e-Pathshala पाठशाला

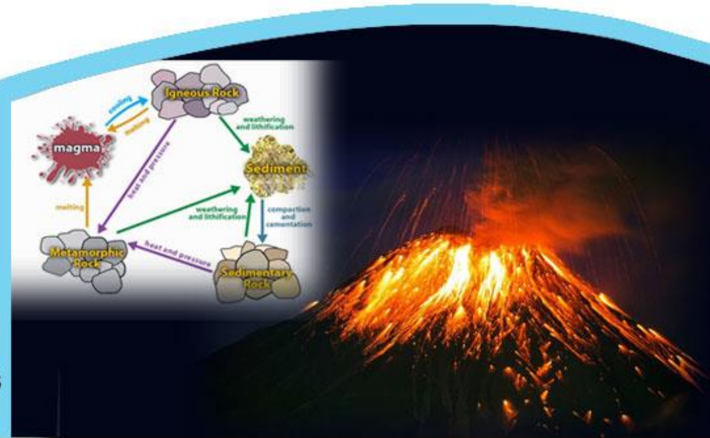
e-Pathshala पाठशाला

A Gateway to all Post Graduate Courses

MHRD Govt. of India

An MHRD Project under its National Mission on Education thought ICT (NME-ICT)

Subject: Environmental Sciences



Production of Coursework

- Content for Post-Graduate Courses

Paper No: 4 Environmental Geology

Module: 05 Volcanoes

e-Pathshala पाठशाला

A Gateway to all Post Graduate Courses

MHRD Govt. of India

Development Team

Principal Investigator & Co- Principal Investigator	**Prof. R.K. Kohli** **Prof. V.K. Garg & Prof. Ashok Dhawan** **Central University of Punjab, Bathinda**
Paper Coordinator	**Prof. R. Bhaskar, , Guru Jambheshwar University of Science and Technology, Hisar**
Content Writer	**Dr. Sushmitha Baskar, SOITS, IGNOU, New Delhi**
Content Reviewer	**Dr. Meenal Mishra, IGNOU, New Delhi**
Anchor Institute	**Central University of Punjab**

Description of Module	
Subject Name	**Environmental Sciences**
Paper Name	Environmental Geology
Module Name/Title	**Volcanoes**
Module Id	EVS/EG-IV/05
Pre-requisites	
Objectives	• define the term volcanoes; • describe the volcanic eruption processes; • explain the hazards of volcanic eruptions; and • list some measures for volcanic hazard mitigation.
Keywords	Volcano, Crater, Caldera, Ash Cloud, explosive eruptions, Magma, Hazards

Module 5: VOLCANOES

Structure

5.0 Objectives

5.1 Introduction

5.2 Definitions

5.3 Distribution of volcanoes

5.4 Different parts of a volcano

5.5 Volcanic eruption processes

5.6 Types of volcanic eruptions

5.7 Factors controlling volcanic eruptions

5.8 Products of volcanic eruptions

5.9 Hazards associated with volcanoes

5.10 Prediction and mitigation of volcanic eruption

5.11 Natural service functions of volcanoes

5.12 Summary

5.0 OBJECTIVES

After reading this unit, you should be able to:

- define the term volcanoes;
- describe the volcanic eruption processes;
- explain the hazards of volcanic eruptions; and
- list some measures for volcanic hazard mitigation.

5.1 Introduction

The name 'Volcano' is given after a small island near Sicily which was named by the ancient Romans. The term volcano is derived from 'Vulcan', the Roman God of fire and metalwork. The study of volcanoes is the significant in the understanding of the earth's interior. Volcanoes emit magma and gases and the volcanic eruption process brings out molten rock material from inside the earth to the earth's surface. These natural processes bring about changes in the earth's landscape. The geologic processes that give rise to volcanoes and volcanic rocks are collectively known as *volcanism*. Majority of the volcanoes are dormant and there are approximately 1500 active volcanoes. Volcanoes can be explosive and non-explosive. There are other volcanoes that alternate between quiet and explosive, i.e. the volcano at Stromboli, near Sicily. The magma composition is an important factor. Siliceous or felsic magma is more viscous and volatile rich in comparison to magma with less silica, i.e mafic. Hence they erupt explosively when compared to the mafic magmas. Scientists estimate that at least 500 million of the total world population is at risk from volcanoes. Millions of people are vulnerable to the effects of dangerous eruptions. Therefore, it is important to improve our understanding of the volcanoes and how they work. Study of volcanos is known as *volcanology* and scientist studying volcanoes is called *volcanologist.*

Let us now learn some definitions of volcanoes and their types.

5.2 Definitions

Volcano: Volcano may be defined as any landform that releases lava, gas or ashes or has done so in the past. A volcano is a vent or chimney and its surrounding accumulations of volcanic material, which connects a pool of molten rock material (magma) below the Earth's surface with the surface. Volcano may appear on the surface through some fissure called fissure type or through a single opening where it assumes shape of a cone called cone or crater type. Volcanoes are often classified by their recent history of activity as active, dormant or extinct.

Active: A volcano is active when it is erupting intermittently or continuously. Active volcanoes are those that have recently erupted or those that show current volcanic activity, such as the eruption of lava, release of gas or seismic activity i.e. Mt. Helens in the state of Washington.

Dormant: A dormant volcano has not erupted for a long time but can erupt again. These are the volcanoes which show eruptions with a lapse of considerable period.

Extinct: An extinct volcano is that which will never erupt again. Extinct volcanoes show no signs of activity and have not erupted for long periods of time. These volcanoes may now only be the remnants of lava flows or the central volcanic pipe.

Volcanism: It is the phenomenon of eruption of molten rock (magma) onto the surface of the Earth or a solid-surface planet or moon, where lava, pyroclastics and volcanic gases erupt through a break in the surface called a *vent*.

5.3 DISTRIBUTION OF VOLCANOES

It is important to understand the distribution of volcanoes. Based on the plate tectonic theory volcanoes and earthquakes are not randomly distributed; but they tend to be concentrated along limited zones along the plate boundaries (Figure 5.1). According to the theory of plate tectonics, the Earth's outer shell (lithosphere) is made up of seven large and many smaller moving plates. When the plates move, their boundaries can collide, diverge from each other or slide past each other, resulting in geological processes such as earthquakes, volcanoes and mountain formations. Volcanoes normally occur around certain specific places of the earth’s crust. They occur in the following areas:

- Along subduction boundaries at continental plate-oceanic plate convergence such as at Mt Saint Helens
- Along oceanic plate – oceanic plate convergence such as at Japan and Philippines
- Ring of Fire surrounding Pacific Ocean
- Hot spots such as the Hawaiian Islands mantle plumes
- Spreading centers mid-ocean ridges such as in Iceland, rift valleys such as at Mt. Kilamanjaro, Africa

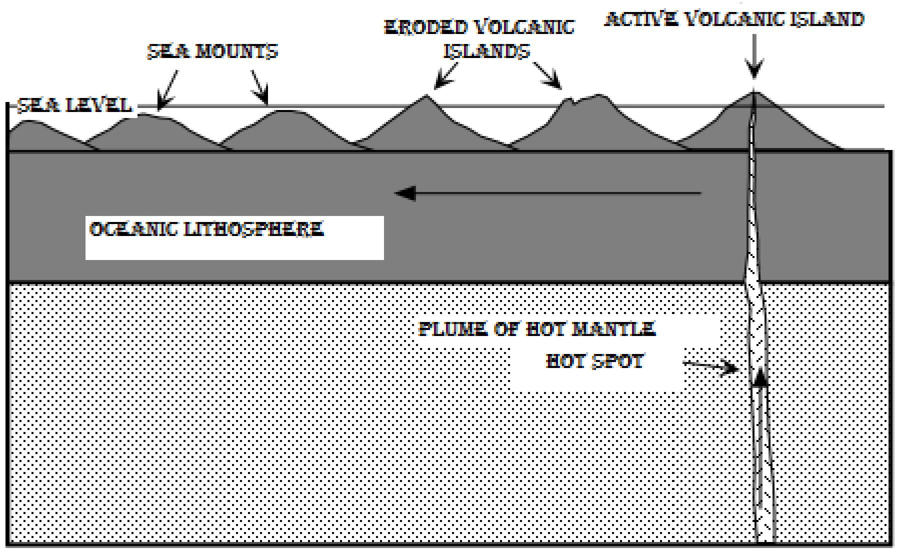


Figure 5.1 Hotspot and volcanoes

5.4 DIFERENT PARTS OF A VOLCANO

A typical volcano has different parts. Typically, volcanoes are openings in the earth's surface from which molten rock; magma and gases escape. The main parts include the following (Figure 5.2):

1. Vent: It is an opening that serves as an outlet for air, smoke and fumes. It is a pipe-like conduit connecting the magma chamber to the surface.
2. Crater: It is a depression or a bowl-shaped geological formation at the summit of a volcano. It is connected by a vent or pipe to the magma chamber below.
3. Fumaroles: They are secondary vents on the flank of a volcano which emit steam and other gases.
4. Throat: Entrance of a volcano. The part of the conduit that ejects lava and volcanic ash.
5. Conduit: It is an underground passage through which the magma flows.
6. Magma Chamber: It is a reservoir of magma in the earth's crust where the magma may reside temporarily on its way from the upper mantle to the earth's surface.
7. Caldera: It is a crater more than 1 km in diameter, formed at the summit of a volcano when lava is drained from an underground magma chamber, causing the summit of the volcano to be unsupported, and to collapse.

8. Pit crater: They are collapse features on the flanks or summit of a volcano that are smaller than the main caldera at the summit of a volcano.
9. Lava Flow: This is sheet of molten or solidified lava.
10. Sill: This is an intrusive body of magma that pushes its way between layers of sediments.
11. Ash Cloud: It is a cloud of volcanic gases, ash and dust that form during an explosive volcanic eruption.
12. Secondary Vent: It is vent that connects to the secondary cone for the lava to flow.

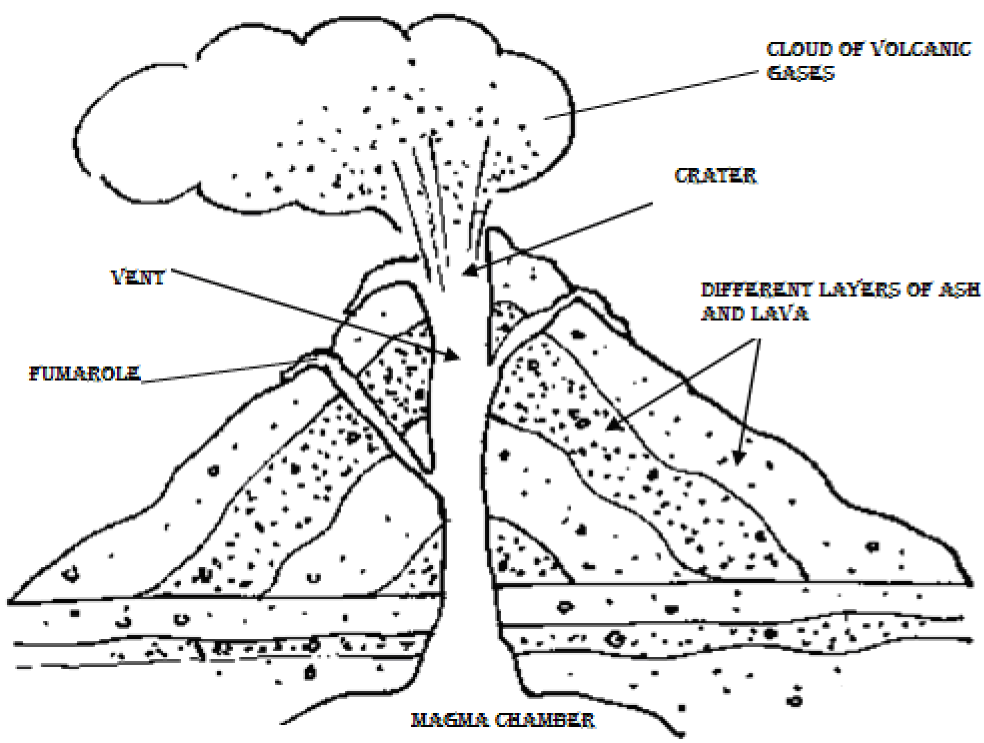


Figure 5.2 Parts of a volcano

5.5 VOLCANIC ERUPTION PROCESS

A volcanic eruption occurs when pressure from gases and steam within the magma build up sufficiently to fracture the surface of solid rock. This allows lava to flow onto the earth's surface.

When fractures occur within the earth's crust, then the pressure on the magma becomes less, and the magma is pushed up to the surface through the crack. When magma reaches the earth's surface it is referred to as lava. Successive eruption of hot, molten matter forms a cone-shaped mountain of lava. The process produces igneous rocks but may also help form metamorphic rocks due to the heat along with the eruptions. The viscosity of the magma is controlled by its acidic, intermediate or the basic nature. If the lava is acidic and rich in silica, it will harden and set quickly. Such volcanoes erupt violently and are called Composite Volcanoes. Some examples are Mount Etna in Sicily, Mount St. Helens in the USA and Mount Vesuvius in Italy. Basic lava which is low in silica but rich in iron content flows freely and sets slowly. Such volcanoes are called Shield Volcanoes. Some examples are those in Hawaii. Stratovolcanoes are built over many thousands of years after dozens of eruptions. Volcanic eruptions result in bringing new rock material from the interior of the earth to the earth's surface. These rocks help in the formations of mountains and islands. Further, the gases and volatiles emitted have contributed to the earth's atmosphere and oceans.

5.6 KINDS OF VOLCANIC ERUPTIONS

As discussed earlier in the chapter, volcanic eruptions can be of two types: explosive and non-explosive eruptions. Let us now learn about this in the following paragraphs.

1. Explosive Eruptions: They occur due the presence of to high gas content or volatiles in highly viscous magmas. During these eruptions magma is fragmented into clots of liquid that cools down and become sand-sized particles. These solid particles become pyroclasts and tephra or volcanic ash. Other fragments released include **blocks and bombs** named according to the angular and aerodynamic shapes. Lapilli are those that consist of mostly gas bubbles. They can also be released resulting in a low density highly vesicular rock fragment called **pumice**. Volcanic gas clouds and ash can rise up to 45 km into the atmosphere.

2. Non-explosive Eruptions: These eruptions occur when the magmas are less viscous and contain less volatile matter. When the viscosity is low these eruptions start with fire fountains as a result of release of dissolved gases. When the gas content is low and the viscosity is high then lava will produce a volcanic dome. Lava flows result on the surface of earth. When the volcanic eruption is submarine then pillow lavas are produced.

SAQ1

1. What are volcanic eruptions and why do they occur?
2. Describe the different parts of a volcano.
3. Describe the major types of volcanoes.

Mount St. Helens, Montana, USA 1980 - resurgence after 123 years

Mount St. Helens was dormant for 123 years. It again erupted on 18th May, 1980 resulting in damage exceeding $800 million. Gas and ash-filled steam came out from the mountain at a speed of around 670 miles per hour. The eruption destroyed six million trees. The volcanic explosion was equivalent to 500 small atomic bombs. There were 34 deaths, 10,000 animals were dead and 15,000 acres of forestland was destroyed.

5.7 FACTORS CONTROLLING VOLCANIC ERUPTIONS

Let us discuss in detail about the different factors that control volcanic eruptions, in the following paragraphs.

Magma composition, temperature and viscosity

Viscosity is the resistance to flow and it depends primarily on the composition of the magma and its temperature. This parameter is of utmost importance in determining the eruptive behaviour of magmas. The magmas with higher silica content have higher viscosity than those with lower silica contents. Granitic or sialic magma is more viscous than basaltic or mafic magma. The shapes of volcanoes also depend on the viscosity of the magma. For example, basaltic lava forms flat shield volcanoes. Gases are not easily released from viscous magmas. Here, the pressure builds up and leads to violent explosions. These are typical of strato-volcanoes.

Characteristics of Magma: They control the kind of eruption that would take place.

a) Magma types: Types of magma are determined by the chemical composition of the magma and three broad general types are recognized:

- Basaltic magma contain SiO_2 45-55 wt%, are high in Fe, Mg, Ca, and low in K, Na
- Andesitic magma contain SiO_2 55-65 wt%, and are intermediate in Fe, Mg, Ca, Na, K
- Rhyolitic magma contain SiO_2 65-75%, are low in Fe, Mg, Ca, and are high in K, Na

b) Volatile content in Magmas: The explosive character of magmas is due to the presence of gases. In the Earth, at depths, all magmas contain gas dissolved in the liquid form. When the magma rises to the surface of the Earth, the gas forms a separate vapour phase due to decrease in pressure. The composition of the gases in magma include: mostly water vapour, carbon dioxide, trace amounts of sulfur, chlorine, and fluorine. The felsic or rhyolitic magmas have higher gas contents as compared to the mafic or basaltic magmas. This is because the amount of gas present in magma is related to the chemical composition of the magma. For example, basaltic lava forms flat shield volcanoes. Gases are not easily released from viscous magmas. Here, the pressure builds up and leads to violent explosions. These are typical of strato-volcanoes.

c) Magma temperature: They are characterized by different temperatures. Geological field observations and scientific measurements suggest that the eruption temperature of various magmas can be different.

- basaltic magma can range between 1000 to 1200°C;
- andesitic magma can range between 800 to 1000°C; and
- rhyolitic magma can range between 650 to 800°C.

5.8 PRODUCTS OF VOLCANIC ERUPTIONS

The products of volcanic eruptions include the following: Lava flows, pyroclastic debris, ash, dust, gases and Nuee ardentes. In addition to the gases that come out of volcanoes, large amounts of solid materials are also ejected. The smaller particles of dust reach the highest levels in the atmosphere. For strong vertical eruptions, dust can be propelled up into the stratosphere, above 17 kilometers. At such heights, the suspended dust particles can block solar radiation, effectively by heating up the stratosphere while the lower troposphere cools causing short term effects.

1) **Solid**: The solid material of different sizes is ejected out of volcano during eruptions. They are called as ‘pyroclastic material’. These materials of varying sizes and grades are known differently based on their size, viz. Volcanic bombs, Lapilli or cinder, Volcanic Ash and volcanic dust.

2) **Liquid**: The most important product of volcanic eruption is magma It is molten rock material consisting of mineral melt. It is. On average the temperature of magma ranges between 1000° and 1200° C. Molten rock material below the surface is called ‘magma’ and when it comes on the surface it is called ‘Lava’. It can be felsic (viscous) or basic (less viscous or fluid).

3) **Gases:** Water vapours form one of the most important part constituting of the total volcanic gases. These water vapours may come from the original magma or due to boiling of underground water in the volcanic area. Volcanic gas samples contain water (70 %), carbon dioxide (15 %) and Nitrogen (5 %) along with sulphur dioxide, hydrogen sulfide, carbon monoxide, hydrogen, hydrochloric acid, and methane, chlorine and argon.

5.9 HAZARDS ASSOCIATED WITH VOLCANOES

Do you think there can be hazards accompanied with volcanic eruptions? Yes, there are. So volcanic hazards are classified into primary and secondary hazards:

1. Primary volcanic hazards

Lava flows are usually not very dangerous. They move slowly and can damage property. Again there can be a few exceptions. For example, at Zaire in 1977 the Nyiragongo volcano had a side fissure which drained the lava lake in the main crater very rapidly. It resulted in the lava squirting out at 60 miles per hour. This volcanic activity caused approximately 1000 fatalities.

- *Violent Eruptions and Pyroclastic Activity:* They are the most dangerous as they can travel rapidly. Hot pyroclastic flows result in suffocation, burns and death.
- *Ash falls:* They characterized by mud ash and gases. An example is the 79 AD eruption of Mt. Vesuvius causing

about 20,000 fatalities.

- *Nuee Ardente*: They are fast moving flows of gas and magma, in a volcanic avalanche. These can be deadly due to fast flows and destructions. An example to cite is the 1902 eruption of La Soufriere, St. Vincent, which killed 1500. Nuee ardentes consist of clouds of volcanic gases and pyroclastic debris that avalanche down the side of a volcano. They can reach speeds of almost 200 km/hr. A nuee ardente from Mount Pelee, on the Caribbean island of Martinique, killed 28,000 inhabitants and destroyed the town of St. Pierre in 1902.
- *Gas emissions*: They accompany every volcano. Some of the gases include: Hydrogen chloride, Hydrogen sulfide, Hydrogen fluoride, and Carbon dioxide. The eruption that occurred at Iceland in 1783 at Mt. Laki had a massive flux of sulfuric and fluorine gas, which killed great numbers of livestock. This resulted in a famine leading to 10,000 fatalities.

2. Secondary and Tertiary Volcanic hazards

- Agricultural catastrophes are secondary consequences of the widespread devastation of volcanic eruptions. These hazards are varied and clearly not easily controlled.
- *Lahars* are volcanic mudflows, typically resulting from eruption under ice and snow at the summit, which mixes with the ash to make fast flowing muds.
- *Tephra falls*: Volcanoes can emit huge quantities of loose, unconsolidated tephra that are deposited on the landscape. They can be removed using water from the melting of snow or ice during the eruption. They can also be removed by emptying of crater lakes during an eruption or due to rainfall. They can also result in roof collapse. Although tephra falls cover an area in the same way as snow, they are very destructive in nature. This is because these deposits have a density twice than that of snow. They also cannot melt like snow. They devastate vegetation, crops, and kill livestock. They bring about a loss in agricultural activities for years after an eruption.
- *Debris Avalanches and Debris Flows*: Volcanic mountains can steepen over time. Such steep slopes may become unstable. It can result in sudden slope failures resulting in landslides or debris avalanches. For example let us see the eruption of Mount St. Helens at Washington that occurred on May 18th, 1980. The eruption of a debris avalanche was triggered by a magnitude 5.0 earthquake. This avalanche removed the upper 500 m of the mountain and flowed into the Spirit Lake. It raised the lake's level by about 40 m. It then moved to the west

filling the upper reaches of the North Fork of the Toutle River valley. Debris avalanches, landslides, and debris flows do not always occur with a volcanic eruption. Some documented cases of such occurrences have been reported where no new magma has erupted.

- *Flooding*: Drainage systems can become blocked by deposition of pyroclastic flows and lava flows. These can create temporary dams that could get filled with water and fail resulting in floods downstream from the natural dam. Volcanoes in cold climates can melt snow and glacial ice. This can rapidly release water into the drainage system and possibly cause floods.
- *Tsunami:* They occur when eruptions displace ocean water. Debris avalanche events, landslides, caldera collapse events, and pyroclastic flows that enter water bodies can generate tsunamis. In 1883, the eruption of Krakatau volcano triggered several tsunamis by pyroclastic flows entering into the sea and by collapse accompanying caldera formation. This tsunami killed 36,400 people, some even 200 km away from the volcano.
- *Volcanic Earthquakes and Tremors:* Earthquakes usually precede and accompany volcanic eruptions, as magma intrudes and moves within the volcano. Although most volcanic earthquakes are small, some can be large enough to cause damage in the area immediately surrounding the volcano. Others can trigger landslides and debris avalanches. Volcanic tremors can also occur. This is the continuous rhythmic shaking of the ground due to moving magma underground.
- *Atmospheric Effects:* Short-term effects on climate are caused when huge quantities of tephra and volcanic gases are released into the atmosphere. Volcanic ash can cause reflection of solar radiation which results in cooler temperatures for several years after a large eruption. For example, the eruption of Tambora volcano at Indonesia in 1813 was the largest in recorded in history. The year later the area was known as the "year without summer". Volcanic gases like carbon dioxide are greenhouse gases that retain heat in the atmosphere. During the mid-Cretaceous period the carbon dioxide content of the atmosphere was 15 times higher than modern times. This could be as a result of voluminous eruptions of basaltic magma on the sea floor. The average temperatures were also around 10 to 12^{o}C warmer than the present times.
- *Famine and Disease:* Another effect is the wide spread damage to crops and livestock. This

can also lead to famine and disease.

The Volcanic eruption of Mt. Pinatubo, Philippines, 1991

On 9th July 1991 the 1,463 metre, dormant volcano near Subic Bay, Mt Pinatubo, Philippine became active after six centuries. It resulted in a series of eruptions which lasted for months. This massive eruption was the largest on record in the Philippines and in the world since Krakatoa erupted at Indonesia in 1883. The eruption spewed billions of cubic metres of magma, gases and ash from a three kilometre-long crater near the mountain's summit. The explosive force ejected enormous clouds of ash and gas vertically to an altitude of ~40 km. The ash settled deep on the ground over huge areas, up to hundreds of kilometres away. On 17th July, the sky was totally black as far south as Manila i.e. 85 km away. A continuous 'rain' of pumice pebbles and ash occurred along with thunder and lightning from a tropical storm. This alternated with brilliant orange flashes from the volcano. Numerous earthquakes were also recorded resulting from Pinatubo's violent eruptions. The bulk of its eruptive energy was directed vertically upwards, so it did not produce large pyroclastic and molten lava flows. The secondary effects caused loss of life and property. This occurred a week later due to heavy rains from Typhoon Brenden. Mud flows wiped many foothill villages and forced thousands of people to flee from their homes. Scientists estimated that Pinatubo's eruption added more aerosols than all anthropogenic 'greenhouse gases' since the industrial revolution. Further, a reduction of up to 1°C in the Earth's average temperature was recorded by NASA satellites within a year of the main eruption and this cooling effect persisted for about two years.

5.10 PREDICTION AND MITIGATION OF VOLCANIC ERUPTION

Volcanic prediction is difficult, but on a comparative scale it is more viable than for earthquakes. The major challenge is that every volcano has a unique behaviour, which must be characterized on a case by case basis. This is challenging because of the long period of repose between explosions.

Most volcanic predictions are based on various phenomena:

1. Behaviour of the volcano
2. Earthquake activity, tracking the ascent of magma
3. Deformation of the ground surface
4. Changes in the gas chemistry and temperature.

For some volcanoes, the statistical behaviour can be characterized if there is a history of 10-20 eruptive sequences. There is no simple physical theory for the eruptive cycle and this is an empirical approach, Statistical methods give gross probabilities, but not short-time prediction. Individual volcanoes differ in the reliability of earthquake precursors, and again each volcano should be characterized. Inflation of the magma chamber below the volcano causes tilting and uplift of the surface which can be measured. This is the direct result of ascent of magma and build-up of gas pressure. There are many instances of successful prediction of major eruptions.

1. Long - Term Forecasting

Understanding the geologic history of a volcano is important in order to assess the types of hazards posed by the volcano and also the frequency at which these hazards occurred in the past. Then volcanologists make forecasts as to which areas surrounding a volcano would be subject to the various kinds of activities if they occur in future. They also make forecasts about the long - term likelihood of a volcanic eruption in the area. Scientists examine lava flows and other deposits of various eruptions which help to the past nature of a volcano. Further radiometric age dating of the deposits and the past frequency of events can be determined. This information is extended for preparing volcanic hazard maps. This is of help to scientists, public officials, and the general public to plan for evacuations, rescue and recovery operations. They also help delineate zones of danger expected from the hazards.

2. Short - Term Prediction

It involves monitoring the volcano to determine when the magma is nearing the surface. It also involves monitoring for precursor events that often signal a likely eruption.

- *Monitoring seismic waves:* **S**eismic waves are generated by both earthquakes and explosions.

S-waves cannot pass through liquids so arrays of seismographs can be placed around a volcano and small explosions can be set off to generate seismic waves. In case a magma body exists beneath the volcano, then there will be a zone where no S-waves arrive. This is known as an S-wave shadow zone. Monitoring the movement of the S-wave shadow zone can help recognize the position and movement of the magma body. As magma moves and deforms rocks it may generate earthquakes. So, there is usually an increase in seismic activity prior to a volcanic eruption. In this way, the movement of magma can be tracked. In addition, volcanic tremor is also an indication that magma is moving below the surface.

- *Changes in geophysical signatures*: Rocks contain minerals such as magnetite that are magnetic. These minerals generate magnetic field. However, above a temperature called the Curie temperature, these minerals show no magnetism. So, if a magma body enters a volcano, the body itself will show no magnetism. If it heats the surrounding rocks to temperatures greater than the Curie temperature (about 500°C for magnetite) the magnetic field over the volcano will be reduced. Thus, by measuring these changes in the magnetic field, the movement of the magma can be tracked. Rocks have resistance to the flow of electrical current which is dependent on temperature and water contents. When magma moves into a volcano the electrical resistivity will decrease. Measurements of the electrical resistivity can allow tracking of the movement of magma. As magma approaches the surface the amount of surface heat flow will increase. These small changes are measured using infrared remote sensing.
- *Changes in ground surface:* As magma moves into a volcano, the structure may inflate causing deformation of the ground surface which can be monitored. Some instruments, like tilt meters measure changes in the angle of the Earth's surface.
- *Changes in Groundwater System:* As magma enters a volcano it may cause changes in the groundwater system. It can result in the water table to rise or fall and the temperature of the water to increase. These changes can be monitored.

- *Changes in chemistry of gases:* The composition of gases emitted from volcanic vents and fumaroles generally change just before to an eruption.

In conclusion, no single event can be used to predict a volcanic eruption. Many events are usually monitored and examined in totality. Each volcanic eruption is unique and until specific patterns are recognized for an individual volcano, predictions vary in their reliability.

5.11 Natural service functions of volcanoes

Volcanic processes have been responsible for outgassing of the Earth to help produce both the atmosphere and hydrosphere. You have read about the destructive effects of volcanism. Now let us discuss the constructive effects of volcanism.

- Volcanism renews the soil. The soils around active volcanoes are very fertile. The lavas produce fertile soil after weathering being derived from virgin materials *e.g.* soils in Java and black soil in central and south India.
- Precious and semi-precious stones are found in volcanic rocks *e.g.* diamonds are found in India and South Africa.
- Ores and mineral deposits are extensively produced by volcanism and related processes. Hydrothermal processes associated with volcanism produce rich ore deposits. The heat rising around magma bodies can be utilized to produce geothermal energy.
- Crater lakes and caldera lakes are formed which provide source of fresh water to us *e.g.* Buldana Lake in Maharashtra.
- The volcanic rocks also provide an abundant local source of materials for landscaping, construction activities and road building.
- Some volcanoes also provide us natural laboratories for observation of some of the natural processes occurring below the surface of the earth.

SAQ 2

1. Describe the factors controlling the volcanic eruptions.
2. How can we predict volcanic eruptions and mitigate volcanic disasters?
3. Write short notes on beneficial aspects of volcanism.

5.12 Summary

In this unit we have studied about volcanic eruption processes, the structure of a volcano, their types, effects, impacts, and forecasting the events. Volcanic eruption processes rock our planet. They lead to the formation of new rock material and fertile soils. They are also natural scientific laboratories where extensive studies can be carried out for understanding the interior composition of our earth and for other geological studies.