CHAPTER -3 INTERIOR OF THE EARTH

This chapter deals with

1. Sources of information of about the earth interior 2. direct sources 3. Indirect sources 4. earth quake 5. Earth quake waves 6. Propagation of earthquake waves 7. emergence of shadow zone 8. types of earthquakes 9. effects of earthquakes 10. structure of the earth 11. the crust 12. The mantle 13. the core 14. volcanoes and volcanic landforms 15. types of volcanoes 16. shield volcano 17. composite volcanoes 18. caldera 19. flood basalt provinces 20. mid ocean ridge volcanoes 21. volcanic landforms intrusive forms, plutonic rocks ,batholiths, laccoliths, lapolith, phacolith ,sills & dykes

Sources of Information about the Earth's Interior

- There are two sources for information about interior of the earth – a) Direct Sources and b) Indirect Sources:
- Direct Sources: Mining, drilling and volcanic eruption are examples of direct sources. During the process of mining and drilling rocks and minerals are extracted which gives information that there are layer system in the crust. Crust is made of many kinds of rocks and minerals. Volcanic eruption suggests that there is some zone inside the earth which is very hot and in liquid condition. Direct sources are not very reliable because mining and drilling can be done only up to some depth only.
- Indirect Sources: Seismic waves, gravitational field, magnetic field, falling meteors etc are example of indirect sources. They are very important for know about earth's interior. Movement of seismic wave suggests that there are three layers in the earth and each layer has different density. Density increases toward the center of the earth.

Movement of seismic wave suggests two things: a) There are three layers in the earth and b) Each layer has different density which increases toward the center of the earth.

EARTH QUAKE

It is the shaking of the earth, natural event. It is caused due to release of energy which generates waves that travel to all directions.

WHY DOES EARTH SHAKE?

The release of energy occurs along the fault line
Rocks along the fault tend to move in opposite directions as the overlying strata press them the friction locks them together.
However, the tendency of movement overcome the friction
As a result, blocks get deformed
They slide over another: as a result energy releases.
Energy waves travel in all directions.
The point where energy releases is called focus/hypocenter
Above the focus point on the surface it is called epicenter

EARTH QUAKE WAVES

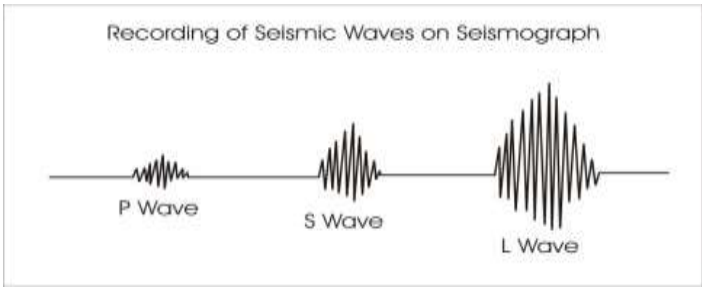
All earth quakes take place in the lithosphere (200 km depth)
An instrument called *Seismograph* records the waves.

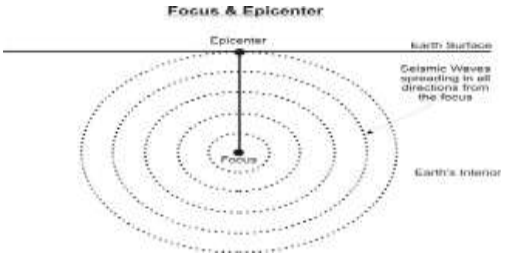
Earthquake and Seismic Waves

Meaning of Earthquake: Sudden movement or vibration on the earth surface is called earthquake. In other words, sudden release of energy due to tectonic activity is called earthquake. An earthquake may be produced due to: a) movement of plates, b) rising of magma, c) folding and faulting, d) violent volcanic eruption etc. When earthquake occurs, three types of wave are produced called as seismic waves. These are: a) P or Primary Wave, b) S or Secondary Wave, and c) L or Long or Surface Wave.

- P and S waves are combinely called as 'Body Wave' as they move inside the body of the earth.

- P wave is the fastest wave. It is also called as longitudinal wave. These waves move forth and back. In other words, P waves move parallel to the direction of wave. These waves can move in both solid and liquid.
- S wave is slower than P wave. It is also called as transverse wave. It moves perpendicular to the direction of the wave. These waves move only in solid and disappear in liquid.
- L wave is the slowest wave. It moves on the earth surface. It causes maximum destruction on the earth surface.





- Focus: It is point inside the earth surface from where an earthquake starts. It is always hidden inside the earth. Focus of an earthquake may be found at the depth of 100-200 km.
- Epicenter: It is a point on the earth surface which records the seismic waves for the first time. Maximum destruction from an earthquake is caused on the epicenter. Epicenter is located just perpendicular to the focus.
- P and S waves are called as Body Wave.
- P wave can pass through both solid and liquid. But S wave can pass only through solid.
- Seismograph: It is an instrument which record seismic waves on a paper.
- Richter Scale: It is an scale which measures the magnitude of an earthquake. In other words, energy released by an earthquake is measured on Richter Scale. Generally, it is from 0 to 10. An earthquake measuring 6 on Richter Scale is 10 times more stronger than 5 and 100 times more stronger than 4.
- Crust and upper part of the mantle is called 'lithosphere'.
- The opening through with magma comes out from a volcano is called as 'mouth' or 'crater'. When crater is collapsed due to a violent explosion it is called as 'caldera'.
- Mid-Oceanic Ridge: When plates move away from each other under the water of the ocean and magma rises up, it form a long hill like landform called as mid-oceanic ridge. Mid-oceanic ridge of Atlantic Ocean is the best example.
- Mercalli Scale: It was developed by an Italian seismologist. It measures the destruction caused by an earthquake. It ranges from 1 to 12.

Effects of Earthquake

a) Ground shaking
b) Destruction to houses and buildings
c) Land slide and tsunami
d) Soil liquefaction [solid soil becomes liquid]
e) Damage to dams and reservoirs
f) Fire accidents
g) Destruction to transport and communication lines.

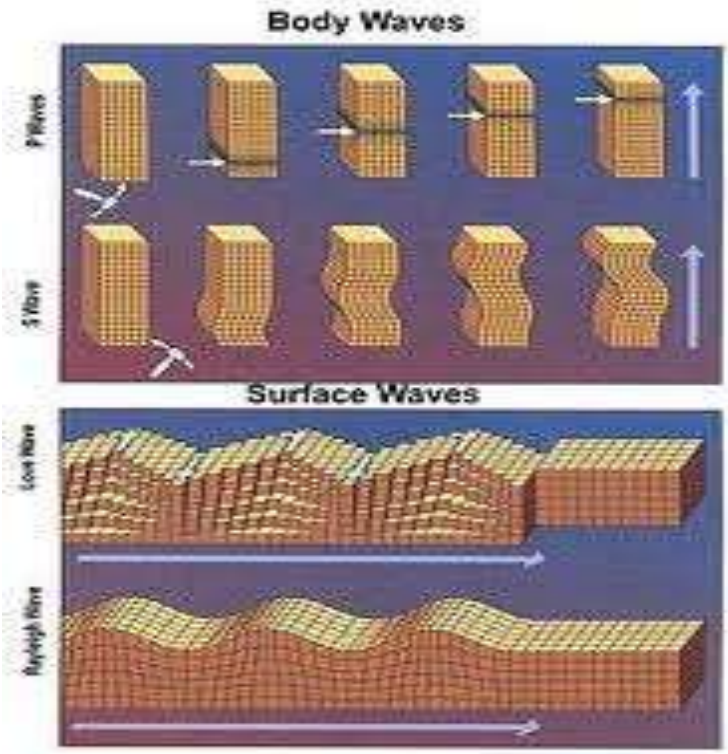
Shadow Zones and Their Formation

Meaning of Shadow Zone: When earthquake takes place, all the places on the earth surface do not record the seismic waves. There are some zones where seismic waves [P and S waves] do not reach during an earthquake. It is called as shadow zone. Shadow zones are formed due to two reasons:

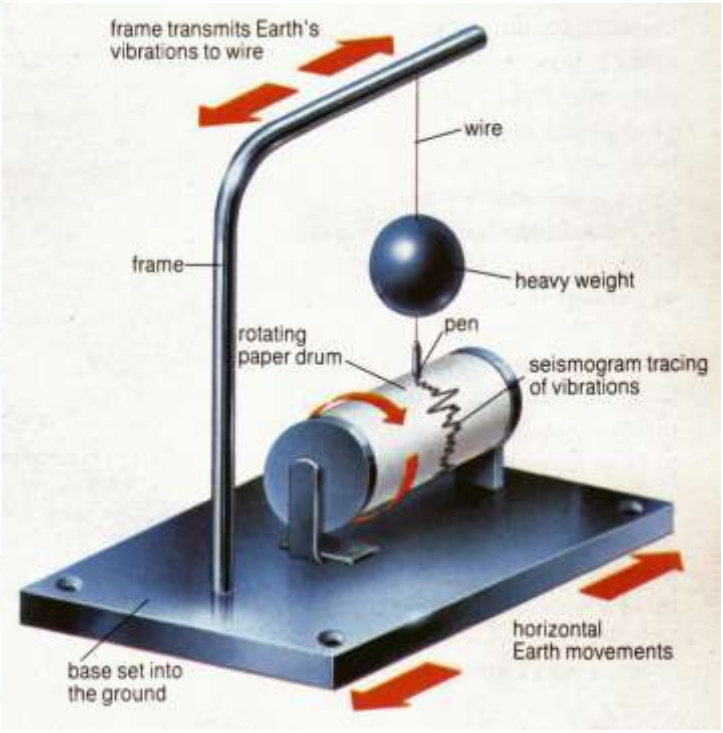
a) Three layers in the earth
b) Varying density of each layer
c) Liquid condition of the mantle

- P Wave Shadow Zone: Ideally seismic waves should move in straight line but due to varying density of layer P wave moves in a curved path. Due to this an area around the earth does not record P wave. This zone is from 105^0 to 145^0 from the focus.

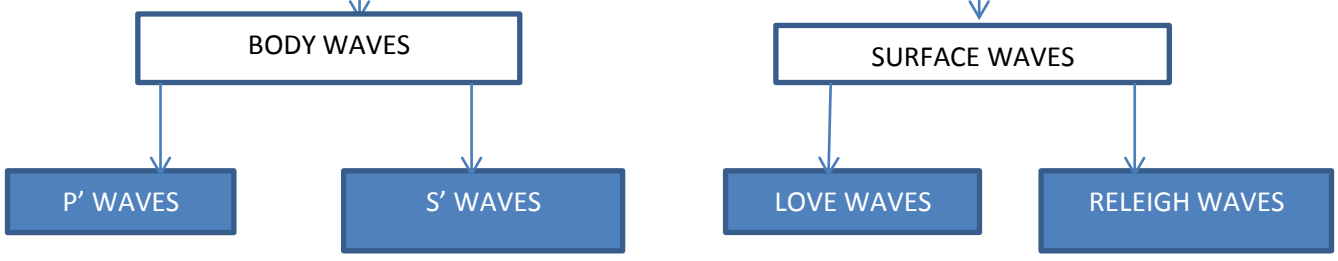
- S Wave Shadow Zone: It is larger zone than P wave shadow zone. It developed because S wave does not pass through liquid mantle of the earth. Therefore, the zone from 105^0 all around the earth from the focus is called as S wave shadow zone.



SEISMOGRAPH



TYPES OF EARTH QUAKE WAVES



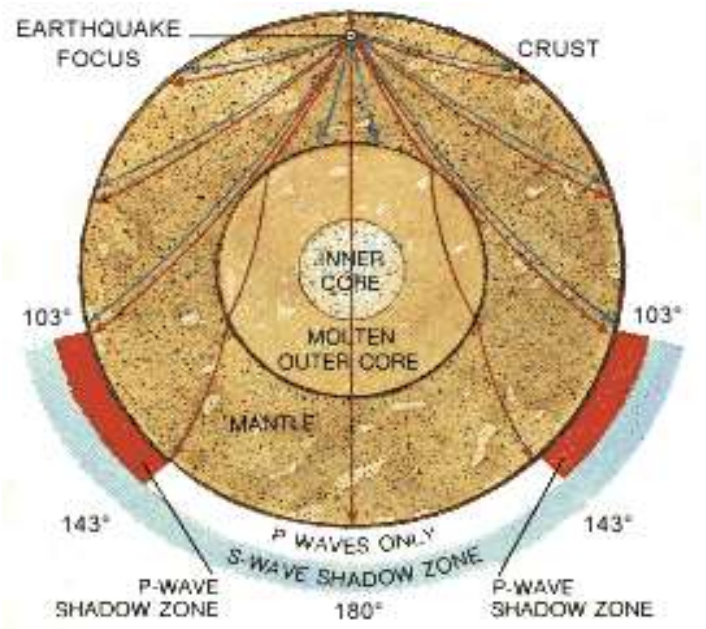
BODY WAVES GENERATED DUE TO ENERGY GENERATED IN THE EARTH'S INTERIOR
They interact with the surface rocks and generate other waves called surface waves
The velocity of the waves changes along with the density of material, denser the material higher the velocity
Their direction also changes according to the density of the material

PROPAGATION OF EARTHQUAKE WAVES
When they travel in the body they vibrate the bodies of the rocks
P waves vibrate parallel to their direction of the movement

It led to the density difference in the material due to stretching and squeezing
Other three waves vibrate perpendicular to their direction

They create troughs and crests over the surface

EMERGENCE OF SHADOW ZONE



Where earthquake waves are not reported, such zones are called earthquake shadow zones.
It is observed that seismographs located beyond 103° from the epicenter do not record the earthquakes.

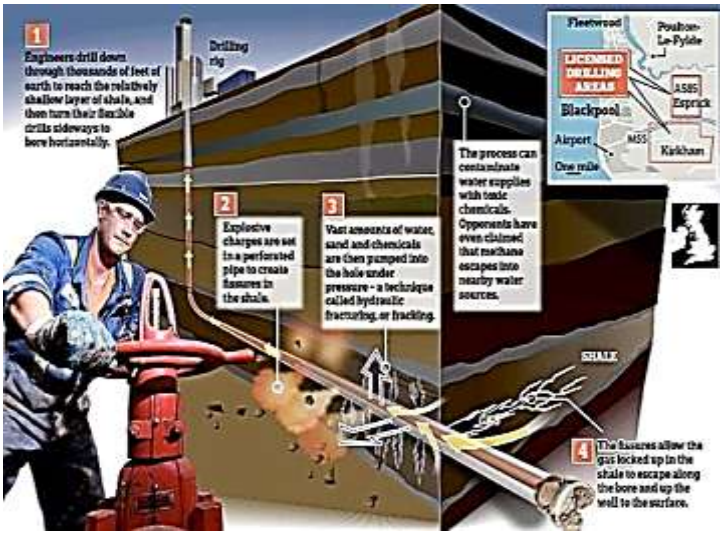
Seismographs located beyond 142° again record 'p' waves only .
The entire zone beyond 142° do not receive 's' waves

The shadow zone of 's' waves is much larger than the 'p' waves it is equal to 40% of the earth surface

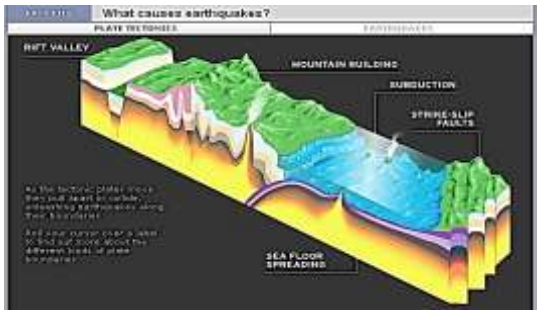
TYPES OF EARTHQUAKES

INDONE

MINING EARTH QUAKE - SOUTH AFRI



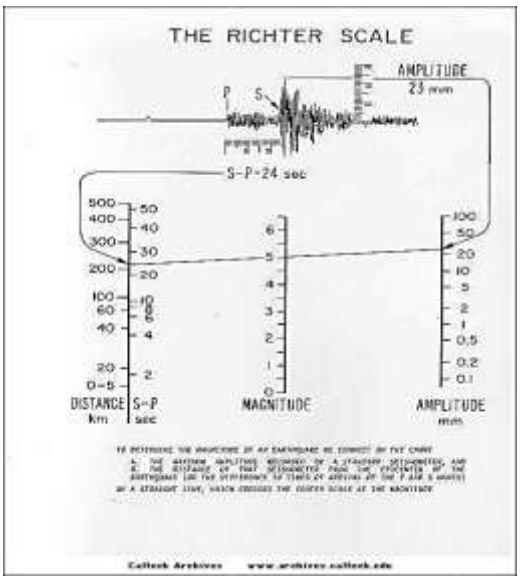
TECTONIC EARTH QUAKE GUJARAT

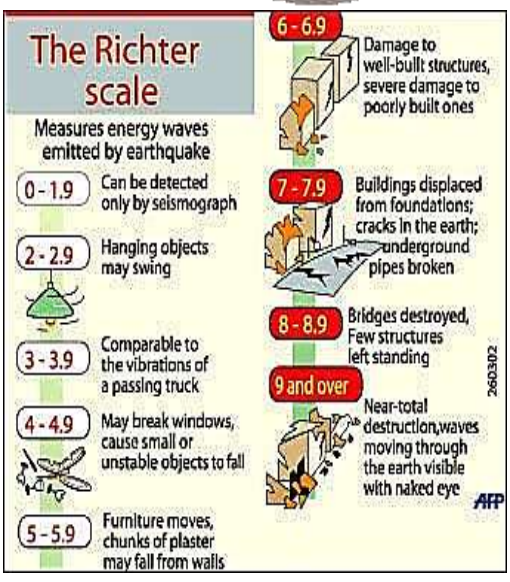


NUCLEAR EXPLOSION EARTH QUAKE JAPAN

RESERVOIR IMPOUND EARTHQUAKE TEHRI DAM

HOW IS EARTH QUAKE MEASURED-RICHTER SCALE





The magnitude of most earthquakes is measured on the **Richter scale,** invented by Charles F. Richter in 1934. The Richter magnitude is calculated from the amplitude of the largest seismic wave recorded for the earthquake, no matter what type of wave was the strongest.

The Richter magnitudes are based on a logarithmic scale (base 10). What this means is that for each whole number you go up on the Richter scale, the amplitude of the ground motion recorded by a seismograph goes up ten times. Using this scale, a magnitude 5 earthquake would result in ten times the level of ground shaking as a magnitude 4 earthquake (and 32 times as much energy would be released). To give you an idea how these numbers can add up, think of it in terms of the energy released by explosives: a magnitude 1 seismic wave releases as much energy as blowing up 6 ounces of TNT. A magnitude 8 earthquake releases as much energy as detonating **6 million tons of TNT**. Pretty impressive, huh? Fortunately, most of the earthquakes that occur each year are magnitude 2.5 or less, too small to be felt by most people.

The Richter magnitude scale can be used to describe earthquakes so small that they are expressed in negative numbers. The scale also has no upper limit, so it can describe earthquakes of unimaginable and (so far) inexperienced intensity, such as magnitude 10.0 and beyond.

Although Richter originally proposed this way of measuring an earthquake's "size," he only used a certain type of seismograph and measured shallow earthquakes in Southern California. Scientists have now made other "magnitude" scales, all calibrated to Richter's original method, to use a variety of seismographs and measure the depths of earthquakes of all sizes.

The Mercalli Scale

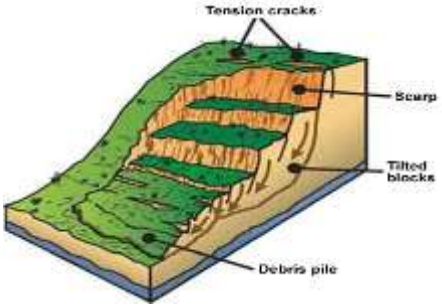
Here's a table describing the magnitudes of earthquakes, their effects, and the estimated number of those earthquakes that occur each year.

Modified Mercalli Scale		Richter Magnitude Scale
I	Only felt by sensitive instruments	1.5
II	Felt by few persons at rest, especially on upper floors, delicate suspended objects may swing	2.0
III	Felt indoors, but may not be recognized as earthquake, vibrations like large passing truck	2.5
IV	Felt indoors by many, some outdoors, may awaken some sleeping persons; dishes, windows, doors may move, cars rock.	3.0
V	Felt by most; some windows, dishes break; tall objects may fall.	3.5
VI	Felt by by all, falling plaster and chimneys, light damage but some fear.	4.0
VII	Very noticeable, damage to weaker buildings on fill; driving automobiles notice.	4.5
VIII	Walls, monuments, chimneys, bookcases fall; liquifaction; driving is difficult	5.0
IX	Buildings shifted off foundations, cracked and twisted; ground is cracked and underground pipes are broken.	5.5
X	Most structures severely damaged to destroyed; ground is cracked, rails are bent, landslides on steep slopes	6.0
XI	Few structures standing; bridges and roads severely damaged or destroyed, large fissures in ground	6.5
XII	Total damage; can see the earthquake wave move through the ground; gravity overcome and objects thrown into the air	7.0
		7.5
		8.0

EFFECTS OF EARTH QUAKE

GROUND SHAKING

LAND &MUD SLIDES



AVALANCHES

GROUND LURCHING

SOIL LIQUEFACTION

GROUND DISPLACEMENT

FLOODS FROM DAM

FIRES

STRUCTURAL COLLAPSE

TSUNAMI

First six listed above have some hearings upon landforms while others may be considered the effects causing immediate concern to the life and properties of people in the region.

Tsunami occurs when the epicenter is below the ocean floor with sufficient magnitude. Tsunamis are waves generated by the termers not by the earthquake. The magnitude should be more than 5 in Richter scale.

The earthquakes of magnitude 8+ are rare occurs once in 1-2 years .tiny types occur every minute.

The structure of the Earth

Imagine a Scotch egg.....

1. The outer shell of the Earth is called the **CRUST** (breadcrumbs)
2. The next layer is called the **MANTLE** (sausage meat)
3. The next layer is the liquid **OUTER CORE** (egg white)
4. The middle bit is called the solid **INNER CORE** (egg yolk)

The deepest anyone has drilled into the earth is around 12 kilometers, we've only scratched the surface. How do we know what's going on **deep** underground?

There are lots of clues:

- 1.The overall density of the Earth is much higher than the density of the rocks we find in the crust. This tells us that the inside must be made of something much denser than rock.
- 2. Meteorites (created at the same time as the Earth, 4.6 billion years ago) have been analyzed. The commonest type is called a contrite and they contain iron, silicon, magnesium and oxygen (Others contain iron and nickel). A meteorite has roughly the same density as the whole earth. A meteorite minus its iron has a density roughly the same as Mantle rock (e.g. the mineral called olivine).
- 3. Iron and Nickel are both dense and magnetic.
- 4. Scientists can follow the path of seismic waves from earthquakes as they travel through the Earth. The inner core of the Earth appears to be solid whilst the outer core is liquid (s waves do not travel through liquids). The mantle is mainly solid as it is under extreme pressure (see below). We know that the mantle rocks are under extreme pressure, diamond is made from carbon deposits and is created in rocks that come from depths of 150-300 kilometers that have been squeezed under massive pressures.

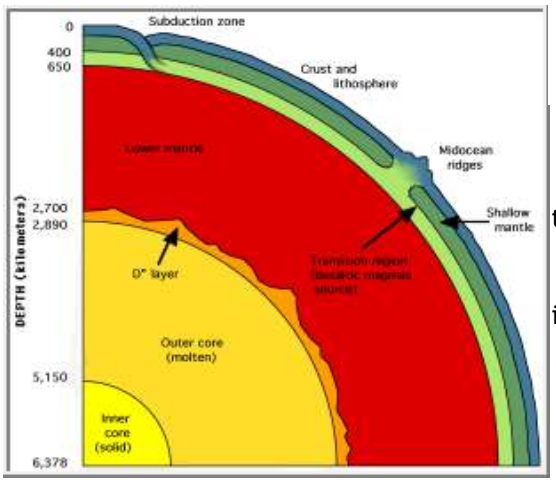
5. The Earth is sphere (as is the scotch egg!) with a diameter of about 12,700 Kilometers. As we go deeper and deeper into the earth the temperature and pressure rises. The core temperature is believed to be an incredible 5000-6000°c.

6. The crust is very thin (average 20Km). This does not sound very thin but if you were to imagine the Earth as a football, the crust would be about ½ millimeter thick. The thinnest parts are under the oceans (OCEANIC CRUST) and go to a depth of roughly 10 kilometers. The thickest parts are the continents (CONTINENTAL CRUST) which extend down to 35 kilometers on average. The continental crust in the Himalayas is some 75 kilometers deep.

7. The mantle is the layer beneath the crust which extends about half way to the centre. It's made of solid rock and behaves like an extremely viscous liquid - (This is the tricky bit... the mantle is a solid which flows????) The convection of heat from the center of the Earth is what ultimately drives the movement of the tectonic plates and cause mountains to rise. Click here for more details

The outer core is the layer beneath the mantle. It is made of **liquid** iron and nickel. Complex convection currents give rise to a dynamo effect which is responsible for the Earth's magnetic field.

8. The inner core is the bit in the middle!. It is made of **solid** iron and nickel. Temperatures in the core are thought to be in the region of 5000- 6000° c and it's solid due to the massive pressure.



EARTH STRUCTURE

The crust - the Outer most solid part

1. Brittle in nature
2. Thickness is 5 km. thin under the oceans and thick under the continents
3. 30 km under oceans and 70 km under mountains

Density in the ocean floor is 3g/cm^3(basalt) mean density is 2.7g/cm^3

The mantle

1. Second layer from the top of the earth
2. 2. it extends from Moho-discontinuity to a depth of 2900 km.
3. 3.the upper portion of the mantle is called ASTHENOSPHERE (Astheno= weak it extends up to 400 km)
4. 4. it is the source of magma
5. average density is 3.4g/cm^3
6. 6. crust and upper most part of the mantle is called Lithosphere. Its thickness is 10 -200km
7. 7. Lower mantle is in solid state

The core

1. It extends from 2900 km to 6300 km depth
2. 2. Outer core is liquid while inner core is solid
3. 3. outer core density is 5 g/cm^3 inner core is 13 g/cm^3
4. made of heavy metals such as Nickel and Iron
5. it is also called as **Nife**

VOLCANOES AND VOLCANIC LANDFORMS

A volcano is place where gases, ashes and or molten rock material lava escape to the ground.

Active volcano Mount Pinatubo, Philippines in 1991.

Lava from Mt. Kilauea pouring into the ocean during the sunset

The Differences between Active, Dormant and Extinct volcanoes

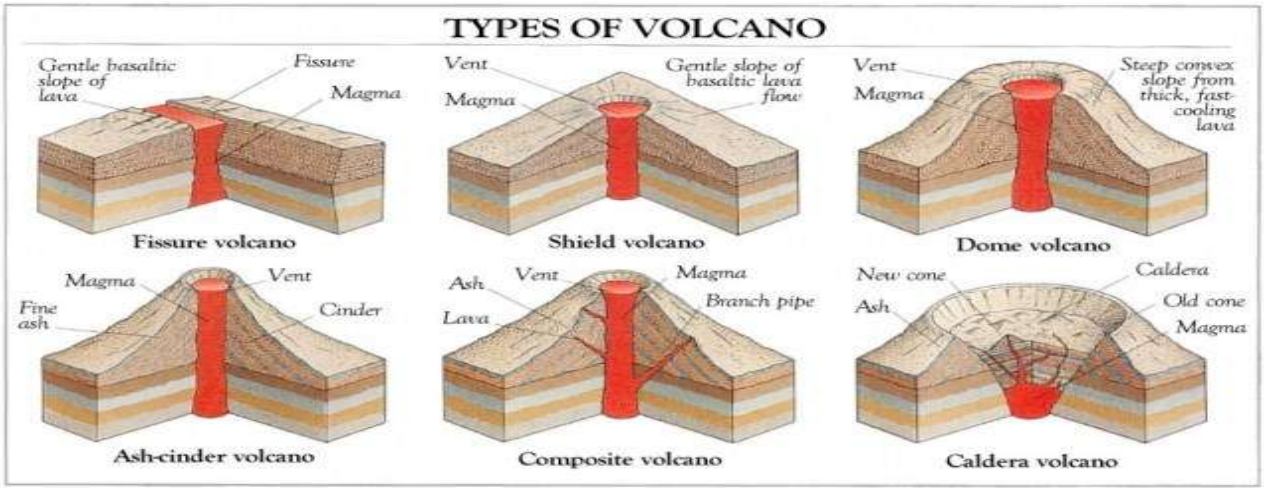
Active Volcano: Is a volcano that is currently erupting or shows signs of unrest activities, like earthquake activity or significant amounts of gas discharged. It is a volcano that is not presently erupting, but has erupted in the past is considered likely to do erupt in the future again.

One of the dormant volcanoes in the Cascades in the "Three Sister Area."

Dormant: These volcanoes are also called "Sleeping" volcanoes because it is presently inactive, but could erupt again. For example, the majority of the Cascade volcanoes arebelieved to be dormant rather than extinct.

This is an Aerial view of Crater Lake in Oregon.

Extinct: Is a volcano that is presently not erupting, that is unlikely to do so for a very long time in the future.



Classification of volcanoes based on nature of eruption and land forms developed on the surface.

SHIELD VOLCANO

1. Largest of volcanoes
2. Hawaiian islands are best examples
3. Basalt lava flow
4. Lava is very fluid
5. They are not steep
6. They become explosive when water is held in tovent
7. Develops in to cinder cone

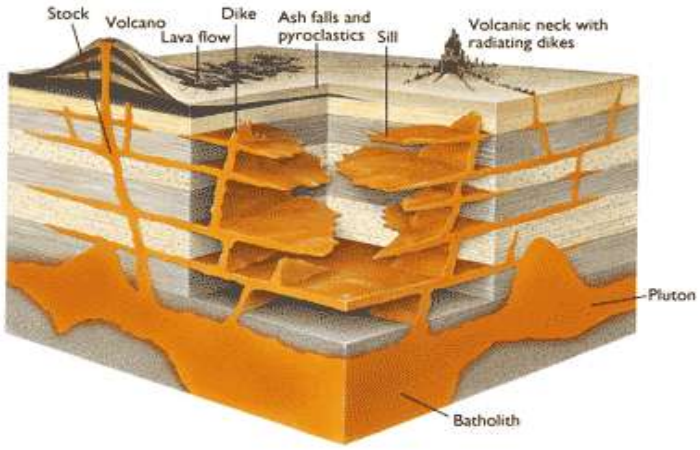
COMPOSITE VOLCANOES

1Cool and more viscous lava
2.Explosive eruptions
3.They erupt pyroclasitc and ashes along with lava
4.Layers are formed

CALDERA

1.These are the most explosive type of volcanoes

2.They collapse themselves and form into lakes
3.The magma chamber is huge and found nearby



FLOOD BASALT PROVINCES

1. Consists of highly fluid lava
2. Some parts of the world are covered by thousands of sq.km of basalt
3. there can be series of flows
4. Average thickness is more than 50 km
5. Individual flow is 100 of sq.k.m
6. Ex. Deccan plateau

MID OCEANIC RIDGES VOLCANOES

1. Found in oceanic surfaces
2. More than 70,000 km length
3. Frequent volcanic eruptions
4. Ex. Mid Atlantic ridge

INTRUSIVE VOLCANIC LANDFORMS

1.when volcanic eruption takes place some lava comes out and some settle down in the lithosphere.
2.when lava comes out forms volcanic rocks, some part cools down in the lower portion forms plutonic rocks

INTRUSIVE FORMS OCCUR INSIDE THE CRUST.

BATHOLITH:

A large part of the magma material that cools in the deeper depthof the crust. They are dome shaped, cover large areas,
They come out when erosion takes place.they are granite bodies.
LACOLITHS: large dome shaped intrusive bodies. Consists of level bodies
Connected through pipe like conduit from below it resembles composite volcanoes found deeper depthsthey are localised source of lava
Ex. Karnataka plateau
LAPOLITHS:concave shaped lava formation phacoliths: wave typed lava formation
SILL: horizontal sheet of lava
DYKES: vertical lava formation