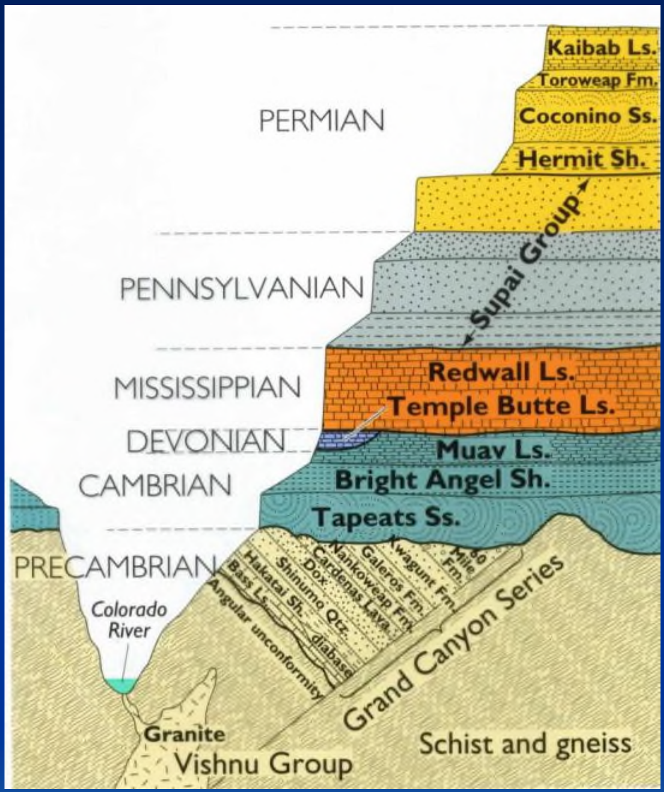
GEOLOGIC DATING

Principles and Applications



Physical Geology - GEOL 100

Ray Rector - Instructor

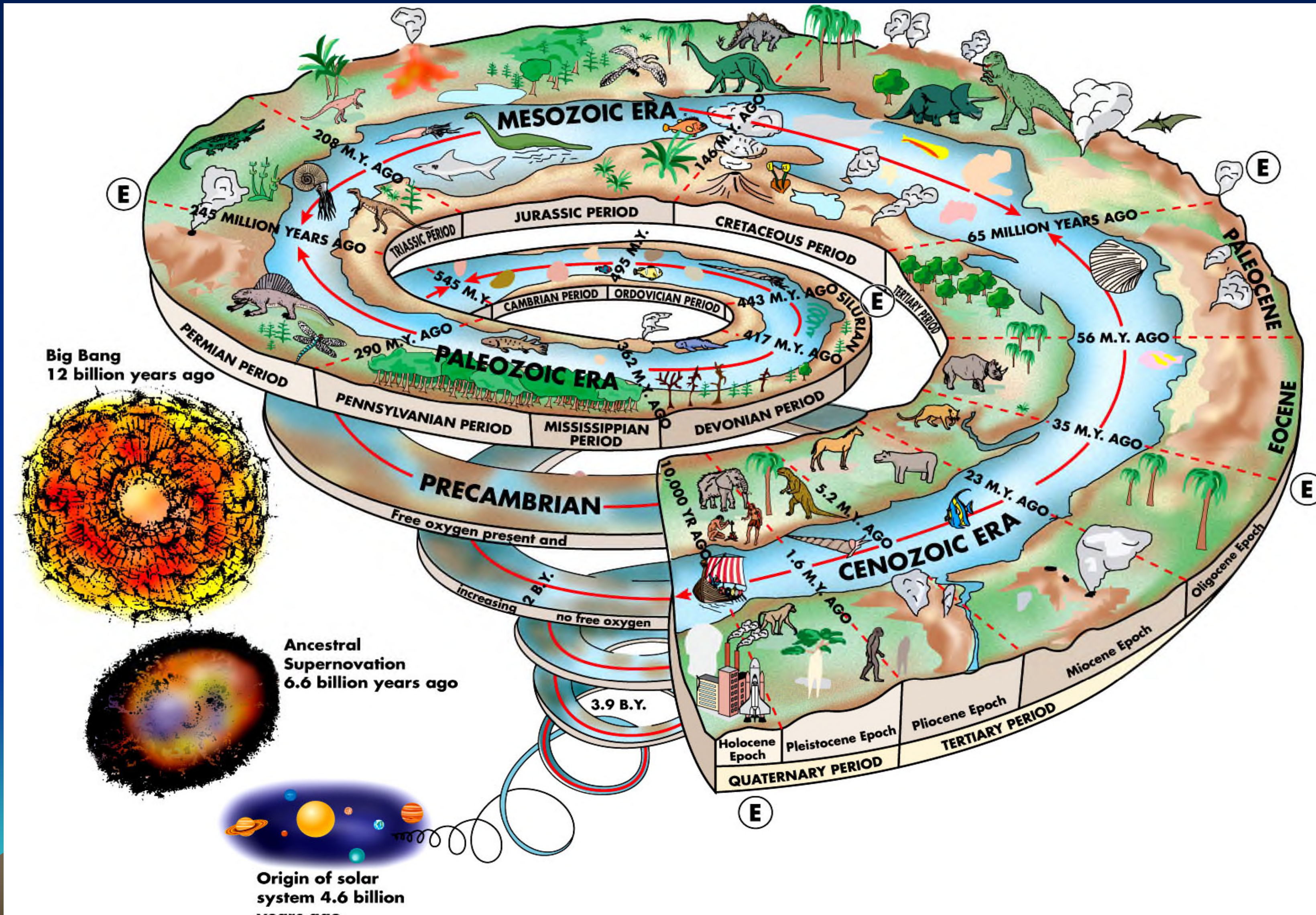
Earth's Age and History

How Old Is the Earth?

How Can We Determine Earth's Geologic History?

How Can We Determine the Age of Geologic Events?

THE TWISTED GEOLOGICAL TIMESCALE



Two Primary Means of Dating Rocks

1) **Relative Dating**
   - ✓ Determines the temporal order of rock forming events
   - ✓ Does not give numeric ages
   - ✓ Use of stratigraphic principles and fossils
   - ✓ Cheap
2) **Absolute Dating**
   - ✓ Determines the numeric age of rock forming events
   - ✓ Only appropriate for ages of igneous rocks and minerals
   - ✓ Primary method is the ***radiometric technique***
   - ✓ Used in conjunction with stratigraphic principles and fossils
   - ✓ Expensive

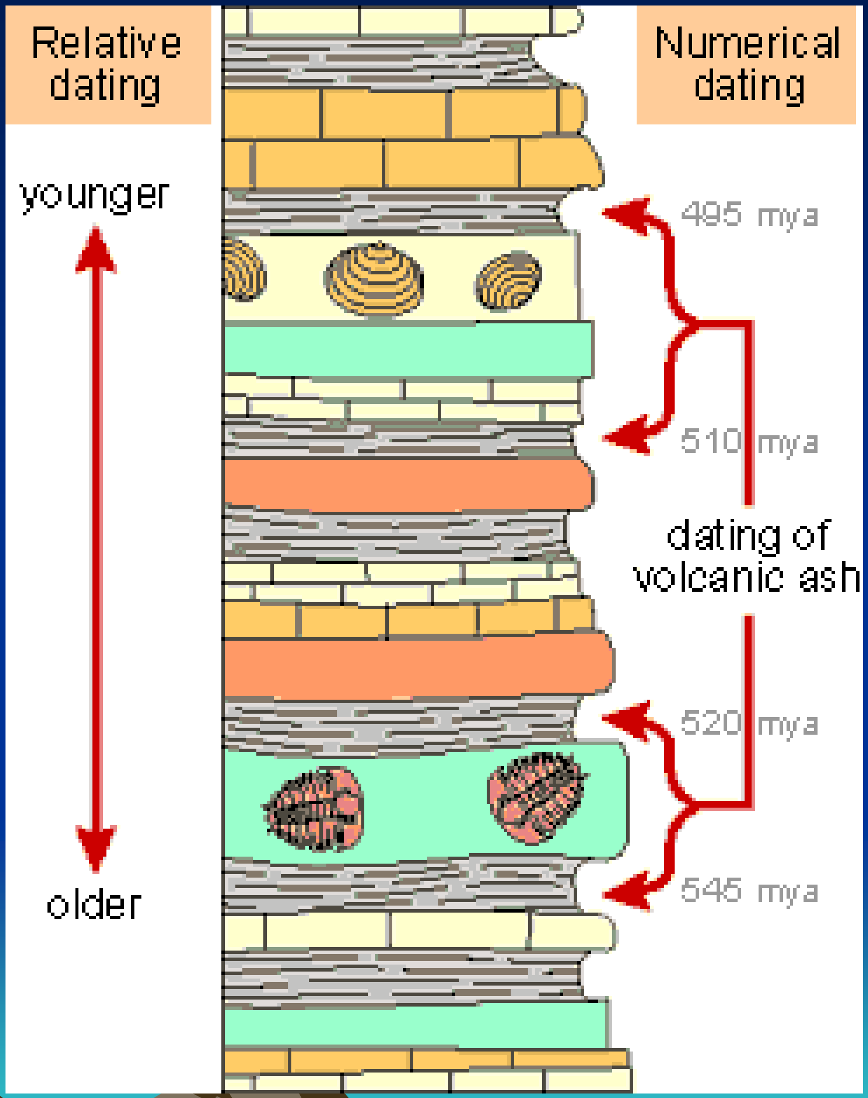
Relative Versus Absolute Dating

Relative Dating

- Stratigraphic principles
- Fossil Succession
- Emphasis on Sed Rocks

Absolute Dating

- Radio-Isotopic techniques
- Emphasis on Igneous Rocks



How Can We Figure Out the Age Sequence of Geologic Events?

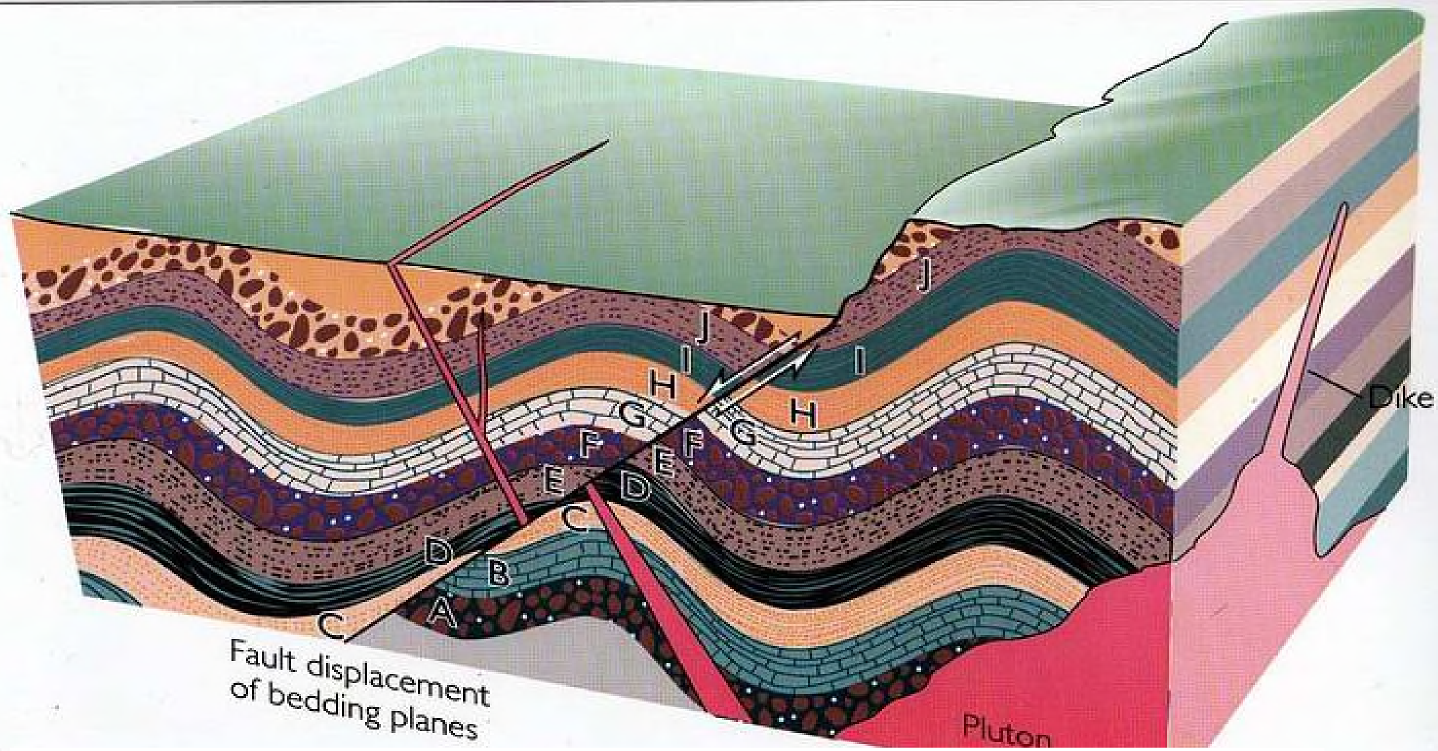


Figure 9.9
Press & Siever: UNDERSTANDING EARTH, Second Edition

Use Stratigraphic Principles and Absolute Dating Methods

The Stratigraphic Principles

1. **Superposition** - Oldest layer occurs at base of a layered sequence and is overlain by progressively younger rock layers.

2. **Cross-Cutting Relations** - If a body or discontinuity cuts across a rock structure, it must have formed after that stratum.

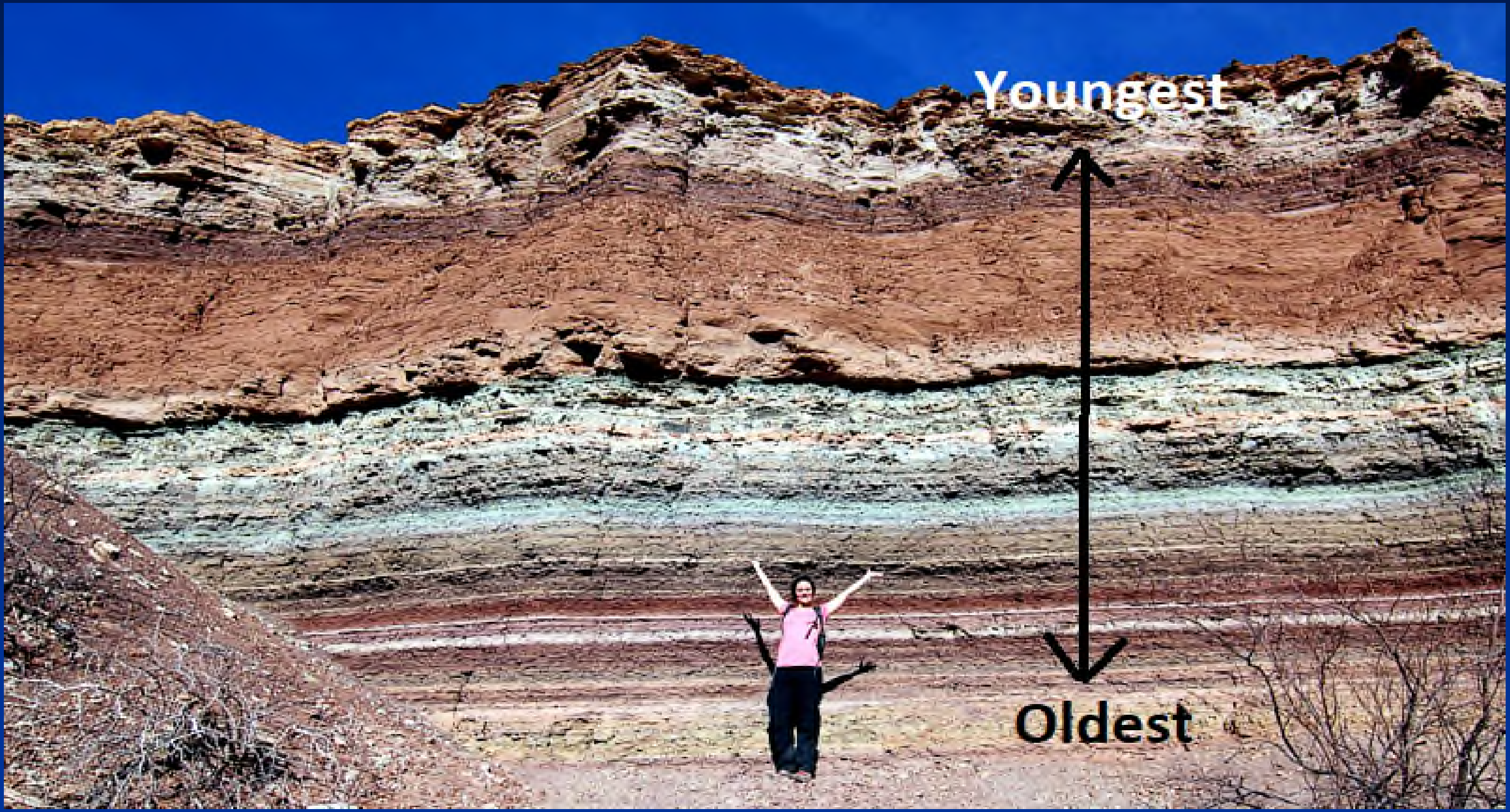
3. **Law of Inclusions** - Rock fragments (in another rock) must be older than the rock containing the fragments.

4. **Law of Fossil Succession** - Unique fossil groups were succeeded by other fossil groups through time.

5. **Original Horizontality** - All sedimentary rocks are originally deposited horizontally. Sedimentary rocks that are no longer horizontal have been tilted from their original position.

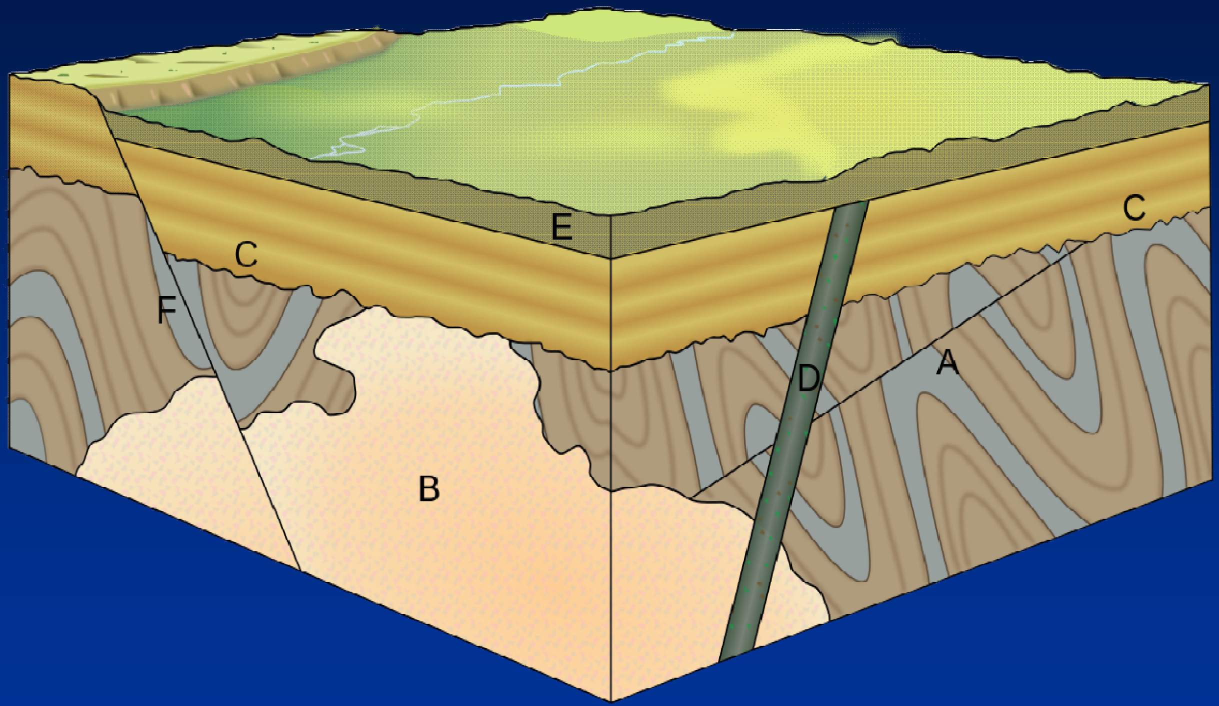
6. **Lateral Continuity** - Sedimentary and volcanic rocks are laterally continuous over large areas.

Principle of Superposition



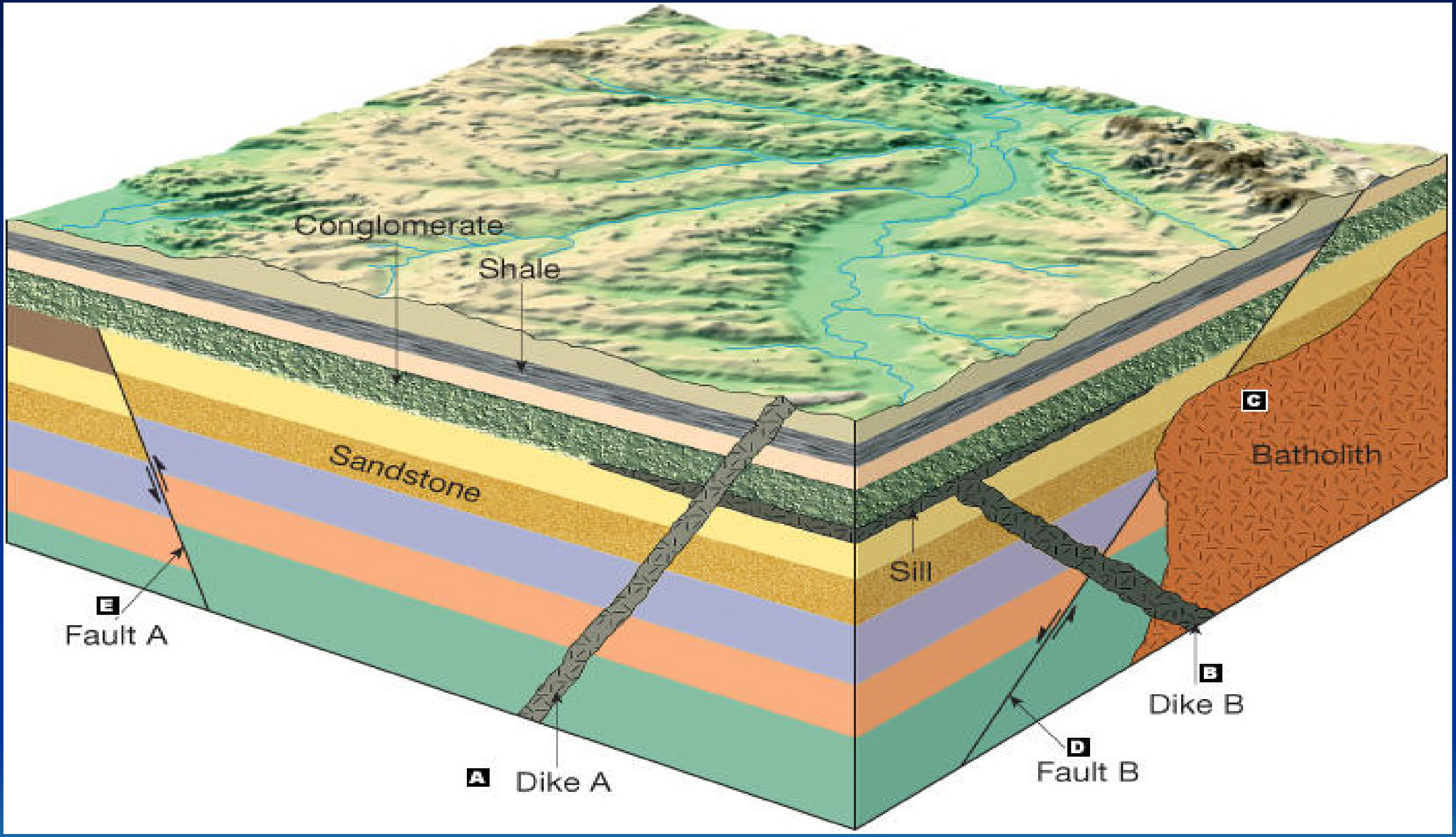
In a vertical stack of layered sedimentary or lava rocks, the overlying layer is younger than the underlying layer. The youngest rock layer is on top – the oldest layer is on the bottom, with middle-aged rocks in the middle.

Principle of Cross-Cutting



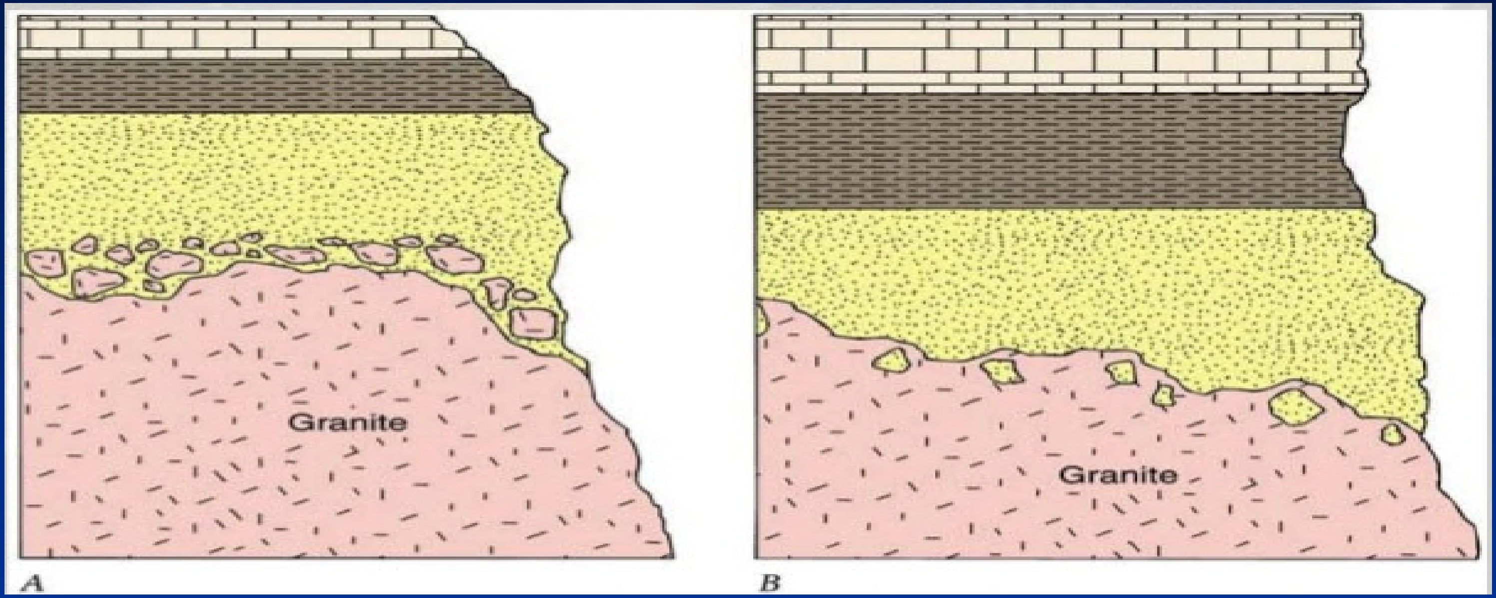
The rock unit whose layer is being crosscut (disrupted or offset) is older than the rock unit or fault that is doing the cross-cutting. In the above illustration, Fault A cross-cuts folds; Intrusion B cross-cuts Fault A; Unconformity C cross-cuts folds, A and B; Intrusion D cross-cuts folds, A, B, and C; Fault F cross-cuts folds, B, C, and E. Therefore, based only on cross-cutting, the order of age – oldest to youngest - is folds, A, B, C, D, E, F.

Principle of Cross-Cutting Relations



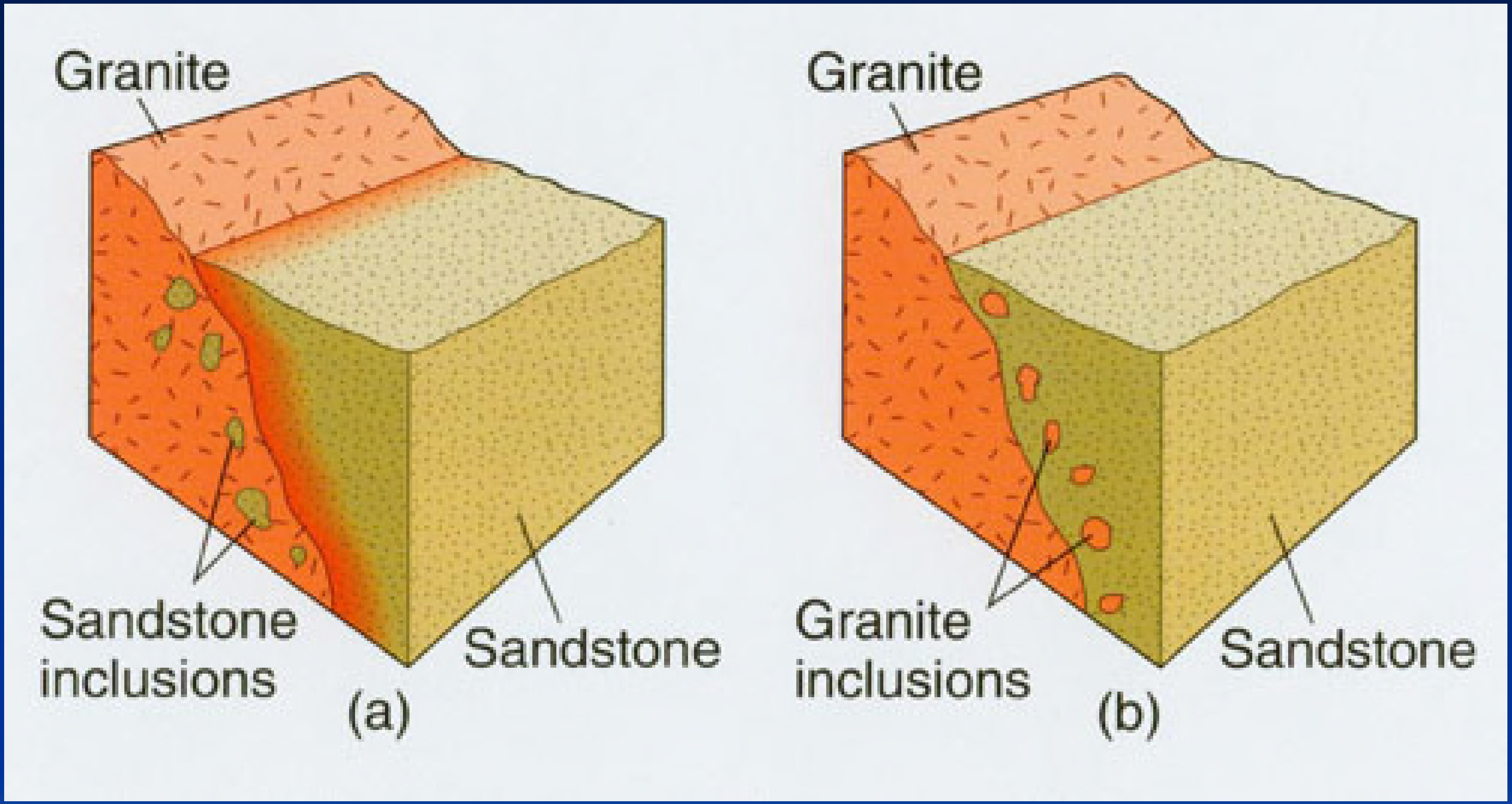
Crosscutting principles works for intrusions and faults.

Principle of Inclusions

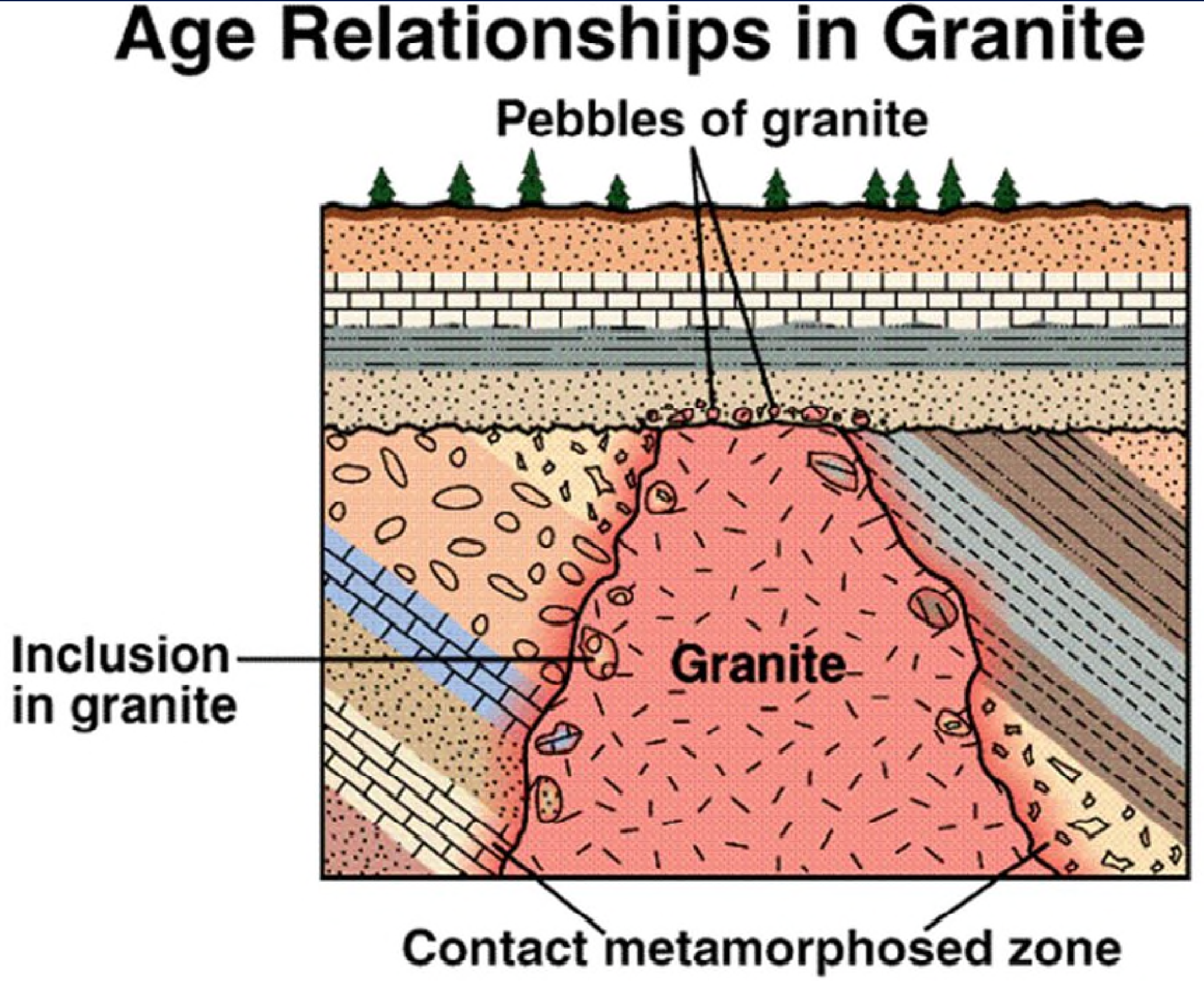


The rock unit that surrounds/encases the inclusions must be younger than the inclusions. In the above illustration "A", the older eroded granite surface sediment gets buried and mixed in with the newly depositing sand. In illustration "B", the newer granitic magma intrudes into the bottom of an older sandstone layer, causes chucks of sandstone to fall into magma.

Principle of Inclusions



The rock unit that surrounds the inclusions must be younger than the inclusions.



Use the principles of cross-cutting and inclusion to determine the age relationships off the granite.

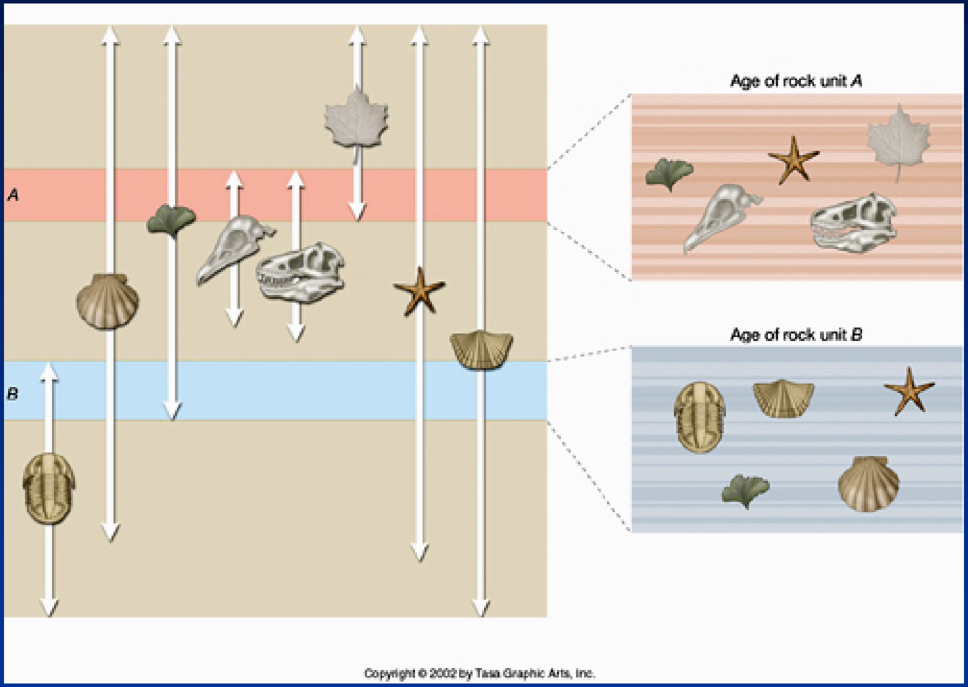
Principle of Faunal Succession

Key Idea:

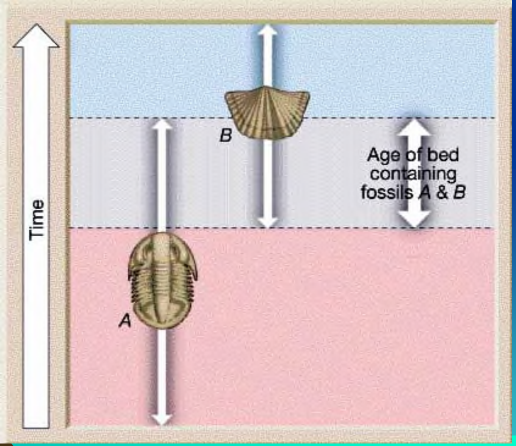
✓ Based on relative dating (law of superposition) and the use of age-specific (index) fossils species.

✓ Unique fossil species of a specific age range are temporally succeeded by other younger fossil species through time.

✓ A rock that contains a specific assemblage of index fossils must be the age of when those organisms (now fossils) were all alive.



Two or more index fossils in a rock can better constrain the rock's age range by overlap

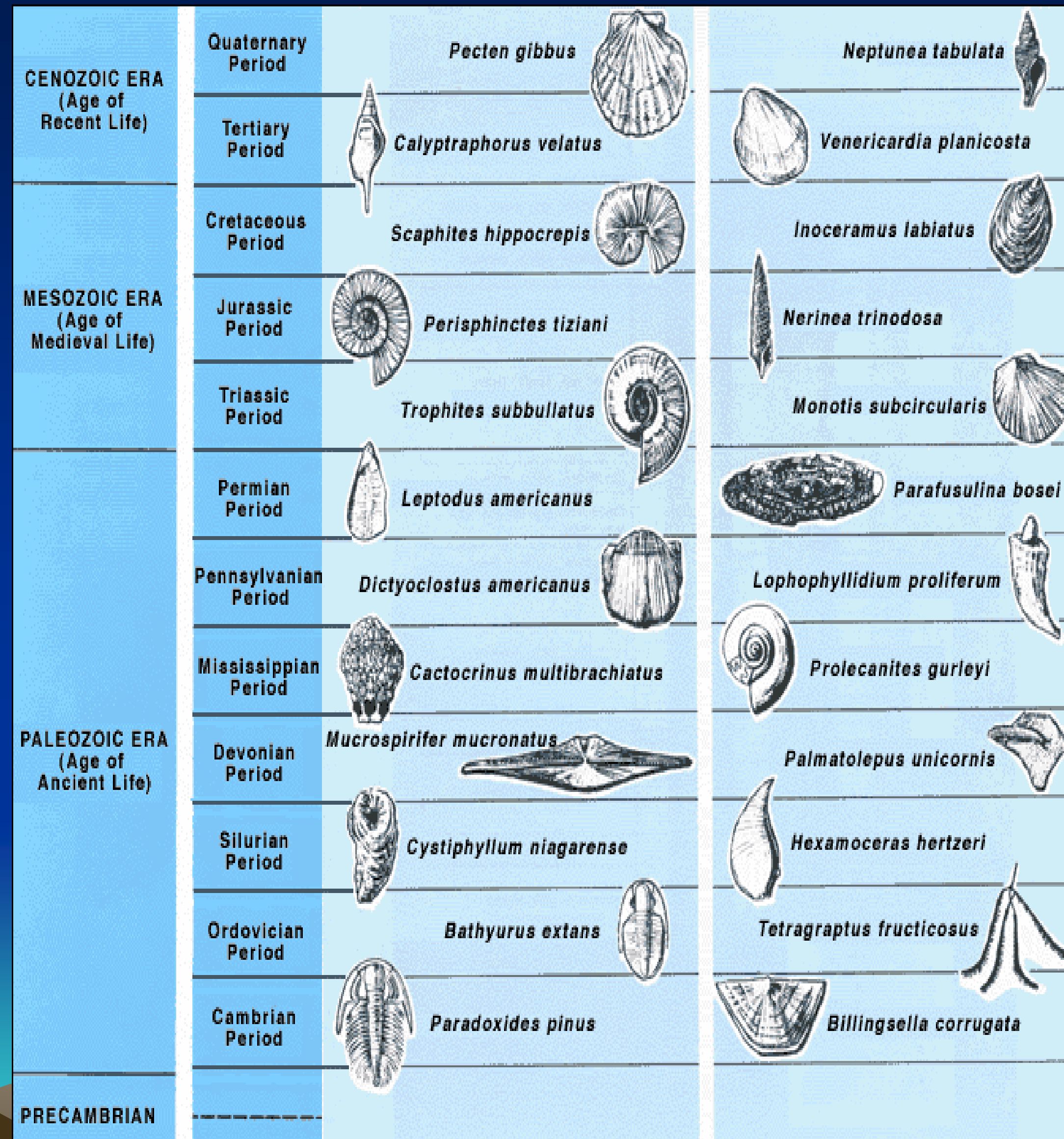


Index Fossils

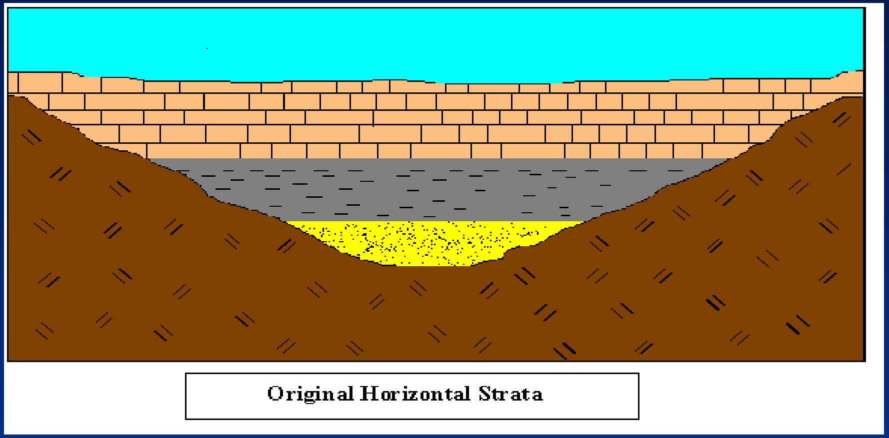
Criteria to be a Very Useful Index Fossil:

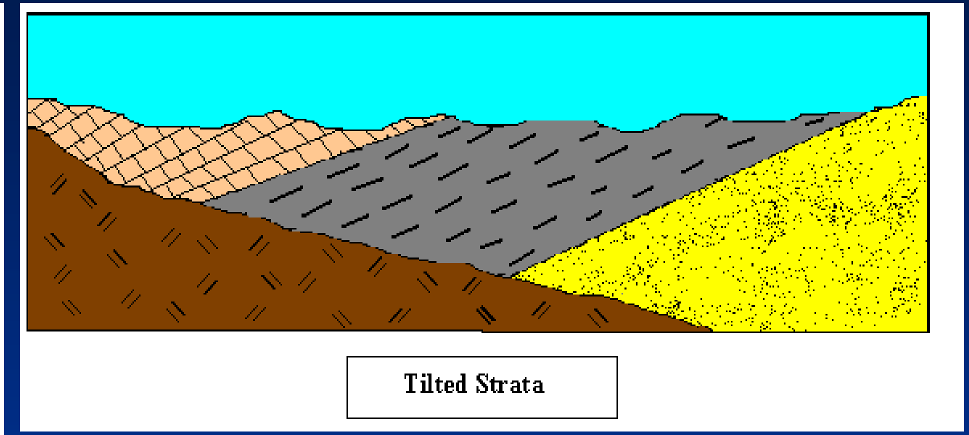
Must have:

1) Narrow time range
2) Worldwide distribution
3) Preserve in a wide range of depositional settings
4) Very Abundant



Principle of Original Horizontality



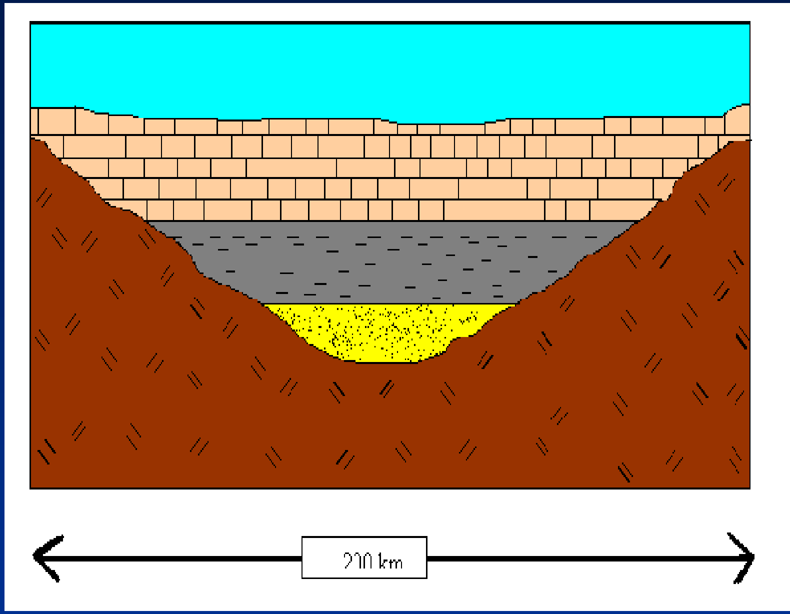


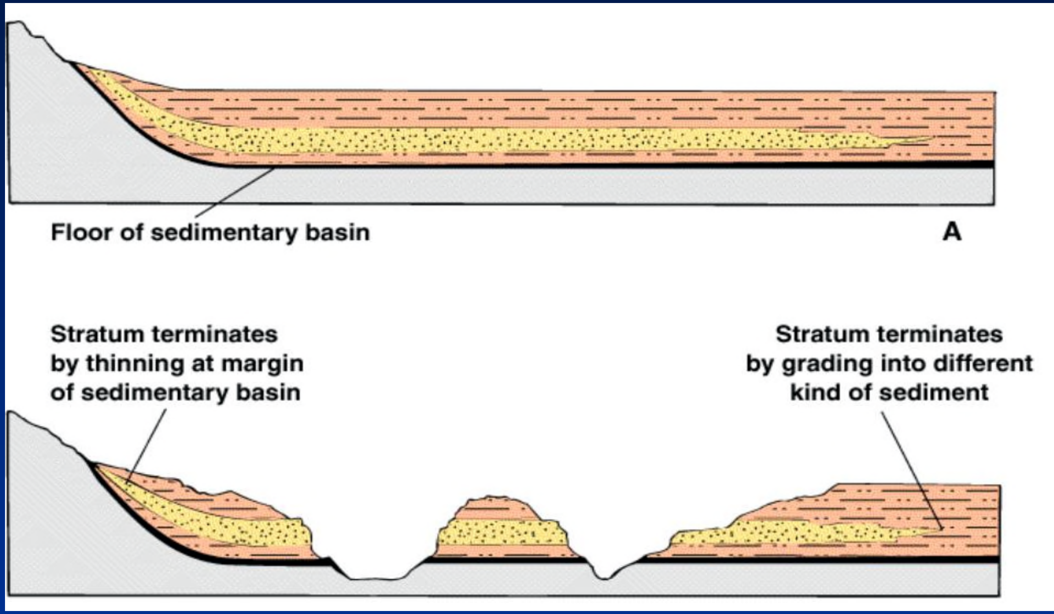
Sedimentary rock units originally deposit in roughly horizontal layers

Tectonic events may cause the layers to become tilted, overturned, and/or folded

This principle postulates that the tilting, overturning and/or folding of the layers had to have occurred after layer deposition

Principle of Lateral Continuity





Layers of sedimentary material initially deposit laterally in all directions across a sedimentary basin. The layers eventually thin to zero and either terminate at the ends of the sedimentary basin or grade into other units.

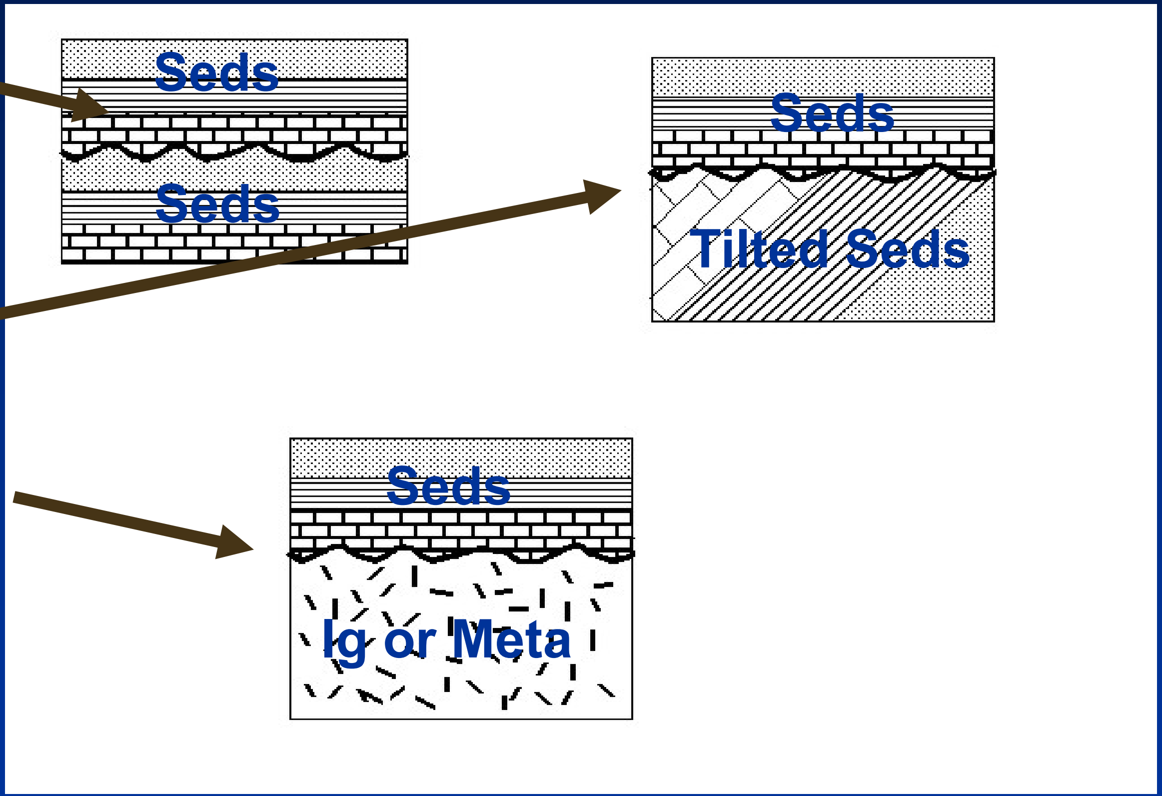
Lateral breaks or gaps in a sedimentary layer are most likely the result of post-deposition erosion and/or deformation events

Principle of Unconformities

Unconformity defined: An unconformity is a buried erosional surface separating two rock formations or strata having great difference in age, indicating a long period of non-deposition and/or erosion of pre-existing rocks.

Three Types of Unconformities

1. Disconformity
2. Angular Unconformity
3. Nonconformity

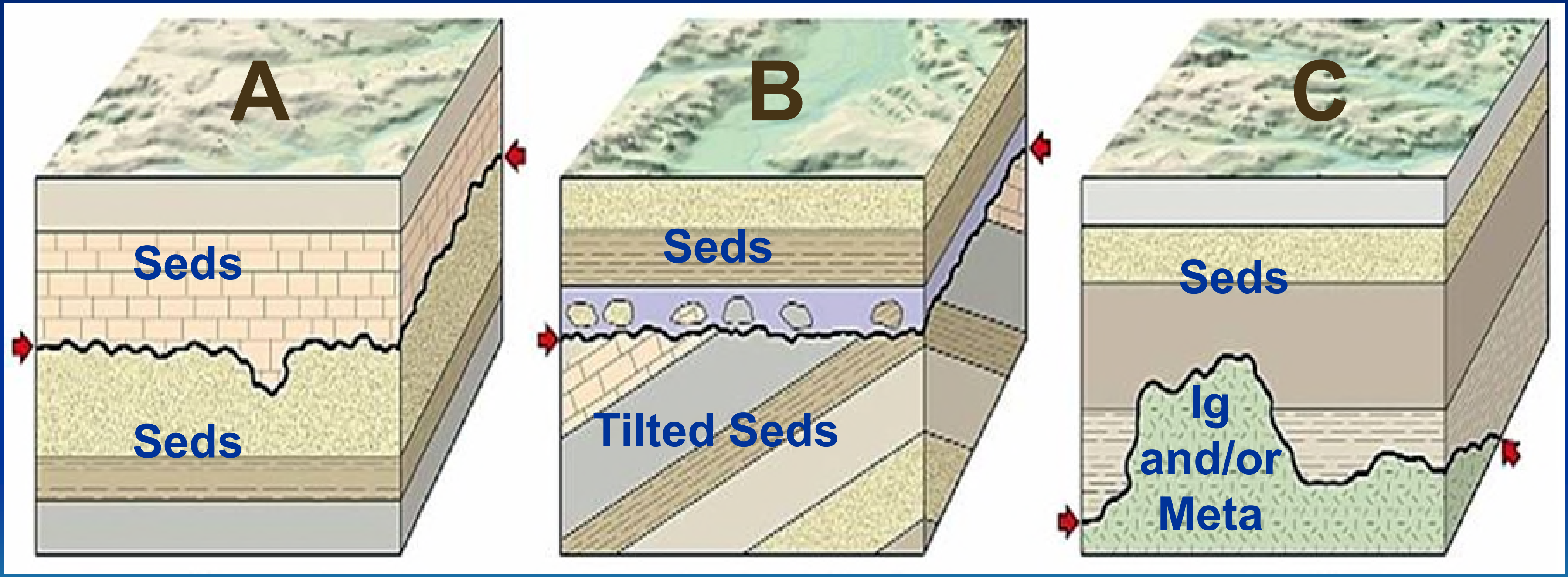


Three Types of Unconformities

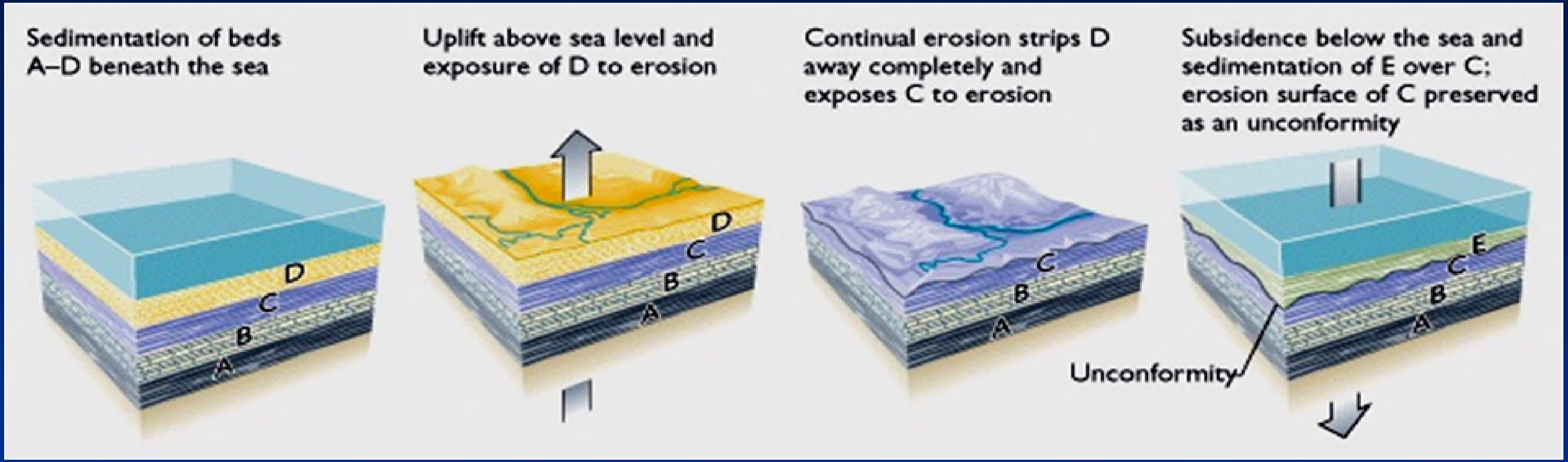
A. Disconformity – Underlain by parallel sedimentary rocks

B. Angular Unconformity - Underlain by tilted sedimentary rocks

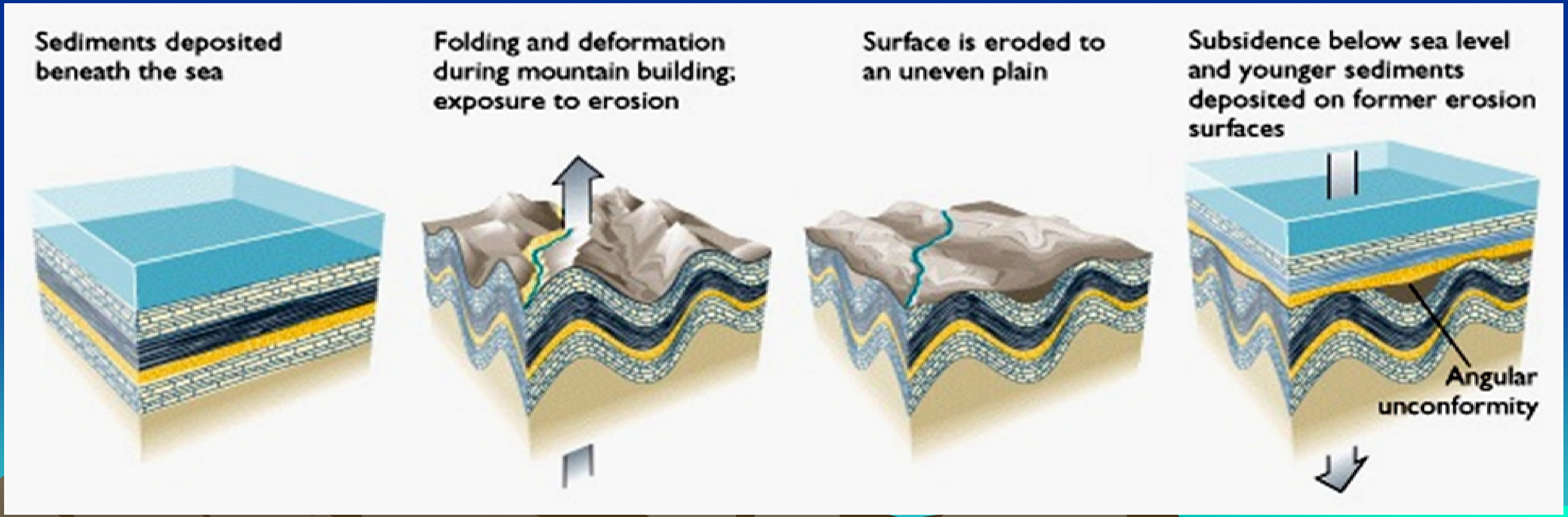
C. Nonconformity - Underlain by igneous and metamorphic rocks



Formation of an Unconformity

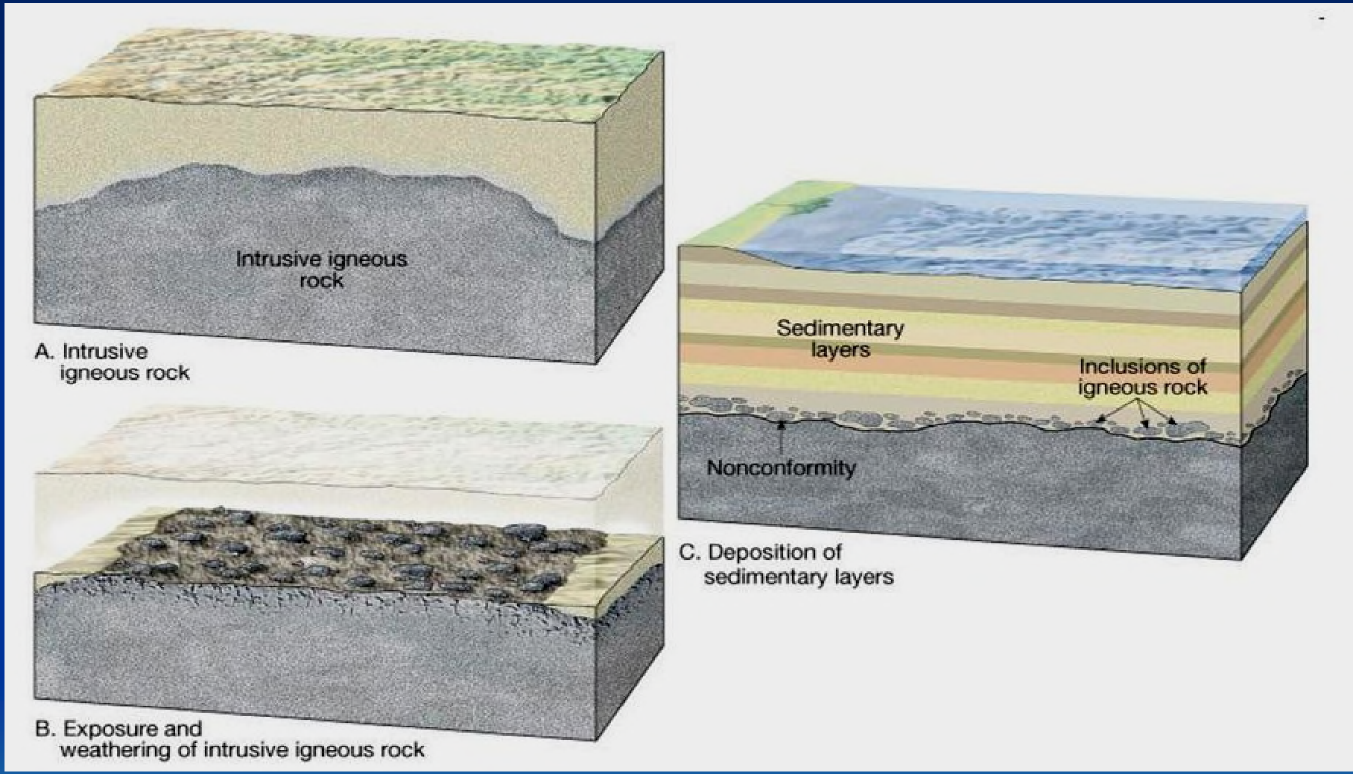


Formation of a Disconformity



Formation of an Angular Unconformity

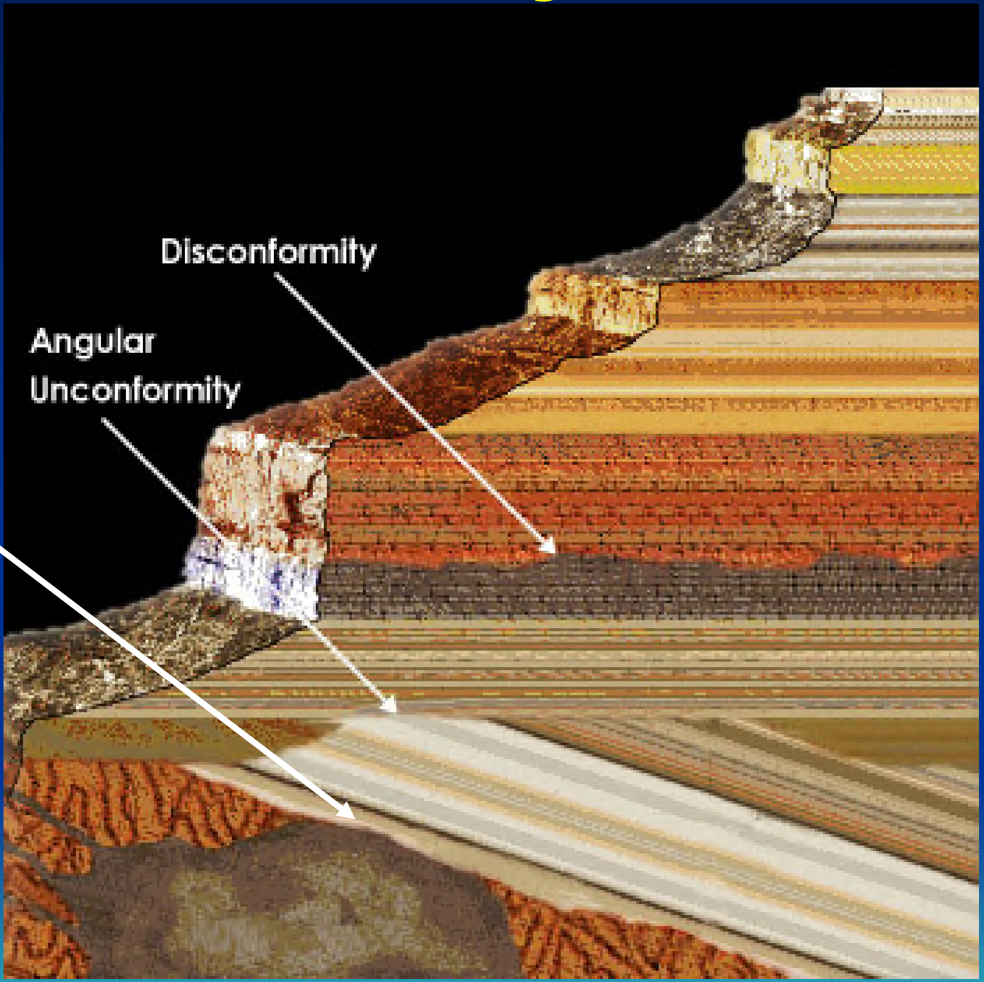
Formation of an Unconformity



Formation of a Nonconformity

Three Types of Unconformities in the Grand Canyon

1. Disconformity
2. Angular Unconformity
3. Nonconformity



Which Type of Unconformity?