Volcanic Caves of Western Victoria

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Abstract

The Western District Volcanic Province extends from Melbourne across to the Mount Gambier area and has been erupting basalt lavas for at least the last 5 million years. Lava caves have formed in several areas across the region, but the best concentrations are in the ~30,000 year-old lavas from Mt. Eccles and Mt. Napier.

There are a variety of volcanic caves, including large feeder tubes that are responsible for the long lava flows (60 km in the case of a flow from Mt Rouse), but also smaller but more complex shallow subcrustal lava caves and one example of a still-open volcanic vent or large hornito.

Lava tubes form in two main ways. The first is by the roofing of narrow surface lava channels, which happens in several ways. This type tends to form linear and simply-branching or anastomosing tubes. The second way is by draining from beneath the crust of a set of spreading lava lobes near the leading edge of a lava flow - these tend to form more complex mazes of shallow, low-roofed chambers and passages, but over time they may evolve by solidification of the more stagnant areas and erosional enlargement of the fastest moving routes to form simpler linear tubes that are difficult to distinguish from the roofed channels.

Both types of tube contain liquid lava flowing beneath a solid crust. At the end of the eruption some of that lava drains out to leave empty caves, but most tubes remain filled with solidified lava. Many lava caves end at solid undrained lava "sumps".

The Western District Volcanic Province

The Western District Volcanic Province of western Victoria (previously known as the Newer Volcanics Province) is one of the world's larger volcanic plains, and has formed by a succession of eruptions and basaltic lava flows over the last five million years. The isolated volcanoes near Mount Gambier are a western outlier of the Province (Figure 1). Eruptions have continued up to quite recent times and further eruptions could occur in the geological future. Current dating suggests that the youngest volcano may be Mount Schank, south of Mount Gambier, which erupted 5,000 years ago. The flows associated with these younger eruptions show better lava caves and surface features than those of the older volcanics. None-the-less, a few of the caves are in flows several million years old.

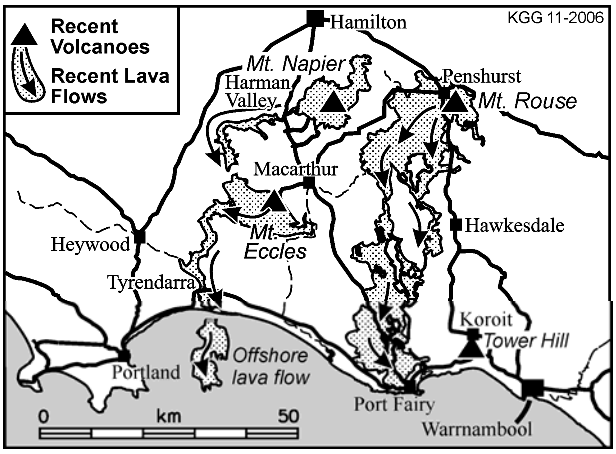

Figure 1.

Western District Volcanic Province & caves.

Lava tubes and other volcanic caves are scattered across the province (Figure 1), but the majority of them are in the western area where they are associated with two of the younger eruptions in the region - Mt Eccles and Mt Napier (Webb & others, 1982, Grimes & Watson, 1995, Grimes, 2008).

Surface landforms

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

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

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

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

Lava flows:

Basaltic lava is a hot (1100°C) liquid that can flow readily. There are two main forms of basaltic lava flow, which grade into each other. *Pahoehoe* lava is the most liquid form - characterised by the formation of thin smooth skins that become wrinkled (hence its alternative name of ‘ropy lava’). Pahoehoe lavas advance as a succession of lobes, each of which develops a skin, is inflated by the liquid pressure within, then ruptures at one or more points to release liquid lava to form new lobes (Figure 4).

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

Behind the advancing lava front solidification of stagnant areas restricts lava movement either to narrow surface channels, or internally in lava tubes beneath a surface crust. Overflow from the surface channels builds up levee banks of thin sheets or spatter. Larger flows across a levee can feed lateral lava lobes with small internal lava tubes. A major breach of a levee may result in a large side flow, fed by its own channel, and the original channel may be abandoned. Good examples of lava channels (locally referred to as ‘canals’) occur at Mount Eccles. A number of shallow lava tubes are known in flows that have run off to the sides from these channels (Figure 14; Grimes, 1995 & 2008).

Lava tubes provide good insulation for the hot lava flowing within them. This allows the formation of very long flows such as the 50km Tyrendarra Flow from Mount Eccles, which extends offshore across the continental shelf (which was dry at the time), and the older 60km flow from Mount Rouse, which may also extend offshore (Figure 2).

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

Formation of Volcanic Caves

Lava tubes form in basaltic lava flows by two main processes (Peterson & others, 1994; Halliday, 2004)> One is by the roofing over of surface lava channels. Figure 3 gives details of the three ways of doing this. Later overflows through sky-lights may thicken the tube's roof from above. On many cases linings plastered on the walls, or collapse modifications, make it hard to distinguish the three modes.

The other way of making lava caves by the draining of still molten material from beneath the solidified crust of a flow. Figure 4 illustrates the formation of these subcrustal lava caves. In its simplest form, drainage of lava from beneath high areas on the crusted surface will form simple isolated chambers. Complex nests of advancing lava lobes create equally complex patterns of active tubes and chambers which can later drain to form open caves (Figure 4, steps 1, 2 & 3a). Lava lobes can be stacked vertically as well as advance forwards so that a complex three-dimensional pattern of branching tubes can form. As lava continues to flow through these complex systems they will evolve by erosion and solidification to form larger, more streamlined, linear tube systems that act as “feeder tubes” to carry hot lava to the advancing lava front (Figure 4, steps 3b & 4). If sufficiently evolved, these linear tubes can converge on the form of the, generally larger, linear tubes formed by roofing of surface lava channels. Thus the genesis of many large lava caves remains difficult to deduce.

The long lava flows in the region would all have been fed by large cylindrical lava tubes; but only parts of these would have drained at the end of the eruption to form open caves. Many lava caves end at solid undrained lava “sumps".

Features found in Volcanic Caves

The lava caves contain a distinctive suite of lava structures or “decorations”, some of which are illustrated in Figures 7-11.

The level of lava within the tubes tends to fluctuate during the course of the eruption, and so we find thin linings plastered onto the walls and roofs, and ‘tide-marks’ are indicated by solidified linings, benches or shelves on the sides of the tubes (Figure 11). Some shelves can reach right across a passage to form a false floor (Figure 8).

The thin wall linings can rupture, peel back and curve over to form draperies and scrolls. Some linings are smooth, but others have a sharp hackly surface which may be due to the bursting of many small gas bubbles (Figure 10). Rafted slabs floating on a flow surface may leave grooves and striations on the semi-solid wall linings. Lava “hands” of semi-solid lava can be squeezed out through cracks or holes in the lining.

Small round-tipped lava stalactites, (lavacicles, lava drips) form where molten lava has dripped from the roof (Figure 10). Lava ribs form where lava dribbled down the walls of the cave, or where the whole lining has sagged and wrinkled. If the floor was already solid (unusual) drips of lava from the ceiling can build up lava stalagmites (Figure 9).

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

The Volcanic Caves

The two main cave areas and some selected caves are described here. Additional descriptions and maps appear in the ASF conference guidebook (Grimes, 2007).

Mount Eccles Area

The main volcano has a deep steep-walled elongate crater which contains Lake Surprise. Current studies on sediments within the crater lake suggest an age of about 33,000 years for the Mt Eccles eruption. The crater wall has been breached at its north-western end by a large lava channel (or "canal" as they are called locally). A line of smaller spatter and scoria cones and craters extends to the southeast from the main crater.

The longer and more complicated caves known at Mount Eccles are associated with the South Canal (Figure 14). These caves are generally formed in the levee banks on the sides of the canal and would have fed small lateral lava lobes or sheets when the canal overflowed. Some are simple linear feeder tubes, but many have branching forms and complexes of low broad chambers which suggest draining from beneath the solidified roof of a series of flow lobes (see Figure 4 and Grimes, 1995, 2008).

3H-8: The Shaft, Mt Eccles

This is the still-open vent of a small volcano (Ollier 1964a). A shaft in the bottom of a funnel shaped crater in a small spatter cone opens up below into a single large elongated chamber with rubble floor. It contains moss-covered lava stalactites. See Figure 12.

3H-9: Tunnel Cave, Mt Eccles

This well-known cave is found beside the walking track at the start of the canal. It is a typical lava tube, 60m long, with "railway tunnel" dimensions and shape (Ollier 1964a). The flat floor is the top of a solidified lava pool. As you walk into the cave the roof becomes lower and eventually reaches the floor. The tube would originally have continued but is now blocked by solid lava (Figure 13). Features of interest are the lava bench on the left side near the entrance, and further in there are lava drips, a ropy lava floor and a sagged wall lining that has opened up a gap behind it. Johnson & others (1968) documented the progressive change in the biology as light decreased away from the entrance.

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

From the crater near the southeast quarry a small lava channel runs off to the south-west. At its SW end, part of the lava channel has been roofed over to form a short 36m section of cave. The pointed, 'gothic' roof of this cave suggests that it was roofed by levee overgrowth (Figure 5 & 3c). The contorted layers visible in its walls would be linings that were built up and then slumped while still hot. Towards the NE end, the east wall has scrape marks formed when the lining was still soft. For a detailed description and map see Grimes (2002b).

3H-51: North Pole Cave, Mt Eccles

This complex system is a set of small interconnected lava tubes running away from the canal (Figure 14 and see detailed map in Grimes & Watson, 1995). There are some good lava features, including sharp aa floors and a photogenic root chamber at the far end. The name refers to a magnetic rock found at an obvious survey point.

3H-70: Carmichael Cave, Mt. Eccles

A complex 605m lava tube system leading away from the canal (Figure 14 and see detailed map and description in Grimes 2002a). It has many small tunnels alternating with low broad chambers. A lower level at the far end has a larger, partly collapsed, chamber. There are many good lava formations, including lava 'turds', drips (Figure 10), floors and an invasive lava lobe (Figure 15). This is an excellent example of a "drained lobe" style of subcrustal lava cave (Grimes, 2008).

The Wallacedale Tumuli.

A Tumulus is a steep-sided mound of lava crust that has been pushed up above the lava surface. The solidified crust above the liquid core of a lava flow generally forms irregular mounded surfaces known as Stony Rises. However, in a few places, the movement is localised to small “soft spots” in the crust which are pushed up to form discrete steep-sided mounds the size of a house rising above a relatively flat surface. While stony rises are a common feature, steep-sided tumuli are rare, and the tumuli seen in the Harman Valley flow are the best examples in Australia (Ollier, 1964b).

Mt Napier

Mount Napier (Figure 2) is a composite volcano with a broad, timbered, lava shield capped by a steeper, bare, scoria cone formed by explosive activity at the end of the eruption (Whitehead, 1991). There are a few small lava caves on the shield. The lava shield flooded the pre-existing Harman Valley, damming the creek to form a major swamp on the upstream (eastern) side, and flowing down the valley as a long linear flow that finally is lost beneath the Condah Swamp (which was dammed up by a lava flow from Mt Eccles). This long flow was fed by lava tubes, drained remnants of which can be entered at the Byaduk Caves, near the head of the valley, and elsewhere. Lavas also flowed down several other, smaller, valleys such as Scotts Creek at Byaduk township.

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

The Byaduk Caves

This lava flow, which came from Mount Napier, is the same one as that seen from the Harman Valley Lookout. It was fed by large lava tubes. In the Byaduk Caves area collapse of parts of the main feeder tube has exposed the largest and most spectacular lava tubes, arches and collapse dolines in the region (Ollier & Brown, 1964, 1965; Grimes & Watson, 1995; Grimes, 2007). The largest tunnels are up to 18 m wide and 10 m high, but not very long (maximum 200m) as they terminate in lava sumps. There are also some smaller but more complicated subcrustal caves, and a multilevel system (3H-33).

3H-11,12: Harman Caves, Byaduk

This is typical of the large "feeder tubes in the area. It is a large lava tube that has been extensively modified by collapse, and is separated into two parts by a large collapse doline. However, some relicts of the original form, including ropy lava floors, can still be seen (Map 16, Grimes, 1998). The connection from H11 to H12 is hard to find and initially a tight squeeze through rubble.

The small surface “blister” beside the track to the western lookout, called Turtle Cave (3H90), is a shallow “drained-lobe” cave on the surface of the flow (c.f. Figure 4). It has some nice lava drips on the ceiling.

3H-33: The Theatre, Byaduk

This multi-level system is the most interesting and complex cave at Byaduk (Figure 17). The upper level is branching crawlways. The middle level is several descending chambers connected by lava cascades that leads to “The Stage”. This faces into a large collapse dome (The Theatre) with sharp low-level crawlways exiting in two directions. The eastern crawl and "cheese-grater" squeeze opens into a short large tube with ropy lava floor (Figure 18). The western section has good examples of lava "tide-marks" (Figures 8 &11) and ends in a tight "high-friction" crawl. The cave has formed by lava rising from the lowest tube to build a surface mound that partly solidified, and then drained back to the lower level to leave the upper passages.

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

These three caves occur in a stacked set of thin, 1-3m, lava flows exposed in the wall of a large collapse doline (Figure 19). The elongated doline formed over a deeper large feeder tube (up to 25 m wide and 15 m high in the Church Arch (3H-16) at its western end) and the thin flows may have been fed by overflows from the feeder tube, or through roof windows. The three shallow caves comprise low-roofed branching passages and chambers very similar to those found beside the channel at Mount Eccles (Figure 14). In the lowest cave (H-74) there are intrusive lava lobes that may have entered through roof holes from the overlying lava flow. Likewise, in the next highest cave (H-108) a lava fall drops a metre to a short section of lower-level passage that might be in the same flow as H-74.

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Figures

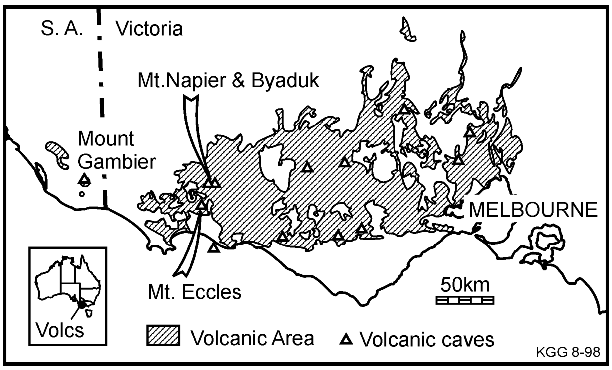

Figure 2.

Recent lava flows in western Victoria.

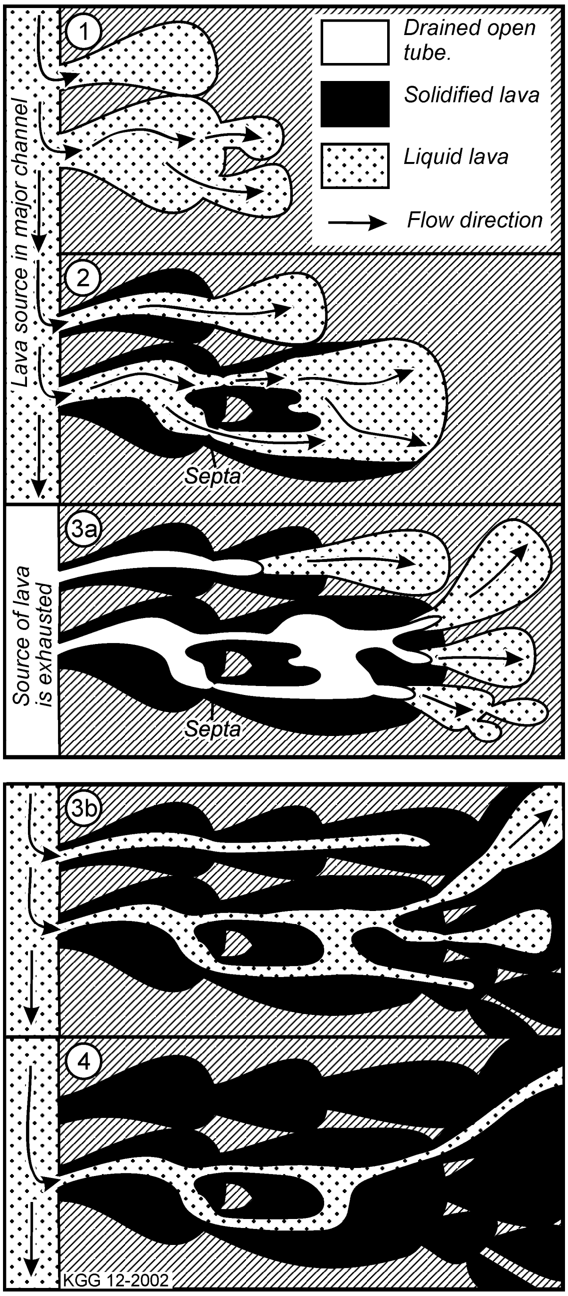

Figure 4:

Stages in the formation of lava tubes by draining of lava lobes.

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

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

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

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

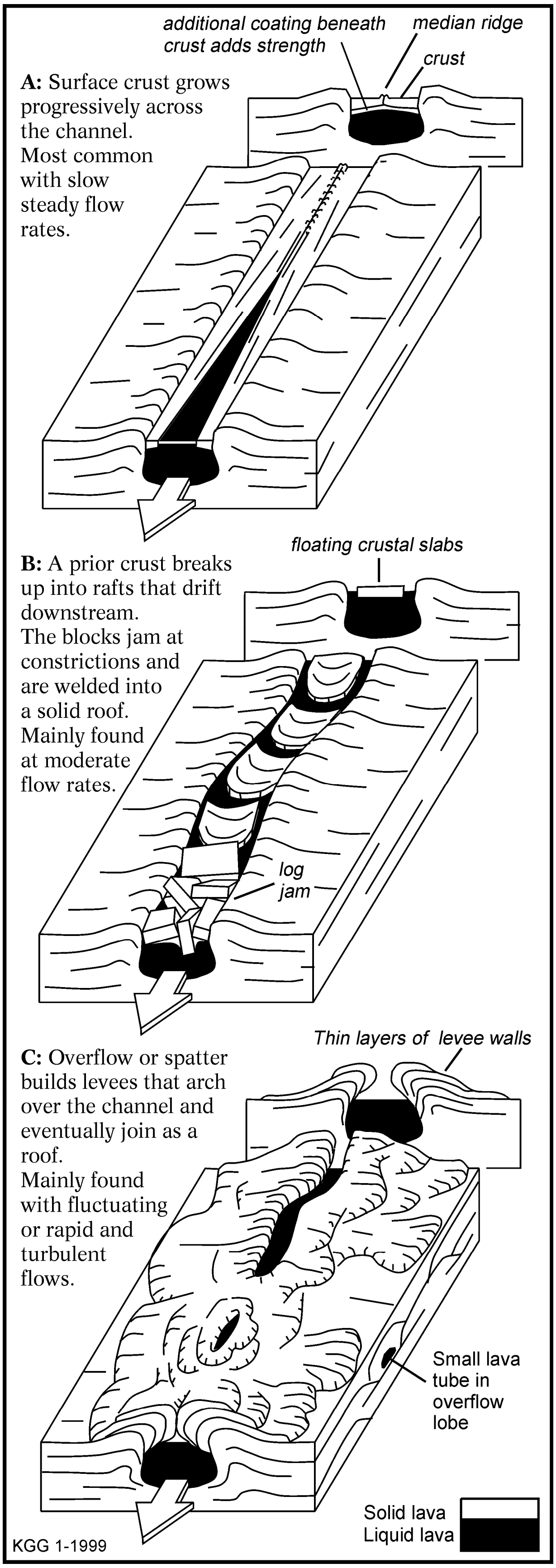

Figure 3.

Three ways to make a lava tube by roofing a lava channel.

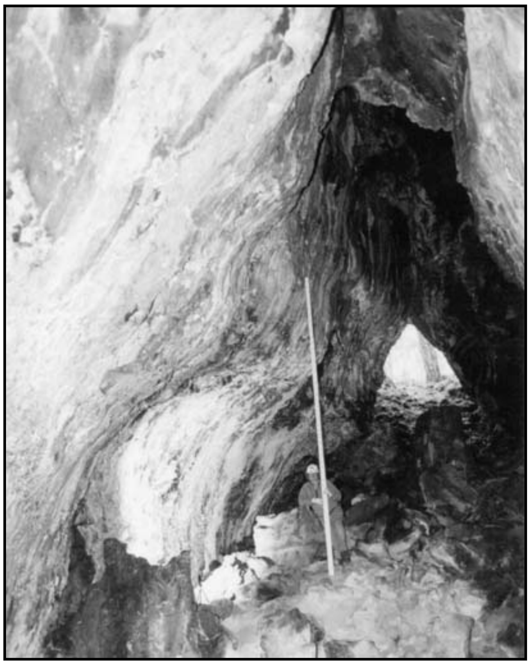

Figure 5.

The ceiling of Natural Bridge (3H-10), Mt. Eccles has a "Gothic" cross-section that suggests it formed by levee overgrowth, as shown in Figure 3c.

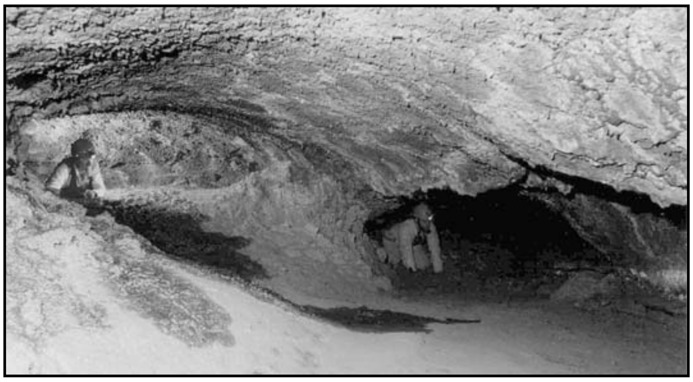

Figure 6.

Caves formed by draining of lava lobes tend to have low broad chambers and passages (see Figure 4). Carmichael Cave, 3H-70, Mt Eccles.

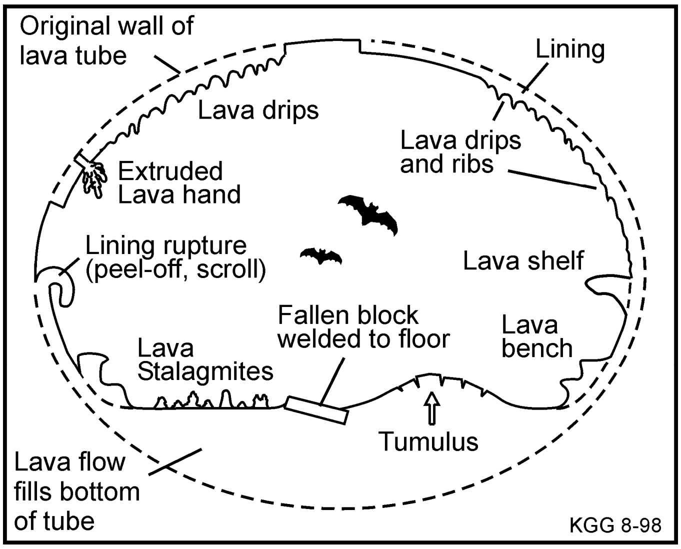

Figure 7.

Formations found in lava tubes.

Figure 8.

Lava shelf, which bridges across the passage behind the caver. 3H-33, Byaduk.

Figure 9.

A lava stalagmite built up of coalesced droplets of viscous lava. The fine spikes may have formed from liquid lava pushed out through small holes by the expanding gas within the lava (see Allred & Allred, 1998). Scale in cm.

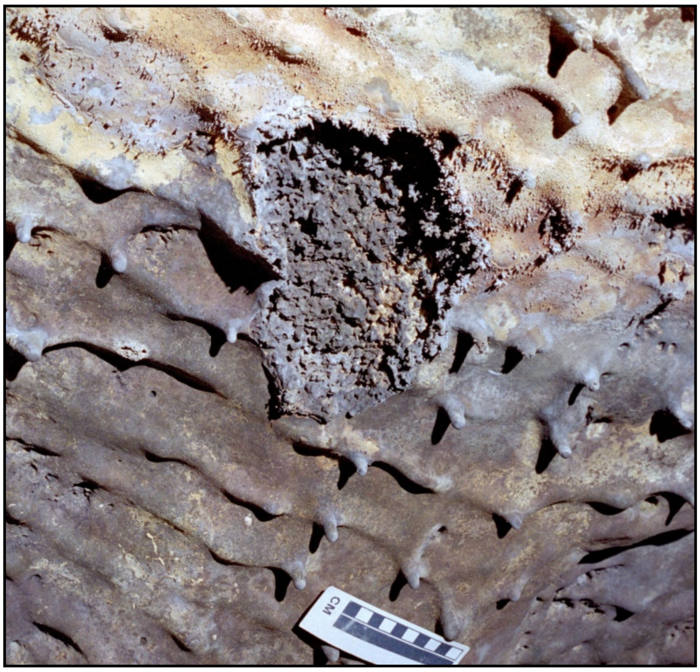

Figure 10.

Lava drips and a hackly burst section of lining on the ceiling of 3H-70, Mt Eccles.

Figure 11.

Lava dip (tide-mark) on a roof pendant. 3H-33, Byaduk.

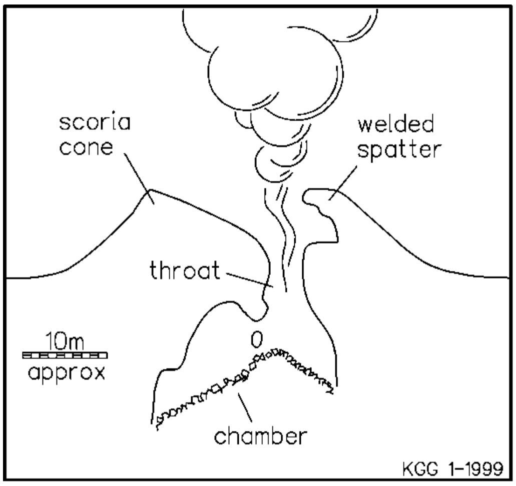

Figure 12.

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

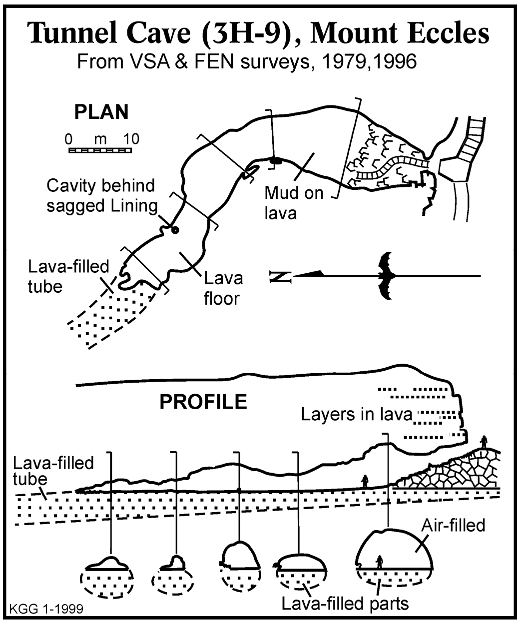

Figure 13.
Tunnel Cave.

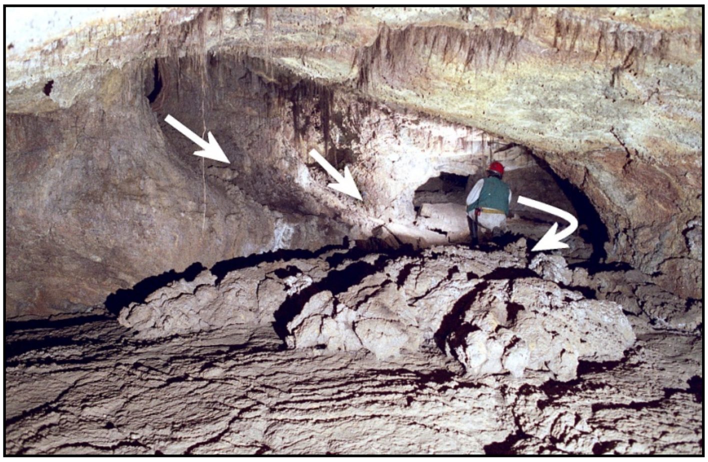

Figure 15.
An aa lava flow has invaded the lower level of Carmichael Cave. Arrows indicate its entry points from a higher level.

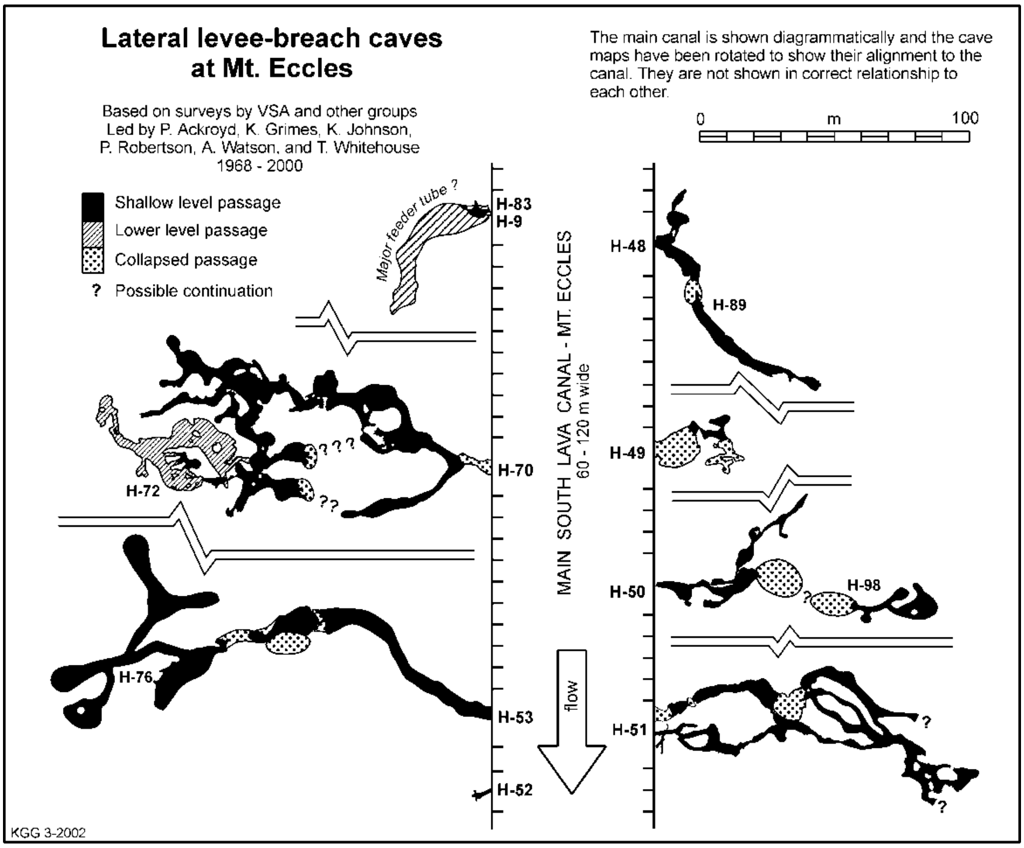

Figure 14.
Lava caves on the sides of the South Canal at Mt. Eccles.

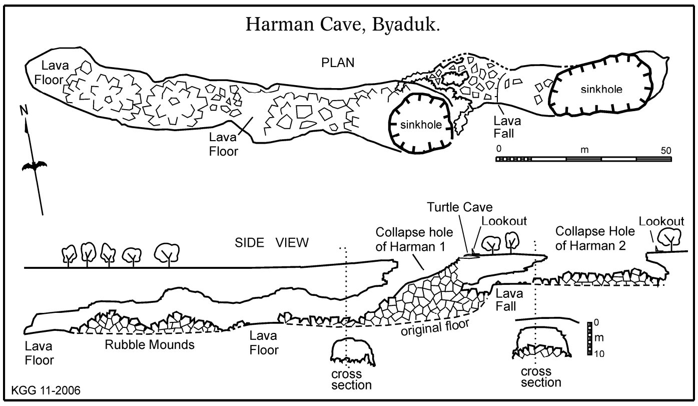

Figure 16.

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

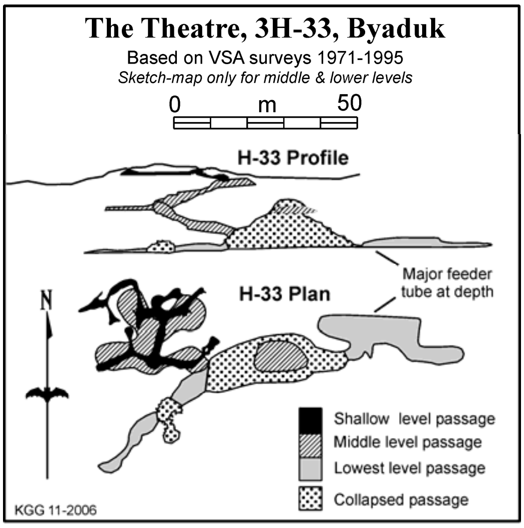

Figure 17.

The Theatre is a multilevel system.

Figure 18.

Feeder tube with a fairly jagged ropy lava floor, at the end of 3H-33, Byaduk.

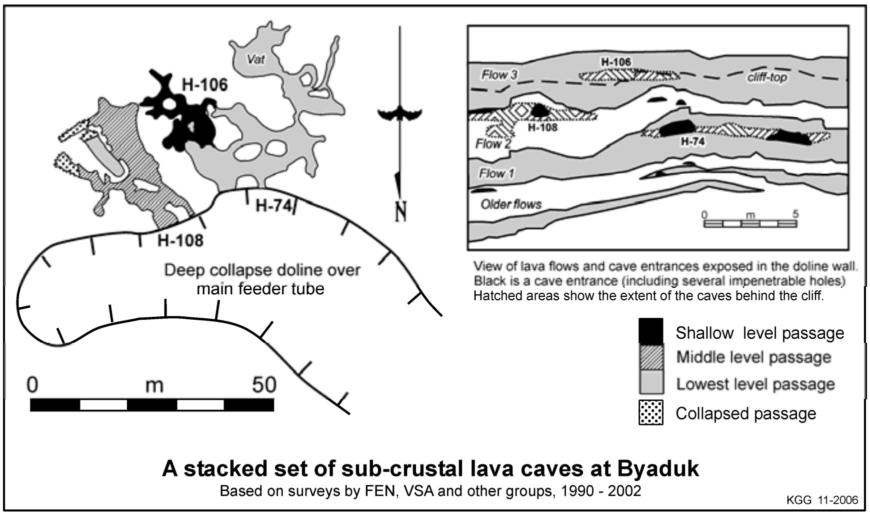

Figure 19.

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