What is Geophysics?

Geophysics is a science that derives from geology and deals with the study of the physical properties of the Earth. It Includes aspects such as the research of the internal composition of the planet, the heat flow from the inside of the Earth, the force of gravity that forms the gravitational field, the attraction magnetic force exerted by an ideal magnet inside the Earth creates the geomagnetic field, and propagation of seismic waves through the rocks of earth's crust.

It helps to an appropriate location for civil works and the prevention of natural disasters; it also optimizes the process of exploration and extraction of minerals, water and energy.

Through the register of different types of seismic waves (indirect method of geophysics), has been possible to define the internal composition of the Earth, dividing it in layers with thickness and contents specifications, without necessarily being in sight of human being.

Nowadays, the most accepted theory establishes that when the Earth began its evolution –about 4,700 million years ago-, its initial temperature was 1,000° C; that temperature began to increase inward due to energy derived from radioactive minerals that as a result of their weight sank toward the center of the planet. The surface then started to cool with the help of external meteoric agents.

By increasing the internal temperature and reaching the melting point of iron and other minerals is how it begins the planet differentiation into layers of different density and therefore other mineral content, staying in the center of the planet most of the heavy minerals and to the outside most of the lighter minerals; thus is accomplished to differentiate layers of the planet in the inner core, outer core, lower mantle, asthenosphere or upper mantle, lithosphere and within this, a thin outer shell called earth crust inhabited by living beings that constitute the biosphere.

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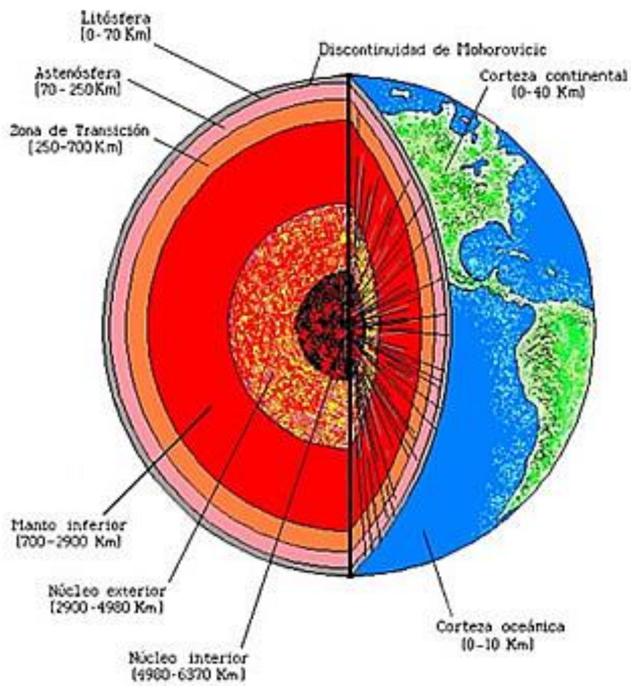

Planet layers

Heat flux is energy in transit and flows from high temperature regions inside the Earth towards low temperature regions located on the surface of the planet, creating convection currents in the molten rock (magma), which in some cases are manifested by creating volcanic areas. When they occur in aperture areas in the sea, oceanic ridges or middle oceanic are formed.

Geothermal energy and its application

Geophysics rests in other branches such as geothermal: science related to the study of the internal heat from the Earth and it is used in the location of natural hot water reservoirs.

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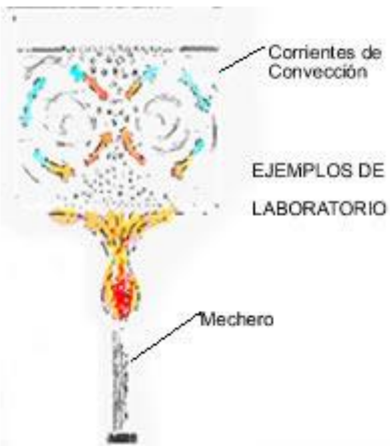
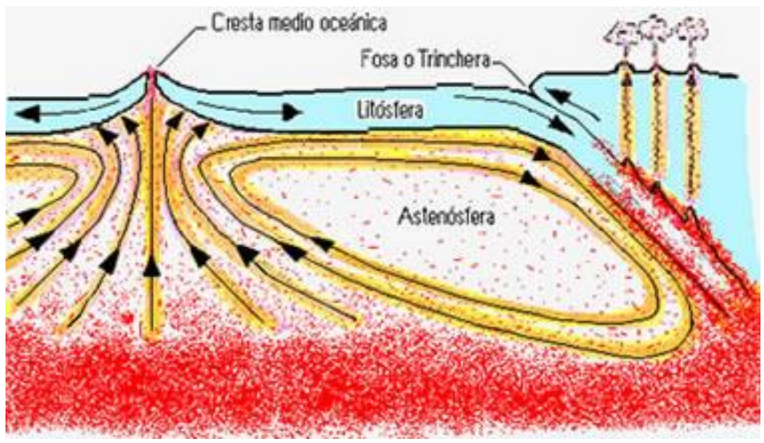
Geothermal energy is manifested as a vibration of atoms whose intensity determines the temperature and reaches the surface by diffusion, by convective movements and by water circulation in the deep. This energy has its origin in the initial temperature of the planet; the second source is radioactivity derived from elements such as thorium, uranium and potassium - which are the minerals in rocks-, and as a third source, the gravity force into thermal energy during the compression process and the planet differentiation.



Laboratory Examples



Heat flow in the interior of the earth

Its use is intended for the generation of electricity as steam produced by the natural hot geothermal fluids, is an alternative to that obtained in power plants by burning fossil material or by nuclear fission.

Modern drilling in geothermal systems reaches water reserves and steam heated by deep magmas, which are up to 3,000 meters below sea level. The vapor is purified in the wellhead before being transported in large pipes and isolated to the turbines. Thermal energy can also be obtained from any cleft and geyser.

Gravitational and magnetic fields

Earth is influenced by two fields of internal origin, affecting all the processes occurring on the surface of the planet, these are:

- *Gravitational field*: is that in which any body attracts others through their gravitational interaction fields, being possible to calculate the gravity effects such as: the acceleration of a falling object, the orbits of planets, the trajectory of a thrown object or an aerial vehicle.

  The gravity local value (G) corresponds to the period –of a full swing time – of a rotating pendulum or, the acceleration of a falling weight.

- *The magnetic field or geomagnetic*: is based on the magnetic properties of iron ore called magnetite, also known as "loaded stone" from which the Chinese invented the first magnetic compass that consisted on a rope suspended from a piece of this mineral.

  This field is described as a model of a small but powerful permanent magnetic bar, located near the center of the Earth and inclined about 11° from the geographic axis; the force lines of the magnetic field indicate the presence of a magnetic force at every point in space.

  The field has intensity and direction; its strength depends on the amount of magnetic material, the distance and direction to the detector. A magnetized needle, free to rotate on a pivot in a horizontal plane will rotate to a parallel position to the local power line, approximately north-south direction, denominating the end pointing to the geographic North, magnetic north pole and will be slightly off to the East or to the West of the geographic North Pole, depending on the location of the observer. This deviation angle of the geographic North is called declination.

Measurement and exploration

Exploration of "potential fields" refers to the work done by magnetic and gravimetric procedures; both are used by specialists to understand and to interpret the behavior of the earth's surface by magnetic susceptibility and rock density. These geophysical methods correspond to indirect tools that help to locate structural features, as faults, fractures, certain rock types and geologic basement. They are also useful in the search for mineral deposits, hydrocarbons and aquifers.

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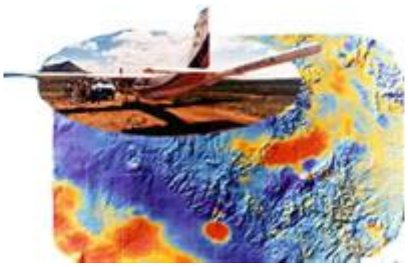
Geophysicists' measure magnetic intensity with a tool called a magnetometer, accurate to 0.1 nT. The measure unit of magnetic field strength is nanotesla (nT), and differs according to the region of the globe, for example, ranges from 25,000 nT in the equator to 70,000 nT at the poles. A nanotesla equals 1 gamma, and 105 gammas equals to 1 oersted.

The magnetometer measures all the effects of earth's magnetic field and slow changes are updated every five years by the International Geomagnetic Reference Field (IGRF), so that data is associated to the organism.

First magnetometry studies are performed with aerial scan (aeromagnetometry), later in specific areas terrestrial magnetic scanning is performed, focused on accurate localization of ferriferous mineral deposits or any metallic deposit, containing magnetic minerals (magnetite, pyrrhotite).



Geophysics

To aeromagnetic exploration and perform of magnetic mapping works, the Mexican Geological Survey (SGM) has three Islander planes. The aircraft is adapted with a magnetic sensor which measures the intensity of the magnetic field, except its direction. This one requires flying continuously in one direction, at the same height and at a constant separation.

SGM, executes two types of flights, on a regional scale (1:250,000), N-S direction, at a constant height above ground level to 300 m and a line spacing of 1000 m; flights direction E-W every 10,000m, as a support to obtain a more accurate magnetic information. Flights of high resolution (1:50,000 scale), where the magnetometer is made, besides radiometry (gamma rays) are performed at a constant height of 120 m above ground level and line spacing every 300 m.

It is noteworthy that flights over the Mexican highlands are made by plane and are highly dangerous. For areas of canyons in the mountains of Mexico it is necessary to adapt the magnetometer in a helicopter, decreasing the risk.

Investment in the application of these methods is apparently expensive, but in the end it turns out to be cheap for being very prompt investigations that cover large areas of land. Successful results may be obtained along with other indirect methods and under the full knowledge of the geological context.

Magnetic field variations

To study the magnetic properties of the rocks, geophysics is based on the discipline called paleomagnetism, also used to show the movement of masses of rock through geologic time. For example, this type of analysis has shown that the North and South Poles have been reversed over the geological years.

Through geologic time, both direction and intensity have been observed with variations in the magnetic field of the Earth. Just like all dipole magnets, the Earth has a magnetic field (core or main field) corresponding to the North and South Poles, therefore the angle between a compass and the true North is called the magnetic declination.

The magnetic field is affected by short variations due to magnetic storms. Even when the strength of earth's magnetic field is not so high, it is able to magnetize some kinds of rocks that contain iron or some other magnetic levels.

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The difference between the measured magnetic values and the model of earth core values are known as "magnetic anomalies", mainly caused by variations in the magnetization of crustal rocks and due to the dipolar nature of the phenomenon, they can be positive or negative.

Most sedimentary rocks are nonmagnetic, igneous rocks rich in iron ores have high magnetic susceptibility or high magnetism (property that describes the amount of magnetic material in a lithological unit).

Rocks have magnetic minerals with two kinds of magnetization:

- Induced: refers to the presence of an external magnetic field.
- Remnant: this is trapped inside the rock.

Graphical representation

The graphical representation of the magnetic data measured, is performed in magnetic anomaly maps and can be represented in countless ways. SGM has the following representations:

- Magnetic map of total field with color outline, embossed in color, and embossed in gray. Magnetic map of total field reduced to the pole with color outline presentations, embossed in color or gray.

- Magnetic map of the 1st vertical derivative from the total field reduced to the pole in color outline presentations, embossed in color or gray.

- Digital terrain elevation model (DEM), with total field magnetometer coverage, reduced to the pole, and 1st vertical derivative.

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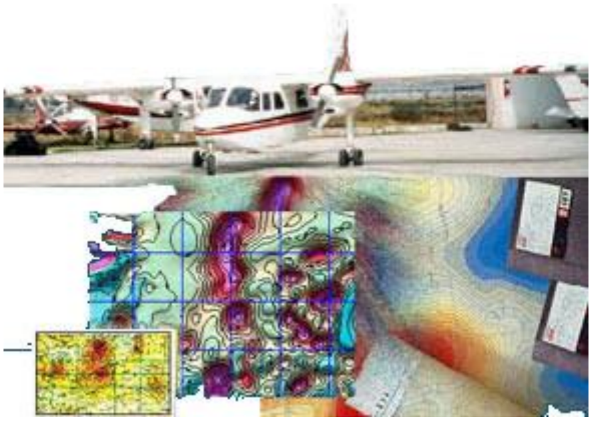

Magnetic chart printed

The scales for regional or low resolution are 1:50,000 and 1:250,000and for high resolution (including radiometry) 1:50,000 and 1:20,000.

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