
LECTURE 4
2023
OLLI
Our Dynamic Planet:
Earthquakes and Volcanoes
Steve Marshak

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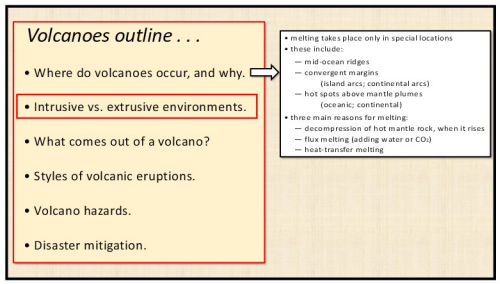
Volcanoes outline . . .
• Where do volcanoes occur, and why.
• Intrusive vs. extrusive environments.
• What comes out of a volcano?
• Styles of volcanic eruptions.
• Volcano hazards.
• Disaster mitigation.
• melting takes place only in special locations
• these include:
– mid-ocean ridges
– convergent margins
(island arcs; continental arcs)
– hot spots above mantle plumes
(oceanic; continental)
• three main reasons for melting:
– decompression of hot mantle rock, when it rises
– flux melting (adding water or CO2)
– heat-transfer melting

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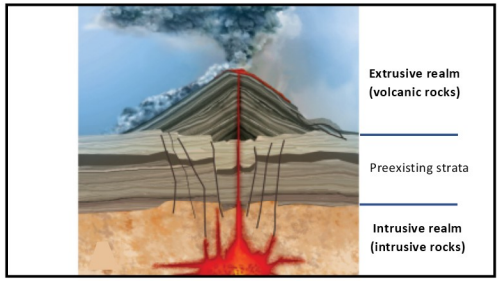
Extrusive realm
(volcanic rocks)
Preexisting strata
Intrusive realm
(intrusive rocks)

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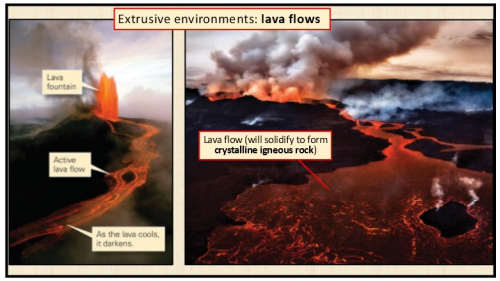
Extrusive environments: lava flows
Lava fountain
Active lava flow
As the lava cools, it darkens.
Lava flow (will solidify to form crystalline igneous rock)

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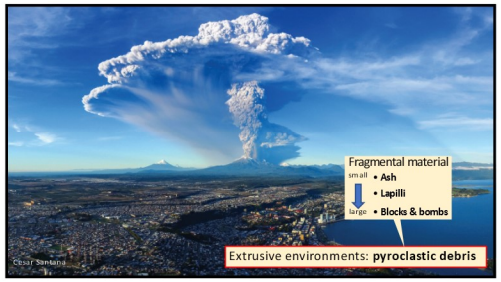
Fragmental material
small
large
• Ash
• Lapilli
• Blocks & bombs
Extrusive environments: pyroclastic debris
Cesar Santana

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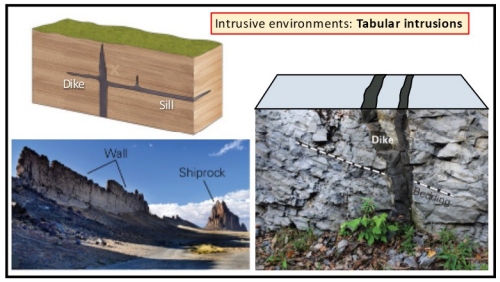
Intrusive environments: Tabular intrusions
Dike
Sill
Wall
Shiprock
Dike

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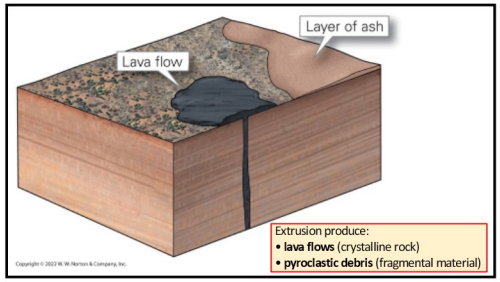
Layer of ash
Lava flow
Extrusion produce:
• lava flows (crystalline rock)
• pyroclastic debris (fragmental material)

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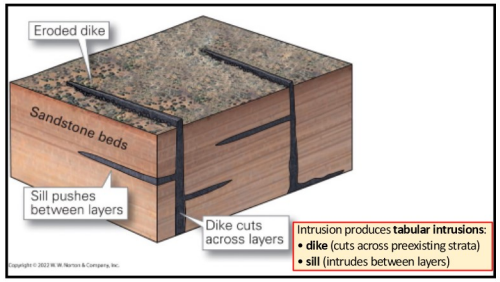
Eroded dike
Sandstone beds
Sill pushes between layers
Dike cuts across layers
Intrusion produces tabular intrusions:
• dike (cuts across preexisting strata)
• sill (intrudes between layers)

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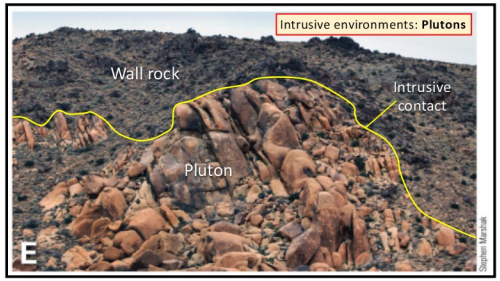
Intrusive environments: Plutons
Wall rock
Intrusive contact
Pluton
E

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Batholith: Composite of many plutons. Formed below a Mesozoic volcanic arc; subsequently exposed by erosion.
Sierra Nevada batholith

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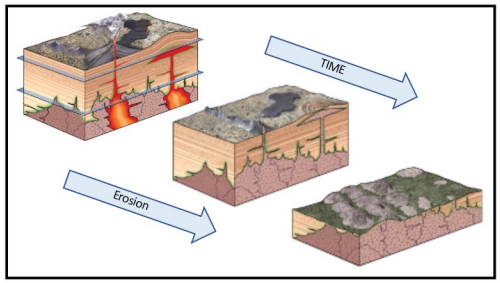
TIME
Erosion

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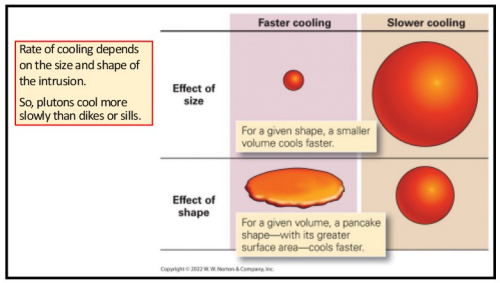
Rate of cooling depends on the size and shape of the intrusion.
So, plutons cool more slowly than dikes or sills.
Faster cooling
Slower cooling
Effect of size
For a given shape, a smaller volume cools faster.
Effect of shape
For a given volume, a pancake shape—with its greater surface area—cools faster.

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Magma is classified based on the proportion of **silica** (SiO_2) that it contains. The silica content largely controls the type of eruption.

Categories of Magma

Felsic (or silicic) magma	67–76% silica*
Intermediate magma	53–66% silica
Mafic magma	46–52% silica

*The numbers provided are "weight percent," meaning the proportion of the magma's weight that consists of silica.

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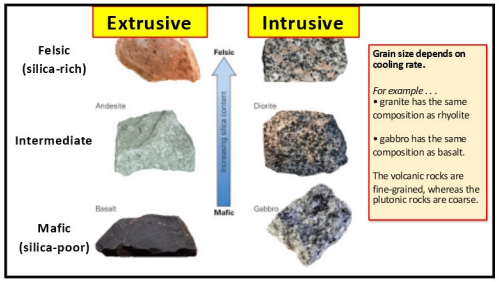

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Volcanoes outline . . .

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- Disaster mitigation.

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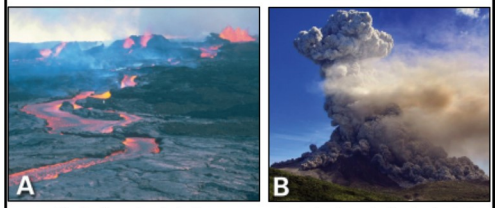
Two general categories of volcanic eruption.



Effusive (lava-dominated) **Explosive** (pyroclastic-dominated)

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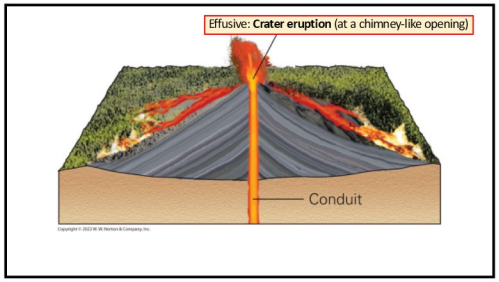

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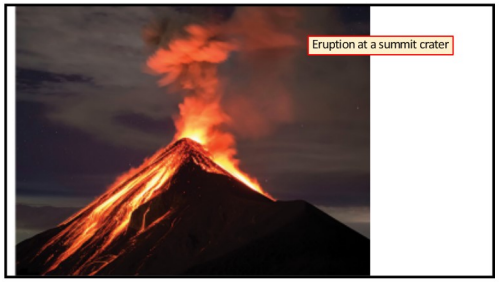

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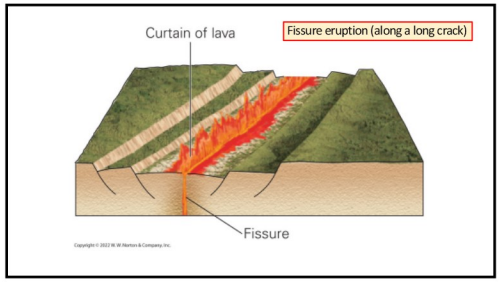

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Viscosity of lava (ease of flow) depends on the proportion of **silica** (SiO_2) that it contains. So, the silica content largely controls the type of eruption.

Categories of Lava

Felsic (or silicic) magma	67–76% silica*
Intermediate magma	53–66% silica
Mafic magma	46–52% silica

*The numbers provided are "weight percent," meaning the proportion of the magma's weight that consists of silica.

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Character of a lava flow depends on the composition of the lava.

Basaltic (mafic) flows are less viscous, so the lava can flow further, and relatively fast.

Hawaii, 2018 eruption

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Lava tunnels (lava tubes) can allow lava to travel long distances under the surface; rock is a good insulator, so the surface is solid, while liquid flows below.

"Skylight" exposing a flow under the surface.

Drained lava tube, exposed in a roadcut.

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Basaltic eruption: lava flows relatively easily

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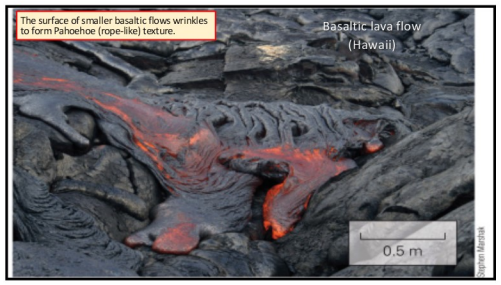

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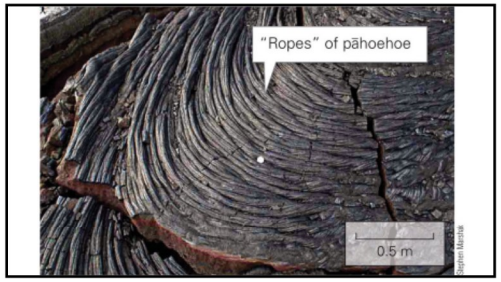

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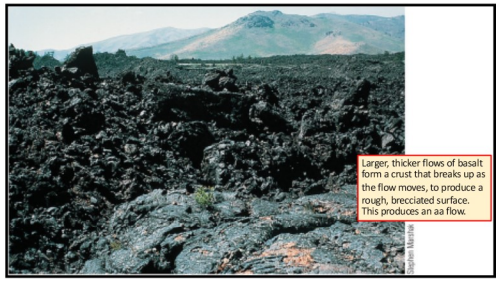

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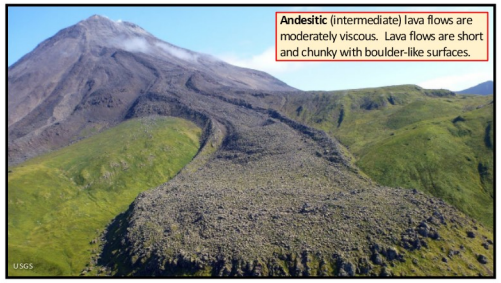

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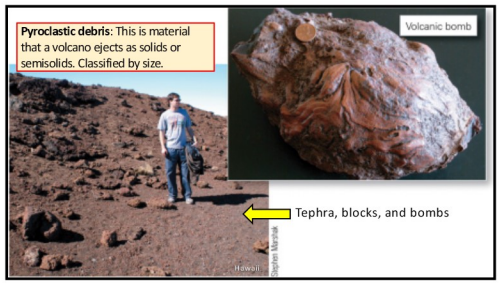

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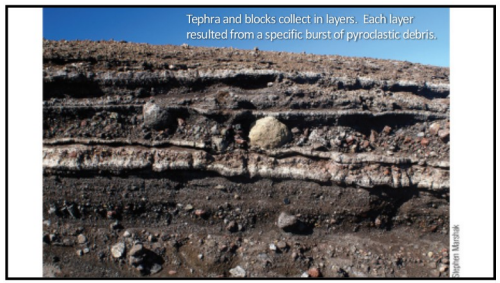

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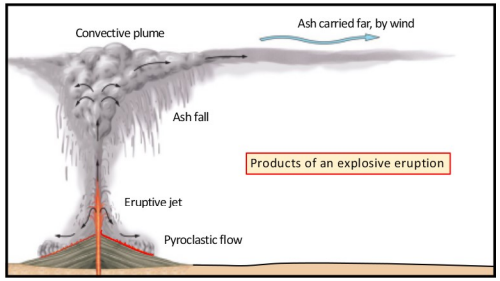

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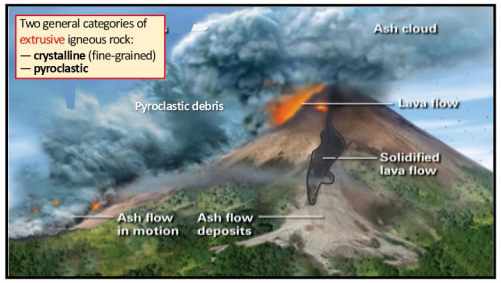

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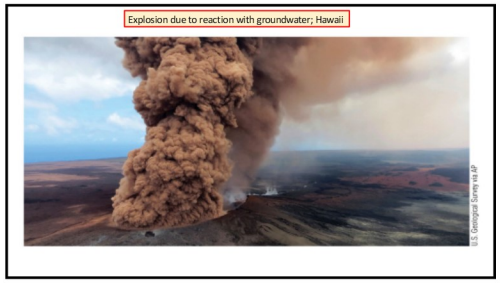

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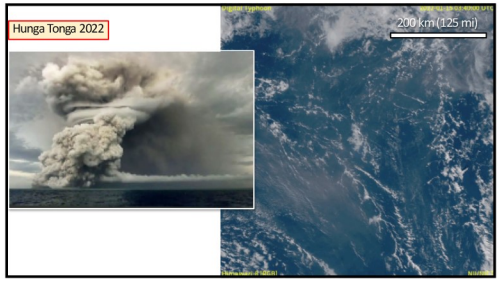

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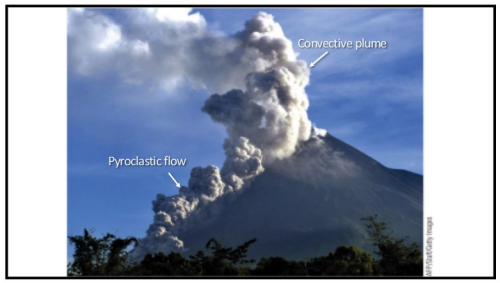

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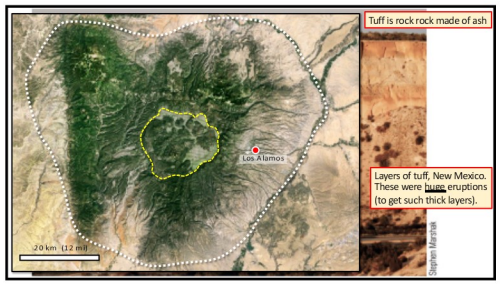

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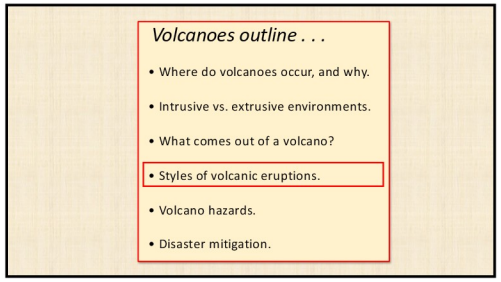

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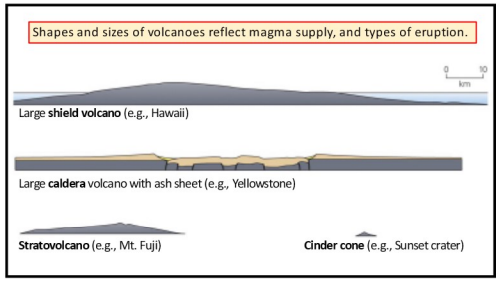

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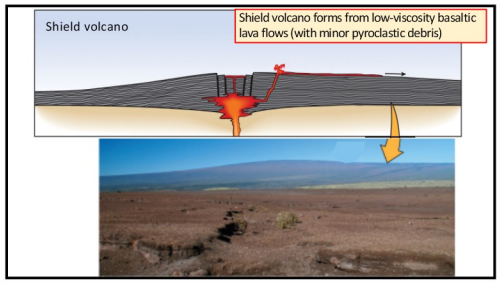

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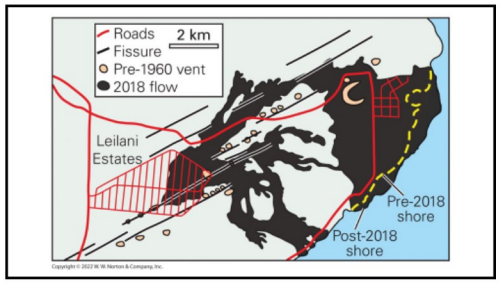

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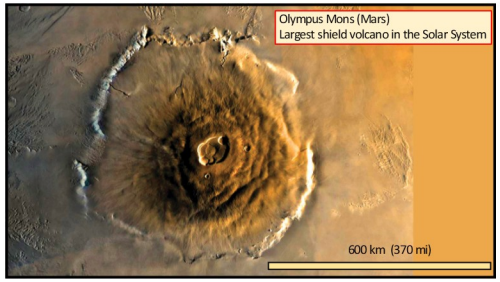

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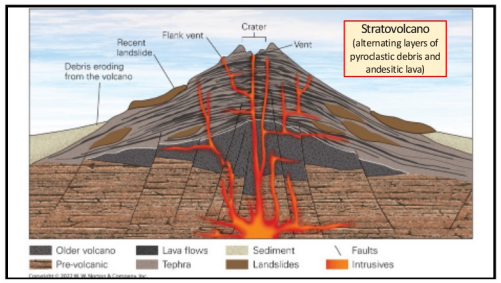

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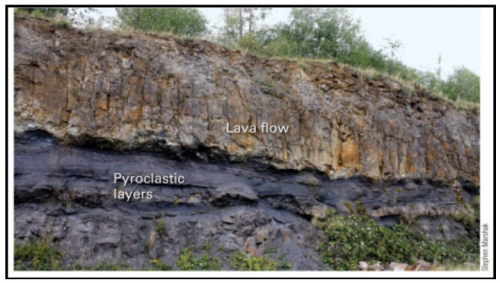

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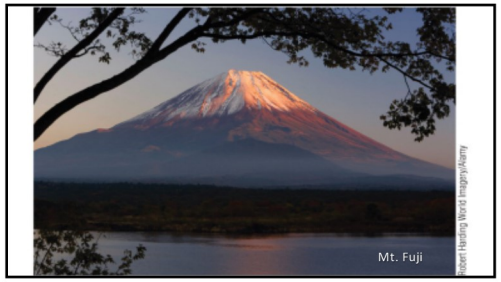

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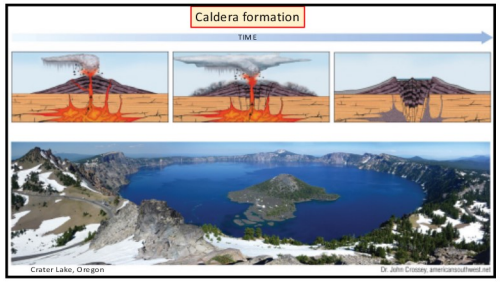

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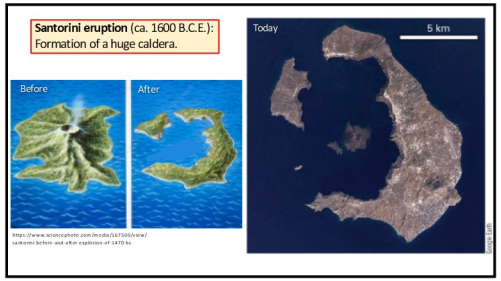

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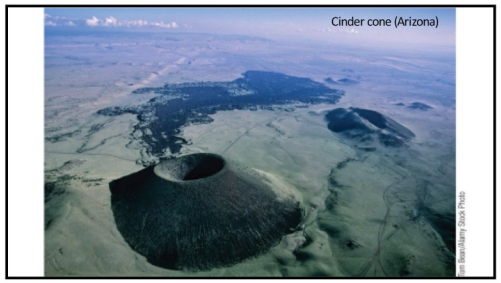

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Volcanoes outline . . .

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- Intrusive vs. extrusive environments.
- What comes out of a volcano?
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- Disaster mitigation.

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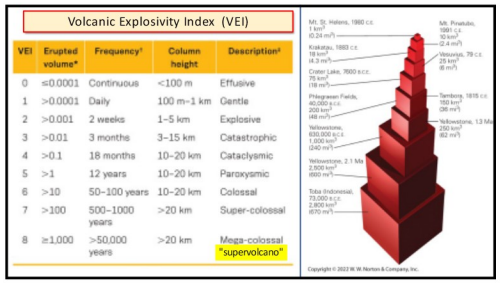

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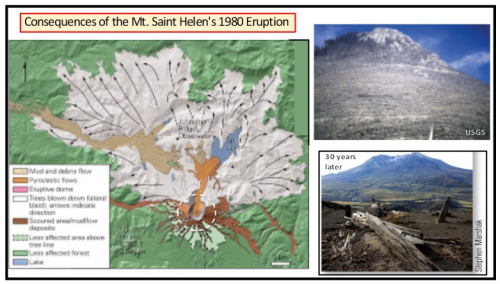

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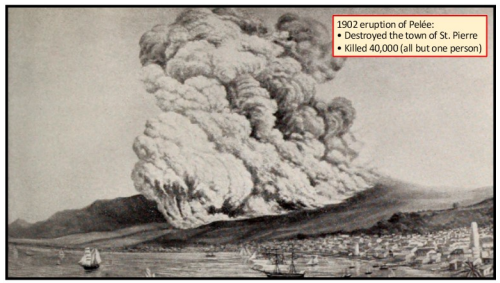

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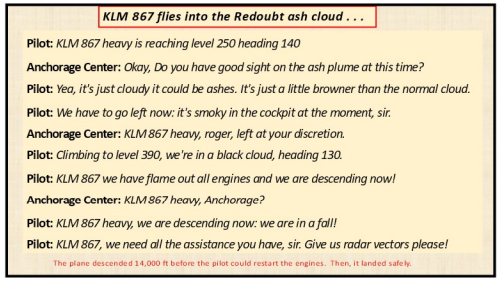

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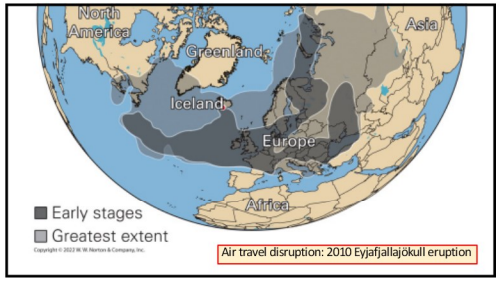

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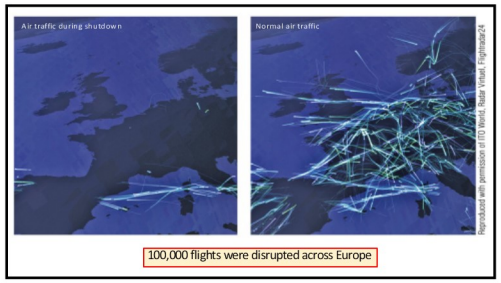

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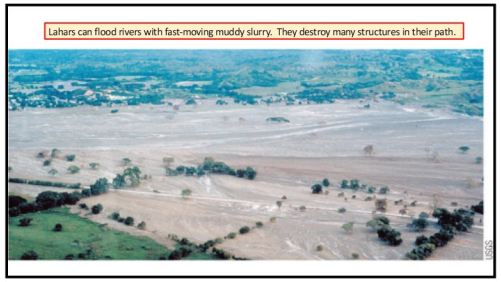

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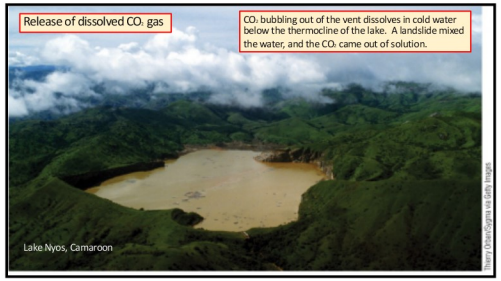

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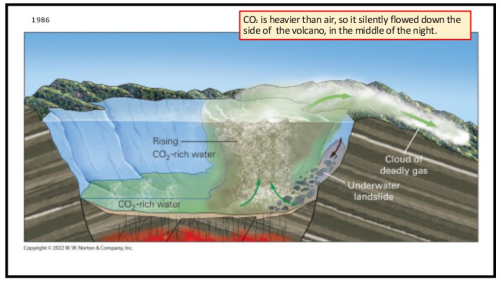

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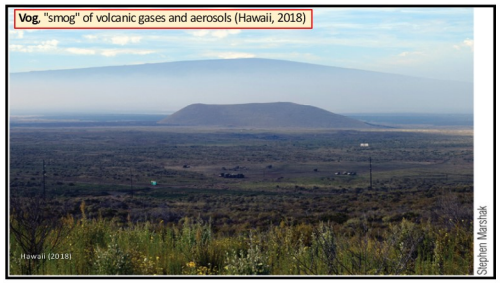

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Laze (acidic steam from reaction of lava and water)

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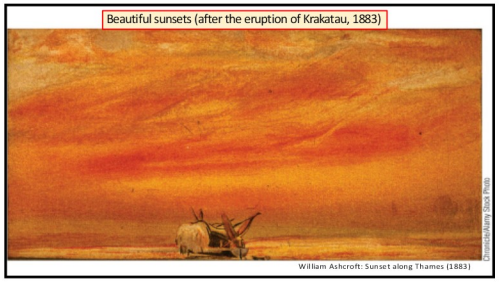
Beautiful sunsets (after the eruption of Krakatau, 1883)



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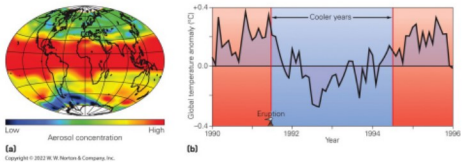
Short-term global cooling (after the eruption of Pinatubo, 1991)



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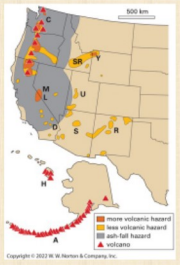


Present volcanic hazards in the USA . . .

- western USA (volcanic arc; hot spot; rift)
- Hawaii (hot spot)
- Alaska (volcanic arc)

Active volcano: Erupted recently or presently; shows many signs of volcanic unrest.

Dormant volcano: Might be active in the future, but currently shows minimal signs of unrest.

Extinct volcano: Ceased to erupt long ago and will never erupt again.

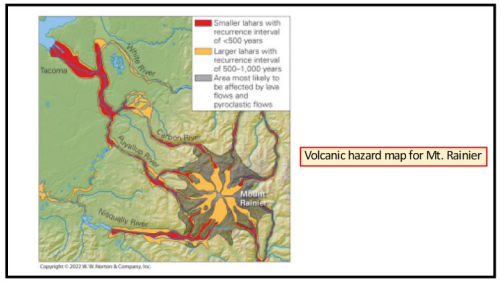
1500 active volcanoes; around 60 eruptions per years

95

Volcano forecasting can be feasible . . .

- Identify volcanic belts and determine recurrence interval of major eruptions.
- Produce volcanic hazard maps (for lava; blast; and lahar)
- Detect seismicity due to the movement of magma.
- Measure the shape change of volcanoes (to detect inflation with magma)
- Measure changes in gas emission.
- Issue warnings.
- Diverting lava flows.

96



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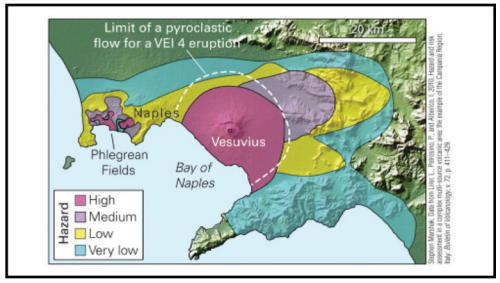

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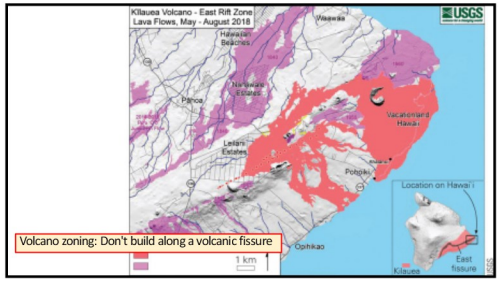

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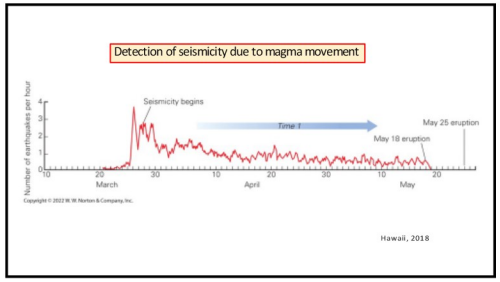

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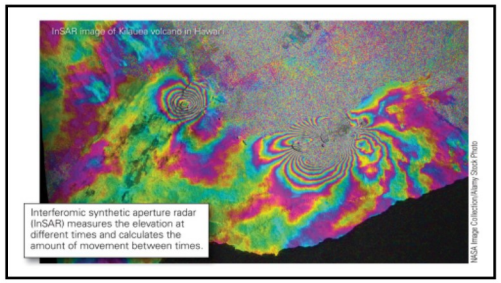

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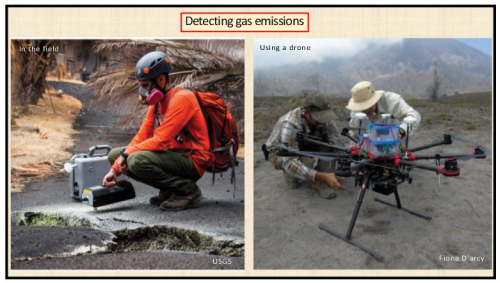

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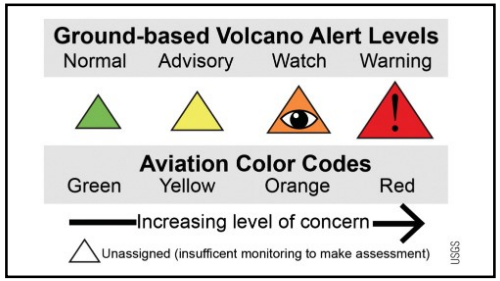

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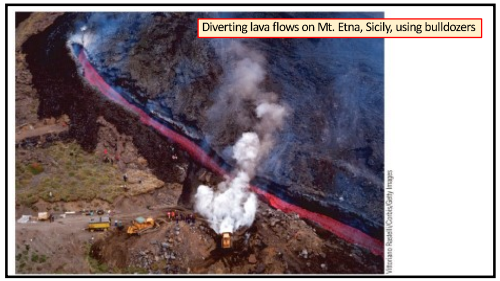

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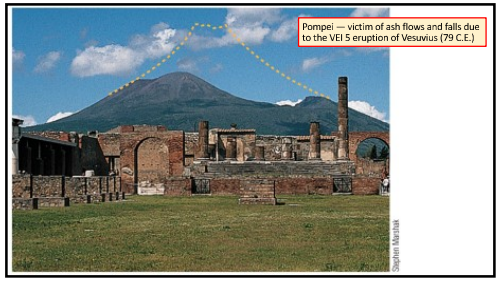

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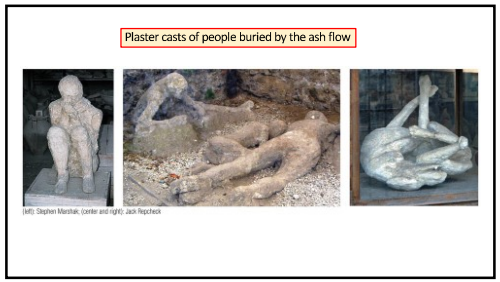

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Greater Naples (3.1 million people) surrounds Vesuvius
Phlegraean Fields
Naples
Vesuvius
N
10 km

109


Thank you !
Tom Pfeiffer

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