Core from the Permian red beds that underlie the High Plains aquifer in southwestern Kansas and the Oklahoma panhandle

Red Beds

- ~1.8 BYA once all iron in ocean reacted with O_2, it could build up in the atmosphere, leading to the oxidation of iron on exposed surface.
- This Fe_2O_3 is seen in geological formations called Continental Red Beds
- Only after the surface iron reacted could O_2 then build up in the atmosphere

Carachipampa Volcano and Red Beds, N.W. Argentina

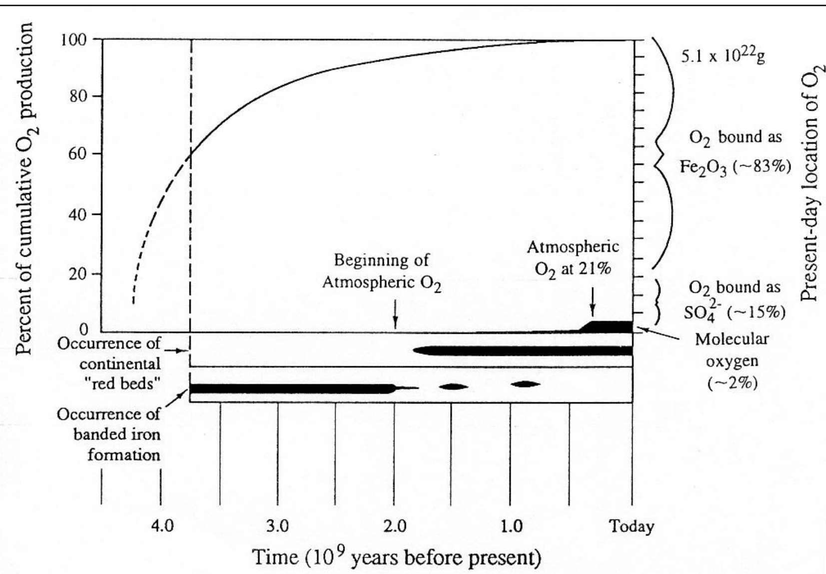
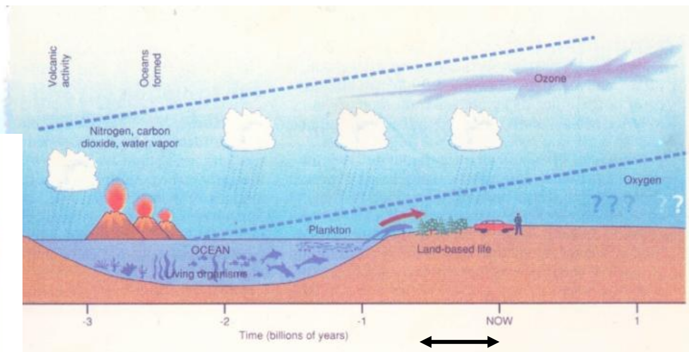


Figure 2.7 Cumulative history of O_2 released by photosynthesis through geologic time. Of more than 5.1×10^{22} g of O_2 released, about 98% is contained in seawater and sedimentary rocks, beginning with the occurrence of Banded Iron Formations at least 3.5 billion years ago (bya). Although O_2 was released to the atmosphere beginning about 2.0 bya, it was consumed in terrestrial weathering processes to form Red Beds, so that the accumulation of O_2 to present levels in the atmosphere was delayed to 400 mya. Modified from Schidlowski (1980).

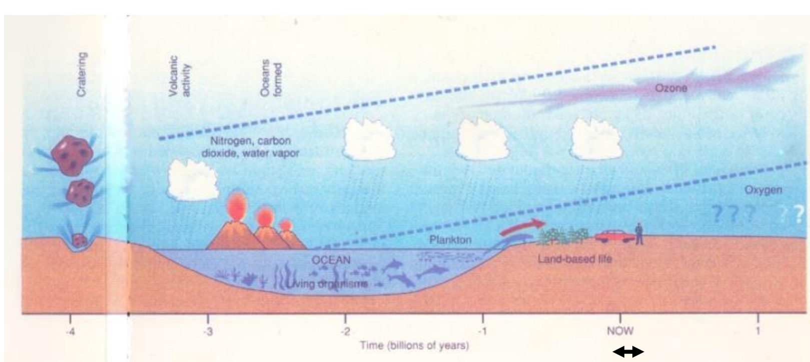
Earth's Modern Atmosphere

- 500 MYA enough O_2 that O_3 layer began
- That protects green plants to colonize land



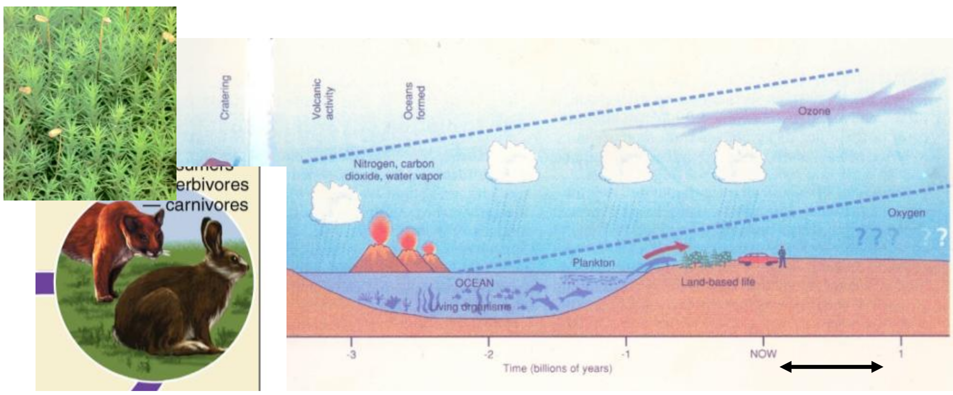
Atmospheric Composition

- The release of O_2 by photosynthesis is probably the most significant effect of life on the geochemistry of the Earth.....until man!

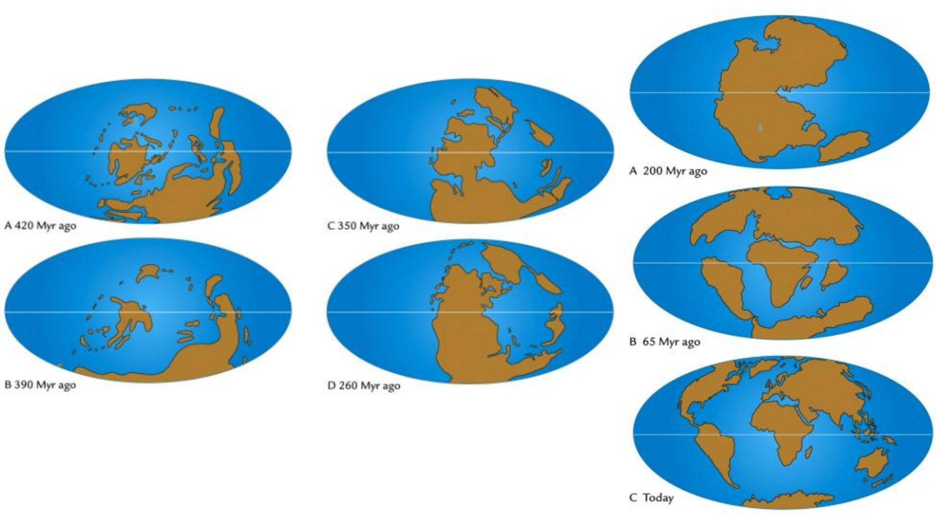


Earth's Modern Atmosphere

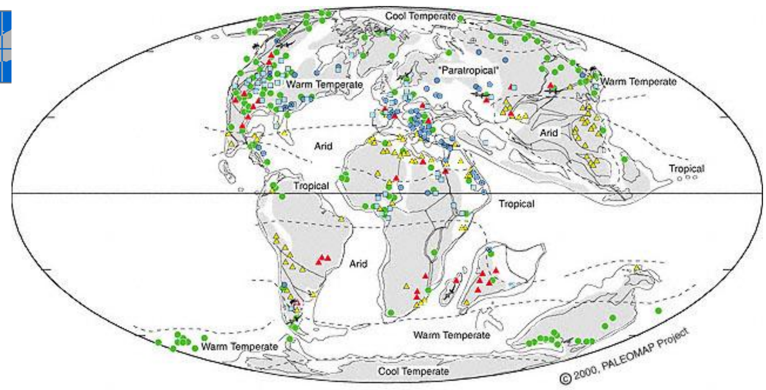
- Just 2% of all O_2 released over 3.8 BY is in atm.
- Now, a balance between O_2 producers and users??



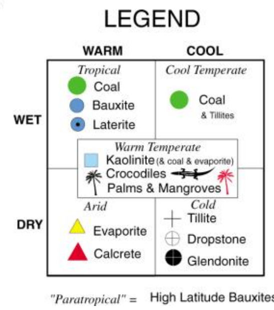
The last 500 MYA or so…



Fossils



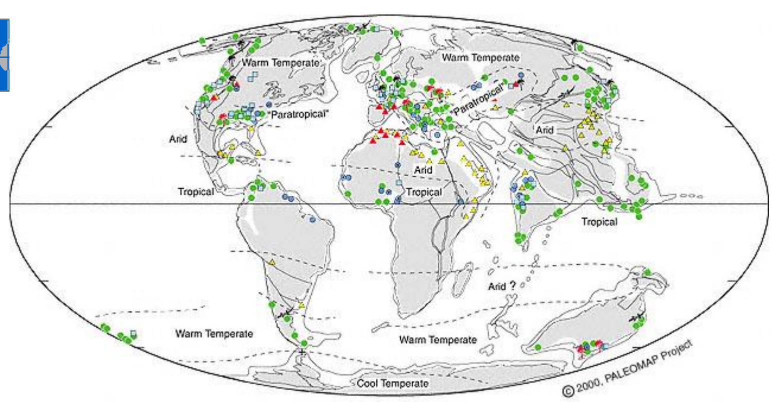
Upper Cretaceous



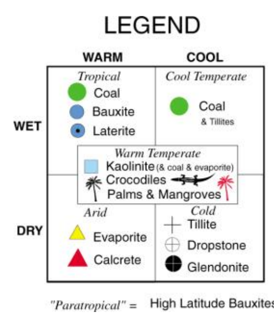
- Cretaceous (100 million ya): +15 C warmer than now
  - Sea level 200 m higher

http://www.scotese.com/Default.htm

Fossils



Lower Eocene



- Early Eocene (55 million ya): +7 C warmer than now

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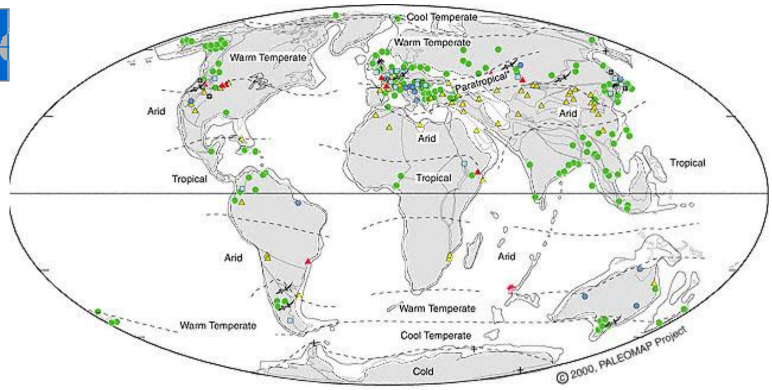
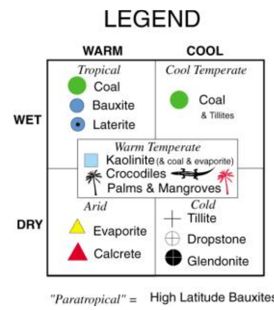
Fossils



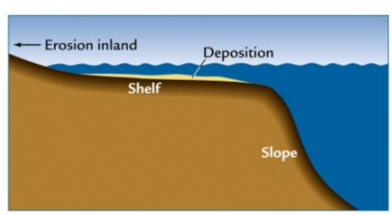
Oligocene



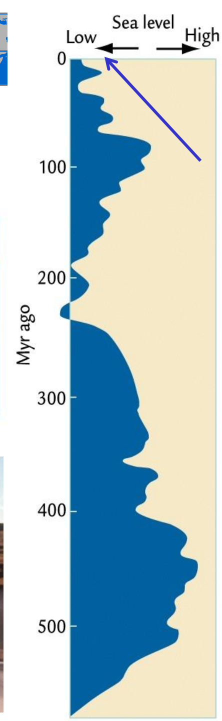
- Messinian Crisis (5-6 Mya): may be coldest, sea level well over 100 m lower than today

Sea-level changes

- Can think of sea level as reflecting relative warmth of whole planet
- Basin factors
  - Shape
  - Slower sea-floor spreading
  - Continental collisions
  - Volcanic plateaus



B High sea level



Sea-level changes

- Climate factors
  - Ice sheets
  - Thermal expansion (0.015% for each 1 C)

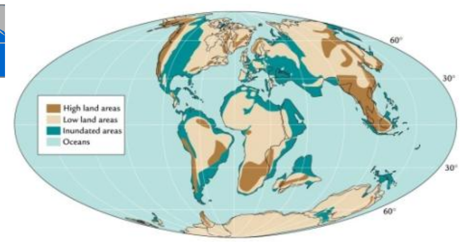
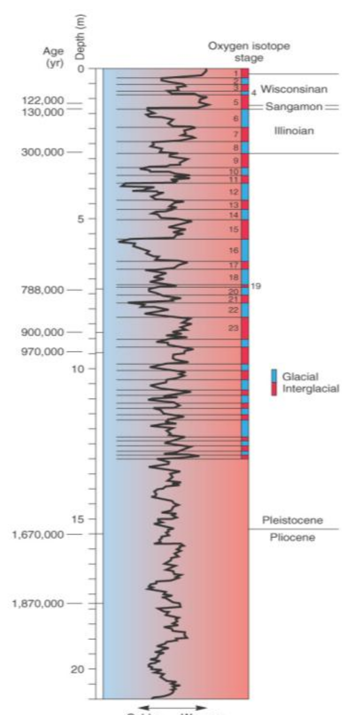


TABLE 6-1 Factors Contributing to Sea Level Fall in the Last 80 Million Years

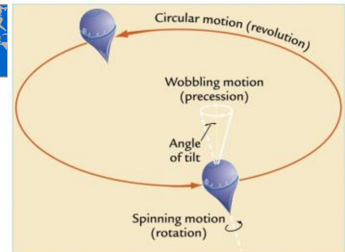
Cause of sea level change	Estimated change (meters)
Decrease in ocean ridge volume	−200 to −300
Collision of India and Asia	−40
Decrease in volcanic plateau volume	−10 to −40
Water stored in ice sheets	−50
Thermal contraction of seawater	−7
All factors	−300 to −440

Past 2.75 Million Years

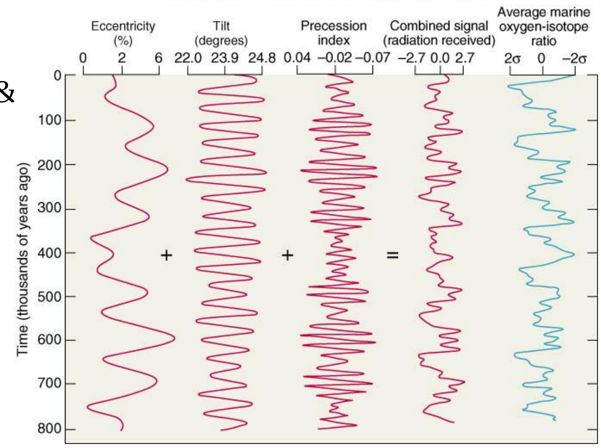
- From deep-sea drilling:
  - At least 50 glacial-interglacial cycles superimposed on the long term cooling trend…
  - 90% of last 0.9 MY there were ice sheets on Earth



Astronomy

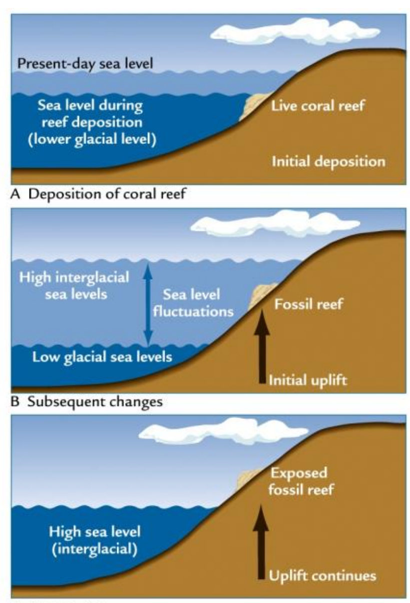


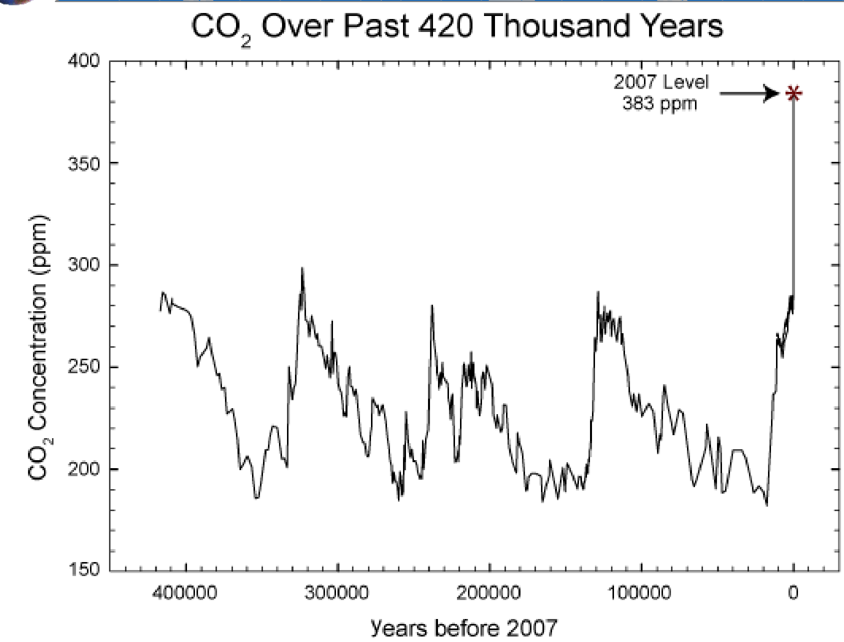
- 1911: Milutin Milankovitch proposes:
  - All 3 cycles (23, 41, & 100 KYA) together control ice ages
  - Summer insolation is driver



Milankovitch Cycles

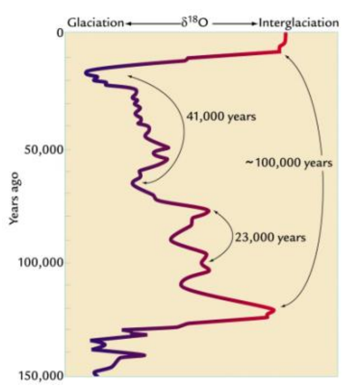
- 1976: Jim Hays, John Imbrie, and Nick Shackleton publish first confirmation of Milankovitch theory
  - Used corals to give dates with uranium decay isotope analysis

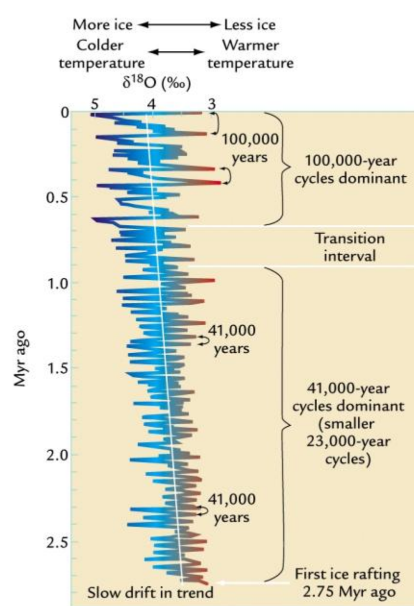




Milankovitch Cycles

- Get reconstructed temps.
  - Switch from 41 & 23 dominant to 100 dominant about 800 KYA





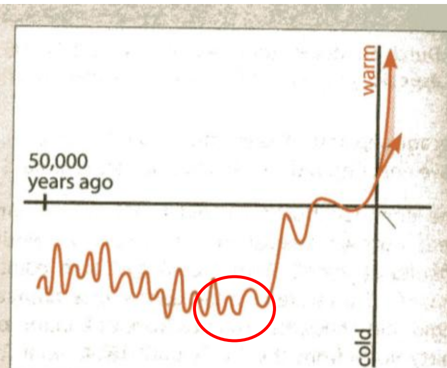
Chronology of Pleistocene Glaciations

North America	Alpine Region	Years before Present
WISCONSINIAN	Würm	— 10,000
Sangamon	Riss-Würm	— 75,000
ILLINOIAN	Riss	— 125,000
Yarmouth	Mindel-Riss	— 265,000
KANSAN	Mindel	— 300,000
Aftonian	Günz-Mindel	— 435,000
NEBRASKAN	Günz	— 500,000
Pre-Nebraskan	Pre-Günz	— 1800,000

In North America, the glacial stages are Nebraskan, Kansan, Illinoian, and Wisconsinian. These terms correspond approximately to the Günz, Mindel, Riss, and Würm in Europe.

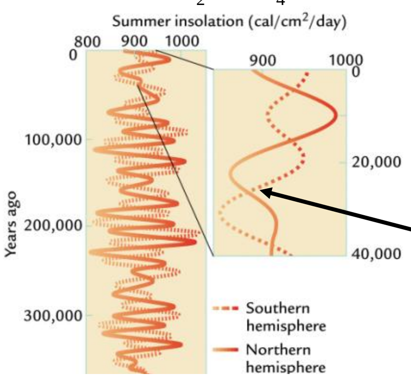
The Last 50,000 Years

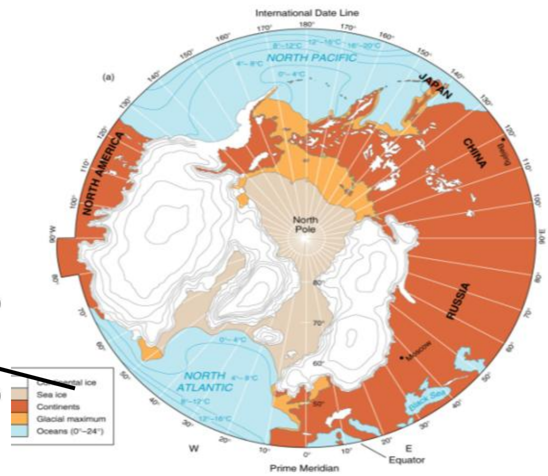
▸ **Over tens of thousands of years** The most recent ice age began about 115,000 years ago and ended about 11,500 years ago. Then came a dramatic warm-up, which lasted until about 3000 BC. Since then, Earth's temperature has changed relatively little, with a very slight cooling interrupted by warmer periods and punctuated by the last century's sharp temperature rise. More than a thousand years from now, after humans have exhausted fossil fuels and the resulting greenhouse gases have left the atmosphere naturally (mostly through slow absorption by the ocean), we may return to cooler times. If the length of the



Last Glacial Maximum

- Cold & Dry
  - Low insolation in northern & southern! (N similar to today)
  - Large ice sheets (lag)
  - Lower CO_2 & CH_4





Last Glacial Maximum

• World sea level fell at least 100 m, thereby causing large expanses of the shallow continental shelves to emerge as dry land

•Disruption of major stream systems.

• The Missouri and Ohio rivers to move into new courses beyond the ice margin.