MAHALAKSHMI
ENGINEERING COLLEGE
TIRUCHIRAPALLI – 621213

DEPARTMENT: CIVIL **SEMESTER: VII**

SUB.CODE/ NAME: CE2403/ BASICS OF DYNAMICS AND ASEISMIC DESIGN

UNIT – III

ELEMENTS OF SEISMOLOGY

Causes of Earthquake – Geological faults – Tectonic plate theory – Elastic rebound – Epicentre – Hypocentre – Primary, shear and Raleigh waves – Seismogram – Magnitude and intensity of earthquakes – Magnitude and Intensity scales – Spectral Acceleration - Information on some disastrous earthquakes

Two Marks Questions and Answers

1. Define Seismology. And Earthquake

Seismology is the study of the generation, propagation generation and recording of elastic waves in the earth and the sources that produce them.

An Earthquake is a sudden tremor or movement of the earth's crust, which originates naturally at or below the surface. About 90% of all earthquakes results from tectonic events, primarily movements on the faults.

2. What are the causes of Earthquake?

Earthquake originates due to various reasons, which may be classified into three categories. Decking waves of seashores, running water descending down waterfalls and movement of heavy vehicles and locomotives, causes feeble tremors these earthquakes are feeble tremors, which don't have disastrous effects.

Contrary to the volcanic earthquake and those due to superficial causes, which can be severe, only locally, the more disastrous earthquakes affecting extensive

region are associated with movements of layers or masses of rocks forming the crust of the earth. Such seismic shocks, which originate due to crustal movements, are termed as tectonic earthquakes.

3. What is mean by Epicenter and focus?

The point at which the rupture begins and the first seismic wave originates is called focus or hypocenter. The point on the ground directly above the focus is called epicenter.

4. Write a short note on Plate Tectonic Theory

Tectonic is the study of deformations of earth materials that result from deformation. Plate tectonics refers to deformation on a global scale. The basic hypothesis of plate tectonics is that the surface of the earth consists of a number of large plates. These plates move relative to one another. The present six important plates are namely

1. African plate
2. American plate
3. Antarctic plate
4. Australian – Indian plate
5. Eurasian plate
6. Pacific plate

5. Write a short note on Seismic waves.

Large strain energy released during an earthquake travel as seismic waves in all directions through the earth's layers, reflecting at each interface. These waves area of two types, body waves and surface waves

6. Write a short note on Magnitude.

The magnitude of an earthquake is a measure of the amount of energy released. The earthquake scale is devised by Charles F. Richter, an American seismologist be based on the total amount of energy released during an earthquake be called magnitude.

7. What is mean by seismogram?

A seismogram is the graph output by a seismograph. It is a record of ground motion at a measuring station. The energy measured in a seismogram may result from earthquake or from some other source.

8. Write a note on Intensity.

Intensity indicates the intensity of shaking or extent of damage at a given location due to particular earthquake. Thus the intensity of some earthquake will be different at different places. Intensity is a measure earthquake in qualitative way by judging what actually happens on the ground, the damage to the buildings and other structures caused by earthquake waves.

9. What is Elastic rebound theory?

The concept of possible mode of origin of tectonic earthquakes is known as Elastic Rebound theory.

10. Name the types of fault.

(i) Dip-Slip fault

(ii) Strike-Slip fault

(iii) Oblique-Slip fault

11. What are the types of Dip-Slip fault?

Dip-Slip fault having two types they are

(i) Normal fault

(ii) Reverse fault

12. What are the types of Body waves and surface waves?

Body waves are mainly of two types, they are

(i) Primary waves (or) P-waves

(ii) Secondary waves (or) S-waves

Surface waves also having two types, they are

(i) Love waves

(ii) Rayleigh waves

13. Compare: Magnitude and Intensity of an earthquake.

Sl.No	Magnitude	Intensity
1.	Magnitude measures the energy release	Intensity measures the strength of

	at the source of the earthquake. It is determined from measurements on seismographs.	shaking produced by the earthquake at a certain location. It is determined from the effects on people, structure and natural environment.
2.	Magnitude of an earthquake is a quantitative measure of its size. Thus the magnitude of the earthquake is a single number which does not vary from place to place.	Intensity is a qualitative measure of an earthquake, based on the damage caused by them.
3.	Bhuj earthquake of January 2001 had a magnitude of 7.7 on Richter scale. The earthquake was felt over a large part of the state such as Bhuj, Ahmedabad etc. Magnitude of the earthquake of all the places remains same, i.e. 7.7.	The intensity of the same earthquake at Bhuj is different from the intensity at Ahmedabad vice-versa.

14. How the earthquakes are classified?

Earthquake can be classified into the following types.

(a) According to plate boundaries

(b) According to its depth of focus

(c) According to its origin of the earthquakes

(d) Based on magnitude (M).

15. What is the difference between Inter plate earthquakes and Intra plate earthquakes?

(i) **Inter plate earthquakes:** The earthquake occurring along the boundaries of the tectonic plates are called as inter plate earthquakes.

Example: 1987, Assam Earthquake

(ii) **Intra plate earthquakes:** The earthquakes occurring within a plate are called as intra plate earthquakes.

Example: 1993, Latur Earthquake

16. What are the factors influences the ground motion?

The factors which influence the ground motion are:

(i) Magnitude of earthquake

(ii) Epicentral distance

(iii) Local soil conditions

17. What is the difference between shallow, intermediate and deep focus earthquake?

(i) **Shallow-focus earthquake:** In this case, the seismic shocks originate at a depth of about less than 70 km. Nearly 80% of the world's earthquakes are shallow-focus earthquakes.

(ii) **Intermediate-focus earthquake:** In this case, the seismic waves originate at a depth between 70 km to 300 km.

(iii) **Deep-focus earthquake:** Here, the point of origin of the seismic wave is at a depth of greater than 300 km.

18. What is Seismograph?

Seismograph is an instrument used to recording motions of the earth's surface caused by seismic waves, as a function of time. A modern seismograph includes five basic parts: a clock, a sensor called a seismometer that measures intensity of shaking at the instruments location, a recorder that traces a chart or seismogram, of the seismic arrivals, an electronic amplifier and a data recorder that stores the information for later analysis.

19. Explain volcanic Earthquake?

Earthquakes associated with volcanoes are more localized both in the extent of damage and in the intensity of the waves produced in comparison to those which are associated with faulting motions. Deep below the centre of volcano, hot magma moves slowly through underground passages under pressure, as its makes it ways towards the earth's surface. As this happens, the surrounding rock is put under pressure as the magma pushes against it. This causes the rock to fracture and small earthquakes to occur.

20. What are the basic difference between Focus and Epicentre?

Focus is the location within the earth where fault rupture actually occurs whereas the

epicentre is the location on the surface above the focus.

21. What is hypocenter?

Focus is an exact location within the earth where seismic waves are generated by sudden release of stored elastic building. It is called as hypocenter.

22. What is accelerogram?

A graph plotted between acceleration of ground and time is called accelerogram. The nature of accelerogram's may vary depending on energy released at focus, type of faults, geology along the fault plane and local soil.

23. Explain Uttarkashi earthquake of 1991?

An earthquake of magnitude 6.6 struck the districts of Uttarkashi, Tehri and Chamoli in the state of Uttar Pradesh on October 20, 1991. About 768 persons lost their lives, with about 5,066 injured. Maximum peak ground acceleration of about 0.31g was record at Uttarkashi. Many four-storey buildings in Uttarkashi with RC frame and infill walls sustained the earthquake. Howe ever, some of the ordinary RC buildings collapsed.

24. Enumerate TSUNAMI.

A tsunami is a wave train or series of waves, generated in a body of water by an impulsive disturbance that vertically displaces the water column. Tsunami is a Japanese word with the English translation, "harbour wave". The term "tsu" means harbour and "nami" means wave. Tsunami can be generated when the sea floor abruptly deforms and vertically displaces the overlaying water. Tectonic earthquakes are a particular kind of earthquakes that are associated with the earth's crustal deformation; when these earthquakes occur beneath the sea, the water above the deformed area is displaced from the equilibrium position. Waves are formed as the displaced water mass, which acts influence of gravity. When large areas of the sea floor elevate or subside, a tsunami can be created.

25. What is Focal depth and Epicentral distance?

(i) **Focal depth:** The distance between the epicentre and the focus is called focal depth.

(ii) **Epicentral distance:** The distance from epicentre to any of interest is called

epicentral distance.

16 MARKS

16 marks question and answer

1. Explain the Plate Tectonics Theory with neat sketch? [Nov | Dec 2007]

All major earth quakes are caused by plate tectonic, in India Assam earth quake in 1897 and 1950, and Bihar earth quake 1934 are the examples of plate tectonic earthquake.

- Convective flows of mantle materials cause the crust and some portion of mantle, to slide on hot molten outer core.
- This sliding of earth mass take place in pieces called tectonic plates.
- The surface of the earth consists of several major tectonic plates and many smaller ones. The following are the major tectonic plates

1. African plate
2. American plate
3. Antarctic plate
4. Australian-Indian plate
5. Eurasian plate
6. Pacific plate

- These plates move in different directions and at different velocities from those of the neighboring ones.
- If the accumulated stress exceeds the strength of the rocks making up these brittle zones, the rocks can break suddenly, releasing the stored energy as on earthquake.
- An earthquake begins when the plates push against each other and the pressure builds. Cracks start to appear in walls and roads.

Types of plate boundaries

There are three type of plate boundaries based on the inter-plate interactions (movement). They are

1. Convergent boundaries
2. Divergent boundaries
3. Transform boundaries as shown in Fig.

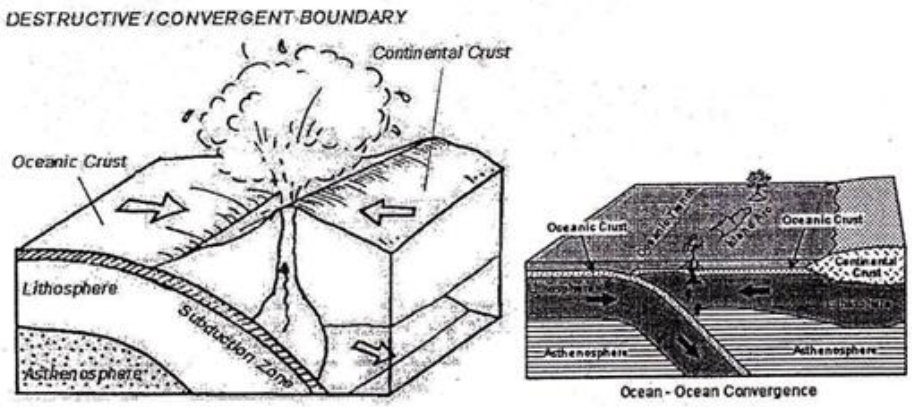
1. Convergent boundaries

In the convergent movement of the plates, the plate boundaries move towards each other and collide. The plate in the front is slower, then the plate is behind it comes and collapse (mountains are formed).

The convergent boundaries as a peculiarity like at the Himalayas that some times neither of the colliding plates wants to slide.

Collisions of a less dense continental plate with a more dense oceanic plate create a subduction zone where the denser plate dives beneath the lets dense plate. A collision between two continental plate results in general uplift in the form of a mountain.

Thus mountain systems are envisaged as born where the plate boundaries converge. When the converging plates come in contact with one another, heat and pressure may built-up at their boundaries. Depending on the collision of their movement, plate edges may break and generate earthquake.

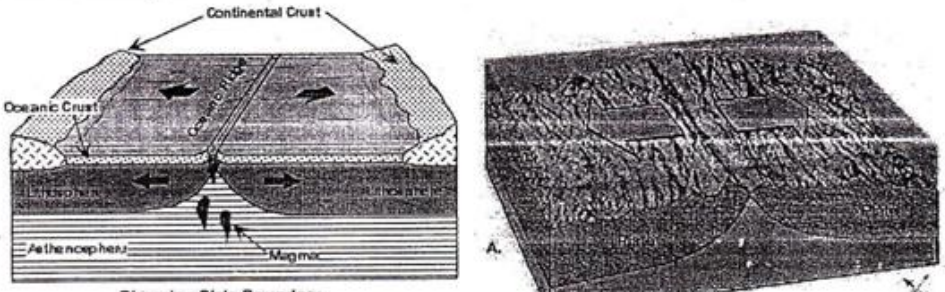


2. Divergent boundaries

In the divergent boundaries, the boundary of two adjoining large plates move away from each other, thereby form a gap which becomes the likely place lot upward movement of hot material from the lower mantle.

Due to this, there is a possibility of volcanic eruptions of extensive magnitude which would occur along the divergent boundaries of plates.

At extensional boundaries, earthquakes ate shallow, aligned strictly along the axis of spreading, and show an extensional mechanism Earthquakes in extensional environments tend to be smaller in magnitudes.

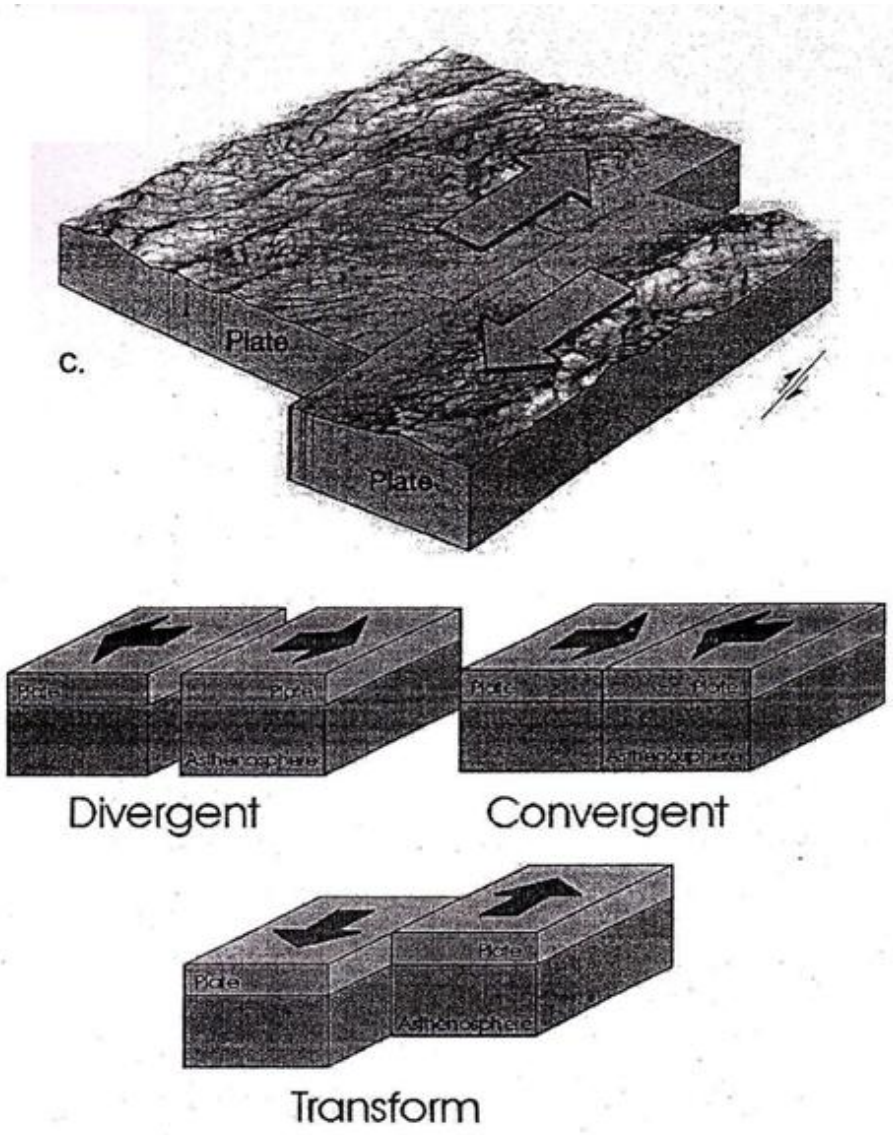


Diverging Plate Boundary
Oceanic Ridge - Spreading Center

3. Transform boundaries

In this boundary, two plates slide by one another in opposite directions or same direction. For example, the San Andrew Fault is the well-known fault with transform boundaries.

The rate of plate movement ranged from above 2 to 12cm per year.


c.
Plate
Plate
Plate
Plate
Asthenosphere
Plate
Plate
Asthenosphere
Divergent
Convergent
Plate
Plate
Asthenosphere
Transform

2. What causes the apparently solid and rigid Earth to move and so produce an earthquake?

Earthquakes mainly occur when the different blocks or plates that makes up the Earth's surface move relative to each other (Figure 2a), causing distortion in the rock (Figure 2b). The distortion builds up very slowly, over tens or hundreds of years.

When rocks are distorted very slowly they behave as if they were springs, or pieces of elastic, in being able to store energy when they are stretched or compressed. Prior to an earthquake, the area is like a spring-loaded system waiting to go off. Eventually the distortion is enough to cause the rock to break and move, releasing energy in the form of an earthquake. The break is called a fault.

It starts as a small fracture (Figure 2c), but grows rapidly (Figure 2d). In general, the larger the area of the fault, the greater is the size of the earthquake. The fault length (the length of the break along which rocks are displaced) can vary from metres for a small earthquake to about 1 000 km for a very large earthquake

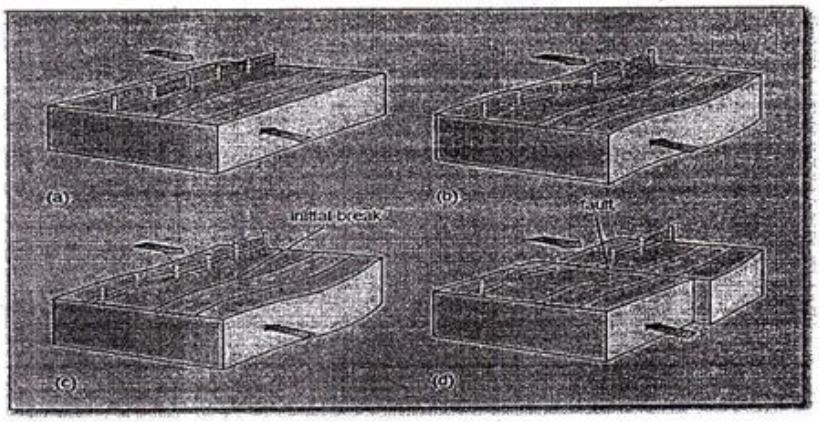


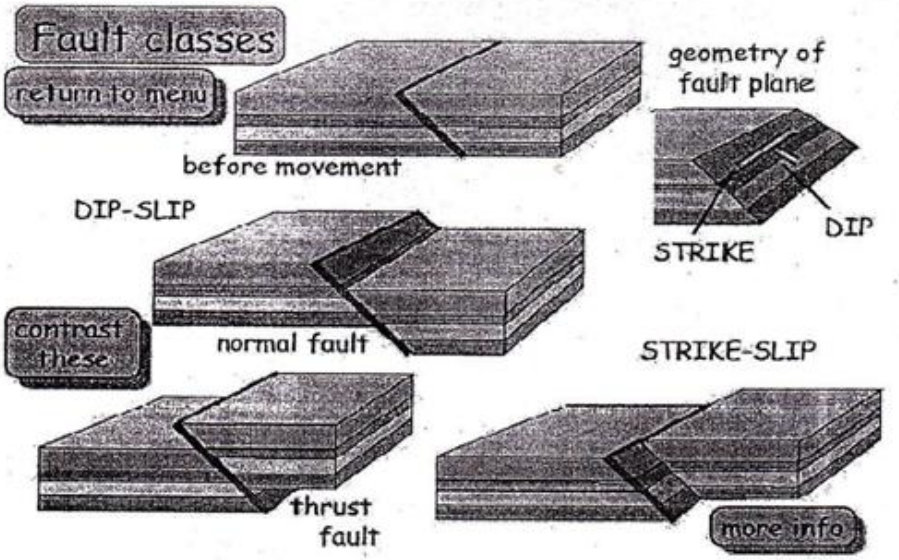
Figure 2 above shows the cause of an earthquake, using block diagrams, illustrating both the surface of the Earth and the Earth in cross-section.

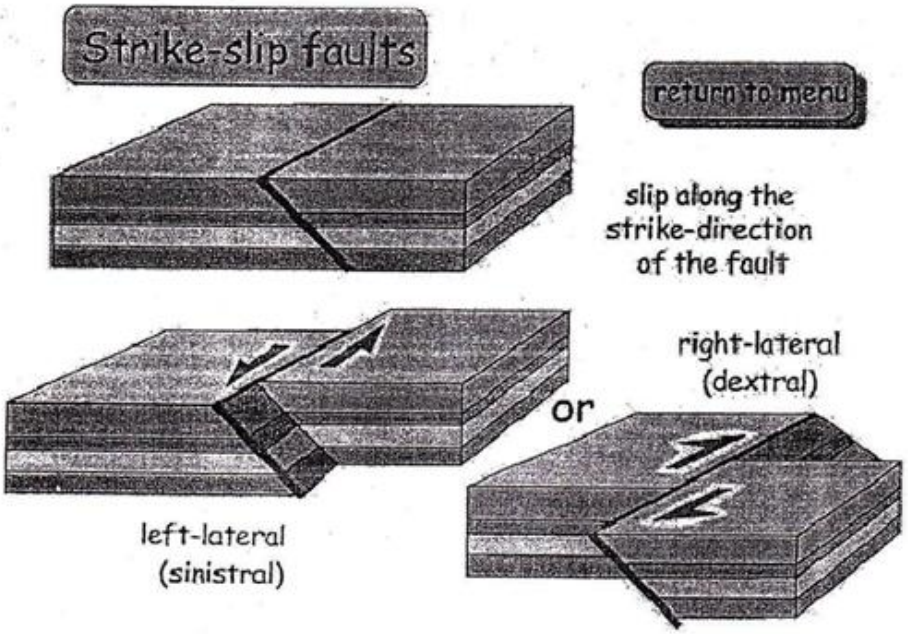
(a) Part of the Earth where forces (shown by arrows) are trying to move the rock in opposite directions.

(b) Before a fault breaks, the rocks stretch.

(c) When the distortion is enough to cause the rocks to break, the break starts at one point

(d) The break spreads rapidly along the fault, releasing energy. Note that faults are not always vertical and the forces causing movement can sometimes result in the rocks on either side of the fault moving up or down.


Fault classes
return to menu
before movement
geometry of fault plane
STRIKE
DIP
DIP-SLIP
normal fault
contrast these
STRIKE-SLIP
thrust fault
more info


Strike-slip faults
return to menu
slip along the strike-direction of the fault
right-lateral (dextral)
or
left-lateral (sinistral)

3. Explain the Elastic rebound theory with neat sketch? [May / June 2009]

- ✓ The concept of possible mode of origin of tectonic earthquakes is known as elastic rebound theory.
- ✓ According to professor of Geology H.f.Reid, materials of the earth being elastic, can withstand a certain amount of stress without deforming permanently, but if the stress is continued for a long period of time, or if it is increased in magnitude, the rocks will first take a permanent deformation or strain and eventually rupture.
- ✓ A fault is a break or fracture in the material of the earth along which there has been displacement.
- ✓ When the rupture occurs, rocks on either side of the fault tent to return to their original shape because of their elasticity and an elastic rebound occurs.
- ✓ This rebound sets up the seismic waves.
- ✓ The earthquake mechanism may be explained as occurring in three phases in aceordance with elastic rebound theory.

a. The preparing process
b. The rupture phase
c. The post failure adjustment

The **elastic rebound theory** is an explanation for how ***energy*** is spread during ***earthquakes.*** As rocks on opposite sides of a ***fault*** are subjected to force and shift, they accumulate energy and slowly deform until their internal strength is exceeded. At that time, a sudden movement occurs along the fault, releasing the accumulated energy, and the rocks snap back to their original undeformed shape.

In ***geology***, the elastic rebound theory was the first theory to satisfactorily explain earthquakes. Previously it was thought that ruptures of the surface were the result of strong ground shaking rather than the converse suggested by this theory.

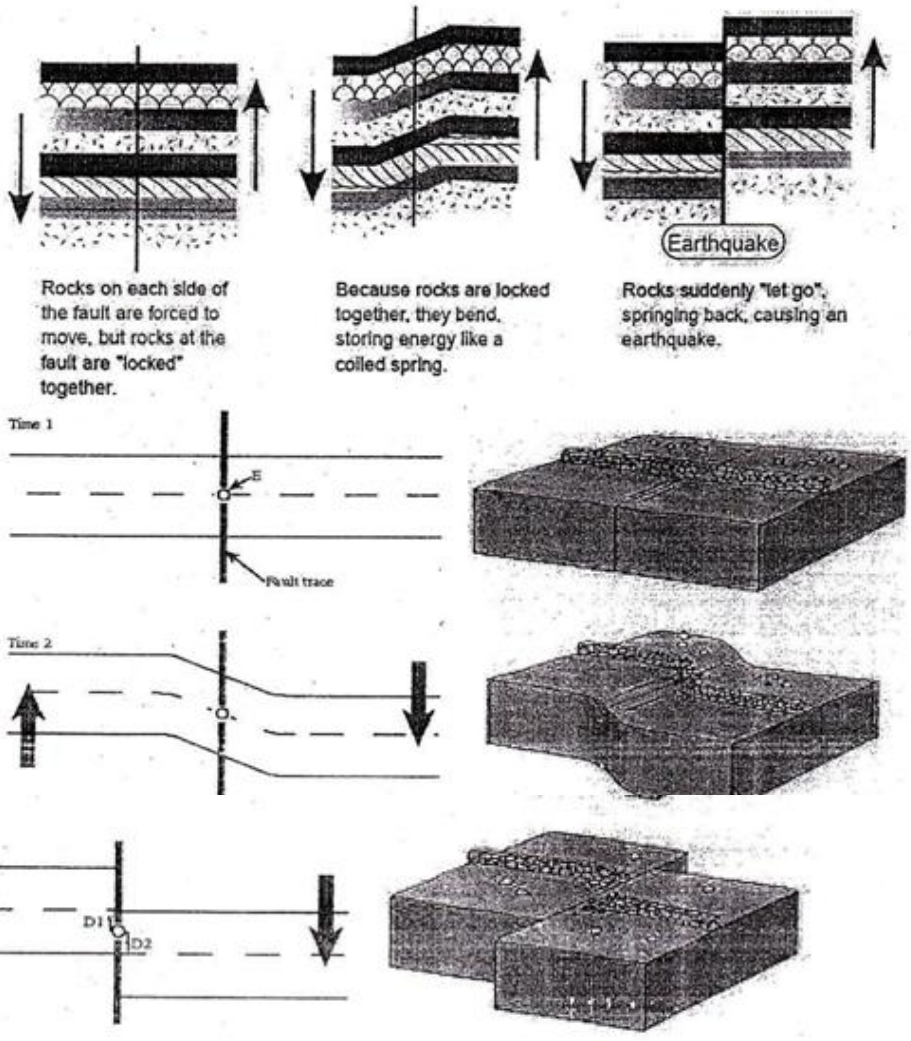
Ancient cultural explanations of earthquakes were often along the lines of the mythical Japanese *Namazu:* A giant catfish with the islands of Japan on his back. A demigod, or daimyojin, holds aheavy stone over his head to keep him from moving. Once in a while the daimyojin is distracted so Namazu moves and the Earth trembles.

The theory explained

Following the great 1906 San Francisco earthquake, Harry Fielding Reid examined the displacement of the ground surface around the San Andreas Fault.[1] From his observations he concluded that the earthquake must have been the result of the elastic rebound of previously stored elastic strain energy in the rocks on either side of the fault. In an interseismic period, the Earth's plates (see plate tectonics) move relative to each other except at most plate boundaries where they are locked. Thus, if a road is built across the fault as in the figure panel Time 1, it is perpendicular to the fault trace at the point E, where the fault is locked.

The far field plate motions (large arrows) cause the rocks in the region of the locked fault to accrue elastic deformation, centimeters per year, over a time period of many years. When the accumulated strain is great enough to overcome the strength of the rocks, an earthquake occurs.

During the earthquake, the portions of the rock around the fault that were locked and had not moved 'spring' back, relieving the displacement in a few seconds that the plates moved over the entire inter seismic period (D1 and D2 in Time 3). The time period between Time 1 and Time 2 could be months to hundreds of years, while the change from Time 2 to Time 3 is seconds. Like an elastic band, the more the rocks are strained the more elastic energy is stored and the greater potential for an event. The stored energy is released during the rupture partly as heat, partly in damaging the rock, and partly as elastic waves. Modern measurements using GPS largely support Reid's theory as the basis of seismic movement, though actual events are often more complicated.



4 Explain the Volcanic earthquake? (May) June 2009)

- ❖ Earthquakes associated with volcanoes are more localized both in the extent of damage and in the intensity of the waves produced in comparison to those which are associated with faulting motions.
- ❖ Deep below the centre of volcano, hot magma moves slowly through underground passages under pressure, as it makes its way towards the earth's surface.
- ❖ As this happens, the surrounding rock is put under pressure as the magma pushes against it; this causes the rock to fracture and small earthquakes to occur.

5 Explain the Rock Faults?

- Fault is a fracture having appreciable movement parallel to the plane of the fracture.
- The moot obvious feature related to faulting is the displacement of marker layers along the actual movement surface called the fault plane.
- The rocks forming the crust of the earth are subjected to stress at certain locations. The rocks along o weak portion in the earth's crust reach their strength, a sudden movement takes place.
- Opposite sides of the fault (a crack (or) fracture in the rocks where movement takes place) suddenly slip and release the large elastic strain energy stored in the interface rocks.
- Earthquakes are caused by the energy released during rapid slippage along faults.
- The largest examples are at tectonic plate boundaries and are called Interplate earthquakes (e.g. Assam earthquake 1987) but many faults occur far from active plate boundaries which are called intra-plate earthquakes (e.g. Lattur earthquake (1993)).
- Tectonic earthquakes commonly originate due to development of new faults within the crust or further displacement of already existing fault tones.

Types of Fault

Based on the directions of the movement of bocks, the faults can be classified into three categories.

1. Dip-Slip fault
2. Strike-Slip fault
3. Oblique-Slip fault

1. Dip-Slip fault

Dip-Slip fault is classified into two types:

a) Normal fault and

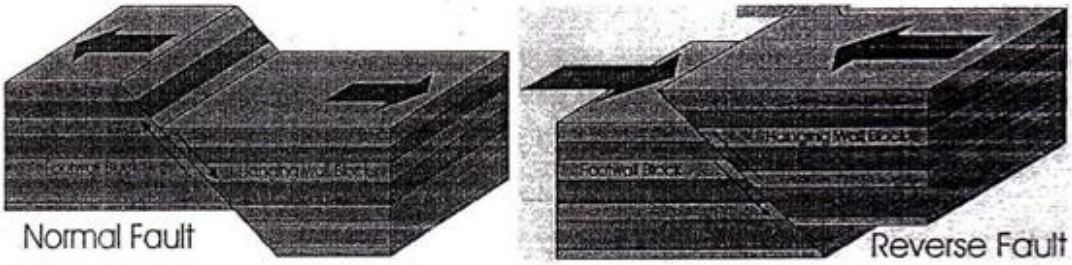
b) Reverse fault

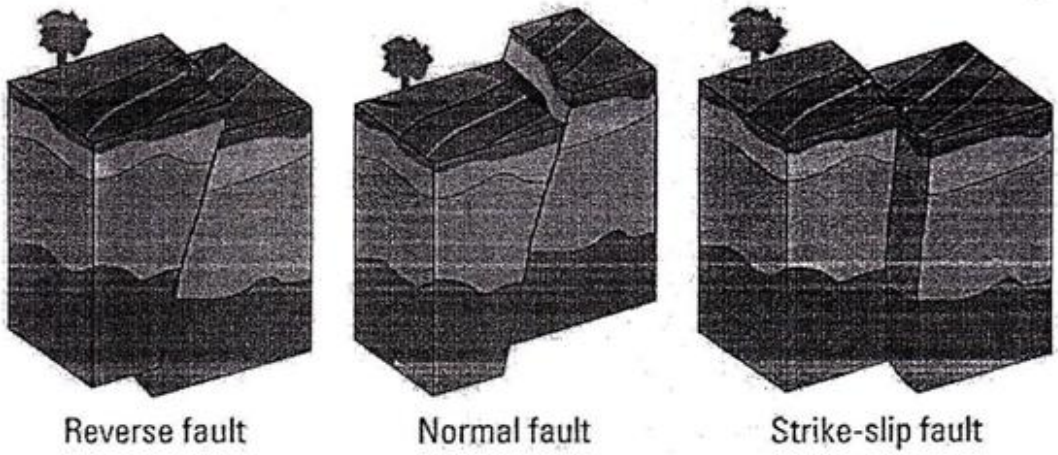
a) Normal fault:

- In a normal fault, the block above the fault moves down relative to the block below the faults as in fig.
- This fault motion is caused by tensional forces and results in extension. It is also called as tensional fault (or) gravity fault.

b) Reverse fault:

- A reverse fault is the opposite of a normal fault. In which the block above the fault moves up relative to the block below the fault as in Fig.
- This fault motion is caused by compressional forces and results in shortening. A reverse fault is called a thrust fault if the dip of the fault plane is small. It is also called as compressional fault.
- The devastating Bhuj earthquake on 26 January. 2001 has a reverse fault focal mechanism.

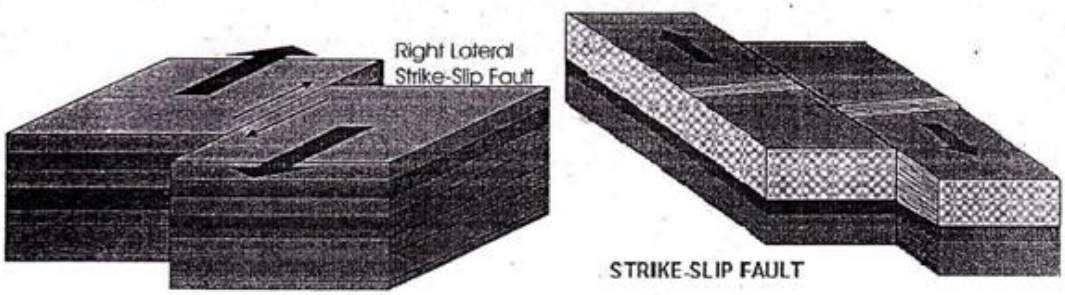




2. Strike-Slip fault

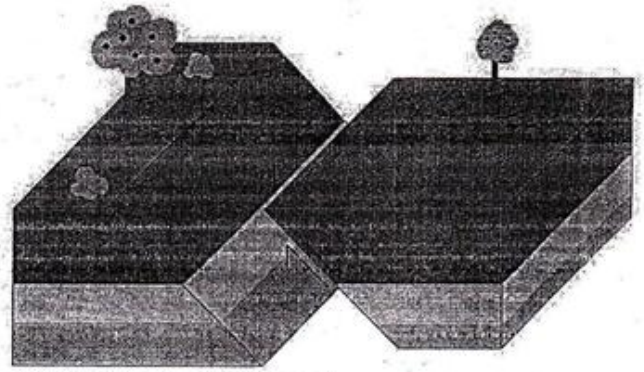
- Movements of blocks along a fault are horizontal Fig. If the block on the far side of the fault moves to the left, the fault is called left-lateral. If the block on the far side moves to right the fault is called right-lateral.

- The fault motion of a strike-slip fault is caused by shearing forces. It is also called as transcurrent fault, tear fault or wrench fault.



3. Oblique-Slip fault

- Oblique-slip faulting suggests both dip-slip faulting and strike-slip faulting. It is caused by a combination of shearing and tensional or compressional forces as shown in Fig.


Oblique-slip fault: Arrows represent relative movement.

Man made source

1. Controlled Sources
2. Reservoir Induced Earthquakes
3. Mining

1. Controlled Sources

- Human have caused explosion earthquakes by detonating nuclear devices.
- Underground nuclear explosions have caused moderate sized earthquakes which have been felt by people up to 50 km away.
- Rock blasting in quarries also produces small seismic events which people sometimes mistakenly believe to be earthquakes.

2. Reservoir Induced Earthquakes

✓ The weight of the water in the reservoir increases the load on the rocks below the valley

surface. It also increases the pressure of the water within the rock in the area, which can lubricate the existing faults making it easier for them to slip.

- ✓ They are basically tectonic earthquakes; they can be related to filling and emptying of the reservoir and hence called reservoir Induced seismicity.
- ✓ Earthquakes that occur around Koyna Dam may belong to the category of reservoir induced seismicity.

3. Mining

- ➢ Small seismic events can be produced when the roof underground caves or mines collapse.

7. Explain the types of Seismic Waves with sketch? [Apr/May 2008]

- During earthquake, large strain energy is released which generates elastic waves at the focus.
- These elastic waves are also called seismic waves and they travel in all directions through the earth's surface. The study or analysis these seismic waves are used to obtain the internal structure of the earth.
- Seismic waves are classified into two types,
    1) Body waves and
    2) Surface waves.

1. Body Waves

Body waves travel through the earth in all the direction and to all depths. They are recorded at far of distance from the foci of the earth quake due to refraction and reflection from deeper zones of earth.

Body waves are mainly of two types:

a. Primary waves and

b. Secondary waves

a) Primary waves or P-waves

- These are longitudinal waves similar to sound waves. These are the fastest of the seismic waves and consequently, the first to arrive at a seismic station. The P-waves can move through solid rock and fluids.
- P-waves are also known as comprcssional waves, because of the pushing and pulling they do. Subjected to P-waves. Particles move in the same direction that the wave is moving in, which the direction that the energy is traveling in. and it sometimes is called the "direction of wave propagation".
- Velocity of this wave is 4.8 km/s.

The first kind of body wave is the **P wave** or **primary wave** . This is the fastest kind of seismic wave, and, consequently, the first to 'arrive' at a seismic station. The P wave can move through solid rock and fluids, like water or the liquid layers of the earth. It pushes and pulls the rock it moves through just like sound waves push and pull the air. Have you ever heard a big clap of thunder and heard the windows rattle at the same time? The windows rattle because the sound waves were pushing and pulling on the window glass much like P waves push and pull on rock.

Sometimes animals can hear the P waves of an earthquake. Dogs, for instance, commonly begin barking hysterically just before an earthquake 'hits' (or more specifically, before the surface waves arrive). Usually people can only feel the bump and rattle of these waves.

P waves are also known as **compressional waves** , because of the pushing and pulling they do. Subjected to a P wave, particles move in the same direction that the the wave is moving in, which is the direction that the energy is traveling in, and is sometimes called the 'direction of wave propagation'. Click here to see a P wave in action.

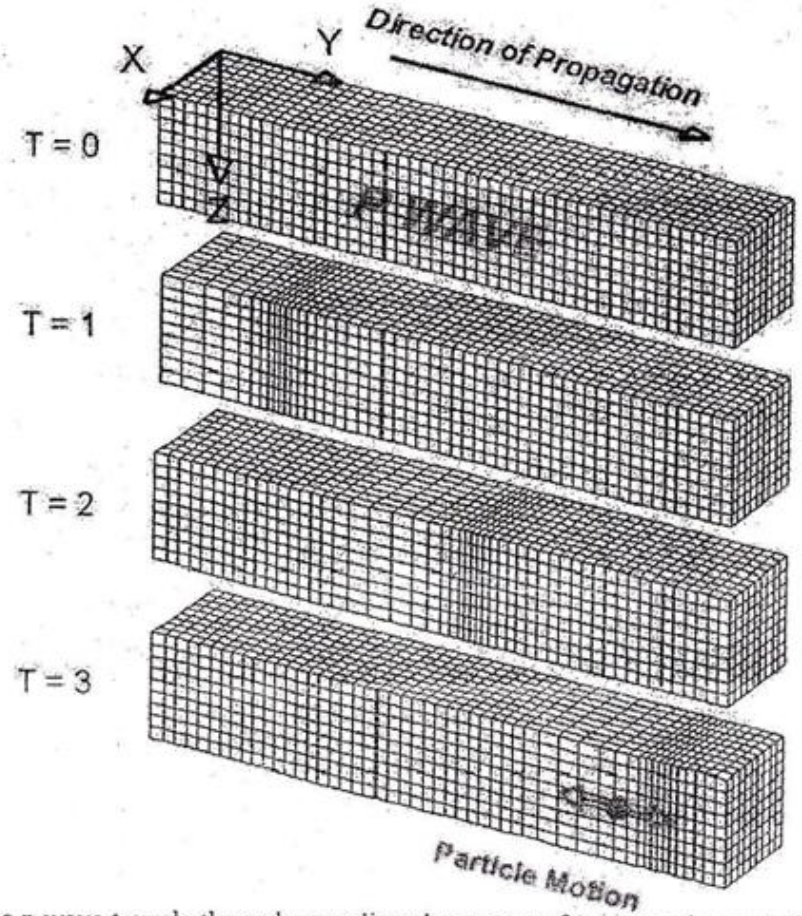


Figure 1 - a p wave travels through a medium by means of compression and dilation. Particles are represented by cubes in this model. Image ©2000-2006 lawrence braile, used with permission.

The other kind of surface wave is the **Rayleigh wave**, named for John William Strutt, Lord Rayleigh, who mathematically predicted the existence of this kind of wave in 1885. A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean. Because it rolls, it moves the ground up and down and side-to-side in the same direction that the wave is moving. Most of the shaking felt from an earthquake is due to the Rayleigh wave, which can be much larger than the other waves.

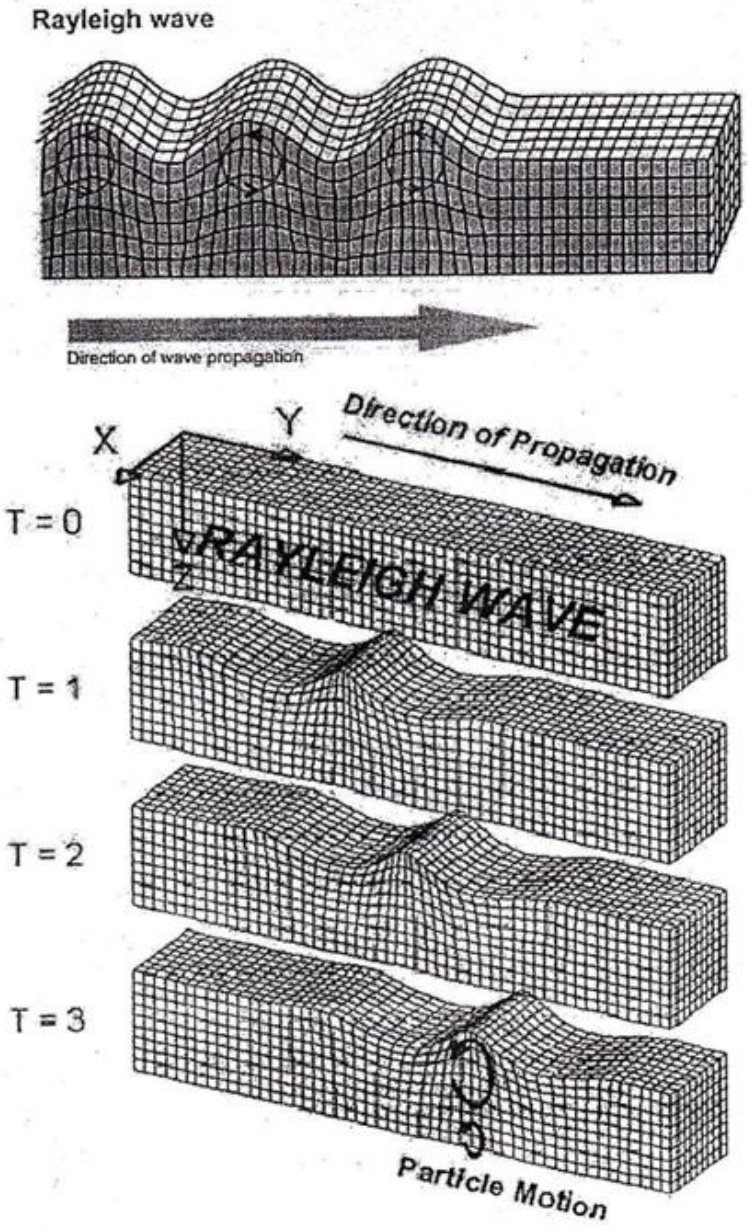
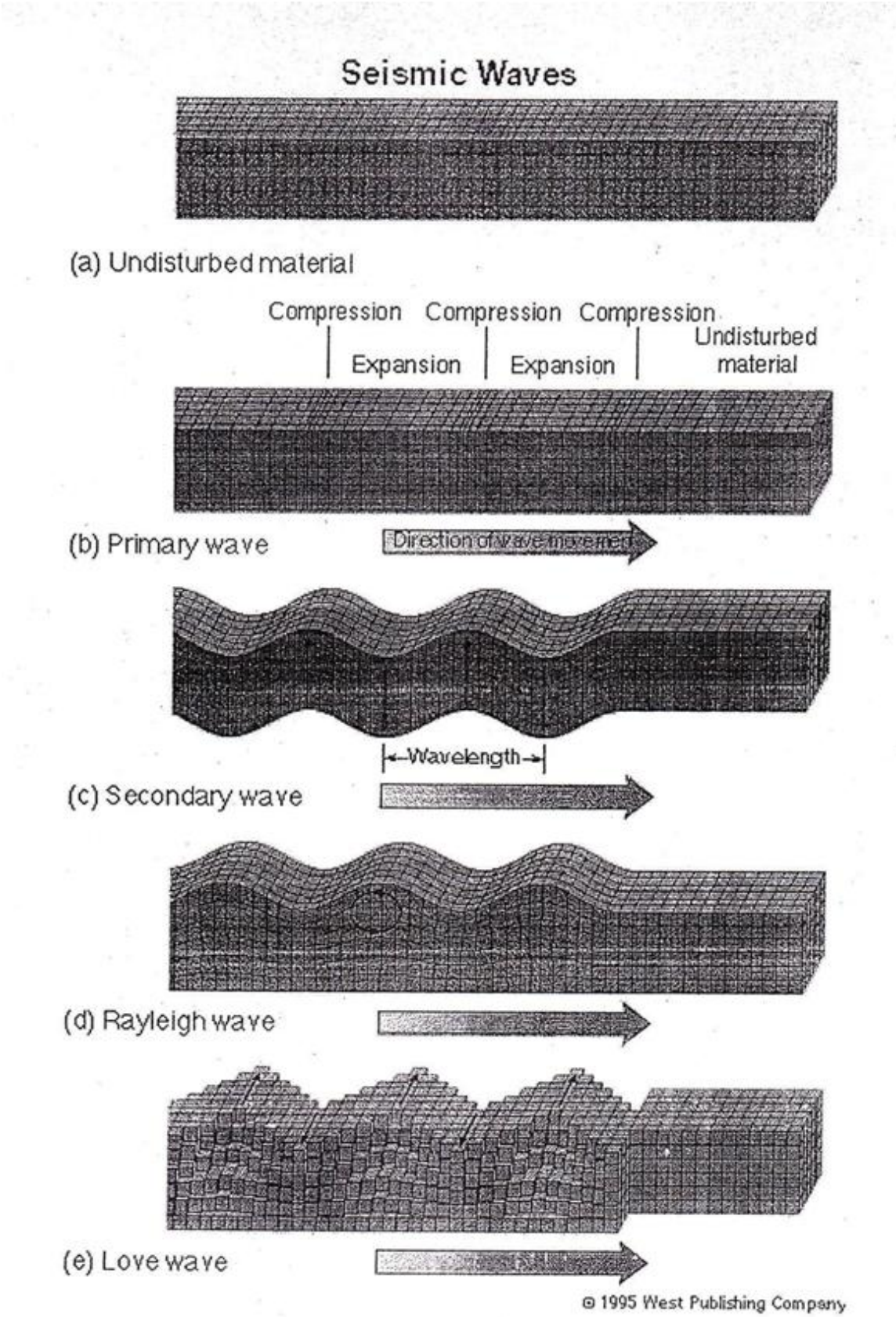


Figure 4 - a rayleigh wave travels through a medium. Particles are represented by cubes in this model. Image ©2000-2006 lawrence braile, used with permission.


Seismic Waves
(a) Undisturbed material
Compression
Compression
Compression
Expansion
Expansion
Undisturbed material
(b) Primary wave
Direction of wave movement
Wavelength
(c) Secondary wave
(d) Rayleigh wave
(e) Love wave
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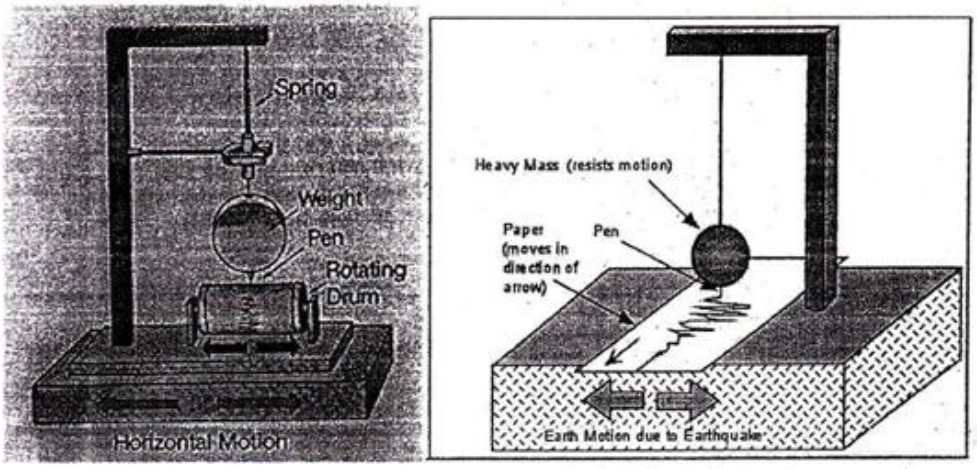
7. How are earthquakes recorded? Explain the seismograph? (Nov | Dec 2008)

- ✓ Seismograph is an instrument used to measure for earth quake vibration is called seismograph. It is recording the motions of the earth's surface caused by seismic waves, as a function of time as shown in fig.
- ✓ It has three major components
  1. Sensor
  2. Recorder
  3. Times

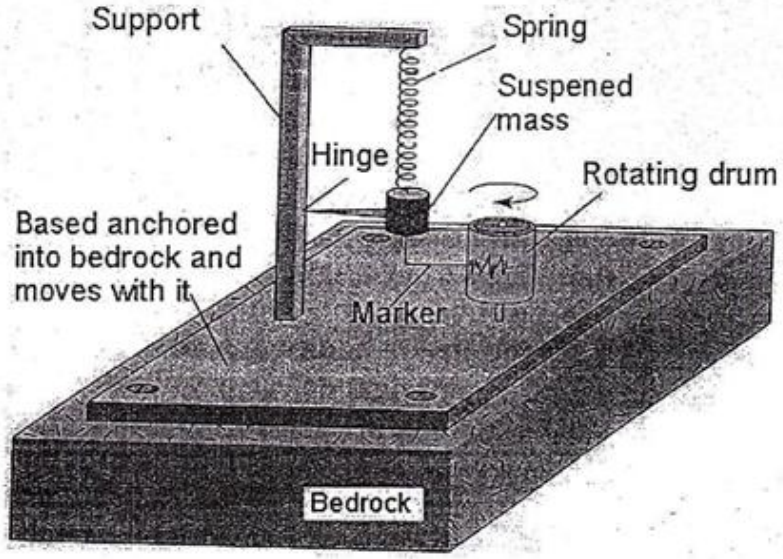


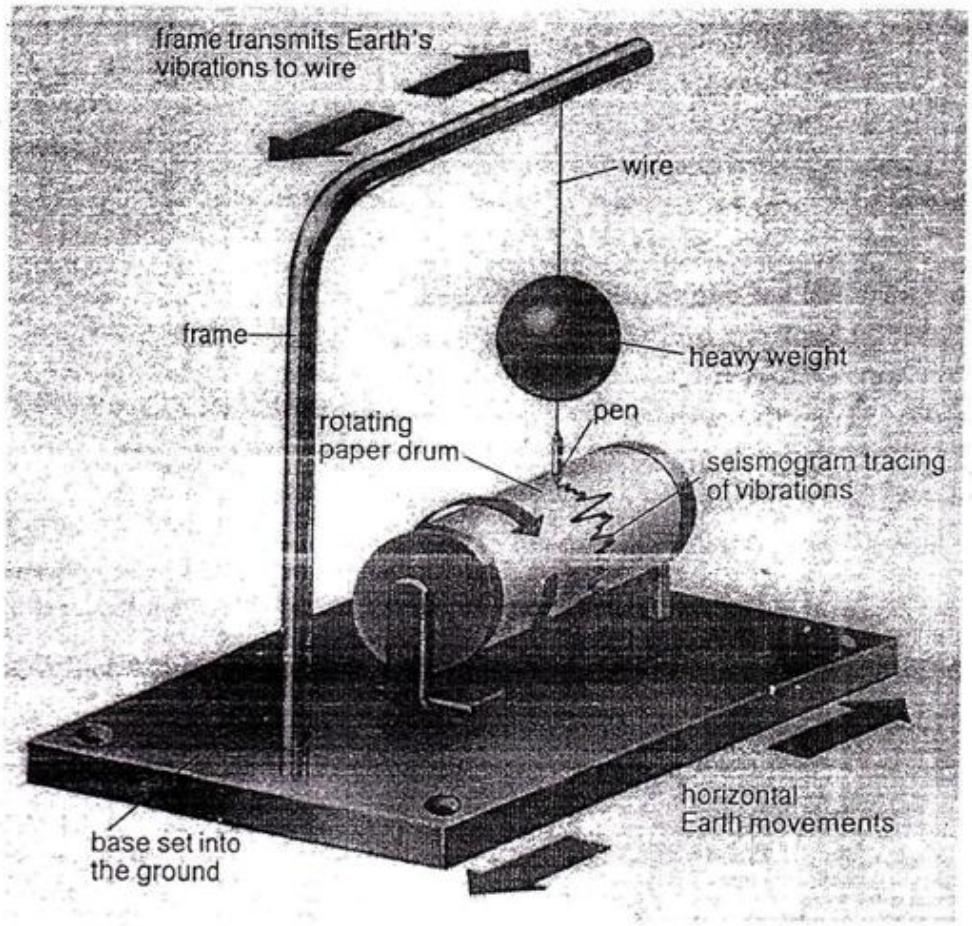
Earthquakes are recorded by instruments called ***seismographs.*** The recording they make is called a ***seismogram***. The seismograph has a base that sets firmly in the ground, and a heavy weight that hangs free. When an earthquake causes the ground to shake, the base of the seismograph shakes too, but the hanging weight does not. Instead the spring or string that it is hanging from absorbs all the movement. The difference in position between the shaking part of the seismograph and the motionless part is what is recorded.

Earthquakes generate seismic waves which can be detected with a sensitive instrument called a **seismograph**.

Advances in seismograph technology have increased our understanding of both earthquakes and the Earth itself.

Perhaps the earliest seismograph was invented in China A.D. 136 by a m an named Choko.

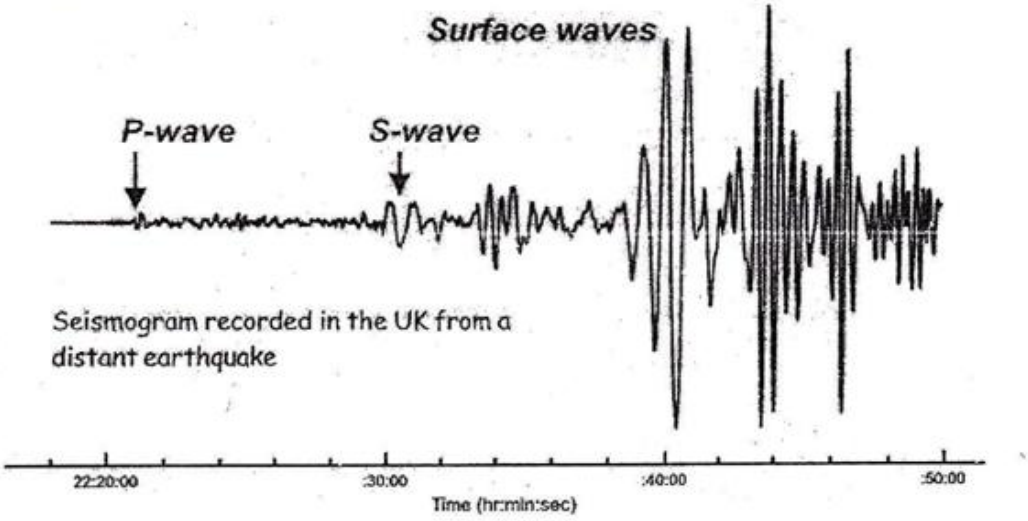

Support
Spring
Suspened mass
Hinge
Rotating drum
Based anchored into bedrock and moves with it
Marker
Bedrock


frame transmits Earth's vibrations to wire
wire
frame
heavy weight
pen
rotating paper drum
seismogram tracing of vibrations
horizontal Earth movements
base set into the ground

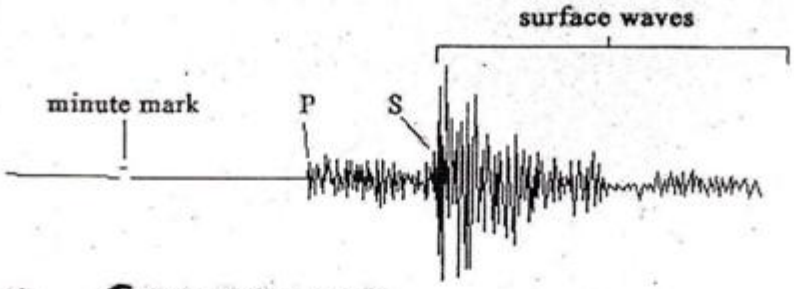
- ✓ A sensor called as seismo-meter that measure intensity of shaking at the instrument location. A recorder that traces a chart or seismogram of the seismic arrivals in the electronic amplifier.
- ✓ That clock records precise arrivals times of specific seismic waves. A pen attached at the tip of an oscillating simple pendulum. A mass hangs by a string from a support to marks on a chart paper that is held on a drum rotating at a constant speed.
- ✓ A magnet around the string provides required damping to control the amplitude of oscillation. The pendulum mass, string magnet and support together constitute the sensor.
- ✓ The drum, pen and chart paper constitute the recorder. The motor that rotates the drum at constant speed forms the times.
- ✓ The analog instrument has evolved over time but today the digital instruments are using in modern computer technology. But the principles of the operation remained the same.
- ✓ The digital instrument records the ground motion on the memory of the micro process that is inbuilt in the instrument.

8. Explain the seismogram? (Nov | Dec 2008)

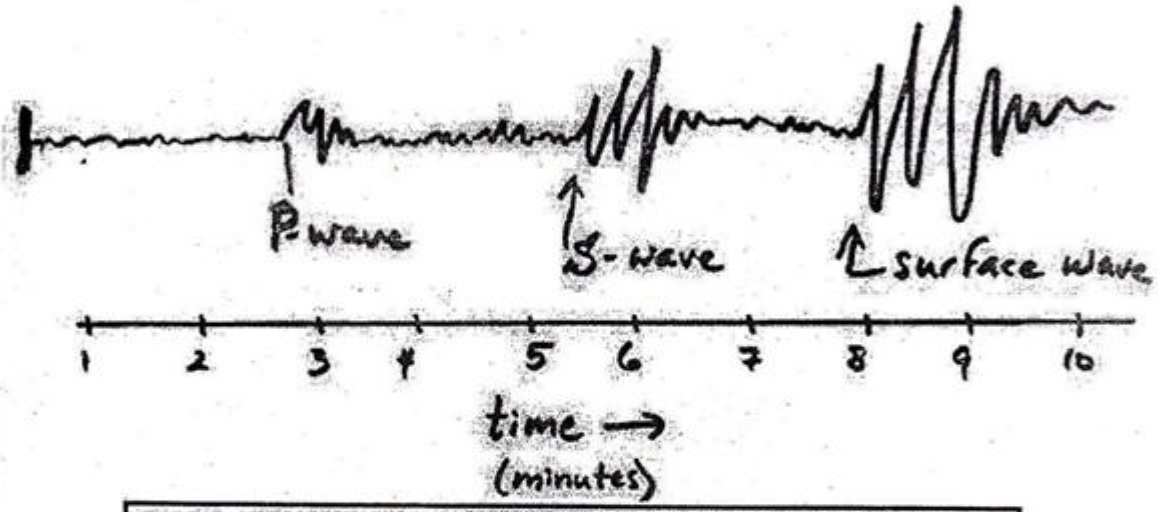
- Seismogram is a seismic record it is obtained from seismographs. It is used to calculate the location and magnitude of an earthquake. It is a graph showing the motion of the ground vs. time as shown in Fig.
- It represents how the ground moves with the passage or lime. A seismogram gives important information about on earthquake.
- The vibrations caused by an earthquake can be seen as waves on a seismogram. All the waves are different in nature. Each wave has its own specific properties, for example, the speed of propagation of a wave. The different kinds of waves are clearly recorded in the seismogram.

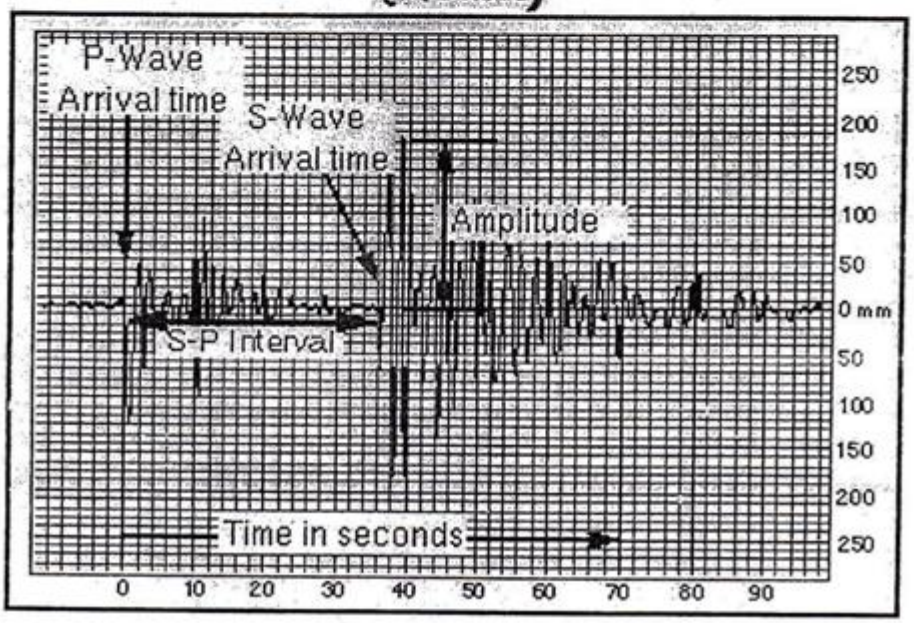


- P-waves indicate the first arrival of energy from the earthquake or other seismic source to be recorded. The next direct arrivals are the S-waves and finally the surface waves.



Seismogram:





9. Explain the Types of Earthquakes? May | June 2013

Earthquakes can be classified into the following four types.

a) According to plate boundaries

1) **Interplate carthquakes**: The earthquakes occurring along die boundaries of the tectonic plates are called as interplate earthquakes.

   Example: 1897. Assam earthquake.

2) **Intraplate earthquake**: The earthquakes occurring within a plate are called as intra plate earthquakes.

   Example: 1993. Latur earthquake

b) According to its depth of focus

1) **Shallow-focus earthquakes**: In this case, the seismic shocks originate at a depth of about less than 70 km. nearly 80% of the world's earthquakes are shallow focus earthquakes.
2) **Intermediate-focus earthquake**: In this case, the seismic waves originate at a depth between 70 km to 300 km.
3) **Deep-focus earthquake**: Here, the point of origin of the seismic wave is at a depth of greater than 300 km.

c) According to the origin of the earthquakes

1. Tectonic earthquakes
2. Volcanic earthquakes
3. Submarine earthquakes

The submarine vibrations often generate very large waves on the surface of the seas and destroy the coastal tracts. There submarine earthquakes generate waves are known as Tsunamis.

d) Based on magnitude (M)

i.	Micro earthquake	$M < 3.0$
ii.	Intermediate earth quake	$3 < M < 4$
iii.	Moderate earthquake	$5 < M < 5.9$
iv.	Strong earthquake	$6 < M < 6.9$
v.	Major earthquake	$7 < M < 7.9$
vi.	Great earthquake	$M > 8.0$

16. Define seismic intensity scale. Explain the details of modified mercalli Intensity (MMI) with intensity numbers.

Seismic intensity scale

The first simple classification of earthquake intensity was devised by Domenico Pignataro in the 1780s. However, the first recognizable intensity scale in the modern sense of the word was drawn up by P.N.G. Egen in 1828; it was ahead of its time. The first widely adopted intensity scale, the *Rossi-Forel scale*, was introduced in the late 19th century. Since then numerous intensity scales have been developed and are used in different parts of the world.

Country/Region	Seismic intensity scale used
China	Liedu scale (GB/T 17742-1999)
Europe	European Macroseismic Scale (EMS-98)[2]
Hong Kong	Modified Mercalli scale (MM)[3]
India	Medvedev-Sponheuer-Karnik scale
Israel	Medvedev-Sponheuer-Karnik scale (MSK-64)
Japan	Shindo scale
Kazakhstan	Medvedev-Sponheuer-Karnik scale (MSK-64)
Russia	Medvedev-Sponheuer-Karnik scale (MSK-64)
Taiwan	Shindo scale
United States	Modified Mercalli scale (MM)[4]

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.

XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.