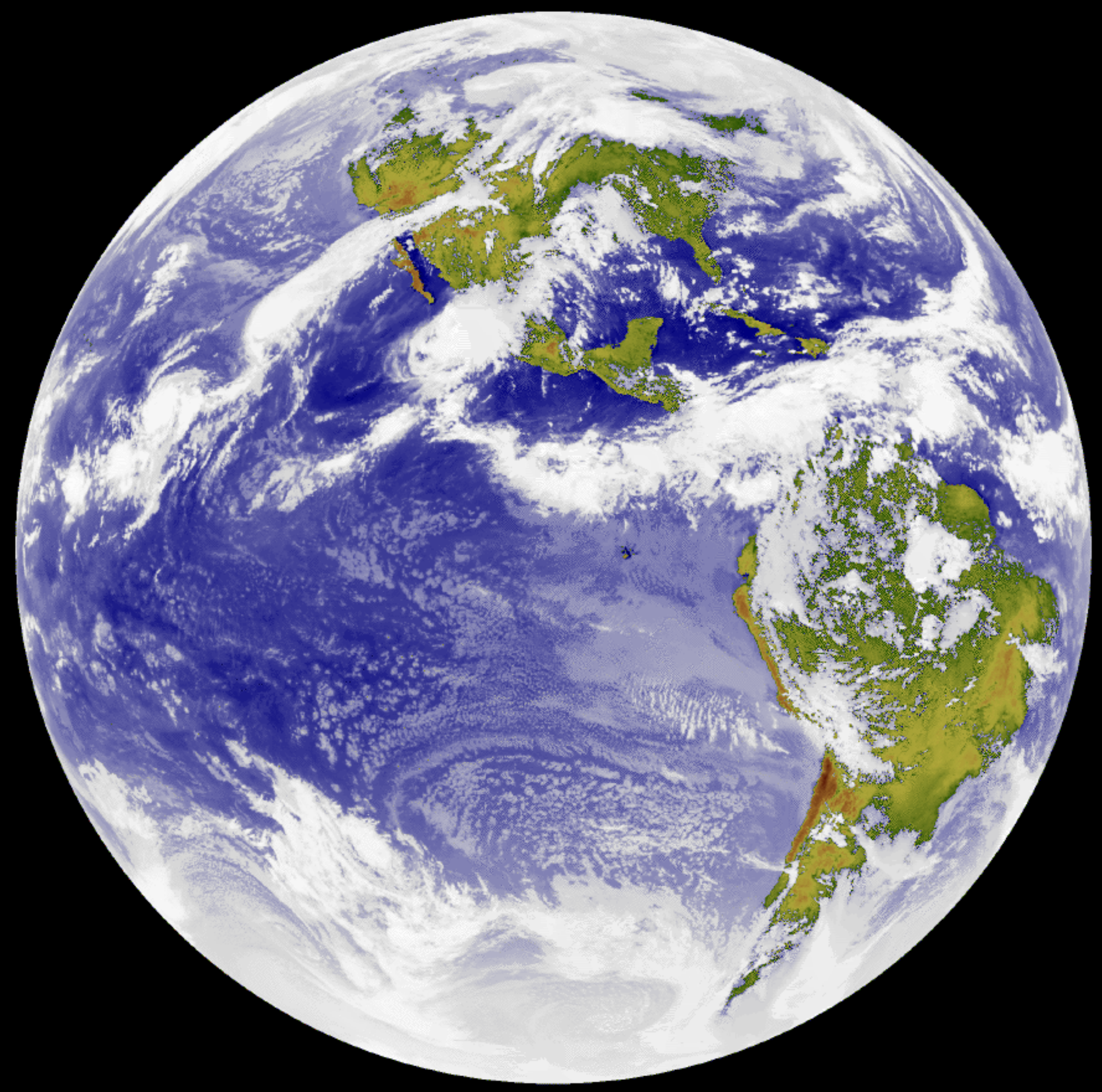
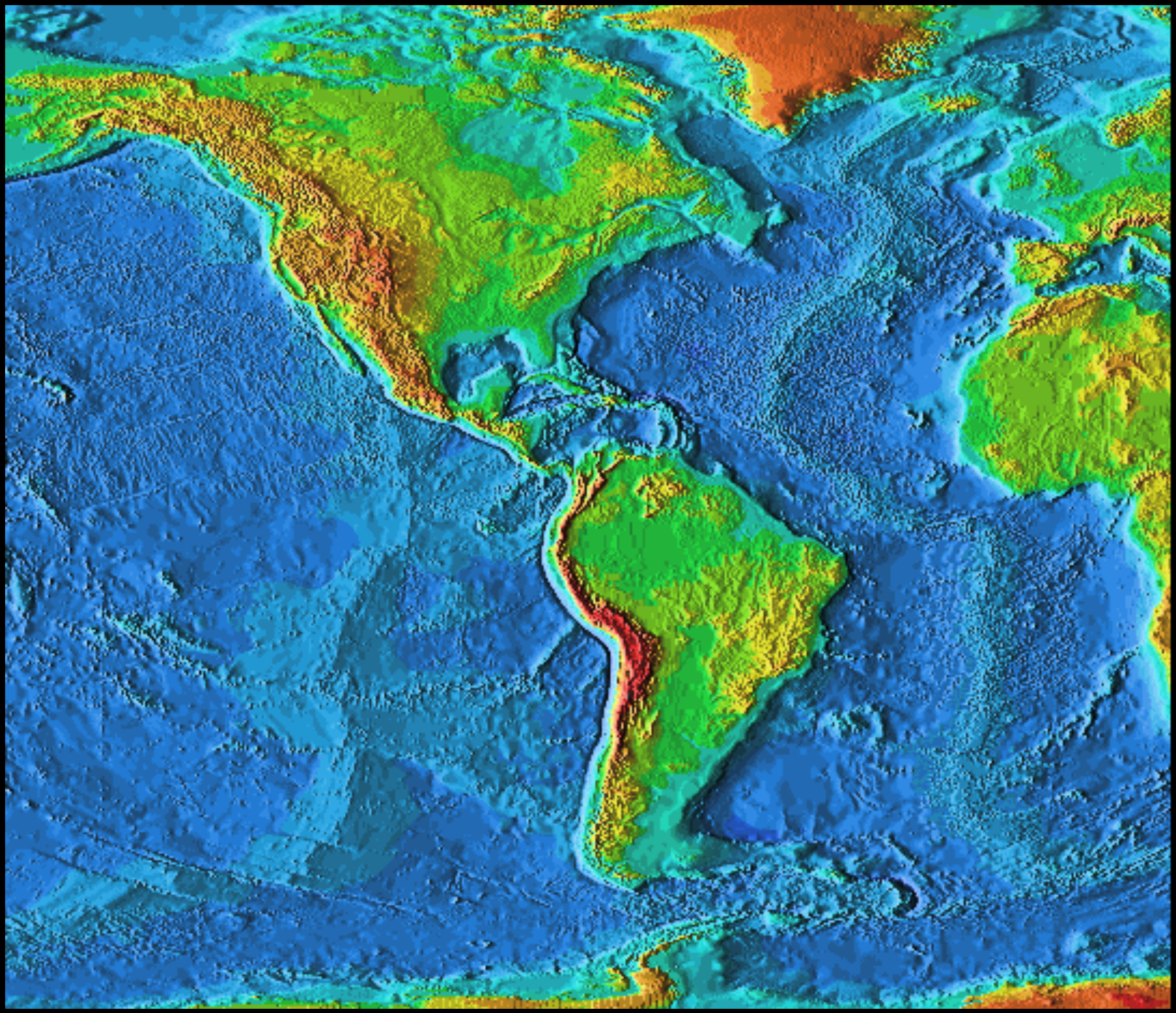


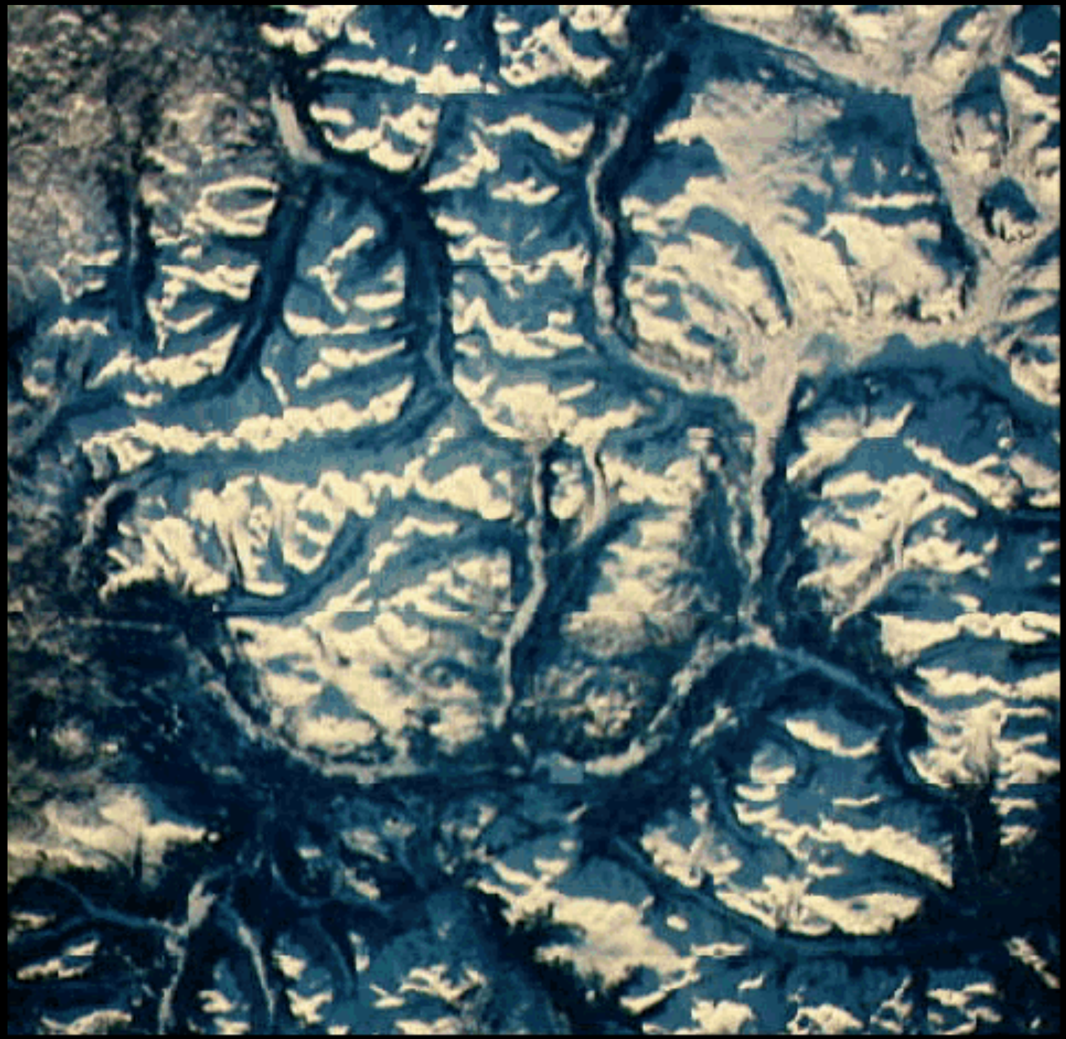
The left image of the Earth was obtained by the Galileo spacecraft when it was about 1.3 million miles from the planet, displays our world as would be seen by a space probe from another solar system. The right is an infrared image.

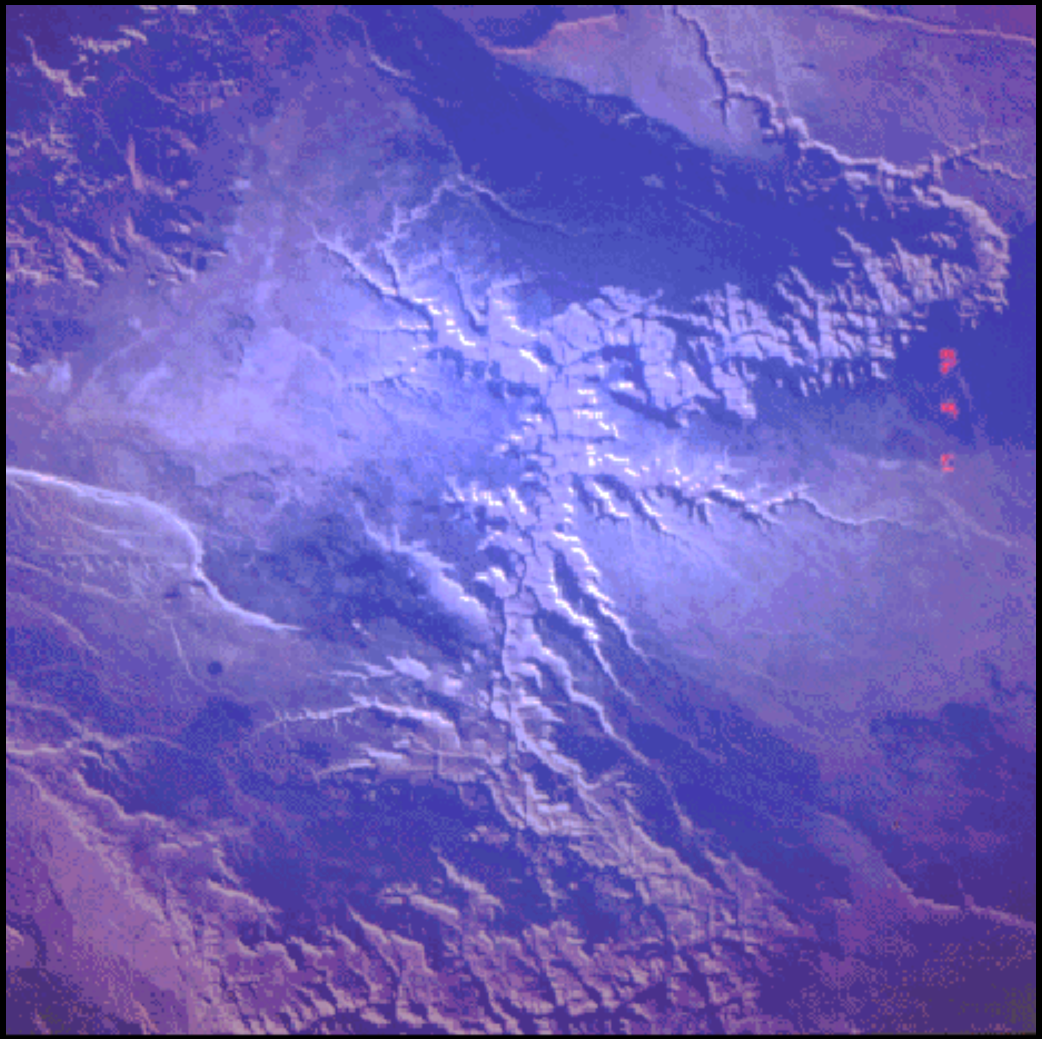
South America is near the center of the picture, and the white, sunlit continent of Antarctica is below. Picturesque weather fronts are visible in the South Atlantic, lower right.



The above image is a map of North and South America using radar altimetry to reflect the underlying topography of the oceans and continents.

Below the ocean's surface are a system of continental shelves, mountains, volcanoes, oceanic trenches, submarine canyons, oceanic plateaus, abyssal plains, and a globe-spanning mid-ocean ridges. The remaining 29.2% (148.94 million km^2, or 57.51 million sq mi) not covered by water has terrain that varies greatly from place to place and consists of mountains, deserts, plains, plateaus, and other landforms.

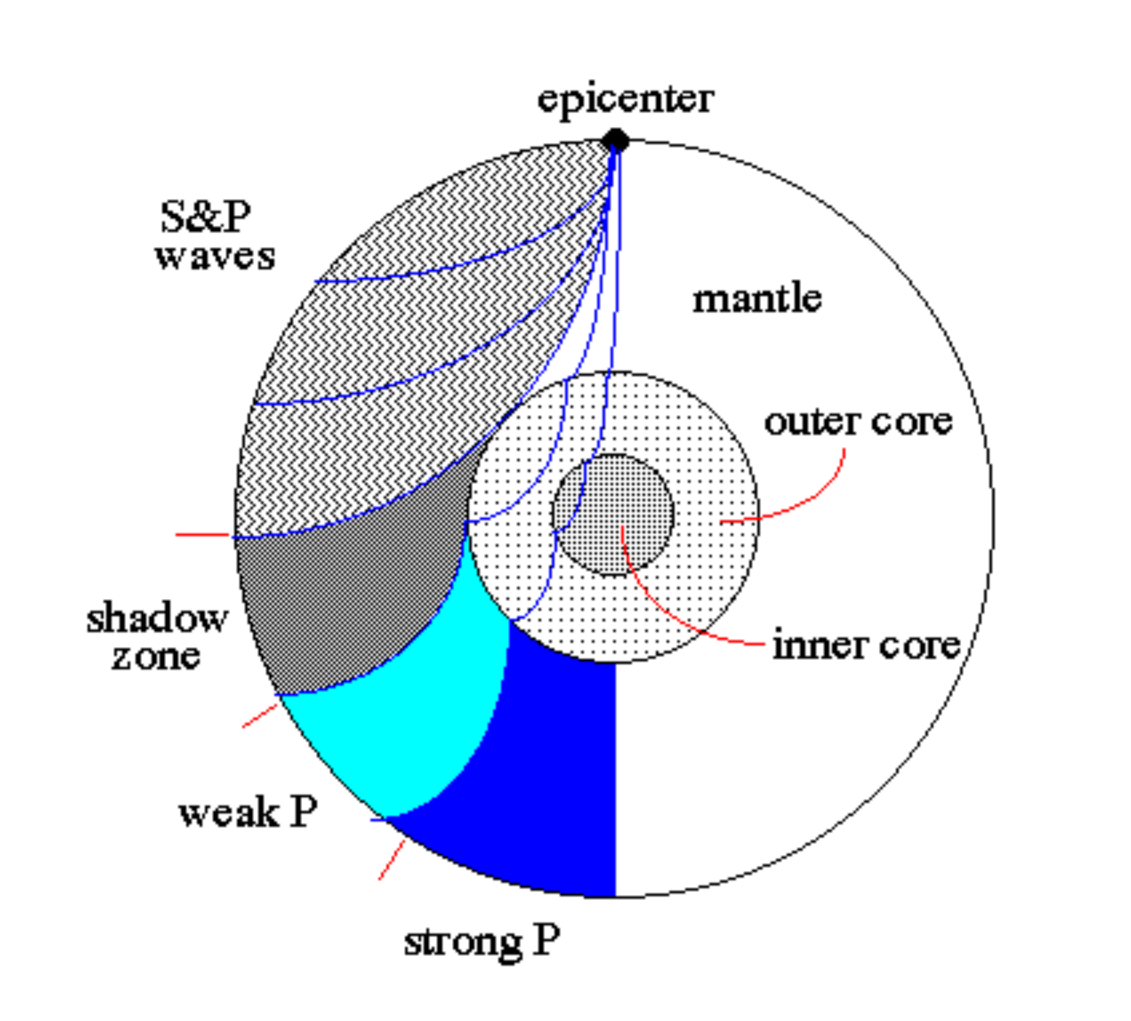




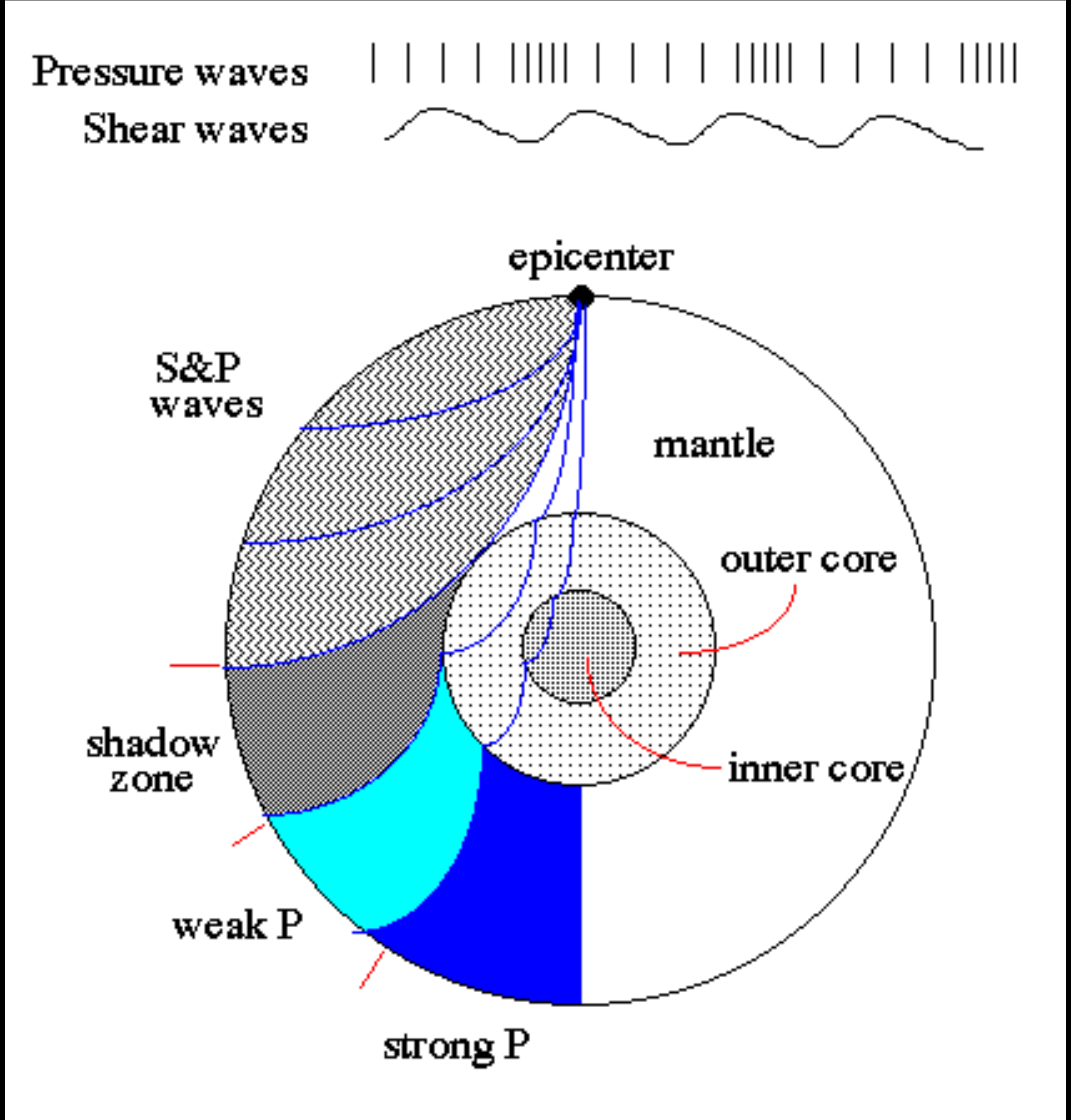
The left image is part of the Rocky Mountain Range in the Yukon Territory of Canada is an excellent example of young mountains on Earth. This space shuttle image was taken when the sun was low on the horizon; the sharp shadows on the snow-covered peaks show how rough and uneven the area is.

The right picture is a space shuttle image of the Colorado River in Arizona captures the Grand Canyon. The canyon is 30 km (18 miles) across at its widest point and 1.6 km (1 mile) deep at rock bottom. The Grand Canyon was created by the erosional action of the Colorado River on the surface as this region has continued to rise high above sea level over the last several million years.

average density = mass of Earth/ volume = 5.5 gm/cc. Granite has a mean density of 3.0, which is mostly what our crust is made of. Therefore, since the mean density of the whole Earth is larger than granite, the core of the Earth must be made of something much denser than granite -> Iron (Fe) and Nickel (Ni).

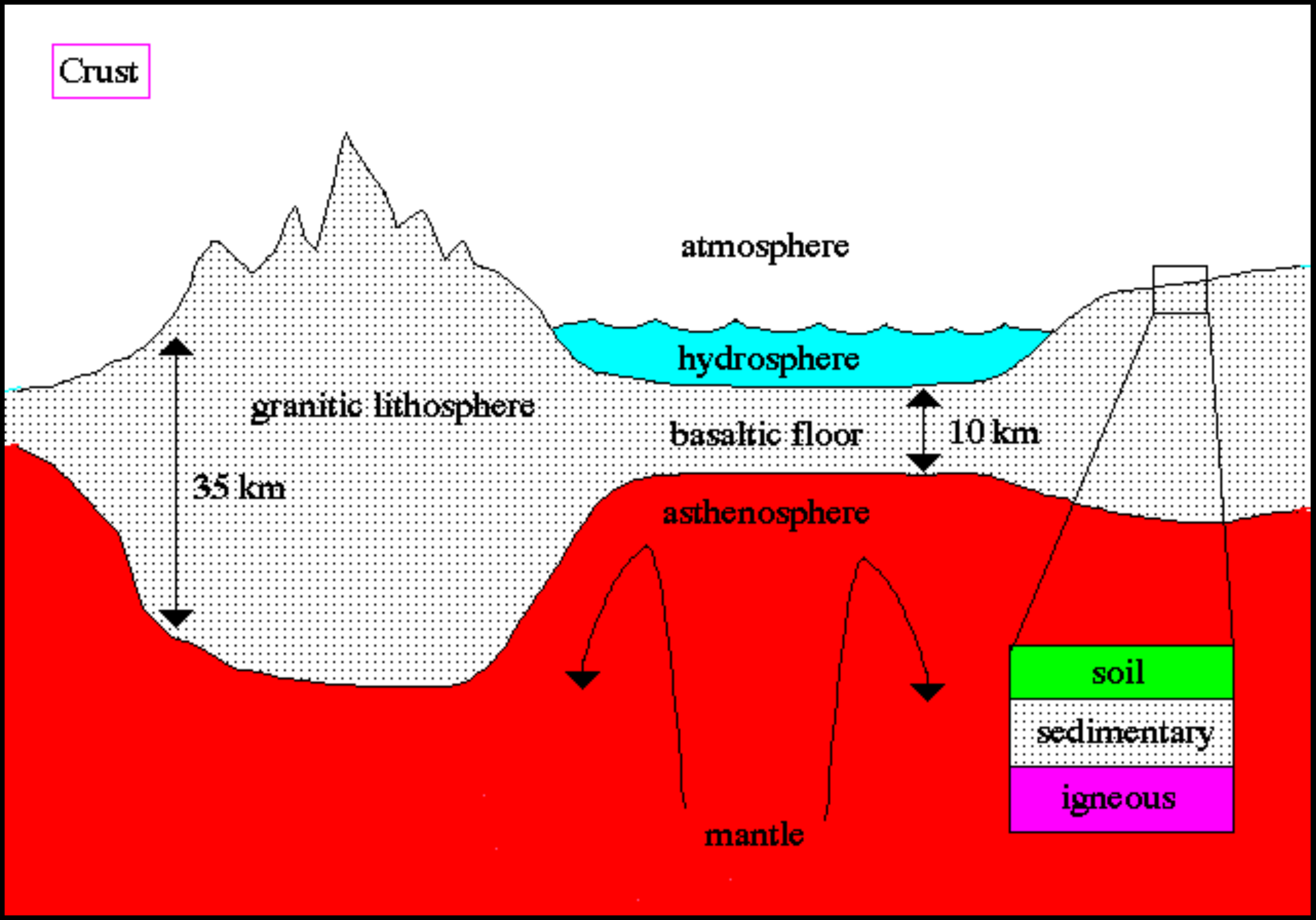


Seismology uses the propagation of seismic waves from earthquakes to study the Earth's interior (similar to refracted light). Two types of seismic waves 1) pressure or P waves and 2) shear or S waves. Shear waves cannot propagate in liquids or gases, since there are no lateral restoring forces. P waves can travel through liquid or solids.

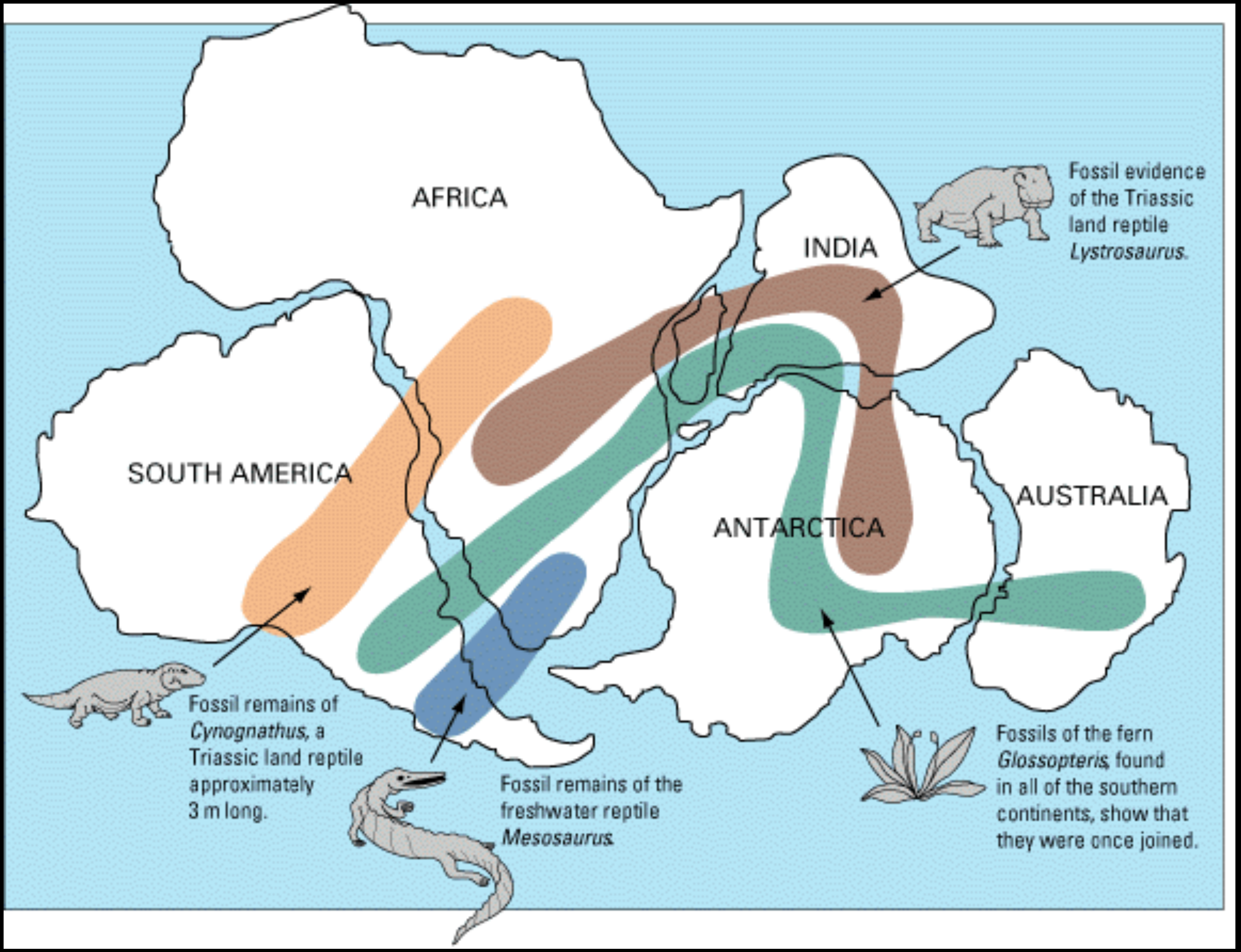


The result is that we know that the interior of the Earth has 4 components:

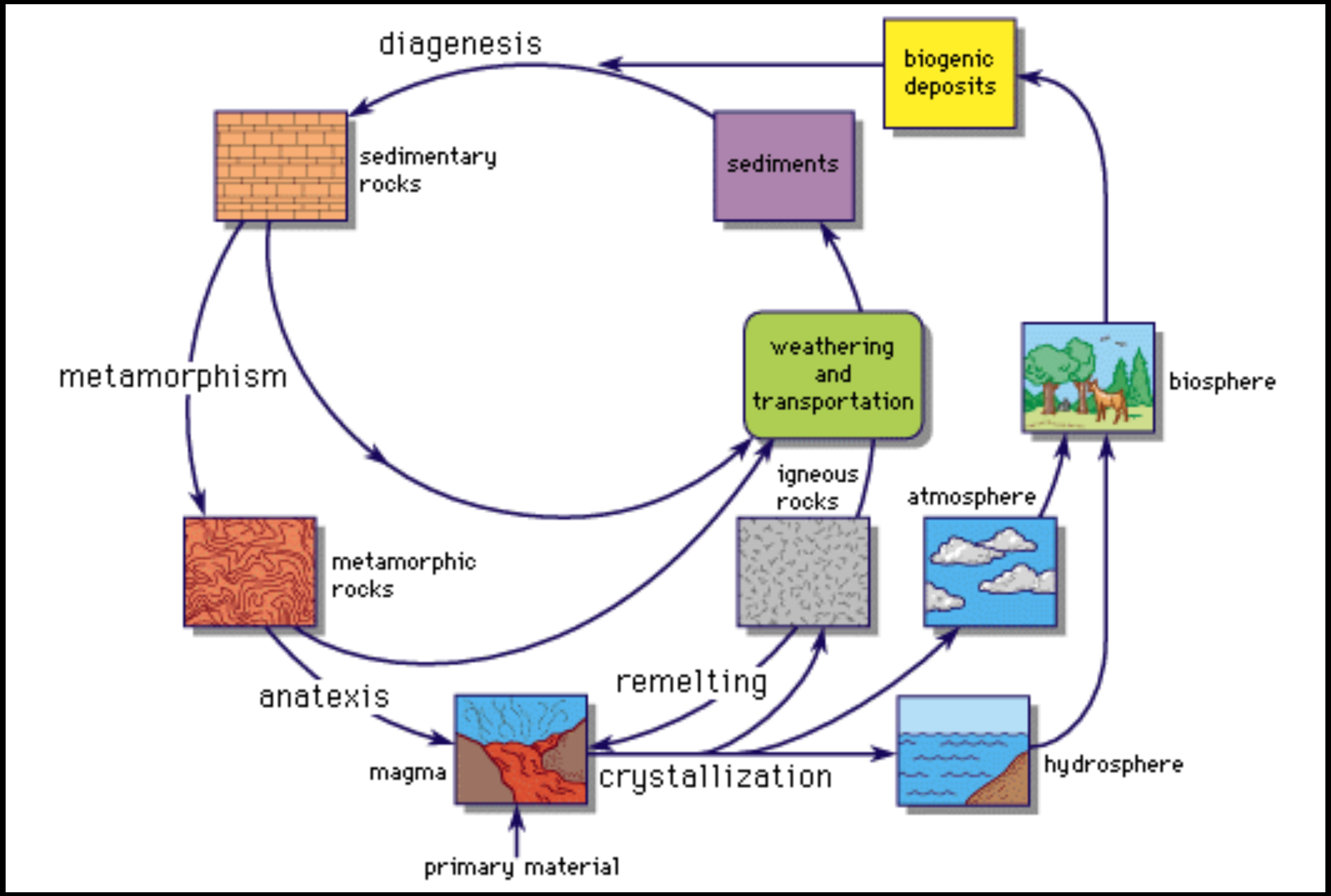
1) a thin crust of density 3.3 gm/cc composed of metals, silicates (a substance called basalt)
2) a semi-solid mantle of density 3.5 to 5.5 gm/cc composed of olivine Fe oxides
3) a liquid outer core of density 9 to 11 gm/cc composed of molten Fe
4) a solid inner core of density 17 gm/cc composed of Fe and Ni.



Note that the crust is thin under the oceans, thick under mountains. The convective motion of the mantle under the thin spots causes sea floor spreading/continental drift. How do we know the continents are moving?



AFRICA
INDIA
SOUTH AMERICA
ANTARCTICA
AUSTRALIA
Fossil evidence of the Triassic land reptile *Lystrosaurus*.
Fossil remains of *Cynognathus*, a Triassic land reptile approximately 3 m long.
Fossil remains of the freshwater reptile *Mesosaurus*.
Fossils of the fern *Glossopteris*, found in all of the southern continents, show that they were once joined.

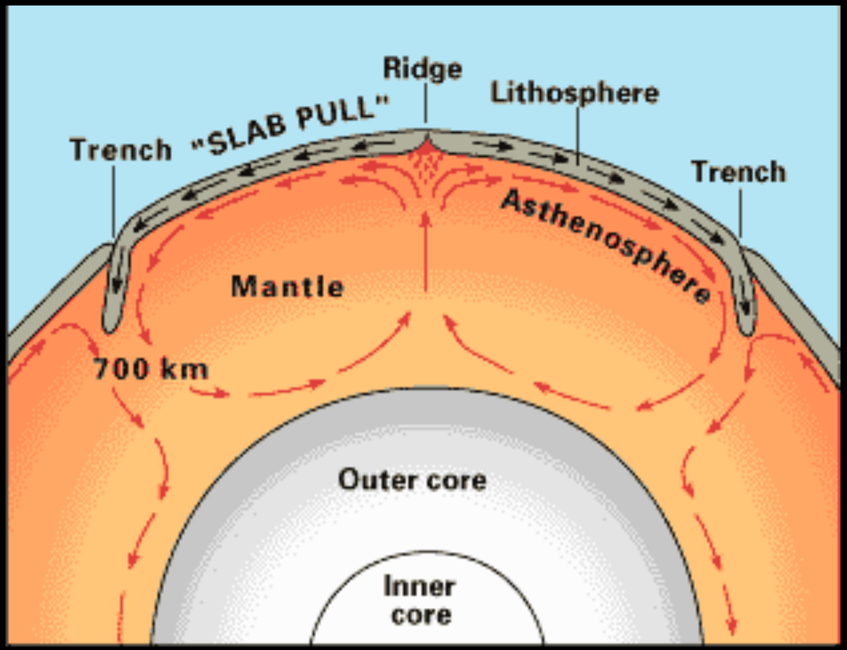


The dry land is composed primarily of:

1) Igneous rock - formed from molten material, such as basalt and granite

2) Sedimentary rock - minerals cemented by pressure, such as sandstone and limestone

3) Metamorphic rock - igneous or sedimentary rock that has been subjected to high temperatures and pressures, such as marble

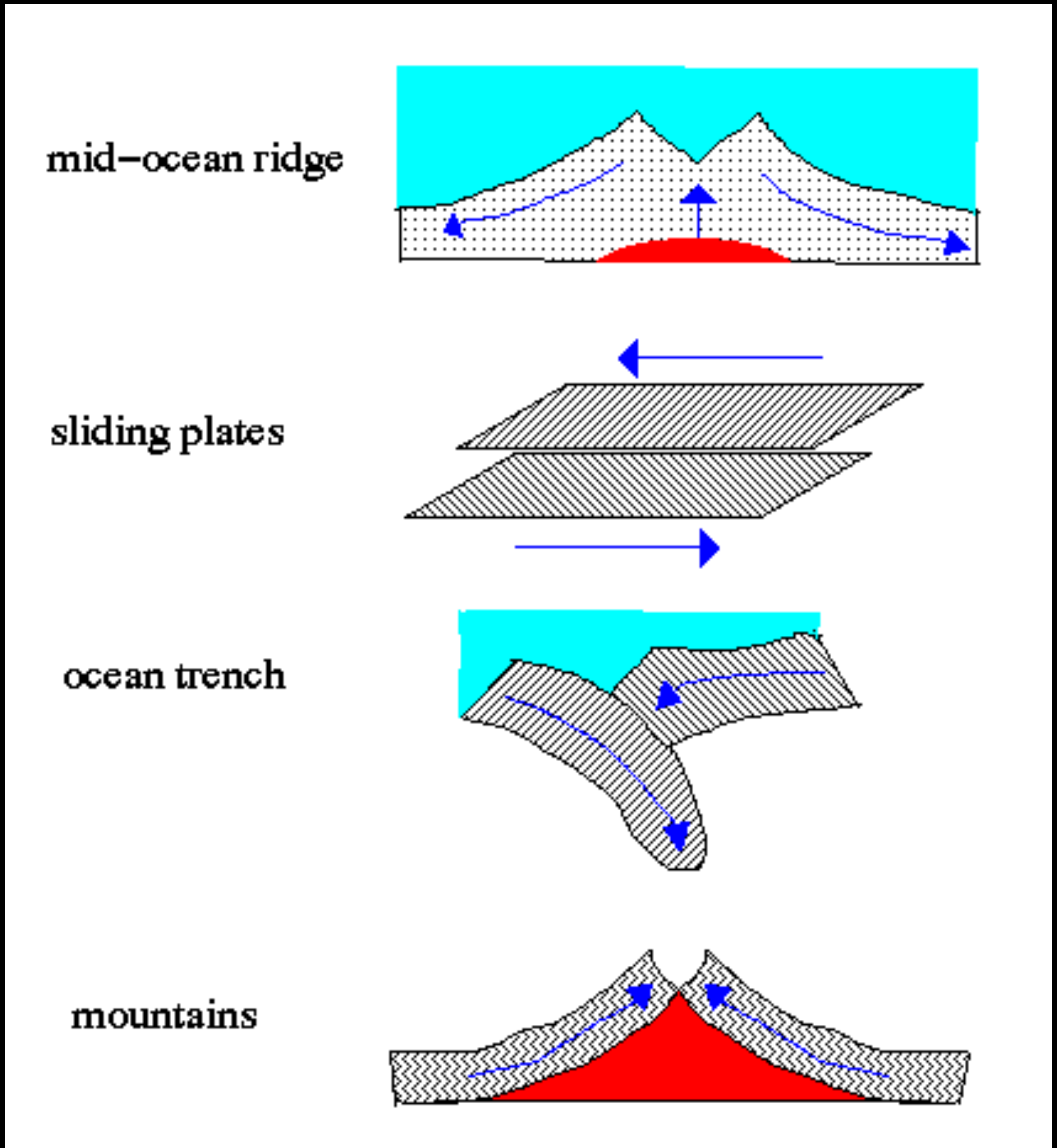


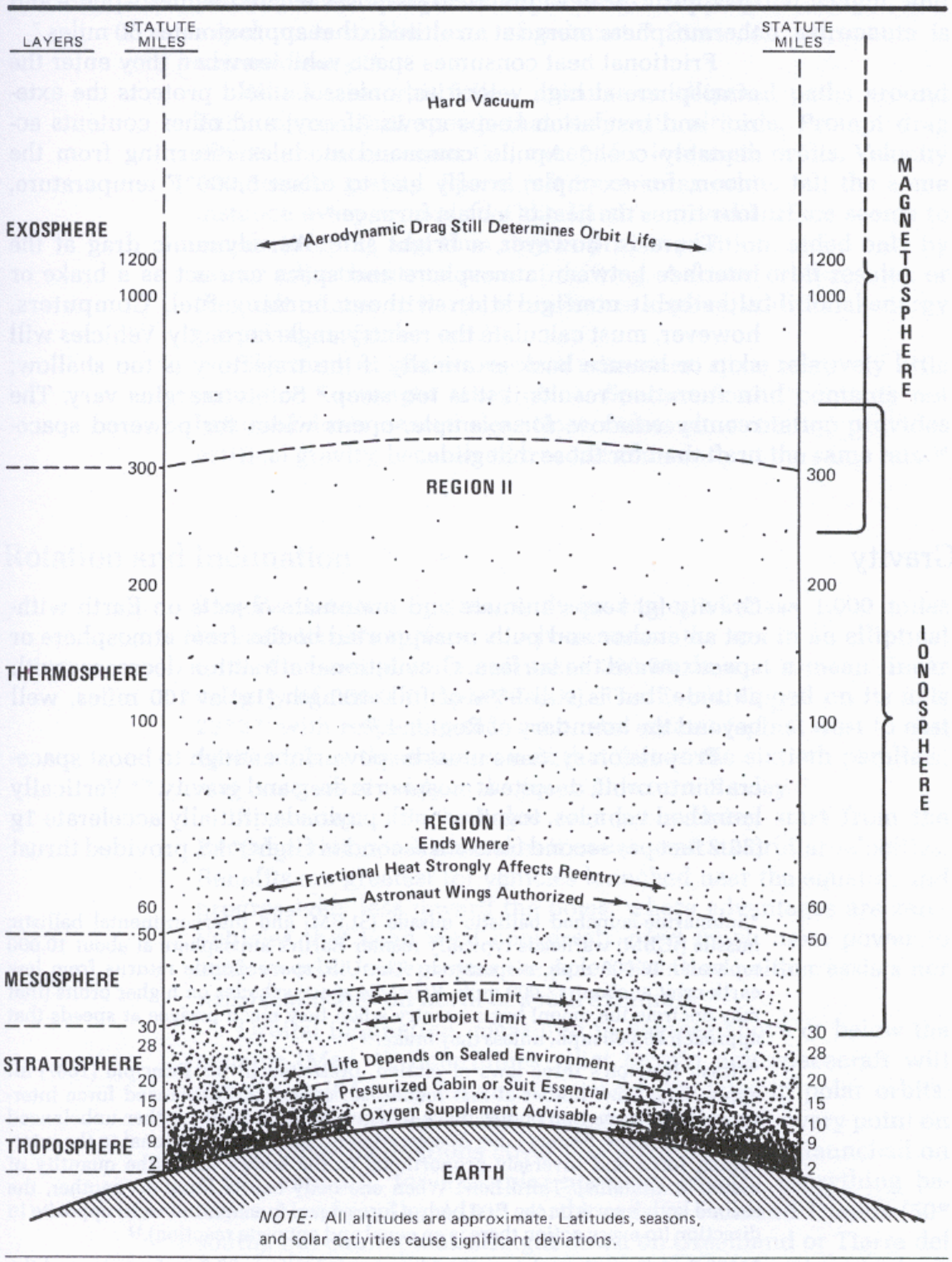
In addition, the crust shaped by the following processes (which will be important for other terrestrial worlds):

1. impact cratering in the early solar system

2. erosion - wind, water, slumping (gravity) - most early cratering erased by erosion on planets with thick atmospheres

3. thermal-tectonic activity (plate tectonics) - outflow of heat from core transfered to convective motion in mantle.


mid–ocean ridge
sliding plates
ocean trench
mountains



At 5000 m (17000 feet)

One half of the mass of the atmosphere is below this attitude. At this point a pilot who is at this cabin altitude must be on oxygen or a condition known as hypoxia (lack of oxygen to the blood or circulatory system) will render the aviator unconscious within 30 minutes.

At 16000 m (16 km or nine miles)

The use of supplemental oxygen fails as a sustainer for human life. An individual must be in a pressurized cabin or wearing a pressure suit.

At 20 km (12 miles)

The outside atmospheric pressure equals the vapor pressure of the human body or about 47 millimeters of mercury. In this environment bubbles of water and other gases begin to form in the body. The bodily fluids begin to literally boil.

At 24 km (15 miles)

An aircraft's pressurization system no longer functions economically. For the human body space begins at this point because above this altitude a human must carry everything in order for the body to survive.

At 32 km (20 miles)

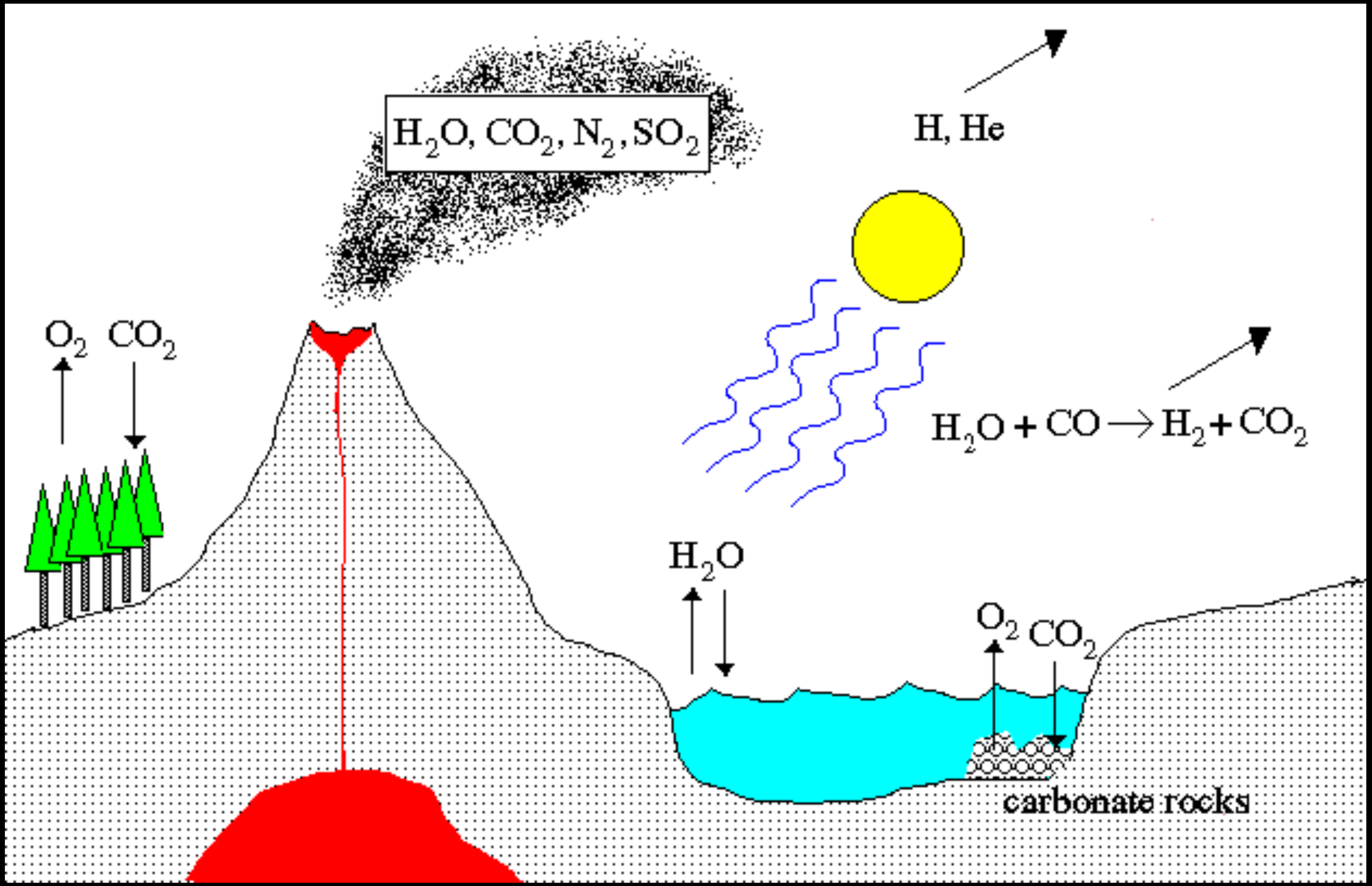
Turbojets can no longer function. Above this altitude aircraft must use ramjets. A ramjet operates similar to a turbojet except that a ram jet compresses air using supersonic shockwaves rather than fans.

At 45 km (28 miles)

There is not enough air even for a ramjet to operate. Above this altitude a propulsion system needs to provide its own oxygen, also known as oxidizer, as well as fuel, i.e. a rocket. To a propulsion engineer space begins above this altitude.

At 100 km (62 miles)

Aerodynamic forces are no longer effective enough to move the various control surfaces to control an aircraft. At this altitude the sky is dark; the stars no longer shimmer, but are hard points of light. Other than on-board equipment, there is no sound; no sonic booms, no explosions, or no shockwaves can be heard in space.



The Earths atmosphere has undergone some extreme changes since the time of its formation. The process has 7 stages:

1) proto-atmosphere phase: the original atmosphere of the Earth, the proto-atmosphere, was accreted from the early Solar System material and was very similar to the composition of Jupiter, thick and rich in light elements (hydrogen,helium,neon/H,He,Ne)

2) early atmosphere phase: The original proto-atmosphere was lost into outer space because a) the Earth is close to the Sun and the atoms are heated plus b) the gravity of the Earth is weak (compared to Jupiter for example). Thus, as atoms were heated by the Sun's radiation, their kinetic motion increased (see microscopic understanding of heat). For the lightest elements, the heating was sufficient to increase their average velocity to greater than the escape velocity, and they left the Earth.

3) secondary atmosphere phase: Most of the original atmosphere was light elements (H and He are more abundant than any of other elements). A secondary atmosphere that was rich in water (H2O), carbon dioxide (CO2), nitrogen (N2) and sulfur (SO2) was built up by outgassing from volcanos. These materials were trapped in the mantle during the Earth's formation and also added to by later bombardment from icy comets.

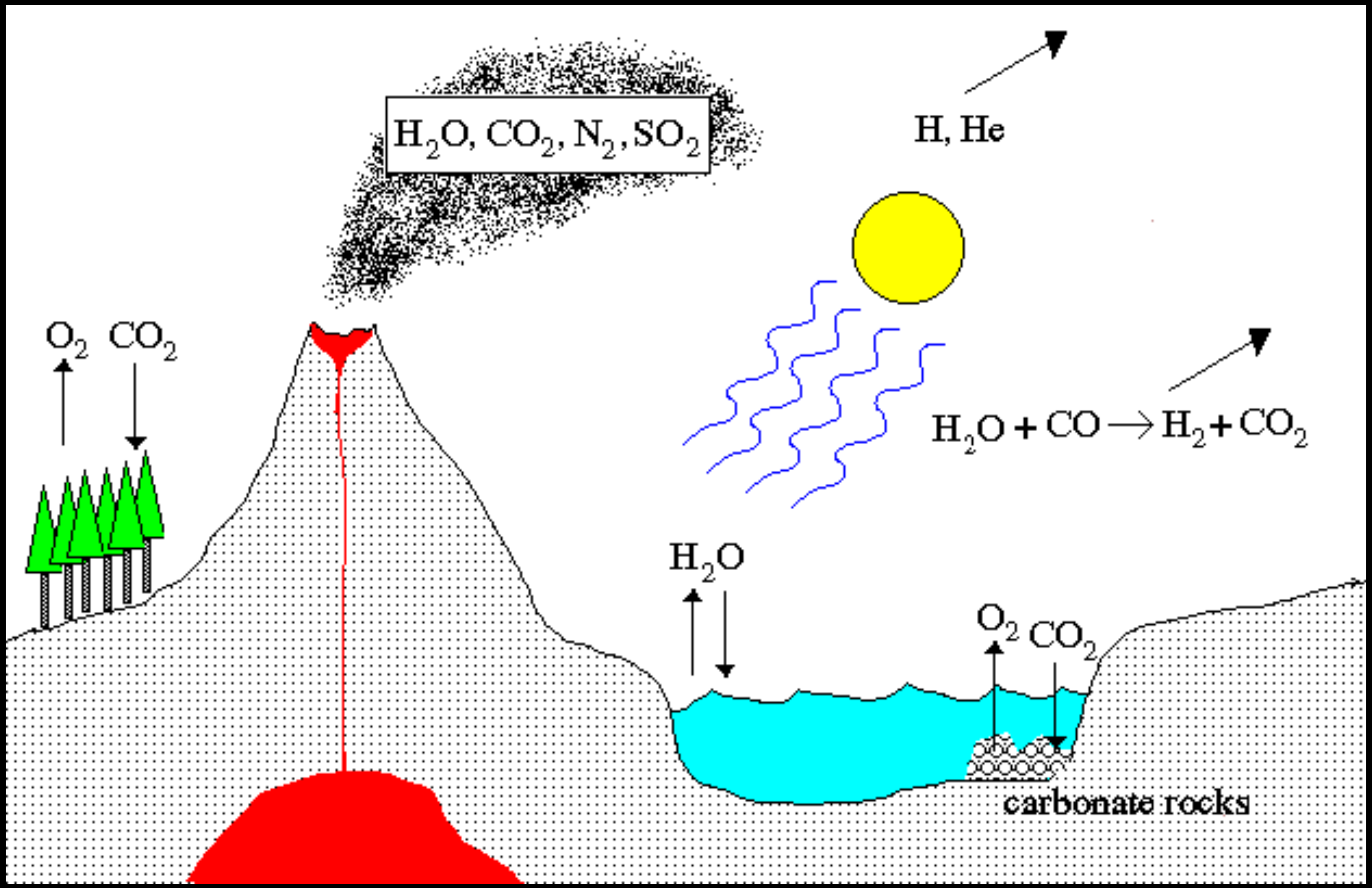
4) cooling phase: As the atmosphere cooled, H2O rains out to become the oceans

5) photodisintegration: extra water vapor is converted into H2 and CO2 by photodisintegration

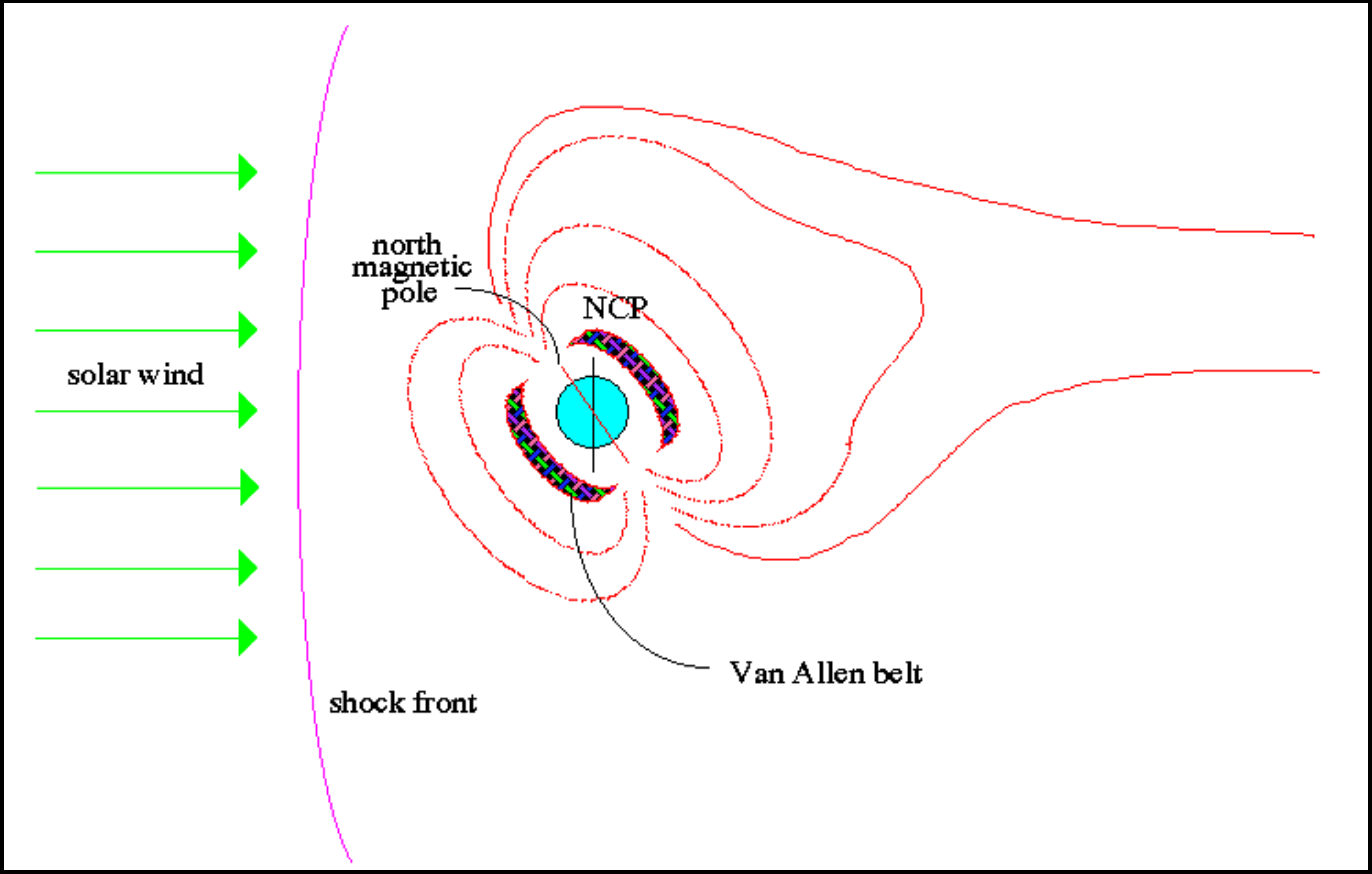
6) carbonate rock formation: H_2O and CO_2 react in the oceans to become carbonate rocks and O_2

7) life: development of living organisms turns more CO_2 into O_2. In fact, since O_2 is highly reactive, biological activity is the main source for the O_2 content of today's atmosphere.

The endresult is a reducing atmosphere with a final composition of 78% N_2, 21% O_2, 1% Ar and trace amounts of H_2O, CO_2 (0.03%), Ne and Xe



The Earth is surrounded by a magnetic field, generated in the core of our planet, in the shape shown below. The field lines (red in diagram below) show different strengths where the lines closest to the Earth are stronger than the lines farther away.



The origin of the Earth's magnetic field is its Iron/ Nickel (Fe/Ni) inner core. The inner core is hot and its rotation produces friction which ionizes the Fe/Ni atoms. Ionization means many free electrons in the core. Free flowing electrons = electric current. By the dynamo effect, a changing electric field produces a magnetic field.