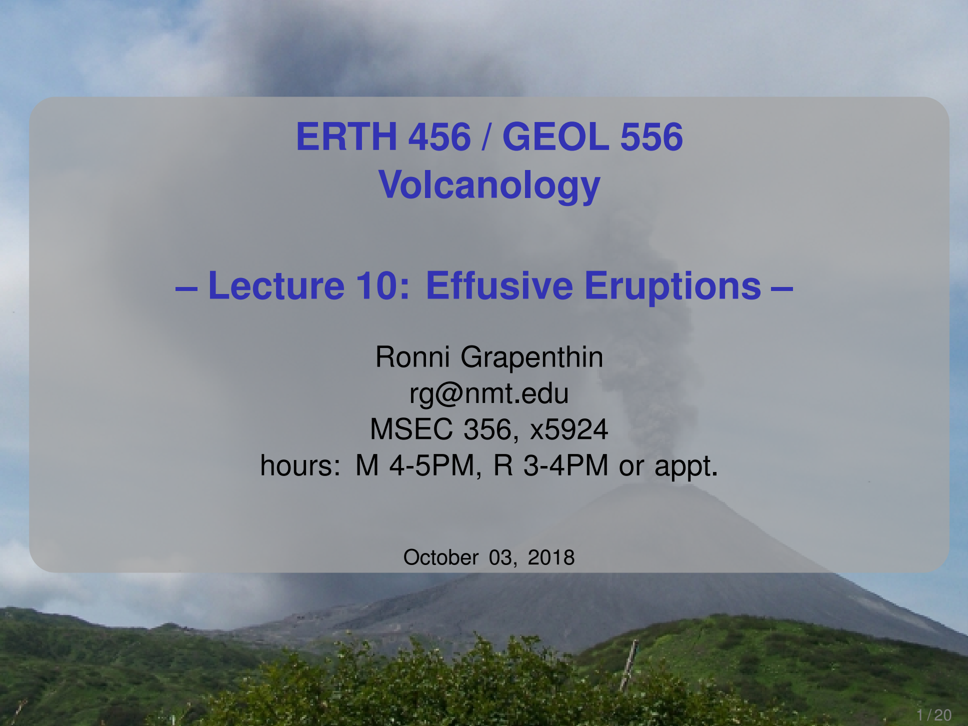


ERTH 456 / GEOL 556
Volcanology

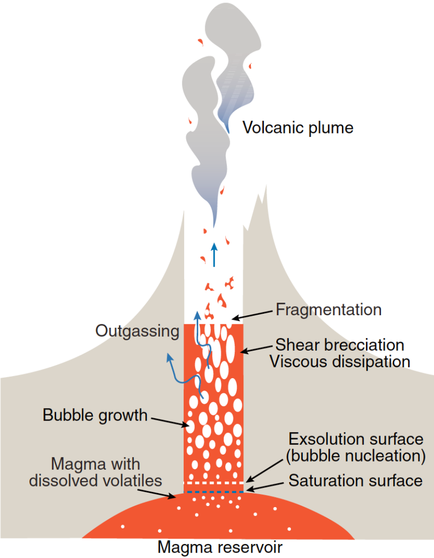
– Lecture 10: Effusive Eruptions –

Ronni Grapenthin
rg@nmt.edu
MSEC 356, x5924
hours: M 4-5PM, R 3-4PM or appt.

October 03, 2018

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 OR few volatiles -> 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

How do we get an effusive eruption?

- magma degassing faster than rate of magma ascent OR few volatiles -> no fragmentation
- can be fast ascent of H_2O-poor magma
- can be slow ascent of H_2O-rich magma accompanied by gas loss
  - How do we get slow ascent?

USGS, 2016

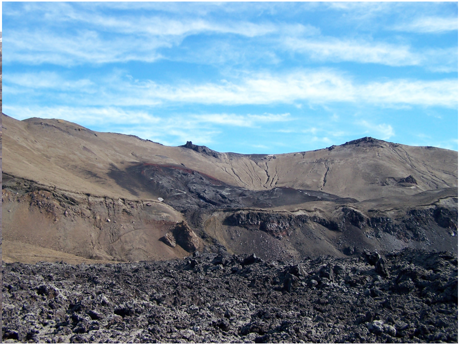
Basics

- individual flow volumes 10^0-$10^{2\ldots3}$ km^3
- variablity of flow morphology, surface textures, dimensions, structures reflects emplacement conditions
- very different behavior for mafic vs. silicic flows

Comparisons

R. Grapenthin

Comparisons



R. Grapenthin

Comparisons


USGS, W. v. Norden

Mafic Flows

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


Grapenthin, G. Solferino

Mafic Flows

- **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

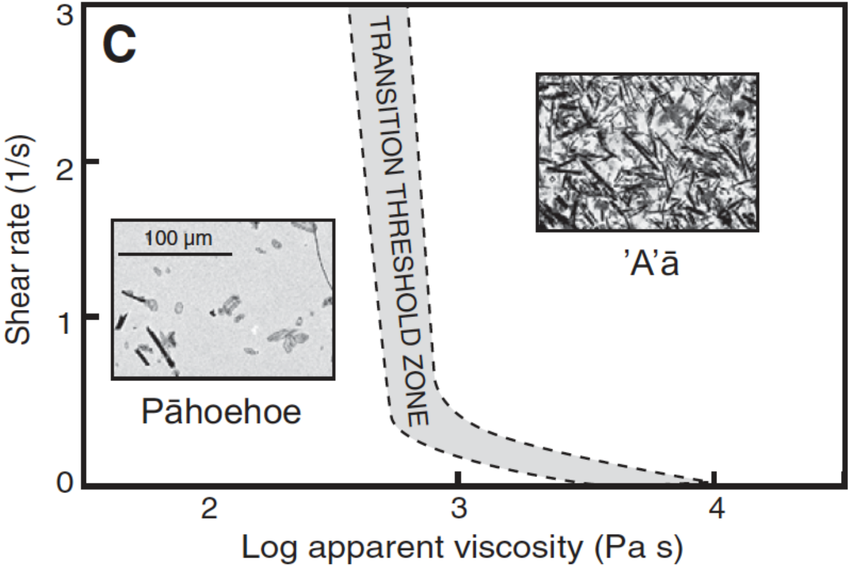
Lava Flows

- 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



Cashman & Sparks, 2013

Pahoehoe

kilauea_lava_flow_2016.mp4

'A'a

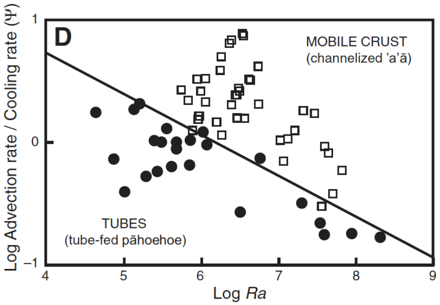
kilauea_aa_2016.mp4
kilauea_channel_aa_2016.mp4
kilauea_channelized_flow_2016.mp4

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