EFFUSIVE ERUPTIONS

Laura Pioli

Effusive eruptions

- The degassed magma (LAVA) is not or poorly fragmented at the vent. It then accumulates above it or it flows away.

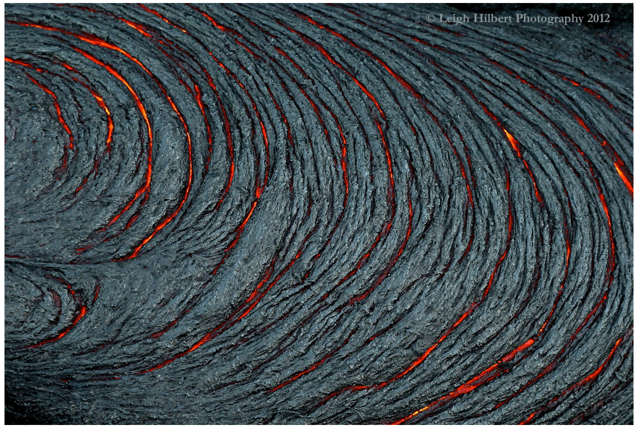
Big Island, Hawaii, 2014

Novarupta dome, Alaska, 1912

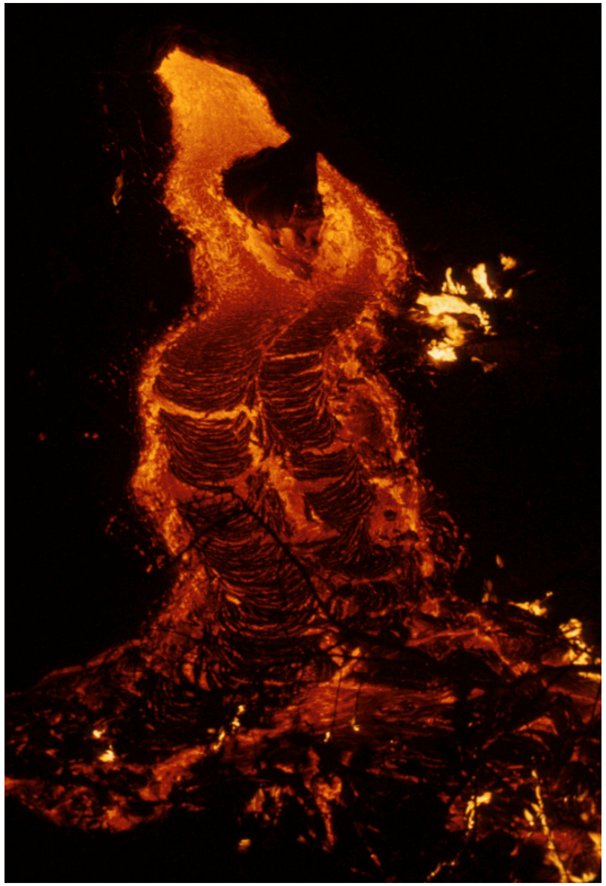
Lava flows

- Pahoehoe

Lava with a ropelike surface texture due to partial cooling as the lava flowed. Relatively hot, low viscosity lava

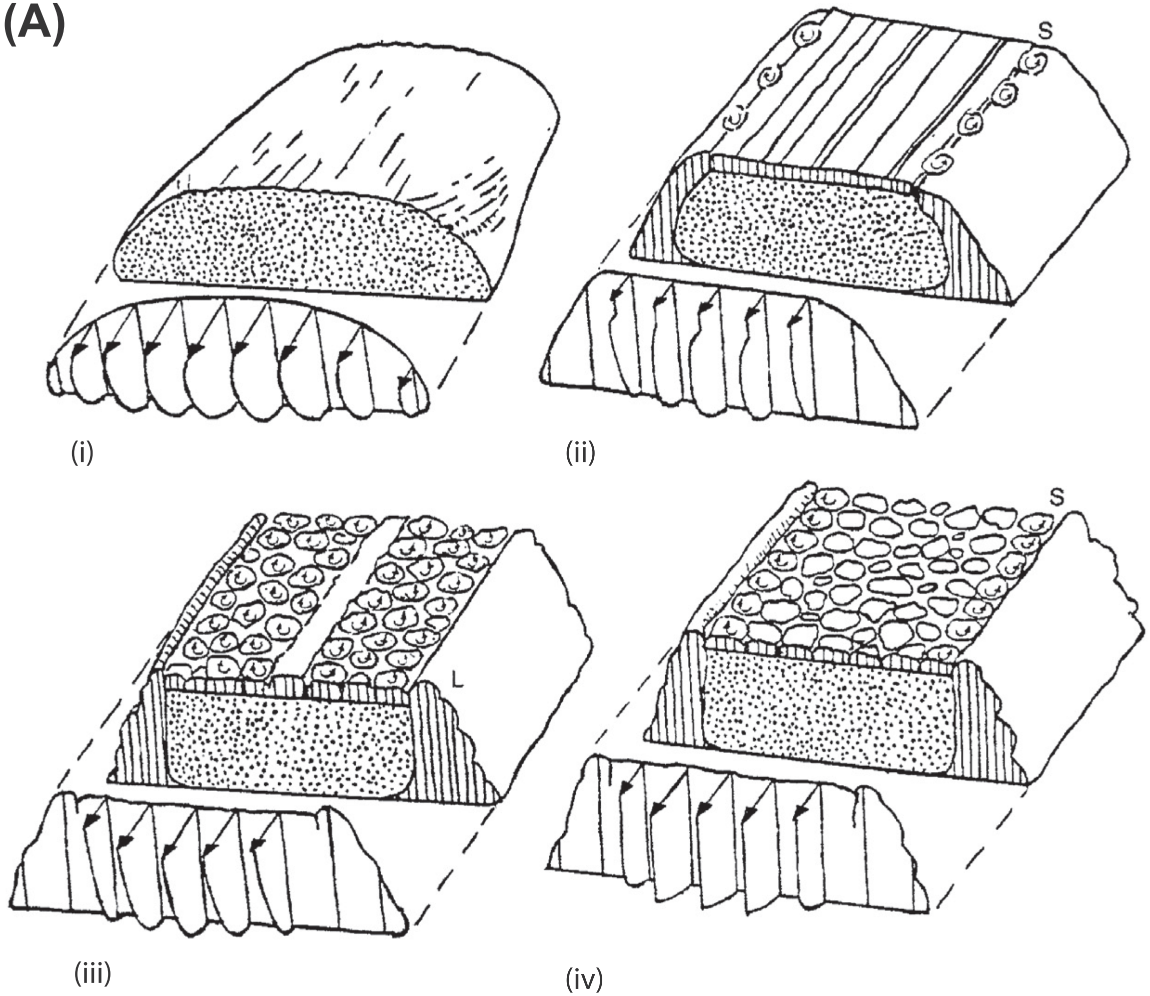


It has a shiny, smooth, glassy surface. It tends to be more fluid (lower viscosity), hence flows more quickly and produces thinner flows (typically 1-3 m).



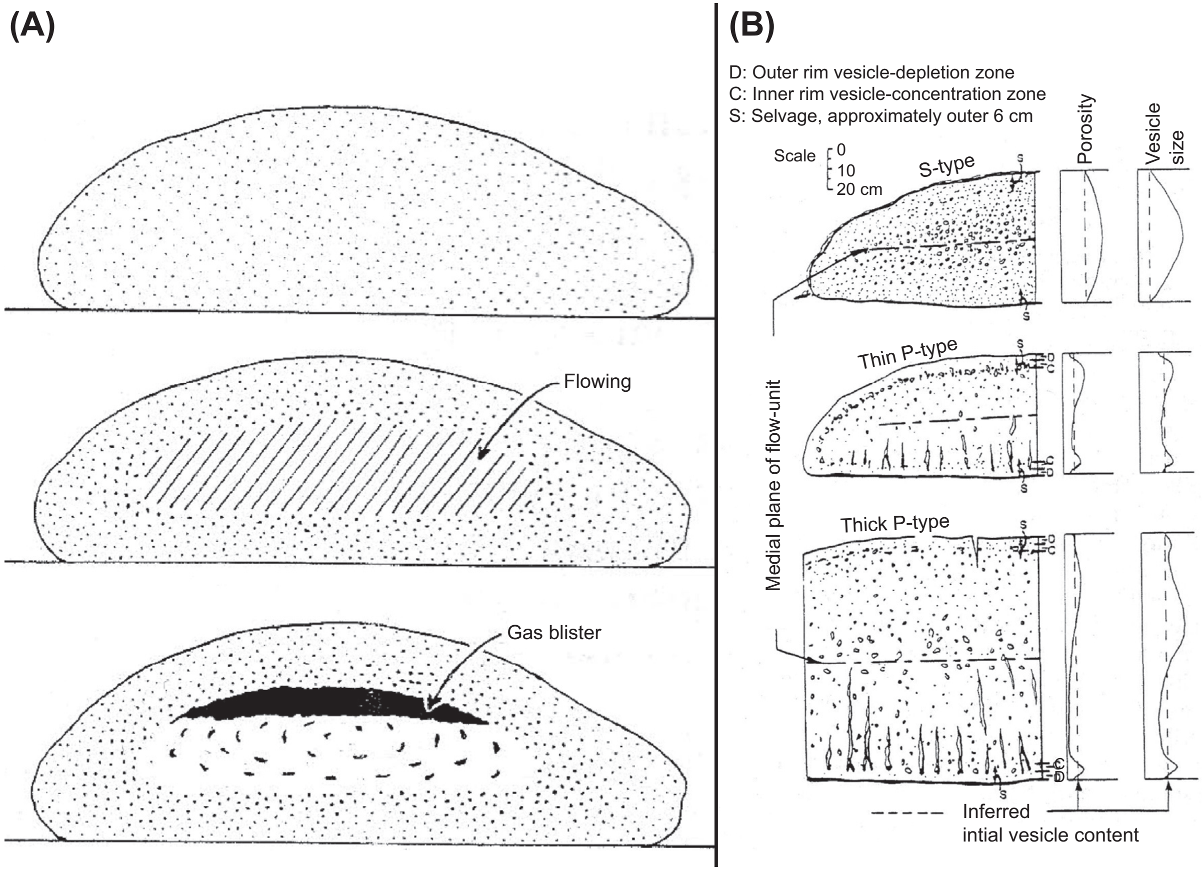
Pahoehoe flows

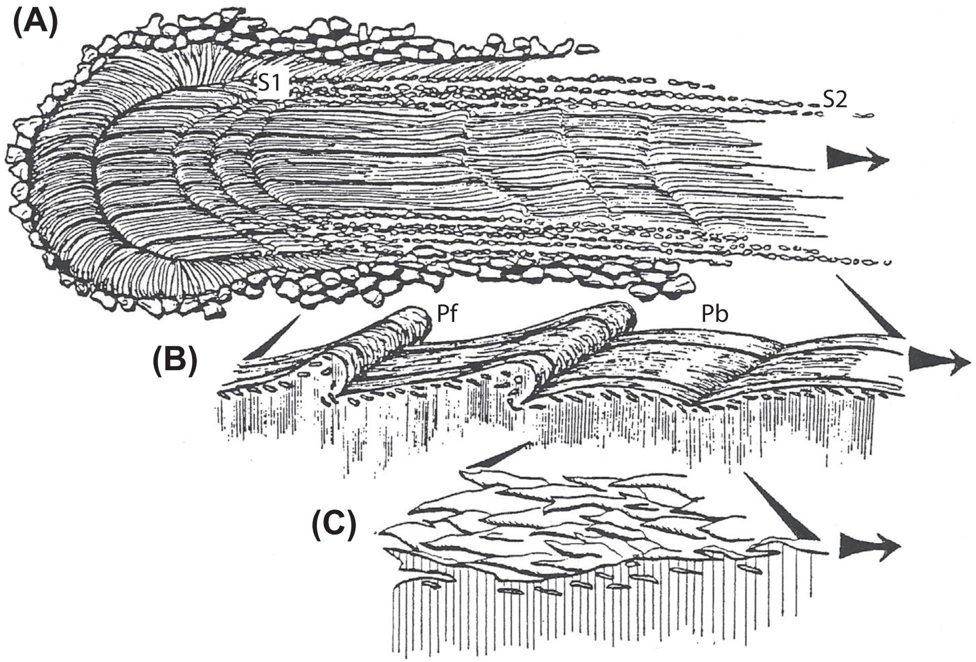
(A)



Rowland and Walker, 1987

Pahoehoe flows





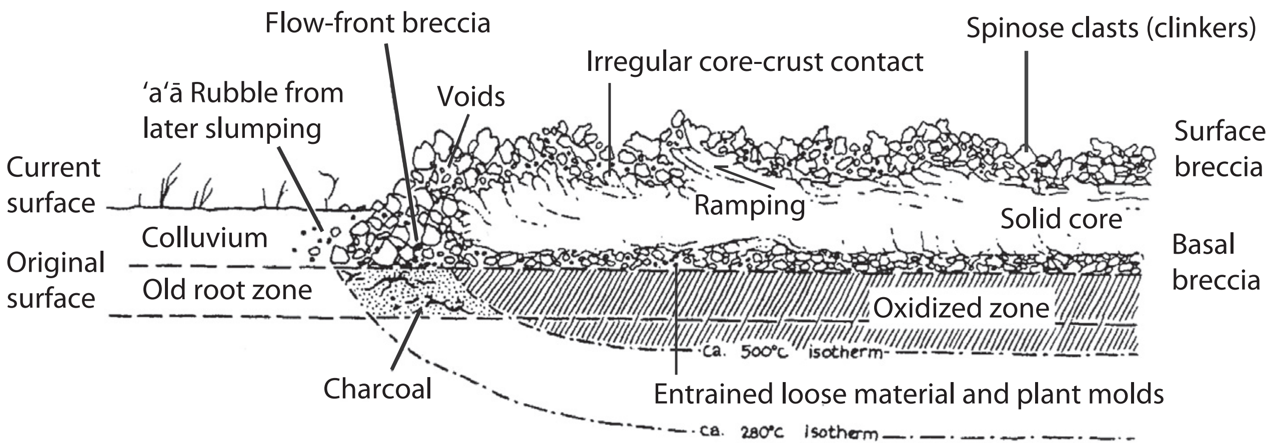
Rowland and Walker, 1987

Lava flows

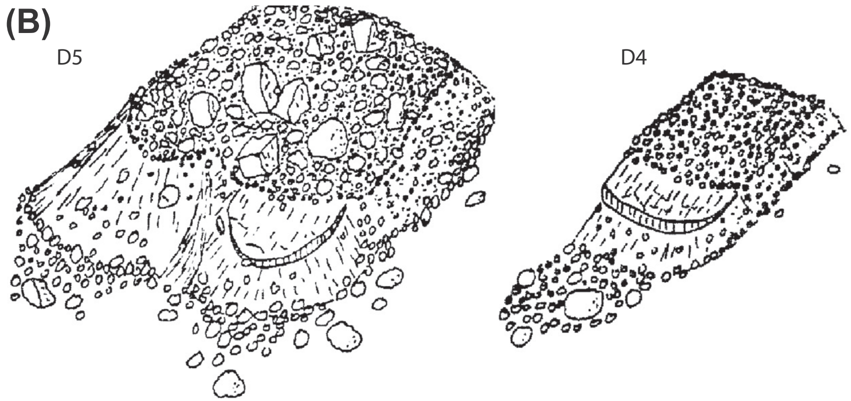
- Aa
- Blocky, rough lava flow. Due to high viscosity lava that flowed pushing chunks of solid and semi-solid blocks.

It is a rubbly flow, with a molten core, with higher viscosity (but same composition) which, therefore, tends to move more slowly and produce thicker flows (typically 3- 20 m).

AA flows



Lockwood and Lipman, 1980



Rowlands and Walker, 1987

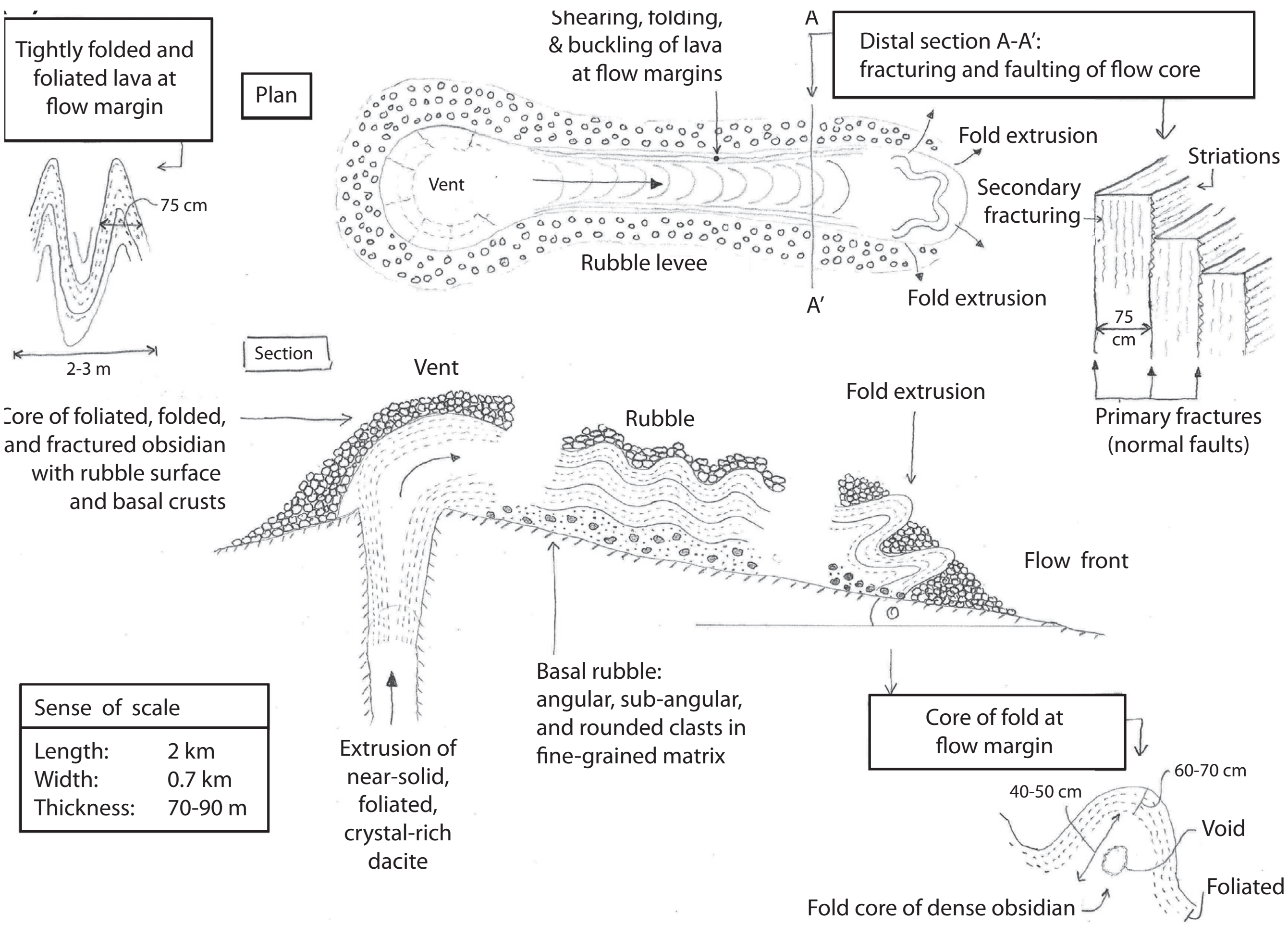
Lava flows

- Blocky
- Larger blocks more viscous material.

Block lava flow, SP Crater, San Francisco Volcanic Field, Arizona

It is similar to Aa, but even thicker (>20 m), with a blocky rather than rubbly surface. Andesites, dacites and rhyolites tend to form blocky flows.

Blocky Lava



Hall, 1978

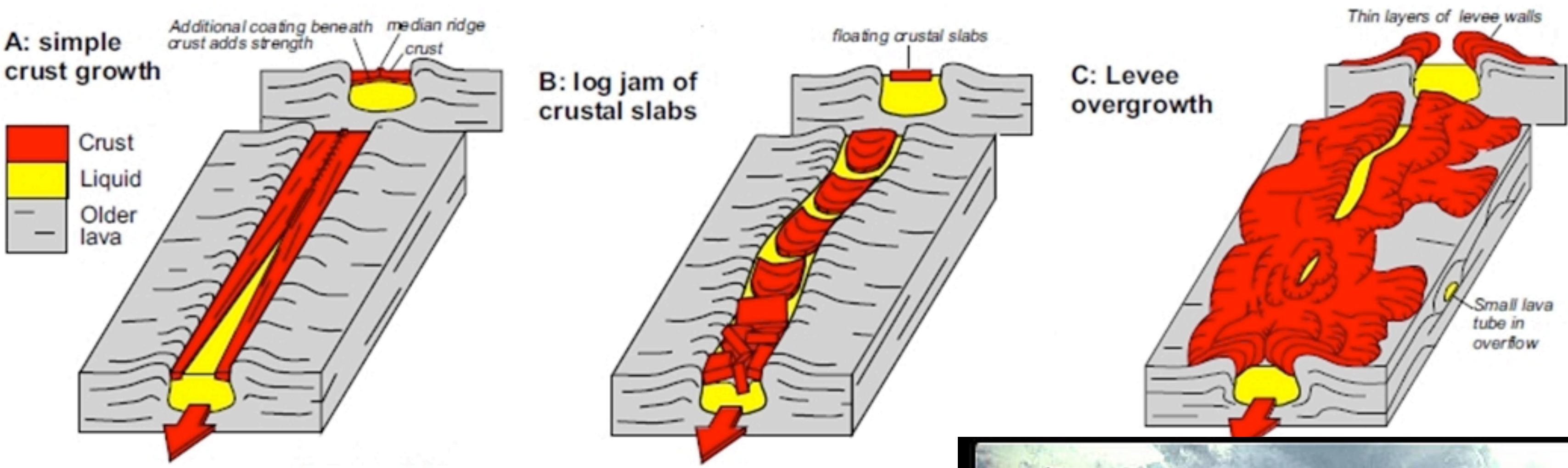
Lava flows

- Pillow
- Submarine flow. Lava is rapidly chilled at the contact with seawater.

The flows have bulbous, spherical, or tubular shapes. A thick crust form on all sides of the pillow lobe, and prevents coalescence into a sheet.

Lava structures

Levees, channels and tunnels



Lava structures

Hornitos

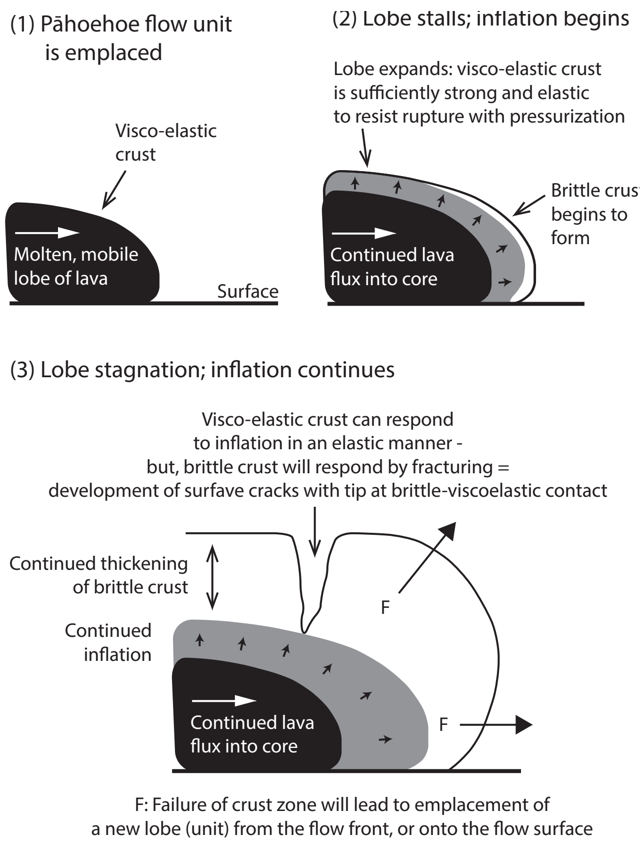
Skylight

Lava structures

Ephemeral vents

Tumuli and blisters

Lava structures



Tumuli formation and propagation of the flow

Calvari and Pinkerton, 1998

Rheology and flow dynamics

Lava properties depends on its composition, crystal content and temperature

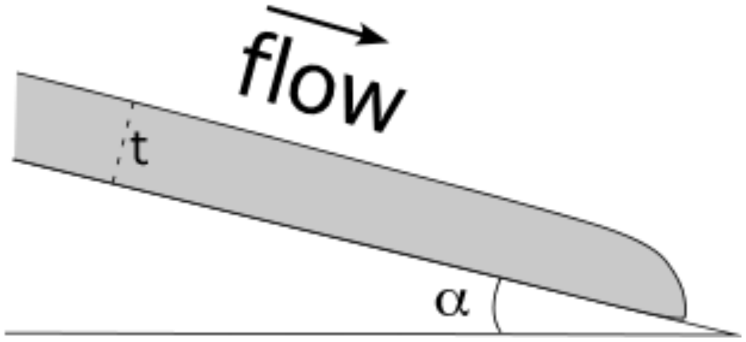
When its T is above the liquidus temperature (no crystals are present) it behaves as a NEWTONIAN fluid

When its T is between liquidus and solidus temperatures it behaves as a NON NEWTONIAN fluid

Rheology and flow rate

For a Newtonian lava in a channel:

$$V = \frac{\rho g t^2}{3\eta}\sin(\alpha)$$



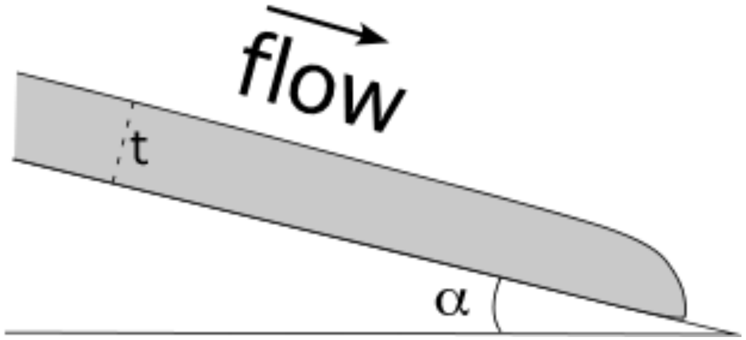
With ρ= lava density
η=lava viscosity
α=slope angle
g=gravity
t= flow thickness

The lower the viscosity the faster the flow!

Jeffreys, 1925

Rheology and flow rate

For a Newtonian lava in a open topography (larger than thick):



$$V = \frac{\rho g t^2}{8\eta}\sin(\alpha)$$

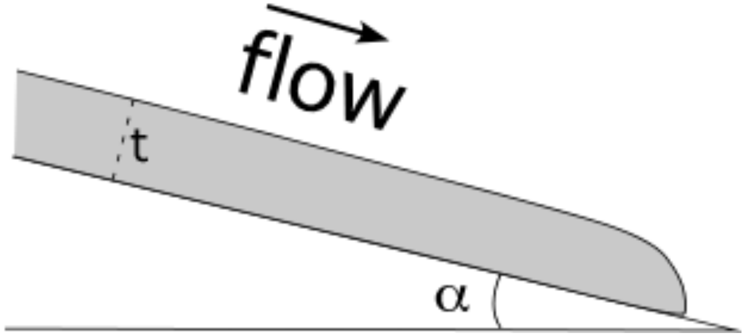
With ρ= lava density
η=lava viscosity
α=slope angle
g=gravity
t= flow thickness

The lower the viscosity the faster the flow!

Jeffreys, 1925

Rheology and flow rate

For a Bingham lava:



$\Gamma = dg\rho \sin(\alpha)$

$$t_0 = \frac{\Gamma_0}{\rho g \tan(\alpha)}$$

With ρ= lava density
α=slope angle
t_0 = minimum flow thickness
Γ=shear stress
Γ_0 =yield strength

The higher the thickness the higher the yield strength!
The critical thickness depends also on substrate slope!

Rheology and flow rate

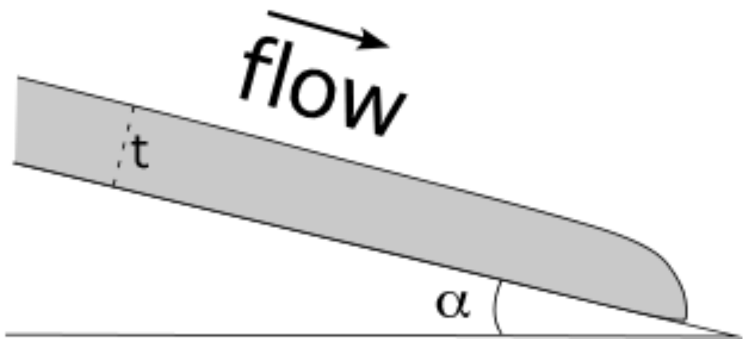
For a Bingham lava:

In an open topography

$$\overline{v} = \left(\frac{r^2 \rho g \sin(\theta)}{8\eta}\right)\left(1 - \frac{4}{3}\frac{\tau_0}{\tau} + \frac{1}{3}\left(\frac{\tau_0}{\tau}\right)^4\right)$$

In a channel

$$\overline{v} = \left(\frac{d^2 \rho g \sin(\theta)}{3\eta}\right)\left(1 - \frac{3}{2}\frac{\tau_0}{\tau} + \frac{1}{2}\left(\frac{\tau_0}{\tau}\right)^3\right)$$

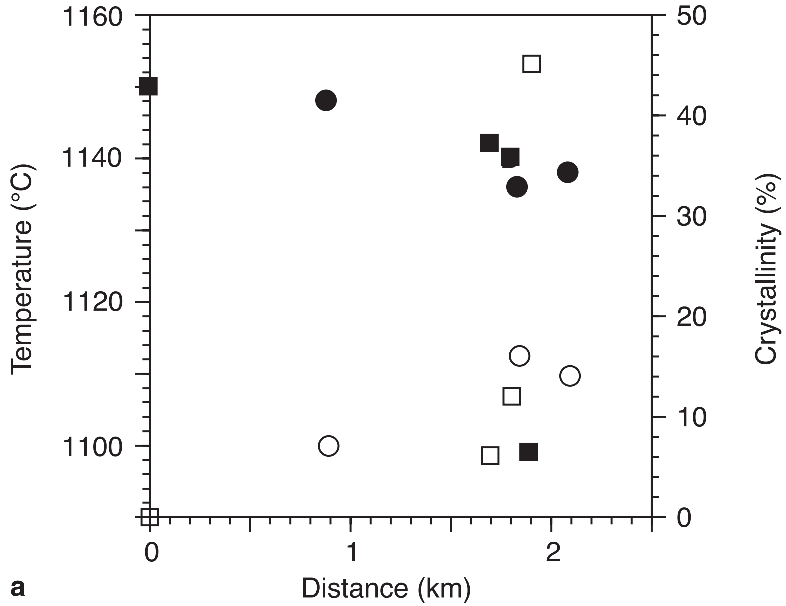


With η= lava viscosity
α=slope angle
t_b =real flow thickness

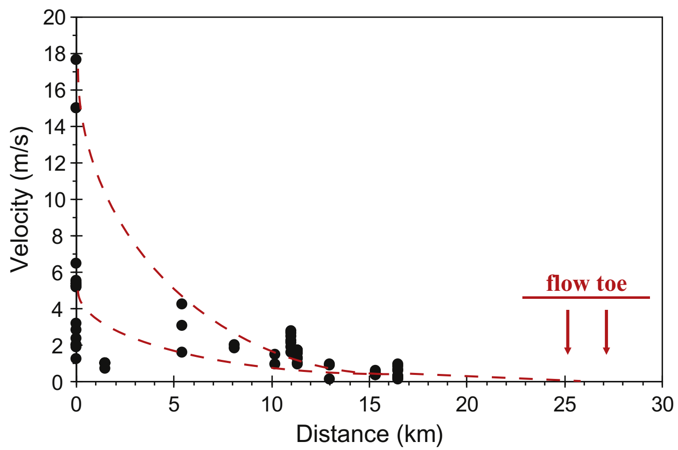
Moore (1987)

Effect of cooling and crystallization

Kilauea volcano, 1997



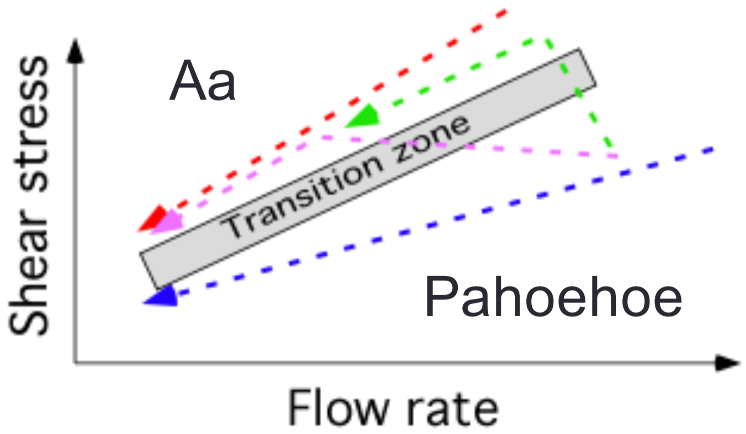
Mauna Loa, 1984



Cashman et al., 1999

Lipman and Banks, 1987

Transition from aa to pahoehoe



Lava flows can start and end with a specific structure depending on their rheology, but can also transform due to cooling, crystallization (which change viscosity) or slope change