

## EARTHQUAKES

The very term "Earthquake", when mentioned, generally creates a sense of panic & calamity in the minds of people, since many earthquakes have taken heavy tolls of life & property in the past, in many countries.

### Causes of Earthquakes:

- Earthquakes with a focus depth less than 60 km are shallow earthquakes.
- If the depth is more than 60 km but less than 300 km, they are intermediate earthquakes.
- Others which have a focus depth more than 300 km are deep earthquakes.

Tectonic earthquakes: These are exclusively due to internal causes, i.e., due to disturbances or adjustments of geological formations taking place in the earth's interior.

### Non-Tectonic eq. earthquakes:

These are generally due to external or surfacial causes. This type of earthquake is very frequent. Such earthquake occurs due to variety of reasons.

- Due to avalanches.
- Due to huge waterfall
- Due to Meteors
- Due to the occurrence of sudden & major landslides.
- Due to Volcanic eruptions

- Due to T-sunamis
- Due to Man-made explosions.
- Due to dams + arsenic.

### Sesmic Belts & Shield Areas:

- Sesmic Belts are those places where earthquake occurs frequently and shield areas are those places where earthquakes occur either rarely or very mildly.
- Occurrence of an earthquake in a place is an indication of underground instability there.
- In other words, all such places which are unstable are prone to earthquake occurrences.
- The study of recorded earthquake shows that they take place on land most frequently along two well-defined tracts, i.e., seismic belts.
- The other belt is circum Pacific belt which accounts for 68% of earthquake occurrence.
- The other belt is Mediterranean belt, which extends east-west from Portugal through Central Europe, Asia, Himalayas & Burma to the Indies with a branch through Tibet & China.
- This belt accounts 21% of earthquake occurrence.
- A minor belt of epicentres occurs along the mid-Atlantic ridge.

## Sesmic Waves:

These are 3 types P-waves, S-waves, and L-waves.

### P Waves:

These are variously called primary waves, push-pull waves, preliminary waves, longitudinal waves, compressional waves, etc....

→ They travel as fast as 8 to 13 km per second.

### S-waves:

→ These are also called shear waves, secondary, transverse waves, etc....

→ Compared to P waves these are relatively slow.

→ They travel the rate of 5 to 7 km/s.

L-waves These are called long waves or surface waves.

These are the slowest among the seismic waves.

∴ These are the last to be recorded in the seismic station at the time of occurrence of the earthquake.

→ They travel at the rate of 4 to 5 km/s.

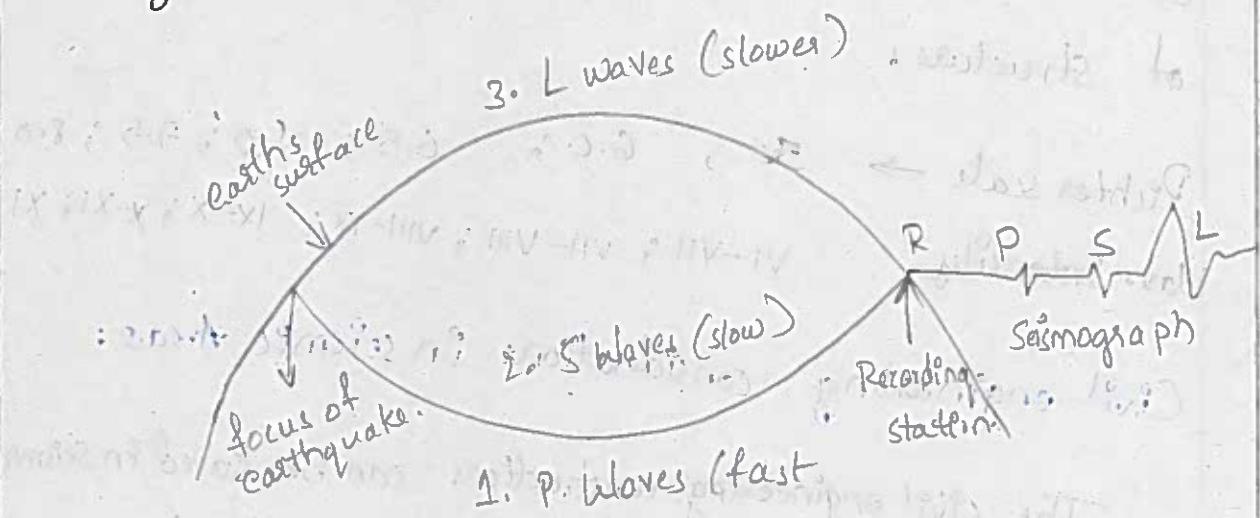


Fig: Seismic wave & seismograph sketch

## Richter Scale:

The Richter magnitudes are quite familiars because they are reported by the news media within few hours of earthquake.

Charles Richter proposed this scale using the size of the surface wave as recorded by a particular type of seismograph.

Earthquake may have Richter magnitude from 3 to 9, but no such shock smaller than 3 causes severe damage.

The energy released in earthquakes of different magnitudes is as follows.

$$M(\text{Richter}) = 3.0; 6.0; 6.5; 7.0; 7.5; 8.0; 8.4; 8.6$$

$$E(10^{20} \text{ erg}) = 0.08; 2.5; 14.1; 80; 446; 2500; 10,000; 20,000$$

The maximum intensity of shaking attained during an earthquake of a given magnitude depends upon the depth of focus and the soil conditions below the foundation of structures.

Richter scale $\rightarrow$	5.0; 6.0; 6.5; 7.0; 7.5; 8.0
Max. Intensity	VI-VII; VII-VIII; VIII-IX; IX-X; X-XI; XI

## Civil engineering considerations in seismic areas:

The civil engineering constructions can be saved in seismic areas if the earthquake can be stopped or if the constructions can be made strong & earthquake proof.

$\Rightarrow$  The exact place of earthquake occurrence.

- Magnitude of the earthquake.
- The duration of the earthquake
- The direction of movement of the group at the time of the earthquake.

### Safety factor:

The base shear force is assumed by the formulae.

$$F = a g .$$

$\therefore a$  = acceleration due to earthquake

$g$  = acceleration due to gravity.

After knowing  $F$ , the overturning moment is calculated

$$M = F Y .$$

$\therefore Y$  = vertical distance of the centre of gravity.

### Construction of Buildings - Precautionary Measures:

- Buildings should be founded on hard bedrock only & never on loose soils or fracture soils.
- This is so because loose ground settles due to earthquake vibrations.
- Foundation should be thoroughly tied up by incorporating keys or reinforcements.
- Buildings should have flat RCC roofs & they should be designed not to yield to lateral stress.
- Slates, tiles & corrugated sheets are unsuitable as roofing material.
- Projections above the roofs are undesirable

## Landslides:

- If a mass of earth or rock moves along a definite zone or surface, the failure is called landslide.
- Debris slides, rock slides & rock falls are the important types of landslides.
- Debris slides are the failures of unconsolidated material on a surface of rupture.
- Rock slides are the movements of essentially consolidated material which mainly consist of recently detached bedrock.
- Rockfalls refer to the blocks of rocks of varying sizes suddenly crashing downwards along steep slopes.

## Causes of Landslides:

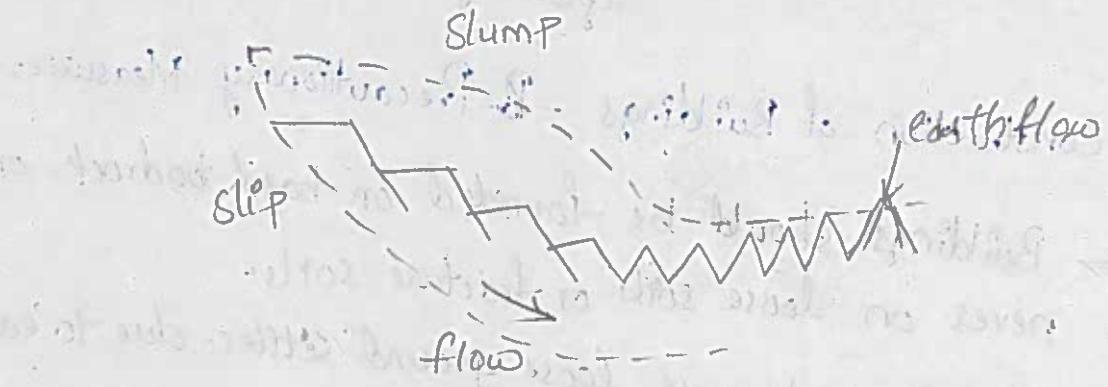


Fig: Debris slide grading into earth flow

## Causes of Landslides:

- Landslides occur due to various causes.
- Broadly, they may be grouped into 2 types i.e.,  
Inherent or internal causes and immediate cause.
- The internal causes are responsible to the extent of creating favourable or suitable conditions for landslide occurrence.

## Effects of landslides:

- If landslides occur at vulnerable places, they may cause:
  - Disruption of transport or blocking of communication
  - Obstruction to the river flow in valleys, leading to their overflow & floods.
  - Damage to sewer & other pipelines.
  - Burial or destruction of buildings and other constructions.
- In addition to these problems, they may cause earthquakes too.

## Preventive Measures for landslides:

- Most factors which contribute to landslide occurrence are slope, water content, structural defects, unconsolidated or loose character of the overburden, lithology & human interference.
- To counter the effect of slope.
- To counter the effect of water.
- To counter the structural defects.
- Not to resort to reduce the stability of existing slopes.
- To counter the loose nature of overburden.
- Avoiding heavy traffic & blasting operations.

## IMPORTANCE OF GEOPHYSICAL STUDIES.

### Importance of Geophysical Study by Gravity Method

Gravity methods represents a set of geophysical methods which make use of the natural gravity field of Earth.

#### Physical Property:

"Density" property of the materials is the controlling physical property.

#### Principle:

The nature of distribution of gravity  $g$  on the surface is analysed. The gravity is influenced positively of the heavier, larger and occurs at a shallow depth.

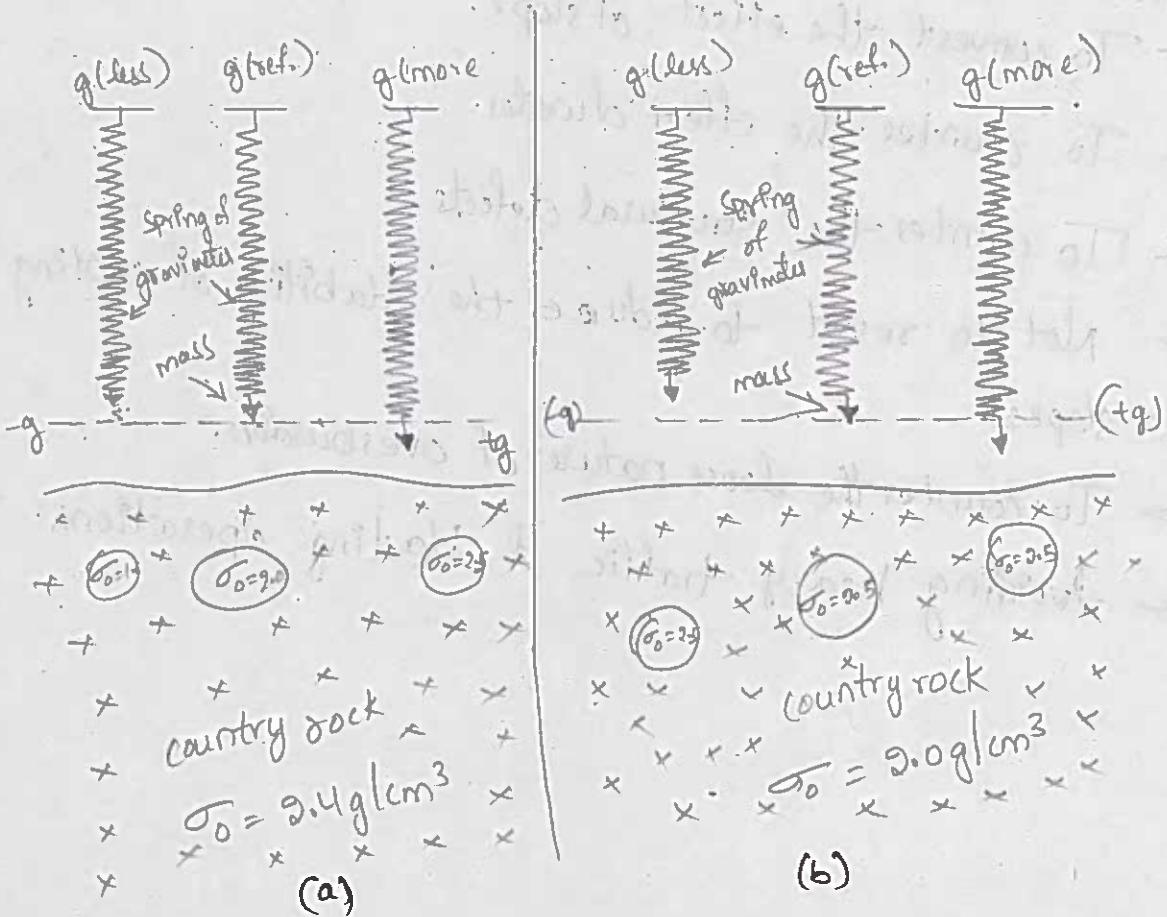


Fig. (a,b) Principle of gravity method.

### Parameters:

$\Delta g$  = variation of gravity field.

$U_{x_3}$  = horizontal gradient

$U_{22}$  = Curvature of equipotential.

### Applications:

- In exploration of ore deposits
- In solving regional geological problems.
- In subsurface geological & structural mapping.
- In exploration of oil & natural gas deposits
- In the study of isostasy, shape of earth etc...,

### Magnetic Method:

These investigations also take advantage of the natural magnetic field associated with the earth & its relation to subsurface geology.

### Controlling property:

The main controlling physical property in magnetic methods is magnetic susceptibility.

### Principle:

The magnetic methods are based on the fact that the magnetic bodies present in the earth's subsurface contribute to the magnetic field of the earth.

### Parameters:

→ Total magnetic field

→ different space components (vertical ( $Z$ ), horizontal ( $H$ ), inclination ( $I$ ), declination ( $B$ )).

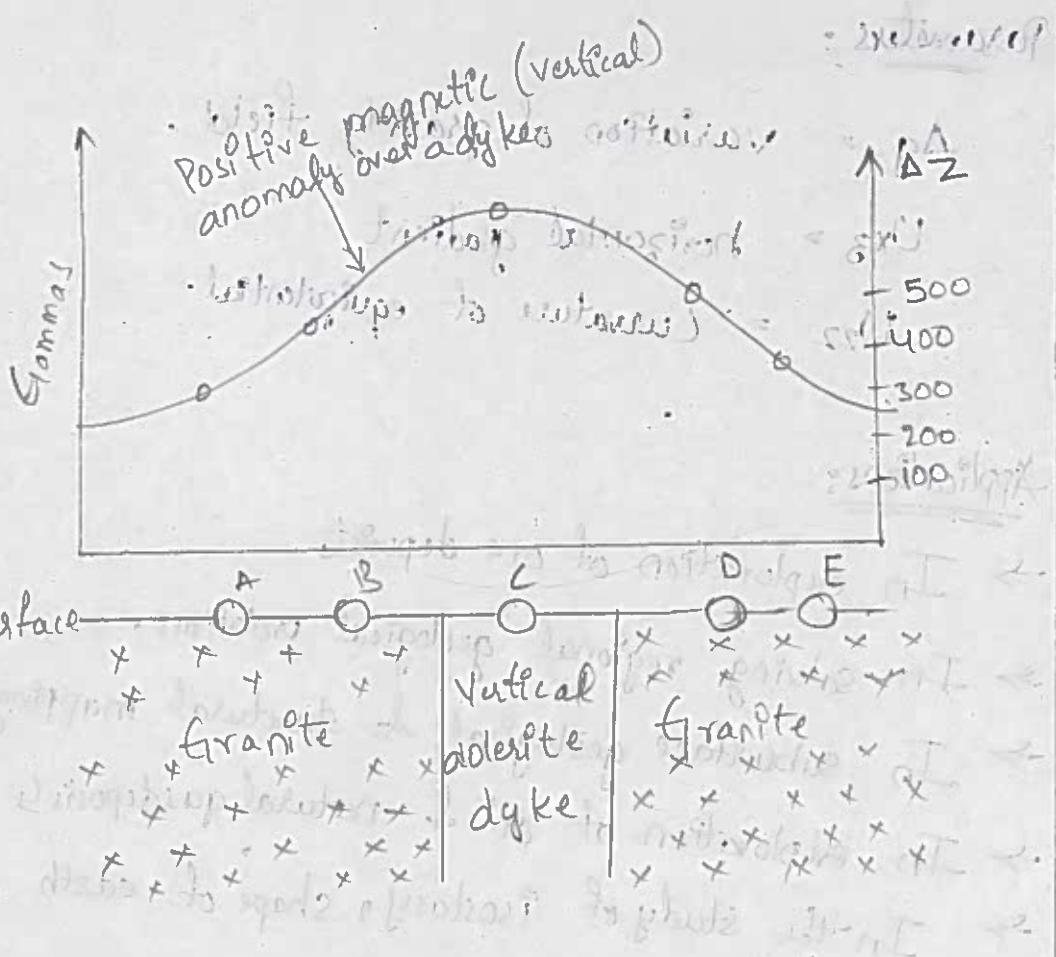


Fig: Principle of magnetic method.

### Applications:

- For the delineation of large structural forms favourable for the accommodation of oil & gas deposit.
- For detection & demarcation of basic & ultrabasic bodies.
- For location & tracing of faults.

### Electrical Methods:

Among the different methods electrical method are numerous & more versatile.

### Controlling Properties:

These are different physical properties which are helpful in investigation.

In electrical methods employing d.c. energization, such a physical property is called the electrical resistivity.

## Seismic Methods:

### controlling property:

Elastic property differences in rocks is the controlling property.

### Principle:

Seismic methods of study are based on the principle that subsurface rock formations bear differences elastic properties.

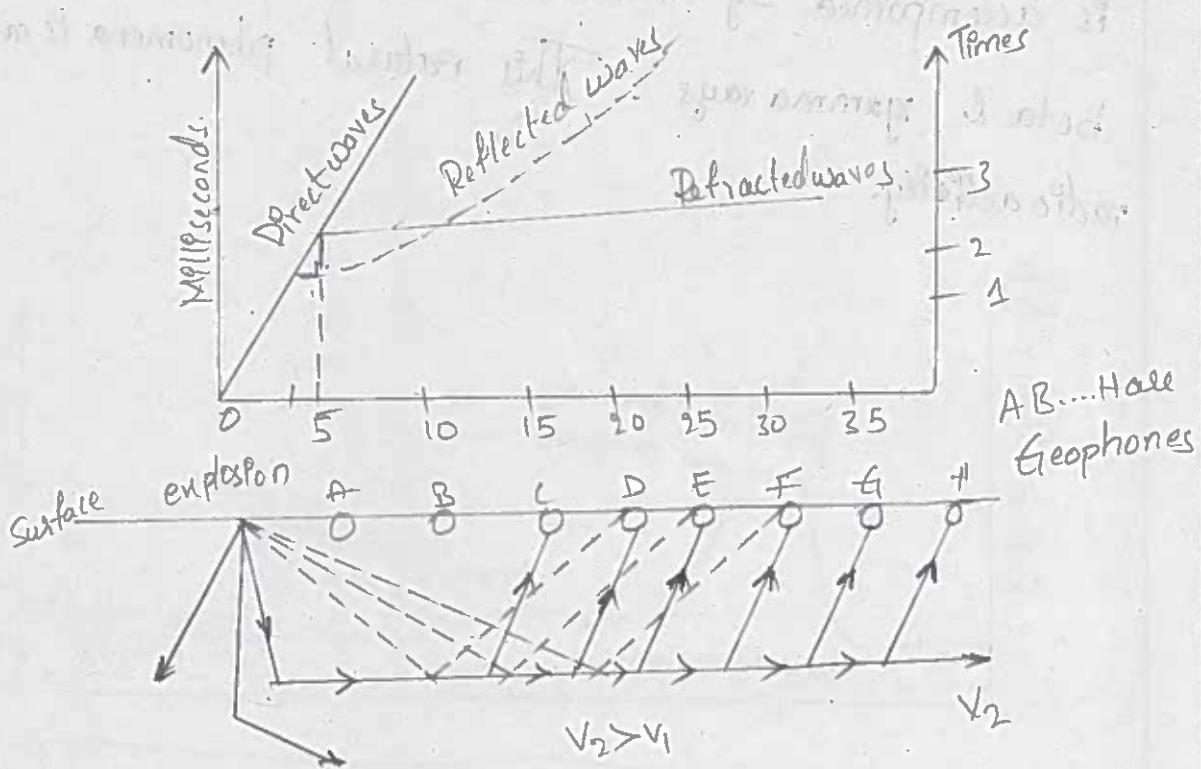


fig: seismic method

### Applications:

- Seismic reflection studies are effective for depths more than 100 metres but are not suitable for shallow explorations.
- Reflection methods of study are considered indispensable for oil exploration.
- These methods are also used to locate sulphur, limestone and gypsum beds.

## Radio metric methods:

controlling Property:

Natural radioactivity of rocks and ores.

### Principle:

The nuclei of certain elements are unstable & change spontaneously into the nuclei of other elements. This change is accompanied by emission of radiation known as alpha, beta & gamma rays. This natural phenomena is called radioactivity.

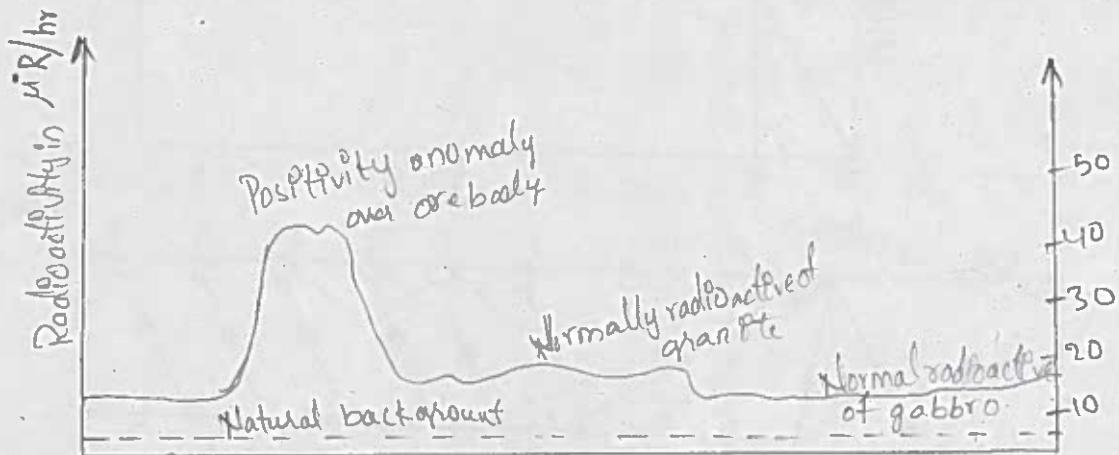


Fig Radiometric method.

### Applications:

- Exploration of uranium & thorium minerals deposits.
- Indirect location of some rare elements & rare earth metals.
- Geological Mapping:
- Exploration of oil & gas
- Ground water studies.
- In civil engineering.

## Influencing Electrical Resistivity:

The various geological factors which influence the electrical resistivity are. mineral content, compactness, moisture content, salinity of moisture & texture of the rock.

### Mineral content:

S.no	Name of Mineral	Resistivity $\rho$ ohm meters	Name of Rock	Resistivity $\rho$ ohm meters
1.	Quartz	$10^{14} - 10^{16}$	Granite	$10^2 - 10^5$
2.	Feldspar	$10^{10} - 10^{12}$	Gabbro	$10^3 - 10^5$
3.	Mica	$10^{10} - 10^{15}$	Basalt	$10^2 - 10^5$
4.	calcite	$10^4 - 10^{12}$	Clay, shale	$1 - 10^3$
5.	Tremolite	$10^4 - 10^6$	Conglomerate	$10 - 10^8$
6.	Magnetite	$0.5 - 10^4$	Sandstone	$10 - 10^3$
7.	Limonite	$10^6 - 10^8$	Limestone	$10^2 - 10^3$
8.	Pyrite	$10^4 - 10^2$	Gneiss	$10^2 - 10^3$
9.	Graphite	$10^4 - 0.5$	Marble	$10^4 - 10^2$

### Improvement of competency of sites by grouting:

- The method of grouting involves the forceful injection of a slurry of water & cement into the fractured rocks of the degree of competence required.
- Grouting reduces percolation by filling the fissures of the site rocks.
- To improve the strength, two special chemicals i.e., Sodium silicate & soln of chloride, are mixed with the slurry.