AUSTRALASIAN CAVE & KARST MANAGEMENT ASSOCIATION Inc.
Seventeenth Australasian Conference on Cave and Karst Management
Buchan Caves, Victoria, Australia
29 April to 5 May 2007

Field Guide to the Buchan Karst

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Conference supported by:

Conference Convenor: Dale Calnin

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PREFACE

The impounded karsts of East Gippsland have attracted explorers, cavers and scientists since European settlement started. This guide outlines sites of interest to cave and karst managers as part of the 17th Australian Conference on Cave and Karst Management at Buchan, Victoria, in 2007.

The guide is in two parts: a general description of the Buchan and associated impounded karsts is followed by descriptions of specific sites.

Note that the sites described here are on government reserves or private land; permission should be sought before entering these areas. In accordance with the policy of the Australian Speleological Federation, we have not printed detailed location information about cave sites.

ACKNOWLEDGMENTS

This field guide draws heavily from previous reports and field-guides, cited in the Bibliography. Most importantly, this guide could not have been written without the extensive exploration, mapping and documentation efforts of numerous VSA, CCV and other cavers over the last 50 years.

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

THE BUCHAN KARST

Introduction

The Buchan area of East Gippsland is a densely cavernous limestone area, some 380 km east of Melbourne. It is one of the largest areas of cave and karst-forming Palaeozoic limestones in southeastern Australia (Figure 1). It is an impounded karst as it is completely surrounded by non-karst rocks, in this case the Snowy River Volcanics.

As well as the main Buchan and Murrindal karst areas, there are several other smaller areas relatively close by and to the east at New Guinea Ridge, The Basin, Jackson's Crossing and Mooresford (Figure 2). Other areas of Palaeozoic limestone in East Gippsland include Limestone Creek and Bindi (Figure 1).

The Buchan-Murrindal impounded karst extends 20 km in a north-south direction and is 2-10 km wide west-east (Figure 2) and contains over 500 known cave and karst features.

Climate

The Buchan district has a warm temperate climate (Köppen-Geiger classification Cfb) (Ellaway and Finlayson, 1984). There is a slight winter maximum in rainfall and mean summer temperature maxima resulting in effective drought for a month or two.

Rainfall varies considerably with topography, ranging from 1300 mm per annum at New Guinea Ridge (800 m ASL) to 817 mm at Buchan (90 m ASL). This large range of annual rainfall has been attributed to a rain shadow effect around Buchan. Flooding of the major streams occurs periodically.

Vegetation

Most of the original vegetation on the limestone areas has been cleared for agriculture. There are a few remnant areas of relatively undisturbed vegetation which imply that the original vegetation on the limestone was a Eucalypt open forest to woodland and was dominated

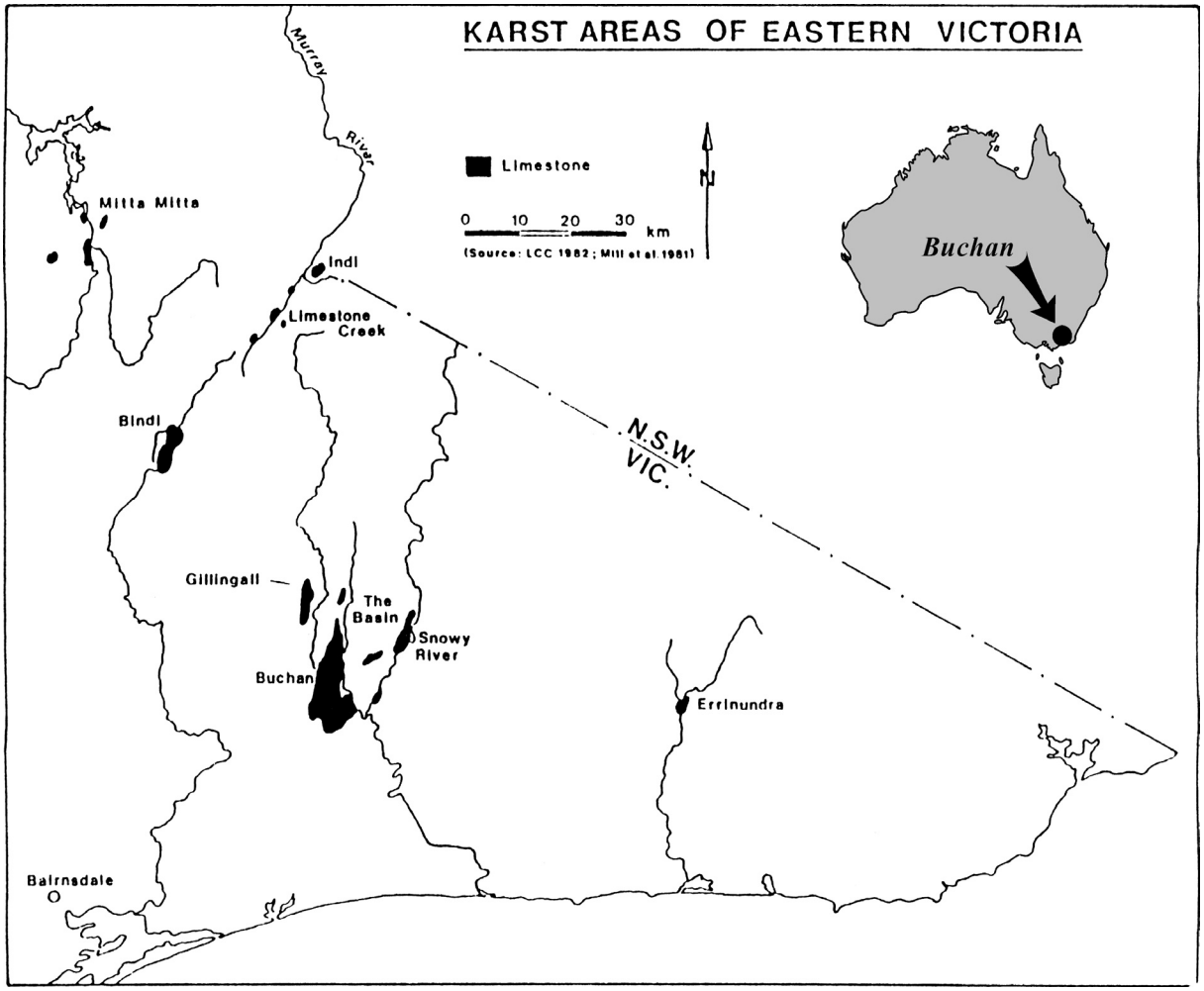


Figure 1: Location of the Buchan Karst and other impounded karsts in eastern Victoria (after Mill et al, 1980).

by Yellow Box (*Eucalyptus melliodora*), Red stringybark (*E. macrorrhyncha),* Red Box (*E. polyanthemos)*, Candlebark (*E.rubida)*, Sheoak (*Casuarina stricta*), Kurrajong (*Brachychiton populneum*), and Pittosporum (*P. undulatum*). There are several wet gullies and sheltered limestone cliff locations that support remnant rainforest species such as Lilly Pilly (*Eugenia smithii*), Kanooka (*Tristania laurina*) and Lawyer Vine (*Smilax Australis*). There are reports of rare ferns on the karst such as Binung (*Cyclosorus parariticus*) associated with carbonate-saturated springs (Mill et al, 1980, LCC, 1982). Tall open eucalypt forest, which has been harvested for timber, is the dominant vegetation on the Snowy River Volcanic areas. These open forest areas have not been extensively cleared for agriculture (LCC, 1982).

Land Use

The main land uses of the district are agriculture and timber production. The limestone areas have been mostly cleared for agriculture, mainly grazing of sheep and cattle. Only limited grazing is conducted on the volcanic areas. Timber production in the district has declined recently with the closure of one of the sawmills and the sources of logs are generally outside the Buchan area.

Quarrying is the other major primary industry and the Buchan Quarry at Rocky Camp (Site 7) is operated for high-grade limestone used by APM in the recovery of pulp leachate at the Maryvale paper mill.

The caves, the Snowy River, scenic drives and other local tourist activities attract considerable numbers of tourists to the area. As Buchan is within day-trip distance from Bairnsdale, Lakes Entrance and the Gippsland Lakes holiday resorts, the tourist industry has increased in the town

Geology

The Buchan Karst area is a basin-like depression in the Lower Devonian Snowy River Volcanics occupied by predominantly calcareous marine sediments of the early Devonian Buchan Group (Figures 2 & 3). The Buchan Group consists of three main formations: the Buchan Caves Limestone, the Taravale Marlstone, and the Murrindal Limestone (Vandenberg, 2003).

The Buchan Group disconformably overlies a complex thick sequence of subaerial and submarine volcanic and clastic sedimentary rocks, called the Snowy River Volcanic Group. These have been recently redescribed in detail, including summaries of previous work (Orth et al, 1995, Vandenberg et al, 1996, Willman et al, 1999).

The Buchan Caves Limestone occurs in all the impounded karsts of the area. The basal Spring Creek Member is a transitional unit, with a range of lithologies increasing in carbonate content upwards. The Buchan Caves Limestone is generally a grey to black recrystallised well-bedded fossiliferous limestone ranging in thickness from 80 m at The Basin to over 800 m at Buchan. The basal 10-25 m are dolomitic and unfossiliferous (Vandenberg, 2003).

Conformably overlying this unit in the southern part of the Buchan area is the Taravale Marlstone, a thick sequence of interbedded mudstone and calcareous mudstone (811 m thick at Buchan and 780 m in the Murrindal area), which occupies most of the southern part of the Buchan basin (Teichert and Talent 1958, Vandenberg, 2003). The Pyramids Member (shown on Figure 3) has now been discontinued as being insufficiently different from the highly variable Taravale Marlstone (Orth et al, 1995). It still appears in some discussions, but can be regarded as part of the Taravale Marlstone.

The Murrindal Limestone is a lenticular unit within the Taravale Marlstone with a maximum thickness of 290 m and is restricted to the northern part of the Murrindal Synclinorium. It is composed of two members; the lower dark-coloured McLarty Member and the upper pale-coloured Rocky Camp Member, The McLarty Member comprises 60-190 m of well-bedded fissile limestone and minor mudstone. Where it flanks Rocky Camp Member it is rich in crinoid stems. The Rocky Camp Member consists of 60-100 m of coarse calcarenite with coralline boulders and crops out over a very restricted area. Outcrops are lenticular or mound-like reflecting the original carbonate mounds (Figure 3; Teichert and Talent 1958; Vandenberg, 2003).

These limestones are all marine; the basal Spring Creek Member representing a variety of transitional coastal environments (Vandenberg, 2003). The sedimentary environments indicate a wide range of marine environments: shallow through to deeper water conditions throughout the basin (Vandenberg, 2003).

Small outliers of Buchan Caves Limestone are widely distributed over the Snowy River Volcanics, e.g. the Basin, Bindi, Gillingal, along the Snowy River at New Guinea Ridge and Jacksons Crossing, and along Limestone Creek (Figures 1 & 2).

The deposition of the Buchan Group carbonates was followed in the Middle Devonian by a series of earth movements which folded the sediments into a large south-plunging syncline with its axis running north-south (Murrindal Synclinorium – a broad syncline with numerous subsidiary fold axes within it). There is no evidence for events between the Middle Devonian and the Tertiary, but we assume it was a long period of erosion.

In the late Eocene valley-filling basalt flows were

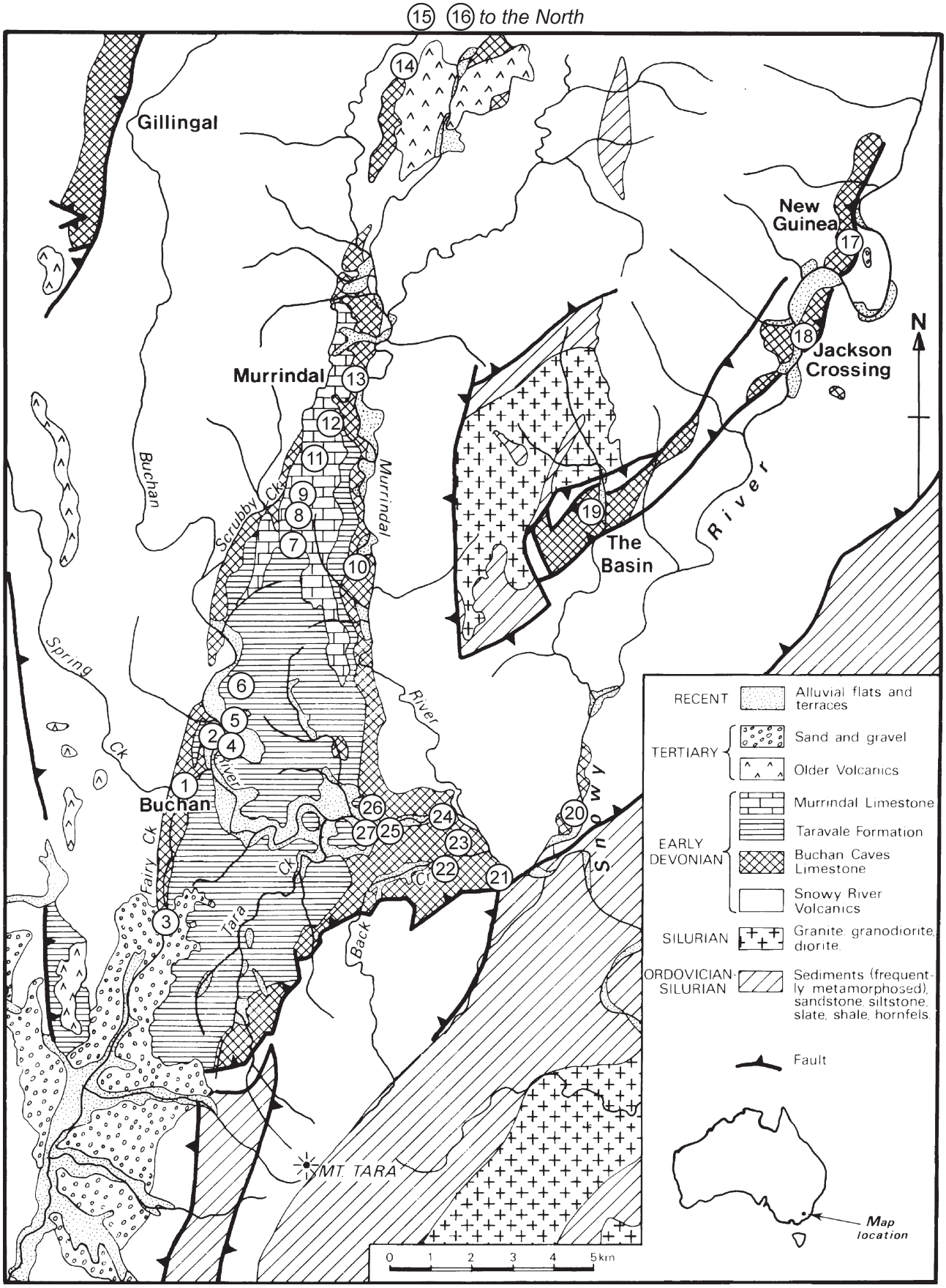


Figure 2: Geology of the Buchan Karst region, and location of sites to be visited (after Webb et al, 1991). See Figure 7 for details of "site 1" in the Caves Reserve.

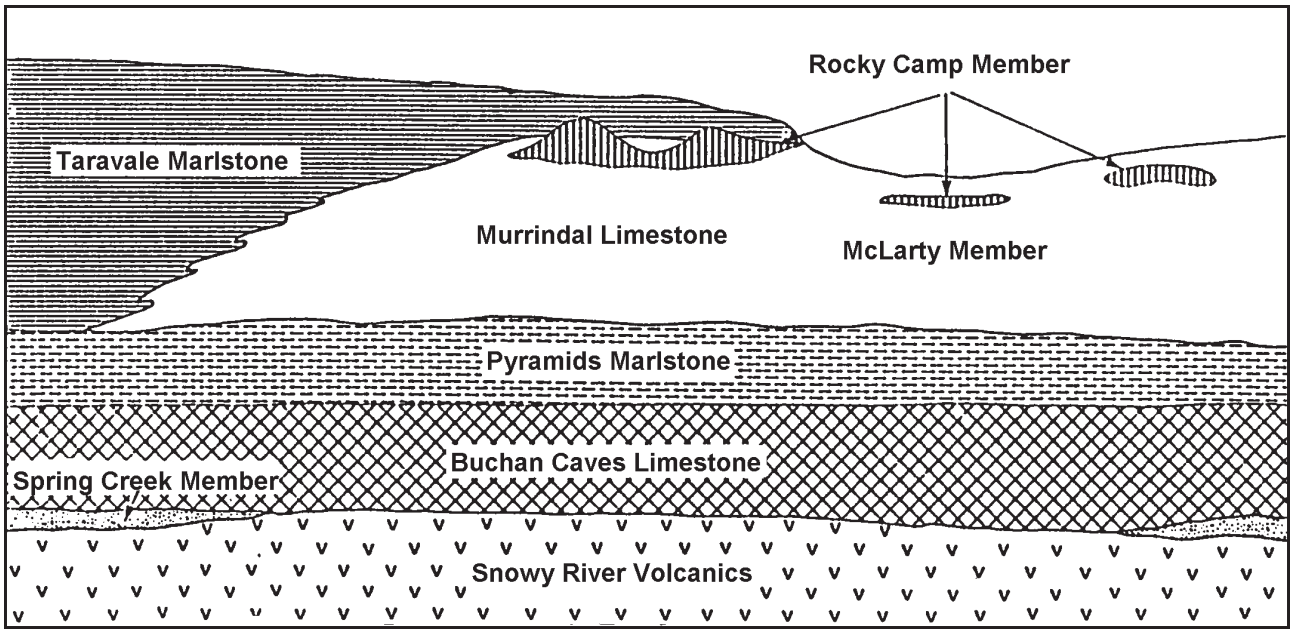


Figure 3: Geological units in the Buchan area, and their stratigraphic relationships. (after Finlayson et al, 1992b)

deposited north and west of Buchan. Subsequent deposition was limited to stream alluvium and colluvial deposits (Webb et al 1992). See the section on landscape development below.

Drainage

The drainage systems of the area are the southerly flowing Buchan and Murrindal Rivers, both of which have their headwaters in the Snowy River Volcanics (Figure 2) The Murrindal River follows the eastern contact between the Buchan Caves Limestone and the Snowy River Volcanics in a well-defined valley. The Murrindal has very few and very limited tributaries. Its channel has three well defined knick-points at the Pyramids but no terraces (Fabel, 1992).

The Buchan River flows through a narrow V-shaped valley cut into the volcanics before entering the karst area from the northwest. Within the karst it crosses the more easily eroded Taravale Marlstone. Here lateral erosion has outstripped vertical erosion resulting in the formation of a broad valley with more identifiable terraces (Figure 9; Webb et al 1992). No knick-points have been identified on the Buchan River itself but they exist on its tributaries (Fabel, 1992). After turning towards the east near the Caves Reserve, the Buchan River has cut another steep-sided valley into the Buchan Caves Limestone before it meets the Murrindal River. This reach exposes the Buchan Thrust Fault (Site 25). The diversion of the river to the east was probably due to the updoming of the area to the south (see below).

The junction of the Buchan River with the Snowy River marks the limit of the carbonate sequence and so acts as base level for the Buchan Karst area. The elevation of this point is 40 m above sea level (ASL) compared to a maximum elevation within the limestone area of about 260 m to the north of Buchan.

A number of intermittent streams, e.g. Scrubby Creek, flow across the limestone into the Buchan River. These generally flow only during wet periods, as for part of their courses they have been captured by underground drainage systems.

Landscape Development

Webb et al (1991, 1992) have deduced a Cainozoic denudation history for the Buchan region; the following summarises their findings.

The history of the landscape can be deduced from preserved surface features, levels of cave development and datable cave deposits. Remnants of basalt lava flows, now preserved high in the topography, and dated at about 40 Ma (late Eocene), show that the ancestral rivers occupied broad valleys running north-south. The highest level of caves at Buchan (at the Potholes) formed as phreatic maze systems along vertical joints below the water table associated with these ancestral rivers (see Stage 1 in Figure 4).

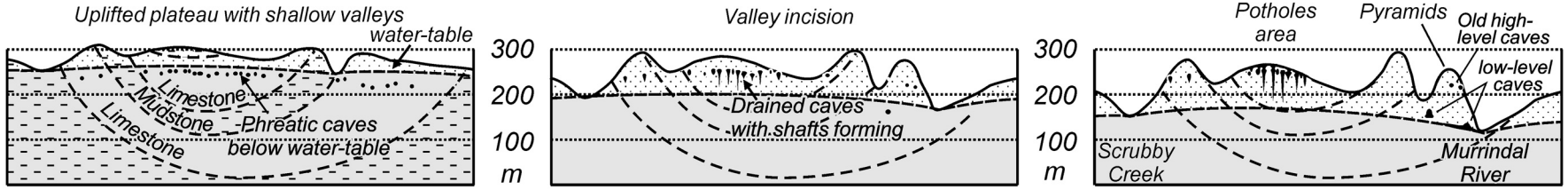
The Late Eocene basalt flows which followed both valleys disrupted drainage to form twin lateral streams in each ancestral valley. Uplift, possibly contemporary with the basalt eruptions, diverted the streams and incised the valleys. The incision lowered the watertable, drained the pre-existing phreatic caves, and then formed vadose shafts and canyons that led down to the new water level (Stage 2 in Figure 4).

A stillstand followed, possibly during the high sea-levels of the Early-Middle Miocene, when the Buchan

Figure 4:

Evolution of the Potholes Area as the surface was eroded.

The erosion of the surface, and the resulting drop in watertable is shown in the upper diagrams.
The development of a typical cave is shown below.



1: Eocene - Oligocene (40-30 million years ago)

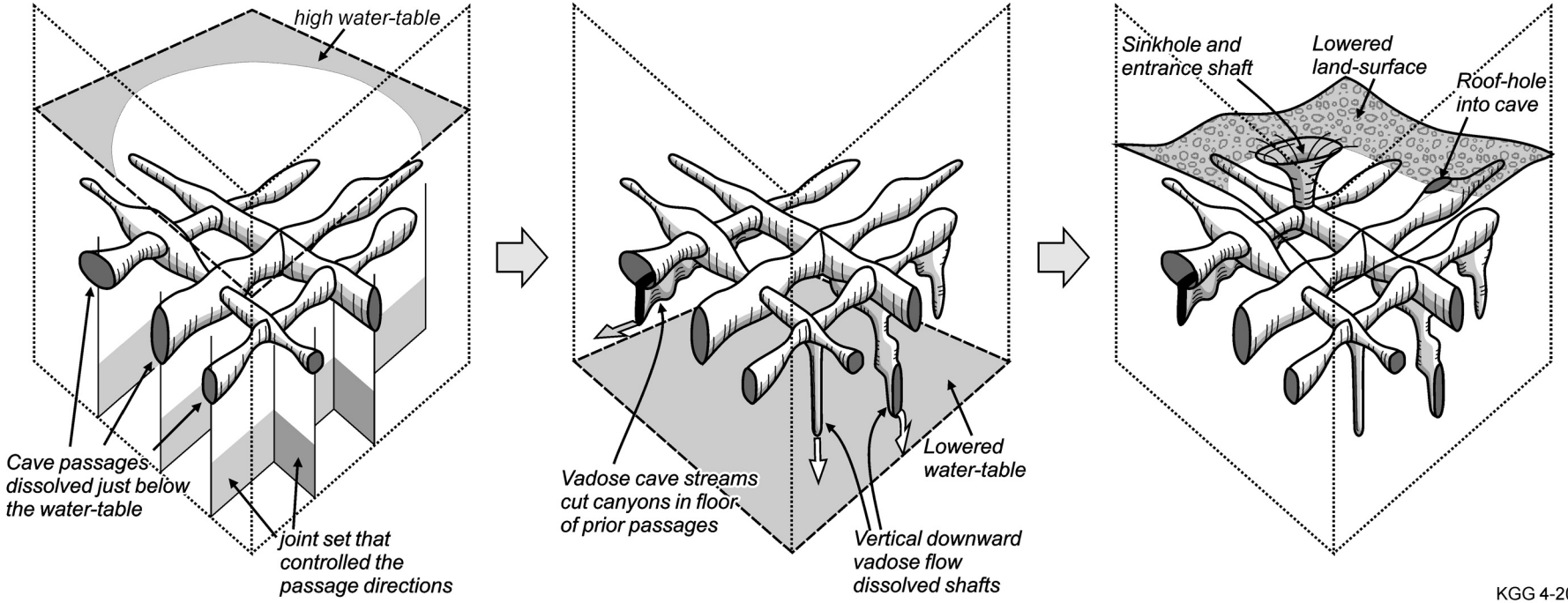
An uplifted plateau with shallow valleys existed.
'Phreatic' caves (formed just below the water-table) dissolved along a network of joints (cracks) in the limestone.

2: Oligocene - Pliocene (30-2 million years ago)

Valley incision lowered the water-table.
The caves drained as the water-table dropped.
Further solution was in a 'vadose' (partly air-filled) environment with downward erosion of shafts and canyons.

3: Quaternary - Present day (the last million years)

Ongoing erosion lowered the surface to intersect the caves.
Sinkholes and entrance shafts formed.
Younger, low-level, caves formed near the modern rivers.



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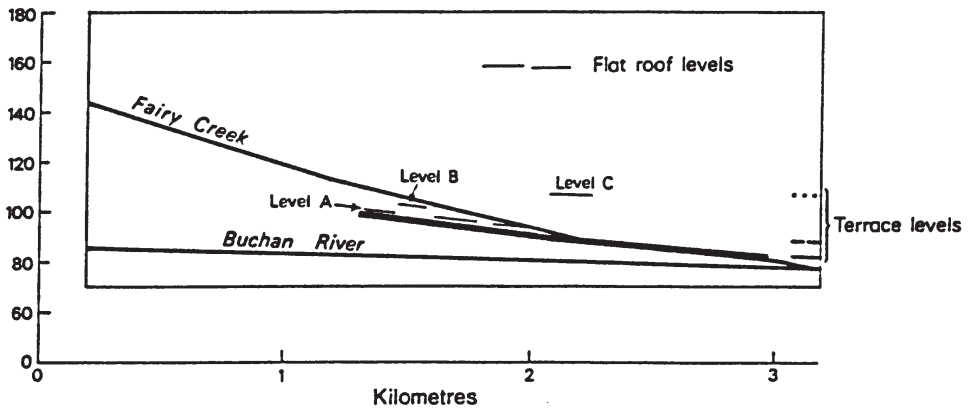

Figure 5: Correlation of cave and terrace levels for the Dukes Cave System (from Webb, et al, 1992).

The three river terrace levels are shown on the right and the cave levels (A,B & C) are shown relative to the profile of Fairy Creek.

River cut sideways to form a broad river valley. Phreatic cave systems formed along joints in the limestone beneath and beside the river.

More recently, in the Quaternary, there has been another period of downcutting. This was followed by another stillstand, during which terraces formed along the Buchan River (Figure 9). Extensive horizontal epiphreatic caves formed at the Caves Reserve (Webb et al, 1992) and a meander loop at the Pinnacle was captured underground (Fabel et al, 1996) – see Stage 3 of Figure 4. Speleothem dates and paleomagnetism in the cave sediments indicate that the lowest level caves were formed over 780,000 years ago (Webb et al, 1992, Musgrave & Webb 2003), even though they are only a couple of metres above the present river levels. The higher levels and their corresponding terraces may be considerably older. A final minor episode of downcutting has incised vadose canyons in these caves.

Caves are developed at various levels in the landscape. The highest caves are those in the Murrindal area, especially The Potholes caves (Site 9, Figures 4, 13 & 14), and caves have formed at other levels where the water table has been stable for sufficient time for solution of passages. A number of caves are found closer to the current river levels e.g. Lilly Pilly (M 8) at Murrindal (Site 13), the Dalleys system (M 26-35-82) at the Pyramid (Site 10, Figure 15), Wilson's (EB 4) at East Buchan (Site 26, Figure 17) and the Dukes cave system (Sites 1.3, 1.4, 1.6 & 1.7, Figures 4 & 7) in the main reserve at Buchan.

The Dukes cave system contains two extensive subhorizontal cave passages, and in the lower passage there are two separate levels identifiable from flat ceilings and wall notches (Figure 8). Thus, three epiphreatic cave levels can be recognised. These three levels can be correlated with the river terraces (Figure 5; Webb et al 1991, 1992). The three levels defined by the flat cave roofs and the river terrace remnants represent three stillstands of local base level.

At one stage the lowest level was almost completely filled with bedded fluvial sediments ranging in size from clay to cobbles. Where these sediments came from is uncertain, but they are of considerable age as a palaeomagnetic reversal at about 780ka has been identified in the sediments (Musgrave & Webb, 2003; see Site 1.6). The two higher levels would be much older.

A similar pattern is seen at the Dalleys Cave System at the Pinnacles, which is an underground cutoff of a meander loop of the Murrindal River (Fabel et al, 1996; Figure 15), The abandoned surface channel now carries only flood waters and includes 3 knick points which have levels that can be correlated with the terraces on the Buchan River. The cave stream bypasses these, with the underground knick-point being at the upstream end (in inaccessible rockpile). Downstream of this knick there is evidence of adjustment of the cave stream levels by both incision of passages and passage abandonment in favour of new lower passages (Fabel et al, 1996).

The amount of incision in the Buchan area throughout the Cainozoic has been small and discontinuous in time. Evidence from basalts and high-level river gravels indicates that total incision since the late Eocene has been only 180 m, and this has occurred in five steps, of which the last three have involved only 30 m of incision altogether (Webb et al 1991, 1992).

The development of the karst landscape of the Buchan valley has been shown to be considerably older than some of the early workers, e.g Sweeting and Talent, postulated. Southeastern Australia was not subjected to Pleistocene glacial (ice age) conditions, including sealevel relationships, similar to those of Northern Europe and North America. As a result we are looking at a karst landscape which has developed over millions rather than thousands of years.

The Karst (an overview)

The Buchan Karst is an impounded karst and a fluviokarst (surface stream drainage dominates over subsurface except in local areas such as Wilsons Creek, East Buchan). Although the area is about 10 by 20 km,

Figure 6: Tufa terraces at Scrubby Creek. [photo by R.K. Frank]

most if the central part is covered by the non-karstic Taravale Marlstone. Thus it is very much a contact karst with a strong influence from allogenic streams entering the limestone from other rock types. For example in the Reserve the limestone belt is only 800 m wide, and Spring Creek sinks as soon as it crosses onto the limestone (Figure 7). The blind valley of Wilsons Cave is another example of a stream sinking shortly after crossing onto the limestone.

Surface karst forms include doline fields in a few areas such as the Potholes (Figure 10 & 12 and the cover photo) and East Buchan, and isolated collapse, subsidence or solution dolines elsewhere. There are some spectacular collapse dolines such as Dalleys Sinkhole at the Pyramids (Site 10) and the Devils Punchbowl at the Reserve (Site 1.10). Dry or blind valleys and stream sinks occur in places, e.g. Wilsons cave (Site 26). Springs occur in many places, e.g. the risings from Dukes and Moon Caves at the Reserve. Spring waters may be saturated and form tufa terraces (Figure 6). Karren are moderately common and there are some very good examples of rillenkarren in the main reserve and at the Potholes. Rundkarren is also found in several areas where there is bare limestone.

The caves tend to be of two main types. The first are vertical shafts and fissures such as those of the Potholes area (Figures 11 & 13). These are joint controlled 3-dimensional systems that can locally form complex mazes (e.g. Figure 14). They are phreatic systems that have been partly modified by vertical vadose flow after the lowering of the water table during the incision of the Buchan and Murrindal Rivers (Figure 4). The vertical development of these caves is generally very clean, with sharp projections and edges, and devoid of calcite decoration, whereas the horizontal phreatic passages have smoother or cuspate walls, more decoration and may have some sedimentation.

The second type are horizontal "stream" caves, such as the Dukes cave system at the Reserve (Figure 7), which tend to follow the strike of the limestone, and also the trend of a nearby dry valley (c.f. Fairy Creek & the Dukes cave system). These stream caves originated as epiphreatic joint enlargements which have been extensively modified by vadose streams over a long time. At present they are generally dry or have a very small flow but they flood extensively in occasional wet periods (Finlayson & Ellaway, 1987)

Both types show evidence of progressive deepening as water tables dropped, and both have cave sediments which provide age and paleoenvironmental evidence (Webb et al 1991; Musgrave & Webb, 2003). Many caves have been further modified by collapse so that the original form is difficult to deduce.

Karst Hydrology

This is an impounded karst with a dominance of allogenic input of aggressive water flowing onto the limestone from adjoining areas. Some areas show a more independent karst drainage, e.g. the Potholes and parts of the East Buchan area.

At the Reserve (Site 1), two main springs are perennial – from Dukes & Moons. Flow within the known cave system is confined to flood periods. That, and the relatively constant spring flows, indicate input from diffuse sources as well as cave conduits.

The allogenic Spring Creek sinks as soon as it reaches the limestone (Figure 7). Fairy Creek follows the strike of the limestone and is dry for most of the time – its

headwaters are near the Buchan Tip, and water tracing (Ellaway, 1991) has shown that water from pools in B 67, not far from the tip, appears in the Dukes Spring.

Elsewhere, the Dalleys Cave System (Site 10) diverts water from the Murrindal River, bypassing a surface meander loop and returns it to the river at a lower level (Fabel, et al, 1996; figure 15). In the Potholes area some underground streams in caves such as Scrubby Creek (M 49), indicate that water table conditions still occur, but the details are unclear. The stream exiting the cave at Scrubby Creek (M 49) is saturated in calcite and deposits tufa in the bed of the creek itself (Figure 6). This underground stream is fed by surface runoff into the aptly named Storm Water Tunnel (M 43) in wet conditions. Wilsons Cave (Site 26) is a simple intermittent through-flow system at the end of a dry valley (Figures 17 &18).

Fauna

The caves support several bat populations of two species: *Miniopterus schreibersii,* and *Rhinolophus megaphyllus. Myotis adversu*s was present in the district until the 1960s but none have been recorded since then. At least two of the caves are known maternity sites for *Rhinolophus megaphyllus* and several others are important for roosting and overwintering. *Miniopterus schreibersii* and *Rhinolophus megaphyllus* were listed as vulnerable under the Victorian Fauna & Flora Guarantee Act in 1996 but no Action Statements have been prepared to date.

There is an invertebrate cave fauna in some caves, especially the ones with streams, but although several species of invertebrates have been identified no detailed fauna study has been undertaken in the area.

Platypus are reported as regularly using the Moons Cave (B 2) underground stream.

Geological and Geomorphological Heritage and Significance.

In Victoria the Geological Society of Australia (Victoria Division) assigns and reviews sites of geological significance. The GSA has developed a methodology and protocol for doing this (White et al, 2003), which has been applied to the Buchan–Murrindal impounded karst (GSA site BR 017) and related geology.

The karst area as a whole has been accorded State significance as it has a complex landscape history, as well as being the site of important fossil deposits. Specific sites and features within the area are accorded their own significance. Anticline Cave (M-11) (BR 048) is rated as being of International significance because of its distinctive and unusual structurally-controlled form (McRae-Williams et al.,1981). The Potholes (BR 073) is one of the best examples of a doline field and associated vertical caves in limestones in eastern Australia and is important for the understanding of the evolution of an old inverted landscape. It includes some of the oldest known cave systems in southeastern Australia, and has therefore been given National significance. Other sites of National significance are the Rocky Camp fossil site (BR 057) and the Cloggs Cave (EB 2) archaeological site. The Scrubby Creek karst area, which includes caves and tufa terraces (BR 074), the Murrindal Caves (BR 048), the Pyramids at Murrindal (BR 049), the Buchan Tourist Cave system and the East Buchan caves (BR 044) are all of State significance. Many individual caves and sites are of Regional and Local significance (White et al, 2003).

The other sites listed in this Field Guide are also documented and assessed for their significance by the GSA – details can be obtained by contacting the Victorian Division of the GSA.

Site Descriptions

The Cave Reserves

Following a visit by Geologist, A. E. Kitson, in 1900 and on his recommendation, several Cave Reserves were established at Slocombes Cave, the unsold part of the township which is the site of the present Main Caves Reserve, Spring Creek Cave, Dicksons Caves and Wilson's Cave. These were then consolidated and re-gazetted as a group in 1938, comprising the Main Caves Reserve, Pyramids, Potholes (3 areas), Slocombes, Wilson's Cave (2 areas), and Dicksons Caves. Other minor adjustments took place over the years. Murrindal and Lilly Pilly Caves were separately gazetted in 1916.

The Main Caves Reserve

As well as the caves and karst, there are several features of historical and cultural importance in the Main Caves Reserve at Buchan (Site 1, Figure 7). This is where the major tourist caves are and there are four walks and several sites of interest.

History

Spring Creek, Moons and Dukes Caves were surveyed and investigated by Stirling in the late 1880s. Both Fairy and Royal Caves were developed by Frederick Wilson (formerly of Jenolan) and provide an example of his skills as a self-taught engineer. The wire netting protection in Royal Cave provides an excellent example of his craftsmanship. He was also responsible for all tunnelling and cutting of the pathway that was necessary in the course of opening the caves. The stalagmites that had to be removed were placed in the *Font of the Gods* and added to the original three stalagmites to create the *Twelve Apostles*. Most of the constructed tracks and small shelters, and the small garden in front of Royal Cave (now restored), were laid down and built by him.

Howard Linacer planned the planting of deciduous trees in the Reserve during the 1930s. Planting took place progressively and relatively slowly until the appointment of Phillip Sandford (formerly from the Melbourne Botanical Gardens) as Manager in 1940. With his expertise he rapidly completed the remainder of the planting as originally designed.

Albert Lind, Minister for Lands in 1938 was committed to the establishment of National Parks. He saw such parks as having to offer a variety of recreational facilities and so preparations for declaring Buchan Caves as a National Park included the entrance archway, swimming pool and tennis courts, camping ground complete with a kitchen and dining hall, children's playgrounds, the car wash area and other facilities.

The Caves

The caves in this part of Buchan are predominantly stream passage caves, which are gently meandering, often joint-controlled horizontal stream passages. Some have upper drier levels containing extensive decoration and can be partially modified by collapse. The lower sections are very wet, with impressive sumps and long, wet and often muddy crawls. Examples include Royal Cave (B 6), The Moons Cave system (B 2 to B 32) and Dukes Cave (B 4). Breakdown passages were developed by collapse into stream passages, in some cases with the removal of the rubble by an active stream. Some of the larger chambers in the Reserve caves are of this type e.g. in Royal Cave (B 6) and Federal Cave (B 7), and contain spectacular bedding-plane hanging walls, dipping at about 40 degrees (as in Royal Cave, Figure 8).

These caves are now known to have formed in at least the early Pleistocene. Early interpretation (Sweeting, 1960 and Talent, 1963) suggested that these caves and the related terraces were Late Pleistocene age. Dating of speleothems from the caves show that the caves were older and this has been confirmed by palaeomagnetic dating from gravels in Royal Cave (Site 1.6; Musgrave & Webb, 2003**),** showing that the caves have contents older than 780 ka, and so must have formed themselves in the early Pleistocene.

The Walks

These walks contain the various sites listed below.

1.1.1: Moon Hill Walk

This walk includes sites 1.2 (Moon Cave (B 2) and resurgence (B 54), 1.10 Devil's Punchbowl and 1.11 Moon's Hill, as well as an excellent view of the Reserve – especially the folded sediments on the opposite slopes above the tourist cave. A short walk across the top of Moon's Hill towards the Buchan River also gives an excellent view of the Buchan valley, river terraces and high level gravels (see Site 1.11).

1.1.2: FJ Wilson Walk

This 2 km walk begins just south of the Visitor Centre and follows the Royal Cave exit track and ends near the Fairy Cave entrance. There are numbered posts relating to particular sites that are described in a *Park Note* about the walk. The walk shows the cave entrances, and many features of the limestone including some excellent examples of karren.

1.1.3: Spring Creek Walk

This is a 3km walk, which splits into the higher track (Tea-tree Track) and lower track (Kanooka) along

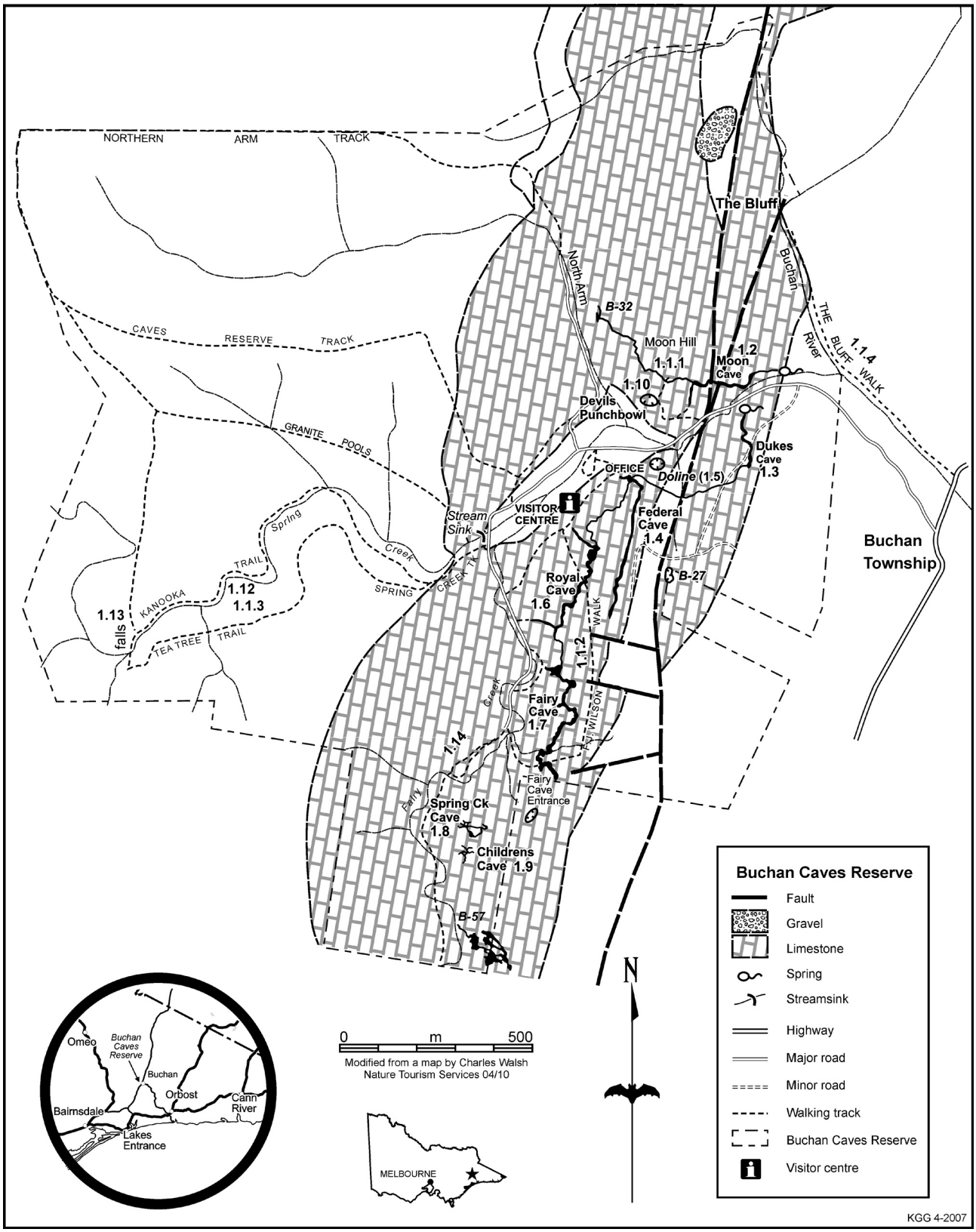

Figure 7: Sites in the Buchan Caves Reserve.
(base-map modified from NTS 2004, geology from Teichert & Talent, 1958)

the creek itself, thus making a round trip. The Tea-tree Track is quite steep in places and the contact between the Snowy River Volcanics and the Buchan Caves Limestone is quite clear near the start. The Falls have a viewing platform. The lower track follows the creek with its remnant rainforest vegetation. The different characteristics of the stream channel in the two rock types can be seen.

1.1.4: Bluff Walk

This walk is along the Buchan River from the main entrance of the Reserve to The Bluff where the Buchan River has cut a cliff into Moon's Hill (see also Site 2). The walk is along the current terrace of the river.

Sites in the Caves Reserve

1.2: Moon Cave (B 2) and resurgence (B 54)

Moon Cave (B-2) was previously used as a tourist cave and consists of a stream passage which is well developed in parts with a permanent stream. The source of the water is unknown although it is thought that B 32 stream provides some of it. Additional water may enter the system from the Buchan River. Platypus has been sighted in the cave stream on several occasions. The main stream resurges from B 54 into Spring Creek. The main entrance is in an impressive bluff known as Spion Kopje. The cave has been considerably vandalised over the years; decoration broken and muddied and steps and railings allowed to deteriorate. Moons Cave was seriously polluted by sewage effluent from the Caravan Park toilet block during the early 1970s (White & Davey, 1977). Significant sewerage works were undertaken to rectify the problem. This is an indication of how easily pollution problems can occur in the karst environment.

1.3: Dukes Cave (B 4) and resurgence

Dukes Cave (B 4) is the name given to the entire tourist cave system, which has over 5 km of passage, sections of which have been developed as tourist show caves (Royal, Fairy and Federal caves, see below). The cave lies entirely within the Buchan Caves Limestone and consists of epiphreatic and vadose passages developed through previously enlarged joints (Webb et al, 1992). The entire system consists of two extensive sub horizontal passages showing three distinct levels in the flat roofs (Figures 5 & 8). These flat roofs cut across the dipping beds of the host limestone and so clearly represent previous water levels (Webb et al, 1992). Details of the cave features are given later in the descriptions of Federal, Royal and Fairy Caves.

The Dukes Cave section has an extensive low wet stream passage and collapse areas and is not easily accessible. The modified stream resurgence is into the swimming pool, and this water drains from the main tourist system, Spring and Fairy Creeks and from the south. B 67, a cave containing a small stream, south of the main reserve has been linked by dye tracing to the Dukes resurgence (Ellaway, 1991).

1.4: Federal Cave (B 7)

Federal Cave was discovered by F. J. Wilson and the government employee W. H. Bonwick in 1915, and was originally developed as a show cave in 1917. In 1970 when mains power was connected to Fairy Cave and Royal Cave, Federal Cave was closed to visitors. It is now being restored by the Friends of Buchan Caves who have installed a wash-water system along the former tourist path, and used it to clean the formations. They have also removed the decaying pre-war electrics and hand-rails and the cave is now being relit with an innovative system using solar charged batteries.

Federal is a horizontal stream cave on two levels. The upper level is the old tourist route and follows a straight passage with little decoration, leading to the lower section. Several small side passages contain some extremely well decorated sections. The lower route leads along the stream passage that connects to Dukes Cave (B 4) in one direction and Royal Cave (B 6) in the other. This classic phreatic passage has little decoration and is prone to flooding in wet seasons (Mill et al, 1980).

1.5: Doline

This doline on the hill behind the Parks Victoria office, and between Dukes and Federal Caves, was used as a rubbish tip for many years. Burning rubbish in this doline caused unpleasant burning odours in Royal Cave, so the practice was discontinued and the doline cleaned up. It does, however, show that even well meaning management can sometimes get things wrong when karst processes are poorly understood and limestone caves are seen in isolation from their host karst. (White & Davey, 1977)

1.6: Royal Cave

This cave was discovered by Frederick Wilson in 1910 and opened to the public in 1913 and is part of the main tourist cave system. Major modifications have occurred including digging an entrance tunnel to open it to the public. Royal Cave is famous for its beautiful calcite-rimmed pools, the most impressive formations being *Niagara Falls* and the *Font of the Gods*.

This is a predominantly horizontal stream cave. It has two main levels with many smaller sections off both. The younger stream passage has little decoration and intermittent water flow, and forms a large loop with the main passage. The normal tourist route is well decorated with a wide variety of speleothems. A large collapse chamber at the eastern end of the cave has extensive calcite over the rubble (Mill et al, 1980). The cave walls in parts of the stream passage show extensive scalloping which can be used to calculate the stream

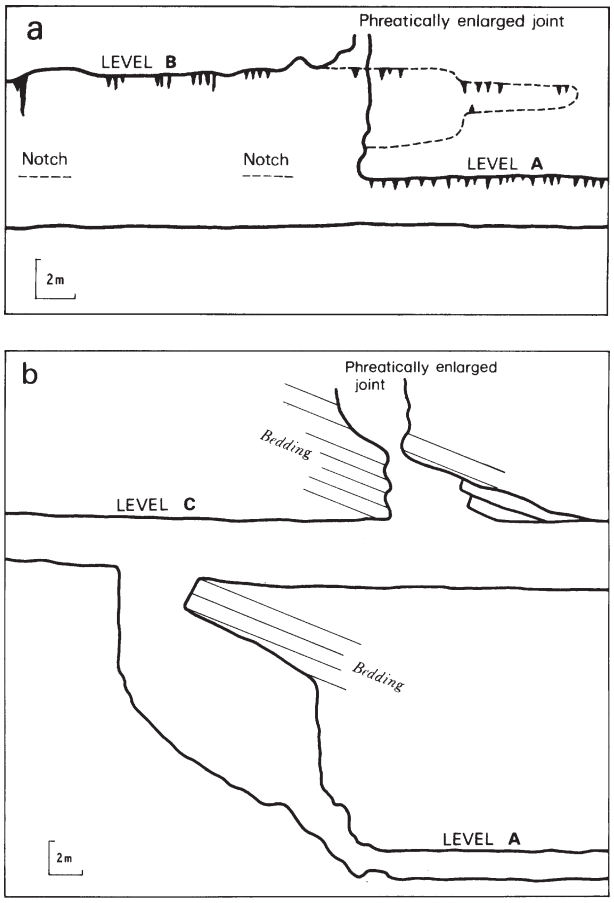

Figure 8: Cross sections in (a) Royal Cave and (b) Fairy Cave. Showing the evidence for the three levels of prior water tables (after Webb et al, 1992).

discharge during cave formation. The cave has several clay and gravel sedimentary sequences. One of these has a palaeomagnetic reversal, which has been interpreted as the Brunhes-Matayama reversal at about 780 ka (Musgrave & Webb, 2003). The cave must have formed significantly prior to this date as the reversal is above the base of the sediments.

1.7: Fairy Cave

This cave is similar to Royal Cave in many respects, and is part of the overall Tourist Cave system. It was discovered in 1907 by Frank Moon and opened to the public the same year. In 1941 the Eastern Chamber was closed to the public due to difficulties with a low roof and frequent flooding, but the Friends of Buchan Caves between 1988 and1990 brought it up to a tour standard. It is a stream passage cave with meandering passages, prone to flooding to a depth of about 15 cm above the path, during very wet episodes. The stream way runs parallel to the tourist path for some of the way and the stream features such as channel shape, depth and meandering pattern can be seen. The speleothems and examples of phreatic and vadose passages are very striking. The roof heights are generally lower than that of Royal Cave and there is less clay-rich gravel sediment. No evidence of palaeomagnetic reversals has been found in any of the sediments in this cave (Mill et al, 1980).

1.8: Spring Creek Cave (B 1)

This old tourist cave is mainly a horizontal joint-controlled maze with a main loop and numerous side passages, chambers and cross connecting passages. The passages are mainly phreatic in form with the occasional vadose canyon and muddy rock pile. Most of the formations are either dead or vandalised. Some of the vandalism dates back to the 19th century when the cave was first discovered. Bats use a chamber in the far northwest corner of the cave (Mill et al, 1980).

1.9: Children's Cave (B 15)

A small well-explored cave with a phreatic network of passages. The cave shows muddying of features and some graffiti, some of which are early signatures.

1.10: Devil's Punchbowl

This is a large elongate collapse doline near the top of Moon's Hill. The collapse walls are very steep and the shape shows the elongate nature of the original cave passage. Good exposures of the Buchan Caves Limestone can be seen in the doline walls.

1.11: Moon Hill

Moon Hill is a prominent hill of Buchan Caves Limestone in the north-eastern part of the main Reserve. It contains Moon's Cave (B 2) and the collapse doline of the Devil's Punchbowl, as well as several smaller caves and dolines. The short path on the hill climbs to an excellent viewpoint from which the folded limestone strata on the opposite hillslope around the main tourist cave system to the south can be seen. You can also see the extent of the limestone on both sides of the Spring and Fairy Creek valley. Further north, at the crest of the hill there is an area of high level gravels left from a ancestral bed of the Buchan River – about 100m above the present river.

1.12: Spring Creek & 1.13 Spring Creek Falls

Spring Creek is the main tributary of the Buchan River in the Reserve. It has its headwaters on the Snowy River Volcanics to the west of the Reserve, and has a significant knick-point in its long profile at the Spring Creek Falls (Site 1.13). Knick-points are localised steep gradients at the upstream limit of an advancing erosional event. There are several such nick-points in the area and Spring Creek falls is one, which occurs west of the change from the Buchan Caves Limestone to the Snowy River Volcanics (Fable, 1992).

Spring Creek sinks into the gravels of its bed sortly after flowing onto the limestone, near the gate on the road to the Royal Cave and Fairy Cave tourist entrances. The

creek only has significant flow during and immediately after times of high rainfall. The base flow moves through the gravel in the channel and attempts to trace it have failed (B. Finlayson, pers comm.). When the creek does flood, levels can be high, sometimes reaching over the tops of the bridge railings. The floods occur relatively quickly and also subside quickly and result in the tour caves and the reserve being closed to tourists for such times.

1.14: Fairy Creek

Fairy Creek is a tributary of Spring Creek and has its headwaters to the south near the Buchan Tip (Site 3). It shows similar flow characteristics to Spring Creek with episodic flooding and a usually dry channel. Unlike Spring Creek, the headwaters of Fairy Creek are in limestone, not Snowy River Volcanics, and are probably more interrelated with the underground streams in the tourist cave system.

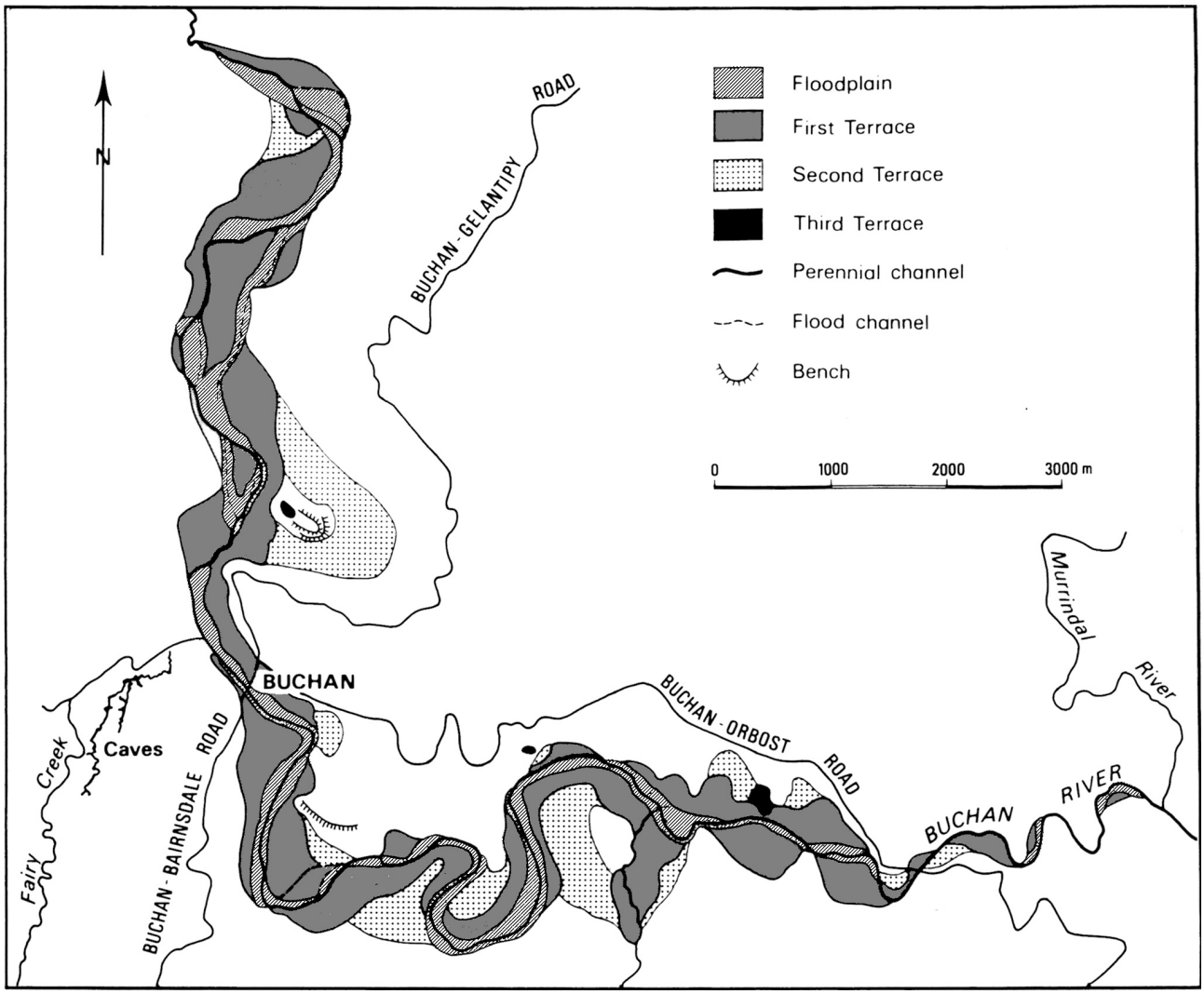

Figure 9: Fluvial terraces on the Buchan River (from Webb et al, 1992).

Sites in the Buchan-Murrindal area

For location of the numbered sites, see Figure 2.

2: Buchan River and The Bluff

Upstream from the Reserve entrance, at The Bluff, the eastern flank of Moon's Hill overlooks the river and is undercut to form cliffs that expose the folded bedding of the Buchan Group Limestone. The western bank of the river is cut into the cliff and the eastern bank is a gravel bar. The undercut area is the deeper part of the river channel and is therefore used for swimming.

3: Tip area gravels

South of the Buchan township are a series of coarse gravels, presumed Tertiary in age. These are similar to the Haunted Hills Gravels, which have extensive exposure across Central and Eastern Gippsland (Holdgate & Gallagher, 2003)

4: Road cutting north of Homeleigh

The thickest accumulation of the Buchan Group sediments and the greatest density of folds occur just north-east of Buchan. The fold axes run north-south; consequently road cuttings which cross these axes east-west provide exposures which give an overview of the structure of the basin. The road cuttings of the Buchan – Murrindal Road, just north of Homeleigh, provide an excellent and readily accessible exposure. At this locality mudstones, nodular limestones and massive limestone beds of the Taravale Formation are folded into broad synclines. Some of the more massive beds contain important coral fossils. The cuttings also show high-level stream gravels, indicating the levels of the Buchan River as it cut down to its current level.

5: Terraces on Buchan River (viewed from road above)

During still stands in valley deepening, valley widening occurs by lateral migration of the river. When river incision recommences, remnants of the floodplain will be left preserved as paired terraces on either side of the river. The river also provides the local base level for the groundwater drainage, and the water table is 'graded' to the river. Caves develop along the top of a watertable and the upper limit of cave development is set by the water table elevation. Three paired terraces are found in the Buchan Valley (Figure 9). The road gives an excellent view, from above, of the abandoned meander of the Buchan River and three terraces (McRae-Williams et al, 1981, Webb et al 1992)

6: Filled solution pipes in Road Cutting, Murrindal Rd

The road cutting shows solution pipes which are now filled with sediment.

7: Quarry

The Buchan Quarry shows exposures of the Rocky Camp Member. The quarry is cut on three levels in a massively bedded limestone deposit. Fossils include stromatoporoids, tabulate and rugose corals with *Receptaculites* (a sponge-like fossil) as a common associate and occasional nautiloids and bryozoa (Teichert & Talent, 1958). Access to working quarries is always difficult due to OH&S issues and they rarely allow excursions to visit.

8: The Potholes and Wyatt's Reserve

Wyatt's Reserve was originally known as the Potholes Reserve and was first gazetted in 1887 for camping purposes, particularly for use by drovers with traveling stock. It was obviously not an ideal site for this purpose but was probably the only available land adjacent to the road. The small reserve was extended to include the Allotment 22A after a concerted campaign by the Victorian Speleological Association in the 1970s and 1980s to conserve the Potholes against a quarry development. Further acquisitions have occurred to the north, which has enhanced the integrity of the Potholes Reserve. The highly fossiliferous Rocky Camp and McLarty members of the Murrindal Limestone outcrop in this area. Thin black shale beds are contained in the limestone. In addition, the limestones are strongly jointed along three planes striking at 60 degrees to each other. This jointing pattern has largely dictated cave development in the area, as most of the cave passages are enlargements of these joints.

Karst topography in Victoria is often subdued, and even in the limestone country around Buchan karst relief is not well developed. However, as the name suggests, the Potholes area has a significant concentration of sinkholes, which, together with surface rillenkarren, constitutes the finest example of this form of karst topography in South-eastern Australia (Figures 10 & 12).

Many of the dolines open into cave entrances and more than 90 caves are recorded in this area (Figure 13). Many of the caves consist almost entirely of vertical shafts with little horizontal development, e.g. Ians Hat Cave (M 54, Figure 13) and Jam Pot (M 48, Figure 11). Several caves have developed extensive horizontal passage systems by the phreatic enlargement of joint planes at old watertable levels (Figures 4 & 14). Such caves tend to have narrow passages with high ceilings, which open, occasionally into large chambers. The passages and chamber floors consist of water worn rock, muds or flowstone, and many of the caves finish in soaks with mud and gravel bottoms. Cave decoration is best developed in this horizontal type of cave and features such as flowstone, stalactites, stalagmites, shawls, rimstone pools and helictites are common. Examples include Exponential Pot (M 125, Figure 14) and Honeycomb Cave (M 41).

The area contains the best example of doline karst

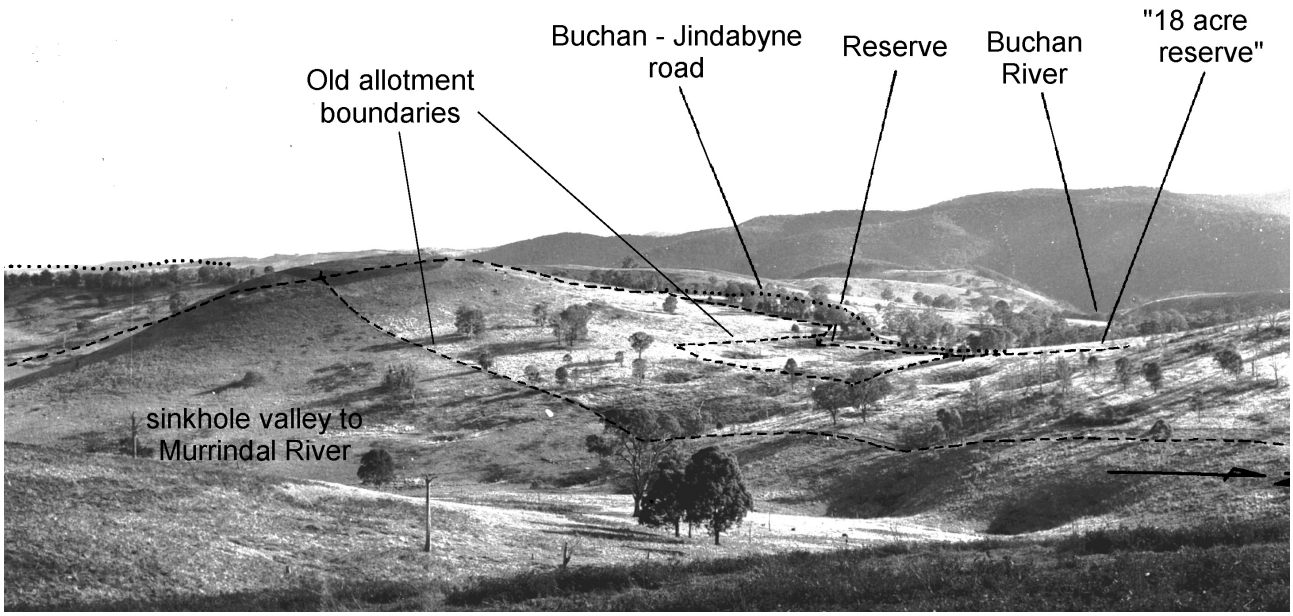

Figure 10: View of the Potholes area, looking southwest. [photo by R.K. Frank]

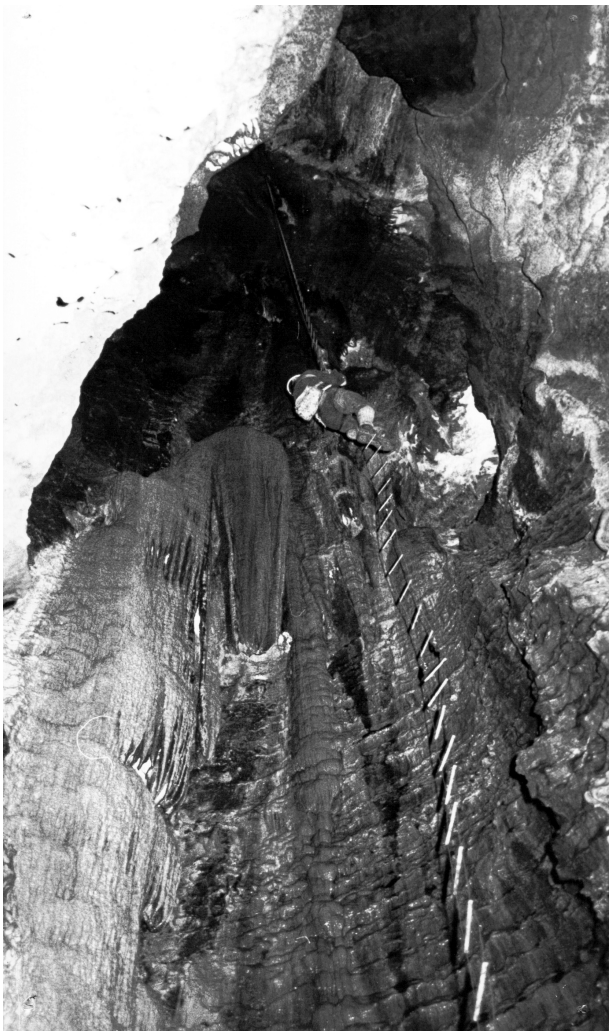

Figure 11: Vadose shaft in 3M-48, Jam Pot, at the Potholes. [photo by R.K. Frank]

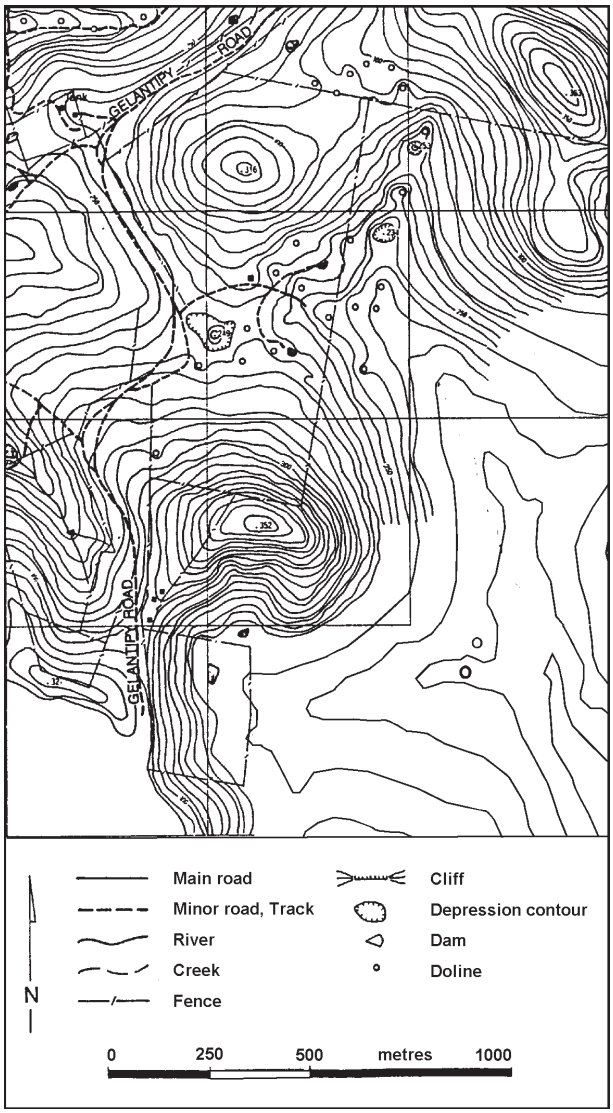

Figure 12: Contours and surface karst in the Potholes area (modified from a map in Finlayson et al, 1992a).

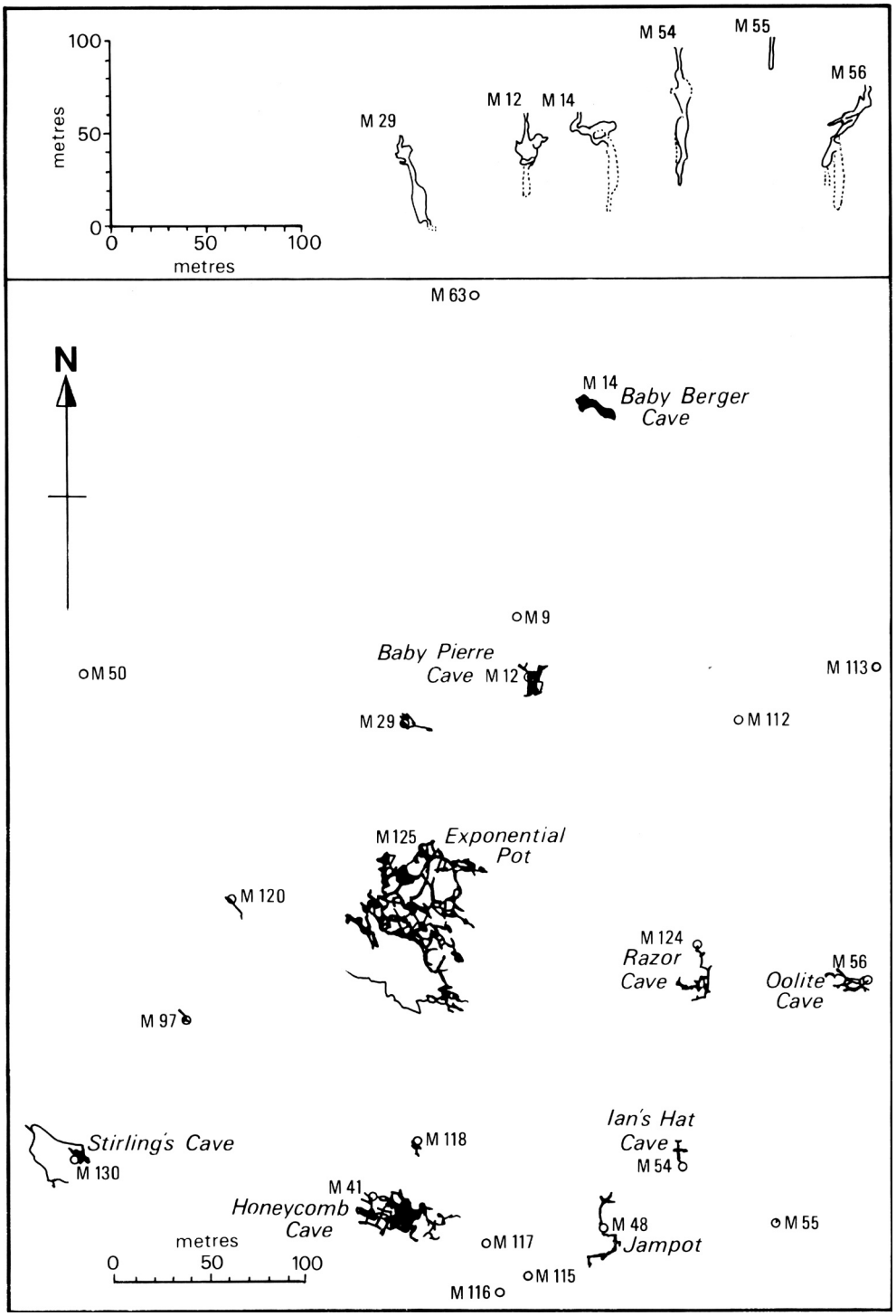

Figure 13: Pattern of caves in the southern part of the Potholes area (from R.K. Frank).

topography and associated cave forms in southeastern Australia. It also has the best examples of joint-controlled cave development in Victoria and some of the best cave decoration in the Buchan area. It has been classified by the Geological Society of Australia's Heritage group as of National significance (White et al, 2003).

9: Dicksons Caves (M 30)

These are two stream-passage caves, originally thought to connect but which do not. They are the highest stream pasages in the landscape and as such are of geomorphological significance. They indicate the highest known level of the water table in the district but attempts to date the sediments have not been successful. Drainage direction is not clear but is possibly towards the Buchan River. One cave was used as a rubbish tip for some years but was cleaned out by the Victorian Speleological Association in the 1970s.

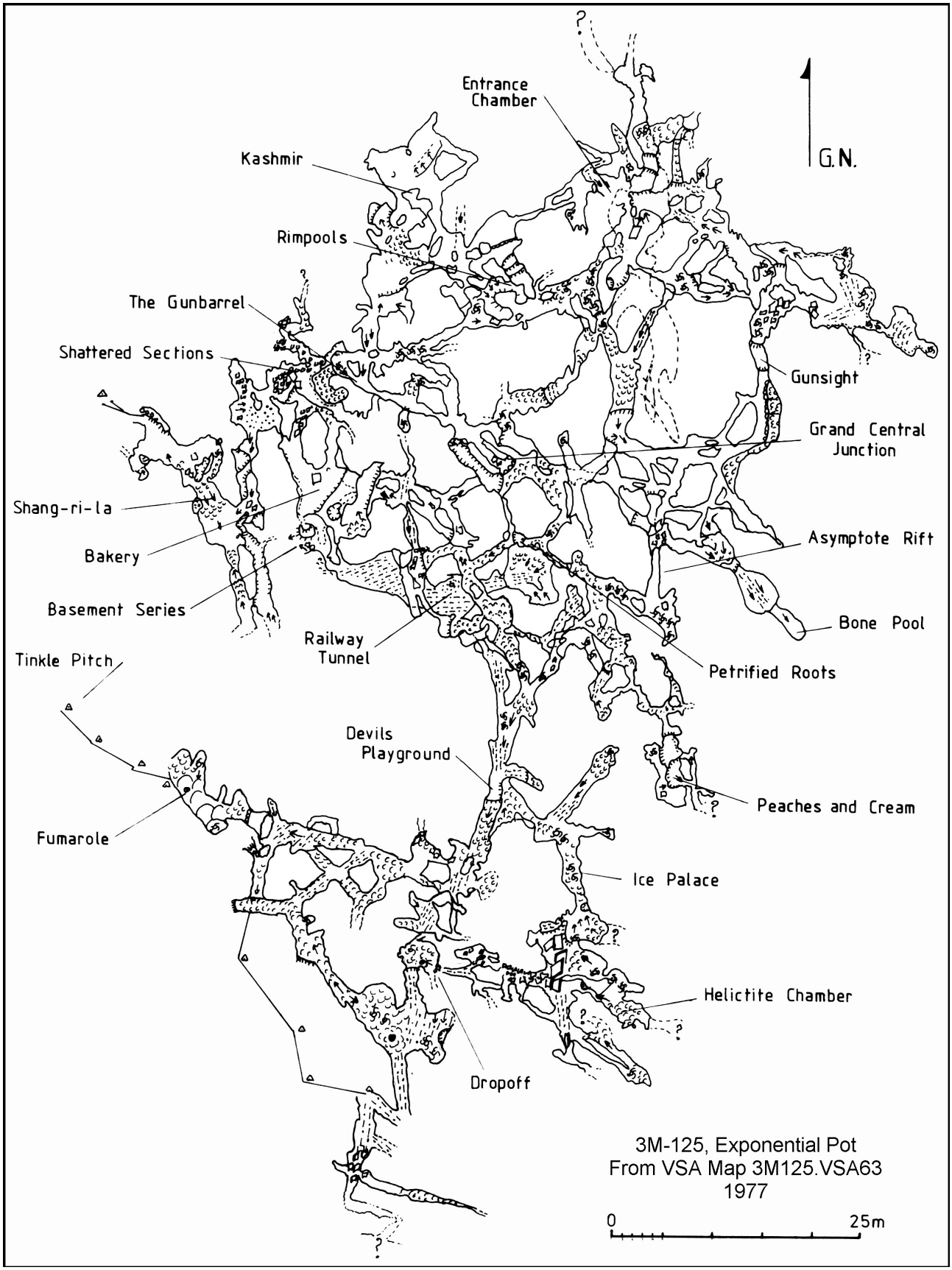

Figure 14: Plan map of Exponential Pot, in the Potholes area (from Mill et al, 1980).
Note that the passages have a significant vertical development which is not shown in this plan view.

10: The Pyramids

The Pyramids Reserve was a popular picnic place for local residents and also for caves visitors but is now less accessible. It was the site of a small but not particularly successful lead mine. The limestone varies from finely interbedded with mudstone to more massive, some of which is highly fossiliferous. As well as the Buchan Caves Limestone, good exposures of Snowy River Volcanics and the "transition beds" or Spring Creek Member occur at the site.

The area has significant geomorphological examples of undercut river drainage, river knick-point development and an associated actively developing cave system, together with surface karst features of note (McRae-Williams et al, 1981; Fabel et al, 1996; Figure 15). Just to the north of the Pyramids, the total low level discharge of the Murrindal River disappears underground into the Pirana (M 82)–Dalley Sinkhole (M 35)–Sub-Aqua (M 26) Caves System. This is a subterranean meander cutoff. High discharges in the Murrindal River overflow around the east of the Pyramids where the channel is in Snowy River Volcanics. Here the channel consists of large pools and coalesced potholes. In several areas small rapids and waterfalls occur, the largest of which is approximately 8 m in height. Three knick-points occur in this abandoned section (Fabel et al, 1996).

The Murrindal River enters Pirana Cave (M 82) through a gravel-choked sinkhole. This cave is estimated to be over 100 m long and consists mainly of a very tight stream passage with a few medium-sized passages. Dalleys Sinkhole (M 35) provides access to the middle section of the underground course of the Murrindal River, which is here some 25 m below the level of the stream sink. The gradient of the cave from here on to its resurgence is quite low (Figure 15b).

A small dangerous entrance leads from Dalleys Sinkhole to an extensive cave system, which is exceptionally well decorated. Here a canyon 20 m high and 10 m wide leads to a relatively large chamber, which leads to stream passages which end in a rock fall from which the river issues. High-level passages occur and these rise to 40 m above the present river level. These passages and chambers are extensively decorated (Mill et al 1980). The downstream, Sub-Aqua, section runs eastward across the strike, and shows rising and falling phreatic loops, now largely entrenched to the present stream level (Fabel, et al, 1996).

The Pyramids themselves provide one of the best examples of large-scale karren topography in the Buchan area. They consist of three isolated stacks of bedded Buchan Caves Limestone separated by fissures up to 3 m deep. The slopes and cliffs surrounding the Pyramids show excellent examples of tufa. In addition the hilltop at the Pyramids contains a large collapse doline, 10-15 m wide with cliffs on each side reaching 20 m in height.

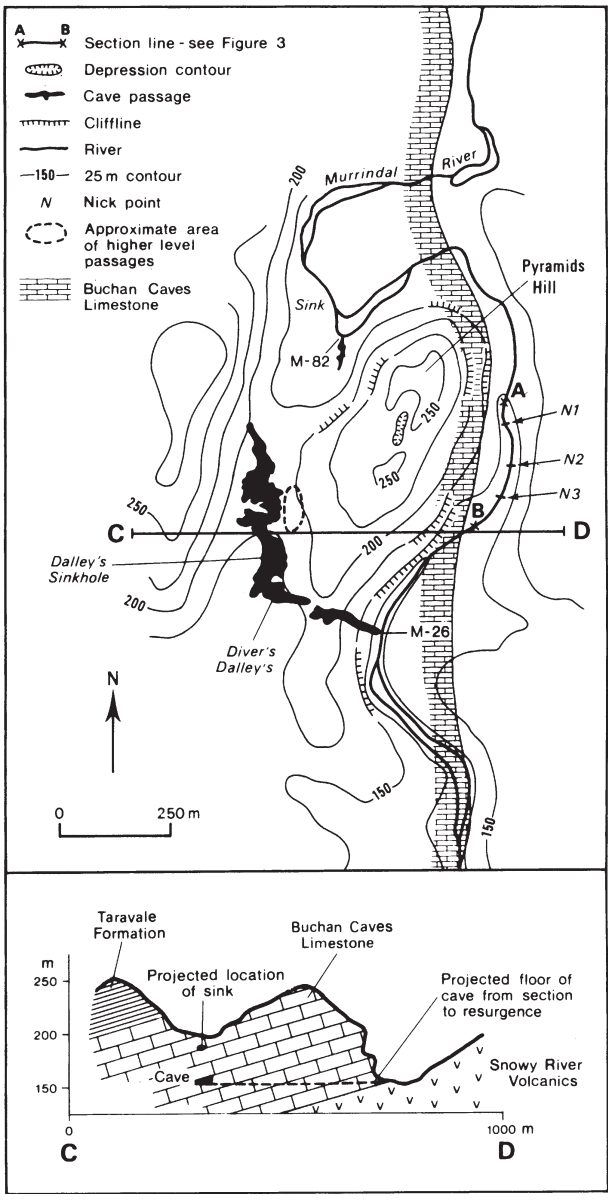

Figure 15: The Pyramids area, showing the underground cutoff of the meander loop, knick-points in the abandoned river section (N1-N3), and the gradients of the present cave system (from Fabel, et al, 1996).

This depression is probably the result of the collapse of caves previously formed by the underground drainage of an older, higher level, Murrindal River.

The Pyramids are of National Significance geologically (GSA Database) as they provide one of the best examples in Victoria of underground stream drainage through an active and well-decorated cave system. In addition, excellent examples of surface karst features, particularly karren and tufa, occur (McRae-Williams, et al, 1982).

11: Hill top gravels

This is an exposure of well-rounded cobble-sized gravels composed primarily of Snowy River Volcanics.

The gravels are now in a colluvial deposit as they have slid down the hill from the original streambed. However, they show that there were significant river channels in the past at this level in the landscape. The size of the cobbles indicate that the river had periods of high discharge and flow, and their composition indicates that the headwaters of the river was in Snowy River Volcanics. These gravels can be found on several ridge tops around the Buchan and Murrindal valleys and are a key to the nature of the old drainage systems.

12: Murrindal Pioneer Memorial area

The Pioneer Memorial on the main road is an excellent site from which to view the Murrindal Valley and its cliffs. Upstream from the Pyramids the river has cut impressive cliffs up to 80 m high in limestone on its western bank. These cliffs contain the entrances of several caves, the most notable of which are M 27, M 28 and M 29. These caves contain fossil bones of small native marsupials and rodents. The road cutting also shows an old cave, which has been filled with volcanic material, probably basalt (Orth et al, 1995, p.146). Unfortunately, the rock is too weathered to be able to be dated, but thin section analysis indicated that it is most likely weathered Eocene basalt (J. Webb, pers. comm.). This confirms the presence of volcanic activity in the area.

13: Murrindal (M 7), Lilly Pilly (M 8), M 4, Shades of Death (M 3) caves

Murrindal Cave (M 7) is a single-entrance cave, which is an abandoned stream passage. It has been used as a tourist cave, both by the government department and under licence to private concessionaires. The stream passage has been substantially modified by sediment and speleothem infilling so that it is now a series of chambers connected by short passages. There is reasonable decoration.

Lilly Pilly (M 8) is also a previous tourist cave, which shared management with Murrindal Cave. It is an intermittent stream cave with some large chambers, draining into the Murrindal River. The passage has developed along a basalt dyke, which was intruded along a possible small fault. The dyke is about 30 cm wide and has a small contact aureole on both sides. The cave is very humid and has excellent decoration including flowstone along the streambed.

M 4 contains a stream and three sumps. The entrance rock fall area leads to a 1.5 m high, 1-2 m wide stream way with several small chambers up to 4 m wide by 10 m long. The first 100 m of stream way is heavily decorated. There are three sumps and the cave has been explored beyond the final sump during dry seasons to the impenetrable fissure. The third sump is the known end of the cave.

Shades of Death Cave (M 3) has also been known as Murrindal Moon Cave and has been operated as a private tourist cave at various times. This cave has two entrances and is a stream cave with intermittent internal flows. It contains some excellent decoration and spectacular chambers and passages.

More Distant Sites

For location of the numbered sites, see Figure 2.

14: W Tree Falls

These impressive falls are 21 km north of Buchan and are an excellent example of a knick-point on a tributary of the Buchan River. W Tree Creek flows over Snowy River Volcanics at this point.

15: Little River Gorge

The gorges of Little River and Boundary Creek and the associated waterfalls are spectacular scenery produced by rapid downcutting of river channels to a local base level of the Snowy River. The waterfalls are knick-points on the Snowy River tributaries. The Little River drops approximately 700 m in 4 km through a gorge with cliffed margins up to 500 m in height. The valley sides show the difference in slope form between the more resistant Snowy River Volcanics and the underlying less resistant granitic rocks (McRae-Williams et al., 1981).

16: McKillops Bridge

This is the major bridge across the Snowy River on the road connecting the Buchan–Jindabyne Road to the Bonang Highway. This area is part of the Snowy River National Park. There are walking tracks which start at the bridge area. The Silver Mine Walking Track is a 15.5 km loop from McKillops Bridge which enables good views of the Deddick Valley, and in good weather views of The Pilot and Mt Cobberas. The main interest of the walk is the vegetation which includes extensive stands of native White Cypress Pine (*Callitris columellaris*), and the relicts of early 1900s silver mining operations close to the Snowy River. The adits, shafts, mullock heaps and tracks are relics from attempts to mine the discontinuous silver lodes in the early part of the twentieth century. The mining ceased by about 1905.

A shorter nature-walk from the bridge also passes through similar environment. The remnants of the original bridge can be seen washed down stream from the where the present bridge stands.

17: New Guinea Ridge (NG)

This is the northernmost of the small outliers of Buchan Caves Limestone which crop out along the Snowy River valley east of Buchan. The limestones have been down faulted into the underlying Snowy River Volcanics (Figure 2). At New Guinea, the limestone crops out low in the landscape at the southern end of

the spectacular Tulloch Ard Gorge, and forms some impressive cliffs at river level (Mill, et al, 1980).

There are a number of known caves. NG 1 is about 700 m long and is a stream passage, which is dry for the first 400 m. However the last 300 m is generally inaccessible due to a sump. The entrance doline is impressive and the cave contains bats and related invertebrate fauna (Mill, et al, 1980). There is impressive speleothem decoration and the gravel sediments need further study.

NG 2 and NG5/6 systems were formed by allogenic streams flowing across and through the limestone towards the river. Both have small permanent streams. NG 2 has important aboriginal wall markings and has been excavated and is currently gated. NG 5 and NG 6 are stream caves with permanent water and are fed by an impassable spring in the doline (Mill, et al, 1980). The chemistry of these stream waters is similar to that of Spring Creek (Ellaway, 1991).

18: Jacksons Crossing (JC)

Jackson's Crossing is at a ford about 20 km NE of Buchan in the Snowy valley. This ford was used by the early settlers to cross the Snowy River, and the river flats nearby were used for camping and cattle grazing. The limestone is folded Buchan Caves Limestone and the Snowy River has cut through them to leave two segments. The main area is on the west side of the Snowy River and is dominated by a 50m high bluff at the SE end of a ridge. There are several small caves known on this ridge. The smaller outcrop is on the eastern bank of the Snowy River and contains dolines and depressions. Only small caves are known from Jackson's Crossing but recent visits showed some potential. The views from the bluffs of the Snowy valley are rewarding (Mill, et al, 1980). Knick-points in the form of waterfalls occur on the all tributary streams of the Snowy River in this area (Li Shu, pers. comm.).

The ford is still used but care needs to be taken as driving off the ford into the river is not unknown! The area is only accessible by 4WD.

19: The Basin

The Basin is an outlying area of about 5 square kilometres of Buchan Caves Limestone located about 12 km northeast of Buchan on the western side of the Snowy River. It is divided by 3 small streams with rocky ridges between of about 120 m of local relief.

The area was settled first in the 1880s and The Basin Ranch established on the Jackson's Crossing Track by the Slocombe family. The Slocombe Cave (BA 1) area is part of the Caves Reserves recommended by Kitson in 1900, and is part of the Parks Victoria Caves Reserves today.

The main cavernous limestone appears to lie between Basin Creek and the Jackson's Crossing Track, but recent exploration of blackberry infested areas have found caves, some of which had previously been known but the locations lost. The area has stream caves and dolines and has some potential for further exploration.

Slocombe's Cave (BA 1) has a large walk-in entrance leading to a short vertical drop of about 7 m. The cave is a generally joint-controlled phreatic maze. It is heavily used by commercial adventure groups and is showing evidence of such use especially in damage to the sediments.. It contains bats at certain times of the year.

20: Mooresford

The faulted contacts between Buchan Caves Limestone and Snowy River Volcanics and the fault contact between the Ordovician sediments and the Snowy River Volcanics have controlled the river valley orientation in this area along the Snowy River. The Buchan Caves Limestone outcrop contains one known cave, a joint-controlled outflow stream cave. It is a known maternity site for the Little Horseshoe Bat (McRae-Williams et al, 1981).

East Buchan (EB) Sites

21: Bitch of a Ditch (EB 49) area, East Buchan

This area has a series of rock shelters, which were investigated in the 1970s (Gallus, 1976). Stone flakes are recorded from the EB 6 site. Bitch of a Ditch (EB 49) is a complex tufa-depositing permanent spring. The 5 m thick tufa deposits extend 80 -100m downstream from the main spring and have more than one level. Complex patterns of drainage are shown at this site. Despite attempts to find a cave behind the tufa, the extent of limestone in this area is limited and the flow of the water is most likely along the faulted contact between the Buchan Caves Limestone and the Snowy River Volcanics. As a result the water is highly aggressive and has dissolved carbonate from the dolomitic sequence of the Buchan Cave Limestone, but not formed caves (Ellaway, 1991 and J Webb, pers comm.). At the spring the water degasses and deposits tufa.

22: Subjacent doline

A small subjacent doline occurs beside the road on the southern slopes of Back Creek valley at East Buchan. It is located in the Snowy River Volcanics, upslope from its fault contact with the Buchan Caves Limestone. It is a sub-circular feature, 5 m deep and about 35 m in diameter, completely within the volcanics (Figure 16). The fault contact has been interpreted as dipping into the slope and as an underthrust (Teichert & Talent, 1958). As a result the younger limestones have been thrust under the older volcanics. Solution of the limestones has formed voids and collapse of the overlying volcanics as

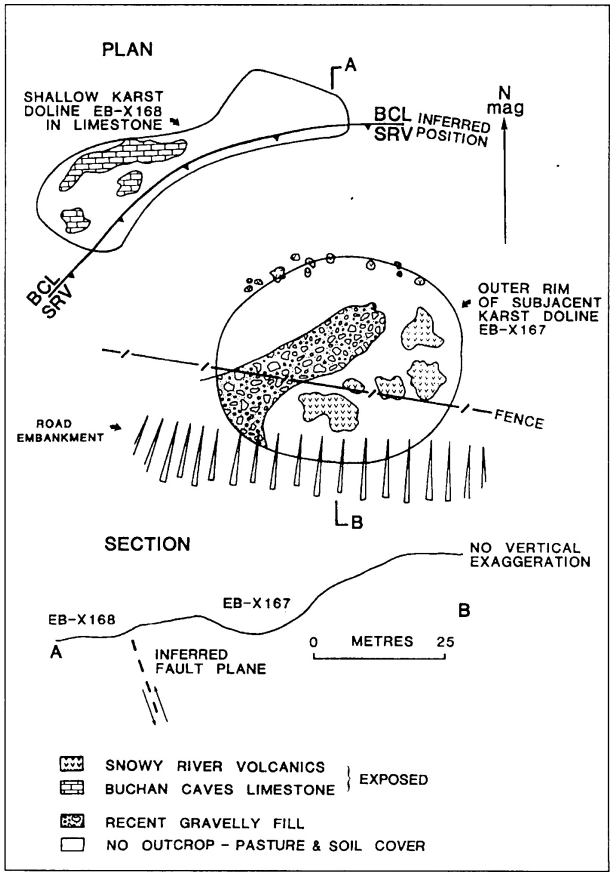

Figure 16: The subjacent doline at Site 22.
(from Davey & White, 1992)

a subjacent doline. Only a few subjacent dolines have been reported in southeastern Australia (Davey & White, 1991).

23: Back Creek area.

Back Creek has small deposits of silver and lead and the miners accessed the ore via its exposure in cave walls of the Back Creek Mine Cave (EB 58) and EB 59.

24: Buchan River, East Buchan

The Buchan River is diverted east close to the main Reserve in Buchan (Figure 2). This was probably the result of updoming and or uplift in the area to the south of Buchan (Fable, 1989**)**. The river has several impressive cliffed areas, and caves such as Mabel Cave (EB 1) are stream cave tributaries of the river. Mabel Cave, and others in the area have significant owl roost subfossil deposits which have been important for the interpretation of the palaeoenvironmental conditions (Baird 1996).

25: Buchan Thrust Fault area

The thrust fault is relatively small and has a throw of about 85 m and a total displacement of less than 150 m. It is well exposed on the southern side of the Buchan River and the details of the folding and fault plane can be clearly seen from the Buchan–Orbost Road.

26: Wilson's Cave (EB 4)

This was initially gazetted as a 73 acre Recreation Reserve, and Tambo Shire was given the responsibility for its management. In 1904 with the creation of a number of caves reserves, 17 acres of it were re-gazetted for protection of the caves and this was later further reduced to 8 acres. During the later years of the 19th Century, it was a popular picnic place for local residents and special events, including the annual New Year's Eve

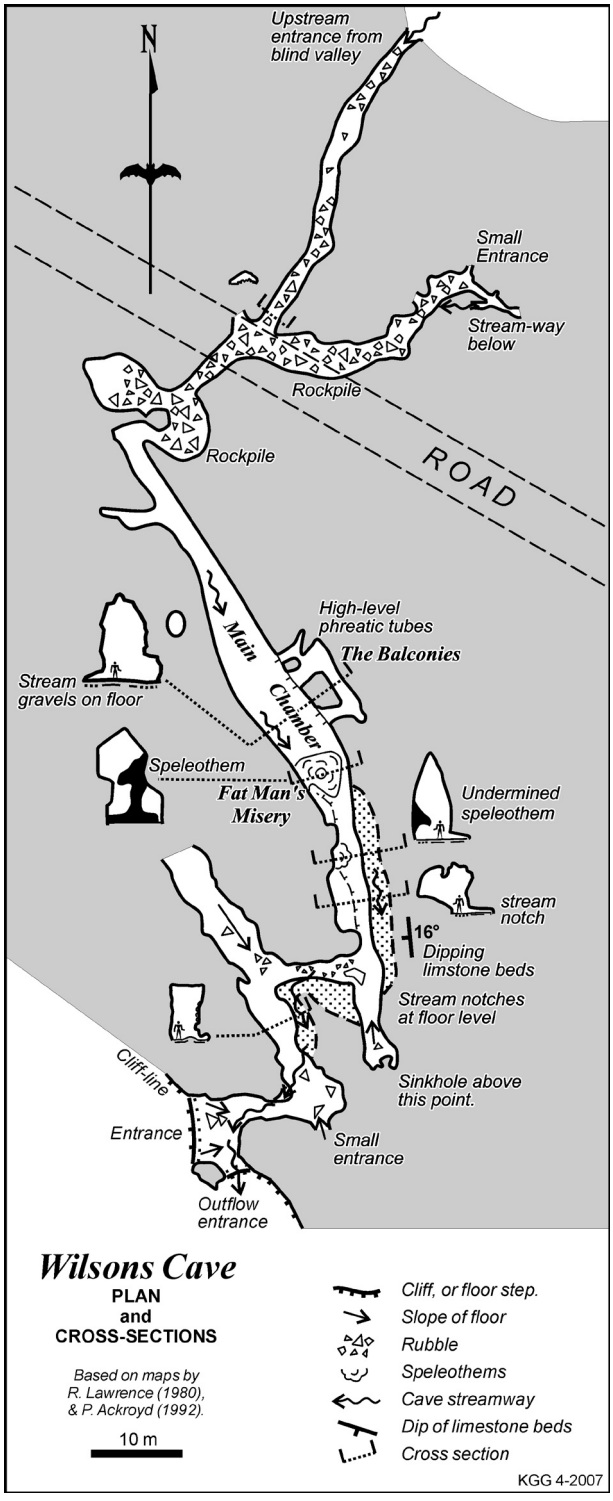

Figure 17: Map of Wilsons Cave.

party were held in the cave itself. When the Governor of the day, Sir Reginald Talbot, opened Fairy Cave in 1907, he was also taken to Wilson's Cave and a well known photo shows him sharing a whisky with Frederick Wilson and others. (NB the Wilson after whom the cave was named was a local landowner and not related to Frederick Wilson). The diagrams shown here (Figures 17 & 18) are taken from an interpretation sign erected recently by the Friends of Buchan Caves.

The cave is at the end of a significant dry valley. During wet conditions this valley contains a flowing stream which enters an upstream entrance of the cave and

Stages in the formation of Wilson's Cave and blind valley

shown as a profile of the valley and cross-sections of the cave

1: A simple valley in the early Pleistocene
(probably more than a million years ago)

A stream flowed down a small valley onto a terrace of the main river valley to the south. Caves were dissolving along the level of the watertable, a few metres beneath the surface.

2: Underground capture of the surface stream

The stream was diverted into the growing cave system, and the valley became "blind". However, large floods, too big for the cave, may have followed the old surface route for some time.

3: Incision of cave passages

The Buchan River was eroding down, and also swung north to cut the cliff that you see today. Wilson's Cave stream cut down into the floor of the passages to form an underground canyon. Stream notches and gravels were left behind on the walls. The gravels may be more than 800,000 years old. Calcite speleothems began to form in the higher levels.

4: Undercutting of the walls

The main river level became stable: so instead of cutting down, the cave stream began to cut sideways, undermining the cave walls which began to collapse. Rubble accumulated in the cave and some collapsed areas reached to the surface to form sinkholes. More speleothems formed.

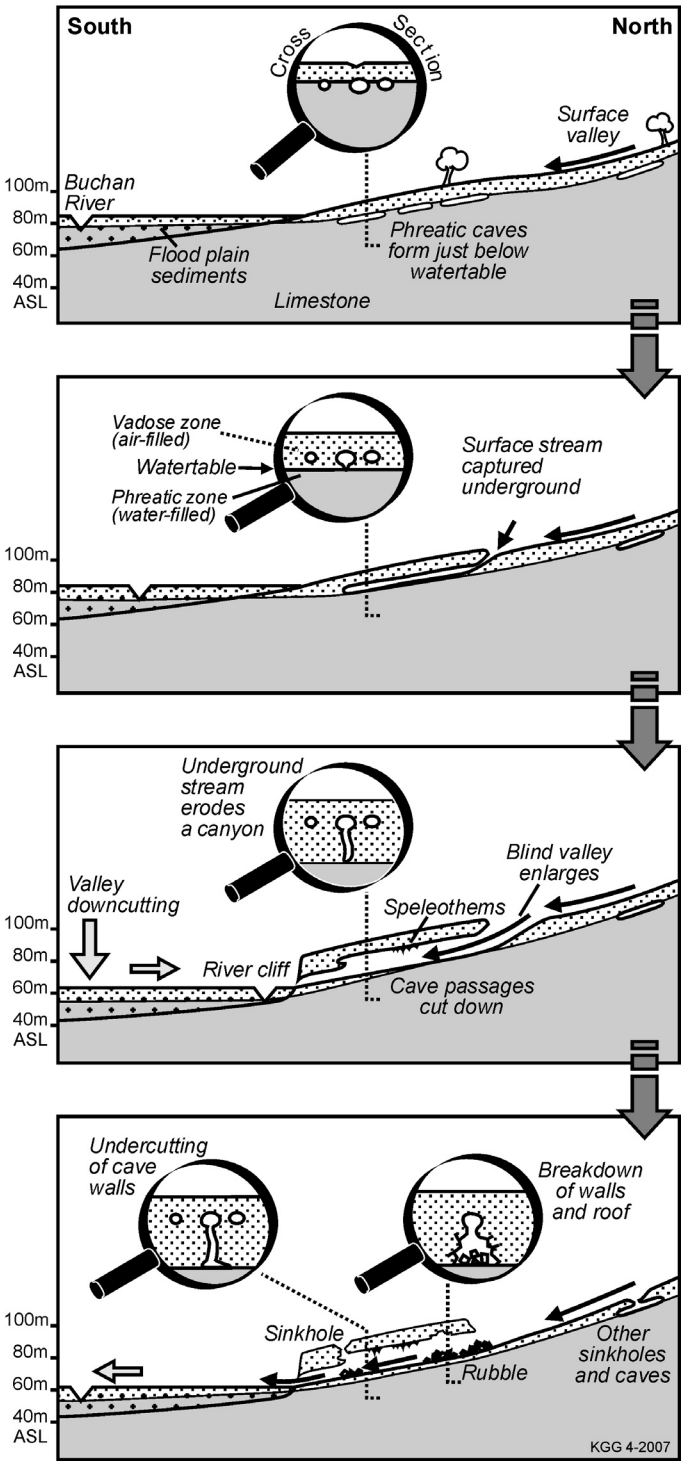

Figure 18: The evolution of Wilsons Cave and its blind valley is tied to that of the Buchan River valley

continues through the cave. It has left obvious stream gravels on the floor of the cave.

Wilsons Cave is a stream cave composed of a set of tall, narrow, stream "canyons" that zig-zag and branch as they follow joints (lines of weakness) through the limestone (Figure 17). The canyon-like passages formed by downward erosion of the underground stream, keeping pace with the down cutting of the adjacent river (Figure 18). The original passage was up at roof level. At the present floor level, the walls have been undercut by the stream, which is now widening its channel rather than cutting down. This undercutting has caused instability and rubble has fallen from the roof and walls. Horizontal wall notches and relict stream gravels plastered to the cave walls show prior levels of the cave stream as it cut down. The cave has some speleothem decoration. South of the *Fat Man's Misery* a speleothem protrudes from the west wall - this probably once sat on the stream bed, but ongoing incision has left it sitting a metre above the present floor.

The stream gravels that have been left stuck to the walls of the cave as its floor was cut down may be the same age as similar ones in the tourist caves. Those have a magnetic record from a time before the earth's magnetic field was reversed - and the last time that happened was about 800,000 years ago (see discussion of Royal Cave, Site 1.6).

27: Cloggs Cave (EB 2)

This cave is formed in an anticlinal fold of the thrust fault zone. This is an important archaeological site investigated by Josephine Flood (Flood, 1974). The cave has stratified sediments containing evidence of human occupation with bone and stone tools in conjunction with a rich faunal assemblage. Occupation extended back as far as about 19,000 years and the site has yielded important information about the paleoenvironment and palaeoclimatology (McRae-Williams et al, 1981)

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