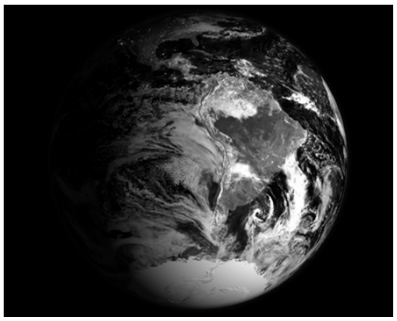
Chapter 11

Earth: The Active Planet



http://wallzoa.com/nature-wallpapers/earth-from-space.html

The Terrestrial Planets (1)

The Terrestrial Planets – Mercury, Venus, Earth and Mars – all have several features in common.

- Venus and Earth are nearly the same size.
- Mars is smaller, and Mercury is much smaller.
- The larger worlds are geologically active.

http://hendrix2.uoregon.edu/~imamura/121/lecture-7/lecture-7.html

The Terrestrial Planets (2)

The Terrestrial Planets – Mercury, Venus, Earth and Mars – all have several features in common.

- All of these planets are made from rock and metals.
- They are differentiated into core, mantle and crust.
- Craters on Mercury's surface indicate its surface is much older than its terrestrial cousins.

The Terrestrial Planets (3)

The Terrestrial Planets – Mercury, Venus, Earth and Mars – all have several features in common.

- There is almost no atmosphere on Mercury, and Mars has a very thin atmosphere.
- Venus has a thick, opaque atmosphere.
- Earth has a thick but relatively clear atmosphere.

The Early History of Earth

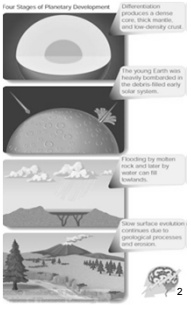
Earth formed 4.6 billion years ago from the inner solar nebula.

Four main stages of evolution:

Two sources of heat in Earth's interior:

- Potential energy of infalling material
- Decay of radioactive material

Most traces of bombardment (impact craters) now destroyed by later geological activity

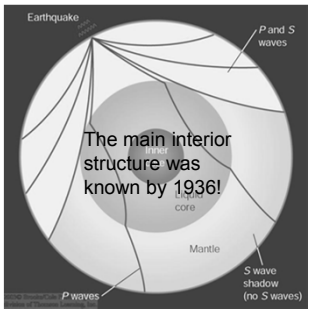


Seismology

Seismic waves do not travel through Earth in straight lines or at constant speed.

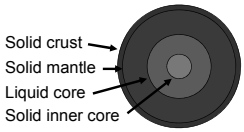
They are bent by or bounce off transitions between different materials or different densities or temperatures.

Such information can be analyzed to infer the structure of Earth's interior.



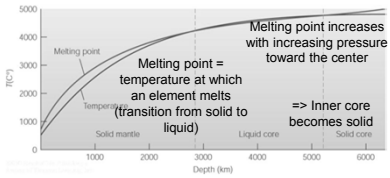
Earth's Interior

Basic structure:



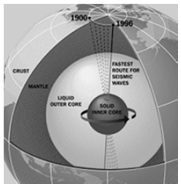
Earth's interior gets hotter toward the center.

Earth's core is as hot as the sun's surface; metals are liquid.

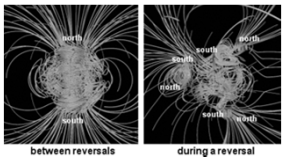


Magnetic Field (1)

Earth's magnetic field is generated due to rotation of the Earth and Earth's outer core. This is called the Geomagnetic Dynamo.



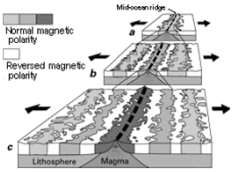
Earth's magnetic field is complex and changes over time, even reversing directions many times in the past.



http://science1.nasa.gov/science-news/science-at-nasa/2003/29dec_magneticfield/

Magnetic Field (2)

Evidence for these reversals is contained in certain rocks, such as the basalts on the ocean floor.

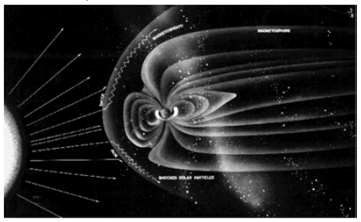


In addition, the poles move over time.

http://science1.nasa.gov/science-news/science-at-nasa/2003/29dec_magneticfield/

Magnetic Field (3)

Interactions between the solar wind and Earth's magnetic field in space (magnetosphere) produce radiation belts around the Earth and cause phenomena like auroras.



http://www.igpp.ucla.edu/public/THEMIS/SCI/Pubs/Nuggets/FTE_nugget/themis_nugget.html/

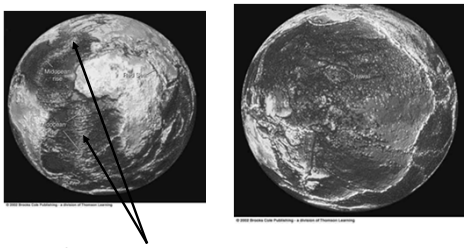
The Active Earth

About 2/3 of Earth's surface is covered by water.

Mountains are relatively rapidly eroded away by the forces of ice and water.

Tectonic Plates

Earth's crust is composed of several distinct tectonic plates, which are in constant motion with respect to each other → **Plate tectonics**

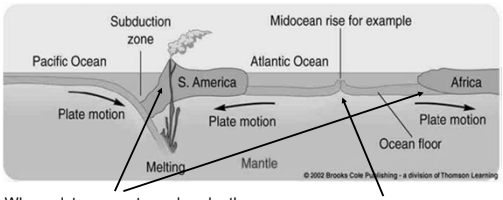


Evidence for plate tectonics can be found on the ocean floor

… and in geologically active regions all around the Pacific

Plate Tectonics

Tectonic plates move with respect to each other.



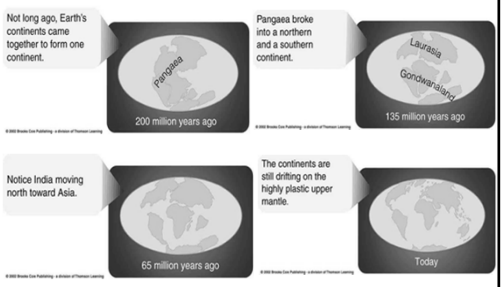
Where plates move toward each other, plates can be pushed upward and downward → formation of mountain ranges, some with volcanic activity, earthquakes

Where plates move away from each other, molten lava can rise up from below → volcanic activity

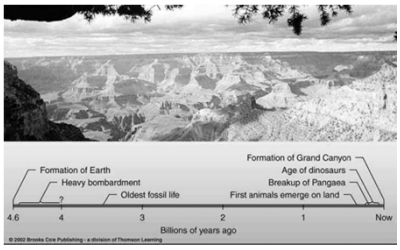
Active Zones Resulting from Plate Tectonics

Volcanic hot spots due to molten lava coming up at plate boundaries or through holes in tectonic plates

Earth's Tectonic History



History of Geological Activity



Surface formations visible today have emerged only very recently compared to the age of Earth.

The Atmosphere

Earth had a primeval atmosphere from remaining gasses captured during formation of Earth

Atmospheric composition severely altered (→ secondary atmosphere) through a combination of two processes:

Earth's Atmosphere

Gas	Percent by Weight
N_2	75.5
O_2	23.1
Ar	1.29
CO_2	0.05
Ne	0.0013
He	0.00007
CH_4	0.0001
Kr	0.0003
H_2O (vapor)	1.7–0.06

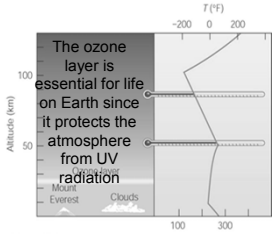
1) Outgassing: Release of gasses bound in compounds in the Earth's interior through volcanic activity

2) Later bombardment with icy meteoroids and comets

The Structure of Earth's Atmosphere

Composition of Earth's atmosphere is further influenced by:

- Chemical reactions in the oceans,
- Energetic radiation from space (in particular, UV)
- Presence of life on Earth



The temperature of the atmosphere depends critically on its albedo = percentage of sun light that it reflects back into space

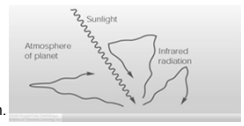
Depends on many factors, e.g., abundance of water vapor in the atmosphere

Human Effects on Earth's Atmosphere

1) The **greenhouse effect**

Earth's surface is heated by the sun's radiation.

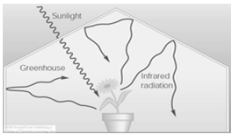
Heat energy is re-radiated from Earth's surface as infrared radiation.



CO_2, but also other gases in the atmosphere, absorb infrared light

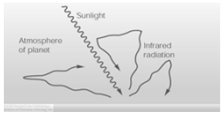
→ Heat is trapped in the atmosphere.

This is the greenhouse effect.

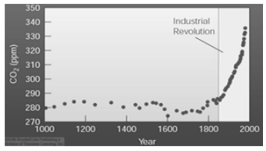


Human Effects on Earth's Atmosphere

The greenhouse effect occurs naturally and is essential to maintain a comfortable temperature on Earth,



but human activity, in particular CO_2 emissions from cars and industrial plants, is drastically increasing the concentration of greenhouse gases.



Global Warming

- Human activity (CO_2 emissions + deforestation) is drastically increasing the concentration of greenhouse gases.
- As a consequence, beyond any reasonable doubt, the average temperature on Earth is increasing.
- This is called global warming
- Leads to melting of glaciers and polar ice caps (→ rising sea water levels) and global climate changes, which could ultimately make Earth unfit for human life!

Human Effects on the Atmosphere (2)

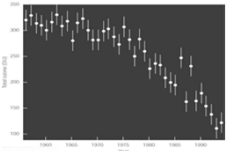
2) Destruction of the Ozone Layer

Ozone (= O_3) absorbs UV radiation, (which has damaging effects on human and animal tissue).

Chlorofluorocarbons (CFCs) (used, e.g., in industrial processes, refrigeration and air conditioning) destroy the Ozone layer.

Destruction of the ozone layer as a consequence of human activity is proven (e.g., growing ozone hole above the Antarctic).

Must be stopped and reversed by reducing CFC use, especially in developed countries!



End of Chapter 20