

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 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 rubblely aa.

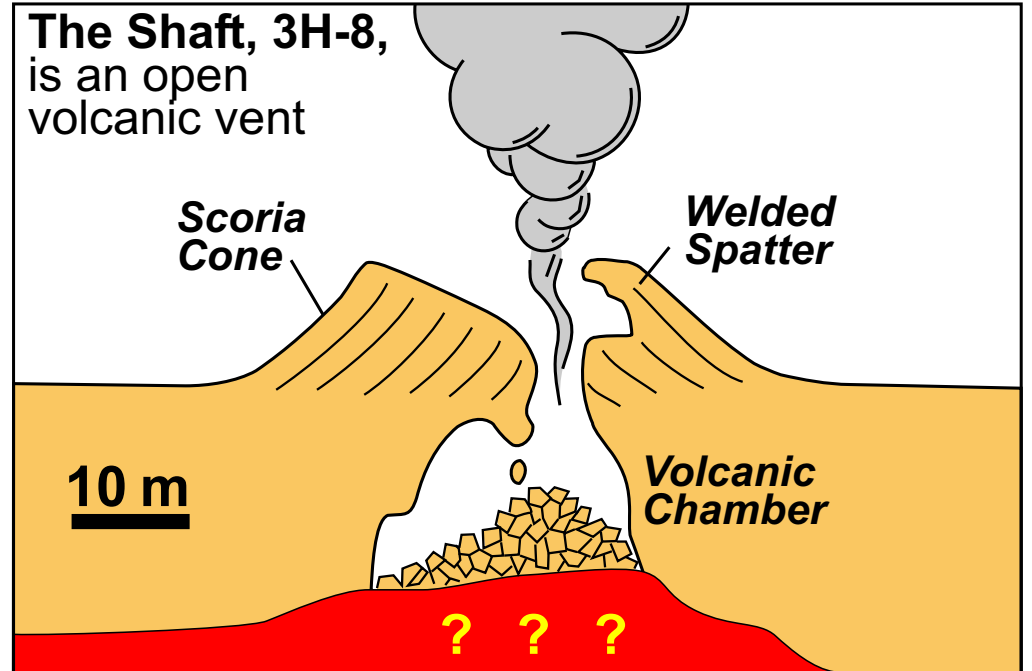
Behind the advancing front the liquid flow becomes concentrated into linear streams: either surface channels or in tubes and chambers beneath the crust. The surface channels may later crust over to form tubes.

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



A typical small, cylindrical, lava tube.

The Shaft, 3H-8, is an open volcanic vent



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. Hon et al, 1994), see panel 3 .

Open Volcanic Vents are a rare type of cave formed by the draining of the lava back into the source vent (figure above). Caves can also form in tectonic fissures.

Weathering of ash and lava can also form secondary caves.

References

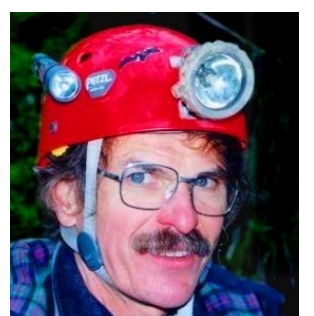
Hon, K., Kauahikaua, J., Denlinger, R., & Mackay K., 1994: Emplacement and inflation of pahoehoe sheet flows: Observations and measurements of active lava flows on Kilauea Volcano, Hawaii. *Geological Society of America, Bulletin*. **106**: 351-370.

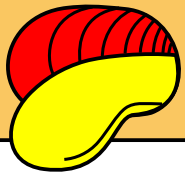
Peterson, D.W., Holcomb, R.T., Tilling, R.I., & Christiansen, R.L., 1994: Development of lava tubes in the light of observations at Mauna Ulu, Kilauea Volcano, Hawaii. *Bulletin of Volcanology*, **56**: 343-360.

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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 downstream. 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

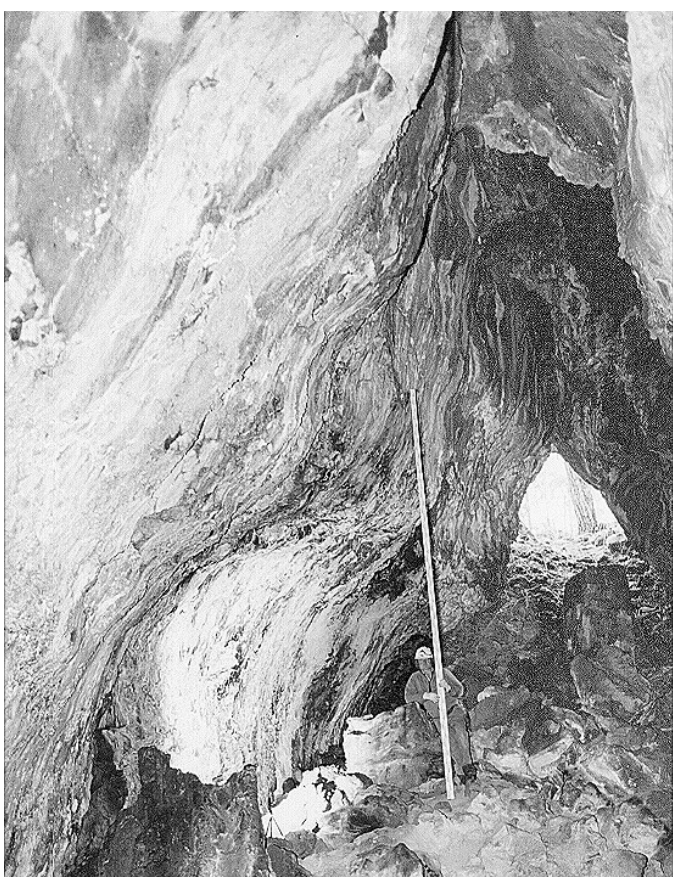
Overflow or spatter builds levees that arch over the channel and eventually join as a roof.

Mainly found with fluctuating or rapid and turbulent flows.

Subsequent evolution.

In all three cases, later overflows through sky-lights may thicken the roof from above.

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

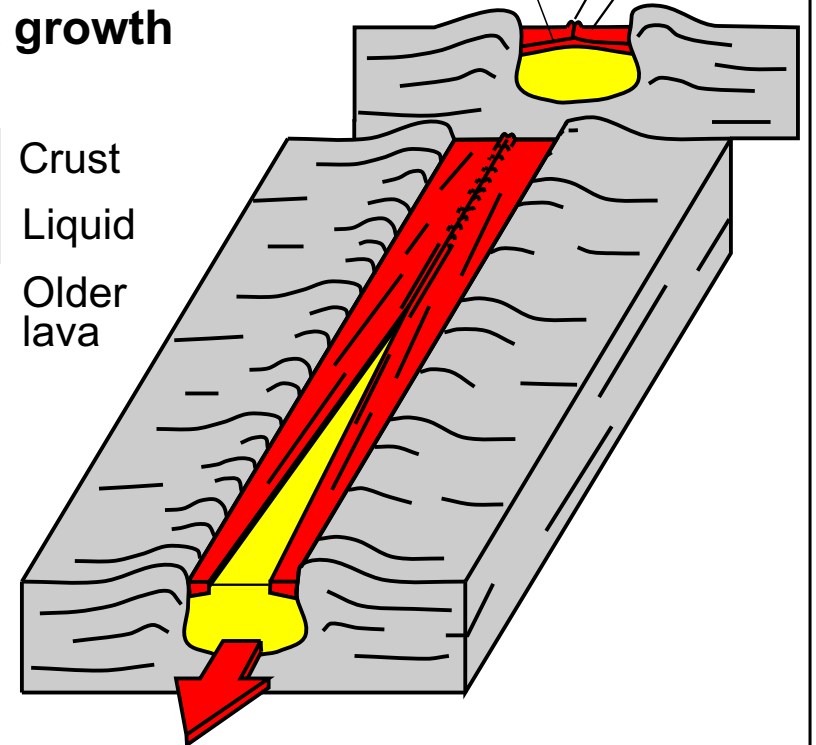
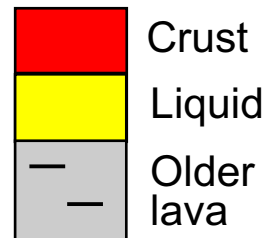


The angular, "gothic", roof of this tube is typical of ones formed by levee overgrowth. (c.f. Figure C →)

5 m staff.

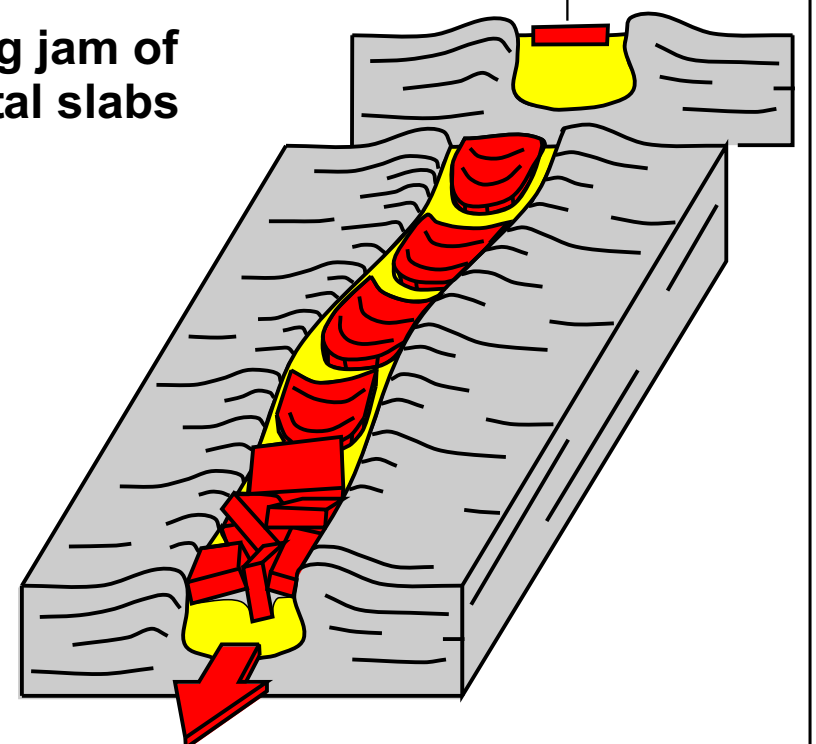
A: simple crust growth

Additional coating beneath median ridge crust adds strength



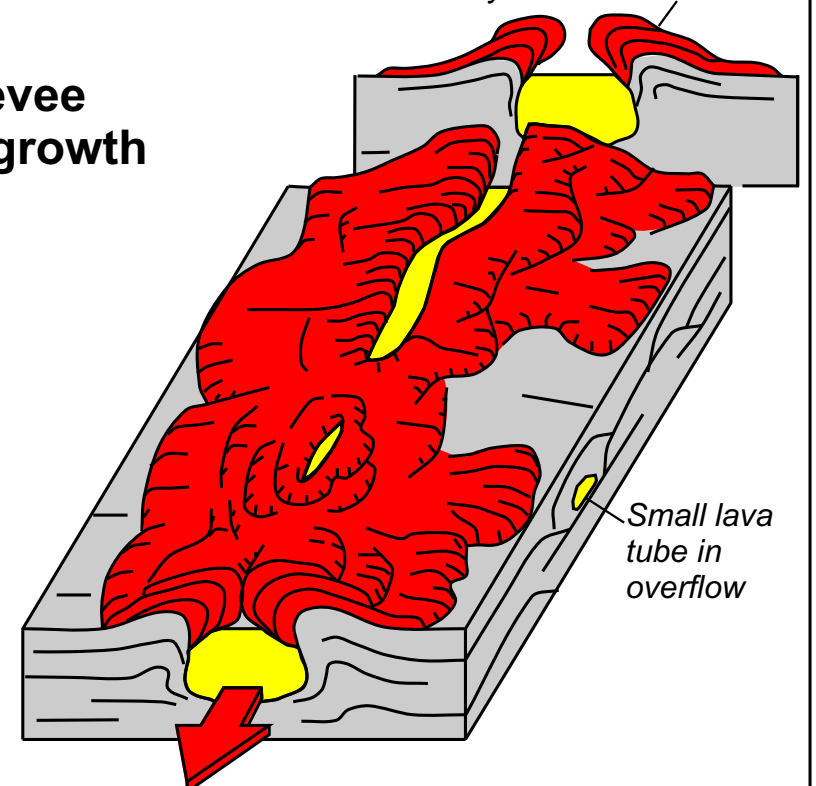
B: log jam of crustal slabs

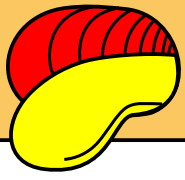
floating crustal slabs



C: Levee overgrowth

Thin layers of levee walls





Lava Tube Formation

Sub-crustal Drainage

Sub-crustal Lava Caves

A newly-formed lava flow quickly develops a crust, which may be inflated upwards.

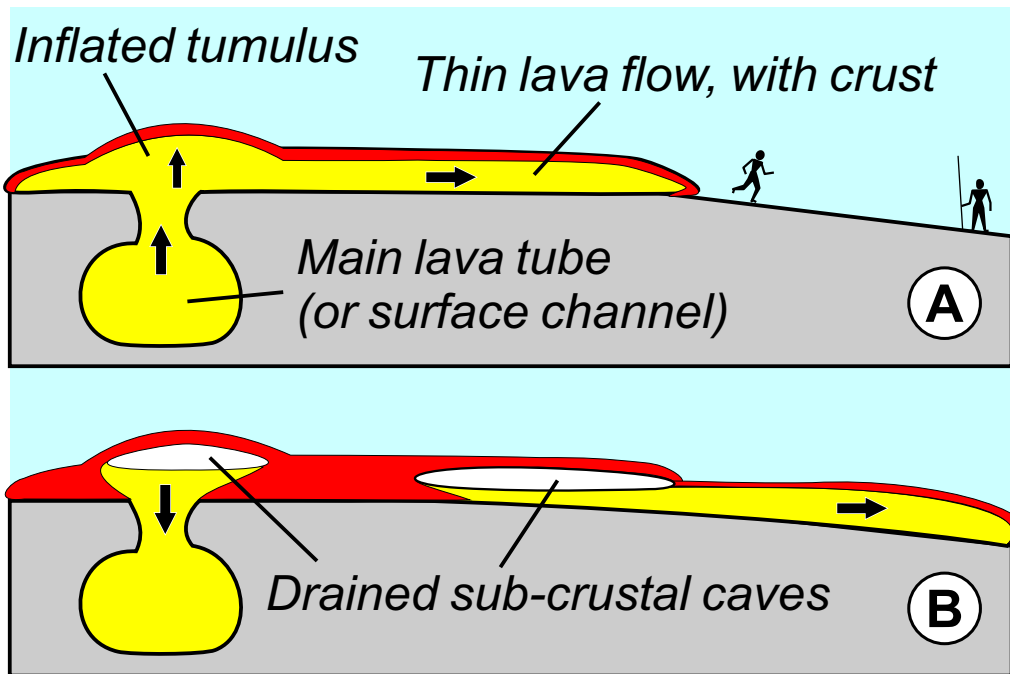
Later drainage of liquid lava from beneath the crust can form small shallow caves.

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

Ongoing flow becomes concentrated into a few "master" tubes.

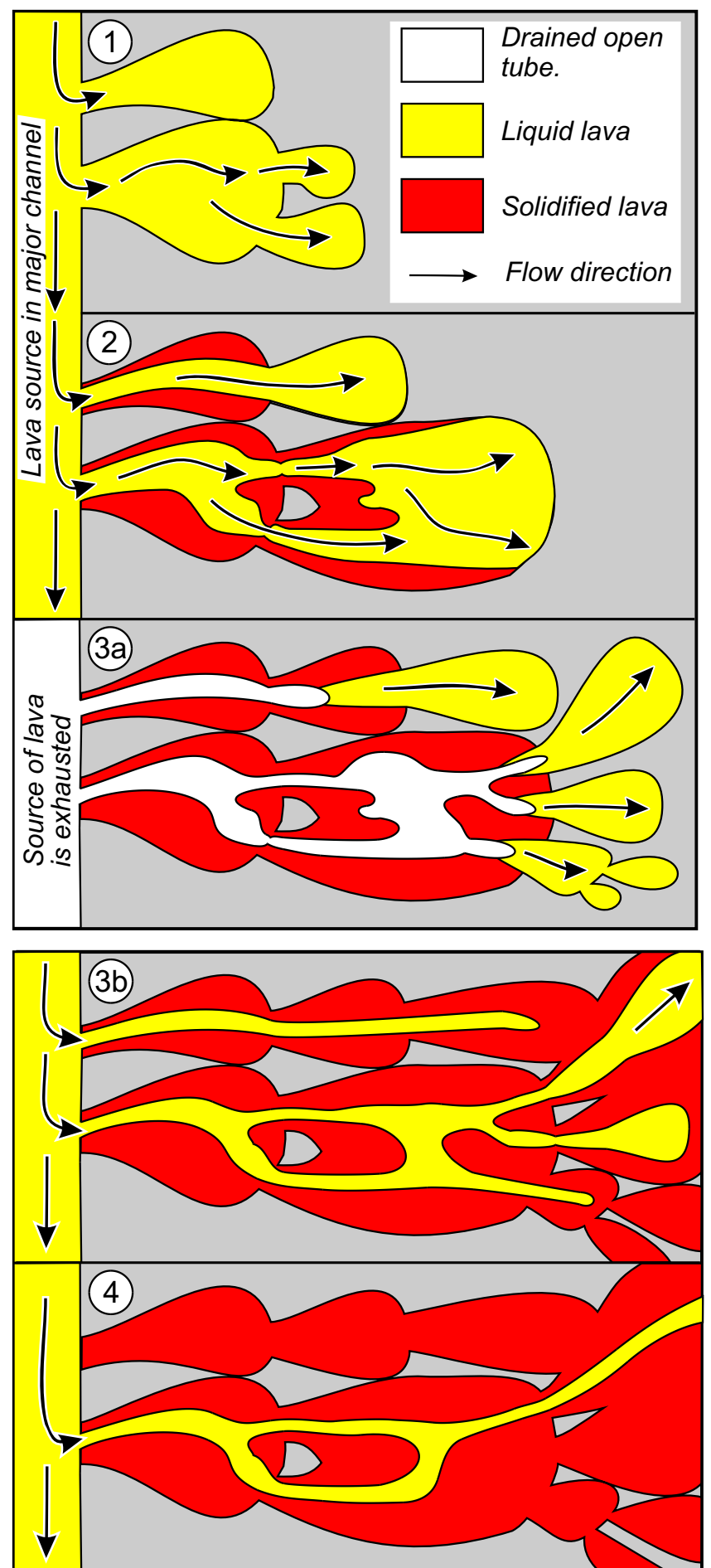


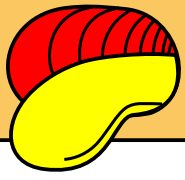
A low chamber in a drained sub-crustal lava cave



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 →).
- ▶ 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 passages (3a →).
- ▶ However, if fresh hot lava continues to be delivered from the volcano (3b →) the sub-crustal flow may become concentrated into linear tubes that feed the advancing lobes, while the surrounding stagnant areas slowly solidify (4 →).
- ▶ The evolving "master" tube can enlarge by erosion of its walls - destroying evidence of its initial mode of formation.





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Formations within Lava Tubes

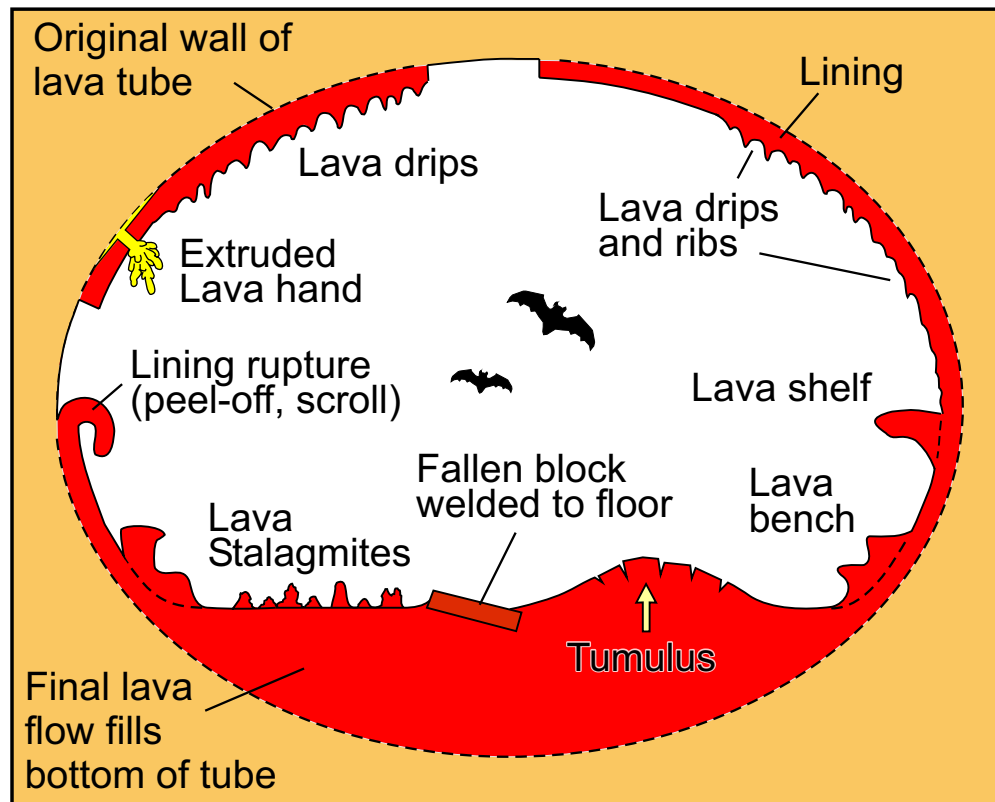
Contents of Tubes

- ▶ Lava caves have a distinctive suite of lava structures.
- ▶ As lava drains from the tube it leaves linings on the walls which can drip, run or peel to form other formations.
- ▶ The fluctuating lava flows through the tube may leave "tide-marks" on the walls.
- ▶ Various flow structures can form on the lava floor.



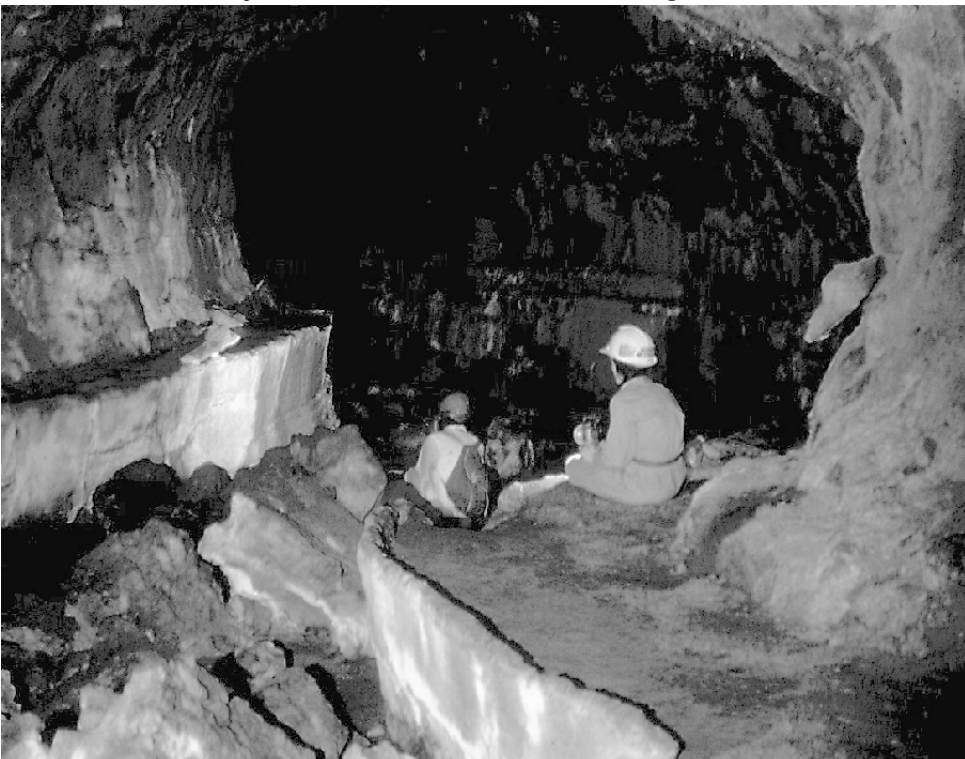
A burst lining, sagged away from the wall

Extruded lava hands and fingers with a stalagmite below.



Lava drips & ribs on a wall

Benches left by an old lava stream through a tube



Some Lava Formations

- ▶ Most tubes have linings on the walls. These may drip or run down the walls. Or burst to leave pockets, or peel off to form scrolls.
- ▶ Burst bubbles may form a sharp hackly surface.
- ▶ Benches & shelves may form at old lava "tide marks" on the base of the walls. Some may reach across the tube to form a false floor or "tube-in-tube".
- ▶ Liquid lava trapped behind the linings may ooze out through holes to form lava "hands", "turds" or "straws".
- ▶ If the floor is already solid (unusual) then drips from above may form stalagmites.