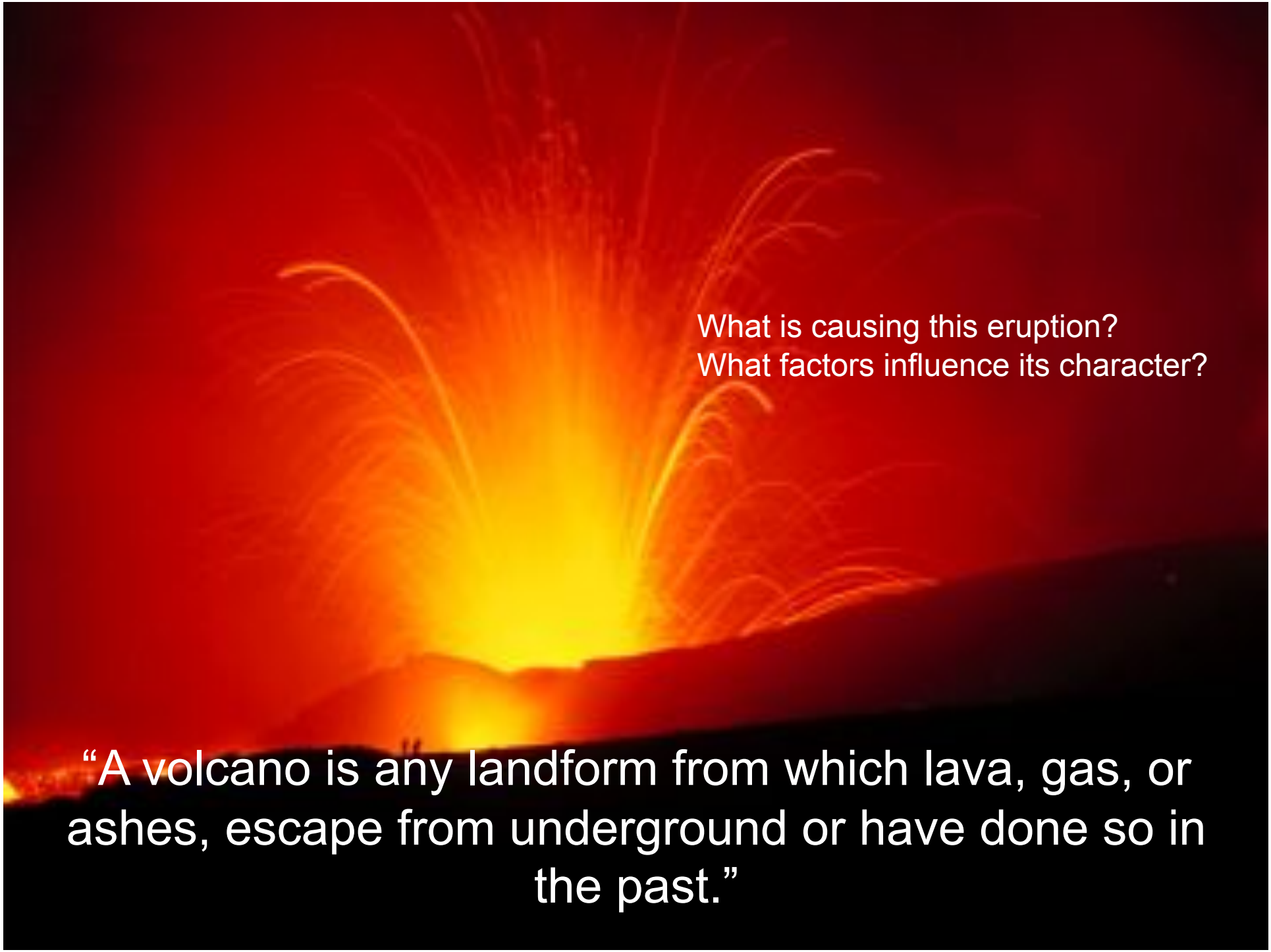
Learning Objectives (LO)

Lecture 12: Volcanoes
Read: Chapter 6
Homework #10 due Thursday

What we'll learn today:

1. Define the term volcano and explain why geologists study volcanoes
2. Compare and contrast 3 common types of magma
3. Describe volcanic gases and the role they play in explosive vs effusive eruptions
4. Identify what gives a shield volcano its distinctive shape


What is causing this eruption?
What factors influence its character?
“A volcano is any landform from which lava, gas, or ashes, escape from underground or have done so in the past.”

From Chapter 5: magma (and lava) can be felsic, intermediate, or mafic.

How does magma chemistry influence the nature of volcanic eruptions?

Hawaiian Volcanism

http://www.youtube.com/watch?v=6J6X9PsAR5w

Indonesian Volcanism

http://www.youtube.com/watch?v=5LzHpeVJQuE

Viscosity

Viscous: thick and sticky

Low viscosity

High viscosity

Viscosity of Water and Honey

Viscosity

Magma Composition (Igneous Rocks)

How does magma chemistry determine lava and eruption characteristics?

Felsic	Intermediate	Mafic

less → Mg/Fe content → more

more ← Si/O content ← less

The Major 7 Types of Igneous Rocks

The Rocks of Volcanoes

Extrusive

Rhyolite

Andesite

Basalt

melt at low temperature ← → melt at high temperature

Felsic Intermediate Mafic Ultramafic

← Composition →

Three Common Types of Magma:

BASALTIC

ANDESITIC

RHYOLITIC

Three Common Types of Magma:

BASALTIC

Basaltic lava flows easily because of its low viscosity and low gas content.

The low viscosity is due to low silica content.

Aa - rough, fragmented lava blocks called “clinker”

Pahoehoe - smooth, shiny, and ropy surface

Three Common Types of Magma:

ANDESITIC

- Erupts explosively because it has high gas content
- It is viscous and therefore traps gas.
- High viscosity is related to high silica content

Three Common Types of Magma:

Rhyolitic lava flow

RHYOLITIC

- **Erupts catastrophically because it has high gas content.**
- **It is viscous and therefore traps gas, builds pressure and explosively erupts.**
- **High viscosity → high silica content**

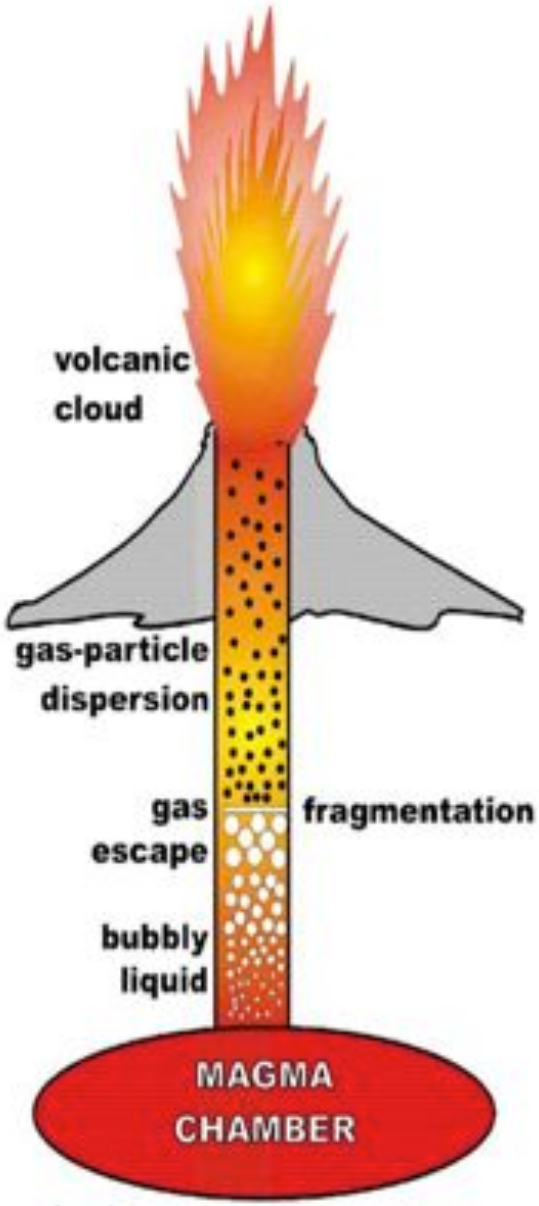
Comparison of Magma Types

TABLE 6.1 Magma Types

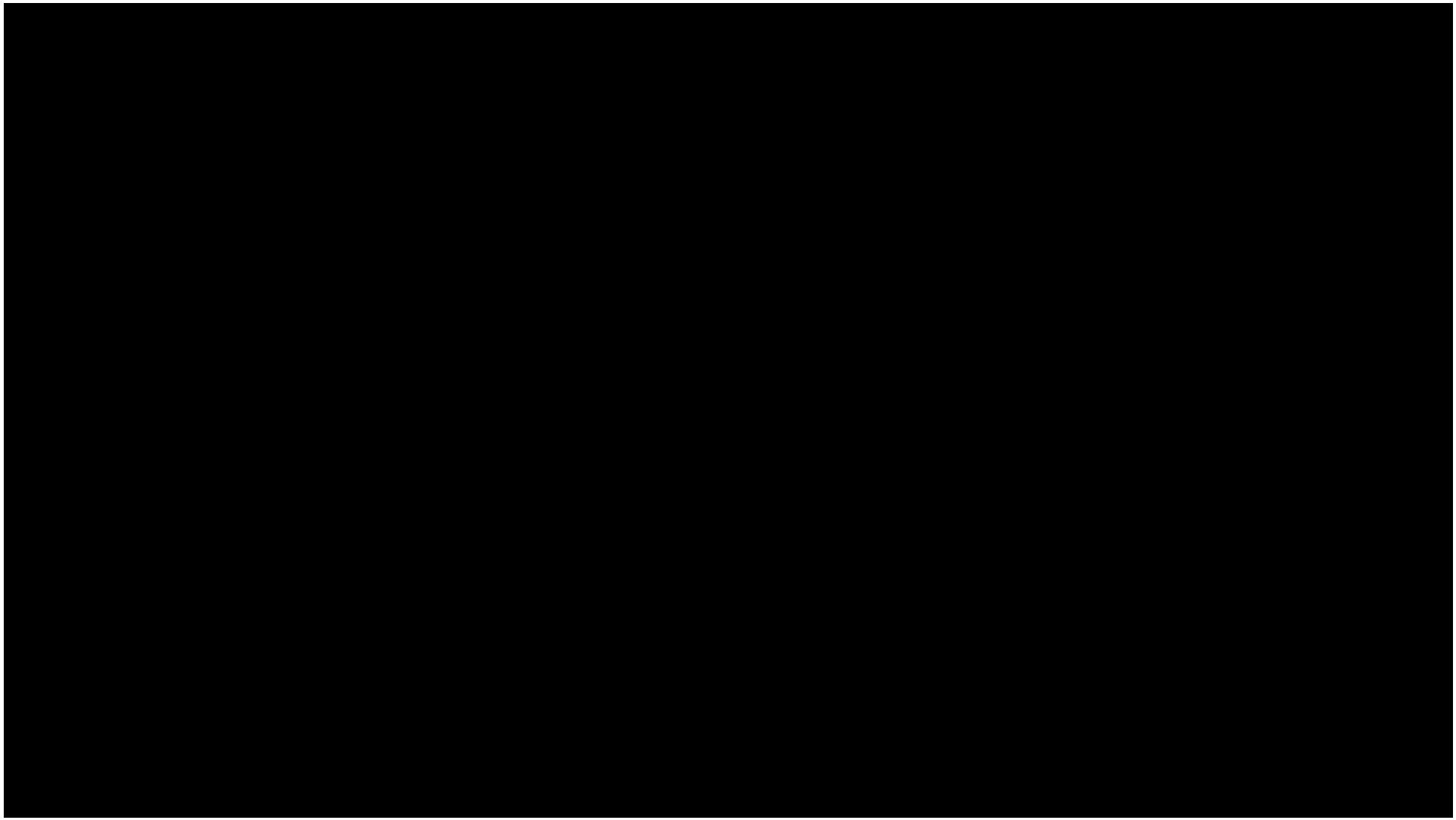
Magma Type	Composition	Silica Content and Viscosity	Gas Content	Explosivity	Lava Temperature	Examples of Volcanoes
Basaltic	Mafic	Least, ~50% (thin, runny)	0.5%–2%	Least	Hottest ~1100°C to 1200°C	Mid-ocean ridges; plateau basalts like Columbia Plateau; Hawaiian Islands
Andesitic	Intermediate	Intermediate, ~60%	3%–4%	Intermediate	Cooler ~900°C to 1000°C	Mount St. Helens, Mount Rainier
Rhyolitic	Felsic	Greatest, >70% (thick, stiff)	4%–6%	Greatest	Coolest ~700°C to 800°C	Yellowstone volcano

Explosive Eruptions

Fueled by violent release of volcanic gas

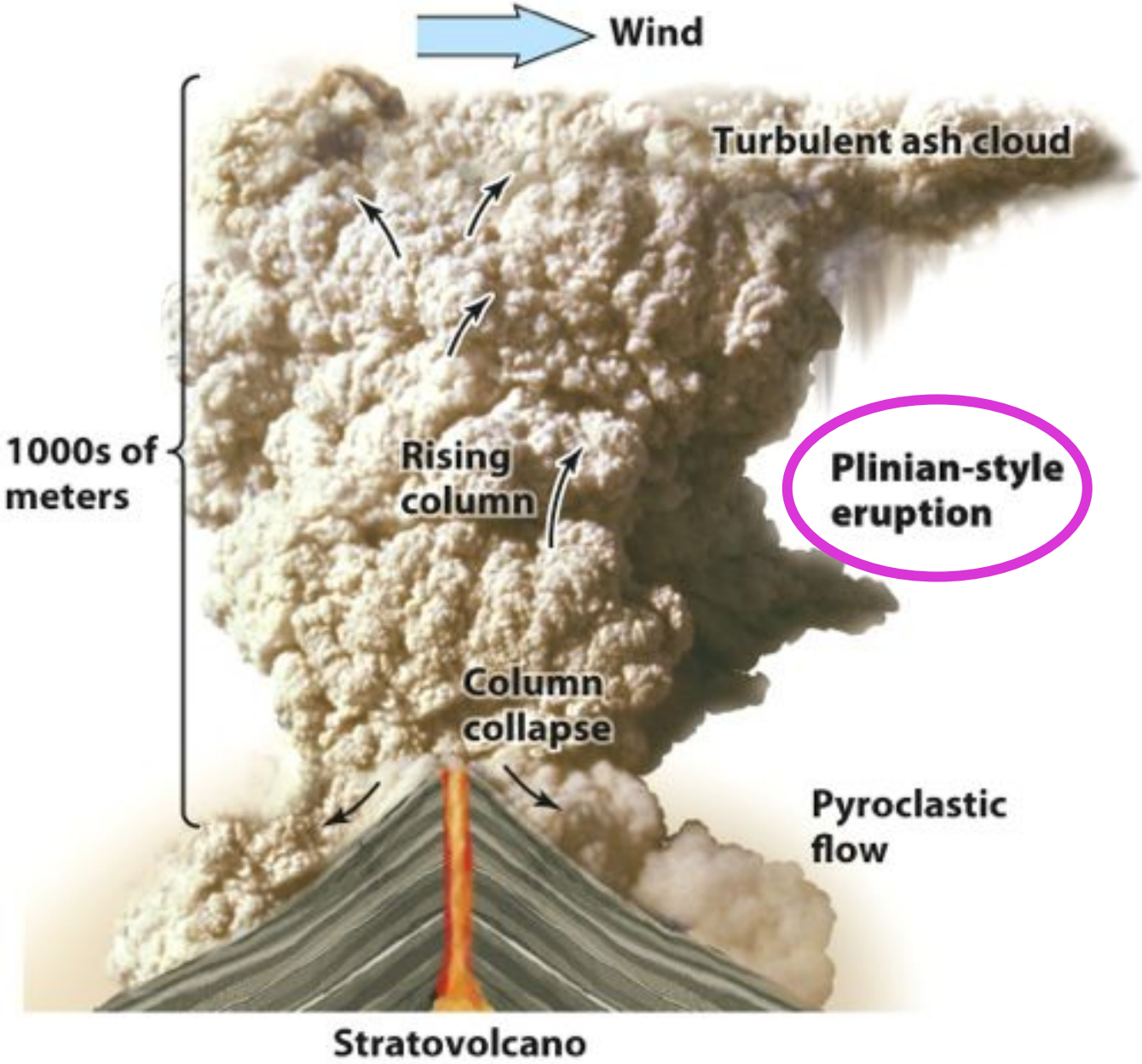


Exploding Trash Can (Trapped Nitrogen Gas) Analogy

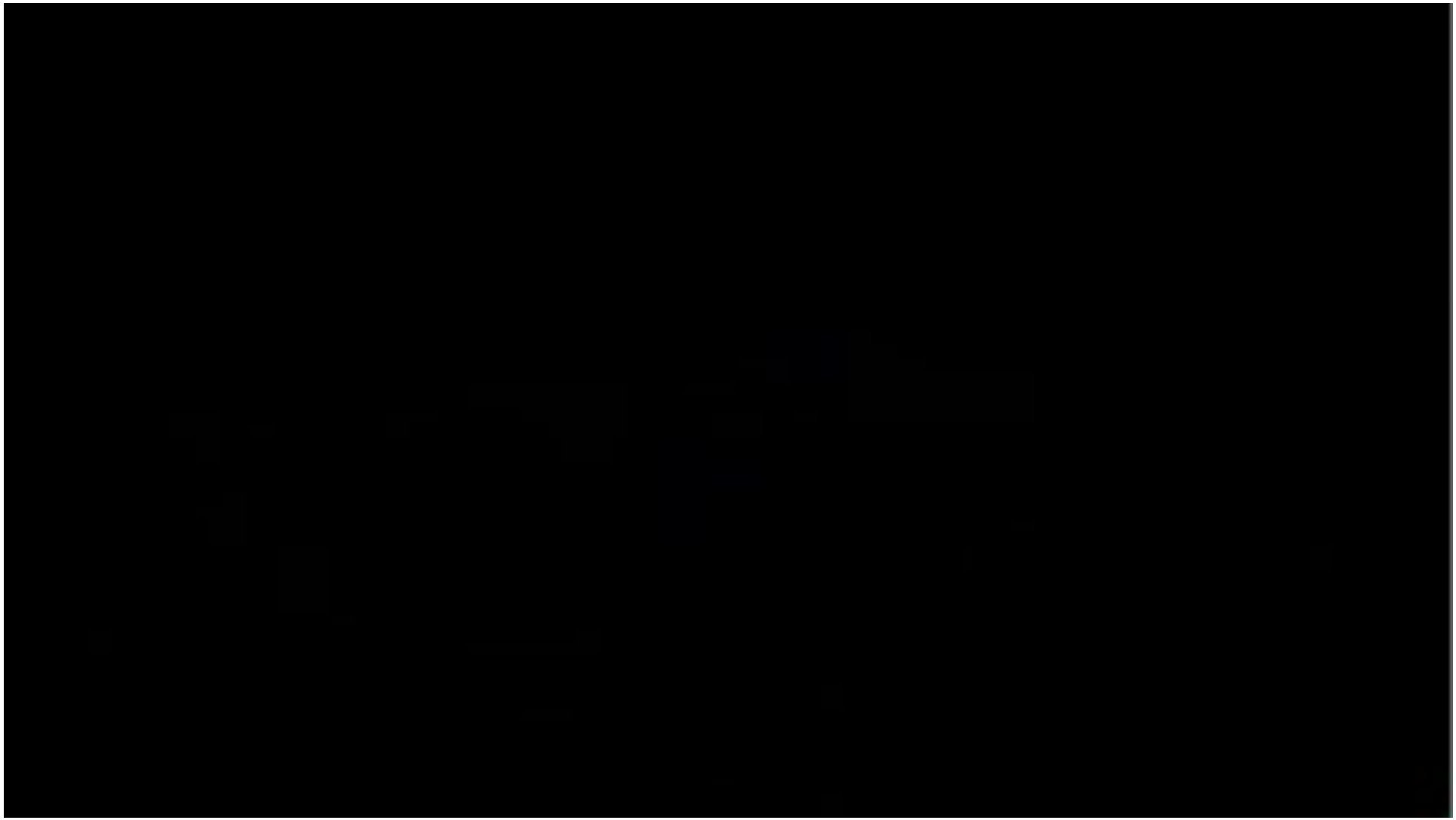


http://www.youtube.com/watch?v=dYatV_KV-u4

Plinian-Style Eruption

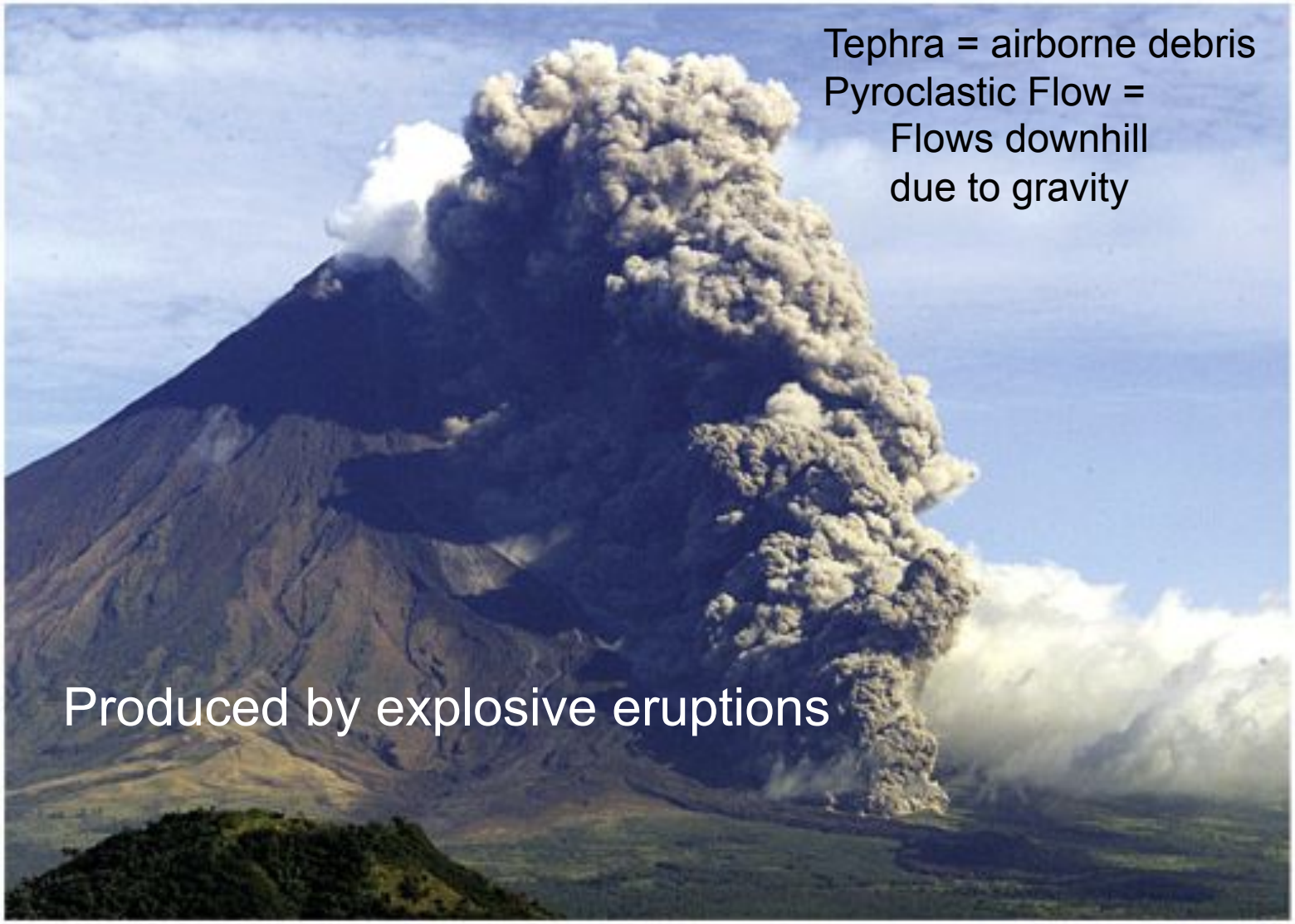


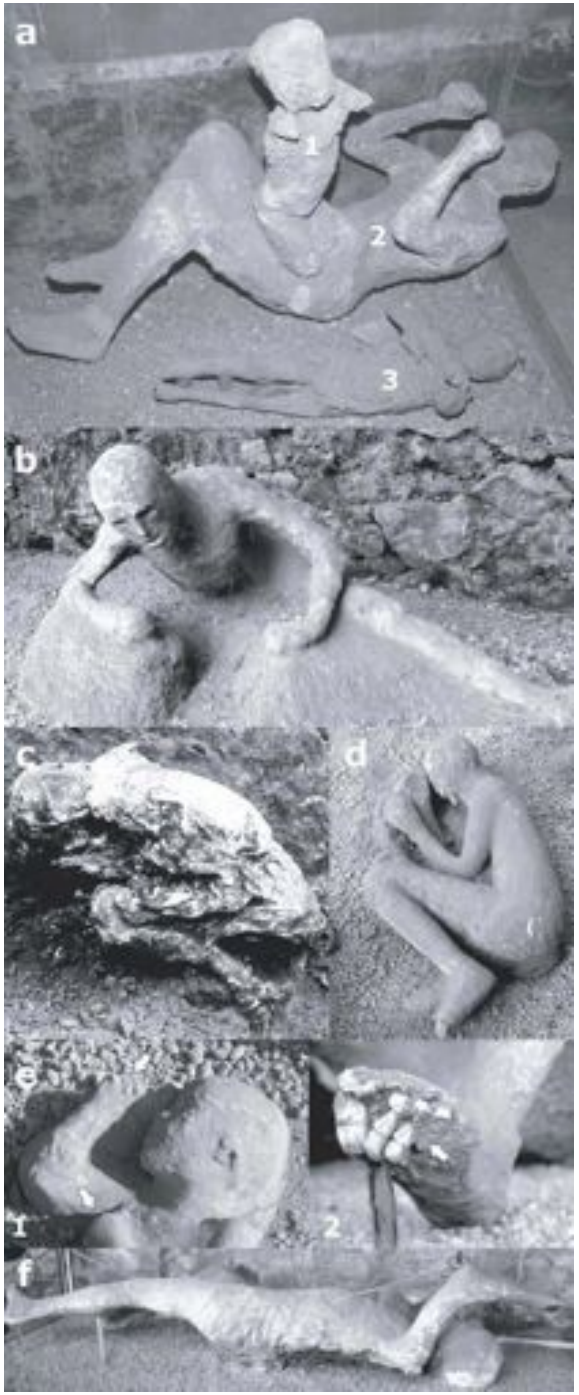
Mt. St. Helens Eruption 1980:



http://www.youtube.com/watch?v=UK--hvgP2uY

Pyroclastic Debris



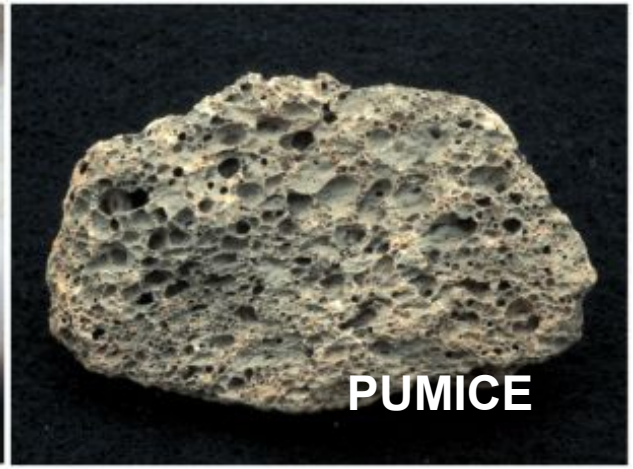


Plymouth, Monserrat (2002)

Aftermath of Pyroclastic Flows

Pompei, Italy (79 AD)

Types of Pyroclastic Debris



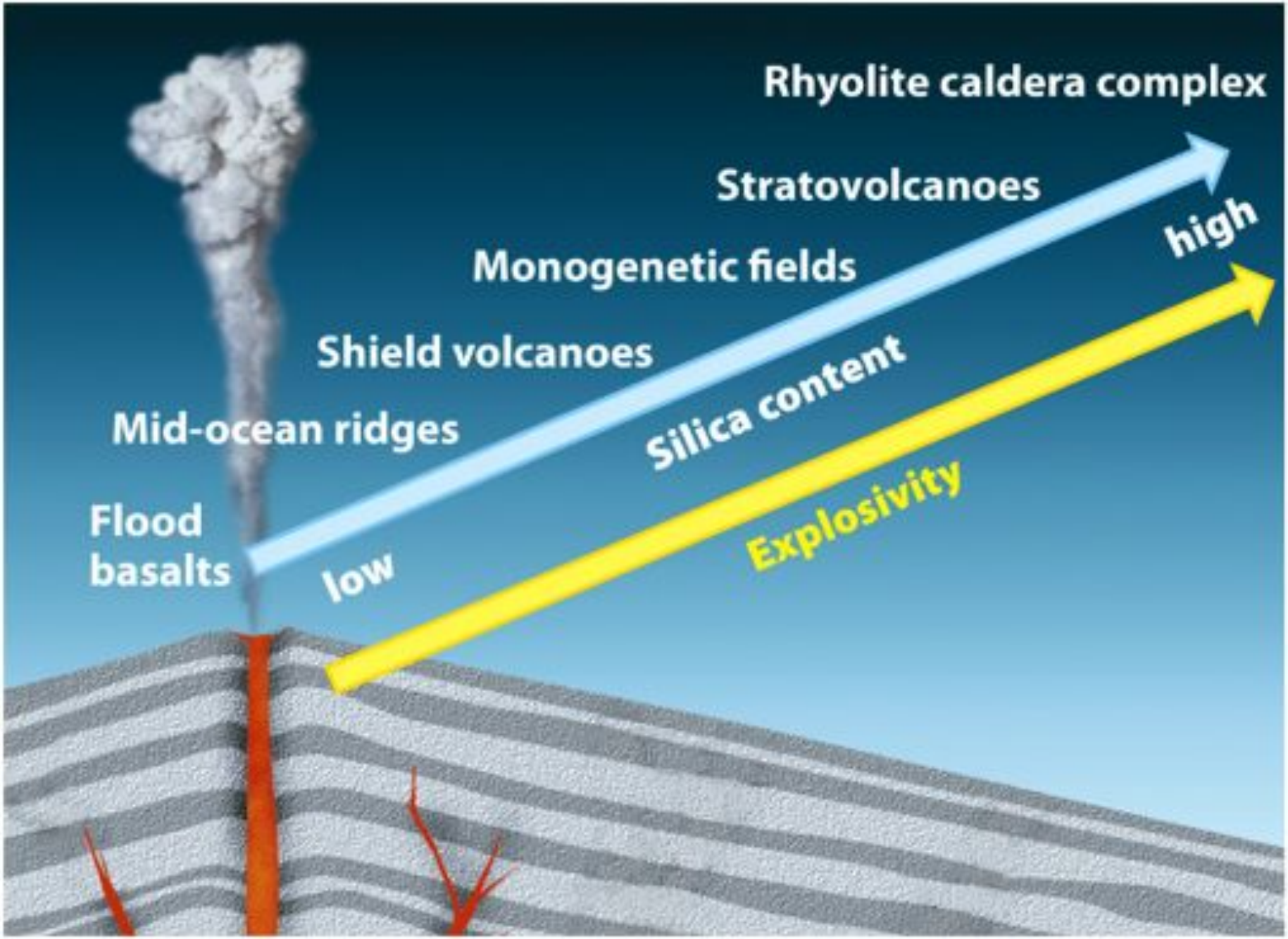
Volcanic Bombs

http://www.youtube.com/watch?v=Qgih2TL-9As

Effusive Eruptions

Relatively fluid lava flow:

- Low viscosity lava
- High temperature lava
- Low gas content of lava
- Long-duration eruptions


Rhyolite caldera complex
Stratovolcanoes
Monogenetic fields
Shield volcanoes
Mid-ocean ridges
Flood basalts
low
Silica content
high
Explosivity

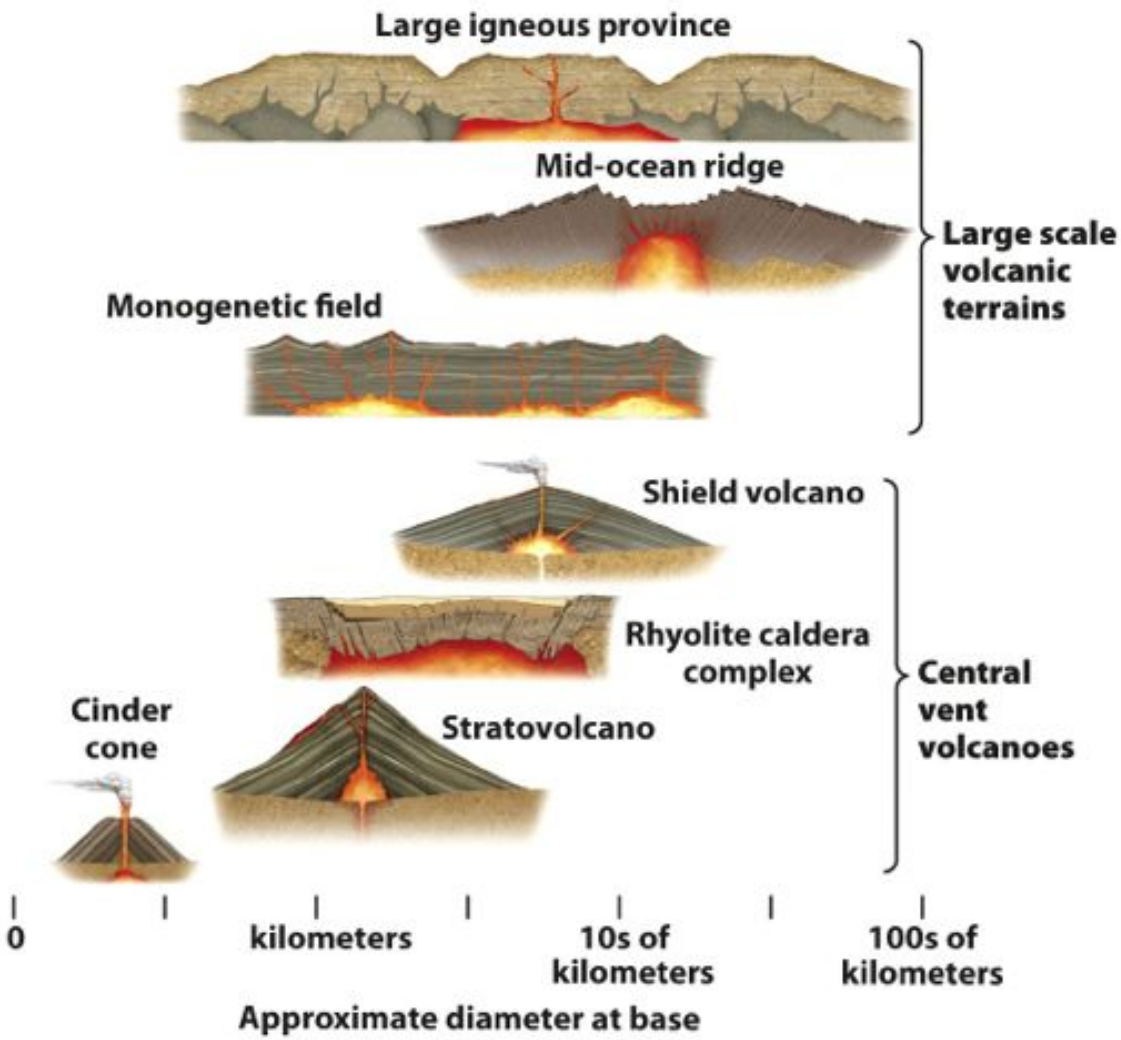
Gases released from a volcano can be deadly.

TABLE 6.2 Percent Volcanic Gas Content at Three Volcanoes

Gas	Kilauea, Hawaii (basaltic magma, 1170°C, hotspot, shield volcano)	Erta Ale, Ethiopia (basaltic magma, 1130°C, divergent margin, shield volcano)	Momotombo, Nicaragua (andesitic magma, 820°C, convergent margin, stratovolcano)
H_2O	37.1	77.2	97.1
CO_2	48.9	11.3	1.44
SO_2	11.8	8.34	0.50
H_2	0.49	1.39	0.70
CO	1.51	0.44	0.01
H_2S	0.04	0.68	0.23
HCl	0.08	0.42	2.89
HF	—	—	0.26

R. B. Symonds, W. I. Rose, G. Bluth, and T. M. Gerlach, "Volcanic Gas Studies: Methods, Results, and Applications," in M. R. Carroll and J. R. Holloway, eds., *Volatiles in Magmas, Mineralogical Society of America Reviews in Mineralogy*, 30 (1994): 1–66.

Volcanoes can be classified into 6 major types based on their size, shape, and origin



Large-scale Volcanic Terrains

- No central vent
- Network of source material
- Generally massive

Central Vent Volcanoes

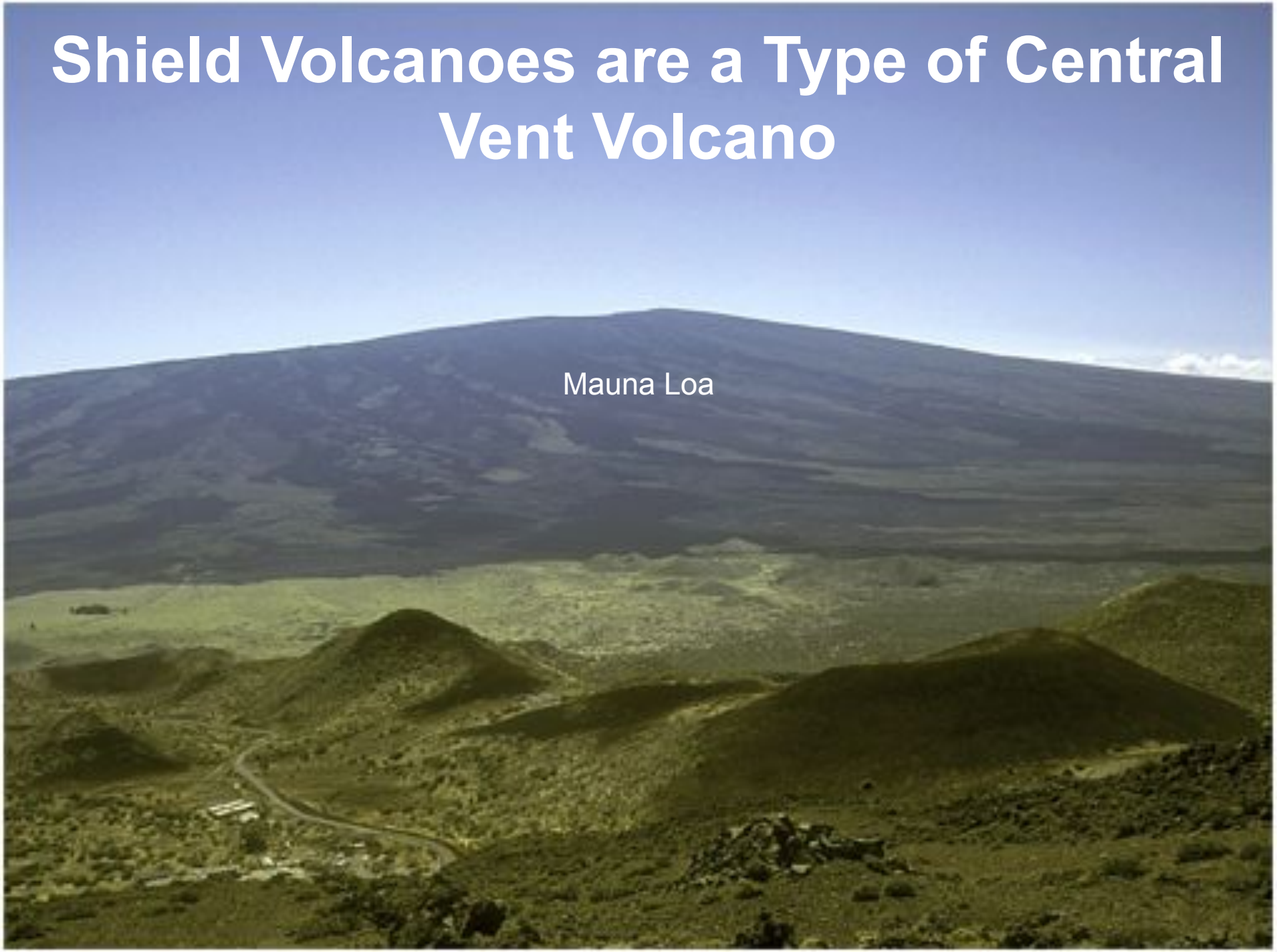
- Central vent
- Summit crater
- Flank eruptions
- Fissure eruptions

Six Types of Volcanoes

TABLE 6.3 Types of Volcanoes

Type	Shape	Magma Type	Tectonic Setting	Example
Central Vent Volcanoes				
1. Shield volcano	Large volume, gentle, low-angle slopes	Basaltic, low-silica	Mid-plate setting (most often) or variable setting	Mauna Loa Volcano, Hawaii
2. Composite volcano or stratovolcano	Tall, with steep slopes, often irregular outline from past explosions and rugged dome areas	Andesitic, silica-rich magma at subduction zone	Convergent boundary (usually)	Mount Pinatubo, Mount St. Helens
3. Rhyolite caldera complex	Low-relief system of collapsed calderas and many small vents	Rhyolitic, silica-rich magma (including melted crustal rock)	Convergent boundary or isolated midplate	Yellowstone National Park
Large-Scale Volcanic Terrains				
4. Monogenetic field	Low-relief system of vents, cones, occasional stratovolcano	Basaltic, low-silica	Convergent boundary, or isolated midplate	Ukinrek Maars, Alaska
5. Large igneous province	High plateau, massive volume (>100,000 km^3), many layers of lava, no single distinct mountain	Basaltic, low-silica	Variable setting, often midplate or continental margin	Columbia Plateau, Washington
6. Mid-ocean ridge	Broad slopes on long, linear ridge with central rift valley	Basaltic, low-silica	Divergent boundary, spreading center along	Segment of the East Pacific Rise mid-ocean ridge

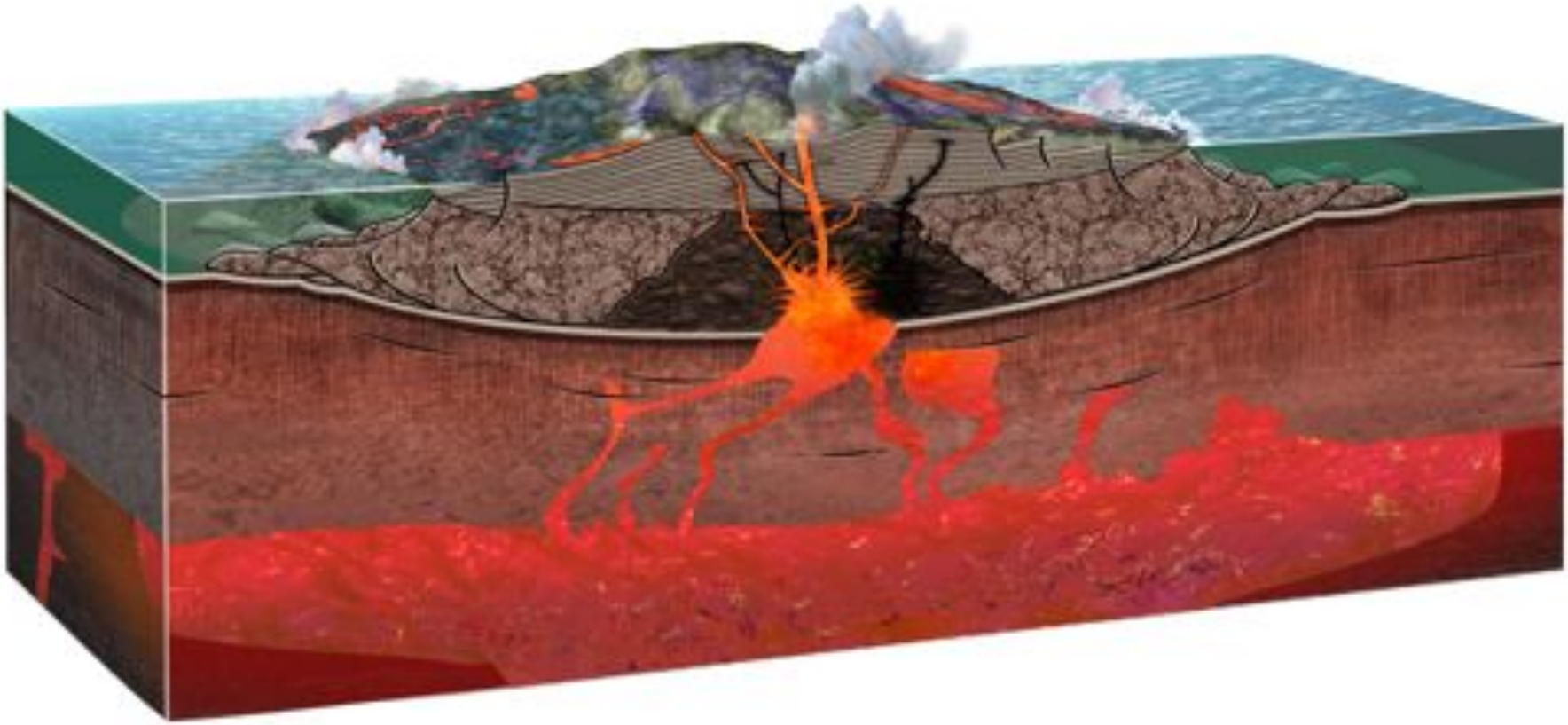
Shield Volcanoes are a Type of Central Vent Volcano




Mauna Kea
S. C. Porter

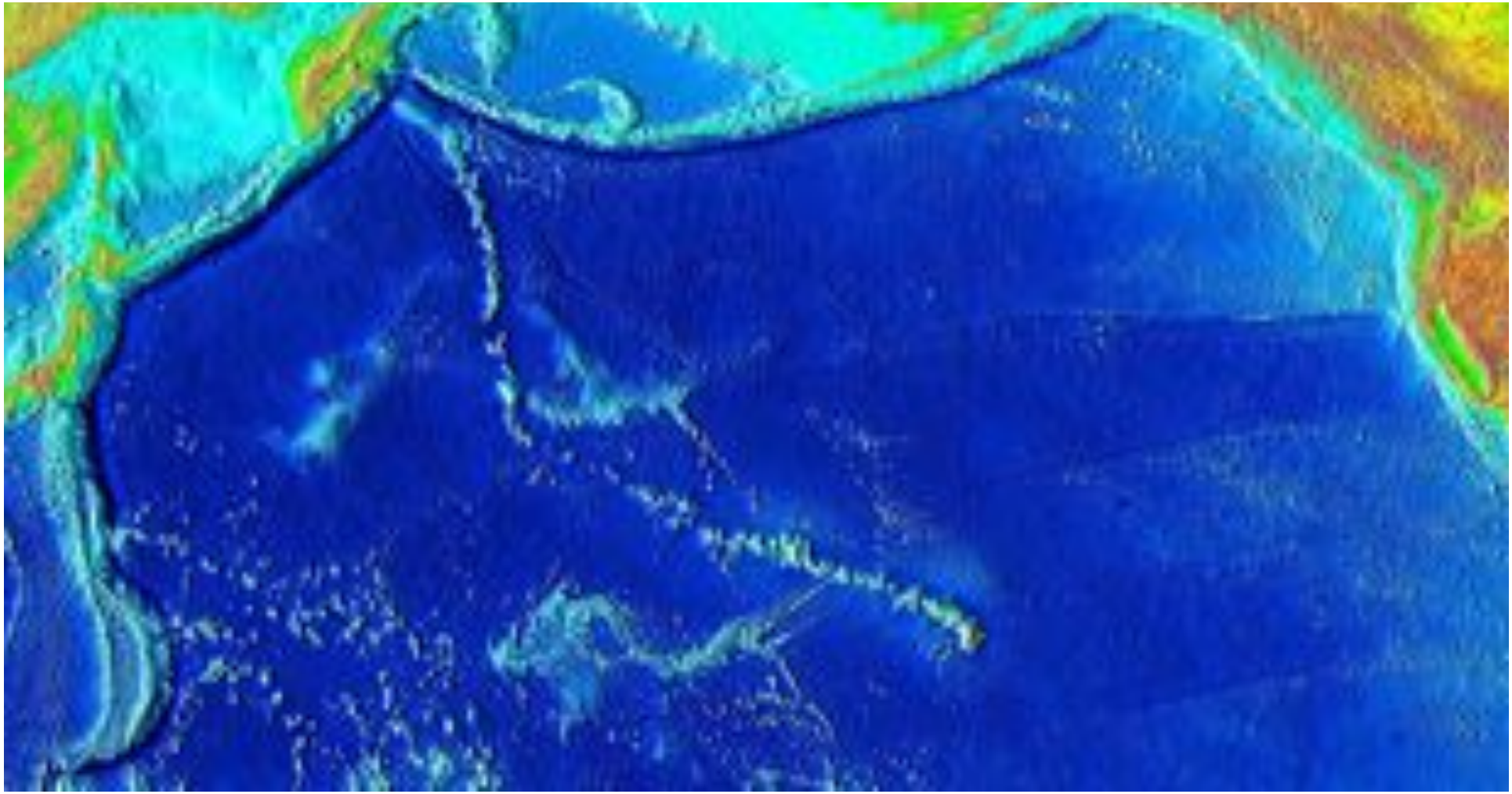
Shield Volcano

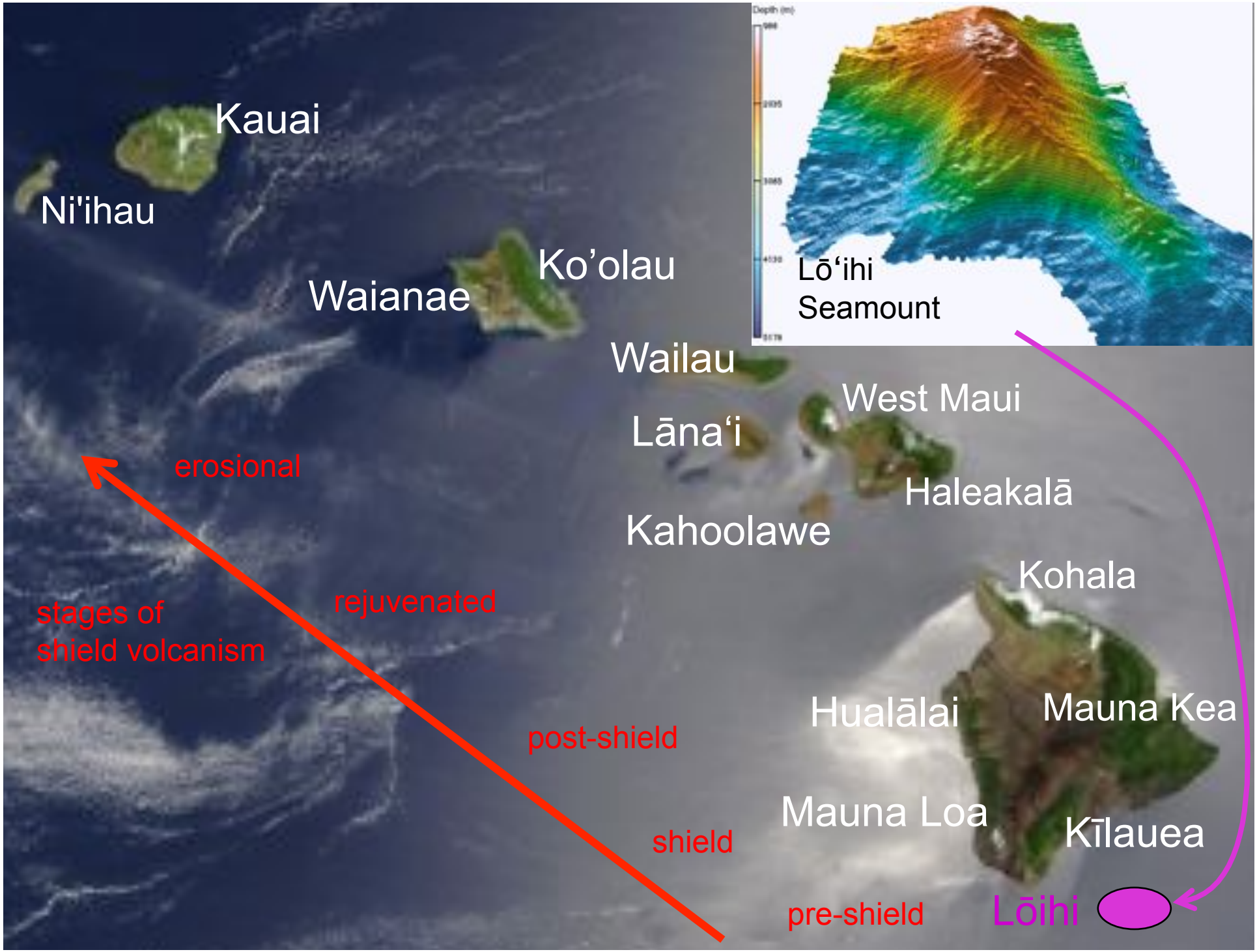
- Low silica, low gas magma originates in the mantle.
- Fluid, basaltic lava results in “Aa” and “Pahoehoe”.
- Low viscosity creates broad, gentle slopes.
- **Phreatomagmatic eruptions** occur when lava contacts water (rapid expansion of steam) .



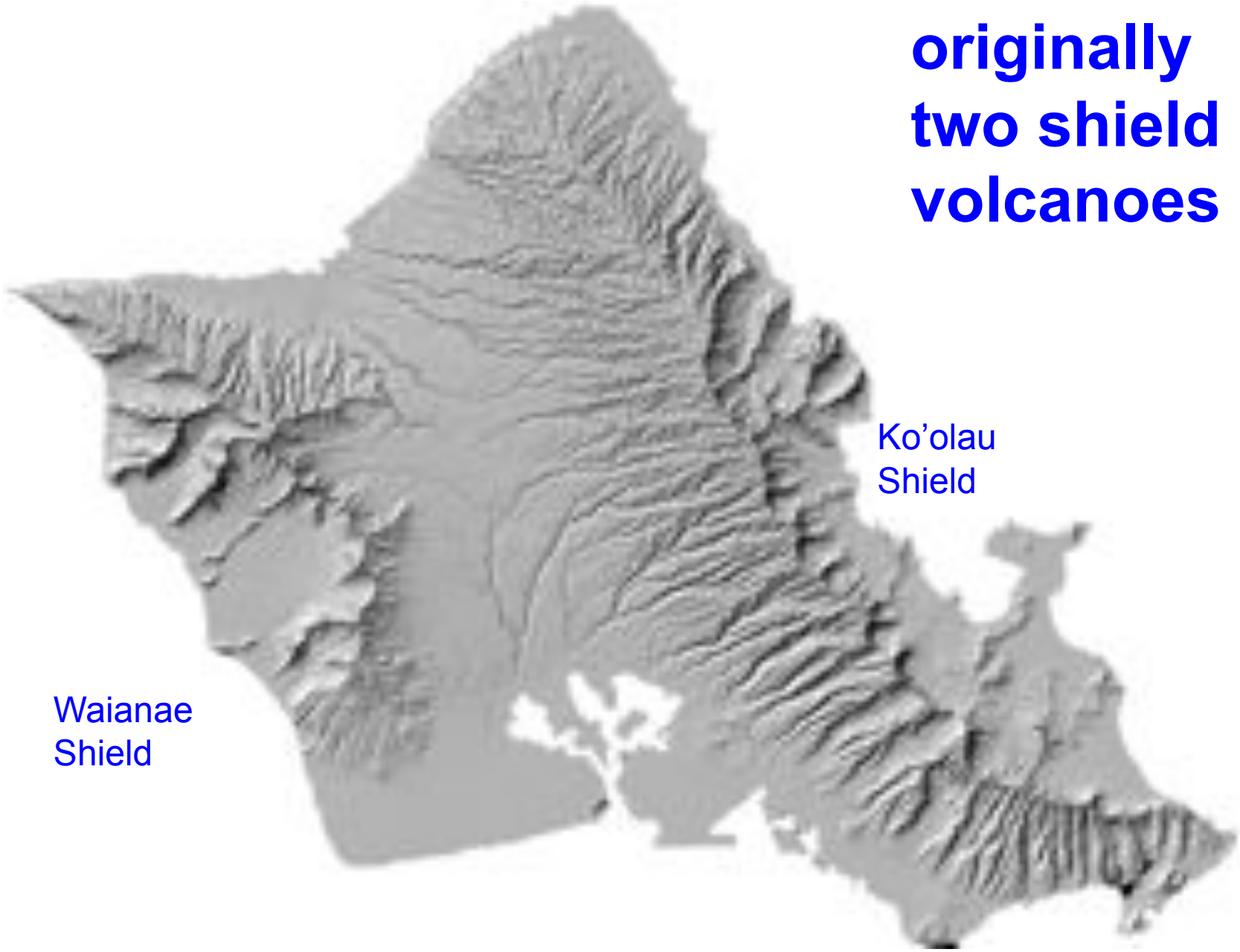
Shield Volcanoes in Hawai‘i

- Eight main islands are exposed tips of the Hawaiian Ridge.
- Age range is modern to ~6 million years old.
- Volcanoes develop as the Pacific Plate moves across the Hawaiian Hotspot.

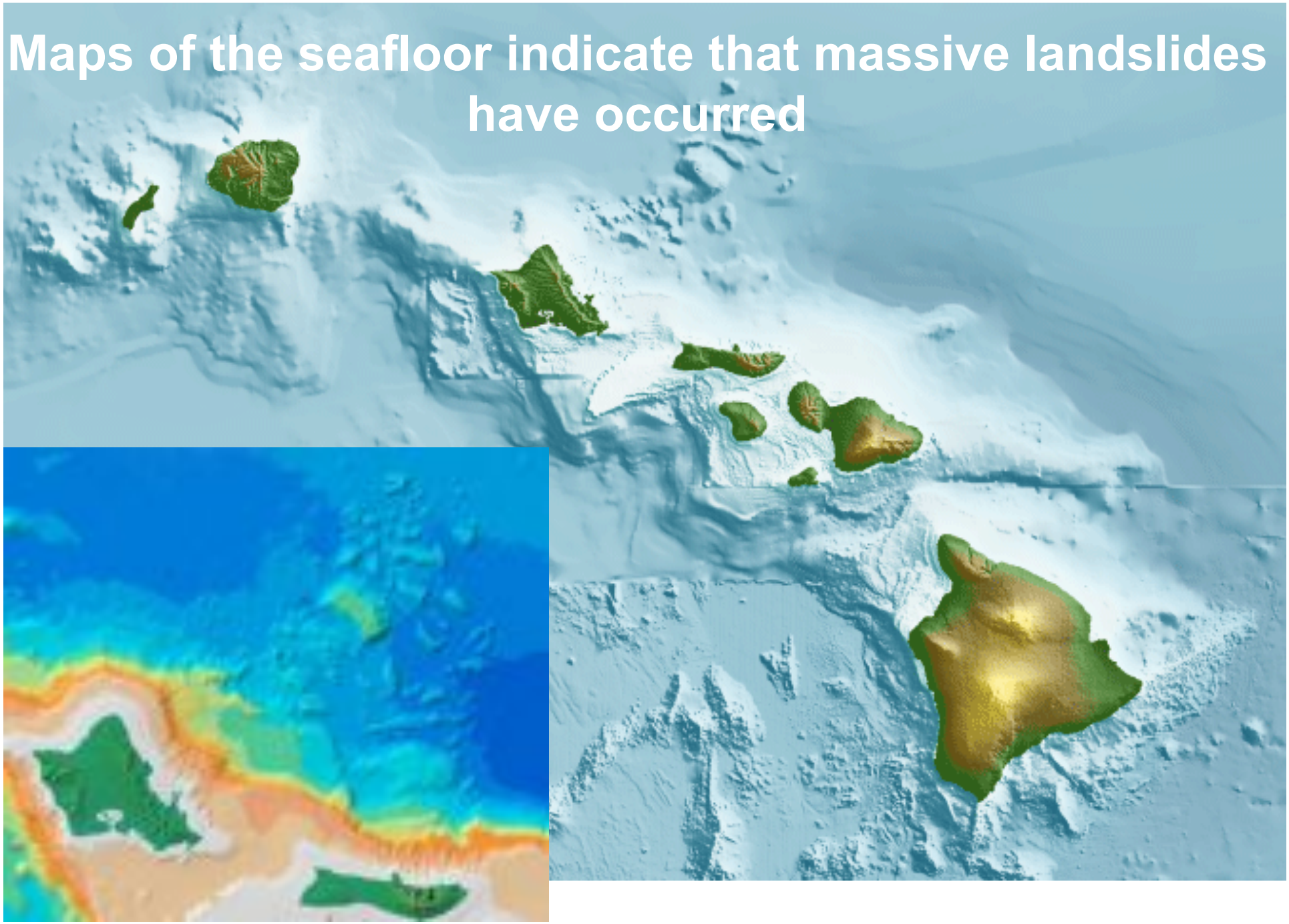



Kauai
Ni'ihau
Ko'olau
Waianae
Wailau
West Maui
Lānaʻi
Haleakalā
Kahoolawe
Kohala
Hualālai
Mauna Kea
Mauna Loa
Kīlauea
Lōʻihi
Seamount
Lōihi
erosional
rejuvenated
stages of
shield volcanism
post-shield
shield
pre-shield

Oahu was originally two shield volcanoes

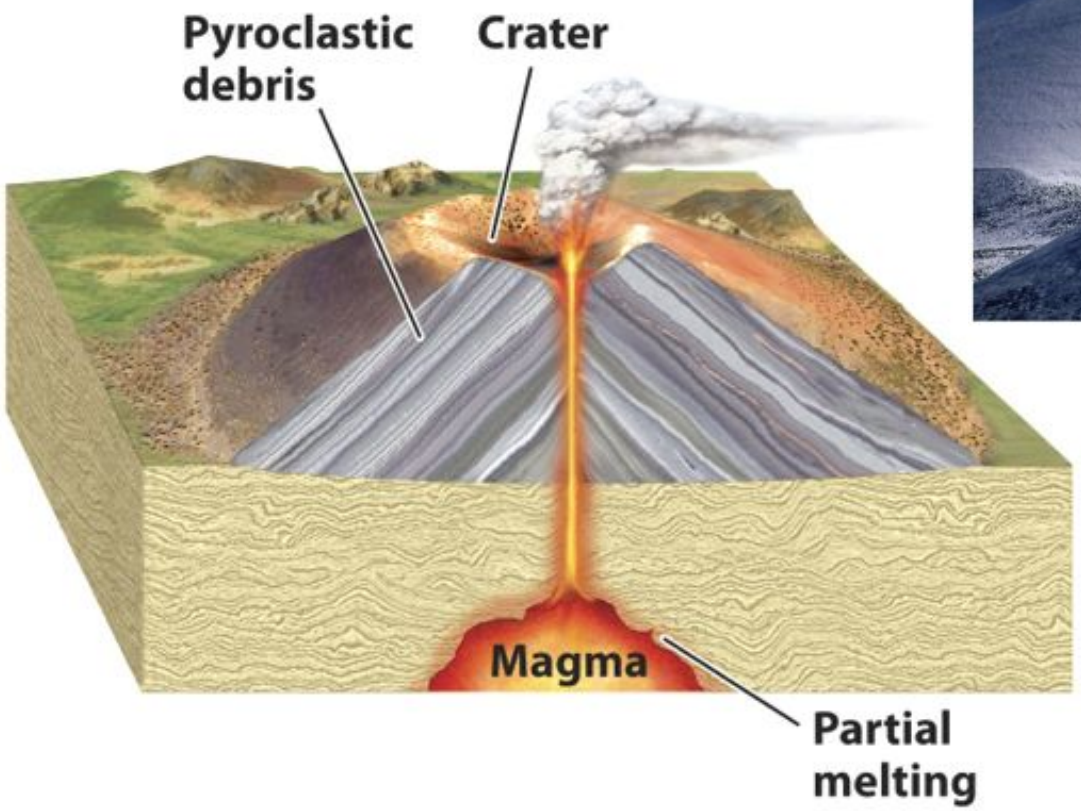


Maps of the seafloor indicate that massive landslides have occurred



Cinder Cones

high lava fountains on the vents of shield volcanoes.

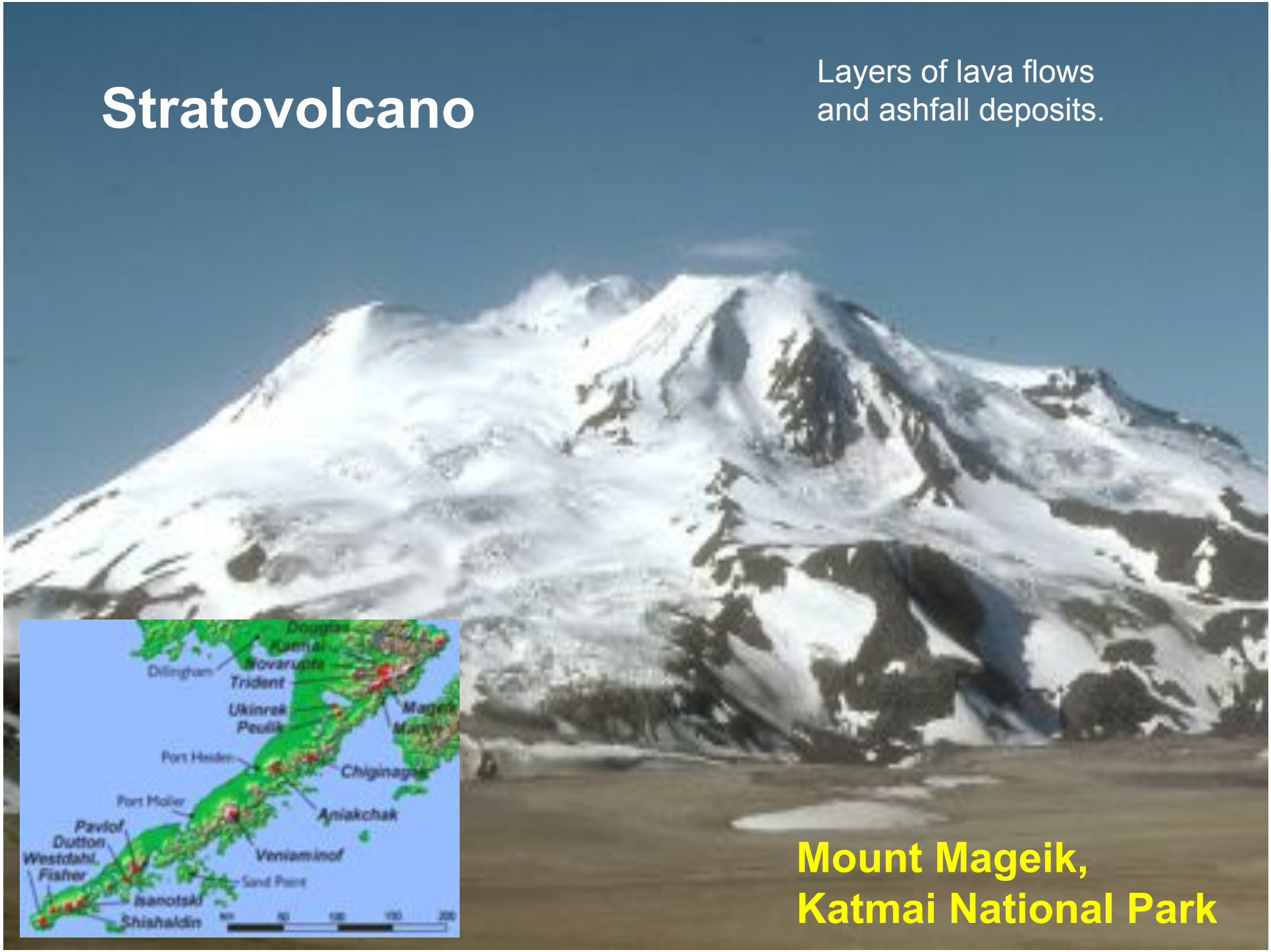


composed of pyroclastic debris caused by high gas content


Diamond Head

Stratovolcano

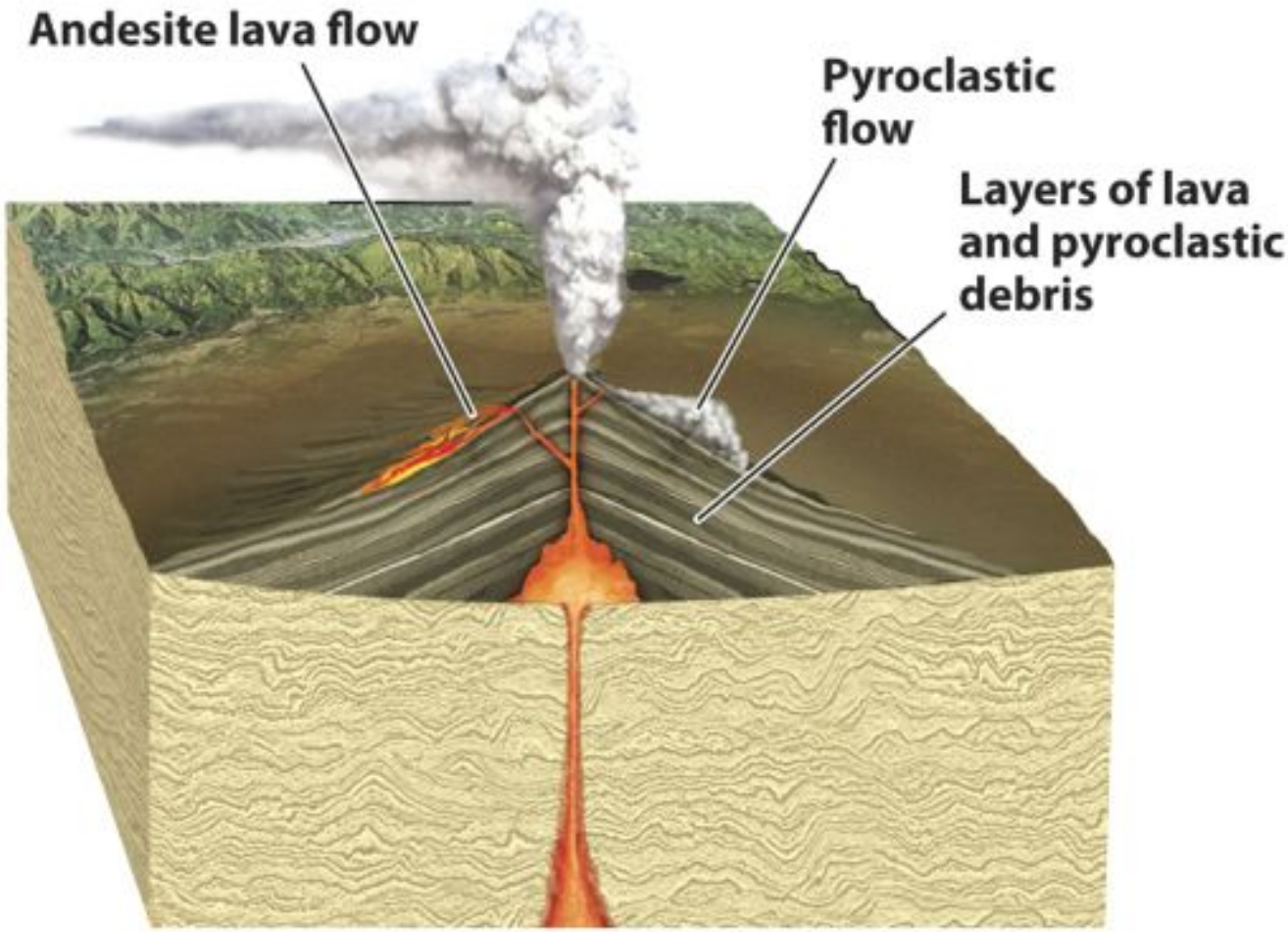
Layers of lava flows
and ashfall deposits.



**Mount Mageik,
Katmai National Park**

Features of Stratovolcanoes (composite volcanoes)

- Alternating andesitic lava flows and layers of explosively ejected pyroclastics.
- Magma is intermediate, making the lava viscous and difficult to erupt
- Explosive eruptions due to buildup of gases.



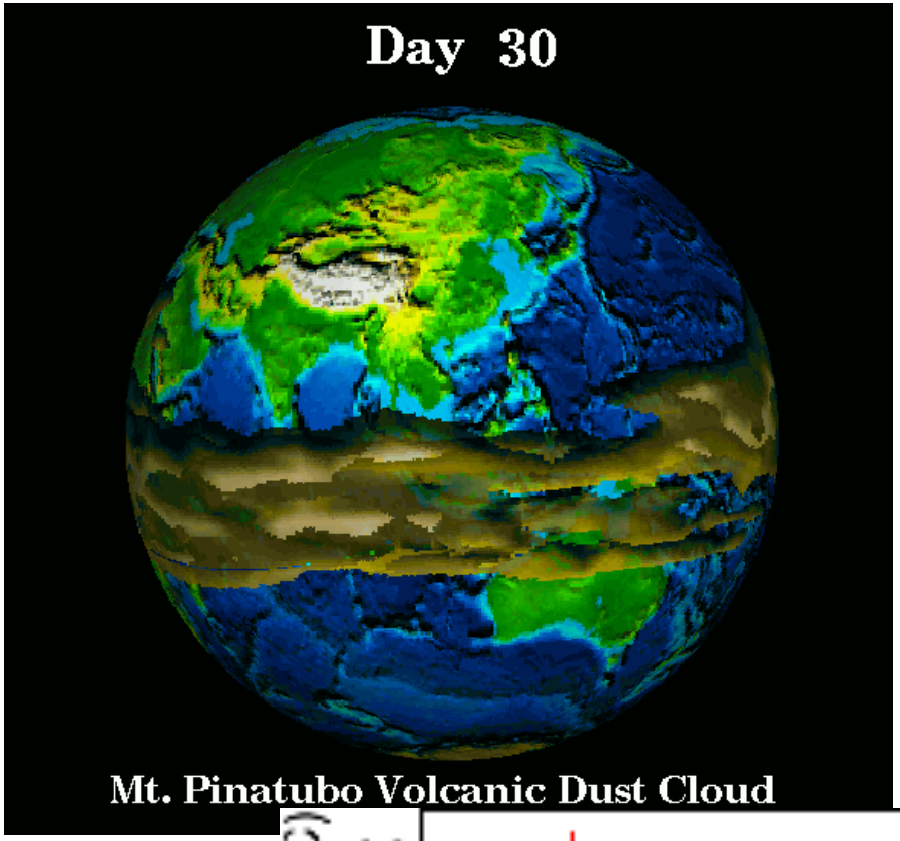

Mt. Fuji

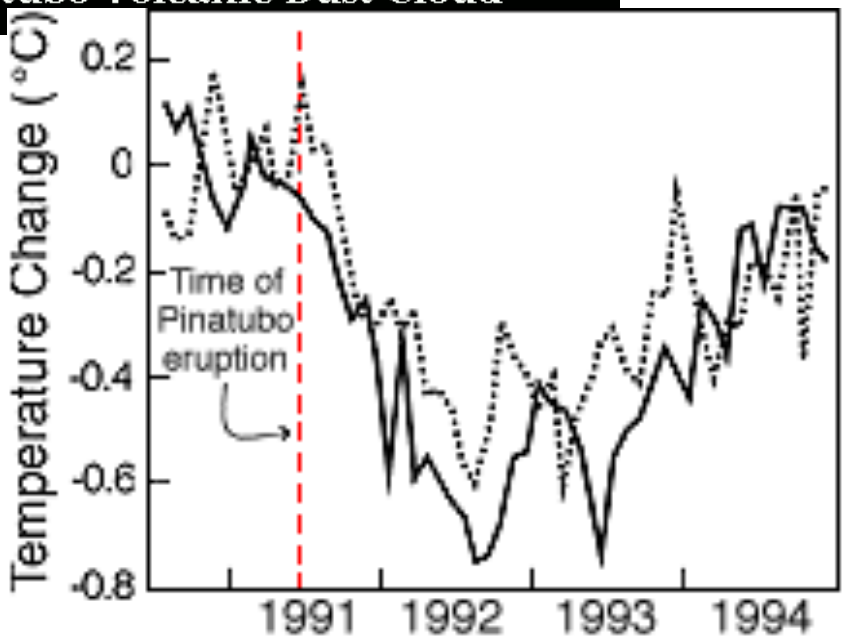

Lava Dome – a plug
that prevents eruption
(until it fails!)

Lahar: A mudflow resulting from an eruption

Lahar Worry in Seattle

http://www.youtube.com/watch?v=7Ct7G5lEHpc

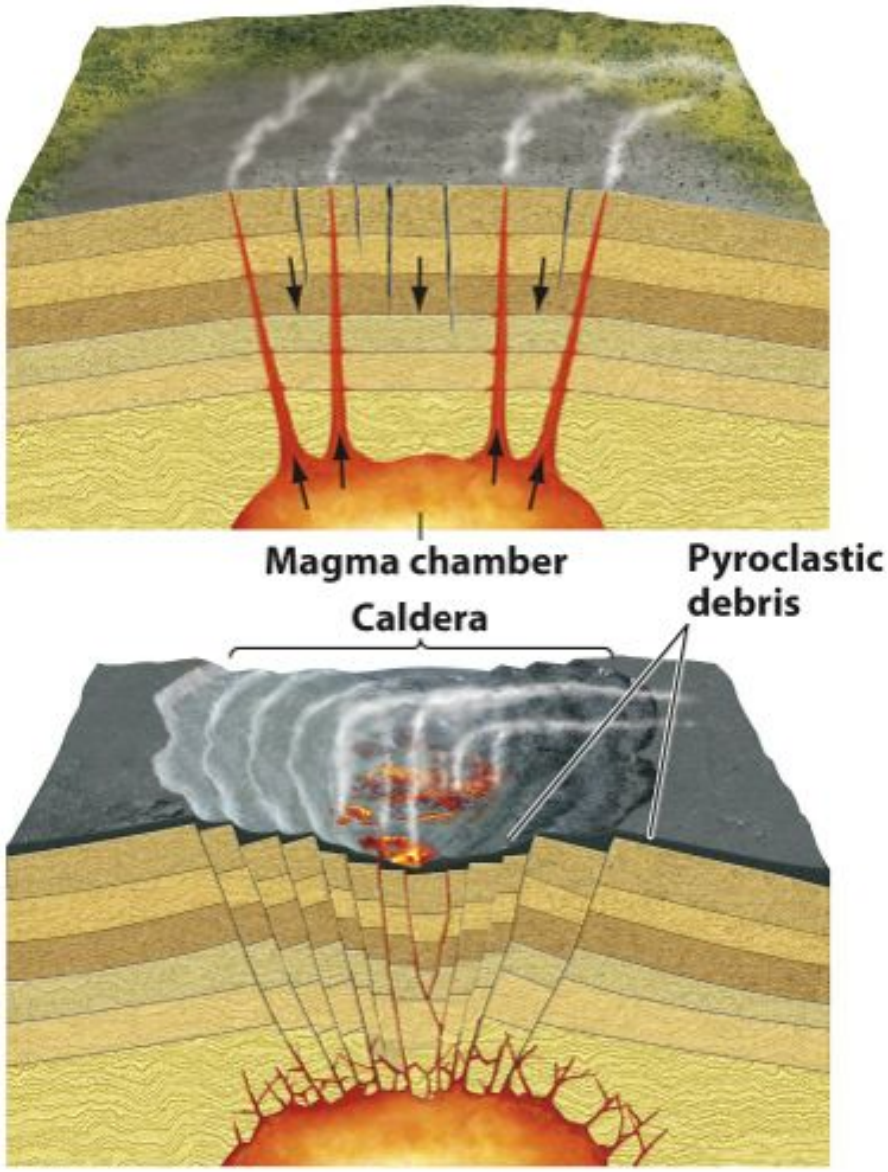




Mt. Pinatubo – 1991
Dust caused global cooling

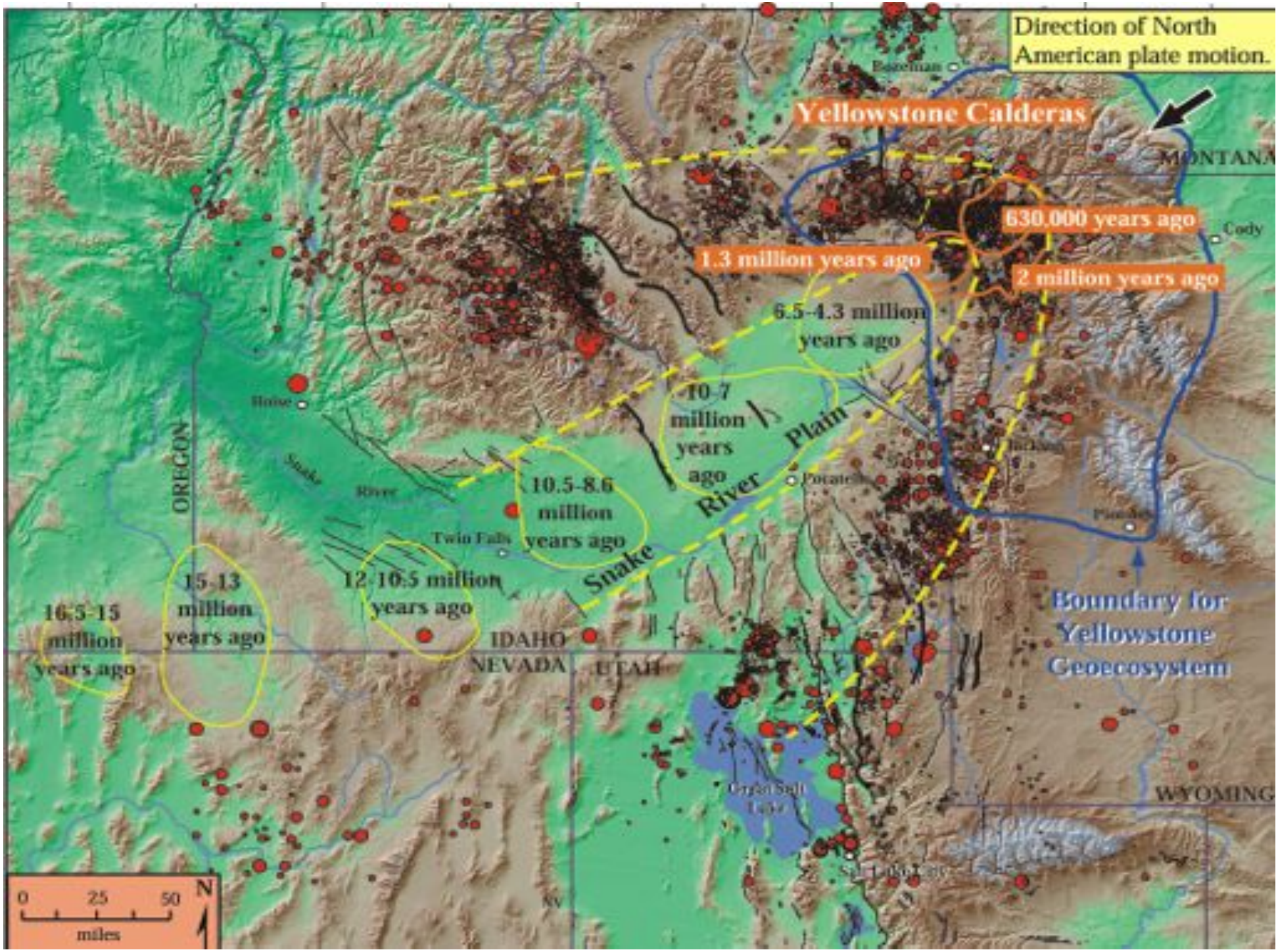
Rhyolite Caldera Complexes are Central Vent Volcanoes

Features of Rhyolite Caldera Complexes



- High-silica, high-gas magmas.
- Massive explosions (most explosive of all types).

- Collapse, producing an "inverse volcano", or Caldera (Spanish for cauldron).

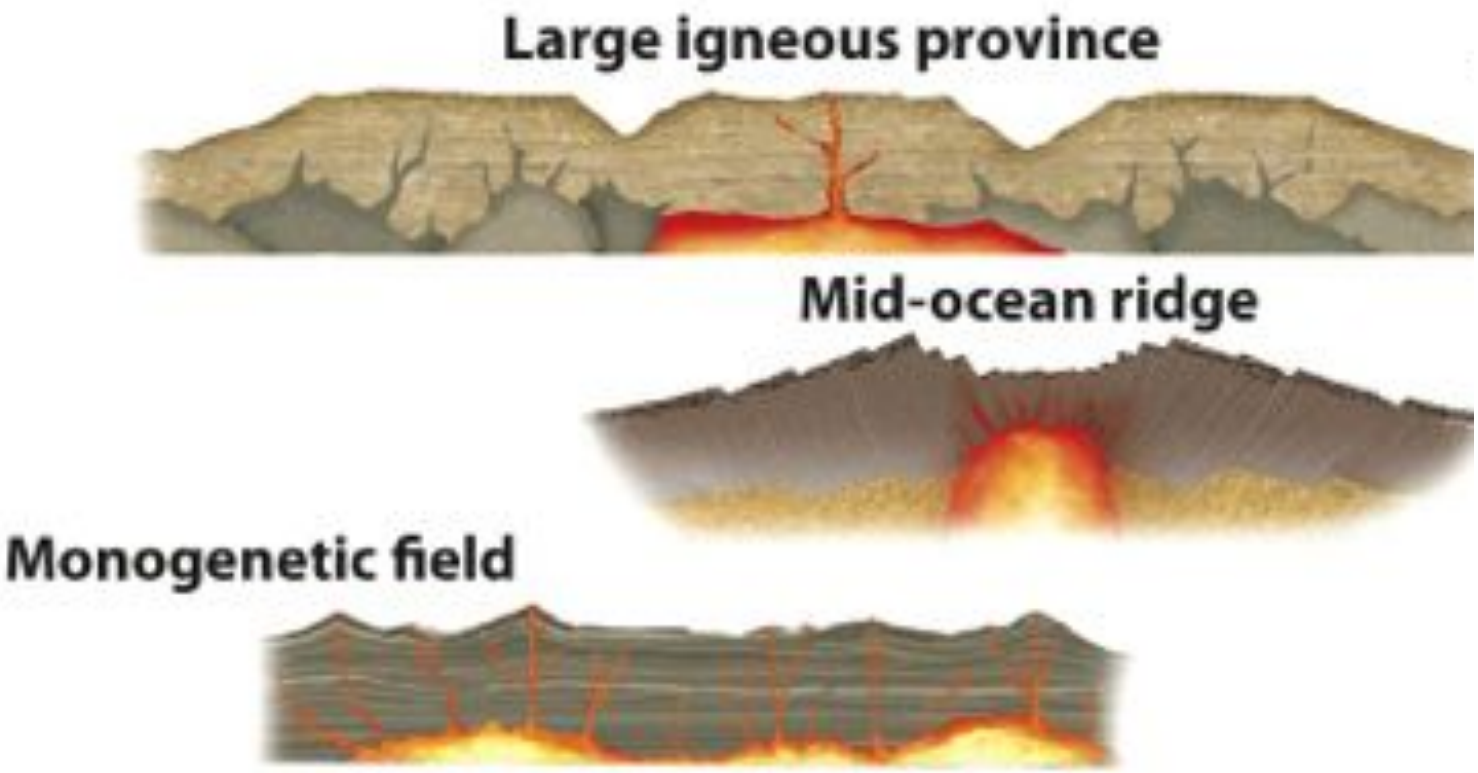

Direction of North American plate motion.
Yellowstone Calderas
MONTANA
630,000 years ago
2 million years ago
1.3 million years ago
6.5-4.3 million years ago
10-7 million years ago
Snake River Plain
10.5-8.6 million years ago
12-10.5 million years ago
15-13 million years ago
16.5-15 million years ago
OREGON
IDAHO
NEVADA
UTAH
WYOMING
Boundary for Yellowstone Geoecosystem
Twin Falls
Cody
0 25 50 miles
N

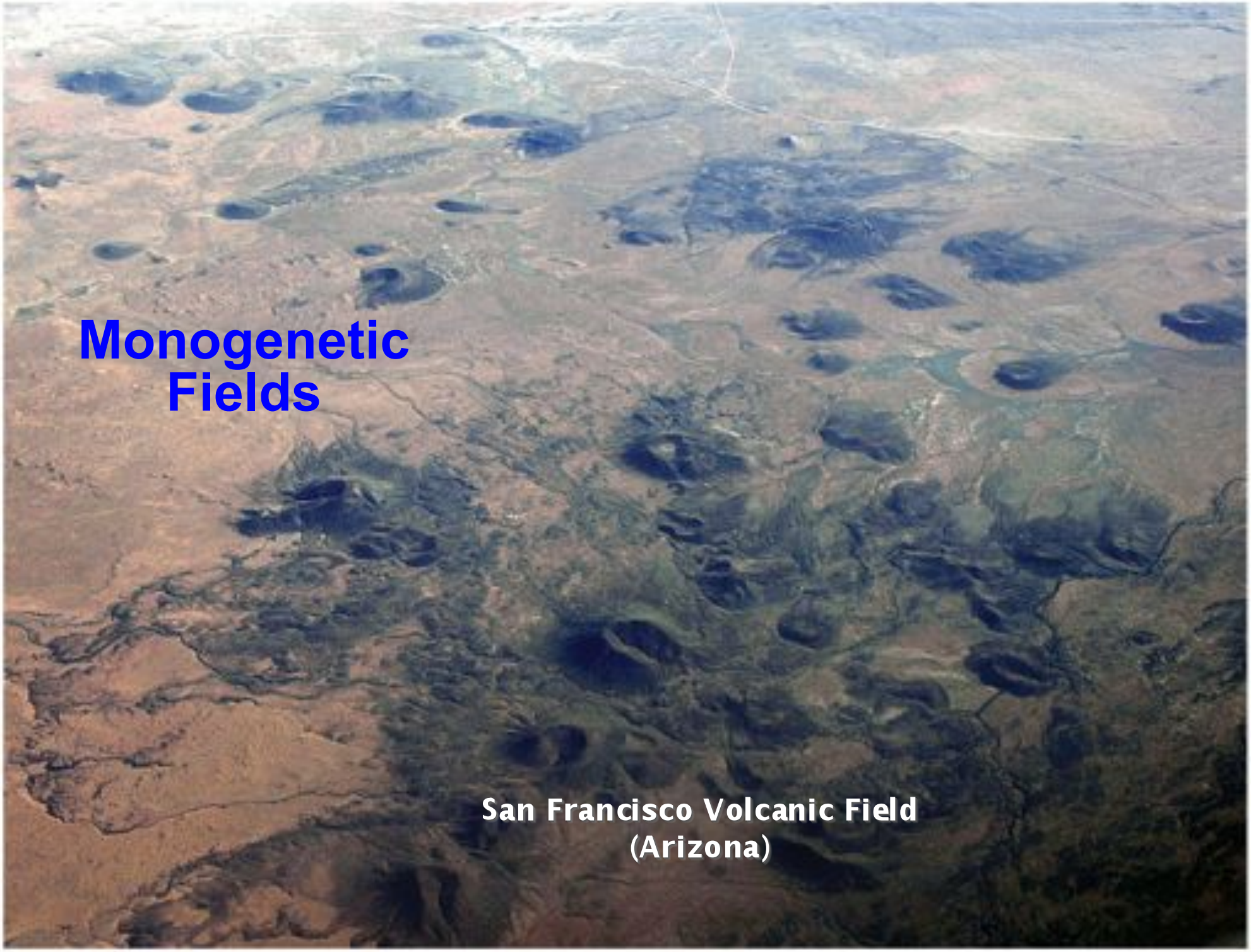
Yellowstone Eruption

http://www.youtube.com/watch?v=VR1bg_Yf0T4

Yellowstone ash beds cover much of the western USA

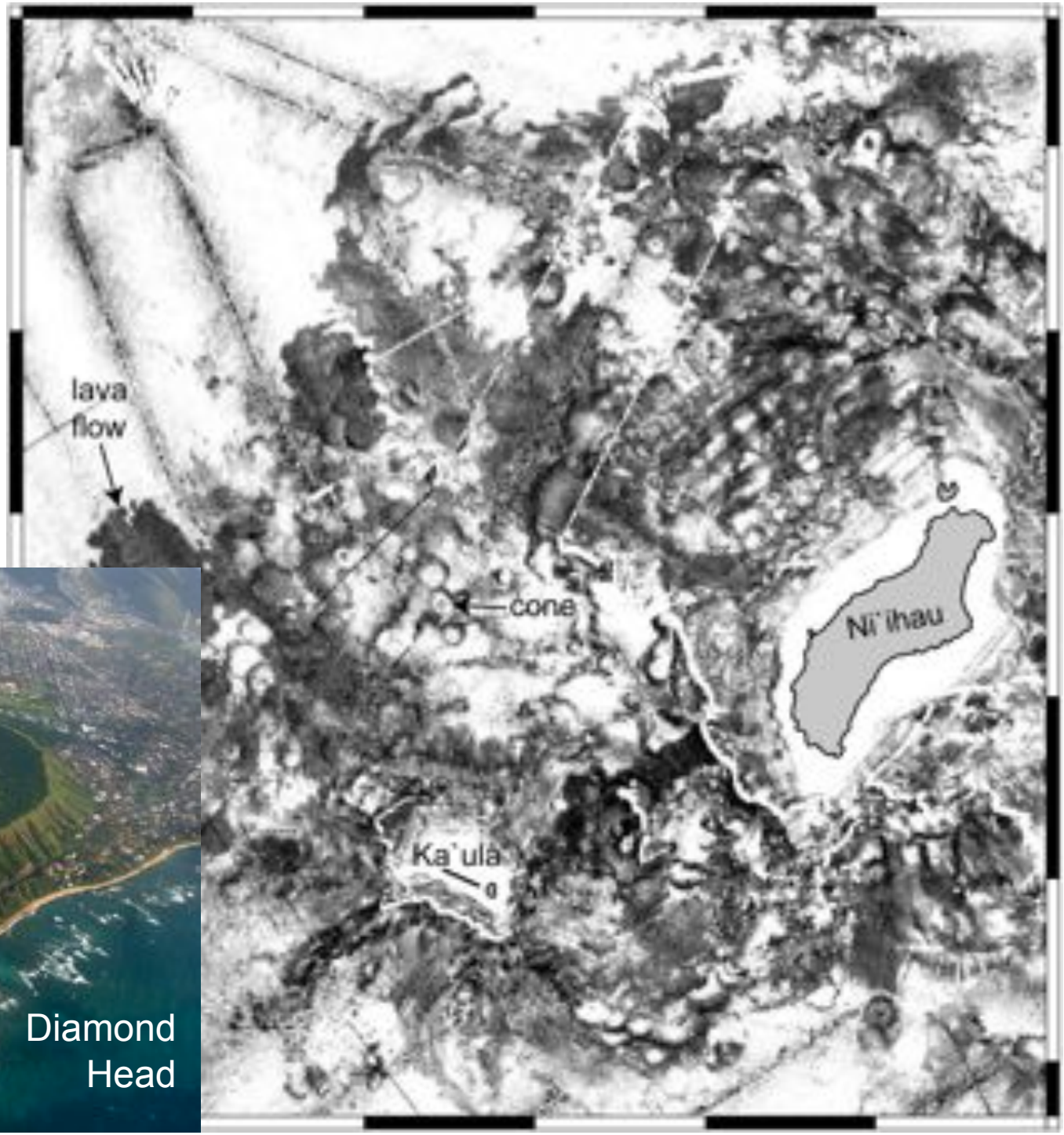
Large-scale volcanic terrains lack a central vent



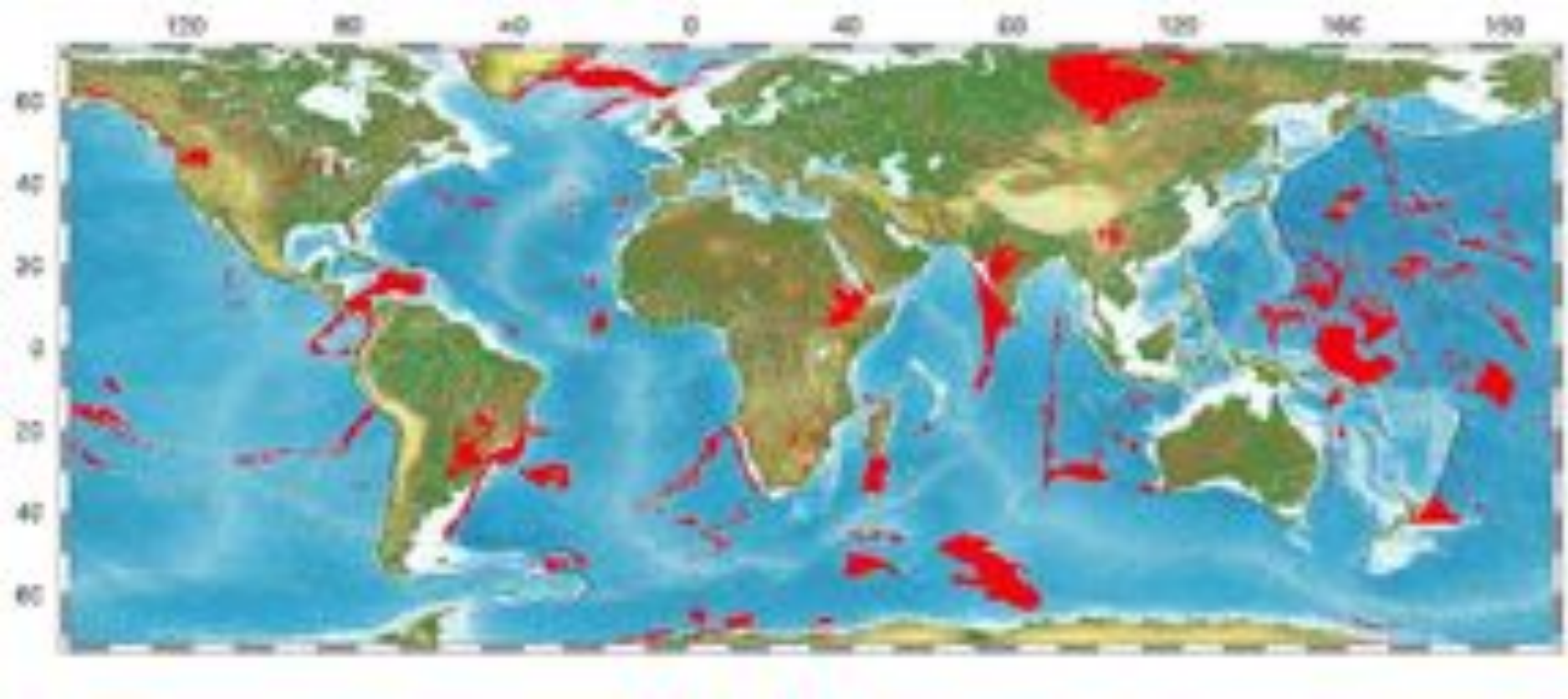

Monogenetic Fields
San Francisco Volcanic Field
(Arizona)

Rejuvenated (secondary) volcanism around Hawaii:

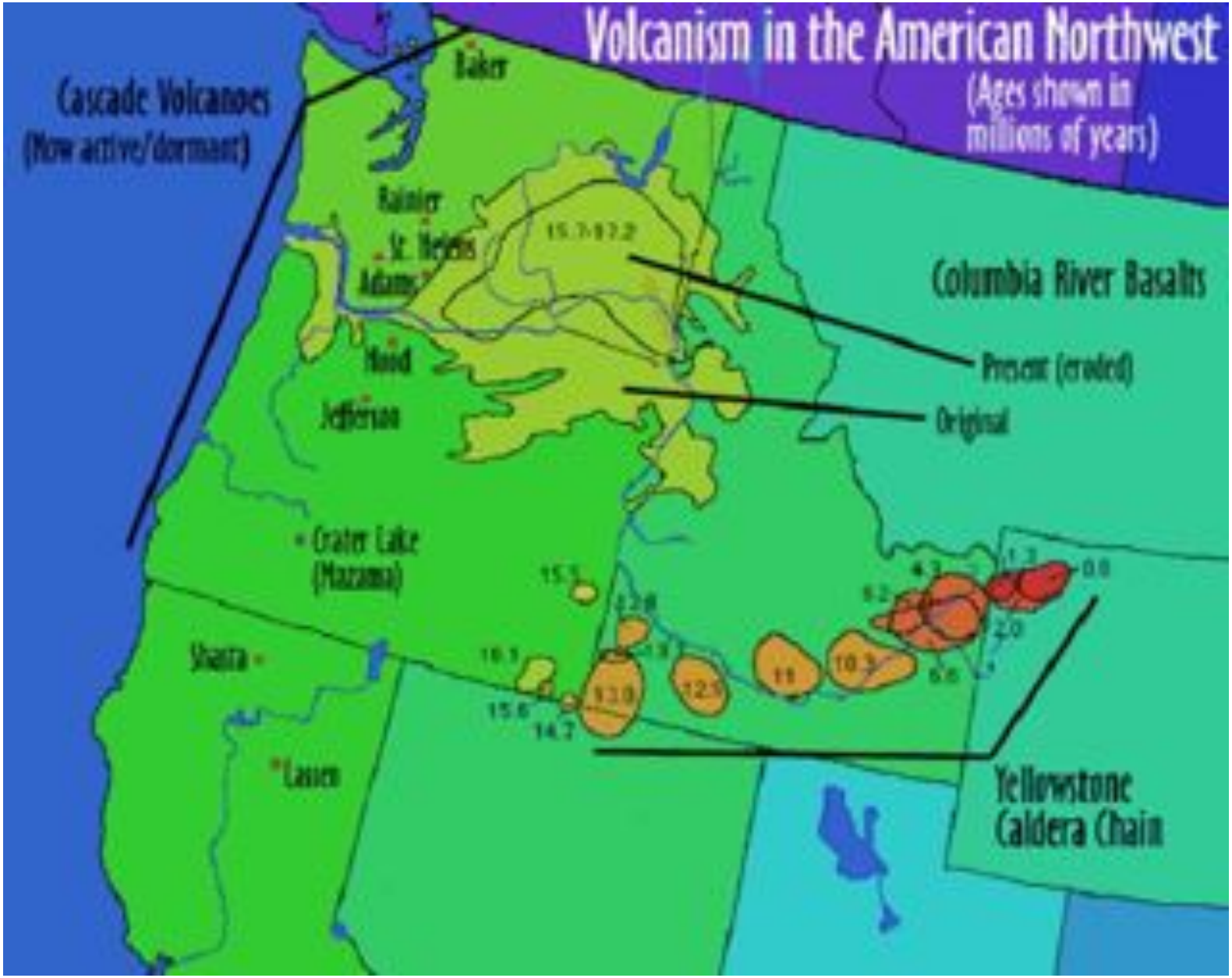
A type of monogenetic field



Large Igneous Provinces occur on land and in the ocean

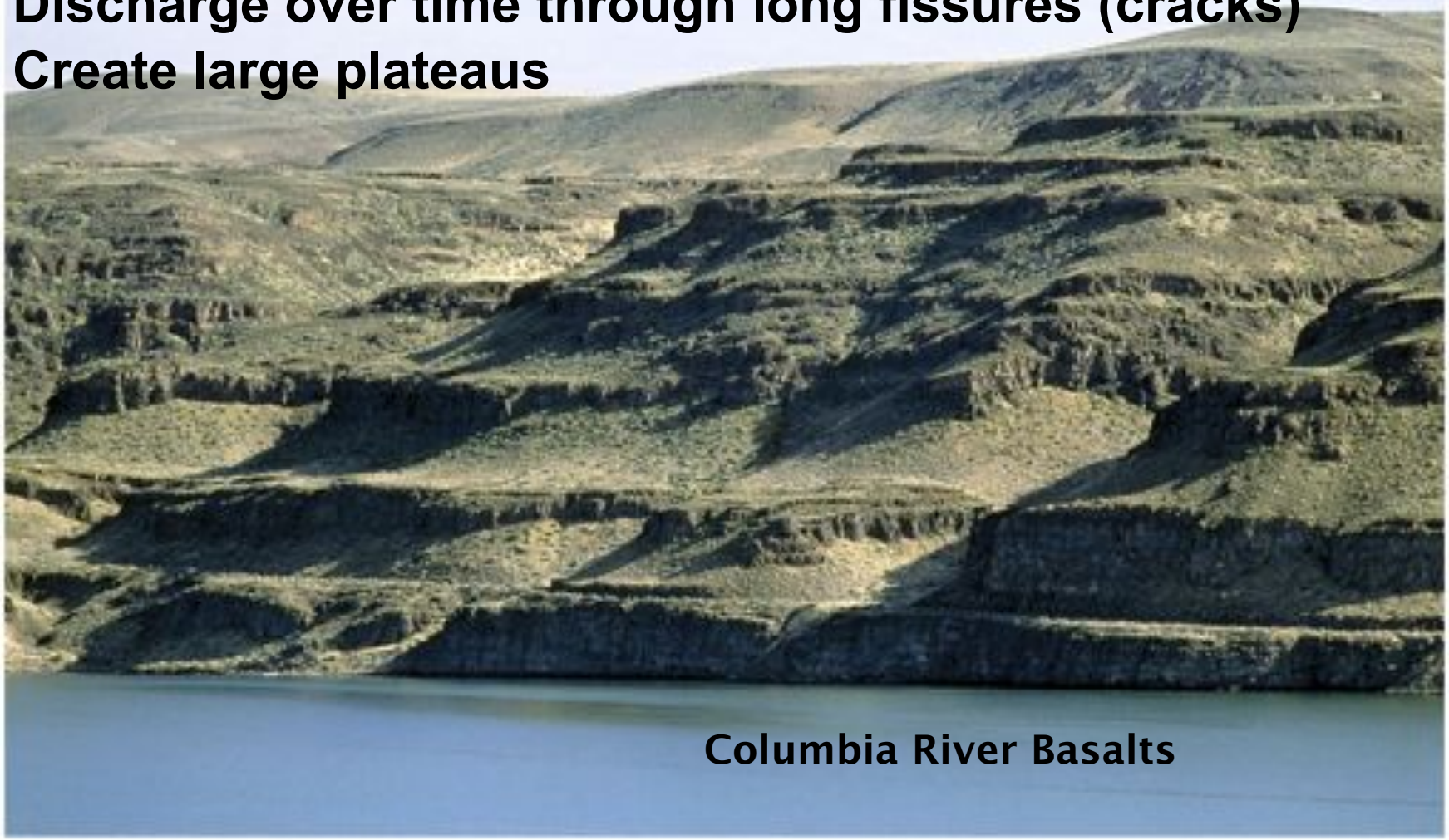


Example: Columbia Flood Basalts mark the beginning of the Yellowstone hotspot



Large Igneous Province

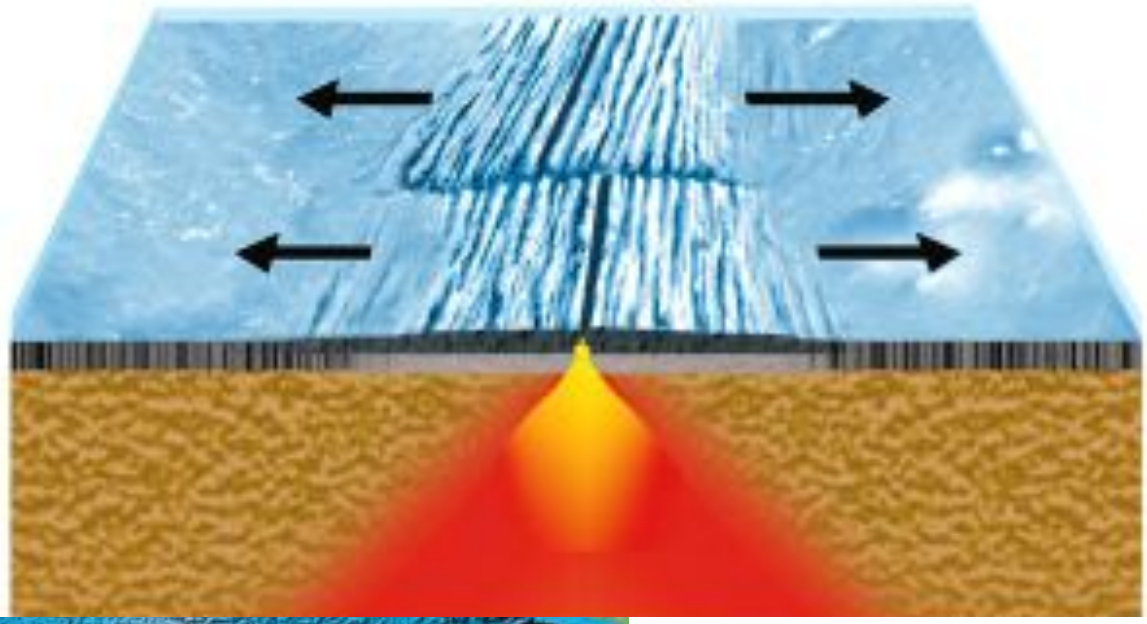
Fed by massive mantle plumes
Caused by flood basalts (especially fluid basaltic lavas)
Discharge over time through long fissures (cracks)
Create large plateaus

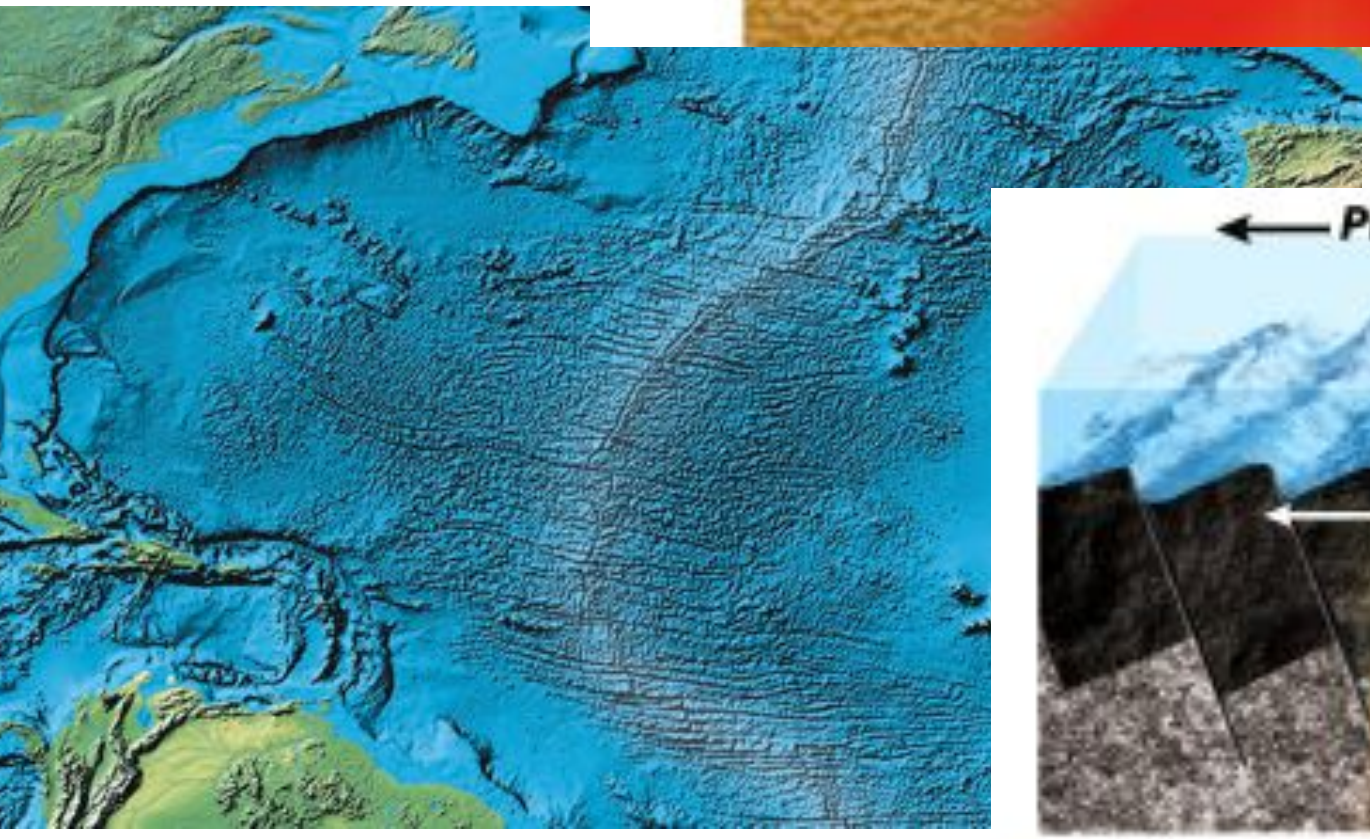


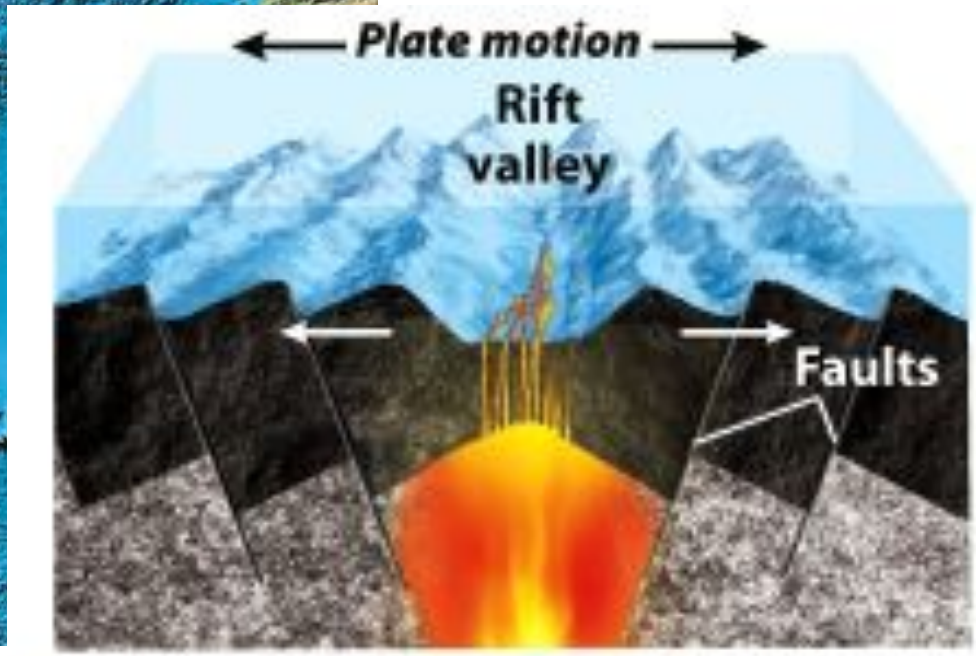
Columbia River Basalts


Mid-ocean Ridges
submarine volcanism
• Develop at **Spreading Centers**
• Basaltic flow creates global network of interconnected ridges

Mid-ocean Ridges

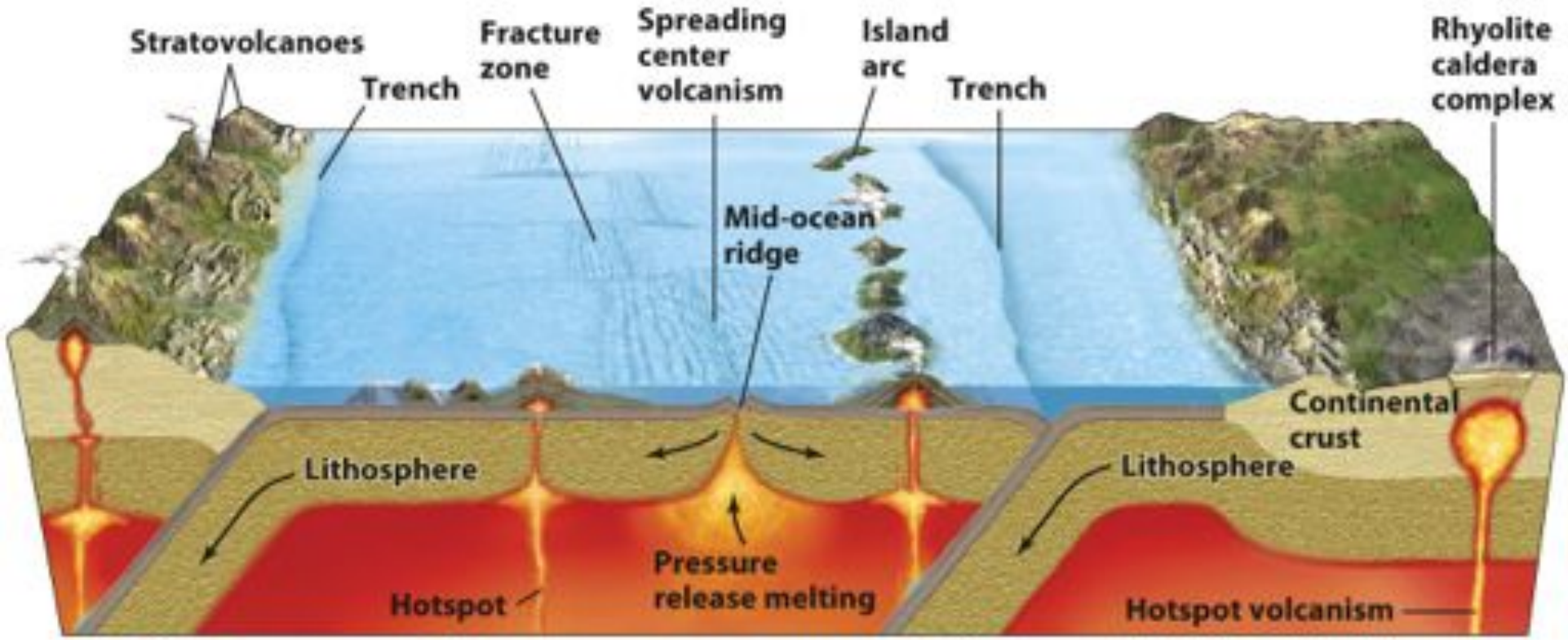






Many volcanoes occur on plate boundaries
- but sometimes in the middle of plates

Most volcanoes are associated with spreading center volcanism, arc volcanism, or intraplate volcanism



Arc Volcanism: Andesitic explosive stratovolcanoes; some basaltic types

Spreading Center Volcanism: Fluid basaltic lavas, divergent margins

Intraplate Volcanism: Shield volcanoes and monogenetic fields (basaltic)
Rhyolite caldera complexes (rhyolytic)

Action Items for Thursday, Oct. 8

1. Read Chapter 6
2. Complete homework assignment #10

What you should know from today:

1. Define the term volcano and explain why geologists study volcanoes
2. Compare and contrast 3 common types of magma
3. Describe volcanic gases and the role they play in explosive vs effusive eruptions
4. Identify what gives a shield volcano its distinctive shape