Cave and Karst Management in Australasia XIX

Proceedings of the 19th Australasian Conference on Cave & Karst Management
Ulverstone, Tasmania, 2011

ACKMA
TASMANIA 2011
wilderness karst

Australasian Cave and Karst Management Association
2011

Proceedings of the
Nineteenth
Australasian Conference
on Cave and Karst Management
2011 Conference
Ulverstone, Tasmania, Australia

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Australasian Cave and Karst
Management Association
2011

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Editor: Rauleigh and Samantha Webb
ACKMA
Western Australia

Publisher: Australasian Cave and Karst Management Association
PO Box 36, Carlton South
Victoria, Australia 3053

www.ackma.org

Date: September 2011

ISSN No: 0159-5415

Proceedings available: Publications Officer
Australasian Cave and Karst Management Assn

Cover illustration: Jay Anderson in Croesus Cave streamway, Mole Creek, Tasmania. Photo by Ross Anderson

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Conference: 8 May – 13 May 2011
Ulverstone, Tasmania, Australia

Organiser: Australasian Cave and Karst Management Association

Conveners: Tony Culberg, supported by Serena Benjamin, David Butler, Pat Culberg, Greg Middleton, Cathie Plowman and Chris Sharples.

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State Of Show Cave Management In The World

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Abstract

The interest of humans into caves started since the prehistory for very practical reasons. Only much later such an interest derived from other reasons. For instance in Roman times, people were attracted by the description of the "Dog's Cave" near Naples, Italy, because of the peculiar release of carbon dioxide close to the floor which killed small animals (hence its name) while standing people were not affected. Later, in the Middle Age, the cave of Postojna, Slovenia, visitors left their signatures in a passage, which is presently known as the "Passage of the Ancient Names".

If a show cave is defined as a cave where a fee is paid in order to have access and visit it, then the oldest one is the Vilenica Cave in Slovenia. Now much attention is paid to avoid damages to the cave environment. A show cave can have a great influence on the local economy and some data concerning such influences all over the world are reported here.

In order to protect the cave environment some guidelines aiming to supply a recommendation to be endorsed for the development of show caves were drafted in the last years and received strong recommendations from the UIS Department of Protection and Management. Such guidelines are reported here.

A Short History of Show Caves

Caves have always attracted the attention of humans since the prehistory, but at that time the interest was mainly quite practical, i.e. to have a shelter, a sanctuary or a burial place. Later, until the Middle Age, caves were associated with the devil or hell in general and people avoided getting into them for fear. For this reason bandits could use caves as hiding-places without problems due to undesired visitors.

Some historical show caves were known already in ancient times. About 2000 years ago Plinius, a Roman writer, described the "Dog's Cave" near Naples, Italy, being visited by people because of the peculiar release of carbon dioxide close to the floor which killed small animals (hence its name) while standing people were not affected. Other caves were visited not purely for tourism but mainly for religious purposes: such shrines may be found everywhere.

In Postojna Cave (Slovenia), on the walls of the so called "Passage of the Ancient Names" on account of the old signatures left by occasional visitors, the most ancient ones date back to 1213, 1323 and 1393 according some authors of the 19th Century. Around 1920 such signatures were scarcely visible on account of the seepage; presently the oldest signature which can be read easily dates 1412 and from the 16th Century onward they became rather abundant. This means that from the 16th Century the cave was visited more frequently by many persons attracted by the underground world. Therefore this period may be considered the start of cave tourism.

In a more recent time the Cave of Antiparos in Cyclades, Greece, became a great attraction in the 17th Century as a result of the many prints reproduced in the cave. The Kungur Cave, 100 km SE of Perm, near Kungur (Urals), Russia, is an ice show cave visited already in the 18th Century. Probably it is the largest show cave in gypsum. On 13th August 1772 the scientist Joseph Banks landed on Staffa Island and in November he wrote in the "Scots Magazine":

> *…there is a cave in this island which the natives call the Cave of Fingal.*

Since that time this cave became one of the best known caves of the world, inspiring poets and musicians. Its fame was so great that it became the natural cave most represented in paintings and engravings all over the world.

The Cango Cave (Oudtshoorn, South Africa) was discovered around 1780 and the first recorded visit was made in 1806. A few years later a farmer bought the land around the cave with the exclusion of the entrance. The

Governor included into the deeds the condition that the farmer was obliged to leave perfectly free and undisturbed the entrance of the cave, to be considered as public property, with a road in his land to reach the cave. This document has a historical importance because it is probably the first attempt in the world to legislate for cave protection.

In the U.S., the Mammoth Cave, Kentucky, was defined "the stellar attraction of the Mammoth Cave National Park" by R. and J. Gurnee (1990). Already known in prehistory, in the late 18th Century the cave was mined for saltpeter to make gunpowder. Only at the beginning of the following century did Mammoth Cave beccome a tourist attraction.

If a show cave is defined as a cave where a fee is paid in order to have access and visit it, then the oldest one is the Vilenica Cave in Slovenia. The cave is close to the village of Sezana, just a few kilometres from the Italian border. At the beginning of the 17th Century the Count of Petac began to invite the people of Trieste and some noble friends to visit the cave. On certain holidays, a hundred metres from the entrance, an area for the orchestra and a dance floor were set up and the entire dripstone passage was illuminated with torches and candles. Probably already in 1633 the Count Benvenut Petac charged an admission to visit the cave. Part of the money was donated to the local church of Lokev where masses were dedicated to "greater safety" of the people in the cave.

The Environmental Protection of Show Caves

A cave is an environment with little contact with the outside. For this reason its equilibrium may be easily changed when additional energy is introduced (Cigna, 1993). Obviously such changes may occur more frequently when the whole energy budget of the cave is small, but in the case of show caves the energy budget is often not very small, because of their size which is generally large. A river or a subterranean lake plays an important role in keeping the natural equilibrium because they may absorb more easily than rock, any further input of energy.

In a show cave both the visitors and the electric lighting system release energy into the environment. A person who is walking releases nearly as much energy as a 200 watt bulb at a temperature of about 37°C. Therefore the total energy released by hundreds or thousands of visitors in a day is not negligible as an absolute amount. The heat released by the electric lighting system has the same order of magnitude.

There are different ways to keep the additional energy input into the cave as low as possible. A limit of the number of visitors is given by the so called "visitors' capacity" which is defined as the maximum number of visitors acceptable in a time unit under defined conditions which does not imply a permanent modification of a relevant parameter. Otherwise, instead of reducing the number of persons, the time they spend in the cave may be reduced. This result may be easily achieved when people enter the cave through one entrance and exit along another passage, instead of returning along the same pathway they entered by.

Using high efficiency lamps can reduce the contribution by the electric lighting system. A further reduction can be obtained if the lamps are switched on only when visitors are in the vicinity.

Another perturbation of the cave environment is also due to the lint (hair, dry-flaking skin, dust from shoes and lint from clothing) left by visitors. In caves visited by a large number of people the accumulation of lint becomes a real problem to be solved by an accurate removal. In fact it would cause deterioration of formations and reduce their pristine white beauty to a blackened mess.

Lint released into a cave might be reduced by means of air curtains at the entrance. Such a solution would "wash people" entering the cave and, at the same time, isolate the cave environment from outside, since an air curtain acts as an invisible door and avoids airflow through it.

The protection of the environment of a show cave is fundamental both from the point of view of avoiding any damage to a not-renewable patrimony and the conservation of the source of income for the cave management. Therefore such a common interest may have an important role in the implementation of any action aiming to safeguard the cave environment.

Visitors also release carbon dioxide as a result of their breathing. Until few years ago such carbon dioxide was considered as a threat to the cave formations since it could have increased the water acidity and, consequently, the corrosion instead of the deposition of new formations. Further accurate studies (Bourges et al., 1998) have shown that in many instances the carbon dioxide produced by natural processes (oxidisation of organic matter in the soil above a cave) may introduce through the water percolating into the cave, amounts very much larger than the carbon dioxide released by visitors.

When the water, with a relatively high concentration of carbon dioxide, reaches the cave environment it releases immediately part of such carbon dioxide, which is not in equilibrium with the carbon dioxide in the air. Therefore the chemical reaction moves towards the deposition of calcium carbonate and the formations continue to grow. In general, rather small caves with a high visitor flux and without any input of natural carbon dioxide might have formations corroded because the chemical reactions would be reversed when the carbon dioxide of air dissolves into water, particularly when water vapor condenses on the cave walls.

Another form of environmental pollution may occur through a joint contribution by visitors and light. Persons release into the cave spores or seeds of plants and they may grow in the vicinity of lamps if the light flux is high enough. The result is the so-called "lampenflora" i.e. green plants (generally algae, fern, moss) developing on cave walls or formations close to a light source. Such plants cover the surfaces with a greenish layer, which can become included into the calcite deposition and no longer removable. In fact the lampenflora may be washed away by bleach or hydrogen peroxide if it is not covered by any calcite. Special care must be paid to avoid any impact on the cave fauna.

The growth of lampenflora can be avoided by the employment of light sources with a very low emission of light useful for the chlorophyllian process and low light flux at the rock surface.

The Development of a Show Cave

A correct development of a show cave must take into account both the protection of the environment and the safety of the visitors. As it has been already pointed out in the previous paragraph the physical and chemical equilibria of the environment should be modified outside the range of the natural variations.

At the same time, any undue source of harm to the visitors must be avoided. This means that the pathways must be strong enough to withstand the very high humidity and, sometimes, also floods. In the past wooden structures were often used, but they had to be replaced frequently; presently some "green" people would still use wood because this material is natural. Nevertheless the rather short life of a wooden structure in the cave environment implies an additional cost which is not justified by any advantage. On the contrary the rotten wood supplies large amounts of food modifying the equilibrium of the cave life.

In particular at present, the criterion to use only structures, which can be easily decommissioned, is substantially wrong because, once it is no longer convenient to manage a show cave, no one will spend any money to take out any structure inside the cave. Only when show cave managers will be obliged to deposit a given amount of money to assure the future decommissioning of any structure, it is possible to use structures to be easily disassembled.

In the meantime, it is preferable to use a material which is compatible with the cave environment and will not release pollutants in the long run. A material with these characteristics and not expensive is concrete. It may be conveniently used for pathways in general.

The handrails in stainless steel are also a convenient solution, particularly when they are also used as pipes to provide water in different parts of the cave to wash out the pathways. In fact, a higher cost of stainless steel is justified by a lack of any maintenance after many years of operation. Sometimes plastic may be used under the condition that it does not contain any contaminant (e.g., heavy metals or organic compounds which may be released).

When an artificial entrance is needed in order to give an easy access to the cave or to establish a circuit by avoiding the return of visitors on the same pathway, it is absolutely necessary to install a system of doors to stop any additional airflow in the cave. Up to now, doors operated mechanically or manually are normally used, but it would be most preferable to install air curtains. This solution (suggested already many years ago by Russell and Jeanne Gurnee) is less expensive, quite safe and has the great advantage of avoiding any sense of claustrophobia to visitors. In addition it also decreases the release of lint by people as reported previously.

The surveillance of the main parameters (temperature, humidity, carbon dioxide, radon, etc.) can be achieved by a monitoring network, which should always be installed in any show cave. Presently it is possible to install networks at a very reasonable cost, which are reliable and require little care, as for instance data loggers, which can be discharged every month, and the data transferred into a computer for any further evaluation. Automatic networks directly connected to a computer are operated more easily but, of course, their cost is higher. In any case it must be stressed that any kind of monitoring network always requires some attention to avoid malfunctioning and calibration, possibly once a year.

Such monitoring networks also have another important advantage because they contribute very interesting data, which has greatly enlarged the knowledge of the behavior of the cave environment. A rather widespread feeling among speleologists, and people in general, that a cave is "lost" to science when it is developed as a tourist attraction, is not at all supported by the important scientific results obtained from within many show caves. Sometimes the borderline between use and abuse may be difficult to define; nevertheless a careful development continuously monitored may be the most efficient way to protect a cave.

It is evident that the economy of a region around a show-cave-to-be can be radically modified by the cave development. Therefore strenuous opposition to any tourist visitation appears to be rather unfair towards the local people particularly when a suitable compromise between strict conservation and a sound development can be found. But in any case, as it was previously reported, a cave development cannot be accepted if it is not supported by appropriate preliminary research.

An evaluation of the number of show cave visitors all around the world (Cigna & Burri, 2000), based on data obtained for about 20% of all show caves, a global number of more than 150 million visitors per year may be estimated. By assuming a budget per person as reported in Table 1 the total amount of money spent to visit the show caves is around 2.3 billion US$. The number of local people directly involved in the show cave business (management and local services) can be estimated to be several hundred per cave, i.e. some hundreds of thousands of individuals in the world.

By taking into account that there are several hundred other people working indirectly to each person directly connected with a show cave (Forti & Cigna, 1989), a gross global figure of about 200 million people receive salaries from the show cave business. Therefore, it can be roughly assumed that behind ten tourists in a show cave there is about one employee directly or indirectly connected (Table 2).

Direct income		6.5
Other local income:		
	Souvenirs & snacks	2.0
	Meals	6.5
	Transportation	2.5
	Travel agency	2.5
TOTAL		**20.0**

Table 1 - Rough estimation of the annual direct and local budget of a show cave per visitor (US $, 2008).

In addition to show caves, consideration must be given to the existence of karst parks, which include a cave within their boundaries. As reported by Halliday (1981) the number of visitors of three top karst national parks in USA (Mammoth Cave, Carlsbad Caverns and Wind Cave) amounted to about 2,500,000 tourists each year. Therefore karst parks give a further increase to the number of people involved in the whole "karst" business.

There are many other human activities, which involve a larger number of people; nevertheless the figure reported above is not negligible and gives an indication of the role that show caves play in the global economy.

Number of show caves in the world	> 5000
Most important show caves	> 800
Total visitors per year	≈ 170,000,000
Money spent yearly to visit show caves	≈ 1.5 billion
People directly employed in show caves	≈200,000
People whose salary comes indirectly from show caves	≈100,000,000

(These figures could probably be doubled if the Natural Parks with karst interest are considered)

Table 2 - Economical importance of show caves (US $, 2008)

The protection of the cave environment

Some guidelines aiming to supply a recommendation to be endorsed for the development of show caves were drafted in the last few years and received strong recommendations from the UIS Department of Protection and Management at both the 14th International Congress of Speleology held in Kalamos, Greece, in August 2005 and the 15th International Congress of Speleology held in Kerrville, Texas, in July 2009. Such guidelines are reported here.

Development Of A Wild Cave Into A Show Cave

The development of a show cave can be seen as a positive financial benefit to not only itself, but also the area surrounding the cave. The pursuit of these anticipated benefits can sometimes cause pressure to be applied to hasten the development of the cave.

Before a proposal to develop a wild cave into a show cave becomes a physical project, it is necessary to carry out a careful and detailed study to evaluate the benefits and risks, by taking into account all pertinent factors such as the access, the synergy and possible conflict with other tourism related activities in the surrounding area, the availability of funds and many other related factors. The conversion should only take place if the results of the studies are positive. A wild cave that is developed into a show cave, and is subsequently abandoned, will inevitably become unprotected and be subject to vandalism in a very short time. A well managed show cave assures the protection of the cave itself, is a source of income for the local economy and also may contribute to a number of scientific researches.

A careful study of the suitability of the cave for development, taking into account all factors influencing it, must be carried out, and must be carefully evaluated, before physical development work commences.

Access And Pathways Within The Cave

In many caves it has been found to be desirable to provide an easier access into the cave for visitors through a tunnel, or a new entrance, excavated into the cave. Such an artificial entrance could change the air circulation in the cave causing a disruption of the ecosystem. To avoid this, an air lock should be installed in any new entrance into a cave. On the other hand it must be mentioned that in some very exceptional cases a change in the air circulation could revitalize the growth of formations. A decision not to install an air lock must be only taken after a special study.

2-1 Any new access into a cave must be fitted with an efficient air lock system, such as a double set of doors, to avoid creating changes in the air circulation within the cave.

Caves are natural databases, wherein an incredible amount of information about the characteristics of the environment, and the climate of the cave, are stored. Therefore any intervention in the cave must be carried out with great care to avoid the destruction of these natural databases.

2-2 Any development work carried out inside the cave should avoid disturbing the structure, the deposits and the formations of the cave, as much as possible.

When a wild cave is developed into a show cave, pathways and other features must be installed. This invariably requires materials to be brought into the cave. These materials should have the least possible impact on both the aesthetics of the cave and its underground environment. Concrete is generally the closest substance to the rock that the cave is formed in, but once concrete is cast it is extremely expensive and difficult to modify or decommission. Stainless steel has the distinct advantage that it lasts for a long time and requires little, to no, maintenance but it is expensive and requires special techniques to assemble and install. Some recently developed plastic materials have the advantage of a very long life, are easy to install and are relatively easy to modify.

2-3 Only materials that are compatible with the cave, and have the least impact on

the cave, should be used in a cave. Cement, concrete, stainless steel and environmentally friendly plastics are examples of such materials.

The environment of a cave is usually isolated from the outside and therefore the introduction of energy from the outside will change the equilibrium balance of the cave. Such changes can be caused by the release of heat from the lighting system and the visitors and also by the decay of organic material brought into the cave, which introduces other substances into the food chain of the cave ecosystem. In ice caves, the environmental characteristics are compatible with wood, which is frequently used for the construction of pathways, as it is not slippery.

2-4 Organic material, such as wood, should never be used in a cave unless it is an ice cave where, if necessary, it can be used for pathways.

LIGHTING

The energy balance of a cave should not be modified beyond its natural variations. Electric lighting releases both light and heat inside the cave. Therefore high efficiency lamps are preferred. Discharge lamps are efficient, as most of the energy is transformed into light, but only cold cathode lamps can be frequently switched on and off without inconvenience. Light-emitting diode (LED) lighting is also very promising. As far as possible, the electric network of a cave should be divided into zones to enable only the parts that visitors are in to be lit. Where possible a non-interruptible power supply should be provided to avoid problems for the visitors in the event of a failure of an external power supply. Local code requirements may be applicable and these may permit battery lamps or a network of LEDs or similar devices.

3-1 Electric lighting should be provided in safe, well-balanced networks. The power supply should preferably be non-interruptible. Adequate emergency lighting should be available in the event of a power outage.

Lampenflora is a fairly common consequence of the introduction of an artificial light supply into a cave. Many kinds of algae, and other superior plants, may develop as a result of the introduction of artificial light. An important method to avoid the growth of green plant life is to use lamps that do not release a light spectrum that can be absorbed by chlorophyll.

3-2 Lighting should have an emission spectrum with the lowest contribution to the absorption spectrum of chlorophyll (around 440 nm and around 650 nm) to minimize lampenflora.

Another way to prevent the growth of lampenflora is the reduction of the energy reaching any surface where the plants may live. The safe distance between the lamp and the cave surface depends on the intensity of the lamp. As a rough indication, a distance of one meter should be safe. Special care should also be paid to avoid heating the formations and any rock paintings that may exist.

3-3 Lighting sources should be installed at a distance from any component of the cave to prevent the growth of lampenflora and damaging the formations and any rock paintings.

The lighting system should be installed in such a way that only the portions of the cave occupied by visitors are switched on, leaving the lighting in the portions of the cave that are not occupied switched off. This is important from the aspects of reducing the heating of the cave environment and preventing the growth of lampenflora, as well as decreasing the amount of energy required and its financial cost.

3-4 Lighting should be installed to illuminate only the portions of the cave that are occupied by visitors.

Frequency Of Visits And Number Of Visitors

The energy balance of a cave environment can be modified by the release of heat by visitors. A human being, moving in a cave, releases about 150 watts – approximately the same as a good incandescent lamp. Consequently, there is also a limit on the number of visitors that can be brought into a cave without causing an irreversible effect on the climate of the cave.

4-1 A cave visitor capacity, per a defined time period, should be determined and this capacity should not be exceeded. Visitor capacity is defined as the number of visitors to a given cave over a given time period, which does not permanently change the environmental parameters beyond their

natural fluctuation range. A continuous tour, utilizing an entrance and another exit, can reduce the time that visitors spend in a cave, compared to the use of a single entrance/exit.

In addition to the normal tours for visitors, many show caves have special activities, sometimes called "adventure tours", where visitors are provided with speleological equipment for use in wild sections of the cave. If such a practice is not properly planned, it may cause serious damage to the cave.

4-2 When visits to wild parts of a cave are arranged, they must be carefully planned. In addition to providing the participants with the necessary speleological safety equipment, the visitors must always be guided by a guide with good experience in wild caves. The pathway, where visitors are to travel along, must be clearly defined, for example with red and white tape, and the visitors should not be allowed to walk beyond this pathway. Special care must be taken to avoid any damage to the cave environment, and the parts beyond the pathway must be maintained in a clean condition.

Preservation Of The Surface Ecosystem When Developing Buildings, Parking, Removal Of Surface Vegetation And Waste Recovery

It is important that the sighting of the above ground facilities, such as the buildings, parking and waste recovery, be well planned. There is a natural tendency to try and place these development features as close as possible to the cave entrance. Sometimes these features are built over the cave itself, or relevant parts of it. The hydrogeology above the cave must not be modified by any intervention such as the watertight surface of a parking area. Any change in the rainwater seepage into a cave can have a negative influence on the cave and the growth of its formations. Care should be exercised also when making any change to the land above the cave, including the removal of the vegetation and disturbance of the soils above the bedrock.

5-1 Any sighting of buildings, parking areas, and any other intervention directly above the cave, must be avoided in order to keep the natural seepage of rainwater from the surface in its original condition.

Monitoring

After the environmental impact evaluation of the development, including any other study of the cave environment, it is necessary to monitor the relevant parameters to ensure that there is no deviation outside acceptable limits. Show caves should maintain a monitoring network of the cave environment to ensure that it remains within acceptable limits.

6-1 Monitoring of the cave climate should be undertaken. The air temperature, carbon dioxide, humidity, radon (if its concentration is close to or above the level prescribed by the law) and water temperature (if applicable) should be monitored. Airflow in and out of the cave could also be monitored.

When selecting scientists to undertake studies in a cave, it is very important that only scientists who have good experience with cave environments be engaged for cave related matters. Many, otherwise competent scientists, may not be fully aware of cave environments. If incorrect advice is given to the cave management, then this could result in endangerment of the cave environment. Cave science is a highly specialized field.

6-2 Specialized cave scientists should be consulted when there is a situation that warrants research in a cave.

Cave Managers

The managers of a show cave must never forget that the cave itself is "the golden goose" and that it must be preserved with great care. It is necessary that persons involved in the management of a show cave receive a suitable education, not only in the economic management of a show cave, but also about the environmental issues concerning the protection of the environment at large.

Cave managers should be competent in both the management of the economics of the show cave and its environmental protection.

Training Of The Guides

The guides in a show cave have a very important role, as they are the "connection" between the cave and the visitor. Unfortunately, in many instances the guides have not been trained properly and, not withstanding that they are doing their best, the overall result will not be very good. It is very important that the guides receive proper instructions about the environmental aspects of the cave as well as dealing with the public. It is important that guides are skilled in tactfully avoiding entering into discussions, which can have a detrimental effect on the overall tour.

The guides are the guardians of the cave and they must be ready to stop any misbehaviour by the visitors, which could endanger the cave environment.

Cave guides should be trained to correctly inform the visitors about the cave and its environment.

Information On Show Caves In The World

There are many books published in different countries providing guides to the local caves. On one hand they report a rather large amount of information but, on the other hand, they are fully reliable for a short time only after their publication. In fact show caves have a certain turnover with changes of the visit details, etc. or, sometimes, on the very existence of the show cave itself.

Recently a rather useful way to obtain up-to-date information became available. "Showcaves of the World" is a website, which can be found at http://www.showcaves.com/. This site changes and grows continually, so on the web the latest version may always be seen.

This paper is drafted after an article: "Cigna A.A., 2011 - *Show Caves*. In: Culver D.S. & White W.B., (Eds.) - *Encyclopedia of caves*. Elsevier/Academic Press, in print", with some modifications.

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Tasmanian Wilderness Karst for the Armchair Explorer

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Abstract

A significant portion of the Tasmanian Wilderness World Heritage Area is underlain by karstic bedrock in terrain having high relief and high rainfall. With such ideal conditions for the development of extensive caves and other karst features, it is no surprise that the limited exploration of the karsts of the Tasmanian wilderness to date have indeed yielded discoveries of impressive cave systems and other features. However it is also notable that with a few exceptions, most exploration of wilderness karst to date has been issues-driven, focussing on areas such as the karst of the Lower Gordon and Franklin Rivers when, and because, they were under threat from development proposals. Elsewhere it is evident that extensive high relief karstic dolomites and limestones underlie wilderness areas such as the Weld Valley and many other places, yet the amount of exploration of these karsts has been surprisingly limited. Indeed, the fact that most intensive karst and cave exploration in Tasmania has been focussed around existing known caves and easy access points is exemplified by the fact that even the nearby surface boundaries of the carbonate rock blocks in which some of Tasmania's best known caves are found – at Hastings and Exit Cave – are still geologically unmapped and little explored. However this review is not a plea for increased exploration of Tasmania's wilderness karst; rather it is a celebration of the fact that an area with so much evident potential for extensive and impressive cave systems, in relative proximity to intensively explored and accessible areas, can remain so little explored and little known for so long. Along with vaguely pointing to some of the potential that Tasmania's wilderness karsts have, and describing some of the limited exploration of these to date, this review considers reasons why wilderness karst exploration has been so limited, and will touch on philosophical issues surrounding the desirability or otherwise of even talking about wilderness karst.

Introduction

Wilderness, however it is defined or regarded, is today one of Tasmania's most iconic defining characteristics, although for 150 years after the settlement of Tasmania by Europeans in 1803 it was regarded as merely 'wasteland'. Following an early phase of intensive European exploration of Tasmania in search of resources for the new colony, several extensive tracts of south-western and north-western Tasmania remained largely unsettled as a result of the early explorers failing to find arable land or easily exploited mineral deposits. Combined with a relatively harsh, wet climate, these remote parts of Tasmania remained little known to most Tasmanians, although in the early to middle part of the Twentieth century some middle class Tasmanians began exploring south-west Tasmania as a recreational activity, returning with photos of romantic glaciated landscapes, wild rivers, rainforests and moorlands.

Then, in the 1950s and 1960s Tasmania's post-war boom led to development authorities realising that these previously-neglected parts of Tasmania actually contained an abundance of potential for hydro-electric power development and industrial forestry. At long last there began a push to open up these areas for resource exploitation, however this long-delayed development push coincided with a growing global awareness of the importance and value of natural ecosystems, particularly large tracts of undeveloped land that could still be regarded as 'wilderness'. Following the initial damming of a beautiful lake in Tasmania's South-west, Lake Pedder, for hydro-electric development in 1972, an intense political debate over the appropriate use of the state's south-west region dominated Tasmanian politics for several decades, and was arguably the crucible of the modern environmental movement in Australia.

In the end, the successful nomination of a large portion of western Tasmania on the UNESCO World Heritage register for its wilderness qualities in 1982, and as an enlarged area in 1989

(DASETT, 1989), resulted in protection of much of the remaining wilderness in a series of large national parks which are today jointly managed as the Tasmanian Wilderness World Heritage Area (TWWHA). Along with Patagonia and New Zealand's Fiordland, this large tract of western Tasmania was recognised as one of the largest temperate climate regions in the southern hemisphere to have remained substantially unaltered by modern human settlement and technology into the Twentieth Century, and Tasmania's possession of this large wilderness area has become one of its primary defining characteristics and selling points.

However, there is today a debate over the proper meaning of the term 'wilderness', and many would hold that if 'wilderness' means 'land unmodified by human activity', then there is actually no wilderness in Tasmania since the whole island was occupied, used and modified by Aboriginal people for several tens of millennia prior to European settlement. Indeed, it now seems clear that much of the landscape character of south-west Tasmania – in particular the moorland/rainforest vegetation mosaics that characterise the region – are a human artefact, resulting from thousands of years of deliberate firing by Aborigines (Jackson, 1968; Bowman, 2008).

Nonetheless, there is clearly something distinctive about the south-west and parts of north-west Tasmania, and that is their marked lack of present-day human occupation and modification by modern technology. Although it is not possible to say they were never influenced by human activities, they are nonetheless places where natural processes today proceed with as little interference from modern human activities as can be found anywhere in temperate climatic regions. Defined in this qualified way, the idea of wilderness calls attention to the value of what is still a very distinctive region in comparison to the rest of Tasmania or indeed, much of the world.

Within the context of this understanding of wilderness, wilderness karst takes on a special meaning. While the term 'wild caves' is commonly used to refer to an 'underground wilderness' which may, in fact, be situated immediately below farmland or other settlement, when a wild cave exists within a broader surface wilderness setting, this adds an additional level to the wildness of these places. What follows is an exploration and, in some sense, a celebration of the wild karsts that are an important part of Tasmania's wilderness heritage.

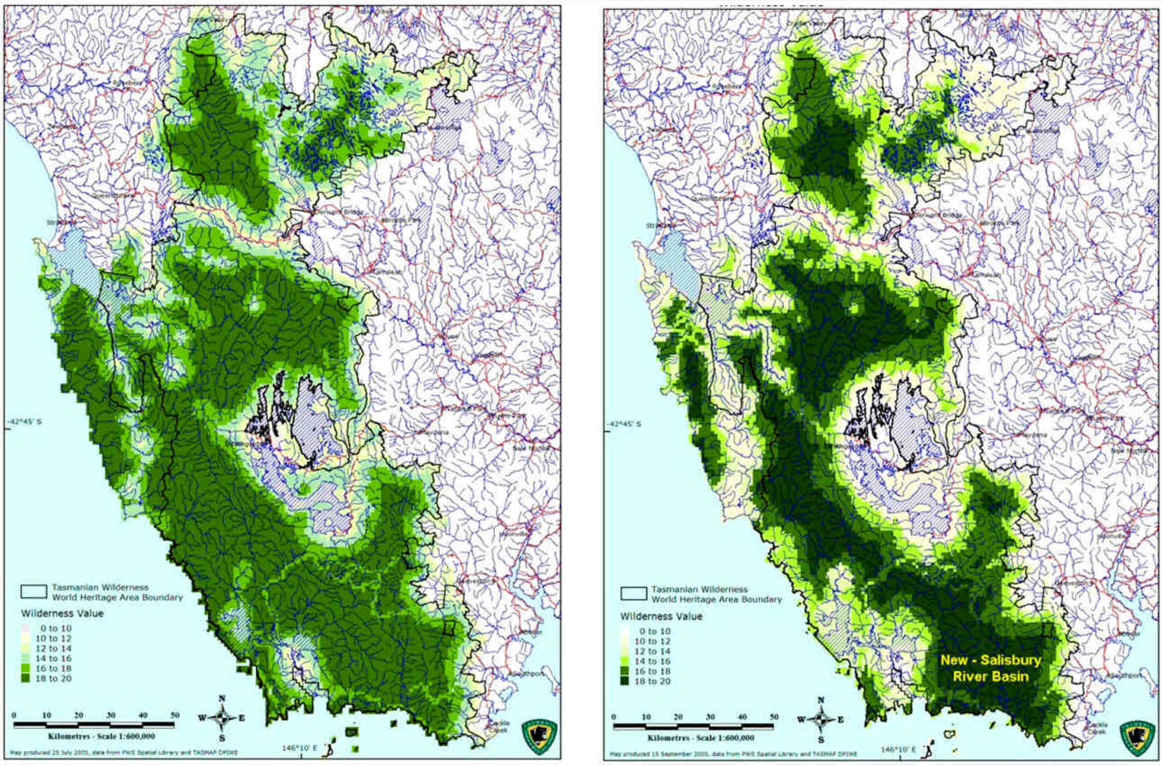

Figure 1: The extent of wilderness in south-western Tasmania (Hawes, 2005). This mapping of wilderness quality is based on grading the biophysical naturalness, apparent naturalness, distance - remoteness and time - remoteness of locations according to (LHS) the established National Wilderness Inventory (NWI) methodology (Lesslie et al., 1988) and a revised methodology used by the Tasmanian Parks & Wildlife Service (RHS). The revised methodology (RHS) achieves a more rigorous delineation of core wilderness areas, and it is noteworthy that this highlights the New-Salisbury River basin as one of the largest core wilderness areas in Tasmania. Note also that a number of smaller core wilderness areas can be similarly defined further northwards in the Tarkine region of north-west Tasmania.

History of Wilderness Karst Exploration in Tasmania

The earliest human discoveries of karst caves in the Tasmanian wilderness were made by Tasmanian Aborigines during the Late Pleistocene, and indeed the caves of south-western Tasmania appear to have been widely used by the Tasmanian Aboriginal people during the last glacial climatic phase when the caves would have provided shelter in a harsh environment, and the surrounding terrain would have been mainly grassland rather than the forest and difficult scrubs which hide many of the caves today. However much of this earlier cave use seems to have declined during the Holocene as new forests and scrub spread through some of the karstic valleys of the southwest. Together with the coming of Europeans and the subsequent displacement of the Aborigines, the previous knowledge of these caves was lost. It has only been with the re-discovery of many of these caves and studies of their archaeological record over the last forty years or so that the widespread extent of former human cave use in the southwest of Tasmania has become apparent (e.g., Jones *et al.,* 1988).

Early European Karst Discoveries in the Wilderness

The karstic limestones of the lower Gordon River area were discovered in the early days of European settlement, and indeed were exploited for lime during the 1830s at the Sarah Island penal settlement in Macquarie Harbour, however there was little systematic exploration of their caves until the 1970s (see further below). Although caves were being explored in some settled areas of Tasmania such as Mole Creek as early as 1829 (Scott, 1962; Clarke, 1999), the karsts of the western and south-western Tasmanian wilderness were only sporadically explored or noted prior to the mid-Twentieth Century.

One of the earliest of the notable discoveries of karst in the Tasmanian wilderness prior to the twentieth century occurred as a result of a remarkable expedition across western Tasmania which was undertaken by the noted (and tragic) arctic explorer Sir John Franklin and his wife Lady Jane Franklin during 1842, while Sir John was serving as Governor of Tasmania prior to his fatal attempt to find a North-West Passage through the Arctic Sea in 1845 - 47. The expedition was one of the first explorations of the region subsequent to the closing of the Sarah Island penitentiary in Macquarie Harbour, and was considered remarkable at the time not only because it was led by a serving governor, but even more so because his wife accompanied him at a time when conventional prejudices held that women were of too delicate a disposition for such exertions (Burns, 1842; Binks, 1980). Lady Jane was the first European woman to travel overland from Hobart to Macquarie Harbour, albeit in deference to the prejudices of the time, she was famously carried part of the way on a palanquin borne by four convict porters! The expedition followed a track expressly cut by an advance party led by Surveyor John Calder, through country which even today remains one of the most remote parts of Tasmania's wilderness (see Figures 1 and 5). On Christmas Eve 1840, the track-cutting party camped under a large overhanging rock on the plains at the eastern side of the Deception Range south of Frenchmans Cap. That evening they watched a fierce lightning storm from their 'rocky fortress', in consequence of which they named the place Christmas Rock, and the surrounds Lightning Plains.

Although briefly recorded in Burns' (1842) account of the expedition, Christmas Rock has remained rarely visited and little known up to the present (but see Luckman, 1979). Consequently, when the writer and several companions unexpectedly stumbled across the Rock during a wilderness bushwalk in the 1980s, we were excited by our apparent discovery of a large dolomite karst tower or hum (residual karst hill) riddled with caves, arches, a subterranean stream and several spectacular deep grikes (see Figures 2 and 3). Although our later researches revealed the prior discovery of the Rock in 1840, the thrill of discovery was as real to us as if we really had been the first to stumble across this feature.

There is little doubt that as numerous explorers fanned out across western Tasmania during the 1800s in search of minerals, timber and farming prospects (Binks, 1980), caves and other karst features would have been found, but doubtless many went unrecorded and were forgotten. An example of one such early discovery that was nearly forgotten was the discovery of Judd's Cavern (also known as Wargata Mina) on a tributary of the South Cracroft River in 1881 by Henry Judd and two companions. The cave was briefly mentioned in a book recounting Judd's explorations and philosophical ramblings (Judd, 1896), which was read by a caver around 1970 and subsequently led to a party of bushwalkers re-locating the cave during Easter 1971 (Cane, 1976). Subsequent exploration has shown this remarkable cave to have over three kilometres of large passages containing alluvial fills dated to over 230 Ka BP (Goede & Harmon, 1983), as well as Aboriginal hand stencils indicative of prior Aboriginal use of the cave (Jones *et al.,* 1988).

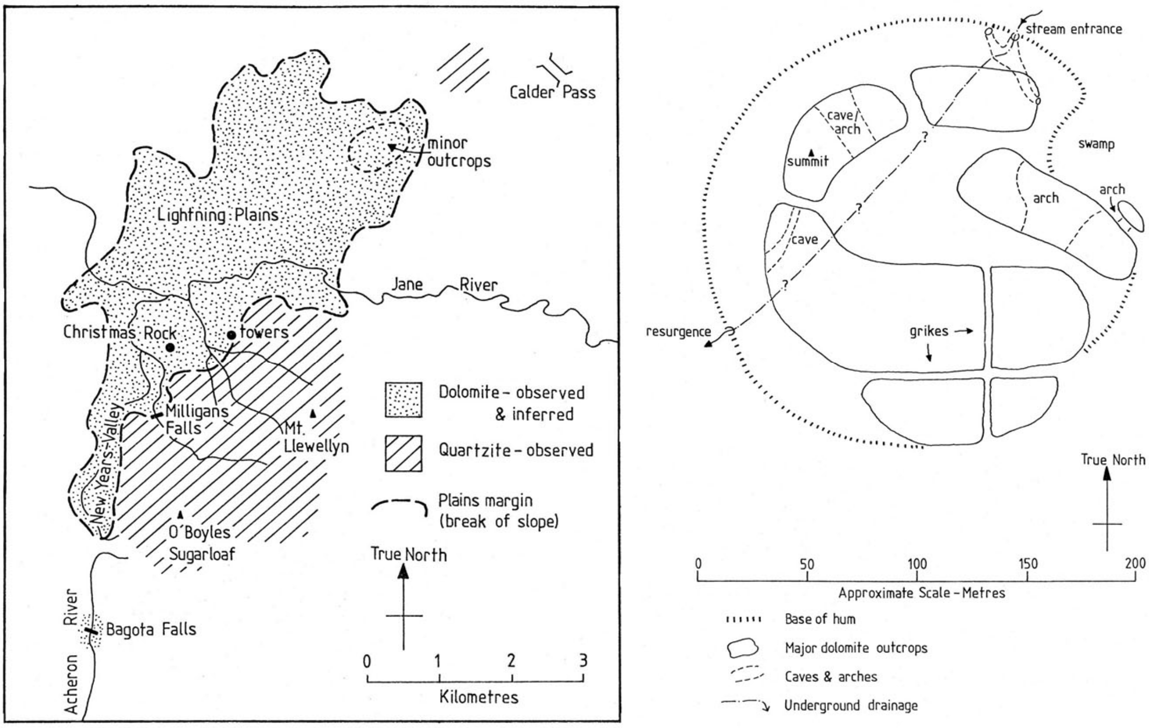

Figure 2: Locality map and sketch plan of Christmas Rock. Reproduced from Sharples (2000).

Figure 3: Karst features at Christmas Rock. LHS: Large arch/overhang;
RHS: One of several deep grikes running through Christmas Rock. Photos by C. Sharples.

Twentieth Century Karst Exploration in the Tasmanian Wilderness

Although bushmen continued to explore the Tasmanian wilderness during the early decades of the Twentieth Century and no doubt noted some caves in the course of their explorations[1], by the middle of the Twentieth Century recreational bushwalkers were beginning to explore the wilderness more frequently. Precipitous Bluff on the South Coast was a peak often visited by bushwalkers, and caves had been reported below the peak by government geologist F. Blake in 1938 (Middleton & Montgomery, 1973). Although one early Tasmanian Caverneering Club expedition which had gained access to the adjacent New River Lagoon by floatplane in 1960 – 61 found several substantial caves (Middleton & Montgomery, 1973), one of which was explored for 200 metres and thought likely to go much further, there was no further real exploration of the karst until a political issue lead to more exploration during the 1970s (see below).

During the 1970s the Tasmanian bush pilot Jim England reported the existence of a probable karst depression in the remote upper reaches of the New River (Kiernan, 1995; Vol. 2, p. 94), and this feature was subsequently visited by Attila Vrana and Jeanette Collin during a legendary trip down the New River on tractor tyre inner tubes which is thought to have been the first rafting trip down that river. The two are anecdotally reported to have found a stream sink and cave entrance within the large depression; however exploration was limited by boulder chokes (R. Eberhard, *pers. comm.*). To the present time, no further exploration of the New River depression is known to the writer.

When the construction of a road to allow damming of Lake Pedder made access to the Mt Anne area quicker during the late 1960s, cavers became interested in a large doline in dolomite on the North-East Ridge of Mt Anne, overlooking the Weld Valley, which had been initially explored by an ASF expedition in 1971. A major push during Easter 1983 resulted in the cave being explored to a Tasmanian depth record of 373 metres (Bunton & Eberhard, 1984). One of the cavers who participated in the exploration of this cave, Rolan Eberhard, had recently returned from a caving expedition to the Muller Range of Papua New Guinea and suggested naming the cave Papuan – style, as 'Anne-a-Kananda', which roughly means 'Anne's Stone House' (R. Eberhard, *pers. comm.*). See Figures 12 and 13.

Further down the Weld Valley, dolomites outcropping on the eastern slopes of Mt Weld were being quietly explored by a group of caving bushwalkers in the middle 1970s, who found a 236m deep cave now known as Arrakis, along with some smaller caves lined with coarse quartz crystals now thought to represent an example of hydrothermal karst (Sharples, 1994; Kiernan, 1995). Kiernan notes that these finds initially went unreported in an effort to minimise the likelihood of environmental impacts resulting from excessive exploration, however the area was subsequently 'rediscovered' by cavers around 1985 and documentation followed. There has unfortunately been some subsequent theft of quartz crystals from one of the caves (Middleton, 2005), however access with large quantities of caving gear remains difficult and the known caves appear to be only infrequently visited.

In general mid- to late- Twentieth Century exploration of the karst potential of the Tasmanian wilderness has mostly occurred in a sporadic fashion, driven by a few individuals with an interest in both karst and wilderness. In contrast, the main examples of intensive cave exploration in the Tasmanian wilderness have been political responses to proposed developments that threatened to destroy karst and other wilderness values. In one case, namely the Franklin – Lower Gordon River dam proposal, the resulting cave discoveries played a pivotal role in Tasmania's political history. Several of these more intensive phases of wilderness karst exploration are described below.

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[1]For example, Hawes (1981) noted that the legendary bushman Denny King is reputed to have noted caves and 'castles' of dolomite in the Weld valley during a trip in 1929.

Precipitous Bluff

During 1971 an entrepreneurial Mining Company, Mineral Holdings Pty. Ltd., applied for a prospecting licence for limestone in the New River Lagoon area below Precipitous Bluff on the south coast of Tasmania's wilderness area (Wessing, 1978). It appears that this was a highly speculative venture based mainly on a 1915 report by the former government geologist Twelvetrees, who obtained assay results indicating high limestone purity from a few limestone samples he had collected at New River Lagoon. In retrospect it is unlikely that these few grab-sample results would have been sufficiently representative as to indicate a large enough resource of similarly high quality as to have justified the development of a limestone quarry and transport infrastructure in a location so remote from existing access. However at the time conservationists were concerned that the plans might have sufficient substance as to threaten the integrity of what was by then regarded by many as a wilderness area of significant value (Greg Middleton, *pers. comm.*). Although an early objection by conservationists in the Mining Warden's Court obtained a decision that appeared to favour conservation, the State Premier at the time, Eric Reece, encouraged the miners to take their case to the Supreme Court of Tasmania, where Mr Justice Nettlefold ruled that the conservationists "did not hold any estate or interest in the area" in a legal sense (Wessing, 1978).

A few caves had previously been discovered at Precipitous Bluff during 1960–61 (Middleton & Montgomery, 1973). In a response to the evident difficulty of using legal avenues to prevent mineral exploration that might lead to mining of limestone in the middle of a wilderness area, a number of conservation-oriented cavers led by Kevin Kiernan undertook an expedition to Precipitous Bluff during 1973. Their explicit hope was that if significant cave development could be demonstrated below Precipitous Bluff, then this might bolster the case for conserving the area. Over ten cavers participated, and while some walked into the area, a seaplane was also used to transfer people and equipment to the cavers' base camp at New River Lagoon (Middleton & Montgomery, 1973). A number of notable caves were explored and mapped during this expedition, although it does not appear that this greatly influenced the eventual demise of the mining proposal which was probably doomed to expire of its own accord in any case. However the controversy which arose highlighted a major inadequacy in the law, namely a failure to acknowledge that objectors may have non-pecuniary interests in an area which are just as important as any financial interest (Wessing, 1978), and an eventual outcome of the case was that the Precipitous Bluff area was ultimately incorporated into the Southwest National Park.

Franklin – Lower Gordon Rivers

Subsequent to the demise of limestone quarrying plans at Precipitous Bluff, a much larger and more real threat loomed for another karst area in the Tasmanian wilderness. The Tasmanian Hydro-Electric Commission's (HEC) plans to dam the Lower Gordon and Franklin Rivers in western Tasmania for electricity generation during the late 1970s and early 1980s led to one of the biggest and most controversial conservation campaigns that Australia has seen; one which was arguably the crucible in which environmentalism became a mainstream movement in Australia (Lines, 2006), and also a turning point in Tasmania's own political history.

Again, caving conservationists realised that the already-known existence of limestone caves in the Lower Gordon and Franklin River valleys might hold a key to preventing this enormous intrusion into the integrity of Tasmania's wilderness from going ahead. Consequently during the late 1970s a number of caving expeditions were undertaken into the river valleys that the HEC planned to flood, involving veterans of the Precipitous Bluff case such as Greg Middleton and Kevin Kiernan. Numerous caves, some quite notable, were discovered and documented. Naqvi (1979) compiled plans and details of many of these.

In this case, karst exploration ultimately proved to be a critical factor in stopping the proposed damming of the Gordon and Franklin Rivers. The political controversy led ultimately to a decision in the High Court of Australia, in which the Tasmanian Government challenged Commonwealth legislation which had been passed to outlaw the dam on the basis of Australia's obligations under the World Heritage Convention. Although much of the campaign against the plans to dam the rivers had centred around the values of wilderness and of wild rivers, in the end the critical issue which swayed the High Court's decision to uphold Commonwealth legislation stopping the dam was the importance of Aboriginal cultural heritage which had been identified in one of the newly – discovered caves along the banks of the Franklin River (see Figure 4).

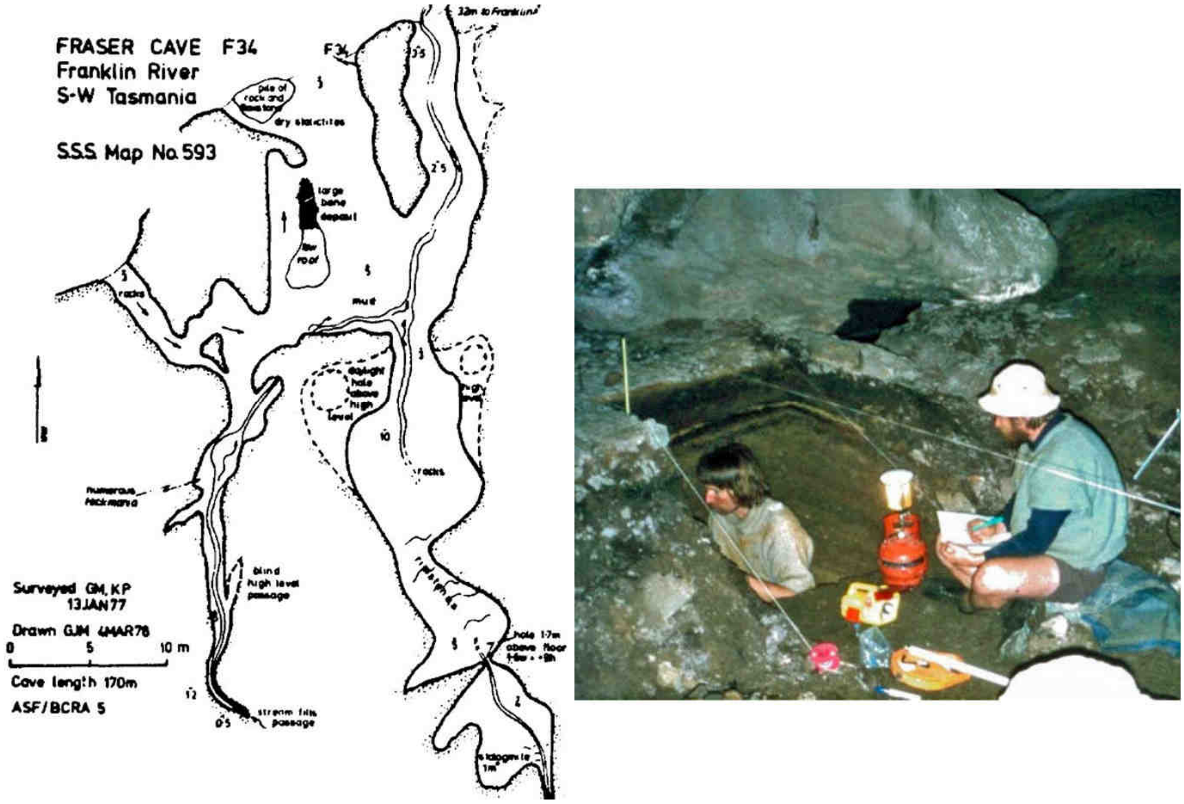

Figure 4: The discovery of Kutikina Cave (initially named Fraser Cave) on the Franklin River, and subsequent discovery of Aboriginal cultural artefacts and evidence within the cave pointing to human occupation of Tasmania during the coldest parts of the last Ice Age, was a turning point in the Franklin River Dam controversy. The potential loss of this cultural heritage was pivotal in the eventual High Court decision to stop dam construction. LHS: Plan of Fraser (Kutikina) Cave , a 170m long cave with a stream passage, dry sections and a large bone deposit, entrance 32m back from Franklin River (reproduced from Naqvi, 1979); RHS: Kevin Kiernan undertaking an excavation in Kutikina Cave with Rhys Jones in March 1981 (Photo by Greg Middleton).

Vanishing Falls

In contrast to the political and to some extent recreational motives that have driven much of the cave exploration that has occurred in Tasmania's wilderness, there has been little exploration driven by purely scientific motives. This is notable given that there is considerable scientific value in being able to study natural systems such as caves in environments where the effects of human disturbance are negligible. Nonetheless, one expedition that was undertaken for this reason has been recorded by Eberhard *et al.* (1991), namely a 1992[2] expedition to Vanishing Falls undertaken by Rolan and Stefan Eberhard along with Vera Wong.

This expedition was motivated by a rare opportunity to examine caves, and in particular cave biology, in an environment as pristine as could be found, albeit the likelihood of discovering new caves in a wilderness setting was also an attraction in its own right (S. Eberhard, *pers. comm.*). As noted elsewhere in this review, Vanishing Falls (Figure 9) lies in the Salisbury River catchment, which is undoubtedly as close to pristine as any karst catchment in Tasmania.

[2] Note that although the resulting *Helictite* paper is dated 1991, it was not actually published until later.

Sponsorship was obtained from *Australian Geographic* magazine, and the expedition used a helicopter to gain access to this very remote location with the quantities of equipment that were needed. Although this method of access attracted some criticism at the time, it was arguably a very low impact method of access, which given the high cost of helicopter time has not resulted in a flurry of similar expeditions trogging remote caves to death. The expedition discovered and mapped a major cave 2.3 kilometres long associated with the underground course of the Salisbury River below its sinking point at the base of Vanishing Falls (Figure 10), and the expedition yielded scientific fruit with a cave fauna of at least 30 taxa being found having a high degree of troglomorphy. Some of the species found are probably endemic to the Vanishing Falls karst (Eberhard *et al.,* 1991), and the scientific results of the expedition have been the subject of several subsequent published papers (S. Eberhard, *pers. comm.*). **From completely unknown, the geomorphic and faunal values of this still-pristine site are now available to inform conservation management decisions.**

There have subsequently been few if any similar expeditions to karsts as remote as Vanishing Falls, and large areas of carbonate rock with obvious karst potential remain mostly unexplored across large parts of Tasmania's wilderness. Much of the remainder of this review comprises an overview of the potential of Tasmanian wilderness karst.

Geological Background

Although the geological mapping of Tasmania's wilderness is incomplete – and likely to remain so for some time - the mapping that has been done over the last century or so has demonstrated the existence of large areas of karstic carbonate bedrock in the Tasmanian wilderness. The most karstic stratigraphic units occurring in Tasmania's wilderness are Ordovician limestones correlated with those forming extensive karst areas such as that at Mole Creek, and thick Late Precambrian age dolomite units including the Weld River Group of the Weld Valley and other correlated units. Some other less extensive carbonates such as the Precambrian magnesite of Tasmania's north-west are also known to have karst landform development. Figure 5 identifies the main areas of known carbonate bedrock within the Tasmanian Wilderness World Heritage Area.

Some of the more extensive areas of limestone illustrated on Figure 5, such as the Giblin River and Olga Valley limestone areas, are low-relief plains karsts occupying the floors of broad strike valleys where water tables are high and cave development is likely to be restricted to small residual limestone rises. However, western Tasmania is a rugged landscape where prominent bedrock folding structures and glacial erosion have both contributed to creating high mountainous relief in many areas. Many areas of carbonate bedrock underlie slopes with up to 400 metres topographic relief on continuous carbonate bedrock, and in the Weld Valley the topographic relief on parts of the karstic dolomites there reaches over 600 metres. Combined with high average annual rainfalls exceeding 3000mm across much of Western Tasmania, there is considerable potential for the development of deep and extensive subterranean drainage and cave systems in these rocks.

It is notable that the magnesium carbonate rocks dolomite and magnesite generally tend to exhibit less karst development than normal limestones in many parts of the world, yet in western Tasmania both these rock types are extensively karstified. It is likely that this is mainly because of a long period of tectonic and landscape stability since at least mid-Tertiary times has provided enough time for significant karst development to occur in these rocks. Indeed Houshold *et al.* (1999) considered that some dolomite and magnesite karst landforms in north-west Tasmania had formed under a warmer, more humid mid-Tertiary climate, were subsequently buried by alluvium, and had only been re-exposed by erosion of the sediment mantle in geologically recent times. However, Houshold *et al.* (1999, p. 16) also identified an additional factor characteristic of western Tasmanian environments that may also contribute to karst dissolution processes in the area, namely that stream and soil waters in western Tasmania are often tea-coloured waters high in dissolved organic material including humic acids. These are derived from the peat soils that mantle much of the western Tasmanian terrain in both moorland and rainforested environments, and were shown by Baker (1986) to markedly increase the rate of dissolution of limestone, dolomite and magnesite. Hence, it is possible that the karst potential of the dolomite rocks of the Tasmanian wilderness is enhanced by one of the other notable characteristics of the region, namely the prevalence of peat soils and derived waters rich in humic acids.

A countervailing factor which inhibits karst development in some areas is the presence of thick slope mantles of glacial and periglacial debris covering carbonate bedrock. However, while these have inhibited karst development in some situations, this is not everywhere the case, and there are many places where karst development has occurred on slopes free of these materials. Indeed it is possible to use slope topography and known upslope geology as a guide to predicting areas most likely to be free of thick mantles of such slope deposits, as they tended to be shed from protruding spurs and funnelled into gullies by the slope mass movement processes which produced these deposits under the colder conditions of past Pleistocene glacial climatic stages.

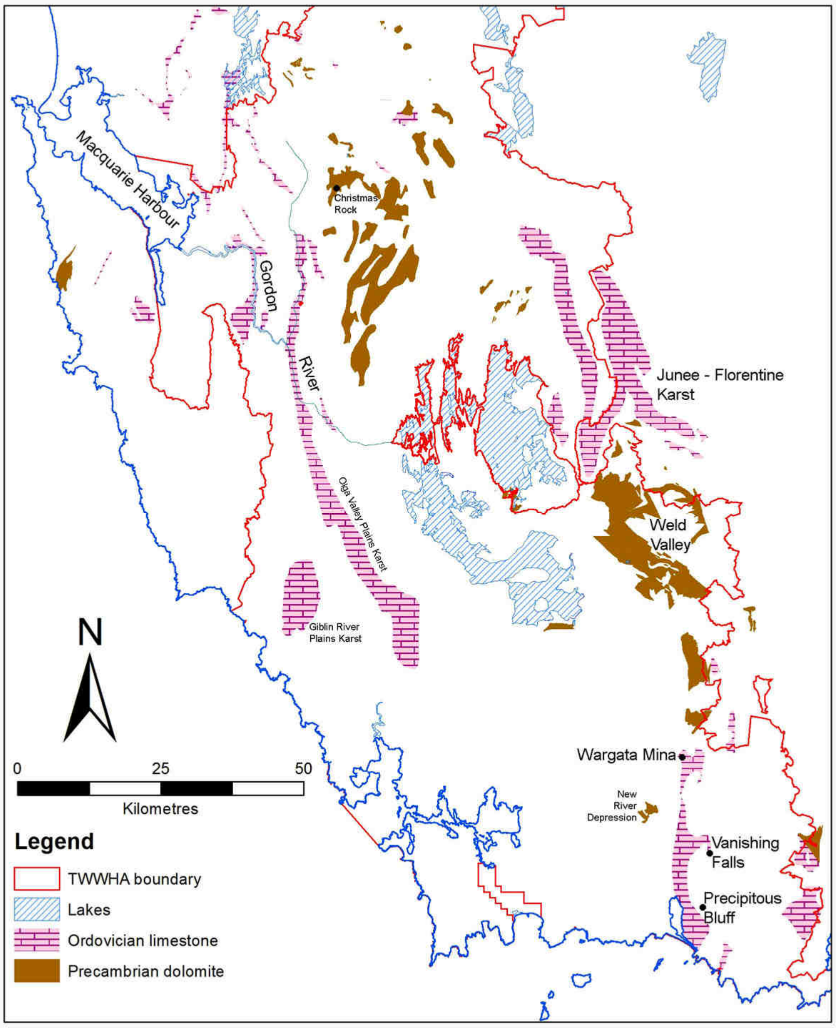

Figure 5: Map of known south-west Tasmania carbonate bedrock with known or potential karst development (based on a digital version of Kiernan, 1995).

Known Unknown Karst (incompletely explored known karst)

It is clear that a great deal of as-yet unexplored karst potential exists in areas of western and south-western Tasmania in locations where carbonate bedrock is known to exist, but either the full extent of the bedrock is unknown and/or the known carbonate bedrock areas have been scarcely examined for evidence of karst.

Indeed, it is of particular note that two of Tasmania's best known caves, the Newdegate show cave in southern Tasmania's Hastings dolomite karst, and Exit Cave in the Ordovician limestone karst at Marble Hill, are both located in bodies of carbonate rock whose boundaries have never been properly mapped on the ground and are in fact quite uncertain in parts. As Sharples (2003a) noted, despite the intensive cave exploration that has occurred in and immediately around both these caves, there have been few attempts to explore their carbonate host rocks for more than a few hundred metres beyond the environs of these cave entrances, nor have these regions been of sufficient mineral exploration interest as to justify them being properly mapped by the Tasmanian Geological Survey. In the case of the Hastings karst, during 2003 Ian Houshold and Chris Sharples spent three days floundering around in thick forest in the Hot Springs Creek valley only one kilometre or so upstream of the Newdegate Cave show cave, and were able to not only properly define the extent of the dolomite up that valley for the first time, but in doing so also discovered a number of vertical cave entrances. One of these, now known as 'Chain of Ponds Cave' (H5) was subsequently explored during 2004 and, with several hundred metres of spacious passages mapped, it turned out to be one of the longest caves now known in the Hastings Karst.

In the case of Exit Cave, Sharples (1994) speculated that the limestone exposed around the Exit Cave outflow might extend beneath the adjacent D'Entrecasteaux Plains and crop out on the slopes of Mt Leillateah across the valley from Exit Cave (Figure 6). Although this speculation was incorporated into 1:250,000 scale Tasmanian Geological Survey maps – for want of any better geological information in that area – no confirmation of these speculations existed until the author and Rolan Eberhard finally located karstic limestone outcrops below Mt Leillateah during March 2011 (see Figure 7). Despite this, the likely extension of limestone around the lower northern slopes of the plains away from Exit Cave itself is still only confirmed for a distance of a few hundred metres away from the cave entrance itself, although there appears every likelihood that it will occur at the surface on slopes well beyond its presently known extent.

These examples are presented not only for self-aggrandizement, but also to emphasise the potential for new karst discoveries that exists even in parts of Tasmania close to road access, which in turn highlights how extensive the undiscovered karst potential of more remote areas may be. The following sections discuss aspects of the karst potential of Tasmanian wilderness in terms of a number of the characteristics that make it of special interest.

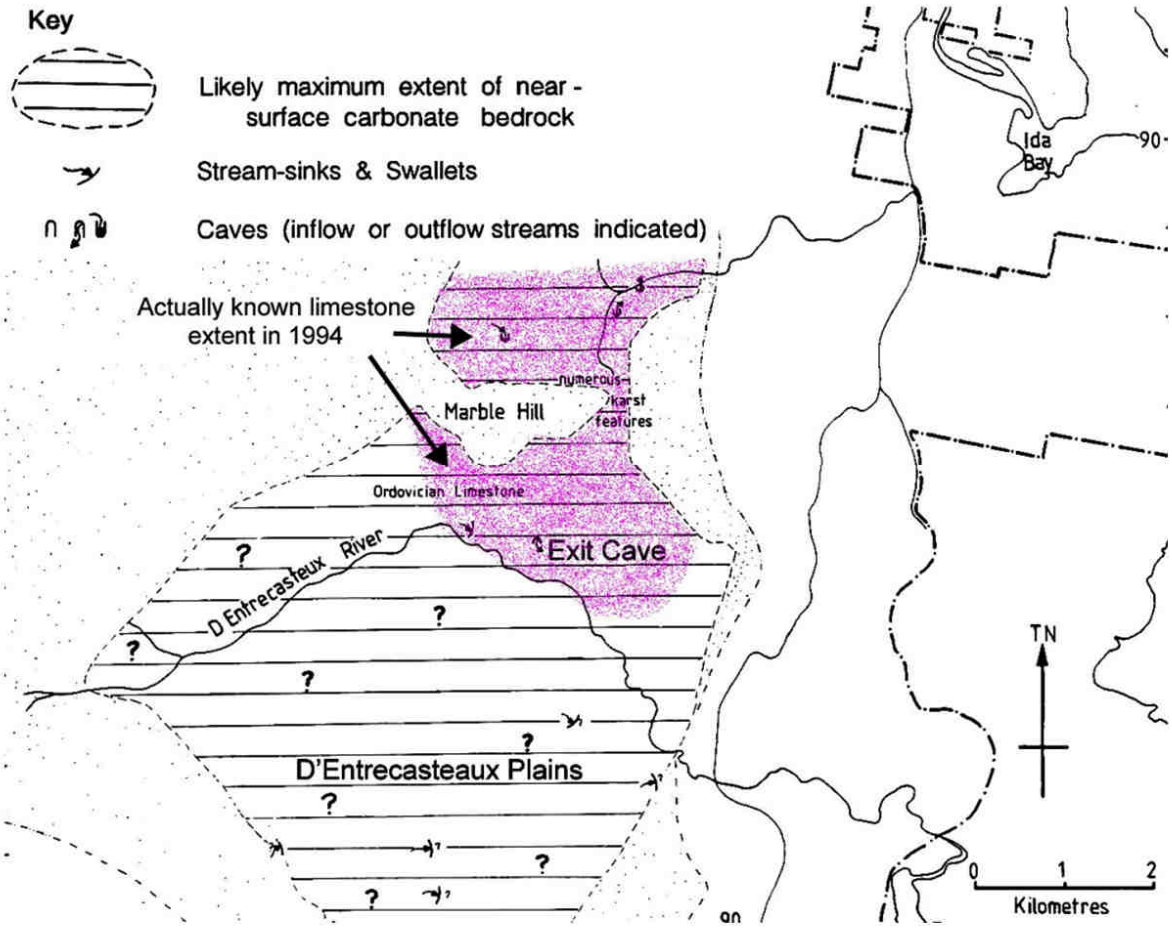

Figure 6: Speculative map of possible limestone extent around the D'Entrecasteaux Plains south of Exit Cave reproduced with annotations from Sharples (1994, p. 57). Although this mapping was later incorporated into Geological Survey 1:250,000 geological mapping (for want of any better information – see Figure 17), at the time it was produced the actual extent of known limestone was only the shaded area around Marble Hill.

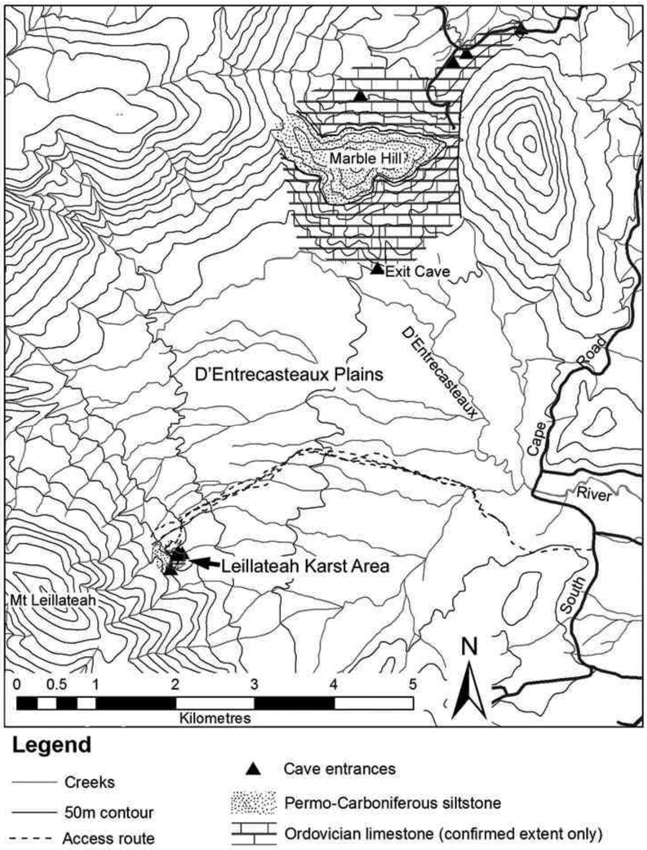

Figure 7: LHS: Location of new karstic limestone area ('The Leillateah Karst') discovered by Rolan Eberhard & Chris Sharples on 21st March 2011. RHS: Draughting fissure in a limestone outcrop in the new karst area. This 'new' limestone area was readily discovered in preparation for this ACKMA Conference, successfully demonstrating how much undiscovered limestone and karst still remains within day-walk distance of roads in Tasmania, let alone the untapped exploration potential in more remote areas of the Tasmanian wilderness.

Pristine Karst

As was noted above, much of the western Tasmanian wilderness has in fact been modified by past human occupation and especially by anthropogenic firing. However within this anthropogenic landscape there still remain some areas which show less evidence of past human impacts – at least during the last 10,000 years of the Holocene – where the impact of human activities can be expected to be as minimal as could be envisaged anywhere. As it happens, one of the largest such areas is the New River – Salisbury River basin, which also contains significant areas of carbonate bedrock with known karst development, and thus has the potential to be of scientific (and ethical) interest as containing karst systems in as close to a truly pristine state as could be found.

New River – Salisbury River Karsts – Ordovician Limestone and Precambrian Dolomite

The New River –Salisbury River catchment in southern Tasmania covers an area of 309 km^2, all of which is contained within the Southwest National Park and the Tasmanian Wilderness World Heritage Area. With the exception of water bodies, some natural alpine grassland on ridge tops, and a small area of button grass and scrub at New River Lagoon, the basin is entirely mantled by old growth forest which has never been logged, roaded, mined, settled, farmed or otherwise significantly disturbed by European settlers, and which also shows no evidence of Aboriginal firing, at least during the Holocene[3]

[3] The Tasmanian Aboriginal Sites Index (TASI) records rock shelters with possible former Aboriginal occupation below Precipitous Bluff, at New River Lagoon (the New River estuarine lagoon), however no Aboriginal sites are recorded on the TASI database anywhere else in the New River Basin (albeit there has been little systematic searching for such sites in that region). The New River lagoon area awaits serious investigation for evidence of human occupation; however the lack of burnt areas anywhere in New-Salisbury Basin above New River Lagoon suggests little likelihood of significant human disturbance during the Holocene.

As such, the New /Salisbury River catchment is the largest entire source-to-sea river catchment basin in Tasmania which can be said to be free of significant anthropogenic process disturbance on current knowledge. Not surprisingly, current Parks and Wildlife Service wilderness mapping identifies the basin as the largest contiguous core wilderness area in Tasmania (see Figure 1), and thus the closest thing we have to a truly pristine large catchment basin with little or no disturbance of fluvial processes. Given this, the New River – Salisbury River basin has the potential to contain the most pristine karst systems in Tasmania.

Ordovician-age limestone has been mapped and explored at only two locations within this catchment basin, namely at Precipitous Bluff and Vanishing Falls, which were respectively explored for caves during 1973 and 1992 as discussed above. Major caves have been explored at both locations, and indeed Vanishing Falls on the Salisbury River is undoubtedly Tasmania's most spectacular stream sink, and possibly its largest (Figures 9 and 10). Correlated limestone has also been explored to the north of the New River catchment, in the adjoining Cracroft River valley where the extensive Wargata Mina Cave (Judds Cavern) was rediscovered during the 1970s (Cane, 1976; Goede & Harmon, 1983). However although limestone has only been confirmed at these three limited locations, consideration of the known regional geology and its structure led Dixon & Sharples (1986) to speculate that these three sites probably lie within a continuous belt of limestone extending at least 30 kilometres north to south, most of which lies within the New/Salisbury River basin (Figure 8). If correct – and there seems no reason to expect otherwise – this is an enormous area of limestone with the potential to have as much cave development along much of its length as has already been documented at Precipitous Bluff, Vanishing Falls and Wargata Mina. With a topographic relief of 420 metres on the limestones at Precipitous Bluff (Burrett *et al.,* 1981) decreasing to about 200 metres at its northern end near Wargata Mina, there is also potential for caves of considerable depth to be present.

Further westwards in the rugged New River Gorge area, a large enclosed depression about 60 metres deep and over a square kilometre in area drains internally to a stream sink which to the writers knowledge has only been visited once on the ground, by Attila Vrana and Jeanette Collin during the1970s (Kiernan, 1995). However Dixon & Sharples (1986) confirmed the presence of dolomite outcrops in the New River Gorge about a kilometre north of this feature (Figure 8). Given the remote, topographically rugged and densely – forested character of the region in which this feature lies, further exploration of this feature and exploration of the extent of the dolomite would be a particularly challenging undertaking.

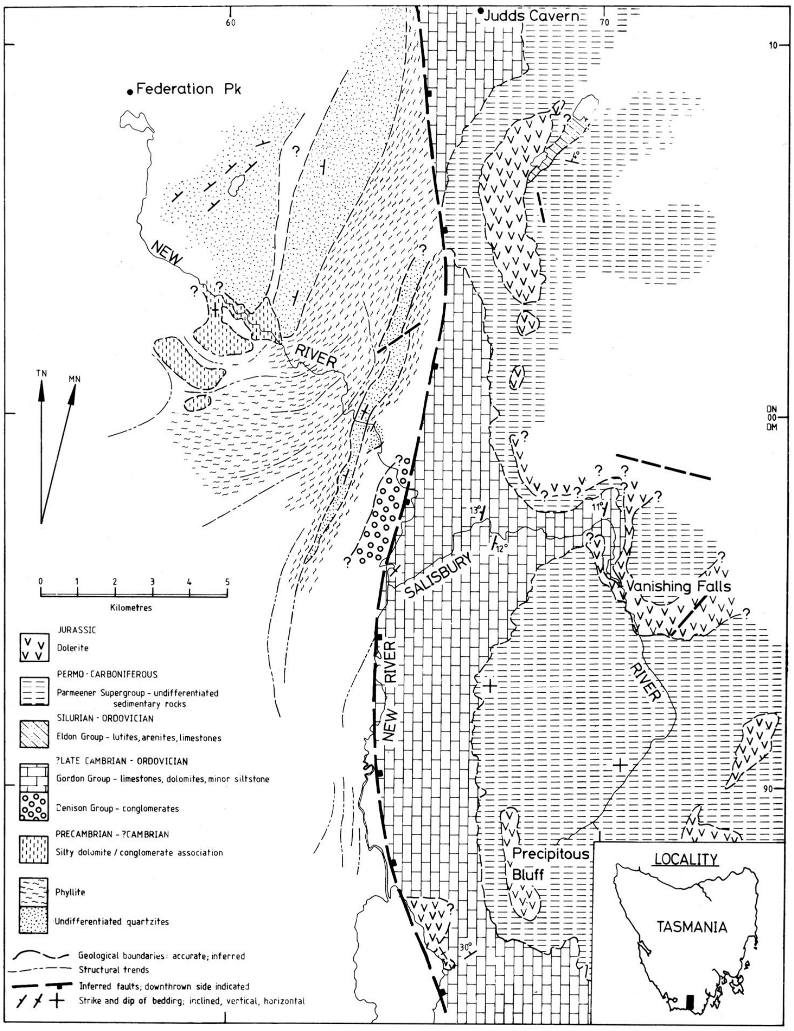

Figure 8: Geological map of the New River – Salisbury River basin, showing the known and interpolated extent of karstic Ordovician Gordon Group limestone in the Precipitous Bluff – Vanishing Falls – Judds Cavern (Wargata Mina) area, and the known plus interpreted extent of karstic Precambrian dolomites (a silty dolomite/conglomerate association) in the New River Gorge area. Map reproduced from Dixon & Sharples (1986).

Figure 9: Vanishing Falls on the Salisbury River (the major tributary of the New River) is undoubtedly the most spectacular stream sink in Tasmania, and possibly the largest. The entire river sinks underground at this point, after falling over a lip of dolerite into the limestone basin below, except when flood overflows occur during high rainfall events. Photo by Rolan Eberhard.

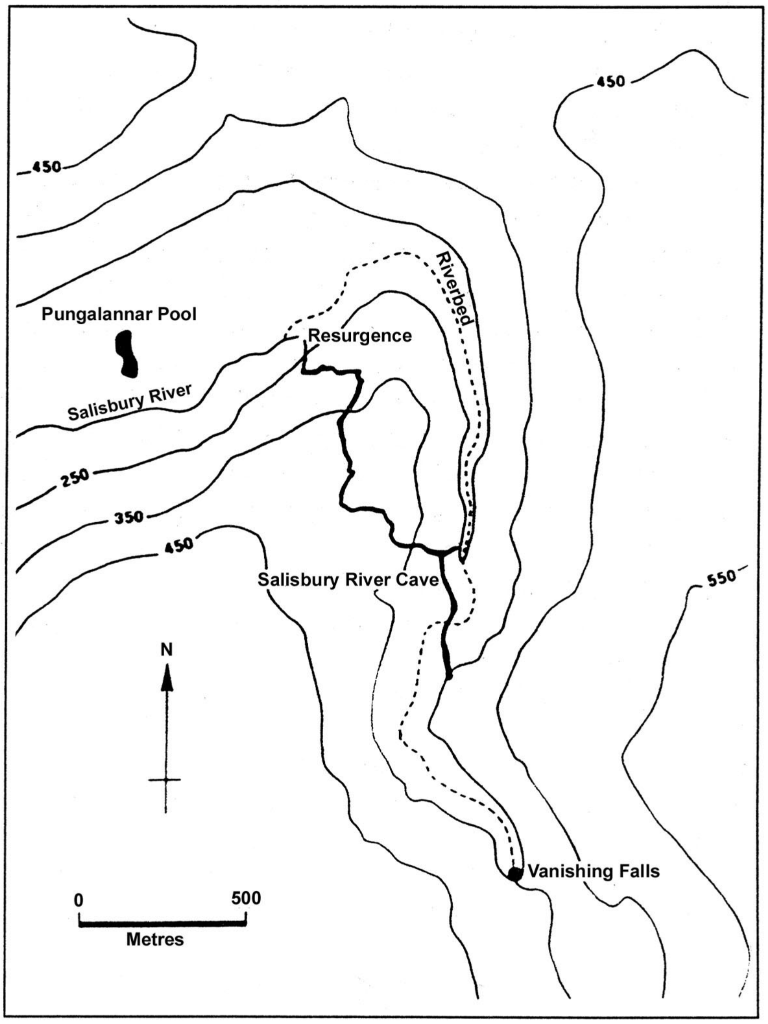

Figure 10: Plan of the Salisbury River Cave, explored at Vanishing Falls by Eberhard et al. (1991). This major cave (>2,300 metres of passage explored) is associated with the underground course of the Salisbury River between its sink at Vanishing Falls and its resurgence several kilometres further down the gorge below the falls.

Extensive Karst

Weld Valley Dolomites

In terms of both topographic relief and horizontal extent of karstic carbonate bedrock, the wild Weld River valley in the eastern part of the Tasmanian Wilderness World Heritage Area stands out as one of Tasmania's most extensive karstic environments, yet its karst exploration potential remains mostly unexplored except at a few locations.

Nonetheless the extent of dolomite in the Weld River valley is well defined thanks to geological mapping undertaken by Clive Calver of the Tasmanian Geological Survey, shortly prior to the area being protected within the Southwest National Park (Calver, 1989). Although the downstream end of the Weld River valley is State forest subject to logging, virtually all of the known extent of dolomite in the valley is protected by National Park and World Heritage status within an extensive forested catchment almost entirely undisturbed by Twentieth Century roads or other developments (see Figure 11, reproduced from Sharples, 2003). A belt of Precambrian dolomite within this catchment covers an area of over 120 square kilometres, with a vertical topographic relief of over 600 metres from its highest outcrops on the alpine North-East Ridge of Mt Anne to contiguous outcrops in the valley floor below. A 373 metre deep cave, Anne-a-Kananda, was explored on the North-East Ridge from its entrance in a spectacular ridge top doline during the 1980s (Figures 12 and 13), however Kiernan (1990) inferred that water draining into Anne-a-Kananda could drain even further underground to springs in the valley about 600 metres below the cave entrance, possibly passing beneath Lake Timk in hydrologically separated passages (see Figure 14). This area has the highest topographic relief of any karst area in Tasmania, and although several caves a couple of metres deeper than Anne-a-Kananda have subsequently been discovered near Maydena in the Junee Valley to the north, it is entirely possible that the discovery of new leads in Anne–a–Kananda could potentially result in cave depths of up to 600 metres being realised here. This is probably the theoretical limit of depth potential for caves in Tasmania.

Nonetheless topography is very rugged throughout the Weld Valley, and although a number of other caves and other karst features are known there has been very little exploration of this valley's karst potential away from the North-East Ridge. One particularly notable feature in the valley is the Weld Arch, a spectacular cave through which the entire Weld River flows underground for about a hundred metres (Figure 15). However about a kilometre south of the arch, on a ridge top to the west of the river, topographic mapping shows a complex uvala depression nearly a kilometre long which is indicative of a degree of karst development likely to be widespread in this valley beyond the known features.

In terms of both areal extent and depth potential, the Weld River dolomites arguably offer the most extensive unexplored karst potential in a wilderness setting anywhere in Tasmania.

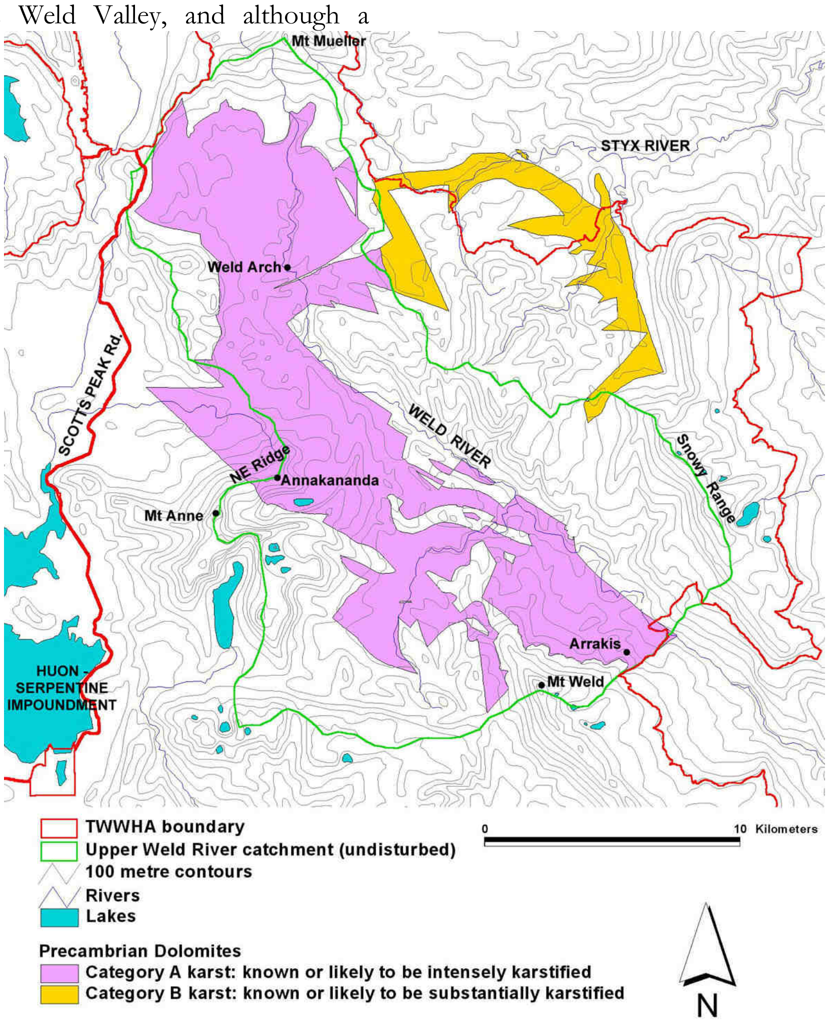

Figure 11: Extent of known karstic dolomites in the Weld valley (figure reproduced from Sharples, 2003), based on field mapping by Calver (1989). The karst categories indicated are based on Kiernan (1995) and are self-explanatory.

Figure 12: Aerial view showing the spectacular entrance doline of Anne-a-Kananda Cave, high on the North-East Ridge of Mt Anne, with the Weld Valley and Lake Timk visible beyond. Photo by Rolan Eberhard.

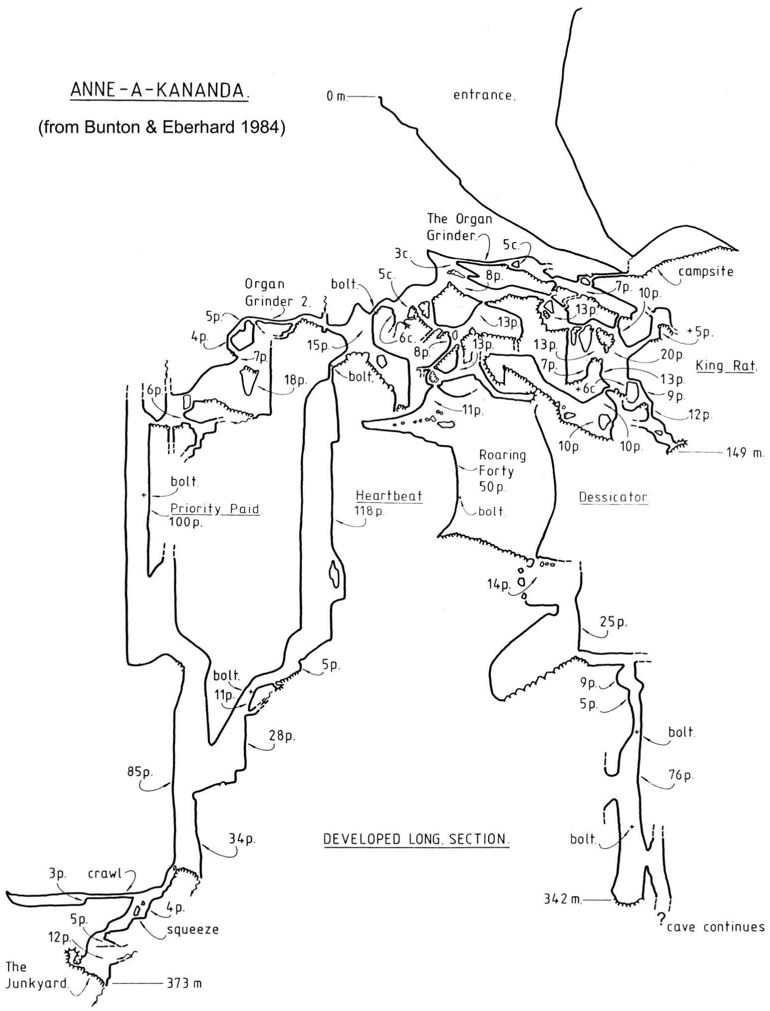

Figure 13: Developed section of the 373 metre deep Anne-a-Kananda Cave (MA9) reproduced from Bunton & Eberhard (1984). Note this section does not show some additional passages discovered subsequently, for example 'The Dessicator' and 'The Rocky Mountain Way' passages linking 'Roaring Forty' to 'The Junkyard' (Butt, 2002). At the time it was first explored, Anne-a-Kananda was the deepest known cave in Tasmania, and subsequent "deepest cave" discoveries in the Junee Valley are only 2-3 metres deeper, which is probably within the error margin of the survey techniques used.

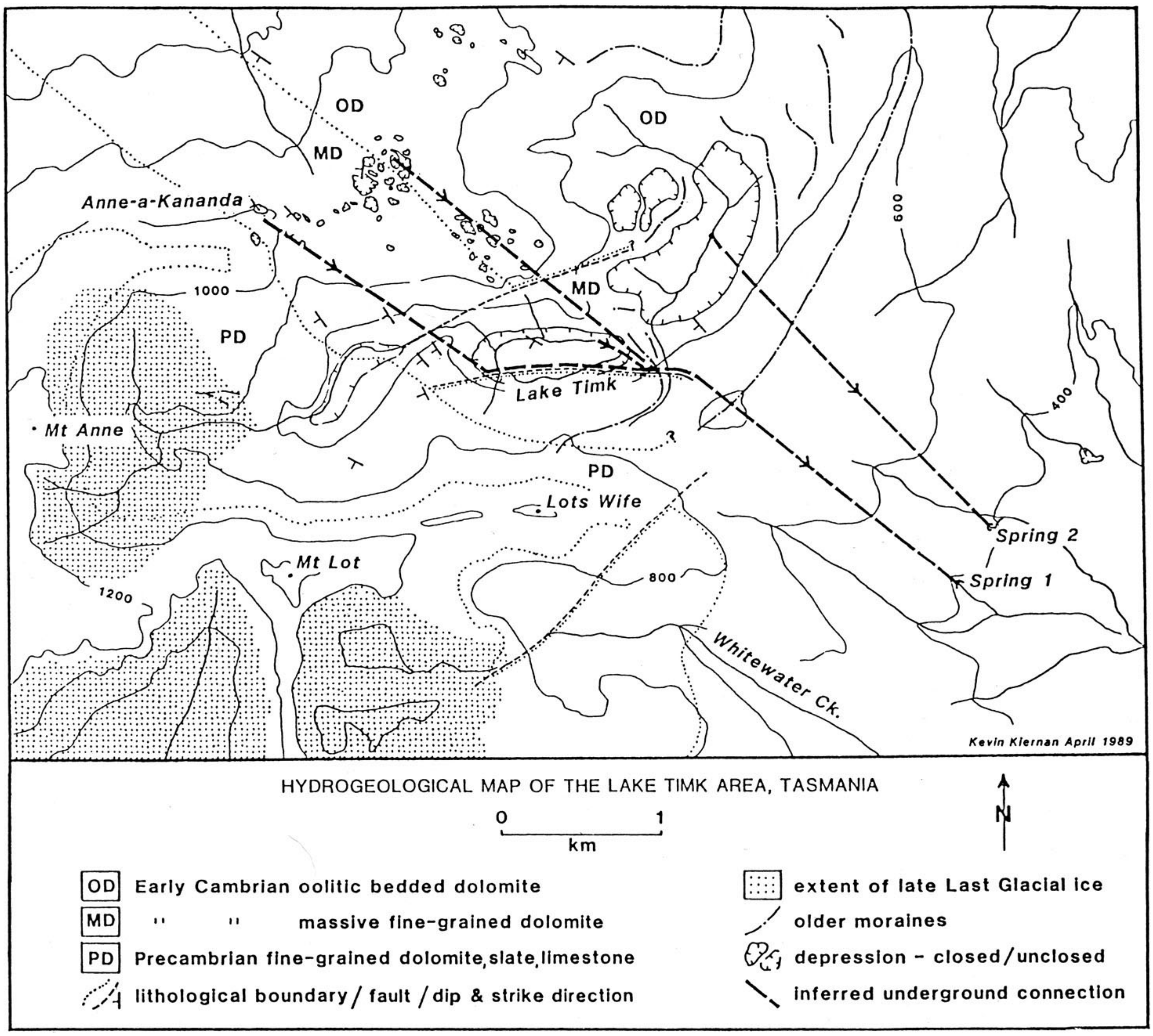

Figure 14: Hydrogeological map of the Anne-a-Kananda – Lake Timk area, showing inferred hydrological connections which suggest subterranean karst drainage of up to 600 metres vertical range (between Anne-a-Kananda and 'Spring1'). This gives a considerably greater karst drainage depth than the explored 373 m depth of Anne-a-Kananda, suggesting that cave depth potentials of up to 600 metres are conceivable. Figure reproduced from Kiernan (1990).

Figure 15: The Weld River Arch. This spectacular feature – through which the entire Weld River flows underground for about 100 metres – is indicative of the scale of known and potential karst development in the Weld Valley dolomites. Although there were rumours of caves in this region from early bushmen, it was not until the late 1970s that this feature was rediscovered by bushwalkers (Hawes, 1981).

Pindars Peak to Surprise Bay

Steeply-dipping Ordovician-age limestone beds striking roughly north-south outcrop on the shore at Surprise Bay, on the south coast of the Tasmanian Wilderness World Heritage Area. Currently published geological mapping (Tasmanian Geological Survey, 2008) infers a northwards extension of the limestone bedrock up the south-west flanks of Pindars Peak. A significant break of slope at 400 metres on the south-west side of Pindars Peak is strongly suggestive of the upper limit of limestone outcrop. Although to the writer's knowledge this limestone has never been explored on the ground (by geologists or cavers) inland of the coastal exposures, Kiernan (1995) notes that there have occasionally been vague reports by cavers of karstified limestone on the southern slopes of Pindars Peak; however the basis for these reports is unknown.

Given the likely extent of the limestone, there would probably be potential for caves up to 400 metres deep to exist in this area, perhaps developed along the north-south strike of the limestone beds. More-over, whilst Pindars Peak has been glaciated during the Pleistocene, the glaciers do not seem to have descended the south-west side of the mountain and so would be less likely to have choked any karst development under a mantle of glacial sediments. A further intriguing possibility also exists; given that the limestone at Surprise Bay extends an unknown distance below present sea-level, it is possible that karst development could have occurred to below present sea-level during Pleistocene glacial climatic stages when sea-level stood as much as 130 metres below present levels. This raises the possibility of present day subterranean streams draining to below present sea-level and discharging as submarine springs off the coast near Surprise Bay.

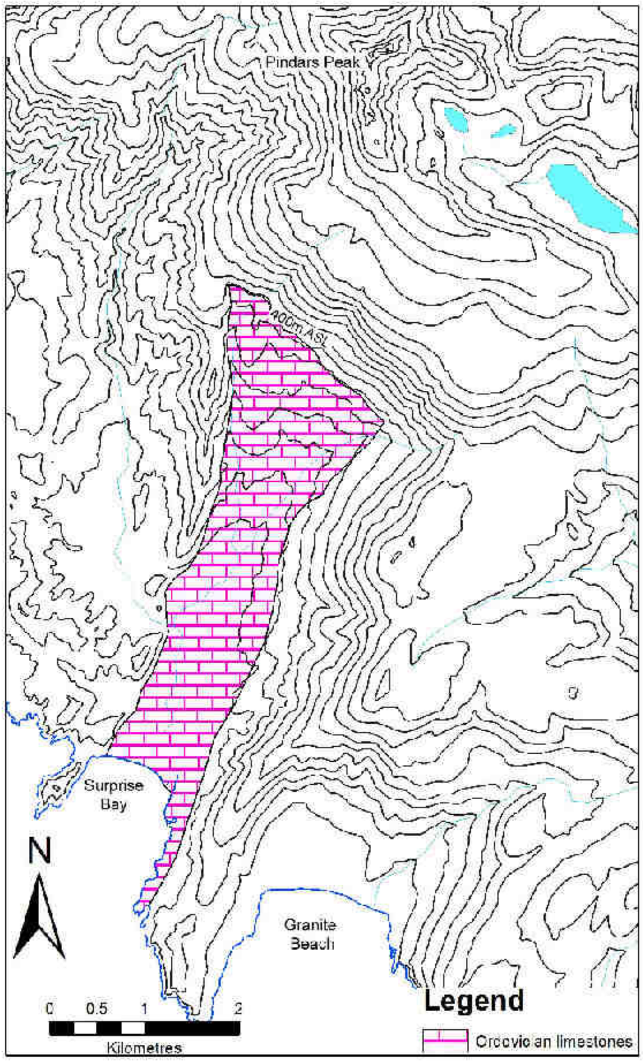

Figure 16: The potential extent of Ordovician limestone between Pindars Peak and Surprise Bay, south coast, Tasmanian Wilderness World Heritage Area. Above sea-level this limestone extends to 400 metres above sea level on a side of Pindars Peak which probably was not glaciated. To the writer's knowledge this potential deep karst area has never been explored landwards of coastal outcrops at Surprise Bay. Map adapted from Tasmanian Geological Survey (2008).

Unusual Karst

The western Tasmania wilderness karst contains a number of karst features that appear unusual in the Tasmanian context, and whose full extent and nature remain unclear because of their mostly remote locations.

Dolomite Tower Karst

Whereas tower karst is generally confined to warmer & more humid climates than Tasmania's, it is a feature of some of the little-known dolomite and magnesite karsts of western Tasmania. Christmas Rock at Lightning Plains, discovered during Governor John Franklin's 1840–42 exploration of western Tasmania (see above), is probably best described as a karst tower, and several smaller towers of dolomite – vertical-sided residual pillars of dolomite up to 15 metres high and 20 x 50 metres across – were observed on the plains within a kilometre or so of Christmas Rock by Sharples (2000). Dixon (1992) has observed similar dolomite karst towers in the remote Algonkian Rivulet valley to the southeast of Lightning Plains, rising to 30m in height and often with caves or overhangs at their base. Houshold *et al.* (1999) also observed notable karst towers in the magnesite karst of the Arthur River in northwest Tasmania. Most of the karst towers noted to date occur in remote areas of dolomite plains karst and little is known about the processes forming them. However while one explanation for the unusual occurrence of tower karst in Tasmania may be the acidic groundwaters of the buttongrass moorland areas in which many of the observed towers occur, Houshold *et al.* (1999) concluded that the magnesite karst towers of the Arthur River site were relict landforms that had developed under warmer and more humid conditions during Tertiary times. Hence it may be that the karst towers of the Lightning Plains – Algonkian dolomites are fossil landforms preserved from a time when Tasmania's climate was warmer and wetter than at present, and so further exploration and study of these features could reveal useful information about Tasmania's past environments.

Magnesite Karst

Magnesite is a magnesium carbonate rock which is generally much less soluble than calcium carbonate limestone under most conditions, and well-developed karst landforms are globally rare in this rock. However, several narrow bodies of Precambrian – age magnesite outcrop in the Arthur Lineament geological structure within the wild Tarkine region of north-west Tasmania, and a number of small caves and other features had been noted in these deposits by cavers during the 1980s and 1990s (Sharples, 1997). However their karst development was not intensively examined until a proposal to mine the magnesite that arose during the late 1990s led – again! – to a phase of intensive study of these features by Houshold *et al.* (1999). A number of small caves and notable karst towers were documented, and interestingly it became apparent that several known warm springs in the karst were associated with a large scale subterranean hydrothermal water circulation system which had also been intersected in large cavities drilled into by mineral exploration drilling within the magnesite. It was concluded by Houshold *et al.* (1999) that many of the magnesite karst landforms evident on the surface were 'fossil' karst landforms which had formed under a warmer and more humid climate during the Tertiary Period, and were now being re-exposed by erosion of overlying younger sediments; however a present-day subterranean hydrothermal karst hydrology also remains active.

Interestingly, a substantial portion of the Arthur Lineament in-between some of the known magnesite occurrences remains difficult of access and little-known geologically, and on structural grounds it is possible that further as-yet unexplored magnesite bodies could be exposed in this area lying along strike to the south-west of magnesite in the upper Lyons River area.

Crystal Caves – Hydrothermal Karst

Partial silicification is a widespread feature of Precambrian-age dolomites throughout Tasmania, and may occur within dolomite bodies as 'box work' veins, amorphous silica masses or, in some places, crystal-lined vughs. It is likely that some of these differing styles of silicification have occurred in response to different geological processes at different times subsequent to deposition of the dolomite sediments. A spectacular example of the crystalline variety occurs in dolomites on the eastern slopes of Mt. Weld, within the South-West National Park, where enterable dolomite caves have walls lined with coarse quartz crystals up to two centimetres diameter and can properly be called 'crystal caves' (Sharples, 1994). Interestingly, some large crystal-lined vughs or avens extend upwards from the dolomite into much younger clastic conglomerate beds which overlie the carbonate rock on an erosional unconformity, implying that the formation of these crystal avens was probably associated with upwards movement of hydrothermal waters dissolving carbonate and precipitating silica at some time after the deposition of the overlying Permo-Carboniferous age rocks. One possibility is that the Mt Weld crystal caves developed in the upper parts of a hydrothermal process system associated with the formation of a metallic ore body that has been explored further down the Weld Valley at Glovers Bluff.

Although no other enterable crystal caves have yet been documented in Tasmanian dolomites, similar coarse silica crystals forming vuggy masses outcrop in dolomites elsewhere in the Weld Valley, in the nearby Styx River Valley, and on Mt Picton (Clive Calver, *pers. comm.*) Coarsely crystalline quartz 'geodes' are also reported from the Tim Shea area near Maydena (Tony Culberg, *pers. comm.*); although the precise source of these is unclear, it is possible they are associated with Precambrian dolomites that occur immediately south of Tim Shea. Whilst enterable hydrothermal karst caves are a rarity in

Tasmania, they do seem to exist in at least one part of the dolomites that are widespread in the Tasmanian wilderness, and the possibility that other such features may exist is a tantalising possibility. However given their apparent rarity, a better understanding of why they are so well-developed on Mt Weld in comparison to other known examples of dolomite silicification in Tasmania will probably require a better understanding of their process of formation in order to predict where other occurrences – if any –may possibly occur.

Unknown Unknown Karst (undiscovered karst areas)

Although some ill-informed commentators occasionally claim that parts of the western Tasmanian wilderness are still 'unexplored', this is in general misleading since early prospectors, surveyors and timber-getters thoroughly combed the region in search of resources during the first century of European settlement. Nonetheless it is true that the geology of the region does indeed remain incompletely mapped at a regional scale. In part this is because geological survey mapping in Tasmania has largely been driven by mineral exploration industry requirements (Emyr Williams, formerly of the Geological Survey of Tasmania, *pers. comm.*), and large areas of (in particular) southwest Tasmania were not thought to have high mineral prospectivity after the early phase of exploration. For the same reason, once large parts of the region were declared National Parks during the late Twentieth Century there was no longer any perceived justification for geological mapping programs in those regions. As a result, even today it remains possible to correctly regard substantial portions of western Tasmania as being genuinely unexplored and unmapped in a geological sense, and it is evident that there still exist possibilities for discoveries of entirely new, previously undocumented areas of carbonate bedrock. The fact that this potential is real is demonstrated by the fact that a number of previously quite unsuspected limestone bedrock areas have indeed been discovered in recent years.

As recently as 1994, geologists Clive Calver and John Everard identified a new area of Ordovician-age limestone on the south banks of the middle Huon River in undeveloped State forest just outside the boundary of the Southwest National Park (Kiernan, 1995). Subsequent exploration of the area, now known as the Riveaux Karst, by officers of the Forest Practices Authority and Department of Primary Industries, Parks Water & Environment led to the discovery of several notable caves including one extensively decorated with Aboriginal hand stencils, whose precise location has remained a closely guarded secret at the insistence of the Tasmanian Aboriginal community.

Even more recently, circa 2009–2010, survey work by Forestry Tasmania officers in State forest at the edge of the Southwest National Park, on the southeast flanks of Mt Picton, led to the discovery of another previously unsuspected Ordovician limestone area in the Lower Picton River valley (M. Cracknell, *pers. comm.*). This limestone may be a structural continuation of the Riveaux Karst, although it is separated from it on the surface by the overlying dolerites and clastic sedimentary rocks forming Mt Picton.

Although unknown unknown karst is by definition unknown, it is possible to speculate about areas whose bedrock geology is unknown but which on grounds of regional geological structures may have potential to contain as-yet undiscovered limestone, dolomite or magnesite bedrock. One area that has interested the writer is identified below; no doubt other possibilities also exist elsewhere in western Tasmania.

Upper Picton River Valley

Current 1:250,000 scale geological mapping published by the Tasmanian Geological Survey (2008) depicts the upper (southern) part of the Picton River valley, immediately east of the New River – Salisbury River basin within the Southwest National Park in southern Tasmania, as comprising a suspiciously extensive and uniform region of 'undifferentiated' Permian and Triassic-age sedimentary rocks (see Figure 17). However this mapping is based on an early regional air photo interpretation of bedrock geology which has subsequently been shown by field mapping to be substantially incorrect for the more downstream (northerly) parts of the Picton valley. In reality no documented ground-based geological observations are known to the writer for this extensive area of around 200 km^2, which is an extensive forested wilderness valley that has rarely been visited by bushwalkers, let alone geologists. This is probably the largest remaining area of Tasmania for which there is simply no credible geological information available, and indeed the writer considers that geological maps should depict this area as a blank, since that would more usefully indicate the status of geological knowledge of the area than the current, probably misleading, depiction (Figure 17).

Nonetheless, it is possible to make some speculations about the geology of this Picton Valley 'hole' based on mapped geology and known structures in surrounding regions. In particular, Ordovician limestones are extensively present in surrounding valleys of the New and Salisbury River, Lune River, the Surprise Bay area to the south, and they also outcrop in the floor of the Picton Valley itself further downstream to the north (see Figure 17). The regional geological structure of these limestones, together with the known heights of the basal Permo-Triassic unconformity which truncates the top of the limestone in surrounding regions, all point to a real possibility of as-yet unidentified limestone outcropping in the upper Picton Valley, albeit it may be restricted to the deeper parts of the valley adjacent to the river itself. On this basis one promising area for limestone and karst exploration within this Picton Valley 'hole' is the lower valley slopes surrounding the Picton – Roberts River Junction, and other parts of the lower valley slopes downstream from there.

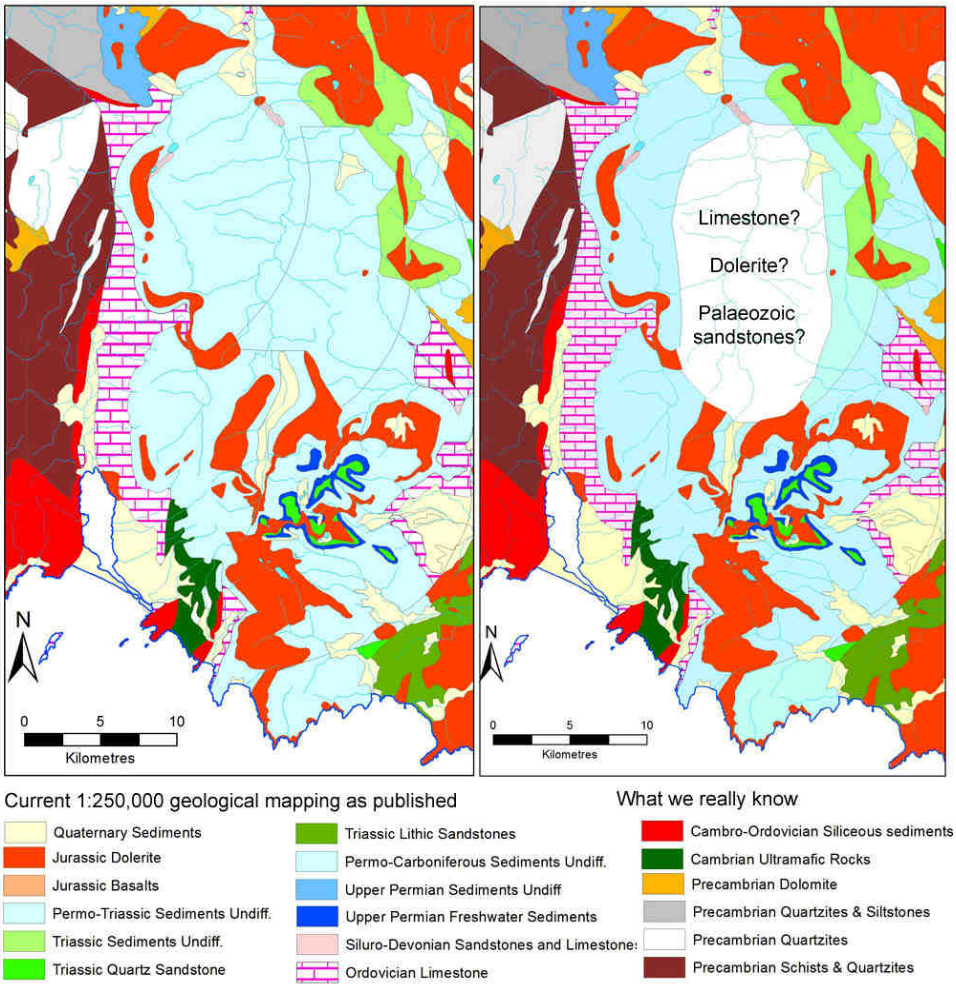

Figure 17: The upper (southern) Picton River valley (within the Tasmanian Wilderness World Heritage Area) is possibly the largest area of Tasmania for which no reliable geological information exists. Although current 1:250,000 scale published geological mapping indicates a (suspiciously large) area of undifferentiated Permo-Triassic sedimentary rocks, this is based on old regional-scale air photo interpretation which has already proven wrong for the downstream (northern) parts of this valley. Given the proximity of known Ordovician limestones and extrapolation of likely geological structures, there is a good chance that significant areas of Ordovician limestone are present in the unmapped Upper Picton 'hole'. Mapping shown is reproduced from Tasmanian Geological Survey (2008).

The Mystery of Wilderness

There is an argument that I should not have written this review of the karst and caving potential of Tasmania's wilderness. It is sometimes held that an ineffable mystery is an irreducible part of the core value of wilderness, and that coming to know wild places better in a scientific sense may in some way reduce their value. Similarly it can be argued that exploring, and in particular documenting wild caves is an intrusion of human egos and cold scientific data-gathering into a realm which is better left free of such anthropic values (Kiernan, 1979).

However mystery is a subjective and ephemeral thing; one person's romantically mysterious wilderness may be another's regularly visited campsite or well-understood baseline monitoring quadrat. Indeed, it is evident that parts of the western Tasmanian wilderness – including in particular its caves – that are today little-known to most people were for several tens of thousands of years the home and regular stomping ground of generations of Aboriginal people. That such well-tramped places can once again today be regarded as mysterious is a testament to the ultimately subjective and contingent nature of the notion of mystery.

The danger of this notion of mystery is that it can easily slide into quasi-religious mysticism (e.g., see Hawes, 2008) which serves little purpose other than to confuse and bemuse. On the other hand, tangible knowledge and understanding of wild places such as caves is today often a necessity if we are to preserve their natural ecological systems, which after all are the real things that still define them as wilderness. Given the numerous threats to the integrity of present-day wilderness from a variety of human activities - and especially considering the looming threat of anthropogenic climate change which will affect all parts of the Earth including wilderness – it is not useful to regard knowledge as a destructive or detrimental thing. On the contrary, in many cases knowledge is the key to protecting the things we value, as was so successfully demonstrated by the cave exploration and studies that ultimately succeeded in preventing the drowning of wild caves and rivers in the Gordon – Franklin River system during the 1980s.

Just as past Aboriginal inhabitants of the present Tasmanian wilderness must have had an intimate knowledge of those places which allowed them to co-exist with their natural environment, so too it is arguable that in the present day an appropriate degree of knowledge of wild places – including especially scientific knowledge – is not a bad thing. Instead, the right type of knowledge is arguably a tool that we must use to prevent the loss of some of the very aspects of wilderness that we value.

The Future for Wilderness Karst Exploration in Tasmania

It is often said that cavers tend to focus on exploration of known caves and their nearby environs, because access is easy and success is more likely. However as was pointed out to me by an experienced cave explorer following our March 2011 discovery of the 'new' Leillateah karst area in southern Tasmania: "it is not necessary to fall back on easy locations like the Junee-Florentine or Marble Hill, where potentially world class caves can be discovered literally hundreds of metres from vehicular access; instead, it is entirely feasible to undertake expeditions at considerable time and expense (not to mention badly scratched arms and knees) bashing your way to remote limestone areas, to find caves 3 or 4 metres long!" (Rolan Eberhard, *pers. comm.*, 23rd March 2011).

More to the point, it seems to this writer as though interest in exploring Tasmanian wilderness karst has waxed and waned alongside a broader waxing and waning of interest in Tasmanian wilderness generally. During the 1970s and 1980s interest in Tasmanian wilderness was at a high level because the future of our wilderness was a high profile political issue, driven in particular by a global awakening of interest in environmental issues, and more locally by plans for imminent hydro-electric development in the Tasmanian wilderness. Interest in bushwalking and wilderness exploration generally was high as a direct result, and for those with an interest in karst, this naturally led to increased interest in exploring karst in the wilderness – in part because of the general interest in wilderness, and in part because it was hoped that major wilderness karst discoveries would provide further reasons to protect the wilderness from development.

Subsequent to the 1980s, with the protection of large swathes of wilderness in National Parks and a World Heritage Area, interest in wilderness exploration seems to this writer to have waned somewhat. Bushwalking is still popular but has become more 'packaged' and tourism – focussed. While forestry has remained a high profile environmental issue, with the protection of large swathes of wilderness forest in places such as the Weld Valley this has arguably been less about wilderness forests and more about native forests *per se* – many of which are not wilderness in any clearly defined sense. This general reduction of interest in wilderness exploration seems to have been paralleled by a reduction of interest in wilderness karst exploration.

However, this review is not a plea for increased exploration of Tasmania's wilderness karst; rather to some extent it is actually a celebration of the fact that an area with so much evident potential for extensive and impressive cave systems, in relative proximity to intensively explored and accessible areas, can remain so little explored and little known for so long. There seems little doubt that future interest in exploration of Tasmania's wilderness karst will wax and wane in response to a variety of factors, including but not limited to political and scientific needs. The fact that a phase of moderately intense wilderness karst exploration during the 1970s and after has not led to all-out trogging of the notable caving potential that remains unrealised in Tasmania's wilderness underlines that we perhaps do not need to be overly cautious or purist in order to protect our wilderness caves; so long as we continue to protect the whole wilderness in which they lie – in tangible, management-oriented ways – the very wildness of these karsts will remain their best long term protection.

Figure 18: How much impact is acceptable in wilderness karst exploration? This Czech expedition to Anne-a-Kananda in 1987 arguably overdid their impacts on the wilderness environment they were exploring. Whilst exploration of wilderness caves is not in principle detrimental to the value of wilderness, it is important that it be undertaken with particular care to preserve the wild character of such places. Photographer unknown; photo supplied by R. Eberhard

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An Overview of the Mole Creek Karst

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Abstract

In 1963, Dr J. N. (Joe) Jennings stated to the Australian Heritage Commission that:

> Australia as a whole is not well off for karst caves…. The Mole Creek area ranks amongst the most valuable.

It was ultimately listed on the Register of the National Estate in 1983. The Marakoopa section of the Mole Creek Karst National Park was added to the Tasmanian Wilderness World Heritage Area in 1989. It is thus one of the seven Australian World Heritage properties (out of 19 sites) with internationally recognised karst values.

In 2003 the Mole Creek karst was identified by Australia's leading karst scientists as one of fifteen most significant karst areas in Australia and thus is a candidate for the new Australian National Heritage List.

The Mole Creek karst is also home to a significant population of farmers, foresters and people developing tourism businesses – one of the few parts of Australia where a dynamic karst landscape provides the background to the well-being of the local community. This highly significant place, then, is the host site for the 19th Australasian Conference on Cave and Karst Management.

This paper, which was commissioned by the conference organisers, briefly outlines the values and significance of the Mole Creek karst area, concentrating on the significant surface karst features and on the subterranean systems and their contents. It also touches on the complex cultural features of the Mole Creek karst which include the interests of indigenous people, the development of cave tourism in Australia and the development of scientifically based management.

Introduction

In 1963, Dr J. N. (Joe) Jennings (considered by many as the 'father' of Australian karst science) stated to the Australian Heritage Commission that:

> Australia as a whole is not well off for karst caves ... The Mole Creek area ranks amongst the most valuable. Indeed it could be argued that it is the most valuable single cave area intrinsically and its comparative nearness to Sydney and Melbourne enhances its value.

It was ultimately listed on the Register of the National Estate in 1983. The Marakoopa section of the Mole Creek Karst National Park was added to the Tasmanian Wilderness World Heritage Area in 1989. It is thus one of the seven Australian World Heritage properties (out of 19 properties) with internationally recognised karst values. The seven are:

- Lord Howe Island;
- Greater Blue Mountains;
- Purnululu;
- Australian Fossil Mammal Sites - Riversleigh/Naracoorte;
- Tasmanian Wilderness;
- Great Barrier Reef; and the
- Ningaloo Coast.

The last, Ningaloo Coast which includes the karst and subterranean biodiversity of Cape Range, has been added since the ACKMA Conference at Ulverstone. This is an important addition to Australia's World Heritage as the karst and subterranean values are explicitly recognised whilst they are only thought of as components of the other seven.

In 2003 the Mole Creek karst was identified by Australia's leading karst scientists as one of fifteen most significant karst areas in Australia and thus is a candidate for the new Australian National Heritage List.

The values of the Mole Creek karst comprise components as follows:

- Permian palaeokarst features exposed at the surface and in caves, potential for Tertiary features;
- Glacio-karstic interactions;
- Magnificent calcite, aragonite and gypsum speleothems (Figure 1);
- Comprehensive and well-developed suite of surface karst landforms;
- Complex karst hydrology exhibiting strong structural control;
- Potential warm water and sulphuric acid-driven solution;
- Sub-fossil bone deposits;
- Diverse invertebrate cave fauna;
- Important research record, particularly in geomorphology, hydrology and palaeoclimatic work;
- Highly significant for recreational caving and regional tourism; and
- An important agricultural and timber production area.

Figure 1. The Forbidden City, Kubla Khan. Photography courtesy of David Wools-Cobb.

Although there has been an extensive history of European use of the caves there appears to be little known about its undoubted importance to the indigenous people of the area. There has been a very large amount of cave exploration and of scientific research. Unfortunately much of the research is reported only in the so-called 'grey' literature – that is, not in formally-reviewed scientific literature. Indeed Armstrong Osborne, in a recent review of the origins of caves in the Eastern Highlands of Australia (which, of course, includes Tasmania), stated:

> It is noteworthy that the 10 page description by Jennings (1967) of the Mole Creek karst is still the major published account of this important karst area. (Osborne, 2010, p. 293)

Much of the research has been aimed at better understanding the karst hydrology of the area and has been much focused towards better management of this area of mixed tenures and land uses.

Location

The Mole Creek karst is a relatively large area of Ordovician limestone, approximately 45 km in length, between five and ten kilometres wide, located 70 km west of Launceston in northern Tasmania. The karst supports a wide variety of land uses and tenures, including dairying, sheep and cattle grazing, native timber harvesting, tree plantations, and reserves for nature conservation and recreation. The small urban settlements of Liena, Mole Creek, Chudleigh and Meander are located within the limestone area.

Natural Diversity

Geology

The Mole Creek karst is developed in hard, dense and well jointed Ordovician limestone. The rock has been moderately to intensively folded into a series of synclines and anticlines, which generally trend in a NW-SE to EW direction. Similar to the Florentine valley, the limestone immediately overlies hard siliceous sediments, locally called the Moina Group, and is conformably overlain by sandstones and mudstones attributed to the Eldon Group.

Unconformably overlying the limestone to the south are flat-lying Permo-Triassic sediments, which have been intruded by massive Jurassic dolerite sills and dykes. Permian palaeokarst features are common in the vicinity of this contact, extending into caves in some areas.

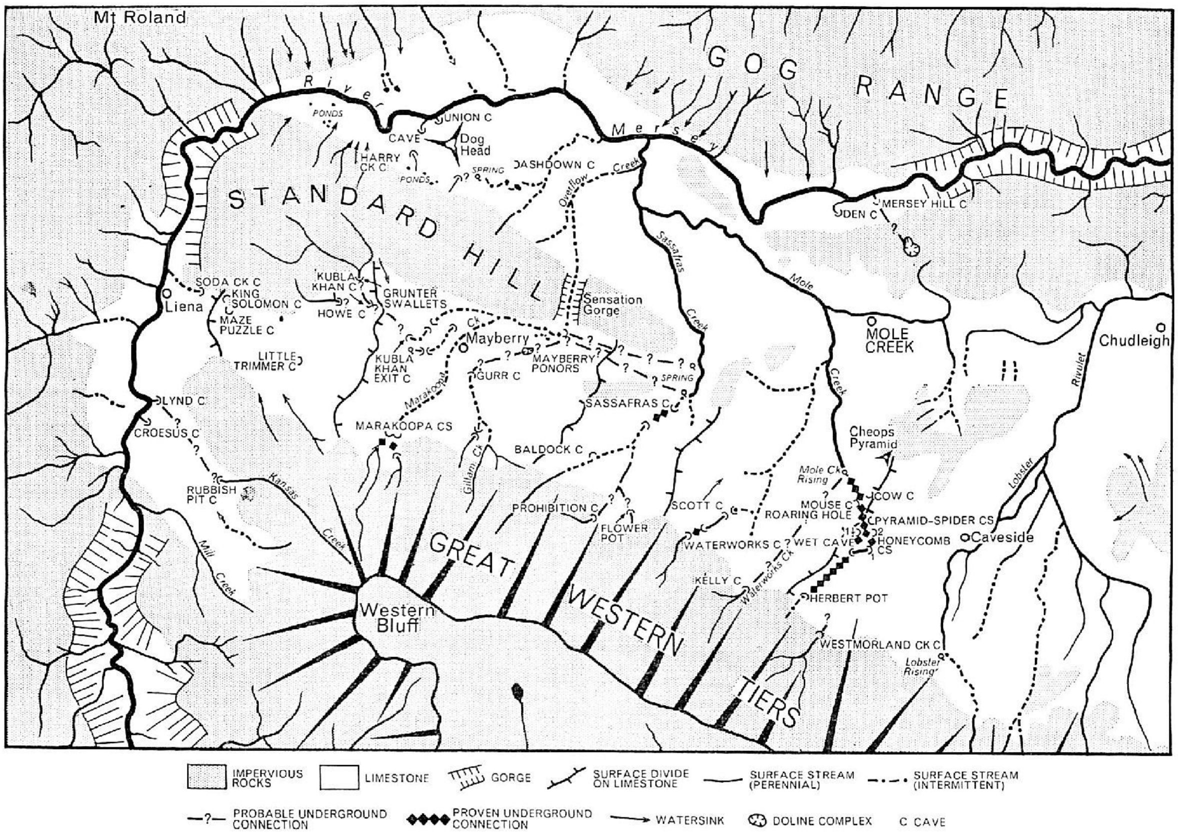
Tertiary basalts and associated sub-basaltic gravels overlie the limestone on valley floors at Mersey Hill and outcrop discontinuously eastwards to the vicinity of Meander. At Liena, limestone clasts form a breccia within these lavas, indicating an eruptive centre.

Thick deposits of Pleistocene fluvio-glacial gravels overlie the limestone across a large area, becoming progressively thicker towards the east, where limestone outcrops are very limited in the vicinity of Meander.

Surface Geomorphology

The karst landscape consists of broad, solutionally planated valley floors, generally oriented perpendicular to major drainage lines. This illustrates the dominance of solutional rather than mechanical erosion processes in large scale landform development. These east-west trending basins are bounded to the south by stepped topography of the Great Western Tiers, rising to elevations approaching 1400 m at Western Bluff, reflecting the underlying structure of horizontally bedded Mesozoic rocks. Distinctive cliff-lines have developed in columnar-jointed dolerite at the escarpment of the Central Plateau.

The central parts of the karst are divided by an east-west trending anticlinal ridge of Moina Group sandstone, which has remained proud of the overlying limestone as solution reduced base levels. In the west this feature is known as Standard Hill. Towards the east it is known as Long Ridge. A spectacular gorge of superimposition (Sensation Gorge) cuts northwards through this ridge, intermittently draining the Mayberry polje during floods (Figure 2). Further east, dry gaps mark previous courses of Western Creek and the Meander River, displaced by both basalt flows and alluvial fan processes.



12.5 Drainage and associated karst features at Mole Creek, Tasmania

Figure 2. Joe Jennings' appreciation of the karst at Mole Creek (Jennings, 1967).

Glacial ice has overridden much of the Mole Creek karst in the Pleistocene. High level tills at Liena are found at approximately the same level as King Solomons Cave, which also contains dolerite fragments, potentially derived from meltwater. A high level till deposit at Mersey Hill suggests that, if Plio-Pleistocene in age, the area around Mole Creek township itself was inundated by ice. However it is not certain that this deposit does not underlie Miocene basalts. If this is the case, Tertiary aged glacial deposits and outwash may be present in some of the nearby cave systems. A fascinating study by Treble suggests that the water which deposited speleothems of last glacial age in Marakoopa Cave was most likely derived by seepage from glacial meltwaters (Treble, 2003). Significantly, this is not evident in the current surface topography of the area.

Because of its comparatively large size (in comparison with other impounded karsts of Australia's Eastern Highlands) the Mole Creek karst contains a wide range of significant surface karst features. Some of the more important features include:

- Large Hums, (residual karst hills) - Dogs Head Hill and Cheops Pyramid.
- Karst margin poljes - the Mayberry and Loatta basins.
- The subjacent karst uvala at Mersey Hill.
- Polygonal karst on the Mayberry/Sassafras divide.
- A wide variety of dolines (closed depressions) including solution, subsidence and collapse features in many areas (Figure 3).
- Blind and semiblind valleys – e.g. Kansas Creek, Marakoopa Creek.
- Dry valleys such as that below Marakoopa 2 Cave entrance and below Westmorland Cave.
- Many distinct streamsinks, generally located at the Permian unconformity - e.g. Devils Pot, Westmorland Cave, Kelly Pot.

- Steepheads - e.g. at Batchelors Spring and Mersey Hill Cave.
- Karst wells (cenotes?) on the plains south of Union Bridge.
- Karst windows such as the unroofed cave between Wet Cave and Honeycomb Cave.

Small-scale surface solution features are comparatively well developed for Tasmania, resulting in part from exposure to direct precipitation in the open woodland or grassland vegetation surrounding exposed rock outcrops. Significant rillenkarren are found on The Grunter, Dogs Head Hill and on north facing slopes at The Den on the Mersey River. Rundkarren are well exposed on the Mole-Lobster divide and in the vicinity of Shooting Star Cave.

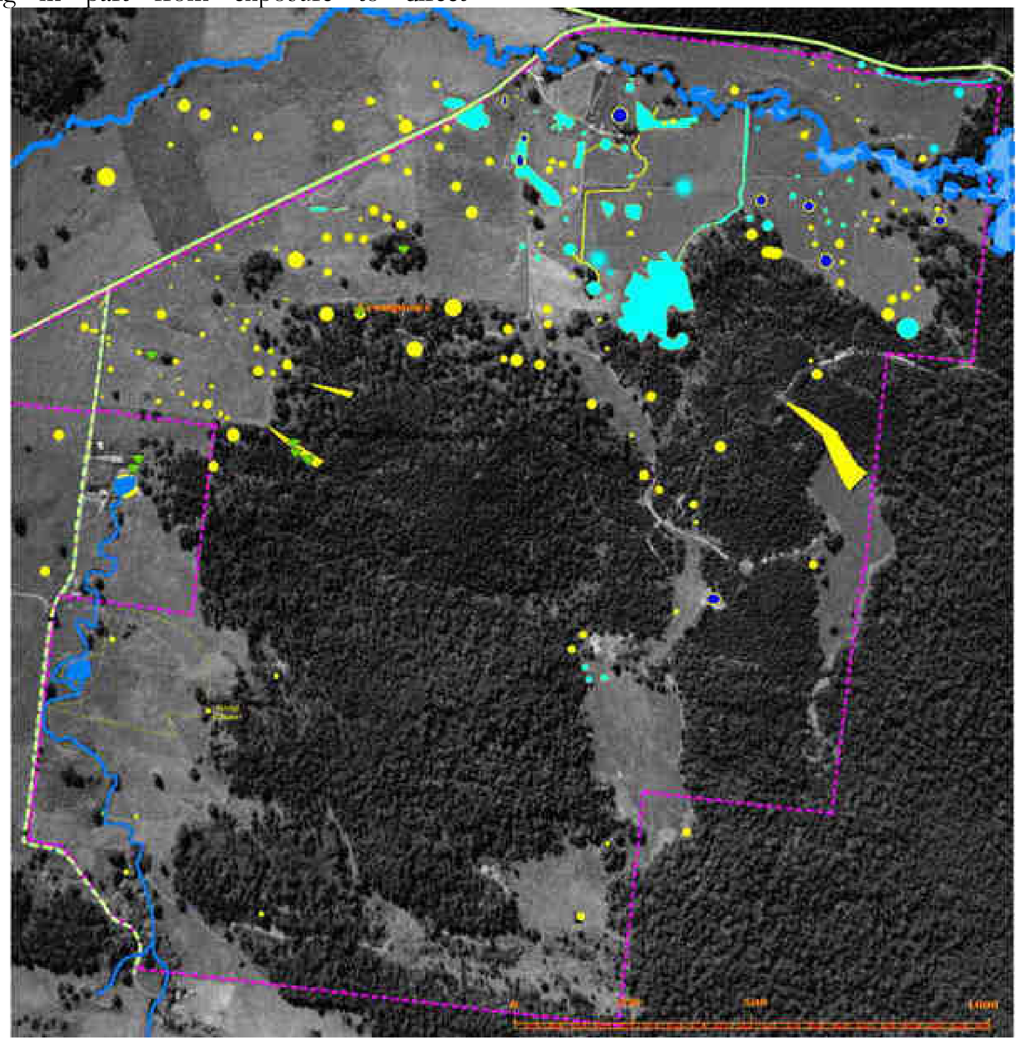


Figure 3. Sinkholes in the north western part of the Mayberry Depression on Circular Ponds property. Yellow = dry sinkhole. Light Blue = Fills with water in winter. Dark Blue = Retains water year round. From: http://www.greatwesterntiers.com.au/ponds/index.htm

Caves and cave contents

Approximately 360 caves have been described from this area. The following is a brief list of the major systems:

- The Mole-Lobster system (Kellys Pot/Westmorland Cave/Herberts Pot/Wet Cave/Honeycomb Cave/Cow- Pyramid Cave).
- The Sassafras system (Prohibition Cave/Baldocks Cave/My Cave/Cyclops Cave/Sassafras Cave).
- The Marakoopa system (Marakoopa 1, Marakoopa 2/Devils Pot/Snailspace Cave).

- The Kubla Khan system (Kubla Khan/Genghis Khan/Kubla Khan efflux).
- The Mill-Kansas system (Hidden Cave/Tatana Magra/Shooting Star Cave/Croesus Cave/Rubbish Heap Cave/Lynds Cave/Rathole/Mill-Tailender Cave).
- The King Solomons system (Execution Pot/Little Trimmer/Lime Pit/Kohinoor/Maze Puzzle/Diamond/King Solomons Cave/Soda Creek Cave).
- Dogs Head-Union Cave system.
- Mersey Hill-Den Cave system.

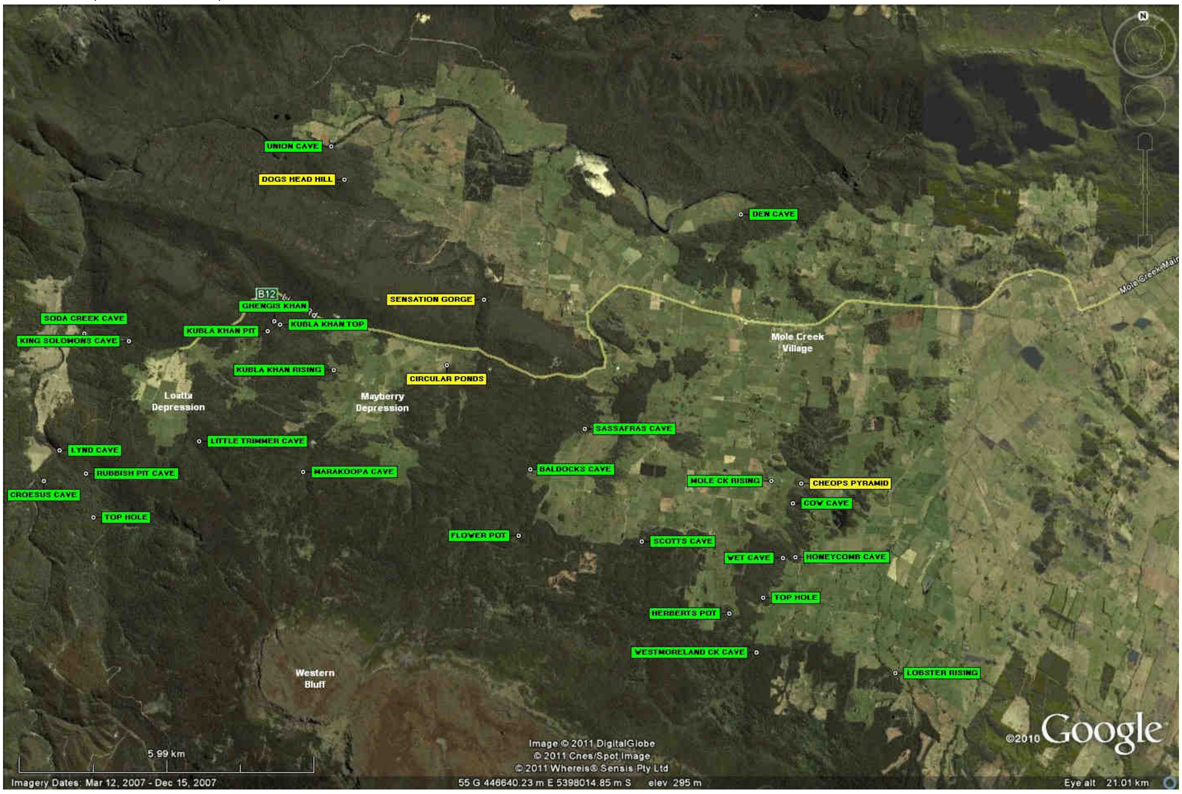


Figure 4. Distribution of the major caves at Mole Creek.

Many caves contain large stream passages developed primarily through vadose solution, including the major Mole/Lobster caves, Croesus, Lynds, Marakoopa, Sassafras and Prohibition caves. Other systems show multiphase development, with distinctive epiphreatic and bathyphreatic forms. Development of many of these forms would require rising water under hydrostatic pressure, and slow-moving, nothephreatic speleogens (Jennings, 1985) are notoriously difficult to separate from speleogens resulting from convectional upwelling of warm waters. The upper levels of Marakoopa Cave exhibit cupolas, vertical shafts terminating in domes, and a massive solutional chamber (the Cathedral) which may potentially have resulted from solution by deep-sourced, warm water. However, they may equally have developed in slow moving, deep nothephreatic systems sourced from meteoric groundwater. Solution by sulphuric acid may be responsible for massive chambers (Xanadu in Kubla Khan, and Stargazer Chamber in Shooting Star) where sulphide-rich palaeokarst sediments are found. Once drained, salt wedging (gypsum) processes in both of these caves has continued stoping roofs and walls.

The Mole Creek caves are internationally famous for their spectacular speleothems, comprising many different forms of calcite, aragonite and gypsum. Kubla Khan, Croesus, Marakoopa, King Solomons and Shooting Star Caves, Herberts

Pot, Mersey Hill and Shish Kebab Cave contain the most diverse and well developed suite of speleothems in Tasmania and potentially in Australia. Kubla Khan (including Ghengis Khan) is renowned for its range of calcite, aragonite and gypsum forms, both in scale and extent (Figure 5). Croesus Cave contains a spectacular set of gours, almost one kilometre in length, along its main streamway. These gours contain large masses of nodular concretions, similar to cave pearls but far more coarsely crystalline. Shooting Star Cave contains massive aragonite flowers, extensive frostwork and extensive deposits of gypsum hair and flowers. Gypsum is also spectacularly displayed in Herberts Pot and Mersey Hill Cave, with spectacular aragonite in Shish Kebab Cave.

Figure 5. The Pleasure Dome, Kubla Khan. Photograph courtesy of David Wools-Cobb.

Many Mole Creek caves contain fluvio-glacial sediments derived from invasive meltwater streams. Croesus and Lynds Caves, Marakoopa 1 and 2 and Kubla Khan are excellent examples. Massive diamictites composed of angular dolerite boulders up to 2 m in diameter are found in Marakoopa Cave, most likely derived from mass movement of slope deposits in the catchment. These are likely to be related to regional periglacial processes during the last glacial stage.

Significant bone deposits are found in the caves, including owl-roost deposits in caves in the Sassafras area. Much bone material was excavated from red earth in King Solomons Cave during track development, with extinct megafauna being recorded. Pig Sty Cave and Kutna Hora also contain bones from megapodes no longer inhabiting the district.

Hydrology

The Mole Creek karst is hydrologically complex, with mature subsurface drainage networks commonly breaching apparent surface divides. This drainage modification has been determined by rock structure in combination with the effects of surficial sediments (Kiernan, 1984, Figure 6) (and potentially basalt flows) throughout the Cainozoic. It is very common for the larger caves in the district to be oriented along the strike of limestone beds, whilst surface valley morphology has been primarily controlled by the hydraulic gradient of streams. This has produced a generally N-S direction for surface valleys in response to the uplift of the Western Tiers, compared with primarily NW-SE orientations of major cave passages.

Glacial and periglacial deposits have blocked cave passages in some systems, returning streams to surface flow in glacial stages, and re-excavating passages in wetter, more stable interglacials (e.g. Marakoopa Cave). In other areas (the Mole-Lobster system for example) fluvioglacial and periglacial deposits have deflected drainage onto valley margins to develop peripheral channels and subsequently caves (Jennings & Sweeting, 1959).

Subsurface drainage divides are often very difficult to define, as at times they occur under the floors of solutional basins. The divide between the Kubla Khan drainage and Soda Creek system is likely to be rapidly changing as cave systems are captured underground. Subsurface divides in the Mill-Kansas area are similarly complex, as Croesus Cave waters have not yet been totally captured by the Lynds and/or Mill/Tailender systems.

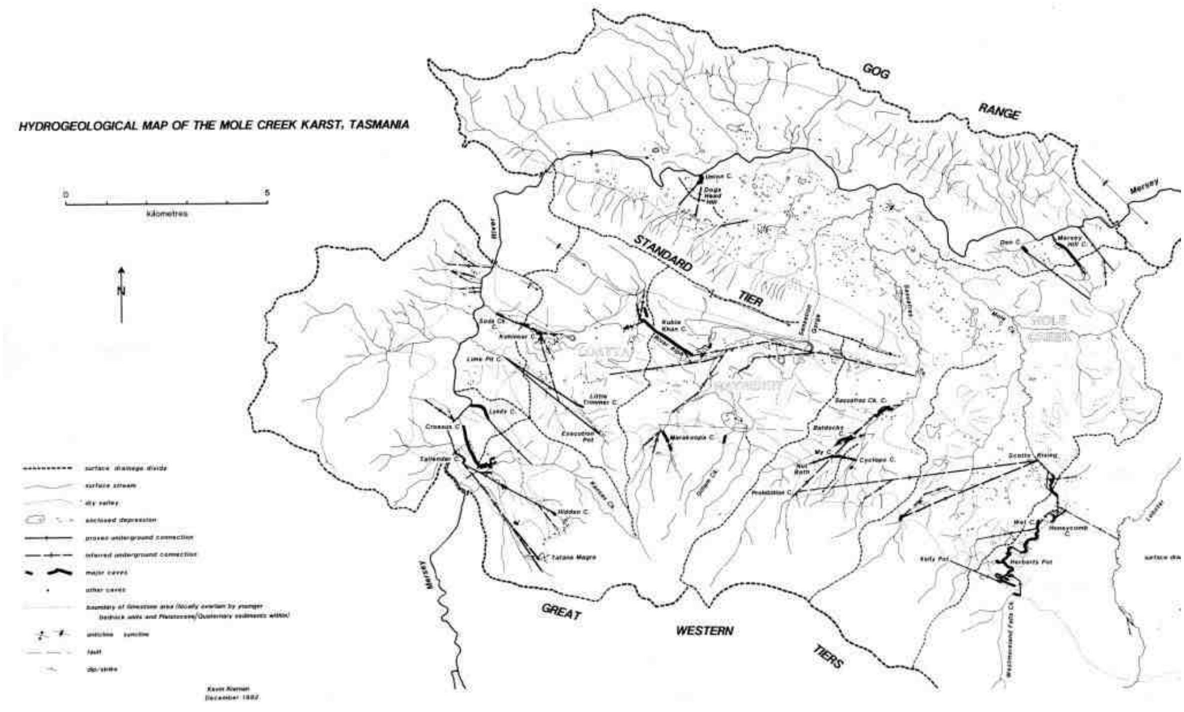


Figure 6. Hydrogeology of the Mole Creek karst (Kiernan, 1984).

Biodiversity

Cave fauna

The Mole Creek karst contains a diverse invertebrate cave fauna, with over 80 species recorded. Three species are known to be endemic to the area, *Tasmanotrechus cockerilli* (cave beetle), *Hickmanoxyomma gibbergunyar* (cave harvestman) and *Pseudotyrannochthonius typhlus* (cave pseudoscorpion). All three species are listed as rare under the State Threatened Species Protection Act 1995.

Baldocks Cave is considered to be particularly important for protection of these threatened species, as all three are present there. The cave is also the type locality for the Tasmanian Cave Spider, Hickmania troglodytes.

Kubla Khan Cave contains the highest diversity of invertebrate species recorded in Tasmania, with 71 species present.

Surface fauna

Along with a wide range of common marsupials and rodents, the mole Creek area is habitat for many bat species, some which use the entrances of caves. The Tasmanian Devil (*Sarcophilus harrissi*) and Eastern barred bandicoot (*Parameles gunnii gunnii*) are listed as vulnerable under the Threatened Species Protection Act 1995.

Boobook Owls (*Ninox novaeseelandiae*) have been recorded roosting in cave entrances. The area is also habitat for two raptors listed under the Threatened Species Protection Act 1995, the Wedge-tailed Eagle (*Aquila audax fleayi*) and the Grey Goshawk (*Accipter novaehollandiae*), both of which are endangered.

Surface flora

The predominantly flat-lying country with deeper soils (primarily developed on fluvioglacial materials) was cleared for agriculture from the 1850s onwards. Significant forestry activity has been undertaken since the beginning of the 20th Century. Most of the lowland environment is therefore considerably modified from natural. Small cave reserves (now part of the disjunct Mole Creek Karst National Park) provide refuge for native plant species within this context. More contiguous areas of native forest and woodland are found on the mid to upper slopes of the karst area and its catchments, although some of these areas on private land are currently being converted to tree plantations.

Habitats range from alpine herbfield and grasslands on the Central Plateau to the south, through sub-alpine woodlands, grasslands and stunted rainforest, to tall wet sclerophyll forests dominated by *Eucalyptus obliqua*, *E. delegatensis* and *E. regnans* on the mid slopes of the Western Tiers. Limestone outcrops generally support grassy forest dominated by *E. viminalis*. Lower marshy areas support *E. ovata*, whilst drier slopes of the internal, sandstone ridges carry open *E. amygdalina* woodland.

Dolines form refugia for lowland rainforest species *Nothofagus cunninghamii*, *Atherosperma moschatum*, *Pittosporum bicolour* and *Monotoca elliptica.* Numerous fern species are common in dolines and damp gullies.

Some drowned dolines contain striking peatlands dominated by *Sphagnum falcatulum*. These are very rare communities and are dependent on the maintenance of groundwater hydrology.

Six species are listed under the State Threatened Species Protection Act 1995: *Acacia mucronata var dependens* (rare), *Desmodium gunnii* (vulnerable), *Epacris exserta* (vulnerable), *Glycine microphylla* (vulnerable), *Pimelea pauciflora* (rare), *Pomaderris phylicifolia* (rare). *E. exserta* is also listed under the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 as endangered.

Cultural diversity

Aboriginal heritage

Surprisingly little archaeological research has been undertaken in the Mole Creek area, with no formal record of Aboriginal cultural material from the caves. Historical records show that large ochre mines in the Gog Range to the north of the karst were important sites, and that the majority of people lived in and used the resources of the Mersey Valley. The Honeycomb Cave area is important to contemporary Aboriginal people living in the Mole Creek area. Hunter (2008, citations removed) states:

> The country of the *Pallittorre* Aboriginal people was not an untamed land hosting passive human inhabitants. British colonists of the 1820s remarked on the “luxuriant pastures” of the “extensive plains” of the district. This was the character of the landscape that resulted from careful management practices of the Aboriginal custodians of the land. Grasslands or meadows were maintained by traditional burning practices, interspersed with copses and woods, lightly burned. The landscape was managed to sustain the hunter-gatherer lifestyle and to keep back the forest that was spreading over the island as the climate warmed and became more humid after the most recent ice age.

The study area has been frequented by Aboriginal people since at least the end of the last ice age, if not much earlier. Their permanent settlement of the district commenced about 3,500 years ago (Hunter, 2008). A network of pathways was established by the Aborigines along the base of the Tiers, south over the Tiers, north over the Gog Range and north-east to Port Sorell, for the purposes of trading, ceremony and hunting.

European heritage

Early European settlement of the Mole Creek area was related to the development of the Van Diemen's Land Company road through the karst area in 1827. Parts of this road's original formation still survive in the Liena area, whilst the main road from Mole Creek past King Solomons Cave follows the original alignment. Not long after, important caves such as Wet Cave, Honeycomb Cave, Sassafras Cave and Cyclops Cave were discovered.

Wet Cave was used for commercial tourism from these early years intermittently to the present day. King Solomons and Marakoopa Caves were discovered in the early 20th Century, and today from the centre of the district's tourism industry, attracting over 40,000 people per year.

Hunter (2008, citations removed) states:

The colonists arrived with their stock in the early 19th century along Pallittorre pathways, to settle the "Westward", a general term for the area around and west of Deloraine (to Mole Creek), establishing several large agricultural estates. The large colonial estates included Wesley Dale in the Mole Creek valley. However, it was during the subsequent phase of colonisation by smallholders in the second half of the 19th century that the transformation of the landscape began in earnest, as small bush blocks were cleared in the valley. Agriculture diversified, coinciding with the Victorian goldrush of the 1850s, the rapid growth of the Australian colonies and increasing demand for primary produce. A new rural community arose in the district, as small holdings were purchased and forged into farms across the Mole Creek valley. The pathways from the valley up onto the Tiers have been used subsequently for recreation, fishing, hunting, trapping and snaring.

The first Europeans to record caves of the area was a group of surveyors working on a rail route to the west coast in the 1830s. Some caves of the study catchment were known and at least partly explored in the 19th century. Soon after the turn of the century, the present show caves, Marakoopa and King Solomons Caves, were discovered and their potential quickly appraised. The Tourism Department had purchased several blocks of land containing cave entrances by the 1920s to allow for dedicated tourism use. The former show caves Scotts and Baldocks were closed early last century due to discolouration of the decorations by smoke from acetylene lighting. The famous James Wiburd from Jenolan made several visits to Tasmania to advise on cave lighting and development. A memento of his visit is held in the Queen Victoria Museum in Launceston (Figure 7).

Figure 7. The Palm Tree, Marakoopa Cave. Left: Photograph by James Spurling III, 1911. Image courtesy of Nic Haygarth. Right: Carving on hardwood by James Wiburd, 1917. Photo courtesy of & copyright by: Queen Victoria Museum and Art Gallery Tasmania, and Parks and Wildlife Service, Tasmania.

Prior to development of these caves, Scotts and Baldocks Caves were developed for tourism, involving the excavation of massive quantities of cave earth and gravel to provide access. Lighting was provided by acetylene generators. Scotts, Baldocks and King Solomons Caves all preserve remnants of these carbide lighting systems, considered some of the best preserved examples of early Australian cave illumination (Figure 8).

Figure 8. Acetylene generator, Scotts Cave. Photograph courtesy of Deborah Ward.

Much of the early agricultural development of the district was constrained by karst hydrology, with the plains between Caveside and Chudleigh frequently inundated in winter as karst springs overtopped, but bone dry in summer as water tables rapidly dropped though drainage into karst systems. Elaborate drainage networks were excavated, often by convicts. Ironically, equally elaborate water supply systems were necessary to supply dairy herds in summer months. The 'nine-foot' channel was created by constructing a water race around the entrance to Westmorland Cave (which previously engulfed all of the Westmorland Creek flows), providing a water supply to lowland farms. Similar systems were developed on the Lobster Rivulet and, later on Kansas Creek. A large fluid-bed landslip down the Westmorland Creek valley in 2010 has resulted in almost complete return of subsurface flows to the previous dry valley below Westmorland Cave, frequently inundating farmland, and now requiring a complex management response to maintain both agricultural and natural values (see Hunter, this volume).

Aesthetic values

Mole Creek combines a patchwork of farms, small settlements, plantation forestry and reserved lands on the flat valley floors with densely forested slopes rising to the spectacular cliffed escarpment of the Central Plateau.

Spectacular surface features such as the Devils Pot, limestone cliffs in the vicinity of Liena, the Mersey Gorge at Alum Cliffs, Westmorland Falls, Lobster Falls and Sensation Gorge are scenic attractions in their own right.

The Mole Creek caves, both the tourist caves and wild caves, are nationally famous for their speleothem displays. Kubla Khan, Croesus, Shooting Star, Lynds, Marakoopa and King Solomons Cave are outstanding. Glow-worm displays in Marakoopa Cave, whilst not as spectacular as those at Ida Bay, are nonetheless a significant attraction.

Scientific research

The karst system has received a moderate amount of scientific attention, including on geomorphology (Jennings, 1967; Jennings & Sweeting, 1959; Jennings & James, 1967; Kiernan, 1984, 1989), hydrology (Kiernan, 1984; Eberhard & Houshold, 2002), cave sediment studies (Burns, 1960; Kiernan, 1984; Goede & Harmon, 1983; Treble, 2003), water chemistry (Kiernan, 1984, 1989; Eberhard & Houshold, 2002), and palaeoenvironmental reconstruction (Goede, 1981; Goede et al, 1982, 1986, 1990). An expanded list can be seen in the References and Bibliography below. Unfortunately, as Osborne (2010) points out much of this important material is in the so-called 'grey' literature.

Tourism and recreation

The two show caves (Marakoopa and King Solomons) are the district's most important tourist attraction, although privately run, commercial wild cave tour operations are becoming popular. Around 40,000 visitors come to King Solomons and Marakoopa caves each year.

The caves have long been very popular with local, mainland and international cavers, primarily because of their spectacular speleothem displays. A trip through Kubla Khan or Croesus Caves at Mole Creek is considered a privilege as access to these fragile systems is restricted to 72 and 154 people annually.

Management

Management of the Mole Creek karst is fraught with difficulties given the range of land uses and tenures – let alone the complexity of the karst systems with their overprints of glaciation, erosion, sediment deposition and landscape evolution generally. Issues include:

- Multiple tenure types;
- The fragmented nature of the Mole Creek Karst National Park (MCKP) – 12 widely separated blocks in no way related to hydrologic systems;
- Agriculture (and associated land and water management issues);
- Forestry – in both native and plantation forests;
- Limestone mining, particularly with the potential for future developments;
- Tourism;
- Urbanisation; and potentially
- Climate change.

Fortunately much of the work of Kiernan and others has been directed at understanding the systems, improving management practices on reserved lands and on other tenures and in extending the reserve system. The references and bibliography below give an indication of the scope of work so far. There is probably a better understanding of the management needs – and of the systems themselves – than in any other karst area in Australia. The scope of management related documentation extends from basic science (e.g. water quality studies for Mole Creek; Eberhard and Houshold, 2002) through to management plans for individual caves (e.g. Kubla Khan; Spate, 1991) to approaches for whole hydrologic systems across differing tenures (e.g. for the Mill-Kansas system).

In a probable Australian 'first' the Meander Valley Council has commissioned a study by a karst professional leading to a Planning Scheme zoning the Mole Creek karst part of the Council area in terms of karst sensitivity (Figure 9).

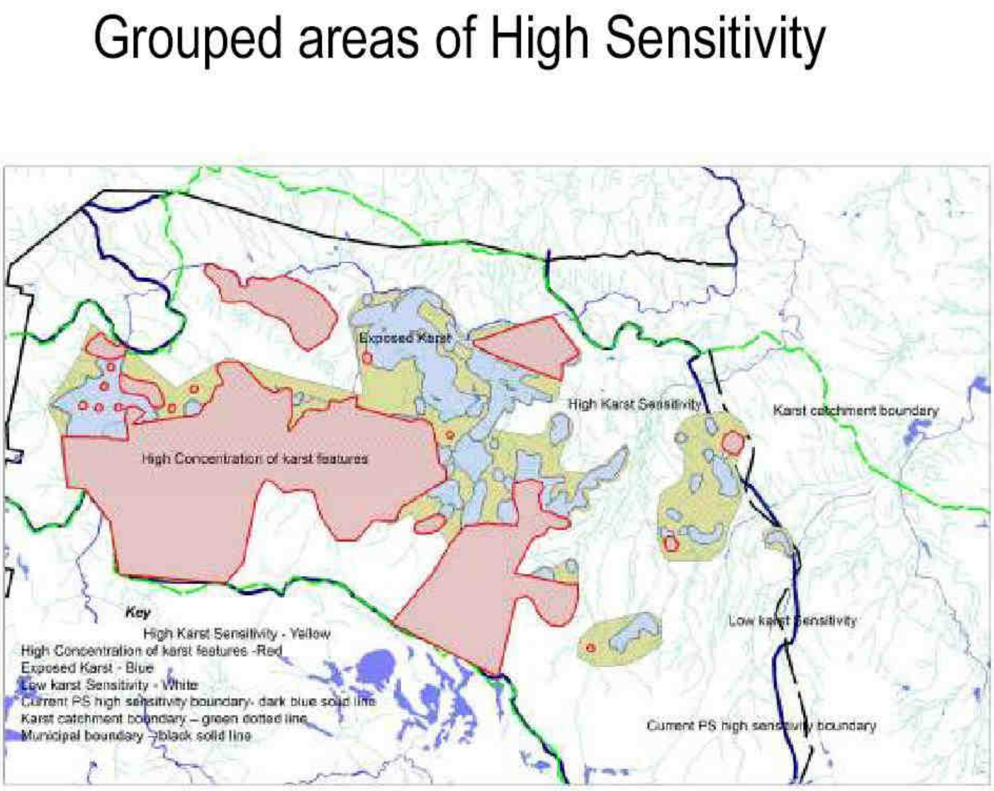


Figure 9. Meander Valley Council's 2008 Planning Scheme – high sensitivity karst areas.

Another initiative to be applauded includes the activities of the local karst care group – carrying out restoration and track marking in caves and vegetation replanting on the surface. Natural Resources Management North, in conjunction with the Australian Government, have recently published an excellent booklet titled *Living on Karst: A guide to Understanding Our Karst Landscapes.* This twelve page booklet is perhaps the best example of this type of community-directed information that we have seen.

Assessment of significance

Nothing that has happened since Jennings'1963 statement quoted above has lessened the undoubted significance of the Mole Creek karst. Indeed, at a meeting of karst specialists convened by the Commonwealth Department of the Environment, Water, Heritage & the Arts in 2006, Mole Creek was identified as one of 15 most important karst sites across the continent (Ambrose et al, in prep). Its inclusion in the Tasmanian Wilderness World Heritage Area gives it a measure of international significance – although the karst values of Mole Creek are not explicitly listed in the World Heritage documentation. The levels of significance of the Mole Creek karst can be summarised as follows:

- Evolutionary history – National
- Rare features and processes – National
- Representativeness – National
- Research – National
- Beauty and grandeur – National
- Cave tourism – Regional
- Speleology – National
- Economic - State

Comparable Australian systems

As with the Junee-Florentine system, the Mole Creek karst should logically be assessed in the context of all other impounded karst systems of the Eastern Highlands and associated basins of Australia. Similar lithology and rock structure, climate and palaeoenvironmental history to that of many of the karst systems from the Sydney Basin south sets a logical context area for comparison. Whilst the Junee-Florentine area possesses the most complex and best developed subsurface hydrological system it is likely that Mole Creek contains the best developed suite of surface karst landforms in this context. The karst areas in the southern part of the Lachlan Fold Belt on the mainland do not have the hydrologic dynamics and complexity of Mole Creek.

In terms of its evolutionary history, palaeokarst deposits at Mole Creek are recognised, but have not been researched. The proximity of the karst to Permo-Triassic sediments, often directly overlying an erosional surface on limestone, makes palaeokarst deposits highly likely to be widespread. Solution by hydrothermal systems and sulphuric acid rich waters may have produced some karst landforms and cave passages. Whilst these values are currently speculative, glacio-karstic interactions at Mole Creek are proven, and probably the most significant in the country. Prof Joe Jennings wrote:

> … glacial moraines reach very close to the caves so there is a good possibility here of unravelling the effects of glacier advance and retreat on cave development in a manner for which the opportunity appears rare in Tasmania and is nowhere present on the mainland. The opportunity in this particular direction is, I think, greater than at Exit Cave near Ida Bay. (Jennings, 1980)

The diversity, scale and quality of calcite, aragonite and gypsum speleothems in the Mole Creek caves is nationally significant, comparing well or better than similar karst systems elsewhere in the Eastern Highlands.

Acknowledgements

This paper was specifically commissioned by the convenors of the Nineteenth ACKMA Conference. Many contributed ideas, encouragement and images. These include Cathy Plowman, David Butler, David Wools-Cobb, Deb Hunter, Nic Haygarth, Arthur Clarke, Greg Middleton and Chester Shaw. Our sincere thanks to these and any others we may have inadvertently omitted. Special acknowledgement should go to Kevin Kiernan for his thorough and detailed analysis of the Mole Creek karst over many years. We also sincerely acknowledge the work of numerous cavers, scientists and natural historians who have been drawn to this fascinating landscape and given freely of their time in exploration, documentation and interpretation, it is by "standing upon the shoulders of giants" many cavers and scientists provided a platform for Kevin, and, indeed, ourselves.

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Dan Pickett: Pioneer Cave Guide

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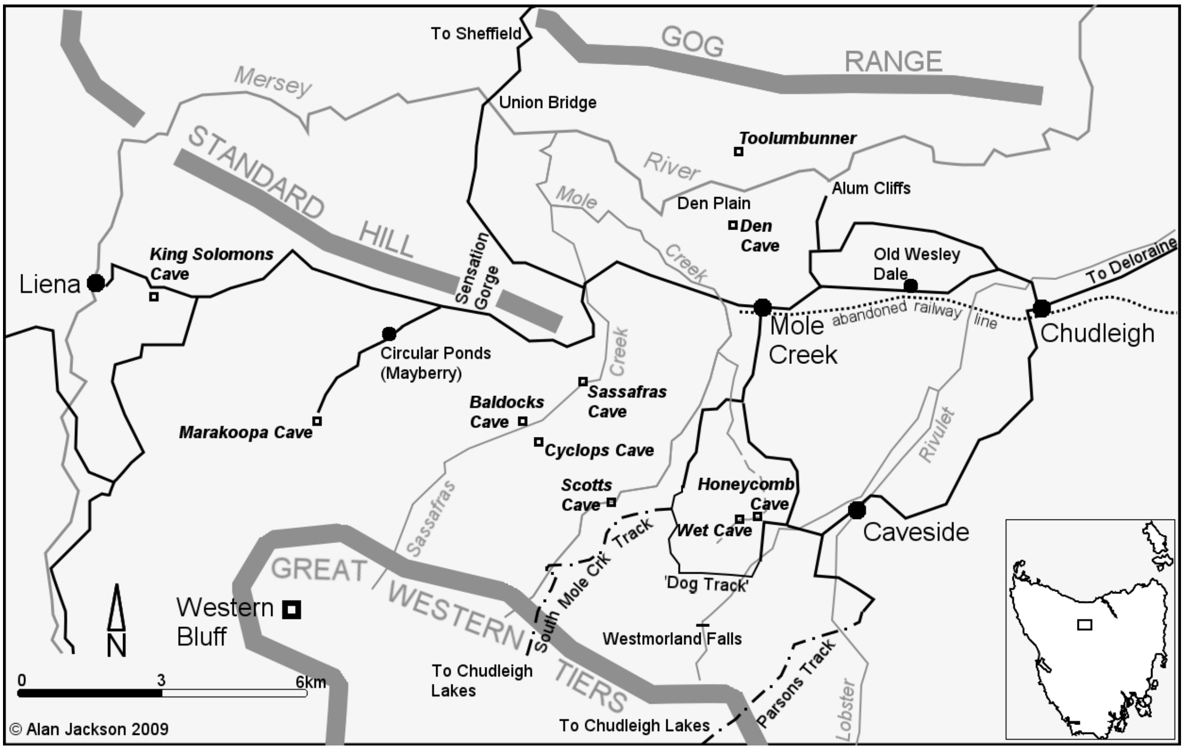
Abstract

Dan Pickett, the house-breaking son of a Berkshire 'strumpet' may have been Australia's first professional cave guide. In his adopted home, Tasmania (Van Diemen's Land), the ex-convict host of the Chudleigh Inn cultivated a reputation as a vice-regal guide to Wet Cave, probably in order to reinvent himself. Separating fact from fantasy in Pickett's career is not easy. In the tradition of cave gurus elsewhere, he took on an heroic status as underground explorer. Despite his age being the subject of legend, however, Pickett did not achieve immortality. He is buried in an unmarked grave, anonymous in death as he was at birth.

Introduction

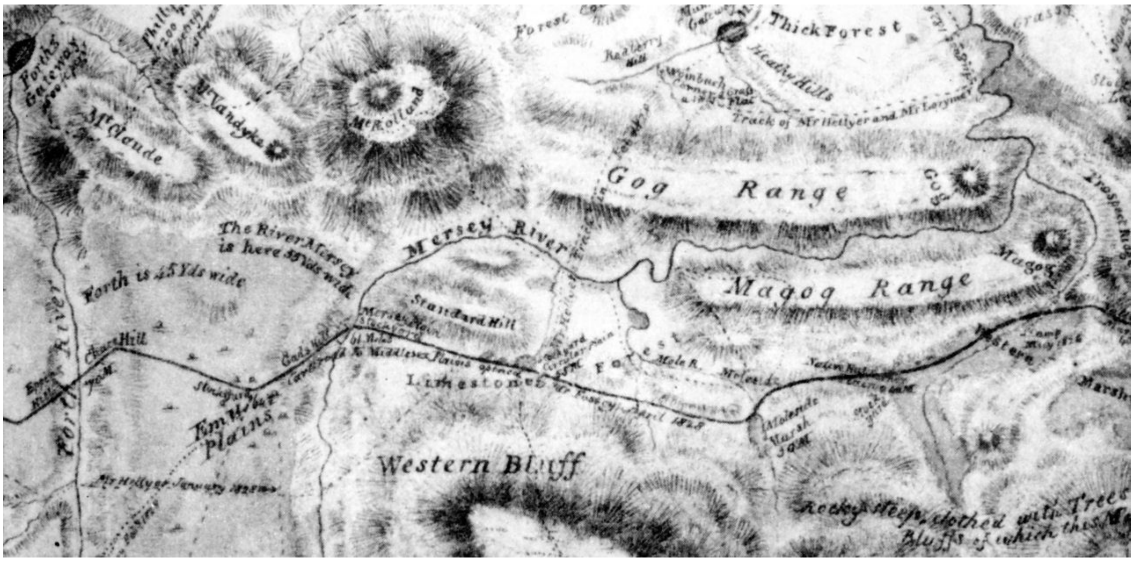
In 1873, in writing a travelogue about his time spent in Australia and New Zealand, British novelist Anthony Trollope turned a Tasmanian country publican into a minor celebrity. Trollope's picturesque description of how Dan Pickett guided him and Governor Charles Du Cane through Wet Cave gave rise to a legend. Over the course of the last 26 years of his life, enjoying his new fame, Pickett regaled his interviewers with colourful tales of a pioneering past which included more than three decades of vice-regal patronage. Rather than gaining immortality, however, a man whose life began in the most ignominious circumstances today lies in an unmarked grave. Was Pickett one of Australia's earliest cave guides and cave tourism operators, or did he re-write his own history as a self-promoting ex-convict who wanted to be somebody else?



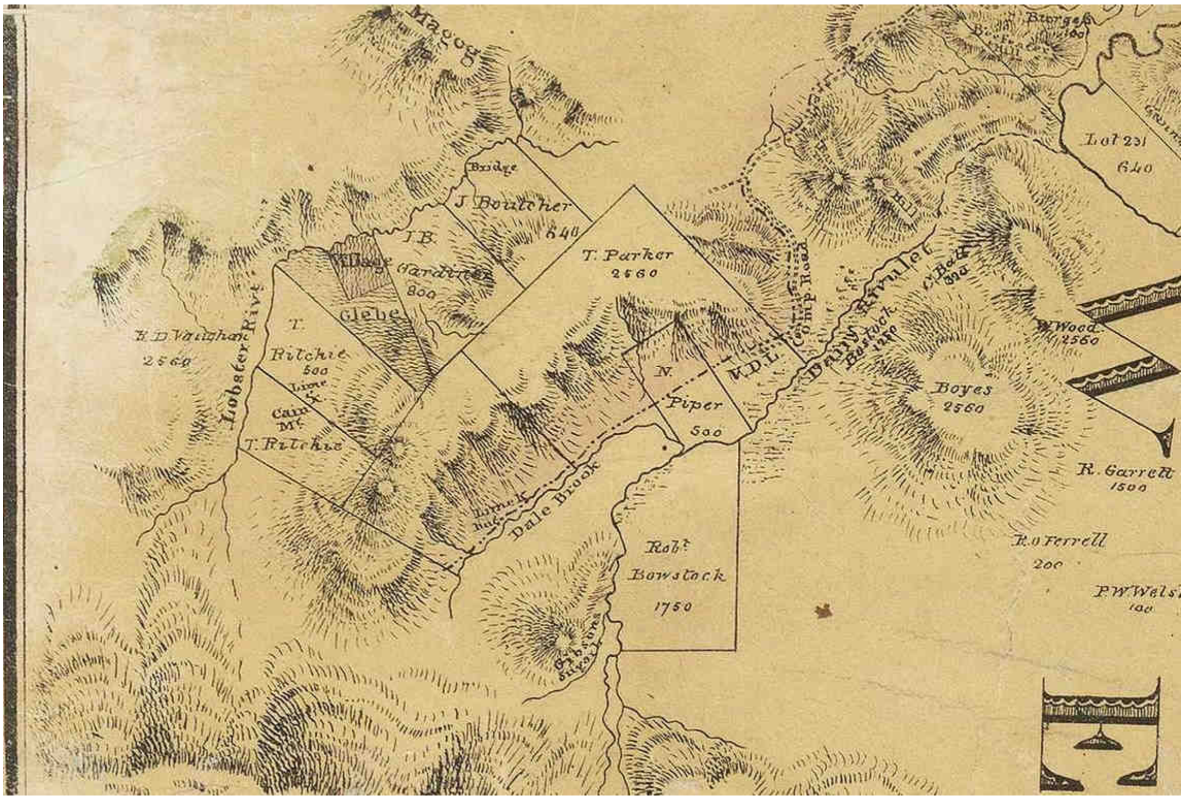
General map of the Chudleigh-Mole Creek district, showing the positions of Wet Cave, Chudleigh and Old Wesley Dale. Map by Alan Jackson.

Mole Creek flowing out of the main entrance of Wet Cave. Photo by Nic Haygarth.

Dan Pickett was born in Berkshire, England, probably in 1813, the son of a prostitute. His baptism record gives his name as 'Daniel Picket' and his mother as 'Lucy Picket'.[1] In 1832, as 'Daniel Piggott', he was sentenced to transportation to Australia for life for housebreaking. His Conduct Record bears a note that he had earlier been imprisoned on suspicion of highway robbery, and that he had 'very bad connexions'. Pickett was described as 5 feet 6½ inches (168 centimetres) tall, with brown eyes, brown hair, a small, sharp nose and small mouth.[2] He arrived in Hobart on the *Jupiter* in May 1833, and was assigned to Lieutenant Travers Vaughan, whose property 'Native Hut Corner', as the name suggests, occupied Aboriginal land on the frontier of European settlement.



This detail from Henry Hellyer's 1828 'Camp Drought' map shows the location of 'Native Hut Corner' (right, south of 'Magog Range') and also the known existence of karst at Circular Ponds ('Limestone Forest'). Courtesy of the Van Diemen's Land Company.

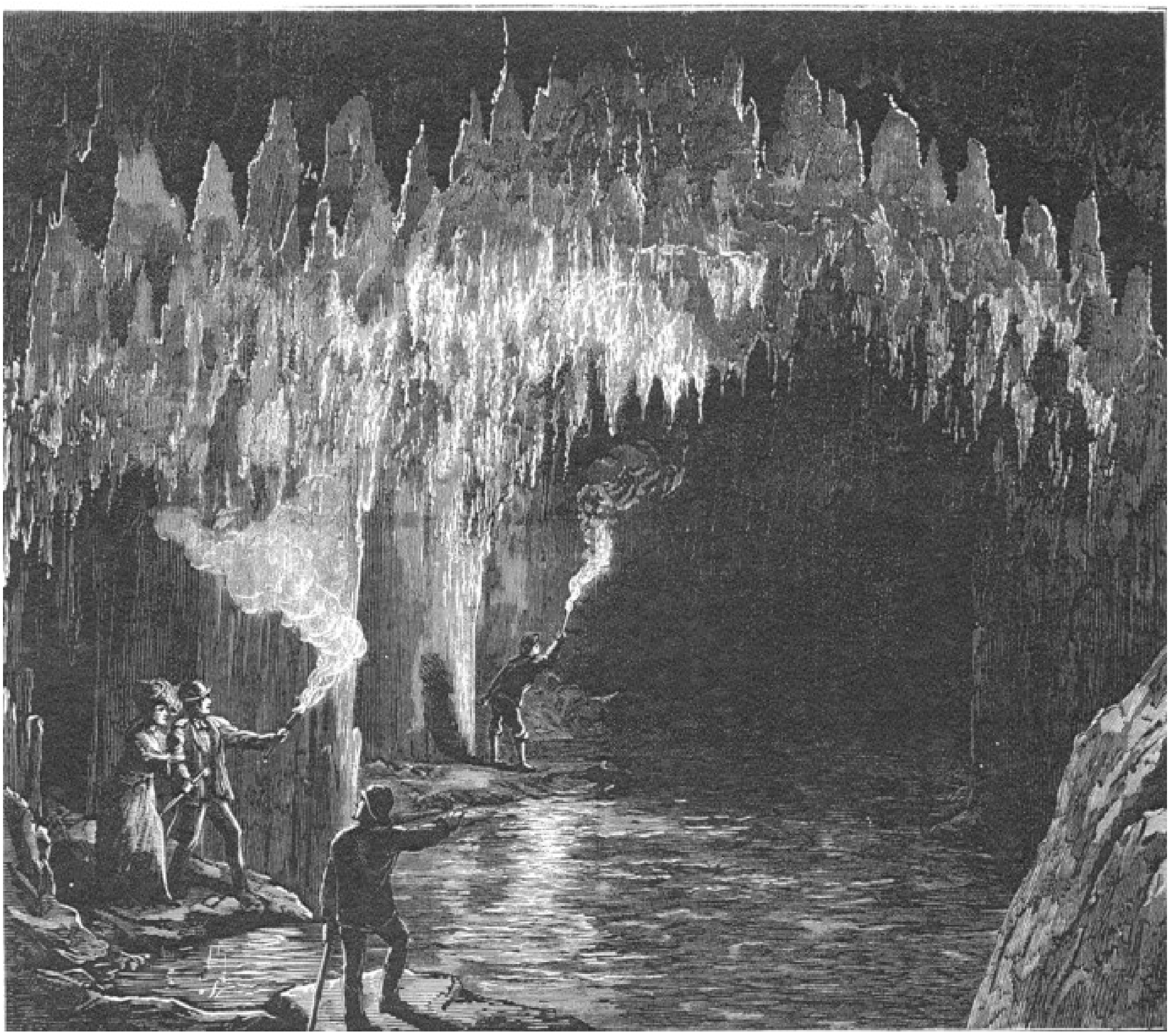


This detail from JL Hughes' 1837 map of northern Tasmania shows the surveyed 'village' (Chudleigh) and Vaughan's 'Native Hut Corner' property (left), soon to become 'Wesley Dale'. Lime kilns are being worked on Thomas Ritchie's property and along Dale Brook. Courtesy of the State Library of Tasmania, Launceston.

Although Wet Cave does not appear on JL Hughes' 1837 map of northern Tasmania, it had probably been discovered by this time. George Augustus Robinson, the so-called 'conciliator' of the Tasmanian Aborigines, visited a cave at 'Moleside Creek' with Godfrey Bentley, Travers Vaughan's nephew, in July 1834. 'There are several caves on the Moleside Creek,' Robinson noted, 'one [possibly Honeycomb I Cave] about one hundred yards long and lofty.'[3] 'Native Hut Corner' was Robinson's supply depot and staging post in the Mole Creek region in 1832 and 1834.[4] Bentley and Vaughan's servants apparently explored the area: they guided Robinson to the 'Moleside Creek' caves and to the fishing spot near where Robinson entered Mersey Hill Cave. Although there is no record of Pickett claiming to have discovered Wet Cave, it is possible that he knew of it by the time of Robinson's final visit to the area in July 1834.

Robinson described Vaughan as 'kind hearted' but in 'embarrassed circumstances'.[5] Perhaps the latter remark explains why in 1837 Vaughan sold 'Native Hut Corner' to the merchant and Wesleyan lay preacher Henry Reed, who renamed it 'Wesley Dale' (today it is known as 'Old Wesley Dale').[6] Pickett passed into Reed's employ. Reed was known to be a benevolent master who even allowed his charges alcohol in moderation.[7] Pickett himself is quoted saying that Reed 'never during his whole life had a single man punished'.[8]

Despite one misconduct charge, Pickett's progress from this point was steady. In 1841 the 26-year-old received a ticket of leave, and in the same year he married 17-year-old Mary How (or Howe), the daughter of free-born immigrants.[9] They had the first of their 15 children in 1842.[10] By the following year, in which the couple's second child was born, Pickett was overseer on a Dunorlan property not far from 'Wesley Dale'.[11] Later he rented farms, the final one being part of the 'Wesley Dale' estate, and he carted lime from Chudleigh to Launceston by bullock team.[12] In July 1845, 13 years after his conviction in Berkshire, Pickett was pardoned.[13]

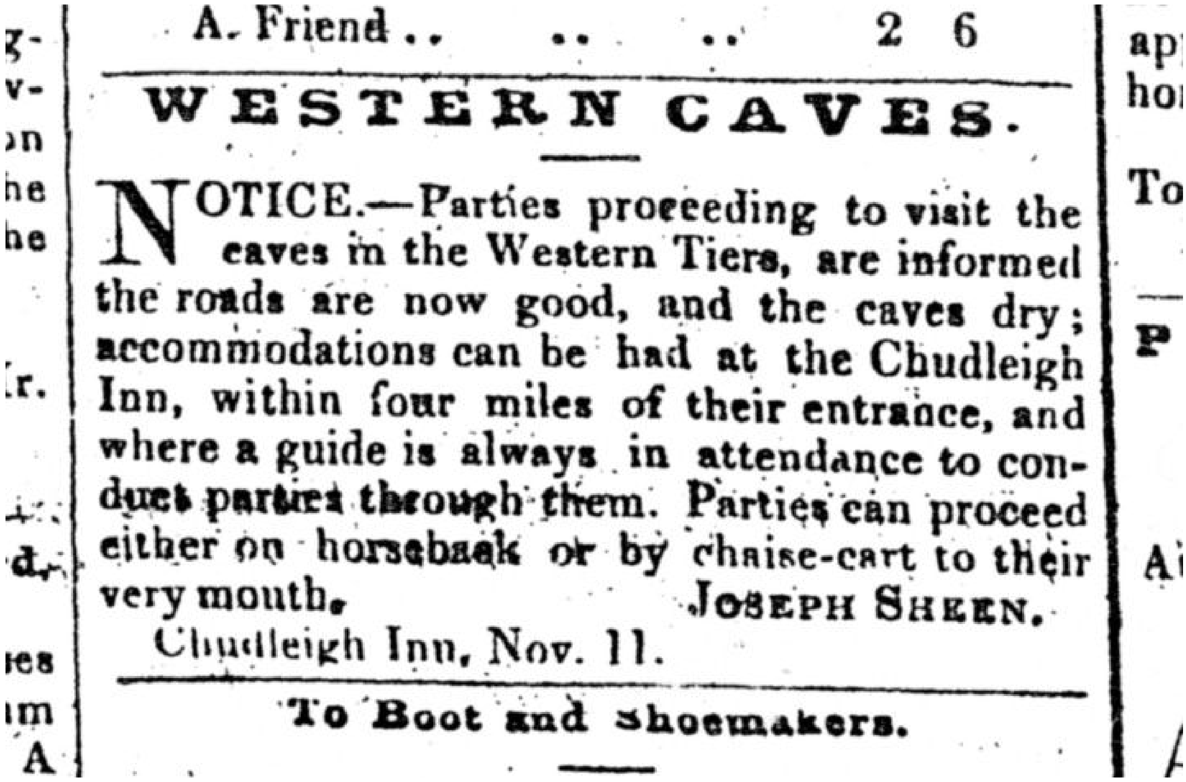


Bark torches light the way in 'Oakden's Cave [Wet Cave], near Chudleigh, Tasmania'. From Illustrated Australian News 1877.

Few people visited Wet Cave at this time. The earliest known report of sightseers in the cave is of an unguided trip in 1840.[14] Three years later William Breton made the first known report of Tasmanian cave fauna when he described glow-worms in Wet Cave.[15] Although Europeans found and explored limestone caves elsewhere in the Australian colonies at an earlier stage, Wet Cave appears to have been Australia's first tourist or show cave.[16]

The Chudleigh Inn in its heyday and as it appears today. The top floor was removed from the building in 1937. Old photo from the Western Tiers newspaper courtesy of Bill James. Modern photo by Nic Haygarth.

The catalyst for this development was probably the establishment of the Chudleigh Inn in 1850 by John Ritchie, with William Motton its first licensee.[17] The solid stone building still stands as a private home on the eastern edge of the Chudleigh village opposite the old Van Diemen's Land Company store. In 1851 Motton transferred his public house licence to Joseph Sheen, who was the first to advertise the Chudleigh Inn as the gateway to the Westward Caves, as he called them, and a guiding service through those caves.[18]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WESTERN CAVES.

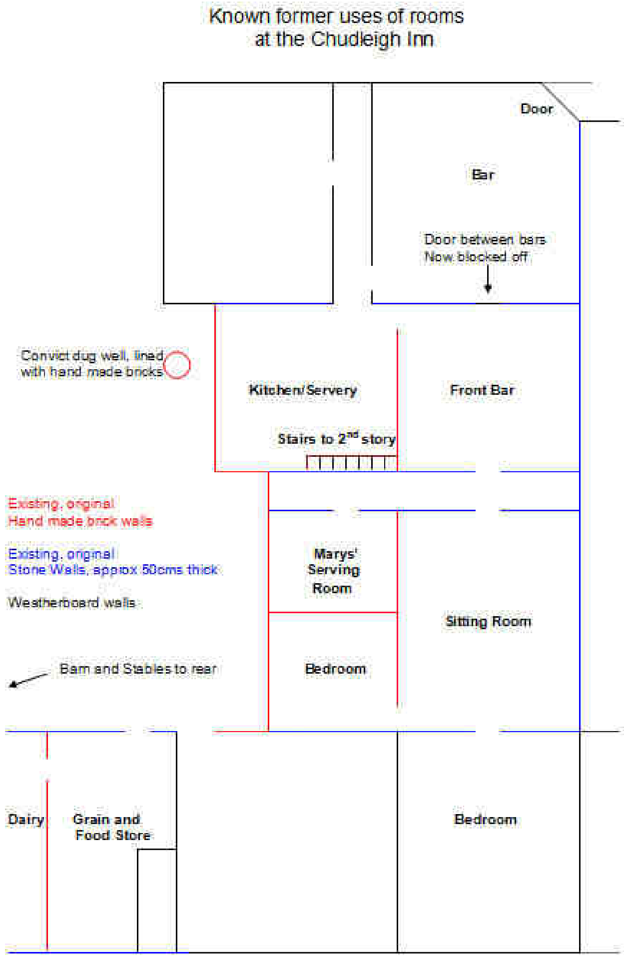
NOTICE.—Parties proceeding to visit the caves in the Western Tiers, are informed the roads are now good, and the caves dry; accommodations can be had at the Chudleigh Inn, within four miles of their entrance, and where a guide is always in attendance to conduct parties through them. Parties can proceed either on horseback or by chaise-cart to their very mouth. JOSEPH SHEEN.

Chudleigh Inn, Nov. 11.

To Boot and Shoemakers.

Cornwall Chronicle newspaper advertisement from 1851.[19]

In the 1850s Pickett became a man of substance. By 1853 he was licensee and owner of the Chudleigh Inn, had his own dairy and pig farm and even at least one farmhand.[20] His purchase of the inn from John Ritchie for £400 suggests both personal enterprise and financial assistance, possibly from his former master Henry Reed.[21]



Plan of the Chudleigh Inn drawn by Wayne and Margaret Williams. In 1866 one of the Pickett children, Valley, drowned in the well behind the building.

Dan Pickett (centre of photo) outside the Chudleigh Inn. Note the door across the corner of the building, as depicted in the building plan. Courtesy of Bill James.

As the owner of a property worth at least £100, in 1856 Pickett qualified for the inaugural House of Assembly Electoral Roll for Deloraine.[22] He became a sportsman, breeding and racing horses alongside the gentry and other ex-convicts who aspired to a higher status, and his expertise as a ploughman was on show in competitions.[23] In 1875 he represented northern Tasmania in an intercolonial ploughing match.[24] One of his leading racehorses was called Bolivar, presumably named after the South American revolutionary Simon Bolivar (1783–1830). This vague suggestion of left-wing political leanings is not in keeping with Pickett's later identification with the British establishment!

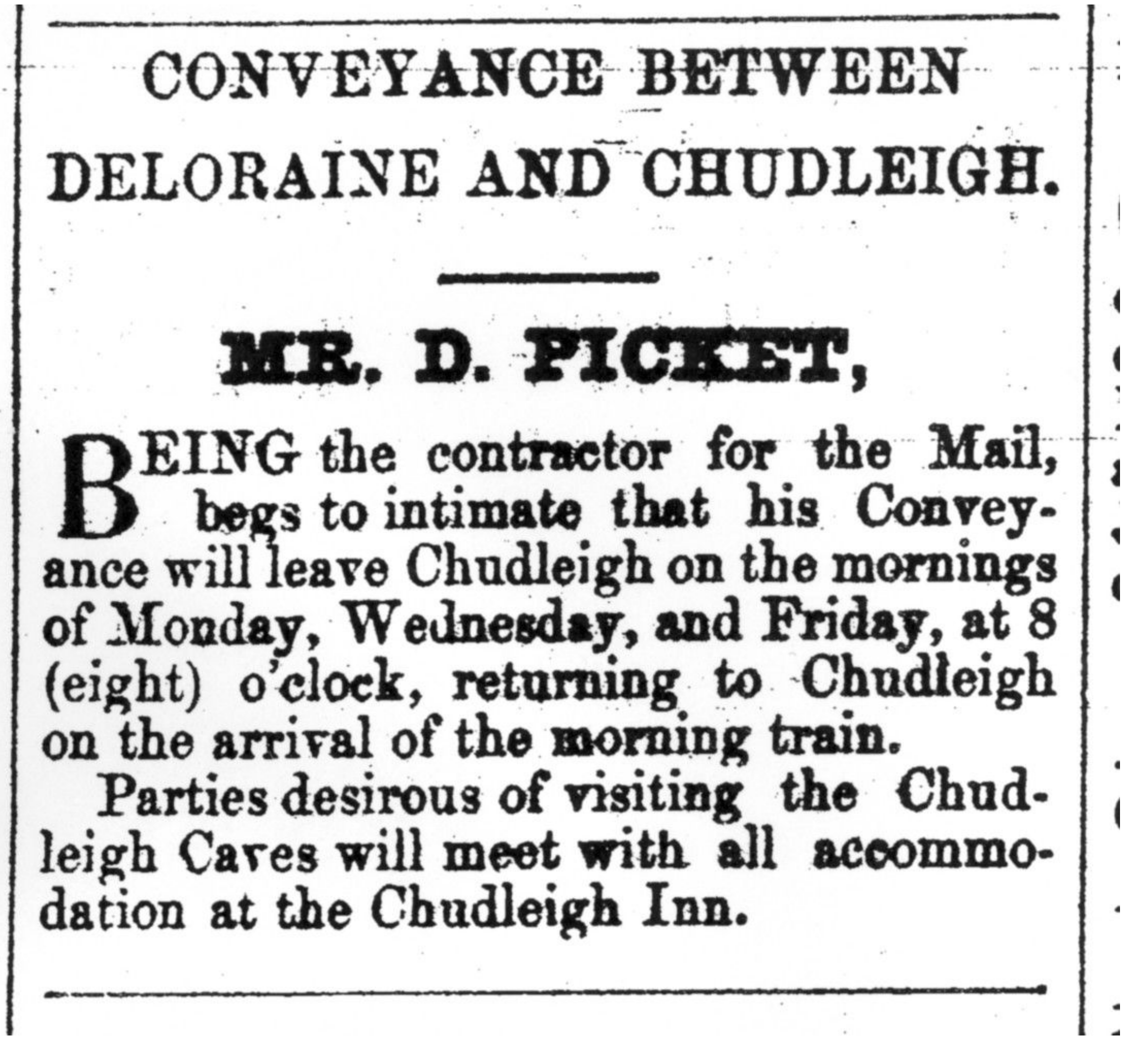
Dan and Mary Pickett in Sunday best. Photo courtesy of Rod How.

As the local hotelier, Pickett was at the centre of village activity, hosting public meetings and even inquests.[25] Like Mary Pickett, who was the local midwife, he was heavily involved in the community, even becoming a provisional director of the ill-fated Mersey River and Devon Tramway between Deloraine and Latrobe.[26] Pickett retained his public house licence for 47 consecutive years, despite two deaths at the Chudleigh Inn as the result of fights, each resulting in a conviction of manslaughter.[27] There were regular thefts from the premises, of which the Pickett family was sometimes the victim, and a near-disastrous fire which killed one man and destroyed a stable, mares in foal, draught horses and harnesses.[28] Pickett secured the contract to carry the mail between Deloraine and Chudleigh, which effectively made him the local passenger and freight operator between the two settlements.[29] He owned and operated a store in the old Van Diemen's Land Company quarters opposite the Chudleigh Inn. By his own enterprise an ex-convict had become the primary businessman of this country village.

He was also a keeper of local lore. In 1865 the surveyor James Calder, while riding east along the Van Diemen's Land Company track, visited a tree stump at the 'Black Heath', somewhere between Circular Ponds and the Mersey River. On the stump now indecipherable words had been scrawled. Calder's guide told him that the words had originally read

> Underneath this lofty bower,
>
> Where I passed my Christmas hour,
>
> Along with those who took the pains
>
> To cut the road to Emu Plains — 1827

The rest of the poem had presumably never been penned or had been obscured on the stump. Upon arrival at the Chudleigh Inn, Calder asked Pickett about the inscription. The publican had also visited the stump and had memorised the verse. He said that it had been written by the bushranger Samuel Britton, then a convict assigned to the Van Diemen's Land Company's track-cutting party. Pickett also revealed that he had once been Britton's hostage.[30] This no doubt referred to Britton's attack on 'Native Hut Corner' in 1833, a few months after Pickett's arrival there. Britton's party apparently forced the assigned convict to carry its booty away from Vaughan's property.[31] Presumably it was during this captivity that Britton told Pickett of his poetics while he himself was on assignment in 1827.


CONVEYANCE BETWEEN DELORAINE AND CHUDLEIGH.

MR. D. PICKET,

BEING the contractor for the Mail, begs to intimate that his Conveyance will leave Chudleigh on the mornings of Monday, Wednesday, and Friday, at 8 (eight) o'clock, returning to Chudleigh on the arrival of the morning train.

Parties desirous of visiting the Chudleigh Caves will meet with all accommodation at the Chudleigh Inn.

Advert for Pickett's mail service, Tasmanian newspaper 3 February 1872, p.16. This suggests that Pickett sold a cave tour package centred on the Chudleigh Inn rather than just his cave guiding service.

So what is recorded about Pickett's involvement with caves? In 1866 he guided a party through Wet Cave—the only documented account of Pickett guiding prior to the Trollope and Du Cane visit.[32] Picket also supplied Chudleigh marble to the Intercolonial Exhibition in 1866.[33] More interestingly, in 1873 Pickett testified in court against Henry Callaghan, a man alleged to have injured 'the Chudleigh Caves', in an incident which prompted the local Deloraine Council to instigate the process of establishing Tasmania's first cave reserves in 1879.[34] Trollope describes Pickett, probably accurately, as an expert horseman in his account of the 1872 Wet Cave visit:

> On our journey an old man attached himself to us, who seemed to have the caves under his peculiar care, and who

> assured us that he had shown all the governors over them. He came out upon us from a public-house, of which he was the proprietor, and promising us that we should have the benefit of his services, followed us on a wonderful rat-tailed mare with which he jumped over every obstruction along the road, and made himself very busy, assuring the governor that no governor could see the caves aright without him, and taking command of the whole party with that air of authority which always carries success with it. I think his name was Pickett. We soon found that we were creatures in Mr Pickett's hand.[35]

Pickett drove them his charges and on through the cave by candle light, assuring them that there was no danger and that there are many wonders still to see. Finally they rebelled and turned back:

> …we were cold to the marrow of our bones, wet through, covered with mud, and assured that, if we did go on, the journey must be made partly on our hands and knees, and partly after the fashion of the serpents.[36]

Trollope's book *Australia and New Zealand*, published in 1873, made Pickett a minor celebrity. It depicted him as the long-term custodian of Wet Cave, a role apparently given vice-regal recognition throughout his time in Tasmania. Pickett told Governor Du Cane that 'he [Pickett] should not enter the cave again till another governor should come to see them.' So this veteran cave custodian now restricted himself to vice-regal visits. It was an outrageous piece of self-promotion.

In 1873 there was no village of Mole Creek. It was still 17 years before the railway would reach Chudleigh, and 21 before railway excursions from Launceston would turn the caves into a day trip destination. Visitors to the caves needed accommodation and transport. The Chudleigh Inn was regularly cited as the base for cave visits.[37] Pickett's personal legend blossomed during this time:

Reports which developed Pickett's legend

- 1873—Pickett claimed that he had shown the caves to 'all the governors' and now only guided governors.[38]
- 1873—Pickett stated that he had travelled 3.5 miles (5.6 kilometres) into Wet Cave.[39]
- 1873—Pickett claimed that he had travelled beyond 'where the water is said to almost fill the cave to the roof' in Wet Cave, that is, beyond the 'Rockfall' into what is now called Georgies Hall.[40] (The 'Rockfall' is thought to have not been breached until the Southern Caving Society forced their way through it from Georgies Hall into Wet Cave during the 1960s.)[41]
- 1883—Pickett said he had guided all governors from Colonel George Arthur (1824–36) to Frederick Weld (1875–80), that is, eight governors, including Sir John Franklin and his wife Lady Jane Franklin. The capsizing of the Franklins' carriage in a narrow defile, Pickett claimed, prompted that place to be named Needles. Pickett 'recalled Windsor and Eton', enjoying 'a confab about castle and college'. Pickett also recalled an Aboriginal attack on the Native Hut Corner property when he was assigned to Travers Vaughan.[42]
- 1887—Pickett reiterated a claim already made to James Calder, that he had been held hostage by Samuel Britton's gang of bushrangers in 1833.[43]
- 1899—Pickett stated that he guided visiting amateur geologist Count Strzelecki in the bush in 1844.[44]

Can we assume that Pickett was reported accurately? Did Pickett, for example, imply that he had attended the prestigious Eton School, or was that construction placed upon his words by his 1883 interviewer, *Mercury* newspaper reporter Theophilus Jones? (Given that Windsor and Eton are only a few kilometres from Pickett's native place, Maidenhead, it is very likely that he could recall both places.) We have no Pickett autobiography, not even a letter written or dictated by him. Pickett's resumé as prepared by his interviewers, however, now effectively included association with two forms of vice-royalty—Tasmanian governors and a pretend Polish count—plus predations by Aborigines and European outlaws. Claims of hobnobbing with vice-royalty suggest self-promotion or self-purification by the ex-convict. Portraying himself as the victim of Aboriginal and bushranger attacks looks like an attempt to identify with the landed gentry. Such stories also enhanced Pickett's status as larger-than-life custodian, lore keeper and explorer of Wet Cave.

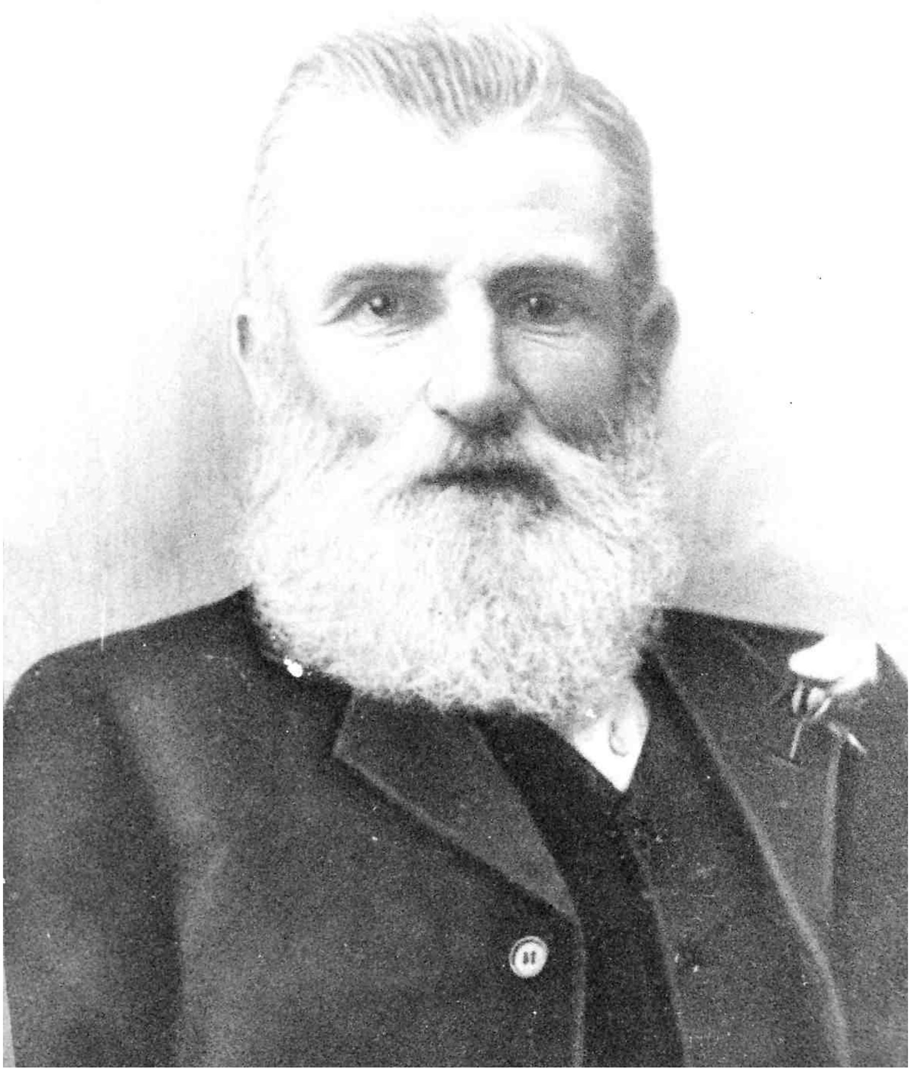
Which of the claims can be verified? The story of Aboriginal attack and the Britton story are plausible. Pickett appears to have been an overseer at Dunorlan, several kilometres from the Van Diemen's Land Company track, in 1844 when the wandering Strzelecki is said to have acquired his services. If Strzelecki did meet Pickett, it is more likely to have been when he was working nearer the track at 'Wesley Dale' at an earlier date. Pickett's familiarity with Britton's inscription at 'Black Heath' is consistent with Strzelecki engaging him as a guide along the Van Diemen's Land Company track. Overall, the Strzelecki story is plausible.

The story of Pickett guiding Governor Arthur is not. Arthur's only trip to the region was in 1829, before Pickett's arrival, and although his party entered a cave it was at Circular Ponds, not Wet Cave.[45] While the Franklins visited the north of the colony in 1837 and 1843, there is no record of them venturing to Chudleigh or Wet Cave.[46] Yet, by 1853 the placename Needles, where the Franklins are said to have come a cropper, was on the map, perhaps as the result of a similar, now anonymous mishap.[47]

Dan Griffin, aka 'The Tramp', wry-witted highland raconteur and journalist, who reported Pickett's recounted exploits. Photo from Weekly Courier newspaper 1923.

It is the detail in the Franklin story that makes it sound plausible. One of Pickett's interviewers was an equally colourful and self-promoting personality, the journalist Dan Griffin. After Pickett's death, Griffin divulged further details of the Franklin party's adventures visiting Wet Cave. Pickett had told him that Sir John Franklin had made *two* visits to the cave, with Lady Jane accompanying him on the second occasion. The aide-de-camp Elliott was now blamed for overturning the vice-regal carriage because, as Pickett reportedly told Griffin, a man might as well be expected to drive through the eye of a needle as through the high rocks through which the bush track wound its way. With Pickett in his grave, Griffin felt free to note wryly that 'all the Dans, from the time of the lion tamer down to date, have been noted for vivid imagination, as well as piety'. ('All the Dans', of course, included Dan Griffin, whose own unreliability, if not his vivid imagination, is evident elsewhere in the same story.) Notably, Griffin, who as a policeman was part of Frederick Weld's entourage when the Governor visited Wet Cave in 1878, does not report Pickett guiding the vice-regal party.[48]

Pickett died in 1899 at the age of about 86—but his legend was not yet done.[49] He left his wife Mary £1,051, none of which she spent giving him a headstone in St Mark's Cemetery in Deloraine.[50] Perhaps if she had it would have prevented Sir Hudson Fysh, in his biography of Pickett's former employer Henry Reed, claiming to have met Pickett at the Chudleigh Inn in 1912, 13 years after his death. Pickett, says Fysh, must have been nearly 100 when he met him—and so Pickett would have been had he still been alive in 1912.[51]



William Woodhouse, alleged discoverer of the Gunns Plains Cave. Photo courtesy of Terry Woodhouse.

The similarities between Pickett's legend and that of alleged Gunns Plains Cave discoverer William Wallace Woodhouse are striking. Like Pickett, Woodhouse belonged to an era in which Tasmania was the penal destination of the Southern Hemisphere. He had Pickett's measure as raconteur and Methuselean patriarch. In old age he claimed to recall the 'Black Line' advance against the Tasmanian Aborigines in 1830, the murder of white settlers by Aborigines in 1831 and the predations of various bushrangers—the only problem being that Woodhouse was not born until 1842. In 1930 the mathematically-challenged Woodhouse claimed to be celebrating the centenary of his birth at Kirkcaldy in Scotland.[52] His faulty reminiscences may have been designed to hide his convict parentage, and perhaps his ambiguous marital status. Woodhouse was actually born in Launceston in 1842, making him 90 when he died, not 102.[53] The stigma of convictism troubled Tasmanians for generations after transportation of convicts ceased in 1853. Pickett and Woodhouse both reinvented themselves in their quest to escape it, and in doing so built a legendary status as raconteur cave keepers.

Following on from Joseph Sheen, Dan Pickett was one of Australia's earliest cave tourism operators. He supplied lodging, horses and guides to Wet Cave tour parties. Sometimes he himself was the guide, and on at least one occasion one of his sons did the job.[54] Confirmation of the story of him guiding Sir John and Lady Jane Franklin through Wet Cave in the 1830s would probably make him Australia's first professional cave tour guide. It is likely, however, that his vice-regal cave guiding career developed retrospectively in his own mind after the social benefits of guiding Governor Du Cane in 1872 became apparent. The possibly illiterate ex-convict was certainly media savvy. How much of his legend is a lie may now never be known.

Acknowledgements

Discussions with Arthur Clarke helped clarify some of the issues addressed by this paper.

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1. He was baptised at East Lockringe or Cookham in Berkshire 14 November 1813, England and Wales Christening Records 1530–1906 (Ancestry database).
2. See Conduct Record CON31/1/35, Appropriation List CON27/1/6 and Description List CON18/1/11, p.235 (Tasmanian Archive and Heritage Office).
3. George Augustus Robinson, *Friendly Mission: the Tasmanian Journal and papers of George Augustus Robinson, 1829–1834* (ed. Brian Plomley), 2nd edn., Queen Victoria Museum and Art Gallery, Launceston, 2008, 27 July 1834, p.943.
4. For Robinson's two earlier visits to 'Native Hut Corner', see *Friendly Mission* 8 April 1832, p.631 and 18 January 1834, p.871.
5. George Augustus Robinson, *Friendly Mission* 8 April 1832, p.631.
6. Fysh, *Henry Reed*, pp.56 and 72. Vaughan's conveyance of 'Native Hut Corner' to Reed was registered 1 August 1837 (Land Titles Office, Department of Primary Industries, Parks, Water and Environment, Hobart).
7. Fysh, *Henry Reed*, p.14.
8. Fysh, *Henry Reed*, p.93.
9. 'Government Notice no.71', *Courier* 30 March 1841, p.2; marriage record 7 September 1841, no.1194/1841 *(Tasmanian Pioneers Index).*
10. Incomplete and inaccurate records make the exact number of children hard to determine. The childbirths registered to Daniel Pickett and Mary Howe were (unnamed on birth record unless otherwise specified) female born 7 August 1842 (no.1095/1842), Lucy born 23 November 1843 (no.1804/1843), Arthur Daniel born 12 February 1847 (no.804/1847), female born 12 November 1848 (no.1014/1848), male born 26

March 1850 (no.1225/1850), male born 16 January 1852 (no.644/1852), female born 24 January 1854 (no.1240/1854), female born 26 August 1855 (no.1621/1855), female born 28 September 1857 (no.345/1857), male born 24 May 1859 (no.275/1859), female born 3 December 1861 (no.248/1862), male born 4 April 1863 (no.293/1863) and female born 30 October 1864 (no.569/1864). Another child, Deliah Picket, born 15 November 1845 (no.1160/1846), and attributed to Daniel and Ellen Picket, is likely to be theirs also. The father's surname on these birth records is given variously as Picket, Pickett or Pukitt, the mother's as How or Howe. The existence of another daughter, Valley, is known only from a newspaper report of her drowning in the well at the Chudleigh Inn at the age of two years and from her death record ('Our Monthly Summary', *Examiner* 18 December 1866, p.2; 13 December 1866, no.122/1866, *Tasmanian Pioneers Index).* The couple may have had more than 15 children, as there are other deaths registered at Deloraine to children with the surname of Pickett or Picket during relevant years.

11. 'Insolvent Court', *Examiner* 8 June 1844, p.6.

12. 'The Tramp' (Dan Griffin), 'An Octogenarian', *Daily Telegraph* 25 November 1893 and 'Some More About Chudleigh', *Daily Telegraph* 2 December 1893; reprinted in (ed. K Bonney), *Early Deloraine: the Writings of Louisa Meredith and Daniel Griffin*, Regal, Launceston, undated, pp.48 and 51 respectively. Early settlers in the Chudleigh region, Gardner, Ritchie and Vaughan, burned limestone in kilns.

13. See Conduct Record CON31/1/35 (Tasmanian Archive and Heritage Office).

14. 'The Oak-Den Caves', *Cornwall Chronicle* 8 February 1840.

15. *Examiner* 2 December 1843; repeated in 'Excursion to the Western Range, Tasmania', *Tasmanian Journal of Natural Science*, vol.II, 1846, pp.138–39.

16. Caves were known and explored in the Wellington Valley in New South Wales by 1826 and at Buchan in Victoria by 1840. See David Hearn, 'Wellington Caves: Past and Present', *Cave and Karst Management in Australasia 9: Proceedings of the 9th Australasian Cave and Karst Management Association Conference*, ACKMA, Margaret River, 1991; and Bob Haldane, 'A Caving Pioneer: Frank Moon and the Caves of Buchan', *Cave and Karst Management in Australasia 17: Proceedings of the 17th Australasian Cave and Karst Management Association Conference*, ACKMA, Buchan, 2007.

17. Ritchie bought the four acres as four separate one-acre Crown blocks in the village of Chudleigh in 1849, paying a total of £24 ('Sale of Crown Lands', *Examiner* 3 March 1849, p.5). For Motton's licence, see list of liquor licence holders, *Hobart Town Gazette* 1 October 1850, p.872–74.

18. 'Westbury', *Courier* 19 February 1851, p.2;

19. *Cornwall Chronicle* 19 November 1851, p.739.

20. For employment of a farmhand, see 'Inquests', *Examiner* 14 January 1852, p.5.

21. Memorial of sale no.4/952, dated 21 July 1852. The conveyance was not registered until 9 March 1855 (Land Titles Office, Department of Primary Industries, Parks, Water and Environment, Hobart).

22. 'List of Persons Entitled to be Placed on the Electoral Roll…', *Examiner* 8 April 1856, p.2.

23. For Pickett in hurdle racing, see 'Hurdle Race', *Examiner* 14 April 1864, p.5; 'Chudleigh Races', *Examiner* 7 January 1865, p.3; 'Deloraine Races', *Examiner* 7 April 1866,p.3; 'Trial of the Hunters', Mercury 6 December 1875, p.2. For Pickett's horses in competition at agricultural shows, see 'North-West Agricultural Show', *Mercury* 28 October 1880, p.3; 'Western Agricultural Show', *Examiner* 25 November 1880, p.3; and 'North-Western Agricultural Show', *Mercury* 27 October 1881, p.2. In 1854 Pickett was treasurer of the Chudleigh Ploughing Association (advert, *Examiner* 1 August 1854, p.1).

24. For Pickett representing the north in intercolonial ploughing matches, see 'Intercolonial Ploughing Matches', *Mercury* 17 September 1875, p.2.

25. See, for example, advertisement for the Chudleigh Road Trust meeting at the Chudleigh Inn, *Hobart Town Mercury* 27 May 1857, p.1.

26. Jill Cassidy, *Deloraine's Industrial Heritage: a Survey*, Australian Heritage Commission and the Queen Victoria Museum, Launceston, 1986, p.119.
27. See 'Deaths from Pugilism', *Courier* 12 February 1858, p.2, in which 'Ned the Bullock Driver' dies as the result of a scuffle at the Chudleigh Inn; 'General News', *Examiner* 22 January 1876, p.3, in which George Monaghan kills James Phillips at the Chudleigh Inn (Monaghan was later convicted of manslaughter and sentenced to a year in prison). The *Deloraine Police Felony Reports Book* records the killing of Phillips (POL126/1/1, Tasmanian Archive and Heritage Office, Hobart).
28. See 'Robbery from the Person', *Examiner* 8 October 1864, p.3, in which Pickett testifies against a thief at the Chudleigh Inn. The *Deloraine Police Felony Reports Book* records a burglary at the Chudleigh Inn 10 May 1869. On 6 December 1877 Pickett's store was broken into (POL126/1/1, Tasmanian Archive and Heritage Office, Hobart). For the fire, see 'Fire and Loss at Chudleigh', *Examiner* 13 April 1865, p.4.
29. 'Official Notices', *Examiner* 18 January 1872, p.3. Pickett contracted to cart mail between Deloraine and Chudleigh for £33 per year, which by 1878 had increased to £45 ('Official Notices', *Examiner* 9 January 1878, p.3).
30. James Calder, 'Notes of a Journey', *Tasmanian Times* 18 May 1867, p.4.
31. For a contemporary report of Britton's visit to Vaughan, see editorial, *Hobart Town Courier* 25 October 1833, p.2.
32. 'The Chudleigh Caves', *Examiner* 25 January 1866, p.5.
33. 'Intercolonial Exhibition Commission', *Mercury* 4 July 1866, p.2.
34. 'Deloraine Municipal Council', *Examiner* 6 May 1873, p.4. There is confusion about which cave was injured, Wet Cave or Sassafras.
35. Anthony Trollope, *Australia and New Zealand* (eds. PD Edwards and RB Joyce), University of Queensland Press, Brisbane, 1967, pp.45–46.
36. Anthony Trollope, *Australia and New Zealand*, p.47.
37. See, for example, Howard Hayward, *Through Tasmania: Howard Haywood's Illustrated Guide for Visitors and Colonists 1885–6*, Examiner, Launceston, 1885, p.17; or the *Union Steam Ship Company's Tasmanian Guide for Visitors to Tasmania*, Union Steam Ship Company, Launceston, 1891, p.44. William Senior, who hired horses at the Chudleigh Inn in 1880, presumably mistook one of Pickett's sons for the publican, reporting that 'the landlord of the inn at which we stop during our stay is a most obliging young fellow' (William Senior, *Travel and Trout in the Antipodes*, Chatto and Windus, London, 1880, p.49).
38. Anthony Trollope, *Australia and New Zealand*, p.47.
39. 'The Fire Brigade's Trip to Chudleigh Caves', *Examiner* 4 January 1873, p.5.
40. 'A Flying Visit to Tasmania', *Mercury* 22 February 1873, p.3.
41. Interview with Bob Cockerill and Barry James 27 August 2010.
42. Theophilus Jones, 'Through Tasmania: no.18', *Tasmanian Mail* 15 December 1883, pp.27–28. Dan Griffin ('Old Dan', 'Chudleigh Caves', *Examiner* 11 November 1890, p.3) adds Lady Jane Franklin's aide-de-camp Elliott to the party which supposedly entered Wet Cave in 1838. In 1893 Griffin claimed that Strahan and Hamilton were the only governors since Franklin's time to have not visited Wet Cave ('The Tramp' [Dan Griffin], 'Deloraine Past and Present: no.9: an Octogenarian', *Daily Telegraph* 25 November 1893; reprinted in [ed. K Bonney], *Early Deloraine: the Writings of Louisa Meredith and Daniel Griffin*, Regal, Launceston, undated, pp.46–49).
43. 'A Correspondent' (James Smith), An Episode of the Early Days of Tasmania', *Examiner* 2 May 1887, p.3.
44. 'Dan Griffin, 'Deloraine', *Tasmanian Mail* 19 December 1899, p.29.
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46. Only fragments of Lady Jane Franklin's diaries and correspondence from her time in Tasmania have survived. None mention caves. They are held by the University of Tasmania Archives, Hobart.
47. See, for example, advertisement for the Chudleigh Road Trust, *Examiner* 15 November 1853, p.4.
48. 'DDG' (Dan Griffin), 'Vice-royalty at Mole Creek', *Examiner* 15 March 1918, p.6. Later in the story, Griffin confused the ex-convict stockman John Francis, whom he claimed to know well, with a Launceston namesake who was transported for treason.
49. 'Country News', *Examiner* 4 January 1900, p.8. See also burial records for St Mark's Anglican Church, Deloraine.
50. 'Testamentary', *Examiner* 11 December 1900, p.7.
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52. 'Death of Gunn's [sic] Plains Centenarian: Born When William IV Was King: Hardy Scot', *Advocate* 27 December 1932, p.6.
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Recent changes in the local hydrology, Lobster Rivulet catchment, Mole Creek karst: The landslides of January 2011

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Abstract

Northern Tasmania's wet conditions of the 2010/2011 summer season commenced in spring, following drought. Caves of the Mole/Lobster drainage sub-system experienced a series of floods. Saturated conditions were maintained in the catchment until 5 mass movements occurred concurrently on the 14th January, and a further 4 in the following days. Included was a 2.5 km debris flow that has changed the hydrology and precipitated some amusing local media coverage. The discussion includes a briefing on local fluviokarst hydrogeology and a destroyed convict built water scheme. Implications for the farming community and the popular wild caves of the sub-system are considered in the context of climate change.

Introduction

The Mole Creek karst, in northern Tasmania, is so-named after the behaviour of one of its streams, which appears from the mouth of Wet Cave only to plunge underground once more after a short distance into Honeycomb Cave. It is a large, densely cavernous *fluviokarst*, in that much of its catchment is on adjacent non-cavernous rocks. Gordon limestone outcrops extend approximately 10 km (north-south) by 26 km (east-west), between approximately 200 and 600 m elevation (Kiernan, 1989, 1995). Karst drainage is well developed, and surface water is scarce. The karst is bounded to the south by the Great Western Tiers, the escarpment of the Central Plateau horst, rising 1000 m above the Mole Creek valley floor. The "Tiers" name reflects the stepped profile, so formed because of the differential erosion resistance of strata of the Parmeener Supergroup sedimentary rock sequence. Harder, igneous Jurassic dolerite rock caps the Central Plateau, forming columnar cliffs atop the Tiers escarpment, a feature distinctive of many Tasmanian mountains. The Tiers, up to 1320 m in elevation, represent a substantial catchment for the karst. The Lobster Rivulet is one of several sub-catchments draining the Tiers and contributing to the karst drainage system. The Lobster's hydrology interacts in a complex manner with that of the adjacent sub-catchment of the Mole Creek itself, according to seasonal and flow stage conditions (Kiernan, 1995; Hunter *et al*, 2008).

Northern Tasmania has a Mediterranean, seasonal distribution of rainfall, annual precipitation in the Mole Creek area ranging from 1111 mm in the valley to >1600 mm in the upper catchments, due to orographic effects (Bureau of Meteorology, 2007).

Like elsewhere in south-east Australia, the Mole Creek area is subject to cycles of drought and flood, due to such influences as the El Nino Southern Oscillation (ENSO). However, the dramatic summer storms on the Tiers that triggered the mass movements of January 2011 in the Lobster catchment are more common occurrences of the north-eastern Tasmania highlands (Langford, 1965). According to locals, supported by the survival of a convict-built water scheme until January, the episode of mass movements is unprecedented in living memory or oral history. The unusual meteoric conditions that led to these events are consistent with the effects of anthropogenic climate change.

Scars in the slope sediments of the Great Western Tiers reveal a history of landslides, with 39 apparent from 2007 mapping (Mineral Resources Tasmania, 2007). However, such events can be infrequent. Two residents of Caveside, in the Lobster Rivulet catchment, recall two narrow landslides occurring more than 50 years ago. Those scars are now difficult to pick out under the (recovered) forest canopy. The escarpment of the Tiers is slowly retreating by weathering of the softer sedimentary rocks underlying the dolerite cap; the dolerite columns topple down as support is removed. Glacio-fluvial and peri-glacial processes have eroded the weathering products downslope. These sediments have formed mantles over the karst geological contact and fans at the footslopes of the escarpment (Kiernan, 1995). The slope deposits have stabilised under a cover of wet sclerophyll (mixed) forest established since the Holocene optimum climatic period. Where slope deposits mantle the karst contact, they function as a perched aquifer, gradually releasing water through constricted vadose conduits in the epikarst to maintain water flow in the karst systems through dry seasons. However, there are additionally a small number of direct stream inflows, or cave swallets.

Media reports covered extensive, record-breaking floods in northern and north-eastern Tasmania over the summer of 2010-11. At Caveside on 14th January 2011, a local farming couple were having morning tea when they heard the Westmorland debris flow descend the mountainside; and when they looked out of their window, they saw tonnes of silt and gravel had swept out of the bush onto their paddock (Figure 1). A stream of water and silt continued from the toe of the debris flow, sustaining an overland water flow for four days. Like other locals in a series of interviews on local radio (ABC 7NT, Country Hour, 24th January 2011), they simply expressed their amazement and privilege, in spite of losses to property and livestock, to have witnessed such amazing events in their lifetime.

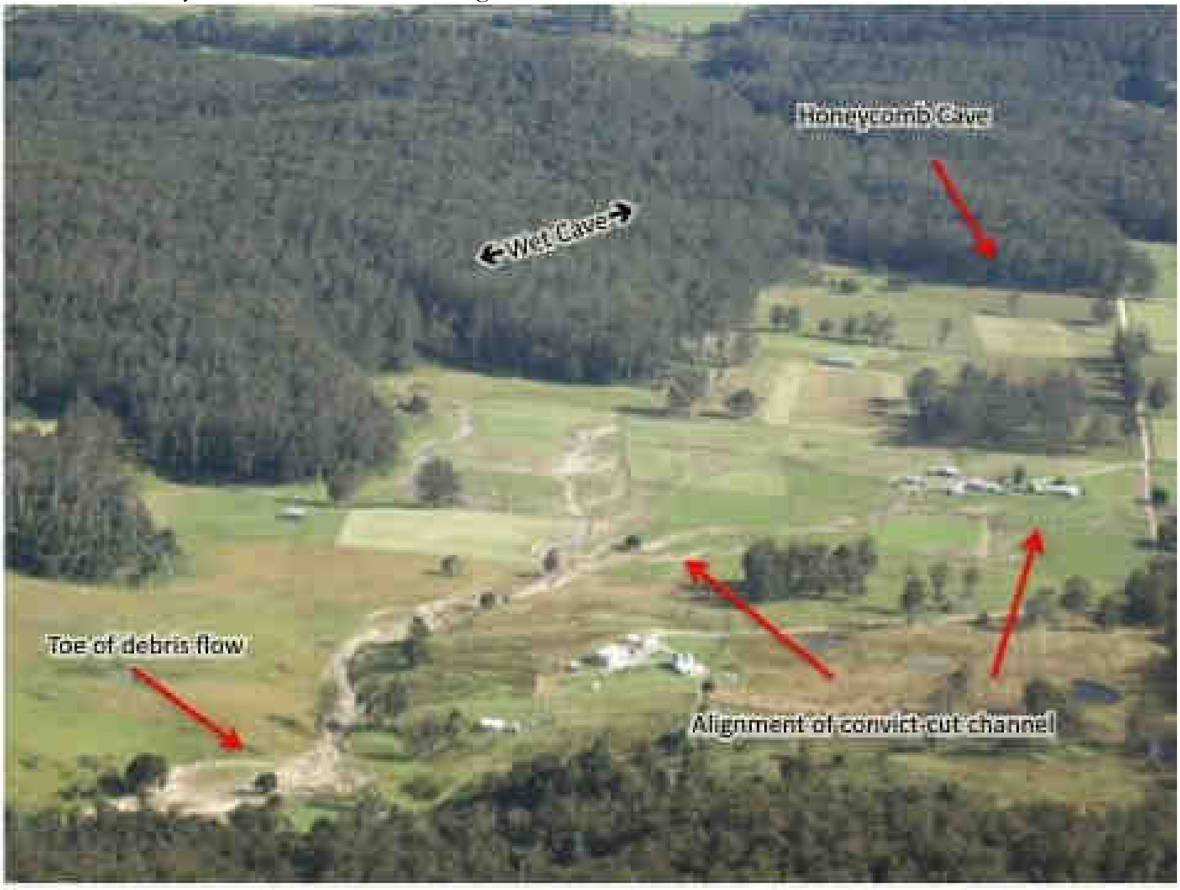

Figure 1: Oblique aerial photograph (looking north from the Tiers) taken 10 days after the debris flow. Paths of silt show the distributory flow of water from the toe of the slide, which occurred because the carrying capacity of the depicted convict-cut channel was exceeded. Where this artificial channel passes under the road to the right, overflow also followed the road, causing substantial damage.

A series of floods over spring and summer followed El Nino drought conditions that had prevailed for three years. Finally, a series of storms which brought 195.5 mm of rain over five days at Caveside (unpublished weather diary of the author) destabilised the mountainside, already saturated by the summer season's La Nina conditions. A total of nine landslides became visible on the slopes of the Lobster Rivulet catchment, triggered by these storms. In contrast, no landslides were apparent in adjacent catchments. Summer storm cells can have localised effects. The mass movements include a slide approximately 600 m in length on the eastern flank of the Lobster Rivulet, its toe resting in the Rivulet gorge. Although not as obvious as this example when viewed from the valley floor, the Westmorland debris flow is by far the most extensive of the features at over 2 km in length, and is the most important in terms of hydrological change in the catchment. The landslides are depicted in context with karst drainage in Figure 2.

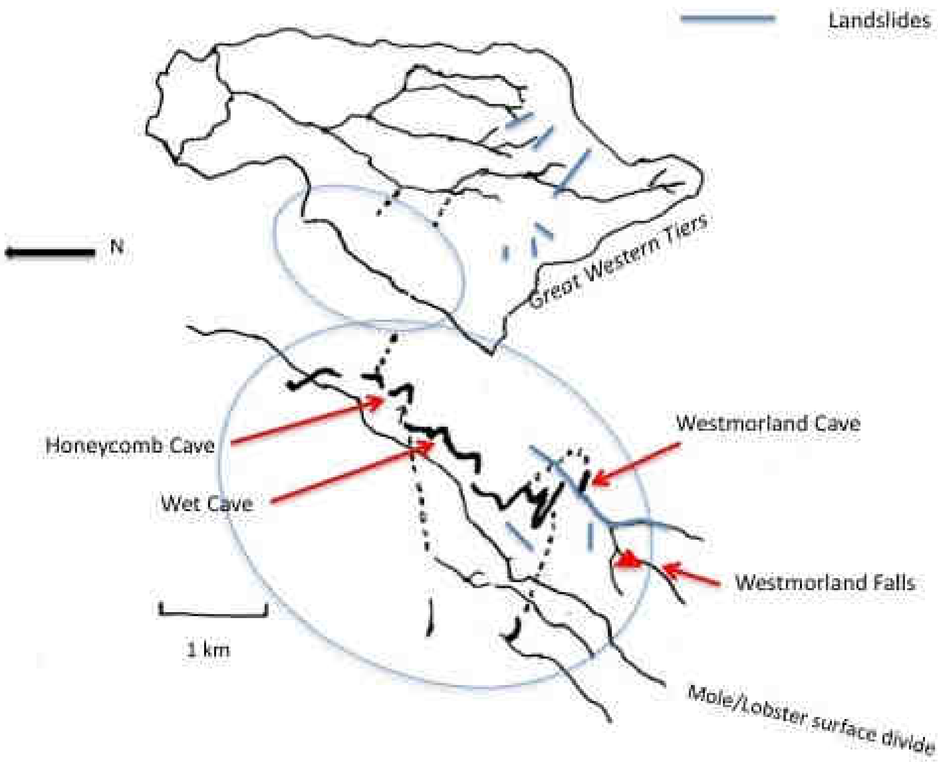

Figure 2: Mass movements in the Lobster Rivulet catchment, January 2011 (drawn after Hunter et al., 2008). The path of the debris flow past Westmorland Cave has scoured a previous overflow channel into a substantial surface watercourse. The inset shows the Lobster/Mole master cave system; the surface divide shown is double-breached by the drainage. Solid lines show known caves. Dotted lines show simplified (proven and inferred) karst hydrological relationship of the Lobster and Mole karst sub-systems (after Kiernan, 1989).

From Figure 2, the path of the Westmorland debris flow bypasses the once-spacious cave swallet, where it then follows the alignment of a vehicular track, constructed to enable access for maintenance and improvement of a historic water diversion at the cave. The track provided a straight path of least resistance for the debris flow to continue to the farmland at the footslopes of the escarpment, where the slope gradient reduces. Most of the water that used to flow into Westmorland Cave now flows down the scour gully of the debris flow, past a blockage of broken trees and boulders at the cave's inflow entrance. Only a trickle of water now passes under that blockage into the cave. Prior to the mass movement, the small water scheme, originally built by convicts, channelled some of the flow down a natural overflow channel to ensure an all-season flow of water, thence reticulated in a ditch through the farms downstream. The convicts cut a 3 x 3 x 3 foot channel ("the nine-foot") through a limestone wall immediately upstream of the cave inflow, and a log was felled to act as a dam that diverted the stream at low flow stage into the cutting and hence into the overflow channel. At high flow stage, water flowed over the log and into a smaller adjacent entrance customarily used by cavers, and the swallet still performed in a manner close to its natural hydrological function. The cave would have first filled to capacity during a flood pulse, the overflow channel only operating if that capacity was exceeded. Problematically for local pastoralists and their infrastructure, the capacity of the blocked cave to provide a buffer against potentially damaging flood pulses is now seriously compromised, and the majority of the stream now flows down the scour channel and hence into the artificial ditch (Figure 3).

Figure 3: Scour gully looking downstream from the vicinity of Westmorland Cave entrance. Note for scale the people making measurements (geomorphology class from the University of Tasmania). From evidence of the removal of soil, the scour was 19.3 m wide at the foreground survey cross-section. The scene in this picture was previously fully covered by the forest canopy, trees growing up to the bank of the small overflow channel.

Debris flows are catastrophic (sudden) mass movements, where saturated slope materials move as if the total was a liquefied mass. At Westmorland, the tributary stream from Westmorland Falls a short distance upstream of the cave (Figure 1) increased the volume of water and the energy of the mass movement in the vicinity of the cave. Trees and soils in the path of the debris flow were carried along to join the mass. Larger boulders, rocks and broken trees deposited first, followed by gravels and sands further downslope, as the energy of the flow lessened with the slope gradient. Silt-laden waters then dispersed in a distributory manner over the glacio-fluvial fan at the footslopes in the flooding conditions, causing flooding on the farms and passing overland to cause washouts at entrances to Honeycomb Cave (Figure 1). Within the first few days of the debris flow, council workers had deepened the ditch through the farms to increase its capacity and repaired the washed-out road. Vehicular access being impossible, the farmers moved rocks by hand at the cave mouth to direct water flow into the cave mouth concealed beneath the debris (Figure 4).

Figure 4: Blockage of Westmorland Cave. To help protect their farms downstream from more floods like those of January 2011, in the days following the debris flow, local farmers diverted as much of the creek as they could back toward the cave swallet under the blockage at its entrance. Note the mixture of rounded, reworked rocks from the streambed, and angular rocks more recently dislodged from their origins.

An attempted inspection of the entrance series of Westmorland Cave from the inside in May 2011, accessed by way of a vertical entrance to a large chamber, revealed tree fern root mats and broken woody debris to 30 cm diameter blocking the inflow passage where it narrows before the large chamber. Below that chamber, the deposition of two sequences of sand and fine organic matter in a depression in the stream bed and the lack of new large woody debris attest to the efficiency of the blockage at the entrance rift and indicate the possibility of sediments constricting drainage in the cave. An old photograph shows evidence of high-energy flows in the past, with sandstone boulders from hundreds of metres above the cave lodged in the initial entrance rift (Figure 5).

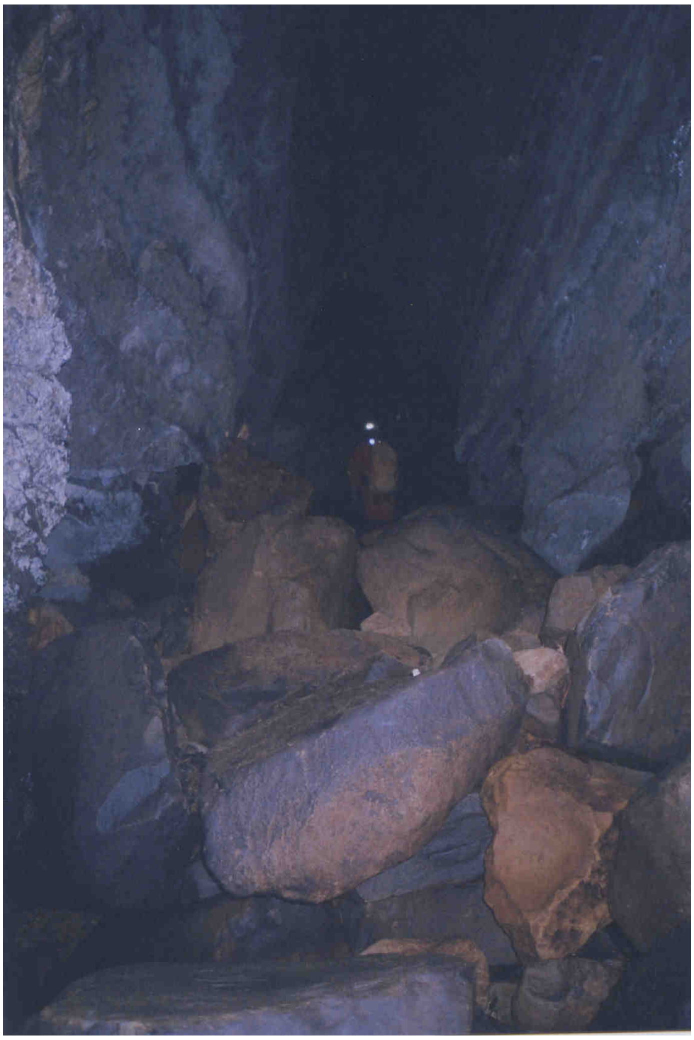

Figure 5: Caver climbing out the entrance rift of Westmorland Cave prior to its recent blockage. Large sandstone boulders can be seen. Further into the cave, the entrance passage narrows, where root mats and woody debris now block it.

Previously, over more than 30 years experience, I had only ever known of flash flooding in Honeycomb Cave. However, while the overland flow persisted for four days, water submerged even high-level passages that I had never known active during flash floods. As the water subsided, sights to be seen included tonnes of displaced glacial gravel deposits and shifted log-jams. Since then up to the time of writing in June 2011, regular visits to the cave have revealed that the numbers of cave-adapted fauna have crashed compared to prior to the flooding.

Conclusion

It is quite possible that such an event as the debris flow in January 2011 has happened before at this site. However, enough time had passed since any previous similar event, that the boulders in Figure 5 were firmly lodged in their places over the long-term, resisting the force of historic flooding water flows, and a closed forest canopy overhung the 2 m wide overflow creek-bed, with riparian vegetation growing on banks with well-structured soils. Few pieces of large woody debris had previously been known in Westmorland Cave, and were confined to a long, tall rift section beyond the entrance passage and a large daylight hole chamber. However, organic matter on the ceiling from water backing up into the large chamber had been noted in the past. Westmorland Cave's hydrological function is likely to be compromised compared to its previous function, due to the limited transmissivity of the phreatic level passage/s, some 600 m beyond the entrances, and the possibility of siltation in those passages. While there may once have been a wetland there absorbing cave overflow water, it has been cleared for farming, a land use with infrastructure requiring protection from further catastrophe. The cave itself may find numbers of curious cavers negotiating the vertical entrance, compromising the delicate organic-rich earth slope under the daylight hole that supports the cave's diverse ecosystem.

Honeycomb Cave may react differently to flood events than in the past. Being the most important recreational wild cave at Mole Creek, this has implications for caver safety and further erosion. While erosion stabilisation works are progressing at the cave, further floods could hamper long-term stability.

The mass movements of January 2011 could represent the vanguard of geomorphic change brought about by anthropogenic climate change. The local community has exhibited adaptability in repair of infrastructure and cave entrances, the efficacy of which remains to be tested by the next series of extreme meteoric conditions.

If indeed climate change means more frequent and more extreme weather events, an increase in erosion rates of the slope deposits on the Great Western Tiers escarpment above the karst could reduce the hydrologic storage and release function of perched epikarst aquifers, causing higher flows in wet times and depriving cave ecosystems of flow in dry periods. Many in the farming community could find their water supplies affected. Should further hydrological change continue, the proportion of Westmorland's water finding its way to each of the two karst systems, Mole and Lobster, could change.

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Karst in Mid-Proterozoic dolomite, Pungalina Station, Northern Territory, Australia – its significance and management

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Abstract

Extensive karst is reported from several places in Northern Australia in particular Pungalina Station in the Northern Territory. This previously little known dolomite karst area contains significant karst, which has been explored and documented by the Victorian Speleological Association Inc., since 2005. Since the purchase of the property by the Australian Wildlife Conservancy (AWC) in 2008, VSA has continued this work and provides karst knowledge and management advice to AWC.

Introduction

In the published literature, karstification in dolomite (dolostone) is not as well documented as for limestone and as it is less soluble in natural waters than limestone, cave development is generally less. However, extensive karst is reported from several places in the Northern Territory, Australia (White & White, 2009) and the Transvaal, South Africa (Martini et al, 2003). A previously little known karst area, of about 150 km^2, in the Mid Proterozoic (Pre Cambrian) stromatolitic and cherty Karns Dolomite on the south-western coast of the Gulf of Carpentaria (N.T.) contains significant karst including caves.

Although the Karns Dolomite was know to geologists, the karst potential had never had any investigation. As a result the karst was not well known until the Pungalina Station owner Owen Davies started operating it as a Safari Operation in partnership with Kirkhope Aviation. Their interest in the caves was as an additional feature to the usual safari activities for tourists. At that stage they knew of one major cave with bats and a few other smaller caves. Since 2005, VSA has undertaken 5 further expeditions to the area, discovering, exploring and mapping a number of caves and karst features.

Access to the area is very dependent on conditions; a heavy summer wet can limit access and movement around the property. VSA trips as a result, have been in June or early July.

Regional Setting

The area is located in the Gulf Coastal bioregion of the Northern Territory (Figure 1) near the Queensland / Northern Territory border and the Savannah Way (Highway 1). The Calvert River flows north through the property and terminates in the Gulf of Carpentaria. The currently known karst is predominantly in the exposed dolostone in the catchment of the Karns Creek, a tributary of the Calvert River.

Figure 1 Pungalina location

At about 16°30' S. latitude, Pungalina has a hot monsoonal climate dominated by distinct wet and dry seasons. The cave temperatures are higher (29-34°C) than the expected yearly average (26.4°C) with cave humidity levels close to 100%. This is possibly due to a combination of summer rain, temperature and the effect of soil heated up by the sun. In some caves, the humidity is such that just moving around causes the moisture to condense as droplets and produce a fog. Some caves flood during the summer monsoonal rains maintaining the high humidity.

The karst areas of the property have a mosaic of open savannah woodland with pandanas and paperbark communities around the creeks and wetlands. Cave entrances often have remnant dry rainforest species not present in the surrounding savannah woodlands. The diverse habitats support a rich fauna.

Geology and Geomorphology

The karst is developed in the Karns Dolomite, a 100-200 m thick cherty dolostone estimated as being between 1.73 to 1.43 billion years i.e. mid Proterozoic (Pre Cambrian) in age. The Karns Dolomite is only intermittently exposed on the surface in this area as it is overlain in some places, by the very late Proterozoic Bukalara Sandstone, isolated outliers of marine Cretaceous sandstone and claystone and Cenozoic sediments and laterite.

The Karns Dolomite was deposited in a shallow marine, tidal environment, characterised by numerous stromatolitic beds dominated by the genus *Conophyton* (Figure 2). Such shallow, upper tidal environments have a variety of sediments reflecting the variable depositional depths. These include more siliceous and clay rich beds, now evident only either in cave walls or as surface rubble. The dolomite is relatively flat lying and exhibits only shallow dips and small structural deformations. In the upper reaches of Karns Creek, several hills and tabular plateaux are capped with a massive banded chert, brecciated in places and up to 10m thick, which appears to terminate the dolostone sequence which may be a

Proterozoic paleosol residual left after the dissolution of cherty carbonates and subsequently cemented together into a massive rock under the effect of diagenesis or very low-grade metamorphism.

Figure 2. Conophyton stromatolites (S.White)

There is a significant gap in the rock history between the cessation of sedimentation in the late Proterozoic and the Cretaceous when extensive sedimentary deposition of sandstones occurred (~ 400 Million years of record missing). Either the area had no deposition or, as is most likely, any deposition that occurred during the Palaeozoic and early Mesozoic (543 – 146 million years), was minimal and was subsequently completely eroded. There are only small remnants of Cretaceous sediments present, which indicates that the extensive deposition, which occurred, has been subsequently eroded during the Cenozoic. The area has been subjected to more sub-aerial erosion throughout the Cenozoic.

Karst Landscape Development

The geological history indicated that the area was probably covered by sediments in the Cretaceous, but by the end of the Cretaceous, the area was exposed and eroding. Extensive landscape lowering has occurred and remnants of a higher altitude landscape with large streams and high level caves remain on the ridge tops, resulting in a landscape inversion (stream cobbles are found on some ridge tops). Much of the karst has the characteristics of a highly eroded landscape where the present features are the relics of previous conditions.

The major relief of the area is seen in the sandstones outcropping to the south and west of the main karst area. The relative relief of the sandstone areas is high – up to 100 m of incision by the Calvert River in places with striking sandstone cliffs. The relative relief of the Karns Dolomite areas is much lower and flatter. The tops of the ridges are 10- 25 m above the rest of the plain.

At least two periods of karst development on the Karns Dolomite have occurred, and there may have been more. The two karst development periods are an upper/older one, which is preserved as remnants on ridge tops e.g. remnant streams, dolines and caves, and a lower/younger one at the break of slope at the foot of the ridge with currently active caves. Other small karst features include degraded dolines and solutional features.

The upper caves are no longer being actively developed, although minor modification is occurring from surface runoff into the cave and degradation of old speleothems (e.g. the Totem Pole in Totem Pole Cave (PUN 07) (Figure 3) and deposition of newer formation in other parts of the cave. The younger and currently active karst development stage is occurring with the formation and modification of narrow, joint controlled maze like caves lower on the ridges, forming especially where surface runoff drains underground through joints and fractures, at the break of slope near the base of the ridges. These are the main caves in the area and have concentrated areas of decoration and calcite formation, interspersed with extensive areas showing solutional features such as rills. These caves also take extensive water during wet seasons and most have evidence of episodic flooding and active solution. There is extensive evidence in the form of small water sinks and degraded dolines and hollows, that the area was a more impressive karst landscape in the past.

Figure 3. Totem Pole Pun 7 (D.Carr)

Preliminary U^{238}/Th^{234} dates of speleothems from an upper level of a higher level cave, indicate at least two periods of speleothem deposition in the mid Pleistocene and Holocene times (J. Hellstrom, pers. com.). Further work is needed to understand the implications of this.

The surface of the dolostone ridges has extensive karren especially as kamanitzas or pans rather than solutional rills. The stromatolites are often "picked out" by solution.

Modern tufa deposits occur in the bed of a small creek near the present homestead. These indicate that the river is highly saturated in calcium carbonate and at specific places is capable of deposition.

Groundwater outflow points were observed close to Karns Creek and the Calvert River and more must occur during the wet season, as evidence of outflow was found in a few places. The warm (~28º C) Bubbling Springs which flow regularly all year round suggest that the ground water flow is slow, buffered by the residual overburden covering the karst as well as by the nature of the wet cave network, which is probably not well integrated.

Caves and karst

Over 50 caves, 20 significant dolines, 2 poljes and several karst springs have been documented. More detailed work is needed.

The caves were initially found from the local knowledge of Owen Davies and subsequently from locations of dolines viewed from the air and from air photos. Since the first expedition, exploration has been by walking to likely places at the break of slope between ridge and plain where there are some discharge caves. On ridges the presence of green vegetation is often associated with sheltered dolines sometimes with caves present.

The caves are generally shallow phreatic, joint and/or bedding plane controlled passage networks. Passage roofs are often flat (Figure 4). Two cave levels can be identified: a dry upper series in the high grounds and residual hills, and an active lower one on the plain and in the valley bottoms. The caves contain aragonite and/or calcite speleothems, sometimes with chert breccia, which show evidence of repeated phases of deposition and re-solution. Chert replacement of the stromatolites has occurred and these are then in relief as the dolostone is dissolved (Figure 5).

Figure 4. Raft Cave PUN 23 Passage shape (D.Carr)

Figure 5. Chert replacement of stromatolite in cave roof, Conyphyton Cave, PUN 36 (D.Carr)

Cave and Karst Values

Extensive solutional karstification is found in dolomite at Pungalina. This is regarded by many karst geomorphologists as unusual, e.g. Ford (2004) states that in dolostone "surface land forms are more limited in type and scale" and that "caves large enough for human entry are quite rare". This makes the dolomite karst areas of the N.T. such as Pungalina, significant. There is a potentially long time for karst to develop and there is no evidence of intense tectonic activity in this area, although more intense faulting and folding does occur to the west. Some faulting and relatively gently warping has occurred but the dolostones are relatively flat lying. The preliminary information from speleothems indicates that there is significant potential for detailed climatic information to be obtained. This is particularly important as there is a dearth of appropriate sites in the Australian tropics for such work. The presence of a previously unknown colony of Ghost bats (*Macroderma gigas*) and the presence of large numbers of the rare Orange Leaf-nosed bats (*Rhinoncteris aurantius*) (Figure 6) indicates important biological values. Initial studies of the invertebrates indicates a predominance of guanophiles (T. Moulds, pers com) but perhaps more work will find other invertebrates. Finally the caves are really spectacular if hot and sticky, but the bubbling karst springs (Bubbling Springs) are a pleasant end to hard caving days.

Figure 6. Orange leaf-nosed bat on cave roof, Conyphyton Cave, PUN 36 (D.Carr)

Conclusion

Significant caves and karst have been discovered, explored and documented in a remote area of Australia with difficult access. The whole exercise is an excellent example of how caver initiated exploration and documentation on a series of self funded expeditions can add to the understanding of caves and karst and assist with their management.

Acknowledgements

We acknowledge the help of the following, as without their enthusiasm and contributions this work would not have been possible:

Pungalina Safaris (Kirkhope Aviation & Owen Davies),
Dr J. Helstrom, (University of Melbourne)
Australian Wildlife Conservancy
The Victorian Speleological Association expeditioners 2005 - 2010.
Daryl Carr for photographs

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'A cup of tea with your cave, madam?': cave tourism as a cottage industry at Mole Creek, Tasmania 1894–28

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Abstract

From the late 1800s, farmers at Mole Creek in Tasmania conducted nature tourism from their homes. Families such as the Parsonses, Scotts, Martins and Byards offered cave tourism experiences as a cottage industry, otherwise engaging in farming and in some cases hunting and other forms of work. While not operated by a Mole Creek farmer, King Solomons Cave was a similar example of family-based private cave entrepreneurship. King Solomons, Marakoopa, Baldocks and Scotts Caves offered rustic, idiosyncratic experiences with home-style hospitality. All four caves were lit by acetylene gas. Ultimately, the family cave trade was unsustainable. The government's purchase of King Solomons and Marakoopa in 1920 and 1921 respectively and the introduction of the electric light gradually brought the era to a close.

Introduction

A recent television news report about the restoration of a hunter's hut on Tasmania's Borradaile Plains highlighted the inequity of heritage listing in the state. While dozens of 19th-Century Tasmanian sandstone mansions are heritage listed (two are World Heritage listed for their convict connections), the mostly wooden structures representative of the lives of yeoman farmers and highland industries have been neglected by an under-funded, architect-dominated Heritage Tasmania. Hopefully that organisation's current examination of the Meander Valley Municipality, which contains cave tourism sites such as the Chudleigh Inn, the Mole Creek Guest House, the Mole Creek Hotel and farms in the Mole Creek district, will give it the chance to partly address this.

Until recent times, rural Tasmania was a divided society. In simple terms, wool-growers, effectively the landed gentry, owned the fertile central plains, and yeoman dairy farmers the island's rural extremities. In 1918 the Midlands and south-east had two-thirds of the state's sheep, while the north-west and north-east owned two-thirds of its dairy cattle.[1] Each industry had its own lobby group, the TFSOA (Tasmanian Farmers, Stockowners and Orchardists Association) for the Midlands and south-east woolgrowers, the Tasmanian Producers' Association (later the TFF, Tasmanian Farmers Federation) for the dairy farmers of the north-west and north-east. Until the 1960s it was almost a case of never the twain shall meet.

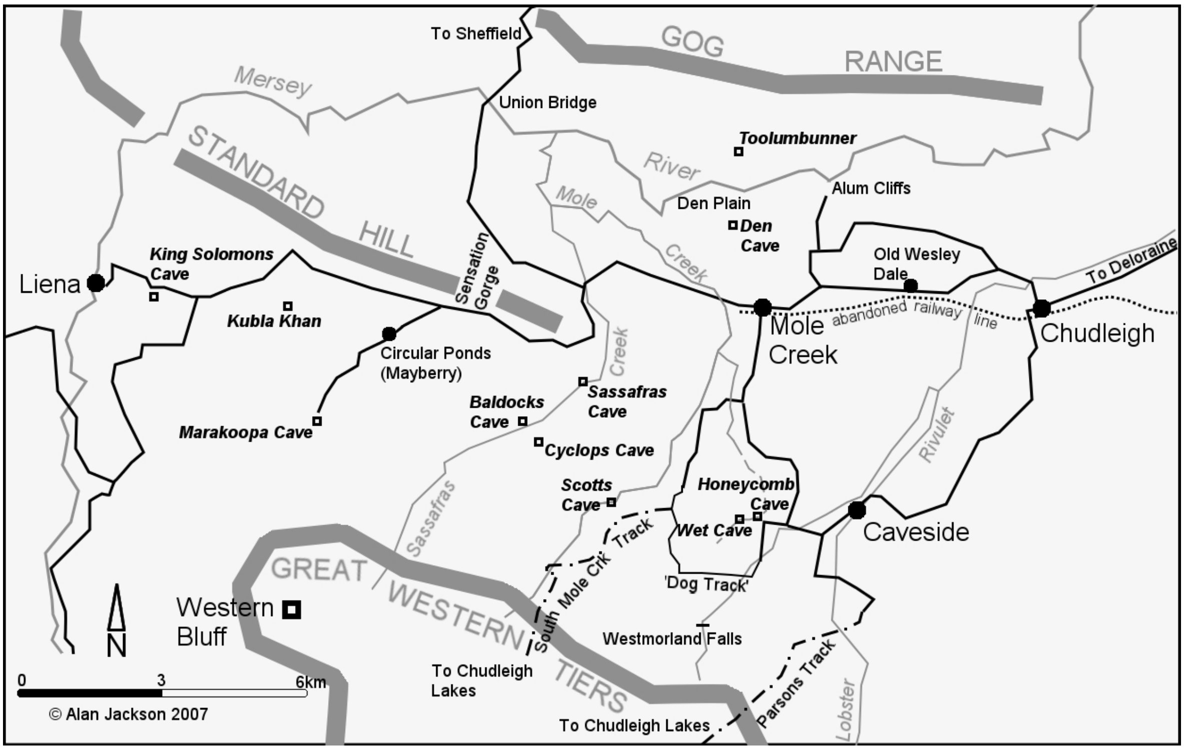
This division reflected different land settlement policies. In the period 1824–31 most of the best grazing land on the island was granted to large-scale growers of fine wool for the European market.[2] From the 1850s, however, when Tasmania's population was being depleted by the Victorian and New South Wales gold rushes, the Tasmanian government opened bush blocks (the so-called 'waste lands') beyond the Midlands plains on liberal terms in order to encourage selection and develop a stronger economy.

From late in the 19th Century, the typical regime for a dairy farmer on bush blocks at Smithton, Winnaleah or Mole Creek might be growing potatoes, oats and peas for human consumption, rye corn or mangolds to feed the cattle, and keeping pigs which lived on the skim milk residue from the dairy. Many backblocks farmers supplemented—or even multiplied—their incomes by hunting for furs in winter, repairing roads, clearing other bush blocks or doing other labouring work. In 1923, for example, when the average wage of a farm labourer was from about £110 to £120 per year, Anderson 'Jack' Scott of Scotts Cave made £240 from wallaby, pademelon and possum furs during one three-month hunting season.[3]

The advent of nature-based tourism at Mole Creek

As branch railways radiated into the backblocks, some of the more enterprising bush farmers also took advantage of their frontier location to provide nature tourism experiences for urban excursionists. In the inner north, proprietors of the Chudleigh Inn had provided an early model for nature-based tourism in the Mole Creek district by guiding visitors through nearby Wet Cave as early as 1851.[4]

From the 1880s there were regular experiments in nature-based tourism in Tasmania. Diego Bernacchi failed in an attempt to sell his Grand Hotel sanatorium on Maria Island to inter-colonial and international tourists.[5] By the 1890s even the remote West Coast offered nature-based experiences such as Gordon River and Macquarie Harbour cruises. Accounts of recreational treks to Cradle Mountain, in the northern highlands, appeared in newspapers by 1888, and five years later John Wat Tyler examined the potential of the Forth River Gorge, Cradle Mountain, Mounts Roland, Pelion and Black Bluff for tourism.[6] Tyler also operated summer tours from Hobart to Russell Falls, Bruny Island, Maria Island and Eaglehawk Neck, as well as a tour from Launceston to the Flowery Gully Caves near Beaconsfield.[7]



Mole Creek district caves known by 1920: map by Alan Jackson

Examples of nature tourism as a cottage industry, that is, carried out in or from the home, were rare. In the early 1890s, at the Henty River on the West Coast, Theophilus Jones and his family turned an old ferry house and farm into a nature tourism resort near the Strahan-Zeehan Railway.[8] Similarly, the advent of railway excursions on the Mole Creek line from 1894 enabled Joseph (JR) and Phil Parsons and their brothers at Caveside to guide tourists through Wet Cave and along their own track to Westmorland Falls.[9] They not only conveyed visitors from railway station to cave, but began the tradition of providing refreshments which became a staple of Tasmanian cave tourism. Dairy farms, of course, were never short of fresh milk, cream, cheese, butter or, usually, ham, bacon, eggs and vegetables.

Traps, tents and even a ladder at base camp during a Railway Department excursion to Wet Cave in 1902. Stephen Spurling III photo

This was only one facet of the Parsons brothers' tourism enterprise. Working in tandem with the Northern Tasmanian Fisheries Association, they increased the traffic through Caveside by stocking the Chudleigh Lakes on the Great Western Tiers with fish. The Parsons track, Parsons Falls and Parsons hut, features of the brothers' hunting regime, now also featured in accounts of hiking and fishing expeditions which they guided on the Great Western Tiers.[10] Phil Parsons declared the Devils Gullet lookout the 'Yosemite Valley of Tasmania', but the Chudleigh Lakes fishing resort was scuttled by the advent of the famous Shannon Rise near Great Lake after 1911.[11]

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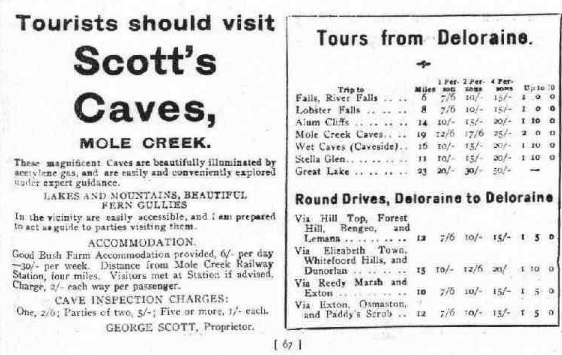
MEALS—Dinner, 2s; Breakfast or tea, 1s 6d. Beds, 1s. As room is limited, advisable write in advance, or wire, prepaid reply. Henty is a Post and Telegraph Station.

T. P. H. JONES.

Henty, February 17, 1891. b1146



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Alum Cliffs	14	10/-	15/-	20/-	1	10	0
Mole Creek Caves	19	12/6	17/6	25/-	2	0	0
Wet Caves (Caveside)	16	10/-	15/-	20/-	1	10	0
Stella Glen	11	10/-	15/-	20/-	1	10	0
Great Lake	23	20/-	30/-	50/-	—		

Round Drives, Deloraine to Deloraine

Via Hill Top, Forest Hill, Bengeo, and Lemana	12	7/6	10/-	15/-	1	5	0
Via Elizabeth Town, Whitefoord Hills, and Dunorlan	15	10/-	12/6	20/	1	10	0
Via Reedy Marsh and Exton	10	7/6	10/-	15/-	1	5	0
Via Exton, Osmaston, and Paddy's Scrub	12	7/6	10/-	15/-	1	5	0

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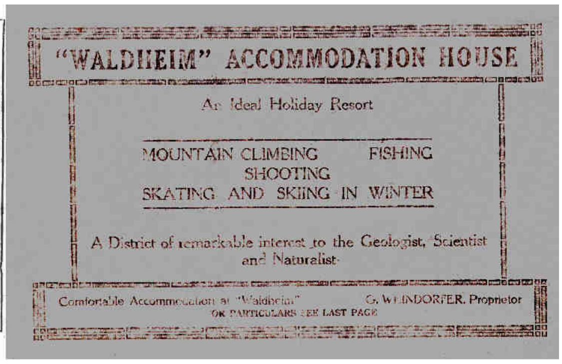

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Like the Jones family at Henty River on Tasmania's West Coast during the 1890s (centre), and Gustav and Kate Weindorfer at Waldheim Chalet near Cradle Mountain from 1912 to 1932 (right), the Scotts (left) exploited a particular natural asset, their cave, but also offered other nature-based recreations, farm-style accommodation and home-grown food. Scotts advert from a 1908 tourist guide; Henty Ferryhouse advert from Mercury newspaper 3 March 1891, p.3; Waldheim advert from Tasmania's Alps brochure, circa 1914.[12]

The advance to entrepreneurship: Scotts Cave

In 1907 the Scott family took the Parsons regime a step further after the discovery of Scotts Cave on their land at South Mole Creek. While the Parsonses made money from their own labour and their own track infrastructure, the Scotts, dairy and potato farmers, spent money to make money. Equipping their cave with acetylene light and applying fantastical names to its features, George Scott and family added private cave tourism, accommodation and guiding to a family work regime of farming and hunting.[13] (While acetylene blackened caves, it was a step up from the equally damaging candles and bark torches, at a time when electricity was not a lighting option.) A four-room Scotts guest-house accommodated those who wanted to see more of the district that had produced such limestone marvels (on one evening there were 32 guests, some in tents and others sleeping on straw in the barn).[14] This anticipated highland tourist regimes like Paddy Hartnett's centred on Pelion Plain and the upper Mersey River and Gustav and Kate Weindorfer's Waldheim Chalet business at Cradle Valley.[15]

(Left) The four-room Scotts guest-house stands to the left of the 'Roslyn Lea' farmhouse at South Mole Creek. Scotts Cave is in the gully behind the farm. (Right) George Scott crossing the apple orchard with acetylene reflector in hand, bound for the cave. Scotts' apples were a culinary highlight for visitors. Photos courtesy of Jim Scott

Just as Gustav Weindorfer became famous for his badger (wombat) stews, the Scotts' goose dinners, apple pie and scones rated highly. The family's general hospitality prompted much banter:

Six precious souls from Westbury
Arrived here yesterday;
Two came upon the bicycle,
Three drawn by Harry's bay.

They saw the Alexander's [Scotts] Caves
And thought them very fine;
They stayed the night at Mr Scott's
And drank up all the wine.

They ate up everything he had,
Sang songs both high and low,
They kept the household out of bed
And filled their souls with woe.[16]

By bullock team to 'fairyland'…excursionists in Sunday best armed with bottles of plonk headed for Scotts Cave. Courtesy of Denise Hilton

References to drinking and adolescent romance, plus the composition of verse, suggest that the intimacy of the small cave made visiting Scotts Cave more of a social experience than visiting the rival Marakoopa Cave:

> What have become of the girls we kissed?
> What of the challenging lips we knew?
> Ah! Let me whisper it - the're [sic] not missed
> Half as bitterly those we kissed
> As those we didn't, but wanted to!!!!![17]

The weekend outing must have been a release for many 'townies'. There were no wowsers in this underworld:

> These stalactite caves make a deep impression on a thinking mind. In the dark recesses you may easy [sic] imagine there are little gnomes hidden. It seemed to me they were offering me goblets of wine and [lager], for they knew I was thirsty, as it was very warm in the upper world...[18]

The cave was also child friendly. The Scotts Cave underworld contained other sparkling fairy 'receptacles' and 'dishes', later known as 'The Waterlilies'. The 'Kings Palace' seemed to be

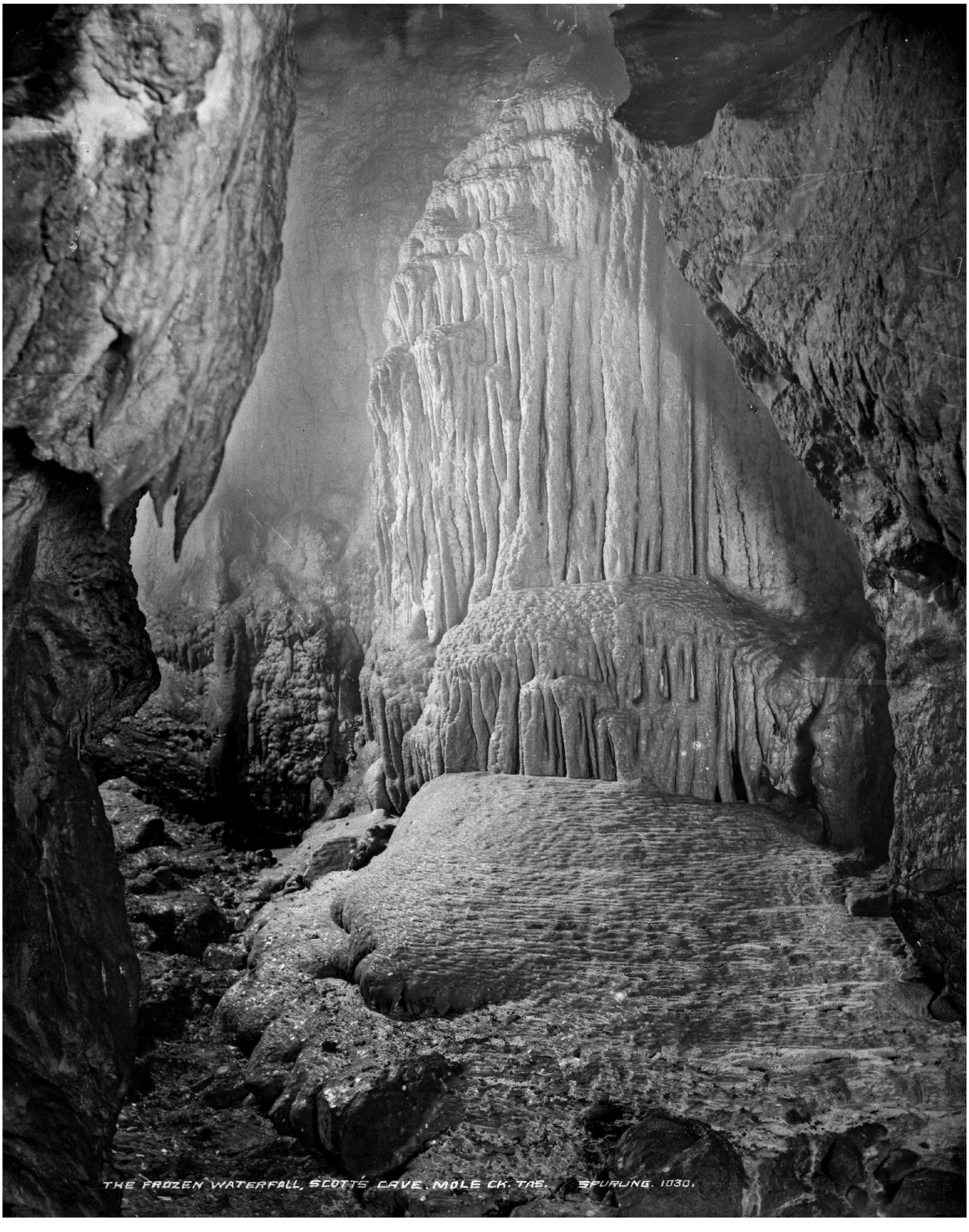
> made for the king of gnomes to hold his court, and has a bower opening out of it fit for his queen, though Titania, queen of fairies herself, need not disdain it.[19]

In 1913 the Scotts hosted the American Presbyterian evangelist John Wilbur Chapman, during his worldwide 'revival' tour. Jack Scott recalled how, as a 17-year-old, he and Lindsay Howe guided a Chapman party into the mountains:

> We were to get a prize for the first one to shoot a kangaroo. None of us shot any the first day, but the next day Dr Norton came around and he said, 'Dr Chapman wants to see you two boys around at the front!' Lindsay and I went around and he gave us a sovereign apiece. We thought we were made.[20]

Scotts' boarding house lasted only until 1915. It was then sledged by bullock team a short distance from 'Roslyn Lea' to replace Mick Scott's house, which had been destroyed by a bushfire.[21] Growing and improving competition, aging parents and scattering offspring sapped the Scott family business.[22] The dawn of the electric light at a rival cave in 1928 cast Scotts Cave into eternal shadow.

(Left and right) The financial limitations of private cave tourism conducted by bush farmers is apparent in these images of Scotts Cave visitors packed onto a rickety cliff-face balcony and a precarious rock perch between fallen logs. Twenty-one people await a tour in the left-hand photo, taken in 1917. Left photo cropped from one by JW Beattie; right photo courtesy of Jim Scott.



Stephen Spurling III backlit this image of the 'Frozen Waterfall' in Scotts Cave. Visitors to the cave would have seen a less glamorous formation by acetylene jet. Stephen Spurling III photo courtesy of Stephen Hiller

Dazed and convinced: selling King Solomons Cave

King Solomons Cave was the next private cave venture in the Mole Creek district to be developed with acetylene light. It was never a farming family affair—but an entire family suffered for it. Edward Charles (EC) James, the cave developer with what his grandson Bill James calls the 'soup-strainer' moustache, was full of bluster. 'I claim and can prove that I with my own money and brains have done more for tourists and mining in Tasmania than any other man or men,' James justified his unsuccessful application to mine the Cradle Mountain Reserve in 1942.[23]

King Solomons tourists saw the input of his money, in the form of stairways, galleries and an acetylene plant with 40 lights, which were in place in time for the cave's official opening in 1908. EC James' family did not see much money, his wife Elizabeth having to grow vegetables in the back yard to sell to support their family and his entrepreneurship.[24] Nor for many years did King Solomons' discoverer WH Pochin see the exchange of money which gave James the right to call himself the cave's lessee.[25] It took the Supreme Court to make James pay up, a deal which was only finalised when the government bought James' lease from him in 1920.[26]

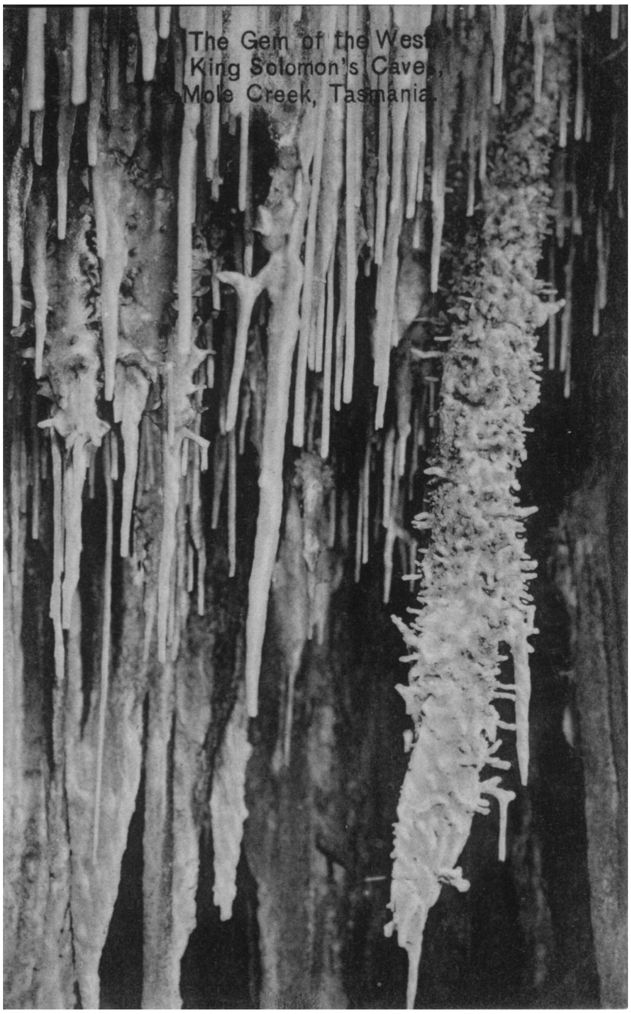
EC James surveyed his realm from this glass lookout at 'Fernleigh', Sandy Bay, Hobart. A vegetable garden behind this grand façade helped sustain his family while he played at cave and mining entrepreneur. Courtesy of Bill James.

The former Dover shopkeeper was a born showman who invited patrons to 'be convinced, mystified and dazed'.[27] He named not only King Solomons Cave but all its features, including the three columns 'Faith, Hope and Charity' after the Christian saints.[28] With qualified backing from Jenolan Caves superintendent Voss Wiburd, James declared his cave the finest in Australia.[29] So keen was James' bluster about King Solomons that he sponsored a lawn bowling trophy in its honour, personally conducted the first Government Tourist Bureau excursion to Mole Creek, and even featured lantern slides of the main cave and nearby Queen of Sheba Cave in his Queenborough (southern Hobart) Council electioneering.[30] James claimed there were six separate caves on the 15-acre King Solomons lease:

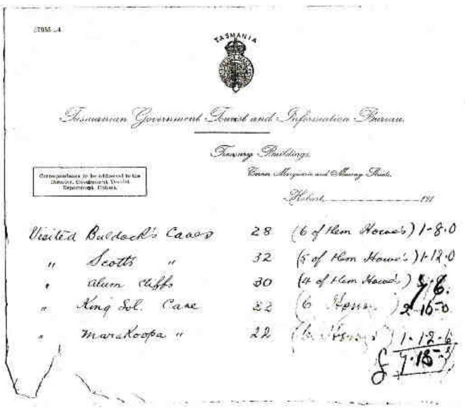
- King Solomons
- Queen of Sheba
- James Wyburd [sic] Cave
- Mammoth Cave
- Jacksons Cave
- Badger Cave

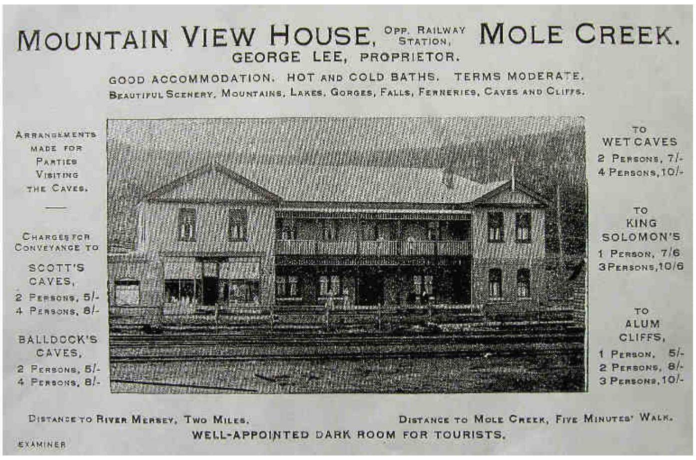
He claimed that there was also an unexplored 'Underground Lake'.[31] Some of these features have never been seen since.

Keeping it in the family: every person in this cropped James family wedding photo had a King Solomons Cave connection. (Left to right) daughter Nellie James ('Little Nellies Grotto' was named after her), wife Elizabeth James ('Mums Bower'), the cave's promoter EC James, daughter Minette James ('Minnies Bower'), daughter and bride Linda James ('Lindas Bower') and groom and King Solomons cave guide Bert Langley. EC's son Fred James (not pictured) also guided at King Solomons. Courtesy of Bill James



For EC James, postcards were a propaganda weapon, a King Solomons calling card that he still dispensed in 1928, eight years after he handed over the cave to the government. The 'Gem of the West' helictite in the unlit Queen of Sheba Cave, however, remained unseen by visitors. Stephen Spurling III postcard courtesy of Mike Simco





An invoice from Mountain View House for the government's 1916 Easter trip to Mole Creek shows that the family-friendly Scotts Cave (32 visitors) was then more popular than the more beautiful King Solomons (22), Marakoopa (22) and Baldocks (28) Caves. Advert courtesy of Denise Hilton; invoice courtesy of Bill James.

More substantial was the tea room which James built at the cave, although the original plan was for something stronger. A legend exists that James' proposal for a Mole Creek hotel was defeated by a temperance clause in the fine print of a property deed, but the truth is more prosaic.[32] James bought a block of land opposite the Mole Creek railway station from the estate of Henry Reed at an auction in December 1908.[33] At that time the nearest pub was at Deloraine, 23 kilometres away, the licence on Dan Pickett's Chudleigh Inn having been allowed to lapse since his death in 1899. The local licensing board met to consider applications in November each year, but in April 1909 it received a lone application from Dan's son, Walter Pickett, to grant him a new licence for the Chudleigh Inn.[34] Pickett had probably got wind of the proposed Mole Creek Hotel only seven kilometres from his establishment and decided to get in first. James either met with local resistance to a second hotel licence in the district or decided that a second licence would not pay.

As Mountain View House, James' pub with no beer remained unlicensed until 1953. James kept it in the extended family by selling to his son's in-laws, George and Alice Lee, who operated it as an accommodation house from which they conducted tours to all the caves and local attractions. James maintained a fatherly watch over King Solomons right up until its official reopening with electric light in 1928, during which visit he stopped off at the Mole Creek State School to 'convince, mystify and daze' small children with postcards of 'his' cave.[35]

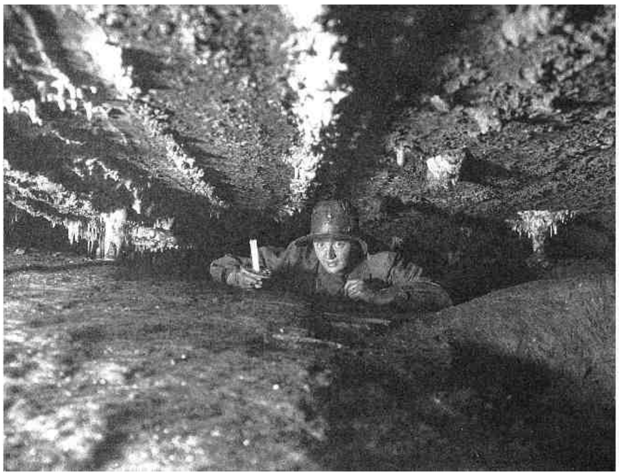
(Left) Lillias (babe in arms) and Mary Martin with Bert Martin, perhaps Tasmania's longest-serving cave guide. (Right) The Martin twins of 1915 were followed by the Martin triplets in 1917. Raymond George, Rita Jean and Reginald Albert (pictured), were an incidental feature of a trip to Baldocks Cave.[36] Photos courtesy of Ivy Crowden

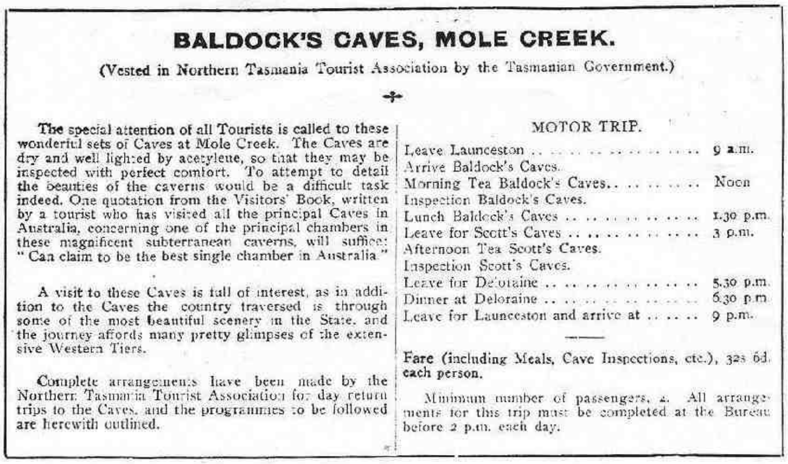
Rustic charm and family fare: Baldocks Cave

There were no homestays at the Martin farm. The government-owned Baldocks Cave, however, provides another example of a backblocks farming family—in this case an *immense* family, at least 12 children being born in the years 1909 to 1925— building a cave tourism business at home. From 1903 the lessee of Baldocks was Albert Herbert Peter Hissell (Bert) Martin, beginning a tenancy of perhaps more than 40 years. This makes him a contender for the title of Tasmania's longest-serving cave guide. His caving feats fitted the bill of heroic explorer. The government-owned cave was lit by acetylene in 1909, and a 'rustic tea house' was constructed at the cave entrance.[37] This building probably perished in 1915, when the Martins lost all but the clothes on their back to the same bushfire which prompted the closure of the Scotts Cave guesthouse.[38] Having survived 'my worst day on earth', Bert and Mary rebuilt their uninsured home, dairy farm and business for the motor touring era:

> When you reach a sign-post which reads: 'Guide's House,' and points up the hillside, you frantically toot the horn of the car; loudly shout and call, and make every ear-splitting noise you can think of!
>
> If that does not attract his attention, you get out of the car—and muttering darkly to yourself—toil up that hillside to the little home perched above.
>
> Then out he comes, apologising all the time and laughing heartily, and leads the way down the hill at a double-quick pace, shouting to his young son to 'hurry-up-there-now-come-along-do!'[39]

Bert Martin was not averse to borrowing a little magic from the rival Marakoopa Cave by claiming that Baldocks was the setting for Marie Bjelke Petersen's romance novel *The Captive Singer*. To demonstrate the plight of the book's heroine, Iris Dearn, Martin extinguished the light—a staple of cave tours worldwide to this day.[40] Magnesium ribbon was burnt to highlight particular features to which the acetylene jets did not do justice.[41] The trailing son referred to above was probably Ernie, who often joined his father in the cave, training, like his sister Thelma, to become a Baldocks guide himself.[42]





BALDOCK'S CAVES, MOLE CREEK.

(Vested in Northern Tasmania Tourist Association by the Tasmanian Government.)

The special attention of all Tourists is called to these wonderful sets of Caves at Mole Creek. The Caves are dry and well lighted by acetylene, so that they may be inspected with perfect comfort. To attempt to detail the beauties of the caverns would be a difficult task indeed. One quotation from the Visitors' Book, written by a tourist who has visited all the principal Caves in Australia, concerning one of the principal chambers in these magnificent subterranean caverns, will suffice: "Can claim to be the best single chamber in Australia."

A visit to these Caves is full of interest, as in addition to the Caves the country traversed is through some of the most beautiful scenery in the State, and the journey affords many pretty glimpses of the extensive Western Tiers.

Complete arrangements have been made by the Northern Tasmania Tourist Association for day return trips to the Caves, and the programmes to be followed are herewith outlined.

MOTOR TRIP.

Leave Launceston	9 a.m.
Arrive Baldock's Caves.	
Morning Tea Baldock's Caves	Noon
Inspection Baldock's Caves.	
Lunch Baldock's Caves	1.30 p.m.
Leave for Scott's Caves	3 p.m.
Afternoon Tea Scott's Caves.	
Inspection Scott's Caves.	
Leave for Deloraine	5.30 p.m.
Dinner at Deloraine	6.30 p.m.
Leave for Launceston and arrive at	9 p.m.

Fare (including Meals, Cave Inspections, etc.), 32s 6d. each person.

Minimum number of passengers, z. All arrangements for this trip must be completed at the Bureau before 2 p.m. each day.

(Left) Lucy King sliding through the 'Dry Swim' entrance to the second chamber of Baldocks Cave. Her clutching of a candle suggests this photo may pre-date the installation of the Baldocks acetylene system in 1909. (Right) Morning tea at noon, lunch at 1.30PM, allowing 90 minutes for Baldocks Cave guide Bert Martin to weave his magic. HJ King photo courtesy of the late Daisy Glennie; advert from a tourism guide

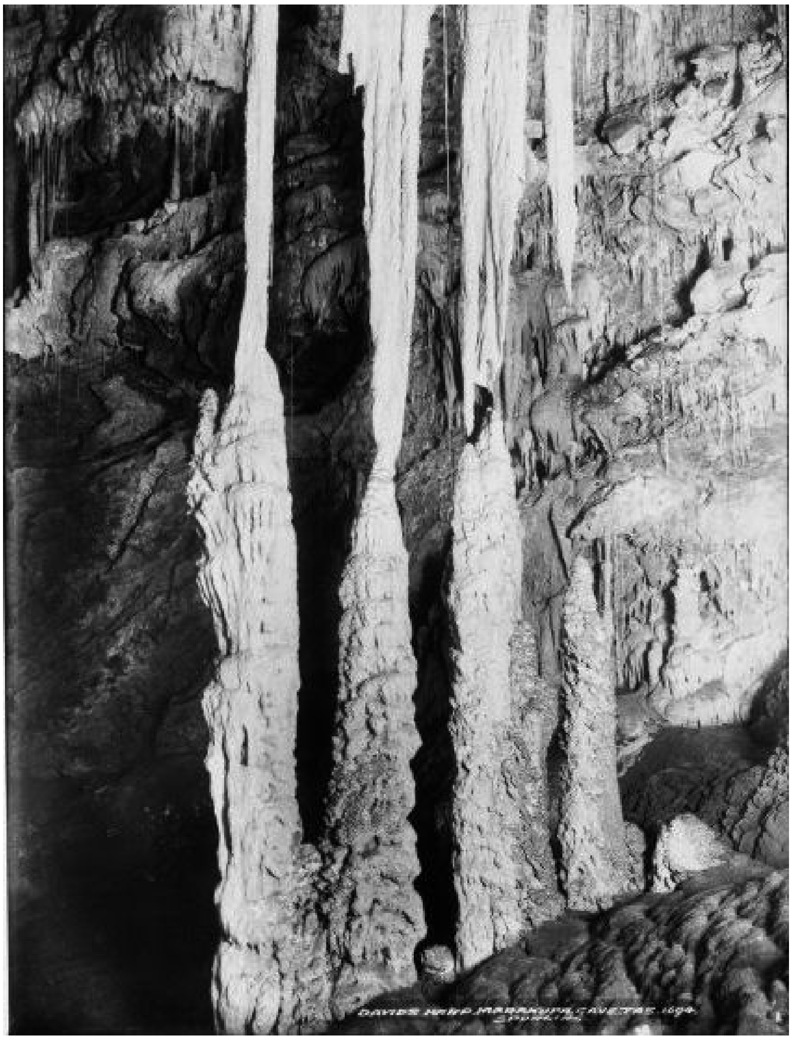
Although the difficult 'Dry Swim' section at Baldocks was cut away during the early 1920s, failure to secure the electric light doomed the cave to a dwindling custom after 1928.[43] Two surviving visitors' books suggest that in the years 1923–29 it received at least 4,500 customers. Praise for the cave (including descriptions such as 'Bonza', 'Tres Bon', 'Top Hole', 'Snifter', 'Splendid' and 'Snodger') and the guide, usually Bert Martin ('Chaplin's Double', 'very fine chap' and 'better than Mark Twain') abound in these books, as do compliments about Mary Martin's hospitality and home-style teas and dinners (featuring cream, cream cakes, raspberries, raspberry jam, tarts, homemade bread and mushrooms).[44]

Members of the Byard family outside the entrance of Marakoopa Cave. Discoverers Jim and Harry (in hat) are at the back. The girl in front of Harry is probably their sister Jane, who also sang and guided in the cave, and the woman at left is probably their mother, Jane, caterer and, presumably, crèche matron. Courtesy of Paul van Nynanten

From cottage to cathedral: songs of praise for Marakoopa Cave

Having their own cathedral must have been very appealing to the Byards. Strict Baptists and dairy farmers Jabez and Jane Byard took the name of their house, 'Berachah', from a town between Hebron and Jerusalem in Israel, the scene of an Old Testament battle.[45] 'Berachah' roughly translates as 'Valley of the Blessings', and blessed were the Byards in about 1905 when along the valley Jim Byard, then in his early 20's, and brother Harry, 11 years his junior, explored a sometimes subterranean creek. It emerged from a cleft in a rock face. 'We'll keep this up our sleeves', Jim told Harry after their second visit to the labyrinthine chambers of what they later called Marakoopa Cave.[46]

Jim bought the adjoining Crown land which contained the cave mouth, and from 1911 Marakoopa operated as a family business. The financial limitations of this, obvious today, probably escaped the censure of first-time show cave visitors. Guard rails and ladders guided travel, but there were no walkways, patrons sometimes having to clamber over flowstone. The cave was lit by hand-held acetylene bicycle lamps and later by miners' lamps. Unlike Scotts or King Solomons, Marakoopa was a massive cave, making it far too expensive to install an acetylene lighting system. Guides supplemented their hand-held lamps by burning magnesium wires at every notable feature, conferring on them a 'weird beauty'. Still, the cave was never effectively lit during the Byard era.[47]



Marakoopa is an acoustic paradise. The Byards played 'Davids Harp' with a mallet during cave tours. Today it receives 'hands off' treatment as a living example of the immensely slow process of calcite column formation. Stephen Spurling III photo courtesy of the National Library

The lamps became very hot, sometimes burning those who came into contact with them.[48] One visitor forgave the 'loss of dignity in crawling', another wetness 'underfoot'.[49] 'The rippingest sight out of England', a Mother-countryman enthused.[50] Small children who might have been admitted to Scotts Cave were checked in at the Marakoopa crèche instead, probably because the three-kilometre-long walk to the cave from the Byard family homestead was too taxing, the hand-held acetylene lamps too dangerous, but also, possibly, out of fear of losing the innocents in the cave labyrinth.[51]

As Scotts Cave was cosy enough for a gnome empire, Marakoopa was big enough for God's. 'Berachah' was a rabbit warren compared to the cave's 'Great Cathedral'. No wonder the Byards, cramped up in their farmhouse, liberated their voices in this vast chamber, exploring its full resonance:

> The guide, in a low voice, asked 'Do you sing at all?'…He walked away several paces, and then in this awe-inspiring cathedral, in the bowels of the earth, he sang Rida Johnson Young's lyric 'Mother Mackree'. I stood dumbfounded. He had a good voice, and away in the depths it was followed with echoes that seemed to run for miles. It was here, there, and everywhere…his voice seemed to travel like wings away and away through caverns and chambers for leagues…[52]

In 1914 Hobart romance novelist Marie Bjelke Petersen and her companion Sylvia Mills joined a

Marakoopa tour party. Like the Byards, Bjelke Petersen was a pious, tee-totalling Christian. The Byards' vocal performance and the shadow and light effects created by the acetylene lamps in the massive, dark cave must have worked on the author's imagination, because her romance novel *The Captive Singer* was clearly derived from the experience.

The Byard farmhouse 'Berachah'—or 'Possum Palace'—today. At least two Byard family weddings were celebrated here. Light refreshments and a crèche service for patrons' children were provided during Marakoopa tours. Photo by Paul Van Nynanten

Corporatising the cottage: the government takes control

By the 1920s, mainlanders accustomed to electric cave lighting disparaged Tasmania's comparatively weak acetylene gas. Entrance requirements of physical agility at Scotts Cave, a head for heights in King Solomons Cave and ability to turn turtle at Baldocks Cave must have limited these caves' custom.[53] The financial stringency of small family businesses was obvious.

The death of private cave tourism was encouraged by a 1918 report on the management of Tasmania's caves by Voss Wiburd. The report is notable for its hysteria. He believed Scotts Cave too dangerous to be open to the public. In fact he used Scotts as an excuse to damn private cave tourism altogether, suggesting that purchases or leases of Crown land be issued with the specification that limestone features on the land remained public property. Wiburd's complaint about Scotts presumably related partly to its rickety cliff-face balcony and awkward entrance, but he also loathed and feared acetylene gas lighting systems. While the safeness of acetylene had been widely debated at its introduction in the 1890s, by now it was commonly used in underground mines, public halls, hotels, private homes, and for street and vehicular lighting. There were regular press reports of acetylene explosions, but only one death by this means had been reported in Tasmania by 1918 and not a single incident was ever reported in any Tasmanian cave lit by acetylene.[54] For Wiburd, however, the installation of acetylene lighting was 'a great mistake':

> The pipes running through beautiful grottoes over head [sic] and under foot, along passages, with props and stays, bends, and reflectors does not improve or add to the beauty of a cave but seems to mar the view, offend the ear by its fizzing, and fumes are very disagreeable to smell and would in many cases overcome a weak

or delicate person. In our caves we will not allow an aceteline [sic] lamp to be carried. We know what happens if anything goes wrong with it. Candles are much safer and can be depended on.

Not even Marie Bjelke Petersen's delicate flower of a heroine in *The Captive Singer*, Iris Dearn, had succumbed to acetylene fumes! Still, Marakoopa and King Solomons, according to Wiburd, needed to be government owned, lit by electricity and safeguarded by iron gates and caretakers. At the time of Wiburd's report, his only son was serving at the front, so it is not surprising to see the Jenolan expert expressing the hysterical anti-German sentiment generated in Australia during World War I. He warned Emmett to guard Tasmania's caves against 'Vandals, Huns and travelling lunatics'.[55]

Wiburd's recommendations were blessed by a Caves Advisory Board appointed by cabinet. King Solomons (1920) and Marakoopa (1921) joined Baldocks as state possessions.[56] This meant that, aside from the sporadically-visited Flowery Gully Cave, Scotts Cave was the only Tasmanian tourist cave left in private hands.[57]

While the full glories of King Solomons and Marakoopa were finally seen under electric light, the tradition of serving refreshments and lunches faltered under government control. In the private cave era, most of the simple fare served had been fresh homegrown produce. Visitor numbers were small, costs minimal, with no administrative overheads or red tape.

It was a different story when government-operated caves got down to business in the post-World War II period. Although tearooms and restaurants attached to King Solomons, Newdegate and Marakoopa Caves were operated as private enterprises, they were a constant headache to both the Tourist Department as well as their operators.[58] Patrons grumbled when food and drink were unavailable. Guides' catering wives were run ragged providing these. Caterers were not employed (that is, *not paid*) by the government, yet the Tourist Department required them to provide teas and meals whenever patrons requested them, even on Christmas Day. Refusal to cater was viewed as a breach of the conditions under which *the married couple* was engaged, making the female partner effectively a round-the-clock slave.[59] If some of the simple pleasures of the cave visit were lost by the new business model, however, the gains were more substantial: safer, less damaged, better lit caves educating a wonderstruck public.

References

1. These figures are derived from a table in *Statistics of Tasmania 1917*, p.246, which quotes stock numbers as at 1 March 1918. Figures for the districts of Evandale, Fingal and Launceston have been removed from the statistical division of north-east, and Westbury has been removed from the north-west division. These districts have been more appropriately included in the Midlands division.
2. Sharon Morgan, *Land Settlement in Early Tasmania: Creating an Antipodean England*, Cambridge University Press, Oakleigh, Victoria, 1992, p.22.
3. *Statistics of Tasmania 1922–23*, p.58; transcript of a 1972 interview with Anderson ('Jack') Scott (held by Jim Scott, Hobart).
4. See Nic Haygarth, 'Dan Pickett, Pioneer Cave Guide', paper in these proceedings.
5. See Marian Walker, *Memories, Dreams and Inventions: the Evolution of Tasmania's Tourist Image 1803–1939*, PhD thesis, University of Tasmania, 2008, pp.192–99.
6. 'Peregrinator' (WD Weston), 'Notes of a Trip in the Vicinity of the Cradle Mountain', *Colonist* 17 March 1888, p. 4; John Wat Tyler to Henry Dobson 11 May 1893, PD1, vol.60 103/93 (Tasmanian Archive and Heritage Office).
7. See Nic Haygarth, 'Ozone-wetted Appetites and Hearts Devoid of Care: Cruising to Cave-land in Nineteenth-century Tasmania', *Proceedings of the Cave and Karst Management in Australasia 17 Conference, Buchan, 2007*, ACKMA, 2007, unpaginated DVD.

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10. See, for instance, 'Quinnat', 'Chudleigh Lakes: no.1', *Weekly Courier* 10 March 1902; 'Trip to Chudleigh Caves', *Launceston Examiner* 11 January 1900, p.5; and 'A Trip to the Caves', *Launceston Examiner* 28 January 1902, p.3.
11. For the 'Yosemite Valley of Tasmania', see 'One of the Party', 'A Trip to Lake McKenzie and the Devil's [sic] Gullet', *Examiner* 24 December 1896, p.10. For general discussion about the Shannon Rise, see Simon Harris, *Selling Tasmania: Boosterism and the Creation of the Tourist State 1912–1928*, PhD thesis, University of Tasmania, 1993.
12. Kate Weindorfer died in 1916, after which her husband Gustav Weindorfer continued to operate Waldheim Chalet until his death in 1932.
13. See Jim Scott, *Down the Crick: Stories of Early Generations of Scotts at Mole Creek*, the author, Hobart, 1996.
14. Transcript of a 1972 interview with Anderson ('Jack') Scott (held by Jim Scott, Hobart).
15. For Hartnett, see Simon Cubit and Nic Haygarth, 'Paddy Hartnett: Tasmanian Frontiersman', *Papers and Proceedings of the Tasmanian Historical Research Association*, vol.57, no.2, August 2010, pp.80–104. For Weindorfer, see GFJ Bergman, *Gustav Weindorfer of Cradle Mountain*, Tasmanian Government, Hobart, 1959.
16. Jim Scott, *Down the Crick…*, p.29.
17. Miss IA Greenhill, Mr Thos HW Jones et al 19 January 1922, p.192, Scott's Cave visitors' book 1911–29, NS1780/1 (Tasmanian Archive and Heritage Office).
18. 9 March 1912, p.30, Scotts Cave visitors' book 1911–29.
19. 'One of the Five', 'In the Fertile North West', *Examiner* 14 February 1911, p.3.
20. Transcript of a 1972 interview with Anderson ('Jack') Scott (held by Jim Scott, Hobart).
21. Jim Scott, *Down the Crick: Stories of Early Generations of Scotts at Mole Creek*, pp.40–41.
22. *Elphinstones: Pioneer Farmers in Tasmania*, no publication details, 1988, p.85.
23. EC James to Colin Pitt, Scenery Preservation Board 12 February 1942, AA577/1/6 (Tasmanian Archive and Heritage Office).
24. Interview with Bill James June 2011.
25. King Solomons Cave was reputedly discovered by WH Pochin and either Ern or Alf Holmes when their dog chased a wounded wallaby among some limestone rocks—where it vanished into a typical 'animal trap', the original cave entrance which can still be seen today near the old generator shed. Other writers claim the men were following a swarm of bees. For various discovery stories, see 'A New Caveland: King Solomon's [sic] Caves at Mole Creek', *Examiner* 14 September 1908, p.6; FAW Gisborne, 'Underground Tasmania', *The Red Funnel* vol.IX, no.1, August 1909, p.3; 'King Solomon's [sic] Caves', *Examiner* 2 November 1911, p.6; or 'The Land of Caves and Caverns', *Advocate* 19 December 1928, p.7.
26. See file TRE 5/1/1075 no.2254/16 (Tasmanian Archive and Heritage Office).
27. EC James, 'King Solomons Caves', *Examiner* 19 November 1908, p.7.

28. James probably recalled the islands named Hope, Faith and Charity in Port Esperance at Dover, his home town. Port Esperance also featured a King Solomons Beach ('Picturesque Port Esperance', *Mercury* 5 March 1930, p.8).
29. Wiburd stated that King Solomons was the finest cave in Tasmania ('King Solomons Caves', *Mercury* 30 January 1915, p.7). James claimed that Wiburd stated King Solomons was the finest cave in Australia (EC James, 'Mole Creek Caves', *Mercury* 29 April 1918, p.2).
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31. EC James to ET Emmett 9 November 1939, AA494/68 227/1/38, 'King Solomons Cave' (Tasmanian Archive and Heritage Office).
32. See Sydney (Bill) James, *The Blazed Track*, the author, Launceston, 1996, p.25.
33. The conveyance (Memorial no 12/212) was not registered until 31 March 1909 (Land Titles Office, Department of Primary Industries, Parks, Water and Environment, Hobart).
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36. Birth records 1469/1917, 1470/1917 and 3475/1917 respectively (T*asmanian Federation Index* database). A birth notice gives the boys' names as Reginald Ernest and Ronald Ernest ('Births', *Examiner* 17 November 1917, p.1).
37. 'Tourist Association: Meeting of Committee', *Daily Telegraph* 9 March 1909, p.8.
38. 'Great Bush Fires', *Examiner* 18 February 1915, p.6.
39. 'Grapho', 'In the Mist of the Mountains: the Magic of Mole Creek', *Advocate* 17 January 1925, p.1.
40. 'Grapho', 'In the Mist of the Mountains…'.
41. 'IHC', 'The Playground of Australia', *Advocate* 14 May 1924, p.11.
42. See Hilton Stott's Wesley Dale website stott.customer.netspace.net.au/Wesley.htm.
43. 'Mole Creek Caves', *Examiner* 3 September 1920, p.7.
44. The Baldocks' visitors' books are held by Ivy Crowden, George Town.
45. See Book of Corinthians 2, 20:24–31.
46. 'Hole in the Ground Led to Marakoopa Wonderland', *Advocate* 30 March 1968.
47. 'Verdant', 'A Visit to the Wonderland of Tasmania', *Weekly Courier* 29 February 1912, p.29.
48. 'History of World-Famous Marakoopa Caves', *Advocate* 12 February 1960, p.18.
49. Mary C Dickson 23 February 1915; ? Webb 27 February 1916, Marakoopa visitors' book (held by Mrs Kelly, South Mole Creek).
50. I Wallis 18 January 1912, Marakoopa Cave visitors' book.
51. 'Verdant', 'A Visit to the Wonderland of Tasmania', p.28.
52. 'The Maracoopa [sic] Caves', *Mercury* 23 March 1928, p.7.
53. See Charles Miscamble, Commissioner of Railways, to Minister for Railways 15 August 1927, AB455/4 R21/1 (Tasmanian Archive and Heritage Office).
54. For the death of Launceston photographer Albert Sargent, see 'Acetylene Gas Explosion', *Mercury* 28 August 1913, p.5.

55. Voss Wiburd to ET Emmett 7 January 1918, 'Tasmanian Caves 1921–28', TC10/1/1882 21/285 (Tasmanian Archive and Heritage Office).

56. Wiburd had recommended the government buy King Solomons after his first visit in 1909. For the Caves Advisory Board, see 'The Caves', *Daily Telegraph* 2 February 1920. Under the *Public Works Execution Act* (1915), £900 were set aside for the government acquisition of King Solomons (see file TRE 5/1/1075 no.2254/16 [Tasmanian Archive and Heritage Office], which also discusses arrangements for WH Pochin to receive some of this money).

57. Scenery Preservation Board minute book 18 September 1918, AA264/1/1 (Tasmanian Archive and Heritage Office).

58. See, for instance, Torry Richardson's report 22 January 1961, AA494/141 703/1/59 'Mole Creek Inspections' (Tasmanian Archive and Heritage Office).

59. See FH Southey to Roy Skinner 13 January 1960; and Roy Skinner to FH Southey 14 January 1960, AA494/1/336 176/6/59 (Tasmanian Archive and Heritage Office).

Wild Cave Tours, the journey: strange, exciting and rewarding (but sometimes political)

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Abstract

Wild Cave Tours, operating at Mole Creek, Tasmania, was created in 1989 as a cave tour specialist business catering to the tourism and special interest group markets. It maintains part time operation, mainly in the summer season. Over the years, the business has led by example in minimal impact caving and safety standards for dependents in the unforgiving environment of wild Tasmanian caves. However, at the same time, the incapacity of Tasmania's tourism marketing machine to fully embrace boutique and regional tourism products, as well as political conflict in the local community over conservation issues, have caused difficulties. The limited commercial success of the business is primarily due to the difficulties inherent in its regional location and Tasmania's tourism marketing structure and culture. Contemporary management initiatives designed to limit the impact of recreational caving in wild caves could threaten business viability.

Introduction

Mole Creek is one of the more popular of Australia's karsts for cavers and tourists alike. Its fame is due partly to the fact that it hosts a large number of caves that are famous for the abundance of their mineral decorations. For caving club visitors, its caves vary in nature, from vertical to horizontal and from simple river caves to complex maze caves, catering to cavers of all abilities or experience. For Australian cavers, a major attraction and challenge are that many caves at Mole Creek are active river caves (cold and wet). Finally, many of the popular recreational caves are relatively easy to access as day-trips from local campgrounds and other accommodation. Two guided show caves cater to the tourism trade. There are no self-timed (self-guided) show caves.

To a prospective tourism operator Mole Creek may seem like an obvious place for a successful "wild" cave venture, complementing the more mainstream experiences offered by its well-established show caves. However, while adventure and environmental tourism took off elsewhere in Australia and New Zealand in the last quarter of the 20th century, until the advent of Wild Cave Tours. The only tourists frequenting wild caves of Mole Creek were self-reliant caving clubs and school, scout and church youth groups, along with guests of a former Deloraine youth hostel owner who undertook some casual guiding.

Wild Cave Tours' organised trips into undeveloped caves of the district in many ways reinvented an earlier tradition established in colonial times by Dan Pickett (see Haygarth, elsewhere in these Proceedings), whereby visitors are treated to both scenic and cultural curiosities by a colourful local character. Many rural communities in Tasmania have embraced tourism as part of an economic transition, shifting some of the reliance on primary industries towards the services sector. Wild Cave Tours was one of the first of many micro-businesses to be established in tourism hinterlands, and was modelled on a 20th century owner-operator tourism tradition pioneered by tenting owner-operators on the iconic Overland Track (e.g. Eric Sargent, "Craclair Tours;" John Boden, "Tasmanian Highland Tours"). The story of Wild Cave Tours is intrinsically also a personal tale of the figure responsible for its inception.

The number of caves potentially available for commercial use is limited by the cross-tenure extent of many caves. While several reserves have been created in recognition of caves, it is common that only the entrance is contained within the reserve, and most of the cave extends into private tenure without depth limits. Many more caves are wholly privately owned, as the landscape is intensively used for farming.

A low volume in trade is a substantial reason Wild Cave Tours' service retains a personal touch, however it means the operator requires a supplementary income and a minimum critical mass to cover costs. Potentially, existing demand for nature-based product could generate more business, as could proximity to the two regional cities of Devonport and Launceston, but there are many reasons it has been difficult to reach out to the market and convert interest to bookings.

Wild Cave Tours' fate has been very much tied to that of fellow tourism operators of Mole Creek, who have been forced to repeatedly reinvent their identity and marketing efforts in response to constant imposed change, including successive state tourism strategies, while competing with other Tasmanian geographical regions for attention. Tasmania's demographics differ from those of mainland states, with the majority of the population living outside the greater metropolitan area of the capital. Although Mole Creek is centrally located to a considerable range of nature-based tourism attractions and activities, the attainment of status as a regional tourism destination in its own right has been evasive. In the state strategic picture, Mole Creek seems like somewhere you drive through on the "touring route" network, or take a day trip to from higher profile northern centres.

Wild Cave Tours was essentially an extension of a caver-conservationist's lifestyle, growing out of a yearning to seed a deeper understanding of the world beneath our feet, a world whose interconnectedness with the surface and our activities upon it was poorly understood. I began my caving life at Mole Creek, after my return to Tasmania to live in 1976. I rubbed shoulders underground with members of the Southern Caving Society and the Northern Caverneers, trudged through the thick wet forests of the Great Western Tiers with Bob Woolhouse tracing the location of the limestone contact and investigating associated features, assisted Kevin Kiernan during his 1983 reconnaissance survey of the Mole Creek karst and attended *Speleomania* (1985 Australian Speleological Federation Conference). I had also witnessed, as a eucalypt seed collection contractor for the Forestry Commission, the transition in forestry to larger coupes in the clearfelling of native forests in the early 1980s. I could understand the threat of such activities, compared to prior selective and smaller scale forestry techniques, on karst processes and land stability. Wild Cave Tours was begun the same year that I joined other local conservationists to work towards a proposal for Great Western Tiers National Park, formally launched the following year, 1990. Consecutively, the growing number of caver-conservationists in the local area formed the Mole Creek Caving Club in 1991.

Figure 1: This was probably Wild Cave Tours' first trip under license to Croesus Cave in 1989. This was a field trip for environmentalists visiting northern Tasmania. Volunteers including the author cleaned the feature behind the group, "the snow bank," of previously placed handprints.

Wild Cave Tours' genesis in 1989 was triggered by a high-profile effort to develop a third show cave at Mole Creek, despite the arguable fulfilment of foreseeable demand in northern Tasmania. The context of the proposal was that the beauty and extent of Mole Creek's caves were becoming more widely known, and having only two of them developed for public view was another under-utilised natural resource; a bit of a waste. It had been recognised that opening the utopian cave, Kubla Khan, would be far too expensive to develop, so a proposal for a tramway in Croesus Cave was underway, driven by politically well-connected persons. I saw licensed commercial caving trips in Croesus as a more appropriate way to make the cave available to the public, and one that could keep the cave in a wild state, as the icon for cavers that it was. With the support of the then Senior Ranger, Chester Shaw, a Tasmanian television film crew was taken into the cave to promote the concept while my licence application was underway. In Tasmania, even tourism is political. I was frustrated that karst systems and their caves lacked acknowledgement in the resource exploitation-conservation debate. I felt I had a chance to communicate this imperative to people, if I could first demonstrate to politicians and community leaders that even undeveloped caves could have direct exploitative-economic value. If I could get this point across, I might be able to develop profiles and support for indirect economic benefits like rural water resources, the health issue of sinkhole dumping and intrinsic values like cave fauna and landscape aesthetics. Like other Tasmanian conservationists starting up micro-businesses in tourism, I believed in a great future for tourism, and tourism's ability to help justify the protection of native forests from big business forestry while retaining timber resources for local communities' use.

In the early years, clients may have been motivated mainly by a sense of adventure and the promise of scenery most people don't get to see, but in the process, they were almost all touched by insight beyond mere facts and figures, for example "A different perspective on life" (from the Visitors Book). In more recent years, a sophisticated clientele has been openly seeking special, genuine nature experiences guided by experts, passionate in their field. Throughout its life, the business may have been successful in catering to corporate group markets, but its limited success in the Tasmanian youth/school group market is regrettable. A brochure supported by the department of Sport and Recreation and Meander Valley Council, specifying the advantages of using specialist guiding (*Youth Outreach Program*), had little effect. Wild Cave Tours' best discount rates are outcompeted by the lure of free of charge services offered by youth workers employed in government service organisations; whereas clients of a micro-business must pay enough to provide the day's "wage." The lack of regulation of the not-for-profit sector, as to which caves are visited and standards of the conduct of dependents, has always been problematic. This sector likely represents the largest cave user group of Mole Creek's undeveloped caves.

Although Wild Cave Tours was started up rather early in the market's maturity of demand for such product, building up the business over some years when little money was left after expenses was made possible by sole parent income support. However, Wild Cave Tours struggled just to cover operating costs in the first few years of operation, with many of the operating days being familiarisation trips ("famils") for others in the tourism industry to get to know the product, and free-of-charge trips for people on the *Visiting Journalists Program*, run by *Tourism Tasmania*. From the bookings diary, the summer period of 1993/94 saw 1 to 3 trips a week, usually for 1 to 5 people. I fully threw myself into tourism operator mode, taking out the inaugural Tasmanian Tourism Award for Environmental Tourism, participated in regional tourism marketing, development and awards and kept doing rounds talking to accommodation operators, Visitor Centres and networking with other emerging nature tourism operators. Wild Cave Tours' business increased up to the 1996/97 year, which carried 139 clients over 57 working days. Business then levelled off at that volume. It had become a very satisfying part time, largely seasonal job. There was a lot of working down-time, preparing for trips and cleaning up after them and carrying out roles in local and regional tourism committees, but each trip was so well received it injected energy.

Revision and development of the Wild Cave Tours product was led by participants' responses. For example, I found everyone keen to help in my "cave maintenance" (cleaning handprints on calcite and picking up rubbish). So it was that active conservation, quickly became part of each trip.

People appreciated novel things about the trips; dressing in caving overalls, the loan of photography equipment and expert assistance with their photography, and the true caving tales as told by the local caver/s guiding them. They relaxed into an otherwise potentially hostile environment when the small numbers allowed them to not feel rushed by younger or more experienced participants. The many journalists made the country home baking quite famous! The product was promoted as a packed itinerary, offering two caves in a half day and up to four in a full day tour. Wet Cave was the focus for many years; this grandly proportioned and decorated stream cave, with a spectacular glow-worm display where I played flute, always made a huge impact on people, was quite adventurous enough for most, and nearby Honeycomb Cave could be used for some physical fun and to warm up after the long cold experience in Wet. Croesus was only used occasionally, for photographers and naturalists prepared to endure the extreme cold and long drive to see it. Those motivated by adventure were better satisfied elsewhere. Baldocks Cave offered historic acetylene lighting relics, a variety of crystal calcite forms, cave fauna and great natural bush setting. A lower level could be used for adventure. Cyclops Cave, a short stream cave near Baldocks, was used as a contrast. Two additional caves came into use for a few trips a year. From 1995, those willing to take the time were conducted into Westmorland Cave, a 20 minute walk each way on Council land upstream of Wet Cave, off the old tourist walking track to Westmorland Falls. It had a wonderful glow-worm display, a fun entrance passage and a lovely "wilderness" rainforest setting. From 1995, My Cave was used occasionally for competent clients, its climbing entry a risk for the unprepared. Finally, Sassafras Cave came into use during 2000. It had an excellent glow-worm display, and was an easy scenery appreciation type experience. Although its small reserve was enclosed entirely by private land, the farmer kindly allowed access.

As operator of Wild Cave Tours, my lifestyle was barrelled along beyond cave tourism, but this has been a transition era, as interest in the Great

Outdoors has rapidly expanded; my involvement in broader roles has been a necessary part of being a specialist operator who has pioneered standards sympathetic to both environmental and client wellbeing. I have been driven to spend uncounted hours of voluntary involvement in the development of national outdoor activity standards, education outdoor activity guidelines, cave rescue exercises and actual rescues, conservation working bees, national caving issues and to agitation for positive change in cave visitor management in Tasmania from within industry, club and environmental organisations. Official response to the latter persistent agitation has been long coming, but is presently coming to fruition with moves to impose obligatory standards of conduct to improve safety, and number restrictions to reduce environmental impact (see Figure 2), on all wild cave users, including the not-for-profit sector. These changes will also impose restrictions on Wild Cave Tours' licensed operations.

Figure 2: Accumulated caver impact on earth slopes in Honeycomb Cave. Left: 1998; right: 2011. Ferns and mosses have reduced in coverage, while some erosion is evident on the climb.

A micro-business such as this has brought some interesting people contacts! Numerous free-of-charge trips have been donated for environmental education, especially field trips for *Forest Festival* participants, special interest groups and conferences. Trips for better-informed audiences such as these groups are more rewarding, as clients interact more with the presenter, allowing in-depth interpretation and discussion of conservation issues. Student groups are especially challenging, but equally rewarding, in the process of bringing them actively into the spirit of teamwork and care with their impact on the natural environment. Extended programs have allowed students more interaction, learning cave surveying techniques, rescue and navigation skills. Journalists on sponsored, all expenses paid tours of Tasmania really excelled themselves, producing thousands of dollars' worth of inspired publicity from personal experience. However, amusing exceptions included a journalist whose experience was terrifying, as she wrote (of being in the cave): "I feel as if I opened my mouth it would fill with black material. I keep my mouth shut." A major coup and highlight for Wild Cave Tours was meeting Sorrel Wilby for the filming of a *Getaway* segment, a person who makes everyone she touches feel special and who knows how to have fun. Collingwood first-graders on leave after the season were sceptical of our ability to challenge such fit blokes as themselves, yet were left virtually quaking at the knees after Honeycomb Cave. Some international millionaires were blissed-out when their raw, wet and dirty adventure was rewarded by silver service dinner and theatre in the bush. However, the weirdest and most wonderful thing of all was to witness the blessings and rituals performed by a Tibetan monk in Wet Cave. His self-appointed mission was to bring about healing for the community's contemporary political turmoil and divisiveness and for Tasmania's forests (Figure 3).

Figure 3: Lama Samten in Wet Cave, 1998.

In 2000, local landowners began to be politically active, following a period of rising tension in the local farming and forestry sector, which saw the listing of the Mole Creek karst landscape on the Register of the National Estate. The negotiation of Tasmania's *Regional Forests Agreement* (RFA) and the rescinding of the generations-long grazing lease over the state reserve at Wet and Honeycomb Caves, when its status was upgraded to National Park, were seen as further insults. The owners of Wet Cave brought a century and a half's public access to a close as a protest (only the entrance is contained in the public reserve) and logged the highly visible hillside adjacent to the reserve, in contravention of the RFA. Access was bulldozed on the farm to an upstream entrance of the cave, which was advertised for lease as a "world class cave system" for tourism, but no lessees came forward. Later that year, access to Westmorland Cave was also closed, marked by an ugly confrontation of a Wild Cave Tours client group by local farmers. An old gentlemen's agreement had provided for the walking track to pass through 200 m of private land onto Council's block, to avoid development of the longer Public Works Road alignment, which was used as an integral part of the farm on either side of it. Although the well-known Westmorland Falls were also inaccessible, the government was unwilling to develop the legal access. Farmers cleared part of the Westmorland walking track for vehicular access, from the farmland to the entrance of the cave, where an old log dam diverting water to the farms was replaced by a small concrete dam and new flume system, to maximise capture of the water from the cave's inflow. Council backed out of any involvement in these issues by gifting their land to the state government for conservation. Four years passed before an access easement over the private land portion of the old walking track was funded and purchased by the government, restoring access. Unfortunately, Westmorland Cave was physically blocked by a catastrophic debris flow during the January 2011 floods (see paper elsewhere in these Proceedings). Meanwhile, the farm used to access Sassafras Cave was purchased by a forestry *Managed Investment Scheme* (MIS) company. Access to this cave was closed in 2002 after only two years' use by Wild Cave Tours. MIS companies were paying prices for land above their market value as food-production farms. Croesus was finally withdrawn from the license in 2003, since it was a restricted access cave that the Parks and Wildlife Service and many club cavers thought should only be available to caving club members. By 2002, the Wild Cave Tours product had changed to mainly half day trips seeing just one cave. Honeycomb has become the main cave, with equal accent on adventure, learning physical caving skills, and environmental interpretation.

Marketing was as problematic as access for Wild Cave Tours. In 1994, the business joined Tourism Tasmania's wholesaling program, *Tasmania's Temptations*. Having such businesses on the books embraced the emerging official "wilderness" branding of Tasmania, and gave micro-businesses presence in a brochure nearly all visitors found. However, like many other owner-operated businesses found, for Wild Cave Tours it was very costly to participate, both in up-front costs each year and in commissions. The communication chain was too long from client to operator, through retail agent and wholesaler, and the nature of boutique product was often poorly represented to clients, causing mismatches and refund requests. Although a collective of up to 14 owner-operators called *Tasmania's Natural Experiences* (TNE) lobbied very actively, the small extra volume for Wild Cave Tours from wholesaling caused more working days in the season for very poor returns and so I left the program in 2002. TNE continued co-operative marketing efforts; furthermore, its members got on the internet. Things were changing; we could afford to market ourselves. Another co-operative, the *Tasmanian Licensed Guiding Operators Association* (TLGOA), was formed to liaise with government regulatory, management and licensing bodies, organising annual meetings with them and representing members' common interests in between times. TLGOA's members were able to survive the Public Liability Insurance crisis of the 1990s, by virtue of the Association's collective buying power.

Still, Tasmania's boutique operators thinned out in the late 1990s, weakened by the "recession we had to have" or having fallen victim to the uncertain returns of regionalism. For example, Mole Creek's operators struggled through council amalgamations and the resulting loss of identity through the merger, two changes in district phone numbers playing havoc with marketing and the rise and fall of inter-municipal marketing co-operatives and Tourism Tasmania's "touring routes." Mole Creek's 4WD tour operator closed up shop. Mole Creek and Wild Cave Tours had little support from a Deloraine Visitor Centre funded out of the RFA, partly because Deloraine openly felt in competition with Mole Creek during and since the RFA funding bid. For Wild Cave Tours, a further reason was the large number of volunteer staff, making it impossible to properly familiarise the Centre with the product. In its struggle to survive, the visitor centre became largely an accommodation booking service, and its "Activities" book was forgotten. Local accommodation establishments and show cave guides have always been very important in referring clients to Wild Cave Tours. However, brochure display at the show cave ticket office was not allowed, and offers to produce co-operative marketing brochures with Parks and Wildlife were unsuccessful. Wild Cave Tours' production of its own brochures ceased in 2004, as they had always prompted more enquiries for the show caves than for my own business.

By 2004 I had acknowledged the business' reliance on cost-neutral promotion like tourism association websites for members and my own web domain and site. I dropped all advertising. I had become convinced of my inability to differentiate the Wild Cave Tours product from the show cave product in the tourism information distribution network, hence tourism marketplace. The practical daily limitations in carrying capacity of a specialist boutique caving operator in regional Tasmania necessitated more working days than I could secure. I faced the need for a day job, and went back to university to re-skill formally, in environmental science. I have been there full time since the summer of 2004/05, have loved every minute of it, and am still energised by taking tours on weekends and occasionally during the week in summer, especially those tours conducted for a small but devoted clientele of student groups.

Conclusion

Wild Cave Tours' success can only be measured on its own terms, not in commercial terms. While it has never made enough profit to support its owner-operator without supplementary income, it survives and continues. It upholds a stewardship ethic towards the popular recreational caves of Mole Creek, high standards in caving leadership and the conduct of dependent groups, and the client experience continues to be enriched by genuine insights into the world of speleology and by environmental education. Even if current moves towards curtailment of all recreational caving activities in the interests of cave protection and the safety of dependents renders Wild Cave Tours incapable of continuing, it may have already achieved enough for one lifetime.

Photography is by the author.

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Planning In A Land Use Mosaic – Innovative Approaches On The Mole Creek Karst

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Abstract

The Mole Creek karst system in northern Tasmania is extensive, complex and contains unique values that require consideration in a planning context. Imposed on this natural system is a mosaic of land uses, including a variety of agricultural enterprises, forestry, lifestyle blocks, quarries and reserves. Planning tools to effectively manage karst in such a setting are not well developed in Australia.

Historically, planning in this karst area has taken a broad compliance approach that poses challenges for both developers and Local Government officers seeking to assess potential impacts.

In step with general planning changes under way in Tasmania, Meander Valley Council has initiated an innovative approach to land use planning in a karst context. Science, through risk matrices, provides a robust guide for collaborative assessment between Council and specialists within the Tasmanian Government. Thus improved transparency, consistency, streamlining of process and karst values management are expected.

Background

Development controls in karst areas are critical, yet standardisation and consensus can be elusive. Imposing settlement patterns on karstic terrain implies risk right from the start: risk to life and property from the karst; risk to karst integrity and values from human activity.

In the Mole Creek area of Tasmania a mosaic of farmland, villages and informal reserves evolved when it was first opened up by European settlers. Timber was initially the resource of choice, whilst trapping and farming played their part in the local economy. Today, a significant portion of the karst and its upper catchment are in formal reserve, whilst farming and forestry dominate a landscape diced up by both the formal and informal reserves. Land on the karst has limited agricultural potential, but has supported dairy and cropping on some of the better soils where supplementary nutrient application and generous, reliable rainfall have made them viable. Most of the private land on the karst is used for raising beef or sheep, fodder crops, private forestry, some limited vegetable and poppy cropping, and a scattering of accommodation and lifestyle blocks with an emphasis on showcasing natural values on their properties and capitalising on the nearby national parks and mountains. There is also a major limestone mine near the Mersey River. Due to changing markets and other factors, there has been a general trend over the last decade away from dairy and toward private forestry.

The geoheritage and biodiversity values of the Mole Creek Karst system are well documented, as are land use interactions (Eberhard, 2007; Eberhard, 2003; Eberhard & Houshold, 2001; Eberhard & Hamilton-Smith, 1997; Kiernan, 1995; Kiernan, 1989), and will not be reviewed here. A geological distribution of karst within the municipality is shown in Figure 1. The karst is also a significant wetland in its own right. It is sufficient to realise that land use planning to assess risk factors must be cognisant of anthropogenic and natural vulnerabilities. It is easy to impact on the equilibrium of karst environments, and changes to it are not forgiving of human intervention. An innovative Local Government approach to development control is the topic of this paper.

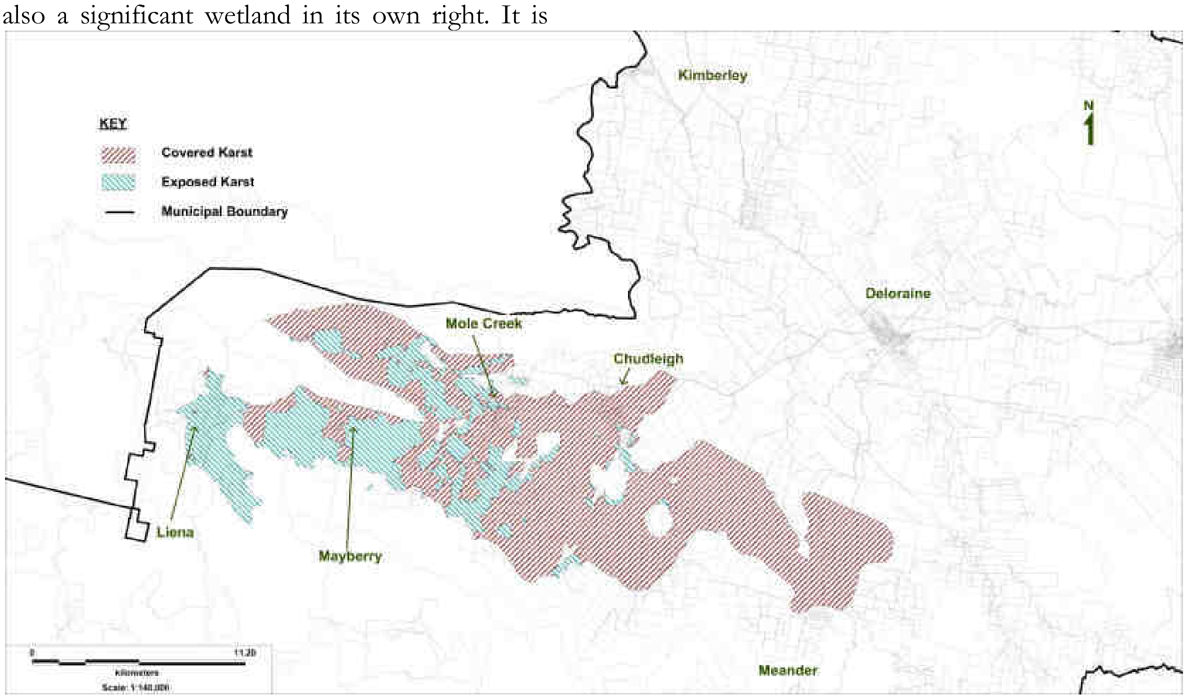

Figure 1: Geology-based Distribution of Karst in the Meander Valley Municipality (Data: Tasmanian Government)

Planning Approaches

Generally karst in Australia is in reserves, or at least in places remote from most development pressures (the Nullarbor Plain may be considered an expansive exception). And so it is with most of Tasmania, with Mole Creek and Gunns Plains being notable exceptions. It is hardly surprising, then, that most municipalities in Tasmania leave karst protection to reserve status, or rely on indirect management that fits neatly with other objectives, such as through water quality and biodiversity schedules in their planning schemes. The Central Coast Council, that has local authority over the Gunns Plains karst, uses zoning criteria as well as general provisions relating to attenuation and land stability. Karst is not specifically addressed (Central Coast Council, 2010). In some jurisdictions elsewhere in Australia a well structured precautionary assessment is advocated (Environmental Protection Authority, 2008), though translating this into consistent, effective Local Government processes is challenging.

The *Meander Valley Planning Scheme 1995* (Meander Valley Council, 1995) is the prevailing land use planning instrument covering the Mole Creek area. However, other land management systems also operate concurrently, including Parks & Wildlife Service reserve planning and a forestry industry Code of Practice (that includes guidelines for karst management). Developments are still subject to Land Use Planning assessment, unless a specific exemption is granted. Overarching legislation exists to regulate chemical use, protect identified natural values, and assess environmental impacts of large development proposals.

In the context of this paper change is of most interest, since it is changes to, or intensification of, land use – plus new developments, that trigger Local Government planning. This includes assessing proposed new structures on properties, subdivisions, as well as the implications of new activities. The need for a multidisciplinary approach to karst planning is becoming more evident (Fleury, 2009 p.19).

Although embodying a clear intent to manage karst well, the *Meander Valley Planning Scheme 1995* has proved a challenge to implement. Under the Karst Areas schedule (s. 4.10), all developments within the defined karst boundary have to demonstrate general compliance with a series of broadly worded objectives. For example, a proposal is deemed prohibited if "it is likely to induce unacceptable levels of soil erosion". Assessment issues arise pertaining to who decides on level of acceptability, whether soil erosion is "likely", what the cost of determining these are, who bears this cost, and what modifications to an application might allay fears all around. In a complex environment it is quite subjective and open to challenge, even with professional advice at hand. The planning boundary for the karst was delineated on specialist advice from the Tasmanian Government in 1995, and included that proportion of requisite geology exhibiting karstic development or exposed rock, and catchment areas immediately associated with these (Figure 2). Implications of developing on covered karst further to the east was less clear and presumably considered less critical, so this was not incorporated.

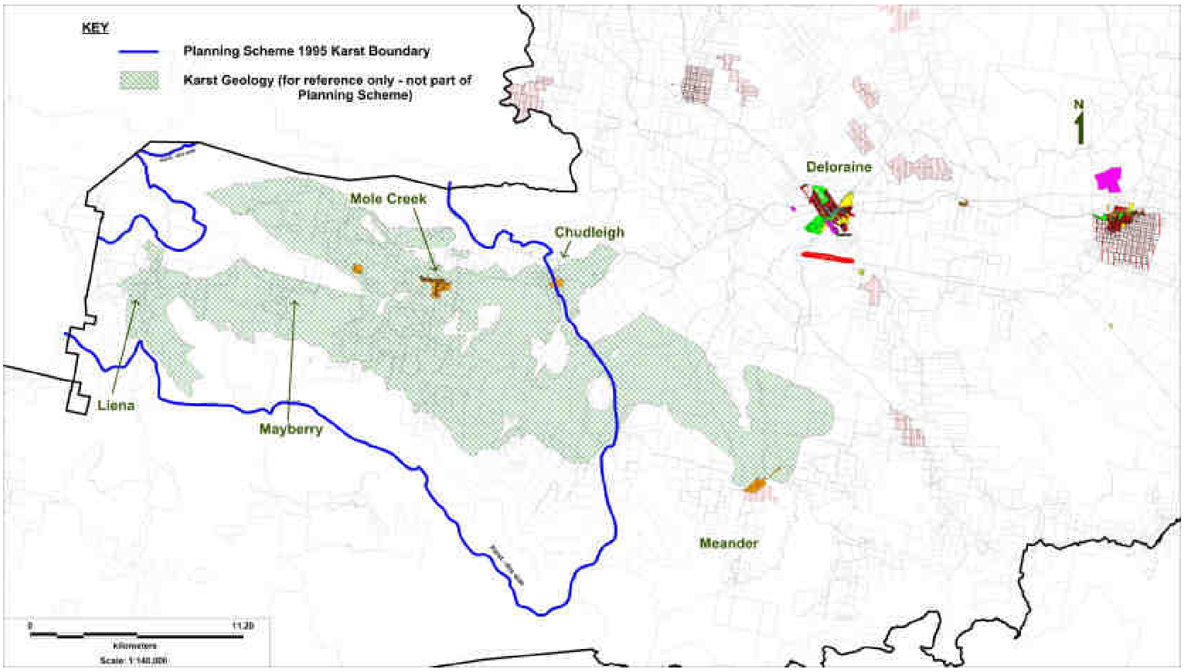

Figure 2: Meander Valley Planning Scheme 1995, with Geology.

Pressures For a New Approach

Quite apart from experience with current planning instruments, other factors provide an impetus for an improved approach. Changes in the fortunes of agricultural markets, tax concessions for the private forestry industry, and demographic trends have led to significant land use changes where outsiders might expect a more conservative situation. Some properties have absentee owners, others have conservation covenants on their land titles, or had portions transferred into reserve. Pressure exists for new tourism opportunities, and for lifestyle blocks to be opened up.

It is also timely to set meaningful protective measures in place, for the integrity of our karst environment, the fragility of which might become more evident as the implications of climate change are better understood. If we impact on the resilience of karst systems through poor planning, then they may be more vulnerable to environmental variation. Various authorities have advocated a cross-tenure approach to karst planning (Williamson D., 2009; Fleury, 2009 pp.20,104; Eberhard, 2003; Eberhard R. and Houshold I., 2001 p.201), and the concept of stewardship on private land is being embraced even more by property owners.

Currently Local Government planning is reaching a crossroads. Overarching, regional planning schemes are being developed to drive consistency and robustness in some areas of planning. Added to this is an intention to upgrade the structure of all local planning schemes to a more modern, performance based style, with common template provisions where appropriate. Thus, change being necessary, it makes sense to go one step further and produce better karst management tools. Meander Valley Council is the only Council in Tasmania working in this area of environmental management.

Some principles for a karst land use planning instrument going forward are:

- It must be spatially based;
- Afford karst protection, based on science and applied for site and landscape outcomes;
- Ensure that an appropriate and proportionate level of assessment can be applied, based on presenting hazard;
- Incorporates triggers for assessment, level of assessment, and quantified acceptable solutions; and
- It must be fair and equitable, recognising the impact of regulation on the community.

Defensible Science

Science makes the planning scheme defensible and transparent. It gives a studied basis for our assessment and solution triggers, and enables supportive spatial mapping. Planning instruments can't work without boundaries, and the more categorical boundaries, the more tailored responses can be made, however there are trade-offs in terms of complexity.

Tasmania is fortunate in two aspects, namely an enviable (though necessarily incomplete) level of spatial environmental data, and a State Government willing to empower other stakeholders in environmental and land use management. The Meander Valley Council saw an opportunity to capitalise on these advantages. In 2007 a decision was made to produce sensitivity mapping in a small number of categories that would allow for appropriate levels of planning response. Spatially determined vulnerability is a requisite contribution to site hazard assessment for karst protection (Ravbar, 2006 p.171). Wakelin Associates Pty Ltd was contracted to produce a sensitivity map and to populate attendant sensitivity indicator/threat matrices with meaningful, quantified, and scientifically sound response actions (White, 2008).

To inform a renewed planning approach, geoscientists within the Tasmanian Government were given permission to provide Susan White (Wakelin Associates Pty Ltd) with spatial data and advice. A review of existing karst GIS data, and sensitivity analysis, allowed Susan to formulate two mapped sensitivity areas. The data was cleaned to create a High Sensitivity Area, based primarily on exposed karst and known surface features, which incorporated buffers and eliminated unworkable slithers of land. In Figure 3 this is shown in yellow, with the balance of catchment for the whole karst geology then forming the Low Sensitivity Area (in blue).

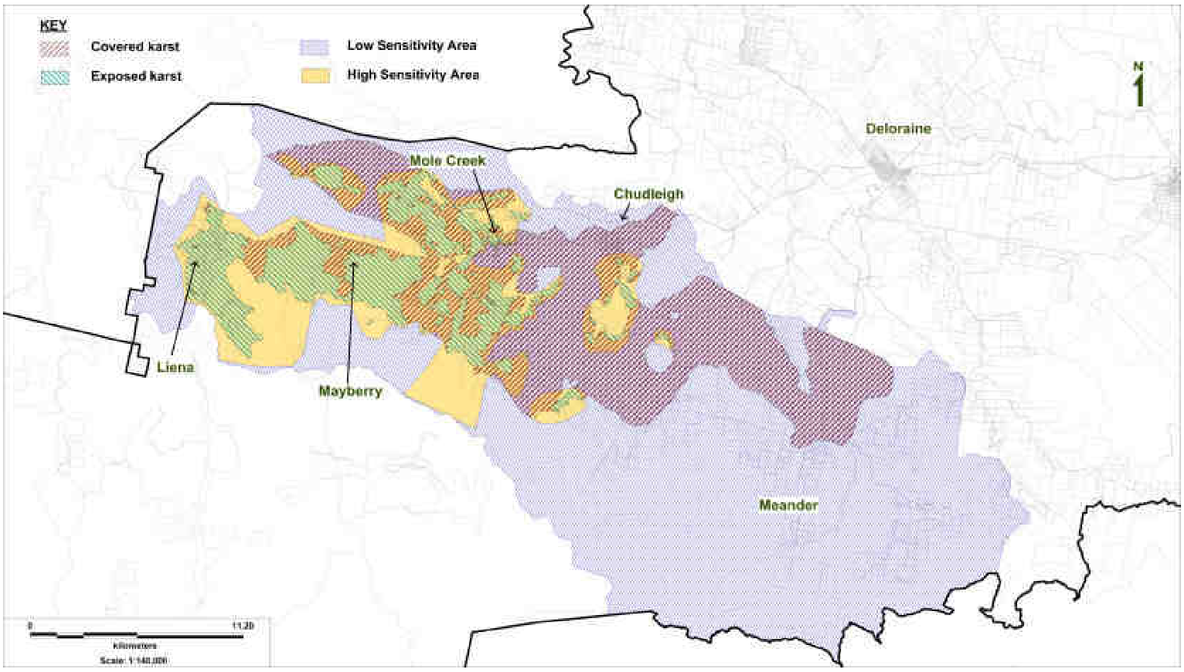

Figure 3: Sensitivity Area Mapping (after White S. (2008) Report to the Planning Department Meander Valley Shire Council, Tasmania: Karst Susceptibility and Planning Matrix).

There are a couple more links required to create a useful planning tool, though. These links are: identifying vulnerable aspects of the karst system, and articulating acceptable solutions to manage risk. What makes a planning tool defensible is its innate scientific credentials, coupled with an ability to explicitly match threats from a development to environmental vulnerabilities either in-situ or in parts of the landscape with demonstrable connectivity.

To this end, a matrix was produced for each Sensitivity Area. In each, sensitivity criteria were mapped against key threatening processes. The matrices were then populated with two types of data:

1. A colour coded response level of Prohibited, Discretionary (refer to specialists), or Permitted if Specific Mitigation is Observed.

2. Alpha-numeric codes linked to a *Key to Acceptable Levels Table* that details aims and performance criteria, trigger levels for vulnerability, and acceptable mitigation responses (for "Permitted if Specific Mitigation is Observed" response level).

A sample from the High Sensitivity Matrix is presented below in Table 1.

SENSITIVITY		THREATS								
KARST SENSITIVITY CRITERIA	KARST SENSITIVITY INDICATORS	Source of detailed indicator data	Induce unacceptable levels of surface soil erosion & sedimentation	Increase sedimentation in underground karst system	Adversely alter the surface hydrology e.g. flow rates	Pollute surface waterways	*All* spillage of chemicals/ petroleum products	Increase underground water flow, increases solution	COLOUR KEY	
		PLANNING RESPONSE LEVELS AND TRIGGERS							PINK	PROHIBITED AT ALL TIMES
	EXCEPT where the only karst sensitivity criteria and indicators are **EXPOSED KARST** i.e. Soil/ sediment thickness < 50 cm, **ALL** planning approval will be either Discretionary or Prohibited.								GREEN	DISCRETION ARY - REFER TO DPIW
Exposed karst	Soil/ sediment thickness < 50 cm	GIS map	T1/ AM 1.3, 1.4, 1.5; T4/ AM 4	T1/ AM 1.3, 1.4, 1.5	T1/ AM1. 1,1.2, 1.3	NO ACCEPTABLE MITIGATION	NO ACCEPTABLE MITIGATION	T1/ AM1. 1, 1.2, 1.3; T2/ AM2. 1,2.2; T6/ AM 6.1,6. 2	YELLOW	PERMITTED IF SPECIFIC MITIGATION IS OBSERVED

Table 1: Sample of High Sensitivity Matrix
White S. (2008) Report to the Planning Department Meander Valley Shire Council, Tasmania: Karst Susceptibility and Planning Matrix.
Wakelin Associates Pty Ltd. Clifton Hill, Victoria.

A New Draft Planning Scheme Tool

Internationally, a number of approaches to land use planning on karst have been implemented. Controls of water, be it stormwater or a utilised aquifer, are common responses. More widely they range from measures to protect life, infrastructure and water resources; to those with a natural values conservation focus. The needs from both perspectives should to be reflected in land use planning, but rarely are (Fleury, 2009, pp.19,118,123-131). For the Mole Creek area, the intent is to conserve identified values associated with karst, and through definition of specific vulnerabilities to articulate acceptable solutions. Generally, these requirements align with the need for asset protection, though a technical report may be required in sensitive areas. If acceptable solutions cannot be met, the developer still has recourse to show how conservation objectives can be met through design or siting adjustments, and these are often possible (Milanovic, 2002), though approval in these cases will be at Council's discretion.

The *Key to Acceptable Levels Table* (Table 2) is the crucial link between the science and planning. It not only embodies the quantified triggers and responses needed, but is similar in structure and semantics to performance-based planning schedules, allowing for ready translation. Such a translation was undertaken by Council's Town Planners, in consultation with its N.R.M. Officer. Choices were made as to what level of detail to put into the planning scheme ordinance, and what to retain as an assessment tool for testing development application details against vulnerability mitigation on a case by case basis.

AIMS & PERFORMANCE CRITERIA	TRIGGER LEVELS FOR VUNERABILITY	ACCEPTABLE MITIGATION
A 1 Minimise erosion to reduce sediment entering all waterways and the Karst System. (Avoid water concentration in any runoff)	**T 1 All** removal of soil including for foundations or tracks	**A M 1.1** Excavation and construction must not alter the structure of karst features. **A M 1.2** Disperse runoff from access ways, buildings and roads to avoid concentration of water flows entering the groundwater system. **A M 1.3** Grassed cut off drains must be used to intercept run off. These drains must run to grassed waterways, settling ponds or reuse dams before water enters streams. **A M 1.4** Excavation and construction must not allow movement of sediment and/or soil around site. Any soil/sediment to be removed must not be stored on karst. **A M 1.5** Short term holding must be in a way that will not allow dispersal in the event of a sudden rain storm.
A 2 Maintain or restore native vegetation in critical areas for soil conservation, such as steep slopes, karst soils and riparian zones. This should be shown in an environmental management plan for the site.	**T 2** 15% slope gradient or 9^0 slope	**A M 2.1** Do not clear vegetation on sites with slopes over 9 degrees (15%). **A M 2.2** Maintain permanent perennial ground cover.

Table 2: Sample of Key to Acceptable Levels Table
White S. (2008) Report to the Planning Department Meander Valley Shire Council, Tasmania: Karst Susceptibility and Planning Matrix. Wakelin Associates Pty Ltd. Clifton Hill, Victoria.

Proposed land use zoning under the *Draft Meander Valley Planning Scheme 2007* (Meander Valley Council, 2007) is presented in Figure 4. It should be noted that this Draft Planning Scheme has no legal attributes, as it has neither been endorsed by the Meander Valley Council as a finished product, nor by the Tasmanian Government to bring it into operation. It has, on the other hand, undergone a public exhibition phase and is indicative of what is intended for the Council's next Planning Scheme.

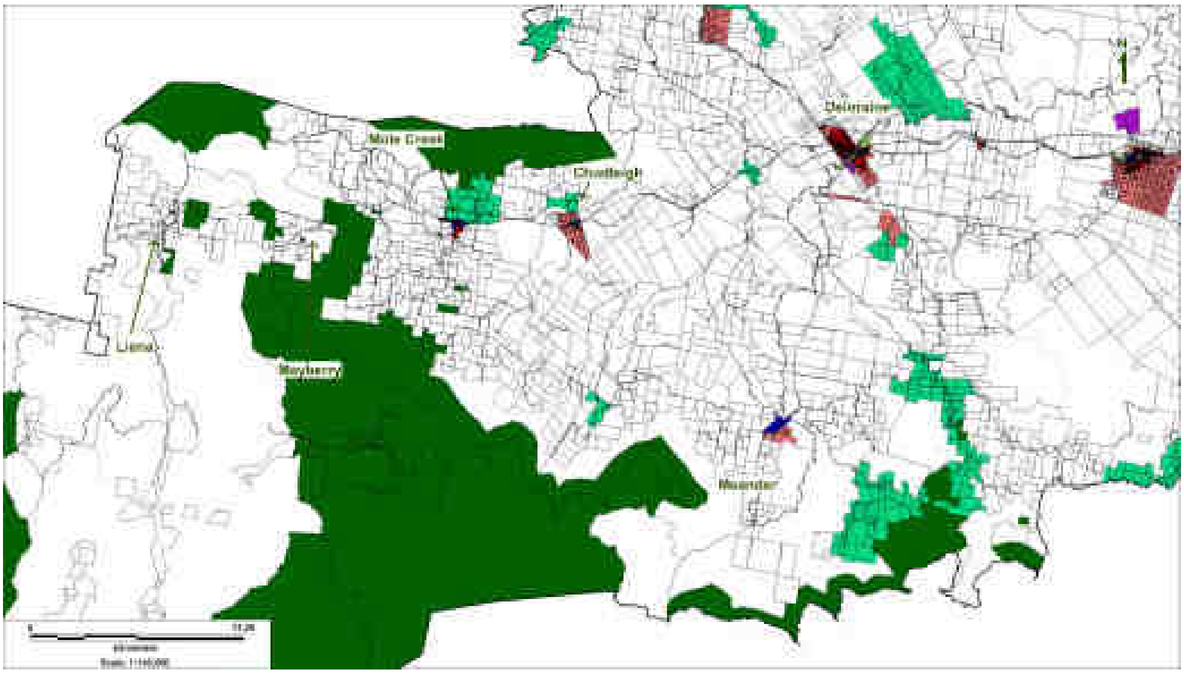

Figure 4: Zoning, Draft Meander Valley Planning Scheme 2007.

Of relevance to this paper is the extent of the dark green Environmental Management zone, expanded to include both public and private reserves. This gives its own restrictions on development, which must meet stringent conservation objectives. A proposed light green Rural Living zone has been added, to meet demand for lifestyle blocks north of Mole Creek and Chudleigh. White represents Rural zoning.

The karst sensitivity areas form a planning overlay, given authority through a Karst Management Schedule and referenced spatial sensitivity zone maps. Thus, development applications must conform to both zone and overlay objectives. Figure 5 displays this interaction. It is the overlay that forms the end point of this paper topic, in a spatial sense. It determines how karst planning ordinance is deployed across the municipality, and what level of assessment is required.

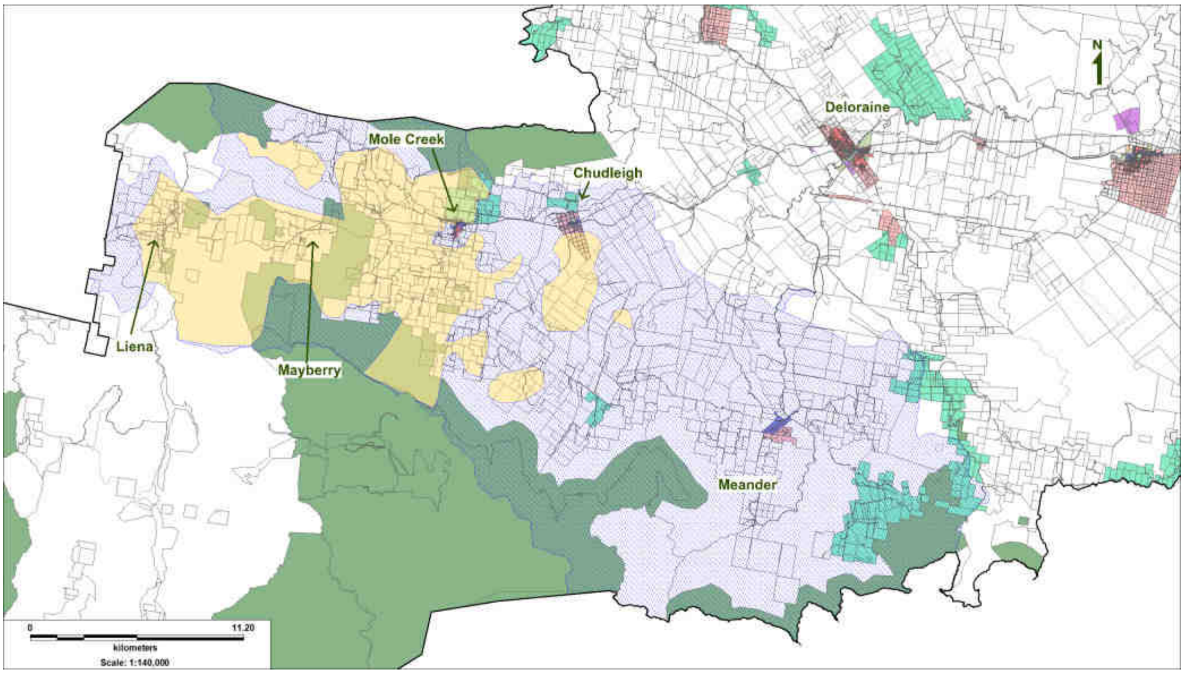

Figure 5: Zoning and Karst Management Overlay, Draft Meander Valley Planning Scheme 2007.

Putting Innovation Into Practice

Because the drafted planning provisions are based on "karst features" that correspond to sensitivity criteria in the matrices, ground truthing is always required to assess actual vulnerability. This is sometimes a challenge given that assessments have to completed within statutory timeframes and technical advice is not always at hand. Where developers can assure requisite mitigation according to the Planning Scheme karst schedule, and the development is within the Low Sensitivity Area, the assessment and approval process appears straightforward. And so it often will be, though there is always the chance of an outlier or unmapped karst feature being present within this area.

A progressive agreement between the Tasmanian Government and Meander Valley Council provides tailored assessments to support planning scheme application. To deal with an outlier anomaly, Council officers have received training to recognise general surficial karst features so that a referral to karst specialists can be made if they are in evidence. Karst specialists also, as a matter of course, provide advice on all development applications in the High Sensitivity Area. To comply with timeframes for assessment, the agreement provides for a streamlined process whereby a single point of entry allows for Tasmanian Government flexibility in allocating staff to reviews to meet deadlines, wherever possible. This results in a process that is more efficient and consistent for everyone involved, including developers.

Planning assessments are triggered by new development or significant changes in land use. These modifications may bring with them some level of hazard, but developers generally recognise limitations of sites and are willing to work toward a responsible development outcome. Indeed, it is often in their interest for structures to be sound and waste correctly disposed of. There is also an increase in general awareness of water and karst values, and the need to take them into account. So, alternative solutions can usually be found.

Conclusion

Limitations of current karst land use planning on karst have been confronted, and a way forward sought. To deal with environmental vulnerability, innovative science-based mapping and matrices designed to articulate into a draft new planning scheme have been developed for the Meander Valley Municipality.

To support the karst planning schedule implementation an assessment process that is targeted, proportionate, defensible and fair has been set up. It embodies credibility and efficiency through a State Government – Local Government partnership.

Acknowledgements

Jo Oliver (Senior Town Planner - Meander Valley Council)

Elizabeth Regent [nee. Grayson] (contracted Town Planner - Pitt & Sherry)

Susan White (Karst Geomorphologist - Wakelin Associates Pty Ltd)

Rolan Eberhard (Karst Officer - Land Conservation Branch, DPIW)

Ian Houshold (Geomorphologist - Land Conservation Branch, DPIW)

Greg Pinkard (Manager - Land Conservation Branch, DPIW) [early in process]

Peter Voller (Manager - Land Conservation Branch, DPIW) [later in process]

John Whittington (General Manager – Resource Management and Conservation, DPIW)

Note: Positions of these contributors are as at 2007-2009, when the Meander Valley Draft Planning Scheme 2007 and supporting processes were being formulated.

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Children's and youth activities at Jenolan – an (R)Evolutionary tale

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Abstract

Cave tours have been running officially at Jenolan Caves in New South Wales since 1867, with adventure tours added to the mix in the 1980s; in 2004 Ted Matthews, Jenolan Caves guide, developed our first child focused activity - 'Stones 'n' Bones', a paleontological and geological treasure hunt for kids. The popularity of this tour alerted us to visitor interest in activities specifically aimed at children. A range of tours were developed and trialled with varying success; activities were modified and more added to the school holiday program. In 2010 activities aimed specifically at the youth market were developed and were an instant hit with high school students. This paper looks at the philosophy behind the children's and youth program at Jenolan and charts the evolution of those activities.

Introduction

Cave tours have been running officially at Jenolan Caves in New South Wales since 1867, with adventure tours added to the mix in the 1980s; in 2004 Ted Matthews, Jenolan Caves guide, developed our first child focused activity - *'Stones 'n' Bones for Dr Jones'*, a paleontological and geological treasure hunt for kids. The popularity of this tour alerted us to visitor interest in activities specifically aimed at children. A range of tours, known as the *Discovery Series*, was developed and trialled with varying success; activities were modified and more added to the school holiday program. In 2010 activities aimed specifically at the youth market, called Beyond the Boundaries, were developed and were an instant hit with high school students.

Together the Discovery Series and Beyond the Boundaries have constituted both an evolution in the way we deliver tours and activities for these age groups, and a revolution in our thinking about products aimed at children and youth. But with such a major shift in our perspective, sometimes it has felt, to those of us running and developing the tours, that we've also been fighting a small revolution.

In the Beginning

In 2004 Andy Lawrence, Visitor Services Manager at Jenolan, asked guides for any ideas they had to increase family visitation. Ted Matthews, a long standing guide and previously a science teacher, developed the instantly popular *Stones and Bones for Doctor Jones* tour, later abbreviated to Stones & Bones. The activity was welcomed by guides; it followed a familiar pattern, being much like a normal tour, but following a treasure map and visiting some off-track sections of the caves. The tour ran sporadically, sometimes being limited to children staying with their families at Caves House, in the hope this would build overnight visitation.

In 2008 Rebecca Lewis developed two more children's tours and an evening craft activity and the Discovery Series were born. The first activity, *Animal Discovery*, was based on a workbook that the children were intended to fill in as they went along. The workbook also included some puzzles to do at home and some pictures to colour in. Children were given a free drawing pack at the conclusion of the tour. While the tour sold well, the kids saw the workbook as being too much like school and were distracted by the puzzles and games.

The next activity, the *Kids Photographic Tour*, never really took off; kids arrived without cameras, without knowing much about how to use them or without much interest in photography. It was a mismatch of good activity with the wrong demographic. The guides struggled to find a way to make it work, but without success, and the tour was dropped.

The *Crafty Kids Club* also proved problematic. Some kids, typically little girls, would put a great deal of effort into their craft works while their brothers would throw something together as swiftly as possible and want to do something else other than craft. After this, the group was intended to go for a torch lit walk to the Blue

Lake, but invariably nobody had a torch and often not enough warm clothes. In addition the activity clashed with family movies run by Caves House, splitting the audience. Numbers remained low. It too was dropped. However we had the beginnings of a program that we could build on.

Discovery Series

Ian Eddison, Rebecca Lewis and I developed the program of four tours that now constitutes the *Discovery Series*. *Stones 'n' Bones* was brought back into the mix and remains highly successful. Animal Discovery was adapted as a more involving, activity based tour and two new interactive games were included.

The aims of the program were to engage children in a new and exciting way; to interpret our above ground karst and to increase visitation by giving families a reason to return. The tours covered areas and ideas that could not be fully investigated on a normal tour.

Two of four tours run on alternate days, with the longer 3 hour tours in the mornings, when the children are fresher. *Stones 'n' Bones* runs with *Junior Guides* and *Bats, Bugs & Beasties* runs with *Junior Explorers* to avoid covering any of the same locations on any one day.

Stones 'n' Bones – treasure map leads to understanding

In *Stones 'n' Bones* children follow a treasure map to locate the amazing geological and paleontological treasures found by a fictitious scientist, weaving on and off the tourist routes. As it progresses the children try to solve the puzzles of how these things came to be in the cave. Helmets and lights are required for off-track sections. Finding Dr Jones' treasure chest provides an opportunity for kids to touch and feel things they normally cannot. With appropriate guidance they come up with their own answers to scientific problems. Partcipants learn some map skills, enticed by the classic concept of a treasure map. The tour lasts for 1.5 hours.

Bats, Bugs & Beasties – on platypus watch

Animal Discovery, rebadged as *Bats, Bugs & Beasties*, looks closely at Jenolan's fauna, past and present. It is a chance to utilise different parts of our beautiful karst environment; dark caves, a twilight cave and the Blue Lake. It meets one of the major aims of the kids program – above ground interpretation. The workbook has been dropped in favour of interactive games, such as the Echolocation Game, which illustrates bats' adaptations to living in the dark and the specifically developed Jenolan Biodiversity Game, a guessing game without winners or losers, which reinforces learnings, but is totally non-threatening. We also visit fossil sites in the caves and discuss the different animals found in different parts of the karst system. The tour finishes with a platypus spotting stroll around the lake. The platypuses seem to understand the importance of getting kids interested in nature and frequently make an appearance, even though it is the middle of the day! The activities run for two hours.

Junior Guides, a three hour session, is shaped around the activities a guide may be involved in; a look at a section of show cave, a matching game that is water themed, a chance to be the guide, map reading, a twilight cave visit, sound mapping in two locations and real caving (involving a treasure hunt). The activity includes a morning tea break, usually by the lake, and is another opportunity to interpret our above ground environments. A range of other activities and games may be substituted or added, according to kids' abilities and interests. Flexibility is essential to the successful outcome of the activity.

Junior Guides – on an underground treasure hunt

The theme of *Junior Explorers*, our other three hour activity, is that cave exploration is cool. In this activity the kids both learn about our explorers, past and recent, and become explorers themselves. After considering what it might be like to be the person to discover a cave the kids learn how to draw cave maps as they move through the caves, using the base layer of the Lucas Cave and River Cave maps developed by the Jenolan Survey Group. The Jenolan maps are layered, so you can select what information you want to print. The version we use includes just the cave outline and tracks. The children add features, names and a key. This is followed by the Explorers Matching Game, where when the kids match a pair of explorer pictures, they get to draw out of a bag photos of what the explorer found. They then follow their own maps out of the cave by headlamp, becoming inspired by the thought that they too can become real cave explorers. After morning tea by the lake we do some sketching of natural objects, to reinforce the idea that explorers need to be observant.

Beyond the Boundaries

Inspired by the success of the *Discovery Series*, and aware that youth is a largely overlooked section of the tourism market, we decided to try some youth adventures. In order to appeal to the target market we named it *Beyond the Boundaries*. It consists of two complementary activities, plus a discounted package for both, and was launched early in 2010.

The morning activity, *Pushing the Boundaries*, lasts for 2.5 hours and includes similar activities to Junior Explorers but is off track by headlamp all the way. It moves gradually into less developed and more challenging sections of the show cave system. Again, options are built in according to the ability and interest of group members. Participants learn about Jenolan's explorers, map making, landmarking and pick up some basic caving skills. Plus they have the thrill of being seen to go where others cannot, as they pass show cave tours on their way from one untracked section to another.

Pushing the Boundaries – map making

Pushing the Boundaries is a great activity for less gung-ho teens and those with limited cash or time. It is also an excellent stepping stone to Breaking the Boundaries, our longer afternoon adventure.

Youth are natural risk takers. They come to the caves with their families, but like to do things independently. *Breaking the Boundaries* provides the perfect means to test themselves out in a seemingly daring activity, develop a range of skills and build self confidence. The activity lasts for four hours during which the teens have to find the cave in McKeowns Valley, using a topographic map with bluffs marked, and then use a very complex cave map to find their way through the cave. There are frequent encounters with wildlife and, in the cave, opportunities to interpret fossils, inscriptions and cave features. The tour operates on the principle of challenge by choice, with easier and harder options available. There are some very tight squeezes for those who really want to beak their mental boundaries.

Breaking the Boundaries – challenge by choice

The combined package, *Totally Beyond the Boundaries*, makes for a truly memorable day and is also suitable for youth groups and schools.

The Learning Curve

The *Boundaries* adventures were welcomed by staff. The only change required was a change of timetable to slightly increase the time for Breaking and to ensure a full lunch break for guides. Most adventure guides are happy to work on Breaking, as it feels much like any adventure tour, with the bonus of being in a beautiful cave. Pushing is marginally less appealing to guides as it requires more facilitation and a high degree of flexibility.

The *Discovery Series* has set us on a much steeper learning curve, as we developed and adapted this ambitious set of activities aimed at children.

While bookings were reasonably strong for *Animal Discovery*, client satisfaction was not as high as we had hoped; to the kids the workbook seemed more like school than fun in a cave. The solution was simple yet complex; drop the workbook and focus on interactivity. This required the development of a range of games and props. It worked a treat with very positive reactions from the children. Unfortunately it still did not sell to the same degree as Stones 'n' Bones, though we knew it was a good product. The solution was to swap to a catchier name. Bats, Bugs & Beasties did the trick, with tour participation jumping from 54% to 94 % almost instantly.

When we began the kids tours we bought some miners helmets, which were cheap, but it turned out they could not adjust to a small enough size for little heads and the visor got in the way. So we used some old caving helmets. They were not only too big, but very heavy for children. The helmets were a constant source of distraction and discomfort. We tried using some dense foam as padding, but it was hard to keep attached and did not solve the problem of the weight. Probably one of the biggest improvements we have made to the kids' tours was to invest in lightweight, smaller caving helmets. The kids are much more engaged and the activities run far more smoothly.

A tougher problem to solve was where to set the age range. It was originally set at 6-12 years of age, trying to ensure a big enough demographic to fill tours and to allow all kids from a family to participate. All participating guides felt this was possibly too young a starting point but bowed to pressure from others, especially ticket sellers, to lower the age range for shorter activities, dropping the starting age to 4 years at one point. This was a total disaster, as the younger kids were not developmentally able to participate fully. Guides had to lower expectations and levels of information, with the tours now less suitable for the older kids they were designed for.

Younger kids tended to have parents attached, which was also undesirable. In addition the constant changes got a lot of staff offside, as they lost confidence in their knowledge of the tours; parents were inadvertently told the wrong age range and then would see others permitted to do the tour their similarly aged kids had been denied. Though the confusion was understandable, it was not helping build the tours. Eventually it was decided to raise the age range to 7-11 years for all tours. Older kids are generally in high school and thus eligible for the *Boundary* activities, though we will include them if requested. Younger children still have a range of cave tours which they can attend with their family.

When we began the *Discovery Series* it was decided, after much debate, that parents would be allowed to participate, but would not be encouraged to do the tours, instead being offered show caves with coinciding times. Many parents were keen to attend, which created major issues for the guides. Firstly we often ended up with more parents than children, which somewhat took the adventure out of it for the kids. Parents who had been talked into a show cave tour would get upset when they saw other parents on the activity. Helicopter parents would disturb the flow of the activity, giving different instructions to those of the guide, and interested parents would be asking questions they wanted answers to, which were not necessarily of interest to the kids, or relevant to the activity.

In addition, some parents would lose interest after they had photos of their child doing something different, or when they realised it really was aimed just at kids. These parents would sometimes then depart, taking their children with them; sad for the kids and bad for the image of the activities. Meanwhile some ticket sellers persisted in selling it **as** an ideal family activity, a role more suited to a traditional show cave tour.

We have now decided to keep the activities strictly child only, as they were originally designed. Numbers have declined initially, but we expect they will build up again as word of mouth spreads. The activities are running more successfully. Kids are more focussed, the activities can be aimed more directly at them and they are working better as a team.

The exception to the no parent rule is if a child has a disability and would benefit by having a known adult with them. This will ensure that no children are excluded, without taking away from the experience of the group.

There is no doubt that parents are keen for cave based activities, other than traditional tours, that they can do as a family. Our next job is to develop activities to meet this demographic; something that will have them working together as a group but that will involve the whole family. However, it is important that we acknowledge that the activities we have developed with a primary school age demographic in mind are not suitable to fill this role.

When the *Discovery Series* began, the morning activities did not sell as well as their afternoon counterparts. The belief among guides who did not run the activities was that this was because there was not a market for three hour activities; the belief among most of those running the activities was that it was partially due to some ticket sellers not feeling confident in the activities and partially due to less interesting, catchy names. The success of the newly renamed *Bats, Bugs 'n' Beasties* confirmed this second conviction. Luckily over time the positive feedback from participants has built seller confidence. Unfortunately, though we have tried, we still haven't come up with names that we think are better and still give a sense of what the activities involve. As we do not wish to chop and change things any more than absolutely necessary we have decided to stick with the original names until we come up with ones that really hit the mark, rather than something marginally better.

Changing Perceptions

Surprisingly, the major issue for the activities was actually gaining the support of the guiding staff. Being familiar with linear, information-based tours, it was difficult for many to comprehend that a three hour cave activity could work. As many are very good at keeping children involved on their tours they also could not see the necessity of running separate activities for them, especially longer ones. This led to under selling of activities. The number of new tours added to the confusion, with sellers being uncertain of what each different activity entailed. In addition, some staff found the activities difficult to facilitate and blamed this on the length of the sessions.

To solve this problem we put copies of the Standard Operating Procedures on the lunch table, in the ticket office, in reception and on links on the desktops. Summaries were also supplied, for swift referral. We offered the opportunity for anyone to come on the activities to observe their operations and we suggested they look at the feedback in the Visitors Book. Unfortunately, as the activities only run in school holiday periods, most people were too busy or not interested enough to take us up on the offer to observe. Information sheets placed in prominent positions frequently went missing. As changes were instigated the info sheets sometimes became out of date.

Another issue was regular selling of tickets to underage children. The solutions listed above should have reduced the incidence of this, but initially did not. The problem has dropped off over time, as staff become familiar with the new, permanent age range and also due to memos sent by the manager. The activities are running more smoothly and children are getting more out of them as a result of the higher age range and more consistent selling to visitors.

Late selling of tickets by well meaning ticket sellers trying to fill activities disrupted the crucial stage setting at the beginning of activities and led to a lot of wasted time as rules and initial concepts were repeated. Parents watching as activities set off observed all of this and were not impressed that their children, who were there on time, were disadvantaged by latecomers.

Some Harsh Realities

The problem of some staff being unsuccessful in running the longer activities also turned other staff off trying. We attempted to overcome this problem by shortening the activities to two hours, a move strongly resisted by those staff who were successful at running the longer activities. They asserted that their success indicated it was not the length of the activities that was the problem, but lack of training for staff members who were having difficulties. There was quite a strong feeling amongst a large number of guides that this was a criticism of the guides who were not having the same degree of success which caused a degree of bad feeling. Eventually a trial was agreed. Feedback from the majority of guides running the program was that, while they could be run at two hours, they were not meeting their objectives and were not as successful as they had been. The activities have been timetabled back at three hours and will now stay **at** that duration.

Lack of guides interested in running the activities has led to burnout in guides involved in the program. There is no doubt that a high energy output and flexibility is required in order to run child friendly activities. It is therefore not ideal for guides to run them day after day; far better to intersperse them with other duties. This needs to be taken account of when rostering for school holiday periods. More guides need to be enticed to be involved. Once involved the rewards are high, as would be attested by most of those running the program.

Running activity based programs has proven to require additional skills than those required to run cave tours. There is also a new spectrum of knowledge that the activities require guides to have. When guides were asked why they did not want to train on the program many said they were interested, but as they already had plenty of work in school holiday periods they could not see an advantage in giving up paid work to train on them. As a result we have now instigated paid training on the program. Initially it is for guides who have an interest in running the activities; when this need has been met the training will be open to other guides to assist in their understanding of the activities. This should overcome much of the resistance and lack of interest that we have been experiencing. Already, having just started paid training, we have two definite new activity guides and another quite interested to do more training.

As an additional incentive, financial benefits are being developed for guides who run the children's and youth activities, commensurate with the higher level of skills required. This recognition will reward the efforts of staff who build their skills base and also assist Jenolan by developing a more flexible workforce.

Sadly, financial constraints have meant that we have not had a budget for promoting either the youth or kid's tours. We are hoping that improved children's and youth information pages on our website will assist in building sales. We also use our weekly local radio spot to promote them in the lead-up to holiday periods. We are developing better on-site signage to encourage families to stay longer once they have arrived, or return to do the activities.

Conclusion All Hail the (R)Evolution!

The children's and youth programs are definitely meeting their objectives. They are selling well and enabling us to better meet the needs of distinct market segments. We are utilising our above ground karst more effectively and adding depth to our interpretation.

We are now entering a period of consolidation of the kid's and youth programs; increasing our guide base and building word of mouth publicity. Once it is firmly bedded in we look forward to beginning work on our family activity program.

In the current financial climate cave tourism, like other tourism, needs to be creative and innovative. Building on the success of the children's and youth programs, the Jenolan team is ready to take on the challenge.

'The New Ball Game? Changing social attitudes to leisure and recreation and the implications for show cave tourism.'

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Abstract

The past decade has seen a series of events, from 9/11 to SARS to the Global Financial Crisis, which have presented serious challenges for the tourism industry. At the same time the retail sector and DIY business have also emerged as direct competitors to tourism as they have become identified socially as alternate recreational pursuits. At the start of the second decade of the 21st century, patterns are emerging suggesting links between some of these factors previously considered independent, patterns that suggest we may be experiencing a broader social shift in attitudes towards leisure time and the traditional conception of the place of tourism within the broader recreational framework that was established following the Second World War. These changes present a serious challenge to the tourism industry. All operators of show caves, amongst the best examples of nature based tourist attractions, must confront this challenge. Future successful show cave tourism will necessarily involve continuous product development, embracing digital media and the delivery of memorable on-site experiences that continually challenge conventional cave tour paradigms.

Introduction

The need to at least cover operational costs – or better, whilst protecting the resource is an underlying principle of the commercial operations at Jenolan Caves. Such a commercial imperative is entirely compatible with the necessity for sound environmental stewardship, if the approach is appropriate. Indeed, the operation of a successful commercial show-cave operation is of great benefit to broader cave conservation efforts as a means of widely promoting conservation values and educating the general public. The economic environment in which commercial cave tours operate is becoming increasingly challenging and difficult. It is tempting to think simplistically of competition in terms of –

- Alternate destinations
- Other attractions

However, the reality is that it is necessary to think of competition in quite different terms. Today, competition includes all of those pursuits and endeavours that people spend their discretionary expenditure on. Our perception of competition should be expanded to include-

- Other forms of entertainment
- Shopping – not just the act of purchasing but increasingly the whole experience of shopping
- Staying at home could be considered as competition as people engage in digital communication and entertainment, big screen TV's, cocoon themselves at home ('holiday at home') and move again towards renovation and do it yourself
- The tendency to save
- Paying down mortgages

The future of tourism in caves, or anywhere for that matter, lies in the ability to provide compelling and sustainable experiences. Understanding the potential market improves the ability not only to compete through promotion but also to develop product that suits the needs of the market and is therefore more appealing.

It is perhaps easy to be dismissive of marketing research as 'mumbo jumbo' but our experience is that it is important in orienting marketing communication, product and promotion to appropriate markets. Increasingly, contemporary market research is helping inform Jenolan's managers about product development and to have more confidence in making decisions about products that are proposed. It is equally becoming evident that certain aspects of market research that could once have been considered more of academic than practical interest to operational managers are now very much an ongoing practical concern.

The, perhaps simplistic, missive of 'orient your marketing towards your market' is easy to say and conceptually appreciate but this becomes more difficult to achieve when you look at who comes to Jenolan – our clients are not a homogenous group, each of our visitors or potential visitors has individual needs, preferences and behaviours.

By grouping potential clients into segments with distinguishing variables and likeminded behaviours we come up with a range of market segments. At Jenolan we have multiple markets. Some forms of segmentation include-

- Geographic i.e. where they live
- Demographic i.e. age, sex and some more sophisticated derivatives include 'Gen X, Gen Y and Gen Z and maybe lifecycle segments are in fact an extension of a demographic approach to segmentation i.e. 'Baby Boomers', Family & DINKS (Double Income No Kids)

Another form of segmentation, mindset segmentation, is a particularly valuable tool for us at Jenolan Caves. The See Australia segmentation was developed by Colmar Brunton and subsequently refined by Roy Morgan Research for Tourism Australia (Undated) and Tourism NSW(2004). This form of segmentation could be described as a mix of both state of mind and demographic approaches.

See Australia Terms	**Tourism Australia Terms**
Pampadors	Luxury Travellers
Compatriots	Family Travellers
True Travellers	Adventure Travellers
Wanderers	Touring Travellers
Groupies	Peer Group Travellers

Mindset segmentation is technically a form of psychographic segmentation which gave us a totally new way of analysing our markets.

Returning to the proposition of 'orienting your marketing toward your markets', we could arrive at the conclusion that each market needs its own suite of communication material oriented to that particular market and all of your marketing issues would be resolved. It sounds simple but the reality is that this would be totally impractical and hugely expensive.

Tourism Australia may well have had a similar problem – how to market to multiple markets across a number of markets with a limited budget and in addition in recent years they have been given a role in domestic marketing.

Tourism Australia is very much committed to the mindset approach to segmentation and conducted research into how to gain optimum economic value. The research identified that even across the mindset segments there is a core group of people with a greater propensity to travel. The attributes of this group drive the need for these people to travel to seek out experiences

Figure 1 Experience Seekers cross into 'conventional' market segments (Tourism NT, (2008) p6)

The experience seekers are the perfect target (Tourism Australia, Undated). They –

- are experienced travellers
- seek out information about holidays and experiences
- spend more on holidays and experiences than typical consumers
- seek more engagement
- are opinion leaders but at the same time seek opinions and ideas
- use technology, particularly to gain information
- see themselves as individuals and seek out activities and experiences that enhance them as individuals
- are likely to be tertiary educated
- don't appreciate a typical sales oriented approach

It is important to be aware that most of us report that word of mouth is our best form of promotion and therefore this group is of particular importance because they have a great propensity to influence the behaviour of others.

In a marketing sense this means that by producing marketing communications that are relevant to this group, the same communications are relevant across a spectrum of segments. By extension from a product development perspective it becomes logical to develop products that meet the needs of experience seekers as these products will also meet the needs of the wider segments.

At Jenolan we overlay this approach with information about the changing nature of tourism and more contemporary approaches to interpretation and we feel we have some very powerful tools to guide us.

Nothing stays the same and the market is constantly changing. Research on experience seekers suggests that increasingly visitors will demand (Tourism NT, 2008 - See Figure 1)-

- special interest experiences
- interactive learning experiences
- authentic experiences
- physical and /or psychological challenges
- ecologically sustainable experiences
- customisation and flexibility value for money.

Any tourist destination or attraction that fails to satisfy the above criteria will find it difficult to effectively compete for what is a diminishing market. Indeed the tourism industry as a whole faces an entirely uncertain future. Although it is dangerous to make broad predictive statements, the current experience at Jenolan Caves strongly suggests that tourism is currently undergoing a fundamental shift. The industry has always been characterised by dynamism and reflections of broader changing social and technological norms. However, the current change may reflect a deeper shift in the social conceptualisation of "leisure" and "recreation", twin concepts that underlie tourism.

1960s	1970s	1980s	1990s	2000s
STAGE 1	**STAGE 2**	**STAGE 3**	**STAGE 4**	**STAGE 5**
Products and Activities, Places and Things	Service Differentiation, Niche Indulgences	Products and Emotions, Exhilaration and Adventures	Experiences: Learning, Authenticity and Sustainability	Experiences: Meaning and Purpose
➢ Pre-packaged holiday rewards for hard work ➢ Hand-written paper Tickets ➢ Bookings via travel agents	➢ Holiday as reward/ opportunity for indulging passions and fulfilling interests and pursuits ➢ Typed tickets ➢ Telex bookings	➢ Holiday as an escapist active adventure with high intensity emotions ➢ Introduction of Global Distribution Systems ➢ Facsimile bookings	➢ Holiday as an opportunity to learn and be engaged. Tap into local knowledge/ culture ➢ Emerging sustainability considerations ➢ Tailoring of holiday packages through travel agents ➢ Beginning of Internet for bookings ➢ Introduction of e- ticketing ➢ Loyalty Programs	➢ Increased demand for special interest needs and rarity. ➢ Seeking authenticity and highly sceptical of over marketing ➢ Emerging environmental and social consciousness ➢ Dynamic packaging and tailored packaging online ➢ Consumer direct bookings over the Internet ➢ Disintegration of traditional distribution channels ➢ E-ticketing and e-check-ins

Figure 2: The decadal changes in Tourism. We have entered into a new stage in this process (Tourism NT, 2008 p8).

Tourism has historically been one area, a highly important one, within the spectrum of activities that constituted how one "recreated", with "recreation" being strongly associated (in some ways almost interchangeable) with "leisure". It is easy to become befuddled with the academic approaches to these terms – there are over 200 definitions of "leisure" in the academic literature for example (Veal, 1992). However, a sufficient summary of conventional theory would be that leisure represents the available <u>time</u> available to pursue recreation – generally defined as the activities undertaken within this leisure time.

The problem with these definitions today lies in the perception of what constitutes "recreation", and in the availability of leisure time. Traditional boundaries between 'work time' and 'leisure time' are being increasingly eroded, partly as a consequence of technology but equally by social and economic necessity. One outcome of this is a reduction in the defined blocks of time available for recreational pursuits. Work itself is increasingly viewed as a possible form of 'recreation' as the concept of job satisfaction and defining oneself through your career can fill the same emotional and social requirements once considered exclusively associated with non-work ('leisure') time.

"Recreation", if considered as the voluntary activities one elects to pursue within available leisure time, has changed even more dramatically as a concept. As we have noted, such activities as home renovations and even online shopping are now legitimate parts of the recreational activity spectrum. The consequence of this is to reduce the percentage of this spectrum once allocated to tourism. When we argue that tourism faces increased competition from non-traditional competitors, we are arguing at a fundamental level.

For our on the ground operations, these changing social patterns are now beginning to manifest themselves in measurable ways. One example has been the steady decline of off-peak visitation (including weekends outside of school holiday periods) while peak periods remain steady or even demonstrate growth. At Jenolan Caves this has emerged as a clear trend over the past 12 months, and appears to reflect a new social pattern: people are still travelling and taking holidays during defined holiday periods, however they are increasingly concentrating all travel within these periods. The once strong tradition of the weekend away is declining.

So what are the future implications of this trend? Such crystal ball gazing is far from an exact science, however what is clear is that operators of tourist attractions such as show caves need to understand that the playing field has changed, and that concepts that were purely academic less than a decade ago are now important considerations at an operational level. Understanding the importance of creating the experiences sought by the "Experience Seekers" dictates a consistent revision of core products. We must be prepared to adapt, change, then adapt and change yet again. The economic implications to a tourism business of an accentuated pattern of peaks and troughs in visitor numbers are significant when considering fixed costs to a business and staffing levels. Collaboration between businesses and the sharing of knowledge and resources may prove to be a critical element in creating growth in key areas such as environmentally based tourism.

There are opportunities within this challenge. 'Ecotourism' remains a strong concept, and 'Geotourism' appears to be a potentially strong subset of this. There is still a strong popular concern with environmental issues that can translate to an increase in the popularity of nature based tourism (though this popular concern may be experiencing a period of decline currently). But underlying these opportunities remains the concern that 'good' is not 'good enough' any more, and that we must work increasingly hard to exceed the increasing demands of our experience seeking visitors.

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Preliminary Survey of Cave Fauna in the Phong Nha-Ke Bang World Heritage Site, Vietnam.

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Abstract

The Phong Nha-Ke Bang National Park (PNKBNP) is situated in the Quang Binh province of north central Vietnam. It was inscribed on the UNESCO World Heritage list in 2003 for its outstanding geomorphological features. The central park area is approximately 860 km^2 and contains over 300 known caves, although to date no investigation of the fauna has occurred, despite the high likelihood of a significant endemic cavernicolous fauna.

The current preliminary survey was undertaken during May 2010 and provides an initial overview of the invertebrate fauna in two cave systems, Phong Nha Cave system (Phong Nha River Cave, Bi Ki Grotto, Fairy and Royal Grottos, and Tien Son Cave) and Dark Cave. These two caves are located approximately 5 km apart within a continuous block of karst. Due to the very limited amount of time available for the current preliminary survey it was decided to use active hand searching (hand foraging) to enable a wide variety of different habitats, and caves to surveyed quickly and detect the majority of species present within. The field component of the survey was conducted over five days, with multiple sites visited during each day.

The preliminary study of the cave fauna from the PNKBNP collected 248 individual specimens, representing at least 41 species from the three caves examined. The species include five (5) Classes, 14 Orders, and 29 families. Five species are common across the three caves, three spiders, a raphidophorid cricket and a millipede. The Dark Cave was found to contain many species that were not recorded from either Phong Nha or Tien Son caves, with 58% of species present found only from Dark Cave, compared with 55% in Phong Nha Cave and 44% in Tien Son Cave.

The survey collected 116 individual specimens from Phong Nha Cave comprising of four (4) classes, 10 orders, 19 families, and 20 species. The survey collected 41 individual specimens from Tien Son Cave comprising of four (4) classes, seven (7) orders, 12 families and 16 species. Diversity in the Dark Cave was high with five (5) classes, seven (7) orders, 15 families and 19 species recorded.

The presence of a blind scorpion in the wild section of Tien Son cave is highly significant, as there are currently only 20 described cave dwelling scorpions in the world that exhibit troglomorphic characteristics. This species is undoubtedly new to science and represents the first troglobitic scorpion in mainland Asia. This is the most significant discovery from the current preliminary survey of cave biodiversity in the PNKBNP.

The main differences in faunal assemblage shown by the current preliminary survey are the dramatic differences in faunal diversity and abundance between areas used by tourists and the wild sections of the same caves. The majority of fauna recorded from the Fairy and Royal Grottos are relatively common species found in several other areas. The abundance of the oniscoid isopod in these areas appears to be unnaturally high compared with Dark Cave populations, most likely a result of the rubbish and food scraps providing additional resources in this area.

The presence of bins within the caves also affects the faunal diversity, with virtually all the species recorded from the tourist section of Tien Son cave being located under or near bins. This fauna is likely to occur in much higher abundances than natural cave levels due to the additional food resources available. The lack of these food sources in the wild section of Tien Son cave resulted in much lower populations, or a complete absence, of species such as millipedes and staphylinid beetles, with only six (6) of the 16 species common between the two sections surveyed.

The results of the current preliminary study do not allow a meaningful comparison with other karst areas, either in Vietnam or the remainder of Asia. The preliminary results do, however, provide an indication of the diversity that may be revealed from this important karst area. The presence of undoubtedly the first cave dwelling troglomorphic scorpion from mainland Asia would suggest that the PNKBNP has a high potential for further important cave biology discoveries.

Introduction

The Phong Nha-Ke Bang National Park (PNKBNP) is situated in the Quang Binh province of north central Vietnam, inland from the city of Dong Hoi (Figure 1). It was inscribed on the UNESCO World Heritage list in 2003 for its outstanding geomorphological features. The central park area is approximately 860 km^2 and contains over 300 known caves, including the largest currently known cave passage in the world Hang Son Doong Cave. The caves in the area were first explored and mapped in 1990 by a British expedition and this has continued to the present, with expeditions approximately every second year. This has resulted in 17 of the known caves in the Phong Nha area, and 3 in the Ke Bang area being mapped, (Figure 2) but to date no investigation of the fauna has occurred, despite the high likelihood of a significant endemic cavernicolous fauna.

Figure 1 Location of Dong Hoi within Vietnam (After www.vietnamtravel.com.au).

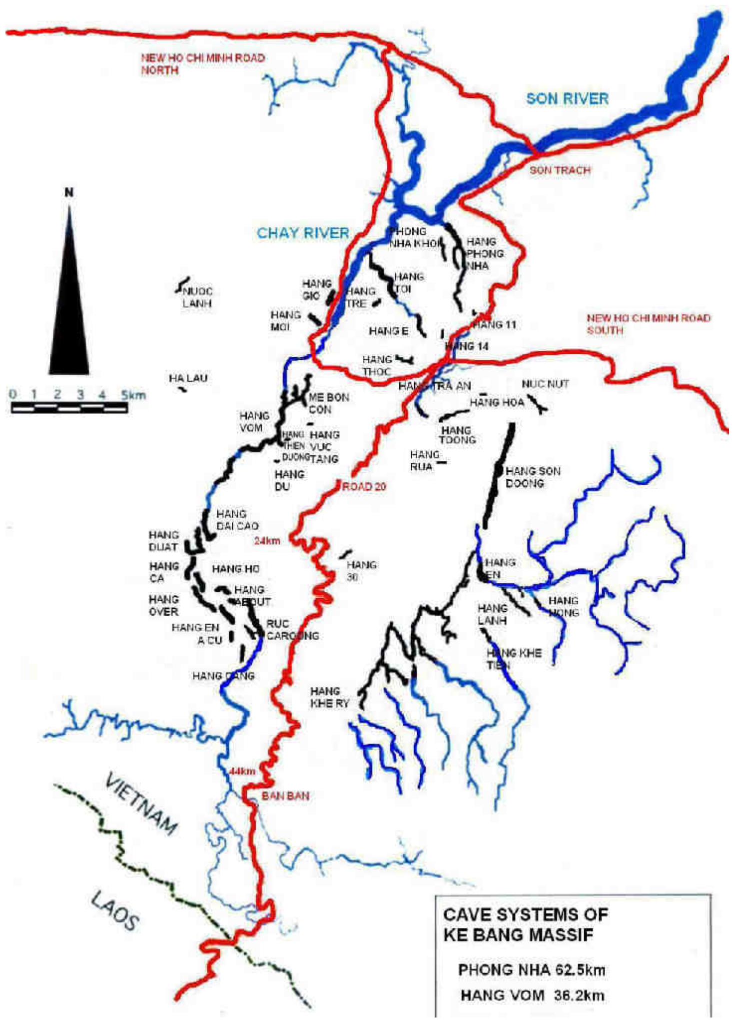

Figure 2 Map of Cave systems in the Ke Bang Massif (After www.vietnamcaves.com 2010).

Aims and Objectives of Preliminary Survey

The current preliminary survey aims to provide a basis for future biological surveys in the Phong Nha-Ke Bang World Heritage Site, Vietnam. The current preliminary survey aims to provide an initial overview of the invertebrate fauna in two cave systems, Phong Nha Cave system and Dark Cave. The Phong Nha Cave system for the purposes of this study consists of the Phong Nha River Cave, and includes three (3) tourist sections, Bi Ki Grotto, Fairy Grotto, and Royal Grotto. Tien Son Cave is situated approximately 200m above the entrance to Phong Nha Cave, and although no human sized connection is known, the caves are linked by micro and meso caverns which can be used by subterranean fauna . The Phong Nha and Dark Cave systems are located approximately 5 km apart within a continuous block of karst. The survey will aim to:

1. Identify the majority of invertebrate fauna within each cave.
2. The key habitats used by the fauna.
3. Threats to the survival of the fauna.
4. Provide management strategies which will ensure fauna survival.
5. Compare and contrast the diversity of the two cave systems.
6. Provide recommendations for future works to compliment the findings of the current study.

Introduction to Subterranean Biology

Caves form a very stable and generally homogenous environment in which to conduct various ecological and evolutionary experiments, such as on competition between species, resource partitioning, and the processes of speciation (Poulson and White, 1969). The total absence of light severely alters or completely removes many circadian cycles affecting ecosystem function (Lamprecht and Weber, 1992; Langecker, 2000). Temperatures are usually constant, varying only slightly between seasons. Humidity is commonly high, providing an ideal habitat for many invertebrate species susceptible to desiccation. The lack of photosynthetic plants changes the trophic structure of cave ecosystems, with energy sources usually being transported from the surface (Poulson and Lavoie, 2000; Poulson, 2005). Caves are defined as human-sized subterranean voids, although cave adapted animals are known to occur in the smaller spaces between large voids called micro- and meso caverns (Howarth, 2003).

Caves are divided into several distinct biological zones to aid interpretation (Figure 3). These correspond to the amount of available light and varying environmental conditions (Humphreys, 2000). The *Entrance Zone* is the area directly around the cave entrance; it is generally well lit, often supports photosynthetic plants, and undergoes daily temperature and humidity fluctuations. The *Twilight Zone* is just beyond the entrance zone and is often dominated by lichen and algae that require low light conditions. The temperature and humidity are still variable but fluctuations are dampened compared with epigean variation.

Deeper into a cave, light is reduced to zero and the *Dark Zone* is entered, which is subdivided into three zones, the transition, deep cave and stale air zones. The *Transition Zone* is perpetually dark, but still fluctuates in temperature and humidity determined by epigean conditions. The *Deep Cave Zone* is almost constant in temperature and humidity conditions. The *Stale Air Zone* is only found in certain caves and is an area of the deep zone that is constricted, and commonly contains elevated levels of CO_2 and lower levels of O_2 (Howarth and Stone, 1990).

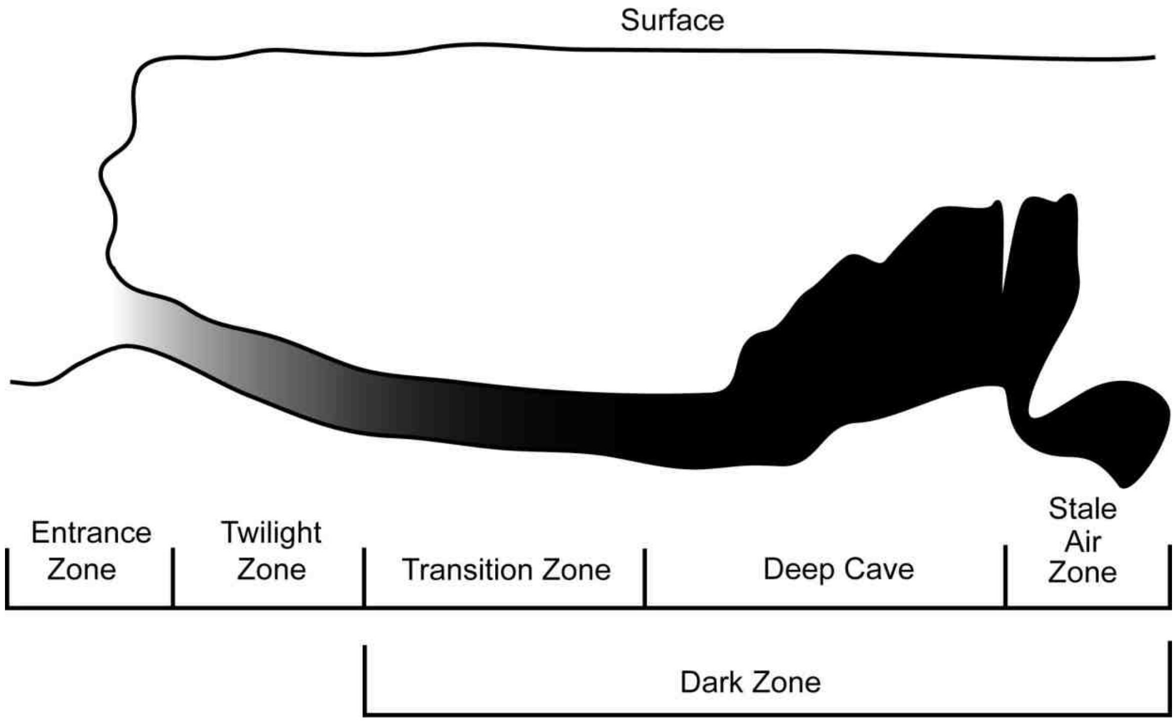

Figure 3 The environmental zones of a cave shown in cross section. After Moulds, 2006).

Classifications of cave dependence

Cave invertebrates are generally classified according to their degree of cave dependence using the Schiner - Racovitza system (Schiner, 1854; Racovitza, 1907), despite numerous other systems and variations being proposed and adopted by various authors (see references in Boutin, 2004).

The Schiner - Racovitza system classifies organisms according to their ecological association with subterranean environments, and relies upon detailed ecological knowledge of animals that is commonly lacking for most species. In order to circumvent this lack of knowledge, the concept of troglomorphy (Christiansen, 1962), specific morphological adaptations to the subterranean environment, is used to define obligate subterranean species. The term troglomorphy, initially confined to morphology has since been used to describe both morphological or behavioural adaptations (Howarth, 1973). This combination provides a practical system, easily applied in the field and with minimum of detailed ecological study required. The level of subterranean dependency for different ecological groupings is described below:

- *Troglobites* are obligate animals that possess specific adaptations (troglomorphisms) such as loss or reduction of pigmentation and/or eyes, flightlessness, elongate appendages and specific sensory adaptations (Barr, 1968; Poulson and White, 1969). These species rely solely on the cave environment for food and reproduction. They are generally restricted to the deep cave zone where conditions are the most stable and are rarely found closer to entrances in the twilight zone.
- *Troglophiles* are animals that can complete their entire lifecycle within a cave but possess no specific adaptations to the cave environment. These species are capable of living outside caves in suitably dark and moist epigean habitats.
- *Trogloxenes* are animals that regularly use caves for part of their lifecycle or for shelter, but must leave the cave to feed. Common examples of these are bats and cave swiftlets.
- *Accidentals* are animals that do not use caves on a regular basis and cannot survive in hypogean environments.

Aquatic hypogean animals are classified using a similar system to terrestrial hypogean animals except the prefix 'stygo' is used instead of 'troglo' (Humphreys, 2000).

The Trophic Basis of Cave Ecosystems

Cavernicolous populations are dependant for their survival upon energy inputs into cave systems. These inputs can vary widely, with availability of food usually being the primary limiting factor (Peck, 1976). Many cave ecosystems revolve around periodic flooding (Hawes, 1939; Humphreys, 1991; Culver *et al.,* 1995) that carries organic material and accidental epigean animals into cave systems. Tree roots penetrating the roofs and walls are another energy source found commonly in tropical caves and lava tubes (Hoch, 1988; Hoch and Howarth, 1999). Guano from bats, birds and Orthoptera is an important energy source (Harris, 1970; Poulson, 1972; Decu, 1986; Blyth *et al*,. 2002; Moulds, 2004; Moulds, 2006) with large, varied and unique ecosystems existing around such deposits. Dead animals can be a source of food for scavengers near cave entrances (Richards, 1971). Accidentals wandering in from cave entrances also provide a food source, although this is generally periodic in nature and inconsistent in quantity, except in caves with large active rivers that are capable of carrying in large volumes of epigean animals, especially during high water flow periods.

For the most part, cave environments are generally depauperate in food and consequently are sparsely populated by cavernicolous animals. However, caves containing guano deposits differ fundamentally because there is a virtually unlimited food supply, commonly resulting in large populations of guano dependant arthropods known as guanobites. Guanobites possess no specific behavioural or morphological adaptations, presumably because of the lack of selection pressure to minimise energy expenditure that dominates the evolution of troglobites. The colonisation and establishment of guano dependent communities in caves is poorly understood. Mechanisms for the dispersal of guano dependent arthropods are potentially numerous, but most are poorly investigated at best (Moulds, 2004).

Sources and diversity of cave guano

Cave guano deposits from specific sources can each possess a unique assemblage of taxa (Horst, 1972; Poulson, 1972). Throughout the world's biogeographic provinces different taxa are responsible for being the most important guano producers.

The most widespread and common guano is that produced by bats and these deposits are generally the largest in volume. The spatial and temporal deposition of bat guano differs from tropical to temperate caves. Cave-dwelling bats in temperate regions show an annual cycle of occupancy over summer months when pups are born, before colonies disperse to cooler, wintering caves where they enter torpor. This annual cycle results in large amounts of guano deposited over summer months and then a cessation of guano input for at least half the year. In contrast, tropical caves generally show constant bat occupancy rather than an annual cycle, and less aggregation of individuals due to warmer ambient temperatures (Trajano, 1996; Gnaspini and Trajano, 2000). Gnaspini and Trajano (2000) note that many bat populations in tropical Brazil are, however, commonly nomadic, resulting in roaming colonies varying their location in an irregular and non-seasonal fashion. This results in non-continuous guano deposition in a single locality over several years. The diet of bats (either haematophagous, insectivorous, frugivorous, or nectarivorous) also influences the composition of guano piles and, hence, the associated guanophilic communities (Gnaspini, 1992; Ferreira and Martins, 1998; Ferreira and Martins, 1999).

Birds are common guano producers in the northern parts of South America, the Caribbean and tropical caves of south-east Asia. Cave-dwelling birds nest in the dark zone, providing an important energy resource for many cavernicolous animals. Swiftlets (*Aerodramus* spp.) nest in the entrance and dark zones of tropical caves in south-east Asia, northern Australia and the Pacific, and are insectivorous (Medway, 1962; Humphreys and Eberhard, 2001; Koon and Cranbrook, 2002). The volumes of bird guano deposited are comparable to similar sized bat populations.

Survey Timing and Participants

The survey was conducted between the 13th – 23rd May 2010. The survey was undertaken by a specialist cave biologist, Dr Timothy Moulds (Australia), and assisted by a Vietnamese colleague Dr Pham Dinh Sac. Additional assistance was provided by Renee Mouritz (Australia) who has experience in cave interpretation, guiding and speleology. Further field assistance was provided by Nguyen Ngoc (Phong Nha - Ke Bang National Park Tourism Centre), Dang Ngoc Kien (Scientific Research and Wildlife Rescue Centre), Dr Joachim Esser (GTZ), Nguyen Thi Phuong Ha (GTZ), and Dirk Euller (German Development Service, DED).

Report Limitations and Exclusions

The current report was produced during a 10 day visit to the PNKBNP in May 2010. The survey was intended as a preliminary investigation into the subterranean biodiversity of two of the cave systems within the park. Identification of specimens collected were undertaken with limited reference material and are considered to be preliminary identification for the purposes of the report. This study was limited to the requirements specified by the client and the extent of information made available to the consultant at the time of undertaking the work. Information not made available to this study, or which subsequently becomes available may alter the conclusions made herein. The survey was planned to include an assessment of the Paradise Cave, but due to construction work currently being undertaken at the cave entrance, access was unavailable.

Survey Methodology

Surveys for subterranean fauna may use many different techniques according to the type of fauna being targeted and the amount of time available for the survey. These methods can include:

- pitfall traps (baited and unbaited).
- hand foraging (using forceps and paintbrushes to actively collect observed fauna).
- litter traps left in situ for days or weeks and then fauna extracted in a tullgren funnel.
- net hauling of water for aquatic fauna.
- nets left in situ in narrow streams to sieve water flows for discrete time periods.

Due to the very limited amount of time available for the current preliminary survey it was decided to use active hand searching (hand foraging) to enable a wide variety of different habitats, and caves to be surveyed quickly and detect the majority of species present within. In order to undertake a more comprehensive survey of the subterranean fauna (vertebrate and invertebrate) a combination of multiple techniques in each cave over longer time periods would be required. This was beyond the scope of the current project.

The field component of the survey was conducted over five days in May 2010, with multiple sites visited during each day. The sites visited are listed below:

1. Phong Nha Cave – Fairy and Royal Grottos
2. Phong Nha Cave – Fairy Cave Swiftlet guano deposit
3. Phong Nha Cave – Bi Ki Grotto
4. Phong Nha Cave – River Banks
5. Phong Nha Cave – Rockpile at end of 1st river section
6. Tien Son Cave – Tourist section
7. Tien Son Cave – Wild section
8. Dark Cave – Twilight Zone
9. Dark Cave – Transition Zone

Material collected was placed in 100% ethanol for preservation, and sorted using an Olympus SZ-60 stereomicroscope. Specimens were identified to lowest practical taxonomic level using the resources available at the time of the survey in Dong Hoi. Araneae were identified by Dr Pham Dinh Sac and all remaining material was identified by Dr Timothy Moulds. All material collected remains the property of the Peoples Republic of Vietnam, and has been handed over with a signed protocol to the Scientific Research and Wildlife Rescue Centre of PNKBNP.

Figure 4 Renee Mouritz and Nguyen Ngoc searching for cave invertebrates, Tien Son Cave. (Photo Tim Moulds).

Survey Results

The preliminary study of the cave fauna from the PNKBNP collected 248 individual specimens, representing at least 41 species from the three caves examined. The species include five (5) Classes, 14 Orders, and 29 families. Five species are common across the three caves, three spiders, a raphidophorid cricket and a millipede. The Dark Cave was found to contain many species that were not recorded from either Phong Nha or Tien Son caves, with 58% of species present found only from Dark Cave, compared with 55% in Phong Nha Cave and 44% in Tien Son Cave.

The rhaphidophorid cave crickets, although not formally recorded from every cave or site were present at every location, however, only adult specimens were collected when present.

The results are presented individually for each cave surveyed, Phong Nha, Tien Son, and Dark Cave. A detailed table of results is presented in Table 1.

Phong Nha Cave

The survey collected 116 individual specimens from Phong Nha Cave comprising of four (4) classes, 10 orders, 19 families, and 20 species.

Fairy and Royal Grottos

This area of Phong Nha Cave contained seven (7) species, of which five (5) are spiders. The remaining species are Oniscoid isopods (slaters), and the ubiquitous cave crickets. The abundance of slaters was greater near the beach sections of Fairy Cave where ground disturbance is lower and also near rubbish bins in the remainder of the cave. Cave crickets were also more abundant near the beach area and away from main foot traffic areas.

The Fairy Cave also contains a deposit of swiftlet guano on an elevated portion of wall, that does not get trampled by foot traffic. This small (1m x 0.4m) deposit contains considerable diversity compared with the remainder of the cave, and was found to contain 3 species of spider which are also found elsewhere in the Fairy Grotto, but more importantly an additional six (6) species not found anywhere else in the Phong Nha Cave. The diversity of the small guano deposit is very different to that observed in any other cave habitat examined during the survey, and included three (3) orders and four (4) species found nowhere else during the survey of the three (3) caves examined.

Bi Ki Grotto

This section of the Phong Nha cave contained the lowest diversity of all the areas examined for cave fauna, with 5 species, and also the lowest abundance of specimens collected, with just 9 individuals recorded. All the species recorded here were also found elsewhere, apart from the freshwater crab, which is considered a surface (epigean) species that is only able to survive here due to the constant light available.

Phong Nha River Passage

Several sand banks on the side of the main Phong Nha River passage were examined during the study and considerable diversity was recorded from these sites. Six (6) species were recorded from this habitat, half of which are spiders found in numerous different cave habitat areas examined during the study. One taxa, an Entomobryid Collembola was found in the river sand beaches and no other areas in the Phong Nha cave, although a longer and more detailed survey may reveal their presence to be more widespread.

Rockpile Section

The end of the first river section of Phong Nha cave, at approximately 2km from the entrance contains a large rockpile chamber. This area of the Phong Nha Cave was found to contain eight (8) taxa, of which seven (7) are spiders, and the other species recorded was the relatively common millipede with reduced eyes. No other insects or crustaceans were recorded from this locality.

					Phong Nha Cave					Tien Son Cave		Dark Cave	
Class	Order	Family	Subfamily / Genus	Species	Fairy/Royal Grotto	Fairy Grotto Guano	Bi Ki Grotto	River Edge	Rockpile	Tourist Section	Wild Section	Twilight Zone	Transition Zone
Oligochaeta				sp. 1						1			
				sp. 2								1	
Crustacea	Isopoda	Oniscoidea?		sp. 1	15							6	
		Philoscoidea?		sp. 1								4	
	Decapoda			sp. 1			1						
Arachnida	Araneae	Amaurobiidae	*Platocoelotes*	sp. 1									4
		Araneidae	*Araneus*	sp. 1	5		3	5	11	2	2	2	
			Araneus	sp. 2							4		
			Araneus	sp. 3									6
		Ctenidae		sp. 1					1				
		Gnaphosidae	*Gnaphosa*	sp. 1	1	2							
		Linyphiidae	*Neoscona*	sp. 1	1	1	3	9	1	3	2	1	
			Neoscona	sp. 2									12
		Lycosidae	*Lycosa*	sp. 1	2					1		1	
		Ochyroceratidae	*Speocere*	sp. 1					1				
		Sparassidae	*Heteropoda*	sp. 1	4	1	1	3	2	1	3		3
			Sinopoda	sp. 1							3		
			Sinopoda	sp. 1						1			
		Symphytognathidae	*Patu*	sp. 1					5				
			Patu	sp. 2							3		
		Telemidae	*Telema*	sp. 1									6
			Telema	sp. 2									2

					Phong Nha Cave					Tien Son Cave		Dark Cave	
Class	Order	Family	Subfamily / Genus	Species	Fairy/Royal Grotto	Fairy Grotto Guano	Bi Ki Grotto	River Edge	Rockpile	Tourist Section	Wild Section	Twilight Zone	Transition Zone
		Tetrablemmidae	*Lehtinenia*	sp. 1							2		
		Theridiidae	*Theridiion*	sp. 1					2				7
	Scorpionida			sp. nov.							2		
	Opilione			sp. nov.								4	
Myriapoda	Julida?			sp. 1						1	1		1
	Diplopoda			sp.1				15	2	9	13	2	1
	Diplopoda			sp.2									1
Insecta	Collembola	Entomobryidae		sp. 1				1					
	Orthoptera	Rhaphidophoridae		sp. nov.	4		1	1					
	Coleoptera	Staphylinidae	Aleocharinae	sp. 1		2				1			
			Oxytelinae?	sp. 1						2			
	Coleoptera		Staphylininae	sp. 2									1
		Ptiliidae		sp. 1						6	1		
	Lepidoptera	Tineidae?		sp. 1		1							
	Hymenoptera	Ichneumonidae		sp. 1		1							
		Chalcidoidea		sp .1		4							
	Diptera	Anthomyiidae		sp. 1		1							

Table 1. Species diversity and abundance from three caves in the Phong Nha – Ke Bang National Park, Quang Binh Province, Vietnam.

Figure 5 Swiftlet guano deposit in the Fairy Grotto contained considerable diversity not found in other cave habitats. (Photo Tim Moulds).

Tien Son Cave

The survey collected 41 individual specimens from Tien Son Cave comprising of four (4) classes, seven (7) orders, 12 families and 16 species.

Tien Son Cave - Tourist Section

The tourist section of Tien Son cave encompasses the entrance, twilight and beginning of the transition zone of the cave (refer Section 1.3). This area did contain considerable diversity, with 11 taxa recorded, however, it must be noted that the vast majority of this was located under or in the vicinity of rubbish bins near the end of the tourist section. Much of the abundance of both millipedes and beetles was also recorded from these areas. Spider diversity was also mostly restricted to isolated areas away from main walking paths and foot traffic areas, where extensive trampling of floors has severely impacted upon available habitat for invertebrates.

Figure 6 Sparassidae Heteropoda sp. 1 from Tien Son Cave, leg span approximately 15 cm (Photo Tim Moulds).

Tien Son – Wild Section

The wild section of Tien Son Cave contains noticeably different habitat to the tourist section due to far less trampling of floor habitats, and it correspondingly contains a different fauna assemblage. This habitat contains the same species richness as the tourist section (11 species), but five (5) of the species recorded here were not found in any other cave sections surveyed. This includes four (4) spiders and a blind scorpion.

The presence of a blind scorpion in the wild section of Tien Son cave is highly significant, as there are currently only 20 described cave dwelling scorpions in the world that exhibit troglomorphic characteristics (Volschenk and Prendini, 2008). This species is undoubtedly new to science and represents the first troglobitic scorpion in mainland Asia. This is the most significant discovery from the current preliminary survey of cave biodiversity in the PNKBNP.

Figure 7 Blind scorpion from Tien Son Cave, Body length approximately 10 mm. (Photo Tim Moulds).

Dark Cave (Hang Toi)

The Dark Cave is situated approximately five kilometres to the west of the entrance of Phong Nha cave on the banks of the Chay River. The cave is a large streamway outflow cave, with minor side passages. The current survey recorded 19 species from the Dark Cave, comparable to both Phong Nha (20 species) and Tien Son Caves (16 species), however, it should be noted the relative survey effort in Dark Cave was considerably lower than that expended in the Phong Nha system.

Diversity in the Dark Cave was high with five (5) classes, seven (7) orders, 15 families and 19 species recorded.

Twilight Zone

The twilight zone of the cave contained some species common across the caves examined including rhaphidophorid crickets, millipedes and what appeared to be the same morpho-species of oniscoid isopod as seen in Fairy Grotto, however, in much lower abundances than in Phong Nha. This species was associated with a small deposit of bird guano, but no other guano associated species were found here, possibly due to the high energy seasonal flooding that occurs here, stopping the establishment of a large and diverse guano community. This locality was also the only site where opiliones were collected.

Figure 8 Oniscoid slater in small bird guano deposit in the twilight zone of Dark Cave. (Photo Renee Mouritz).

Transition Zone

The transition zone of Dark Cave consisted of a small side passage which was subject to seasonal flooding. This passage contained considerable amounts of organic material which attracts a diverse range of 1st order consumers including passalid beetles, millipedes, and crickets. This resulted in a very diverse spider assemblage with seven (7) species recorded, and five (5) of these not found in any other caves examined during the current study.

Cave Biodiversity Discussion

Comparison of Cave Biodiversity in Phong Nha-Ke Bang NP

The three caves examined show similarity in diversity, as well as some distinct differences, based upon the hydrology, morphology and age of the caves. The Phong Nha Cave System (Royal and Fairy Grottos, Bi Ki Grotto, and the main Phong Nha river cave passage) and Tien Son Cave, situated approximately 200m above the current river level of Phong Nha Cave, do not have a human sized connection, however, cave fauna can invariably move between the caves via the network of meso and micro caverns that are present in all karstic systems.

The main differences in faunal assemblage shown by the current preliminary survey are the dramatic differences in faunal diversity and abundance between areas used by tourists and the wild sections of the same caves. Phong Nha cave contains three tourist sections, Bi Ki Grotto, and the contiguous Royal and Fairy Grottos near the cave entrance. These areas are extremely heavily impacted by foot traffic over every horizontal surface, with no defined paths through much of the tourist route. This has resulted in limited habitat remaining that is capable of supporting cave fauna. The large amount of rubbish in the tourist sections, and the presence of rubbish bins within the caves have also affected the assemblage of cave fauna in these areas. The majority of fauna recorded from the Fairy and Royal Grottos are relatively common species found in several other areas. The abundance of the oniscoid isopod in these areas appears to be unnaturally high compared with Dark Cave populations, most likely a result of the rubbish and food scraps providing additional resources in this area.

The presence of bins within the caves also affects the faunal diversity, with virtually all the species recorded from the tourist section of Tien Son cave being located under or near bins. This fauna is likely to occur in much higher abundances than natural cave levels due to the additional food resources available. The lack of these food sources in the wild section of Tien Son cave resulted in much lower populations, or a complete absence, of species such as millipedes and staphylinid beetles, with only six (6) of the 16 species common between the two sections surveyed.

The cave fauna recorded from the Dark Cave showed the greatest difference to both Phong Nha and Tien Son caves, due to both the different cave morphology and the absence of tourism within the Dark Cave. While the overall species diversity was not significantly greater, the species recorded from Dark Cave were mostly not recorded from either of the other caves surveyed. It is impossible to confirm the cause of this difference with the current preliminary data, however, it is likely to be a combination of both natural faunal compositions and absence of impacts to the available habitat within Dark Cave compared with Phong Nha and Tien Son Caves.

Regional Significance

The results of the current preliminary study do not allow a meaningful comparison with other karst areas, either in Vietnam or the remainder of Asia. As the specimens collected are identified further and additional, more comprehensive surveys are carried out in the PNKBNP the true significance of the areas subterranean biodiversity will become apparent. The preliminary results do, however, provide an indication of the diversity that may be revealed from this important karst area. The presence of undoubtedly the first cave dwelling troglomorphic scorpion from mainland Asia would suggest that the PNKBNP has a high potential for further important cave biology discoveries. The sheer amount and diversity of caves within the area provide extensive and varied habitats to support a wide variety of different subterranean communities, that when properly studied will likely reveal a rich and important diversity for Vietnam and the PNKBNP World Heritage Site.

Recommendations to Preserve Cave Biodiversity

Cave Management

People going off the designated path have the potential to damage cave habitat. People leaving rubbish in the cave, spitting, toileting in the cave all create artificial food sources which attract outside fauna. Noise levels in the cave are also disturbing the bat and swiftlet populations which reside in the cave, relying upon the cave for shelter.

Noise/Uncontrolled Behaviour

Both bats and swiftlets use Phong Nha Cave and Tien Son Cave as a roosting/nesting ground. This was determined through visual observation of the animals and the presence of their droppings or guano. Old guano deposits found in areas of the caves indicate that bat and swiftlet population numbers were much higher in the past than those currently. The excessive noise in the cave, due to the excited nature of people, are having an impact on the natural assemblage of bat and swiftlets. These animals both provide a very important source of energy for many invertebrate species within the cave system. A change in bat and swiftlet populations will result in a dramatic alteration to the faunal assemblage seen in the caves. The following actions will aid in reducing noise:

- Staff training – all staff must be made aware of the importance of maintaining low noise levels inside the caves.
- Ensure staff have the authority to maintain low noise levels in the caves.
- Adequate signage to educate visitors about the bat and swiftlet populations and the importance of their presence to a healthy cave and surface ecosystem (they eat insects outside the caves). and the need for them to keep quiet so as not to further disturb them.

Rubbish (Accumulation of rubbish within the caves)

There is little to no enforcement of the park rules about eating, drinking, and smoking in the caves. This is resulting in large amounts of rubbish being found throughout the cave including plastic drink bottles, fruit juice cartons, beer and soft drink cans, good luck money, footwear, clothing, fruit peel, eggshells, and peanut shells. These artificial food sources have the potential to attract pest species into the caves, artificially altering community structures and greatly impacting on the natural species diversity in the cave systems.

The cave survey found evidence of rat presence in Tien Son Cave. It is obvious that eating and drinking in the caves is a huge problem and needs to be stopped. Rubbish bins are in place throughout Tien Son Cave and Phong Nha Cave and are to a point being used but they in themselves act as an artificial food source as the faunal assemblage found around the base of one showed. It is highly recommended that the rubbish bins are removed from the cave, an extensive cave clean up is done to remove rubbish that has been disposed of inappropriately throughout the caves and the rules of not eating and drinking within the cave are strictly enforced, as that of no smoking.

- Staff training – all staff must be made aware of why the worldwide accepted rules of No Smoking, No Eating and No Drinking within the cave are so important and be given guidance in how to enforce them.
- Conduct a thorough clean up of the caves with ALL rubbish removed and disposed off appropriately.
- Ensure staff have the authority to prohibit visitors from carrying food and drink items into the caves .
- Remove rubbish bins as they are acting as artificial food sources and should no longer be necessary if people are not eating and drinking in the caves.
- Instead of 'good luck' money make it good luck to pick rubbish up from the cave and take it outside to the bin.

Figure 9 Peanut shells discarded in Tien Son Cave creates artificial food sources that attract surface species and enable rats to live inside the cave. (Photo Tim Moulds).

Figure 10 Cigarette butts and other rubbish in Bi Ki Grotto. Rubbish provides food for pest species such as rats inside the cave. (Photo Tim Moulds).

Inappropriate Lighting

The current lighting system in both Phong Nha and Tien Son is not conducive to creating a suitable habitat for cave fauna. The constant light is having a detrimental effect on the bat and swiftlet populations in the caves. The current lighting system also creates a fantasy world cave experience that is a potential source of the excitement (exhibited as noise) felt by visitors in the cave. This noise will be of great disturbance to the bat and swiftlet populations within the cave systems.

Lampenflora is also another problem resulting from the inappropriate lighting in the caves. The growth of algae, moss and in extreme cases ferns deep into the cave system again has the potential to create an artificial food source.

These problems can be greatly improved by reducing the amount of light being used as well as the type of light used and duration of time that the lights are left on throughout the cave (as per recommendations made by Brian Clark, 2009a).

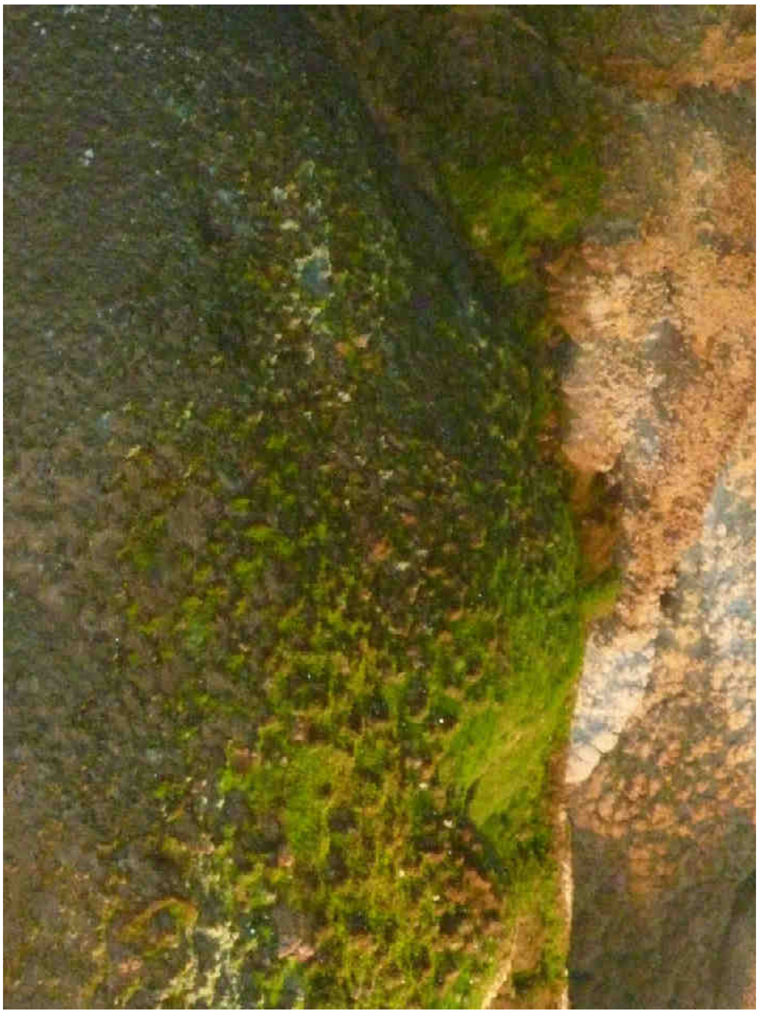

Figure 11 Lampenflora growth on a speleothem inside Tien Son Cave. This not only damages the speleothem but also creates an artificial food source in the cave that attracts surface species into the cave. (Photo Tim Moulds).

Floor – habitat destruction

Due to the undefined nature of the pathways in both Tien Son Cave and the Phong Nha Cave the floor of the cave has been badly trampled with any suitable habitat destroyed as a result. It is imperative that the movement of visitors through the caves be restricted to distinct pathways. Ideally these would be elevated to prevent further damage to the cave floor but in the early stages roping off walkways would be an effective and cheaper option.

- Staff training and control/enforcement of where visitors walk.
- Roping off walkways to define where tourists are allowed to walk.
- Ultimately developing a series of elevated pathways to further minimise any impact on the cave floor and to allow habitat to reinstate itself.
- Clean the cave of both rubbish and compacted mud on floor areas to further reinstate habitat for cave fauna.

Figure 12 Floor compaction in Phong Nha Cave. (Photo Tim Moulds)

Figure 13 Floor compaction in Tien Son Cave. (Photo Tim Moulds).

Summary of Key Management Recommendations to Preserve Cave Biodiversity

The preliminary survey results lead to several very important recommendations to ensure the caves maintain their biodiversity in the future:

1. Immediately make defined pathways in the tourist caves marked by posts and rope to stop the cave floors being destroyed by people walking on them. This destroys habitat for many insects and spiders that live in the cave. Ultimately raised walkways should be installed in all tourist areas to minimise impact to cave floors.
2. Clean the compacted mud from the cave floor to allow habitat for cave insects and spiders to recover.
3. Clean up the rubbish left throughout the cave. Rubbish attracts rats into the cave that will eat cave insects and spiders.
4. Remove the rubbish bins which attract rats (see above), and also attracts surface insects which are affecting the diversity and abundance of cave insects and spiders.
5. Stop people eating and drinking inside the caves as food scraps dropped encourage rats to live in the caves.
6. Reduce noise in the caves as this is disturbing the bat and swiftlet populations which support diverse insect

communities in the caves. If the noise continues, the bats and swiftlets may leave the cave permanently, destroying the cave guano insect ecosystem.

7. Enforce the 'No Smoking' ban inside the caves as this is also disturbing the bat and swiftlet populations, and also increases rubbish dropped on floors as butts and empty packets.
8. Change the lighting in the caves as it is causing the growth of lampenflora (plants that grow under artificial light in caves). The lampenflora is providing an artificial food source for surface species not usually found in caves, and thus affecting the diversity and abundance of cave insects and spiders.
9. Additional, more comprehensive biodiversity surveys are required in order to fully appreciate the diversity of cave fauna in the PNKBNP. This will provide a far greater understanding of biodiversity and the unique species present here.
10. Prior to the development of additional caves for tourism, they must be comprehensively assessed for cave biodiversity to provide baseline data to enable annual monitoring of impacts to fauna. The baseline survey will also identify any key habitats to be preserved within each cave, and any important species that may require special protection.

These recommendations (1 - 8), are the same as those made by Brian Clark (Clark, 2009a, 2009b), to stop the destruction of the caves and formations and ensure World Heritage Values are maintained, but are made here in order to ensure the biodiversity values of the caves are preserved.

Recommendations for Future Work

The current study provides only a very preliminary study of three easily accessible caves within the large PNKBNP. The diversity contained in these caves is invariably much greater and considerably more survey effort will be required before a fuller understanding of the caves true biodiversity values can be ascertained. With this in mind a series of future studies are recommended below to build upon the information gathered during the current survey.

Key recommendations for future cave biodiversity studies are:

1. The specimens collected during the current survey should be held by an appropriate research institute with suitable laboratory space and access to specialised library resources such as the Hanoi University to enable their continued identification and study by taxonomic experts. Due to the limitations in both time and available local resources in Dong Hoi the level of identification of the material collected during the current survey is preliminary and considerable further work is required to determine the number of species new to science collected. This collection can then form the basis for any future surveys to be conducted on the cave fauna of PNKBNP.
2. Undertake a literature review of cave fauna known from PNKBNP including any references in cave exploration reports of the area. This could also include the whole of Vietnam, due to the general absence of records making this a readily achievable task. This would enable the biodiversity in PNKBNP to be placed and ranked in a local and regional context, and provide a 'state of play' for additional work to be undertaken effectively.
3. A follow up survey of the Phong Nha Cave system (Phong Nha and Tien Son Caves) 12 months after any cave cleaning and installation of walkways have been undertaken. This will enable an assessment of the cave biodiversity and effects of rehabilitation. Monitoring of cave fauna should be repeated annually to provide an ongoing assessment of the effectiveness of the rehabilitation actions including; installation of defined walkways, rubbish removal, alteration of lighting and cleaning of lampenflora, smoking ban enforced, etc. This should be undertaken by a specialist in cave biology in

conjunction with a local Vietnamese organisation with experience in cave biodiversity, ideally with previous experience in the PNKBNP karst.

4. Undertake a comprehensive biological survey of three to four caves in the PNKBNP situated in different hydrogeologic areas to provide a greater understanding of cave biodiversity within the entire park. This should include caves from both the main drainages identified in the Park.

Conclusions

The present study has undertaken a preliminary investigation of three easily accessible caves situated on the edge of the karst contained within the Phong Nha – Ke Bang National Park World Heritage Site. This small study will provide a basis for more detailed work on the diversity of the PNKB karst in the future by providing an indication of the potential for endemic fauna and rare and significant species to be identified. In order to properly understand the biodiversity values within the caves of the PNKBNP and enable adequate protection further, more comprehensive surveys must be undertaken across several caves in the two main karst drainage systems identified (Figure 2). This will likely lead to the addition of 'Biodiversity Values' for the recognised World Heritage values of the park.

In addition to further research programmes in the caves, the currently known cave biota must be adequately protected and managed. This requires some immediate actions in the current tourist caves to stop the destruction of key cave fauna habitats, including:

1. Immediately make defined pathways in the tourist caves marked by posts and rope to stop the cave floors being destroyed by people walking on them. This destroys habitat for many insects and spiders that live in the cave. Ultimately raised walkways should be installed in all tourist areas to minimise impact to cave floors.
2. Clean the compacted mud from the cave floor to allow habitat for cave insects and spiders to recover.
3. Clean up the rubbish left throughout the cave. Rubbish attracts rats into the cave that will eat cave insects and spiders.
4. Remove the rubbish bins which attract rats (see above), and also attracts surface insects which are affecting the diversity and abundance of cave insects and spiders.
5. Stop people eating and drinking inside the caves as food scraps dropped also encourage rats to live in the caves.
6. Reduce noise in the caves as this is disturbing the bat and swiftlet populations which support diverse insect communities in the caves. If the noise continues, the bats and swiftlets may leave the cave permanently, destroying the cave guano insect ecosystem.
7. Enforce the 'No Smoking' ban inside the caves as this is also disturbing the bat and swiftlet populations, and also increases rubbish dropped on floors as butts and empty packets.
8. Change the lighting in the caves as it is causing the growth of lampenflora (plants that grow under artificial light in caves). The lampenflora is providing an artificial food source for surface species not usually found in caves, and thus affecting the diversity and abundance of cave insects and spiders.
9. Additional, more comprehensive biodiversity surveys are required to able to fully appreciate the diversity of cave fauna in the PNKBNP. This will provide a far greater understanding of biodiversity and the unique species present here.
10. Prior to the development of additional caves for tourism, they must be comprehensively assessed for cave biodiversity to provide baseline data to enable annual monitoring of impacts to fauna. The baseline survey will also identify any key habitats to be preserved within each cave, and any important species that may require special protection.

The implementation of these simple and generally low cost options will dramatically improve the habitat for cave fauna and allow a more natural community to re-establish within the highly impacted areas of Phong Nha Cave system (Bi Ki Grotto, Fairy Grotto, and Royal Grotto areas).

The caves of the Phong Nha – Ke Bang National Park are highly likely contain a very important and diverse community of cave fauna. This preliminary survey provides only a small insight into the biological treasures to be discovered by future research in this rich and unique World Heritage Site.

Acknowledgements

The authors would like to acknowledge the Peoples Republic of Vietnam for the opportunity to visit their beautiful country and the very warm welcome received. This preliminary survey would not have been possible without the co-operation of the Phong Nha – Ke Bang National Park, the Phong Nha – Ke Bang Tourism Centre and the Scientific Research and Wildlife Rescue Centre. The authors wish to thank the Phong Nha – Ke Bang National Park Region Project, supported by the German Ministry of Cooperation and Development (BM) for supporting this important project to begin the understanding of cave biodiversity in PNKBNP. Special thanks to all the GTZ - staff in Dong Hoi for their tireless efforts to make this survey possible and make us all feel extremely welcome.

Figure 14 The authors (left to right), Renee Mouritz, Pham Dinh Sac, and Timothy Moulds in Bi Ki Grotto, Phong Nha Cave. (Photo Dang Ngoc Kien).

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Waitomo Glowworm Caves Visitor Centre – Rises From The Ashes

The Development Of Cultural Elements To Enhance The Visitor Experience

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Abstract

This paper is presented to ACKMA in the memory of Walter Anderson, Kaumatua, Local Elder, Land Owner, former Chief Cave Guide at the Waitomo Glowworm Cave, who dedicated his life to the benefit of the Glowworm Cave and enhanced the visit for thousands of people throughout his lifetime.

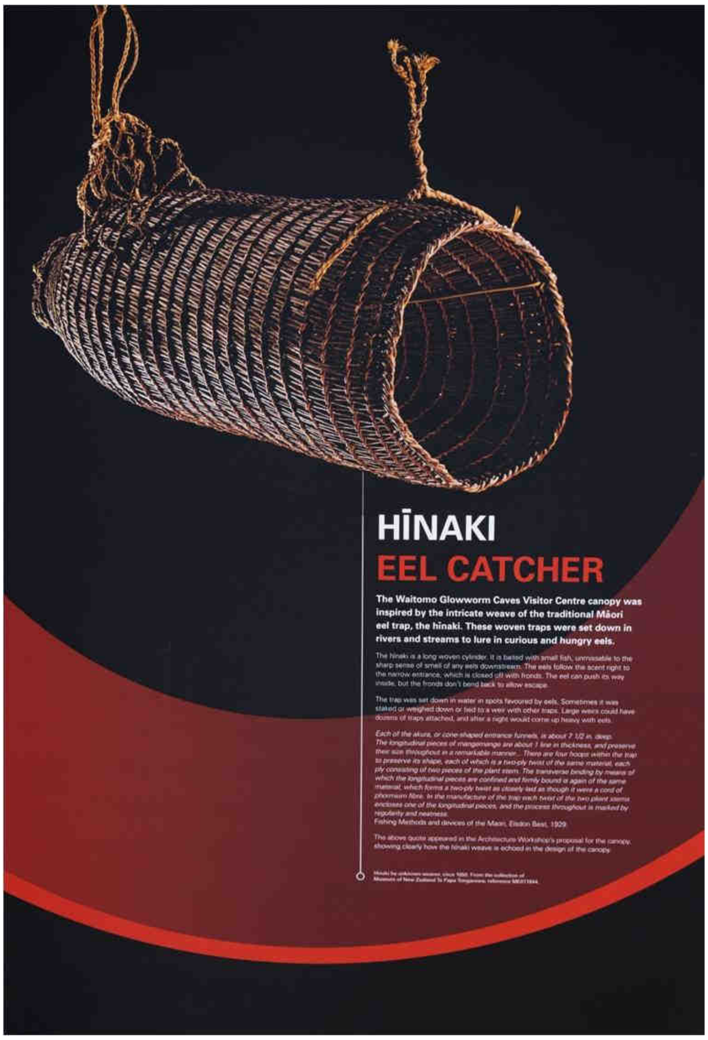
In memory of Walter Anderson, Kaumatua, Owner and former Chief Guide

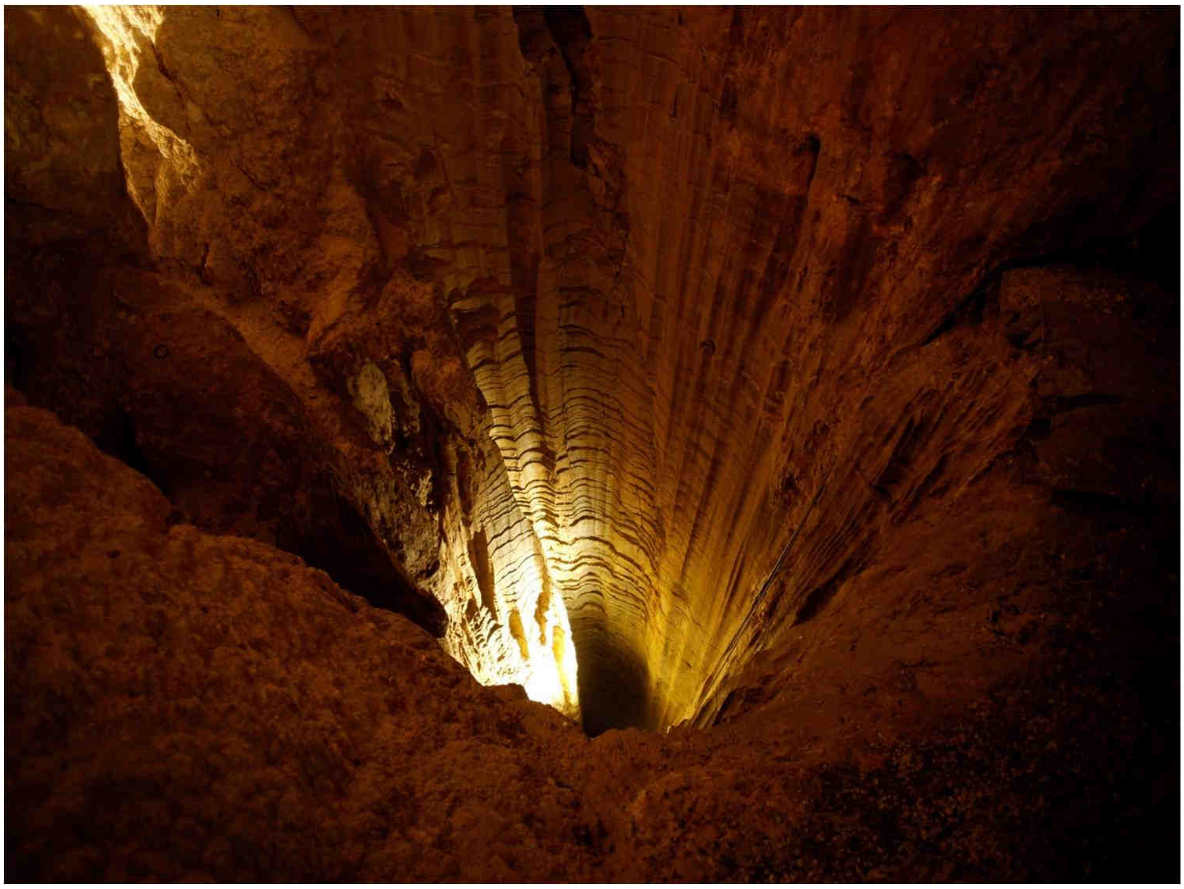
Background

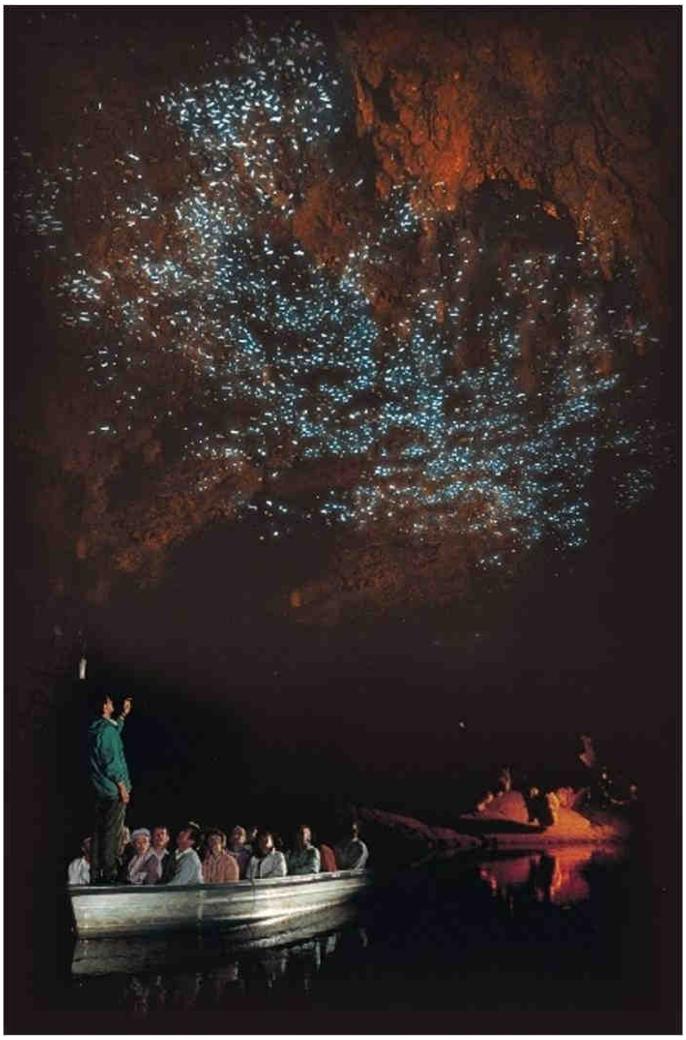
The facilities buildings at the Waitomo Glowworm Caves were completely razed to the ground from a fire on 14 December 2005. The loss of the infrastructure coincided with the renewal of the Licence to operate the Cave Guiding business which was held by one of New Zealand's largest tourism companies, Tourism Holdings Limited (THL). The Company remained committed to re-establishing the facilities in a way that was befitting for the status of the Glowworm Caves as a New Zealand Tourism icon.

The design contract for the new facilities was awarded to the Wellington based firm, Architecture Workshop under the direction of architect, Chris Kelly.

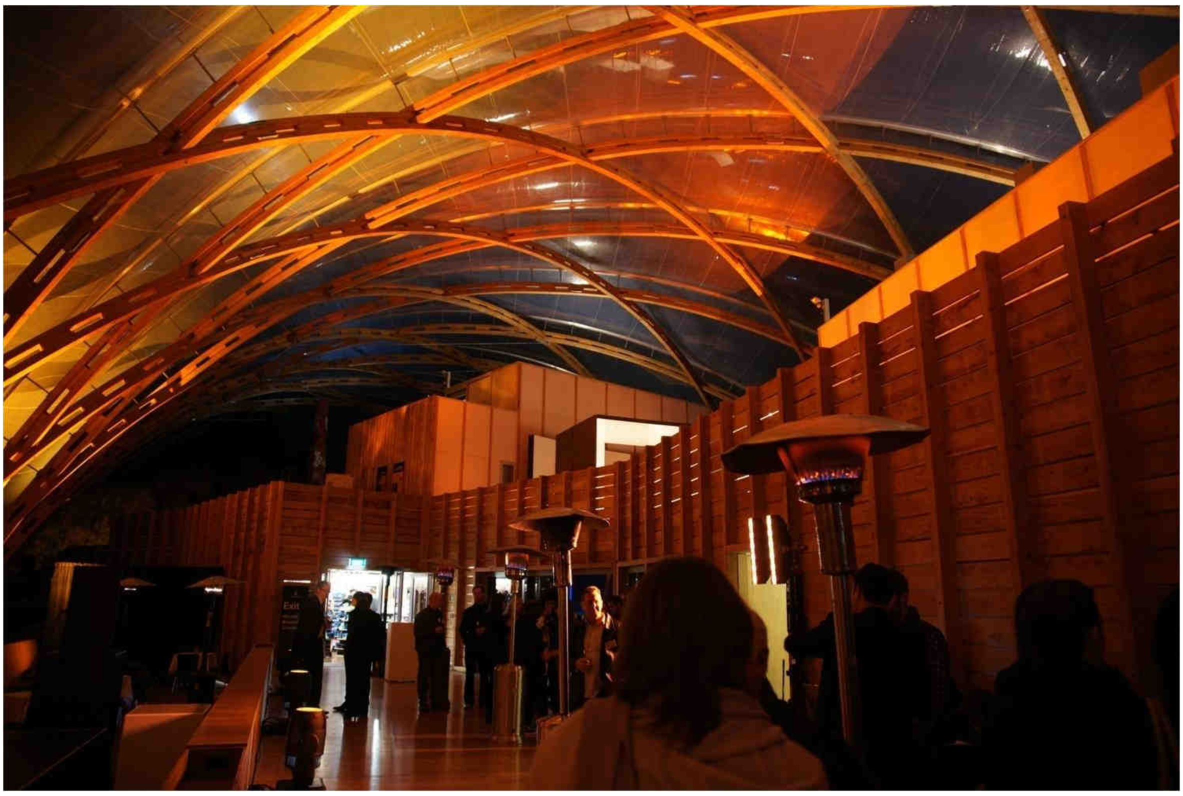
The concept for the structure was based on a hinaki (traditional Maori fishing trap) with the main frames supporting the Efte (Teflon) pillows canopy, constructed of large curved laminated timber beams representing the woven pattern of the fishing trap. This design channelled the visitors through to the cave entrance. The concept was to have the buildings constructed in a minimalistic style to produce an interesting , innovative and memorable structure, without taking anything away from the natural experience that visitors were about to see when visiting the cave.


HĪNAKI
EEL CATCHER
The Waitomo Glowworm Caves Visitor Centre canopy was inspired by the intricate weave of the traditional Māori eel trap, the hīnaki. These woven traps were set down in rivers and streams to lure in curious and hungry eels.





An important aspect of the design was the provision of toilet facilities sufficient to accommodate the high volume of visitors to this location, as the Caves are often the first stop off point for many visitors who arrive by tour coaches from Auckland. The toilet facilities are positioned right at the entrance to the facility and are built into the embankment from where the foundations for the curved beams of the canopy structure are set. The three levels of buildings within the overarching structure contain a 250 seat restaurant on two levels, a cafe, souvenir shop, audio visual theatre, meeting rooms, display/exhibition area, office administration and cave guides rooms, and a staff cafeteria.



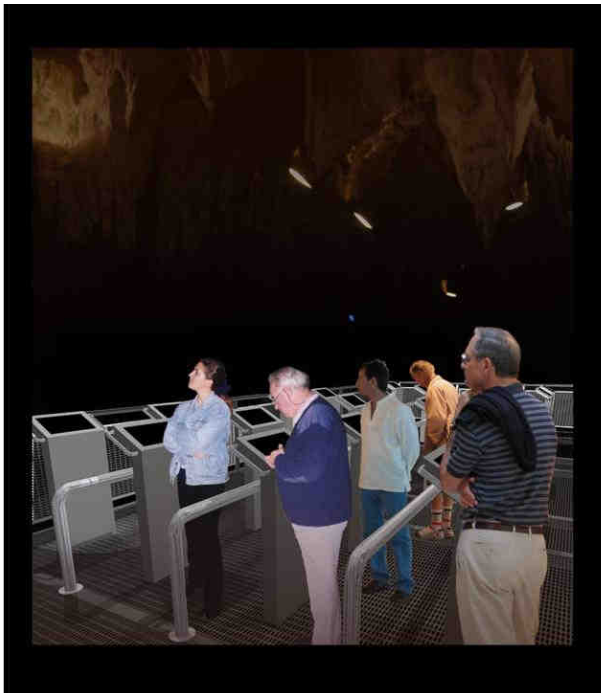

Tickets
Tickets
Tickets
Entry

The original design concept envisaged a purpose built theatre centrally located in the structure. The concept was to provide a multi sensory experience taking visitors on a journey to the centre of the earth starting with the Maori mythology of the "creation" story. The theatre was to be state of the art, high technology with sound effects, hot and cold temperature differentials and visitors would stand in front of individual monitors which would display different aspects of the story. As this part of the project developed, the production costs escalated to more than $5 million and the decision was taken to abandon the concept on the grounds of costs, maintenance and a comparatively short life (5 years) before it would require refreshing or complete renewal.

Proposal Review

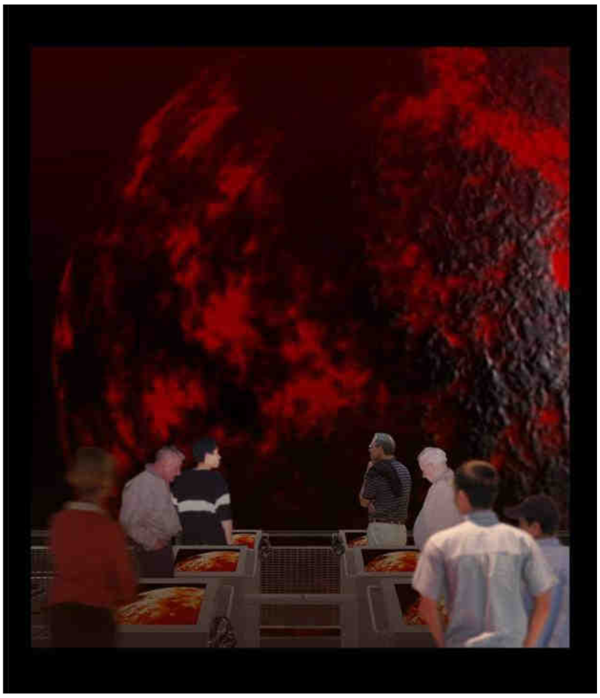
ORIENTATION

On the viewing platform, there are video consoles, headphones and leaning rails.



EARTH SCIENCE

The visitors are now taken on a journey back through time with the earth becoming a ball of gas.



Cultural Elements

The Waitomo Glowworm Caves Management Committee worked with the designers and Tourism Holdings Limited to develop the cultural elements to be incorporated into the new facilities. The process commenced with a review of the elements that had existed in the previous facilities. These included a focus on traditional Maori designs such as the motif of the Maori god of darkness which was incorporated into signage and traditional carved pou on fences at the former entrance.


WAITOMO
GLOWWORM CAVES
WELCOME
COME AND EXPLORE
OUR SECRET
WORLD
Tickets
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WAITOMO
GLOWWORM CAVES
HAERE RA
GOODBYE

The main carved pou which depicts the traditional story of the Caves was completely refurbished and now has pride of place at the front of the building and under the shelter of the canopy. This is one of the most photographed Maori carvings in New Zealand and its position needed to provide sufficient space for visitors to take the famous photo as part of their experience.


WAITOMO
CAVES
1887 1987
CAVE

Structure Design Issues

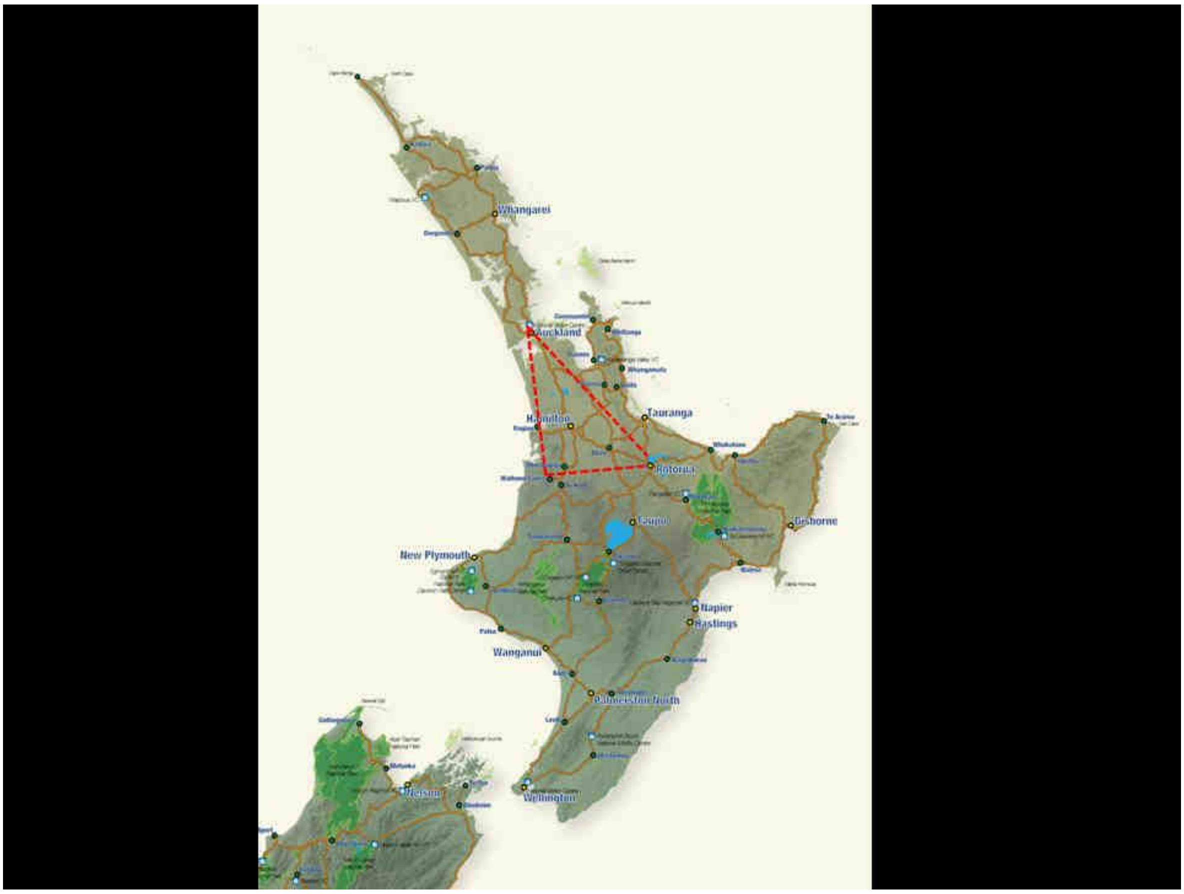
The Efte (Teflon) pillows which blanket the canopy substructure, were designed with the expectation that the air temperature within the structure would not be greater than 2 – 3 degrees C above the external ambient temperature. This issue was of particular importance to the Cave Owners as the control of temperature within the cave is essential to maintain the optimal environment and habitat for the survival of the glowworms. It was conceivable that air warmed under the canopy through convection, could end up passing through the main cave entrance if the right breeze conditions prevailed. Post construction, temperatures of 43 degrees C were recorded in some peak summer days and as a result electric fans and umbrellas were placed to improve visitor comfort.

In the design phase consideration was given to the incorporation of traditional Maori designs in the canopy material such as the Koru or unfurling fern frond, or the traditional patterns such as those often depicted on the tahuhu or ridge poles in Whare (traditional Maori Meeting houses). The cost of this was seen as prohibitive at the time. One solution to provide shade and cooling from the intense sunlight, is to provide mechanical blinds which can be drawn up the laminated beams of the sub-structure of the canopy in strategic locations.

Efte (teflon) inflated pillows provide the roof canopy

Visitation

Waitomo is on what is described as a "Tourism Triangle" in New Zealand. Auckland Airport is the largest international arrival point into the country and many visitors commence their tour of New Zealand in Auckland, travel to the Waitomo Glowworm Caves and then continue on to Rotorua to experience the "Geothermal Wonderland" before returning back to Auckland.



Visitation to the Waitomo Glowworm Caves has been monitored now since 1889. Eighty percent of visitors to the Caves are international and as a consequence, the Caves are important to the local, regional and national economy. In tracking the visitation over such a long period it is possible to identify every major global event, i.e. World War II, the Oil Crises, Gulf War, SARS, the Global Recession and most recently, the Christchurch Earthquakes. What is evident is that traditionally the market has recovered very quickly after each event.

Presenting a View of the Local Culture

After abandonment of the initial concept of the high-tech "Journey to the Centre of the Earth", The Cave Resource Owners and the Lessee, Tourism Holdings Limited reconsidered what would be most appropriate in this location. The local Maori people, tangata whenua, the Ruapuha Uekaha Hapu, consulted their elders and thought about their cultural traditions and customs which are practised at significant events on their Tokikapu Marae.

The Waitomo Glowworm Caves Owners and Lessee - Tourism Holdings Ltd

Tokikapu Marae – Waitomo

It was agreed that it would be appropriate to impart something of the local culture to visitors, most of whom are international and who have an inquisitiveness about our country and its people. The members of the Hapu did not have a desire to replicate the performing arts and cultural ceremonial traditions as that is a particular theme that is well delivered in Rotorua. Many of the visitors to the Glowworm Cave are en-route to Rotorua. The question then was "How do you capture and present the essence of this place to visitors"?

The decision was then made to contract in an Auckland Based documentary production company THEDOWNLOWCONCEPT to develop a short Audio Visual production made up of a series of interviews with local people who live in or have an attachment to Waitomo. The end result is a 12 minute production, commencing with a traditional Mihi or welcome from Kaumatua, Walter Anderson and then a series of interviews describing different aspects and insights into life at Waitomo. The show runs continuously in a purpose built Audio Visual Theatre and is designed to be incorporated into the Cave Tour and is a valuable addition to enhance the visitors' experience and understanding of the place they are visiting.

thedownlowconcept Production Company was commissioned to capture the stories

In tandem with the new Audio Visual production, has been the development of a training programme for the Cave Guides to enhance their delivery of the guiding experience for visitors through story telling techniques and the style of delivering messages and interpretation of the cave and its natural features.

Having invested in a major new visitor centre, Tourism Holdings Limited have recognised the need to enhance and provide for a quality visitor experience to meet the expectations of visitors today. This enhancement of the guiding experience has commenced and it will continue to be developed in the years ahead.

An ongoing training and development programme for guides in hosting and storytelling -Manaakitanga

Canterbury Earthquake Causes Damage To Local Caves

Moira Lipyeat

Abstract

Living at Redcliffs, 12km from the centre of Christchurch, I have been associated in many ways with the appreciation of local caves. My book, *Delving Deeper: 'The first 50 years of Caving in New Zealand'* was even launched in one and I have taken many groups to visit them.

Though our history doesn't compare with that of Australia, Europe or South Africa, von Haast in 1872 excavated Moa Bone Point Cave (very near our home) and it can be noted from the results of this work that caves were very important gauges of geology and climate changes as well as of Maori occupation.

Introduction—Geological History

Geological time covers a tremendous period. It is hard to visualize the building of Canterbury over millions of years of huge pressures caused by earth movements and volcanic activity. Over 60 million years ago we (NZ) separated from Gondwanaland, were immersed under the sea and thrust up to gradually form the Southern Alps. Subsequent climate changes melted glaciers to form the Canterbury plains.

Volcanic activity commenced 12 million years ago and alternate layers of ash and lava were pushed up to form Banks Peninsula and our Port Hills. As a result of these forces we were blessed with an exciting environment of caves, tors, rocky crags and deep harbours. This was great country for rock climbing, mountain biking, walking trails, photography and some lava caving.

September 4th, 2010 at 4.38 am, a 7.1 magnitude earthquake altered forever some of this landscape that had been forming for aeons. The epicentre was located approximately 40 kilometres inland. Some rocks were dislodged, but apart from a severe shaking, there was little damage to the Port Hills. Around 24,000 people, including many local cavers chose to live in the Port Hills environment and smugly felt the rock beneath us was "solid as".

However, on February 22nd, 2011, the second earthquake was centred under our volcanic Port Hills. At 12.51 pm, within a period of 24 seconds many places, including a number of CCG members' homes, were reduced to rubble; trampers and residents were killed in rock falls. I was terrified when the red cliffs near our house started noisily crumbling down. Throughout the city area nearly 200 were killed and our city centre of Christchurch, (only 10 kms away) was devastated, especially heritage buildings. Some of our local caves and climbing areas were geographically altered forever, while huge boulders, the size of cars tumbled down.

Figure 1: After the Event. Cave at end of our street.

A Place to Live and Love

My love affair with these caves and rocky crags goes back to 1985 when we moved into this area. I was thrilled to have a cave virtually at my back door. I had shown to the Museum various objects of Maori flax art preserved inside caves nearby. So we lobbied that the Council should have two caves and a house purchased by Council and therefore protected. Our request was unsuccessful.

The more research I did the more important the site became. **Moa Bone Point Cave** was first recorded in 1872 by officers of the survey ship Acheron, and moa bones were found. These were later sent to Richard Owen at the Museum of Science in London to be identified. Julius von Haast also found this a most important archeological site and in 1872 he drew the first cave survey in New Zealand, of this cave. He excavated to a great depth and recorded that it was evident there had not been any geological upheaval in the last thousand years.

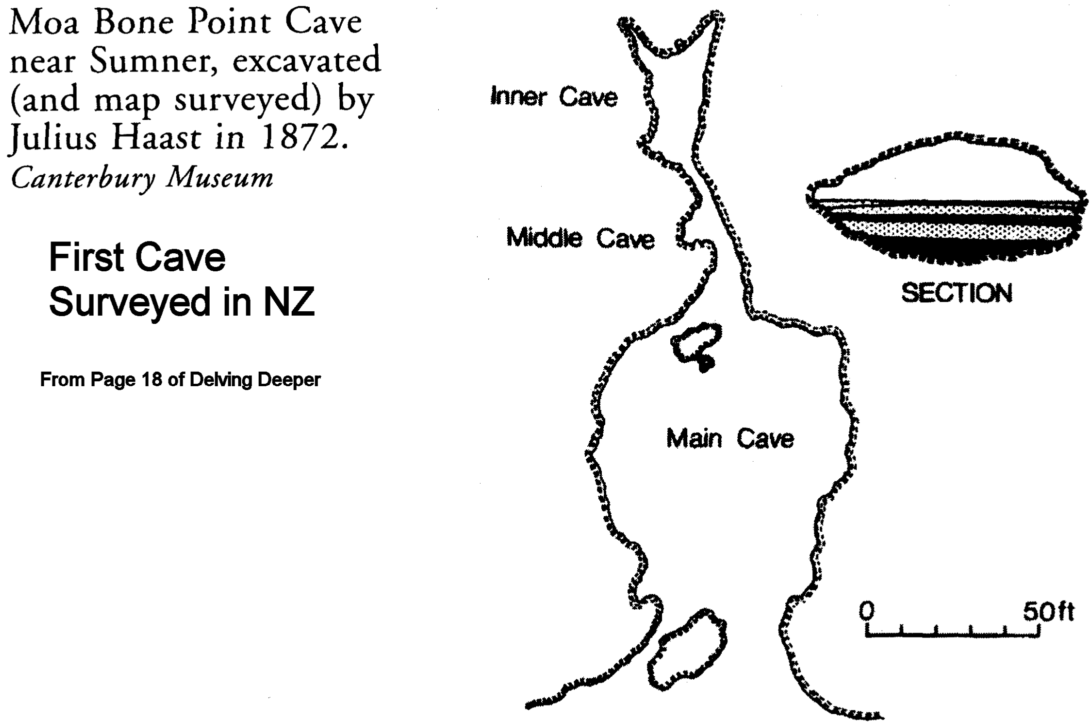


Figure 2: Showing map of Moa Bone Point Cave by Julius von Haast 1849

Local Damage

Five hundred metres away a landslide had exposed **Moncks Cave** in 1899 during roadwork nearby. Important and rare Maori artifacts (Figure 3) were found and can be seen in Christchurch Museum (when it is declared safe to enter!). Though damaged, it is fortunate that this cave has survived at all. (The supermarket adjacent was being completely demolished owing to liquefaction.)

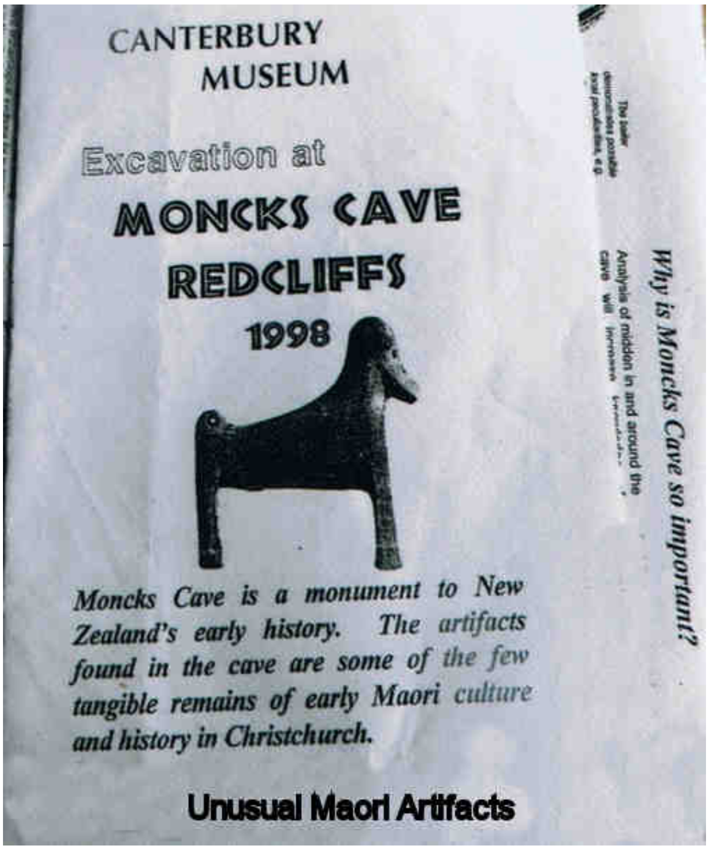


Figure 3:

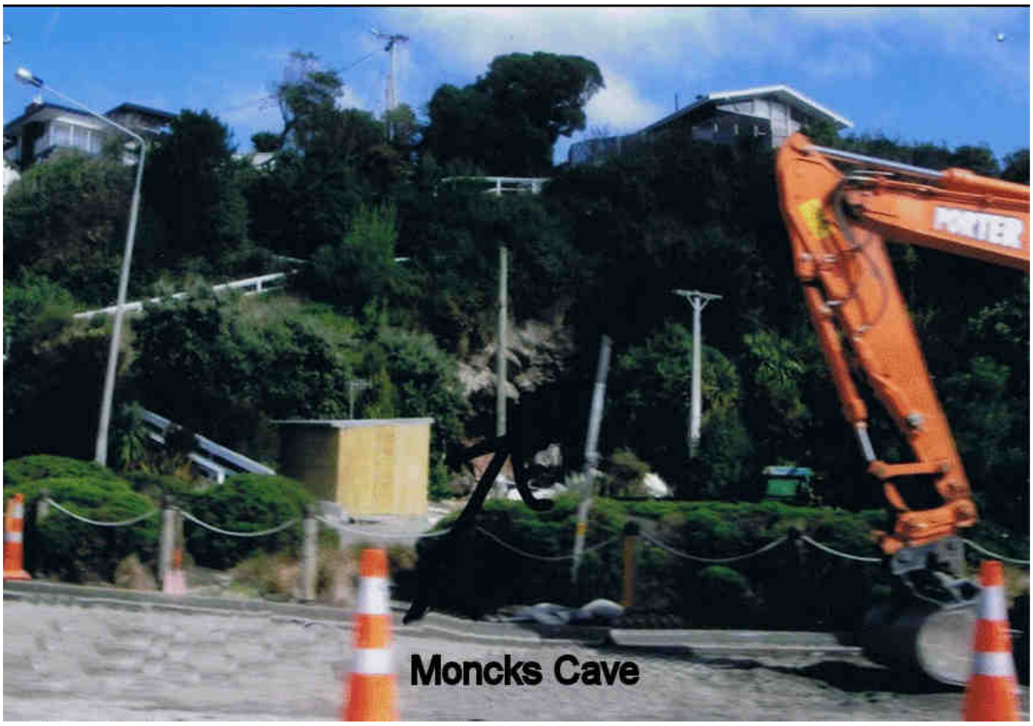


Figure 4: Moncks Cave Site after February 2011

Nearby in Barnet Park a walkway leads to another lava cave. The steps to the cave area are damaged and still cordoned off. My husband Derek (over 80) enjoys this area to keep fit for more serious caving. The historical cave residences at Taylors Mistake, 4 kilometres away, are also barricaded. At the end of our street is a cave which was most suitable for youth groups. Access will be impossible now as enormous rocks have blocked the entrance.

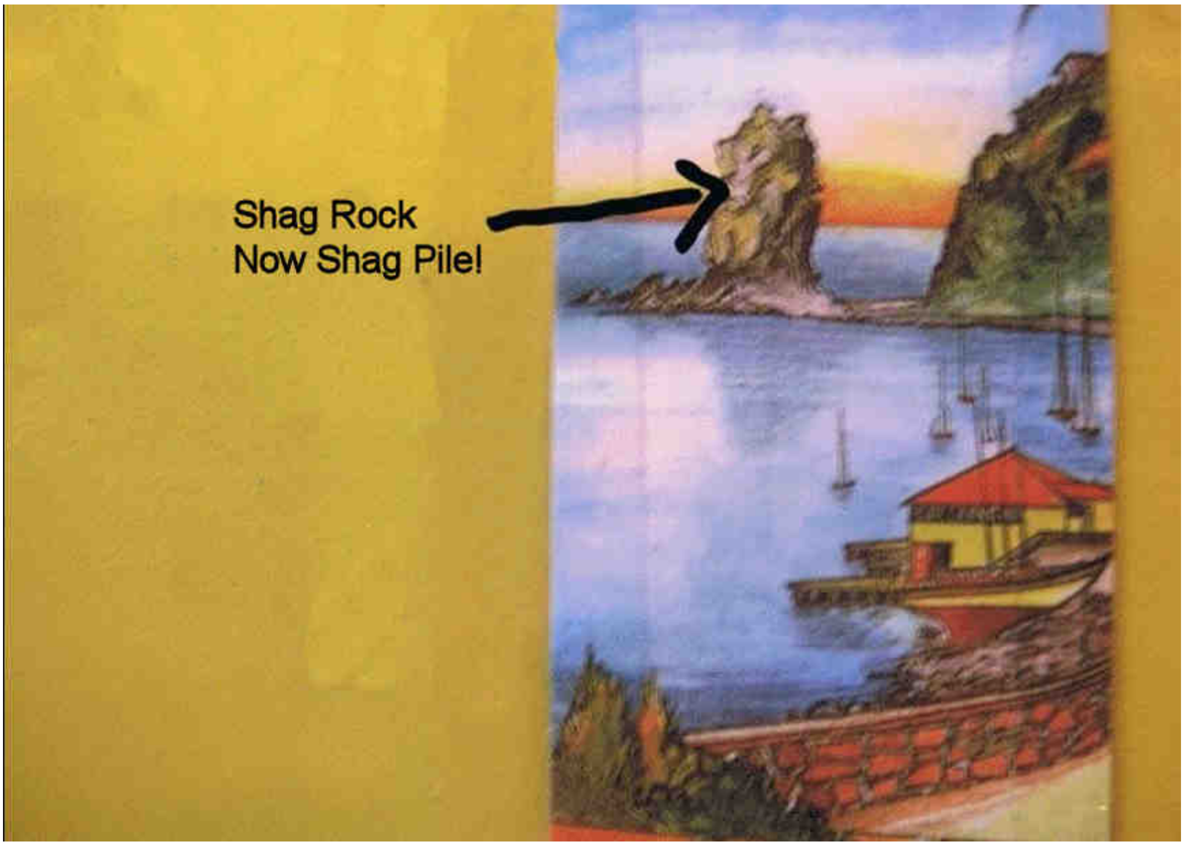


Figure 5: Shag Rock as named, now tumbled to a pile of broken rock

Nearby a landmark volcanic monolith has been reduced from Shag Rock to Shag Pile. On Sumner Beach three kilometres away Cave Rock has always been a popular volcanic site as a cave goes through its centre. The entrance rock has been modified but fortunately little or no damage has occurred to the inside.

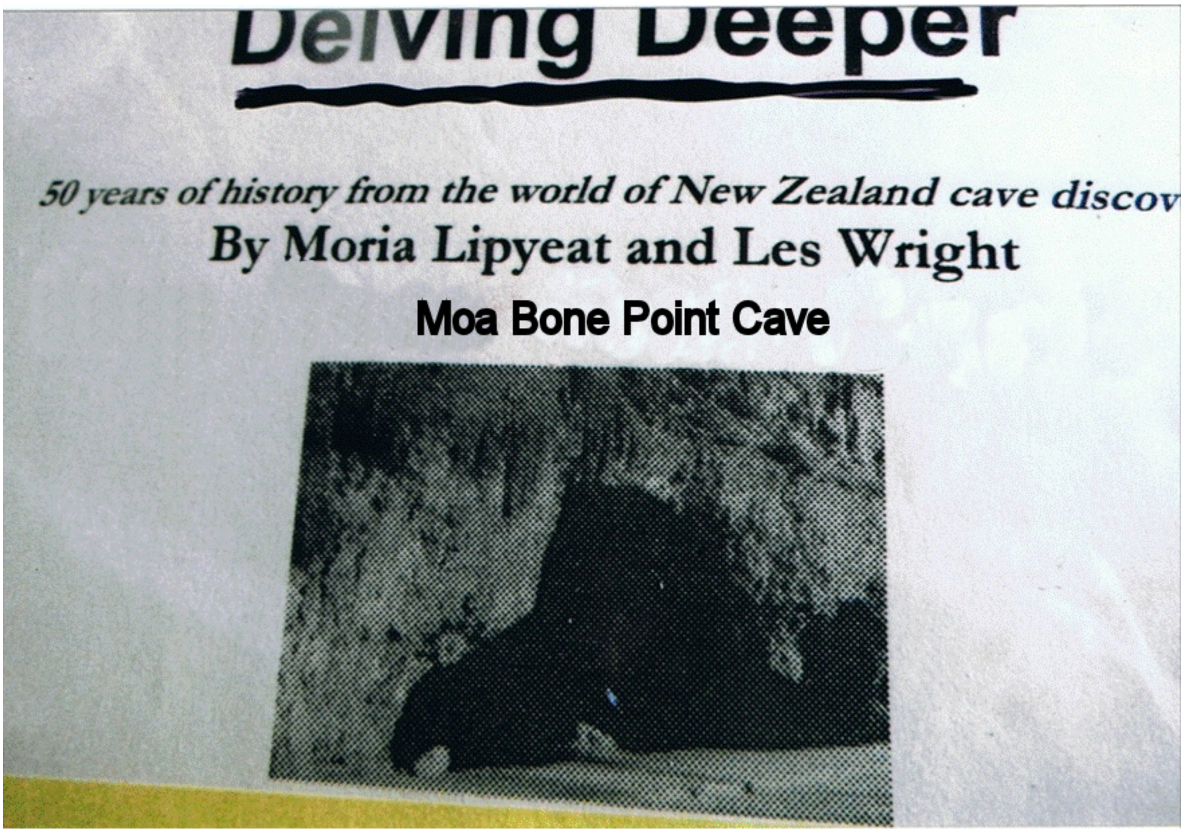


Figure 6:

Delving Deeper

Some of you may own a copy of "Delving Deeper: Fifty Years of Caving in New Zealand" (Figure 6). I compiled this book with Les Wright's able assistance. The Book Launch was convened in **Moa Bone Point Cave**. At that event, Richard Holdaway, palaeontologist, spoke on the human history of the area. He referred to the thorough investigation by officers of Christchurch Museum and evidence of at least 600 years of Maori occupation in Moa Bone Point cave. Following Richard's talk we transferred to another cave nearby (discovered in 1928). The latter had been opened as an "Event Centre" – a very suitable place to have a cave book launch, with candlelight, ample wine and nibbles with soft music. However there would have been no soft music on February 22nd when a gigantic boulder collapsed the entrance.

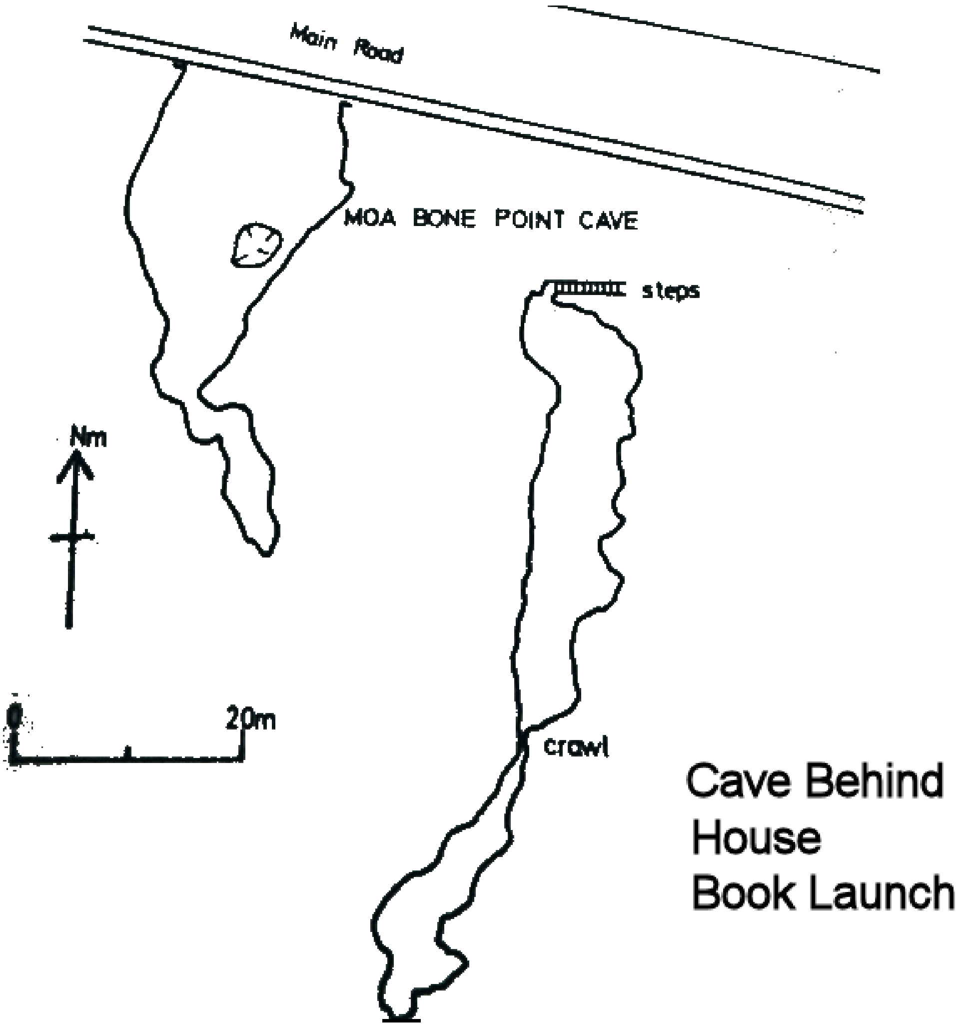


Figure 7: Map of Moa Bone Point Caves

A house built over a cave is teetering over the edge waiting for an aftershock to collapse it on to the road below. This house should not have been built and the area should have been protected.

Figure 8: A house built over a cave is tottering over the edge waiting for an aftershock to collapse it on to the road below.

Aftershocks

We have had over 6,000 aftershocks since September! Millions of years of land formation can be shattered in seconds. Forces of nature can be fickle – some parts of Christchurch were very little affected.

Every cloud has a silver lining.

A group of us cavers has purchased land to build a cave base on the West Coast of the South Island. With recycled material from a retirement village (that had to be demolished after the September 2010 earthquake), we have built a cabin on the land as a work base to build a "Cave Lodge". There is now plenty of recyclable material!

However grants and donations we were hoping for will now all be needed for earthquake rehabilitation.

Structural Control In Limestone Cave Formation

Ted Matthews

Jenolan Caves Australia

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Abstract

Australia has many significant caves developed within its limestones. Of particular interest are those in the Eastern States, where caves are generally formed within Palaeozoic rock, which has been folded and metamorphosed over the past 350 Ma. Such hardened limestone is non-porous. Fluids such as water may penetrate via more porous inter-bedded structures. Additionally; joints, faults, or porous fill may allow internal access.

A statement regarding the formation of these caves may include the following geological concepts:

- 'Limestone caves' result from the weathering and erosion of rock;
- For the most part,(and over considerable time), the less resistant materials in the rock are being, or have been removed;
- Development of drainage allows a lowering of the water table and so a previously submerged space may become air-filled.

Explanation as to why any cavern is specifically located within its envelope of resistant limestone may involve further and comparative observation, in order to recognise and note:

- Geological structure such as folding and textural change of sedimentary rock beds of the Limestone Unit in question (eg 'Jenolan Caves Limestone') ;
- The chemical nature and shape of inter-bedded materials;
- The enclosure and array of anomalous sediments housed within the caves.

Over the past 30 years a great deal of work has been put towards drawing perhaps biased yet popular conclusions from such observation. It remains conclusive that much, if not most of the sediment within these caves is autochthonous and that the cave boundaries often represent eroded casings of previously inter-bedded clay lenses of similar age to that of recognised fossil reef material.

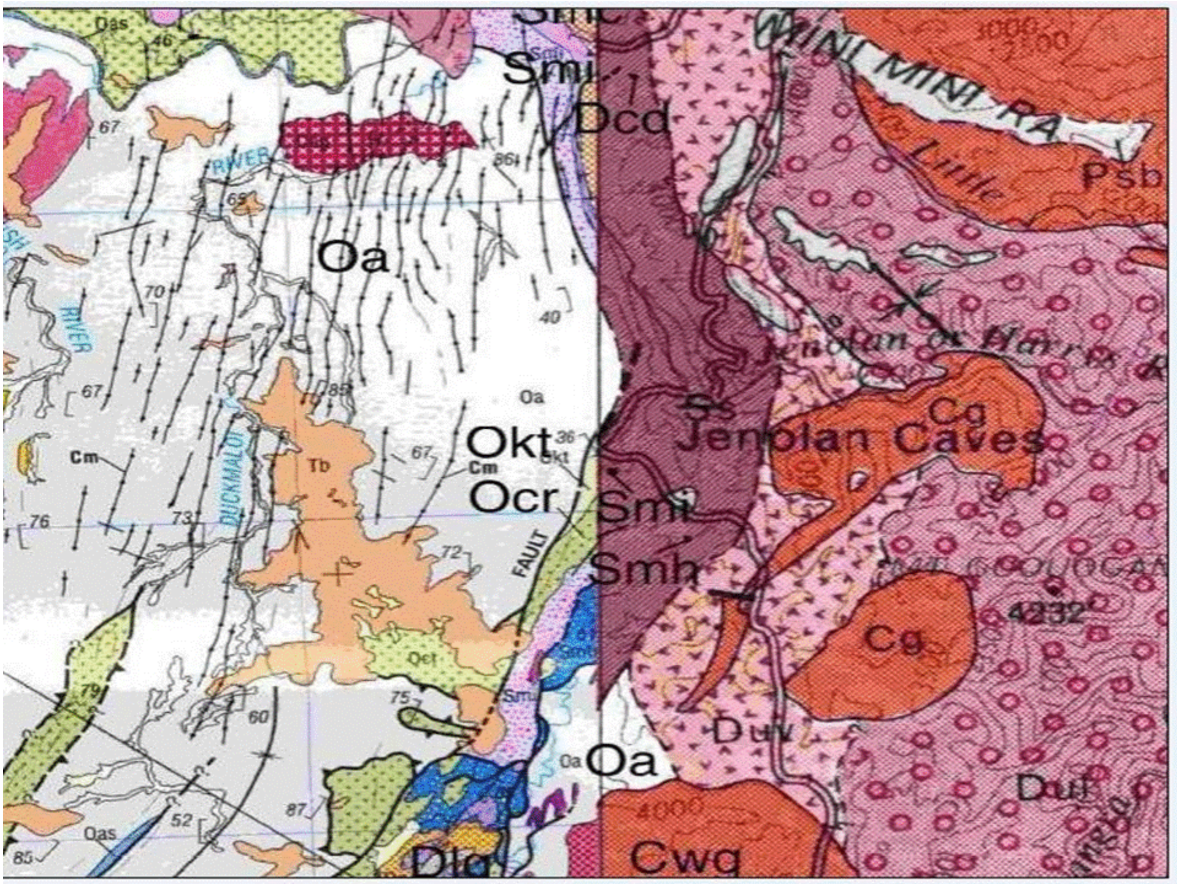

Figure 1: Area map. Width of image: approximately 45 km. (Rowling, 2004 Figure 3.1)

Introduction--Folded Rock

The coloured composited Geological map (Figure 1) shows a small part of the recognised N-S lineament common to Palaeozoic rocks of Eastern Australia. We would expect such a structure to be caused by an 'East-West' compression or collision; with subsequent folding of continental crust.

At the Kanangra Walls lookouts near Jenolan Caves the view allows a comparison between the older folded palaeozoic and horizontal Mesozoic sedimentary rock layers (Figure 2). Vertical sections (Figure 3) give a realistic idea of the immense size of some of the folds.

Figure 2: Kanangra Walls. View towards East. Folded Devonian and older beds appear behind and below the horizontal sandstones of the Sydney Basin (right foreground)

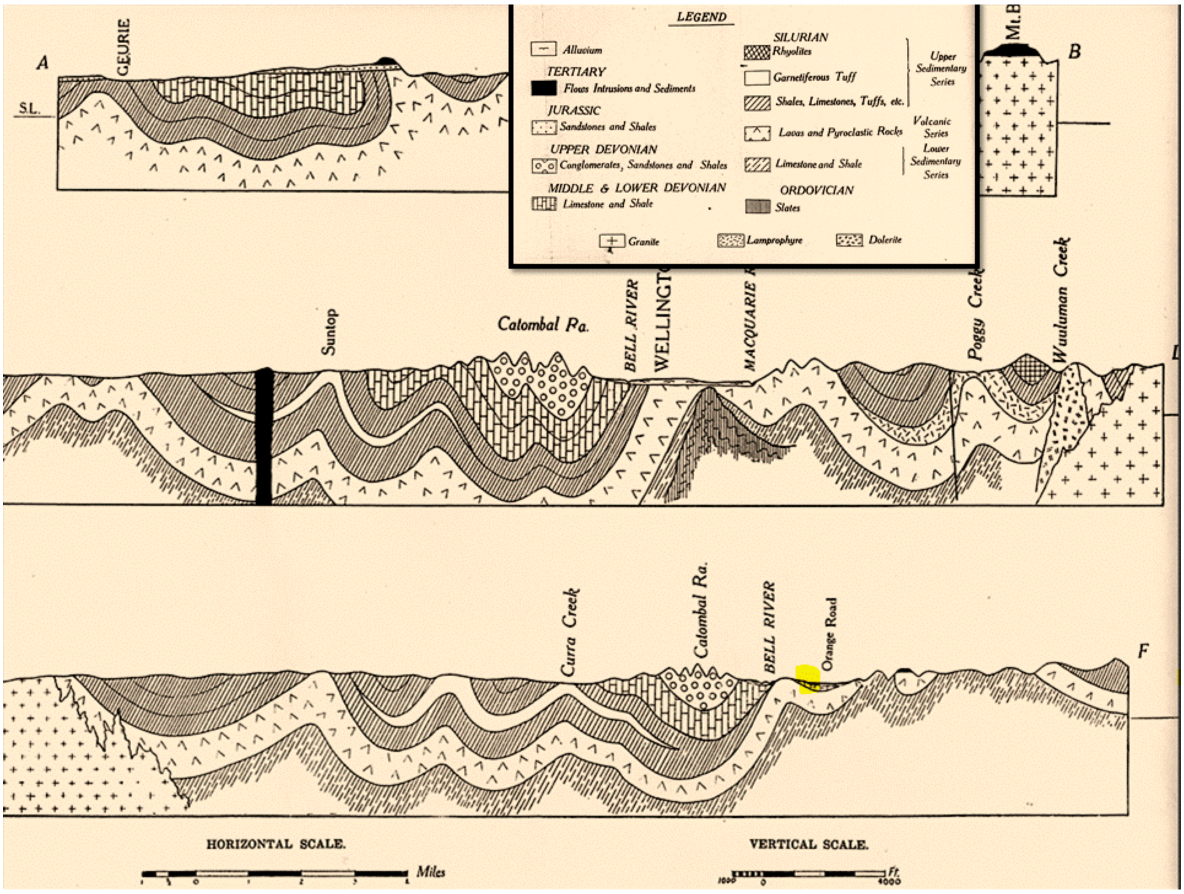

Figure 3: from Elizabeth M. Basnet and Margaret J.Colditz(1945):
"General Geology of the Wellington District, N.S.W."
Plate 3(Wellington Caves are located to the North of the lower section, approximate location highlighted in yellow.)

Within the Cave Space we have a far more intimate view. The limestones at Dip Cave, Wee Jasper and Mammoth Cave Jenolan exemplify steeply dipping inter-bedded sedimentary rock. Observations are that the cave direction <u>follows the strike of these steeply dipping beds</u>.

Figure 4: Steeply dipping beds, Dip Cave.

Figure 5: Steeply dipping beds, Mammoth Cave

Implications

Comparative notice should be taken of the more erratically formed caverns developed within limestones at less structurally controlled sites. A natural consequence of horizontal beds (which, by definition, have no strike) is that the caves are somewhat less directed. Their more random development is regulated by other structures such as jointing and indeed by any other appropriate cause.

The point to be emphasised here is that – '***following of strike'*** – factors in "<u>the involvement of the inter-bedded material.</u>" Such material has been, or is being, removed over time.

Figure 6: Two photographs taken of the same cavern showing cavities formed erratically in a less structurally controlled site (Buchan region Vic).

Figure 7

The caverns of Dip Cave, Wee Jasper NSW, mapped (1955-57) by Jennings et al. evoked the following comment…

> *"The clarity, with which the morphology of the cave reflects the geological structure, is almost counterbalanced by the obscurity which hinders any effort to interpret the origin and evolution of the cave."*

Joe Jennings (1963)

Here we detect Joe Jennings' frustration at being unable to describe the mechanism for a cave such as 'The Dip' to have formed and developed over time. Essentially he is concerned that erosional waters seem to lack both an entrance to and an exit from the cave, as the geomorphology of the immediate area shows little if any relationship to this Cave forming inside the limestone.

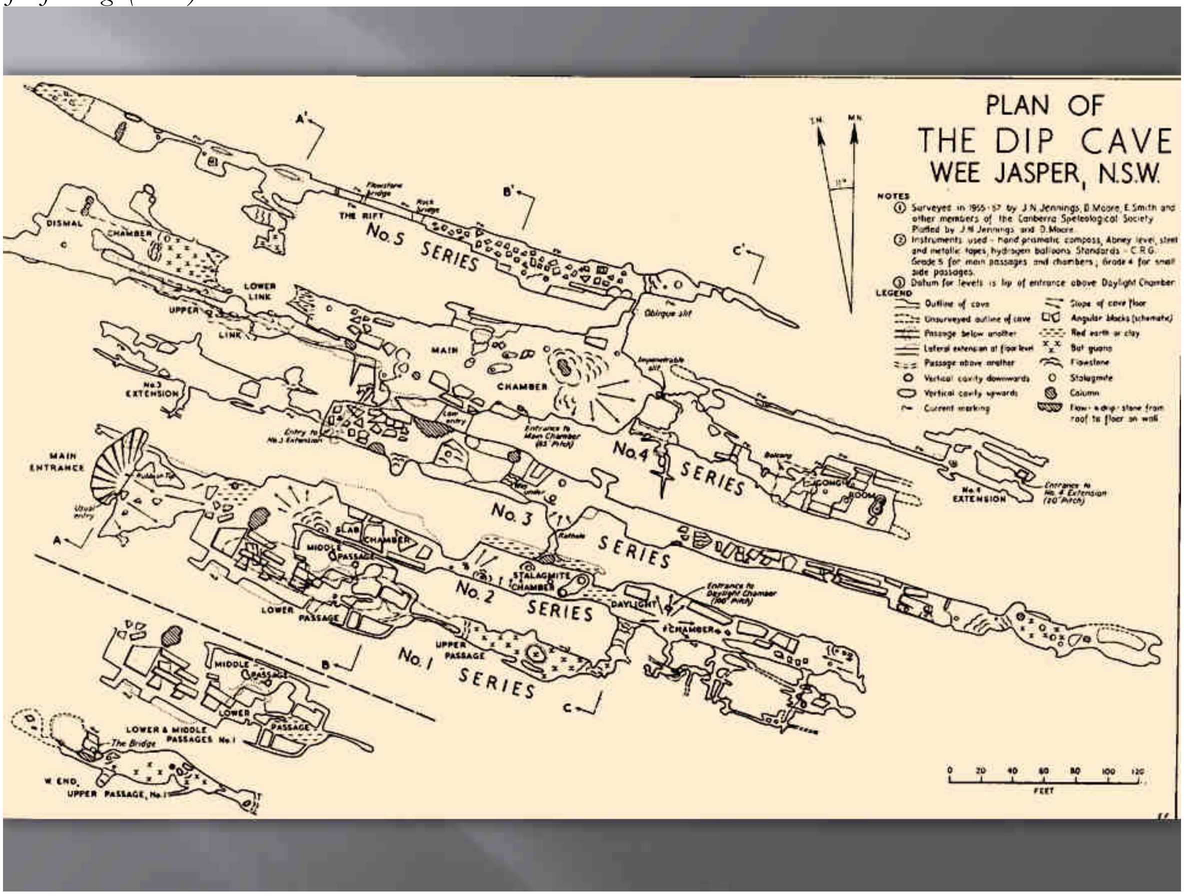

Figure 8: Dip Cave exemplifies a set of caverns following strike. (From the surveyed 'Plan of the Dip Cave' Jennings et al 1955-57. Jennings, 1963)

"An Isometric Diagram" of Mammoth Cave Jenolan by E.G. Anderson in 1971 (Figure 9) is worthy of comment also. The significance of its effective portrayal isometrically, and yet with relative accuracy seems to have gone almost unnoticed. Armstrong Osborne in his "Halls and Narrows" paper (2001) refers to this kind of observation, perhaps without clearly highlighting or concluding a general case, which may be that…

> *'The clay/silt-(stones)may occur unevenly and often form lenses…Connecting passages transverse to strike are less well developed'*…TM

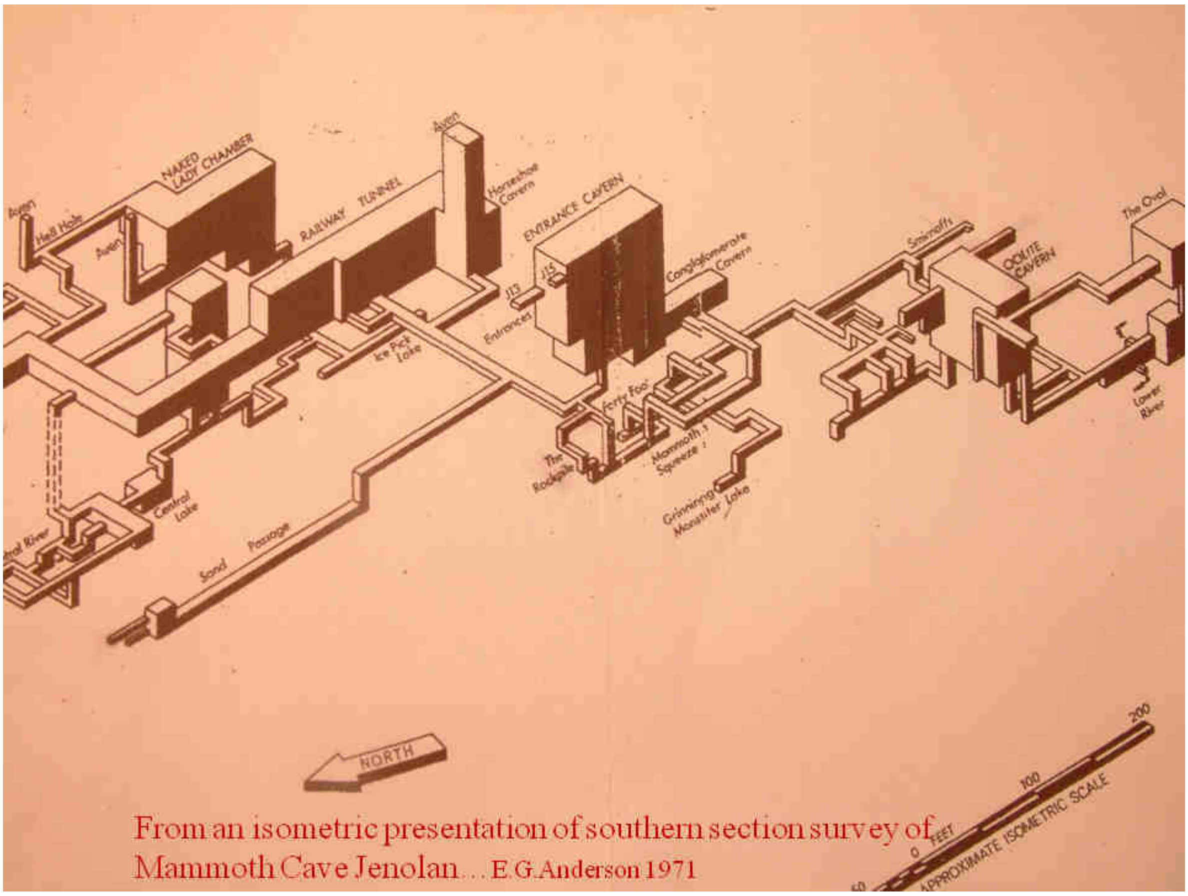

Figure 9: "An Isometric Diagram" of Mammoth Cave (Anderson, 1971)

Additionally, strike of the bedding in Mammoth Cave Jenolan is close to NNW. Remarkably, the overall trend of the Mammoth Cave clearly follows that direction…Why does this need to be so?...And why is it that so many plan maps of our Eastern Australian caves can be fitted so conveniently into a vertical format, with North to the top of the page?

Back to Basics

Generally Speaking;

- *Caves in limestones form by the… 'weathering' and erosion of rock.*
- *For the most part, and over considerable time, the less resistant materials in the rock, are being, or have been removed.*
- *The development of drainage allows a progressive lowering of the water table and the cave space previously submerged becomes filled with air.*

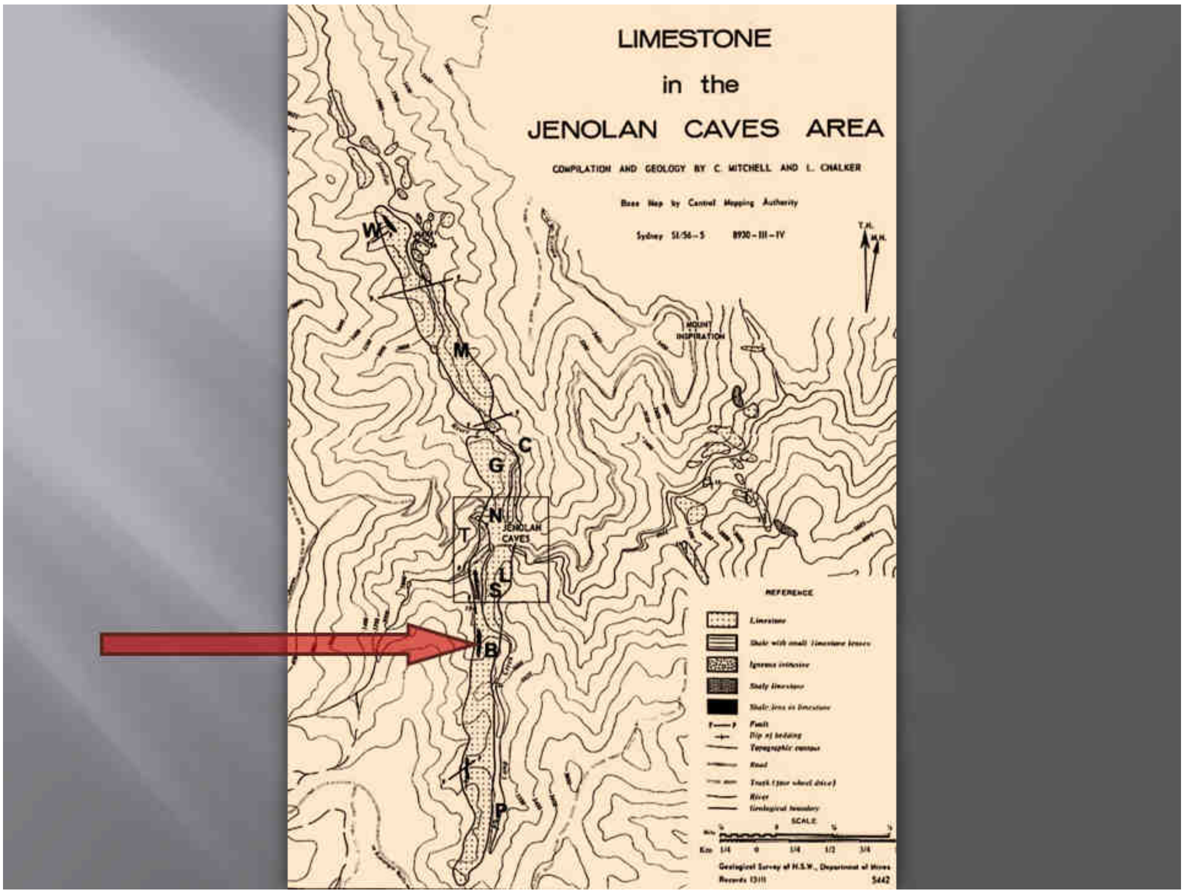

Figure 10: Leonie Chalker's map of Jenolan (Chalker, 1970, Lishmund et al., 1986)

Lenses of Clay

Leonie Chalker's shale lenses remain unrecognised in any published discussions on Limestone Cave formation. Chalker's work from which her map including its reference here to "Shale lenses" has been used in many publications since, including the Geological Survey by NSW Department of Mines, later Mineral Resources. Leonie's access to the Jenolan Cave Limestone was limited to rock exposed at the surface. She had less than reasonable access to rock exposures within the Caves. (Ron Newbould. pers. comm.)

Today remnants of "shale lenses" survive; their being exposed in walls and ceilings within the Jenolan Caves.

Figure 11: Shale lens bedded within ceiling of Indian Chamber, Orient Cave Jenolan

Based on the Jenolan scene, (which may illustrate a common Eastern Australian structure) a cartoon shows overturned limestone beds. In the diagram the 'under'-(or older)-side appears to be on top and to dip down to the west at say '70' degrees to the horizontal. Entombed clay lenses are represented by the ochre colour. These are structurally related to the claystone/clay inter-beds, expressing a similar strike and dip. The photograph to the left of the diagram shows an actual set of such overturned limestone beds with an inter-bedded remnant of a red claystone. (Both photographs are taken directly in front of the Guides' Office, Jenolan and presented here as Figure 12).

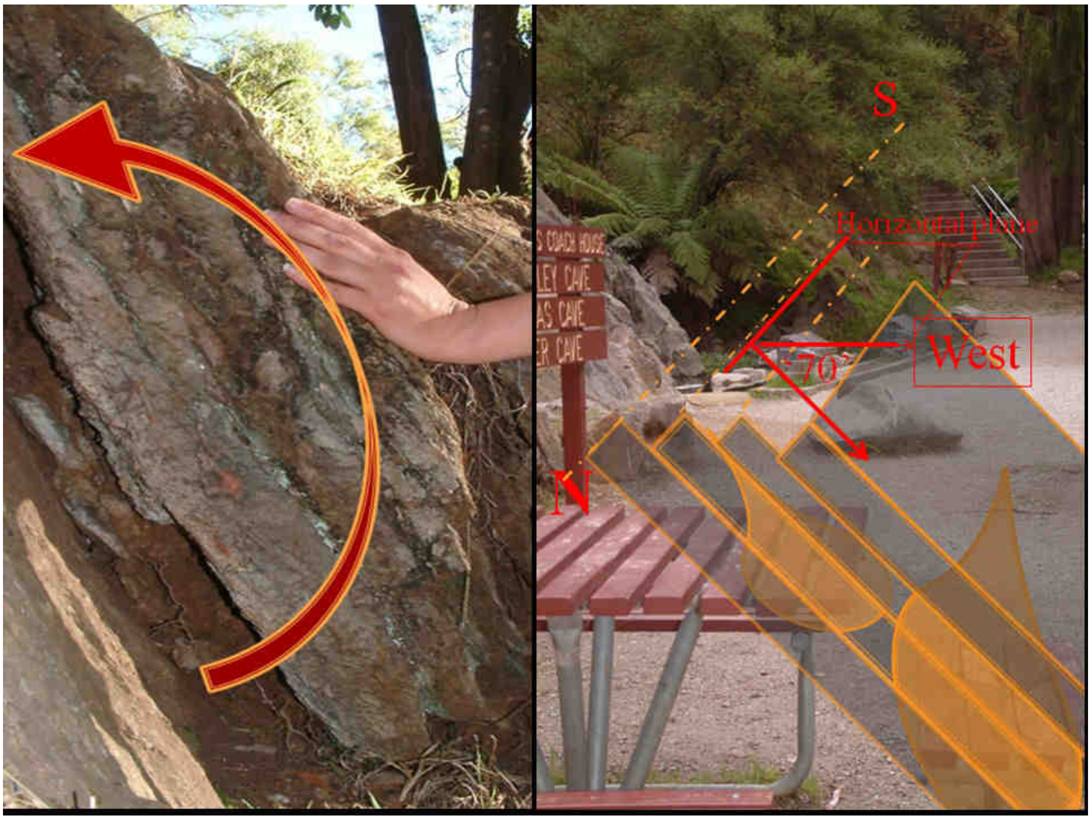

Figure 12: Composite representation and photograph of overturned beds Jenolan

This Illustrates the Concept that;

- *Caves within many Eastern Australian limestones, including Jenolan are aligned parallel to the strike of the folded strata (connecting passages transverse to strike are the less well developed.)*
- *The impervious limestone beds are commonly separated by porous interbeds of clay and silt.*
- *These "clays" occur unevenly and often as in lenses.*

Three 'areas of cave geology' where questions could be better answered.

1. *Age of the Sediment*
2. *Textural Change*
3. *Brecciation: Cave vs Reef*

Age of the Sediment

It was argued by Osborne et al. (2006), that Jenolan Caves were around 340 million years old. Initially eight primary samples of illite-rich clay cave sediment were separated into individual size fractions and dated using radio-active K-Ar techniques. Ages varied from a possible 400 Ma. to a possible 250 Ma. The coarse fraction of each sample tended to provide the oldest dates.

This data provides an extremely old age for the cave sediments. However, it is possible that the sediments represent material laid down with the ancient reef debris.

At the locations from which 'O1', 'J174' and 'JRV9' samples were removed for dating it is notable that the outcrops sampled may be associated with near-vertically bedded sediments.

It would seem that for some of us there remains;

- A difficulty in recognising bedding planes in these limestones
- A failure to recognise the presence of key fossils;
- An ignorance relating to the formation of clays and of dolomite.

The images to be discussed are examples of ancient sedimentary sandy beds which partially line vertical walls of the 'Colosseum', (Spider Cave) and of the 'Jungle', (Orient Cave), Jenolan. Bedding in both walls and ceilings of these caverns is near-vertical…

Figure 13: 'Vertical' cross-bedded sandstone, Spider Cave.

Figure 14: 'Vertical' sandy bedding of 'The Jungle', Orient Cave.

Any sedimentary layers so rotated from near horizontal attitude would be described by most as having an age older than that of the folding of the region (say >350 Ma.). Whenever fossils are located within the sedimentary rock, a most reliable age may be assumed.

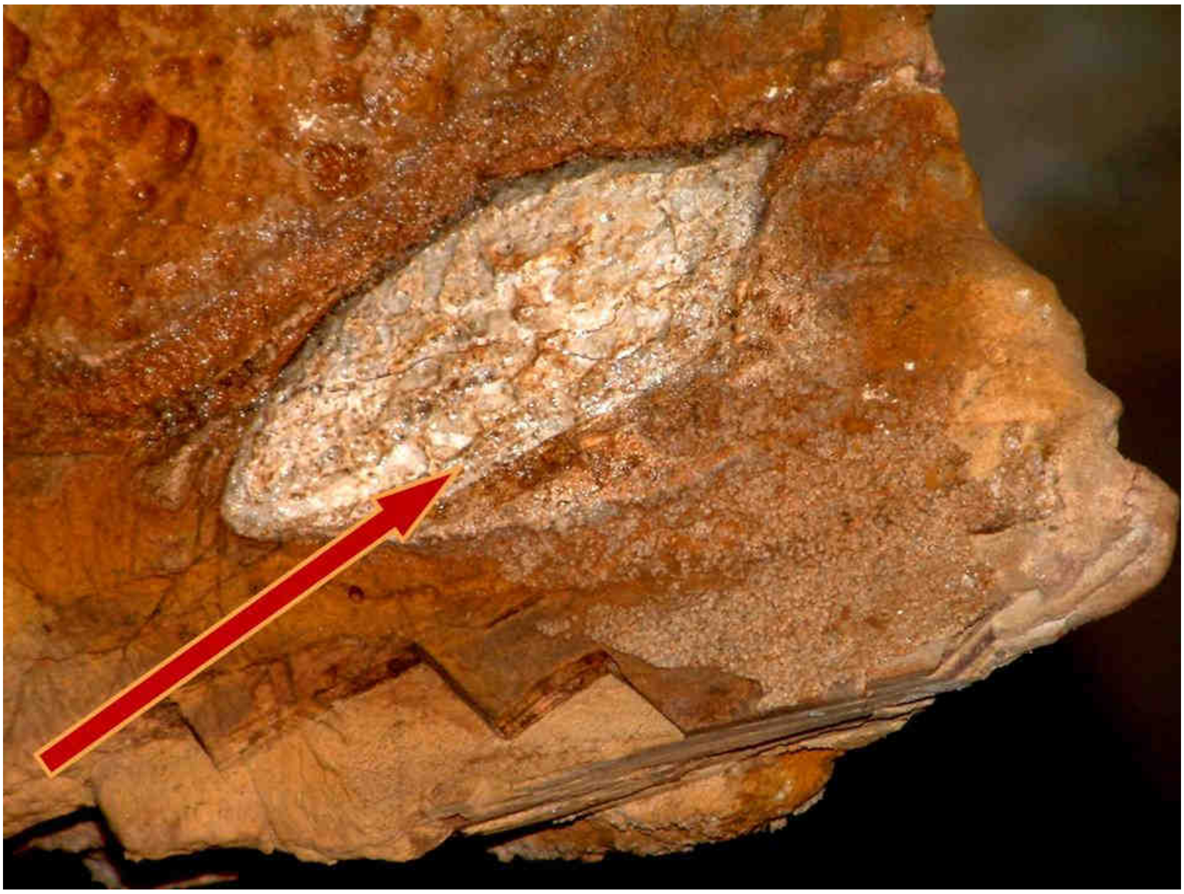

Figure 15: Silurian brachiopod in claystone, River Cave Jenolan.

In another sample (Figure 16) the material surrounding the corals is dolomite. A commonly held theory suggests that calcite may change to dolomite due to a process called '***dolomitisation***'.

Dolomite differs from calcite in that: magnesium carbonate substitutes for up to a 50% proportion of and spreads evenly throughout, the original calcium carbonate crystal lattice.

There is no known simple chemical process which would change calcite to dolomite at or around 'room temperature' (Chemists refer to this as 'The dolomite problem').

J.C. Deelman gives evidence that so called 'dolomitisation' needs not to occur at all. (1999) (2003) (2011) and (2008 unpubl.) The change to dolomite is slow and irreversible; dolomite does form, for example at reefs in lagoons, under **specific** and **repeated** natural conditions; essentially involving fluctuations in pH value. Clays may form by similar irreversible geochemical reactions.

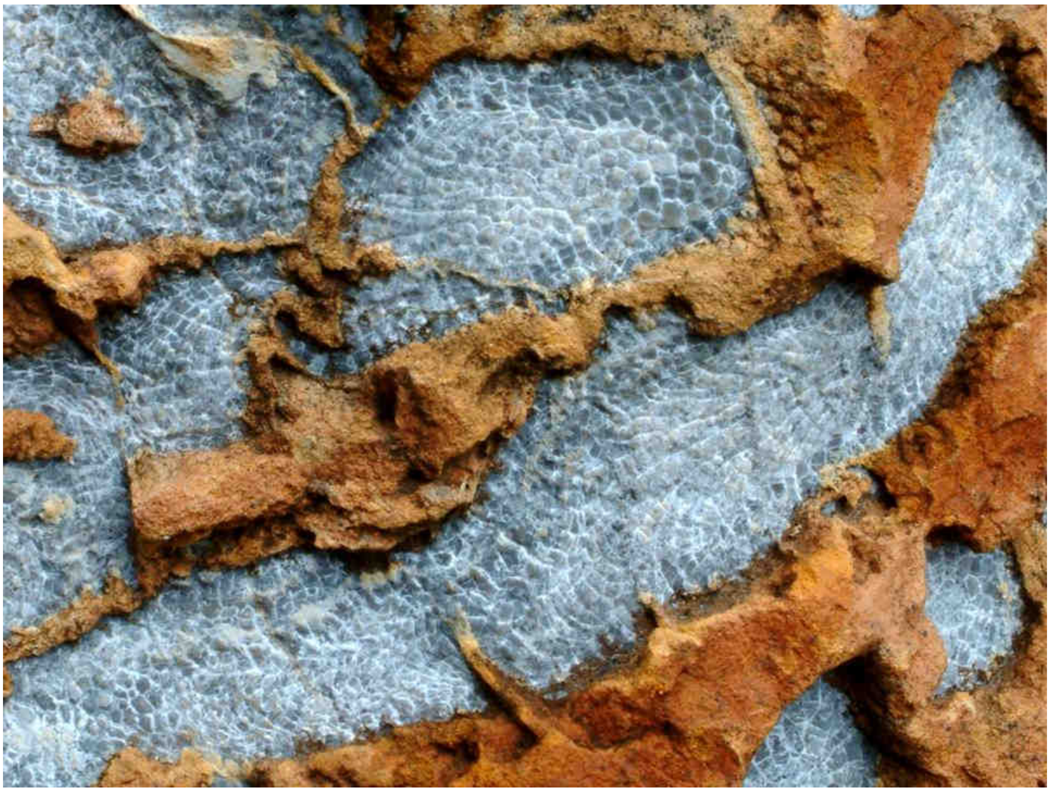

Figure 16: Iron-rich dolomite imprinted by and engulfing corals of Silurian age.

Figure 17: Notice the chemical attack at boundaries of fossil components of the rock. Compare with Figure 15.

The chemistry occurring at the contact between inter-bedded materials needs special investigation. Whatever the reaction is here at the fossil boundaries results in the dissolving of limestone. The acid reactant is presently unrecognised.

'Elk River streamway' photographs (Figures 18-19) are text-book typical of inter-bedded Eastern Australian folded limestone textures…fossils shown are of earliest Devonian age, attached to the limestone bed now above them. The clay inter-bed in which they were once enclosed is all but removed by erosion, leaving the fossils exposed at the roof of this cave.

Figure 18: Clay inter-beds at 'Elk River streamway' Buchan

Figure 19: Early Devonian fossils exposed by natural erosion of clays.

The debris of clay and much coarser sediments e.g. cobbles, so removed, may regularly remain in the cave; not necessarily far from their original location within the limestone sequence. Any fair observer should not fail to recognise the common occurrence of clays in the floors, walls and ceilings.

Cobbles are common; even boulders which may be rounded to sub-rounded. In many Caves such as Temple of Baal, Mammoth and Jubilee (Jenolan), cobbles regularly remain unsorted from the clay fraction of the sediment forming floor and indeed many walls to the cave spaces.

The observation of similar stones outside the cave is rare and when such is the case, may often be reasonably explained as being remnant debris from a long-since collapsed cave of ages past.

Figure 20: The scar left by a cobble now fallen off the cave wall. Note the preserved indentation in the limestone substrate indicating that the cobble has been part of the reef forming debris. (Buchan. Vic)

Textural Change

- Theories with reference to periods of palaeokarst are regularly suggested to account for the infilling of cavities with such ancient deposits as illustrated.
- The resulting effect is that the ancient textures may not be viewed as critically as is necessary.

Photographs of Diamond Cave's walls and ceiling (Figures 21-22), show macro-crystalline texture which displays a particular symmetry. This may be the metamorphic response to a prolonged heating and of pressure applied to certain original sediments and rock. The new texture preserves no fossils and is presently porous. Porosity is made evident by growth of helictites and other speleothems.

Similar texture has been interpreted by some (Osborne, 1999) as representing an in-filling by crystal 'palaeokarst.'

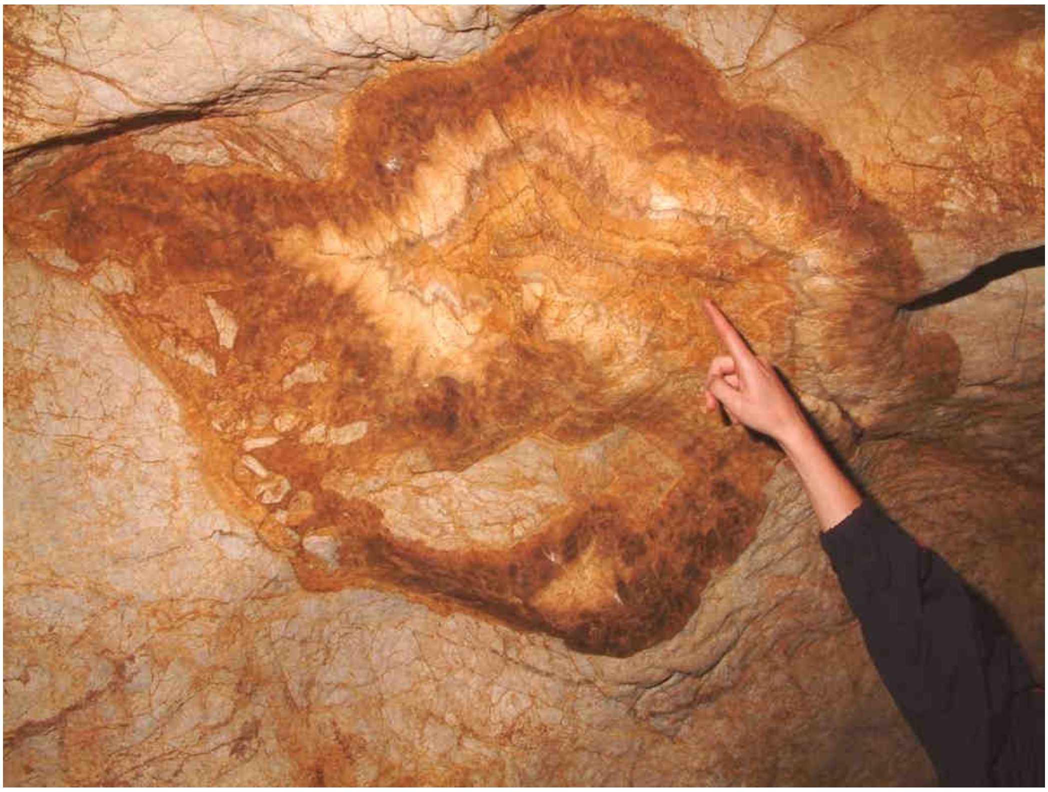

Figure 21

Figure 22

Other references to palaeokarstic character (Osborne, 1999, 2007) relate to textures, which alternately, may be quite original.

The geology of folded or overfolded limestones may enclose somewhat foreign sedimentary material. We can recognise the enclosure by the attitude of the foreigner. For example, should the foreign body be overturned along with the fossil beds, we can assume that the foreigner had been in place prior to the folding.

Applying this argument to the foreign sediments shown in Figure 23:- Is the sediment perhaps overturned within the enclosing framework of a slightly earlier sedimentary structure?...or more simply…Which way is up?

Figure 23: Which way is up?

Brecciation: Cave Vs Reef

- Sedimentary process and mechanism affecting the reefs as they form requires further study
- The reasoned view that many textures in cave walls may tell a part history of an ancient coral reef cannot be dismissed

Figure 24 shows a wall/ceiling of Katie's Bower, Chifley Cave Jenolan. Brecciation has occurred on at least two separate occasions. Once before, and again after sediment has become bedded and lithified. The beds are torn apart and displaced slightly; with the larger brecciated debris falling away and rotated yet held suspended in the iron-rich 'clays'.

Figure 24: A story from the reef

Conclusion

Explanation as to why any cavern is specifically located within its envelope of resistant limestone may involve further and comparative observations in reference to:

- Geological structure such as folding and textural change of sedimentary rock beds of the Limestone Unit in question (e.g. 'Jenolan Cave Limestone').
- The chemical nature and shape of inter-bedded materials
- The enclosure and array of anomalous sediments housed within the caves

Over the past 30 years a great deal of work has been put towards drawing perhaps biased yet popular conclusions from scant observation.

Serious, logical reason brings us to a conclusion that much, if not most of the sediment within these caves is autochthonous and that the cave boundaries often represent eroded casings of previously inter-bedded clay lenses of similar age to that of recognised fossil reef material.

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The Enigma of Bellholes

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Abstract

Many caves in the Gunung Mulu National Park, Sarawak, Malaysia have outstanding displays of bellholes. Prolific bellhole arrays are also found in the caves of the Neotropics and Madagascar. The riddle lies in how these surprisingly symmetrical speleogens form. In Lagang Cave, beneath an exceptional display of bellholes, Australasian Cave and Karst Management Association members held a brain storming session focusing on their formation that resulted in a wide range of theories. However, in the recent speleological literature, only two theories have been put forward which have been substantiated by research: that bellholes are formed by harems of bats, or are formed by condensation corrosion. These two hypotheses will be combined into one, that bellholes are initiated and developed by condensation corrosion and modified by bats. Bellholes are believed to be a fast forming speleogen in tropical caves. In caves outside tropics where they are not common, they may be slow forming or relict.

Introduction

Bellholes were first reported in Jamaica in 1953 by V.A. Zans (White, 1962) and in Sarawak in 1966 (Wilford, 1966). In 1971, Miller commenced documenting their occurrences in the Neotropics. Recently they have been reported from Madagascar (Grunwald and Wolozan, 2006 and Middleton pers. com., 2010). Bellholes have been extensively studied in the Neotropics (Birmingham et al., 2011). Extensive arrays of bellholes are found in caves of the Gunung Mulu National Park, Sarawak, Malaysia. To date, there have been a number of hypotheses as to the formation of these remarkable speleogens. The terminology of Jennings (1971) will be used, that is *bellhole*, as per the geomorphic *pothole*. The split "bell hole" is also found throughout the literature on this topic.

Discussion

Bellholes (Figure 1) are symmetrical, circular, vertical cavities found in the ceilings and overhangs of caves interiors and are most striking where they have pock marked extensive areas of flat cave ceilings (Figure 2). Bellholes have circular diameters of 50-500 mm, with the height of the cavity extending from a few millimetres to two metres. They are usually found in solid rock without obvious control by dip, bedding, joints, lithology or morphology. The angle from horizontal of the rock surface is unimportant and examples have been recorded in speleothems. When their diameter and cavity height are closely related, the holes resemble the interior surface of a bell, especially as the entrance to the bellhole shaft is slightly flared. The bellholes with extended cavity heights resemble the interior of a pipe capped with rock or calcite. To be a bellhole these features must be capped and in solid rock or speleothem calcite.

Figure 1. The holes resemble the interior surface of a bell. The bellholes in the figure are up to 150 mm in diameter and 300 mm in depth. Photo Julia James.

Figure 2. Bellholes in Lang's Cave, Gunung Mulu National Park, Sarawak.
The bellholes are found on the flat roof of the entrance passage within the twilight zone. Photo Julia James.

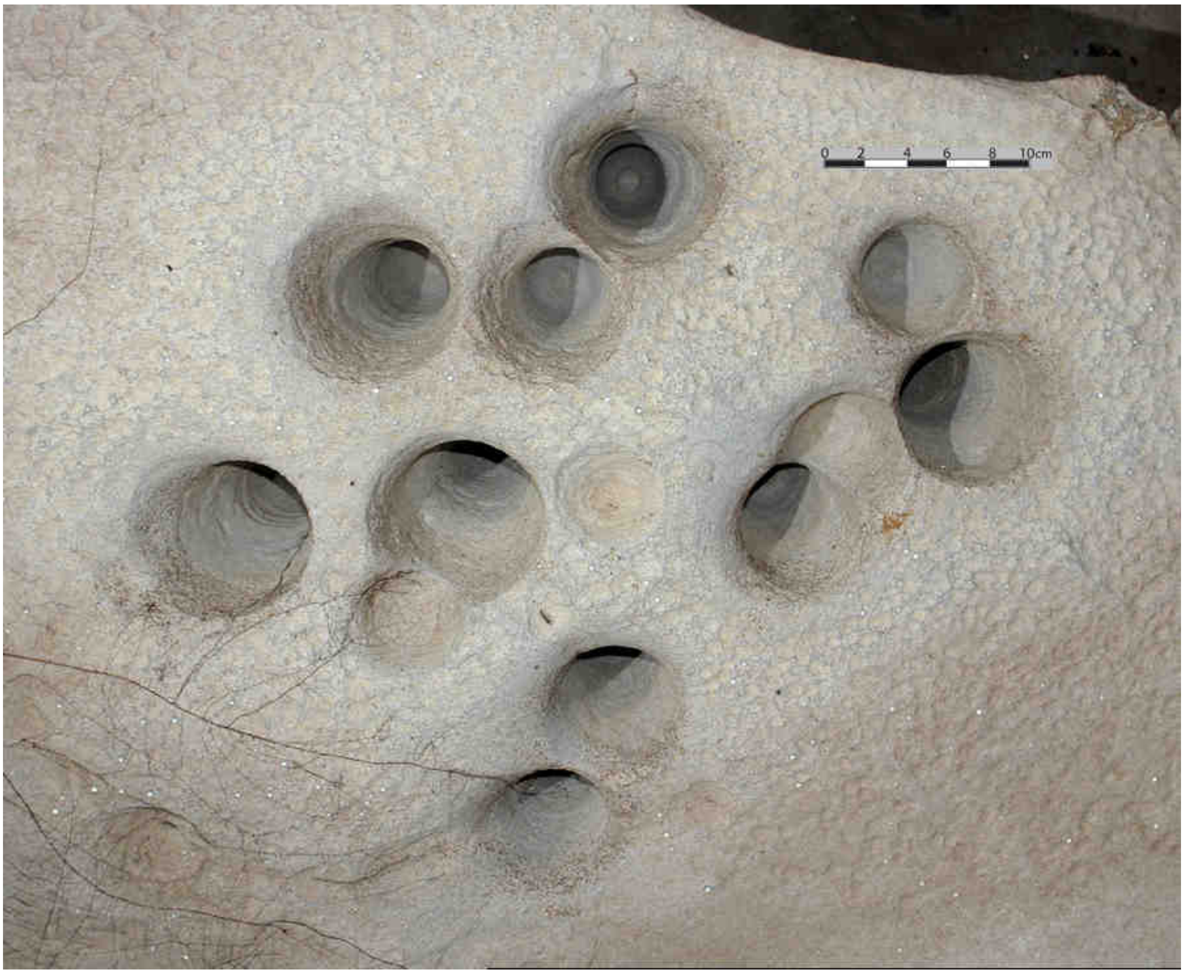

Figure 3. A display of bellholes in Fruit Bat Cave, Gunung Mulu National Park, Sarawak. Photo John Brush.

Speleologists attending the Australasian Cave and Karst Management Association AGM, 2010 at Gunung Mulu National Park, Sarawak while waiting at the gated entrance to Lagang Cave had a brain storming session as to how the bellholes above their heads formed.

- A geologist postulated that they were inverted rock mills that were formed by abrasive material carried in by floods. A related explanation was that of Wilford (1966) who attributed their formation to turbulent eddies in fast flowing water. However, he acknowledged there were problems with the physics of such a process.
- A geomorphologist had proposed that they were formed by mixing corrosion. Mixing corrosion can take place when two solutions that are saturated with calcite on mixing dissolve more calcite. There is no evidence in Figures 1, 2 and 3 to suggest that there are two solutions mixing for their formation.
- A biologist suggested that as they were occupied by birds and bats, that these creatures were responsible for the erosion of the limestone.
- My contribution as a speleochemist was that they were a feature of condensation corrosion as proposed in Ford and Williams 2007 p249.
- The official Mulu National Park explanation of this phenomenon is displayed on a graphic below, examples of bellholes in Lang's Cave (Figures 2 and 4).

Figure 4. Bellholes in Lang's Cave Gunung Mulu National Park, Sarawak. Photo Julia James

That text on the information board below the bellholes in Lang's Cave is reduced and adapted here. Their formation is attributed to the power of a simple gas (carbon dioxide). If there is more carbon dioxide in the cave than the seepage waters, the gas flows from the air to the water and the water dissolves limestone from where it touches the roof. It is suggested that the visitors lookup at the roof behind them and a question is asked, see the holes. The comment follows with, a bit too much carbon dioxide in here when that happened.

Two theories have come to the forefront, both acceptable and to some extent compatible with observations, theory and experiment, and are outlined below.

First, the role of bats has been advocated as a major way in which bellholes form and become elongated vertically. Miller and Figueroa-Mulet (2009) state that in the caves of the Neotropics bellholes are only found where there are the frugivorous bats (*Artibeus jamaiciensis).* The bats are harem bats and roost in the bellholes. In the bellholes that are used for roosting and in the bellbasins below minerals, associated with the reaction of guano with limestone have been identified.

The coffee table book "Tsingy Stone Forest - Madagascar"(Grunwald and Wolozan, 2006) contains excellent photographs of bellholes with and without bats. The following quote presents the hypothesis for bat induced bellhole formation:

> *Bats appear and disappear in an elegant acrobatic ballet performance, passing from one niche to another. They never seem satisfied with what they find, though they were probably the architects of this unique décor. This geological phenomenon can*

be explained by the concentration of bat urine and the carbonic gases, which the bats release, in combination with humidity, which causes spot erosion. The limestone is thus weakened and detaches easily as the bats cling to it. This can be seen by closely examining the bats' fur. When a bat wishes to descend from a niche, it plunges in the deep opening until it reaches the open space, where it merely beats its wings to prevent it falling further. The return, however, is awkward and challenging – the bat attaches to the bottom of a niche and must crawl upwards – causing more pieces to detach thus enlarging the niche. This action repeated by thousands of bat generations has pierced hundreds of niches in the roof of the Bemaraha caves, some now more than a meter deep.

Greg Middleton during his exploration of caves in Madagascar has taken many significant photographs pertaining to bellholes, one used as a bat roost is shown below (Figure 5).

Figure 5. A harem of bats roosting in a small bellhole about 15 cm across in the roof of a 2 m high flat roofed chamber in Ambinda burial Cave, Beanka Reserve, Madagascar. Photo Greg Middleton,

The author agrees with the conclusion of Ford and Williams (2007) that bats do not form the bellholes and their presence in them is purely opportunistic. However once *in situ* they do have considerable potential to modify the bellhole. The bats breathe out a mixture of water vapour and carbon dioxide at a temperature higher than that of the cave wall. The mixture condenses to form a carbonic acid solution. This corrosive solution is focused at the top of the bellhole slowly eroding it upwards. Lundberg and McFarlane (2009) have calculated that a bellhole

1 m deep may be formed in 50,000 years by this mechanism alone. Bats also excrete, their urine is an ammoniacal solution of urea and is basic, it will only attack limestone if oxidized by bacteria to uric and nitrous acids. Bats faeces contain phosphates plus vegetable and insect remains. In acidic solution, phosphates will react with carbonate rocks according to the equation below.

$$9H^{+}(aq) + PO_4^{3-}(aq) + 5CaCO_3(s) \Leftrightarrow Ca_5(PO_4)_3(OH)(s) + 5CO_2(g) + 4H_2O$$

In other words, the corrosion of limestone with phosphoric acid produces apatite, a mineral that is found in association with both bellholes and bellbasins. Although never stated in the literature the bellholes would provide suitable environments for a multitude of oxidizing bacteria especially those inhabited by bats. Other opportunistic inhabitants of the bellholes at Mulu are cave swiftlets, which rest in the bellholes in Lagang Cave during the middle of the day when temperature and humidity in the rainforest are greatest. Some fifty birds were observed to fly out of the bellholes in the entrance to Lagang Cave each bird leaving a separate bellhole. Although a solitary bird would not be as effective in modifying a bellhole as a harem of bats, any visitor either animal or vegetable will alter the bellhole to some degree.

If bats and birds are using the bellholes to hide from predators, they have to be large enough. Figure 4 shows where the bellholes are shallow the bats do not occupy them but are hanging from the roof adjacent to them.

While hypotheses of how bellholes become larger abound and are substantive, what are missing are suggestions as to how bellholes are initiated. It is here that one must examine the condensation corrosion mechanism initially proposed by Tarhule-Lips and Ford (1998). First, there is evidence of both condensation and condensation corrosion processes in the caves of Mulu. Condensation is a diurnal process in the tropics as is exemplified by the observation that the area of condensation droplets shown in Figure 6 actively increased around noon. In many of the Mulu caves, there is abundant evidence that both the bedrock and speleothems are weathering by condensation corrosion (Figure 7).

Figure 6. Condensation droplets in the entrance passage of Lagang Cave, Gunung Mulu National Park, Sarawak. Photo Julia James

Figure 7. Speleothems degraded by condensation corrosion in Stone Horse Cave Gunung Mulu National Park, Sarawak. Photo Garry Smith.

It is now essential to re-examine Figure 3, a photograph taken in Fruit Bat Cave. From this cave, there is a connection to the lower Kenyalang Cave and because of the difference in elevation between the caves, air movement is governed by the chimney effect (Wigley and Brown, 1976). Diurnally as external temperatures and relative humidity rises, warm wet air is drawn into Fruit Bat Cave where it condenses on the colder walls.

The following observations can be made from Figure 3.

- There are condensation droplets sparkling on both the rock and tree roots.
- Tree roots are spreading across the rock invading the bellholes searching for moisture.
- The rock has a scalloped surface that is characteristic of condensation corrosion.
- In this collection of bellholes, there are embryo bellholes illustrating that the condensation corrosion is being focused into circular shapes.
- The embryo bellholes start as shallow saucers ranging in size until they can be classed as mature bellholes.
- In a number of places, mature bellholes have joined and embryo bellholes have joined to mature bellholes.
- The bellholes are clean and there are only a few dark areas around them to indicate that bats or birds may roost around the holes.

Miller and Figueroa–Mulet (2009) postulate that where there are no bats, there are no bellholes for example beyond a siphon. Beyond a siphon, there is little or no condensation corrosion because condensation requires airflow (James, 2004). Hence, the observation above does not distinguish between the two mechanisms.

Rates of condensation corrosion can be fast for instance, they have been measured in the Jenolan Show Caves at a rate of 30 mm ka^{-1} (James, 2004). Using this figure, a bellhole 200 mm across and 300 mm deep would form in 10,000 years. This rate of development would increase if it becomes a site for roosting bats. At Mulu, bellholes will be a rapid forming speleogen as the conditions are ideal for condensation corrosion. In Madagascar where there is a less favourable external climate, bellholes will form more slowly. Bellholes and embryo bellholes can be found in caves outside the tropics and the question must be asked are these a youthful speleogen still forming or a feature of much older processes in a cave. Figure 8 shows two features in the Jenolan Show Caves that resemble bellholes, and Lauritzen and Lundberg (2000) describe a number of features that resemble bellholes. At least for Jenolan, at present there is insufficient evidence to class these as bellholes or to determine whether they are developing speleogens or are relict.

Figure 8. The roof between the Indian and Persian Chambers, Orient Cave Photo Gary Whitby. The insert is a 20 cm wide bellhole in the Diamond Cave, Photo Julia James. Both caves are part of the Jenolan Show Caves.

Conclusion

Bellholes are striking symmetrical speleogens found largely in tropical caves. The most complete hypothesis of how these features form combines the most common hypotheses, bats and condensation corrosion. Bellholes are initiated by a condensation corrosion mechanism, which can be supplemented by the impacts produced by use of these developing features by opportunistic species such as bats.

Acknowledgements

I am particularly grateful to Andy Spate who knowing my obsession with bellholes suggested I write an 'Andy Sez' for ACKMA. This is an introduction to the topic. Andy and I intend to prepare a more extensive review for the refereed speleological literature. I wish to thank Craig Barnes for criticism of and proof reading this paper and John Brush, Greg Middleton, Garry Smith and Gary Whitby for the use of their photographs. My special thanks to Brian Clark of Gunung Mulu National Park, Sarawak for providing guides and permission to visit bellhole sites.

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History and Long-term Conservation Management of Karst at the Vale of Belvoir, North-West Tasmania

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Abstract

The Vale of Belvoir supports a unique mosaic of biological and geomorphological values, layered with a rich historical background. In addition to its extensive list of threatened flora, fauna and vegetation communities, the Vale is significant as one of Australia's few subalpine karstlands.

The property was purchased in 2010 by the Tasmanian Land Conservancy (TLC), following on from a 150-year history of summer cattle grazing. The TLC is now managing the land for its conservation values, and is undertaking practical on-ground work in partnership with the community to research and conserve these values into the future.

Introduction

The Vale of Belvoir is a magnificent natural grassy valley in Tasmania's highlands. The valley supports unique geological and geomorphological values and is one of only a few subalpine karstlands in Australia. The Vale of Belvoir also supports numerous threatened species and vegetation communities, and is recognised as one of the best remaining examples of Tasmania's highland grasslands. In concert with the natural values, the valley has a rich historical background, including both indigenous and European heritage.

The Vale of Belvoir is located 8km northwest of Cradle Mountain, in Tasmania's northwest. The Tasmanian Land Conservancy (TLC) purchased the 476 hectare Vale of Belvoir Reserve in 2008, in order to protect its many conservation values in perpetuity. The TLC manages the land as a private conservation reserve, in partnership with the community.

The Tasmanian Land Conservancy

The Tasmanian Land Conservancy is a private, not-for-profit conservation organisation, whose goal is to protect Tasmania's biodiversity through conservation on private land. From the TLC's beginnings in 2001, more than 50,000 hectares of private land have been protected. The TLC use a range of mechanisms to protect land, including the Permanent Reserves Program, which acquires land to be kept and managed in perpetuity by the TLC as private conservation reserves.

The TLC's permanent reserves are funded through private philanthropic donations and, where possible, competitive grants. The TLC has also established a perpetual trust fund, to ensure an ongoing income stream to cover land management costs into the future. The Vale of Belvoir was the TLC's eighth permanent reserve, which now has ten properties covering 3,500 hectares.

Natural values

The Vale of Belvoir Reserve supports a wide array of natural values, both biological and geological. The valley provides habitat for twelve threatened plant and animal species, and the highland grasslands are recognised by scientists as one of the best remaining examples of this vegetation community in Tasmania. The area also has some of the highest recorded densities of marsupial carnivores in the world, including Tasmanian devils, quolls and, at least historically, Tasmanian tigers.

The Vale of Belvoir also has a complex geology and geomorphology that is unique in Tasmania. The area is a limestone valley, partly infilled by basalt. Glaciation during the Pleistocene resulted in redistribution of the basalt and the transportation of dolerite erratics from Cradle Mountain. The area is recognised twice on the Tasmanian Geoconservation Database for its national significance, as Tasmania's only example of a sub-alpine karstland and as a part of the Central Highlands Cainozoic Glacial Area.

The Vale of Belvoir is a highly active karstic landscape, with hundreds of sinkholes and numerous karst outcrops.

Figure 1: The Vale of Belvoir from the air. © Matt Newton 2008

Three new sinkholes have been recorded since 2008, focussed around two karst outcrops near the valley bottom.

Sixteen caves have been mapped in the valley by local caving clubs and individual speleologists, and no speleothems have been recorded. The longest cave, 'Fossey's Slot', measures 257m long and comprises a series of tunnels, including underground sections of a creek.

The karstic landscape at the Vale of Belvoir provides for unusual hydrological features. A mound spring was discovered at the Vale of Belvoir by Rolan Eberhard and Denna Kingdom in 2009, and is possibly the only sub-alpine mound spring in Australia. In addition, Lake Lea, to the north of the valley, is believed to flow in two opposite directions – to the north via the River Lea and to the south via the karst into the Vale River.

Management past and present

Evidence of Aboriginal occupation has been found in the region around the Vale of Belvoir, including domed bark huts and artefacts. These are supported by historical accounts by early European observations of Aboriginal tribes hunting, burning and travelling through the area.

The land now owned by the TLC was owned from 1897 to 2008 by a single family, who developed an extensive knowledge of the landscape and its seasonality. Their management of the area remained relatively consistent over this time, with mosaic burning of the grasslands at the end of winter and light cattle grazing during the summers. No pasture improvement or other development ever occurred, with the land used to supplement the family's main farming practices at lower altitudes.

The TLC is continuing the management regime of the past 114 years, and is undertaking research to quantify the effects of the grazing and burning on the high levels of grassland diversity, and their role in the ecology of threatened plant species.

Before purchasing the Vale of Belvoir, the TLC investigated the specific conservation values of the valley and the real and potential threats to these values. An assessment was undertaken on how to manage these threats, and this assessment has formed the basis for the TLC's current management plan for the reserve.

The greatest threat to the karst values of the reserve is nutrification and/or sedimentation of rivers and creeks upstream of karst. This is most likely to occur due to soil disturbance (pugging) and faecal input by cattle, and inappropriate fire regimes and vehicle use causing soil erosion.

Managing the impact of cattle is recognised as the highest priority for protecting the karst values. To do this, the TLC has instigated strict grazing lease conditions, which limit the maximum grazing intensity (0.3 cattle/ha) and specify the times of year that the cattle are permitted. The TLC has also installed fencing to exclude cattle from 24.5 hectares of sensitive wetlands, riparian areas and karst outcrops. Water quality is being monitored to assess any changes resulting from the exclusion of cattle from these areas.

Fire regimes and vehicle use are being managed in co-operation with the Parks and Wildlife Service, who manage the adjacent land. This includes the development of a fire management plan that will continue the mosaic burning patterns used over the past century, and the installation of signage restricting vehicle use for management purposes only.

To ensure that these threats are managed into the future, the TLC has also registered a perpetual conservation covenant over the land. This covenant restricts activities that may negatively impact the conservation values on the land. The covenant is registered on the land titles, ensuring that any future owners of the land are also bound by these restrictions.

Future management and research

Successful management of the karst at the Vale of Belvoir depends on our understanding of the areas past, and the processes that threaten or maintain it. Passing this understanding on to others who use or manage karst is also critical to ensure that other karstlands are protected.

The TLC encourages researchers to use the Vale of Belvoir to further our understanding of the caves and the history of the area. Opportunities exist for scientific research into palynology, palaeontology, cave biology and hydrogeology. The TLC also seeks research partnerships that will provide information to assist the TLC and others to manage this landscape.

Sharing our knowledge of the Vale's values and threats with the community is also important. The TLC is looking to develop interpretation and education materials about the Vale of Belvoir, for general public use. Our volunteer program also provides opportunities for individuals to visit and work at the Vale of Belvoir, allowing us to share our knowledge of the landscape in-situ. By focussing on engaging and retaining long-term volunteers, these individuals also develop a deeper understanding of the area, which they can also share with others.

Conclusion

The Vale of Belvoir's array of biological and geological conservation values are unique in Tasmania. The TLC is working to further our understanding of these conservation values and the processes that threaten and maintain them, in order to ensure their protection for generations to come.

Acknowledgements

Thanks to: the conference convenors for the invitation to attend and present; Keith Corbett for providing the geology map; Matt Newton for his stunning photography; and Rolan Eberhard for assistance in identifying karst values and threats to these at the Vale of Belvoir.

'It is an alluvial soil, and capable of being drained': the perilous integrity of Dismal Swamp

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Abstract

Surveyor John Helder Wedge clambered knee-deep through wet swamps while searching for grazing land in the Circular Head region in 1828. Dismal Swamp, one of a few intact poljes known in Tasmania today, formed part of the swamp area on Wedge's map which he believed could be profitably drained. Like the nearby Mowbray, Montagu, Welcome and Brittons Swamps, Dismal was a favourite habitat of blackwood *(Acacia melanoxylon)* timber — a staple of the Circular Head sawmilling industry for more than a century. When logging began in Circular Head, swamps were synonymous with disease, degradation and fear of the primeval. Clearing them represented not just financial profit but social justice. Precambrian dolomite swamps were logged and never regenerated, since agricultural land was needed for yeoman farmers and post-World War II soldier settlement. Only Dismal Swamp survived Wedge's quest for pastoral supremacy.

Introduction

Dismal Swamp, one of few intact poljes known in Tasmania, owes its reservation to Smithton District Forester Wes Beckett. The swamp's survival before Beckett's intervention in the 1960s was just as remarkable, given the pressure exerted to log, drain and cultivate the dolomite swamps west of Smithton. The Circular Head-Arthur River region is rich in karst features, including the State-reserved Trowutta Arch; Lake Chisholm, a nationally significant sinkhole lake; and the Julius River underground stream and decorated caves (Lake Chisholm and the Julius River features are managed in Forestry Reserves by Forestry Tasmania).[1] Graziers and vegetable producers had little interest in karst geomorphology, however, beyond the rich dolomite soil and the gushing mound springs it produced. Sawmillers were grateful for the swamp drainage regimes that created optimum conditions for the growth of blackwood *(Acacia melanoxylon),* a staple of the Circular Head timber industry. Unlike adjacent swamps, which were deforested, drained and therefore never regenerated, Dismal Swamp was only selectively logged, allowing its blackwood timber to return and its unusual geomorphology to be preserved by a dedicated forester.

(Left) eucalypts soar over the Tarkine Forest Adventures (Dismal Swamp) visitor complex.
(Right) The white-knuckle slide experience deposits the visitor on the floor of the Dismal Swamp polje.
Photos by Nic Haygarth

For Tasmanian governments looking for new settlement areas, the far north-west has sometimes been embraced as the place of last resort. So it was at the beginning of European settlement. In 1825 the Van Diemen's Land Company (VDL Co) was established under a royal warrant to grow fine wool in Van Diemen's Land (later Tasmania) for the European market. When the company's officers arrived in the colony in 1826, they discovered that Lieutenant-governor George Arthur was not pleased to have them here. Rather than giving them the fine pasture they expected, Arthur shunted them into the far north-west of the island where the company would not interfere with land selection.

When the VDL Co complained that it could find little grazing land in this portion, in 1828 Arthur sent the surveyor John Helder Wedge to explore the country.[2] Wedge was soon wallowing in the Montagu Swamp south of what would become the VDL Co's Woolnorth block:

Wednesday 26 [March, 1828]

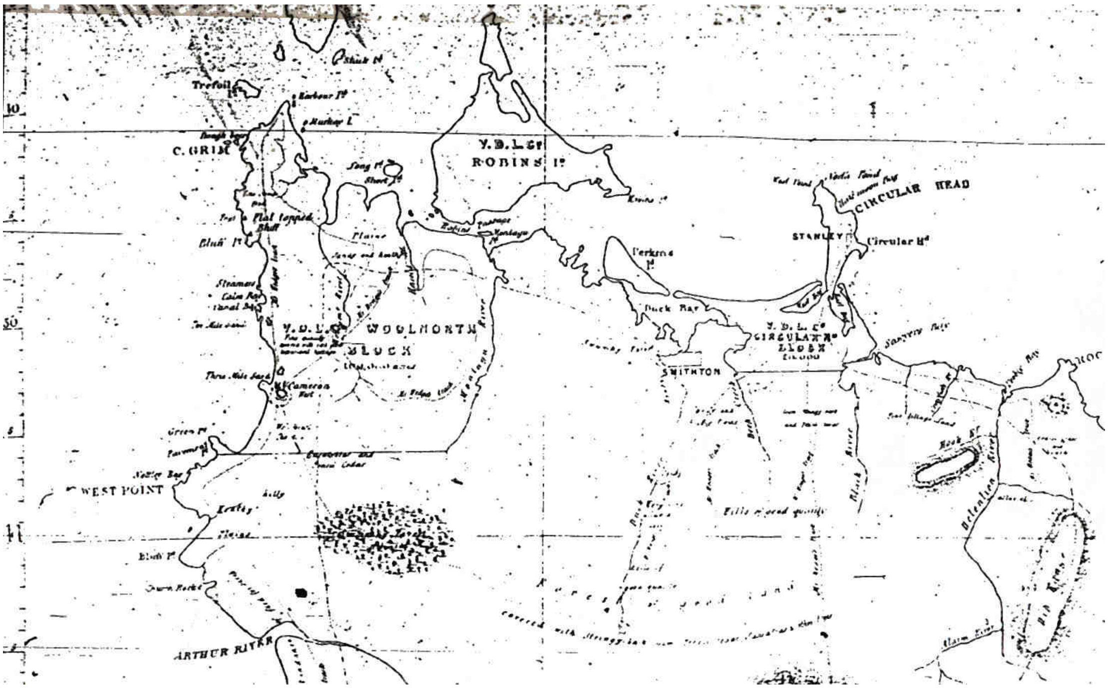
To Swamp—mid leg deep in water. Thick Tea Tree and Sedge obliged to sleep on the tops of the Bushes—during the night I found myself lying at an angle of 20 degrees. Head downwards.

Thursday 27

Swamp Knee deep in water—wet night—Some of the men slept on the trunks of fallen trees, keeping themselves from falling into the water by stakes, and I slept on a small mound caused by a tree having given way and raised its roots above the surface of the water, with stakes to keep myself from rolling in…

Friday 28

Out of Swamp to forest—light Soil—Stringy Bark & Myrtle—Wet day and night.[3]



Far north-western Tasmania, as surveyed by JH Wedge in 1828. The Montagu, Dismal and Welcome Swamps are denoted generally by the dotted area south of the Woolnorth block. Map reproduced from Pat Brown's book, From Montagu Swamp to Togari.

Wedge claimed that at least 40,000 acres of grazing land was already available to the VDL Co. Even the swampy forest had an alluvial soil and was 'capable of being drained'. Another 700,000 acres, representing 'some of the most valuable land in the Island', lay beneath forests which Wedge invited the company to clear, defraying their expenses by exporting the timber, mostly 'pencil cedar' (blackwood), a beautiful native timber ranging in colour from light golden-brown to deep brown, sometimes with a reddish tint or black streaks.[4] Extensive logging operations were not a welcome prospect for a grazing company.

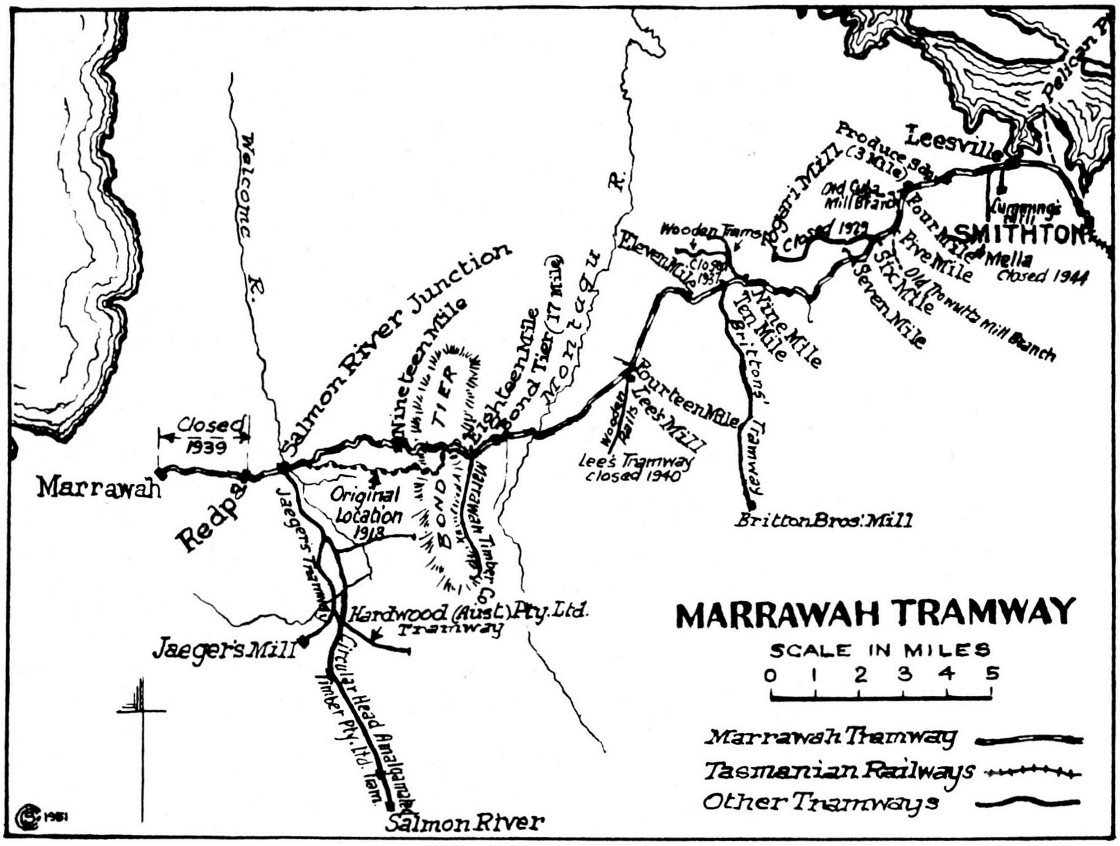
However, it was good news for Arthur. In January 1829 he and his entourage rode northward from Hobart, through the Mole Creek karst into the far north-west, where he saw for himself the country and the forests the VDL Co was faced with.[5] The success of Arthur's meeting with VDL Co agent Edward Curr can probably be judged from the fact that the company took up the Woolnorth block explored by Wedge, and that within three years Curr was trumpeting the ornamental properties of blackwood. Curr regarded it as far superior to imported cedar, and recommended it for making furniture.[6] He regularly requested blackwood from the Woolnorth property for the company's own building purposes, and by 1839 believed the timber would command 'an extensive market at a high price'.[7]

Having learned to appreciate other north-western assets besides sheep pasture, the VDL Co was encouraged by Polish amateur geologist Paul Strzelecki's 1841 analysis of the mound spring at Deep Creek, at the western end of its Circular Head block near present-day Smithton. Strzelecki recognised 'a slight indication of lime' in the 'aperient and tonic' waters, concluding that 'they are also sufficiently disgusting to the palate to pass for highly medicinal'.[8] Curr optimistically imagined that Strzelecki's opinion of the spring would attract 'a great deal of attention'.[9]

Circular Head did not become a health spa. In fact the VDL Co fared so badly from the 1840s that the company became an absentee landlord in the years 1852 to 1869, letting its properties.[10] Potatoes and blackwood were the stock in trade of coastal farmers at settlements like Montagu, but for decades few penetrated the forested tiers.

The timber industry starts to clear the swamps

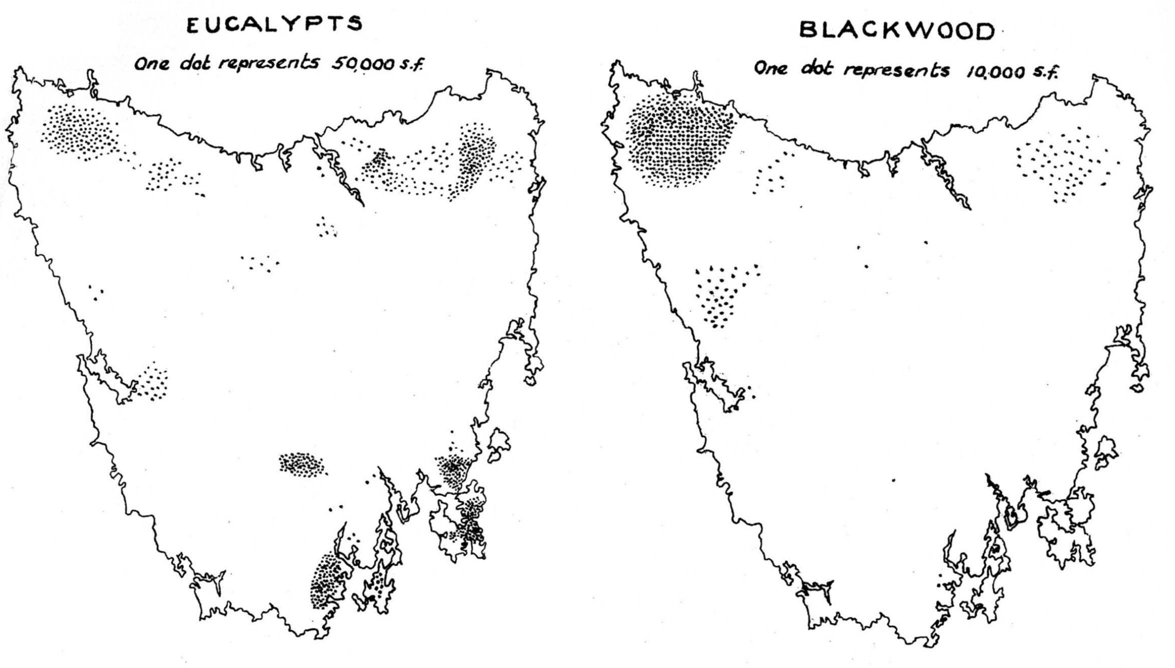
By 1886 Joseph (JS) Lee operated the fastest, most sophisticated, steam-operated sawmill in the colony at a settlement called Blackwood Mill (now Leesville), west of Smithton. It was said that Lee's timber resource reached from there 'to the shores of the Southern Indian Ocean between West Cape and the debouchment of the Arthur [River]'.[11] Lee was soon attacking the blackwood on the edges of the Mowbray (or Blackwood) Swamp and later the Montagu Swamp, enabling pioneer farmers to select holdings on the denuded land. By 1890 the VDL Co was exporting blackwood timber to England.[12] In 1901, Thomas Just, in the *Cyclopedia of Tasmania*, recommended blackwood for the construction of railway carriages and trucks, coaches, felloes (the outer sections of wheels, to which spokes are attached), agricultural implements, furniture and cabinet work and for use in telegraph poles. In addition, blackwood produced fine staves for barrel making.[13] By 1907 other companies like Britton Brothers had found their own blackwood stands on the dolomite swamps west of Smithton.[14]



The Marrawah Tramway enters the dolomite Mowbray and Montagu Swamps on its journey fromSmithton to Marrawah. Brittons' branch tramway penetrates Brittons Swamp. Dismal Swamp lies between Bond Tier and Jaeger's tramway, under the notation 'Original location 1918'. Map from 'Wanderer', 'Railways and Tramways of the Circular Head District', Australian Railway Historical Bulletin no.168, October 1951.

A Britton Brothers wooden tramway across swamp lands Courtesy of the Britton family

The Marrawah Tramway was started by JS Lee in order to harvest the timber on the Mowbray Swamp. The State Government took it over and extended it to Marrawah on the west coast, and private timber tramways radiated from the Marrawah Tramway into the Montagu, Brittons, Arthur River and Welcome Swamps.[15] The rapaciousness of the Circular Head timber industry was captured in Bernard Cronin's novel *Timber Wolves*, published in 1920, the year before the establishment of the Tasmanian Forestry Department in an effort to make the industry sustainable.[16] In 1925-26, 6 million super feet of blackwood sawlogs, most of them from Circular Head, were cut in Tasmania. The result of glutting the market for blackwood and eucalypt was a severe downturn in the industry, with rationalisation of Circular Head timber operators being investigated even by the middle of 1926.[17]



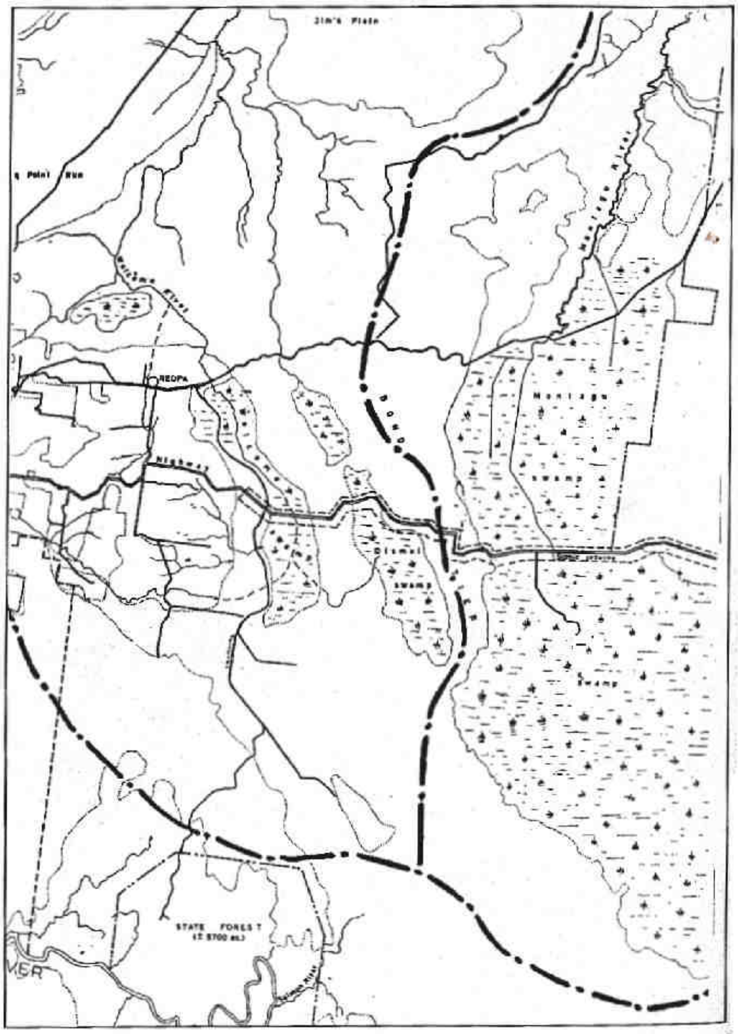
Circular Head (far north-west) is shown to be a significant eucalypt producer and Tasmania's predominant blackwood producer in 1926–27 (from Acting Conservator of Forests, Forestry Handbook, Tasmanian Forestry Department, Hobart, 1928).

Draining the 'dismal' out of the swamps: the moral imperative

Swamps have been dismal at least since the Romantic period in literature and art. Peter the Great, tsar of Russia, for example, is said to have drained 'dismal swamps' to create St Petersburg, his 'window on Europe', in 1703.[18] Perhaps the best-known Dismal Swamp in the world was in North Carolina, and in the mid to late 19th Century it was apparently a lawless place of lynch mobs, runaway slaves and criminals. In 1856 it featured in Mrs Beecher Stowe's novel *Dred: A Tale of the Dismal Swamp*, and a stage version of this book toured Tasmania on several occasions. Similarly, in 1887 imperial explorer and journalist Henry Stanley famously marched through a 'dismal swamp' in darkest Africa, a place of perpetual gloom.[19] It was not only physically but morally oppressive, since slavery was still practiced there. Late in the 19th Century, typhoid epidemics were still common in Australia through poor sanitation, being almost a rite of passage for a new mining town. The fear remained that disease was spread by 'miasma' (swamp gas) and rotting vegetation, providing a moral imperative to rid the world of swamps. In British culture a boggy road was typically described as a 'slough of despond' and a boggy forest was a 'dismal swamp'.

For example, venturing over the tier from the settlement of Montagu into Montagu Swamp, in December 1878 District Surveyor Charles Sprent's party emulated Wedge's trials 50 years earlier:

> We camped on a dry sandy ridge and to our dismay found the place swarming with mosquitoes. Very little sleep visited us that night and we were glad enough to be off next morning. However our troubles were only commencing, for we immediately got into the worst place I have seen in the colony. A great dismal swamp of tea, blackwood, bauera, cutting grass and all manner of abominable scrubs and in addition the place was knee deep in water. We tumbled about in the slop for nearly three hours and then came out on a patch of button grass, a most abominable slop. The grass concealed great water holes and into these we kept tumbling, one after the other up to our knees in water, we must have fallen fifty times going a quarter of a mile.[20]



A 1954 CSIRO map shows the relative positions of the Welcome, Dismal and Montagu Swamps, plus the Marrawah Tramway and Bass Highway. Brittons and the Mowbray Swamp are further east. Map from Pat Brown, From Montagu Swamp to Togari.

Another thing that made forested swamps dismal was that they isolated the settlers trying to conquer and exploit them. In 19th- and early 20th-century Tasmanian stories were common of bush selectors having to ringbark and burn trees on their properties because there was no means of getting the timber to market. One Brittons Swamp settler had the novel idea of burying the trees he felled, only to be exhausted by the exercise.[21] The closeness of the forest, which blocked out both the landscape and social interaction with those living close by, was oppressive.

Social justice was also put to work on the dolomite swamps west of Smithton. From about 1820 to 1831 Tasmania created effectively a landed gentry by granting large acreages to pastoralists. From the middle of the 19th century, however, when the Victorian and New South Wales gold rushes drained Tasmania's vigorous young male population, more was done to encourage the yeomanry to stay or to return to Tasmania after seeking their fortune. A series of *Waste Land* and *Crown Land Acts* contained provisions designed to open up the bush, and it was as a result of this westward spread of settlement that many caves were discovered in the Mole Creek region, including the tourist caves Scotts, Baldocks, King Solomons and Marakoopa. Early in the 20th century, there was further pressure for a fairer society, and the first *Closer Settlement Act* (1907) was designed to break up the big estates into small farms and sell them to yeoman farmers, but also to open up new areas of the bush.[22]

Smithton dolomite swamp	**Cleared & drained**	**Legislative agent**
Mowbray (Blackwood, Mella)	1904–06 1913+	*Crown Land Act* (1904); *Closer Settlement Act* (1913)
Welcome	1922-27	*Closer Settlement Act* (1913); *Drainage Promotion Act* (1917)
Brittons	1933-38	*Closer Settlement Act* (1929)
Montagu (Togari)	1953+	*(Commonwealth) War Service Land Settlement Act* (1945)

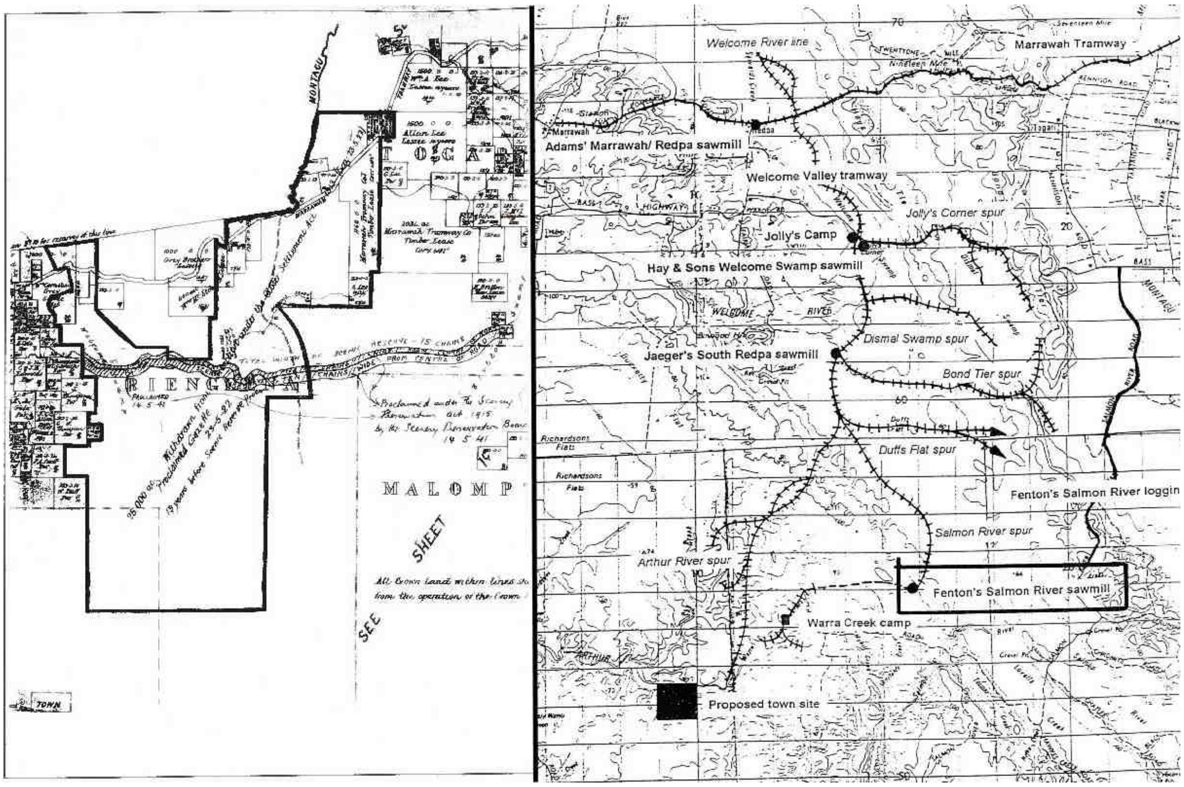
Mowbray Swamp was opened up by selectors and by two government drainage schemes. In 1910, while cutting a drain through his peaty soil, the recently arrived potato grower Ernest Carrington Lovell made the first of his two discoveries of *Nototherium* (Pleistocene megafuana) bones.[23] In 1931 a Mowbray Swamp selector claimed that there were 31 miles (50 kilometres) of underground drains on his property.[24] Lionel Gregory, now 94 years old, dug drains on a Mowbray Swamp property during the early 1930s. He recalled digging 15 feet (almost five metres) below the surface. One man would shovel dirt out of the bottom of the drain up to a ledge, where a second person would shovel it up to the surface. He remembered the clover growing so high on the swamp that prone cattle were invisible amongst it.[25] A traveller passing through the swamp on the Marrawah Tramway in 1929 marvelled at the 'improvements', quipping that 'today the "dismal" has gone'.[26]

The Smithton Dolomite swamp's natural waterworks intrigued locals. The 'limestone blows' were said to be among the milder of these gushing springs.[27] They were traced across Mowbray Swamp by their accompanying mounds, some of these six metres high. Although some blows were considered toxic, cattle gained more joy from them than Strzelecki had from the spring at Deep Creek, reputedly enjoying this particular water so much that they would seek it out.[28]

Surveyors' reports of the country west of the Christmas Hills echoed those of Wedge three-quarters of a century earlier. Miles (1902) and Carroll (1906) met 'deep swamps', 'worthless' land and bauera scrub.[29] Still, the successful Mowbray Swamp drainage brought an influx of Victorian selectors and by 1921 had convinced the government to drain the Welcome, Montagu, Brittons and Arthur River Swamps. The Surveyor-general stressed the importance of reclaiming

> a large area of swamp lands, now lying in useless waste, but which when reclaimed and opened up will form one of the largest and best agricultural and dairying propositions in the state.[30]

Disappointment followed. The development of the Smithton Dolomite Welcome Swamp near East Marrawah (Redpa) was a comparative disaster. Drainage was inadequate, the scheme was extremely expensive, and superintendent of the works, Thomas Strickland, faced accusations of foul play. Strickland resigned with the job incomplete after being criticised by a Royal Commission into the reclamation scheme.[31] For years afterwards no land on the Welcome Swamp was ploughed.



(Left) In 1922 Dismal Swamp was included in an area withdrawn under the Closer Settlement Act (1913) as part of the development of Welcome Swamp.[32] The scheme failed and Dismal Swamp was never drained. (Right) During the 1930s logging tramlines crossed Dismal Swamp (near centre of map) from adjacent sawmills. Left map from Pat Brown, From Montagu Swamp to Togari; right map cropped from one by Parry Kostoglou, Regional Forest Agreement.

The Welcome Swamp scheme brought sawmilling to Dismal Swamp. The Marrawah Tramway Company established a sawmill, huts and steel-railed branch line from the Marrawah Tramway to harvest a reputed six million feet of blackwood in the area, but the contract was abruptly cancelled in the wake of the Royal Commission.[33] This company may even have applied the name 'Dismal Swamp', which appeared on a Forestry Department map in 1925.[34] By 1936 FD Hay and Sons and Frank Jaeger operated mills with branch tramlines into Dismal Swamp.[35]

New impetus for swamp drainage came from the demand for new farming land and construction of the main road from Christmas Hills to Marrawah during the early 1930s. Engineer Lewis East, of the Victorian Rivers and Water Supply Commission, provided guidance on swamp clearance.[36] The Circular Head Chronicle hoped and expected 'that every swamp in Circular Head will be brought under grass within the life of persons now living'.[37] Even the sawmiller Elijah Britton, after whom the swamp was named, eventually agreed:

> There was a difference of opinion on the opening up of Brittons Swamp. Some thought it should be kept as a timber reserve to grow blackwood, but after much thought Dad thought it was too valuable as grass land to be held for timber reserve.[38]

An additional moral incentive for developing this scheme was to provide unemployment relief during the Great Depression.[39]

Agriculture or forest regeneration?

While demand for sawlogs dropped during the Great Depression, another line in blackwood remained buoyant: staves for beer barrels. Britton Brothers, for example, fed Tooth's Brewery's insatiable demand for staves. These came from good quality cross-cut timber, split into various lengths. Stacks of staves were removed from the bush on horse-drawn sledges, railed or driven to the port of Stanley, then shipped to Sydney to be shaped by coopers in order to house Australia's favourite drop. Much blackwood was wasted by cutters, however, disgusting the sawmillers.[40] Just as millions of blackwood staves had been cut from the Marrawah tramway, the new road opened up Dismal Swamp as a tent town of stave cutters—taking only the best timber.[41]

Blackwood sawmiller Eljah Britton (bent over at back) and Britton family members with a stack of blackwood staves waiting to be transported out of the bush, probably during the 1920s. Courtesy of the Britton family.

Yet Elijah Britton's ambivalence about the future of Brittons Swamp expressed the tension existing between forestry and agriculture in the region. Closer settlement of the swamps ensured that after being cleared of millable timber they were never regenerated. Moreover, established bush selectors wanted cut-out timber leases for agistment of stock, not regeneration, and blamed adjacent forestry reserves for putting them at risk of bush fire.[42] The announcement of a proposed forestry reserve on 'swamp country' near the Arthur River excited the response that:

> it seems that the Forestry Department could not find a more suitable place to establish its reserves than in a farmer's paddock. For what is the Far North West, if not the remaining last paddock of agricultural Tasmania?[43]

In 1938, after the failure of closer settlement at Welcome Swamp and Roger River, the Forestry Department's AH Payne judged that 'the success of agriculture on the high land appears to be very doubtful', and warned that forest management and protection of the high land was needed.[44]

Social justice, in the form of soldier settlement, again interfered in the Forestry Commission's conservation plans. As part of World War 2 (1939-45) resettlement, from 1953 part of the Montagu Swamp was drained and turned into a farmland region known as Togari.[45] Millable timber was removed prior to the scrubbing and burning of the land. The demand for blackwood staves had, meanwhile, almost disappeared as demand grew for a cold one. The wooden cask would not withstand the additional pressure required to keep cold draught beer carbonated. Nor could a wooden cask be sterilised, and this led to the development of the stainless steel cask in 1950.[46] At that time, Hobart's Cascade Brewery had a stockpile of blackwood staves that would last it 20 years.[47]

While the blackwood stave trade disappeared, by the 1960s Circular Head sawmillers were looking to the county south of the Arthur River (a region now known as the Tarkine) for a new timber supply. North of the Arthur, an agreement was reached to open flat swamp land containing mostly blackwoods for settlement, while keeping the higher swamp lands containing mostly eucalypts for forestry purposes.

Accordingly, and through the efforts of Wes Beckett, Dismal Swamp was declared a Forestry Reserve in 1976.[48] Ninety-seven hectares of that Forestry Reserve plus three additional hectares were gazetted as a State Reserve in 1979.[49] In 1982 Dismal Swamp was placed on the Register of the National Estate 'especially for its natural scientific interest', noting 'the need for some continued logging to retain that scientific interest', that is, recognition that blackwood growth is stimulated by disturbance.[50] The sculpture of a cow nonchalantly grazing the floor of the regenerating polje today is a neat reminder of the disturbance that Dismal Swamp narrowly avoided.

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Dismal Swamp - a modern tourism venture set in an ancient karst sinkhole

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Abstract

Dismal Swamp is a polje or large sinkhole at Togari in the far north-west of Tasmania. The swamp was a source of valuable blackwood timber for several generations but was reserved in the 1970s to prevent it from being converted to pasture. Dismal Swamp has been developed by Forestry Tasmania into a modern tourism attraction that includes a sensitively constructed visitor centre, the option to descend to the sinkhole floor via a 110 metre slide ride, a maze of paths that take the visitor into secluded crannies of the ancient blackwood forest and the installation of artistic pieces that give people opportunities for contemplation.

Besides allowing visitors to experience the blackwood swamp forest, the development of the site successfully sought to showcase Tasmania's fine timbers. Since opening in 2004, the site has had successes and challenges as a tourism destination. In late 2010, Forestry Tasmania leased the business, now known as Tarkine Forest Adventures, to private operators Graham and Michelle Gallaher.

Introduction

Dismal Swamp is a 600 ha polje in a Forest Reserve managed by Forestry Tasmania. A small part is "Nature, Recreation and Conservation Area" and is managed by Parks and Wildlife. Currently, the Southwest quarter of the swamp is zoned as multiple use forest and harvesting activities may occur there although use of tracked or wheeled machinery is not permitted. Historically, blackwood trees in the swamp had been harvested for several generations until a forester named Wes Beckett proposed the area as a reserve. Wes saw that Dismal Swamp was particularly important because of the underlying karst as well as the magnificent blackwood forests. A number of nearby blackwood forest swamps had been logged and cleared for agriculture, in particular dairy farming.

Forestry Tasmania developed the Dismal Swamp eco tourism site in 2003 and it was officially opened in 2004. Progressive changes were made to the site between 2004 and 2010. A significant addition was the development of "The Edge" Mountain Bike Track to provide further diversification to the site. In late 2010 Forestry Tasmania leased the site to the current managers, Graeme and Michelle Gallagher.

Why was Dismal Swamp developed as a Tourist Site?

In the late 1990's the board of Forestry Tasmania set the goal that 10% of income for FT should come from Eco-tourism. The first eco-tourism site developed by FT was Tahune Airwalk near Geeveston. The Airwalk has proven to be a very successful venture and it was hoped Dismal Swamp would follow suit.

Local tourism operators in Circular Head, in the far Northwest of Tasmania, supported the development as it would draw tourists further into the region. Previously the trend was tourists would come for a day visit to Circular Head, generally as far west as Stanley, and then return to Burnie or Devonport. It was thought that Dismal Swamp would draw the tourists deep into the Circular Head region, increase the number of overnight stays and provide more business for the other tourists attractions.

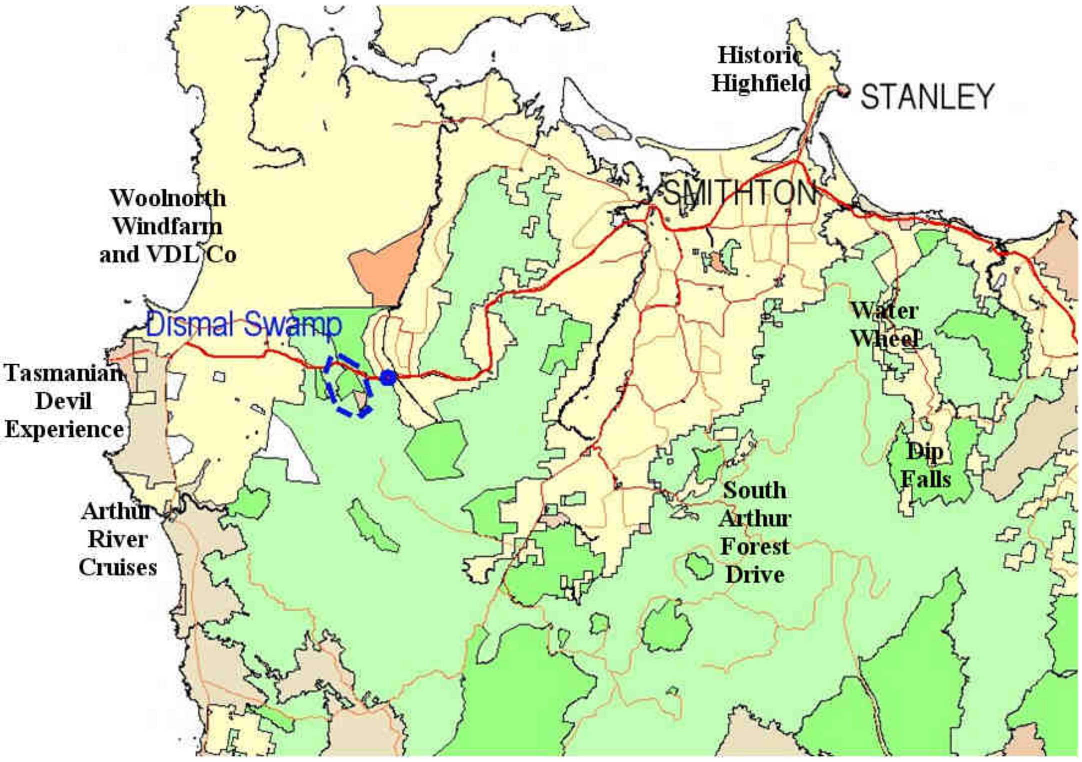

Figure 1. Location of Dismal Swamp and surrounding tourist attractions.

Local sawmillers and timber workers were also keen to see Dismal Swamp developed into a site that showcased Tasmania's specialty timbers, particularly blackwood (*Acacia melanoxylon*). At the Dismal Swamp site it is possible to see where and how the blackwood trees grow as well as seeing blackwood timber highlighted as furniture and as a building material in the visitors centre.

Figure 2. Blackwood trees growing in the swamp.

Figure 3. Blackwood timbers used in the visitor centre.

Concepts of Development

Evan Rolley was the Managing Director of Forestry Tasmania during the period when the Dismal Swamp Eco-tourism site was conceived and developed. Evan strongly believed there should be minimal disturbance to the natural environment and wanted it to appear that the infrastructure had just been carefully placed into the forest.

Figure 4. Presence of the visitor centre has low visual impact.

The aim of the tourist site was to have definite elements of adventure, mystery and discovery. A competition was run in which Tasmania's leading architects were invited to visit the area and then propose a design that would highlight the magnificence of the site. There was a very open brief given so that the designers could interpret the site in their own way.

Prudence Cotton from the firm Jaws 2 was employed to oversee the development of interpretation for the site. Pru did not want the site cluttered with excessive signage but instead used the subtlety of artwork to draw tourists attention to the wonders of nature in the swamp.

Development Challenges

A location immediately beside the Bass Highway was originally chosen for a tourist development of some kind. This original site had numerous limitations so the current site was chosen instead to allow safer access from the highway and more room for car parking. It also allowed the visitor centre to be built on the edge of the sinkhole with opportunity for views overlooking the blackwood forest on the swamp floor.

A challenge was made to the development application questioning the measures to manage erosion and sediment runoff into the sinkhole and karst systems. Concerns regarding the use of treated pine timber in the construction of the boardwalks were also raised. Through the (REMPAT) Arbitration commission these issues were resolved and extra boardwalk was used to minimise side cutting of the steep slopes on the edge of the sinkhole. Treated pine was approved for use as long as it was contained within cement foundations. The challenge to the development application had the unfortunate result of delaying construction by several months so the majority of the construction was carried out in the wettest months of the year.

Figure 5. Use of boardwalk to minimise erosion on sides of sinkhole.

Construction of the slide also posed some problems. Much had to be developed by careful planning and calculation because there were not any similar structures in Australia that could be copied. The slide is 110m long and tourists reach 25 to 30 km/h as they descend the slide on special mats. Over the years numerous types and designs of mats have been trialled to achieve an exciting ride while staying within the parameters of acceptable risk.

Figure 6. The slide.

Since the site is not connected to municipal amenities careful thought has been given to collection and provision of safe drinking water and the installation of a 'Blivet' to process waste water and sewerage.

Operational Challenges

Initially Dismal Swamp was staffed with specialists who had set jobs. As the years progressed and retaining staff at a remote site became difficult, much more multi-skilling of staff was used. Management of staff working conditions and remuneration under the restricting Human Resources structures of Forestry Tasmania, a large government enterprise, was difficult. It is possible that under the current model the Lessee can be much more flexible with staffing.

The forest setting of the tourist site presents many challenges from an OH&S perspective. The most costly issue is the risk management of hazardous trees. An ongoing commitment to arborist inspections and associated tree-lopping work is essential. Unfortunately, the site needs to close to the public at times of very strong winds (risk of limbs/trees falling)or heavy frosts (very slippery on the boardwalk). Grooved boards were used in the construction of the boardwalks to improve the drainage of water from the boards. Due to the swamp setting the boards stay shaded and damp. Regular pressure cleaning was done to minimise the build-up of slippery lichens and mosses. Due to the design of the slide which provides for an exhilarating ride, there have been a number of minor accidents and injuries to patrons. Ongoing management has resulted in changes to the material the slide mats are made from. Another change has been that the mats now enclose the slider's feet and legs. Further modifications have been made to the base of the slide. The last 3m have been elevated and a large foam stopper has been installed.

Artistic Interpretation

There are numerous artworks featured at Dismal Swamp, particularly within the maze of tracks on the swamp floor. Along with the swamp forest, the artwork is intertwined with mystery and imagination. The artists specifically chose to use their art to provoke questioning and exploration. They encourage the tourists to feel and sense the swamp and be a part of it. They deliver the message that the more you look into the artwork and the swamp, the more you see. One artist simply placed some chairs so that a visitor can sit and realise that nature doesn't just inspire the artwork, it "is" the artwork.

Figure 7 The Living Room, or is it the rib cage of a pre-historic mammal buried in the swamp?

Specific Karst Interpretation

In keeping with the themes of mystery and discovery, there is not a huge amount of explanation of the geomorphological attributes of the polje. There are some simple references to sinkholes and the mysteries of karst drainage on pamphlets and some small signs in the maze.

What has worked?

The infrastructure of the site has been very successful with very few exceptions. The cafe serving fine Tasmanian food and beverages continues to be a highlight for tourists wishing to sit and take in the beautiful forest views. The cantilever continues to provide an exciting place to stand and gaze out over the blackwood forests. The steel mesh floor of the cantilever platform allows tourists to look down into the forest below their feet and tests the nerve of those who are not comfortable with heights. The slide is still a draw card particularly for teenagers starting to feel bored on the family holiday. One could walk around the maze for hours (even without being lost!) enjoying the intricate sights and sounds of the blackwood forest.

A small farm buggy is a valuable asset for the site to help elderly tourists travel between the visitor centre and the maze. It doubles as the workhorse to bring the trailer of mats from the bottom back to the top of the slide.

Figure 8 The Cantilever Viewing Platform.

What hasn't worked

There have been a couple of initiatives that haven't worked. A self guided tour was developed that made use of iPods to convey the stories of the swamp to tourists as they walked around. A package was developed for night tours that similarly did not take off.

One difficulty in the visitor centre has been managing the temperature in the cafe area on hot summer days. Since the kitchen is open-plan, the main doors can't be left open on hot summer days to allow the breeze to flow through because many flies enter the cafe and the kitchen.

Dismal Swamp has not attracted the numbers of visitors that it was expected to attract. Forestry Tasmania's other eco-tourism sites have continued to show growth in the numbers visiting. A key tourist group that Dismal Swamp should attract are those that come into the state with their own car and plenty of time to travel and explore. Statistics show that the number of visitors to the north-west of Tasmania that arrived by sea (Spirit of Tasmania) peaked in 2003 and has declined since then. During the time that Dismal Swamp tourist site was being planned the 'target audience' numbers were increasing but just as Dismal opened, the numbers declined.

Acknowledgements

Thankyou to Dean Tuson from Forestry Tasmania for delivering this presentation at the conference.

Why train adventure cave guides?

Sasa Kennedy

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Abstract

In 2000 the first nationally recognised training course for adventure cave guides was developed as a skill set within the Certificate III in Outdoor Recreation as part of the Australian Qualification Framework. The set of training modules has since been extended and modified on two occasions. It is used by both TAFEs and non-government Registered Training Organisations (RTOs) to deliver competency based training to adventure cave guides. This paper discusses the need for standardised training, continues with an overview of the current training modules and then briefly details the training options and how they can be tailored to meet the needs of different organisations.

Introduction

Adventure cave guides, those who are paid to lead clients through a wild cave, or who lead organised groups in a voluntary capacity, come to the job via a range of pathways. Predominantly they are drawn from the ranks of show cave guides, school teachers, outdoor adventure guides and cavers. The skills gained from these backgrounds are not insignificant, however none of these pathways will necessarily ensure development of the full range of skills required by an adventure cave guide. Standardised training ensures that qualified guides can do their job effectively, safely and efficiently.

It is important to understand that people who choose to join a caving club are often very different to those who come adventure caving. Club cavers are there because they are expecting to enjoy the activities - they have an active interest in caves and an adventurous spirit; adventure cavers typically have a more casual interest in caves. They may be there because they are school students with no choice, or their partner wants them to overcome claustrophobia, or their mates are doing it, they like extreme sports in general, or because caving appeals to them but they want the security of handing responsibility to a professional. They may be there because it's the most expensive tour and therefore must be the best.

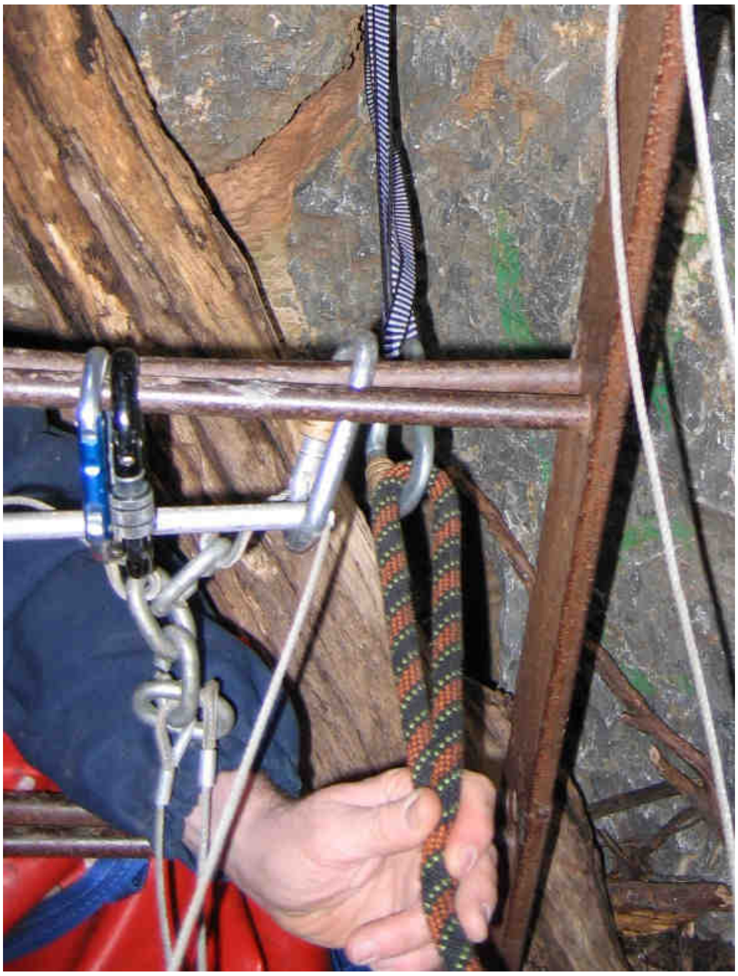
As paid professionals adventure cave guides have three major responsibilities; a duty of care to their clients, the need to uphold the professional reputation of their organisation and an imperative to protect the caves they are working in.

Duty of Care

To ensure that we meet our duty of care to clients we must deliver a product that meets industry standards, ideally we should deliver "industry best practice". This begins with gaining informed consent to participate in the activity. Without this formality taking place the organisation can be in deep water in the event of any incident leading to injury. Guiding students are taught the importance of fully explaining the risks involved in an activity and how to do this without causing undue concern to clients. They should understand the importance of carefully studying any medical issues noted on the consent/waiver form and following up with further questioning of the client, showing due respect for privacy. They should be frank about any concerns they have and not underplay any risks.

Consent needs to be followed up by clear, concise and comprehensive briefings delivered at appropriate times; gear briefings, briefings on what to expect of the trip, safety briefings, minimal impact briefings and briefings to deal with specific situations as they arise. A good briefing looks effortless, but nevertheless requires good communication skills. Trained guides have learnt how to best structure and deliver briefings and have an understanding of the important role briefings play in an activity. Briefings are frequently overlooked or poorly delivered by untrained leaders.

Industry standards on safety, rigging and dealing with emergencies have been established to ensure the safety of clients partaking in adventure activities. Without training it is not possible to ensure that these standards are met. For example only locking carabiners should be used in rigging and a carabiner should be used between the ladder clips to prevent it "unzipping"; there should be two stand alone anchors, no single point of failure and two points of contact at all times; so a belay should be used when climbing a cave ladder.



three carabiners – all unsafe

Standing in contrast is the ladder rigged by a well-meaning school teacher leading a group of schoolgirls through B4-5 Cave at Bungonia. Having utilised three carabiners he obviously thought he was being pretty cautious, however the carabiners were connected to a rung of the cave ladder, where they could easily be pulled to one side as the ladder was weighted, putting undue strain on the connection between the rung and the wire. All three carabiners were connected to the paired treads of an old iron tourist cave ladder (ships ladder), one at the back, so when the caving ladder was weighted that carabiner would be forced against the front tread. One of the front pair of carabiners was larger than the other two, so it was taking no weight, and the gate was not locked, anyway. This left a clip-lock carabiner as the only one to rely on. The pitch is over 10m so any ladder failure would have the potential to cause a spinal injury or worse. The problem was that the school teacher did not have an understanding of rigging principles. He was relying on his previous experience, not on standard safety practices.

Of course there are many ways to rig ladder pitches, which will still be safe as long as proper rigging practices are applied. In accredited courses students are taught the principles behind the practice, ensuring safe practice at all times, not just on pitches they have seen rigged.

It is industry standard for all clients using ladders to be belayed at all times. The teacher at Bungonia did not use a belay. This was the first caving experience for his students. They were at the end of a reasonably challenging cave, on a 10m pitch, with some decidedly tricky sections of climb, where it is difficult to get fingers around ladder rungs and a degree of skill is required to get toes through rungs also. Regardless of his goodwill in providing this experience for his students, this was an accident waiting to happen.

There are many ways in which common caving practices differ from industry practice, not because industry is right and cavers are wrong, but because their needs are different and the duty of care factor is also different. Examples include cavers using lightweight, compact gear where industry best practice would recommend "failsafe" gear; cavers typically carry their own first aid, whereas a comprehensive first aid kit and hypothermia kit should be within reach at all times when adventure caving.

Stops or racks are the descenders of choice for cavers, being kinder to the rope and more sensitive to handle, but for commercial use figure eights are preferred, being simpler for beginners to manage. In a commercial situation all climbs must be spotted, belays must always be used and clients are, typically, more dependent; whereas in other caving situations self belaying is the norm and group members tend to be more self-reliant.

Different backgrounds tend to equate with a pattern of skills and skill gaps in untrained adventure cave guides. There are, of course, many exceptions to the general trend. The gaps are not a reflection on the guide as a person or caver, merely a result of their accumulated experience, or lack thereof.

In my experience as a trainer of adventure guides, cavers generally are very good at navigating through a cave and at abiding by minimal impact practices; rigging, safety and leadership standards vary greatly between individuals and clubs but are often not up to industry standards. For example a single point of contact on a rope is not unusual in caving – using a self-belay is often looked at as a strange deviation from standard practice.

School teachers have variable caving experience when they take on outdoor education roles in a school; often caving may be something they do because it is another option at a site they have chosen primarily for its other attributes. Rigging, safety and minimal impact specific to caves tend to be areas where training is required, though leadership qualities are usually strong.

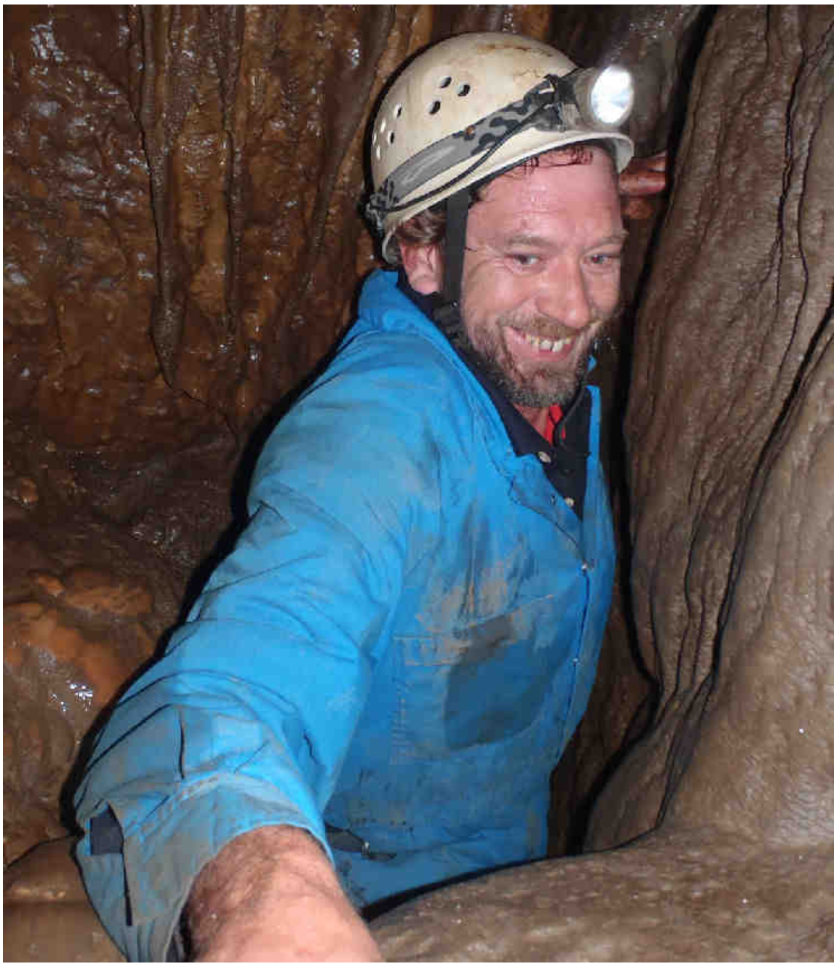
Show cave guides who move on to adventure guiding frequently have no roping experience at all to begin with, so they have little understanding of industry standards for rigging or safety. They may not be experienced at finding their way through an unlit cave and minimal impact may be limited to what is needed to guide an on-track tour. Group management skills are often very good, though leadership required is of a much higher level when off-track.

In contrast guides coming from a background in outdoor education or adventure guiding including climbing, canoeing and bushwalking generally have very strong leadership skills and frequently excellent roping skills, but very little experience in a cave environment.

In order to provide industry best practice duty of care to clients there are skill areas in each group which need strengthening. Standardised training is the best way to address this.

Professional Reputation

After duty of care to clients a guide's next responsibility is to uphold the professional reputation of their employer or organisation. Reputation stands or falls on word of mouth from clients. For good word of mouth a client needs to enjoy themselves and to feel they have got value for their money. Therefore a guide needs to attend to more than just safety. Guides must facilitate opportunities for social interaction before, during and after the caving. At Jenolan one way we do this is by taking photos during the trip and posting them on the web for free download, but facilitating interaction must be in response to a particular group dynamic. Facilitation skills are a further component of accredited training courses.



Challenge by choice: knowing he can back out assists this client cope with fear of a tight squeeze

Nervous beginners often need encouragement to overcome their fear of exposure, heights or getting stuck. Confident cavers sometimes cannot see this fear that others may be hiding. When we follow the principle of challenge by choice enjoyment is greatly increased. People who pay to go with a guide are often more risk averse than your average caver and this is something that training helps guides to understand and to deal with. Sometimes people actually come on tours in the hope of overcoming their phobias. Guides need to use high level interpersonal skills to help people get past their fear of heights, the dark or the unknown. Panic attacks are not uncommon in adventure caving situations. This can put group members at risk. The skills to deal with these situations are not instinctive; they need to be learnt.

Though not a central feature of adventure caving, interpretation of cave formation, features, fauna and history can add another layer of meaning and enjoyment to the experience. Show cave guides sometimes need to be restrained in this aspect of their adventure guiding, but for outdoor adventure guides, cavers and school teachers, with the notable exception of science teachers, this aspect is often neglected without quality training.

When all of these aspects of your operation are running smoothly you can be assured you are providing the requisite value for money which guarantees excellent word of mouth publicity. Until, that is, the dreaded "major incident" occurs.

In the case of a death occurring both guide and employer can find themselves in front of the Coroner's Court with the threat of a charge of negligence, or worse, hanging over them. To be charged with negligence three things must be proven:

1. You had a duty of care to the injured party
2. You breached an industry standard
3. An injury or loss must result from that breach

Without an understanding of industry standards how can you be sure you are not in breach of them? Lack of knowledge is not an acceptable defence in this situation. This in itself is a very strong argument for nationally recognised training in adventure cave guiding.

Cave Protection

For those of us with a passion for caves an even stronger argument is the need to protect these fragile, precious environments. Historic graffiti must be protected, without being added to; fragile decorations and bone remains must be preserved, cave creatures must not be disturbed. The Australian Speleological Federation (ASF) has comprehensive standards for minimal impact in caves, but adventure participants who are not led by someone with this background, or by a qualified guide, are unlikely ever to learn of these standards. It is clear from the damage done in caves which have unlimited access that this is the case.

If we want to protect our caves, including isolated wilderness karst, from intentional vandalism or unwitting damage we need to educate as many people as possible on this aspect of caving and the values of cave preservation. This responsibility is stressed in accredited training courses.

Additional Incentives

If you still feel additional incentives are required to train adventure guides it is worth considering that the ASF insurer wants clubs to meet to Victoria's Australian Activity Standards (AAS) for caving. AAS stresses that workers must conform to requirements of Training Packages, or nationally recognised qualifications.

Earlier this year Blue Mountains region of the National Parks and Wildlife Service (NPWS) added a new condition to canyon licenses for commercial operators in the park; all guides must have a minimum qualification of Certificate 3 in Canyon Guiding. The licensees were given only three weeks to meet the new requirement. It is highly likely that the same requirement will be made in other parks, for other activities, including caving.

Training Packages

So what training provides a nationally recognised qualification that meets industry best practice? The base level course is the Certificate 3 in Guide Horizontal Caving. This is suitable for caves with no vertical pitches and allows the guide to work in familiar environments or under supervision.

The Certificate 3 in Guide Single Pitch Vertical Caving is suitable for caves with single ladder or rope pitches. It includes simple rescue skills for vertical situations. At Certificate 3 level the guide must still be working under supervision or in familiar environments.

The Certificate 4 in Guide Multi Pitch Vertical Caving is a higher level than is needed in most commercial situations. It is suitable for caves with multiple ladder or rope pitches and includes training in complex rescues. Guides with this qualification are qualified to work unsupervised in unfamiliar environments.

For a comprehensive grounding in all basic aspects of guiding a full Certificate 3 in Outdoor Recreation is suggested and for those required to act independently a full certificate 4 in Outdoor Recreation is the standard. These courses will comprise core modules such as risk assessment, logistics and client service, plus two or three skill sets, one of which would be caving. Other suitable skill sets are bushwalking and abseiling or climbing.

A further qualification that should be considered essential to all adventure cave guides is the Remote Area First Aid Course (RAFA). It is considered a necessary qualification in other sections of the outdoor recreation industry, but seems to have been largely ignored by the caving fraternity. Senior First Aid is only suitable when medical help can be expected within fifteen to twenty minutes. This is clearly not the case in most caves. RAFA provides a framework for ongoing patient care. For adventure guides to be without this qualification is breaching an industry wide standard.

Training Pathways and Training Providers

If all this training is sounding way too extensive, expensive and difficult, fear not! There are many pathways to achieving the qualifications. Course work is best for those who are setting out on their career. It gives a thorough grounding in all aspects of adventure cave guiding. For those already in the industry or those with caving experience, who feel they have all the necessary skills, Recognition of Prior Learning (RPL) is available. Training providers will also provide skills gap training, where RPL is given for skills already attained and training is provided where there is a need to fill in any gaps. Assessment only pathways are also available. Basically there is an option available to suit every student.

The major limiting factor is the relatively small number of Registered Training Providers (RTOs). Currently the only providers are Blue Mountains College of TAFE, Chillagoe Caving Club and Above and Below Adventures. As demand for training grows within the industry, more RTOs will supply training opportunities.

Conclusion

The Australian caving and cave management fraternity needs to embrace the concept of nationally recognised qualifications for adventure cave guides. We need to do it so that we meet our duty of care requirements to our clients by providing skilled, versatile guides. We need to do it to protect our individual, corporate and industry reputations. We cannot afford to lag behind the rest of the outdoor recreation industry when it comes to safety standards.

Perhaps most of all, we owe it to our cave and karst areas, including wilderness karst, to inspire as many people as possible to treasure them. We can do this by encouraging them to follow minimal impact practices and leading by example, but most of all we can do it by ensuring that every cave experience they have is a memorable one – memorable for all the right reasons.

Acknowledgements

Bungonia rigging and first aid scenario photo Allie Fenton.

Gunns Plains Cave: Caver's Contributions

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Abstract

Gunns Plains Cave is a developed tourist cave located 30 minutes drive south of Ulverstone, and is included on the ACKMA conference itinerary.

David Wools-Cobb coordinates an environmental group called Karstcare: cavers looking after caves.

In this paper David will outline what work his group has achieved, both within the tourist section and in the 'wild' section of this particularly beautiful cave.

Introduction

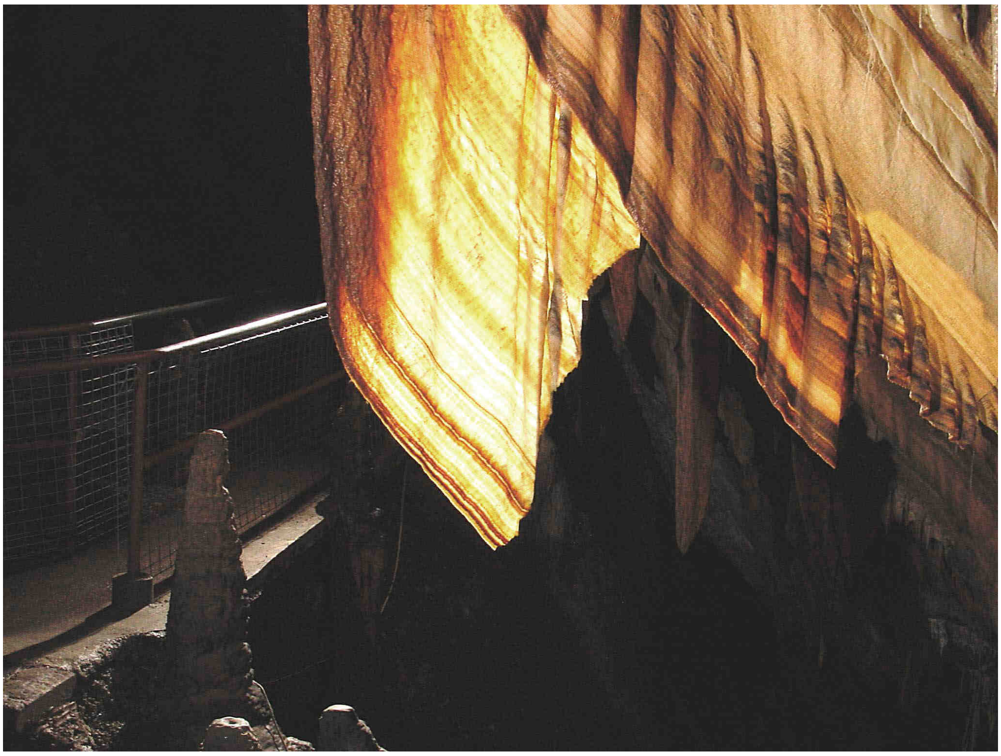
Gunns Plains Cave was discovered in about 1894 by William Woodhouse. It opened as a developed tourist cave in 1909, being lit with acetylene gas.

Over the years there have been further developments, particularly in regard to lighting.

The cave was re-wired in 1947 and in 1958 changed from 240 volt system to 100 volts. In 1980 there was some further electrical renovation and more recently in 2008 a complete re-wiring and re-lighting project was completed under the consultancy of Neil Kell. (Blanden, 1999)

The cave has been surveyed a number of times, with the tourist section within about 1/3 of the entire cave. Its surveyed length is 1328 metres. (Blanden, 2008)

The land managers are the Parks and Wildlife Services, with current concession holders being our own ACKMA members Geoff & Trish Deer since 2004. Gunns Plains Cave hosts up to 11,000 visitors each year.



Initial Caver Project

Several years before Geoff and Trish Deer took over the concession, a number of local cavers noted a considerable accumulation of "rubbish" within the tourist section. It was decided, with permission of the operator that we'd have a basic working bee to clean things up. This was all before Karstcare actually existed. Six or seven of us met one week night, taking in a heap of large bags, with each of us concentrating on different sections of the cave.

It was amazing what we removed. From memory: over 70 broken light bulbs, dozens of pieces of chewing gum, several combs, 1 cheap camera, 1 pair of sunglasses, lots of old wiring, bits of metal and timber that had been dumped in various places. The section immediately below the high viewing platform was particularly interesting. Just below is a long semi-tubular drop that clearly had been the repository for many people's litter, particularly chewing gum!

A total of 13 super bags of rubbish was removed, as well as some scrubbing down of areas at ankle height that had been marked by the considerable foot traffic that this cave has experienced. (Wools-Cobb, 2008)

After that evening's work we all felt considerably disgusted at how the operators over many decades had discarded blown light bulbs and clearly not supervised visitors adequately, however we were pleased that we'd left the cave in a much better state.

Wild Cave Section

I believe the section of Gunns Plains cave beyond the tourist section is only rarely visited by cavers, in fact probably less than 20 per year. I think I know why. To access this requires climbing from the final viewing platform, down to stream way level, then squatting in usually freezing cold water to at least chest height and slipping through a tight section as quickly as you can. It could be said that the 'wild' part of Gunns Plains cave is somewhat self protective!

Notwithstanding this, the wild part of this cave is truly magnificent. I feel that if not for the considerable restriction, much of this section of the cave would have been developed previously.

On a trip many years ago with local Gunns Plains caver Stephen Blanden, I noted several muddied areas, and areas of clay leading to flowstone pavements. Even light caver traffic had resulted in some mud and clay tracking.

It was decided in conjunction with Karst officer Ian Houshold that some Karstcare management could rectify this mud tracking and reduce further damage in the future.

Karstcare ran a working bee to this area in March 2008. We cleaned most of the mud and clay tracking and placed rubber matting on areas usually walked, to avoid further mud tracking in the future. We also used minimal string lines to delineate the preferred route where this was not obvious. Unfortunately with the recent extreme flooding of the cave, although our stringlines remained intact, most of the matting didn't. We have since returned to replace this matting and hopefully it will remain secure. We have also used local rocks to cover some areas not cleanable to prevent boots picking up mud or clay as cavers exit the stream way.

Relighting Of Gunns Plains Cave.

During the middle of 2008, Neil Kell, known by many ACKMA members, designed and supervised the re-wiring and re-lighting of the tourist section of the cave.

Karstcare was approached by "Parks" about the possibility of carrying out a general clean-up of the cave, including any litter, old electrical wiring and fittings and to recover some of the more inaccessible fittings if deemed safe.

Before the working bee, considerable liaison occurred regarding risk management and safety issues. It was quite funny reading a risk assessment written by a non-caver, with some of the risk mitigation principles actually increasing the risk to the participants. Karst managers, of course have to consider such things, however they also have to acknowledge that cavers are inherent risk managers, and are undoubtedly the people most comfortable in such a work environment.

With only 2 week's notice we managed to get 11 Karstcare volunteers from Northern Caverneers and Savage River Caving Club, together with Neil and 3 Parks' staff to work on site.

The day commenced with an explanation of the OH&S issues from a PWS officer, and explanation of what was expected from the group by David Wools-Cobb, with work areas being allocated to groups of two, and rubbish bags distributed.

One member coordinated each group, explaining each area to those unfamiliar with the cave, while Neal & David examined each "exposed" area requiring work which had been deemed unsuitable for contractors to remove old wiring & fittings.

Each pair worked both sides of the pathway and at times higher to the sides where old wiring could be removed, and the pathway was freshly vacuumed. Parks' staff made several trips with rubbish bags and assisted by fetching tools when needed. Some of the working conditions, under rocks, in the stream way and under the walkway were not the most comfortable, but who is better accustomed to such conditions than cavers?

One of our tasks was to cut a long thick cable in several places where it headed through a rock fall. It was amazing just how heavy copper wire can be!

Some of the previous wiring required considerable climbing and rope skills to remove, something I'm sure the electrical contractors would not be prepared to do.

Our own Cathie Plowman managed to recover some old wiring and other bits of historical interest to add to other historical artefacts that are currently held by Parks at the Ulverstone office.

At the grand re-opening, the electrical contractor was extremely impressed with our work and possibly the fact that we went beyond what was expected and probably saved his men a couple of days work. A substantial donation was made shortly afterwards for on-going Karstcare projects.

Lampenflora Project.

During the re-lighting project Neil Kell had observed some 48 sites of Lampenflora- an algal growth due to artificial light proximity. In late 2008 a project was put together by Cathie Plowman and Karst scientist Rolan Eberhard to locate the sites of this unnatural intrusion, photograph them and commence treatment. They managed to re-locate 35 sites, of which 24 were photographed. They observed that to a large extent this Lampenflora seemed to be receding, so decided not to treat it at that stage, but monitor it further. (Plowman, 2008) It appears that with the removal of the stronger lighting and relocation of many lights that this growth may not survive, however a re-examination of these sites is planned in the near future.

Conclusion

The projects I've outlined have contributed 198 hours work to the management of Gunns Plains Cave. These projects have been varied and involved several different skills. We cavers have not concentrated on only the parts the tourists see, as management of the whole cave is important.

Some managers think that the best way to manage a cave is to just keep people out; however in a developed tourist cave, many of the management problems are exacerbated by the high visitor numbers. Karstcare's philosophy has always been management for people not against them. Our works have long term strategies to minimise impact from human visitation. We cavers are comfortable in dark, wet cold environments (well at least Tasmanian cavers are!), we have a variety of skills and can contribute in a very positive way to cave management.

Since its inception just over 10 years ago, Karstcare has contributed almost 2000 hours of hands-on work of karst and cave management, plus of course the many hours that go into administration and funding applications. We like to think that our visit to a cave leaves it in a better state.

Acknowledgements

Many thanks to my band of willing caver volunteers and the cooperation of Geoff & Trish Deer.

Photos by D. Wools-Cobb and C. Plowman

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Managing Access to Caves in the Digital Age

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Abstract

After an explosion of caving activity in the south west of WA in the 1960s to 1980s controls have been gradually put in place. WA speleological groups initiated the Caves Access Committee to manage access to the more vulnerable sites. This incorporated voluntary restriction of group size and trip frequency as well as gating select sites. Later Government initiatives included the formation of the Caves Management Advisory Committee, the introduction of the Cave and Abseil Permit System, removal of restricted access caves from maps, and the introduction of a Cave Leader Course.

These initiatives have seen a reduction in cave rescues, a reduction in non show cave visitation, and a reduction in visitor impacts.

Several developments in recent years have the potential to reverse much of the progress made in the past two decades. The power of the internet and associated search engines, the development of GPS technology and its infiltration into broader society, and the activity of geocaching are examples of digital technology that can potentially impact on the management of access to caves and increase undesirable visitor impacts.

Introduction

There is no doubt that the age of the internet, web pages and GPS technology have brought massive managerial change to our natural world. In one small but destructive instance demonstrated by the U.S. military blowing Al Quaida operatives out of the remote Tora Bora caves in Afghanistan. But closer to home, the same technologies are having implications in recreational caving in the delicate and irreplaceable environment of the aeolian calcarenite of the Leeuwin-Naturaliste ridge.

The sites we are concerned with in this paper are the non show cave sites in the Leeuwin-Naturaliste National Park, in the extreme south west of Western Australia. They range from sites that may be visible from a public road to an astute observer to sites that are well off the beaten track. They may be difficult to find, in karri forest or dense coastal heath with no path indicating the location. Many of these sites rely on their obscurity as their main protection.

Recent History and Management Initiatives

As background to this paper, we will briefly outline the history of cave access in the Leeuwin-Naturaliste National Park (LNNP). Prior to the 1990's, access to the caves was pretty much unfettered, self governed quite successfully by caving groups, with the support and blessing of relevant government agencies. Following an explosion of recreational and commercial access in the 1980's and early 1990's, with, at some sites, major environmental degradation, a permit system, cave management classification and leader accreditation was introduced. Caving groups and other stakeholders in WA stood at the forefront and took ownership of the whole process, indeed dragging the department that is now the Department of Environment and Conservation (DEC) into cave management. Consequently the over 100 caves with dark zones, and the myriad other karst features in the LNNP are now classified as public access, adventure or restricted access, with a permit and leader accreditation required for access into all caves in the LNNP with the exception of Calgardup Cave and Giants Cave, which are operated as show caves.

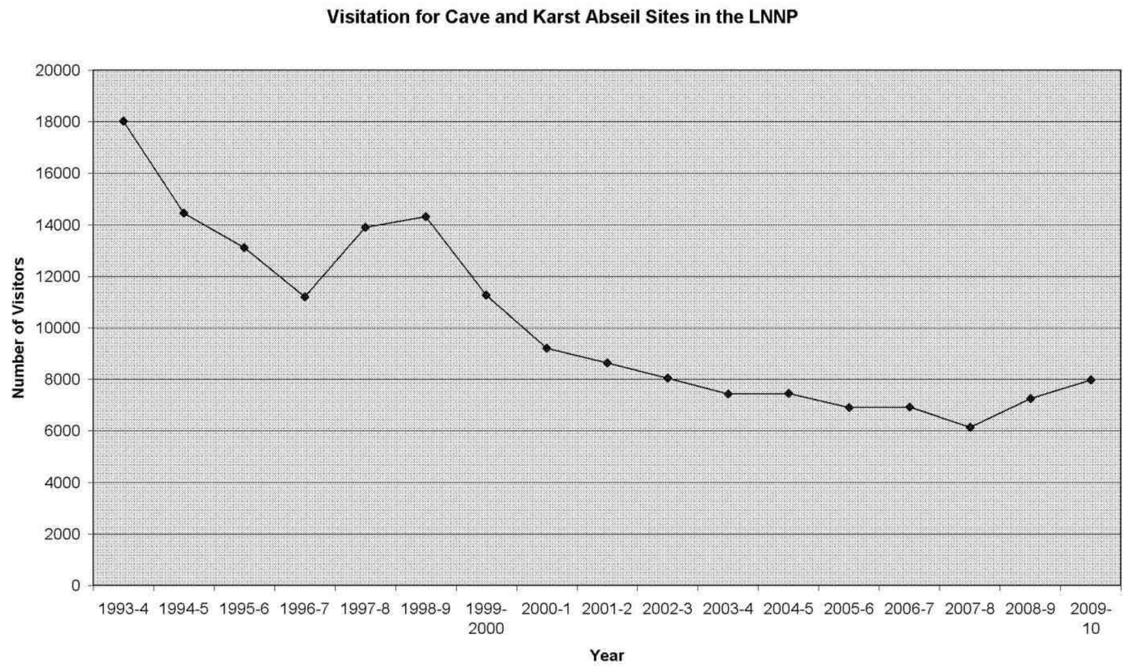
Classification		User Group	Recommended Management
PUBLIC ACCESS	TOURIST CAVE (Guided or self-guided) eg. Crystal Cave, Yanchep National Park (YNP); Calgardup Cave, Leeuwin-Naturaliste National Park (LNNP)	General public	• Developed and managed for tourist use and/or as an educational resource; • Clearly signposted with access restricted to specified times. • Payment of a fee required for entry. • Infrastructure installed to facilitate access, decrease visitor impacts and improve safety.
	ADVENTURE CAVE – Class 1 eg Tunnel Creek, Kimberley.	General public	• May be required to register at the cave entrance and/or pay a fee. • May be some infrastructure and signage to decrease visitor impacts and improve safety.
	ADVENTURE CAVE - Class 2 (horizontal) eg. Golgotha Cave, Calgardup Window Extension (LNNP) Yonderup Cave, Mambibby Cave (YNP). - Class 3 (Vertical) eg Mill Cave (LNNP)	Novice groups (general public) lead by an experienced leader, eg. school groups and licensed commercial tour operators. Speleologists.	• General protection • Entry permit needed. • DEC approved leader needed. • May be limited infrastructure.
RESTRICTED ACCESS	Restricted Access Note: All caves are in this category unless designated otherwise. ref. 2.4.2	Experienced and responsible speleologists, scientists.	• Maximum protection • Entry permit needed • DEC approved leader needed. • Speleological club visits. • Research, monitoring or management purposes.

DEC CAVE MANAGEMENT CLASSIFICATION SYSTEM (2006)

Results

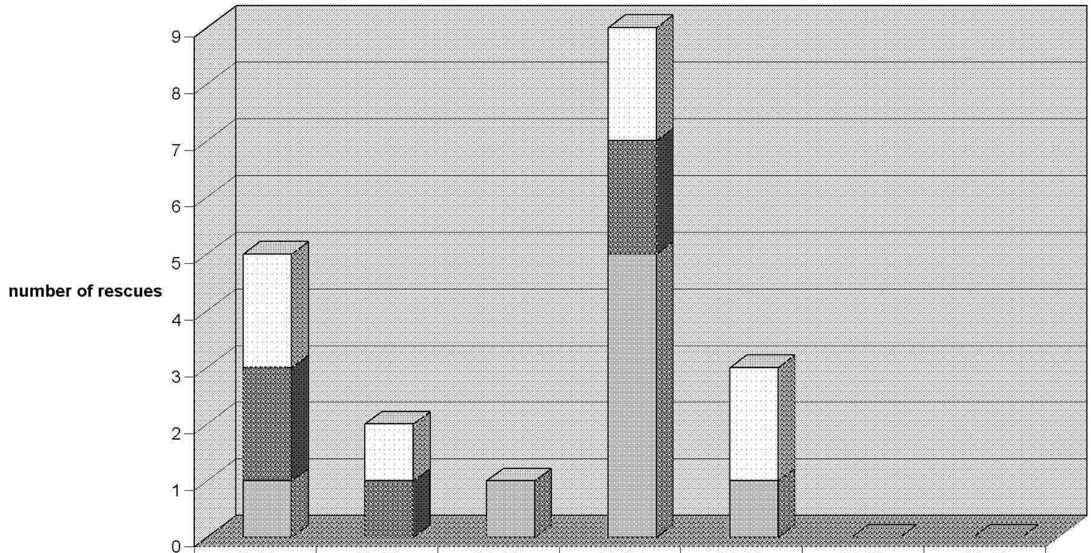
The management initiatives that have been introduced since 1990 can be expected to have resulted in changes to visitation figures for adventure caves and karst abseil sites, the number of cave rescues, and visitor impacts.

Visitation figures for cave and abseil (karst) permits show a steady decline from 1993 to 2010, reflecting in part the increasing number of hurdles to be jumped to obtain a permit; in chronological order – self registration as a leader, a current first aid certificate, cave leader accreditation, requirement to maintain currency by keeping a log book, registration as a single pitch abseil guide under the National Outdoor Leader Registration Scheme (NOLRS) for vertical entry sites and abseiling. Other factors may be the increasing amount of administrative paperwork required for out of school excursions and the change in the perception of risk and adventure in a society where people spend ever increasing amounts of time in front of a screen. These figures do not include entry into Giants and Calgardup Caves, both managed as unlit self-guide show caves, where visitation is increasing.



Cave Visitation LNNP (excluding general tourist entry to Calgardup and Giants Caves)

There have been no cave rescues in the last 10 years. The most common sites for rescues in the past were Giants Cave, Bride Cave, and Terry's Cave. Giants Cave is now track marked, with infrastructure such as stairs and boardwalks through some sections, and people enter under the direction of DEC staff or under the control of an accredited leader. Bride Cave, which is accessed by abseiling, is only available to groups with an accredited leader. Some questionable practices such as star jumping and angel jumping have been banned. Terry's Cave was popular with commercial adventure tour operators prior to 1992 when the permit system was introduced, but was classified as a restricted access cave and is no longer available for that use.



	76-80	81-85	86-90	91-95	96-00	01-05	.06-10
□	0	0	0	0	0	0	0
□ Others	2	1	0	2	2	0	0
▩ Brides	2	1	0	2	0	0	0
▤ Giants	1	0	1	5	1	0	0

year

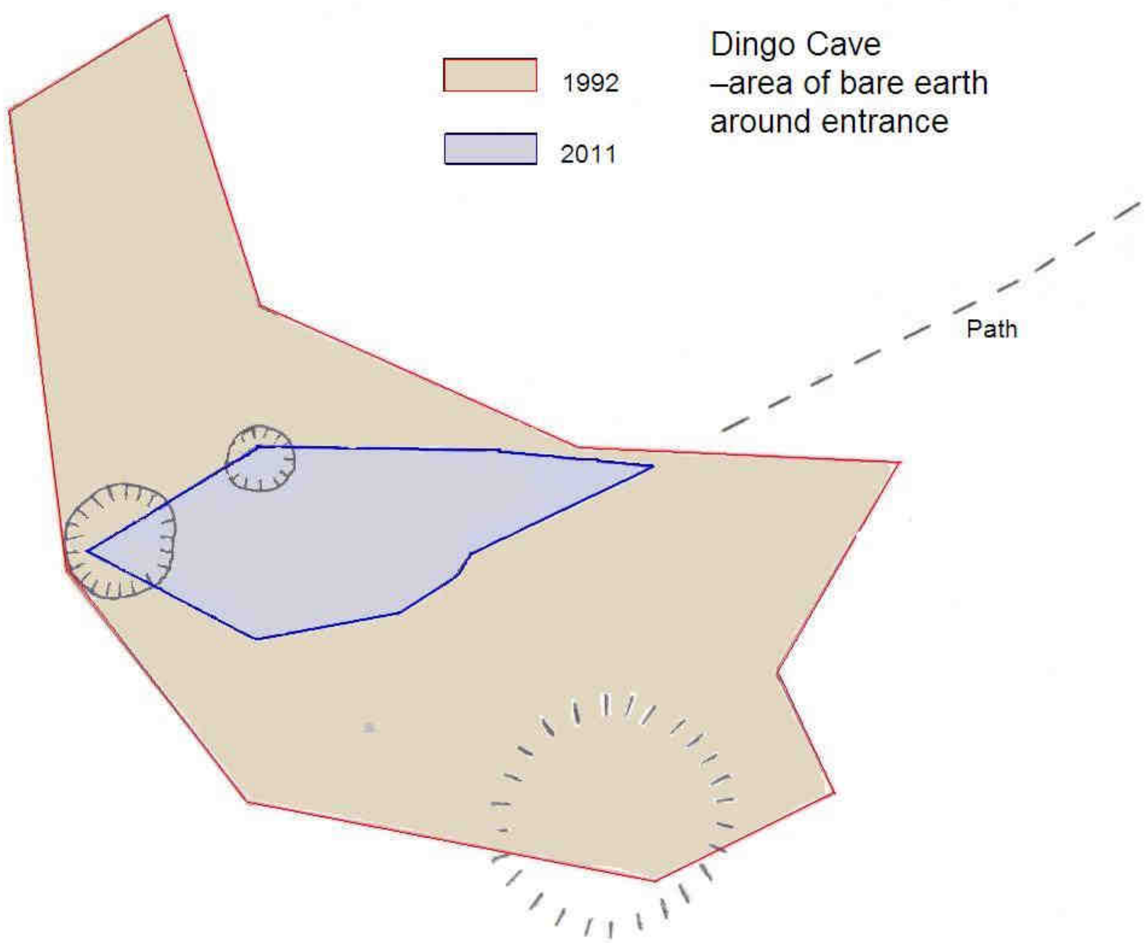
State Emergency Service Cave Rescues (excluding Tourism Association managed show caves) Data from LEMAC of AMR (1999).

On a subjective, qualitative basis it can be claimed that visitor impacts have decreased since the introduction of the Cave and Abseil Permit System and associated initiatives. However there is little quantitative evidence for this. One example is a study of surface vegetation around the entrance of Dingo Cave.

The first time the authors visited Dingo Cave was in the very early 1990's. After we made our way down from the "pretty" section into the main rock breakdown chamber as we were exiting the cave we encountered about 40 boy scouts. They were swarming like ants over every surface in the chamber and asked if the cave went anywhere else. We replied "no" fairly safe in the belief that they would not find the way on. We made our way up past more scouts and only two adults. After the introduction of the permit system the maximum group size for this cave was set at six people.

Compass Bearing	Extent of Bare Earth (metres)	
	July 1992	April 2011
0	1.7	0.0
88	4.0	3.0
90	8.5	5.0
115	7.4	2.8
120	8.8	2.7
140	7.5	2.4
180	4.2	2.0
210	2.8	1.9
250	1.8	0.0
325	5.6	0.0
350	6.0	0.0

Extent of Bare Earth Surrounding Dingo Cave Entrance



Extent of Bare Earth Surrounding Dingo Cave Entrance

The authors selected this site to carry out a "Limits of change" survey in 1992. Part of this involved measuring the devegetated area around the cave entrance. At this time the bare area surrounding the entrance was extensive. Recent measurements and the accompanying photographs show the vegetation is now quite extensive, covering all but the access path.

Entrance of Dingo Cave

New Challenges

Given the apparent low rate of non compliance with the permit system over the past few years, the decrease in rescues and the decrease in environmental impacts in many areas it is easy for managers to rest on their laurels.

However many of the emerging generation of cavers were either in nappies or at best primary school when the very hot war regarding access to these cave systems was being debated. Our two decades of an inclusive management culture is seeing the arrival of a generation of computer and internet savvy instant communicators whose initial research into the world of caves involves accessing websites with GPS plugged, ready to download before they pass by their local Anaconda franchise on their way to their latest adventure. The old days of joining a caving group and sitting for 12 months at meetings in awe of those who "held the maps" are over.

Allied to this brave new world are the caving groups and the ASF themselves, large portions of whom are promoting and coordinating a national programme, the Karst Information Database or KID, with the object of electronically centralising all cave locations for Trip Leader access. The temporary nature of many individuals affiliation with caving groups is obvious testament of the ability of the whole system to "leak".

Many people of course dispute that particular assertion; however the same sort of anecdotal evidence that prompted the initiatives of the early 1990's is being again witnessed in the

LNNP. That is chains at cave gates that have been padlocked being cut with bolt cutters and carefully replaced to appear intact, poorly equipped and untrained groups rigging at vertical sites and the "re-exploring" of track marked caves, all in contravention of permit conditions, minimal impact caving codes and other ASF standards. The frequency of such events appears to have increased significantly over recent months. The incident that prompted the topic of this paper occurred in February when four people reported that the gate on a restricted access cave was not locked. These people were not cavers but had a "mate" with a GPS full of cave locations, and they had been visiting several of them. As managers our question is - How many people are wandering around with a GPS full of cave locations and where or from whom do they source this information?

Solutions

So the solutions, which will hopefully be found before we witness any repeat of the random and unacceptable environmental damage of the late 1980's. The following list of Cave security options is adapted from a table in the DECC NSW Cave Access Policy (2010). Further information on rationale, advantages and disadvantages of each option can be found in that document.

Cave Security Options

- Legislation
- Permit system and/or access policy
- Confidentiality of information (particularly sensitive cave locations)
- Public awareness and education
- Psychological deterrents
- Divert access
- Accompanied access/guided tours
- Isolation/rerouting of tracks
- Installation of remote surveillance/ monitoring
- Camouflage
- Signage
- Built security measures (gates fences and barriers)

Most of the options listed here are in place to varying degrees. The only options not implemented in the LNNP are camouflage and installation of remote surveillance.

Some specific targeted actions include;

1. Increase in monitoring. On the premise that knowledge is power we need to get out and find just who is accessing these sites and how they are gaining that knowledge.
2. Consultation. On the premise that there may be an organised body of some sort that has contacts with this new generation, or at least some of them. Is it ASF affiliated? Four wheel drive clubs? Geocaching websites? Education Dept? Leaking from commercial groups? After all we are not trying to deny these new lovers of all things karst related any access, we just insist that environmental standards are adhered to and that those standards are seen to be adhered to. We all know that broken calcite and mud deposition is always the result of the previous or next party's activities.
3. Policing. DEC has put regulations in place for fining miscreants in National Parks. Given that there is a system of access and a stream of activity for all levels of activity, and those streams are under near constant review, we must ask; why not apply on the spot fines.
4. Increased public education and awareness.
5. Digital information. Coming back to our original point. When an information savvy young potential caver enters "Caving south west WA" into a search engine, one option needs to be "Regulatory framework to protect an irreplaceable resource", which leads onto DEC and other relevant information. All explained clearly and concisely, which is a problem in itself because the system in the LNNP, having been designed to accommodate so many diverse groups, is very convoluted.

On the same subject we personally, and we say personally because it is not any official position taken by DEC or our ASF affiliated caving group, Caver's Leeuwin [inc], are concerned as to just where the ASF's drive toward embracing the KID process is taking the rest of us. Please call us old fashioned, it's a title we sometimes wear with pride, but we thought the system was good, in the security sense, when caving groups zealously guarded cave locations and maps in hard copy. Before every cave location in Australia is divulged to someone who may only be a trip leader or full member of a caving group for 12 months before falling out with that group and walking away with loaded GPS, we should take a good look over the cliff. Although ultimately there's not much we can do about the information factor in this age, we can deal with the protocols that govern its use. It is ultimately a problem we share with fishermen fighting over fish stocks, miners arguing over mineral deposits, and we could even spare a sympathetic thought for Al Quaida, not to mention the caves and karst features that they were holed up in.

Conclusion

Many of the caves in the LNNP and other karst areas rely on the confidentiality of their location as their prime protection against unauthorised access. In this time of GPS and internet technology it will be a challenge to maintain this protection. The photograph below shows an example of what is at risk.

Photo Ross Anderson

Acknowledgements

Ross Anderson provided many of the photographs used in the presentation and figure 5 in this paper.

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Use Of Chemical Methods For The Control Of Lampenflora: Sodium Hypochlorite And Hydrogen Peroxide

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Abstract

To avoid the development of lampenflora the first action is a proper intervention on the lighting. But if lampenflora develops, notwithstanding a good lighting system, it is necessary to adopt some action to stop its growth. The chemical methods, which have the best risks/benefits ratio, utilize sodium hypochlorite and hydrogen peroxide. Here advantages and problems of both compounds are discussed.

Introduction

It is well known that lampenflora is a typical problem in show caves, because the light that is necessary for the visitors supplies enough energy to some plants, which may grow to the point of seriously defacing and damaging the cave itself.

Therefore it is extremely important to avoid the development of lampenflora by adopting the best solutions in order to keep as low as possible the supply of energy for its proliferation.

Notwithstanding the implementation of the best methodology to control such a development, in many instances there is a growth of lampenflora, which must be destroyed by appropriate methods.

Chemical methods

Many products have been used up to now with different results and disadvantages. In particular strong herbicides, which were sometimes suggested in the past, must absolutely be avoided because of their toxicity on the cave environment.

Among the chemical substances which are frequently used to control lampemflora in show caves, sodium hypochlorite (NaOCl) and hydrogen peroxide (H_2O_2) are the most popular (Aley, 2004; Mulec & Kosi, 2009; Cigna, 2011).

Sodium hypochlorite (NaOCl)

This substance is probably the most commonly used because it is the bleach that is frequently used at home and, therefore anyone is quite familiar with it. There are two main negative aspects: the smell and the law.

The smell is well known because we are accustomed to it any time it is used at home. Luckily it disappears in a short time and therefore it is not a big practical problem. But in many countries the law forbids it or, at least, its use has a number of constraints.

According to some authors (Faimon et al., 2003; Mulec & Kosi, 2009) it represents a burden for the cave environment. From a theoretical point of view they are quite right because Cl is surely a poison, but since we are dealing with a show cave where the impact by the visitors on the cave fauna is already relevant, the additional negative effect of sodium hypochlorite is in general negligible. It must be stressed that such a treatment with sodium hypochlorite is not carried out frequently (from one to a few times per year, in general) as it still reduces its impact, since the concentration commonly used is at 5%.

Hydrogen peroxide (H_2O_2)

It is difficult to find another substance more environmentally friendly because the products released into the environment are water and oxygen. Therefore from this point of view hydrogen peroxide seems to be absolutely the best choice.

Faimon et al. (2003) studied extensively the effects on limestone and calcite speleothems. They found that the dissolution rates by hydrogen peroxide at a concentration of $15\%_{vol}$. are one order of magnitude higher than the corresponding rates by water. Therefore hydrogen peroxide attacks carbonates somewhat more aggressively than karst water.

To avoid this effect they experimented with a simple procedure consisting of leaving the hydrogen peroxide solution at $15\%_{vol}$. to react with a few fragments of calcite for a minimum period of 10 hours, but not prolonged over 24 hours, before the application of the solution. A near complete saturation with respect to calcite is reached and the solution will not significantly attack calcite.

The treatment of lampenflora with hydrogen peroxide is somewhat less effective than hypochlorite. Exposure of the eyes to concentrations of 5%$_{vol}$ or more can result in permanent eye damage. Skin exposure causes painful blisters, burns and skin whitening. Therefore special attention must be paid when used to control lampenflora because the concentration is three times higher than the limit reported above. The fact of being odourless is evidently an advantage when compared to the smell of sodium hypochlorite but, on the other hand, it does not prevent exposure to the skin without any warning.

Conclusion

Both compounds reported above have a number of advantages and risks. The choice between them should take into account carefully their characteristics and the local situation.

First of all there are a number of constraints established by the law, which may be different according to the country. Such constraints depend both upon the principles of safety of individuals and protection of the environment. The trend in the establishment of limits for toxic substances is negative in a mathematical sense, i.e. their value is continuously lowered. Sometimes such a procedure, instead of achieving an increase of safety for the person exposed to the toxic chemical leads to a status of overprotection. In fact when the values become too low they imply an additional burden, which is not rewarded by real improvement of safety.

Since chlorine is poisonous the trend is to consider also its compounds as possibly poisonous. This assumption is correct in many instances, but the degree of danger depends on the amount or the time of exposure. Therefore an occasional exposure to bleach, as it happens at home, should never be considered as a dangerous situation for anyone in a cave, cave guides included.

In practice the most evident problem is due to the smell that, luckily is not persistent and disappears in a short time.

For the cave fauna it was already reported above that the impact of visitors in the tourist part of a show cave is much more relevant in comparison with a low concentration of sodium hypochlorite when some lampenflora is washed away. In addition it must be stressed that the cave fauna moves out from the tourist pathway into wild parts of the cave, where the possible concentration of sodium hypochlorite is still lower.

Moving to hydrogen peroxide, the biocide effect is due to a strong oxidation reaction without the release of products harmful to the environment. But, as it was reported above, a concentration of 15%$_{vol}$, which is necessary to achieve a good result in the treatment of lampenflora, may have no negligible health effects for the persons using it.

The dissolution rate of calcite by hydrogen peroxide, which is about 10 times higher than karst water, is around 1 g m^{-2} h^{-1}. From the point of view of a limestone wall or most formations, such an effect may be considered negligible because the exposure time to hydrogen peroxide is rather short. On the contrary in the case of speleothems with a glossy surface, e.g. cave pearls, the action of hydrogen peroxide could deface the formation.

Faimon et al. (2003) stated that as cleansing agents against lampenflora only "two alternatives" remain: either (1) the rapid and effective lampenflora elimination with hypochlorite, albeit with cave "devastation" or (2) environmentally acceptable but slower and less effective eradication using hydrogen peroxide.

Such a rather strong statement could be reduced, given the long experience of Bertolani et al., (1991) with sodium hypochlorite which was found not to deface the cave environment. According to Aley (2004) treating areas as soon as the lampenflora is visible minimizes adverse impacts and, possibly, the runoff of the treating solution should be captured.

When hydrogen peroxide is used, it is possible to avoid the corrosion of calcite, with a previous saturation with calcite, as suggested by Faimon et al. (2003) or the procedure suggested by Grobbelaar (2000) with the application of hydrogen peroxide followed by washing after 5-10 minutes with karst water. This author suggested also collecting the wash water, but probably the hydrogen peroxide had already decomposed after the treatment and therefore it is not necessary to perform a special disposal of the wash water. If necessary this treatment could be conveniently repeated after 6 months or one year but it must be stressed that the use of other chemical biocides may seriously endanger the cave fauna and therefore must be avoided.

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The ACKMA Conference Paper Template

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Abstract

The ACKMA holds conferences every two years and produces an electronic proceeding's from each conference. The quantity of work required to produce these proceedings is considerable. In order to significantly reduce this quantity of work, into the future, a Conference Paper template has been designed to allow the proceedings editor to easily complete the proceeding's document, as well as the required HTML file for the Proceedings CD-ROM.

Using the Conference Paper template the addition of each paper to the Conference Proceedings document takes about 10 minutes and the HTML document about 2 minutes. This is achieved by using word macros that perform 90%+ of the work to generate each of these required documents.

This paper describes the use of the template and how it will greatly reduce the time spent editing conference proceedings in the future.

Introduction

The ACKMA holds conferences every two years and produces an electronic proceeding's from each conference. The electronic proceedings consist of a PDF and an HTML document for each individual paper, as well as the complete conference proceedings in a single PDF document.

The quantity of work required to produce these proceedings is considerable. In order to significantly reduce this quantity of work, a Conference Paper template has been designed. This template will allow the proceedings editor to easily complete the proceedings documentation for the Proceedings CD-ROM.

The Template Location

The ACKMA Template and documentation on how to use the template are located on the ACKMA website (http://ackma.org).

The Template is located at:-

http://www.ackma.org/papertemplate/ACKMA Template.doc

The Template Documentation is located at:-

http://www.ackma.org/papertemplate/Using the ACKMA Paper Template.pdf

For examples of papers completed using the ACKMA Template go to the page:-

http://www.ackma.org/papertemplate/index.html

The Template Format

General Guidelines

The important features of the template are that the general text of the template does not require specific font type or size. Text should be entered into the main body of the template using whatever font is displayed when you start the body of your paper. Please don't bother changing font's as the proceedings editors will just have to change it back again!

Special characters such as bold, italics, underline or symbols can just be included in your paper using standard Microsoft Word features. If you want a word **bolded** just **bold** it as you normally would using Microsoft Word. The same applies for *italics* or underline. All of these features will just translate from your paper, which has been prepared using the template. If you have special symbols or characters such as:-

©, ®, ±, £, µ, ÷, ™, ¼, ½, ¾, è, é, ë, etc

then please just use them and the template will convert them into the proceedings document as well as to HTML.

No pagination or page numbering should be applied to your paper. That will be applied automatically in the final proceedings document.

Special ACKMA Template Tags

A number of special tags are required to allow the template macros to process your paper into the two different formats required. These special tags are all in the same format. They consist of a word or phrase followed by a : (colon) and a space. They are used to designate a specific type of text or formatting within your paper. For example the most simple tags are generally one liners such as:-

Title:

The text following the Title: tag is the full name or title of your paper. Therefore the Title: tag would be followed immediately by the title of your paper. For example:-

Title: This is the Name or Title of your Paper

All of the other special tags are listed in Table 1. Some of the special tags are already included in the ACKMA Template. **These tags should not be removed**. For example the Author: tag is used to list the Author(s) of the paper. The words or phrase in the tag attempts to describe what the tag is used for. For example Section: is used to create a section heading within the document. The Required? column in Table 1 indicates whether the tag MUST be used or if it is optional. **If your final document is missing any of the required tags it cannot be processed**.

Allowed Tags

Tag	Used For	Required?
Title:	The name of the paper	YES
SubTitle:	The sub-title of the paper	Optional
Author:	The author(s) of the papers	YES
Office:	The office, affiliation or qualification of the author(s)	Optional
EmailAddress:	The email address of each author. Use Superscript numbers to identify each author	YES - if available
Body:	The start of the body of the paper and the beginning of the two column format of the paper in the Proceedings document.	YES
Section: Abstract	The start of the paper abstract.	YES
Section:	The **first section** should occur directly after the abstract and should be Introduction or similar. This separates the Abstract from the paper. **All other sections are optional**.	YES
InsertImage:	Used to insert an image into the document. The images are stored externally in a folder and inserted into the paper as required by the ACKMA macros.	For inserting an Image
Caption:	The caption tag describes an image that has been inserted or a Table or Figure that requires a caption. If an image is being inserted but no caption is required the Caption: tag should be placed after the InsertImage: tag but with no text on the line.	Optional except after an InsertImage: tag where it is required.
StartBullets:	Used as the line prior to the beginning of a list of bulleted items.	As the first line of a list of bulleted items.
EndBullets:	Used as the line at the end of a list of bulleted items.	As the last line of a list of bulleted items.
StartBullets1:	Used as the line prior to the beginning of a secondary list of bulleted items. i.e. A list of indented bullets within a list of bullets.	As the first line of a secondary list of bulleted items.
EndBullets1:	Used as the line at the end of a secondary list of bulleted items. i.e. A list of indented bullets within a list of bullets.	As the last line of a secondary list of bulleted items.
StartNumbers:	Used as the line prior to the beginning of a list of numbered items.	As the first line of a list of numbered items.
EndNumbers:	Used as the line at the end of a list of	As the last line of a list of

Tag	Used For	Required ?
	numbered items.	numbered items.
StartNumbers1:	Used as the line prior to the beginning of a secondary list of numbered items. i.e. A list of indented numbers within a list of numbers.	As the first line of a secondary list of numbered items.
EndNumbers1:	Used as the line at the end of a secondary list of numbered items. i.e. A list of indented numbers within a list of numbers	As the last line of a secondary list of numbered items.
Indent:	Used to indent a paragraph within the paper in the Proceedings document and the HTML.	Optional, if applicable
BodyEnd:	The end of the body of the paper and the end of the two column format of the paper in the Proceedings document	YES
Section: References	The start of the list of references in the Proceedings document	Optional, if applicable
EndRef:	Used to define the end of the references to maintain the formatting of the list of references	Optional, if applicable
Section: Acknowledgements	The start of the acknowledgements in the Proceedings document	Optional, if applicable

Table 1

Tables

If you require a table within your paper please use the standard Microsoft Word Table format. You can use background colours on the table heading rows to highlight the headings. These will be transferred into the proceedings document and converted to HTML.

Formatting such as **bold** or *Italics* can also be used on text within the table cells. The Caption: tag can be used beneath a Table if you want a caption that describes the tables contents or numbers the table. .e.g. Table 1 See example below for how the Caption: tag should be used with tables.

Here's an example of a table:-

Dataset
Geological Feature data
Biospeleological data
Hydrological data
Archaeological data
Palaeontological data
Meteorological data
Microbiological data
Cultural Heritage data
Cave Inventory data (Speleological)

Caption: Table 2

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If your paper contains figures or photographs then the images are placed in a folder external to the paper. It should be called "(YourSurname)figs". Note if more than one paper then the subfolder should be called "(YourSurname)1figs".

Into this folder "(YourSurname)figs" place any figures or photographs that you have for your paper. The files should be named in the following way:-

(ConferenceNo)(YourSurname)fig01.jpg

(ConferenceNo)(YourSurname)fig02.jpg

(ConferenceNo)(YourSurname)fig03.png

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e.g. 19webbfig01.jpg

e.g. 19webbfig02.gif

The Tasmanian conference in 2011 is number 19 and each subsequent conference will be numbered so this is the number to use in the image names above.

Note that up to 99 figures are supported within any one paper and the three common graphics file formats of jpg, png and gif are the only supported graphic file formats. Please use the highest quality graphics files that you have for the figures or photographs. They may be reduced in quality but if they are not of good quality to start with they cannot be improved.

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The images will automatically be inserted into your paper in the order of the numbered images e.g. (ConferenceNo)(YourSurname)fig01.jpg will be inserted first followed by (ConferenceNo)(YourSurname)fig02.jpg etc.

Note the left and right brackets used above are just to delineate the ConferenceNo and YourSurname in the filename. They should not and cannot be used in filenames. Spaces should not be used in these filenames either.

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Please provide the images in the largest size that you have available (less than 8Mb please) and in either JPG, GIF or PNG file formats.

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If you require a multi-line caption then please use soft returns (Shift-Enter) at the end of each line in the multi-line caption.

Numbered Lists

1. Should you require a numbered list within your paper, create the numbered list using the word "Numbering" toolbar button. Once the list is created place the tag on the line immediately above the numbered list and place the tag on a line immediately after the list. e.g.

StartNumbers:

1. Item 1
2. Item 2
3. Item 3

EndNumbers:

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Should you require a bulleted list within your paper, create the bulleted list using the word "Bullets" toolbar button. Once the list is created place the StartBullets: tag on the line immediately above the bulleted list and place the EndBullets: tag on a line immediately after the list. e.g.

StartBullets:

- Item 1
- Item 2
- Item 3

EndBullets:

Nested Lists

Should you require one list within another e.g. a bulleted list within a numbered list (see below)

1. Numbered Item 1
2. Numbered Item 2
   - Bullet Item 1
   - Bullet Item 2
3. Numbered Item 3

Once the list above has been created then place the tag on line immediately above the bulleted list and place the tag on a line immediately after the list. Then place the tag on a line immediately above the first Bullet item and then the EndBullets: tag on a line Numbers:

StartNumbers:

1. Numbered Item 1
2. Numbered Item 2

   StartBullets:

   - Bullet Item 1
   - Bullet Item 2

   EndBullets:
3. Numbered Item 3

EndNumbers:

Indentation

If you require a paragraph or text within your paper to be indented e.g. for a quotation. Create the text with no indentation, and then place the tag INDENT:<space> at the beginning of the first line of text e.g.

INDENT: *"the integration of karst knowledge by providing a comprehensive, community-driven central repository of this knowledge, including gray literature, raw data, and published journal articles."*

Note that the indented text or paragraph can contain any formatting such as *Italics*, **Bold** or Underline etc that you require.

References Section

References should have the following format. Examples provided. If you have no references then please delete this entire section including the EndRef: tag.

Example references follow:-

Fleury E. S., G. Veni, T. Chavez, P. J. Boston, D.E. Northup, H. L. Vacher and P. Seiser. (2008). *Superior Karst Stewardship through Superior Data Management: The Karst Information Portal.* Proceedings of the 18th National Cave and Karst Management Symposium. St Louis, MO. Edited by William R. Elliott. pp 290-294.

Kowallis B. (2009) *The Cave Hazards Rating System.* NSS News (Submitted for publication). http://www.brandonkowallis.com/Resources/CavePrograms/CaveRatingSystem.htm

Webb, R. (1999). *Cave Management Prescriptions – An alternative to Cave Classification Systems.* In Henderson, K and Bell, P., (eds.) Proceedings of the Thirteenth Australasian Cave and Karst Management Association Conference, Mount Gambier, South Australia, April 1999, Australasian Cave and Karst Management Association. http://www.ackma.org/papers/cmprescriptions.html

If you want to reference these works within the body of the text they should be referenced like one of these Fleury *et al.* (2008) or (Fleury *et al.*, 2008) depending on the context of the text or for multiple references at one time (Fleury *et al.*, 2008; Kowallis, 2008; Webb, 1999).

Things to Avoid if Possible

Overall the macros that process the ACKMA Paper template are able to cope with most features that can be placed into a Microsoft Word document. However one feature that is difficult to translate into both the full document for the proceedings and the HTML document are footnotes. So please avoid these if at all possible. Some authors have indicated the "normal" referencing is difficult for certain types of papers e.g. historical references and have requested to use footnotes instead of references. This is possible but is not the preferred paper format.

Also our documentation and the ACKMA Paper Template contain angle brackets (< >) which are used to delineate the beginning and ending of items such as the paper title etc. These brackets should be removed when you place your text into the template.

When you refer to a Figure or Table within the body of paper please refer to it using the full word Figure e.g. Figure 1. When you place the caption on the Figure follow the Caption: tag with Figure 1.

Spelling Check and ACKMA Dictionary

Before submitting your paper please perform a spelling check by downloading the ACKMA dictionary zip file from the ACKMA website (http://ackma.org/papertemplate/ACKMADicV1.0.zip). Place the ACKMA dictionary zip file into a new folder called "Dictionary", anywhere on your computer. Extract/Copy the files from the zip file to the new "Dictionary" folder. If you are using a version of Microsoft Windows then to configure the ACKMA dictionary for use in Microsoft Word (2000 or 2003) just double click on the file "InstallACKMADicFile.vbs". This script will configure the ACKMA dictionary as your default custom dictionary, but any other dictionaries will remain available.

Once this has been done then perform the spelling check and any words relating to caves and karst that are not located in the dictionaries then just choose Add to Dictionary and the will be added to the ACKMA dictionary. If you have updated the ACKMA dictionary then just email the latest copy (ACKMA.DIC located in your Dictionary folder) to webmaster@ackma.org. The updated dictionary will then be shared with all members.

Note that if you don't download and use the ACKMA dictionary then during your spelling check you are likely to get prompted for all of the ACKMA tags. If you use the ACKMA dictionary they are already in the dictionary and hence you will not be prompted.

Conclusion

Many organisations around the world use Conference Paper Templates (AIAA, (2010); ALS, (2005); CHI, (2008); IEEE, (2011); IEPDE, (2010)). However all of the organisations wrote extensive complicated templates describing every possible item that anyone was likely to place in their paper. These templates also dictated exactly how the paper's were to be laid out. The ACKMA Paper Template takes a different approach that allows flexibility within the template with the full knowledge that the template macros will resolve any problems in the final document(s).

The ACKMA Template was used for the 18 conference proceedings but the proceedings editors had to do all the work. For the 19 conference proceedings the paper authors have been requested to write their papers using the conference template. We are certain that considerable time that would have been spent formatting documents will all allow the 19 conference proceedings to be delivered in a timely manner but still ensure that the quality of the proceedings are maintained.

References

AIAA. (2010) http://www.aiaa.org/events/jpc/Papers_Template_S1_03192010.doc

ALS. (2005) http://www.als.asn.au/proceedings/als2005/kurniasih-gender.pdf

CHI. (2008) http://www.chi2008.org/chi2008pubsformat.doc

IEEE. (2011) http://www.icsdm2011.org/download.asp?FileName=samplePaper.doc

IEPDE. (2010) http://www.iepde.org/epde10/Files/Paper%20templates/EPDE10-Word_Instructions_FINAL%20Full_Paper.doc

Abstracts only

Lost in Tasmania's wilderness karst

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From 1962-1995, four young men have disappeared without a trace (never seen again) after traversing separate areas of Tasmania's southern wilderness karst. During the latter part of this same period, a student teacher and two young high school pupils drowned in *Mystery Creek Cave* in the far south of Tasmania. To this day, the disappearance of the 15 year old Guy Bardenhagen near Mount Picton in late January 1962 remains a mystery. Bardenhagen was with two fellow YMCA members led by then YMCA Southern Secretary, on a bushwalk from the old *Lake Pedder* to Geeveston. On January 30th 1962, the party of four made a detour to climb Mt. Picton, departing from their campsite at *North Lake*, south of Red Rag Scarp. After lagging behind the others, Bardenhagen failed to reach the summit, but did not return to the camp site. Given the proximity of the known karstified Pre-Cambrian dolomite and nearby pseudokarst, it is possible that Bardenhagen fell into a crevice or vertical opening following his separation from the other walkers. An intense weeklong search failed to locate any sign of Bardenhagen.

In mid-October 1969, John Boyle, became lost when separated from three other cavers in the forested sub-alpine dolomite karst on the northeast ridge of Mount Anne, east of *Lake Pedder*. Reported in the media as a "lost Sydney caver", the 26 year old Boyle was actually a member of the Tasmanian Caverneering Club (TCC) on a club trip lead by former flatmate Alan Keller. In the early afternoon, on Saturday October 18th 1969, Boyle became separated from the others during their search for potholes (vertical cave entrances) in the upper reaches of Camp Spur, adjoining the northeast ridge of Mt. Anne. Despite an intensive search by cavers, rockclimbers, bushwalkers, Tasmanian Police and Navy helicopters, no trace of Boyle was ever found. On October 27th newspapers reported that the search for Boyle had ended, and that he was now officially listed as a "missing person". Interestingly, there was no TCC trip report or article in TCC's *Speleo Spiel* relating John Boyle's disappearance and at the time of compiling this ACKMA Conference Abstract, Boyle was not listed on the Tasmania Police Missing Persons Register. Descending mist and/or low cloud cover were both relevant factors when Bardenhagen and Boyle disappeared and during the subsequent ill-fated searches.

Fifteen years later, the writer was one of several Tasmanian cavers involved in the search for another 26 year old man: Robert Ferguson a student from the University of Tasmania who disappeared in or near the Ida Bay karst during Easter, 1984. While on route to *Exit Cave* with a party of youth hostellers, Mick Flint, a Dover-based member of TCC, had collected Ferguson from the Lune River Youth Hostel early on Easter Sunday morning (April 22nd) 1984, depositing him at the start of the track to *Mystery Creek Cave* (and the Southern Highlands). Prepared only for a short day walk, Ferguson told Flint and other hostellers that he was heading to the old limestone quarry near *Mystery Creek Cave*, then taking the Southern Highlands track to Moonlight Flats and possibly Moonlight Ridge, returning to the hostel that same evening; he was never seen again. A number of theories were devised by search and rescue personnel regarding Ferguson's actual walking route, all of which suggested he may have left the established track. During the weeklong search for Ferguson and subsequent forays by cavers and youth hostellers, about a dozen new vertical caves were found and explored at Ida Bay including *Chicken Bone Pot* and *Smelly Cave*, where a recently deceased wallaby was found.

On Monday July 2nd 1990, following a 5-6 day period of intense almost constant rainfall with snow in the highlands, a party of students and teachers from Taroona High School were caught by a flood surge in *Mystery Creek Cave* at Ida Bay. Well prepared for caving, wearing neoprene wetsuits and gumboots, the school party entered the cave in shin to knee deep water, but were caught unawares by a significantly deeper and faster flow during their exit several hours later. Two young pupils, Anita Knoop and Frances O'Neill and student teacher Joanne Cuthbert were swept off their feet, drowning in the passage that now bears the name: Walls of Sorrow. It was the same day that the writer (Arthur Clarke) guided Rolan Eberhard to IB-47 (*National Gallery*), inserting fluorescein into a washed-out makeshift dam (previously constructed by Ian Houshold and Andy Spate), but successfully achieving the first successful dye trace to *Exit Cave* from a cave in the near vicinity of the former Benders Quarry.

In mid-November 1995, Wade Butler (son of Sydney mountaineering pioneer Dot Butler) disappeared during a solo walk to Precipitous Bluff (PB) near Tasmania's south coast. After being deposited at the start of the Southern Highlands track on Tuesday November 14th 1995, at the same spot where Robert Ferguson was last seen, Butler's proposed six-day walk from Ida Bay to Cockle Creek via PB involved a route through at least two areas of limestone karst. It was a walking trip he had previously undertaken and it was understood that on this occasion, he wanted to explore the possibility of finding a new route from PB to the south coast. Given the vast extent of unexplored limestone on the southern and western side of PB, it is highly likely that Butler may have fallen into one of the steep-sided dolines, possibly in the polygonal karst on the upper western side of PB. In late February 1979, the writer also suffered a mis-adventure becoming "lost" in this upper level limestone area immediately west of PB High Camp, devising an "escape" route by traversing these high level deep and expansive dolines in the dense King William Pine forest on the western side of PB. Arthur subsequently survived a night on his own without a tent seemingly lost in Tasmania's wilderness karst on the lower western slopes of PB, almost within sight of *New River Lagoon.*

Acknowledgements

Rolan Eberhard; Ian Houshold; Max Miller (Tasmania Police); Chris Sharples and STC (TCC) Archives.

What turns glow-worms on? Baseline monitoring of the Tasmanian glow-worm and other cave fauna in Exit and Mystery Creek caves

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Exit Cave and Mystery Creek Cave in the Ida Bay karst system in south-east Tasmania contain a diverse and significant cave fauna. The most superlative faunal feature of these caves is the light displays by the Tasmanian Glow-worm Arachnocampa tasmaniensis. These displays have been recognised as a world heritage value under the criterion relating to outstanding natural phenomena. Remarkably, there has been no previous study on the ecology of the Tasmanian glow-worm. Glow-worms and other cave fauna were monitored monthly for 24 months to obtain information on their ecology and to establish baseline population data. A strong seasonal pattern was found for glow-worms, with pupae and adults most common in spring and summer. The increase in numbers of pupae and adults coincided with an increase in the number of prey caught in silk threads produced by the larvae. Larvae were present throughout the year but the number glowing varied both seasonally and spatially. In Mystery Creek Cave, the number of larvae glowing was generally highest during summer and autumn, and lowest in winter and early spring. In Exit Cave, there was no consistent seasonal pattern in the number of larvae glowing among sites, and overall there was less variation between monthly counts than at Mystery Creek Cave. This difference in seasonal patterns between the two caves may be due to a difference in cave climate, with Mystery Creek Cave possibly experiencing a greater drying out of the cave air in winter than Exit Cave. Monthly counts of cave crickets and other cave fauna, which were common in Exit Cave and uncommon in Mystery Creek Cave, revealed few interpretable patterns. The only consistent pattern observed was in the part of Exit Cave known as the 'wind tunnel' where cave cricket and cave beetle numbers were high during the warmer months and low during the cooler months. This is likely to be a response to the winter effect in that part of Exit Cave. Further information on this research is available in Driessen, M.M. (2009). "Enhancing the conservation of the Tasmanian Glow-worm (Arachnocampa tasmaniensis) by monitoring seasonal changes in light displays and life stages". Journal of Insect Conservation 14: 65–75, and in Driessen, M.M. (2009) "Baseline monitoring of the Tasmanian Glow-worm and other cave fauna". Nature Conservation Report 09/02, Department of primary Industries and Water, Tasmania. Both articles are available from the author.

Bioluminescence in cave glow-worms: do cave tours have an effect?

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Glow-worm larvae emit light to attract prey into their sticky silken web threads. Glow-worms are found in suitable wet caves as well as in rainforest settings. In wild caves of Tasmania and New Zealand, glow-worms (*Arachnocampa tasmaniensis* and *A. luminosa*, respectively) maintain synchronised rhythmic light output. The time of peak light output is different to forest glow-worms. Cave populations glow most brightly when it is daylight outside the cave and most weakly during the night; they are completely out of phase with adjacent rainforest populations. We show that cave glow-worms synchronise their bioluminescence by detecting and matching each others' glows. Placing artificial lights in caves causes glow-worms to synchronise to the imposed light cycle because they interpret the light as coming from other glow-worms.

From studies in wild caves at Ida Bay, we also show that where *A. tasmaniensis* are located in the cave mouth, experiencing cycles of daylight and darkness (light:dark), they still possess an underlying rhythmic tendency to glow most brightly during the day, just like their counterparts deeper in the cave. When cave mouth larvae are placed in constant darkness in the laboratory, they show a free-running endogenous rhythm with a peak occurring during the daylight hours. We conclude that this underlying rhythmicity is modulated by exposure to natural light, inhibiting the glowing during daylight hours. The accumulation of drive during the inhibitory period causes the glow-worms to release their light most intensely just after dark and progressively through the night.

In this regard, the rhythm of bioluminescence in *A. tasmaniensis* is completely different to that of the Australian mainland rainforest species, *A. flava*. The bioluminescence of *A. flava* has an underlying rhythmicity that promotes maximum bioluminescence during the night. Natural light inhibits bioluminescence — just as it does in *A. tasmaniensis* — but the inhibitory period coincides with the trough phase of the underlying rhythm of *A. flava*. We suggest that *A. tasmaniensis* shows this unusual rhythmic pattern because it is adapted as a cave-dweller, while *A. flava* is not.

We demonstrate that in *Marakoopa Cave* at Mole Creek, the timing of show cave tours happens to coincide with the brightest component of the natural bioluminescence cycle. Further, the artificial lighting in the main glow-worm viewing chamber above Zambezi Falls, does not substantially affect the display. The lack of effect of cave lighting on the bioluminescence intensity is readily explained in terms of the experimental results on the bioluminescence rhythm.

The Mole Creek Karst Forest Program

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The Mole Creek Karst Forest Program was funded by the Commonwealth Government as a component of the Tasmanian Forest Conservation Fund. The object of the program was to provide landowners in the Mole Creek area with native forest overlying karst the opportunity to either sell the land to the Tasmanian Government so that it could be added to the public land reserve system or to receive a financial consideration for placing a conservation covenant on the land. The Tasmanian Land Conservancy was contracted by the Department of Environment Water Heritage and the Arts, now Department of Sustainability, Environment, Water, Population and Communities, to implement the program. A technical panel identified and allocated a priority to karst areas, a guidance group assisted with implementing the program. The program was successful in adding 376 ha of karst to the reserve system on public land and protecting a further 201 ha with conservation covenants on private land.

Palaeontology and Cave Tourism: Opportunities for Engagement

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Fossil bones are often found in caves, where a constant cave environment and undisturbed sediments can result in exceptional preservation. Most cave fossils are of Pleistocene age ('Ice Age'), since bones older than this usually disintegrate over time. Extinct animals first known from caves include the massive marsupial *Diprotodon*, the marsupial 'lion' *Thylacoleo*, and the northern Cave Bear. Some tourist caves have capitalized on their fossil faunas by promoting scientific research and showcasing the results in interpretive centres and publications. This provides visitors with new excitement, education and a deeper understanding of the caves' history. An outstanding example is Naracoorte Caves in South Australia, a World Heritage area because of the unique nature of its fossil mammals. Cave displays of extinct animals, an interpretive centre and publications greatly enrich the visitor experience. Jenolan Caves in New South Wales -- the oldest show cave system in the world - has not been widely recognised for its extinct fauna, although Ice Age species have been found (for instance, Tasmanian Devil fossils are showcased on the Imperial Cave tour). New research into Jenolan's fossil fauna, the initial results of which are presented here, aims to investigate Jenolan's deeper history through identification and analysis of fossil bones within the caves. Work to date includes the identification of a probable *Zygomaturus*, a large marsupial herbivore nearly as large as *Diprotodon*; confirmation of a Tasmanian Thylacine in the Jersey Cave, and the'discovery' of many Jenolan fossils at the Australian Museum in Sydney. Many of these species are now either completely extinct or gone from the Jenolan area (as in the case of the Tasmanian Devil). Fresh insights into Jenolan's past will undoubtedly bring new opportunities to add to the visitor experience in many ways, as well as help to raise the scientific profile of Jenolan Caves.

An Overview of Caves and Caving in Slovakia

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The tradition of professional and organized caving in Slovakia will be presented, including the history of the Slovak Caves Administration and its changes over the time. The legislative background and consequent tools for cave preservation will be mentioned. Also an overview of the types of karst and caves, approach to cave management and operation of show caves in Central European conditions will be described. The practices in protection of both wild and show caves will be introduced. Ways of computer handling of different issues connected with caves will be presented as well.

The Vatnshellir Project — a First for Iceland

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Vatnshellir ('Water Cave') in Snæfellsnes, Iceland, is a 205 m long lava cave/tube on three levels. The uppermost part (first level) is the ' original' Vatnshellir, from where the farmers at Malarrif, a farm and a lighthouse, 3 km to the SSW, fetched water for their livestock. This part of the cave is partially collapsed, just under the surface and 35 m long.

The lower part is on two levels (floors) and in a surprisingly good condition. It is accessible through askylight, or funnel, in the downfall basin of Vatnshellir. This part of the cave has been named Undirheimar (Underworld). The middle level (floor) is 12-20 m under the surface and about 100 m long. At the southern end of the middle level is a 12 m high vertical lavafall, leading into the 12 m deeper lowermost level. This part of the cave is about 32 m below the surface, almost horizontal and just over 70 m long. In December 2009 a platform was built over the entrance funnel leading into Undirheimar.

In May 2010 an 8 m high spiral staircase was put up, leading into the 100 m long middle floor. This part of the cave was opened to the public on 15 June 2010 as ' the first 20 vertical metres of the route to the centre of the earth' (alluding to the fact that Jules Verne placed the start of the journey in this vicinity in his 1864 novel, Journey to the Centre of the Earth). In October 2010 a second spiral staircase, now under construction, will provide access down to the lowermost level, to about -32 m. (Then there will be just 6,370 km to go!)

It is an interesting project; the first of its kind in Iceland. It is done with humility, wit, nature protection and service to the community in mind. The mayor of the community, a renowned architect, the head of the ruine (collapsed buildings due to earthquakes, etc) rescue school in Gufuskálar and his son, Lions, some members of the Rotary Club and the rescue squad at Hellissandur are taking part. Among other things some 28 cu metres, or 60 tons of rock, volcanic ash and soil has been hauled from a depth of 10-12 m. The Environmental Institute is financing about 1/3 of the cost, the platform over the funnel and the two spiral ladders, the rest is voluntary labour and donation. Vatnshellir is within the Snæfellsjökull National Park, the park manager and the management have wholeheartedly supported the project from the very beginning.

Four broken spatter stalagmites found in Vatnshellir have been repaired and put back. Vandalism to two of these, The Twins, was in fact the spark that lead to the development of the cave into a tourist cave. Replicas of the 37 stalagmites (now all gone) that decorated the end of Borgarhellir in Hnappadalur, when found in 1957, were put up in a sheltered corner in the north end of the middle floor, to give people a feeling of how the great caves, a world that was, once looked.

Caves and Ruiniform features in Sandstones of Northern Australia

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The flat-lying sandstone areas of tropical north Australia have a range of interesting landforms that include caves, dolines, and other karst-like features, and also spectacular ruiniform terrains. These landforms can be classed as silicate karst, parakarst, pseudokarst and non-karst (but the last have ruiniform areas that have considerable scenic and scientific interest). Caves range from small rock shelters through small tunnels and large tubes which may have dark zones, to larger stream caves (both active and abandoned) and complex maze systems. Dolines are mainly collapse or subsidence features, and some may be due to subjacent karst effects. Blind valleys and stream sinks are associated with the stream caves. Small-scale features include solution pans and runnels, sculptured walls that resemble karren, and sandstone pillars within some caves or exposed in cliffs. The pillars appear to be a type of diagenetic cementation by focussed vertical water flow.

Ruiniform features are giant grikefields, stone cities and stone forests which result from structurally controlled weathering and erosion. At the edge of a plateau developed on flat-lying sandstones one finds that erosion first attacks the joints, widening them to form grikes which grow larger and deeper to become giant grikefields. As the grikes enlarge further they widen at the expense of the higher areas between them to make stone cities. Eventually the low ground dominates and we get a stone forest and finally scattered pinnacles on a low-level pavement. Stone cities are referred to by the tourism industry as “lost cities”. These features are analogous to karst grikes, pinnacles and towers, but solution is not the main process involved. Whilst solution of silicate cement may be involved in the original weathering process (along with oxidation of iron and aluminium compounds, and clay mineral formation), the majority of material is subsequently removed by fluvial processes, or, less commonly, by wind. Grikes etc on both limestone and sandstone are best classed as ruiniform, rather than “karst-like”, as the structural control is more important than the processes of chemical and physical weathering that are involved.

Many important sites have developed in Proterozoic sandstones and quartzites. Whalemouth Cave in WA is a particularly large and spectacular stream cave in sandstone. On the plateau above the cave several blind valleys and stream sinks can be seen from the air. In the NT there appear to be large and complex horizontal maze cave systems at Kakadu and possibly at Bunju, but these have not been studied in any detail and access is difficult. Also in the NT, large collapse dolines, some with water-table lakes (i.e. cenotes), occur in sandstones of eastern Arnhem Land, near Borroloola and on the Newcastle Range in the Gregory/Judbarra NP. Again, access is difficult and the genesis is uncertain as the host sandstones either have a carbonate cement or are underlain by limestone units. In Queensland, Widdallion cave in the Lawn Hill (Boodjamulla) NP is a stream cave similar to, but much smaller than Whalemouth. Further east in Queensland, Mesozoic sandstones have a range of features. A surface stream within the grikefields of Cobbold Creek Gorge has several underground segments. In the sandstone ranges of central Queensland there are many rock shelters, and also large tubes and small tunnel caves. The main interest there is in the extensive small horizontal tubes, and three-dimensional networks of smaller tubelets, even though they are too small for human access.

Managing Climate Change Impacts in karst — The Lake Cave Eco-Hydrology Recovery Project

Sarah Davies (presented by Simon Ambrose), Jayme Hatcher and Dr Stefan Eberhard

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Lake Cave, located in the Margaret River region of southwest Western Australia is renowned for its beautiful and spectacular underground lake. The cave has been visited by tourists for more than 100 years, and it continues to be a major tourism drawcard in the region, attracting more than 44,000 visitors annually. Besides its important tourism values, the cave also harbours a Subterranean Groundwater Dependent Ecosystem (SGDE) comprising aquatic subterranean invertebrates (stygofauna) recently nominated as a Threatened Ecological Community (TEC) under the *Environmental Protection and Biodiversity Conservation Act* (status critically endangered).

Groundwater levels in Lake Cave remained relatively stable and showed no sign of decline up until 2005, after which time there has been a progressive decline and noticeable reduction of the size of the lake in the cave. This has reduced the visual appeal for visitors, and threatened the stygofauna community. Without management intervention, at the current rate of decline (1 mm per week) the lake will be dry within two to three years.

Lake Cave is managed by the Augusta Margaret River Tourism Association (AMRTA), and its Environmental Management Plan makes a commitment to conserving natural values within the cave and its water catchment, including monitoring and maintenance of hydrology, subterranean fauna and habitats (AMRTA 2008). As part of this commitment, AMRTA initiated the Lake Cave Eco-Hydrology Recovery Project in July 2010, supported through grant funding from the W.A. Government's Natural Resource Management Grant Scheme.

The Lake Cave Eco-Hydrology Recovery Project aims to:

1. Control the water level decline in Lake Cave, by harvesting rainfall and using this to supplement recharge of the lake;
2. Monitor the ecological condition of the aquatic root mat community and other stygofauna in Lake Cave;
3. Develop a hydrological model of the cave and karst catchment with a view to managing water resources and dependent SGDE's in the face of a drying climate future.

Since October 2010, AMRTA has been supplementing the natural flow of water in Lake Cave by subsoil discharge of rainwater into the cave. Initially this is a 12 month trial with assessment of the success of the trial to take place in September 2011. Baseline monitoring of water quality was undertaken during the preceding year to ensure that ongoing post-trial monitoring can detect any changes within the cave system, enabling appropriate management actions to be taken. This presentation documents baseline water quality and water levels, and the ecological condition of the aquatic root mat community and stygofauna, prior to commencing the recharge trial.

In relation to water quality, EC, pH, DO, redox and major ions were analysed for both lake water and drip water in the cave. The two water bodies exhibited different characteristics, confirming earlier indications that a portion of the lake water is of different origin from the vadose percolation waters.

In relation to stygofauna, the declining water levels and drying out of the root mat habitat in Lake Cave has resulted in a 74% decline in species richness over the past 10 years. Fourteen species with root mat associations were not recorded in 2010. Maintenance of the current water level is imperative for the conservation of the remaining stygofauna community.

The next stage (12 months) of the Project will continue monitoring of water levels, water quality and stygofauna, and undertake a detailed catchment-scale investigation to build a hydrological model of the cave and its catchment. This will be used to inform management and conservation of Lake Cave's water resources and SGDE's in the face of a drying climate future.

The Plains Karsts of the Smithton Basin

Chris Sharples

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The Togari Group of younger Precambrian rocks in the Smithton Basin of far northwest Tasmania includes two thick horizons of karstic dolomite, namely the upper Smithton Dolomite and the lower Black River Dolomite, separated by volcanics and clastic sediments. These were folded into a broad north-south oriented synclinorium, and subsequently reduced to a broad coastal plain by an unusually long (for Tasmania) period of continuous sub-aerial exposure and erosion lasting over 400 million years from Late Cambrian through to Early Tertiary times. Lateral karstic corrosion at the water table has created very broad, flat and (formerly) swampy karst plains on the Smithton Dolomite in the Duck and Montagu River valleys, with characteristic short steep marginal slopes. This extensive karst plain is one of the largest distinctively karstic landscapes in Tasmania. Mound springs in the Duck Valley are a notable feature of the plains karst; however the high water tables and flat relief mean that only a few caves have developed on isolated residual outcrops of dolomite rising above the plains surface; nonetheless some of these contain notable marsupial megafauna remains as at Montagu Caves. The mostly poorly-drained conditions resulted in accumulation of peat swamps during the Pleistocene, from which numerous megafauna bones have also been recovered near Smithton. Nonetheless much of the plains karst has been cleared and developed for agriculture, which historically required development of possibly the most extensive complex of artificial drainage channels in any part of Tasmania. The underlying Black River Dolomite is relatively siliceous, and so outcrops in a fringe of hillier country surrounding the plains karst, where sinkhole lakes such as Lake Chisholm and the Trowutta Arch cenote have developed along with some cave development as at Julius River Caves. Despite this, Tasmania's best example of an enclosed plains karst or polje has also developed in carbonate rocks assumed to correlate with the Black River Dolomite at Dismal Swamp. Although some logging has occurred in the past, Dismal Swamp remains undrained and much of the polje has been protected as an important remnant Blackwood swamp forest habitat.

Conference acknowledgements and introduction

Welcome to the Conference

The Conference Organising Committee warmly welcomes you to Tasmania and the 19th Australasian Cave and Karst Management Conference. The seaside town of Ulverstone has been chosen as a convenient central location allowing travel to the cave and karst areas of Mole Creek, Gunns Plains, Rocky Cape and Dismal Swamp at Togari. As well, the Ulverstone Surf Life Saving Club is an enjoyable conference venue beside the beach and with views over Bass Strait. It is within easy walking distance of the accommodation.

Tony Culberg – Conference Convener

While practicality dictates a need for a conference venue some distance from the Tasmanian wilderness, the conference theme of wilderness karst celebrates the large areas of wild and still largely unexplored karst that lie within the Tasmanian Wilderness World Heritage Area. The conference theme and field trips highlight th contrasts between the need to properly manage show cave adventure cave geotourism, and also protecting the ecological values and scope for rare adventure that wild karsts embody.

Caves at Mole Creek and Gunns Plains have been famed Tasmanian beauty spots for more than a century while the Dismal Swamp polje has been developed as a surface karst tourism site in recent years. We look forward to visiting these places with you on the field trips, enjoying their splendour and discussing management issues and options with you.

The Conference Organising Committee members feel very privileged that His Excellency Honourable Peter Underwood, AC, Governor of Tasmania is officially opening the conference and that His Excellency and Mrs Underwood have accepted our invitation to visit Gunns Plains Cave after the conference opening.

Thank you for coming to Tasmania to participate in this conference. There is a great program of speakers and field trips. We hope you will enjoy the conference and your time in Tasmania. If there’s something you need our assistance with during the week, please ask one of the locals and we’ll try and assist.

– Conference Organising Committee

Acknowledgements - Support for the conference

The conference has not had the benefit of any sponsors or the backing of a government agency. We are grateful for the following individuals and organisations for their assistance.

- Julie Hawkins, *In Graphic Detail* for her design and donation of the conference logo.
- Geoff and Trish Deer, Gunns Plains Cave for complimentary admission to the cave.
- *Tasmanian Parks and Wildlife Service* for providing complimentary admission to the Mole Creek Caves and Rocky Cape National Park.
- *Forestry Tasmania* for providing complimentary access to the Tarkine Forest Adventures (Dismal Swamp polje).

- *Business Events Tasmania* has provided a small subsidy.
- *The Wilderness Gallery*, Cradle Mountain, has kindly lent its collection of photographic images of Kubla Khan Cave taken by Fred Koolhof. Thanks to the gallery manager, Tracy Thomas, for her assistance.
- The Ulverstone Surf Life Saving Club has provided us with a great venue and kind support. Our special thanks to committee member and clubhouse manager, Graeme Rollins.

We thank the following businesses and community groups that have provided accommodation, transport and catering for their friendly and helpful assistance:

- In Style Uniforms, Launceston
- McDermott's Coaches
- Beachway Motel
- Big 4 Holiday Park
- Ish Catering
- Anglican Womens Group, Ulverstone
- River Arms Hotel
- Togari Community Hall
- Graham and Michelle Gallaher, Tarkine Forest Adventures

We extend our thanks to Northern Caverneers members Stephen Blanden, Nic Haygarth, Janice March, Jean and Paul Van Nynanten, David Wools-Cobb and Jessica Wools-Cobb for their assistance with organising the Conference and leading associated caving trips. Thanks also to Deb Hunter from Mole Creek Caving Club for her assistance in various ways. We thank Linda Pittard for her kind assistance with re-visiting history in Marakoopa Cave. A special thanks to Joy Wools-Cobb for harnessing her creative talents into decorating our conference dinner venue.

Conference Photo, Ulverstone, Tasmania (Rauleigh Webb. photo)

List of delegates

(alphabetically arranged)

1. Jay Anderson
2. Ross Anderson
3. Ann Augusteyn
4. Peter Austen
5. Serena Benjamin
6. Steven Bourne
7. John Brush
8. David Butler
9. Dale Calnin
10. Deborah Carden
11. Peter Chandler
12. Libby Chandler
13. Professor Arrigo Cigna
14. Arthur Clarke
15. Marjorie Coggan
16. Daniel Cove
17. Travis Cross
18. Pat Culberg
19. Tony Culberg
20. Geoff Deer
21. Trish Deer
22. Kirsty Dixon
23. Peter Gazik
24. Peter Grills
25. Nic Haygarth
26. David Head
27. Nicholas Heath
28. Deb Hunter
29. Daniel Huth
30. Dr. Julia James
31. Geoff Kell
32. Sasa Kennedy
33. Moira Lipyeat
34. Greg Martin
35. Derek Mason
36. Ted Matthews
37. Mary Mccabe
38. Phillip McGuinn
39. Scott Melton
40. Jan Miller
41. Dr. Timothy Moulds
42. Dr. Anne Musser
43. Cathie Plowman
44. Barry Richard
45. Regina Roach
46. Catherine Sellars
47. Chris Sharples
48. Chester Shaw
49. Dave Smith
50. Andy Spate
51. Dianne Vavryn
52. Rauleigh Webb
53. Samantha Webb
54. Nicholas White
55. Anne Wood
56. Peter Wood
57. David Wools-Cobb
58. Celina Yapp

Part Time Attendees

59. Simon Ambrose
60. Stephen Blanden
61. Denna Kingdom
62. Ian Brumby
63. Michael Driessen
64. Rod Pearse