EARTHQUAKE AND VOLCANOES

Earthquake

An earthquake in simple words is shaking of the earth. It is a natural event. It is caused due to release of energy, which generates waves that travel in all directions. The release of energy occurs along a fault. A fault is a sharp break in the crustal rocks. Rocks along a fault tend to move in opposite directions. As the overlying rock strata press them, the friction locks them together. However, their tendency to move apart at some point of time overcomes the friction. As a result, the blocks get deformed and eventually, they slide past one another abruptly. This causes a release of energy, and the energy wave's travel in all directions. The point where the energy is released is called the *focus* of an earthquake, alternatively, it is called the *hypocentre*. The energy waves travelling in different directions reach the surface. The point on the surface, nearest to the focus, is called *epicentre*. It is the first one to experience the waves. It is a point directly above the focus.

Earthquake Waves

All natural earthquakes take place in the lithosphere. The lithosphere refers to the portion of depth up to 200 km from the surface of the earth. An instrument called 'seismograph' records the waves reaching the surface. Earthquake waves are basically of two types — *body waves* and *surface waves*. Body waves are generated due to the release of energy at the focus and move in all directions travelling through the body of the earth. Hence, the name body waves. The body waves interact with the surface rocks and generate new set of waves called surface waves. These waves move along the surface. The velocity of waves changes as they travel through materials with different densities. The denser the material, the higher is the velocity. Their direction also changes as they reflect or refract when coming across materials with different densities propagation. As a result, it creates density differences in the material leading to stretching and squeezing of the material. Other three waves vibrate perpendicular to the direction of propagation. The direction of vibrations of S-waves is perpendicular to the wave direction in the vertical plane. Hence, they create troughs and crests in the material through which they pass. P-waves move faster and are the first to arrive at the surface. These are also called 'primary waves'. The P-waves are similar to sound waves. They travel through gaseous, liquid and solid materials. S-waves arrive at the surface with some time lag. These are called secondary waves. An important fact about S-waves is that they can travel only through solid materials. This characteristic of the S-waves is quite important. It has helped scientists to understand the structure of the interior of the earth. Reflection causes waves to rebound whereas refraction makes waves move in different directions. The variations in the direction of waves are inferred with the help of their record on seismograph. The surface waves are the last to report on seismograph. These waves are more destructive. They cause displacement of rocks, and hence, the collapse of structures occurs.

Emergence of Shadow Zone

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

Types of Earthquakes

(i) The most common ones are the *tectonic* earthquakes. These are generated due to sliding of rocks along a fault plane.
(ii) A special class of tectonic earthquake is sometimes recognised as *volcanic* earthquake. However, these are confined to areas of active volcanoes.
(iii) In the areas of intense mining activity, sometimes the roofs of underground mines collapse causing minor tremors. These are called *collapse* earthquakes.
(iv) Ground shaking may also occur due to the explosion of chemical or nuclear devices. Such tremors are called *explosion* earthquakes.
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(v) The earthquakes that occur in the areas of large reservoirs are referred to as *reservoir induced* earthquakes.

Measuring Earthquakes

The earthquake events are scaled either according to the magnitude or intensity of the shock. The magnitude scale is known as the *Richter scale*. The magnitude relates to the energy released during the quake. The magnitude is expressed in absolute numbers, 0-10. The intensity scale is named after *Mercalli*, an Italian seismologist. The intensity scale takes into account the visible damage caused by the event. The range of intensity scale is from 1-12.

Effects Of Earthquake

Earthquake is a natural hazard. The following are the immediate hazardous effects of earthquake:
(i) Ground Shaking

(ii) Differential ground settlement

(iii) Land and mud slides

(iv) Soil liquefaction

(v) Ground lurching

(vi) Avalanches

(vii) Ground displacement

(viii) Floods from dam and levee failures

(ix) Fires

(x) Structural collapse

(xi) Falling objects

(xii) Tsunami

The first six listed above have some bearings upon landforms, while others may be considered the effects causing immediate concern to the life and properties of people in the region. The effect of tsunami would occur only if the epicentre of the tremor is below oceanic waters and the magnitude is sufficiently high. *Tsunamis* are waves generated by the tremors and not an earthquake in itself. Though the actual quake activity lasts for a few seconds, its effects are devastating provided the magnitude of the quake is more than 5 on the Richter scale.

Frequency of Earthquake Occurrences

The earthquake is a natural hazard. If a tremor of high magnitude takes place, it can cause heavy damage to the life and property of people. However, not all the parts of the globe necessarily experience major shocks. Normally it is observed that most of the earthquake occurs near plate boundaries.

Volcanoes And Volcanic Landforms

A volcano is a place where gases, ashes and molten rock material – lava – escape to the ground. A volcano is called an active volcano if the materials mentioned are being released or have been released out in the recent past. The layer below the solid crust is mantle. It has higher density than that of the crust. The mantle contains a weaker zone called *asthenosphere*. It is from this that the molten rock materials find their way to the surface. The material in the upper mantle portion is called *magma*. Once it starts moving towards the crust or it reaches the surface, it is referred to as *lava*. The material that reaches the ground includes lava flows, pyroclastic debris, volcanic bombs, ash and dust and gases such as nitrogen compounds, sulphur compounds and minor amounts of chlorene, hydrogen and argon.

Volcanoes

Volcanoes are classified on the basis of nature of eruption and the form developed at the surface. Major types of volcanoes are as follows:

Shield Volcanoes

Barring the basalt flows, the shield volcanoes are the largest of all the volcanoes on the earth. The Hawaiian volcanoes are the most famous examples. These volcanoes are mostly made up of basalt, a type of lava that is very fluid when erupted. For this reason, these volcanoes are not steep. They become explosive if somehow water gets into the vent; otherwise, they are characterised by low-explosivity. The upcoming lava moves in the form of a fountain and throws out the cone at the top of the vent and develops into cinder cone.

Composite Volcanoes

These volcanoes are characterised by eruptions of cooler and more viscous lavas than basalt. These volcanoes often result in explosive eruptions. Along with lava, large quantities of pyroclastic material and ashes find their way to the ground. This material accumulates in the vicinity of the vent openings leading to formation of layers, and this makes the mounts appear as composite volcanoes. more than 50 m. Individual flows may extend for hundreds of km. The *Deccan Traps* from India, presently covering most of the Maharashtra plateau, are a much larger flood basalt province. It is believed that initially the trap formations covered a much larger area than the present.

Caldera

These are the most explosive of the earth's volcanoes. They are usually so explosive that when they erupt they tend to collapse on themselves rather than building any tall structure. The collapsed depressions are called *calderas*. Their explosiveness indicates that the magma chamber supplying the lava is not only huge but is also in close vicinity.

Flood Basalt Provinces

These volcanoes outpour highly fluid lava that flows for long distances. Some parts of the world are covered by thousands of sq. km of thick basalt lava flows. There can be a series of flows with some flows attaining thickness of

Mid-Ocean Ridge Volcanoes

These volcanoes occur in the oceanic areas. There is a system of mid-ocean ridges more than 70,000 km long that stretches through all the ocean basins. The central portion of this ridge experiences frequent eruptions. We shall be discussing this in detail in the next chapter.

Volcanic Landforms

Intrusive Forms

The lava that is released during volcanic eruptions on cooling develops into igneous rocks. The cooling may take place either on reaching the surface or also while the lava is still in the crustal portion. Depending on the location of the cooling of the lava, igneous rocks are classified as *volcanic rocks* (cooling at the surface) and *plutonic rocks* (cooling in the crust). The lava that cools within the crustal portions assumes different forms. These forms are called *intrusive forms*.

Batholiths

A large body of magmatic material that cools in the deeper depth of the crust develops in the form of large domes. They appear on the surface only after the denudational processes remove the overlying materials. They cover large areas, and at times, assume depth that may be several km. These are granitic bodies. Batholiths are the cooled portion of magma chambers.

Lacoliths

These are large dome-shaped intrusive bodies with a level base and connected by a pipe-like conduit from below. It resembles the surface volcanic domes of composite volcano, only these are located at deeper depths. It can be regarded as the localised source of lava that finds its way to the surface. The Karnataka plateau is spotted with domal hills of granite rocks. Most of these, now exfoliated, are examples of lacoliths or batholiths.

Lapolith, Phacolith and Sills

As and when the lava moves upwards, a portion of the same may tend to move in a horizontal direction wherever it finds a weak plane. It may get rested in different forms. In case it develops into a saucer shape, concave to the sky body, it is called *lapolith*. A wavy mass of intrusive rocks, at times, is found at the base of synclines or at the top of anticline in folded igneous country. Such wavy materials have a definite conduit to source beneath in the form of magma chambers (subsequently developed as batholiths). These are called thephacoliths.

The near horizontal bodies of the intrusive igneous rocks are called *sill* or *sheet*, depending on the thickness of the material. The thinner ones are called sheets while the thick horizontal deposits are called sills.

Dykes

When the lava makes its way through cracks and the fissures developed in the land, it solidifies almost perpendicular to the ground. It gets cooled in the same position to develop a wall-like structure. Such structures are called dykes. These are the most commonly found intrusive forms in the western Maharashtra area. These are considered the feeders for the eruptions that led to the development of the Deccan traps.

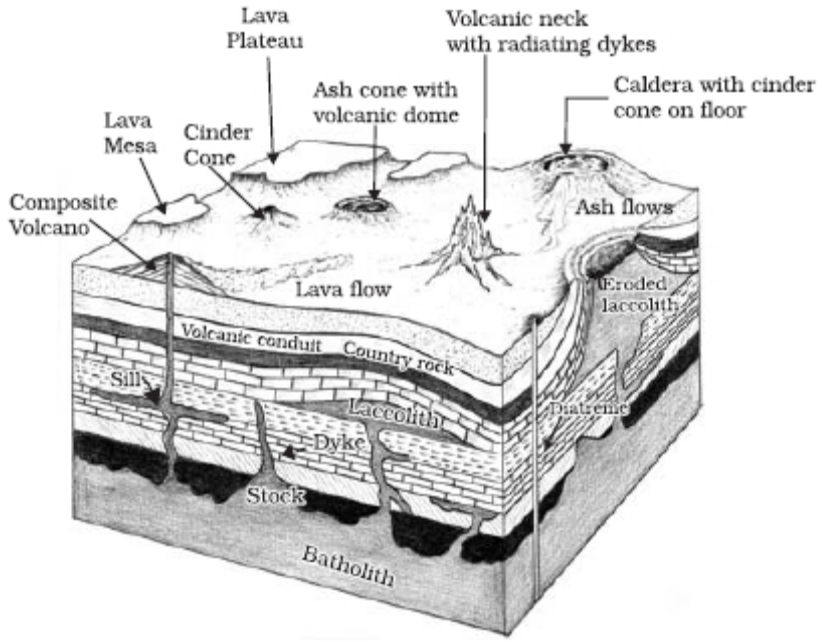

Figure 3.5 : Volcanic Landforms

Multiple choice questions.

1. Which one of the following earthquake waves is more destructive?
   a) P-waves
   b) S-waves
   c) Surface waves
   d) None of the above
2. Which one of the following is a direct source of information about the interior of the earth?
   a) Earthquake waves
   b) Volcanoes
   c) Gravitational force
   d) Earth magnetism
3. Which type of volcanic eruptions have caused Deccan Trap formations?
   a) Shield

b) Flood
c) Composite
d) Caldera

4. Which one of the following describes the lithosphere:
a) upper and lower mantle
b) crust and upper mantle
c) crust and core
d) mantle and core

5. The major constituents of the gaseous material that comes out of a volcano is:
a) Carbon Monoxide
b) Carbon Dioxide
c) Sulphur Dioxide
d) Steam

6. Match List I with List II and select the correct answer from the codes given below the lists:

List I (Volcanoes)	List II (Countries)
A. Vesuvius	1. Sicily
B. Mauna Loa	2. Indonesia
C. Krakatoa	3. Hawaii
D. Stromboli	4. Ecuador
	5. Italy

Codes:

	A	B	C	D
a)	3	4	2	5
b)	5	2	3	1
c)	2	3	1	4
d)	5	3	2	1

7. Which of the following is the main cause of major earthquakes:
a) Collapse of roofs of mines
b) Collapse of roofs of tunnels
c) Explosive eruption of volcanoes
d) Tectonic forces

8. In the map given below a major earthquake belt of South America is shown:

The landmasses that constitute this belt belong to

a) Argentina, Uruguay and Paraguay
b) Bolivia, Brazil and Surinam
c) French Guiana, Guyana and Venezuela
d) Chile, Peru and Ecuador

9. Which one of the following is the biggest volcano in the world?

a) Mounaloa
b) Pelee
c) Stromboli
d) Etna

10. Tsunamis, Mercalli scale, hypocenter and epicenters refer to

a) Volcanic activity
b) Typhoons
c) Earthquake
d) More that one of the above.

11. The balancing movements of the lithosphere and asthenosphere is known as

a) Isostasy
b) Plate tectonics
c) Buoyancy
d) Gravitational Compensation

12. Mt. Kilimanjaro is the highest peak of:

a) South America
b) Africa
c) Europe
d) Australia

13. A theory states that a super continent once existed, from which all present day masses broke away this single block was known as:

a) Panagea
b) Gondwanaland
c) Laurasia
d) Thethys

14. The point directly below the epicenter in an earthquake is known as:
a) Seismic Focus
b) Shake point
c) Epicentral distance
d) Focal depth

15. Which one of the following statements relating to earthquake is/ are correct?
1. The point of origin of an earthquake is called the epicenter.
2. The lines joining the places which were affected by the earthquake at the same point of time are called homoseismal lines.
Select the correct answer using the code below
a) 1 and 3 only
b) 2 only
c) 3 only
d) 1, 2 and 3

16. Composite volcanic cone is also called strata cone because of the:
a) Alternating sheets of lava and pyroclastic materials
b) Uneven streams of lava flow
c) Cataclysmic eruption
d) Eruption of lava flow from a fissure

17. Which of the following decides landforms characteristics?
1. Fluidity of magma
2. Strength of magma
3. Manner in which magma escapes to surface
Select the correct answer from the following codes
a) Only 2
b) Only 1 and 3
c) Only 2 and 3
d) 1, 2 and 3

18. Consider the following statements?
1. Intrusive rocks are formed while magma thrust to surface cool and solidify within crust.
2. Plutonic rocks are extrusive landforms
3. Igneous rocks are formed by either plutonic or volcanic activity.
Select the correct answer from the following codes
a) Only 2
b) Only 1 and 3
c) Only 2 and 3
d) 1, 2 and 3

19. Which of the following are intrusive landforms?
1. Sills
2. Dykes

20. Consider the following statements?
1. Laccolith are saucer shaped igneous intrusions.
2. Lopolith is dome shaped igneous intrusions
3. Phacolith is lens shaped igneous intrusion
Select the correct answer from the following codes
a) Only 3
b) Only 1 and 2
c) Only 1 and 3
d) 1, 2 and 3

21. With reference to batholiths which of the following are true?
1. It is huge mass of igneous rocks
2. It is usually granite
3. They are most spectacular of intrusive landforms
Select the correct answer from the following codes
a) Only 1
b) Only 1 and 2
c) Only 2 and 3
d) 1, 2 and 3

22. Which of the following gases is present in magma?
1. Carbon-di-oxide
2. Sulphurated hydrogen
3. Nitrogen
4. Methane
Select the correct answer from the following codes
a) Only 2 and 3
b) Only 1, 2 and 3
c) Only 1 and 4
d) 1, 2, 3 and 4

23. Consider the following statements?
1. Dormant volcanoes are the ones that have not erupted at all in historic times, but retains features of volcanoes.
2. Active volcanoes are ones which erupt frequently and erupted in recent times.
3. All volcanoes pass through active, dormant and extinct stages.
Select the correct answer from the following codes
a) Only 1
b) Only 1 and 2
c) Only 2 and 3
d) 1, 2 and 3

24. Which of the following are extrusive landforms?
1. Cones
2. Domes

3. Dykes
4. Pyroclast
Select the correct answer from the following codes
a) Only 2
b) Only 1, 2 and 3
c) Only 3 and 4
d) 1, 3 and 4

25. Mt. Kratatau, a small volcanic island is located midway in Sunda strait. Name the countries in between which it is located-
a) Java and Sumatra
b) Sumatra and Malaysia
c) Java and Philippines
d) Malaysia and Thailand

26. Which of the following are associated with Geysers?
1. It is associated with volcanic regions.
2. It is emitted with explosion
3. Its emission is triggered off by gases
Select the correct answer from the following codes
a) Only 1
b) Only 1 and 2
c) Only 2 and 3
d) 1, 2 and 3

27. What makes lava flow one of the less deadly volcanic processes?
a) It is far cooler than other types of volcanic hazards
b) It is clearly visible from miles away, so can be easy to avoid
c) It flows very slowly, moving perhaps a few miles within an hour
d) It contains less toxic and life threatening gases

28. What is the classification of a volcano that has not erupted in the past 10,000 years, but has the potential to erupt in the future?
a) An extinct volcano
b) A Dormant volcano
c) A Active volcano
d) A Cinder-cone volcano

29. Volcanism does not usually occur-
a) Along sea floor spreading centres
b) Along subduction boundaries where continental and oceanic plates collide
c) Along the convergent boundary where two continental plates collide

d) At hotspots

30. Lava from volcanoes which erupts under water cools rapidly, this may result in the formation of which rounded structure?
a) Black smokers
b) Gabbros
c) Pillow lava
d) Shield volcano

31. Which of the following does not occur when two continental plates collide?
a) Uplift occurs and results in the formation of mountain belts
b)One plate sinks below the other
c) The crust floating on the earth's mantle develops a deep root
d) The crust becomes folded and deformed

32. On earth's surface, volcanoes and earthquakes seem to be-
a) Concentrated at the poles
b) Concentrated in zones
c) Randomly scattered on continental plates only
d) Randomly scattered on oceanic plates only

33. Which of the following countries has most volcanoes?
a) Italy
b) Japan
c) Indonesia
d) USA

34. What does 'dormant' means when used to refer to a volcano?
a) Extinct
b) Active
c) Ready to erupt
d) Sleeping

35. Historically the largest known volcanic explosion is which of the following?
a) Karakotoa (Indonesia 1883)
b) Tambora (Indonesia 1815)
c) Mt Tarawera (Newzeland 1886)
d) Katmai (Alaska USA 1912)

36. The deadliest volcanoes tend to occur in the presence of this geologic phenomenon-

a) Erosion
b) Conservative- margin plate tectonics
c) Convection
d) Subduction

37. This is the scale used to measure the size of volcanic eruptions-
a) Richter scale
b) Vulcan index
c) Volcano eruptivity scale
d) Volcanic explosivity index

38. Which part of a volcano can have a global impact?
a) Lahars
b) Pyroclastic flows
c) Ash
d) Debris

39. Which of the following is a positive effect of a volcano?
a) Damaged buildings
b) Habitat loss
c) Tourism
d) Environmental loss

40. Which of the following is a characteristic of a composite volcano?
a) Gentle sides
b) Layers of ash and lava
c) Basic lava
d) Eruption of gases only

41. Which is an instrument that helps to monitor volcanoes?
a) Barometer
b) Richter scale
c) Tiltmeter
d) None of the above

42. The two volcanic islands in the Indian territory are:
a) Kavaratti and New Moor
b) Bitra and Kavaratti
c) Pamban and Barren
d) Narcondam and Barren

43. The term "epicenter" is associated with
a) Earthquake
b) Folding
c) Faulting
d) Earth's interior

44. Which of the following statements relating to tsunami is/ are correct?
As the tsunamis leave the deep water of the open sea and travel towards shallow water
1. The speed is reduced considerably
2. They attain enormous height
3. They appear as a gentle rise and fall of the sea
Select the correct answer using the code given below.
a) 1 and 2 only
b) 2 and 3 only
c) 1 only
d) 1, 2 and 3
