VOLCANIC GEOMORPHOLOGY

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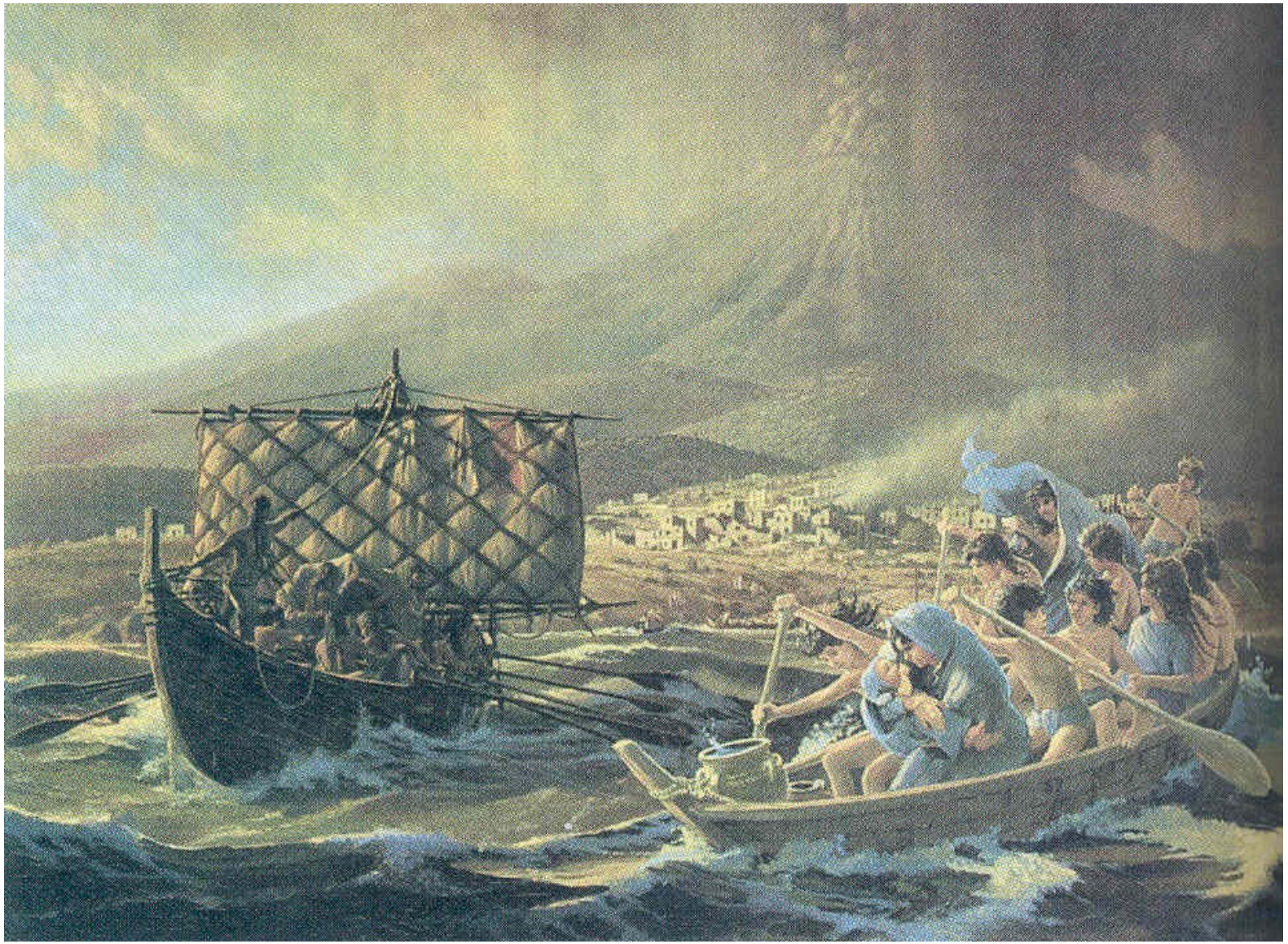
An artist's rendition of the volcanic eruption on Thera that destroyed most of the island in about 1390 BC. Most of the island's inhabitants escaped the devastation



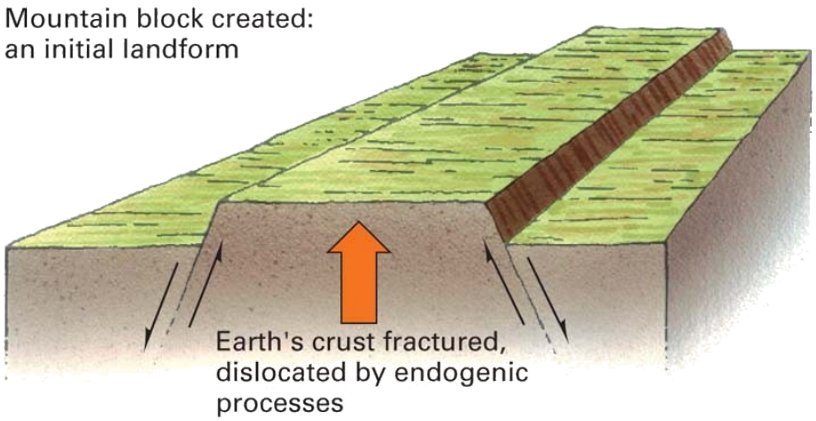
Continental landforms are the result of endogenic and exogenic processes.

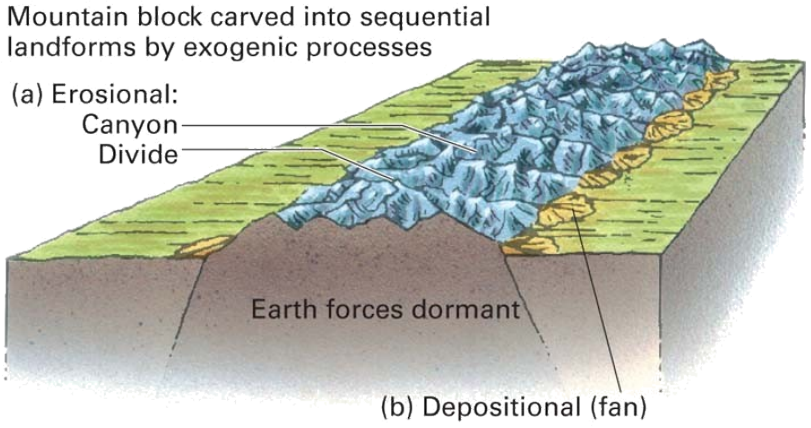
Endogenic process: works from within the Earth

- Produces *initial landforms*
- Uplifts; brings fresh rock to the surface
- Powered by Earth's internal energy

Exogenic process: works at Earth's surface

- Wears down initial landforms
- Creates *sequential landforms*





A VOLCANO is a vent in earth's crust through which molten rock, steam, gas, and ash are expelled

<u>volcano:</u> opening in Earth's crust through which molten rock, gases, & ash erupt to the land around the opening

Volcanoes is the Windows of Earth's interior

- **Help us understand plate tectonic process and mantle convection**
  - ***At present, but also millions to billions of years in past using radioisotopic dating***
- **Impact Earth's atmosphere and hydrosphere**
- **Pose hazards to millions of people**
- **Geothermal energy sources**

  Regions near hot springs and geysers have hot water that can be tapped and used to drive turbines to generate electricity.

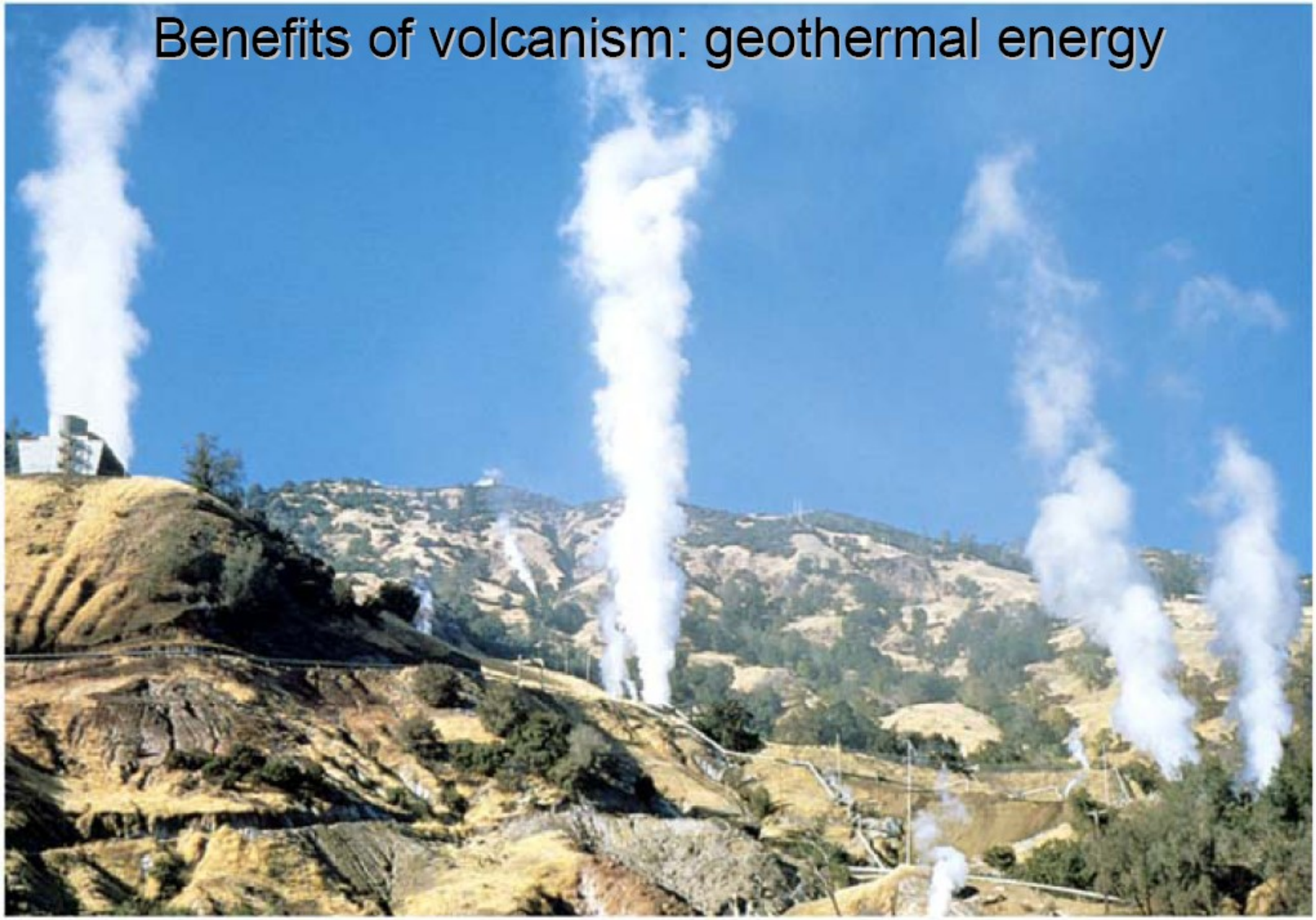
Volcanic Hazards

- **Lava flows**
- **Pyroclastic flow and falls**
- **Ash flows**
- **Lahars and Debris Avalanches**
- **Volcanic gases**
- **Volcanic dome collapse**
- **Caldera collapse**
- **Eruption clouds**
- **Landslides**
- **Seismicities**
- **Tsunami**

Resources

- volcanic soils
- industrial materials
- ore formation
- geothermal energy

Benefits of volcanism: geothermal energy



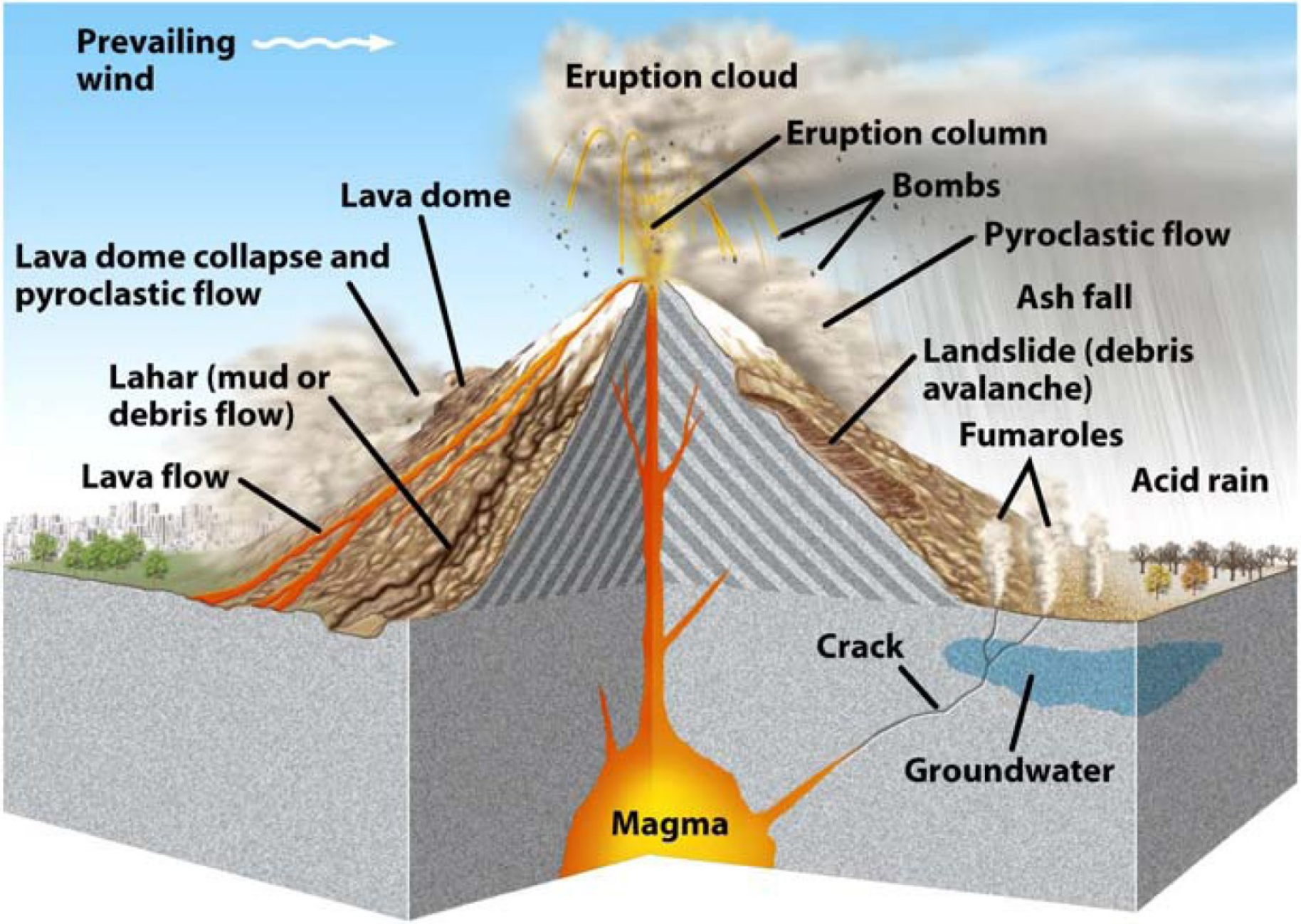
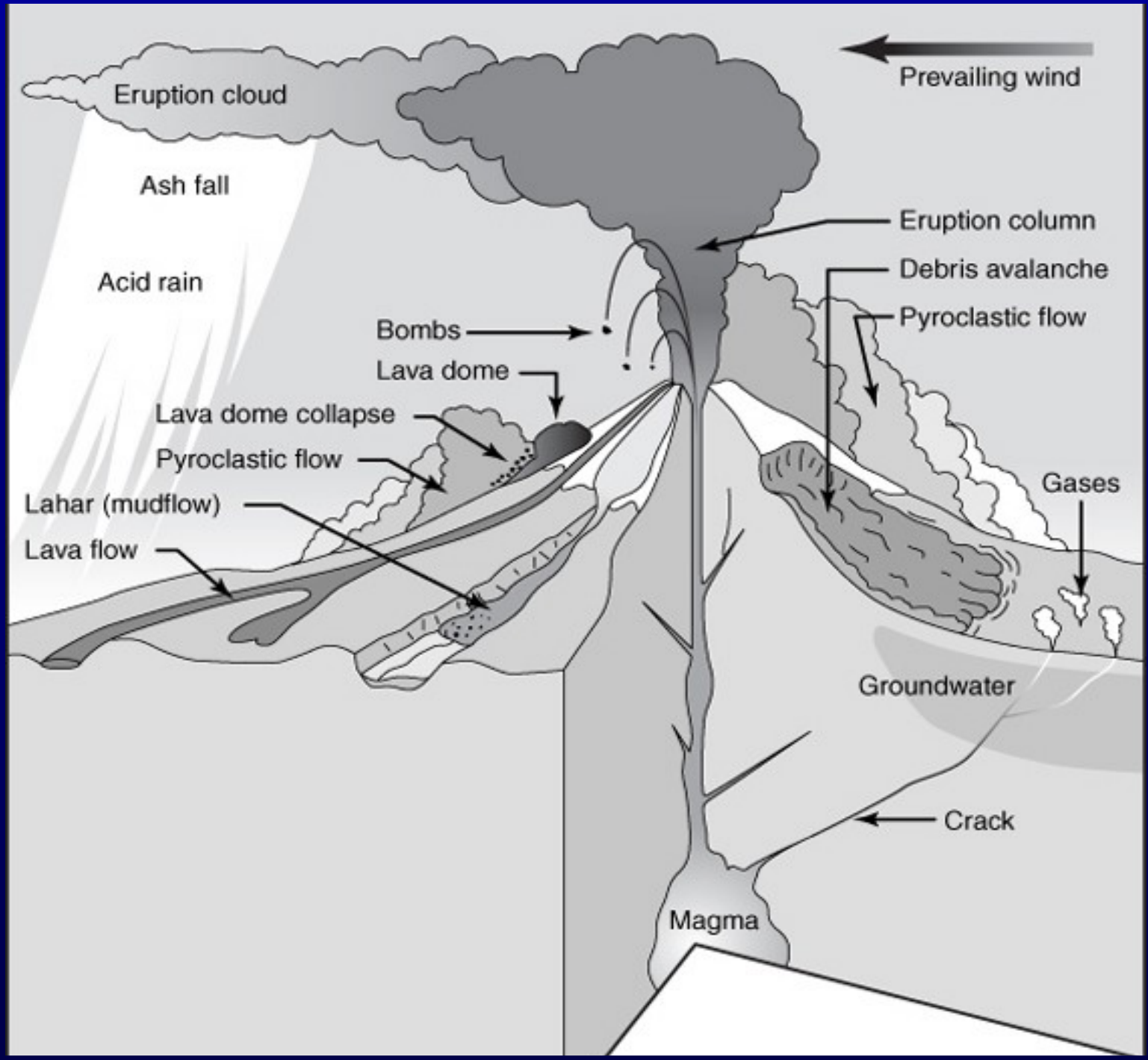
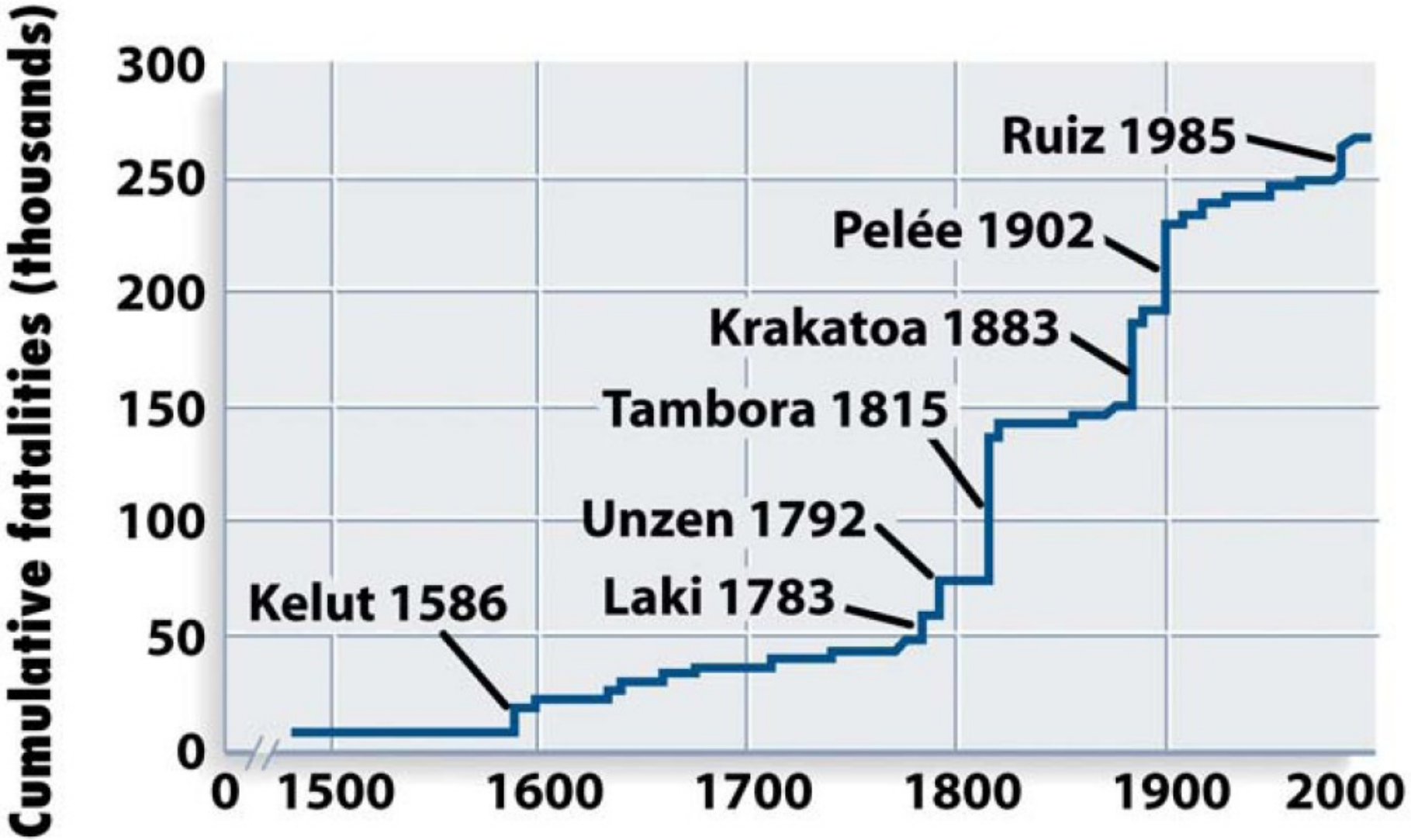
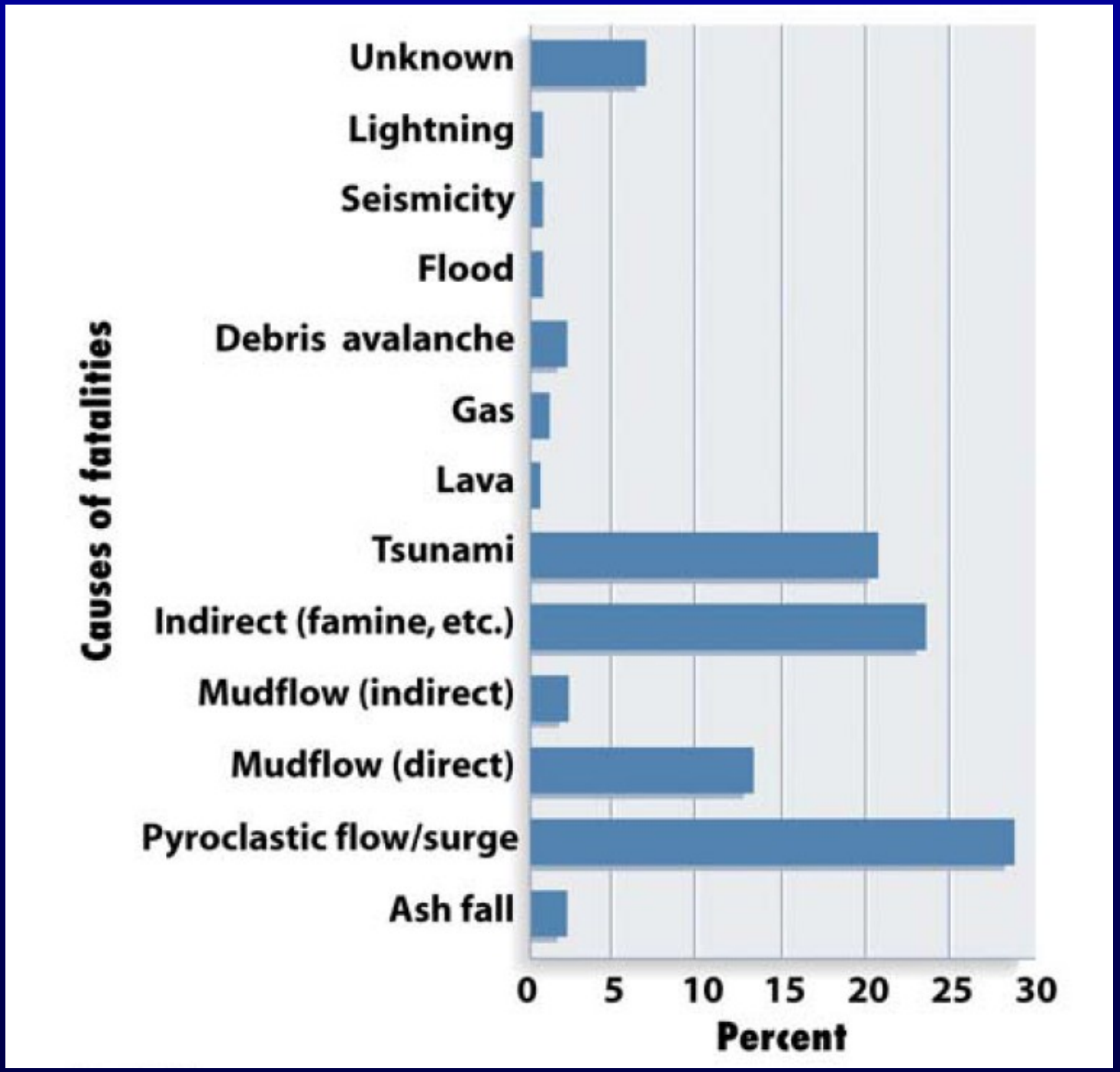


Figure 12-25
Understanding Earth, Fifth Edition


Eruption cloud
Prevailing wind
Ash fall
Acid rain
Eruption column
Debris avalanche
Pyroclastic flow
Bombs
Lava dome
Lava dome collapse
Pyroclastic flow
Lahar (mudflow)
Lava flow
Gases
Groundwater
Crack
Magma

Volcanism and human affairs




Causes of fatalities
Unknown
Lightning
Seismicity
Flood
Debris avalanche
Gas
Lava
Tsunami
Indirect (famine, etc.)
Mudflow (indirect)
Mudflow (direct)
Pyroclastic flow/surge
Ash fall
0
5
10
15
20
25
30
Percent

Magma Formation

A volcanic eruption occurs where magma (molten rock) rises to the surface.

Most of the asthenosphere is solid because of the pressure exerted on it by the lithosphere above it, but some materials do melt.

Conditions for Magma Formation in the Asthenosphere

1. A decrease in pressure can lower the melting temperature of the materials.

   → along rift valley at mid-ocean ridge where the lithosphere is thinner & exerts less pressure

2. An increase in temperature can cause materials to melt.

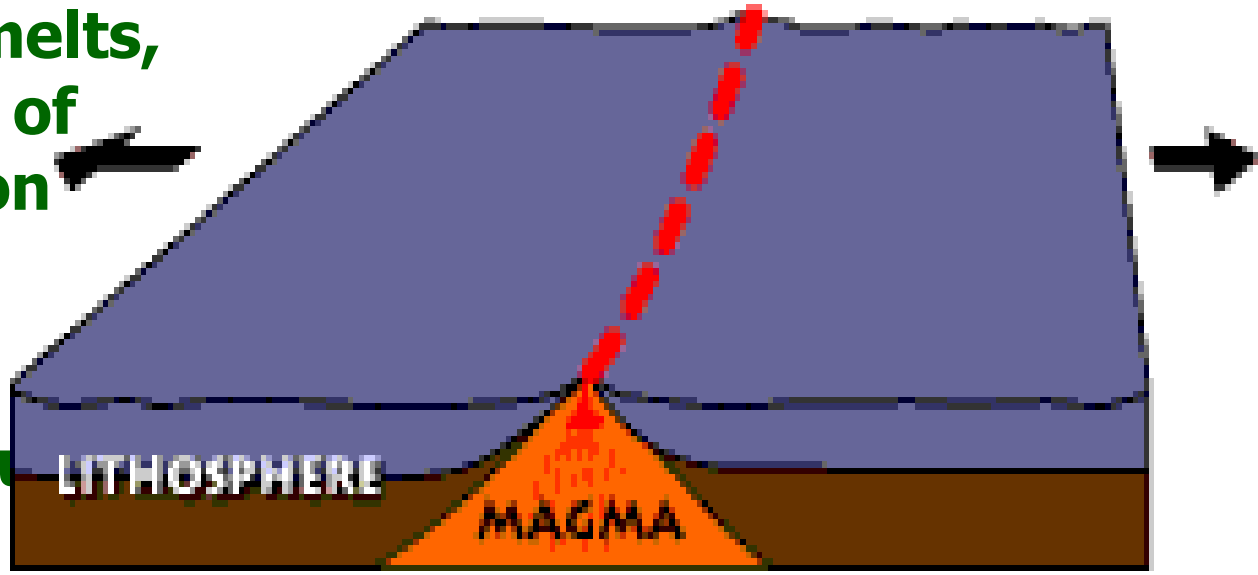
   →at a hotspot

3. An increase in the amount of water in the asthenosphere can lower the melting temperature of the materials.

   →At subduction boundaries

Magma generation at mid-ocean ridges

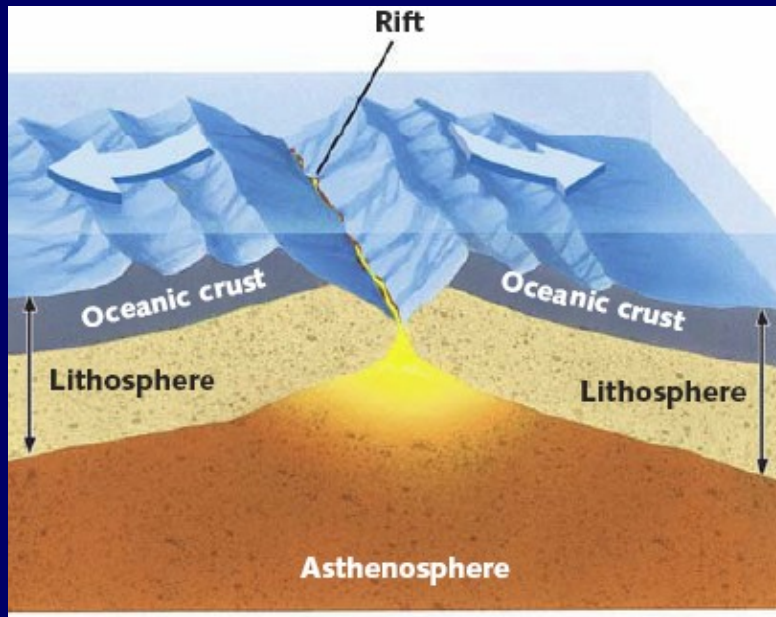
- In these zones, the mantle rises and melts, producing magma of silicate composition



- the magma continu
to rise, and erupts
mainly as basaltic lava
flows

At Divergent Boundaries

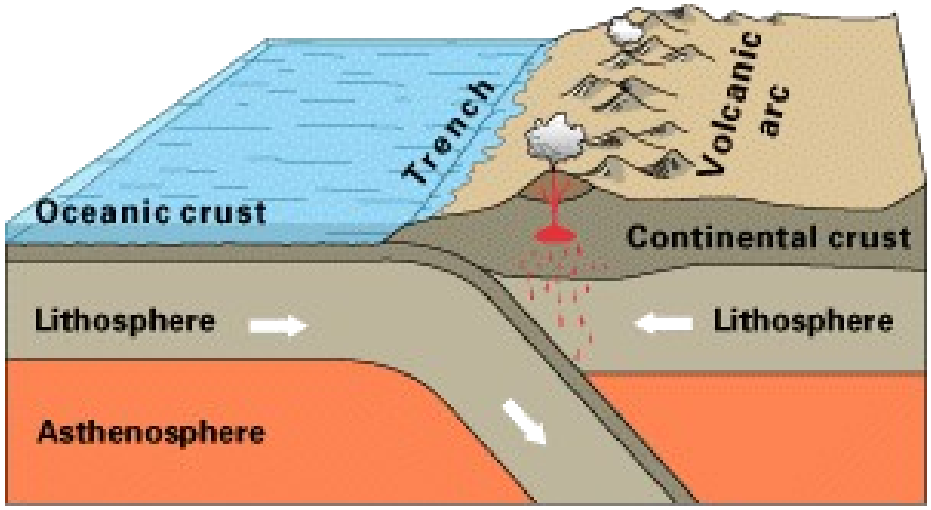
- Most magma that reaches the Earth's surface is at divergent boundaries along mid-ocean ridges
  - Most volcanic activity takes place beneath oceans
  - Iceland → Mid-Atlantic Ridge is ABOVE sea-level



MAGMA FORMATION AT A MID-OCEAN RIDGE

Magma generation at subduction zones

- During subduction, the subducted oceanic plate is heated as it plunges into the mantle
- At a depth of 80-120 km, melting begins, and volcanoes are produced which parallel the subduction zone

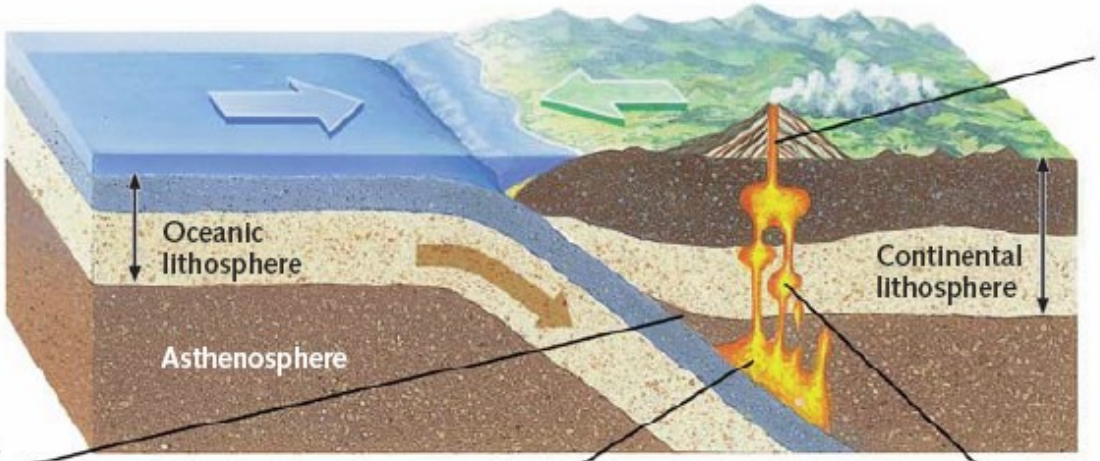


Oceanic-continental convergence

Andesitic magmas are typical of these volcanoes

Volcanic Activity at a Subduction Boundary

BETWEEN AN OCEANIC PLATE AND A CONTINENTAL PLATE



1 Water in the subducted rock is released into the asthenosphere.

2 The water lowers melting temperatures of materials in the asthenosphere, leading to the formation of magma.

3 The magma is less dense than its surroundings, so it rises.

4 Some of the magma reaches Earth's surface, and volcanoes form on the overriding continental plate.

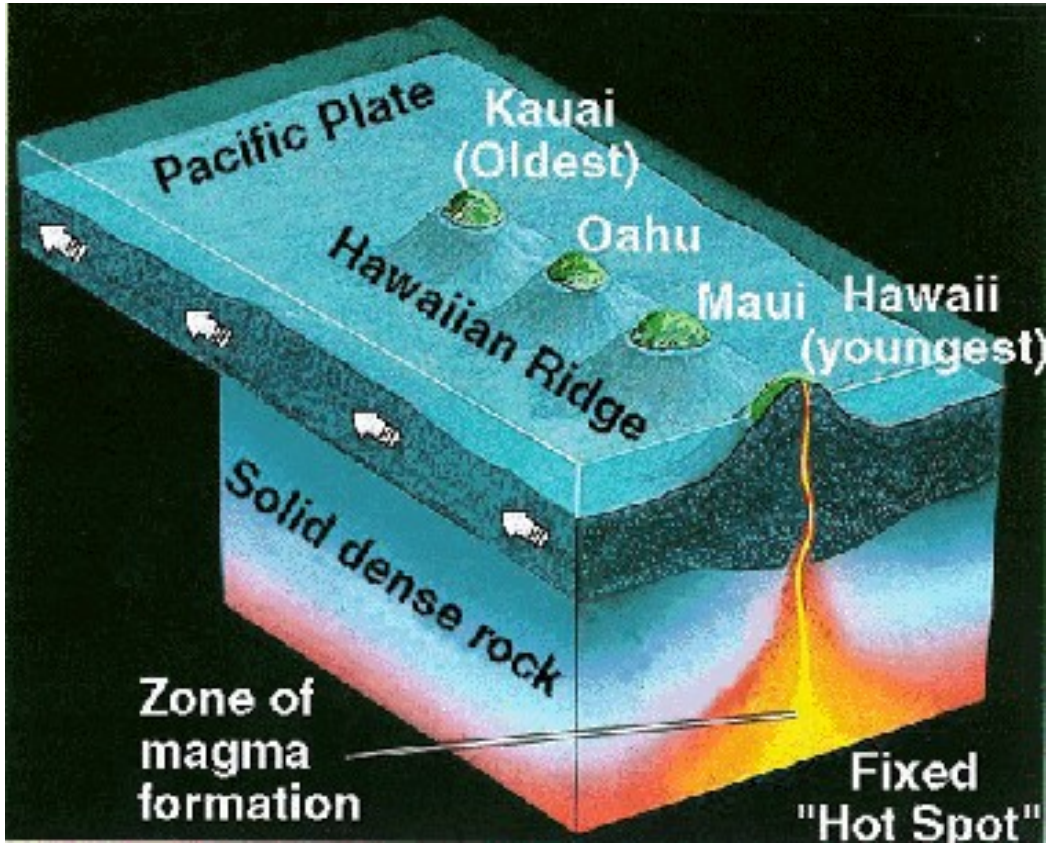
BETWEEN OCEANIC PLATES

The process by which magma forms at an oceanic-oceanic subduction boundary is similar to the process at an oceanic-continental boundary. Notice that the difference between the two processes occurs at step 4.

4 Magma that reaches Earth's surface is underwater. Thus, an arc of volcanic islands forms on the overriding oceanic plate.

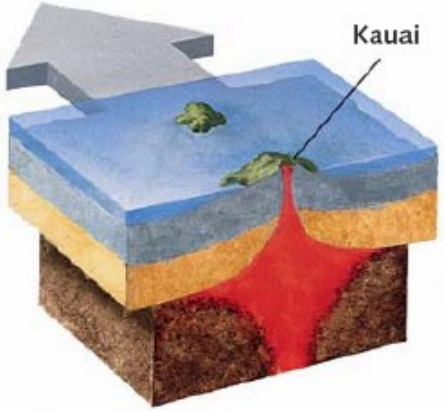
Magma generation at hot spots

- Magmas at hot spots are derived from deep within the mantle
- the magmas are fed by deep mantle plumes which are stationary relative to the drifting tectonic plates

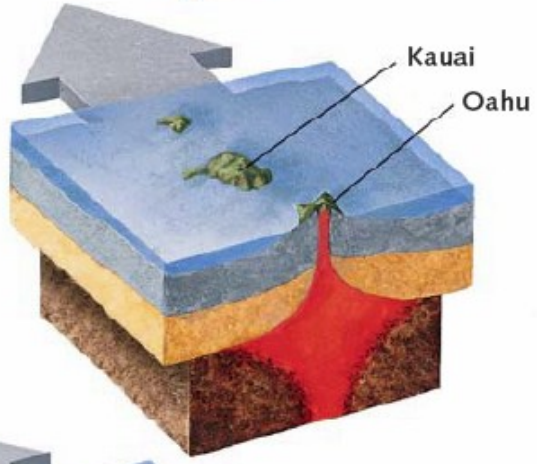


Formation of Hawaiian Islands

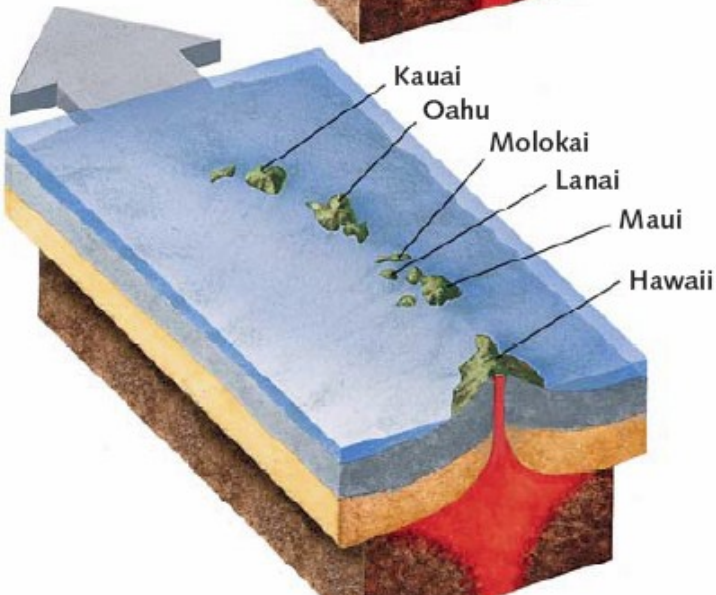
5.3 TO 4.9 MILLION YEARS AGO
The island of Kauai formed as molten rock hardened and built up on the seafloor over the hot spot. As the plate moved northwest, it carried the island away from the hot spot.



3.8 TO 2.5 MILLION YEARS AGO
The island of Oahu formed after the volcano on Kauai had moved away from the hot spot. Again, molten rock hardened and built up until Oahu rose above sea level.



TODAY The island of Hawaii now sits over the hot spot. The hot spot fuels three active volcanoes, including one underwater (not shown here). This seamount is located to the east of the island.



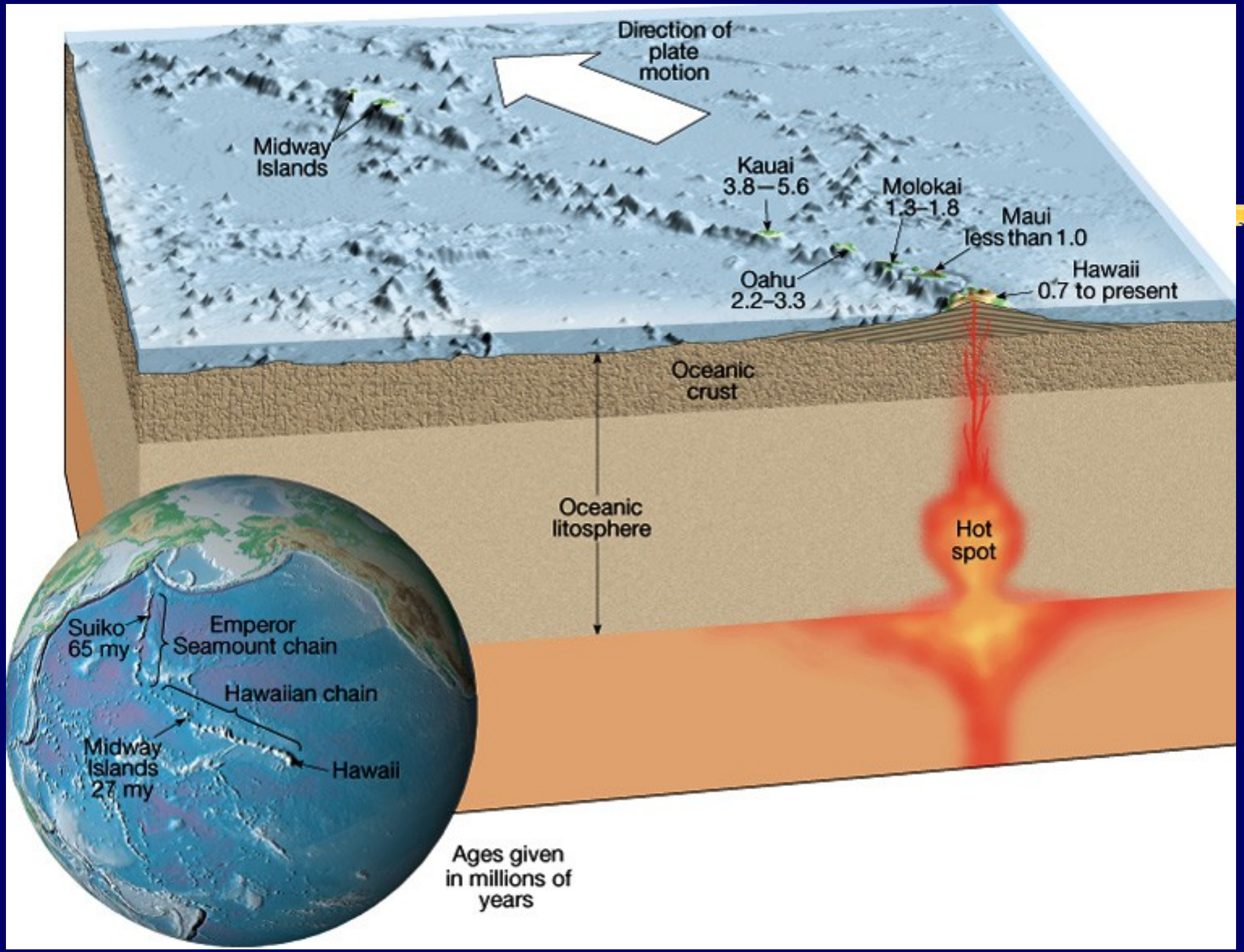
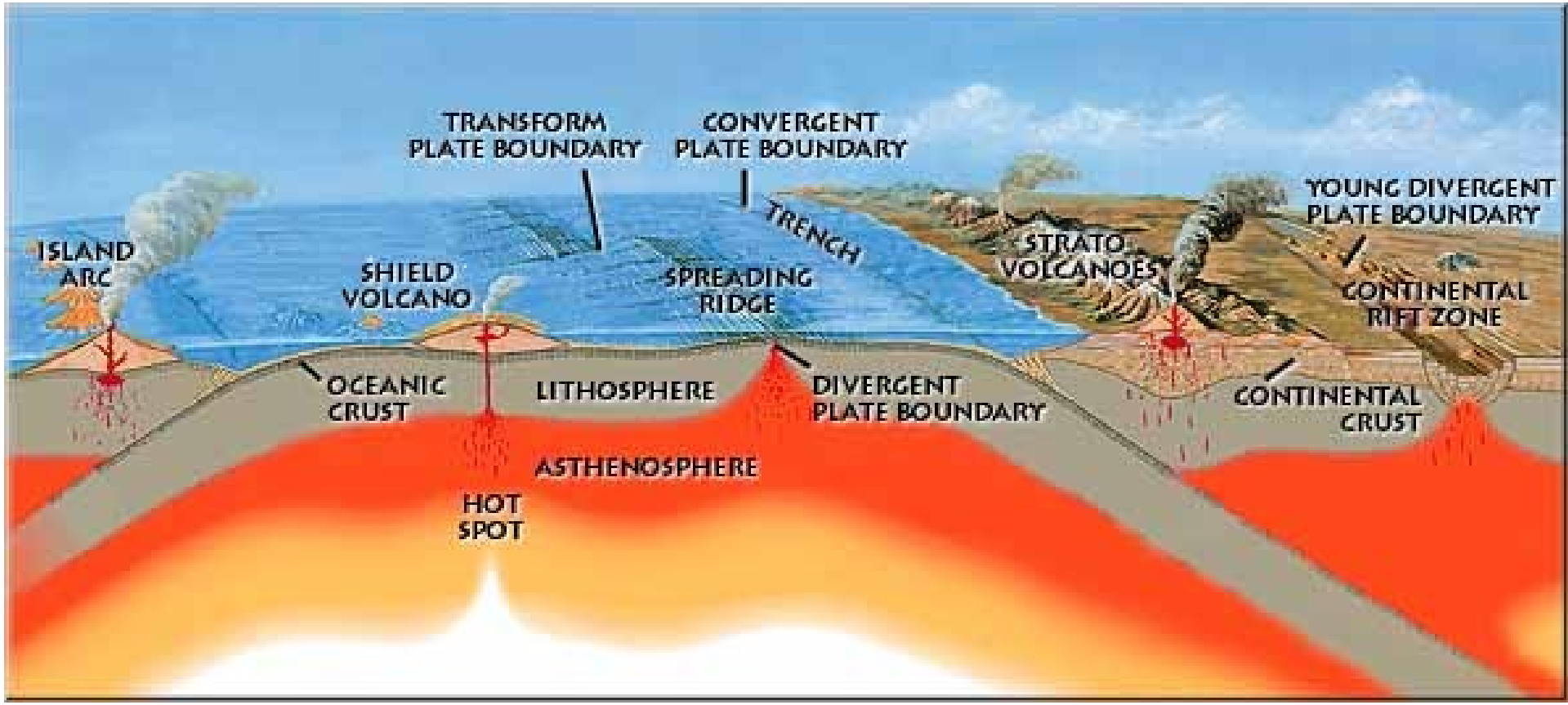

Direction of plate motion
Midway Islands
Kauai 3.8–5.6
Molokai 1.3–1.8
Maui less than 1.0
Oahu 2.2–3.3
Hawaii 0.7 to present
Oceanic crust
Oceanic litosphere
Hot spot
Suiko 65 my
Emperor Seamount chain
Hawaiian chain
Midway Islands 27 my
Hawaii
Ages given in millions of years

Plate tectonics and volcanism



Factors that determine the violence of an eruption and viscosity

- Composition of the magma
- Temperature of the magma
- Dissolved gases in the magma

Viscosity of magma

- Viscosity is a measure of a material's resistance to flow

- Factors affecting viscosity
  - Temperature (hotter magmas are less viscous)
  - Composition (silica content)
    - High silica – high viscosity (e.g., rhyolitic lava)
    - Low silica – more fluid (e.g., basaltic lava)
- Dissolved gases (volatiles) (Provide the force to extrude lava, Violence of an eruption is related to how easily gases escape from magma)
  - Mainly water vapor, Sulper, and carbon dioxide
  - Gases expand near the surface

Magma & Erupted Materials

Differences in volcanic activity result partly from differences in magma

SUMMARY Characteristics of Magma

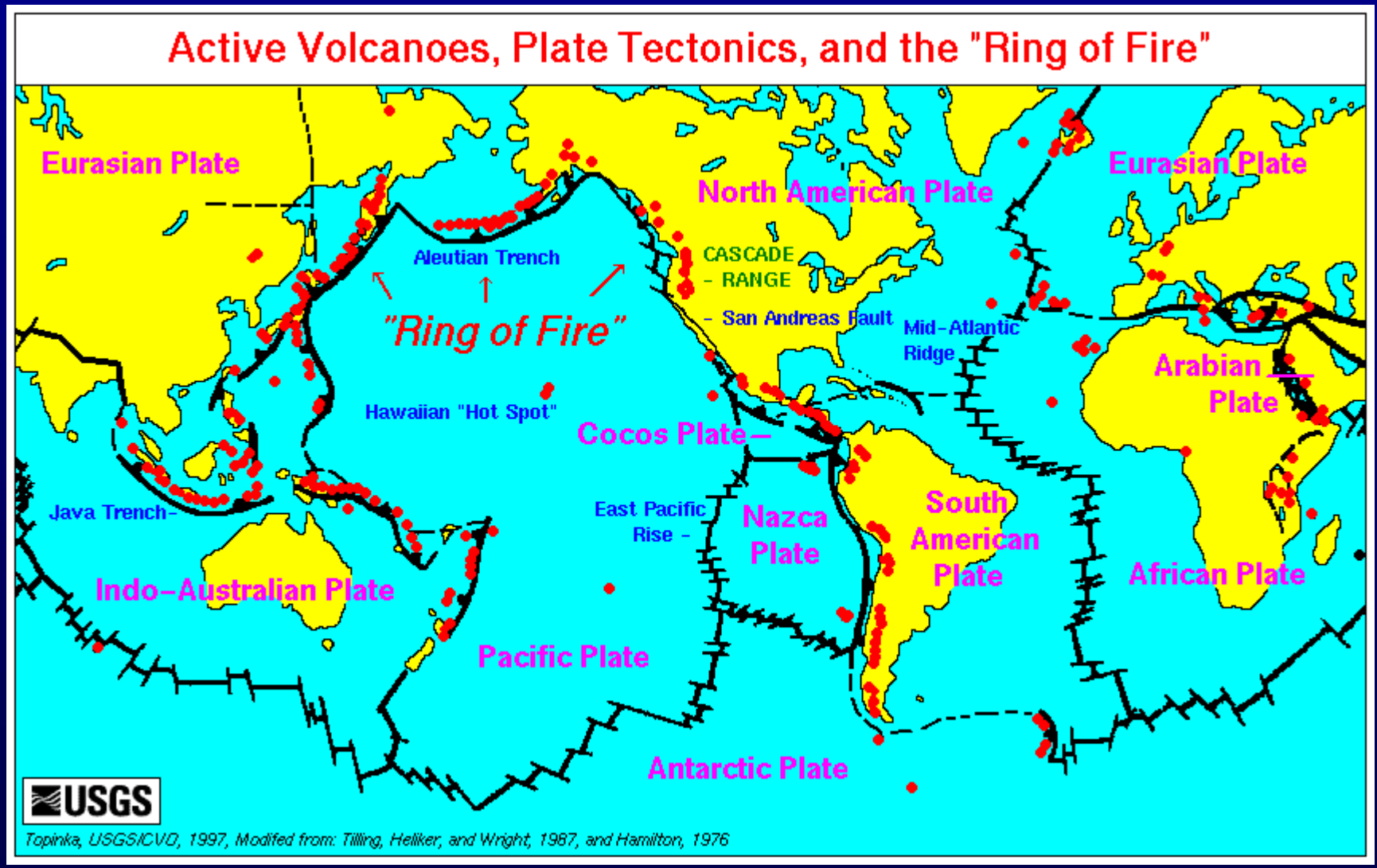
	Basaltic Magma	Andesitic Magma	Rhyolitic Magma
Silica content	Least (about 50%)	Intermediate (about 60%)	Most (about 70%)
Gas content	Least	Intermediate	Most
Viscosity	Least viscous	Intermediate	Most viscous
Type of eruption	Rarely explosive	Sometimes explosive	Usually explosive
Melting temperature	Highest	Intermediate	Lowest
Location	Rifts, oceanic hot spots	Subduction boundaries	Continental hot spots

Kilauea

Mount St. Helens

Yellowstone caldera

Global distribution of volcanoes



Global distribution of volcanoes

DISTRIBUTION OF VOLCANOES

CIRCUM-PACIFIC BELT

More than 60 % of active volcanoes
Ring of Fire (follows the convergent boundary of the pacific plate)
Alaskan volcanoes

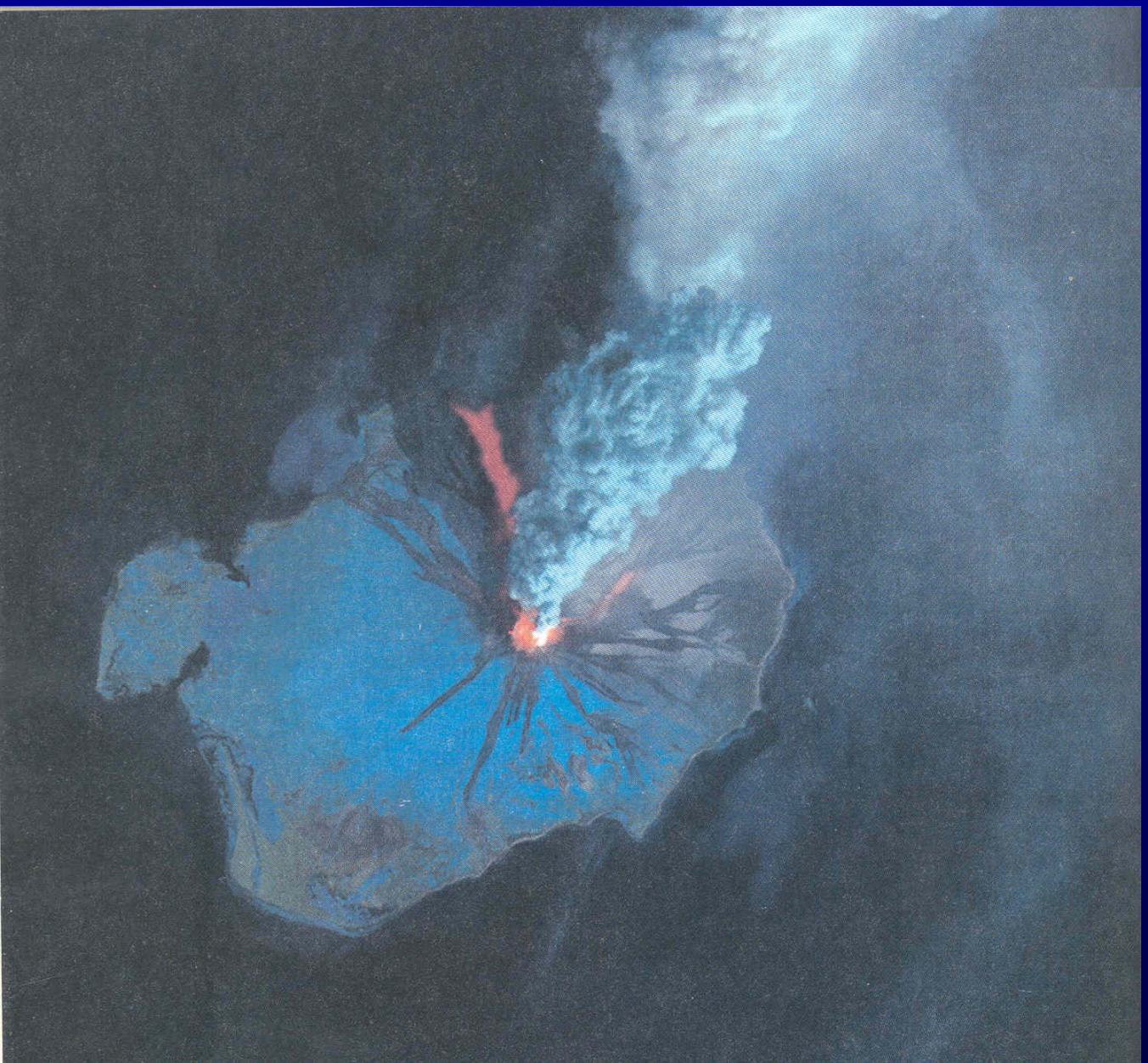
MEDITERRANEAN BELT

About 20 % of active volcanoes
Mount Etna, Italy.

Rest of the active volcanoes are at or near mid-oceanic ridges.

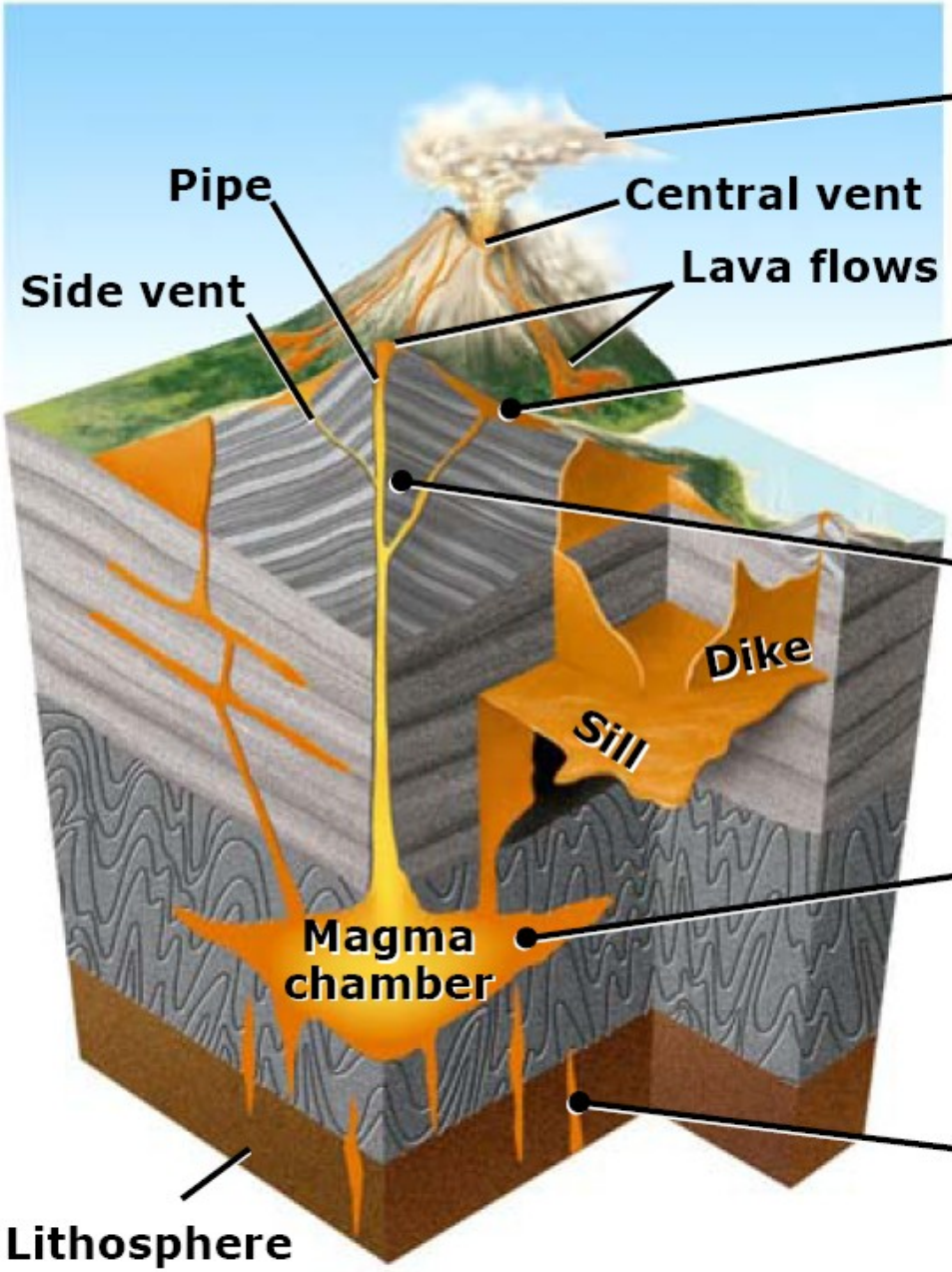
The longest of these ridges is the MID-ATLANTIC RIDGE.

VOLCANO, AUGUSTINE ISLAND, ALEUTIAN ISLAND ARC



This image was recorded by Landsat 5. Red represents flowing hot ash, blue indicates snow and gray-brown shows flows of cool ash. This type of explosive eruption represents a fundamental type of volcanism resulting from converging tectonic plates.

Volcanic geosystem



Gases injected into atmosphere (H_2O, CO_2, SO_4).

...accumulating on the surface to form a volcano.

Lavas erupt through a central vent and side vents,...

...rises through the lithosphere to form a crustal magma chamber.

Magma, which originates in the asthenosphere...

Classification of Volcanoes

Based on . . . . .

State

1. Active
2. Dormant
3. Extinct

Mode of Eruption

1. Central Vent type or cone
2. Fissure type

Type of Eruption

1. *Hawaiian*
2. *Strombolian*
3. *Vulcanian*
4. *Vesuvian*
5. *Pelean &*
6. *Plinian*

Based on the State of the Volcanoes

Active volcano

- are those which are active at present or have been in eruption at least during the historic past.

Dormant or Slumbering volcano

- are those which have not been in eruption in the historic period but at the same time may have time to erupt in future.

Extinct volcanoes

- these are geologically ancient and have totally stopped all their activities.

ACTIVE VOLCANO


10 m high fountain of lava

Based on the mode of Eruption

1. CENTRAL VENT TYPE :

Based on eruptive force, composition and Viscosity of the magma …

- VOLCANIC CONES (due to low viscosity magma)
- CINDER CONES (glassy material around the cone)
- COMPOSITE CONES (alternating layers of pyroclastic material and lava)

2. FISSURE TYPE :

Lava eruption takes place through fractures and fissures.

Based on eruption

- **Hawaiian: Volcanoes with mild eruption belong to this phase is free from explosion (e.g. Hawaiian volcanoes). Lava is ejected mildly. Such quite eruption build shield volcanoes and lava plateaus and plains. Low silica basaltic composition make the lava mobile.**

- **Strombolian: Eruption of lava punctuated by periodic, mild explosions is known as Strombolian phase. (e.g. Stromboli, Italy). In this type of eruption lava is ejected out in fountains with bombs and scoria and light-colored clouds (mostly steam) reach upward only to moderate heights.**

- **Vulcanian: More Viscous and less mobile lavas; allowing gas buildup below surface; over longer periods of quiet until lava crust is broken up, ejecting bombs, pumice, ash and thick clouds and built the Composite cone. (e.g. Vulcano, Sicily)**

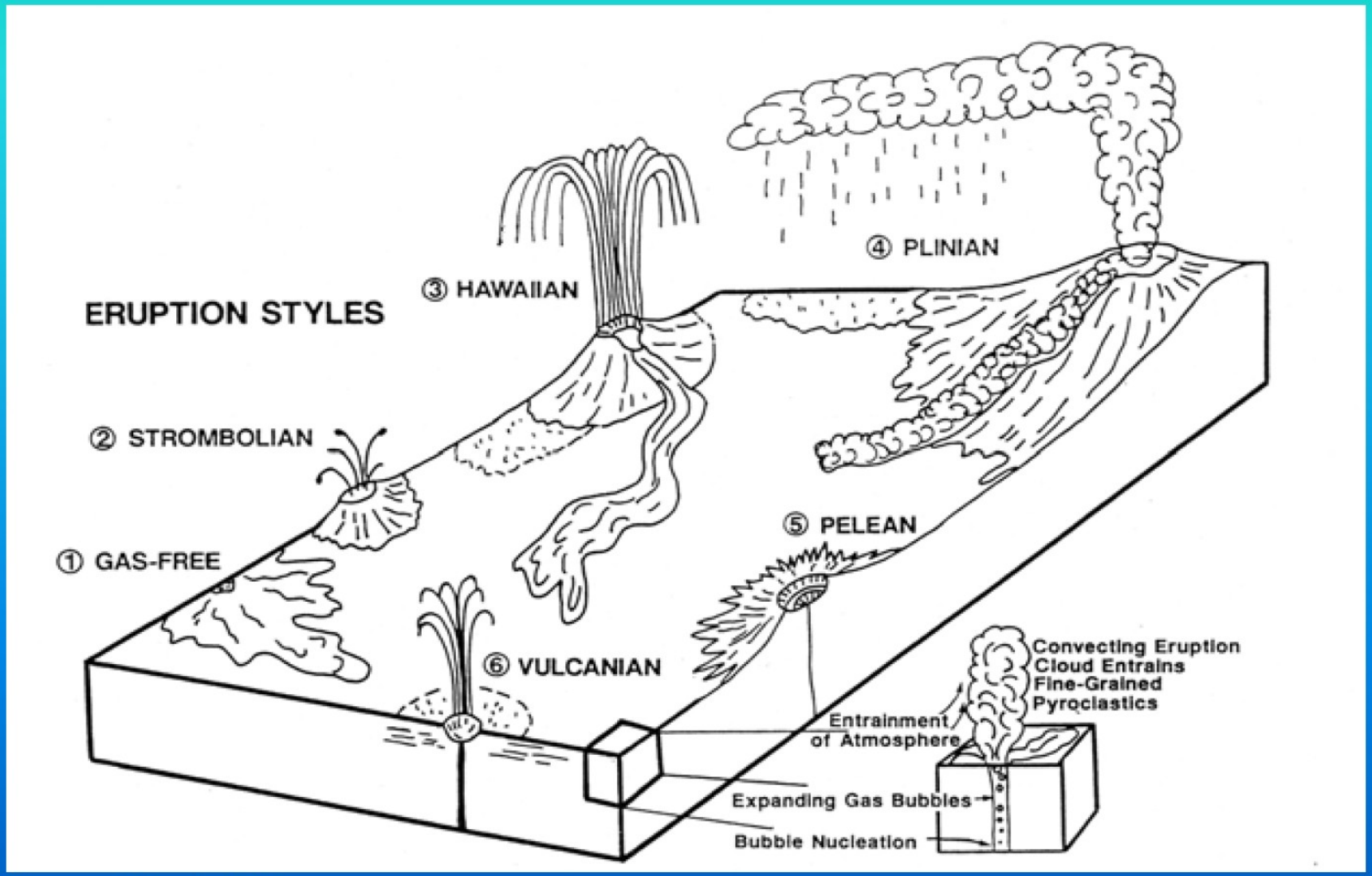
- **Vesuvian:** More stronger then Strombolian or Vulcanian types; extremely violent expulsion of gas; eruption occurs after long interval of quiescence of mild activity; vent tends to be emptied to considerable depth; lava ejects in explosive spray, repeated clouds (cauliflower) that reach great heights and deposit tephra.

- **Plinian**: More violent form of Vesuvian eruption; Calderas are formed. Volume of erupted materials is enormous. It is named after the observer Pliny who lost his life during the observations.

- **Pelean:** Results from high-viscosity lavas, erupts pyroclastics in violent explosion, forming the Volcanic domes, Glowing cloud is typical are typical feature of Pelean phase (e.g. Mount Pelee, West Indies)

No volcano erupts in the same manner through out its life. A single Volcano may erupt in different types at different times

Eruption styles
based on example volcanoes



Wilson and Head, 1994

Volcanic activity & Hazards

Volcanic Hazards

- Lava flows
- Pyroclastic flow and falls
- Ash flows
- Lahars and Debris Avalanches
- Volcanic gases
- Volcanic dome collapse
- Caldera collapse
- Eruption clouds
- Landslides
- Seismicities
- Tsunami

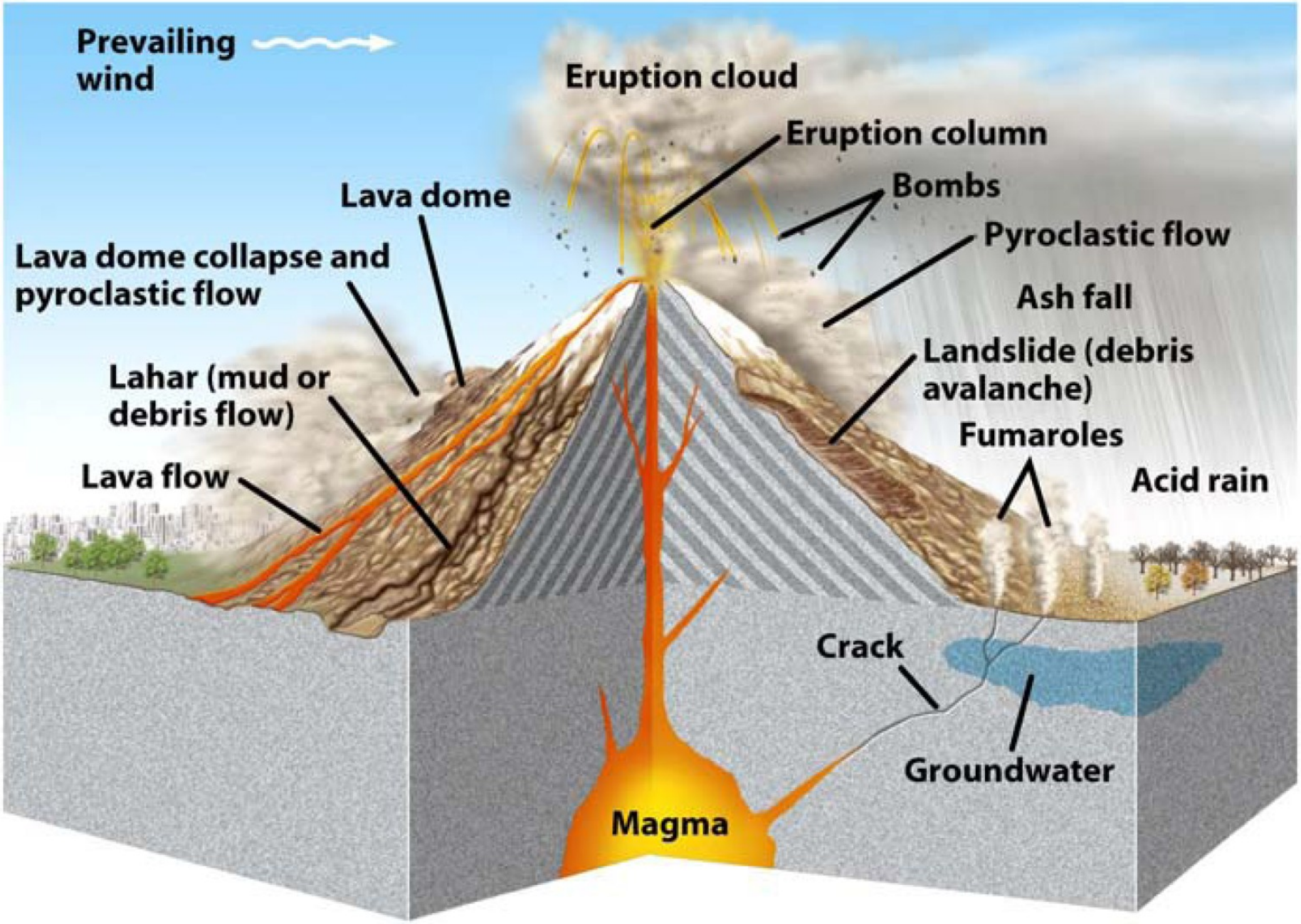


Figure 12-25
Understanding Earth, Fifth Edition

LAVA FLOWS

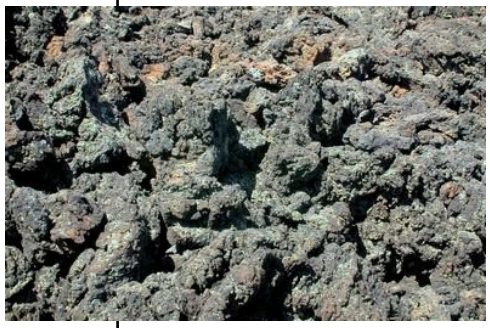
- This is a basalt lava flow in a channel
- Due to its low silica content and high temperature, it is quite fluid
- Yet lava usually flows fairly slowly

Lava Flows

- lava: magma that reaches Earth's surface
- temp. & speed affect appearance of hardened surface

- **ON LAND**
  - Hotter basaltic lava
    - Flows quickly out of vents
      - Forms pahoehoe
        - » Smooth, ropelike surfaces

  - Cooler basaltic lava
    - Moves slowly, cools quickly
      - Forms aa
        - » Rough, jagged surfaces



- **UNDERWATER**
  - Distinctive shape
    - Rounded, pillow-like, hard crust
      - Forms pillow lava

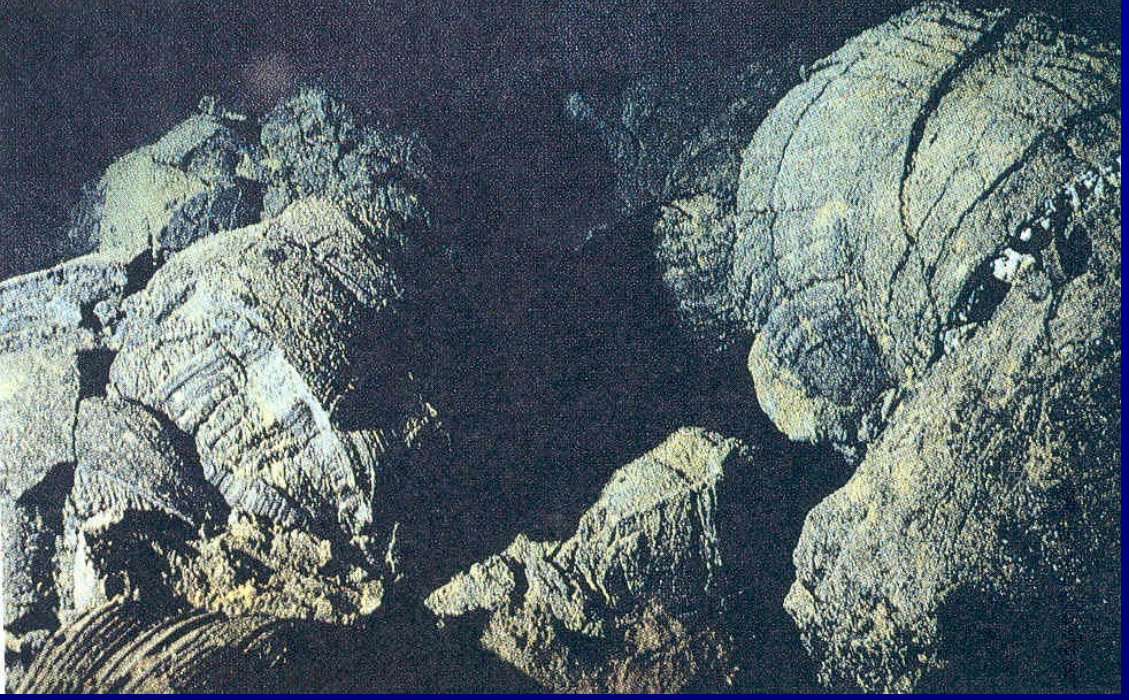
Pahoehoe lava

This is a Hawaiian term for smooth, ropy lava

It generally exhibits fluid-like textures

Aa lava

- This type of lava is quite blocky on the surface, and comparatively cool
- Yet below the surface, the lava is fairly massive and much hotter
- Also called Blocky Lava



It was photographed at close range by scientists in the deep-diving submersible *Alvin*. Little or no sediment covers the basalt because this part of the sea floor is very young. The large elliptical structure is approximately 1 m long.

PILLOW BASALT, MID ATLANTIC RIDGE

Tubular-shaped pillows of basalt photographed in the central rift of the East Pacific Rise, at a water depth of about 500 m.

Fire Fountaining

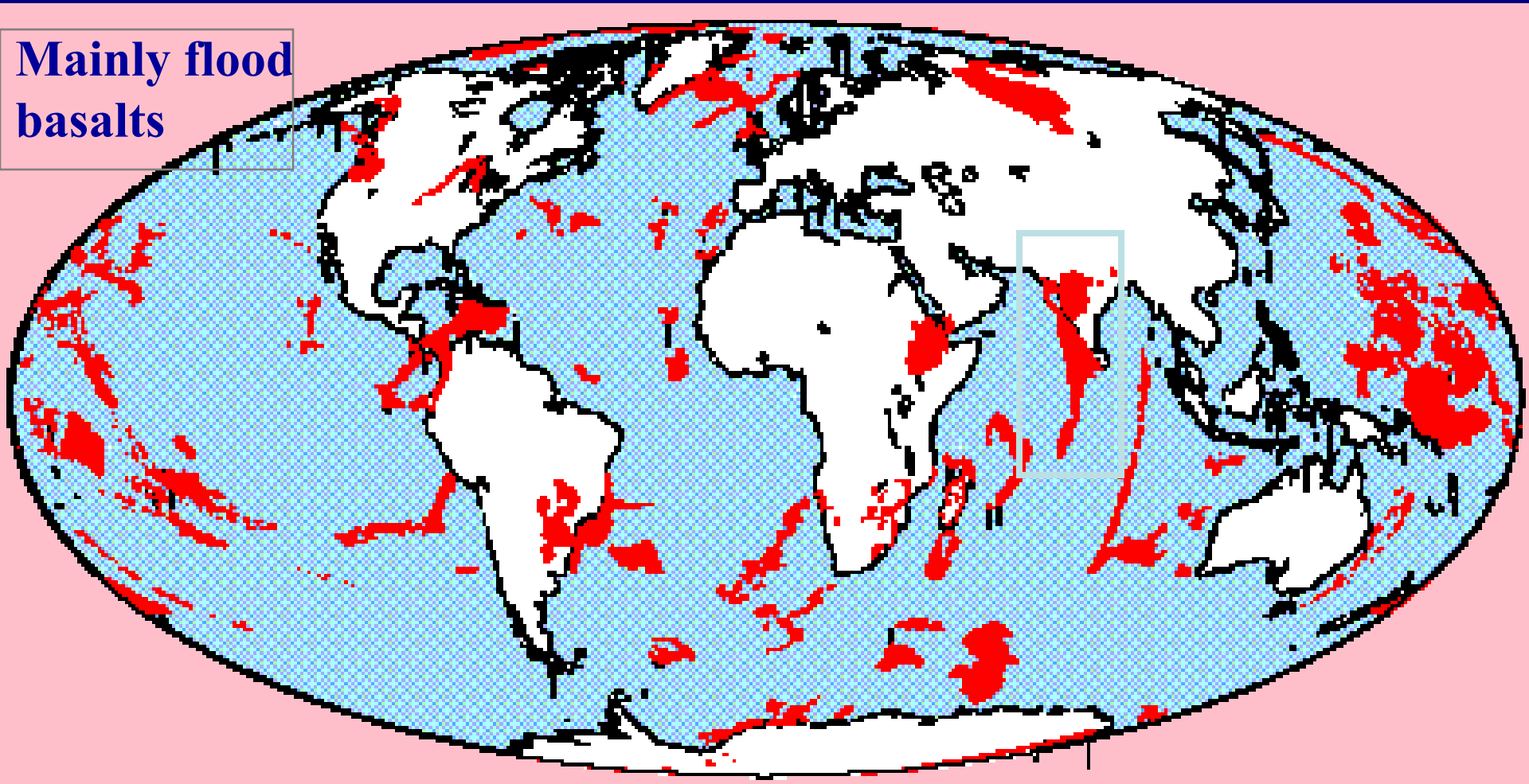
- Sometimes, basaltic lava can contain lots of gas
- Then, small explosive eruptions form fire fountains
- As partially liquid drops fall back to the ground, they may coalesce to form a lava flow

Flood basalts

- The previous examples represent small-scale activity
- But basaltic eruptions can be huge, forming lava plateaus
- These huge outpourings may occur quickly (1-3 Ma) and may contribute to mass extinctions

- (e.g. Deccan Plateau, Columbia Plateau)

Global distribution of large igneous provinces (LIPS)



Lava domes

Mt. Unzen, Japan

Unzen began growing a lava dome in mid-1991. The dome complex continued to grow until 1995

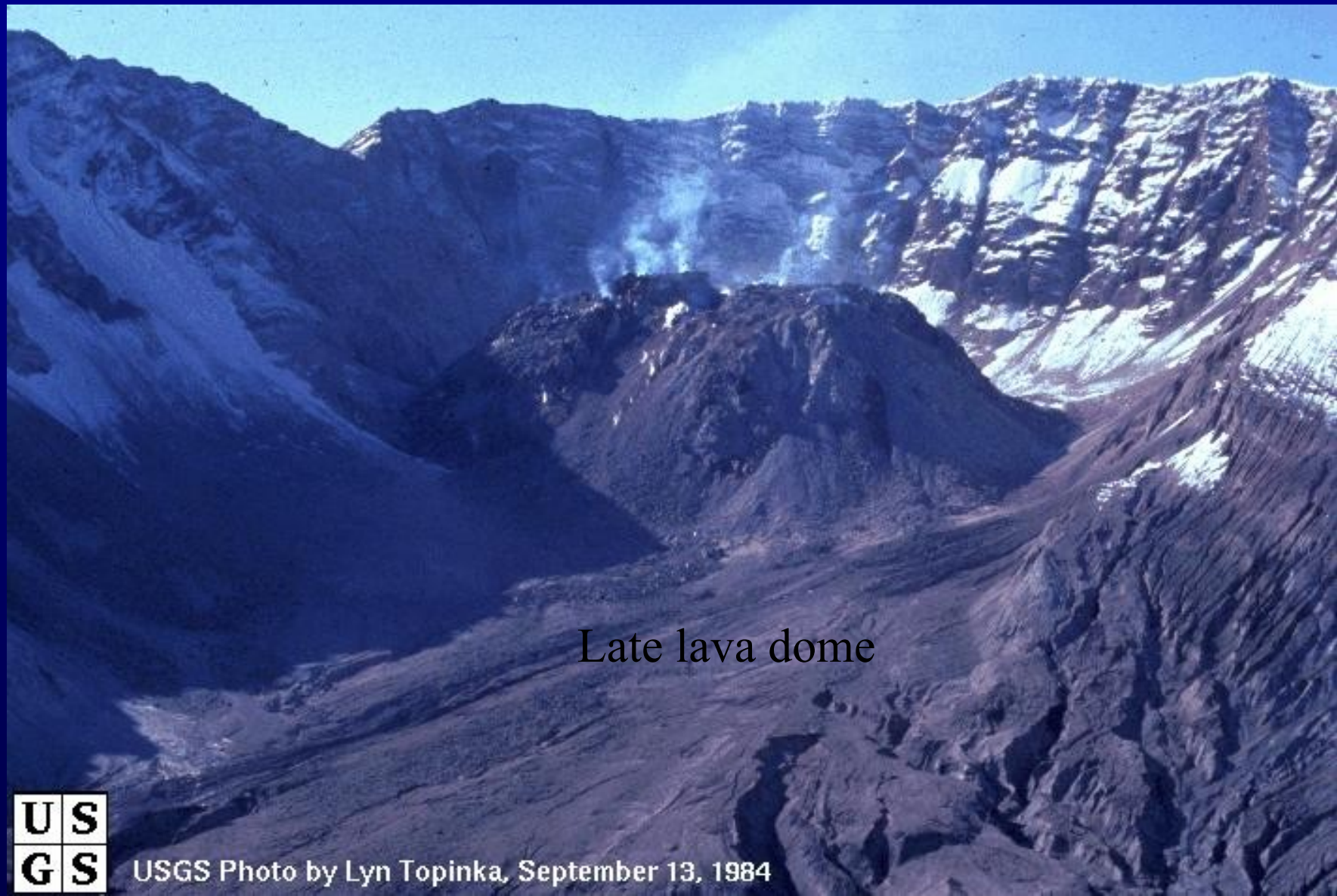
Lava domes at Unzen

- The lava is silica-rich and thus highly viscous (sticky) and cannot easily flow
- Thus it tends to form steep-sided domal structures

Volcanic activity: lava domes

- By early 1995, the dome complex had grown substantially and was highly oversteepened
- As pieces of the dome broke off, they would fragment, creating pyroclastic flows

Dome growth-destruction cycles



Ash & Rock Fragments

- Explosive eruptions usually involve magmas which contain trapped gasses
  - When gasses are released, solid pyroclastic material may be ejected
    - Classified by size
      - Smallest → ash
      - Intermediate → lapilli
      - Largest → blocks & bombs

- If pyroclastic materials combine with hot gasses → pyroclastic flow (dense, superheated cloud that travels downhill with amazing speed)

Volcanic activity: Pyroclastic flows

- **"A *Pyroclastic flow* is a fluidized mixture of solid fragments and hot, expanding gases that flows down the volcano vent.**
- **Pyroclastic flows are suspensions of hot pyroclastic material, air, and gas which descend under the influence of gravity**
- **Their velocity is generally very high (50-500 km/hr)**
- **This example is a flow from Mt. St. Helens**

Pyroclastic falls

- During explosive volcanic eruptions, ash falls downwind of the volcano
- In the case of very large eruptions, the ash may be deposited over a vast area

Pyroclastic flows

- **This is another example, descending the slopes of Unzen volcano after part of the dome has collapsed**
- **The flow has a dense core which is hidden by the billows of ash which are rising**

Unzen, 24 June 1993

Pyroclastic flows - note big rounded pumices

Volcanic activity: lahars

- Lahar is an Indonesian word for volcanic debris flow
- Lahars are flows of water and loose volcanic debris
- They are especially prevalent at snow-clad and ice-clad volcanoes

Lahars on snow/glacier clad volcanoes

Major changes in valley floor elevation after single lahar has formed after typhoon.

The impact on villages within the path of a lahar can be extreme

While old houses are buried, new homes are built on stilts to try to avoid the next lahar

An old church has been partially-buried so that you now enter on the 2nd floor. Ronnie Torres shows the church prior to the lahars.

Some homes, once buried by lahar, and now being exposed by recent erosion

The human cost at Armero

- A victim just after rescue from the lahar
- She is completely coated in the mud of the lahar
- In general, survivors had great difficulty extricating themselves

If a volcano's lava is thick and stiff, the lava may explode into the air and harden into ash, cinders, and bombs.

VOLCANIC BOMBS

Volcanic activity: debris avalanches

- **Sometimes a volcanic structure is weakened**
- **Wholesale collapse of part of the volcano may result**
- **During collapse, a debris avalanche occurs, and a scar remains**

Unzen volcano, with the 1792 scar in the foreground

Volcanic activity: gases

- Volcanic gases are typically highly acid
- Major constituents include H_2O, CO_2, HCl, SO_2, and HF
- This photo shows gas emission from Masaya volcano in Nicaragua

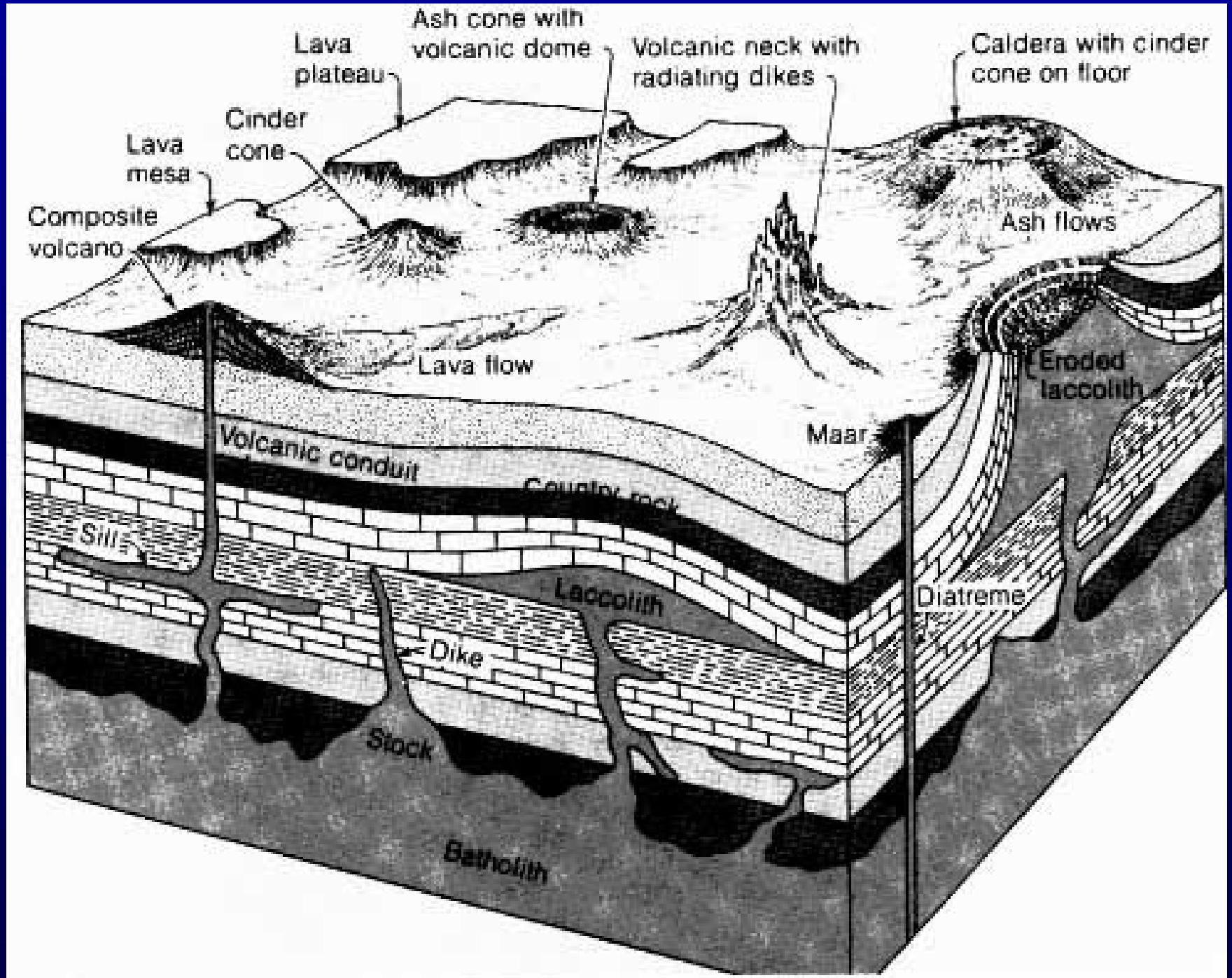
Volcanic activity: gases

- This is also Masaya volcano…
- but this photo was taken from the space shuttle
- it shows the gas plume being blown out over the Pacific Ocean

Volcanic activity: gases

- About 15 km downwind from Masaya, the coffee crop is adversely affected by the acid gases

Volcanic Landforms

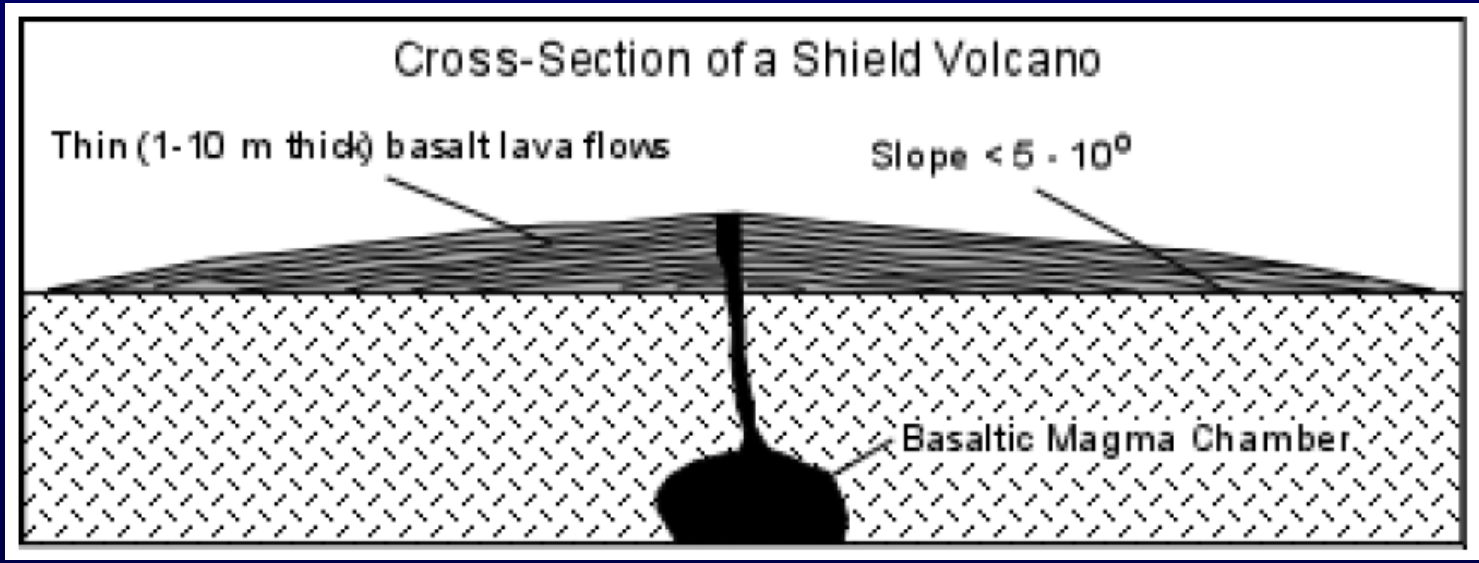

Ash cone with volcanic dome
Lava plateau
Volcanic neck with radiating dikes
Caldera with cinder cone on floor
Cinder cone
Lava mesa
Composite volcano
Ash flows
Lava flow
Eroded laccolith
Maar
Volcanic conduit
Country rock
Sill
Laccolith
Diatreme
Dike
Stock
Batholith

Shield Volcanoes

A shield volcano is characterized by gentle upper slopes (about 5°) and somewhat steeper lower slopes (about 10°).

Shield volcanoes are composed almost entirely of relatively thin lava flows built up over a central vent.

Most shields were formed by low viscosity basaltic magma that flows easily down slope away form the summit vent.

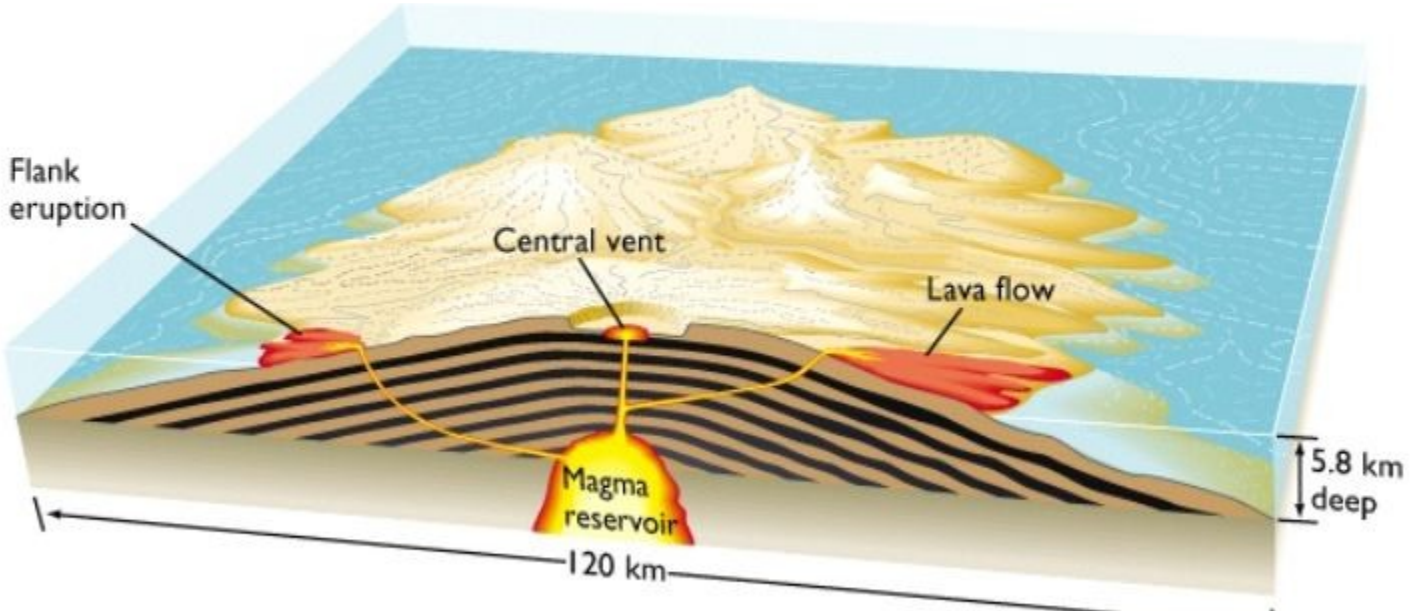


Shield Volcanoes

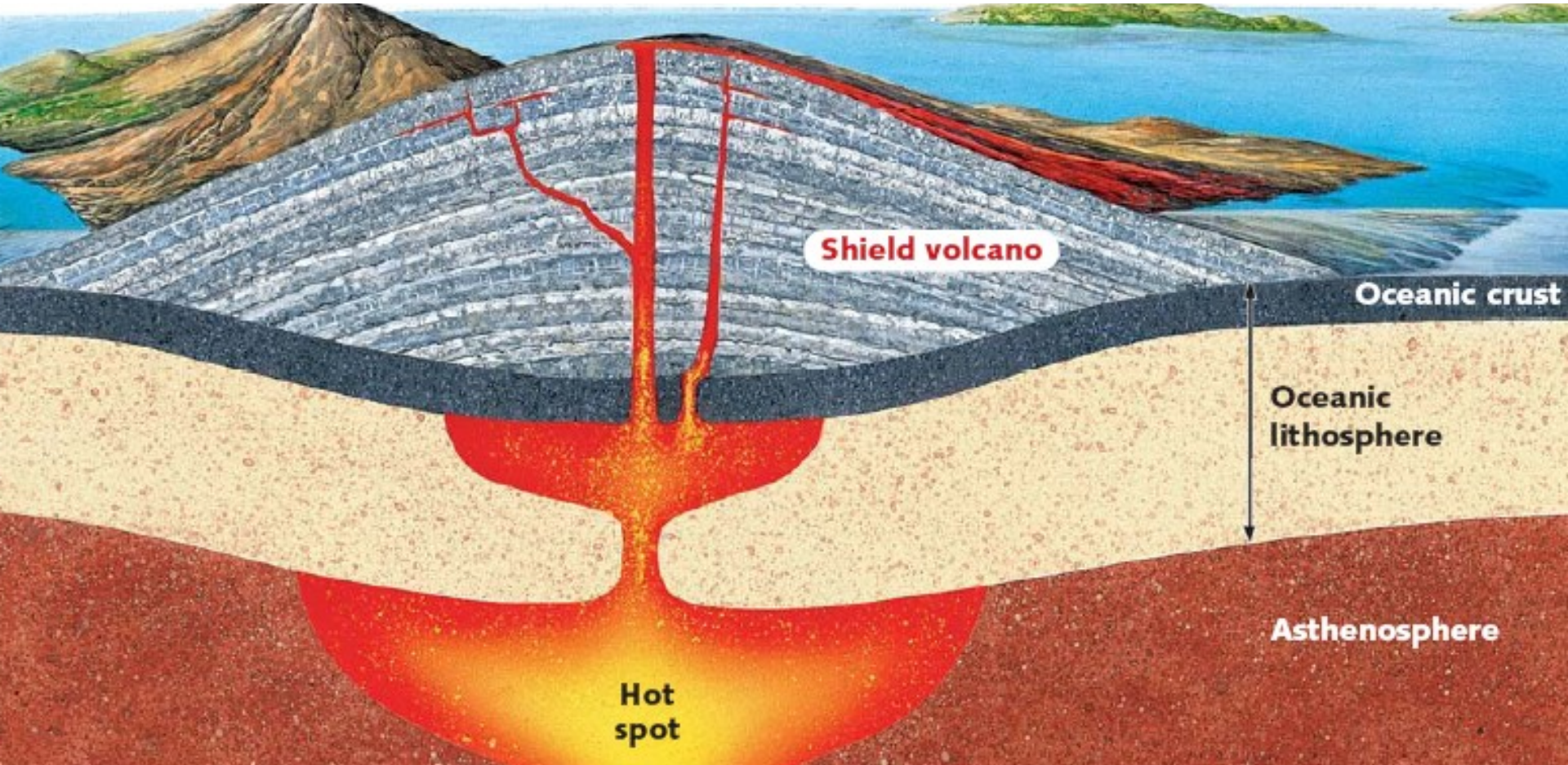
Most shield volcanoes have a roughly circular or oval shape in map view.

Very little pyroclastic material is found within a shield volcano, except near the eruptive vents, where small amounts of pyroclastic material accumulate as a result of fire fountaining events.

Shield volcanoes thus form by relatively non-explosive eruptions of low viscosity basaltic magma.



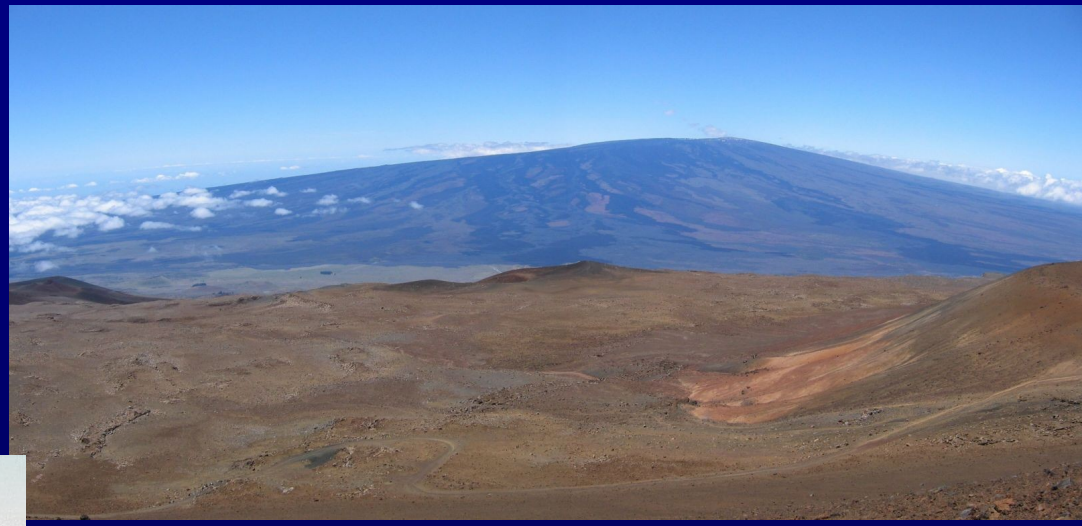
»Ex. Mauna Loa in Hawaii is 9170 m tall (4170 m above sea level & 5000 m below sea level)



Tend to be less explosive than other types of volcanoes

However, flows may be frequent & large in volume and results in damage to homes, highways, & other property

Tend to form over hotspots & in oceans (b/c oceanic crust is made of basalt)



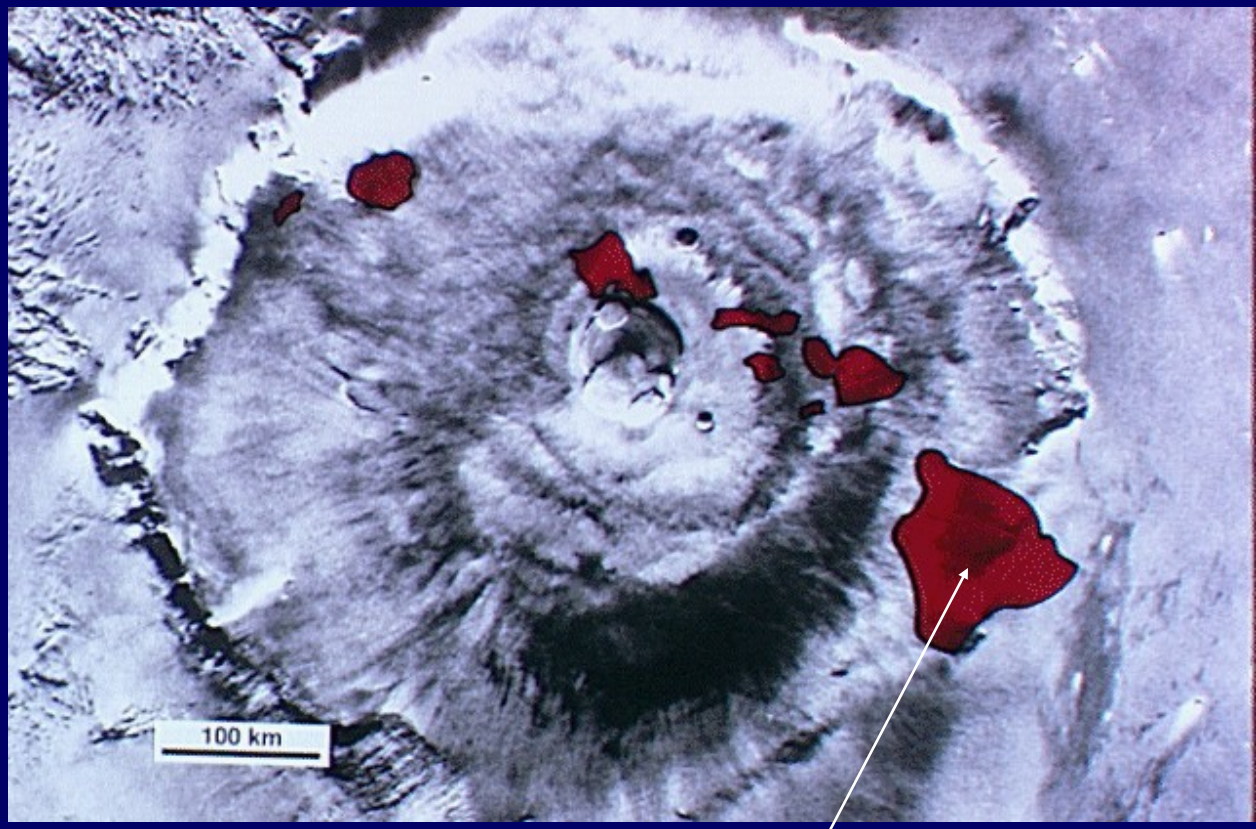
Mauna Loa is the tallest volcano on Earth, as measured from the sea floor

Shield volcanoes on Mars

- Other planets also have shield volcanoes
- This is the largest shield volcano in the solar system, Olympus Mons on Mars

Shield volcanoes: Earth vs. Mars

- Red = Hawaiian chain, which is superimposed on Olympus Mons

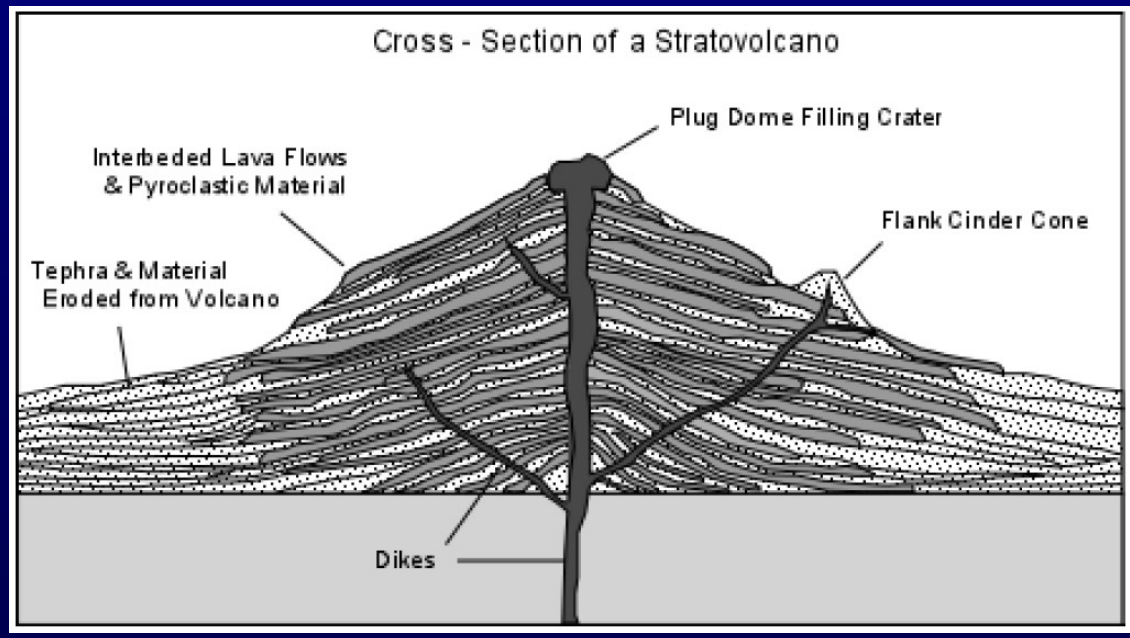


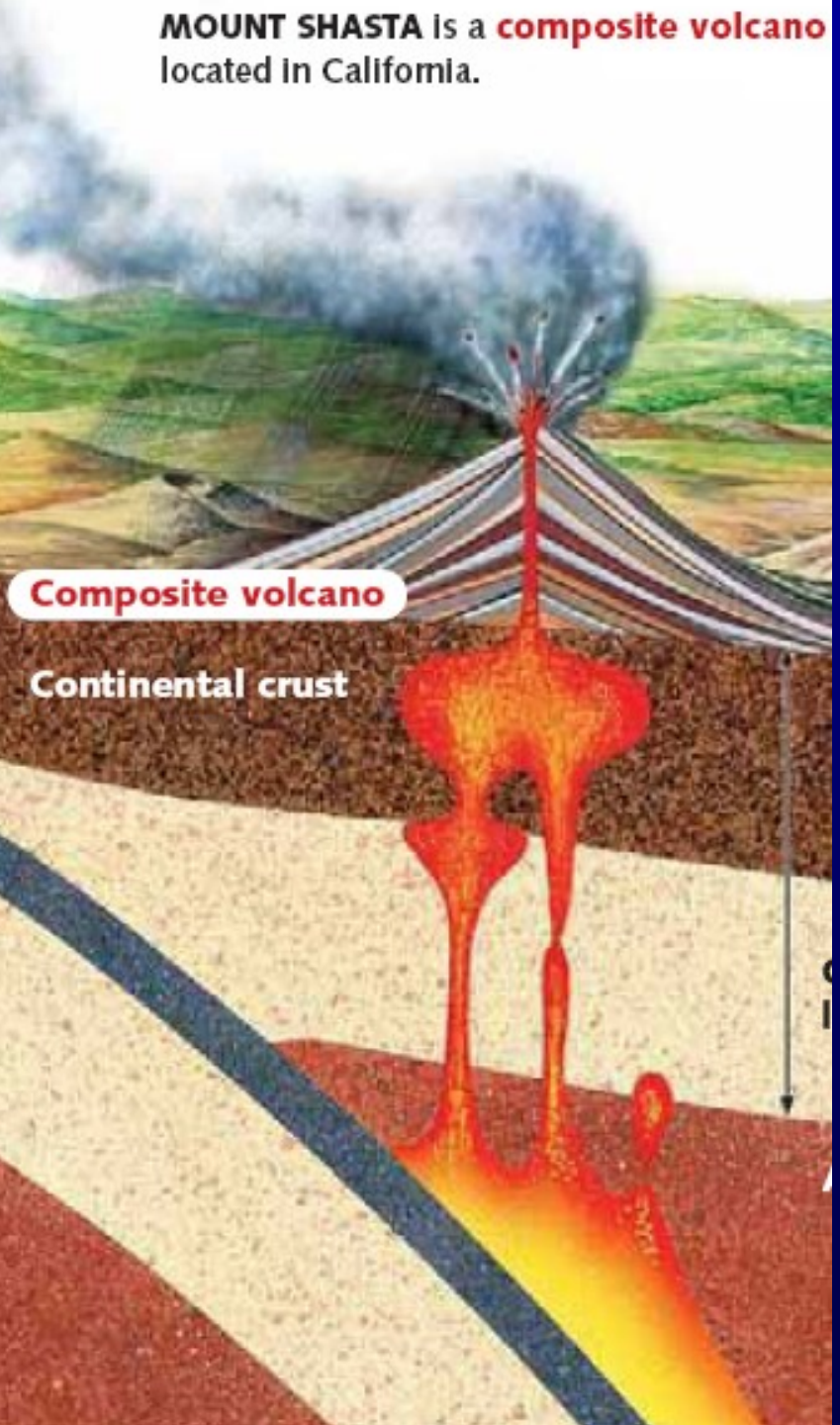
Stratovolcanoes (also called **Composite Volcanoes**)

Have steeper slopes than shield volcanoes, with slopes of 6 to 10° low on the flanks to 30° near the top.

The steep slope near the summit is due partly to thick, short viscous lava flows that do not travel far down slope from the vent.

They show an internal layered structure due to varying intensities of the explosions that deposit different sizes of pyroclastics.




MOUNT SHASTA is a composite volcano located in California.
Composite volcano
Continental crust

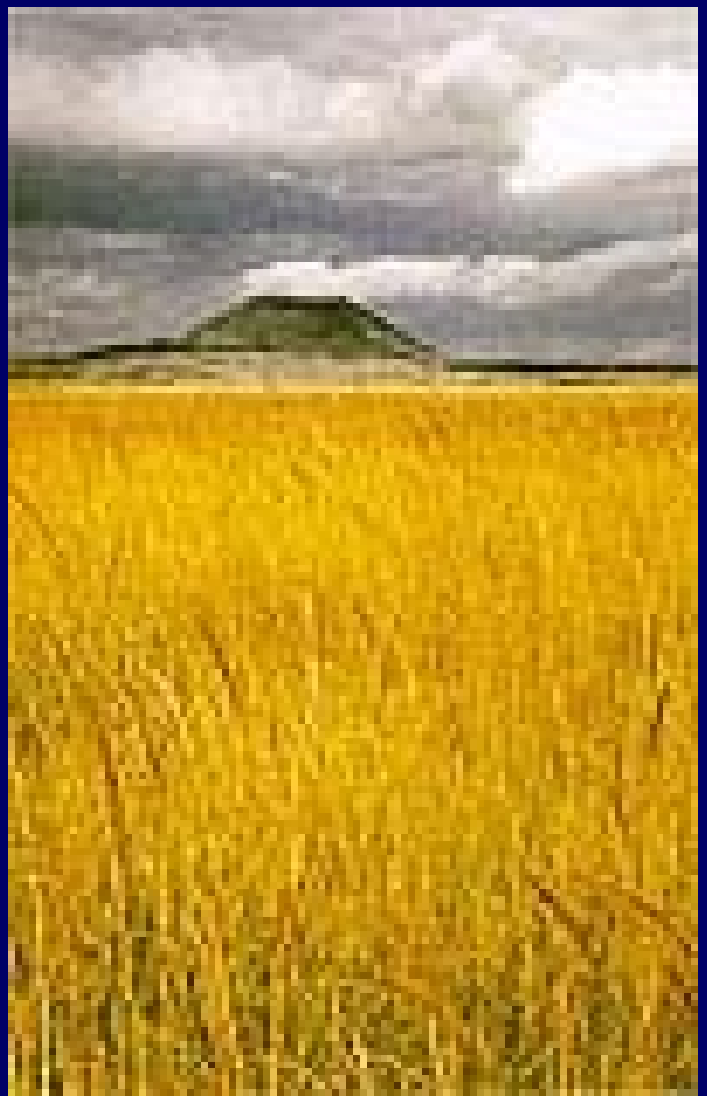

Mt. Shasta
USGS


Mount St. Helens

- The gentler slopes near the base are due to accumulations of material eroded from the volcano
- Stratovolcanoes show inter-layering of lava flows and pyroclastic material, So it is also called composite volcanoes. Pyroclastic material can make up over 50% of the volume of a stratovolcano.
- Lavas and pyroclastics are usually andesitic to rhyolitic in composition.
- Due to the higher viscosity of magmas erupted from these volcanoes, they are usually more explosive than shield volcanoes.
- Stratovolcanoes sometimes have a crater at the summit that is formed by explosive ejection of material from a central vent. Sometimes the craters have been filled in by lava flows or lava domes, sometimes they are filled with glacial ice, and less commonly they are filled with water.
- Long periods of repose (times of inactivity) lasting for hundreds to thousands of years, make this type of volcano particularly dangerous, since many times they have shown no historic activity, and people are reluctant to heed warnings about possible eruptions.

Cinder cones (Tephra Cones)

- Cinder cones are volcanoes which erupt only during one episode
- They are explosive, but small in size
- The cone is a pile of pyroclastic debris which piles up at the angle of repose



Cinder cones

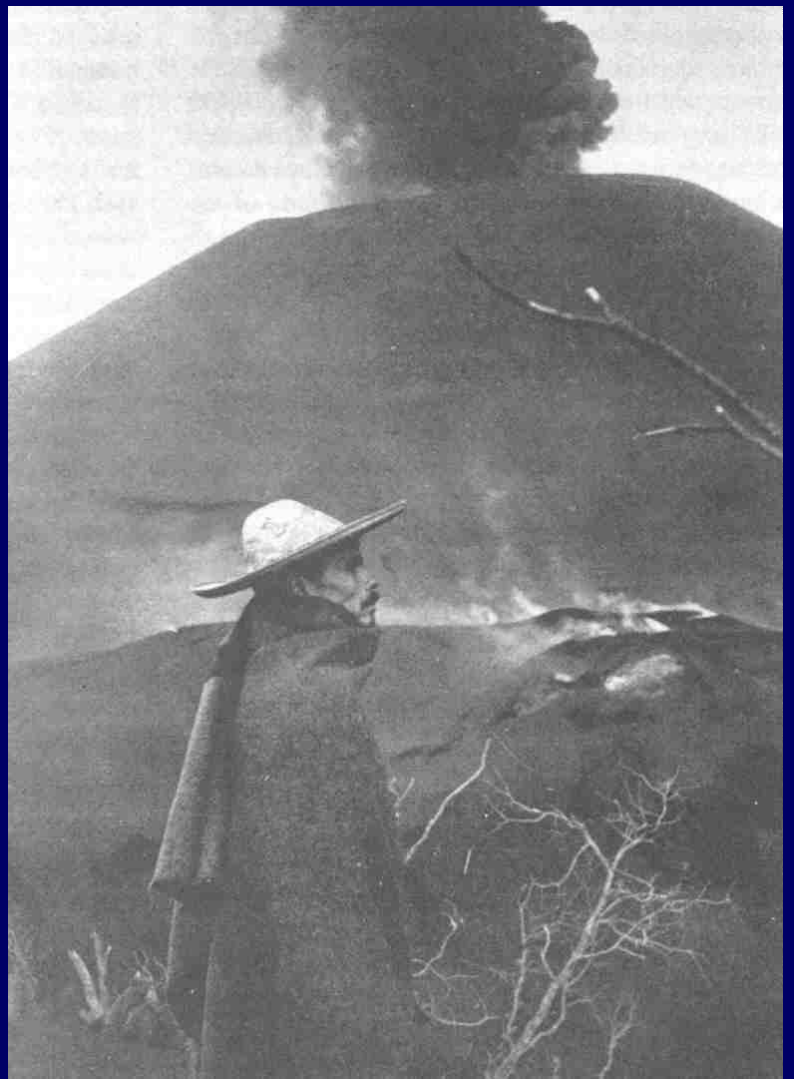
- The cinders are generally of basaltic composition
- The eruptive activity typically lasts a few months or years

Cinder cones: Parícutin

- Parícutin volcano in Mexico is a classic cinder cone
- The region contains many cinder cones
- It consists of both pyroclastics and lava

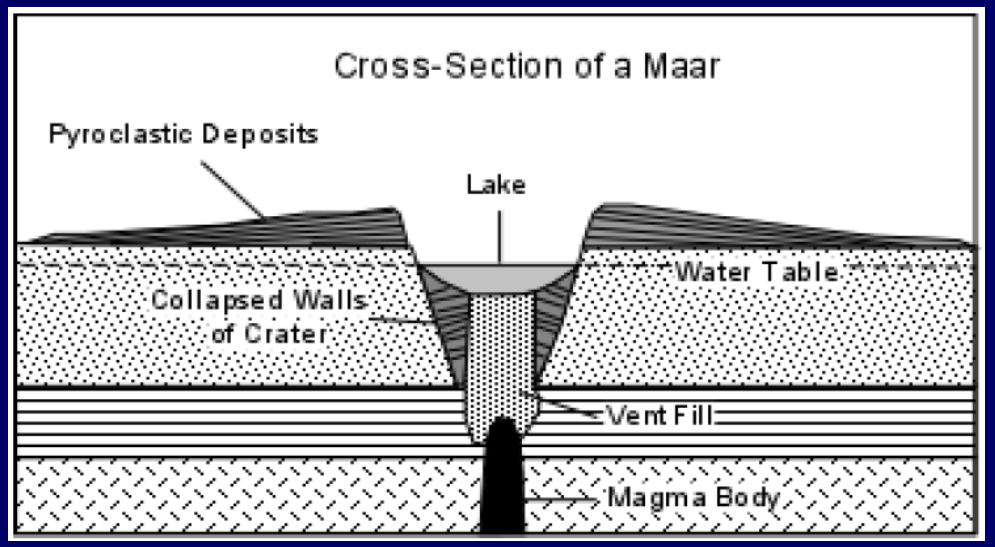
Parícutin

- Here is a photo of the volcano showing the classic form of cinder cones
- In the foreground is the obviously distressed farmer, Dionisio Pulido



Maars

Maars result from phreatic or phreatomagmatic activity, wherein magma heats up water in the groundwater system, pressure builds as the water to turns to steam, and then the water and preexisting rock (and some new magma if the eruption is phreatomagmatic) are blasted out of the ground to form a tephra cone with gentle slopes.



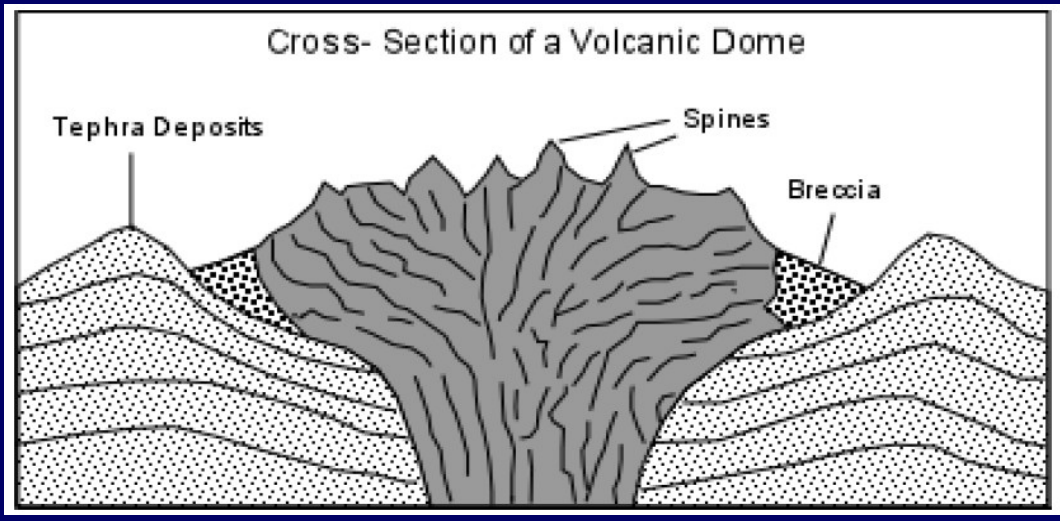
Parts of the crater walls eventually collapse back into the crater, the vent is filled with loose material, and, if the crater still is deeper than the water table, the crater fills with water to form a lake, the lake level coinciding with the water table.

Lava Domes (also called **Volcanic Domes**)

Volcanic Domes result from the extrusion of highly viscous, gas poor andesitic and rhyolitic lava. Since the viscosity is so high, the lava does not flow away from the vent, but instead piles up over the vent.

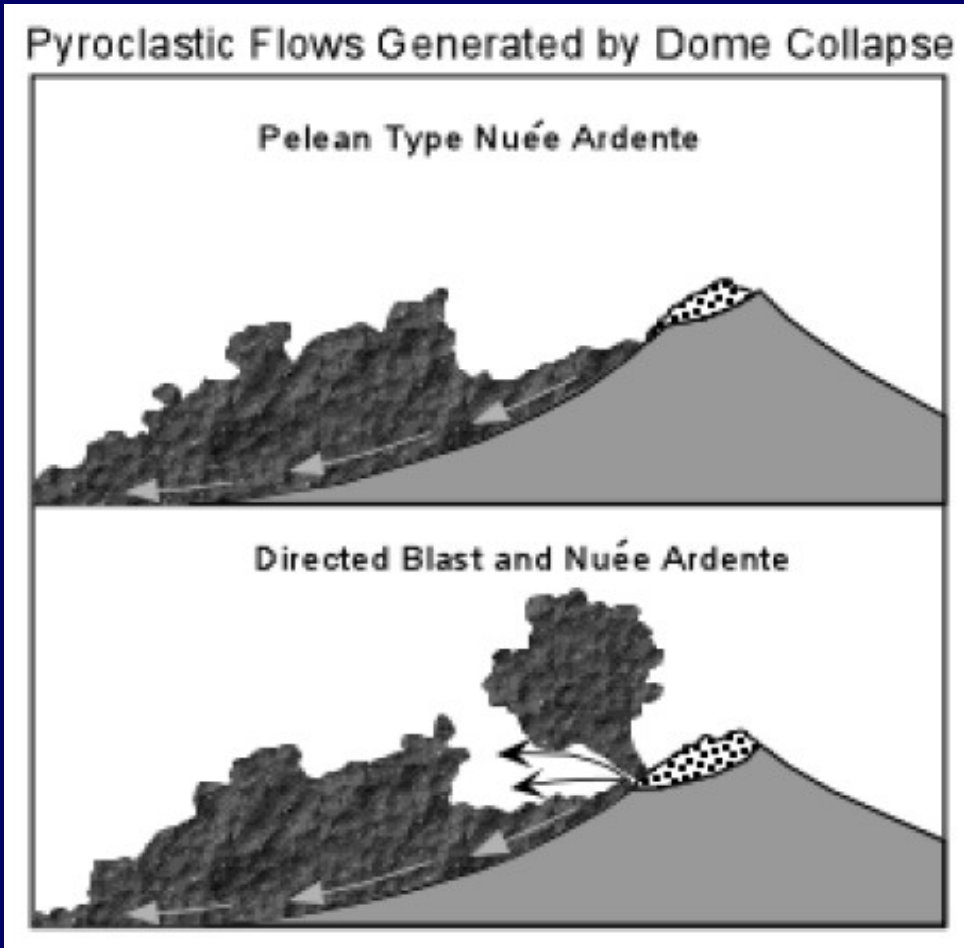
Blocks of nearly solid lava break off the outer surface of the dome and roll down its flanks to form a breccia around the margins of domes.

The surface of volcanic domes are generally very rough, with numerous spines that have been pushed up by the magma from below.



Most dome eruptions are preceded by explosive eruptions of more gas rich magma, producing a tephra cone into which the dome is extruded.

Volcanic domes can be extremely dangerous. because they form unstable slopes that may collapse to expose gas-rich viscous magma to atmospheric pressure. This can result in lateral blasts or Pelean type pyroclastic flow (nuéeardentes) eruptions.



CRATERS AND CALDERAS

- Craters are circular depressions, usually less than 1 km in diameter, that form as a result of explosions that emit gases and tephra.

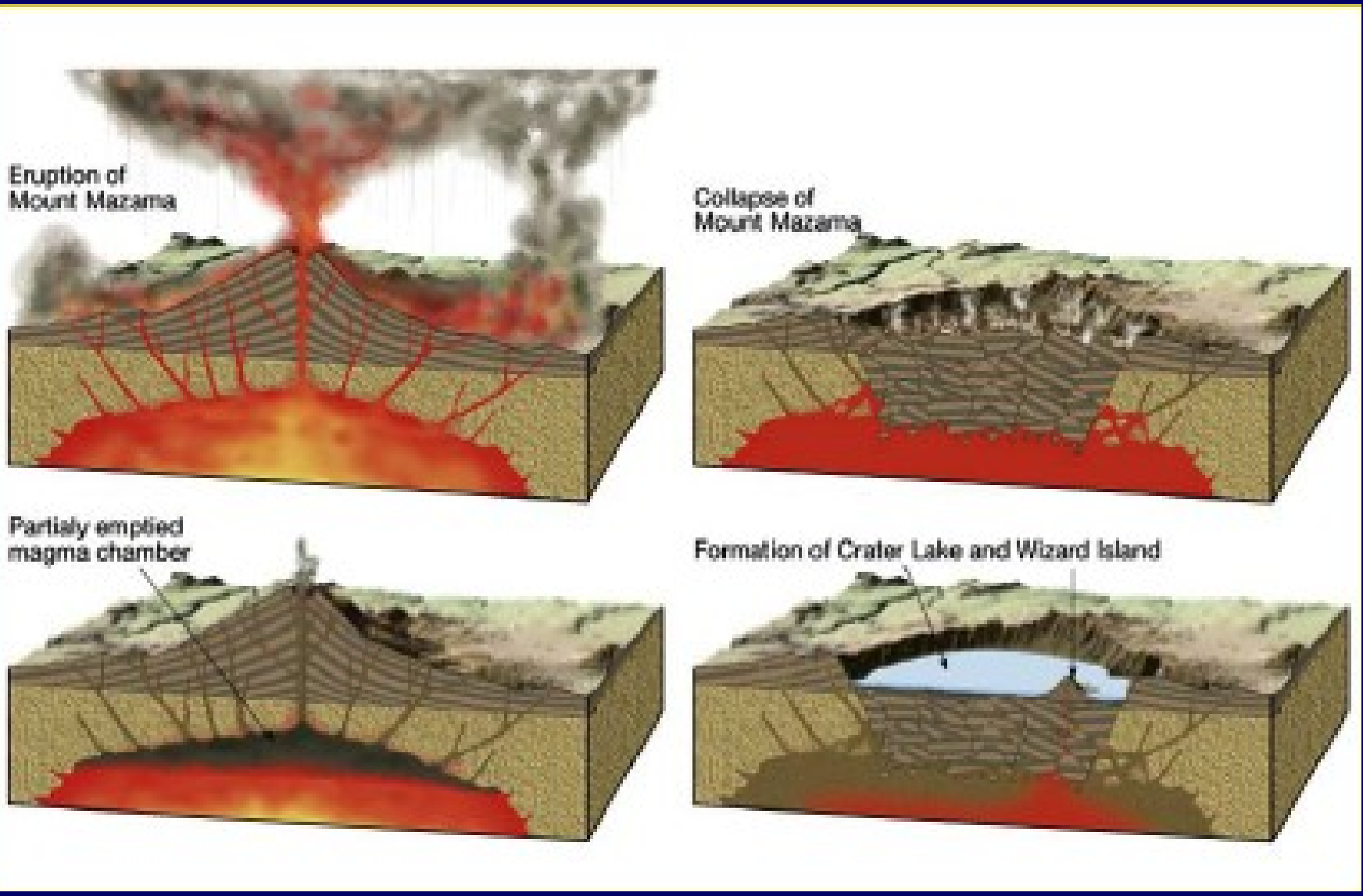
- Calderas are much larger depressions, circular to elliptical in shape, with diameters ranging from 1 km to 50 km. Calderas form as a result of collapse of a volcanic structure. The collapse results from evacuation of the underlying magma chamber.

- In shield volcanoes, like in Hawaii, the evacuation of the magma chamber is a slow drawn out processes.

- In stratovolcanoes the collapse and formation of a caldera results from rapid evacuation of the underlying magma chamber by voluminous explosive eruptions that form extensive fall deposits and pyroclastic flows.

- Calderas are often enclosed depressions that collect rain water and snow melt, and thus lakes often form within a caldera.

CALDERAS


Eruption of
Mount Mazama
Collapse of
Mount Mazama
Partialy emptied
magma chamber
Formation of Crater Lake and Wizard Island

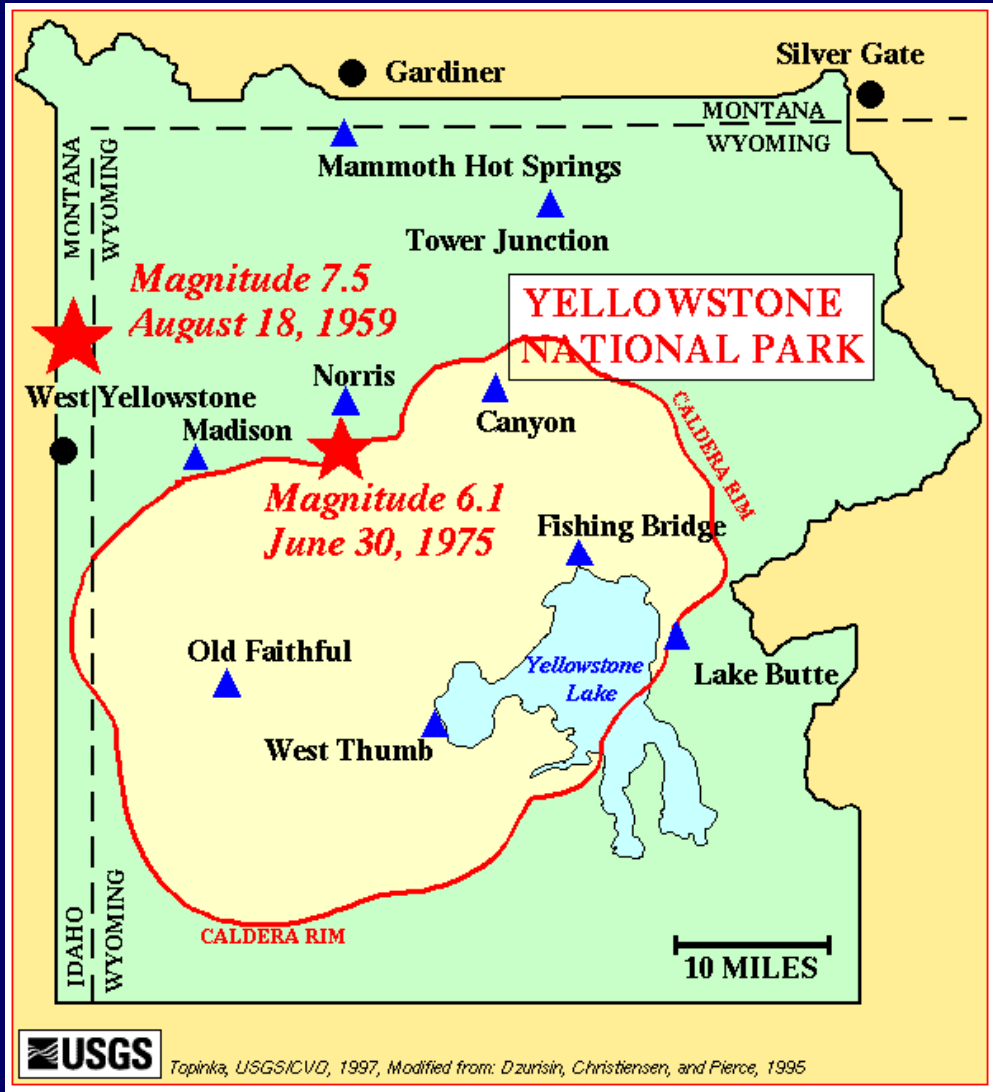
Crater Lake caldera

- Crater lake is a medium-sized caldera, about 10 km in diameter
- The upper parts of a big stratovolcano (Mt. Mazama) once rested on top
- Mt. Mazama is now at the bottom of Crater Lake

Crater Lake fills caldera formed by collapse during massive eruption of Mt. Mazama 6600 years ago.

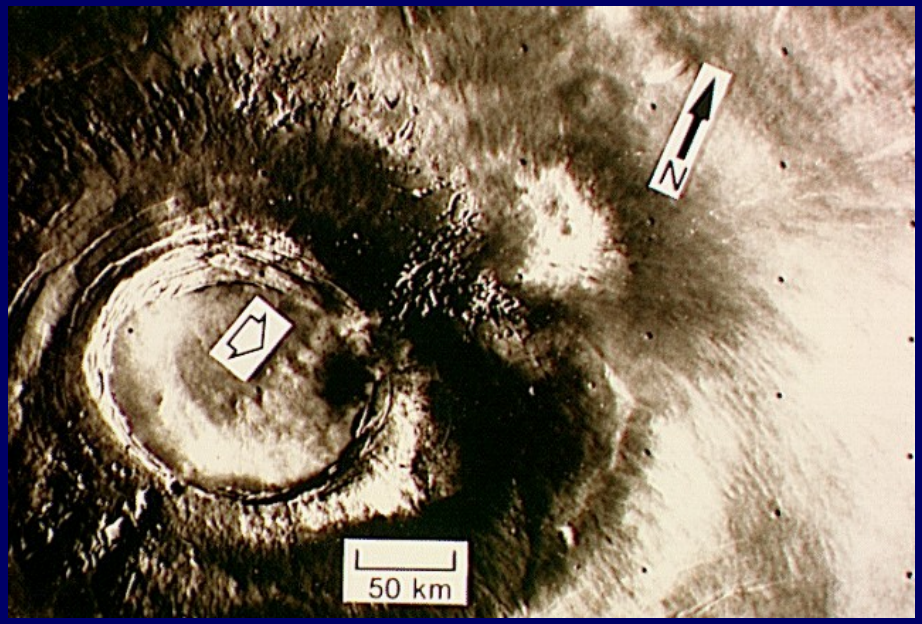
Yellowstone caldera

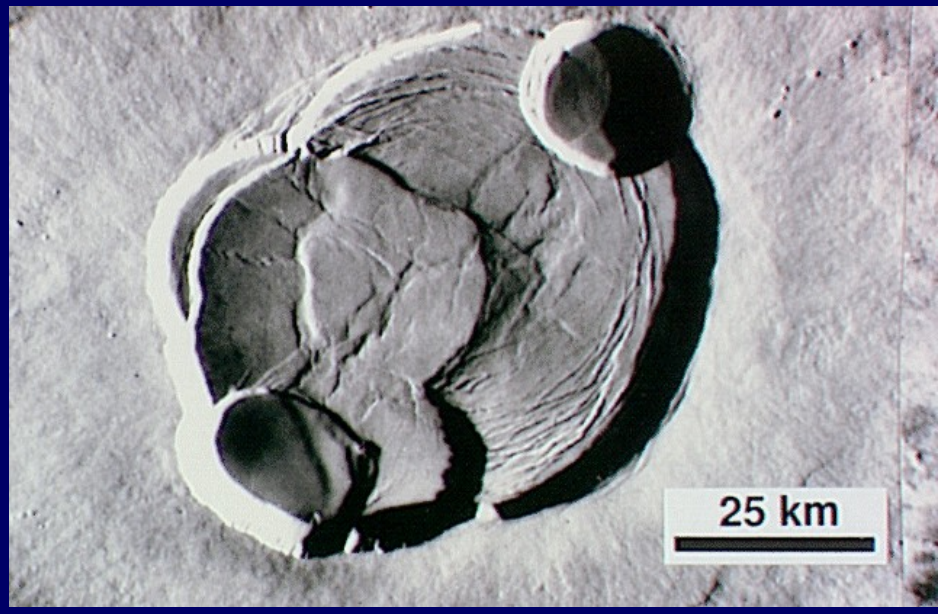
- Yellowstone is a good example of a **big** continental caldera
- It is rhyolitic in composition and formed about 600,000 years ago
- It actually sits within an older, much larger caldera extending west into Idaho



Martian calderas

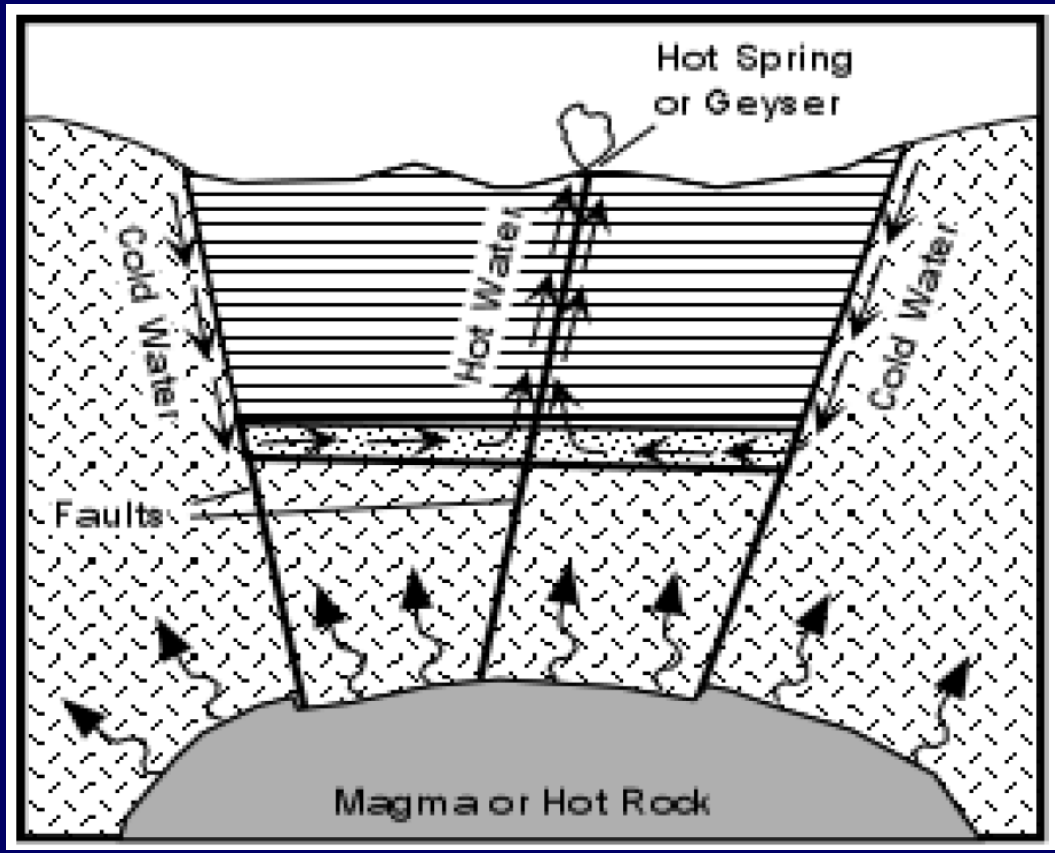
- Here are two Martian calderas. Again, you should appreciate the difference in scale between these structures and those on Earth





Geysers, Fumaroles and Hot Springs

A fumarole is vent where gases, either from a magma body at depth, or steam from heated groundwater, emerges at the surface of the Earth. Since most magmatic gas is H2O vapor, and since heated groundwater will produce H2O vapor, fumaroles will only be visible if the water condenses. (H2O vapor is invisible, unless droplets of liquid water have condensed)



Hot springs or thermal springs are areas where hot water comes to the surface of the Earth. Cool groundwater moves downward and is heated by a body of magma or hot rock. A hot spring results if this hot water can find its way back to the surface, usually along fault zones.

A geyser results if the hot spring has a plumbing system that allows for the accumulation of steam from the boiling water. When the steam pressure builds so that it is higher than the pressure of the overlying water in the system, the steam will move rapidly toward the surface, causing the eruption of the overlying water.

Some geysers, like Old Faithful in Yellowstone Park, erupt at regular intervals. The time between eruptions is controlled by the time it takes for the steam pressure to build in the underlying plumbing system.

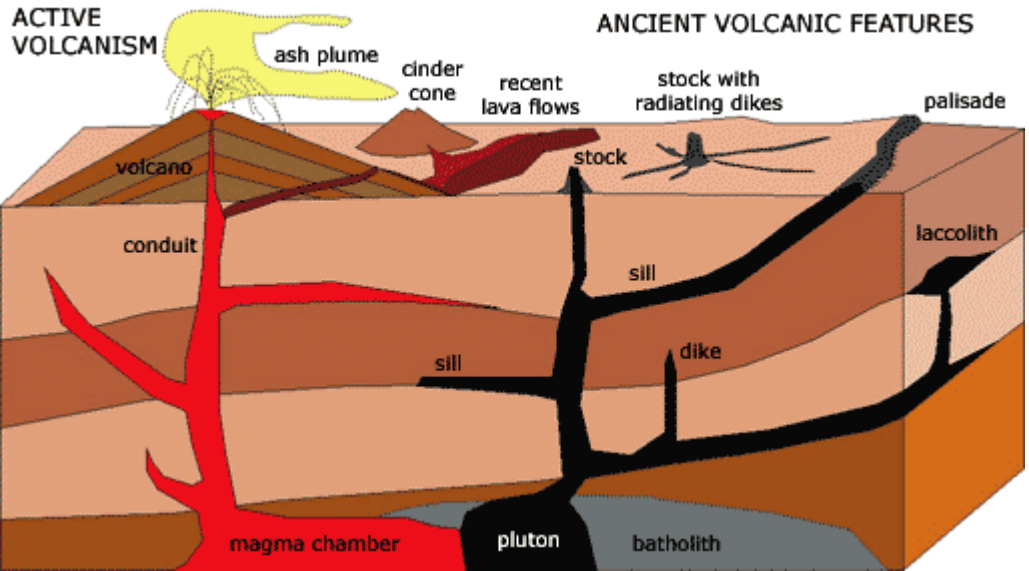
Plateau Basalts or Flood Basalts

Lava plateaus

Sometimes, plate tectonics results in a long, narrow crack (fissure) in Earth's surface

Basaltic lava pouring from the fissure spreads across the land, forming a lava plateau

Due to erosional processes the plateau gives Mesa and Buteau



Flood basalt, Columbia Plateau,Washington

Figure 12-16 part 1
Understanding Earth, Fifth Edition

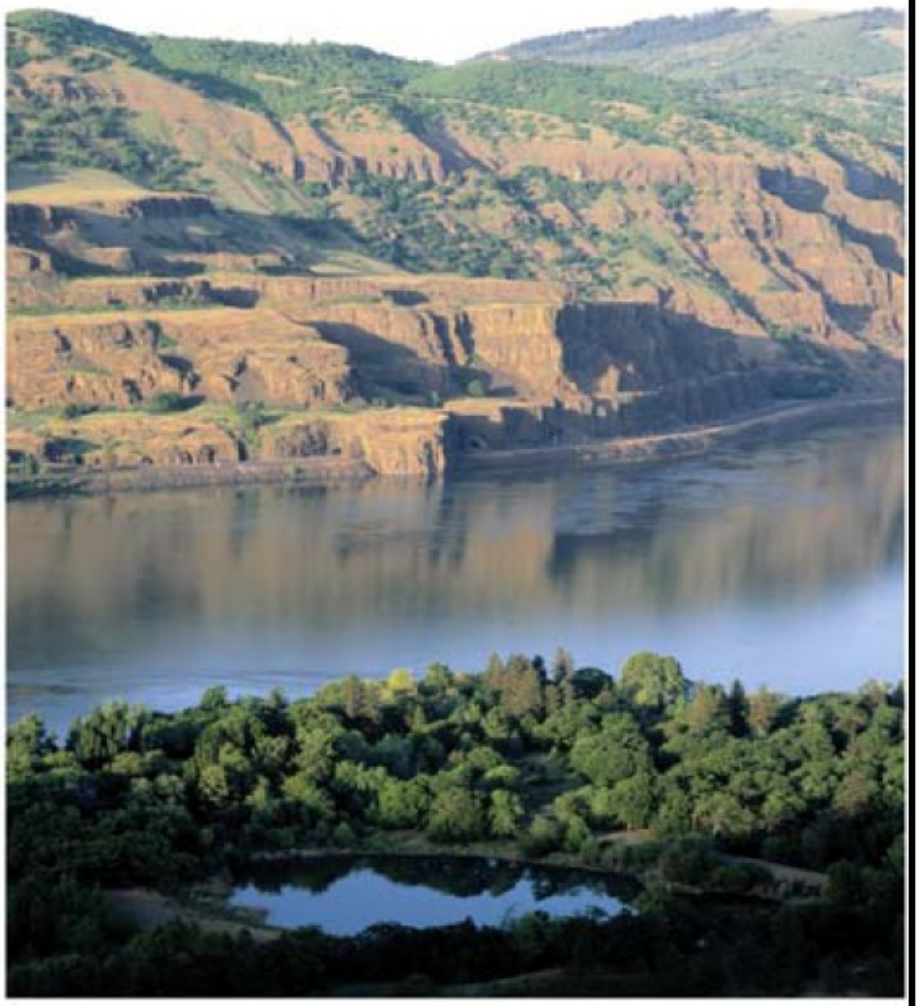


Figure 12-16 part 2
Understanding Earth, Fifth Edition

Columbia Plateau basalts

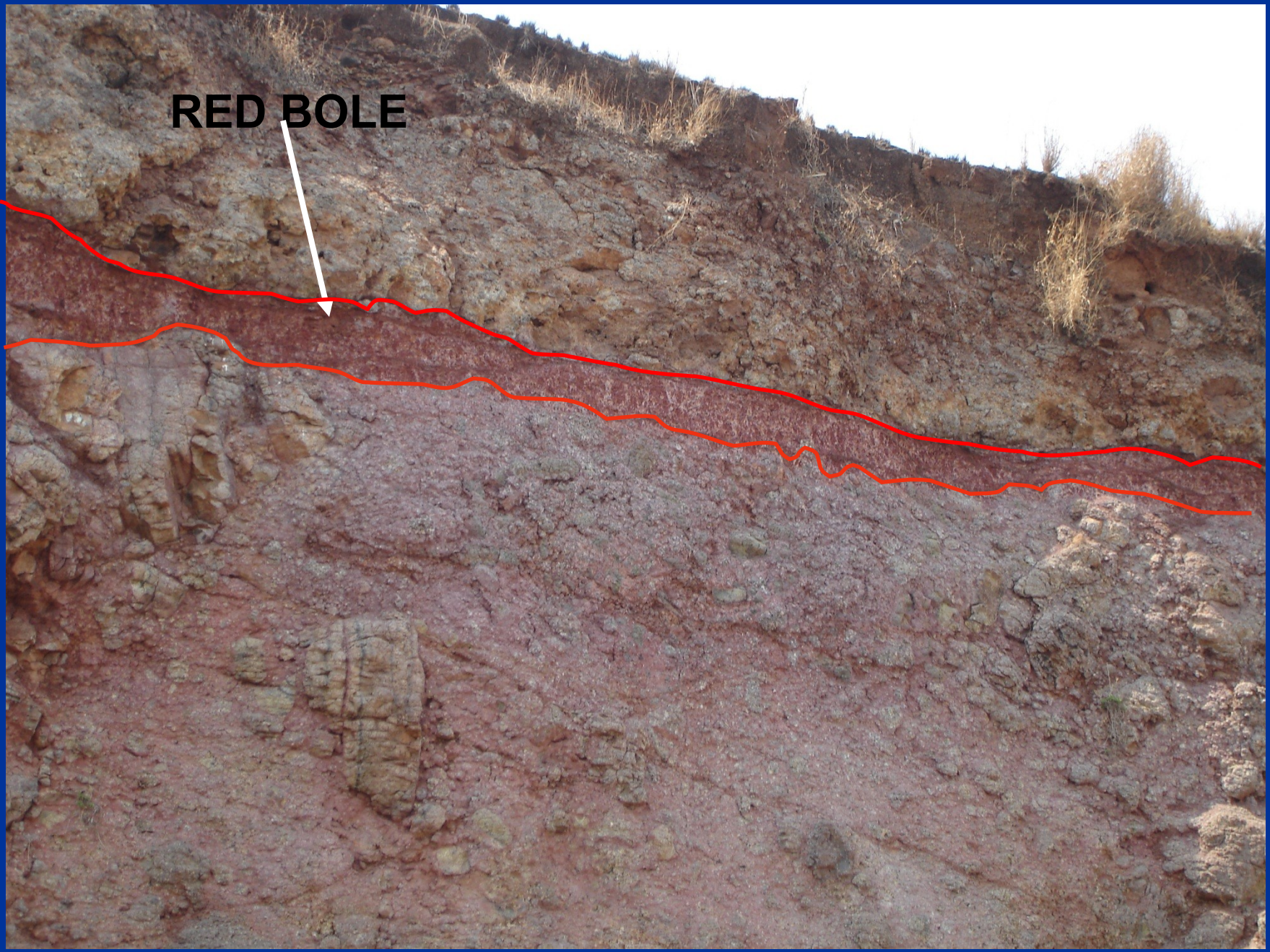
Western Edge,Columbia Plateau
West of Quincy, WA - M. Mustoe

The Anatomy of a Basalt Flow

Basalt Layering

In western India are the Deccan plateau basalts, whose extrusions for more than 70 million years are related to the collision of India against the southern margin of the Asian plate.

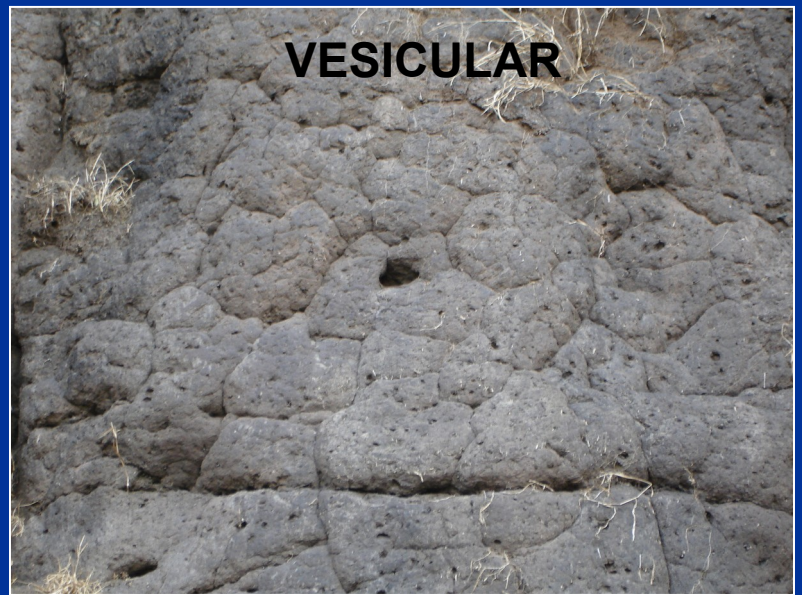
- Deccan trap forms unique and self styled geological formation with rhythmic and repetitive layers of volcanic flows numbering over 40 – 50
- These 40 – 50 flows have repetitively erupted intermittently
- Each flow contains
  - Red bole / flow breccia in the bottom followed on the top by Massive flow
  - Columnar flow
  - Vesicular and Amygdaloidal basalt on the top
  - These multiple flows are intensively dissected and hence depending upon the levels of dissection and erosion different flows are spatially exposed in different locations


RED BOLE


Vesicular / Amygdoloidal
Columnar
Massive


MASSIVE

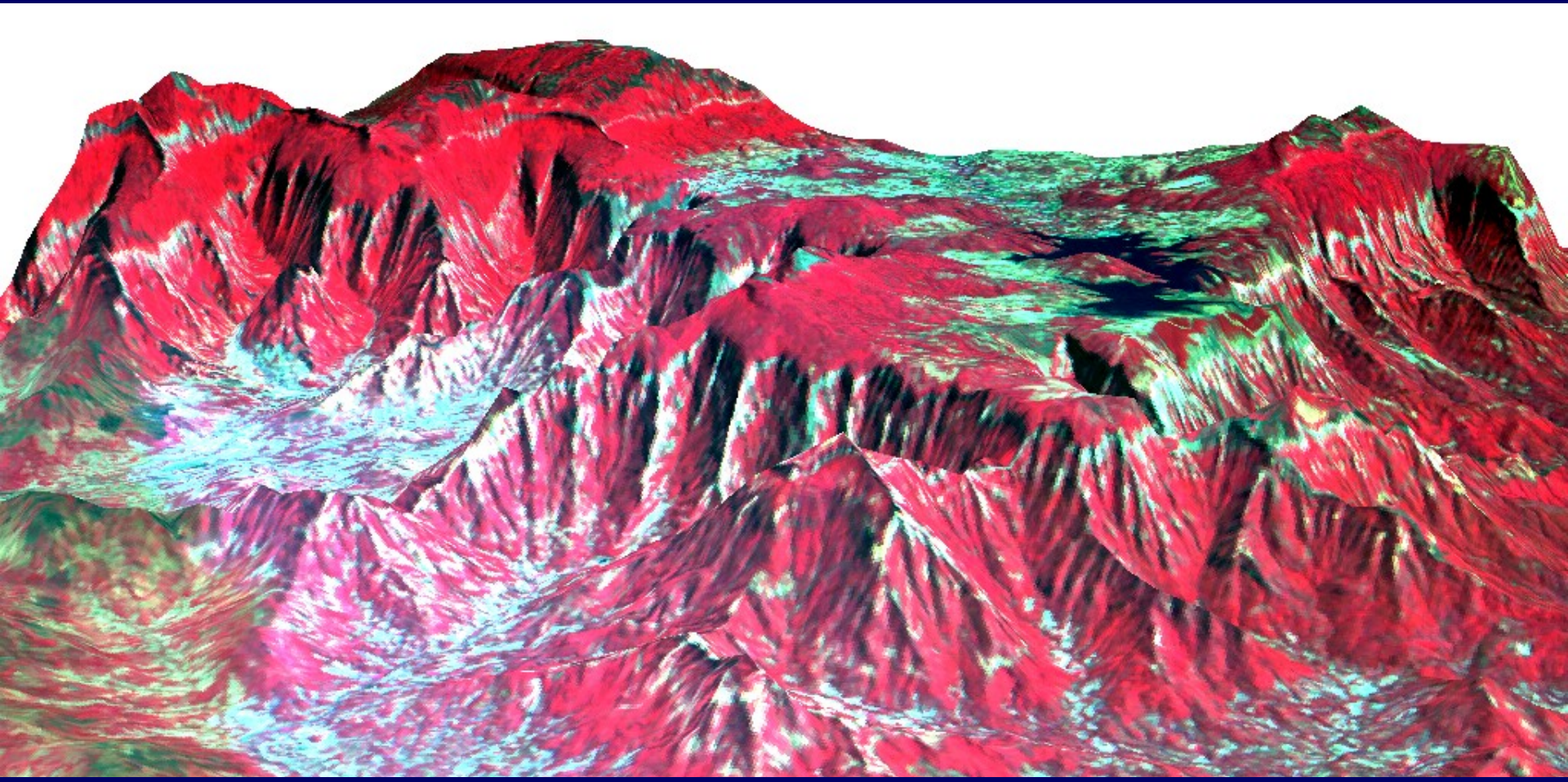

COLUMNAR


VESICULAR

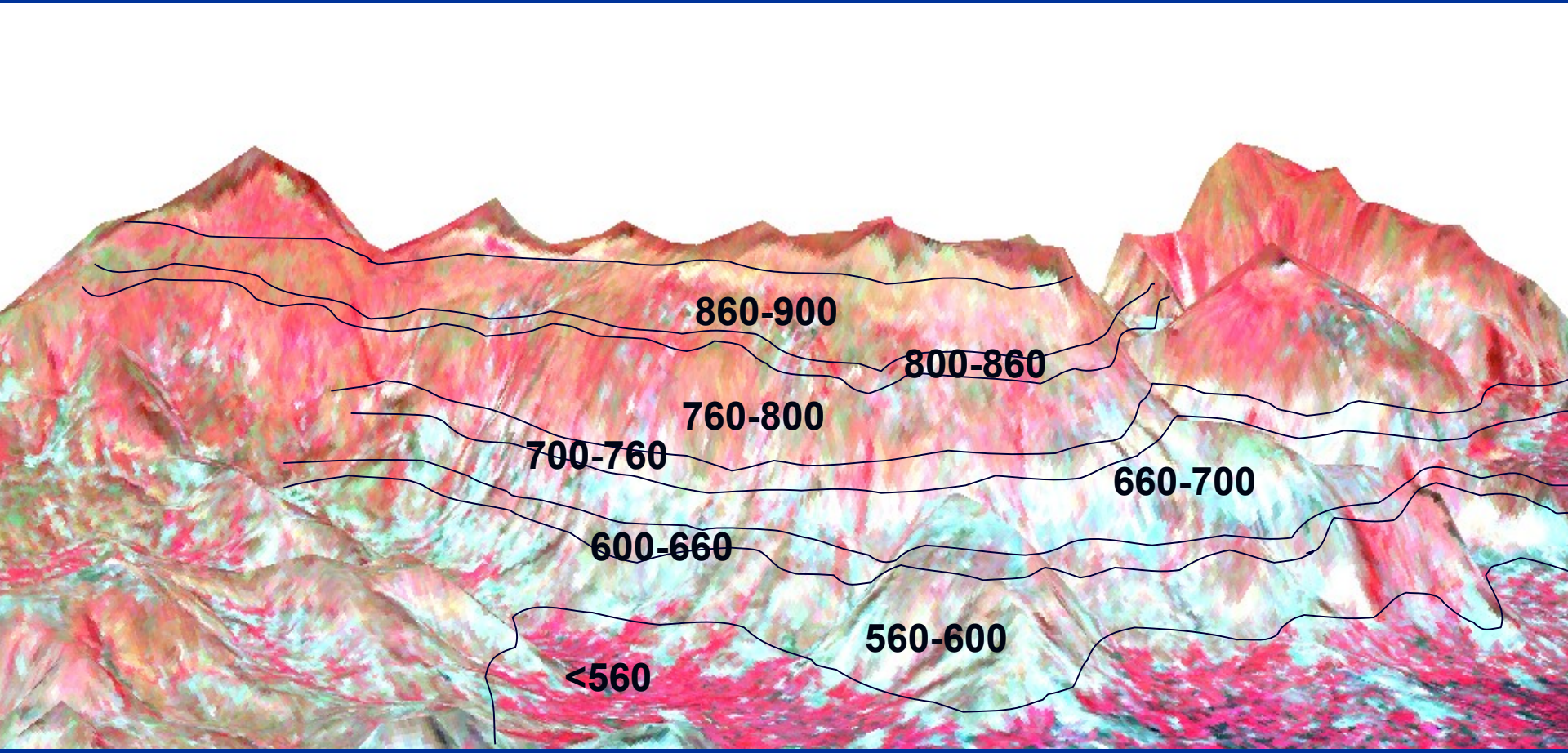

AMYGDALOIDAL


Transitional Flow
Massive Flow

Multiple flows



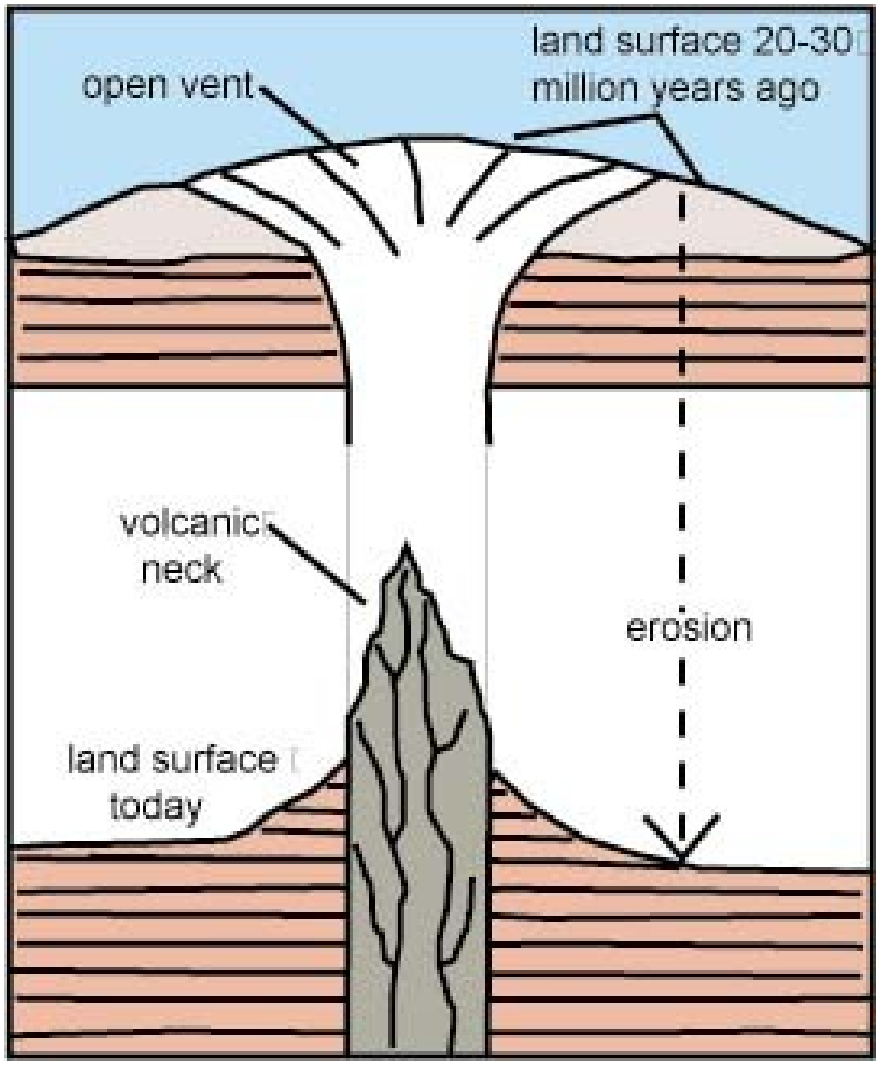
DEM Wrapped FCC image showing different level of flow elevation



- Sometimes magma rises upward through cracks in the crust but does not reach Earth's surface.
- The magma cools and hardens into rock beneath the surface
- Features formed by magma include volcanic necks, dikes, and sills, as well as batholiths and dome mountains.

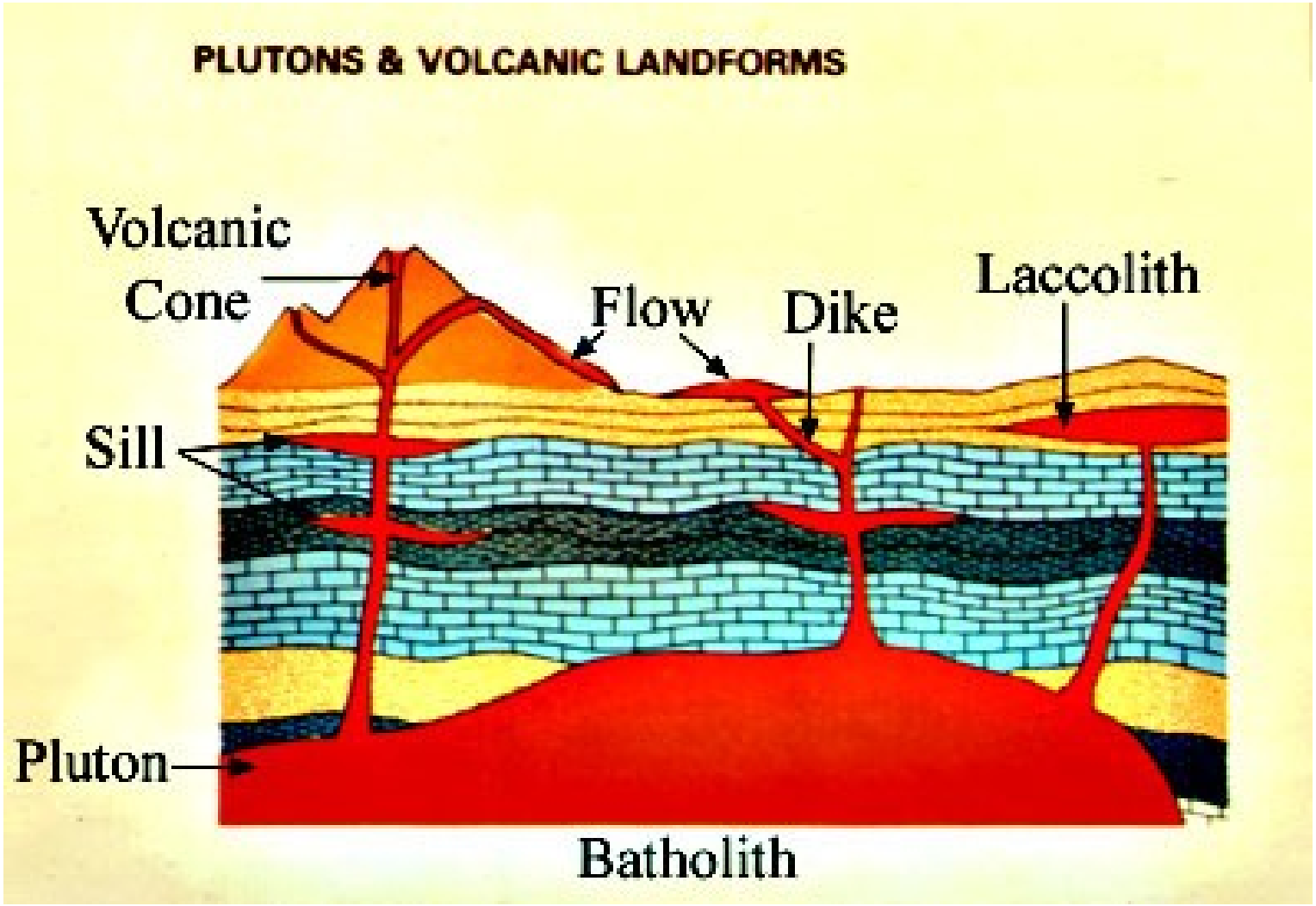
- **A volcanic neck forms when magma hardens in a volcano's pipe.**

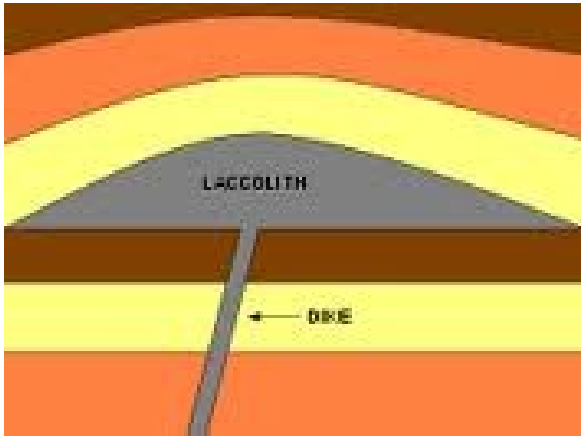
- **The softer rock around the pipe wears away, exposing the hard rock of the volcanic neck.**



- A **dike forms when magma forces itself across rock layers** and hardens.

- A **sill forms when magma squeezes between layers of rock** and hardens.





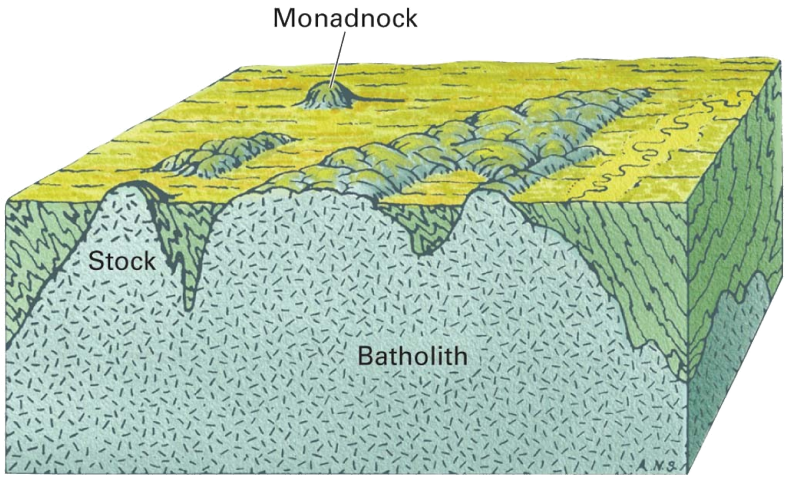
Laccolith: A laccolith (also called a plutonic formation or an igneous intrusion) is a formation in which magma (molten rock) is trapped beneath the surface of the Earth and pushes the rock located above it into a dome shape. It has a flat base and a convex upper surface. The magma cools and solidifies, and eventually, it is exposed (as the fractured sedimentary rock above it erodes away). Laccolith means "cistern stone" in Greek.

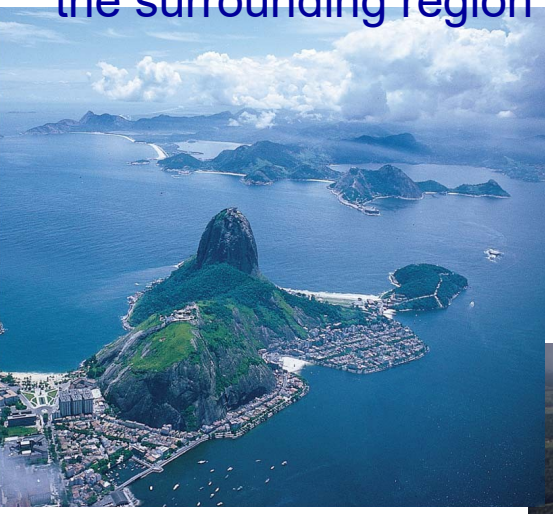
- When a large body of magma cools inside the crust, a mass of rock called a **batholith forms.** Because of erosion, it will be exposed in the surface

Exposed Batholiths and Monadnocks

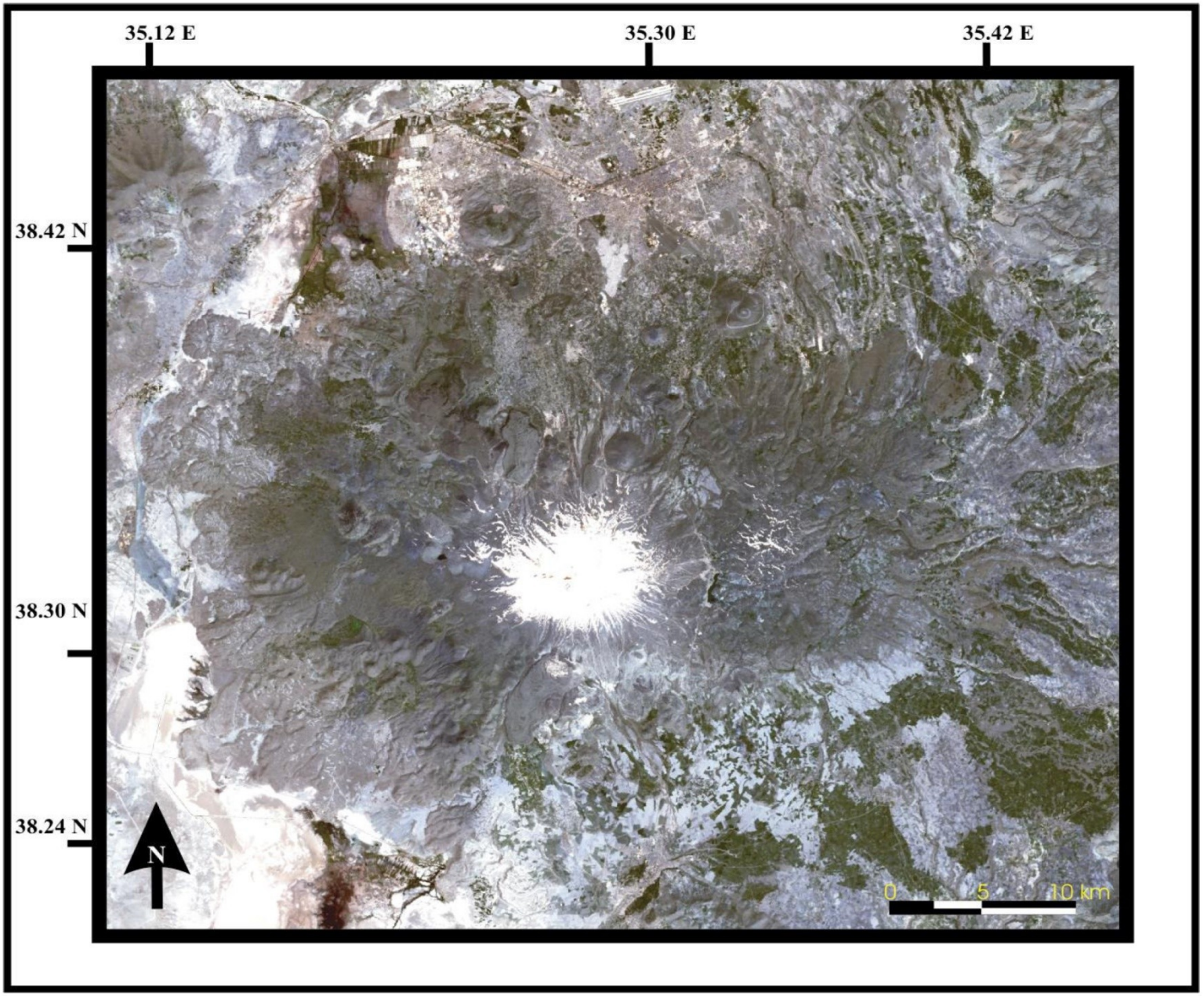
Batholiths: huge bodies of intrusive igneous rock

- Form hilly or mountainous uplands
- *Monadnock*: a mountain that rises out of a surrounding plain and that develops because it consists of more resistant rock than the bedrock of the surrounding region





- **Smaller bodies of hardened magma can** form dome mountains.



gure 1. Landsat ETM image of Erciyes Stratovolcano

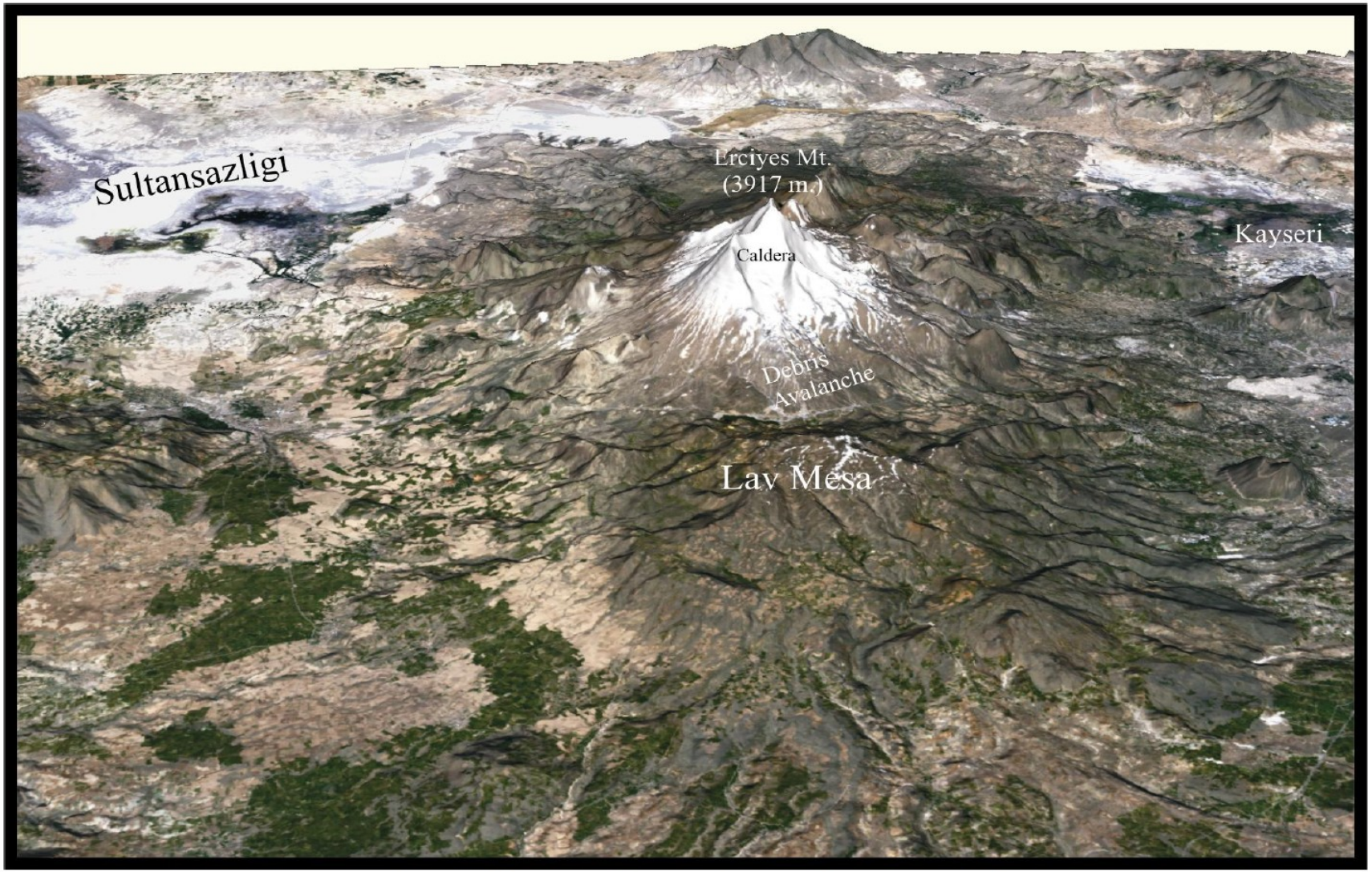
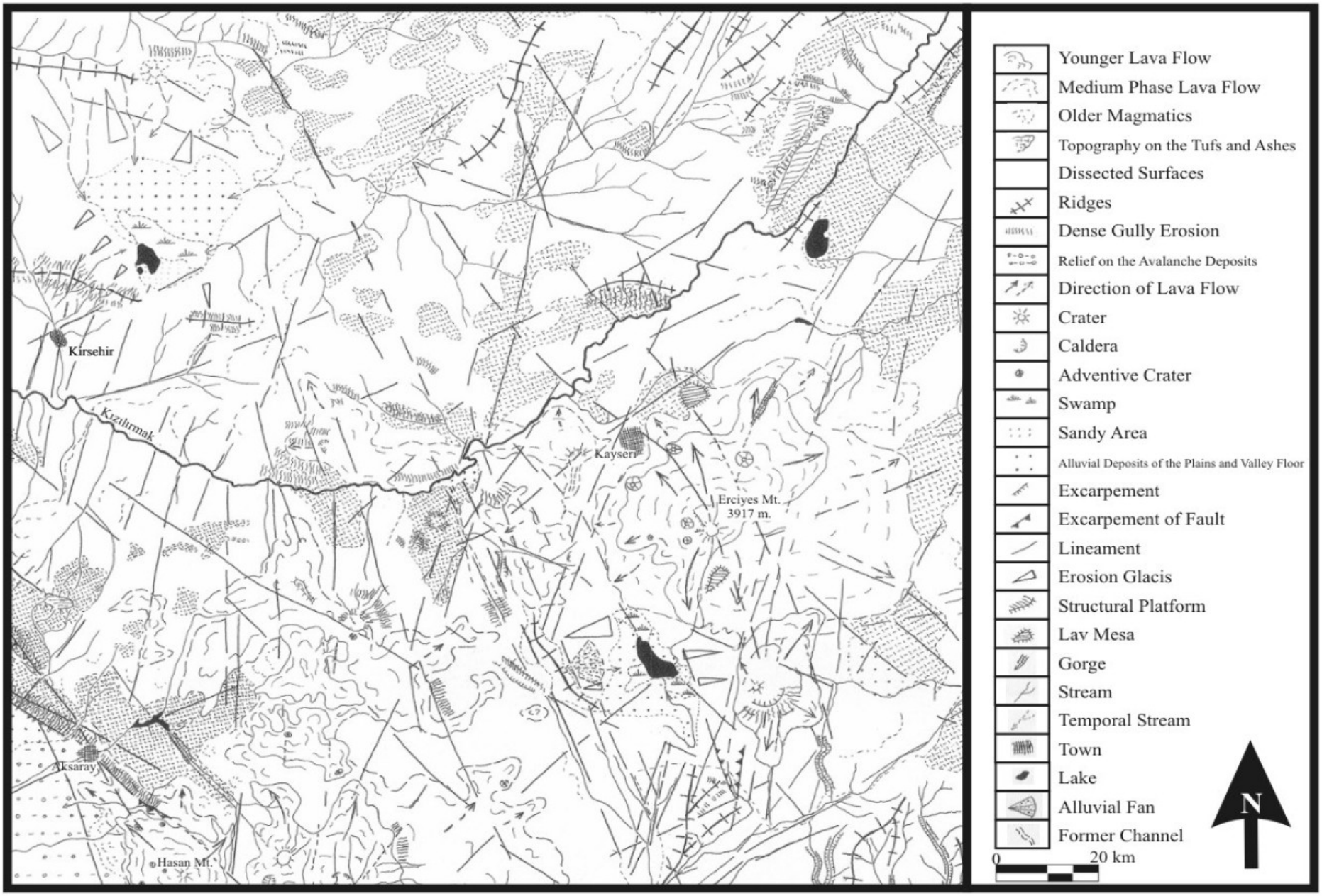


Figure 3. Perspective view of Erciyes Stratovolcano Complex.


Kirsehir
Kızılırmak
Kayseri
Erciyes Mt.
3917 m.
Aksaray
Hasan Mt.
Younger Lava Flow
Medium Phase Lava Flow
Older Magmatics
Topography on the Tufs and Ashes
Dissected Surfaces
Ridges
Dense Gully Erosion
Relief on the Avalanche Deposits
Direction of Lava Flow
Crater
Caldera
Adventive Crater
Swamp
Sandy Area
Alluvial Deposits of the Plains and Valley Floor
Excarpement
Excarpement of Fault
Lineament
Erosion Glacis
Structural Platform
Lav Mesa
Gorge
Stream
Temporal Stream
Town
Lake
Alluvial Fan
Former Channel
0
20 km
N

When Mt. Vesuvius erupted in A.D. 79, the people in nearby Pompeii were trapped and suffocated beneath a layer of volcanic ash up to 8 m thick. When Pompeii was excavated, archaeologists found cavities lines with an exact imprint of the decomposed bodies: by pouring plaster into the cavities they were able to make casts that displayed the victim's musculature, agonized facial expressions and in some cases even the folds in their clothing.