent dehydration of the glowworms.

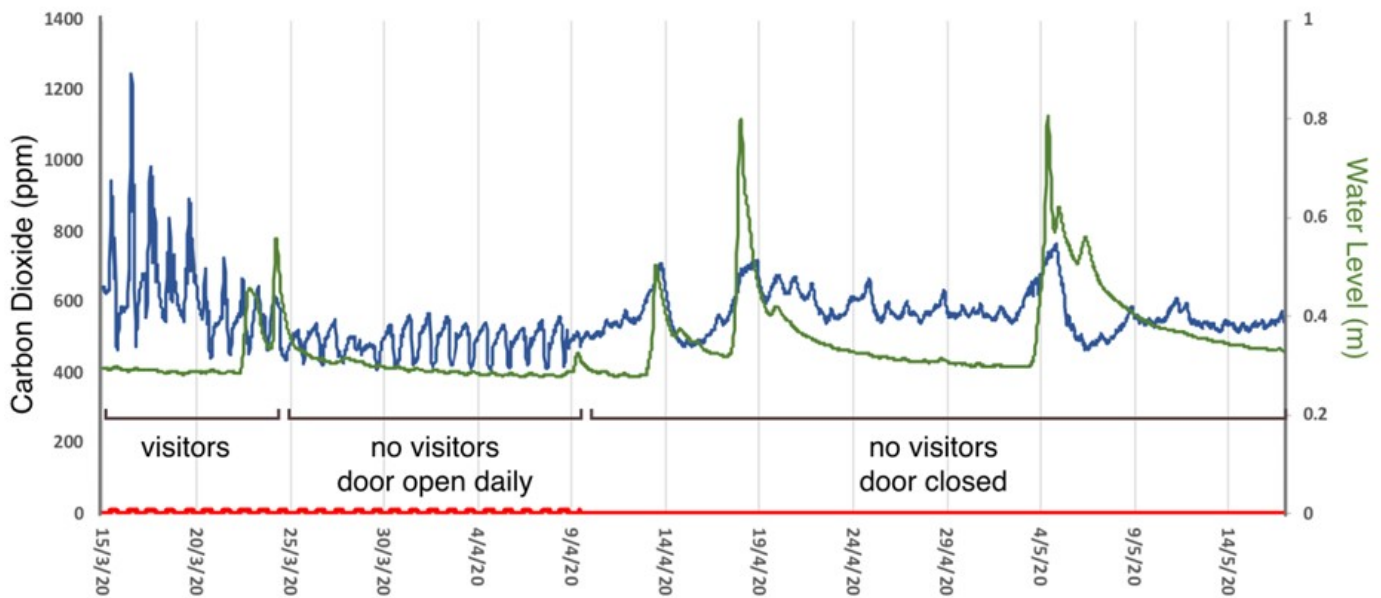
The normal daily operation is to open the door during the day when visitors are in the cave. After tours are finished and the staff have gone home, the door stays open allowing ongoing flushing until the CO<sub>2</sub> in the cathedral chamber reaches 800 ppm. At that point the door automatically closes until the next day when the cycle repeats. The level of 800 ppm, as the threshold for closure of the door, was chosen because CO<sub>2</sub> continues to drop through the night to reach about 600 ppm next morning. The absence of visitors gave us the unprecedented opportunity to observe CO<sub>2</sub> levels with no people adding their exhalations.

As expected, the height of daily peak in CO<sub>2</sub> that usually occurred in mid-afternoon dropped dramatically as visitor numbers dropped through March (Figure 1 on next page).

Once visits stopped entirely on 24 March, the daily range was low. For the next 17 days, a daily pattern was seen in CO<sub>2</sub> levels because the door was opening and closing under the automated procedure, despite there being no visitors. The pattern suggested that the cave is producing above-ambient CO<sub>2</sub> levels even in the absence of visitors and automatic door opening was introducing fresh air at ambient CO<sub>2</sub> levels of around 400 ppm.

On 9 April, the door code was remotely changed to leave the door closed to minimise airflow for the glowworms and to allow us to assess the CO<sub>2</sub> levels. Since then, CO<sub>2</sub> stabilised at around 500-600 ppm.

Interestingly, floods - as measured by water level near the pier in the grotto (Figure 1) - produce a CO<sub>2</sub> spike in the cathedral and other chambers. Note that the CO<sub>2</sub> levels begin to increase before the water level increases, probably due to drip-water from the associated rainfall releasing CO<sub>2</sub> into the cave.



**Figure 1. Carbon dioxide levels in Waitomo Glowworm Cave (blue) and water level in the grotto (green). Periods when the door is open are shown as above baseline (red).**

These observations confirm a scientific study (MSc) done by Natalie Miedema at University of Waikato under Dr Chris Hendy's supervision. Natalie analysed monitoring data and determined that floodwaters release CO<sub>2</sub> into the cave - probably due to their bringing in water that has flowed through humus and soil and dissolved the CO<sub>2</sub> contained therein. While the contribution of flood-water and drip-water to CO<sub>2</sub> levels is small when compared to that of humans, we are now able to separate the contributions of natural and exhaled sources to the over-

all cave CO<sub>2</sub> levels.

**Kermode, LO** (1977), Some aspects of the influence of tourists on the microclimate of Waitomo Cave, Research Report New Zealand Geological Survey. Department of Scientific and Industrial Research.

**Miedema, NM** (2009), Non-anthropogenic sources of carbon dioxide in the Glowworm Cave, Waitomo, MSc thesis, Earth and Ocean Sciences and Chemistry, The University of Waikato.



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