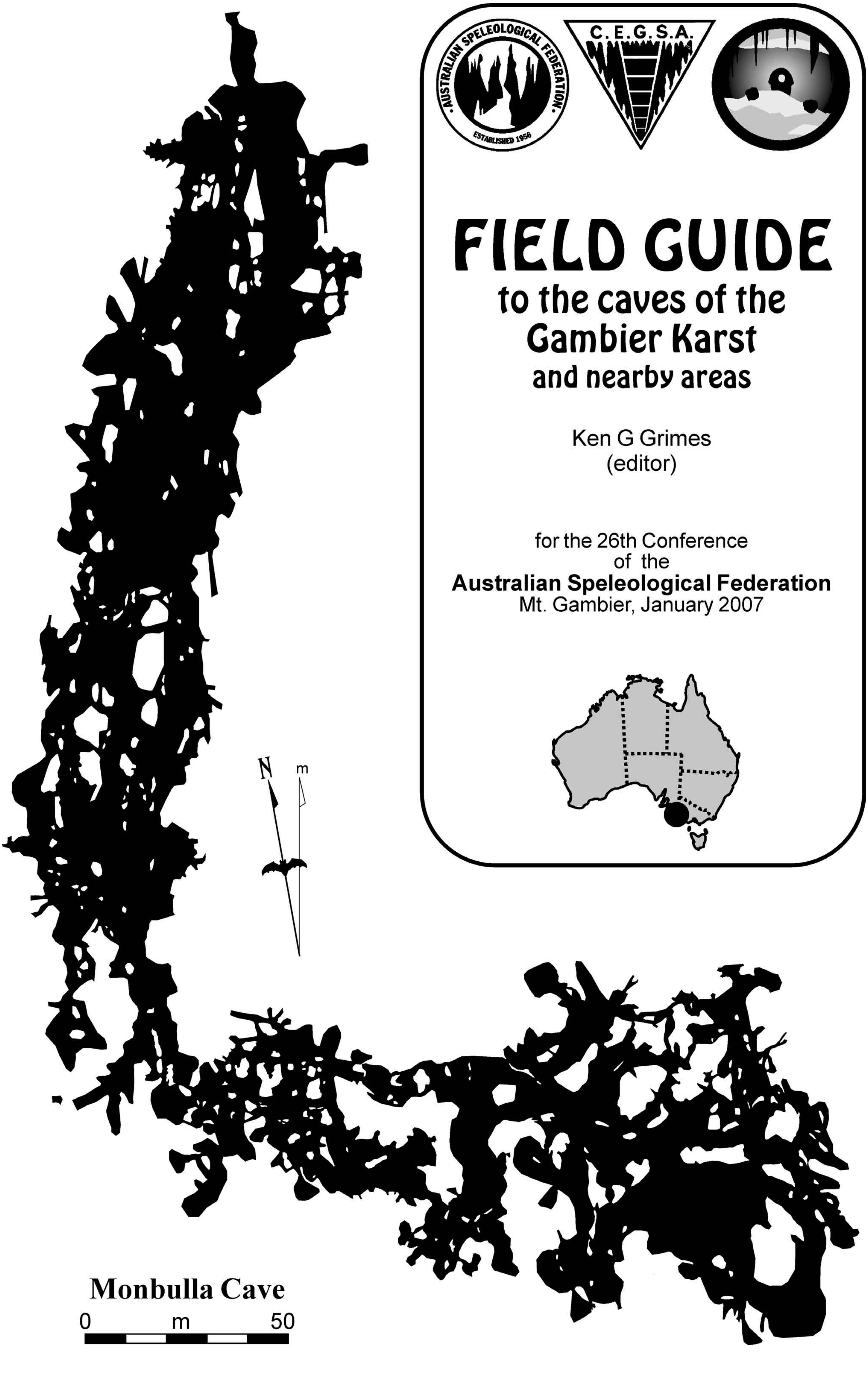
FIELD GUIDE

to the caves of the Gambier Karst and nearby areas

Ken G Grimes
(editor)

for the 26th Conference
of the
Australian Speleological Federation
Mt. Gambier, January 2007



Monbulla Cave

Field Guide

to the Caves of the

Gambier Karst

and nearby areas

Edited by

Ken G. Grimes

with contributions by

Steve Bourne, Marie Choi, Ken Grimes, Paul Harper, Richard Harris, Peter Horne, Kevin Mott, Graham Pilkington, Mia Thurgate and Susan White.

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Field guide to the caves of the Gambier Karst and nearby areas.

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1 Karst - South Australia - Guidebooks. **2** Karst - Victoria - Guidebooks. **3** Volcanoes - Victoria - Guidebooks.
4 South Australia - Guidebooks. **5** Victoria - Guidebooks.

I Grimes, Ken (Kenneth George), 1944 - . **II** Cave Exploration Group, South Australia. **III** Title.

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CONTENTS

PREFACE

The first edition of this Guidebook was compiled by Ken Grimes & Susan White for a Karst Studies Seminar at Naracoorte in 1996. Later revised and expanded versions have been produced for other conferences and the authorship has expanded with each edition. This version has a greater emphasis on the caves than previously. Readers with an interest in surface karst sites are referred to earlier versions, e.g. Grimes (2004b), Grimes & others (1999a). Earlier guidebooks to SA and western Victoria which we have drawn from are: Mill & others (1980, Vic); Pilkington & others (1983, SA); Baddeley (1995, Vic); Kraehenbuehl (1997, Flinders, SA). There is also Ian Lewis' (1976) South Australian Cave Reference Book, which has brief descriptions of all caves known in SA at that time; and Peter Horne's excellent Cave Reference Book to the caves of the Lower southeast of SA (Horne, 1993).

The guide is in six parts. Two background chapters describe the geology and karst features of the Gambier Karst Region as a whole, and the formation of volcanic caves and associated features. The third part describes limestone caves in the Naracoorte - Mt Gambier area, South Australia. The fourth and fifth parts describe limestone and volcanic caves in Victoria and the final part describes Corra Lynn Cave on theYorke Peninsula, South Australia.

Most of the sites described here are on private land or in government reserves for which permission should be sought before entering. Entry to caves in South Australian National Parks requires a permit obtained from the Department for Environment and Heritage, South Australia (DEHSA) at least one month beforehand. Diving in the cenotes and springs in South Australia requires a permit from DEHSA at Mount Gambier, and divers must show that they are suitably qualified. For Victorian caves permits are needed from Parks Victoria for all caves apart from those that are open to the general public. A requisite of entry permits is that you have suitable experience and equipment.

In accordance with the policy of the Australian Speleological Federation (ASF) we avoid printing detailed location information concerning cave sites. Accredited scientists or speleologists can obtain access details from the Victorian Speleological Association (VSA) or the Cave Exploration Group, South Australia (CEGSA), or from the authors during the conference.

A Geological Overview of the Caves

There are three distinctive geological settings for the caves of South Australia and Western Victoria.

The "soft-rock" karst areas have developed on youthful, weakly-consolidated limestones and are quite different from the "hard rock" indurated Palaeozoic or older limestone karsts of eastern and northern Australia. Our caves have an entirely different quality, characterised by soft walls, cap rock effects, solution pipes, extensive low horizontal phreatic mazes, abundant collapse modification and extensive large flooded systems. The cenotes are unique within Australia.

There are two subdivisions: the younger, Quaternary, syngenetic karsts of the coastal dune limestones (e.g. Eyre Peninsula, Kangaroo Island and the Gambier Karst); and the older Tertiary marine limestones of the Nullarbor, the Murray Basin and the Gambier Karst. In this guidebook we cover only the Gambier Karst, which extends east into Victoria (Chapters 3 & 4).

The "hard-rock" karsts of South Australia are more "typical" but still have a distinctive character. They tend to be less deformed than those of eastern Australia - with shallow dips and limited metamorphic modifications. They also sit in a drier climate. Here we describe only caves in the Cambrian limestones of the Yorke Peninsula (Chapter 6). Other areas are the Adelaide Hills (Pilkington & others, 1983) and the Flinders Ranges (Kraehenbuehl, 1997).

In addition to limestone caves the Western District Volcanic Province of the Victorian part of the region has many lava tubes and other volcanic caves (Chapter 5).

ACKNOWLEDGMENTS

This field guide draws heavily from previous reports and field-guides. Contributors to the present edition are listed on the title page, and at the start of each chapter. Most importantly, this guide could not have been written without the extensive exploration, mapping and documentation efforts of numerous CEGSA, VSA and other cavers over the last 50 years.

Production of the guide was partly sponsored by the organisations listed below.

THE GAMBIER KARST PROVINCE

Ken Grimes, Susan Q. White, Kevin Mott, Mia Thurgate.

The two 'soft-rock' karst regions of south-east South Australia and western Victoria (Gambier and Port Campbell Karst Provinces, White 2005) correspond generally with the Tertiary Gambier Basin (Smith & others, 1995) and its continuation into Victoria as the Tyrendarra and Port Campbell Embayments of the Otway Basin (the Otway Basin also includes older Mesozoic rocks, Holdgate & Gallagher, 2003). However, in South Australia Quaternary dune limestone extends northwest across the adjoining Murray Basin.

The karst is developed on poorly consolidated Tertiary and Quaternary limestones. It is also influenced by the thin younger sediments that overlie the limestones. Most of the karst is covered by soil or thin sediments but some areas of bare karst occur southwest of Mount Gambier. In Victoria, some karstic limestone is overlain by basalt flows, e.g. at Drik Drik and Scotts Creek (Byaduk).

The region is generally low-lying and flat, with Quaternary dune ridges providing the most common relief, although Quaternary volcanoes form unexpected hills. Many of the inter-dune flats were waterlogged for much of each year but have now been artificially drained. The Glenelg River is the only major drainage line and is incised into the limestone to form a major gorge. Other surface streams, e.g. Mosquito Ck, have small flows and some streams in Victoria are also incised. Coastal cliffs of limestone occur in many places, especially in the far east.

The climate of the region is a 'Mediterranean' one with wet winters and cool dry summers. Annual rainfall increases towards the coast and from west to east; ranging from 550 mm in the Naracoorte area, through 850 mm at Portland to nearly 1000 mm at Port Campbell at the eastern end of the karst region.

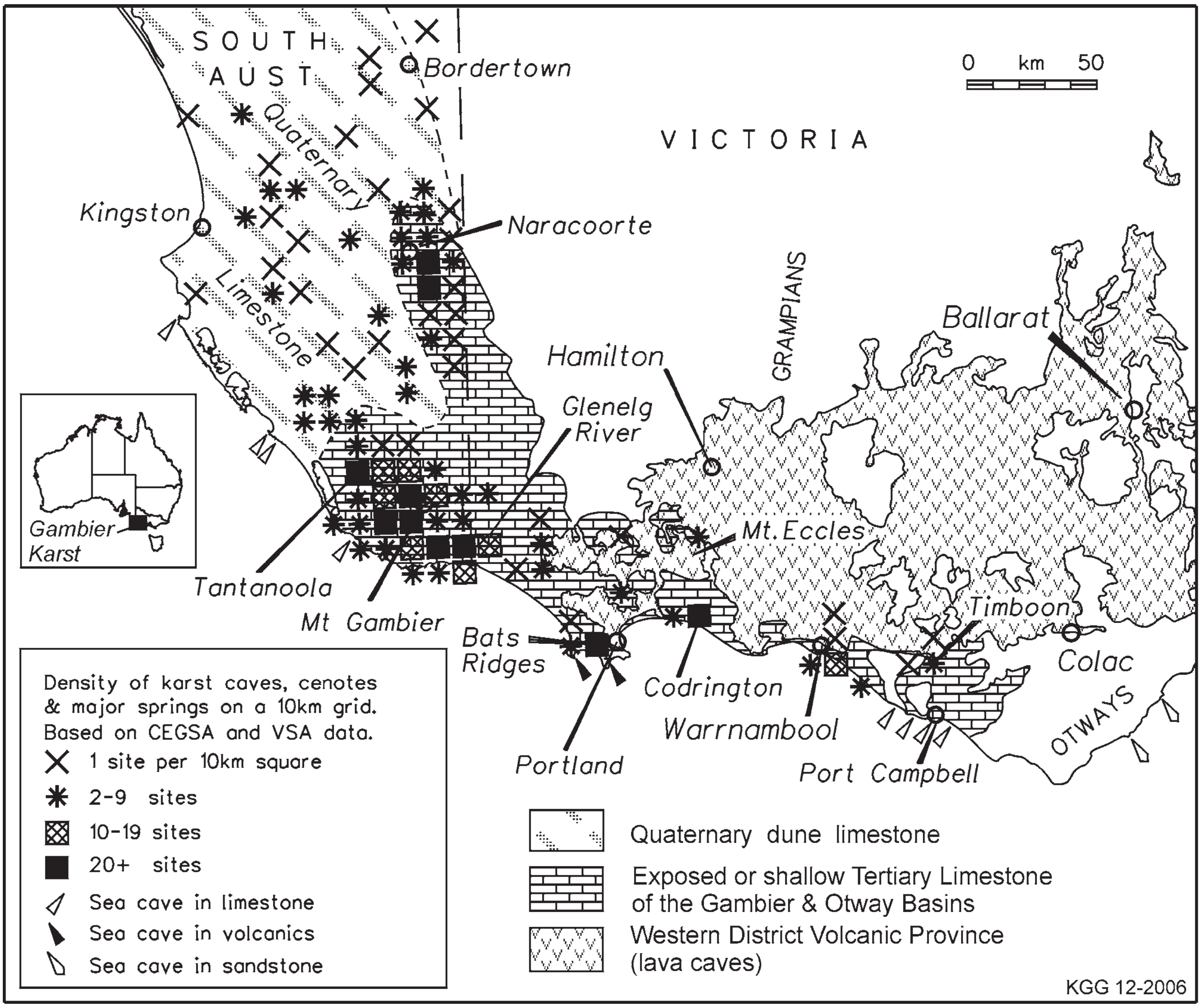


Figure 1.1: Distribution of limestone caves in the Gambier and Port Campbell Karst Provinces.

During the Quaternary the present type of climate would have alternated with colder, drier and windier climates during the peaks of the glacial stages (Williams, 2001; Ayliffe & others, 1998). The windy periods would be responsible for lunette ridges bordering some lakes, and possibly for deflation of some of the enigmatic shallow hollows in the old coastal plains. Much of the region would have been intermittently flooded by the sea during the interglacial periods of the early Quaternary.

GEOLOGY

See Marker (1975), Grimes (1994) and White (1994, 2000a, 2005) for earlier studies of the karst geology. The limestones fall into two groups, both relatively young: the Tertiary (Oligocene to Miocene) limestones are the Gambier Limestone in South Australia and westernmost Victoria and the slightly younger (mid late Miocene) Port Campbell Limestone further east (Alley & Lindsay, 1995; Holdgate & Gallagher, 2003); the younger Quaternary Bridgewater Group aeolianite comprises calcareous dune limestones following old shorelines and associated calcareous marine and coastal sediments of the inter-dune flats (Belperio, 1995; Cupper & others, 2003). White (2005) assigned the eastern areas to a separate Port Campbell Karst Province, based on the differences in the Tertiary limestone and its karst. The dune limestone caves are similar throughout.

The ***Tertiary limestones*** were deposited in a shallow sea that flooded the region in the Oligocene and Miocene (about 10-35 million years ago). Figure 1.1 shows the northern limit of these limestones for the purposes of modern cave development - they continue further to the north in South Australia, but with a progressively thicker cover of non-calcareous sediments that inhibits karst development. In Victoria the Port Campbell Limestone is more variable in composition and much of it is covered by late Cainozoic volcanic rocks – limiting its karst and cave potential.

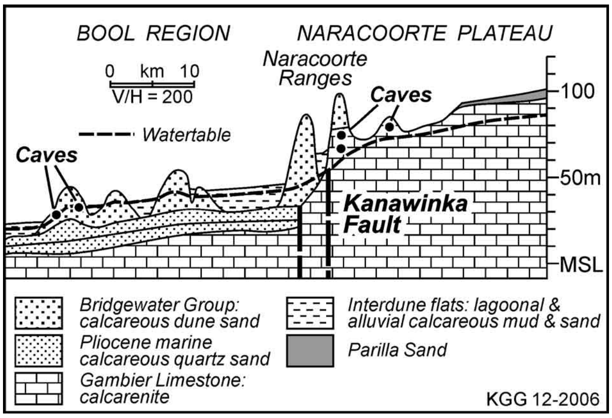


Figure 1.2: Cross-section in the Naracoorte area showing watertable.

The limestone is relatively soft in the subsurface but develops case hardening and calcrete cappings on exposure. It is locally well jointed with a dominant north-west trend in the Gambier Karst Province, but a north-east trend in the Port Campbell Province. The influence of both the vertical jointing and the horizontal bedding are exhibited in the cave passage forms (e.g. Figures 3.18, 3.26). The Tertiary limestones are similar to those in the Nullarbor, which also shows similarities in the cave styles. However, apart from some of the flooded cenote caves, we have few of the huge cave systems that occur in the Nullarbor. The Kanawinka Fault and its related scarp have a major influence on the hydrology and karst development in the Naracoorte area (Figures 1.2, 1.4 & 1.5), as does the Jones Ridge Fault at Drik Drik (White 2005, Figure 4.1).

In the Bool Region of South Australia (Figure 3.1) the Gambier Limestone is mantled by ***late Pliocene marine*** calcareous quartz sands (the Coomandook Formation and others) up to 17 m thick (Figure 1.2, Cook and others, 1977; Belperio, 1995). Towards the Victorian border these quartz sands grade into shelly calcareous sands and muds of the Pliocene to early Pleistocene Werrikoo Limestone.

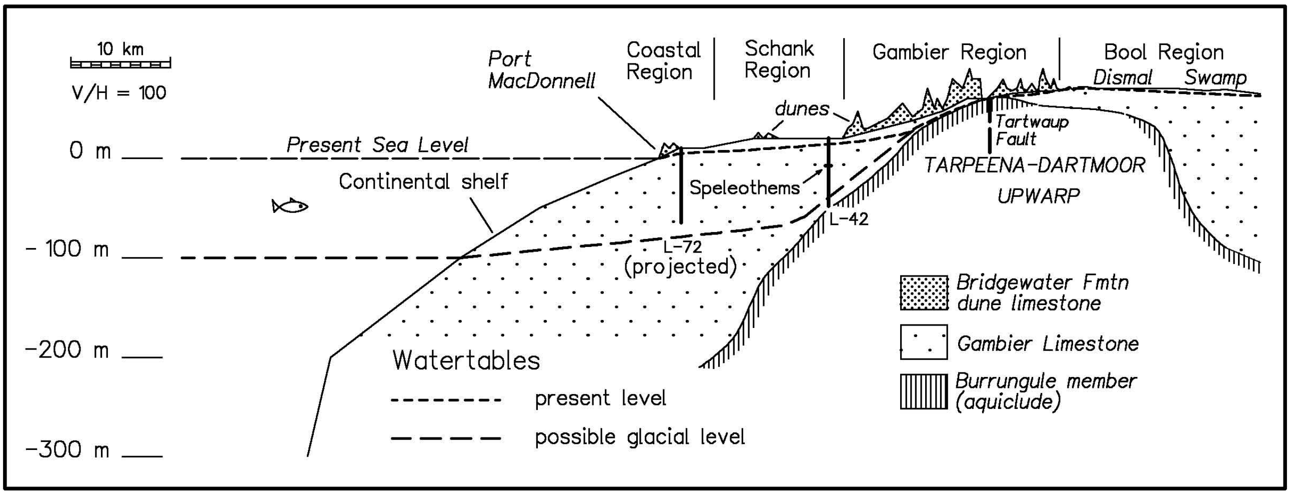


Figure 1.3: Cross-section in the Mount Gambier area, showing present and past watertables.

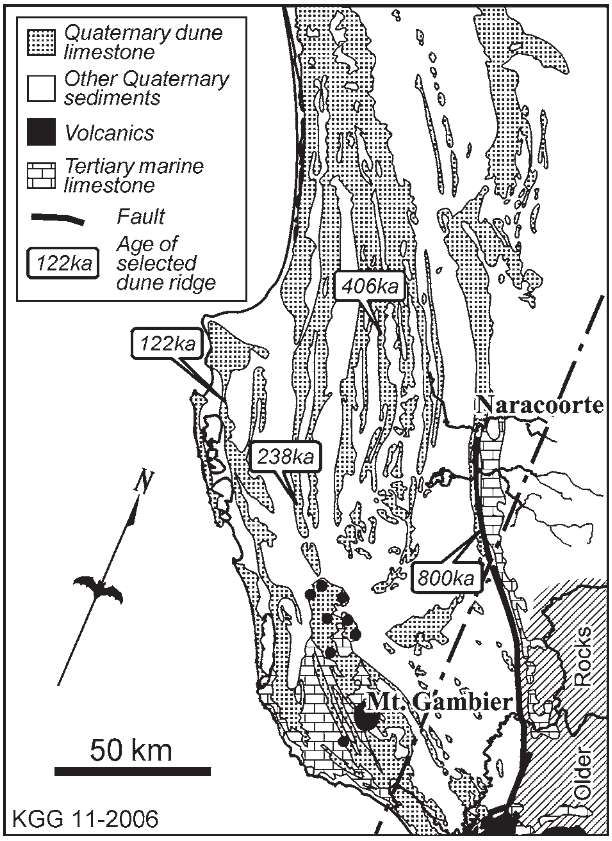


Figure 1.4: Geology of the Gambier Karst.
Dune ages are shown in thousands of years (ka)

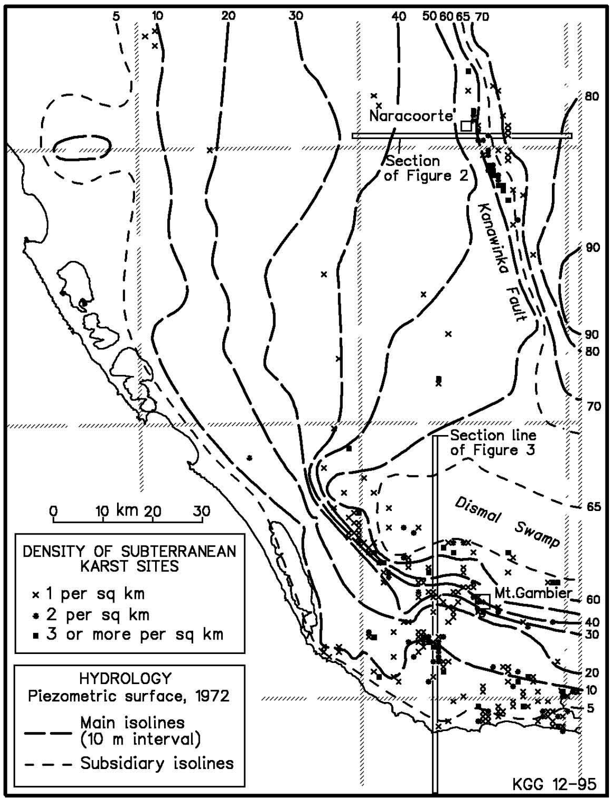


Figure 1.5: Ground water-table contours, after Holmes & Waterhouse (1983).

The ***Quaternary dune limestones*** (aeolianites) are a series of calcareous coastal dunes along old shorelines that developed during an overall regression of the sea during the Quaternary. In South Australia they form linear north-west trending ranges (Figure 1.4), which extend northwards beyond the limit of the Gambier Basin to overlie the sediments of the Murray Basin. In Victoria the distribution of the dune limestones is less regular, and east of Portland they are mainly restricted to a narrow belt along the modern coast, though some older ridges (mostly without karst) occur further inland.

These Quaternary limestones are similar to those on Kangaroo Island, the Eyre Peninsula, and the coastal areas of Western Australia (Grimes 2006). The dune ridges are now partly-consolidated calcarenites and contain syngenetic karst features in which caves and solution pipes developed as the sands were being cemented into a limestone (see later). The limestone has well-developed dune cross-bedding with shallow-angle medium to thin bedding in places – flat-bedded beach and intertidal sands occur at the dune margins. There is little or no jointing. Some caves are developed mainly in the underlying Tertiary limestones but have their entrances in the overlying dune limestones. Some younger, reworked, dunes are dominantly quartzose.

Between the dune ridges there are extensive swampy plains. These are ***old coastal flats*** and comprise estuarine to lacustrine limestones, dolomites, marls and clays up to 13 m thick (Figure 1.2). These plains have many shallow swampy depressions of complex origin (Figure 1.9).

Pliocene to Holocene basaltic volcanics form the extensive Western District Volcanic Province of Victoria (Figure 2.1, Price & others, 2003), and some isolated volcanoes of this province occur in South Australia (Sheard, 1978). The southern margin of the volcanic area overlies the Tertiary limestones. Lava caves are associated with several of the volcanoes in Victoria (see chapters 2 & 5). Volcanogenic CO_2 may have contributed to the development of the large cenote chambers south of Mt Gambier (Lewis, 1984; Webb & others, 2000).

HYDROLOGY

The Tertiary limestone forms a major aquifer in the region. The Gambier Limestone has been referred to as one of the best aquifers in Australia (Holmes & Waterhouse, 1983, Stadter, 1999). Much of the ground water from the Mount Gambier area is discharged in major springs along the southern coast, and divers have entered caves below some of these.

At the regional scale the Gambier Karst shows many characteristics of a porous aquifer; for example, it has a continuous, well-defined watertable and the springs show none of the "flashy" behaviour of conduit-driven karst aquifers (Holmes & Waterhouse, 1983, Stadter,

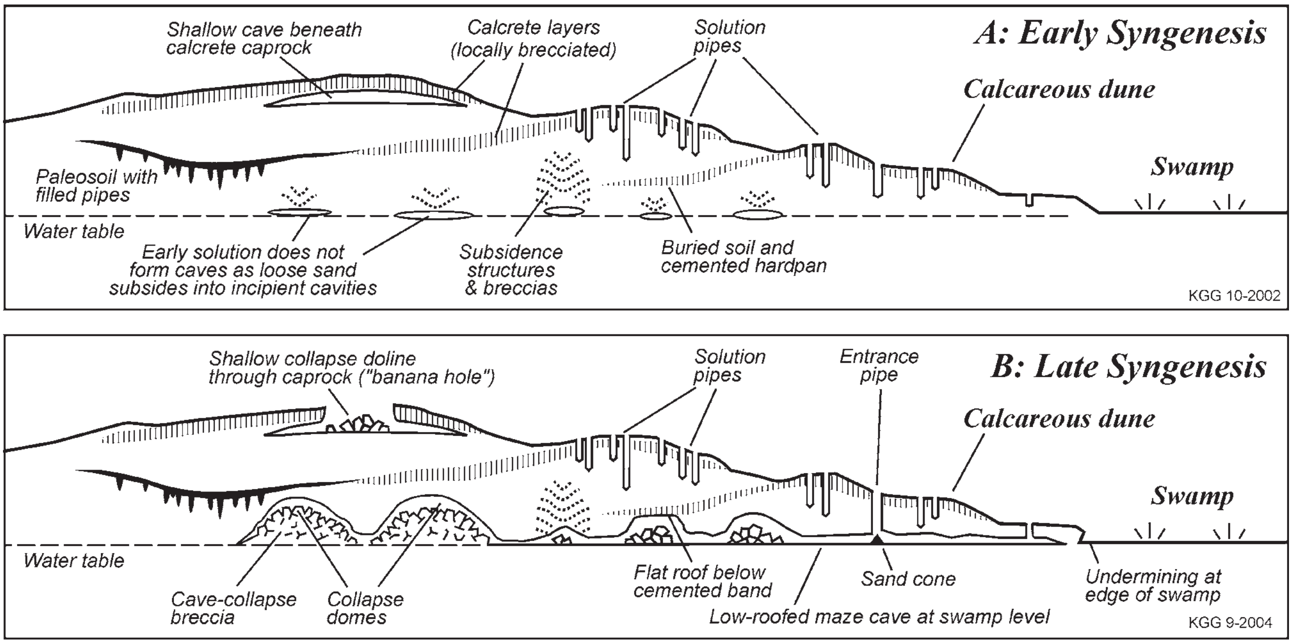


Figure 1.6: Features of syngenetic karst developed on a calcareous dunefield next to a swamp.

1999). On the other hand the transmissivity in places is much higher than one would expect from the porosity of the limestone alone (Telfer, 1993, Emmit & Telfer, 1994), and at the local scale we see the typical irregular and unpredictable characteristics of conduit aquifers (Emmit & Telfer, 1994). The aquifer is unconfined, deep, and open (uncapped). Most water input comes from rain and normally enters the aquifer diffusely through the porous surface sands, but some point input occurs via "runaway holes" in dolines (Herczeg & others, 1997). Some water enters from the allogenic Glenelg River, and further east in Victoria there are other allogenic rivers that rise outside the karst area but cross it on the way to the sea.

The well-developed water table has a gentle slope towards the coast in South Australia, with two zones of steeper gradients (Figure 1.5, Holmes & Waterhouse, 1983): along the line of the Kanawinka Escarpment (Figure 1.2), and north-west through Mount Gambier (Figure 1.3). Marker (1975) noted a correlation between high cave densities and the zones of steep gradients, and also with areas of greater than normal depth to the water table.

The lower sea levels during the glacial periods caused a significant drop in the ground water levels in the coastal parts of the region, but not further inland (Figure 1.3). This is shown by submerged speleothems and mudcracks in some South Australian caves. There is also evidence for recent drops in the water table. For example, stromatolites are found up to 2 m above the present water level in the cenotes (Photo 1.13), and there are historical records of higher levels in some cenotes. Local fluctuations of over a metre have been recorded in association with land clearance (a rise) and the growth of exotic pine plantations (a drop).

KARST LANDFORMS

Syngenetic Karst

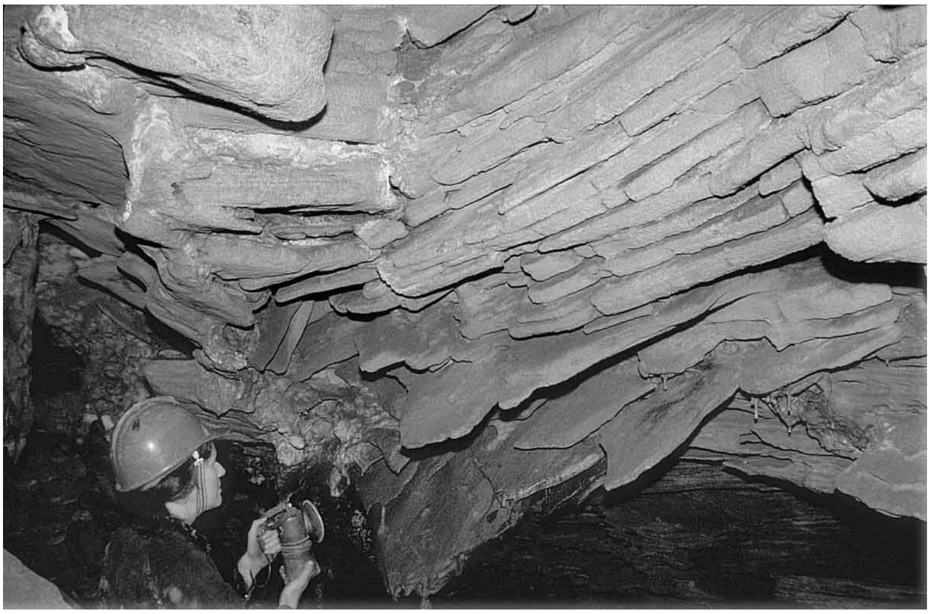
In the calcareous Quaternary dunes some karst features are syngenetic, in that they have developed at the same time as the sand was being cemented into a rock (Jennings, 1968; White, 1994, 2000a, Grimes, 2002a, 2006). Mylroe & others (2001 and later) used the term "eogenetic karst" in a context that overlaps with "syngenetic" as used here. Unconsolidated calcareous sand is converted to limestone gradually by simultaneous near-surface solution and deeper redeposition of calcium carbonate by percolating water. The downward percolating water also dissolves vertical solution pipes, and simultaneously cements the surrounding sand. At the same time, enhanced mixing corrosion occurs where percolation water meets the water table, typically at the level of an adjacent swamp; or where sea water mixes with a fresh water lens at a coastline.

In the early stages of dissolution (**Early Syngenesis**, Figure 1.6a) the loose sand subsides at once into any incipient cavities, possibly forming soft-sediment deformation structures (Photo 1.7). Subsidence dolines may form without caves. An exception is that beneath the cemented cap-rock, which appears to form in the soil zone quite early, some shallow caves may form. Once the bulk of the rock is sufficiently hardened to support a roof (**Late Syngenesis**, Figure 1.6b), caves can develop. However, the rock is still poorly consolidated, so collapse plays a very important role at all stages. Re-cemented breccias are seen in the walls of several of the dune limestone caves.

In the early stages, when the sea was present adjacent to the dune ridges, mixing between a freshwater lens and

Figure 1.7: Subsidence structures exposed in a syngenetic cave formed in a flat-bedded beach sand.

The beds were weakly cemented into plates, but undermining by solution caused them to subside, rotate and slip against each other before being further cemented to form a more solid rock. Later solution of a stable cave passage has exposed the synclinal structure. [Photo: KGG]



an underlying body of sea water could have contributed to the development of caves. This is the “flank margin” model of Mylroie & Carew (2000), Mylroie & others (2001) and Jenson & others (2006) developed for the "soft-rock" caves of the Bahamas and oceanic islands in general. However, in Australia this sea water interface may have less importance than the acidic swamp waters. The higher parts of some caves, e.g. Monbulla (5L-5, Figure 3.11) appear to have been initiated in a flank margin setting while the sea was still present, but were extended and modified at a lower level by later swamp waters.

The uniform matrix porosity, slow moving groundwater, and lack of joint control means that directed linear conduits seldom form. Instead, horizontal cave systems of low, wide, irregular, interconnected chambers and passages (Figures 3.11, 3.19 & 3.21) form either in the zone of maximum solution at the water table, or by subsidence of loose material from beneath stable cap-rock layers. Flat cave ceilings are common (Photo 1.11): either marking the limit of solution at the top of the water table, or where collapse has reached the base of an indurated (cap-rock) zone.

Solution pipes are one of the most distinctive features of syngenetic karst (Grimes, 2003, 2004a). They are vertical cylindrical tubes, typically 0.5 to 1 m in diameter, which can penetrate down from the surface as far as 20 metres into the soft limestone. The pipes may be associated with roots (though which came first is debatable), and their margins may be a case-hardened cylinder (Photo 4.3) They occur as isolated features, or in clusters with spacings as close as a metre or less. Many caves are entered via such pipes (Photo 3.17).

Syngenetic karst development is typical of the Quaternary dune calcarenites; however, the Tertiary limestone is also a relatively soft porous limestone, and consequently it shows some of the features of syngenetic karst, in particular the development of solution pipes and calcreted caprocks.

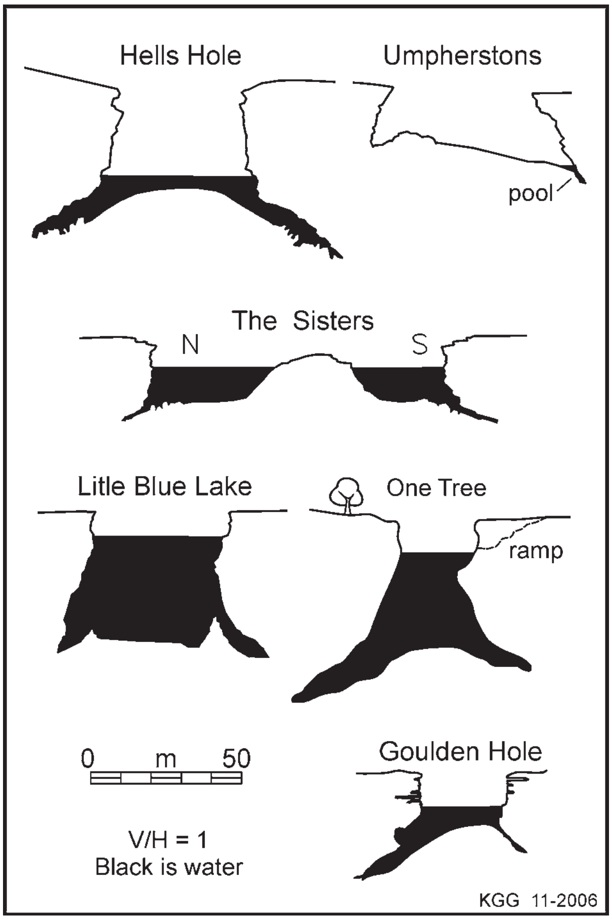
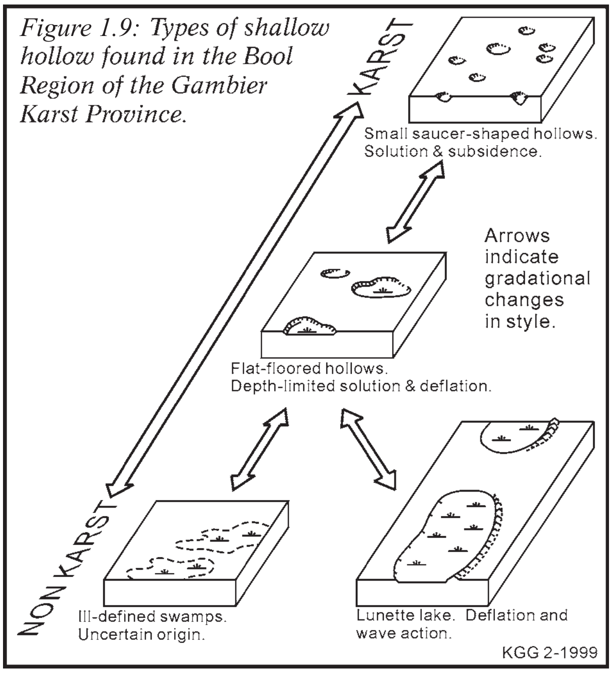


Figure 1.8: Cross-sections of typical cenotes. Black is water

Figure 1.9: Types of shallow hollow found in the Bool Region of the Gambier Karst Province.



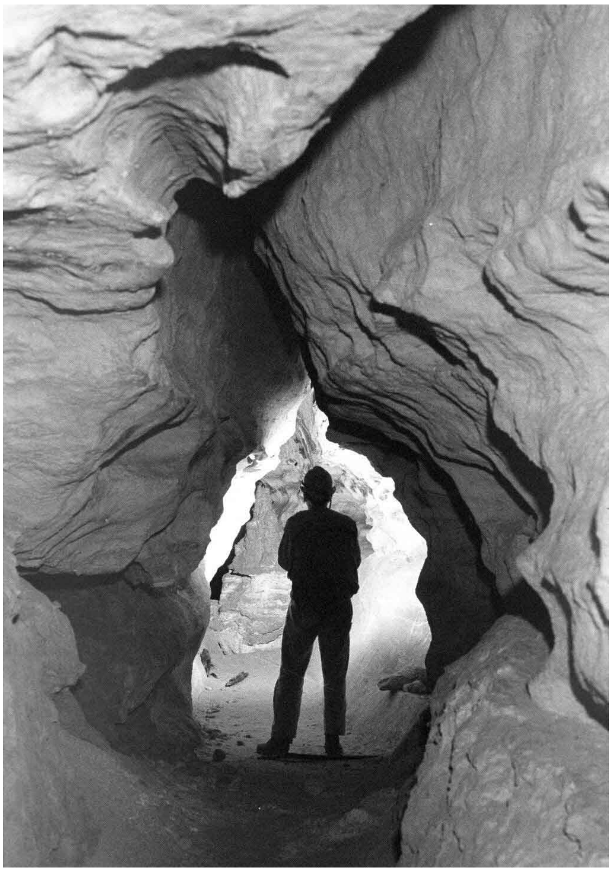


Figure 1.10: Joint-controlled phreatic passage in Tertiary limestone (5L-34). [KGG]

Surface Karst

Surface karst features are extensive in some parts of the area, but inhibited by thick cover material in others. Features include uvalas, dry valleys, a variety of doline types, exposed subsoil karren and coastal phytokarst.

The most spectacular surface karst features are the ***collapse dolines***, especially those in the Mount Gambier area that extend below the water table to form ***cenotes***. These have formed by the collapse of large phreatic caverns. Figure 1.8 shows several typical cenotes and related features. In the Gambier Region (Fig 3.1) the watertable is deeper and the collapse dolines are only partly flooded (e.g. Hells Hole & Umpherstons), however, further south in the Schank Region, the water levels are higher and we find deep lakes (e.g. Little Blue Lake, Photo 3.12). The Shaft (Figure 3.24) is an example of the situation before the roof of a large flooded collapse dome falls in to form a cenote – the present entrance is a small solution pipe.

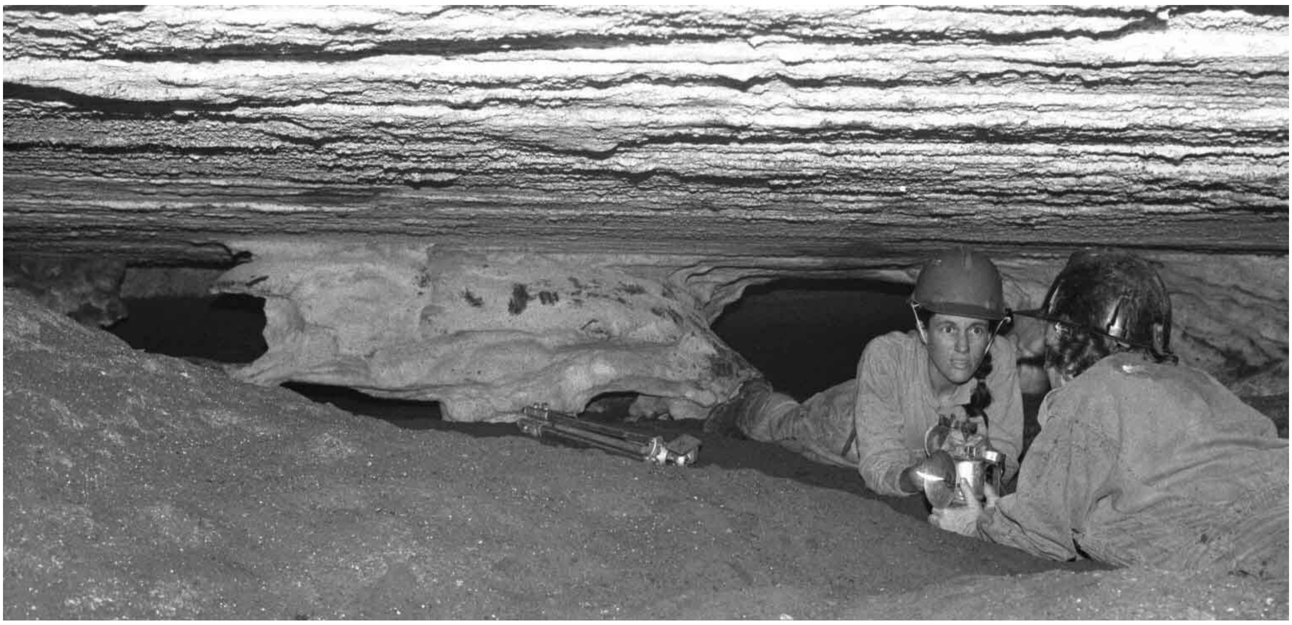


Figure 1.11 Syngenetic cave in dune limestone, with low flat roof developed at an old water-table. [KGG]

Fields of dolines and uvalas are extensive in South Australia and extend into the westernmost part of Victoria. Good examples occur on the Naracoorte Plateau and at Glencoe. Isolated doline fields also occur further east (e.g. between Allansford and Peterborough). These hollows generally have sandy or muddy floors and rarely have cave entrances.

In the dune fields many of the larger depressions are dune hollows, but these may be modified by karst solution to produce uvala-like features. The distinction between dune hollows and karst depressions is difficult to make in many areas. The 'hummocky' terrain north of Mount Gambier is a case in point.

In the Pleistocene coastal plains which form the Bool Region there are numerous shallow hollows which are poly-genetic; with solution, deflation and other processes operating in parallel, or in sequence, or alternating in step with glacial–interglacial climatic fluctuations. The resulting hollows range from small well-defined saucers which appear to be true karst to large shallow lunette lakes which appear to owe their origin mainly to deflation and wave modification of primary coastal lagoons, though there is a possibility of subjacent karst influences in places (Figure 1.9). Some ill-defined hollows are irregular in plan or form chains which suggest the influence of the original drainage on the coastal plain.

Caves

The caves in the Tertiary limestones are dominantly phreatic in origin, i.e. formed by slow moving ground water at and below the water table. The limited local relief means that vadose stream flow features are extremely rare in South Australia, but some vadose streams occur in Victoria at Drik Drik (Photo 1.12), in the caves beside the Glenelg River gorge, and also further east in the Warrnambool and Timboon regions. Both joint and bedding plane control can be seen (Photo 1.10. Figures 3.18, 3.26), but solution at temporary water-table levels can make the latter hard to recognize in this area of flat bedded limestone. Many of the primary phreatic caverns and passages have been modified by breakdown to form collapse domes and rubble-filled passages (Figure 3.15).

Cave diving has demonstrated the existence of extensive underwater cave systems in South Australia (e.g. Horne, 1993, Figure 3.24). It appears that in the southern part of the Lower Southeast area most of the cave conduits may be below the present water table though these passages would have been partly or wholly drained during the previous low sea levels (Figure 1.3).

Typical syngenetic cave forms in the Quaternary dune limestones are shallow horizontal systems developed beneath the caprock or at the level of an adjoining swamp (Figure 1.6). They have multiple entrances (often via solution pipes or the collapse of the surface crust) and an irregular outline of chambers, pillars and short connecting passages, generally with a roof height less than one metre throughout (Figures 3.11 & 3.19). The walls are often difficult to see (and map) as they are out of reach where the roof slowly drops to floor level. These caves are mainly epiphreatic – formed in the zone of mixing just below the water table; but vertical vadose seepage is responsible for the solution pipes.

Figure 1.12: Vadose stream passage in 3DD-4 [KGG]

The dune limestone caves differ from those in the Tertiary limestone in generally having smaller chambers and passages and only limited joint control.

Speleothems are generally not abundant in either type of cave – a consequence of the frequent collapse. However, there are many spectacular exceptions to that rule (Photo 3.16), and these include some extensive and very delicate forms; especially clusters of long straws and soft deposits of moonmilk. Moonmilk (Photo 4.11) is composed of micro-crystalline carbonate needles with a high water content between the crystals and is generally rare in hardrock limestone areas in eastern Australia (James, 2003). Cave-coral is also well developed. Still pools may be partly covered by calcite rafts.

Figure 1.13: A one metre high face of stromatolites exposed on the wall of a cenote by a drop in the water table over the last 100 years. Gouldens Sinkhole, Mount Gambier (5L-8). [KGG]

BIOLOGY AND ARCHAEOLOGY

There are two maternity caves for the Bentwing Bat (*Miniopterus schreibersii bassanii*) at Naracoorte and Warrnambool (Dwyer, 1969), and several caves along the Glenelg River host the (locally) rare Large Footed Bat (*Myotis adversus*). Such sites contain guano deposits that host diverse communities of invertebrate fauna (Moulds, 2004).

The cenotes, water-filled cave passages and big springs contain an interesting aquatic fauna and flora. The springs contain a number of endemic and threatened vertebrate species. A diverse invertebrate fauna, particularly crustaceans and amphipods, are also found in these subterranean wetlands (Thurgate et. al. 2001).

Another important feature of the subterranean wetlands and other wetlands in the area, including the Blue Lake crater, are stromatolites: columnar or platy underwater calcareous growths formed by microbes such as bacteria and algae (Photo 1.13, Thurgate, 1996a,b; 1999). These have been found as deep as 25 m in the cenotes, and 45 m in the Blue Lake crater, and also extend 2 m above the present water level – implying a higher watertable at some time in the past.

The solution pipes and collapse dolines form excellent pitfall traps and thus bone deposits of Quaternary age have been found in many caves (Wells & Pledge, 1983, Reed & Bourne 2000). The most important, and world famous, bone deposit is in the Victoria Fossil Cave at Naracoorte (Wells & others, 1984), but significant bone sites occur in both states, including the volcanic caves and some underwater bone deposits in the cenotes.

The Tertiary limestones in the Mount Gambier area have bands of chert nodules which make excellent stone tools. Evidence of aboriginal mining of chert is seen in several caves, as is also aboriginal art in the form of scratch marks and finger marks (Bednarik, 1986).

CONCLUSION

This area of ‘soft rock’ caves developed on youthful, weakly-consolidated porous limestones is quite different from the ‘hard rock’ indurated limestone karsts of eastern Australia and elsewhere. The caves have an entirely different quality, characterised by soft friable walls, cap rock effects, solution pipes, extensive low horizontal phreatic mazes, abundant collapse modification and extensive large flooded systems. The cenotes are unique within Australia. The karst aquifer is one of the best in Australia, but careful management will be needed to maintain that quality. Management is also required to maintain the surface karst features, the caves and their environment.

VOLCANIC CAVES AND RELATED FEATURES

Ken Grimes

The Western District Volcanic Province

The Western District Volcanic Province of western Victoria (previously known as the Newer Volcanics Province) is one of the world's larger volcanic plains, and has formed by a succession of eruptions and basaltic lava flows over the last five million years. The isolated volcanoes at Mount Gambier are a western outlier of the Province (Figure 2.1). Eruptions have continued up to quite recent times and further eruptions could occur in the geological future. Current dating suggests that the youngest volcano may be Mount Schank, south of Mount Gambier, which erupted 5,000 years ago. The flows associated with these younger eruptions show better lava caves and surface features than those of the older volcanics. None-the-less, a few of the caves are in flows several million years old.

Lava tubes and other volcanic caves are scattered across the province, but the majority of them are in the western area where they are associated with two of the younger eruptions in the region – Mt Eccles and Mt Napier (Webb & others, 1982, Grimes & Watson, 1995, Grimes, in press). See chapter 5 for cave descriptions.

Surface landforms

The volcanics are dominantly built up from basalt lava flows, but there are numerous small volcanic cones built by explosive activity, as well as larger maar lakes formed by major explosions (Price & others, 2003; Joyce & Webb, 2003).

The older volcanoes of the region have degraded features, and thick lateritised soils, which make their recognition difficult. By contrast, the flows from the younger eruptions have only minimal soil development and rough undulating surfaces known as *stony rises*; isotope dating suggests that these are all less than 500,000 years old.

The best modern model for the nature of vulcanism in this region is provided by the Hawaiian volcanoes. There we see broad lava shields built up by successive flows of very fluid basaltic lava spreading out from a central crater or fissure. In the crater area we see lava pools with fountains jetting into the sky and building local small cones of welded spatter or loose scoria. The long lava flows are seen to be fed either by surface channels, or underground by lava tubes.

Local examples of lava shields are the lower slopes of Mount Napier and the lava fields surrounding Mount Eccles. However, in Victoria we also have slightly more explosive eruptions which build larger scoria cones; and the maar lakes (eg. Tower Hill), which are large but shallow craters formed by major steam-driven explosions where rising magma intersected water-saturated limestone. At Mount Eccles a line of scoria cones running southeast from the main crater could have formed along a fissure eruption (Figure 5.2).

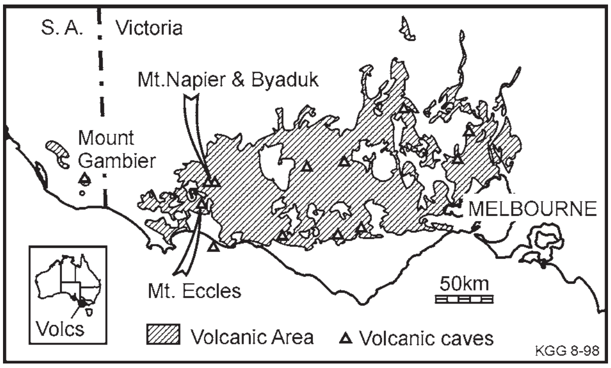


Figure 2.1: Western District Volcanic Province & caves.

Lava flows:

Basaltic lava is a hot (1100°C) liquid that can flow readily. There are two main forms of basaltic lava flow, which grade into each other. *Pahoehoe* lava is the most liquid form – characterised by the formation of thin smooth skins that become wrinkled (hence its alternative name of 'ropy lava'). Pahoehoe lavas advance as a succession of lobes, each of which develops a skin, is inflated by the liquid pressure within, then ruptures at one or more points to release liquid lava to form new lobes (Figure 2.3).

As pahoehoe loses gas and cools it becomes frothy and stiffer. The surface tends to crack, twist and break into angular, often spiny, blocks to form what is called *aa* or 'blocky' lava.

Behind the advancing lava front solidification of stagnant areas restricts lava movement either to narrow surface *channels*, or internally in *lava tubes* beneath a surface crust. Overflow from the surface channels builds up *levee* banks of thin sheets or spatter. Larger flows across a levee can feed lateral lava lobes with small internal lava tubes. A major breach of a levee may result in a large side flow, fed by its own channel, and the original channel may be abandoned. Good examples of lava channels (locally referred to as 'canals') occur at Mount Eccles (Figure 5.2). A number of shallow lava tubes are known in flows that have run off to the sides from these channels (Grimes, 1995 & in press).

Lava tubes provide good insulation for the hot lava flowing within them. This allows the formation of very

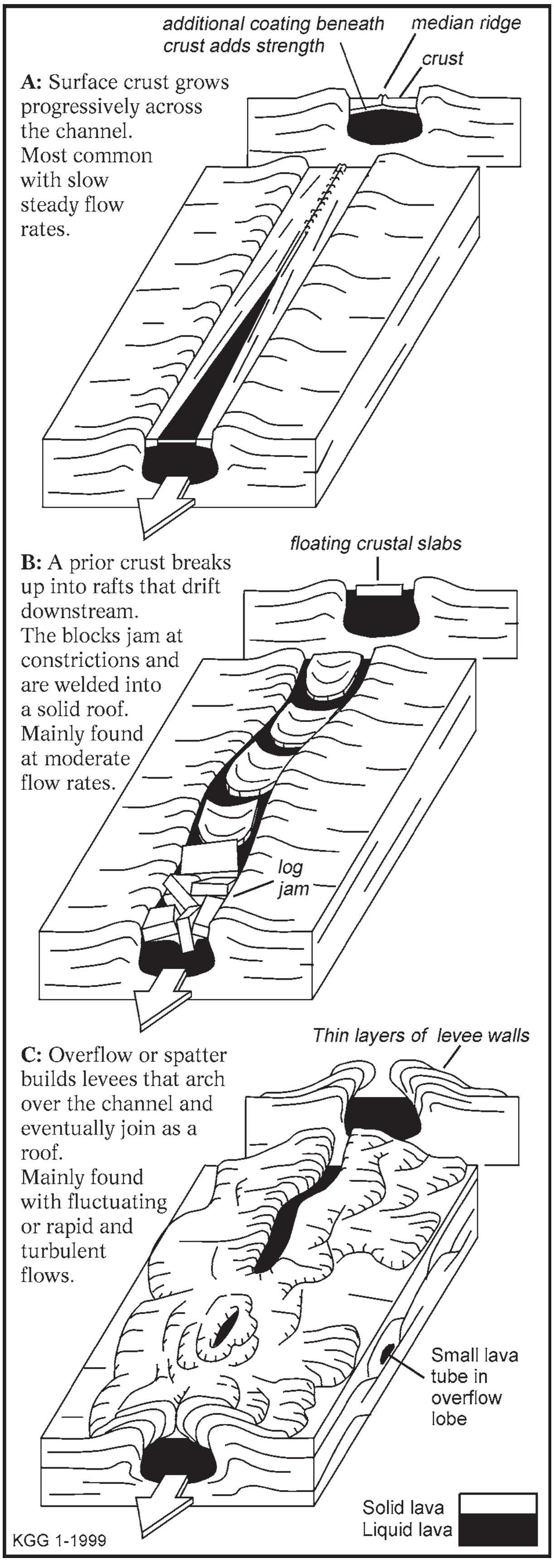


Figure 2.2: Three ways to make a lava tube by roofing a lava channel.

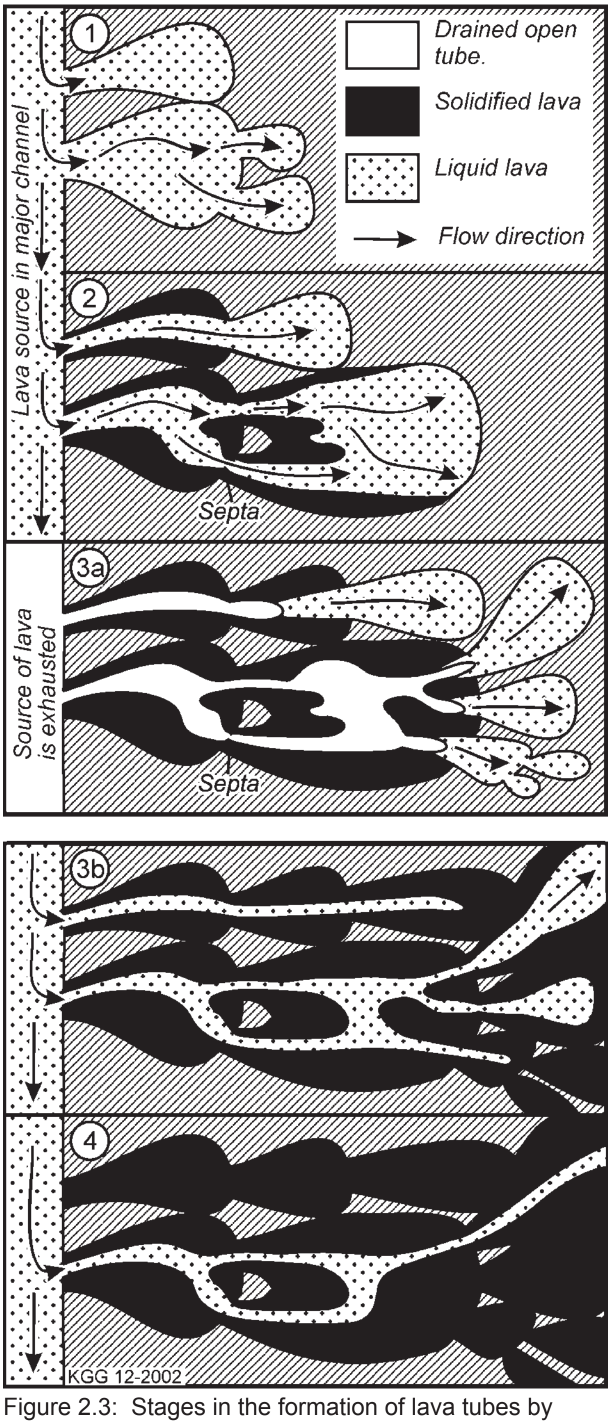


Figure 2.3: Stages in the formation of lava tubes by draining of lava lobes.

Step 1: Thinly crusted lobes of lava expand by breakouts through ruptures and budding of further lobes.

Step 2: Stagnant areas of the older lobes solidify, but flow from the source keeps the feeder conduits liquid.

Step 3a: If the source flow ceases some of the conduits may drain to form air-filled cavities.

Steps 3b and 4 indicate the further evolution into more linear feeder tubes as lava continues to flow through the system.

long flows such as the 50km Tyrendarra Flow from Mount Eccles, which extends offshore across the continental shelf (which was dry at the time), and the older 60km flow from Mount Rouse, which may also extend offshore (Figure 5.1).

When a lava flow follows a valley, as in the Harman Valley flow from Mt. Napier and the Tyrendarra flow from Mount Eccles, it disrupts the drainage. Twin *lateral streams* may run down each side of the original valley. *Swamps or lakes* will form where the flow enters the valley, and where tributary valleys have been dammed by the flow.

Formation of Volcanic Caves

Lava tubes form in basaltic lava flows by two main processes (Peterson & others, 1994; Halliday, 2004): first by the roofing over of surface lava channels in several ways (Figure 2.2); and second by the draining of still molten material from beneath the solidified crust of a flow (Figure 2.3).

Tubes formed by draining of crusted lava lobes and flows are generally smaller than those formed by the roofing of a channel, but tend to have more complex forms. Lava lobes can be stacked vertically as well as advance forwards so that a complex three-dimensional pattern of branching tubes can form. The long lava flows in the region would all have been fed by large cylindrical lava tubes; but these need not have drained at the end of the eruption to form open caves.

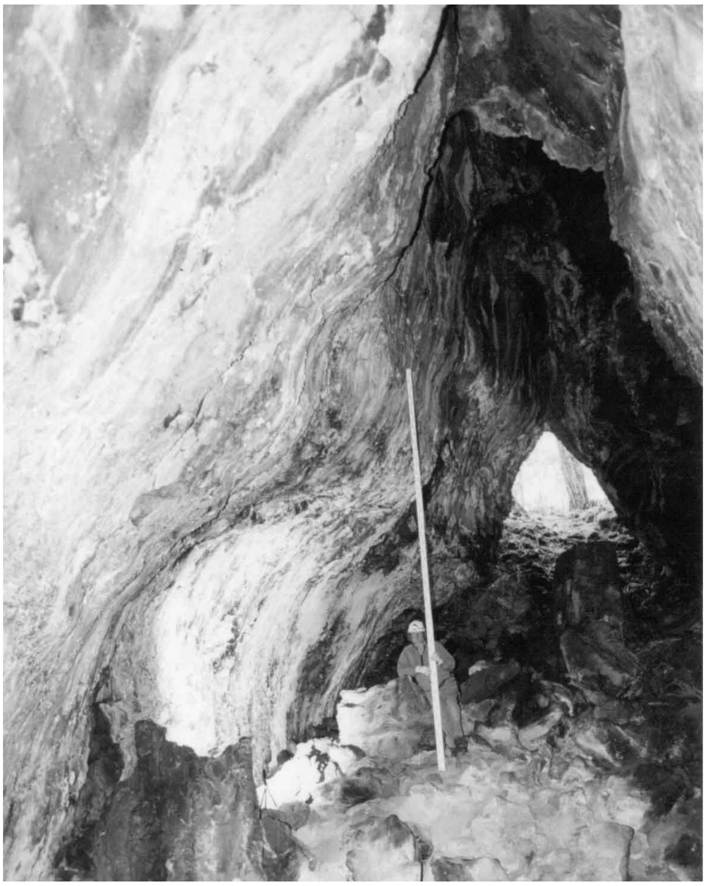


Figure 2.4: The ceiling of Natural Bridge (3H-10), Mt. Eccles has a "Gothic" shape that suggests it formed by levee overgrowth, as shown in Figure 2.2c, [KGG]
See also Figure 5.7.

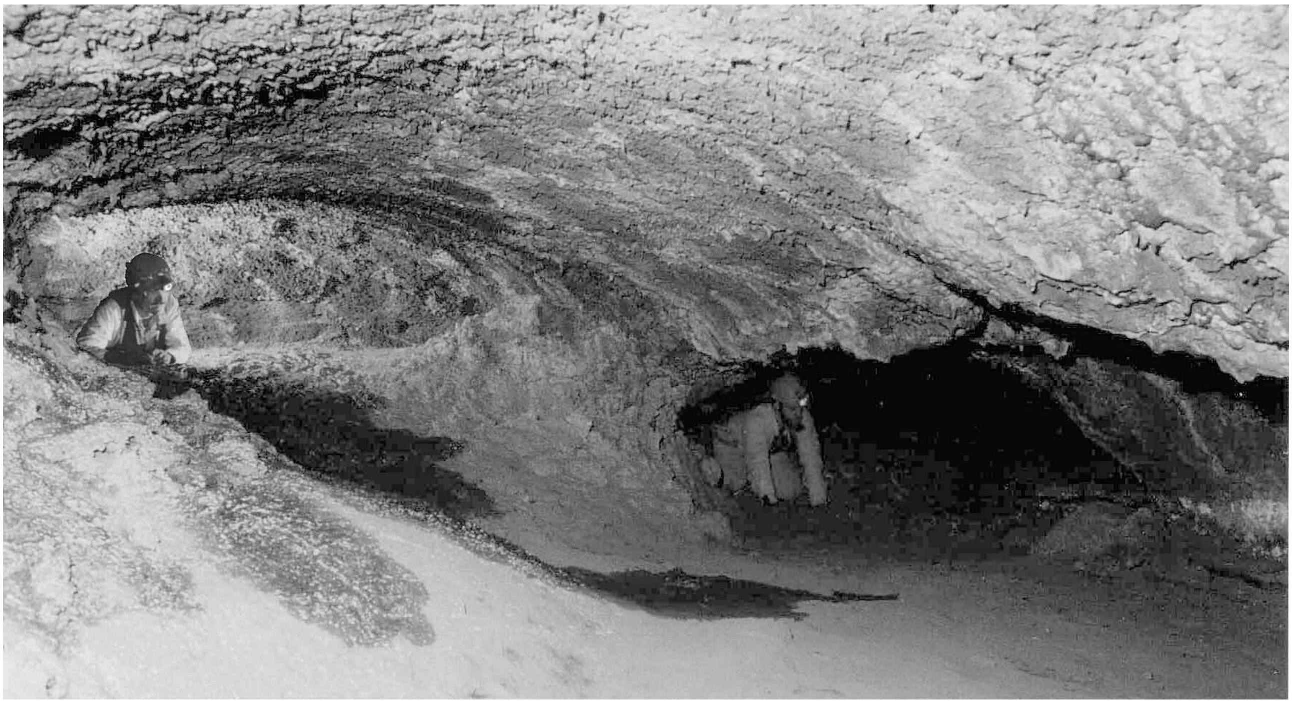


Figure 2.5: Caves formed by draining of lava lobes tend to have low broad chambers and passages (see Figure 2.3). Carmichael Cave, 3H-70. [KGG]

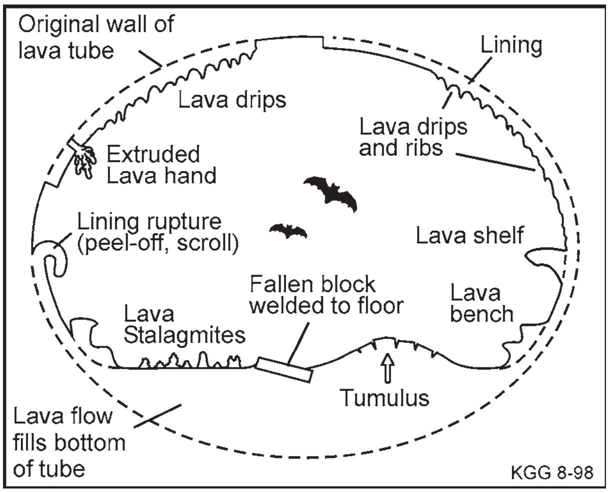


Figure 2.6: Formations found in lava tubes

Features found in Volcanic Caves

The lava caves contain a distinctive suite of lava structures or "decorations", some of which are illustrated in Figure 2.6.

The level of lava within the tubes tends to fluctuate during the course of the eruption, and so we find thin linings plastered onto the walls and roofs, and 'tide-marks' are indicated by solidified benches or shelves on the sides of the tubes. Some shelves can reach right across a passage to form a false floor.

The thin wall linings can rupture, peel back and curve over to form draperies and scrolls. Some linings are smooth, but others have a sharp hackly surface which may be due to the bursting of many small gas bubbles. Rafted slabs floating on a flow surface may leave grooves and striations on the semi-solid wall linings. Lava "hands" of semi-solid lava can be squeezed out through cracks or holes in the lining.

Small round-tipped lava stalactites, (lavacicles, lava drips) form where molten lava has dripped from the roof. Lava ribs form where lava dribbled down the walls of the cave, or where the whole lining has sagged and wrinkled. If the floor was already solid (unusual) drips of lava from the ceiling can build up lava stalagmites.

The floor of the tube is often flat or slightly arched; being the surface of the last flow of lava through it. If a lava flow within a tube forms a solid crust, and then drains away from beneath it, we get a tube-in-tube effect with a thin false-floor bridging the tunnel. Small lava mounds, or tumuli, may be heaved up by pressure from below. In some caves the crusted floor has buckled and broken into a jumble of heaved up plates, or cracked into a mosaic of jostling plates with rounded or upturned edges (Photo 5.14). Material falling from the roof may be rafted some distance downstream and may end up welded into the floor, or piled up in 'log jams'.

Figure 2.7: Lava drips and a burst section of lining.on the ceiling of 3H-70, Mt Eccles. [KGG]

Figure 2.8: Lava tide-mark on a roof pendant. 3H-33, Byaduk. [KGG]

CAVES IN SOUTH-EASTERN SOUTH AUSTRALIA

Ken Grimes, Steve Bourne, Marie Choi, Richard Harris, Peter Horne, Kevin Mott, Graham Pilkington, Mia Thurgate, Susan White.

In the Australian Karst Index the Upper Southeast cave area (5U) is separated from the Lower Southeast (5L) by an arbitrary line along the Penola-Robe road. Within both areas we can recognise several geologically distinct karst regions, some of which continue across the boundary (Figure 3.1).

Upper South East (5U)

Naracoorte Plateau

The Naracoorte Plateau is an uplifted area of Tertiary limestone to the east of the Kanawinka Fault (Figure 3.2). Along the western margin a pair of large dune ridges are separated by the Kanawinka Scarp. The westernmost ridge (The West Naracoorte Range) is a thick calcareous dune sand and has little cave or karst development. The eastern ridge (The East Naracoorte Range) is perched above the old sea cliff of the Kanawinka Scarp and has only a relatively thin dune cover over Tertiary limestone (Figure 1.2). This is where most of the larger known caves occur – various reasons have been suggested for this localisation (Marker, 1975; White, 2005; Grimes & White, 2006, Lewis & others, 2006; White & Webb, 2006). Most of the larger depressions in the ranges are dune hollows. However, on the main plateau to the east there are many well developed uvalas, dolines and dry valleys, but fewer caves. The plateau continues east into Victoria but karst is inhibited by a thick cover of Pliocene quartz sands (Figure 1.2).

The **Naracoorte Caves National Park** is a World Heritage Fossil Site covering 600 hectares along the East Naracoorte Range. There are about 26 caves within the park with 20 fossil deposits identified to 2000 (Reed & Bourne 2000; Reed & Gillieson, 2003).

Several surface features in the main park area are of interest (Figure 3.3). The entrances U-9, U-12 and U-98 are solution pipes as is the entrance to Wombat Cave (U-58) further east (U-98 is a pair of coalesced pipes). There are several walking trails within the main cave complex (Fig 3.3) and a 1 km walking trail runs south from Cathedral Cave to Victoria Fossil Cave. Beyond Victoria Fossil Cave the track continues south to Mosquito Creek which is an example of superimposed drainage – the creek entrenched its channel and maintained its course as the East Naracoorte Range was uplifted along the

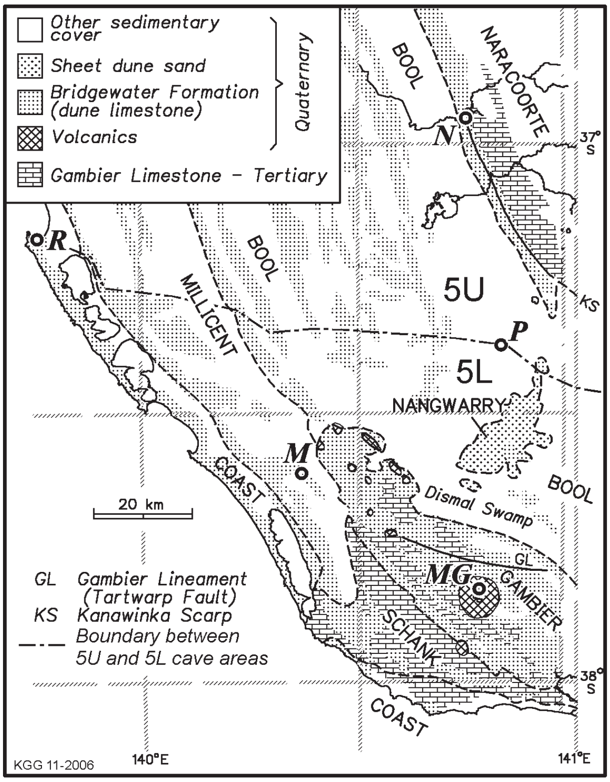


Figure 3.1: Karst regions and geology in south-eastern South Australia. Towns are: R Robe, N Naracoorte, P Penola, M Millicent, MG Mt. Gambier.

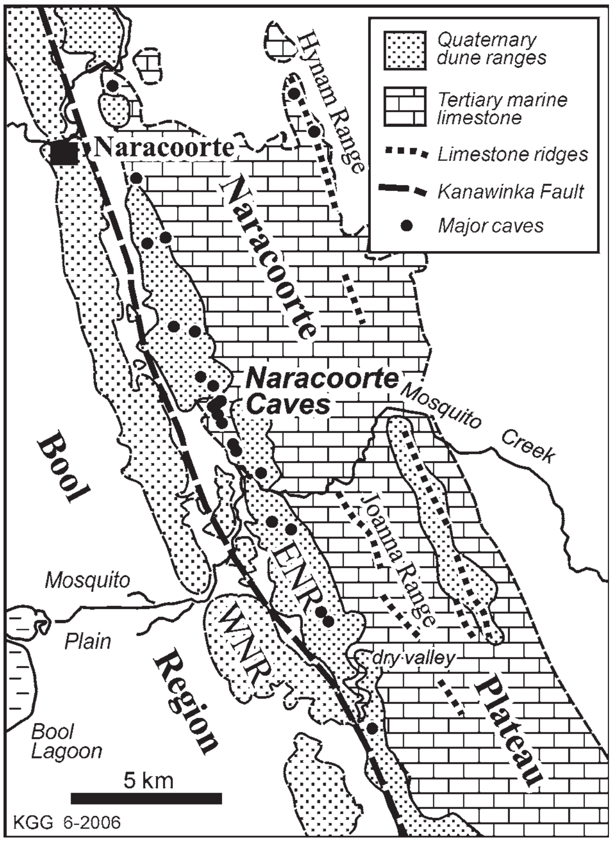


Figure 3.2: The Naracoorte Plateau, showing the distribution of the major caves along the East Naracoorte Range (ENR)

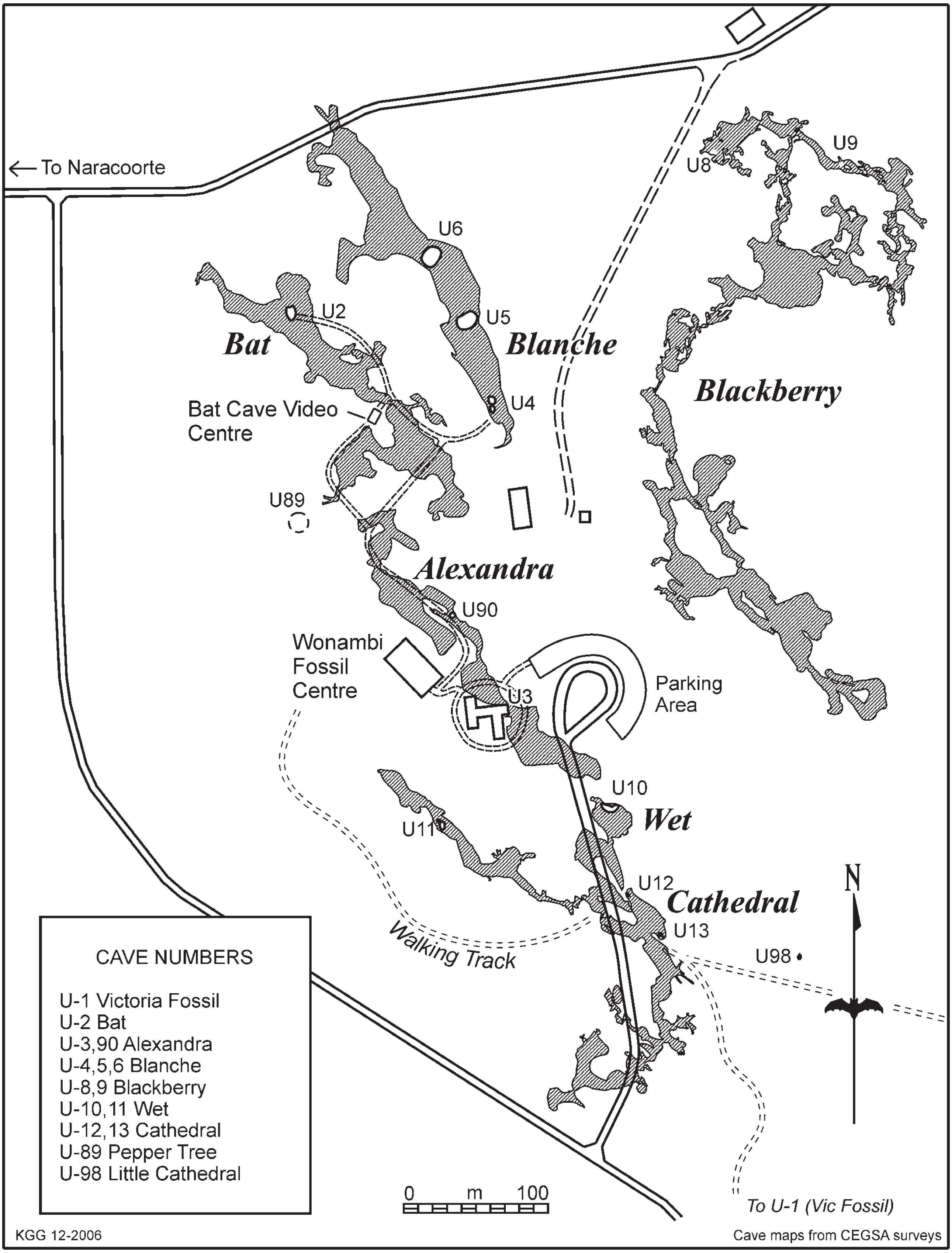


Figure 3.3: The main Naracoorte Caves area. See Figure 3.4 for Victoria Fossil Cave.

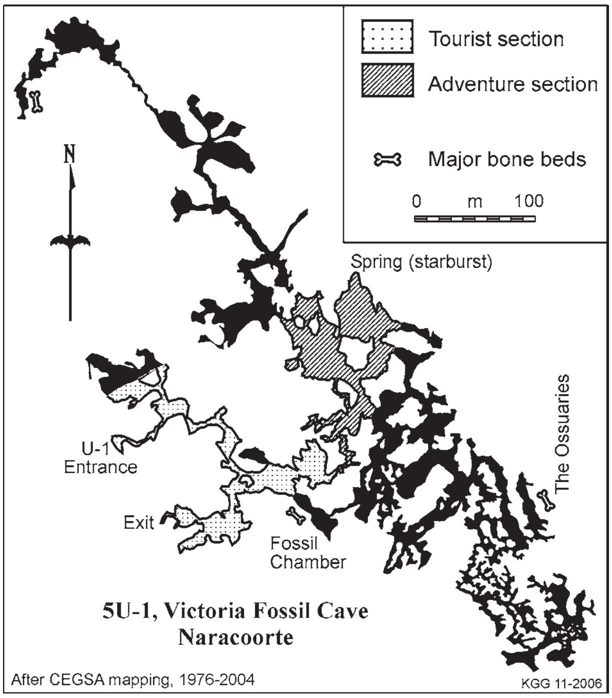


Figure 3.4: Victoria Fossil Cave is in Tertiary limestone

Kanawinka Fault. The cliffs beside the creek have a couple of small caves and some examples of solution pans, rain pits and horizontal solution ripples, but karren are not well developed here. The track continues south about 1.5 km to the picnic ground and swimming hole at Stony Point, which can also be reached by car.

Described caves are 5U-1, 3, 4, 8, 10-11, 12-13, 15, 22, 37 & 47.

Bool Region

The Bool Region, to the southwest of the Naracoorte Plateau, comprises extensive flat swampy plains crossed by dune limestone ranges which formed at old coastlines. Watertables beneath the plains are very shallow – at the surface during the wet season! Caves are almost entirely restricted to the calcareous dune ridges (e.g. Monbulla Cave 5L-5, Figure 3.11). At its southeastern end, this region continues into the "5L" area and across the border into Victoria where it is called the Follet Plain (see chapter 4).

The Avenue Ranges are a north-western part of the Bool Region, and similar in character. Caves have been known here for some time, but recently there have been new discoveries and exploration. The syngenetic caves include collapse-dominated systems, and some with well-preserved horizontal "swamp-margin" mazes in which the walls can be hard to find! There are some unusual speleothems and root formations (Photo 3.9)

See cave description for 5U-218 and also 5L-5 & 23.

Cave Descriptions

5U-1: Victoria Fossil Cave

Access & time: Guided tours of the show section take about 1 hour. Guided adventure cave trips are led into part of the non-tourist section, taking about 3 hours. Other areas are reserved for reference (Map 3.4)

Gear & Hazards: Standard cave gear for 'adventure' tours is supplied as part of the fee. For the conference, bring your own.

Description: This is an extensive, rambling, horizontal, network of collapse-dome chambers connected by low phreatic passages and flatteners (Map 3.4). The tourist section is mostly a group of collapse domes and the low connecting passages have been artificially enlarged. There are some extremely well decorated areas, especially in the chambers beyond the tourist section. The cave contains important fossil bone sites which is the main reason for the World Heritage status of the area. There are extensive areas of bone-bearing sediment beneath old (now filled) pitfall entrances (Wells & others, 1984; Moriarty & others, 2000).

5U-3: Alexandra Cave

Access & time: Show cave trips last 30 minutes.

Gear & Hazards: -

Description: This show cave comprises several large well-decorated phreatic chambers connected by low sand-floored passages. The northern extensions were largely sand and silt-filled before they were excavated to extend the tour area. For map see Figure 3.3.

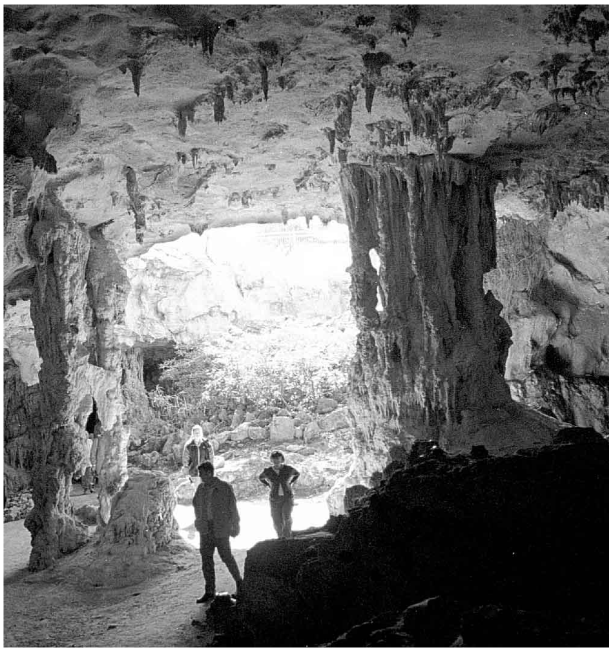


Figure 3.5: These massive speleothems in Blanche Cave (5U-4) are beneath a very thin roof – suggesting that there was a thicker cover when they formed. [KGG]

5U-4: Blanche Cave (U-4)

Access & time: Show cave.

Gear & Hazards: -

Description: Blanche Cave is a show cave comprising a line of large partly collapsed passages and chambers with several roof windows. The roof is a thin but well-developed caprock. There are solutional bell-holes and massive speleothems beneath this thin roof (Photo 3.5). The large size of these, compared with the thin roof is difficult to explain unless there has been a prior thicker cover – possibly of dune sands. The formations had dried up and degraded, but since the overlying pine trees have been removed seepage has resumed and deposition recommenced. For small-scale map see Figure 3.3.

5U-8: Blackberry Cave

Access & time: Entry is by prior permit only, and there is a locked gate at the start of the southern extension. Adventure cave tours are run by Park staff — lasting about 1.5 hours.

Gear & Hazards: Normal horizontal.

Description: This is an extensive well-decorated system of phreatic and collapse passages and domes. For small-scale map see Figure 3.3.

5U-10,11: Wet Cave

Access & time: Self-guided section with automatic lights (1 hour). Adventure cave tours are run into the western section (U-11) by Park staff (1.5 hours).

Gear & Hazards: Normal horizontal.

Description: Also known as Tomato-Stick Cave, the original name, Wet Cave, was reinstated when it was converted to a self-guided cave. A large roof window leads to a group of interconnected chambers and passages showing both collapse and original phreatic character. In the final, low-level chamber of the self-guided tour there is a flat roof with well-developed bell-holes (avens) and rock pendants. Well decorated in places For small-scale map see Figure 3.3.

5U-12,13: Cathedral Cave

Access & time: Entry is by prior permit only. Adventures tours run for 3 hours.

Gear & Hazards: Normal horizontal

Description: A group of solution pipes and bell-holes (U-12) and a roof window (U-13) lead to a large chamber, then alternating areas of high collapse domes and passages and smaller phreatic and collapse chambers, passages and flatteners. Sand cones occur beneath several soil-filled solution pipes. Locally well-decorated. For small-scale map see Figure 3.3.

Figure 3.6: Breakdown passage in 5U-15. [KGG]

5U-15: Beekeepers Cave

Access & Time: Private land. 3 hours.

Gear & Hazards: A double solution pipe entrance requires an 8m ladder.

Description: The cave consists of several large rubble passages (Photo 3.6) with low cross-connections that sometimes sump. There is a small amount of degraded decoration. A simple cave, yet a number of locals (non cavers) have become lost in it. Over 670 m – not all mapped.

5U-22: Fox Cave

Access & time: Fox Cave is about four kilometres south of the Naracoorte Caves. There is a locked gate. 3 hour adventure cave tours are run by Park staff.

Gear & Hazards: Standard cave gear for 'adventure' tours is supplied as part of the fee. For the conference bring your own (normal horizontal). Significant crawling and squeezing.

Description: A collapse entrance section leads via a gated tight squeeze to a series of large collapse-modified passages and chambers connected by smaller phreatic passages and low-roofed chambers (Map 3.7). A feature of the cave is the large sand cones beneath soil-filled solution pipes (Photo 3.8). These had suffered from excessive foot-traffic but have now been restored, and marked trails added around them. Several chambers are well decorated and require careful movement. There is a growing problem in sand falling from cavers clothing onto the floors of the decorated areas. Give yourself a good shake before entering them.

5U-37: Cave Park Cave

Access & Time: Private Land.

Gear & Hazards: Entrance has a 3 m ladder pitch. Snakes.

Description: A large entrance leads to a large rubble passage with extensive low areas. Bats are known to frequent this cave at certain times of the year. Cave varies from walking to crawling passages.

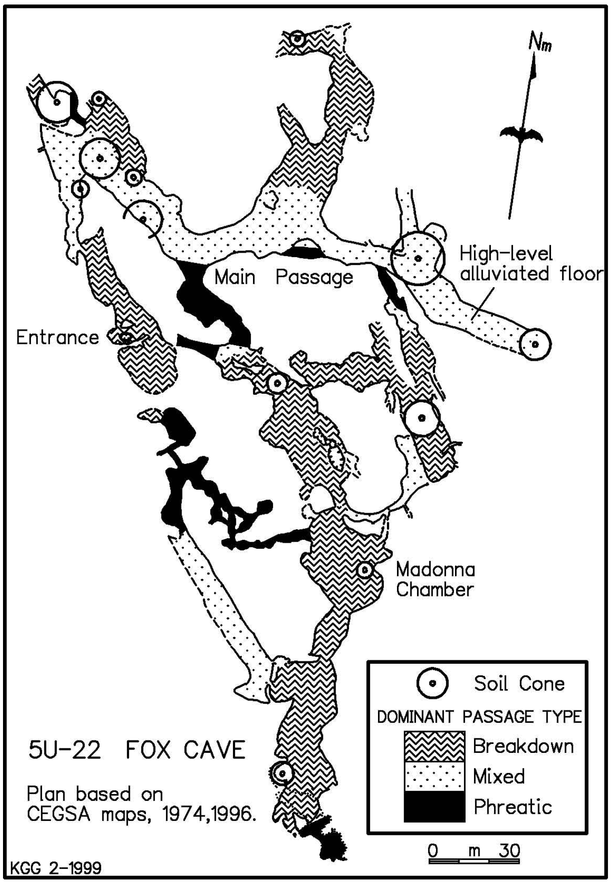


Figure 3.7: Fox Cave, in Tertiary limestone

Figure 3.8: Sand cone in Fox Cave, 5U-22. [KGG]

5U-47: "S102" cave

Access & Time: Private property. 2 hours minimum.

Gear & Hazards: A 15 m (approx) ladder pitch in solution pipe. Snakes.

Description: The entrance pitch starts off wide but narrows to a body-size solution tube then a couple of metres of free hanging ladder climb. A sandy slope leads to a large walking passage that once had a lake in it but has been dry for the last couple of years. A narrow vertical crawl-way leads into the main section of the cave. This has large passages and chambers with large sand cones and a number of underground lakes – stains on the wall indicate past water levels of several meters, and there are calcite flakes.

5U-218: Graetz's Cave (Avenue Range)

Access & time: Private Land. 15 minutes walk from road. 2-3 hours underground.

Gear & Hazards: Standard horizontal + knee-pads.

Description: A newly discovered and only partly mapped system. A tight slot leads down to a broad low-roofed chamber with only a few pillars – the walls are generally well out of sight. The cave is well decorated: The floor has various colourful pool deposits (though now dry) including rim-pools, mesas and "volcano" cones with central hollows. Tree roots cross the floor and under drip points they climb upward to form "Bottersnikes" (Wakefield, 1967): fluffy 5 cm high columns of fine brown roots (Photo 3.9).

Figure 3.9: A "Bottersnike" root mass (5cm high) climbing up out of a drip-pit in 5U-218. [KGG]

Lower Southeast (5L)

The Lower southeast comprises several karst regions (Figure 3.1). The ***Bool Region*** is described above and continues south to the range just north of the GambierAirport. See cave descriptions for 5L-5 & 23.

Gambier Region

The Gambier Region (Figure 3.1) is a composite area comprising several geological and geomorphic zones. High dune ridges alternate with lower sand hills and exposures of Tertiary limestone and some flatter swampy country. About the town of Mount Gambier there is a strong 'hummocky' terrain in which rounded hills built partly of calcareous dune limestone stand above broad hollows in Tertiary limestone; this appears to be a combinationof dune and karst topography.

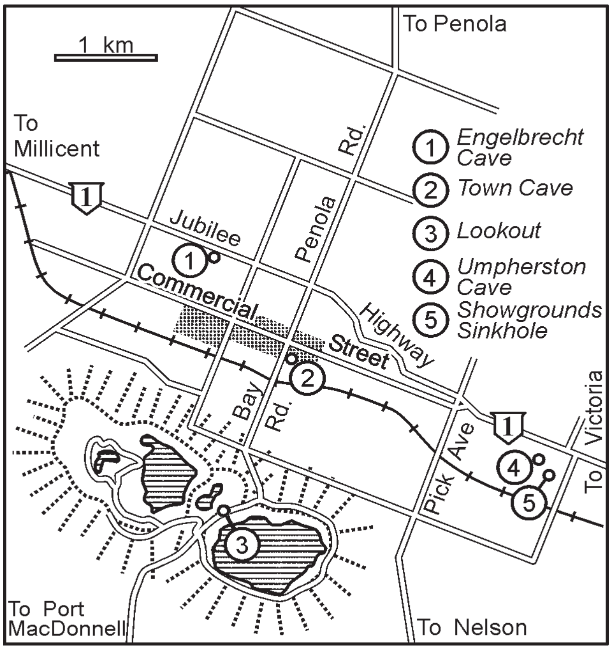


Figure 3.10: Sites within the city of Mount Gambier.

A variety of caves occur both in the Tertiary limestone and as syngenetic karst in the dune limestones. See descriptions below for 5L-4, 6, 12, 15, 19, 34, 40, 61, 69, 119, 144 and 304.

Many spectacular large collapse dolines occur, some of which extend below the water table to form cenotes (Figure 1.8). Good examples of solutional uvalas occur to the north-west of Mount Gambier but are difficult to pick from the adjoining 'hummocky' terrain. Dry valleys occur in the Dry Creek area adjacent to the Glenelg River gorge in the far south-east.

Blue Lake (crater lake)

The Mount Gambier volcano is a set of maars produced by steam-driven explosions when rising magma intersected ground water in the limestone about 28,000 years ago (Sheard, 1978, Leaney & others, 1995). The walls of the Blue Lake crater show a sequence of grey volcanic ash over darker basaltic lava flows over white limestone. There are several small caves near the waterline and also at the basalt-limestone contact. At the central lookout (Figure 3.10.3) one can see outcrop of dipping volcanic ash that contains numerous fragments of limestone blasted up from below.

While the origins of this lake are not directly related to karst processes, the crater rim sits on top of the Gambier Limestone, and the waters of the lake are derived directly from the same regional karst aquifer system that is exposed by the cenotes.

The blue colour appears suddenly each November, when the lake becomes thermally stratified, and disappears in April-May when mixing occurs. The colour is thought to be due to finely-divided calcite crystals which grow when the surface water above the isocline warms up and looses CO_2 (Allison & Harvey, 1983) The reason for the rapidity of the colour change probably lies in some sort of seeding process as the crystals form.

Actively-forming stromatolites occur in the Blue Lake (Thurgate, 1996a,b). At least eight stromatolite growth forms are present, with complex internal structures that are very different to the cenote examples. They are found on both the vertical walls, and on the sediment-covered, sloping lake floor. The stromatolites are best developed at depths of 5-10 m below the surface of the lake, where a single structure may attain heights of up to 12 m. Generally the size and abundance of these stromatolites becomes increasingly less with depth, however, the clarity of the water and the seepage of carbonate-rich groundwater through even the deepest parts of the lake allow the development of large structures to depths of up to 45 m.

The Schank Region (the Cenotes Area)

The Schank Region is an area of relatively bare karst on a flat, stripped Pleistocene coastal plain to the south of the Gambier Region (Figure 3.1). The narrow Coastal Region separates it from the sea. Much of the region has thin soil or bare pavements of Tertiary limestone. Karst features include spectacular cenotes (Figure 1.8, Photo 3.12), well-developed karren pavements and caves. Many of the caves are partly or wholly flooded by the present high watertable though they would have been drained during the low sea levels of the last glacial period. Divers have been exploring these submerged systems for many years now. Stromotlites are common in the cenote lakes (Thurgate, 1996, 1999, Photo 1.13)

Caves here include 5L-7, 8, 9, 158, 238 and 441.

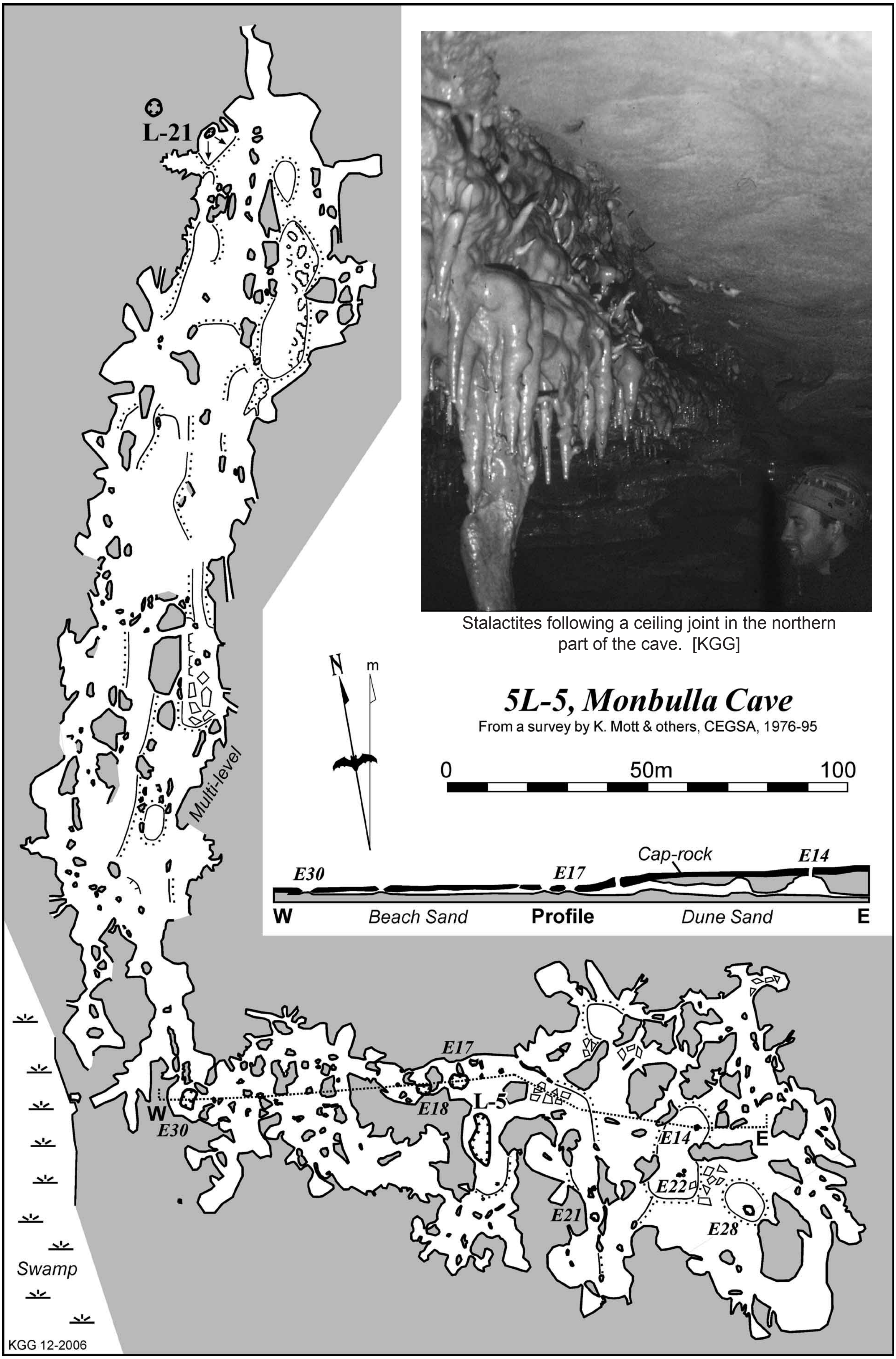
Sister's Road limestone pavements.

The Mount Salt area, southwest of Mount Gambier in the Schank Region, has numerous limestone pavements which show subsoil karren that have been exposed by stripping of the soil.

These pavements are now threatened by the introduction of large machinery that crushes the surface to improve its use for irrigation and improved pastures – but destroys the karren (Bourne, 2002).

The Coastal Belt

The Coastal Region is a narrow belt of land that extends up to 6 km inland from the present coast; its inner margin being a 120,000 year old coastline. It consists of a low erosional coastal plain developed on Tertiary limestone, and partly covered by recent coastal dunes and beach ridges. The watertable is close to the surface. Numerous springs occur, many of them rising from submerged dolines and caves. Most of the caves



Stalactites following a ceiling joint in the northern part of the cave. [KGG] can only be entered by diving. Coastal karren (lapies) are well developed on the limestone cliffs and there are some small sea caves.

See descriptions of 5L-72, and 159-161.

Cave Descriptions

Note: an excellent general reference to caves in the Lower south-east is Peter Horne's 1993 book, which provides descriptions and maps (where available) for all caves from 5L-1 to 5L-300. There are descriptions and maps of many underwater caves and cenotes on the CDAA web site: http://www.cavedivers.com.au/sites.php but details are only available to members.

5L-4: Doline of Town Cave

Access & time: In a small park beside Bay Road in the centre of Mt Gambier (Figure 3.10.2). A look from the balcony takes 10 minutes. No entry to cave.

Gear & Hazards: Falling off balcony when drunk!

Description: This small but impressive collapse doline has been landscaped with viewing platforms. The 18 m deep doline bells out at the base into a chamber with a small lake.

5L-5, 21: Monbulla Cave

Access & time: Private Land. West of Penola. Prior permission from landowner. 2-5 hours, longer with photographers or if you get lost.

Gear & Hazards: Normal horizontal + knee-pads. Much crawling, getting lost, snakes.

Description: Monbulla cave is one of the best examples of a syngenetic cave formed in the side of a ridge of Quaternary dune calcarenite. It has a shallow horizontal development under a calcrete cap-rock, comprising a confusing maze of collapse-modified phreatic flatteners and pillars, mostly forming low crawlways, and occasional larger collapse and solutional chambers (Map 3.11). It is locally well decorated. Navigation is difficult as many apparent walls turn out to just be rows of stalactites and the true wall is out of sight. Reference: Mott 1993.

Monbulla Cave shows many of the features that are typical of syngenetic karst caves. The cave is in two distinctive parts. The northern (Wrecked Car, L-21) and south-western sections are in flaggy flat-bedded (beach or intertidal) limestone and are dominated by a low horizontal system of collapse-modified solutional flatteners with occasional larger chambers. It is well decorated in places. In this area enlarged slots in the roof and the alignment of walls and roof steps and lines of speleothems all suggest joint control, which is unusual for syngenetic caves in dune limestone. The dune is about 725,000 years old – so perhaps its age is sufficient for joints to develop.

The south-eastern section is mainly in cross-bedded dune limestone and largely beneath a ridge with extensive areas of bare rock on the surface. There is less joint control in this maze of alternating crawls and higher chambers. Speleothem development is less extensive here – possibly because of the reduced soil and vegetation cover on the surface. These large chambers rise well above the adjoining swamp level, and have phreatic sculpturing, including bell-holes, some of which penetrate the thin cap-rock (see section on Map 3.11). This could indicate that these large chambers formed in an early stage as flank-margin caves during the same high-stand of the sea that built the dunes.

5L-6: Umpherston 'Cave'

Access & time: Public Parkland. This large collapse doline (Figure 1.8) is in a park on the south side of the highway at the eastern outskirts of Mount Gambier (Figure 3.10.4). 30 minutes.

Gear & Hazards: -

Description: A set of stairs, first constructed in 1886, gives access to the floor which has been landscape gardened. The floor was a lake in the early 1900's (the display area has photographs of row-boats), but the ground-water levels have dropped since. There is a small water-filled cave beneath the eastern wall, and good exposures of Tertiary limestone in the walls. Beware the large diurnal possums which prey on passing tourists!

5L-7: One Tree (Wurwurkooloo)

Access & time: Private Land. South of Mt Gambier.

Gear & Hazards: CDAA "Sinkhole" level.

Description: A large open cenote (water filled sinkhole) about 36 metres in diameter with 8m high sheer walls all around except for a cut ramp. Below the water the walls bell out, creating a flooded cavern which has a much larger diameter than the entrance lake (Figure 1.8). The top of the silt-covered collapse mound is at a depth of 32 metres, where there is some old farming machinery. The bottom then drops away under the walls to a flatter floor, with many large boulders and an almost-buried, upside-down car. There are also some "swim-throughs" between the boulders.

5L-8: Goulden Hole

Access & time: Crown Land. South of Mt Gambier.

Gear & Hazards: CDAA "Sinkhole" level.

Description: Goulden Hole is not the largest of the cenotes in the region, but it shows a good range of the features typically found in them (Figure 1.8). It is a deep sheer-walled collapse doline containing a lake and widens out into an underwater cave that is a single large

Figure 3.12: 5L-9, Little Blue Lake, a cenote south of Mt. Gambier [KGG] See Figure 1.8 for cross-section.

collapse chamber with a central silt-covered rubble cone (Horne, 1988b). The water is 26 m deep and the cliffs rise 12 m above the lake surface. There are good examples of stromatolites exposed up to 2m above the present water level (Photo 1.13). Access to the lake is by an artificial cut ramp, with a shed and water pump. The ramp walls provide a convenient exposure of the Tertiary Gambier Limestone: a friable bryozoan limestone with bands of chert nodules. A long, dry, horizontal, cylindrical cave passage extends back beneath the ramp.

5L-9: Little Blue Lake

Access & time: Crown Land. South of Mt Gambier.

Gear & Hazards: CDAA "Sinkhole" level.

Description: A popular swimming hole, this cenote is a water-filled collapse doline about 45m across with cliffs 6m high above a water depth of 40m (Figure 1.8 & Photo 3.12).

5L-12: Tantanoola Tourist Cave

Access & time: Tour Cave. West of Mt Gambier on the Princes Highway. 30 minute tours

Gear & Hazards: -

Description: Tantanoola Cave is a show cave beside the Princes Highway. It has a complex genesis (ASF, 1983 and see Figure 3.13). The cave occurs in partly dolomitised Tertiary limestone behind the Up-and-down Rocks, which are an old sea cliff. This coast existed about 300 000 years ago, and the sea broke into an earlier phreatic chamber, possibly a flank-margin cave, which was then modified by wave action and partly filled with marine sediments with well rounded pebbles and some bone material, including seal bones. These deposits were later cemented to varying degrees and then partly eroded. The final stage was one of extensive speleothem development, but strongly redissolved remnants of an earlier generation of speleothems can also be seen.

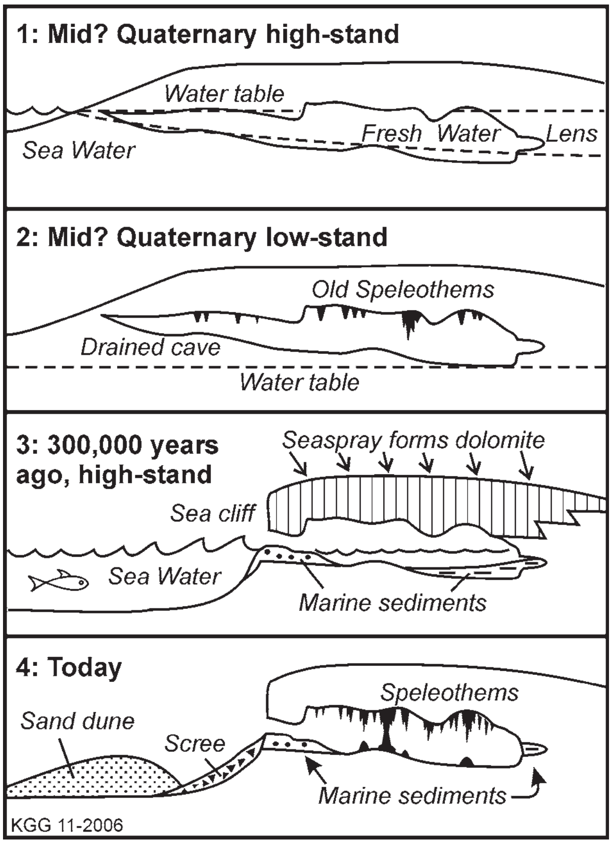


Figure 3.13: Stages in development of Tantanoola Cave, 5L-12 (not to scale).

1: High stand of sea. Solution of a "flank margin cave" at the edge of a freshwater lens behind an old coast.

2: Low stand of sea. Oldest Speleothems formed after cave was drained.

3: High stand. Breaching of the initial cave by the eroding sea-cliff. Deposition of marine sediments, re-solution of early speleothems.

4: Low stand. Drop in water level, formation of younger speleothems, dunes and scree deposits.

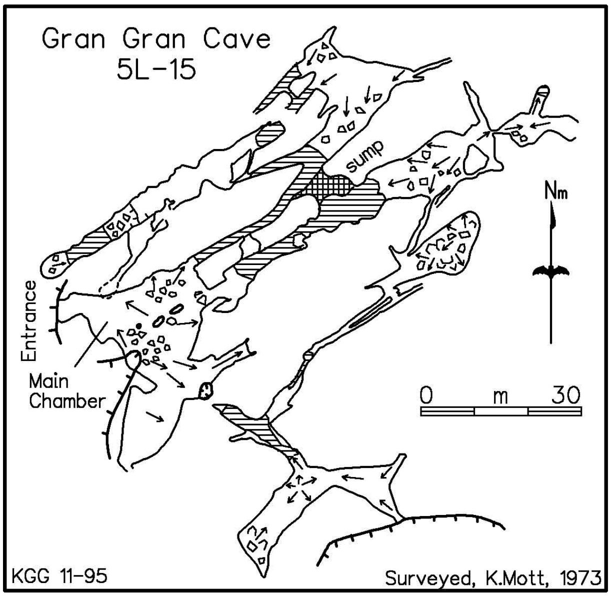


Figure 3.14: Gran Gran Cave, 5L-15, is in jointed Tertiary limestone

5L-15: Gran Gran Cave

Access & time: Controlled by Main Roads Dept. Northwest of Mt Gambier. The cave entrances have been gated but not locked as the matter of access has not yet been finalised. 1-2 hours underground.

Gear & Hazards: Normal horizontal. Some wading.

Description: This cave is in the Tertiary limestone and is a set of joint-controlled phreatic passages and collapse chambers (Map 3.14). The passages going north-east from the main chamber have sculptured roof pendants and pronounced, bed-controlled zones of phreatic spongework in the lower parts of the walls. Extensive pools occur, but the water levels fluctuate over time.

As well as being a representative example of a Tertiary limestone cave, the site has special significance in the presence of both aboriginal markings and evidence of their mining of the chert nodules that occur within the limestone.

5L-19: Engelbrecht Cave

Access & time: This is in a park (signposted) on the southern side of the West Jubilee Highway within Mount Gambier city (Figure 3.10.1). The short air-filled section is a tour cave (30 minutes). The rest is for divers.

Gear & Hazards: CDAA: East Cave – Cave level, West Cave – Penetration (Full Cave) level.

Description: This is a large linear system of phreatic and collapse passages with some large collapse domes (Map 3.15). Most of it is submerged and only accessible to cave divers. The SE section has good examples of phreatic sculpture and roof avens (bell-holes) in the lake chamber. Divers descend under the southern wall and swim via low, silty passages and flatteners to an 80 metre long air chamber.

The north-western submerged section is a 90-metre long flooded passage around 10 metres wide by 3 metres high that leads to a large collapse chamber directly beneath the Princes Highway – drive gently! Several other flooded passages run off to the north and south-west from this inner chamber.

5L-23: Quarry Cave

Access & time: Private Land. Locked, key from owner. 2 hours.

Gear & Hazards: Standard horizontal + knee-pads. Much crawling & some squeezes.

Description: A low-roofed horizontal system in flaggy beach or inter-tidal sands rather than dune sand. Some areas have "synclinal" syngenetic subsidence

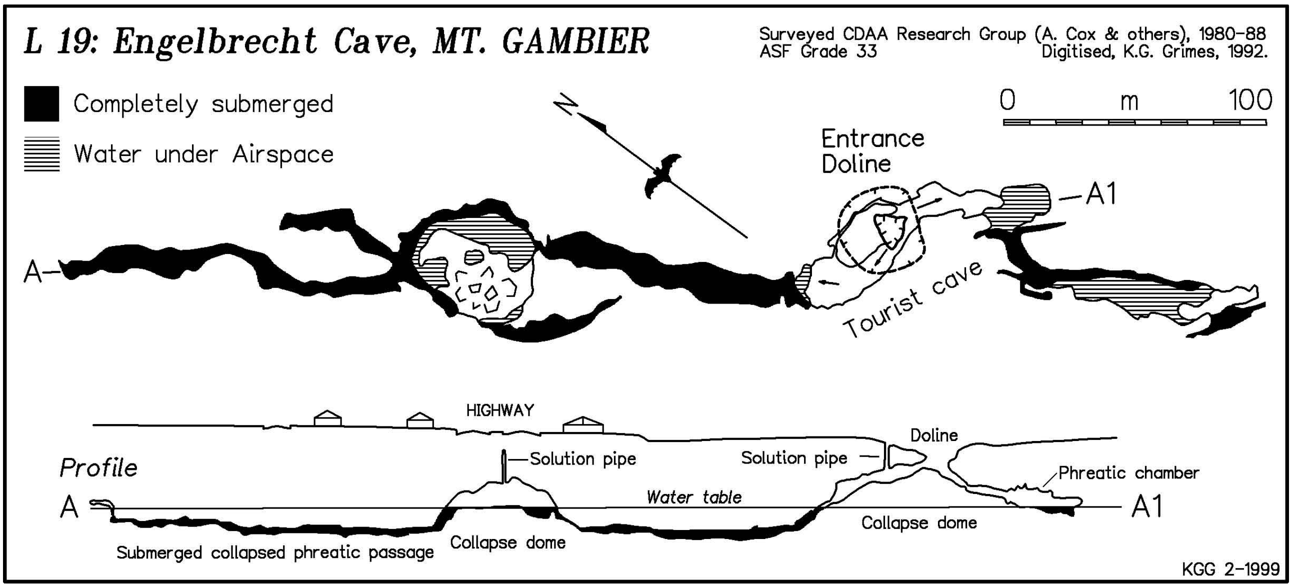


Figure 3.15: Engelbrecht Cave runs beneath the city of Mount Gambier, in the Tertiary limestone.

structures – dipping beds in the roof (Photo 1.7). The main passage set is joint-controlled, but at the northern end it changes character into a broad irregular crawl-maze. Locally well decorated (speleothems and roots; see Photo 3.16).

5L-34: Morgans Cave

Access & time: Crown Land (Foresty). Locked. 20 minutes drive west from Mt Gambier, the last bit on forest tracks. 2 hours underground.

Gear & Hazards: Short ladder or SRT for entrance, standard horizontal gear for rest.

Description: Morgans Cave is a good example of a complex joint-controlled fissure system in the Tertiary limestone, albeit rather spoilt by abundant graffiti (Map 3.18, Photo 1.10). The main beauty here is in the phreatic sculpturing of the rock rather than in speleothems. The entrance is a nice example of a solution pipe that leads to the main fissure (Photo 3.17). To the southeast is a single fissure choked with tree roots from the pine plantation above and a final pool. To the northwest the fissure leads to an area of mazy crawls along two intersecting joint sets. Note that the broad areas on the map are not all chambers, but areas of low-level flatteners alternating with higher fissures.

5L-40: Hells Hole

Access & time: Crown land (Forestry). 20 Minutes SE from Mt Gambier via gravel forest road. Lookout platform. Diving by permit.

Gear & Hazards: CDAA: "Sinkhole" level.

Description: This impressive, deep, sheer-walled, collapse doline is in a small patch of native scrub on the side of a high dune ridge in the Caroline Forest. A viewing platform allows one to see the water table lake 27 metres below the surface. The water reaches depths of 26 m under the overhang (Figure 1.8). The vertical walls

Figure 3.16: A field of straws in 5L-23. [KGG]

Figure 3.17: Solution pipe entrance to 5L-34. [KGG]

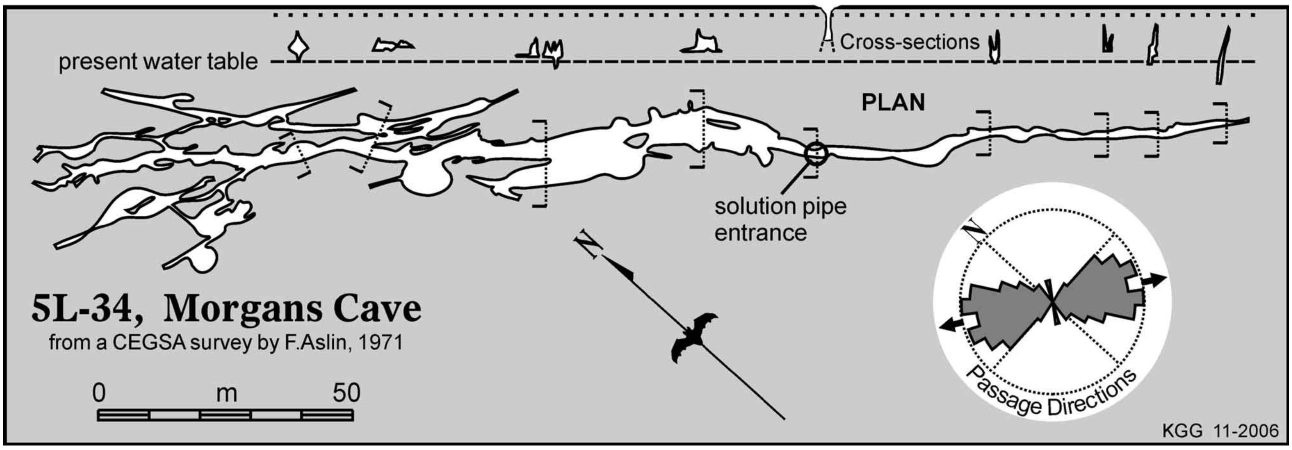


Figure 3.18: Morgans Cave shows strong joint control in the Tertiary limestone.

expose dune limestone in the upper part, and Tertiary Gambier Limestone lower down. Case hardening effects and weathering pockets can also be seen.

5L-61: The Pines

Access & time: Forestry land. West of Mt Gambier.

Gear & Hazards: CDAA Dual Rated Cave and Penetration (Full cave) A full dive to the end of the cave requires at least one stage cylinder and sidemounts are recommended.

Description: The Pines is one of the most popular cave diving sites in the Lower South East. It has a small cenote-style sinkhole entrance, which is the portal to a large boulder-strewn cavern filled with "air-clear" water.

The talus mound slopes away quickly to the south, dropping to a readily-attained depth of around 27 metres some 40 metres penetration distance from the entrance lake, and to more than 30m in a small, very silty alcove behind some of the huge boulders which lie against the wall. Daylight, and most of the lake surface, can easily be seen from most areas in the main chamber, and in ideal conditions divers can clearly see their companions on the far side of the chamber without the aid of artificial lighting. There are also a number of more technically-demanding areas where no natural light ever penetrates, and some of these can only be safely reached by divers who are trained and experienced in the skills and techniques needed to negotiate underwater restrictions in zero-visibility conditions.

On the right hand side of the main lake starting at a depth of approx 5m is a newer extension which leads down into phreatic passages extending along and then up into a large chamber know as the CCR or Crazy Czech's Room (Fundova & Funda, 2004).

5L-69: Mount Burr Cave

Access & time: Forestry Land, no entry during winter (bats). 1-2 hours.

Gear & Hazards: Normal horizontal + knee-pads.

Description: This is an extensive, horizontal, irregular, phreatic maze system developed in dune limestone at the level of an adjoining swamp (Map 3.19). Parts have been considerably modified by collapse. The entrance chamber has excellent examples of phreatic spongework sculpture (Photo 3.20) and used to contain a lake. Fallen blocks within the lake have been sculptured by solution. The level of the lake has varied in response to the vegetation on the surface, which is an exotic pine plantation. At the peak of the plantation growth the lake dries out. Following bushfires in 1983 the level rose about a metre to cover most of the floor of the chamber, but has fallen again in recent years as new pine forest has grown.

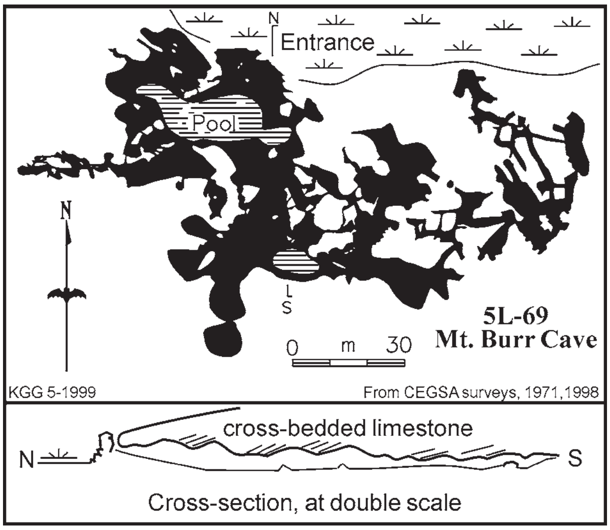


Figure 3.19: Mount Burr Cave is syngenetic karst in dune limestone. The pool size is that seen in 1992, it is now dry.

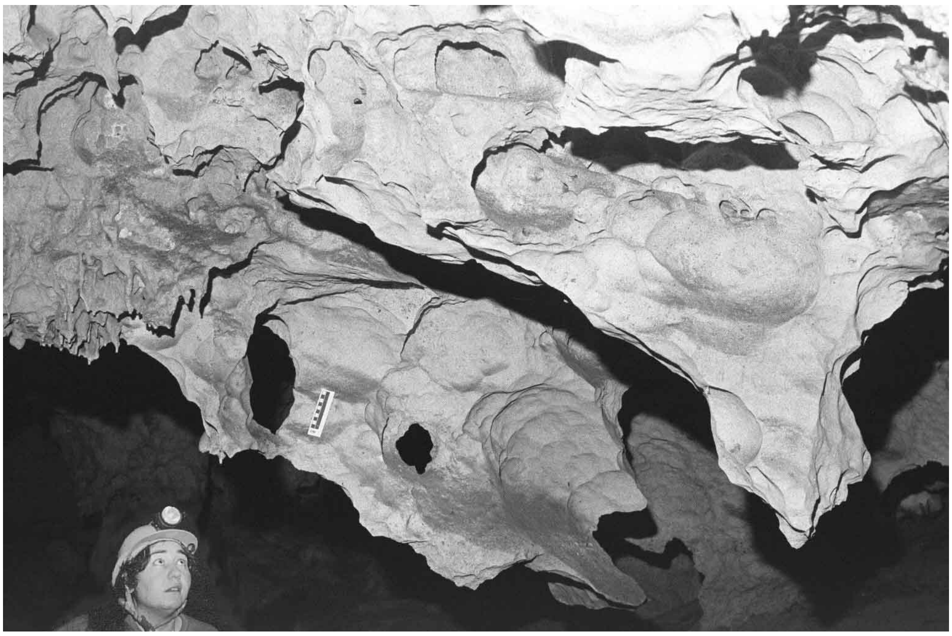


Photo 3.20: Phreatic spongework in Mount Burr Cave, a syngenetic cave in cross-bedded dune limestone [KGG]

5L-72: Piccaninnie Ponds

Access & time: Conservation Park. 20 minutes drive SE from Mt Gambier. Permits needed to dive or snorkel.

Gear & Hazards: (see dive notes) - the water is cold, use wetsuits for snorkling. Several divers have drowned in this cave.

Description: Piccaninnie Ponds is one of the major springs on the coastal plain. The enclosing Conservation Park includes 4 km of coastline and comprises shallow swamps surrounding a series of spring-fed lakes that have formed in karst depressions. The wetland area is bounded by a stable coastal sand dune system to the south and a low dune limestone range to the north. The ponds contain a very interesting aquatic flora and fauna (Thurgate, 1999).

The main spring system, Piccaninnie Ponds, includes the First Pond, which is a 10 m deep, gently-sloping bowl-shaped basin. This leads to The Chasm, a funnel-shaped, steep-sided feature that is over 90 m deep. A wide channel leads off the Chasm, terminating in Turtle Pond, a shallow 6 m deep basin. A large flooded phreatic chamber (the Cathedral) is located at the western end of the Chasm, and is over 33 m deep. The Chasm intersects the salt/freshwater interface and consequently the waters of Piccaninnie Ponds are brackish.

A walking track leads to the outflow point on the beach, where one can view the total flow from the system of about 1000 L/s.

5L-119: Snake Hill Caves

Access & time: Crown Land (Forestry). Permit needed. 15 minutes drive East from Mt Gambier, the last bit on Forestry tracks. 2 hours underground is typical (up to 5 hours for a full look).

Gear & Hazards: Standard horizontal + kneepads

Description: The main Snake Hill Cave (L-119) is formed in a dune limestone ridge and the adjoining plain. It is an extensive horizontal maze of phreatic chambers, passages and flatteners with numerous entrances and daylight holes through the calcreted caprock roof. The small scale map (Figure 3.21) is misleading for

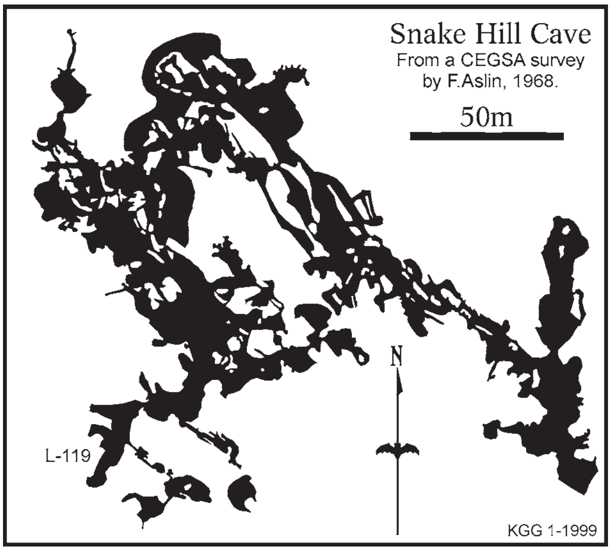


Figure 3.21: 5L-119 is a syngenetic karst maze developed in Quaternary dune limestone.

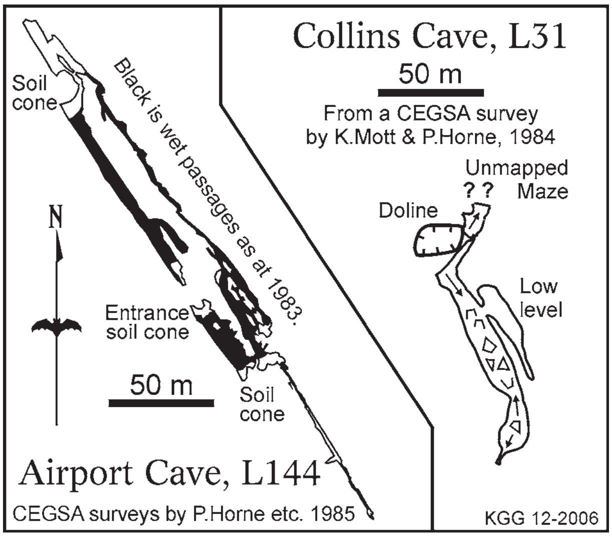


Figure 3.22: 5L-144 & 5L-31.

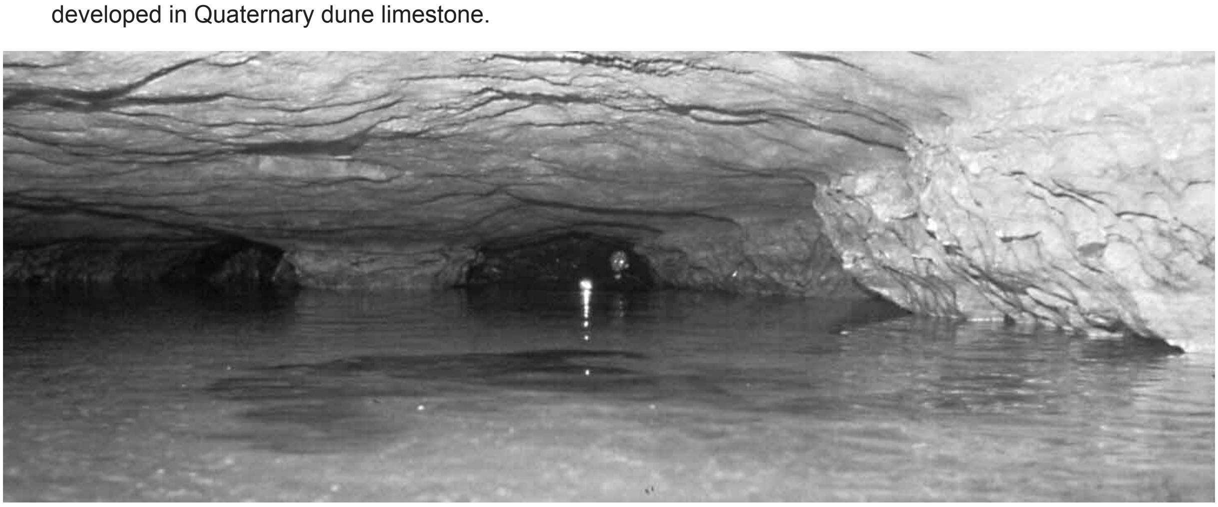


Figure 3.23: Partly flooded section of 5L-144, as seen while the water-table was dropping c.1983. [Andrew Cox]

navigation, as much of the apparently large chambers comprises low flatteners at ankle level and these areas are not obvious as one travels through the cave. The cave has suffered badly from physical damage, marking and rubbish but there was a cleanup operation in 2000. The other caves in this area (L-262, L-263) are mainly smaller collapse dome chambers, but have suffered less damage.

5L-144: Airport Cave (alias Sheathers Cave)

Access & time: Crown Land (Forestry) 2 hours

Gear & Hazards: Normal horizontal. muddy.

Description: Essentially a pair of parallel, flooded, flat-roofed, joint-controlled passages (Map 3.22); the main interest in this cave is its history of drying up of the lake in step with the growth of the pine forest above. When first discovered in 1963 only the small entrance chamber was air-filled and the initial exploration, which started in 1982, was by cave divers (Horn, 1988a). Between 1982 and 1986 the water dropped a metre as the pine trees grew above the cave – eventually allowing exploration without scuba gear (Photo 3.23).

5L-158: The Shaft

Access & time: Private Land.

Gear & Hazards: CDAA "Sinkhole" level.

Description: The Shaft is a fabulous, gigantic water filled cavern which is renowned throughout the international cave diving community for its unbelievable clarity and spectacular lighting effects, especially when the summer sun slices through the water like a bright-blue, scintillating laser beam, spotlighting divers 60 metres distant like tiny blue dancers in a vast, darkened amphitheatre.

A narrow solution pipe opens into the ceiling of a lake at the top of a very large flooded cavern with a central rockpile and very deep sections all around the walls, especially on the north-western side, where a huge passage (the "Big Tunnel") drops away to great depths ending at a constriction at a depth of 87 metres. During the past few years a small groundbreaking team of ASF-CDG divers using trimix have explored other parts of the cave to its deepest accessible areas, reaching a depth of more than 125 metres, resulting in an excellent and very accurate map (pers. comm. Tim Payne & Chris Brown, 2005; see simplified version of the map in Figure 3.24).

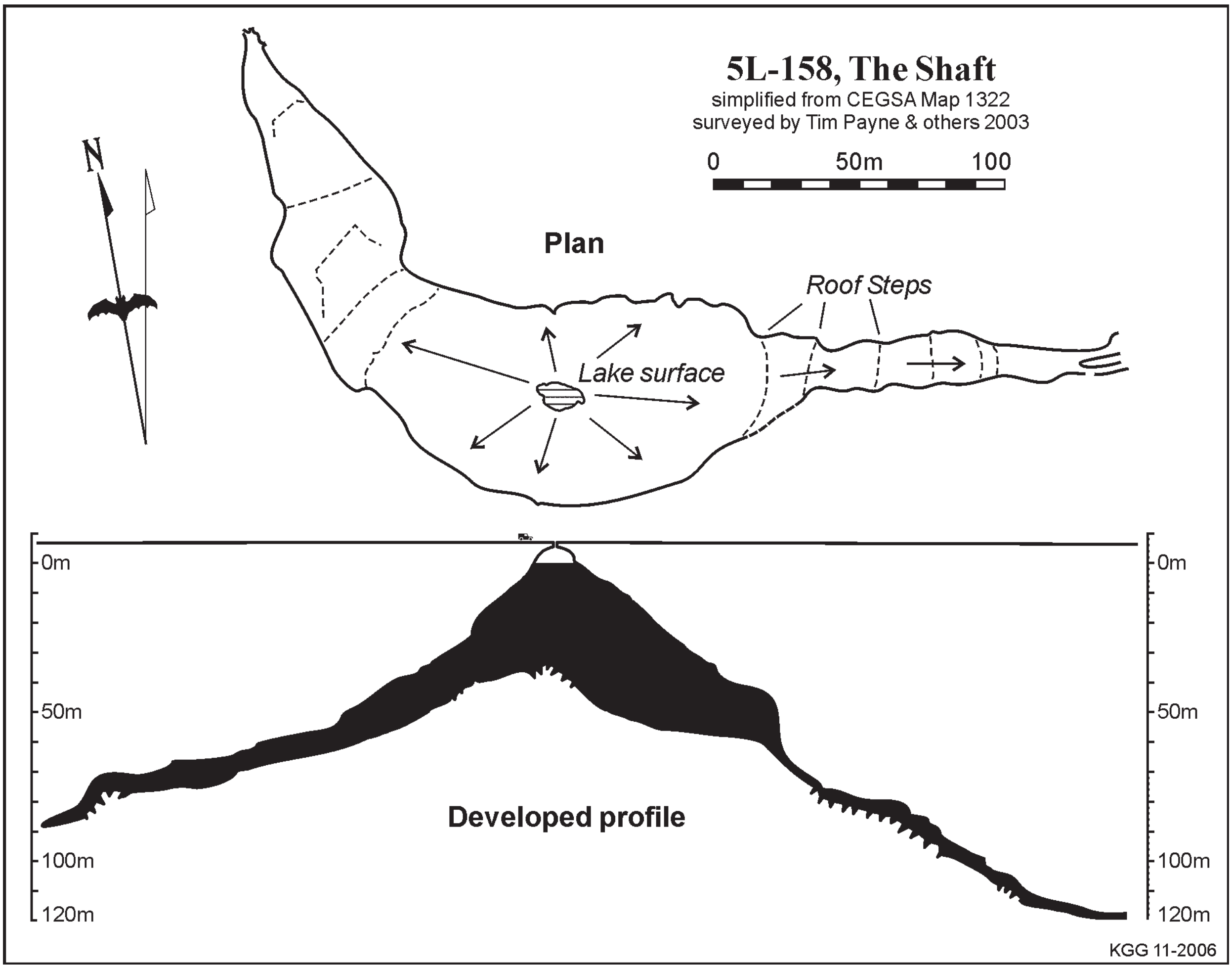
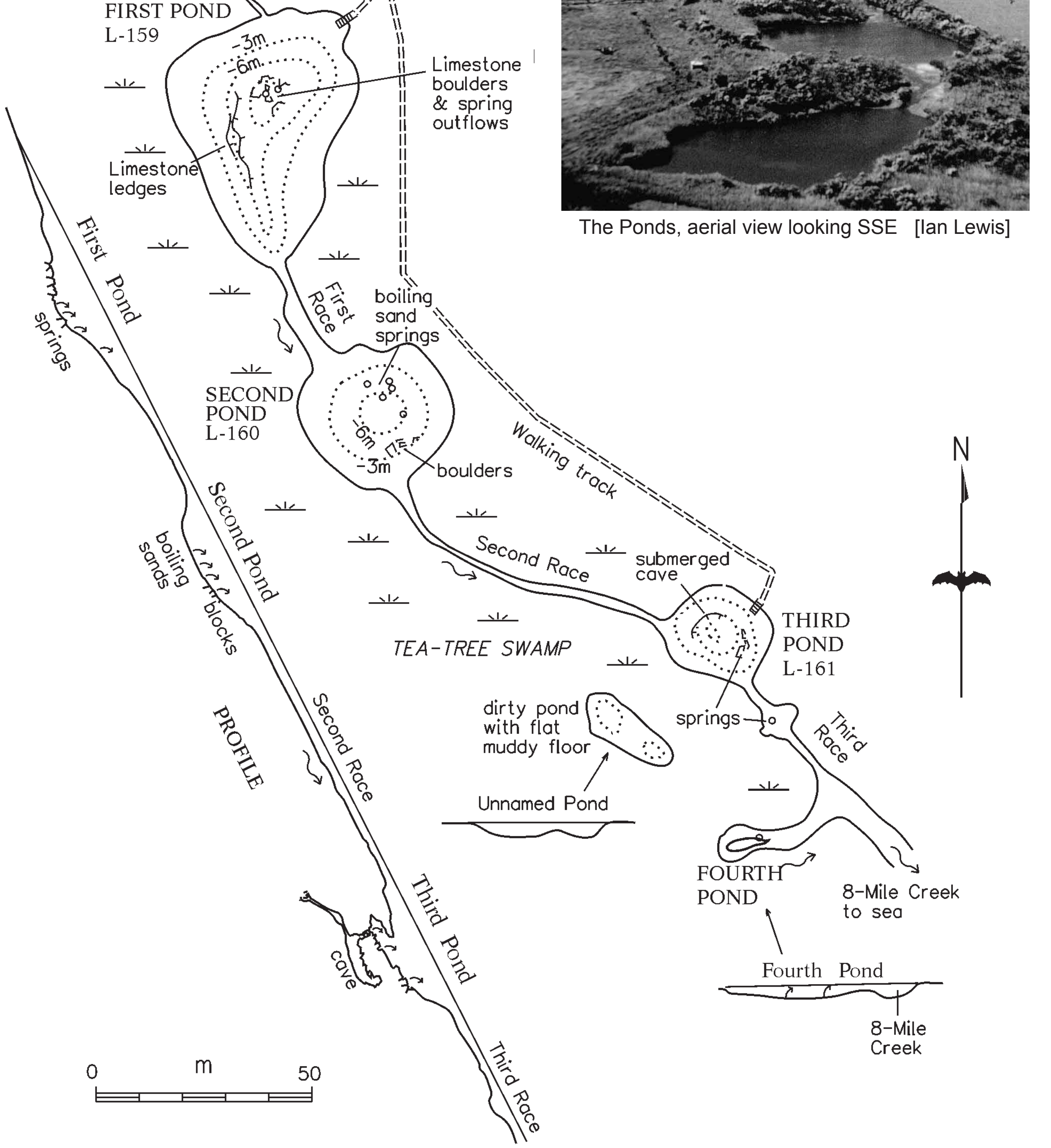


Figure 3.24: The Shaft is the precursor to a cenote - it is a large flooded collapse-dome chamber that has not yet broken through to the surface.



The Ponds, aerial view looking SSE [Ian Lewis]

K.G. Grimes, 8-2004

5L-159, 160, 161: Ewens Ponds

Access & time: Crown Land (Conservation Park). Permits to snorkel. 30 minutes for a surface look. 45 minutes to snorkle from pond 1 to pond 3. 3.5 hours to snorkel to coast (2.5 km).

Gear & Hazards: Snorkel gear, cold water (wetsuits).

Description: Ewens Ponds are a set of spring-fed ponds up to 13 m deep connected by fast-flowing races and feeding the head of Eight Mile Creek (Map 3.25). The ponds are flooded dolines, and one contains a cave. The water bubbles up through the sandy floor or exits from the caves and fissures. The total flow is about 2000 L/s, of which most comes from the NW pond. The water is cold (17.5ºC) and very clear. Most of the originally extensive swamp has been drained and cleared for agriculture. However, the small conservation park containing Ewens Ponds supports a number of aquatic plant communities (Thurgate, 1999). A diverse aquatic invertebrate community is also present that is dominated by insects, crustaceans and molluscs.

5L-238: Glendene Park Cave

Access & time: Private Land. SW of Mt Gambier. 2 hours underground.

Gear & Hazards: Entrance needs 3m ladder, then standard horizontal.

Description: One of the area's prettiest little fissure caves (although quite large for the region). A pitch drops into a beautiful phreatic passage that splits in two (see Map 3.26). The small walls are coated in vivid white moonmilk in excellent condition. There are few other speleothems, This cave needs to be kept to minimum visitation to preserve its beautiful passages and moonmilk.

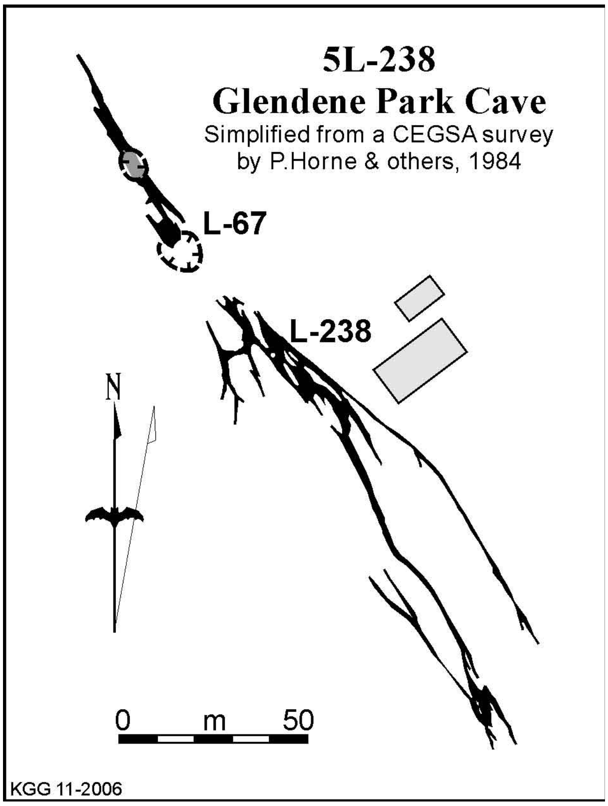


Figure 3.26: 5L-238 shows strong joint-control in the Tertiary limestone.

5L-304

Access & time: Crown Land (Forestry). Permit needed. 15 minutes drive NW from Mt. Gambier. 1-2 hours underground.

Gear & Hazards: Standard horizontal + knee-pads.

Description: A horizontal maze of phreatic passages and low chambers. Some evidence of possible past stream passages and of joint control on passage orientation. Still being mapped.

5L-441

Access & time: Private Land. SW of Mt Gambier

Gear & Hazards: Standard horizontal.

Description: A simple little fissure entrance about a metre wide and 2-3 m deep drops into a very narrow walking passage in both directions. It has a small but an amazing fossil deposit in pristine condition. This cave's location is carefully protected and since discovered by CEGSA members there has only been one other trip to this site.

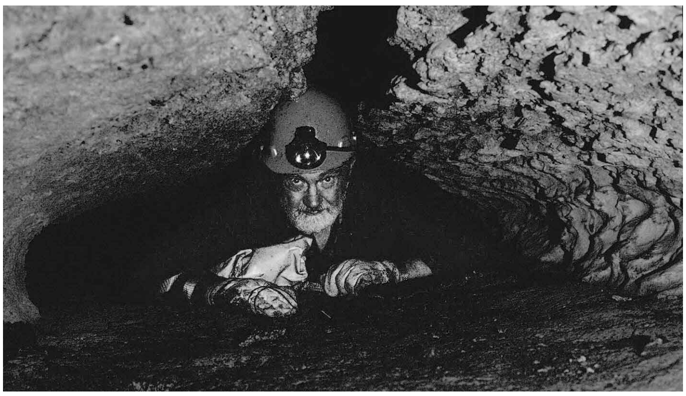


Figure 3.27:
Elery Hamilton-Smith
in a crawlway in 5L-304.
[KGG]

VICTORIAN LIMESTONE CAVES

Susan Q. White, Ken Grimes

West Victorian Karst Areas

This section describes the coastal soft-rock karst of western Victoria. The volcanics and volcanic caves are described in Chapter 5. In Victoria the Tertiary limestones are variable in their purity, and partly buried under volcanic rocks, so only limited parts of the region show significant cave or karst development. The main areas of Tertiary caves and karst are the Glenelg River area (including Kentbruck and Drik Drik) in the west, and Warrnambool and Timboon in the far east (Figures 1.1 & 4.1). Quaternary dune limestones host syngenetic karst and caves such as those at Bats Ridge, Tyrendarra and Codrington. In addition, there is the coastal scenery that is a world-famous feature of the coast east from Warrnambool. More detailed descriptions are given in White (1984, 1989, 1995a,b, 2000a, 2005).

Bool Region

The swampy flats of the South Australian Bool Region continue into Victoria, where they are part of the Follett Plain (which also includes the Glenelg & Coastal regions, Joyce & Webb, 2003, p.554). The area extends a short distance east of the Glenelg River – terminating against a fault scarp at Drik Drik (Figure 4.1). Syngenetic caves occur within some of the dune limestone ranges, e.g. at Cave Ridge (3CR) and elsewhere. 3CR-1 is a complex horizontal maze system that is not yet fully mapped.

Glenelg Region (3G)

The Glenelg Region adjoins the Glenelg River: a permanent stream with its headwaters outside the limestone province. In this section it is incised into the limestone plain as a 30–45 m deep gorge. This tract of the river shows evidence of Pleistocene river piracy and major changes in river direction and mouth location (Boutakoff, 1963; White, 2005). To the south of the river is an extension of the South Australian Gambier & Coastal Regions dominated by dune landforms (Figure 4.1)

The caves are small joint-controlled vadose systems found mainly in the Tertiary limestone; the overlying aeolianites only contain solution pipes or dolines which allow access to the underlying caves. These caves are concentrated in particular areas e.g. around Princess Margaret Rose Tourist Cave, and along small tributaries e.g. Dry Creek. From the river one can see cave entrances at several levels in the limestone. Most caves are now perched 3-5 m above current river level and formed when the river levels were raised by higher Pleistocene sea levels. Many of those at river level have outflowing streams. Active solution at the present river level is undercutting the cliffs to form notches and small cavities.

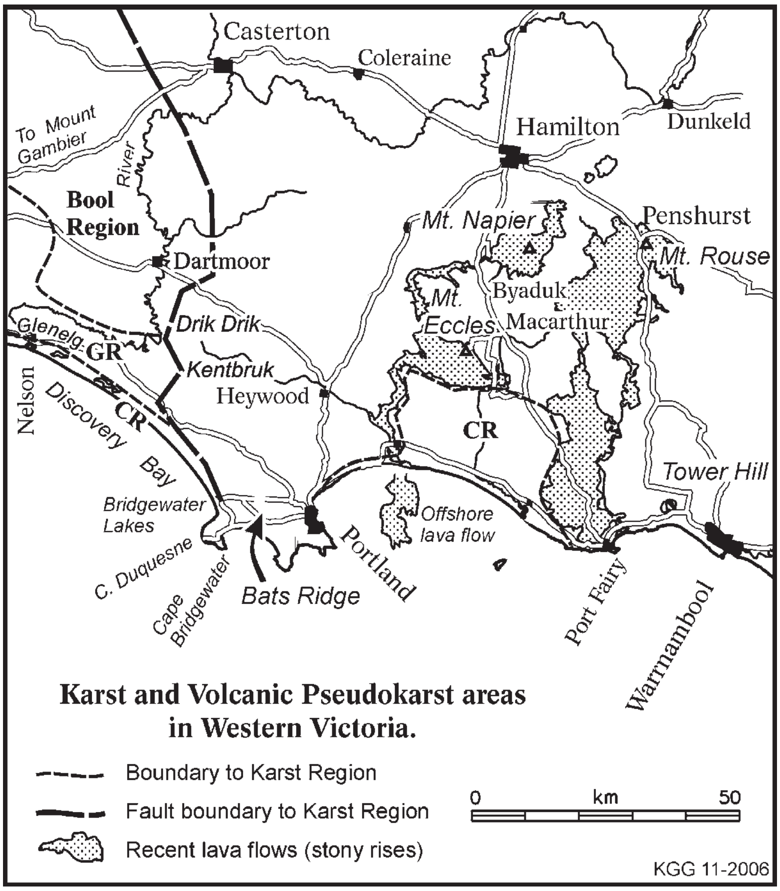


Figure 4.1: West Victorian locations.
GR = Glenelg Region
CR = Coastal Region

3G-6: Princess Margaret Rose Cave

Access & time: Tour cave. About 40 minutes.

Gear & Hazards: -

Description: This show cave is a single joint-controlled fissure passage with extensive good decoration (Map 4.2). It is in the nose of a river meander and a continuation of the cave (3G-3) opens into the river cliffs to the southeast, but there is no passable connection. Other caves occur in the area. Tracks lead down to the river, and to cliff-top view points. There is a pleasant bush camping area with cabins.

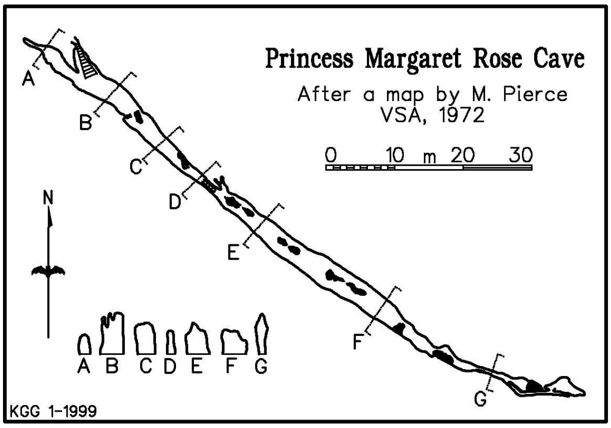


Figure 4.2: Princess Margaret Rose Cave (3G-6)

Drik Drik area (3DD & 3KB)

To the east of the Glenelg Region a fault scarp borders a plateau with a thin cover of basalt and younger dune sands over Tertiary limestone. Subjacent karst dolines penetrate through the basalt, and others occur in the limestone of the scarp. A 2 km long vadose stream cave (3DD-4; Photo 1.12) runs beneath the plateau, circling over itself and tapping water from a large uvala to the east. The Kentbrook area (3KB) has a similar geology but only a single small cave is recorded.

Portland Region (3P)

This is a composite area, and has the Bats Ridges area (3BR) embedded within it. It comprises Tertiary limestones, Quaternary dune limestone, coastal tufa deposits and sea caves developed in volcanic rocks,

Bridgewater Lakes and Tarragal Caves.

The best broad view is from the road at the top of the hill north of the lakes. The lakes resulted from drainage disruption by the coastal dune barriers. The Tarragal Caves (3P-9) are relict flank margin caves breached by a sea cliff that may also be fault-controlled (Photo 4.4). In

Figure 4.3: Solution pipes, with cemented rims, at the *Petrified Forest,* Cape Bridgewater [KGG]

the Bridgewater area much of this former coastline has been obscured by younger mobile dunes.

Cape Bridgewater and Cape Duquesne.

Cape Bridgewater has a number of sea caves in the Pliocene tuffs and basalts. The volcanics are overlain by the Pleistocene calcarenites so both the sea cliffs and the caves show tufa and other secondary calcite deposits derived from calcite saturated springs.

The ***"Petrified Forest"*** is an area on Cape Duquesne named for the tree-like features. These features are actually solution pipes which are quite common in the calcarenites of the Bridgewater Group. However, the concept of the "buried forest" still lingers on (Grimes, 2004a). The pipes at Cape Duquesne have formed syngenetically by solution of the dune limestone. They were infilled with calcareous sand or soil which was then cemented and later exposed by further erosion. The

Figure 4.4: Tarragal caves, in an old sea-cliff, with the Bridgewater Lakes to the right. [KGG]

Figure 4.5: 3P-14 is a small stream cave following the limestone-basalt contact at The Springs. [KGG]

smaller hard root-like bodies are rhizomorphs, formed by calcite cementation adjacent to plant roots that have grown down through the dune sand.

The Springs, two km north from the parking area at Cape Duquesne, has extensive spring tufa terraces and ponds. Along the walking track you will pass areas with dune cross-bedding, calcrete bands, rhizomorphs, and solution pipes.

Climb down the cliffs at a post 150 m beyond the 'Springs Lookout' and head back to the south. **Warning:** do this only when the sea is calm, several people have been washed off the platforms at the base of these cliffs by unexpected waves. Half way down you pass a palaeosoil in the cross-bedded dune limestones which includes solution pipes with a reddish soil fill. At the base of the cliffs, which is the contact between the limestone and the basalt, springs emerge and the water has built up large platforms of tufa with pools and overhung edges. Walk south around a headland to see a set of small streams cascading down a large tufa mound. In places the tufa has grown over and enclosed the channels. A small cave (3P-14, Photo 4.5) behind this mound is the abandoned stream passage, the present stream can be heard in an inaccessible passage below its floor.

Bats Ridge (3BR)

The Bats Ridge area is a particularly intensive example of syngenetic karst caves developed in Pleistocene dune calcarenites (White 1989, 1994, 1995b, 2000a). The dune limestone here has been dated by TL at 290,000 ±34,000 years old (White, 2000b). Detailed cave descriptions and maps of most of the caves are presented in White (1984).

There are peat swamps on both northern and southern sides of the main dune ridge. The swamps to the north are more complex and connect with swamps in the swales between the spurs (Figure 4.6). The ridge has the appearance of a longitudinal strandline dune which has been subjected to "blowouts" at right angles to the dune axis during periods of sand instability. The large enclosed depressions appear to be swale lakes modified by solution.

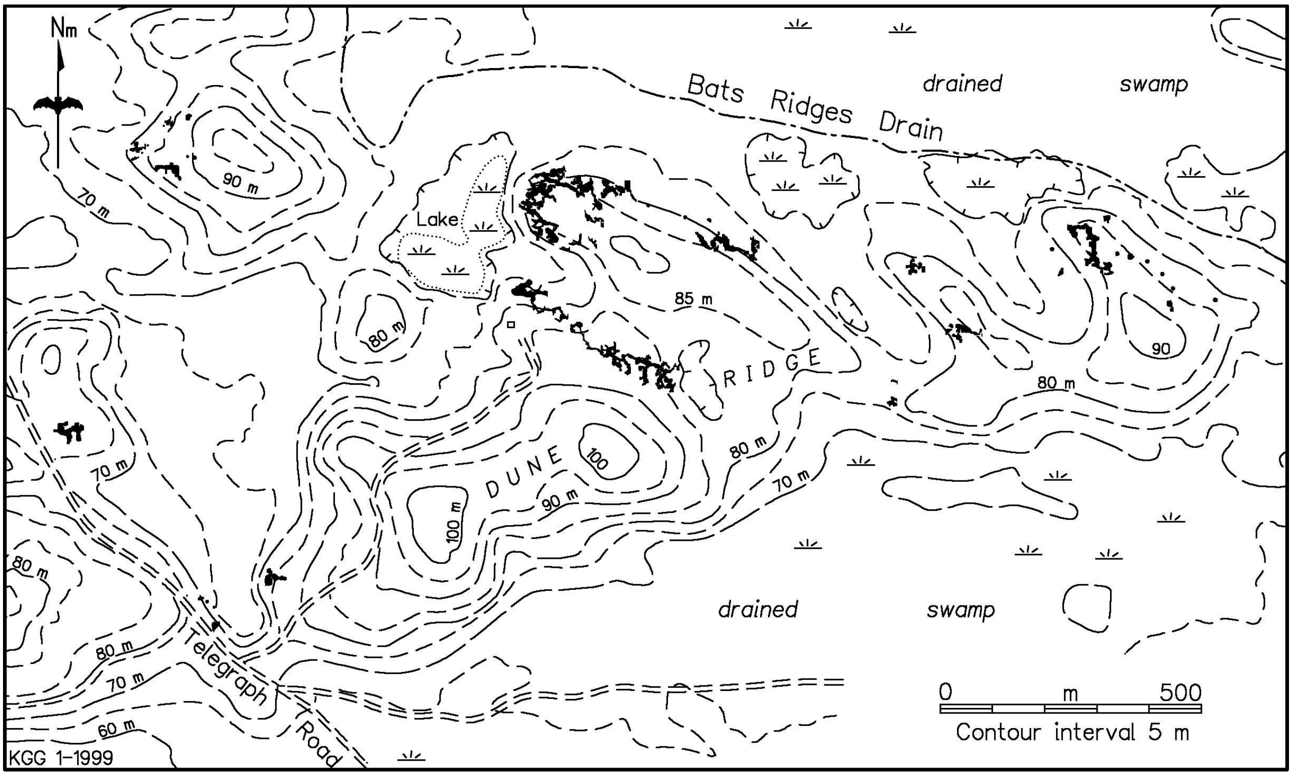


Figure 4.6: Bats Ridge karst area. Syngenetic caves in calcareous dunes.

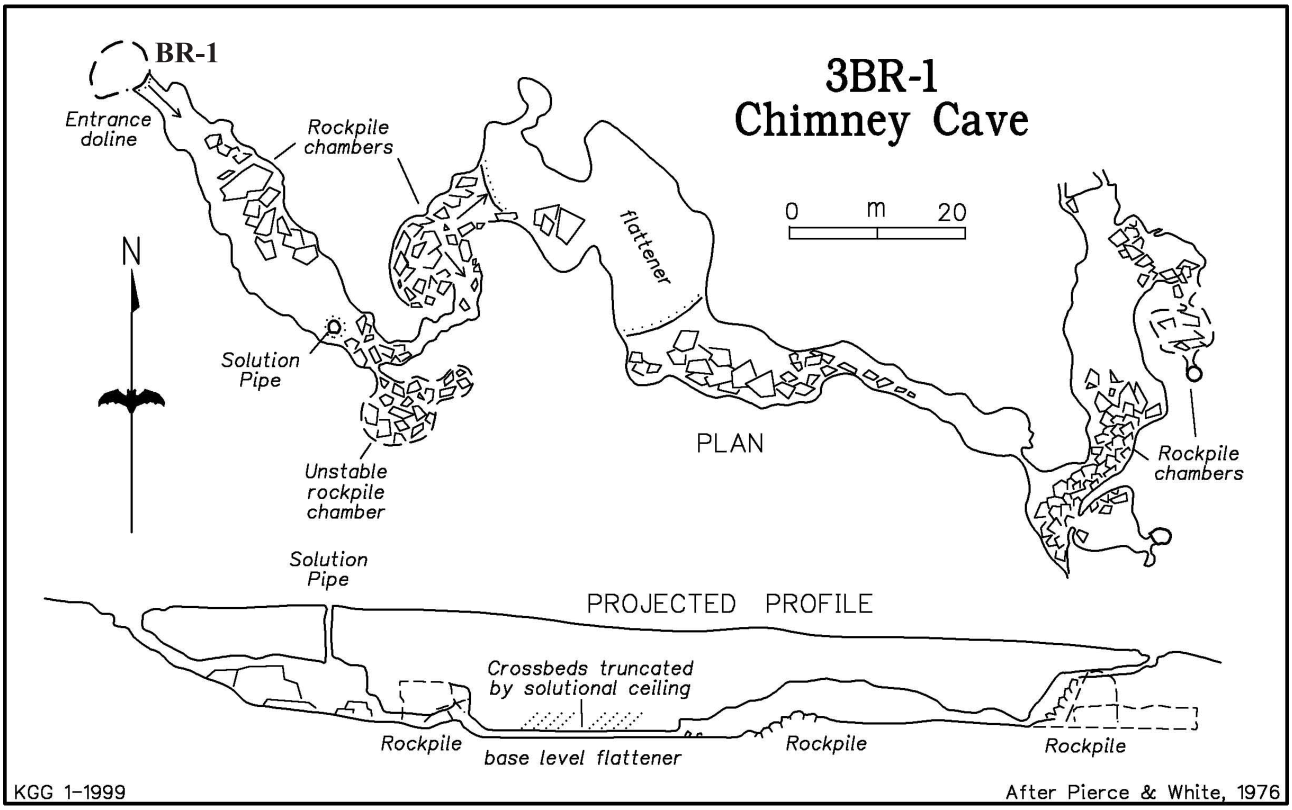


Figure 4.7: Chimney cave, at Bats Ridge, shows syngenetic characters modified by collapse.

The caves are shallow sinuous horizontal systems, often with a number of entrances. They have formed horizontally under a hardened cap rock or calcrete layer. Some solutional chambers and broad flatteners are preserved (Photo 1.11), but collapse has extensively modified the entrance, passage and chamber shapes (Figure 4.7). The cave floors, as well as having rock piles, are covered with clastic sediments derived predominantly from the insoluble residues of the calcarenite host rock. The caves contain a range of calcite speleothems including large expanses of moonmilk (Photo 4.11). Solution pipes, roof avens and bell-holes are common. However, no soil-filled pipes were found at Bats Ridge, despite their presence in other areas of Bridgewater Formation.

Syngenetic karst processes are clearly present. The caves have developed on the spurs of the main ridge (Figure 4.6) and at the top of a previous water table, about 5 to 8 m above the present water table. This concentration may be a consequence of the influence the small swampy depressions and lakes have had on the aggressiveness of the ground water, or may be a "flank-margin" effect related to varying water-tables and mix-water corrosion at times in the past when the sea was nearby.

Land status and Access: State Wildlife Reserve except for BR 10 which is private land (access negotiated if needed for the conference). Bats Ridge is best visited with a guide as many of the caves are hard to find in the thick scrub. Access is via Telegraph road, then down a bush track to the hut.

Equipment for all caves: normal plus kneepads

Hazards: loose rocks in some caves; snakes; leeches

3BR-1 Chimney Cave

Access & time: 15 minutes walk from car along the track; 1-2 hours.

A shallow linear cave in Pleistocene dune limestone.

A long, multi entrance linear developed cave with low horizontal passage, two largish chambers and rockfall passages. Three entrances are small collapse dolines and one is a solution pipe 12.5 m deep and 1 m in diameter. Passages range from spacious tunnels to wide low (0.3 - 0.6 m high) flatteners and rock pile chambers. Bats used to winter in one chamber in the 1970s, but numbers have declined dramatically. Some straw and calcite speleothem development. "Moonmilk" present on walls. Length: 200 m. See Map 4.7.

3BR-2 Hut Cave

Access & time: 5 minutes walk from car along the track; 1-2 hrs, more if the connection between BR-6 and BR-2 entrances is done.

A large multi entrance cave with linear development. The cave is seen in two sections which are connected by a narrow crawl way. BR-2 end of the cave has four entrances in an obvious collapsed doline (only one of

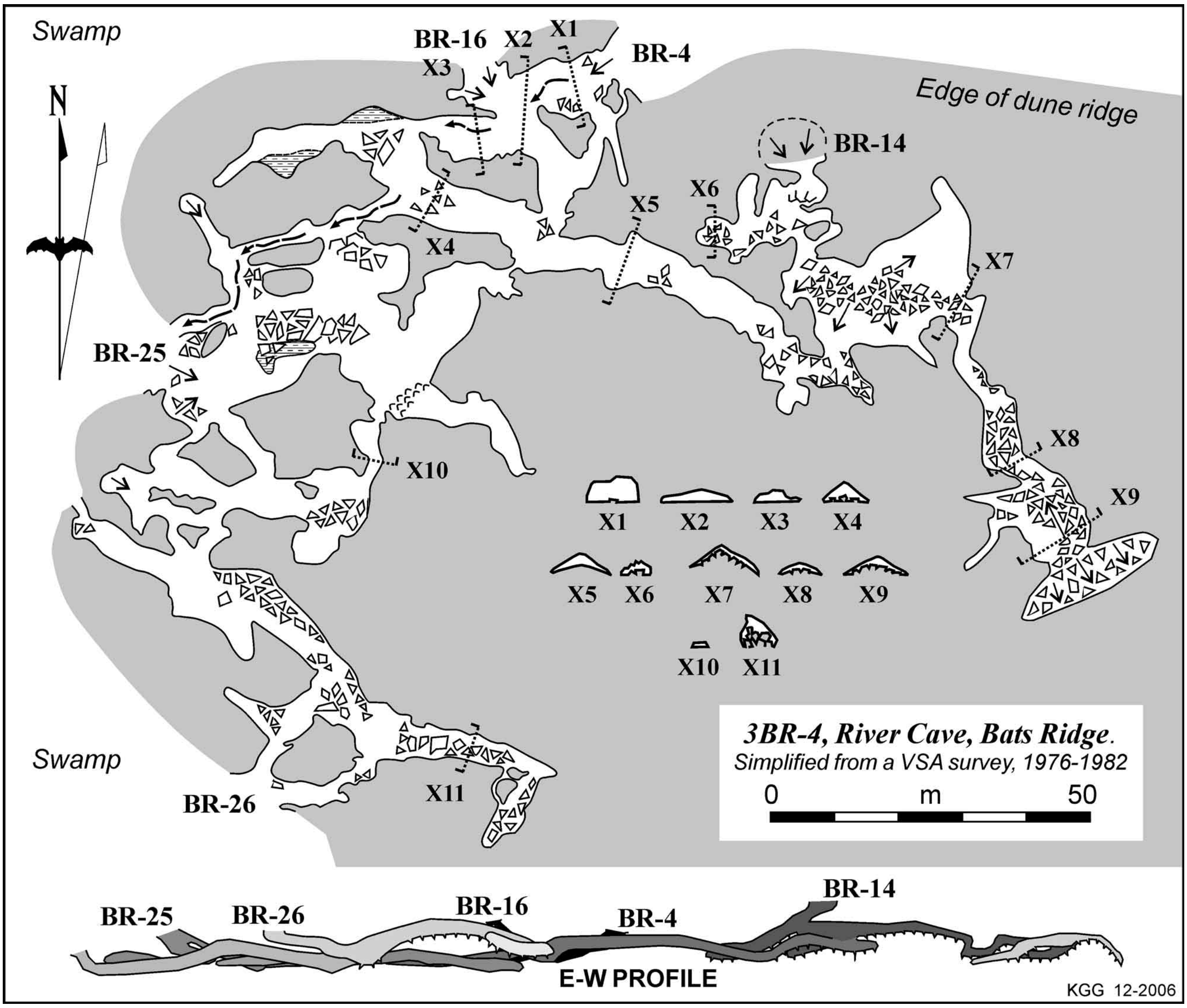


Figure 4.8: River Cave (3BR-4) is developed in a dune (grey) at the level of the adjoining swamp.

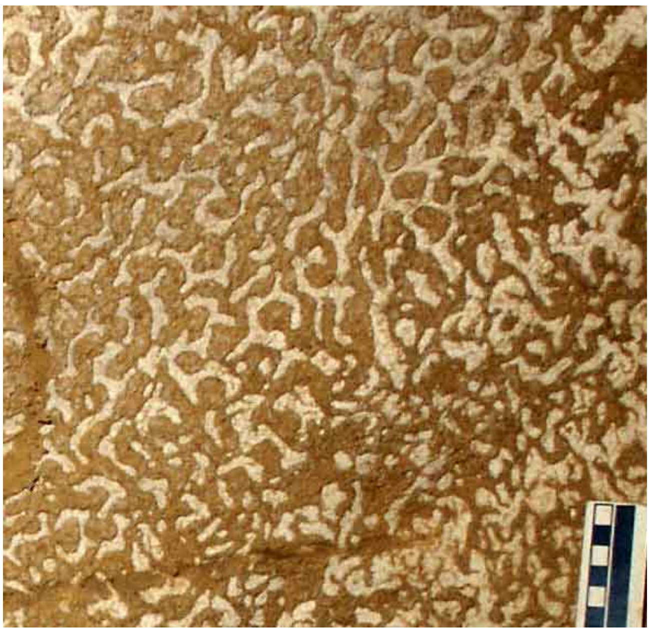


Figure 4.9: Vermiculations formed by a drying mud film on the wall of 3BR-1. Scale in cm. [KGG]

these entrances is numbered), and a narrow passage which connects to BR-6. Some dry speleothems. BR-6 entrance leads to large domed chambers with rock pile and sediment floor. This section also has extra entrances. The large chamber connects to BR-2 via a narrow crawlway. Horizontal development of cave, with rock collapse and dome roof structures. Some speleothems present. Length: 230 m. See small-scale map in Figure 4.6.

3BR-4: River Cave

Access & time: 15 minutes scrub bash from car around the swamp; 1–5 hrs (or even more) depending on how much you want to see.

Very long, complex, horizontally developed cave with nine entrances , mostly collapsed dolines. This cave is a complex maze of low flat passages, rock fall chambers and tunnel passages with rock pile and mud floors. The cave is partly filled with water from the Bats Ridges drain diversion in wet seasons and has inflow and outflow entrances. Evidence of stream modifications of the floor sediments from these wetter periods can

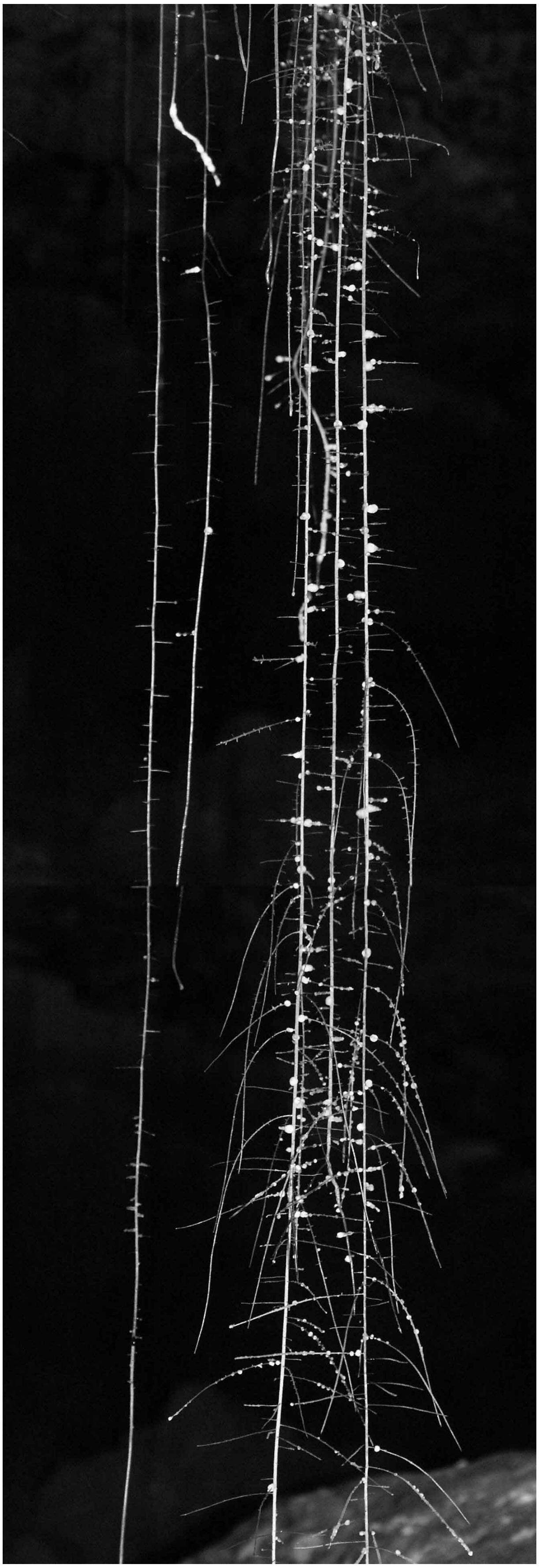


Figure 4.10: Roots with calcite nodules, in BR-59. [KGG]

Figure 4.11: Moonmilk mass (Scale in cm) [KGG]

be seen. Speleothems include large stalactites and stalagmites. Length: 1250 m. See Map 4.8.

3BR-10 Waterfall Cave & 3BR-11 Old Cave (1864 Cave)

Access & time: 20 minutes walk from car; 1-2 hrs but this depends on surveying!

Several collapse doline entrances into relatively spacious cave with several inter-connecting chambers. Sediment floors and considerable rock collapse. Some active and inactive calcite speleothems and moonmilk. Several entrances nearby which may connect. Old graffiti (1864 dates). Partly surveyed and survey work needed.

3BR-59: Nearby Cave

Access & time: 15 minutes scrub bash from car to find the entrance; 1-3 hours.

Large entrance in side of collapse doline with small tight crawl on eastern wall. Narrow passage over rockpile drops down collapse into stream passage with water/mud evidence on walls. Small collapses. Water levels marked with mud on walls. Main passage is a sinuous stream bed type. Some very active formation as shawls, helictites and flowstone in restricted areas. Length: 900 m. See small-scale map on Figure 4.6.

VOLCANIC CAVES in WESTERN VICTORIA

Ken Grimes

Volcanic Caves and other Volcanic Features

This chapter describes the lava caves and other volcanic features of two recent volcanoes in the western part of the volcanic region: Mt Eccles and Mt Napier (Figure 5.1). Chapter 2 describes how lava caves form, and some of the features associated with them.

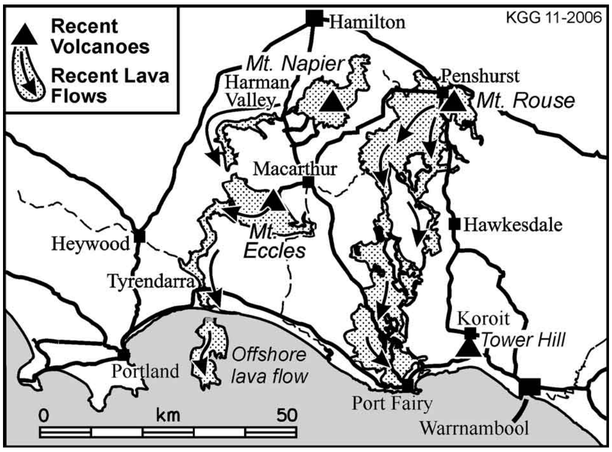


Figure 5.1: Recent lava flows in western Victoria.

Mount Eccles Area

The post-conference trips will be based at the camp ground at Mt Eccles. The main volcano has a deep steep-walled elongate crater which contains Lake Surprise. The crater wall has been breached at its north-western end by a large lava channel (or "canal" as they are called locally). One lava cave (Tunnel Cave, 3H-9, Figure 5.6) is found beside the walking track at the start of the canal (Ollier 1964a). A line of smaller spatter and scoria cones and craters extends to the southeast from the main crater (Figure 5.2). A small but well-defined lava canal runs southwest from one of these smaller cones and ends at the Natural Bridge (3H-10), which is a roofed over section of the canal.

The longer and more complicated caves known at Mount Eccles are associated with the South Canal (Figures 5.2, 5.10). These caves are generally formed in the levee banks on the sides of the canal and would have fed small lateral lava lobes or sheets when the canal overflowed. Some are simple linear feeder tubes, but many have branching forms and complexes of low broad chambers which suggest draining from beneath the solidified roof of a series of flow lobes (see Figure 2.3 and Grimes, 1995, in press).

Current studies on sediments within the crater lake suggest an age of about 33,000 years for the Mt Eccles eruption.

Main Lookout

Below you is the crater and present lake, which is about 14 m deep. The lake is at the level of the regional groundwater, and its level fluctuates by several metres. To the left is the small peak of Mount Eccles. At the time of the eruption the crater would have been filled with a lake of liquid lava, with a large roaring fountain of lava at the southeast end spurting up several hundred metres into the air. The lava droplets from the fountain would have frothed and partly solidified as they fell, and were also blown to the east by a westerly wind to build up the peak, which is composed of loose or partly-welded scoria (frothy lava fragments). The cliffs below you and visible on the far side are solidified lava that overflowed from the quieter part of the crater lake. The main overflow point was at the north-western end where a major lava channel runs away from the crater.

Further out

Beyond the area of craters, the lava channels fed a broad lava shield about 10 km across which has diverted several streams and eventually narrows to run south to the coast as the long Tyrendarra flow (Figure 5.1). That flow continues offshore – the continental shelf was dry at the time as it was near the peakof the last glacial period (Boutakoff, 1963). A few caves are known within the

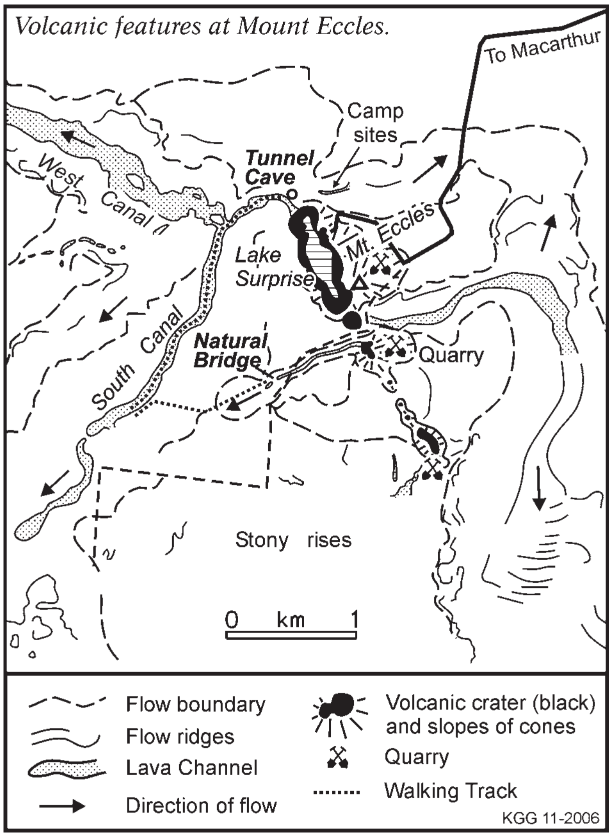


Figure 5.2: The Mt Eccles volcano.

lava shield and on the Tyrendarra flow but much of that remains unexplored.

Where the lava met Darlot Creek to the west it dammed it up to form Lake Condah and the Condah Swamp. This was an area of extensive wetlands that was developed by the Aboriginal people into a complex system of fish-traps and stone-based houses. It was drained by the Europeans, but there are plans to re-flood the system and reactivate the fish-traps.

Wallacedale Tumuli.

A Tumulus is a steep-sided mound of lava crust that has been pushed up above the lava surface. The solidified crust above the liquid core of a lava flow generally forms irregular mounded surfaces known as Stony Rises. However, in a few places, the movement is localised to small "soft spots" in the crust which are pushed up to form discrete steep-sided mounds the size of a house rising above a relatively flat surface (Figure 5.3). A close look shows tilted remnants of the original crust's surface split apart by gaping cracks on the sides and top of the mounds and in places small tongues of liquid lava have been squeezed out through the cracks. Even more rarely one finds that the liquid core has drained back down to leave a central hollow and a "donut" ring, or perhaps a small cave within the tumulus.

While Stony Rises are a common feature, steep-sided tumuli are rare, and the tumuli seen in the Harman Valley flow are the best examples in Australia (Ollier, 1964b).

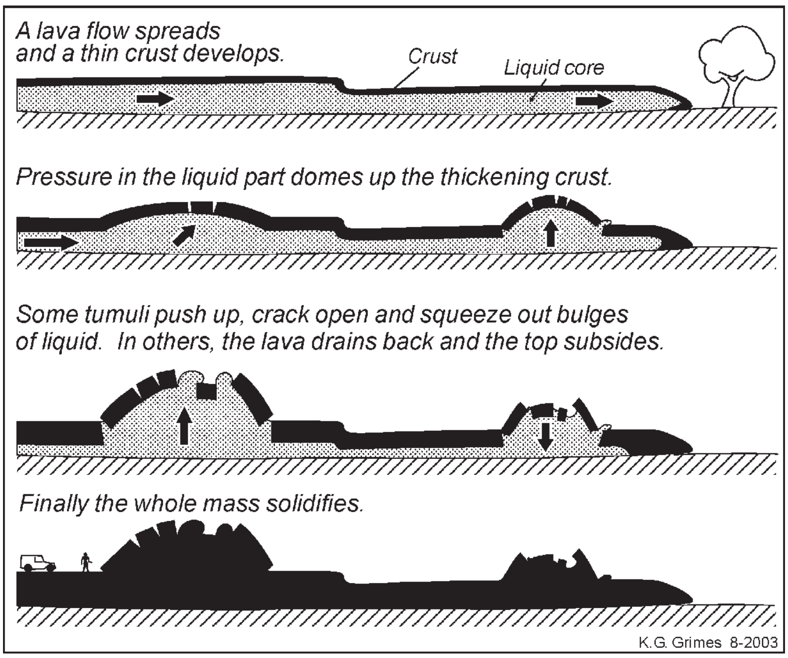


Figure 5.3: Development of tumuli on the surface of a crusted lava flow.

Mt Napier

Mount Napier (figure 5.1) is a composite volcano with a broad, timbered, lava shield capped by a steeper, bare, scoria cone formed by explosive activity at the end of the eruption (Whitehead, 1991). There are a few small lava caves on the shield. The lava shield flooded the pre-existing Harman Valley, damming the creek to form a major swamp on the upstream (eastern) side, and flowing down the valley as a long linear flow that finally is lost beneath the Condah Swamp (which was dammed up by a lava flow from Mt Eccles). This long flow was fed by lava tubes, drained remnants of which can be entered at the Byaduk Caves, near the head of the valley, and elsewhere. Lavas also flowed down several other, smaller, valleys such as Scotts Creek at Byaduk township.

For a long time the eruption was thought to have been a bit over 8,000 years old, based on a "minimum age" radiocarbon date from peat material in the swamp dammed by the flow. However, more recently, Stone and others (1997) used isotopes generated by cosmic radiation hitting the lava surface at the Byaduk caves to deduce an age of 32,000 years.

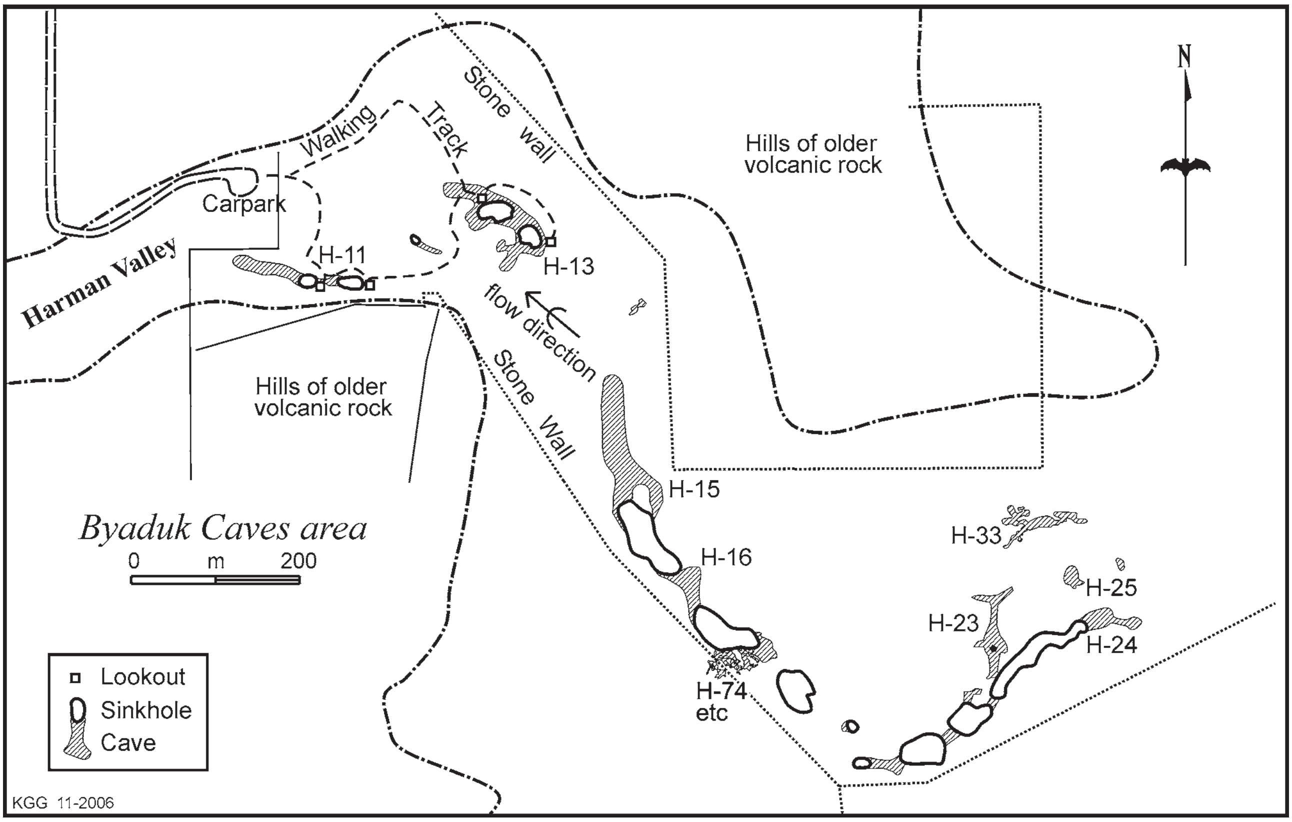
Harman Valley Viewpoint

This is a good viewpoint on the Hamilton–Port Fairy Road that looks up the Harman Valley towards the volcano of Mount Napier. There is a parking area with interpretation signs.

The volcano can be seen in the distance, and is described above. Below the lookout one can see the lava flow that came down the valley from the mountain. This flow was fed mainly by lava tubes, but some surface channels were also present. One can see a lava channel below and to the right of the lookout.

The Byaduk Caves

This lava flow, which came from Mount Napier, is the same one as that seen from the Harman Valley Lookout. It was fed by large lava tubes. In the Byaduk Caves area collapse of parts of the main feeder tube has exposed the largest and most spectacular lava tubes, arches and collapse dolines in the region (Ollier & Brown, 1964, 1965; Grimes & Watson, 1995; Figure 5.4). The largest tunnels are up to 18 m wide and 10 m high, but not very long (maximum 200m) as they terminate in lava sumps. There are also some smaller but more complicated caves, and a multilevel system (3H-33). There is a



Fiure 5.4: Byaduk caves - location map.

walking track and viewing platforms with interpretation signs at several of the sinkholes.

Cave Descriptions

Additional descriptions and maps of these and other volcanic caves appear in Ollier 1964a; Ollier & Brown, 1964, 1965; Grimes & Watson, 1995.

3H-8: The Shaft, Mt Eccles

Access & time: National Park. Short walk from a track. Half hour to rig. 10 minutes each on bottom is tons! Avoid the congestion from large parties.

Gear & Hazards: 23m ladder or SRT, with an extra 20m of slings to tie back to a large boulder hidden in bracken on outer SE slope–this is the preferred rigging point as the rope/ladder then hangs free and avoids damage to ferns in the narrow part of the shaft. **Danger:** keep children away from this site, and take care around the edges and on the slippery inner slopes, you may reach the bottom faster than you intended!

Description: The still-open vent of a small volcano (Ollier 1964a). A shaft in the bottom of a funnel shaped crater in a small spatter cone opens up below into a single large elongated chamber with rubble floor. Contains moss-covered lava stalactites. See Map 5.5.

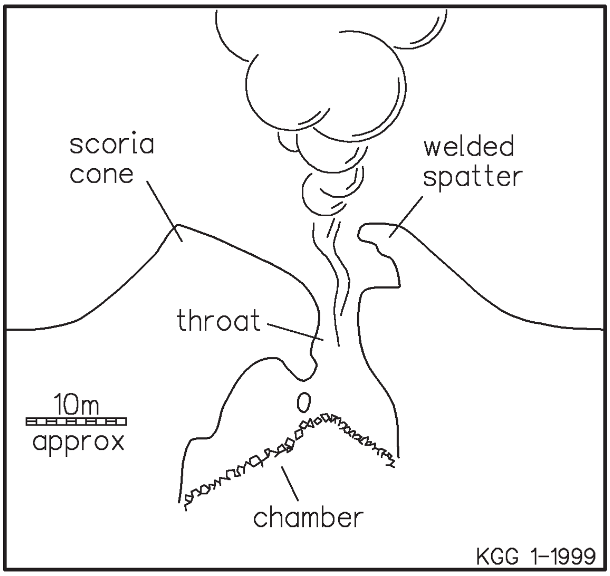


Figure 5.5: The Shaft (3H-8), Mt Eccles.

3H-9: Tunnel Cave, Mt Eccles

Access & time: National Park. Right beside Crater Rim walking track. Half an hour to visit

Gear & Hazards: Lights only.

Description: A detailed leaflet describing this cave can be obtained on request from the ranger. It is a typical lava tube, 60m long, with "railway tunnel" dimensions and shape. The flat floor is the top of a solidified lava pool. As you walk into the cave the roof becomes

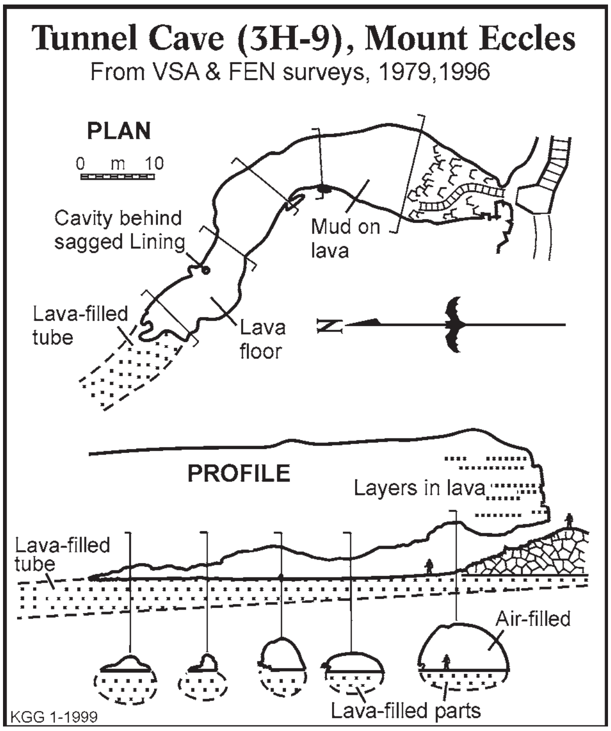


Figure 5.6: Tunnel Cave.

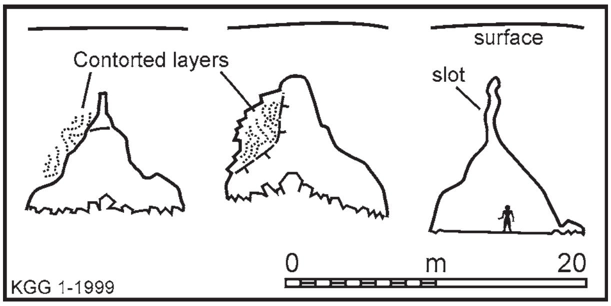


Figure 5.7: Cross sections of Natural bridge showing the "gothic" roof and contorted layers.

lower and eventually reaches the floor. The tube would originally have continued but is now blocked by solid lava (Map 5.6). Features of interest are the lava bench on the left side near the entrance, and further in there are lava drips, a ropy lava floor and a sagged wall lining that has opened up a gap behind it. References: Ollier 1964a; Johnson & others, 1968 (biology & ecology).

3H-10: Natural Bridge (Gothic Cave), Mt Eccles

Access & time: National park. 5 minutes walk from carpark. 10 minutes drive from campground. Enter from SW end. Half hour in cave.

Gear & Hazards: standard horizontal.

Description: A detailed leaflet describing this cave can be obtained on request from the ranger. From the crater near the southeast quarry a small lava channel runs off to the south-west (Figure 5.2). At its SW end, part of the lava channel has been roofed over to form a short 36m section of cave (Figure 5.7). The pointed, 'gothic' roof of this cave suggests that it was roofed by levee overgrowth (Figure 2.3c & Photo 2.4). The contorted layers visible in its walls would be linings that were built up and then slumped while still hot. Towards the NE end, the east wall has scrape marks formed when the lining was still soft. Reference: Grimes 2002c.

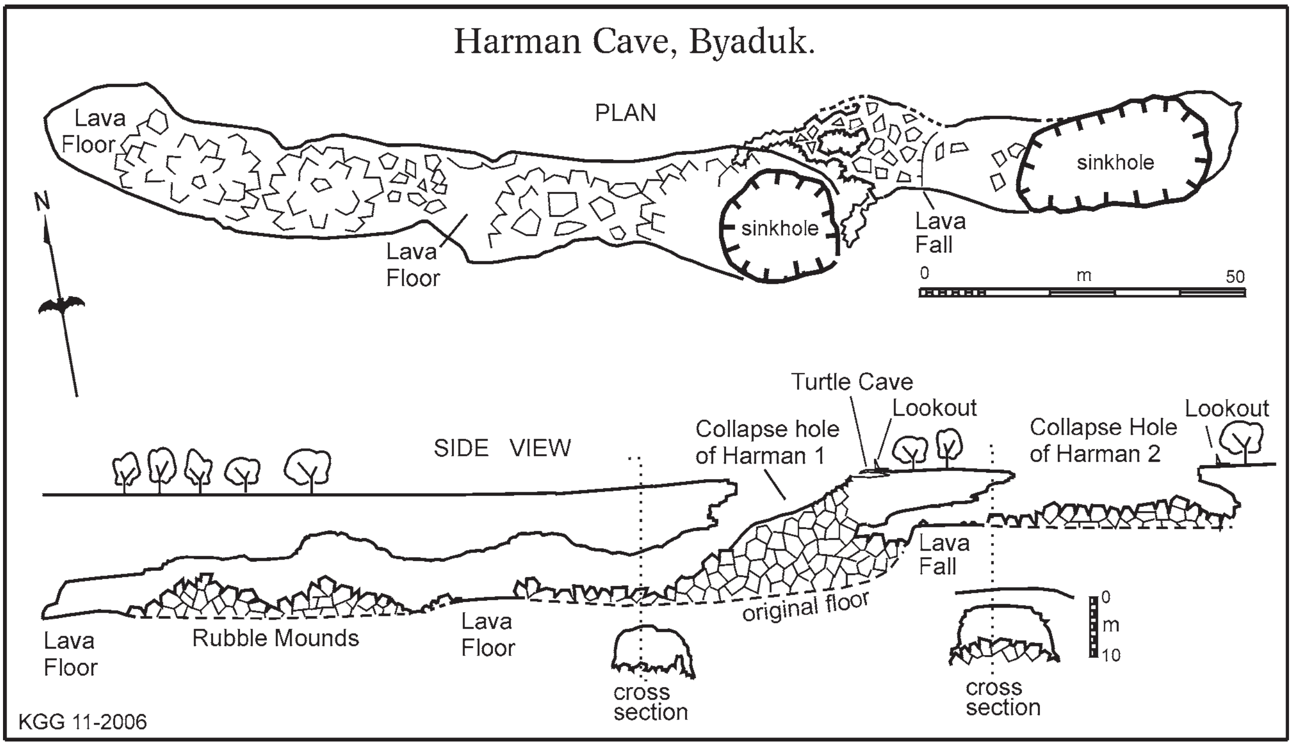


Figure 5.8: Harman Cave is a large lava tube with considerable collapse modification.

3H-11,12: Harman Caves, Byaduk

Access & time: National Park. 5 minutes walk from car park. 1-2 hours.

Gear & Hazards: Standard horizontal, handline for Harman 2 sinkhole. Much scrambling over large slippery blocks. Stick to a single route at start to avoid damage to ferns.

Description: This large lava tube has been extensively modified by collapse, and is separated into two parts by a large collapse doline. However, some relicts of the original form, including ropy lava floors, can still be seen (Map 5.8). The connection from H-11 to H-12 is hard to find and initially a tight squeeze through rubble.

The small surface "blister" beside the track to the western lookout, called Turtle Cave (3H-90), is a shallow "drained-lobe" cave on the surface of the flow (c.f. Figure 2.3). Poke your head in (but watch for snakes), it has some nice lava drips on the ceiling. Reference: Grimes 1998.

3H-13, 14: Bridge Dolines, Byaduk

The walking track leads to a pair of connected large collapse dolines over what would have been a large branching lava tube. Little of the original tube remains (Figure 5.4). Reference: Ollier & Brown 1964

3H-15: Church Cave, Byaduk

Access & time: National Park. 15 minutes walk from car park, over sharp stony ground. 1 hour underground.

Gear & Hazards: Standard horizontal. Much scrambling over large slippery blocks. Stick to a single route at start to avoid damage to ferns.

Description: Similar in style to Harmans (west) cave, but on a bigger scale. See small scale map in Figure 5.4. Reference: Ollier & Brown 1964.

3H-16: Church Arch, Byaduk

Access & time: National Park. 20 minutes walk from car park, over sharp stony ground. Half hour underground.

Gear & Hazards: Minimal gear, daylight from both ends.

Description: This is a spectacular arch connecting two long sections of collapsed tunnel. The tunnel is about 12m high, 25m wide and 60m long with an uneven rubble floor. One can see thin lava benches on the wall in places, and elsewhere the lining has broken away to reveal layers of lava that would have overflowed from the original open lava channel as the valley filled up. Reference: Ollier & Brown 1964.

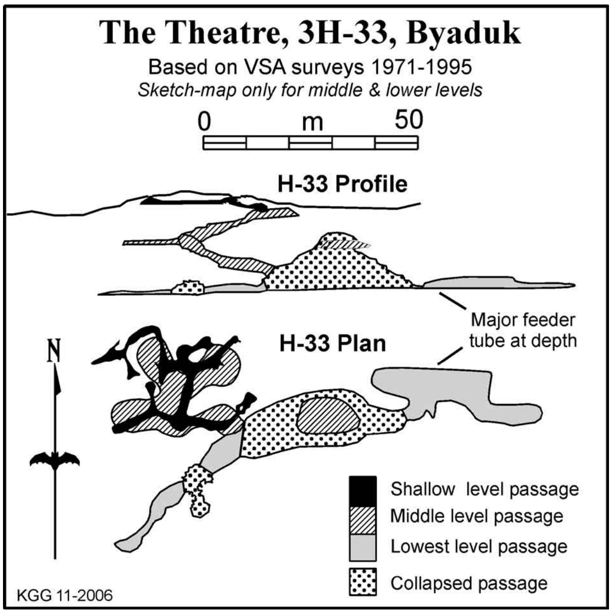


Figure 5.9: The Theatre is a multilevel system.

3H-33: The Theatre, Byaduk

Access & time: National Park. 40 minutes walk from car park over sharp stony ground. 2-3 hours

Gear & Hazards: Short ladder or handline for first drop (short people will need a leg-up on exit), 10m ladder or SRT for second drop (a piton or chock is handy for tie-off). There is a connection to 3H-25 but via a dangerous unstable rubble pile. Use an old trog suit you don't mind ripping.

Description: The most interesting and complex cave at Byaduk (Map 5.9). The upper level is branching crawlways. The middle level is several descending chambers connected by lava cascades that leads to "The Stage". This faces into a large collapse dome (The Theatre) with sharp low-level crawlways exiting in two directions. The eastern crawl opens into a short large tube with ropy lava floor. The cave has formed by lava rising from the lowest tube to build a surface mound that partly solidified, and then drained back to the lower level to leave the upper passages. The connection to H-25 is unmapped, so if you DO want to do that bit take survey gear! Reference: Grimes & Watson 1995.

3H-51: North Pole Cave, Mt Eccles

Access & time: National Park. 20 minute drive on rough road then 10 minute track walk. 1-2 hours.

Gear & Hazards: Standard horizontal, old trogsuits, Mostly 1m or less headroom.

Description: A set of small interconnected lava tubes running away from the canal. Some good lava features, including sharp aa floors. Photogenic root chamber at far end. The name refers to a magnetic rock found at an obvious survey point. Small map in Figure 5.10.

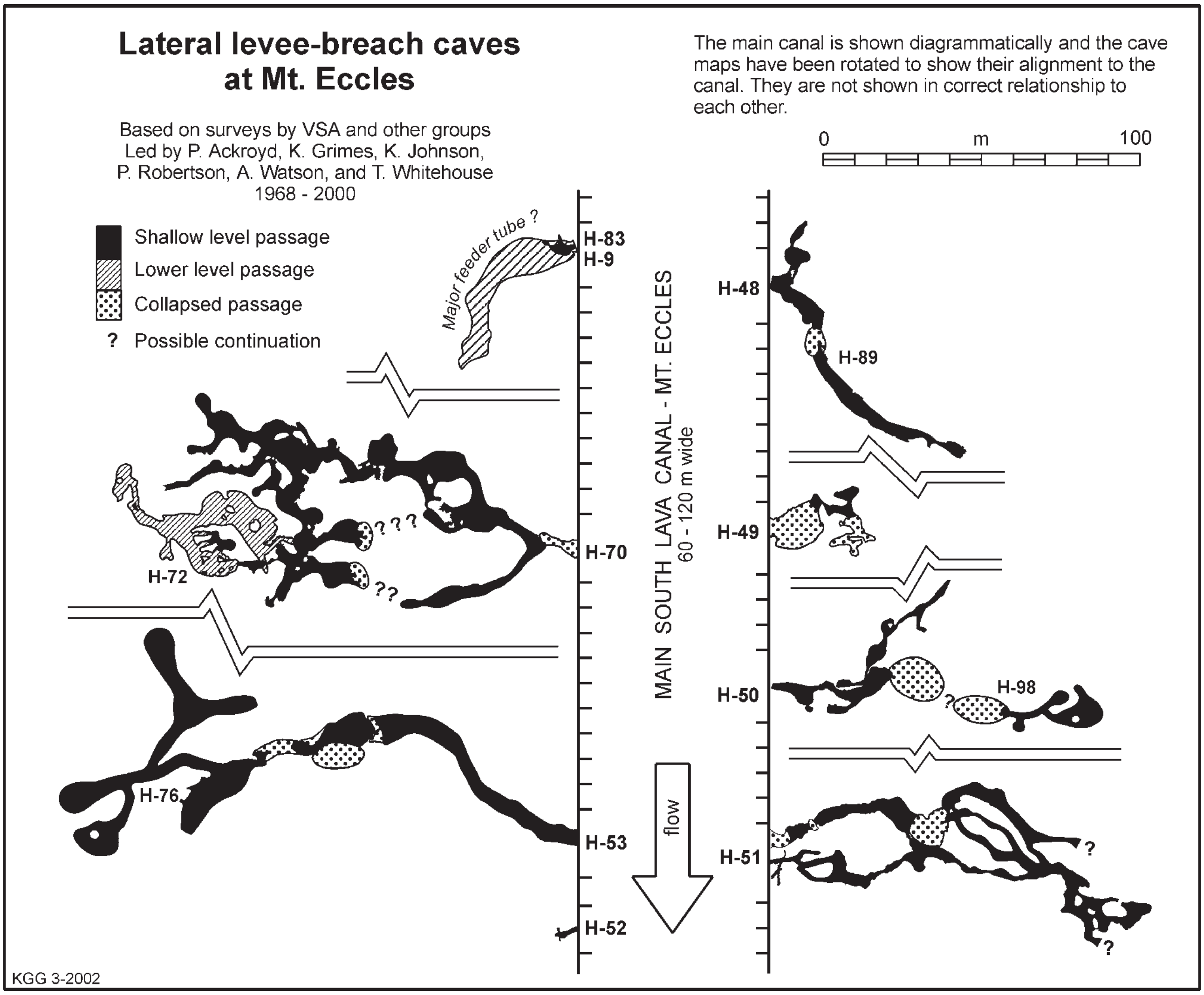


Figure 5.10: Lava caves on the sides of the South Canal at Mt. Eccles.

3H-53,76: Mt Eccles.

Access & time: National Park. 20 minute drive on rough road then 20 minute track walk. 1-2 hours.

Gear & Hazards: Standard horizontal, significant crawling.

Description: A medium-sized linear tube leads away from the canal becoming smaller and after a squeeze past a group of small tumuli reaches a collapse doline. A second entrance leads to several branching low crawls. Some good lava formations. Small map in Figure 5.10.

3H-70, 71, 79: Carmichael Cave, Mt. Eccles

Access & time: National Park. 20 minute drive on rough road then 30 minute track walk. 2-4 hours.

Gear & Hazards: Standard horizontal.

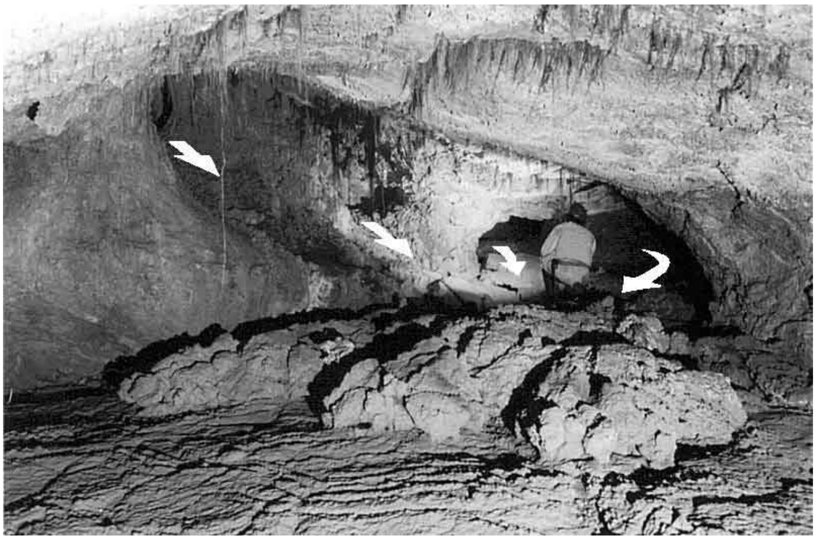
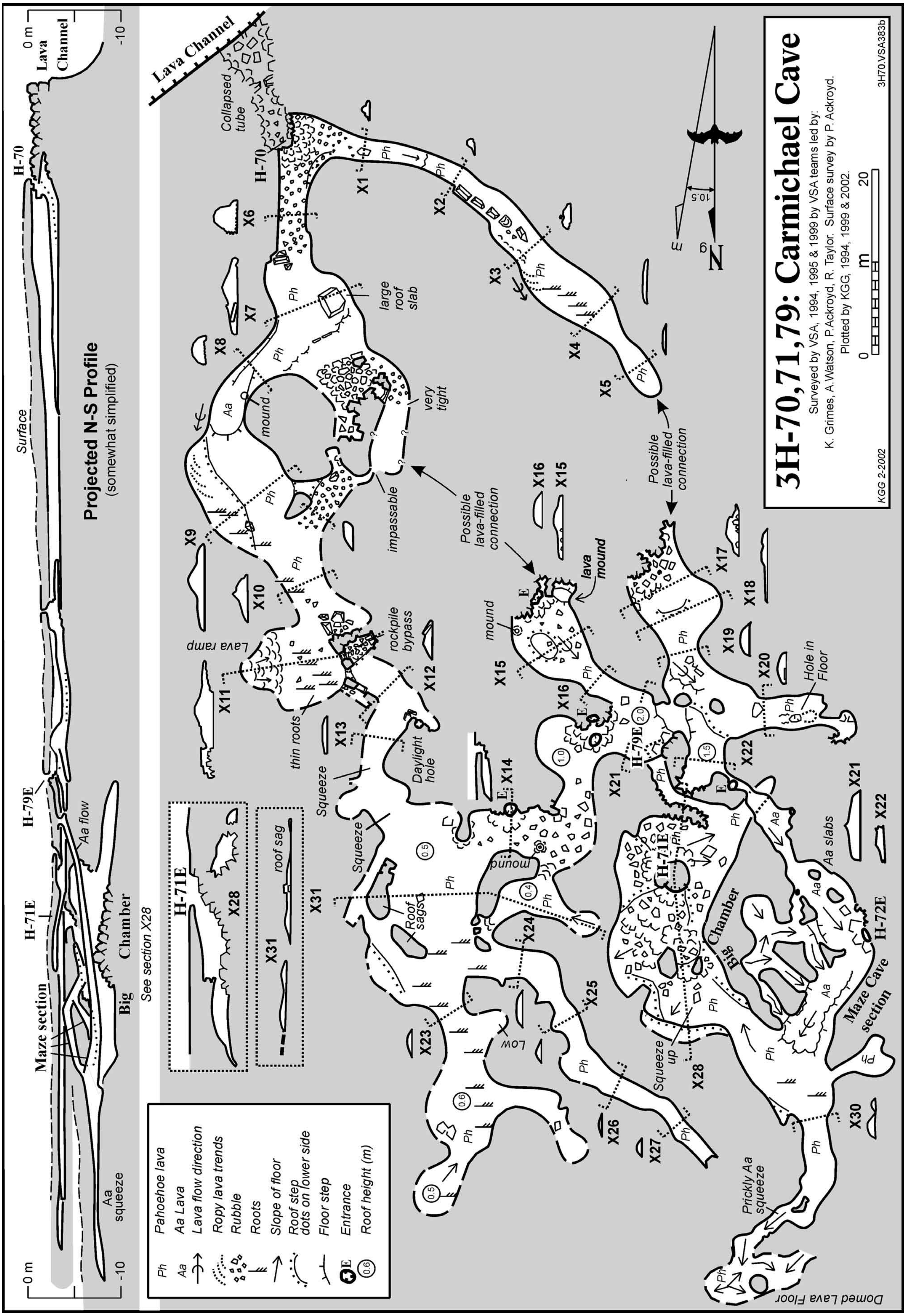


Figure 5.11: An aa lava flow has invaded the lower level of Carmichael Cave. Arrows indicate its entry points from a higher level. [KGG]

Figure 5.12: Map of Carmichael Cave (opposite).


3H-70,71,79: Carmichael Cave
Surveyed by VSA, 1994, 1995 & 1999 by VSA teams led by:
K. Grimes, A.Watson, P.Ackroyd, R. Taylor. Surface survey by P. Ackroyd.
Plotted by KGG, 1994, 1999 & 2002.
KGG 2-2002
3H70.VSA383b
0 m 20
Projected N-S Profile
(somewhat simplified)
Surface
Lava Channel
Collapsed tube
Maze section
Big Chamber
See section X28
Aa squeeze
Aa flow
Ph Pahoehoe lava
Aa Aa Lava
Lava flow direction
Ropy lava trends
Rubble
Roots
Slope of floor
Roof step dots on lower side
Floor step
Entrance
Roof height (m)
large roof slab
very tight
impassable
Possible lava-filled connection
lava mound
mound
Lava ramp
rockpile bypass
thin roots
Daylight hole
Squeeze
Roof sags
Low
Squeeze up
Hole in Floor
Aa slabs
Maze Cave section
Prickly Aa squeeze
Domed Lava Floor
roof sag
H-70
H-71E
H-72E
H-79E

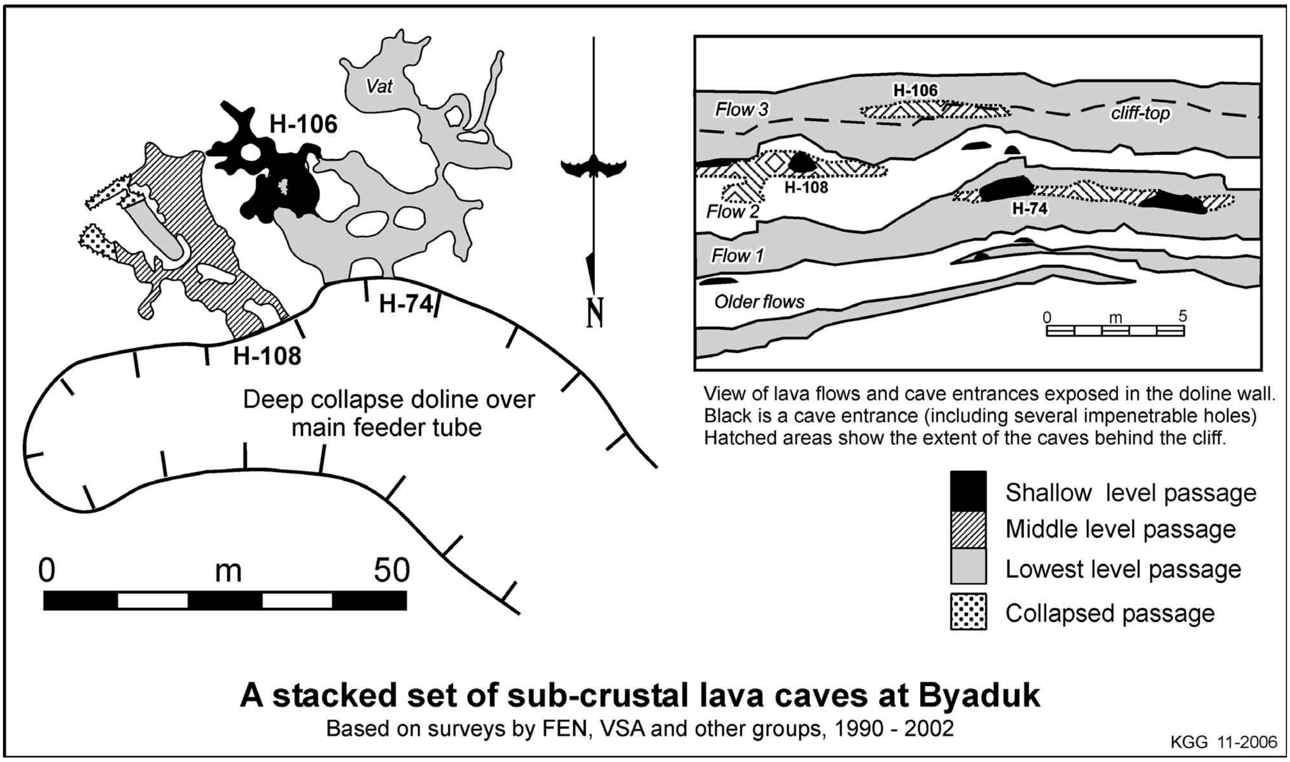


Figure 5.13: 3H-74, 106 and 108 form an interesting set of stacked lava caves.

Significant crawling and a few tight squeezes.

Description: A complex 605m lava tube system leading away from the canal. It has many small tunnels alternating with low broad chambers. A lower level at the far end has a larger, partly collapsed, chamber. Many good lava formations. This is an excellent example of a "drained lobe" style of lava cave. See Map 5.12 and Photos 2.5 and 5.11. Reference: Grimes 2002b.

3H-74, 106,108: Chocolate Surprise Cave (and neighbours). Byaduk

Access & time: National Park. 30 minutes walk from car park over sharp stony ground. 2-3 hours to explore the group

Gear & Hazards: SRT or ladders to reach the separate cliff entrances of H-74 & H-108. Long tie-offs involved for each. The caves are low crawly things, locally sharp.

Description: A group of three lava caves in separate flow layers stacked on top of each other, but without connections between the levels (Map 5.13). The entrances to H-74 and H-108 are exposed in the cliff of a large collapse doline and a ladder is needed to get into these. H-106 has a small entrance in a mound behind the cliff. All three are low-roofed crawls with alternating small passages and broad low chambers. Some good lava formations in all three caves, including intrusive lava tongues and the "Chocolate Vat" (a lava floor) in H-74. H-74 needs a better map (c.f. Mansfield, 1990).

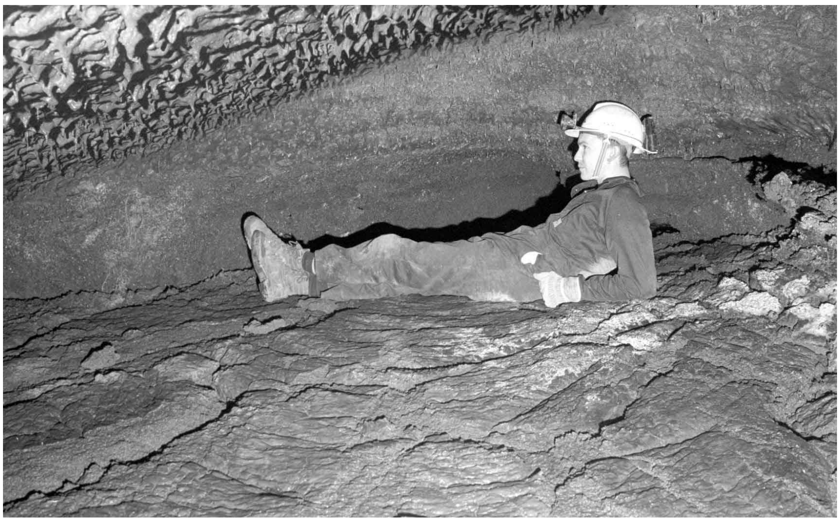


Figure 5.14: The Chocolate Vat in 3H-74. Lava floor and lava drips above. [KGG]

YORKE PENINSULA, SOUTH AUSTRALIA

Graham Pilkington, Paul Harper & Ken Grimes

The Yorke Peninsula has only a few known caves, but these include the large and complex Corra Lynn Cave (5Y-1) and the moderately sized Town Well Cave (5Y-2) which are both in Cambrian limestone, Coobowie Corner Cave (5Y-18) in Tertiary soft-rock limestone, and several smaller caves less than 30m long or deep (Lewis, 1976).

The Early Cambrian Parara Limestone, which hosts Corra Lynn cave, is a sub-horizontally bedded, well-jointed nodular limestone and dolomitic limestone - the hard nodules are in beds alternating with softer material (Crawford, 1965; Wopfner, 1969). The basin of Curramulka township is a large uvala (Lewis 1976).

Corra Lynn Cave, 5Y-1

Access & Time: Private Land. The cave is 1.5 km south of Curramulka in the centre of Yorke Peninsula in the middle of farming paddocks at the top of a hill. CEGSA has been granted permission by the farmer to enter Corra Lynn Cave in mid January 2007 even though it would normally be off-limits due to the fire risk. Party sizes are limited to 6 per leader and no children. Allow a full day. It would take a week to see the whole cave!

Gear & Hazards: Light-weight horizontal gear, including knee & elbowpads. There are moderately hard free climbs between the different levels, in several places there are fixed ropes to use as handlines. The cave is hot, muggy, strenuous and dirty with a lot of crawling and many squeezes. There's no water in the cave but the humidity is in excess of 80% and the temperature constant at about 20ºC – overheating can be a problem and only light clothing should be worn. Areas of foul air have been reported. Hazards include getting lost and the numerous squeezes and crawls.

Description: Corra Lynn has had many entrances in its history but only the current central one via a 6m deep 2m wide slot at the bottom of a 6m deep doline has been accessible since European settlement. Total known cave length is 14.1 km covering an area of 450 x 300m and 40m depth.

The cave is an extensive phreatic joint-controlled network on four main levels each separated from the next by 6m deep fissures that sometimes amalgamate into continuous drops. Passages are usually no more than 2m wide and typically have a centreline crack along the roof that is often enlarged into a tapering slot.

The grey rock has weathered into nodules that flake off every few thousand years to form much of the floor covering. The weathering has also been preferential along bedding planes giving many walls a set of horizontal ledges. The weakest beds are separated by 0.75m and exist from the bottom of the cave to the top with a particularly vulnerable bed every 6m (hence the 6m separation of the major cave levels). This means that passages often look like a series of just-connected horizontal tubes on top of each other; and sometimes become separate tubes for sort distances.

The dolomite is topped by 6m of calcareous soils and calcrete. Many fissures appear to be truncated at this interface implying that the rock surface was not ground level when the cave formed. The cave has been filled with debris coming down these "open" fissures and what we have access to appears to be some smaller unfilled passages and larger voids created after the fill has slumped or been otherwise removed by downward movement.

The highest level (white on the map) is mostly small rough tubes but is sometimes the only path to get from one part of the cave to another.

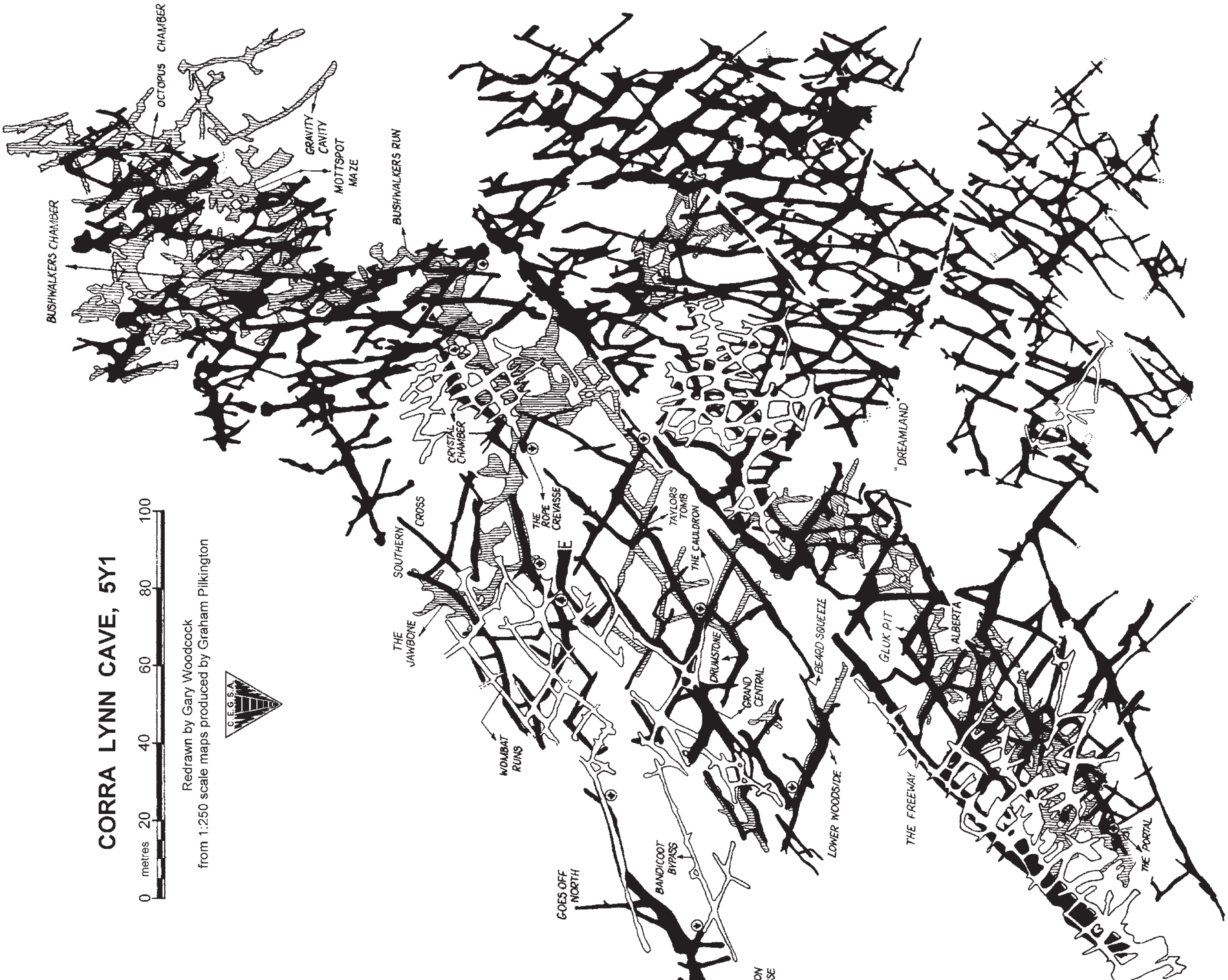
The middle levels (black on the map) are the largest open space with roof heights over 10m in places but usually only 3m high. Passage widths are typically less than 2m but can get up to 4m.

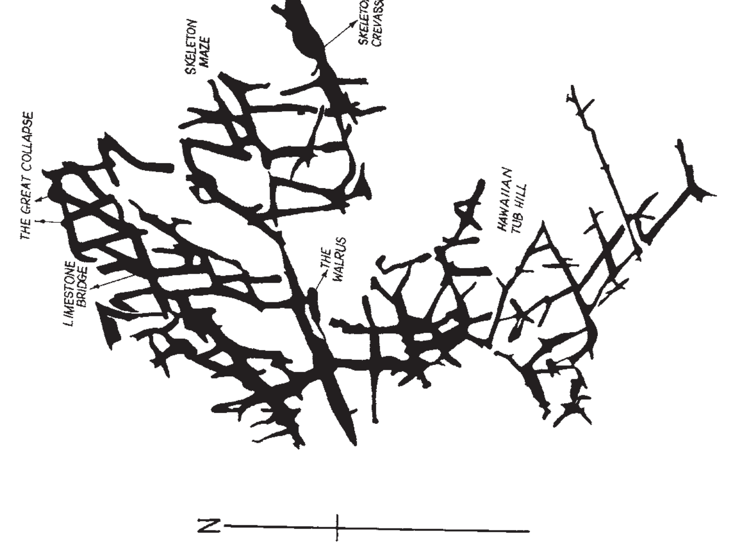
The lowest accessible level (hatched on the map) is largely filled with dirt. Many passages are over 8m wide but less then 0.3m high and have a dirt floor and a central domed groove allowing traversing.

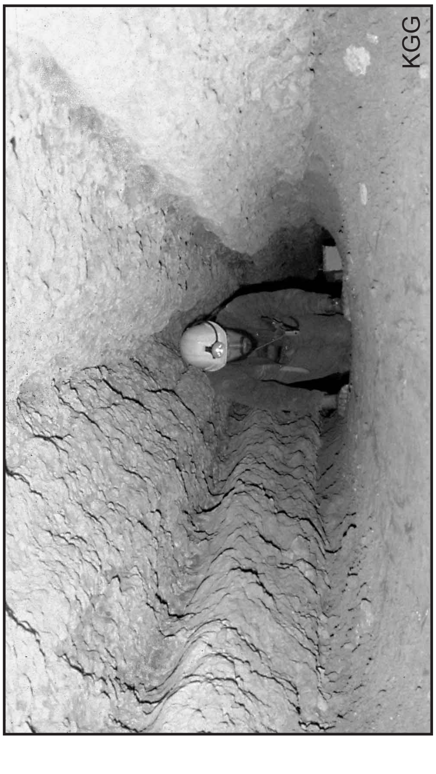
The next (inaccessible) level, called the basement, has more than the usual 6m between major levels and is at least 9m below the lower level. In one place there is a breeze issuing from the basement via a 0.1m diameter vertical rock tube.

Trilobite fossils have been found in the rocks but most bones are sub-recent, sometimes still having flesh on them! However, many bones dating back a few tens of thousands of years have been found and one section of the cave is yielding bones (not fossils) that are in the order of 3 to 5 million years old. The oldest bones were and are locked into a calcite-sand solid matrix that has protected them from the cave environment. Once exposed (by fretting? as the passage fill drops away) the bones/teeth change from solid to a powder. The time involved is not known but it takes the time to fret off 100mm of rock to do the destruction.

The dark rock walls absorb light making photography intriguing.


CORRA LYNN CAVE, 5Y1
Redrawn by Gary Woodcock
from 1:250 scale maps produced by Graham Pilkington
C.E.G.S.A.
0 20 40 60 80 100
metres
N
OCTOPUS CHAMBER
GRAVITY CAVITY
MOTTSPOT MAZE
BUSHWALKERS CHAMBER
BUSHWALKERS RUN
CRYSTAL CHAMBER
THE ROPE CREVASSE
TAYLORS TOMB
THE CAULDRON
"DREAMLAND"
SOUTHERN CROSS
THE JAWBONE
WOMBAT RUNS
DRUMSTONE
GRAND CENTRAL
BEARD SQUEEZE
GLUK PIT
ALBERTA
LOWER WOODSIDE
THE FREEWAY
THE PORTAL
GOES OFF NORTH
BANDICOOT BYPASS
SKELETON MAZE
SKELETON CREVASSE
THE GREAT COLLAPSE
LIMESTONE BRIDGE
THE WALRUS
HAWAIIAN TUB HILL




KGG

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