

ERTH 456 / GEOL 556

Volcanology

– Lecture 04: Types of Volcanism and Development of Storage Systems–

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hours: TR 3-4PM or appt.

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Earthquake swarm at Katla Volcano, Iceland

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 monogenetic volcanoes (Cinder Cones)

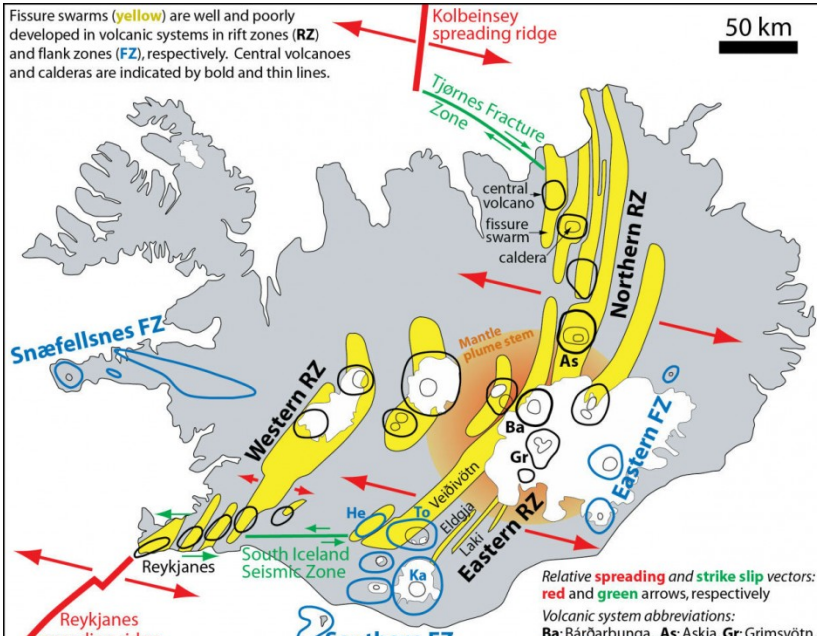
Mafic - Shield Volcano - Mauna Loa



Mafic - steep sided cones - Kliuchevskoy



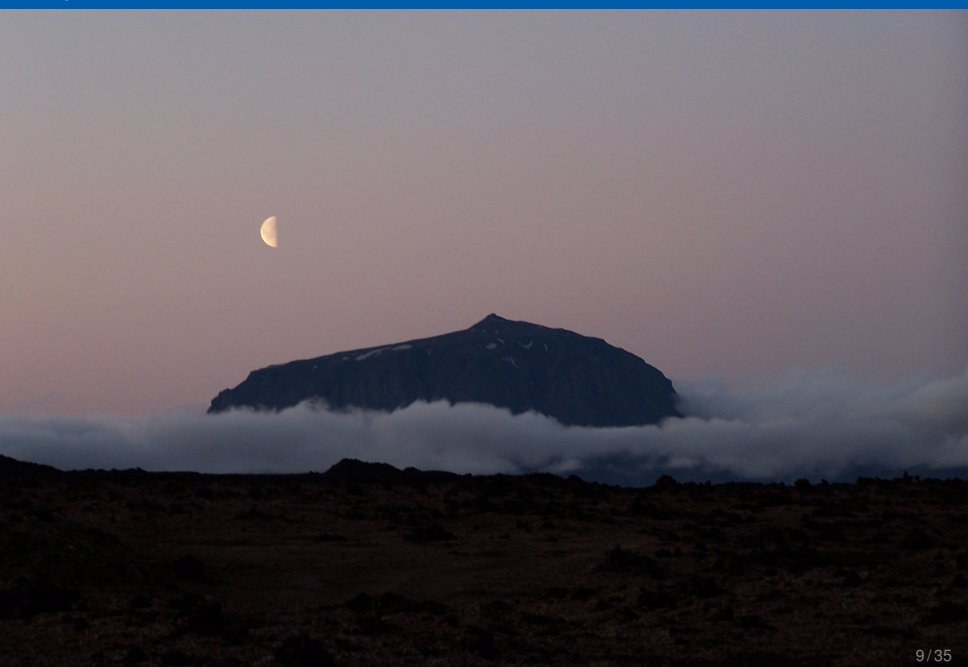
Fissures w/ central volcanoes (Iceland)



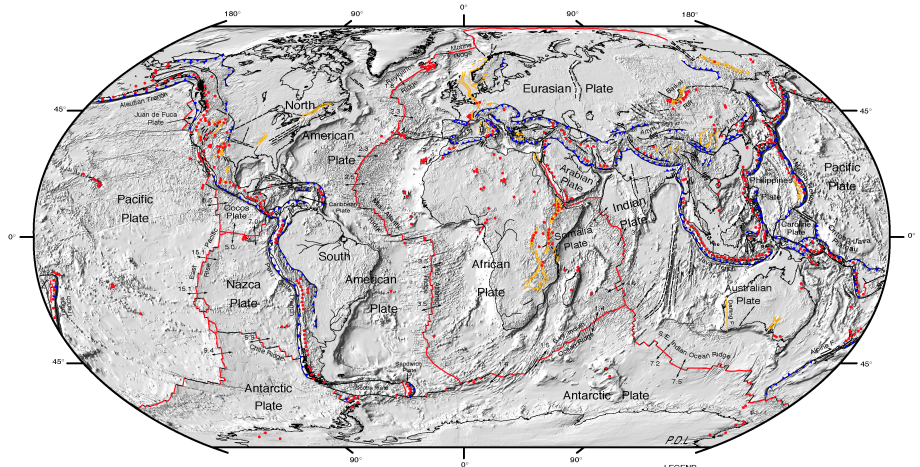
Fissures w/ central volcanoes - Barðabunga, Iceland



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; bars on upthrown side
 - Volcanic centers active within the last one million years; generalized. Minor basaltic centers and seamounts omitted.

- <https://youtu.be/hmM1spNoZMs?t=5s>

Monogenetic Volcanoes - Cinder Cone, Lassen



Monogenetic Volcanoes - Cinder Cone



Internet

- **stratovolcanoes** (not Fuji, Etna): steep-sided, stacked lavas, pyroclastic flow deposits
- 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 (Yellowstone)
- effusive silicic eruptions: domes, spines, high-aspect ratio flows

Intermediate / silicic Hekla, Iceland



Internet

Stratovolcano: Mt. Pinatubo



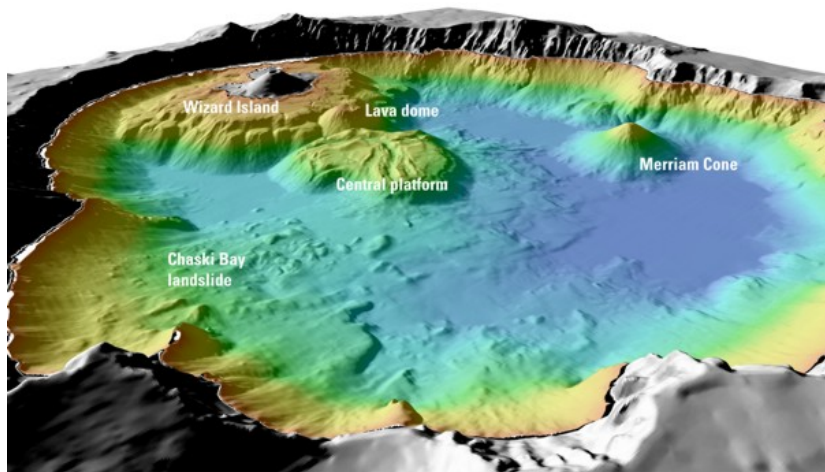
Internet

Caldera - Mt. Mazama / Crater Lake



Internet

Caldera - Mt. Mazama / Crater Lake



wikipedia

Domes / Spines: Mt St. Helens



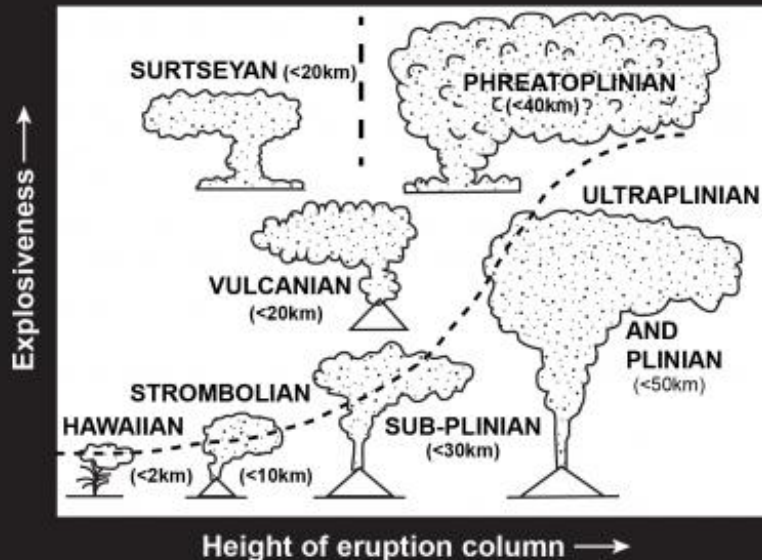
wikipedia

Domes / Spines: Mt St. Helens



wikipedia

Eruptive Styles



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>

- 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`

- **Erebus:**

`https://www.youtube.com/watch?v=ZeQEeKAFdac`

Sub-Plinian Eruption

- explosive, sustained eruptions
- volume: 0.1-1 km³ 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: $>1 \text{ km}^3$ dense rock equivalent
- plume heights: $>20\text{-}25 \text{ km}$

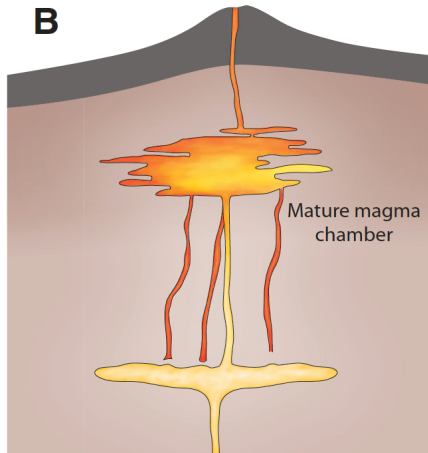
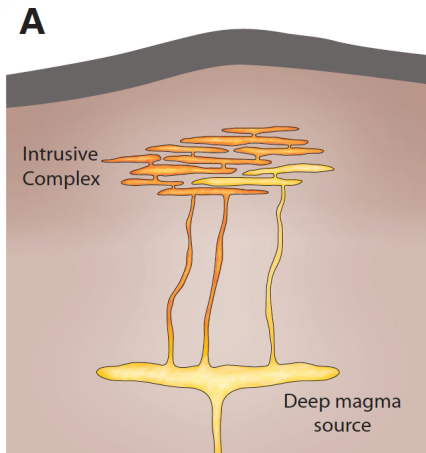
Plinian Eruption

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

Magma Chamber / Storage Region Formation

- 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

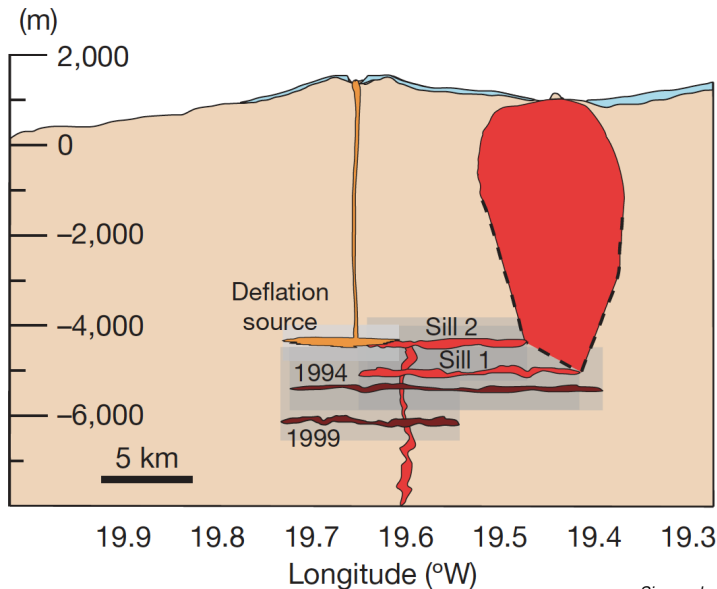


Cashman & Sparks, 2013

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