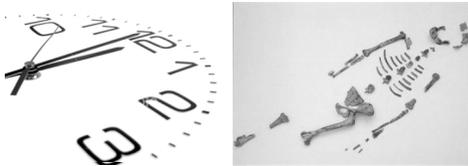


Many Planets, One Earth

The Habitable Planet Ch. 1

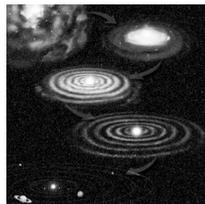
Geologic Time

- Simple organisms first appeared on Earth ~ 3.8 billion years ago
- Complex life forms emerged ~ 2 billion years ago
- Humans are latecomers in geologic time:
 - 1/2 minute before midnight



Nebular Hypothesis

- Solar system formed from a solar nebula (cloud of gas and dust) 4.56 billion years ago.
- Gas giants condensed at cold temperatures. (hydrogen and helium)
- Terrestrial planets cooled closer to the sun (iron and silicates)



Early Earth

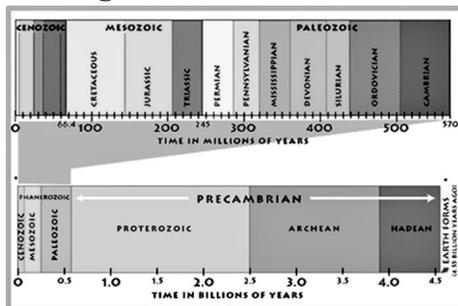
- Hadean (after *Hades*)
 - The first eon of Earth's history
 - From about 4.5 to 3.8 billion years ago
 - Intense Heat from-
 - Radioactive elements decaying within its mass
 - Impacts from Meteorite collisions
- About 4 billion years ago, conditions moderate.
 - Surface cooled
 - Water vapor to condense in the atmosphere (Hydrologic Cycle)
 - Oceans existed as long ago as 3.5 billion years.

Venus - Earth - Mars

- Venus: Thick atmosphere of CO₂
 - Runaway Greenhouse Effect - 850°F
- Mars: 100 times thinner than Earth
 - Temperatures rarely reach above freezing at the equator
- Neither presently have a Hydrologic Cycle



Geologic Time Scale

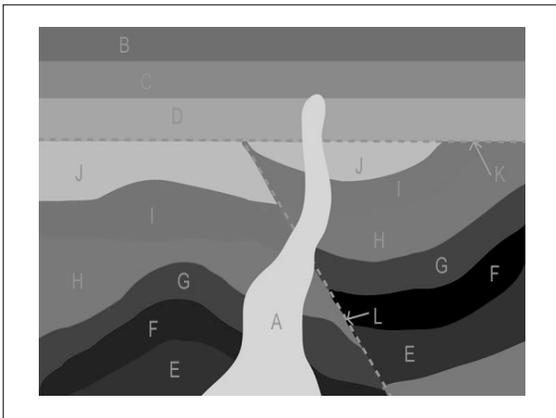


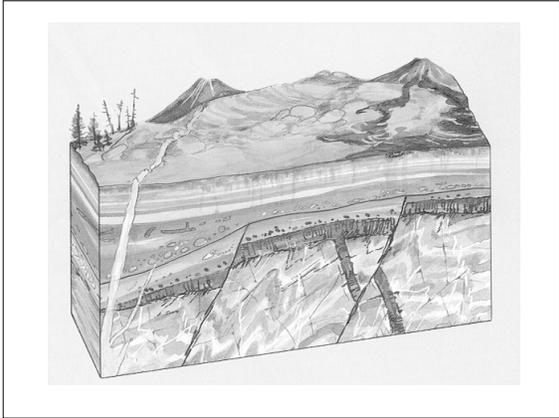
Geologic Time Scale

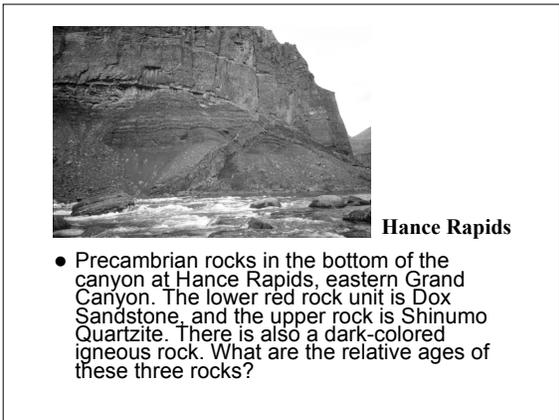
- Each unit is based on stratigraphic and fossil record
- Stratigraphic record: Sequences of rock layers. Correlating the sequences of rock layers in different areas enables scientists to trace a particular geologic event to a particular period.
- Results in relative dating

Stratigraphic Record

- Original Horizontality
- Superposition
- Cross Cutting Relationships
 - Unconformity
 - Buried Erosional Surface
 - Discontinuity
 - Fracture
 - Intrusions
 - Dikes and Sills







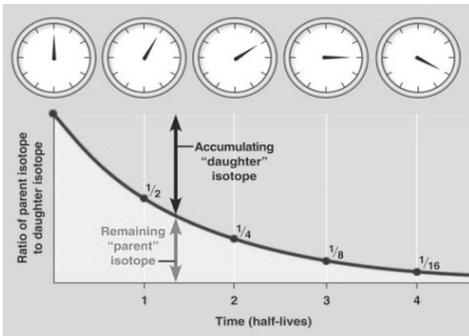
Hance Rapids

- Precambrian rocks in the bottom of the canyon at Hance Rapids, eastern Grand Canyon. The lower red rock unit is Dox Sandstone, and the upper rock is Shinumo Quartzite. There is also a dark-colored igneous rock. What are the relative ages of these three rocks?

Radiometric Dating

- A technique used to date materials based on a knowledge of the decay rates of naturally occurring isotopes, and the current abundances. It is the principal source of information about the age of the Earth and a significant source of information about rates of evolutionary change.

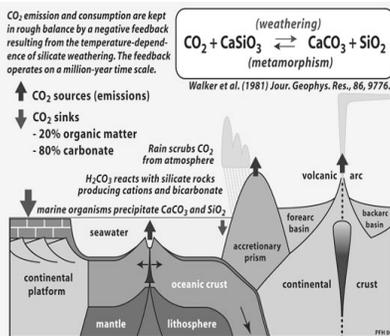
Radiometric Dating



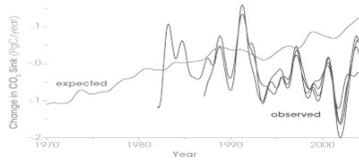
Geochemical Carbon Cycle

1. Rainfall scrubs CO₂ out of the air, producing carbonic acid (H₂CO₃).
2. Carbonic acid reacts on contact with silicate rocks to release calcium cations.
3. Calcium carbonate (CaCO₃), also known as limestone, is precipitated in sediments.
4. Oceanic crust containing limestone sediments is forced downward into Earth's mantle through subduction.
5. Volcanic activity returns CO₂ to the atmosphere.

Geochemical Carbon Cycle

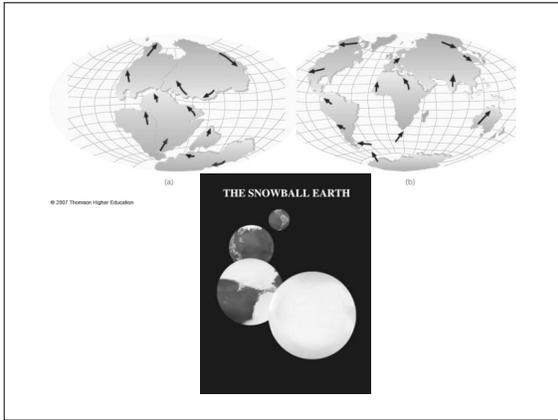


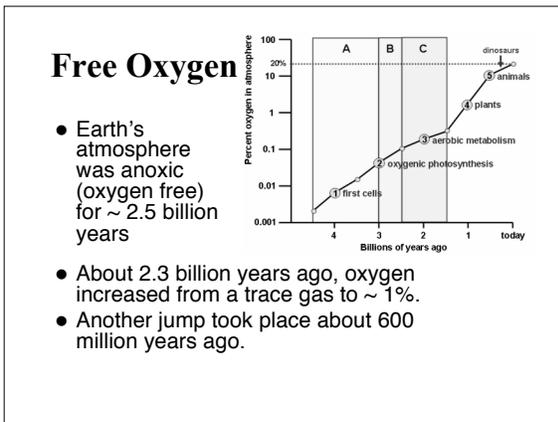
- sink—a process that removes excess carbon from the atmosphere
- Between 1981 and 2004 carbon dioxide concentrations in the Southern Ocean didn't change at all, even though global atmospheric levels continued to rise. This graph shows the changes scientists expected to see (blue line) compared to their estimate of actual carbon dioxide absorption (red line).

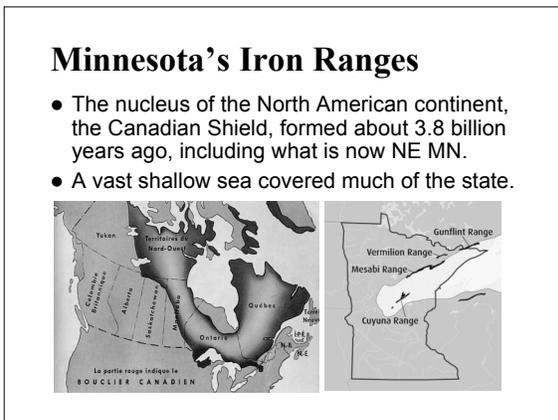


Snowball Earth

- Hypothesis that proposes that the Earth was entirely covered by ice at times in history
- The first "Snowball Earth" phase occurred ~ 2.3 billion years ago, followed by several more between 750 and 580 million years ago.
- Continents were clustered at low latitudes
- Weathering reactions continued even as the Earth became colder and colder.
- Ice-albedo effect occurred: ice reflected incoming solar energy back to space, cooling the surface and causing still more ice to form.







Minnesota's Iron Ranges

- By 1.8 Billion Years ago increased atmospheric oxygen dissolved into this sea oxidizing free iron cations and causing iron bearing silicates to settle to the bottom along the warm shore.
- As oxygen levels continued to increase, iron was more scarce as a free cation
- Other sediments covered these thick deposits compressing them into layers of iron-bearing rocks such as magnetite, hematite, and taconite.

Hull Rust Mahoning Mine - Hibbing