Lecture 2 & 3

Geologic Time

Geologic Time

- Two ways to relate time in geology:
  - Relative: Placing events in a sequence based on their positions in the geologic record.
  - Chronologic : Placing a specific number of years on an event or rock sample.

Geologic Time Scale

- a combination of the two types of age determinations
  - a *relative* sequence of lithologic units
    - established using logical principles
  - measured against a framework of *chronologic* dates.

Geologic Time and the "geologic column"

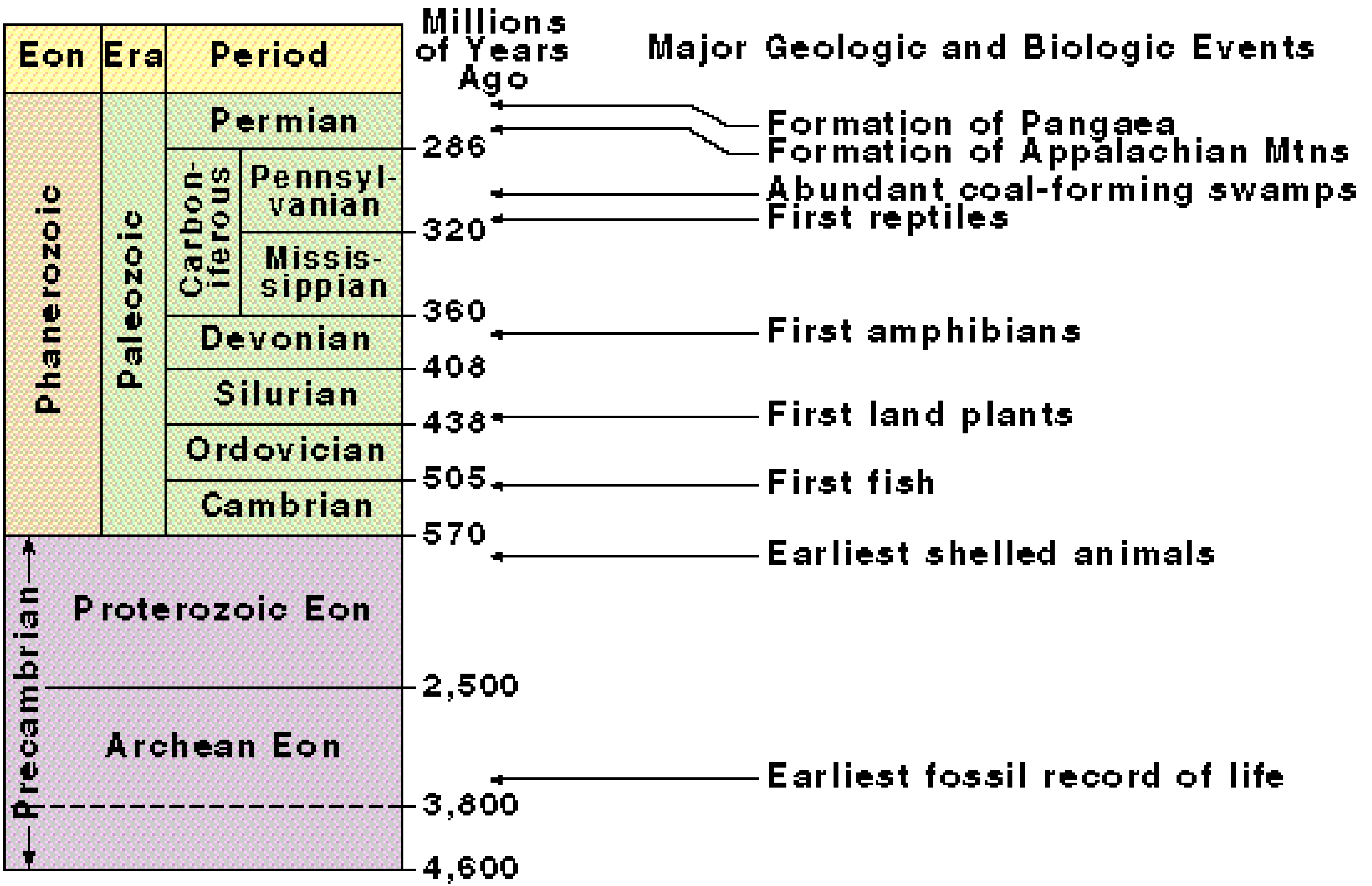
- *Developed using logical rules to establish relative sequences of events*
  - ***superposition***
  - ***cross-cutting relationships***
  - ***original horizontality***
  - ***lateral continuity***

- *Added to as new information is obtained and data is refined*
  - ***Use of fossils for correlation and age determination***

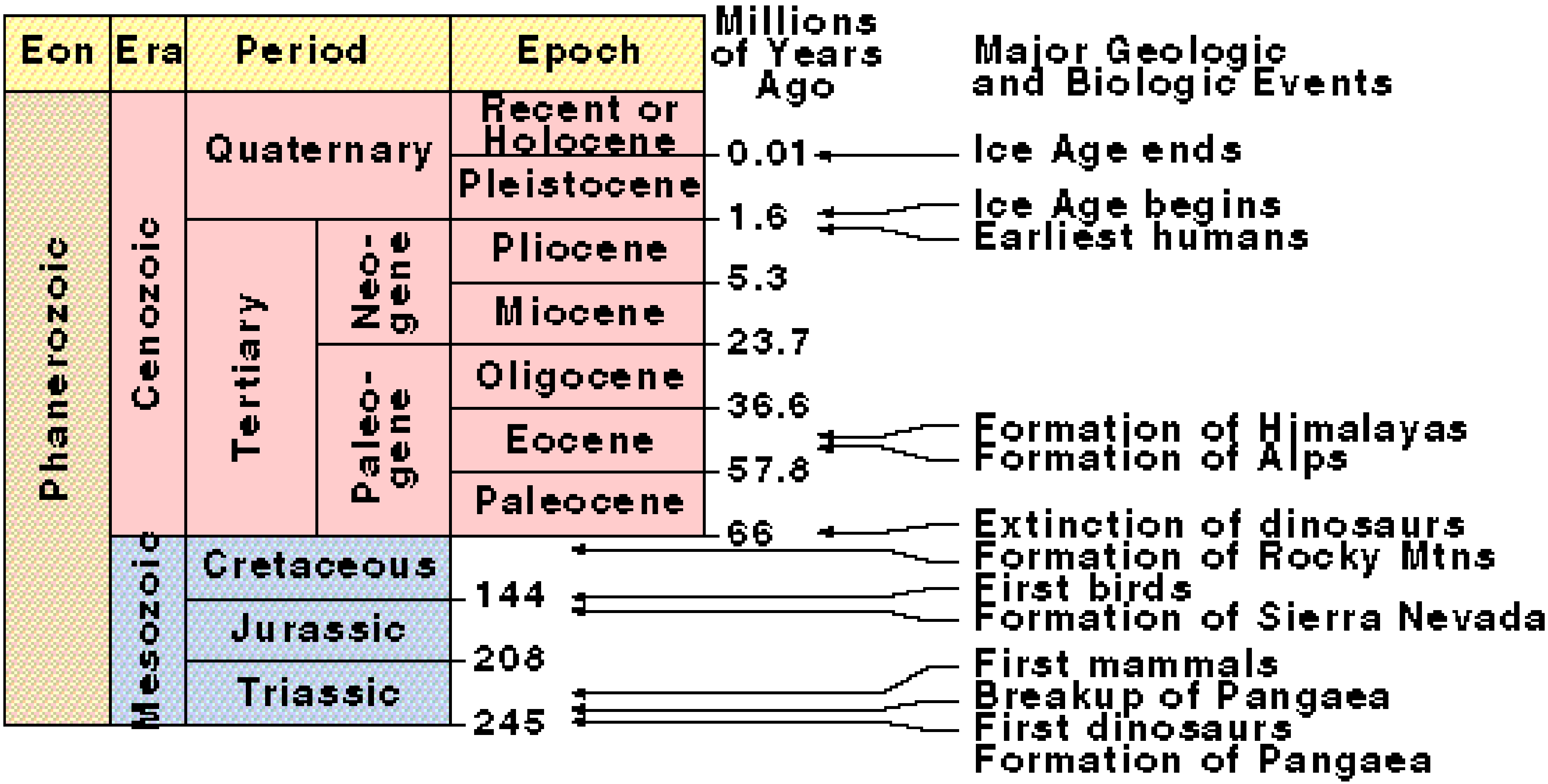
- *Numerical Dates attached to strata after the*
  - *development of Radiometric techniques*

Still being refined as more information becomes available

The Geologic Time Scale (1:2)



The Geologic Time Scale (2:2)



Relative Dating Methods

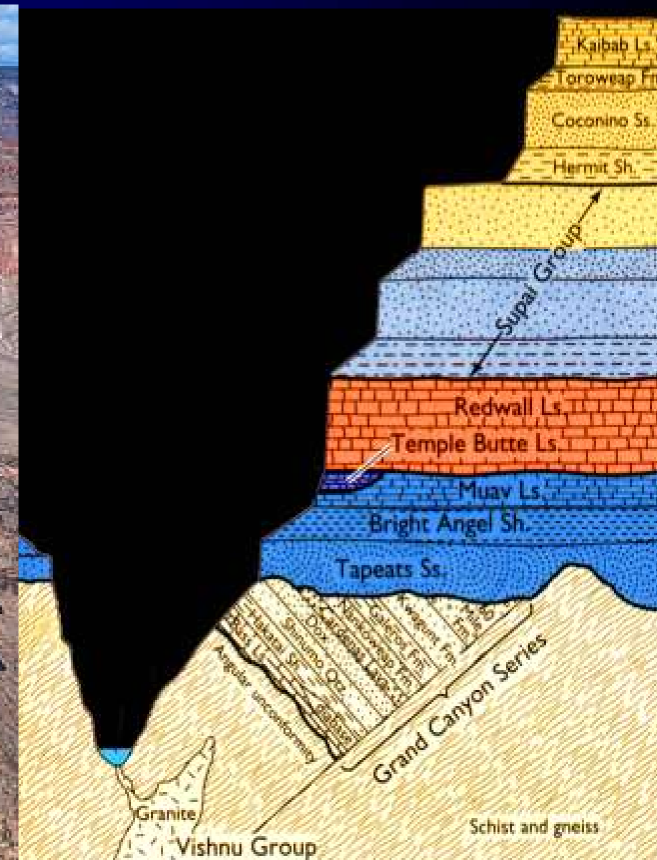
- determines the relative sequence of events.
  - which came first, which came last.
  - no numeric age assigned

- 6 Relative age principles:
  - Superposition
  - Lateral continuity
  - Inclusions
  - Original Horizontality,
  - Cross-cutting Relationships
  - Fossil succession.

Those in yellow are most useful

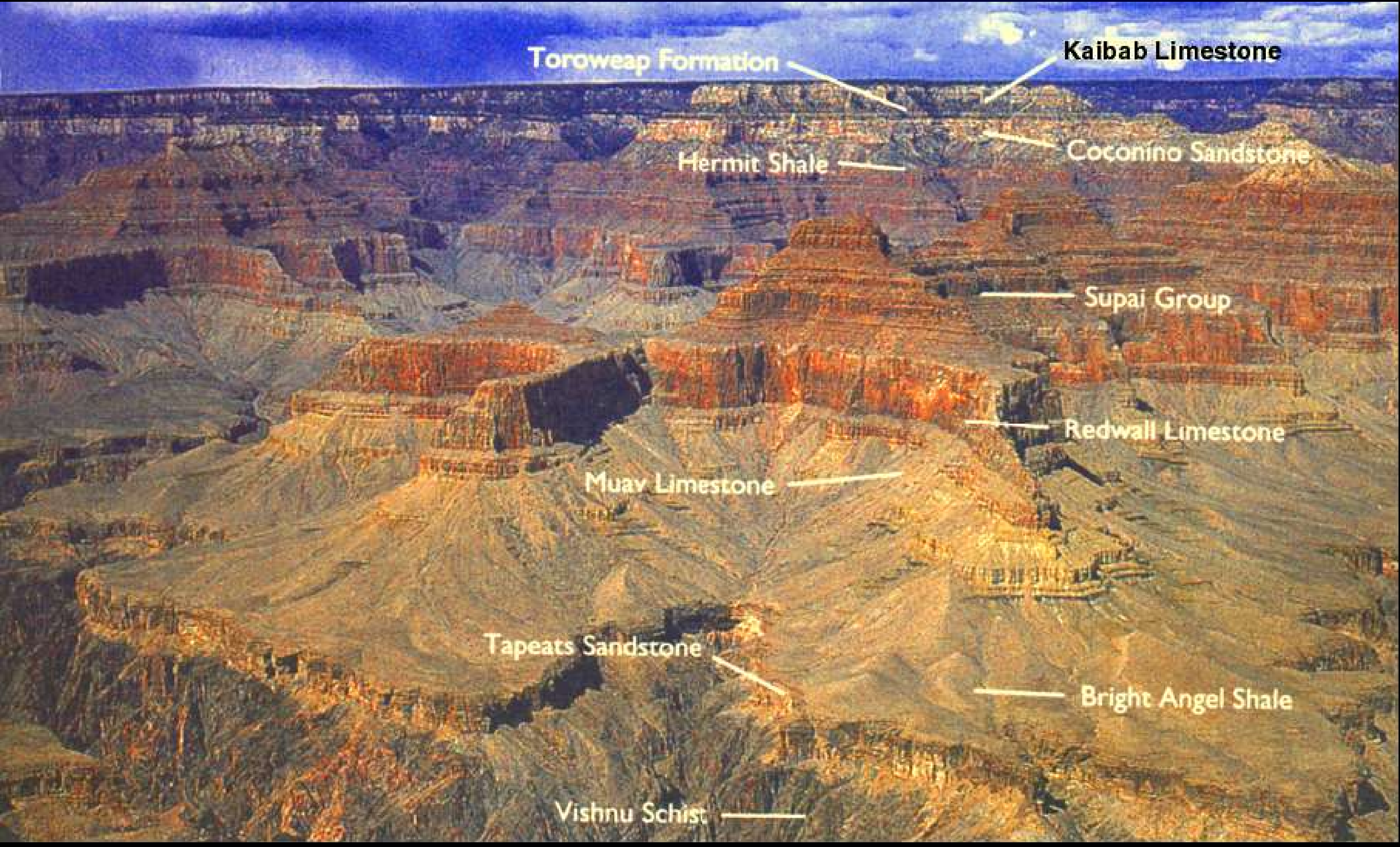
History of Historical Geology

- *Niels Stensen (Nicolaus Steno)*
  - ***Fundamental Principles of Relative Time***
    - > ***Principle of Superposition- see below***
    - > ***Principle of Original Horizontality- see below***
    - > ***Principle of Original Lateral Continuity- see below***



Law of Superposition

- In undisturbed strata, the layer on the bottom is oldest, those above are younger.



Original Horizontality

- Sediments are generally deposited as horizontal layers.

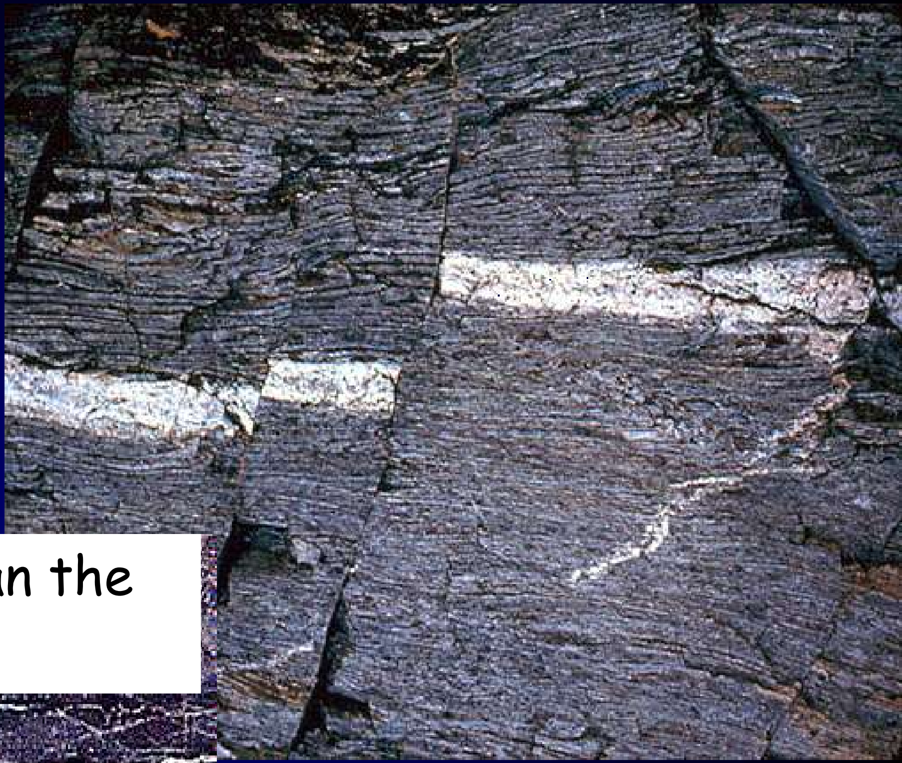
Lateral Continuity

- Sediment layers extend laterally in all direction until they thin & pinch out as they meet the edge of the depositional basin.

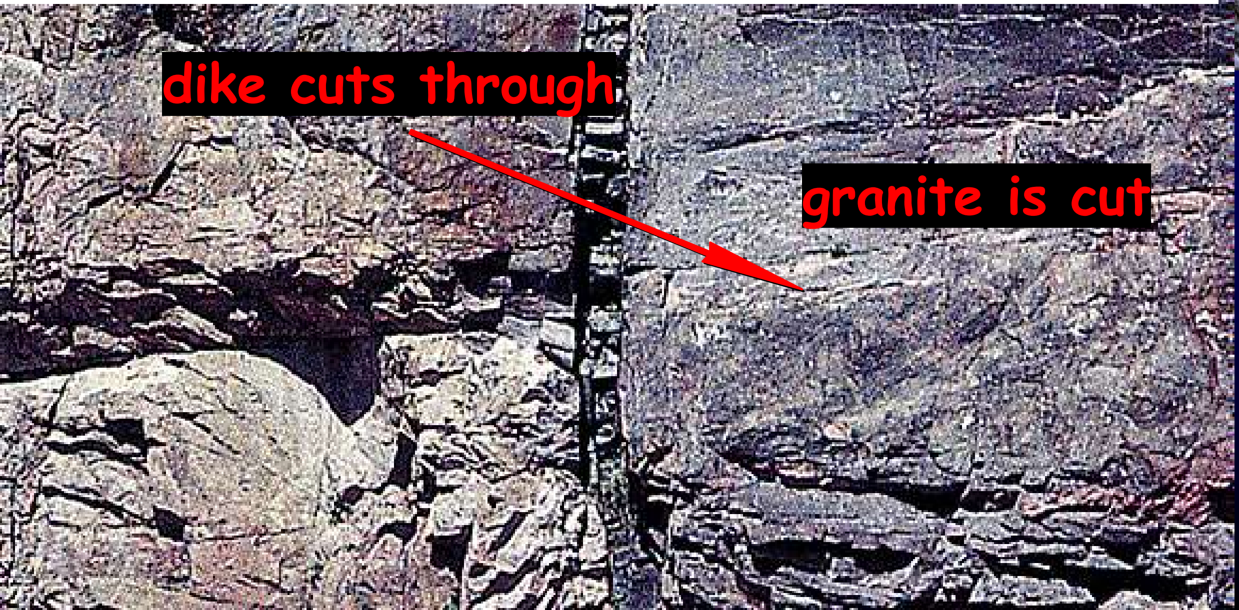
Charles Lyell

- 1st Principles of Geology text
  - included description and use of
    - principles of cross-cutting relationships
    - principles of inclusions
- relative time tools

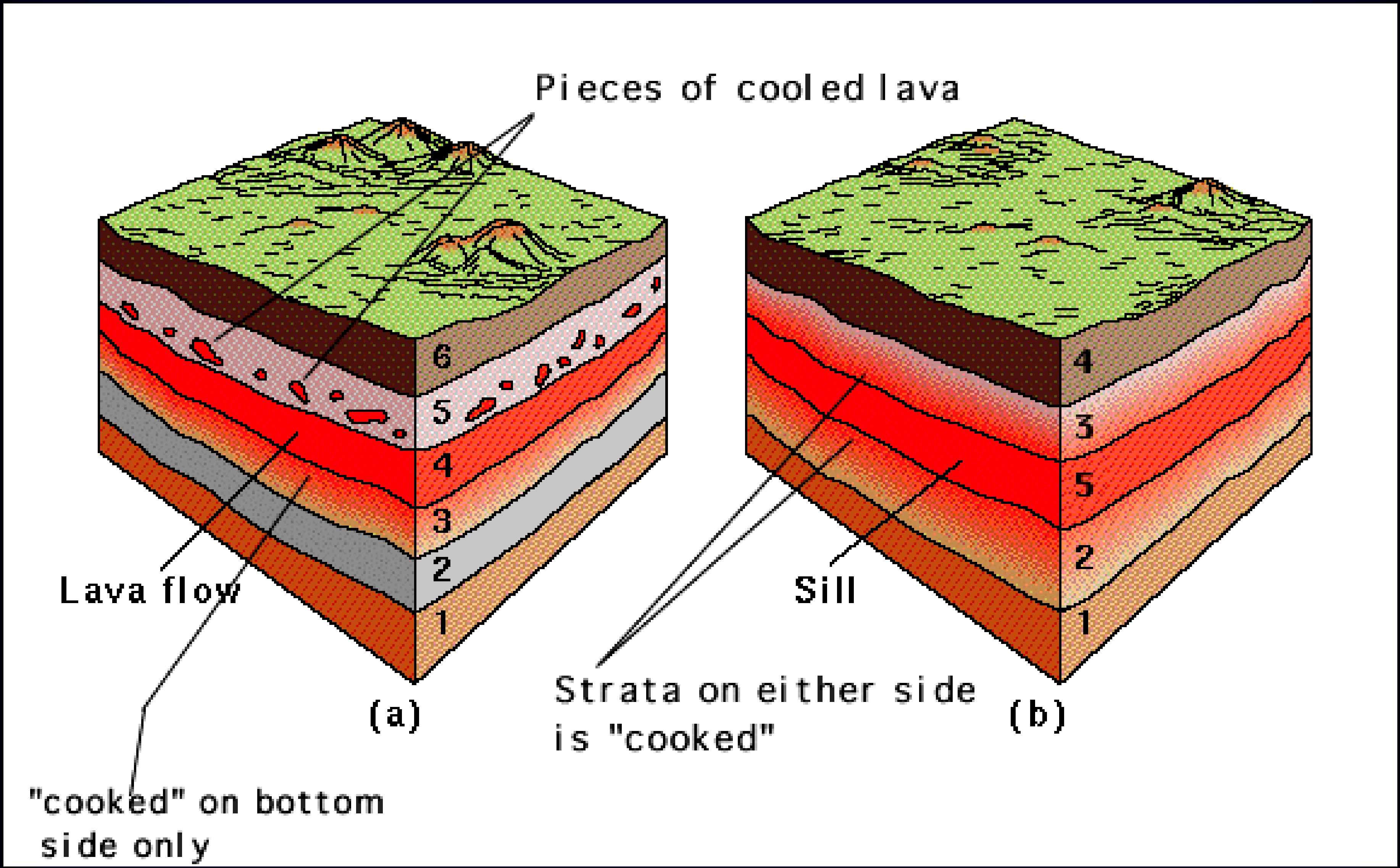
Cross-cutting Relationships



That which cuts through is younger than the Object that is cut

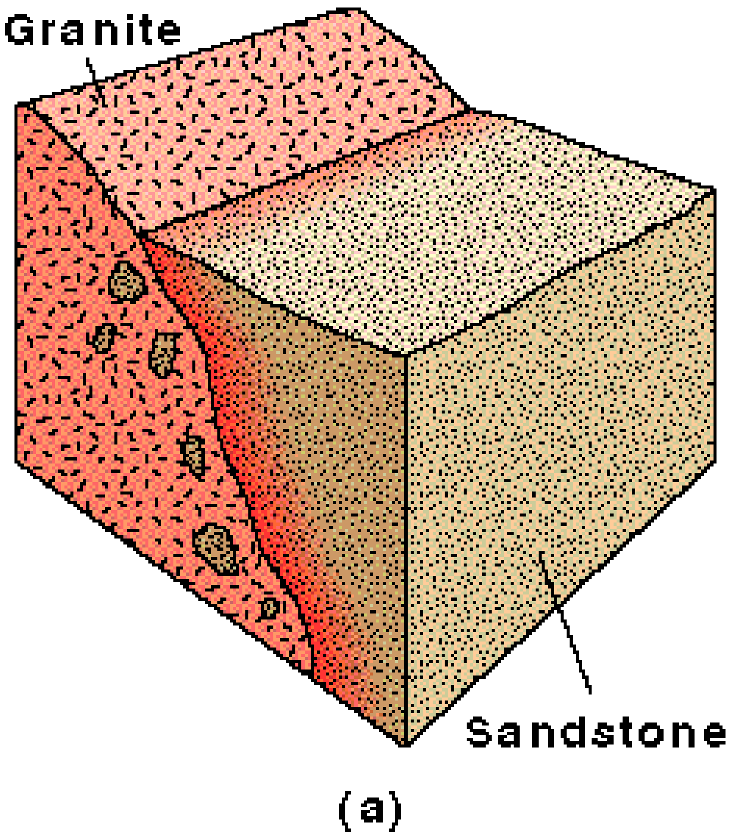


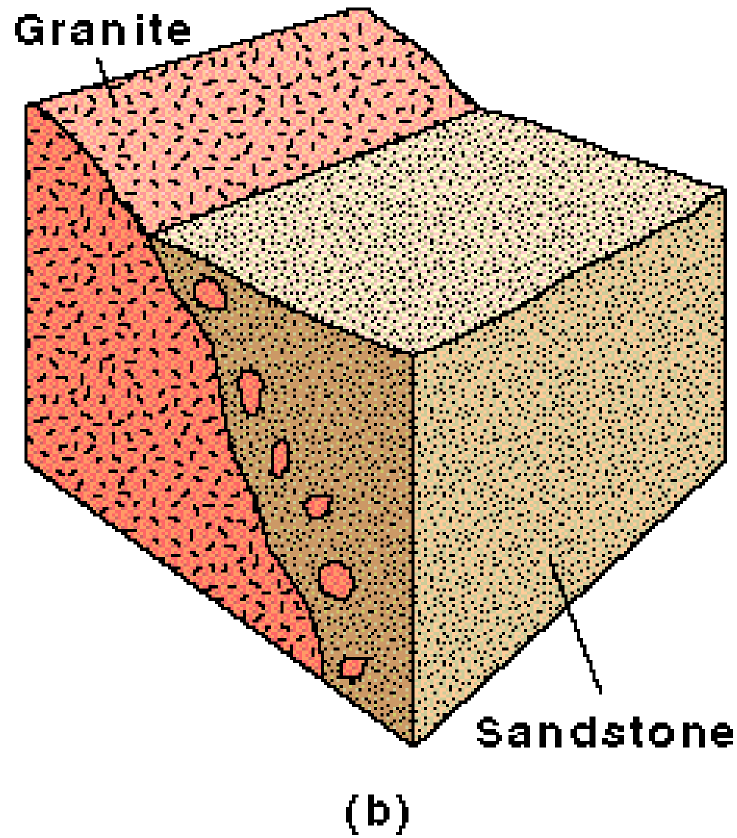
Relative Ages of Lava Flows and Sills



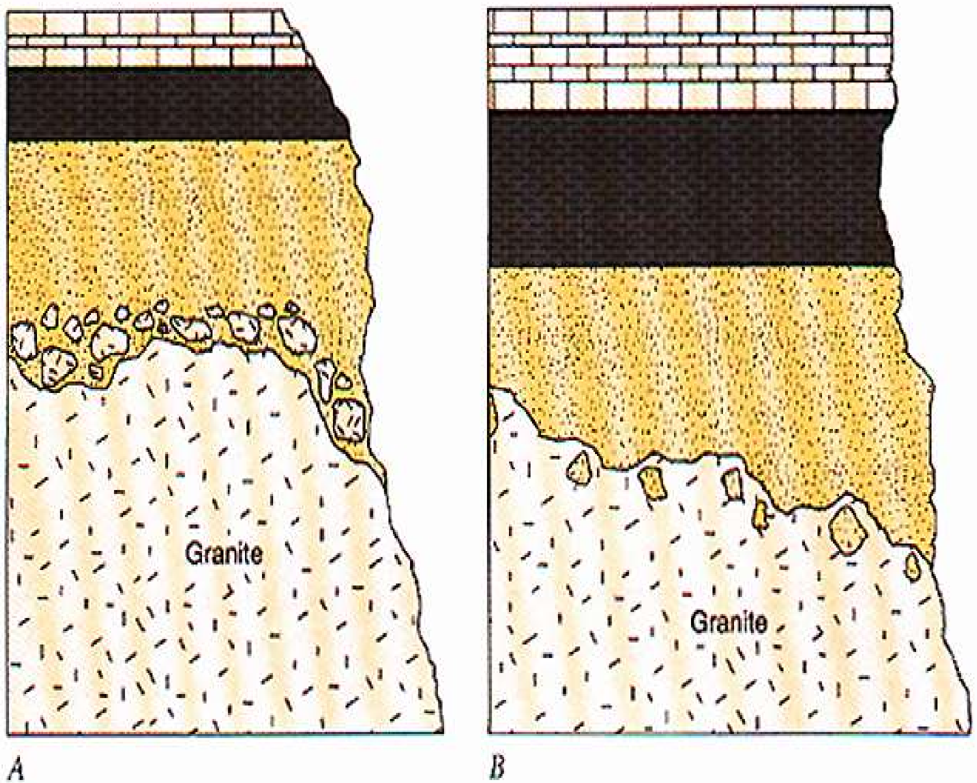
Principle of Inclusions

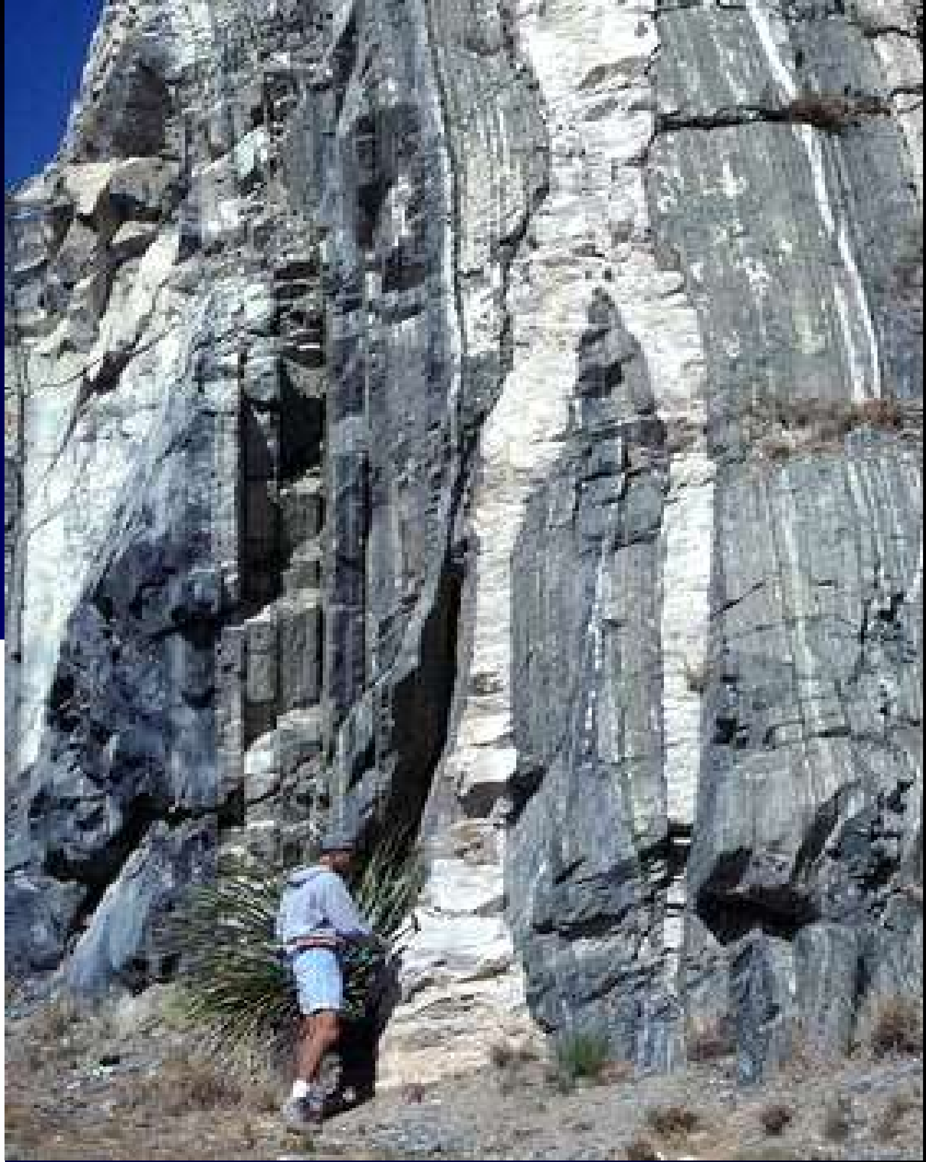
- Inclusions (one rock type contained in another rock type) are older than the rock they are embedded in. That is, the younger rock contains the inclusions





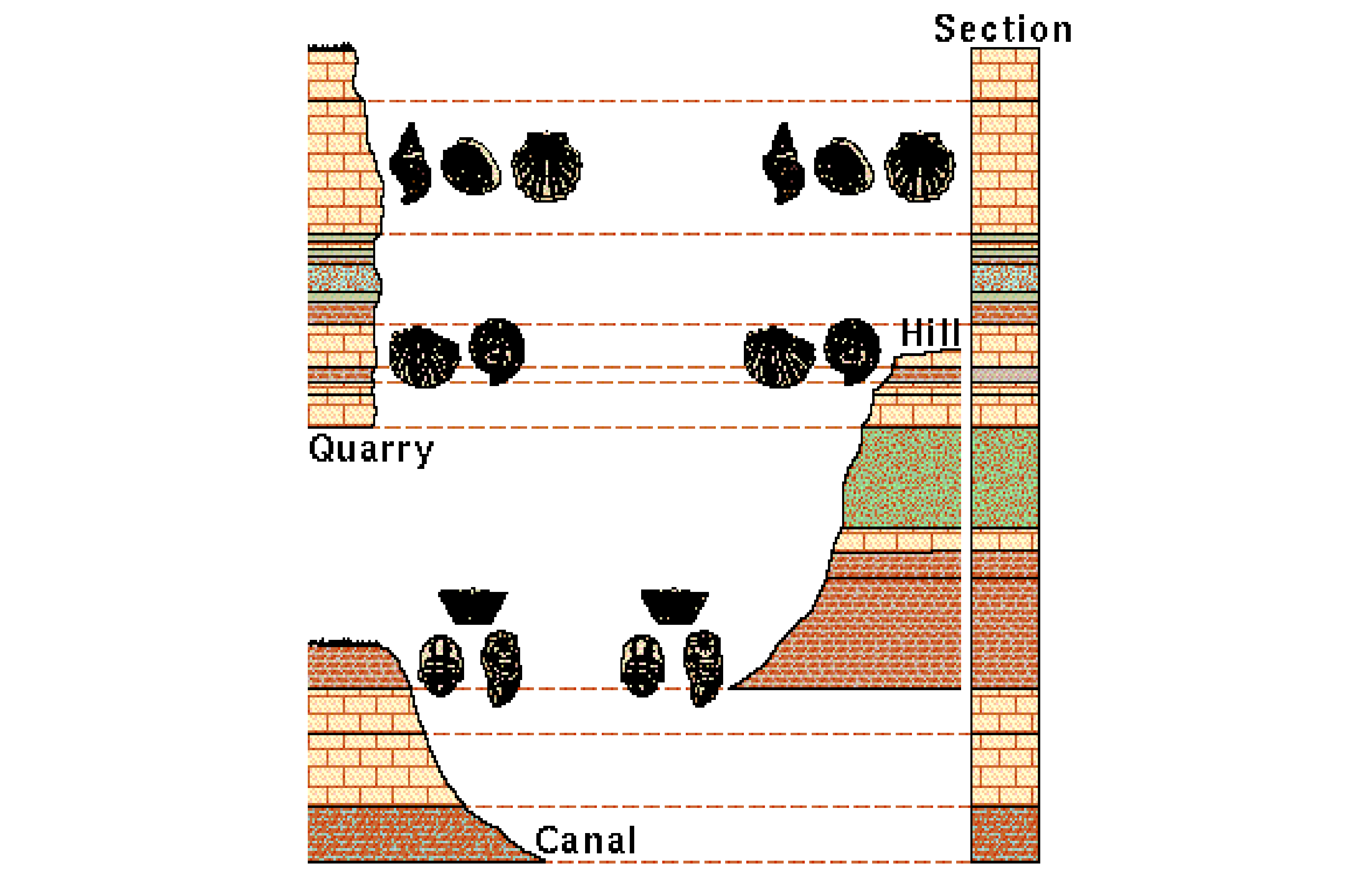
Principle of Inclusions



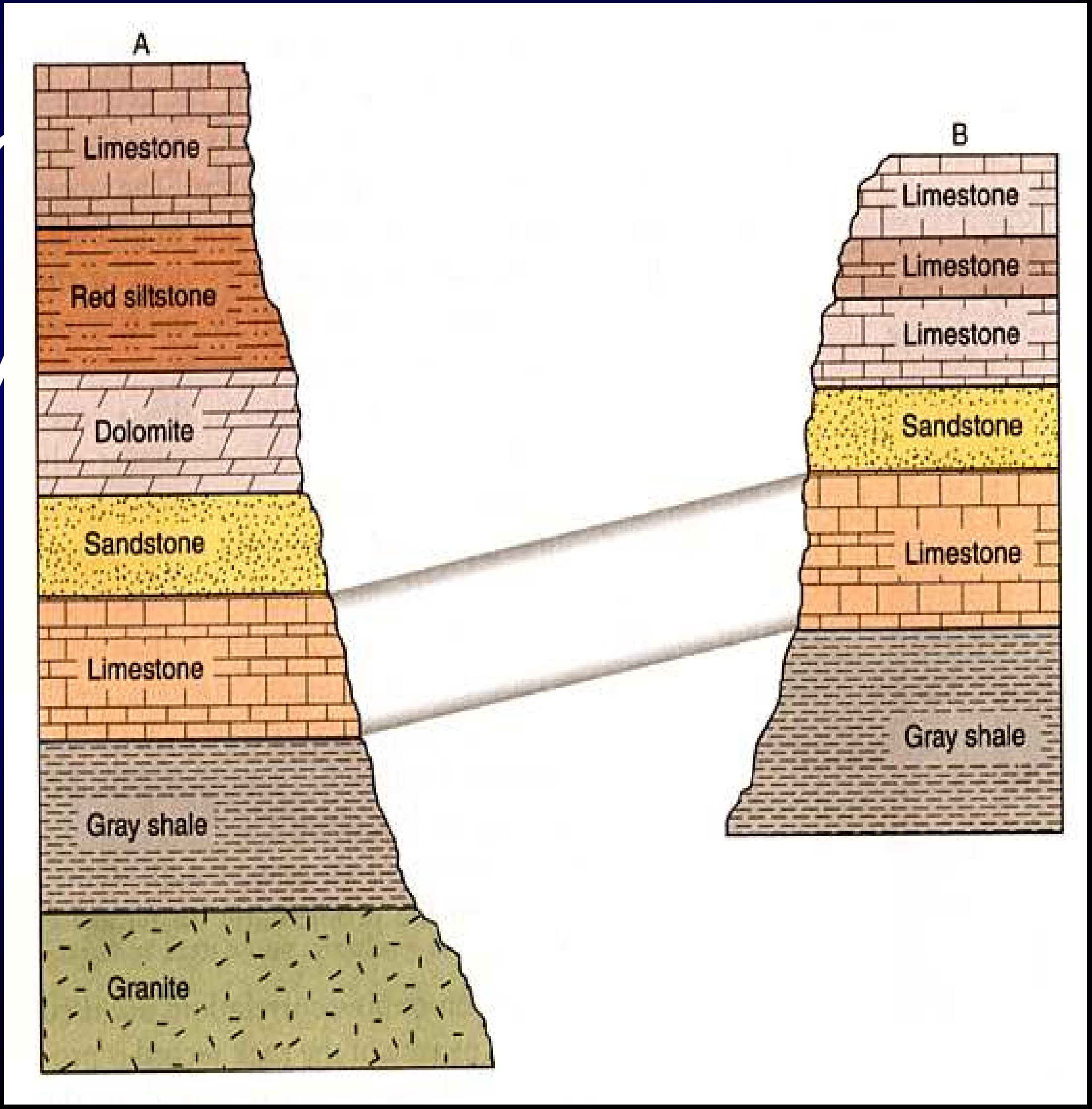


Faunal/Floral Succession

- Fossil assemblages (groupings of fossils) succeed one another through time.



- **Correlation-**
  relating rocks in one location to those in another using relative age stratigraphic principles
  - Faunal Succession
  - Superposition
  - Lateral Continuity
  - Cross-cutting



Unconformities

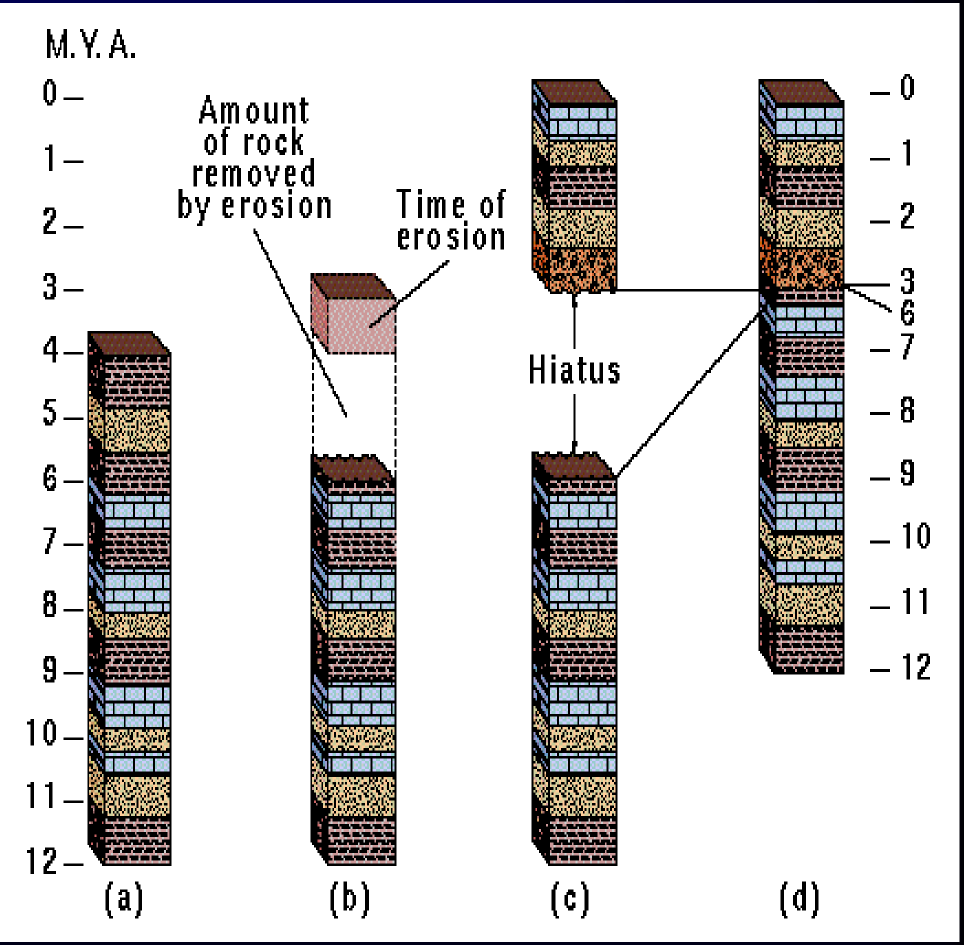
- surfaces represent a long time.
  - a time when rocks were not deposited or
  - a time when rocks were eroded

Hiatus

the gap in time represented in the rocks by an unconformity

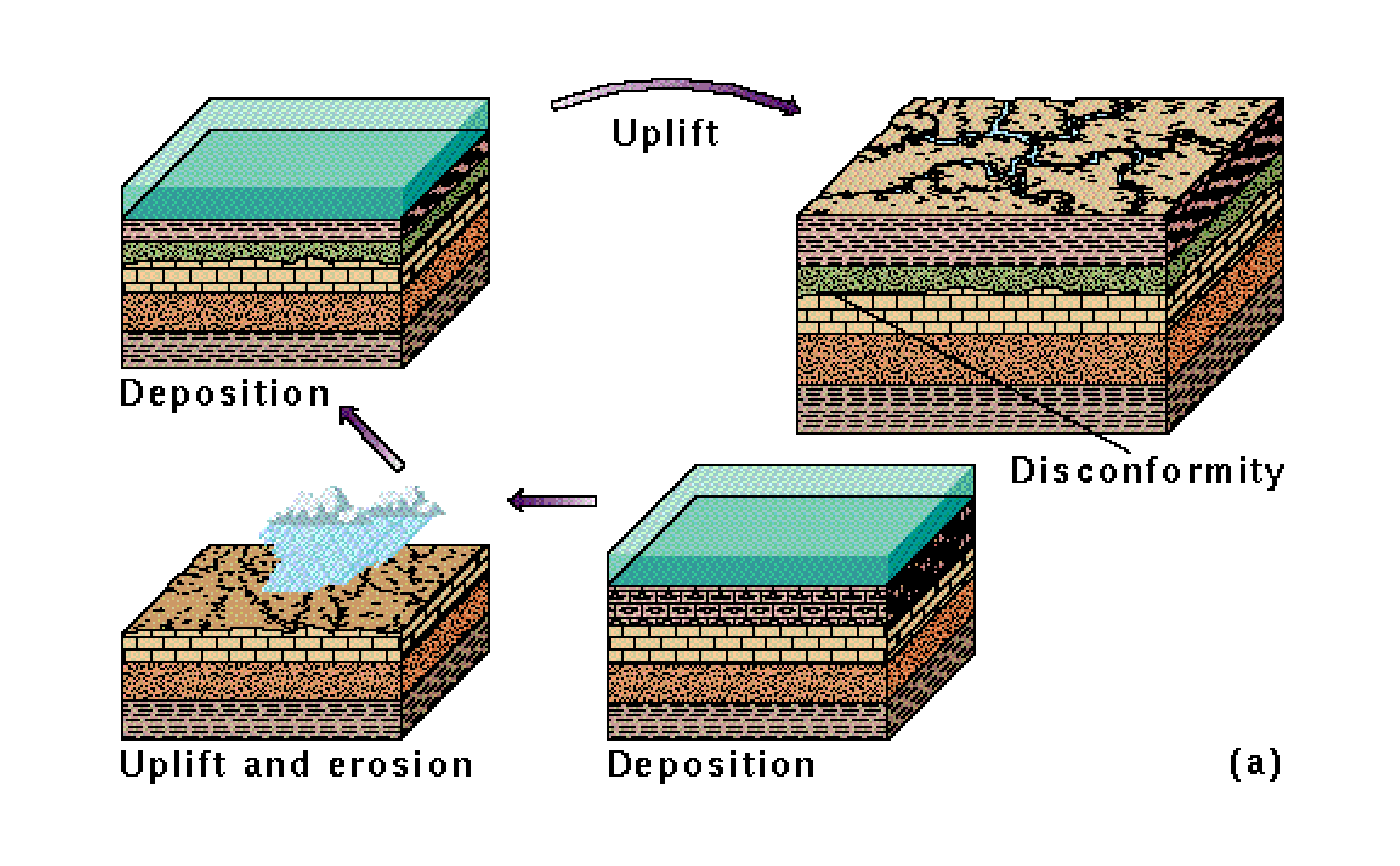
3 kinds

- Angular Unconformity
- Nonconformity
- Disconformity



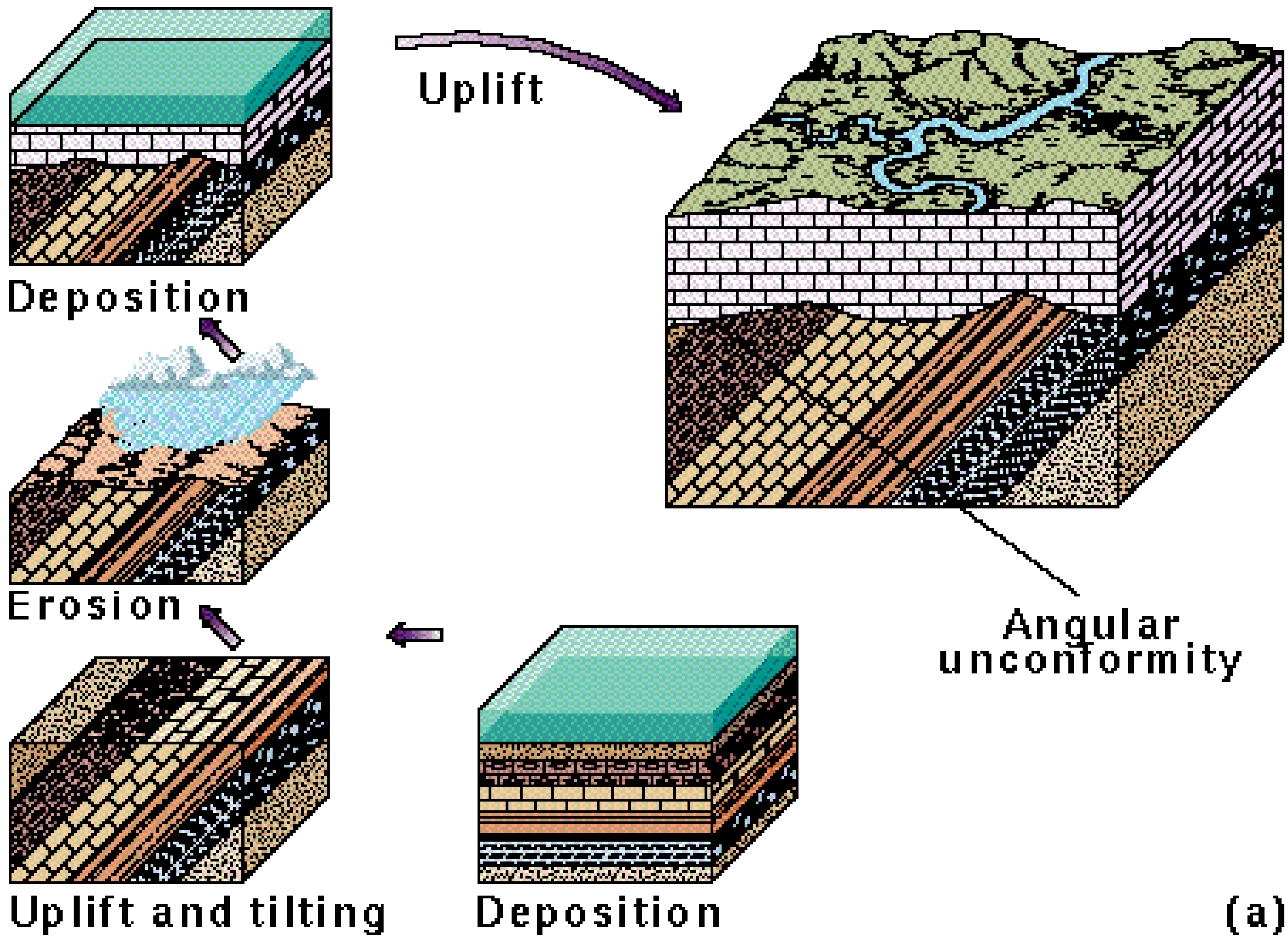
Disconformities

A surface of erosion or non-deposition between **Parallel sedimentary rock beds** of differing ages.



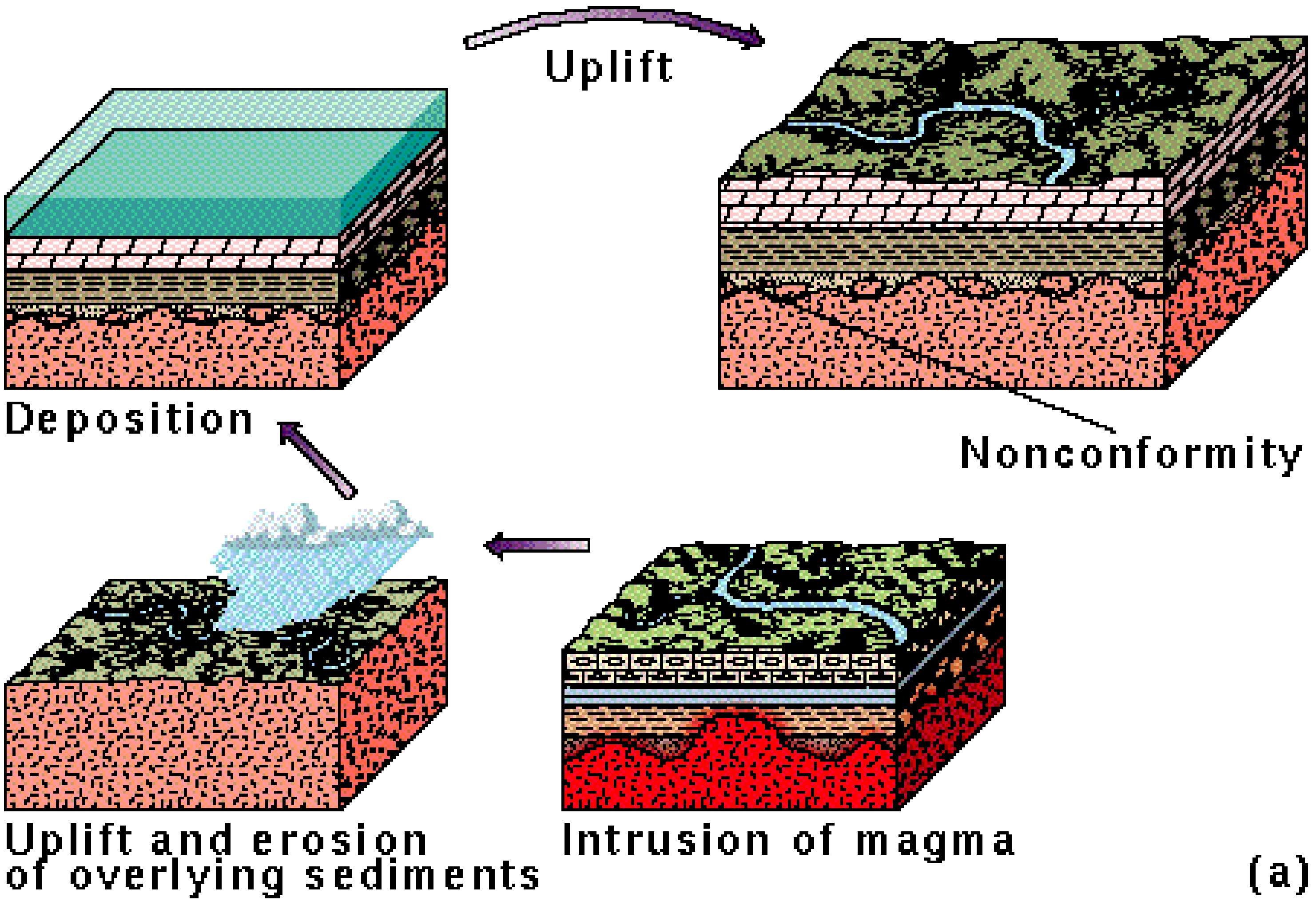
Angular Unconformities

- An angular unconformity is an erosional surface on tilted or folded strata, over which younger strata have been deposited.

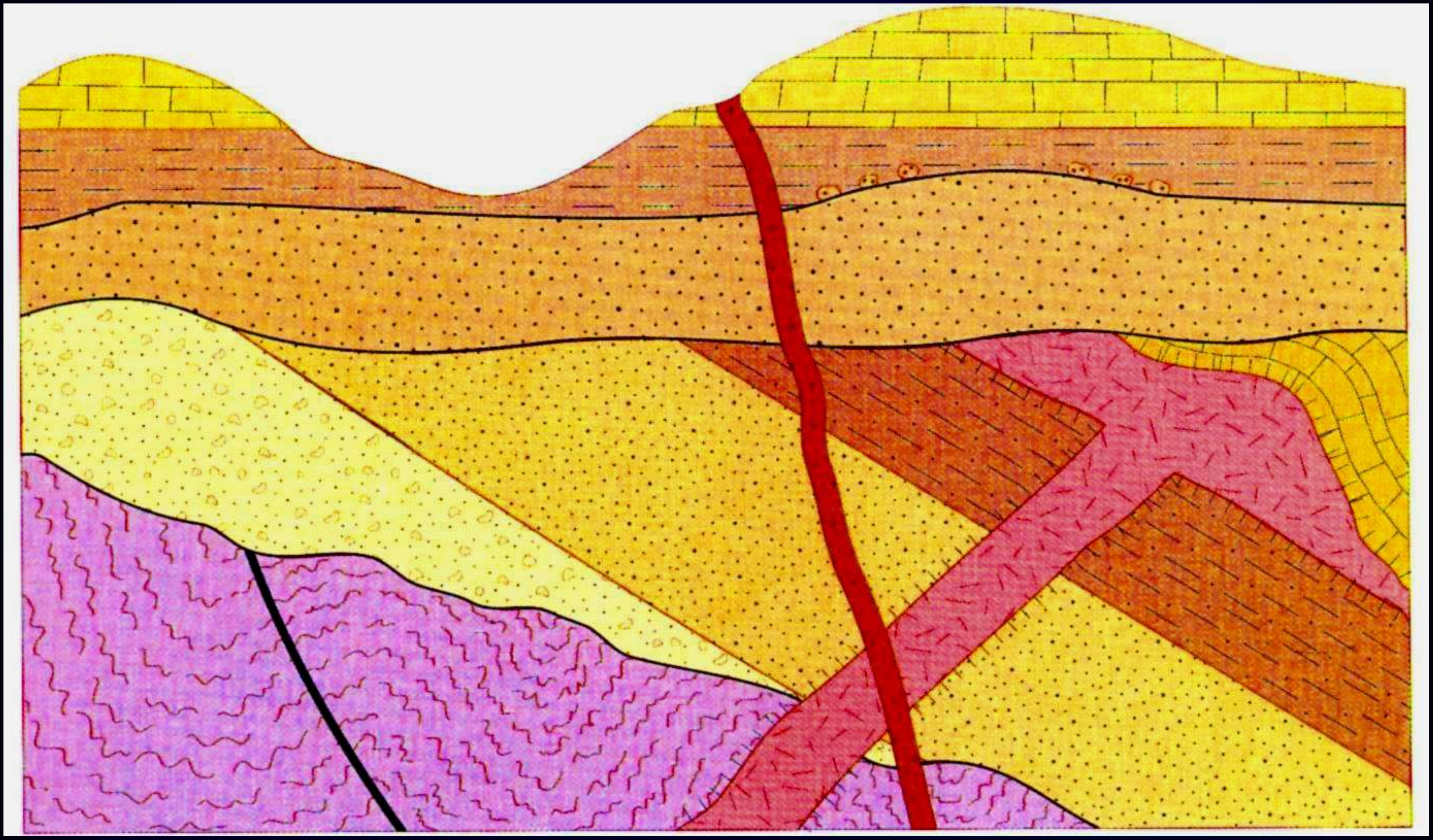


Nonconformities

A **nonconformity** is an erosional surface on igneous or metamorphic rocks which are overlain by sedimentary rocks.



Breakout into groups and discuss the sequence observed here



Age Estimates of Earth

Counting lifetimes in the Bible

Comparing cooling rates of iron pellets.

Determine sedimentation rates & compare

Estimate age based on salinity of the ocean.

all age estimates were off by billions of years

some were more off than others!

Absolute Dating Methods

Radioactive Decay sequences

acts as an atomic clock

- we see the clock at the end of its cycle
- analogous to starting a stopwatch

allows assignment of numerical dates to rocks.

> Radioactive isotopes change (**decay**) into daughter isotopes at known rates.

- rates vary with the isotope
  - e.g., ^{235}U , ^{40}K , ^{14}C, etc.

Decay

unstable nuclei in parent isotope emits subatomic particles and transform into another isotopic element (daughter).

does so at a known rate, measured in the lab

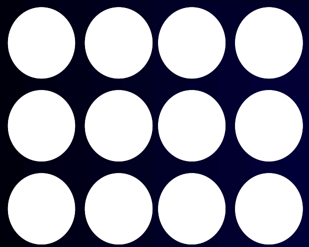
Half-life

The amount of time needed for one-half of a radioactive parent to decay into daughter isotope.

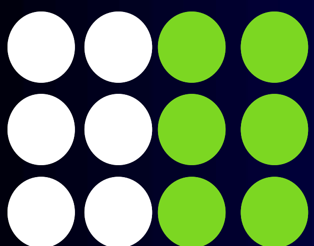
Assumptions?-you bet

Cross-checks ensure validity of method.

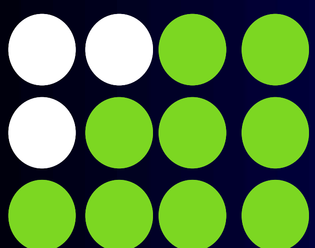
Rate of Decay



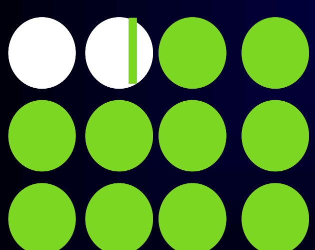
t_0 All atoms are parent isotope or some known ratio of parent to daughter



t_1 1 half-life period has elapsed, half of the material has changed to a daughter isotope (6 parent: 6 daughter)



t_2 2 half-lives elapsed, half of the parent remaining is transformed into a daughter isotope (3 parent: 9 daughter)



t_3 3 half-lives elapsed, half of the parent remaining is transformed into a daughter isotope (1.5 parent: 10.5 daughter)

We would see the rock at this point.

Five Radioactive Isotope Pairs

Isotopes		Half-Life (Years)	Effective Dating Range of Parent (Years)	Minerals and Rocks That Can Be Dated
Parent	*Daughter*			
Uranium 238	Lead 206	4.5 billion	10 million to 4.6 billion	Zircon Uraninite
Uranium 235	Lead 207	704 million		
Thorium 232	Lead 208	14 billion	48.8 billion	
Rubidium 87	Strontium 87	4.6 billion	10 million to 4.6 billion	Muscovite Biotite Potassium feldspar Whole metamorphic or igneous rock
Potassium 40	Argon 40	1.3 billion	100,000 to 4.6 billion	Glauconite Muscovite Biotite Hornblende Whole volcanic rock