ERTH 456 / GEOL 556
Volcanology

– Lecture 03: Types of Volcanism and Development of Storage Systems–

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hours: M 4-5PM, R 3-4PM or appt.

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Types of Volcanism

- mafic
- intermediate / silicic

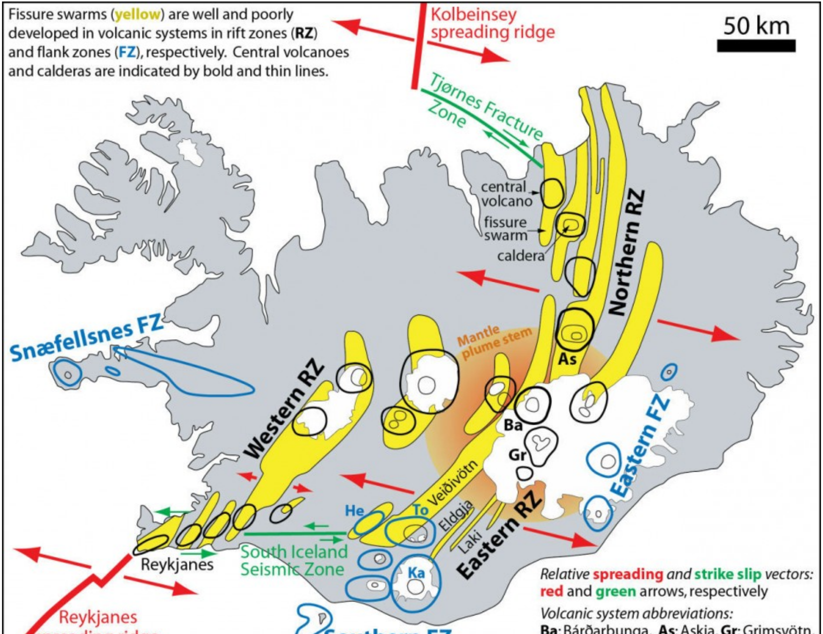
Mafic Volcanism

- great variations in shape and construction
- can be highly explosive!
- shield volcanoes (Mauna Loa): successive lava flows, low slopes
- steep-sided cones (Kliuchevskoi): higher volatile content
- fissure volcanoes (Iceland, rift systems) (w/ central subsidence caldera)
- tuya volcanoes (subglacial / shallow marine)
- mid-ocean ridges
- fields of monogenetic volcanoes (Cinder Cones): regions of extension / transtension, gas escapes first often ended with lava flow

Mafic - Shield Volcano - Mauna Loa

Mafic - steep sided cones - Kliuchevskoy

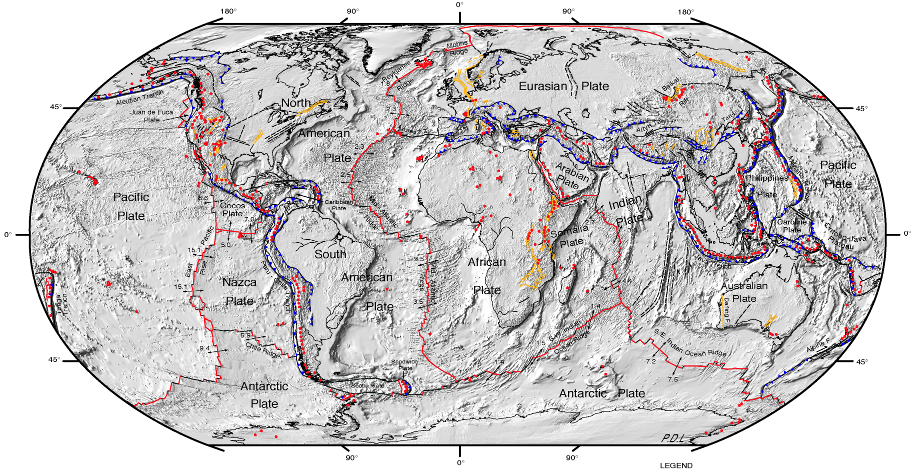
Fissures w/ central volcanoes (Iceland)



Fissures w/ central volcanoes - Bárðabunga, Iceland

Tuya Volcanoes - Herðubreið, Iceland

Mid-Ocean Ridges



DIGITAL TECTONIC ACTIVITY MAP OF THE EARTH

Tectonism and Volcanism of the Last One Million Years

DTAM - 1

NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771

Robinson Projection
October 2002

LEGEND

- Actively-spreading ridges and transform faults
- Total spreading rate, cm/year
- Major active fault or fault zone; dashed where nature, location, or activity uncertain
- Normal fault or rift; hachures on downthrown side
- Reverse fault (overthrust, subduction zones); generalized; barbs on upthrown side
- Volcanic centers active within the last one million years; generalized. Minor basaltic centers and seamounts omitted.

NASA

Pillow Lavas

- https://youtu.be/hmMlspNoZMs?t=5s

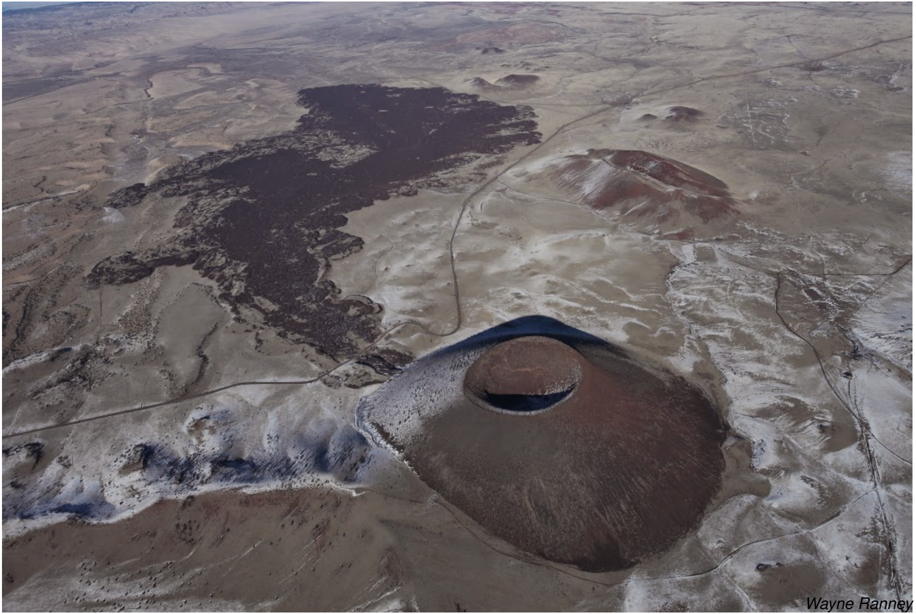
Monogenetic Volcanoes - Cinder Cone, Lassen

Internet

Monogenetic Volcanoes - Cinder Cone

Internet

Monogenetic Volcanoes - S P Crater



Wayne Ranney

Intermediate / Silicic Volcanism

- **stratovolcanoes**: steep-sided, stacked lavas, pyroclastic flow deposits (Fuji, Etna: mafic)
- prone to failure by sector collapse (Mt. St. Helens, 1980), or caldera formation (Katmai 1912, Pinatubo 1991)
- Caldera collapse after withdrawal of large amounts of magma
- silicic sub-marine volcanoes are common in submarine arc volcanoes (e.g., West Pacific)
- after caldera formation resurgent domes can form (Valles Caldera)
- effusive silicic eruptions: domes, spines, high-aspect ratio flows

Intermediate / silicic Hekla, Iceland

Internet

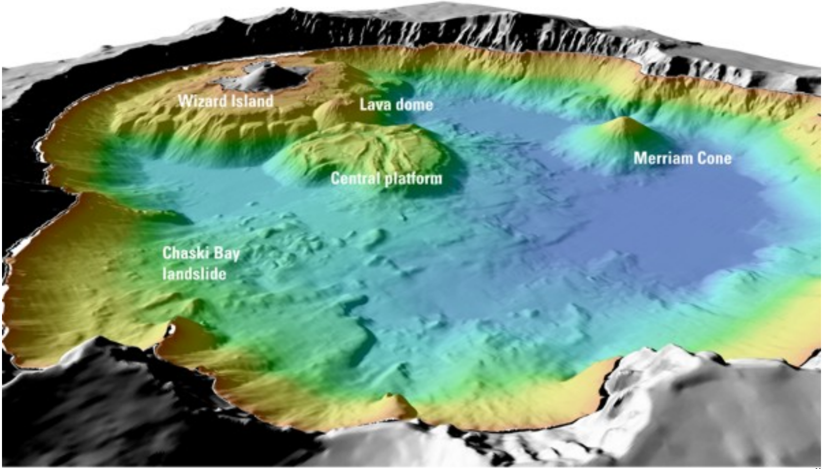
Stratovolcano: Mt. Pinatubo

Internet

Caldera - Mt. Mazama / Crater Lake

Internet

Caldera - Mt. Mazama / Crater Lake



wikipedia

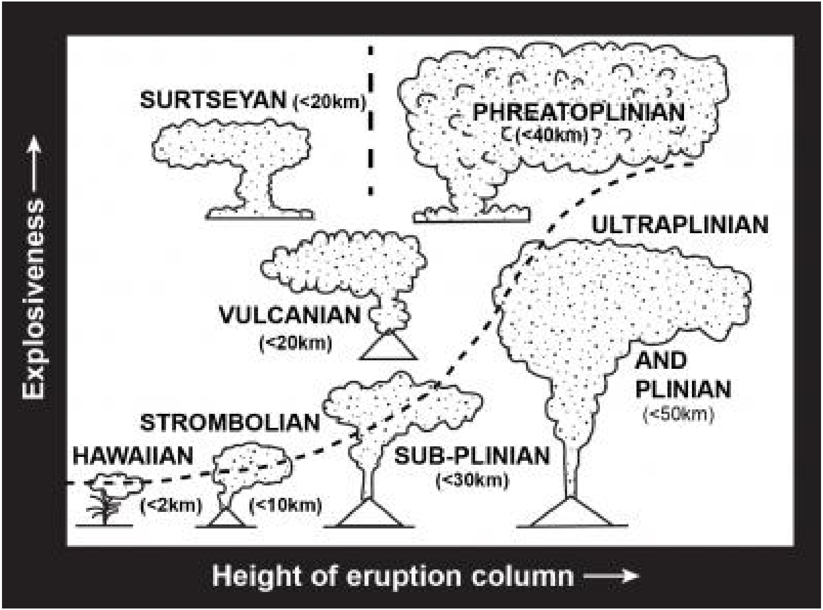
Domes / Spines: Mt St. Helens

wikipedia

Domes / Spines: Mt St. Helens

wikipedia

Eruptive Styles



USGS

Hawaiian Eruption / Fissure Eruption

- dominated by fluid lava flows
- emerge often directly from dike fed fissure systems
- stacks of these build Hawaiian shield volcanoes
- hazard: groundwater interaction - Kilauea had episodes of highly explosive activity (caldera drained, water backflow)

Hawaiian Eruption / Fissure Eruption

- Hawaii:
  https://www.youtube.com/watch?v=UdTuEnO9kMU
- Iceland / Holuhraun:
  https://youtu.be/fmCJSS2YAP0?t=22s

Strombolian Eruption

- frequent small explosions from rise and busting of large individual gas bubbles
- open system volcanoes: gases can move freely through system
- more gas than lavas are produced

Strombolian Eruption

- Stromboli: `https://youtu.be/VlbkQ9xsZ6U?t=8s`
- Erebus:
  `https://www.youtube.com/watch?v=ZeQEeKAFdac`

Vulcanian

- short-lived, but intense (tens of seconds)
- typically andesitic to dacitic
- plume heights: 5-10 km

Vulcanian Eruption

- Sakurajima:
  `https://www.youtube.com/watch?v=mIX43uy4Zvg`

Sub-Plinian Eruption

- explosive, sustained eruptions
- volume: 0.1-1 km^3 dense rock equivalent
- plume heights: <20-25 km

Sub-Plinian Eruption

- Tungurahua:
  `https://www.youtube.com/watch?v=OwdZc31GdaY`

Plinian Eruption

- Pliny the Younger report of Vesuvius 79 AD eruption
- large, sustained, with wide-spread tephra deposits
- volumes: >1 km^3 dense rock equivalent
- plume heights: >20-25 km

Plinian Eruption

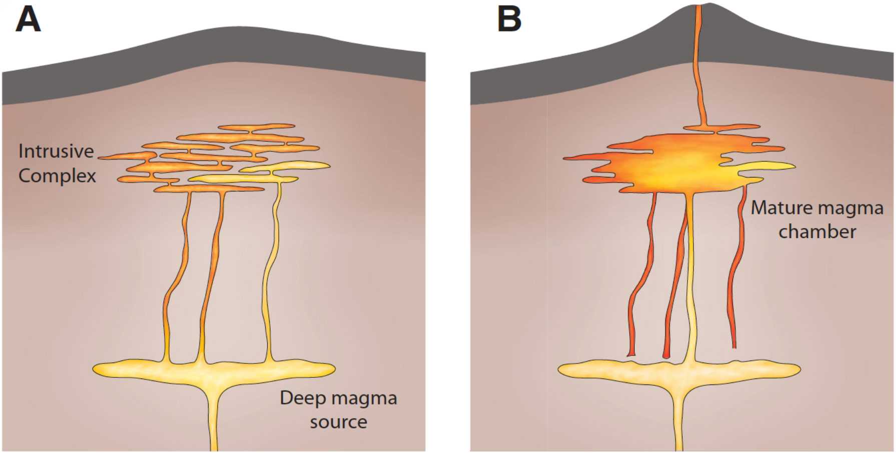
- Pinatubo: `https://youtu.be/SMe0VPQftsc?t=7m17s`
- Mt. St. Helens: `https://youtu.be/ZhvkITCGqK4?t=1m14s`

Magma Chamber / Storage Region Formation

Magma Storage

- magmatic systems commonly seen as:
  - interconnected crystal-melt mush zones
  - melt-dominated regions
  - magma chambers
- mush: non-eruptible
- melt: eruptible
- threshold depends on crystal size, shape, and strain rate

Magma Storage Formation

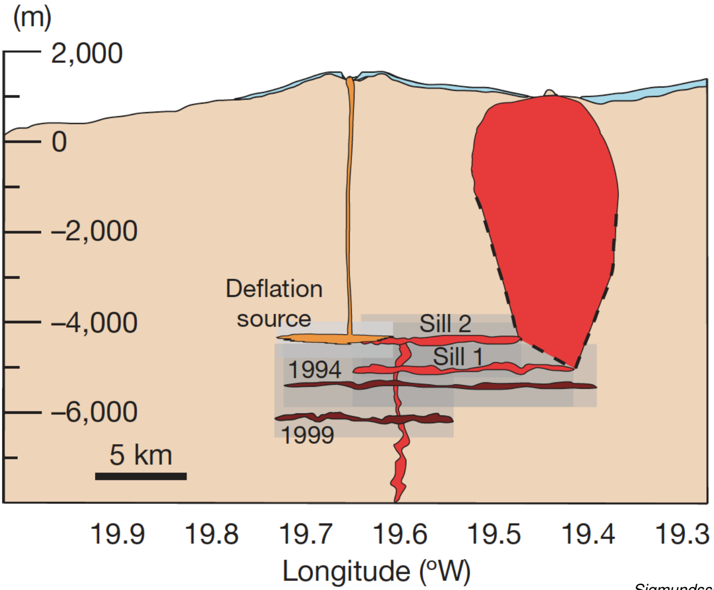


Cashman & Sparks, 2013

Magma Storage Formation

- rising magma can stall:
  - insufficient driving pressure
  - density too high
  - edifice creates high stress below
  - thermal death of dikes due to cooling
  - viscous death of dikes due to crystallization
- sills form when magma moves laterally, due to:
  - rigidity barrier
  - density barrier
  - minimum principal stress is vertical
- dike sill complexes can amalgamate to form magma reservoir
- needs sufficient heat

Magma Storage: Eyjafjallajökull 2010



Sigmundsson et al., 2010