LEBANESE UNIVERSITY
Faculty of Sciences (1)

Course: ENVI 100 - English

GEOSPHERE- PLANET EARTH

First year Biology- Second semester 2008/2009

Prepared by Dr. Samir Zaatiti

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GEOSPHERE

Our planet Earth is active. The testimonies are numerous: the ground shakes, volcanoes are erupting, the compass is oriented to magnetic north, the rivers carry fresh water and particles to the oceans, tornadoes are common in Florida, etc. ...
As with any machine, as well as any living system, understand the dynamics of the Earth requires to identify and assess sources of energy, understanding the mechanisms of transfer and the arrangements for the dissipation energy.

Our planet may be unique compared to its neighbors in the solar system. So you should also consider that the Earth is a planet in the universe, and we re together the history of the Earth and its components since the beginning of the universe, there are 15 Ga, until Today.

So as a first step, you will land the envelope confers no doubt has its uniqueness Earth biosphere.

Going to the discovery of our planet as we are able to do so for any planet in the solar system, Earth's face is clearly present as a series of concentric envelopes even more difficult to observe that they are deep. Whether the atmosphere, hydrosphere, I e external fluid envelopes of the Earth or the 'geosphere' internally, these three main enclosures are clearly heterogeneous in both dimensions vertical and horizontal. It follows that our planet is fascinating in its originality: it has a strong internal and an external intense activity related to the presence of water and living organisms.
But it is unlikely that the current face of the earth is always one. The Earth is now older than 4.5 Ga (billion years). In this long history, there are only a few sporadic and fragmentary images, from which we must date the phenomena. Geology is also a story.

An indispensable tool for the study of our 'old' world is well on the timeline. In what order are the successive phenomena? How long have they lasted? These are all questions that will not answer without concept of chronology.

Then, to understand how they arranged the various components of the planet to the Earth's surface, it is essential to understand the representations' flat 'that we are given a three-dimensional geometry. It is therefore to acquire a tool essential to geology which is intrinsically three-dimensional science. This tool will also be very useful in many scientific fields.

. Now that you have these new tools, you will be able to discover the dynamics of the atmosphere and ocean, which is still called external geodynamics. You then travel to the center of the Earth was located about 6370 km beneath your feet, exploring the main features of the internal geodynamics.

THE UNIVERSE

Look up at the sky on a clear, starry night. What you see is part of the universe. You could never see the entire universe. No one even knows whether the universe has an edge or if it goes on forever. The universe contains all matter and energy. The universe holds all space and time. You are a part of the universe. The universe includes everything there is.

Distant Galaxies: The universe is gigantic. It contains Earth, the planets, the stars, and everything else in outer space. The universe is so big that a spaceship could travel for billions of years without reaching the end of it. It might even go on forever!

WHAT MAKES UP THE UNIVERSE?

Earth and all the planets in our solar system make up just a tiny part of the universe. Billions of other stars like our Sun all form a group called the Milky Way Galaxy. With telescopes we can see billions of other galaxies. Galaxies are in turn clumped together in enormous groups called clusters and super clusters. The universe is a big place!

The universe holds many strange things, such as exploding stars. It holds great clouds of gas and dust where new stars form. It also holds black holes.

Black holes have a pulling force called gravity. Gravity is the force that holds you to the ground and makes things fall when you drop them. Black holes suck in all the matter around them. The gravity of black holes is so strong that nothing, not even light, can escape.

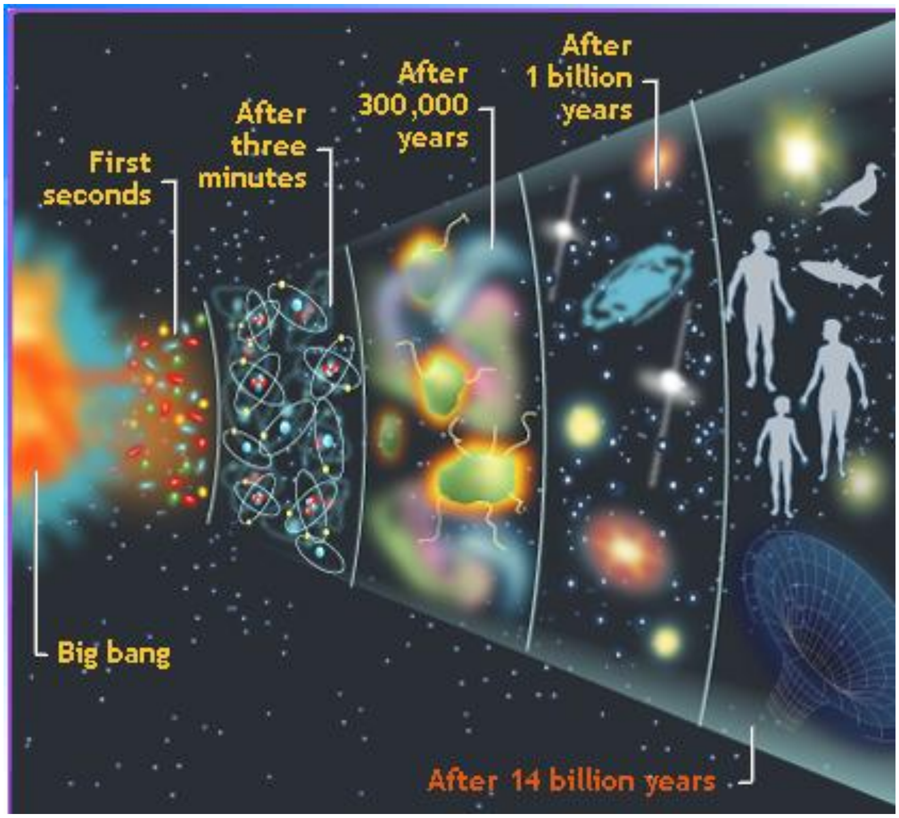
Astronomers think there is even more matter in the universe than we can see. The matter we see makes up gas, dust, galaxies, stars, and planets.

Astronomers think there is a type of invisible matter that they call dark matter. They think there may be a lot more of this mysterious dark matter in the universe than there is regular matter that we can see.

Astronomers also think the universe holds a strange substance that they call dark energy. They don't know much about dark energy except that it seems to make the universe expand.

WHEN DID THE UNIVERSE BEGIN?

Many astronomers think the universe began about 14 billion years ago. They think it suddenly exploded into being. They call this beginning the big bang. All space and time began with the big bang. With a special telescope, astronomers can see radiation left over from the big bang. They call this cosmic background radiation.



The big bang theory says that the universe was hotter than you can even imagine at the moment it began. The universe started to fly outward, or expand. As it expanded, it started to cool. Tiny particles that would make up matter started to form. All of this happened in just a few minutes.

Big Bang: Scientists believe that about 14 billion years ago a tremendous explosion occurred. Known as the big bang, this explosion is thought to be the start of the universe. At its beginning, the universe was so hot that nothing solid could form, not even tiny particles of matter.

WHAT HAPPENED AFTER THE BIG BANG?

First seconds: Within the first seconds after the big bang, the new universe expanded in all directions from a size smaller than an atom to a hot fireball larger than a galaxy.

After three minutes: As the universe expanded, temperatures dropped. Three minutes after the big bang the first particles of matter had formed, including protons, neutrons, and electrons.

After 300,000 years: After 300,000 years, the expanding universe had cooled enough to allow particles of matter to join together to form the first atoms. These atoms would become the building blocks of all matter and life.

After one billion years: One billion years after the big bang, hydrogen gas began to form clumps. These clumps came together to make stars and galaxies.

After 14 billion years: As galaxies clustered together, stars died in explosions that thrust matter into space. This matter eventually formed Earth and all the planets in our solar system. About 10 billion years after the big bang, life began to form on Earth. Today, more than 14 billion years after the big bang, the universe continues to expand.

When the universe was about 1 million years old, it had cooled to about 5900° Fahrenheit (3300° Celsius). This temperature was still scorching, but it was cool enough that tiny bits of matter called atoms started to form. All the objects around you the computer, the floor, the air are made of atoms. The hot atoms gave off rays of light. The universe was like a huge, hot fireball.

Over millions of years, the force of gravity pulled gas and dust together. Stars and galaxies formed from clumps of gas and dust. The stars began to shine. Our Sun and our solar system formed about 4.6 billions years ago.

Rays of light, travel across the universe. Even though light travels extremely quickly, it takes light millions or billions of years to travel from galaxies far away. When astronomers see light from the most distant galaxies they know the light is “old.” They know they are seeing the galaxies as they were billions of years ago.

WILL THE UNIVERSE END?

Astronomers want to know what will happen to the universe. They think it is still expanding. In fact, the universe seems to be expanding faster and faster as time goes on. Many astronomers think the universe will go on expanding forever. If it keeps on expanding, everything in the universe will eventually grow cold. Billions of years in the future even the stars will stop shining.

GALAXIES

Astronomers—scientists who study things in space—have been trying to figure out where our solar system is in the universe. They have learned that our Sun is part of a huge group of stars called a galaxy. Our galaxy is called the Milky Way. The Milky Way is just one of billions of galaxies.

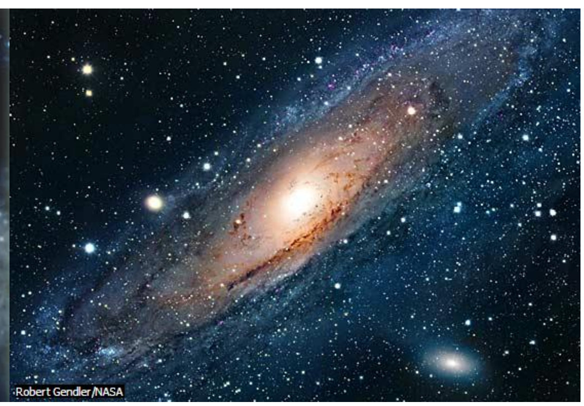
WHAT ARE GALAXIES MADE OF?

A galaxy is made up of millions or billions of stars. Big clouds of gas and dust swirl in space between the stars.

Astronomers believe that most galaxies have an enormous black hole in their centers. A black hole is an object with lots of matter packed into it. A black hole has a powerful pull of gravity. Gravity is the force that holds you to the ground and pulls a ball back down after you throw it up in the air. The gravity of a black hole is so strong that it sucks in and crushes anything that comes near. Not even light can escape from a black hole.

WHAT DO GALAXIES LOOK LIKE?

Galaxies come in different shapes. Some galaxies look like giant whirlpools or. They have long arms made of gas and dust clouds and stars. These are called spiral galaxies because the arms spiral into the center. The Milky Way is a spiral galaxy.



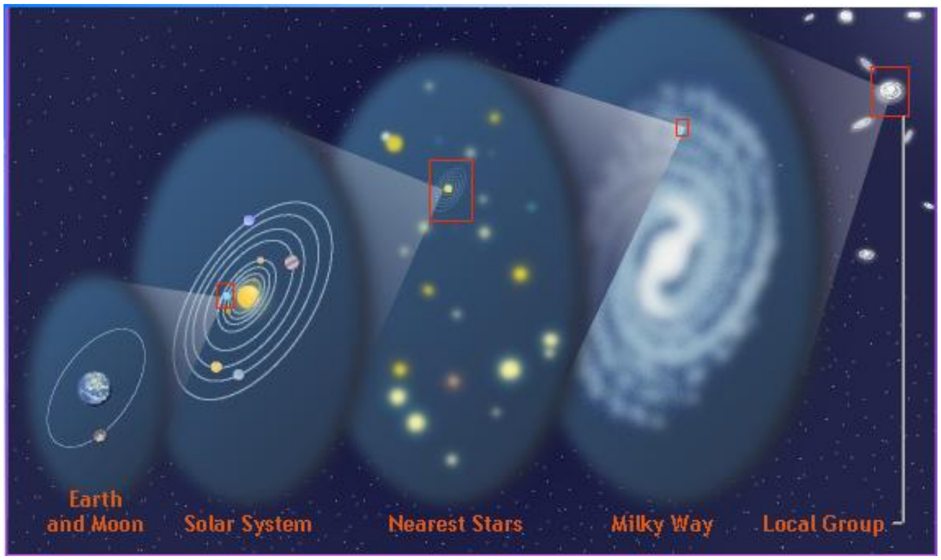
Galaxy M100 Andromeda

Milky Way

When you look up at the sky on a clear night, you see thousands of tiny points of light. A couple of the brightest points might be planets in the solar system. The rest are all stars. If you look closely, you might see a thick glowing band of faint white light crossing the sky. To see it, you'll need to be somewhere without many streetlights. Ancient Greeks named this band of light the Milky Way.

The Sun is a star. It's a lot closer to Earth than any other star, so it appears a lot brighter. The white glow of the Milky Way is made by billions of stars so far away that our eyes can't see them as individual points of light.

Milky Way Galaxy
Our solar system, which includes the Sun, Earth, and other planets, is just a tiny part of the Milky Way Galaxy. The Milky Way contains billions of stars!

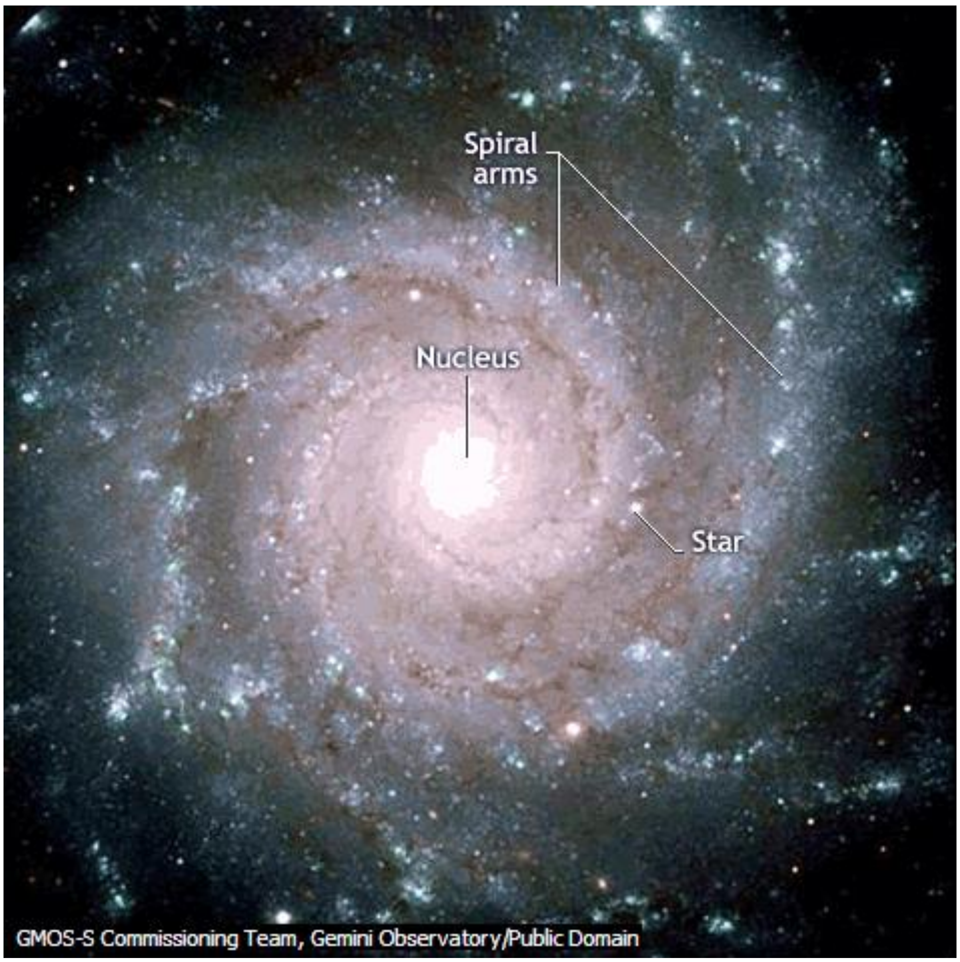


Local group: The Milky Way Galaxy belongs to a cluster of about 30 galaxies called the Local Group. Within the Local Group, the Andromeda Galaxy is the galaxy closest to the Milky Way. The Andromeda Galaxy is so far from Earth that it takes about two million years for its light to reach us from there.
Milky Way: The Sun joins about 400 billion other stars to form a galaxy called the Milky Way. The Milky Way Galaxy is shaped like a pinwheel, with curved arms that circle around the center. The Sun and solar system are located in one of the pinwheel's arms out toward the edge of the galaxy.

Nearest stars: After the Sun, the closest star to Earth is Proxima Centauri, more than 20 trillion miles (30 trillion kilometers) away. While light from the Sun takes only about eight minutes to reach Earth, other stars are so distant that their light takes billions of years to reach Earth.

Solar system: Earth is one of the planets that circle around the Sun to form a solar system. The Sun's gravity is so powerful that it can hold objects in orbit that are billions of miles away.

Earth and moon: Scientists think that the Earth and Moon formed about 4.6 billion years ago. Gravity keeps the Earth and Moon near each other as they travel together around the Sun.



Spiral Galaxy

The Milky Way is a spiral galaxy. Spiral galaxies look like giant whirlpools or pinwheels. They have long arms made of gas-and-dust clouds and stars. The arms spiral, or circle around, the nucleus (center).

STARS

Go outdoors at night and look up at the sky. There are twinkling points of light everywhere. You are seeing thousands of stars that are millions of miles away. The stars look tiny because they are so distant. But if you could see those stars up close, you would see huge balls of fire.

Stars
Why do stars light up the night sky? Stars are huge balls of very hot, glowing gases. Light from stars travels through space. It can take billions of years for the light of the farthest stars to reach Earth!

The closest star to you on Earth is the Sun. The Sun is a star at the center of our solar system. Our Sun is about 4.6 billion years old. There are stars that are older or younger than our Sun. There are stars that are much bigger. There are stars that have exploded and stars that are just being born.

WHAT IS A STAR?

A star is a big ball of hot, glowing gas. The gas is mostly hydrogen and helium. Stars give off heat, light, and other kinds of energy.

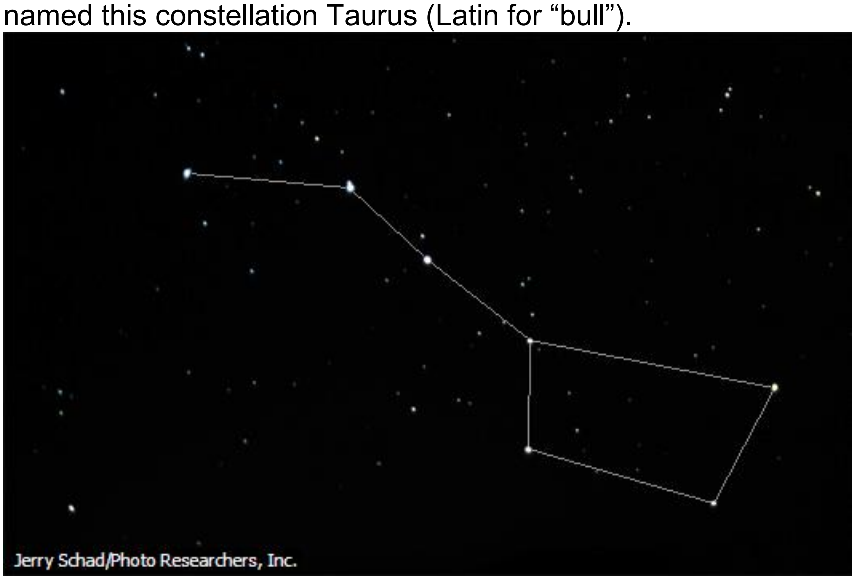
A star has several layers. The part at the center of a star is called its core. A star shines because of its core. The core is so hot and tightly packed that atoms crunch together. Atoms are tiny bits of matter much too small to see. Hydrogen atoms crunch together and become helium atoms. This is called nuclear fusion. Nuclear fusion gives off enough energy to make the stars shine.

GROUPS OF STARS

Stars are part of groups called galaxies. Our Sun is in the Milky Way Galaxy.

People in ancient times grouped stars by patterns they thought they saw in the sky. The patterns are called constellations. They thought the patterns looked like people, animals, or objects. The Big Dipper is a constellation of seven stars in the shape of a dipping ladle. Astronomers map where the stars are in the sky using the constellations.

The Constellation Taurus
In ancient times people thought these stars looked like the front half of a bull, so they named this constellation Taurus (Latin for “bull”).



The Big Dipper
The Big Dipper is a group of seven stars arranged in a pattern that looks like a water ladle. It is also known by the names Ursa Major (the Great Bear), the Plow, Charles’s Wain, and the Wagon.

A STAR’S LIFE

There are different stages in a star’s life, just as there are different stages in the lives of people. Right after a star is born it starts to get smaller. After a million years of shrinking, the star enters the main sequence of its life.

After about 10 billion years, the star's core runs out of fuel. The star grows many times larger than it was during the main sequence. At this stage the star is called a red giant. What happens next depends on the size of the star.

Nebula: A star begins its life as a cloud of dust and gas known as a nebula.

Gas and dust come together: If the gas and dust of a nebula get close enough together, gravity pulls them into a giant spinning ball.

Protostar: As the ball spins, it gets hotter and more tightly packed, leading to the birth of a protostar. Eventually, nuclear fusion—in which two atoms fuse together to form another type of atom—begins. Here, hydrogen atoms fuse together to form helium. Nuclear fusion releases huge amounts of energy that fuels a star throughout its life.

Star: A protostar becomes a star when it reaches a temperature of 18 million degrees Fahrenheit (10 million degrees Celsius). Then, the star begins to shine.

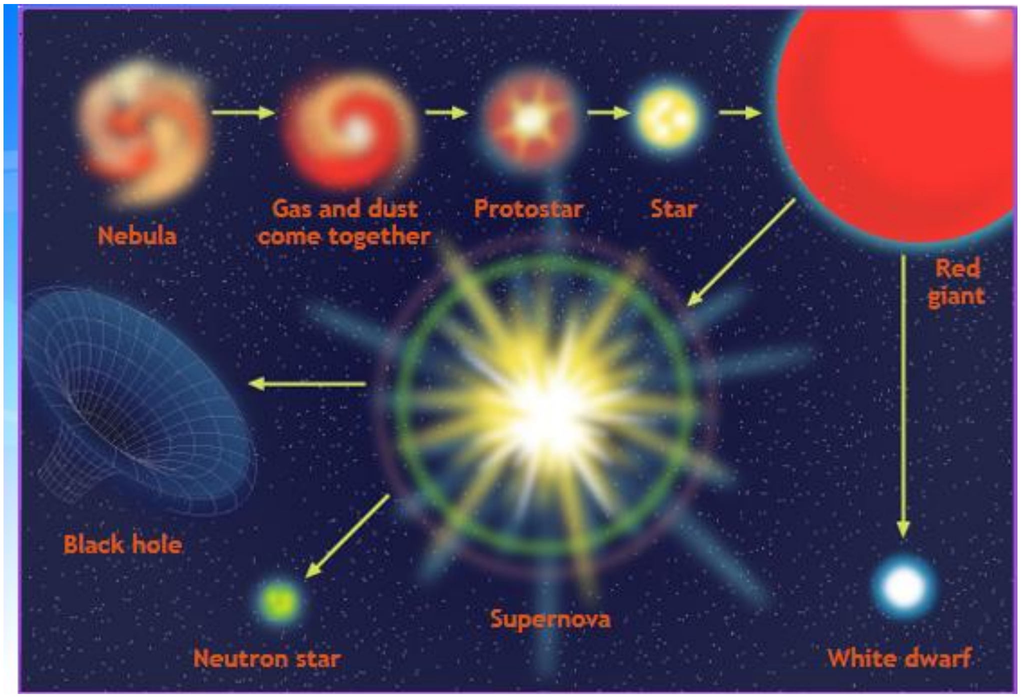
Red giant: A star turns into a red giant when its hydrogen fuel begins to run out. The star's core shrinks and the outer layers expand, cool, and become less bright. A red giant glows with a red color.

White dwarf: A white dwarf forms when a small- to medium-sized star—one that is up to eight times the mass of the Sun—uses up its fuel and collapses. A white dwarf is very dense—a spoonful of its core can weigh as much as a dump truck. White dwarfs continue to glow because of energy trapped in their core.

Supernova: A supernova occurs when a very massive star—one that is more than eight times the mass of the Sun—uses up its fuel and collapses under its own weight. The collapse leads to an explosion that sends a shock wave through space. The supernova may completely destroy the star, or it may leave the core of the star intact.

Neutron star: A neutron star forms from the core of a star that has undergone a supernova. The atoms in the star condense and collapse until two of the particles that compose atoms, protons and electrons, fuse to form neutrons, another type of atomic particle. Neutron stars have the highest density of any type of star—a teaspoonful of the star's crust would weigh ten billion tons on the surface of Earth.

Black hole: When an extremely massive star undergoes a supernova, the remaining core shrinks and eventually collapses completely. The collapsed core forms a black hole, which has such a strong pull of gravity that nothing can escape it, not even light.



GIANTS AND DWARFS

Medium-sized stars like our Sun become white dwarfs. White dwarfs can explode. The outside gas layers blow off and make clouds called nebulas. The core keeps shrinking. A spoonful of white dwarf core could weigh more than a dump truck. After several billion years, the star loses all its energy and becomes a cold black dwarf.

Really big stars become super giants. Super giants become *supernovas,* which are big exploding stars. The explosion sends gas and dust into space to make new stars. The core gets packed tighter and tighter. Some cores then turn to iron and become neutron stars. Some supernova cores turn into *black holes,* which swallow everything around them in space. Not even light can escape from a black hole.

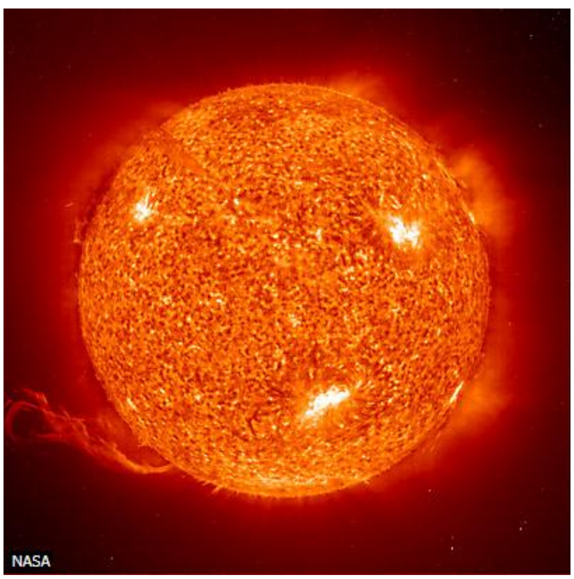
This photography, taken with a very long exposure time, represents in foreground amazing Delicate Arch of the national park of the Arches in Utah (the United States) and background the apparent movement of stars in the sky, generated by the rotation of the Earth. To the center of the arch, the "furrow" more shining and of smaller ray corresponds to the apparent movement of pole star (constellation of Small Bear), located in the prolongation of the axis of rotation of the Earth, near the celestial north pole.

The Sun

The Sun is very important to you. You play in sunshine. You see in daylight. The Sun keeps you warm. Even ancient people knew the Sun was very important. They thought the Sun was a god. The ancient Greeks thought the Sun god drove a chariot across the sky every day. The ancient Egyptians thought the Sun god sailed a boat across the sky. Today we know that the Sun is a star. The Sun is the star at the center of our solar system. Earth and all the other planets orbit, or go around, the Sun. The Sun is very important to all life on Earth.

THE SUN IS A STAR

The Sun is a star- a ball of hot, glowing gas. It does not have any solid parts. It is made up mostly of hydrogen gas and helium gas. The Sun is huge compared with Earth. If the Sun were hollow, a million Earths could fit inside it. The Sun looks small only because it is far away. The average distance from Earth to the Sun is 93 million miles (150 million kilometers). You would have to go around the world more than 3,700 times in order to travel that far on Earth.



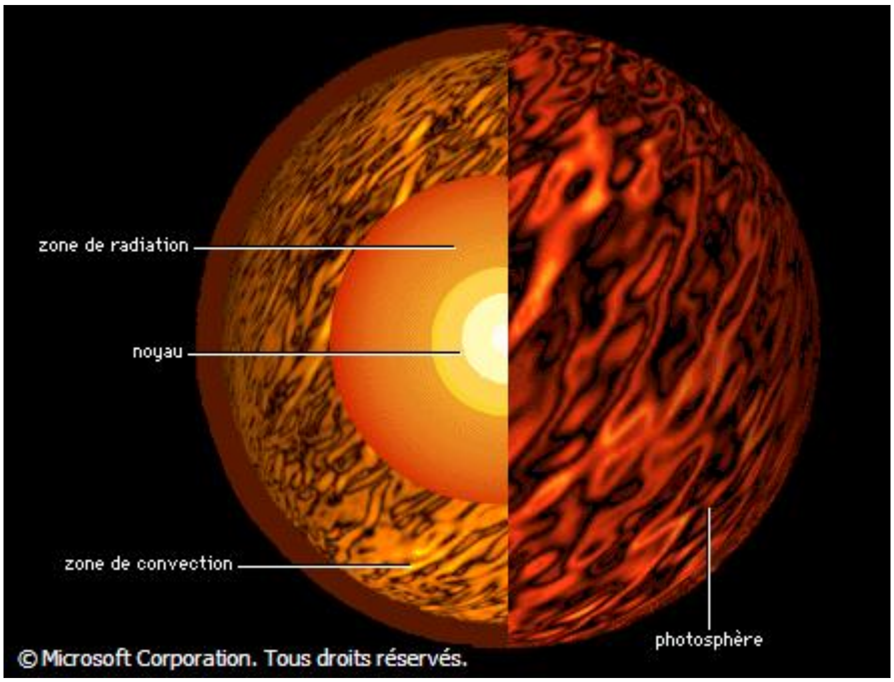
The Sun is a star at the center of our solar system. It is so big that a million Earths could fit inside of it. But there are stars in the universe that are much larger!

The force of Earth's gravity holds you on the ground. The Sun's gravity holds Earth and the other planets in their orbits. It holds asteroids, comets, and dust in orbit.

The Sun is one of about 400 billion stars in the Milky Way Galaxy. A galaxy is a large group of stars. The Sun and all the other stars orbit the center of the Milky Way.

THE CORE OF THE SUN

The center of the Sun is called the core. The core is extremely hot. The heat sends tiny bits of matter called atoms crashing into each other. The crashing atoms set off atomic or nuclear reactions. All the energy of the Sun comes from these nuclear reactions in its core. It takes a long time for the energy from the core to reach the surface of the Sun—about 170,000 years!



Temperatures of the internal layers of the Sun

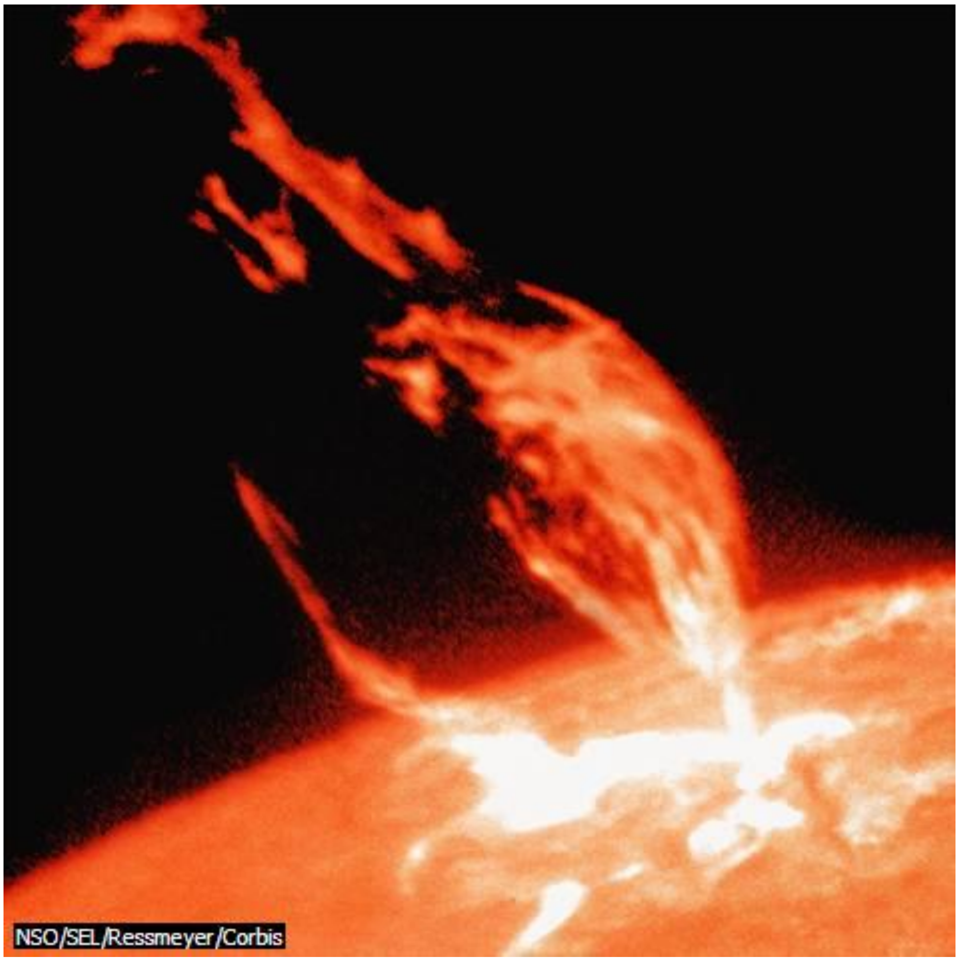
The Sun consists of a core, a zone of radiation and a zone of convection. The temperature of the core is about 16 million degrees; it is in the core that the reactions of thermonuclear fusion occur which transform the hydrogen cores into helium cores by releasing a phenomenal quantity of energy. The core is surrounded by a zone of radiation, where the average temperature rises to 5 million degrees. The zone of convection is colder, with 2 million degrees. Lastly, on the surface of the Sun (called photosphere), the temperature is not any more but of 6.000 °C.

THE SURFACE OF THE SUN

The photosphere is the outer part of the Sun that we can see. Like the rest of the Sun, the photosphere is made of hot hydrogen and helium gas. Heat and light from the photosphere reach Earth. The temperature of the photosphere is about 9950° Fahrenheit (about 5500° Celsius).

Fountains of red-hot gas shoot up thousands of miles from the photosphere into the Sun’s atmosphere. Cooler dark spots called sunspots form on the photosphere.

Far above the photosphere is the corona. The corona is the top layer of the Sun’s atmosphere. The corona is so faint that the only time you can see it is when the light from the rest of the Sun is blocked. Astronomers use discs to block the light so they can study the corona. The temperature of the corona goes up to 4 million degrees Fahrenheit (2 million degrees Celsius). The corona trails off into space. Gases that blow off the corona are called the solar wind. The solar wind reaches far beyond Earth.



Surface of the Sun

The surface layer of the Sun is called the photosphere. Sometimes hot gas can shoot thousands of miles above the photosphere, as this picture shows.

THE SUN IS A MAGNET

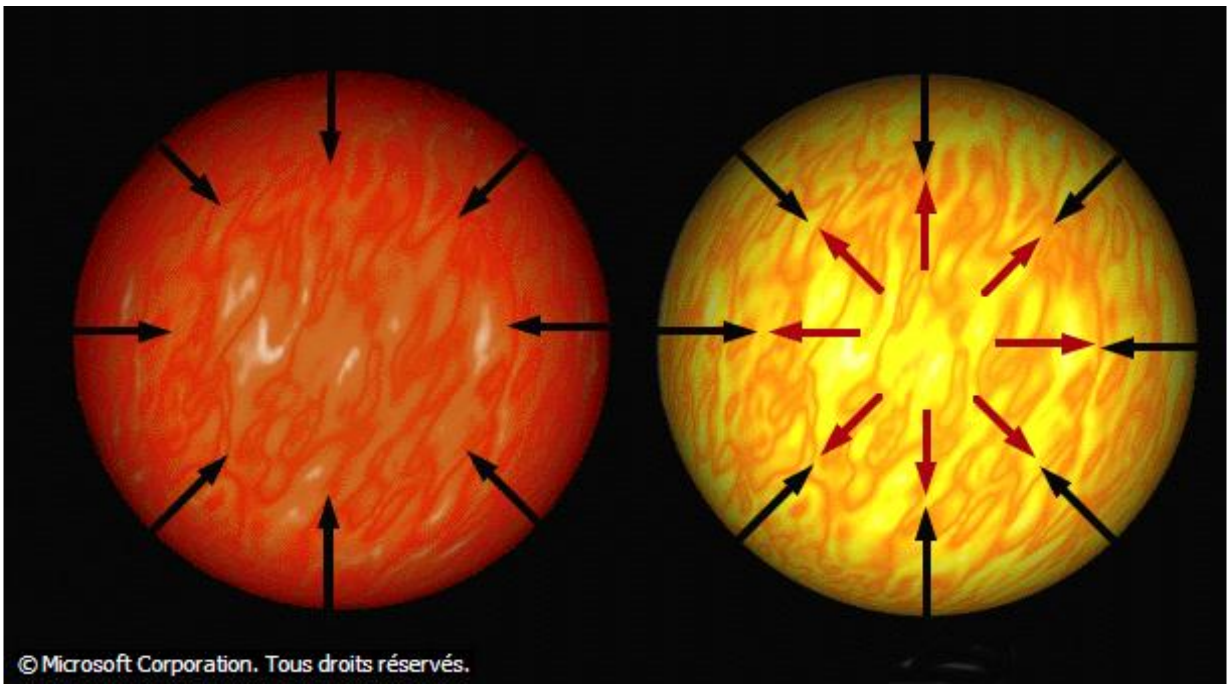
The Sun is a huge magnet. The magnetism of the Sun causes strange things to happen. Bright explosions called solar flares flash in the corona. The flares send gases looping out into space. Sometimes there are huge explosions in the corona that send billions of tons of material into space. The flares and explosions can cause magnetic storms on Earth. These storms cause problems for satellites and cell phones.

HOW DID THE SUN FORM?

Astronomers believe our solar system formed about 4.6 billion years ago from a swirling cloud of dust and gas. The Sun formed first at the center of the cloud. Then the planets formed from dust and gas going around the Sun.

Someday the Sun will burn out. It will use up all the fuel in its core. You don't need to worry. Astronomers say that the fuel will last several billion more years.

Sun evolution

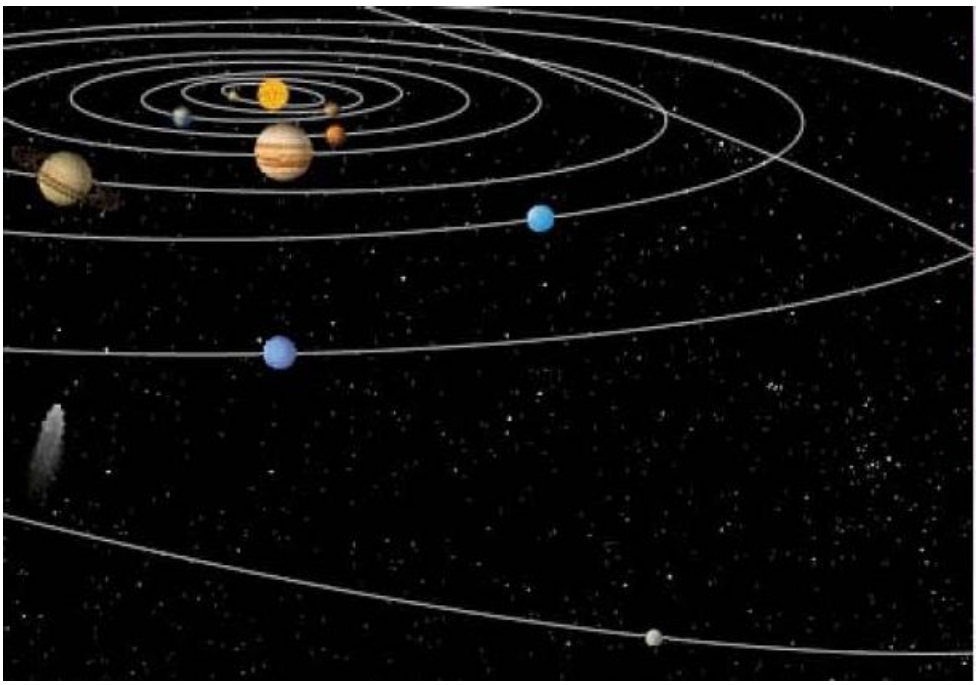


The figure of left represents the first stage of the formation of the Sun, at the time of its contraction until its current size. The right-hand side corresponds to the evolution of the Sun nowadays: the contraction of star is counterbalanced by the compressive forces created by the reactions of helium thermonuclear hydrogen fusion in the middle of the Sun. In the absence of energy produced in its center, the Sun would crumble under the effect of its own weight. Born there is approximately 4,6 billion years, the Sun is currently almost with semi-life; it will probably die out in 5 billion years to finish dwarf white, once the heart of the Sun will have burned all its nuclear fuels.

Solar system

Do you think our planet is the only place in the universe where there is life? Until 1995, astronomers had never found a solar system like ours. A solar system is made up of a star surrounded by planets and other objects. In 1995, astronomers found a planet orbiting (going around) a distant star like our Sun. Since then, they have found other solar systems. Astronomers now think that there are many solar systems in the universe. They do not know whether there is life in any of these other solar systems.

Our solar system is the one we know the most about. The Sun is at its center. Our solar system includes everything that orbits around the Sun. Planets, moons, asteroids, comets, gas, and dust are all part of the solar system.

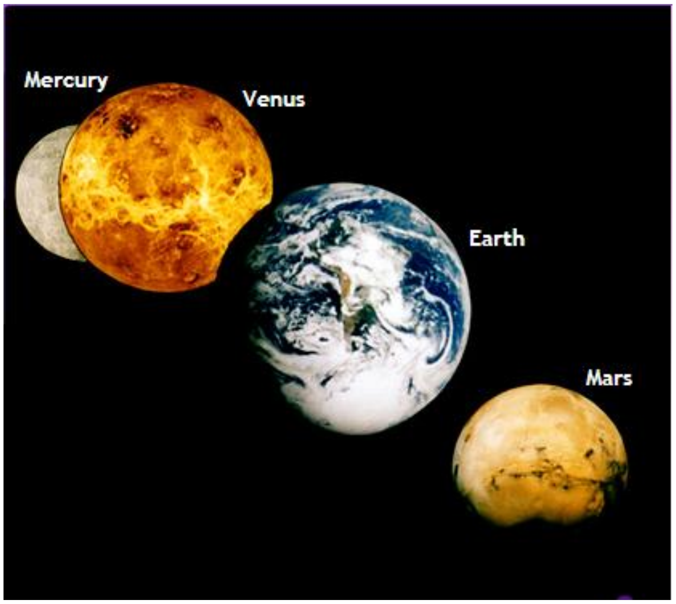


Our planet, Earth, is one of the planets in our solar system. The solar system is made up of the Sun and everything that goes around it. In addition to the planets and their moons, the solar system includes asteroids, comets, and all the other bits of rock, dust, and ice that circle the Sun.

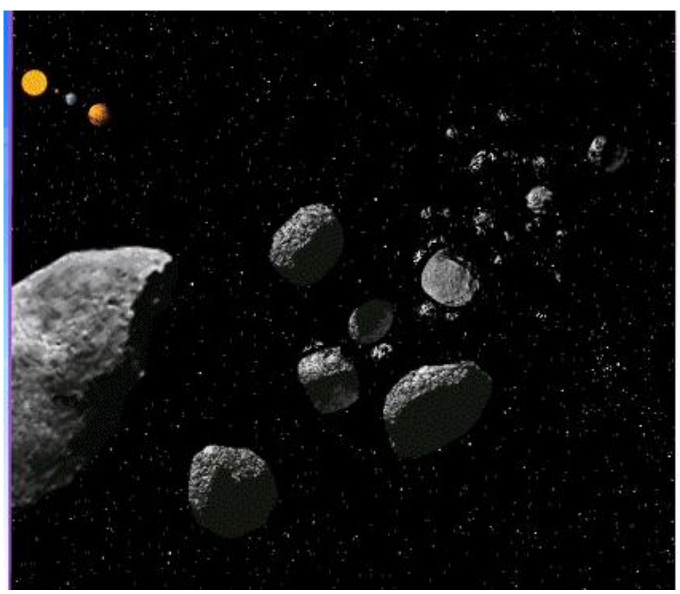
Our solar system lies near the edge of the Milky Way galaxy. A galaxy is a huge collection of stars. The Milky Way is shaped like a whirlpool. All the stars in the galaxy, including our Sun, orbit around the center of the Milky Way.

THE NINE PLANETS

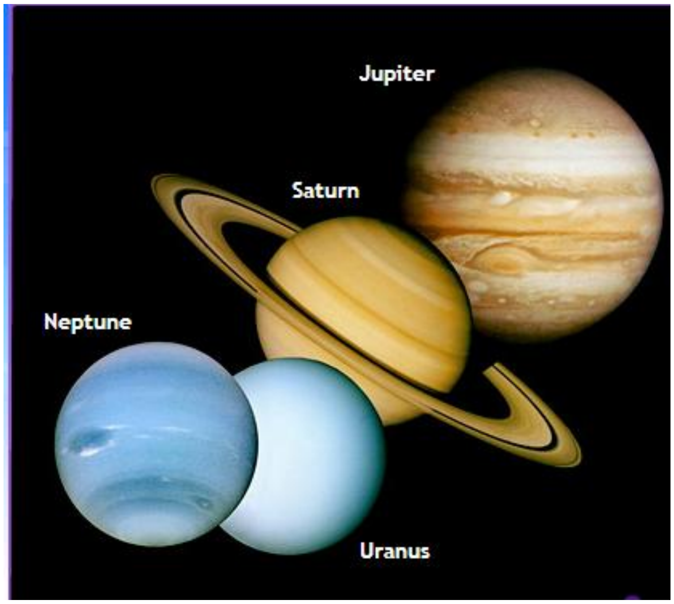
Eight of the nine planets in our solar system fall into two groups called the inner planets and the outer planets. The four planets closest to the Sun are called the inner planets. They are Mercury, Venus, Earth, and Mars. The inner planets are also called the rocky planets, because they are made mainly of rock and iron. There are four outer planets: Jupiter, Saturn, Uranus, and Neptune. The outer planets are also called the gas giants because they are huge and made mainly of gas. Pluto, the farthest planet from the Sun is a small ball of ice. Some astronomers wonder whether Pluto should be called a planet.



The inner planets are the four planets closest to the Sun: Mercury, Venus, Earth, and Mars. They all have hard, rocky surfaces. Mercury and Venus get hot enough to melt lead, while Mars is colder than Antarctica. Only Earth is known to have life and liquid water on its surface.



Asteroids are big pieces of rock and metal in space. There are thousands of them between Mars and Jupiter in an area called the asteroid belt. They go around the Sun just like planets do.



Beyond the asteroid belt lie the outer planets. Jupiter, Saturn, Uranus, and Neptune are giant planets made mostly of gas. They have no solid surface. Jupiter is the biggest planet in the solar system. More than a thousand Earths could fit inside it.

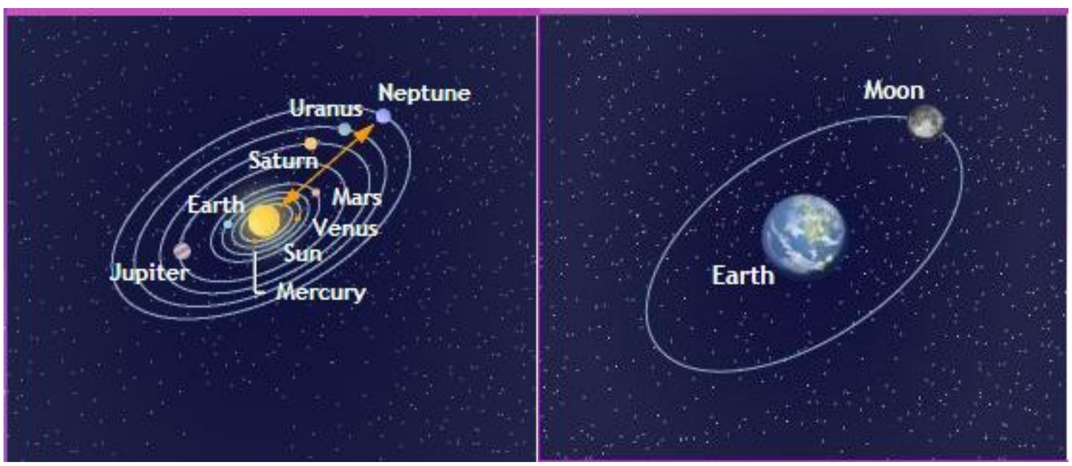
Comets are big chunks of ice and dust that go around the Sun. When comets come close to the Sun, they develop long, bright tails. Sometimes we can see them from Earth.

Mercury is the planet that is closest to the Sun. It has a large core, or center, that is made of iron. Venus, the next planet from the Sun, is the hottest of the planets. The temperature on Venus is about 890° Fahrenheit (about 477° Celsius). Earth is the only planet known to have life. It also has plenty of liquid water. There are signs that liquid water may once have flowed on Mars, but now Mars is cold and dry. What happened to the water on Mars is a great mystery that scientists are trying to solve.

Jupiter is the largest of the planets. A thick atmosphere made of hydrogen and helium surrounds it. Jupiter's clouds look like white, brown, and orange stripes going around the planet. There is an oval-shaped red spot in the clouds. Astronomers think this spot is a big storm that has been raging for hundreds of years! Saturn is the second largest planet and the sixth planet from the Sun. It has bright rings around it. Uranus and Neptune look like smooth blue balls. Methane gas gives these planets their blue color. Pluto is the smallest planet in our solar system. It is far from the Sun and very cold. Temperatures on Pluto can drop down to -387° Fahrenheit (-223° Celsius).

EARTH

In the Solar system, the Earth occupies the third position on the basis of the Sun. In the last place Pluto is, which is located at approximately 6 billion km of the Sun.



The Earth is a planet of the Solar system. It has one natural satellite: the Moon, orbits about it around the Earth with the average distance of 381.547 km. The Earth and the Moon turn around the Sun in 365 days, with the average distance from 149, 6 million km.

The Earth is the third planet nearest to the Sun among new the planets which account the Solar system. It is the only planet where water is under its three states: solid (ice), liquid (water) and gas (steam).

This photograph taken by the vessel Apollo 17 in 1972, watch Arabia, the African continent and the Antarctic (the white area on the lower end).
Researchers photograph, Inc. /NASA/Science Source.

Earth in the solar system

The Earth turns around the Sun at a speed close to 108.000 km/h and at an average distance from 149, 6 million km. It carries out a full rotation quasi-circular around the Sun (revolution) in one year, that is to say approximately 365 days. It also rotates (rotation) in 23:56 min, that is to say approximately a day. The Earth has only one natural satellite: the Moon. This satellite turns around the Earth in a little more than 27 days, to approximately 384.000 km of altitude.

Formation and evolution of the ground

The Earth is old of 4, 6 billion years. It was formed by the agglomeration (accretion) "remainders" of dust and gases which were not used for the formation of the Sun. These matter grains whirling around the Sun were also used to form other planets of the Solar system.

After its original condensation starting from dust and of cosmic gases and by gravitational attraction, the Earth was to be homogeneous and relatively cold. However, the contraction continues this dust and of these gases, as well as the radioactive radiations emitted by certain heavy elements, caused the warming of planet. The Earth then began to melt under the effect of gravity. There was thus formation of the crust, of the coat and the core, the lighter silicates going up to form the heavier coat and crust, and elements, mainly iron and nickel, reaching the center of the Earth to constitute the core.

Earth moving

The average distance from the Earth to the Sun is approximately 149,6 million km. The Earth and its natural satellite, the Moon, move on an elliptic orbit around the Sun. The eccentricity of this orbit being low, the trajectory is practically circular. One year corresponds to the time put by the Earth to carry out a full rotation around the Sun, that is to say approximately 365 days. The Earth turns around its axis of rotation in one day, that is to say 23:56 min 4,1 S. a point of the equator turns at a speed slightly higher than 1.600 km/h and a point located at 45° of northern latitude turns to approximately 1.073 km/h.

Movements on the surface of the ground

The Earth is made up of twelve plates which recover all its surface: they are the tectonic plates. The majority of the volcanoes are formed exactly at the place where these plates are touched. The plates move, meet and clash: it is what one calls the continental drift. These movements are extremely slow: the plates move only few centimeters per annum.

The collisions between the plates create the relief of the Earth, but also the earthquakes (or seism). The relief on the continents (mountains) exceeds 8.000 m of altitude above the sea level. The highest mountain is the Everest (8 850 m of altitude), in Nepal. The average depth of the oceans is of 3.800 Mr. more the great depth under the seas was raised with the pit of Marianne (11 033 m of depth), in the Northern Pacific. However, the relief of the Earth is constantly reorganized by erosion (action of water, the wind and freezing) and by the activities of men (urban expansion, creation of transportation routes, etc).

Alternation day night and the seasons

The life on the Earth proceeds according to two different scales of time: the day and the year. Over one day the day and the night alternate, over one year, the seasons. The night and the day do not have a duration equalizes the summer and the winter. The countries close to the equator have neither winter nor be, whereas the countries close to the poles have very long winters and summers. With what are due these differences?

Answer: these differences exist because the Earth turns around the Sun while rotating and that it is tilted on its axis of rotation.

The Earth rotates

We do not feel it but the Earth rotates, around an axis passing by its poles. One day a cycle made up and one night lasts 24 hours, time that the Earth puts to make a full rotation. Constantly, only the half of the Earth facing the Sun is enlightened (it is the part where it is dawning).

The movement of the Sun in the sky is called apparent movement, because it is the movement which the Sun has if one regards the Earth as motionless. If one takes a fixed point on the Earth (Paris, for example), the moment when the Sun is with most in the sky corresponds to the moment when Paris is more opposite the Sun; it is then midday with the Sun. Two hours later, the Earth turned; the Sun moved towards the west; it is thus lower on the horizon. Lastly, in the twilight, Paris is found in the shade of the Earth, it is the night.

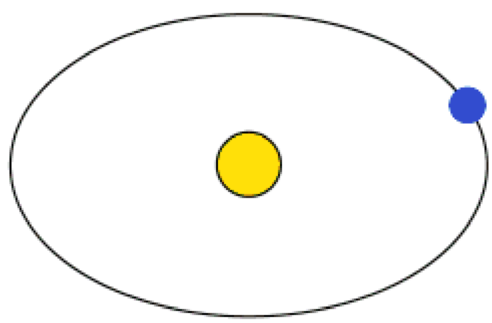
The solar rays are more or less tilted

In one day, the temperature varies: the weather is hotter in the middle of the day than the evening or the morning. It is about midday (solar hour) that the weather is hottest. The solar rays arrive then almost perpendicularly (in summer) at the surface of the Earth, they heat the ground thus effectively. The evening or the morning, they are almost tangentially on the surface of the Earth. Energy that they transport is thus distributed on a larger surface. The heat produced by the solar rays arriving on the ground is thus less large. Moreover, even while exposing oneself faces the Sun, one rather catches sunstrokes at midday than the morning or the evening. The atmosphere filters part of the solar radiations. The more the solar rays reach tangent at the surface of the Earth, the more the layer of the atmosphere which they cross is large and the energy they are.

The Earth turns around the Sun

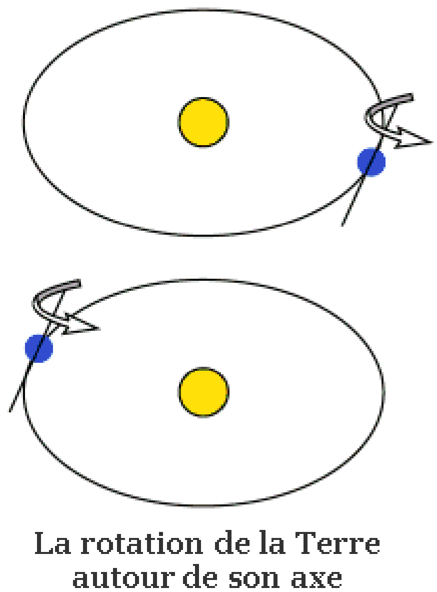
The Earth turns around the Sun in 365,25 days. She traverses an ellipse while remaining in a plan called ecliptic plan. An ellipse resembles a flattened circle; that described by the Earth corresponds to a circle having an average radius of 150 million kilometers. The Earth is thus not all the year with the same distance from the Sun. On the following diagram, the scales are not respected.

The axis around who’s the Earth turns to a constant direction. It is tilted compared to the ecliptic plan of 23°30'.



La rotation de la Terre
autour du Soleil

Earth rotation around the sun

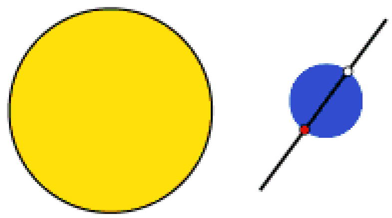


Earth rotation around hose axis

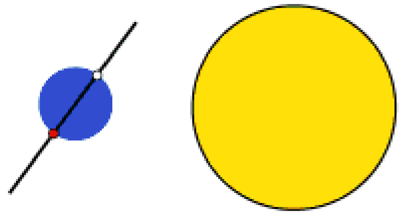
The alternation of the seasons

The seasons are defined according to the duration of the day. The winter is the season when the day hard the least long. The four seasons that we know do not exist in the countries close to the equator. The duration of the day varies there little during the year. On the other hand, on the level of the polar circle, the winter is very long (six months) and for approximately three months, the night lasts 24 hours.

With the poles: let us study the illumination of the North Pole (not white on the diagrams which follows) during the winter. As the axis of the Earth is inclined, the North Pole remains in the shade permanently. With the south pole (not red) on the contrary, it is dawning all the time. On the two following diagrams, the slope of the axis of the Earth is exaggerated.



Six months later, the Earth is different with dimensions Sun and it is the summer in the northern hemisphere: the duration of the days and the nights between the north poles and South is then reversed.



In the northern hemisphere: one cuts out the year in four seasons. The vernal equinox, first day of spring, corresponds to the equality of the day and the night. Here a summary of the course of the seasons:

- **The spring**: beginning with the vernal equinox (on March 20th) where the day is equal to the night. Then, the days increase and the nights decrease.

- **The summer**: beginning with the summer solstice (on June 21st), the longest day of the year (approximately 16 hours). Then, the days decrease whereas the nights increase.

- **The autumn**: beginning with the autumnal equinox (on September 22nd); the day is equal to the night there. The days decrease; the nights increase.

- **The winter**: beginning with the winter solstice (on December 21st), the shortest day of the year, approximately 8 hours. The days increase; the nights decrease.

In the southern hemisphere, the rate/rhythm of the seasons is reversed compared to that of the northern hemisphere. To the spring of the northern hemisphere the autumn of the southern hemisphere corresponds, to the summer corresponds the winter.

TOPOGRAPHIC & GEOGRAPHIC MAPS

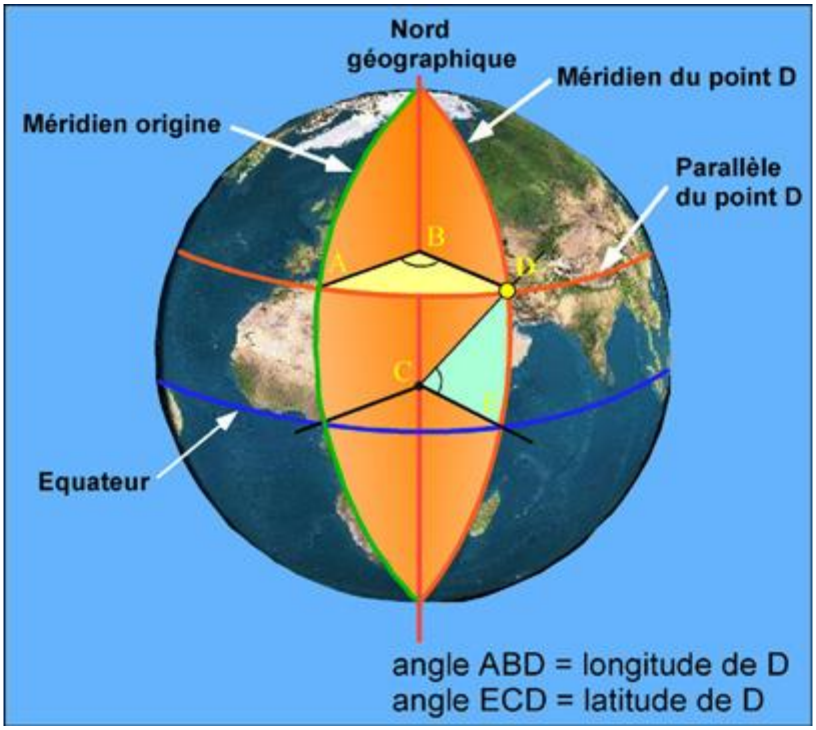
The map is a **reduced** image, and **symbolic plane** (= **conventional)** used to represent data of various characters, distributed in space. The map covers a large area. Only the main features are represented. The topographic map, by contrast, covers a relatively small portion of the earth's surface and contains the largest possible number of details in the field.

Reduced image

A map is a "model" of the earth's surface. The report is off the **scale** of the map are expressed as a simple fraction: 1 / 25 000, 1 / 50 000, 1 / 250 000 ...
For example, on a map at 1 / 100 000th, 1 cm on the map corresponds to 100 000 cm or 1 km on the ground.
The choice of scale is guided by the type of use desired. A hiker uses a map in 1 / 25 000th while motorists prefer a map at 1 / 100 000th see 1 / 250 000th.

Plane Image geometrically exact

The map is a plan that represents a correct geometry, a portion of a generally spherical object: the Earth. The Earth is actually the form of an ellipsoid flattened at the poles (equatorial radius: 6378 km, polar radius: 6367 km). On the map is therefore a spherical shell or, more accurately a portion of the ellipsoidal surface. It is necessary to make a transformation such that each point on the surface of the ellipsoid corresponding a point in the plan. This mathematical operation establishing a correspondence between spherical coordinates (Fig.1) and Cartesian coordinates is a **projection.** It is inevitably accompanied by deformations: alterations in angular measures, or lengths, or surfaces.



. Figure 1: Geographical coordinates (latitude and longitude) of a point.

Many projection systems exist; they can be grouped into four main groups:

Conform Projections retain measures of angles.
Equivalent projections retain the report of surfaces.
Equidistant projections retain some reports of lengths.
Azimuthally projections preserve directions.

In France, the system used by the IGN (National Geographical Institute) is the **Lambert Conformal Conic projection.** It can be likened to a geometrical projection of a portion of the Earth on a cone whose apex is located on the axis of the poles and which is tangent to the ellipsoid along a parallel said parallel means of contact (Fig.2). For alteration of the lengths is negligible, France is divided into 4 zones each have a projection system, so their parallel way. In the Lambert projection, meridians are represented by lines concurrent.

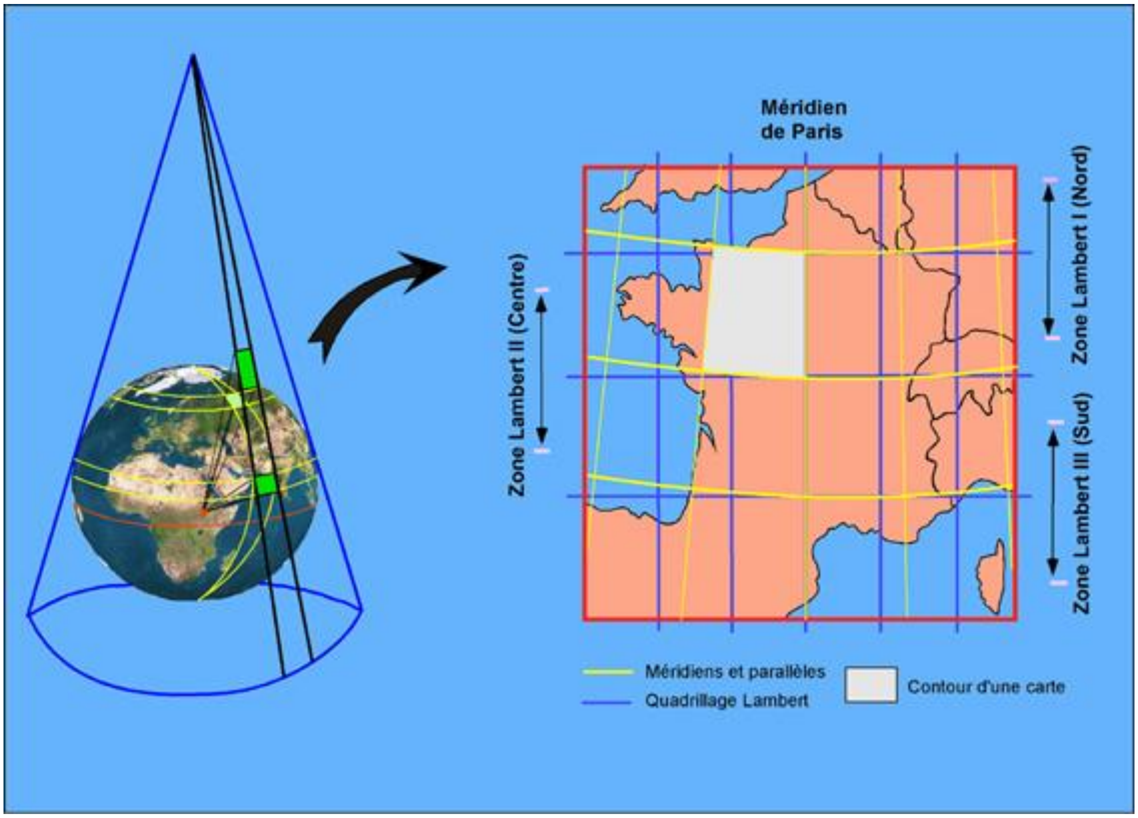
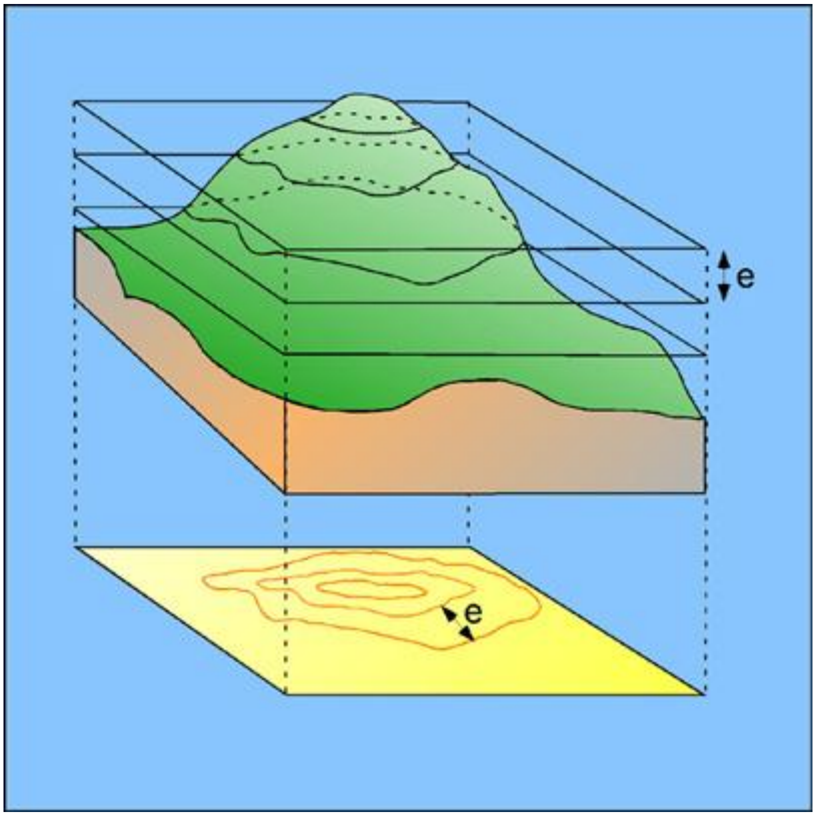


Figure 2: Principles of the conical projection of Lambert and Lambert Zones in France.

The surface topography of the land is returned via **standard curves.** Curve corresponds to the intersection of the surface topography with a horizontal plane to altitude; it joins a set of points of equal elevation. The difference in elevation between the horizontal planes is called **equidistance** contour lines (Fig.3).



Principle Established curves level.

Conventional image
Natural elements (source, rivers, nature of vegetation ...) and artificial (housing, power lines, bridges ...) are replaced by symbols evocative. An inventory of such symbols is contained in the **legend** of the map (Fig.4). On the maps published in full color, blue is reserved for hydrographic (lakes, ponds, rivers ...), green for vegetation (wood, crops), black markers for human activity (housing, power lines , railroads), administrative boundaries, geodetic points, toponymy (place names), the red lines of communication traffic. For the topography (level curves) are the bistre (brown-red) and gray are used, with the exception of steep rock that are in black.

Terrestrial atmosphere

The atmosphere is an immense layer of gas and dust which wraps the terrestrial sphere.

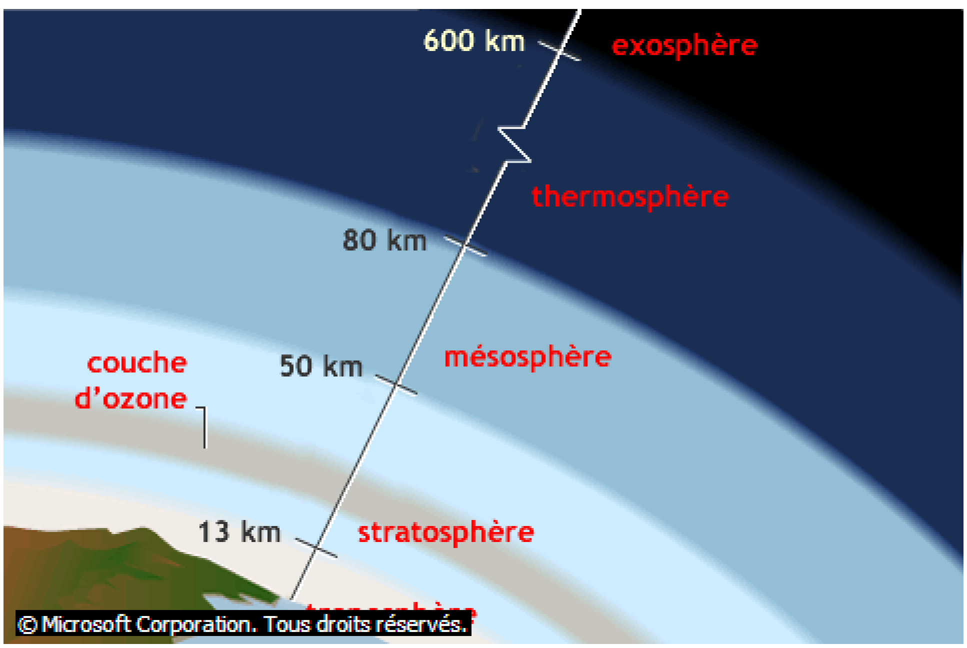
THE COMPOSITION OF THE TERRESTRIAL ATMOSPHERE

The three principal gases of the atmosphere (without taking account of the steam) are the nitrogen (78,1%), oxygen (20,9%) and argon (0,9%). Many of other gases are present in the atmosphere, but in extremely small quantities: carbon dioxide, neon, helium, krypton, hydrogen, the xenon and ozone. There is also steam in the atmosphere: between 1% (towards the poles) and 4% (towards the equator).

In addition, various types of fine particles (called aerosols) are also suspended in the air: dust coming from volcanoes, grains of sand and of salt, pollens, polluting gas rejected by industries, etc These aerosols circulates in the low layers of the atmosphere.

VARIOUS LAYERS OF THE TERRESTRIAL ATMOSPHERE

The atmosphere is thick approximately 10.000 km. But 99% of its mass are in the first 30 kilometers. The atmosphere is divided into 5 superimposed layers. Each one of these layers has different properties (thickness, temperature, pressure).



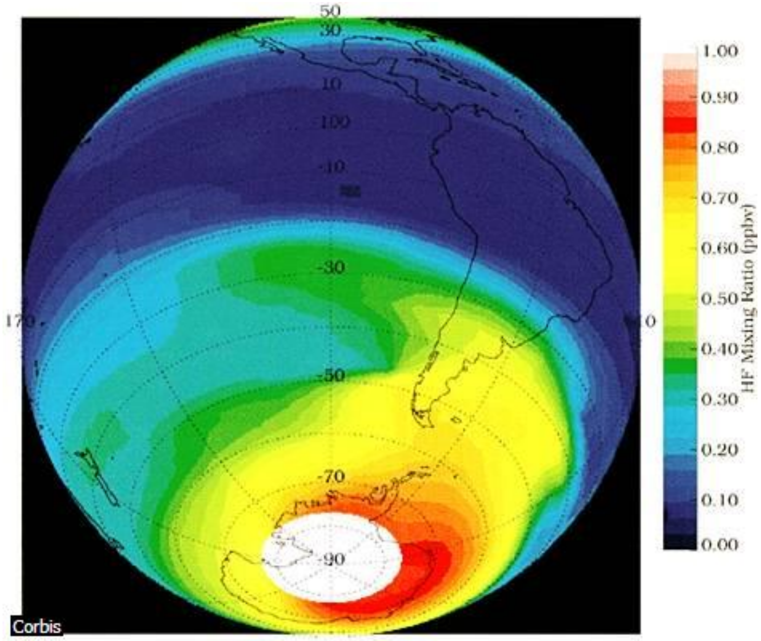
From the surface of the Earth, these layers are:

Troposphere
Troposphere is the layer nearest to the surface of the Earth. Its temperature decreases by 6,5 °C per km of altitude. Its average thickness is of 13 km. Its higher limit is called the tropo pause (temperature of approximately - 60 °C).

The mass of troposphere accounts for 80% of the total mass of the atmosphere, whereas its volume accounts for only 1,5% of total volume. It is in troposphere that the weather phenomena (precipitations, tornadoes, flashes, etc) proceed.
It is also there that the polluting gas resulting from the human activities (industries, transport) accumulates. When one speaks about atmospheric pollution, it is thus mainly about the air pollution of troposphere.
Stratosphere
Stratosphere is a layer which goes up until an altitude of 50 km (called strato pause), where the temperature is close to that of terrestrial surface. The temperature increases gradually in stratosphere because the layer of ozone absorbs the solar radiation (between 20 and 30 km of altitude). The famous hole of the layer of ozone is also located in this layer.
Polar lights
The polar lights are formed in the layer of the upper atmosphere called ionosphere (or thermosphere), which extends from 80 to 600 km of altitude. This layer, the molecules of air enter in collision with the solar wind (flow of particles charged coming from the Sun), causing a spectacular luminous phenomenon. This northern light, observed in Fairbanks in Alaska, takes the shape of waves colored according to the lines of the terrestrial magnetic field.

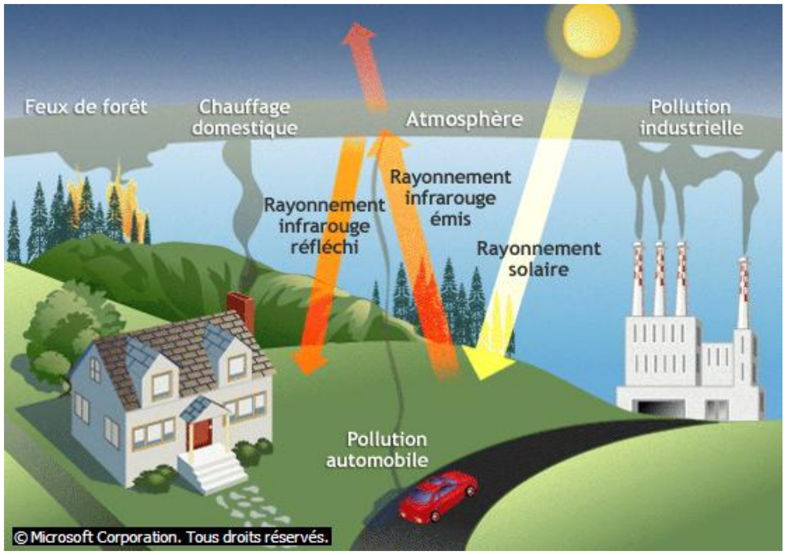
The mesosphere
The mesosphere ranges between 50 and 80 km of altitude. The temperature decreases until - 140 °C on the level of the summit of the mesosphere (called mesopause). It is in this layer that the meteors burn and form shooting stars.
The thermosphere
The thermosphere extends between 80 and 600 km from altitude. The molecules of air become very rare. The temperatures are very high (up to 1.200 °C). It is in the thermosphere that the polar lights occur (northern lights in the Northern hemisphere and the aurora austral in the southern hemisphere).
The exosphere

The exosphere extends up to 10.000 km from altitude, where the atmosphere stops and where space starts. It is in this zone that the artificial satellites revolve.
The distribution of ozone in the atmosphere
The layer of ozone is the part of the atmosphere where the ozone concentration is O3 is maximum. According to this image, obtained starting from data collected by the satellites of NASA, the concentration of ozone around the Earth is not uniform; it varies according to the geographical areas. It is in particular weaker above the Antarctic (zone materialized by the white color), where famous “the hole” of the layer of ozone is formed.

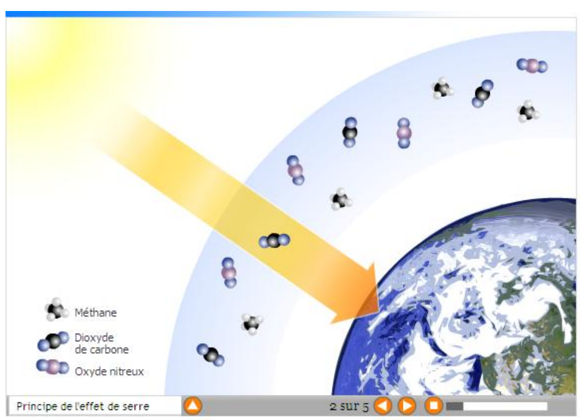


It will be noted that the color range used in this image corresponds in fact to the concentrations of a gas (hydrofluoric acid HF) which makes it possible to follow the evolution of the ozone concentration: the higher the concentration of hydrofluoric acid is, the more the ozone concentration is weak. In the lower atmosphere also a variable proportion of polluting gas and very small quantities of aerosols concentrate (dust of volcanic or industrial origin, grains of sand and of salt, pollens, etc). The polluting gas - carbon monoxide (CO), methane (CH4), nitrogen oxides (N2O, NO, NO2), ammonia (NH3), sulfur dioxide (SO2), chlorofluorocarbons (CFC), etc -, mainly results or testifies to an old human action), is in the beginning various environmental degradations, such as the effects of the acid rains, the hole of the layer of ozone or the greenhouse effect.

The principle of the greenhouse effect



The greenhouse effect is a natural phenomenon, but it is disturbed today by the human activities which reject many gases in the atmosphere. This atmospheric pollution reinforces the greenhouse effect and involves a climate warming prejudicial with the environment.



l'effet de serre

l'effet de serre

l'effet de serre

The ORIGIN AND EVOLUTION OF the Terrestrial atmosphere

The terrestrial atmosphere evolved/moved in a continuous way since the birth of the Earth (there is approximately 4,6 billion years). The atmosphere initially consisted of hydrogen and helium; but these very light gases are quickly escaped in space because of the weak gravity (attraction force) of the Earth.

The first true atmosphere (made up mainly of carbon dioxide, nitrogen and steam) was formed thanks to the volcanic eruptions. At that time indeed, the Earth was covered with very active volcanoes, which ejected enormous quantities of gas of the interior of the Earth. More than 80% of this atmosphere constituted themselves during the first 150 million years after the formation of the Earth.

The Earth then cooled and most of the steam of the atmosphere condensed (passage of the gas state in the liquid state): pouring rain fell then down on Earth and formed the oceans.

During two following billion years, oxygen appeared in the atmosphere thanks to the activity of marine organizations (bacteria and algae) practitioner photosynthesis (indeed, during photosynthesis, of oxygen is produced and rejected into the medium). It still was necessary two billion years before oxygen is in sufficient quantity in the atmosphere to form a layer of ozone able to protect the Earth from the ultraviolet rays of the Sun. That made it possible the living beings to leave the oceans, approximately 440 million years ago.

ATMOSPHERE OF ANOTHER PLANETS OF the Solar system

Another planets of the Solar system have an atmosphere, but their chemical composition is very different from that of the Earth. The planets closer to the Sun (Venus, Mars) have a weak atmospheric layer, made up to carbon dioxide 90%. The planets further away from the Sun (Jupiter, Saturn, Uranus, Neptune) have a thicker atmosphere, made up mainly hydrogen and of helium.

To determine the chemical composition of the atmosphere of these planets, two methods are used: analysis since the Earth of the radiations emitted by these planets or the sending of space probes directly on studied planets.

What is the "external Geodynamic"?

The Geodynamic external means all the **forces** involved and **movements** that result from the actions of those forces in the **external envelopes.** These envelopes, known as "superficial", are the lightest of the Earth: the **oceans** and the **atmosphere.** Composed of liquid or gas, they have the properties of the fluid, thus presenting a dynamic, with intense very fast movements. It is frequently associated with external envelopes all **current marine sediments** that line the ocean floor and carry dynamic coupling between the hydrosphere (I e all surface water), the continental lithosphere, and biosphere Navy. Atmosphere, oceans and sediments are the three major reservoirs of surface we will be discussing.

Why the atmosphere and oceans are dynamic?

For a body to be dynamic, it needs an important energy source. Thereafter, the energy is converted into mechanical energy (movement forces), and finally into kinetic energy (motion). In the case of a car for example, the burning fuel produces energy, which is used to actuate pistons and create mechanical forces that can be rotated to the car.

In the case of plate tectonics, the energy stored by the Earth during its accretion and its condensation, it also restores continuously interstellar medium, which is responsible for the movement of lithospheric plates (see Geodynamics internally).

Unlike the latter instance, the **energy source** at the origin of the **dynamics of** the **external envelope** is external to the Earth: the Sun.

In its totality, the Earth is in the **balance thermal** infrared radiation emitted by the Earth in space is strictly offset by solar energy it absorbs to the surface. The average temperature of the Earth at the top of the atmosphere, 255 K, or -18 ° C, is determined by this balance. The presence of an atmosphere made up of "greenhouse gases" increases the mean surface temperature of the Earth (ground level and oceans) of about thirty degrees from the one at the top of the atmosphere.

But locally, the surface temperature varies due to the uneven distribution of solar energy. It is this inequality that is, strictly speaking, the engine of atmospheric and oceanic circulations: indeed they are organized so as to reduce the temperature on the surface of our planet.

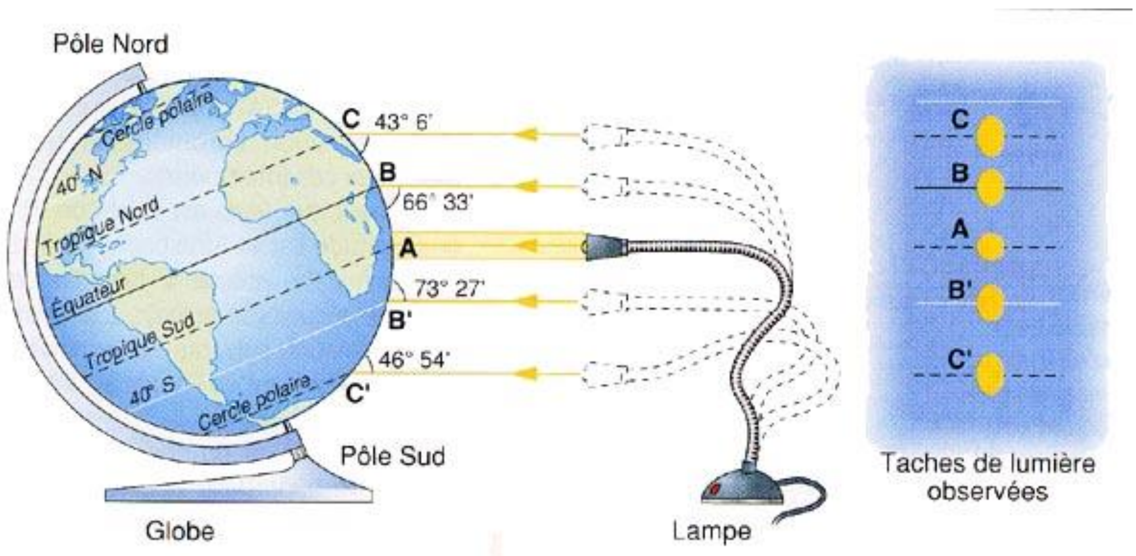
First, we will examine the global **energy balance** of the Earth (or its balance sheet “radiation” in order to understand, what are the parameters that control the mean temperature at the Earth's surface. Then we look at what set up regionally, **temperature variations.**

The energy balance of the Earth

How is broken sunlight at the Earth's surface?

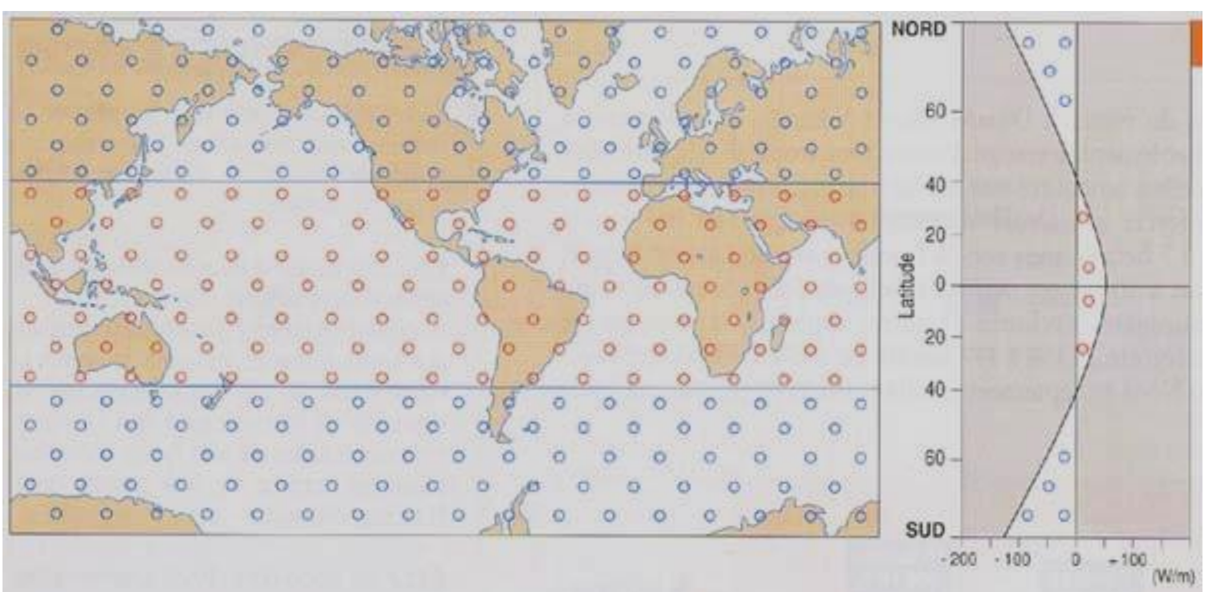
If the earth is the overall equilibrium temperature, solar energy is still distributed in various ways on its surface. We will see below how this uneven distribution causes fluid circulations envelopes and how the thermal balance is maintained throughout the globe.

- A simple experiment illustrated in the paper 1, makes it possible to visualize how the sunlight is distributed over the surface of the Earth.



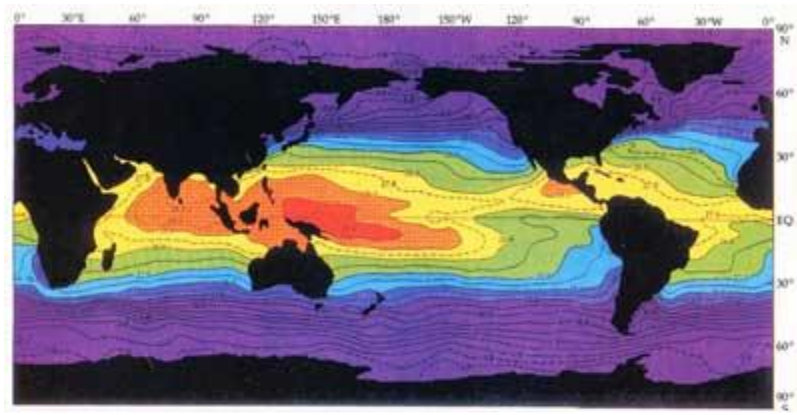
Document 1: Experimental approach to the distribution of solar energy at the Earth's surface. A beam of light low section, ships on the surface of a globe, simulates sunlight. The displacement of the beam from the equator towards the poles used to visualize the effect of variation of incidence radiation with latitude.

- Because of the variation of incidence of solar radiation with latitude, the energy balance of the Earth is not balanced anywhere on the planet: the difference between the solar flux absorbed and reemitted infrared radiation by the Earth in the Space is positive or negative - and locally zero (see 2).



Document 2: Energy balance anywhere on the globe (the difference between solar radiation absorbed and reemitted radiation by the Earth), in watts per square meter. The round red corresponds to a positive while blue circles correspondent to a negative balance.

- The uneven distribution of solar energy causes variations in temperature as a function of latitude.



Document 3 : Spatial distribution of the mean surface temperature of the world's oceans. The red color indicates a temperature above 29 ° C, the color purple a temperature below 18 ° C.

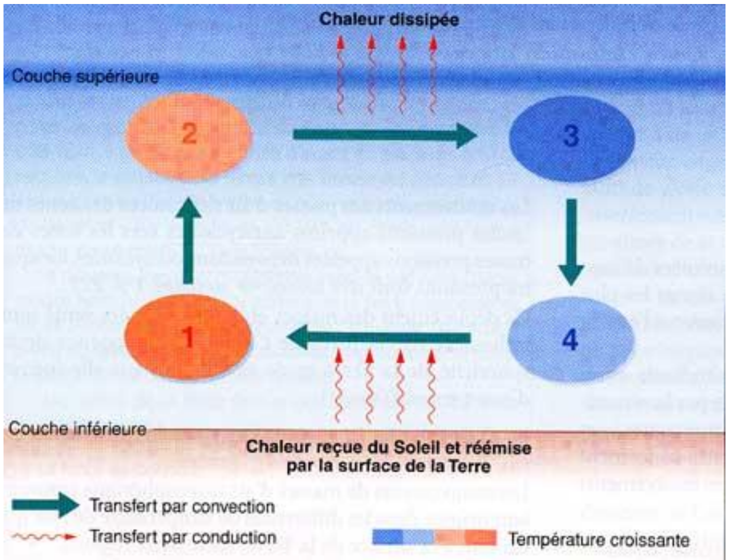
How do you explain the dynamics of air masses?

The dynamics of the external envelope is directly related to the variation of incidence of solar radiation on the surface of our planet.

The first layer of the atmosphere, the **troposphere,** is heated to its base by solar energy received and re-emitted by the Earth's surface: it is what allows the movement of air masses in the form of **convection cells**.

The tropospheric circulation, eventually, leads one of bodies of surface water and in this way induces a surface ocean circulation. We will consider how to put in place a convective cell in the **troposphere.**

The vertical movement of air masses **in the troposphere** are caused by variations in density (created by temperature differences), while horizontal movement can be attributed to variations of pressure.



Document 4: Circulation of a fluid between two layers of different temperature limits: principle of a convective cell.

In a volume of material between two layers limits and heated by its base, a "loop flow" or "convective cell" stood as the following mechanism (see Document 4):

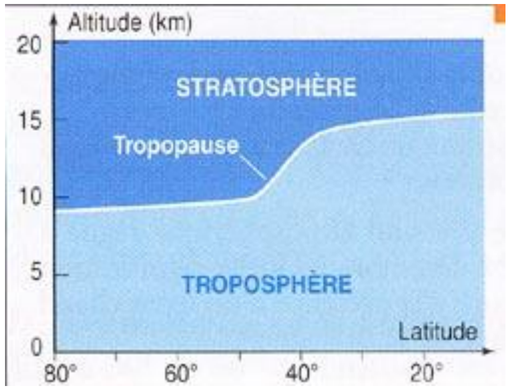
- The volume of material is heated by its base and the density of the material decreases (1)
- This volume of material is lighter than the one who overcomes, and rises to the top layer (2)
- Having migrated horizontally and lost part of its heat, volume of material becomes heavier than its environment and fall (3 and 4)
- The return to the initial state is provided by the lower layer, where it migrates horizontally winner of the heat.

The dynamics of the atmosphere

It is necessary, first, to know the **chemical composition** and **structure** of the atmosphere prior to examining the movements that animate. We may at a later study the dynamics of the atmosphere. The atmospheric circulation mainly takes place in a particular layer of the atmosphere: the lower **troposphere.** However, the above-surface layer, the **stratosphere,** is also affected by the movements of matter very slow.

Additional courses on the structure of the atmosphere:

The troposphere is the layer of air between the earth's surface and other layers of the atmosphere: it is the air we breathe. It is characterized by the presence of clouds and weather phenomena (precipitation, etc.). This layer contains 99% of the water vapor in the atmosphere and the temperature decreases by 6.5 ° C per kilometer. The upper limit of the troposphere varies with latitude: it is about 18 km above the equator where the air is hot and dilated, and to 8 km in the high latitudes, near the poles, where the air is cold and contracted.



Document 5: Altitude Variation of the tropo pause (boundary between the troposphere and stratosphere), with latitude.

The stratosphere is the second major layer of the atmosphere located above the troposphere. The mesosphere and the thermosphere layers are called "superior". The temperature increase in the thermosphere is due to absorption of solar radiation of short wavelength (UV and X-ray) by the dioxygen.

The atmosphere of the Earth is permanent lively movements, particularly as regards its lowest setting, the troposphere. In this layer of the atmosphere, air masses are moving currents horizontal and vertical, latitudinal direction and / or meridian. The winds may be modified by the distribution of land and sea, the presence of mountains and… vary with the seasons. While these movements were primarily the troposphere, there are also horizontal movements in the stratosphere.

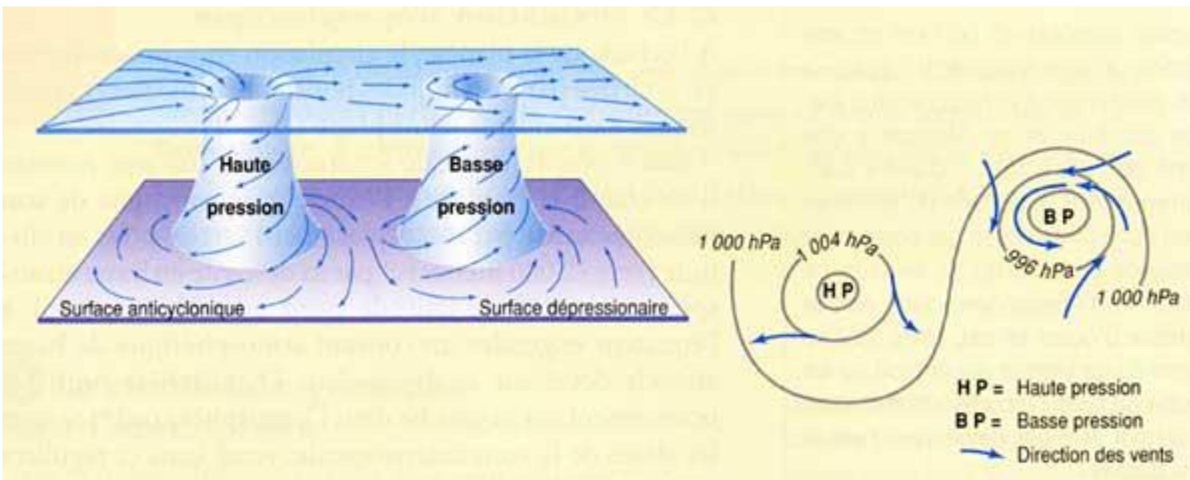
The tropospheric circulation

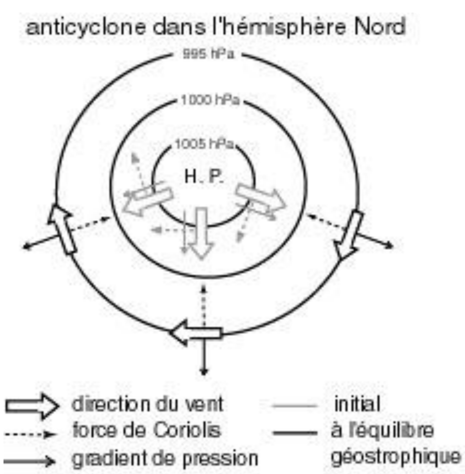
Document 6: Depression focus on Ireland, photographed by a satellite. The movement of rotation than clockwise, characteristic of depression in the northern hemisphere is well evidenced by the distribution of the cloud mass.

Important movements animate the atmospheric air masses, these "corridors" resulting from atmospheric unequal distribution, of solar energy reaching the Earth's surface and the Earth's rotation on itself. That level of the troposphere, were born surface winds that can homogenize the temperature at the earth's surface. The movements in the troposphere are likely convective **(see Document 4)** and can be turbulent. The vast majority of clouds are the highlight.

Complements on the tropospheric circulation

The movement of air masses is made initially areas of high pressure (anticyclones) to areas of low pressure (vacuum) (Document 7). The **Coriolis force** then deflects air masses to the right (relative to the direction of movement) in the Northern Hemisphere, and left in the southern hemisphere.

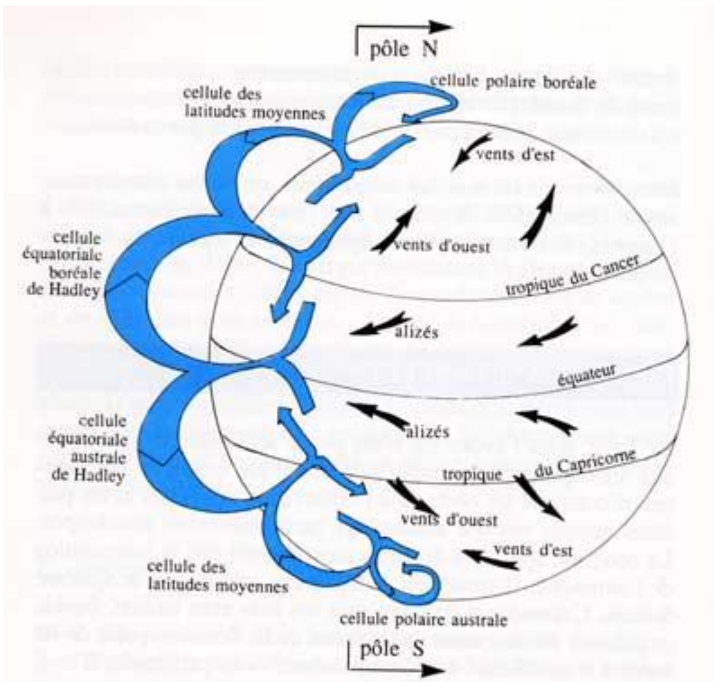




Document 7: Path air at the Earth's surface, in the northern hemisphere. In the northern hemisphere, air moves anticyclonic areas by conducting a downward spiral in the direction turning clockwise and approximates depressions where it wraps itself in an upward spiral turning in the opposite direction clockwise.

In areas anticyclonic in the northern hemisphere, air describes a downward spiral in the direction turning clockwise away and join a low pressure area in which climbed a spiral turning in the opposite direction of the needles a watch (7). These movements winding in the opposite direction for the same hemisphere resulted from the combination of the Coriolis force, anticyclonic expulsion forces and the forces of suction depression.

At the global level, the tropospheric circulation is characterized by three main loops and helical symmetric in each hemisphere.



Document 9 : The tropospheric circulation loops are organized into three symmetrical in each hemisphere. Because of the Coriolis force (see document 14), surface winds are deflected in the direction clockwise in the northern hemisphere and in the opposite direction in the Southern Hemisphere, so the thermal loops form - They continued a downward spiral in each band of latitude.

- A loop **"tropical",** characterized by a rise of warm, moist air at the equator with her cooling, by its movement towards the poles in altitude (about 12000 meters), and its descent in low atmospheres to 30 degrees latitude north or south. The return to the equator generates a stream of low-level atmospheric drifted to his right in the northern hemisphere (and vice versa on the left in the southern hemisphere): these are the winds of the Indian Ocean region, slow and steady winds blowing d 'east to west,
- A loop **"temperate"** descent with a warm and temperate air to 60 degrees and down in the tropics (30 ° north or south). The return of the air mass at low altitude to the latitude of 60 degrees is associated with westerly winds characteristics of the temperate zones,
- A loop **"polar"** associated with the same warm air rising and tempered at 60 ° north or south, but with a downhill air cold at the poles. In these high latitudes are of easterly winds, cold and dry.

The direction of surface winds

The study of maps shows that horizontal movement, and hence the wind, the movement of clouds and… the weather, can be correlated to differences in air pressure between two regions. The movement of air masses carried zones of high pressure, called anticyclones to the areas of low pressure, called depressions or hurricanes when pressures are very low. This movement of clouds and wind direction are influenced by the Coriolis force, as a consequence of the sphericity of the earth and its rotation on itself, from west to east (see 7).

At the global level, areas descent of air (equator and 60 ° latitude), are areas of low pressure. On the other hand, the descent of cold air is generating high pressures (tropics and poles). As the trade winds in the tropics, are headed toward the equator, blowing from east to west because of the Coriolis force.

In the same way, the area is affected by temperate winds of tropical high pressure to low pressure located near 60 degrees north latitude, but diverted to the east by the Coriolis force (9).

Document 10: The winds on the Earth's surface: The length of peak schematically arrow indicates the wind speed.

The stratospheric circulation

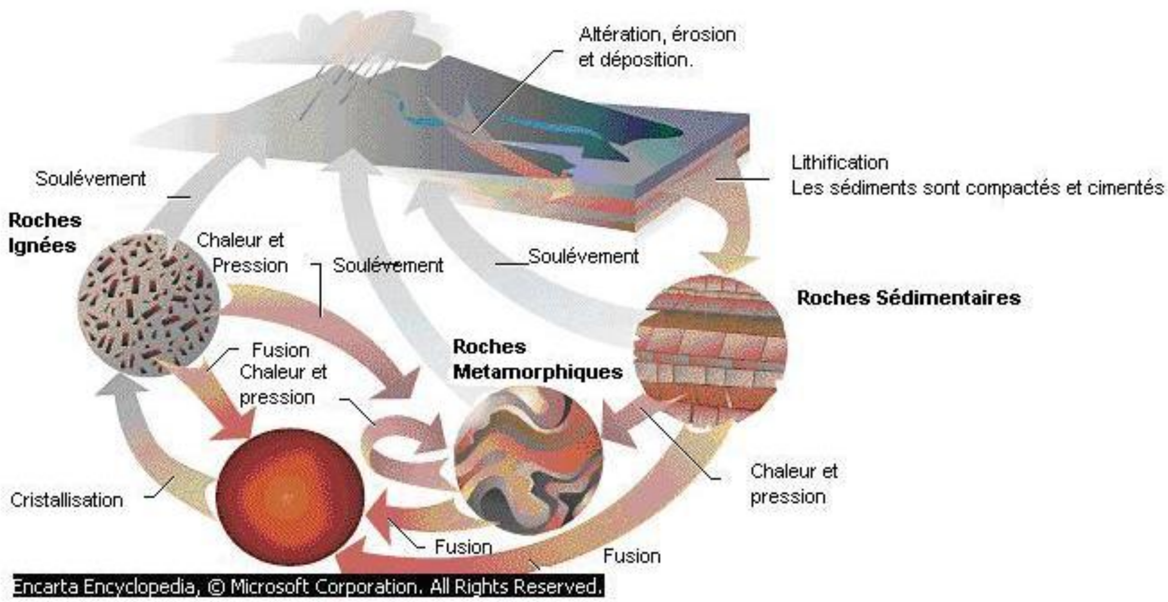
If the transport of air masses in the troposphere is by far the most effective in terms of speed, load quantities of matter and energy exchanged, there are still another mode of transport, atmospheric much slower, which affects the stratosphere. The movements in the lower stratosphere are sometimes visible through the clouds very dishes that appear near the tropo pause (cirrus). They may also be highlighted, around the world, when violent volcanic eruption injects enough of the dust and gases in the stratosphere: the dispersion of compounds possible to trace the direction and speed of transport.

INTERNAL GEODYNAMICS

GEOLOGY

Geology, science treating of the origin of the Earth, of its history, of its form, the materials which compose it and the processes which influence or which influenced it.

Geology is interested in the rocks and the derived materials which compose the external layers of the terrestrial sphere. In order to include/understand the genesis of these materials, geology resorts to knowledge of other scientific disciplines, like physics, chemistry and biology. Thus, of the very important sectors today of geology, like geochemistry, geophysics, the geochronology (use of the methods of dating) or paleontology, can now be regarded as disciplines with whole share, which give to the geologists the possibility of better apprehending the operation of the planet Ground through time.



Cycle de la roche

The cycle of the rock represents the interaction of the internal processes (endogenous) and external (exogenic) of the Earth. It describes in particular the processes of transformation of each of the three principal types of rocks (sedimentary rocks, metamorphic and magmatic) into rocks of one or the other of the two other types, even in rocks of a specific type different. The compacted, cemented and sometimes recrystallised sediments form sedimentary rocks; the rocks subjected to strong heats and pressures form metamorphic rocks; the rocks resulting from the cooling then of the solidification of magma form magmatic rocks (or igneous).

The structure interns Earth: Seism

The seism or earthquakes constitute a geological phenomenon which from time immemorial terrorized the populations which live in certain zones of the sphere.

Relative chronology: Elementary principles

To tell the history of the Earth and planets, it is necessary to have temporal reference marks or, at least, to locate in time, the ones compared to the others, the objects or the events geological. It is easy to observe, at the edge of a road or in a career, successions of rocks of various possibly deformed or broken natures: such rock is with the top of such other, a fault re cuts such whole of formations. One of the fundamental problems of geology is to establish, starting from the geometrical relations observed between these rocks, of the temporal relations, i.e. to build a chronology: this rock settled after this other, the fault is posterior with the re cut formations…

A second question relates to the comparison of two or several chronologies built in different places: how to establish correlations between them?

Relative chronology

The passage of a geometrical succession to a temporal succession rests on some elementary principles, called “principles of chronology” (or “principles of stratigraphy” because stated starting from the study of the sedimentary rocks).

1. **Principle of superposition**: When several layers are superimposed, the sub-base is oldest, the road base most recent (Fig.1).

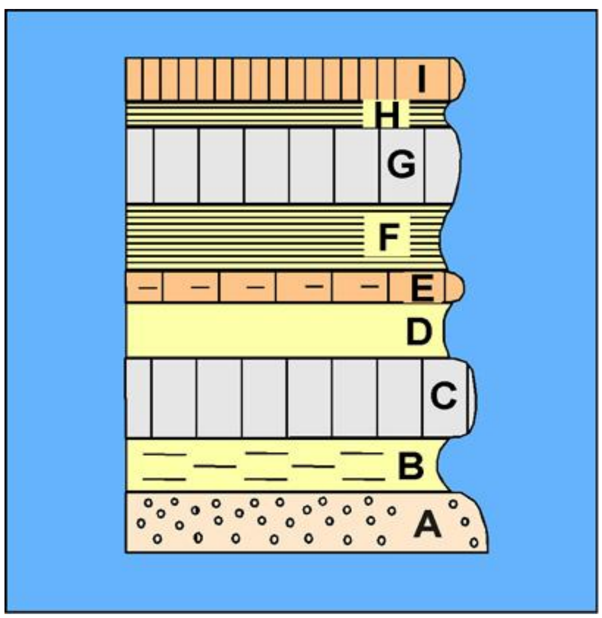


Figure 1: Principle of superposition: The layer B settled after layer A; Layer I is the last deposited.

This principle seems obvious, but it is valid only in two conditions The layers were laid out horizontally; The layers were not turned over by later tectonic events

2. Principle of cutting: An event or an object which affects another event or another object is posterior with this last.

Ex: a fault is posterior with youngest a formation that cuts (Fig.2).

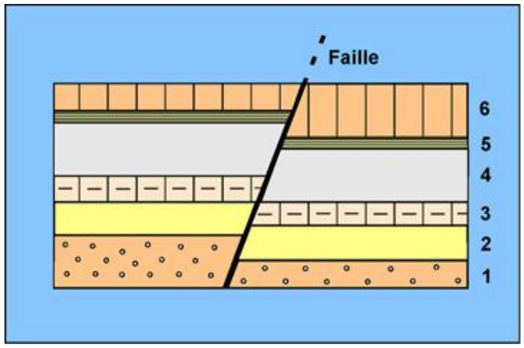


Figure 2: Principle of cutting: The fault is more recent than the layer 6 how re cuts.

Correlations

The basic principle used to compare litho logical successions observed in various areas is called “Principle of continuity”: On all its extent, the same bench has everywhere the same age, i.e. which it settled or formed in the same amount of time.

Age (Ma)	ERE	Système
	QUATERNAIRE	
2	CENOZOIQUE ou TERTIAIRE	Néogène
25		Paléogène
65	MESOZOIQUE ou SECONDAIRE	Crétacé
144		Jurassique
205		Trias
245	PALEOZOIQUE ou PRIMAIRE	Permien
290		Carbonifère
360		Dévonien
400		Silurien
425		Ordovicien
495		Cambrien
530	PRECAMBRIEN	Protérozoïque
2500		Archéen
3800		

Figure 3: Stratigraphical divisions of geological times.

The comparisons are based on litho logical nature or the fossil assemblies. Thanks to various groups: Foraminifera, ammonites, pollens…, one has been able to establish scales bio stratigraphical (successions of fossils or fossil groups that one always meets in the same order) and to cut out geological times in periods of variable duration: eras, systems, stages, zones (Fig.3).

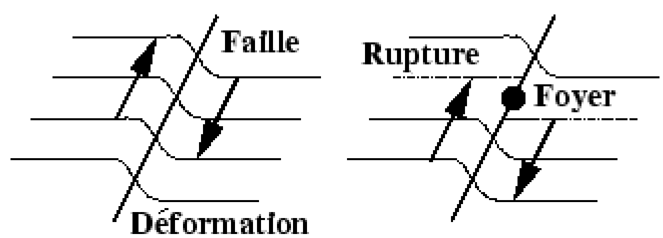
Earth internal structure: Seism

The seism or earthquake constitutes a geological phenomenon which from time immemorial terrorized the populations which live in certain zones of the sphere.

The origin of the earthquakes

When a rigid material is subjected to shear stresses, it initially will become deformed in an elastic way, then, when it reaches its elastic limit, it goes rupturer, by releasing in an instantaneous way all the energy which it accumulated during the elastic strain.

It is what occurs when the lithosphere is subjected to constraints. Under the effect of the constraints generally caused by the movement of the tectonic plates, the lithosphere accumulates energy. When in certain places, the elastic limit is reached, it occurs one or of the ruptures which result in faults. The energy abruptly released along these faults causes seism (earthquakes).



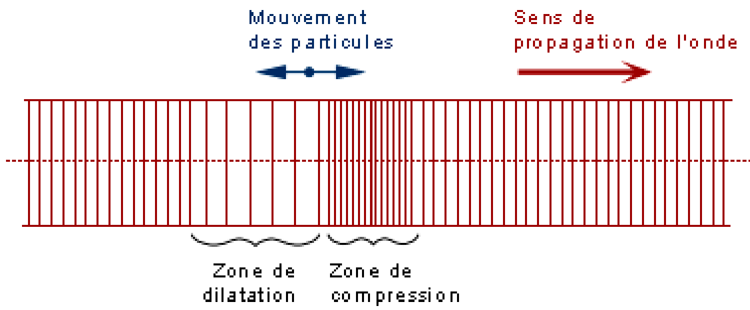
If the constraints continue in this same area, energy again will accumulate and the consequent rupture will be done in the already existing fault planes. Because of the forces of friction between the two walls of a fault, displacements along this fault are not done in a continuous and uniform way, but by successive blows, releasing each time a seism. In a given area, seism will occur on several occasions along the same fault, since the latter constitutes a plan of weakness in the lithosphere.

It should be noted that the seism occur only in rigid material. Consequently, the seism will always occur in the lithosphere, never in the asthenosphere which is plastic. When a seism is started, a wave front seismic is propagated in the earth's crust.

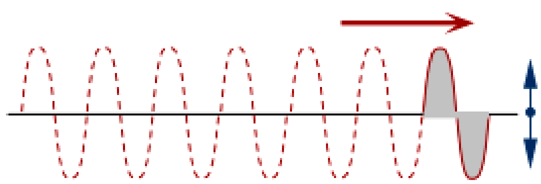
One names hearth the place in the fault plane where really the seism occurs, whereas the epicenter indicates the point on the terrestrial surface with the vertical of the hearth. One distinguishes two great types of waves emitted by a seism: the basic waves, those which are propagated inside the ground and which include/understand the waves S and the waves P, and the waves of surface, those which are only propagated surfaces some and which includes/understands the waves of Coils and of Rayleigh.

The waves P are compression waves comparable to the sound waves and which are propagated in all the states of the matter. The particles move according to a movement before back in the direction of the wave propagation. The waves S are waves of shearing which are propagated only in the solids. The particles oscillate in a vertical plan, with right angle compared to the direction of propagation wave. The waves of Coils or waves L are waves of shearing, like the waves S, but which oscillate in a horizontal plane. They print on the ground a side movement of vibration. The waves of Rayleigh are comparable to a wave; the particles of the ground move according to an ellipse, creating a true wave which affects the ground at the time of the great earthquakes.

Onde P (compression)

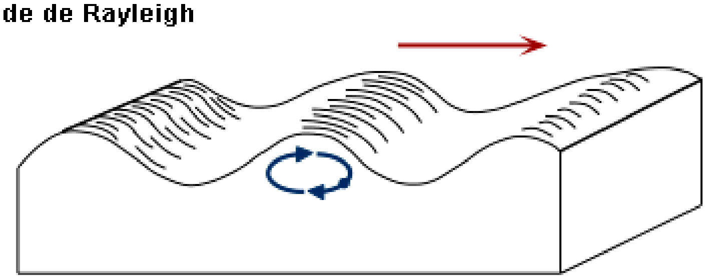


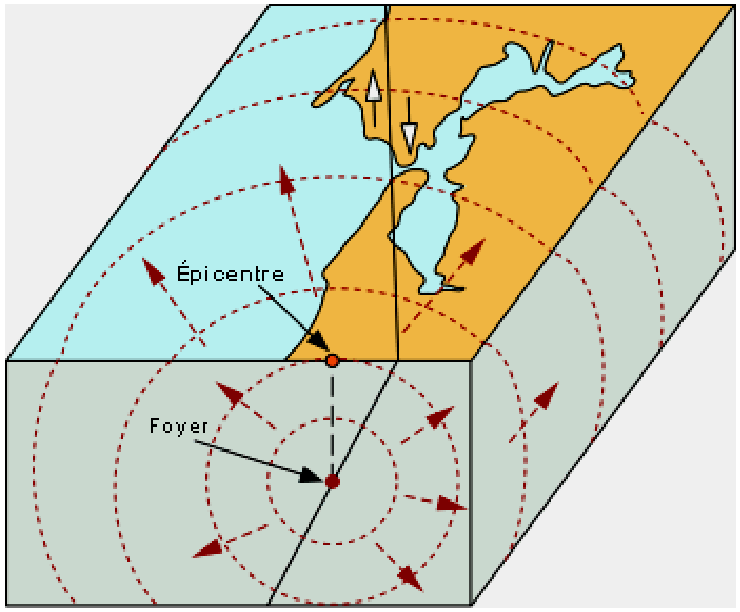
Onde S (cisaillement)



Onde L (de Love) (cisaillement)

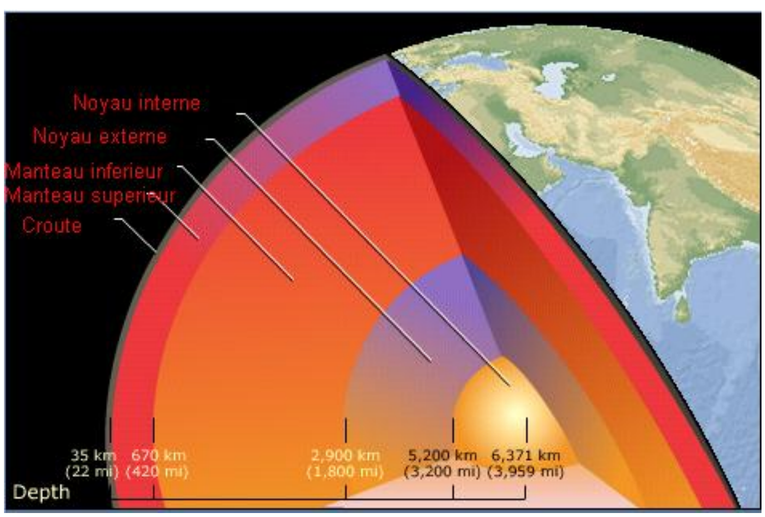
Onde de Rayleigh



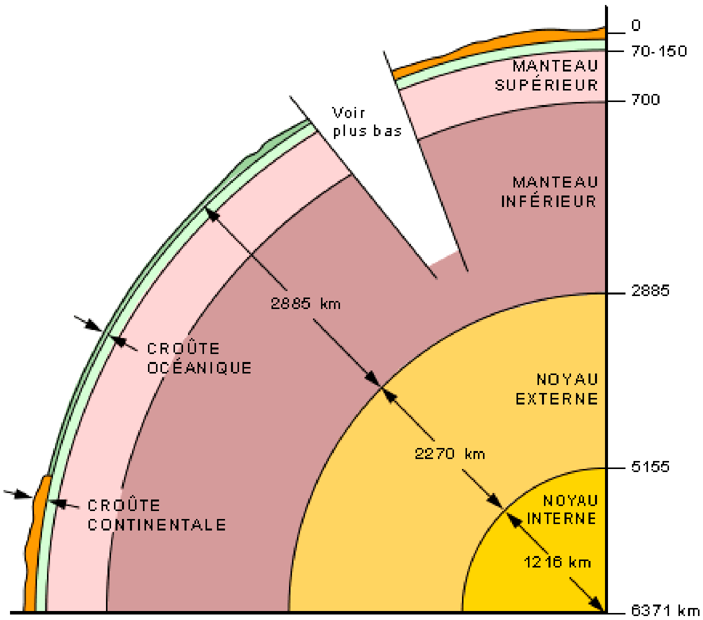


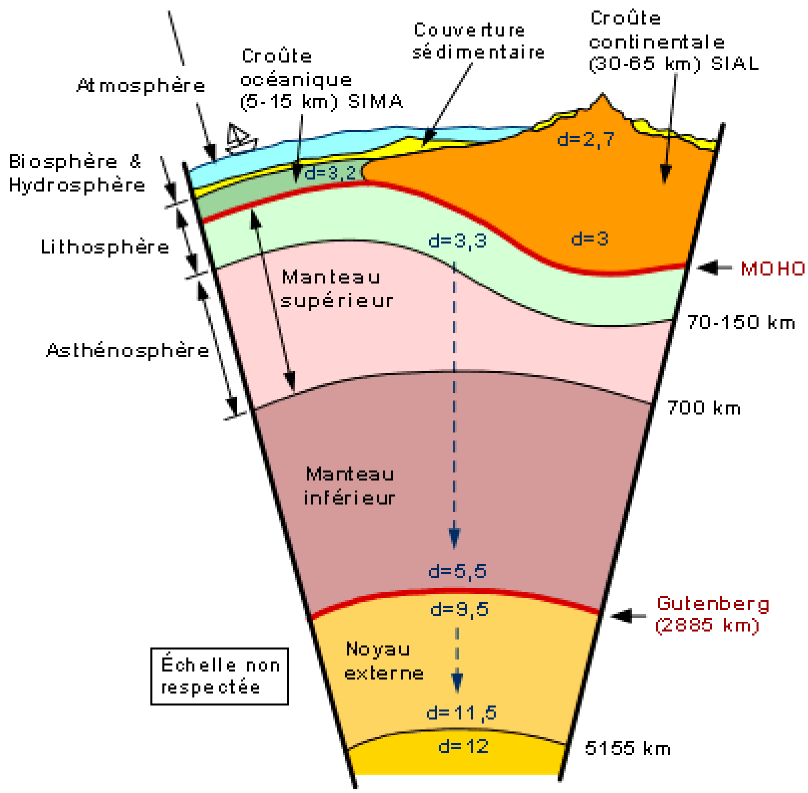
Interior of the Earth

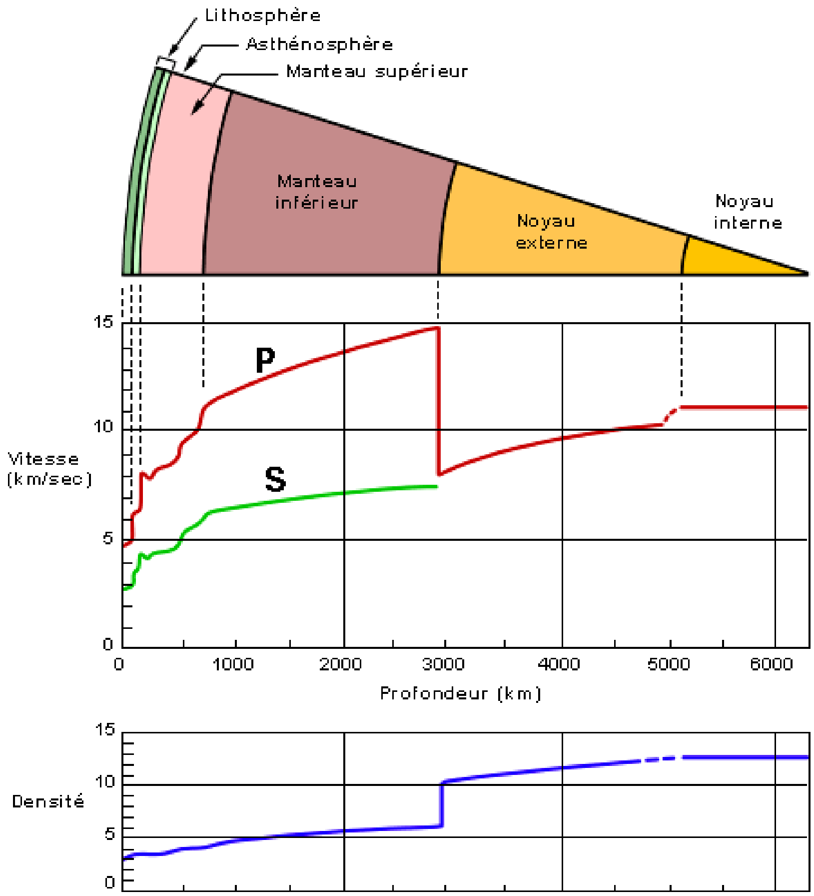
The interior of the Earth makes up of a succession of layers, physical properties different. In the center, the core, which forms 17% of the terrestrial volume, and which is divided into core interns solid and liquid external core; then the coat, which constitutes large terrestrial volume, 81%, and which is divided into solid lower coat and mainly plastic higher coat, but the completely higher part is solid; finally, the crust (or bark), which counts for less than 2% in volume and which is solid.



Two important discontinuities separate crust, coat and core: the discontinuity of Mohorovicie (Moho) which marks a contrast of density between the earth's crust and the coat, and the discontinuity of Gutenberg which marks also an important contrast of density between the coat and the core.


0
70-150
MANTEAU
SUPÉRIEUR
700
Voir
plus bas
MANTEAU
INFÉRIEUR
2885
2885 km
CROÛTE
OCÉANIQUE
NOYAU
EXTERNE
2270 km
5155
CROÛTE
CONTINENTALE
NOYAU
INTERNE
1216 km
6371 km


Atmosphère
Croûte
océanique
(5-15 km) SIMA
Couverture
sédimentaire
Croûte
continentale
(30-65 km) SIAL
d=2,7
Biosphère &
Hydrosphère
d=3,2
Lithosphère
d=3,3
d=3
MOHO
Manteau
supérieur
70-150 km
Asthénosphère
700 km
Manteau
inférieur
d=5,5
d=9,5
Gutenberg
(2885 km)
Échelle non
respectée
Noyau
externe
d=11,5
d=12
5155 km



The plastic layer of the higher coat is called asthenosphere, whereas together, the two solid layers which surmount it, is the solid layer of the upper part of the higher coat and the earth's crust, form the lithosphere. Two types of earth's crust are recognized: the oceanic crust, that which approximately is located under the oceans, and which is made of basaltic rocks of density 3,2 and that one names also SIMA (silicon magnesium); and the continental crust, that which is at the level of the continents, and which is thicker because of its more weak density (granites rocks with intermediaries of density 2,7 to 3) and that one names SIAL (silicon aluminum). The sedimentary cover is a thin film of sediments produced and redistributed on the surface of the crust by the various agents of erosion (water, wind, ice) and which counts for very little in volume.

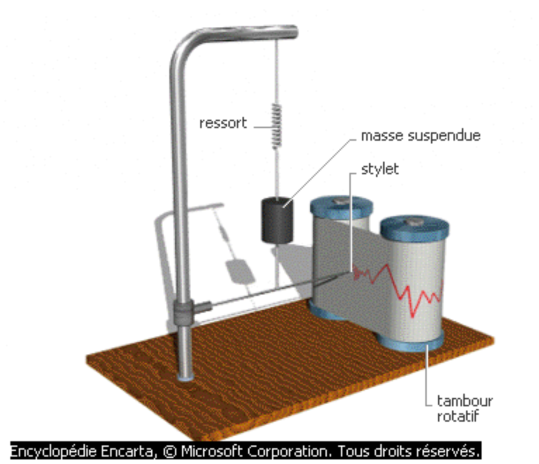
The interior of the Earth thus makes up of a certain number of superimposed layers, which are characterized by their solid state, liquid or plastic, like by their density. A kind of echo graph of the interior of the Earth was established starting from the behavior of the seismic waves at the time of the earthquakes. The seismologists Mohorovicie and Gutenberg succeeded in determining the state and the density of the layers by the study of the behavior of these seismic waves. The propagation velocity of the seismic waves is function of the state and the density of the matter. Certain types of waves are propagated as much in the liquids, the solids and gases, whereas other types are propagated only in the solids.

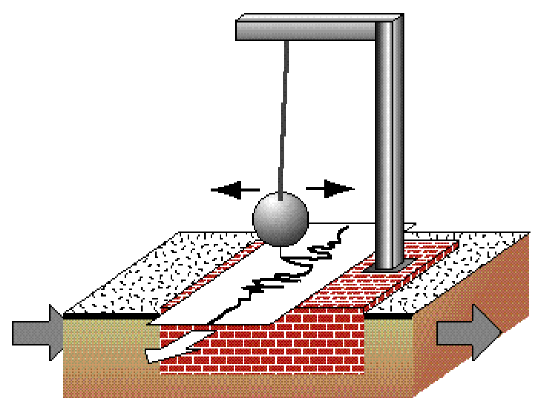
With earthquake striking on the surface of the earth, there is emission of waves in all the directions. There exist two great fields of propagations waves: waves of surface, those which are propagated on the surface of the sphere, in the earth's crust, and which cause all this damage associated with the earthquakes, and the basic waves, those which are propagated inside the ground and which can be recorded in several points of the sphere. At the basic waves, one recognizes two great types: waves of shearing or waves S, and compression waves or waves P.

How measure Earthquake?

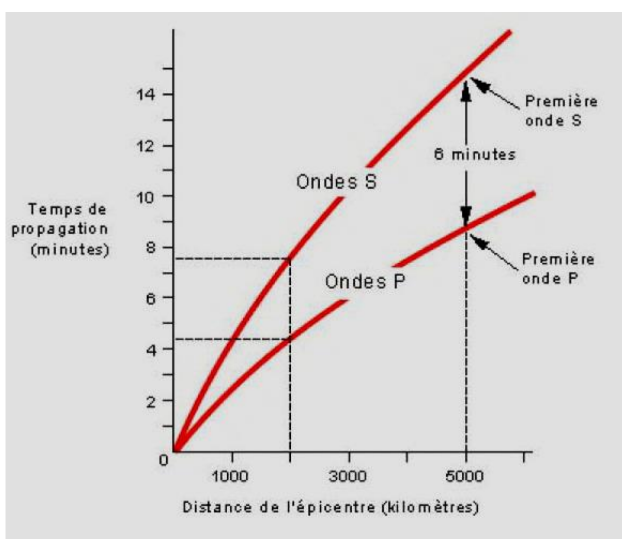
Localization of Earthquakes

The waves P are propagated more quickly than the waves S; it is this property which makes it possible to locate a seism. The seismic waves are recorded in several places of the sphere by apparatuses which one names seismographs.

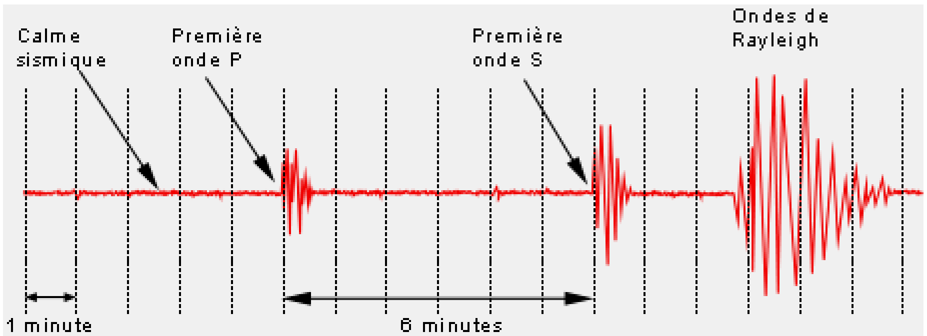




A seismograph: apparatus which records and measures the amplitude, the hour and the duration of the earthquakes. Approximately, it is about an apparatus able “to feel” the vibrations of the rock; these vibrations are transmitted to a needle which registers them on a cylinder which turns at a constant speed. One obtains a recording of the type of this one.



In a given place, as the waves P arrive in first, there will be on the seismographic recording a shift between the beginning of recording of the two types of waves; here for example, there is a delay of 6 minutes of the waves S compared to the P. waves propagation velocities of the two types of waves in the earth's crust were established and one has consequently calibrated curves, like this one.



Recording Graphic, produced by a seismograph.

This graph says to us, for example, that to cross a distance of 2000 kilometers, the wave P will spend 4,5 minutes, whereas the wave S spends 7,5 minutes to traverse the same distance; there is a 3 minutes shift. For a given seism, it is a question of finding to which distance on this graph the shift obtained on the seismographic recording corresponds; one then obtains the distance between the seism and the point of recording. In our example, the distance which corresponds to a shift of 6 minutes is of 5000 km. This does not give us however the place of the seism on the surface of the sphere. To know this point, we need at least three recordings.

In this example, let us consider the recordings of a seism in three points: Halifax, Vancouver and Miami. The recordings indicate that the seism is in a radius of 560 km of Halifax, a radius of 3900 km of Vancouver and a radius of 2500 km of Miami. One thus locates the seism at the point of intersection of the three circles that is to say with the Evil bay. In practice, one uses obviously more than three points.

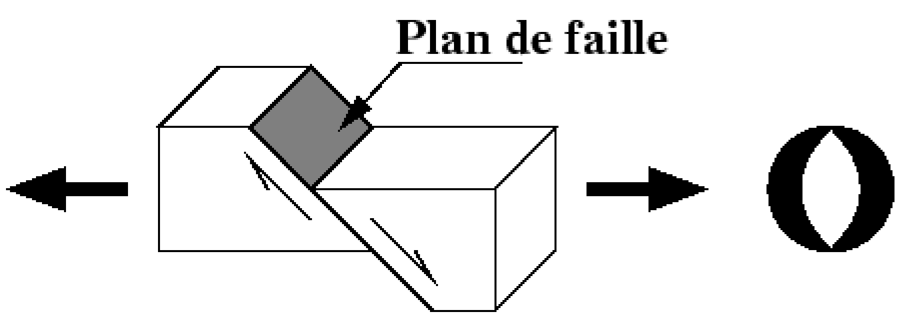
Seismic activity and plate tectonics

The homes are still located earthquakes in the brittle lithosphere. Their location on the Earth's surface is very uneven: large areas aseismic (absence of earthquakes) materialize the **lithospheric plates** and are separated by narrow strips in which is located almost all of the global seismicity. Earthquakes are almost always associated with **ridges,** the **trenches** and **mountain ranges.** The homes are divided more or less depth:

- Superficial earthquakes (up to 70 km deep) are located along the ridges and in the mountain,
- Intermediate earthquakes between 70 and 300 km deep,
- Deep earthquakes and up to 700 km in the trenches. They lie on an inclined plane, plan-Wadata Benioff, indicating the presence of a **subduction zone** where one lithospheric plate plunges into the mantle.

The study of **mechanisms in the home** helps to know what kind of movement to the origin of the earthquake and hence determine the relative movements of the plates. It lists the first movement, **compression** or **dilatation,** observed on all seismic stations on a sphere surrounding the fireplace, the projection of the sphere surface demarcate areas of compression and expansion zones, separated by the **fault plane** and the auxiliary plane, perpendicular to the previous one. On seismograms, if the first pick is up (resp. down), the first movement is a movement observed in compression (resp. expansion in), then associated to each type of fault, a mechanism in the home:

- **<u>The normal faults</u>** result from a movement stretching between the two blocs, they are in a context of **divergence**.



: Diagram of a normal fault and associated mechanism in the home

- **<u>Reverse faults</u>** result from a movement of compression between the two blocks and are located in contexts of **convergence**.

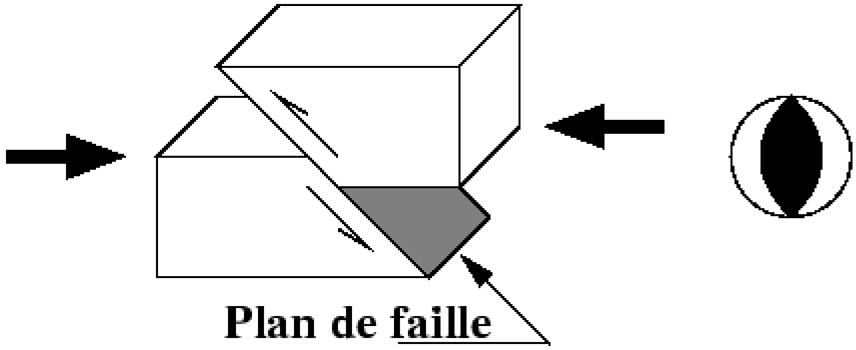


Figure 5: Diagram of a reverse fault mechanism in the home associated

- **faults** resulting **in** a **deflection** **(coulisse)** two blocks one over the other, the movement is horizontal. The deflection is dextral (resp. sinister) if for an observer on one of the two blocks, the relative movement of the other block is to the right (resp. left) (see fig. 6).

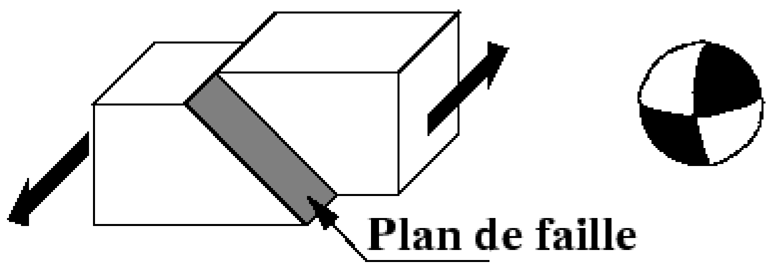


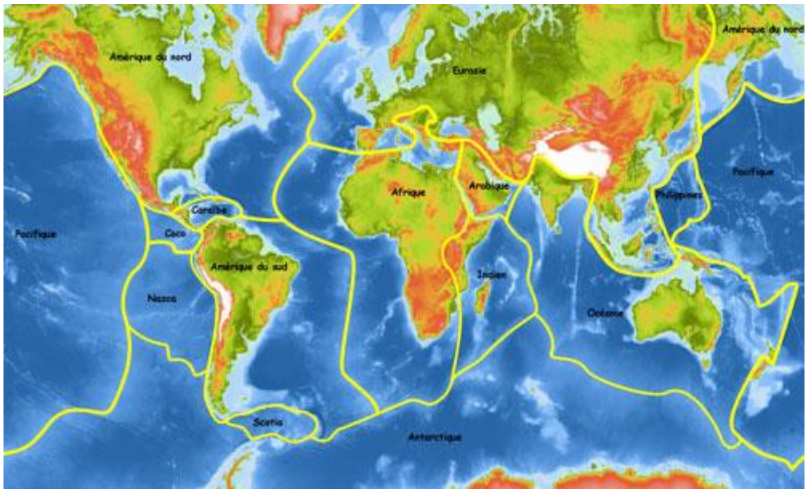
Figure 6: Diagram of a rift stalled and mechanism involved in the home

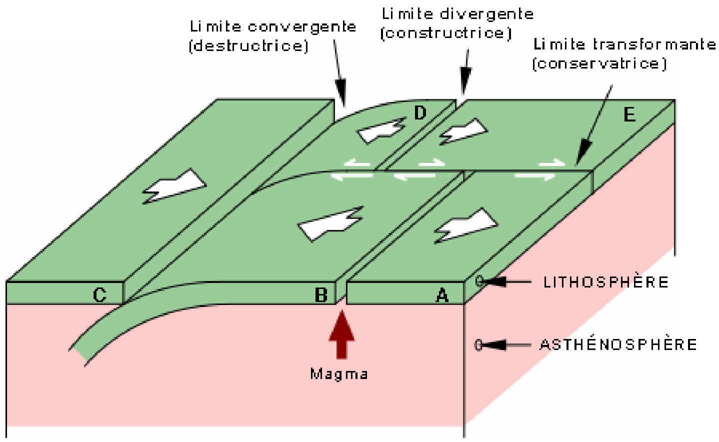
These mechanisms allow the home to determine three different behaviors at borders between patches: a **boundary divergent** at the level of **mid-ocean ridges** where the oceanic lithosphere created by melting of the mantle, a **convergent boundary** at **subduction zones** where oceanic lithosphere reintegrates the mantle, but also during the **collision** between two continental plates, and a **sliding boundary,** without production or destruction of materials at the level of **transform faults.** The relative movements of these plates are the order of a few centimeters per year and are the expression of surface movements that occur within the Earth. Our planet is a thermal machine that evacuates its internal heat (heat and primitive heat produced by the decay of radioactive elements) by thermal convection in the mantle and is the engine of plate tectonics.

The geographic distribution of volcanic activity is not random: with the exception of volcanic hot spots like all volcanoes are located at the oceanic ridges, and behind the trenches.

PLATE TECTONIC THEORY

Tectonics is that part of geology that studies the nature and causes of deformation of rock groups, specifically in this case, the deformations on a large scale, the Earth lithosphere. **Plate tectonics** is a unifying global scientific theory that proposes that the deformation of the lithosphere are related to internal forces of the earth and that these distortions result in the cutting of the lithosphere into a number of rigid plate (14) moving to each other by sliding on the asthenosphere.





These movements define three types of boundaries between plates:

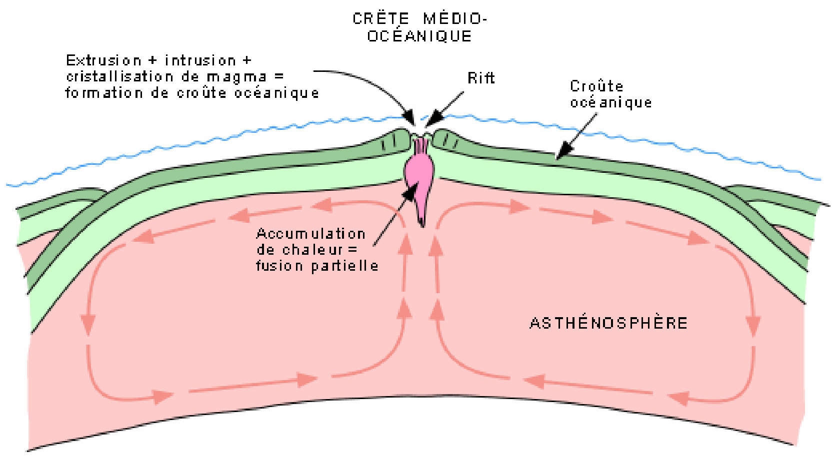
1) **Divergent** boundaries where plates move away from each other and where there is production of new oceanic crust, here between the plates A and B, and D E,

2) **Convergent** boundaries where plates collide, the result of divergence, here between plates B and C, and D and C,

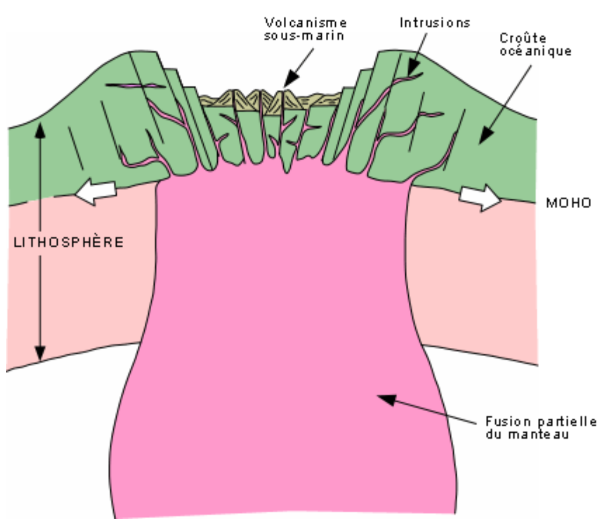
3) **Transforming** the border, where the plates slide laterally against each other along faults, such limits can accommodate differences in travel speeds in the plates to each other, as here between A and E, and between B and D, or even reverse the meaning of displacement, as here between plates B and E.

The divergent boundaries

We know there is a heat flow that goes from the center out of the earth, a flow caused by the radioactive decay of certain chemical elements in the mantle and creates convection cells in the plastic mantle (asthenosphere) . Due to this convection, the heat is concentrated in an area where the heated material expands, hence the uprising for the ocean ridge. The concentration of heat led to partial melting of the mantle that produces magma. Convection product in the rigid part of the envelope of the earth (lithosphere), the tension forces that cause two plates diverge and it is driving the belt, resulting in the oceanic lithosphere on both sides of the backbone. Between these two divergent plate, the arrival of magma creates new oceanic crust.



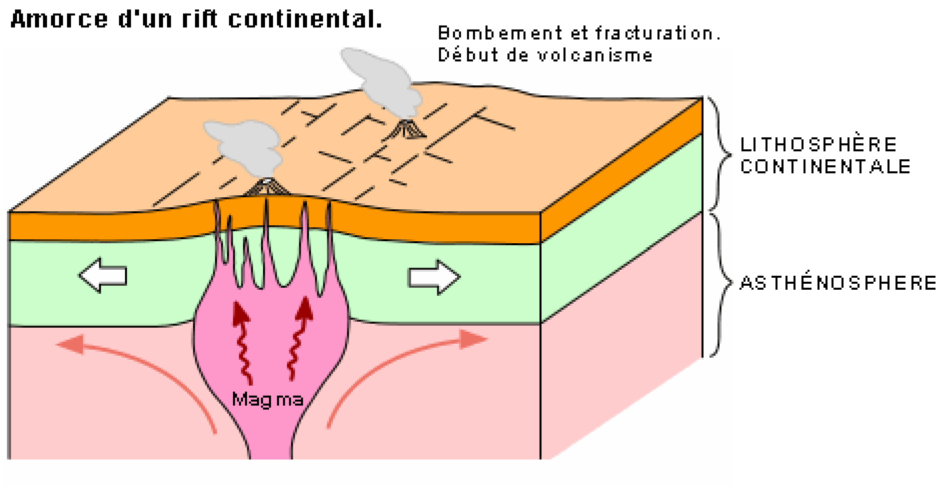
The following diagram is a close-up of the area of divergence.



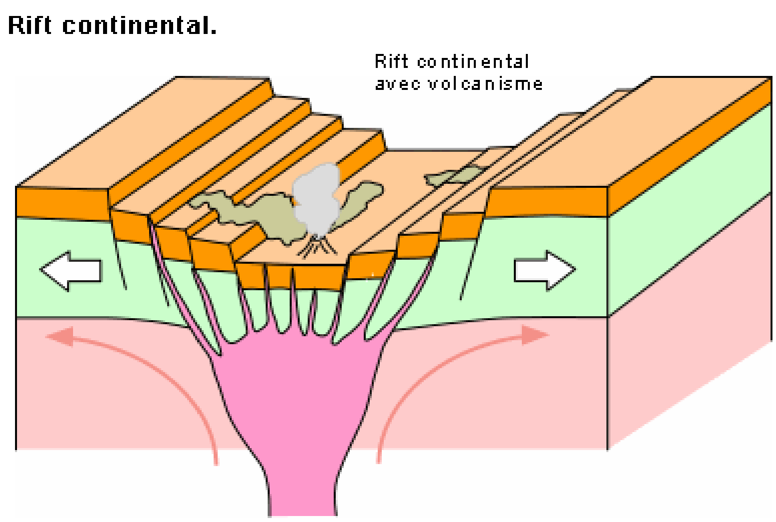
Spreading of the ocean floor created in the dorsal area, tensions that result in holes collapse and open fractures, which form in the middle of the ridge, a ditch is called a collapse oceanic rift. The magma produced by partial melting of mantle enters faults and fractures of the rift. Part of this magma crystallizes in the lithosphere, while another was expelled on the seafloor as lava and forms of undersea volcanoes. This magma crystallized to form the new oceanic crust as the spread of funds.

So as to be perpetually creates new oceanic lithosphere at the borders divergent, I e the mid-ocean ridges. It is these processes that explain how an ocean is formed as Atlantic.

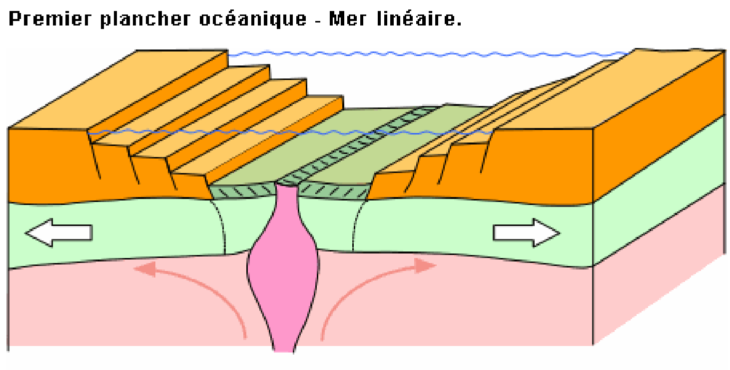
The diagrams below show the four stages of the formation of an ocean.



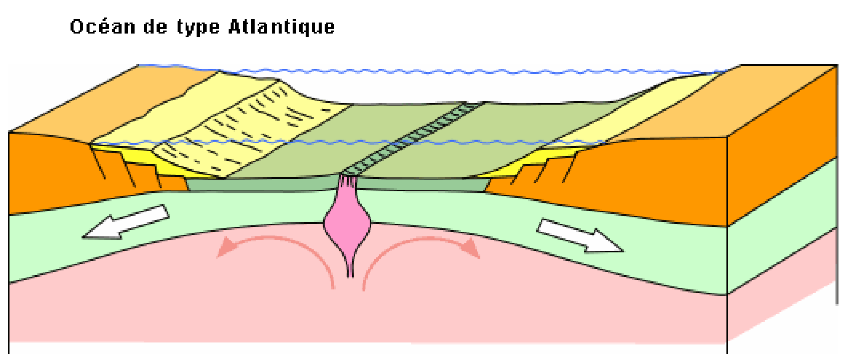
The accumulation of heat under a continental plate causes a dilation of the matter which led to a bulging of the lithosphere. It follows the tension forces that fracture the lithosphere and begin the movement of divergence driven by the combined effects of mantle convection and gravity. The magma will seep into cracks, which cause localized volcanic continental lava volcanoes form or pass along the cracks. An example of this first stage the precursor to the formation of an ocean is the Rio Grande valley in the USA.



The continuing tension produces a stretching of the lithosphere, it will then collapse step, resulting in a valley called a rift continental. Il y aura des volcans et des épanchements de laves le long des fractures. The Great African Rift in East Africa is a good example.



With further stretching, the rift is sinking under the sea level and sea water invaded the valley. Two pieces of continental lithosphere are separated and move gradually from one another. The submarine volcanism forms a first ocean floor basalt (oceanic crust) on both sides of a ridge of embryonic, but the stage Wednesday linear, such as the Red Sea.



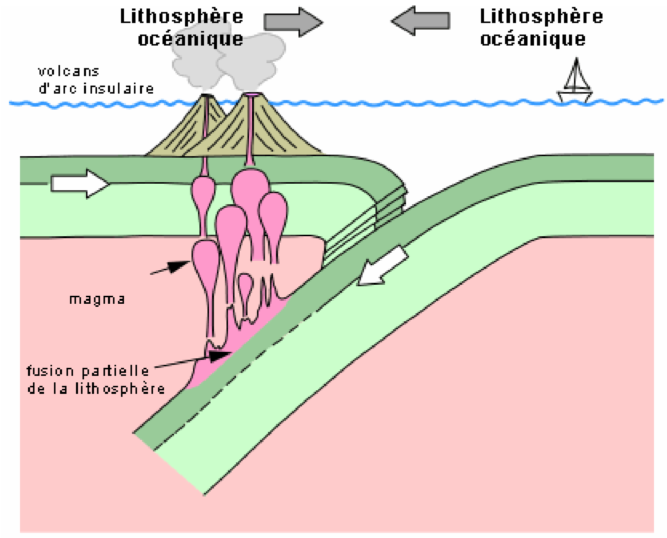
The enlargement of the sea by the linear spreading of the ocean floor leads to the formation of an ocean-type Atlantic, with its dorsal well individualized, abyssal plains and continental shelves for the margin of continental crust.

Oceanic ridges are important areas of dissipation of internal heat of the Earth.

The converging boundaries

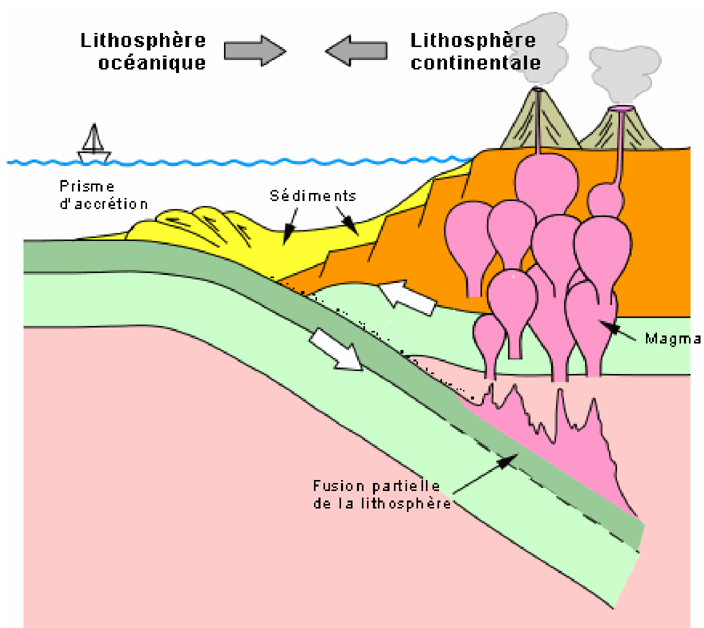
Today, physicists and astro-physicists are quite agreed that the earth is not expanding as proposed by Carey. If the surface of the earth is a finite space, the fact that the plates grow at the borders to be different means to destroy the lithosphere elsewhere to keep the Earth's surface. This destruction is border converging, as the name indicated, mark the contact between two lithospheric plates that converge toward one another. The destruction of plate is through the draft in the asthenosphere of a plate under the other plate, and the digestion portion of the plate inserted into the asthenosphere. The results (earthquakes, volcanoes, mountain ranges, deformations, differ depending on the plates (oceanic or continental) which come into collision.

A **first type of collision** results from the convergence between two oceanic plates. In this type of collision, one of the two plates (the most dense, usually the oldest) sinks below the other to form a subduction zone (literally: lead below).



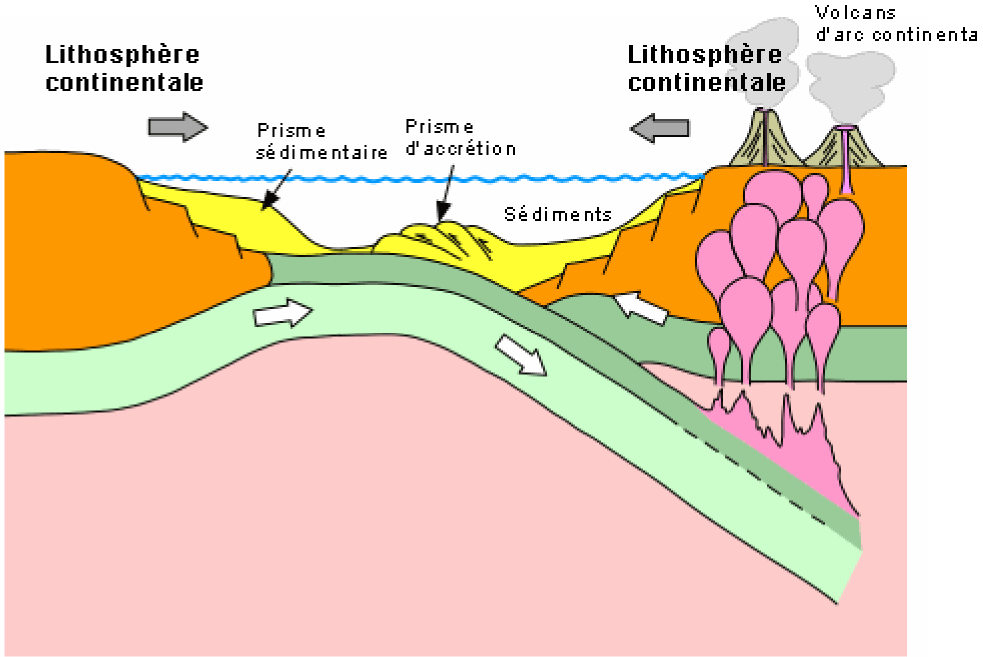
It pushes less dense material (d ~ 3.2) in the more dense material (d ~ 3.3), less hot material in equipment warmer. The asthenosphere "digests" gradually lithospheric plate. It is a phenomenon of partial melting of the plate swallowed. The fluid resulting magma, is less dense than the surrounding medium, rising to the surface. Much of this magma remains trapped in the lithosphere, but part is expelled to the surface, producing volcanoes in the form of a series of volcanic islands (island arc volcanic) on the ocean floor. Good examples of this are found in the Pacific West, with large pits Marianas, Tonga, the Kuril and Aleutian Islands, each with their volcanic island arc, and the pit of Puerto Rico who gave birth to the Antilles arc bordering the Caribbean Sea Atlantic.

A **second type of collision** is the result of convergence between an oceanic plate and a continental plate. In this type of collision, the denser oceanic plate sinks under the continental plate.



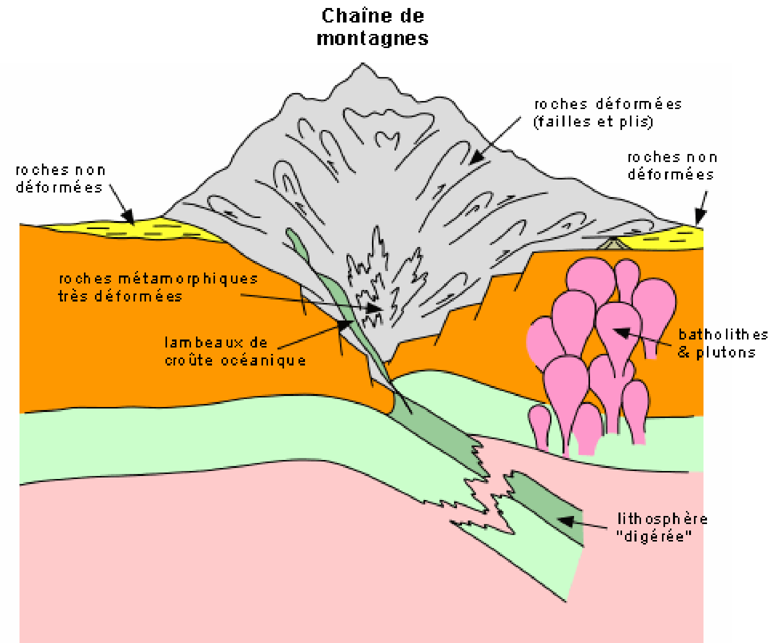
Basalts of the oceanic plate and sediments of the ocean floor sink into the material more dense. Placed at a depth exceeding 100 km, the plate is partially melted. As in the previous case, most of the magma will remain trapped in the lithosphere (by Continental), the magma to be able to make inroads to the surface will form a chain of volcanoes on the continents (continental volcanic arc). Good examples of this situation are at the margins of the East Pacific, as the volcanoes of the <u>Cascades Range</u> *(Cascade Range)* in the USA (including Mount St. Helens) result of the subduction in the pit of Juan de Fuca and those of <u>the Andes</u> in South America related to the pit of the Peru-Chile. In an advanced stage of the collision, the sedimentary material that is on the ocean floor and is transported by the conveyor belt just focus on the subduction zone to form an accretion prism.

A **third type of** convergence involves the **collision** of two continental plates. The ocean space closing as the approximation of two continental plates, the sedimentary material of the ocean floor, most abundant near the continents, and the accretion prism focus more and more, the lens grows.



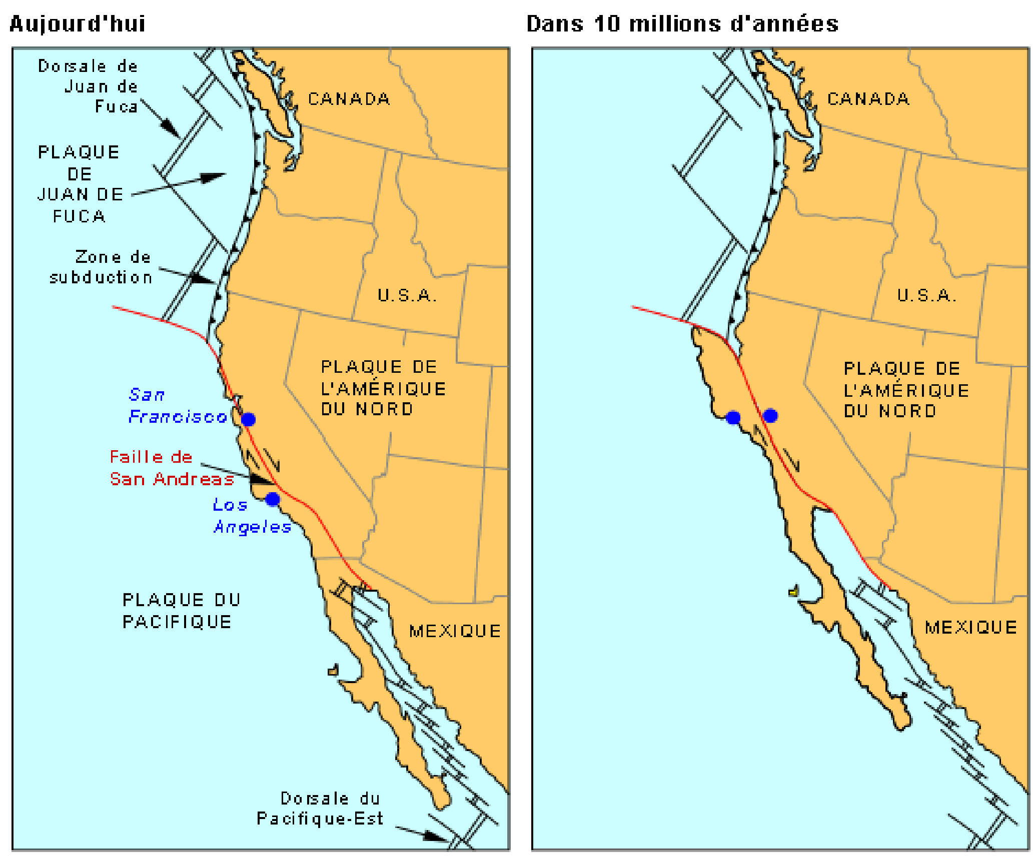
When two plates collide, the mechanism jammed the engine of the movement (convection in the upper mantle and severity) is not strong enough to push one of two plaques in the asthenosphere due to too low density of the continental lithosphere relative to that of the asthenosphere.

All the sedimentary material is compressed and rises to form a chain of mountains where the rocks are folded and faulted. Scraps of oceanic crust may be trapped in holes. This is the weld between two continental plates into one.



All major chains folded mountains were formed by this mechanism. A good recent example of this is the welding of India to the Asian continent, there are only a few million years, with the formation of <u>the Himalayas.</u>

Transform Boundaries



Transforming the boundaries correspond to major fractures that affect the entire thickness of the lithosphere and is used more often the term transform faults. They are mostly but not exclusively, in the oceanic lithosphere. These faults can accommodate differences in travel speeds, or even opposing movements between the plates, or make the link between the divergent and convergent boundaries (these faults transform movement between divergence and convergence, hence the name fault processors).

The famous San Andreas Fault in California is a good example of this is that it will relay the movement between the divergent boundary of the ridge-East Pacific, the convergent plate boundary Juan de Fuca-North America and the limit divergent the backbone of Juan de Fuca.

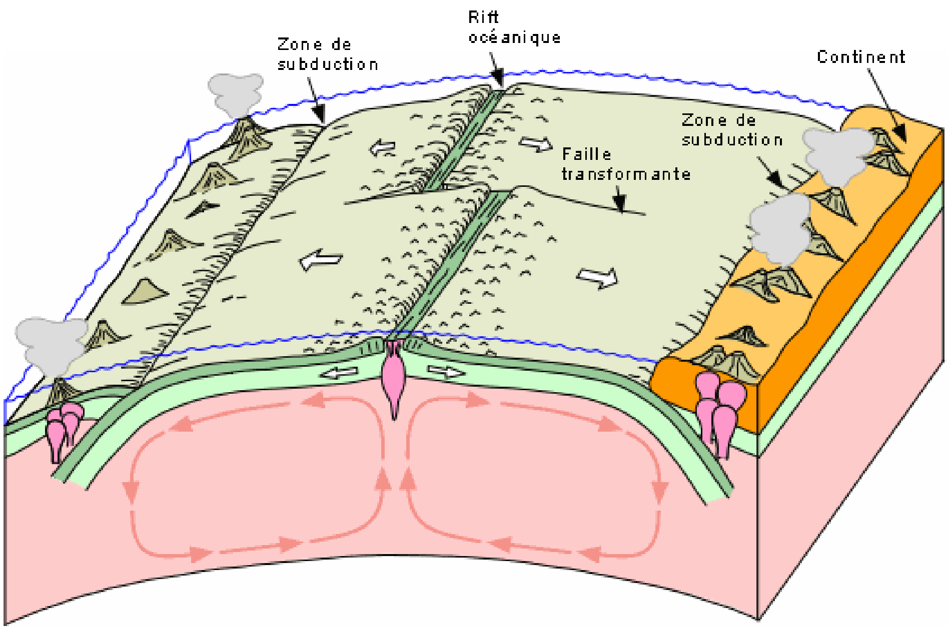
It affects both the oceanic lithosphere and continental lithosphere. It forms the boundary between three plates: plate of Juan de Fuca plate North American plate and the Pacific. It also has the disadvantage of crossing the city of San Francisco! At the current rate of displacement (~ 5.5 cm / year), the city of Los Angeles will be the right of San Francisco in 10 Ma

How fast are these movements of convergence and divergence?

The rate of divergence and convergence are not the same everywhere. The difference varies from 1.8 to 4.1 cm / year in the Atlantic and 7.7 to over 18 cm / year in the Pacific. Convergence occurs at a rate of 3.7 to 5.5 cm / year in the Pacific. Note the rate of lateral movement on along the San Andreas Fault in California (~ 5.5 cm / year).

In summary

The earth is a system where all the parts, all the elements, form a large machine driven by thermodynamics.



The engine is the combined action of gravity and large convective cells in the mantle resulting from the heat flow that goes from the center out of the ground, a heat flux which is related to the decomposition of radioactive elements in the mantle minerals. These cells concentrate the heat in their bottom part, which causes partial melting of mantle quite higher and expansion of materials. This expansion produces a mid-oceanic line *. The flow of the asthenosphere under the rigid lithosphere causes the latter, it results in tension in the back, causing the discrepancy and associated magmatic. Thus, there is continual training of new oceanic lithosphere at the ridge and progressive enlargement of the ocean. In return, since the earth is not growing, you must destroy the lithosphere, which is done by deflection of oceanic lithosphere in subduction zones that correspond to the deep ocean trenches of up to 11 km (Marianas Trench). The ridges are dissected by faults called transform to accommodate differences in rates of divergence.