LAVA CAVES OF AUSTRALIA

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ABSTRACT

During the Cainozoic, there was widespread basaltic igneous activity in eastern Australia, but only the relatively young (post Miocene) lava field provinces in northeast Queensland and western Victoria have numerous, well-preserved lava caves (over 40 in northeast Queensland and over 50 in western Victoria). The northeast Queensland caves are large, simple in plan and cross-section, and are concentrated in particular groups; each group represents a lava tube system. In general, the Victorian caves are smaller and often more complex, especially in plan, and they tend to occur in isolation. A range of origins and geomorphic settings is represented by the Victorian caves, including tubes in flank flows, valley flows, lava plains and channel overflows, as well as spatter cone shafts and roofed lava channels.

Isolated, older caves are also present in eastern Australia. Early Miocene lava in southeast Queensland contains a small lava tube, and a very small cave in early Oligocene basalt in New South Wales may be a lava tube remnant.

INTRODUCTION

During the Cainozoic, there was widespread basaltic igneous activity in eastern Australia (Figure 1), in a band up to 300 km wide, extending 4,000 km from Tasmania to Torres Strait and beyond (Stephenson, *et al*, 1980). Volcanism commenced in the Late Cretaceous (approximately 70 Ma) and continued through the Cainozoic at a nearly constant rate (Wellman and McDougall, 1974a). More than 50 igneous provinces have been recognized, activity in each generally lasting less than 5 Ma and resulting in lavas covering a region 50-200 km across. The extruded rocks range from mafic to felsic in composition, with basaltic types predominating (Wellman, 1978). The provinces are generally of either the lava field (areal) type, with a diffuse eruptive area, or less commonly the central volcanic type, in which flows are extruded from a well-defined vent area.

Lava tubes are present in basalt flows within six of the areal Cainozoic provinces in eastern Australia, five in Queensland, and one in Victoria (Figure 1). Some of the Victorian caves have been known since the mid-19th century, and Ollier and Brown (1965) reviewed much of the information known about them. Most of the Queensland examples have only been described fairly recently, and new caves are still being found. The present review gives a general description and comparison of all known lava caves in Australia, concentrating on those formed by volcanic action. The term "lava tube" as used herein refers to a cave formed as an internal lava conduit within a flow, whereas the general term "lava cave" encompasses any cave within a lava flow, however it was formed. Lava caves which owe their origin to groundwater or stream action are only briefly mentioned in this review, and caves in pyroclastic deposits interbedded with flow are excluded from this discussion.

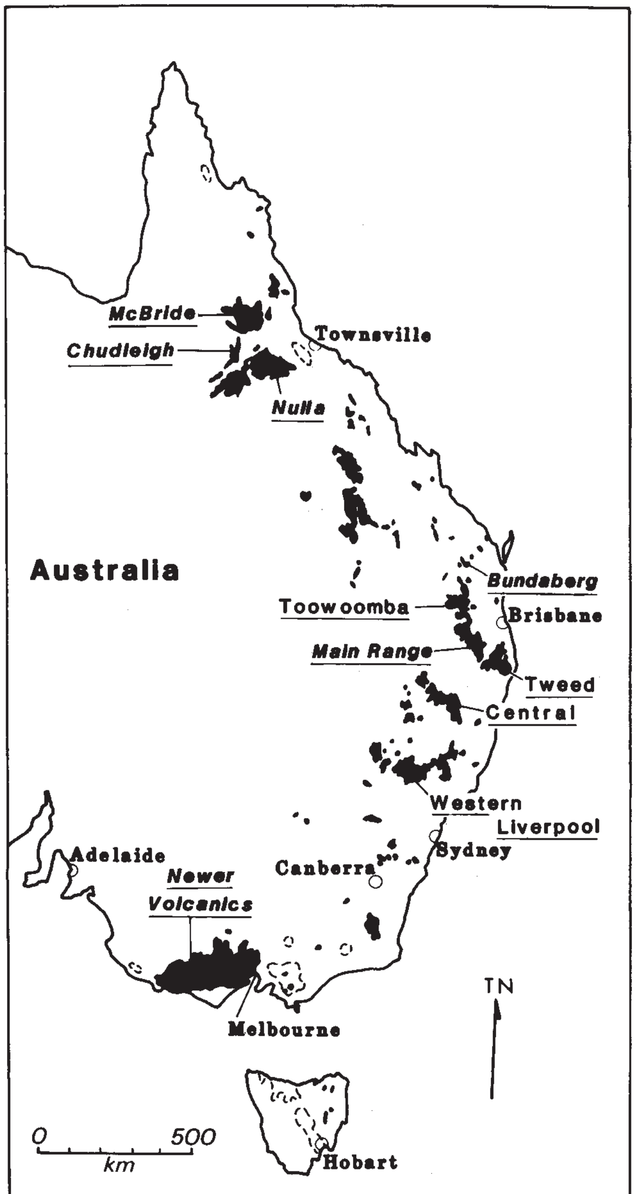

Figure 1. Cainozoioc volcanic areas in eastern Australia; dashed lines enclose areas too small to show clearly at this scale. Modified from Stephenson et al. (1980). Provinces named in italics contain lava tubes; provinces labelled in roman script contain basalt caves formed by the action of streams or groundwater.

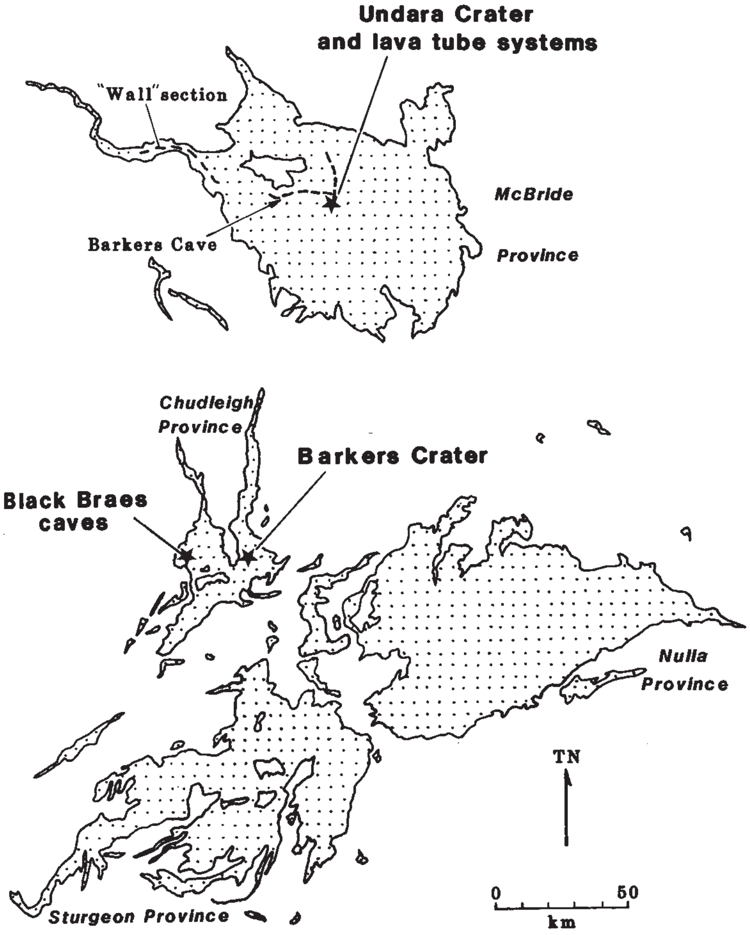

Figure 2. North Queensland volcanic provinces, with major lava cave areas

NORTHEAST QUEENSLAND

In northeast queensland, there are 12 main volcanic provinces, most being lava fields. Volcanic activity has been intermittent since Paleocene-Eocene time, with a major period of volcanism extending from five Ma almost to the present. The age of the youngest eruption is somewhat uncertain, but the Toomba flow in Nulla Province overlies carbonaceous sediments that yielded a radiocarbon date of 13,000 years (Stephenson, *et al*, 1980). Three of the northeast Queensland provinces are known to have lava tubes: McBride, Chudleigh and Nulla (Figure 2).

McBride Province: The largest and best-known lava caves in Queensland are associated with Undara Crater in McBride Province. This province is roughly circular, with a diameter of 80 km and consists of a broad lava plain with numerous cones; there are 164 known vents (Stephenson, *et al*, 1980). As a whole, the province forms a broad volcanic dome with Undara Crater as the highest point. Two long lava flows, both 190,000 years old, extend from Undara Crater, one reaching 90 km to the north and northwest, the other extending 160 km to the west-northwest and west (Figure 2). The great length of these flows is attributed to continued high effusion rates and favorable topography which resulted in channeling and the formation of efficient, heat-insulated lava tubes, able to maintain a supply of fluid lava over long distances (Stephenson, *et al*, 1980; Atkinson, *et al*, 1977). Usually, low viscosity is not believed to be a factor.

The lava tube system in the Undara basalts extends north of the crater for 4 km, and then splits into two, following the course of the flows (Figure 2). The system is marked by a series of elongate depressions and well-preserved lava tubes. In the western flow, these extend perhaps 35 km (Atkinson, *et al*, 1977), their continuation is the "wall" section, a narrow ridge 35 km long, up to 20 m high and 70-300 m wide (Stephenson and Griffin, 1976). Although no caves have been found in the "Wall," it is believed to have formed above a pre-existing stream channel and apparently represents an undrained lava tube (Stephenson, *et al*, 1980).

The elongate depressions associated with the lava tube system are conspicuous from the air because of the dark green vine-thicket vegetation growing in them, and they allow the course of the lava tube system to be traced easily on air photos. The depressions are 50-100 m across, with elevated rims, and probably represent former lava ponds that have drained and collapsed after crusting over (Stephenson and Griffin, 1976; Atkinson, *et al*, 1977).

Although closely related to the lava caves, the depressions seldom give access to them. Entrance to the caves is usually effected via narrow, less obvious depressions 30-60 m wide caused by roof collapse. There are 27 caves known in the area (Grimes, 1977), and undoubtedly more remain to be discovered. Tunnel-like in appearance, the caves are up to 21 m wide and 13 m high, and are unbranched to once-branched in plan. The longest cave, Barkers Cave (Figure 3, Figure 4), is just over 900 m long and ends in a lake (Grimes, 1977); other caves terminate downflow with collapses or a downward curve of the ceiling to the floor. The maximum slope of any cave is 3°, and the average slope of the whole lava tube system is 1° or less. Most caves have silty floors, but in some, the original lava floor is exposed and shows ropy surfaces and gutters. Lava linings on the walls often have lava stalactites and lines marking former lava levels. The basalt above the tube roofs is exposed in some entrance collapses, and indicates that the caves were initiated by roofing of running lava channels, apparently by crusting (Atkins, *et al*, 1977).

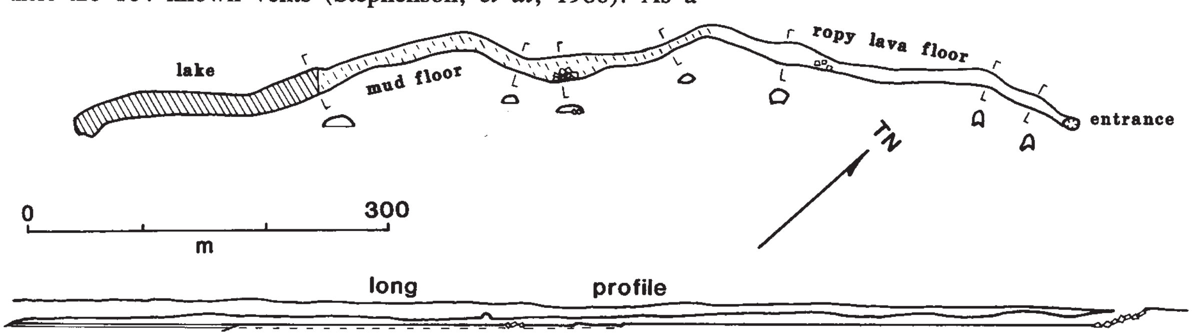

Figure 3. Barkers Cave, McBride Province, north Queensland (see Fig. 2 for location). From Grimes (1977).

Four species of bats roost in the caves, and two (*Miniopterus schreibersii* and *Eptescicus pumilus*) use some of the caves as maternity sites (Grimes, 1977). Guano deposits on the floor of Taylor Cave have yielded the phosphate minerals taranakite, struvite and brushite (Hamilton-Smith, 1978).

Chudleigh Province: This province forms a broad irregular upland characterized by partly dissected lava plains between numerous pyroclastic cones (Stephenson, *et al*, 1980). The flows extend down former river valleys; one traveled over 100 km down a valley from Barkers Crater (Figure 2). The exact age of the lavas is uncertain, but they are likely to be Pliocene or younger. Lava tubes are present in flows from Barkers Crater and from a volcano 6 km west of Black Braes homestead (Figure 2).

There are seven caves near Black Braes, ranging in size from small overhangs to a large cave 300 m long, 20 m wide and 7 m high (Grimes, 1978). In plan, the caves are unbranched or once-branched, and some contain large mounds of rubble fallen from the roof. Lava stalactites are occasionally present on walls and roofs. Associated with the caves are a number of irregular shallow depressions up to 5 m deep, with flat floors. Some of these depressions appear to be related to the caves, and may represent partially drained lava ponds, by analogy with the larger depressions at Undara described above. Three species of bats roost in the caves (200,000-300,000 are present at one site), and *Miniopterus schreibersii* uses one cave as a maternity site (Hamilton-Smith, 1978).

Figure 4. Barkers Cave, McBride Province, north Queensland; note lines on walls marking former lava levels.

From Barkers Crater, a lava channel extends some distance, bounded by raised levees of lava, and caves have apparently former where sections of the channel have roofed over (Shannon, 1974). Five caves are known, with a total length of 250 m, and a maximum height of 10 m and width of 15 m; bats are present.

Nulla Province: This province comprises a wide area of lava plains with 25 vents (Figure 2). The youngest flow (Toomba flow) is less than 13,000 years old and shows original pahoehoe surface textures and negligible soil development (Stephenson, *et al*, 1980). Some short caves are present in this flow, but have yet to be described in detail.

SOUTHEAST QUEENSLAND

Bundaberg Province: This province includes an area around Coalstown Lakes comprising 125 km of basalt flows and three pyroclastic cones; the flows continue down a river valley for a total distance of about 140 km (Grimes, 1979; Ellis, 1968). Lakes occupy two craters in one of the cones. The lavas have a total thickness of up to 20 m, and are 0.6 Ma old (Wellman, 1978).

A single cave, Dundurrah Lava Tube, is known from the Coalstown Lakes area; it is 50 m long, and up to 4 m high and 15 m wide. The cave shows two generations of benches next to the walls, as well as well-preserved wall linings and lava drips, and a large pillar separates the main tunnel from a small anabranch. The roof of the cave appears to have formed by welding of a fragmentary crust (Grimes, 1979). Bats (Miniopterus sp.) roost in the cave.

Main Range Province: The Main Range Province comprises a sequence of nearly horizontal Tertiary volcanics up to 90 m thick, forming the Great Dividing Range in the area (Stevens, 1965). The lavas probably issued from fissures along the highest points of the range, and are dominantly basaltic in composition, with some trachytes. Radiometric dating has given ages of 22-24 Ma (late Oligocene-early Miocene) for the volcanics (Webb, *et al*, 1967).

A small cave (Holy Jump Lava Cave) is present in the upper part of the sequence (Webb, 1979). It has 60 m of passage up to 5 m wide and 2 m high, and consists of portions of lava tubes in two superimposed flows (Figure 5). Part of the lower tube shows wall linings and lava drips, but elsewhere the cave has suffered extensive breakdown, and only small sections of the original walls are present. Secondary silica mineralization (chalcedony, opal-A, opal-CT) encrusts the walls in places and the bat guano on the floor contains gypsum and taranakite (Webb, 1979). Forty centimeters of laminated mud covers the floor of the easternmost part of the lower tube (Figure 4). Two species of bats roost in the cave, and there is an abundant insect fauna, including an endemic species of pseudoscorpion (Muchmore, 1982).

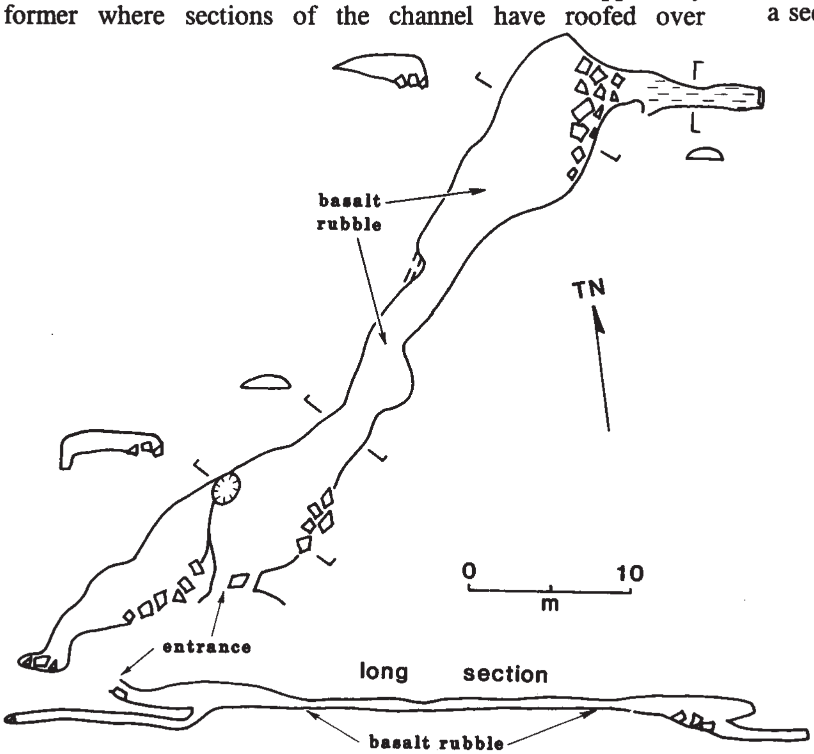

Figure 5. Holy Jump Lava Cave, Main Range Province, southeast Queensland.

Toowoomba and Tweed Provinces: Late Oligocene-early Miocene caves in both these provinces in southeast Queensland (Figure 1) contain caves which have not formed by volcanic action. The cave within the Bunya Mountains in Toowoomba Province has about 45 m of passage; the entrance chamber is 10 m wide and 2 m high (Graham, 1971). Groundwater erosion of vesicular basalt along well-developed joints appears to have caused this cave to develop (Willmott, *et al*, 1981).

Natural Bridge in Tweed Province consists of a single large chamber 46 m long, 26 m wide and 6 m high, with waterfall cascading through a hole in the roof. This cave probably owes its origin to erosion behind the waterfall (Willmott, *et al*, 1981). Bats (*Miniopterus schreibersii*) roost in both caves.

NEW SOUTH WALES

Central Province: Ten kilometers south of Glenn Innes in Central Province is a small basalt cave, 10 m long; nearby basalts have been dated as early Oligocene (33-34 Ma; Wellman and McDougall, 1974b). This cave is tubular in shape and not related to joints or vesicular zones in the basalt (J. Taylor, personal communication). Thus, it seems possible that the cave was originally a lava tube; identifying wall and floor features have presumably been destroyed by weathering.

Western Liverpool Province: Five caves are known in this province, in basalts of early Oligocene age (Wellman and McDougall, 1974b). The largest cave has 70 m of passage, including an entrance chamber 20 m wide and 12 m high (Osborne, 1979). The caves all appear to have formed by groundwater erosion of zeolite-rich amygdaloidal basalt (Osborne, 1979).

VICTORIA

A large Cainozoic volcanic province occupies much of western Victoria and part of southeast South Australia (Figure 6), with a total area of approximately 15,000 km^2; it contains basalts collectively referred to as the Newer Volcanics (Joyce, 1975). This province has more than 400 points of eruption, none of which grew to any great size, most being less than 100 m high. The volcanics are predominately lavas, and only 1% of the total volcanic material is fragmentary (Ollier and Joyce, 1973). Although there are some late Miocene eruptions (McKenzie, *et al*, in prep.), the main period of vulcanicity probably commenced in the late Pliocene, and continued into the Holocene (McDougall, *et al*, 1966). Physiographic features, such as tumuli and lava caves, are well preserved and the most recent flows are characterized by a distinctive hummocky, rock-strewn topography known as "stony rises" (Ollier and Joyce, 1973).

Over 50 lava caves have been found in the Newer Volcanics in Victoria and South Australia, at the localities shown on Figure 7. These will now be described area by area, starting in the northeast.

Parwan: A single lava tube with 240 m of passage is present at Parwan. Basalts 25 km to the east-southeast are 2.5-2.7 Ma old (McDougall, *et al*, 1966), and the flows enclosing the cave

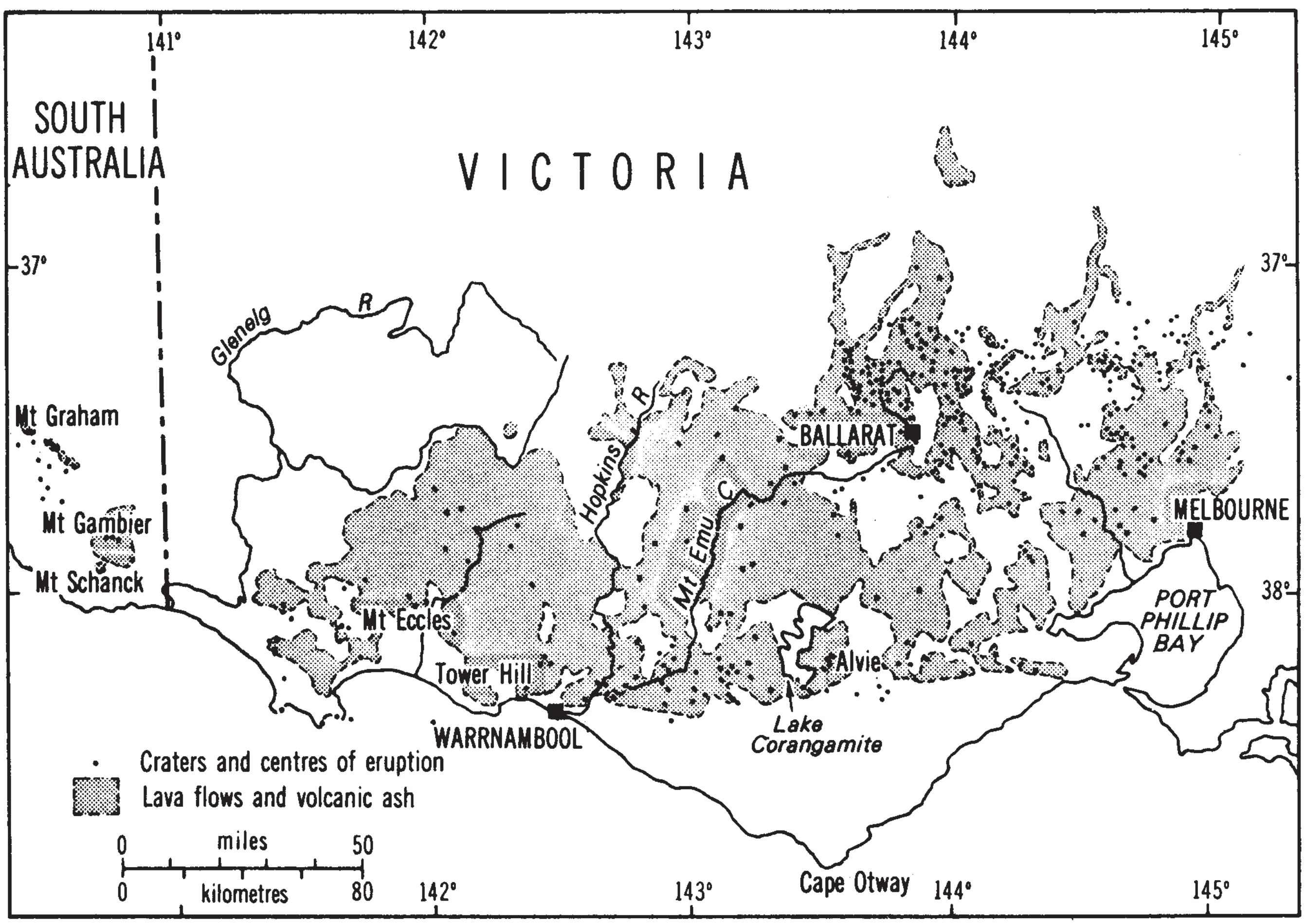

Figure 6. Extent of Newer Volcanics in western Victoria and southeast South Australia, showing eruption points. From Laseron (1972).

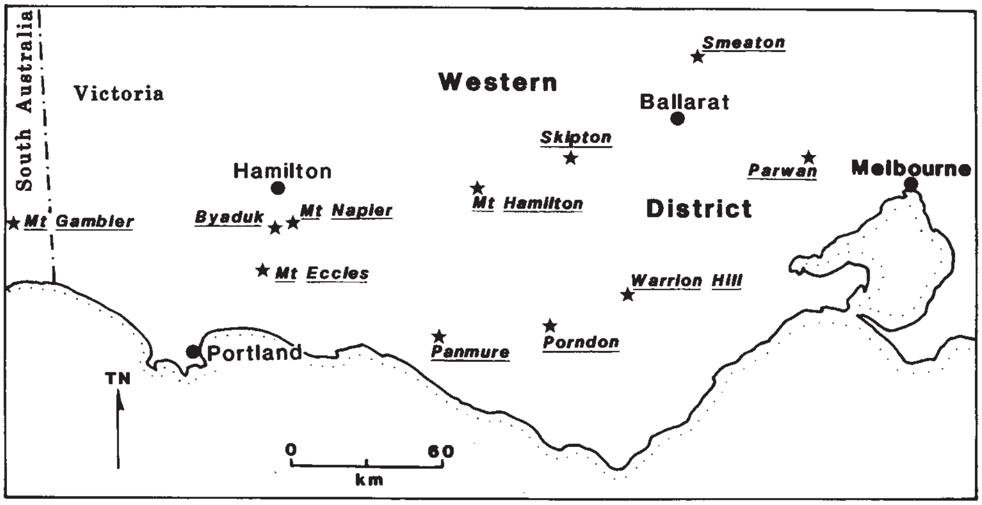

Figure 7. Lava cave locations in western Victoria and southeastern South Australia indicated

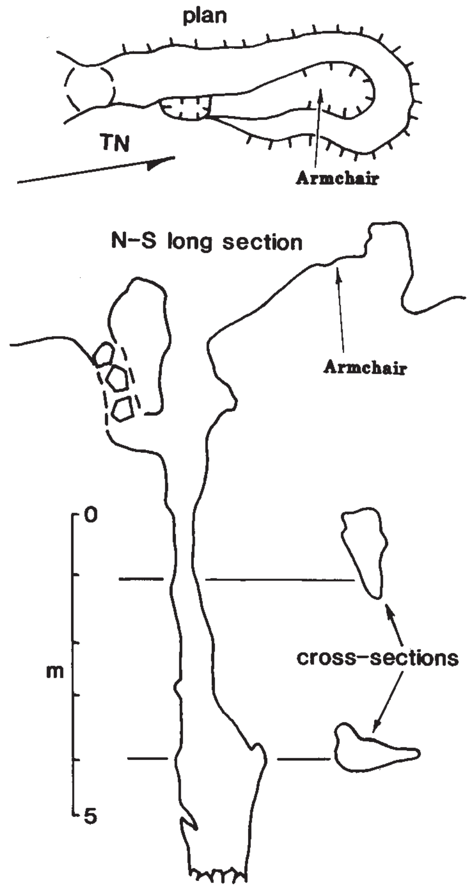

Figure 8. Armchair Shaft, near Smeaton, western Victoria. From Smith (1980a).

are probably of similar age. The cave is a simple tube up to 15 m wide but averaging only 1.5 in height; there is extensive collapse in places, but portions of the original roof, covered with short lava stalactites, are still present. The floor is mostly covered with clay, and is 8-10 m below the ground surface, indicating that the basalt flows at this locality are thicker than elsewhere in the vicinity, perhaps filling a river valley (Rees and Gill, 1959).

Smeaton: Near Smeaton there is a large composite ash cone, Mt. Kooroocheang, which has on its southwest flank a prominent radial dike and two hornitos. One of the hornitos has an open shaft 9 m deep and up to 1.5 m wide (Figure 8). A peculiar channeled lip on the up slope side of the hornito appears to be a "lid" of sticky lava that was flipped open when the hornito erupted, and has given the cave its name of Armchair Shaft (J. Hillis, personal communication; Smith, 1980a). The walls of the shaft are lined with well-preserved spatter and lava stalactites. The second hornito, 100 m up slope of the first, has a vent almost completely filled with a convex plug of basalt (J. Hollis, personal communication).

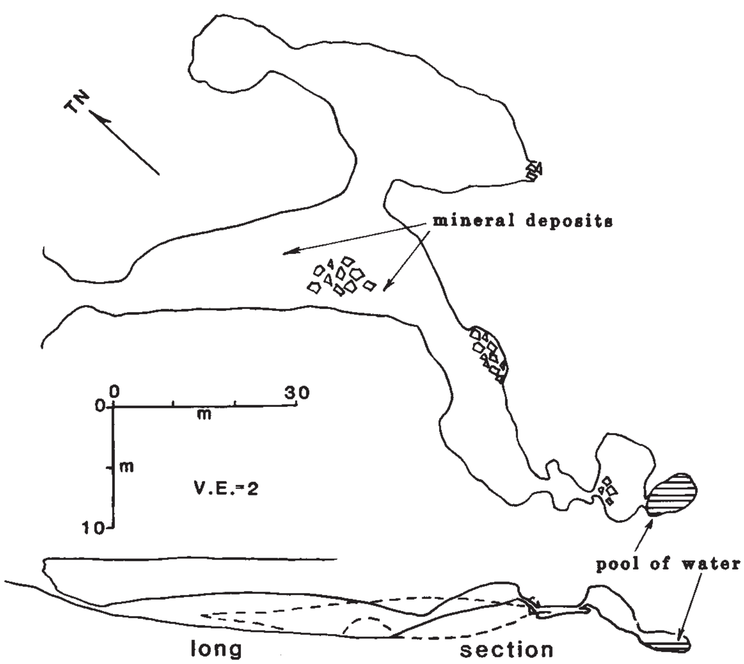

Figure 9. Skipton Cave, western Victoria. Redrawn from Ollier (1963a).

Skipton: One large lava cave is known at Skipton (Figure 9). Although it has only 150 m of passage, this cave contains one of the largest chambers in Victorian lava caves (50 m long, 15 m wide and 5 m high; Ollier, 1963a). The cave has suffered extensive collapse, but original wall linings are well preserved in places, and parts of the walls are covered with small stalactites of opaline silica (Figure 10). The lowest chamber in the cave has a permanent lake which is pumped for irrigation. Bats were recorded in Skipton Cave in 1866 (Selwyn and Ulrich, 1866), but had disappeared by 1895 (Fletcher, 1895). Possible reasons for the desertion include human interference or a change in the cave climate, perhaps linked to the clearing of the forest on the surface above (Simpson and Smith, 1964). Bones in the guano in the cave indicate that the bats were *Miniopterus schreibersii*, and the cave was probably a maternity site for this species (Simpson and Smith, 1964; Hamilton-Smith, 1968). The insect fauna living in the guano consists of six species (Hamilton-Smith, 1968); these survived the vanishing of the bats and consequent change in food supply, but may have been recently exterminated by human interference. The guano has been mined for fertilizer, and yielded a number of unusual phosphate minerals, newberyite, struvite, brushite, hannayite and taranakite (Pilkington and Segnit, 1980; W. Birch, personal communication).

Mt. Hamilton: At Mt. Hamilton, three lava caves are known (Figure 11), one of which has 1,200 m of repeatedly branching passages, making it the longest and most complex lava cave in Victoria. The total distance between the

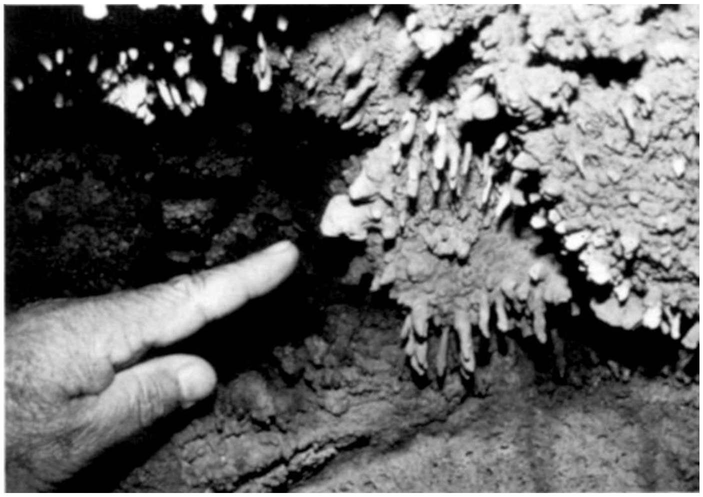

Figure 10. Stalactites of opaline silica, Skipton Cave, western Victoria.

northernmost and southernmost extremities of this cave is 30 m (Ollier, 1963b). The entrance is a narrow collapse, and the cave passages are semicircular in cross-section, being up to 8 m wide and 4 m high. Domes are present occasionally, and there are abundant lava stalactites. Laminated clay deposits occur both in cavities in the basalt and on the floor of the cave, and gypsum stalactites and crusts are found on the walls. Sub-fossil mammal bones have been collected from several parts of the cave; 26 species have been identified, three of these being prehistoric and a further 12 no longer found in Victoria (Wakefield, 1963, 1964b).

The other two caves at Mt. Hamilton are at the same level as the first, and each consists of 50-60 m of more or less straight passage (Figure 11. The westernmost cave contains extensive alluvial fill, which is unusual for lava caves in Victoria (Ollier and Joyce, 1968).

Warrion Hill: Around Warrion Hill, five caves have been discovered, up to 50 m long. These are simple in plan and quite shallow, apparently running inside hummocks on the lava flow surface (Fran, 1971).

Porndon: Near Porndon, there is an unusual volcano, Mt. Porndon, comprising scoria cones overlying a "disc" of lava 3 km across, with a distinct wall-like "ring barrier" formed at the edge (Skeats and James, 1937; Ollier and Joyce, 1973). This disc, in turn, overlies extensive basalt flows containing two lava caves.

Arch cave, the bigger of the two, is a straight tunnel 100 m long, with a symmetrical cross-section up to 15 m wide and 9 m high (Figure 12). Just outside the entrance, there is a small arch left by the collapse of part of the tube roof. The walls have a well-preserved lava lining with some small lava stalactites, and along the base of the walls on either side of the cave, are lava benches 40-60 cm high and 30-40 cm wide, representing peeled-off wall linings (Ollier and Joyce, 1978; Smith 1980b).

The second cave is distinguished by the large mound of putrefying rubbish occupying most of the entrance. Bats (*Miniopterus schreibersii*) roost in both caves (Hamilton-Smith, 1965; Smith, 1980b).

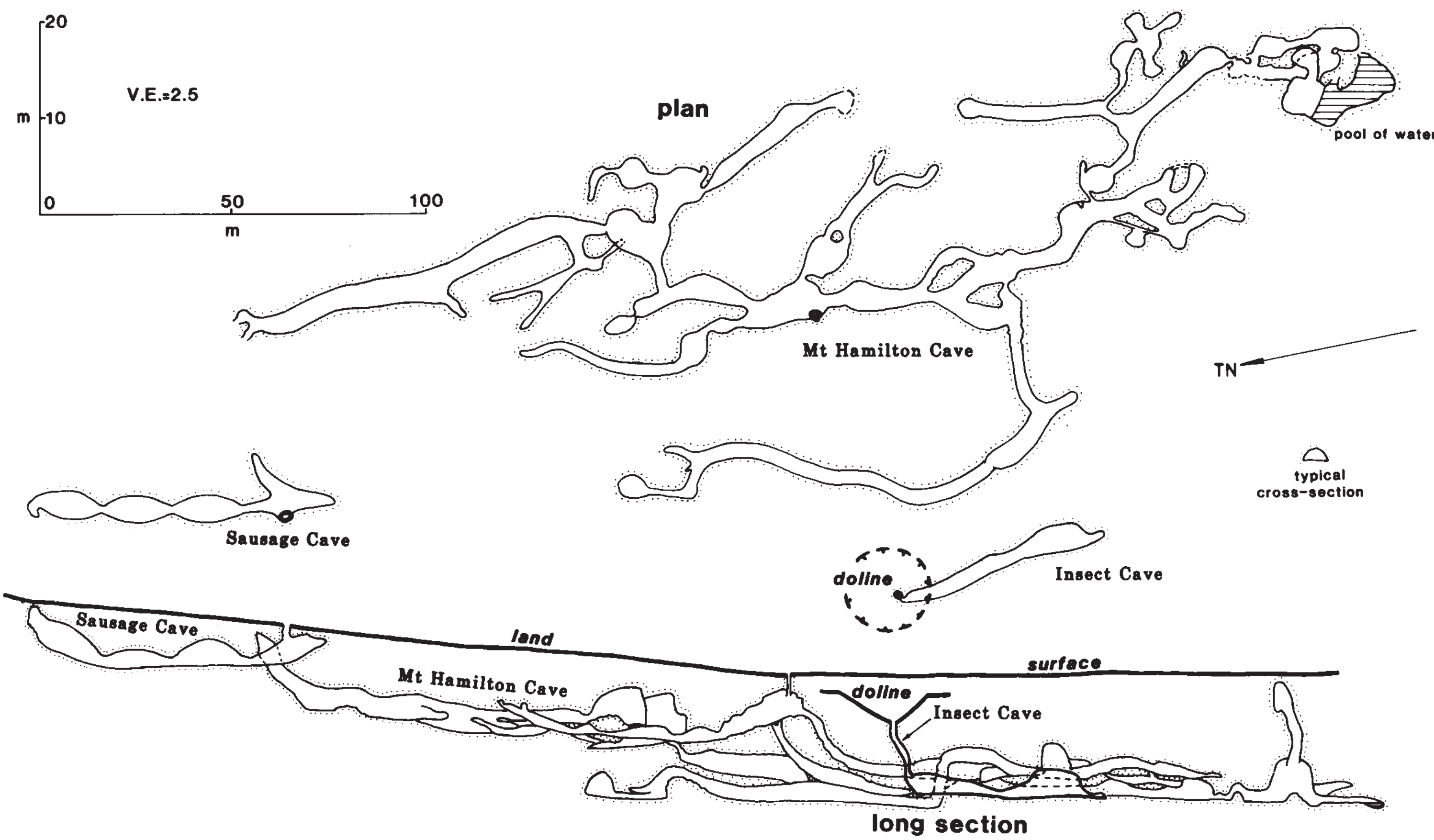

Figure 11. Mt. Hamilton caves, western Victoria. Modified from Ollier (1963b) and Ollier and Joyce (1968). Note that previously published long sections of Mt. Hamilton Cave had erroneous vertical scales, and as a result Fig.1 in Ollier and Joyce (1968) showed Insect Cave as being deeper than Mt. Hamilton Cave; these mistakes are corrected in the present diagram.

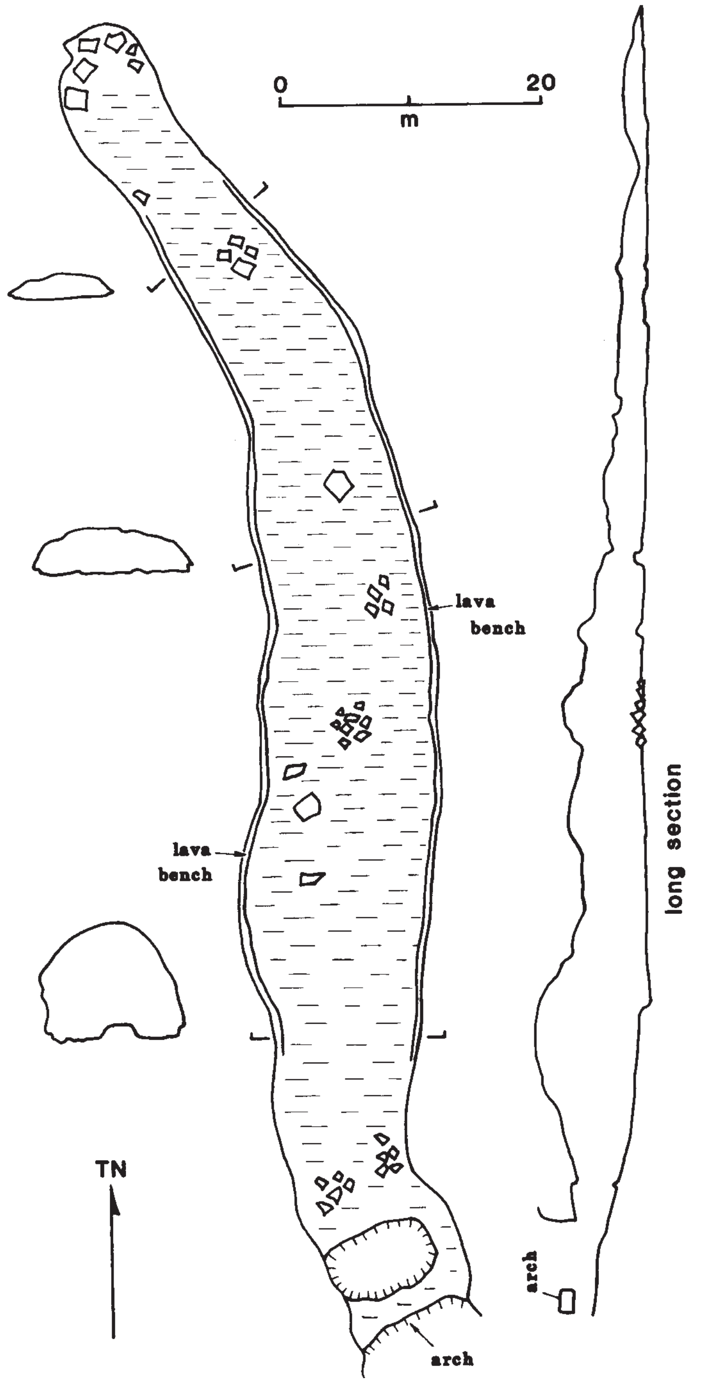

Figure 12. Porndon Arch Cave, western Victoria. From Smith (1980b).

Panmure: The lava cave at Panmure consists of a tube-like passage that bifurcates into two subequal, nonparallel branches, with a total length of about 100 m. The cave used to be entered by a small hole at ground level which led down steeply, but adjacent quarrying has enlarged the entrance slightly (Gill, 1944). The cave is probably in a flow erupted from a volcano 16 km to the northeast about 0.57 Ma ago (Ollier and Joyce, 1968; McDougall, *et al*, 1966), and bifurcates upstream. It is a roosting site for *Miniopterus schreibersii* (Hamilton-Smith, 1965).

Mt. Napier: Mt. Napier is a multiple scoria and spatter cone resting on a broad lava dome approximately 10 km across (Joyce, 1976). Buckley's Swamp to the northeast (Figure 14)

Figure 13. Porndon Arch Cave, western Victoria; note lava bench formed as a peeled-off wall lining.

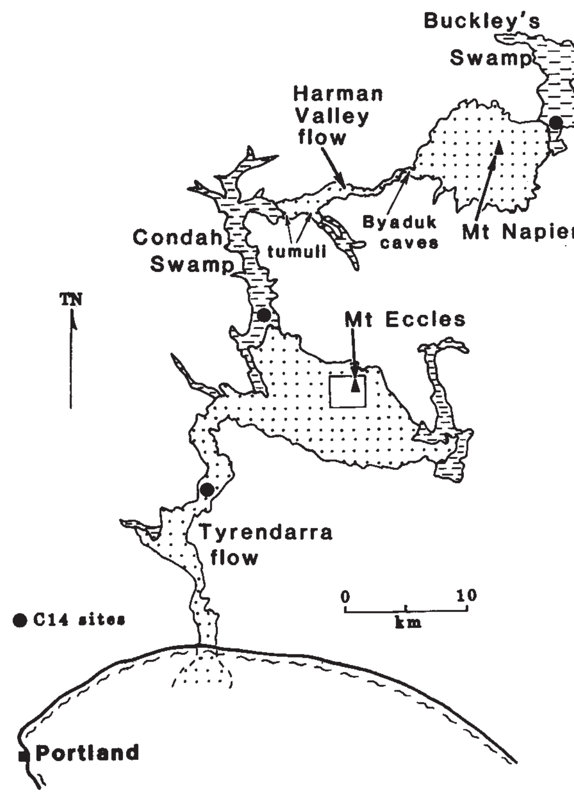

Figure 14. Lava flows and swamps surrounding Mt. Napier and Mt. Eccles, western Victoria (for location see Fig. 7); area around Mt. Eccles shown in more detail in Fig. 21. Radiocarbon dating sites shown by black dots. From Gill (1979).

originated when flows from Mt. Napier blocked drainage in the valley; a radiocarbon date of 7,000 years from the base of the peat in this swamp gives an approximate age for the eruptions (Gill and Elmore, 1973).

There are two small blister caves on the northwest flank of Mt. Napier, and on the western flank, close to the crater, are two more caves. One of the latter is in a small done of lava in line with a lava channel, and has a cross-section in the form of a pointed arch (Joyce, 1976). The walls of both western caves

Figure 15. Needle-like stalactites in a cave on the western flank of Mt.

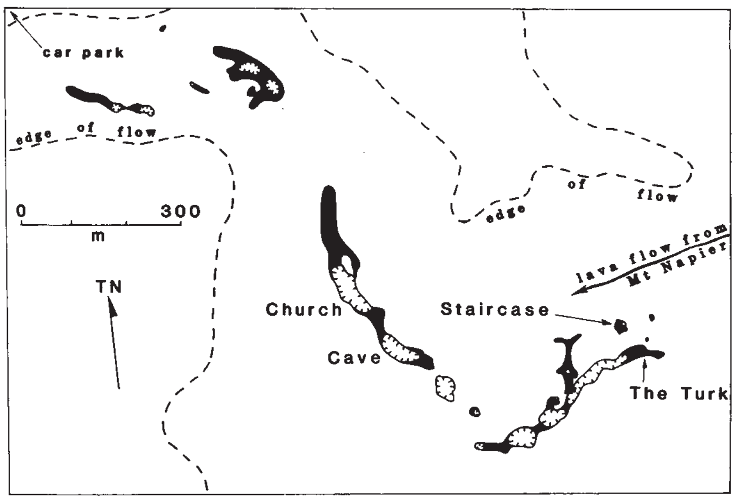

Figure 16. Byaduck Caves, near Mt. Napier, showing caves (solid shading) and collapse dolines (for location see Fig. 14). Modified from Ollier and Brown (1964).

display groups of needle-like stalactites, 1 mm or less in diameter, some of which are inclined downstream.

About 2 km west of Mt. Napier is a scoria cone 25 m high. A lava canal, starting as a lava tube 10 m long, runs southwest from the cone of 400 m, with a natural bridge 50 m from the tube section (Gill and Elmore, 1974). Two other caves, up to 20 m long, are close by.

Byaduk: The Harman Valley flow (Figure 14) extends 24 km from Mt. Napier down a river valley (Ollier and Joyce, 1973). Near the end of the flow are a number of exaggerated tumuli, up to 10 m high and 20 m across (Ollier, 1964a), and nearer the volcano are the Byaduk lava caves. These caves follow the center of the flow, and are upstream of the first point of constriction, where the lava is only 0.2 km across (Figure 16). The basalts have a total thickness of at least 20 m (The maximum depth of the caves), and have a very low gradient, 1.5° or less (Ollier and Brown, 1964; Ollier and Joyce, 1973).

Nineteen caves are known in the area (Matthews, 1979), but many are grouped in interconnected systems opening to the surface at collapse entrances, and arches and natural bridges are common. The collapse dolines contain a striking dark green vegetation easily visible from the air and are characterized by abundant ferns (20 species), mosses (62 species, one unknown elsewhere in Australia), lichens and liverworts (Beaglehole and Learmonth, 1957).

Church Cave (Figure 18) is the longest cave, with 400 m of passage up to 15 m wide and almost as high. In places, the floor of the cave has cracked into slabs with spaces below, apparently as a result of fluid lava draining away beneath a crust on the last flow through the cave (Ollier and Brown, 1964). There are two levels of lava tube within Church Cave (Figure 18); other caves at Byaduk belong to either one of these levels. The deeper caves have ceilings 7 m below the surface and floors about 20 m deep; The less common, shallower caves have floors less than 4 m below ground level. Most of the Byaduk caves are simple or once-branched in plan, but some of the shallower caves have anastomosing branching patterns (Taylor, 1971).

Although the Byaduk caves have collapsed extensively, original wall roof and floor features can still be seen in many places and are well preserved because of the youthfulness of the caves. The Turk (Figure 16) illustrates many of these features. The wall lining shows drips and wrinkles and along the base of one wall is a roll of lava, apparently a combination of a peeled-off lining and a bench from a former lava level. The floor is composed of original lava, broken into fragments about 1 m across. Some of the fragments have bumped against each other and developed upturned edges. The inner portion of The Turk has an unusual asymmetric cross section, in contrast to most of the Byaduk caves, which are quite symmetric tunnels.

In Staircase (Figure 16), horizontal lava "tidemarks" along one wall resemble a set of steps, and mark successive levels as the lava surface subsided (Ollier and Brown, 1964). Another wall in the cave is well decorated with unusual lava stalactites, which project up to 30 cm from the wall as complex drooping "hands," some coated with opaline silica. One of the shallower caves contains lava stalagmites, which are rare in Victorian lava caves (Ollier and Joyce, 1968).

Three of the caves have yielded mammal bones, apparently the remains of animals eaten by owls. The fauna, of the 25

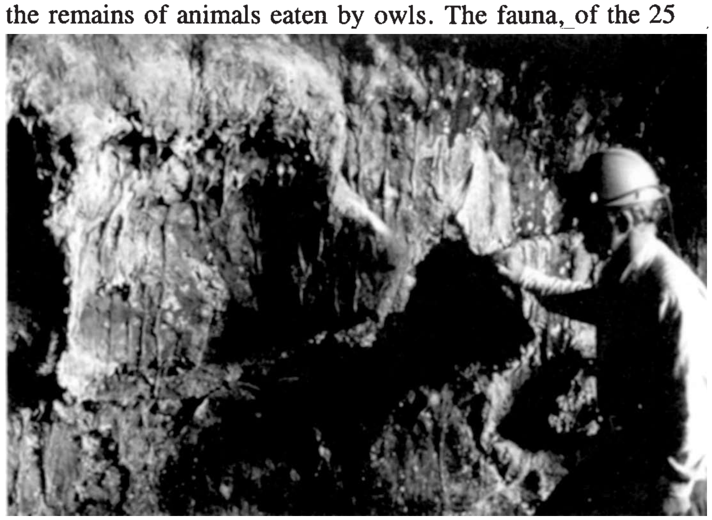

Figure 17. Wrinkles and drips on wall lining in The Turk, Byaduck, western Victoria

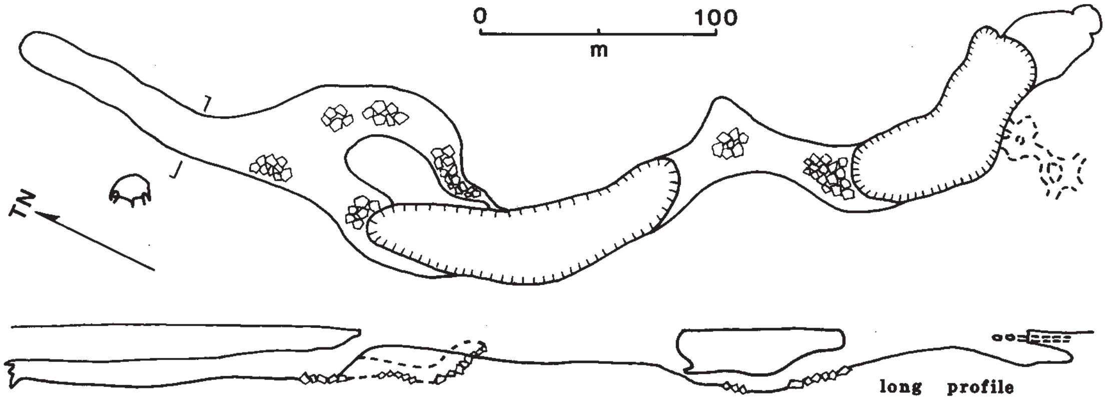

Figure 18. Church Cave, Byaduck; dashed outline shows shallower section of cave (for location see Fig. 16). Modified from Ollier and Brown (1964).

Figure 19. One of the collapse entrances to Church Cave, Byaduck, western Victoria; characteristic doline vegetation, dominated by ferns, visible in foreground.

species, is a modern one (Wakefield, 1964a, 1964b). One cave serves as a roosting site for *Miniopterus schreibersii* (Hamilton-Smith, 1965).

Mt. Eccles: Mt. Eccles is surrounded by an area of lava about 10 km wide (Figure 14), from which the Tyrendarra flow runs west and south 40 km to the coast, with a further 16 km submerged on the continental shelf (Joyce, 1976). A radiocarbon date on wood from a stream bed buried by this flow (Figure 14) indicates that the lava is about 19,000 years old (Gill, 1979). Condah Swamp (Figure 14) was presumably formed because of blockage of the valley by flows from Mt. Eccles. Peat at the base of this swamp gave a date of about 6,000 years. (Gill, 1978).

The main volcano at Mt. Eccles is a steep-walled elongate crater containing Lake Surprise (Figure 21). From the north end of the crater, a lava channel runs out into the lava plain where it splits into two branches, which extend up to 4 km from the crater (Joyce, 1976). These channels vary from 80-220 m wide and 4-12 m deep, and in places have levees comprising successive thin flows. At least 14 lava caves are associated with the channels (Matthews, 1979), although only a few have been mapped and located accurately (Figure 21). Most of the caves run more or less perpendicular to the channels; some branch complexly and connect the channels to large collapse dolines (Franz, 1980). The largest cave, with 45 m of passage, is Tunnel Cave (Figure 22), and this has an almost perfect arch-like cross section with intact walls, a low lava bench and a thin covering of earth over a flat lava floor. The entrance section of Tunnel Cave supports a flora of ferns, mosses, lichens and algae, zoned according to light intensity, humidity and moisture, with lichen and algae occurring furthest into the cave (Johnson, *et al*, 1968). Tree roots hang down from the walls and ceiling in the high humidity areas of the cave, up to 17 m below the ground surface, and probably belong to *Eucalyptus viminalis* (Johnson, *et al*, 1968).

The smaller caves along the channels have well-preserved internal features (e.g., gutters, tidemarks and lava stalactites), and tree roots are often abundant in them (Figure 24).

Southward of Mt. Eccles, along the line of the main crater, is a series of spatter cones (Figure 21). The alignment of these points of eruption may indicate fissure eruption, or, less likely, adventitious cones on a straight lava flow (Ollier and Joyce, 1973). From one cone, a steep-sided lava channel 10-18 m wide runs about 2 km west (Figure 21); this has a 30 m roof section, Gothic Cave, so called because of its "gothic arch" cross-section (Joyce, 1976). The cave passage is about 7.5 m high, and the wall lining consists of more or less vertical contorted layers of lava, behind which are sub-horizontal layers in the lava of the channel wall (representing successive thin levee flows) (Figure 25). The vertical layering apparently formed as the open channel filled, subsided and filled again, leaving a lining on the walls of the channel each time. The linings gradually grew in from the sides until they joined in the middle, making a complete roof over the lava channel. This roof later sagged to give the contortions in the layers. Harter (1978) described similar examples from lava caves in the USA. Mammal bones collected from Gothic Cave were identified by Wakefield (1964a, 1964b), and represent 24 species (two of which are no longer found in the area).

Figure 20. The Turk, Byaduck, western Victoria; note asymmetrical

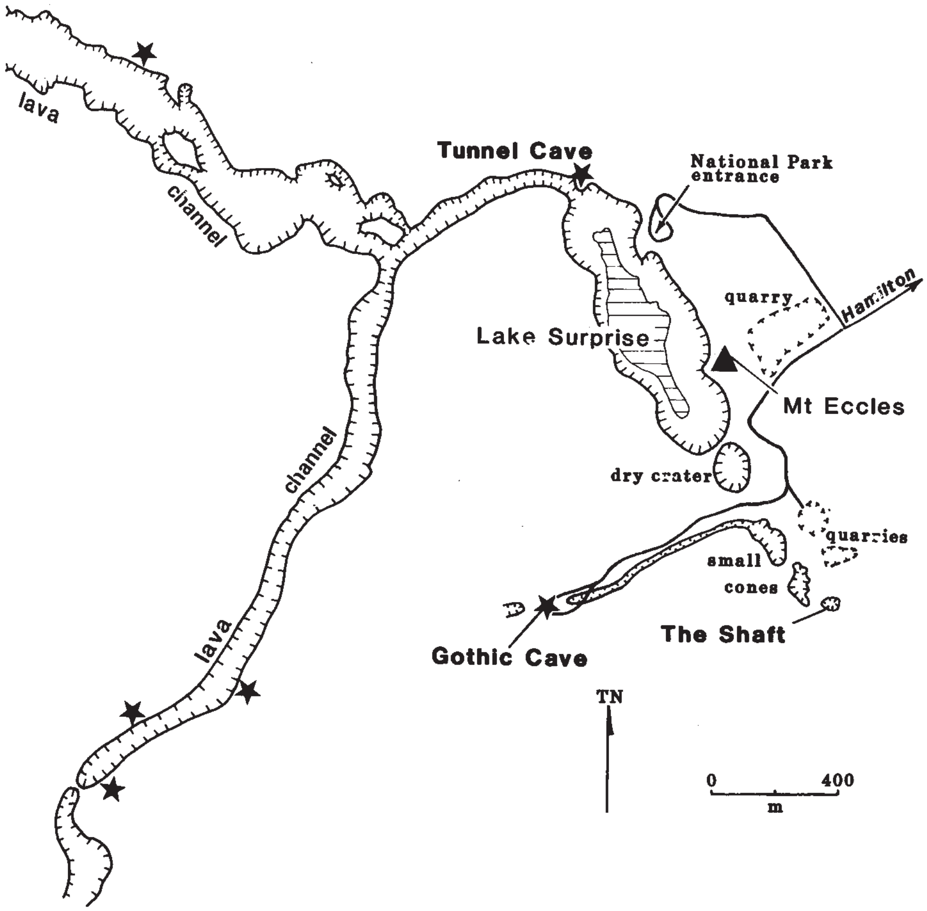

Figure 21. Mt. Eccles area, showing caves (indicated by stars), cones and channels; for location see Fig. 14. Modified from King and Spurgeon (1980).

Another of the spatter cones south of Mt. Eccles has an open vertical vent, known as The Shaft (Figure 21, Figure 27). The cone is about 10 m high, but the vent is 23 m deep, extending below the level of the surrounding plain and widening at depth (Ollier and Joyce, 1973). It is lined with abundant lava stalactites and floored by large boulders of vesicular basalt. Another small cone nearby had an open vent 10 m deep (Ollier, 1964b) but this has been filled in by a local farmer.

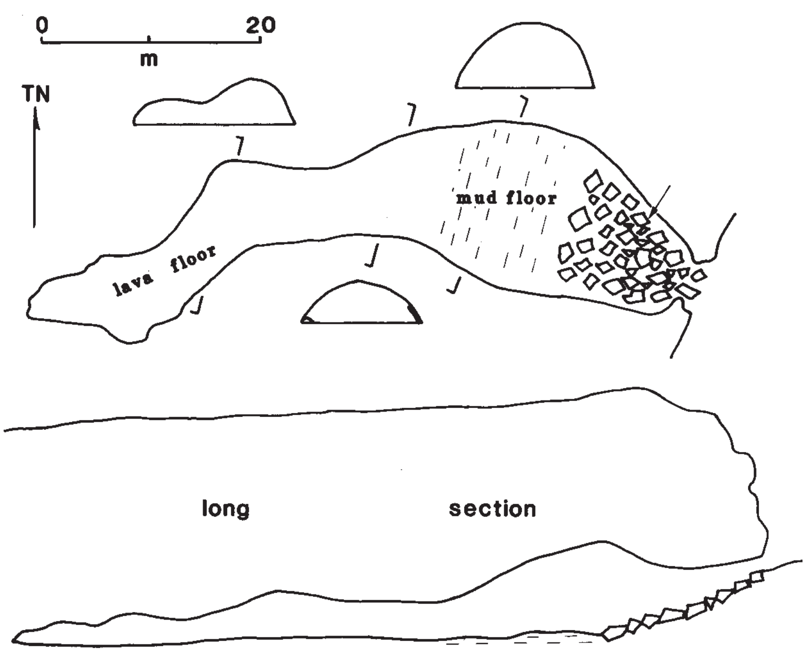

Figure 22. Tunnel Cave, Mt. Eccles area (for location see Fig. 20). Modified from Johnson et al. (1968).

SOUTH AUSTRALIA

The Mt. Gambier volcanic complex (Figure 6) comprises a close knit series of composite maars with a complicated history of eruption around 4,000-4,300 years ago (Blackburn, *et al*, 1982). During the first period of eruption, two basalt sheets were extruded, and several small lava caves are known from the bases of these lava flows (Sheard, 1978). One of the largest caves was 10m long and 2.5 m wide and high, and contained lava stalactites; it was destroyed by a natural landslide in 1977 (Sheard, 1978).

TASMANIA

Several tiny caves, up to 10 m in length, have been found in Tertiary basalts near Mole Creek, central Tasmania (Anon., 1970). They appear to be the result of groundwater erosion of zeolite-rich amygdaloidal basalt.

CONCLUSION

From the foregoing descriptions, it can be seen that the two most significant groups of lava caves in Australia are in basalt flows within areal igneous provinces in western Victoria and northeastern Queensland, and that there are a number of differences between the caves from each state. The northeast Queensland caves are large, simple in plan and cross-section, and are concentrated in particular areas; each area represents a lava tube system. In general, the Victorian caves are smaller and often more complex, especially in plan, and they tend to be scattered and isolated from each other. Even where several caves are present in the same area, they are usually completely unrelated, except at Byaduk, where most of the caves were probably part of a single lava tube system. Indeed, the Victorian lava caves represent a range of origins and geomorphic settings including spatter cone shafts, roofed lava channels, and tubes in flank flows, valley flows, lava plains and channel overflows.

These differences probably reflect differences in the rate of discharge and viscosity of the basalt magma in the two areas, also influenced by the topography of the land surface beneath the flows. The great length of the northeast Queensland flows apparently resulted from a very high rate of effusion of low viscosity lava, coupled with topography which favored channeling and the formation of efficient, heat-insulated lava tubes, able to maintain a supply of fluid lava over long distances. In Victoria, it would appear that this favorable combination of circumstances rarely occurred.

Figure 23. Drips marking successive lava levels in small cave off one

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Figure 24. Unnamed cave off lava channel, Mt. Eccles area; note tree roots.

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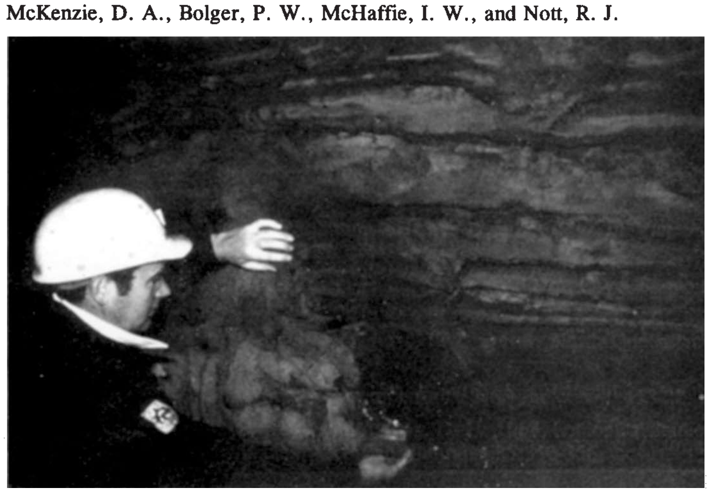

Figure 25. Wall lining in Gothic Cave, Mt. Eccles; section has cracked off revealing subhorizontal layers in lava of channel wall, representing sucessive thin levee flows.

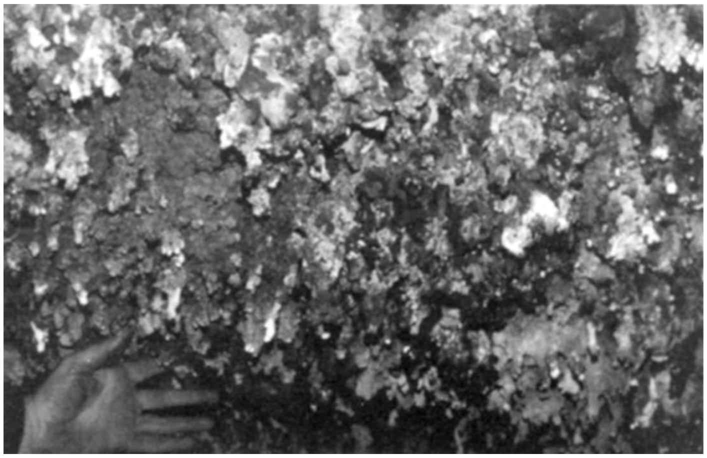

Figure 27. Complex lava stalactites, thinly coated with opaline silica, in Staircase, Byaduck, western Victoria.

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Figure 28. Entrance to the Shaft, Mt. Eccles area, western Victoria.

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