Historical Geology

Historical Geology

- It is based on Stratigraphy and tries to depict the earth history during the geological time
- Therefore observations are made on the layers of the earth's rocks and its fossils

Historic Geology

The study is dealing with each period of the geological time as a separate unit
Concerning:

Representation on maps of what the earth looked like (Paleogeography)
Determination of Climate (Palaeoclimatology)
Identification of organisms (Palaeontology)
Their distribution and locomotion (Paleobiogeography)
Determination of living or depositional environments (Palaeoecology)
Tectonic events (Tectonics)

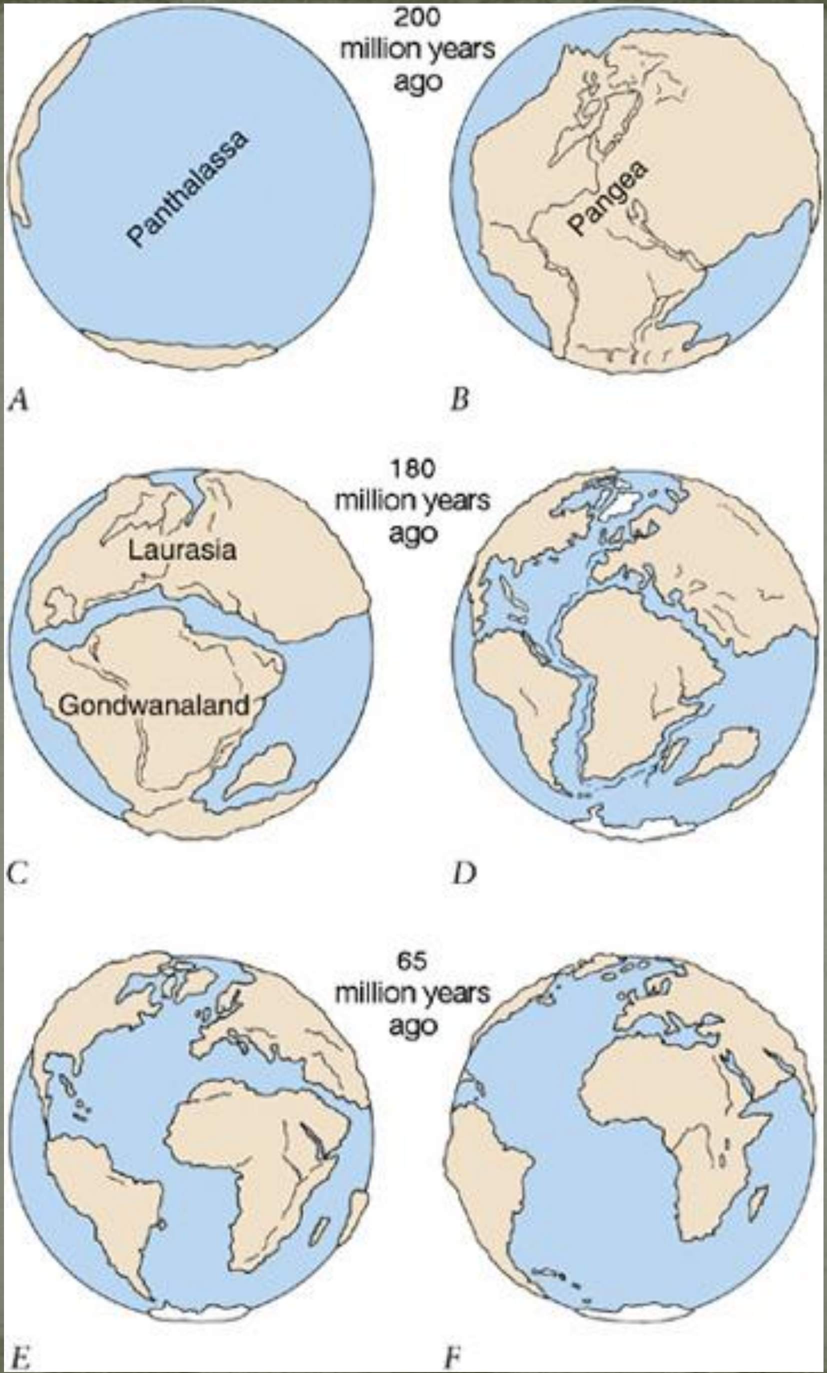
Paleogeography

- The form and representation of the image of the earth in different geological periods
- It identifies the causes that caused these changes and the geodynamic phenomena affecting the distribution of land and sea
- Study of rocks with stratigraphic methods as well as elements from other geosciences
- Finally construction of Paleogeographic maps

Paleogeographic maps

- Simple (spread of geographic areas during a geological period)
- Complex (include the elements that led to the simple maps)
- Expert (mention additional information such as glaciations, palaeogeogeographic or palaeoclimatological data, etc.)

  They include thick contours of contemporary continents to understand their past position and orientation in space


200
million years
ago
Panthalassa
Pangea
A
B
180
million years
ago
Laurasia
Gondwanaland
C
D
65
million years
ago
E
F


170° E
180°
170° W
160° W
150° W
0
200
400 km
Arctic Ocean
Beaufort Sea
Wrangel Island
Siberia
Alaska
Anadyr R.
Chukotka Peninsula
Seward Peninsula
Norton Sound
Yukon River
120
100
Pribilof Islands
Bering Sea
70°
65°
60°
55°

Palaeoclimatology

- Determination of the climate in different geological periods of the earth
- It is based on climatic indicators, mathematical calculations and natural methods
- Climate-related factors include land-sea distribution, latitude, solar radiation, marine currents, wind and air circulation, relief, altitude, water cycle, astronomical movements of the earth
- Principle of uniformism

Climatic Indices

- Lithological
- Biological
- Geomorphological

Lithological Indices

- Certain minerals are formed in specific climatic conditions
  Evaporites - hot and dry climate
  Loess deposits - desolate climate
  Laterites - humid and tropical climate
  Red earths- dry and warm climate

Biological Indices

- Fossils are valuable climatic indicators
  eg. plants and palynology

- They are subject to subjective considerations such as selective fossilization, selective collection of taxa, incorrect determinations

Geomorphological Indices

- They determine climatic conditions
- Other times clear, such as drumlins or moraines indicating glaciers
- Other unclear and need detailed study like River terraces to Determine Sea Level Changes

Warm climate indices

- Red weathering products
- Carbonate deposits in caves (aragonite> 15,6 ° C, calcite <15,6 ° C)
- Deposition of $CaCO_3$ in the seas, during cold periods lower content than hot periods
- Corals, shallow, well-ventilated waters, constant salinity with an mean annual temperature of 21 ° C, latitude 30 ° north-south
- Terrestrial animals. Cold-blooded (reptiles, amphibians) to survive need high temperatures
- Flora. In tropical regions leaves with continuous contour, in cold serrated. In tropical regions larger number of species
- Coal and lignite warm and humid climate

Cold climate indices

- Presence of glacial geomorphs, moraines, dublins, tilites
- River terraces indicating fluctuations in sea level (glacier-interglacial)
- Weathering phenomena and mineralogy, chemical weathering only of easily weathered minerals (Bowen series)
- Flora and fauna

Dry climate indices

- Redearths
- Evaporites
  Desert geomorphs (dunes, Loess)
  Fauna and Flora (xerophytic characters)

Wet climate indices

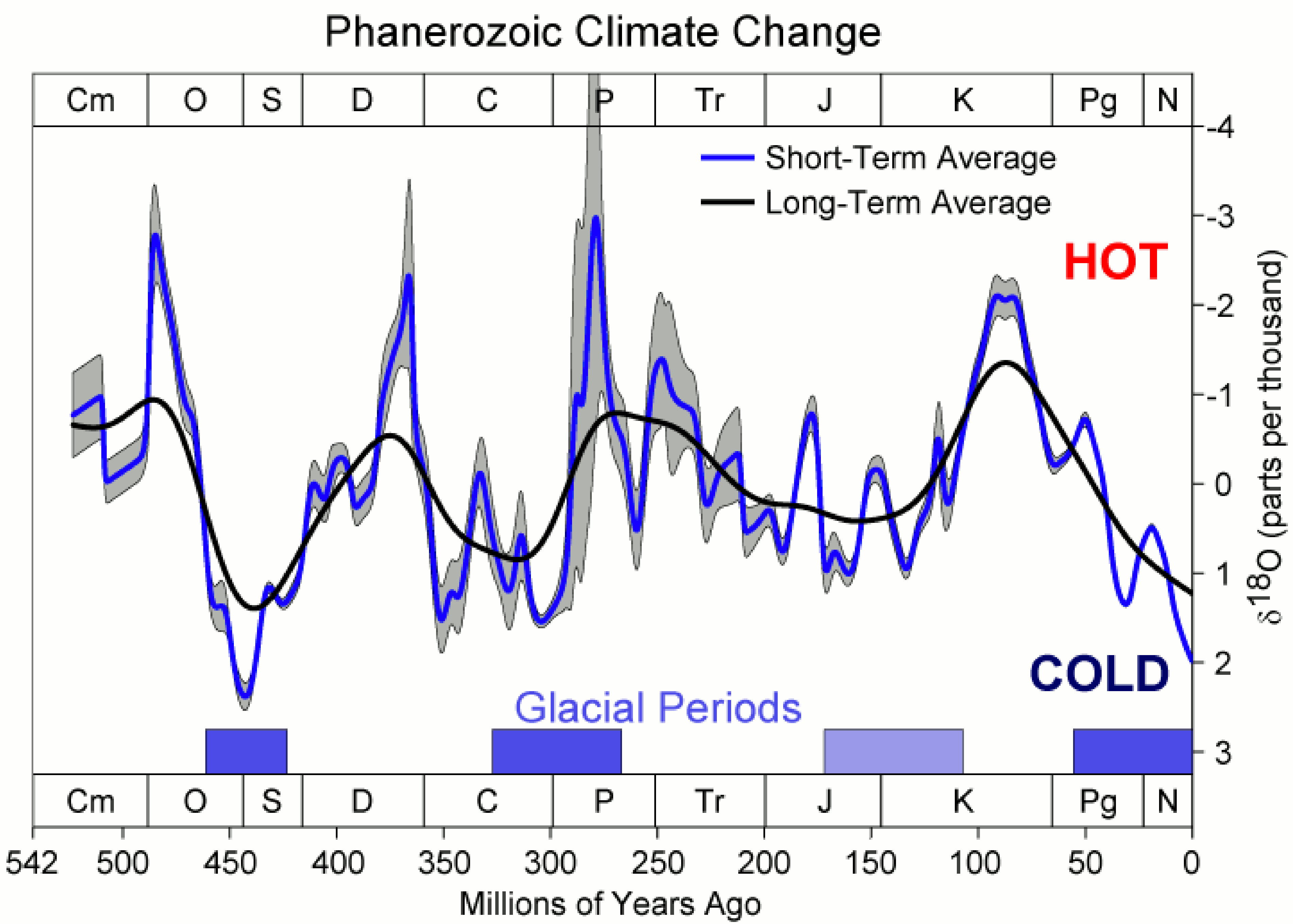
- Inorganic indicators, high chemical weathering
  Lake deposits and terraces
  Flora
  Coal and lignite deposits

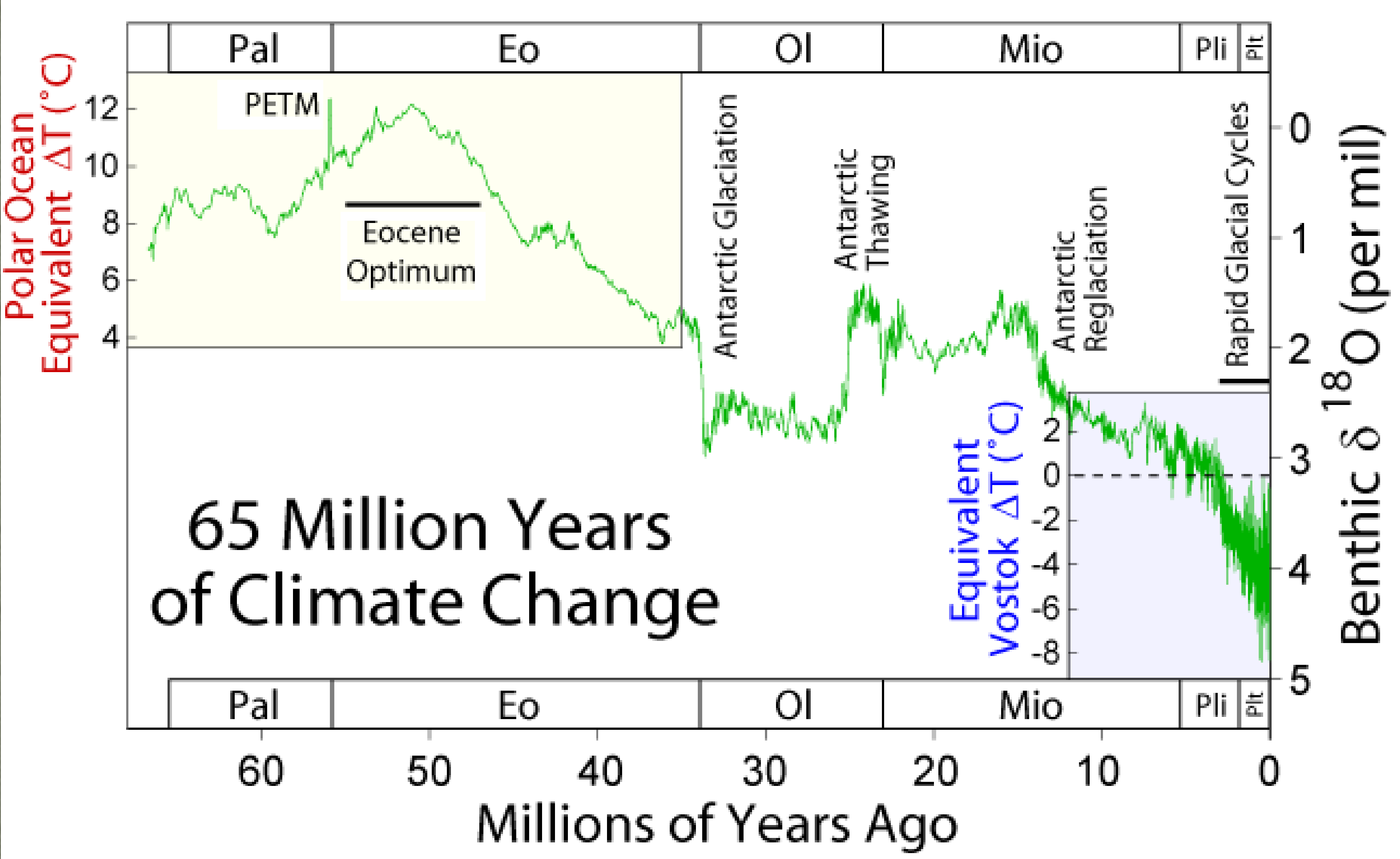
Palaeotemperature

- One of the most important factors influencing the climate
- Which way?
- In 1946 Urey studied the behavior of three oxygen isotopes O^{16}, O^{17}, O^{18} during the evaporation of water
- The most common O^{16} was more easily evaporated and water was enriched in the two heavier
- In seas and oceans greater evaporation and hence enrichment in the heavy isotopes
- Therefore, in oxygenated sediments and animal shells heavy ones are found in larger proportion

Palaeotemperature

- Also segregation of marine and lake sediments
- The relative proportion of O isotopes in carbonate sediments is dependent on ambient temperature at the time of deposition
- It was originally applied to the Jurassic Belemnites growth rings
- A scale of palaeotemperatures was then developed from invertebrate shell analyses based on the O^{18} / O^{16} ratio


Phanerozoic Climate Change
Cm
O
S
D
C
P
Tr
J
K
Pg
N
Short-Term Average
Long-Term Average
HOT
COLD
Glacial Periods
-4
-3
-2
-1
0
1
2
3
δ18O (parts per thousand)
542
500
450
400
350
300
250
200
150
100
50
0
Millions of Years Ago



65 Million Years of Climate Change
Pal
Eo
Ol
Mio
Pli
Plt
PETM
Eocene Optimum
Antarctic Glaciation
Antarctic Thawing
Antarctic Reglaciation
Rapid Glacial Cycles
Polar Ocean Equivalent ΔT (°C)
12
10
8
6
4
Equivalent Vostok ΔT (°C)
2
0
-2
-4
-6
-8
Benthic δ18O (per mil)
0
1
2
3
4
5
60
50
40
30
20
10
0
Millions of Years Ago

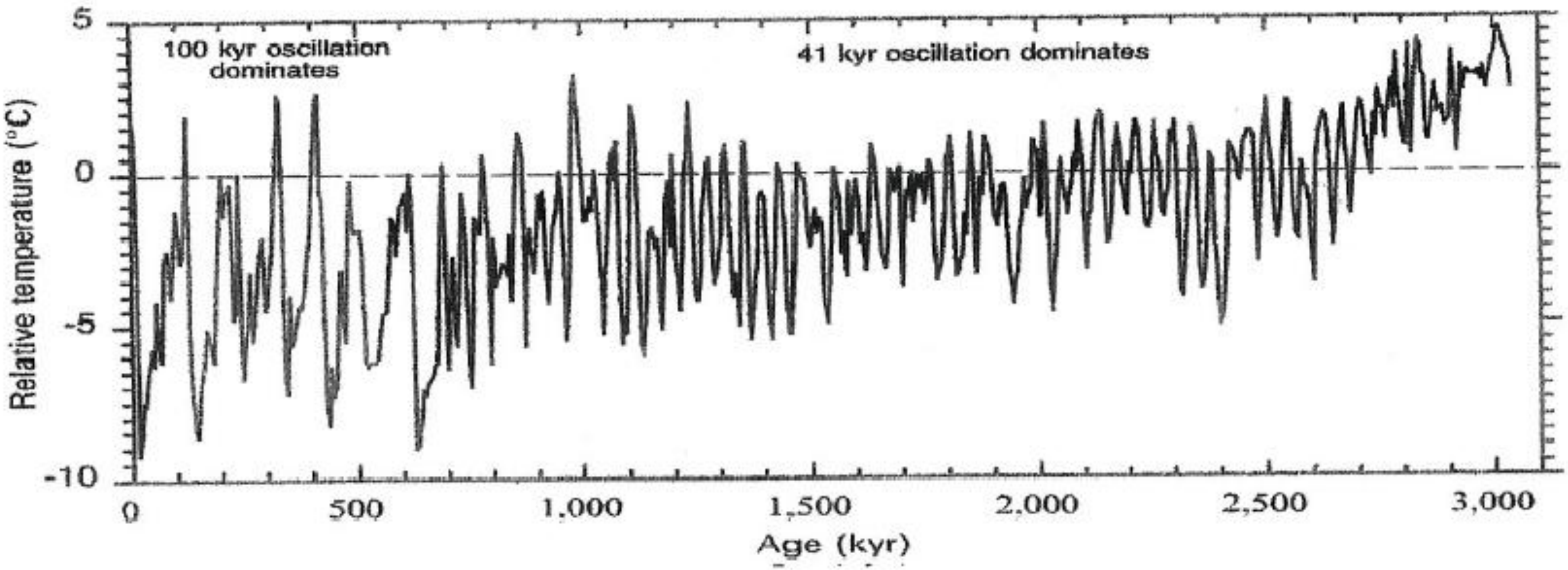
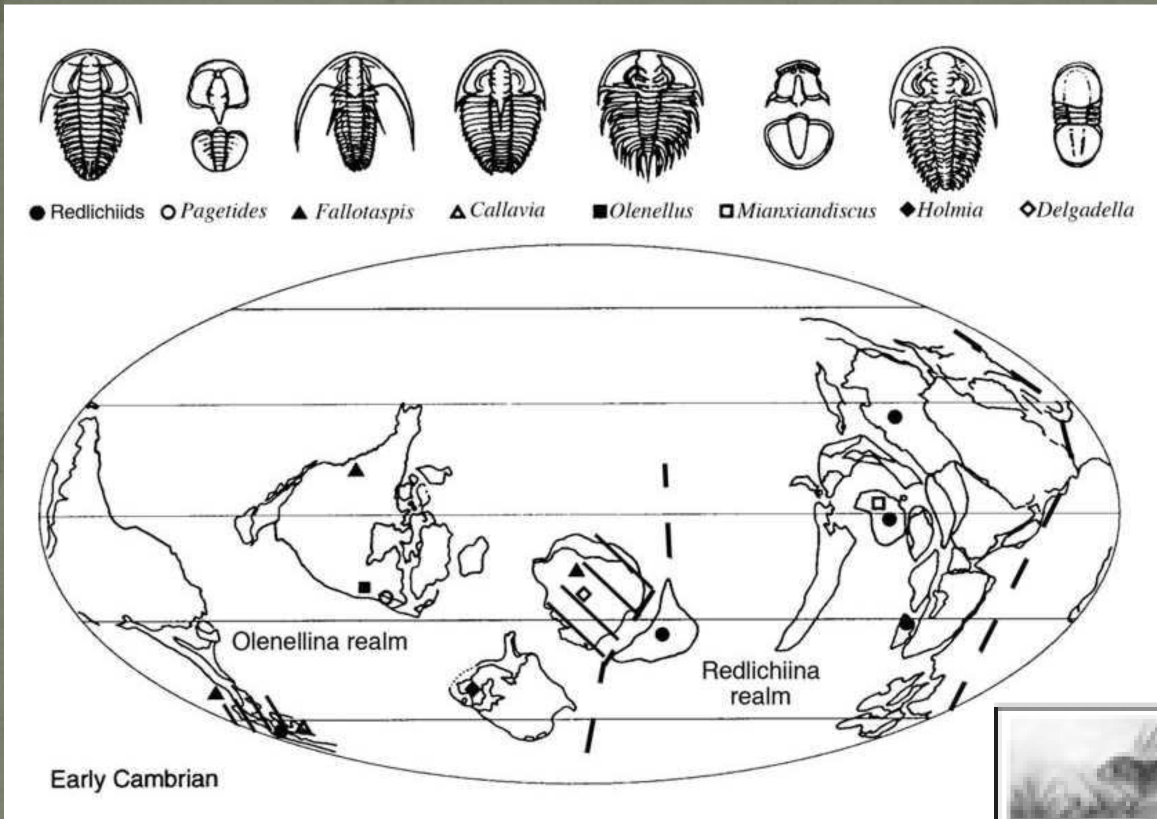
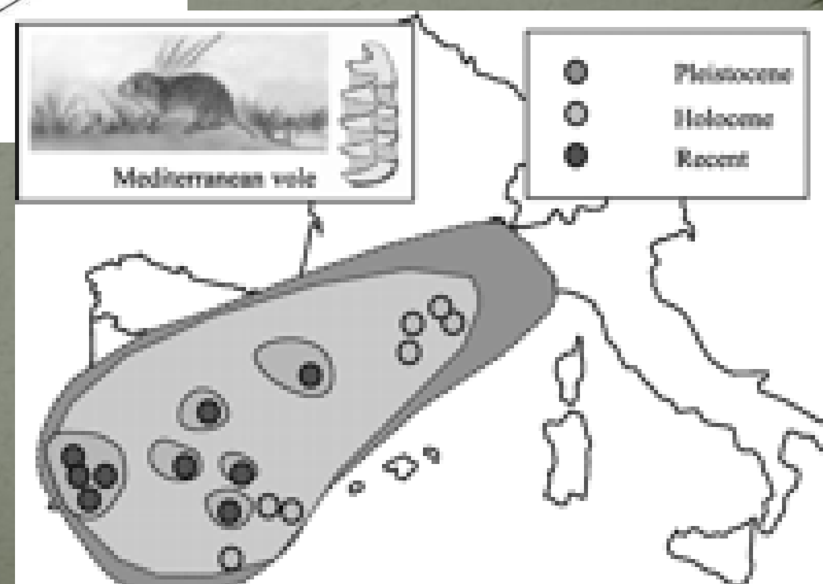


Fig. 1.6. Climate of the last 3 million years.

Palaeobiogeography

- It deals with the geographical distribution of organisms during different periods of the geological time
- the communication relationships between floras and faunas of different regions
- Their distribution is affected by environmental conditions and the geomorphology of their expansion area
- Immediate relationship with palaeoecology, palaeogeography
- It is divided into palaeozoogeography and palaeophytogeography
- The earth's space is divided into biogeographical regions, the bioprovinces, which vary and change through geological time
- They are separated in marine, terrestrial and lacustrine


Redlichiids
Pagetides
Fallotaspis
Callavia
Olenellus
Mianxiandiscus
Holmia
Delgadella
Olenellina realm
Redlichiina realm
Early Cambrian


Mediterranean vole
Pleistocene
Holocene
Recent

Cryptozoic (Precambrian) Eon

4600 – 541 million years

Precambrian Eon

- Hadean Era (4560-4000 my)
- Archean Era (4000-2500 my)
- Proterozoic Era (2500-541 my)

Precambrian covers 87% of geological history.

Archean Era is separated into EoArchean, PaleoArchean, MesoArchean, NeoArchean

Proterozoic Era is separated into PaleoProterozoic, MesoProterozoic, NeoProterozoic

Hadean Era (4560-4000 my)

- Formation of the Earth by planitoids (4560 my)
- Formation of the core
- Impacts with meteorites, comets, etc. Originated from the Kuiper belt and the Oort nebula
- The first atmosphere, from gases that originated from the interior of the earth and from impacts with comets etc.
- The first oceans as soon as the earth began to cool down
- The first organic molecules found in comets or meteorites may have survived on the surface (?) or formed on earth

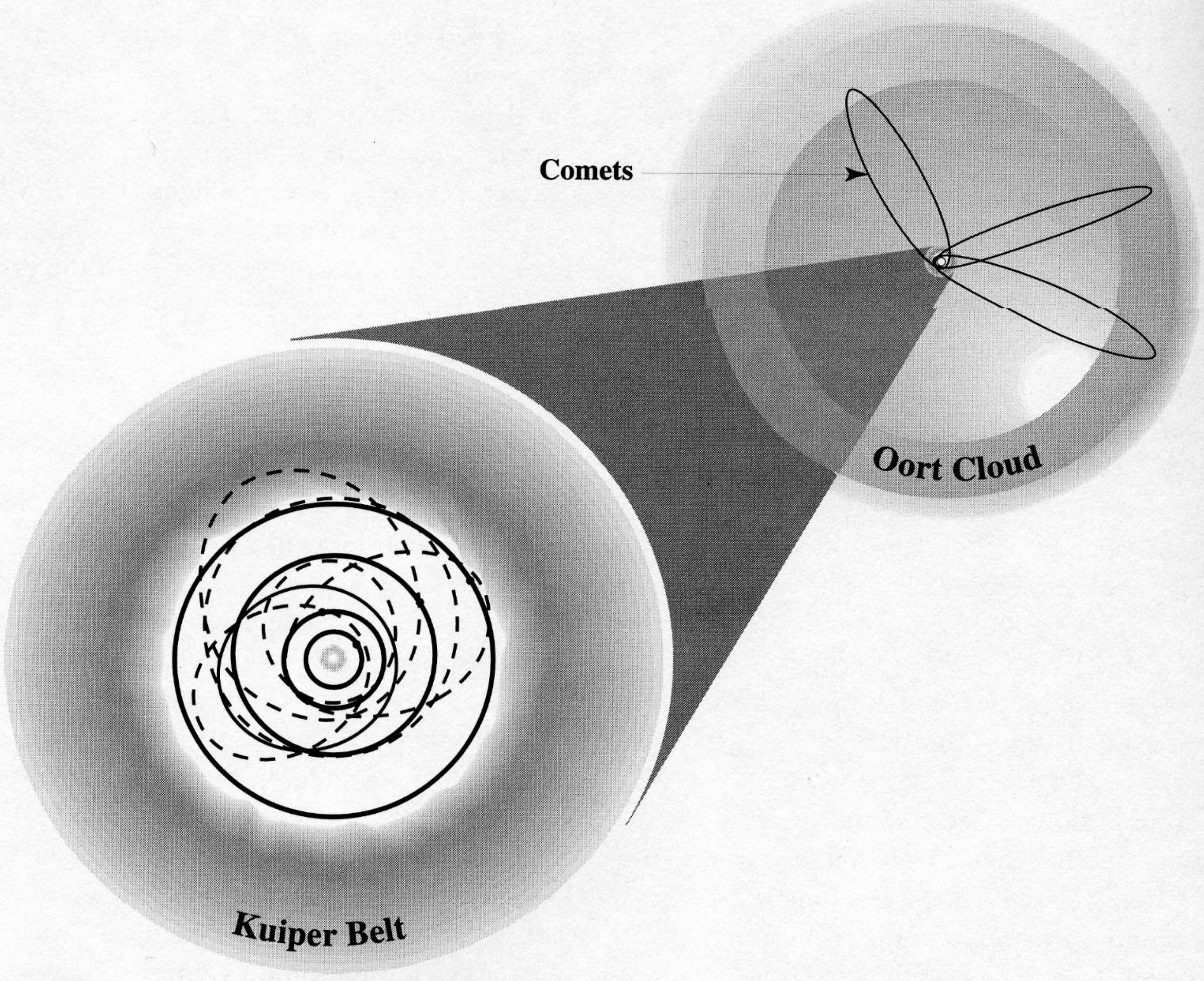
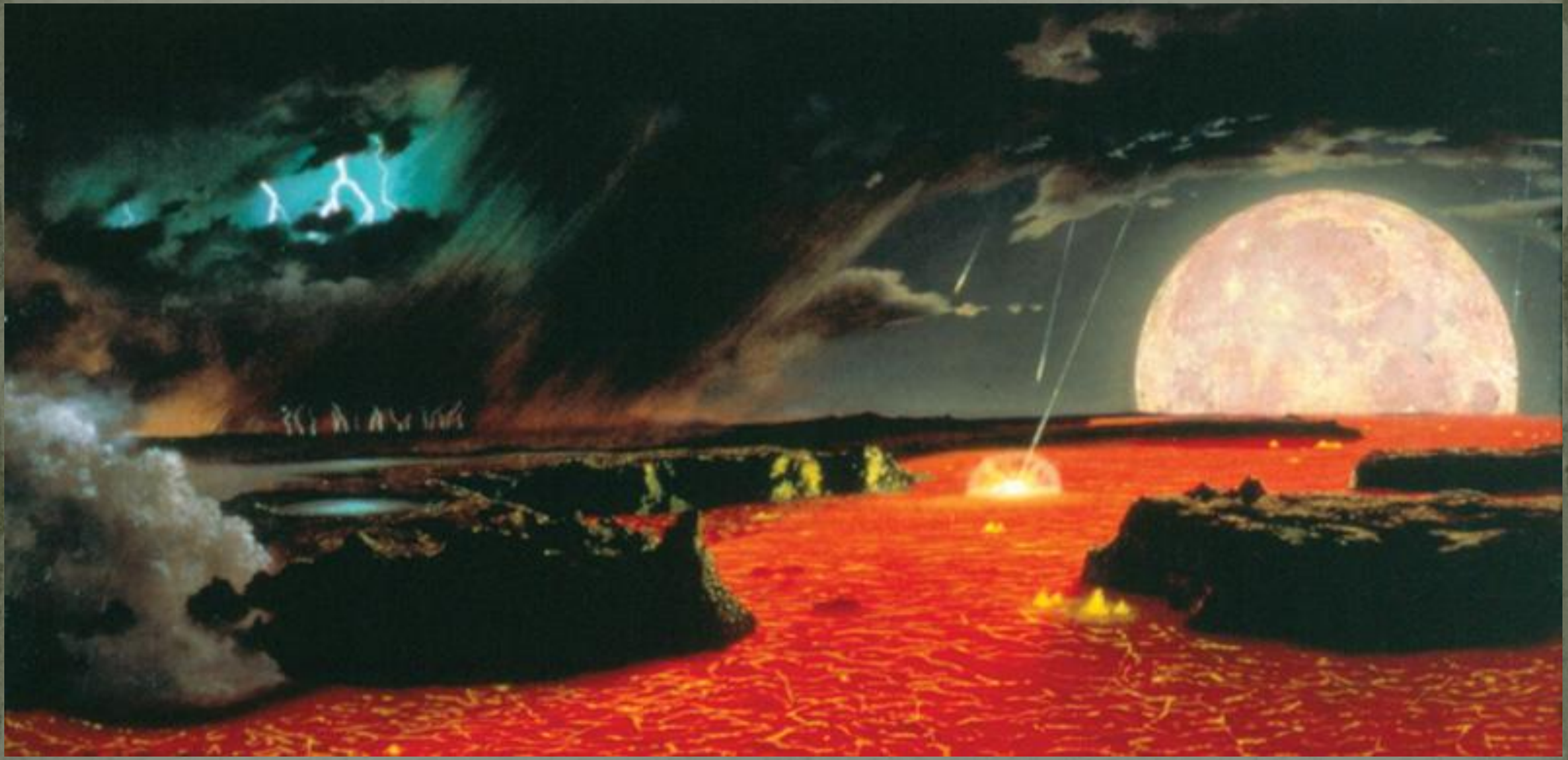


Figure 10.7. Sketch of the outer solar system, showing the location of the Kuiper Belt as the shaded region. The solid orbits are (from inside outward) Jupiter, Saturn, Uranus, and Neptune. Pluto's orbit, not shown, places that planet in a stable part of the Kuiper Belt. The dashed lines show orbits of Centaur objects, which probably have been perturbed inward from the Kuiper Belt by Neptune's gravity as well as, perhaps, through collisions in the Belt itself. On the upper right is a diagram showing the much larger Oort Cloud and a few sample long-period comet orbits. The Oort cloud is so much larger than the Kuiper Belt that the latter can hardly be seen on the scale of the former.



Age of the Solar System?

- Radiometric datings of lunar rocks and meteorites give us ages of about 4.6 billion years.

Earth

- Diameter = ~ 13,000 km
  The oceans cover 71%
  Atmosphere = 78% N and 21% O
  Surface temperature -50 to +50 oC
  Average density = 5.5 g / cm3
  Surface density = 2.5-3.0 g / cm3

Formation of the Earth

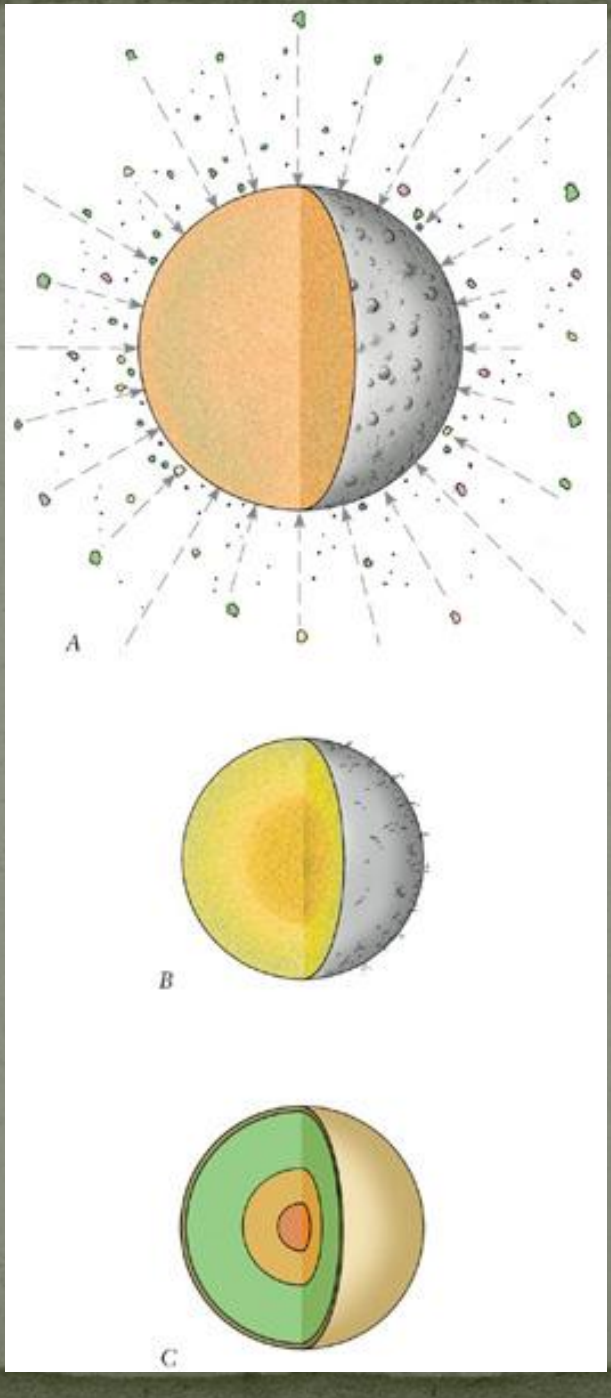
- It was created by the accumulation of dust and larger pieces of various dimensions
- Originally homogeneous, a mixture of space rubbish.
- The "stratification" of the earth due to the differentiation of the different materials.
- Differentiation was the effect of heating and of at least partial melting.

Possible heat sources

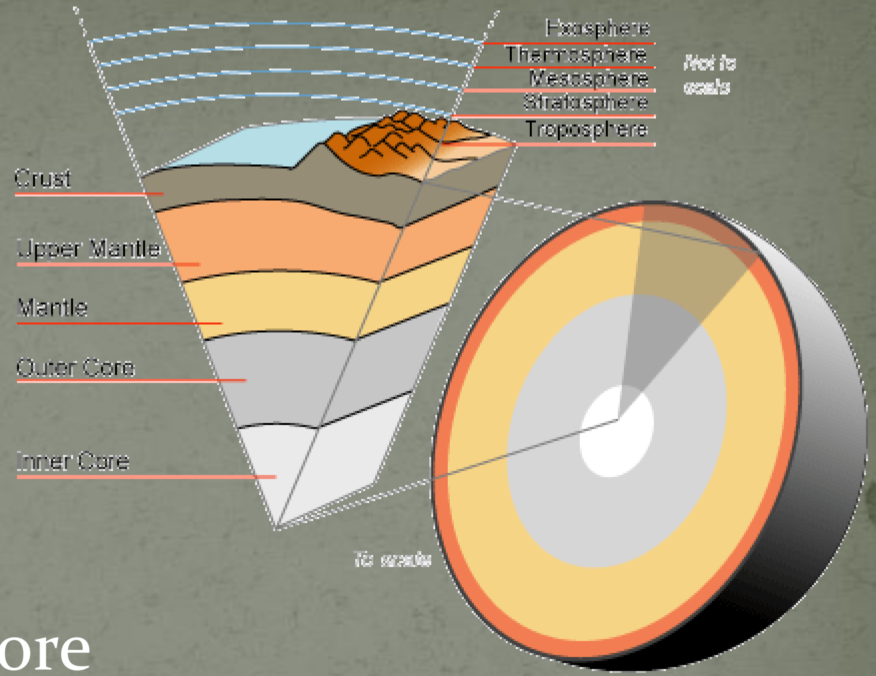
- Heat accumulation by bombardments
- Heat from gravity compression with material accumulation.
- Decay of radioactive materials

Differentiation

- Fe and Ni submerged to form the core.
- Less dense materials form the mantle and the lighter crust.
- The presence of volatile gases indicates that no complete melting occurred
- The earth was partly melt but continuously from major impacts.


A
B
C

Earth



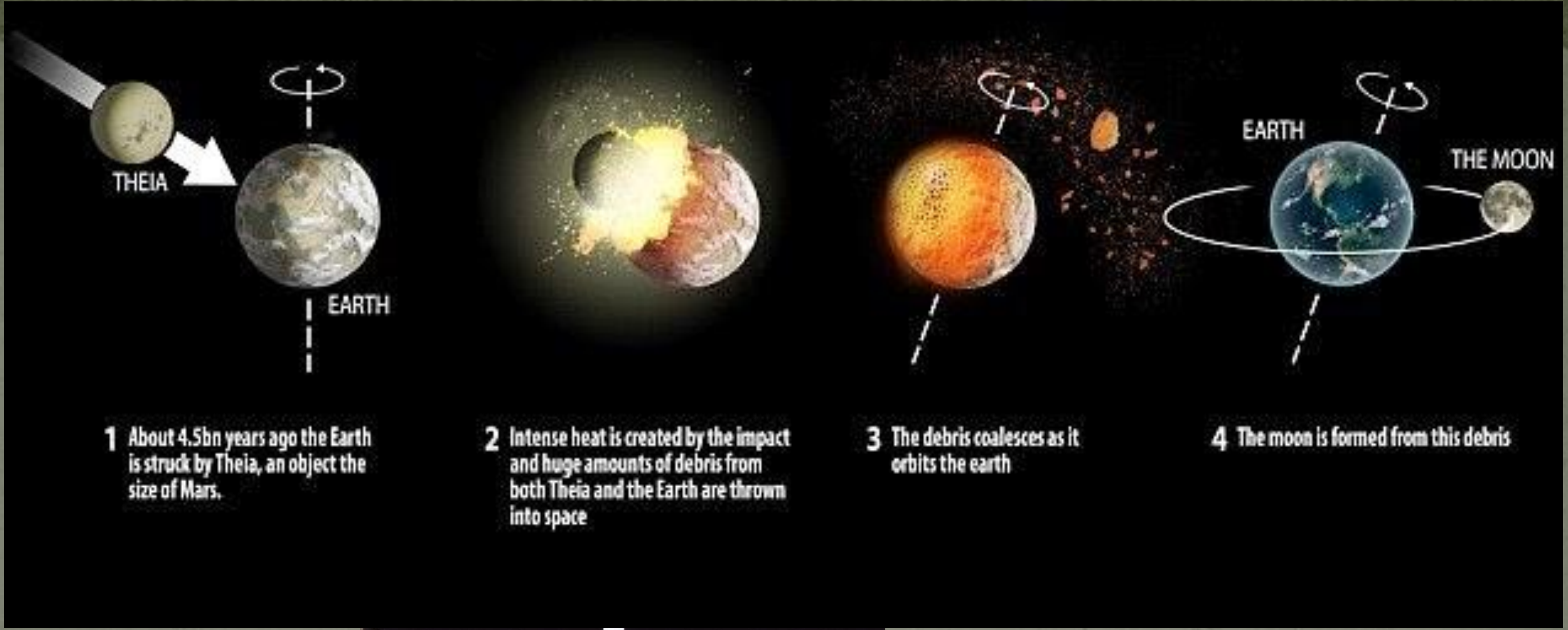
- It consists of crust, mantle, core
- Core has a diameter of 7000 km, liquid.
- Crust is the outer solid casing.
- The mantle between the crust and the core. Thickness 2900 km.
- Geologically active
- The only known body in the universe that has life.

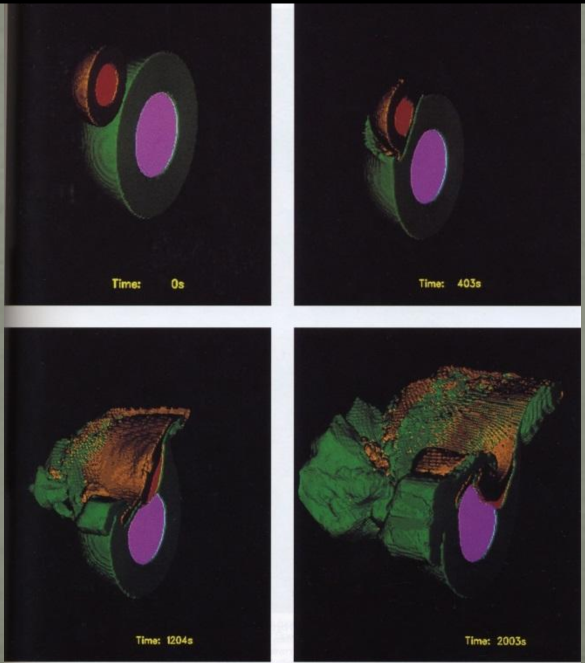
The moon

- Diameter = 1/4 of the earth.
- Density = ~ 3.3 g / cm3 (similar to the mantle of the earth).
- It rotates around its axis at the same rate as it rotates and around the earth (29.5 days). The result is the same side is always facing the earth.
- The distal side has more craters.
- No Atmosphere.
- Ice on the poles.

Origin of the moon

- The age of lunar rocks is more than 4.2 billion years old.
  Composition similar to that of the earth's mantle with a characteristic lack of metals.
  Formation of the moon by a large, planet-like body that collided with the earth (4400-4500 my).
  Pieces from the impact were thrown into orbit around the earth and joined together to form the moon.





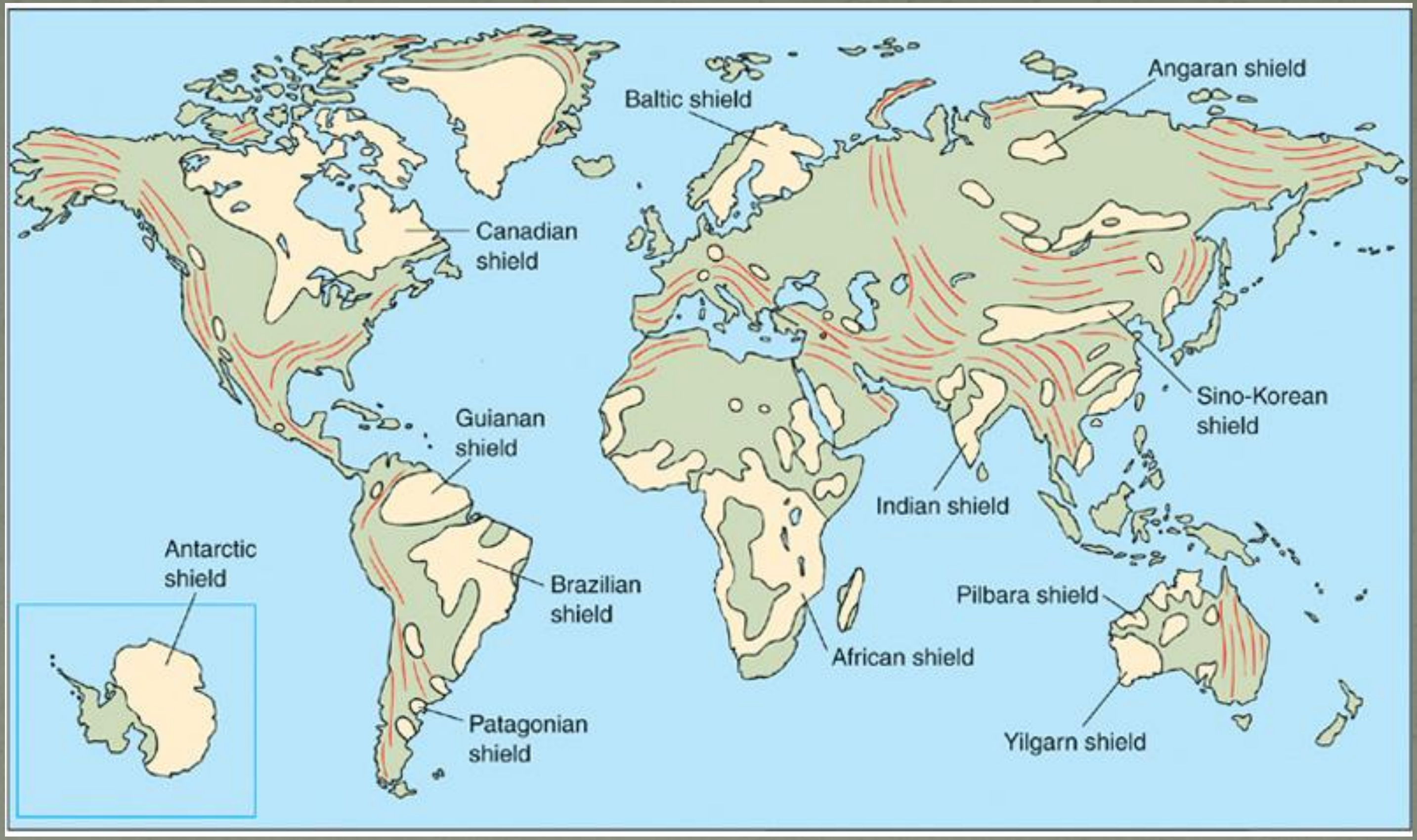
Color Plate V. Computer calculations by M.E. Kipp (Sandia National Laboratories) and H.J. Melosh (The University of Arizona), showing formation of the Moon as a Mars-sized planet strikes Earth. Both Earth and the impacting planet are shown sliced in half so as to reveal what is happening in the interiors. The iron-rich core can be seen as an inner circle in each planet prior to impact. Compared to the mantle of Earth, the core is hardly disrupted. Elapsed time is shown on each panel. Images courtesy of H.J. Melosh.

The oldest rocks on earth

- There are no rocks in the earth that are 4.6 billion years old, as the earth is tectonically active and the older rocks have been destroyed either due to erosion or by tectonicsm (rocks circle).
  Most of our knowledge of the early history of the earth comes from indirect sources, the meteorites.

The oldest rocks on earth

- They consist of metamorphic rocks
  Radiometric Dating is an important help for their identification and study
  Relatively large expansion
  They consist of:
  the nuclei of the large mountain ranges
  Large stable masses that were not covered by sediments, the shields or Craton regions



The areas where Precambrian rocks are found (yellow).
The red lines indicate the orogenetic belts

Shields

- Baltic
  Canadian
  Ankara
  Ethiopian
  Indian
  Australian
  Amazonian
  Guyana
  Arabic
  Antarctic

The oldest rocks on earth

- Found in Canada.
- Their age is 4.04 billion years.
- But even older grains of minerals. Sand-sized zirconium grains in Australia's metamorphic sedimentary rocks at 4.4 billion years.
- 3.8 billion years old from Greenland
- Pieces of old crust of 3.9 billion years in Antarctica

The Plate theory

- At about 4 billion years the earth had cooled enough to form geological plates.
- The original basaltic crust is strengthened by granitic and intermediate rocks, thus forming the first stable masses, the first continents
- These masses formed the nuclei around which the first continents were developed

- A zone of petrified land (palaeosoil) was found in Australia at 3.46 billion years. Continental masses above the sea surface.
- First signs of weathering, erosion, soil formation.
- The presence of zirconium mineral grains from W. Australia at 4.4 billion years suggests weathering of already formed rocks and the presence of water in liquid form