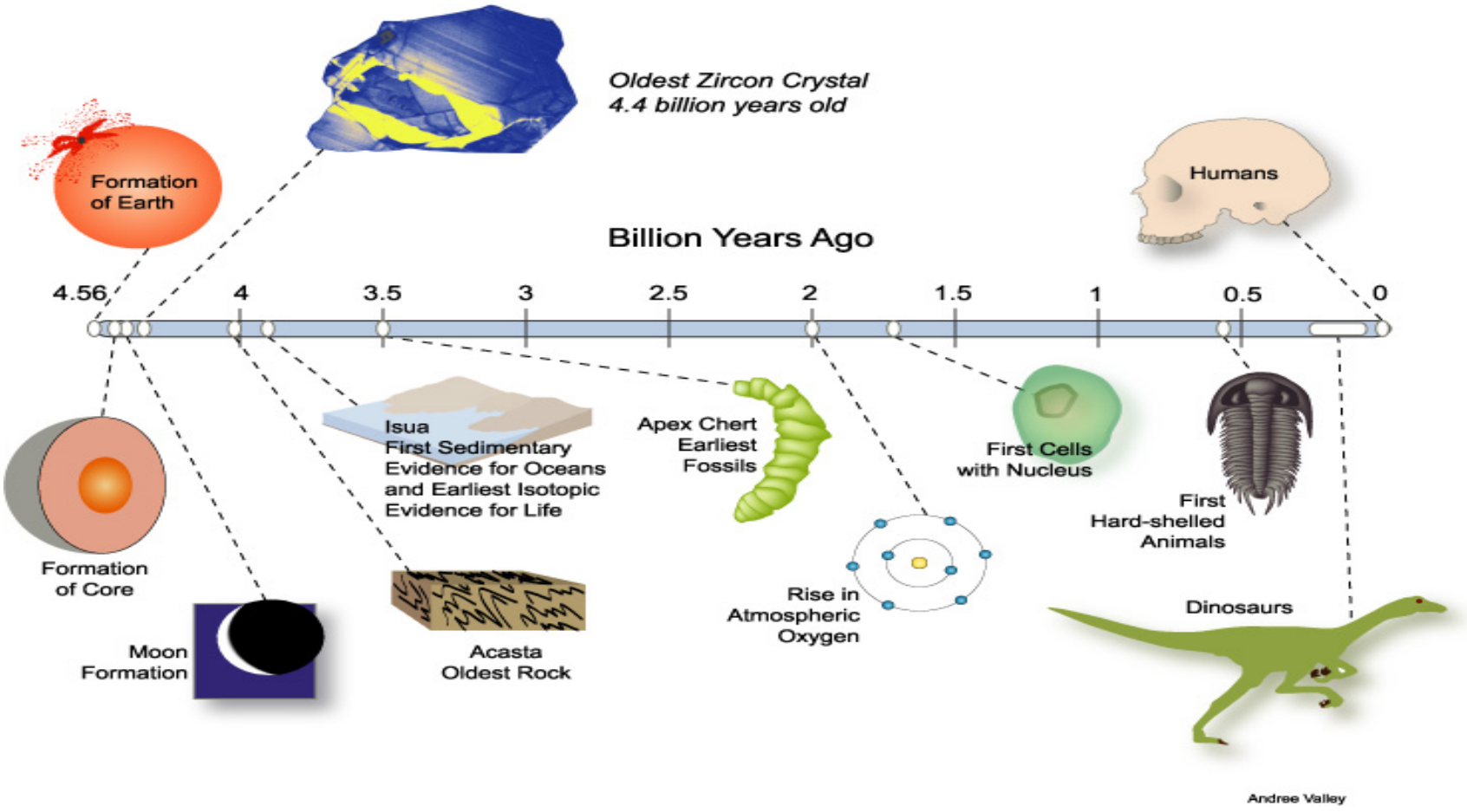
Geologic Laws

How to decode the secrets of time within rock layers...dun, dun, dah!

Relative Age

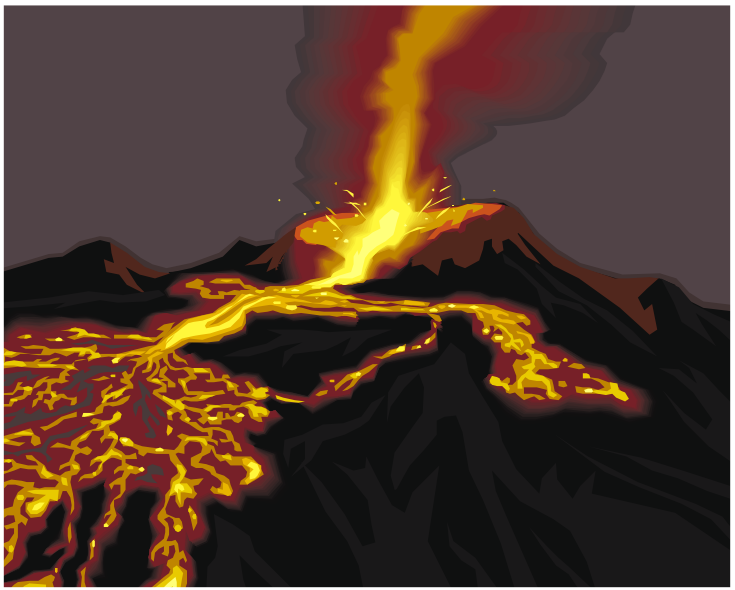
- **Age of rock, fossil, geologic features or events, RELATIVE to other rock, fossil, geologic features or events.**
- **Not an exact age in years!**

- Example of relative age:
  - The formation of the Earth's core is older than the rise of oxygen in the atmosphere.



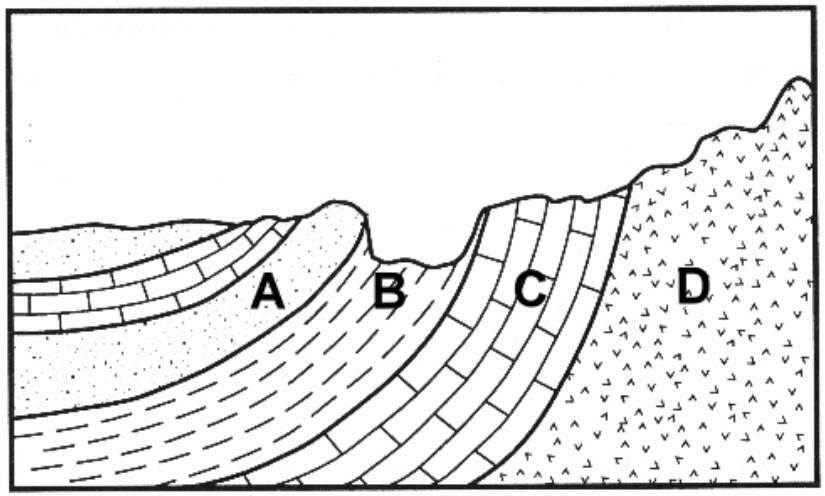
Uniformitarianism

- “The present is the key to the past.”
- All of the processes happening on Earth today also happened in the past.



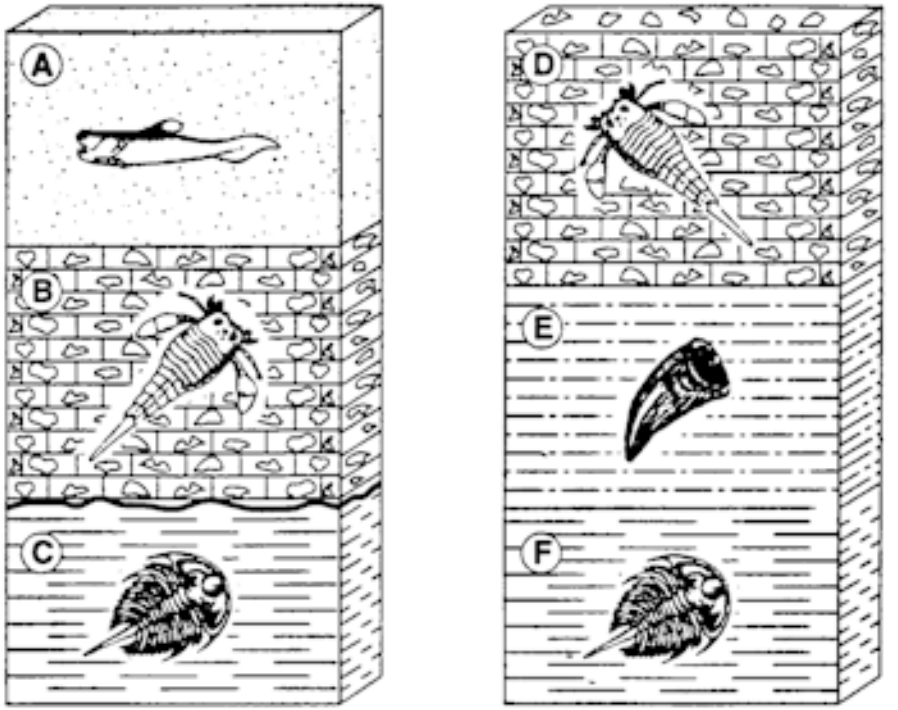
Law of Original Horizontality

- Sediments deposited form flat, level layers
- If layers are currently angled, then the rock layer has moved.



Principle of Superposition

- **The bottom layer is the oldest, with layers on top being younger**

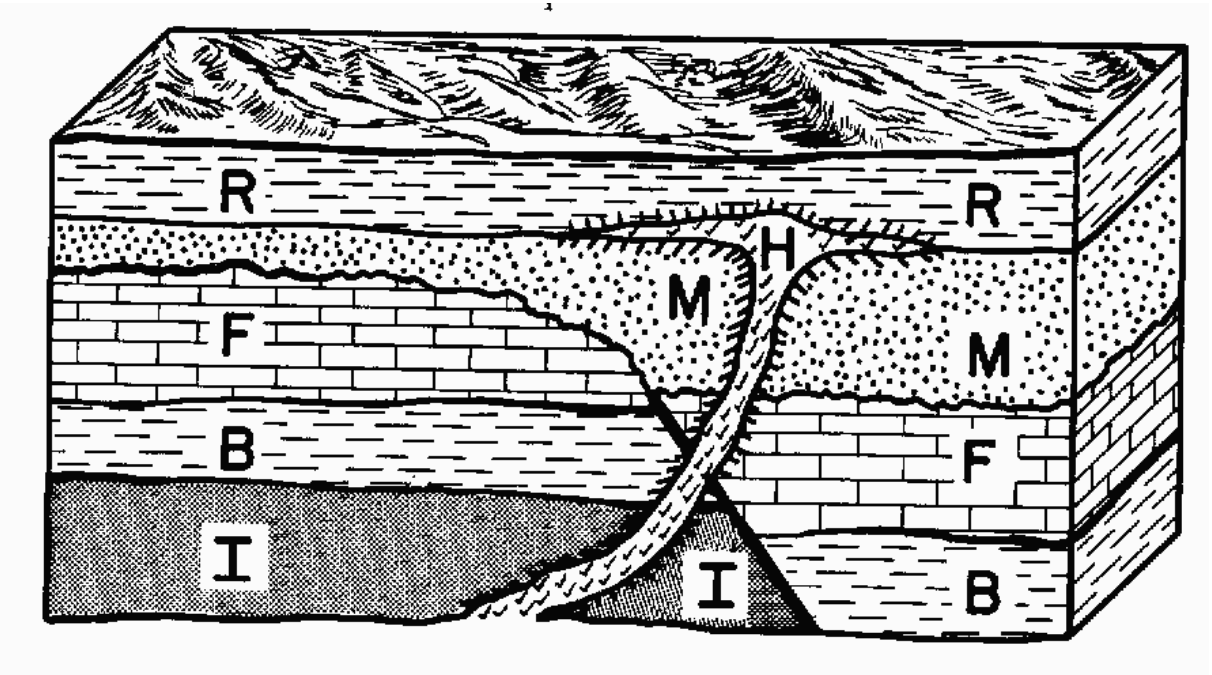


Layers C and F are the oldest layers

Law of Cross Cutting

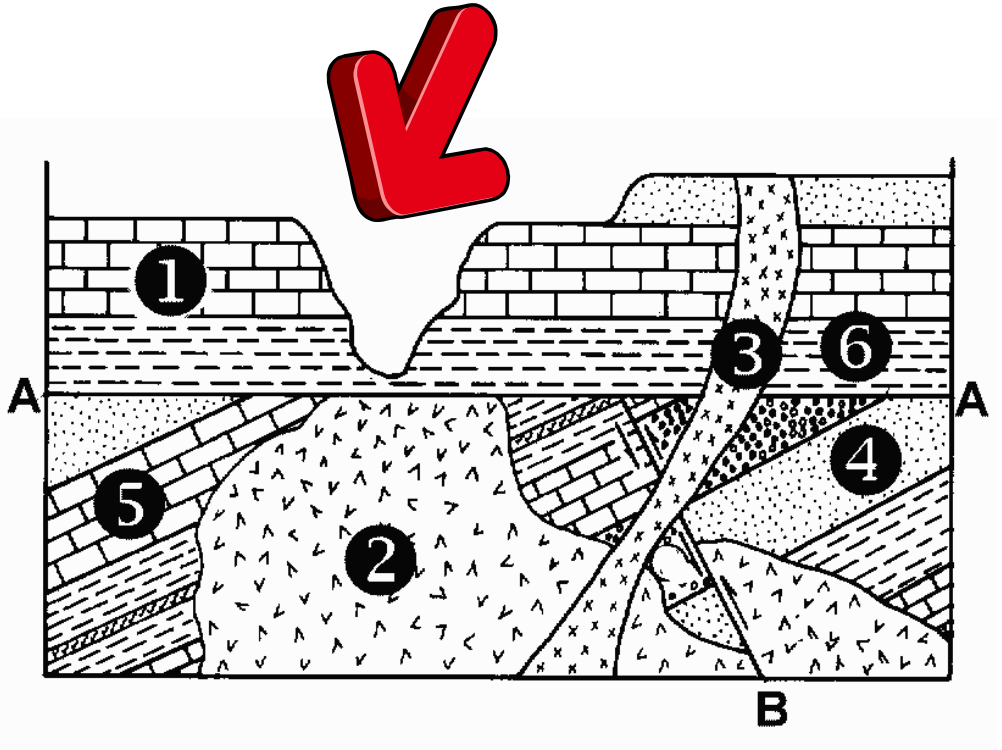
- Igneous rock (intrusions) or faults/folds are younger than the rocks it has intruded or cut through

Layer H is younger than layers: R, M, F, B and I



Unconformities

- Buried erosional surfaces
- Cause gaps in the geologic time record



Fossil Evidence and Correlation:

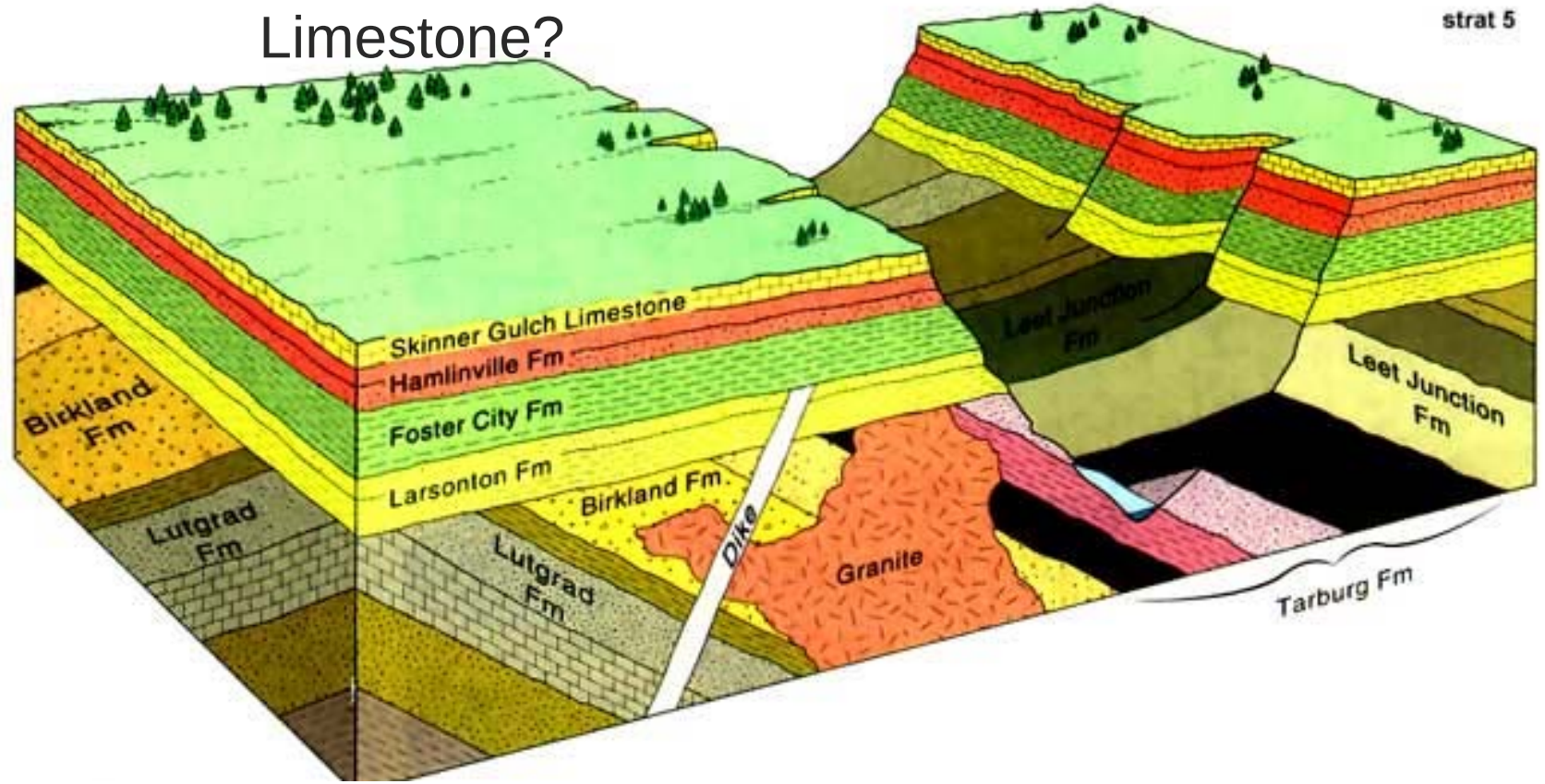
- Found exclusively in sedimentary rocks
- Provide clues to the environments in which the rocks formed
- Example: Trilobites = marine/ocean environment
- Index fossils –organism that lived over a large area (preferably over the entire Earth) for a relatively short period of time.

Volcanic Time Markers

- Violent volcanic eruption can deposit a thin layer of volcanic ash over the entire Earth.
- This layer is very distinguishable and is similar to index fossils (cover entire earth and represent a very short period of time)

Which layer is older:

- Foster City or Larsonton?
- Lutgrad or Birkland?
- Granite or Birkland?
- The unconformity or Skinner Gulch Limestone?



Radiometric dating

- Radiometric dating uses the ratio of radioactive isotopes in a sample to determine the age of the sample.

So, how does Radiometric dating work?

Radioactivity- the nuclei of some elements break apart or decay

- Isotope- an atom with the same number of protons but different number of neutrons. Radioactive elements decay from parent isotopes to daughter isotopes.

- The rate of decay is expressed in half-lives. One half-life is the amount of time necessary for one half of the parent isotopes to decay to the daughter isotopes
  - 1 half-life = 1/2 or 50% parent material remains
  - 2 half-lives = 1/4 or 25% parent material remains
  - 3 half lives = 1/8 or 12.5% parent material remains
  - 4 half lives = 1/16 or 6.25% parent material remains

To determine the age of the sample use the formula:

1. $\frac{\text{Number of parent isotopes}}{\text{Total number of isotopes}} = \%$ of parent isotopes remaining

2. Use the percentage to determine the number of half lives passed.

3. Use the known half life times the number of half-lives passed to find the age of the sample

Example:

A sample of rock has 500 parent atoms and 1500 daughter atoms. The element has a half-life of 1000 years. What is the age of the sample?

1. 500 parent atoms/2000 total atoms = 25% parent atoms remaining.

Using the chart:

2. You can see 2 half-lives have passed

1 half-life = 1/2 or 50% parent material remains
2 half-lives = 1/4 or 25% parent material remains
3 half lives = 1/8 or 12.5% parent material remains
4 half lives = 1/16 or 6.25% parent material remains

3. The half-life of the element is 1000 years times 2 half-lives passed = a 2000 year old sample

Example 2:
A sample of rock has 2000 parent atoms and 14000 daughter atoms. The element has a half-life of 3 million years. What is the age of the sample?

1. 2000 parent atoms / 16000 total atoms = 12.5% parent atoms remaining.

Using the chart:

2. You can see 3 half-lives have passed

1 half-life = 1/2 or 50% parent material remains
2 half-lives = 1/4 or 25% parent material remains
3 half lives = 1/8 or 12.5% parent material remains
4 half lives = 1/16 or 6.25% parent material remains

3. The half-life of the element is 3 million years times 3 half-lives passed = a 9 million year old sample.

Commonly used isotopes for geologic samples:

Radioactive parent	Stable daughter	Half-life
Uranium-238	Lead-206	4.5 billion years
Uranium-235	Lead-207	713 million years
Potassium-40	Argon-40	1.3 billion years