TOPIC: STRUCTURE AND COMPOSITION OF THE EARTH

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   - 1.2 The mines
   - 1.3 Geological surveys
2. Indirect methods: geophysical prospecting.
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3.Models of the internal structure of the Earth.
   - 3.1. Geochemical model of the structure of the Earth.
   - 3.2. Geodynamic model of the structure of the Earth.

GEODESY: part of the geology that studies the origin of the Earth, its layered structure and the materials from which it is formed.

-Antiquity: the interior is equal to the surface.

-18th century: for the count of BUFFON the interior is homogeneous and glassy.

-19th century: debate between "solidists" for whom the interior is solid and cold and the "fluidists" who considered the interior to be hot and liquid.

1. DIRECT METHODS FOR THE STUDY OF THE INTERIOR OF THE EARTH.

The structure and composition of the Earth can be studied through study methods that can be direct and indirect.

Direct methods are based on the direct collection of materials for further study. They can be by:

- collection of samples in geological exploration,
- the mines
- the polls

With them we can only explore the most superficial part of the Earth

1.1. GEOLOGICAL EXPLORATION

Samples are taken on the surface and outcrops (slopes, volcanoes) of rocks and minerals and analyzed in the laboratory. From this we obtain information from:

Type of material, layout, structure, age ...

Then geological maps are produced where this information is reflected.

1.2. THE MINES

-They are excavations in the subsoil.

-Types: underground (wells and galleries) or open pit.

-Up to 3 km deep.

1.3. THE GEOLOGICAL SURVEYS

-A survey is a drilling of the ground.

-By opening very small holes (60 cm).

-Using augers or probes (percussion or crown rotary).

-Obtaining a column of materials called witness of up to 12.5 km.

2. INDIRECT METHODS FOR THE STUDY OF THE EARTH: THE GEOPHYSICAL PROSPECTION

Direct methods do not allow us to know the interior of the Earth, for it we must use indirect methods such as:

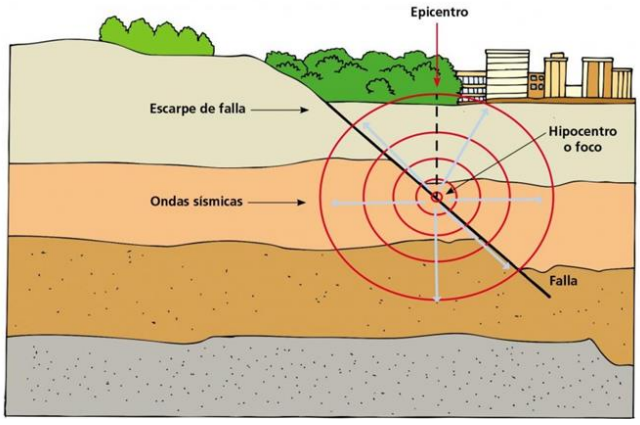
- the seismic method,

- gravimetric, magnetic, electrical and geothermal methods,

- the study of asteroids and meteorites,

2.1. Seismic method

They are based on the study of waves released in earthquakes or controlled explosions.



THE SIX:

Earthquakes or earthquakes are the vibration of the Earth by a rapid release of energy.

THEY ARE PRODUCED: generally due to breakage of the rocks causing failures or rock displacements on a plane of pre-existing fault.

ELEMENTS: - Hypocenter or focus.

- Epicenter: surface point on the hypocenter
- Seismic waves: they originate in the hypocenter and are transmitted to all directions.

MECHANISM: They originate as a result of forces acting on the rocks. These forces can be so powerful that they deform the rocks, but if they persist they can cause them to break into blocks that move between them. The break releases the accumulated energy and causes a vibration movement that ends when the deformed rocks return to their starting position, the "elastic rebound" according to Reid. These vibrations are the earthquake and energy propagates in the form of seismic waves.

The break begins at one point and extends throughout a fault plane. It is the focus or hypocenter. From it split seismic waves in all directions.

Before the main earthquake there are usually small shocks, precursor earthquakes. The adjustments that follow the main earthquake often generate shorter earthquakes called replica earthquakes. In both cases their hypocenters are also located in the same fault plane,.

DETECTION: seismic waves are detected with seismographs in seismological observatories and recorded in graphs called seismograms.

The IMPORTANCE of an earthquake depends on:

-MAGNITUDE: is the amount of energy released and is measured with the "Richter Scale" (it is logarithmic, each degree is 30 times lower than the next).

-INTENSITY: it indicates the superficial effects, that is to say the devastation and damages produced. The most used is the "Modified Mercalli Scale"

B) THE SEISMIC WAVES:

The energy released in a seism is transmitted in the form of seismic waves.

They are transmitted in all directions.

When moving from one medium to another with different stiffness: they are reflected, refracted, changed speed or diffracted. This allows us to study the interior structure of the Earth. There are three types of waves.

PRIMARY OR WAVES P:

-They are the first to be detected.

-The vibration occurs in the same direction of propagation.

-They are compression and decompression waves.

SECONDARY OR WAVES S:

-They are the second to be detected.

-The vibration occurs perpendicular to the direction of propagation.

-Its speed is less than that of the P waves.

-They are not transmitted in liquids.

SURFACES:

-Generated when the previous ones reach the surface. They are formed from the epicenter

-They are only transmitted by the earth's surface. They have no interest for the study of the interior of the Earth.

-They are the cause of seismic disasters.

C. GRAPHICS OF THE SEISMIC WAVES:

DATA TO TAKE INTO ACCOUNT:

- Speed increases with increasing density / stiffness ⇒ DISCONTINUITIES
- S waves do not travel by liquid means.

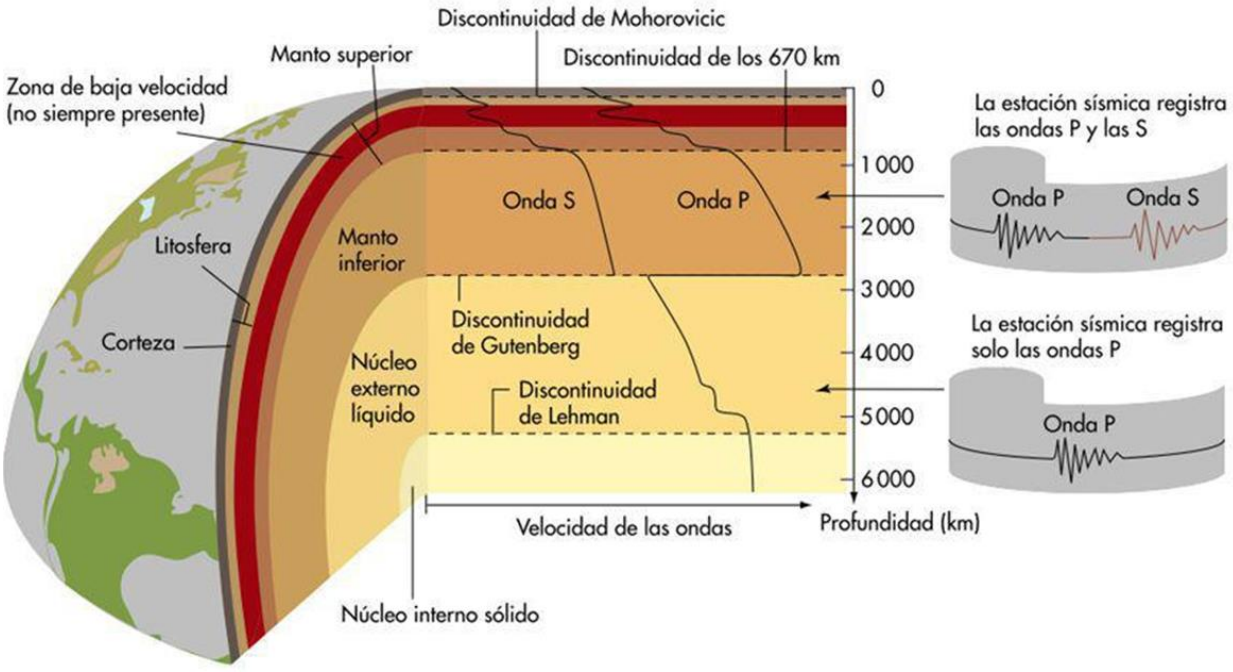
GRAPHICS: speed / depth, Sudden changes produce jumps in the graph that are called discontinuities. Discontinuities indicate changes in the composition of the Earth.

DATA: 30-70 km Mohorovicic discontinuity ⇒ Bark-Mantle.

. 670-1,000 km separation upper and lower mantle

. 2,900 km Gutenberg discontinuity ⇒ Mantle-External core.

.5,000 km According to Jeffrys .... Wiechert-Lehman discontinuity ⇒ External-internal core



c) Due to the different density of the subsoil materials.

MEASUREMENT OF g: gravimeters are used.

GRAVIMETRIC ANOMALIES: Normally the difference between the measured value and the theoretical value is very small. But if it is appreciable it is said that there is a gravimetric anomaly at that point:

If the measured value> theoretical value ..... positive anomaly. It occurs in the oceans because the crust (low density) is thinner.

If the measured value <theoretical value ..... negative anomaly. It is produced in mountain ranges because the crust is thicker.

IMPORTANCE: the positive anomalies indicate that there are denser materials (metals) in the subsoil, the negative ones would indicate areas with less dense materials (saline domes or warmer areas of the mantle).

2.3. MAGNETIC METHOD

IT IS BASED: in the variations of the Earth's magnetic field.

TERRESTRIAL MAGNETIC FIELD: the rotation of the Earth's core (O-E ≈ 1 year, every 400 years ago) makes it behave like a dynamo and generates a spherical magnetic field twice the Earth's diameter.

- Magnetic poles: They do not match the geographical ones. The angle formed is called magnetic declination, δ (about 11º). It has varied throughout Earth's history.
- Variations of the magnetic field by: Solar radiation, magnetic storms of the sun and local variations due to the geological differences of the Earth.

MEASUREMENT INSTRUMENT: the device used is the magnetometer

MAGNETIC ANOMALIES: The rocks that contain iron can be magnetized and form a weak magnetic field but that alters the intensity and orientation of the current field in that area, a magnetic anomaly has formed.

2.4. ELECTRICAL METHOD

IT IS BASED: in the study of the changes in the electrical conductivity of the different materials. As it is very low we talk about electrical resistivity.

2.5 GEOTHERMAL METHOD

IT IS BASED: in the study of terrestrial geothermal energy

TEMPERATURE VARIATION:

-From the land surface inland: every 33 m increases 1º C.

-This variation is called a geothermal gradient.

-This variation becomes smaller as we approach the core.

2.6. STUDY OF THE METEORITES

- The age of the meteorites is 4,500 Million years old = to Earth.
- Its composition can be comparable to that of the inner layers of the Earth.
- They are of different types, but in general, in their composition we find:

-Iron, calcium and magnesium silicates ≈ to basalt Earth's oceanic crust. (9% of the total)

-magnesium silicates ≈ to the earth's mantle (86% of the total)

-organic compounds and water

-Fe and Ni ≈ alloys to the Earth's core (4% of the total)

3. MODELS OF THE INTERNAL STRUCTURE OF THE EARTH

3.1. GEOCHEMICAL MODEL OF THE STRUCTURE OF THE EARTH

It is based on the chemical and mineralogical composition of the Earth.

The Earth is divided into three concentric layers:

Crust, mantle, core

CRUST

THICKNESS: 8-70 km ..... Mohorovicic discontinuity.

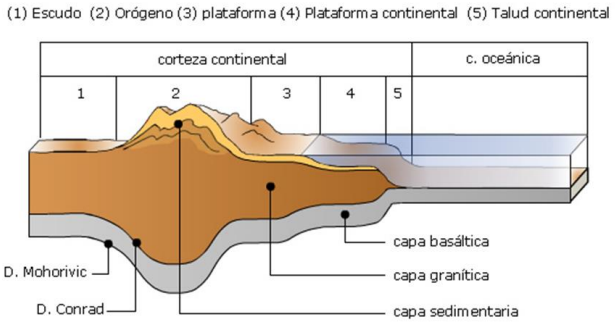
MEDIUM DENSITY: 2'8 g / cm3 ..... Solid state materials.

TYPES:

- CONTINENTAL: discontinuous, thicker and less dense

Superficially recognize the following elements:

-Cratons or shields: (thickness 30 km)



. Very stable areas, with little seismic activity.

. Very old igneous and metamorphic rocks> 250 Mya (Paleozoic - the oldest known are 3800 Mya).

. They appear covered by modern and horizontal sediments.

. Little relief due to prolonged erosion.

. Examples: The Baltic, Siberia, the Congo, Canada, Galicia and the mestas.

Orogens: (thickness of 70 km)

. Areas with relief, are more modern, are the mountain ranges.

- The oldest> 250 Mya ⇒ Paleozoic (Urals, Appalachians and Galicia)
- The most modern> 65 Mya ⇒ Tertiary (Alps, Andes, Himalayas, Pyrenees, Penibetic System).

. They are more unstable.

. Formed by igneous, metmorphic and sedimentary folded rocks.

Continental shelf: (thickness 7-15 km)

. Submerged in the ocean (less than 100 m) covered with sediments.

OCEAN: very fine (8-10 km) ocean floor from the continental slope.

-Sediments 1300 m thick. > further from the dorsals and closer to the coast.

-Oceanic plinth: 2000 m thick. Formed by padded and laminar lavas, crossed by vertical dikes. Very fractured

-Oceanic layer 5000 m deep, formed by gabbro

-In its horizontal structure we recognize: *continental slope, the abyssal plain, ocean trenches and underwater ridges*

B) THE MANTLE

Approximately 70% of earthly matter.

THICKNESS: From 30 km (Mold) to 2900 km (Gutenberg).

ZONES: They are distinguished:

-Upper mantle: Mold - 400 km ⇒ of peridotites (olivine)

-Transition zone: 400 - 700 km

-Lower mantle: 700 - 2900 km Gutenberg ⇒ of peridotites (perovskite)

C) THE NUCLEUS

DENSITY: Denser layer = 11 g / cm3.

TEMPERATURE: in the center it is 6700ºC.

LAYERS:

-External core (2900-5150 km) ⇒ Composed of Faith and Ni Fluid and mobile.

- Internal core (5150 - 6730 km) ⇒ Composed of Faith Solid and with rotation.

3.2. GEODYNAMIC MODEL OF THE STRUCTURE OF THE EARTH

A) Lithosphere

More superficial part. Rigid Variable thickness and vertically fractured

THICKNESS: 50 to 100/300 km

CONSTITUTED: Bark + upper part of the mantle.

TYPES: - Continental lithosphere:

Oceanic lithosphere: lacks continental crust.

B) ASTENOSPHERE

DEPTH: <400 km but it is not a continuous layer. It is very discussed.

It is a "low speed channel"

-About 150 km thick. It is a very variable area.

-It is characterized because seismic waves greatly reduce their speed ⇒> plasticity.

C) MESOSPHERE

-400-2900 km

-Rigid but convection currents occur there.

Layer D - Last 200 km.

-Decrease speed ⇒ partially melted.

-High Tª, the material rises slowly like feathers to the surface (related to cortical volcanic activity).

D) THE ENDOSPHERE

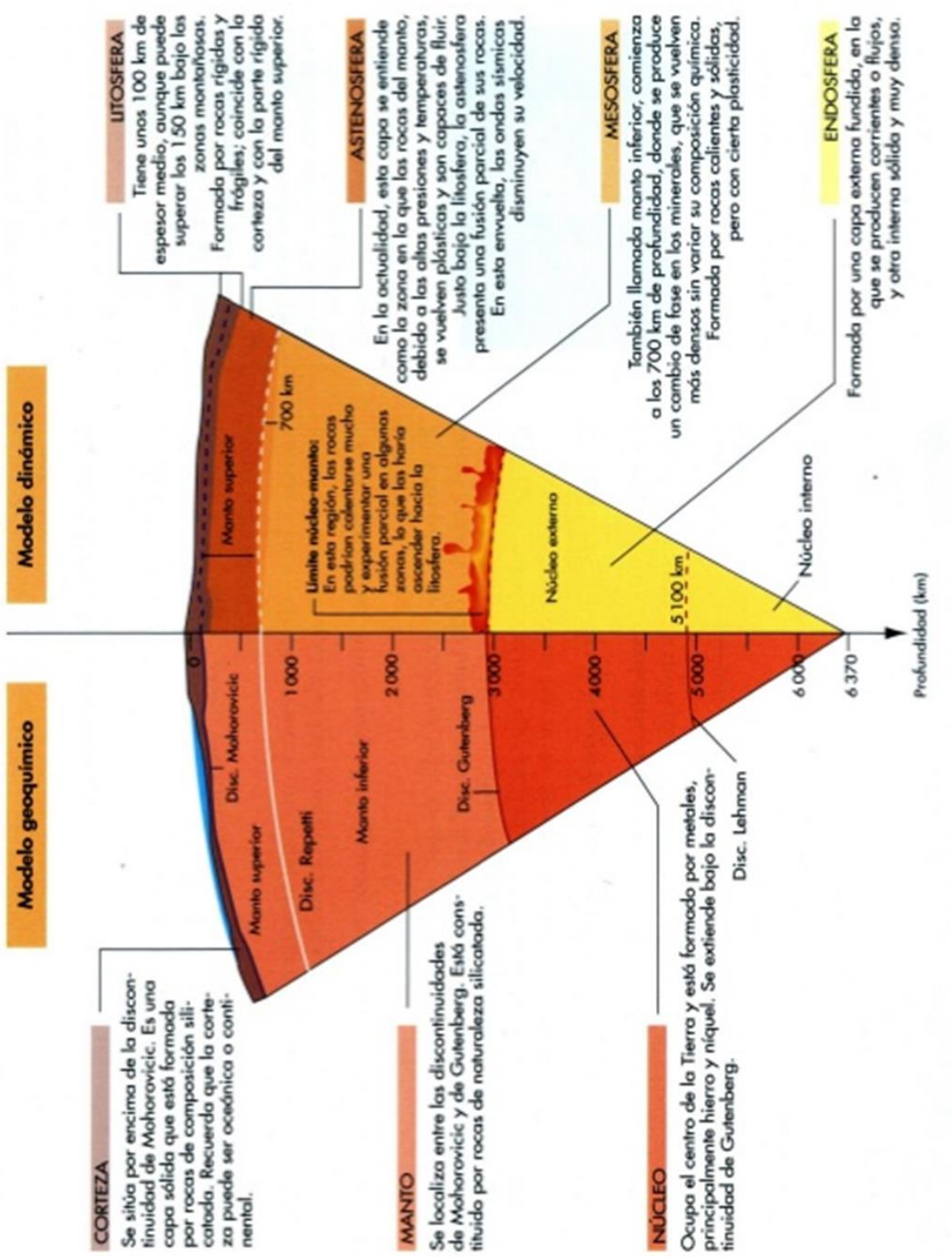
-DENSITY: Denser layer = 11 g / cm3.

-TEMPERATURE: in the center it is 6700ºC.

-LAYERS: - External core (2900 - 5150 km) ⇒ Fluid and mobile.

- Internal core (5150 - 6730 km) ⇒ Solid and with rotation.

The earth's magnetic field originates.


Modelo geoquímico
Modelo dinámico
CORTEZA
Se sitúa por encima de la discontinuidad de Mohorovicic. Es una capa sólida que está formada por rocas de composición silicatada. Recuerda que la corteza puede ser oceánica o continental.
MANTO
Se localiza entre las discontinuidades de Mohorovicic y de Gutenberg. Está constituido por rocas de naturaleza silicatada.
NÚCLEO
Ocupa el centro de la Tierra y está formado por metales, principalmente hierro y níquel. Se extiende bajo la discontinuidad de Gutenberg.
LITOSFERA
Tiene unos 100 km de espesor medio, aunque puede superar los 150 km bajo las zonas montañosas. Formada por rocas rígidas y frágiles; coincide con la corteza y con la parte rígida del manto superior.
ASTENOSFERA
En la actualidad, esta capa se entiende como la zona en la que las rocas del manto, debido a las altas presiones y temperaturas, se vuelven plásticas y son capaces de fluir. Justo bajo la litosfera, la astenosfera presenta una fusión parcial de sus rocas. En esta envuelta, las ondas sísmicas disminuyen su velocidad.
MESOSFERA
También llamada manto inferior, comienza a los 700 km de profundidad, donde se produce un cambio de fase en los mineroles, que se vuelven más densos sin variar su composición química. Formada por rocas calientes y sólidas, pero con cierto plasticidad.
ENDOSFERA
Formada por una capa externa fundida, en la que se producen corrientes o flujos, y otra interna sólida y muy densa.
Manto superior
Disc. Mohorovicic
Disc. Repetti
Manto inferior
Disc. Gutenberg
Disc. Lehman
Núcleo externo
Núcleo interno
700 km
5 100 km
6 370
0
1 000
2 000
3 000
4 000
5 000
6 000
Límite núcleo-manto: En esta región, las rocas podrían calentarse mucho y experimentar una fusión parcial en algunas zonas, lo que las haría ascender hacia la litosfera.
Profundidad (km)