

CAVE MANAGEMENT AT MAMMOTH CAVE, U. S. A.

- Mia Thurgate and Rick Olson

Booths Amphitheatre in Mammoth Cave, showing a section of the entrance passage near the saltpetre mining site. Photo: M. Thurgate.



Introduction

Mammoth Cave is a globally significant karst site with many important cultural, biological and geological values. This has been recognised by a listing in 1981 as a World Heritage area and in 1990 it became the focal point of an International Biosphere Reserve. The values of Mammoth Cave are summarised below.

- **Indigenous culture:** Archaeological sites dating back to 4000 years before present are found within Mammoth Cave. These sites provide information about the use of the caves as a source of minerals by American Indians. Artefacts such as fragments of reed torches, gourds, sandals and even a 2500 year old wooden scaling pole are preserved deep in the cave system.
- **European culture:** Inside the caves are the remains of a mining operation which produced saltpetre for gunpowder supplies for the War of 1812. At the end of the war, saltpetre prices plummeted, and the mining operation was replaced by cave tourism. Nearby is an extensive display of historic signatures – many dating back to the cave visitors and explorers of the mid 1800s. Ruins of an experimental underground Tuberculosis Hospital from 1842 are also present.
- **Biodiversity:** Over 130 species, which are regular inhabitants of park caves, have been identified that are partially or wholly cave-dependent. These include cave fish, many crustaceans (amphipods, isopods, and crayfish), spiders, cave crickets, beetles, millipedes and

flatworms. One special species is the Kentucky Cave Shrimp, which is endemic to the Mammoth Cave area and listed as endangered. Bats utilise caves within the National Park including two endangered species, which are the Indiana and Gray bats.

Surface environments are support a rich diversity of animals and plants. The Green River which runs through the park contains over 80 species of fish and 50 species of freshwater mussels, six of which are listed as endangered.

- **Geology/geomorphology:** Mammoth Cave is the longest known cave in the world (over 580 kilometres of passage and still going). There are up to six different levels of cave passage in four main ridges. Important fossil and other cave deposits and many areas of unusual mineral deposits have been found in different parts of the system.

Mammoth Cave National Park is managed by the US National Park Service. The park covers an area of over 21 000 hectares. Nearly 2 million people visit the caves each year, and many of these experience at least one of the 13 guided cave tours. These tours provide access to over 16 kilometres of passage. Not surprisingly, the National Park is also a focal point for caving groups who are involved in exploration, mapping and conservation projects. The park is popular for a range of outdoor recreational pursuits including fishing, canoeing, hiking and camping.

The area surrounding the park has been largely cleared and land uses include agriculture, tourism and rural, industrial and urban development. A number of private commercial cave operations are also found in the area.



*A blind crayfish in Mammoth Cave Gothic Avenue in Mammoth Cave, showing an experiment using a plastic curtain to reduce condensation drips
Photo: M. Thurgate.*

*Mia Thurgate (centre) with Rick Olsen and Peggy Palmer (Peggy is well-known cave explorer who has done a lot of research at Mammoth).
Photo: M. Thurgate.*



All of this adds up to a very complex management situation. This article focuses on the management issues currently being addressed within the National Park.

Changes to the entrance passage

The original entrance passage to Mammoth Cave, known as Houchins Narrows, has been periodically modified over the past 180 years. The entrance passage has been excavated, so that in places it is more than double its original height. The cave floor has been smoothed and altered to make way for paths. Masonry walls and gates that restricted airflow were installed to protect the cave from unauthorized entry, and to moderate the temperature within during winter.

While these changes have made access to the cave easier for tour groups, they have caused a change in cave air flows and climatic conditions. Most notably there had been an increase of cold air into the cave in winter in some sections, while in other areas natural airflows have been restricted by infrastructure. As a result:

- The millions of bats that once used the cave as an over-wintering site have abandoned the cave. Disturbance from cave tour groups and unsuitable gating (prior to 1990) have compounded this problem. Woodrats that once lived in the loose rocks on the floor of the entrance passage have also abandoned the cave. Some terrestrial invertebrate communities have also been displaced.
- Increased moisture due to condensation is now found in places it did not naturally occur. In periods of colder than average weather this has allowed moisture to freeze between bedding planes causing localised rock falls. Fallout of fine sulphate salts from the roof in some sections of the cave has also increased.
- Increased moisture levels have allowed fungal growth to develop on wooden artefacts from the

indigenous archaeological sites, threatening their long-term survival. This problem was observed over two kilometers into the cave from the Historic Entrance.

- Since 1989 cold winter air entering through the Historic Entrance has mixed with warmer moist air flowing from Gothic Avenue. A cloud forms at the ceiling level and water collects on all surfaces in contact with the cloud. This condensation drips onto War of 1812 saltpetre leaching vats below, and has promoted active fungal growth. Restriction of airflow through the gate by application of plexiglass panels in 1996 has significantly reduced this problem.

Work is now underway at Mammoth Cave to restore air flows and climate to original conditions. A major hurdle to be overcome in this restoration process has been the lack of historical data about what conditions in the cave were like before entrance modifications commenced. Paleontological information is being used to develop a more detailed history of changes to the entrance passage.

Bat deposits are being investigated to find out which species used the cave as an over-wintering site, and how many bats were involved. Current research suggests that six species of bats used the cave in the past. At least 9-13 million bats (mostly Gray and Indiana bats) hibernated in areas that are now used as main tour routes. This figure is a conservative estimate. The two main bat species have very narrow temperature range preferences. This provides the staff at Mammoth Cave with target temperature range for climate restoration work.



Rafinesque's Big Eared Bat from Long Cave, Mammoth Cave National Park. Photo: R. Olsen.

Other measures to make the cave more attractive to bats include:

- Restriction of access to the cave by visitors at the critical times of dusk and dawn
- Reconfiguration of entrance lighting to be less intrusive
- Rerouting of cave tours to leave some areas free of disturbance

Plexiglass baffles were installed on the entrance gate in March of 1996. Winter cave temperatures can be manipulated by the use of these baffles so that temperatures are approaching the range required by the endangered Indiana bats.

Three additional management issues have been improved by controlling winter cave temperatures. First, the rock fall rate has been dramatically reduced. From 1994-95, six rock falls were recorded in the cave.

Since the baffles were installed, only one rock fall has occurred. Secondly, fungal growth on indigenous artefacts has become dormant. Finally, based upon field observations, condensation dripping on the saltpetre leaching vats at Booth's Amphitheater has been greatly reduced.

Park staff is now working to eliminate condensation completely. During the winter of 2002, a section of passage was blocked to prevent the mixing of warm and cold air flows above the saltpetre mining site. The passage was blocked using plastic sheeting attached to a timber frame. The frame was custom made to fit the narrowest part of the passage and was wedged into place to prevent damage to the limestone. This structure can be easily dismantled and removed. The barrier was effective in reducing condensation levels to extremely low levels. Further refinement of the technique along with other restoration activities should eliminate the problem in the near future.



*A cave harvestman in Mammoth Cave
– an arachnid related to spiders. Photo: R. Olsen.*

Dust and Lint

Historically, paths in Mammoth Cave were built of cave sediment which was mined from the cave. The historic paths were vulnerable to drying in winter, and dust raised by tours was suspended in the air, mixed with lint from visitors, and then settled on features near the paths.

In 1960s and 1970s water was applied to the paths to control dust and calcium chloride and ammonium nitrate were added to retain the moisture. The effect of these chemicals on the cave environment is unknown, but it is likely that there were impacts on water quality and cave invertebrates.

These management practises are no longer in use at Mammoth Cave, but the legacy of the past needs to be repaired. New paths are being installed that are made of concrete or recycled plastic lumbar.

Lint curbs have been added to capture low-level dust and lint. (Chemical residues from the surface of historic paths are being manually collected and removed from the cave - nope).

Finally, the surfaces of many formations are being hand cleaned with brushes to remove lint and dust.

Cave infrastructure

Sections of the historic paths near the River Styx include raised wooden boardwalks and platforms. These are also being colonised by fungal communities, and may have introduced an unnatural food supply into the cave, upsetting the ecological balance of invertebrate populations. Of greater concern is the fact that the wood was treated with creosote, which was leaching into the underground stream.

A lighting system from the 1960s also started to corrode and was polluting waterways. These pollutants have probably impacted on aquatic ecosystems which support the endangered Kentucky Cave Shrimp.

To prevent further decline in water quality, the wooden pilings and decking and old lighting system are being manually dismantled and are being carried out of the cave. This has been a massive operation and has relied on volunteer efforts coordinated by the National Speleological Society. As an example of the effort involved, over 300 meters of boardwalk has been dismantled and removed to date.

Conclusion

The goal of management efforts at Mammoth Cave is to realize a long-term, holistic management strategy that truly protects the world-class natural and cultural resources.

There have already been a number of positive outcomes, and major achievements can be recognised. However this is a long-term process with many difficult problems still to be solved.

ON A PERSONAL NOTE...

I had a wonderful time during my visit to the Central Kentucky Karstlands. Yes folks, southern hospitality is as generous as the rumours say. At the risk of putting some of my readers to sleep, I would like to acknowledge the many people that made my visit so memorable.

Rick Olson and his wife Colleen took me under their wing for the week I was in the area. They provided me with a place to stay, great meals and hospitality, showed me around the area, introduced me to people and places, and were great company. Thanks to you both for everything, including smores and walks with Kitty. My Kentucky Cave Shrimp giant mug (which happens to hold half a plunger of coffee or a whole can of beer) is a constant reminder to come back.

Thanks also to: Bruce Powell for starting the ball rolling; Kurt Helf for the White Cave biospeleology extravaganza; Ted and Cheryl Messenger for Kentucky moonshine and gourmet jelly beans; and all the other Mammoth Cave staff that made me feel welcome; Gary Berdeaux for the tour of Diamond Caverns and cave photography; Art and Peggy Palmer for our road trip and visit to the famous Crystal Cave; Judy and Bill Austin and staff for your extra special attention and for showing me around Kentucky Down Under and Kentucky Caverns; David Foster and staff for the friendly welcome at the American Cave Museum and Hidden River Cave; the wonderful and friendly cavers of the Cave Research Foundation for letting me hang out on a cave survey trip. And for anyone else that I may have forgotten to mention, thanks a bunch.

Mia Thurgate

2001 A CAVE ODYSSEY FIVE MONTHS OF CAVES AND KARST PART 2 – HUNGARY TO UKRAINE

- Armstrong and Penney Osborne

Penney and friend in the Castle Labyrinth, Budapest



From July to December 2001, Armstrong took study leave from the University of Sydney. During this time Armstrong and Penney attended the International Speleological Congress in Brasilia and spent four months in Europe working with colleagues on palaeokarst and non-meteoritic caves.

During the journey we both visited numerous show caves, tourist mines, conservation areas and museums etc. and saw much of interest relating to conservation and management. This brief report tells of the second part of our journey from Hungary to Ukraine. In Part 3, to follow in the March 2003 ACKMA Journal, we look at the third part of our journey from Croatia to Turkey. In addition, some issues of interest to cave managers that we observed during the whole of our trip will be discussed.

HUNGARY

We made four visits to Hungary during the trip, two were only for one day and two were for a much longer period. Australians are one of the very few nationalities that require visas for Hungary, and multiple entry visas are not cheap. Since our last visit in 1997 there has been very significant economic and political progress in Hungary, making it a very interesting country to visit as it is now well on the way to joining the EU.

Aggtelek National Park

We visited Baralda Cave, the main cave in Aggtelek National Park in August from Slovakia with our colleagues from the Czech Geological Institute. Aggtelek National Park is the Hungarian section of the Aggtelek and Slovak Karst World Heritage Area located in the Hungarian-Slovakian border region.

Baralda Cave in Hungary and Domica Cave in Slovakia are two sections of the same very large cave system. While Domica Cave attracts approximately 30 000 visitors annually, Baralda receives 170,000,

this appears to be partly due to the better tourist facilities and accommodation at Baralda.

Baralda has two entrances; we took an extended tour between them beyond the fixed lighting of approximately 5 km. This is a very long tour mainly following the stream, but also traversing large breakdown piles. The main passage is approximately 50 m across and is quite impressive.

The very large spaces are illuminated using giant old-fashioned floodlights with 500 to 1000 watt normal filament bulbs. Wiring is to mine standards and a particular effort has been made to hide the giant iron-clad switchboards. New lighting and stainless steel handrails are being installed. An outstanding sound and light show is presented in a large breakdown chamber near the main office.

Friendly staff and excellent colour printed, multilingual, brochures, videos and high-quality souvenirs are important features of Aggtelek National Park



Cavers exploring an up market ouilding site, Buda Hills

Buda Hills

Our first long stay in Hungary was for two weeks in September and our second was for one week in October. We stayed in a cheap hotel in Budapest near the castle, which has now been converted into a computer college. Our host in Hungary was Dr Szabolcs Leel Ossy of the Eotvos University. During our stay the university was moving from its historic buildings in the Museum Quarter to an out-of-town site. As is often the case the historic buildings were being occupied by bureaucrats.

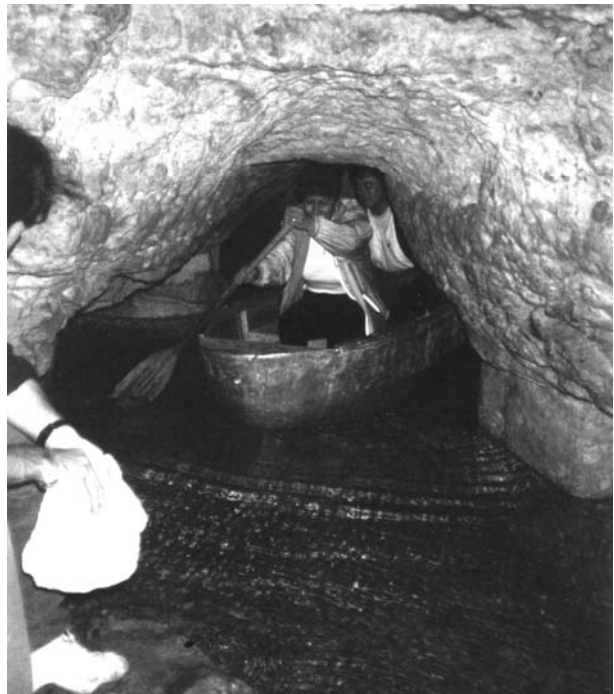
The main aim of this visit to Hungary was to take a detailed look at the thermal caves of the Transdanubian Mountains. An important group of these caves are in the Buda Hills, which includes the old castle-city of Buda and the exclusive residential and diplomatic suburbs of Budapest. Most of these caves do not have natural entrances. Interestingly,

caves are legally protected in Hungary, whether they are discovered or not. This means that if a cave is discovered during excavations it must be assessed by specialists.

There are several unusual outcomes from this situation: -

- Szabolcs can do field work only a few minutes drive from home
- There are extensive caves under exclusive residential land
- Caves are frequently intersected in building site excavations

There is work for cave geologists and cavers exploring the newly discovered caves and assisting builders and civil engineers in devising foundations that will both support the building and protect the caves.



The tour boat return, Tapolca Lake Cave

We inspected three show caves in the Buda Hills, Castle Labyrinth, Pal-volgyi Cave and Szemlo-hegyi Cave. One unusual feature of Castle Cave and Szemlo-hegyi Cave is that they have a street address. Castle Labyrinth is a series of artificial tunnels and segments of natural cave located under Castle Hill. It is entered through a shopfront. It is an amazing tourist feature well worth visiting. A range of sculptures and rather strange display items are spread throughout the tunnels. These include “fossils” of a computer, auto teller (bankomat) and a sand shoe print and a fountain that runs with red wine. The displays are interpreted as representing a history of Hungary. There is another section of the Labyrinth open to tourists, but it was out of season during our visit.

Pal-volgyi cave was intersected by a quarry. It is a complex network cave, a small section of which is used as a show cave. The show cave receives

approximately 40 000 visitors per year and has recently been refurbished at a cost of \$300 000 USD! Pal-volgyi Cave is a good example of the thermal caves of the Buda Hills. Cave development is guided by joints and features rift-like cavities, outlet cupolas and significant deposits of cemented cave rafts.

Szemlo-hegyi Cave is the largest show cave at Budapest. It is located in a suburban street and has an imposing entrance building with an impressive museum and cave model as well as a separate entrance for speleotherapy patients. The cave is a series of large rifts decorated with thick deposits of cave coral and small amounts of conventional speleothem.

Many of the features seen in the Show Caves of Budapest will be familiar to our colleagues at Wellington (New South Wales), in fact Szemlo-hegyi Cave is somewhat like a giant version of Gaden-Coral Cave!

Jozsef-hegyi Cave

Armstrong was privileged to visit Jozsef-hegyi Cave, one of the most important non-tourist caves in the Buda Hills. The cave was discovered during a building excavation in 1984 and our host Szabolcs was one of the original discoverers. After much amazing communist era politicking the cave was protected and a cave house built near the entrance. Jozsef-hegyi Cave is another unusual Budapest locality, a “wild” cave with a house, letterbox and street address.

The cave is entered through a concrete bunker. Then it descends about 30 metres through a series of narrow squeezes and climbs that took the original explorers 60 days of digging to penetrate. At the base of the narrow climb there is a large cylindrical chamber 70 m long, 20 m wide and 10 m high.

The main chamber is electrically lit and has a narrow marked path through it. The cave wall, ceiling and floor are covered with amazing deposits of aragonite, gypsum and calcite coral and crystals. These deposits are white or cream and are offset by younger deposits of red flowstone.

It is thought that thermal waters excavated the cave and that these deposited the gypsum and aragonite. The “normal” speleothems were deposited by seepage water after the thermal waters had departed.

Satorkopuszta Cave

Satorkopuszta Cave near Estergon on the Danube Bend is one of the most important textbook examples of a thermal cave. We took the bus from Budapest to Estergon and met up with Thomas and Melinda, two cavers in their 20s with excellent English and a very positive outlook.

Satorkopuszta Cave is about 30 m deep and in cross-section consists of a large irregular basal chamber sitting below a series of cavities taking the form of an upside-down bunch of grapes.

Each “grape” is a spherical cavity 2.4-2.6 m in diameter called a “spherical wall niche”. The opening in the spheres is neither vertical nor horizontal but lies between the 3 o’ clock and 6 o’ clock position.

The upper part of the cave consists of larger spheres and cupolas, and in the top of the hill above the cave there are several very large unroofed cupolas forming an arch-like structure called Angel Gate.

Satorkopuszta Cave is now in a national park and is managed by a local caving club who have built a wooden floor in one of the upper cupolas for sleeping and installed a quite scary fixed ladder on the pitch into the main chamber.

Small groups of the public are taken on “adventure” tours on Sundays. This cave is not as impressively decorated as Jozsef Cave, but for anyone interested in speleogenesis or speleogens it is essential to crawl through the spherical niches, if only to see how some of the textbook diagrams have got it wrong.

Lake Balaton

Lake Balaton, south of Budapest is Europe’s largest freshwater lake and an important tourist area for fishing, swimming, sailing and thermal waters. The limestone hills along its western shore contain a number of caves as well as economically significant karst bauxite deposits.

We made a very short, 3 days and 2 nights, visit to the area but would recommend taking more time. Take the train from Budapest to Topolca and stay as we did at the Szent Goyrgy Panzio (Pension St George).

This accommodation is located directly above the largest show cave, (the cave and the pension have the same street address) and serves great grilled trout for dinner.

Topolca Lake Cave (under the Pension St George) was intersected by excavation of cellars and was largely inaccessible until pumping of water from the bauxite mine lowered the local water table. For Australians the cave has two very unusual characteristics: -

- 1 Like the Buda Hill caves it is located in the centre of town
- 2 It is operated by a mining company. The Bauxite Mining Company Head Office is located across the street from the cave entrance.

The first part of the Topolca Lake Cave tour is through a series of large cupolas. They are formed in quite rubbly limestone. In places brickwork appears in the cave ceiling where cellars of the buildings above have been sealed off from the cave. The really interesting part of the tour is the boat trip. Visitors are helped into small aluminium boats in groups of three or four and one of them is given a paddle. They then paddle around a circular passage that is electrically lit and return to the starting point. This takes about 15 minutes and is a real highlight.

The other show cave in the area is Loczy Cave, located in the hill behind Balatonfüred, one of the main towns on the lake. We took the local train from Topolca to Balatonfüred and a taxi to the cave. This is a very small cave with an elderly guide who did not speak one word of English. He instructed his dog to sit at the cave entrance and took us on the tour. The tour was excellent.

He was enthusiastic and very proud of his cave and soon worked out that we were really interested. He showed us his precious aragonite deposit and the other main features of the cave.

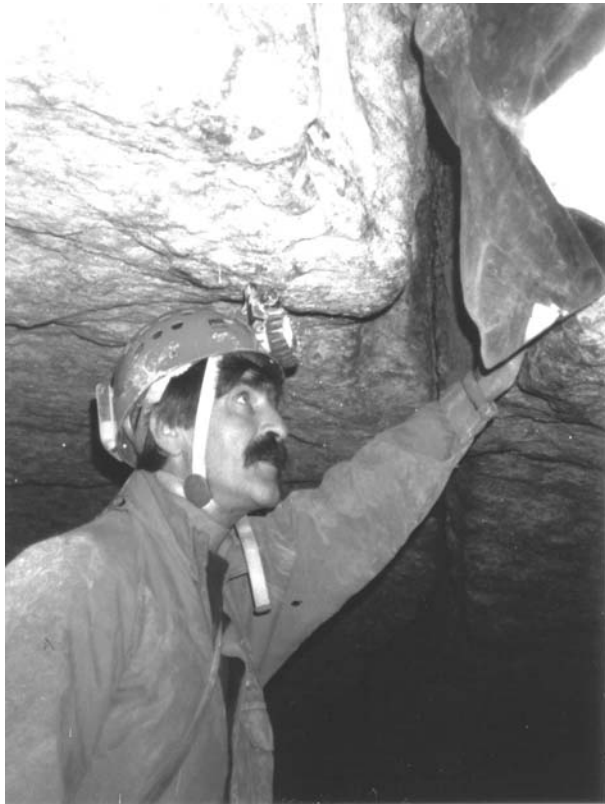
When we returned to the entrance the dog was waiting for us. Loczy Cave is small and difficult to find. It is not well decorated, but the tour with the old guide and his dog was one of the highlights of our trip.

A narrow headland with a hill at its end sticks out into Lake Balaton from Balatonfüred. Sitting on the top of this hill is the church town of Tihany next to a small high-level (possibly volcanic) lake. This is a real tourist trap but it has two features of speleological interest.

The hill with the historic church has an old geyser mound on it, and in the mound a small cave is developed. Around the lake and over the hill is Aranyhaz gejztrupk a set of old geyser mounds also with caves.

Hungary has many features of interest to cave managers and cave scientists and is well worth a visit.

Professor Alexander Klimchouk in Gypsum Cave



UKRAINE

For two weeks in late September we left Budapest and travelled east to the Ukraine. The visit to the Ukraine required lots of preparation. Tourist visas to the Ukraine are very restrictive and require you to follow an approved itinerary and stay in particular hotels.

Our host, Professor Alexander Klimchouk arranged an official letter of invitation for us from the Ukraine Academy of Science and we were issued with private visas.

We travelled by train from Budapest to Kiev. We left Budapest a 5 pm on Friday and arrived in Kiev at 6 pm on Saturday. Travelling on the Tiser Express is quite an experience.

The nice lady at Budapest Keleti Station assured us that we would travel in a Hungarian carriage, this turned out to be a great blessing as the Hungarian carriage had 2-berth compartments, while the Russian carriage was all 6-berth.

The train moves quite slowly and goes through a bogie exchange for wide gauge just after crossing the Hungarian-Ukrainian Border. The most scenic part of the journey, crossing the Carpathians, always occurs in the middle of the night.

On reaching Kiev we stayed with Alexander, his wife Natalie and their grandson Klim in their house in a village outside Kiev. The purpose of the visit was to have discussions with Alexander, use his extensive personal library and visit the great gypsum caves of western Ukraine.

Great Gypsum Caves

The gypsum caves are located in western Ukraine, so we had to retrace our steps by car for ten and a half hours west from Kiev to reach the gypsum region. Since we don't have gypsum strata or caves in Australia (please someone prove us wrong!) a few words of explanation may help.

Gypsum is a very light grey coloured rock, it is considerably more soluble than limestone and unlike limestone dissolves by simple solution (no acid required and no mixing corrosion). Alexander has shown that the gypsum caves of Ukraine (including the world's second longest cave) formed by artesian water rising up through the gypsum and dissolving it.

Armstrong inspected two wild caves and we both visited Crystal Cave, a gypsum maze cave that is developed as a show cave. The caves are extensive rectilinear mazes of narrow tubes and rifts, sometimes on multiple levels. While we don't have caves of this type, or of this scale in Australia, there are some features of these caves which appeared remarkably familiar and should make us think about the origin of Australian network caves.

