NDA PREPARATION MATERIAL

GAT– GEOGRAPHY

TOPIC 2A

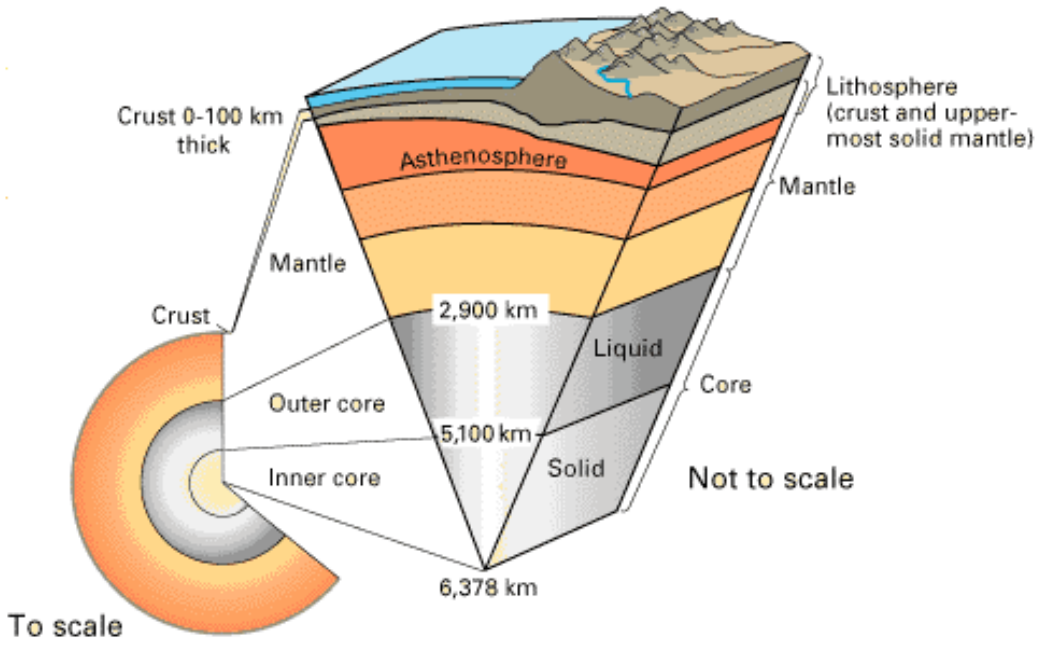
STRUCTURE OF THE EARTH INTERIOR

Just like an onion, the earth is made up of several concentric layers with one inside another. The important zones include:

The crust: The outer layer of the earth is known as the crust. It comprises about 0.5% of the earth's body. Its thickness ranges from 5 to 40 km. The crust is thicker beneath the continents than beneath the oceans. It is made up of two layers: upper lighter layer (density=2.7 g/cc) called the sial (silica + aluminium) and a lower denser layer (density=3.0 g/cc) called sima (silica+ magnesium). The average density of earth's surface is less than 3 gm/c.c. The upper layer of the crust is mainly composed of crystalline igneous and metamorphic rocks, acidic in nature. The lower layer of the crust contains basaltic & ultra-basic rocks. Conrad discontinuity separates the outer and the inner crusts.

The mantle: Below the crust of the earth is a thick layer called mantle. This layer extends up to a depth of 2900 km. The mantle consists predominantly of solid olivine rocks made up of silicates of magnesium and iron and displaying plastic properties. Its average density is 56.8. This layer is separated from the crust by Mohorovicic Discontinuity. The outer and the inner mantle are separated by another discontinuity named Repetti discontinuity.

The core: Beyond a depth of 2900 km lies the core of the earth. It is named as barysphere and also nife (nickel and ferrous). Average thickness is 4671 kms. Average density is 17.2. By volume it constitutes 17% of the earth's body. The temperature of the core is about 200°C. The core is believed to be a reason for the earth's magnetism. It is separated from the mantle by Gutenburg - Wiechert Discontinuity.



Lithosphere & Aesthenosphere:

Beneath the upper mantle there is a soft layer in which the mantle rock is at the temperature close to the melting point. It sets in at an average depth of about, 80 km which is well below the base of the continental crust. This layer is called as “Aesthenosphere" and the rigid layer above it is called as “Lithosphere". The aesthenosphere extends to a depth of about 400 km.

Composition and properties of different layers of the earth

Temperature: In upper 100 km the increase in temperature is estimated at the rate of 12°C per km descend. In the next 300 km, the increase is of 2°C per km and below that the rate of increase is 1°C per km. In the core the temperature is about 2000°C. But at the same time there is a huge pressure of overlying layers of the earth’s interior. So even under extremely high temperature towards the central part of the earth the liquid nature of the earth core has acquired the properties of a solid and is probably in a plastic state.

Sources of information about the interior

The earth's radius is 6,370 km. To reach the centre of the earth and make observations or collect samples of the materials is almost impossible. Under such conditions, most of our knowledge about the interior of the earth is largely based on analogies and inferences. Yet, a part of the information is obtained through direct observations and analysis of materials.

Direct Sources

The readily available solid earth material is surface rock we get from mining areas. Besides mining, scientists world over are working on two major projects such as "Deep Ocean drilling

Project" and "Integrated Ocean Drilling Project". The deepest drill at Kola, in Arctic Ocean, has so far reached a depth of 12 km. These drilling projects have provided large volume of information through the analysis of materials collected at different depths. Volcanic eruption forms another source of obtaining direct information. As and when the magma comes out to the surface of the earth during volcanic eruption it becomes available for laboratory analysis.

Indirect Sources

Analysis of properties of rocks and magma indirectly provides information about the interior. Through mining we know that temperature and pressure increase with the increasing depth. It is also known that the density of the material also increases with depth. Scientists have estimated the values of temperature, pressure and the density of materials at different depths.

Meteor is another source of information about the interior of the earth. However, the material, that becomes available for analysis from meteors, is not from the interior of the earth. It is only similar to that of the earth. Meteors are solid bodies developed out of materials same as, or similar to, earth. So, by analogy meteors provide valuable information about the earth's interior.

Other indirect sources include gravitation, magnetic field and seismic activity. The gravitational force is greater near the poles and less at the equator. It also differs according to the mass of material. Thus the uneven distribution of material within the earth influences its value. The readings of the gravity, may, at places differ from the expected values, Such a difference is called gravity anomaly. Gravity anomalies give us information about the distribution of mass of the material in the crust of the earth,

Seismic/Earthquake Waves

The study of seismic waves provides a complete picture of the layered interior. An earthquake in simple words is shaking of the earth. It is a natural event. It is caused due to release of energy, which generates waves that travel in all directions. The energy waves travelling in different directions reach the surface.

Earthquake waves are basically of two types- body waves and surface waves. Body waves are generated due to the release of energy at the focus and move in all directions travelling through the body of the earth. They interact with the surface rocks and generate new set of Waves called surface waves. These waves move along the surface. The velocity of waves changes as they travel through materials with different densities. Denser the material, higher is the velocity.

There are two types of body waves. They are called P and S-waves. P waves move faster and are the first to arrive at the surface. These are also called 'primary waves'. The P waves are similar to sound waves. They travel through all materials gaseous, liquid and solid. S-waves arrive at the surface with some time lag. These are called secondary waves. S-waves can travel only through solid materials. This characteristic of the S-waves has helped scientists to understand the structure of the interior of the earth.

Different waves travel in different manners. P-waves vibrate parallel to the direction of the wave. This exerts pressure on the material in the direction of the propagation. As a result, it creates density differences in the material leading to stretching and squeezing of the material. Other waves vibrate perpendicular to the direction of propagation. The direction of vibrations of S-waves is perpendicular to the wave direction in the vertical plane. Hence, they create troughs and crests in the material medium through which they pass. Surface waves are considered to be the most damaging waves.

Shadow Zone

Earthquake waves are recorded in seismographs located at far off locations. However, there are certain areas where the waves are not reported. Such a zone, where the waves are not recorded, is called the 'shadow zone'. The study reveals that for each earthquake, there exists an altogether different shadow zone.

Continental drift

The theory of continental drift, expounded by Alfred Wegener in 1915, holds that portions of the original continent which comprised the entire landmass of the world underwent a series of horizontal displacement before the present continents were formed.

According to this theory, about 280 million years ago, the entire landmass formed one super continent, called Pangaea. According to Wegener, after the breaking of the super continent Pangaea, the movement of the continents took place in two directions- one towards the equator due to centrifugal force of the earth which gave rise to fold mountains like the Hitnalayas, the Alps etc. and another towards west due to tidal force of sun and the moon which gave rise to Andes and Rockies.

A glance at the world map shows that S. America particularly Brazil can be fitted into the Gulf of Guinea of Africa; Antarctica can roughly be fitted into S. Australian coast and S.E-African coast. Similarly NW-Australian coast and E-Indian coast are liable to fit. After the drifts some water bodies developed between them. Geological evidences prove that S. America and Africa were probably joined together till the upper Triassic. Biological history of certain animals like marsupials and placental mammals also throw significant light on the continental drift.

PLATE TECTONICS

Plate tectonics deals with rock structures which are in the form of the plates and it is not only the continents which are in motion but the oceans as well. These plates include not only the earth's upper crust but also the part of denser mantle below. They have an average thickness of 100 km. They float on the plastic upper mantle called "aesthenosphere" and carry the continents and oceans on their back. The edges of the plates are designed as boundaries and margins where movements occur.

All these plates are in constant motion both in relation to each other and with regard to the earth's motion. Some movements are responsible for the volcanic activities, seismic and other plate disturbances on the margjns of the plates.

Types of movements of plates

A. Convergence: When the oceanic lithosphere moves towards the continental lithosphere, due to its thickness the continental crust is unable to go down and it is the oceanic crust which is involved in subduction. The down went plate of the oceanic crust melts and produces magma. This magma rises slowly and emerges as intrusive igneous rock in the form of volcanic mountains on the continental crust. Thus origin of volcanic mountains like Andes takes place.

When the two oceanic lithospheres lie on both side of subduction, then either of the two plates may subduct. The subducted part melts and the magma rises above the oceanic surface and volcanic islands are formed in arc form like Aleutian island, Kuril Island, Ryuku Island etc.

When the continental lithosphere lies on both sides of subduction, the sediments get scrapped off the descending plate margin. In the next stage the two continents collide, squeezing the sediment mass and throwing it into complicated fold and high alpine ranges like Himalayas and Alps are formed.

B. Divergence/continental rupturing: It is also termed as "ocean floor spreading". Deep beneath the continental plate a column of heated mantle rock begins to rise and reach the plate above, causing the plate to fracture, which is called "continental rupture". At first block mountains are formed. Next a long narrow valley called "rift valley" appears. The widening crack in its center is continuously filled in with magma rising from the mantle below. The magma solidifies to form new crust and also a new oceanic crust and lithosphere.

C. Parallel movements of plates: Parallel plates, as they slide past each other along a common boundary, do not create a new crust or destroy the old one but they produce "transform faults" which are fractures in rock formation. Fractures imply displacement of rocks. As the plates continue to move, the locked rocks snap. They shift violently back to equilibrium like a bent -stick breaking. This violent shift causes earthquakes.

Multiple choice questions

1. Another word for the crust of the earth is the:
a) Lithosphere
b) Mesosphere
c) Asthenosphere
d) Troposphere
2. The Moho Discontinuity line lies between:
a) Crust and Mantel
b) Mental and core
c) Troposphere and Stratosphere
d) Stratosphere and Asthenosphere
3. Which geologist gave his name to a theory that continents drift apart:
a) Suess

b) Wegener
c) Bronowski
d) Richter
4. A theory states that a super continent once existed, from which all present day masses broke away this single block was known as:
a) Panagea
b) Gondwanaland
c) Laurasia
d) Thethys
5. The Latin word Petra means:
a) Coal
b) Mineral
c) Rock
d) Ore
6. Which one of the following is/ are direct source(s) of information about the interior of the earth?
1. Earthquake wave
2. Volcano
3. Gravitational force
4. Earth magnetism
Select the correct answer using the code given below.
a) 1 and 2 only
b) 2 only
c) 3 and 4 only
d) 1, 2, 3 and 4
7. Where do most earthquakes and volcanoes occur?
a) Near Plates
b) At the plate margins
c) Within the plates
d) Both (b) and (c)
9. Along which plate boundary the plates grind against each other:
a) Converging boundaries
b) Diverging boundaries
c) Constructive boundaries
d) Transform boundaries
10. Lithosphere consists of
a) Upper and lower mantle
b) Crust and core
c) Crust and uppermost solid mantle
d) Mantle and core
11.The boundary between the mantle and the core lies at a depth of approximately_____.
a) 300 Kms
b) 1000 Kms
c) 3000 Kms
d) 5000 Kms
12. Continental crust can be up to _____ Kms thick.
a) 5
b) 35
c) 65
d) 100

13. Where do P waves travel fastest?
a) Upper mantle
b) Lower mantle
c) Outer core
d) Inner core
14. Which of the following statements about the Moho is false?
a) Seismic waves spped up as they pass across the Moho heading downward
b) The Moho seperates denser rocks below from less dense rocks above
c) The Moho separates the crust from lower mantle
d) The Moho marks the top of a partially molten layer
15. What drives plate tectonics?
a) Thermal convection
b) Thermal conduction
c) Solar energy
d) Erosion
16. In a deep mine, temperature increase at the rate of_____.
a) 3 degrees C/ Kms
b) 30 degrees C/ Kms
c) 300 degrees C/ Kms
d) 1 degree C/ Kms
17. Which one of the following lists most accurately describes oceanic crust?
a) Basaltic- density of 3.0 g/ cm3
b) Granitic- density of 3.0 g/cm3
c) Quartz arenites- density of 2.6 g/ cm3
d) Basaltic- density of 2.6 g/ cc
18. The Moho seperates:
a) The outer core from the inner core
b) The lithosphere from the asthenosphere
c) The asthenosphere from the Mesosphere
d) The crust from the mantle
19. Which of the following term associations is false?
a) Asthenosphere- Plastic behavior
b) Lithosphere- Rigid solid
c) Outer core- Right solid
d) Continental crust- Rigid solid
20. Which of the following statements is false?
a) The crust- mantle boundary is called the Mohorovicic discontinuity
b) The oceanic crust consists of basalt and gabbro
c) The crust is less dense than the mantle
d) P- waves travel faster in the crust than in the mantle
21. Which of the following statement is false?
a) The asthenosphere lies beneath the lithosphere
b) The asthenosphere is stronger than the lithosphere
c) The asthenosphere rises close to the surface beneath mid- ocean ridges
d) The asthenosphere is partially molten
22. The lithosphere is approximately_____ kilometers thick
a) 25
b) 100
c) 250
d) 2900
23. Which of the following statements is true

a) The lithosphere contains the crust
b) The crust contains the lithosphere
c) The lithosphere and crust are different terms for the same part of the earth
d) The lithosphere and crust are totally separate parts of the earth
24. What element makes up most of the earth's core?
a) Silicon
b) Oxygen
c) Iron
d) Nickle
25. Density of the core is highest-
a) Due to heavy pressure of overlying rocks
b) Due to heavy temperature of overlying rocks
d) None of the above
26. The average density of the earth is-
a) 2.3 gm/ cm3
b) 5,5 gm/ cm3
c) 17.2 gm/ cm3
d) 6.5 gm/ cm3
27. Who discovered the core-
a) Harold Jeffreys
b) R D Oldham
c) Inge Lehman
d) None of the above
28. The inner core is solid first proved by-
a) Inge Lehman
b) Suess
c) Cavendish
d) R D Oldham
29. The core of the earth is made of the mixture of-
a) Silica and nickel
b) Nickel magnesium
c) Silica and magnesium
d) Nickel and iron
30. The asthenosphere is-
a) Totally molten
b) Partially molten
c) Totally solid
d) Partially solid
31. Which waves cannot pass through liquid materials?
a) Primary waves
b) Secondary waves
c) Surface waves
d) All of the above
32. Which of the following is an example of direct source to study interior of the earth?
a) Gravitation
b) Sesimic activity
c) Magnetic field
d) Volcanic eruption
33. Which of the following forms outermost solid part of the earth?
a) Core
b) Crust

c) Mantle
d) Magma
34. Which of the following is known as most dense layer of the earth?
a) Core
b) Crust
c) Mantle
d) Magma
35. Which of the following layer of the earth is termed as Sial?
a) Core
b) Crust
c) Mantale
d) None of the above
36. Lithosphere is the combination of
a) Upper core and lower core
b) Upper crust and lower mantle
c) Crust and uppermost part of mantle
d) Mantle and core
37. Which of the following rocks found in Oceanic crust?
a) Granite
b) Basalt
c) Igneous rocks
d) Metamorphic rocks
38. Which of the following is the major element in earth crust?
a) Silicon
b) Oxygen
c) Iron
d) Aluminium
39. Which of the following is known as thinnest layer of the earth?
a) Crust
b) Mantle
c) Core
d) None of the above
40. Which is the most abundant metal in the Earth’s crust? `
a) Silicon
b) Iron
c) Aluminium
d) Zinc