Course Code: GEGE-01

BASICS OF PHYSICAL GEOGRAPHY

DEPARTMENT OF GEOGRAPHY AND

NATURAL RESOURCE MANAGEMENT

SCHOOL OF EARTH AND ENVIRONMENTAL SCIENCE

UTTARAKHAND OPEN UNIVERSITY

(Teenpani Bypass, Behind Transport Nagar, Haldwani (Nainital), Uttarakhand, India)

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Basics of Physical Geography

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AND NATURAL RESOURCE MANAGEMENT
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UNIT 1 - THE SOLAR SYSTEM

1.1 OBJECTIVES

After reading this unit the learner will be able to understand:

- Basic understanding of the solar system.
- Structure of our solar system.
- Basic knowledge of planets and other celestial bodies.

1.2 INTRODUCTION

The solar system is an awe-inspiring topic that captivates the minds of young learners. Our solar system consists of the sun, eight planets, numerous natural satellites/moons, asteroids, and comets. While some might consider it merely a collection of celestial bodies, we must recognize its profound significance. Understanding the solar system can unravel the mysteries of our existence and inspire us to explore beyond our home planet. The exploration of space has led to technological advancements and has broadened our knowledge of the universe. Therefore, as learner, we should embrace the solar system as a gateway to curiosity, discovery, and the limitless possibilities that lie beyond the boundaries of our Earth.

The solar system can be defined as the group of planets, natural satellites/moons, asteroids, and comets that revolve around the sun. Moreover, the solar system is a vast and intricate cosmic arrangement that comprises a star, the sun, and all the celestial objects bound to its gravitational influence. These objects include eight major planets, namely Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune, along with their respective moons, numerous smaller objects like asteroids, comets and various other cosmic debris. The sun, situated at the center, exerts gravitational forces that keep these celestial bodies in their orbits, forming a harmonious and dynamic system that has been a subject of fascination and exploration by astronomers and space enthusiasts alike.

The solar system, which serves as our cosmic neighborhood, is a captivating realm of celestial objects, each with its unique characteristics and mysteries waiting to be unraveled. Join me as we explore the sun, eight fascinating planets, their many moons, and other celestial bodies that make up this enchanting system. At the centre of our solar system, lies the Sun, a brilliant and blazing star that provides us with warmth and light. This immense ball of gas is so massive that it holds everything in its gravitational embrace. Orbiting around the Sun are eight planets, each with its distinct features and intriguing secrets. From the inner terrestrial planets, Mercury, Venus, Earth, and Mars, to the outer giants, Jupiter, Saturn, Uranus, and Neptune, each world offers a glimpse into the diversity of the cosmos.

In addition to the planets, the solar system hosts an assortment of fascinating natural satellites/moons. These natural satellites accompany their parent planets, and some, like Earth's Moon, have played significant roles in shaping our planet's history. The solar system also houses asteroids (rocky remnants from the early days of our solar system) and comets, icy wanderers that bring a touch of celestial magic as they streak across the night sky. This exploration of the solar system is not just a lesson in astronomy; it is a gateway to understanding the marvels of the universe and our place within it. By diving into the mysteries of the solar system, we can learn more about our own planet, appreciate the beauty of the cosmos, and perhaps even be inspired to explore beyond our boundaries and reach for the stars. So, fasten your seatbelts and get ready to be captivated by the wonders of our extraordinary solar system!

One question that arises in the mind of scientists and scholars that was, how the solar system formed. To find this question’s answer, various scientists and scholars developed hypotheses and theories. Theories concerning the origin of the solar system have captivated scientists for centuries, and two prominent hypotheses have emerged to explain this cosmic event. The first is the Nebular Hypothesis, proposed by Immanuel Kant and further developed by Pierre-Simon Laplace. This theory posits that the solar system formed from a rotating cloud of gas and dust, known as the nebula. As the nebula contracted under its own gravity, it began to spin faster, eventually flattening into a disk. Within this disk, matter coalesced into clumps and eventually formed the sun at the center and the planets around it. Other important theories related to the origin of solar system are the Planetesimal hypothesis of Chamberlin, the Tidal hypothesis of James Jeans, the Binary Star hypothesis of Russell, the Inter-Stellar Dust hypothesis of Otto Schimidt and the Big Bang theory of George Lamaitre.

1.3 THE SOLAR SYSTEM

As discussed in the earlier section, the solar system is a collection of mainly one star and eight planets (Fig. 1.1). Based on energy emission, the celestial bodies can be divided into two parts one is star and the second is planet. A star is a luminous celestial object composed mainly of hot gases like hydrogen and helium. It generates energy through nuclear fusion reactions that occur at its core, releasing vast amounts of light and heat. In our solar system, the Sun is the star around which all the planets, including Earth, orbit. The Sun provides the energy that sustains life on Earth. On the other hand, a planet is a non-luminous celestial body that orbits a star. Unlike stars, planets do not produce their own light but reflect the light they receive from their star. They are mostly composed of rocky or gaseous materials. In our solar system, there are eight recognized planets which vary in size, composition, and distance from the Sun. A brief description of the star (Sun) and planets of our solar system is presented in the following paragraphs.

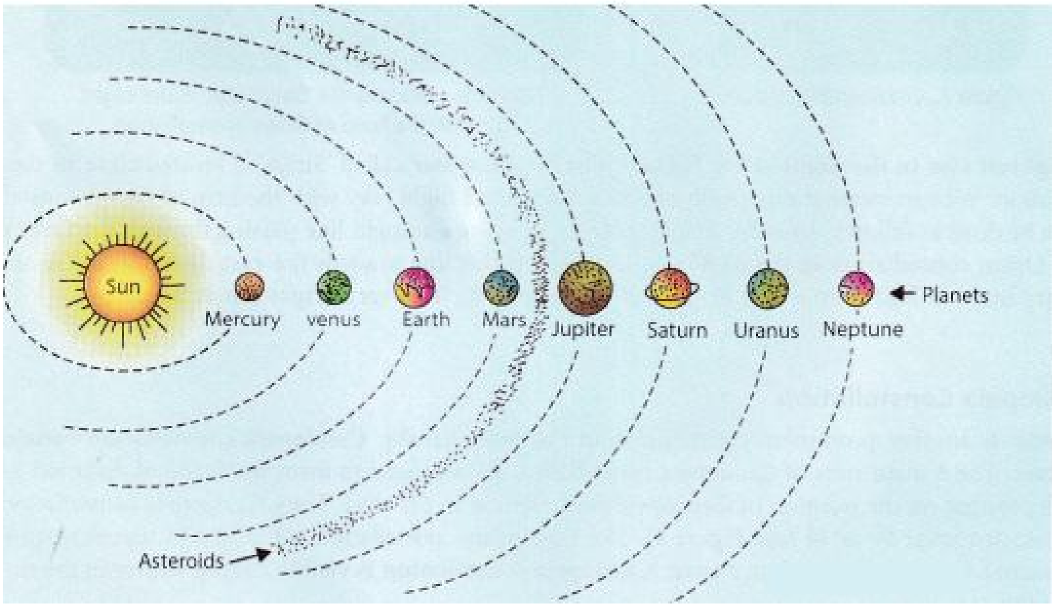

Fig. 1.1: The solar system (Source: Google).

The Sun

The Sun is a star that lies at the center of our solar system and one of the most crucial celestial objects in the universe. It lies approximately 150 million kilometers away from Earth and serves as the primary source of light, heat and energy for all life on our planet. The Sun's diameter is approximately 1.4 million kilometers. To put it into perspective, the Sun's diameter is about 109 times that of Earth. The Sun is composed mainly of hydrogen (about 70.6% by mass), and helium (about 27.4% by mass) and with trace amounts of other elements (Drishti, 2017). The

Sun rotates on its axis from west to east. About 8 minutes take the solar light to reach the Earth's surface.

The structure of the Sun consists of six layers, starting from the corona to the core. At the core, temperatures reach an astounding 15 million degrees Celsius. Here, nuclear fusion occurs as hydrogen atoms combine to form helium, releasing a tremendous amount of energy in the process. The core is surrounded by the radiative zone, where energy is transported outward by photons. Beyond the radiative zone lies the convective zone. In this region, energy is transported by convection, as hot plasma rises to the surface, cools down, and sinks back down to the interior, creating the Sun's granulated appearance. The visible surface of the Sun is known as the photosphere. It has a temperature of around 5500 degrees Celsius and appears as a yellowish disk due to its temperature and the scattering of light in Earth's atmosphere. Above the photosphere are the chromosphere and corona. The chromosphere is a thin layer of burning gases and emits a reddish glow during solar eclipses. The corona is the outermost layer of the Sun. This layered structure allows the Sun to sustain the vital nuclear fusion process, produce solar energy and influence space weather phenomena.

The Sun is a dynamic object with an 11-year solar cycle marked by variations in solar activity. Solar activity includes sunspots, solar flares, and coronal mass ejections (CMEs). Sunspots are cooler regions on the Sun's surface caused by magnetic disturbances, while solar flares and CMEs are explosive events that release immense amounts of energy and can influence space weather and Earth's magnetic field. Sunspots take place in the photosphere while solar flares take place in the chromosphere. The Sun constantly emits a stream of charged particles, primarily electrons and protons, known as the solar wind. The solar wind flows outward in all directions from the Sun and carries with it the Sun's magnetic field. The Sun's energy is harnessed through solar radiation and is essential for sustaining life and powering various human activities. However, solar activity can also have adverse effects on technology and infrastructure through space weather phenomena like solar storms, which can disrupt satellite communications, power grids and navigation systems.

One of the remarkable effects of the solar wind interacting with Earth's magnetosphere is the aurora, also known as the Northern and Southern Lights. When solar wind particles collide with gases in Earth's upper atmosphere, they produce beautiful, glowing displays of light in the polar region. The colors in auroras are a result of different gases being excited by the charged particles, with oxygen producing green and red hues, and nitrogen producing blue and purple hues.

Planets

The definition of a planet was set by the International Astronomical Union (IAU) in 2006. According to the IAU's definition, for an object to be considered a planet, it must meet three criteria:

i. A celestial body that orbits the Sun.
ii. Sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a nearly round shape (in other words, it should be nearly spherical).
iii. It has cleared its orbit of other debris. In other words, a planet has become gravitationally dominant in its orbital region and has removed or absorbed most other objects in its vicinity.

According to this definition, as of 2006, there were eight recognized planets in our solar system: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Pluto, which was previously considered the ninth planet, was reclassified as a "dwarf planet" since it did not meet the third criterion, as its orbit overlapped with other objects in the Kuiper Belt (IAU, 2006). A brief description of the planets of our solar system is presented in this chapter.

Mercury

Mercury is the smallest planet in our solar system and the closest one to the Sun. It is a rocky/terrestrial planet, similar to Earth, but much smaller. Mercury has a diameter of about 4879 kilometers. Mercury's axial tilt is nearly negligible, with an inclination of only about 0.01 degrees. This means it has almost no axial tilt, and as a result, it lacks significant seasonal variation. One of its most noticeable characteristics is its extreme temperatures. During the day, the temperature can reach scorching hot levels of about 430 degrees Celsius. However, at night, the temperatures drop drastically to as low as -180 degrees Celsius. Due to its lack of atmosphere, Mercury cannot retain heat like Earth does, causing these extreme temperature fluctuations. Another interesting feature is its slow rotation. It completes its orbit around the Sun in 88 days. Additionally, Mercury has a heavily cratered surface, with many impact craters from meteoroids that have struck its surface over billions of years. The planet also lacks significant geological activity, like volcanoes or plate tectonics, which means that these craters remain relatively unchanged. Mercury does not have any natural satellite/moon orbiting around it. These characteristics make Mercury a fascinating and unique planet in our solar system.

Venus

Venus is often referred to as Earth's "sister planet" due to its similar size and composition. It has a diameter of about 12104 kilometers, which is roughly 95% the size of Earth. It is the second planet from the Sun and is known for being the hottest planet in our solar system. This extreme heat is caused by its thick and toxic atmosphere, primarily composed of carbon dioxide with traces of sulfuric acid. The greenhouse effect traps heat on Venus, leading to a surface temperature that can soar up to a scalding 470 degrees Celsius, hotter than even Mercury, despite being farther from the Sun. Another unique feature of Venus is its slow retrograde rotation, meaning it rotates on its axis in the opposite direction compared to most other planets. Its orbit around the Sun takes around 225 Earth days. The planet's surface is obscured by thick clouds that are rich in sulfuric acid, making it challenging to observe its topography from space. However, radar mapping has revealed that Venus has vast volcanic plains, mountains, and large impact craters, suggesting a history of volcanic activity and geological processes. Furthermore, Venus does not have a significant magnetic field like Earth, which has resulted in the loss of much of its original atmosphere over time due to solar winds. Venus also does not have any satellite/moon. These unique characteristics make Venus an intriguing and scientifically important planet to study in our solar system.

Earth

Earth is the third planet from the Sun and the only known planet to support life. Earth's axis is tilted about 23.5 degrees relative to its orbital plane around the Sun. This tilt is responsible for the changing seasons as different parts of the planet receive varying amounts of sunlight throughout the year. Earth has a diameter of about 12765 kilometers and a mass of approximately 5.97 kilograms, making it the fifth-largest planet in the solar system. One of its most vital features is its atmosphere, primarily composed of nitrogen and oxygen, which provides the essential air we breathe. The presence of liquid water on Earth is another critical characteristic, as it supports various forms of life, making it a diverse and vibrant planet. Earth is often referred to as the "Blue Planet" due to its vast oceans and bodies of water. Earth's surface is composed of continents and oceans, with complex geological features like mountains, valleys and plains. It also experiences the phenomenon of tectonic plate movement, leading to earthquakes, volcanic activity and the creation of mountain ranges. The Earth's rotation on its axis results in day and night cycles and its orbit around the Sun takes approximately 365 days. The planet's magnetic field, generated by its core, protects us from harmful solar radiation and cosmic rays. Earth is rich in biodiversity, with millions of species, from tiny microorganisms to large animals, living in various ecosystems. Human beings have made significant advancements in technology, art, science, and civilization, creating diverse cultures around the world. One of Earth's companions in space is its natural satellite that is the Moon. The Earth's capacity to sustain life and its remarkable diversity make it a unique and precious planet in our solar system. As the only known habitable world, Earth inspires us to protect and preserve its delicate balance to ensure a sustainable future for all living beings.

Mars

Mars, often called the "Red Planet" due to its rusty appearance, is the fourth planet from the Sun in our solar system. Mars rotates on its axis, completing one rotation approximately every 24.6 hours. This period is very close to Earth's day, which is around 24 hours. Mars has an axial tilt of about 25.2 degrees. This tilt is responsible for the planet's distinct seasons, similar to Earth. Its diameter is approximately 6792 kilometers, about half the size of Earth, and its mass is about 0.642 kilometers. Its orbit around the Sun takes approximately 687 days. One of the most prominent characteristics of Mars is its surface, which is covered in reddish iron oxide dust, giving it a distinctive red color. The planet's thin atmosphere is primarily composed of carbon dioxide, with trace amounts of other gases. Despite the thin atmosphere, Mars experiences weather phenomena such as dust storms, which can sometimes cover the entire planet and last for weeks or even months. Mars has a diverse topography, including massive volcanoes, such as Olympus Mons, which is the largest known volcano in the solar system, and vast canyons like Valles Marineris, one of the deepest canyons in the solar system. Additionally, one of the most significant discoveries on Mars is evidence of ancient river valleys and lakebeds, suggesting the presence of liquid water in the distant past. Mars has two small natural satellites namely, Phobos and Deimos, which are irregularly shaped and much smaller than Earth's Moon. The exploration of Mars continues to captivate the imagination of scientists and space enthusiasts alike, as it holds important clues about the planet's history and the potential for life beyond Earth.

Jupiter

Jupiter, the largest planet in our solar system, is a gas giant and the fifth planet from the Sun. Its immense size sets it apart, as Jupiter's diameter is about 11 times higher than that of Earth. Composed mostly of hydrogen and helium, Jupiter lacks a solid surface and has a dense atmosphere with bands of colorful clouds swirling around it. The planet's rapid rotation results in a short day, with Jupiter completing one full rotation on its axis in about 9.9 hours while the orbital period around the Sun is approximately 4331 years. Another fascinating feature of Jupiter is its intricate system of rings, though they are less prominent than Saturn's. Jupiter has a strong magnetic field, which is about 20000 times stronger than Earth's. This magnetic field traps charged particles, creating intense radiation belts around the planet. Jupiter has a remarkable system of moons, the four largest of which are known as the Galilean moons: Io, Europa, Ganymede, and Callisto. These moons are some of the most fascinating worlds in the solar system, with volcanic activity on Io, the possibility of an ocean beneath the icy crust of Europa, Ganymede being the largest moon in the solar system, and Callisto displaying a heavily cratered surface. Jupiter's immense size and gravitational pull play a significant role in influencing the dynamics of the solar system, affecting the orbits of other planets and celestial objects. The study of Jupiter and its moons has provided valuable insights into the formation and evolution of our solar system.

Saturn

Saturn, the sixth planet from the Sun, is a gas giant known for its stunning and iconic ring system, making it one of the most visually striking planets in our solar system. It has a mass of approximately 568 kilograms, making it the second-most massive planet in our solar system, surpassed only by Jupiter. Its diameter measures about 120536 kilometers, making it the second-largest planet after Jupiter. The planet has a rapid rotation, completing one full rotation on its axis in about 10.7 hours which gives it an oblate shape due to its fast equatorial rotation. In terms of its orbit around the Sun, it takes approximately 29.5 years to complete one orbit. Saturn has an axial tilt of about 26.7 degrees resulting in seasons similar to Earth's but more prolonged due to its longer orbit. It is composed mainly of hydrogen and helium, similar to Jupiter, and lacks a solid surface. Saturn's most distinct feature is its extensive ring system, which consists of icy particles ranging in size from tiny grains to several meters in diameter. These rings orbit around Saturn's equator and create a mesmerizing spectacle when observed from Earth or spacecraft. Its atmosphere is rich in ammonia and methane, giving it a pale golden hue. Saturn has a relatively small, rocky core, but its vast gaseous envelope contributes to its large overall size. The planet has a complex system of satellites/moons. Titan is Saturn's largest moon, is particularly notable as the second-largest moon in the solar system and is enveloped by a thick atmosphere, featuring lakes and rivers of liquid hydrocarbons on its surface. Enceladus is another moon of Saturn. The study of Saturn and its moons has provided valuable insights into planetary formation and the diverse conditions that exist within our solar system.

Uranus

Uranus is the seventh planet from the Sun, and a unique and fascinating world in our solar system. It is a gas giant, much like Jupiter and Saturn, but it stands out due to its distinct features. Uranus has a bluish-green appearance, primarily caused by the presence of methane in its atmosphere, which absorbs red light and reflects blue and green wavelengths. The planet has a mass of approximately 86.8 kilograms, making it about 20 times higher than the mass of the Earth, and a diameter of roughly 51118 kilometers. Uranus is tilted significantly on its side, with an axial tilt of about 98 degrees, leading to its unique characteristic of "rolling" on its side as it orbits the Sun. This extreme axial tilt results in extreme seasons on Uranus, with each pole experiencing 42 years of continuous daylight and darkness during its 84 year orbit around the Sun. The planet has a faint ring system, composed of dark particles and dust. Uranus has 27 known moons, with the largest ones being Miranda, Ariel, Umbriel, Titania and Oberon. One of its most intriguing features is its atmosphere, consisting mainly of hydrogen, helium, and methane. The upper atmosphere of Uranus is characterized by distinct cloud bands, while the lower atmosphere experiences strong winds. Due to its remote location and challenging conditions, Uranus remains a subject of ongoing scientific study and observation, as we continue to seek a deeper understanding of this enigmatic and mysterious planet.

Neptune

Neptune, the eighth and farthest planet from the Sun in our solar system, is a gas giant with a striking blue hue. It was first discovered through mathematical predictions before being observed directly. Neptune has a mass of approximately 102 kilograms, making it about 24 times more massive than Earth. The planet has a diameter of about 49520 kilometers, making it the fourth-largest planet in terms of size. Neptune has a faint system of rings, although they are not as prominent as the rings of Saturn. These rings are composed of dust and ice particles. Neptune takes about 16 hours to complete one full rotation on its axis. Neptune takes approximately 164.8 Earth years to complete one orbit around the Sun. The axial tilt of Neptune is approximately 28.3 degrees, similar to Earth's axial tilt. Neptune's atmosphere is primarily composed of hydrogen, helium, and traces of methane, which give it its blue color. The methane in the atmosphere absorbs red light, reflecting blue light. The planet's weather is dominated by incredibly strong winds, with the fastest winds in the solar system. Its surface is covered by thick clouds and is not visible from space. Its weather patterns include massive storm systems, such as the famous Great Dark Spot, which was observed by the Voyager 2 spacecraft. Neptune's magnetic field is significantly tilted and offset from its center, possibly due to its unique magnetic interior. Neptune has a total of 13 known moons, the largest of which is Triton. Triton stands out as an intriguing moon with a retrograde orbit (opposite to Neptune's rotation) and a surface featuring geysers of nitrogen and dust. The study of Neptune and its moon Triton provides valuable insights into the dynamic processes that shape planetary bodies and moons in our solar system. Neptune is a fascinating and mysterious planet, and space missions like Voyager 2 and the Hubble Space Telescope have provided valuable insights into its characteristics and features.

Dwarf Planet

Dwarf planets are a distinct category of celestial objects in our solar system that share some characteristics with planets but do not meet all the criteria to be classified as full-fledged planets. The concept of dwarf planets was introduced by the International Astronomical Union (IAU) in 2006 during their redefinition of the term "planet." Here are some details about dwarf planets:

The dwarf planet can be defined as a celestial body that orbits the Sun, is nearly spherical (has sufficient mass for self-gravity to overcome rigid body forces and assume a nearly round shape), but has not cleared its orbital neighborhood of other debris. In other words, it lacks gravitational dominance in its orbital region, unlike the eight recognized planets in our solar system. Dwarf planets are typically smaller than the major planets and they do not have enough gravitational pull to clear their orbits of other objects. As a result, they often share their orbital regions with other celestial bodies, such as asteroids and other dwarf planets. There are some known dwarf planets which are discussed here. They are:

i. Pluto: Formerly considered the ninth planet, Pluto was reclassified as a dwarf planet in 2006. This is the largest known dwarf planet of our solar system. It is located in the Kuiper Belt, a region beyond Neptune.
ii. Eris: Discovered in 2005, Eris is one of the largest known dwarf planets. It is also located in the Kuiper Belt and was a catalyst for the redefinition of "planet" due to its similar size to Pluto.
iii. Haumea: Haumea is a relatively elongated dwarf planet with a unique shape and it is also located in the Kuiper Belt.
iv. Makemake: Also found in the Kuiper Belt, Makemake is relatively large and notable for its very low surface temperature.
v. Ceres: Unlike the other four, Ceres is located in the main asteroid belt between Mars and Jupiter. It is also classified as a dwarf planet due to its shape and size.

As our technology and observational capabilities improve, more dwarf planets will likely be discovered in the future. Scientists continue to explore the outer regions of the solar system, and new objects are regularly being identified and assessed for their classification.

Natural Satellites/Moons

A natural satellite/moon of a planet refers to a celestial body that orbits around a planet due to the parent planet's gravitational pull. The natural satellites do not have their own source of energy like planets. So, they also get light from the sun. These moons are a fundamental component of many planetary systems in the universe. Natural satellites come in various sizes, shapes, and compositions and play a crucial role in the dynamics and evolution of their parent planets. The gravitational force between the planet and its moon keeps the satellite in its designated path. They can be composed of various materials, including rock, ice, and sometimes a mixture of both. Natural satellites significantly influence their parent planets and their environments. They can create tides through gravitational interactions, affect axial tilts, and even provide valuable scientific insights through study and exploration. Throughout the solar system, many planets have multiple natural satellites. For instance, Jupiter, the largest planet, has maximum satellites while Mercury and Venus do not have even a single satellite.

The Moon

The Moon, Earth's only natural satellite, holds an enchanting allure in the night sky, captivating people for centuries with its mesmerizing beauty and intriguing features. This celestial body is an essential companion to our planet, offering unique characteristics that have profoundly influenced Earth's history and continue to play a vital role in shaping our environment. The Moon orbits around the Earth in a slightly elliptical path. This means that its distance from Earth varies during its orbit, causing slight variations in its apparent size in the sky which results in apogee and perigee. The apogee is the point in the Moon's orbit where it is farthest from the Earth. The perigee is the point in the Moon's orbit where it is closest to the Earth. When the Moon is at perigee, it appears slightly larger in the sky, and this is often referred to as a supermoon. The Moon's orbital period is approximately 27 days 8 hours. This is the time it takes for the Moon to complete one full orbit around the Earth. Due to its synchronous rotation with the Earth, the Moon takes the same time to complete one rotation on its axis, which is why we always see the same side of the Moon from Earth. Its average distance from Earth is approximately 384400 kilometers. A lunar eclipse occurs when the Earth comes between the Sun and the Moon, causing the Earth's shadow to be cast onto the Moon's surface. There are two types of lunar eclipses: partial lunar eclipses and total lunar eclipses.

Another remarkable characteristic of the Moon is its lack of atmosphere. Unlike Earth, which boasts a protective atmosphere that shields us from harmful radiation and meteoroids, the Moon's surface is directly exposed to the harsh conditions of space. This absence of atmosphere is why the Moon lacks weather phenomena such as clouds, wind, and rain. As a result, any footprints or imprints made by astronauts during the Apollo missions remain remarkably preserved, as there is no wind or water erosion to erase them. Furthermore, the Moon has a unique gravitational interaction with Earth, giving rise to tides in our oceans. Its gravitational pull causes the water in the oceans to bulge, creating the ebb and flow of tides. This tidal effect not only affects our planet's seas but also plays a significant role in the behavior of certain marine species, influencing their migratory patterns and feeding habits. In recent times, the Moon has become a subject of scientific exploration, with various space missions sending orbiters, landers, and rovers to study its geology, composition, and history. In conclusion, the Moon's allure lies not only in its captivating beauty but also in its diverse and intriguing features. As Earth's constant companion, it has played an essential role in shaping our planet's history, from influencing tides to inspiring human creativity.

Comets

Comets are celestial objects composed primarily of ice, dust, and rocky material. Comets are distinguished by their highly elliptical orbits around the Sun, and they become visible to us when they get close enough to the Sun, causing their ice to vaporize and produce a bright coma and a tail that points away from the Sun. Comets have highly elliptical orbits around the Sun, and their orbital periods can vary widely. Some comets may have orbital periods of just a few years, while others may take centuries or even millennia to complete one orbit. One of the most well-known comets is **Halley**. It is a periodic comet that returns to the inner solar system approximately every 76 years. Named after the English astronomer Edmund Halley, who predicted its return based on historical observations, it last appeared in 1986 and is expected to return in 2061. The structure of a Comet is given below:

Nucleus: The nucleus is the solid core of a comet and is made up of a mixture of water ice, frozen gases (such as carbon dioxide, methane, and ammonia) and other solid particles. It is usually a few kilometers to tens of kilometers in diameter.

Coma: As a comet approaches the Sun, its nucleus begins to heat up, causing ice and volatile substances to sublimate directly from solid to gas, creating a cloud of gas and dust around the nucleus. This glowing cloud is known as the coma and can extend for thousands of kilometers.

Tail: This is the backside part of Comet the gas and dust in the coma away from the nucleus, forming a tail that always points away from the Sun. The tail can be many millions of kilometers long and is typically the most visible part of a comet.

Asteroids

Asteroids, also known as minor planets or planetesimals, are small rocky bodies that orbit the Sun. They are remnants from the early solar system formation. These celestial objects vary in size, ranging from just a few meters to hundreds of kilometers in diameter. The majority of asteroids are found in the asteroid belt, a region between the orbits of Mars and Jupiter. Asteroids are made up of different materials like rocks, metals, and sometimes ice. They are remnants from the early solar system formation. Asteroids orbit the Sun, just like planets, but they generally have more elongated and irregular paths. Ceres is the largest asteroid in our solar system and Vesta, Eros, Pallas, Juno, Mathelde, Bennu etc are other asteroids.

Meteors/Meteorite

Meteors and meteorites are fascinating celestial objects associated with space debris entering Earth's atmosphere. Meteors, commonly known as "shooting stars," are streaks of light that occur when small rocks or debris, called meteoroids, burn up as they enter Earth's atmosphere. They create a spectacular display due to the intense heat generated by friction with the air, causing the meteoroid to vaporize and ionize the surrounding gases, producing a glowing trail. Meteors are typically visible for just a few seconds before completely disintegrating. Most meteors are relatively small and pose no danger to us on the ground.

However, on occasion, some meteoroids are large enough to survive the atmospheric entry and reach the Earth's surface. These surviving fragments are known as meteorites. Meteorites can vary greatly in size, from small pebbles to large boulders. They are essential to scientists as they provide valuable insights into the composition and history of our solar system. Some meteorites come from the asteroid belt, while others are fragments from comets or other celestial bodies. When a meteorite lands, it leaves behind an impact crater and can be studied by researchers to understand the processes that shaped our solar system and its early history.

1.4 SUMMARY

The solar system is a vast and fascinating collection of celestial bodies that are held together by the gravitational force of our Sun. It consists of the Sun at its center, eight planets, their moons, asteroids, comets, and other small objects. The eight planets, in order from the Sun, are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. These planets vary in size, composition, and atmospheric conditions.

The Sun, a massive ball of hot, glowing gas, provides light and heat to all the planets in the solar system. It is the dominant gravitational force, keeping all the planets and other objects in their orbits.

Each planet has its unique characteristics and features. Mercury, closest to the Sun, is a hot and rocky planet. Venus has a thick, toxic atmosphere, making it the hottest planet in the solar system. Earth, our home, is the only known planet with life. Mars is a cold, desert-like planet with hints of past water. The gas giants, Jupiter and Saturn, are composed mainly of hydrogen and helium and have spectacular ring systems. Uranus and Neptune are ice giants with deep blue atmospheres.

The solar system also contains numerous moons, some of which are quite large and even have their atmospheres. For example, Jupiter's moon, Europa, is believed to have a subsurface ocean, making it a prime target for potential extraterrestrial life.

In addition to the planets and moons, the solar system contains a region called the asteroid belt, located between the orbits of Mars and Jupiter, where numerous asteroids are found. Comets, icy bodies with long tails, originate from the outer reaches of the solar system and occasionally visit the inner regions.

The study of the solar system is crucial for understanding planetary formation, the history of our solar system, and the potential for life beyond Earth. Through space exploration and scientific research, we continue to learn more about the wonders of our solar system and the universe beyond.

1.5 GLOSSARY

Asteroid Belt: A region between the orbits of Mars and Jupiter where many asteroids are found.

Asteroids: Small rocky objects that orbit the Sun, most of which are found in the asteroid belt.

Comets: Celestial bodies made up of ice, dust, and gases that have highly elongated orbits around the Sun.

Dwarf Planets: Celestial bodies that are similar to planets but have not cleared their orbits of other debris. Examples include Pluto and Ceres.

Exoplanets: Planets that exist outside our solar system, orbiting stars other than the Sun.

Gas Giants: The outer planets are composed mostly of hydrogen and helium with no solid surfaces.

Heliosphere: The region of space dominated by the Sun's solar wind and magnetic field.

Inner Planets: The four rocky planets closest to the Sun are Mercury, Venus, Earth and Mars.

Kuiper Belt: A region beyond Neptune's orbit containing many small icy bodies and dwarf planets.

Meteorites: Meteoroids that survive their journey through Earth's atmosphere and land on the surface

Meteors: Meteoroids that burn up in Earth's atmosphere, producing bright streaks of light (shooting stars).

Natural Satellite/Moons: Natural satellites that orbit planets. Some planets have multiple moons, like Jupiter with its numerous moons, while others have none, like Mercury.

Orbit: The path followed by a celestial body as it revolves around another body due to gravitational attraction.

Outer Planets: The four gas giants located farther from the Sun - Jupiter, Saturn, Uranus, and Neptune.

Planets: Large celestial bodies that orbit the Sun and do not produce their own light. There are eight planets in our solar system: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

Solar System: The system comprising the Sun, its planets, moons, asteroids, comets, and other celestial objects bound together by gravity.

Solar Wind: A stream of charged particles (mostly electrons and protons) emitted by the Sun into the solar system.

Sun: The central star of the solar system, a massive ball of hot plasma that provides light and energy to all the planets.

Terrestrial Planets: The inner rocky planets with solid surfaces, similar to Earth.

1.6 ANSWER TO CHECK YOUR PROGRESS

1. The solar system consists of the Sun, planets, moons, asteroids, comets, and other celestial objects bound by gravity.
2. The Sun, a massive ball of hot gases, is at the center of the solar system and provides light and heat to all the planets.
3. There are eight major planets in the solar system, with Mercury being the closest to the Sun and Neptune being the farthest.
4. Planets can be divided into two main groups: terrestrial planets (Mercury, Venus, Earth, and Mars) and gas giants (Jupiter, Saturn, Uranus, and Neptune).
5. Moons, or natural satellites, orbit planets and come in various sizes and shapes.
6. Earth's moon is one of the most well-known natural satellites in the solar system.
7. Asteroids are rocky objects that orbit the Sun, mainly found in the asteroid belt between Mars and Jupiter.
8. Comets are icy bodies that develop tails when they approach the Sun due to the heating of their ices.
9. The solar system is vast, with the distance from the Sun to Pluto, when it was considered a planet, varying over the years due to its elliptical orbit.
10. The solar system's formation is thought to have begun from a giant rotating cloud of gas and dust called the solar nebula.
11. The four inner planets are primarily composed of rock and metal and are relatively smaller than the gas giants.
12. The outer planets are mainly composed of gases and have larger sizes compared to the terrestrial planets.

13. Jupiter, the largest planet, has a prominent system of rings and numerous moons, including the four Galilean moons.
14. Saturn is known for its striking ring system, which consists of icy particles and debris.
15. Uranus and Neptune are often referred to as ice giants due to their icy and watery compositions.
16. The Kuiper Belt, located beyond Neptune, is a region containing many icy bodies, including Pluto and other dwarf planets.
17. The solar system is constantly in motion due to the gravitational forces between the Sun and the planets.
18. Space exploration has led to the discovery of new moons, asteroids, and other objects within the solar system.
19. The solar system is a tiny part of the Milky Way galaxy, a vast collection of stars, gas, dust, and dark matter.
20. Studying the solar system provides insights into the origin, evolution, and dynamic nature of celestial bodies in the universe.

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1.8 TERMINAL QUESTIONS

Long Questions

1. What is the solar system and what are their main components?
2. Explain the role of Sun in the solar system especially for our mother Earth.

Short Questions

1. What is the Solar System, and what are its main components?
2. Describe the Sun, composition, and importance to the Solar System.
3. How do the planets in our Solar System differ in terms of size, composition, and distance from the Sun?
4. What are the inner planets, and why are they called terrestrial planets?
5. Explain the characteristics of the outer planets, often referred to as gas giants.
6. Describe the role of asteroids and comets in the Solar System and their potential impact on Earth.
7. What are the major natural satellites/moons of some planets and how do they differ from one another?
8. Discuss the concept of space exploration and its importance for humanity's future.

Multiple Choice Questions

1. Which celestial body is at the center of our solar system?

a) Moon

b) Earth

c) Sun

d) Jupiter

2. The largest planet in our solar system is:

a) Earth

b) Saturn

c) Neptune

d) Jupiter

3. Which planet is known as the "Red Planet"?

a) Venus

b) Mars

c) Saturn

d) Jupiter

4. Which planet has the most prominent ring system?

a) Uranus

b) Jupiter

c) Saturn

d) Neptune

5. What is the fifth planet from the Sun?

a) Jupiter

b) Saturn

c) Mars

d) Venus

6. Which planet is closest to the Sun?

a) Venus

b) Mercury

c) Mars

d) Jupiter

7. What is the largest moon in our solar system?

a) Ganymede

b) Titan

c) Luna (Moon)

d) Europa

8. The asteroid belt is located between which two planets?

a) Earth and Mars

b) Mars and Jupiter

c) Jupiter and Saturn

d) Saturn and Uranus

9. Which planet has the Great Red Spot, a persistent storm?

a) Mars

b) Neptune

c) Jupiter

d) Uranus

10. What is the name of the first human-made object to reach interstellar space?

a) Voyager 1

b) New Horizons

c) Cassini

d) Juno

11. What is the name of the bright, rocky object that enters Earth's atmosphere and creates a streak of light?

a) Meteoroid

b) Meteorite

c) Meteor

d) Asteroid

12. Which planet has the most extensive system of rings?

a) Uranus

b) Neptune

c) Saturn

d) Jupiter

13. Which planet has the most moons in our solar system?

a) Earth

b) Mars

c) Saturn

d) Jupiter

14. The Oort Cloud is believed to be the source of:

a) Comets with short orbital periods

b) Asteroids in the asteroid belt

c) Meteoroids that burn up in Earth's atmosphere

d) Comets with long orbital periods

15. What is the name of the mission that successfully landed on the surface of Mars in February 2021?

a) Spirit

b) Opportunity

c) Curiosity

d) Perseverance

16. What is the largest known dwarf planet in our solar system?

a) Pluto

b) Eris

c) Haumea

d) Makemake

17. Which spacecraft visited Pluto in 2015, providing the first close-up images of the dwarf planet?

a) Voyager 1

b) New Horizons

c) Cassini

d) Juno

18. What is the name of the spacecraft that has been studying Saturn and its moons since 2004?

a) Galileo

b) Voyager 1

c) Cassini

d) New Horizons

Answers

1. C	10. A
2. D	11. C
3. B	12. C
4. C	13. D
5. A	14. D
6. B	15. D
7. A	16. B
8. B	17. B
9. C	18.C

UNIT 2: INTERIOR OF THE EARTH

2.1 OBJECTIVES

After reading this unit learner must be able to understand the following points:

1. Basics about the interior of the earth.
2. Understanding the structure and composition of the earth.
3. Understanding the sources of information related to the earth interior.

2.2 INTRODUCTION

The interior of our planet Earth has long been an enigma that has captivated the imagination of scientists, geologists and curious minds alike. Beneath the solid surface that we tread upon, lies a realm of unfathomable complexity, where unimaginable forces shape the very fabric of our existence. Embarking on a journey to explore the depths of our planet, we peel back the layers of time and geology to understand the captivating story hidden within. At first glance, the Earth's interior appears inaccessible, concealed beneath thousands of kilometers of solid rock. Yet, scientific inquiry and advancements in technology have allowed us to glimpse the secrets hidden within. Through seismic studies, mineral analysis, and a comprehensive understanding of geophysical phenomena, a vivid portrait of the Earth's interior begins to take shape.

The interior of the Earth is comprised of several distinct layers, each contributing to the planet's dynamic behavior and fascinating evolution. The outermost layer, the crust, is the thinnest and most accessible. It serves as our home and sustains the vast diversity of life. But beneath this fragile shell lie the vast territories of the mantle, and at the core, an unimaginable inferno of molten metal and immense pressure awaits us. The mantle, a semi-solid region (upper mantle), plays a pivotal role in the Earth's geology and its ever-changing surface. Magma movements within the mantle give rise to volcanoes and earthquakes, reshaping the crust and shaping the landscape. Delving deeper, the mysterious inner core, composed mainly of iron and nickel, remains under immense pressure and temperatures exceeding those found at the surface of the Sun.

As we traverse through time and space, we uncover the journey of our planet's formation, starting from a seething, chaotic mass to the vibrant, life-sustaining oasis we now call home. The intricate interplay between the Earth's interior and the atmosphere, hydrosphere, and biosphere unveils the delicate balance that has allowed life to thrive for millions of years. Understanding the interior of the Earth is not merely a quest for knowledge but also holds practical significance. Unraveling the mysteries of the Earth's core empowers us to predict seismic activity, enhance resource exploration, and comprehend climate patterns more accurately. It opens avenues for discovery and innovation, spurring us to develop technologies that are harmonious with our planet and mitigate potential risks posed by geological phenomena. As we journey deeper into the core, the veil of the unknown lifts, and we are left with awe and reverence for the boundless wonders that lie beneath our feet.

2.3 INTERIOR OF THE EARTH

Due to the lack of sufficient scientific evidences of the internal structure of the earth, there is no unanimity among the scientific family. We can understand the concept of earth's interior with the help of an example that is consider earth as a egg, we know all about the cover of the egg until we broke the egg. Same like this, we know all about the crust and little bit about the interior of the earth. There are some sources which helps us in gathering information regarding the earth's interior. A detailed description of the sources related the evidences of earth's information are given below.

Sources/Evidences Related to Internal Structure

The internal structure of the Earth has been studied extensively through various scientific methods, providing a wealth of evidence that helps us understand the composition and structure of our planet's interior. The scientists have used three types of evidences (Fig. 2.1) to study the internal structure of the Earth. These are:

1. Artificial sources/evidences,
2. Evidence from the Theories of the Origin of the Earth and
3. Natural sources/evidences

A detailed description of the evidences of earth's interior is presented in the following paragraphs.

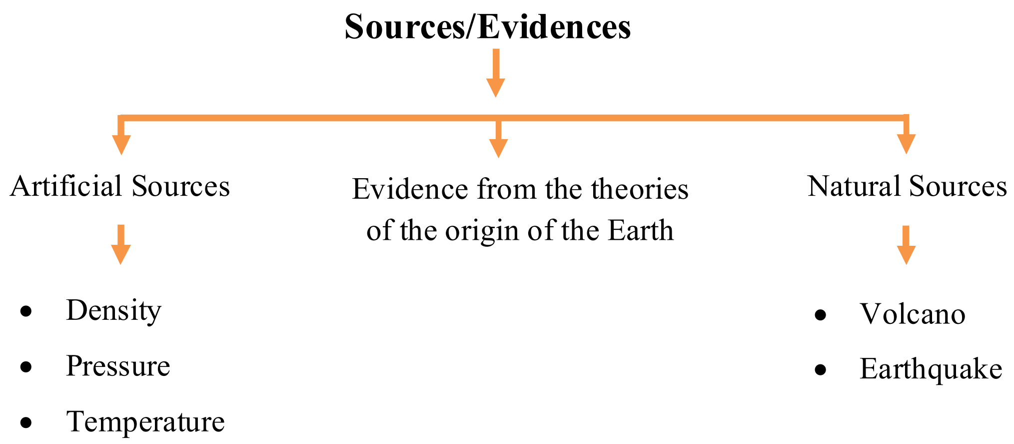

Fig. 2.1: Sources/evidences of the interior of the Earth.

Artificial Sources

Density

The Earth's density varies throughout its interior due to the differences in composition and pressure at various depths. The average density of the entire Earth is approximately 5.5 gcm^3. However, this density is not uniform, and the Earth's interior can be divided into several layers based on variation in density. The Earth's outermost layer, the crust, is relatively less dense and consists of lighter elements such as silicon, oxygen, aluminum, and magnesium. The average density of the continental crust is around 2.8 gcm^3, while the oceanic crust has a slightly higher density of about 3.0 gcm^3. Beneath the crust lies the mantle, which is composed mainly of silicate minerals rich in iron and magnesium. The mantle's density ranges from about 3.0 gcm^3 near the crust-mantle boundary to around 5.5 gcm^3 at its lower boundary, which is known as the mantle-core boundary. The outer core is composed primarily of liquid iron and nickel, and its density is estimated to be around 10.0 gcm^3 due to the high concentration of heavy metals. The Earth's innermost layer is the inner core, which is primarily composed of solid iron and nickel. Due to upper layers' pressure, the density of the inner core increases with depth and is estimated to be around 13.6 gcm^3. The overall density of the Earth is determined by the combination of these different layers and their respective compositions. The increase in density with depth is a result of the increasing pressure and the presence of heavier elements in the deeper layers. Thus, the density of the earth interior varies from upper lying layer to bottommost layer which provides the information about the earth's interior that earth interior's density varies.

Pressure

The Earth's interior experiences a significant increase in pressure as one moves deeper into its layers. This pressure arises due to the immense weight of the overlying rock and materials, as well as the gravitational forces acting on them. Starting at the crust, the pressure is relatively low and varies based on factors like the thickness of the crust and the weight of the materials above. As one descends into the mantle, the pressure steadily increases due to the weight of the rock layers above. In the upper mantle, pressures range from tens of thousands to hundreds of thousands of times atmospheric pressure. This pressure increase contributes to the solid-state behavior of minerals and rocks despite the high temperatures present. In the lower mantle, pressures can reach millions of times atmospheric pressure, causing minerals to undergo phase changes and exhibit unique properties under such extreme conditions. In the outer core, pressures continue to rise significantly, contributing to the maintenance of the liquid state of the iron and nickel mixture despite the high temperature. In the solid inner core, pressures can exceed several million times atmospheric pressure, allowing the solid iron and nickel to remain stable even at extremely high temperature. The distribution of pressure within the Earth's interior plays a critical role in providing information about the earth’s interior, determining the behavior of materials, influencing the formation and movement of magma, the properties of minerals and even the creation of new mineral phases under extreme conditions.

Temperature

The Earth's interior is characterized by a range of temperatures that increase with depth. Starting at the crust, temperature is relatively cooler and more variable, influenced by factors such as sunlight and geothermal activity. As one delves deeper into the mantle, temperatures gradually rise due to the heat generated by the decay of radioactive isotopes in the Earth's rocks. The gradual increase in temperature, known as the geothermal gradient. With the increasing depth, the temperature increases with an average rate of 3.5 degree Celsius per 100 meters. In the outer core, the temperatures become high enough to melt iron and nickel, creating the liquid metal that generates the Earth's magnetic field through convective motions. Temperature in the outer core is estimated to be between 4300 and 4500 degrees Celsius. At the center of the Earth lies the solid inner core, where extreme pressures keep the iron and nickel solid despite temperatures that can reach up to 5500 degrees Celsius. The distribution of temperature within the Earth's interior plays a crucial role in driving geological processes such as mantle convection, plate tectonics, and the generation of the planet's magnetic field. It also influences the behavior of rocks and minerals, affecting their physical properties and behaviors under varying conditions.

Evidence from the Theories of the Origin of the Earth

Regarding the origin of the Earth, several theories have been proposed to explain its formation. These theories also explain how the earth got its present shape including geology and earth interior. There is no unanimity among the scholars and theories regarding the interior of the earth. These theories are supported by various lines of evidence, including the composition of Earth and the other planets, as well as the distribution of elements and isotopes. While these theories provide valuable insights, the exact details of how Earth formed and how the geology shaped.

Natural Sources

Volcanic Eruption and Earth Interior

Volcanoes are geological features that provide essential insights into the Earth's interior and its dynamic processes. They result from the movement of molten rock called magma from deep within the Earth to the surface. Understanding volcanoes and their activity is crucial for comprehending the structure and behavior of the Earth's interior. Magma forms in the mantle through various processes, such as partial melting of rocks, decompression melting, and the addition of volatile substances. As magma accumulates and pressure builds up, it seeks pathways to the Earth's surface through weaknesses in the crust, such as fractures and faults. When the pressure becomes too great, the magma erupts as lava, ash, and gases, giving rise to volcanic eruptions.

The connection between volcanoes and the Earth's interior lies in the movement of magma from the mantle to the Earth's surface. As explained earlier, the mantle is a significant source of magma and volcanic activity occurs when this magma rises and erupts at the Earth's surface. Volcanic eruptions are a way for the Earth to release internal heat and pressure generated by various processes within the mantle and core. By studying volcanic eruptions and the compositions of volcanic rocks, geologists gain insights into the chemical and mineralogical makeup of the Earth's interior. Additionally, the heat and gases released during volcanic eruptions contribute to the Earth's atmosphere and impact global climate patterns.

In brief, the study of volcanoes and the Earth's interior are interconnected, providing valuable information about the dynamic processes occurring deep within our planet. Volcanic activity serves as a visible manifestation of the Earth's internal processes, and understanding these processes is crucial for comprehending the complex geological and tectonic activities shaping the Earth's surface and its environment.

Earthquake and Earth Interior

An earthquake is a natural geophysical event that occurs when there is a sudden release of energy in the Earth's crust, resulting in seismic waves that propagate through the ground. Earthquakes are primarily caused by the movement of tectonic plates and the release of stress accumulated along faults. Understanding earthquakes is closely related to studying the Earth's interior, as seismic waves generated during earthquakes provide valuable information about the planet's internal structure.

The point within the Earth where an earthquake originates is called the focus. It is the location where the sudden release of energy occurs, causing the rocks to rupture and generate seismic waves. The point directly above the focus on the Earth's surface is known as the epicenter (Fig. 2.2). Seismic waves play a fundamental role in our understanding of the Earth's interior. They provide crucial information about the composition, density and structure of the planet's deep layers. Seismic waves are generated by earthquakes, explosions, or other sources, and they propagate through the Earth, carrying valuable data that seismologists use to create images and models of the Earth's interior. There are two mainly two types of seismic waves which provides us information about the Earth’s interior. So, here a brief description of earthquake as a source of information for earth interior is discussed in the following paragraphs.

P-Waves (Primary Waves) are compressional waves that cause particles to move in the direction of wave propagation. They can travel through both solid and liquid materials, making them the fastest seismic waves. As P-waves pass through different layers of the Earth, their velocities change, providing insights into the density and compressibility of these layers. The study of P-wave behavior helps identify the boundaries between the Earth's major layers, such as the crust-mantle boundary (Mohorovic discontinuity), the mantle-core boundary etc.

Secondary Waves (S-waves) are shear waves that cause particles to move perpendicular to the direction of wave propagation. Unlike P-waves, S-waves cannot travel through liquids, so their presence or absence helps define the liquid outer core of the Earth. The inability of S-waves to pass through the core creates a seismic shadow zone, an area on the opposite side of the Earth from an earthquake's epicenter where no S-waves are detected (Fig. 2.3).

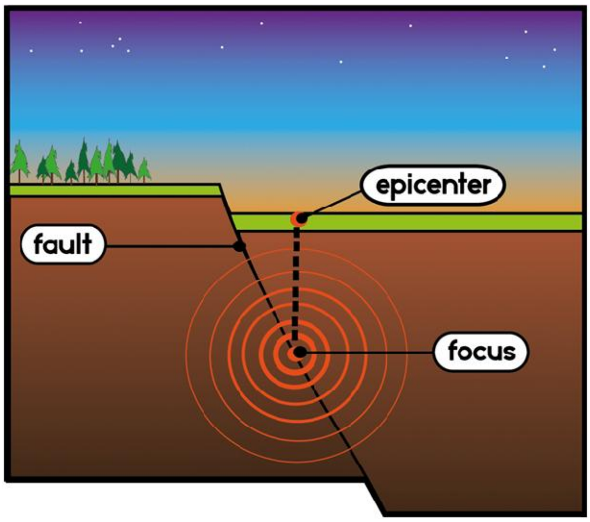

Fig. 2.2: Focus and epicenter of an earthquake (Source: Google)

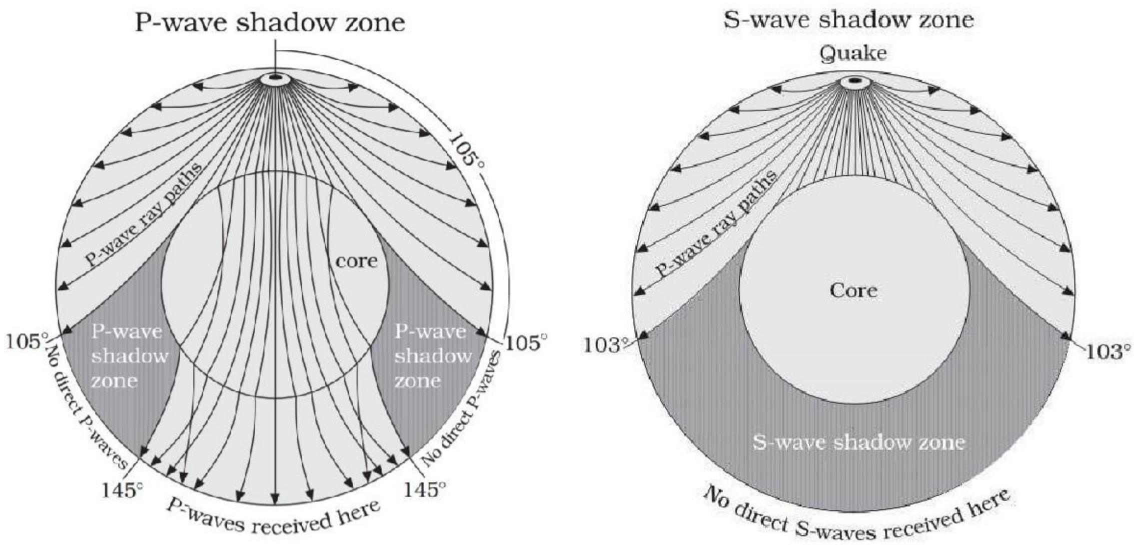

Fig. 2.3: Shadow zone of P and S waves (Source: Google)

In brief, seismic waves are invaluable tools for studying the Earth's interior. They provide crucial data that allows seismologists to create models of the Earth's layered structure, identify important boundaries, and understand the composition and physical properties of the planet's interior. By analyzing seismic wave behavior, scientists continue to gain insights into the dynamic processes and evolution of our planet's interior over geological time scales.

Chemical Composition and Different Layers of the Earth

Eduard Suess made a significant contribution to our understanding of Earth's interior composition and structure. He introduced the concepts of SIAL, SIMA and NIFE (Fig. 2.4). These ideas were proposed in the late 19th and early 20th centuries and have since been refined with modern scientific understanding. Let's understand these terms in detailed in the following paragraphs:

SIAL: Suess used the term SIAL to refer to the upper layer of the Earth's crust, which is composed primarily of silicate minerals and aluminum. SIAL is an acronym that stands for Silicon (Si) and Aluminum (Al) which is abundant elements in this layer. The continental crust is mostly made up of SIAL. It is less dense and contains a higher concentration of lighter elements compared to the deeper layers of the Earth.

SIMA: Suess also introduced the term SIMA to describe the lower layer of the Earth's crust and the upper part of the mantle. SIMA is composed mainly of silicate minerals and magnesium. Like SIAL, SIMA is also an acronym that stands for Silicon (Si) and Magnesium (Mg). The oceanic crust is predominantly composed of SIMA. It is denser than SIAL due to the higher concentration of heavier elements.

NiFe: Suess proposed the presence of a core in the Earth's interior composed of a combination of nickel (Ni) and iron (Fe). While Suess did not describe the core in extensive detail, subsequent research and seismic studies have revealed that the Earth's core consists of a solid inner core primarily composed of iron and nickel, surrounded by a liquid outer core. The core is responsible for generating the Earth's magnetic field.

It's important to note that our understanding of Earth's interior has evolved significantly since Suess's time, thanks to advancements in seismic imaging, mineralogy, and geophysics.

Modern research has provided more detailed insights into the composition and layering of the Earth's interior, including the division of the mantle into several layers and the dynamics of plate tectonics.

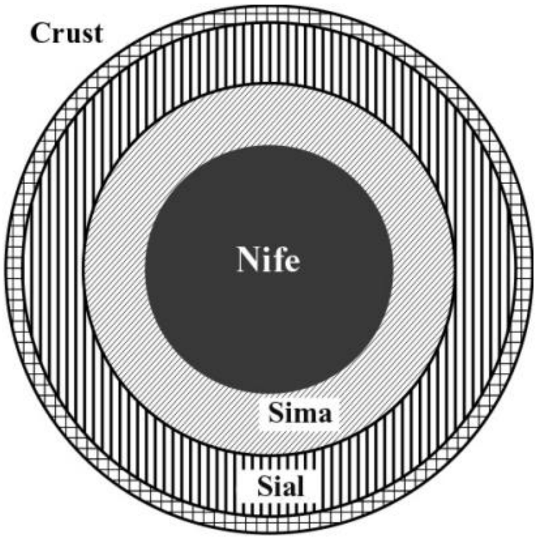

Fig. 2.4: Interior structure of the earth according to E. Suess (Source: Google).

Recent Views

Recent advancements in seismology and geophysical studies have provided a more detailed and refined view of the Earth's internal structure, revealing complex discontinuities that mark the boundaries between different layers. Seismic waves, generated by earthquakes or artificial sources, have been instrumental in mapping these interior layers and their characteristics. Figure 2.5 depicts the different layers and discontinuities of the Earth's interior diagrammatic. As earlier discussed that the there are three layers beneath the earth surface which are crust, mantle and core. A brief description of these layers is presented below:

Crust: The Earth's outermost layer consists of two main types: the continental crust and the oceanic crust. The continental crust is thicker and less dense, primarily composed of granitic rocks. The oceanic crust is thinner, denser, and primarily composed of basaltic rocks. The boundary between the upper crust and the lower crust is known as the Conrad discontinuity. The boundary between the crust and the underlying mantle is known as the Mohorovic/Moho discontinuity, or the Moho. It marks a significant change in rock composition and density, resulting in variations in the speed of seismic waves.

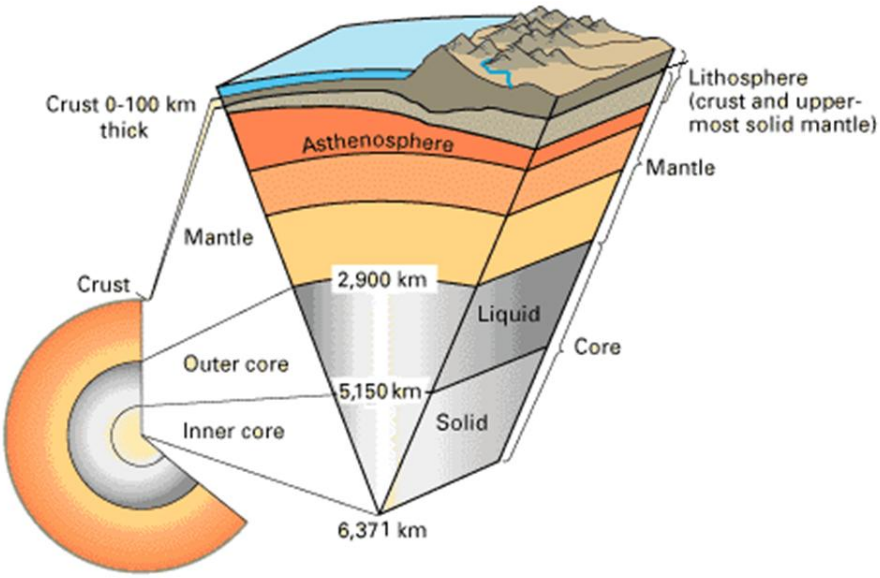

Fig. 2.5: Internal structure of earth *(Source: Google).*

Mantle: The mantle lies beneath the crust and extends to a depth of about 2900 kilometers. It is divided into the upper mantle and the lower mantle. Recent studies have shown that the upper mantle has distinct layers, including the lithosphere (rigid outer shell) and the asthenosphere (semi-fluid layer beneath the lithosphere). The transition between the upper and lower mantle is marked by the Repetti discontinuity. Below the transition zone lies the lower mantle, extending to about 2900 kilometers in depth. The boundary between the lower mantle and the outer core is known as the Gutenberg discontinuity.

Core: The core lies beneath the mantle and extends from 2900 to 6371 kilometers in depth. It is divided into the upper outer core and the inner core. The outer core is a liquid layer composed mainly of iron and nickel. It extends from 2900 to 5150 kilometers in depth. The boundary between the outer core and the inner core is called the Lehmann discontinuity. The innermost layer of the Earth is the solid inner core, extending from about 5150 to 6371 kilometers in depth. It is primarily composed of iron and nickel.

2.4 SUMMARY

The Earth's interior is a layered and dynamic realm that holds clues to our planet's formation and ongoing processes. The outermost layer, known as the crust, consists of solid rock and is divided into continental crust, forming the landmasses, and oceanic crust, underpinning the vast oceans. Beneath the crust lies the mantle, a semi-solid region of flowing molten rock. This mantle is categorized into an upper and lower section, and it plays a pivotal role in the movement of tectonic plates, which are massive fragments of the Earth's lithosphere that drift and interact due to the convective currents within the mantle.

Core lies beneath the mantle, a central region comprised mainly of iron and nickel. The core is divided into the outer core, where molten iron generates the Earth's magnetic field through convective motion, and the inner core, solid despite its composition due to immense pressure. The lithosphere, comprising the crust and a portion of the upper mantle, is fragmented into tectonic plates that slide, collide, and diverge along their boundaries, giving rise to earthquakes, volcanoes, and the reshaping of continents over millions of years.

The phenomenon of convection, driven by the heat generated from the decay of radioactive isotopes and the primordial heat from the Earth's formation, causes molten rock in the mantle to rise and cool, creating a continuous cycle that propels the movement of tectonic plates. Seismic waves, generated by earthquakes, provide invaluable insights into the Earth's interior composition and structure. The Mohorovic discontinuity (Moho) marks the boundary between the crust and the mantle while the Gutenberg and Lehmann discontinuities delineate the separations between the mantle and outer core and between the outer core and inner core, respectively.

Volcanoes, resulting from the eruption of magma onto the surface, and earthquakes, triggered by the release of energy along faults, are testament to the dynamic nature of the Earth's interior. In summary, the Earth's interior is a captivating realm of change and movement, shaping the landscape and influencing geological, climatic, and biological phenomena that define our world.

2.5 GLOSSARY

Asthenosphere: The partially molten, ductile region of the upper mantle beneath the lithosphere. It facilitates the movement of tectonic plates.

Convection: The transfer of heat through the movement of a fluid (like magma in the mantle). It plays a significant role in driving tectonic plate movement.

Core: The innermost layer of the Earth, consisting mainly of iron and nickel. It is divided into outer core and inner core.

Crust: The outermost layer of the Earth is composed of solid rock. It's divided into continental crust (under continents) and oceanic crust (under oceans).

Earthquake: The shaking of the Earth's surface caused by the sudden release of energy in the Earth's crust, usually due to tectonic activity.

Geothermal Energy: Heat from the Earth's interior that can be harnessed for various purposes, such as electricity generation and heating.

Geothermal Gradient: The rate of increase in temperature with depth in the Earth's interior. It is used to estimate temperatures in the Earth's layers.

Gutenberg Discontinuity: The boundary between the Earth's mantle and outer core, where seismic waves undergo drastic changes.

Lehmann Discontinuity: The boundary between the Earth's outer core and inner core, marked by changes in the behavior of seismic waves.

Lithosphere: The rigid outer layer of the Earth, including the crust and a portion of the upper mantle. It is divided into tectonic plates that move and interact with each other.

Magma: Molten rock beneath the Earth's surface. When it reaches the surface, it's called lava.

Mantle: The layer beneath the crust, composed of semi-solid rock that flows over long periods of time. It is divided into the upper mantle and the lower mantle.

Mohorovic Discontinuity (Moho): The boundary between the Earth's crust and mantle, where there's a significant change in seismic wave velocities.

Seismic Waves: Vibrations that travel through the Earth due to earthquakes. They provide valuable information about the Earth's interior.

Tectonic Plates: Large sections of the Earth's lithosphere that move and interact due to the convective currents in the mantle.

Volcano: A vent in the Earth's crust through which molten rock, ash, and gases can escape from the interior.

2.6 ANSWER TO CHECK YOUR PROGRESS

1. The Earth's interior is composed of several layers that vary in composition, temperature, and density.
2. The outermost layer is the crust, which is a thin shell of solid rock that forms the planet's surface.
3. Beneath the crust lies the mantle, a semi-solid layer composed of hot, flowing rock called magma.
4. The mantle is divided into the upper mantle and the lower mantle, with the upper mantle being partially responsible for tectonic plate movements.
5. The boundary between the crust and the mantle is known as the Mohorovic Discontinuity, or Moho.
6. The Earth's core is located beneath the mantle and consists of two parts: the outer core and the inner core.
7. The outer core is composed of liquid iron and nickel and is responsible for generating Earth's magnetic field through the process of convection.
8. The inner core is solid and primarily composed of iron and nickel, reaching incredibly high temperatures due to the immense pressure.
9. The core-mantle boundary is referred to as the Gutenberg Discontinuity, where seismic waves behave differently as they pass through the core.

10. The temperatures and pressures increase significantly as you move deeper into the Earth's interior.
11. The study of the Earth's interior is done through seismic waves, which provide insights into the properties and composition of the different layers.
12. The lithosphere, composed of the crust and uppermost mantle, is divided into tectonic plates that float and move atop the semi-fluid asthenosphere beneath.
13. Convection currents in the mantle play a critical role in driving the movement of tectonic plates and shaping the Earth's surface features.
14. The process of subduction occurs when one tectonic plate is forced beneath another into the mantle.
15. The heat generated by the decay of radioactive elements contributes to the temperature of the Earth's interior and influences geological processes.
16. The transition zone in the mantle, located between the upper and lower mantle, is characterized by changes in mineral composition due to increased pressure.
17. The deepest known point on Earth is the Challenger Deep in the Mariana Trench, which reaches down into the Earth's crust and mantle.
18. The pressure at the Earth's core is estimated to be around 3.6 million times greater than atmospheric pressure.
19. The Earth's interior has a significant influence on the planet's surface, affecting phenomena like earthquakes, volcanoes, and mountain formation.

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2.8 TERMINAL QUESTIONS

Long Questions

1. What do you understand by the interior of the earth? Explain in details.
2. What are the sources of information of the interior of the earth? Explain.

Short Questions

1. What are the three main layers of the Earth based on composition, and what are they called?
2. Describe the composition of the Earth's crust. What elements are most abundant in it?
3. Explain the difference between the continental crust and the oceanic crust.
4. What is the mantle, and how does its composition differ from that of the crust?
5. How is the Earth's core divided into different parts? What are these parts composed of?
6. Describe the structure of the Earth's inner core and outer core.
7. How do scientists study the interior of the Earth using seismic waves?
8. What is the Mohorovic discontinuity (Moho) and why is it significant in understanding Earth's interior?
9. How do convection currents in the mantle contribute to the movement of tectonic plates?
10. How are earthquakes generated and how do they provide insights into Earth's interior?
11. Explain how the different layers of the Earth affect the behavior of seismic waves during an earthquake.
12. What are some of the challenges and limitations scientists face when studying the Earth's deep interior?

Multiple Choice Questions

1. What is the outermost layer of the Earth called?

a) Mantle

b) Core

c) Crust

d) Lithosphere

2. Which layer of the Earth is responsible for generating the planet's magnetic field?

a) Crust

b) Outer Core

c) Inner Core

d) Mantle

3. The Earth's core is primarily composed of:

a) Silicon and oxygen

b) Iron and nickel

c) Carbon and hydrogen

d) Gold and silver

4. Which type of tectonic plate boundary is characterized by plates moving apart?

a) Convergent

b) Transform

c) Divergent

d) Subduction

5. The Mohorovic discontinuity (Moho) marks the boundary between:

a) Crust and mantle

b) Mantle and outer core

c) Outer core and inner core

d) Inner core and mantle

6. Earthquakes are caused by:

a) Meteor impacts

b) Volcanic eruptions

c) Tectonic plate movement

d) Atmospheric pressure changes

7. Geothermal energy is derived from:

a) Solar radiation

b) Wind power

c) Earth's internal heat

d) Nuclear fission

8. Which layer of the Earth is believed to be solid despite its composition of molten metals?

a) Outer Core

b) Inner Core

c) Mantle

d) Crust

9. The movement of molten iron in the outer core generates the Earth's:

a) Gravitational pull

b) Magnetic field

c) Ocean currents

d) Cloud formations

10. Which layer of the Earth is associated with convection currents in the mantle?

a) Crust

b) Mantle

c) Core

d) Lithosphere

11. The geo-dynamo is responsible for generating:

a) Earthquakes

b) Volcanic eruptions

c) Earth's magnetic field

d) Geothermal energy

12. What type of waves is generated by earthquakes and provides insight into the Earth's interior?

a) Sound waves

b) Light waves

c) Seismic waves

d) Electromagnetic waves

13. The innermost layer of the Earth is the:

a) Mantle

b) Outer Core

c) Inner Core

d) Crust

14. The movement of tectonic plates is driven by:

a) Wind currents

b) Ocean currents

c) Convection currents in the mantle

d) Solar radiation

15. The lithosphere is composed of:

a) Mantle and core

b) Crust and upper mantle

c) Outer and inner core

d) Mantle and asthenosphere

16. What is the main factor responsible for generating the heat within the Earth's interior?

a) Solar energy

b) Radioactive decay

c) Gravitational forces

d) Cosmic radiation

17. The boundary between the mantle and the outer core is called the:

a) Mohorovic Discontinuity

b) Gutenberg Discontinuity

c) Lehmann Discontinuity

d) Crust-Mantle boundary

18. Which layer of the Earth exhibits convection currents that drive tectonic plate movement?

a) Core

b) Mantle

c) Crust

d) Lithosphere

19. What is the process by which molten rock rises from the Earth's mantle to the surface?

a) Conduction

b) Convection

c) Subduction

d) Accretion

20. The geological time scale organizes Earth's history based on:

a) Human civilizations

b) Mass extinctions

c) Geological events and changes

d) Astronomical phenomena

Answers

1. C	11. C
2. B	12. C
3. B	13. C
4. C	14. C
5. A	15. B
6. C	16. B
7. C	17. B
8. B	18. B
9. B	19. B
10. B	20. C

UNIT 3 - ROCKS

3.1 OBJECTIVES

3.2 INTRODUCTION

3.3 ROCKS

3.4 SUMMARY

3.5 GLOSSARY

3.6 ANSWER TO CHECK YOUR PROGRESS

3.7 REFERENCES

3.8 TERMINAL QUESTIONS

3.1 OBJECTIVES

After reading this unit you will be able to:

- Basic understanding of rocks.
- Understand the different types of rocks.
- Get know the importance of rocks in human life.

3.2 INTRODUCTION

Rocks are the solid materials that make up the Earth's outer layer, known as the crust. They come in all sorts of shapes, sizes, and colors. Rocks are made up of different minerals, which are like the building blocks of rocks. Some rocks are really hard and tough, like granite, while others are softer, like sandstone. People have been using rocks for thousands of years for things like making tools, building houses, and even creating beautiful sculptures. Rocks are an important part of our planet's history and play a big role in shaping the landscapes we see around us.

Studying rocks provides us with a glimpse into the immense timeline of Earth's history. The layers of sedimentary rocks, like pages in a history book, reveal the changing landscapes, climate shifts, and even the evolution of life forms over millions of years. By analyzing the fossils preserved within these rocks, scientists can piece together the story of the planet's past inhabitants and how they adapted to changing environments.

Rocks can be broadly categorized into three main types: igneous, sedimentary, and metamorphic. Igneous rocks originate from molten magma that cools and solidifies. This process can occur either beneath the Earth's surface, resulting in intrusive rocks, or on the surface, creating extrusive rocks. Sedimentary rocks, on the other hand, form from the accumulation and compaction of sediments over time. These sediments can include fragments of other rocks, organic matter, and minerals. Metamorphic rocks undergo transformation due to intense heat, pressure, or chemically active fluids, altering their original mineral composition and structure.

Rocks have a profound impact on our daily lives, often in ways that go unnoticed. They serve as the source of many valuable minerals, such as iron, copper, and gold, which are essential for various industries, including manufacturing and electronics. In addition, rocks play a critical role in construction, providing materials for roads, buildings, and infrastructure. Without rocks, our modern society would lack the essential resources needed for its functioning.

Rocks interact with natural forces, such as wind, water, and ice, to shape the Earth's surface through processes like erosion and weathering. The Grand Canyon's awe-inspiring cliffs and valleys, for instance, were sculpted over millions of years by the Colorado River carving through layers of sedimentary rock. The remarkable diversity of landscapes we admire today is a testament to the intricate interplay between rocks and the elements. Rocks also hold clues about the Earth's past climates and environmental conditions. By studying the composition and structure of rocks, scientists can deduce ancient atmospheric compositions, ocean temperatures, and even past volcanic activities.

3.3 ROCKS

Rocks are the fundamental building blocks of the Earth's crust, composed of various minerals and formed through intricate geological processes. They offer a unique glimpse into the planet's history, revealing clues about its formation, evolution, and the forces that have shaped its surface. Rocks can be classified into three main types. These are:

i. Igneous rocks,
ii. Sedimentary rocks and
iii. Metamorphic rocks.

A detailed description of these rock types is presented in the following paragraphs.

Igneous Rocks

Igneous rocks are a remarkable class of rocks that offer us insights into the molten heart of our planet's geology. Derived from the Latin word "ignis," meaning fire, igneous rocks hold the key to understanding the intense heat and geological activity that have shaped Earth's surface over millions of years. These rocks, formed from the solidification of molten material, come in a diverse range of textures, colors, and compositions, offering a fascinating glimpse into the forces that govern our planet's creation.

Types of Igneous rocks:

Igneous rocks, born from the fiery depths of the Earth, come in a variety of forms, each reflecting distinct characteristics and origins. These rocks provide us with a window into the geological processes that have shaped our planet over eons. Based on the occurrence, the igneous rocks can be divided into two parts. These are:

- Intrusive igneous rocks
- Extrusive igneous rocks

Intrusive Igneous Rocks

These rocks formed when magma cools slowly beneath the Earth's surface, it has ample time for mineral crystals to grow; resulting in visible crystals that can be identified with the naked eye is called intrusive igneous rocks. Granite, a widely recognized intrusive rock, showcases this feature with its speckled appearance formed by interlocking crystals of minerals like quartz, feldspar, and mica. The slow cooling beneath the surface allows these minerals to arrange themselves into well-defined grains, giving the rock a coarse texture.

Extrusive Igneous Rocks

Result from the cooling of lava on the Earth's surface, leading to the formation of fine-grained rocks and have a finer texture. Basalt, a common extrusive rock, is known for its dark color and fine-grained appearance. The quick cooling prevents large crystals from forming, resulting in a more homogeneous texture. Basalt often covers vast areas of ocean floors and makes up a significant portion of the Earth's crust.

Characteristics of Igneous rocks

Igneous rocks, products of molten material's cooling and solidification, bear distinct characteristics that unveil their fiery origins. Their texture, crystalline composition, and formation conditions vary widely, dividing them into intrusive and extrusive types. Intrusive igneous rocks, like granite and diorite, display visible mineral crystals due to slow cooling beneath the Earth's surface. In contrast, extrusive igneous rocks such as basalt and andesite form rapidly on the Earth's surface, yielding finer textures. These rocks' mineral content, including quartz, feldspar, and pyroxene, conveys crucial insights into the processes that have shaped Earth's geology, offering a tangible link to the planet's tumultuous past.

Sedimentary Rocks

Sedimentary rocks are one of the three major types of rocks, alongside igneous and metamorphic rocks. They form through the accumulation and compaction of sediment, which includes particles of minerals, rocks, organic matter, and even remains of plants and animals. Over time, these sediments become solidified into rock due to the pressure and cementation processes. The sedimentary rocks develop through the following formation processes:

Weathering: The process starts with the breakdown of existing rocks through physical, chemical, and biological weathering. This produces sediments of various sizes, from clay and silt to sand, gravel, and even larger fragments.

Transportation: The weathered particles are transported by agents like water, wind, ice, and gravity. Water is the most common transportation agent, moving sediments in rivers, streams, and oceans. During transportation, sediments may undergo sorting, where particles of similar sizes are separated due to the differential settling rates.

Deposition: When the transporting energy decreases, sediments settle out of the transporting medium and accumulate in layers. This deposition typically occurs in environments such as riverbeds, deltas, beaches, deserts, and ocean basins.

Compaction: As layers of sediment accumulate on top of one another, the weight of the overlying sediments compacts the lower layers. This compaction reduces the pore spaces between particles, leading to the expulsion of water and air. Compaction also contributes to the gradual solidification of the sediment.

Cementation: Minerals dissolved in the remaining water between the particles crystallize and form cement that binds the sediment grains together. The most common cementing minerals include calcite, silica, and iron oxide. This cementation further strengthens the sediment, turning it into rock.

Types of Sedimentary Rocks

Sedimentary rocks are classified into three main categories based on their origin which are presented below:

Clastic Sedimentary Rocks: These rocks are formed from the accumulation and lithification of fragmented particles. The size of the particles determines the specific rock type:

- Conglomerate: Composed of rounded pebbles and larger particles.
- Sandstone: Made up of sand-sized particles.
- Mudstone/Shale: Consisting of fine particles like clay and silt.

Chemical Sedimentary Rocks: These rocks form from the precipitation of minerals from water solutions. They often occur in environments with abundant evaporation, like shallow seas and lakes. Examples include:

- Limestone: Composed mainly of calcium carbonate.

- Evaporites: Formed from the evaporation of water, yielding minerals like gypsum and halite.

Organic Sedimentary Rocks: These rocks are derived from the accumulation and compaction of organic materials, primarily plant and animal remains. The most common type is:

- Coal: Formed from the compression and alteration of plant material in swampy environments.

Sedimentary Rocks Characteristics

Sedimentary rocks exhibit a range of characteristics that provide valuable information about their origin, the environments in which they formed, and the processes involved. Here are some key characteristics of sedimentary rocks:

Stratification: Sedimentary rocks often display visible layers or beds known as stratification. Each layer represents a distinct episode of sediment deposition, and the arrangement of these layers can provide insights into the history of the area.

Grain Size: The size of the sediment particles in a sedimentary rock can vary widely. This grain size is indicative of the energy of the environment in which the rock formed. For example, larger particles suggest high-energy environments like riverbeds, while smaller particles are associated with lower-energy environments like lakes or deep ocean floors.

Sorting: The degree of sorting refers to the uniformity of grain sizes within a sedimentary rock. Well-sorted rocks have grains of similar size, indicating thorough sorting during transportation. Poorly sorted rocks contain a mix of grain sizes, suggesting minimal transport and deposition.

Texture: Sedimentary rocks can have various textures, including clastic, crystalline, and friable (breakable). Clastic textures result from the accumulation of fragmented particles, while crystalline textures occur in rocks formed from the precipitation of minerals from solution.

Composition: Sedimentary rocks are composed of different types of minerals and materials. Clastic rocks contain mineral fragments derived from pre-existing rocks. Chemical rocks form from the precipitation of minerals from water solutions. Organic rocks are made up of plant and animal remains.

Fossils: Fossils are often found in sedimentary rocks, especially those formed in environments conducive to preserving organic materials. Fossils provide valuable information about past life forms and the history of life on Earth.

Color: Sedimentary rocks come in a wide range of colors, influenced by the minerals present and the conditions of formation. For example, iron-rich sediments can give rocks a red or brown color, while organic-rich sediments can lead to dark colors.

Porosity and Permeability: Many sedimentary rocks are porous, meaning they have tiny open spaces or pores between grains. Permeability refers to the ability of a rock to allow fluids to flow through it. These characteristics are important for understanding the potential for storing and transmitting fluids like water or oil.

Metamorphic Rocks

Metamorphic rocks are a fascinating type of rock that form through the transformation of pre-existing rocks (either igneous, sedimentary, or other metamorphic rocks) due to changes in temperature, pressure, and sometimes the presence of chemically active fluids. This process is known as metamorphism, and it leads to the development of new mineral assemblages, textures, and often significant changes in the rock's appearance and properties. Metamorphism can occur through various processes, resulting in different types of metamorphic rocks:

Contact Metamorphism: This occurs when rocks are heated due to their proximity to an igneous intrusion or magma chamber. The heat causes minerals in the surrounding rocks to re-crystallize, forming new minerals and changing the texture of the rock. Marble, formed from limestone, is a common product of contact metamorphism.

Regional Metamorphism This type of metamorphism happens over large areas and is associated with tectonic forces and high pressures. Rocks subjected to regional metamorphism often undergo significant changes in mineral composition and texture. Examples include gneiss, schist, and slate.

Dynamic Metamorphism: Also known as cataclastic metamorphism, this occurs along fault zones where rocks are subjected to high pressure and shear stress. The rocks are crushed and ground down, resulting in finely fragmented rocks.

Common Metamorphic Rock

Slate: A fine-grained, foliated metamorphic rock that originates from shale. It has excellent splitting properties and was historically used for roofing and as writing tablets.

Schist: A coarse-grained, foliated metamorphic rock with visible mineral grains. It forms from the metamorphism of shale or other fine-grained rocks and often contains mica minerals.

Gneiss: A banded metamorphic rock that displays alternating light and dark layers. It results from high-grade regional metamorphism and often forms from granite or other igneous rocks.

Marble: A non-foliated metamorphic rock derived from limestone or dolomite. It has a distinctive crystalline appearance and is commonly used for sculptures and buildings.

Quartzite: A non-foliated metamorphic rock formed from quartz-rich sandstone. It is extremely hard and durable, making it suitable for construction.

Classification of Metamorphism

Metamorphic rocks possess a range of distinctive characteristics that set them apart from other types of rocks. These characteristics are a result of the processes of metamorphism, which involve changes in temperature, pressure, and sometimes chemical activity. Here are some key characteristics of metamorphic rocks:

Mineral Composition: Metamorphic rocks often have new mineral compositions compared to their parent rocks. The minerals present are typically stable under the new temperature and pressure conditions. Some minerals are indicative of specific types of metamorphic conditions. For example, the presence of garnet might suggest high-pressure metamorphism.

Texture: The texture of a metamorphic rock refers to the arrangement, size, and shape of its mineral grains. This texture develops as a result of re-crystallization during metamorphism. There are two primary texture categories:

- **Foliated Texture-** This texture is characterized by the alignment of mineral grains in parallel layers or bands. Foliation develops under directed pressure, and it can be seen in rocks like schist and slate.

- **Non-Foliated Texture-** Rocks with a non-foliated texture lack distinct layering or banding. Instead, their minerals are equi-dimensional and lack preferred orientation. Non-foliated rocks include marble and quartzite.

Color and Appearance: The color and appearance of metamorphic rocks can vary widely due to the new minerals formed and the presence of impurities. For example, chlorite-rich minerals can give rocks a green hue, while iron-rich minerals may result in reddish or rusty colors.

Hardness and Texture: Metamorphic rocks can have varying degrees of hardness, with some becoming quite hard due to the re-crystallization of minerals. Quartzite, for instance, is often harder than the parent rock it formed from due to the re-crystallization of quartz grains.

Parent Rock Influence: The characteristics of the parent rock (the rock from which the metamorphic rock forms) play a role in determining the characteristics of the resulting metamorphic rock. For instance, shale can transform into slate, phyllite, schist, or gneiss depending on the intensity of metamorphism.

Occurrence: Metamorphic rocks are found in a variety of geological settings. They can be found in mountain ranges, where regional metamorphism has occurred due to the immense pressures and heat associated with tectonic activity. Contact metamorphism occurs around igneous intrusions, where the heat from the molten rock affects the surrounding rocks.

Rock Cycle

The rock cycle is a fundamental concept in geology that describes the continuous processes through which rocks are formed, transformed, and recycled over geological time scales. Figure 3.1 illustrates the dynamic interactions between the three main types of rocks—igneous, sedimentary, and metamorphic—driven by Earth's internal heat, external forces, and various geological processes. Here's a detailed overview of the rock cycle:

Igneous Rock Formation: The rock cycle begins with the formation of igneous rocks. These rocks originate from the cooling and solidification of molten magma or lava. When magma cools and solidifies beneath the Earth's surface, it forms intrusive igneous rocks like granite. When lava erupts onto the surface and cools rapidly, it forms extrusive igneous rocks like basalt.

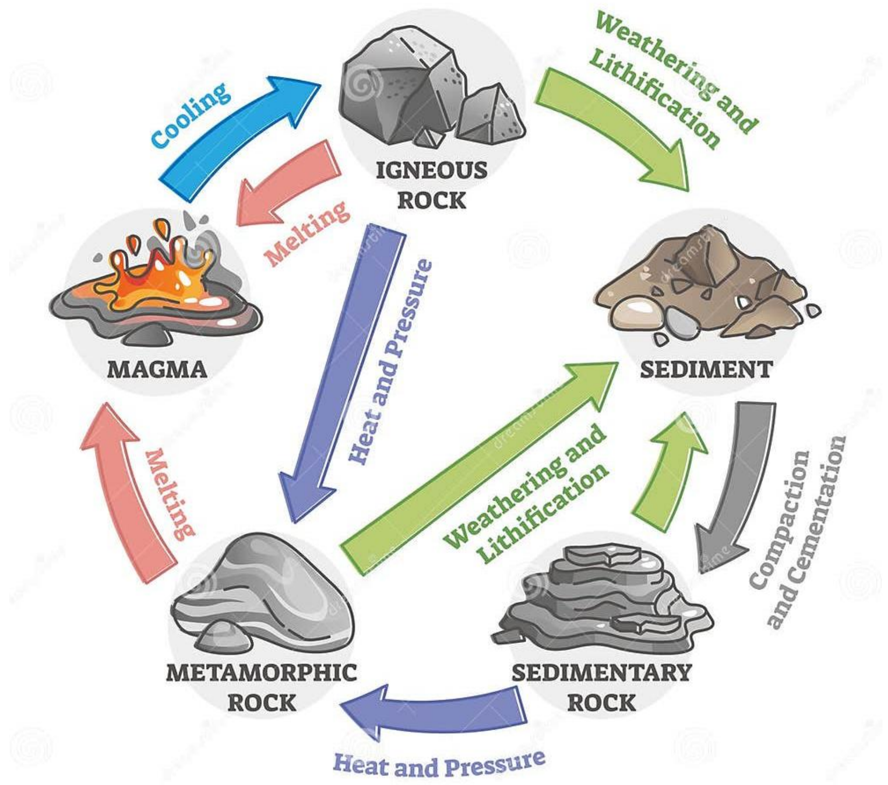

Fig. 3.1: Presentation of rock cycle (Source: illustration/rock-cycle-diagram.html).

Weathering and Erosion: Igneous rocks exposed at the Earth's surface are subject to weathering and erosion caused by natural forces such as wind, water, ice, and chemicals. Weathering breaks down rocks into smaller fragments, while erosion transports these fragments to new locations.

Sediment Deposition: Eroded particles and rock fragments, known as sediment, are transported by wind, water, or ice and eventually settle in various environments such as rivers, lakes, oceans, and deserts. Over time, these sediments accumulate and undergo compaction and cementation to form sedimentary rocks.

Sedimentary Rock Formation: Sedimentary rocks are formed through the processes of lithification, which involves compaction and cementation of sediments. Examples of sedimentary rocks include sandstone, limestone, shale, and conglomerate. These rocks often preserve evidence of past environments, as well as fossils of ancient plants and animals.

Heat and Pressure: As sediments accumulate over time, they can become buried by more sediment, resulting in increased pressure and temperature. This process, known as burial metamorphism, can lead to the formation of metamorphic rocks. However, for more intense metamorphism, such as during tectonic collisions, rocks may be subjected to higher pressures and temperatures, causing significant changes in mineral composition and texture.

Metamorphic Rock Formation: Metamorphic rocks form when pre-existing rocks (igneous, sedimentary, or other metamorphic rocks) are subjected to heat, pressure, and often chemically active fluids. This causes minerals within the rock to re-crystallize, leading to changes in texture and mineral composition. Examples of metamorphic rocks include marble, schist, and gneiss.

Melting and Magma Formation: Metamorphic rocks can undergo further changes if they are exposed to high temperatures. This can cause partial melting, resulting in the formation of magma. The magma can then rise to the surface and cool, completing the cycle by forming new igneous rocks.

3.4 SUMMARY

Rocks are like Earth's history books, telling stories about how our planet has changed over time. There are three main types of rocks: igneous, sedimentary, and metamorphic. Imagine that rocks can change clothes—this is a bit like how rocks change from one type to another in the rock cycle. First, there are igneous rocks that form when melted rock, called magma, cools down. These rocks can be found deep underground or on the surface after a volcano erupts. Then comes weathering and erosion, like nature's way of breaking rocks into tiny pieces. These pieces, called sediment, pile up and get squished together to make sedimentary rocks. These rocks often keep secrets, like fossils of ancient plants and animals.

But rocks don't stop changing there. When they get pushed deep underground, they feel the heat and pressure and start changing into metamorphic rocks. It's like they're getting a makeover! Their minerals rearrange and make new patterns. Sometimes, if things get really hot, rocks melt and turn into magma again. This magma can become new igneous rocks, starting the cycle over.

This whole rock cycle happens over a very, very long time. Earth's movements and forces, like tectonic plates shifting, also play a role in changing rocks. So, rocks are like a puzzle that helps scientists understand how our planet has evolved through millions of years. Just by looking at rocks, we can learn about ancient landscapes, climates, and even the powerful forces that shape our world.

3.5 GLOSSARY

Erosion: The process of transporting weathered rock particles and sediments by natural agents such as wind, water, ice, and gravity.

Foliation: A planar arrangement of mineral grains or structural features within a rock, often seen in metamorphic rocks due to directed pressure.

Igneous Rocks: Rocks that form from the cooling and solidification of molten magma or lava. They can be either intrusive (formed below the surface) or extrusive (formed on the surface).

Lava: Molten rock that reaches the Earth's surface during a volcanic eruption.

Magma: Molten rock beneath the Earth's surface, formed from the melting of rocks due to high temperature and pressure.

Metamorphic Rocks: Rocks formed from pre-existing rocks (igneous, sedimentary, or other metamorphic) through heat, pressure, and sometimes chemical reactions. They undergo changes in mineral composition and texture.

Minerals: Naturally occurring, inorganic substances with specific chemical compositions and crystalline structures. They are the building blocks of rocks.

Re-crystallization: The process by which minerals within a rock rearrange themselves into new crystal structures under changed conditions.

Rock Cycle: A continuous process describing the transformation of rocks from one type to another over geological time scales which involving processes like melting, cooling, denudation and pressure.

Rocks: Solid, naturally occurring materials that make up the Earth's crust. They are composed of minerals and can vary in size from tiny pebbles to massive mountains.

Sedimentary Rocks: Rocks that result from the accumulation, compaction, and cementation of sediments. They often contain fossils and provide clues about past environments.

Sediments: Loose particles and fragments of rock, mineral, and organic material that result from weathering and erosion. They can be compacted and cemented to form sedimentary rocks.

Texture: The arrangement, size, and shape of mineral grains within a rock, which provides insights into the conditions under which the rock formed.

Weathering: The breakdown of rocks into smaller fragments due to exposure to environmental factors like wind, water, temperature changes, and chemicals.

3.6 ANSWER TO CHECK YOUR PROGRESS

1. Rocks are solid, naturally occurring substances that make up the Earth's crust.
2. Minerals are the building blocks of rocks, each with a unique composition and structure.
3. Igneous rocks form when magma cools and solidifies, either underground or on the Earth's surface.
4. Sedimentary rocks result from the accumulation and compaction of weathered sediments.
5. Fossils are often found in sedimentary rocks and provide insights into past life forms.
6. Metamorphic rocks form from existing rocks due to heat, pressure, and sometimes fluids.
7. The rock cycle illustrates the continuous transformation of rocks between the three main types.
8. Weathering breaks down rocks into smaller particles through natural processes.
9. Erosion transports these particles to new locations, shaping landscapes over time.
10. Sediments are compacted and cemented to create solid sedimentary rocks.
11. Foliation is a texture seen in some metamorphic rocks, characterized by layered mineral alignment.
12. Cleavage refers to the tendency of rocks to split along specific planes due to mineral alignment.
13. Index minerals are useful indicators for determining the conditions under which metamorphic rocks formed.
14. Plate tectonics play a significant role in the movement and transformation of rocks.
15. Magma is molten rock beneath the Earth's surface, while lava is molten rock that reaches the surface.
16. Rocks provide valuable clues about Earth's history, including ancient environments and past geological events.

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3.8 TERMINAL QUESTIONS

Long Questions

1. What do you understand by rocks? Explain different types of rocks?
2. Explain rock cycle with suitable diagram.

Short Questions

1. What are rocks made of?
2. How do igneous rocks form?
3. What happens to rocks during weathering?
4. What's the difference between sedimentary and igneous rocks?
5. What's the name for rocks that change under heat and pressure?
6. How does the rock cycle work?
7. How are fossils connected to rocks?
8. How do mountains and volcanoes relate to rocks?
9. Can rocks turn into liquid? Explain.

Multiple Choice Questions

1. What are rocks primarily composed of?

a) Water

b) Air

c) Minerals

d) Plants

2. Which type of rock forms from the cooling of molten magma or lava?

a) Sedimentary rock

b) Metamorphic rock

c) Igneous rock

d) Fossil rock

3. What kind of rock can be formed from the accumulation of sediments?

a) Igneous rock

b) Volcanic rock

c) Sedimentary rock

d) Fossil rock

4. What is the process called when rocks are broken down into smaller particles by natural forces?

a) Compaction

b) Erosion

c) Solidification

d) Fossilization

5. Which type of rock is often associated with fossils?

a) Igneous rock

b) Sedimentary rock

c) Metamorphic rock

d) Volcanic rock

6. What is the process called when sediments are pressed together to form a solid rock?

a) Weathering

b) Melting

c) Erosion

d) Compaction

7. Which type of rock is formed by the alteration of pre-existing rocks under heat and pressure?

a) Sedimentary rock

b) Igneous rock

c) Metamorphic rock

d) Volcanic rock

8. Which process involves the movement of Earth's lithospheric plates and contributes to the formation of mountains?

a) Erosion

b) Weathering

c) Plate tectonics

d) Sedimentation

9. What is the molten rock beneath the Earth's surface called?

a) Sand

b) Magma

c) Sediment

d) Fossil

10. Which rock type often has a layered appearance due to the alignment of mineral grains?

a) Igneous rock

b) Sedimentary rock

c) Metamorphic rock

d) Fossil rock

11. Which rock type is likely to have crystals that formed from cooling lava?

a) Igneous rock

b) Sedimentary rock

c) Metamorphic rock

d) Fossil rock

12. What is the name for the continuous process of transforming rocks from one type to another?

a) Geologic shift

b) Rock revolution

c) Tectonic cycle

d) Rock cycle

13. What does weathering do to rocks?

a) Makes them bigger

b) Makes them hotter

c) Breaks them down

d) Turns them into fossils

14. Which type of rock is often used to make statues and buildings?

a) Sedimentary rock

b) Igneous rock

c) Metamorphic rock

d) Volcanic rock

15. What process forms sedimentary rocks from layers of sediments?

a) Melting

b) Erosion

c) Compaction and cementation

d) Metamorphism

16. Which rocks can change into magma when exposed to high heat?

a) Igneous rocks

b) Sedimentary rocks

c) Metamorphic rocks

d) All of the above

17. What do scientists study in rocks to learn about Earth's history?

a) Fossils

b) Leaves

c) Clouds

d) Waves

18. What's the name for the process that turns sediment into sedimentary rock?

a) Erosion

b) Compaction and cementation

c) Volcanism

d) Metamorphism

19. How are metamorphic rocks different from igneous rocks?

a) They are formed from melting

b) They are formed from cooling magma

c) They are formed from compression and heat

d) They are formed from layers of sediment

20. How do sedimentary rocks often form layers?

a) By melting

b) By weathering

c) By erosion

d) By deposition over time

Answers: 1-c, 2-c, 3-c, 4-b, 5-b, 6-d, 7-c, 8-c, 9-b, 10-c, 11-a, 12-d, 13-c, 14-c, 15-d, 16-d, 17-a, 18-b, 19-c, 20-d.

UNIT 4 - EARTHQUAKES AND VOLCANOS

4.1 OBJECTIVES

Reading this unit will help the students in building their concepts as regards the following:

- Gaining the knowledge of earthquakes.
- Learning the volcanism, volcanism features & hazardous effects of volcanism eruptions.
- Discussing the prediction of earthquake and preparedness.

4.2 INTRODUCTION

The Earth's restless nature is vividly showcased through the phenomena of earthquakes and volcanoes. These awe-inspiring events are manifestations of the planet's inner dynamics, reflecting the intense forces that shape its surface. In this chapter, we delve deep into the mechanisms, causes, impacts, and significance of earthquakes and volcanoes, unraveling their profound influence on Earth and its inhabitants.

4.3 EARTHQUAKES, CAUSES OF EARTHQUAKES, CLASSIFICATION OF EARTHQUAKES, WORLD DISTRIBUTION OF EARTHQUAKES, EFFECTS OF EARTHQUAKES, PREDICTION OF EARTHQUAKE AND PREPAREDNESS

An earthquake is a natural geological phenomenon caused by the sudden and violent shaking of the Earth's surface, typically caused by the release of accumulated energy within the Earth's crust. This energy release creates seismic waves that propagate through the Earth, causing ground shaking and potentially leading to the displacement of rocks and other materials. The seismic waves that radiate outward from the point of origin, are known as the focus or hypocentre. The point on the Earth's surface directly above the focus is called the epicentre. Earthquakes can range in magnitude from very small tremors that are barely perceptible to massive events that can result in widespread destruction and loss of life. The science that deals with the seismic waves, is called seismology.

Causes of earthquakes

Most earthquakes are caused by the movement of tectonic plates, which make up the Earth's outer shell. Stress and pressure build up along faults and plate boundaries as tectonic plates interact and either slide past each other, move apart or collide. When the accumulated stress overcomes the friction holding the rocks together, sudden movement occurs, releasing energy in the form of seismic waves.

Several causes have been assigned to cause disequilibrium in the earth's crust such as volcanic eruptions, up-warping and down warping, faulting, and folding, gaseous expansion and contraction inside the earth, hydrostatic pressure of man-made water bodies like reservoirs and lakes, and plate movements. Earthquakes are primarily caused by the movement of tectonic plates and the stress that builds up along faults due to the interactions between these plates. Here are the main causes of earthquakes:

(i) Tectonic Plate Movement: Tectonic plates are large, rigid pieces of the Earth's lithosphere that float on the semi-fluid asthenosphere beneath them. These plates are in constant motion due to the convection currents in the Earth's mantle and are responsible for the movement and shaping of the Earth's surface, including the formation of continents, oceans, mountains, and earthquakes. The theory that describes the movement of these plates is known as plate tectonics. As the plates move, they interact at their boundaries. The boundaries can be of several types:

- **Divergent Boundaries:** Here, tectonic plates are moving away from each other. This type of boundary is common along mid-ocean ridges, and it leads to the formation of new crust as magma rises from the mantle.
- **Convergent Boundaries:** At these boundaries, tectonic plates move toward each other. One plate may be forced beneath another in a process called subduction. The intense pressure and friction at these zones can result in powerful earthquakes.

(ii) Transform Boundaries: These boundaries occur when tectonic plates slide past each other horizontally. The friction between the plates can cause stress to build up until it is suddenly released, causing an earthquake.

(iii) Faulting: Faults are fractures in the Earth's crust where movement has occurred. The movement can be vertical, horizontal, or a combination of both. Stress builds up along faults due to the movement of tectonic plates. When the stress exceeds the friction holding the rocks together, they suddenly slip, releasing energy in the form of seismic waves.

(iv)Volcanic Activity: Earthquakes can also be caused by volcanic activity. As magma rises within a volcano, it can create pressure and stress in the surrounding rocks. When this pressure becomes too great, it can cause the rocks to fracture and generate earthquakes.

(v) Human Activities: Some earthquakes are induced by human activities, such as mining, reservoir-induced seismicity (due to the filling of large reservoirs behind dams), and hydraulic fracturing (fracking) for oil and gas extraction. These human-induced earthquakes are generally of smaller magnitude compared to natural tectonic earthquakes but can still have local impacts.

It's important to note that while tectonic plate movement is the primary cause of earthquakes, other factors, such as volcanic activity and human activities, can also contribute to seismic events. Seismologists study these causes to better understand the behavior of the Earth's crust. Here are some major terms related to earthquakes

(i) Epicentre and Hypocenter: The epicentre is the point on the Earth's surface directly above the focus. The focus (or hypocenter) is the actual location within the Earth where the earthquake originates. The depth of the focus can vary widely, from shallow depths near the surface to deeper within the Earth.

(ii) Seismic Waves: The energy released during an earthquake propagates in the form of seismic waves. Seismic waves are vibrations or waves of energy that travel through the Earth in response to sudden releases of energy, such as those that occur during earthquakes, volcanic activity, or explosions. There are several types of seismic waves, each with distinct properties and behaviors. Generally, these waves are divided into in 3 broad categories:

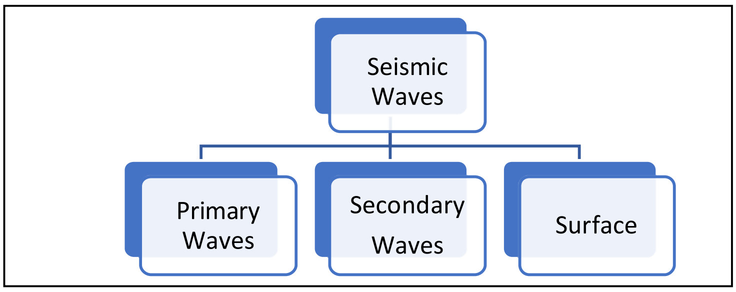

Fig 4.1: Seismic Waves.

(a) Primary Waves (P-Waves):

- P-Waves are the fastest seismic waves and are the first to be detected after an earthquake.
- They are compression waves that travel through both solids and liquids, causing particles in the material to move back and forth in the direction of wave propagation.
- P-Waves can travel through the Earth's core, mantle, and crust.

- They cause minimal ground shaking compared to other types of seismic waves.

(b) Secondary Waves (S-Waves):

- S-Waves follow P-Waves and are slower than them.
- These waves are shear waves that cause particles to move perpendicular to the direction of wave propagation.
- S-Waves only travel through solids and cannot pass through liquids, which helps scientists deduce that the Earth's outer core is liquid.
- They produce more pronounced ground shaking than P-Waves.

(c) Surface Waves:

- Surface waves are the slowest but often the most damaging seismic waves.
- They propagate along the Earth's surface and include two main types: Love waves and Rayleigh waves.
- Love waves have a horizontal side-to-side motion that is similar to S-Waves but occurs on the Earth's surface.
- Rayleigh waves have a rolling, elliptical motion that is also confined to the Earth's surface.
- These waves can produce the strong, prolonged shaking that causes the most damage during an earthquake.

Seismic waves play a crucial role in understanding the Earth's internal structure. Seismologists use seismic data collected from earthquakes and other sources to create models of the Earth's interior.

(iii) Magnitude: Magnitude in the context of earthquakes refers to the measurement of the energy released by an earthquake. It provides a quantitative assessment of the earthquake's size and strength. The magnitude of an earthquake is typically determined using various scales that take into account the amplitude of seismic waves recorded by seismometers. There are a few different scales used to measure earthquake magnitude, with the two most common ones being the Richter scale and the moment magnitude scale (Mw):

- **Richter Scale:** The Richter scale, named after its creator Charles F. Richter, is a logarithmic scale used to measure the magnitude of earthquakes. It was developed in the 1930s as a way to quantify the energy released by earthquakes and provide a standardized measurement of their size and strength. The Richter scale assigns a single numerical value to each earthquake, indicating its magnitude.

- **Moment Magnitude Scale (Mw):** The moment magnitude scale (Mw) is a modern and more accurate measure of earthquake magnitude. It takes into account the seismic moment, which is a combination of the area of the fault that slipped, the amount of slip along the fault, and the rigidity of the rocks involved. The Mw scale is also logarithmic, similar to the Richter scale, but it provides a more accurate representation of the earthquake's energy release, especially for larger earthquakes.

(iv) Intensity: Intensity refers to the effects of an earthquake on people, structures, and the environment. The Modified Mercalli Intensity (MMI) scale is commonly used to assess the intensity of an earthquake based on observed damage and the impact on human experience.

(v) Aftershocks: After the main earthquake, smaller tremors known as aftershocks may occur. These are a result of readjustments in the Earth's crust following the initial release of energy.

Classification of earthquakes

(1) BASED ON LOCATION:

Based on the location of tectonic plate boundaries, earthquakes can be classified into three main categories:

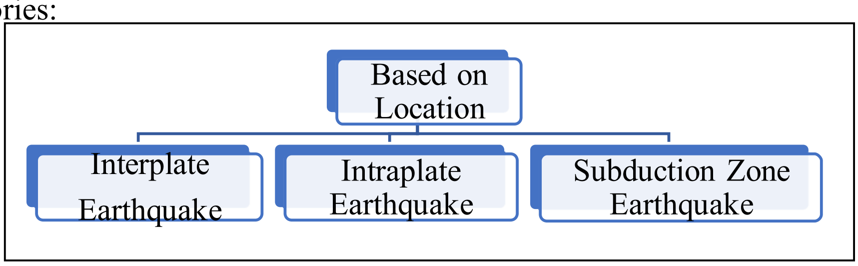

Fig 4.2: Earthquake Based on Location

(i) Interplate Earthquakes: Interplate earthquakes occur at the boundaries between tectonic plates. These boundaries are where two plates interact with each other. There are three primary types of interplate boundaries:

(a) Divergent Boundaries: Interplate earthquakes at divergent boundaries happen along mid-ocean ridges where tectonic plates are moving away from each other. These earthquakes are usually relatively mild but can contribute to the formation of new oceanic crust.

(b) Convergent Boundaries: Interplate earthquakes at convergent boundaries occur where tectonic plates are colliding or being subducted (one plate is forced beneath another). These earthquakes are often powerful and can lead to the formation of mountain ranges, deep ocean trenches, and volcanic activity.

(c) Transform Boundaries: Interplate earthquakes at transform boundaries take place where tectonic plates are sliding past each other horizontally. These earthquakes are characterized by strike-slip motion along faults and can cause significant ground shaking.

(ii) Intraplate Earthquakes: Intraplate earthquakes occur within the interior of a tectonic plate, away from its boundaries. These earthquakes are less common than interplate earthquakes and can be challenging to predict because they are not directly associated with the motion of plate boundaries. Intraplate earthquakes can be caused by reactivated ancient faults, magmatic activity, or other geological processes.

(iii) Subduction Zone Earthquakes: Subduction zone earthquakes are a specific type of interplate earthquake that occurs at subduction boundaries, where one tectonic plate is being forced beneath another. These earthquakes are often some of the most powerful and destructive due to the massive release of energy during subduction.

(2) Based on focal depth: earthquakes can be classified into three main categories:

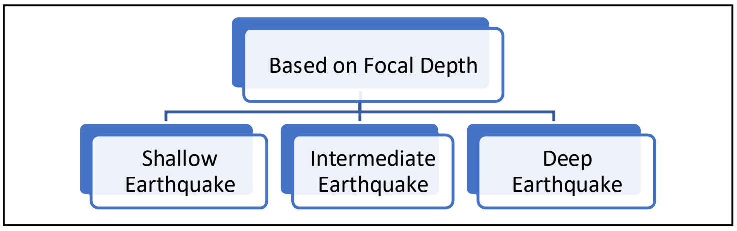

Fig 4.3: Earthquake Based on Focal Depth

(i) Shallow Earthquakes: Shallow earthquakes occur at depths of up to 70 kilometers (43 miles) below the Earth's surface. They are the most common type of earthquakes and typically cause the most intense ground shaking. Shallow earthquakes are often associated with tectonic activity along plate boundaries, faults, and rift zones.

(ii) Intermediate Earthquakes: Intermediate earthquakes occur at depths ranging from 70 kilometers (43 miles) to 300 kilometers (186 miles) below the Earth's surface. These earthquakes are less common than shallow ones and tend to have slightly weaker shaking. They often occur in subduction zones and along thrust faults in mountainous regions.

(iii) Deep Earthquakes: Deep earthquakes occur at depths greater than 300 kilometers (186 miles) within the Earth's mantle. They are the least common type of earthquake and are usually associated with the subduction of oceanic plates beneath continental plates. Deep earthquakes can still generate significant shaking, especially in areas close to the epicenter.

(3) BASED ON THE CAUSE: Based on the cause, earthquakes are divided into two categories:

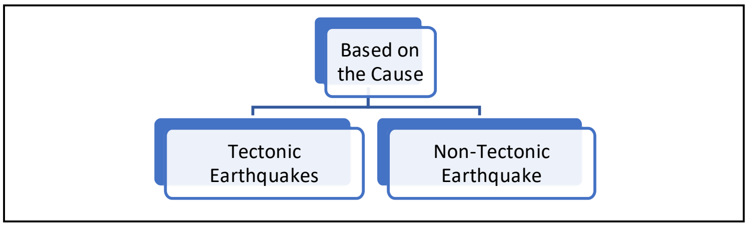

Fig4.4: Earthquake Based on the Cause

(i) Non-Tectonic Earthquakes: These are due to volcanic activities and manmade reasons e.g., nuclear testing, blasts, construction of large dams, deforestation etc

(ii) Tectonic Earthquakes: These are due to sudden slip in the fault of the tectonic plates of the earth.

(4) Based on the magnitude of the earthquake:

Based on the magnitude, earthquakes can be divided six broad categories which are given in Table-4.1.

Table-4.1: Categorization of earthquakes and their magnitude.

S.No.	Class	Magnitude
i.	Great	8 or more
ii.	Major	7-7.9
iii.	Strong	6-6.9
iv.	Moderate	5-5.9
v.	Light	4-4.9
vi.	Minor	3-3.9

World distribution of earthquakes

Earthquakes occur across the globe, but their distribution is not uniform. They are most common in regions where tectonic plates interact and create stress along faults. There are three major belts in the world which are frequented by earthquakes of varying intensities. These belts are: (i) Circum-Pacific Belt (ii)Mid-continental Belt (iii) Mid-Atlantic Ridge Belt

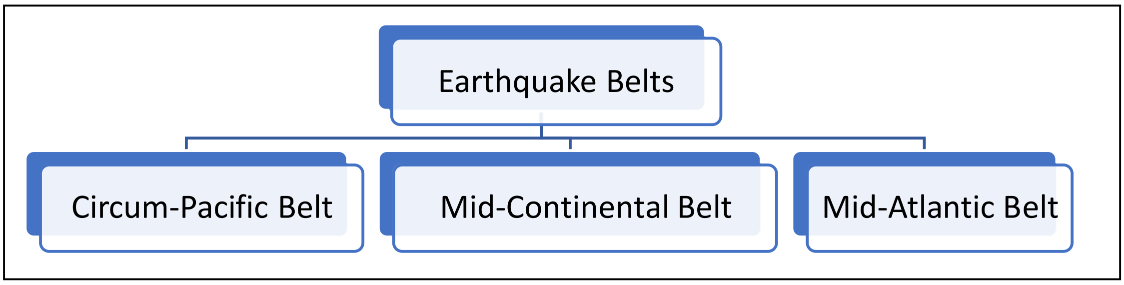

Fig4.5: Distribution of Earthquake

1. The Circum-Pacific Belt:

The Circum-Pacific Belt, often referred to as the "Pacific Ring of Fire," is a horseshoe-shaped area that encircles the Pacific Ocean. It is known for its high seismic and volcanic activity. This region is characterized by the presence of numerous tectonic plate boundaries and subduction zones, which contribute to the frequent occurrence of earthquakes and volcanic eruptions. Here's a brief overview of the Circum-Pacific Belt distribution region:

- **Pacific Coast of North America:** The western coast of North America, from Alaska down through the western United States and Mexico, is part of the Pacific Ring of Fire. The San Andreas Fault in California is a major fault system along this coastline, generating numerous earthquakes.
- **West Coast of South America:** The entire western coast of South America, from Chile up through Colombia, is part of the Circum-Pacific Belt. The Andes mountain range, created by the subduction of the Nazca Plate beneath the South American Plate, is characterized by frequent earthquakes and volcanic activity.
- **Japan and Southeast Asia:** Japan, the Philippines, Indonesia, and other countries in Southeast Asia are located along active subduction zones and volcanic arcs. The convergence of tectonic plates in this region leads to significant seismic and volcanic activity.
- **Kamchatka Peninsula and Aleutian Islands:** The Kamchatka Peninsula in Russia and the Aleutian Islands in Alaska are part of the Pacific Ring of Fire. These areas experience frequent earthquakes and are home to several active volcanoes.

- **East Asia:** Countries along the eastern coast of Asia, such as China, Taiwan, and the Korean Peninsula, are also affected by the Circum-Pacific Belt. Subduction zones and tectonic interactions in this region contribute to seismic and volcanic events.
- **New Zealand:** Located on the boundary between the Pacific Plate and the Australian Plate, New Zealand experiences earthquakes and volcanic activity along the Alpine Fault and the Taupo Volcanic Zone.
- **Pacific Islands:** Many Pacific islands and archipelagos, including the Mariana Islands, Tonga, Fiji, and Papua New Guinea, are situated within the Circum-Pacific Belt. These areas are prone to earthquakes and volcanic eruptions due to their location near tectonic plate boundaries.

2. The Mid-Atlantic Belt:

- This belt is characterized by the sea floor spreading which is the main cause of the occurrence of earthquakes in it. This earthquake belt runs along the mid-oceanic ridges and the other ridges in the Atlantic Ocean.

- In this belt, most of the earthquakes are of moderate to mild intensity. Their foci are generally less than 70 km deep. Since the divergent plates in this belt move in opposite directions and there is splitting as well, transform faults and fractures are created.
- All this becomes the causative factor for the occurrence of shallow-focus earthquakes of moderate intensity. The sea floor spreading is the main cause of the occurrence of earthquakes in this belt.

3. The Mid-Continental Belt:

- This belt is also known as the Mediterranean Belt or Alpine –Himalayan belt which represents the collision or subduction zones of continental plates.
- It extends along the young folded Alpine Mountain system of Europe, North Africa, Asia Minor, Caucasia, Iran, Afghanistan, and Pakistan to the Himalayan Mountain system. This belt continues further to include Tibet, the Pamirs, and the mountains of Tien Shan etc.

- The young folded mountain systems of Myanmar, China and eastern Siberia fall in this belt. This belt happens to be the subduction zone of continental plates. It is in this belt that the African as well as Indian plate subducting below the Eurasian plate.
- This Mid-continental belt is characterized by experiencing about 20 percent of the earthquakes in the world. This belt records earthquakes of shallow and intermediate origin. However, sometimes earthquakes of great violence indeed occur in this belt.
- This belt forms a great circle approximately east and west around the earth, through the Mediterranean, Southern Asia, Indonesia and the East Indies, where the great majority of recorded shocks occur.
- It may be pointed out that more than 50 percent of all earthquakes are associated with the young folded mountains which are said to be still growing.

4.4 VOLCANISM: THE CONCEPT, COMPONENTS OF VOLCANOES, ERUPTED MATERIALS, TYPES OF VOLCANOES, MECHANISM AND CAUSES OF VOLCANISM, WORLD DISTRIBUTION OF VOLCANOES

A volcano is like a mountain that can sometimes spit out hot melted rock, ashes, and gases from deep inside the Earth. It happens when the Earth's insides get all stirred up, and the melted rock, called magma, pushes its way to the surface. When this magma comes out, it can create new land, but it can also be dangerous because it's really hot and can cause big explosions. Some volcanoes are big and tall, while others are smaller hills, and they can be found on land or underwater.

Components of volcanoes

Magma - Molten rock beneath the Earth's surface.

Parasitic Cone - A small cone-shaped volcano formed by an accumulation of volcanic debris.

Sill - A flat piece of rock formed when magma hardens in a crack in volcano.

Vent - An opening in Earth's surface through which volcanic materials escape.

Flank - The side of a volcano.

Lava - Molten rocks that erupt from volcanoes.

Crater - Mouth of a volcano (surrounds a volcanic vent).

Conduit - An underground passage through which magma travels.

Summit - Highest point, i.e.(apex).

Throat - Entrance of a volcano. The part of the conduit that ejects lava and volcanic ash.

Ash - Fragments of lava or rock smaller than 2 mm in size that are blasted into the air by volcanic explosions.

Ash Cloud - A cloud of ash formed by volcanic explosions.

Erupted materials

Three basic kinds of materials may erupt from a volcano. They are Lava, Rock fragments and Gases.

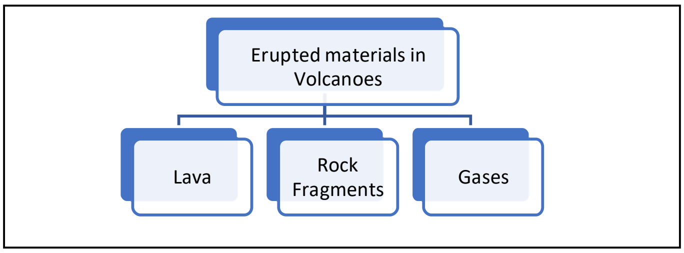

Fig 4.6: Erupted materials of Volcanoes

(1) Lava: Lava is the super-hot, melted rock that comes out of a volcano when it erupts. It flows like a very thick liquid, and it can be bright and glowing because of its extreme heat. Lava can create new land as it cools and hardens, but it can also be dangerous because it can burn anything in its path.

(2) Rock fragments: Rock fragments generally called tephra, are formed from sticky magma. Such magma is so sticky that its gas cannot easily escape when the magma approaches the surface or central vent. Finally, the trapped gas builds up so much pressure that it blasts the magma into fragments.

(3)Gases: Gases discharge out of volcanoes in large quantities during most eruptions. The gas is mainly made-up steam. But it also includes carbon dioxide, nitrogen, sulfur dioxide, and other gases. Most of the steam comes from a volcano's magma.

Types of volcanoes

Volcanoes are classified into two types:

(i) Classification based on the Mode of Eruptions

(ii) Classification based on Periodicity of Eruptions

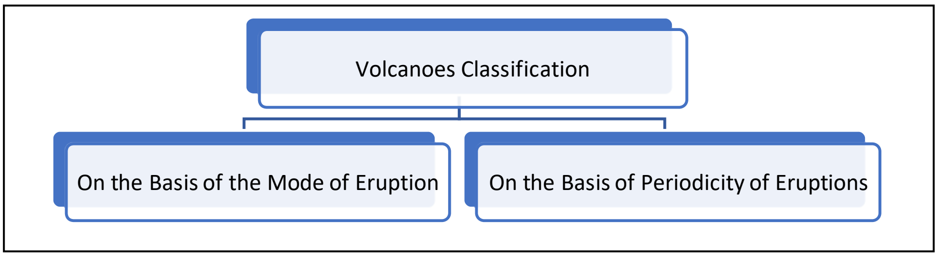

Fig4.7: Classification of Volcanoes Types

(1) Classification based on the mode of eruptions divided into two categories.

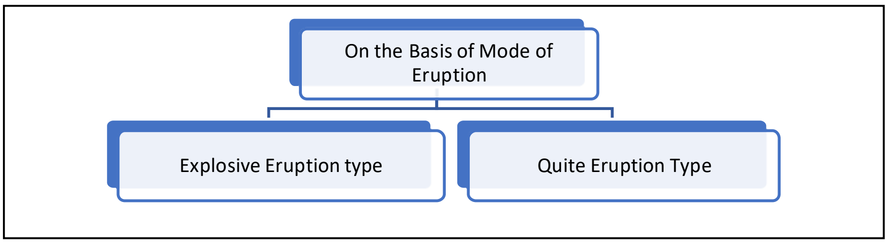

Fig4.8: Classification based on the mode of Eruption

(i) Explosive eruption type

Explosive type of eruption of lavas, volcanic dusts, volcanic ashes and fragmental materials through a narrow pipe and small opening under the impact of violent gases. Explosive type volcanoes are further divisible into five categories viz., Hawaiin type, Strombolian type, Vulcanian type, Peleean type and Visuvius type.

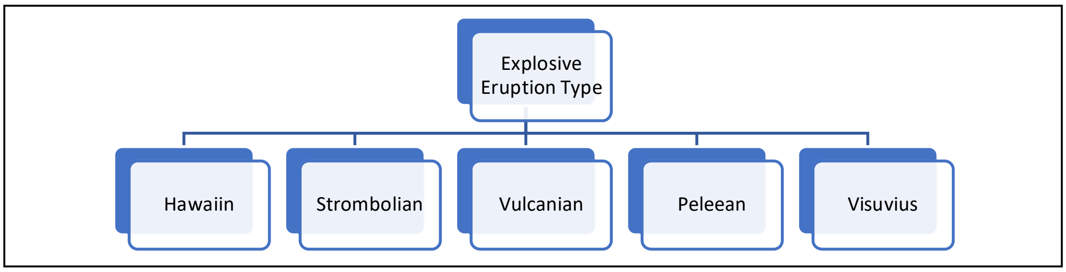

Fig 4.9:Explosive Eruption Type Volcanoes

(ii) Quite eruption type: Quite a type eruption volcanoes divided into 3 categories viz: Lava flow, Mud flow, Fumaroles.Quiet type eruption along a long fracture due to weak gases and huge volume of lavas.

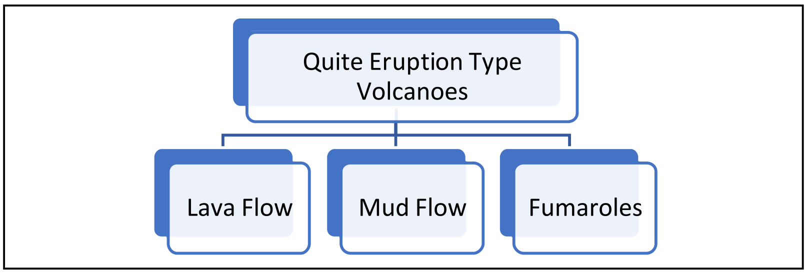

Fig 4.10: Quite type eruption volcanoes

(2) Classification based on periodicity of eruptions

Based on the periodicity of eruptions volcanoes are divided into 3 categories viz: (i) Active volcanoes, (ii) Dormant volcanoes and (iii) Extinct volcanoes.

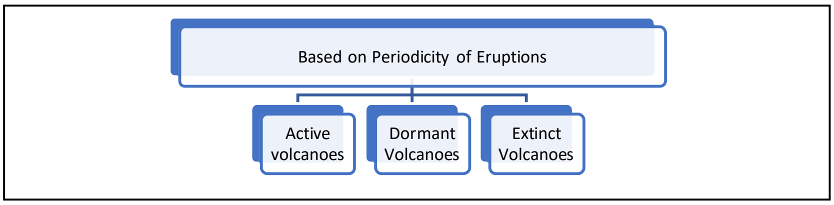

Fig 4. 11: Volcanoes classification based on periodicity of eruptions

Mechanism and causes of volcanism

Volcanoes are created by the movement of molten rock, called magma, from deep within the Earth to the surface. This movement is driven by the Earth's internal heat and the movement of tectonic plates, which are like huge puzzle pieces that make up the Earth's crust.

Here is how the mechanism of volcanoes works:

(i) Magma Formation: Magma is formed when rocks deep inside the Earth melt due to high temperatures and pressure. This molten rock is lighter than the solid rocks around it, so it rises towards the surface.

(ii)Magma Chamber: The magma collects in underground pockets called magma chambers. These chambers are like reservoirs of molten rock beneath the Earth's crust.

(iii) Pressure Buildup: As more magma accumulates in the magma chamber, it creates pressure. This pressure pushes the magma upwards, seeking a way to escape.

(iv) Cracks and Weak Points: The Earth's crust is not solid and continuous; it has made up of pieces called tectonic plates. There are cracks and weak points in these plates where magma can find a way to reach the surface. These weak points are often near the edges of tectonic plates.

(v) Eruption: When the pressure becomes too much, the magma forces its way through the cracks and weak points. This is when a volcanic eruption occurs. The magma travels through a passage called a conduit, and it can shoot out of the volcano's vent, which is the opening on the surface.

(vi) Lava Flows and Ejecta: During an eruption, the magma can flow out as lava, which is the melted rock that cools and hardens as it reaches the surface. Along with the lava, other materials like ash, rocks, and gases can be ejected into the air.

(vii)Volcanic Features: Over time, as the magma continues to erupt and solidify, it forms the shape of the volcano. The type of volcano and its features, like its shape and size, depend on the kind of magma and the eruptive style.

Causes of Volcanoes

Volcanoes are caused by a combination of geological processes and the movement of material within the Earth's crust and mantle. The main causes of volcanoes are related to the movement of magma, which is molten rock, and the Earth's tectonic plate system. Here's a breakdown of the primary causes:

1. Tectonic Plate Movements: The Earth's outer shell, called the lithosphere, is divided into large pieces known as tectonic plates. These plates are constantly moving, albeit very slowly, due to the convective currents in the semi-fluid layer below them, known as the asthenosphere. There are three main types of tectonic plate interactions that can lead to volcanic activity:

- **Subduction Zones:** When one tectonic plate slides beneath another in a process called subduction, the descending plate carries water and minerals into the Earth's mantle. This causes the mantle to melt and generate magma, which rises to the surface and can lead to the formation of volcanoes at the subduction zone.
- **Divergent Boundaries:** At divergent boundaries, tectonic plates move away from each other, creating gaps. Magma from the mantle can fill these gaps, solidify, and eventually form underwater volcanoes. This process is common along mid-ocean ridges.
- **Hotspots:** Hotspots are areas of unusually high heat in the Earth's mantle that can generate magma. Even though the tectonic plates are moving, these hotspots remain fixed. As the plates move over these hotspots, magma can erupt through the crust,

forming a chain of volcanoes. The Hawaiian Islands are an example of a hotspot-related volcanic chain.

2. Magma Generation and Ascent: The primary cause of volcanic eruptions is the movement of magma from the Earth's mantle towards the surface. This can occur due to a variety of factors, including changes in pressure, temperature, and volatile content within the mantle. When the magma is less dense than the surrounding rock and has enough pressure behind it, it can force its way to the surface through cracks and weaknesses in the crust, leading to volcanic eruptions.

3. Geothermal Heat: The Earth's interior is very hot due to the heat left over from its formation and the ongoing radioactive decay of elements within the Earth. This heat can lead to the melting of rocks in the mantle, generating magma that can eventually make its way to the surface and form volcanoes.

In summary, the primary causes of volcanoes are related to the movement of tectonic plates, which create conditions for the generation and ascent of magma from the Earth's mantle. These geological processes, combined with the heat within the Earth's interior, play a significant role in shaping the planet's surface and creating volcanic features.

World distribution of volcanoes

A volcanic belt is a geographical region in which very high levels of volcanic activity are present. Volcanoes are distributed all around the world, mostly along the edges of tectonic Plates, although there are intra-plate volcanoes that form from mantle Hotspots (e.g., Hawaii). Some volcanic regions, such as Iceland, happen to occur where there is both a hotspot and a plate boundary.

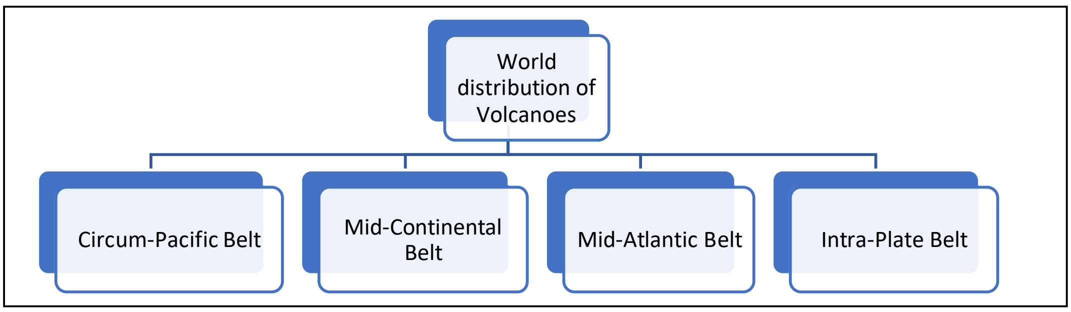

Fig 4.12: World Distribution of Volcanoes.

1. Circum-pacific belt

The Pacific "Ring of Fire" is a string of volcanoes and sites located on most of the Earth's subduction zones having high seismic activity, around the edges of the Pacific Ocean. The Pacific Plate hits other plates nearby and that causes them to sink because of O-O or O-C convergence. The crust melts producing the magma that feeds the different volcanoes in the Pacific Ring of Fire or it will help produce new volcanoes. The Ring of Fire is the result of plate tectonics. Most tectonic activity in the Ring of Fire occurs in these geologically active zones. It is believed that the Pacific Ring of Fire has a total of 452 volcanoes. Most of the active volcanoes on The Ring of Fire are found on its western edge, from the Kamchatka Peninsula in Russia, through the islands of Japan and Southeast Asia, to New Zealand.

2. Mid-continental belt

This volcanic belt extends along the Alpine Mountain system of Europe, North America, through Asia Minor, Caucasia, Iran, Afghanistan and Pakistan to the Himalayan Mountain system, including Tibet, the Pamir, Tien-Shan, Altai, and the mountains of China, Myanmar and eastern Siberia. This zone is characterized by larger volcanoes &earthquakes of shallow origin and some of intermediate origin. Deep-focus earthquakes are almost absent in this belt. About 21 percent of the total earthquakes of the world are recorded in this belt. This belt includes the volcanoes of the Alps mountains, the Mediterranean Sea (Stromboli, Vesuvius, Etna, etc.), volcanoes of the Aegean Sea, Mt. Ararat (Turkey), Elburz, Hindukush, and the Himalayas.

3. Mid-Atlantic belt

The Mid-Atlantic Ridge is composed of discrete spreading segments that are tens of kilometers long, and offset by transform faults and non-transform offsets. The axis of the Mid-Atlantic Ridge is marked by a major rift valley 1 to 1.5 kilometers deep, a central floor 4 to 15 kilometers across, and ranges of crestal mountains on each side of the valley separated by 20 to 40 kilometers. The median valley walls are composed of large faults that move the crust upwards to form the crestal mountains. The central valley floor is the primary site of ocean crust construction, and most segments contain an axial volcanic ridge that runs down the center of the median valley floor. The axial volcanic ridges are themselves made up of smaller ridges, round domes, and a variety of topographic features that all amalgamate into a single larger ridge. Axial volcanic ridges may be 2 to 4 kilometers across and 100 to 600 meters high, and represent a much larger scale of volcanic relief than found on fast-spreading ridges, which are characterized mainly by flat-lying flows. There are two types of volcanic features: Some are composed of lava hummocks 50 to 200 meters in diameter and at most 10 to 20 meters high, while other features are coated with smooth lava flows that cover most of the median valley floor.

4. Intra-plate volcanoes

A third tectonic setting where volcanism occurs is called intraplate- or hot-spot-volcanism, which describes volcanic activity that occurs *within tectonic plates* and is generally not related to plate boundaries and plate movements. Most volcanic activity occurs at plate boundaries, but there are also many volcanoes located with a plate, some of which are exceptionally active. These areas of so-called intraplate volcanism are called hot spots.

4.5VOLCANIC FEATURES, HAZARDOUS EFFECTS OF VOLCANIC ERUPTIONS

Volcanic landforms are divided into extrusive and intrusive landforms based on whether magma cools within the crust or above the crust.

Extrusive Volcanic Landforms

- Extrusive landforms are formed from material thrown out during volcanic activity.
- The materials thrown out during volcanic activity include lava, pyroclastic debris, volcanic bombs, ash and dust and gases such as nitrogen compounds, sulphur compounds and minor amounts of chlorine, hydrogen, and argon**.**

1-Conical Vent and Fissure Vent

- A conical vent is a narrow cylindrical vent through which magma flows out violently. Conical vents are common in andesitic (composite or stratovolcano) volcanism.
- A fissure vent, also known as a volcanic fissure or eruption fissure, is a narrow, linear volcanic vent through which lava erupts, usually without any explosive activity.

The vent is often a few meters wide and may be many kilometers long. Fissure vents are common in basaltic volcanism.

2-Mid-Ocean Ridges

- 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.
- The lava is basaltic in nature (Less silica and hence less viscous).
- Cools slowly and flows through longer distances.
- The lava here is responsible for sea floor spreading.

3-Composite Type Volcanic Landforms

- They are conical or central type volcanic landforms.
- Along with andesitic lava, large quantities of pyroclastic material and ashes find their way to the ground.
- Andesitic lava along with pyroclastic material accumulates in the vicinity of the vent openings leading to the formation of layers, and this makes the mounts appear as composite volcanoes.
- The highest and most common volcanoes have composite cones.
- They are often called strata–volcanoes.
- Stromboli 'Lighthouse of the Mediterranean', Mt. Vesuvius, Mt. Fuji etc. are examples.

4-Shield Type Volcanic Landforms

- 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.
- These volcanoes are not steep.
- They become explosive if somehow water gets into the vent; otherwise, they are less explosive.
- Example: Mauna Loa (Hawaii).

Fig. 4.13: Volcanic eruption *(Source: Google).*

5-Fissure Type Flood Basalt Landforms [Lava Plateaus]

- Sometimes, a very thin magma escapes through cracks and fissures in the earth's surface and flows after intervals for a long time, spreading over a vast area, finally producing a layered, undulating (wave like), flat surface.
- Example: Deccan traps (peninsular India), Snake Basin, U.S.A, Icelandic Shield, Canadian Shield etc.

6-Caldera Lake

- After the eruption of magma has ceased, the crater frequently turns into a lake at a later time. This lake is called a 'caldera'. Examples: Lonar in Maharashtra and Krakatao in Indonesia.

7-Cinder cone

- A cinder cone is a steep conical hill of loose pyroclastic fragments, such as volcanic clinkers, cinders, volcanic ash, or scoria that has been built around a volcanic vent.

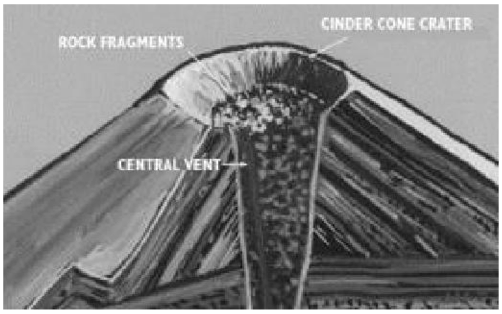

Fig 4.14: Presentation of Caldera and Cinder cone *(Source: Google).*

Intrusive Volcanic Landforms

- Intrusive landforms are formed when magma cools within the crust [Plutonic rocks (intrusive igneous rock)].
- The intrusive activity of volcanoes gives rise to various forms.

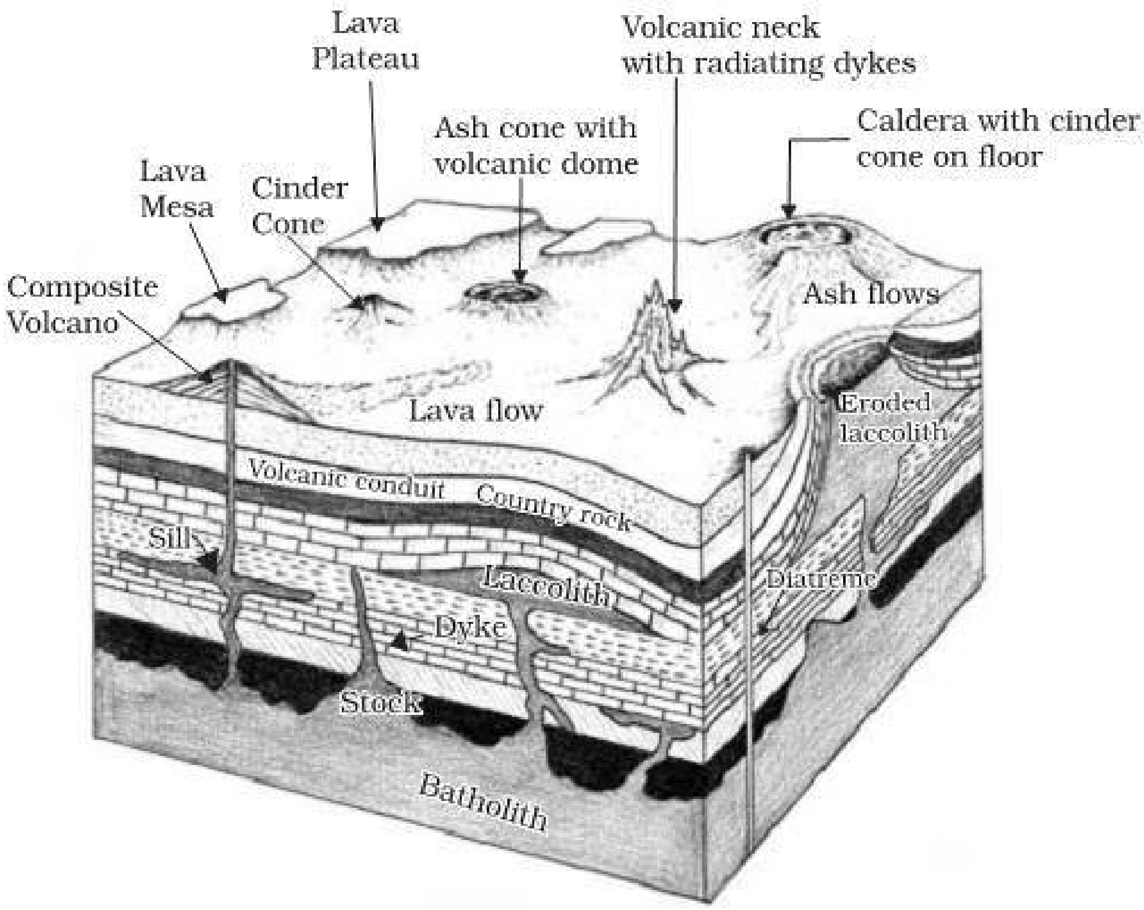

Fig 4.15: Presentation of intrusive and extrusive volcanic landforms *(Source: Google).*

Batholiths

- These are large rock masses formed due to the cooling down and solidification of hot magma inside the earth.
- They appear on the surface only after the denudation processes remove the overlying materials.
- Batholiths form the core of huge mountains and may be exposed on the surface after erosion.
- These are granitic

Laccoliths

- These are large dome-shaped intrusive bodies connected by a pipe-like conduit from below.
- These are basically intrusive counterparts of an exposed domelike batholith.
- The Karnataka plateau is spotted with dome hills of granite rocks. Most of these, now exfoliated, are examples of laccoliths or batholiths.

Lapolith

- 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.

Phacolith

- A wavy mass of intrusive rocks, at times, is found at the base of synclines or at the top of the anticline in a folded igneous rock.
- Such wavy materials have a definite conduit to source beneath in the form of magma chambers (subsequently developed as batholiths). These are called the Phacoliths.

Sills

- These are solidified horizontal lava layers inside the earth.
- 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.

Hazardous effects of volcanic eruptions

Volcanoes can cause multiple hazards (both primary and secondary hazards). Each hazard can have varying impacts. Below is a summary of volcano major hazards and their likely impact:

1. Primary Hazards: Hazards that are a direct result of the eruption and are caused by the released of substances during the eruption.

- **Lava Flow:** The most associated hazard with volcanoes. Lava flows are simply rivers of molten rock. Viscous (thick) lava flows are very slow, which means most lava flows can be avoided by humans. However, they can cause massive damage to land and property and trigger fires.
- **Tephra (Lava Bombs):** Any material that is ejected from a volcano during an eruption. If you are standing a safe distance, humans should not be affected by tephra although they can damage buildings and start secondary fires.
- **Pyroclastic Flow:** Probably the most dangerous of all volcanic hazards are pyroclastic flows (sometimes called nuee ardentes) which are superheated clouds of ash, gas and small tephra. They can travel at speeds up to 500km/hr and incinerate anything in their path.
- **Ash Cloud:** Ash clouds are normally released into the atmosphere. Although they don't pose much immediate danger they can disrupt air travel and when the ash falls to ground it can crush buildings and bury farmland and also cause the secondary hazard of acid rain.
- **Poisonous Gases:** Often released before a major eruption these gases can be deadly to animals and humans if inhaled in sufficient quantities.

2. Secondary Hazards: Hazards that happen as a result of primary hazards.

- **Lahar (mudslide):** Volcanoes ash and/or lava can cause snow to melt or they can mix with river/rain water and create mudslides, commonly known as lahars.
- **Acid Rain:** Gases released during an eruption e.g. sulphur dioxide can mix with water vapour in the atmosphere and create acid rain which can damage buildings and change the pH of soils and lakes killing plant and animal life.

- **Climate Change:** Gases released into the atmosphere e.g. sulphur dioxide can enhance the greenhouse effect causing global warming. However, ash released into the atmosphere can also absorb or reflect incoming solar radiation and reduce global temperatures.
- **Fires:** Tephra and lava flows can start fires which can cause widespread damage to buildings and land.

4.6 SUMMARY

Going thoroughly through this unit, you must have understood about earthquakes concept. Studying this chapter, you might have also known about volcanism. In the first part of this unit, we tried to understand earthquakes & their concepts. After studying the objectives of this unit, you have learned about the volcanism. Studying these features, you will be able to understand how did volcanoes formed? Types of volcanoes, features of volcanoes & how did earthquakes occur?

4.7 GLOSSARY

Crater: A large hole or depression that has been created by a volcano. Lakes will often form in the bottom of lakes, they are known as crater lakes**.**

Epicentre: The point on the Earth's surface directly above where an earthquake originates below the ground.

Eruption: A release of volcanic lava, ash or gas.

Hypocenter: The hypocenter is the point within the Earth where an earthquake originates.

Lava: Molten rock above the surface of the earth.

Magma Chamber: A store of magma found below the surface of the earth. When the pressure becomes too great in the magma chamber, volcanoes occur.

Magma: Molten rock below the surface of the earth.

Seismology: Science of studying earthquakes.

Tectonic Plate: Tectonic plates are large, moving pieces of the Earth's crust that interact at their boundaries, causing earthquakes, volcanoes, and the formation of mountains and oceans.

Vent: The main passage by which magma travels from the magma chamber to the crater. You can also get smaller secondary vents that often split off from the main vent.

4.8 ANSWER TO CHECK YOUR PROGRESS

1. Volcanoes are natural geological formations that occur when molten rock, ash, and gases escape from within the Earth's crust.
2. These eruptions can be explosive or effusive, depending on the type of magma and gases involved.
3. Volcanoes are typically found at tectonic plate boundaries, such as along the Pacific Ring of Fire.
4. The magma that fuels volcanic eruptions is generated by the melting of rock deep beneath the Earth's surface.
5. Volcanic eruptions can have varying degrees of impact, from local ash clouds to global climate effects.
6. Some famous volcanoes include Mount Vesuvius in Italy, Mount St. Helens in the United States, and Mount Fuji in Japan.
7. Volcanic eruptions can result in the formation of new landforms, such as islands and calderas.
8. Volcanic ash and lava flows can pose significant hazards to nearby communities and infrastructure.
9. Understanding volcanoes is crucial for both scientific advancement and ensuring the safety of populations living near active volcanic zones.
10. Volcanoes that erupt frequently are known as active volcanoes.

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4.10 TERMINAL QUESTIONS

Long Questions

1. What are the causes of volcanic eruptions? And explain the different types of volcanic eruptions.
2. Explain the world distribution of volcanoes.

Short Questions

1. What is earthquake and what the causes of earthquake?
2. What is tectonic plate Movement?
3. What is Epicentre and Hypocenter?
4. How is the volcanoes caused? Classify the main types and give their distribution?
5. How many earthquake belts are found worldwide? Write about them.
6. What is seismicity and explain the effects of earthquake?

7. How many major volcanic belts are found worldwide? Write about them.
8. What are the hazardous effects of volcanic eruptions?

Multiple Choice Questions

1. What is a volcano?

A) A type of mountain

B) A large body of water

C) A natural geological formation with eruptions

D) A deep ocean trench

2. What causes volcanic eruptions?

A) Underground rivers

B) Earthquakes

C) Escaping gases, molten rock, and ash

D) Solar radiation

3. Where are volcanoes commonly found?

A) In deserts only

B) On every continent

C) In valleys and canyons

D) Underneath oceans only

4. What is the substance erupted from a volcano called?

A) Lava

B) Water

C) Sand

D) Mud

5. What determines the explosiveness of a volcanic eruption?

A) The time of day

B) The color of the magma

C) The type of magma and gases involved

D) The altitude of the volcano

6. Which famous volcano is known for its eruption in AD 79 that buried the city of Pompeii?

A) Mount Everest

B) Mount Kilimanjaro

C) Mount Vesuvius

D) Mount Fuji

7. What is the "Ring of Fire"?

A) A popular rock band

B) A zone of intense volcanic and seismic activity

C) A circle of volcanic islands in the Pacific Ocean

D) A type of volcanic rock

8. How is new land sometimes formed by volcanic activity?

A) Through meteor impacts

B) By the erosion of existing landforms

C) By the deposition of sediment from rivers

D) Through the accumulation of volcanic materials

9. What hazards can volcanic eruptions pose to nearby communities?

A) Excessive rainfall

B) Increased plant growth

C) Volcanic ash and lava flows

D) Strong winds

Answers: 1-C, 2-C, 3-B, 4-A, 5-C, 6-C, 7-B, 8-D and 9-C.

UNIT 5 - EARTH MOVEMENT: EPEIROGENESIS AND OROGENESIS

5.1 OBJECTIVES

- Understanding the formation process of landforms.
- Role of earth movement in human life.
- Role of earth movement in earth balance.
- Comparison between Epeirogenetic and orogenetic movement.
- Effect of climate change trends on Landforms.

5.2 INTRODUCTION

The forces (Endogenetic and Exogenetic forces) that provide physical stability or instability on the earth's surface are known as earth movement. In the earth movement process, where on the one hand large land units are created by endogenetic forces and conditions of imbalance are created, on the other hand, stability is provided to the process of equilibrium by exogenetic forces. In this way, it is generally understood that geodynamics is the study of global and geological movements between internal and external forces. The origin of the geological process has been considered mainly responsible for the heat pressure and tectonic processes occurring in the earth's crust, through which many types of Dynamic changes in unevenness and landforms keep on happening at a slow and rapid pace. The major forces that trigger development and denudation on the earth's surface are divided into two parts.

1. Endogenetic Force
2. Exogenetic Force

5.3 EARTH MOVEMENT: EPEIROGENESIS AND OROGENESIS

Endogenetic force

Generally, this force is taken from the unevenness occurring in the interior of the earth; endogenous forces are related to the earth's geology, by which new topographies are born on the interior and exterior of the earth. That means inequality gains strength. These forces arise from horizontal and vertical movement in the earth. By which imbalance is provided by providing instability to the balanced state of the earth. Sometimes there is excessive movement in land blocks.

Exogenetic force

The force arising on the surface of the earth is called the exogenetic force, which is also called the plane-setting force. These forces are the ones retarding the work done on the earth's surface by endogenic forces. The unevenness created accidentally by endogenetic forces tends to impart asymmetry to the surface over a long period of time. This work is governed by the process of exposure. The activities of denudation mainly take two forms for earth movement.

1. Weathering
2. Erosion

Weathering: In the weathering movement, the exogenetic forces of weathering have a special contribution to the leveling process. These landforms created by continental drift and mountain drift are weathered by physical, chemical, biological, and human forces. In which the rocks are broken and deposited in their place. There is no large-scale transmission or change in them.

Erosion: In the process of earth movement, the process of erosion remains the most important in the form of flat-setting force. The river, which is operated by erosive forces like wind, wind, glaciers, and peri glaciers, through erosion, transportation, and deposition, in the process of the formation of continents and mountains, becomes the reason for their origin. A cyclic process takes place between the endogenetic force and the external force. Internal forces play a greater role in the movement. Because after the process of movement, the work of making balance in the earth is done by erosion and deposition.

In this way, from the study of the geological history of the earth, it is known that the earth's movement has always remained in the earth. Which is active at present and will remain active in the future as well, in which only short-term changes and external changes will be felt by humans sometimes. All the landmasses raised on all the continents of the earth are the result of this process, evidence of which is the emergence of mountain chains from the sediments or rocks deposited in seas and oceans and their sedimentary deposits in the horizontal layers. Presenting the evidence of antiquity. Whose present form takes millions of years. Movement activity from the beginning of geological time to the present has created many landforms, and orogenic activities that bend and fragment the crust of the site have always been dynamic. Some 600 to 3500 million years ago, in the Cambrian period Which mainly three events present the form of mountain building movements: Caledonian, Hercynian, and Alpine. The Himalayas, Alps, Andes, and Rockies are some of the main new movements in the Alpine Age.

The forces of earth movement

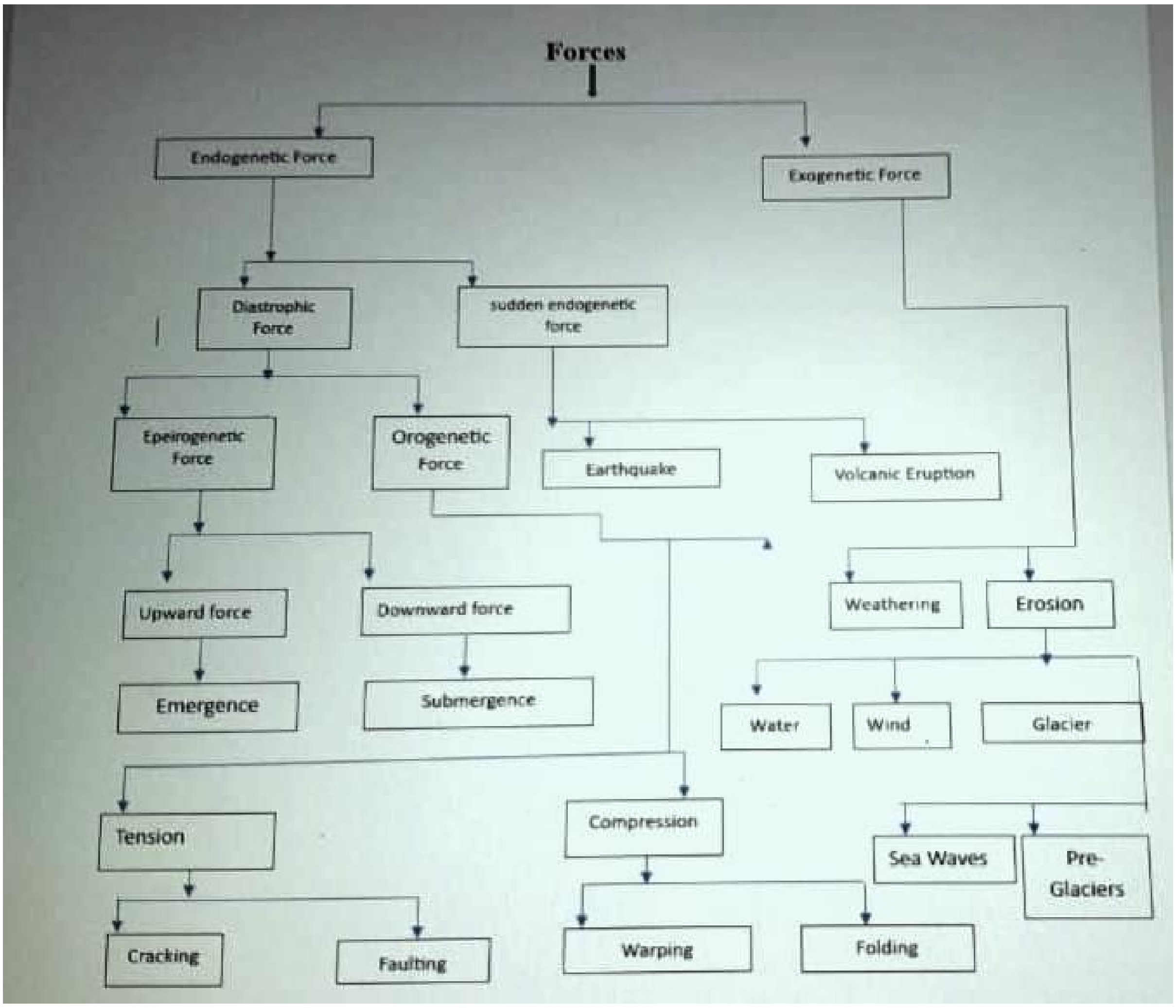

Fig. 5.1: Details of endogenetic and exogenetic force of the earth.

The following are the main reasons that give force to the process of earth movement: By the way, the force that gives force to earth movement is understood to be the endogenic force, but the main forces that activate these forces are the following:

1. excess heat in the interior of the earth.

2. Convection action in the liquid substances deposited in the interior
3. Energy produced by the fission of radioactive nuclear elements.
4. As a result of the transportation and deposition done by the factors of erosion, the imbalance of land, the eruption of ghosts, and the activation of mountain building activities.
5. Earthquakes and plate tectonic movement

Epeirogenetic movement

The word Epeirogenetic is derived from the Greek words epeiros and genesis. The word epeiros literally means continent, and genesis means origin or birth. In general, epigenetic movement means the origin of continents, under which the processes of uplift, subsidence, and outflow of continents take place. This movement is slow and vertical, and over thousands of years, the origin of the continents has taken the form of mountains, which mainly operate vertically. Which is divided into two parts.which is clear from figure 5.2.

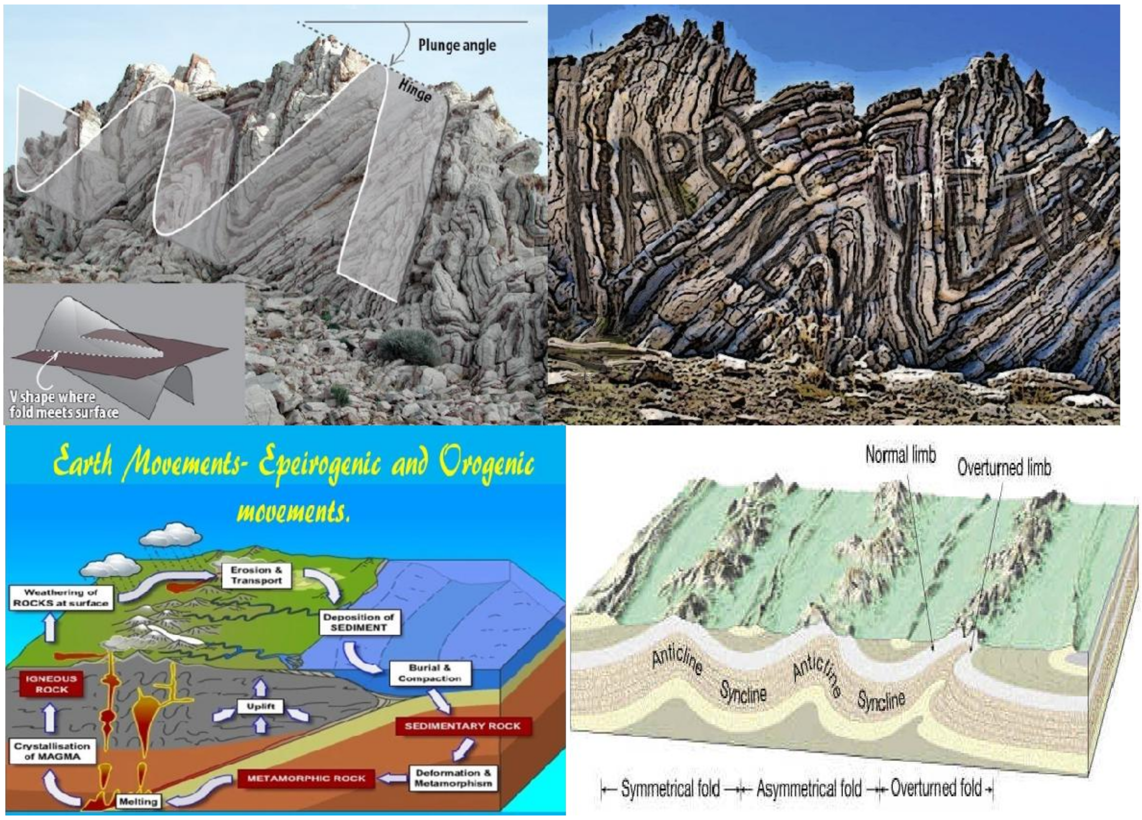

Fig. 5.2: Source: Youtube.com/@brototi1, wikipedia.org2.bp.blog&pot.com, openpros.usask.ca/physicalgeo.

I. **Upward movement**

The continents are uplifted in two ways. The first continental part rises above its adjacent part, which is called upliftment. The second class includes the coastal parts of the continent. Those who were immersed in water before upliftment Which is called exit emergence. Thus, it is called the upliftment of land. The latest examples of this in India are the Gulf of Kutch, Kolkata, and Porbandar Oyster Reserves, while the Madhavpur (Bangladesh) forest has risen up to One meter. Norway's seafloor continental shelf, northern Britain, caves in New Zealand, and the east coast of Sweden are examples of current uplift.

II. Downward Movement:

In this way, there are two types of subsidence on the continents. In the first stage, the continental land mass sinks below its adjacent land mass, which is also known as subsidence, while in the second stage, the land mass sinks below the flat surface, which is called submergence, which is specially performed in deep oceanic coastal areas. Is Examples of which are Alaska, Canada, Greenland, Pondicherry, and Mumbai, give modern evidence that downward landforms are not directly visible on the surface as a result of being submerged.

Orogenetic movement: The word orogenetic is derived from the Greek word Oros in which the meaning of OrosThe meaning of mountains and genesis is origin. As a whole, the mountain is the origin of the force. Mountain formation mountainI work with a set of formative motions that include all the internal forces thatThe processes of crushing, cracking, sublimation, and weathering take place in the rocks because of these forces. Rocks fold and rise up to form mountains; hence, they are called mountain-forming forces. This force works in two ways at the origin of mountains.

1. Tensional force
2. Compression force

Tensional force: Tension is equally taken to mean the stretch that is exerted by an internal force. Occurs through which faults, cracks, and fractures occur on the surface. Somewhere, deep pits are formed and start spreading between two parts of the ground.

Compression Force: The surface builds mountains out of mainly these two movements. When the force of compression forces face-to-face against the force of stretching, that situation is called compression, due to which the formation of convulsions occurs in the surface rocks and the mountain ranges start to fold which is clear from figure 5.3.

Folds: When the condition of compression occurs horizontally in the rocks by earth's endogenetic forces, the rocks are bent in wave form. In other words, the meaning of folding is the process of folding rock layers due to compressional forces acting horizontally on a normal plane. Are Folding always occurs in the order of crests and troughs. Due to the force, some parts rise up and some parts sink down. The uplifted part is called anticlines, and the depressed part is called synclines.

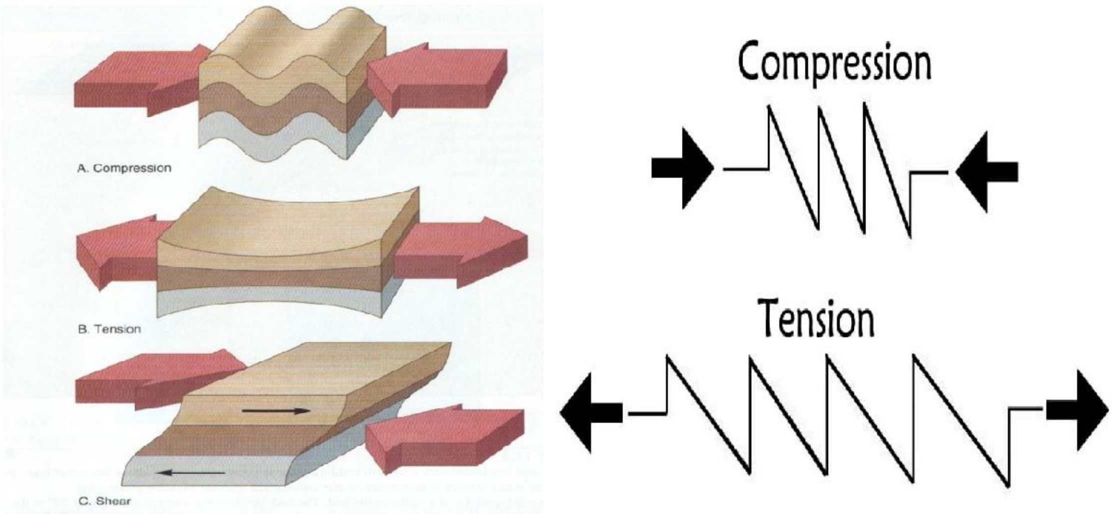

Fig. 5.3: Source: www.bing.com/image.tensional/geography.

Anticlines: The part of the force produced due to contraction in the cracks of rocks due to horizontal movement due to endogenetic force that rises up is called anticlines. In a declination, the rock strata on both sides are inclined in opposite directions. On the basis of the angle of the slope, the slope is kept in two categories.

- When the fold angle is 1 degree or 2 degrees, then it is called a gentle anticline.
- Second, when the inclination of the steep anticline is between 40 and 90 degrees, it is called a sharp or steep anticline.

Syncline: As a result of the horizontal movement of endogenetic folds, the part of the mountain range that folds down and gets sunk is called thrust, which is the folded-down area of the fold. Sometimes it looks like the shape of a boat with more folds.which is clear from figure no. 5.4.

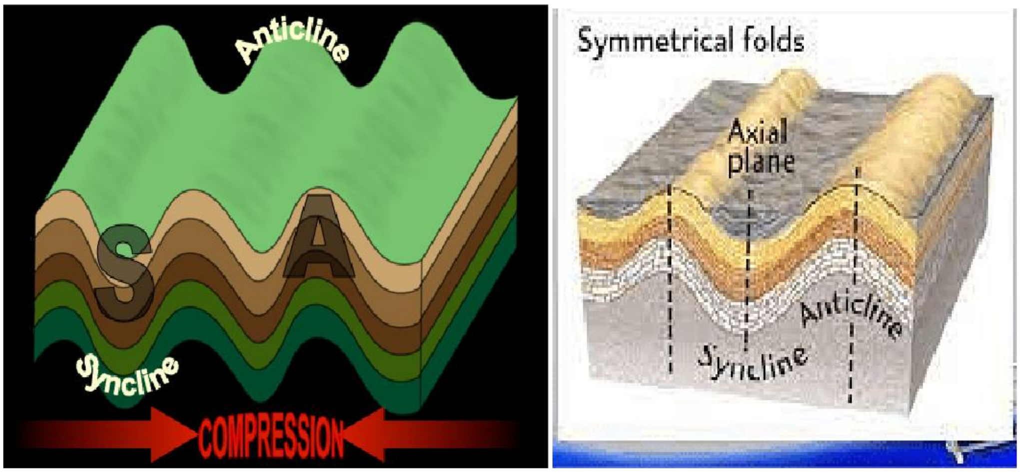

Fig. 5.4: Source: www.bing.com/image.tensional<geography.

Types of folding

The types of folds are mainly determined by the nature of the rock. If the rocks are flexible and soft, then the folding is greater; if the rocks are hard, then the folding is of a moderate level, which is determined by the speed of compression. By this nature, the types of folding are determined mainly in 10 parts.

Symmetrical Folds: The meaning of symmetrical folds is clear: that equally means folding lying equally on all sides. The slope of both sides of a symmetrical fold is equal. It is also called open fold.which is clear from figure 5.5.

Asymmetric Folds: There is inequality in both arms of an asymmetric fold. One arm is simple, the other arm is short, and the inclination is greater. Thus, there is an inequality in the inclination and length of the two sides.which is clear from figure 5.6.

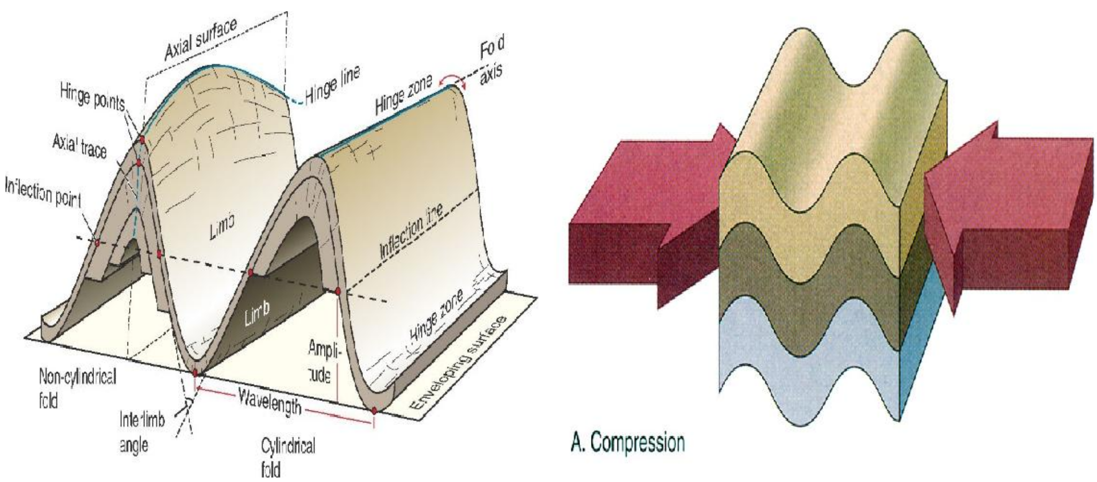

Fig. 5.5: Source: www.bing.com/image.symmericalfolds/geography.

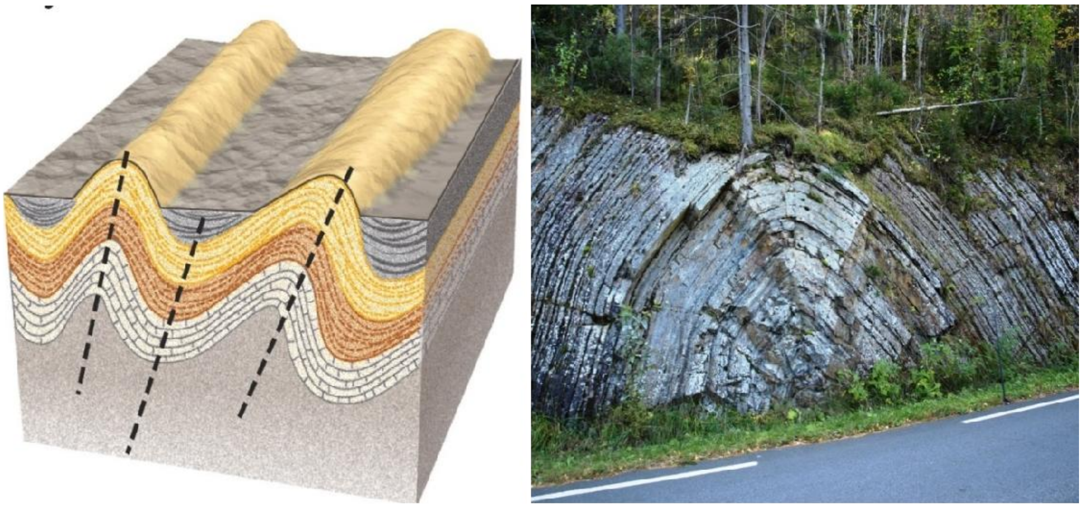

Fig. 5.6: Source:www.bing.com/image.asymmetric.

Monoclinal Folds: When the inclination of one arm of the fold is normal and the branch of the other arm is vertical, then it is called a monoclinal fold. This is formed by vertical movement. Due to excessive compression, the arm of this fold breaks, and the break leads to the formation of a fault.which is clear from figure 5.7

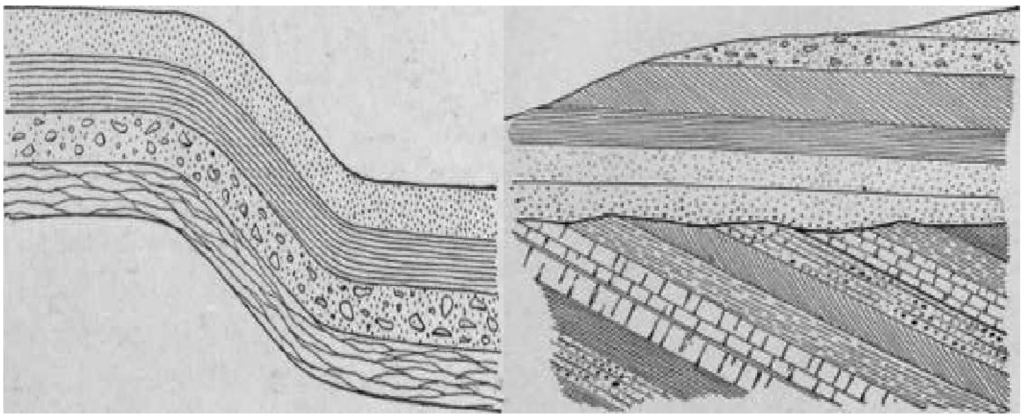

Fig. 5.7: Source: www.bing.com/image.monoclinal/geography.

Isoclinal Folds: Due to equal compression in isoclinal folds, both arms of the fold bend equally, and as they come closer to each other, the arms of the fold become parallel. The sides of the fold are mutual; due to which it is called an isoclinals fold which is clear from figure 5.8.

Recumbent Folds: create convergent movement, but the action of extreme compression happens by Due to excessive compression, both arms of the soil become parallel to each other and remain in the horizontal direction which is clear from figure 5.9.

Overturned Folds: When one side of the fold overturns on the other due to excessive compression, it is called an overturned fold.which is clear from figure 5.10.

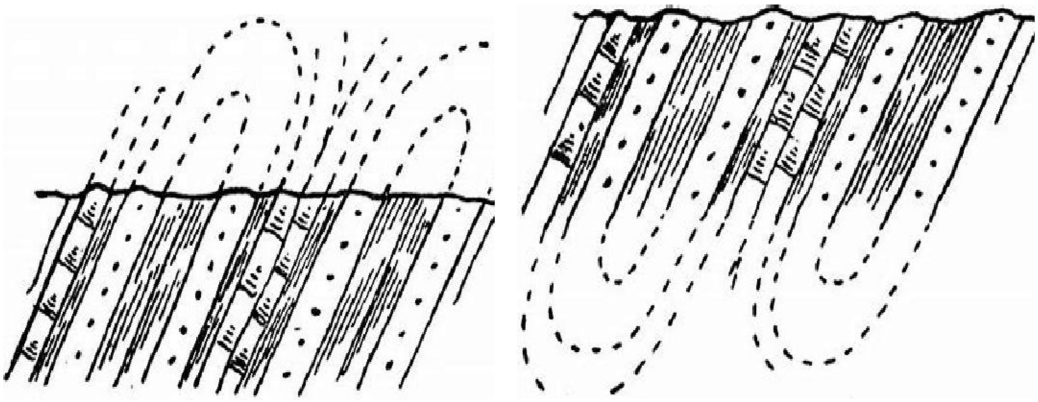

Fig. 5.8: Source: www.bing.com/image.Isoclinal/geography.

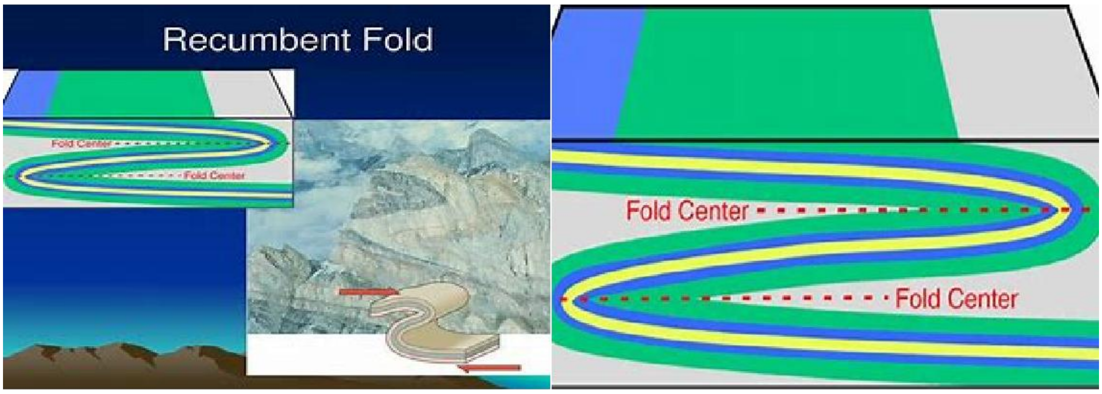

Fig. 5.9: Source: www.bing.com/image.recumbent/geography.

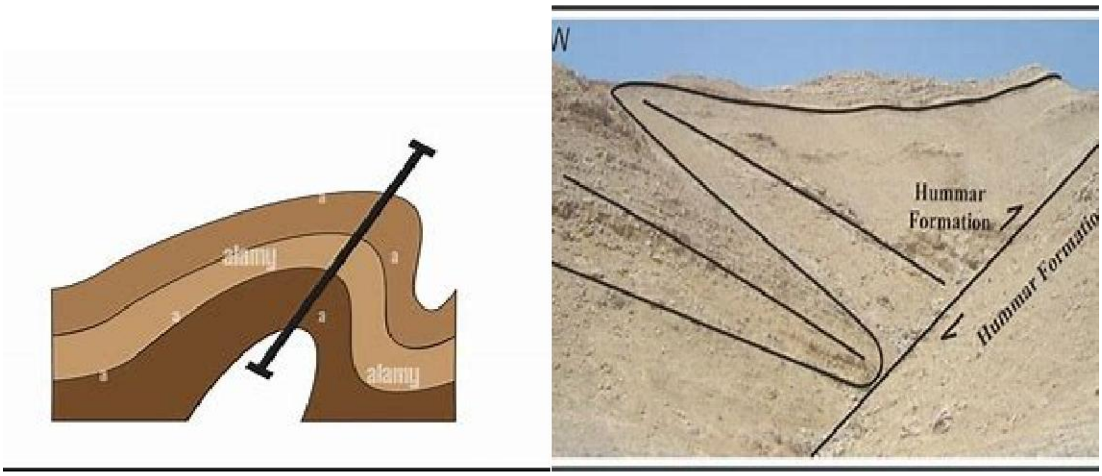

Fig. 5.10: Source: www.bing.com/image.overturned/geography.

Plunging Folds: When the axis of the fold is not parallel to the horizontal plane and makes an angle with it, then it is called a plunging fold which is clear from figure 5.11.

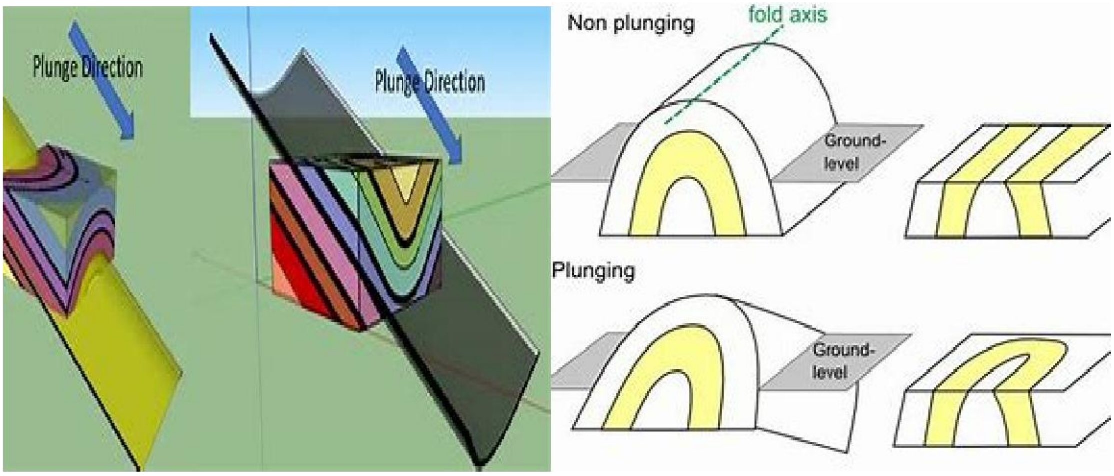

Fig. 5.11: Source: www.bing.com/image.plunging/geography.

Fan Folds: When many small folds are found in the large anticline and syncline of a large fold, it is called a fan fold. Which looks like a fan.which is clear from figure 5.12.

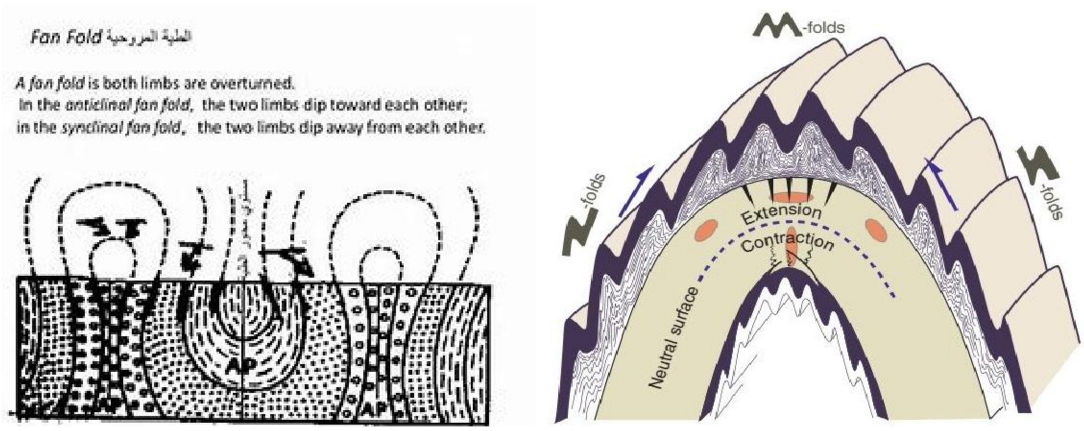

Fig. 5.12: Source: www.bing.com/image.fan folds /geography.

Open Folds: When a greater angle is formed between the arms of a fold, that fold is called open folding; it is formed by luma folding due to normal compression.

Closed Fold: When there is an acute angle between the two sides of the fold, it is called a closed fold.

Crust Fault: A crust fault is edited due to tension and compression due to horizontal movement generated by endogenic force. This transfer of rocks along a plane by endogenic force is called a crust fault. If the movement of stress soil is more rapid, then the transfer of rocks along the fault plane takes place on a large scale, which is called a fault.

Fault

Due to the intensity of stress-state movement when the rocks are shifted along a plane in the earth's crust. So, the structure made from it is called a fault. The floor on which the rocks of the earth's crust move So, it is called the fault plane. This plane can move in any direction, from vertical to horizontal. Which spreads to thousands of kilometres in length, which is not the result of the movement happening at one time but is implemented at different times. The movement of the fault shows the weak terrain of the earth's crust, with the help of which the earthquake continues for a long time and is displayed in different parts. On the basis of this, the fault is divided into four parts.

Normal fault: When both rocks move in opposite directions due to a crack in the rock, it is called a normal fault. Fault planes are often vertical or steeply branched. The steep vertical portion formed by a normal fault is called a fault margin.which is clear from figure 5.13.

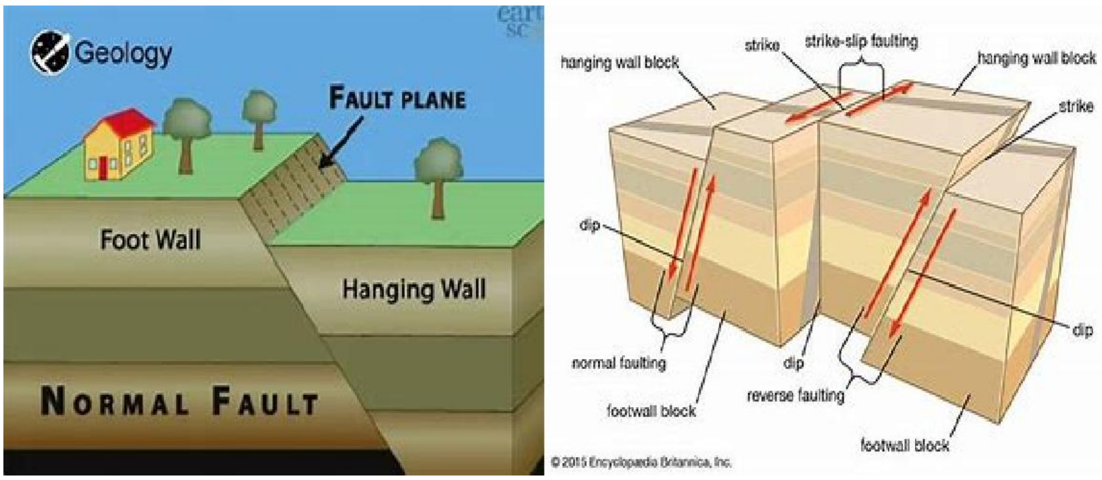

Fig. 5.13: Source: bing.com/normal fault/geology.

Inversion Fault: When both the rock blocks can face each other due to a crack in the rocks, the fault formed from it is called an inversion section. In this type of fault, the rock blocks climb on top of each other, and the slope of the fault is normal. Inversions are mainly formed by compression caused by horizontal movement; hence, they are also called a compressional fault which is clear from figure 5.14.

Lateral Fault: Horizontal movement along the fault plane due to movement in the horizontal direction if their horizontal movement is called a lateral fault, the creation of edges is very limited.which is clear from figure 5.15.

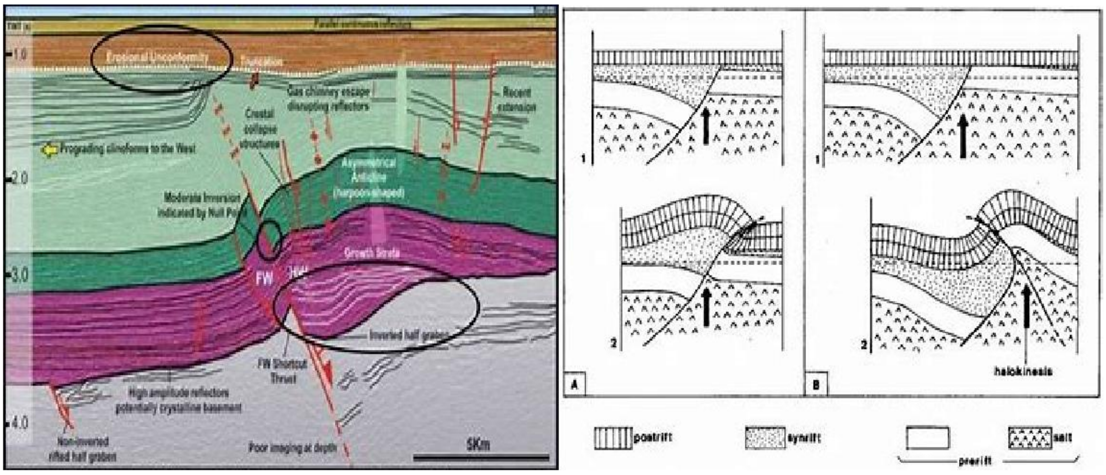

Fig. 5.14: Source: bing.com/inversion fault/geology.

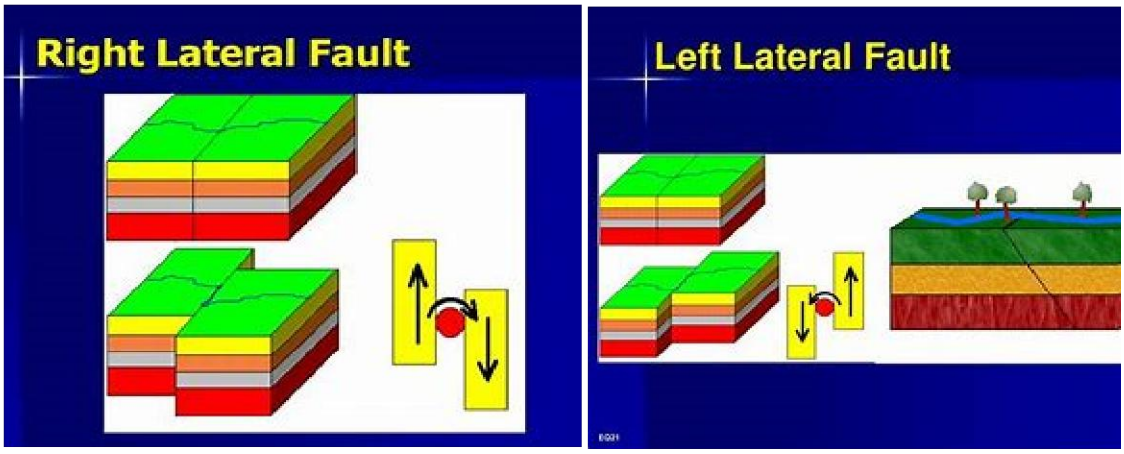

Fig. 5.15: Source: bing.com/lateral fault/geology.

Step Fault: When the condition of many faults in a terrain is in one direction, then it is called terraced or stepped. To form a fault, the land must be thrown in only one direction.which is clear from figure 5.16.

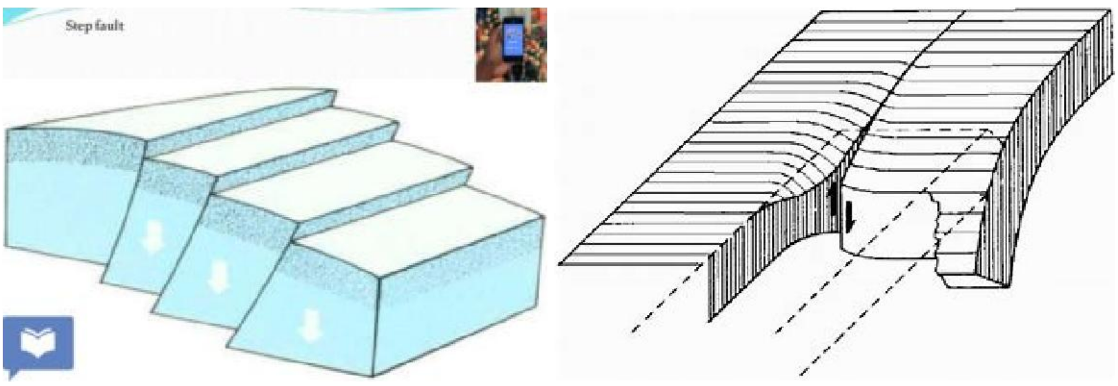

Fig. 5.16: Source: bing.com/step fault/geology.

Fault Topographies

Due to the process of earth movement, some parts of the landmass rise and some parts go down. Due to this, many types of topography are formed, in which erosion is also active. Host, Goben, Donika, Rift Valley

Rift Valley: Rift valleys are the major topographies formed by rifts. This is the most prominent topography in the Rift Valley faulting process, which is formed when two normal faults lie several kilometres in length in such a way that the middle part of them sinks down and the rift valley is formed. Also called Graben. Which is the introduction to the pit. rift party It is formed when the central part remains fixed and the adjacent parts rise up. The rift valley is generally long, narrow, and extremely deep; for example, the Rhine River, which is spread over a length of 32 km, is said to have originated on the basis of the stress country and compressional hypothesis.which is clear from figure 5.17.

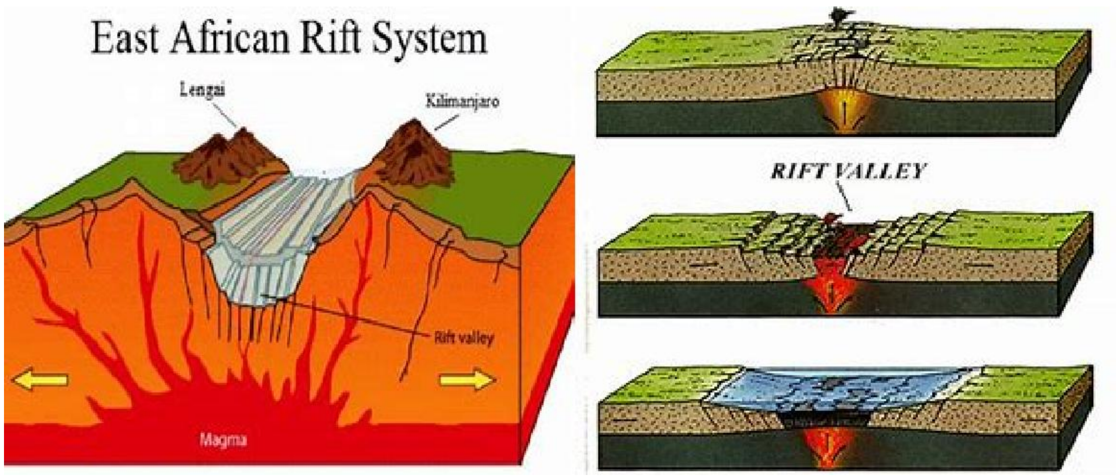

Fig. 5.17: Source: bing.com/Rift valley/geology.

Fault Ledge: A steeply sloping edge formed on the earth's surface due to faulting is called a fault ledge. This is another topography of the process of movement; an uneven surface is formed by any normal fault-subducted segments in the rift ledge. Which is clear from figure 5.18.

Crack Valley: When two normal faults are created in a plot by stress and the plot between these two axes sinks, a long, narrow valley is formed, which is called the Rift Valley.

Fig. 5.18: Source: bing.com/ fault ledge/geology.

5.4 SUMMARY

The importance of earth movement in the earth is known from the adjective of the above unit in such a way that earth movement is a continuously displacing natural process. The surface of the earth is called the crust. Which has been active from the origin of the Earth until the present century and will remain active till the end of time. Those who destroy the old topographers and give birth to new landforms An earthquake is the process of performing both foundational and non-formative works. The forces that trigger the process of earth movement are mainly radioactive elements located in the earth. The heat generated by, movement in coastal plate due to tectonic reasons, the force generated by the rotation of the earth Climatic force, isostasy, etc. are included.

Which works to bring the conditions of physical imbalance on Earth into balance. Due to this organic and natural elements maintain their stability in the ground. Due to the activation of many types of internal and external forces, upliftment, downfall, downward erosion, transportation, deposition, compression, faulting, etc. continue to move on the earth. In conclusion, earth movement is the physical mechanism responsible for rendering all categories of relief. Continental and oceanic transfer and construction work take place in the mass movement. Formation of mountain plateau plains and lakes in medium movement and development of renewable, erosional, and depositional landforms done by exogenetic processes (originating from the atmosphere) water, river water, sea water, underground water, wind, glaciers, and peri-glaciation in final movement the process of making or unwrapping is all involved in this. An earthquake is a physical force that prevents a natural catastrophe from occurring on Earth, which is useful and necessary for balance.

It is known from the above title analysis that internal forces have a special role in the movement of the earth's crust. The forces arising from the interior of the earth are known as endogenetic and exogenetic forces, while the forces arising on the surface of the earth are identified as external forces. Endogenetic force is related to the Earth's geology, whereas external force is mainly the result of atmospheric weather events. Exogenetic forces are constantly trying to create vertical variation in the earth, whereas external forces try to remove inequality with the help of river erosion factors and weathering. Which provides cyclic form and stability to the process of balance on the earth. Exogenetic force is also called flat foundational force on the earth's surface. Based on intensity, the movement of endogenetic force is divided into two parts which are: diastrophic movement and catastrophic movement

Diastrophic movement is a slow movement whose effect is visible after thousands and millions of years, due to which huge landforms are formed. Which is a continent-forming and mountain-building movement? There are actions of emergence and submergence which again divided into upward and downward movements. Subsidence and submergence are included under the downward movement. Submergence takes place only in coastal or oceanic areas. Under mountain building movement, the force acts horizontally. When the force acts in two opposite directions, it is called a tensional force, due to which cracks are formed in the ground. On the contrary, when the force acts face-to-face, if it is, then it is called compressive force. Due to the compression force, when the phenomenon of upward and upward emergence occurs in the crustal rocks due to cracking, faults are born in the surface, and many types of shapes are born, like lakes, mountains, horsts, faulted valleys, rift valley fault scarap, etc.

5.5 GLOSSARY

Anticline- Mountain top raised by movement

Compressional Force- The process of falling made in the mountains

Denudation- Combined action of erosion and Weathering

Earth Movement – Movement by internal and External Force

Emergence- The Formation of land masses

Endogenetic Force – Movement by Internal Force

Epeirogenetic Movement – Process of continental rise

Exgenetic Force – Movement by external force

Fault- Cracks between rocks

Folds – Bends resulting from the process of compression

Orogenetic- Process of mountain uplift

Syncline- subsidence of a mountain by movement

Tension- Stretching caused by the process of faults

Upward Movement – Uplift of a part by earth Movement

5.6 ANSWER TO THE CHECK YOUR PROGRESS

1. Earth movement is the gradual movement on the surface of the earth due to endogenous and exogenous forces.
2. The most important topography in the faulting process is the Rift Valley.
3. Endogenous forces are identified as the forces causing ground imbalance.
4. Exogenous force is also known as a destructive force.
5. The word epeirogenic is derived from the Greek word eperoj.
6. Epirogenic movement is also known as continent continent-generating force.
7. The forces that help in mountain building are known as orogenic forces.
8. The general meaning of tensional force is the stretch that is produced by endogenetic forces.
9. The condition of stretching which is in the opposite direction of the forces is known as tensional force.
10. Crystal fracture is the result of horizontal movement caused by endogenic force.

5.7 REFERENCES

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www.com/normal fault/geology

www.bing.com/image.tensional geography.

5.8 TERMINAL QUESTIONS

Long Questions

1. What is earth movement? Explain the different forces of endogenetic and exogenetic movement.
2. What is catastrophic and diastrophic force? Explain with the help of a suitable diagram.
3. Define different types of folds and faults with the help of suitable diagrams.

Short Questions

1. What are the causes of earthquake?
2. Explain the difference between exogenous and endogenous force?
3. Explain the epirogenetic force?
4. What are the main forces affecting the endogenous forces?
5. What is the importance of earth movement in human life?
6. Explain the role of earth movement in earth balance.

Multiple Choice Questions

1. What is earth movement?

a) Endogenetic & Exogenetic force instability.
b) Earthquake
c) Volcanic eruption
d) Climate Change

2. Endogenetic force in Generated?

a) Exterior of the Earth
b) Interior of the Earth
c) Plate movement
d) Both of I & III.

3. What are the forms of the denudation?

a) Erosion
b) Weathering
c) Accumulation
d) Erosion and weathering

4. What is the effect of epeirogenetic force on the surface?

a) Upward
b) Downward
c) Both A & B
d) None of the above

5. What is the effect of orogenetic forces on the surface?

a) Water
b) Earthquake
c) Tensional force & compression force.
d) Downward movement.

6. What is a anticlines?

a) Mountain top raised by movement
b) Mountain Bottom
c) Groups of mountain
d) Cracks between rock

7. What is a tension forces?

a) Movement by External force
b) Process of mountain lifting
c) Stretching Caused by the process of Faulty
d) The formation of land masses

8. What is a compressional force?

a) The process of falling made in the maintain
b) Crack in Rock
c) Subsidence of a mountain
d) Movement of External force

9. How many types at Folds?

a) 8
b) 7
c) 6
d) 10

10. What is the name of the country which have Longest Rift valley in the world?

a) China
b) Jordan (Rhine)

c) India
d) USA

11. What is a syncline?

a) Upward of a mountain Part
b) Subsidence of a mountain by movement
c) Crack in beds
d) All of the above

12. What is name of the sudden endogenetic forces?

a) Volcanic eruption
b) Earthquake
c) Erosion
d) A and B

Answers: 1-A, 2-C, 3-D, 4-C, 5-C, 6-A, 7-C, 8-A, 9-D, 10-B, 11-B, 12-D.

UNIT 6 - WEATHERING AND EROSION

6.1 OBJECTIVES

After studying this unit, you should be able to:

- Understand the meaning and concept of weathering
- Understand the meaning and concept of erosion
- Know the factors affecting the weathering
- Know the Marvelous Role of Weathering in Geography
- Know the processes and agents of erosion.

6.2 INTRODUCTION

Welcome to the fascinating world of weathering, where the forces of nature work tirelessly to reshape the rocks and landscapes around us. Weathering, a gradual process driven by the elements, reveals the remarkable power of water, wind, temperature, and organisms to transform even the sturdiest rocks into new forms. In this chapter, we will explore the intricacies of weathering and erosion, uncovering how these forces shape our environment and contribute to the ever-changing face of the Earth.

Denudation is the collective term encompassing the processes by which the Earth's surface is gradually worn down, eroded, and exposed due to the action of various geological forces. It involves the removal of rock and soil from higher elevations and its transportation to lower areas, ultimately leading to the reshaping of landscapes over time.

The denudation process comprises several interrelated activities, including weathering, erosion, transportation, and deposition.

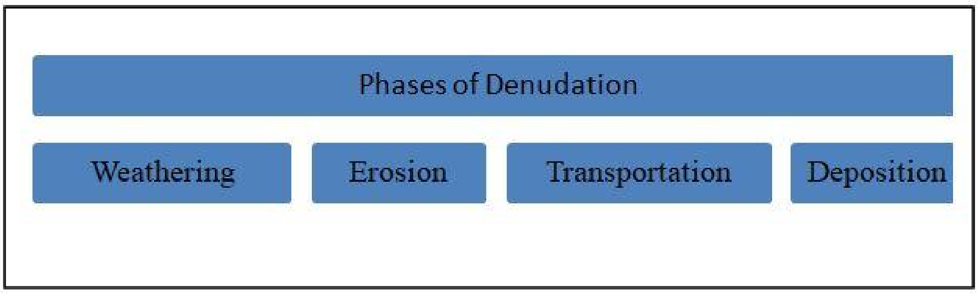

Fig. 6.1: Phases of Denudation.

All four phases of the denudation process take place simultaneously in different parts of the world at different rates, much depending on the nature of the relief, the structure of the rocks, the local climate and interference by man. But here in this chapter, we are discussing only weathering and erosion.

6.3 WEATHERING AND EROSION

Weathering is the intricate process through which rocks and minerals on the Earth's surface undergo gradual alteration, disintegration, and breakdown due to various natural forces. It is a vital geological phenomenon that shapes landscapes and sculpts the features we observe today. At its core, weathering represents the combined effects of physical, chemical, and biological processes that lead to the decomposition of rocks over extended periods. These processes can occur due to factors such as temperature fluctuations, the actions of water, wind, and ice, the presence of acids, and the influence of living organisms. As weathering progresses, solid rock gradually transforms into smaller particles, sediments, and eventually soil.

The concept of weathering is pivotal to understanding the dynamic interaction between the Earth's surface and the forces that shape it. It serves as a foundation for comprehending various geological processes, including erosion, sedimentation, and the formation of distinctive landforms. By exploring the intricacies of weathering, geologists and scientists gain insights into the intricate dance between Earth's elements, ultimately leading to a deeper understanding of our planet's history and evolution.

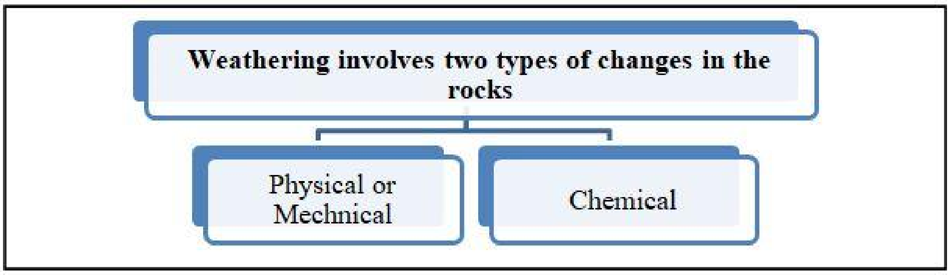

Fig. 6.2: Two Types of changes in the Rocks.

Controlling Factors of Weathering: Unveiling Nature's Balance

Weathering, the intricate process that transforms rocks and minerals over time, is influenced by several controlling factors. These factors determine the intensity, rate, and type of weathering that occurs in a particular location.

1. Climate: Climate is a pivotal factor influencing weathering. Regions with high rainfall and temperature variations experience more intense weathering due to the prevalence of water and the freeze-thaw cycles that can cause physical disintegration. In contrast, arid climates might experience slower weathering due to the scarcity of moisture.

2. Rock Composition: The mineral composition of rocks plays a significant role. Some minerals are more resistant to weathering than others. For instance, quartz is relatively resistant to chemical weathering, while minerals like feldspar are more susceptible.

3. Topography: The shape of the land also matters. Steep slopes might experience enhanced physical weathering due to the gravitational forces that contribute to rockfall and erosion. Flat terrain might be more susceptible to chemical weathering due to water pooling and stagnant conditions.

4. Vegetation: Plants can both accelerate and inhibit weathering. The roots of plants can physically break apart rocks as they grow, a process known as biological weathering. Additionally, organic acids released by plants during decomposition can promote chemical weathering.

5. Time: Weathering is a slow process that unfolds over geologic timescales. The longer rocks are exposed to weathering agents, the more pronounced the effects become.

6. Human Activities: Human activities, such as construction, mining, and pollution, can significantly alter weathering patterns. Urban areas might experience accelerated weathering due

Agents of Weathering: Nature's Sculptors

7. Parent Material: The original composition of the rock also matters. Some rocks, due to their inherent properties, might be more prone to specific types of weathering.

8. Altitude and Elevation: Higher altitudes often experience more intense physical weathering due to temperature variations, freeze-thaw cycles, and the presence of glaciers.
In brief, there are four major controlling factors of weathering
(i) Composition and Structure of Rocks (ii) Nature of ground Slope
(iii) Climatic Variations (iv) Floral Effects

Weathering, the transformative process that shapes the Earth's surface, is carried out by a variety of agents, each contributing to the gradual breakdown and alteration of rocks and minerals. These agents, driven by both natural and environmental forces, work tirelessly to reshape landscapes and sculpt the features we observe today. The weathering agents are divided into 3 types as follows.

Table-6.1: Weathering agents.

Weathering Agents			
S. No	**Physical or Mechanical Agents**	**Chemical Weathering Agents**	**Biological weathering agents**
1.	Moisture and water	Oxygen	Vegetation
2.	Frost	Carbon dioxide	Animals, mainly micro-organisms
3. 4.	Isolation (temperature) Wind	Hydrogen	

Types of Weathering Processes

Weathering is a multifaceted process that encompasses various types, each shaped by different mechanisms and forces. Weathering is divided into 3 categories based on weathering agents. Here, we delve into the details of the main types of weathering: physical, chemical, and biological.

Table-6.2: Weathering agents.

WEATHERING PROCESS

S.N.	Physical/Mechanical Weathering Process	Chemical Weathering Process	Biological Weathering Process
1.	Frost Action (Freeze-Thaw Weathering)	Oxidation	Plant Root Growth
2.	Exfoliation (Pressure Release):	Hydrolysis	Burrowing Animals and Insects
3.	Abrasion	Carbonation	Organic Acids
4.		Solution	

1. Physical/Mechanical Weathering

Physical or mechanical weathering involves the breakdown of rocks into smaller fragments while retaining their chemical composition. It occurs due to physical forces that weaken and disintegrate rocks. This weathering type is propelled by diverse natural agents that exert pressure on rocks, leading to fragmentation. Notable agents encompass frost action, where freezing water in rock cracks expands and causes breakage. Abrasion arises from water, wind, or ice carrying abrasive particles, wearing down rock surfaces. Exfoliation, tied to pressure release, leads to the peeling of rock layers. These agents collaboratively reshape rocks into smaller components, influencing landscape evolution over extended periods.

a. Frost Action (Freeze-Thaw Weathering): In cold climates, water enters cracks in rocks. When this water freezes, it expands, exerting pressure on the rock and causing it to fracture. Repeated freeze-thaw cycles progressively break rocks apart.

b. Exfoliation (Pressure Release): Overlying rocks exert pressure on rocks beneath them. As these overlying layers erode away, the pressure decreases, leading to the peeling away of rock layers like the layers of an onion.

c. Abrasion: Rocks can be worn down through friction caused by the movement of water, wind, or ice. Particles carried by these agents can scrape and abrade the rock's surface, leading to smoother textures.

2. Chemical Weathering

Chemical weathering alters minerals in rocks through chemical reactions, driven by water and atmospheric gases. Chemical weathering transforms rocks and minerals via reactions. It occurs when rocks interact with elements like water, oxygen, CO_2, and acids in the environment. Oxidation, a common type, happens when iron-bearing minerals react with oxygen, changing color and structure. Hydrolysis involves minerals reacting with water, breaking them down and creating new compounds. Carbonation, where CO_2 dissolves in rainwater, forms carbonic acid that reacts with minerals like limestone, causing dissolution. These reactions slowly break rocks, changing their properties and contributing to geological features.

a. Oxidation: Oxygen in the atmosphere reacts with certain minerals, especially those containing iron, causing them to rust and change color. This process can weaken the rock's structure.

b. Hydrolysis: Water reacts with minerals in rocks, breaking them down into new compounds. For instance, feldspar minerals in granite can react with water to form clay minerals.

c. Carbonation: Carbon dioxide from the atmosphere dissolves in rainwater, forming weak carbonic acid. This acid reacts with minerals like calcite, found in limestone and marble, leading to their dissolution.

d. Solution: Certain minerals are soluble in water, and they dissolve as water infiltrates rock pores. Minerals like halite (rock salt) can dissolve and be carried away.

3. Biological Weathering

Living organisms aid in weathering by their actions and chemical releases. This occurs when plants, animals, and even small organisms like bacteria contribute to breaking down rocks. Plant roots can crack rocks while burrowing animals and bacteria speed up the breakdown process. Over time, these activities collaboratively transform large rocks into smaller fragments.

a. Plant Root Growth: As plants grow, their roots can exert pressure on rocks, widening cracks and causing the rock to break apart. This is known as root wedging.

b. Burrowing Animals and Insects: Burrowing creatures create openings in rocks that allow water to penetrate, accelerating chemical weathering.

c. Organic Acids: Decomposing organic matter, such as fallen leaves and dead organisms, can release weak acids that promote chemical weathering by dissolving minerals.

Biochemical weathering is a process where living things, like plants, animals, and microorganisms, team up with natural chemicals to break down rocks. For instance, plants release special acids that can dissolve parts of rocks, and tiny organisms can create chemical changes that make rocks weaker. This kind of weathering can happen slowly, as these living things work together with nature's chemicals to transform rocks into smaller bits over a long time.

Combining Forces: It's important to note that these types of weathering often work together, as one type can create conditions that enhance another. For instance, physical weathering can create smaller fragments that expose more surface area to chemical weathering agents, speeding up the overall process.

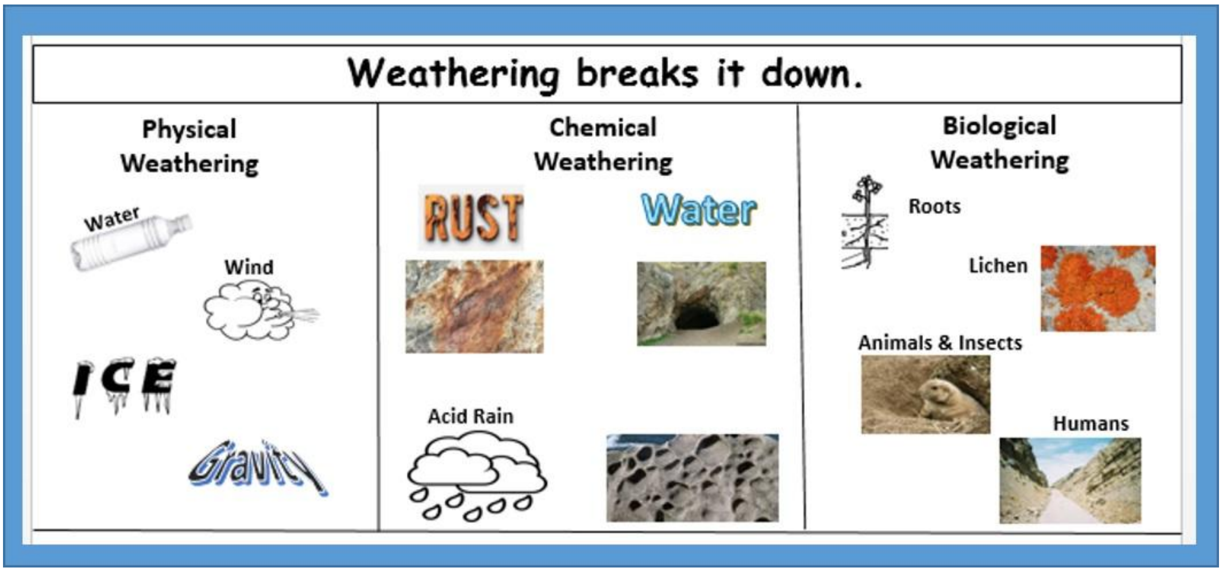

Fig. 6.3: Weathering, Source: Google.

The Marvelous Role of Weathering in Geography

Weathering is like nature's sculptor, shaping the Earth's landscapes and playing a vital role in geography. Let's dive into how weathering is so important in simple words:

1. **Landform Creation:** Weathering is like an artist that carves mountains, valleys, and other landforms. It breaks down rocks over a long time, creating the shapes we see on Earth's surface. Think of how weathering made the Grand Canyon – that's its incredible artwork!

2. **Soil Formation:** Soil is like Earth's blanket for plants. Weathering helps break rocks into tiny pieces that become soil. Plants grow in this soil, and we get yummy fruits, vegetables, and beautiful flowers.

3. **Coastal Beauty:** Weathering teams up with waves and currents at the coast. Together, they sculpt rocks into breathtaking cliffs, coves, and sandy beaches. So, every time you enjoy a day at the beach, thank weathering!

4. **Historical Insights:** Rocks tell stories about the past, and weathering helps uncover these tales. Layers of rocks reveal how the Earth changed over millions of years. It's like a time machine for geographers to understand ancient times.

5. **Natural Resources**: Weathering gives us things we need, like metals and minerals. When rocks break down, they release these valuable resources that we use to make tools, buildings, and even electronics.

6. **Architecture and Monuments:** Ancient architects knew the power of weathering-resistant rocks. They used these durable stones to build historic monuments and structures that have stood the test of time.

7. **Water Cycle Connection:** Weathering impacts the water cycle. Rainwater interacts with rocks, carrying minerals into rivers and oceans. This affects how water moves around our planet.

8. **Erosion and Change:** Weathering works with erosion to shape our environment. Erosion, driven by wind, water, and ice, moves weathered materials from one place to another, constantly changing the land.

9. **Unique Caves and Formations:** Weathering can create magical places like caves, arches, and unique rock formations. These natural wonders become great sites for exploration and tourism.

So, remember, weathering isn't just rocks breaking apart – it's a force that sculpts our world, fuels geography, and leaves a mark on everything around us. It's a fascinating process that makes our planet the diverse and beautiful place it is!

Erosion: Nature's Art of Reshaping Landscapes

The word erosion has been derived from a Latin word, erodere' which means to gnaw. Erosion is when wind, water, ice, or gravity wear away and move pieces of rocks, soil, and land over time. It's like nature's slow but powerful sculptor, shaping the Earth's surface and creating new landscapes.

Understanding the concept of erosion

Understanding the concept of erosion is akin to unlocking the intricate mechanisms that shape our dynamic Earth. Erosion encompasses the gradual wearing away, removal, and transportation of rocks, soil, and sediment by natural agents such as water, wind, ice, and gravity. It's a process that embodies the relentless interaction between the Earth's surface and the forces of nature. Delving into erosion involves grasping the powerful effects of water carving valleys, wind sculpting dunes, glaciers shaping mountains, and gravity orchestrating mass movements. Through this understanding, we gain insights into the profound changes that our planet undergoes over geological time, appreciating how landscapes emerge, evolve, and transform under the persistent influence of these sculpting forces.

Erosion processes are usually considered under four distinct categories:

(1) Mass Wasting: the processes that occur on slopes, under the influence of gravity, in which water may play a part, although water is not the main transporting medium.

(2)Fluvial: the processes that involve flowing water, which can occur within the soil mass (e.g. soil piping), over the land surface (e.g. rills and gullies), or in seasonal or permanent channels (e.g. seasonal streams and rivers).

(3)Wind: the processes that involve the action of rapidly moving air streams in dry areas, which can be cold or hot deserts.

(4)Glacial: the processes that involve the presence of ice, either in the soil (e.g. solifluction), or as the transporting medium (e.g. glaciers).

Importance of studying erosion

Studying erosion holds immense significance as it unravels the intricate processes that shape the Earth's surface and influence various aspects of our environment and society. Here's why the study of erosion is crucial:

1. Landscape Formation and Evolution: Erosion plays a pivotal role in sculpting landscapes, creating iconic features like mountains, valleys, and canyons. By understanding erosion processes, we can decipher the history of these formations, revealing the dynamic changes that have shaped our planet over millions of years.

2. Natural Resource Management: Erosion affects the availability and quality of essential resources like soil, water, and minerals. By studying erosion patterns, we can develop strategies to manage soil fertility, prevent soil degradation, and conserve water resources crucial for agriculture and ecosystems.

3. Environmental Conservation: Erosion can lead to sediment pollution in water bodies, affecting aquatic ecosystems and water quality. By studying erosion's impact on ecosystems, we can implement conservation measures to safeguard biodiversity and maintain ecological balance.

4. Hazard Assessment and Mitigation: Erosion can trigger landslides, rockfalls, and other mass movements, posing risks to communities and infrastructure. Understanding erosion patterns and triggers helps in hazard assessment and the development of strategies to mitigate potential disasters.

5. Coastal Management: Coastal erosion poses threats to coastal communities, infrastructure, and ecosystems. By studying coastal erosion dynamics, we can develop effective management strategies to protect shorelines, preserve habitats, and plan sustainable coastal development.

6. Climate Change Implications: Erosion can be influenced by climate change, altering erosion rates and patterns. Studying erosion in the context of climate change provides insights into potential impacts on landscapes, water resources, and sediment transport.

7. Cultural Heritage Preservation: Erosion can affect archaeological sites and historical structures. Understanding erosion's effects on cultural heritage sites helps in their preservation and conservation efforts.

8. Geological Research: Erosion patterns provide valuable information about geological processes, tectonics, and the history of Earth's surface. By studying erosion, geologists can piece together the Earth's past and unravel its complex geological history.

9. Sustainable Land Use Planning: Erosion studies guide land use planning, helping to determine suitable locations for infrastructure, agriculture, and urban development. By considering erosion processes, we can ensure sustainable land use practices that minimize environmental impacts.

10. Educational and Awareness Purposes: Studying erosion helps educate people about the Earth's dynamic processes, fostering a deeper understanding and appreciation of our planet's ever-changing landscapes.

The role of erosion in shaping landscapes and landforms

The role of erosion in shaping landscapes and landforms is nothing short of remarkable. Erosion acts as a geological sculptor, tirelessly chiseling away at the Earth's surface over eons to create the awe-inspiring features that define our world. Here's a closer look at the profound role erosion plays in shaping landscapes and landforms:
(i) Carving Valleys and Canyons (ii) Forming Coastal Features (iii) Crafting Mountainous Terrains. (vi) Building Desert Landscapes (v) Creating Geological Wonders (vi) Revealing Rock Layers (vii) Sculpting Coastal Features (viii) Shaping Plateaus and Mesas (ix) Transforming River Systems (x) Influencing Human Settlements

Erosion Agents and Processes

Erosion agents—water, wind, ice, and gravity—stand as nature's sculptors, tirelessly shaping the Earth's surface over vast periods. Water, from gentle rains to mighty rivers, carves valleys and reshapes coastlines through its hydraulic action and abrasive forces. Wind, seemingly delicate, carries sand and dust across deserts, forming dunes and abrasively shaping rock surfaces. Glacial ice, a force of immense power, carves valleys and deposits moraines, leaving its mark on mountainous landscapes. Gravity, the silent influencer, triggers mass movements like landslides and soil creep, guiding the reshaping of slopes. These agents, often intertwined, are the architects of geological change, carving the landscapes that captivate our gaze.

Mechanisms and Processes of Erosion: Nature's Reshaping Forces

Erosion is a multifaceted process driven by a complex interplay of natural forces and geological dynamics. Understanding the mechanisms and processes through which erosion occurs provides insight into the intricate ways in which our planet's surface is transformed. Here's a closer look at the key mechanisms and processes that underpin erosion:

1. Hydraulic Action: In water erosion, the force of flowing water against rock surfaces can dislodge and remove particles. The sheer pressure of the water exerts a mechanical impact on the rock, causing it to break apart and be carried away by the current.

2. Abrasion: Abrasion involves the scraping and grinding of rock surfaces by particles carried by agents like water, wind, and ice. These particles act like natural sandpaper, slowly wearing down the surface of rocks and contributing to their erosion.

3. Attrition: Attrition occurs when particles carried by erosion agents collide with each other, causing them to break into smaller fragments. In rivers, for example, sediment particles become smoother and smaller as they collide during transportation.

4. Corrosion (Solution): In chemical erosion, corrosive agents such as acidic water or chemicals in the erosion agents dissolve minerals from rocks. This dissolution weakens the rock's structure, leading to disintegration and transportation.

5. Freeze-Thaw (Frost Action): In regions with freeze-thaw cycles, water enters cracks in rocks. As the water freezes and expands, it exerts pressure, widening the cracks. When the ice thaws, the cracks contract. Over time, repeated freeze-thaw cycles lead to rock fragmentation.

6. Salt Crystal Growth: In arid regions, salt crystals in the soil and rock expand as they absorb water. As the water evaporates, the crystals contract, exerting pressure on the surrounding rock. This process, called salt crystal growth or crystal wedging, gradually breaks down rocks.

7. Plucking (Glacial Erosion): Glaciers freeze onto rocks, and as they move, they pluck rocks from the ground, especially from the bedrock. These rocks become incorporated into the glacier's ice and are transported, contributing to erosion.

8. Wind Abrasion: Wind erosion involves the abrasion of rock surfaces by sand and dust particles carried by the wind. The particles impact the rocks, wearing them down over time and shaping unique features in arid landscapes.

9. Differential Erosion: Some rocks are more resistant to erosion than others due to differences in hardness, mineral composition, and structure. This leads to differential erosion, where softer rocks erode faster, creating contrasting landforms.

10. Mass Movement: Gravity-driven mass movements, such as landslides and rockfalls, dislodge and transport rocks and soil downhill. These movements are often triggered by factors like heavy rainfall, earthquakes, or human activities.

11. Interaction of Erosion Agents: Processes can interact to amplify erosion effects. For example, rivers eroding valleys can expose rocks to freeze-thaw cycles, accelerating rock breakdown.

Interaction between Erosion Agents and Geological Structures: A Dance of Creation and Transformation

The Earth's surface is a canvas shaped by a dynamic dance between erosion agents and the intricate geological structures that lay the foundation. This interaction weaves a tale of creation, transformation, and adaptation, sculpting landscapes that bear the fingerprints of these powerful forces. Here's a closer look at how erosion agents and geological structures harmonize to shape the Earth's topography:

1. Water Erosion and Geological Structures: Erosion agents, especially water, engage in an intimate tango with geological structures. Rivers, for instance, follow the paths of least resistance along geological fault lines or weaker rock layers, deepening valleys and shaping landscapes. Water erosion carves out meanders in response to the natural curvature of rock formations, forging sinuous river channels that create oxbow lakes and floodplains.

2. Wind Erosion and Geological Structures: Wind, though seemingly capricious, respects geological boundaries. It sculpts rock formations and desert landscapes, eroding softer rocks at different rates to expose intricate layers and geological strata. Wind erosion has a hand in shaping unique landforms such as hoodoos and mesas, highlighting the interaction between wind patterns and rock resistance.

3. Glacial Erosion and Geological Structures: Glacial ice interacts with geological structures on a grand scale, grinding and carving through mountains and valleys. Glaciers often amplify pre-existing geological features, enhancing the sculpting effects of erosion. The U-shaped valleys left in their wake reflect the interplay between ice and underlying geological structures.

4. Gravity and Geological Structures: Gravity's influence is pervasive and shapes the way other erosion agents interact with geological structures. Mass movements such as landslides and rockfalls are triggered by geological weaknesses, topographical inclines, and structural alignments. These movements can expose hidden layers and dramatically alter the landscape.

Water Erosion

Water erosion is the process by which flowing water, whether in the form of rain, rivers, or streams, wears away and transports soil, sediment, and rock particles. Through mechanisms like hydraulic action, abrasion, and corrosion, water reshapes the Earth's surface by carving valleys, creating river channels, and shaping coastlines. This natural force plays a vital role in shaping landscapes and contributing to geological changes over time.

River Erosion: Carving Valleys and Gorges in Nature's Gallery

Rivers persistently carve landscapes through water's erosive force and sediment. This ongoing process creates a remarkable geological history, witnessed in valleys' formation and the creation of gorges.

Stages of River Erosion: River erosion unfolds in stages, showcasing the river's dynamic impact on the landscape:

(i) Youthful Stage: In the youthful stage, rivers often flow in V-shaped valleys. The river's energy is focused on vertical erosion, carving down into the land.

(ii) Mature Stage: As the river matures, it meanders and broadens its course. Lateral erosion becomes more prominent, widening the valley and creating floodplains.

(iii) Old Age Stage: In the old age stage, rivers may exhibit dramatic meanders and floodplain development. Erosion decreases, and sediment deposition becomes more prevalent.

Stream Erosion

Stream erosion, a subset of water erosion, is the embodiment of nature's patient yet persistent artistry. Streams, with their flowing currents, carve delicate channels through the landscape, shaping the Earth's features in a rhythmic dance of erosion and deposition. Understanding stream erosion and its channel dynamics reveals the intricate balance between the force of water and the resilience of the land.

Rainfall-Induced Erosion: Unveiling Nature's Tearful Touch

Rainfall, seemingly gentle and nurturing, has the power to shape landscapes through its erosive touch. Rainfall-induced erosion occurs through a sequence of processes—sheet, rill, and gully erosion—that showcase the profound impact of even the tiniest raindrop on the Earth's surface.

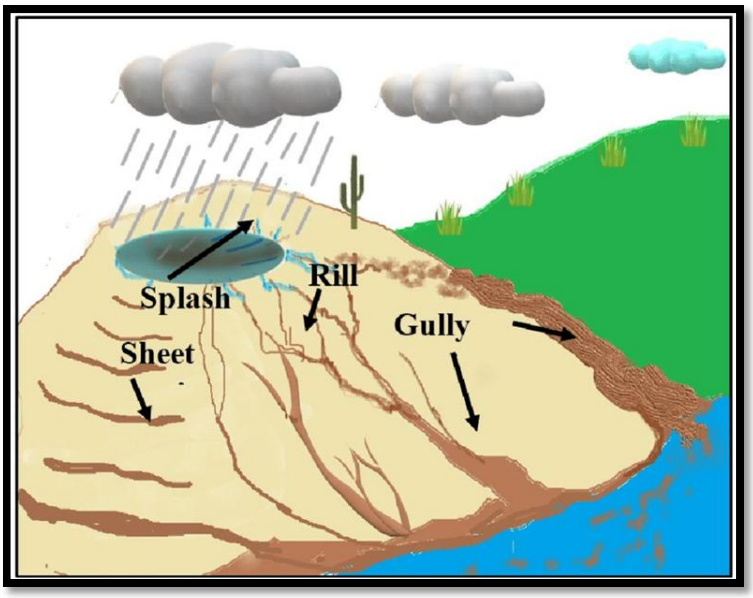

Fig. 6.4: Rainfall Induced Erosion, Source: Google.

(i) Rain Drop or Splash Erosion: The erosion due to the impact of falling raindrops on the soil surface leading to the destruction of the crumb structure is known as raindrop or splash erosion.

(ii) Sheet Erosion: Rainwater flows evenly over land, removing a thin layer of soil.

(iii) Rill Erosion: As the rain's intensity increases, the water's flow begins to concentrate in small, shallow channels known as rills. Rill erosion emerges when these miniature channels—often just a few centimeters deep—start to form, carrying away soil and sediment as they meander across the land.

(iv) Gully Erosion: When rill erosion becomes more prominent, it can evolve into gully erosion.

Impact and Mitigation: Rainfall-induced erosion holds far-reaching consequences for ecosystems, agriculture, and landscapes:

Impacts: Soil Degradation, Sedimentation, Landscape Alteration.

Mitigating rainfall-induced erosion involves implementing erosion control measures such as contour plowing, terracing, and using cover crops. These practices help slow down the flow of water, reduce the potential for surface runoff, and minimize soil loss.

Coastal Erosion: Where Waves, Tides, and Time Sculpt the Shoreline

Coastal erosion is a dynamic and relentless process that illustrates the ongoing interaction between the land and the sea. Driven primarily by wave action and tidal forces, coastal erosion reshapes coastlines, carving cliffs, forming beaches, and molding coastal landforms. This intricate dance between the forces of nature and the vulnerability of the land showcases the ever-changing nature of coastal environments.

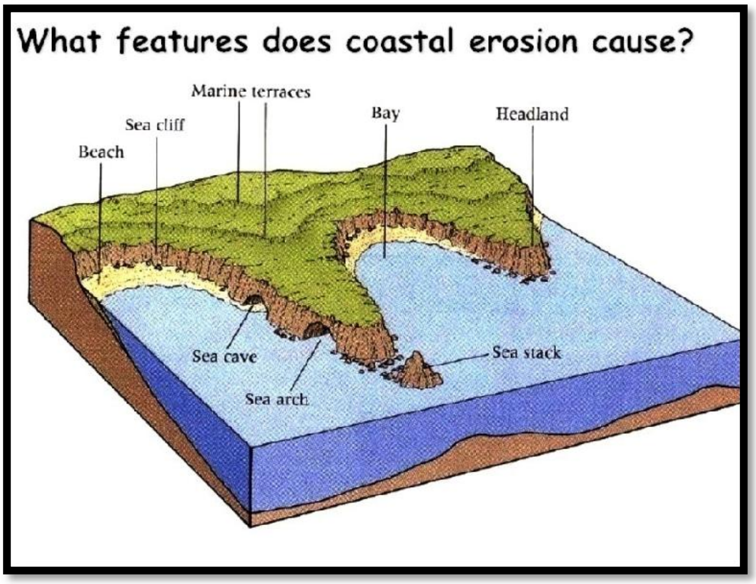

Fig. 6.5: Coastal Erosion, Source: Google.

Impact and Management: Coastal erosion carries significant consequences, both ecological and societal:

(i) Ecosystem Vulnerability: Coastal ecosystems are sensitive to erosion, impacting habitats for marine life and coastal vegetation.

(ii) Infrastructure and Settlements: Human settlements, infrastructure, and buildings near coastlines are vulnerable to erosion-induced land loss.

(iii) Sea Level Rise: Erosion can exacerbate the effects of sea level rise, potentially displacing communities and altering coastal landscapes.

Managing coastal erosion involves a combination of strategies such as building seawalls, creating artificial reefs, beach nourishment, and implementing sustainable coastal development practices. These approaches aim to strike a balance between preserving the integrity of coastal ecosystems and safeguarding human interests.

Wind Erosion: Nature's Whispered Reshaping

Wind, a seemingly gentle force, possesses the power to transform landscapes through wind erosion. This process occurs primarily in arid and semi-arid regions where sparse vegetation and loose soil make the land vulnerable. As the wind sweeps over the surface, it lifts and carries particles, sculpting dunes, abrading rocks, and shaping the land in its own unique way.

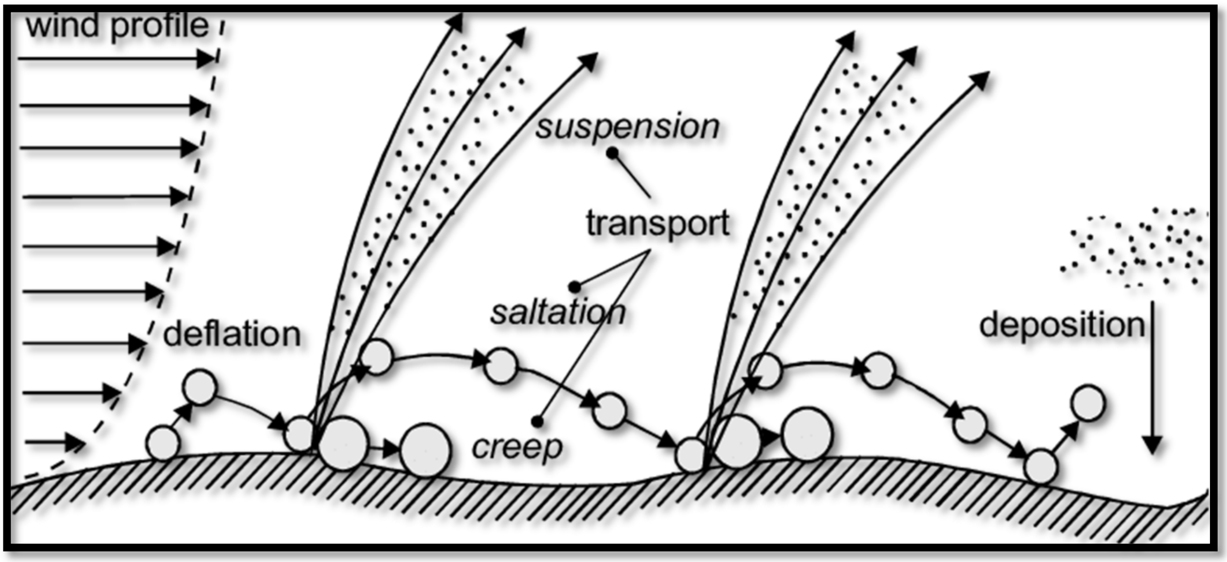

Fig 6: Wind Erosion, Source: Google.

Characteristics of Wind Erosion in Arid and Semi-Arid Regions

In arid and semi-arid regions, wind erosion unfolds as a distinctive sculptor of the landscape. With sparse vegetation and loose, dry soils, these regions are vulnerable to the whispering forces of wind. Fine particles are lifted from the surface, creating a phenomenon known as deflation, which shapes flat, barren expanses. Wind abrasion sculpts rock surfaces, while the accumulation of wind-driven sand forms mesmerizing dunes. These unique characteristics of wind erosion in arid and semi-arid regions remind us of nature's delicate yet persistent artistry in shaping the Earth's most challenging terrains.

Wind Erosion Landforms: Nature's Sculpted Masterpieces

Wind erosion crafts a gallery of remarkable landforms in arid and semi-arid regions, where the relentless force of wind reshapes the landscape with patient precision. From the delicate ripples of sand to the towering majesty of dunes, these landforms are testaments to the elegance and power of wind's artistic touch. Landforms created by wind erosion are:
(i) Sand Ripples (ii) Yardangs (iii) Deflation Hollows (iv) Ventifacts.(v) Desert (vi) Pavements (vii) Playas and Playa Lakes

Wind Erosion's Impact on Soil Fertility and Land Degradation

Wind erosion, while often seen as a subtle force, can have profound consequences for soil fertility and overall land health. This phenomenon, prevalent in arid and semi-arid regions, can significantly contribute to land degradation, altering the composition of ecosystems and impacting human livelihoods.
(i) Soil Fertility Loss: Wind erosion strips away the delicate top layer of soil, rich in organic matter and nutrients

(ii) Structural Changes: Wind erosion can also alter the soil's physical structure. It reduces the soil's ability to hold water and retain

(iii) Desertification and Land Degradation: In severe cases, wind erosion can contribute to desertification—a process where once-productive land transforms into desert-like conditions due to prolonged degradation.

(iv) Erosion Offsets Carbon Sinks: Soil is a critical carbon sink, holding vast amounts of carbon that would otherwise contribute to the greenhouse effect. Wind erosion can release this stored carbon into the atmosphere as eroded particles disperse. This not only impacts soil fertility but also contributes to climate change.

Mitigation and Conservation: Mitigating the impacts of wind erosion involves a combination of sustainable practices:

(i) Vegetative Cover: Planting native grasses, shrubs, or cover crops helps anchor the soil, preventing erosion and enhancing soil structure.

(ii) Windbreaks: Planting windbreaks like trees and hedges forms protective barriers that reduce wind speed, minimizing soil particle movement.

(iii) Conservation Tillage: Adopting reduced tillage or no-till practices in agriculture helps maintain soil structure and reduces the vulnerability of soil to wind erosion.

Glacial Erosion: The Sculptor of Glacial Landscapes

Glacial erosion is a geological masterpiece created by the movement of enormous masses of ice. Glaciers, shaped by gravity's pull, carve through mountains, valleys, and entire landscapes. As they flow, glaciers pluck rocks from the earth's surface, grind mountains into valleys, and leave behind awe-inspiring features like U-shaped valleys, cirques, and moraines. Glacial erosion's slow yet relentless force showcases the profound impact of ice on shaping the Earth's terrain over millennia.

Glacial Processes: Nature's Mighty Remodelers

Glacial processes are the awe-inspiring forces that shape landscapes through the relentless movement of immense masses of ice. **Three key processes—plucking, abrasion, and moraine deposition**—reveal the intricate ways in which glaciers reshape the Earth's surface, leaving behind iconic landforms that narrate the story of glacial sculpting.

Impacts and Landforms: The interplay of these glacial processes creates iconic landforms that resonate with the grandeur of nature's sculpting:

(i) U-shaped valleys: Abrasion and plucking shape valleys into U-shaped profiles, contrasting with the V-shaped valleys carved by rivers.

(ii) Cirques: Glacial erosion carves steep-walled amphitheater-like depressions known as cirques, which can transform into picturesque glacial lakes over time.

(iii)Horns and Arêtes: As glaciers erode surrounding peaks, sharp-edged features like horns and arêtes emerge, presenting striking mountain landscapes.

Glacial Retreat: Unveiling the Legacy of Ice's Withdrawal

Glacial retreat, a consequence of changing climatic conditions, is a phenomenon that unveils the influence of ice on land morphology over time. As temperatures rise and glaciers melt, they leave behind distinctive marks on the landscape, revealing the dynamic interactions between ice, land, and climate. Glacial retreat is a reminder of Earth's ever-changing nature and the delicate balance between climate, ice, and land.

Gravity-driven Erosion (Mass Wasting): Nature's Downward Sculptor

Gravity, an omnipresent force, orchestrates a unique form of erosion that shapes landscapes through its relentless pull. Gravity-driven erosion, also known as gravitational erosion or mass wasting, involves the downward movement of rock, soil, and debris under the influence of gravity. This process plays a crucial role in reshaping slopes, cliffs, and landforms, leaving behind distinctive geological features.

Types of Gravity-Driven Erosion

1. Rockfall: In rockfall, individual rocks or boulders detach from a slope or cliff face and plummet downward due to the pull of gravity.

2. Landslides: Landslides involve the sudden, rapid movement of a mass of soil, rock, or debris down a slope.

3. Slumping: Slumping occurs when a mass of soil or rock moves along a curved surface, creating a rotational movement.

4. Creep: Creep is a slow, gradual movement of soil and sediment down a slope due to the expansion and contraction caused by freeze-thaw cycles and wet-dry conditions.

Impact and Landscape Evolution:

Gravity-driven erosion profoundly impacts landscapes

Landform Creation: Mass wasting contributes to the formation of various landforms, including terraces, scarps, and slump features.

Slope Stability: Understanding gravity-driven erosion is crucial for assessing slope stability and mitigating potential hazards, especially in urban and construction areas.

Mass wasting is influenced by several factors:

(i) Slope Angle: Steep slopes are more susceptible to mass wasting due to the increased gravitational force.

(ii) Vegetation: Vegetation stabilizes slopes by binding soil and rock, reducing the risk of erosion.

(iii) Water: Excess water, from rainfall or snowmelt, can saturate soil and increase its weight, triggering mass wasting.

Mitigation and Prevention:

Preventing and managing mass wasting involves understanding local geology, slope characteristics, and potential triggers. Strategies include:

(i) Slope Stabilization: Reinforcing slopes with retaining walls, rock bolts, or vegetation can prevent movement.

(ii) Drainage Management: Proper drainage systems can reduce excess water accumulation, minimizing the risk of saturation-triggered events.

(iii) Land-Use Planning: Avoiding construction on unstable slopes and implementing proper construction practices can reduce human vulnerability to mass wasting.

6.4 SUMMARY

Weathering, a complex process, changes landscapes. It involves Earth's elements breaking down rocks over time. Forces like heat, chemicals, and living things work together to do this. As rocks weaken, their shape and makeup change. Weathering sets the stage for erosion and shapes land and soil. This chapter looks at how weathering happens, its types, and its effects on our planet.

Erosion, another process, reveals how nature shapes Earth's surface. Wind, water, ice, and gravity move rocks and soil. Erosion forms valleys, coastlines, and mountains. This chapter explains how erosion works and its agents, like waves and glaciers. It shows how landforms change over time. Beyond what we see, erosion affects soil, water, and climate. Learning about erosion helps us see the bigger picture of Earth's changes.

In the end, we've uncovered the secrets of weathering and erosion. Imagine rocks changing slowly, rivers shaping valleys, and wind sculpting landscapes. These processes are like nature's artists, crafting the world around us. Weathering breaks rocks, while erosion moves and changes them. From big mountains to small pebbles, everything is touched by these forces. Remember, as time goes by, weathering and erosion continue to shape our Earth, creating new landscapes and telling stories of the past. So, whenever you see a rocky hill or a flowing river, you'll know that weathering and erosion are at work, creating beauty in every corner of our amazing planet.

6.5 GLOSSARY

Abrasion: Abrasion, often referred to as "glacial sandpaper," is a dynamic process where rocks carried by the glacier act as tools, grinding against the underlying bedrock.

Cirques: Glacial erosion carves steep-walled amphitheater-like depressions known as cirques, which can transform into picturesque glacial lakes over time.

Denudation: Denudation is the collective term encompassing the processes by which the Earth's surface is gradually worn down, eroded, and exposed due to the action of various geological forces.

Erosion: the active wearing away of the earth’s surface by moving agents like running water, wind, ice, waves etc.

Glacial Retreat: Melting and shrinking of glaciers over time.

Landslides: Landslides involve the sudden, rapid movement of a mass of soil, rock, or debris down a slope.

Mass wasting: Downhill movement of rocks, soil, and debris due to gravity.

Rockfall: In rockfall, individual rocks or boulders detach from a slope or cliff face and plummet downward due to the pull of gravity.

Slope Angle: Steep slopes are more susceptible to mass wasting due to the increased gravitational force.

Topography: The shape of the land also matters. Steep slopes might experience enhanced physical weathering due to the gravitational forces that contribute to rockfall and erosion.

Ventifacts: Ventifacts: Rocks shaped and polished by wind-blown sand.

Weathering: the gradual disintegration of rocks by atmospheric or weather forces

Yardangs: Erosion carves yardangs, elongated ridges of rock or sediment, into the landscape.

6.6ANSWER TO CHECK YOUR PROGRESS

1. Do you know that denudation process comprises several interrelated activities, including weathering, erosion, transportation, and deposition**.**
2. Do you know that weathering involves mainly two types of changes in the rocks i.e. Physical and Chemical?
3. There are three types of weathering process i.e. Physical, Chemical and Biological.
4. Do you know that Physical weathering is also known as Mechanical?
5. Are you aware that burrowing animals, creatures, and insects create openings in rocks that allow water to penetrate, accelerating chemical weathering?
6. Do you know that splash erosion is the initial stage of rainfall-induced erosion?
7. Do you know that different Types of Gravity-Driven Erosion like Lanslides, Creep, Rockfall, Slumping etc.?
8. Do you that glacial retreat is a reminder of Earth's ever-changing nature and the delicate balance between climate, ice, and land?
9. Are you aware that climate change is a major cause of glacial retreat?
10. Do you know that any river undergoes three stages of erosion?
11. Do you know that any river undergoes three stages of erosion?
12. Do you know that frost is one of the major weathering agents in cold regions?

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6.7TERMINAL QUESTIONS

Long Questions

1. What are the phases of denudation? Explain in details.
2. What is the difference between weathering and erosion?

Short Questions

1. What is weathering? Explain it in detail.
2. What are the different types of weathering processes?
3. What is the difference between weathering and erosion?
4. What is water erosion? Explain it in detail.
5. Explain the Mechanisms and Processes of Erosion.

Multiple Choice Questions

1. Weathering is....

a) Erosion
b) The breaking down or dissolving of rocks and minerals on the surface of the earth in their place.
c) denudation
d) All of the above

2. How many types of weathering changes in rocks occurred?

a) Two Types
b) Three Types

c) Five Types
d) None of the above

3. Which of the following is/are controlling factors of weathering?
a) Climate
b) Rock Composition
c) Time
d) All of the above

4. What is another name of Physical weathering?
a) Chemical Weathering
b) Mechanical Weathering
c) Biological weathering
d) None of the above

5. Which of the following is not Physical weathering agent?
a) Moisture and Water
b) Insolation
c) Frost
d) Oxygen

6. Which of the following is not Chemical weathering agent?
a) Oxygen
b) Frost
c) Carbon dioxide
d) Hydrogen

7. Which of the following is not Biological weathering agent?
a) Vegetation
b) Animals
c) Micro-organisms
d) Water

8. Which of the following is Physical weathering agent?
a) Micro-organisms
b) Water
c) Oxygen
d) None of the Above

9. Which of the following is Chemical weathering agent?
a) Hydrogen
b) Vegetation
c) Insolation
d) Micro-Organisms

10. Which of following is not rainfall induced erosion?

a) Splash Erosion
b) Glacial Erosion
c) Sheet Erosion
d) Rill Erosion

11. How many stages are in Cycle of erosion?

a) 5
b) 2
c) 3
d) None of the above

12. Which of the following is not types of Gravity-Driven Erosion?

a) Landslide
b) Rockfall
c) Creep
d) Earthquake

13. U-Shaped Valleys is a landform created by which erosion agents?

a) Water
b) Wind
c) Glacier
d) None of the above

Answers: 1-B, 2-B, 3-D, 4-B, 5-D, 6-B, 7-D, 8-C, 9-A, 10-B, 11-C, 12-D and 13-C.

UNIT 7 - COMPOSITION AND STRUCTURE OF ATMOSPHERE

7.1 OBJECTIVES

- Understanding the structure and composition of atmosphere.
- Scientific study of the stability of the atmosphere.
- To recognize the utility of the atmosphere of the biosphere.
- To understand the importance of atmosphere for the earth.
- Importance of ozone layer for human animal and plants.

7.2 INTRODUCTION

The atmosphere is a mixture of chemical gases that surround the earth like a shield. Provides oxygen for breathing to the living world, protects the inhabitants of the earth from the ultraviolet harmful rays coming from the sun and makes life possible on the planet Earth, because due to the lack of atmosphere on other planets, life could not be possible there. All the atmospheric gases (similar to Earth) used for living life are not found here jointly. Nor is the gravitational force that stops or stabilizes these gases found on other planets. The atmosphere is a gaseous cover spread around the Earth in a thickness of several hundreds of kilometres.99% of the atmosphere is made up of two gases, Nitrogen 78% and Oxygen 21%, the remaining part consists of light and heavy gases like argon, carbon dioxide, hydrogen, neon, krypton, helium, xenon and ozone. Due to which unique layers are formed in the atmosphere, specific temperature, pressure and other events keep happening in each layer.

Earth is the only planet in the Solar System to have an atmosphere, or to have life. Whose analysis scientists use for light spectroscopy. The layered structure of the earth's atmosphere works to stop the sun's heat and circulate it in a limited amount. Virtual balloons have also been used to explore the atmosphere. In addition to the gases in the atmosphere, water vapor, dust particles and toxic gases released from the use of biofuels are also included in this. The structure of the atmosphere is in the form of the troposphere, stratosphere, mesosphere, volume sphere, exosphere, photosphere and magnetic, the magnetic sphere is used for scientific investigative work which is clear from figure 7.1.

Fig. 7.1: Source: www.bing.com> Earth atmosphere.

In the atmosphere, carbon is present as carbon dioxide. While we obtain oxygen from green trees and plants, whose soil is released with the use (burning) of petroleum products, fuel, and coal? The same plants continue to absorb nitrogen from the soil. The decay of plants and animals actively releases nitrogen back into the atmosphere. In light of this, the atmosphere is a unique element of the biosphere. where the gases that are required for the survival of the diverse creatures in the biosphere are stored and released.

The height of the atmosphere is generally estimated to be between 16 to 29,000 km above sea level. Space researchers estimate that 97% of the effective atmosphere is found up to this 29000 km. In chemical organization, this region is divided into homosphere and heterosphere. Its height is spread from 90 km and 90 to 10000 km respectively from the sea level.

6.3 COMPOSITION AND STRUCTURE OF THE ATMOSPHERE

Due to the composition and composition of the atmosphere being made up of different types of gases, dust particles and water vapor particles, its composition remains in an unstable state. It varies based on time and place. The details of the main types present in the atmosphere have been clarified in the Table-7.1 and Fig. 7.2.

Table-7.1: Main Gases of the Atmosphere.

S.N.	Gases	Quantity in percentage	Total
1	Nitrogen	78.1	99%
2	Oxygen	20.9	
3	Argon	0.9	
4	Carbon dioxide	0.03	
5	Hydrogen	0.01	0.99%
6	Nion	0.0018	-

7	Helium	0.0005	-
8	Ozone	0.00006	-
9	Other	-	-

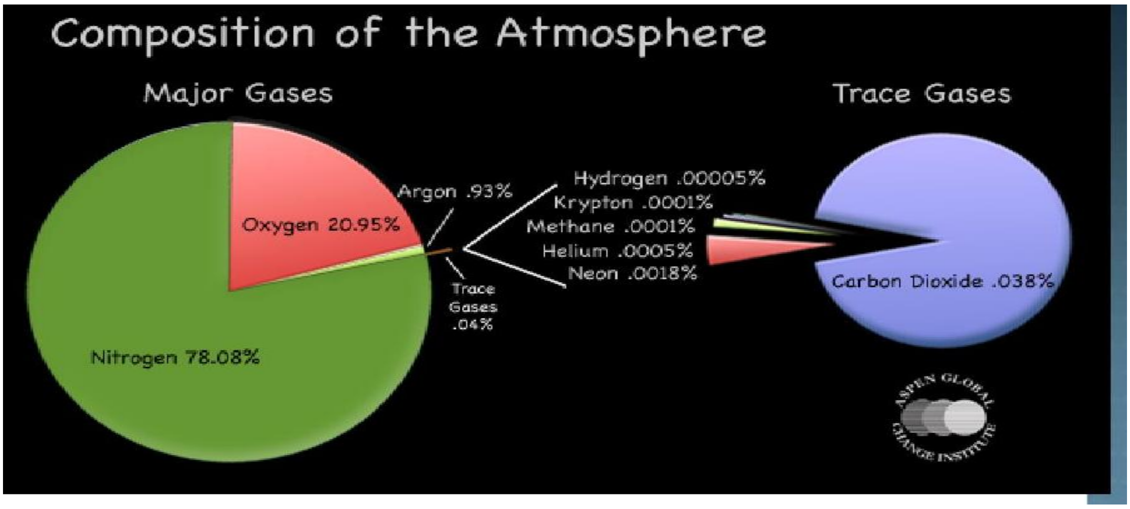


Fig. 7.2: Source: www.bing.com>composition of the atmosphere.

Water Vapour

The gaseous form of water present in the atmosphere is called water vapor. The amount of water vapor present in the air and its availability in the lithosphere make life possible on Earth. The amount of water vapor present in the atmosphere is the source of precipitation on the whole earth; its maximum amount in the atmosphere is up to 4 percent. But when the atmosphere is dry, it remains only up to one percent. The maximum amount of water vapor is found in tropical regions; generally, on moving from low latitudes to high latitudes, its quantity decreases. Condensation is the source of water vapor in the atmosphere, which condenses around the dust particles in the form of water droplets. Its direct form is received by the earth in the form of clouds and precipitation. Water vapor in the atmosphere also occurs in the form of evaporation due to the transpiration of seas, rivers, ponds, lakes, plants, and animals. The climate-penetrating solar radiation is less transparent than the transparent ambient wave, so it helps in heating the surface and the atmosphere. Which is clear from figure 7.3.

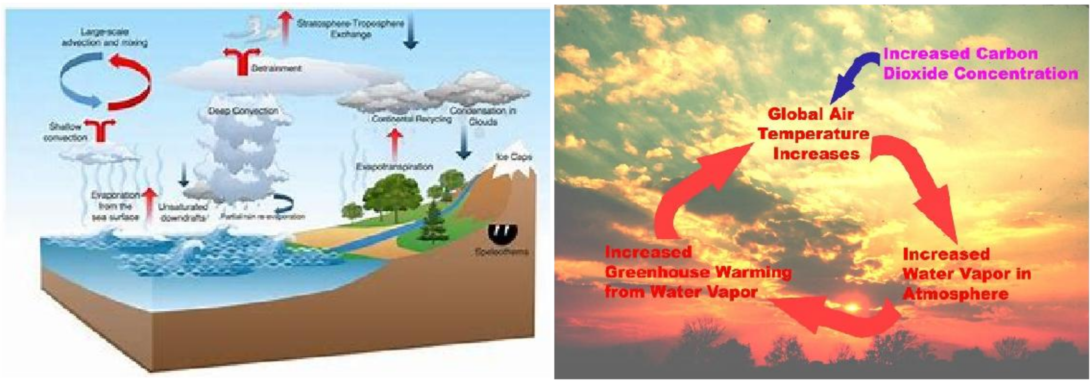


Fig. 7.3: Source: www.bing.com>water vapour.

Dust Particles

Dust particles are mostly found at lower levels in the atmosphere. Which are found in the form of dust, smoke, salt particles, and sea salts. Dust particles have special importance in the atmosphere; these dust particles help in condensation. The solid particles (dust and salt) present in the atmosphere help in the scattering of solar radiation. Due to this scattering, the color of the sky becomes blue, and the eyes become bright in the morning and red in the evening. In salt particles form moisture-receptive nuclei, and different forms of precipitation are formed from fog, water droplets, clouds, and condensation. Which is clear from figure 7.4.

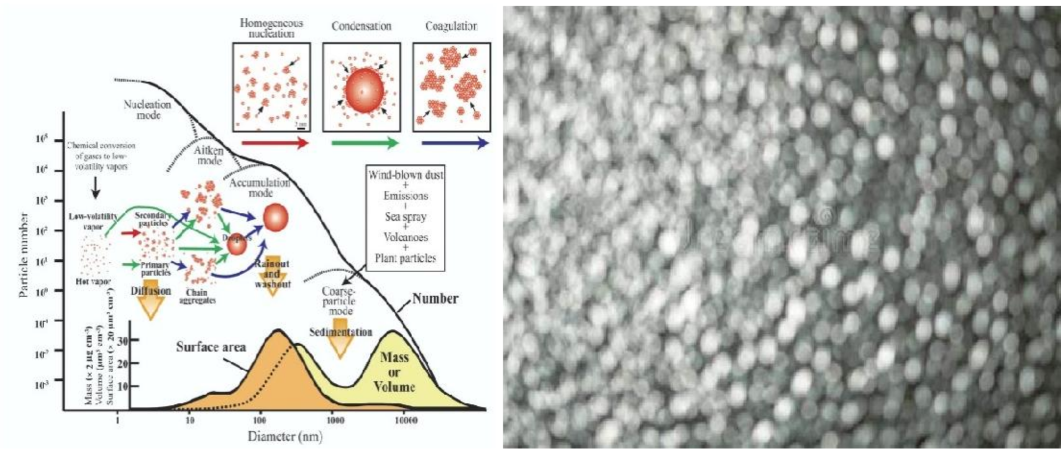


Fig. 7.4: Source: www.bing.com>Dust Particles.

Structure of the Atmosphere

When the atmosphere is a special part of the earth, it pervades all around it as one. Generally, it extends up to a height of 1600 kilometers from the surface, which is not certified information, but in modern times, for accurate information about the atmosphere, the help of rockets, radars, Sputnik, etc. equipment is being taken, based on which the atmosphere is 800 kilometers above the surface. It has been said to be more useful from a human point of view. Based on gas density, temperature, and air pressure, the atmosphere is divided into 5 layers, respectively, from sea level to increasing height. Which is clear from figure 7.5.

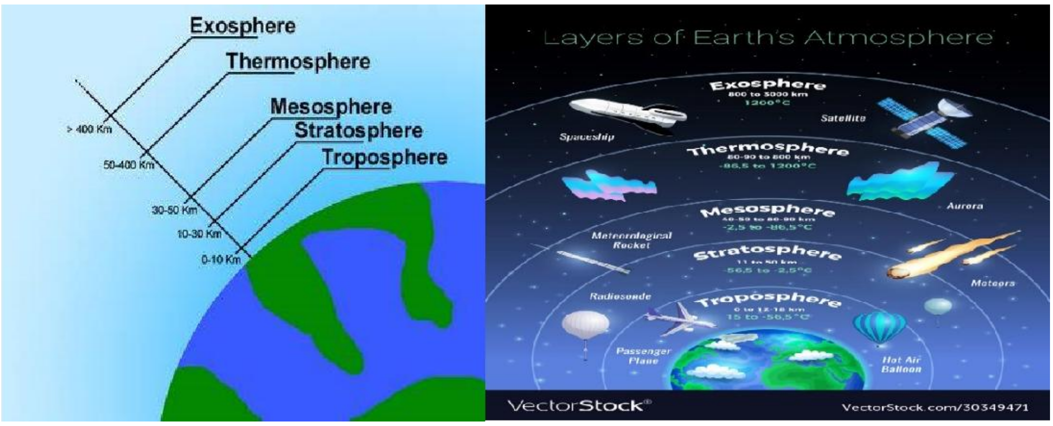


Fig. 7.5: Source: www.bing.com>Stratification of the Atmosphere.

1. Troposphere or troposphere
2. Stratosphere
3. Mesosphere
4. Ionosphere
5. Exosphere

Troposphere

The troposphere is the lowest layer of the atmosphere. It is most useful for the ecology of the biosphere, which has an average height of 12 kilometers, but it decreases to 6 kilometers in the polar regions and 16 kilometers on the equator. The temperature in this circle varies with the height by 6.5 degrees Celsius per thousand meters, which is called the normal temperature fall rate. In comparison, its limit becomes higher in the summer. All the living beings found on the surface are related to this division, and most of the heavy gases, water vapor, and dust particles are occupied in this division. The work of heating and cooling the troposphere is governed by radiation, conduction, and convection; hence, it is also called the convective zone. All the weather events like frost, frost, fog, cloud, hail, thunder, electric light, and storms occur in this part. Which is clear from figure 7.6.

Fig. 7.6: Source: www.bing.com>troposphere.

Stratosphere

The stratosphere is located as the second layer in the atmospheric structure, which is known by its name because this layer is of uniform temperature. It is located above the troposphere; its height is considered to be 25 to 30 kilometers in the mid-latitudes, but some scholars give its extent up to 50 kilometers and the width up to 40 kilometers. Critchfield has said the upper limit of the stratosphere is up to 25 kilometers at the middle latitude, and its temperature remains the same. (Up to the extent of Tropopause, this circle is devoid of seasonal movements, and up to 15 km in height, there are no temperature-related changes here, after which the temperature starts increasing slightly. It is considered the most ideal circle for the flight of the atmosphere which is clear from figure 7.7.

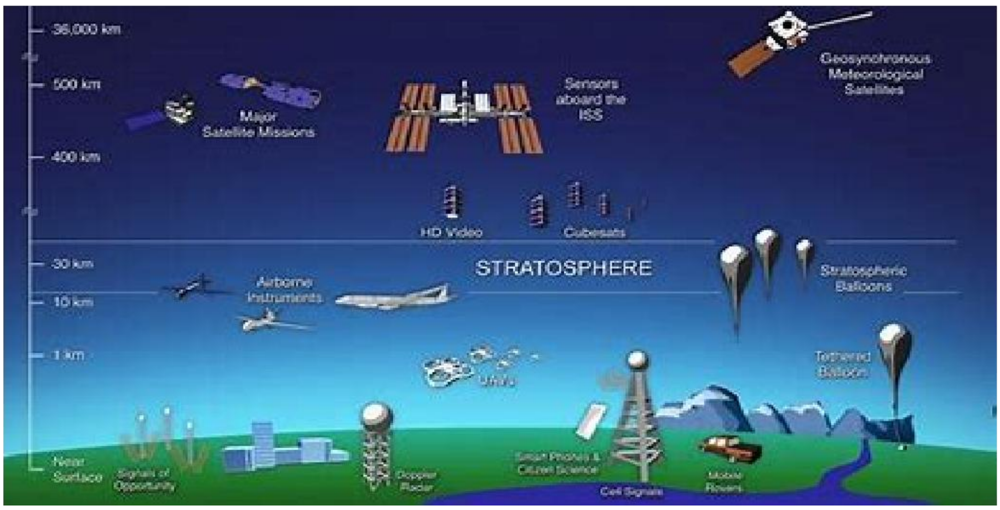


Fig. 7.7: Source: www.bing.com>stratosphere.

Mesosphere

The extension of this layer is situated above the stratosphere up to a height of 80 km from the surface and up to a thickness of 30 km. In the mesosphere, the temperature goes down from 0 °C to -4 °C at an altitude of 80 km, but after the mesopause, the temperature again increases. Which is clear from figure 7.8.

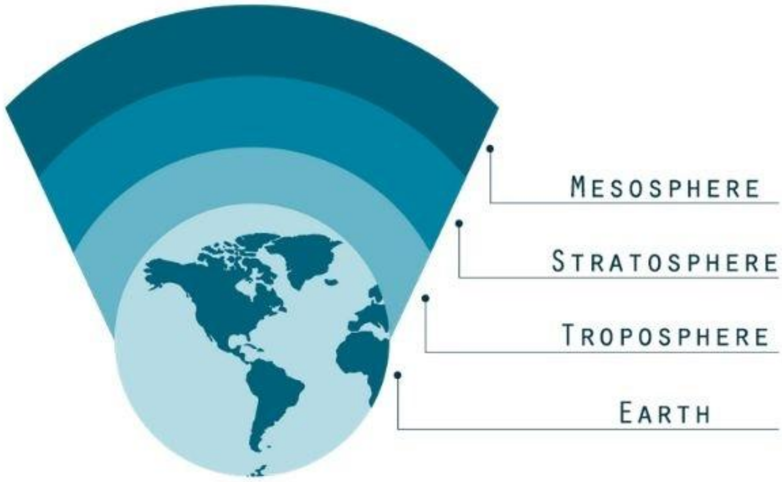


Fig. 7.8: Source: www.bing.com>stratosphere.

Thermosphere

It is the fourth layer of the atmosphere that lies above the mesosphere. This layer extends from 80 kilometers below the surface to advanced altitudes. With height, the temperature increases rapidly in this circle; at the upper limit, the temperature reaches 1700 degrees Celsius. The temperature of this layer cannot be compared with a thermometer because the gas at this height becomes so light that the temperature cannot be measured with a normal thermometer. That's why heat cannot be felt in this circle. Which is clear from figure 7.9.

Exosphere/Ionosphere

The wide part of the ionosphere up to a height of 80–640 kilometers from the surface is known as the ionosphere; its thickness is about 300 kilometers. Amazing electro-magnetic events take place in this circle. Due to the absence of gravity in this region, the gases are extremely rare, and the density of air is very low. Universe in this part Rays of light are reflected, and based on some specific features of this circle, it is divided into three circles which is clear from figure 7.10.

1. D-Layer
2. E-Layer
3. F-Layer

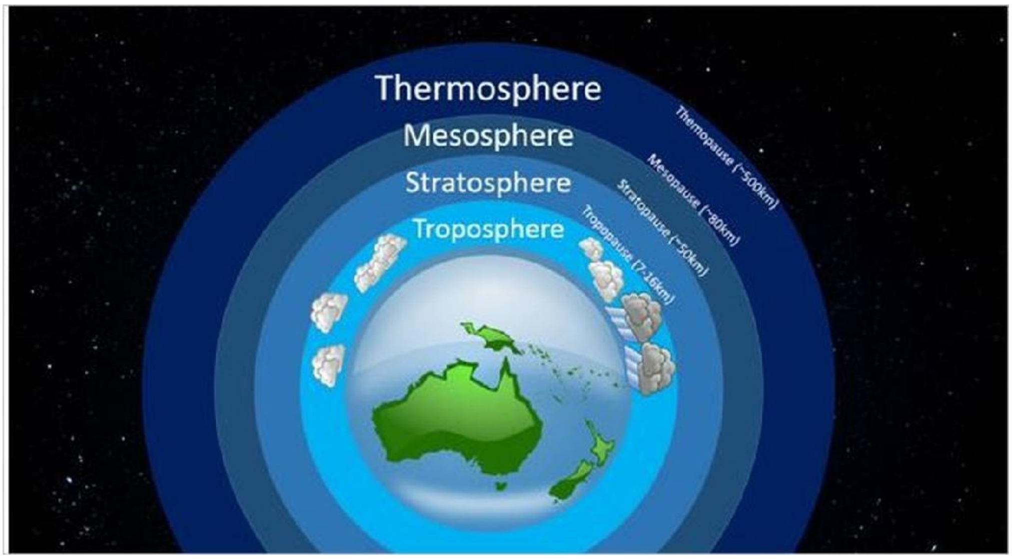


Fig. 7.9: Source: www.bing.com>thermosphere.

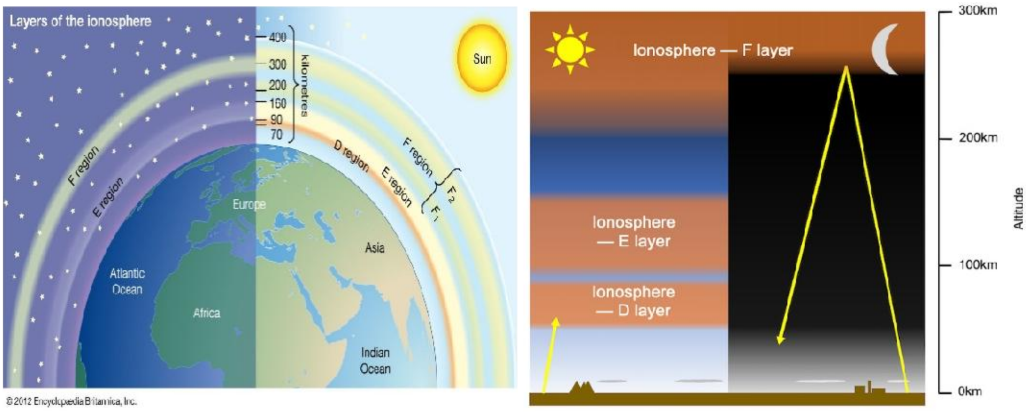


Fig. 7.10: Source: www.bing.com>ionosphere.

D Layer- This layer occupies an altitude of about 60 km to 96 km above the earth. for whom the atmosphere (ionosphere) is considered to be the most durable layer. It is also called the Kenali heavy sand layer.

E Layer- The extension of this layer is found up to 96,144 km, which is rich in ions. Some of these waves move towards the sky; such waves get reflected from the ionosphere and reach different parts of the earth. From this circle, the short waves of radio get reflected.

F Layer- This layer is found at the top of the sub-layers of the ionosphere. Whose extension is from 144 to 360 kilometers, in the same way, radio waves get reflected. The ionosphere itself works to stop the radio waves; if there were a lack of the ionosphere, the radio waves would never return to the surface and would go up to the advanced sky. Northern and southern polar light shines in the ionosphere itself. The lowest part of the thermosphere is called the ionosphere.

Above the ionosphere lies the volume sphere, whose height is above 640 kilometers, about which there is no certified information to date.

Chemical Establishment Structure/Organization of the Atmosphere

The chemical composition of the atmosphere is divided into two zones based on the density of light and heavy gases.

Homosphere

The homosphere is considered to be the lowest part of the Earth's atmosphere. It is located between the heterosphere and the earth's surface, up to a height of about 80 to 90 km. whose structure consists mainly of nitrogen (78 percent), oxygen (21 percent), and the remaining part of gases like argon (0.34%), carbon dioxide (0.033 percent), hydrogen, helium, etc. It covers more than 99 percent of the mass of the Earth's atmosphere; the atmosphere is called the stratosphere because of the similarity of gases in its composition. Under this, the troposphere, stratosphere, and mesosphere are included. Whose structure remains similar to many extents of layers, but as the height increases, there are many major changes in the amount of air.

Heterosphere

The heterosphere is located in the Earth's atmosphere at altitudes ranging from 90 to 10,000 km, including the thermosphere and the entire exosphere, with increasing altitude separating the gases from molecular diffusion. It consists of light molecules of gas whose separation layer forms the exact boundary between the different molecules, varying with temperature and solar activity. The hectosphere extends from the tropopause to the atmosphere of the planet and exists above the homosphere. Due to the diffuse nature of the gases in the hectosphere, its thickness is entirely dependent on temperature. The major factors that provide density variation in the homosphere are the day-night cycle, solar activity, geomagnetic activity, and the weather cycle; the homosphere contains about 0.001% of the total mean mass of the Earth's atmosphere. For the convenience of study, it has been divided into four parts.

i. Molecular Nitrogen Layer
ii. Molecular oxygen layer
iii. Helium layer
iv. Molecular hydrogen layer

Molecular Nitrogen Layer: In this layer, mainly nitrogen molecules are found. Its height is found up to 200 kilometres below the surface.

Molecular oxygen layer: In the molecular oxygen layer, there is zero oxygen. The altitude is set from 200 to 1100 km.

Helium layer: Helium molecules H_2 are found in this layer, which extends from 1100 to 3500 kilometres.

Molecular Hydrogen Layer: This layer has 3500 to 14000 km of hydrogen in it. There is an excess of H.

Other Layers of the Atmosphere

Ozone Layer

The ozone layer is located in the troposphere and stratosphere between 16 and 35 km, although many scientists think that the range is also reported to be 55 km. Three oxygen atoms combine to produce the ozone molecule for living things, the ozone layer in the atmosphere is crucial because it serves as a screen that prevents UV rays from penetrating the surface. Which is clear from figure 7.11.

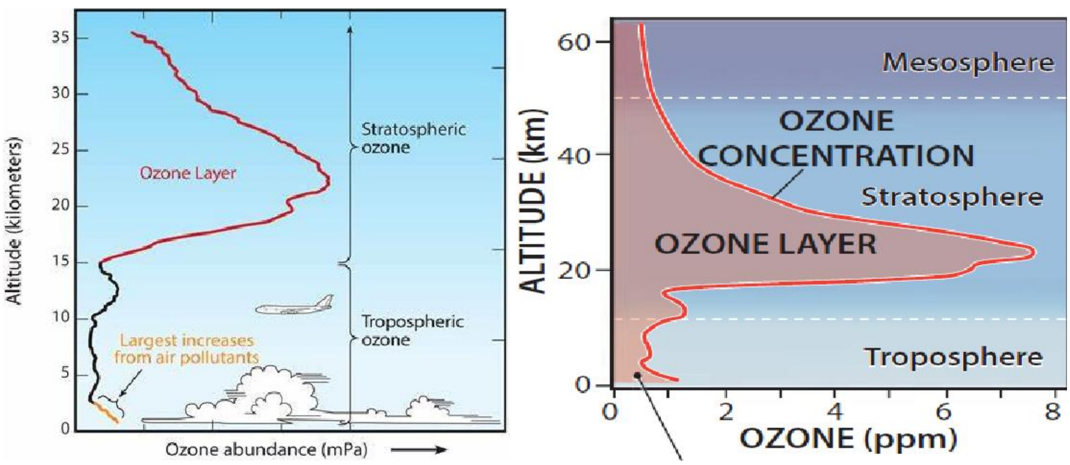


Fig. 7.11: Source: www.bing.com>ozone sphere.

No living thing can live on this planet after radiation reaches the surface because of the extreme temperature rise. The ozone layer in the atmosphere acts as an umbrella to shield the entire green planet Earth from precipitation during the rainy season.

Tropopause

This layer extends between the troposphere and the stratosphere and has a thickness of 1.5 km. Which acts as a transition belt in both these circles. In this part, all the seasonal changes in the troposphere almost cease. The maximum height of the troposphere at the equator remains 17 km, and at the poles it remains 9 to 10 km. The stratopause layer is found between the stratosphere and the mesosphere. As soon as 50 kilometres in height are reached, there is a gradual increase in temperature, which becomes 0 °C or 32 °F. Its height varies according to the season, and this transition layer is free from seasonal movements. This layer was first discovered in 1902 by Tijerens de Bort which is clear from figure 7.12.

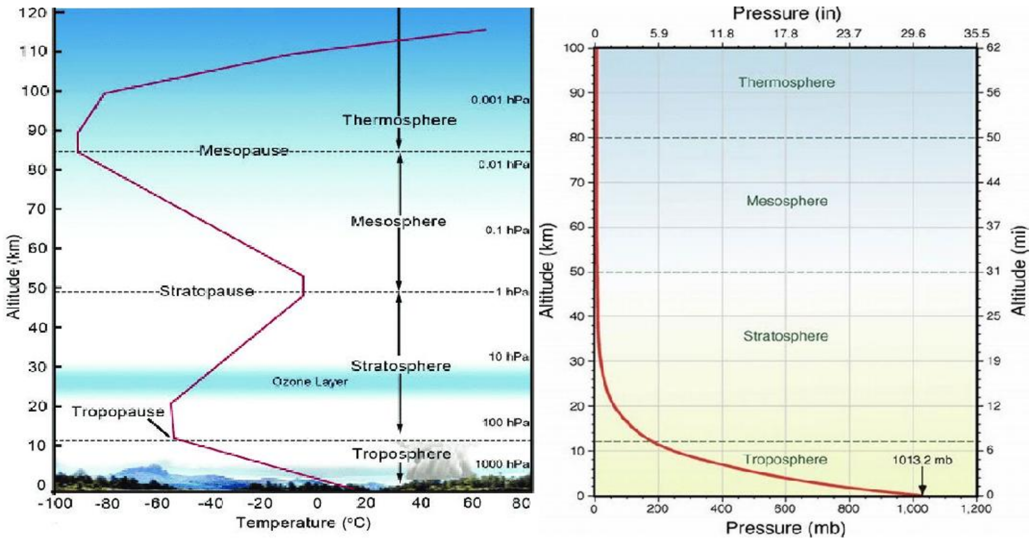


Fig. 7.12: Source: www.bing.com>tropopause.

Mesopause

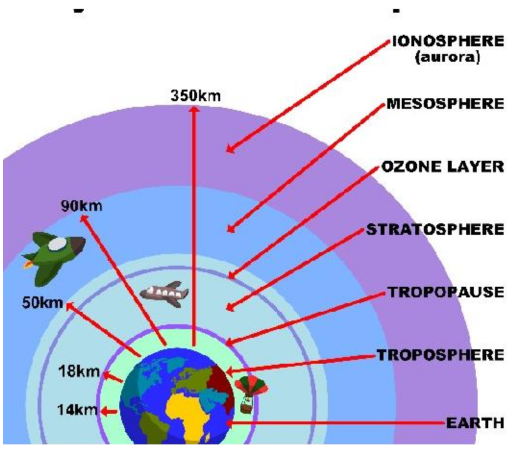
This boundary is located between the mesosphere and the thermosphere. The minimum temperature is found in it. That's why it is called the Mesopause, which is located at an average height of 80 km. After going beyond this limit, the temperature gradually starts increasing again.

Magnetosphere: This layer is located at an altitude of 1000 meters, where scientists install various satellites, and it protects the Earth from harmful solar radiation.

Celestial Sphere: The celestial sphere is found after the magnetosphere, which studies the position of celestial objects. Which is considered the last radius of the earth.

Chronosphere: Seven colors are studied under this layer, which is found after the celestial layer. It is located above the photosphere and below the corona.

Photosphere: This is the layer of the atmosphere from which the earth receives the sun's rays and heat. Which you can see with your own eyes. Which is clear from figure 7.13.



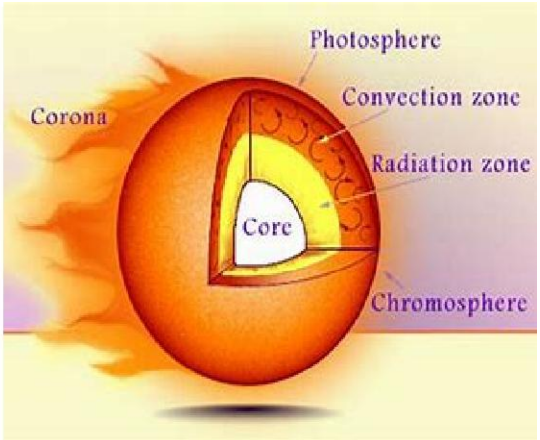


Fig. 7.13: Source: www.bing.com>another layers.

7.4 SUMMARY

Being the protective shield of the earth, the atmosphere is a cover made of a mixture of natural elements (gases, dust particles, and salt particles) essential for life on the earth. Without which water and life on earth cannot be imagined. It also works to stop the solar rays, which are harmful to the living beings living on the earth, and to provide a balanced amount of radiation. It affects the elements of the climate by filtering sunlight reaching the Earth; thus, it is an important factor in climate control and a major source of life's sustenance on Earth.

It is a colorful, odorless, transparent, and multi-layered gaseous cover that plays an important role in the operation of all seasonal and terrestrial activities through the action of the atmosphere. The atmosphere is transparent to short waves of solar radiation and opaque to long rays of terrestrial radiation. Which maintains the average temperature on Earth. In the atmosphere itself, oxygen is provided for breathing by humans and animals and carbon dioxide is provided for plants to survive. The amount of water vapor present in the atmosphere provides sufficient life by affecting precipitation and the plant world. In this way, it is concluded that the operation of the whole earth is controlled by the atmosphere.

The atmosphere is a chemical composition in which many types of gases are found. Which remains in the atmosphere due to the effect of gravitational force. The weight of the atmosphere in the form of different layers is known as weight or air pressure weight. The amount of air pressure provides stability for oxygen and other gases at the site.

Mainly, the concentrations of two gases (oxygen at 21% and nitrogen at 78%) are found to be high in the atmosphere. While all others are found in the 1 percent part. Depending on the different layers of the atmosphere, there are changes in the temperature and amount of rainfall. The availability of the atmosphere itself provides indications of life on Earth as compared to other planets in the Solar System. The heat of the sun is conducted through the different layers of the atmosphere through terrestrial and short rays. The height of the atmosphere has been measured up to a height of 29000 km above sea level. In the chemical gas division, it is divided into two parts: the homosphere and the hectosphere. The composition of the atmosphere is made up of a combined mixture of water vapor, dust particles, salt particles, and gases. The relationship between protecting the earth and this atmosphere gives life to all living beings and plants. Apart from this, layers like the celestial, chromosphere, and photosphere also perform the functions of space in the atmosphere. In this way, the importance of the atmosphere is like a mirror for the earth, in which the reflection of the entire biosphere is visible.

7.5 GLOSSARY

Atmosphere: Branches dealing with the study of the atmosphere.

Celestial sphere: Science studying the position of celestial objects.

Homosphere: Equivalence base of atmosphere gases.

Ionospheres: Uppermost layer of earth's atmosphere.

Ozone: Layer that absorbs the ultraviolet rays coming from the Sun.

Photo spare: Bright part at the sun's surface.

Spectroscopy: The branch of physics that deals with the spectrum of electromagnetic radiation emitted by matter.

Stratosphere: Layer of uniform atmospheric conditions.

Tropopause: The layer found between the troposphere and stratosphere.

Ultraviolet rays: Harmful rays from this sun.

7.6 ANSWER TO THE CHECK YOUR PROGRESS

1. The atmosphere is a mixture of chemical gases that surround the earth.
2. The sufficiency of the atmosphere gives the Earth a special place in comparison to other planets.
3. 99% of the atmosphere is made up of oxygen and nitrogen gases.
4. Relative to other elements, dust, water vapor and salt particles are found in large quantities in the atmosphere.
5. Helium is the lightest gas found in the atmosphere.
6. The height of the atmosphere is estimated approximately 29000 kms from the sea level.
7. From the point of view of chemical composition, the atmosphere is divided into two layers, homogeneous and heterogeneous.
8. All the weather events of the atmosphere take place in the troposphere.
9. The stratosphere is considered the best layer of the atmosphere for aircraft operations.
10. Reflection of radio waves from the ionosphere towards the earth's surface.
11. The ozone layer is known as the life-saving belt of the earth.
12. The entire atmosphere is held together by the force of gravity.
13. The study of the atmosphere is known as meteorology.

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7.8 TERMINAL QUESTIONS

Long Question

1. Explain the meaning of atmosphere and its main elements.
2. Describe the gas percent in the composition of the atmosphere with a diagram.
3. Explain the different layers of atmosphere, and structure with the help of a diagram.
4. Give a summary of the present atmospheric condition in your own words.

Short Questions

1. What is atmosphere?
2. Which is the main gas found in the atmosphere?
3. What is the percentage of Oxygen and carbon dioxide found in the atmosphere?
4. Q4. The height of the atmosphere is fixed?
5. What is the importance of the ozone layer to the Earth?
6. Describe the elements that help in the composition of the atmosphere.
7. What is the process of heating and cooling of the troposphere?
8. What do you mean by stratosphere?
9. What is the homosphere?
10. Describe the chemical composition of the atmosphere.

Multiple Choice Questions

1. The surface of the atmosphere is formed?

a) Gases
b) Dust Particles
c) Water vapor particles
d) All of the above

2. What is the amount of Oxygen in the atmosphere?

a) 78 %
b) 72 %
c) 76%
d) 21%

3. What is the amount of Nitrogen in the atmosphere?

a) 74%

b) 78%
c) 77%
d) 21%

4. What is the amount of water vapor in the atmosphere?

a) 4%
b) 5%
c) 3%
d) 2%

5. What is the height bone the surface of the atmosphere?

a) 100Kms
b) 1100Kms
c) 1600Kms
d) 1800kms

6. How many parts are the layers of the atmosphere divided ?

a) 4 layers
b) 5 layers
c) 3 layers
d) 2 layers

7. What is the average height of atmosphere?

a) 14Kms
b) 12Kms
c) 16Kms
d) 18kms

8. In which zone do weather events mainly occur?

a) Troposphere
b) Stratosphere
c) Mesosphere
d) Ionosphere

9. In which layer D, E and F sub-layers are found?

a) Ionosphere
b) Stratosphere
c) Mesosphere
d) Troposphere

10. What is the height of the Ozone layer?

a) 20-30Kms
b) 16-35Kms
c) 18-40Kms
d) 20-50kms

11. What is a photosphere...?

a) Layer of ozone sphere
b) Branch of atmosphere
c) Bright part of the sun surface
d) Science studying

12. What is the height of the hectosphere?

a) 100-1000Kms
b) 90-10,000Kms
c) 120-20,000Kms
d) 500-30,000kms

Answers: 1-D, 2-D, 3-B, 4-A, 5-C, 6-B, 7-B, 8-A, 9-A, 10-B, 11-C, 12-B.

UNIT 8 - AIR PRESSURE AND WINDS

8.1 OBJECTIVES

After studying this unit, you should be able to:

- Understanding Weather Dynamics
- Know the meaning concept and meaning of air pressure and winds
- Know the factoring affecting the air pressure
- Understand the elements that influence atmospheric pressure.
- Understand the High and Low Pressure Systems
- Learn about the Coriolis effect.
- Understand about erosion meaning and concept
- Know about the different type of winds

8.2 INTRODUCTION

Welcome to the world of air pressure and wind! In this chapter, we'll explore the invisible forces that shape our weather, influence our daily lives, and make our planet's atmosphere come alive. From the weight of the air pressing down on us to the gentle or powerful breezes that touch our skin, we'll uncover the secrets behind these natural phenomena. Let's journey through the fascinating realm of air pressure and wind, understanding how they work together to create the winds that whisper and roar across our Earth

8.3 AIR PRESSURE AND WINDS

Air pressure, also known as atmospheric pressure, refers to the force exerted by the weight of the air molecules in Earth's atmosphere on a given area of the Earth's surface. It is the pressure that the air exerts in all directions due to the gravitational attraction between the Earth and the air molecules above it. In simpler terms, it's the "weight" of the air column above a specific point on the Earth's surface. The atmosphere is composed of a mixture of gases, primarily nitrogen (about 78%) and oxygen (about 21%), along with trace amounts of other gases. These gas molecules are constantly moving and colliding with each other and with surfaces, including the Earth's surface.

As you ascend in altitude, there are fewer air molecules above you, which means less weight pressing down. Consequently, air pressure decreases with increasing altitude. At sea level, the average atmospheric pressure is around 1013.25 millibars (mb) or 1013.25

hectopascals (hPa), which is roughly equivalent to 14.7 pounds per square inch (psi). These measurements provide a standard reference point for describing air pressure variations. Air pressure plays a vital role in weather systems and atmospheric processes. It's a key factor in determining wind patterns, as air flows from areas of higher pressure to areas of lower pressure. Variations in air pressure contribute to the development of high and low-pressure systems, which influence weather conditions, cloud formation, and the movement of storms.

Understanding air pressure is essential for meteorologists, pilots, and scientists studying atmospheric phenomena. Changes in air pressure are closely linked to changes in weather patterns, making it a critical element in weather forecasting and climatology.

Measuring Air Pressure and units of Pressure Measurement

The quantification of air pressure is achieved by gauging the elevation of mercury within a glass tube. At sea level, the conventional air pressure registers as 1013.25 millibars. The most precise method for gauging air pressure involves the utilization of a mercurial barometer, often referred to as Fortin's barometer. The mercury barometer, invented by Evangelista Torricelli in the 17th century, is a classic example. Modern barometers use various technologies, including aneroid cells, to provide accurate readings of atmospheric pressure.

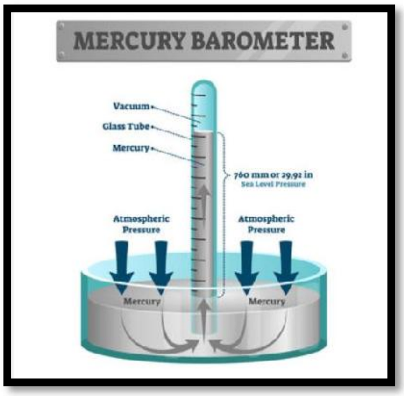

Fig. 8.1: Mercury Barometer, Source: Google.

In addition to the mercurial barometer, there exist various other types of pressure recording instruments. These include the aneroid barometer, an altitude barometer known as an altimeter, an automatic recording aneroid barometer called a barograph, as well as the micro-barograph and micro-barovariograph. Within the aviation context, a modified version of the aneroid barometer, specifically the altimeter micro-barovariograph, is employed as an exceptionally sensitive air pressure recorder. It has the capability to capture extremely subtle changes in air pressure, measuring variations on the scale of hundredths to thousandths of a millibar. The standard unit for measuring atmospheric pressure is the pascal (Pa), which is the force of one newton per square meter. However, other common units, such as millibars (mb) and inches of mercury (inHg), are often used in meteorology and everyday weather reports.

Pressure at Different Altitudes

Air pressure varies significantly at different altitudes within the Earth's atmosphere.As one ascends vertically, the weight of the air above decreases, leading to a decrease in atmospheric pressure. This relationship is due to the decreasing density of air molecules at higher elevations. For instance, at sea level, where the majority of Earth's atmosphere is concentrated, the pressure is highest, often referred to as 1 atmosphere or 1013.25 millibars. As altitude increases, such as when climbing a mountain, atmospheric pressure decreases steadily. This decrease in pressure has implications for both human physiology and weather patterns. Lower air pressure at high altitudes can lead to challenges in breathing and acclimatization for individuals not accustomed to such conditions. Moreover, in meteorology, the variation in pressure with altitude plays a crucial role in the formation of clouds, precipitation, and wind patterns, contributing to the diverse and dynamic nature of Earth's atmospheric phenomena.

Factors Affecting Air Pressure

Several factors influence air pressure, some of them are:

Temperature:

- As air warms, it becomes less dense and rises, leading to low-pressure areas.
- Cooler air is denser and sinks, causing high-pressure zones.

Altitude:

- Air pressure decreases with increasing altitude due to the decreasing weight of the air above.
- Higher altitudes have lower pressure because there is less air pressing down from above.

Humidity:

- Moist air is less dense than dry air because water vapor molecules are lighter than the molecules of nitrogen and oxygen in dry air.
- Higher humidity can lead to lower air pressure in a given volume.

Vertical Movement of Air Masses:

- Rising air leads to areas of low pressure, as it creates a void that needs to be filled.
- Sinking air creates areas of high pressure, as it compresses the air below.

Wind Patterns and Coriolis Effect:

- Wind blowing horizontally affects air pressure by redistributing air masses.
- The Coriolis effect, caused by the Earth's rotation, influences wind patterns, which in turn affect air pressure distribution.

Local Geography and Topography:

- Mountains and valleys can disrupt air flow, causing variations in pressure.
- Coastal regions experience different pressures due to interactions between land and sea breezes.

Solar Heating and Seasons:

- Sunlight warms the Earth's surface, creating regions of lower pressure at the equator and higher pressure at the poles.
- Seasonal changes alter temperature distribution, affecting pressure patterns.

Latitude:

- The equator receives more direct sunlight, leading to warm air rising and lower pressure.
- The poles receive less sunlight, resulting in cooler, denser air and higher pressure.

Variations in Air Pressure and Weather

Variations in air pressure observed across various meteorological stations display noteworthy disparities, a significant aspect that holds key implications for analyzing and comprehending weather dynamics. The standard reference for air pressure at sea level remains constant at 1013.25 millibars (mb). Nevertheless, air pressure undergoes constant fluctuations, both on a daily basis and across varying time intervals, rendering it an inherently dynamic parameter. Taking a global perspective on sea level pressure readings, the range spans from approximately 982 mb to 1033 mb. Notably, the highest recorded sea level pressure occurred on January 14th, 1893, in Irkutsk, Siberia, reaching an extraordinary 1075.2 mb.

The geographical distribution of air pressure across the Earth's surface is analyzed through the utilization of isobars, which are pivotal in delineating high-pressure zones, also known as anticyclones, and low-pressure areas, often referred to as cyclones or depressions.

These pressure categories, namely high and low, play a defining role in weather phenomena. Traditionally, it's widely held that elevated air pressure values correspond to clear and stable weather conditions, while lower atmospheric pressure is linked to inclement weather patterns. However, a more logical assertion would be that a consistent rise in air pressure suggests impending fair and settled weather, while a steady decline in barometric readings signals the approach of unsettled and cloudy conditions.

Pressure Gradient

In the context of air pressure, the pressure gradient refers to the rate of change of air pressure per unit horizontal distance. It represents the change in atmospheric pressure between two points along a line that is perpendicular to the isobars (lines connecting points of equal pressure on a weather map). In simpler terms, the pressure gradient indicates how quickly air pressure decreases or increases over a certain distance.

A steep pressure gradient occurs when there is a rapid change in pressure over a short horizontal distance, leading to closely spaced isobars on a weather map. This often corresponds to strong variations in weather conditions and can result in higher wind speeds as air rushes from high-pressure areas to low-pressure areas. On the other hand, a weak pressure gradient is characterized by a gradual change in pressure over a larger distance, leading to more widely spaced isobars. This situation typically corresponds to calmer weather and lighter winds.

Pressure gradient plays a fundamental role in understanding wind patterns and atmospheric circulation. The wind flows from areas of high pressure to areas of low pressure due to the pressure gradient force. This force, along with the Coriolis effect caused by the Earth's rotation, helps determine the direction and speed of winds on a global and regional scale.

Pressure Variations-Diurnal and Seasonal

Air pressure diminishes as altitude rises, decreasing about 0.1 inch or 3.4 millibars (mb) every 600 feet in altitude. However, this reduction rate is applicable primarily within a limited range of a few thousand feet. Roughly half of the total atmospheric pressure is confined to an altitude of approximately 1800 feet. Air pressure further undergoes seasonal, diurnal, and spatial fluctuations, with an average range spanning from 982 mb to 1033 mb. This pressure is far from uniform, showcasing substantial variations. Beyond the conventional horizontal and vertical pressure alterations, significant types of pressure variations include diurnal and seasonal fluctuations, each contributing to the intricate dynamics of atmospheric pressure distribution.

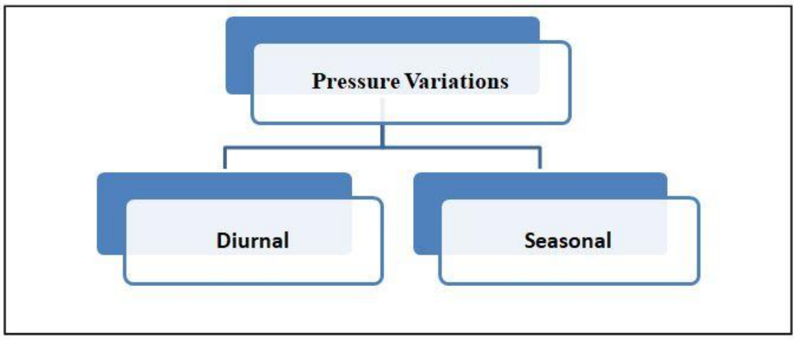

Fig. 8.2: Pressure Variation.

Diurnal Variations: Diurnal variations in air pressure refer to the daily fluctuation in atmospheric pressure that occurs over a 24-hour period. These variations are primarily influenced by the heating and cooling of the Earth's surface due to the Sun's daily cycle.

Seasonal Variation: Seasonal variation in air pressure refers to the changes in atmospheric pressure that occur over different seasons throughout the year. These variations are influenced by various factors, including the tilt of the Earth's axis, the Sun's angle, and the distribution of land and water on the planet.

High and Low Pressure Systems

Basically there are two atmospheric pressure patterns viz. low pressure systems and high pressure systems. High-pressure systems, or anticyclones, are areas where air pressure is higher than its surroundings, leading to descending air and generally clear and stable weather conditions. Low-pressure systems, or cyclones, have lower pressure and are associated with rising air, clouds, and potentially stormy weather.

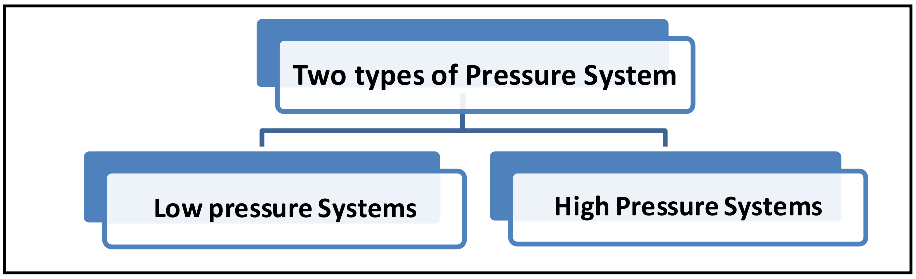

Fig. 7.3: Types of Pressure System.

High and low-pressure systems refer to areas of the Earth's atmosphere where air pressure is either higher or lower than the surrounding areas. Air pressure is the force exerted by the weight of the air molecules in the atmosphere above a particular location. These pressure systems play a crucial role in shaping weather patterns and determining the movement of air masses.

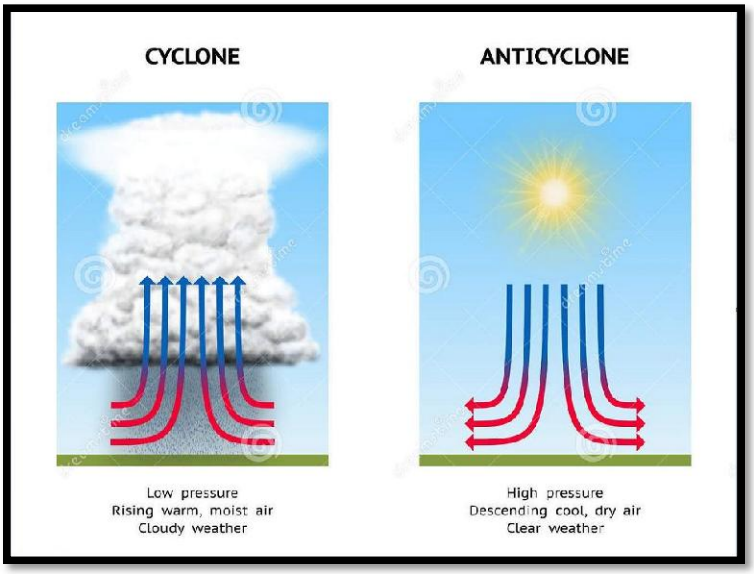

Fig. 7.4: Source:Google.

High-Pressure System (Anticyclone): A high-pressure system is characterized by air pressure that is higher than the pressure in the surrounding areas. In a high-pressure system, air tends to sink and diverge at the surface. As the air sinks, it warms up and becomes denser. This density creates an area of relatively clear skies and calm weather. High-pressure systems are associated with fair weather, stable atmospheric conditions, and light winds. Because the air is sinking and warming, it inhibits the formation of clouds and precipitation.

Low-Pressure System (Cyclone): A low-pressure system is characterized by air pressure that is lower than the pressure in the surrounding areas. In a low-pressure system, air tends to rise and converge at the surface. As the air rises, it cools and condenses, leading to the formation of clouds and precipitation. Low-pressure systems are associated with unstable atmospheric conditions, changing weather patterns, and often result in cloudiness, precipitation, and stronger winds. These systems are responsible for the development of weather phenomena such as rain, snow, and storms.

In the Northern Hemisphere, air flows clockwise around high-pressure systems and counterclockwise around low-pressure systems due to the Coriolis effect, which is a result of the

Earth's rotation. In the Southern Hemisphere, the flow direction is reversed. High and low-pressure systems are constantly moving and interacting, driven by various factors such as temperature differences, the Earth's rotation, and the distribution of land and water. These systems play a significant role in shaping weather patterns, and their movement can lead to shifts in weather conditions on a regional or even global scale.

Pressure Gradient Force

The pressure gradient force is the driving mechanism behind the movement of air from areas of high pressure to areas of low pressure. It influences wind direction and speed and is responsible for initiating atmospheric circulation patterns. In meteorology, the Pressure Gradient Force (PGF) is a fundamental concept that describes the change in air pressure over a given distance. It is the driving force behind the movement of air from areas of higher pressure to areas of lower pressure. The PGF plays a crucial role in the formation and dynamics of winds within the Earth's atmosphere. When there is a difference in pressure between two points, the PGF induces air to flow along the pressure gradient, leading to the establishment of wind patterns.

The PGF's effect is most pronounced when pressure differences are significant over short distances. This force is a primary factor in initiating atmospheric circulation, from gentle breezes to strong winds. However, in reality, the Coriolis effect and friction also come into play and influence the actual wind direction and speed. In summary, the Pressure Gradient Force is a key mechanism that helps to drive air movement and the development of winds, ultimately shaping weather patterns and contributing to the overall dynamics of the Earth's atmospheric circulation.

Coriolis Effect

The Coriolis effect, a consequence of Earth's rotation, exerts a significant impact on dynamic systems like wind patterns and ocean currents. In the Northern Hemisphere, moving air masses veer to the right, while in the Southern Hemisphere, they deflect to the left. This phenomenon arises due to the varying speeds of Earth's rotation at different latitudes. As Earth spins faster at the equator than at the poles, objects in motion, like air or water, appear to curve as they traverse the planet's surface. The Coriolis effect thus guides the development of prevailing winds, trade winds, and ocean gyres, steering weather systems and shaping global climate patterns. Understanding this force enhances our comprehension of Earth's intricate atmospheric and oceanic circulations, facilitating more accurate meteorological and oceanographic predictions.

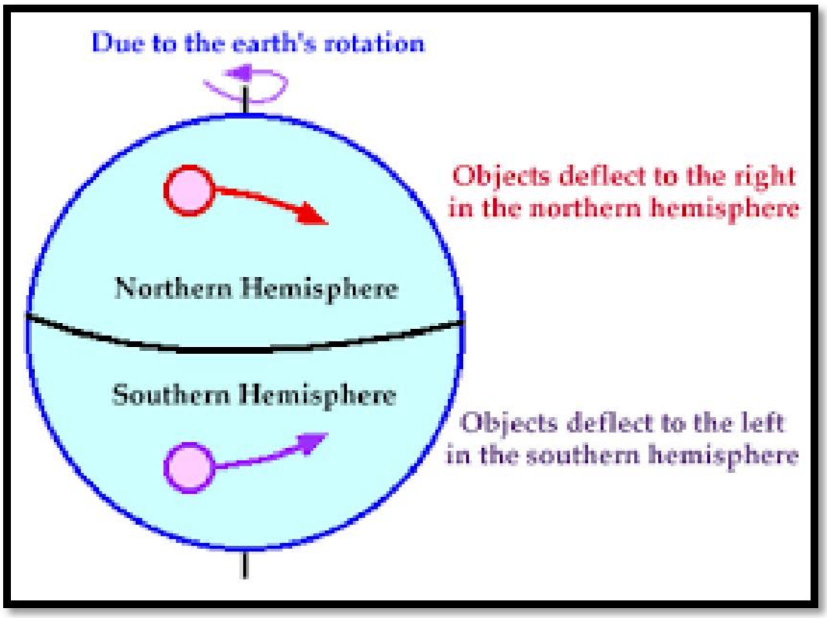

Fig. 7.5: Coriolis effect,Source:Google.

Isobars and Pressure Patterns

Isobars and pressure patterns are essential tools in meteorology for understanding and visualizing the distribution of air pressure across the Earth's surface. Isobars are lines on a weather map that connect points of equal atmospheric pressure. These lines provide a visual representation of pressure patterns, highlighting areas of high and low pressure systems. By closely observing the spacing and configuration of isobars, meteorologists can infer the presence of pressure gradients, which in turn influence wind patterns and weather conditions. Tighter isobar spacing indicates a steep pressure gradient, leading to stronger winds, while wider spacing suggests a weaker gradient and lighter winds. The arrangement of isobars also indicates the flow of air: wind tends to blow perpendicular to isobars, from high to low pressure areas due to the Pressure Gradient Force. Thus, isobars and pressure patterns serve as invaluable tools for meteorologists to predict and interpret weather phenomena, enabling the understanding of atmospheric dynamics and the anticipation of potential weather changes.

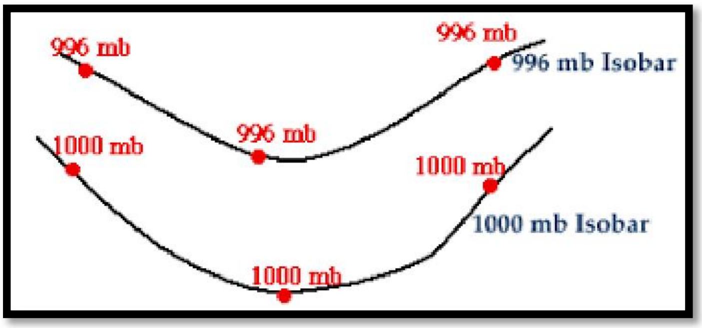

Fig. 8.6: Isobars, Source:Google.

Geostrophic Winds

Geostrophic winds are the result of the balance between the pressure gradient force and the Coriolis effect. These winds flow parallel to isobars (lines of constant pressure) at high altitudes, and their direction is determined by the pressure gradient.

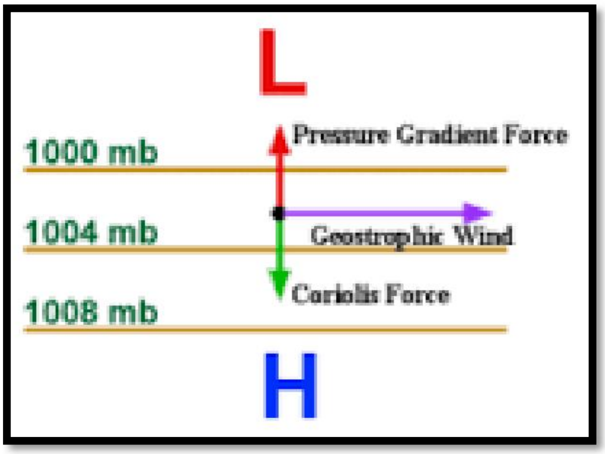

Fig. 8.7: Geostrophic Wind, Source:Google.

AIR PRESSURE BELTS

Air pressure belts are distinct zones that encircle the Earth, characterized by relatively consistent atmospheric pressure patterns. These belts result from the distribution of solar energy across the planet's surface, leading to variations in temperature, air density, and pressure. There are three primary air pressure belts:

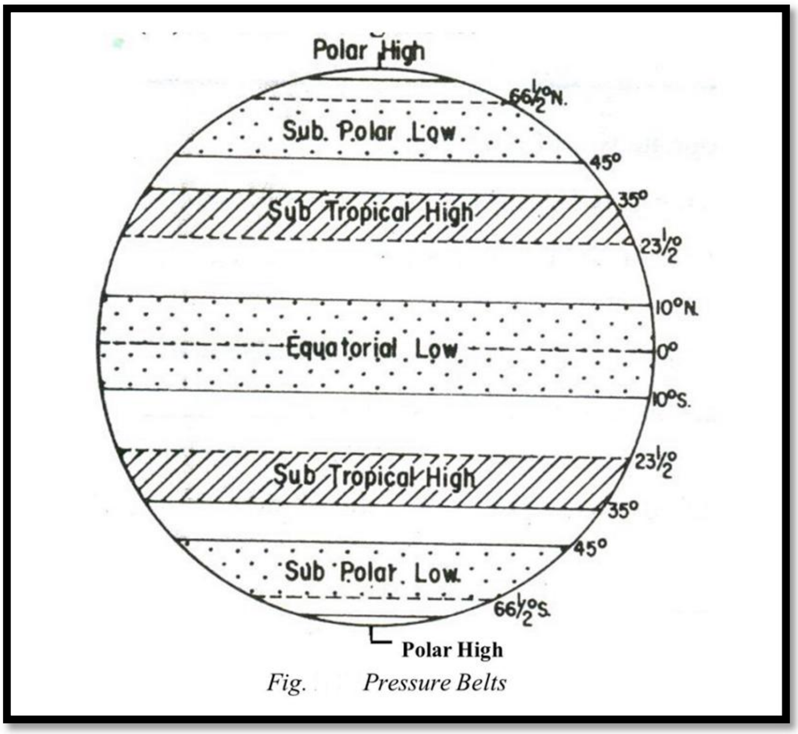

Fig. 8.8: Pressure Belt, Source: Google.

Equatorial Low-Pressure Belt (Doldrums): Found around the equator, this belt experiences low pressure due to intense solar heating. Warm air rises, creating an area of convergence with rising moist air, resulting in abundant rainfall.Associated with the Inter-Tropical Convergence Zone (ITCZ), characterized by frequent thunderstorms.

Subtropical High-Pressure Belts (Horse Latitudes): Located around 30 degrees north and south of the equator, these belts experience high pressure. Sinking cool and dense air creates areas of divergence and dry conditions.Favorable for trade winds and arid climates, such as deserts.

Sub-polar Low-Pressure Belts: Situated around 60 degrees north and south of the equator, these belts display low pressure. Rising moist air and convergence cause cloudy and wet conditions, often resulting in frequent storms. The position and intensity of these air pressure belts shift seasonally due to the tilt of the Earth's axis and its orbit around the Sun. Understanding air pressure belts aids in comprehending global atmospheric circulation patterns, which in turn influence weather, climate, and wind systems on a global scale.

WIND

Imagine standing outside on a breezy day, feeling the air gently tousling your hair. Have you ever wondered why the wind blows? Well, get ready to unravel the secrets of wind – the invisible force that stirs up the air around us.

What is Wind?

Wind is like the Earth's way of talking to us. It's the movement of air from one place to another. You can't see it, but you can feel its touch. Wind happens because the sun heats our planet unevenly. Some places get warmer than others, and warm air rises while cool air sinks. This creates a kind of air traffic – warm air rushes to cooler areas, and this movement is what we feel as wind. OR In very simple sentence we can say that moving air is called as wind.

Factors Affecting Wind Motion

Various factors influence the motion of wind, shaping its direction and speed. These factors work together to create the complex patterns of wind we observe in the atmosphere. Here are some key factors that affect wind motion:

(i)Pressure Gradient Force: Differences in air pressure between two points drive the movement of air from high-pressure areas to low-pressure areas. The greater the pressure difference over a given distance, the stronger the resulting wind.

(ii) Coriolis Effect: The Earth's rotation causes moving air to be deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. This effect influences the direction of wind patterns and causes them to curve.

(iii) Friction: Friction with the Earth's surface slows down the wind, especially near the ground. This is why winds at higher altitudes often move faster and in a more direct path than near the surface.

(iv) Temperature Differences: Variations in temperature between different regions cause differences in air density. Warmer air is less dense and tends to rise, creating areas of lower pressure. Cooler air is denser and tends to sink, leading to areas of higher pressure.

(v) Land and Water Contrasts: Land heats up and cools down more quickly than water. This temperature difference between land and water surfaces influences the development of local wind patterns, such as sea breezes and land breezes.

(vi) Mountainous Terrain: Mountains can obstruct the flow of air, causing it to be forced upward. As air ascends the windward side of a mountain, it cools and can lead to the formation of clouds and precipitation. On the leeward side, the air descends, warming and becoming drier.

(vii) Ocean Currents: Ocean currents influence the temperature and moisture content of the air above them. Air passing over warm ocean currents becomes more humid, while air over cold currents becomes cooler and drier.

(viii) Planetary Scale Circulation: The Earth's global atmospheric circulation patterns, such as the Hadley, Ferrel, and Polar cells, play a role in steering winds at different latitudes and creating prevailing wind patterns.

These factors interact in intricate ways, resulting in the diverse and complex wind patterns that drive weather systems and shape climates around the world. Understanding these influences is crucial for meteorologists and climatologists in predicting and explaining atmospheric phenomena.

Classification of Winds

The Winds are classified into two broad categories:

1. Invariable winds/ Permanent winds /Planetary winds/Prevailing winds
2. Variables winds

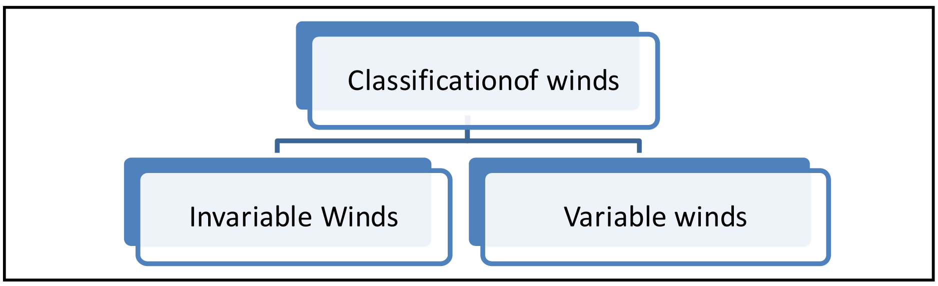

Fig. 8.9: Classification of Winds.

Invariable Winds: Navigating the Global Air Highways

Invariable winds, also known as global winds/permanent winds/prevailing winds/planetary winds, are large-scale wind patterns that encompass the Earth's surface and play a pivotal role in shaping weather, climates, and ocean currents. Invariable winds are consistent patterns prevailing over specific regions. These winds result from the complex interaction between solar heating, the Earth's rotation, and the distribution of land and water. Let's explore these intricate patterns in detail:

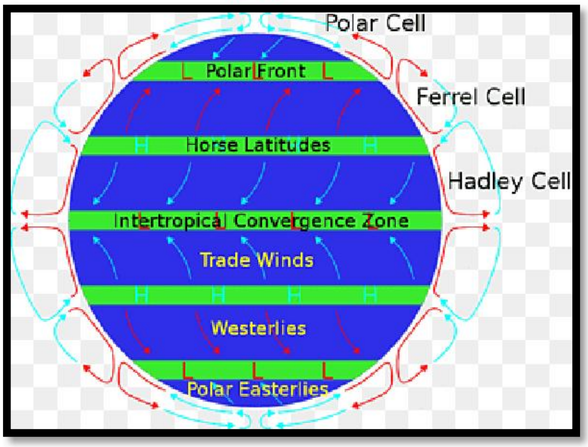

Fig. 8.10: Invariable Winds, Source: Google.

1. Trade Winds: Trade winds are easterly winds that flow from the subtropical high-pressure zones towards the equator. In the Northern Hemisphere, they are deflected by the Coriolis effect and curve westward, becoming the northeast trade winds. In the Southern Hemisphere, they curve to the west, forming the southeast trade winds. Trade winds are consistent and reliable, making them historically crucial for maritime trade routes.

2. Westerlies: Westerlies blow from the subtropical high-pressure zones towards the poles. In the Northern Hemisphere, they flow from the west, and in the Southern Hemisphere, from the east. The Coriolis effect deflects them, resulting in the prevailing westerly winds in the mid-latitudes. Westerlies are responsible for steering weather systems across continents and are instrumental in the movement of mid-latitude cyclones.

3. Polar Easterlies: Polar easterlies originate from the polar high-pressure zones and flow towards lower latitudes. The Coriolis effect deflects them to the west in both hemispheres, creating the polar easterly winds. These winds are cold and dry due to their origin from the polar regions.

Interplay with Pressure Zones: The interactions between invariable wind belts are influenced by the distribution of high and low-pressure zones. The equator experiences a low-pressure zone due to intense solar heating, while the poles have high-pressure zones due to the cold air sinking. These pressure differences create the driving force behind the planetary winds.

Hadley Cells and Ferrel Cells: The combination of trade winds, westerlies, and polar easterlies gives rise to circulation cells in the atmosphere. Hadley cells exist near the equator, where warm air rises, moves poleward at high altitudes, and then descends in the subtropical high-pressure zones. Ferrel cells exist in the mid-latitudes, driven by the interaction between polar easterlies and westerlies.

Effects on Climate and Weather: Planetary winds have profound effects on climate and weather patterns. Trade winds contribute to the arid conditions of deserts at around 30 degrees latitude, while westerlies influence the weather in mid-latitude regions. These winds also influence ocean currents, as they drive the movement of surface waters, affecting marine ecosystems and regional climates.

Variable Winds

Variable winds, a fascinating aspect of atmospheric dynamics in geography, exemplify the dynamic and unpredictable nature of our planet's air currents. Variable winds divided into four category viz seasonal winds, Local winds, mountain winds. Unlike the well-defined global wind patterns , variable winds fluctuate in both direction and intensity due to an array of influencing factors. These factors encompass diverse elements such as local weather conditions, topography, pressure gradients, and interactions between land and sea. Urban areas, with their intricate structures, also contribute to the complexity of variable winds, creating distinct microclimates. These winds, while challenging to predict, have significant implications across domains like aviation, wind energy, fire behavior, navigation, and meteorological research. Studying variable winds not only unveils the intricate dance of atmospheric forces but also underscores the importance of understanding their impact on our lives and the environment.

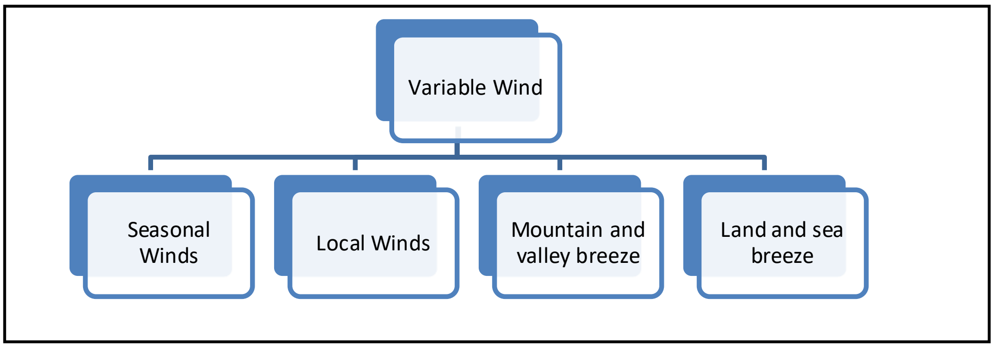

Fig. 8.11: Variable Winds.

Seasonal Winds

Seasonal winds, a fascinating component of Earth's atmospheric circulation, bring rhythmic changes to weather patterns and climates in different regions. Also known as monsoons, these winds exhibit distinct reversals in direction between seasons. In summer, when land heats up faster than oceans, low-pressure zones form over the landmass. Cooler air from the ocean rushes in, resulting in a moist, maritime air mass that brings heavy rainfall. Conversely, in winter, the land cools rapidly, creating high-pressure areas that draw dry air from the land to the ocean. These alternating wind patterns impact vast areas, significantly influencing agriculture, ecosystems, and water resources. Monsoons play a crucial role in regions like South Asia, where they shape the wet and dry seasons and have profound cultural and economic significance. Understanding seasonal winds offers insights into the complex interactions between solar radiation, temperature, and atmospheric pressure, contributing to a deeper comprehension of Earth's dynamic climate systems.

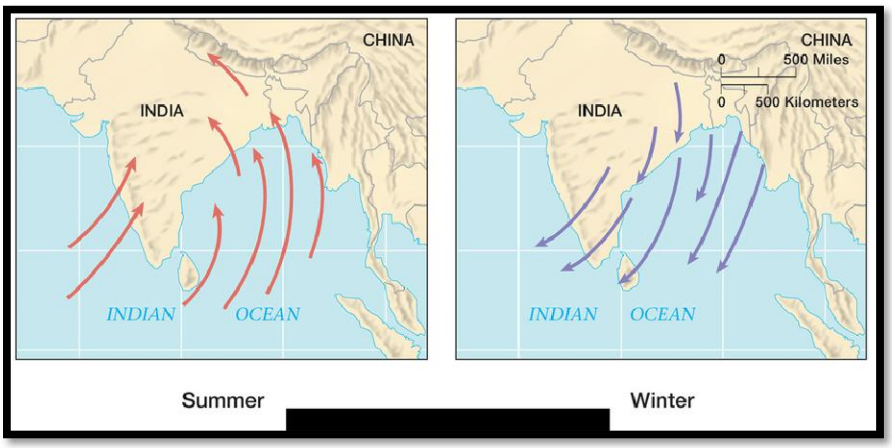

Fig. 8.12:Seasonal Winds, Source:Google.

Mountain Breeze and Valley Breeze

A mountain breeze, a phenomenon in geography, refers to the flow of cooler air from higher elevations, such as mountains, down to lower valleys or plains. This breeze typically occurs during the night when the Earth's surface cools down after sunset. As mountains lose heat faster than valleys, the air above them becomes colder, denser, and heavier. This dense, cool air then descends down the slopes of the mountain and flows into the valleys, creating a gentle wind known as the mountain breeze. It's a natural process driven by temperature differences and is part of the intricate play between land and atmosphere.

Valley breeze, a simple concept in geography, happens during the day when the Sun warms up the Earth's surface. As the valley's air heats up, it becomes lighter and rises. Cooler air from the surrounding higher areas, like hills or mountains, rushes in to fill this space, creating a breeze that flows up the valley. This gentle wind is the valley breeze, a natural outcome of the Sun's warmth and the movement of air.

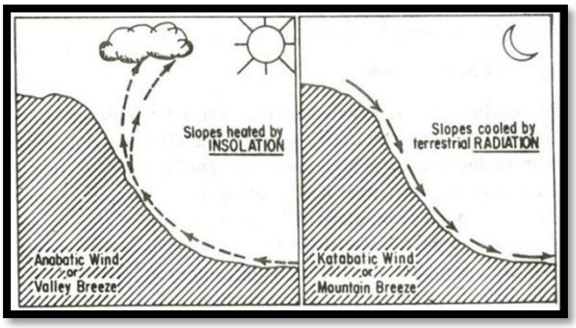

Fig. 8.13: Valley and Mountain Breeze, Source: Google.

Sea Breezes and Land Breezes

Sea Breezes: During the day, the land heats up more quickly than the adjacent sea. This causes air to rise over the land, creating a low-pressure area. Cooler air from the sea moves in to replace it, forming a sea breeze.

Land Breezes: At night, the land cools more rapidly than the sea. This causes higher pressure over the land and lower pressure over the sea. Air moves from the land to the sea, creating a land breeze.

Fig14: Land and Sea Breeze, Source: Google

Local winds

The local winds are an important part of World geography. These winds are formed by the heating of land. There are many local winds around the globe. Besides major wind systems of the earth's surface , there are certain types of winds , even though on a much smaller scale , which are produced by the topographical peculiarities or local temperature differences. These wind systems are generated by purely local factors and their zone of influence is quite limited, they have been classified as local winds, quite distinct from the large macro-scale global circulation global circulation. Following is a brief account of some of the well-known local winds which are found different parts of the world. Excepting land breeze, sea breeze, mountain breeze, and valley breeze The local winds are put in two broad categories: hot winds and cold winds.

Hot local winds, which are warm winds specific to a certain area, result from the movement of warm air originating in a hotter region. Alternatively, they can be generated when air descends from higher terrain to lower areas, warming dynamically due to the descent.

Certainly, here is a list of hot local winds along with their respective countries or regions:

- Chinook: United States and Canada (Rocky Mountains)
- Santa Ana Winds: United States (Southern California)
- Foehn: Europe (Alps), New Zealand (Southern Alps), Argentina (Andes)
- Sirocco: Mediterranean region (especially North Africa)
- Zonda: Argentina (Andes)
- Sharav: Israel and surrounding areas
- Bora: Adriatic Sea region (especially Croatia)

- Nor'wester: New Zealand (Canterbury Plains)
- Khamsin: Egypt and Sudan
- Harmattan: West Africa (Sahel region)

Local cold winds are chilly winds specific to particular areas, often causing colder temperatures. Here are three examples with their corresponding countries:

- Mistral: France
- Bise: Switzerland
- Buran: Russia

8.4 SUMMARY

Air pressure and wind are essential components of Earth's atmospheric dynamics that shape weather patterns, climate, and local conditions. Air pressure, the weight of the atmosphere pushing down on the Earth's surface, varies with altitude and influences wind patterns. Wind, the movement of air from areas of high pressure to low pressure, arises due to differences in temperature and pressure. These two phenomena are closely interconnected, driving the circulation of the atmosphere.

High-pressure areas result from descending air that warms and suppresses cloud formation, leading to fair weather. Conversely, low-pressure zones form where rising warm air cools and condenses, resulting in cloudiness and precipitation. The movement of air between these pressure zones creates wind, with the Coriolis effect, caused by the Earth's rotation, influencing wind direction. Global wind patterns include trade winds, westerlies, and polar easterlies. These planetary winds are driven by the uneven heating of the Earth's surface and its rotation. Additionally, local wind systems like sea and land breezes and mountain and valley breezes are influenced by temperature differences between land and water or topographic features.

Understanding air pressure and wind is crucial for comprehending weather phenomena such as storms, monsoons, and local weather patterns. It also has practical applications in aviation, agriculture, and energy generation. By grasping these fundamental concepts, students can delve into the intricate workings of Earth's atmosphere and the forces that shape our world's climate and weather.

In conclusion, the interplay between air pressure and wind is a fundamental force shaping our planet's atmosphere. The variations in air pressure, driven by temperature differences and the Earth's rotation, give rise to wind patterns that influence weather, climate, and local conditions. The movement of air from areas of high to low pressure creates a dynamic circulation that affects our daily lives and the natural world around us. Understanding this relationship deepens our appreciation of the complex forces driving atmospheric dynamics and their profound impact on Earth's systems.

8.5 GLOSSARY

- **Aneroid barometer:** A device for measuring air pressure without using liquid, also known as a barometer without liquid.
- **Coriolis Effect:** The apparent deflection of moving objects due to the Earth's rotation.
- **Ferrel Cells:** Intermediate atmospheric circulation cells located between polar and Hadley cells, contributing to global wind patterns.
- **Geostrophic Winds:** Geostrophic winds are upper-level winds that flow parallel to isobars due to the balance between the Coriolis effect and pressure gradient force.
- **Hadley Cells:** Large-scale atmospheric circulation patterns near the equator, characterized by rising warm air at the equator, poleward movement at high altitudes, and descending cool air in the subtropics.
- **Land Breezes:** A gentle wind that flows from land to sea during the night, caused by the temperature difference between the land and the water.
- **Ocean Currents**: Ocean currents are continuous flows of water within the Earth's oceans, driven by various factors such as wind, temperature, and Earth's rotation.
- **Pressure Gradient**: Pressure gradient, a change in air pressure across a given distance.
- **Sea Breezes:** Local winds that occur during the day as cooler air from the sea moves towards warmer land.
- **Trade Winds:** Steady, easterly winds flowing towards the equator, caused by the Earth's rotation and pressure differences.

- **Wind:** Moving air, driven by differences in atmospheric pressure and temperature.

8.6 ANSWER TO CHECK YOUR PROGRESS

1. Do you know that moving air is called wind?
2. Do you know that air pressure, also known as atmospheric pressure?
3. Do you know that as we climb any mountain, we have trouble in breathing because of the low atmospheric pressure at high altitude?
4. Do you know that at sea level, the average atmospheric pressure is around 1013.25 millibars (mb)?
5. Do you know that the mercury barometer, invented by Evangelista Torricelli in the 17th century?
6. Do you know that the standard unit for measuring atmospheric pressure is the Pascal (Pa)?
7. Do you that an altitude barometer known as an altimeter?
8. Do you that the study of weather is called meteorology, and a person who studies the weather is called a meteorologist.
9. Do you know that Winds are classified into two broad categories i.e. invariable wind and variable wind?
10. Do you know that Indian monsoon is an example of seasonal wind?
11. Do you know Monsoon is derived from the Arabic word 'mausim', which means seasons?
12. Do you know that invariable winds also know as Planetary winds?

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8.8 TERMINAL QUESTIONS

Long Questions

1. What is air pressure? Discuss the pressure belts of the earth.
2. How many types of winds? Explain in detail with the help of appropriate diagrams.

Short Questions

1. What is Coriolis Effect?
2. What are the Factors that Affecting the Air Pressure?
3. Write definition of Mountain Breeze and Valley Breeze.
4. What are the factors that Affecting Wind Motion.
5. Write in 150-200 words paragraph on High and Low Pressure Systems.
6. What is anticyclone?
7. What is cyclone?
8. Classification of Winds.

Multiple Choice Questions

1. **What is another name of Air Pressure?**
   a) Atmospheric Pressure
   b) Wind Pressure
   c) Closed Pressure
   d) Water Pressure

2. **What is the atmosphere made up of?**
   a) Gases
   b) Dust Particles
   c) Water Vapour
   d) All of the above

3. **What is the average air pressure of the Atmosphere?**
   a) 1012.25 Mb

b) 1013.25 Mb
c) 1000.00 Mb
d) 1253.00 Mb

4. What is the measurement unit of Air Pressure?
a) DB
b) Mb
c) Meter
d) Kilogram

5. What are the affecting factors of Air Pressure?
a) Temperature & Wind
b) Humidity & altitude
c) Latitude
d) All of the above

6. **How many types of Pressure variation**.
a) 3
b) 1
c) 2
d) None of the above

7. What is Isobar line?
a) Line of Equal Temperature
b) Line of Equal Height
c) Line of Equal Air Pressure
d) Line of Sea Level

8. How many types of Pressure Belts?
a) 5
b) 3
c) 4
d) 7

9. Winds are mainly divided into how many parts?
a) 3
b) 2
c) 1
d) 4

10. Trade winds blow in which Hemisphere?
a) Northern and Southern Hemisphere
b) Southern Hemisphere
c) Northern Hemisphere
d) Western Hemisphere

11. Which of the following is a seasonal wind?

a) Chinook
b) Monsoon
c) Santa Ana
d) Bora

Answers: 1-A, 2-D, 3-A, 4-B, 5-D, 6-C, 7-C, 8-D, 9-B, 10-A and 11-B.

UNIT 9 - ECOLOGY AND BIODIVERSITY WITH SPECIAL REFERENCE TO UTTARAKHAND

9.1 OBJECTIVES

- Importance of biodiversity for environment and humans.
- Outline the interrelationship of a wide range of human, animals and micro-organisms.
- To study the biodiversity of Uttarakhand.
- To develop an understanding of biodiversity conservation & degradation.
- Suggestion for biodiversity conservation in Uttarakhand.
- To understand the diversity and regional distribution of Uttarakhand.

9.2 INTRODUCTION

Ecology is a branch of biology and geography. This science is going to study the mutual relations of living communities with their environment; each living being or plant lives in a certain environment. How animals and plants interact with the environment in the complex structure of the earth. Its regional in-depth study runs only on ecology. In which many diversities of animals and plants are found. The variations found in the earth's crust are known as biodiversity. In a nutshell, diversity means the number of fauna and flora found in a certain land area, which is related to the study of types of plants, animals, and microorganisms and their mutual relations. Biodiversity is studied in three parts based on genetic variations among community species.

A geographical study of biodiversity in the context of Uttarakhand reveals that about 4000 species of plants belonging to 1198 species are found in 192 clans of the geographical biological community of the entire country. This biodiversity is found from the Terai region to the ranges of the Great Himalayas; most of the ecological biodiversity is seen in the Shivalik and Central Himalayan regions; and about 102 species of North India are found in Uttarakhand. The excellence of biodiversity is estimated from Asia's first National Park "Jim Corbett Park", which is the world's first Biodiversity Conservation Park Center. The expansion of biodiversity in Uttarakhand is present in a landscape spread over an area of 38000 square kilometers. This is 45 percent of the total forest area of Uttarakhand. The Uttarakhand Biodiversity Board was constituted in 2006 by the Government of Uttarakhand as per the Biodiversity Act 2004.

It was reconstituted in 2011, and work was done to conserve biodiversity on a large scale. Under which Wildlife Sanctuary, National Park, and forest reserve schemes have been included. Due to human development and forest marginalization, the biodiversity structure of Uttarakhand is in a state of crisis, due to which 161 species are in rare and endangered condition, while the Himalayan state of Uttarakhand is home to various flora and fauna. And it is a region rich in animals. In terms of biodiversity, all types of animals, plants, grasslands, and shrubs are found in Uttarakhand in its various river valleys, mountain ranges, plains (Bhabar Terai), and Shivalik regions.

9.3 ECOLOGY AND BIODIVERSITY WITH SPECIAL REFERENCE TO UTTARAKHAND

The word ecology is derived from the Greek word oikos, which means domestic or living space and is made up of two words, oikos and logos, oikos meaning house and logos meaning study; that is, the science of studying the house is called ecology. Is. The term ecology was first used by the German scholar Ensert Haeckel in 1869 AD.

In general terms, ecology is called that general science that includes the study of mutual relations between the living community and its environment. Because every organism or plant has a certain environment, in ecology, the important relationships between all organisms, including humans, and the physical environment around them are understood.

According to Odum, "Ecology is the study of the structure and function of the ecological system, or ecology is the study of the structure and function of nature".

Thus, the ecosystem is the basic unit of ecological study. All affect each other. Understanding the study of complete biotic-abiotic components and signs of complex processes is clear. The similarity and disparity of ecology are also known because, in the beginning, bioscience, confined to biology, was limited to a narrow level. It was left until now, but at present, its field has become wider with all the sciences. The laws, concepts, and principles of ecology are gradually being used in planning works; the principles of ecosystem, energy-nutrient level, cycling of substances, and Evolutionary changes in flora are being prominently included. which is clear from figure 9.1.

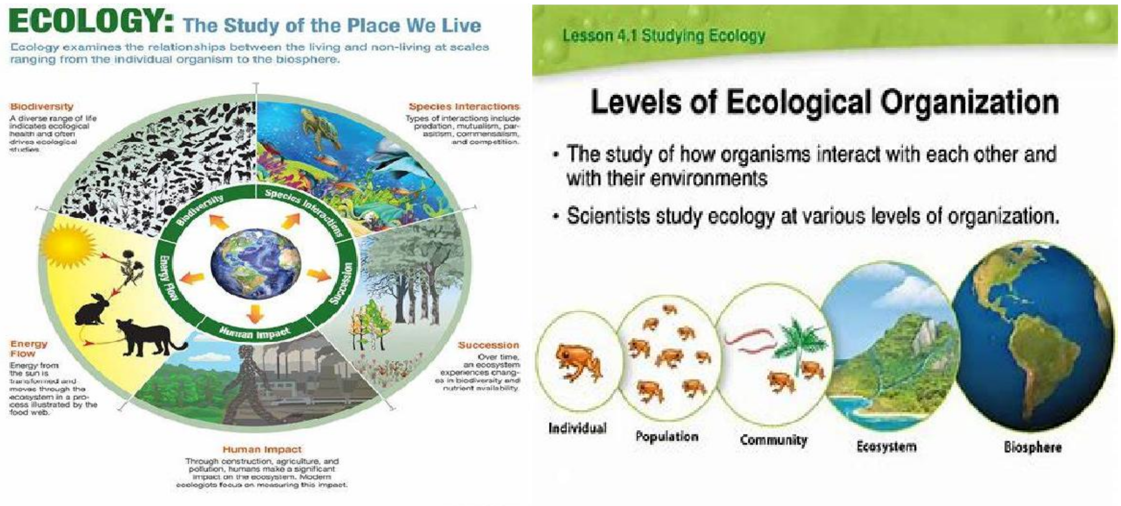


Fig. 9.1: Source: www.bing.com>Ecology.

Branches of ecology

The study of ecology is mainly done in three branches.

Autecology: It involves the study of an individual plant, animal, or species, its immediate environment, and its relationships and effects. Which is clear from figure 9.2.

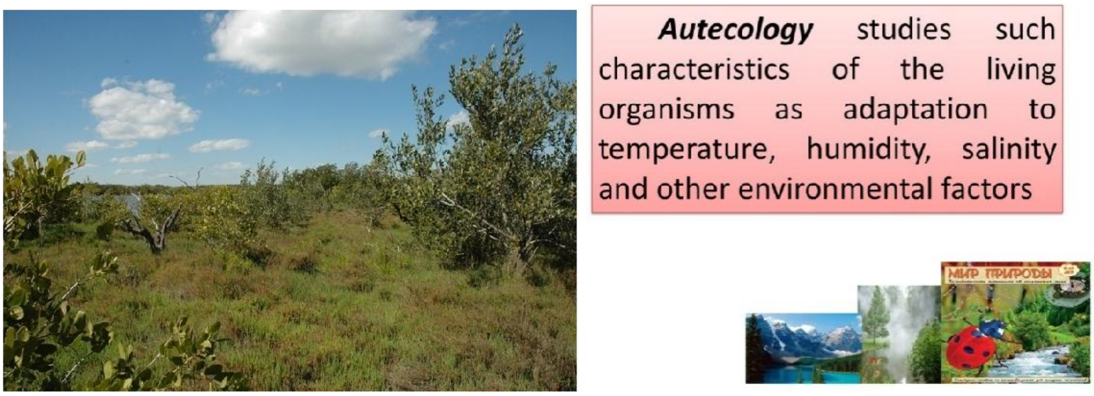


Fig. 9.2: Source: www.bing.com>Ecology.

Synecology: In community ecology, all plant and animal communities found in one place are studied for their composition, behavior, and environmental relations. Which is clear from figure 9.3.

Ecosystem ecology: The overall study of the interrelationships of life and livelihood in the ecosystem of a place, the cycling of energy flow elements and the food web is done under this which is clear from figure 9.4.

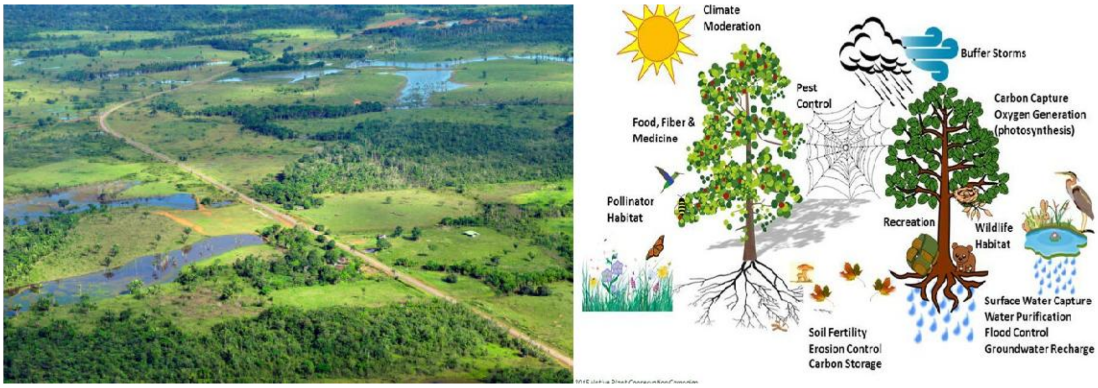


Fig. 9.3: Source: www.bing.com>synecology.

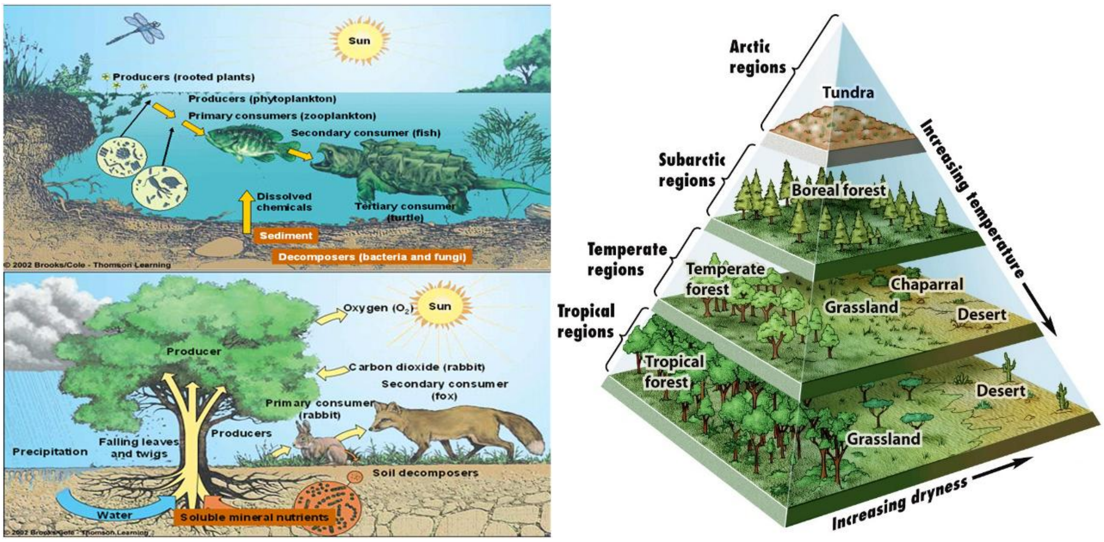


Fig. 9.4: Source: www.bing.com> ecosystem Ecology

Therefore, in this way, the knowledge of the ecology of Uttarakhand is a comprehensive study of the elements of the habitat and environment of all the living beings in this region. The daily activities of living beings, which are necessary for survival, are determined based on the geographical variations of the region, in which sunlight, water or rain, air, atmospheric moisture, the height above sea level of a particular place, and land type play a role. Slope, the form of underground water, and biological factors mainly affect its ecology. Based on these elements, the development and structure of biodiversity and infrastructure contribute to the development and understanding of the ecological system of Uttarakhand, the proof of which is the unique and rich biodiversity of Uttarakhand state. Based on strong ecology, the regional distribution of biodiversity has been established for a long time in different parts of the earth (especially in Uttarakhand).

Meaning and Definition of Biodiversity

Biodiversity is made up of the two words bio and diversity, where bio means Bio and diversity means variety. That is, the number of organisms found in a certain geographical area and their diversity are called biodiversity. Biodiversity is the abundance of species of humans, naturally nourished animals, and plants found in a natural region. The term biodiversity was widely used in the 1992 conference held in Rio de Janeiro on biodiversity. Diversity is the diversity found among all terrestrial, marine, inter-regional, and aquatic ecosystems. Biodiversity is the combined form of diversity located among different species. The term biodiversity was first used by WG Rogan in 1985, but in 1986, ET Wilson suggested the term biodiversity in place of biological diversity.

By definition, biodiversity is the variation, heterogeneity, and ecological complexity found in living organisms.

Nature of biodiversity

Biodiversity is diverse in nature. The diversity of animals, plants, fungi, and even microorganisms that make up our natural ecosystem is a complex structure that naturally maintains balance and holds life together in an ecosystem. Which is clear from figure 9.5.

Fig. 9.5: Source: www.bing.com> Biodiversity in Uttarakhand.

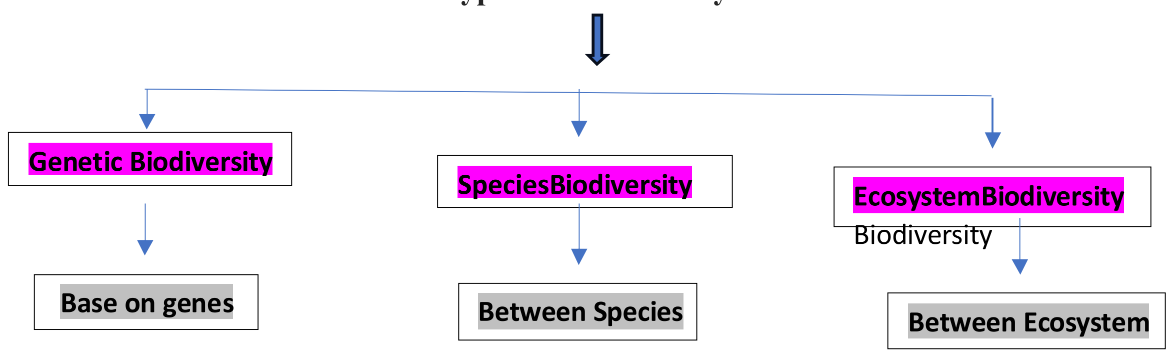
Area of biodiversity

All the areas of life existing on the earth are included under the category of biodiversity. Variation in climate, physical structure, altitude, and soil enables many types of animals and plants to arise in different forms in different regions. The entire biosphere is a region of biodiversity. Continental influence, climate change, mountain building forces, and landslides determine the local area of biodiversity.

Types of biodiversity

The current biodiversity of the earth's surface is a unique creation of nature. According to geographical diversity, the place of living plants in the whole world is determined. Climate change gives rise to biodiversity in many forms by determining the habitat, physical diversity, environmental adjustment, and adaptation of animal species on earth. In which mainly Gene Pool, Genetic Drift, Genetic advancement, Genetic illumination, and the gradient of Biodiversity determine the types and areas of diversity. Biodiversity is made up of the sum of the two words bio and diversity, where bio means Bio and diversity means diversity. That is, the number of organisms found in a certain geographical area and their diversity are called biodiversity. In general, the biodiversity is divided into three types.

Types of Biodiversity



Genetic Diversity: In general terms, the meaning of genetic diversity is the change in the genes of the same species of organisms in a community.

Species Diversity: The diversity that exists in biological beings (living beings) is called species diversity. There are many inequalities in biodiversity on earth, to which climate has a special contribution. The monsoon climate of India is a typical example of diversity and gives rise to species diversity.

Ecological diversity: The difference found between natural habitats and ecosystem types is called ecological diversity.

Biodiversity in Uttarakhand

The geographical structure and Himalayan location of Uttarakhand provide richness for biodiversity. The physical asymmetry where the northern part is glaciated gives rise to a biodiversity characterized by polar characteristics that adapt to complex environmental conditions. Where limited species of animals and plants can flourish, the intermediate highlands are characterized by a temperate climate and form many river valleys due to the origin of rivers. With the help of many types of diverse flora and fauna, this area is going to imbibe both the characteristics of the upper and middle Himalayas. Biodiversity: Wide conifer trees are found more in the plant species here due to the snow cover in winter, and the recognition of the reduction in the number of animals or animals or migration gives this area a special identity.

In the same summer, when the snow melts here, many types of small grasses grow, and small grasslands like meadows are born in many places. With more and more soft grass, the beautiful natural scenery attracts the elders as well as the seasonal shepherds and sheep. By providing animal fodder for rearing, the summer biodiversity provides a unique form in the central Himalayan region which is a unique natural creation in the world of biodiversity in this geographical area. The Shivalik ranges, located to the south of the Central Himalayas, have the world's densest biodiversity in terms of biodiversity. which is clear from figure 9.6.

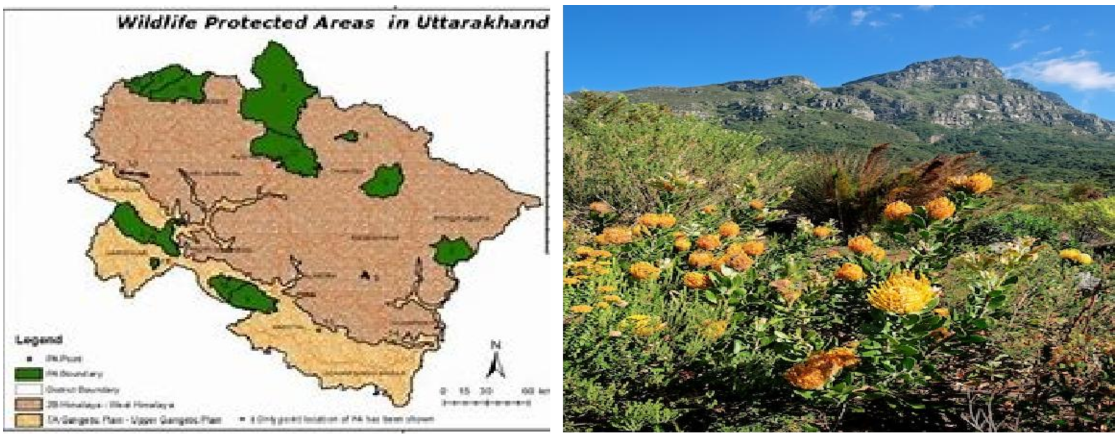


Fig.9.6: Source: www.bing.com> Biodiversity in Uttarakhand.

This Himalayan region, characterized by a temperate tropical climate and present in the entire Himalayas at an altitude of 800 to 1200 meters, has been home to many types of flora and fauna for a long time. Almost all the vegetation found in Uttarakhand presents a unique example of biodiversity here; the comparison of botanical diversity in biodiversity is in the middle place here. The densest forest cover is found in the Shivalik tract. The southern part of Shivalik, the Doon-Dwar valleys, Bhabar, and Tarai regions are plains characterized by a distinct climate. Where many types of fauna are found, which is an optimal natural and human diversity habitat for micro- to giant organisms, while the vegetation cover is less rich than the Shivalik region. Due to its flatness, this area is the highest multi-use plot in terms of biodiversity development and human use. Where all the climatic and physical conditions are optimal for artificial biodiversity development.

Biodiversity is an invaluable treasure in Uttarakhand. It is a rich state in terms of fauna and flora, which holds its special place in India with intensive bio-diversity and provides richness to the state with biodiversity, in which the number of organisms is dense, whereas in some Himalayan regions, this diversity is rare. is in fact, Uttarakhand's diverse physical conditions, structure, climate conditions, and flora and fauna provide a special form of biodiversity. According to the Uttarakhand Forest Research Institute, 43 plant species are found here, of which about 56 are in a state of sensitive extinction and 4000 are in protected habitat. 161 species are currently endangered and have been declared rare by the International Union for Conservation of Nature. Which is clear from figure 9.7.

Fig.9.7: Source: www.bing.com> Biodiversity in Uttarakhand.

In the fauna's species diversity, there are about 102 species of mammals, 623 types of birds, 124 types of fish, 19 types of amphibians, and 69 types of vertebrates. Due to human cultural interference, some unique species in a state rich in biodiversity are becoming extinct. In which the main ones are (Asian Elephant, Snow Leopard, Tiger, Musk Deer, Himalayan Monal, King Cobra Bharal).Flora and Fauna According to the 2030 census, 3167 tigers have been found here, which is in third place after Madhya Pradesh and Karnataka. Apart from this, a number of microorganisms have been found here.

Distribution of Biodiversity in Uttarakhand

The distribution of biodiversity in Uttarakhand is mainly divided into four parts based on characteristics of physical structure and climatic elements.

Biodiversity-rich region: This region, from the flat plains to a height of about 1200 meters (the Shivalik Himalayan region), is included under it. There is a rich habitat of many types of flora and fauna on the slopes of the Shivalik Himalayan part adjacent to the Bhabar region, which is included in the protected major biodiversity areas of the whole of India. The plains and lowlands are long and the habitat of dense trees and giant animals gives it uniqueness, mainly lion, elephant, stag, chital, tiger, cheetah, nilgai, wild boar, bear, sambar, monkey and langur. Along with hundreds of birds, they are found here. Apart from this, many types of medicinal species exist, including Anantmool Satakshi Giloy, Paniya Ban Tulsi, Ginger, Tejpat, Fenugreek, and Bhang. Which is clear from figure no. 08.

Fig 9.8: Source: www.bing.com> Biodiversity in Uttarakhand.

Common Biodiversity Area: This geographical region is an area with a height of 1200 meters in the Shivalik Himalayas and 3000 meters in the Central Himalayas. In some special species of broad-leaved plants, pine, cedar, eagle, buransh, kafal, and other plants, bear, deer, cockerel, chital, tiger, monkey, langur, along with many types of birds, reside here. At the same time, soft grass is also located here; there is a decrease in biodiversity here with the height, but it is a normal area in terms of biodiversity. In the form of medicinal botanical varieties, Kesar Glorium tea, Chirayata, Vajradanti, KachariDhatura, and Reetha are prominent here. which is clear from figure 9.9.

Fig.9.10: Source: www.bing.com> Biodiversity in Uttarakhand.

Areas with rare biodiversity: This diversity zone is the region existing at a height of 3000 to 4600 meters. Most of it remains frozen with snow in the winter. The temperature sometimes remains below the freezing point. Due to this, the full development of animals and plants does not take place, nor does it get enough sunlight to grow. Summer only lives here. Where this is a suitable time for the growth of small grasses, in some places small shrubs also grow for a limited time. Many types of animals also start their seasonal migration here, mainly bears, monkeys, musk deer, and snow leopards. Bioecology productivity is very low in this region which is clear from figure 9.11.

Fig.9.11: Source: www.bing.com> Biodiversity in Uttarakhand.

Areas without biodiversity: This area is part of the height above 4600 meters. where a harsh, cold desert climate is found. The temperature here is always negative, rain is in the form of snow, and most of the high mountains are always covered with snow, so the development of any type of grass, flora, or fauna is not possible. This area is rich in terms of water resources. Which is clear from figure 9.12.

Fig.9.12: Source: www.bing.com> Biodiversity in Uttarakhand.

Conservation of Biodiversity

In Uttarakhand, all the policies made at the national level have been adopted for the conservation of biodiversity, in which mainly national parks, wildlife sanctuaries, and biosphere reserves have been implemented to preserve and protect dimensions like biodiversity. Biodiversity is a natural gift that, once damaged, is difficult to recover. That is, it becomes extinct forever. Whose main factor has been humans. The measures adopted for biodiversity conservation in Uttarakhand are described as follows.

Forest Movement: For biodiversity and forest conservation in the state of Uttarakhand, the work of conservation has been done by the local public community according to religious beliefs since ancient times, but in the present period, many people's movements have been born in order to protect it, including the Ravai Movement in Tehri in 1930 and the Chipko Movement in 1972. Chamoli 1977 Forest Movement Dugi Pantoli Movement (Chamoli), Raksha Sutra Movement 1994 (Tehri), Jhapto-Chhino Movement 1998 (Chamoli), Meti Movement 1996 (Chamoli), Apart from Mixed Forest Model (Rudraprayag), have been primarily functional. Which is clear from figure 9.13.

Fig 9.13: Source: www.bing.com> Biodiversity in Uttarakhand.

Wildlife National Park: As the country's first wildlife conservation centre in the state, 1935 Corbett National Park, 1980 Govind National Park, 1982 Nanda Devi National Park, 1982 Valley of Flowers National Park, 1983 Rajaji National Park, and 1989 Gangotri National Park are fully protected biosphere reserves. Diversity is the theme. Where no human intervention is permitted for biodiversity use which is clear from figure 9.14.

Fig 9.14: Source: www.bing.com> Biodiversity in Uttarakhand.

National Wildlife Sanctuary: For the protection of wildlife, the Motipur Wildlife Sanctuary of Dehradun was established in 1935 with some limited human intervention, which was a successful attempt to establish a relationship between humans and the environment. Presently, Govind Wildlife Sanctuary 1955, Kedarnath Wildlife Sanctuary 1972, Askot Wildlife Bihar 1986, Sona River Wildlife Sanctuary, Winsor Wildlife Sanctuary in 1987, Mussoorie Wildlife Sanctuary in 1988, and Nandor Wildlife Sanctuary in 2012 have been adopted for the conservation of biodiversity and human participation.Which is clear from figure 9.15.

Fig 9.15: Source: www.bing.com> Biodiversity in Uttarakhand.

Other Protection Measures: Wild Biodiversity Assets In other conservation efforts, Asan Wetland Reserve, Jheelmil Lake, Pavalgarh Conservation, Nanda Devi Himalaya Bird Conservation Reserve, High-Level Zoological Park, Chav Protected Area, Nanda Devi, and Valley of Flowers National Park as World Heritage for Bio-Security has been preserved. Apart from this, Snow Leopard, Tiger, KachulaKhark, and G. F.M. community-based programs like. Eco-friendly Tourism Development has been run for the conservation of biodiversity.

Loss of Biodiversity in Uttarakhand

The loss of biodiversity in Uttarakhand has been observed mainly in two forms.

1. Loss of biodiversity in natural form
2. Biodiversity loss in human form

Natural Biodiversity Loss: Natural degradation of biodiversity is caused by landslides, earthquakes, forest fires, soil erosion, snow cover, avalanches, cloud bursts, floods, droughts, heavy rains, and climate change effects, affecting biodiversity and land imbalance and widening the area of biodiversity loss. Bio-wealth and animals are being harmed. 16–17 June 2013 Kedarnath landslide, 2002 Tehri, Kedar 1998, Pithoragarh Malwa 1998, Rudraprayag Unkhi Math 1992, Chamoli Pindar Valley 1980, Gyansu Uttarkashi landslide and 1803, Badrinath and 1809 Garhwal 9 points and 8.50 re, respectively. Earthquakes and the Past incidents of cloudbursts since a decade, respectively 2nd May 2018 Chamoli, 1st June 2018 Tehri Pauri, Uttarkashi, Nainital Pithoragarh, 11th July 2018, Dehradun 2021 Major incidents in Nainital district involve accidentally harming natural flora and fauna, and hundreds The biological wealth spread over a kilometre-square area is being harmed. Which is clear from figure 9.16.

Fig.9.16: Source: www.bing.com> Biodiversity in Uttarakhand.

Biodiversity Loss Due to Human Activities: The mountainous structure of Uttarakhand covers 86% of the state's land area, and due to physical disparity, it is constantly affected by human interference. Man has harmed biodiversity due to the damage done by the activities done for the development of himself, such as urbanization, roads, rail tunnels, hydropower, and other developmental projects, due to which there is a continuous loss of habitat, ecosystem, and vegetation cover for animals. Apart from this, human fires in forests for agricultural productivity and animal fodder are burning thousands of hectares of forest land every year, due to which the habitat of animals and many plants is ending forever, which is very important for the destruction of rich biodiversity. There are sensitive signs. Apart from this, human interference in the natural habitats of organisms, unplanned deforestation, development projects, natural adjustments, fragmentation, and excessive use of biological resources display red signals for biodiversity, resources, and ecosystems, both nature-provided and man-made. Ignorance of the importance of diversity is helping to destroy biodiversity in Uttarakhand. Which is clear from figure 9.17.

Fig.9.17: Source: www.bing.com> Biodiversity in Uttarakhand.

9.4 SUMMARY

Ecology is a major link in determining the structure of the ecosystem. Various areas like forests, soil, sea, ocean, lake, grassland, and desert, and their relationships with elements and organisms of the physical environment are studied by the scientific method. In which the special contribution of ecology and community ecology itself remains in the demarcation of biodiversity. Ecology is also defined in the light of science as providing balance with the environment because disregarding ecological balance also causes natural and human disasters. In which different types of crises cause sorrow for humans. As the effect of climate change is affecting the ecosystem and biodiversity systems of the whole world, its fearful consequences have been seen on the earth's surface, but the environmental crisis has become more acute in the last 3–4 decades.

Biodiversity is the variation or variety found among organisms, which includes the diversity of ecosystems among species. In order to work in any particular community, it is necessary to have racial diversity. Animal and human life are impossible due to a lack of biodiversity. The result of diversity is that it fulfills all the needs of humans and the ecosystem, which are connected in a chain. Just as the human body works together with many tissues, the ecological system operates with biodiversity. In which all the water from the creatures that harm nature to the beneficial ones is included, for which Uttarakhand is in the form of a wonder house of all these. Due to special climatic conditions, all the flora and fauna produced here are used in one way or another by the residents of this place; no natural product is useless. It has been called a botanical forest in the Puranas for medicinal needs. Biodiversity holds an important place in environmental pollution disposal, scavenging, nutrition, soil formation, and ecosystem stability.

Geographical conditions of Uttarakhand: huge biodiversity here determines its place in the world heritage along with the entire country, and the economy of the entire state is currently moving towards the condition of being operated from the bio-wealth here, the resources there, and the natural structure here. resting on. Environmental features and diversity have made eco-tourism promotion and livelihood pillars here. Forest cover and fauna diversity are the identities of this Himalayan state. Its conservation in its own and natural form is very important because it is the basis of life on earth and in creating balance.

9.5 GLOSSARY

Autecology- the study of single life in an environment.

Correlation- a relationship of one species with another species.

Directory- group of different species

Ecological complexity- ecological complex area.

Ecology- the science of the relationship of living things.

Flora and fauna- vocabulary related to plant animal life.

Genetic diversity- variation derived from a net characteristic.

JFM- Joint Forest Management.

National park- government-protected wildlife area.

Rich biodiversity- a place within biodiversity.

Synecology– study of all the organisms and communities in one place.

Wildlife sanctuary- protected area of wildlife.

9.6 ANSWER TO CHECK YOUR PROGRESS

1. The number of species in an area has increased, indicating positive progress in biodiversity.

2. Monitoring the water quality shows improvements in the overall ecological health of the river.
3. Planting native trees has led to the return of various bird species, showcasing successful ecological restoration.
4. The decrease in pollution levels is positively impacting the biodiversity of aquatic ecosystems.
5. Conducting regular wildlife surveys helps track changes in animal populations and their habitats.
6. The establishment of protected areas has contributed to the preservation of diverse plant and animal species.
7. The decline in invasive species suggests a more balanced and stable local ecosystem.
8. Efforts to reduce deforestation are crucial for maintaining the ecological balance and biodiversity of the region.
9. Observing the interactions between different species helps researchers understand the intricate web of life in an ecosystem.

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9.8 TERMINAL QUESTIONS

Long Questions

1. Discuss the relationship between ecology and bio-diversity?
2. Describe in detail the biodiversity pattern at Uttarakhand?

3. Explain the usefulness of biodiversity to Uttarakhand. Describe the suggestions given in the Earth Summit 1992?
4. Briefly describe the new Schemes adopted for Biodiversity Conservation in Uttarakhand.

Short Questions

1. What is the literal meaning of ecosystem?
2. When and who uses the word ecosystem for the first time?
3. What is the biodiversity?
4. Explain the types of biodiversity by writing the meaning and definition of biodiversity.
5. Discuss the relationship between ecology and biodiversity.
6. Explain the nature of biodiversity and its area in Uttarakhand.
7. Describe in detail the biodiversity pattern at Uttarakhand.
8. Explain the work done for biodiversity destruction and conservation in Uttarakhand, and give your suggestions.

Multiple Choice Questions

1. The word ecology originated from which Language?

a) Greek word oikos.
b) German word Logos
c) Gerek word oikos & Logos.
d) Nove of the above.

2. Who used the word ecology for the first time?

a) Devid
b) Haeckel
c) J.C. Bosh
d) J.P. Marsh

3. Which are the main branches of ecology?

a) Autecology
b) Synecology
c) Eco-System ecology

d) All of the above

4. The term biodiversity was first widely used in -

a) 1992 Rio de Janeiro.
b) 1987 Montreal
c) 1997 quanto protocol
d) None of the above

5. How many types of Bio-diversity?

a) 2
b) 3
c) 4
d) 5

6. Rich bio-diversity area is found in Uttarakhand ?

a) About 1200 meters.
b) 1200-3000 Meters
c) 3000- 4600 Meters
d) 3000 -above

7. Low-Level biodiversity area is found in Uttarakhand?

a) 3000-4000 m.
b) 4600-above
c) 6000 - above
d) Below- 3000

8. The work done for biodiversity conservation in Uttarakhand?

a) Forest management
b) Wildlife National Park
c) National wildlife sanctuary
d) All of the above

9. Which was the first National Park of Uttarakhand?

a) Govind National Park
b) Jim Corbett Park
c) Gangotri Nations Park

d) Rajaji Nation Pank.

10. The main types of biodiversity are....?

a) Genetic bio-diversity
b) Species Bio-diversity
c) Ecosystem Bio-diversity
d) All of the above

11. The Full form of JFM is….. ?

a) General Forecasting Management
b) Joiner Forest management
c) Joint Forest Management.
d) None of the above

12. Auteology means..... ?

a) Study of single life is environment
b) A Place within bio-diversity.
c) The study of multi-living life is the environment
d) All of the above

Answer: 1-C, 2-B, 3-D, 4-A, 5-C, 6-A, 7-B, 8-D, 9-B, 10-D, 11-C and 12-B

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