Lava Tube Formation

Lava Flows and their Caves

Lava Flows and Caves

- ➤Long lava flows are invariably fed by tubes which insulate the lava travelling within them.
- ➤The leading edge of a flow is an advancing wall of pahoehoe lobes or aa rubble.
- ➤Behind the edge, flow is concentrated into surface channels, or hidden tubes beneath the crust. Stagnant areas solidify.
- ➤When the lava drains out of these conduits, an open cave is left.

Lava Flows

Liquid lava spreads out from a vent but quickly crusts over. The crust can be smooth and wrinkly (Pahoehoe or Ropy lava) or if the lava is stiffer it may break into jagged fragments (Aa lava).

Liquid lava continues to flow beneath the crusted surface, inflating it and pushing out in front as lobes of pahoehoe or walls of rubbley aa.

Behind the advancing front the liquid flow becomes concentrated into linear streams: either as surface channels or in tubes and chambers beneath the crust. The surface channels may later crust over to form tubes.

Lava flowing within a tube is well insulated, and can travel for long distances. Most long lava flows are tube-fed.

A typical small, cylindrical, lava tube.

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Peterson, D.W., Holcomb, R.T., Tilling, R.I., & Christiansen, R.L., 1994: Development of lava tubes in the light of observations at Mauna Ulu, Kilauea Volcano, Hawaii. *Bulletin of Volcanology,* **56:** 343-360.

Overview of lava cave formation

Observations of active lava flows has shown that there are two distinct ways in which lava tubes or caves form:

Roofing of surface lava channels. This can happen in three ways (e.g. Peterson et al, 1994), see panel 2.

Sub-crustal drainage within thin lava lobes or sheets. (e.g. Peterson et al, 1994 & Hon et al, 1994), These evolve from isolated chambers and proto-tubes into multi-chamber and multi-level systems. See panels 3-5 .

Both Types (roofed channels and sub-crustal systems) evolve over time into large linear **feeder tubes**, and the evidence of their original formation may be destroyed.

Draining of the liquid lava from these tubes will leave open caves. Most tubes never drain and become blocked with solid basalt.

Open Volcanic Vents are a rare type of cave formed by the draining of the lava back into the source vent.

Caves can also form in **tectonic fissures**.

Weathering of ash and lava can also form secondary caves.

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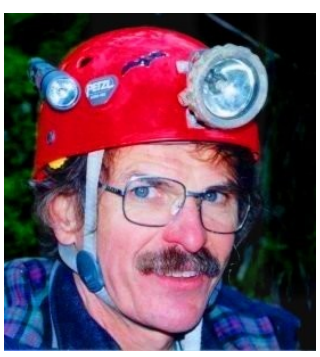
With acknowledgements to my predecessors who conceived most of the ideas expressed here: In particular Don Peterson, Ken Hon, Bill Halliday, Anne Atkinson, and many other speleo-geologists.



Lava Tube Formation

Roofing of Lava Channels

Roofing a Channel

Surface lava channels can be roofed over to form tubes.

This has been seen to happen in three ways.

A: Simple crust growth.

Surface crust grows progressively across the channel. It may then be thickened from below.

This is most common with slow steady flow rates.

B: Log jam of floating slabs

A prior crust breaks up into rafts that drift down-stream. The slabs may form "log jams" at constrictions and are then welded into a solid roof.

Mainly found at moderate flow rates.

C: Levee overgrowth

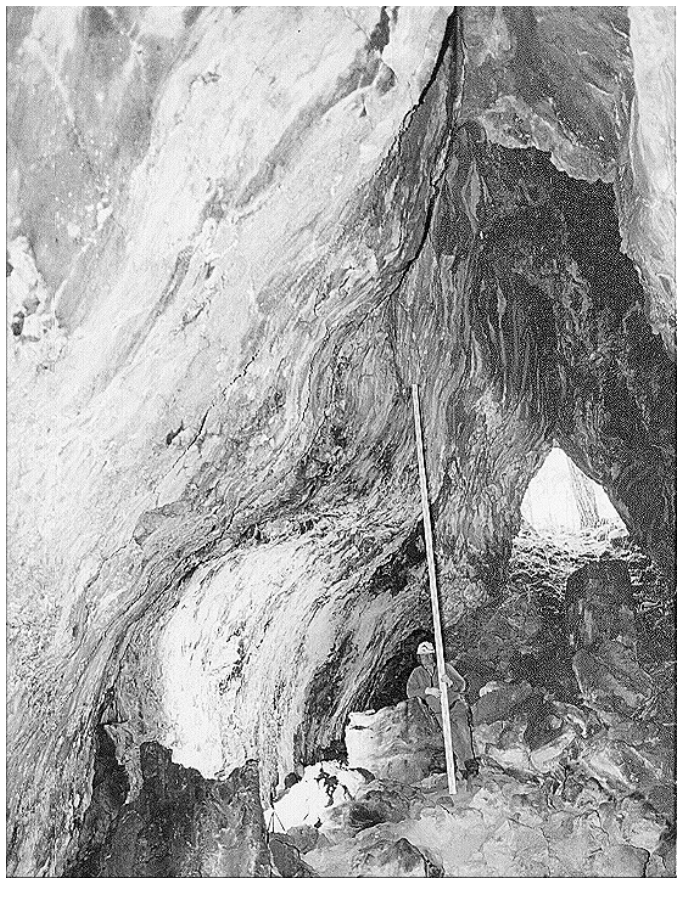
Overflow or spatter builds levees that arch over the channel and eventually join as a roof.

Mainly found with fluctuating or rapid and turbulent flows.

Subsequent evolution.

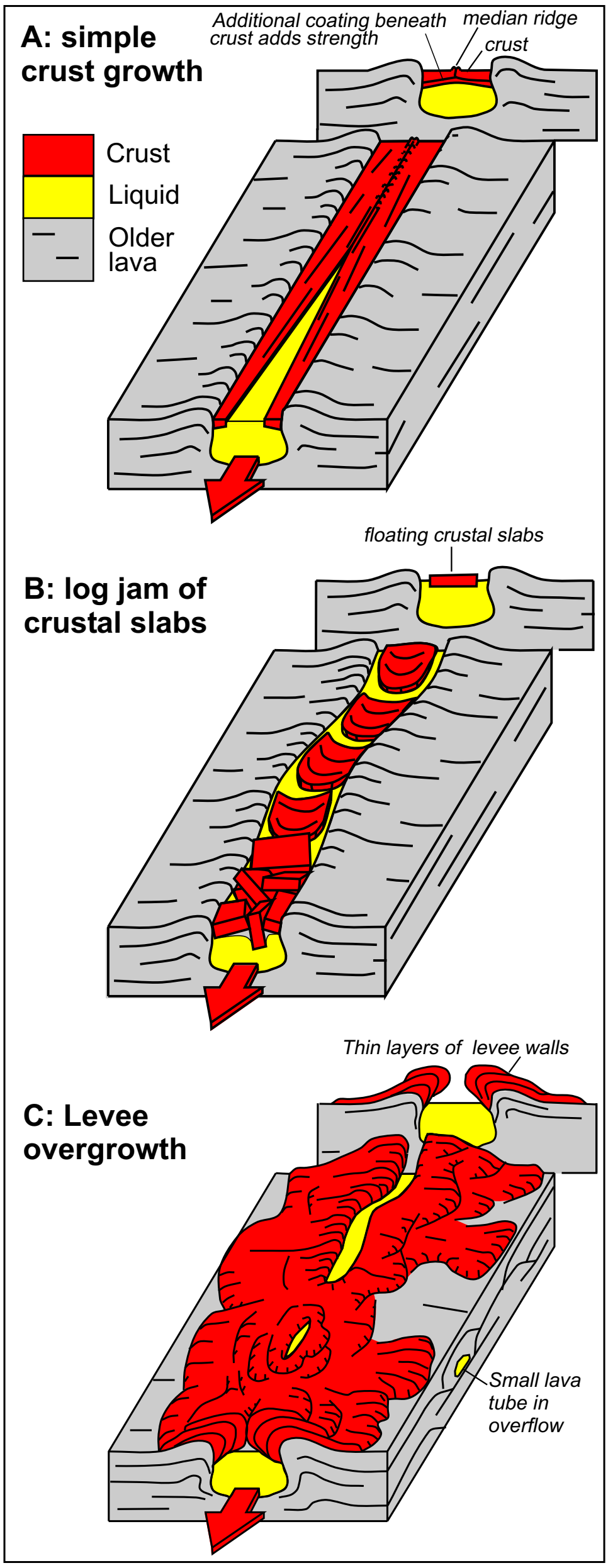
In all three cases,underplating and overflows through sky-lights may thicken the roof.

In many cases linings plastered on the walls, or collapse modifications, make it hard to distinguish the three modes.



The angular, "gothic", roof of this tube is typical of ones formed by levee overgrowth. (c.f. Figure C ➔)

5 m staff.



Lava Tube Formation

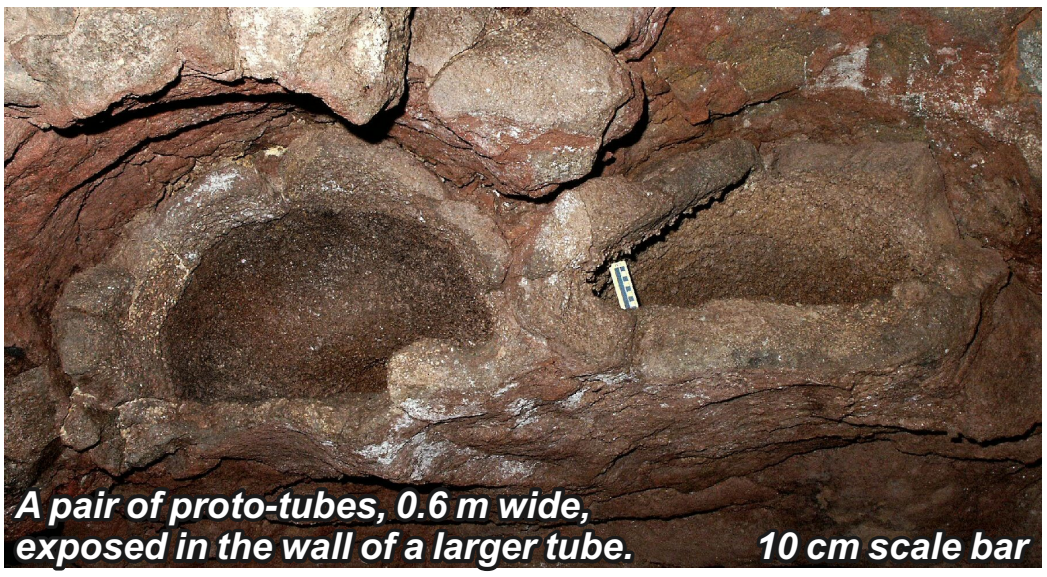
Sub-crustal Drainage

Sub-crustal Lava Caves

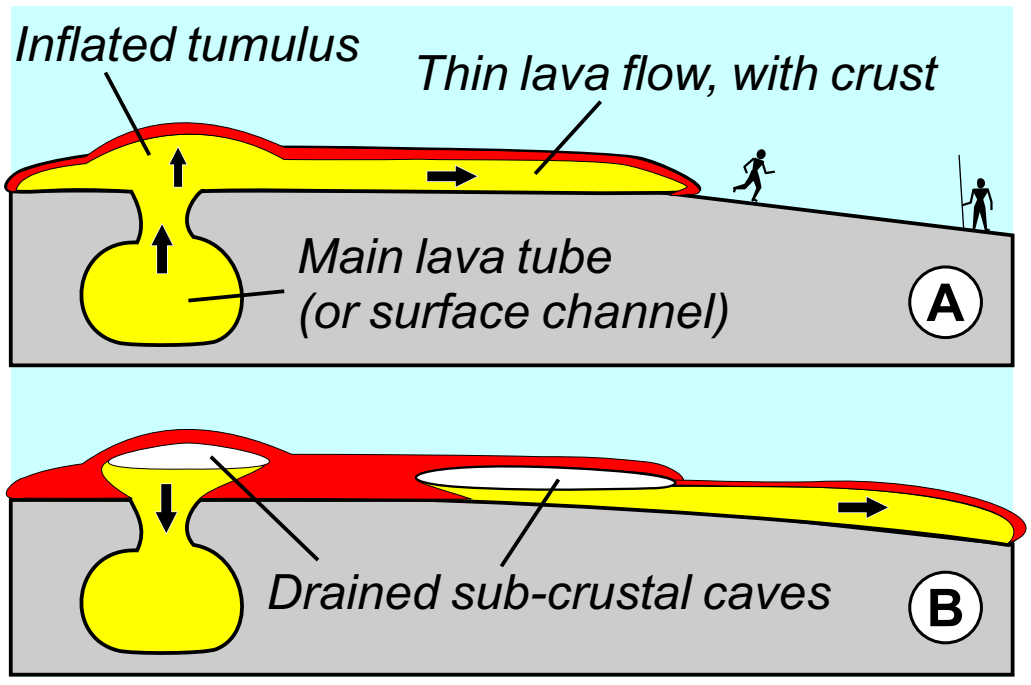
A newly-formed lava flow quickly develops crusted lobes which grow by budding and may be inflated upwards.

Flow of liquid lava through a set of crusted lobes can form small sub-crustal chambers or networks of small *proto-tubes*.

As the flow advances and expands, more complex sub-crustal drainage systems form.



A pair of proto-tubes, 0.6 m wide, exposed in the wall of a larger tube. *10 cm scale bar*



Development of sub-crustal caves

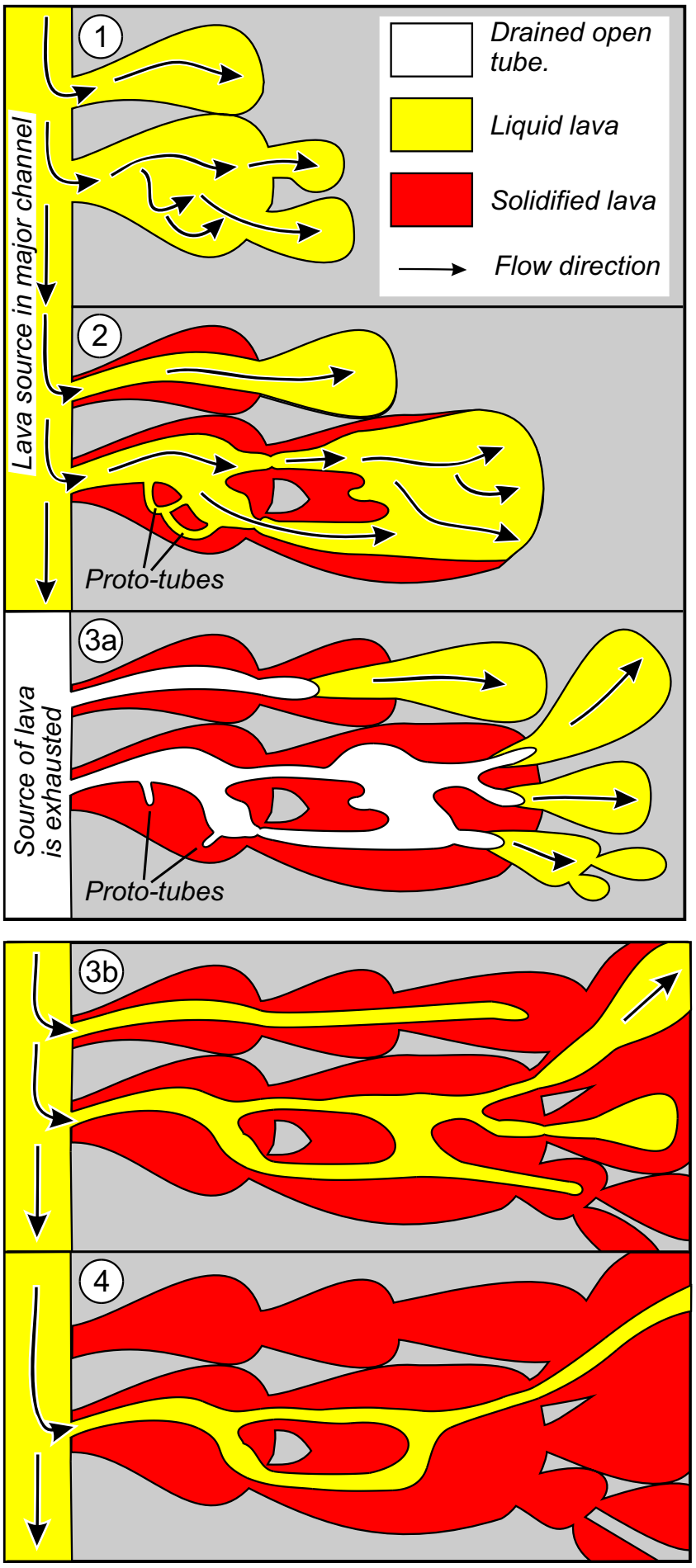
➤ Lava spreads from a skylight above a tube(A ↑), or by overflow from a crater or a lava channel (1, ➔). The spreading lobes grow by a process of 'budding' in which a small lobe develops a skin, and is inflated by the lava pressure until the skin ruptures in one or more places.

➤ Lava escaping through the rupture develops new lobes and so on (B ↑, and 1 & 2 ➔). Stagnant areas solidify leaving liquid-filled chambers (in larger lobes) or a network of small proto-tubes.

➤ If the supply of fresh lava is cut off, the liquid parts of the lobes may be drained to form a set of broad but low-roofed chambers and connecting passages (3a ➔).

➤ However, if fresh hot lava continues to be delivered from the volcano (3b ➔) the sub-crustal flow may become concentrated into a few linear tubes that feed the advancing lobes, while the remainder stagnate and solidify (4 ➔).

➤ The evolving feeder tube can enlarge by erosion of its walls – destroying evidence of its initial mode of formation.

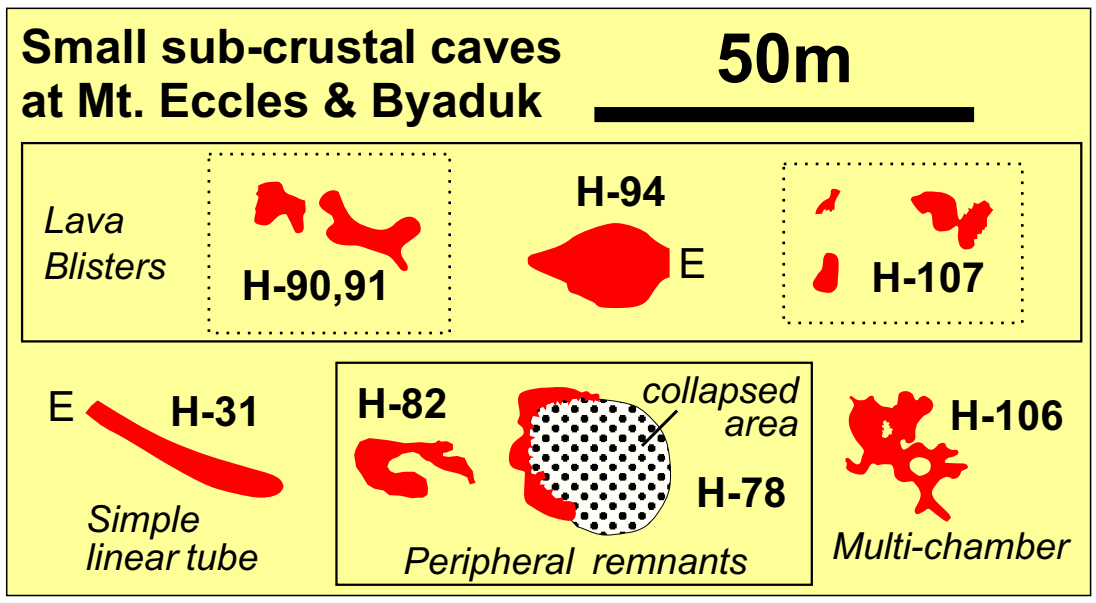


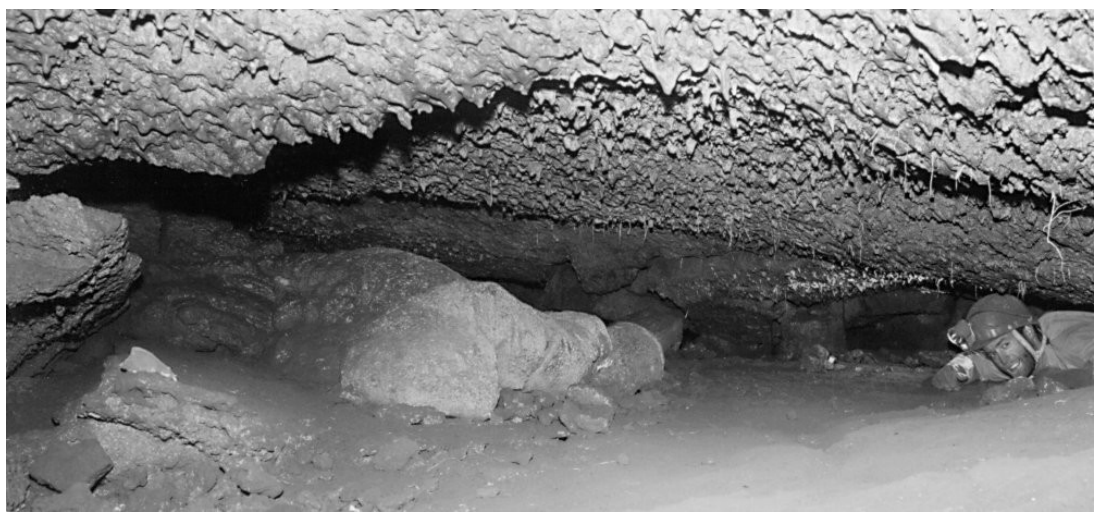
Lava Tube Formation

Small sub-crustal lava caves

Small isolated caves & tubes

Small isolated chambers and proto-tubes occur scattered through the undulating lava fields.



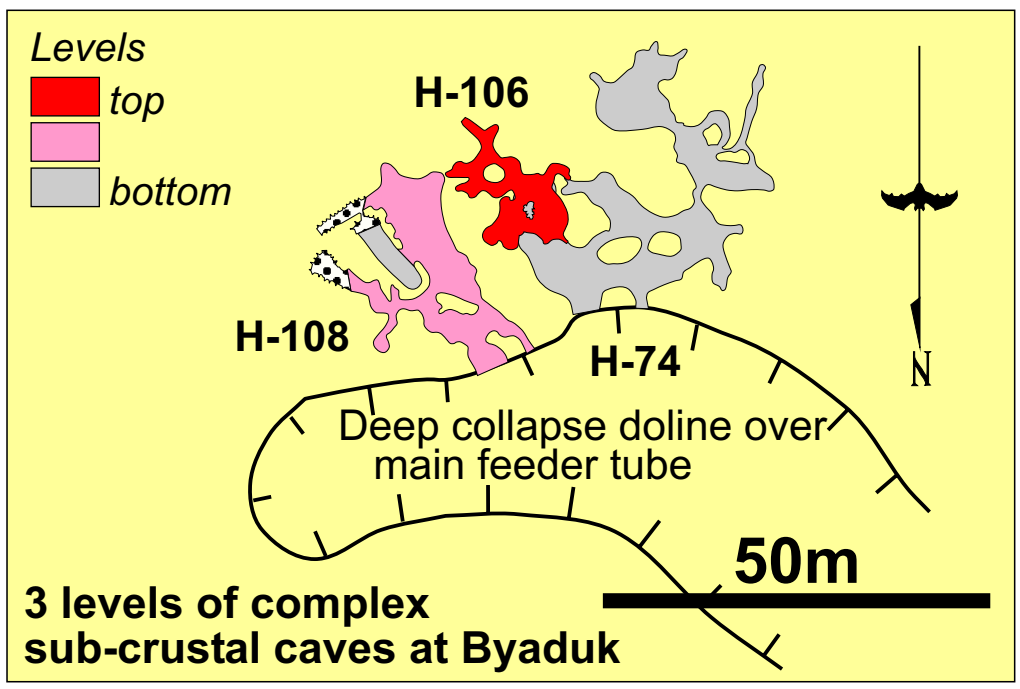


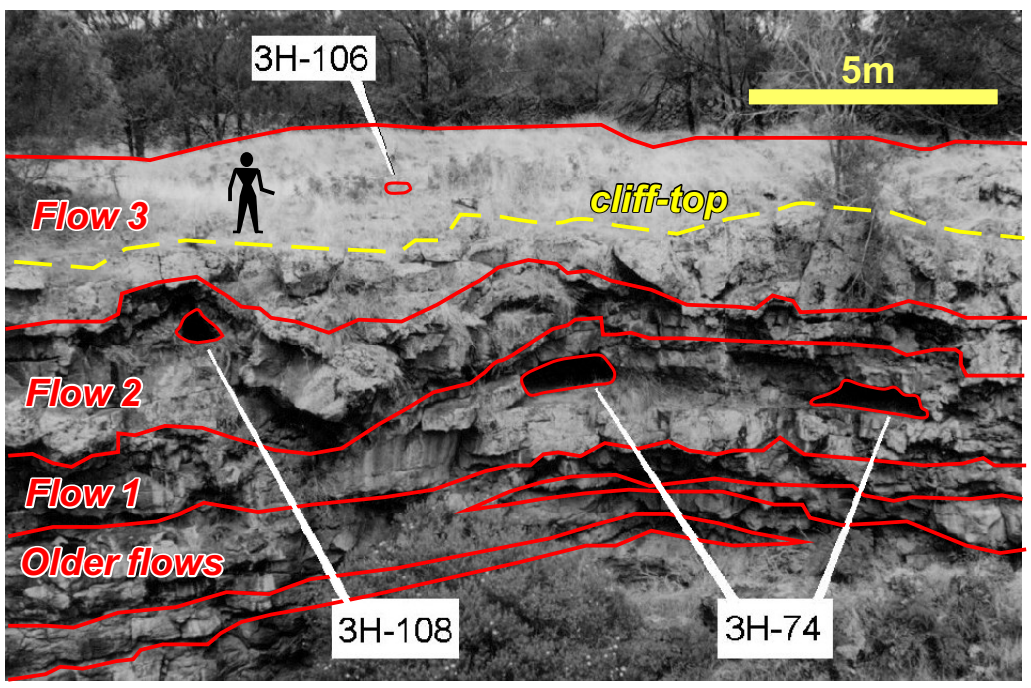
Broad low chamber in H-106. A mound of invasive lava lobes enters from the left.

- The simplest caves are small chambers (*lava blisters*), typically only 1m high with a thin roof, which occur scattered through the lava fields. They generally are found beneath low rises, though some have no surface relief at all.
- They can be circular, elongate or irregular in plan; up to 20m or more across but grading down to cavities too small to enter.
- In cross-section, the outer edges of the chamber may be smoothly rounded or form a sharp angle with a flat lava floor.
- The ceiling may be arched or nearly flat, and can have a central "soft" sag that would have formed while the crust was still plastic
- *Peripheral remnants* can be left around a central sagged ceiling, or at the edges of a shallow collapse doline (e.g. H-78).
- *Multi-chamber* systems can occur where the lobes coalesce. Several small chambers are connected by short tubes (e.g. H-106).
- The more elongate versions grade into small linear tubes (e.g. H-31).
- Networks of small *proto-tubes* are more common than chambers in situations where the lobes form discrete, but connected, bodies.

A stacked set of multi-chamber caves at Byaduk, Victoria.

Three distinct multi-chamber sub-crustal caves have developed; each in a separate lava flow, 1-3 m thick. The flows and cave entrances are exposed in the cliff of a collapse doline developed over a large feeder tube at greater depth. The thin lava flows may have been fed by overflow from this major tube - either through a skylight, or when it was an open channel





Lava Tube Formation

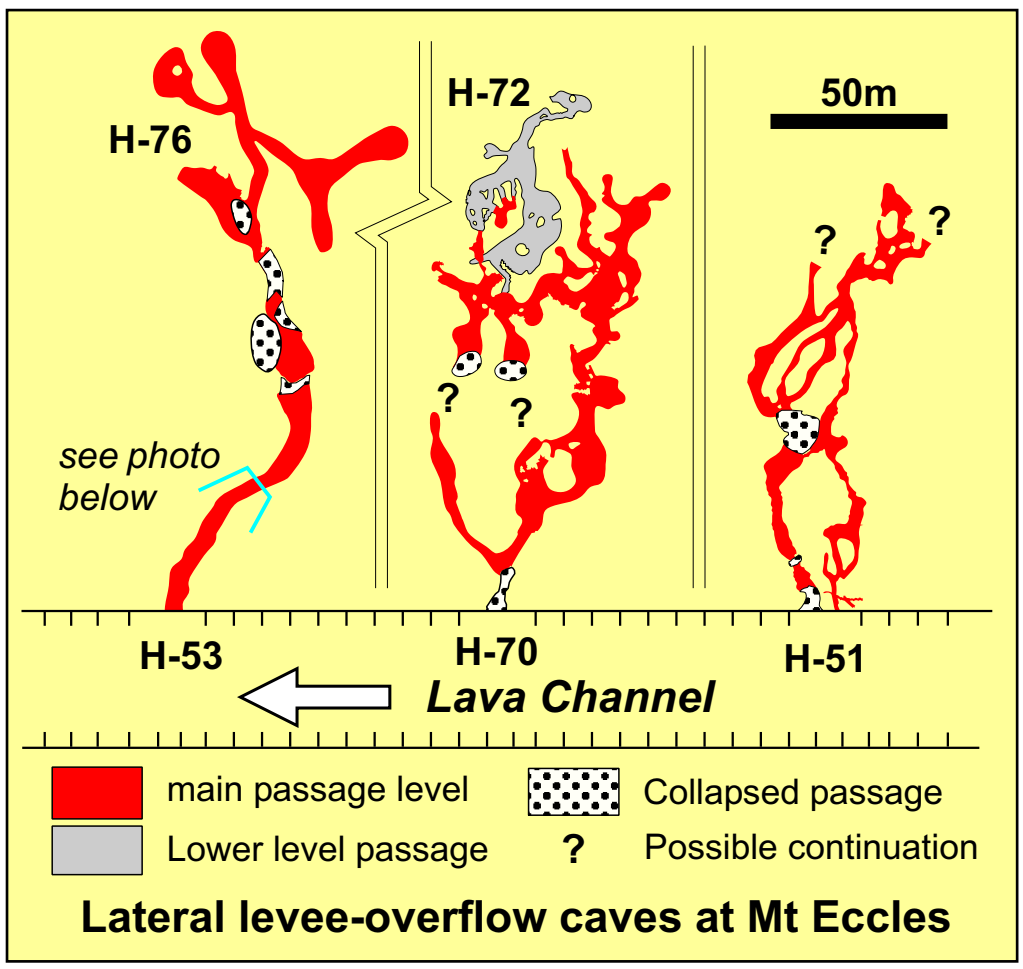
Complex sub-crustal lava caves

Complex Caves

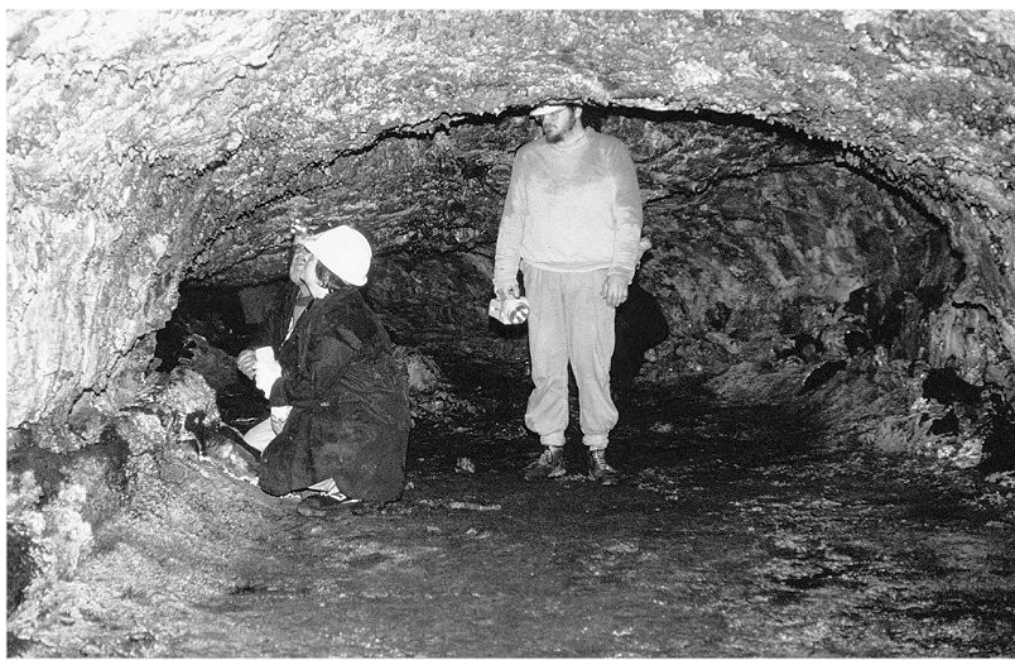
In larger flow systems the original simple "lava blisters" and "proto-tubes" evolve into branching systems of larger passages that bifurcate and rejoin, or open out into broad, low chambers.

Over time these simplify into a few linear feeder tubes, and abandoned parts stagnate.

Tubes formed as roofed channels also become simplified and can be difficult to distinguish from the sub-crustal tubes.



Lateral levee-overflow caves at Mt Eccles



Continuous concentrated flow through this section of H-53 has produced a linear cylindrical form typical of major feeder tubes.

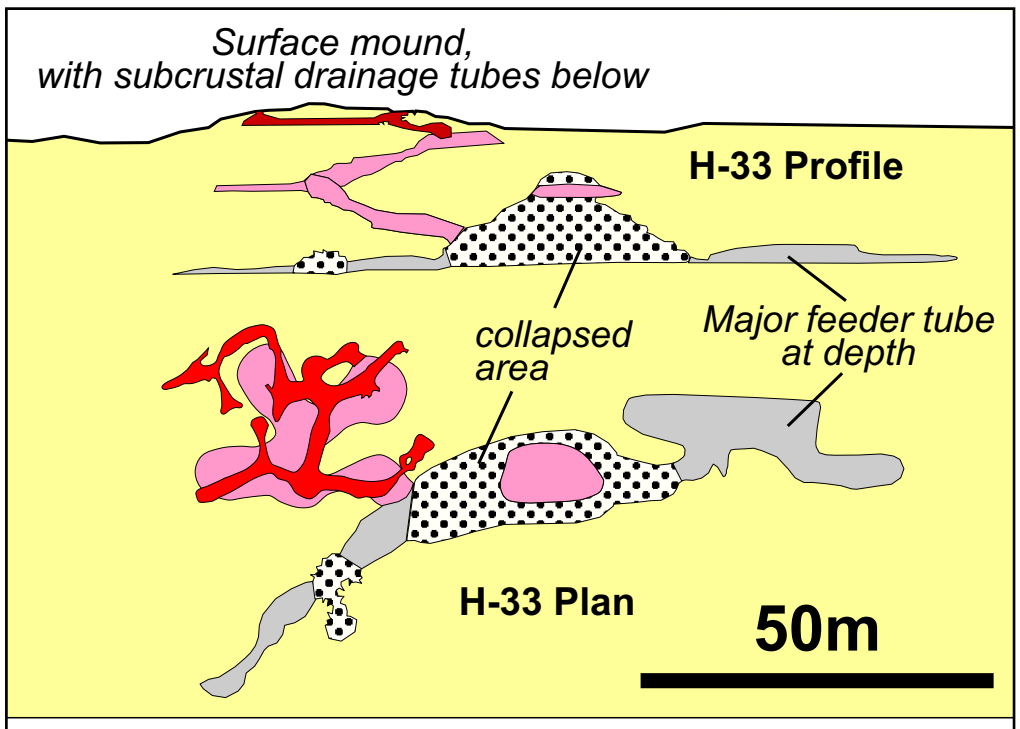
Developed Systems

More complex systems evolve where lava continues to flow beneath the crust for an extended time and over a greater distance.

Thus, at the leading edge of a flow we find initial complex multi-chamber systems and small networks of "proto-tubes" (eg. H-76); but further back, up-flow, these are replaced by simpler patterns of larger tubes and chambers and eventually one or two large linear **feeder tubes** that are maintained in areas of rapid flow, while slow moving areas solidify (eg. H-53).

Small networks of these tubes may extend radially from a central source (e.g. the upper level of H-33, see map below) or laterally from the breached levee of a lava channel (maps to left).

Large feeder tubes expand in diameter by thermal and mechanical erosion of their walls and floor. These can feed lava for long distances to the advancing front of the lava flow, where it spreads out through a network of smaller tubes, proto-tubes and chambers.



In this multi-level system, overflow to the surface from a major feeder tube has formed a domed mound with a branching tube pattern. Draining back to the lower level left several low-roofed chambers and tubes at progressively lower levels. The Theatre (H-33), Byaduk.

Lava Tube Formation

Example: Carmichael Cave, 3H-70, Mt. Eccles

A complex sub-crustal cave

H-70 comprises alternating linear tubes, mazes and broad low-roofed chambers. It was formed by over-flow from a lava channel. The lower level may be an earlier system invaded by the later one.

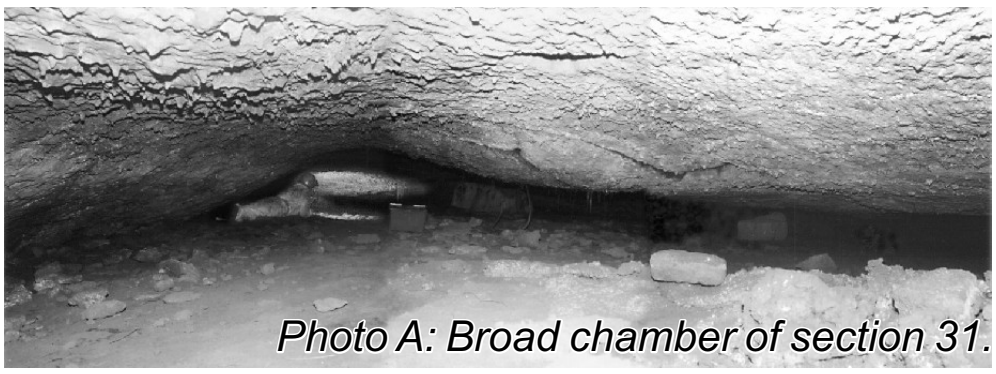


Photo A: Broad chamber of section 31.

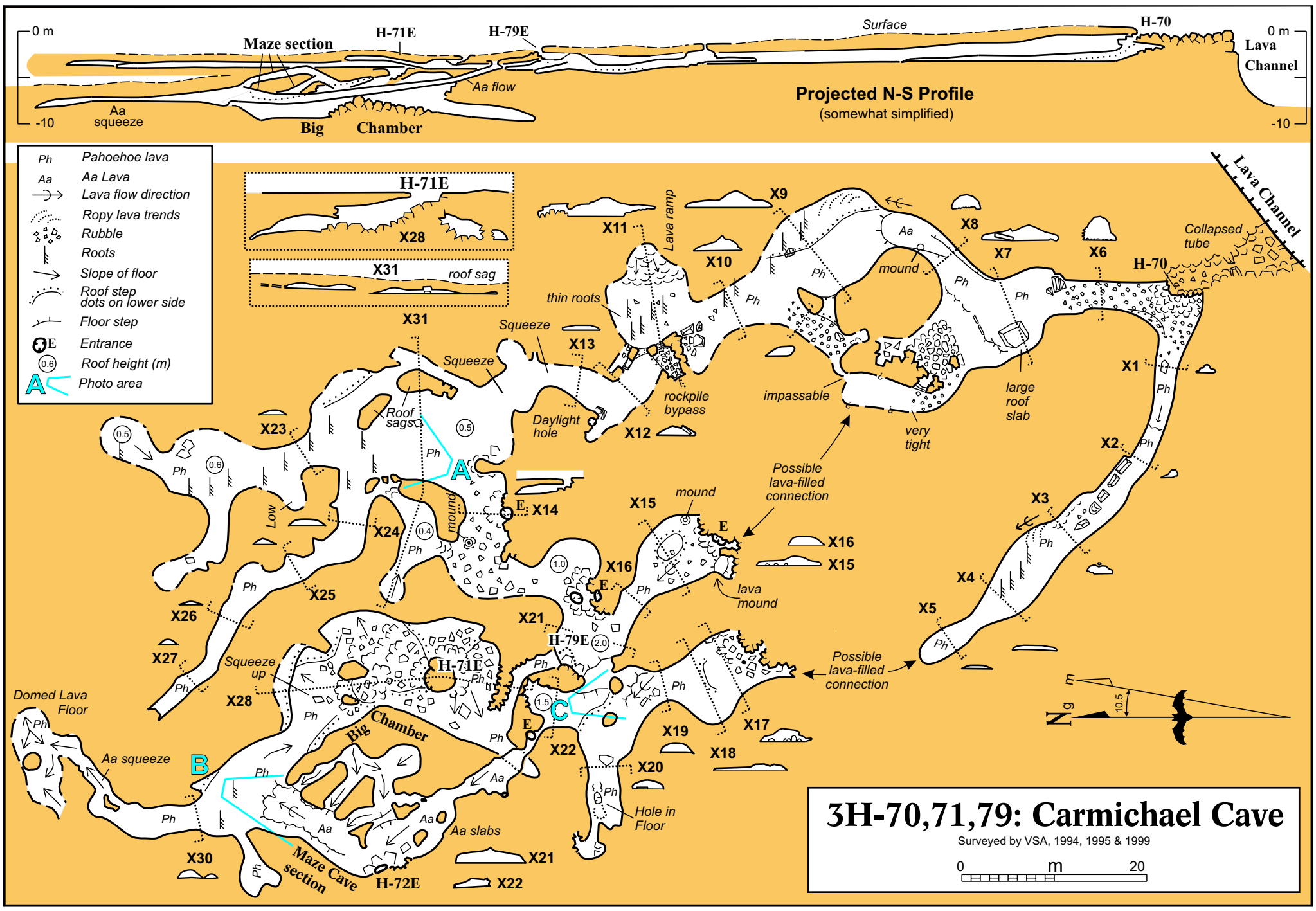
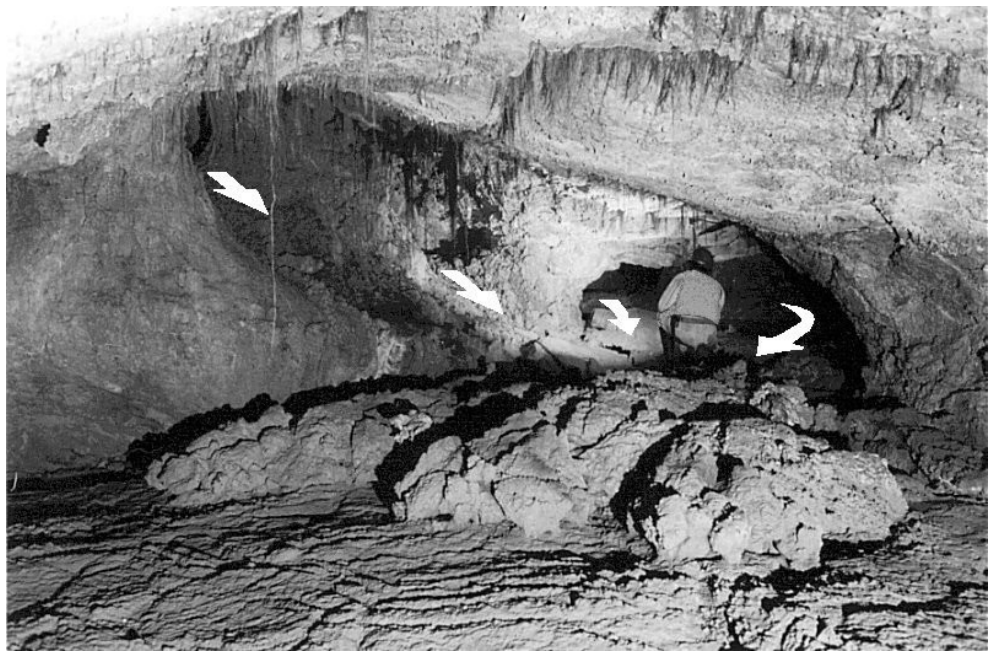


Photo B: Maze section: Aa flow invading from higher levels (arrows)



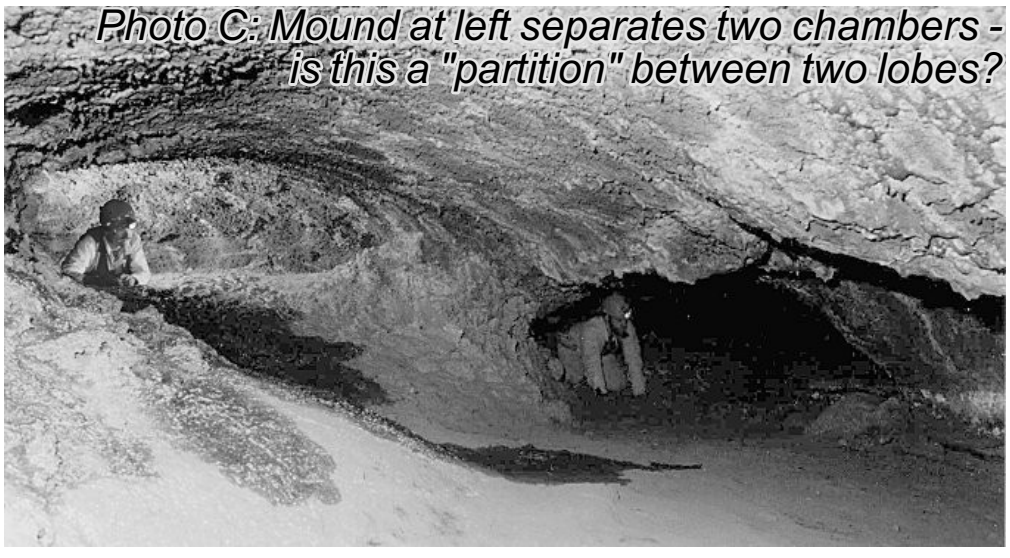


Photo C: Mound at left separates two chambers - is this a "partition" between two lobes?