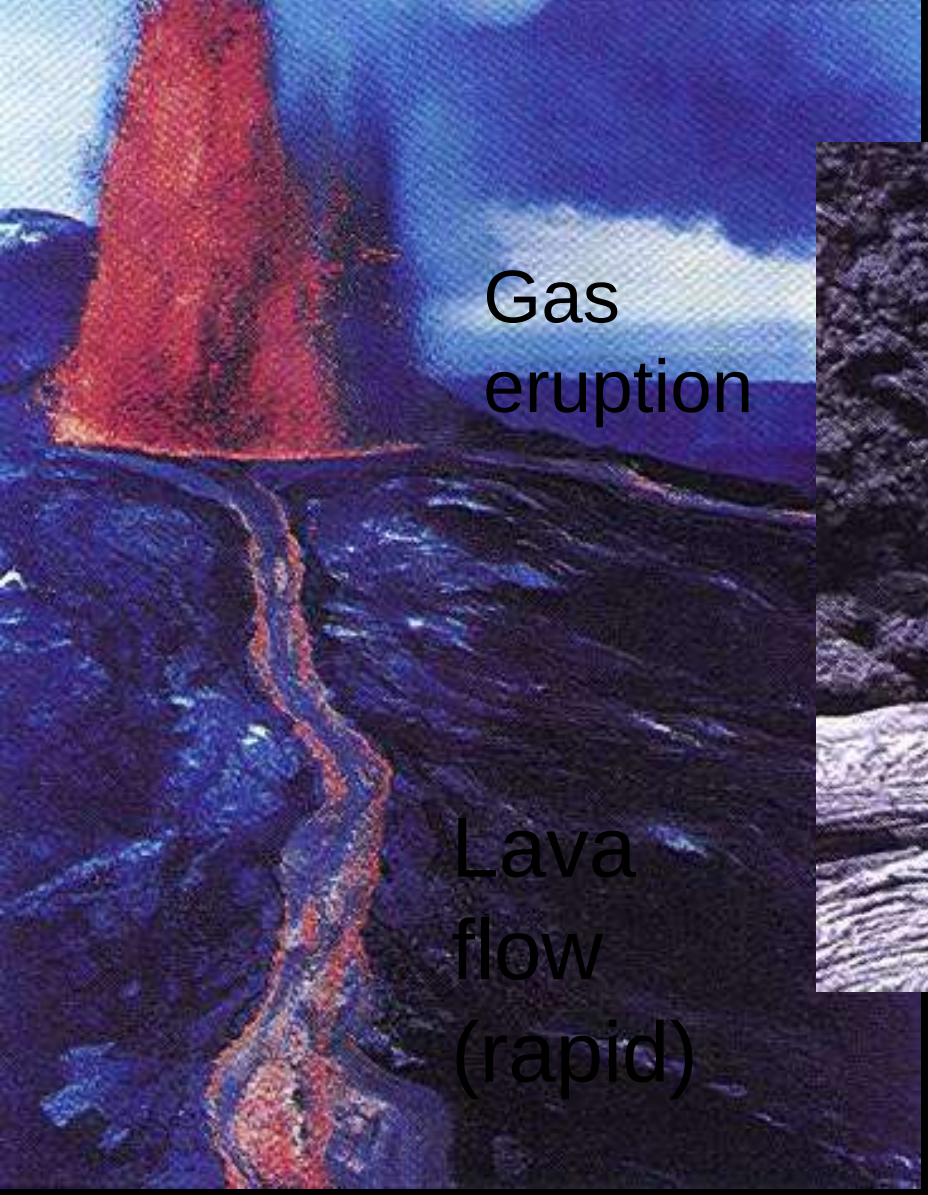
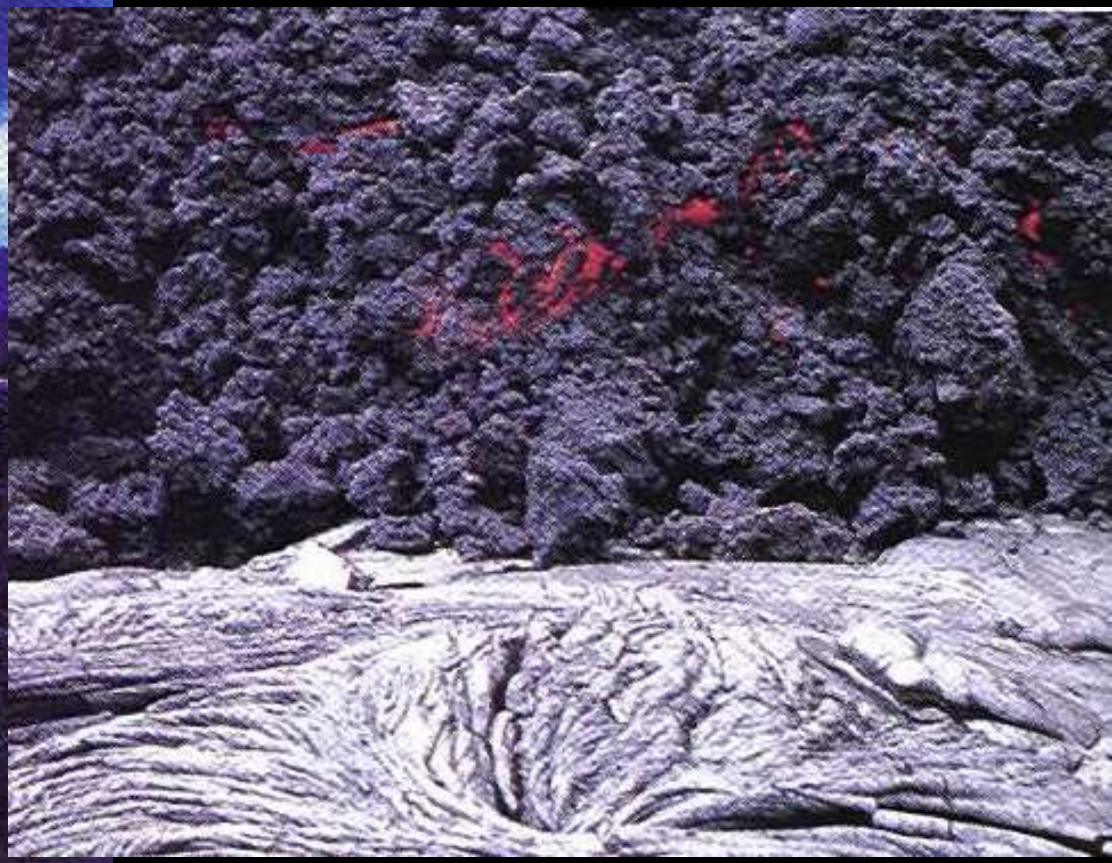
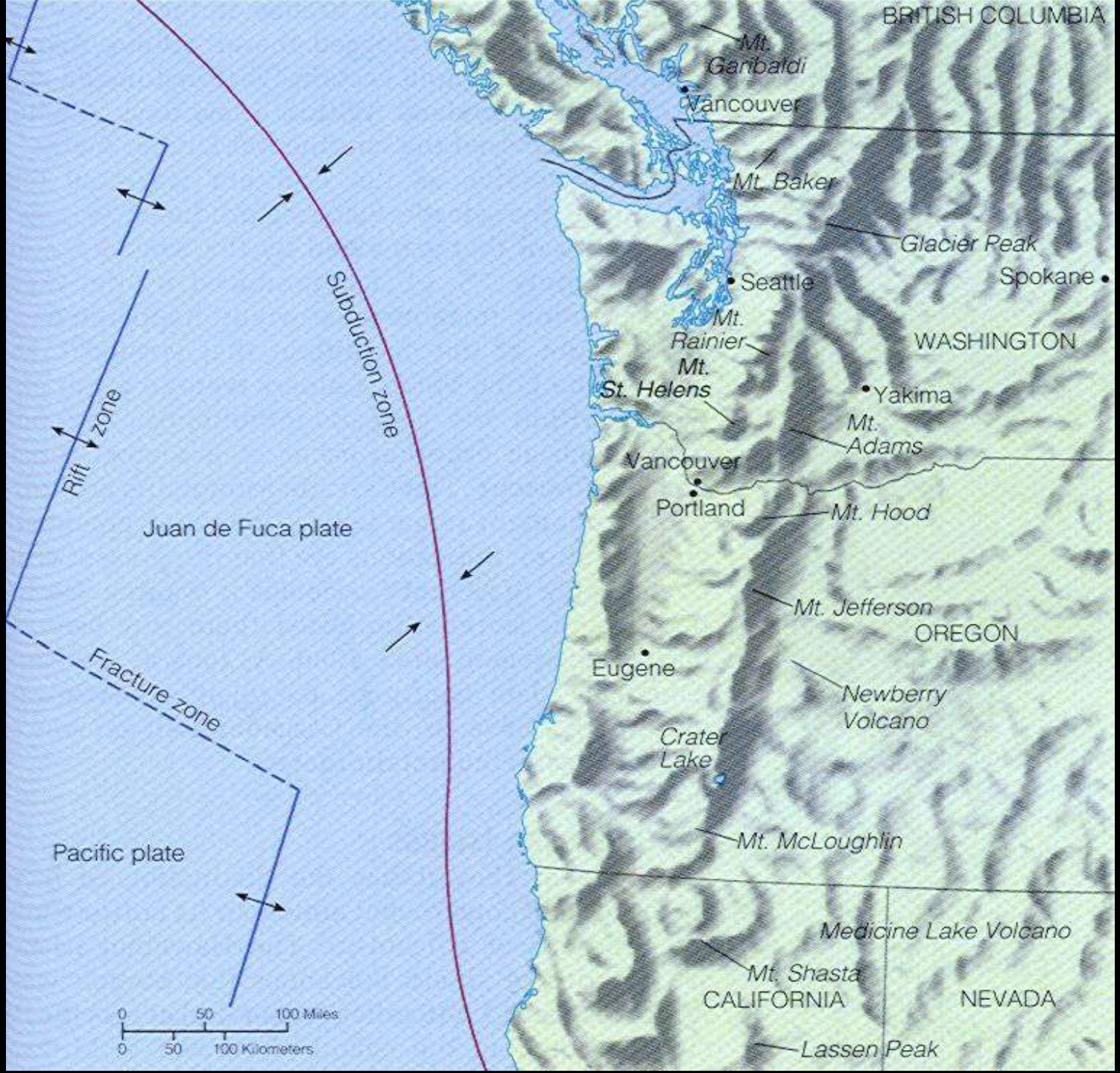
Table 7.1 ■ **Variations in properties among magmas of differing compositions**

| Property | Basaltic magma | Andesitic magma | Granitic magma |
|---|---|---|---|
| Silica content | Least (about 50%) | Intermediate (about 60%) | Most (about 70%) |
| Viscosity | Least ("thinnest") | Intermediate | Greatest ("thickest") |
| Tendency to form lavas | Highest | Intermediate | Least |
| Tendency to form pyroclastics | Least | Intermediate | Greatest |
| Melting temperature | Highest | Intermediate | Lowest |

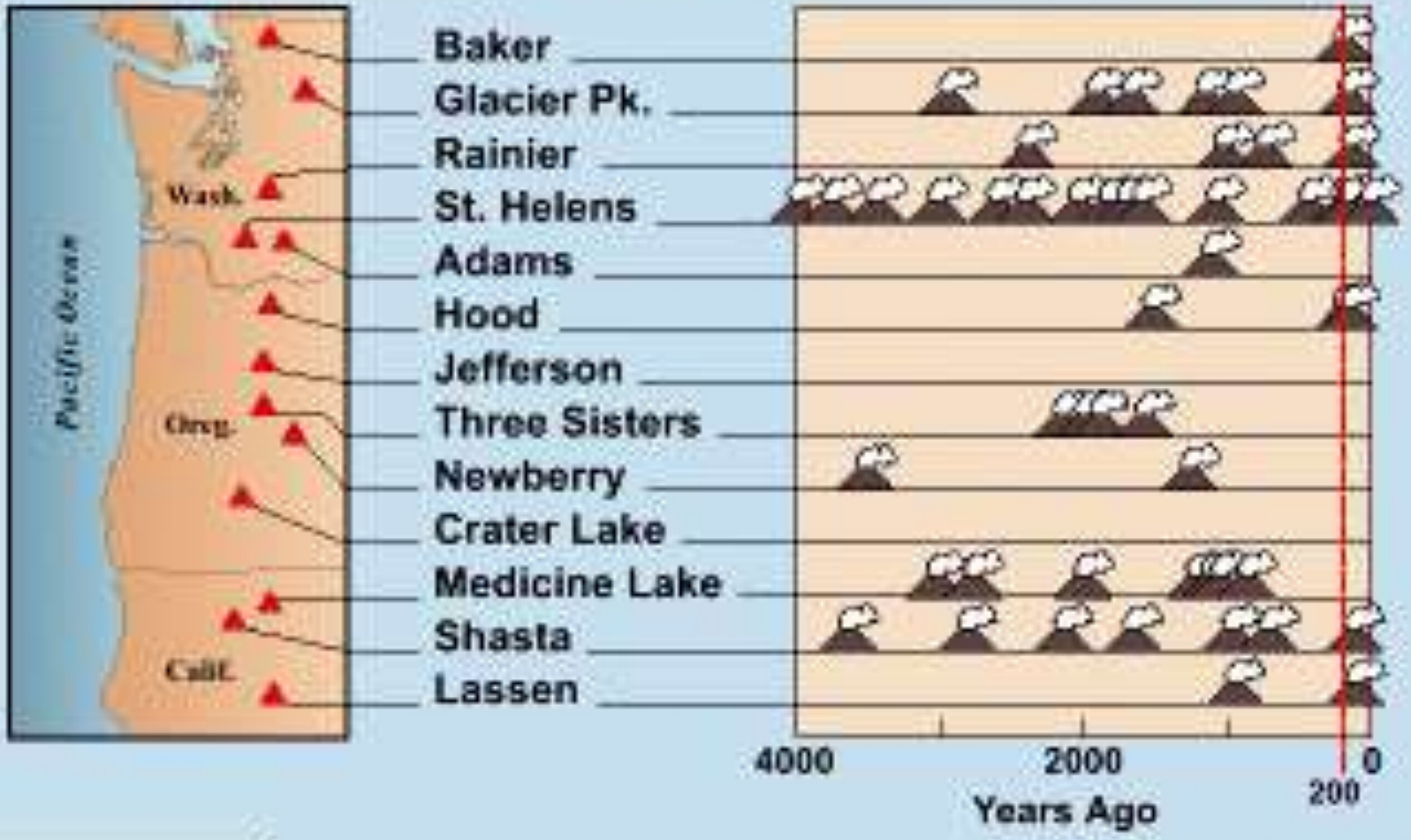

Gas
eruption
Lava
flow
(rapid)



# Lava tubes


BRITISH COLUMBIA
Mt. Garibaldi
Vancouver
Mt. Baker
Glacier Peak
Seattle
Spokane
Mt. Rainier
WASHINGTON
Mt. St. Helens
Yakima
Mt. Adams
Vancouver
Portland
Mt. Hood
Subduction zone
Rift zone
Juan de Fuca plate
Fracture zone
Mt. Jefferson
OREGON
Eugene
Newberry Volcano
Crater Lake
Mt. McLoughlin
Pacific plate
Medicine Lake Volcano
Mt. Shasta
CALIFORNIA
NEVADA
Lassen Peak
0 50 100 Miles
0 50 100 Kilometers

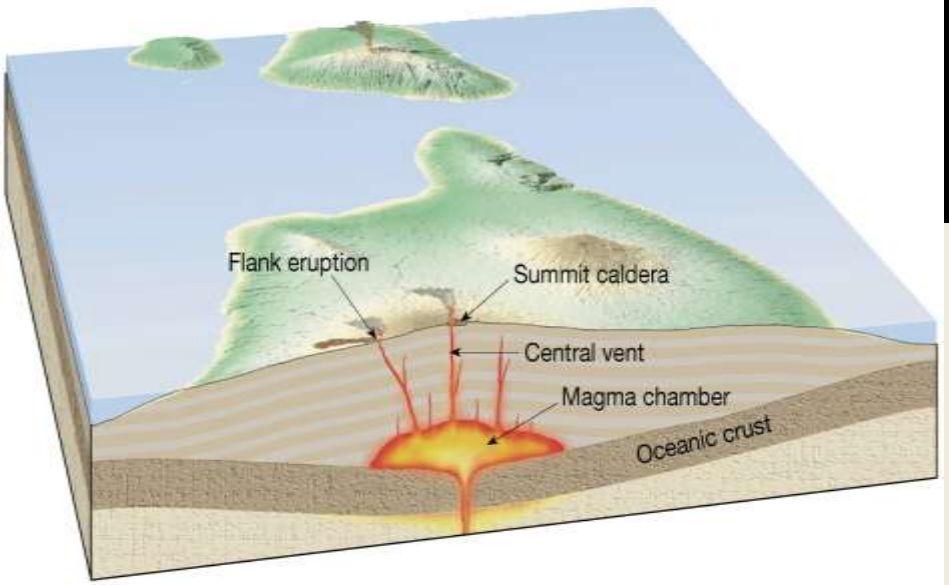
# Cascade Eruptions During The Past 4,000 Years

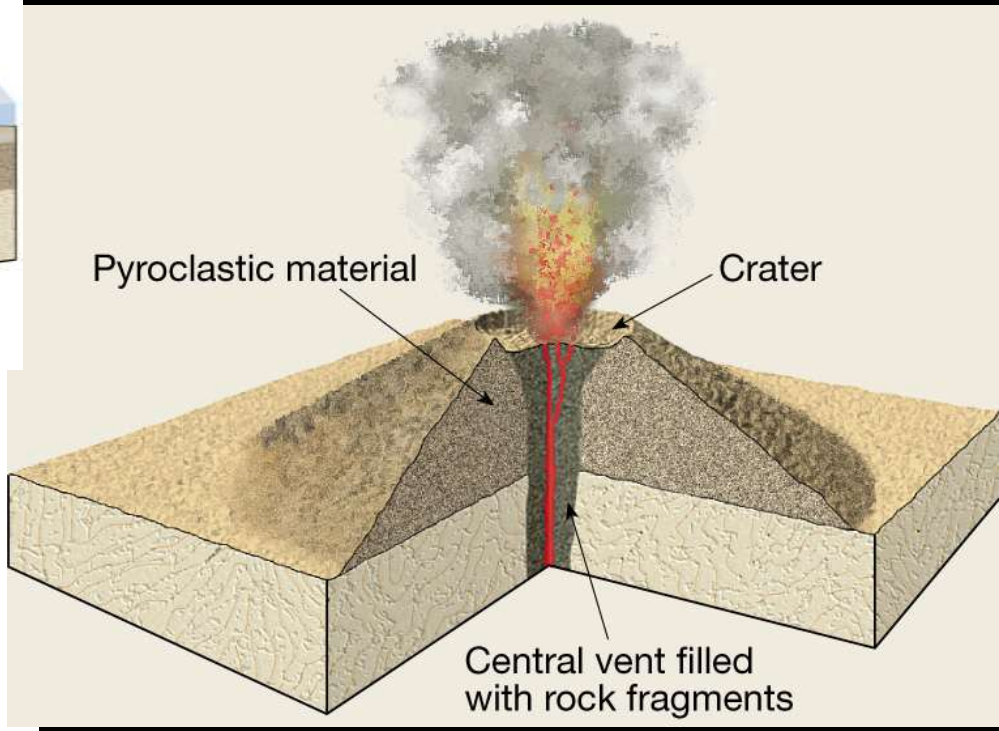


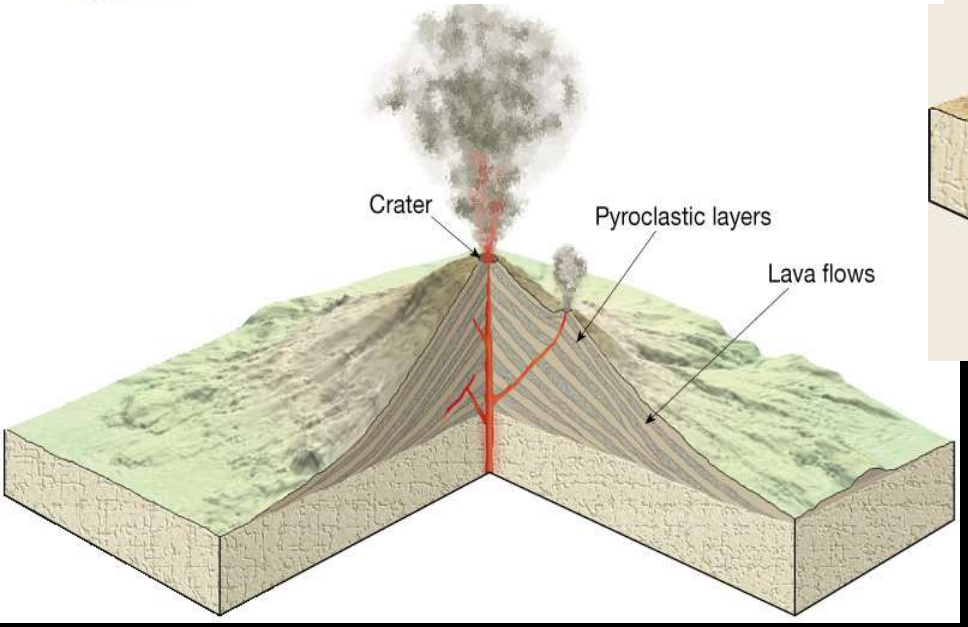

USGS

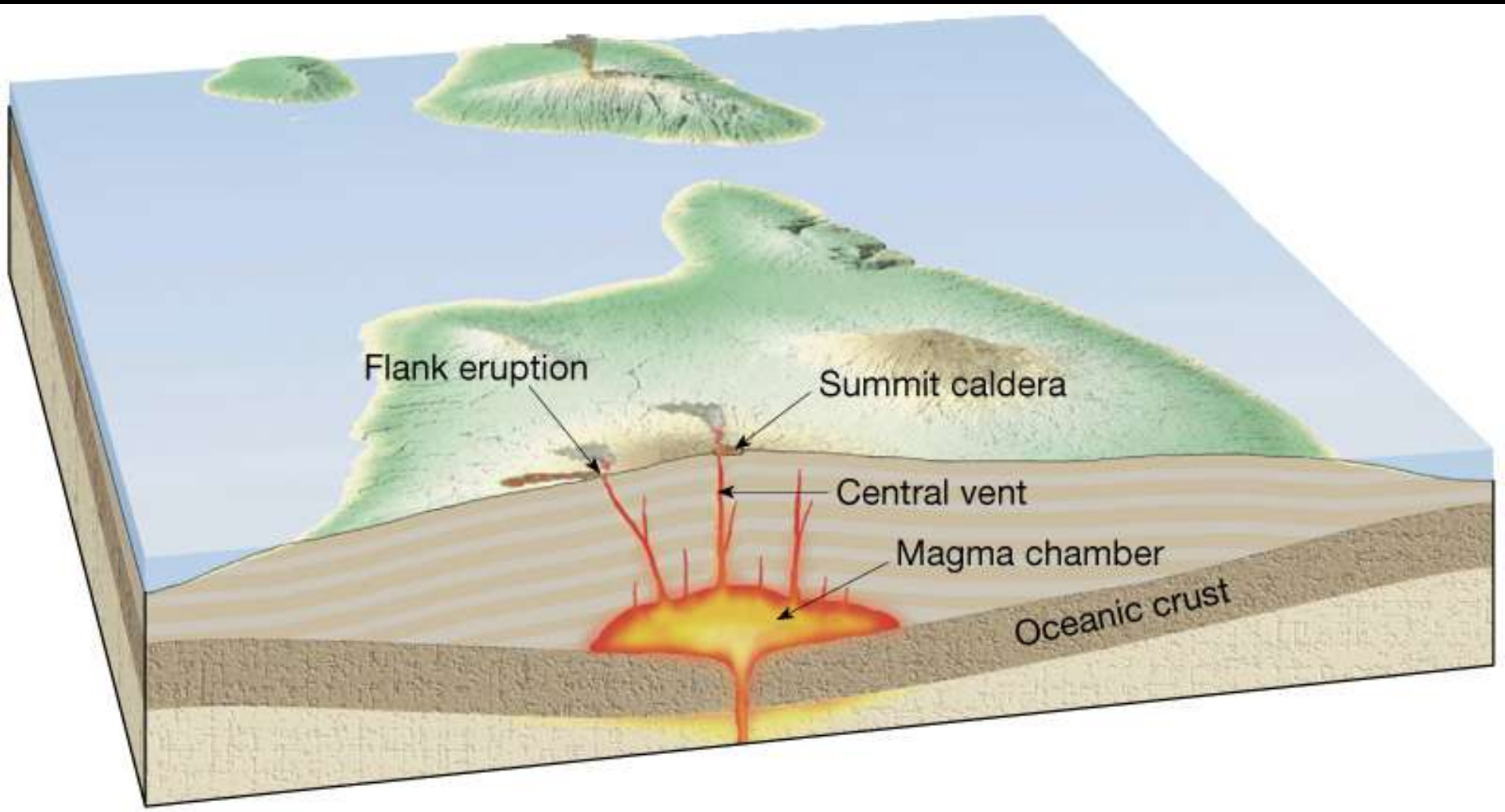
USGS/CVO Graphic by B. Myers, 2000

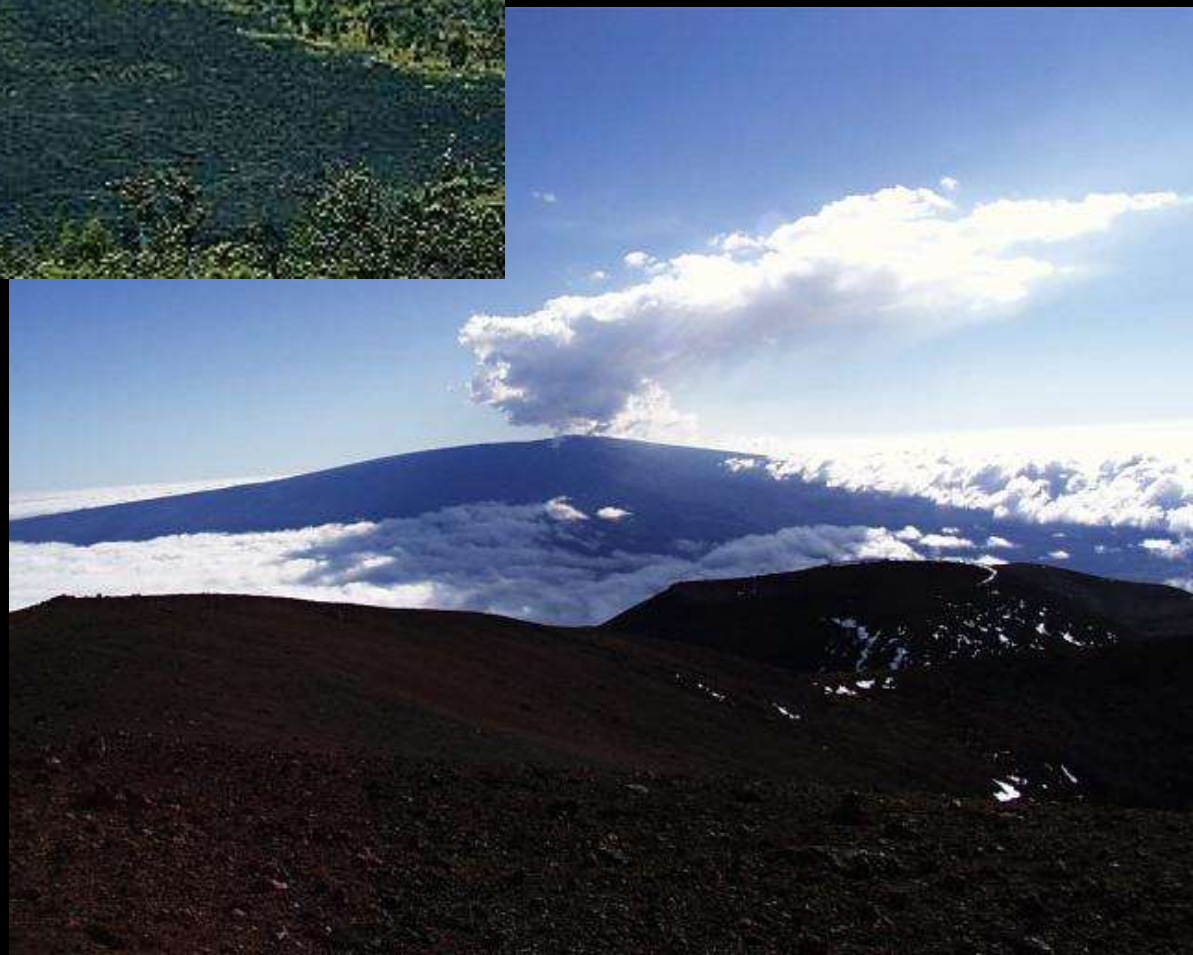
Bomb


Flank eruption
Summit caldera
Central vent
Magma chamber
Oceanic crust

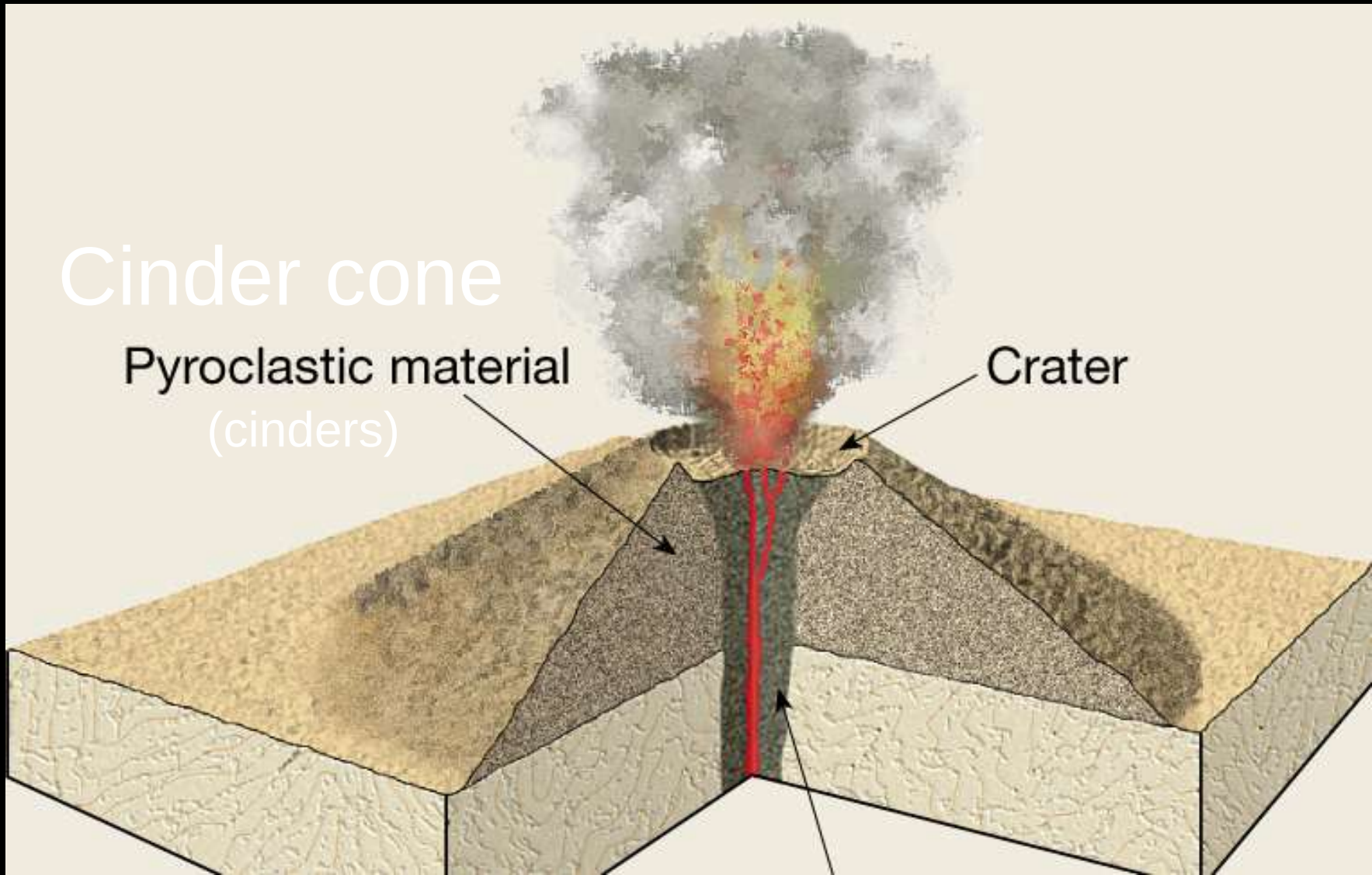

Pyroclastic material
Crater
Central vent filled
with rock fragments

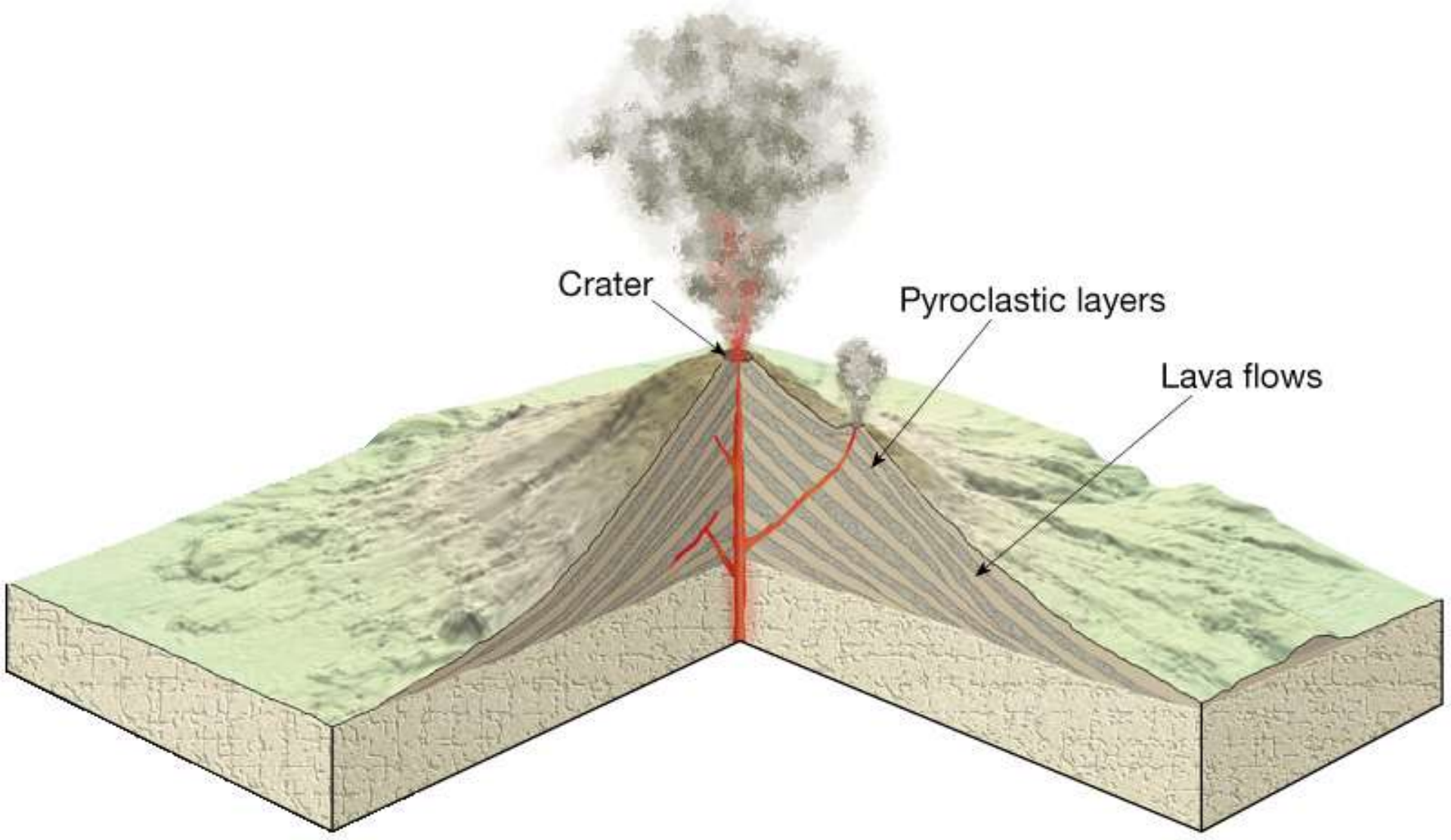

Crater
Pyroclastic layers
Lava flows

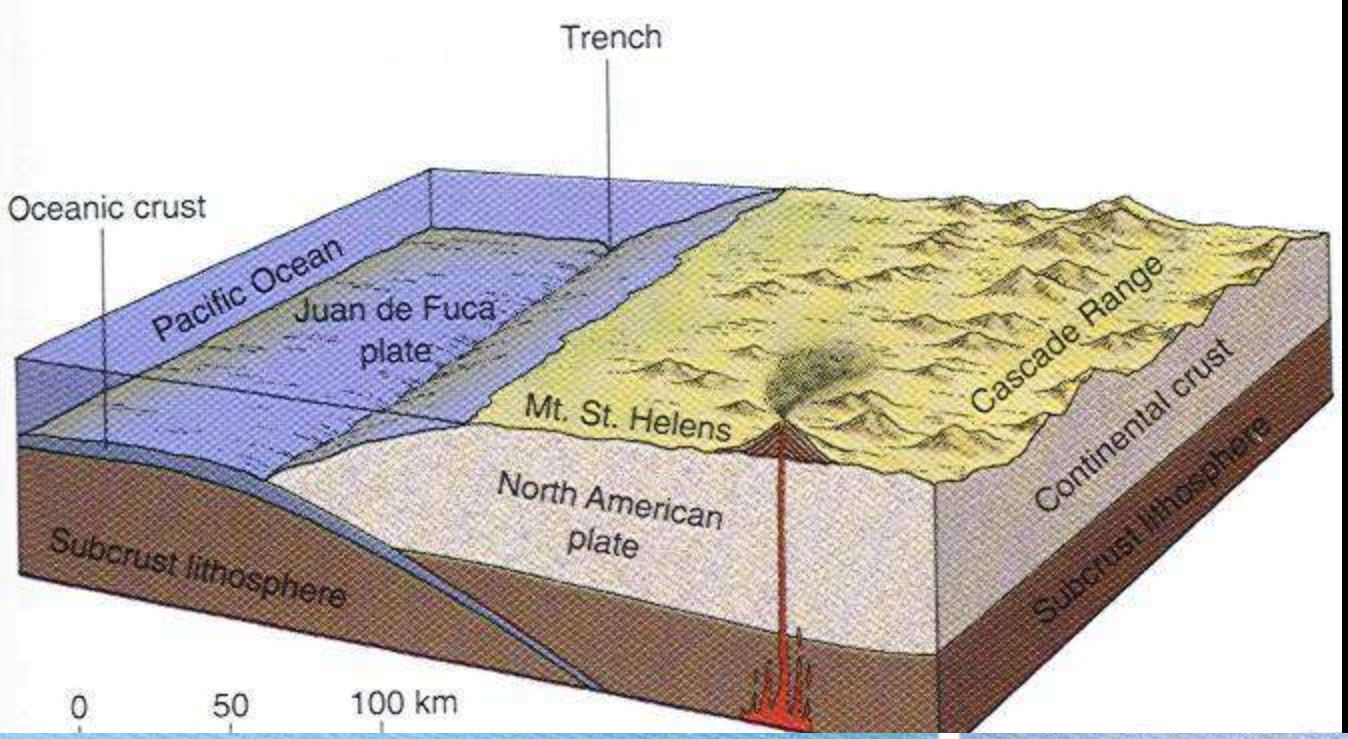

Flank eruption
Summit caldera
Central vent
Magma chamber
Oceanic crust

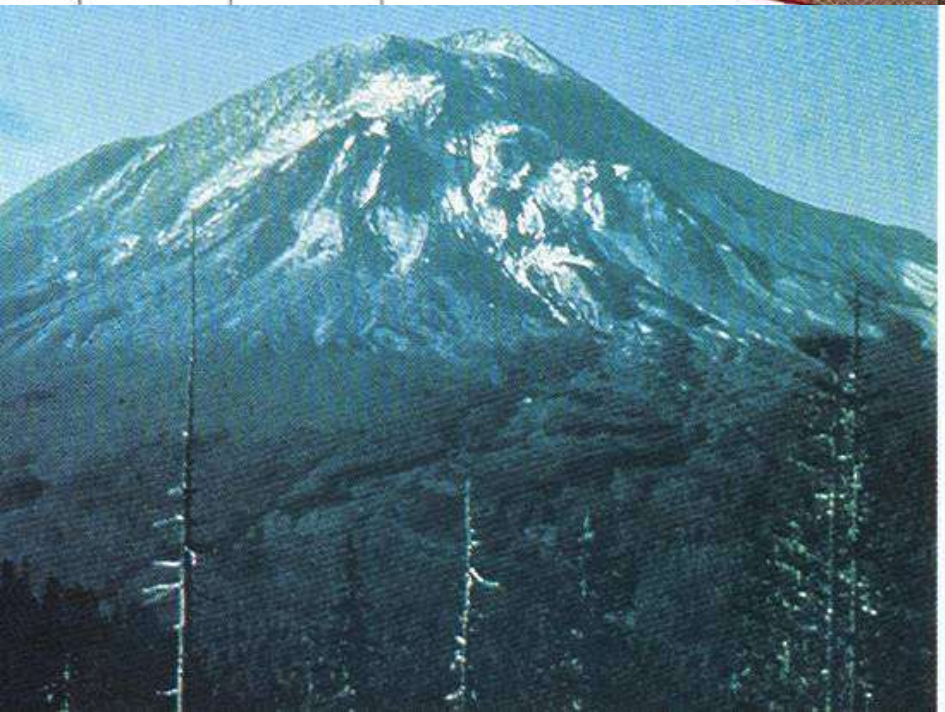


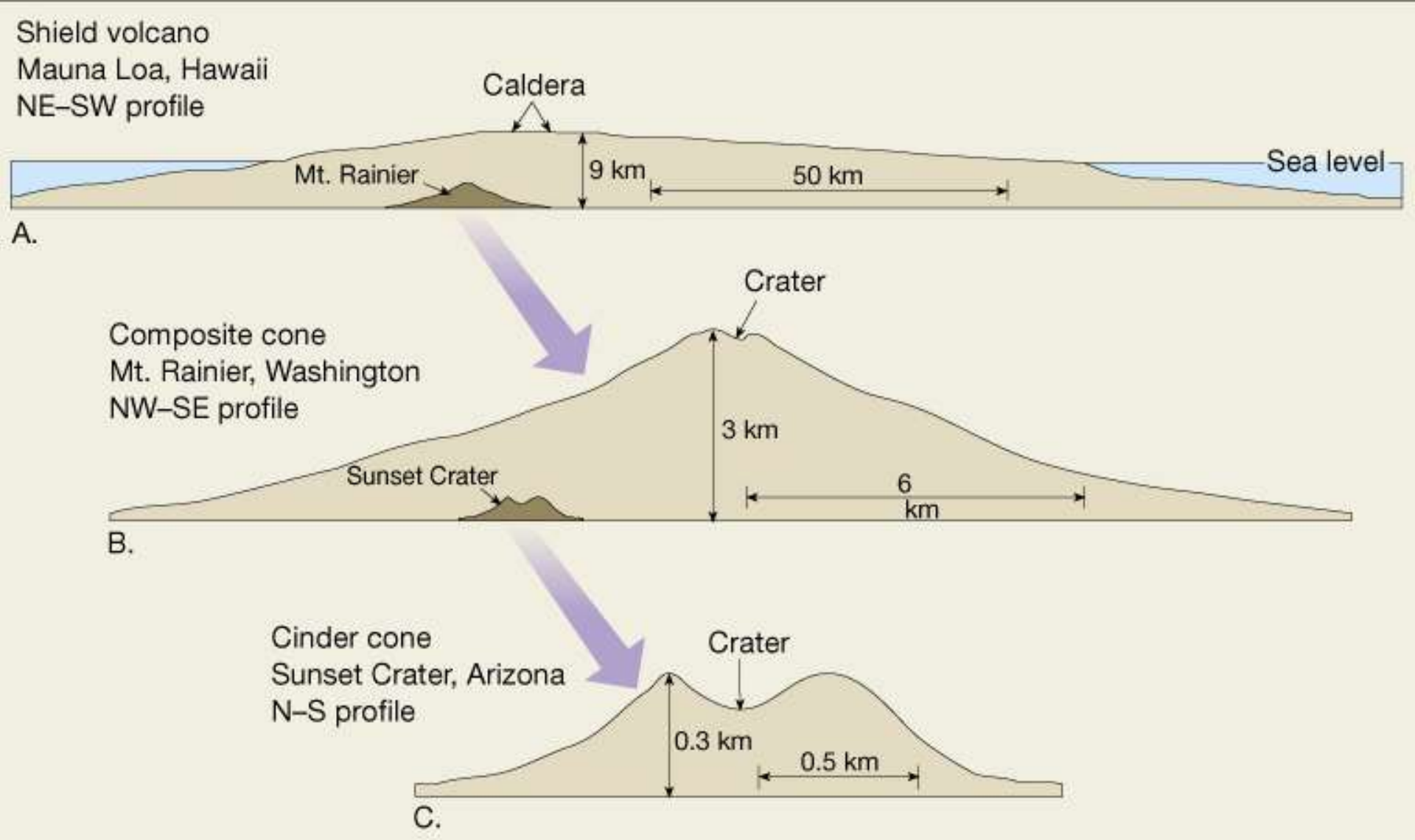
# Cinder cone

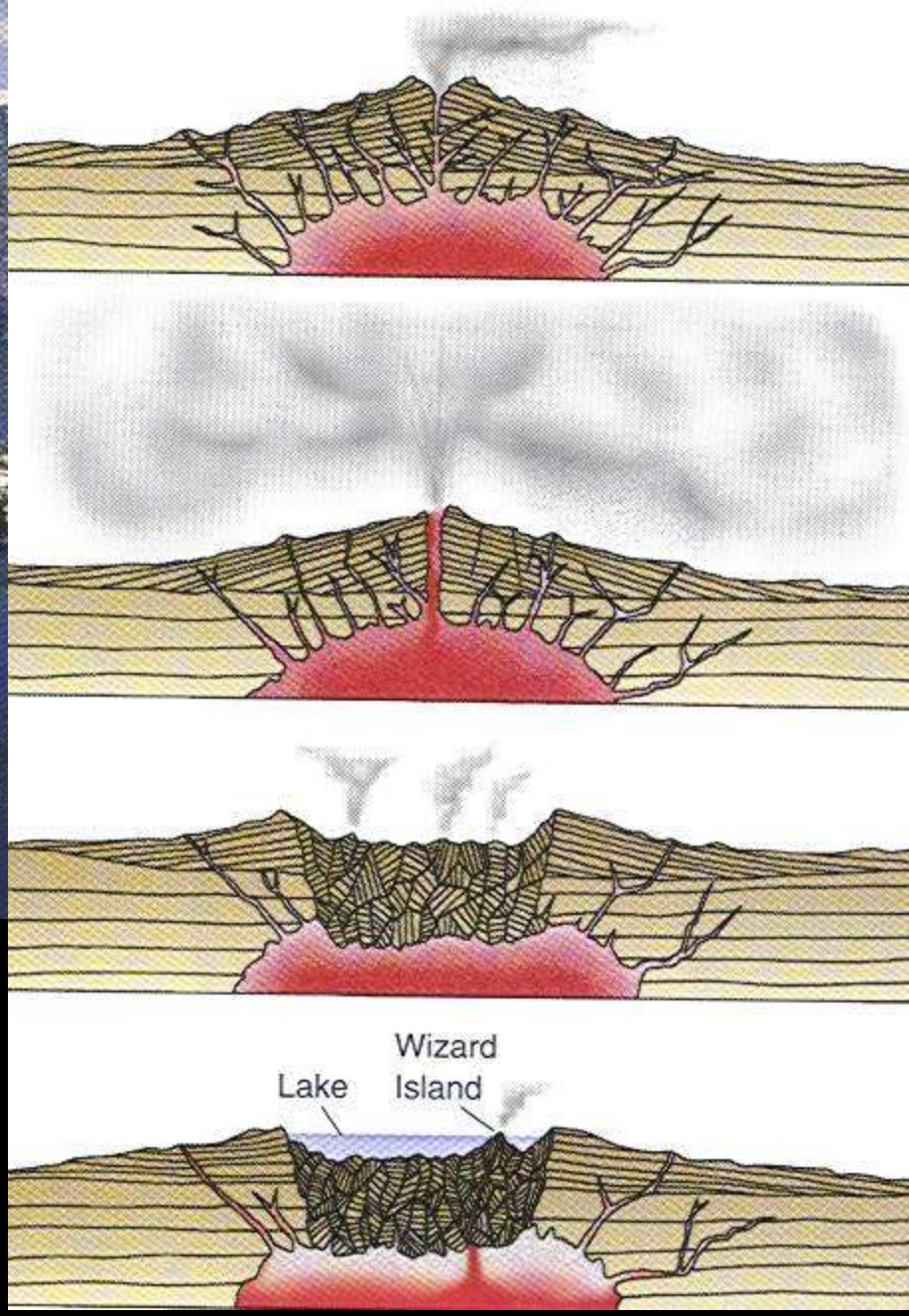


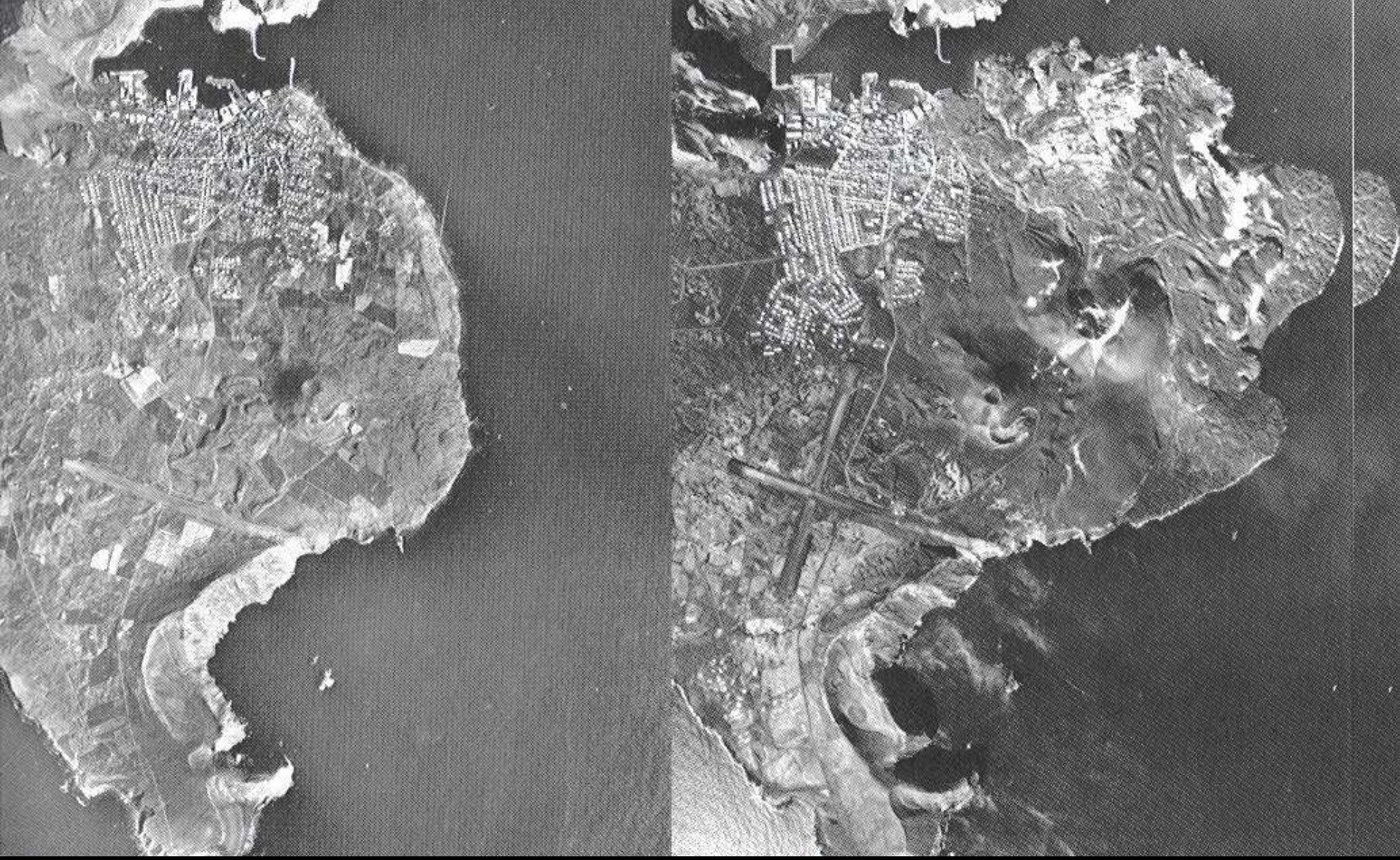

Crater
Pyroclastic layers
Lava flows

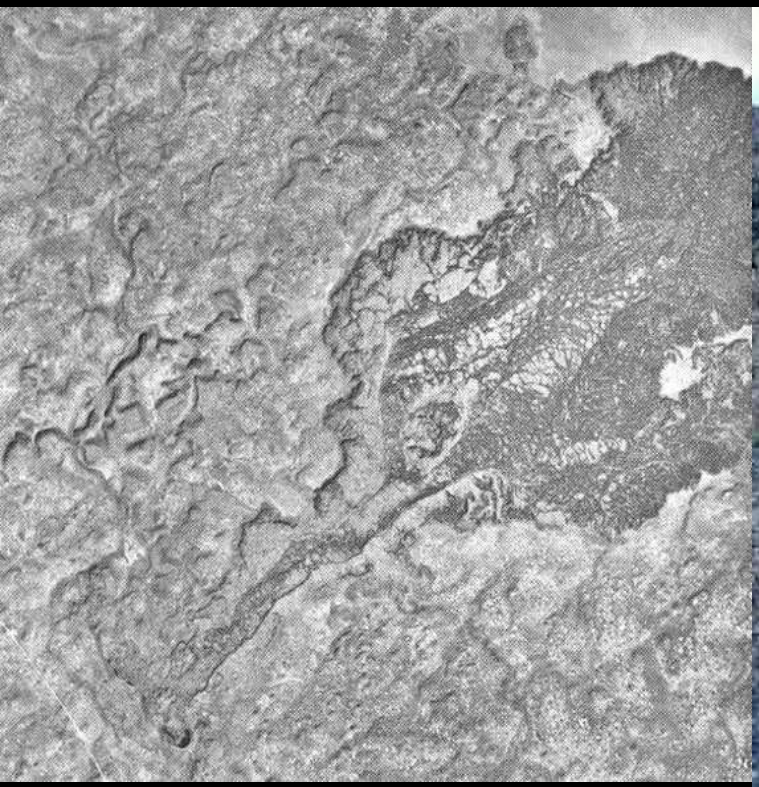

Trench
Oceanic crust
Pacific Ocean
Juan de Fuca plate
Mt. St. Helens
Cascade Range
Continental crust
North American plate
Subcrust lithosphere
Subcrust lithosphere
0
50
100 km

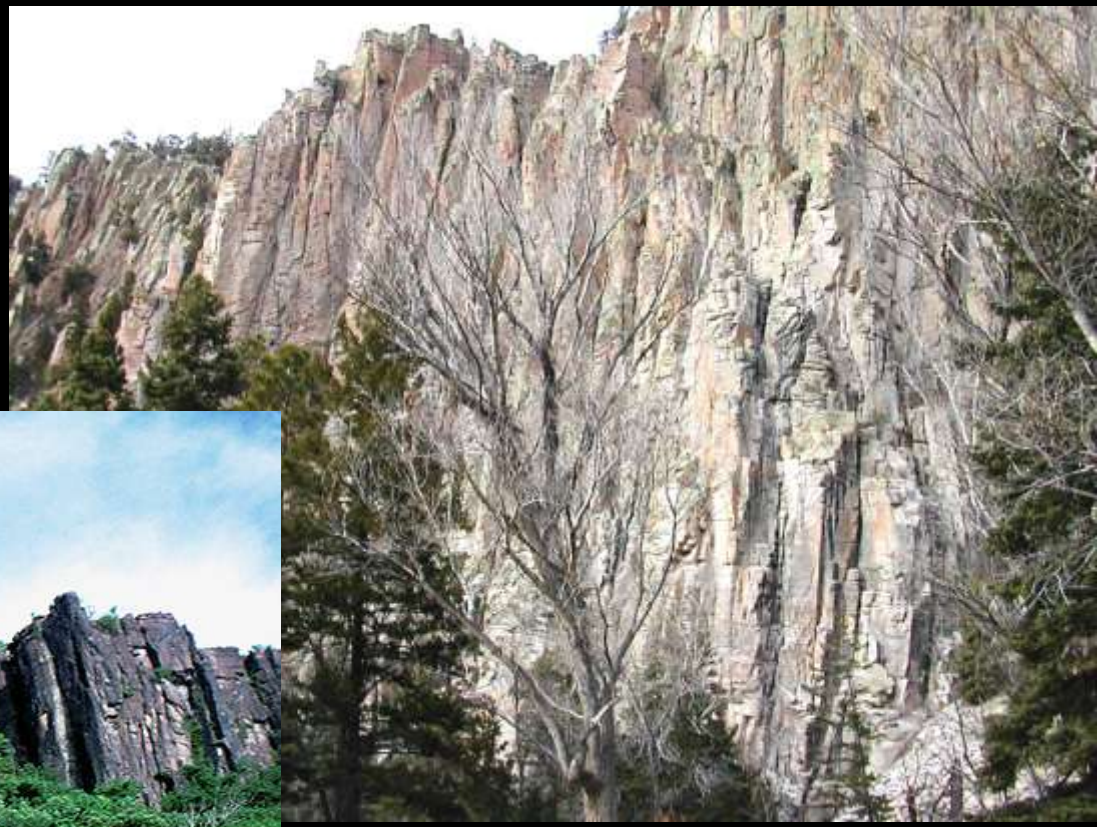


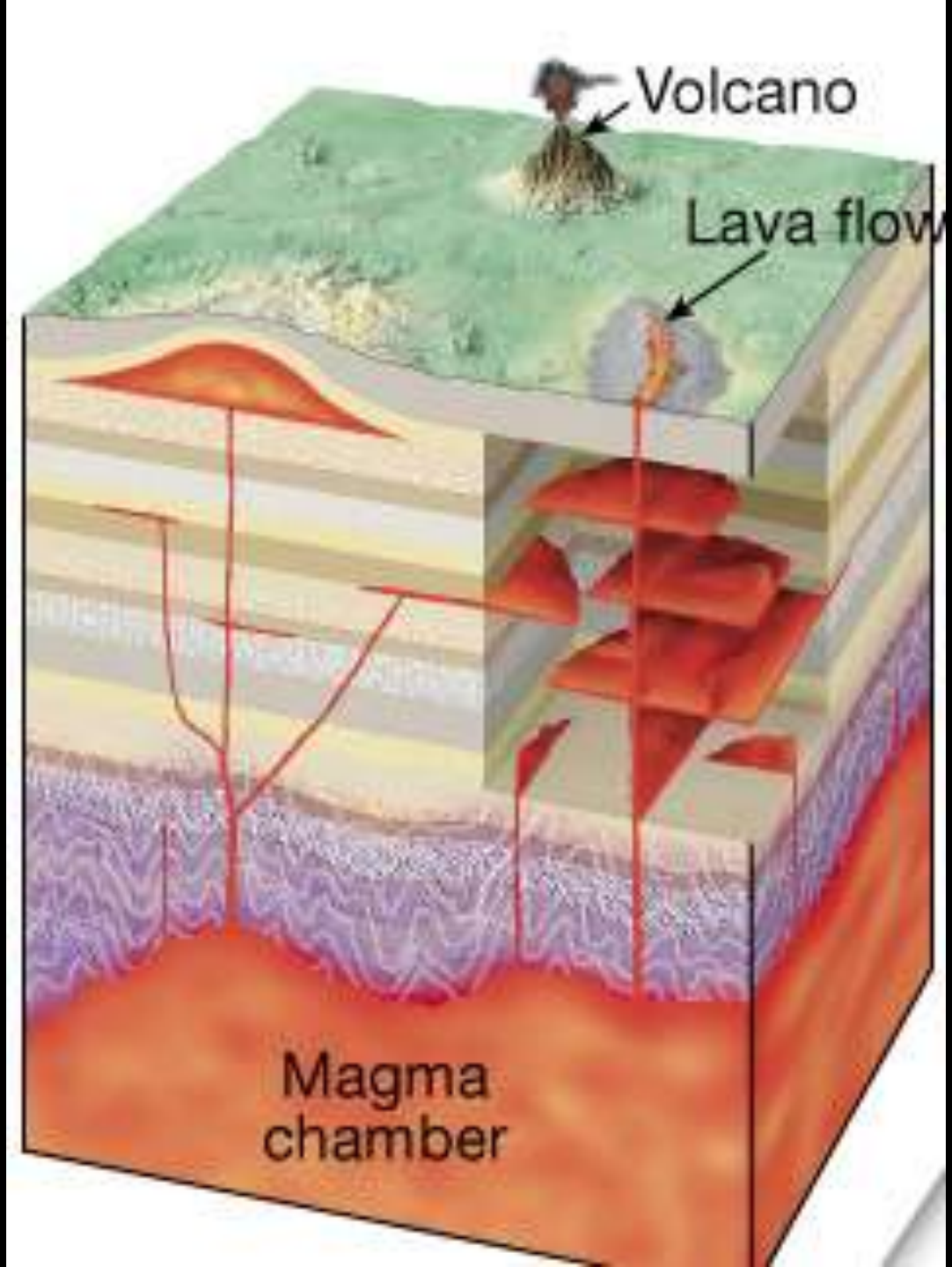

Shield volcano
Mauna Loa, Hawaii
NE–SW profile
Caldera
Mt. Rainier
9 km
50 km
Sea level
A.
Composite cone
Mt. Rainier, Washington
NW–SE profile
Crater
3 km
Sunset Crater
6
km
B.
Cinder cone
Sunset Crater, Arizona
N–S profile
Crater
0.3 km
0.5 km
C.

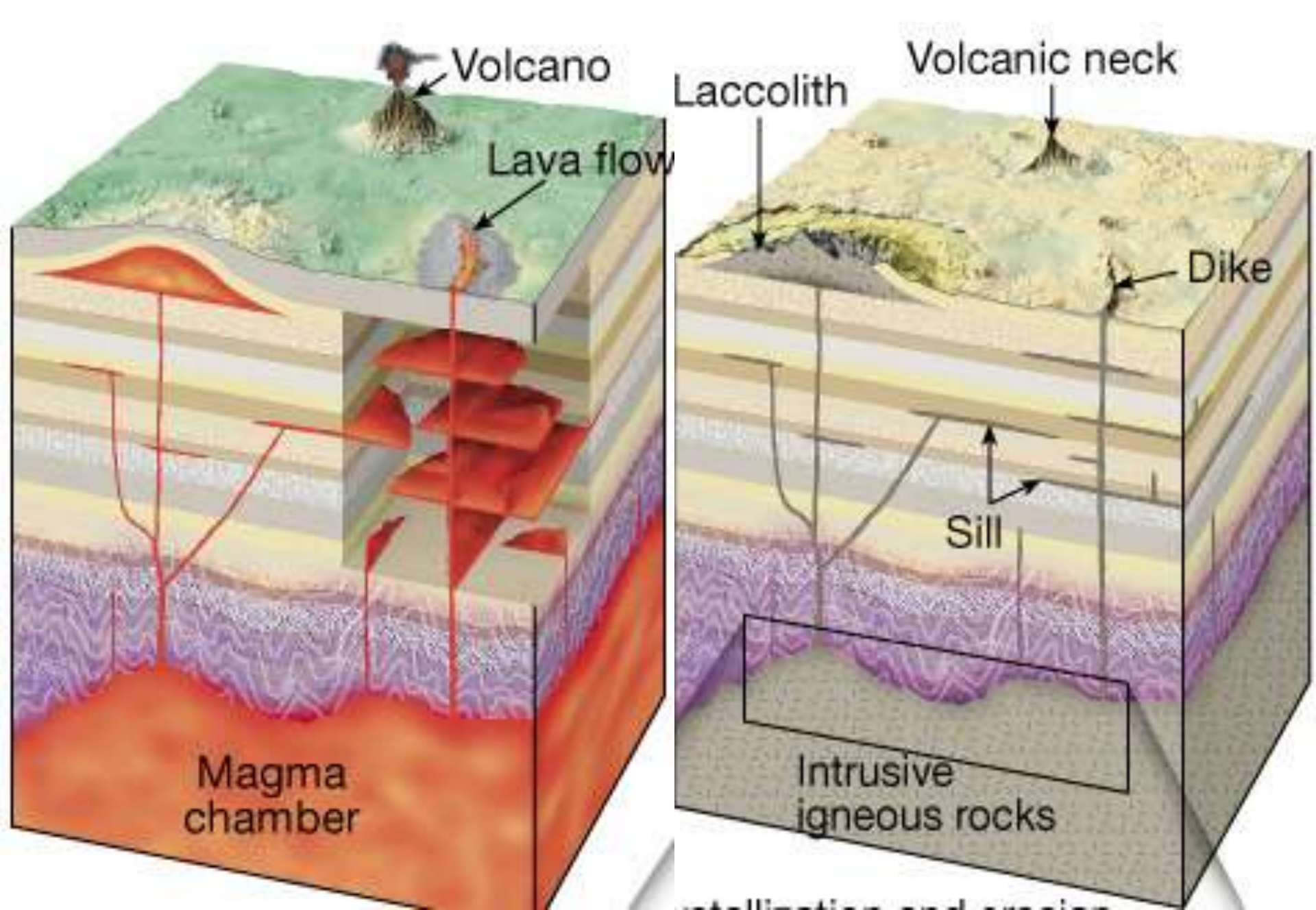

Wizard
Lake
Island

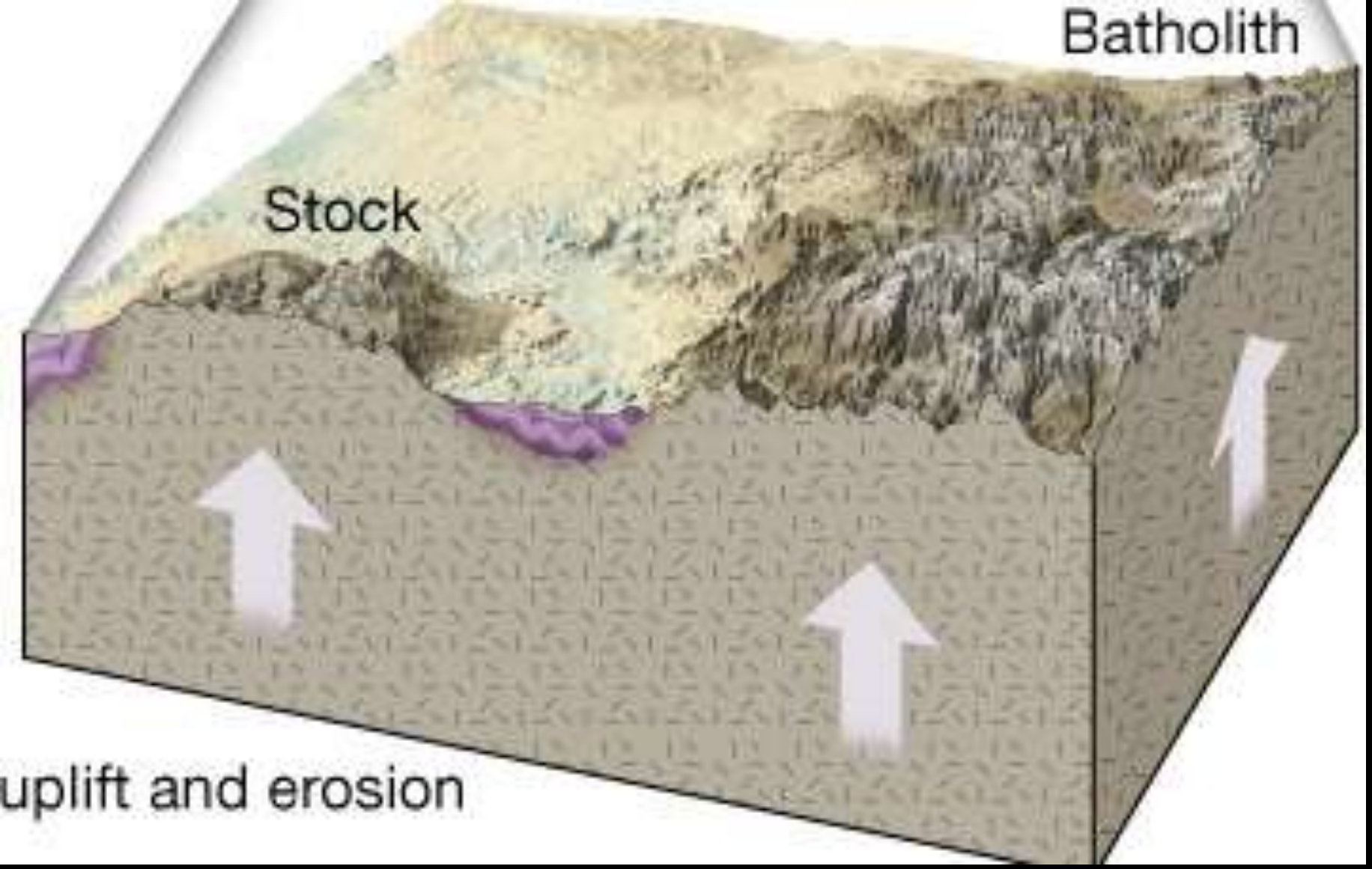


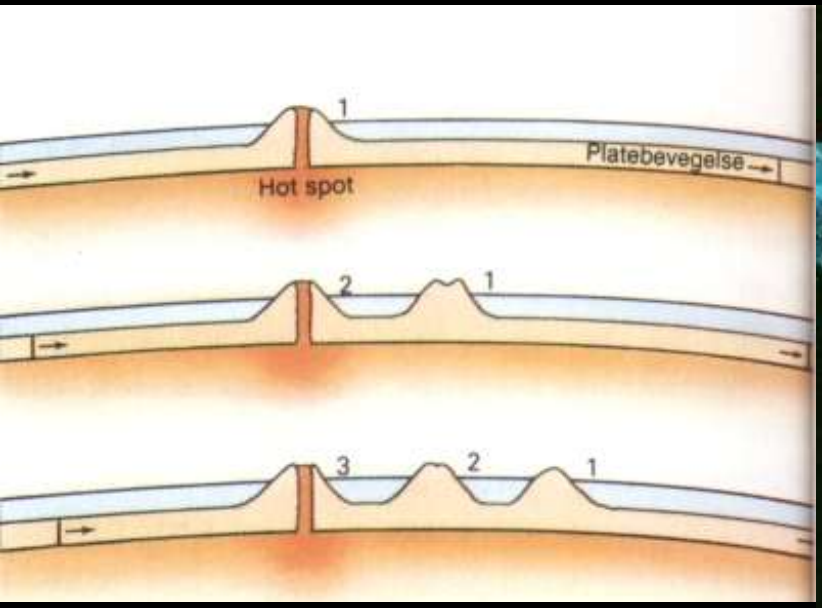


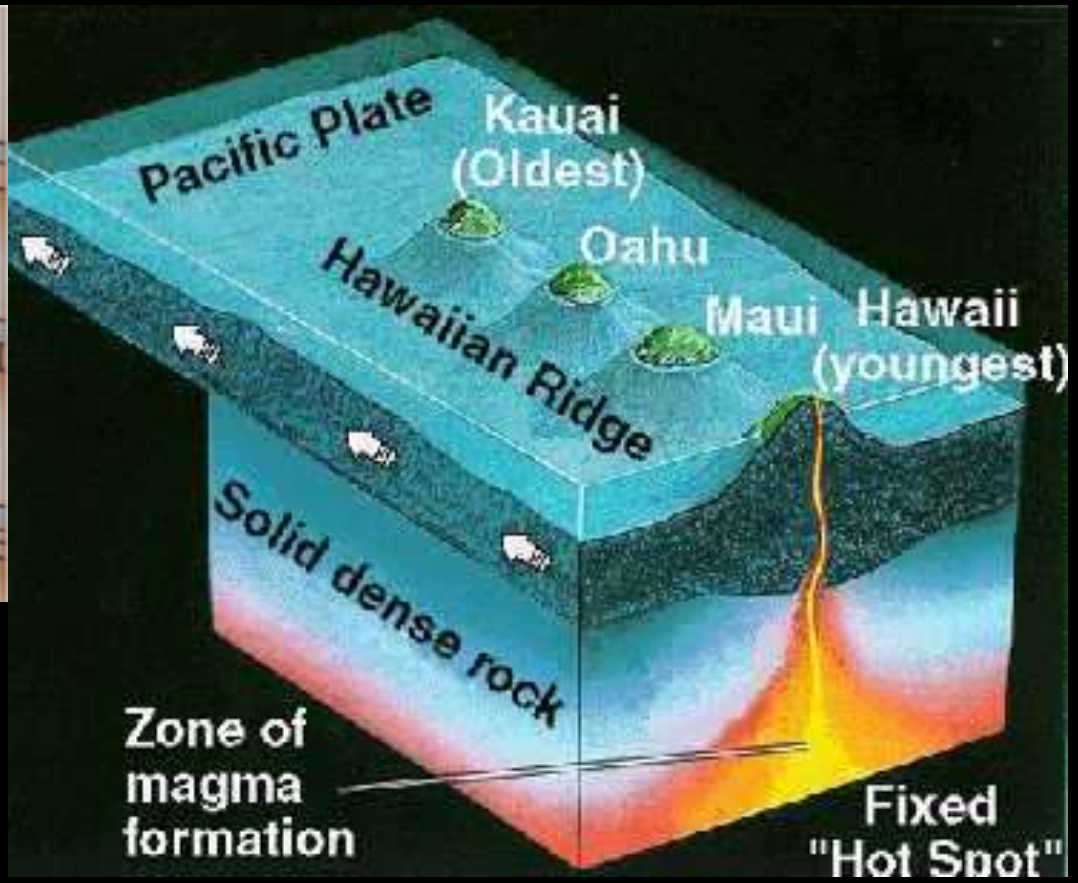


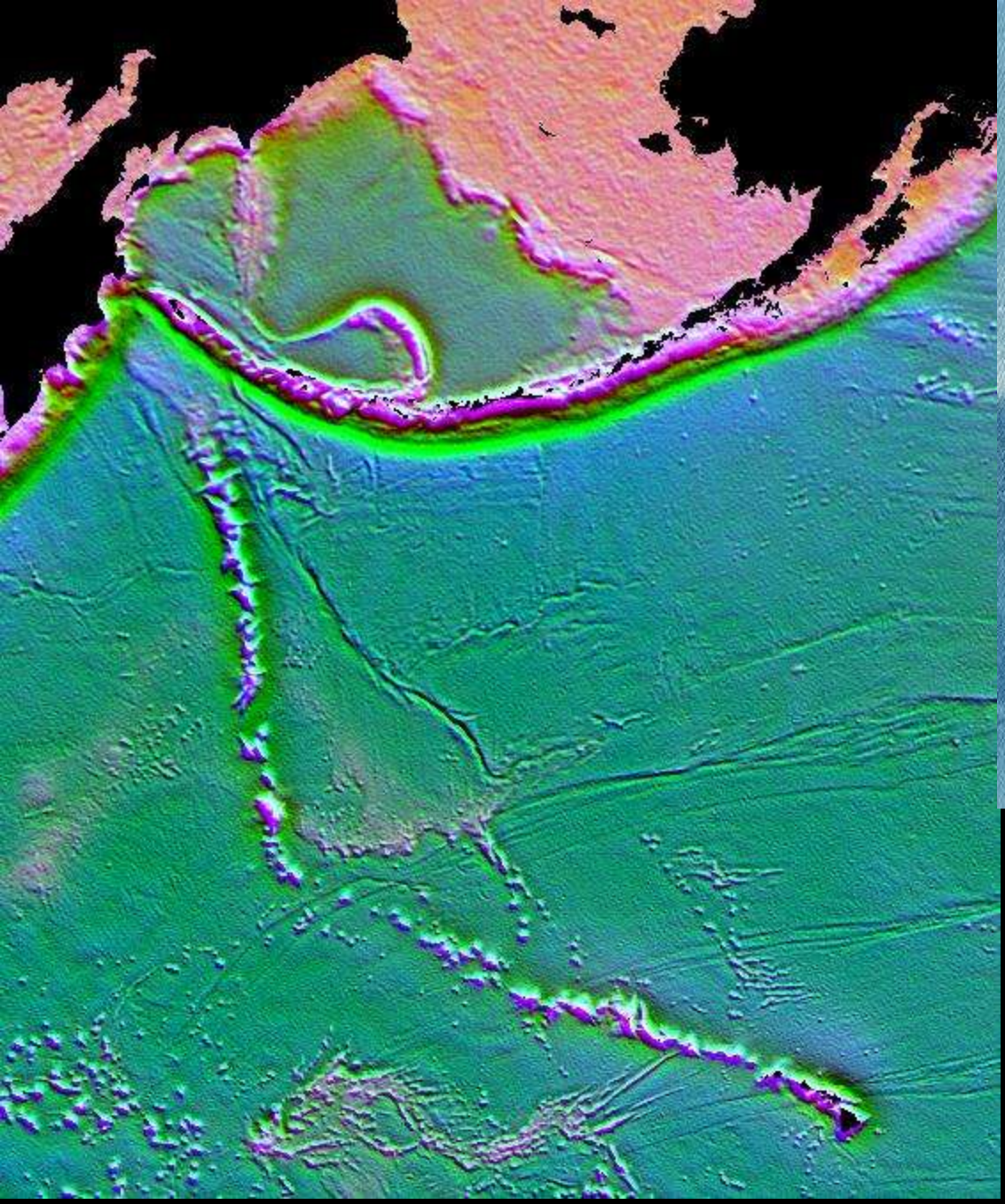

Volcano
Lava flow
Magma
chamber

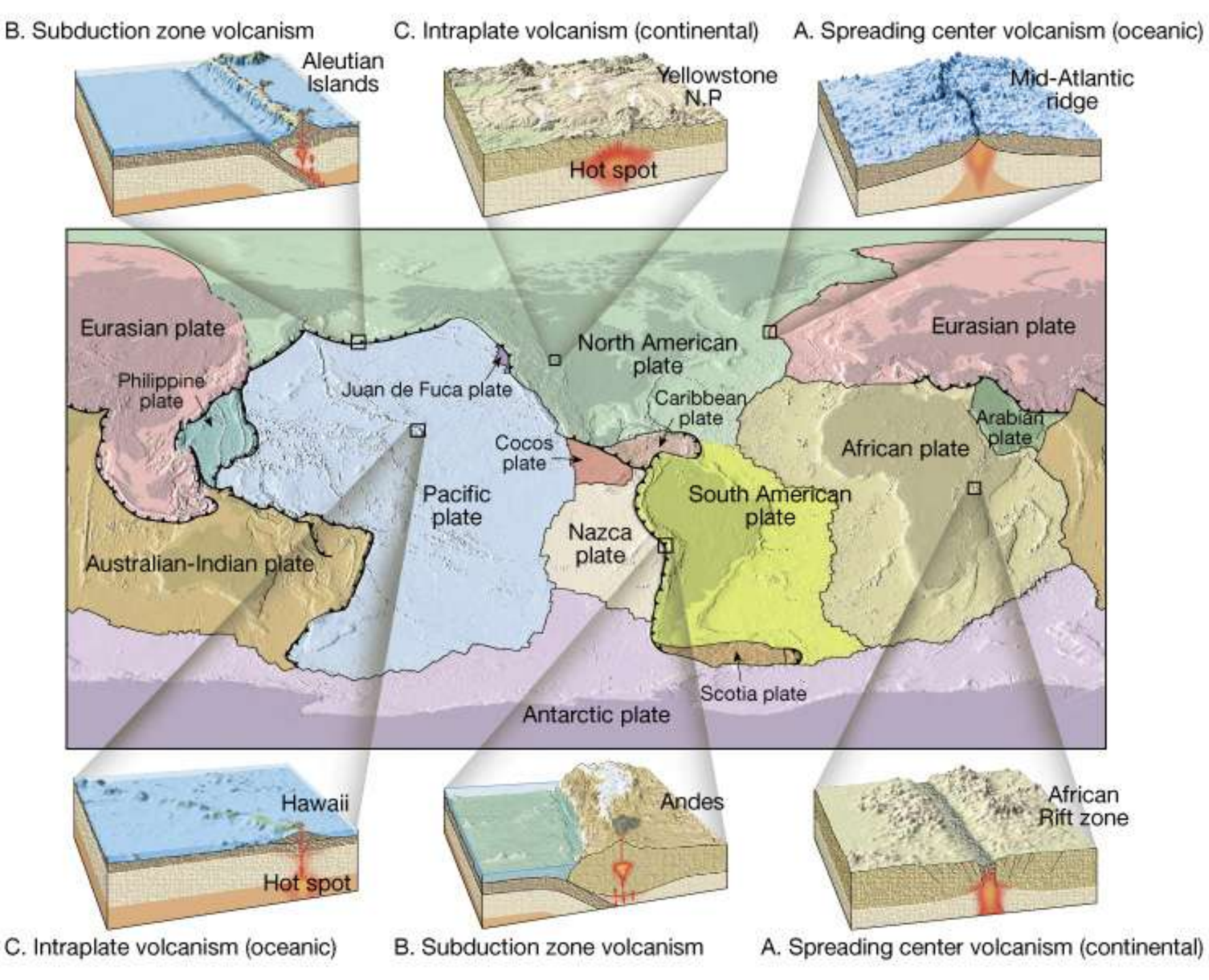

Volcano
Lava flow
Magma chamber
Laccolith
Volcanic neck
Dike
Sill
Intrusive igneous rocks


Batholith
Stock
uplift and erosion


1
Platebevegelse
Hot spot
2
1
3
2
1


Pacific Plate
Kauai
(Oldest)
Oahu
Maui
Hawaii
(youngest)
Hawaiian Ridge
Solid dense rock
Zone of
magma
formation
Fixed
"Hot Spot"




B. Subduction zone volcanism
Aleutian Islands
C. Intraplate volcanism (continental)
Yellowstone N.P
Hot spot
A. Spreading center volcanism (oceanic)
Mid-Atlantic ridge
Eurasian plate
Philippine plate
Juan de Fuca plate
North American plate
Caribbean plate
Cocos plate
Pacific plate
Nazca plate
South American plate
African plate
Arabian plate
Eurasian plate
Australian-Indian plate
Scotia plate
Antarctic plate
C. Intraplate volcanism (oceanic)
Hawaii
Hot spot
B. Subduction zone volcanism
Andes
A. Spreading center volcanism (continental)
African Rift zone

# Old Faithful

Granite
(Rock)

Quartz
(Mineral)

Hornblende
(Mineral)

Feldspar
(Mineral)

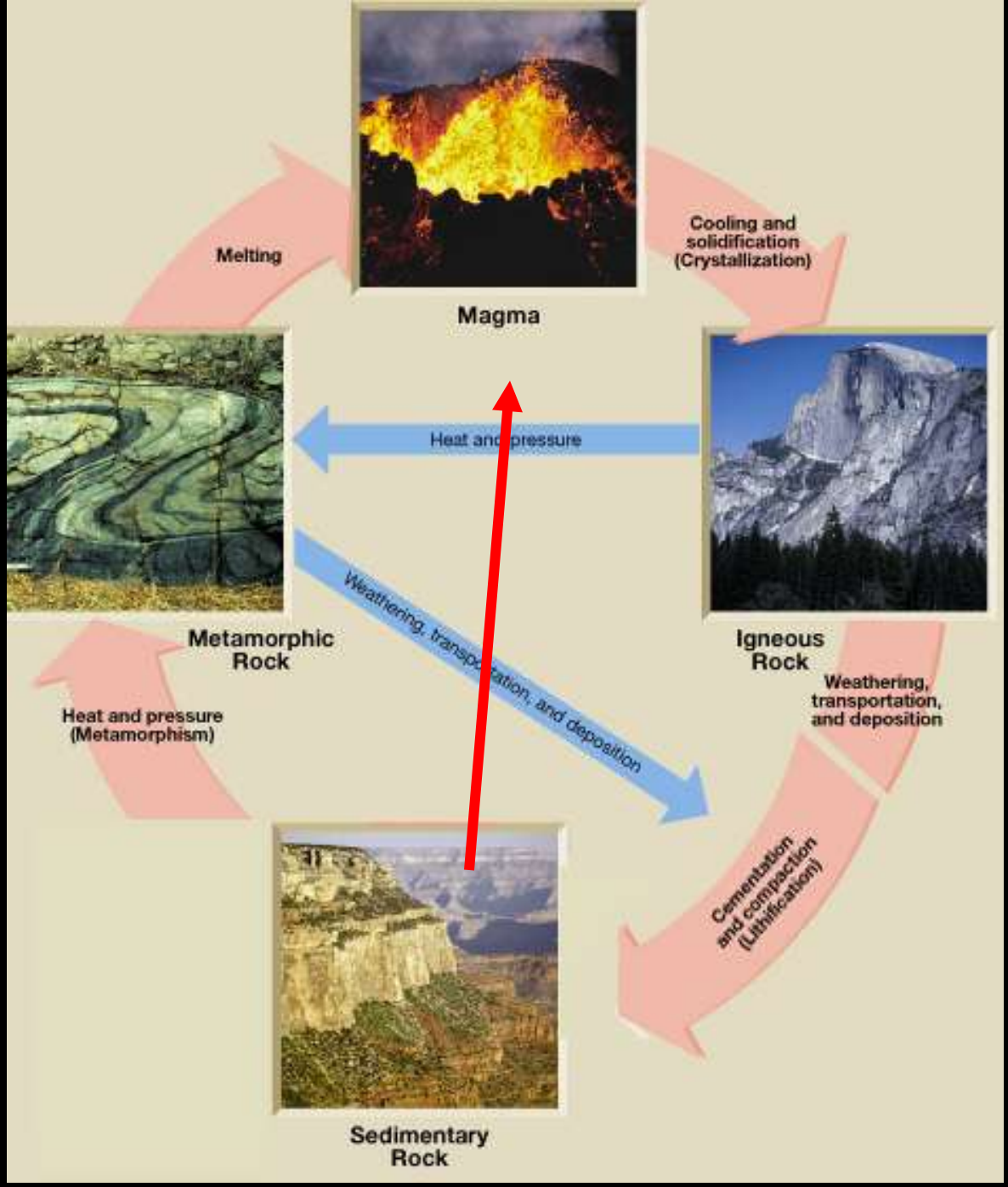

1 cm


14

## Table 1.1 ■ Mohs scale of mineral hardness

| Relative Scale | | Mineral | Hardness of Some Common Objects |
|---|---|---|---|
| Hardest | 10 | Diamond | |
| | 9 | Corundum | |
| | 8 | Topaz | |
| | 7 | Quartz | |
| | 6 | Potassium Feldspar | |
| | 5 | Apatite | 5.5 Glass, [redacted] |
| | 4 | Fluorite | |
| | 3 | Calcite | [redacted] |
| | 2 | Gypsum | 2.5 Fingernail |
| Softest | 1 | Talc | |

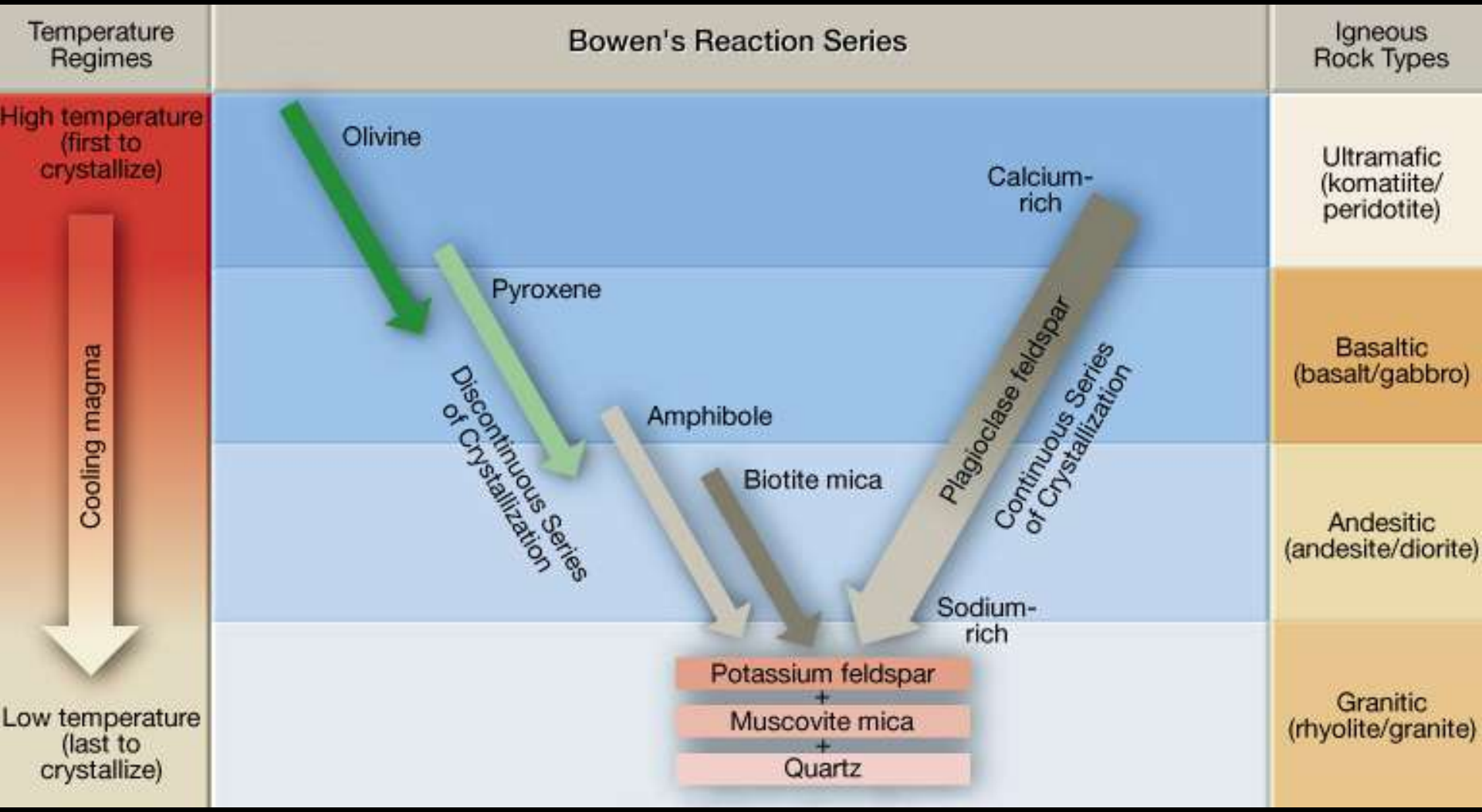

5

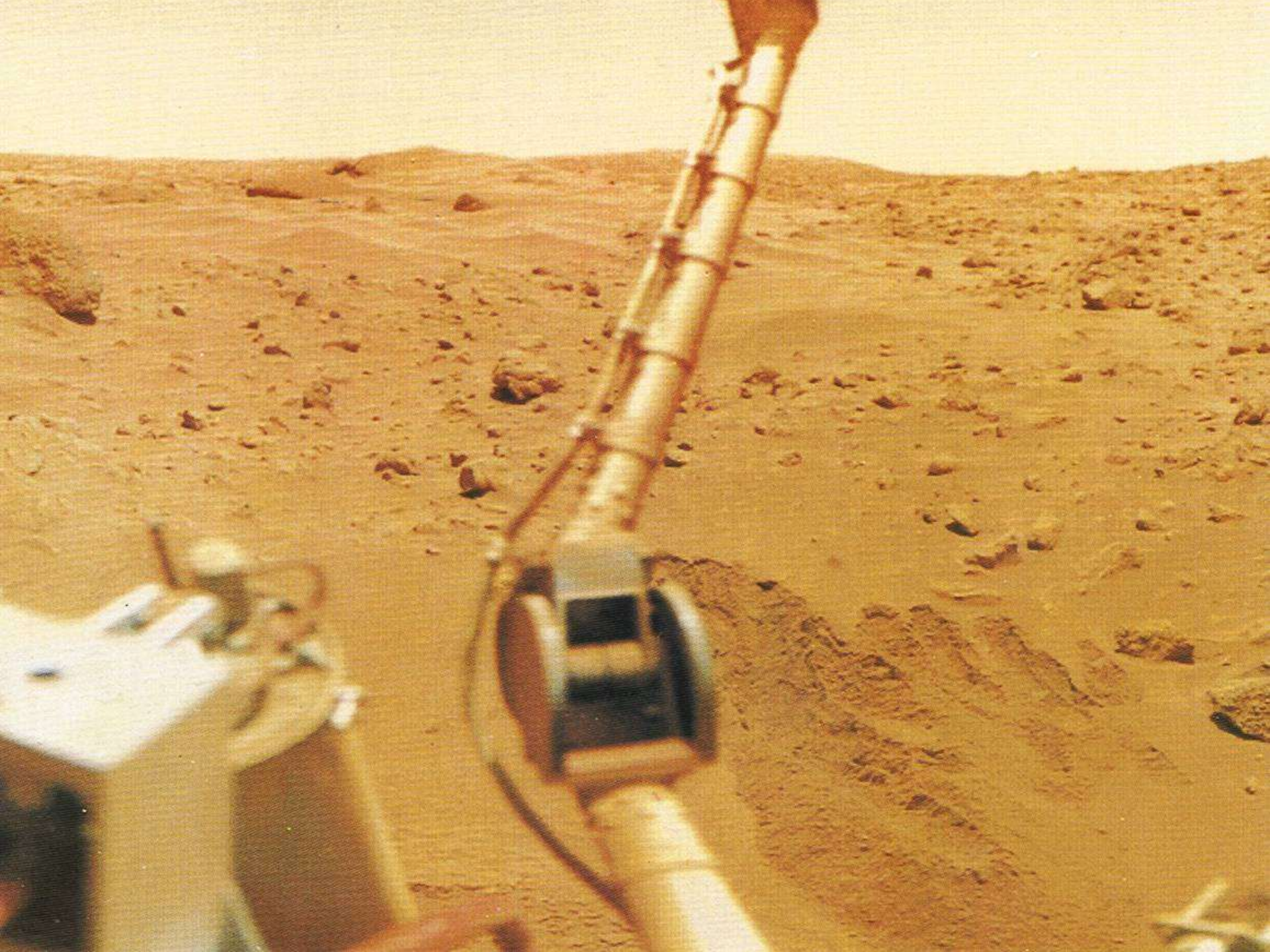

Magma
Cooling and solidification (Crystallization)
Igneous Rock
Weathering, transportation, and deposition
Sedimentary Rock
Cementation and compaction (Lithification)
Metamorphic Rock
Heat and pressure (Metamorphism)
Melting
Heat and pressure
Weathering, transportation, and deposition

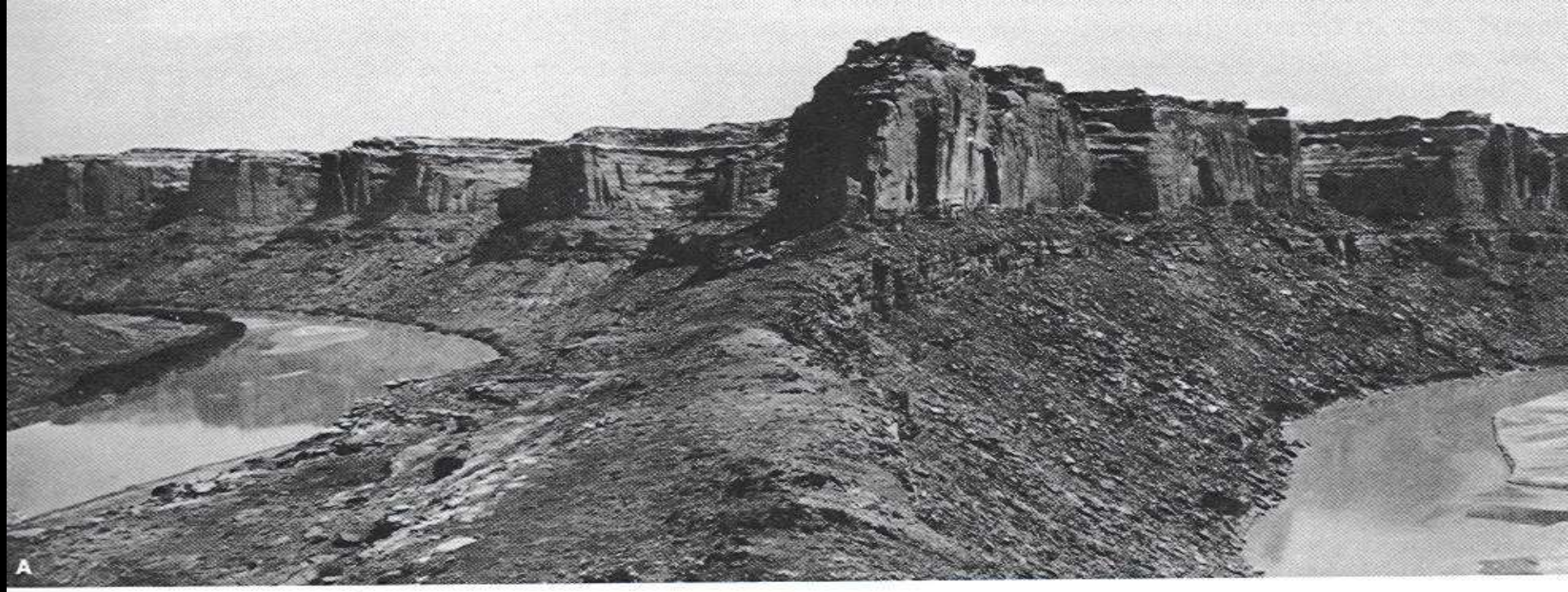

Fine


Coarse


?????

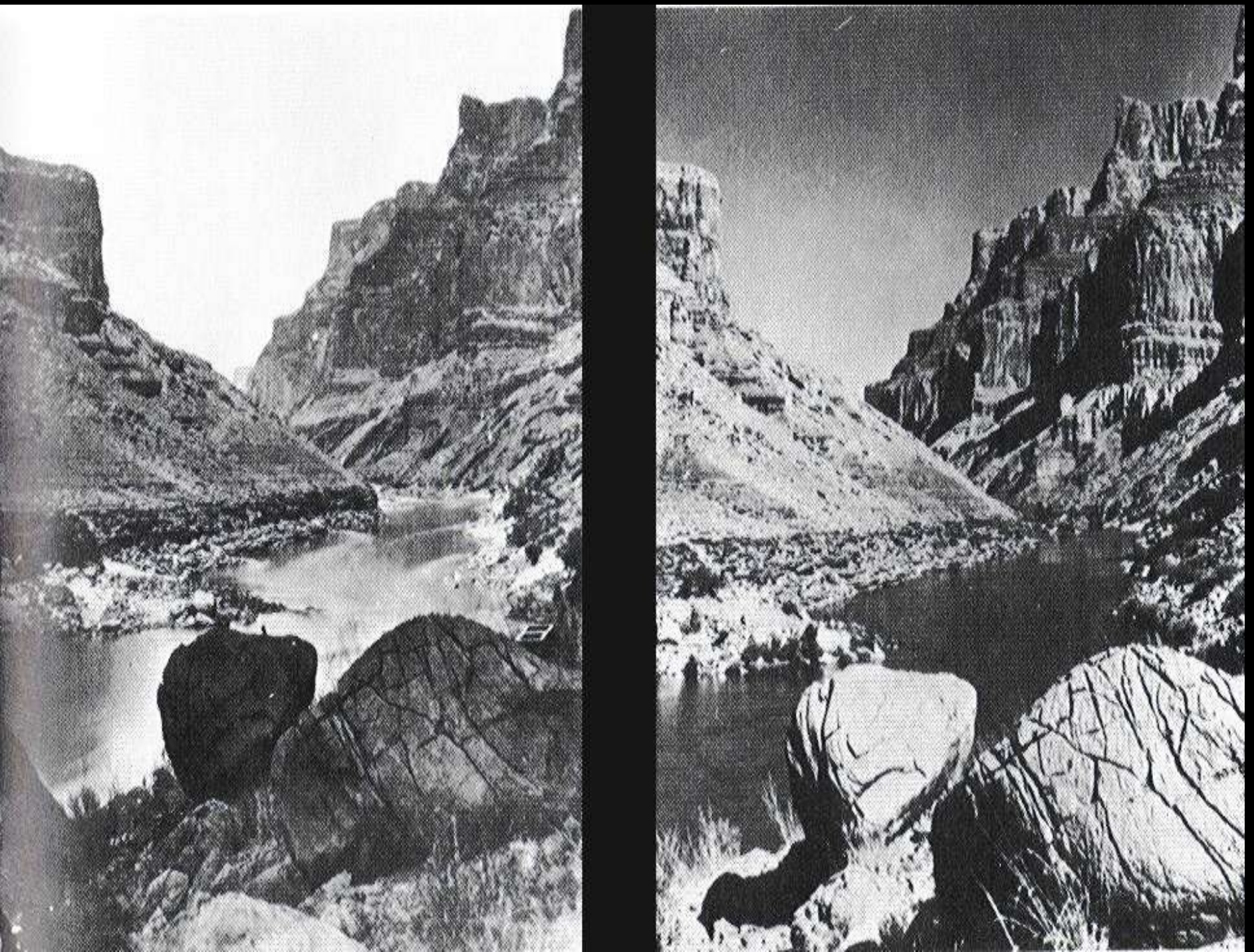

Temperature Regimes
Bowen's Reaction Series
Igneous Rock Types
High temperature (first to crystallize)
Cooling magma
Low temperature (last to crystallize)
Olivine
Pyroxene
Amphibole
Biotite mica
Potassium feldspar
+
Muscovite mica
+
Quartz
Discontinuous Series of Crystallization
Calcium-rich
Plagioclase feldspar
Continuous Series of Crystallization
Sodium-rich
Ultramafic (komatiite/ peridotite)
Basaltic (basalt/gabbro)
Andesitic (andesite/diorite)
Granitic (rhyolite/granite)





A

B



# Conglomerate

# Breccia

# Sand 1/16 to 2 mm

# Shale

# Conglomerate

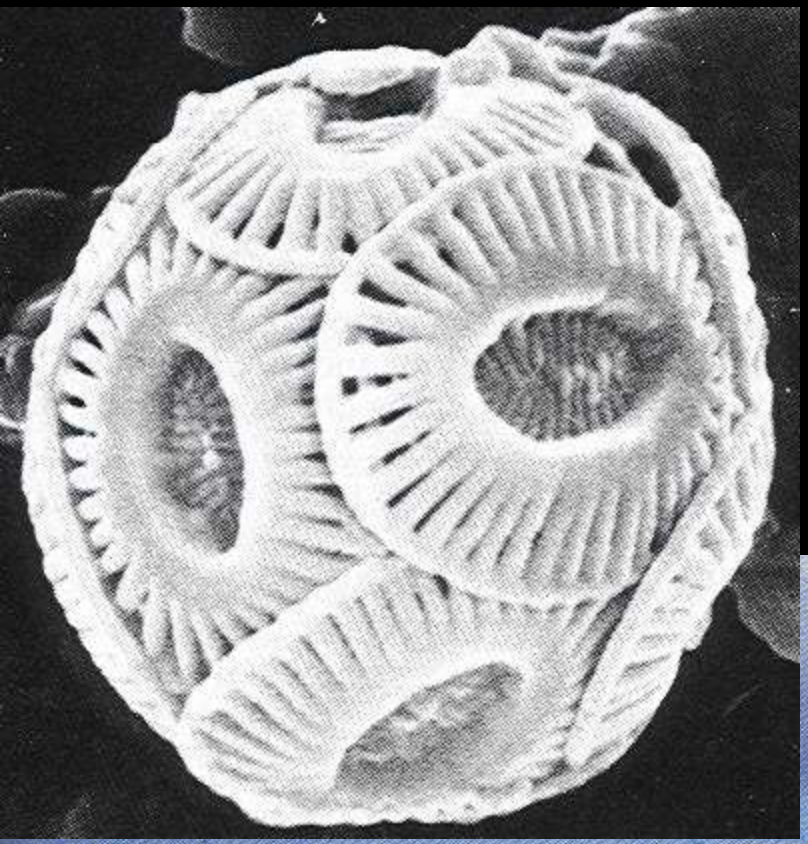

more eroded

# Breccia

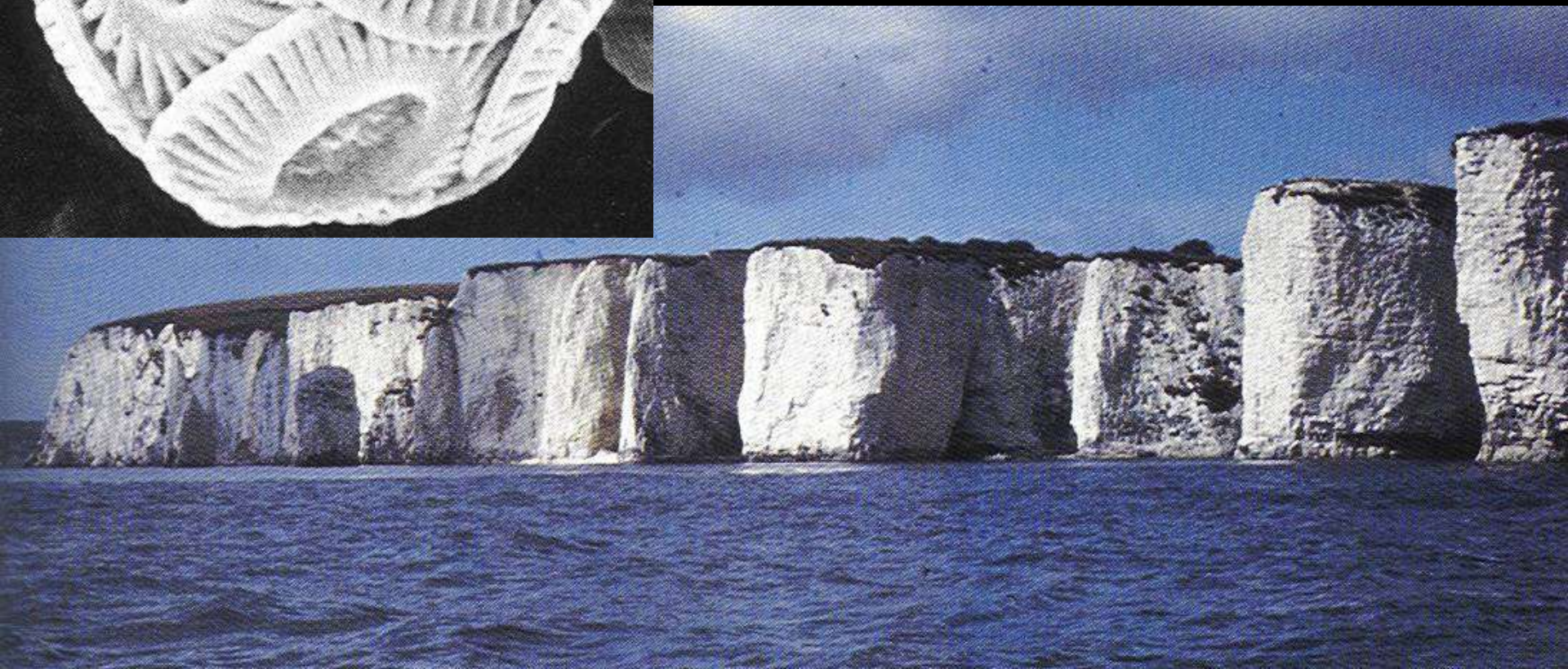

less eroded

# Gypsum

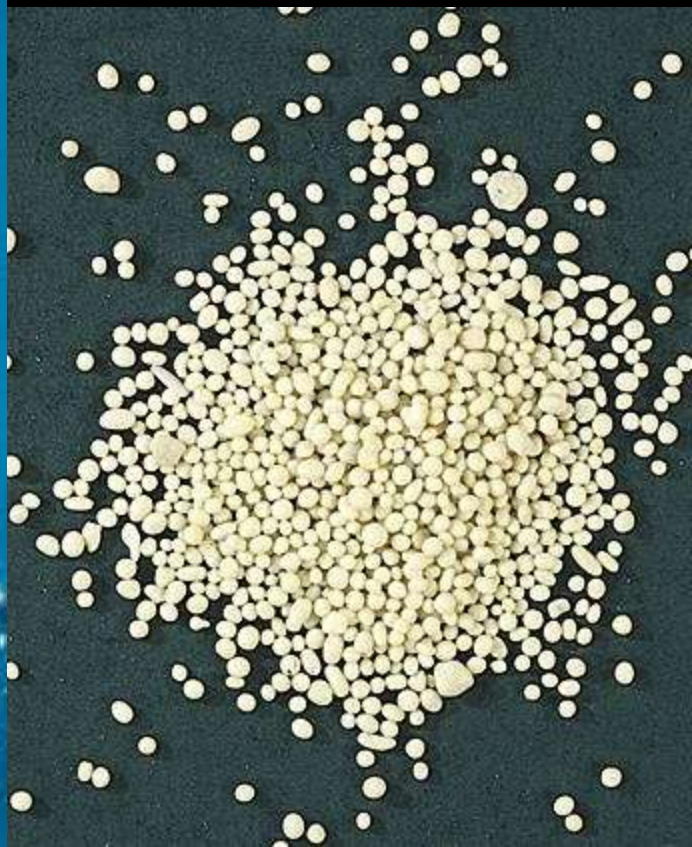

A



# Chalk

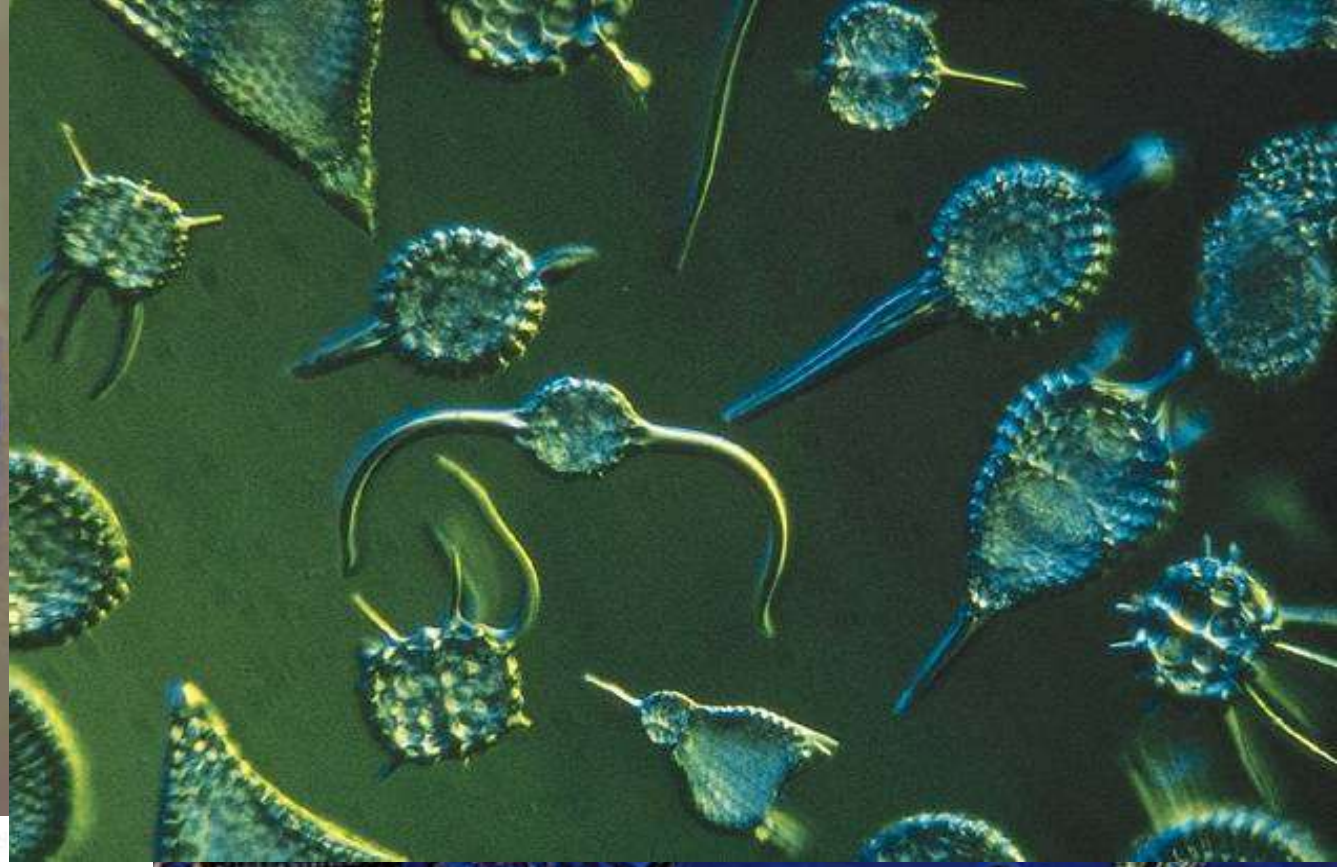


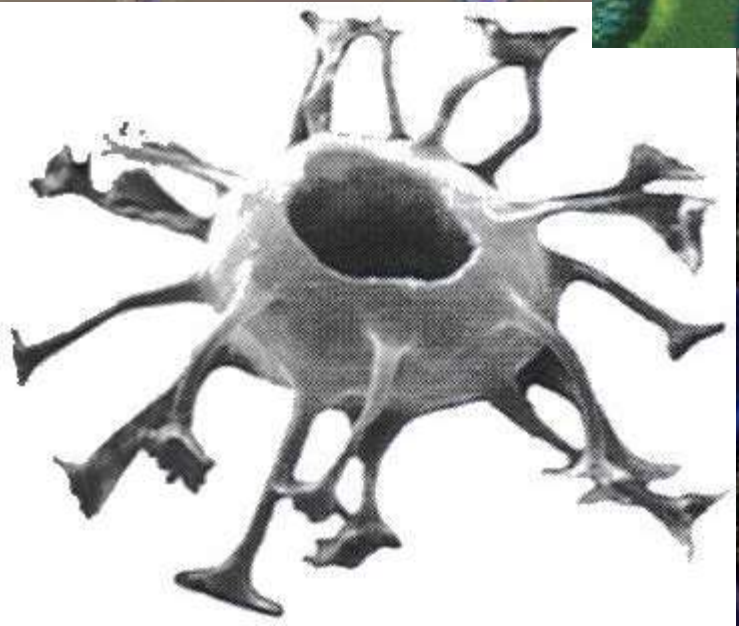
# Oolites

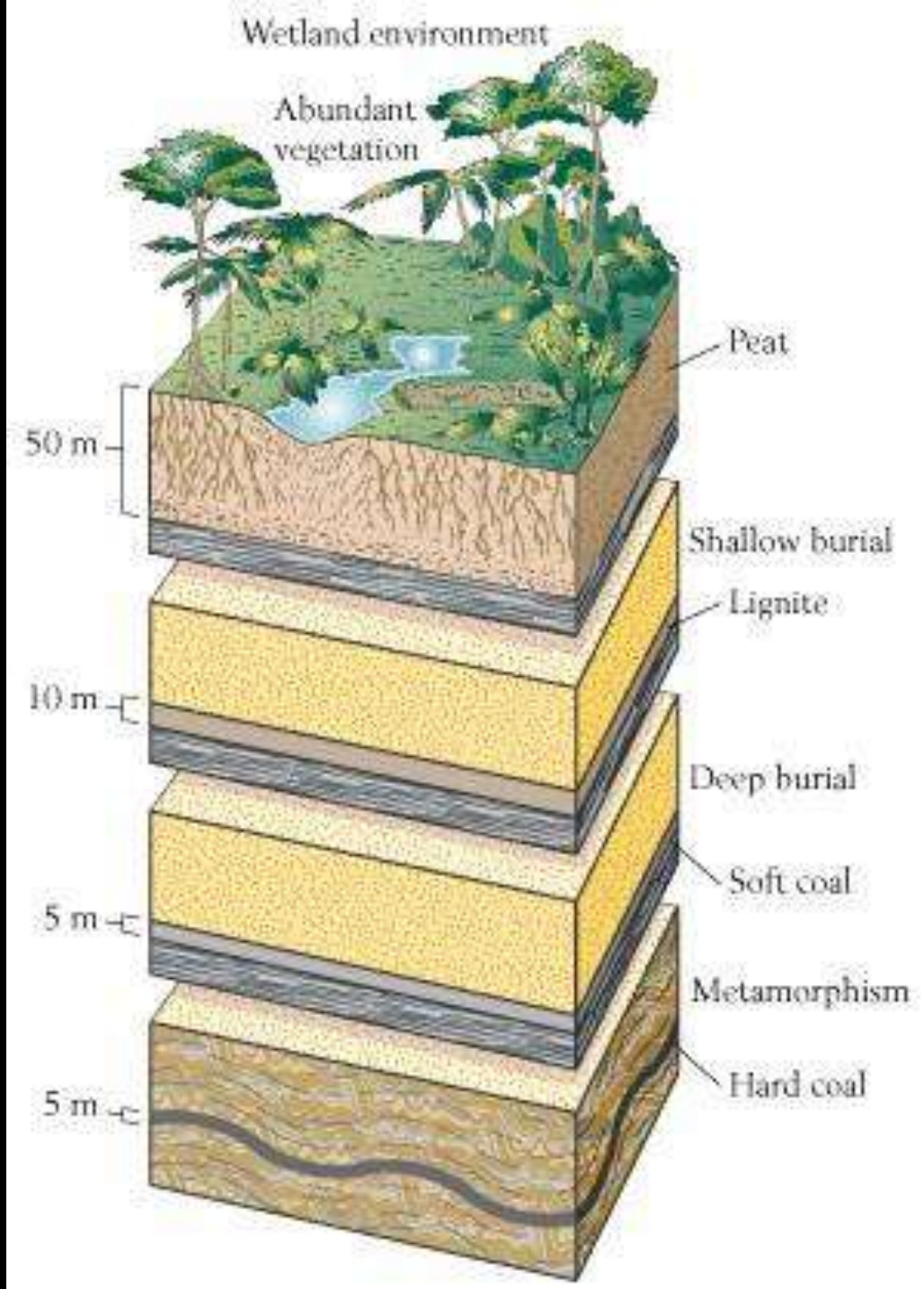


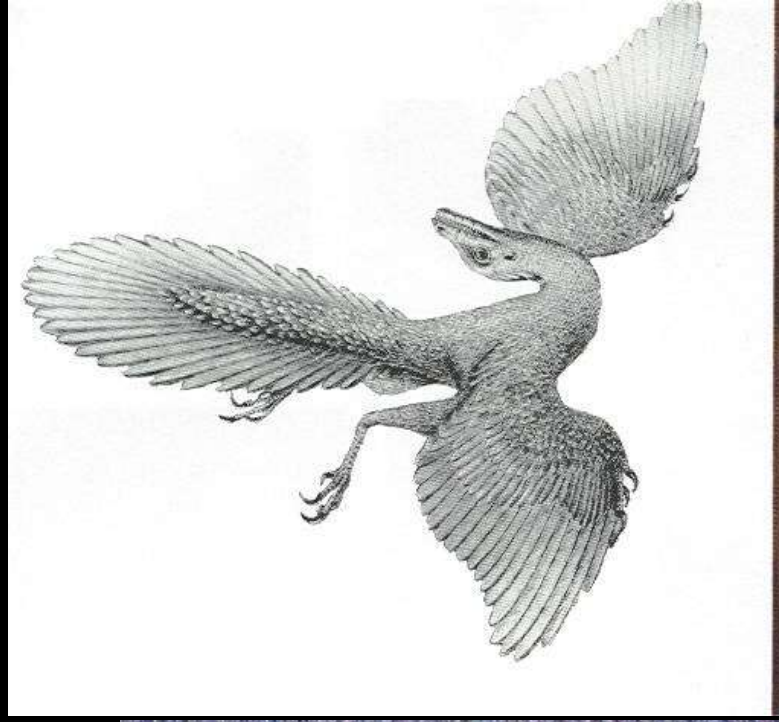
Travertine

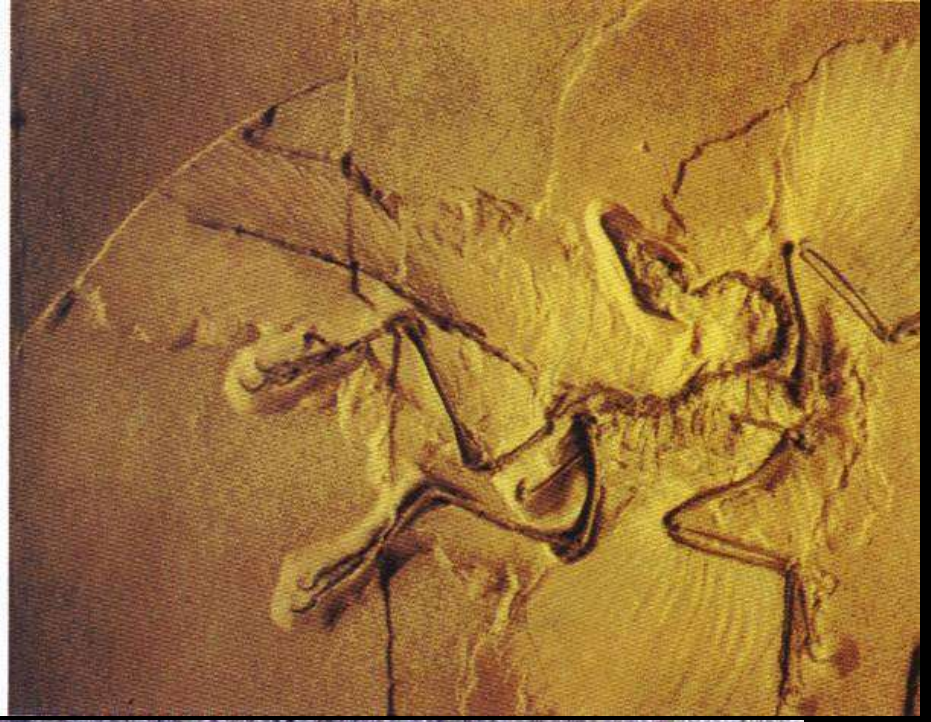
# Chert=silica

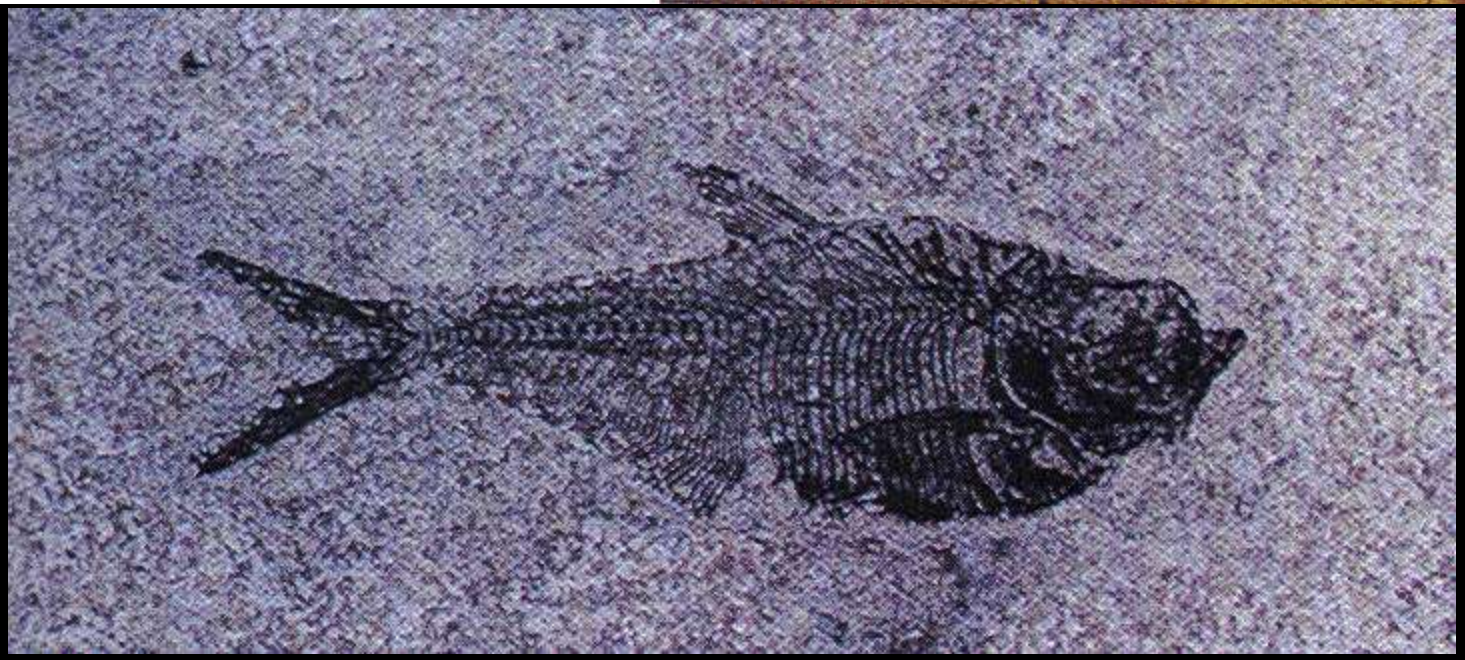





Wetland environment
Abundant vegetation
Peat
50 m
Shallow burial
Lignite
10 m
Deep burial
Soft coal
5 m
Metamorphism
Hard coal
5 m

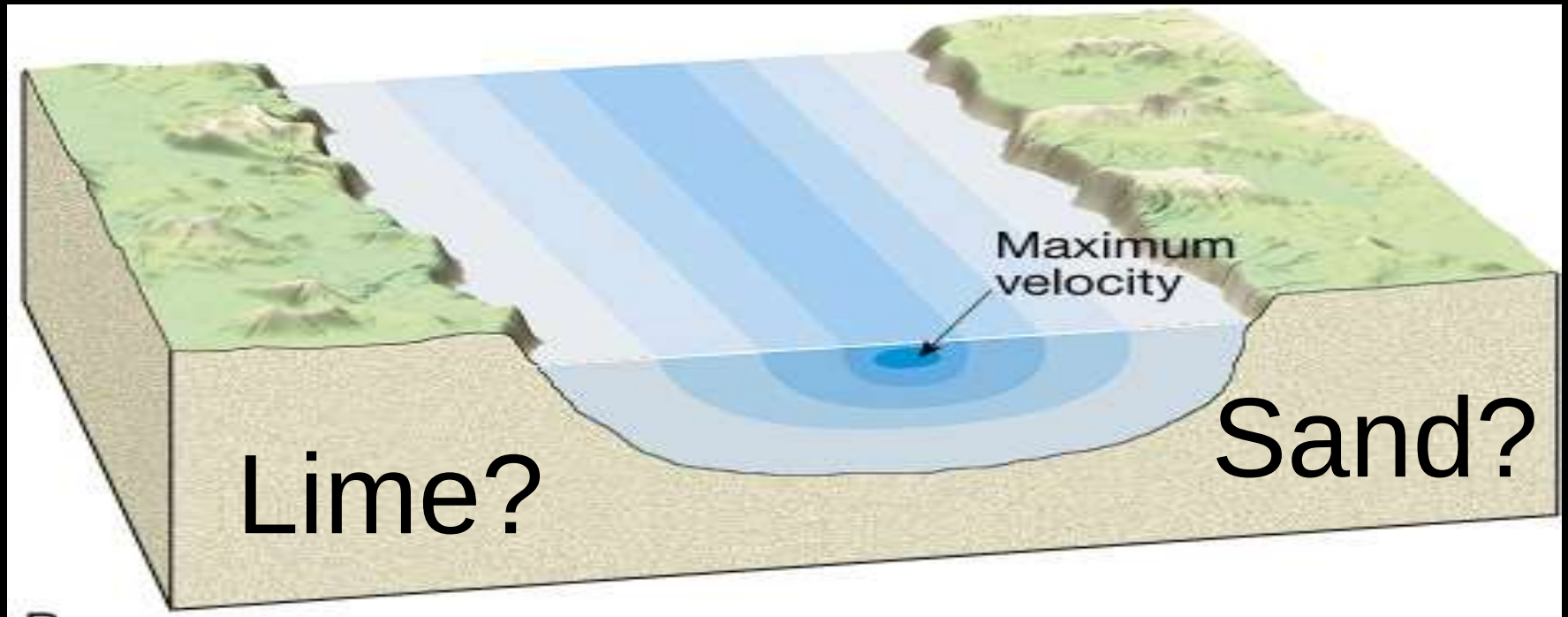




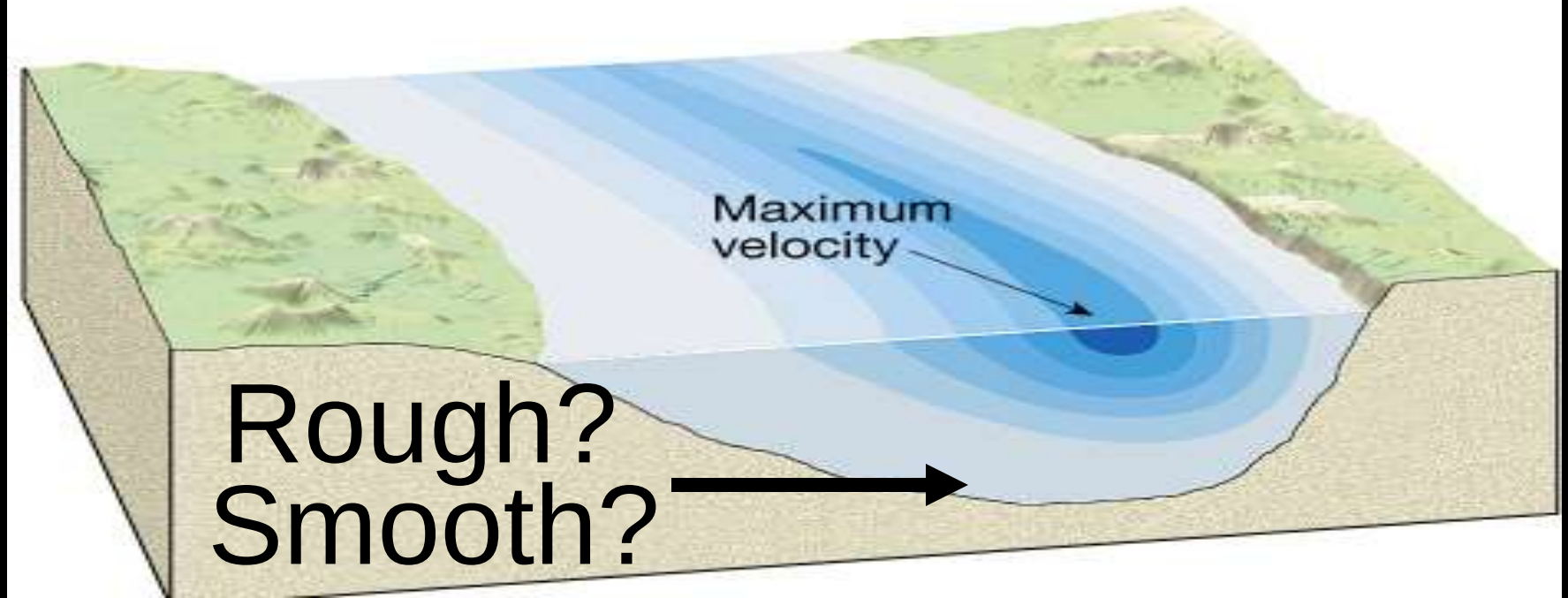


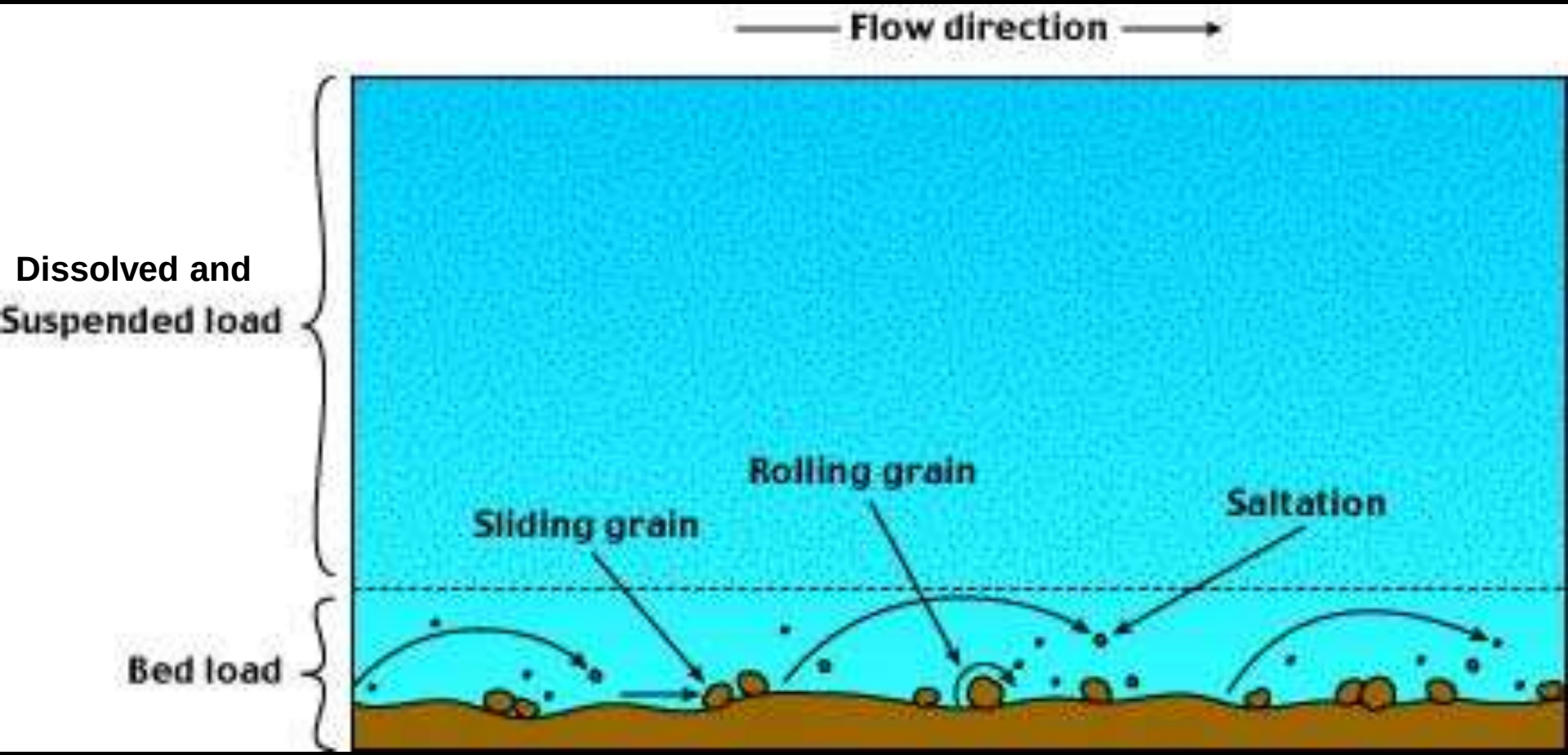
# Water is the great eroder

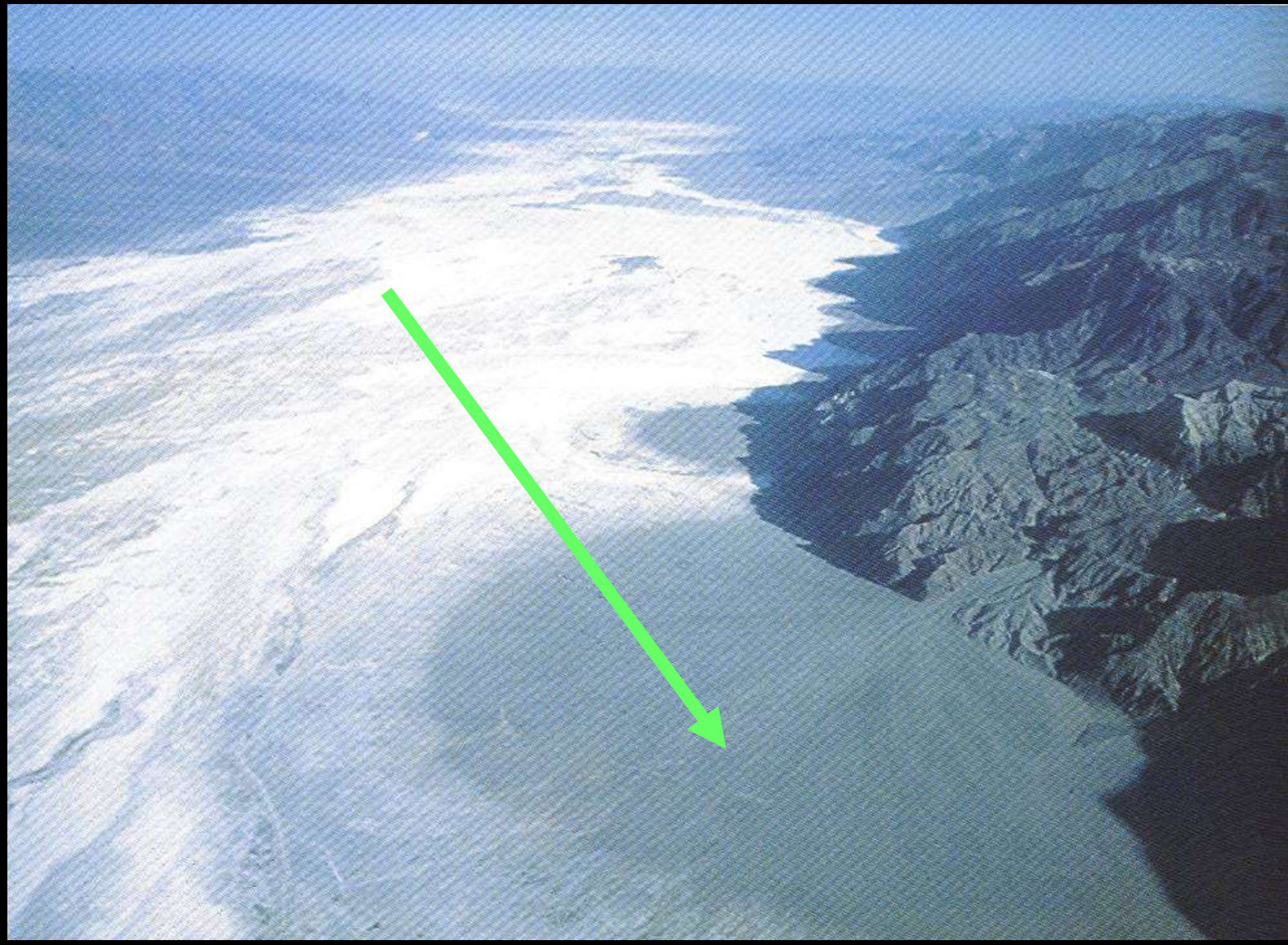

Amazon

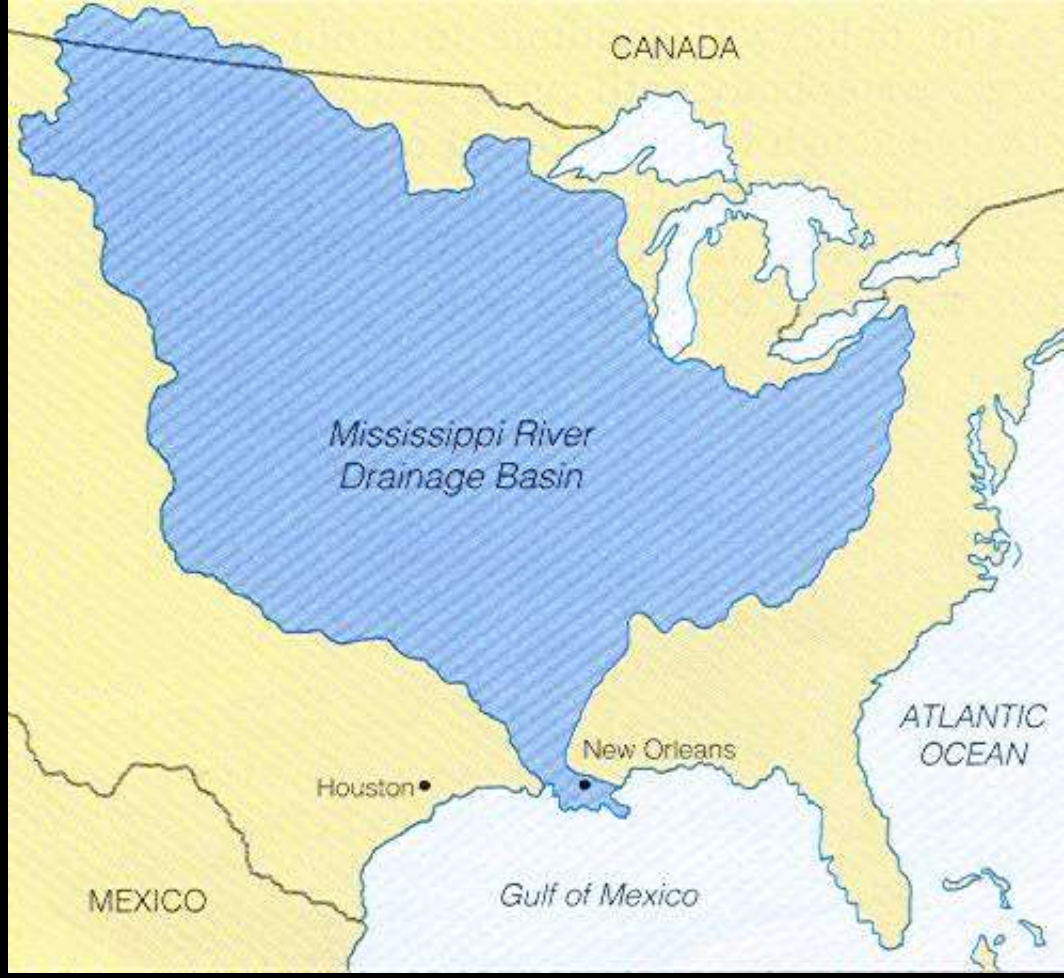


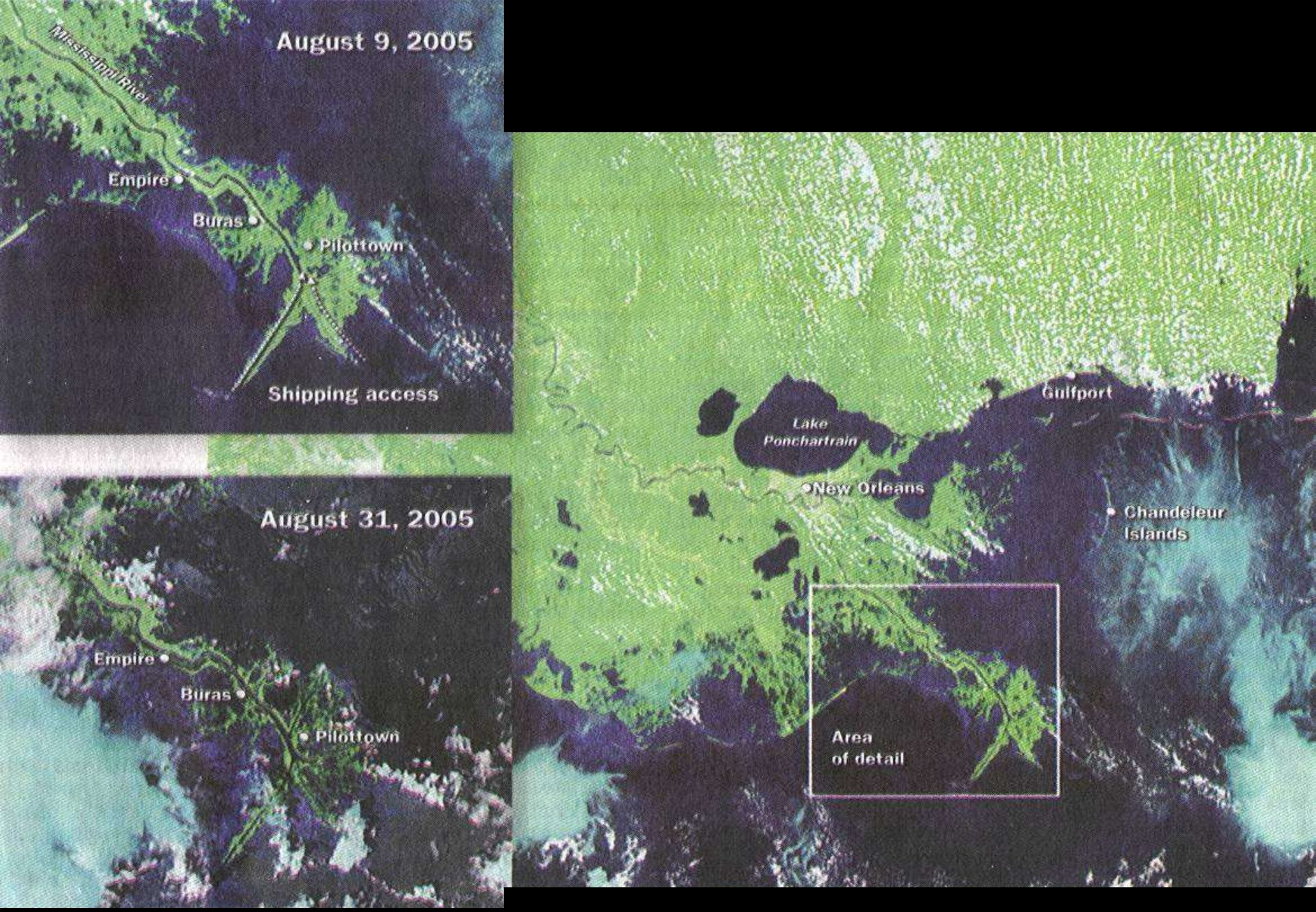

B.



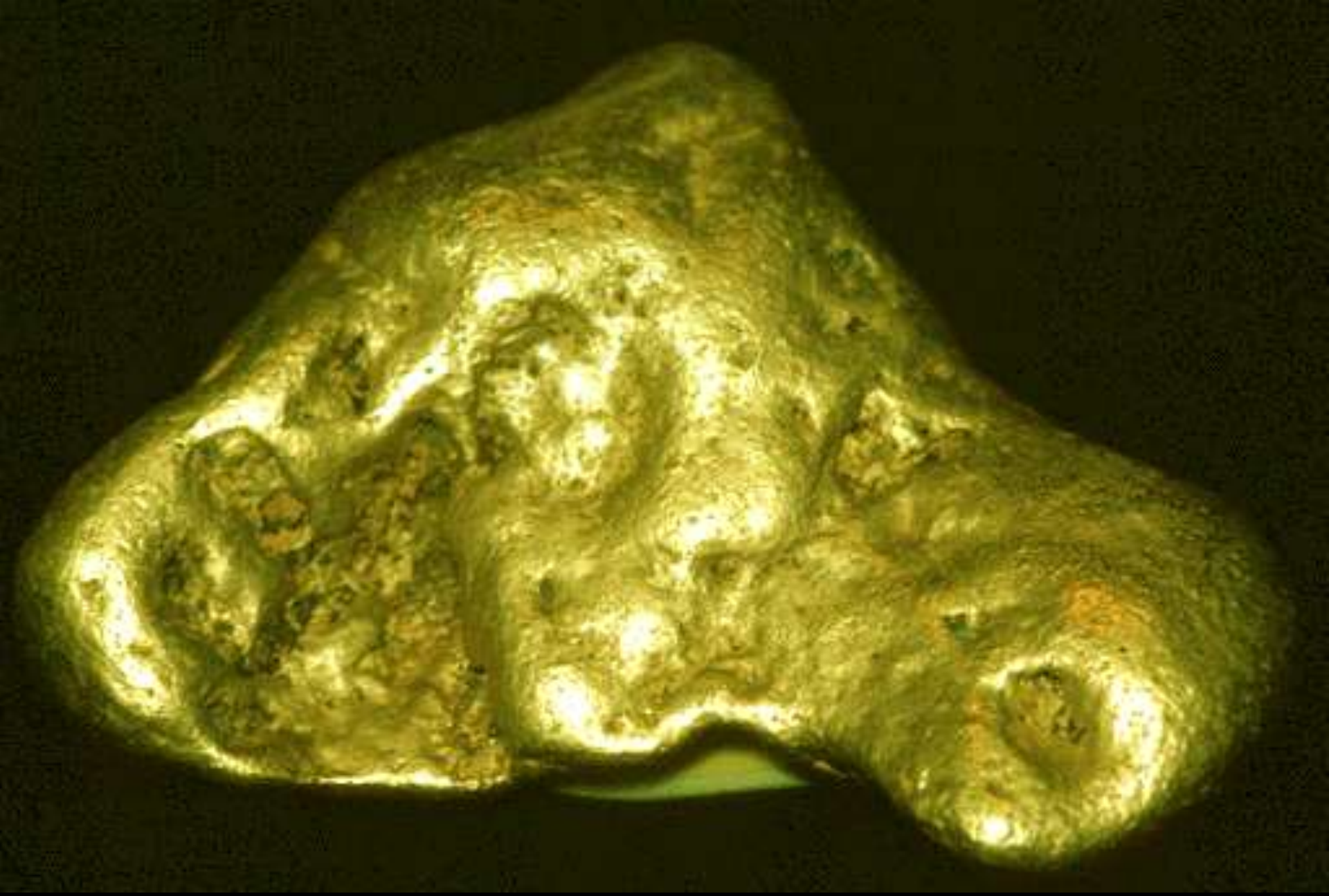

Flow direction
Dissolved and
Suspended load
Rolling grain
Saltation
Sliding grain
Bed load

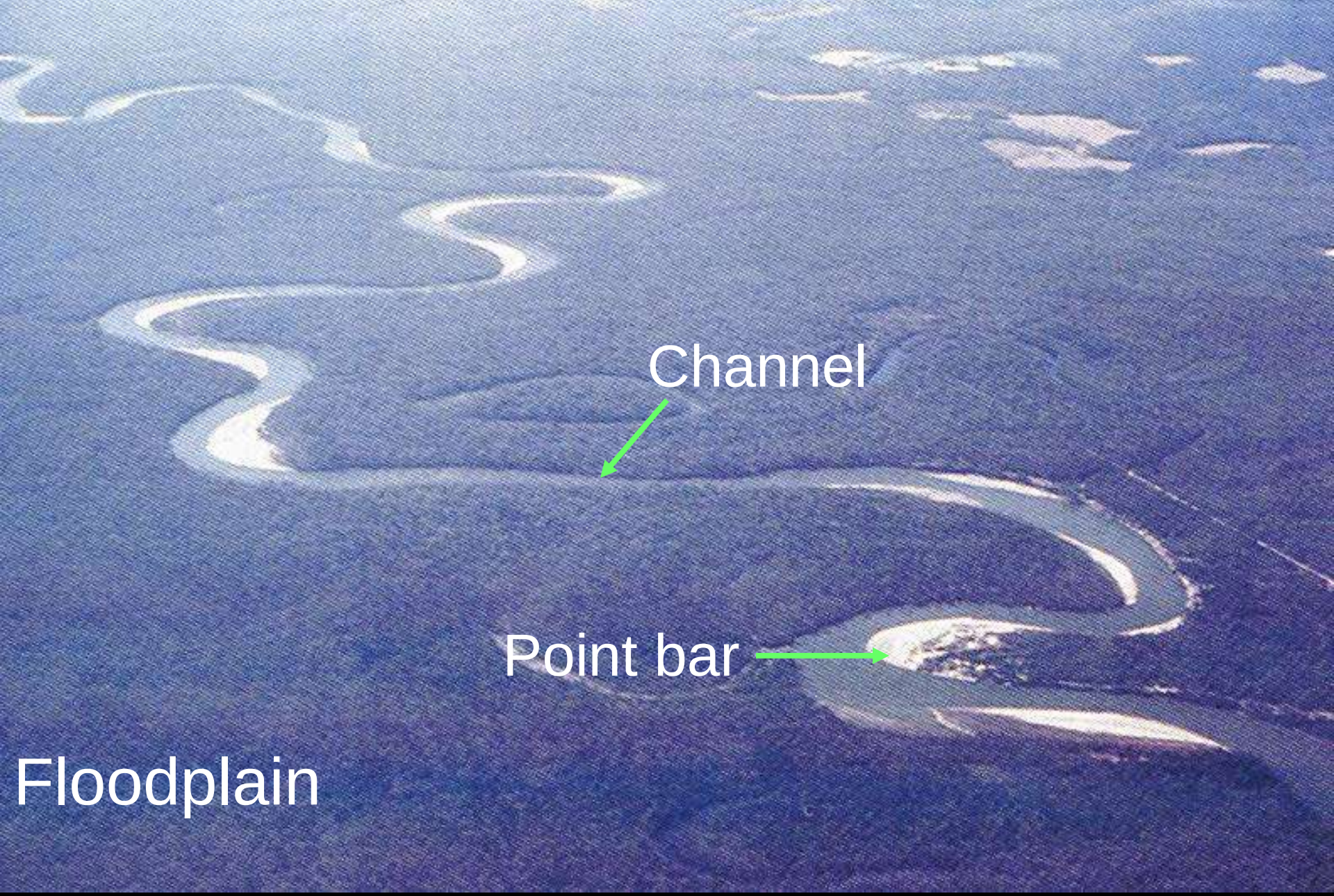


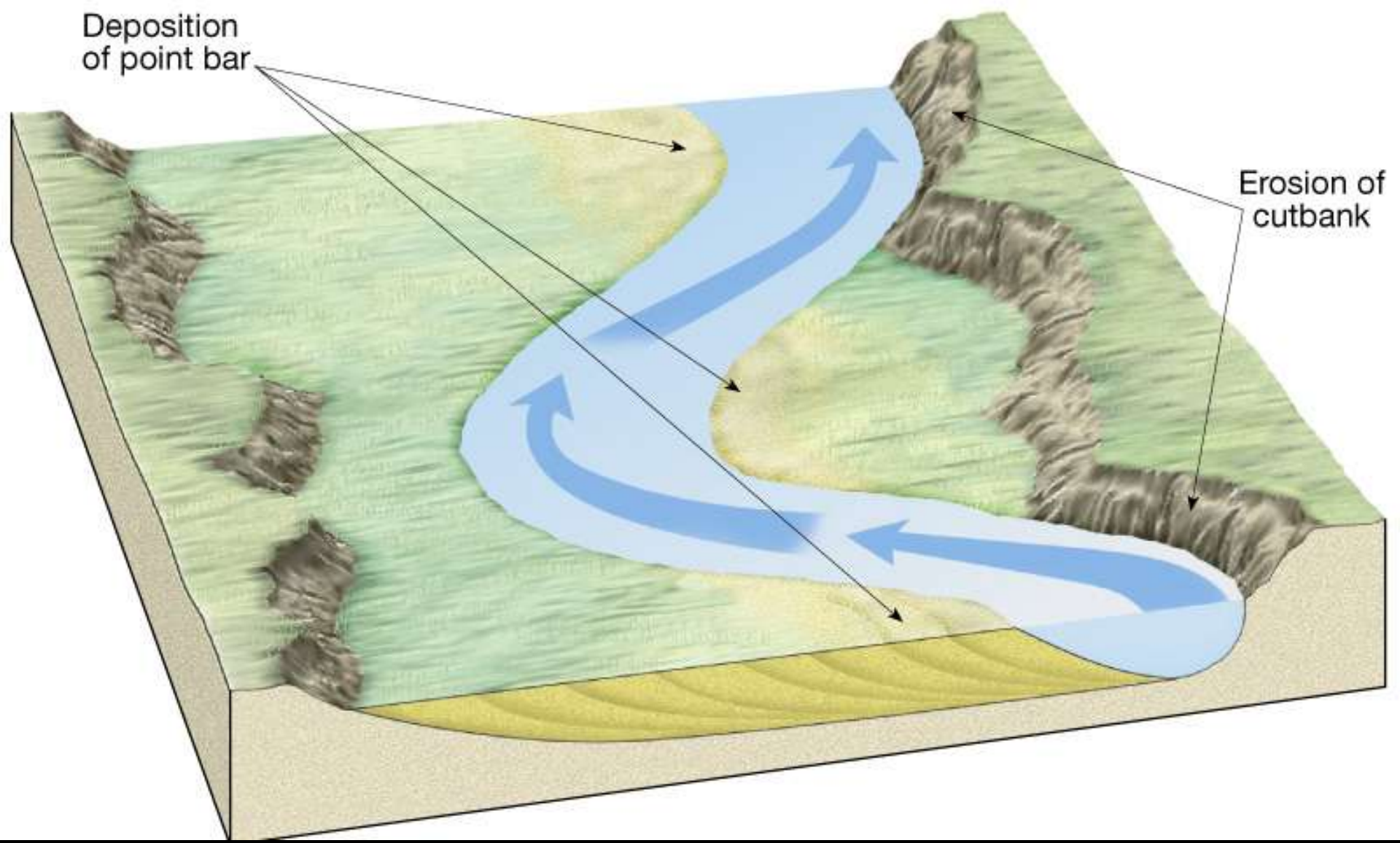

CANADA
Mississippi River
Drainage Basin
ATLANTIC
OCEAN
New Orleans
Houston
MEXICO
Gulf of Mexico

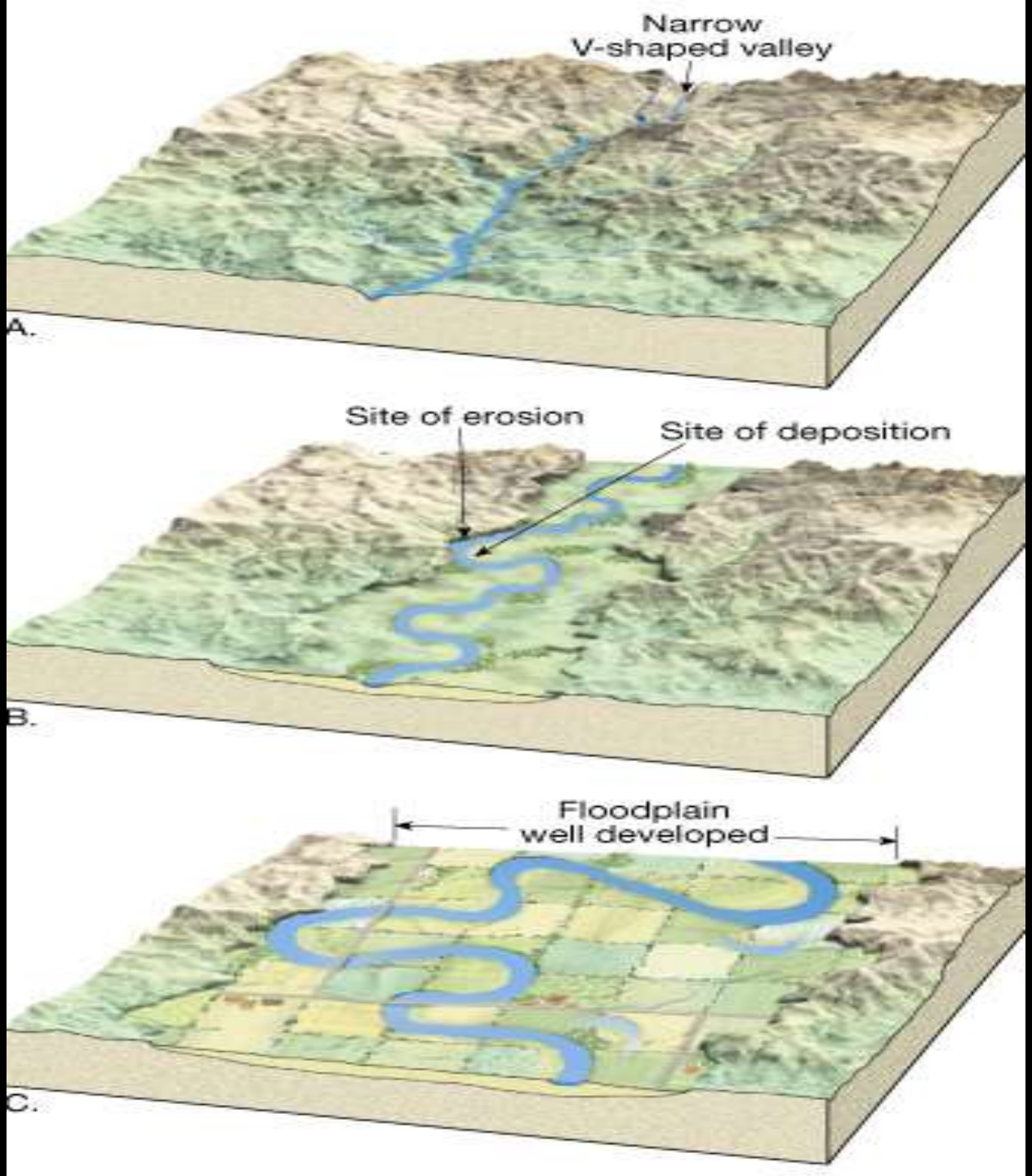

August 9, 2005
Mississippi River
Empire
Buras
Pilottown
Shipping access
August 31, 2005
Empire
Buras
Pilottown
Lake Ponchartrain
New Orleans
Gulfport
Chandeleur Islands
Area of detail

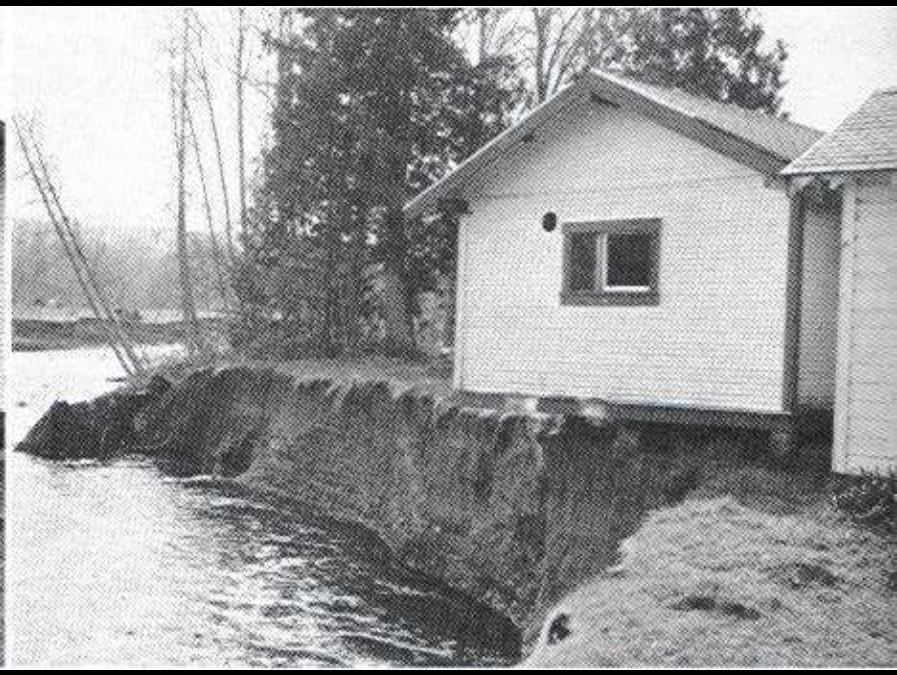

A




Channel
Point bar
Floodplain


Deposition
of point bar
Erosion of
cutbank

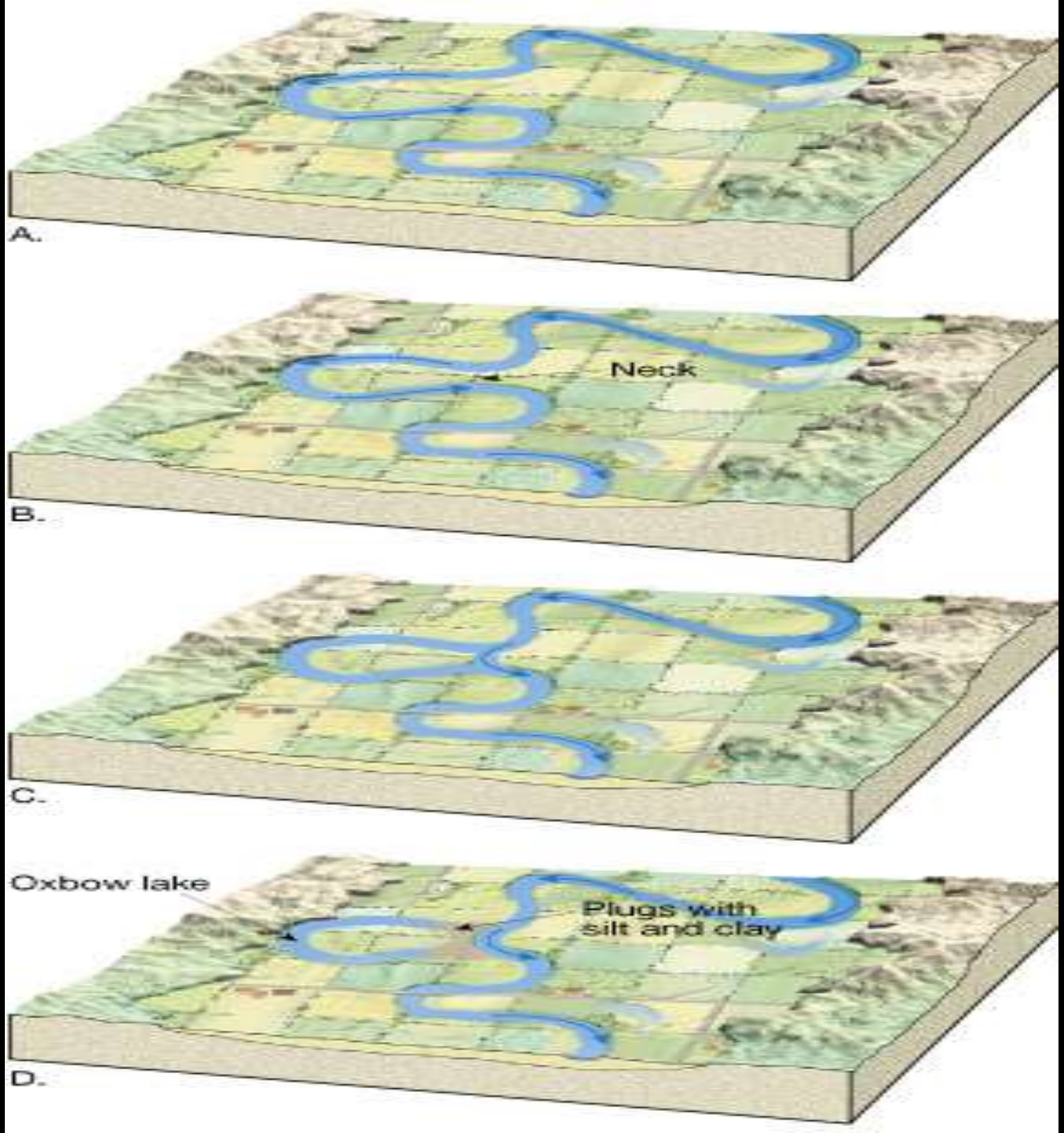

Narrow
V-shaped valley
A.
Site of erosion
Site of deposition
B.
Floodplain
well developed
C.

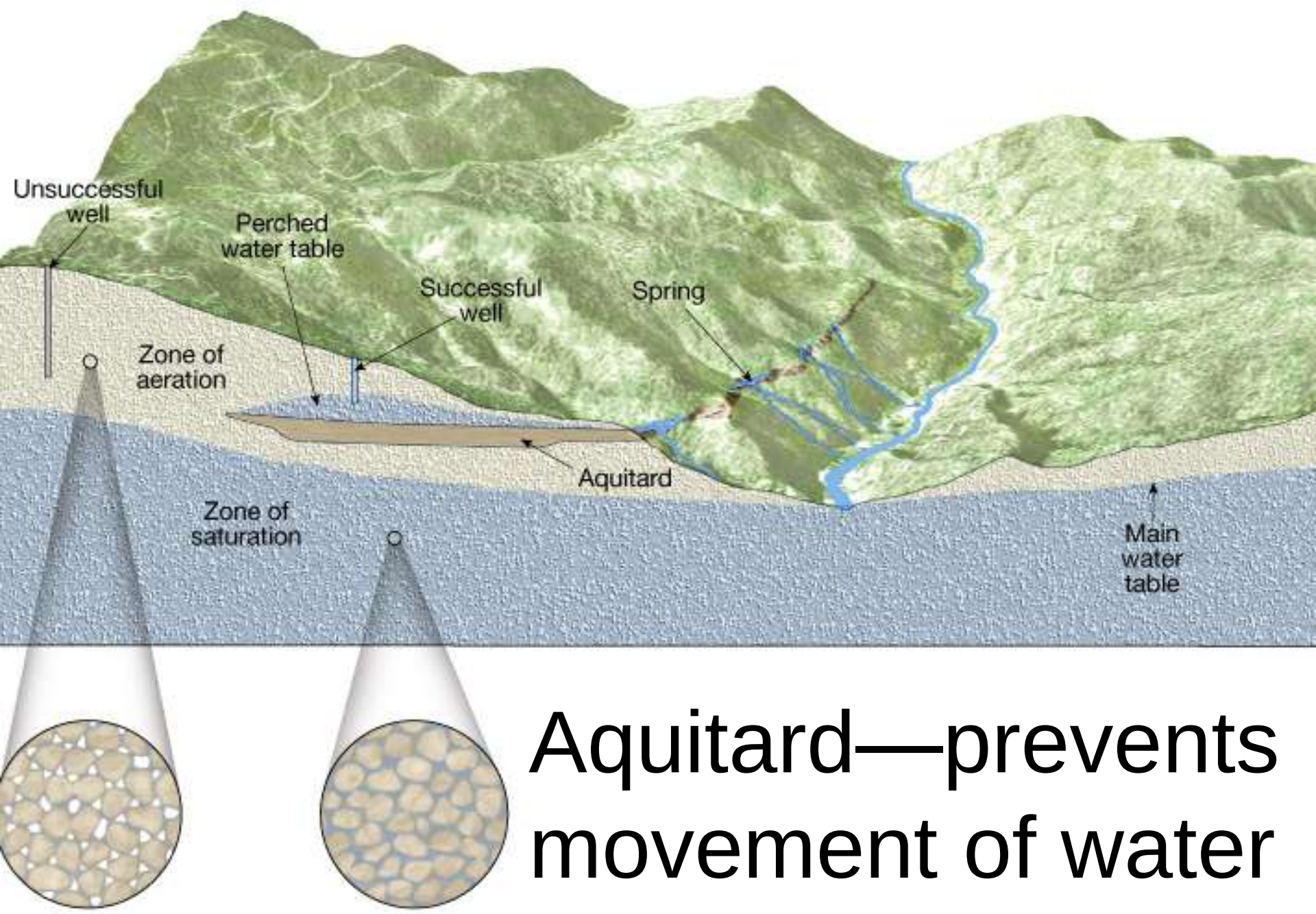



Baton
Rouge
New Orleans
80 kilometers
50 miles

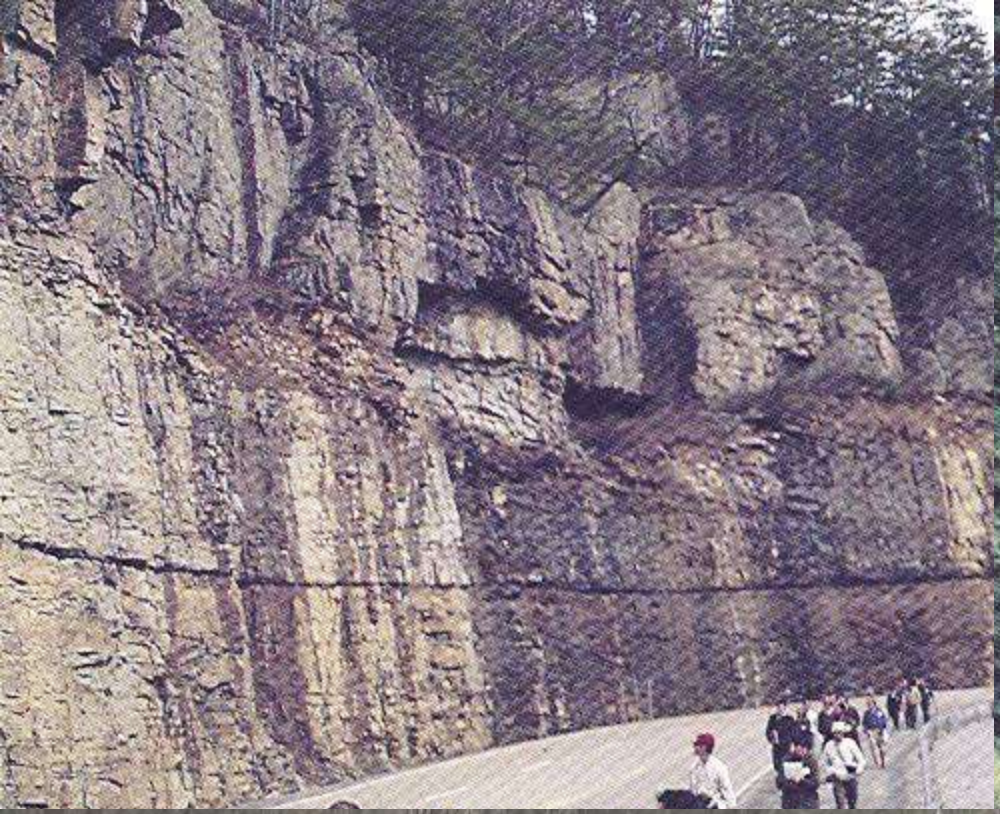

Oxbow

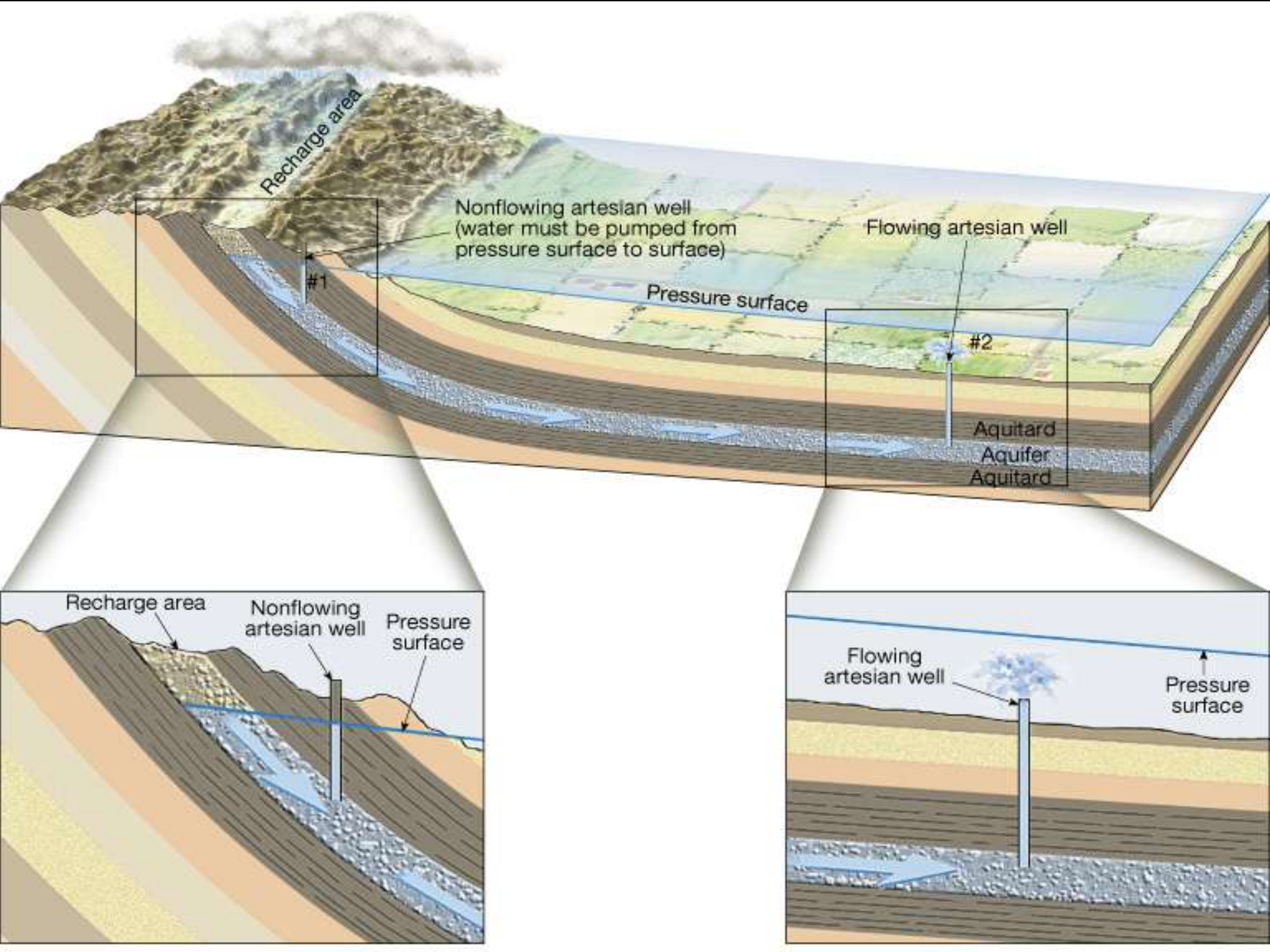

Oxbow lakes

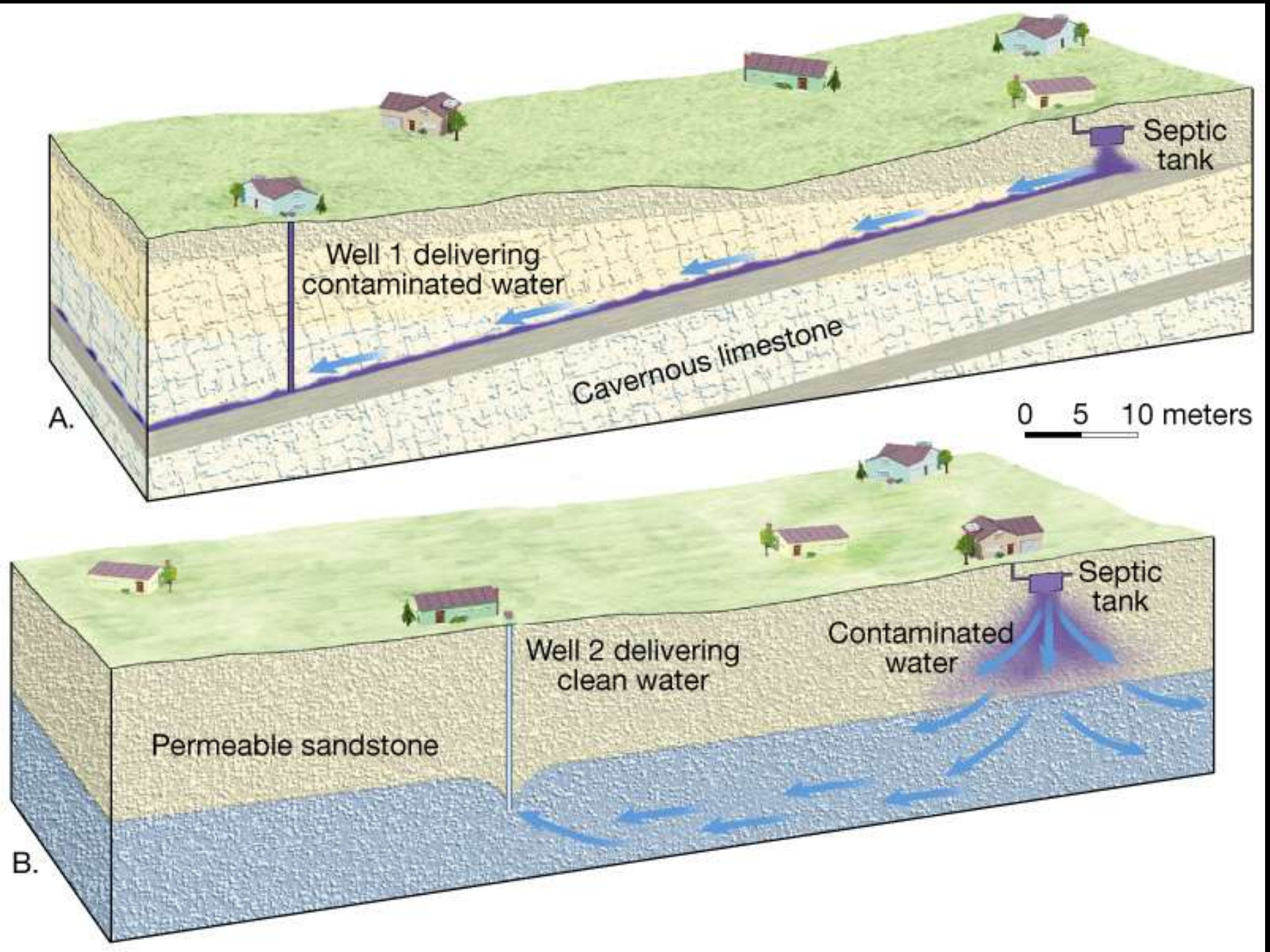

A.
Neck
B.
C.
Oxbow lake
Plugs with
silt and clay
D.




# Aquitard—prevents movement of water

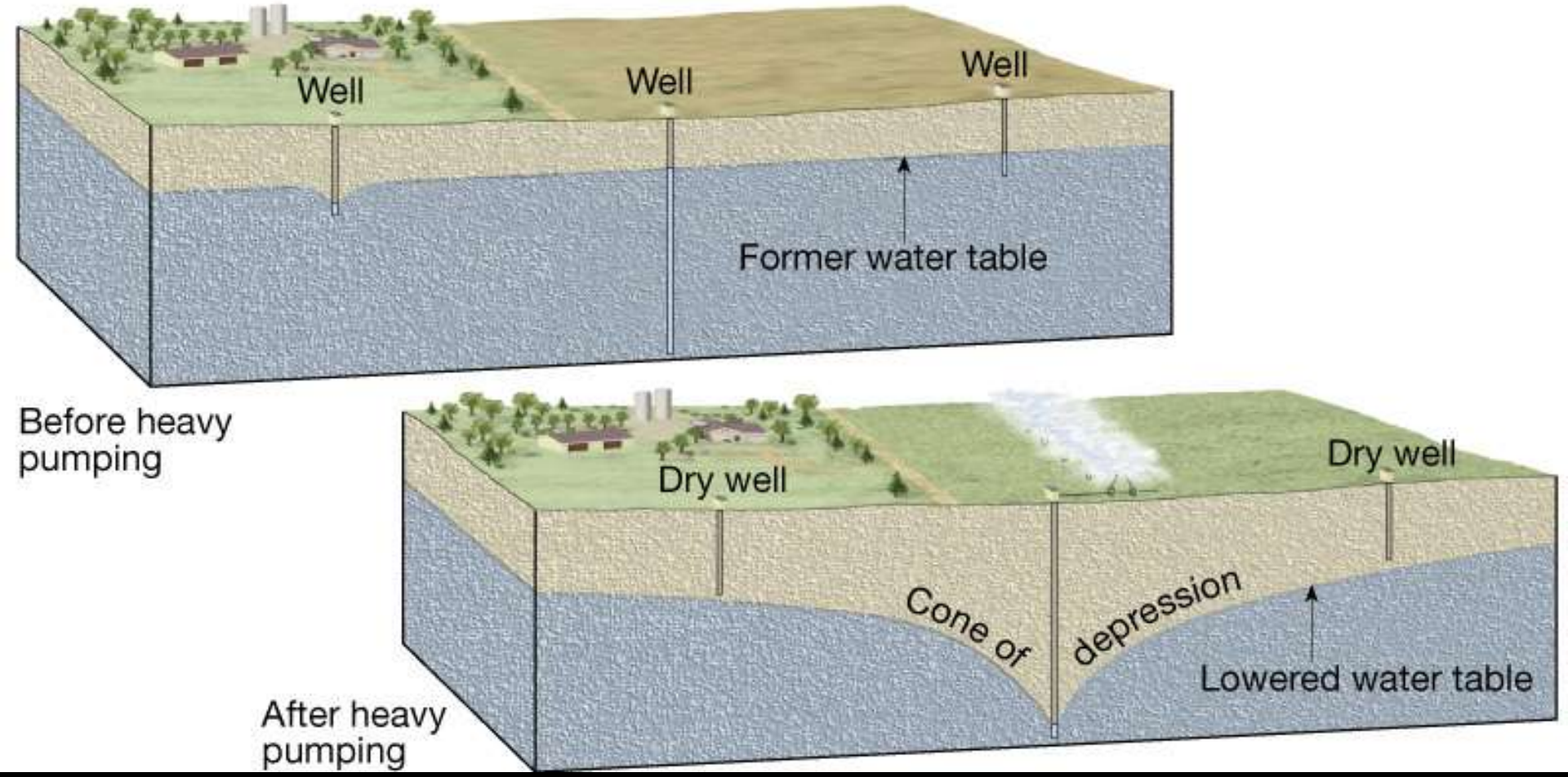



Recharge area
Nonflowing artesian well
(water must be pumped from
pressure surface to surface)
Flowing artesian well
#1
Pressure surface
#2
Aquitard
Aquifer
Aquitard
Recharge area
Nonflowing
artesian well
Pressure
surface
Flowing
artesian well
Pressure
surface

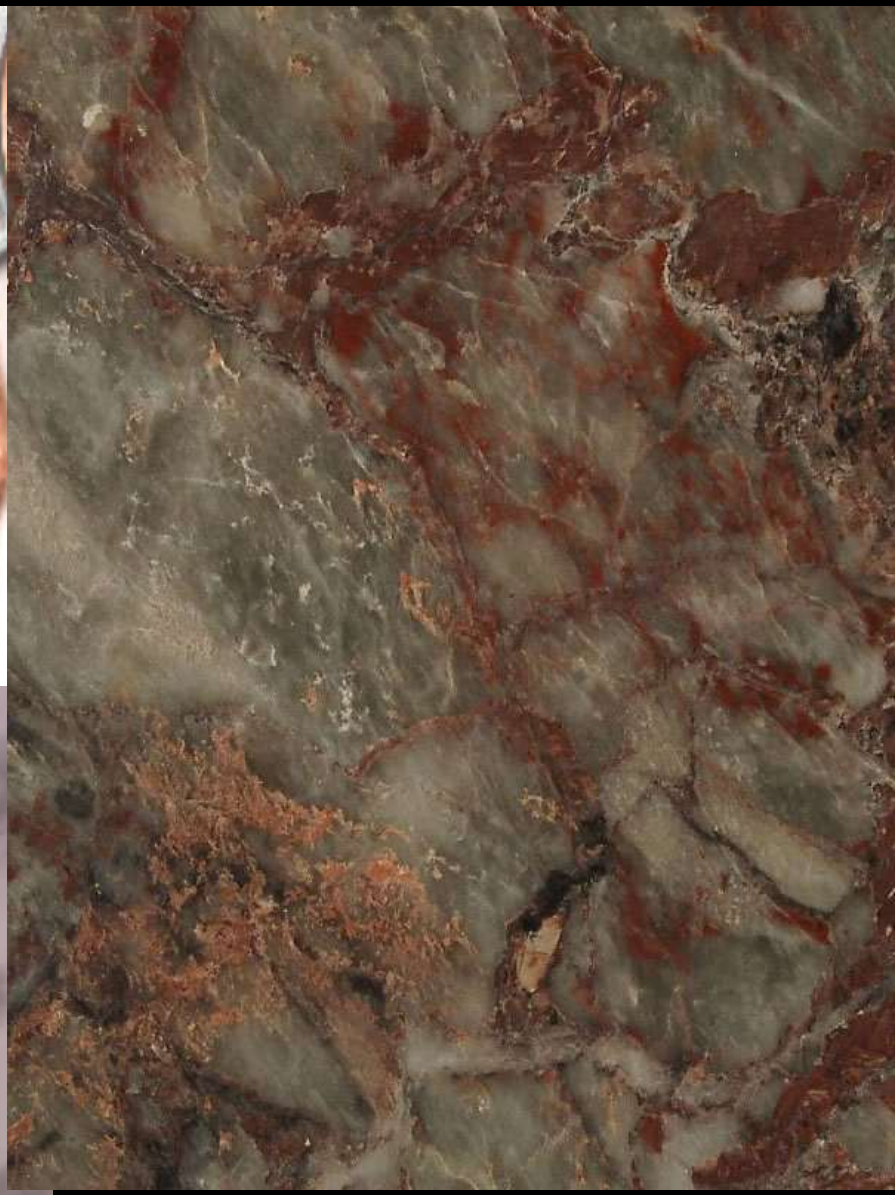

Septic tank
Well 1 delivering contaminated water
Cavernous limestone
A.
0 5 10 meters
Septic tank
Contaminated water
Well 2 delivering clean water
Permeable sandstone
B.

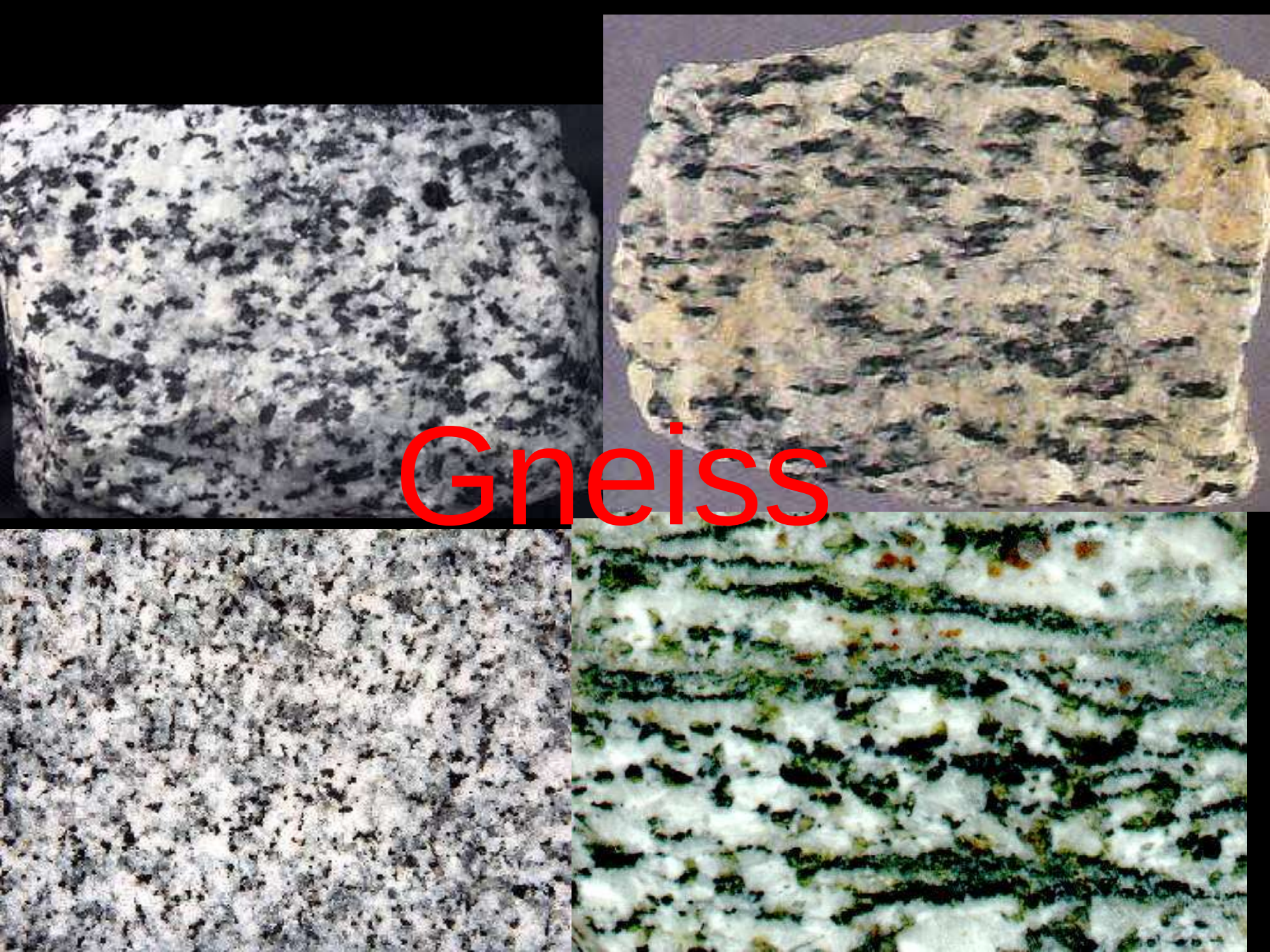

FMC

# Overpumping



Also carves caves and can lead to sinkholes




Gneiss

# Slate

# Schist