UNIT 1

Lithosphere – I Endogenetic Processes

Learning Objectives

- To know about the spheres of the Earth
- To illustrate the internal structure of the Earth
- To study the rock types and its cycle
- To explain the internal processes of the Earth
- To understand the processes of Earthquakes and volcanoes

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Introduction

The Earth is a unique planet of the Solar family. The Earth is composed of four spheres namely, the lithosphere, the atmosphere, the hydrosphere and the biosphere. This lesson focuses on the internal processes of the Earth. The sequence of lessons generally follows the spheres of the Earth system in a comprehensive manner.

Have you ever wondered what our Earth is made up of? Or what lies underneath the Earth's surface?

"The Earth can physically be described as a ball of rock (the lithosphere), partly covered by water (the hydrosphere) and wrapped in an envelope of air (the atmosphere). To these three physical zones it is convenient to add a biological zone which includes all the living organisms (the biosphere)."

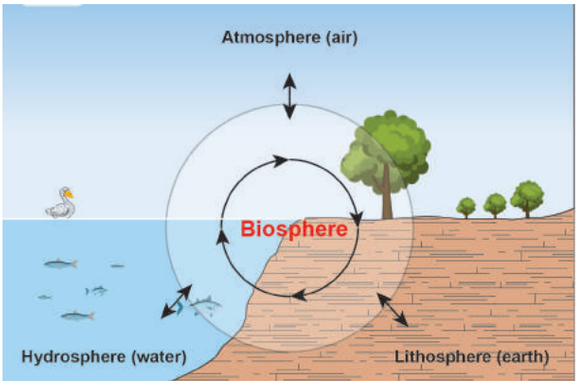
Arthur Holmes

1.1 Spheres of the Earth

Earth's surface is a vast area of 510 million sq.km, where four spheres of the Earth interact. The abiotic spheres are the lithosphere, atmosphere and hydrosphere. The biotic sphere is the biosphere. Together, these spheres constitute the planet, Earth.

1.2 Structure of the Earth

The outer surface and inner core of the Earth are totally different in their nature and structure. The structure of the Earth's interior is divided into three layers namely **the crust, the mantle and the core**.



Spheres of the Earth

The **lithosphere** is the solid outer part of the Earth.

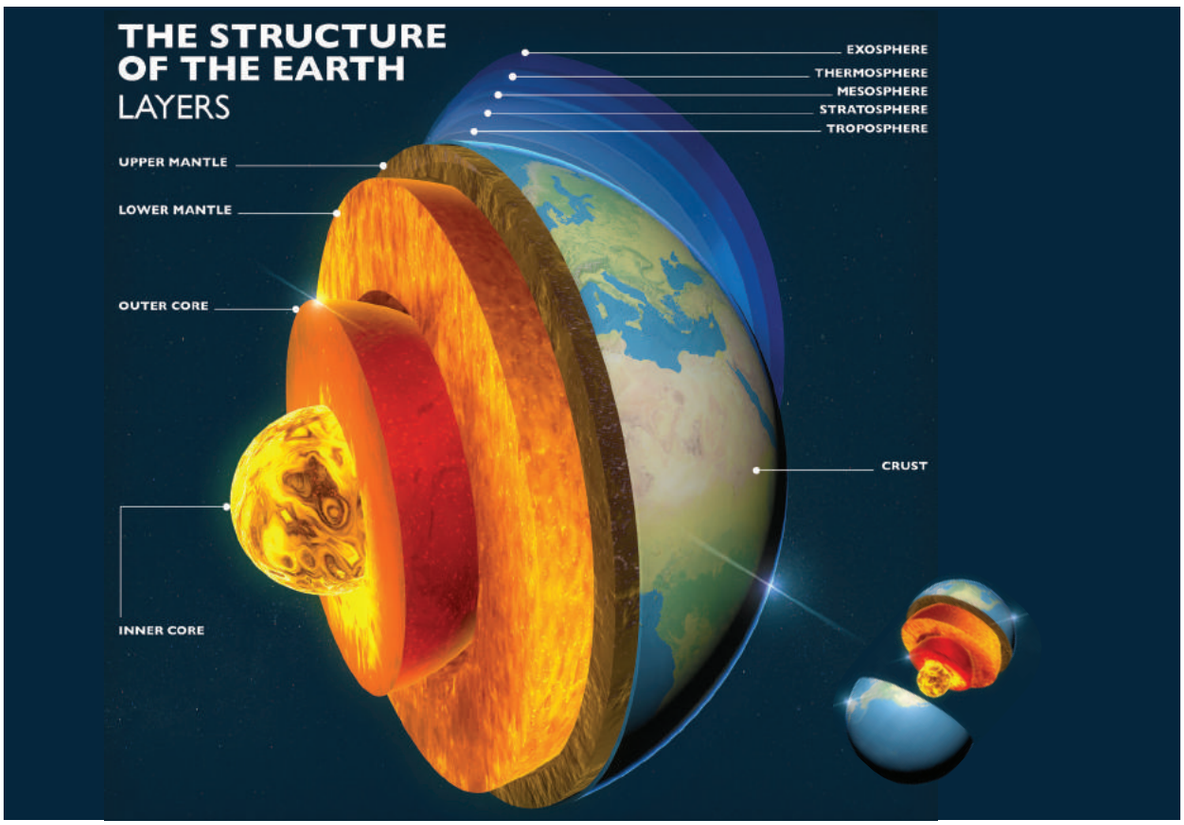
The **atmosphere** is a thin layer of gases that surrounds the Earth.

The **hydrosphere** is the watery part of the Earth's surface including oceans, rivers, lakes and water vapour

The **biosphere** is the layer of Earth where life exists.

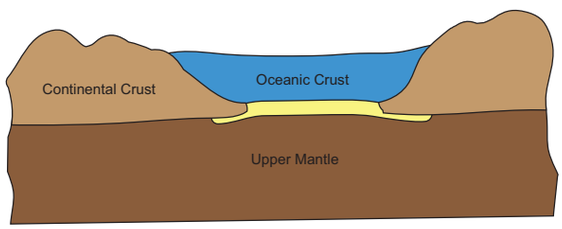
The terms **'lithosphere'** and **'crust'** are not the same. The lithosphere includes the crust and the uppermost part of the mantle.

All terrestrial planets have lithosphere. The lithospheres of Mercury, Venus, and Mars are much thicker and more rigid than that of the Earth.



Crust

Crust is the outer layer of the Earth, where we live. It is the skin of our Earth, which ranges between **5 to 30 km**. It is the solid and rigid layer of the Earth. The thickness of the crust is greater below the continents than the ocean floor. The crust is classified as **continental crust** and **oceanic crust.** The major elements of crust SIAL are Silica (**Si**) and Aluminium (**Al**) and SIMA (**Si** - Silica and **MA** - Magnesium)



Continental Crust is made up of SIAL and Oceanic Crust is made up of SIMA

Mantle

The interior part beneath the crust is called mantle, which is about 2,900 km thick. In the upper part of the mantle, the rock remains solid, whereas in the lower part of the mantle, rocks are in molten form. This molten rock inside the Earth is called '**magma**'.

Core

The **core** is the innermost and hottest layer of the Earth which lies below the mantle. It is composed mainly of Nickel **(Ni)** and Iron **(Fe)**. Hence it is called **NIFE.** The core is divided into **Solid inner core** and **Liquid outer core.** The presence of large quantities of iron in the core is responsible for the Earth's gravitational force. As the Earth rotates on its axis, the liquid outer core spins over the solid inner core and generates the Earth's magnetic field. This is responsible for the functioning of the magnetic compass. Due to high pressure, the materials in the inner core are unable to move and hence remain solid.

1.3 Rocks

The crust is a storehouse of rocks. An aggregate of minerals on the Earth's crust is called 'rock'. It may be hard and compact like 'granite' or soft as 'clay' or loose as 'sand'.

The Deepest Place ever reached by human technology vary from time to time. Till 2011 **Kola Super Hole** (12,262m) in Murmansk, Russia was the deepest place. But in 2012, **Z-44 Chavyo Well** (12,376m) broke the record, and is supposed to be 15 times the height of **Burj Khalifa in Dubai**.The exploration of Earth's interior continues.

Types of Rock

Based on formation, rocks are classified as:

- Igneous,
- Sedimentary and
- Metamorphic.

Fact

The ancient city of Petra in Jordan is an example of an entire city carved out of rocks. There are many specimens of magnificent rock-cut architecture in India, like the Ajanta and Ellora caves in Maharashtra, the Aihole and Badami temples in Karnataka, the Konark temple in Odisha and Mamallapuram in Tamil Nadu.

Igneous Rocks

The word 'igneous' is derived from the Latin word **Ignis** meaning '**Fire**'. The interior of the Earth contains very hot molten material called '**Magma**'. When the magma reaches the Earth's surface, it is referred to as **'Lava'.** The lava on the surface cools down and gets solidified as rocks called igneous rocks. Granite and basalt are examples of such rocks. Igneous rocks are also called **Primary or Mother rocks** because all other rocks are directly or indirectly formed from them.

Sedimentary Rocks

These sedimentary rocks are named after the latin word 'sediment' meaning ' settle. Rivers, glaciers and winds carry bits of rock and soil and deposit them in layers. After a few million years, these deposits harden into compact rocks and are called **Sedimentary rocks.**

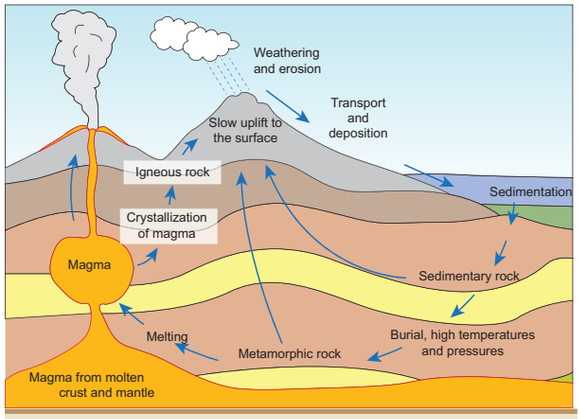
The bodies of plants and animals that fall on the deposits get embedded in the layers and form **Fossils**. Sandstone, limestone, chalk, gypsum, coal and conglomerate are examples of sedimentary rocks.

Metamorphic Rocks

The term 'metamorphic' is derived from the word 'metamorphosis', which means, 'change of form'. When igneous or sedimentary rocks are subjected to extreme heat and pressure, they undergo a complete change in their form and character .i.e., in course of time, granite may get transformed to gneiss, basalt to schist, limestone to marble and sandstone to quartzite.

Rock Cycle

The Rock cycle is a continuous process through which igneous, sedimentary and metamorphic rocks are transformed from one form to another.



Activity

Narrate the processes involved in the given rock cycle diagram in your own words.

1.4 Geomorphic Processes

The forces that act from the Earth's interior towards the Earth's surface are called **Internal processess** or **Endogenetic processes**. These forces build the landscape and create topographic relief.

The forces that act on the surface of the Earth due to natural agents like running water, glacier, wind, waves etc. are called **External processes** or **Exogenetic processes**. These external processes tear the landscape down into relatively low elevated plains and shapes the landform created by Endogenetic process.

Internal Processes

The internal processes generate heat and eject materials from deep below the Earth's crust. **Internal radioactivity** is the principal source of power for this process.

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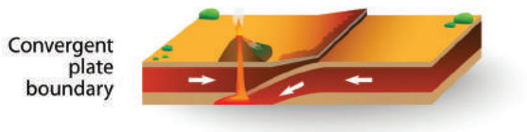
Plate Tectonics

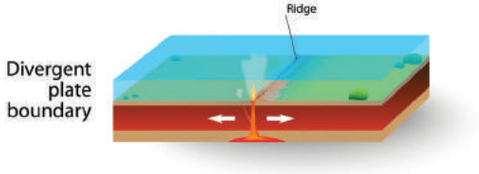
The lithosphere is divided into a number of huge slabs of rocks called '**Tectonic plates**.' These tectonic plates are divided into major and minor plates. These plates float independently over the mantle. Collisions of these plates produce mountain ranges and other irregular surface features, both on land and the ocean floor. This phenomenon is called '**plate tectonics**'. The movement of tectonic plates is due to thermal energy from the mantle. Now we have a better understanding about the plate movements and its relation to Earthquake and volcanic activities.

Types of Plate Boundaries

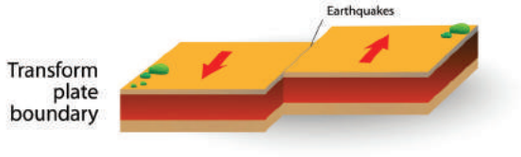
Convergent Boundary - Here the plate moves toward each other and sometimes, a plate sinks under another. The location where the sinking of a plate occurs is called a subduction zone (eg) Fold Mountain-Himalayas.



Divergent Boundary – Here the plates pull away from each other as magma pushes up from the mantle (eg) Mid Atlantic Ridge



Conservative/Transform Boundary – Here the plates slide horizontally past each other. (eg) San Andres Fault.



Movements of Continental Plates

Due to lateral compressional forces, the plates are forced to move upwards and downwards. This is called '**Folding**'. Mountains formed by folding are called fold mountains. The process of folding creates lofty mountain ranges such as the Himalayas and the Alps

According to plate tectonics, the plates are in constant motion with an average rate of few centimetres per year. The movement might seem slow, but over millions of years, the plates and the continents riding on them move a long way. For example, about 250 million years ago, the Indian Plate was a part of the **Gondwana land**, which comprised of modern Africa, Australia, Antarctica, and South America.

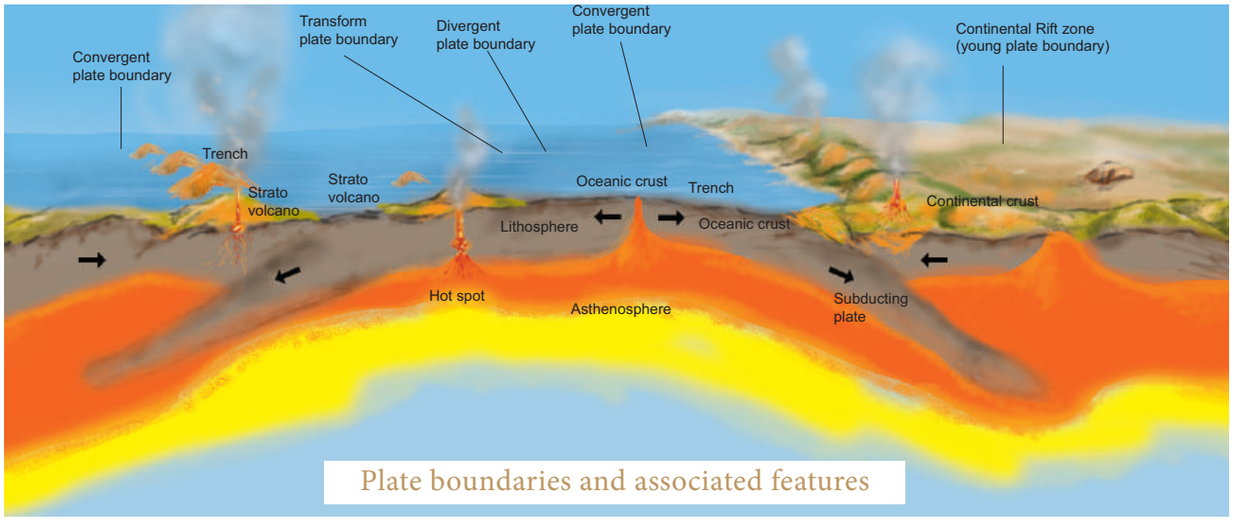
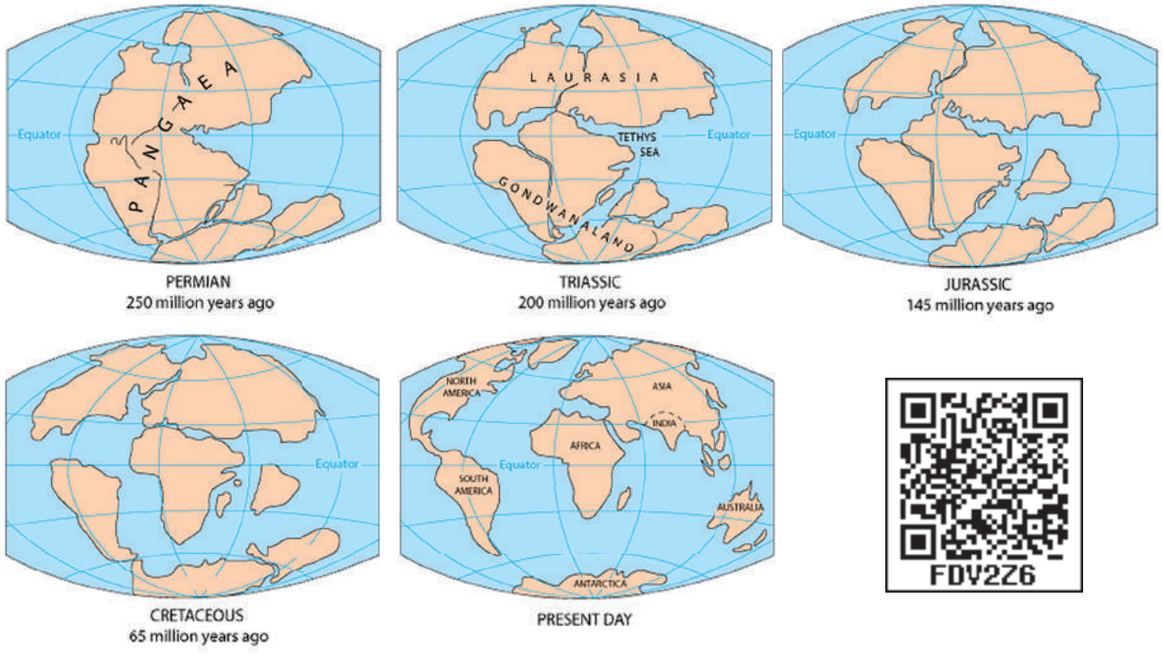


Plate boundaries and associated features



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Approximately 140 million years ago, the Indian plate broke away from the ancient super continent 'Gondwana' and began moving north and collided with Asia. The collision with the Eurasian Plate along the boundary between India and Nepal formed the **Orogenic** belt that created the Tibetan Plateau and the mighty Himalayan Mountains.

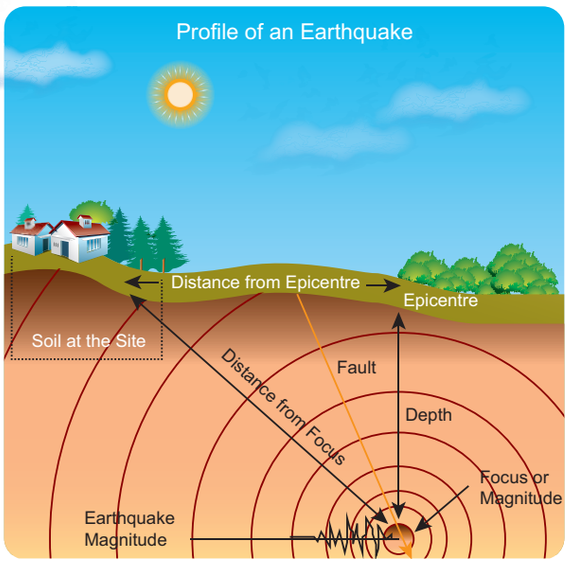
Activity

Here is a list of a few mountains.

- Ural Mountains, Andes Mountains, Vindhya Range, Alps mountains,
- Satpura range, Rocky Mountains, Sierra Nevada.
- Identify and Locate with help of atlas

Earthquake

Earthquakes are generally caused by the sudden vibrations in the Earth's crust, which spreads outward in all directions as waves from the source of disturbance. The point of origin of an Earthquake is called **'Focus' (Hypocenter)** which generates a series of elastic waves. **'Epicentre'** is a point on the Earth's surface that lies directly above the focus. The impact of the Earthquake is felt the most at the epicentre.



Seismic Waves

Earthquakes generate **seismic waves**. The nature, force and speed of these seismic waves depend on the nature of the medium through which it passes. Accordingly, there are three major types of waves.

Primary or P-waves are the fastest of all the Earthquake waves and the first to reach the epicentre. These waves pass through solids, liquids and gases, either through push or pull with an average velocity of 5.3km per second to 10.6 km per second.

Fact

C.F. Richter devised a scale to measure the magnitude of Earthquakes. This scale relates to the energy released at the epicentre and provides an estimation of the severity of an Earthquake. It is an open ended scale. The highest magnitude ever recorded is 9.5 on Richter scale (Bio-Bio, Chile in 1960).

Secondary or S-waves travel only through solids. These transverse waves shake the ground perpendicular to the direction in which they propagate. The average velocity of these waves is 1Km per second to 8 km per second.

Surface Waves (or) L-waves are similar to P-waves but they travel primarily along the ground surface. These waves travel comparatively slower and are the most destructive waves. The average velocity of these waves are 1 km per second to 5 km per second.

DO YOU KNOW?

The instrument which records the Earthquake waves is called 'seismograph' or 'seismometer'. The science that deals with Earthquakes is called 'seismology'.

Tsunami

The word 'Tsunami' is a Japanese term, meaning harbour waves. It is adopted to describe

large seismically generated sea waves caused by Earthquakes, submarine explosions and landslides. These waves travel at a great speed (more than 500 km per hour) and the length of the waves exceeds 600 km. These waves reach to a height of more than 15 m near the sea shore and are capable of causing destruction along the coastal area.

The 2004 Indian Ocean Earthquake that caused tsunami is the sixth-deadliest natural disaster which travelled at a speed of 600 km per hour with an estimated death toll of 2,80,000. The Earthquake which occurred near Indonesia at 00.58 hours took nearly 7 hours to reach Chennai.

DO YOU KNOW?

On 26 December 2004 a tsunami occurred in the Indian Ocean. It was the **result** of the Indio-Australian Plate **subducting** below the Eurasian Plate. It was caused by an Earthquake **measuring** a magnitude of above 9 in the Richter scale. The Earthquake caused the **seafloor** to **uplift**, displacing the seawater above.

Volcanoes

A volcano is a vent or an opening on the surface of the Earth crust, through which hot solid, liquid and gaseous materials (**Magma**) erupt out to the surface from the Earth's interior. Magma rises up and ejects on the surface as **Lava**. Volcanoes are also formed when plates move apart.

Volcanoes generally have the following major components. They are:

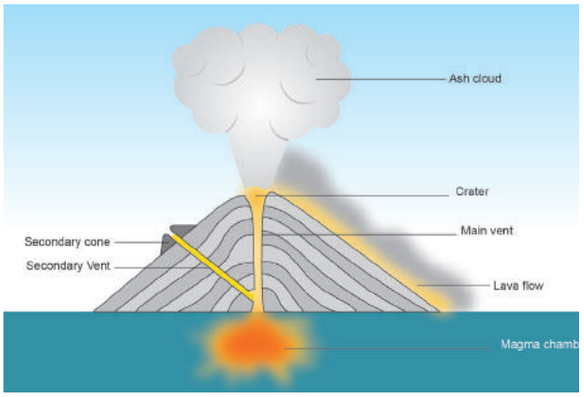
i. Magma chamber - a large pool of liquid rock found beneath the surface of the Earth
ii. Vents - an opening serving as an outlet for air, smoke, fumes, magma etc
iii. Volcanic cone - a landform built by the magma ejected from the vent in the shape of a cone.
iv. Crater - a bowl shaped depression found at the top of the volcano through which the magma flows out.

Based on the periodicity **of eruptions**, volcanoes are classified into

(i) Active volcano, (ii) Dormant volcano, (iii) Extinct volcano.

DO YOU KNOW?

The term 'volcano' is derived from the Latin term VULCAN, which is the name of Roman "God of Fire".



a. Active Volcano

Active volcanoes are those which constantly eject volcanic lava, gases and fragmented materials. (eg.) Mount St. Helens in the United States.

b. Dormant Volcano (or) Sleeping Volcano

Volcanoes that do not show any sign of volcanic activity for a long period of time are known as dormant volcanoes. Sometimes there may be a sudden explosion which may cause unimaginable loss to life and property (e.g.) Mt. Fuji , Japan

c. Extinct or Dead Volcano

When a volcano permanently stops its volcanic activity, then it is

called as extinct or dead volcano (e.g.) Mt. Kilimanjaro, Tanzania.

Activity

Take a bottle flled with soda. Shake the bottle twice or thrice. Now twist the cap open. What do you observe?

Volcanoes can also be classified based on their **structure and composition as** composite volcano, shield volcano and dome volcano

d. Composite Volcano

Composite volcano, also known as strata volcano, is a conical volcano built by many layers of hardened lava, pumice and volcanic ash. These are commonly found in the Pacific Ocean Eg. Mt. Fuji, Japan

e. Volcanic Dome

A lava dome or volcanic dome is roughly a circular mound formed due to the slow ejection of viscous lava from a volcano. As the lava is rich in silica with intense viscosity, it is prevented from flowing far from its vent. e.g. Parícutin, Mexico

Hots

Pacific Ring of Fire — Most seismically and volcanically active. Why?

f. Shield Volcano

Shield volcanoes are formed by intense viscous lava.

These are shallow depositions with gently sloping sides.

Hence the lava flows out in all directions to create a shield.

E.g., Mauna Loa, Hawaii

Distribution of Earthquakes and Volcanoes

Most Earthquakes and volcanic eruptions do not strike randomly, but occur along the plate boundaries. One such area is the ***Circum-Pacific Ring of Fire,*** where the Pacific Plate meets many surrounding plates. The Ring of Fire is the most seismically and volcanically active zone in the world. The other distinctive major belts are Mid-Oceanic Ridges ,Mid-Continental Belts and Alpine - Himalayan belt.

Effect Of Volcanoes

Constructive Effects

Volcanic materials enrich the soil fertility that promotes agricultural activities. The hot volcanic region helps in generating geothermal energy. Many dormant and active volcanoes are the most attractive tourist spots of the world. Most of the volcanic materials are used as building materials.

Destructive Effects

Volcanic eruption causes Earthquakes, flash floods, mud slide and rock fall. Lava can travel very far and burn, bury, or damage anything in its path. The large amount of dust and ash makes breathing hard and irritable. Volcanic eruptions can alter the weather conditions and disrupt transport (Iceland volcanic eruption) in and around the volcanic region.

Recap

- The spheres of the Earth are the lithosphere, atmosphere, hydrosphere and biosphere.
- Earth's interior is divided into three layers - Crust, Mantle and Core.
- Based on composition, the crust, mantle and core are referred to as SIAL, SIMA and NIFE respectively.
- The formation and deformation of landforms on the surface of the Earth are due to continuous internal and external processes.
- The lithosphere is composed of major and minor tectonic plates.
- Earthquake is the shaking or trembling of the Earth's crust.
- Earthquake and volcanoes are useful to understand the Earth's interior.

EXERCISE

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I Choose the correct answer

1. _____ is the rigid outer layer of the Earth.
   a. core b. mantle
   c. Crust d. inner core
2. _____ layer is made up of liquid iron
   a. Inner core b. Outer core
   c. Mantle d. Crust
3. Magma is found in the _____
   a. crust b. mantle
   c. core d. None of the above
4. The movement of tectonic plates is induced by _____ energy.
   a. hydel b. thermal
   c. wave d. tidal
5. In the ancient period, Gondwanaland moved towards _____ direction.
   a. north b. south
   c. east d. west
6. Many million years ago , India was a part of the super continent _____
   a. Gondwana b. Laurasia
   c. Panthalasa d. Pangea.
7. The movement of plates that creates stress and tension in the rocks causing them to stretch and cracks result in _____.
   a. fold b. fault
   c. mountain d. earthquake
8. _____ refers to a bowl-shaped depression found at the top of the volcano.
   a. crater b. vent
   c. chamber d. volcanic cone
9. The point of origin of an Earthquake is called the _____
   a. epicentre b. focus
   c. seismic wave d. magnitude

II. Match the following

1. Endogenetic process — Seismograph
2. Mantle — Subduction Zone
3. Convergent boundaries — Volcanic
4. Earthquake — Pacific Ocean
5. Composite volcano — SIMA

III. Consider the given statements

1. i. Mt. Fuji is a dormant volcano.
   ii. Mt. Kilimanjaro is a dormant volcano.
   iii Mt. Tanzania is a dormant volcano.
   Which of the statement(s) is/are true?
   a. i is true b. ii is true
   c. iii is true d. i, ii, iii are true
2. **Statement:** Magma gushes out when it finds vents.
   Reason: Interior of the Earth contains compressed hot magma
   a. Statement & reason are true
   b. Statement is true, reason is false
   c. Statement is false reason is true
   d. Statement & reason are false
3. **Statement I:** Mountain ranges are formed by the collision of tectonic plates
   Statement II: The movement of tectonic plates is due to the thermal energy from the mantle
   a. Statement I is false II is true
   b. Statement I and II are false
   c. Statement I is true II is false
   d. Statement I and II are true

IV. Answer in brief:

1. Write a brief note on the various spheres of the Earth.
2. Mention the layers of the interior of the Earth.
3. Define Plate tectonics.
4. What is Tsunami?
5. What is a Volcano? Mention its major components.
6. What is an Earthquake and how it occurs?
7. What are seismic waves and mention its types?
8. Write about the Pacific Ring of fire.

V. Give Reasons for the following:

1. Igneous rocks are also called Primary Rocks or Mother rocks.

VI. Distinguish between

1. Core and crust.
2. Epicentre and Hypocentre
3. Divergent and convergent boundaries.
4. Primary waves and Secondary waves.
5. Shield volcano and volcanic Dome.

VII. Write answers in a Paragraph

1. Describe the structure of the Earth.
2. Write a note on the internal and external processes of Earth.
3. How are volcanoes classified based on the periodicity of their eruptions?
4. Explain the effects of Volcanoes.

VIII. Map Skill

On the given outline map of the world, mark the following:

a. Pacific Ring of fire
b. Earthquake prone zones (any two)
c. Locate any two active volcanoes of the world.
d. Himalayas and Alps ranges

IX. Life Skills

Imagine that you feel tremors or shocks in your locality. What will be your role in saving lives from destruction? List out the Do's and Don'ts.