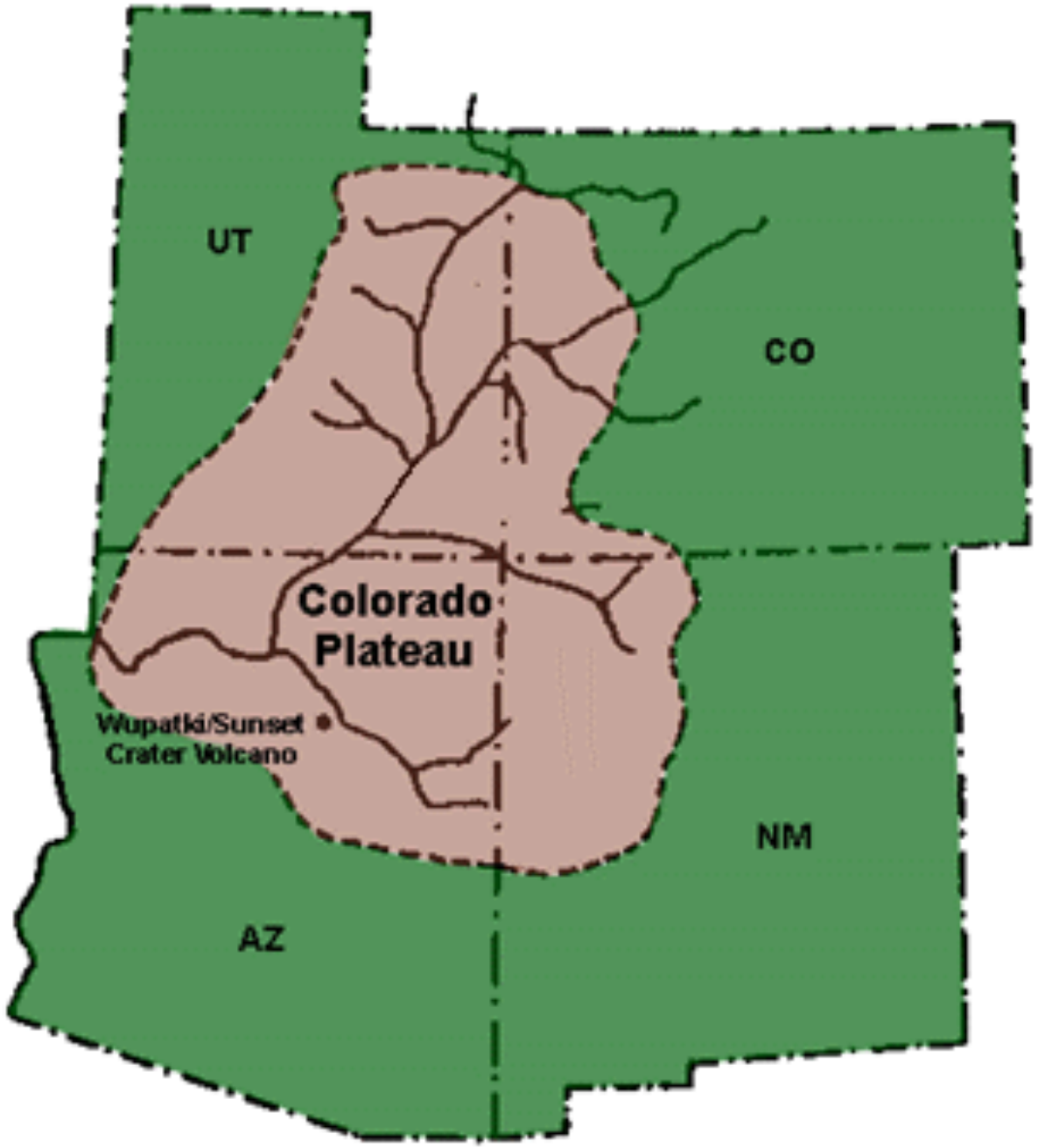
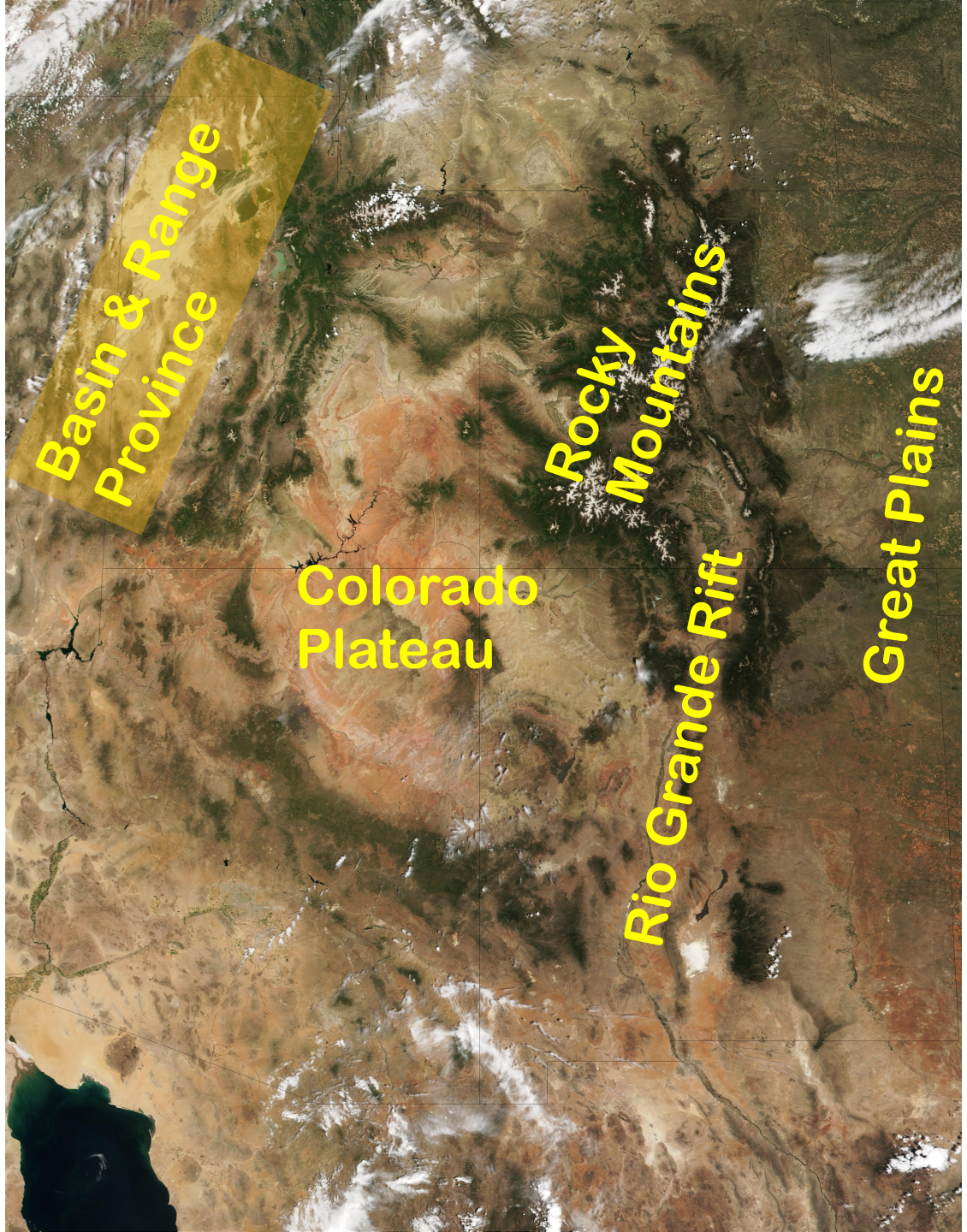
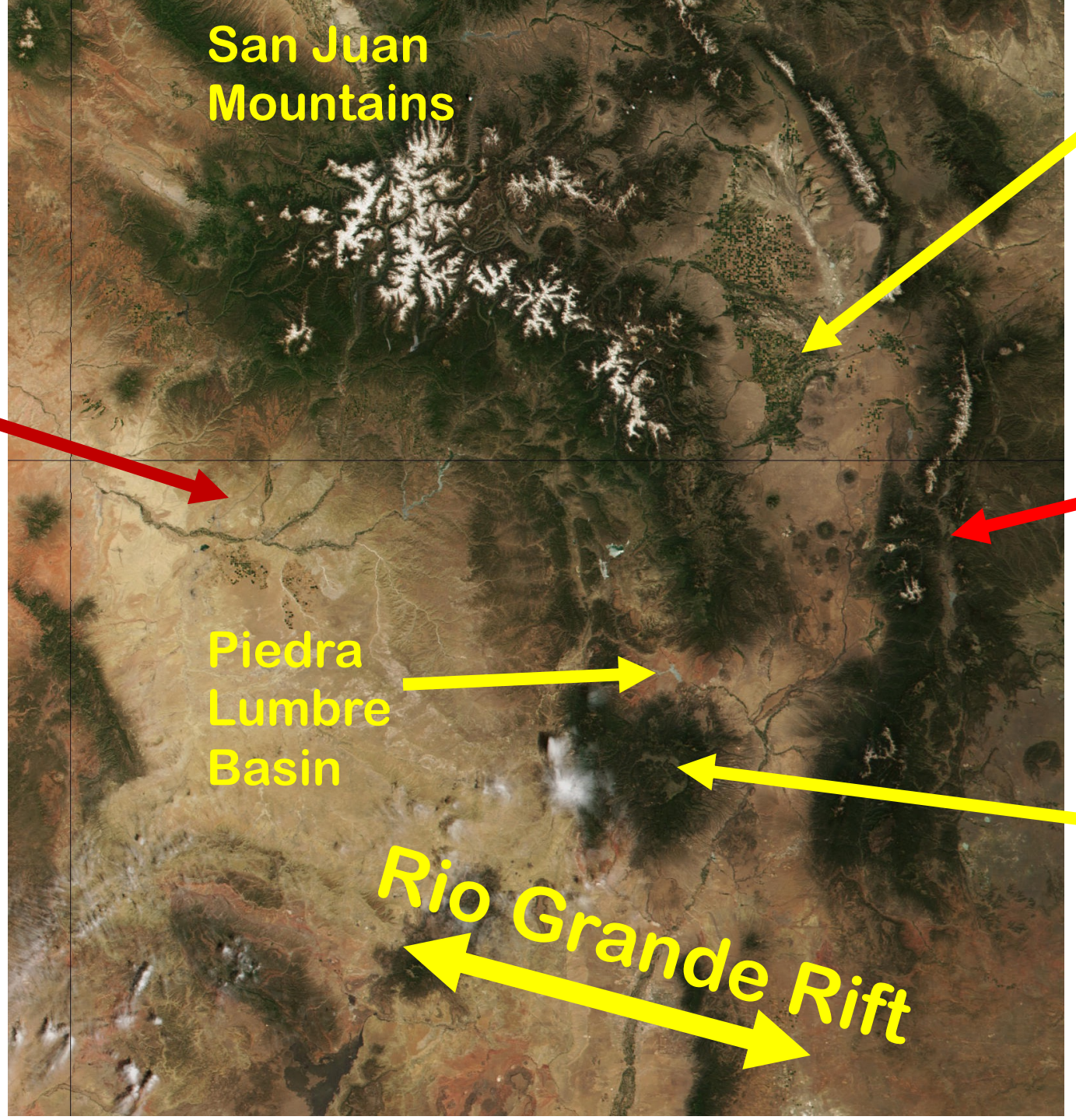
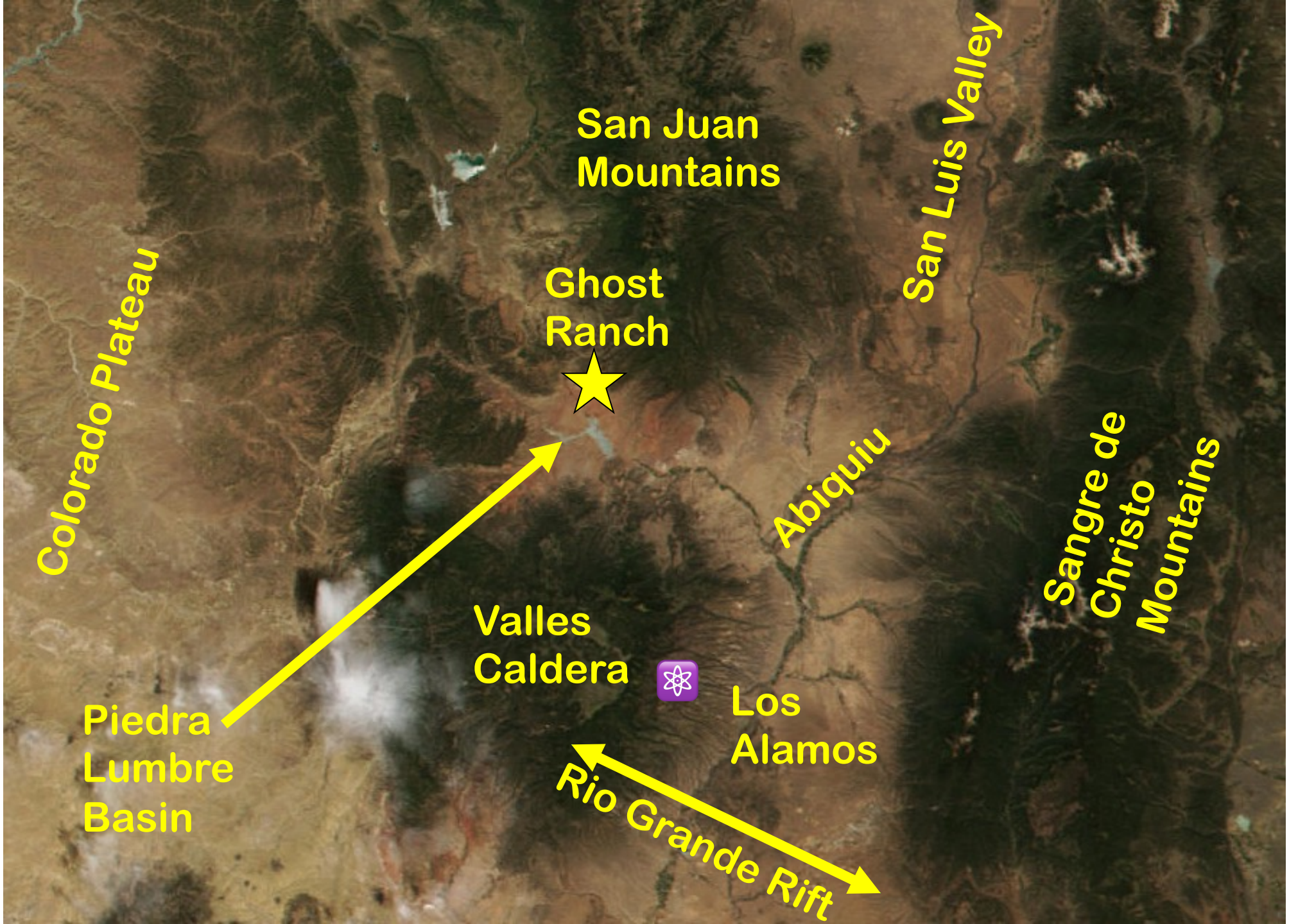
Geography & Geology


UT
CO
Colorado
Plateau
Wupatki/Sunset
Crater Volcano
NM
AZ


Basin & Range
Province
Rocky
Mountains
Colorado
Plateau
Rio Grande Rift
Great Plains


San Juan Mountains
San Luis Valley
Colorado Plateau
Sangre de Christo Mountains
Piedra Lumbre Basin
Valles Caldera
Rio Grande Rift

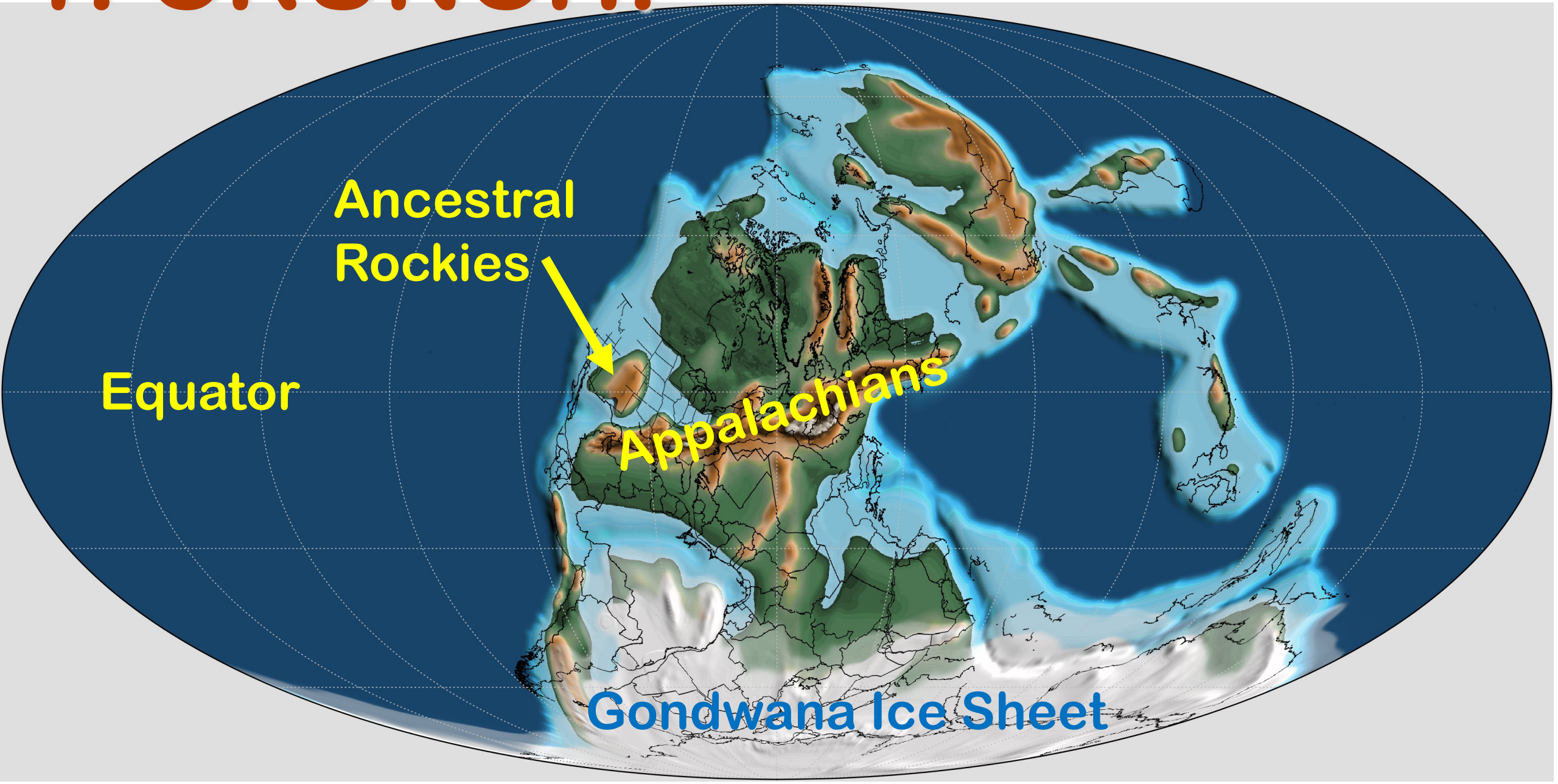

San Juan Mountains
San Luis Valley
Ghost Ranch
Colorado Plateau
Abiquiu
Sangre de Christo Mountains
Valles Caldera
Los Alamos
Piedra Lumbre Basin
Rio Grande Rift

Sequence of Events

1. **Crunch!**
   (ancestral Rockies; 300 mya)
2. **Crunch!**
   (modern Rockies; 70 mya)
3. **Crack!**
   (Spreading; last 17 my)
4. **Boom!**
   (volcanic eruptions; last 14 my)

1. CRUNCH!

300 million years ago



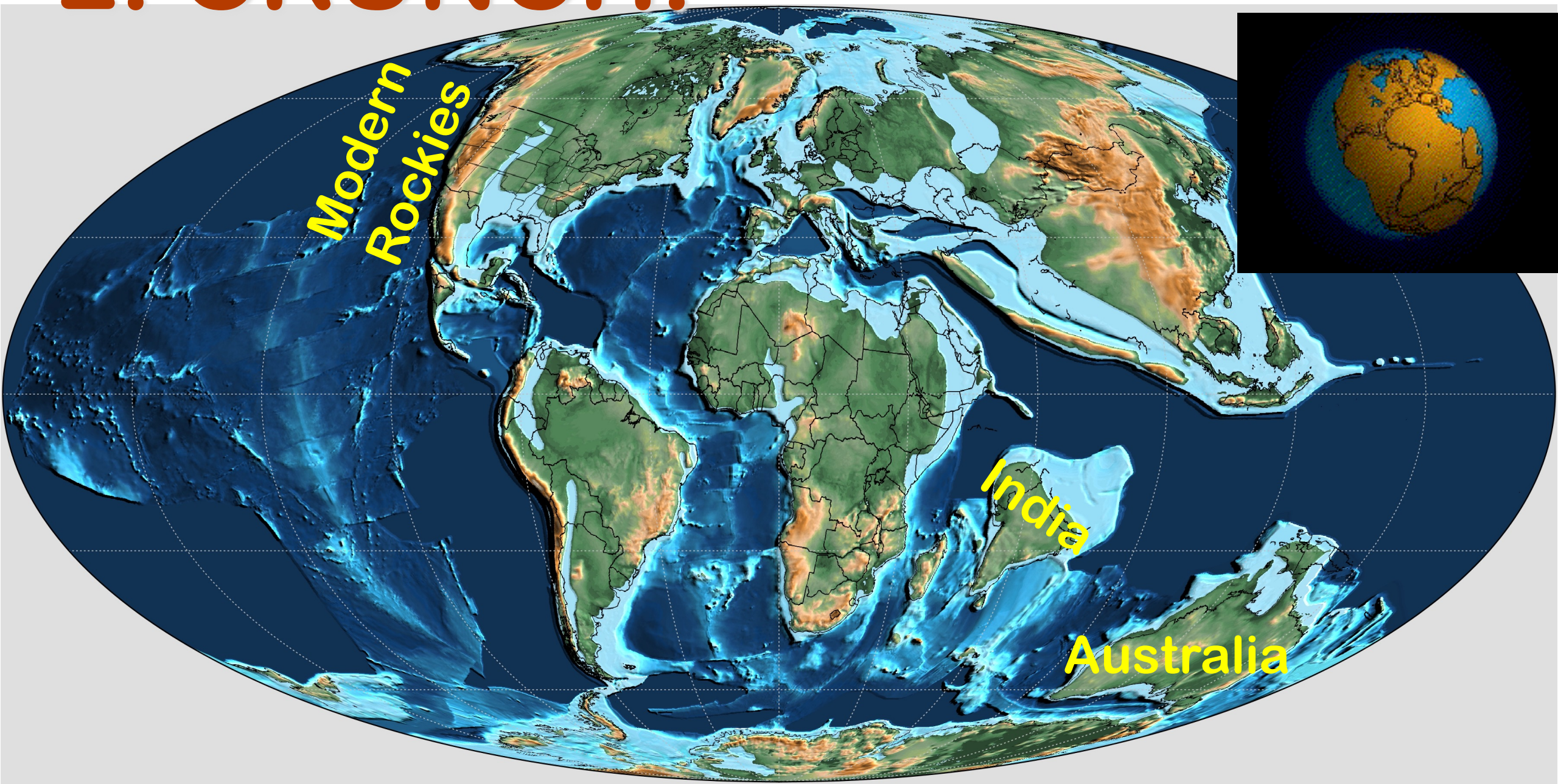
Ancestral Rockies

The Ancestral Rocky Mountains, about 300 million years ago

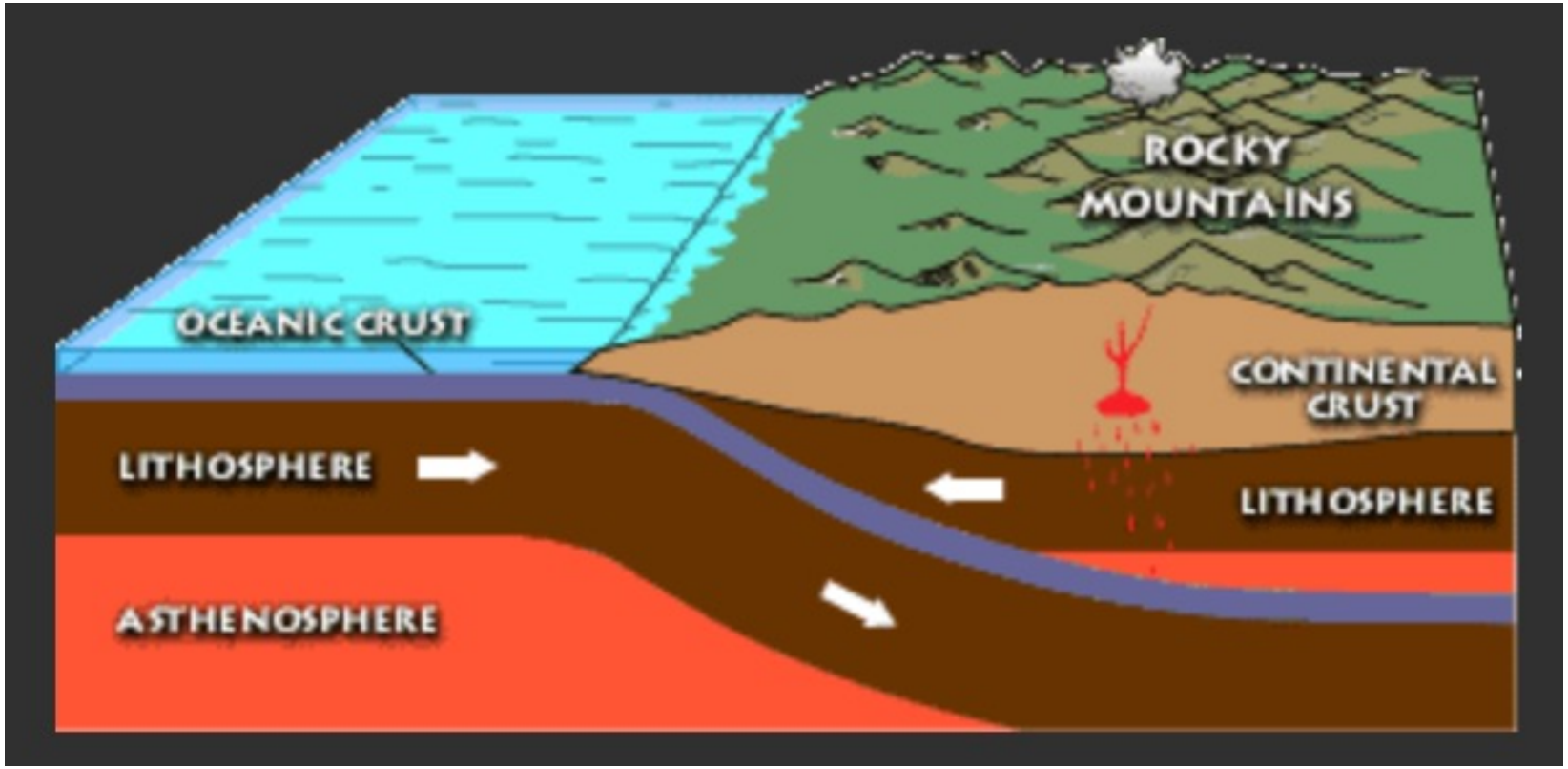
- 300 million years ago, before the world was remade in the Great Dying
- Gigantic ice sheet lay across the Antarctic (Gondwana Land)
- Appalachians/Hebrides/Scandinavia: a colossal range along the Equator
- Ancestral Rockies formed as a wrap-around peninsula from that great range
- They eroded to make our familiar Mesozoic sedimentary rocks

2. CRUNCH!

70 million years ago



Laramide Orogeny



- 100's of millions of years passed
- Ancestral Rockies eroded to sea level
- Atlantic opened and drove North America westward

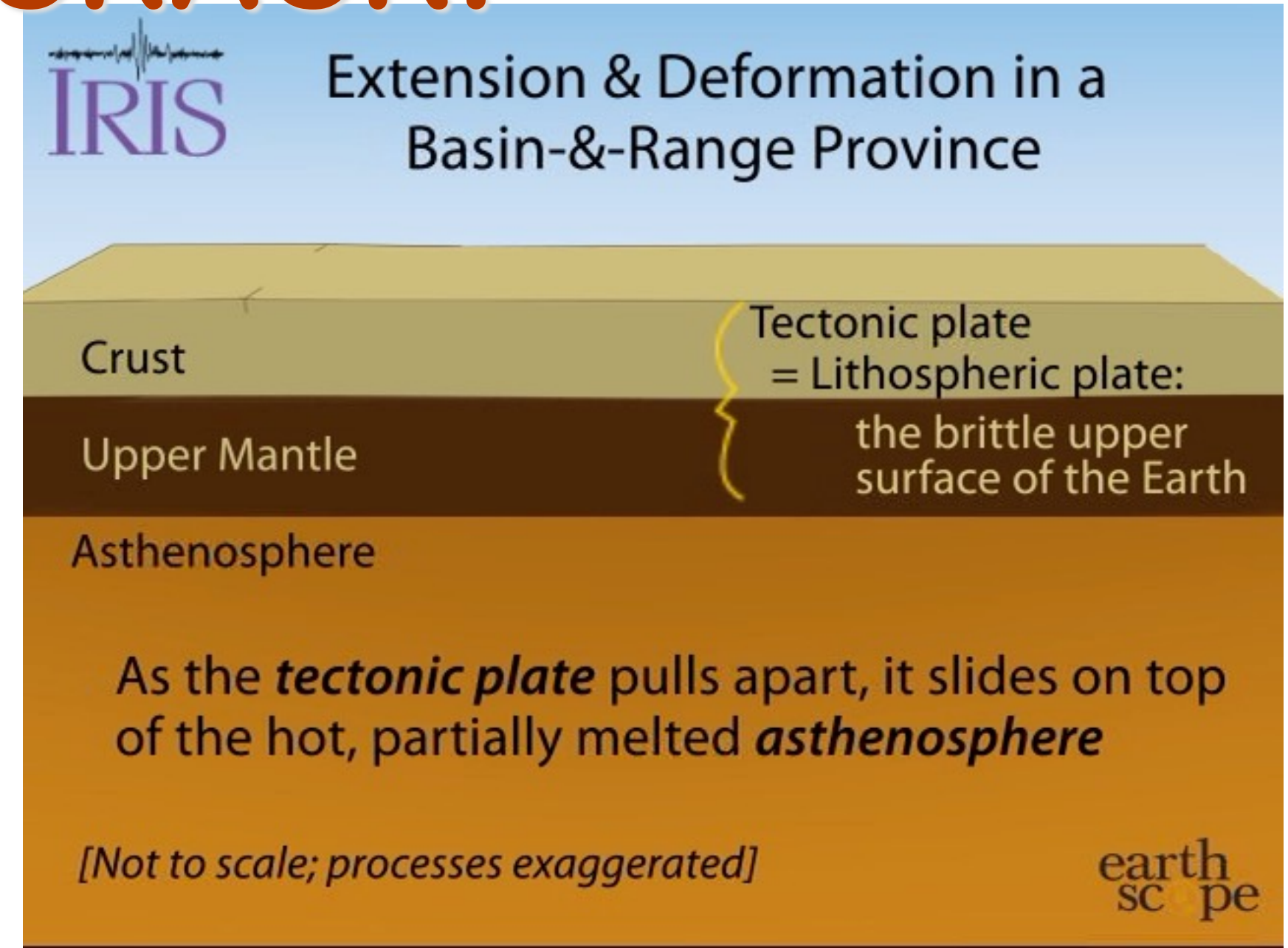
- Modern Rockies formed about 70 million years ago when the Atlantic spread faster, driving the North American Plate over the Farallon Plate faster than subduction could get it out of the way!

Sequence of Events

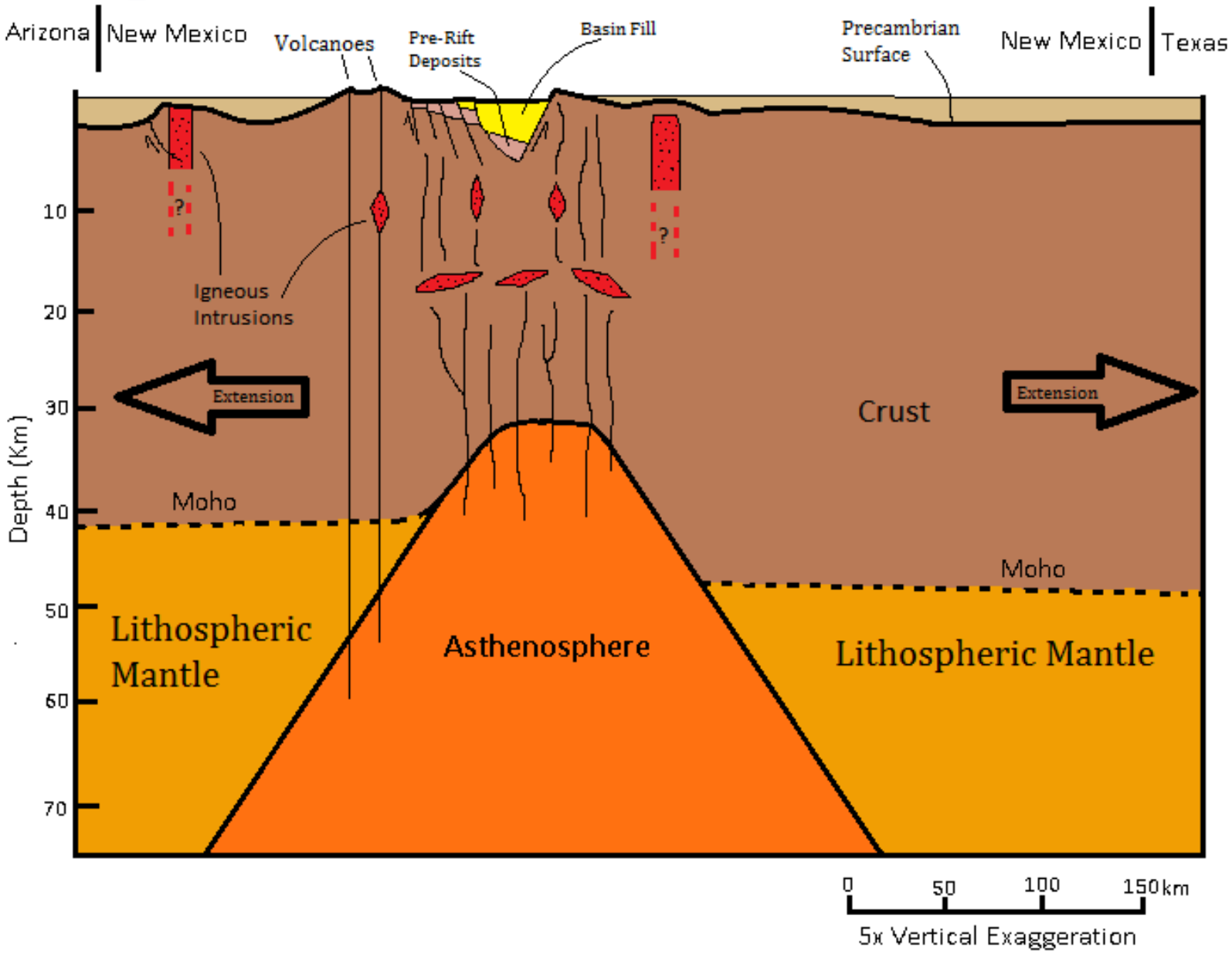
1. Crunch!
   (ancestral Rockies; 300 mya)
2. Crunch!
   (modern Rockies; 70 mya)
3. Crack!
   (Spreading; last 17 my)
4. Boom!
   (volcanic eruptions; last 14 my)

3. CRACK!

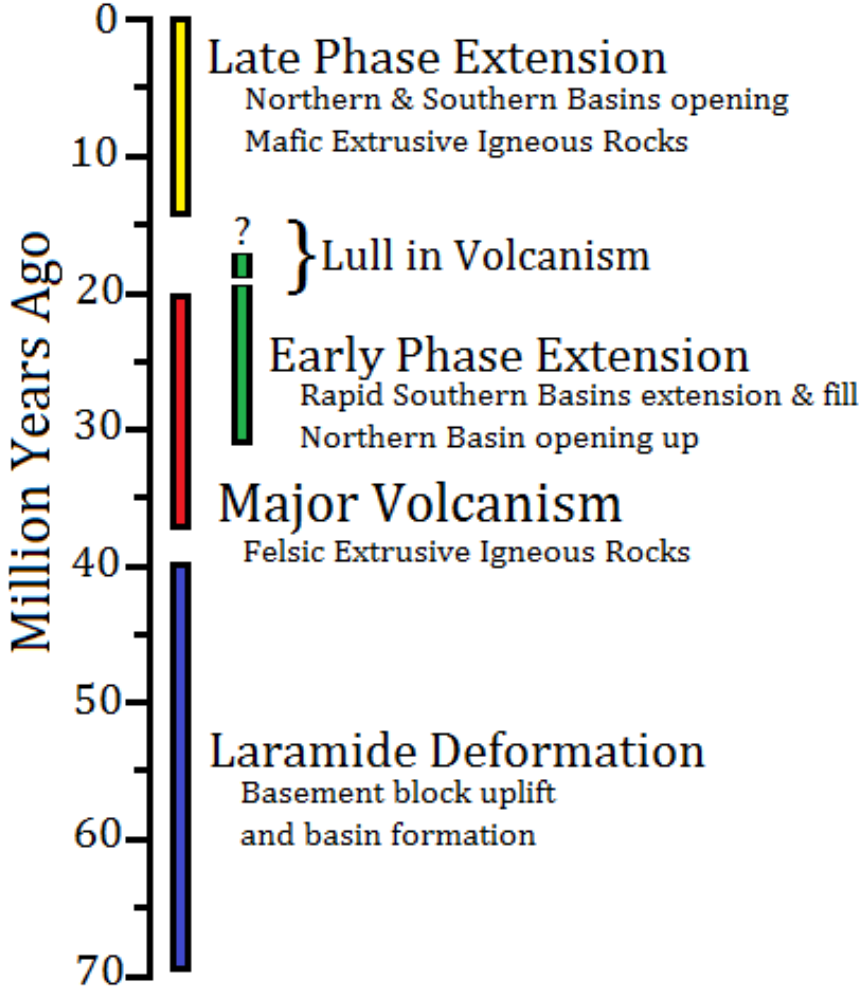
Past 17 million years



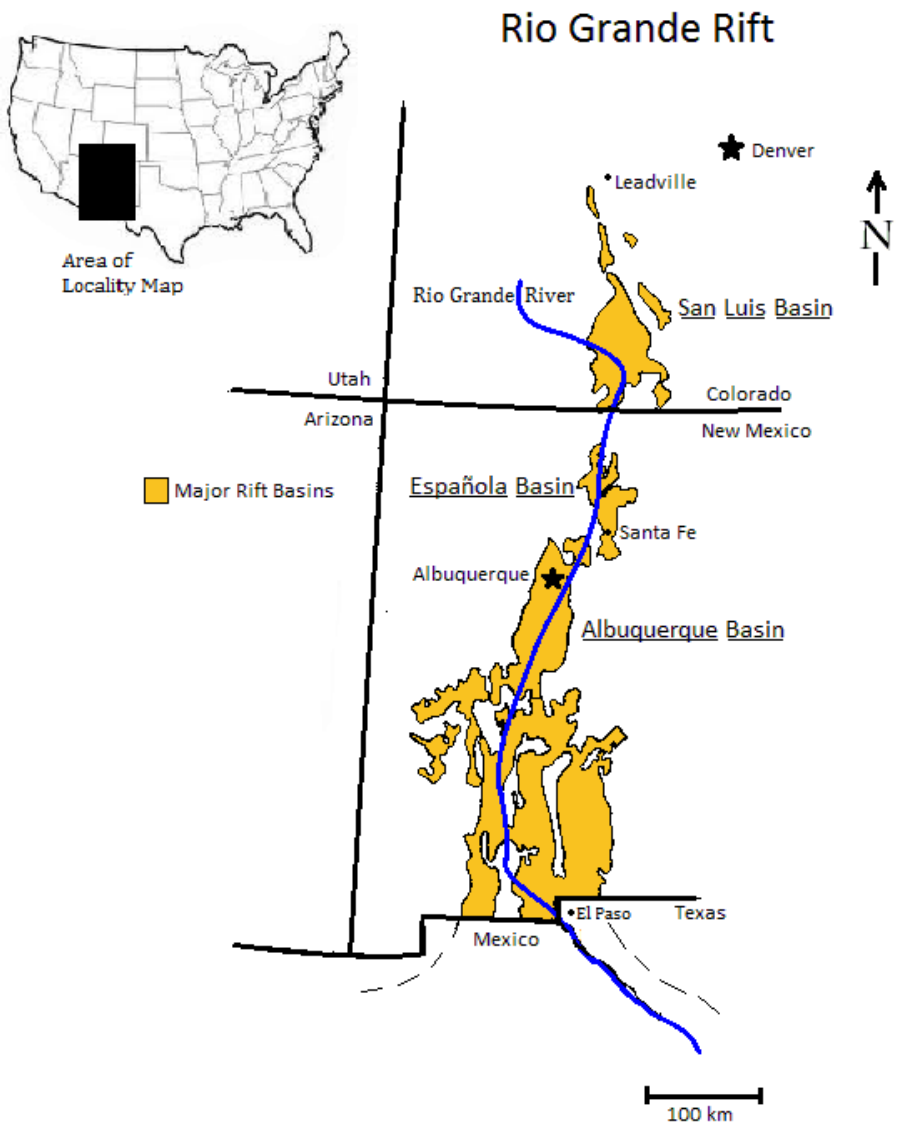
Generalized Cross Section of the Rio Grande Rift

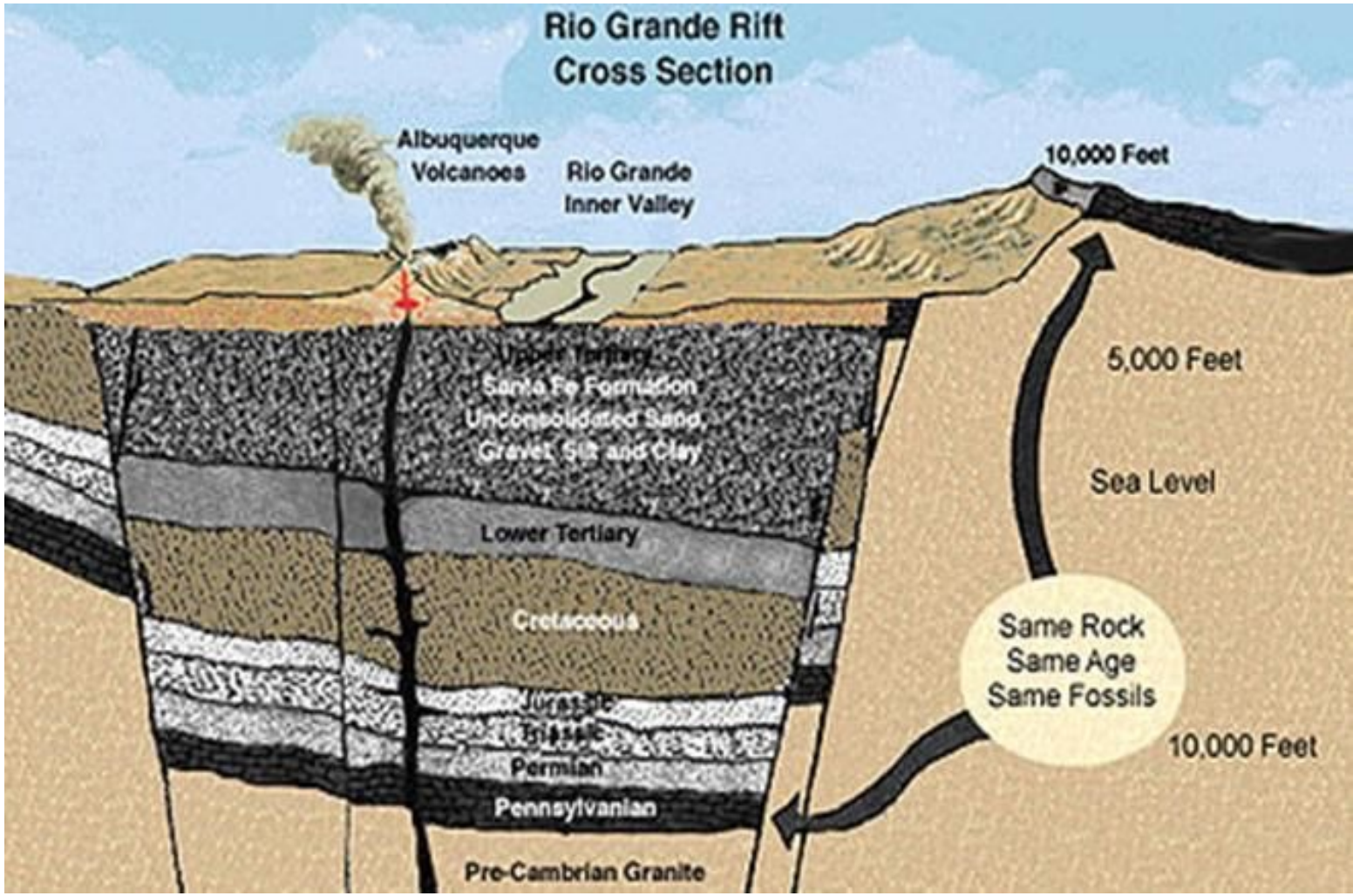


Generalized Timeline of Rio Grande Rift Formation



Rio Grande Rift


Rio Grande Rift
Area of
Locality Map
Denver
Leadville
N
Rio Grande River
San Luis Basin
Utah
Arizona
Colorado
New Mexico
Major Rift Basins
Española Basin
Santa Fe
Albuquerque
Albuquerque Basin
El Paso
Texas
Mexico
100 km


Rio Grande Rift
Cross Section
Albuquerque
Volcanoes
Rio Grande
Inner Valley
10,000 Feet
5,000 Feet
Sea Level
Santa Fe Formation
Unconsolidated Sand,
Gravel, Silt and Clay
Lower Tertiary
Cretaceous
Jurassic
Triassic
Permian
Pennsylvanian
Pre-Cambrian Granite
Same Rock
Same Age
Same Fossils
10,000 Feet

Sequence of Events

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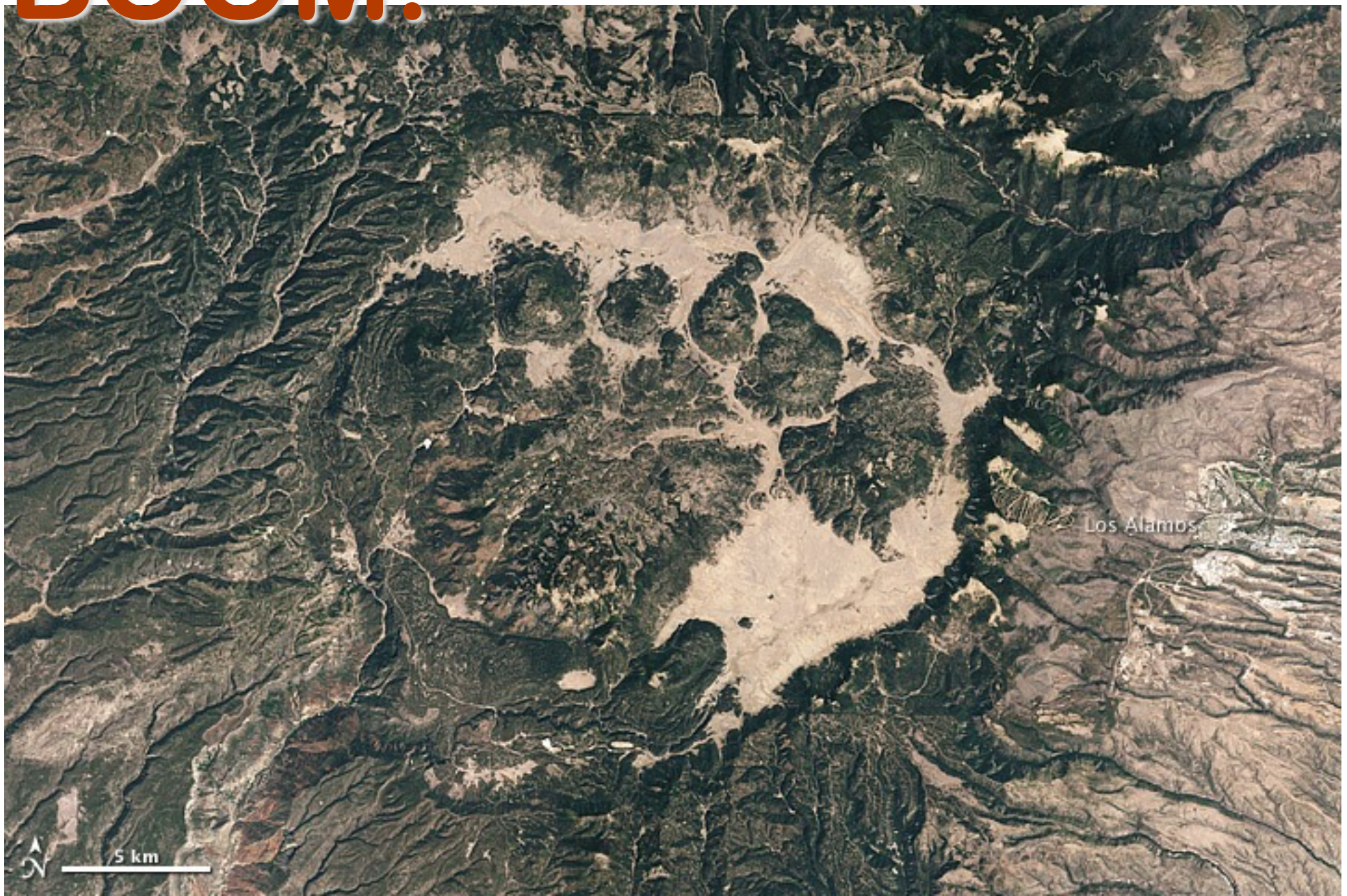
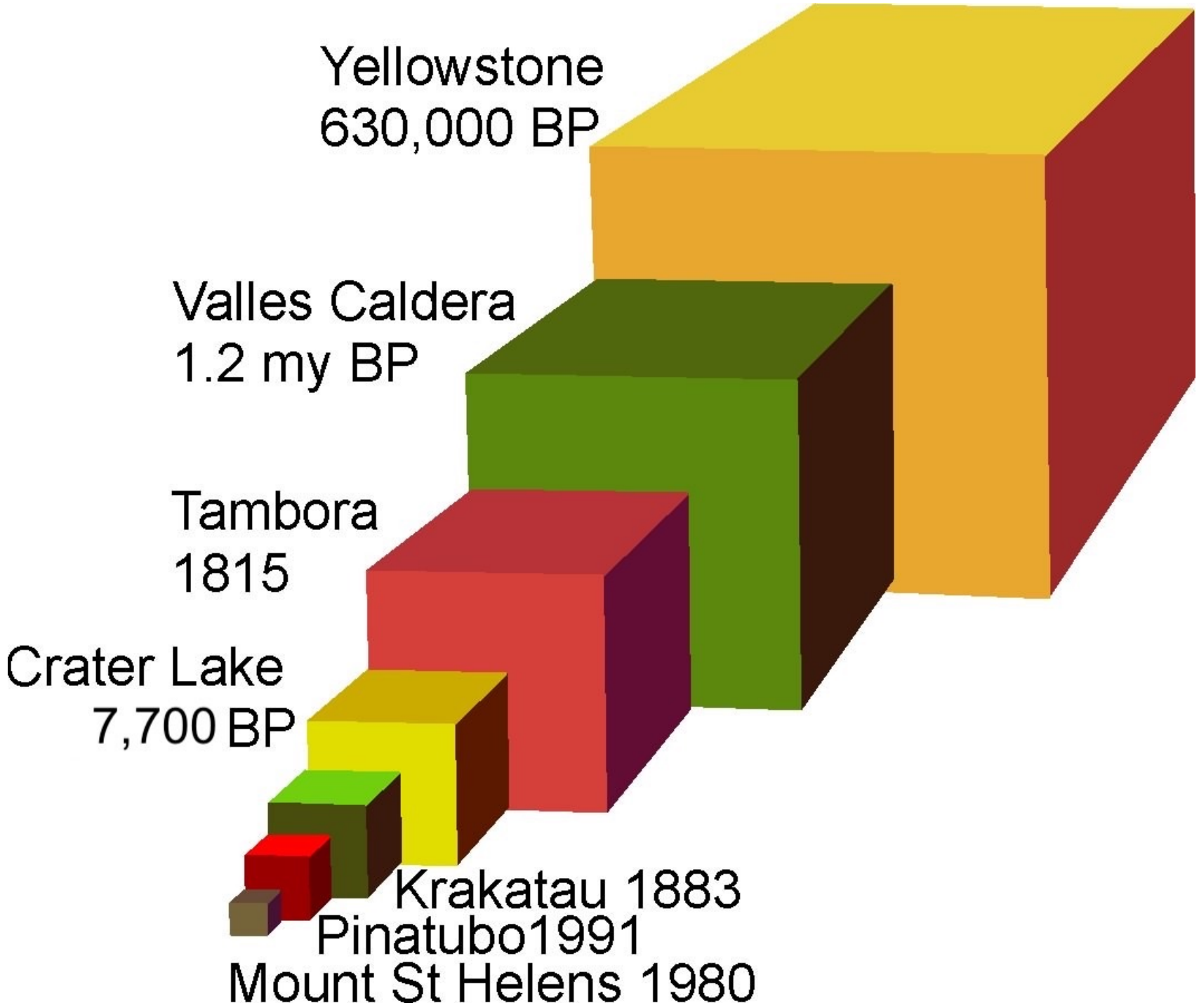
   (volcanic eruptions; last 14 my)

4. BOOM!

Past 14 million years



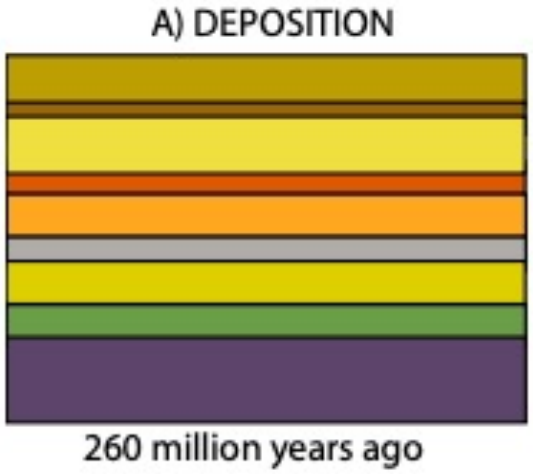
Huge Volumes of Eruptive Material



Colorado Plateau

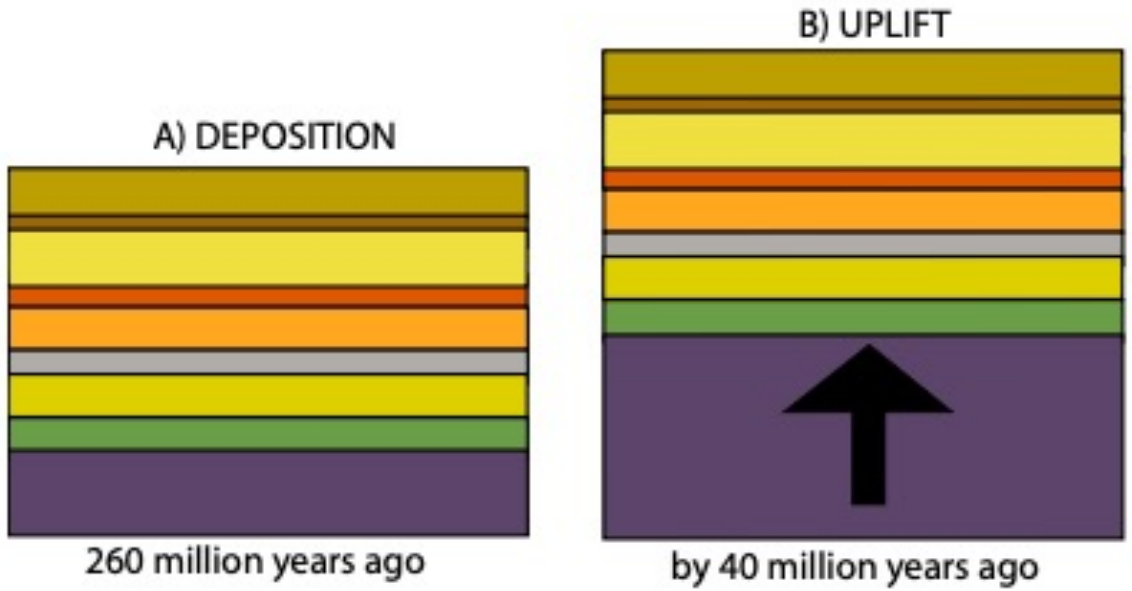

What the Heck Happened Here?

What the Heck Happened Here?



A) Oceans came & went, depositing layers of sand, clay, & seashells over & over again for 100s of millions of years

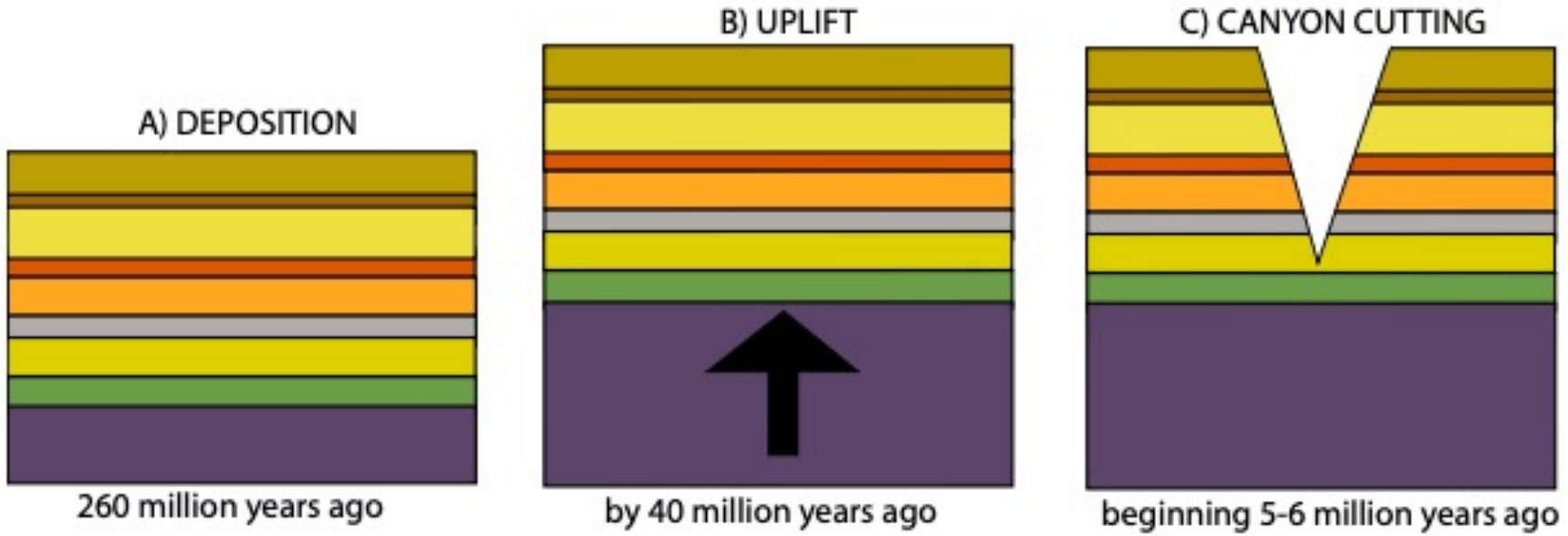
What the Heck Happened Here?



A) Oceans came & went, depositing layers of sand, clay, & seashells over & over again for 100s of millions of years

B) Land rose like an elevator, lifting intact layers of rock a mile high

What the Heck Happened Here?

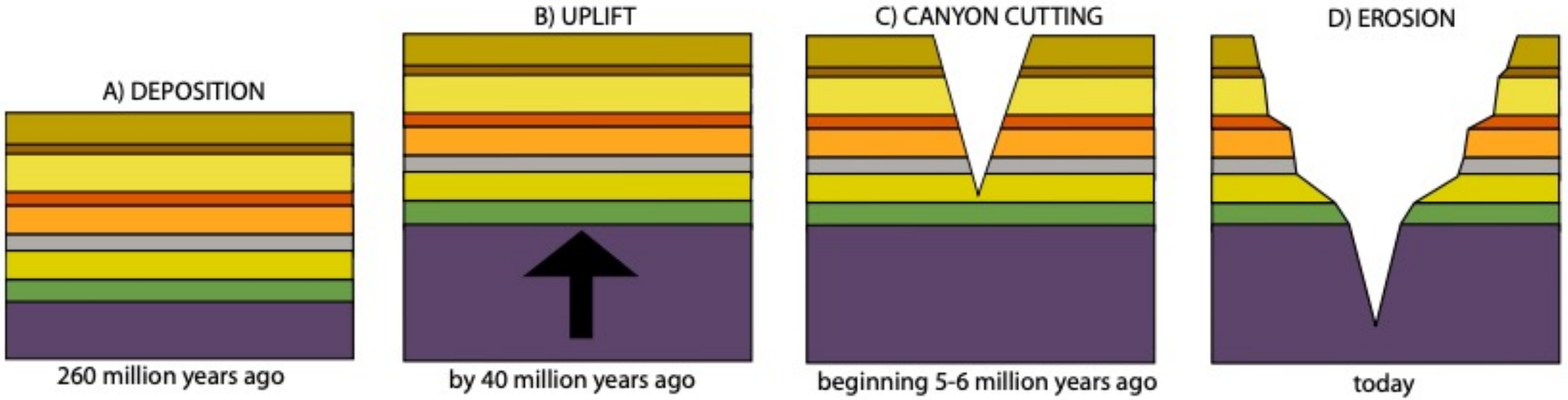


A) Oceans came & went, depositing layers of sand, clay, & seashells over & over again for 100s of millions of years

B) Land rose like an elevator, lifting intact layers of rock a mile high

C) The Colorado River cut down through the layers like a knife

What the Heck Happened Here?



A) Oceans came & went, depositing layers of sand, clay, & seashells over & over again for 100s of millions of years

B) Land rose like an elevator, lifting intact layers of rock a mile high

C) The Colorado River cut down through the layers like a knife

D) Raindrops and rivulets scooped rock & soil from the canyon walls, washing it down to the flatlands and the Sea of Cortez

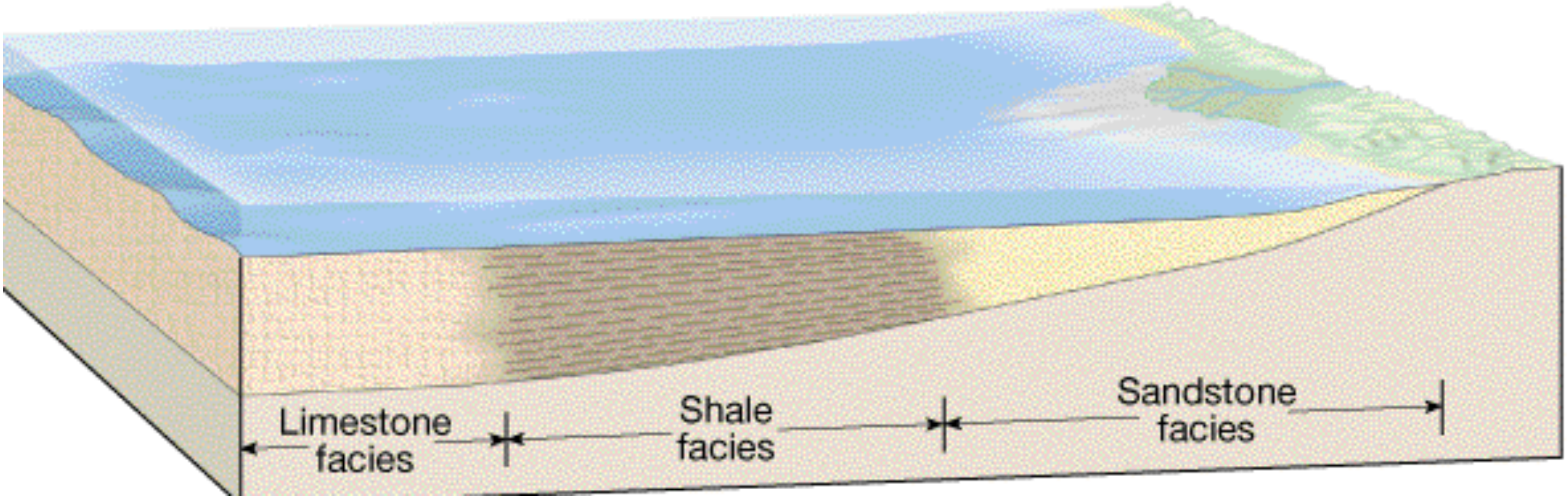
Stacking up the layers

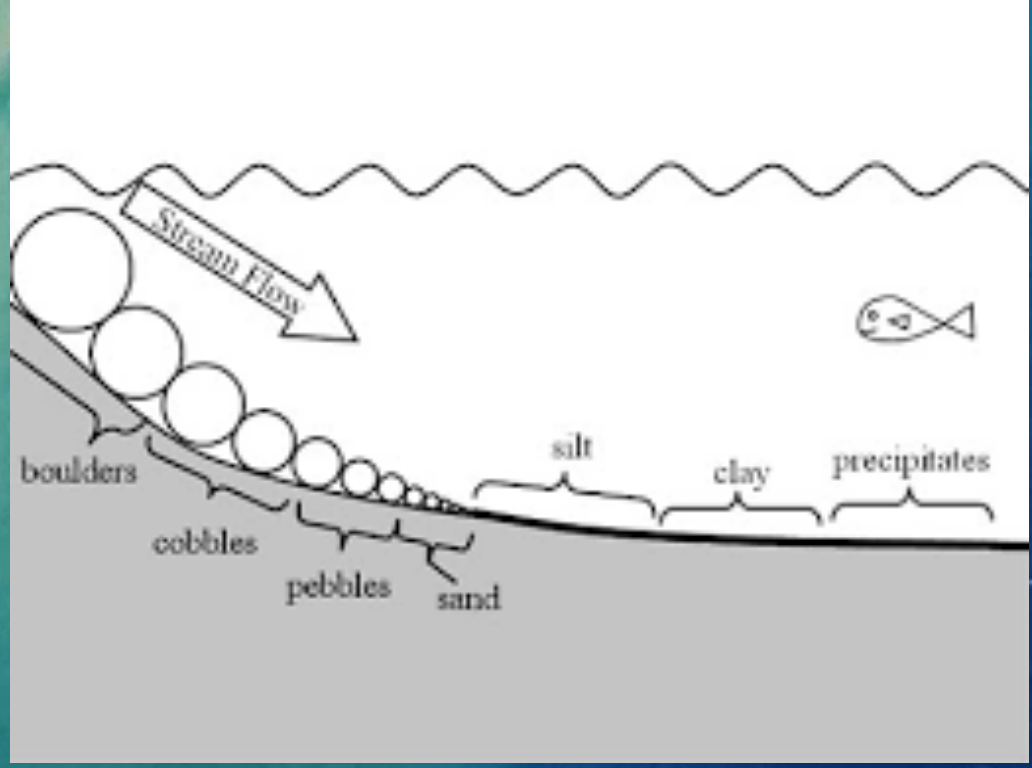
Hundreds of millions of years
Ocean comes in …
… Ocean goes out

Slicing Down through the Cake

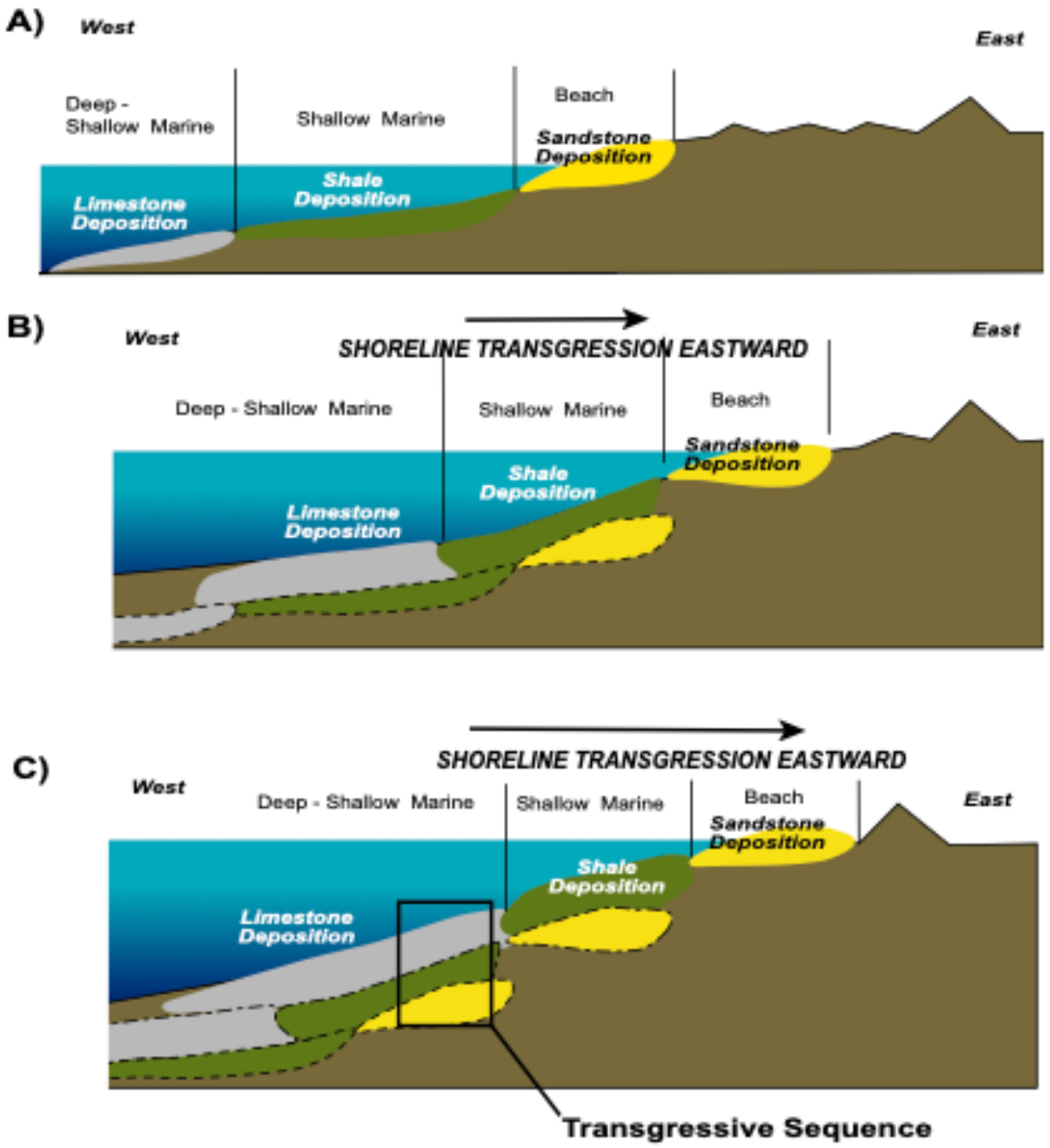
ONIONS HAVE LAYERS.
OGRES HAVE LAYERS.

Most Colorado Plateau Rocks formed at the Bottom of the Sea!

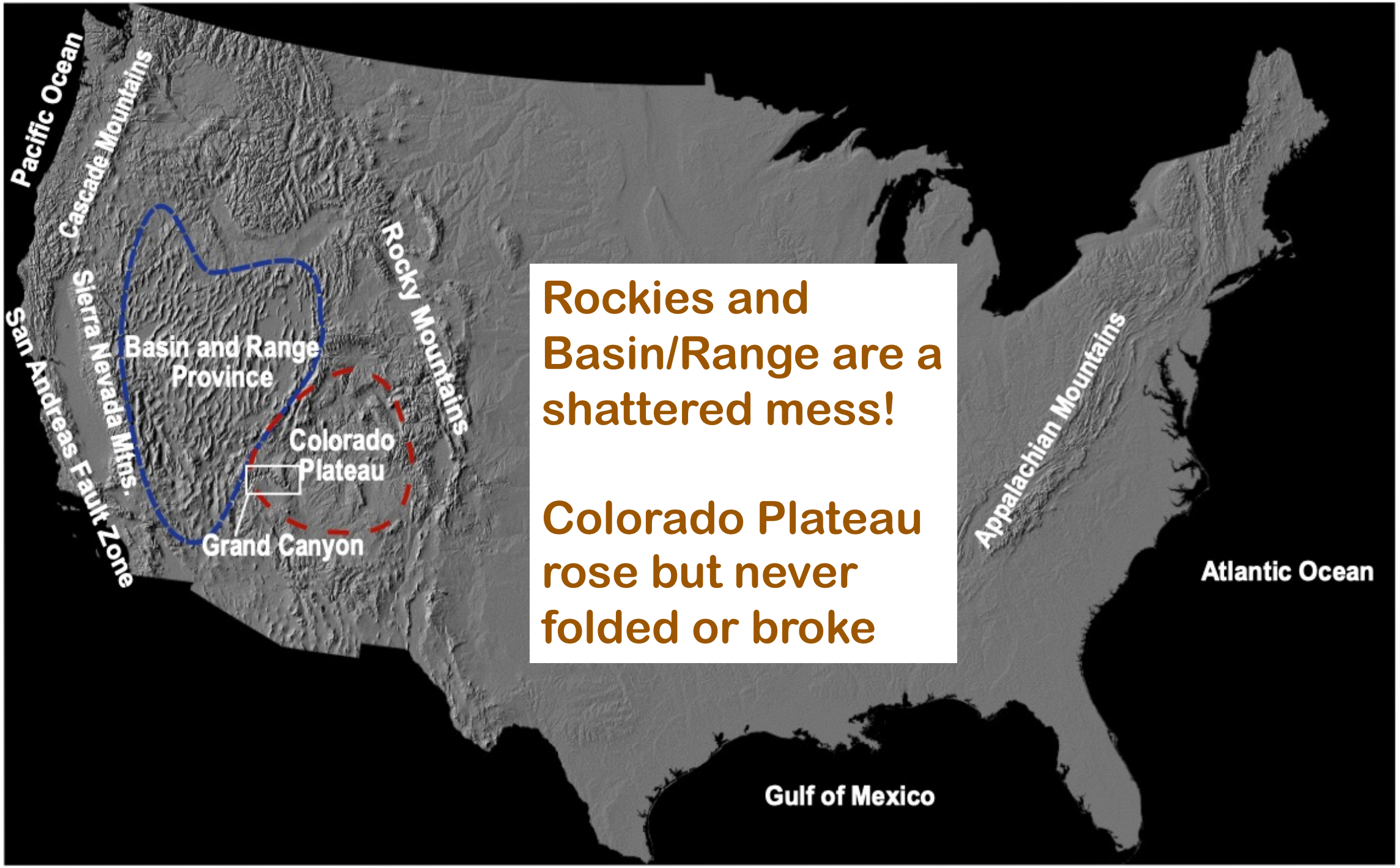




Sand -> Silt -> Clay -> Lime



Continents Drift Around, Oceans Rise & Fall

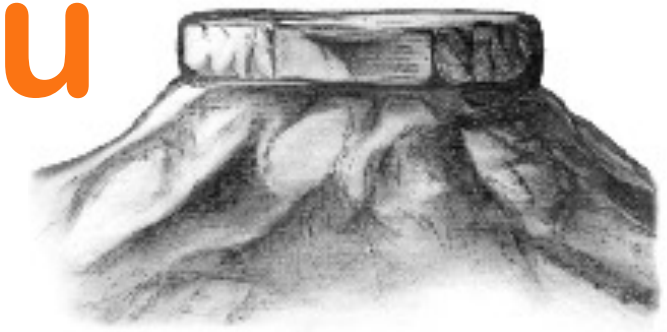

Pacific Ocean
Cascade Mountains
Sierra Nevada Mtns.
San Andreas Fault Zone
Basin and Range Province
Rocky Mountains
Colorado Plateau
Grand Canyon
Appalachian Mountains
Atlantic Ocean
Gulf of Mexico
Rockies and Basin/Range are a shattered mess!
Colorado Plateau rose but never folded or broke

The Colorado Plateau

"Erosion sculpts the flat layers of rock
from *plateau*
to *mesa*
to *butte*
to *monument*
to *memory*"

James Michener

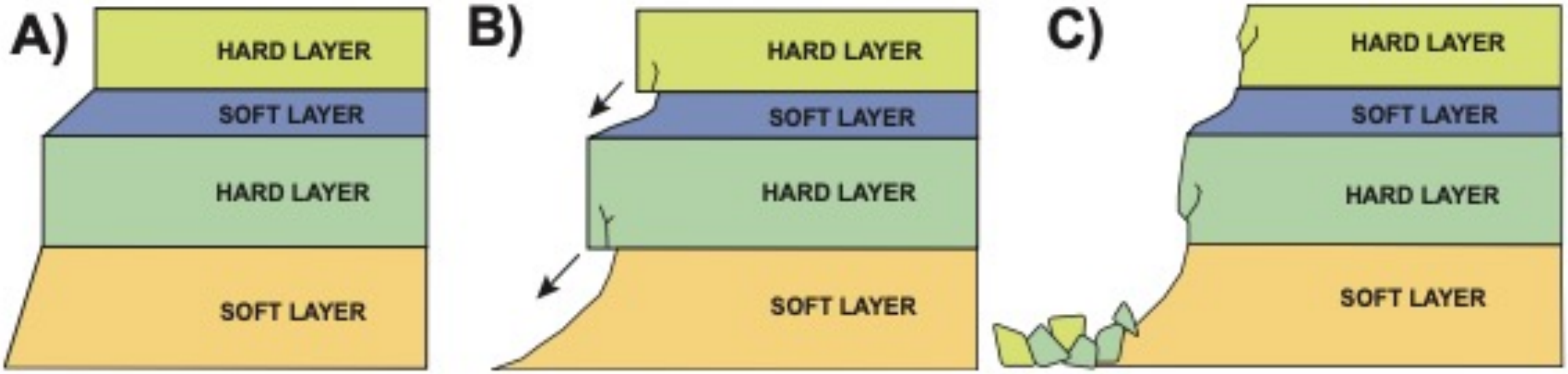
Mesa



Butte

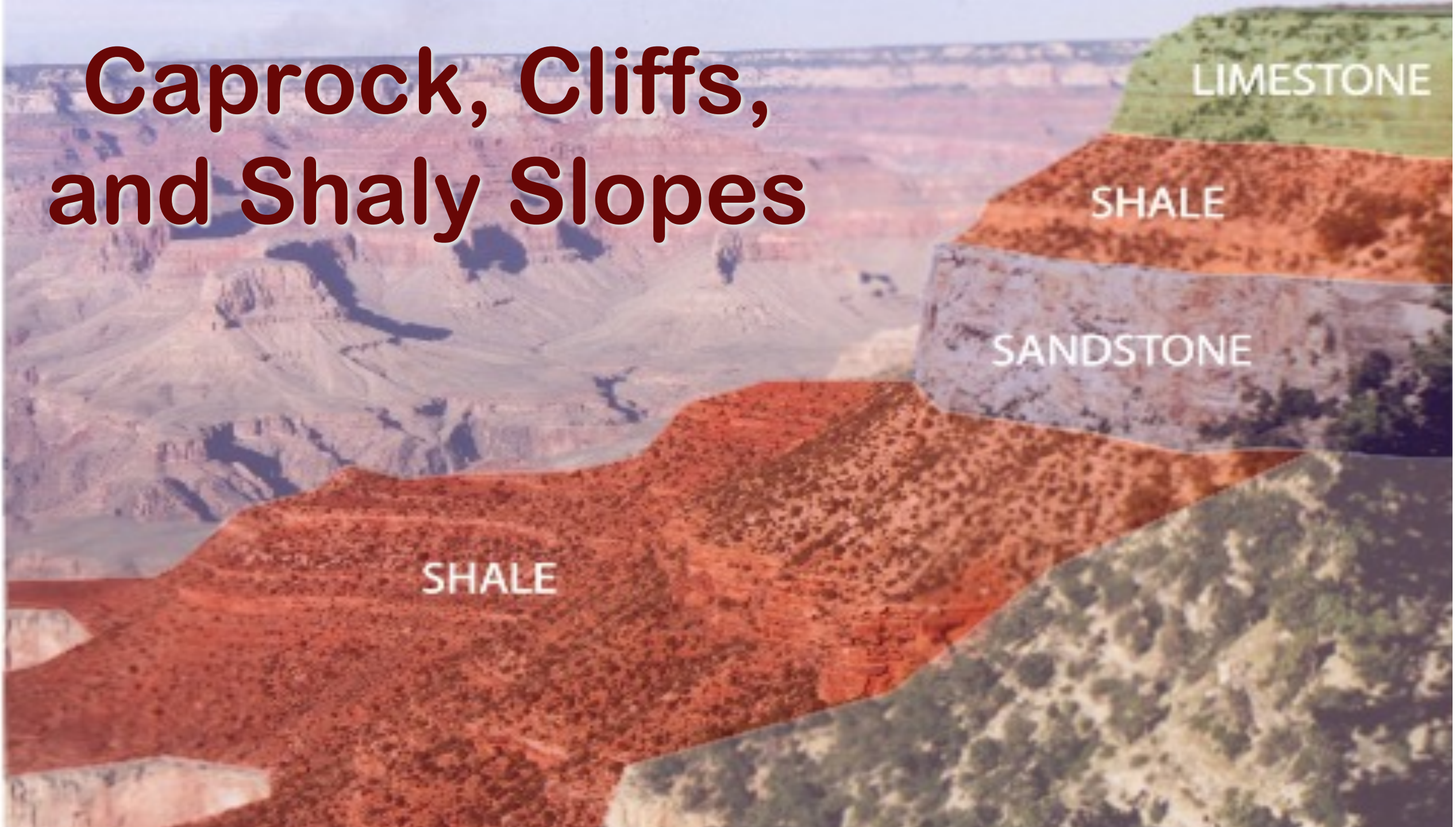
Spire (Temple)

Widening the Canyons
Building the Stair-Steps

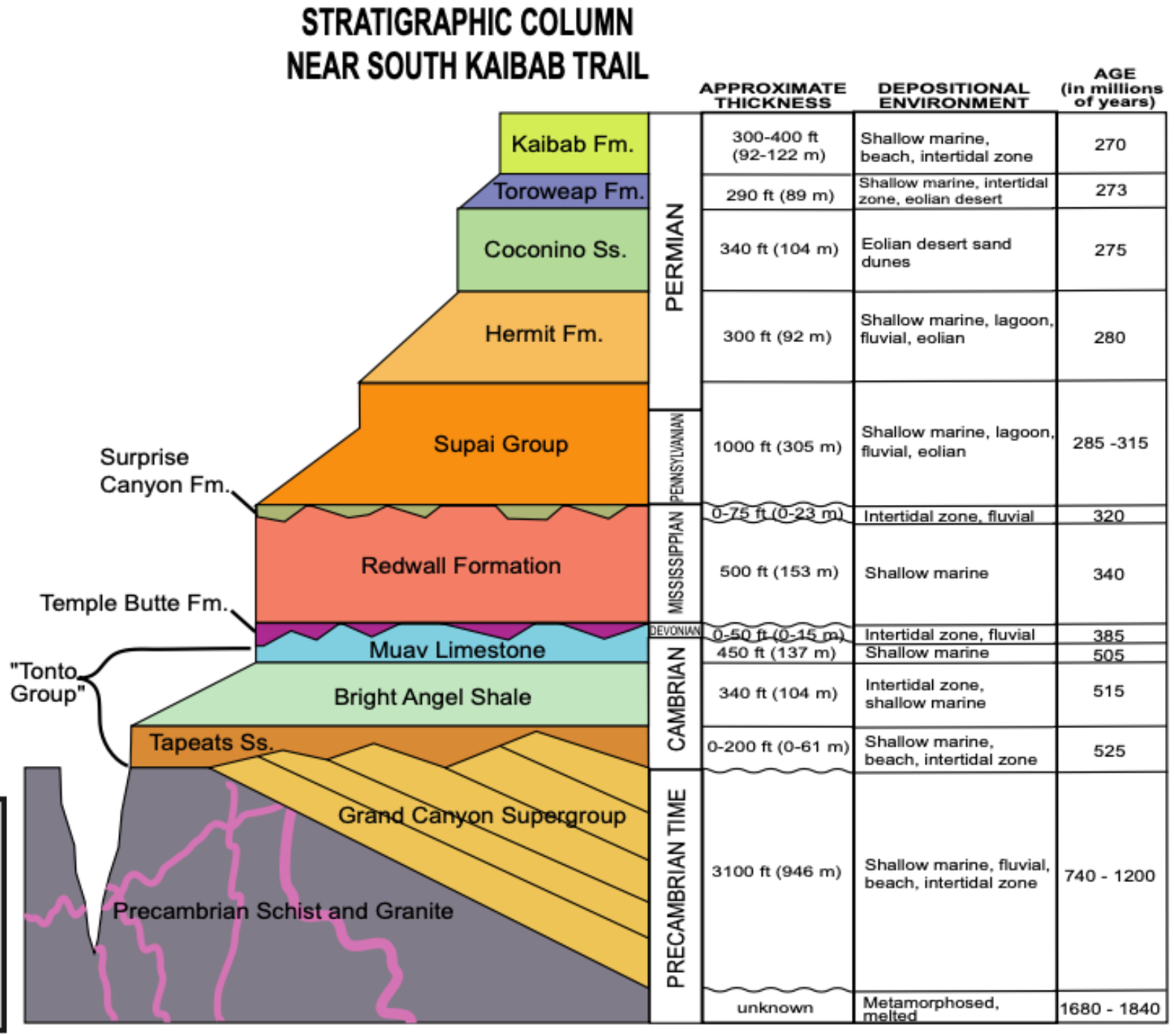


HARD LAYER – SANDSTONE – Near-shore, wave action, (the beach!)
SOFT LAYER – SHALE – Deeper water, fine silt & clay drifting down (sea-bottom mud)
HARD LAYER – LIMESTONE – Deep water, sea shells , corals, (fossils)

Caprock, Cliffs, and Shaly Slopes



Layers of Time Open Like a Book

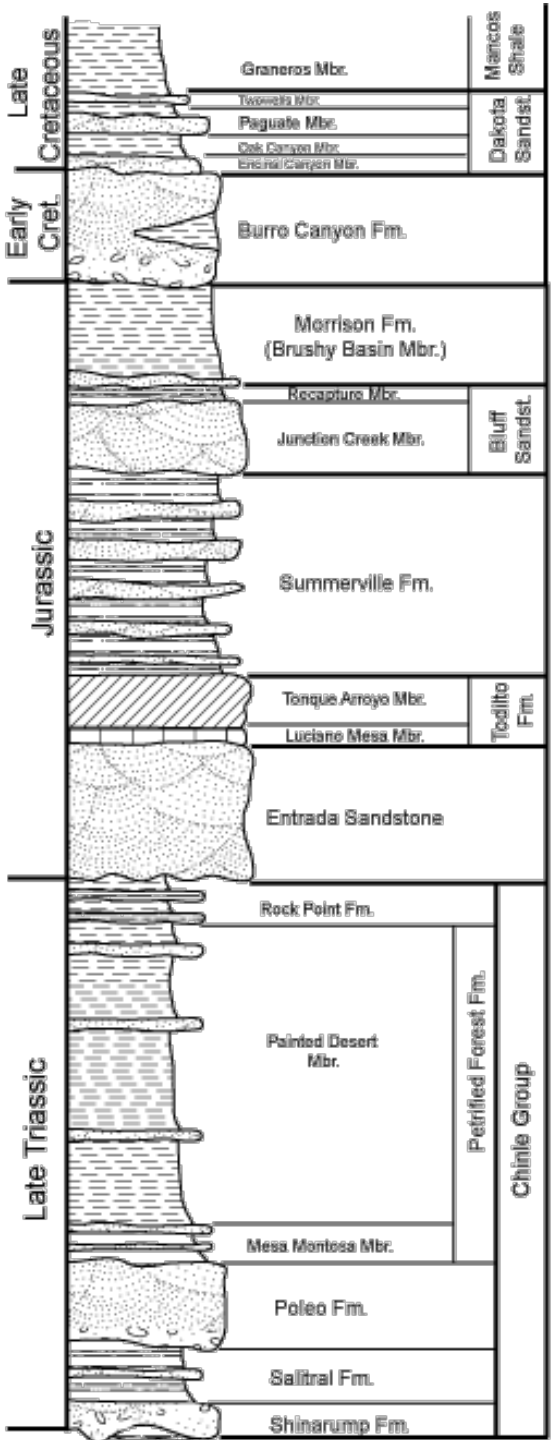


It's a different canyon down there. The rocks of the inner canyon do not have the classic stair-step appearance that is characteristic of the upper layers of Grand Canyon. The inner canyon is steep and narrow because of the metamorphic and igneous rocks. They are not composed of alternating soft and hard layers as are the sedimentary rocks of the upper canyon. The igneous and metamorphic rocks are hard and very resistant to weathering so they do not easily erode to form gentle slopes. It is difficult (but not impossible) for water to break down and smooth out the hard inner canyon walls, even for the raging Colorado River.

66 million yr

Mesozoic Era

225 million yr



Stratigraphy of Ghost Ranch

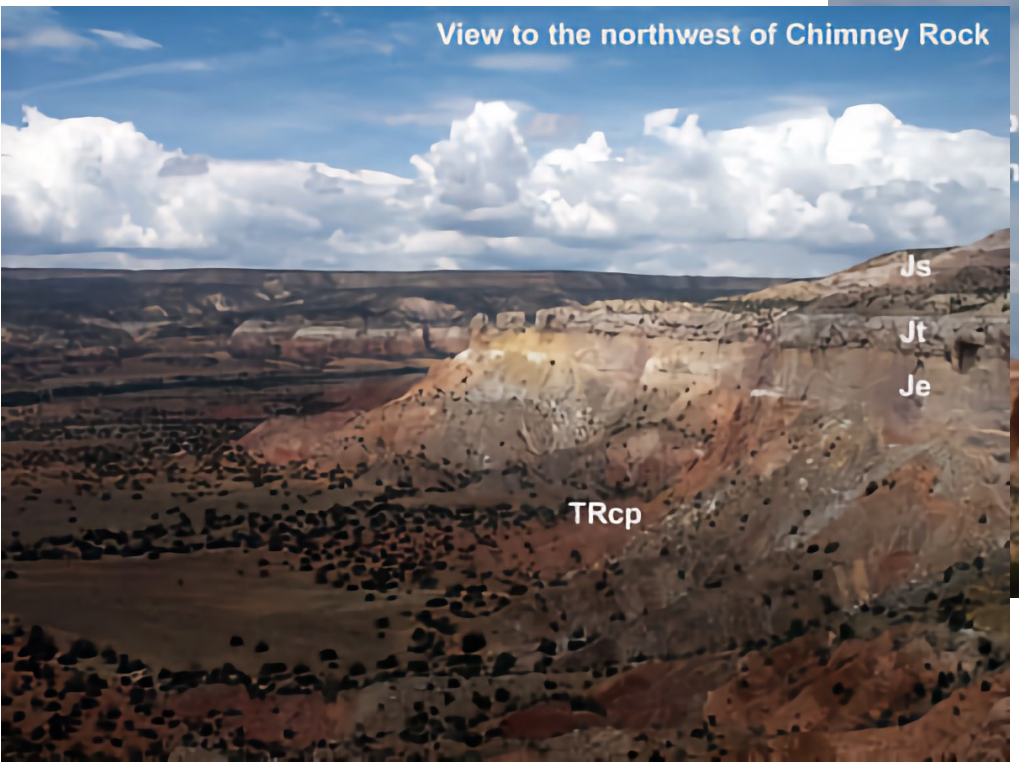
Spencer G. Lucas and Kate E. Zeigler

Key

- Conglomerate
- Crossbedded sandstone
- Siltstone
- Mudstone
- Limestone
- Gypsum

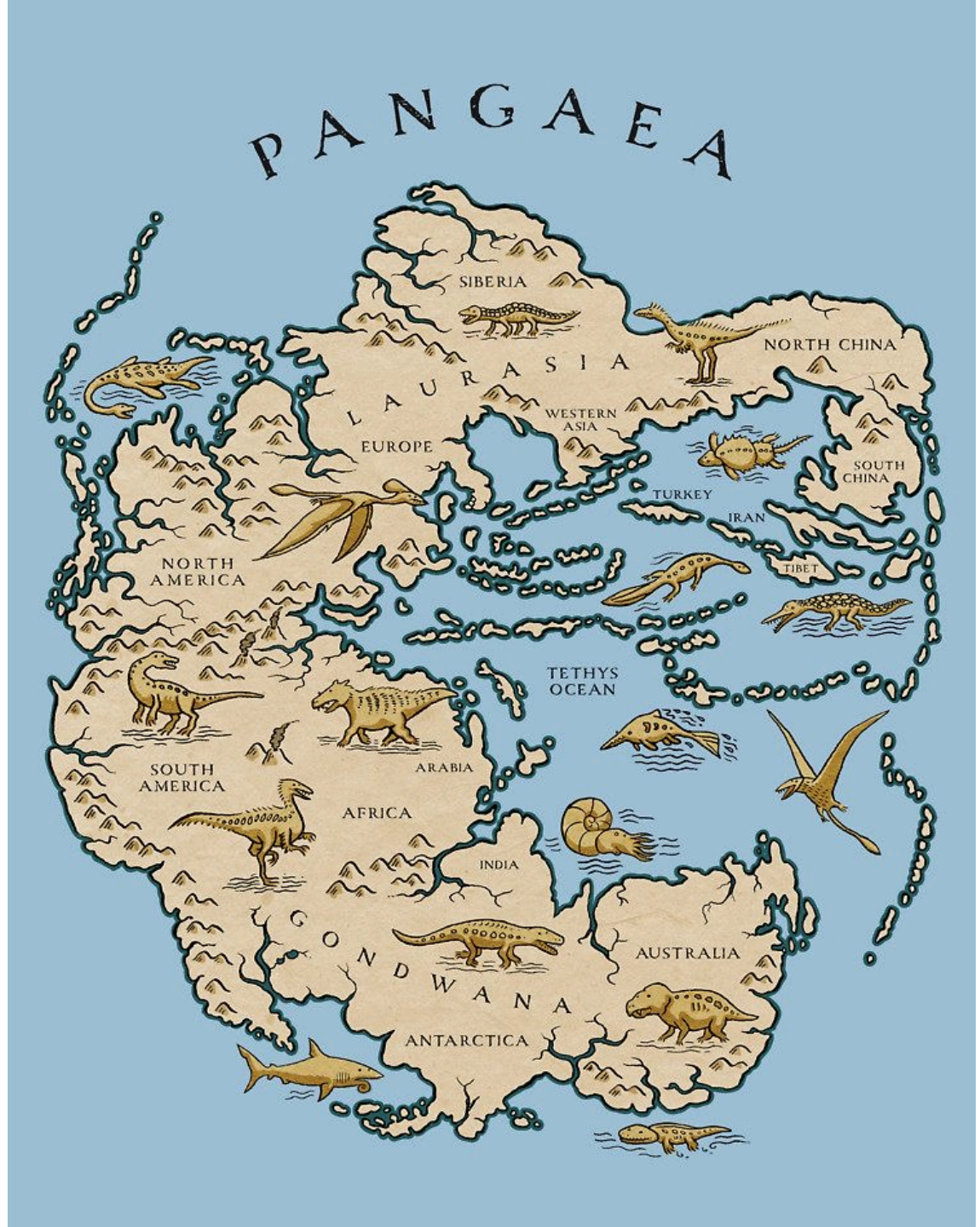
20 m

Chapters of the Story of Ghost Ranch



Triassic & Jurassic Rocks

Triassic and Jurassic sedimentary rocks form this cliff near the Box Canyon trail at Ghost Ranch. The brick-red Chinle Group at the base of the cliff is overlain by red, white, and yellow-banded Jurassic Entrada Formation. The banding is caused by variable chemical reactions with iron within the sandstone. The cliff is capped by gray Todilto Formation.


PANGAEA
SIBERIA
NORTH CHINA
LAURASIA
WESTERN ASIA
EUROPE
SOUTH CHINA
TURKEY
IRAN
TIBET
NORTH AMERICA
TETHYS OCEAN
ARABIA
SOUTH AMERICA
AFRICA
INDIA
GONDWANA
AUSTRALIA
ANTARCTICA

Jurassic Entrada Sand Dune Field

was desiccated when
gion, as evidenced by the
roup. The Entrada

The Jurassic Entrada Sandstone dune field extended hundreds of miles to the northwest.

Echo Amphitheater is cut into the Jurassic Entrada Formation. This rock unit is underlain by brick-red Chinle (lower right) and overlain by Todilto Formation.

Chavez Slot Canyons

Chavez Slot Canyons

Cretaceous Seaway