

ERTH 456 / GEOL 556
Volcanology

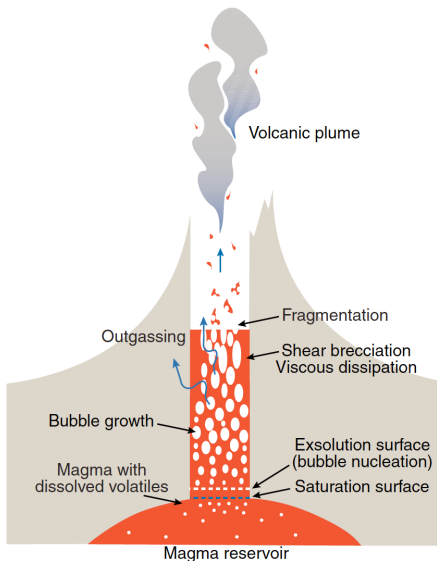
– Lecture 07: Effusive Eruptions –

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hours: TR 3-4PM or appt.

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What happens once magma makes it to the surface?

Volcano Anatomy



Gonnermann & Manga, 2007

How do we get an effusive eruption?

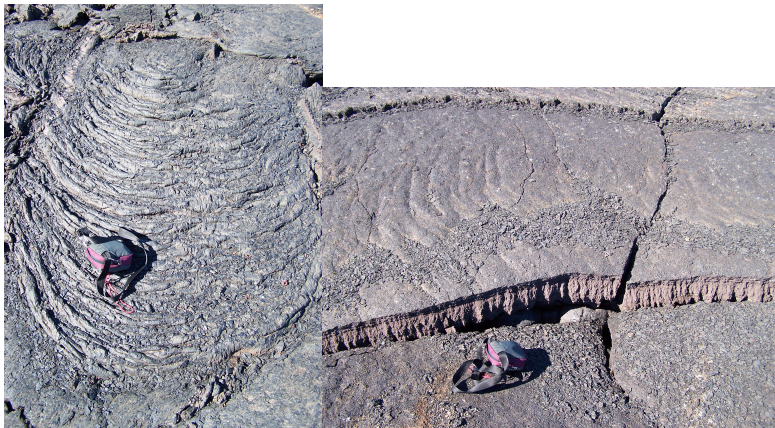
- magma degassing faster than rate of magma ascent -> no fragmentation
- can be fast ascent of H_2O -poor magma
- can be slow ascent of H_2O -rich magma accompanied by gas loss



USGS, 2016

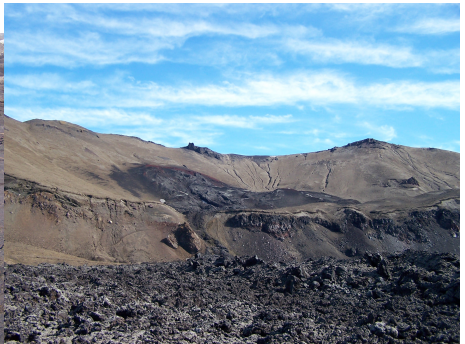
- individual flow volumes 10^0 - $10^{2...3}$ km³
- variability of flow morphology, surface textures, dimensions, structures reflects emplacement conditions
- very different behavior for mafic vs. silicic flows

Comparisons



R. Grapenthin

Comparisons



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Comparisons



USGS, W. v. Norden

Mafic Flows

Examples: Hawai'i (H_2O -poor), Etna (H_2O -rich)



Grapenthin, G. Solferino

- **Hawaiian** lava near liquidus temperatures, cools rapidly during flow, develops crust
- flow rates and advance mechanisms controlled by:
 - development of crust on flow surface
 - cooling induced crystallization in interior
- lava flows from **water-rich** magmas: higher viscosity, slower, shorter than Hawaiian flows
- syneruptive crystallization due to volatile loss
- **both** show pahoehoe and 'a'a morphologies

Lava Flows

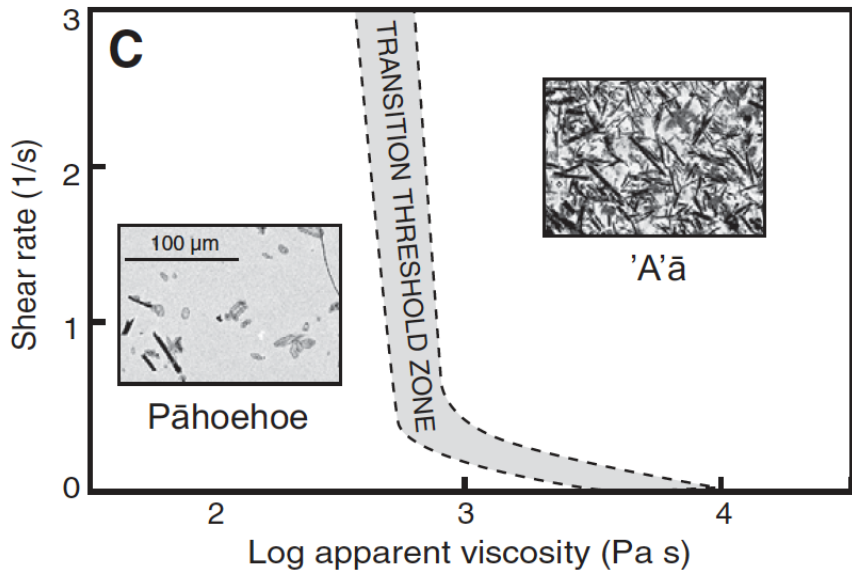
- flow lengths are limited by erupted volume or cooling
- when cooling limited: lengths are proportional to extrusion rate (may not work all the time, Hawaii)
- higher effusion rate: faster advancement of flow
- flow advance rate diminishes with distance from vent
- can create levees
- lava field / compound flow: many individual lava lobes, e.g. Pu'u 'O'o flow field
- lava flow hazards determined by: distance from vent & rates of effusion
- This hazard assessment is challenging! Also depends on terrain:
<https://www.youtube.com/watch?v=eYOIPi1TN0Y>

Pahoehoe vs. 'A'a



R. Grapenthin

Pahoehoe vs. 'A'a

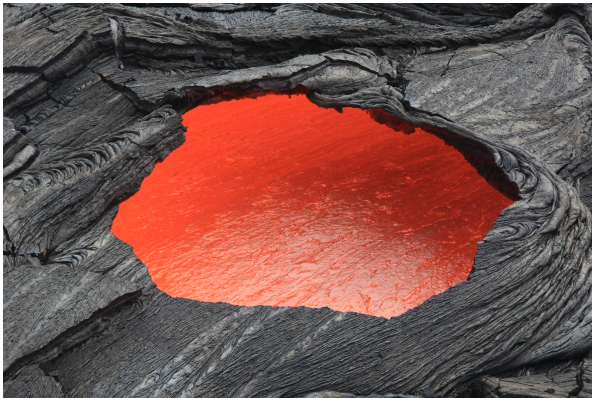


kilauea_lava_flow_2016.mp4

kilauea_aa_2016.mp4
kilauea_channel_aa_2016.mp4
kilauea_channelized_flow_2016.mp4

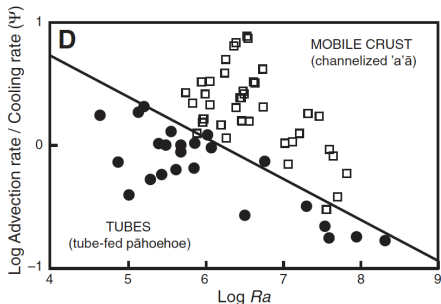
Lava Tubes

- form where roof solidifies, feed Pahoehoe flows
- lava has low thermal conductivity: insulates tubes, allows for long transport
- important: flow inflation, Hawaiian flows inflate from cm to meters:
<https://www.youtube.com/watch?v=myxTc32foGs>
- when flow rate drops, tubes can drain, roof can collapse



Lava Tubes vs. Mobile Crust

- Ra: Rayleigh number, dimensionless, expresses natural convection, below a threshold heat transfer mainly conductive
- high cooling rates compared to flow advance: tubes form
- rapid flow advance: crust breaks, interior cools rapidly, 'a'a flow is formed



Cashman & Sparks, 2013

Silicic Flows

- degassing and crystallization increase viscosity (orders of magnitudes!!)
- lava dome morphology controlled by magma ascent rate
- rapid ascent retains volatiles and limits crystallization: obsidian flows (e.g., Newberry)
- density of obsidian requires gas loss through permeable foam or wall rock



Newberry Obsidian flow, Internet

Silicic Flows

- slow ascent: degassing and crystallization make non-Newtonian rheology
- extreme cases: flow solidifies, extrudes as rigid spine (Mt. St. Helens)
- large range of morphologies: pancake dome - spine explained by effusion rate
- St Helens Dome Growth:

<https://www.youtube.com/watch?v=h6B1myUKAS4>



W. v. Norden