*Some Fundamental Causes of the Earthquakes**

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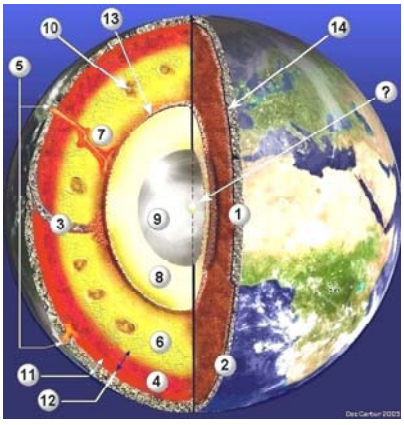
The earthquake is one of the biggest natural catastrophes which have killed thousands of people around the world. From 1994 to 2007, the earthquake killed more than 200,000 people world widely. Although it is considered as a hazard natural phenomenon, there exist some causes which lead to have an earthquake. In order to understand well about the causes of an earthquake, we start this article with some reviews of the internal structures of the earth and also the theory of plate tectonics.

Internal structures of the Earth

The internal structure of the Earth is simply divided into several envelopes successive of which the most important are the crust, the mantle and the core. The picture here represents the juxtaposition of different layers forming the earth.



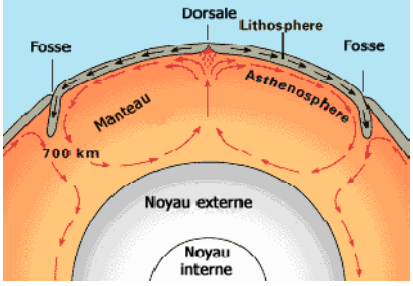
(1) The solid continental crust, thicker than the oceanic crust (30 km to 100 km in the mountains). The crust represents about 1.5% of the Earth's volume. (2) The solid oceanic crust, mainly composed of basaltic rocks, relatively thin (about 5 km). (3) Subduction zones where one plate slides under another at the depths of several hundred kilometers in the mantle. (4) The upper ductile mantle, primarily composed of mineral rock. (5) The eruptions on the areas of active volcanism. Two types of volcanic activity are represented in that picture; the deepest is called "hot spot". This would be the volcanoes of which the magma comes from the depths of the mantle which places near to the boundary mantle/liquid core. (6) The lower mantle whose the property is like an elastic solid which is less "rigid" than the other layers. That mantle represents 84% of the earth volume.

(7) The plume of warmer material, starting from the boundary of the core to the surface of the Earth. It produces the hot spot volcanism. (8) The extern liquid core consists mainly of iron (about 80%), nickel and some more lightweight elements. Its viscosity is close to that of water, the average temperature of 4000°C and a density value of 10. The flow of iron liquid can generate electrical currents that create to magnetic fields. The liquid core is therefore the source of the magnetic field. (9) The inner solid core, essentially metallic, consists of progressive crystallization of the extern core. The pressure maintained the core in a solid state even at a temperature above 5000°C and a density of about 13. Inner and extern core represent 15% of the Earth's Earth. (10) The mantle convection cells in which the material is in slow motion. The mantle is the place of the convection currents that transfer most of the heat energy from the Earth's core to the surface. (11) The lithosphere: it consists of the crust (tectonic plates) and a portion of the upper mantle. The inferior border of the lithosphere is at the depth of between 100 and 200 km, at the limit where peridotites approach their melting point. (12) The asthenosphere: the lower part of the upper mantle (below the lithosphere). (13) Gutenberg discontinuity: transition zone mantle/core. (14) Mohorovicic discontinuity: transition area of crust / mantle.

Plate tectonics theory

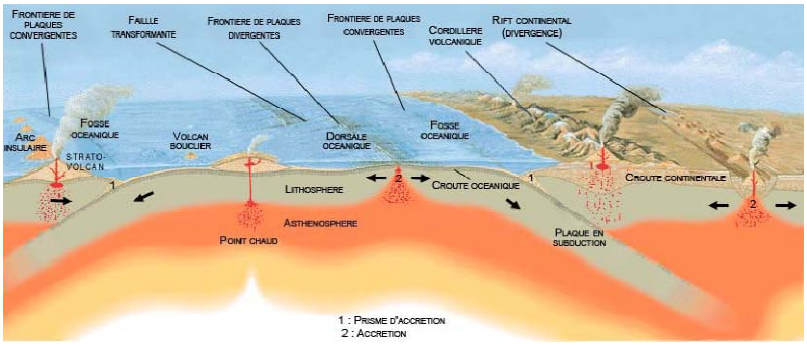
The theory of plate tectonics is introduced in the beginning of the years sixties and found its origin in the theory of continental drift proposed at the beginning of the century by the physicist-meteorologist Alfred Wegener, who tried to explain the similarity in the layout of the ribs on both sides of the Atlantic. In order to understand well the plate tectonics model proposed recently by the scientists, we examine the definitions of some words which are the lithospheric plates, the magma and the motion of the asthenospheric convection. (i) The fragments obtained by the breaking of the rigid and brittle lithosphere are called "lithospheric plates". According to geologists and geophysicists, seven major plates cover the Earth's surface. The motion of the convection in the asthenosphere makes these plates move with the speeds of a few centimeters per year. This phenomenon, commonly known as continental drift, drives the plates to the contact areas between them (relative movements of divergence, convergence or sliding).

(ii) Magma is the liquid that is formed by partial melting of the mantle (or rarely of the crust). This liquid, more or less rich in dissolved gases, can reach, at the depth, a temperature of 1300°C. (iii) The convection in the asthenosphere is due to the rise from the base of the mantle of hot materials which are less dense. Going back to the surface, they become cooler and become denser and then dive back into the depths to warm up again. These vortices brew throughout the asthenosphere at a very low speed (1cm/year).



It is now recognized that the tectonic plates are carried by the movements of the underlying asthenospheric mantle. One identifies three types of relative motion of the plates relative to each other: the divergence, convergence and sliding.

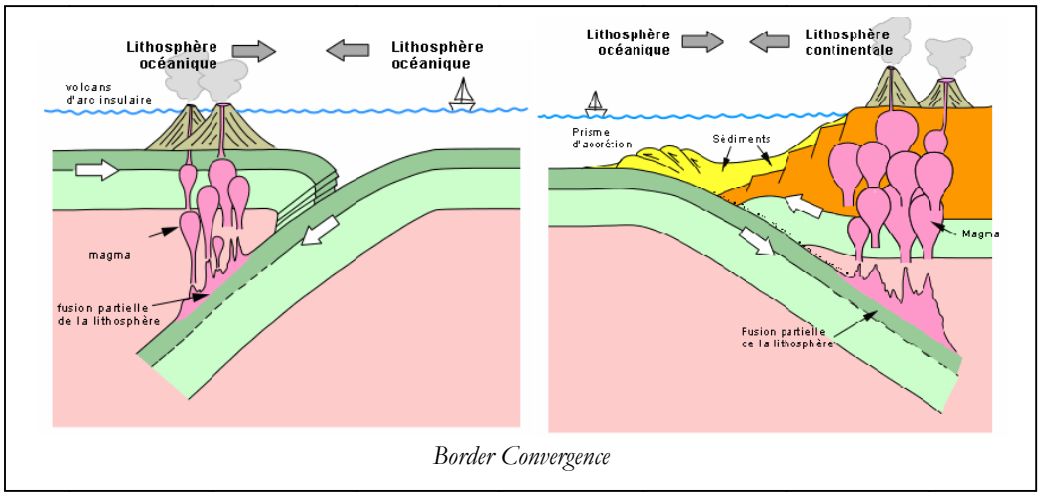
(*) Divergence: refers to a movement that two plates get away from each other. This principle is the basis for the creation of oceanic crust. The areas of divergence of plates are marked on the bottom of the ocean by ocean ridges, which are the most important volcanic systems on the Earth. They correspond to the rising of magma which hardens and form



The Oceanic Ridges, Areas of Divergence of Plates

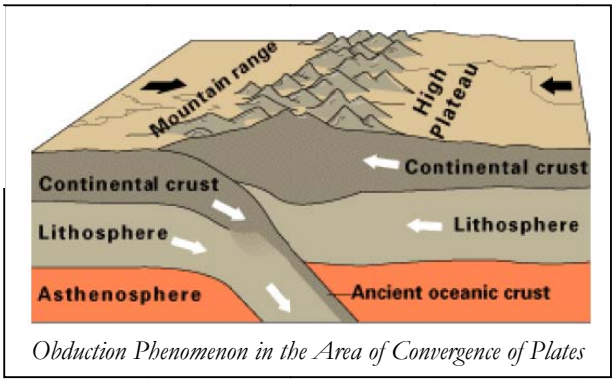
the oceanic crust when they reach the surface. The newly formed crust moves away from the ridge; it is called “Divergence”.

(**) Convergence: refers to a movement that two plates approach to each other, compensating the oceanic spreading (expansion) in the other areas of the globe. This is the main cause of the formation of the mountain ranges, the volcanism and the earthquakes. When two plates converge, the amount of material which disappears under mantle is equal to that formed at the ridges. There are three types of convergence: (1) *The subduction* occurs when denser plate dives under another with a lower density. This is usually created on the surface by the formation of a chain of volcanic mountains, such as the Andes.

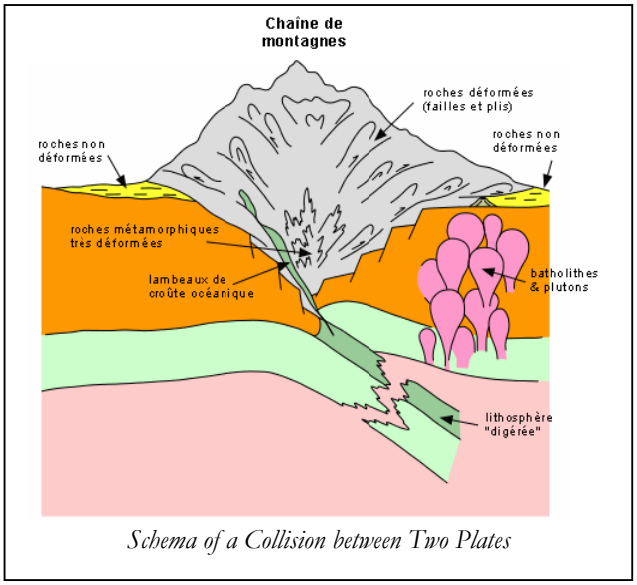


Border Convergence

(2) *The obduction* occurs where an oceanic lithosphere is transported on a continent. We don't know yet about the obduction which is currently active on the surface of the Earth.



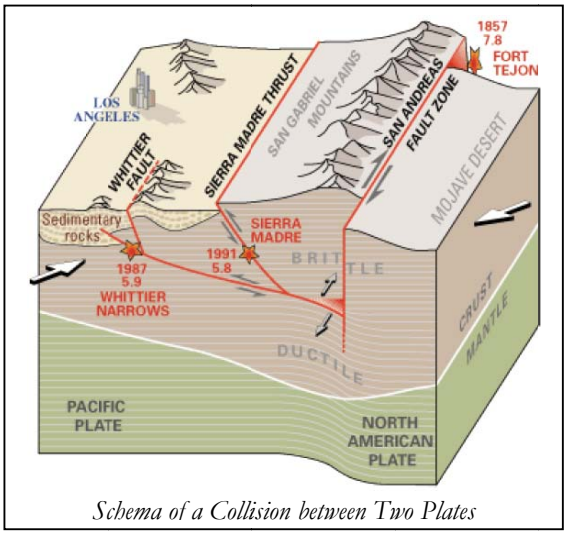
Obduction Phenomenon in the Area of Convergence of Plates



Schema of a Collision between Two Plates

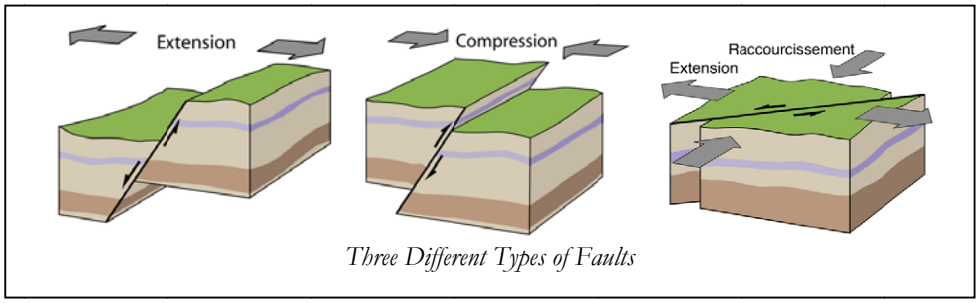
(3)*The collision* occurs where two plates confront. Unlike the two previous cases, this convergence does not lead to subduction, but a collision. The weakest plate puckers, where were born the mountains and the major fault systems. The collision of Indian plate with the Eurasian plate resulted in the formation of the Himalayas.

(***) The sliding: During the convergences and divergences, the movements are substantially perpendicular to the plate boundary along the fault plans. When this movement is mainly parallel to the border, the phenomenon is called sliding. As the convergence of two continental plates, the sliding results in a high seismicity and volcanism. Thus, the San Andreas Fault, which marks a sliding between the oceanic Pacific Plate and the North American continental plate, is responsible for many earthquakes affecting the region of San Francisco.



Schema of a Collision between Two Plates

These three types of interaction are associated with three main types of faults: the normal fault is divergent (extensive); the reverse fault is convergent (compressive) and the strike-slip fault is extensive (the axes of extension and compression are in the horizontal plane).



Three Different Types of Faults

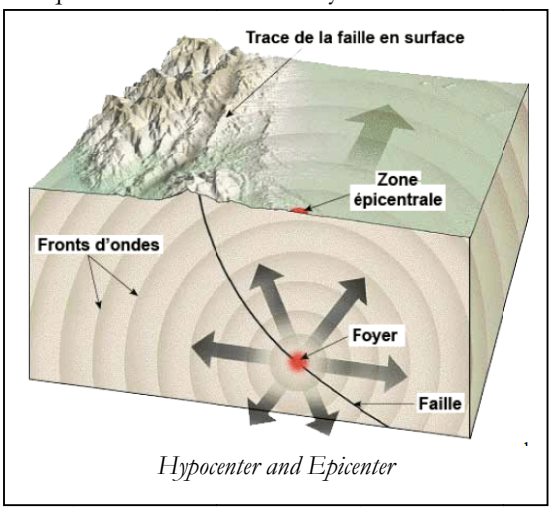
So what is the general definition of an earthquake?

An earthquake is the sudden release of energy in the Earth's crust, when the threshold of the mechanical rupture of rocks in depth is reached. This is the result of an accumulation of energy along the faults, the weakness areas of the crust which releases this energy. This accumulation phenomenon is cyclic and a direct result of the movement of the plates at the surface of the asthenosphere considered ductile. The earthquake generate, on the surface of the ground, the vibrations whose amplitudes can reach some centimeters or decimeters and the accelerations of several percents of the gravitational acceleration g, in the periods which can vary from a few seconds to several minutes.

To understand the process of an earthquake, the most recent explanation is provided by the theory of plate tectonics. Each plate has approximately a thickness of 80km, and moves horizontally with respect to the neighboring plates on the layer of ductile rock located at the mantle level. Since most of the earthquakes occur near the border of the plates, it can be concluded that the geological or tectonic forces that shape the landscape in mountains, rift valleys, mid-ocean ridges and ocean trenches are also the results of the great earthquakes. Thus, the elastic rebound was being given as the immediate cause of earthquakes. The rocks of the crust accumulate so much energy. During a fault, the elastic energy which is stored in the rocks is released to be the heat and to be the elastic waves. These waves create therefore an earthquake.

Ones can distinguish 4 types of earthquakes which are the tectonic earthquake, the earthquake caused by the volcanic activity, the collapse earthquake and the earthquake which is caused by the human activities.

Three important parameters of an earthquake are hypocenter, epicenter and seismic waves. The hypocenter is the point in the fault plan which is the origin zone of earthquake. The epicenter zone is the zone on the surface where the maximum effects are observed. Normally this zone is situated on the vertical of the hypocenter. About the seismic waves, they are the elastic waves which cross the medium of the soil. Two types of seismic waves are distinguished following their properties. The first one is called "volume wave", those who cross the soil medium, and the second one is called "surface wave", those who propagate on the surface of the soil. (…)



Hypocenter and Epicenter