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Lava caves and channels at Mount Eccles, Victoria.

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Introduction

Mount Eccles and nearby Mount Napier are two of the youngest volcanoes in the Newer Volcanic province of Victoria. Summaries of both the surface landforms and the volcanic caves of the province appear in the *Vulcon Guidebook* (Grimes, in press; and Grimes & Watson, in press). The earlier lava cave literature by Ollier, Joyce and others is reviewed in the *Vulcon Guidebook*, and in Webb & others, 1982, and Grimes, 1994.

The Newer Volcanics range in age from Pliocene (about 4.5 Million years) up to very recent times. Recent isotopic dates from Condah Swamp (Head & others, 1991) support the previously suggested 20,000 BP dates for the onset of the volcanism at Mount Eccles, but there is no definite date for its end, though this would seem to have been prior to 7000 BP.

At Mount Eccles the main volcano is a deep steep-walled elongated crater which contains Lake Surprise. The south-eastern end is a high cinder cone, but at the north-western end the crater wall has been breached by a lava channel that flows west and then branches into two main channels (referred to locally as 'lava canals') running to the north-northwest and to the south-southwest (see Figure 1). Extending to the southeast from the main crater there is a line of smaller spatter and scoria cones and craters and a second smaller scoria cone (Little Mount - now largely removed by quarrying). One of the spatter cones contains 'The Shaft' (H-8), a still open throat and volcanic chamber. Further south east, another possible volcanic throat was The Pit (H-28), reportedly destroyed by recent quarrying.

Beyond this central area of explosive activity basalt flows form a lava field about 16 km long and 8 km across (see district map in the *Vulcon Guidebook*). From the western end of this lava field a long flow, the Tyrendarra Flow, runs 30 km southwards to the present coast and continues offshore for a further 15 km. This must have had a major feeder tube, but no drained sections have been discovered to date.

Lava Channels

The lava channel that leaves the western end of the main crater branches almost immediately. The Main West Canal extends about 3 km to a 'wrinkled' area of strongly developed transverse pressure ridges and from there it fed most of the northwestern part of the lava field (Figure 1). The other branch (the Main South Canal) runs about 3 km to the south and south-southwest. It is not as wide but is deeper and has better developed levee banks along its sides. This channel ends abruptly, and probably originally flowed into a tube, but no entrances have been found to date. The flow continues south then west, and may have been the one that fed the long Tyrendarra Flow.

In addition to the two main lava channels there are several smaller, and less well-defined channels (Figure 1). A set of narrow and discontinuous linear depressions can be seen on the air photos running westward between the Main West Canal and the Main South Canal; this could be a partly roofed channel and would have potential for drained lava tubes between the surface depressions. A broad but shallow lava channel starting at the Dry Crater, immediately to the southeast of Lake Surprise, runs east and feeds a major flow that then runs south and southeastward. Another narrow but well-defined channel runs west-southwest from a small spatter cone near the Little Mount quarry and ends at the Natural Bridge / Gothic Cave (H-10). The western part of this 'channel' may have originally been a tunnel which has been exposed following collapse of most of its roof: Natural Bridge is the remaining part of this tunnel. A small lava channel also runs through the camping area north of Lake Surprise.

The channel gradients are generally steepest near the source vent, but vary between channels (Table 1). The depths of the channels varies and lava mounds and ridges are found along the floors. Joyce (1976) measured the west channel as being from 140 to 220 m wide and 4.5 to 5 m deep. The southern channel is deeper (6 to 12 m) but not as wide (60 to 120m). Channel walls can be steep to even overhanging. They have been considerably modified by collapse and cambering.

Table 1: gradients of lava channels (from map contours)

Channel	In channel		Flow beyond channel end
	At top	At bottom	
Main West Canal	1:175	1:175	1:175
western canal & tubes	1:100	1:125	1: 75?
Main South Canal	1: 60	1:163	1:300
eastern channel	1: 55	1: 75	1:125
Natural Bridge channel	1: 25	1: 30	1: 48?

Lava Caves

Lava tubes can form by two main processes: by the roofing over of surface lava channels (Figure 3a-c); and by the draining of still molten material from beneath the solidified crust of a flow (Figure 3d). Both types occur at Mount Eccles. For a more detailed description of the processes see the text and figures in the *Vulcon Guidebook* (Grimes & Watson, in press)which are based on the work of Atkinson (1988), Greeley (1987), Joyce (1980) and Wood (1977).

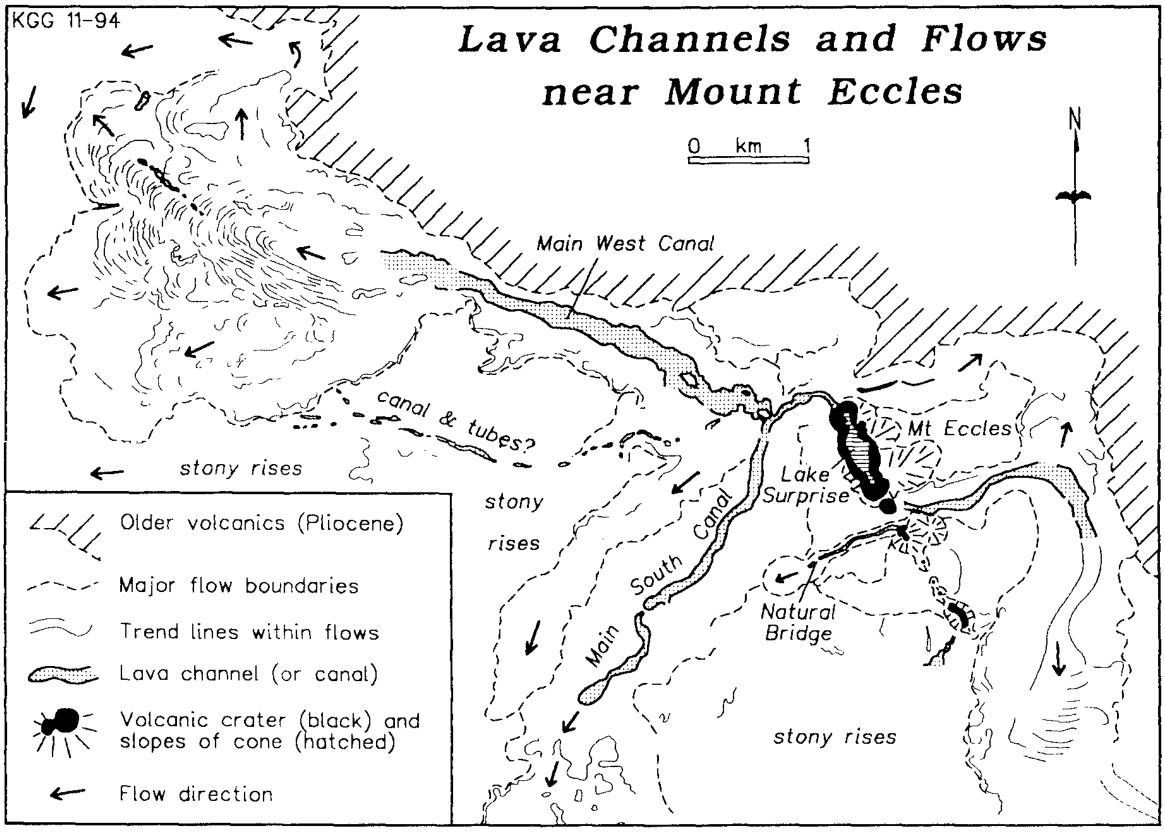

Figure 1: Lava Channels and Flows near Mount Eccles

Most of the longer caves known at Mount Eccles are in or adjacent to the lava channels, but there are a number of small caves scattered throughout the area, and the known distribution may simply reflect the more intensive exploration along the main canals. There are several types of lava cave in the area. Roofed channels include H-10, and also possibly H-9. Drainage caves include two types: complex, lateral, levee-breach systems on the sides of the major lava channels, e.g. H-51; and small, isolated, drained chambers within the stony rises (e.g. H-78) - see maps in Grimes & Watson (in press). The Shaft (H-8) is an explosive cavity and throat within a spatter cone that remained open after the volcanism ceased.

The genesis of Natural Bridge / Gothic Cave (H-10) by roofing can be seen from its obvious location at the end of a narrow surface channel, though the present cave is just a remnant of what was originally a longer roofed section. The exposure of numerous thin and contorted linings in the walls and roof, together with its pointed 'gothic' roof outline, suggest that it formed by the inward growth of overhanging levees, which slumped inwards and downwards while hot to produce the contortions (see also Joyce, 1976, 1980). The genesis of Tunnel Cave (H-9) is less obvious, but its large, high-arched passage and the floor level, which is close to that of the adjoining canal, suggests that it was a major feeder tube which may have originated as an open channel at much the same time as the main canal, but was later roofed over.

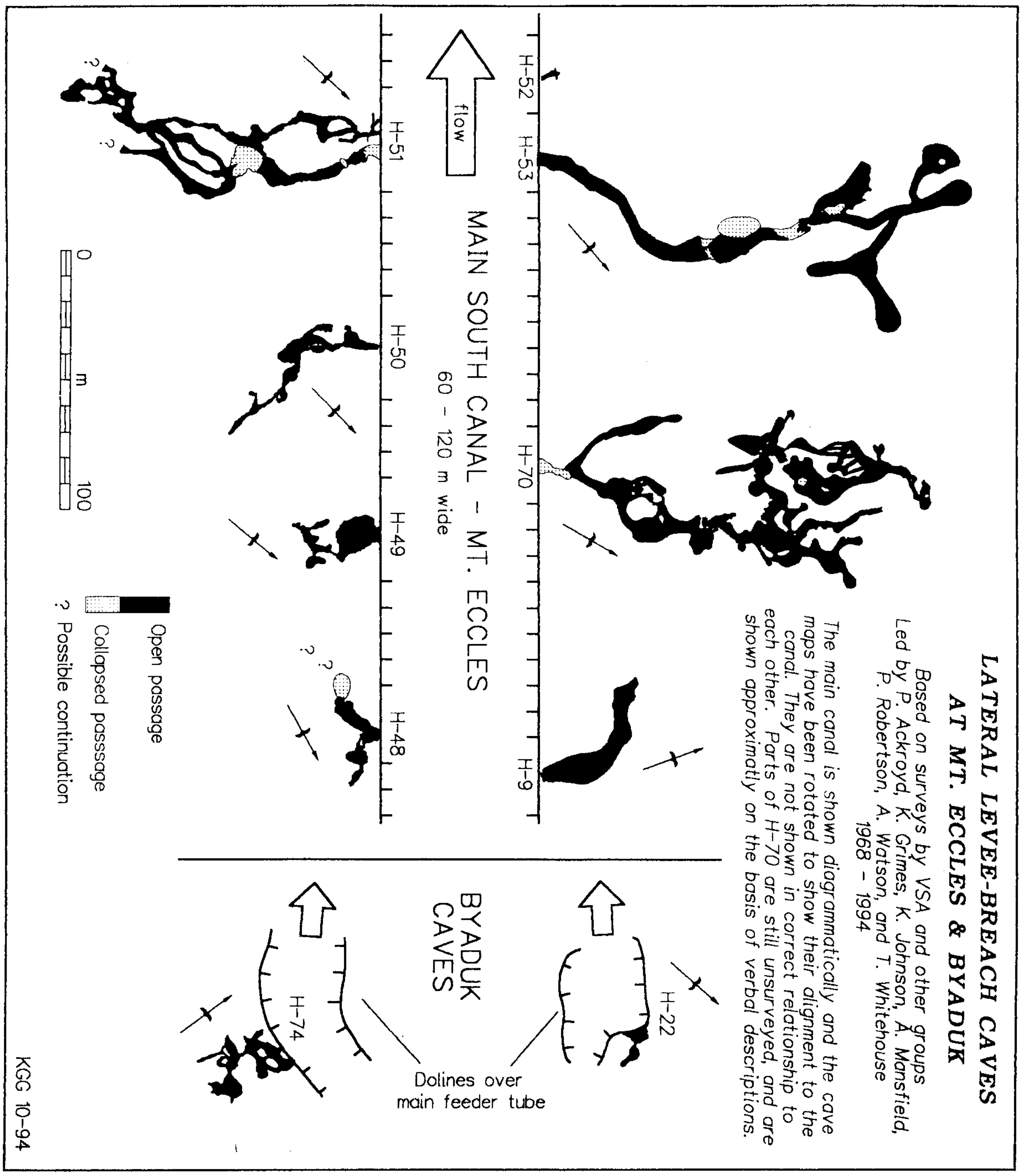

Figure 2: Lateral levee-breach caves at Mt. Eccles and Byaduk

The lateral caves associated with the canals are generally shallow systems formed in the levee banks on each side and would have fed small lateral lava lobes or sheets when the canal overflowed or breached through the levee (Figure 3d and 4). Figure 2 shows the lateral caves associated with the Main South Canal. The canal is shown diagrammatically, and the cave maps have been rotated to show their orientation relative to the canal wall. H-9 has been included in Figure 2, even though I feel that it is a major feeder tube and has a different origin to the others.

Some caves start as simple linear tubes (e.g. H-53), but mostly they are branching systems with complexes of low passages that bifurcate and rejoin, or open out into broad low chambers. The form suggests draining from beneath the solidified roof of a series of flow lobes. Some of the passages are large enough to stand in, typically (but not always) those nearest the canal entrance (e.g. H-48, H-53, H-70), but most of them are crawlways about a metre high with low arched roofs and flat lava floors. Some of the smallest passages have an elliptical cross-section. The roof is generally only a metre or so below the present surface, and in places breakdown has exposed the bases of overlying pahoehoe flows, indicating that the original roof was less than a metre thick. In some chambers the roof has sagged down in a smooth curve to reach the floor. The floors are generally pahoehoe, with smooth, platy or ropy surfaces; but sharp aa lava floors occur in several places (e.g. H-51 and H-70). Some transitional forms (which I call 'knobby pahoehoe') also occur. Small tumuli and lava boils or 'puddings' occur on the floor in places.

Where not disrupted by breakdown the walls and roof typically have thin (2 - 20 cm) linings with lava drips and runs, and occasional pealed back flaps. Some linings have a hackly surface, possibly due to bursting of gas bubbles. lava 'hands' have been squeezed out through cracks in the linings in a few places and small agglutinated stalagmites may occur beneath some of these. Most caves are at a single level, but some show evidence of several levels (only a metre or so apart vertically) that either have coalesced into a single passage or chamber (e.g. H-51) or are joined by short lava falls (e.g. H-70).

In the stony rises small caves form by the irregular draining of cavities beneath the crust of a broad lava flow (See Figure 5-4 in the *Vulcon Guidebook*, Grimes, in press). The process is similar to that which forms tubes (Figure 3d), but less organised so that only isolated low chambers appear to result. Commonly the chamber roof sags (while hot) or later collapses so that only a crescentic 'peripheral remnant' survives, as at H-78. This type of single-chamber cave has previously been referred to as a 'blister cave' but that term is best restricted to chambers formed by gas pressure.

The Byaduk Caves

The Byaduk Caves are near the start of a long, tunnel-fed lava flow that runs down the Harman Valley to the west of Mount Napier, 20 km to the north of Mount Eccles. Collapse of parts of the main feeder tunnel has exposed the large tunnels, arches and collapse dolines (see map in the *Vulcon Guidebook*). The largest tunnels are up to 18 m wide, 10 m high and extend to depths of 20m below the surface. There are also some smaller but more complicated caves, including two (H-22 and H-74, Figure 2) that seem comparable to the lateral levee-breach systems described above. H-74 (Chocolate Surprise) is the most convincing - this is a high level system entered half way up the side wall of a large collapse doline formed over the main feeder tube (Mansfield, 1990). It is a set of low branching passages and chambers very similar to those found beside the channel at Mount Eccles. I therefore suggest that the main feeder tube at Byaduk was initially an open channel which built up high banks by repeated overflow before roofing over to form the large tubes. The 'layered lava' reported by Ollier & Brown (1965) in the walls of the big tube may be thin lateral flow units of the levees, and H-74 would be a cave system developed in one such overflow.

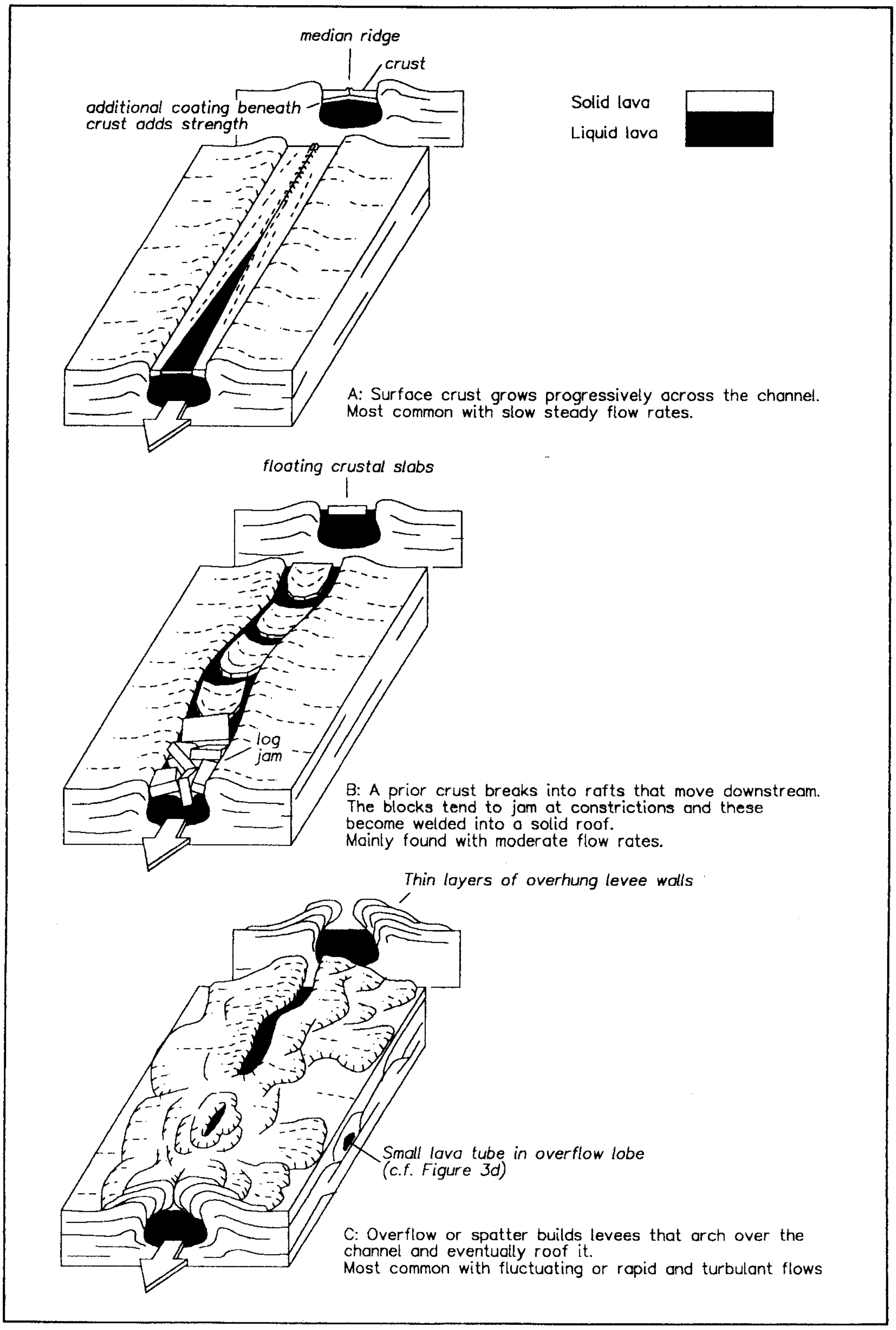

Figure 3: Formation of lava tubes, by roofing over of a lava channel (A-C), or by drainage from beneath crusted lava lobes (D, next page)

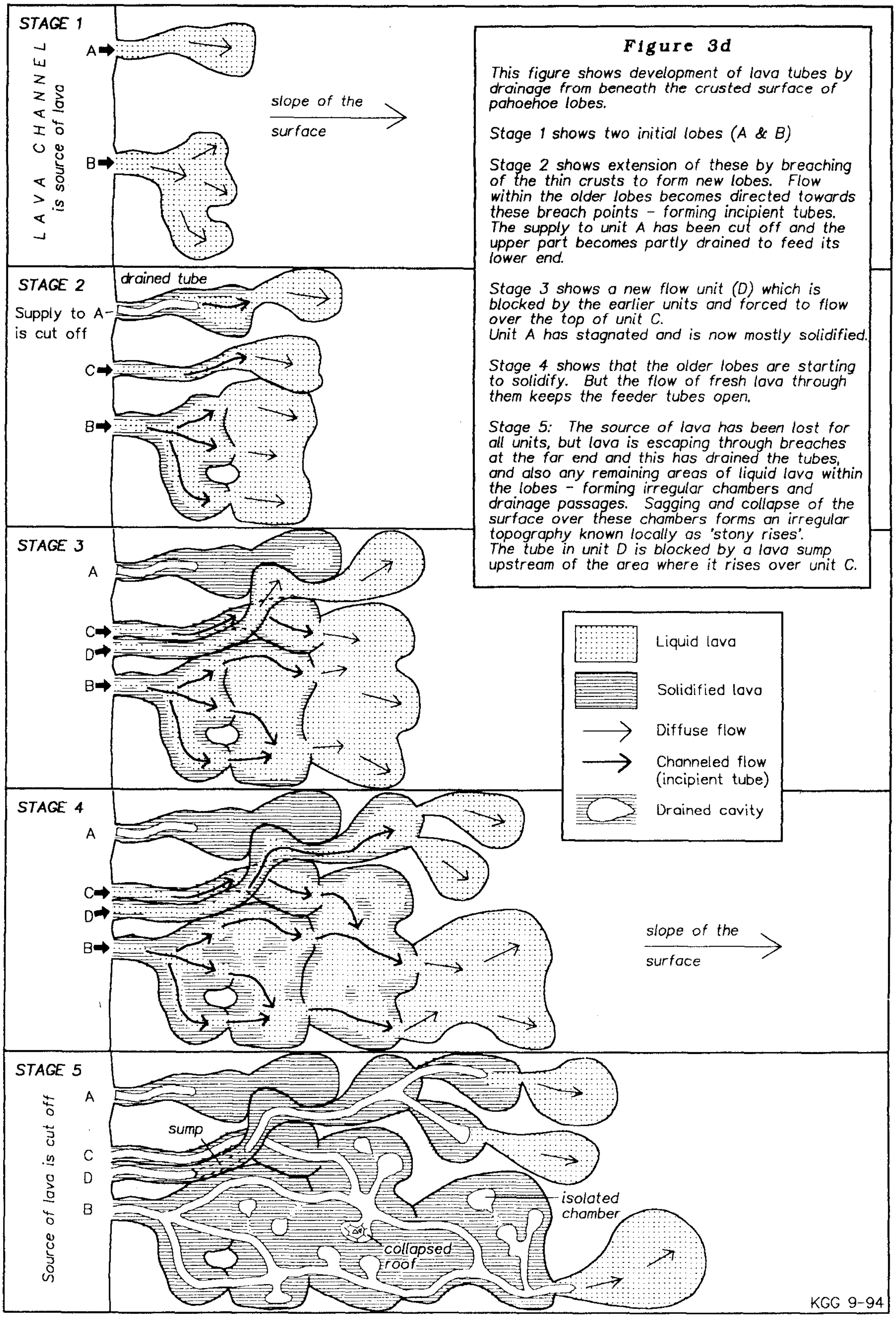

Figure 3d

This figure shows development of lava tubes by drainage from beneath the crusted surface of pahoehoe lobes.

Stage 1 shows two initial lobes (A & B)

Stage 2 shows extension of these by breaching of the thin crusts to form new lobes. Flow within the older lobes becomes directed towards these breach points - forming incipient tubes. The supply to unit A has been cut off and the upper part becomes partly drained to feed its lower end.

Stage 3 shows a new flow unit (D) which is blocked by the earlier units and forced to flow over the top of unit C. Unit A has stagnated and is now mostly solidified.

Stage 4 shows that the older lobes are starting to solidify. But the flow of fresh lava through them keeps the feeder tubes open.

Stage 5: The source of lava has been lost for all units, but lava is escaping through breaches at the far end and this has drained the tubes, and also any remaining areas of liquid lava within the lobes - forming irregular chambers and drainage passages. Sagging and collapse of the surface over these chambers forms an irregular topography known locally as 'stony rises'. The tube in unit D is blocked by a lava sump upstream of the area where it rises over unit C.

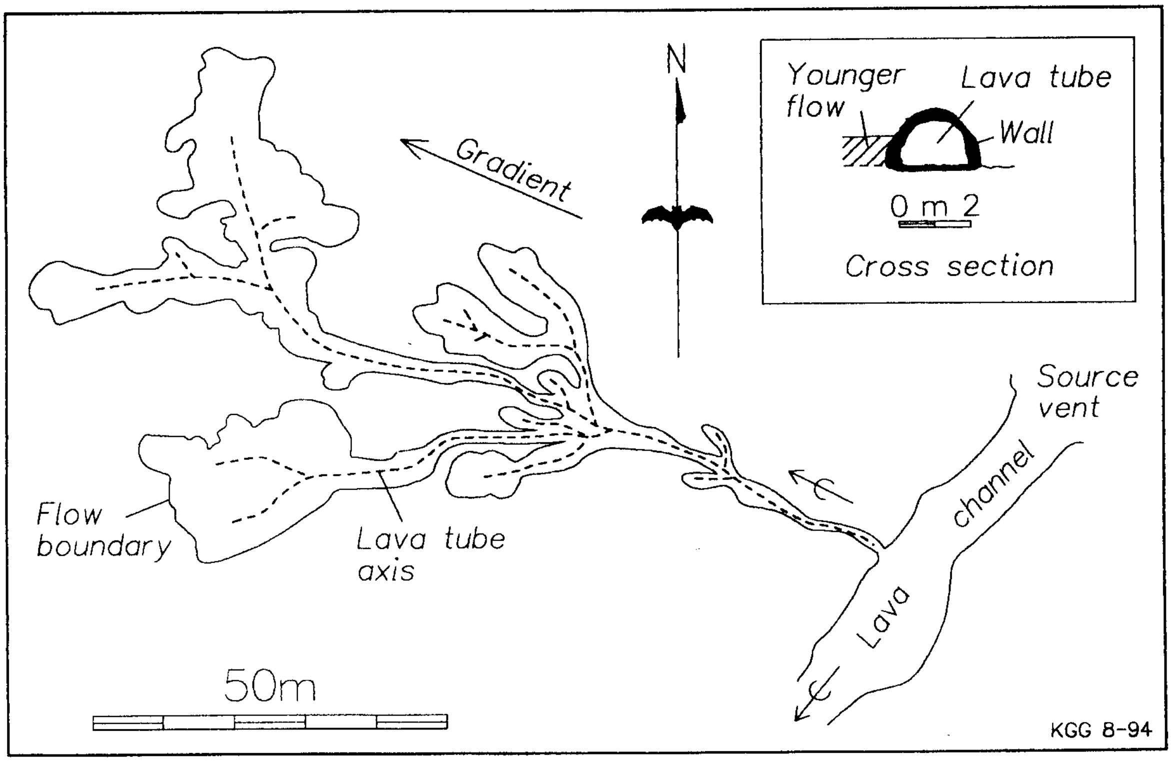

Figure 4: Example of a distributary system of small lava tubes feeding pahoehoe lobes. From near Bend, Oregon. (after Greeley, 1987)

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