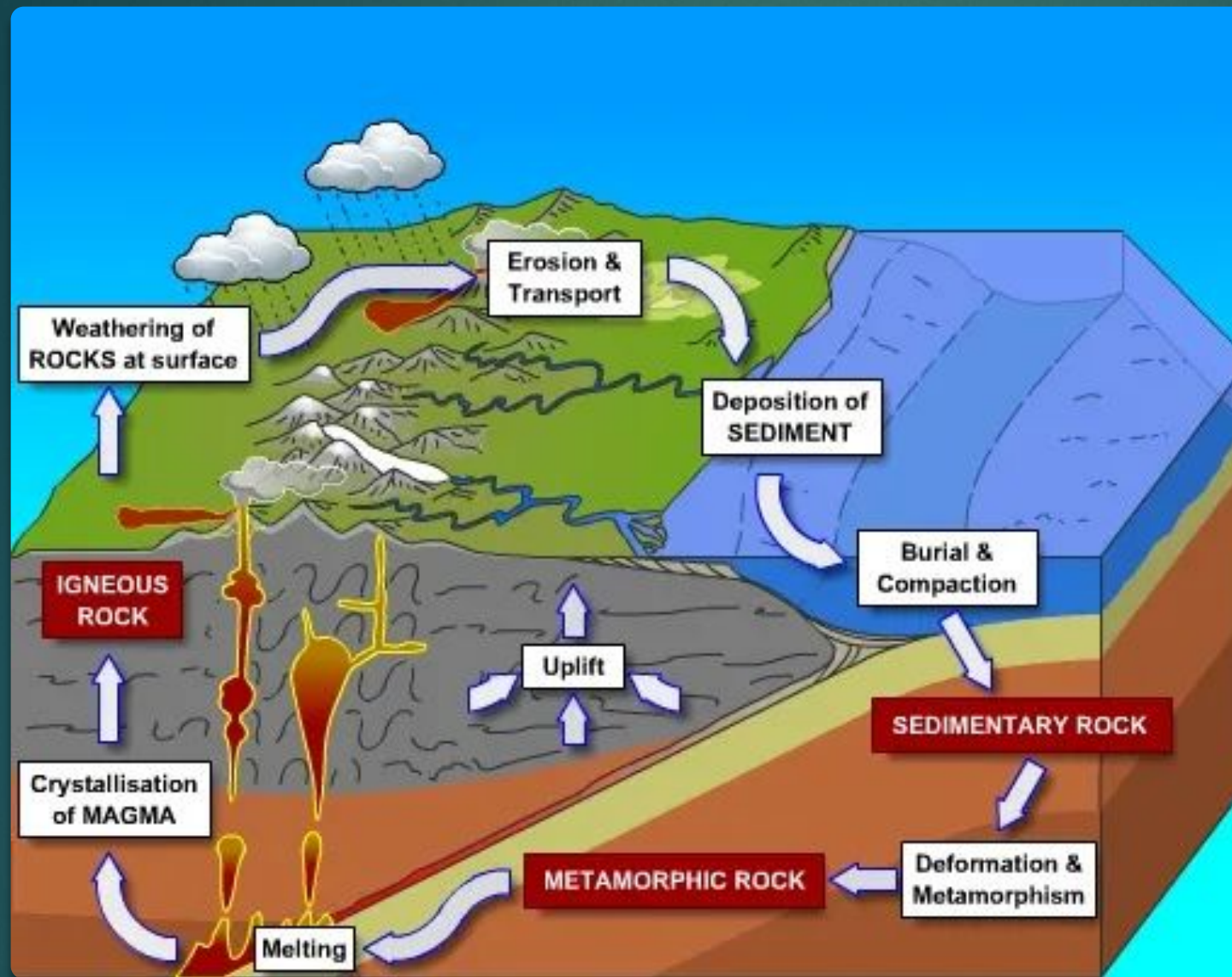




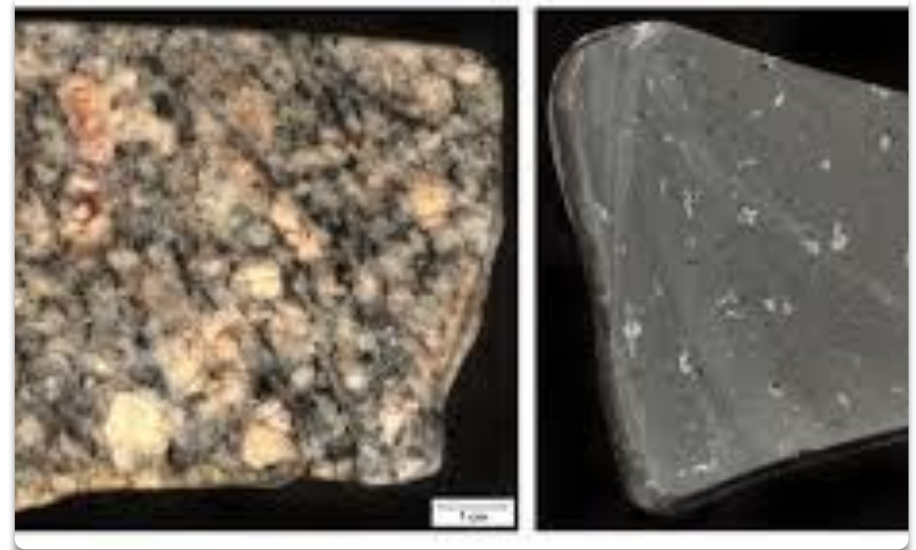
# Stratigraphy and Steno's Laws



# Rock Reveiw

# Igneous Rocks

- ▶ **Rocks that form from cooling magma**
  - ▶ Extrusive igneous rocks form at the Earth's surface and create fine grained textures
  - ▶ Intrusive (plutonic) igneous rocks form beneath the Earth's surface and create coarse grained textures



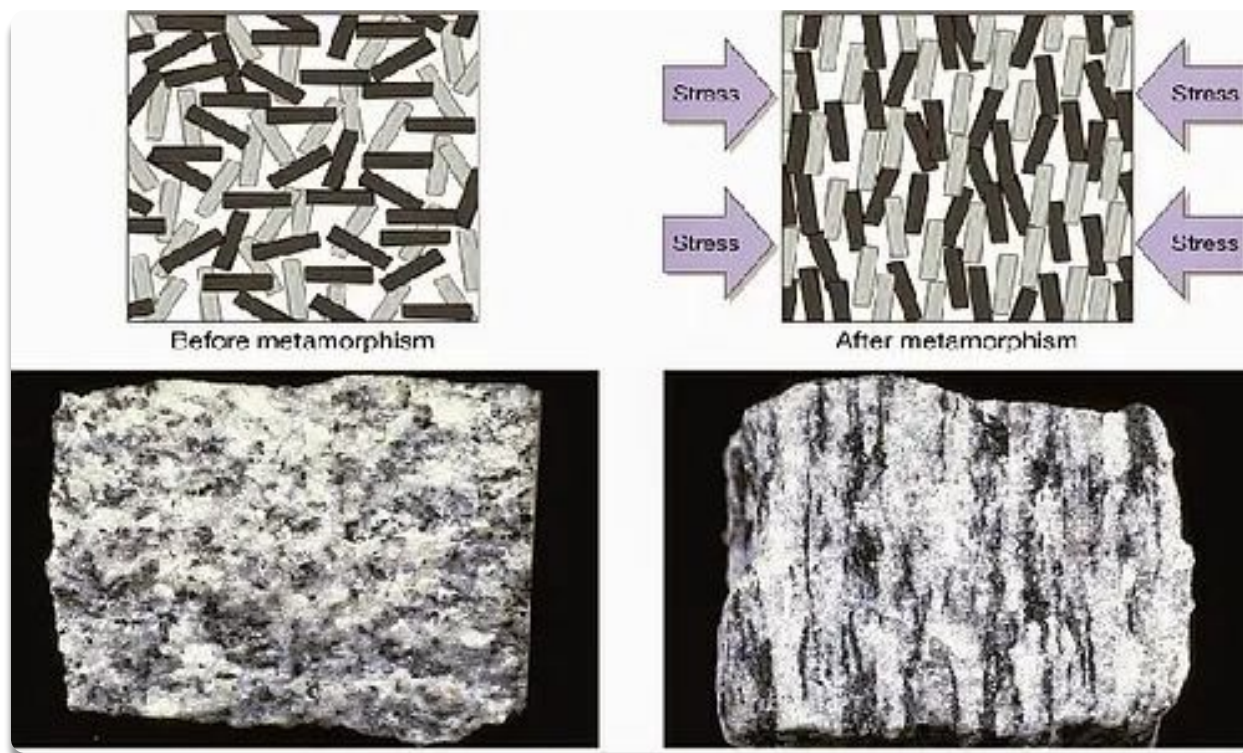
# Metamorphic Rocks



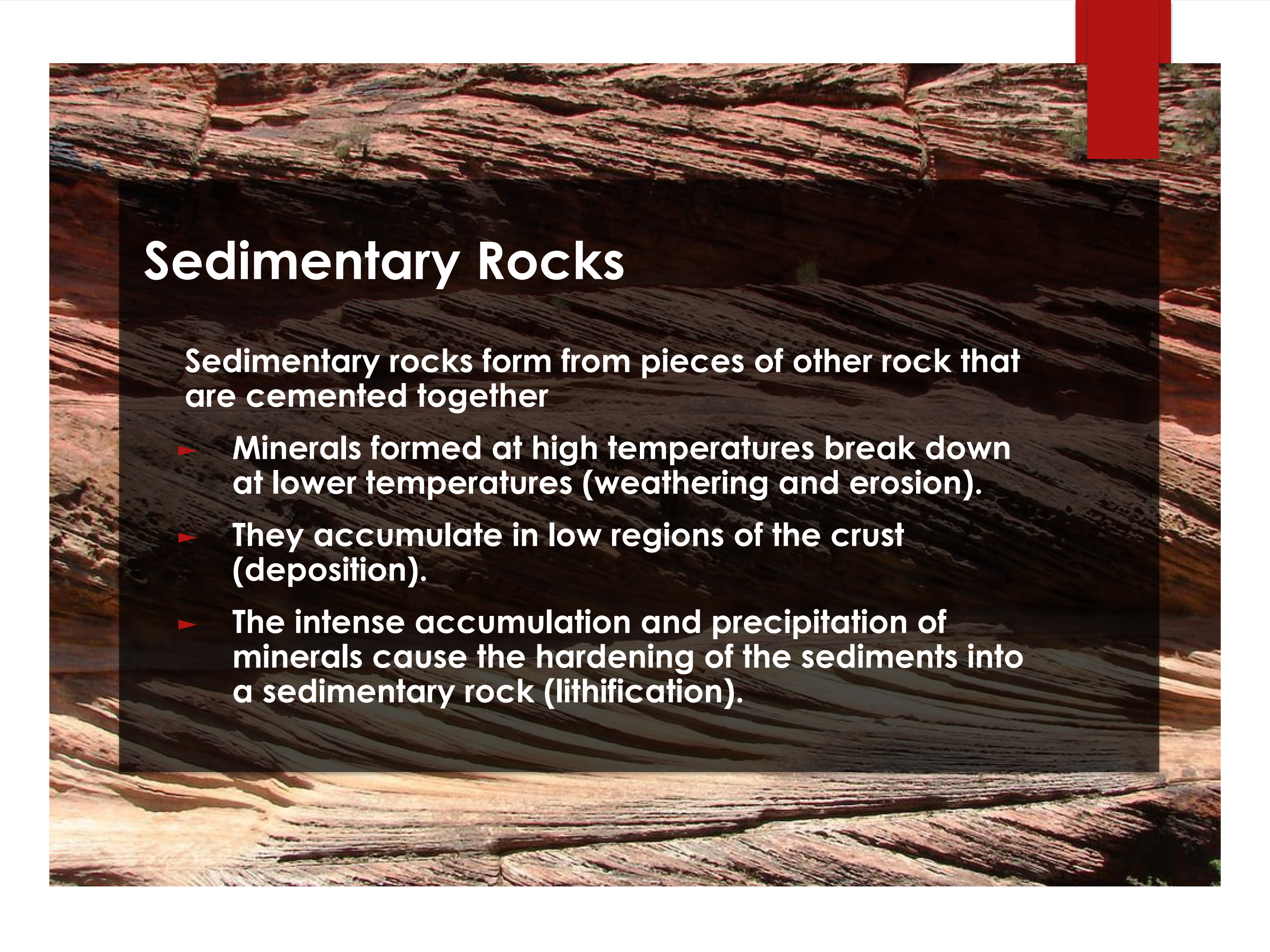
Rocks that have been altered physically and/or chemically by:

- ▶ Pressure
- ▶ Temperature
- ▶ Chemical reaction with fluids

# Metamorphic Textures: Foliation



- ▶ Foliation is a preferred orientation of elongated mineral grains within a rock
- ▶ Degree of foliation often increases with metamorphic grade



# Sedimentary Rocks

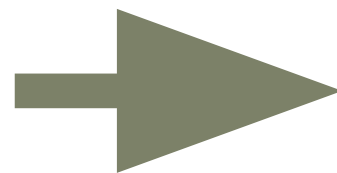
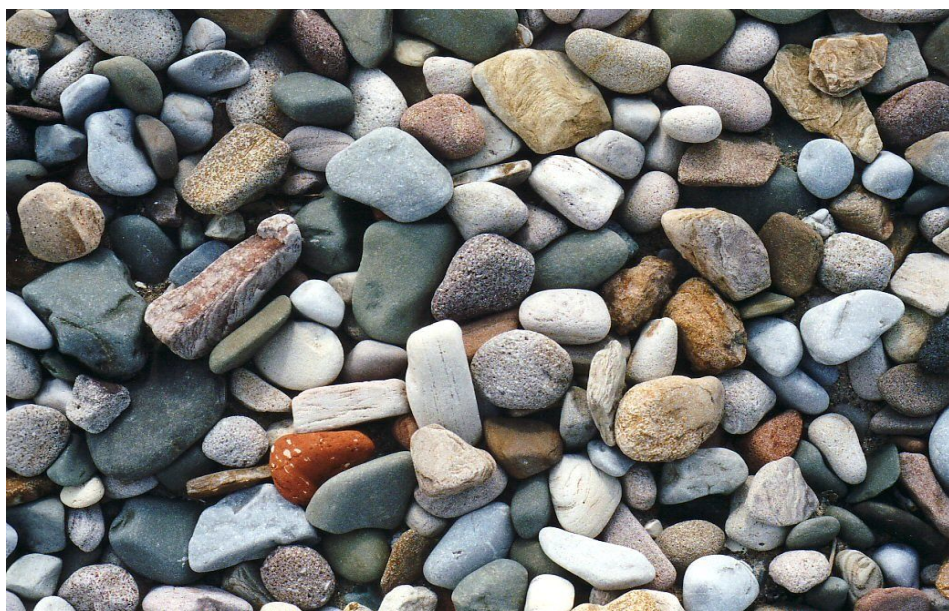
**Sedimentary rocks form from pieces of other rock that are cemented together**

- ▶ **Minerals formed at high temperatures break down at lower temperatures (weathering and erosion).**
- ▶ **They accumulate in low regions of the crust (deposition).**
- ▶ **The intense accumulation and precipitation of minerals cause the hardening of the sediments into a sedimentary rock (lithification).**

# Lithification Process

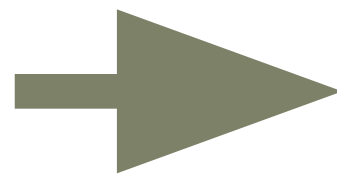
Weathering breaks source materials down into sediment.

Sediments are loose rock fragments, mineral grains, & hard biological matter.



Sedimentary rocks are formed from the deposition, compaction (squeezing), and cementation (gluing together) of sediments called lithification.

*Pressure + Time +  
Cementation*



# Types of Sedimentary Rocks

## CLASTIC:

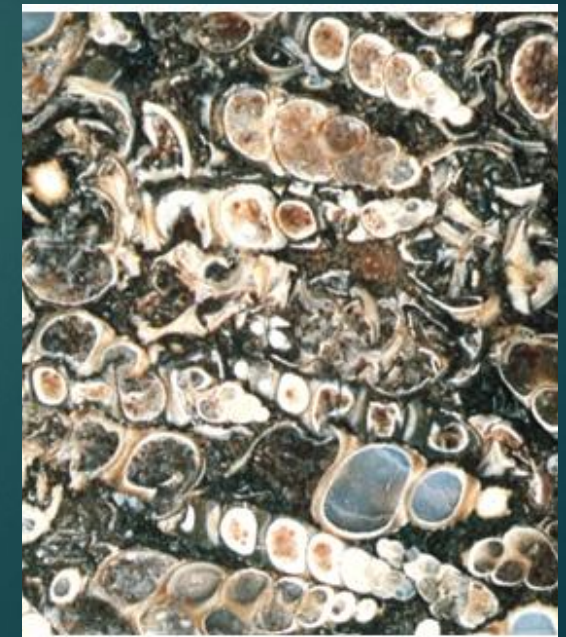
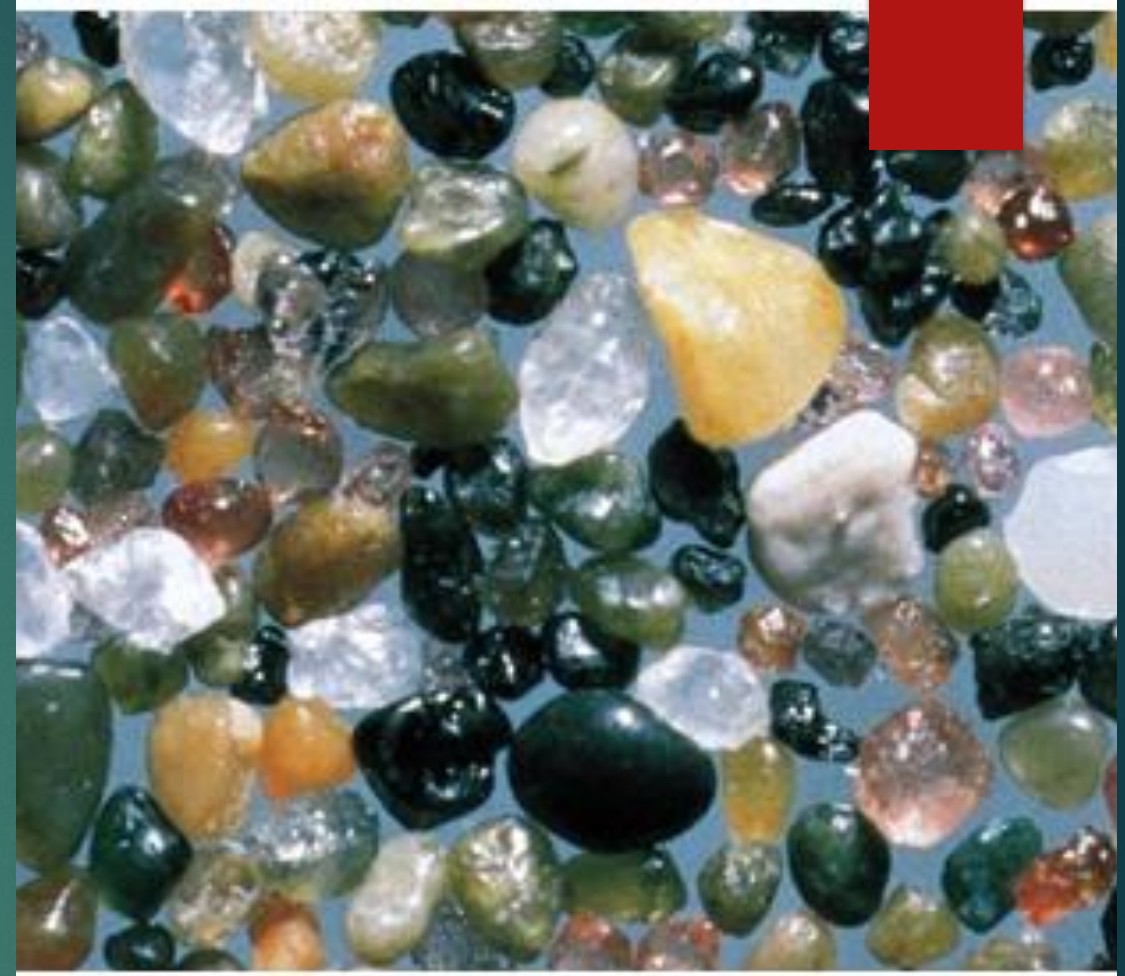
- Minerals and rock fragments named according to sediment grain sizes
- Ex: conglomerate, breccia, quartz sandstone, and shale

## CHEMICAL:

- Crystals that precipitate from water.
- Ex: Oolitic limestone and chert

## BIOCHEMICAL

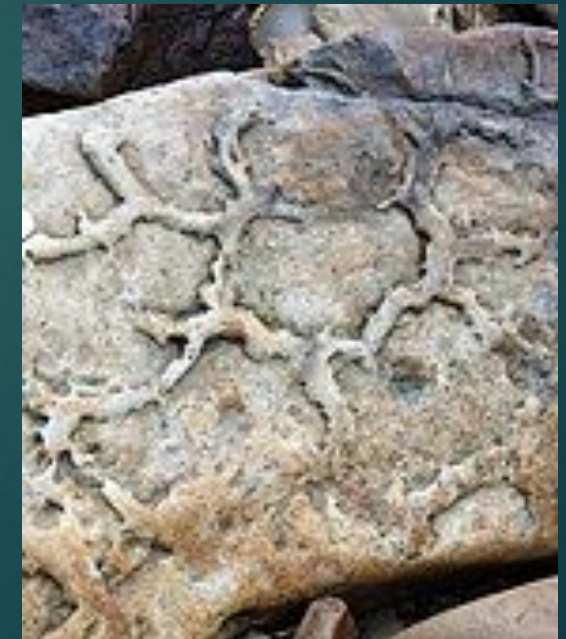
- Remains or fragments of organisms (shells, animals, plants). Fragments may be visible or small/microscopic.
- Often reacts with HCl (with exception of coal)
- Ex: Fossiliferous limestone, chalk, coquina, coal



# Depositional Clues

Sedimentary rocks give clues as to the environment in which they were deposited.

1. Grain size, sorting, and rounding:
  - Tell the distance from the source – well rounded, well sorted are carried further
  - Tell the amount of energy required – small grains indicate low energy source, large grains indicate high energy source
2. Structural features:
  - Deposition creates features that are preserved in the rock: cross bedding, ripple marks, mud-cracks
3. Fossils:
  - Tell types of organisms living in the environment (i.e. seashells =marine)



# Steno's Laws

## Six key principles

- Original horizontality
- Superposition
- Lateral continuity
- Cross-cutting relationships
- Inclusions
- Unconformities

# Principal of Original Horizontality

- ▶ Sedimentary rocks are laid down in horizontal layers
- ▶ Any tilting occurs after they form



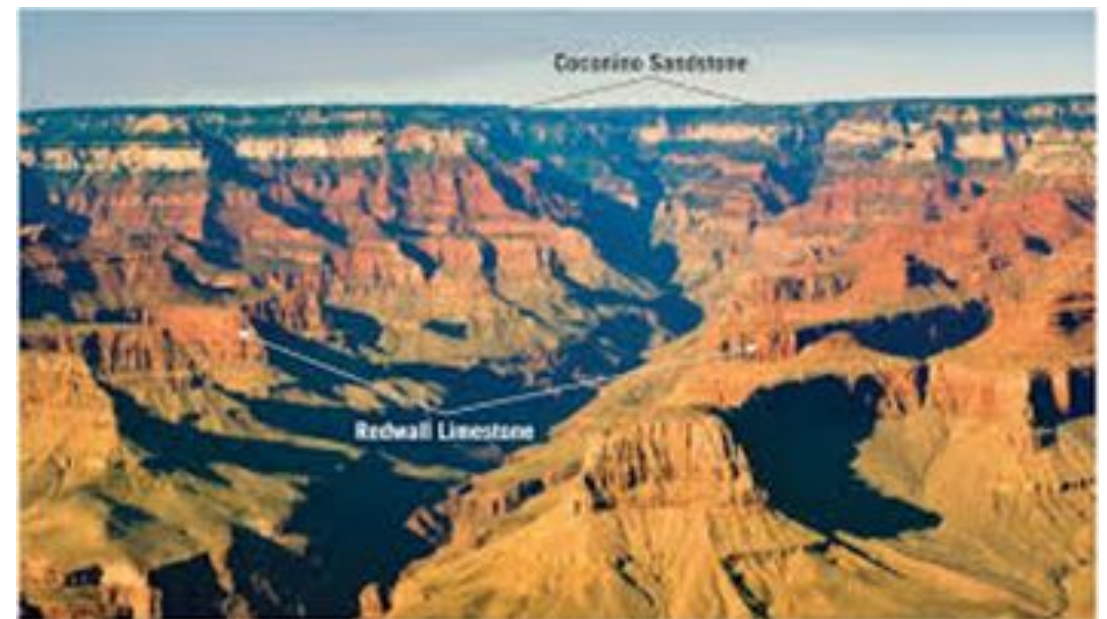
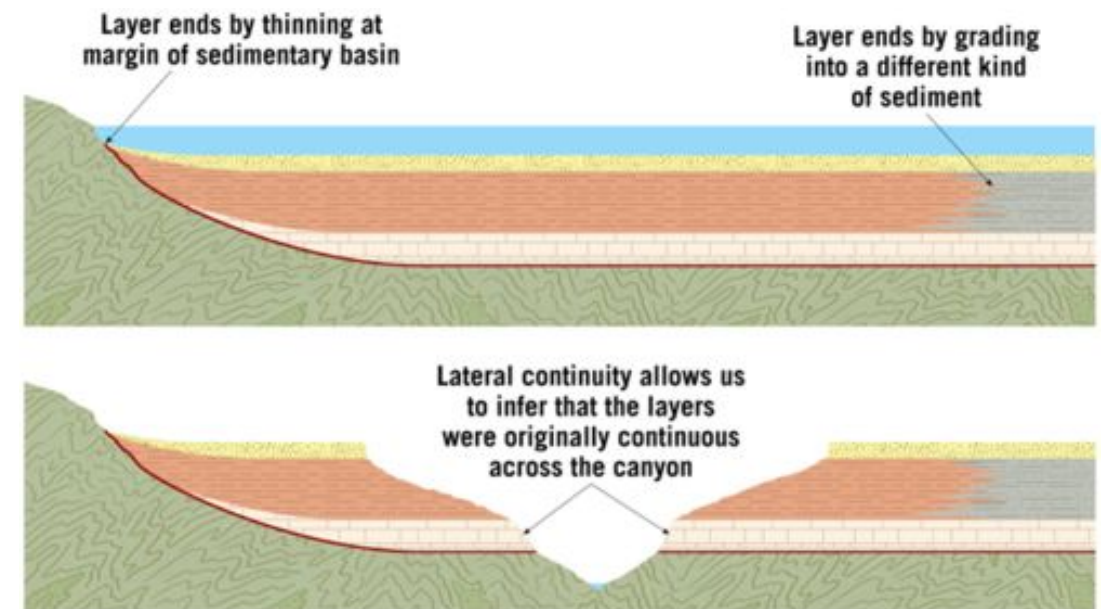
# Principle of Superposition

- ▶ Younger rocks are laid down on top of older rock in an undisturbed sequence.
- ▶ Therefore, rock layers on the bottom are older than rock layers on the top



# Principle of Lateral Continuity

- ▶ Sedimentary rock layer will continue until they:
  - ▶ Reach the end of the depositional basin
  - ▶ Thin out as deposition stops
- ▶ Later erosive events may leave gaps in the layers



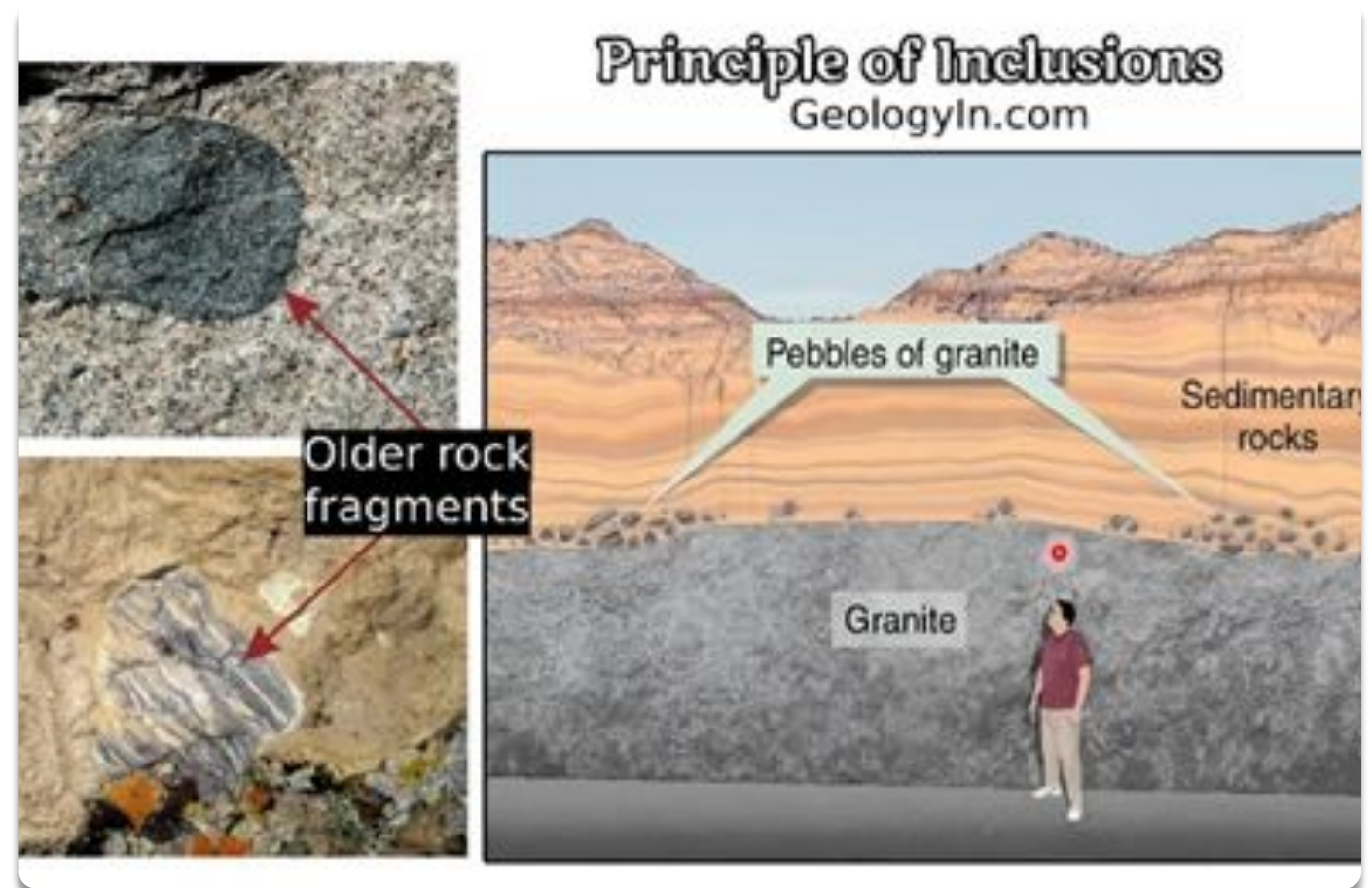
# Principle of Cross-cutting Relationships

- ▶ When magma intrudes into rock layers, it must be younger than the rocks it cuts across.
- ▶ Any igneous structure (pluton, dike, sill, etc.) is younger than the rock it intrudes
- ▶ Similarly, when a fault cuts across rock layers, it must be younger than the layers



# Principle of Inclusions

- ▶ Younger rock units may incorporate pieces of older rocks when they form.
  - ▶ i.e. pieces of surrounding rock may collapse into a mass of magma as the molten rock forces its way upward through the crust.
- ▶ These preserved pieces of rock are known as inclusions and are always older than the rock they are found in.



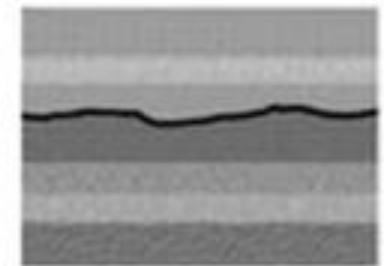
# Unconformities

- ▶ Unconformities are missing layers in the rock record that eroded away
- ▶ 3 Types:
  - ▶ Disconformity – sedimentary rocks are parallel above and below the unconformity surface
  - ▶ Nonconformity – sedimentary rocks are deposited over igneous or metamorphic rocks.
  - ▶ Angular unconformity – sedimentary rocks are deposited over underlying tilted layers.

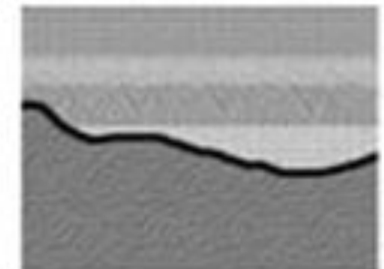
## TYPES OF UNCONFORMITY

- Three types of surfaces can be unconformities:

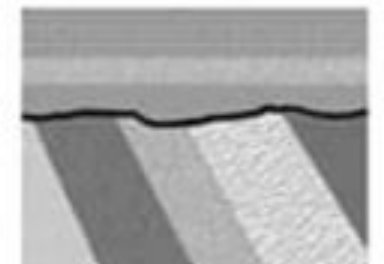
- A **disconformity** is a surface separating younger from older rocks, both of which are parallel to one another



- A **nonconformity** is an erosional surface cut into metamorphic or intrusive rocks and covered by sedimentary rocks

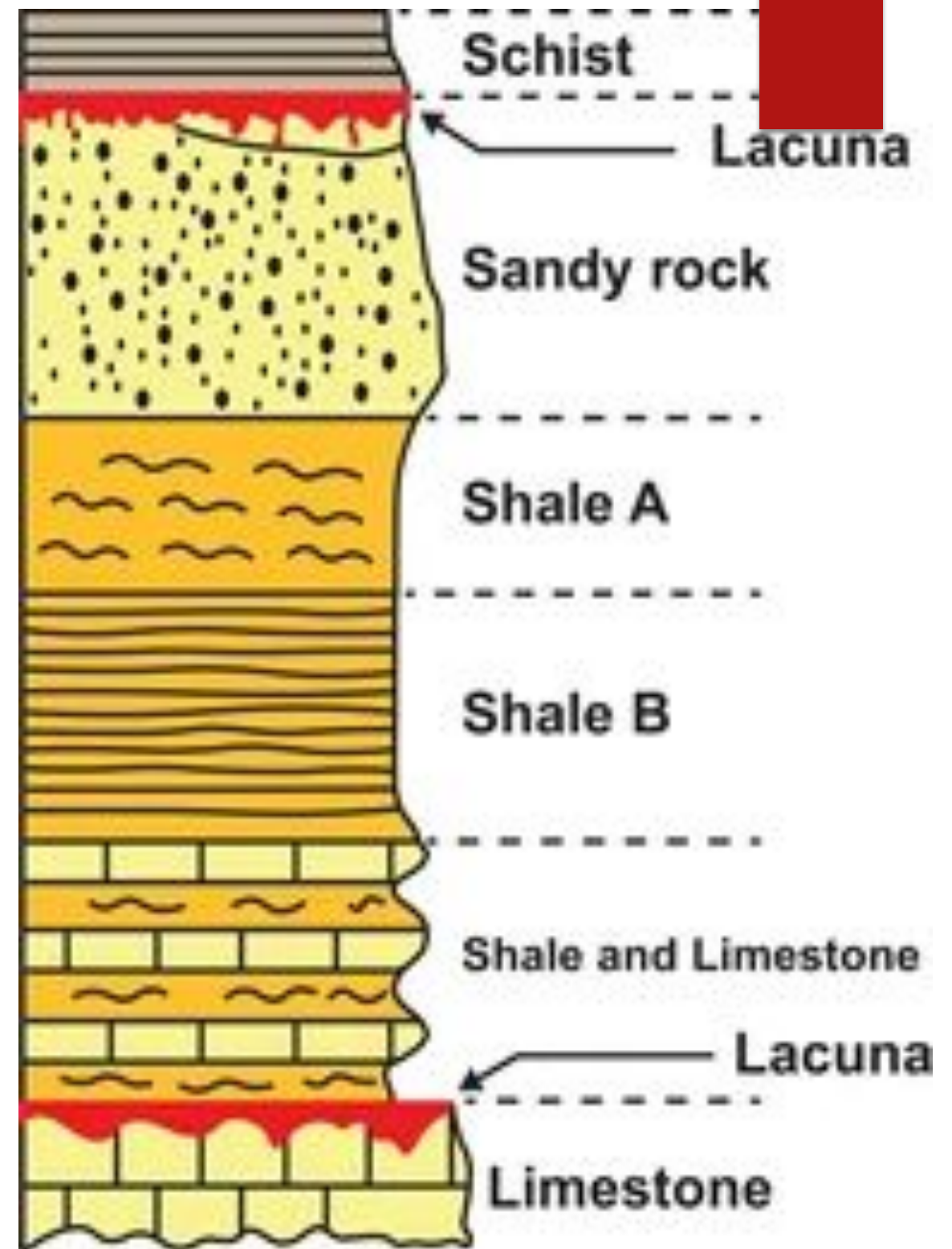


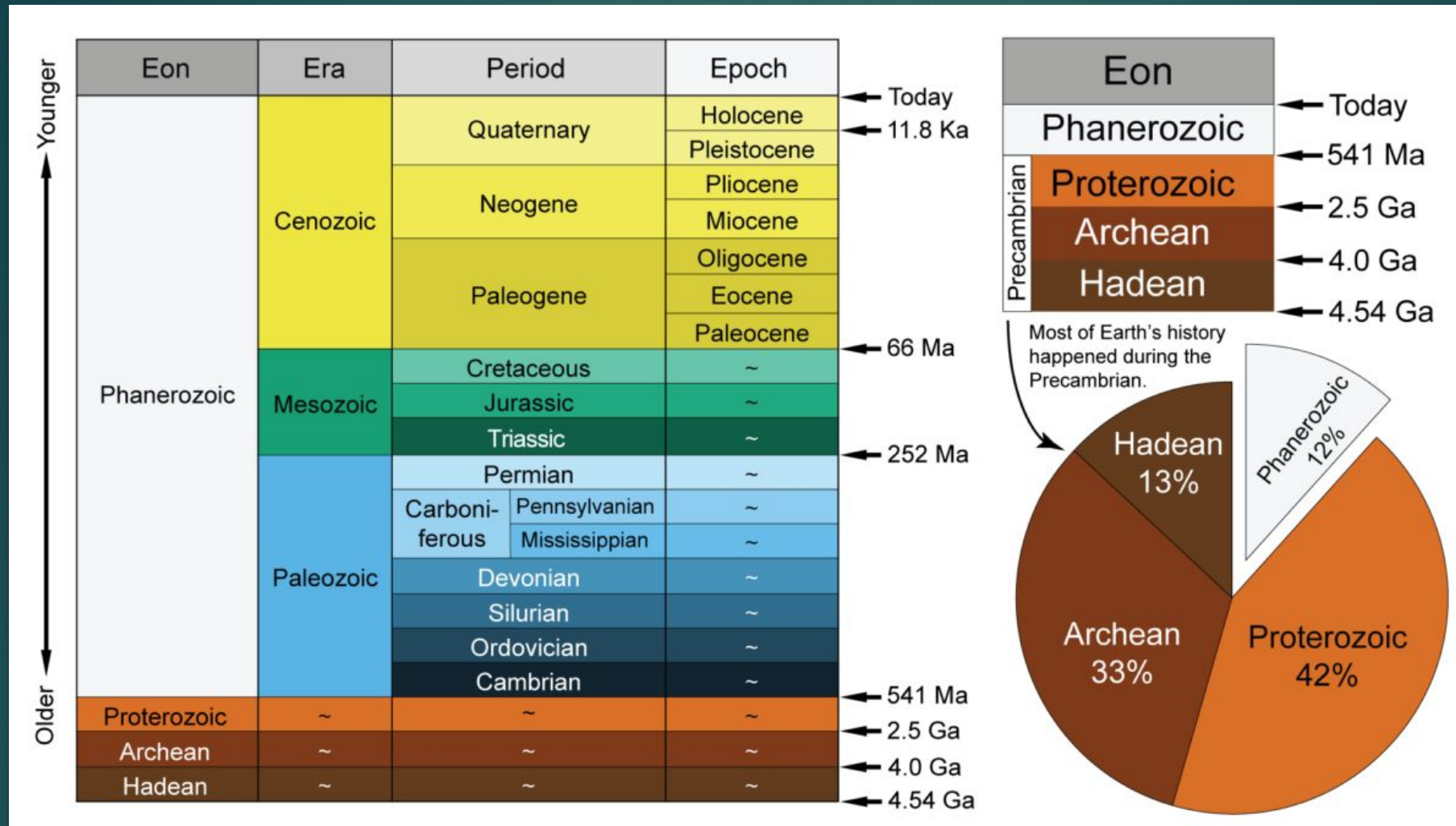
- An **angular unconformity** is an erosional surface on tilted or folded strata over which younger rocks were deposited



# Stratigraphy

- ▶ Stratigraphy is the branch of geology concerned with the order and relative position of strata and their relationship to the geological time scale.
- ▶ A stratigraphic column is a drawing representing the layers of rock present in geologic unit.





# Geologic Time Scale

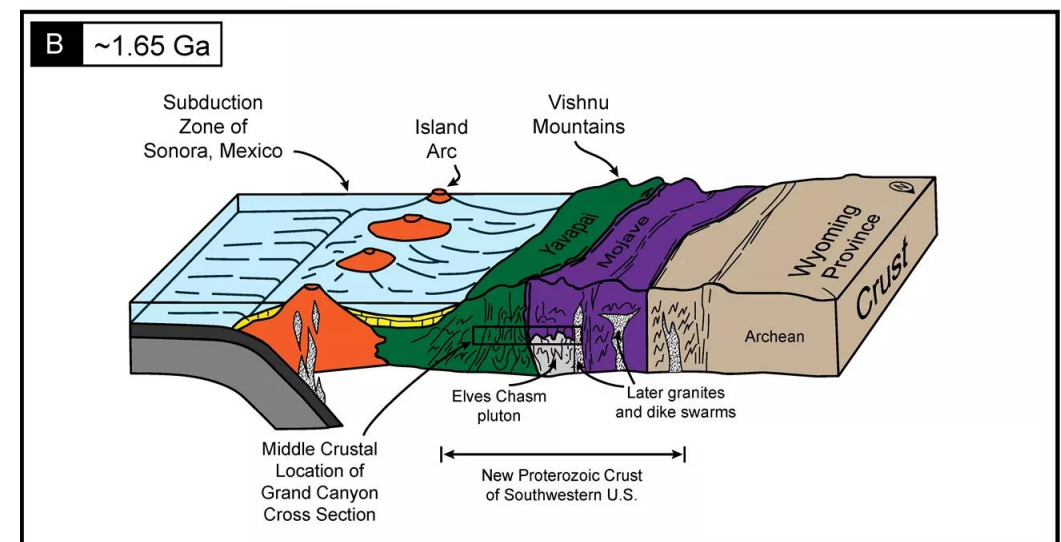
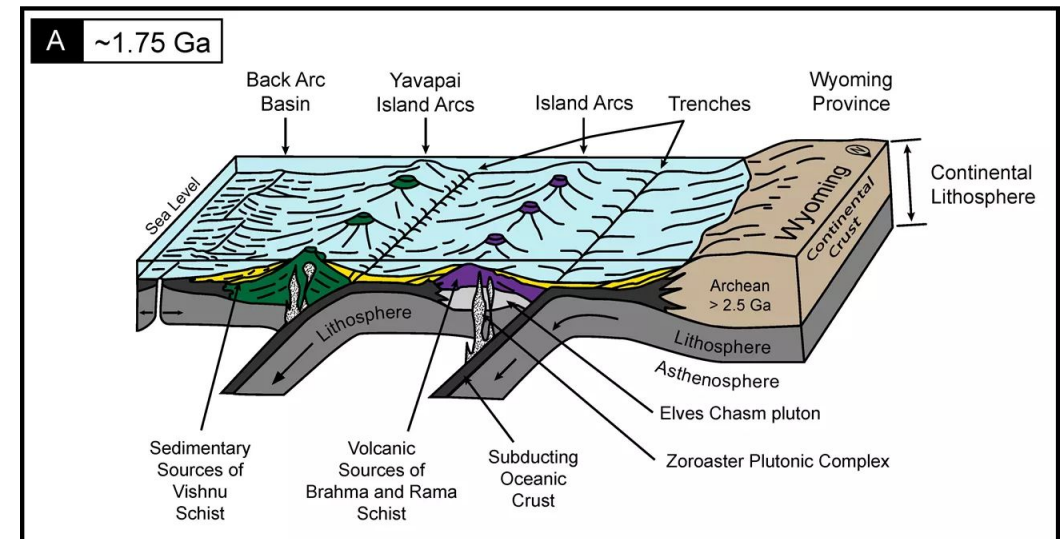
A SYSTEM OF ORGANIZING EARTH'S HISTORY INTO BLOCKS OF TIME BASED ON SIGNIFICANT EVENTS



# Formation of the Grand Canyon

# Basement Rock

- ▶ The Vishnu basement rocks were once part of a volcanic arc that collided with North America.
- ▶ This collision formed the Vishnu mountains.
- ▶ The volcanic rocks were squeezed and heated creating the metamorphic rocks seen today.

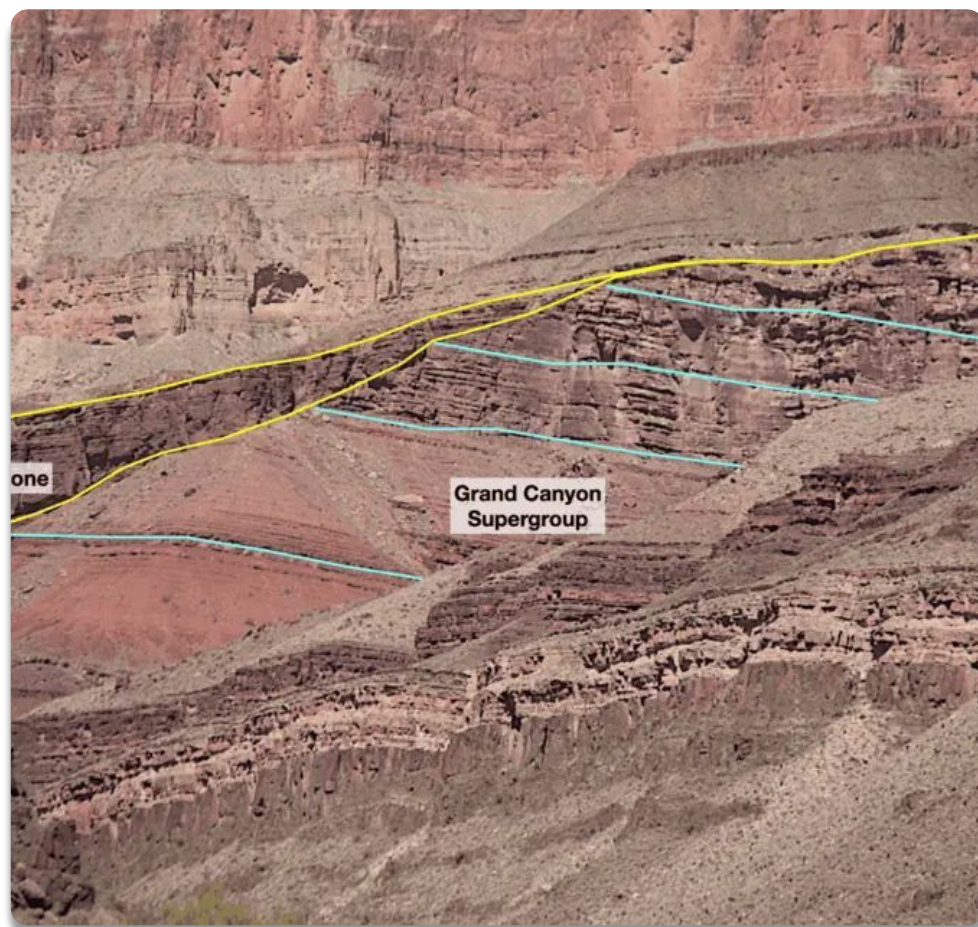


# The Great Unconformity

- ▶ The Great Unconformity in the Grand Canyon is a missing block of time of approximately 1.2 billion years.
- ▶ During this time, the Vishnu Mountains were eroded away.



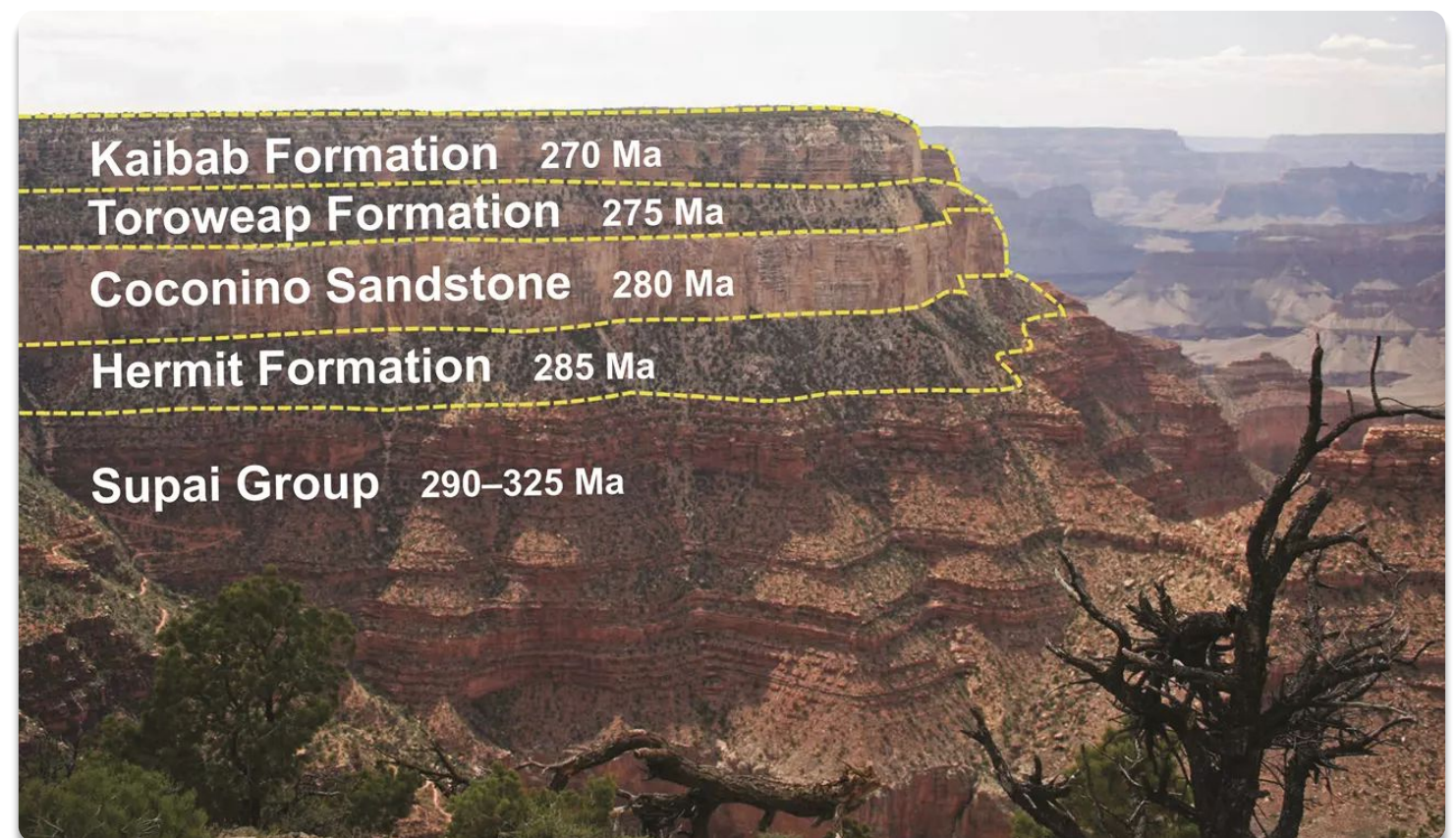
# Grand Canyon Supergroup



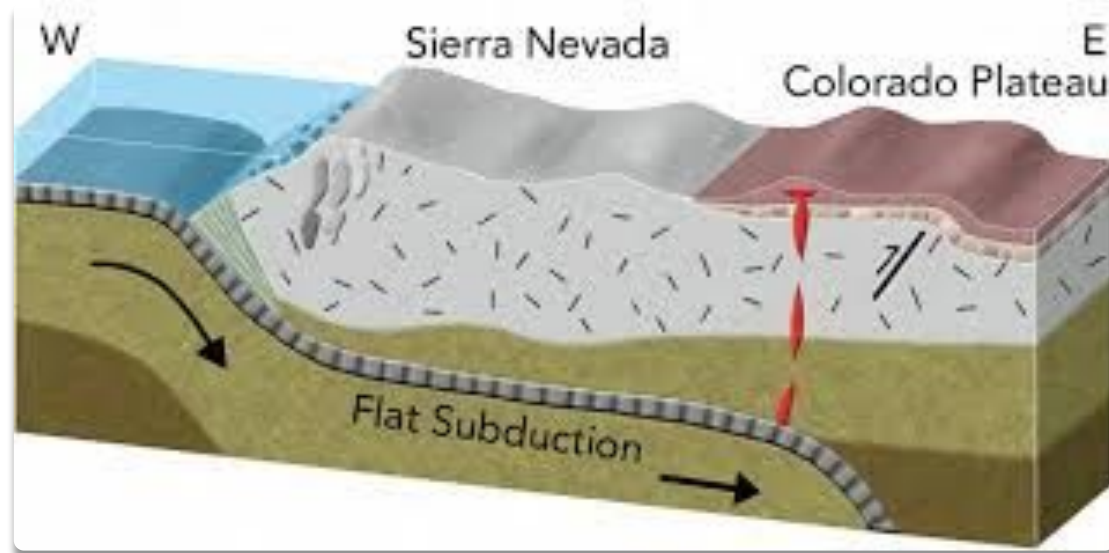
- ▶ The Supergroup is a set of tilted sedimentary layers deposited 1255-729 million years ago.
- ▶ They are only found in the eastern part of the Grand Canyon.
- ▶ They form an angular unconformity with the horizontal layers above.
- ▶ They are mainly sandstones, shales, and mudstones from river deposition.
- ▶ The Chuar group contains numerous species of single-celled fossils.

# Layered Paleozoic Rocks

- ▶ Horizontal layers 3,000-5,000 ft thick representing 530-270 million years ago.
- ▶ Deposited by changing environments of shallow seas to large sand dunes.



# Uplift of the Colorado Plateau



- ▶ 70-40 million years ago, subduction of the Farallon Plate resulted in the uplift of the western United States.
- ▶ However, instead of deforming, the rocks of the Colorado Plateau were pushed straight up.
- ▶ Scientists theorize that low angle subduction allowed for this uplift without deformation.
- ▶ Currently in South America, high angle subduction creates deformation and volcanic activity, but low angle subduction causes uplift without deformation.

# Erosion and River Dynamics

- ▶ The Colorado River has carved the Grand Canyon in a surprisingly short amount of time (5-6 million years).
- ▶ 3 reasons for the rapid erosion:
  - ▶ The step gradient caused by the uplift of the Colorado Plateau has allowed for the river to carry large amounts of sediment.
    - ▶ Faster currents can carry more sediment
  - ▶ The Colorado River carries large volumes of water, especially during floods, allowing it to carry more sediment.
  - ▶ The arid climate of the southwest has allowed for rapid mechanical weathering to occur.
    - ▶ Lack of vegetation and little soil allows for rock to be exposed.
    - ▶ Exposed rock is broken down by fluctuation in temperatures and ice-wedging.
    - ▶ Precipitation then easily erodes away broken pieces of rock

