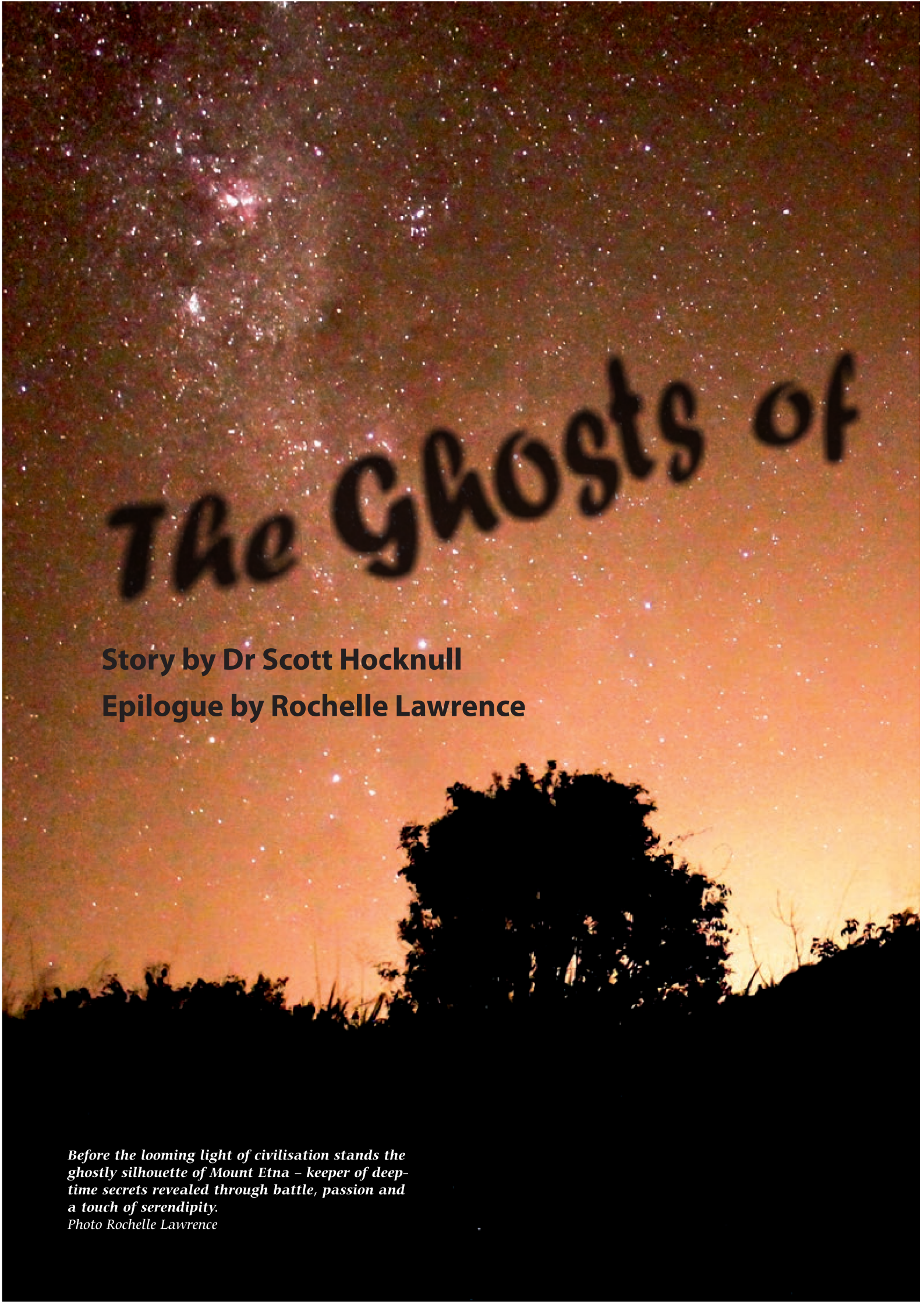
The Ghosts of

Story by Dr Scott Hocknull
Epilogue by Rochelle Lawrence



Before the looming light of civilisation stands the ghostly silhouette of Mount Etna – keeper of deep-time secrets revealed through battle, passion and a touch of serendipity.
Photo Rochelle Lawrence

Mount Etna

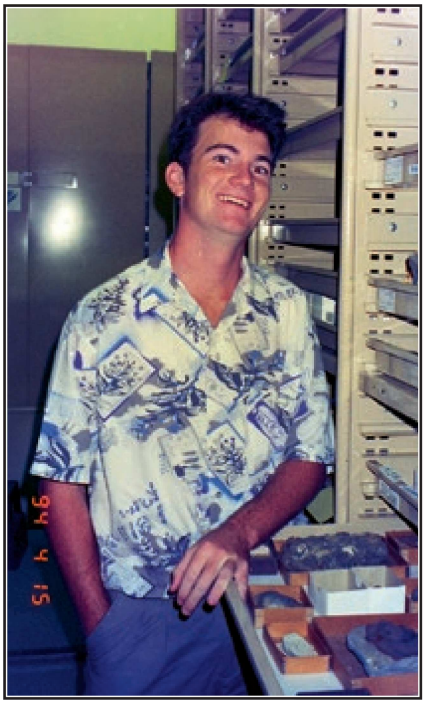
Within the vast and dimly lit fossil collection of the Queensland Museum's Palaeontology and Geology Department, a large sack sat hidden from view, high up on the top shelf of a compactus unit. The sack was filled to near-bursting – its sides slightly torn, and a brown dust of its own making filtered through its ageing hessian sides. A piece of string tied its top together, keeping its secrets from spilling out. It had sat on this shelf for years – unmoved, unopened – waiting to be rediscovered perhaps by some famous professor who would decree its significance to the world. Instead it got me; an inquisitive teenager with dreams of palaeontological grandeur and the impatience of a young mind eager to learn.

I couldn't tell what was inside the sack. To be where it was, someone at some time must have believed that its contents were important, but its true scientific value had yet to be determined. "This looks pretty interesting," I thought to myself, hoping that whatever was inside could be a project to keep me busy for a while. I had been a volunteer at the Museum for four years by this time and had earned the trust of the staff so I asked Joanne Wilkinson, one of the Museum's vertebrate fossil technicians, if I could sort its contents. Joanne agreed and after confirming this with vertebrate palaeontologist and Curator, Dr Ralph Molnar – who was more than happy to see me doing something I was interested in, I set to work. No doubt Joanne and Ralph thought that this was a great way to keep me distracted and out of their hair for a while! Today, more than twenty years later, I look back at that 'little distraction' and marvel at the twists and turns of fate and how that dusty sack of fossils changed my life as a vertebrate palaeontologist.

I lugged the sack into our small department lab and cleared a spot on one of the tables. I undid the string tie, opened the sack and looked inside. I still remember the puff of dust that came out, along with a distinctly musty smell that I would come to know so well. It was the smell of cave dirt and bones – thousands of bones! These tiny bones and teeth were light brown to yellowish in colour, and the surfaces of many were covered with weird dendritic manganese patterns. "Wow," I thought, "It is going to take me forever to sort through this lot and identify what these little bones belonged to."

The tray upon which the sack had sat had no label, but it had been placed within the shelving units dedicated to cave fossil deposits. These are conspicuous within the Museum's fossil collection, with most of them consisting of thousands of bones and teeth collected from old owl-roost deposits. After they have eaten their prey, owls roosting in caves regurgitate the bones, teeth, fur and feathers of their meal on to the cave floor. This process, repeated over thousands of generations, leads to fossil deposits that provide a broad survey of the surrounding area over extensive periods of time. Just below the sack's tray were trays of specimens labelled 'Fern Cave, Chillagoe, far north Queensland'. Naturally, I assumed the fossils in the sack came from this same cave. That was my first mistake!

I began sorting the tiny bones, one ice-cream bucket at a time. First, I sorted the most obvious pieces: the teeth, jaws and complete limb bones. Over the next couple of years I dedicated every moment of my volunteering to this task. My biggest hurdle was figuring out what these specimens were and what animals they had belonged to. It was obvious that they came from species similar to those of today because they didn't look that old; perhaps only a few thousand years old. To be sure, however, I would need to learn the telltale shapes and structures of every tooth and bone from every native species known to Australia. In order to do this I needed some help, so I wasted no time in identifying my key museum allies and mentors. At the museum I introduced myself to zoologists Jeannette Covacevich, Patrick Couper, Steve Van Dyck and Heather Janetzki who looked after the collections of modern animals and, most importantly, collections of their skeletons! I would spend hours, days and weeks poring over these specimens, examining every bump on each tooth, documenting the shape of every bone and measuring specimens so that I could compare them with my fossils. I was awestruck by the great diversity of shape, structure and size of the many species. It was a world of confusion and a steep learning curve for a kid who had been taught at school that science was a fixed process of 'fact accumulating upon new fact'. I'd never encountered scientific doubt, the concept of variation, abnormality, or things like *ontogeny*, *phylogeny* and *taphonomy*. These all affected the identification of the specimens I had in front of me. I had never imagined how something as simple as a tooth



The Fossil Collection Room at the Queensland Museum, Southbank in 1994 *(left)* ***where an unmarked hessian sack containing fossils and cave dirt from an unidentified cave system*** *(top right)* ***was 'rediscovered' by 16-year-old museum volunteer Scott Hocknull*** *(above)*. ***Scott's quest to unravel the secrets of the sack's contents formed the basis of his PhD and the beginnings of a distinguished career in vertebrate palaeontology.***

Photos Morag Hocknull

Photo Scott Hocknull

could tell you so much about the animal it came from.

Almost immediately I made my first discovery and it was a strange one: a tooth that didn't match any of the species I had been able to observe in the museum collections. After many months of trawling through papers and books I thought I knew what it was: a molar from a greater bilby (*Macrotis lagotis*). Although the museum had bilbies in the collection, their teeth were all worn flat. However, some papers showed the telltale cusps unique to this bizarre marsupial. After verifying this with my friend and mentor Henk Godthelp at the University of New South Wales, I became more confident in my identification. But how could this be – a bilby from Chillagoe? Bilbies are, supposedly, an arid-adapted species, found only in central Australia and definitely not from far north Queensland. More strange species surfaced as I continued sorting, including the pig-footed bandicoot (*Chaeropus ecaudatus*) and the central earless dragon (*Tympanocryptis cephalus*).

After three years of sorting I was nearing the end when, out of one scoop, a tattered and folded label fell. It read: *'Elephant Hole Cave', 1986, Kerry Williamson & Dianne Vavryn*. No cave at Chillagoe had the name Elephant Hole Cave! After some investigation I discovered that the sack of fossils actually came from a cave deposit collected from the Mount Etna Caves, north of Rockhampton. The name Elephant Hole Cave was well known to the University of Queensland Speleological Society because they had mapped it in the 1970s and, serendipitously, copies of their reports were kept at my university library. Even though I had now positively determined where the fossils came from, the strange arid-adapted list of species still didn't make any sense. Rockhampton is dry, but nowhere near as dry as central Australia!

Caves hold a great many secrets and my curiosity for them had been sparked the year before I made the 'rediscovery' of the Elephant Hole Cave fossils in the museum. I had heard that a meeting of Australian vertebrate palaeontologists – the Conference of Australasian Vertebrate Evolution, Palaeontology and Systematics (CAVEPS) – was to be held that year (1993) in Adelaide, South Australia, so I asked my parents if I could go. Here I was, 15 years old and wanting to travel to Adelaide in order to attend a professional science conference all by myself! I did have one ace up my sleeve however. My grandmother lived in Mount Pleasant, just a stone's throw from Adelaide, and she had supported my interest in dinosaurs and museums since I was a toddler. When Gran agreed to fund my conference experience and the post-conference field trip I was beyond excited!

On arrival at Adelaide I met three of the organising palaeontologists: Dr Rod Wells, Neville Pledge and Gavin Prideaux (who was a student at the time). I developed a great friendship with these men over the course of the conference and the post-conference field trip to Naracoorte Caves. It was during this field trip that I fell in love with caves and the secrets their fossils can tell us. Rod passionately described the discovery of the Victoria Fossil Cave and how the megafauna fossils accumulated in great sediment cones – all of which were directly beneath my feet. I was an information sponge, listening to how fine excavations can reveal amazing details of how each animal lived and died over millennia; even how the climate of the time was different and could become trapped as molecules inside the beautiful cave formations. My mind was blown. I couldn't wait to get back to Queensland and make a great cave discovery of my own and I have no doubt that this is what led me to investigate the dusty sack of secrets hidden away in the Queensland Museum.

I was in second year university when I made my great discovery. By this time I had explored many fossil sites throughout Queensland, taking every opportunity I could to tag along or venture out on fieldwork into remote areas with potential for caves. On one such trip to the Broken River in far northwest Queensland,

***Scott Hocknull** (far left, back row) **and Paul Tierney** (far right, front row) **in 1995 with a Queensland Museum team outside Dodgey's Cave in the Broken River Province of far north Queensland** (left). **When a similar excursion to the Broken River by Scott and Paul in 1998 was abandoned due to extreme weather, they returned home via Rockhampton hoping to collect from a cave at Mount Etna known as Elephant Hole Cave. Their plans were thwarted when they discovered that much of Mount Etna had been mined for limestone** (right). **The Elephant Hole Cave had been blasted during mining operations and no longer existed**.*

Photo (left) Queensland Museum

carried out with long-term friend and museum volunteer Paul Tierney, our expedition was cut short by a massive hailstorm over our campsite. We were on a two-week trip but had to get out quickly. After many hours of mud-sliding over hail-strewn roads, we made it to Bowen where we licked our wounds and thought of where else we could go. Elephant Hole Cave was an immediate option – we would be travelling back through Rockhampton after all. Unfortunately however, we had no idea of where this cave was or how to get to it. On a hunch I called the museum and got a phone number for the Central Queensland Speleological Society.

I remember standing at the pay phone of our motel calling the number. A lady answered the phone and informed me that I would need to call back and speak to her husband, Noel Sands, after he returned from work. That afternoon I called the number again and Noel answered. I could immediately hear the apprehension in his voice. This kid had called him up claiming to be a volunteer for the Queensland Museum and wanting to find fossils in caves on Mount Etna. I had no idea of the controversy and conservation battles that had been waged at Mount Etna over the preceding decades. Noel said if we could arrange a permit to access the National Park, he'd be happy to show us some fossil sites. I'm sure he was doubtful that we'd manage to get it.

I proclaimed to Noel that we would get the permits and that we'd be very interested in visiting Elephant Hole Cave. There was silence at the end of the line and then a response came that I now know is typical of Noel: "Yeah, nah, that's not possible mate. It was part of the mine and they blew that one away, *just blew-it-a-way* – poof!" This was quickly followed by, "But I know where there are other caves I can take you to with some bones." I was devastated. My holy grail, gone! I didn't know what to think. Based on my studies to that point, Elephant Hole Cave must have been full of amazing fossils and would have contained clear indicators of major past climatic changes, faunal evolution and extinction – all gone, just like that. I wondered if it was even worth going to Mount Etna to see these other sites.

I consoled myself and, after discussing our options, Paul and I decided to try for the permit anyway. Maybe these other caves contained similar deposits that also preserved arid-adapted fauna. So we arranged a permit and went to Mount Etna in search of an arid fossil fauna. What we found was nothing of the sort; in fact, it couldn't have been further from it, but it was a life-defining discovery for me.

We met with Noel and headed off up the limestone karst. I was soon to find out the reason for his apprehension during our phone conversation. As a long-serving member of the Central Queensland Speleological Society, Noel was heavily involved in the longest-running conservation battle so far waged in Queensland. Starting in the 1960s and still going at the time we met, this period was a monumental time for many of the close friends I was to make at Mount Etna over the years. Noel explained that two huge cave systems, Speaking Tube Cave and Elephant Hole Cave, located on the western ridge of Mount Etna, were once the main roost sites for the endangered ghost bat (*Macroderma gigas*) along with a suite of other bat species. In an effort to save their environment, Noel was just one of the many people who staged protests, legal battles and blockades against the limestone mine but, in spite of their efforts, the entire western ridge of Mount Etna, including its vast cave systems, was blasted into oblivion for cement powder. Hearing these firsthand accounts about the mining operations during the peak of the blockades, it was clear that blasting of these two major cave systems was more a political statement than one of necessity. Indeed, soon after blasting the caves, the mine stopped operations in the area of the caves because of vast clay infill that had no economic value. It was heartbreaking to know that these same clay deposits would have contained countless fossils.

Following Noel across the limestone karst, I soon realised that he was a man with an infinite knowledge of the area and a passion for the preservation of its natural history. It was easy to find a common ground between his ideals and my own and before long we had forged a great friendship. Fortunately, I was familiar with the razor-sharp nature of limestone karst from earlier expeditions to Riversleigh and the Broken River in northern Queensland so I was in my element as we explored a number of caves in the National Park and visited the Capricorn Caves tourist caves nearby. We headed for a tiny cave aptly named Mini Cave. We ducked through a small opening in the limestone and carried on along a short chamber to the back wall. What confronted us was one of the most beautiful fossil sites I've ever seen. Layer upon layer of old cave floor sediment, jam-packed with bones and teeth that had cemented together with calcium carbonate over millennia. Over a similar time period

Photo Scott Hocknull

the entire floor had been exposed in cross section by erosion, revealing all of the layers of clay, cave formations and fossils.

Our torches zipped back and forth across the cave walls, picking out bones and teeth everywhere. Suddenly, I spotted my first jaw. Years of sorting through fossil teeth from Elephant Hole Cave had instilled a mental catalogue of shapes in my brain that I could never forget so identifying this species should have been a breeze. Nope! The tooth was large and serrated and followed by rounded molars. It was not like anything I'd seen before. The next jaw was just as unfamiliar as the first, as was the next and the next. We collected dozens of specimens, all of which were just hanging on to the wall by the tiniest bridges of sediment and ready to fall off at any moment. I had no idea what these species were but I knew they were definitely not from the same species that made up the Elephant Hole Cave fauna. Much of the fossil cave floor had broken off and fallen as blocks on to the present floor, so we collected these for acid-processing back at the museum. We consciously decided never to collect fossils from the wall unless they were naturally exposed and in danger of becoming lost. The natural beauty and scientific value of Mini Cave remains intact today.

I couldn't make sense of the specimens from Mini Cave. They looked like species I knew well, but were clearly not. "I've found new species," I thought to myself, "and not just one new species but dozens – a single cave deposit full of new species!" On my return to the museum I immediately started to compare the species we had found with those in the collections. Apart from some possums that are only found today in New Guinea, I couldn't find anything similar in the museum's modern or fossil collections. It wasn't until I took a trip down to Sydney to visit the New Guinea mammal collections at the Australian Museum, and got to show Henk Godthelp the rodents from these new sites, that it all became clear. We had discovered a super-diverse rainforest fauna – one with a species diversity matched only by the Oligo-Miocene faunas from the World Heritage-listed Riversleigh fossil mammal site. In search of an

The western side of Mount Etna following the completion of mining operations *(above)*. ***The red clay on the upper benches is cave infill sediment within Speaking Tube Cave. To the immediate right of the red soil, a pale-brown patch (on the edge of the photograph) is all that remains of Elephant Hole Cave. Although these cave deposits contain fossils from an extinct rainforest fauna, they were once situated below a much younger deposit containing an arid-adapted fossil fauna. The arid-fauna deposits were, unfortunately, completely removed by mining processes.*** *Photo Scott Hocknull*

arid fauna, I'd found one from a rainforest!

It just didn't seem right; mammals considered endemic to New Guinea shouldn't be in a cave site at Rockhampton. I was utterly perplexed. Both fossil deposits, Elephant Hole Cave and Mini Cave, were characterised by faunas comprised of completely different species from those found at the caves today. What's more, they contained species found in environments that, today, are as far from Rockhampton as they are from each other. The sites simply didn't correlate with biogeographic or palaeoecological thinking at that time, especially the relationship between species present in Australia and New Guinea. In basic terms, the species found in Australia and New Guinea were thought to have established their current ecological and biogeographic patterns many millions of years ago, with the only significant change to have occurred in more recent times being the Pleistocene extinction of the megafauna. This meant that the fossil sites we had found must have been very, very old. That was my second mistake!

Following my initial visit to Mount Etna I mounted yearly expeditions to search for new sites and new specimens. As word spread amongst the local cavers, Noel reported to me that he had found a bone deposit on the limestone mine itself. While investigating the mine for freshly exposed caves during continued mining operations, Noel and fellow caver Clive Kavanagh discovered a vast clay deposit full of bones. Hoping that I was not too late, I immediately contacted the mine and asked for permission to come on site and collect. Expecting a negative response, I was surprised when the mine's general manager Chris White readily agreed. In 2000 we set up camp near the limestone mine and, during the weekends when the mine wasn't operating, fossicked along the exposed benches. Immediately we discovered huge deposits of bones and it was soon obvious that the main limestone quarry benches on the western side of Mount Etna consisted of two huge sediment deposits, each larger than an Olympic-sized swimming pool. These bone-rich deposits were the clay-filled interiors of two enormous cave systems. I later discovered that for nearly a decade these clay deposits had sat unmined and earmarked for revegetation once operations at the mine site had stopped. Using maps of the caves on the mountain created by cavers in the 1970s before mining commenced, I was able to align the fossil deposits and the original cave entrances. The largest was Speaking Tube Cave, and you can probably guess the other: it was Elephant Hole Cave! I had finally been reunited with the remnants of my holy grail.

On one of my first trips to the mine I met with quarry manager Don Kime who had been at the quarry for many years, including those during which the conservation battle had been waged. Don recalled the discovery of fossil bones when the caves were opened up, which occurred in the late 1980s and early 1990s. This corresponded with the removal of the sack of material in 1986. During my investigations I also made contact with Kerry Williamson and Dianne Vavryn who had originally collected the fossils from Elephant Hole Cave. The collection was essentially a salvage operation to collect samples

Photo Warwick Willmott

The eastern side of Mount Etna as it was in 1965 *(above)*. ***Limestone mining by Central Queensland Cement Ltd commenced on Mount Etna in 1966, but operations were soon embroiled in controversy between the company and environmentalists, including the Central Queensland Speleological Society. Major conflict erupted between the groups in 1987 and 1988*** *(right and below right)* ***when Speaking Tube Cave and Elephant Hole Cave were earmarked for destruction, threatening a resident population of the rare ghost bat*** *Macroderma gigas (below)*. ***Unfortunately, protests were unsuccessful and the caves were destroyed in November 1988.***

Photos (right) courtesy Capricorn Caves.

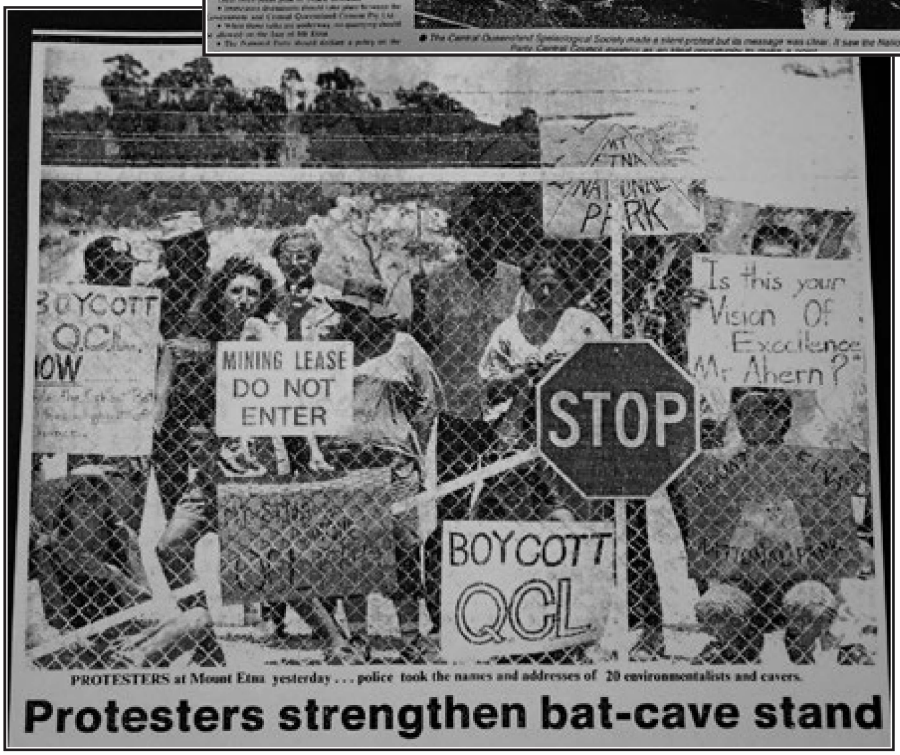
KEEN CAVERS LOBBY NATS TO SAVE BATS

Protest aims to stop mine at Mt Etna

Unknown to many people, there was a second protest outside the National Party Central Council talks on Saturday

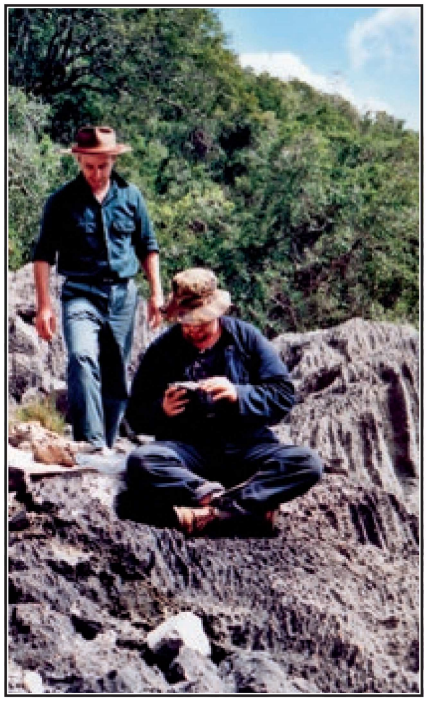
SAVE MT ETNA CAVES

Photo John Augusteyn



PROTESTERS at Mount Etna yesterday . . . police took the names and addresses of 20 environmentalists and cavers.

Protesters strengthen bat-cave stand



Paul Tierney and Scott Hocknull inspect fossil specimens at the mouth of Mini Cave in 2000 *(left)*. ***The discovery of fossils within the limestone mine around this time led to a major collection effort on Mount Etna by the Queensland Museum. In the photo*** *(above)*, ***Scott Hocknull, Paul Tierney, Kristen Spring and Noel Sands climb the slopes of Mount Etna to inspect fossil deposits within the mining lease.*** *Photos Joanne Wilkinson*

before mining operations obliterated the site. Elephant Hole Cave was the first to go, followed by Speaking Tube Cave. As mining operations moved into Speaking Tube Cave the miners came across large pieces of cemented cave sediment with large bones in them. They contacted the Queensland Museum and, as I would later find out, sent a 44-gallon drum of rock containing bones to the museum. I eventually located the drum tucked away in the collection. Fortunately, Don had the foresight to stockpile a small batch of this bone-rich cave sediment but, in the absence of further communication from the museum, mining continued. Thankfully, due to the fact that the deposits comprised mainly clay and lacked economic value, mining operations soon moved to other areas and the remaining deposits were left in place.

We explored the limestone benches and a menagerie of discoveries came thick and fast – literally thousands upon thousands of specimens representing species of all kinds. Now that we were right where Elephant Hole Cave had been, I was certain we would find more of this arid fauna but, to my surprise, all of the deposits contained species from the ancient rainforest fauna. Fossils have been found of tiny millipedes, snails, fish, frogs, lizards, snakes, turtles, crocodiles, birds, rodents, bats and a menagerie of marsupials. The richness of species is outstanding. Some thirty species of possum have been recognised, ranging from species of pygmy to giant ringtail possums, cuscuses, gliders and completely new, extinct groups. There are about twenty species of kangaroo including one of the smallest kangaroos ever found, several species of tree kangaroo, and the extinct giant tree kangaroo *Bohra*. A pygmy marsupial lion (*Thylacoleo hilli*) that lived alongside its lion-sized cousin and probably preyed on wombats, marsupial mice, bandicoots and koalas, have also been discovered. Other predators, large and small, are also present, including pythons and venomous snakes, an extinct madtsoiid snake, the Komodo dragon, thylacines, devils and the strange crocodile *Quinkana*. We have even found the vertebrae of tiny blind snakes, as well as frogs by the dozen, ranging from tiny microhylid frogs (common in northern mountainous rainforests) to a giant extinct frog with the impressive scientific name of *Etnabatrachus maximus*.

Eventually, I would discover that the Speaking Tube Cave deposit was almost entirely made up of sediments containing the rainforest fauna whereas the Elephant Hole Cave deposits included both rainforest and arid faunas. The transition between the two environments in which these faunas lived must have been preserved somewhere in one of these cave systems but, unfortunately, mining operations had removed it. Later I would find a series of photos taken of the deposits when they were first broken into. The layers, now lost, were definitely there and as clear as day. It would take another twelve years of searching caves in the area before I found anything remotely similar.

Although we have since found a replacement for these lost deposits, I still lament the unfortunate and unnecessary sequence of events that led to the loss of this material. The apparent lack of interest from the Queensland Museum seems to be the primary reason that mining continued without further salvage. When the mine managers learned how significant the deposits were, they were surprised – and they too lamented the loss. This one lesson has guided my work in palaeontology ever since. Determined to make amends, I worked closely with Cement Australia, Central Queensland Speleological Society and National Parks to secure the remaining fossil deposits. By this time the deposits were very difficult to get to and would require significant earthworks to gain safe access. Cap in hand, I approached Cement Australia (then Queensland Cement Limited) with the bold request to stockpile the entire series of deposits – some thousands of tonnes of fossil-bearing clay and rock.

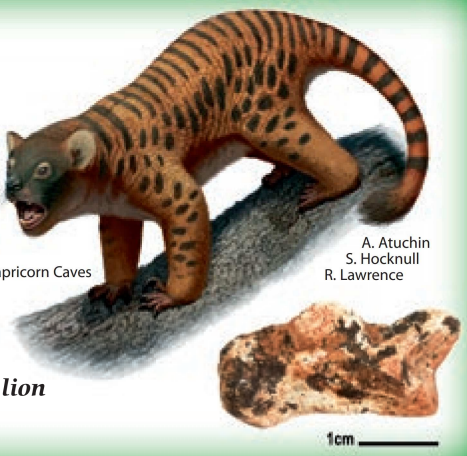
Chris White considered the proposal and agreed that they would designate an area that would never be touched as a laydown position for the deposits. It was also agreed that this area would eventually become part of a proposed new national park. Over a period of several months I travelled frequently to the Mount Etna mine and, with Noel's help, supervised removal of the fossil deposits ensuring that laying down of the sediments was conducted systematically and recorded for posterity. The process was very quick and illustrated to me how easily such a salvage operation could be undertaken. With a little bit of co-operation, the best of a bad situation can be made: these deposits are now secured and stockpiled for future generations of researchers to collect from and analyse.

Paul Tierney and Scott Hocknull inspect newly discovered cave floor deposits on the lower benches of Mount Etna Mine *(right).* ***The deposits – remnants of Speaking Tube Cave and Elephant Hole Cave – were identified by comparing their position with early cave records of the University of Queensland Speleological Society. The significance of the discovery prompted Scott to approach Central Queensland Cement Ltd with a request to stockpile the remaining cave sediments, ensuring their availability for future research*** *(below).* ***Under the guidance of Scott and Noel Sands*** *(inset below)* ***the deposits were relocated to an area designated as part of a proposed national park at Mount Etna in 2003.***

Photos courtesy Queensland Museum

SPECIES FROM THE ANCIENT RAINFORESTS OF MOUNT ETNA

Photos by Scott Hocknull and Rochelle Lawrence



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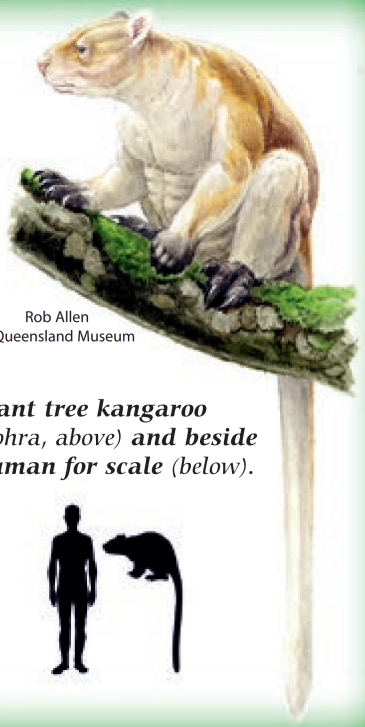
A. Atuchin
S. Hocknull
R. Lawrence

***Tooth** (above) **and ankle bone** (right) **from the pygmy marsupial lion** (Thylacoleo hilli).*



Rob Allen
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***Giant tree kangaroo** (Bohra, above) **and beside Human for scale** (below).*

***Vertebra of the giant madtsoiid snake** (Yurlunggur sp, right).*
***A madtsoiid snake swallows a wallaby** (below).*

Rob Allen
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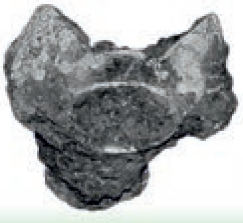
Cuscus jaws.

***Vertebrae from giant goannas** (below) – **including the Komodo Dragon** (Varanus komodoensis, right).*

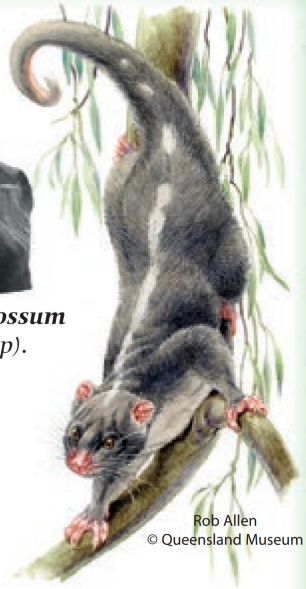


V. Konstantinov A. Atuchin S. Hocknull © Capricorn Caves

Over thirty species of possum have been found in the ancient rainforest deposits of Mount Etna. Many more await identification, including these teeth from new species *(below)* ***and this peculiar tooth*** *(top left)* ***believed to be from a totally new genus of possum.***

Two types of striped possum *(Dactylopsila sp).*

Giant ringtail possum *(Pseudokoala sp).*



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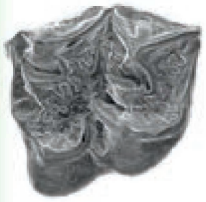

Woolly ringtail possum *(Pseudochirops sp).*

Two as-yet unnamed species of ringtail possum.

Pygmy greater glider *(Petauroides sp).*

The giant ringtail possum *(Pseudokoala).*

Tooth of the (possibly) terrestrial crocodile *(Quinkana).*

Illustration Rob Allen
Photo G. Cranitch
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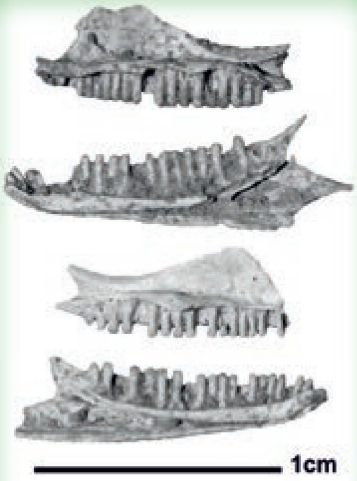
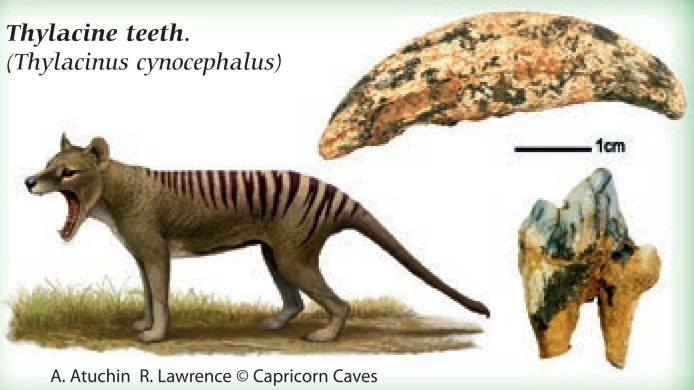


Fossil skink jaws from Elephant Hole Cave deposit.

Fine fossil jaws of frogs and lizards from Mini Cave.

Thylacine teeth.
(Thylacinus cynocephalus)



A. Atuchin R. Lawrence © Capricorn Caves

In 2006 an open day was held by the Queensland Museum and Cement Australia (formerly Queensland Cement Ltd) for interested members of the public. Over 2,000 people attended and, over a period of several hours, numerous fossils including dozens of new species were discovered. The stockpile is now enclosed within the Mount Etna National Park Scientific Reserve as a resource for future generations.

Photo Scott Hocknull

Shortly after the deposits were stockpiled, Cement Australia and the Queensland Museum held an open day for the public so that interested people could assist us in sorting through the thousands of tonnes of sediment for fossils. We had over two thousand people turn up over only a few hours, and dozens of specimens belonging to new species were discovered. This event only scratched the surface of the stockpiles: there are literally hundreds of years of work remaining for future generations.

Research into the fossils continues and, as the depth of our work expands, so too does our understanding of the diversity of species that once inhabited the ancient rainforests of Mount Etna. Much of this research has turned conventional wisdom on its head, with one of the greatest upheavals caused by my research into the age of the deposits. The fact that fossils of rodents were present in all of the deposits we had collected meant that the Mount Etna deposits were younger than the Riversleigh fossil faunas, as none of those sites record rodents. Rodents are thought to have arrived relatively recently in mainland Australia, having island hopped from southeast Asia some four to five million years ago during the Pliocene Epoch. Consequently, a Pliocene age for the rainforest fauna at Mount Etna seemed reasonable. As the species lists grew, I recognised several groups that were closely related to those from other Pliocene-aged sites, and even holdovers from the older Riversleigh faunas. I didn't see any clear marker species that would suggest anything different.

The arid fauna, on the other hand, was completely different in preservation so it would have to be much younger. When I had some of the bones and teeth dated using a technique called uranium-series radiometric dating, the resulting age was quite surprising. I had thought the sites would date back to the Last Glacial Maximum, around 20,000 years ago, when the climate was exceptionally dry. This, of course, would explain the presence of an arid fauna. Instead the results indicated that the fossils were somewhere between 208,000 and 149,000 years old! The next question, then, had to be "How old was the rainforest fauna?"

Further sorting of the fossils revealed a couple of species common to both the Elephant Hole Cave and Speaking Tube Cave deposits. One was a new species of possum that I thought was unique to the arid fauna, until it turned up in the rainforest fauna. The second was an ankle bone from a tree-kangaroo found amongst the bones of the arid fauna. These specimens conflicted with the dry habitat idea, although it was possible that they represented animals that were living in a refugium, kept alive by the buffering nature of limestone karst. Nevertheless, this interpretation implied that the rainforest faunas were much younger than I had suspected.

In an effort to find out, I trialled a couple of samples using a new uranium-series technique that had been perfected by University of Queensland researchers led by Dr Jian-xin Zhao. I was not expecting much of a result, so I was completely blown away when samples from most of the sites were dated to between 500,000 and 280,000 years old. We had found the only Quaternary-aged rainforest fauna anywhere in Australia! In fact, we had captured a snapshot of time when the last of the great lowland rainforests had existed along the eastern coast of Australia. It was a period of major extinction of Australian rainforests; a timeframe critical to our understanding of how rainforests responded to periods of past climatic upheaval. It also filled a major evolutionary gap in our knowledge between the ancient faunas from Riversleigh, some 15 million years earlier, and the present rainforest species found in the highlands of New Guinea and the Wet Tropics of Queensland. What an incredible discovery! After nearly a decade of working with a team of collaborators I submitted a manuscript to the prestigious journal *Nature* for publication. Within hours our paper was unceremoniously rejected without review – my third and final mistake.

The great species diversity of the Mount Etna deposits indicates that the rainforests that existed in Australia only 280,000 years ago (or less) were much more biodiverse than those of the Wet Tropics or even the mountain rainforests of New Guinea today. They show that over the last 280,000 years Australian rainforests have retracted northwards into small refugia. During this period of time dozens of small species have gone extinct and were replaced with a dry-adapted fauna. These older rainforest faunas did not return when wetter times prevailed; instead, the arid fauna was driven extinct and replaced by a third wave of species that are more representative of what can be found there today. These climatic phase shifts, which have dominated the tropical north of Australia over hundreds of thousands of years, trend toward intensifying aridity. This does not bode well for the rainforests of

today, particularly under current predictions of future climate change.

The great diversity in our rainforests is already on a hiding to nothing due to processes that started some 280,000 years ago and continue to the present day. Major changes in the Earth's climate continue to have an impact and have likely been, and will continue to be, exacerbated by anthropogenic warming. Precisely when the last of these megadiverse rainforests went extinct along the east coast of Australia is hard to tell. Their decline might have been rapid, or perhaps heralded by a slow death knell over thousands of years. One thing is for sure: they're not coming back. What is left must be protected to the best of our ability, both in Australia and New Guinea. The fossils from Mount Etna show that the rainforests of New Guinea today are the refugium for Australia's once diverse and expansive rainforests. Consequently, in this world of major climatic change, we should not consider their plight any different to that of our own Wet Tropics.

When you walk through an Australian rainforest today you are sure to hear the tranquil sounds of a few species of birds in the trees. If you are lucky and it has just rained, you might hear a frog or two calling. However, when I compare these sounds of today to the sounds that would have echoed through Australia's ancient rainforests I hear silence. I can only imagine the sounds and sights of life in the trees, on the ground, in the logs and in the streams of what was once Australian rainforest. Perhaps it would have been similar to what one can experience in the last remaining rainforests of Borneo or the Amazon today. Is this silence the future for the remaining megadiverse rainforests of the world? I hope not.

Coincidence plays a big part in our lives and I still marvel at how the simple act of pulling a dusty hessian sack down from its obscure position in the Queensland Museum collection could lead me to where it has. It took the unnecessary quarrying of a limestone cave, a salvage operation, a hailstorm, a persistent teenager, a big dose of serendipity, a bunch of mistakes and a great team of friends and colleagues to begin unravelling the secrets of central Queensland's fossil cave faunas. After many thousands of years the ghosts of Mount Etna have finally been given the chance to tell their stories – all we need to do is listen.

Capricorn Caves – an epilogue

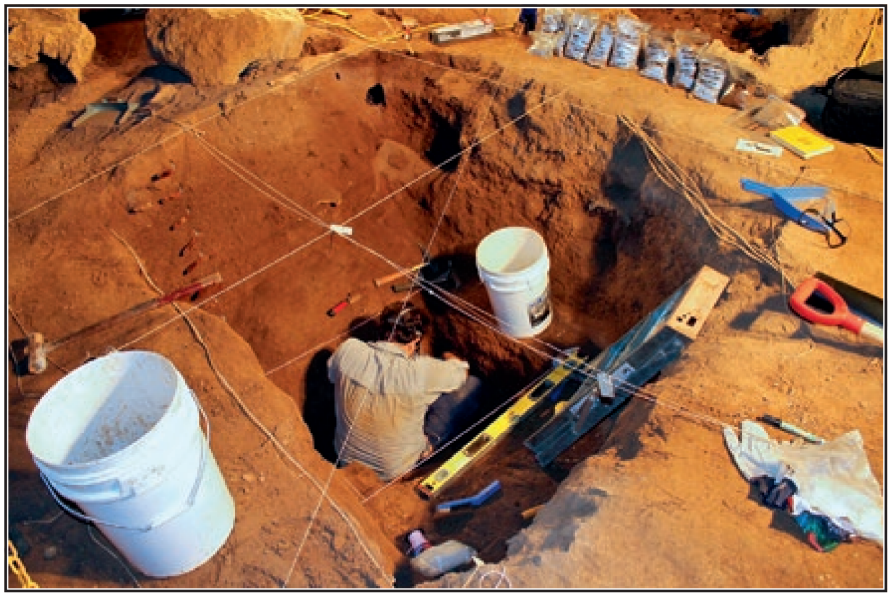
by Rochelle Lawrence

In 2012 we arrived in the hot and humid subtropical climate at Capricorn Caves Tourist Park, near Rockhampton in central Queensland. Dr Scott Hocknull of the Queensland Museum led the way around the limestone karst to Colosseum Chamber. He stopped to point out pieces of fossil bone breccia lining the path, marking the presence of a collapsed cave chamber that had exposed a fossilised cave floor. Further along the path we climbed up a set of old timber stairs to reach the entrance to Colosseum Chamber where we were relieved to feel the cool air of the cave. Inside was a unique fossil deposit found in 2002 by Scott and Noel Sands (Central Queensland Speleological Society). Scott and his team had excavated the site over several years, working in co-operation with Ann Augusteyn, owner and operator of Capricorn Caves. This year Dr Julien Louys, Dr Gilbert Price and their team from the University of Queensland (UQ) continued the excavation into a deeper section. A series of lights shone down on a deep pit surrounded by stringlines that indicated past excavations. The UQ team were loading buckets with fossil sediment, to be carried down to base camp for wet sieving and fossil sorting.

As I walked over the floor of the chamber I realised I was walking on an entire fossil deposit some two metres deep. How were there so many bones preserved? Scott pointed to the spot where he had first seen an owl roosting in the cave at the time he and Noel found the deposit. Pellets containing the bones of animals that had been eaten and regurgitated by owls had been found on the cave floor. These pellets had become incorporated into the silt and clay of the cave floor over thousands of years, making Colosseum Chamber one of the largest and most concentrated owl roost deposits found anywhere in Australia. Among a suite of species still found in the region today the layers also contain the remains of the extinct Capricorn rabbit rat (*Conilurus capricornensis*), which was first found at Capricorn Caves and recently described by Jonathan Cramb and Scott.

A suspension bridge through dry rainforest offers a fun way back to the main entrance of Cathedral Cave, one of the popular visitor attractions at Capricorn Caves. *Photo Rochelle Lawrence*

We continued through a dark passageway, going deeper into the cave system. The flap of large wings overhead revealed the presence of a lone ghost bat (*Macroderma gigas*) that had taken residence in the cave. Although the ghost bat has survived for over 500,000 years in the region, it is now in dramatic decline. With only our torches to guide us, we moved around overhanging stalactites and ducked under low ceilings. I felt a cool breeze being pushed through the passage – a sign that there was another entrance to the cave further on. Upon reaching the entrance we climbed the rocky stairs out of the cave and found ourselves on the other side



Dr Julien Louys digs down through layers of sediment in Colosseum Chamber in 2012 *(below left)*. ***Fossils in these sediments represent bones of small animals that have been eaten and regurgitated by owls roosting in the cave over thousands of years, similar to this modern owl pellet containing undigested material*** *(top left)*. ***The deposits of Colosseum Chamber vary in age from several thousand years old to recent and have produced bones of many small animals that still exist in the region today. One exception, the now-extinct Capricorn rabbit rat*** *(Conilurus capricornensis)*, ***is known from bones, including this maxilla*** *(below)*, ***found in Colosseum Chamber.***

Photos Rochelle Lawrence

of the karst. Here, a path meanders through dry rainforest and semi-evergreen vine thicket. This remnant forest is a relic of a much wetter past, having adapted to a drier climate by developing small waxy-coated leaves for moisture conservation. The limestone rock has provided a protective habitat for this now-endangered type of rainforest.

The ancient rainforests of northern Queensland were the reason we were here, continuing our search for a connection between the faunas of Capricorn Caves and the ancient rainforest faunas of Mount Etna. Hearing a rustle in the undergrowth, we caught a glimpse of an echidna just before it curled up into a protective ball. For a dry rainforest, the area still holds a diverse array of species. We came to a huge fig tree at the entrance of Belfrey Chamber. Figs are great cave indicators as they send their massive roots down through limestone crevices into the underground water table and fertile deposits of bat guano on the cave floor. Searching the chambers, I felt the occasional flicker from a little bent-wing bat (*Miniopterus australis*) as it whisked past me. We found a few nice fossilised bones eroding from the damp brown sediment of the cave floors but it was still not what we were really looking for.

I spotted a small fern *(Tectaria devexa)*, growing in a thin pocket of soil on the wall near one of the main entrances. The survival of this endangered fern is yet another reminder of the heavily forested past of the caves. The Caves district is the only known site in Australia to preserve this fern. We continued along a timber ramp and past a suspension bridge – like something you would envisage from an Indiana Jones movie. In front of us a surprised rock-wallaby bounded over the limestone karst before disappearing in an overhang near the cave entrance. Climbing yet another set of stairs we walked over a false floor

Scott's 15 year search to find a replacement for the lost arid-adapted fossil fauna – destroyed by mining at Mount Etna – finally paid off with a visit to nearby Capricorn Caves with Rochelle Lawrence in 2012. Their discovery of a new rainforest fauna in Harp Chamber *(inset)*, ***was soon surpassed when, crawling under a false floor next to the stairwell*** *(above right)*, ***they discovered thousands of bones sticking out of the roof*** *(above left)*. ***These fossils represent the missing arid-adapted fauna and will help complete a fossil record spanning over 500,000 years.***

Photos Rochelle Lawrence

before stepping down into a small cavern called Harp Chamber. Lights from a previous public tour of the cave illuminated the chamber's famous formation, reminiscent of a harp. Scott's attention was drawn to the red terra rossa clay on the chamber floor. This was identical to the sediment he had found at Mount Etna that preserved the rainforest fauna. We both started to poke around in the sediment, pulling out tiny bones and fragments but nothing really identifiable. It wasn't until I found a small tooth that Scott got really excited. It was a tooth belonging to a bandicoot that had lived in the ancient rainforests. We had discovered a new deposit linking Capricorn Caves to Mount Etna.

With renewed excitement we continued to investigate the chamber to find the extent of the fossil deposit. I heard a call from Scott, who had disappeared under the false floor over which we had just walked. Clambering under it, I was amazed when I shone my head torch on to the ceiling. Scott had just found an entire cave floor deposit that had cemented thousands upon thousands of bones and teeth into rock over millennia. Dazzled by the number of bones, it didn't take us long to find an identifiable species. It was a tooth from a pig-footed bandicoot, a recently extinct species of arid-adapted bandicoot that once thrived in central Australia. Scott couldn't believe what he was seeing. Twelve years prior he had been confronted by the loss of one of the most significant fossil sites at Mount Etna due to mining. Today we had found its replacement. For the first time at Capricorn Caves we had found evidence for the faunal succession from the oldest rainforest fauna (~500,000–280,000 years old) through to an arid fauna (~200,000 years old) and finally to a modern fauna at Colosseum Chamber (~50,000 years old–present).

With the connection between the fossil faunas of Mount Etna and Capricorn Caves now established, we have started to unravel the secrets of faunal evolution in central eastern Queensland over hundreds of thousands of years. The development of new tours at Capricorn Caves will focus on these amazing new fossil deposits, where visitors will discover the direct evidence of our past. It is right there, just under their feet.

The Authors

Dr Scott Hocknull is Senior Curator of Geosciences at the Queensland Museum and holds a number of honorary positions in organisations throughout Queensland. Rochelle Lawrence is Capricorn Caves' Palaeontologist and a Research Assistant in Geosciences at the Queensland Museum. Their combined research focuses on understanding palaeoecological transitions throughout the Mesozoic and Cenozoic. Scott uses new 3D technology to capture and interpret geo-heritage digitally and scientifically for a wider audience. Rochelle has a specific interest in microfauna representing a variety of palaeo-ecologies from tropical rainforest to arid-zone springs.

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