Caves, Cement,Bats and Tourists: Karst science and limestone resource management in Australia

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Caves, Cement, Bats and Tourists: Karst science and limestone resource management in Australia.

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Abstract: There is a long history of acrimonious disputes in eastern Australia between the conservation of caves and limestone (karst) landscapes and the extraction of limestone for industry. These disputes have often set legal precedents that have had important consequences in other areas of conservation. The disputes can be best understood as competition over a limited resource between users who hold conflicting world- views and value systems.

* Can these disputes, which have cost millions of dollars, be avoided in the future?
* Is it possible to achieve effective conservation and management of our karst resources **and** maintain an economically viable limestone industry?
* What should we do to rehabilitate abandoned limestone quarries?
* How do we avoid the environmental and engineering problems that can arise when urbanisation and infrastructure extends over limestone?
* How do we prevent recreational and tourist use of caves from causing irreparable damage?

These issues can only be resolved in the long term by political decisions, but such decisions will need to be informed by sound scientific advice.

Karst studies which could provide this advice are both fragmented and poorly developed in Australia. It is imperative for both economic and environmental reasons to expand and promote quality scientific research into Australia's karst and caves.

INTRODUCTION

Until late January this year I had very firm thoughts about the topic on which I would address you tonight, in fact, I had written a large portion of the text for an address "On the origin of limestone chambers" and was in the process of preparing illustrations. Events in the last week of January, however, resulted in a complete change of tack, so that I am now presenting an address about a highly politicised issue concerning the relationship between science, industry, government and the environment, rather than speculation about the origin of natural phenomena which I have always found somewhat puzzling.

On the 27th and 28th of January 1994 I attended a government enquiry in Adelaide into Sellicks Hill Quarry Cave as an expert witness for the Australian Speleological Federation Inc. This enquiry examined the most recent example of a land use conflict between cave conservation and limestone mining in Australia and illustrated in a microcosm a number of issues which have concerned me for some time, principally, how to balance the resource needs of Australia for limestone with the conservation and proper management of caves and other aspects of the karst environment developed in and on limestones.

FINDING AN OVERVIEW

Disputes between limestone miners and conservationists have often been understood as being about the relative values of resources and activities, such as are caves more valuable than miners' jobs, or is cement more valuable than bats?

In this discussion I have taken a different approach which seeks to understand karst management disputes, not only between limestone miners and conservationists but also between caving groups and karst managers, in terms of three key issues :-

* competition for a limited resource
* conflicting goals and values
* resource security.

Competition for a Limited Resource

One of the most important factors underlying disputes about limestone resource management in eastern Australia is that the disputes involve competition for a limited resource. This factor forms an essential part not only of disputes between conservationists and miners, but also of disputes between members of other competing user groups such as caving clubs.

There are three absolutely fundamental reasons why this is so, firstly limestone, caves and karst landscapes are, in human terms at least, limited and non-renewable resources, secondly the purest and therefore most economically valuable limestone forms the most extensive and most highly decorated caves and the most spectacular limestone karst landscapes, and thirdly limestone deposits close to major cities and transport routes are the most economical to exploit for mining, tourism and recreation. Thus all users and potential users of limestone and limestone landscapes are competing for the same limited, non-renewable, resource; high purity limestone in close proximity to transport and population centres.

It is competition for a limited resource that leads the the perennial issue among recreational cavers of which persons or groups should be allowed access to caves. Some cavers have argued that in order to protect the resource, people (usually , but not always, members of other groups) should be discouraged from taking up the activity. Recreational access to caves on public land in Australia has in many instances been controlled by permit systems operated on a "merit" basis (Hamilton-Smith, 1990). As a result member societies of the Australian Speleological Federation have secured, and jealously guarded, exclusive access to many caves. Conflict has resulted since the Australian Speleological Federation does not represent the majority of people involved in caving.

Secrecy has also been used by cavers to in an attempt to protect caves from vandalism and from damage by persons "lacking in merit". One example of this approach is the suggestion by Webb (1990) that the names and location of caves should be removed for topographic maps available to the public.

Conflicting Goals and Values

Competition for a limited resource would not be difficult to resolve if there was general agreement among the protagonists as to the goals and values on which the management of karst resources should be based. Disputes over karst resources involve competition over which group's values should form the basis of management. Although the public is most aware of disputes between limestone miners and conservationists, karst management has been plagued by disputes between; government agencies involved in resource conservation (e.g. national parks services) and those involved resource exploitation (e.g. mines departments) (Kiernan, 1993), the Australian Speleological Federation and other cavers, recreational users of caves and tourist users of caves, cave managers wishing to restrict access for conservation reasons and various groups wishing to gain access.

Each of these groups considers the limestone and its karst features to be important on the basis of different value systems. While miners and show cave operators both have a financial interest in the limestone, recreational cavers could claim to have a right to enjoy public assets, and that this should not be a privilege extended to certain groups on the basis of assumed "merit". Conservationists and some managers on the other hand hold that the integrity of the resource is the prime value.

Limestone and karst landscapes are thus competed for by those who seem them primarily as a financial resource to be exploited, those who see them as a recreational resource to enjoy, those who claim to have a scientific interest in them, and those who wish to preserve them in a state relatively unaffected by humans.

Resource Security (Tenure Issues)

The third issue common to all disputes concerning the use and management of limestone and karst landscapes is that of resource security. Resource security is generally discussed in terms of access to resources by primary industries and so we are used to hearing resource security raised as an issue by the forestry and mining industries. Resource security, however, is an important issue in all areas of karst management and it

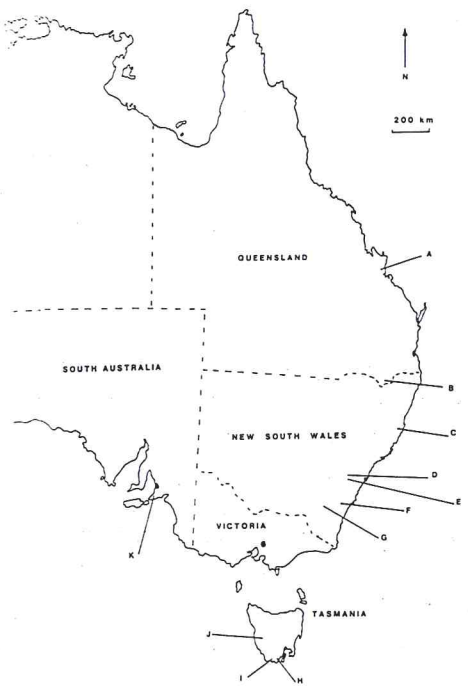

Figure 1:- Eastern Australia:- A, Mt. Etna; B, Texas Caves; C, Yessabah; D, Jenolan Caves; E, Colong Caves; F, Bungonia; G, Cave Island; H, Ida Bay; I, Precipitous Bluff; J, Gordon-Franklin Karst.

has been the desire for secure access to resources or for security for resources from access by other users that has lain at the heart of many environmental disputes concerning limestone.

Limestone miners would expect that once they obtained a mining lease they would be able to pursue their mining plan without disruption or interference. In a number of the disputes I will discuss later, for example Mt. Etna and Ida Bay, this has not been the case.

Similarly conservationists would expect that once a karst area was dedicated as a "Reserve for the Preservation of Caves", activities which damage or destroy caves would not occur. Caves reserves in New South Wales, however, are not exempt from mining title, with mining occurring in the reserves at Wellington and Wombeyan Caves. This issue was central to the Colong dispute of the 1960s. The desire for resource security was also a central factor in the decision by conservationists to take legal action in the case of Yessabah Caves, New South Wales. The current situation in most parts of Australia is that resource security for purposes other than mining, only exists in the case of limestone areas in National Parks where in some states it is clear that mining is prohibited.

Resource security also plays a role in tensions between recreational cavers and management authorities, with cavers wishing to maintain traditional access to caves and some cavers feeling that they have a degree of ownership over caves which they have discovered or initially explored. Management authorities, however, feel that their duty to protect the caves from damage, and their undoubted legal responsibilities outweigh any traditional use rights or rights that come from discovery and exploration.

ENVIRONMENTAL DISPUTES OVER LIMESTONE MINING

There is a long history of landuse disputes in eastern Australia over use of limestone for extractive purposes and the conservation of karst caves and their fauna. The history of these disputes has parallelled the growth of conservation movement in Australia and the outcomes of these disputes have had repercussions for environmental practice and law in areas far broader that cave conservation.

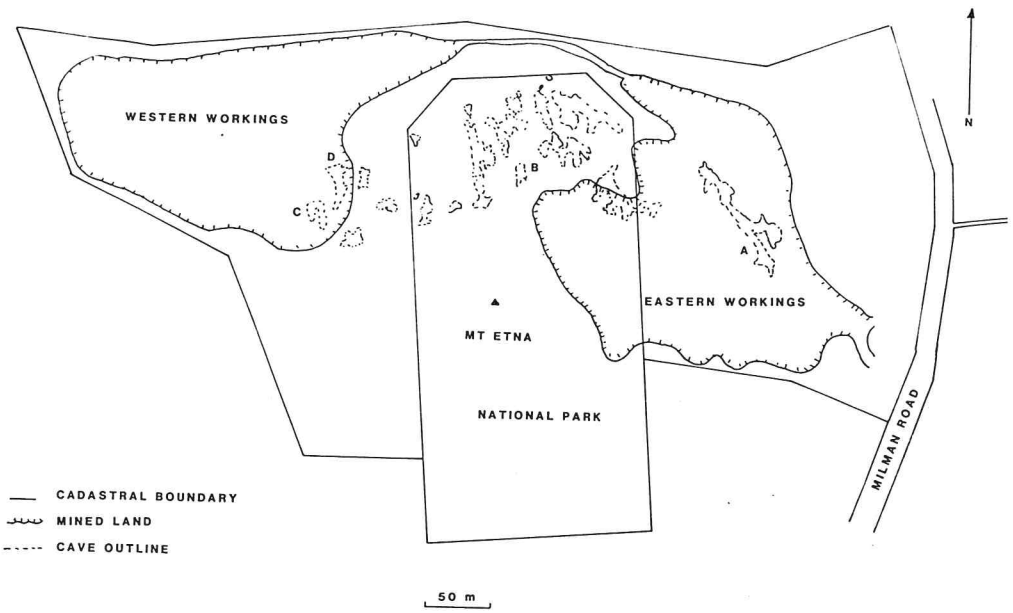

Figure 2:- Mt.Etna, Queensland:- A, Resurrection Cave; B, Bat Cleft; C, Elephant Hole; D, Speaking Tube.

Mt. Etna, Queensland

By far the longest-running and most acrimonious dispute in Australia has centred on Mt. Etna, a conical limestone hill, 25 km north of Rockhampton in Central Queensland (Fig. 1, A). Leases were issued over parts of Mt. Etna in 1962 and mining commenced on its eastern face in 1966.

In April 1967 the mine intersected a blind cave which became known to the cavers as Resurrection Cave and the miners as Quarryman's Cave (Fig. 2, A). An agreement was reached, and has been honoured, that this cave would be preserved in future mining activities. Other restrictions, such as not mining within 66 feet (20 m) of a cave entrance were placed on the operation, but were lifted in 1988 when the company surrendered 13 ha of the central part of Mt. Etna from it leases which became a reserve and later National Park to protect Bat Cleft (Fig. 2, B). Mining operations moved to the western side Mt. Etna in 1970 and operations on the eastern face ceased in 1975. Mining on the western side of the mountain destroyed Crystal Palace Cave in 1982.

Mining at Mt. Etna has been strongly opposed by conservation groups since its inception and a variety of actions have been taken stop the mine's operation including several legal actions, listing of the caves on the Register of the National Estate, filling drill holes with cement, obtaining support from the International Union for the Conservation of Nature and Natural Resources and numerous media campaigns. A number of publications including Sprent (1970), and Anon (1988) were produced during the course of the dispute.

In 1989 a major legal and protest campaign was launched to protect Elephant Hole (Fig. 2, C) and Speaking Tube (Fig 2, D) Caves from being destroyed by the western workings. This involved highly publicised sit-ins in caves adjacent to the quarry, police action against protesters and appeals to international conservation bodies.

Legal action to protect the caves on the basis that either they were the "nest" for ghost bats or that mining would harm the bats themselves was undertaken by the Central Queensland Speleological Society. The Society first had to show that it had standing in the matter. This led to an appeal to the High Court of Australia. On May 26, 1989, after proceedings had been remitted to the Supreme Court of Queensland, Mr. Justice De Jersey ordered the plaintiffs to deposit $ 45,000 with the court as security against the defendant's costs; this could not be raised and the action lapsed.

The dispute left behind a highly divided community and had a significant social impact, as many cavers and mine workers are neighbours in the small village of The Caves. In spite of this, current events at Mt. Etna suggest that new approaches to dealing with environmental disputes over limestone mining may be developing. Under new ownership Central Queensland Cement Ltd. has now included members of the Speleological Society on its committee to advise on the rehabilitation of the eastern mine workings and I have undertaken consulting work for the Company to ensure that rehabilitation work does not damage Resurrection Cave.

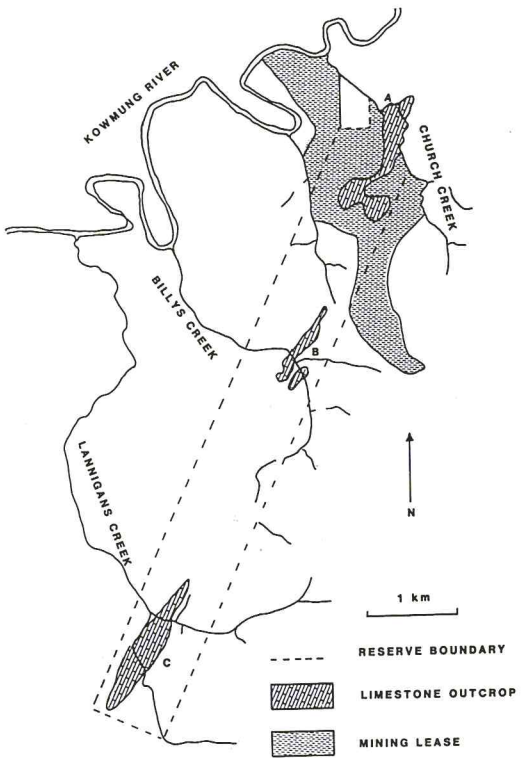

Figure 3:- Colong Caves, New South Wales after Middleton (1969):- A, Church Creek Cave; B, Billys Creek Caves; C, Colong Caves.

Colong, New South Wales

In January 1967 (Middleton, 1969) the New South Wales Government announced that it would grant a mining lease at Church Creek (Fig. 1, E) within the area of the then proposed Kanangra-Boyd National Park and within land reserved in 1899 for "the Preservation of Caves" (Fig. 3) . This action resulted in the so-called Colong dispute and led to the formation of the Colong Committee, now Colong Foundation for Wilderness, which continues to be an active lobby group. One practice that developed during this dispute was to name caves after politicians, a practice used with some

controversy in the Franklin Dam dispute (see below). In the end the limestone was not mined, the mining leases were cancelled and the land incorporated in Kanangra-Boyd National Park.

Bungonia, New South Wales

In 1970 applications for mining leases were made at South Marulan (Fig. 1, F), north of Bungonia Canyon, near the site of the present South Marulan Limestone Quarry (Middleton, 1972) (Fig. 4). Objections to the leases were made by the Colong Committee and Mr. W.J. Counsell. At a hearing of the Mining Wardens Court in 1971 the objectors and their expert advisors were able to present evidence, making this the the first time that environmental groups had access to mining tribunals and first time that scientific experts (one of whom is a current Council Member of this Society) were used by environmental groups to develop alternative mining plans.

The Colong and Bungonia disputes made members of the caving fraternity in New South Wales aware of the need to document karst areas which they wished to preserve and resulted in the production of *Sydney Speleological Society Occasional Paper No 4* (Ellis *et .al* . 1972) which for the first time presented an overview of a karst area in New South Wales, including cave maps, in a bound volume available for public sale. Concern about conservation and mining issues at Timor Caves, near Scone resulted in a similar publication (James et. al. 1976).

Precipitous Bluff, Tasmania

Precipitous Bluff rises 1200m above sea level, just 2 km from the sea, on the

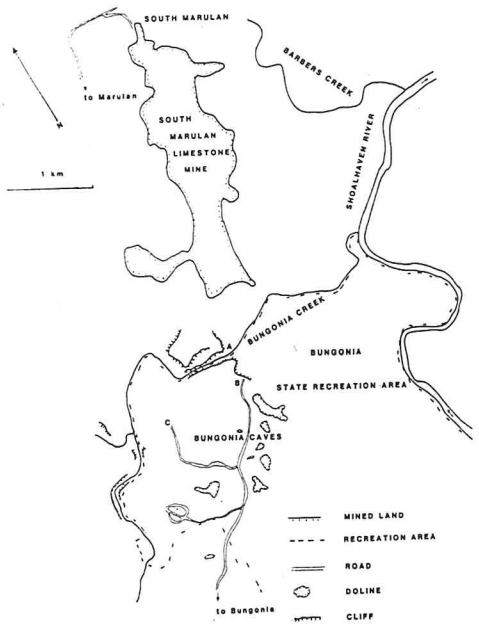

Figure 4:- Bungonia Caves and South Marulan Limestone Mine, New South Wales:- A, Bungonia Canyon; B, Bundonia Lookdown; C, Adams Lookout.

remote southern coast of Tasmania (Fig. 1, I). The Bluff consists of a cliff-lined edifice of Jurassic dolerite overlying the Ordovician Gordon Limestone (Fig. 5).

In December 1971 application was lodged for a Prospectors Licence over the limestone at Precipitous Bluff (Wessing, 1979). The National Parks and Wildlife Service and a number of conservation groups objected to the application which was heard in the Devonport Mining Wardens Court in December 1972. The applicant claimed that the conservation groups lacked standing in the case while the National Parks and Wildlife Service was prevented from appearing by the newly elected (Labor) state government. The Mining Warden, however, decided to hear the conservationists case. The applicant appealed to the Tasmanian

Supreme Court which held in June 1973 that the conservationists did not have a legal interest in the area and ordered that their objections be struck out. An appeal by the conservationists in 1975 was unsuccessful and Tasmania Supreme Court's judgment was upheld.

Despite the legal decisions of the 1970s Precipitous Bluff was never mined and is now part of the Southwest Tasmania World Heritage Area.

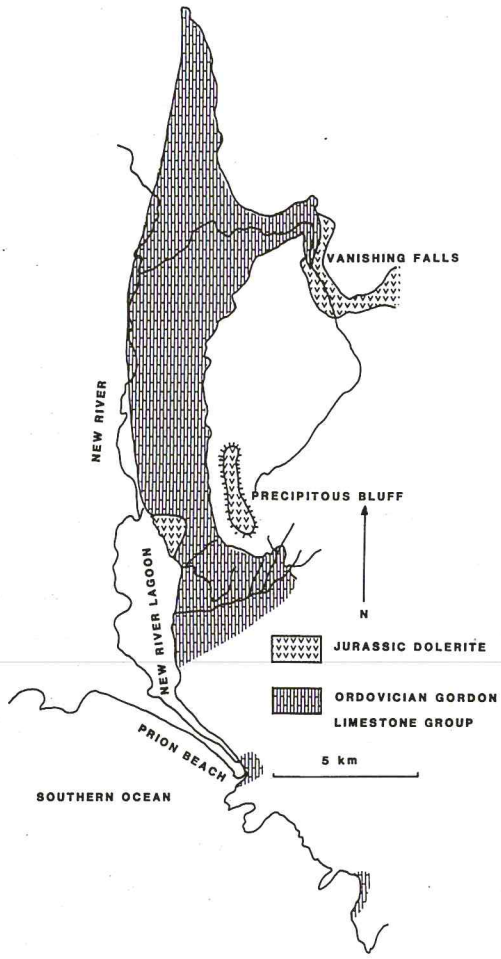

Figure 5:- Precipitous Bluff, Tasmania after Eberhard *et. al.* (1992).

Yessabah, New South Wales

A relatively small mine for agricultural lime operated in the Recreation Reserve at Yessabah Caves, near Kempsey, New South Wales (Fig. 1, C) between 1923 and 1991. The mine is directly adjacent to an area of intensely karstified limestone covered by significant dry rainforest and containing an important bat roosting cave, (Fig. 6). In 1980s the mining lease lapsed and in 1986 a new lease was granted which covered most of the karst area. This lease was later withdrawn and a period of complex negotiations and lobbying followed during

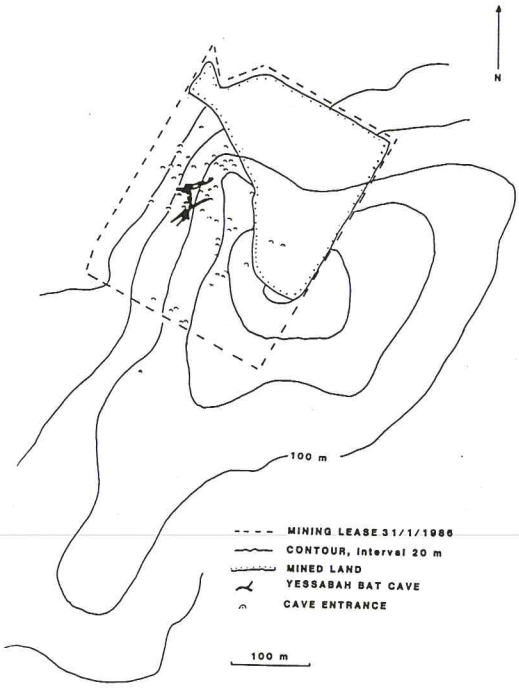

Figure 6:- Yessabah, New South Wales

which various proposals were made which would have restricted the area available for mining.

In 1990 Mr. K.G. Vaughan-Taylor began legal action to to require the miners, David Mitchell-Melcann Ltd., to prepare an environmental impact statement and obtain planning permission. As the legal action proceeded in 1991 the likelihood that mining might do harm and that the mining was likely to significantly affect the environment was conceded by the mining company and the Minister and the case concentrated on two legal issues (Larkin, 1992):-

> Was the mining company entitled to expand the mine laterally and double output without planning approval and therefore an environmental impact statement ?
>
> Was the Minister entitled to grant a mining lease without there being an environmental impact statement for him to consider ?

In June 1991 the Land and Environment Court ruled that mining at Yessabah could continue without an environmental impact statement, but only at a rate of 18,000 tonnes per annum, far short of the Company's mining plan. The case went to appeal and on Friday November 15, 1991 three judges in the New South Wales Court of Appeal ruled that an environmental impact statement was required before the Minister could lawfully grant a new mining lease and that existing use rights only applied to land "actually and physically used" for mining in the past. An injunction was issued preventing further mining until the mining company and the Minister had complied with their legal obligations. This ruling has resulted in the abandonment of mining at Yessabah.

Exit Cave and the Lune River (Bender's) Quarry, Tasmania

Exit Cave near Ida Bay, Tasmania (Fig. 1, H) is the largest cave developed in lower Palaeozoic limestone in Australia and is thought to consist of some 40 km of cave passages. Exit Cave lies just within the South West Tasmania World Heritage Area. Limestone mining at Lune River Quarry, directly north of Exit Cave (Fig. 7, A), became highly controversial in 1990 when water tracing experiments indicated that there was a direct hydrological connection between Exit Cave and the mine (Fig. 7, B). Detailed investigations in November 1991 (Kiernan, 1993) confirmed the connection. A complex series of protests, political actions and state/federal interactions resulted in the mine being closed in October 1992. Rehabilitation of the mine site is now largely complete.

Sellicks Hill, South Australia

At Sellicks Hill Quarry, 50 km south of Adelaide (Fig. 1, K), dolomite is extracted largely for use as high quality aggregate. In September 1991 the mine intersected a large cavity. On the invitation of the operators, Southern Quarries Pty Ltd., members of the Cave Exploration Group of South Australia explored, mapped, and made a video of the cave. The cavers signed a legal document agreeing to keep information concerning the cave secret.

On the tenth of December 1993 the largest chamber of the cave was blasted, using a blast pattern based in part on information obtained from the cavers' map.

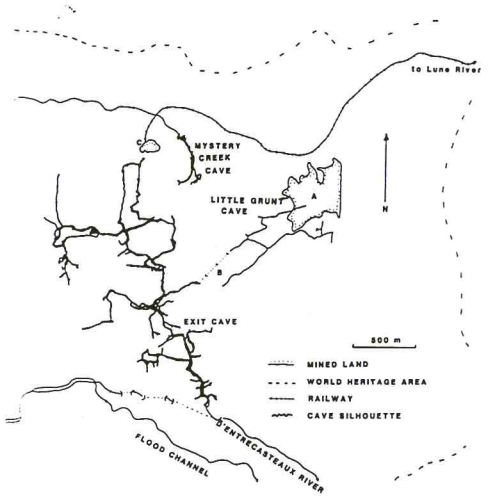

Figure 7:- Ida Bay, Tasmania after Kiernan (1993):- A, Lune River (Bender's) Quarry; B, Hydrologic connection confirmed by water tracing; C, Old Lune River Quarry.

Following the blast the cavers made information about the cave and its unusual aragonite speleothems public, resulting in considerable media and political interest. In January 1994 a closed government enquiry was held into the likely condition of the cave before and after the blast.

Currently the Australian Speleological Federation Inc. is taking legal action in an attempt to protect the cave and a member of the Cave Exploration Group of South Australia has been threatened with legal action for libel by the mining company.

PREVENTING AND SOLVING DISPUTES OVER LIMESTONE MINING

Given the number and severity of the disputes that have arisen between limestone miners and conservationists over the last 25 or so years, and the potential for disputes to arise in the future, there is clearly a need to devise policies and practices that will produce a balance between the need to extract carbonate rocks and the preservation of karst environments.

Preventing Disputes

The factors outlined before indicate that karst resource management will always involve conflicts of interest, however it is not inevitable that these conflicts will become acrimonious and the focus of intense media, political and legal activity. Two measures that will assist in developing less emotional and costly disputes are simply to ensure that proper data is available and to open lines of communication between the different interested parties.

Ensuring Proper Data is Available

Resource information for the limestone industry has been traditionally provided by state geological surveys and departments of mines. This work has been collated into major volumes such as Connah (1958) for Queensland, Carne & Jones (1919) and Lishmund *et. al.* (1986), for New South Wales and Hughes (1957) for Tasmania.

Given the times at which most of these works were produced one it would not be surprising if they contained little information about karst features or the environmental values of the deposits they describe. The two editions of *Limestone Deposits of New South Wales*, however show and unexpected and quite worrying trend. Carne and Jones contains much detail about the caves developed in the State, no doubt influenced by the participation of Oliver Trickett in the project.

The comments about karst features

and environmental issues in Lishmund *et al.* are somewhat surprising for a work published in 1986. There is no reference whatsoever to any scientific literature on Australian karst. This is gravely concerning given that one of the founders of modern karst geomorphology, J.N. Jennings (1916-1984), lived and worked in Canberra from 1952 until his death, published on the karst of New South Wales in local and international journals, and produced an introductory text (Jennings, 1971) which cited many examples from New South Wales. Also a refereed Australian scientific journal, *Helictite*, devoted to cave science, and containing numerous papers on the limestone deposits described by Lishmund *et al.*, has been published regularly since 1962.

Although there have been a number of officers in state mines departments who have extensive knowledge of karst issues (e.g. G.R. Wallis, see Wallis, 1976) there have been few occasions where this expertise has been brought to bear on cases involving conflict over mining and karst conservation (one outstanding exception being Wallis' work at Wombeyan, Wallis, 1965).

Standard works and journals on karst are rare or absent among the volumes in mines department libraries and papers in general scientific journals concerning karst are often not referenced in departmental data collations about limestone deposits.

Limestone miners and mines department staff are thus not necessarily alerted to environmental issues concerning potential limestone mining localities. Expanding the information base available to miners and mines administrators is an essential first step in defusing potential disputes between miners and conservationists over karst. No mines department library should be without a copy of the *Australian Karst Index* (Matthews, 1985), a subscription to *Helictite* and as a minimum a copy of *Karst Geomorphology* (Jennings, 1985) and works on the environmental management of karst such as *The Management of Soluble Rock Landscapes* (Kiernan, 1988).

Opening Dialogue

Frequently mining company decision makers and leading conservationists only see each other in the media or on the steps of the courthouse, neither setting being very conducive to constructive dialogue. It would seem to be very beneficial if a forum could be developed at which issues of limestone resource management could be discussed in a non-confrontational manner. Such a forum should involve representatives of the Australian Mining Industry Council (or state Chambers of Mines) and the Australian Speleological Federation Inc., and could possibly be expanded to include representatives of government agencies concerned with mining and nature conservation.

Initial steps in this direction appear to be underway in New South Wales where dialogue between the Australian Speleological Federation and the Chamber of Mines is imminent. This is an important positive step in improving the management of our limestone resources.

The Environmental Assessment Process

Environmental planning laws in some

Australian states require that an environmental impact statement is prepared for all major developments. Where such requirements exist, limestone mining is usually of such a scale as to require the preparation of an E.I.S. One of the problems with this process is that environmental, conservation and heritage legislation in most states is designed to protect flora, fauna, Aboriginal and European cultural heritage items and lacks specific references to non-living (abiotic) heritage such as geological sites and karst. At present there is no guarantee that karst will be properly addressed (except as an environment for bats or other vertebrates or as a substratum for particular floras) in the environmental assessment process.

Environmental studies prior to limestone mining should include extensive investigation of the hydrogeology of the karst, of the surface karst landscapes and, in particular, should focus on the presence or otherwise of any inter-linked systems of cavities. A major part of such studies should consider the likely effects of any mining activity on the environmental and heritage significance of any cavity system and its contents.

Environmental plans and regulations designed to apply to non-karstic environments can have unexpected bad consequences when applied to limestone areas. This has been highlighted in the case of Sellicks Hill, South Australia where regulations designed to reduce the visual impact of mines on the Adelaide Hills resulted in the mine being sited in a valley between two limestone hills, a locality where the was a greater than average chance of the mine intersecting cavities.

Is is essential that karst and other non-living natural heritage items gain the status afforded to flora, fauna, Aboriginal and built cultural heritage items by being given specific reference in environmental planning legislation and procedures, and that planning regulations are assessed to ensure that they do not cause unintended damage to karst environments.

Monitoring of Mining

Standard procedures for the environmental monitoring of open cut mines may not be appropriate in the case of limestone mines operating in or adjacent to cavernous limestone. The complexity and conduit nature of karst aquifers mean that there are special risks of pollution and hydrological disruption that do not exist when mines operate in rocks that are either insoluble or granular aquifers.

Officials charged with responsibility for inspecting and monitoring mines in limestone should be provided with special training in the karst process and in the environmental management and monitoring of soluble rock landscapes.

The Problem of Chance Intersections

Even with the most exhaustive pre-mining studies, mines in limestone are likely to intersect cavities whose presence was unexpected. Presently operating mines for which prior studies were not carried out are very likely to intersect cavities. Intersection of

unexpected cavities by mines is one of the most difficult issues in limestone resource management.

Hearsay evidence, and material observed in mine waste dumps, would suggest that operating limestone mines frequently intersect cavities containing vertebrate fossils and speleothem, and on occasions major hydrological conduits. There have been few occasions where scientists have been permitted to study vertebrate fossil deposits exposed in mines (one case being at Wombeyan Caves, Hope, 1982) or where miners have attempted to preserve fossils by storing fossil bearing muds in separate stockpiles (as D. Kime has done at Mt. Etna).

It would appear that the, entirely understandable, reaction of many mine operators is to quickly fill, remove or otherwise destroy cavities intersected by mining so as not to run the risk of significant and costly interruption to mining. This reaction undoubtably results in the loss of significant information of scientific value and may also result in the loss of heritage items of great value to the community.

A fair and workable approach to the problem of chance intersections would involve a process of compulsory reporting, rapid appraisal, high quality and quickly undertaken scientific study, documentation and where appropriate salvage and, in cases where features are of extremely high value, restriction of mining in exchange for appropriate and fair compensation.

Solving Disputes

Legal Solutions

Mt. Etna in Queensland and Yessabah in New South Wales are two examples where legal processes have been used as a means of resolving disputes between conservationists and miners. In each case the outcome was different, Mt. Etna favouring the miners and Yessabah favouring the conservationists, however, on reflection, both cases illustrate the problems inherent in using the law to settle environmental disputes.

Firstly such legal actions are extremely costly as illustrated by the order for security for costs in the Mt. Etna case; $45,000 was to be set aside to cover the defendant's costs up to and including the first day of the trial. The cost of legal action can not only make legal action inaccessible but can also prove economically disastrous to the losing side

Secondly, legal procedures tend to explore legal issues rather than environmental or resource management issues. In the Mt. Etna case the environmental evidence was never heard because the case did not proceed to trial, while in the Yessabah case the matter was decided on legal grounds and so the environmental evidence was never subjected to the scrutiny of cross examination. Thus neither case resolved the truth or otherwise of the environmental, economic and resource management assertions being made by the disputing parties.

A third major limitation of legal processes is pointed out by Larkin (1992). Environmental law is more concerned with how decisions are made, rather than with the outcome of the decision making process. The role of the courts in general is to ensure that proper and informed decisions are made by

those entrusted by law with the responsibility of decision making, e.g. ministers and executive government, not to make decisions in their place. Thus if a court rules that a decision has been made incorrectly, it is possible to start the process again in a correct manner, resulting in exactly the outcome that the legal action was intended to halt.

Legal solutions lack certainty for other reasons. Most environmental law gives great discretionary powers to ministers, and parliaments can enact legislation to overrule court decisions, thus winning the court battle does not, necessarily result in the victor's cause prevailing. It is probably true to say that the success of Vaughan-Taylor's court action in preventing expansion of mining at Yessabah was due more to the volatile nature of the New South Wales Parliament, where independent members held the balance of power, than to any inherent advantages of seeking a legal solution.

Political Solutions

Many more limestone resource disputes have been resolved by political means than by any other. Political solutions have three advantages over legal solutions; firstly they are nowhere near as expensive as legal solutions, secondly they are more likely to result in the losing party gaining some form of compensation or trade off as a result of whatever decision is reached, and thirdly political decisions frequently result in resolutions that provide a high degree of security of tenure for the particular land use favoured by the decision.

Historically these advantages have worked to the benefit of both miners and conservationists. Colong Caves became part of a national park, the South Marulan quarry opposite Bungonia Caves is highly unlikely to be closed prior to the end of its planned working life, Precipitous Bluff is in a World Heritage area and the former operators of the Lune River Quarry have received a compensation package.

Negotiated Solutions

There are no examples of disputes over limestone mining which have been resolved principally by negotiation. In both the Mt. Etna and Yessabah cases there were attempts at negotiation, but these were in a climate of litigation where success was unlikely. It is difficult to see how a negotiated solution could take place outside a framework of litigation unless there were active government involvement, as conservationists have little to offer miners in return for concessions except for good publicity and support for environmentally friendly projects.

Involvement of conservationists through the public decision making process in environmental planning and, as is the current case at Mt. Etna, in decisions about mine rehabilitation do, however, offer an opportunity through which negotiated solutions might be possible. Furthermore should dialogue open between miners and conservationists there is hope that in the future disputes about the merits of mining or conserving limestone resources may be settled through negotiation rather then through legal or political confrontation.

LIMESTONE MINE REHABILITATION

The rehabilitation of limestone mines is becoming a significant issue in eastern

Australia. A number of large mines have ceased, or will soon cease, production, some for economic reasons and some for environmental reasons. How such rehabilitation should be carried out is a new issue for Australia and one in which the international literature is of fairly recent origin.

Doing nothing

From studies I have carried out over the last twelve months it has become clear that doing nothing is not a good management approach for abandoned limestone mines.

Abandoned mines where no rehabilitation has occurred are frequently overrun by exotics such as Blackberry, Lantana, Briar Rose and Tree of Heaven. Vine and cane type exotics such as blackberry and lantana appear to have a great advantage in these areas as they are able to spread from small isolated soil pockets over large areas of bare rock. Where this has not occurred eg. Old Lune River Quarry, Tasmania (Fig. 7, C) and Pilkinton's Quarry at Mt. Etna, Queensland only sparse revegetation by native pioneer species has occurred.

Natural vegetation on karst areas largely depends on talus containing fines, sediment-filled cavities and open joints for its support . Some species (e.g. figs and kurrajongs) are able to send roots great distances down open joints in order to obtain water. In abandoned mines many of these niches for vegetation have been destroyed. Mining generally removes the outer zone of rock where joints are open and small solution cavities which trap soil are common. Machinery working on benches tends to compact sediment in exposed cavities making it unsuitable for vegetation.

In most mines where there has been revegetation by native species a particular pattern, shown in Figure 8 can be observed:-

a. A zone of bare rock and compacted gravel occurs between the base of talus cones and the disturbed edge of benches. In this zone water often ponds and mosses, sedges and reeds may grow. If ponding does not occur and /or there are no voids or clay masses in the rock, the bench zone will remain as bare rock for decades after the cessation of mining.

b. Plant growth on talus slopes is controlled by the presence of non-limestone fines (usually silt and clay derived from cave sediment bodies intersected by the mine). Vegetation will grow on talus slopes containing fines, but not on those composed of pure limestone rubble.

c. Joint-penetrating species such as kurrajongs and figs are very slow to revegetate abandoned mine areas.

Revegetation

If abandoned limestone mines are unlikely to satisfactorily revegetate of their own accord then it is necessary to actively revegetate them. Because limestone mine

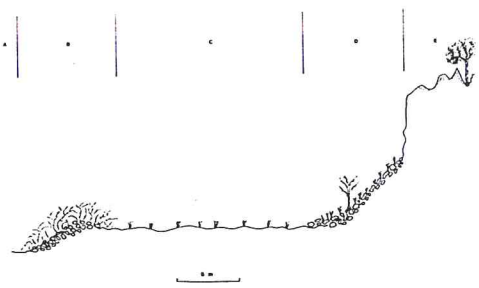

Figure 8:- Revegetation zones on limestone mines showing an idealised profile across a single bench limestone mine.

A partly disturbed zone at edge of quarry.

B Rubble zone at edge of bench with brambles such as lantana and blackberry.

C Bare zone on bench surface, poorly vegetated with reeds and sedges.

D Talus cone, supports small trees and grass where fines are present.

E Undisturbed karst landscape with cacliphile trees such as figs and kurrajongs.

benches are an inhospitable environment for most plants it is essential that seed-bed material containing fines is applied to them. Care must be taken that this material is sterile and it is preferable to use clay waste from the mine itself, rather than to import fines.

There has been some concern expressed about the likely impact of fines laid on quarry benches on the underlying karst system and, clearly, action must be taken to ensure that the fines are retained and do not wash into the underground drainage system. Planting in drill holes also has considerable potential, particularly if the holes intersect joints. From my observations of abandoned mines it is unlikely that revegetation will be successful unless fines capable of holding moisture are provided.

Finding Alternate Landuses

Abandoned limestone mines have been put to a number of uses some of which are good alternatives to revegetation while others are quite unsuitable. Many small abandoned limestone mines have been used as tips for domestic and commercial waste. This is a very bad practice as effluent from the waste can directly enter the karst groundwater system, causing intractable pollution problems.

One very aesthetic use of an abandoned mine is found at Taree, New South Wales where the Chatham Quarry, (see Carne & Jones, 1919 Plate facing page 274) which has filled with water, now forms an ornamental lake in a retirement housing complex. Western's Quarry at Wingham New South Wales (Carne & Jones, 1919, p 273) is now the site for a Sports Complex which includes a velodrome and go cart track. One less environmentally-friendly alternate use is found at the large abandoned limestone mine at Brogans Creek, New South Wales which is used as a film set for scenes involving flammable liquid fires.

Secondary (Restoration) Blasting

One of the most controversial issues in limestone mine rehabilitation involves techniques developed in the United Kingdom called "secondary" or "restoration" blasting. These techniques, pioneered by John Gunn and his associates (Gagen & Gunn, 1988, Gunn & Bailey, 1991), use explosives to reshape limestone mines either after

extractive working has ceased, or at a final stage of the mining process. The objective of these techniques is to produce a post-mining landscape that resembles natural karst features, rather the leaving the mine landscape of faces and benches intact.

"Restoration" blasting is particularly suited to the U.K. where broad limestone valleys lined by cliffs with talus slopes at their base are common features of karst landscapes. This type of landform is rare or absent in eastern Australia restricting the applicability of "restoration" blasting.

These techniques were proposed at Lune River Quarry in Tasmania but rejected due to opposition by some conservation groups to the use of explosives. I have suggested that these techniques could be of benefit at Mt. Etna and would go some way to restore the original volcano-like profile of the mountain's eastern face, however there is no indication as yet as to whether these techniques will be used or not.

Earthworks (non-explosive) and Revegetation

Recent restoration work at the Lune River Quarry in Tasmania has seen the development of techniques to prevent mud from entering stream sinks in the mine floor. These techniques are an important advance in limestone mine rehabilitation and are a great credit to those involved.

INFRASTRUCTURE AND KARST

Dams

Karst landscapes with their complex underground drainage systems pose significant problems for dam construction. Dam construction can also result in the inundation of karst areas and cave systems. The best documented cases of karst being inundated in eastern Australia are Cave Flat in New South Wales, now forming Cave Island in Burrinjuck Dam (Fig. 1, G), and Texas (Viator Hill) Caves in Queensland (Fig. 1, B) now inundated by the Glenlyon Dam. Both Cave Flat (see Osborne, 1991) and Texas Caves (Grimes, 1978) are recognised vertebrate fossil localities.

Caves of the Gordon-Franklin River system in Tasmania (Middleton, 1979) (Fig. 1, J) were threatened with inundation by proposed hydroelectric dams on the Franklin and Lower Gordon Rivers. The presence of Pleistocene archaeological material in these caves played a major role in the dispute which was finally resolved as a result of the 1983 federal election when the newly elected Labor Commonwealth Government used foreign affairs power to prevent construction of the dams and protect the South West Tasmania World Heritage Area.

Roads

Road failure is a common problem in karst areas. Of particular concern is sinkhole failure where withdrawal of fines from filled dolines can cause rapid and catastrophic failure. Kiernan (1988) describes a number of such events at Mole Creek in Tasmania, while the most significant recent event in New South Wales involved the failure of the Snowy Mountains Highway near Yarrangobilly Caves in 1986.

Many of these problems can be avoided if appropriate geotechnical surveys are carried out prior to road construction and if drainage is designed to prevent inflow of

water into sediment-filled cavities.

Forestry

Forestry can have a severe impact on karst regions in that it can cause significant amounts of erosion, lead to ground instability, alter infiltration rates and change soil and groundwater chemistry. The impact of forestry operations on karst has been a particular issue in Tasmania with significant forestry operations being undertaken in the Mole Creek and Florentine Valley karst areas. Tasmania is unique in having two karst specialists, K. Kiernan and R. Eberhard, employed by its Forestry Commission.

In New South Wales there has been particular concern about the effects of pine plantation forestry in the catchment of the Jenolan River upstream of Jenolan Caves (Fig. 1, D). Detailed studies of the effects of pine forests on limestone caves are being undertaken by K. Kiernan in Tasmania and by A. Spate in New South Wales.

High Tension Lines

High tension lines and their associated access roads can have a significant impact on karst landscapes. During the construction phase erosion increases and surface karst landforms may be destroyed by heavy vehicles. The Mt. Piper to Marulan 5,000 KV line was deviated near Wombeyan Caves in New South Wales to minimise impact on the karst. An example of the unsightly effects of power lines on karst can be found at Rosebrook, near Cooma in southern New South Wales where poles are set into a karst field.

URBANISATION AND KARST

There had been little urbanisation of karst in eastern Australia until quite recently. Karst areas in South and Western Australia have been urbanised for a considerable period of time, the most significant examples being Mt. Gambier in South Australia and the dune limestone areas surrounding Perth in Western Australia.

This situation is now beginning to change. Both small holdings and suburban blocks are currently expanding over limestone areas near Taree in New South Wales and at The Caves, near Rockhampton in Queensland. This has significant implications for resource sterilisation, environmental impact and engineering. Planning controls are urgently needed in these areas to protect viable limestone resources from sterilisation, home owners from foundation failure and the environment from pollution and the possible loss of significant features.

TOURISM, RECREATION AND KARST

Tourists and recreational cavers; like miners, engineers, foresters and householders are users of karst who have a significant environmental impact. Although their use of karst is in conflict with that of limestone miners, and despite the significant contribution made by cavers to conservation, recreational and tourist users have a significant impact on the karst environment.

Show Caves

The ongoing impact of tourists using developed show caves is to a large extent controlled due to the massive modification of

show caves undertaken during their development. This "hardens" the environment reducing future breakages, wear and entrainment of mud. Despite this tourists visiting show caves have an impact by introducing lint and altering the composition of the cave atmosphere. Tourists introduce garbage, spores and foreign microorganisms and the lighting systems in the caves allow the growth of algae and moss (so called *lampenflora*) and heat the cave atmosphere.

Cleaning of show caves to remove lint and introduced dirt, now mainly carried out by high pressure washing, erodes the surface of speleothems and has the potential to destabilise mud substrata on which the speleothems have been deposited. An important issue in the management of show caves is thus how to determine the carrying capacity of the cave. Studies to explore this issue are currently underway at Jenolan Caves.

"Wild" Caves

Recreational cavers who use "wild" caves to which have few if any changes have been made, have a significant impact on the caves they use. These impacts include; accidental breakage of speleothems, wear of limestone surfaces, entrainment of mud and in the worst cases deposition of litter and outright vandalism. An excellent review of these issues is provided by Spate and Hamilton-Smith (1991) who begin by stating that:-

> "We have long held that caves, their contents and values are more at threat from cavers and their activities than they are from the activities of quarry operators and other users, or abusers of karst areas."
>
> [Spate & Hamilton-Smith, 1991, p 20]

Clearly the impact of recreational cavers can, and has been, reduced by education, training, developing a conservation ethic, installing track markers and restricting access to caves or parts of caves considered to be particularly fragile. The desire to explore is, however, in the nature of people going caving and this means that cavers impacts, unlike those of tourists are not easily restricted to a single pathway.

If recreational used of "wild" caves is to continue then agreement needs to be reached among all users as to an overarching system of values or ethics, appropriate training standards for leaders and how access and use of a limited resource might best be managed. It is becoming clear that if this does not occur managers may exercise their duty to protect the caves in their care in ways that will severely restrict recreational caving activities.

INCREASING SCIENTIFIC UNDERSTANDING OF AUSTRALIAN KARST

Central to any improvement in the way we manage, conserve and exploit the limestone and karst resources of Australia is an improvement in our understanding of all fields of science as they relate to karst. Karst research in Australia is currently fragmented and underfunded, in fact the largest single recent grant to any individual researcher related to caves has been for a study of the history of cave science in Australia. Karst research also has a major image problem, being seen by science administrators as not being relevant or as being somehow sullied by

its association with caving as a recreational activity.

Nevertheless workers and graduate students in academic, scientific and government agencies in Australia, frequently working in isolation, are undertaking high quality research into the biology, chemistry, geology and geomorphology of karst.

What is needed is an institutional focus for karst studies where a multidisciplinary research group above critical mass can be established, where a library of publications, maps and a data bases can be assembled and where graduate students can work knowing they will have access to appropriate supervision and facilities. The institution could take the form of a centre or key centre at a university or it could be a research institute attached to a museum at a major tourist venue such as Jenolan Caves. Karst research needs much more support from government, the show cave industry, research funding bodies and from the mining industry.

We can manage our limestone resources better and it is possible to both extract limestone as a mineral commodity, use caves for tourism and recreation and conserve significant karst landscapes and their ecosystems for posterity. To achieve this we require better basic data, workable decision making processes and a willingness on the part of all involved to communicate and take responsibility.

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