For UPSC Civil Services and State PCS Exam

NEW EDITION

CERTIFICATE PHYSICAL AND HUMAN GEOGRAPHY

SUMMARY NOTES CERTIFICATE PHYSICAL AND HUMAN GEOGRAPHY
CHAPTER:- 1 TO 25
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NOTES FOR 2020 & 2021.

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CHAPTER: 1 - THE EARTH AND THE UNIVERSE

Exploring the Universe

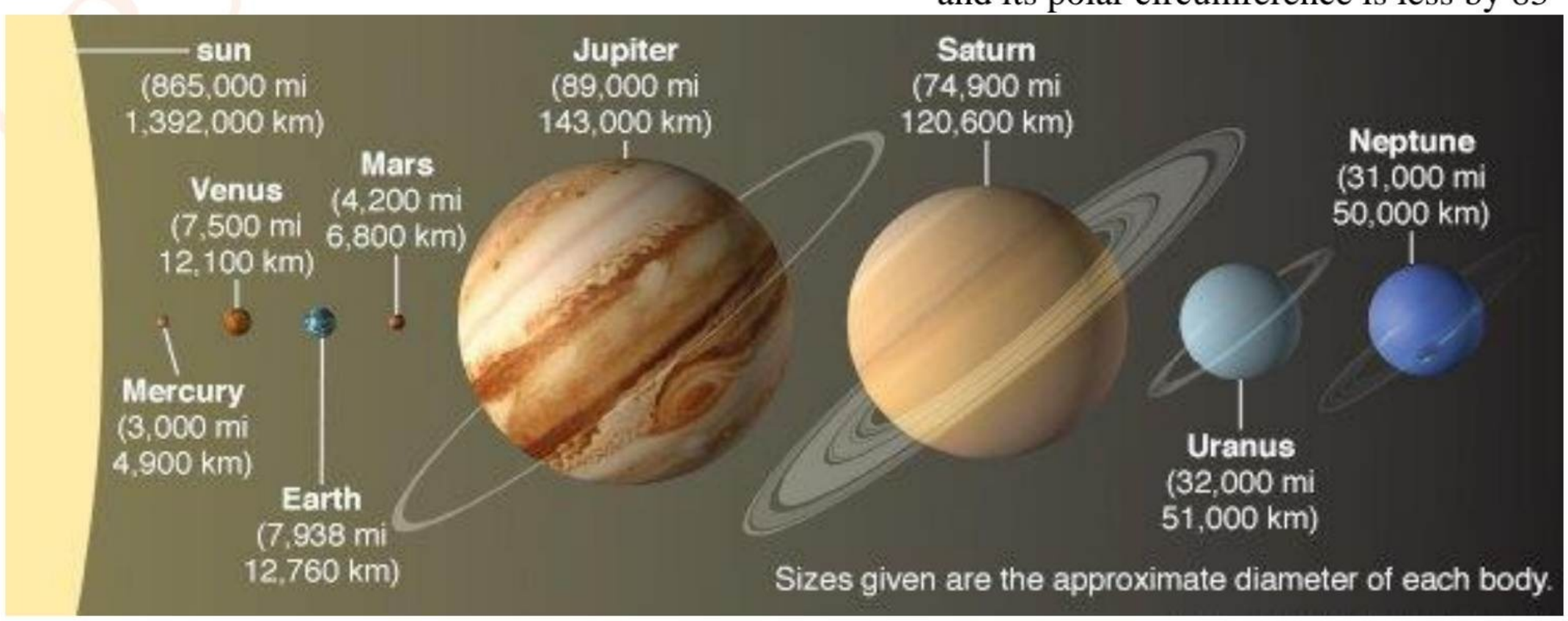
- It is believed that the earth's own galaxy (the Milky Way) alone contains as many as 100,000 million stars. The stars appear small to us even through a telescope because they are so far away.
- The light from the nearest star travelling at the speed of light (i.e. 186,000 miles per second) takes something like four years to reach us. A ray of light from the sun takes about eight minutes to reach the earth. Light takes only a second to reach us from the moon.

The Solar System

- The solar system comprises the Sun and its nine planets. All the planets revolve round the Sun in elliptical orbits. The Sun has a surface temperature of 6,000°C. (10,800°FE) and increases to 20 million°C. (36 million°F) in the interior.
- In size, the **Sun** is almost unimaginable. It is about 300,000 times as big as the earth.
- Mercury is the smallest and closest to the sun, only 36 million miles away. A year in Mercury is only 88 days.
- **Venus**, twice the distance away from the sun, is the next closest planet. It is often considered as **'Earth's twin'** because of their close proximity in size, mass (weight) and density.
- Earth which has life and all the living things we see around us. Like many other planets, the Earth has a natural satellite, the Moon, 238,900 miles away, that revolves eastward around the Earth once in every 27 days.
- **Mars** which has dark patches on its surface and is believed by most professional astronomers to be the next planet after Earth to have the possibility of some plant life.
- **Jupiter** the largest planet in the solar system. Its surface is made up of many gases like hydrogen, helium, and methane. The twelve satellites that circle round it. As it is more than 485 million miles from the Sun, its surface is very cold, probably about -200°F (-130°C).
- **Saturn** which has three rings and nine satellites around it. In size, it is the second largest after Jupiter. It is so far from the Sun that it takes 29 Years to complete its orbit.
- **Uranus**, it another giant planet, 50 times larger than Earth and 15 times as heavy unlike other planets, Uranus orbits around the sun in a clockwise direction from east to west with five satellites revolving round it.
- **Neptune** closely resembles Uranus, except that it has only two known satellites and is probably much colder.
- Pluto is smaller than Earth. As the orbits of the planets are not circular but elliptical, the distance of Pluto from the Sun during perihelion is 2,766 million miles. A year in Pluto is no less than 247 years on earth.

The Shape of the Earth

- Its **spherical** shape is an established fact, proved, and accepted by all. It has an equatorial circumference of 24,897 miles and its polar circumference is less by 83



miles. Its equatorial diameter is 7,926 miles and its polar diameter is shorter by 26 miles.

Evidence of the Earth's Sphericity

There are many ways to prove that the earth spherical. The following are some of them.

1) Circum-navigation of the earth
2) The circular horizon
3) Ship's visibility
4) Sunrise and sunset
5) The lunar eclipse
6) Planetary bodies are spherical
7) Driving poles on level ground on a curved earth
8) Aerial photographs

The Earth's Movement

- The earth moves in space in two distinct ways: it **rotates** on its own axis from west to east once in every 24 hours, causing day and night; it also **revolves** round the sun in an orbit once in every 365t days. Causing the seasons and the year.

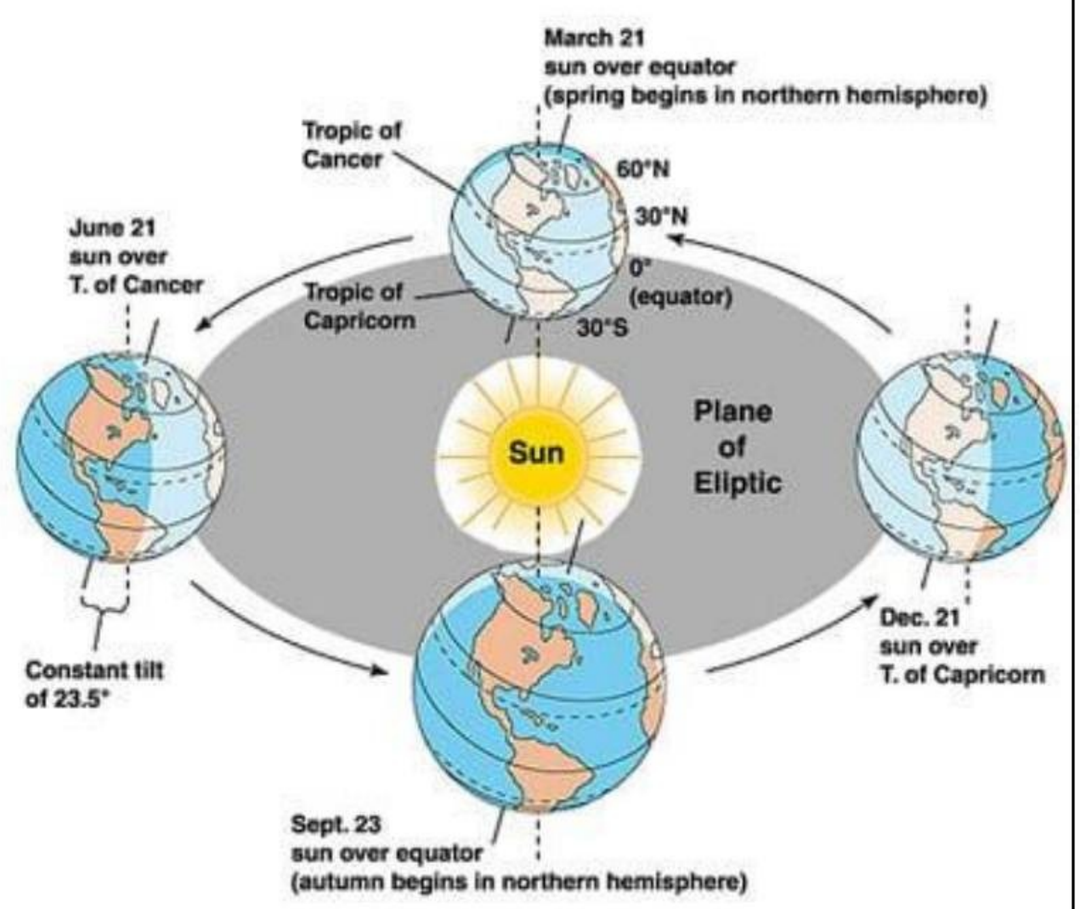
Day and Night

- When the earth rotates on its own axis, only one portion of the earth's surface comes into the rays of the sun and experiences **daylight**. The other portion which is away from the sun's rays will be in **darkness**.

The Earth's Revolution

When the earth revolves round the sun, it spins on an **elliptical orbit** at a speed of 18.5 miles per second or 66,600 m.p.h. One complete revolution takes 365 days or a year.

1) **Varying Lengths of Day and Night**
   - The axis of the earth is inclined to the plane of the **ecliptic** (the plane in which the earth orbits round the sun) at an angle of 66 $^{1/2\,o}$ giving rise to different seasons and varying lengths of day and night.
   - If the axis were perpendicular to this plane, all parts of the globe would have equal days and nights at all times of the year, but we know this is not so. In the **northern hemisphere** in winter (December) as we go northwards, the hours of darkness steadily increase.
   - At the Arctic Circle (66 $^{1/2}$°N.), the sun never 'rises' and there is darkness for the whole day in mid-winter on 22 December. Beyond the Arctic Circle the number of days with complete darkness increases, until we reach the North Pole (90°N.) when half the year will have darkness.
   - In the **summer** (June) conditions are exactly reversed. Daylight increases as we go poleward. At the Arctic Circle, the sun never 'sets at mid-summer (21 June) and there is a complete 24-hour period of continuous daylight.
   - In summer the region north of the **Arctic Circle** is popularly referred to as Land of the mid- night Sun'. At the North Pole, there will be six months of continuous daylight.
   - In the **southern hemisphere**, the same process takes place, except that the conditions are reversed.



2) **The Altitude of the Midday Sun**
   - The sun is vertically overhead at the equator on two days each year. These are usually equator usually **21 March and 21 September** though the date changes because a year is not exactly 365 days.

- This is known as the June or summer solstice when the northern hemisphere will its longest day and shortest night. By about 22 tropic December, the sun will be overhead at the Tropic of Capricorn (231°S.). This is the **winter solstice** when the southern hemisphere will have its loon day and shortest night.
- Beyond the **Arctic Circle (661°N)** and the **Antarctic Circle (661°S)** where darkness lasts for 6 months and daylight is continuous for the remaining half of the year.

3) **Seasonal Changes and their Effects on Temperature**
   - When the sun is overhead its rays fall almost vertically on the earth, concentrating its heat on a small area; temperature therefore rises and summers are always warm.
   - In winter the oblique rays of the sun, come through the atmosphere less directly and have much of their heat absorbed by atmospheric impurities and water vapour. The **sun's rays** fall faintly and spread over a great area. There is thus little heat, and temperatures remain low.
   - In addition, days are longer than nights in summer and more heat is received over the longer **daylight duration**. Nights are shorter and less heat is **l0s**. There is a net gain in total heat received and temperature rises in summer. Shorter days and longer nights in winter account for the reverse effects.

Dawn and Twilight

- This is caused by fact that during the periods of **dawn** and **twilight** the earth receives diffused or **refracted** light from the sun whilst it is still below the horizon. Since the sun rises and sets in a vertical path at the equator the period during which refracted light is received is short.
- But in temperate latitudes, the sun rises and sets in an oblique path and the period of refracted light is longer. It is much longer still at the poles, so that the winter darkness is really only twilight most of the time.

Latitude

- Latitude is the **angular distance** of a point on the earth's surface, measured in degrees from the centre of the earth. These lines are therefore called **parallels** of latitude. The equator represents 0^0 and the North and South Poles are 90°N. And 90°S. Between these points lines of latitude are drawn at intervals of 1°.
- The most important lines of latitude are the equator, the Tropic of Cancer ($23^{1/2}$°N.), the Tropic of Capricorn ($23^{1/2}$°S.), the Arctic Circle (661°N.) and the Antarctic Circle ($66^{1/2}$°S.). As the earth is slightly flattened at the poles, the linear distance of a degree of latitude at the pole is a little longer than that at the equator.
- For example, at the equator (0°) it is 68.704 miles, at 45° it is 69.054 miles and at the poles it is 69.407 miles. Bombay is 18-55° N; it is therefore 18 55x 69 or 1280 miles from the equator.

Longitude

- Longitude is an **angular distance**, measured in degrees along the equator east or west of the Prime (or First) Meridian. On the globe longitude is shown as a series of semi-circles that run from pole to pole passing through the equator. Such lines are also called **meridians.**
- The degree of longitude therefore decreases in length. It is longest at the equator where it measures 69.172 miles. At 25° it is 62.73 miles, at 45° it is 49 miles, at 75 18 miles and at the poles 0 mile.

Longitude and Time

- Local Time. Since the earth makes one complete revolution of **360° in one day or 24 hours,** it passes through 15° in one hour or **1° in 4 minutes.**
- If G.M.T. 1s 8.00 a.m. and it is noon in the local region, it means that he is four hours ahead of Greenwich, and must be east of Greenwich. His longitude is 4 x 15° or 60°E.

Standard Time and Time Zones

- The Indian Government has accepted the meridian of **82:5°** east for the standard time which is 5 hrs. 30 mins. Ahead of Greenwich Mean Time. The whole world has in fact been divided into 24 Standard Time Zones, each of which differs from the next by 15° in longitude or one hour in time.
- U.S.S.R. which have a great east-west stretch have adopt several time zones for practical purposes. U.S.S.R. the largest country, which extends through almost 165° of longitude is divided into eleven time zones. Both Canada and U.S.A. have five time zones-the Atlantic, Eastern, Central, Mountain and Pacific Time Zones.

The International Date Line

- A traveller going eastwards gains time from Greenwich until he reaches the meridian **180°E**. When he will be 12 hours ahead of G.M.T. Similarly, in going westwards, he loses 12 hours when he reaches 180°W. There is thus a total difference of 24 hours or whole day between the two sides of the 180° meridian.
- This is the International Date Line where the date changes by exactly one day when it is crossed. A traveller crossing the date line from east to west loses a day (because of the loss in time he has made); and while crossing the dateline from west to east he gains a day (because of the gain in time he encountered).

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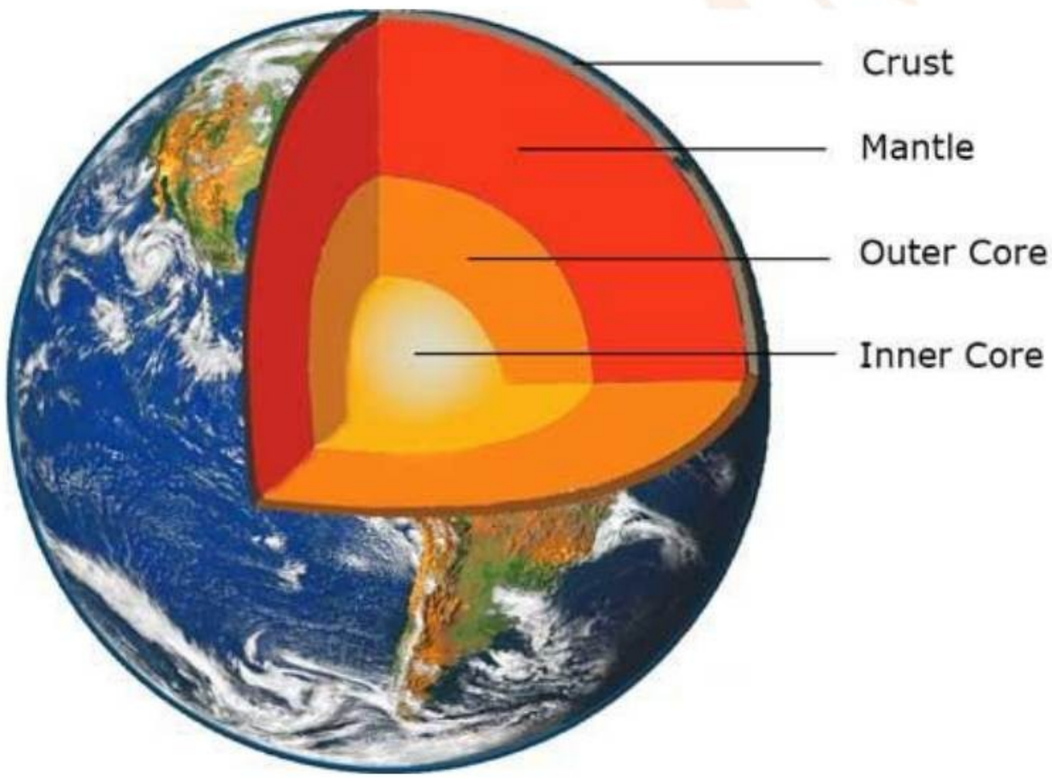
CHAPTER: 2 – THE EARTH'S CRUST

The Structure of the Earth

- The outer layer is the earth's crust the **lithosphere**-which comprises two distinct parts. The upper part consists of **granitic rocks** and forms the continents. Its main mineral constituents are silica and alumina so it is collectively referred to as the sial. It has an average **density of 2.7.** The lower part is a continuous zone of denser basaltic rocks forming the ocean floors, comprising mainly silica, iron and magnesium.
- It is therefore called sima and has an average density of 3.0. The sial and the simna together form the earth's crust which varies in thickness from only 3-4 miles beneath the oceans to as much as 30 miles under some parts of the continents.
- Immediately beneath the crust or lithosphere is the mantle (or mesosphere) about 1,800 miles thick, composed mainly of very dense rocks rich in **olivine**. The interior layer is the core, (or **barysphere**) 2,160 miles in radius, and is made up mainly of iron (Fe) with some nickel and is called nife. The temperature here is estimated to be as high as 3,500°F., and the core is subject to extremely high pressure.



The Classification of Rocks

Generally speaking, all rocks may be classified into three major groups-igneous, sedimentary and metamorphic, according to their origin and appearance.

1. **Igneous Rocks**
   - They are normally **crystalline** in structure. They do not occur in strata (**layers**) nor do they contain fossils. Igneous rocks may be sub-divided on the basis of **mineral composition**. When they contain a high proportion of silica, they are said to be acid. **Acid igneous rocks**, such as granite, are less dense and are lighter in colour than basic rocks.
   - These contain a greater proportion of basic oxides, e.g. of iron, aluminium or magnesium, and are thus denser and darker in colour. In terms of origin there are two main classes of igneous rocks.
     - **Plutonic rocks: -** These are igneous rocks, formed at some depth in the earth's crust. These intrusive rocks, such as granite, diorite and gabbro, are exposed at the surface by the processes of denudation and erosion.
     - **Volcanic rocks: -** These are molten rocks poured out of volcanoes as lavas. They solidify rapidly on the earth's surface and the crystals are small. **Basalt** is a common volcanic or extrusive rock and forms lava flows, lava sheets and lava plateaux, e.g. those of **Antrim in Northern Ireland**, the Deccan Plateau in India and the **Columbia-Snake Plateau in U.S.A.**
2. **Sedimentary Rocks**
   - Sedimentary rocks are formed from **sediment** accumulated over long periods, usually under water. They are distinguished from the other rock types in their characteristic **layer** formation and are termed **stratified rocks.**

- The strata may vary in thickness from a few inches to many feet. The rocks may be coarse or fine-grained, soft or hard. Sedimentary rocks may be classified under three major categories in accordance with their origin and composition.

3. **Mechanically formed sedimentary rocks**
   - These rocks have been formed from the accumulation of materials derived from other rocks which have been cemented together. **Sandstones** are probably the most familiar sedimentary rocks they are made from sand grains, often quartz fragments derived from granites.
4. **Organically formed sedimentary rocks**
   - These rocks are formed from the remains of living organisms such as corals or shellfish, whose fleshy parts have been decomposed, leaving behind the hard shells the most common rocks formed in this way are of the **calcareous** type.
5. **Chemically formed sedimentary rocks**
   - Such rocks are precipitated chemically from solutions of one kind or another. **Rock salts** are derived from sedimentary rocks. Such strata which once formed the beds of seas or lakes. Gypsum or calcium sulphate is obtained from the evaporation of salt lakes
6. **Metamorphic Rocks**
   - All rocks whether igneous or sedimentary may become **metamorphic or changed rocks** under great heat and pressure. In this manner, clay may be metamorphosed into slate limestone into marble, sandstone into quartzite granite into **gneiss, shale into schist and coal into graphite**.

Earth Movements and the Major Landforms

- Since the dawn of geological time, no less than nine orogenic or mountain building movements have taken place, folding and fracturing the earth's crust. Some of them occurred in Pre-Cambrian times **between 600-3,500** million years ago. The three more recent orogenies are the **Caledonian**. Hercynian and Alpine. The Caledonian about 320 million years ago raised the mountains of Scandinavia and Scotland, and is represented in North America.
- **Hercynian** earth movements about 240 million years ago, were formed such ranges as the Ural Mountains, the Pennines and Welsh Highlands in Britain, the Harz Mountains in Germany, the Appalachians in America.
- **Alpine**, about 30 million years ago. Young fold mountain ranges were buckled up and overthrust on a gigantic scale. Being the most recently formed, these ranges, such as the Alps, Himalayas, Andes and Rockies are the loftiest and the most imposing.

Types of Mountains

- **Fold Mountains**
  - They are caused by large-scale **earth movements**. When stresses are set up in the earth's crust. Such stresses may be due to the increased load of the overlying rocks, flow movements in the mantle, magmatic intrusions into the crust, or the expansion or contraction of some part of the earth.
  - When such stresses are initiated, the rocks are subjected to compressive forces that produce wrinkling or folding along the lines of weakness. The upfolded waves are called **anticlines** and the troughs or downfolds are synclines.
  - When the crest of a fold is pushed too far, an overfold is formed. If it is pushed still further, it becomes a recumbent fold. In extreme cases, fractures may occur in the crust, so that the upper part of the recumbent fold slides forward over the lower part along a thrust plane, forming an overthrust fold.
  - The over-riding portion of the thrust fold is termed a nappe. Since the

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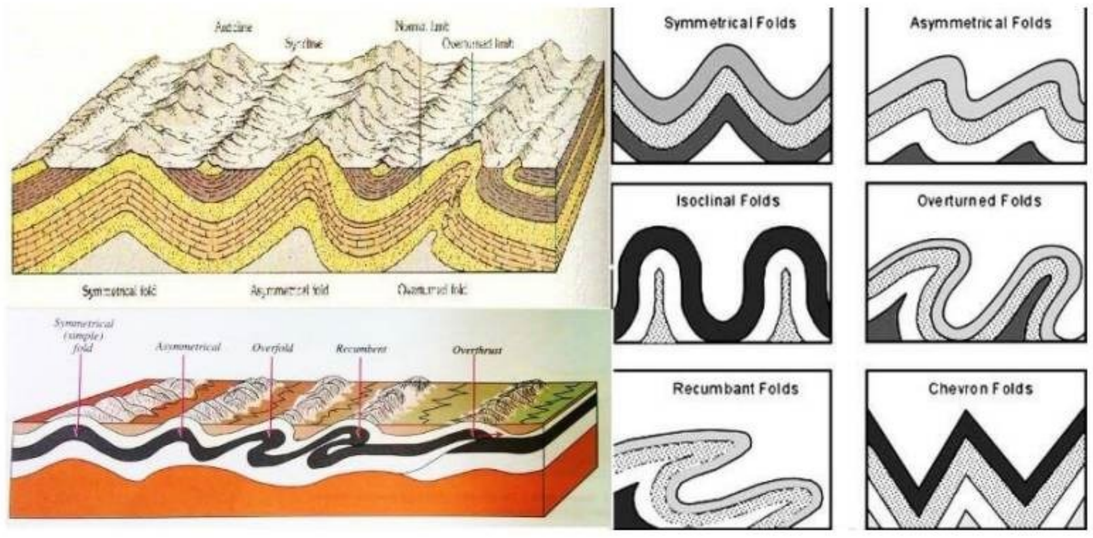
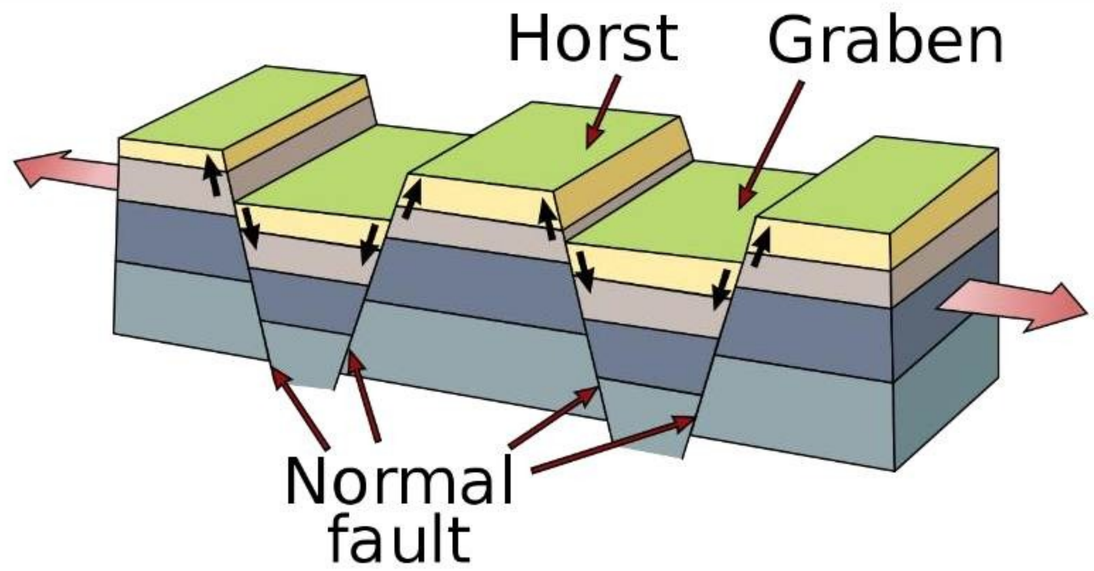
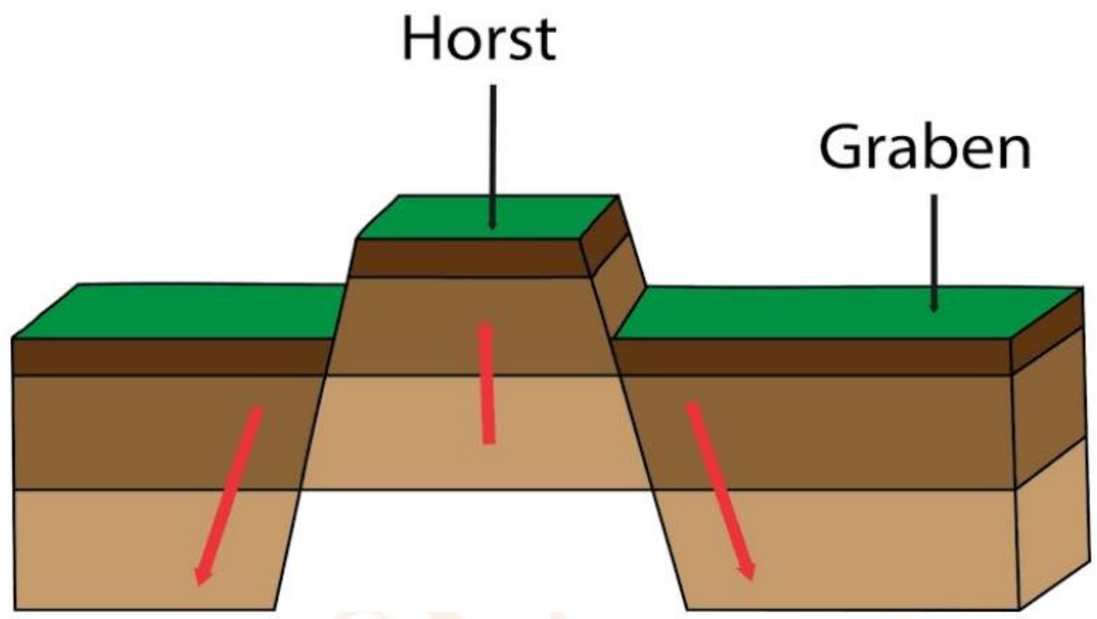
rock strata have been elevated to great heights sometimes measurable in miles, Fold Mountains may be called mountains of elevation. The fold mountains are also closely associated with volcanic activity. They also contain rich mineral resources such as tin, copper, gold and petroleum.

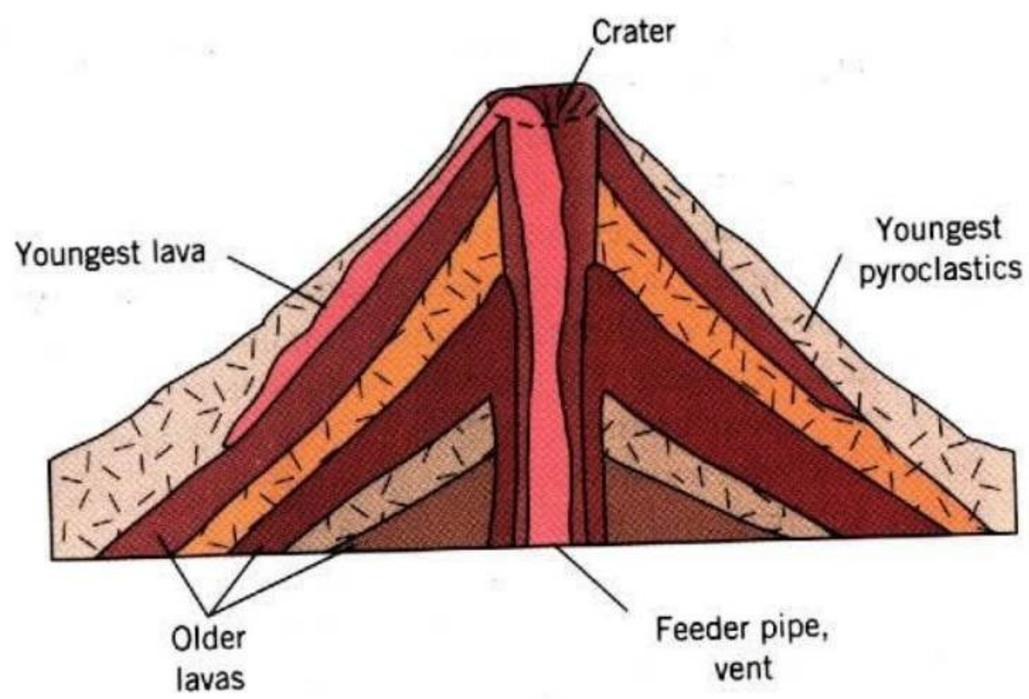


- **Block Mountains**
  - When the earth's crust bends folding occurs, but when it cracks, **faulting** takes place. Faulting may be caused by tension or compression, forces which lengthen or shorten the earth's crust, causing a section of it to subside or to rise above the surrounding level.
  - Earth movements generate tensional forces that tend to pull the crust apart, and faults are developed. If the block enclosed by the faults remains as it is or rises and the land on either side subsidies, the upstanding block becomes the horst or block mountain. Tension may also cause the central portion to be let down between two adjacent fault blocks forming a graben or rift valley.
  - **Compressional forces** set up by earth movements may produce a thrust or reverse fault and shorten the crust. A block may be raised or lowered in relation to surrounding areas. A rift valley formed in this way. In general, large- scale Block Mountains and rift valleys are due to tension rather than compression.

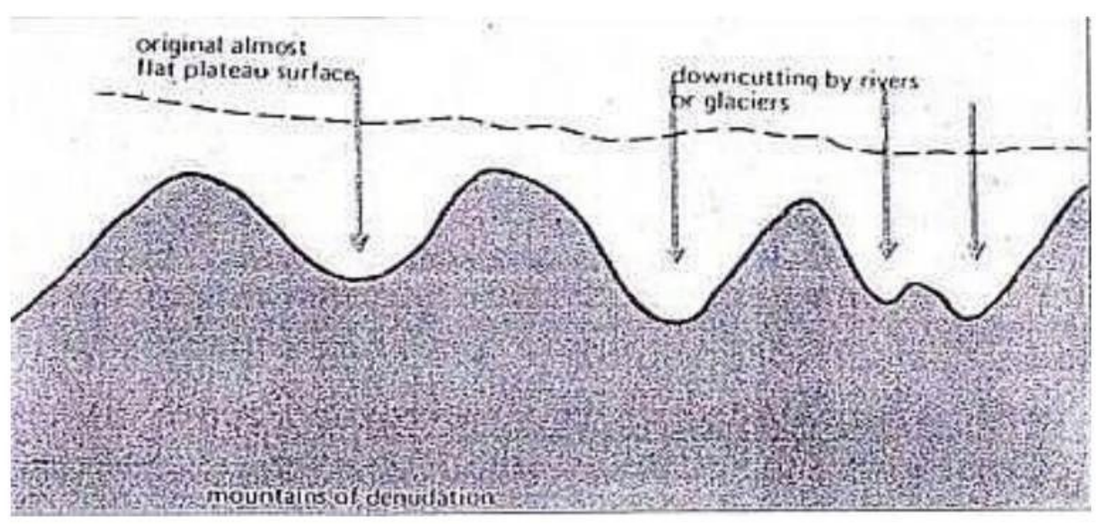




- **Volcanic mountains: -** These are, in fact, **volcanoes** which are built up from material ejected from fissures in the earth's crust. The materials include molten lava, volcanic bombs, cinders, ashes, dust and liquid mud.



- **Residual mountains: -** These are mountains evolved by **denudation**. Where the general level of the land has been lowered by the agents of denudation some very resistant areas may remain and these



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form **residual** mountains, e.g. Mt. Monadnock in U.S.A.

Types of Plateaux

- Plateaux are elevated uplands with extensive level surfaces, and usually descend steeply to the surrounding lowland. They are sometimes referred to as **tablelands**, like all highlands, plateaux are subjected to erosional processes. AS a result, their original characteristics may be greatly altered.
    1. **Tectonic plateaux -** These are formed by **earth movements** which cause uplift, and are normally of a considerable Size, and fairly uniform altitude. They include **continental blocks** like the Deccan Plateau in India. When plateaux are enclosed by Fold Mountains, they are known as intermont plateaux. Examples are the Tibetan Plateaux
    2. **Volcanic plateaux -** Molten lava may issue from the earth's crust and spread over its surface to form successive sheets of basaltic lava. These solidities to form a lava plateau. Some of the better-known volcanic plateaux are the Antrim Plateau of Northern Ireland and the north-western part of the Deccan Plateau.
    3. **Dissected plateaux -** In the humid highlands, stream action and sometimes glaciation cut deep, narrow valleys in the plateaux, which are then described as dissected plateaux. An example is the Scottish Highlands.

Types of Plains

A plain is an area of lowland, either level or undulating. It seldom rises more than a few hundred feet above sea level. There may be low hills which will give a typical rolling topography. Plains may be grouped into three major types based on their mode of formation.

- **Structural plains -** These are the **structurally depressed** areas of the world that make up some of the most extensive natural lowlands on the earth's surface. They include such Great Plains as the Russian Platform, the Great Plains of U.S.A. and the central lowlands of Australia.
- **Depositional plains**
    - These are plains formed by the **deposition** of materials brought by various agents of transportation. They are comparatively level but rise gently towards adjacent highlands. Their fertility and economic development depend greatly on the types of sediments that are laid down.
    - Some of the largest depositional plains are due to deposition by large **rivers**. Active erosion in the upper course results in large quantities of alluvium being brought down to the lower course and deposited to form extensive **alluvial plains, flood plains and deltaic plains**.
    - Winds may blow Aeolian deposits very fine particles known as loess- from interior deserts or barren surfaces and deposit them upon hills, valleys or plains forming a loess plateau, as in north-west China, or a loess plain, as in the Pampas of Argentina.
- **Erosional plains**
    - These plains are carved by the agents of erosion. Rain, rivers, ice and wind help to smooth out the irregularities of the earth's surface, and in terms of millions of years, even high mountains can be reduced to low undulating plains. Such plains of denudation are described as peneplains a word meaning 'almost-plains'.
    - Finland is estimated to have **35,000 lakes,** occupying 10% of the total land surface of the country.

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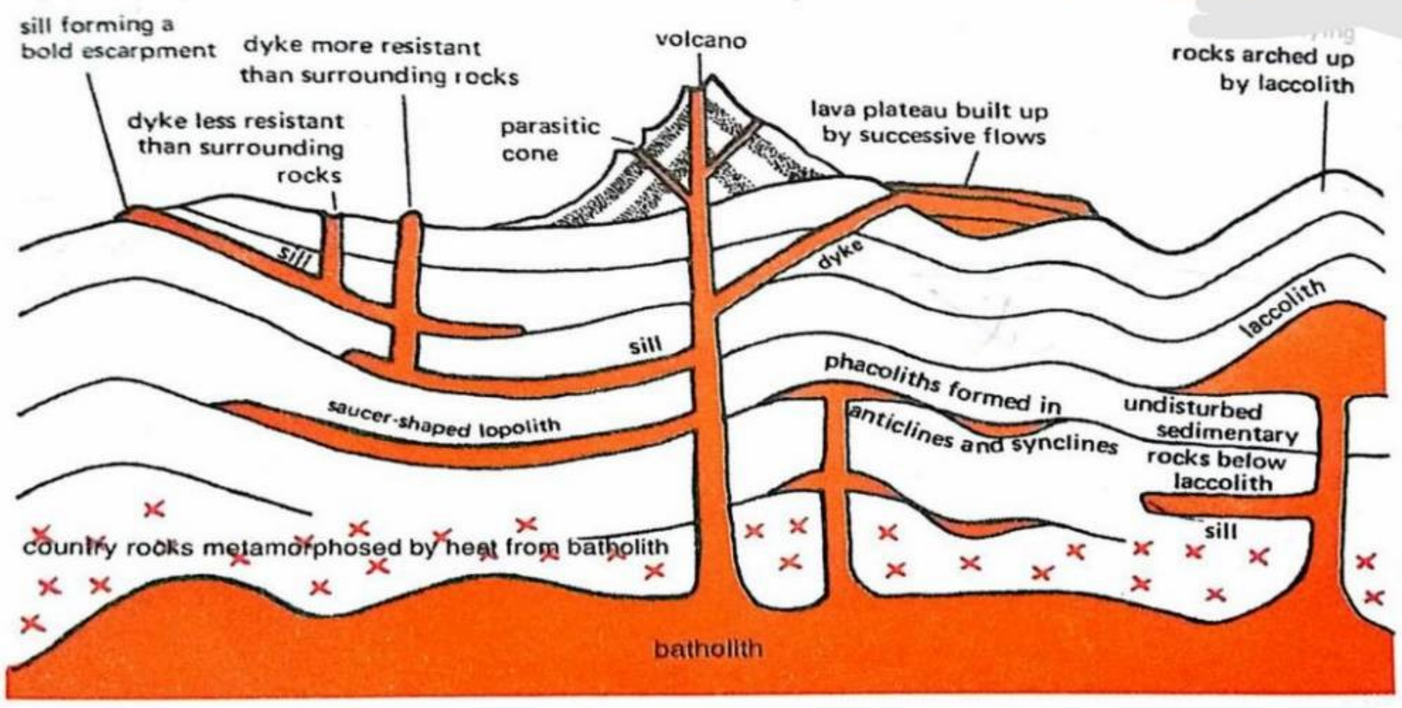
Landforms Associated with Vulcanic Activities

- Solid, liquid or gaseous materials may find their way to the surface from some deep-seated reservoir beneath. **Molten magma** is mobile rock that forces its way into the planes of weakness of the crust to escape quietly or explosively to the surface.
- Magmas that reach the sur- face and solidify, form extrusive landforms. Rocks formed by either plutonic or volcanic activity are called **igneous rocks.**

Landforms of lgneous Intrusions

- Perhaps the commonest intrusive landforms are sills and dykes. When an intrusion of molten magma is made **horizontally** along the bedding planes of sedimentary rocks, the resultant intrusion is called a sill. Similar intrusions when injected vertically as narrow walls of igneous rocks within the sedimentary layers are termed as **dykes.**
- When exposed to denudation they may appear as upstanding walls or shallow trenches depending on whether they are more or less resistant than the rocks in which they are emplaced. Examples of dykes are the Cleveland Dyke of Yorkshire England.
- Igneous intrusions on a larger scale are the various types of liths: laccoliths, lopoliths, phacoliths and batholiths.
- A **laccolith** is a large blister or igneous mound with a dome-shaped upper surface and a level base fed by a pipe-like conduit from below. It arches up the overlying strata of sedimentary rocks, e.g. the laccoliths of the Henry Mountains, in Utah U.S.A.
- A **lopolith** is another variety of igneous intrusion with a saucer shape. A shallow basin is formed in the midst of the country rocks. The Bushveld lopoliths of Transvaal, South Africa are good examples.
- A phacolith is a lens-shaped mass of igneous rocks occupying the crest of an anticline or the bottom of a syncline and being fed by a conduit from beneath. An example of a phacolith is Corndon Hill in Shropshire, England.
- A **batholith** is a huge mass of igneous rocks, usually granite, which after removal of the overlying rocks forms a massive and resistant upland region such as the Wicklow



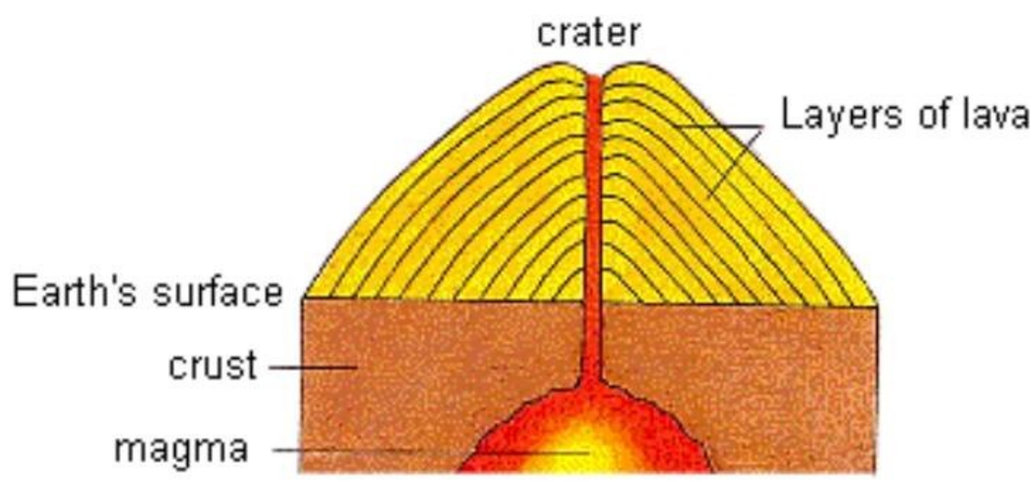
Mountains of Ireland, the uplands of Britanny, France and the Main Range of West Malaysia.

The Origin of Volcanoes

- As temperature increases with increasing depth below the earth's crust, at an average rate of about 1°F. For every 65 feet of descent, the interior of the earth can be expected to be in a semi-molten state, comprising solid, liquid and gaseous materials, collectively termed magma.
- The magma is heavily charged with **gases** such as carbon dioxide, sulphurated hydrogen, and small proportions of nitrogen, chlorine and other volatile substances. The gases and vapour increase the mobility and explosiveness of the lavas which are emitted through the orifice or **vent of a volcano** during a volcanic eruption. There are two main types of lavas.
  1. **Basic lavas -** These are the hottest lavas, about 1,000°C. (1,830°F.) And are **highly fluid**. They are dark coloured like basalt, rich in iron and magnesium but poor in silica. As they are poured out of the volcano,

they flow quietly and are not very explosive. Due to their high fluidity, they flow readily with a speed of 10 to 30 miles per hour. They affect extensive areas, spreading out as thin sheets over great distances before they solidify. The resultant volcano is gently sloping with a wide diameter and forms a flattened **shield or dome.**

2. **Acid lavas -** These lavas are **highly viscous** with a high melting point.



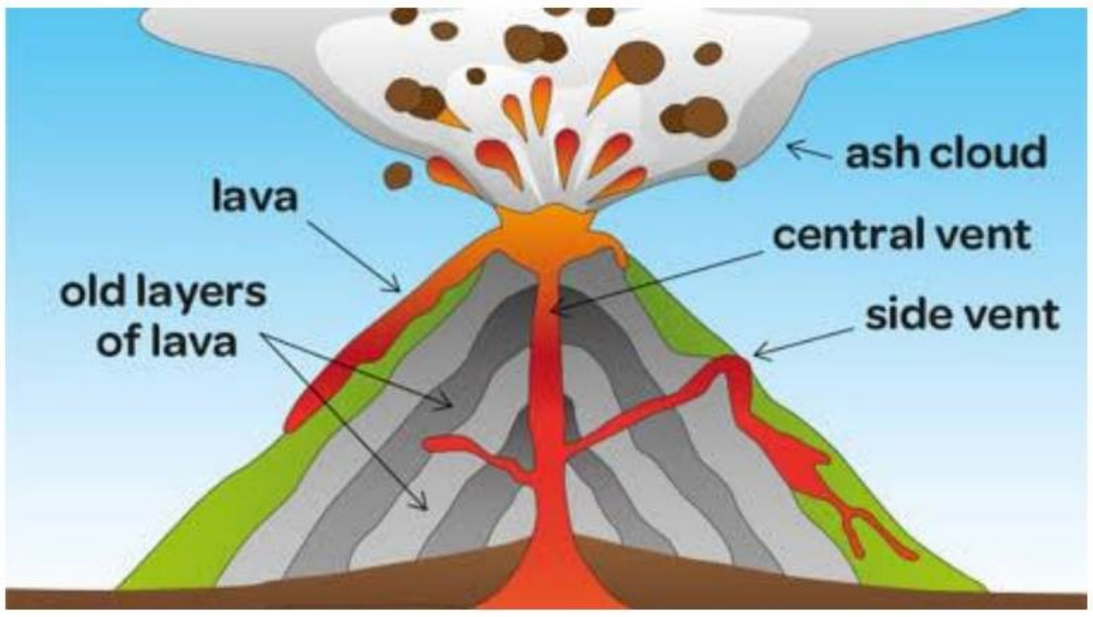
They are light-coloured, of low density, and have a high percentage of silica. They flow slowly and seldom travel far before solidifying. The resultant cone is therefore stee sided.

Types of Volcanoes

- There are three types of volcanoes: active, dormant and extinct.
- Volcanoes are said to be **Active** when they frequently erupt or at least when they have erupted within recent time.
- Those that have been known to erupt and show signs of possible eruption in the future are described as **Dormant**. Volcanoes that have not erupted at all in historic times but retain the features of volcanoes are termed extinct.

Extrusive Landforms

- Extrusive landforms are determined by the nature and composition of the lava and other ejected materials that reach the surface of the earth. The fluid basic lava, flowing for long distances produces extensive lava plans and basalt plateaux. Such as the great lava plains of the Snake **Basin, U.S.A.** The base plateaux are found in many continents, e.g. the north western part of the Deccan Plateau and in Iceland.
- Volcanic cones are most typical of the extrusive features. The highly fluid lavas build up **lava domes or shield volcanoes** with gently rising slopes and broad, flattened tops. The volcanoes of Hawai have the best developed lava domes. The spectacular Mauna Loa and Kilauea are so accessible that they have been closely studied.
- The less fluid lavas that explode more violently form **ash and cinder cones** with large central craters and steep slopes. They are typical of small volcanoes, occurring in groups and seldom exceeding 1,000 feet in height, such as Mt. Nuovo, near Naples and Mt. Paricutin in Mexico.
- The very fine particles are the volcanic dust which may be shot so high into the sky that it travels round the world several times before it eventually comes to rest. The dust or ash falls as **black snow'** and can bury houses and people. The coarser fragmental rocks are collectively called pyroclasts and include cinders or lapilli, scoria, pumice and volcanic bombs.
- The highest and most common volcanoes have composite cones. They are often called **strato- volcanoes**. The cones are built up by several eruptions of lava, ashes and other volcanic materials from the main conduit which leads down a reservoir of magma.
- From the main conduit, subsidiary dykes or pipes may reach the surface as feeders to parasitic cones. Lava escapes through them to the sides of the main cones. Mt. Etna in Sicily has hundreds of such parasitic cones. Another interesting composite volcano is **Mt. Strom boli** whose frequent eruptions that make the summit glow have earned for it the name Lighthouse of the Mediterranean'.
- During an eruption material from the top of the cone is blown off or collapses into the vent widening the orifice into a large **crater**. Some volcanoes may have greatly enlarged depressions called calderas.



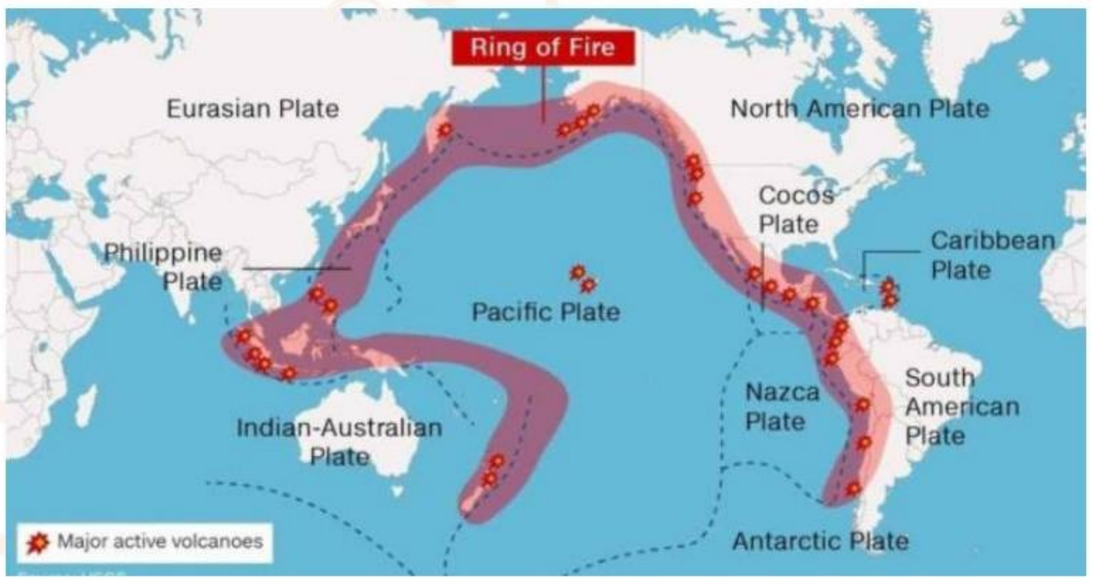
Some Volcanic Eruptions

In the history of mankind perhaps the most disastrous eruptions were those of Mt. Vesuvius, Mt. Krakatau and Mt. Pelee.

- **Mt. Vesuvius:** Mt. Vesuvius, standing 4,000 feet above the Bay of Naples, erupted violently on 24 August A.D.
- **Mt. Krakatau:** Krakatau is a small volcanic island in the Sunda Straits, midway between Java and Sumatra.
- **Mt. Pelee:** The eruption of Mt. Pelee of the West Indies in May 1902 was the most catastrophic of modern times.

The Distribution of Volcanoes in the World

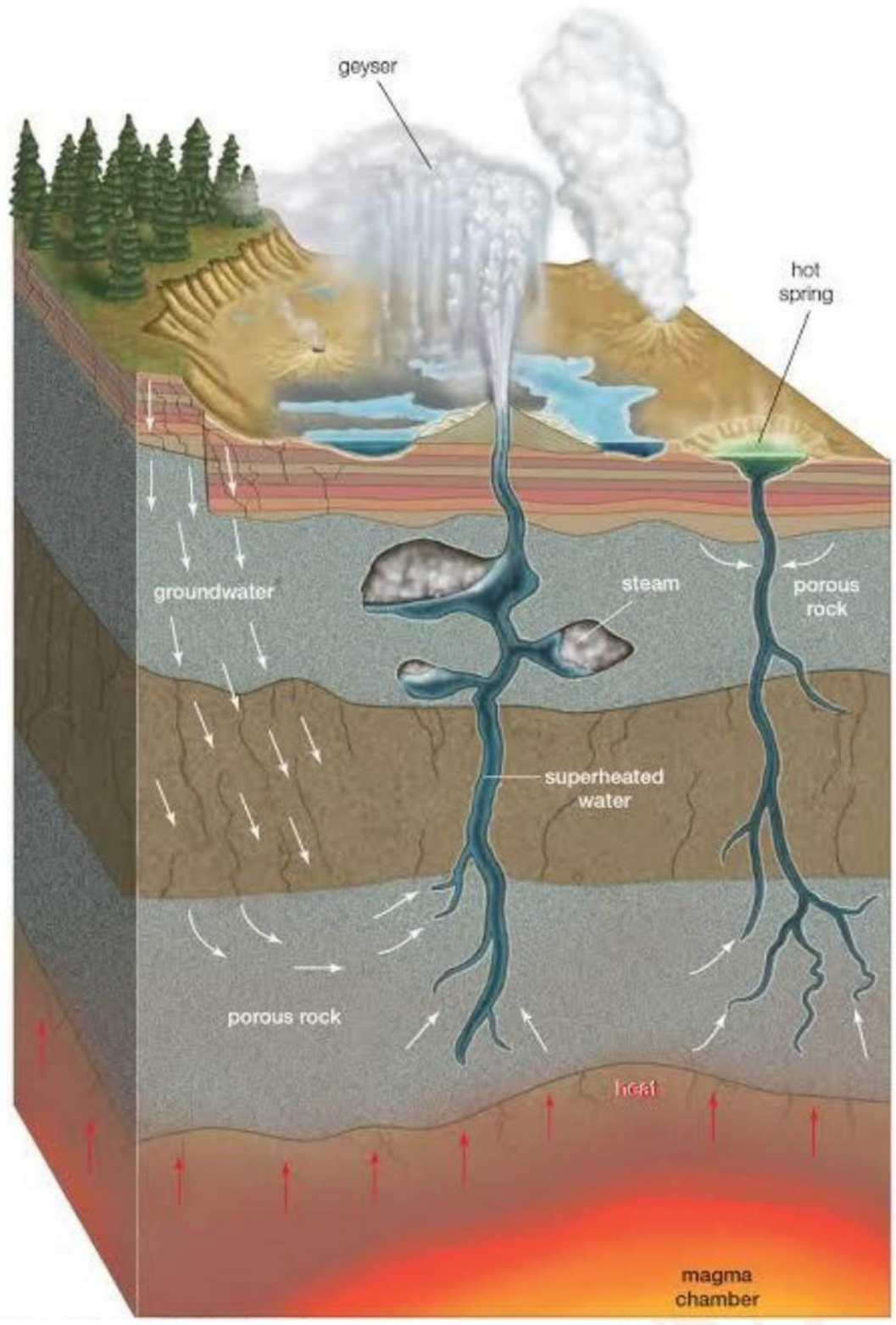
- There are well over 500 active volcanoes and thousands of dormant and extinct ones. They occur along coastal mountain ranges, as off-shore islands and in the midst of oceans, but there are few in the interiors of continents.
- The greatest concentration is probably that in the **Circum-Pacific region.** Popularly termed the 'Pacific Ring of Fire', which has been estimated to include two-thirds of the world's volcanoes.
- The chain of volcanoes extends for almost 2,000 miles from the Aleutian Islands into Kam-chatka, Japan, the Philippines, and Indonesia (Java and Sumatra in particular), southwards into the Pacific islands of Solomon, New Hebrides, Tonga and North Island, New Zealand.
- It is said that there are almost 100 active volcanoes in the Philippines, 40 in the Andes, 35 in Japan, and more than 70 in Indonesia.
- In contrast, the Atlantic coasts have comparatively few active volcanoes but many dormant or extinct volcanoes, e.g. Madeira, Ascension, St. Helena, Cape Verde Islands and Canary Islands, but those of Iceland and the Azores are active.
- Volcanoes of the Mediterranean region are mainly associated with the Alpine folds, e.g. Vesuvius, Etna, Stromboli, Volcano and those of the Aegean islands. A few continue into Asia Minor **(Mt. Ararat, Mt. Elbruz).** The Himalayas have, surprisingly, no active volcano at all.
- The only active volcano of West Africa is Mt. Cameroon. The West Indian islands have experienced some violent explosions in recent times.



Geysers and Hot Springs

- Geysers are **fountains of hot water** and superheated steam that may spout up to a height of 150 feet from the earth beneath. The phenomena are associated with a thermal or volcanic region in which the water below is being heated beyond boiling-point (100°C. or 212°F).
- Almost all the **world's geysers** are confined to three major areas: Iceland, the Rotorua district of North Island, New Zealand and Yellowstone Park of U.S.A. The world's best-known geyser is perhaps Old Faithful' in Yellowstone National Park, Wyoming which erupts at regular intervals -every 63 minutes on the average.
- Hot springs or thermal springs are more common, and may be found in any part of the earth where **water sinks deep** enough beneath the surface to be heated by the interior forces.

- Iceland has thousands of hot springs. Some of them have been harnessed to heat houses, swimming pools and for other domestic purposes. **Hot springs and geysers** have become tourist attractions e.g. in Japan and Hawaii.



Some Major Earthquakes

- One of the greatest earthquakes ever known was the Great Lisbon Earthquake on 1 **November 1755**. It originated in an abrupt subsidence of the ocean floor in the Atlantic west of Lisbon.
- Tidal waves as high as **35 feet** were set up which swept across the coastal districts of Lisbon, drowning thousands.
- A fracture that occurred in the earth's crust off the coast of Japan caused the earthquake.

The Distribution of Earthquakes

- The world's distribution of earthquakes coincides closely with that of volcanoes. Regions of very greatest **seismicity** are Circum-Pacific areas, with the **epicentres** and the most frequent occurrences along the **Pacific Ring of Fire'.**
- It is said that as many as 70 per cent of earthquakes occur in the Circum-Pacific belt. Another 20 per cent of earth- quakes take place in the **Mediterranean-Himalayan** belt including Asia Minor, the Himalayas and parts of **north-west China.** Elsewhere, the earth's crust is relatively stable and is less prone to earthquakes, though nowhere can be said to be immune to earth tremors.

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- The process of wearing away the earth causes a general lowering and levelling out of the surface. It is known as **denudation** and is carried out in four phases.
  I. **Weathering**: the gradual disintegration of rocks by atmospheric or weather forces;
  II. **Erosion**: the active wearing away of the earth's surface by moving agents like running water Wind, ice and waves
  III. **Transportation**: the removal of the eroded debris to new positions;
  IV. **Deposition**: the dumping of the debris in certain parts of the earth, where it may accumulate to form new rocks.
- All four phases of the denudation process are taking 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.

Weathering

The work of weathering in breaking up the rocks is of two kinds, namely chemical, and physical or mechanical weathering, but the processes involved in each are closely interrelated.

1) **Chemical weathering**
   - Chemical weathering is the basic process by which denudation proceeds. It is the extremely slow and gradual **decomposition** of rocks due to exposure to air and water.
   - For example, in Malaysia, the surface of granite which has been exposed to the weather is found to be pitted and rough. This is because the granite is made of three main minerals: quartz, felspar and mica. The felspar is more quickly weathered than the quartz and thus the felspar crystals are worn away.
   - Regolith is simply the mineral remains of decomposed rocks, but soil contains organic materials, such as the roots of plants, fallen leaves, small animals such as worms, bacteria and so on.
   - When a soil cover exists, chemical weathering of the underlying rocks does not cease; on the contrary it is usually **enhanced**, this is because the soil absorbs rain-water and keeps the underlying rocks in contact with this moisture.
   - The rain-water absorbs organic acids from the soil and thus becomes a stronger weathering agent than pure rain-water acting on bare rock. There are three major chemical weathering processes.
     - **Solution**
       - Many minerals are dissolved by water, especially when, as with rain-water, it contains enough carbon dioxide to make it a weak acid.
       - The **dissolved** calcium carbonate is carried away by the water, joints and cracks in the rock are quickly widened and whole systems of caves and passages are worn out. Limes-tone, however, is by no means the only rock to suffer from solution.
       - The rate at which solution takes place is affected not only by the mineral composition of the rock but also by its structure, Sedimentary rocks often have pore-spaces between the grains in which air

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and water can lodge and thus attack the rock.

- In tropical countries, where the heavy rainfall and warm climate both promote rapid chemical reactions, weathering often proceeds very rapidly. This produces the very deep **regoliths** or soils overlying the solid rocks. Often these regoliths contain core-stones. These are pieces of solid rock which have resisted weathering while all the surrounding rock has been weathered.
- Rates of weathering are also affected by climate Warm wet climates promote rapid chemical weathering, while dry climates inhibit chemical weathering. Dry climates, however, provide good conditions for physical or mechanical weathering.

▪ **Oxidation**

- Oxidation is the reaction of oxygen in air or water with minerals in the rock.
- For example, most rocks contain a certain amount of iron, which when it comes in contact with air is changed to iron Oxide, familiar brownish crust or rust. Iron oxide crumbles easily and is fat more easily eroded than the original iron.

▪ **Decomposition by organic acids**

- Within the soil which covers most rocks are bacteria which thrive on decaying plant or animal material.
- These bacteria produce acids which, when dissolved in water, help to speed up the weathering of the underlying rocks. In some cases, micro-organisms and plants like mosses or lichens can live on bare rock, so long as the surface is damp.
- These absorb chemical elements from the rocks as food and also produce organic acids. They are thus agents of both chemical and mechanical weathering.

2) **Physical or Mechanical weathering**

- Mechanical weathering is the physical disintegration of a rock by the actual prising apart of separate particles. Mechanical weathering takes place in several ways.
- **Repeated temperature changes**
  - In deserts, rocks are exposed to the blazing sun during the day and are intensely heated. The outer layers expand much faster than the cooler interior of the rocks and tend to pull away from the rest.

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- At nightfall the temperature drops rapidly and the outer layers contract more rapidly than the interior, setting up internal stresses.
- Well- bedded and jointed rocks tend to split along the joints or cracks, breaking up into rectangular blocks. Shales and slates may split up into platy fragments because of their platy structure.
- In crystalline rocks such as granite the crystals of the various minerals (quartz, mica, and felspar) will expand and contract at different rates, enhancing the stresses and accelerating the dis- integration of the rocks.
- Stresses and pressures will naturally be greatest from near the surface and where there are sharp angles the rocks. Rectangular block's are thus gradually rounded by the splitting away of sharp corners.

- **Repeated wetting and drying**
  - Exfoliation is not confined to desert areas.
  - This takes place especially in tropical reg- ions, like Malaysia, where short downpours saturate the rocks and then the hot sun quickly dries them again. When they dry this moisture evaporates and they quickly shrink.
  - When this happens repeatedly the outer layers split off. It should also be stressed that the wetting and drying of the rocks in deserts is probably just as important as temperature changes in mechanical weathering.
- **Frost action**
  - In temperate latitudes frost is a potent rock breaker. When water freezes it expands by one-tenth -its volume and exerts a bursting pressure of almost 140 kg per square cm (2,000 lb. to the square inch).
  - Repeated freezing of this kind will deepen and widen the original cracks and crevices and break the rock into angular fragments.
  - On mountain peaks this process creates sharp pinnacles and angular out- lines. Such peaks are described as frost-shattered peaks.
- **Biotic factors**
  - Small fragments of rock loosened by either chemical or mechanical weathering lodge in cracks and crevices in the rock and plants may sprout in such crevices.
  - As they grow their roots penetrate the rocks below, usually along joints and other lines of weakness, prising them apart.
  - You have often come across large trees growing near roads or the courtyards of houses that finally prise open the concrete or paving stones above their roots.

Mass Movement

- Mass movement is the movement of weathered materials down a slope due to gravitational forces. The movement may be gradual or sudden, depending on the gradient of the slope.
  1. **Soil Creep**
     - This is a slow, gradual but more or less continuous movement of soil down hillslopes. The movement is not very noticeable,

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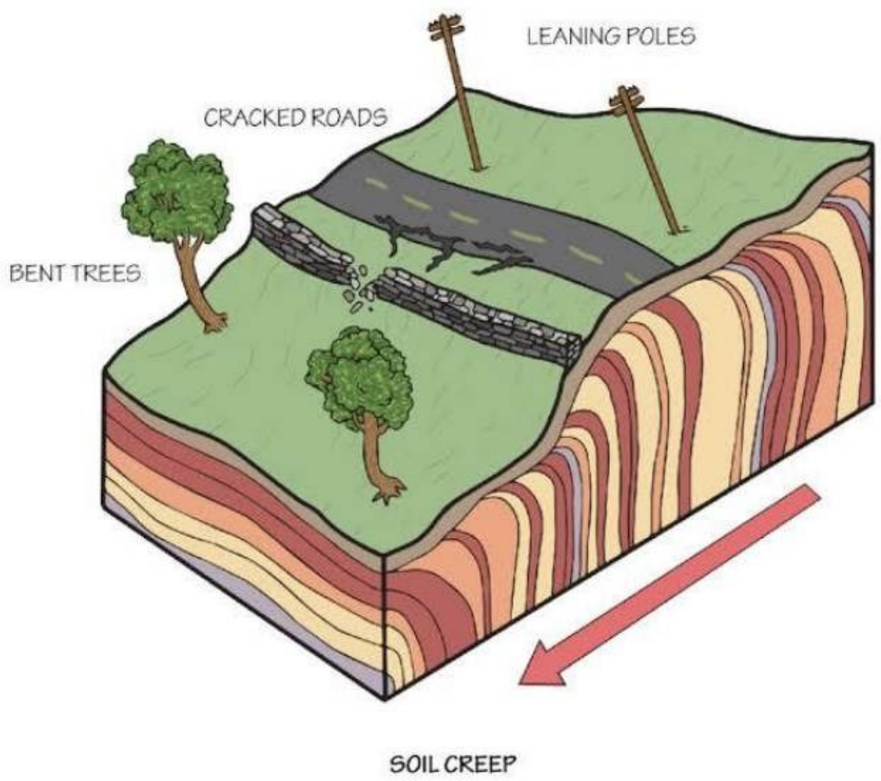
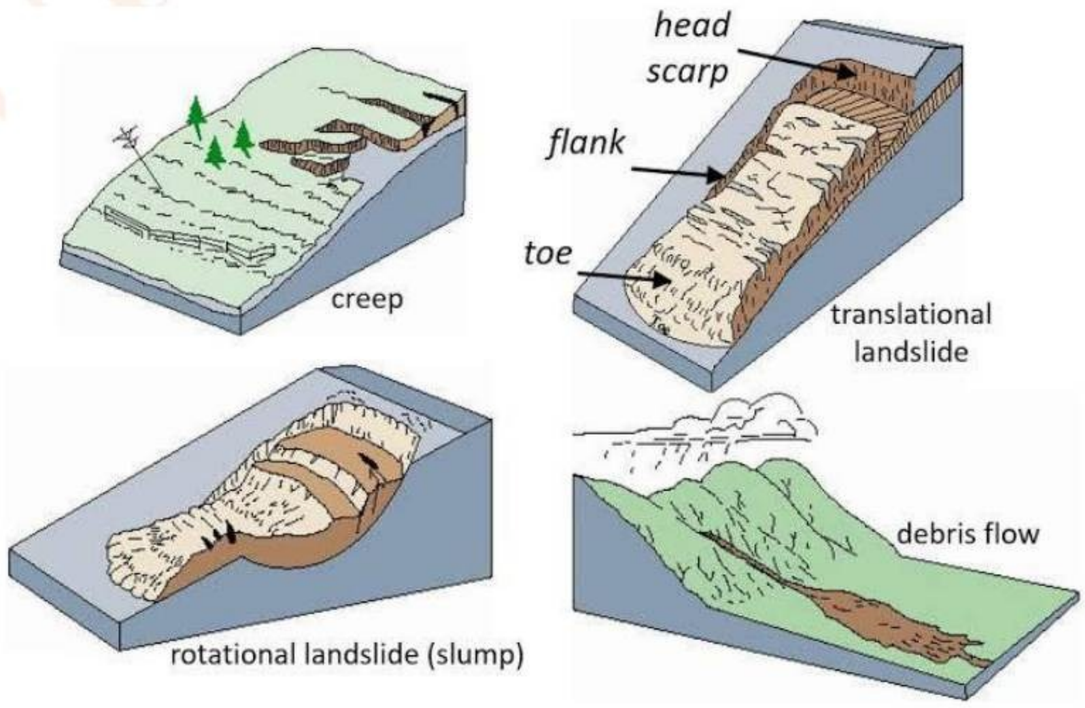
especially when the slope is fairly gentle or when the soil is well-covered with grass or other vegetation.

- Soils where the water acts as a lubricant so that individual soil particles move over each other and over the underlying rock.



2. **Soil Flow (Solifluction)**
   - When the soil is completely saturated with water the individual particles are almost suspended in the water and move easily over one another and over the underlying rock.
   - The soil acts like a liquid and a soil-flow or mud-flow occurs. In arid regions a mantle of weathered debris may become saturated with rain water after a storm and flow downslope as a semi-liquid mass. In Ireland such flows are known as bog-bursts



3. **Landslides (Slumping or Sliding)**
   - Landslides usually occur on steep slopes such as in mountainous areas, on cliffs or where man has artificially steepened slopes, for example, in road or rail cuttings (Plate 4.C). Landslides may be caused because a **steep slope** is undercut by a river or the sea so that it falls by gravity. But often landslides are caused by the lubricating action of rain- water.
   - Slumping is particularly common where permeable debris or rock layers overlie impermeable strata such as clay. Water sinking through the permeable material is halted by the clay. The damp clay provides a smooth slippery surface over which the upper layers easily slide.
   - Water may collect at the base of the regolith because it sinks readily into the weathered material but more slowly into the solid rock beneath. The water may allow the regolith to slide away from the underlying rock.
   - Man, often enhances the possibility of landslides by clearing natural vegetation for agriculture or housing. Removal of the plant cover allows more water to penetrate the soil and rocks.

Groundwater

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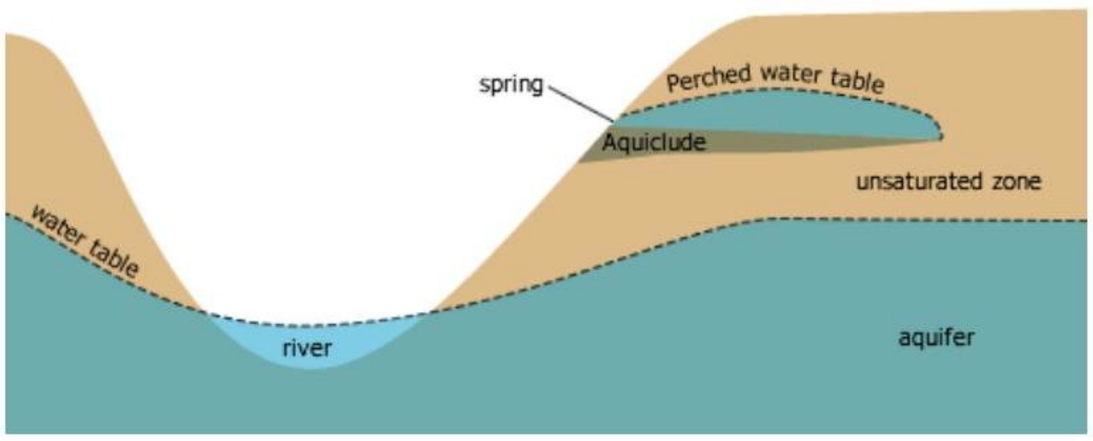
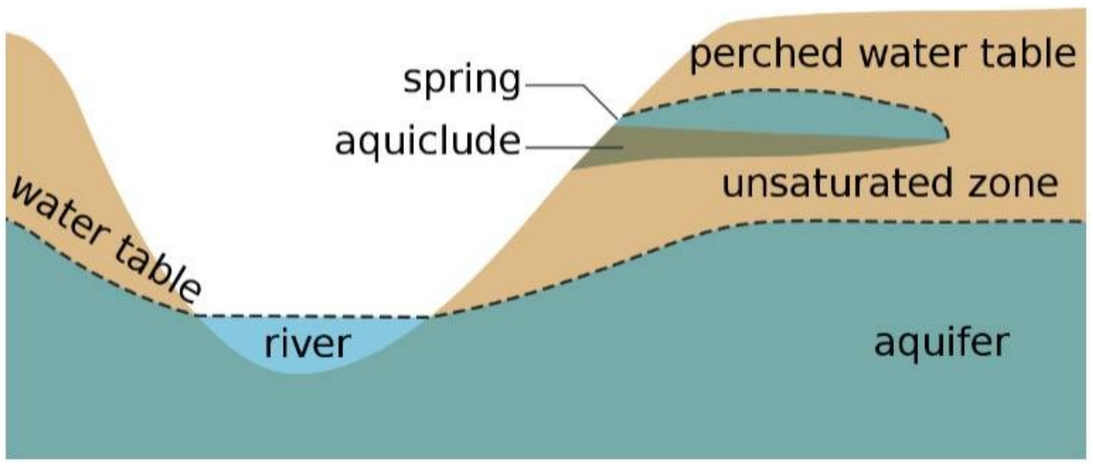


- The whole process of the circulation of water between the land, sea and atmosphere is known as the hydrological cycle.
- When rain falls on the earth it is distributed in various ways. Some is immediately **evaporated and thus returns** to the atmosphere as water vapour. Some is absorbed by plants and only gradually returned to the atmosphere by transpiration from the leaves of plants. Much of it flows directly off slopes to join streams and rivers, eventually reaching the seas and oceans. This is known as run-off.
- A considerable proportion of the water received from rain or snow, however, percolates downwards into the soil and rocks, filling up joints and pore-spaces and forming what is known as groundwater.
- **Groundwater** plays an important part in weathering and **mass movement** and is also important as a means of natural water storage. It re-enters the hydrological cycle by way of springs.
- In moderately humid areas water, both runs off and sinks into the ground. The proportion of the rainfall absorbed as groundwater may depend on the season of the year.
- Porous rocks are those, like sandstone, which have many pore-spaces between the grains. Water is easily absorbed by such rocks and may be stored in the pore-spaces.
- Permeable or pervious rocks are those which allow water to pass through them easily. Thus **most porous** rocks are also permeable. However, some rocks are porous but impermeable.

The Water-Table



- Water which seeps through the ground moves down. Ward under the force of gravity until it reaches an impermeable layer of rock through which it cannot pass.
- If there is no ready outlet for the groundwater in the form of a spring, the water accumulates above the impermeable layer and saturates the rock.
- The permeable rock in which the water is stored is known as the aquifer. The surface of the saturated area is called the **water-table the depth of the water table** varies greatly according to relief and to the type of rocks. The depth of the water-table also varies greatly with the seasons.

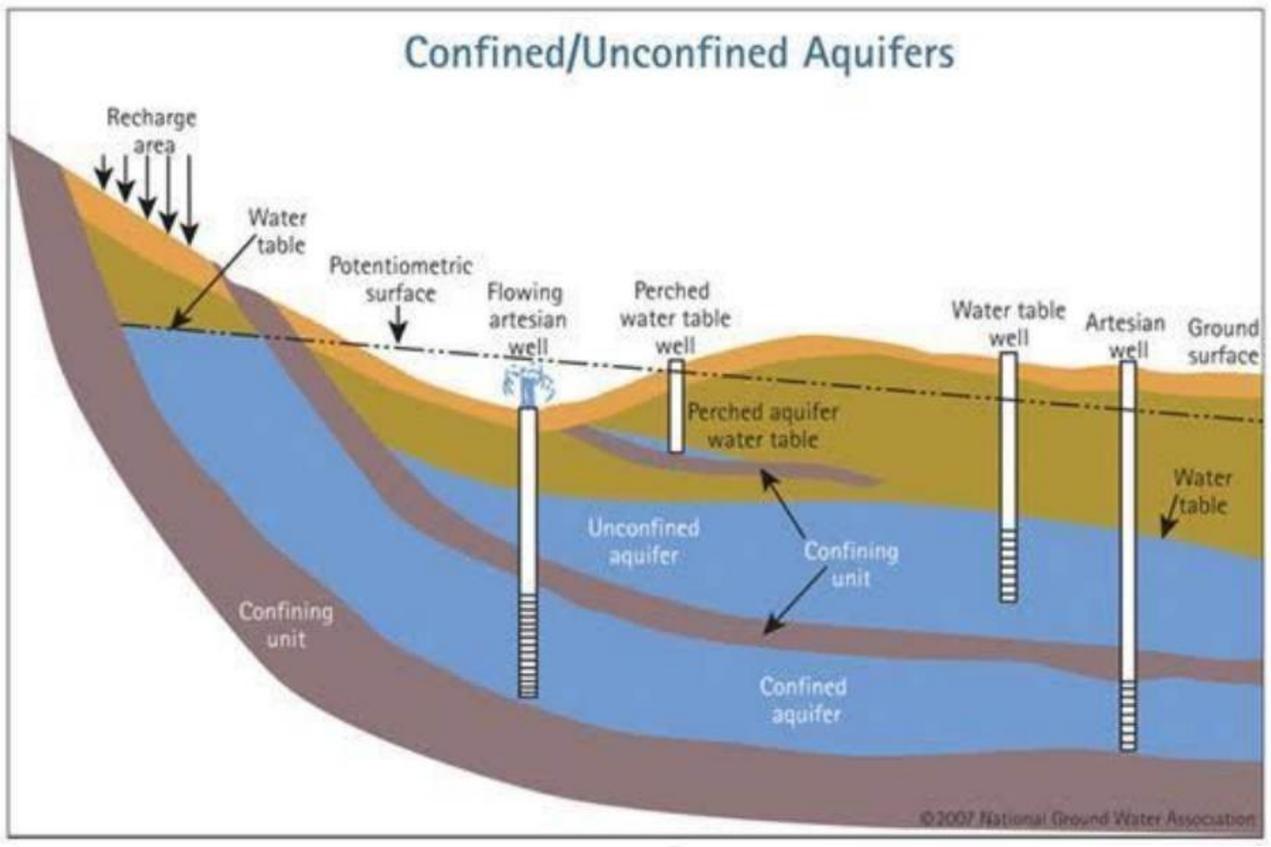
Springs and Wells

1) **Springs**
   - The groundwater stored in the rock is released onto the surface at points where the water-table reaches the surface. **A spring** is simply an outlet for such water. The water may seep gradually out of the rock or may gush out as a fountain.
     a) In areas of tilted strata, where permeable and impermeable rocks alternate, water emerges at the base of the permeable layers
     b) In well-jointed rocks water may percolate downwards until it reaches a joint which emerges at the surface. The water may come to the surface through the joint

c) Where a dyke or sill of impermeable rock is intruded through permeable rocks it causes the water-table to reach the surface and the water issues as a spring

d) In limestone or chalk escarpments, where the permeable water issues at the foot of the scarp as a scarp-foot impermeable stratum, rock lies between springs.

e) In karst regions rivers often disappear underground. They then flow through passages worn in the rock by solution, and may re-emerge when limestone gives place to some impermeable rock.



2) Wells

- Springs are the natural emergence points of ground water, but Man can make use of stored water below ground by **sinking wells,** a hole is bored through the earth until the water-table is reached. The well must be sunk to the depth of the permanent water-table, if a constant supply of water is to be obtained.
- A particularly important type of well is the artesian well, which owing to the nature of its formation is quite distinctive. Where rock layers have been down- folded into a basin shape, permeable strata such as chalk or limestone may be sandwiched between impermeable layers, such as clay.
- The permeable rocks may only come to the surface at the edges of the basin, but water falling on them will gradually seep downwards by the force of gravity until it reaches the lowest part of the basin.
- The water is thus trapped in the aquifer under great pressure and when a well is bored, the pressure of water downwards from all around the basin is sufficient to force the water up the bore-hole so that it gushes onto the surface like a fountain.

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CHAPTER: 5 – LANDFORMS MADE BY RUNNING WATER

The Development of a River System

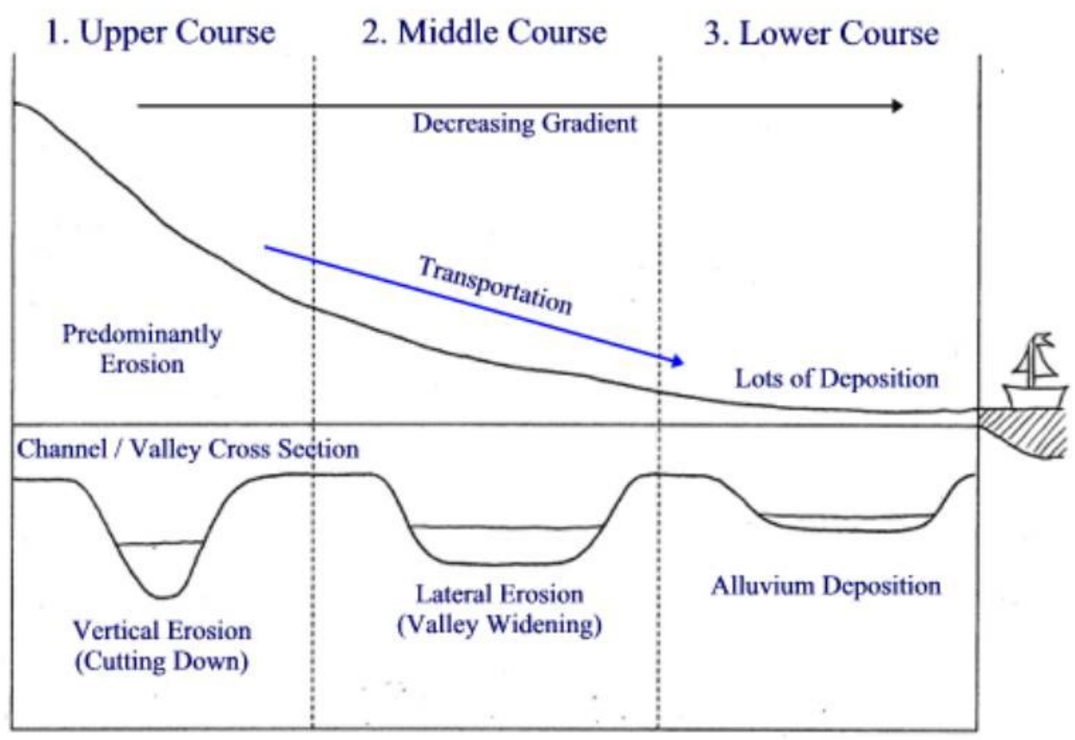
- This running water forms a potent agent for denuding the earth's surface. Denudation is the general lowering of the earth's surface. This takes place because such agents of erosion as rivers, ice, wind and waves wear away the rocks and transport the eroded debris to lower land or right down to the sea. But **erosion** cannot take place unless the rocks are first weakened.
- Running water is thus the **most important single agent of denudation.**
- The source of a river may be a spring, a lake or a marsh but it is generally in an upland region, where precipitation is heaviest and where there is a slope down which the **run-off** can flow.
- The uplands therefore form the catchment areas of rivers. The crest of the mountains is the divide or watershed from which streams flow down the slopes on both sides to begin their journey to the oceans. The initial stream that exists as a consequence of the slope is called the consequent stream.
- If the rocks are composed of homogeneous beds of uniform resistance to **erosion**, the tributaries will join the main valley obliquely as in sequent streams.
- The drainage pattern so evolved will be tree-like in appearance, and is therefore described as **dendritic drainage**, after a Greek word dendron meaning "tree. On the other hand, if the rocks are made up of alternate layers of hard and soft rocks, the tributaries tend to follow the pattern of the rock structure.
- The drainage pattern so developed will be rectangular in shape and is called trellised drainage.

The Mechanism of Humid Erosion

- Humid erosion covers the entire scope of sculpturing effects of running water from the action of rainwater to that of the rivers.
- Mass movements of earth and weathered materials on hill-slopes down to valleys are mainly due to the **lubricating action** of water which allows a mass of materials to move under gravity.
- The slow movement of soil down a hill-slope is call soil-creep. A more sudden movement due to the lubricating effect or rain-water may cause widespread landslides.

The Processes of River Action

- When a river flows it carries with it eroded materials. These comprise the river's **load**, and may be divided into three distinct types.
  1. **Materials in solution -** These are minerals which are dissolved in the water.
  2. **Materials in suspension -** Sand, silt and mud are carried along suspended in the water as the stream flows.
  3. **The traction load -** This includes coarser materials such as pebbles, stones, rocks and boulders, which are rolled along the river bed.
- It has been estimated that for every square mile of the earth surface, more than 200 tons of solid materials in **suspension** and more than 50 tons of materials in solution are being carried off by running water every year.
- The ability of a river to move the various grades of materials depends greatly upon the volume of the water, the velocity of the fiow and lastly the size, shape and weight of the load. It is said that by doubling the



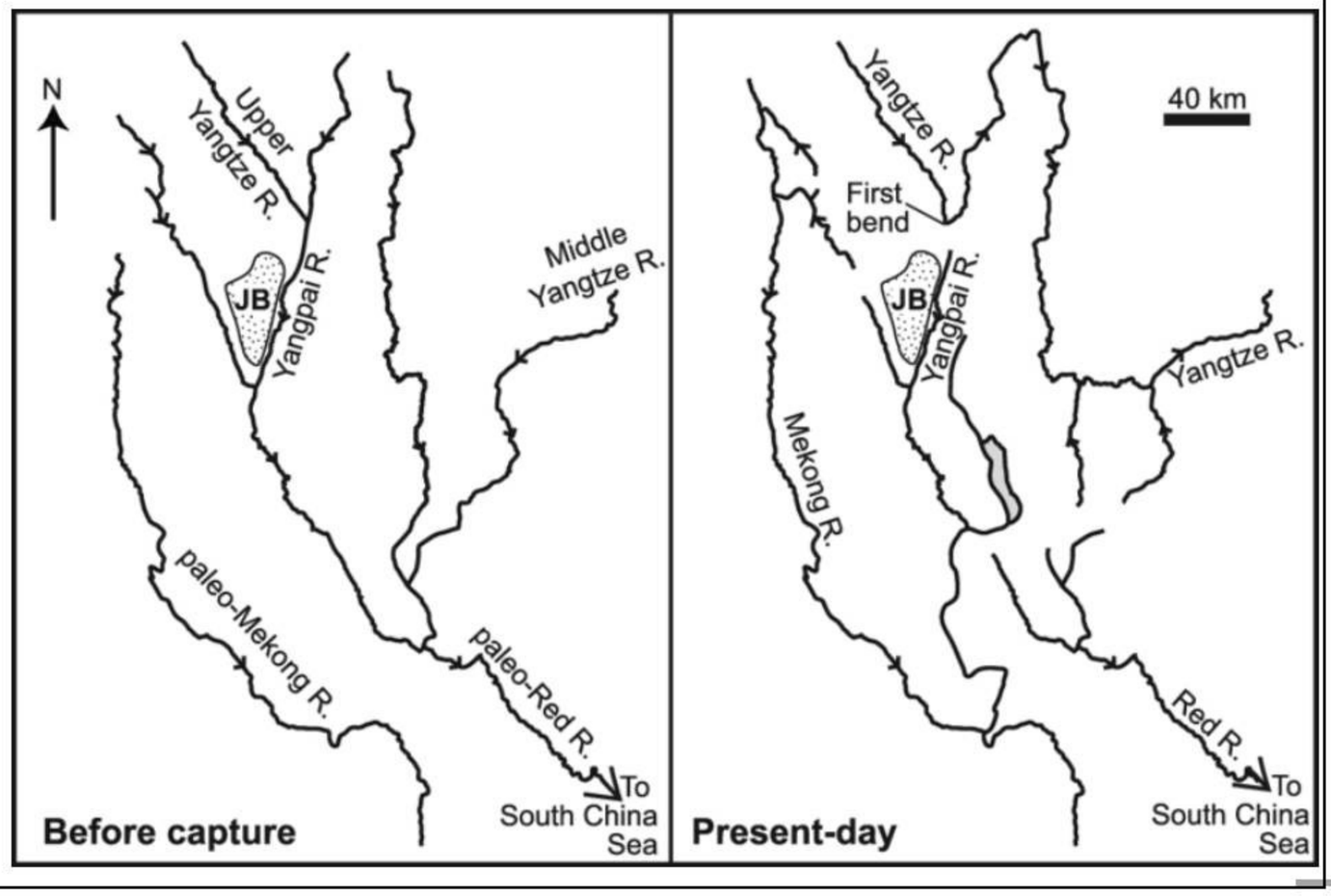
velocity of a river, its transporting power is increased by more than 10 times.

River Erosion and Transportation

1) **Corrasion or abrasion -** This is the mechanical grinding of the river's traction load against the banks and bed of the river.
   a) Corrasion takes place, in two distinct ways.
   b) Lateral corrasion. This is the **sideways** erosion which widens the V-shaped valley
   c) Vertical corrasion. This is the **downward** action which deepens the river channel.
2) **Corrosion or solution -** This is the **chemical or solvent** action of water on soluble or partly-soluble rocks with which the river comes into contact. For example, calcium carbonate in limestones is easily dissolved and removed in solution.
3) **Hydraulic action -** This is the mechanical loosening and sweeping away of materials by the river water itself. Some of the water splashes against the river banks and surges into cracks and crevices. This helps to disintegrate the rocks. The water also **undermines** the softer rocks with which it comes into contact.
4) **Attrition -** This is the wear and tear of the transported materials themselves when they roll and collide into one another. The coarser boulders are broken down into smaller stones; the angular edges are smoothed and rounded to form pebbles.

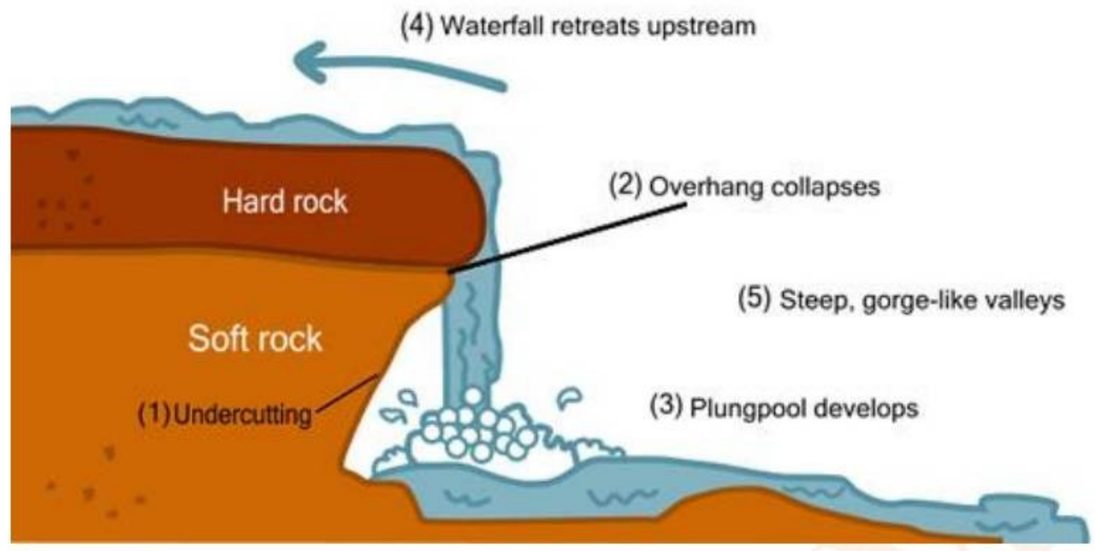
The Course of a River

1. **The Upper or Mountain Course**
   - This begins at the source of the river near the water-shed, which is probably the erect of a mountain range. The river is **very swift** as it descends the steep slopes, and the predominant action of the river is vertical corrasion.
   - The valley developed is thus deep. Narrow and distinctively V-shaped. In some cases where the rocks are very resistant, the valley is so narrow and the sides are so steep that **gorges** are formed.
   - In arid regions, where there is little rainfall to widen the valley sides, and the river cuts deep into the valley-floor, precipitous valleys called canyons are formed.
   - Some of the more outstanding features that are often best developed in the upper course of a river include the following.
   - **River capture**
     i. This is also known as river piracy or river beheading. Its development is dependent on the different rate of back-cutting (headward erosion) into a divide.
     ii. For instance, if one side of the divide is of greater gradient or receives more precipitation than the other, stream A will cut back more rapidly than stream B. Its greater **erosive power** will succeed in enlarging its basin at the expense of the weaker stream.
     iii. Stream A may eventually break through the divide and capture or pirate stream B. The bend at which the piracy occurred is termed as the



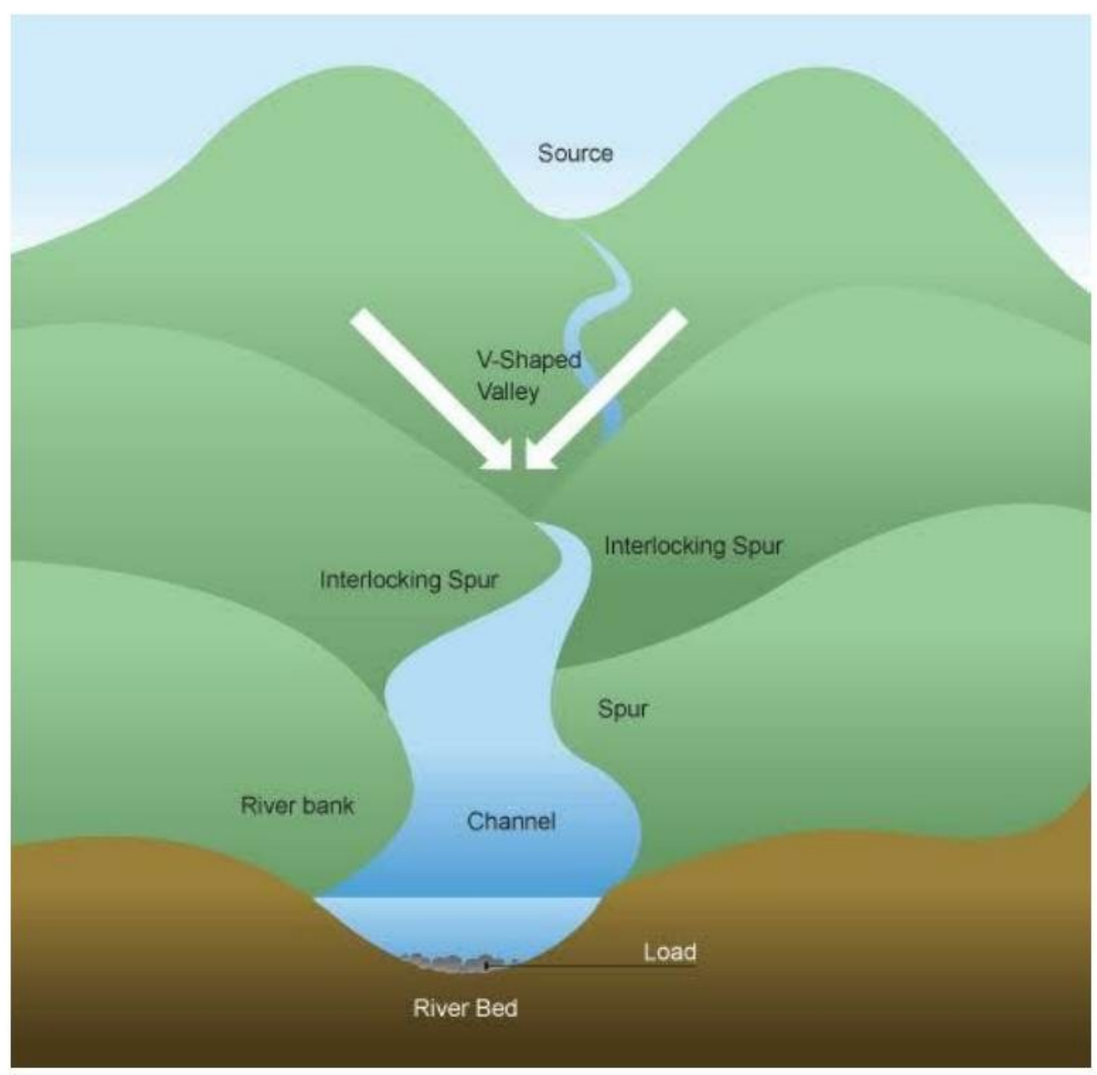
elbow of capture. The beheaded stream (Z) is called the **misfit**. The valley below the elbow is the wind gap, and may be valuable as a road and rail route.

- **Rapids, cataracts and waterfalls**
  i. These are liable to occur at any part of the river course, but they are most numerous in the mountain course where changes of gradient are more abrupt and also more frequent.
  ii. Due to the unequal resistance of hard and soft rocks traversed by a river, the outcrop of a band of hard rock may cause river to **"jump' or "fall'** down-stream. Rapids are formed.
  iii. Similar falls of greater dimensions are also referred to as cataracts, of which there are five along the Nile that interrupt smooth navigation. When rivers plunge down in a sudden fall of some height, they are called waterfalls. Their great force usually wears out a plunge-pool beneath several ways. **Waterfalls are formed in several ways.**
    1. When a bar of resistant rock lies transversely across a river valley, e.g. the Niagara Falls, U.S.A.
    2. When a fault-line scarp caused by taulting lies across river, e.g. Victoria Falls
    3. When water plunges down the edge of a plateau like the River Congo
    4. Glaciation produces hanging valleys



2. The Middle or Valley Course

- In the middle course, lateral corrasion tends to replace vertical corrosion. Active erosion of the banks widens the V-shaped valley. The volume of water increases with the confluence of many tributaries and this increases the river's load. The work of the river is predominantly transportation with some deposition.
- The river's treble task of valley-cutting, bed-smoothing and debris-removal are being carried out in a more tranquil manner than in the mountain course though the velocity does not decrease. Some of the load is dropped or deposited. Again this depends on the volume of flow, for in the event of flood, the river's erosive power and its capability for load-carrying is greatly increased.



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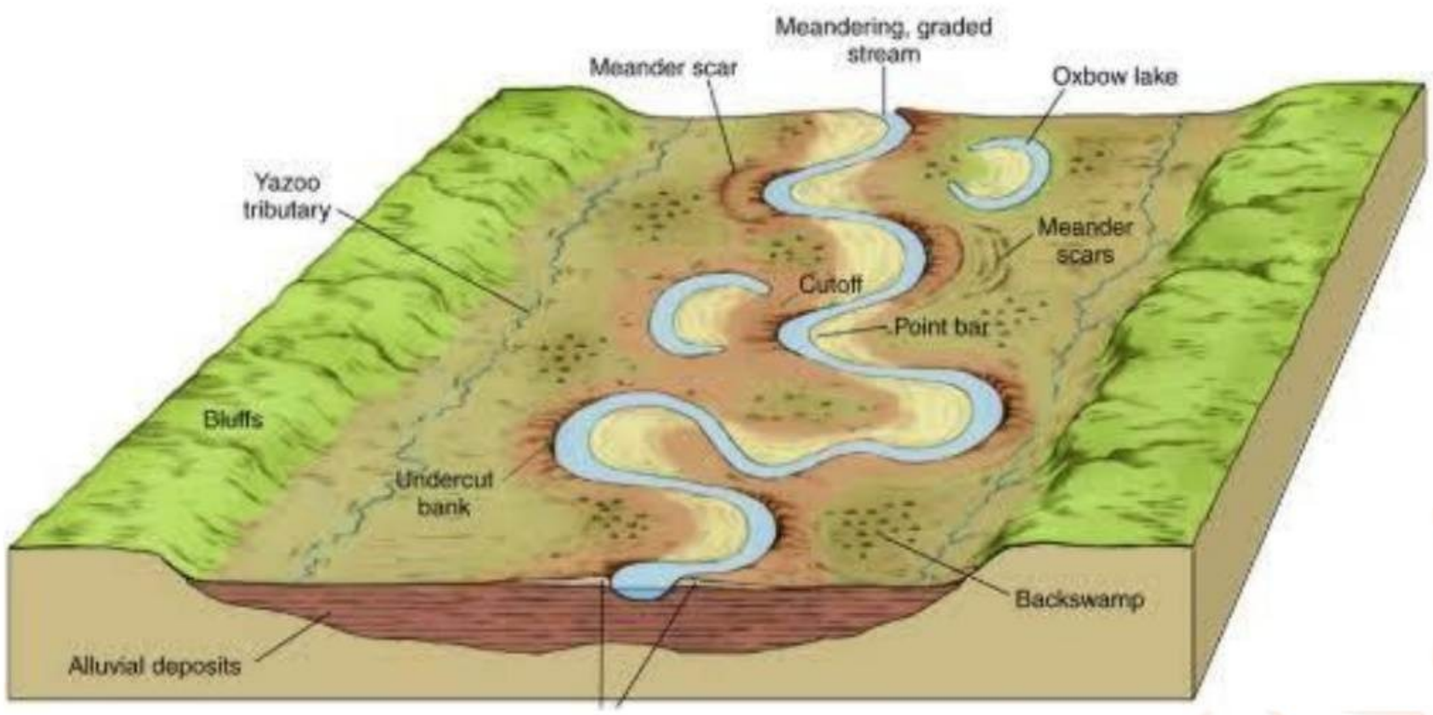
i. **Meanders -** As water flowing under gravity seldom flows straight for any long distance, a winding course soon develops. The irregularities of the ground force the river to swing in loops, forming meanders, a term derived from the winding River Meandered in Asia Minor.



ii. **River cliffs and slip-off slopes -** When the tow of water PQ enters the bend of the river, it dashes straight into Q. eroding the outer bank into a steep river-cliff at Q. The water piles up on the outside of the bend because of the centrifugal force. A bottom current RS is set up in a cork- screw motion and is hurled back into mid-stream and the inner bank. Shingle is thus deposited here at S. outer bank is therefore the bank of continuous erosion and the inner bank is the bank of continual deposition

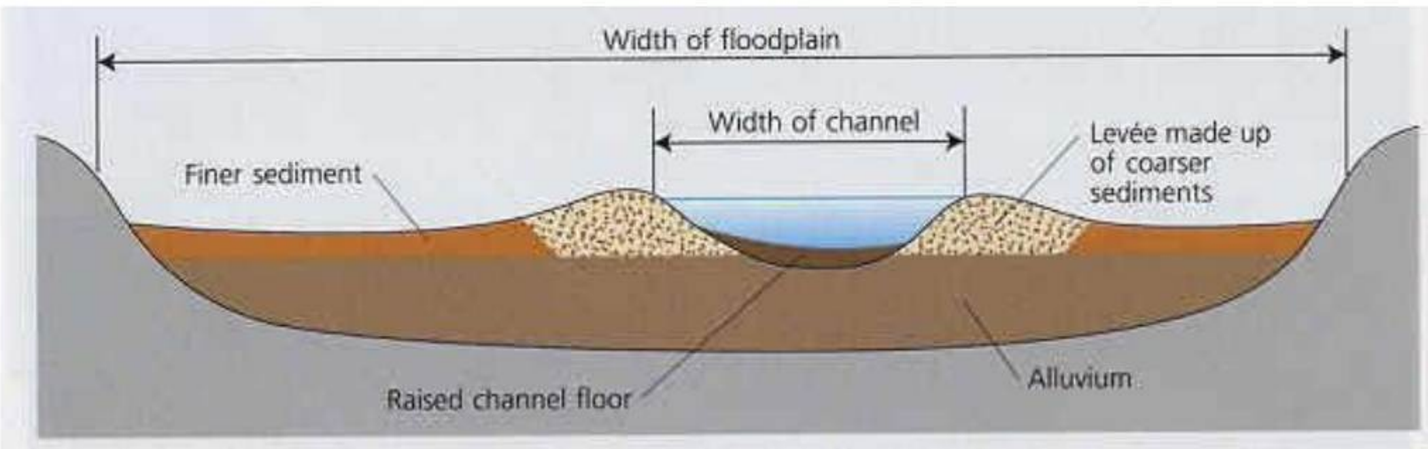
iii. **Interlocking spurs -** As the stream flows on, the meanders migrate progressively outwards with the interlocking spurs alternating with the undercut slopes as shown in. It must be pointed out at this stage that meanders in the middle course are only the beginning of the downstream swing, for bends are restricted by the interlocking spurs. In the lower course, the loops are enlarged across the level plain and meanders are fully developed.

3. **The Lower or Plain Course**

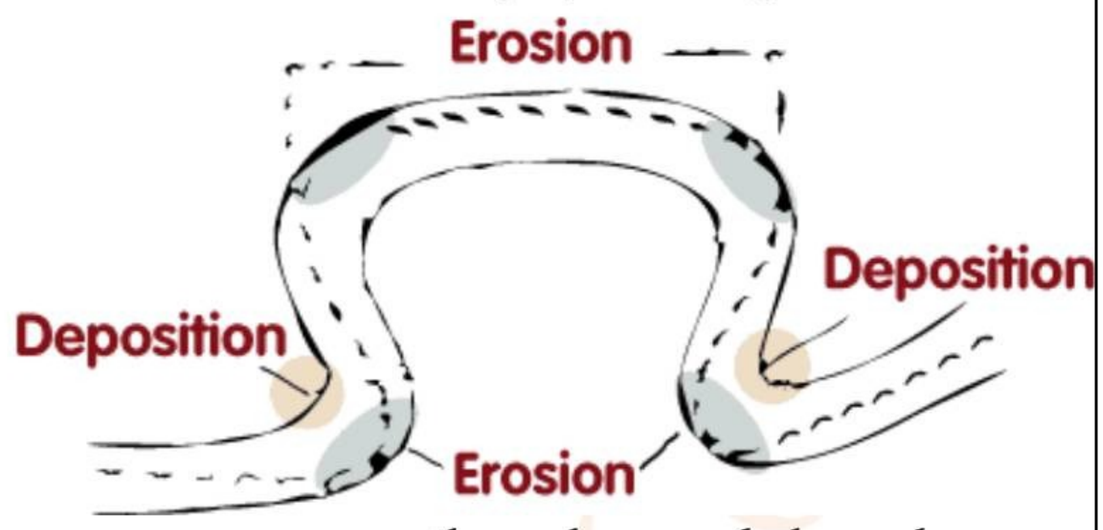
- Vertical corrasion has almost ceased though lateral corrasion still goes on to erode its banks further. The work of the river is mainly deposition, building up its bed and forming extensive flood plains.
- The volume of water is greatly swelled by the additional tributaries that join the main stream. Coarse materials are dropped and the finer silt is carried down **towards the mouth of the river.**
- Large sheets of materials are deposited on the level plain and may split the river into several complicated channels, so that it can be described as a braided stream. Some of the major plain course features are the following.
- **Flood plain**
  i. During annual or sporadic floods, these materials are spread over the low-lying adjacent areas. A layer of sediment is thus deposited during each flood, gradually building up a fertile flood plain.
  ii. When the river flows normally its bed is raised through the accumulation of deposits and material is also dropped on the sides forming raised banks called **levees.**
  iii. In an attempt to minimise the risk of floods, artificial embankments are erected on the natural levees, but this

allows the river to rise further.

iv. Hwang-Ho breached its bank, killing a million people and did untold damage to farms and properties. The river's course was diverted over 300 miles away, draining into the Gulf of Pohai instead of the Yellow Sea. Nowadays, huge dredgers help to deepen the channels to avoid excessive sedimentation.



- **Ox-bow lakes**
  i. These are also known as cut-offs or bayous in the Mississippi basin. In the lower course of a river, a meander becomes very much more pronounced.
  ii. The outside bend or concave bank is so rapidly eroded that the river becomes almost a complete circle.
  iii. There will come a time when the river cuts through the narrow neck of the loop, abandoning an **ox-bow lake** or mortlake (meaning dead lake). The river then flows straight.
- **Delta**
  i. When a river reaches the sea, the fine materials it has not yet dropped are deposited at its mouth, forming a fan-shaped alluvial area called a delta.
  ii. This alluvial tract is, in fact, a seaward extension of the flood-plain. Due to the obstruction caused by the deposited alluvium, the river may by discharge its water



through several channels called distributaries.
  iii. For his reason, several types of delta are recognisable. The Mississippi has a bird's-foot delta with several main branches like the foot of a bird extending into the Gulf of Mexico. The Nile, Ganges and Mekong have the fan-shaped arcuate deltas with numerous distributaries.
  iv. Some other rivers such as the Amazon. **Ob and Vistula** have their deltas partly submerged in coastal waters to form estuarine deltas
  v. The following summarises the conditions favourable for the formation of deltas.
    1. Active vertical and lateral erosion in the upper course of the river to provide extensive sediments to be eventually deposited as deltas.
    2. The coast should be sheltered preferably **tideless.**
    3. The sea adjoining the delta should be shallow or else the load will disappear in the deep waters.

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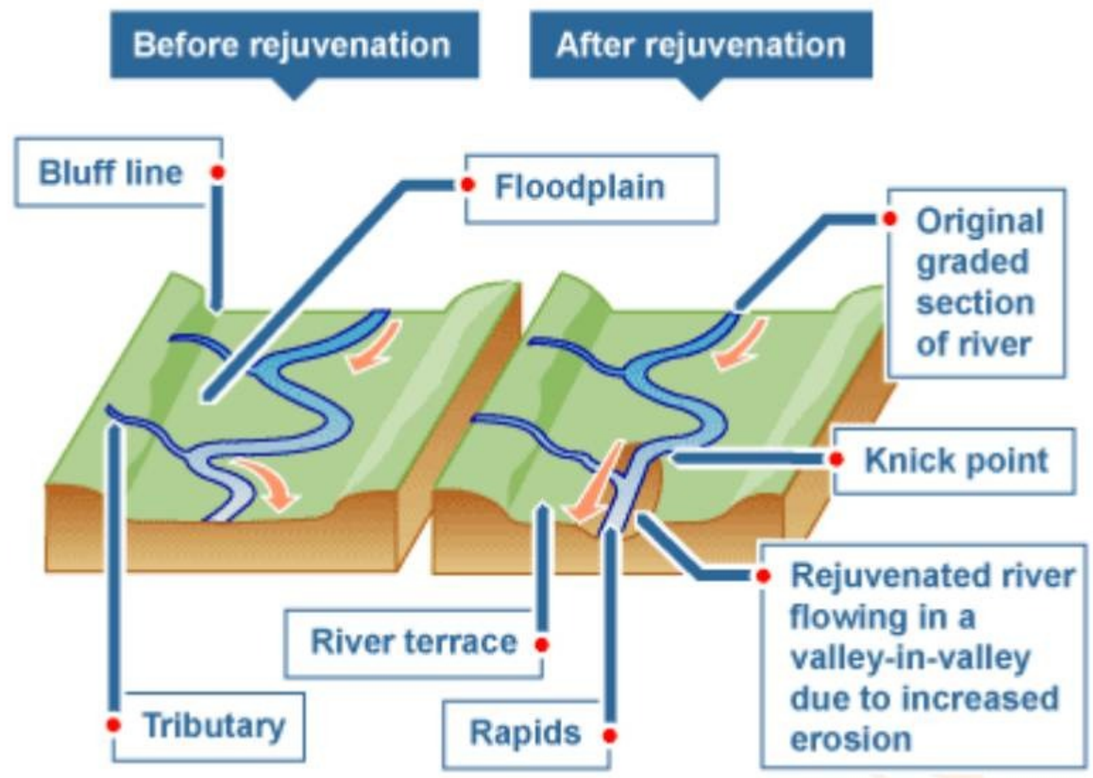
4. There should be no large lakes in the river course to filter off the sediments.
5. There should be no strong current running at right angles to the river mouth, washing away the sediments



River Rejuvenation

- The earth's crust is far from stable and it is not surprising that, in the course of a river's development, parts may be uplifted or depressed, giving rise to certain characteristic features associated with rejuvenation, i.e. being young again.
- A negative movement occurs when there is an uplift of land or a fall in sea level. This will steepen the slope so that active down-cutting is renewed.
- This point where the old and rejuvenated profile meet is called the Knick point or rejuvenated head.
- If rejuvenation occurs in the upper-course, the river valleys are deepened and steep-sided **gorges are formed**. In the middle and lower course vertical corrasion replaces lateral corrasion and the existing meanders are vertically eroded by the rejuvenated stream.
- A distinct new inner trench is cut in the old valley, and the river develops a deep valley with entrenched or incised meanders.
- A positive movement occurs when there is a depression of land or a rise in sea level. This will submerge the lands along the coast, drown' the **valleys and weaken** the **erosive** power of the river.
- The upper course is little affected when there is a rise in sea level. In many areas where the sea has risen this was probably caused by the release of water locked up in the ice masses during the Quaternary Ice Ages.

The Human Aspects of Rivers

- In many countries, rivers form the chief highway of commerce and transport. The Yangtze Kiang is navigable up to a thousand miles from its mouth. The Amazon, the world's greatest river is navigable 2**,300 miles up-stream** to the foot of the Andes, though it is less extensively used.
- Rapids and waterfalls, interrupt the navigability of a river. By depositing large quantities of sediments in the lower course, the river silts up ports preventing large steamers from anchoring close to the shores. Deltas are thus less satisfactory sites than estuaries for the siting of large ports.
- In the upper course, rivers with steep gorges and waterfalls, provide natural sites for the generation of hydroelectric power, leading to the establishment of metallurgical industries, engineering and aluminium Smelting, which can be profitably run on cheap, abundant power. **Dams** constructed across rivers hold back flood-water.
- In regions of insufficient rainfall such as Egypt and the Chao Phraya basin in Thailand irrigation canals fed by the main stream enable many crops to be successfully cultivated. The upper streams develop river captures and the resultant wind gaps may facilitate construction of upland roads and railways. The river valleys provide a convenient means of land communication.
- The Mekong separates Laos from Thailand; and the Yalu forms a well-defined border between North Korea and the eastern U.S.S.R.

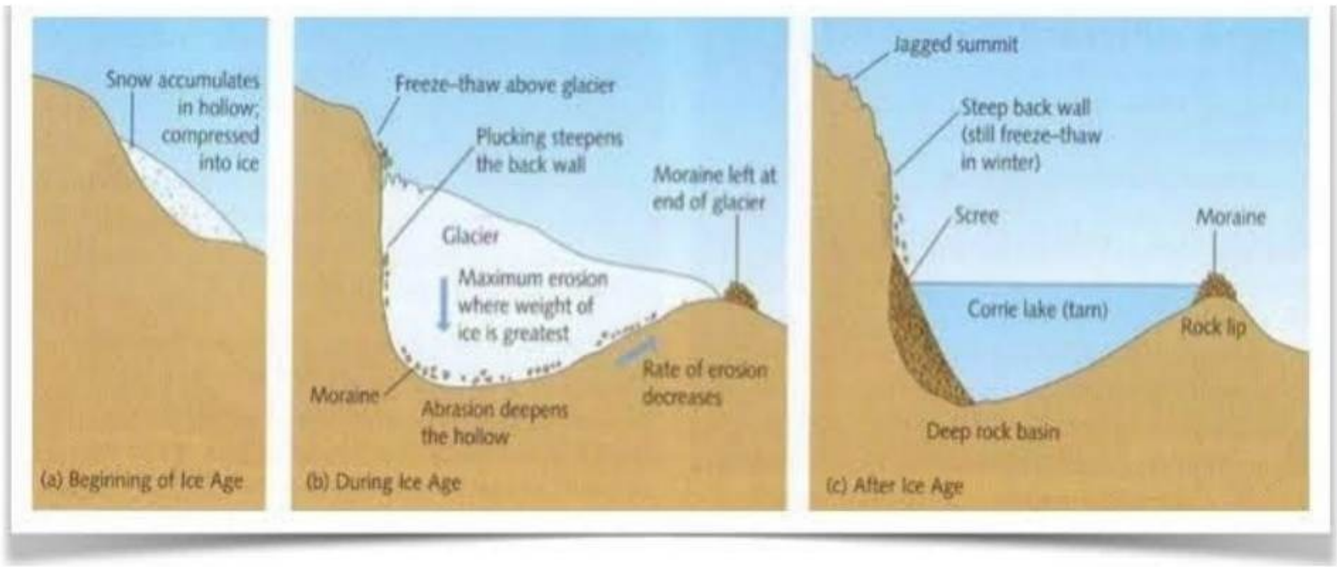
CHAPTER: 6 – LANDFORMS OF GLACIATION

The Ice Age and Types of Ice Masses

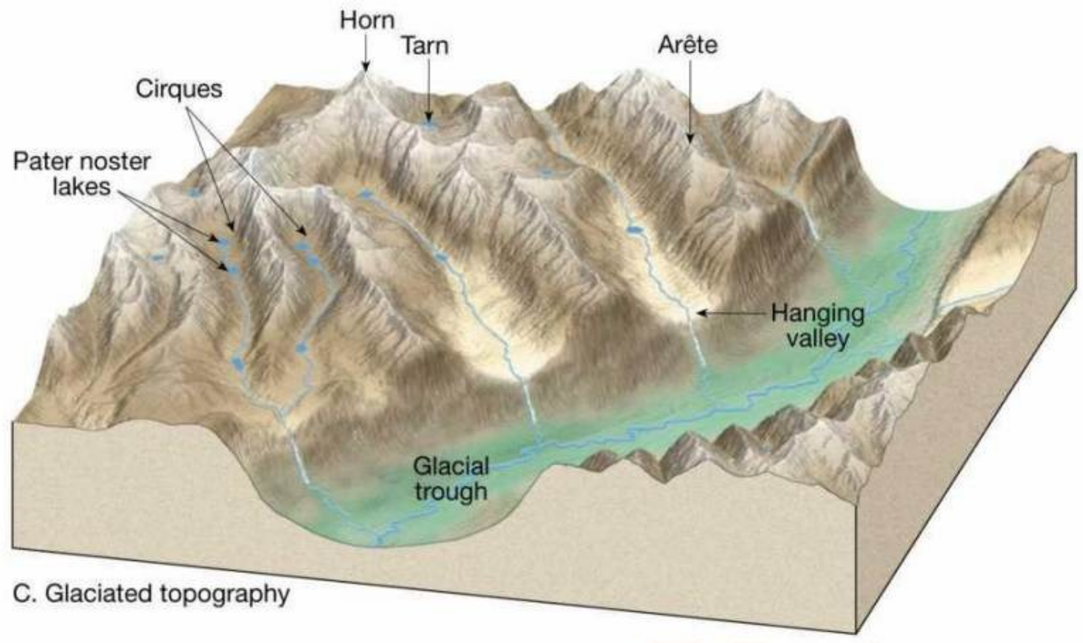
- During the Pleistocene period or the Ice Ages, about 30,000 years ago, great continental **ice sheets** covered much of the temperate latitudes. It is estimated that more than 12 million square miles of the northern hemisphere were buried by ice, half of which was in North America and the rest in Europe, Greenland and the high mountains of Eurasia.
- Today only two major **ice caps** are still present, in Greenland and Antarctica. The former covers an area of 720,000 square miles while the latter is more than 5 million square miles. They are made up of compact sheets of ice, hardened and crystallised to a depth of over a mile.
- The peaks of the loftier mountains project above the surface as nunataqs. When the ice sheets reach right down to the sea they often extend outwards into the polar waters and float as ice shelves. They terminate in precipitous cliffs. When they break into individual blocks, these are called **icebergs.** While afloat in the sea, icebergs assume a tabular or irregular shape and only one-ninth of the mass is visible above the surface.
- Apart from Greenland and Antarctica, glaciation is still evident on the highlands of many parts of the world, which lie above the snowline.
- Permanent snowfields are sustained by heavy winter snowfall and ineffective summer melting and evaporation. Where the slopes are gentle and the hollows are sheltered from both direct sunlight and strong Winds, any snow that falls is rapidly accumulated. Part of the surface snow may melt during the day, but by nightfall it is refrozen. This **process is repeated until it forms a hard.**
- Owing to gravitational forces, the neve of the upland snowfield is drawn towards the valley below. This is the beginning of the flow of the glacier-river of ice. The rate of movement is greatest in the middle where there is little obstruction.
- The Aletsch Glacier in the Bernese Oberland of Switzerland is 10 miles long, affording some spectacular sights to Alpine tourists. Though it is the longest glacier in Europe.
- At the foot of mountain ranges, several glaciers may converge to form an extensive ice-mass called a piedmont glacier. The best-known piedmont glacier is the Malaspina Glacier of Alaska which is 65 miles long and 25 miles wide, covering an area of more than 1,600 square miles.

Landforms of Highland Glaciation

- Glaciation generally gives rise to erosional features in the highlands and depositional features on the lowlands.
- A glacier erodes its valley by two processes plucking and abrasion. By plucking the glacier freezes the joints and beds of the underlying rocks, tears out individual blocks and drags them away. By abrasion, the glacier scratches, scrapes, polishes and scours the valley floor with the debris frozen into it. These fragments are powerful 'tools denudation. Large angular fragments cut deep into the underlying rocks so all glaciated floors be evidence of striation or scratching.
- The rate of erosion determined by several factors such as the velocity of flow, gradient of the slope, the weight of the glacier the temperature of the ice and the geological structure of the valley.
- **The characteristic features of a glaciated highland are as follows.**

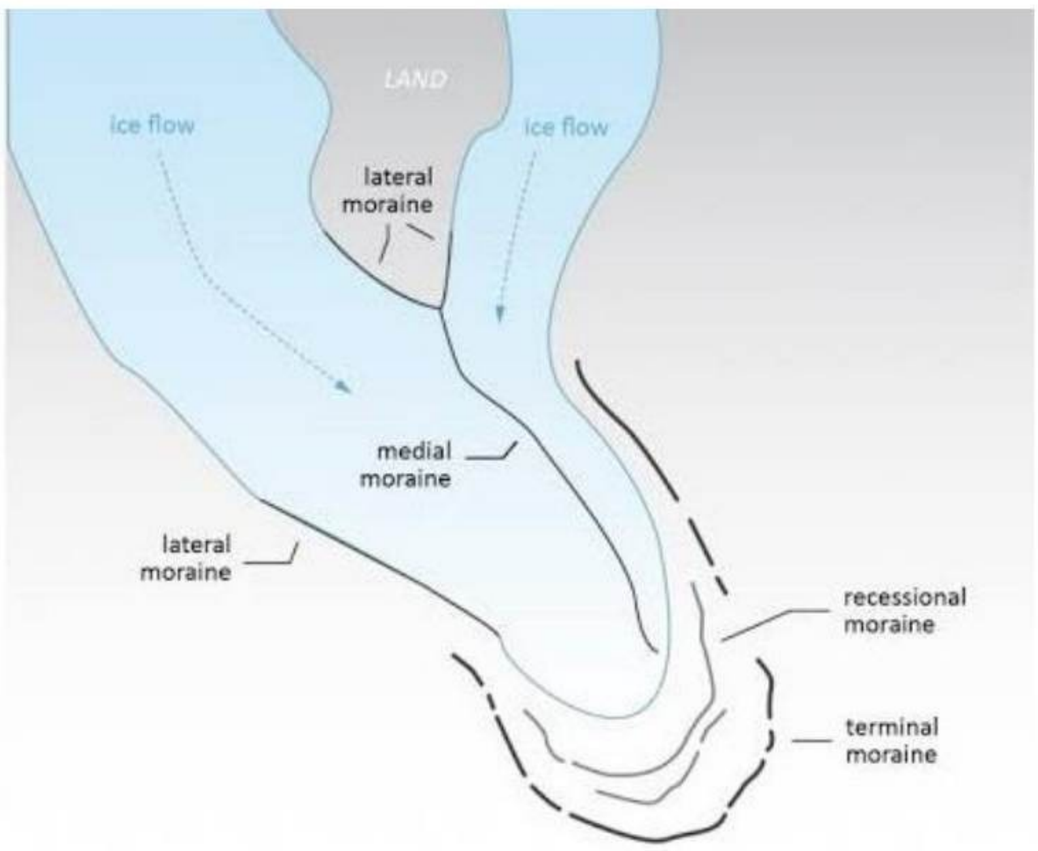


1. **Corrie, cirque or cwm -** Deepening the depression into a steep. Horse-shoe-shaped basin called a cirque (in French). It is also known as a **corrie** in Scotland and a cwm in Wales.
2. **Aretes and pyramidal peaks -** When two corries cut back on opposite sides of a mountain, knife-edged ridges are formed called aretes (a French word). Where three or more cirques cut back together, their ultimate recession will form an angular horn or pyramid peak. The Matterhorn of Switzerland is a classic.
3. **Bergschrund** - At the head of a glacier, where it begins to leave the snowfield of a corrie, a deep vertical crack opens up called a bergschrund (in German) or rimaye (in French). This happens in summer when, although the ice continues to move out of the corrie, there is no new Snow to replace it. Further down where the glacier negotiates a bend or a precipitous slope, more crevasses or cracks are formed.
4. **U-shaped glacial trough -** A valley which has been glaciated takes a characteristic U-shape, with a wide, flat floor and very steep sides. After the disappearance of the ice, the deep sections of these long, narrow glacial troughs may be filled with water forming ribbon lakes, such as Loch Ness and Lake Ullswater in Britain.
5. **Hanging valleys -** After the ice has melted a tributary valley therefore hangs above the main valley so that its stream plunges down as a waterfall. Such tributary valleys are termed hanging valleys.
6. **Rock basins and rock steps -** The unequal excavation gives rise to many rock basins later filled by lakes in the valley trough. Where a tributary valley joins a main valley, the additional weight of ice in the main valley cuts deeper into the valley floor at the point of convergence forming a rock step.



C. Glaciated topography

7. **Moraines** - Moraines are made up of the pieces of rock that are shattered by frost action, imbedded in the glaciers and brought down the valley. Those that fall on the sides of the glacier, mainly screes, form lateral moraines. When two glaciers converge their inside lateral moraines unite to form a medial moraine. The deposition of the end moraines may be in several succeeding waves, as the ice may melt back by stages so that a series of recessional moraines are formed. Where the lower end of the trough is **drowned by the sea** it forms a deep, steep- sided inlet called a fiord, typical of the Norwegian and south Chilean coasts.



Landforms of Glaciated Lowlands

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- Landforms of glaciated lowlands are mainly depositional in nature, brought about by both valley glaciers and continental ice sheets. The former leaves behind the eroded materials in only restricted areas.
- As a result, it has been estimated that almost a third of the total land surface of **Europe and North America** is littered with glacial and fluvio-glacial materials of all descriptions-moraines, boulder clay, tills, drifts, rock-flour, gravels and sands.
- Most of the glaciated lowlands have depositional features, but where rock masses project above the level surface, they result in striking features of erosion, such as the **roche moutonnee and crag and tail:**
    1. **Roche Moutonnee -** This is a resistant residual rock hummock. The surface is striated by ice movement. Its upstream side is smoothed by abrasion and its downstream side is roughened by plucking, and is much steeper. The term roche moutonnee is used to describe such a feature because it resembles a sheepskin-wig once worn in France
    2. **Crag and Tail -** The crag is a mass of hard rock with a precipitous slope on the upstream side, which protects the softer leeward slope from being completely worn down by the on-coming Ice. It therefore has a gentle tail, strewn with the eroded rock debris.
    3. **Boulder clay or glacial till -** This is an unsorted glacial deposit comprising a range of eroded materials boulders, angular stones, sticky clay and fine rock flour. It is spread out in sheets, not mounds, and forms gently undulating till or drift plains. Some of the boulder clay plains such as East Anglia and the northern Mid-West of U.S.A. form rich arable lands.
    4. **Erratics -** These are boulders of varying sizes that were transported by ice. They came with the advancing glaciers or ice sheets but when the ice melted, they were Lett 'stranded in the regions of deposition. They are called **erratics** because they are composed of materials entirely different from those of the region in which they are found.
    5. **Drumlins -** These are swarms of oval, elongated whale-back' hummocks composed wholly of boulder clay, with their elongation in the direction of the ice flow, that is on the downstream side. They feet in are low hills varying from a few yards to 400 height and may be a mile or two long. They appear a little steeper at the onset side and taper off at the leeward end. They are arranged diagonally and so are commonly described as having a basket of eggs topography.
    6. **Eskers -** These are long, narrow, sinuous ridges composed of sand and gravel which mark the former sites of sub-glacial melt-water streams. They vary from a few feet to 200 feet in height and may be several miles long. In some parts of Maine, U.S.A, the outstanding eskers form a continuous ridge of 100 miles.
    7. **Terminal moraines -** These are made up of the coarse debris deposited at the edge of the ice-sheet.
    8. **Outwash plains -** These are made up of fluvio- glacial deposits washed out from the terminal moraines by the streams and channels of the stagnant ice mass. The melt-waters sort and **re-deposit** the material in a variety of forms from the low hilly heathlands. Kames, small rounded hillocks of sand and gravel may cover part of the plain. Where the deposition takes the form of alternating ridges and depressions, the latter may contain kettle lakes

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and give rise to characteristic knob and kettle' topography.

The Human Aspects of Glaciated Landforms

- Their most striking impact is felt in the temperate regions of Europe and North America which were once under continental ice sheets.
- Soils that do exist are so thin that they are incapable of supporting effective agriculture. Glacial drifts in the valleys and benches or Alps which were not affected by glaciers have good pastures during summer. Cattle are driven up to graze on the grass and return to the valley bottom in winter. This form of animal-migration type of farming is called **transhumance.**
- The loess plains of Europe and central U.S.A., with a high proportion of humus are good farming land too. On the other hand, the sandy or gravelly outwash plains e.g. **the heath-covered geest of northern Germany**, the marshy boulder clay deposits of central Ireland, the barren ice-scoured surfaces of the Canadian and Baltic Shields are infertile. The presence of numerous **erratics** and perched blocks in parts of Britain and in Alberta.
- Large lakes formed by former glaciation, e.g. the Great Lakes of North America, make excellent waterways. They may also cut deep overflow channels while draining off, making natural routeways across a mountainous terrain e.g. the Hudson-Mohawk Gap that links the interior with the Atlantic seaboard of U.S.A.
- In the outwash plains, eskers and kames have been excavated to provide sands and gravels for highway and building construction. The purest sands are extracted to make moulds for metal castings. The lake basins of glaciated mountains provide natural reservoirs. In countries like **Scandinavia, Switzer land and Canada** where there is little available coal, streams and waterfalls that plunge down from hanging valleys or other glaciated uplands are being harnessed to provide hydro-electric power.
- With the magnificent scenery provided by the glaciated mountains e.g. the French, Italian and Swiss Alps, large numbers of tourists are attracted to them annually. Skiing, mountain climbing and sight-seeing are all popular with Alpine tourists.

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Types of Deserts

- About a fifth of the world's land is made up of deserts, some rocky, others stony and the rest sandy. Deserts that are absolutely barren and where nothing grows at all are rare and they are better known as true deserts.
- Almost all the deserts are confined within the **15° to 30° parallels of latitude north and south of the equator.** They lie in the trade wind belt on the western parts of the continents where Trade Winds are off-shore. They are bathed by cold currents which produce a 'desiccating effect' so that moisture is not easily condensed into precipitation. Dryness or aridity is the key note.
- Such deserts are tropical hot deserts or Trade Wind deserts. They include the great Sahara Desert; Arabian, Iranian and Thar Deserts; Kalahari, Namib, and Atacama Deserts; the Great Australian Desert and the deserts of south-west U.S.A, and northern Mexico. In the continental interiors of the mid latitudes, the deserts such as the Gobi and Turkestan are characterised by extremes of temperatures, **has given rise to five distinct kinds of desert landscape**.
    1. **Hamada or rocky desert -** This consists of large stretches of bare rocks, swept clear of sand and dust by the wind. The exposed rocks are thoroughly Smoothed and polished. The region is bare and sterile. The best known rocky deserts are those of the Sahara Desert.
    2. **Reg or stony desert -** This is composed of ex- tensive sheets of angular pebbles and gravels which the winds are not able to blow off. Such stony deserts are much more accessible than the sandy deserts, and large herds of camels are kept there.
    3. **Erg or sandy desert -** This is a sea of sand which typifies the popular idea of desert scenery. Winds deposit vast stretches of undulating sand-dunes in the heart of the deserts. The intricate patterns of ripples on the dune surfaces indicate the direction of the winds.
    4. **Badlands -** The term 'Badlands was first given to an arid area in **South Dakota, U.S.A.,** where the hills were badly eroded by occasional rain-storms into **gullies and ravines.** The extent of water action on hill slopes and rock surfaces was so great that the entire region was abandoned by the inhabitants.
    5. **Mountain deserts -** Some deserts are found on highlands such as plateaux and mountain ranges. Erosion has dissected the desert highlands into harsh, serrated outlines of chaotic peaks and craggy ranges. Their steep slopes are cut by wadis (steep-sided, often dry, valleys) and the action of frost has carved out sharp, irregular edges.

The Mechanism of Arid Erosion

- Arid landforms are the results of many combined factors, one reacting upon the other. Insufficient rainfall (often less than 5 inches) coming at most irregular periods, coupled with very high temperatures (87°F. is the average) and a rapid rate of evaporation, are the chief causes of aridity. Sub-aerial denudation through the processes of weathering (mechanical and chemical). Wind action and the work of water have combined to produce a desert landscape that is varied and distinctive.
- **Weathering**
    - This is the most potent factor reducing rocks to sand in arid regions. Even though the amount of rain that falls in the desert is small some manage to penetrate into the rocks and Sets up chemical reactions in the various minerals. Intense heating during the day and rapid cooling at night by radiation, set up

stresses in the already weakened rocks so that they eventually crack.

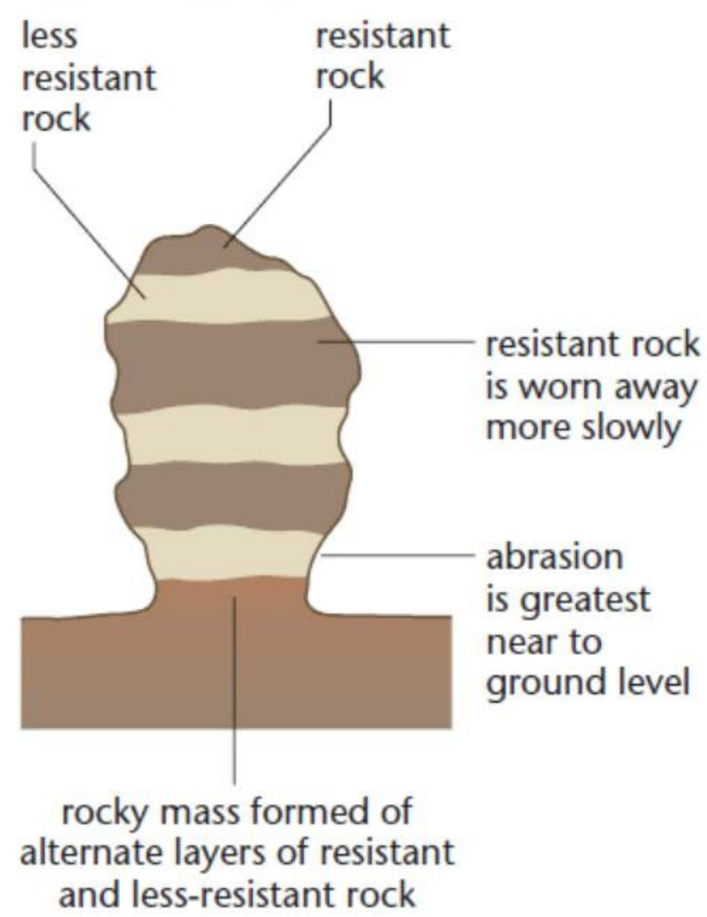
- So that it peels off in successive very thin layers. Such an onion-peeling process of mechanical weathering is called **exfoliation.** Angular rock debris is found in abundance as screes at the foot of upstanding rocks.
- The water freezes and therefore expands by 10 per cent of its volume. Successive freezing will prise off fragments of rock which accumulate as screes. These rock fragments become the '**teeth**' or tools of wind erosion.

- **Action of winds in deserts:** Wind erosion is carried out in the following ways.
  1. **Deflation -** This involves the lifting and blowing away of loose materials from the ground. Such unconsolidated sands and pebbles may be carried in the air or rolled along the ground depending on the grain size. The finer dust and sands may be removed miles away from their place of origin, and be deposited even outside the desert margins. Deflation results in the lowering of the land surface to form large depressions called **deflation hollows.**
  2. **Abrasion -** The sand-blasting of rock surfaces by winds when they hurl sand particles against them is called abrasion. The impact of such blasting results in rock surfaces being scratched, polished and worn away. Abrasion is most effective at or near the base of rocks, where the amount of material the Wind is able to carry is greatest. This explains why tele- graph poles in the deserts are protected by a covering of metal for a foot or two above the ground.
  3. **Attrition -** When wind-borne particles roll against one another in collision they wear each other away so that their sizes are greatly reduced and grains are rounded into millet seed sand

Landforms of Wind Erosion in Deserts

In the combined processes of abrasion, deflation and attrition, a wealth of characteristic desert landforms emerges.

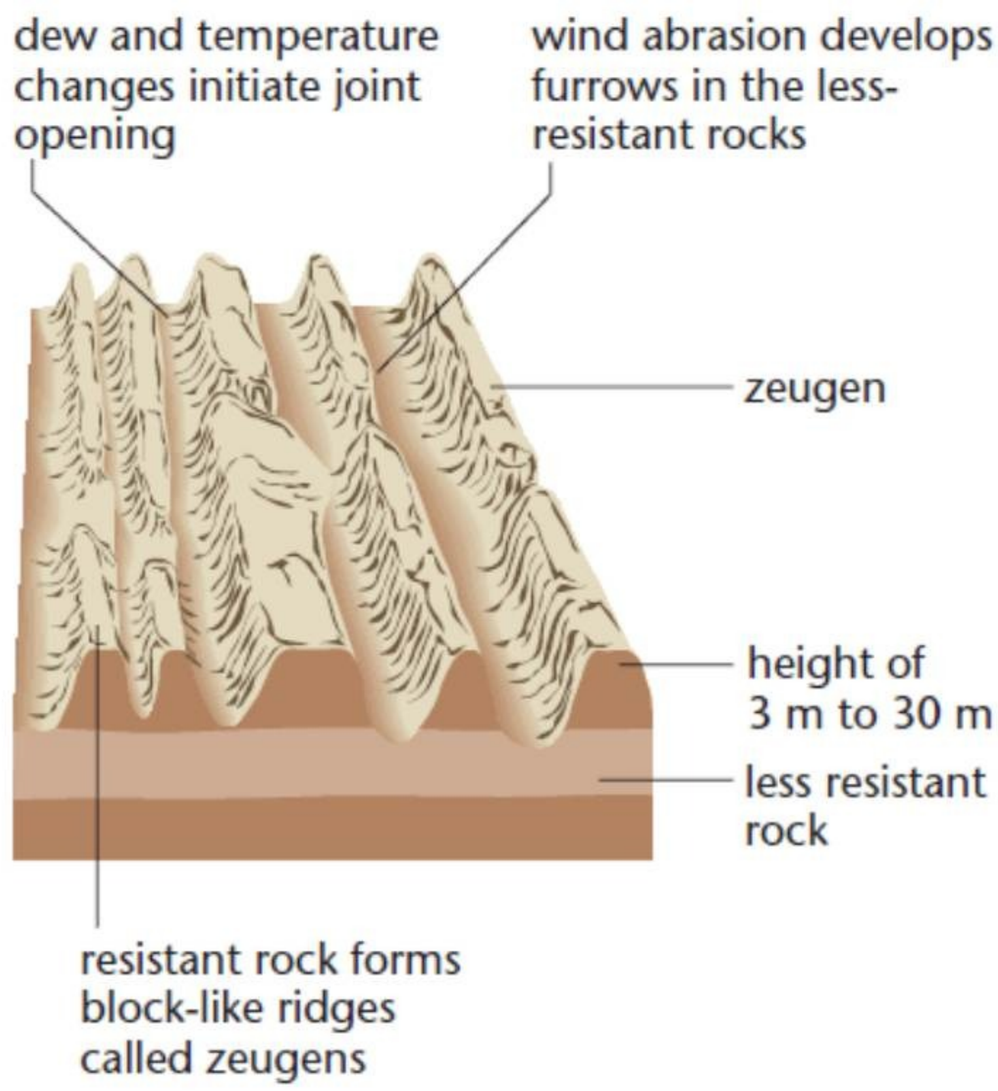
1. **Rock pedestals or mushroom rocks -** The sand- blasting effect of winds against any projecting rock masses wears back the softer layers so that an irregular edge is formed on the alternate bands of hard and soft rocks. **Grooves and hollows** are cut in the rock surfaces, carving them into fantastic and grotesque- looking pillars called rock pedestals. Such rock pillars will be further eroded near their bases where the

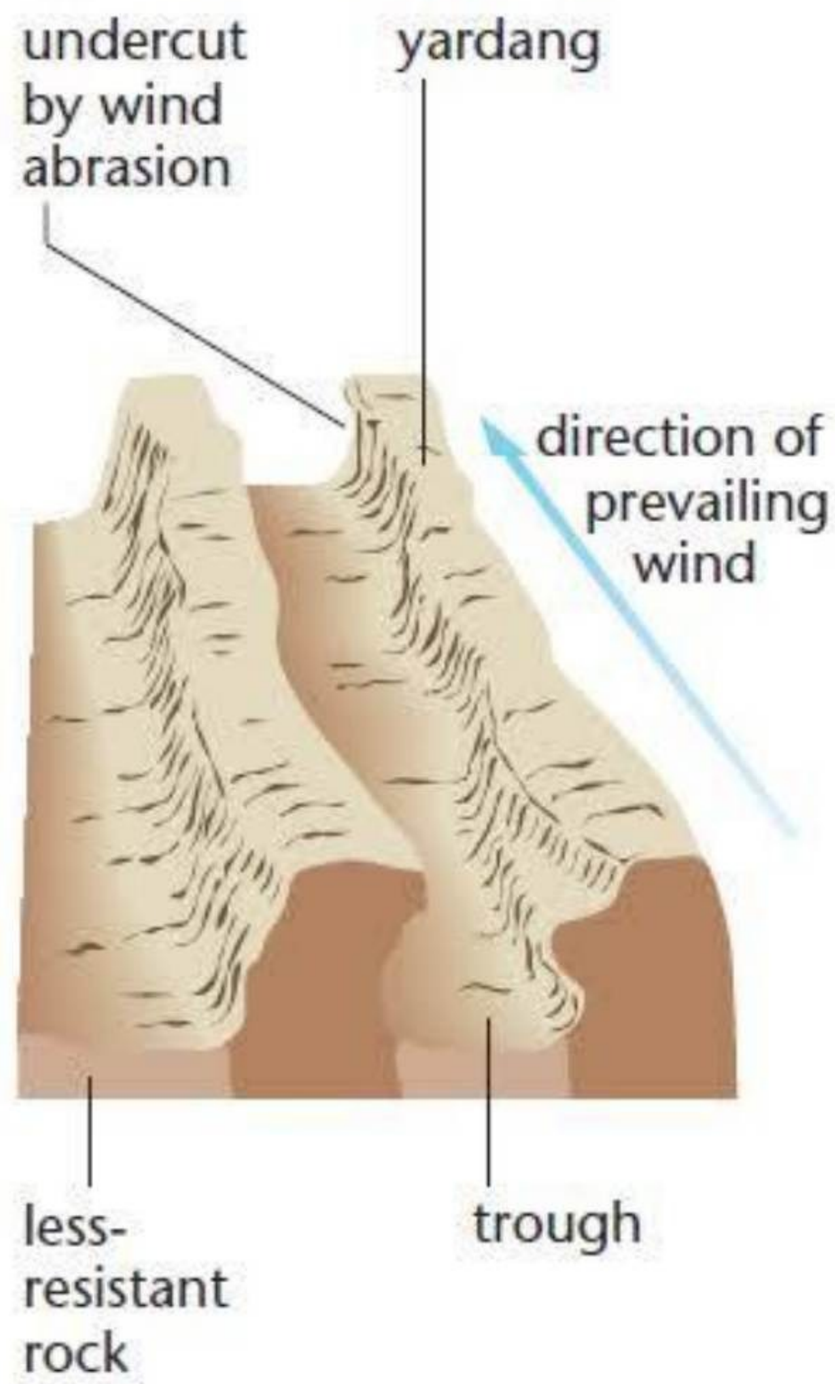


friction is greatest. This process of under-cutting produces rocks of mushroom shape called **mushroom rocks** or gour in the Sahara.

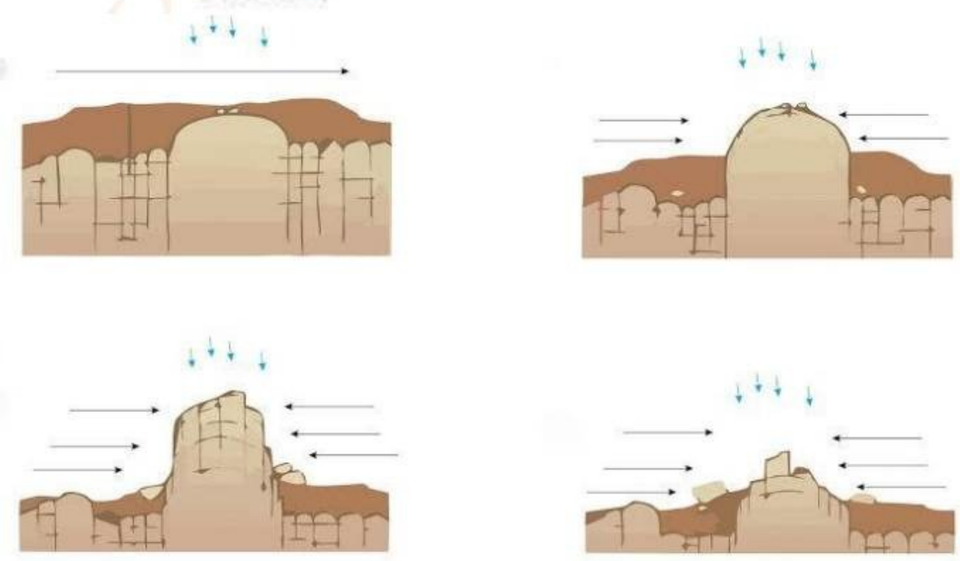
2. **Zeugen -** These are tabular masses which have a layer of soft rocks lying beneath a surface layer of more resistant rocks. The sculpting effects of wind abrasion wear them into a weird-looking 'ridge and furrow' landscape. Mechanical weathering initiates their formation by opening up joints of the surface rocks. Wind abrasion further 'eats into the underlying softer layer so that deep furrows are developed. The hard rocks then stand above the furrows as ridges or zeugen, and many even overhangs. Such tabular blocks of zeugen may stand **10 to 100 feet**

above the sunken furrows. Continuous abrasion by Wind gradually lowers the zeugen and widens the furrows.





3. **Yardangs -** Quite similar to the 'ridge and furrow landscape of zeugen are the steep-sided yardangs. Instead of lying in horizontal strata upon one another the hard and soft rocks of yardangs are vertical bands and are aligned in the direction of the prevailing winds. Wind abrasion excavates the bands of softer rocks into long, narrow corridors, separating the steep-sided over-hanging ridges of hard rocks, called **yardangs**. They are commonly found in the Atacama Desert.
4. **Mesas and buttes -** It is a flat, table-like land mass with a very resistant horizontal top layer, and very steep sides. The hard stratum on the surface resists denudation by both wind and water, and thus protects the underlying layers of rocks from being eroded away. Mesas may be formed in canyon regions e.g. **Arizona**. Continued denudation through the ages may reduce mesas in area so that they become isolated flat-topped hills called buttes. Many of them in arid countries are separated by deep gorges or canyons.



5. **Inselberg -** They are isolated residual hills rising abruptly from the level ground. They are characterised by their very steep slopes and rather rounded tops. They are often composed of granite or gneiss, and are probably the relics of an original plateau which has been almost entirely eroded away.
6. **Ventifacts or dreikanter -** These are pebbles faceted by sand-blasting. They are shaped and thoroughly polished by wind abrasion to shapes resembling Brazil nuts. Rock fragments, mechanically weathered from mountains and upstanding rocks, are moved by wind and smoothed on the windward side. If wind direction changes another facet is developed. Such rocks have characteristic flat facets with sharp edges. Amongst the ventifacts those with three wind-faceted surfaces are called dreikanter.

7. **Deflation hollows -** Winds lower the ground by blowing away the unconsolidated materials, and small depressions may form. Similarly, minor faulting can also initiate depressions and the eddying action of oncoming winds will wear off the weaker rocks until the water table is reached. Water then seeps out forming oases or swamps, in the deflation hollows or depressions. The Faiyum Depression in Egypt lies 130 feet below the sea level. Large areas in the western U.S.A., stripped of their natural vegetation for farming, were completely deflated when strong winds, moved materials as dust-storms, laying waste crops and creating what is now known as the **Great Dust Bowl.**

Landforms of Wind Deposition in Deserts

- Materials eroded and transported by winds must come to rest somewhere. The finest dust travels enormous distances in the air, and may be moved completely out of the desert. It has been estimated that some dust grains travel as far as 2,300 miles before they are finally **deposited on land or sea.**
- The dust from the Sahara Desert is sometimes blown across the Mediterranean to fall as blood rains' in Italy or on the glaciers of Switzerland. Dust that settles in the **Hwang-Ho basin from the Gobi Desert** has accumulated over past centuries to a depth of several hundred feet.
- Since they are rarely static, their migration pattern depends on a number of factors: the size of the particles they carry, the direction and velocity of the winds, the location and nature of the surfaces over which the particles are transported and the presence or absence of water and natural vegetation.
- **The following are some of the major features of wind deposition.**
- **Dunes -** Dunes are, in fact, hills of sand formed by the accumulation of sand and shaped by the movement of winds. They may be active or live dunes, constantly on the move, or inactive fixed dunes, rooted with vegetation, the following two types of common dunes, **barchans and seifs**, will be described in more detail.

a) **Barchan**

- These are shaped dunes which occur individually or in groups. They are live dunes which advance steadily before winds that come from a particular prevailing direction. They are most prevalent in the deserts of Turkestan and in the Sahara.
- They occur transversely to the wind, so that their horns thin out and become lower in the direction of the wind due to the reduced frictional retardation of the winds around the edges. The windward side is convex and gently-sloping while the leeward side, being sheltered, is concave and steep (the slip-face).
- The crest of the sand dune moves forward as more sand is accumulated by the prevailing wind. The sand is driven up the windward side and, on reaching the crest, slips down the leeward side so that the dune advances.
- The migration of the barchans may be a threat to desert life for they may encroach on an oasis burying palm trees or houses. Long-rooted sand-holding trees and grasses are therefore planted to halt the advance of the dunes thus preventing areas of fertile land from being devastated.

b) **Seifs or longitudinal dunes**

- Seif is an Arabic Word meaning 'sword'. They are long, narrow ridges of sand, often over a hundred miles

long lying parallel to the direction of the prevailing winds. The high, serrated ridges may attain a height of over 200 feet.

- The crestline of the self rises and falls in alternate peaks and saddles in regular successions like the teeth of amonstrous saw. The dominant winds blow straight along the corridor between the lines of dunes so that they are swept clear of sand and remain smooth.
- The eddies that are set up blow towards the sides of the corridor, and, having less power, drop the sand to form the dunes. In this manner, the prevailing winds increase the length of the dunes into tapering linear ridges while the occasional cross winds tend to increase their height and width. Extensive seif dunes are found in the Sahara Desert.

c) **Loess**

- The fine dust blown beyond the desert limits is deposited on neighbouring lands as loess.
- It is a yellow, friable material and is usually very fertile. Loess is in fact, fine loam, rich in lime, very coherent and extremely porous.
- Water sinks in readily so that the surface is always dry. Streams have cut deep valleys through the thick mantle of soft loess and badland topography may develop.
- It is so soft that roads constructed through a loess region soon sink and their walls rise steeply

Landforms due to Water Action in Deserts

- But thunderstorms do occur and the rain falls in torrential downpours, producing devastating effects.
- As deserts have little vegetation to protect the surface soil, large quantities of rock wastes are transported in the sudden raging torrents, or fiash-floods. Loose gravels, sand and fine dust are swept down the hill sides.
- They cut deep gullies and ravines forming **badland topography**. Subsequent downpours widen and deepen the gullies when they wash down more soft rocks from the surface.
- The pasty alluvial deposits are subjected to **rapid evapordtion** by the hot sun and downward percolation of water into the porous ground, and soon dry up leaving mounds of debris.
- Apart from gullies there are many larger dry Channels or valleys. These are deepened by vertical corrasion by raging torrents during the occasional cloudbursts. These are the wadis and are dry for most of the time.
- Sometimes water collected in a depression or a desert basin does not completely disappear by evaporation or seepage, and a temporary lake is formed. Such lakes contain a high percentage of salts, because of high evaporation, and are glistening white when they dry up. The lakes and the alluvial plains formed by them are called playas, Salinas or salars in the United States and Mexico, and shotts in northern Africa.
- The floor of the depression is made up of two features, the bajada and the pediment.

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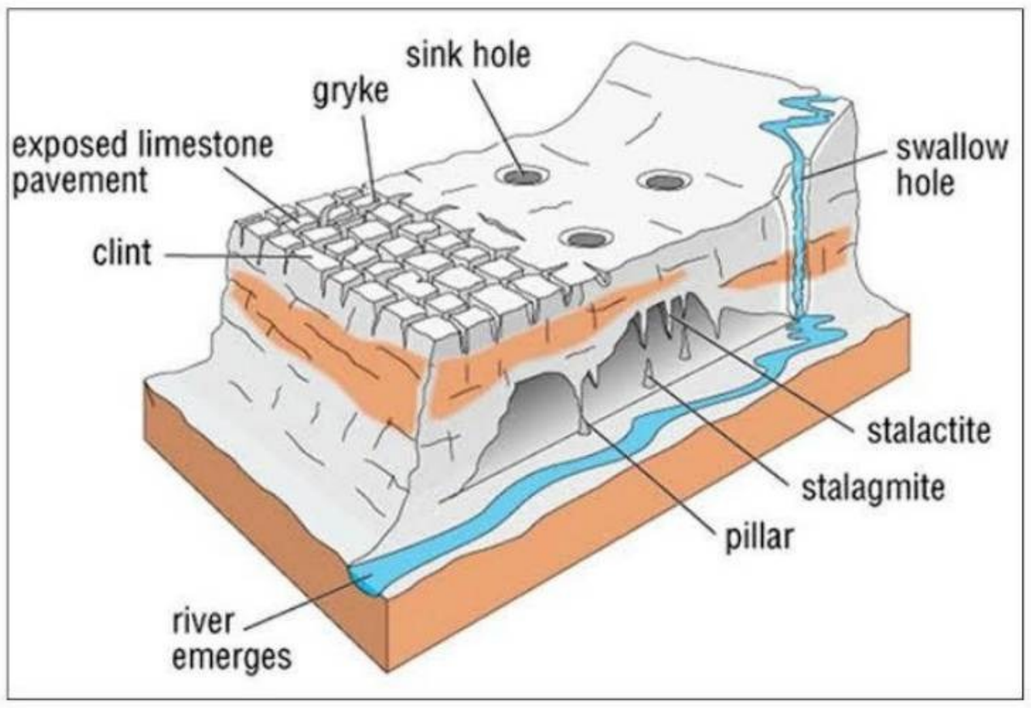
CHAPTER: 8 – LIMESTONE AND CHALK LANDFORM

Limestone and Chalk

- Limestone and chalk are sedimentary rocks of organic origin derived from the accumulation of corals and shells in the sea.
- In its pure state, limestone is made up of **calcite or calcium carbonate**, but where magnesium is also present it is termed dolomite. Chalk is a very pure form of limestone, white, and rather soft.
- Limestone is soluble in rain-water, which, with carbon dioxide from the air, forms a weak acid. A region with a large stretch of limestone therefore possesses very distinct type of topography. It is then termed a karst region.

Characteristic Features of a Karst Region

- Generally speaking, karst regions have a bleak landscape, occasionally broken by precipitous slopes there is a general absence of surface drainage as most of the surface water has gone underground. Streams rising on other rocks only flow over limestone for a short distance and then disappear underground.
- For the greater part of their course, they cut their way along the joints and fissures of the rock wearing out a system of underground channels. The surface valleys are therefore dry. When the water penetrates to the base of the limestone and meets non-porous rocks it re-emerges onto the surface as a spring or resurgence.
- Limestones are well jointed and it is through these joints and cracks that rain-water finds its way into the underlying rock. Progressive widening by solution enlarges these cracks into trenches and a most intriguing feature called limestone pavement is developed. The enlarged joints are called **grikes** and the isolated, rectangular blocks are termed **Clints**.
- On the surface of the limestone are numerous Swallow holes, which are small depressions carved out by solution where rain-water sinks into the limestone at a point of weakness. They are also known as sink holes. Gaping Ghyll in Yorkshire is a fine example. These holes grow in size through continuous solvent is action.
- When the roof of an underground tunnel collapses, a precipitous limestone gorge such as the Cheddar Gorge is formed. Where a number of swallow holes coalesce a larger hollow is formed and is called a doline. Several dolina may merge as a result of subsidence to form a larger depression called an uvala.
- In Yugoslavia, some very large depressions called **polje** may be as large as a hundred square miles but these are partly due to faulting.
- Where subterranean streams descend through swallow holes to underground passages, the region may be honeycombed with caves and caverns, some containing ponds and lakes. The most spectacular underground features that adorn the limestone caves are stalactites, stalagmites and pillars.
- Stalactites are the sharp, slender, downward-growing pinnacles that hang from the cave-roofs. The water carries calcium in solution and when this lime-charged water evaporates, it leaves behind the solidified crystalline calcium carbonate.
- As moisture drips from the roof it trickles down the stalactite and drops to the floor where calcium is deposited to form stalagmites. They are shorter, fatter and more rounded. Over a long period, the stalactite hanging from the roof is



eventually joined to the stalagmite growing from the floor to form a pillar

The Major Limestone Regions of the World

- The most characteristic stretch of limestone occurs in north-west Yugoslavia. Other regions include: the Causses district of southern France, the Pennines of Britain, Yorkshire and Derbyshire in particular, the Kentucky region of the United States, the Yucatan Peninsula of Mexico, the Cockpit Country of Jamacia, and the limestone hills of Perlis.

Human Activities of Karst Regions

- Karst regions are often barren and at best carry a thin layer of soil. The porosity of the rocks and the absence of surface drainage make vegetative growth difficult, so that limestone can usually support only poor grass and short turf; some sheep grazing is possible.
- Limestone vegetation in tropical regions, how- ever, is luxuriant because of the heavy rainfall all the year round. Settlements are scattered and the population is often sparse. The only mineral of importance is lead which occurs in veins in association with limestone. Besides this, good quality limestones are often used as building materials or quarried for the cement industry.

Chalk

- The landforms of chalk are rather different from those of other limestones. There is little or no surface drainage and valleys which once contained rivers are now dry. These are often called **coombes**. The chalk forms low rounded hills in southern and south eastern England, where they are called downs and in northern France.

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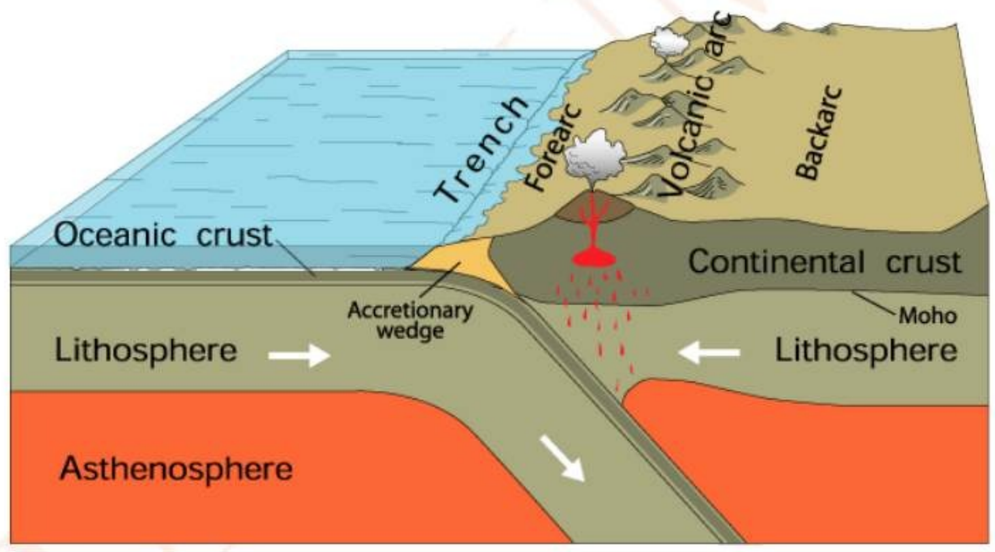
CHAPTER: 9 - LAKES

General

- They occupy the hollows of the land Surface in which water accumulates. They vary tremendously in size, shape, depth and mode of formation. The tiny ones are no bigger than ponds or pools, but the large ones are so extensive that they merit the name of seas, e.g. the **Caspian Sea.**
- Lakes may exist temporarily filling up the small depressions of undulating ground after a heavy shower. But those which are deep and carry more water than could ever be evaporated remain permanent.
- Most of the lakes in the world are fresh-water lakes fed by rivers and without-flowing streams e.g. **Lake Geneva, Lake Poyang and the Great Lakes of North America**. In regions of low precipitation and intense evaporation where there are few rivers strong enough to reach the sea, streams drain into a lake forming a basin of inland drainage. Because of the intense evaporation these lakes are saline.
- But, the Black Sea, into which drain many large rivers, has a salinity of less than 17 parts per thou- sand! Playas or salt lakes, are a common feature of deserts.

The Formation and Origin of Lakes



1) **Lakes Formed by Earth Movement**
   a) **Tectonic lakes** - Due to the warping, sagging, bending and fracturing of the earth's crust, tectonic depressions occur. Such depressions give rise lakes of immense sizes and depths. They include Lake Titicaca, sea level the highest lake in the world; and the Caspian Sea.
   b) **Rift valley lakes -** Due to faulting, a rift valley is formed by the sinking of land between two parallel faults, deep, narrow and elongated in character. Water collects in these troughs and their floors are often below sea level. It includes such lakes as **Lakes Tanganyika** (4,700 feet deep, the world's deepest lake), Dead Sea 1,286 feet below mean sea level, the world's lowest lake.
2) **Lakes Formed by Glaciation**
   a) **Cirque lakes or tarns -** A glacier on its way down the valley leaves behind circular hollows in the heads of the valleys up in the mountains. Such hollows are the arm-chair-shaped cirques or corries, e.g. Red Tarn in the English Lake District.
   b) **Kettle lakes -** These are depressions in the outwash plain left by the melting of masses of stagnant ice. They are irregular because of the uneven morainic surface and are never of any great size or depth e.g. the meres of Shropshire in England.
   c) **Rock-hollow lakes -** These are formed by ice-scouring when valley glaciers or ice sheets scoop out hollows on the surface. Such lakes of glacial origin are abundant in Finland, indeed the Finns call their country Suomi the Land of Lakes. It is said that there are over 35,000 glacial lakes in Finland.
   d) **Lakes due to morainic damming of valleys -** Valley glaciers often deposit morainic debris across a valley so that lakes are formed when water accumulates behind the barrier. Both lateral and terminal moraines are capable of damming valleys e.g. **Lake Windermere** of the Lake District, England.
   e) **Lakes due to the deposition of glacial drifts** - In glaciated lowlands with a predominant drumlin landscape, where drainage is poor, there are intervening depressions. These depressions are often

water-logged, forming small lakes like those of County Down in Northern Ireland.

3) **Lakes Formed by Volcanic Activity**
   a) **Crater and caldera lakes -** During a volcanic explosion the top of the cone may be blown off leaving behind a natural hollow called a crater this may be enlarged by subsidence into a caldera. The outstanding ones are the Crater Lake in Oregon, U.S.A. which in fact occupies a caldera; Lake Toba in northern Sumatra and Lake Avernus near Naples.
   b) **Lava-blocked lakes -** In volcanic regions a stream of lava may flow across a valley, become solidified and thus dam the river forming a lake, e.g., a lava flow blocks the Jordan valley forming the Sea of Galilee which is an inland lake, rather elongated in shape.
   c) **Lakes due to subsidence of a volcanic land surface -** The crust of a hollow lava flow may collapse the subsidence leaves behind a wide and shallow depression in which a lake may form, e.g. Myvatn of Iceland.
4) **Lakes Formed by Erosion**
   a) **Karst lakes -** The solvent action of rain-water on limestone carves out solution hollows. When these become clogged with debris lakes may form in them. The collapse of limestone roofs of under- ground caverns may result in the exposure of long, narrow lakes that were once underground e.g. the Lac de **Chillexon in the Jura Mountains**. The large depressions called poljes, which normally do not have surface outlets. Solution is important in other rocks such as rock salt.
   b) **Wind-deflated lakes -** The deflating action of winds in deserts creates hollows. These may reach ground water which seeps out forming small, shallow lakes. Excessive evaporation causes these to become salt lakes and playas. These are found in **the Qattara Depression** in Egypt, and the Great Basin of Utah, U.S.A.
5) **Lakes Formed by Deposition**
   a) **Lakes due to river deposits -** A river may shorten its course during a flood by cutting across its meandering loops, leaving behind a horseshoe-shaped channel as an ox-bow lake.
   b) **Lakes due to Marine deposits -** The action of winds and waves may isolate lagoons along coasts by building spits or bars. As these lagoons of shallow water are enclosed only by a narrow spit of land comprising mud, sand and shingle, they may drain away at low tide. They are commonly found off the deltas of large rivers such as the Nile and the Ganges in East Germany and Poland, lagoons are called haffs.
   c) **Lakes due to landslides, screes and avalanches -** Lakes formed by these processes are also known as barrier lakes. Landslides or screes may block valleys so that rivers are dammed. Such lakes are short- lived. Because the loose fragments that pile across the valleys will soon give way under the pressure of water. When they suddenly give way, the dammed water rushes down, causing floods. Examples of lakes of this type are, Lake Gormire in Yorkshire.
6) **Lakes Formed by Human and Biological Activities**
   a) **Man-made lakes -** Besides the natural lakes, man has now created artificial lakes by erecting a concrete dam across a river valley so that the river water can be kept back to form reservoirs.
   b) **Lakes made by animals -** Animals like beavers are particularly interesting. They live in communities and construct dams across the rivers with timber. Such beaver dams are quite permanent and are found in North America, e.g. Beaver Lake
   c) **Other types of lakes** - These include ornamental lakes, especially made to attract tourists, e.g. Lake Gardens,

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Kuala Lumpur, and Taiping Lakes.
Man's mining activities.

Lakes and Man

A careful examination of the lakes of the world will reveal their immense human significance. In countries where they are found in abundance, such as Finland, Canada, U.S.A., Sweden

1. Means of communication
2. Economic and industrial development
3. Water storage
4. Hydro-electric power generation
5. Agricultural purposes
6. Regulating river flows
7. Moderation of climate
8. Source of food
9. Source of minerals
10. Tourist attraction and health resorts

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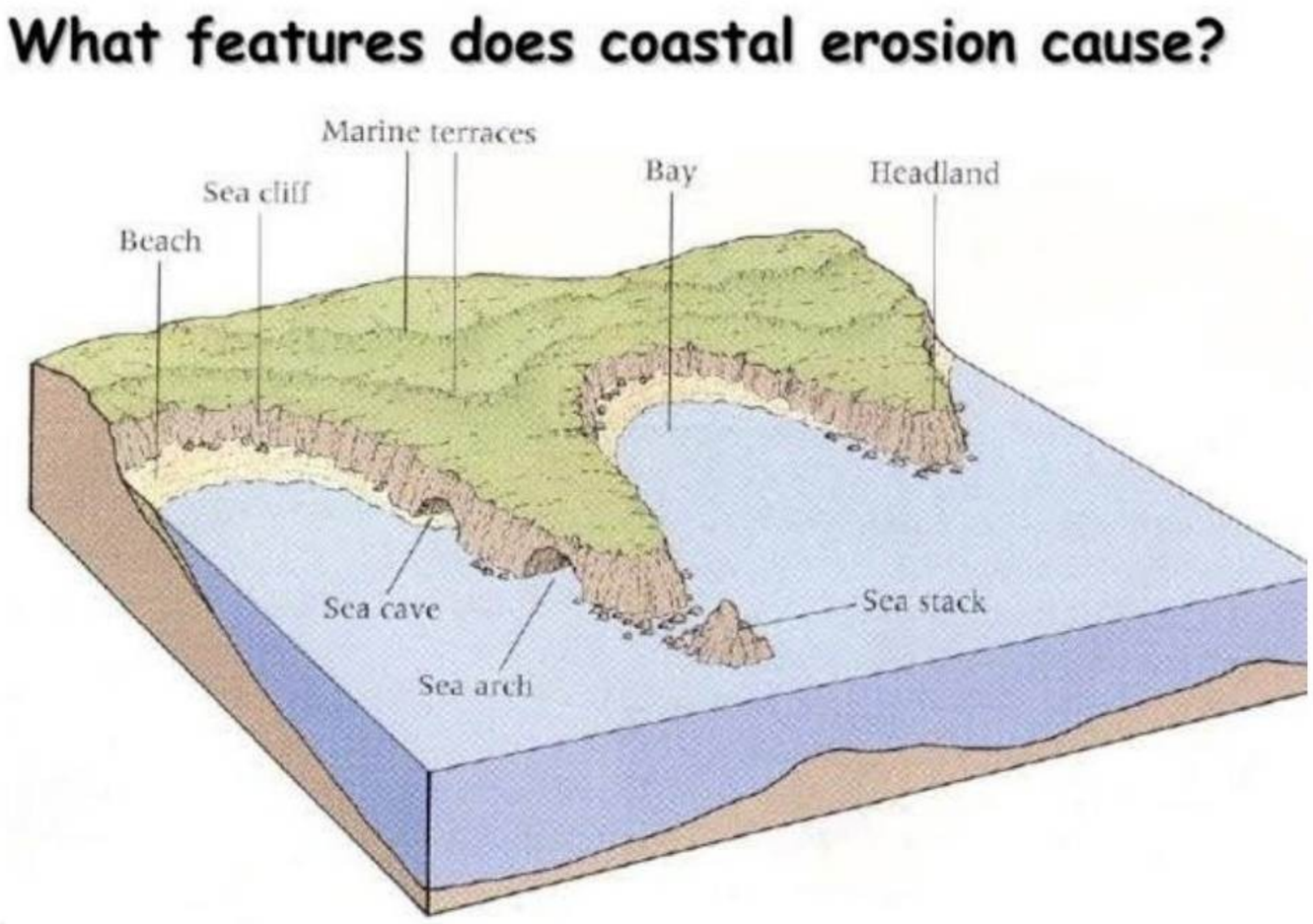
The Action of Waves, Tides and Currents

- The coastline, under the constant action of the Waves, tides and currents, is undergoing changes from day to day. On calm days, when winds are slight, waves do little damage to the shoreline and may m- stead help to **build up beaches** and other depositional features. It is in storms that the ravages of the waves reach their greatest magnitude.
- Tides affect marine erosion mainly by extending a line of erosion into a zone of erosion. This zone corresponds to the area between the low water level and the high-water level. Currents help to move eroded debris and deposit it as silt, sand and gravel along the coasts

The Mechanism of Marine Erosion

- The most powerful agents of marine erosion are waves. Their origin is due to the sweeping of winds over the water surface, which sets a series of undulating swells surging forward. These become higher and swifter.
- On approaching shallow water near the shores, their speed is reduced and the waves are curved or refracted against the alignment of the coast. Shallow water, when it is less than the height of the waves, checks their forward movement, the crests curl over and break into the shores in a mass of foam as breakers.
- The water that finally rushes up the beach and hurls rock debris against the land is termed Swash. The water is sucked back and retreats as backwash.
- Another element in offshore drift is the undertow, which flows near the bottom away from the shore. This current exerts a pulling effect which can be dangerous to sea-bathers.
- **Marine agents of erosion operate in the following ways to transform the coastal landscape.**

1. **Corrasion -** Waves armed with rock debris of all Sizes and shapes charge against the base of the Cliffs, and wear them back by **corrasion**. On-coming currents and tides complete the work by sweeping the eroded material into the sea.
2. **Attrition -** The constantly moving waves that transport beach materials such as boulders, pebbles, shingle



and fine sand also hurl these fragments against one another, until they are broken down by attrition into very small pieces. The grinding and polishing of such fragmental materials against **cliff faces** and against each other is largely responsible for the fine sand which forms the beaches that are so typical of the seaside resorts.

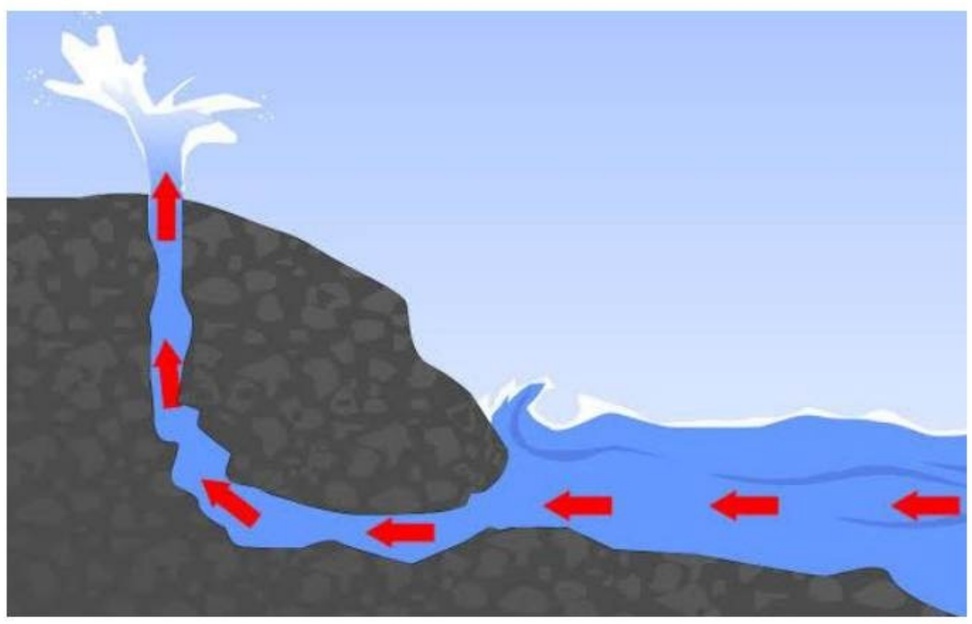
3. **Hydraulic action -** In their forward surge, wave splashing against the coast may enter joints and crevices in the rocks. The air imprisoned inside is immediately compressed. When the wave's retreat the compressed air expands with explosive violence such action repeated again and again soon enlarge the cracks and rock fragments are prised apart.

4. **Solvent action -** On limestone coasts, the solvent action of sea water on calcium carbonate sets chemical changes in the rocks and disintegration takes place. This process is limited to limestone coasts.

Coastal Features of Erosion

1) **Capes and bays**
   - On exposed coasts, the continual action of waves on rocks of varying resistance causes the coastline to be eroded irregularly. Particularly pronounced where hard rocks, e.g. granites and limestones, occur in alternate bands with softer rocks e.g. sand and clay. The softer rocks are worn back into inlets, coves or bays and the harder ones persist as headlands, promontories or capes.
   - Along the Dorset coast of southern England, Swanage Bay and Durlston Head are examples. Even where the coast is of one rock type irregularities will be caused by variation within the rock.

2) **Cliffs and wave-cut platforms**
   - Generally any very steep rock face adjoining the coast forms a Clift. The rate of recession will depend on its geological structure that is the stratification and jointing of the rocks and their resistance to wave attack.
   - If the beds dip seawards, large blocks of rock will be dislodged and fall into the sea. The cliff will rise in a series of 'steps'. On the contrary, if the beds dip landwards the Clift will be more resistant to wave erosion.
   - At the base of the cliff the sea cuts a notch, which gradually undermines the cliff so that it collapses.
   - As a cliff recedes landwards under the pounding of waves, an eroded base is left behind, called a wave-cut platform. The platform, the upper part of which is exposed at low tide, slopes gently seawards and its surface is strewn with rock debris from the receding cliff.
   - Further abrasion continues until the pebbles are swept away into the sea. The eroded materials are deposited on the off-shore terrace.



3) **Cave, arch, stack and stump**
   - Prolonged wave attack on the base of a cliff excavates holes in regions of local weakness called caves. When two caves approach one another from either side of a headland and unite, they form an arch, e.g. the Neddie Eye near Wick, Scotland.
   - Further erosion by waves will ultimately lead to the total collapse of the arch. The seaward portion of the headland will remain as a pillar of rock known as a stack.
   - In the course of time, these 'stubborn stacks will gradually be removed. The vertical rock pillars are eroded, leaving behind only the stumps which are only just visible above the sea level.

4) **Geos and gloups**
   - The occasional splashing of the waves against the roof of a cave may enlarge the joints when compressed air is trapped inside.
   - The enlargement of blow-holes and the continued action of waves weakens the cave roof. When the roof collapses a long, narrow inlet or creek develops. Such deep clefts, which may be 100 feet deep and equally long, are called geos.

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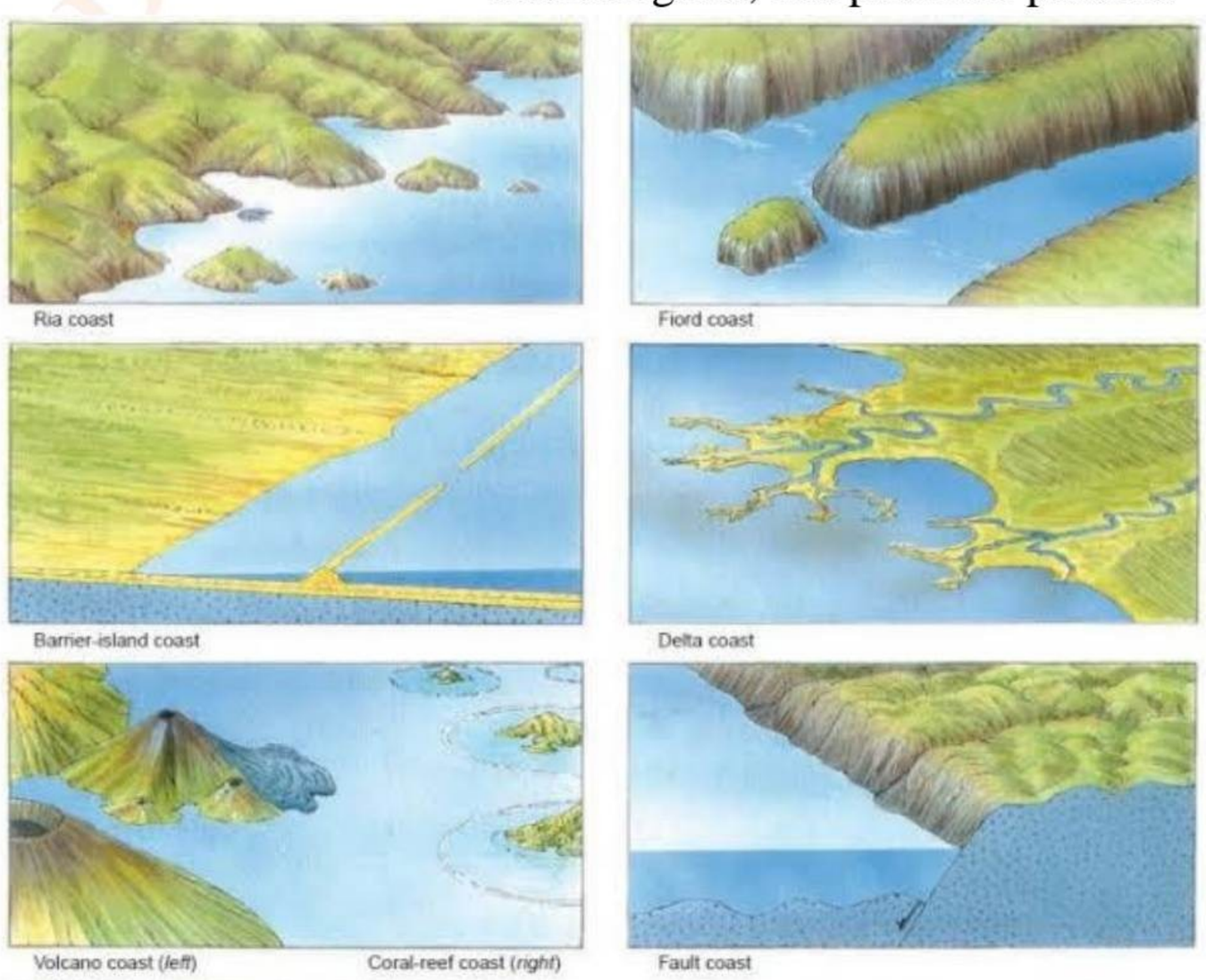
Coastal Features of Deposition

1) **Beaches**
   - Sands and gravels loosened from the land are moved by waves to be deposited along the shore as beaches.
   - The eroded material is transported along the shore in several distinct ways. The longshore drift which comes obliquely to the coast carries the material along the shore in the direction of the dominant wind. At the same time, the backwash removes part of the material seawards along the bed of the sea, and deposits it on the off-shore terrace and even beyond.
   - The constant action of the waves automatically sorts out the shoreline deposits in a **graded manner**. The coarser materials (cobbles and boulders) are dropped by the waves at the top of the beach. The finer materials (pebbles and sand grains) which are carried down the beach by the backwash are dropped closer to the sea.
2) **Spits and bars**
   - The debris eroded by waves is continually moved by longshore drift and where there is an indentation in the coast, such as the mouth of a river or a bay, material may continue to be deposited across the inlet.
   - As more materials are added, they will pile up into a ridge or embank-ment of shingle forming a tongue or spit, with one end attached to the land and the other end projecting into the sea.
   - When the ridge of shingle is formed across the mouth of a river or the entrance to a bay it is called a bar.
   - Such a connecting bar that joins two land masses is better known as tombolo.
3) **Marine dunes and dune Belts**
   a. With the force of on-shore winds, a large amount of coastal sand is driven landwards forming extensive marine dune that stretch into dune belts. Their advance inland may engulf farms, roads and even entire villages.
   b. The dunes of the Lands, south-west France, cover 6,000 square miles; the crests of the dunes are over 130 feet high. Dunes are common in the coast- lands of Belgium, Denmark and the Netherlands. To arrest the migration of the dunes, sand-binding species of grass and shrubs, such as marram grass, and pines are planted.



Types of Coasts

Despite a great variety of coastal features coast-lines may be divided into two basic types.

1. **Coastlines of submergence -** These are due to the sinking of the land or the rise of the sea, including such coasts as ria coasts,

fiord coasts, estuarine coasts and Dalmatian or longitudinal coasts.

2. **Coastlines of emergence -** These are due to the uplift of the land or a fall in the sea level. They are less common and are represented by the uplifted lowland coast and the emergent upland coast.

Coastlines of Submergence

1. **Ria coasts**
   - During the Ice Age a great deal of water was locked up in ice. The warmer climate that followed melted much of the ice. Subsequently there was an increase in the waters of the oceans and the sea level rose appreciably.
   - In upland coastal regions where the mountains run at right angles to the sea, that is transverse or discordant to the coast, a rise in the sea level submerges or drowns the lower parts of the valleys to form long, narrow branching inlets separated by narrow headlands.
   - They differ from fiords in two important respects, i.e. they are not glaciated, and their depth increases seawards. A **ria coast is typical of the Atlantic type** of coast like those of north-west France north-west Spain, south-west Ireland, Devon and Cornwall.
2. **Fiord coasts**
   - Fiords are submerged U-shaped glacial troughs. They mark the paths of glaciers that plunged down from the highlands. They have steep walls, often rising straight from the sea, with tributary branches joining the main inlet at right angles.
   - Due to the greater intensity of ice erosion fiords are deep for great distances inland but there is a shallow section at the seaward end formed by a ridge of rock and called the threshold.
   - Fiord coasts are almost entirely confined to the higher latitudes of the temperate regions which were once glaciated e.g. Norway, Alaska, British Columbia, southern Chile and the South Island of New Zealand.
3. **Dalmatian coast**
   - This is the longitudinal coast where mountains run parallel or concordant to the coast. The name is taken from the coast of Dalmatia, Yugoslavia, along the Adriatic Sea, where the submergence of the coastline produces long, narrow inlets with a chain of islands parallel to the coast.
   - The elongated islands are the crests of former ranges and the narrow sounds were the former longitudinal valleys. The Dalmatian type of coast is also typical of the Pacific coast where the ranges are parallel to the coast e.g. western coasts of North and South America but there the coastline is more regular.
4. **Estuarine coasts -** In submerged lowlands, the mouths of rivers are drowned so that funnel-shaped estuaries are formed. If their entrances are not silted by moving sand-banks, they make excellent sites for ports, e.g. the **estuaries of the Thames**.

Coastlines of Emergence

1) **Uplifted lowland coast** - The uplift of part of the continental shelf produces a smooth, gently sloping coastal lowland. The offshore waters are shallow with lagoons, salt-marshes and mud-flats. Where the emergent deposits from the continental shelves are sandy and gravelly, beaches and marine dunes are formed.
2) **Emergent upland coast -** Faulting and earth movement may thrust up coastal plateaux so that the whole region is raised, with consequent emergent features. A raised beach is the most prominent. The raised beach is beyond the reach of the waves, though it may still possess arches, stacks and other coastal features. The emergent upland coast is quite straight with steep cliffs and deeper off-shore water.

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CHAPTER: 11 – ISLANDS AND CORAL REEFS

An island is a piece of land surrounded on all sides by water. It may occur individually or in a group, in open oceans or seas. Smaller ones of only local significance are found even in lakes and rivers. Generally speaking, all islands may be grouped under the following types.

1. **Continental islands**
   - These islands were formerly part of the mainland and are now detached from the continent. They may be separated by a shallow lagoon or a deep channel. Their separation could be due to subsidence of some part of the land or to a rise in sea level, so that the lowland links are submerged by the sea. Their former connection with the neighbouring mainland can be traced from the similar physical structure, **flora and fauna** that exist on both sides of the channel.
   - **Continental islands may appear as:-**
     1. **Individual islands -** These lie just outside the continent, very much associated with the characteristic features of the mainland of which they were once part. Some of the outstanding examples are Newfoundland, separated from the mainland by the Strait of Belle Isle; Madagascar, by the Mozambique Channel: Ceylon by the Palk Strait; Tasmania by the Bass Strait and Formosa by the Formosa Strait.
     2. **Archipelagos or island groups -** These comprise groups of islands of varying sizes and shapes, e.g. the British Isles, the Balearic Islands of the Mediterranean and also those of the Aegean Sea.
     3. **Festoons or island arcs -** The islands form an archipelago in the shape of a loop around the edge or the mainland, marking the continuation of mountain ranges which can be traced on the continent, e.g. the East Indies, the Aleutian Islands, Ryukyu Islands, Kurile Islands and other island arcs of the Pacific coasts.
2. **Oceanic islands**
   - These islands are normally small and are located in the midst of oceans. They have no connection with the mainland which may be hundreds or thousands of miles away. Due to their remoteness from the major trading centres of the world, most of the oceanic islands are very sparsely populated.
   - Some of them provide useful stops for aeroplanes and ocean steamers that ply between continents across vast stretches of water. Generally speaking, oceanic islands fall into one of the following groups.
     i. **Volcanic islands -** Many of the islands in the oceans are in fact the topmost parts of the cones of volcanoes that rise from the ocean bed. Most of them are extinct, but there are also some active ones. The best-known volcanic peak of the Pacific Ocean is Mauna Loa in Hawaii.
     ii. **Coral islands** - Unlike the the coral islands are very much lower and emerge Just above the water surface. These islands, built up by coral animals of various

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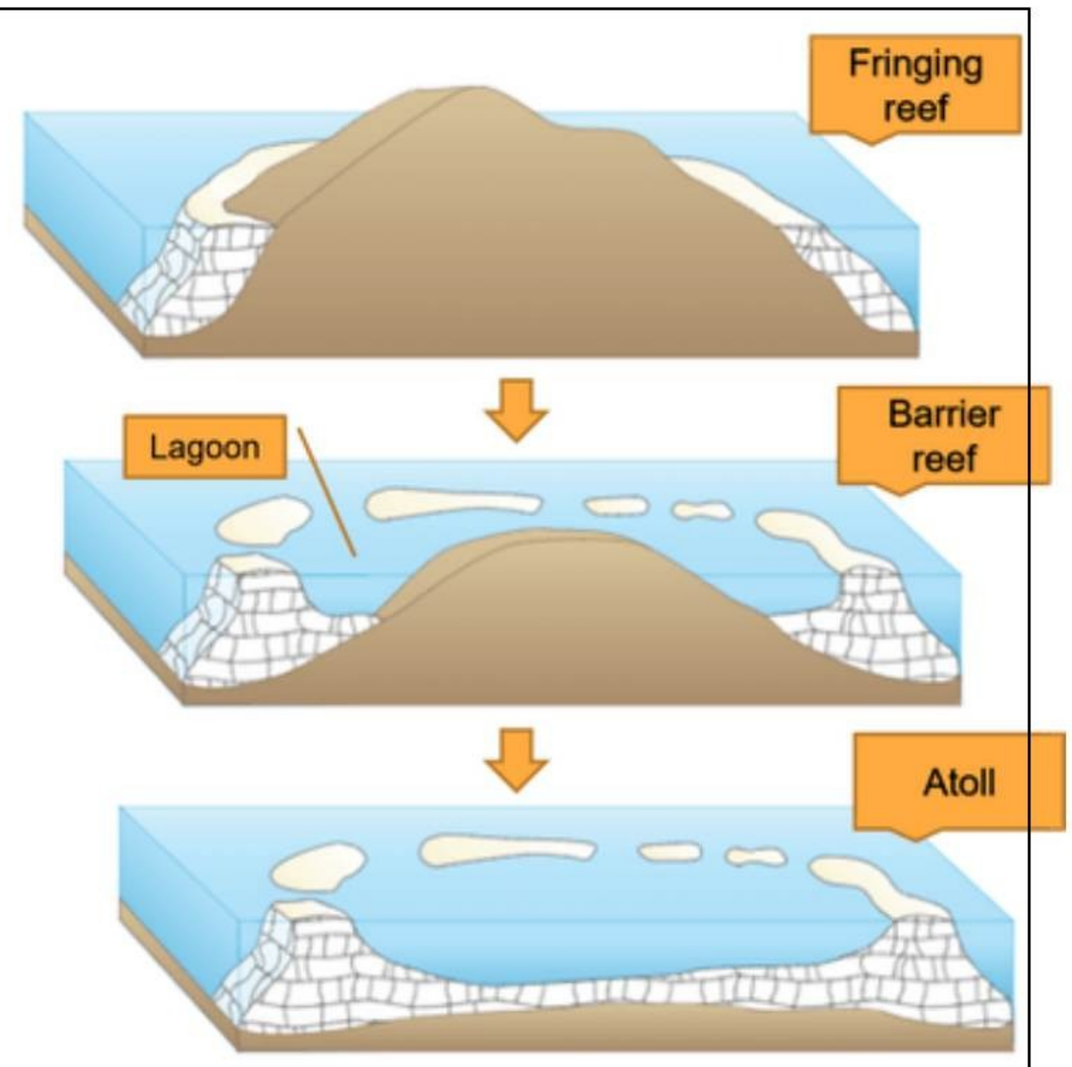
species, are found both near the shores of the mainland and in the midst of oceans.

Coral Reefs

- In tropical seas many kinds of coral animals and marine organisms such as coral polyps, calcareous algae, shell-forming creatures and lime-secreting plants live in large colonies. Though they are very tiny creatures, their ability to secrete calcium carbonate within their tiny cells has given rise to a peculiar type of marine landform. They exist in numerous species of many forms, colours and shapes.
- Taking coral animals as a whole, the polyps are the most abundant and also the most important. Each polyp resides in a tiny cup of coral and helps to form coral reefs. When they die, their limy skeletons are cemented into coralline limestone. The reef-building corals survive best under the following conditions.
    1. The water temperature must not fall below 68°F. (20°C.). This virtually limits the areal distribution of corals to the tropical, and sub-tropical zones. Again they will not flourish where there are cold currents. This explains why coral reefs are generally absent on the western coasts of continents.
    2. The depth of the water should not exceed 30 fathoms or 180 feet, because beyond this depth sunlight is too faint for photosynthesis to take place.
    3. The water should be saltish and free from sediment. Corals therefore survive best in the moving ocean water well away from the silty coasts or muddy mouths of streams. The corals are best developed on the seaward side of the reef.
- **Types of Coral Reefs:** There are three main types of coral reefs.
    1. **Fringing reefs -** A fringing reef is a coralline platform lying close to the shore extending outwards from the



mainland. It is sometimes separated from the shore by a shallow lagoon. It is widest when fringing a protruding headland but completely absent when facing the mouth of a stream. The outer edge grows rapidly because of the splashing waves that continuously renew the supply of fresh food. The reefs may be about a mile wide lying just above the level of low water and sloping steeply downwards on the seaward side to a depth of about 100 feet.

2. **Barrier reefs -** A barrier reef is separated from the coast by a much wider and deeper channel or lagoon. The reef is partially submerged. Where it lies above the water level and sand can accumulate on it, a little vegetation is possible. The barrier reefs have narrow gaps at several places to allow the water from the enclosed lagoon to return to the open ocean. The best-known barrier reef is the Great Barrier Reef off the **coast of Queensland, Australia.**
3. **Atolls** - Atolls are similar to barrier reefs except that they are circular in shape, enclosing a shallow lagoon without any land in the centre. The encircling ring is usually broken in a few places to allow the free flow of

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water. On the inside of the reefs, sand and limestone debris collect and palm trees like coconuts may grow. Some of the large atolls, e.g. Suvadiva in the Maldives west of Ceylon, have a lagoon over 40 miles across.

The Probable Origin of Coral Reefs

- Charles Darwin, after his voyage to the Pacific islands in 1842. It is known as the subsidence theory. Darwin assumed that all coral reefs began as fringing reefs around an island or the topmost portions of extinct volcanoes that stood above the ocean bed. Due to a general down warping of the earth's crust, the islands gradually subsided.
- The corals continued to grow upwards to keep pace with the subsidence. The growth was more vigorous at the outward edge than the landward edge because of the more favourable living conditions for corals, so the encircling reef widened. It then formed a **barrier reef**, with a lagoon between the island and the reef. Eventually, when the land completely submerged, only the outer rims of the reefs were seen, forming an atoll.
- R.A. Daly's glacial control theory put forward in 1910 is worth consideration. During his visit to Mauna Kea in Hawaii, he noticed the close relationship between glaciation and the development of coral reefs. He believed that during the height of the Ice Ages, the water was too cold for any coral growth to take place.
- With the absence of a coral barrier, marine erosion was able to attack and lower the islands. With the return of the warmer climate, the water that was locked up in the ice sheets melted. Consequently, there was a rise in the **sea level** which in some cases. Submerged these lower Islands.
- On these wave-planed platforms, coria began to grow upwards at the rate of a foot in a decade to keep pace with the rising water level. Coral reefs, where islands still project above sea level, and atolls were thus formed.

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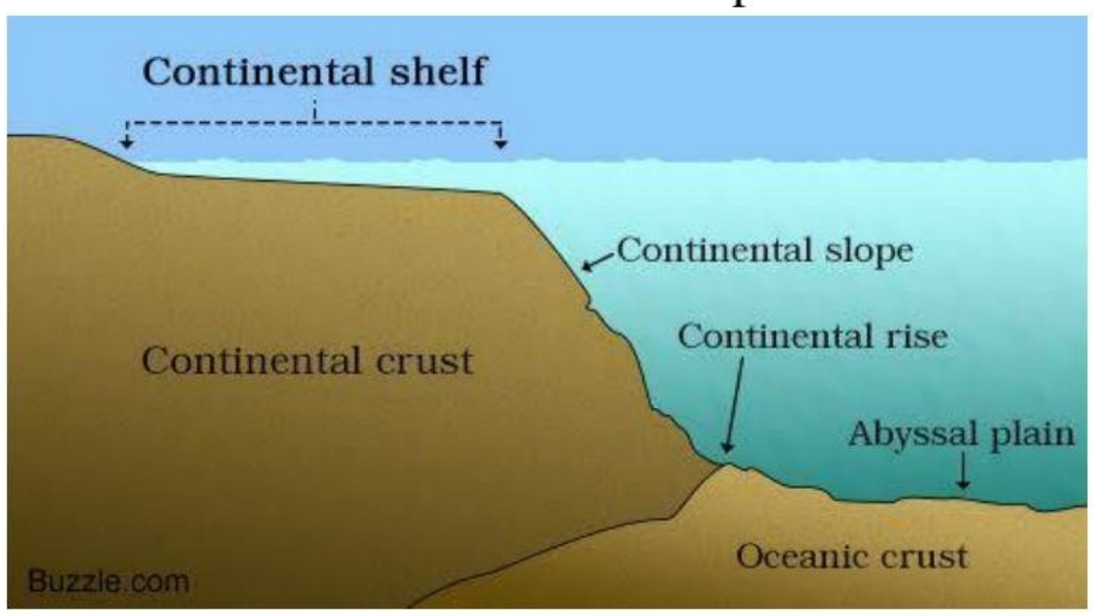
CHAPTER: 12 – THE OCEANS

Exploring the Oceans

- The oceans, comprising more than 70 percent. Formal oceanographic investigation began only with the British expedition of the Challenger (1873-1876), the first successful world-wide deep-sea expedition.
- Oceanography, the science of the oceans. The most famous international oceanographic research centre is the International Council for the Exploration of the Sea with its headquarters in Copenhagen.
- It involves the operation and maintenance of specially equipped vessels in mid- ocean for long periods, and large-scale Oceanographic researches are thus best undertaken by international bodies. The older echo-sounding techniques have now been replaced by radar sounding and electrical echo devices to find the precise depths of ocean floors and map the relief of the oceans.

The Relief of the Ocean

- The ocean basins are in many ways similar to the land surface. There are submarine ridges, plateaux, canyons, plains and trenches. A section drawn across an ocean the typical submarine relief feature.
    1. **The continental shelf**
        - The continental shelf is thus a shallow platform whose width varies greatly, from a few miles in the North Pacific off the continent of North America, to over 100 miles off north-west Europe.
        - In some places where the coasts are extremely mountainous, such as the Rocky Mountain and Andean coasts, the continental shelf may be entirely absent.
        - The angle of the slope is also variable, and is normally least where the continental shelf is widest.
        - Many regards the continental shelf as part of the continent submerged due to a rise in sea level.
        - **The continental shelves are of great geographical significance for the following reasons.**
            i. Their shallowness enables sunlight to penetrate through the water, which encourages the growth of minute plants and other microscopic organisms. They are thus rich in plankton on which millions of surface and bottom-feeding fishes thrive. The continental shelves are therefore the richest fishing grounds in the world.
            ii. Their limited depth and gentle slope keep out cold under-currents and increase the height of tides. This sometimes hinders shipping and other marine activities since ships can only enter and leave port on the tide.



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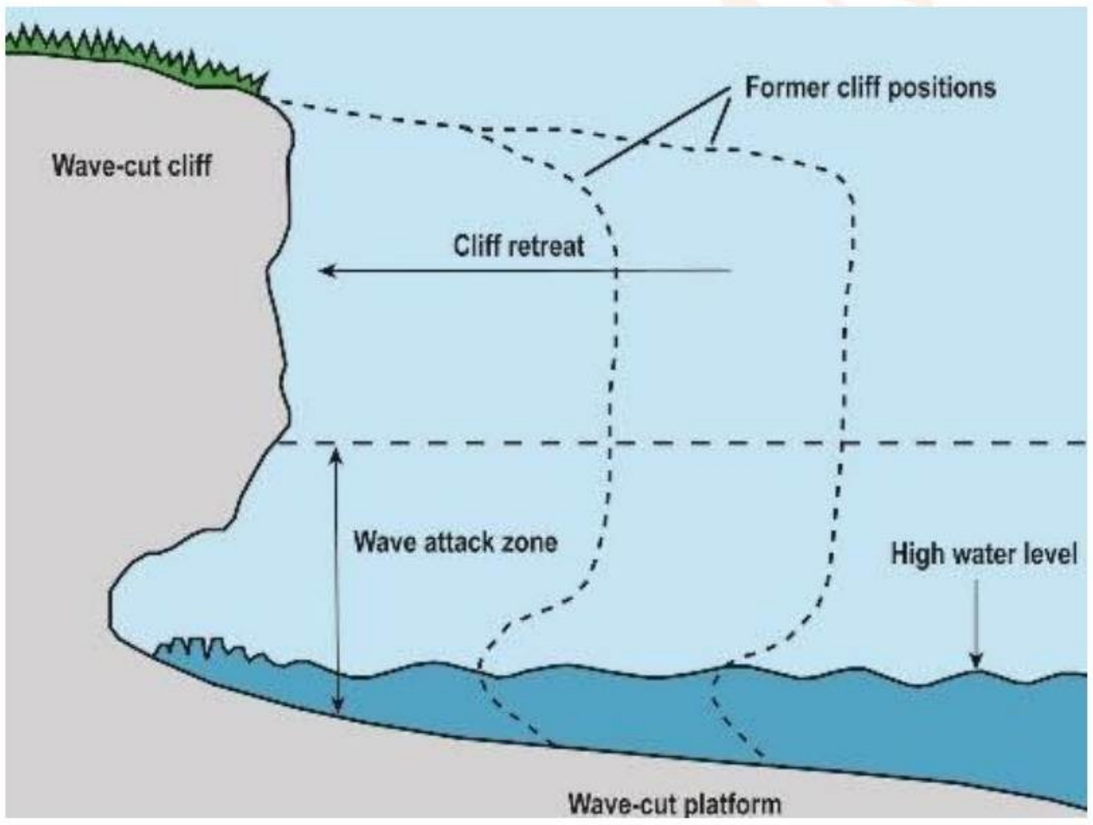
2. **The continental slope -** At the edge of the continental shelf, there is an abrupt change of gradient to about 1 in 20, forming the continental slope.
3. **The deep-sea plain** - This is the undulating plain lying two to three miles below sea level, and covering two-thirds of the ocean floor, generally termed the **abyssal plain**. It was once thought to be featureless, but modern sounding devices reveal that the abyssal plain is far from being level. It has extensive submarine plateaux, ridges, trenches, basins.
4. **The ocean deeps -** These are the long, narrow trenches that plunge as great Ocean deeps to a depth of 5,000 fathoms or 30,000 feet! Contrary to our expectations, most of the deepest trenches are not located in the midst of oceans. They are more often found close to the continents, particularly in the Pacific Ocean, where several deep trenches have been sounded. The greatest known ocean deep is the **Mariana Trench near Guam Island**, which is more than 36,000 feet deep.



The Oceanic Deposits of the Ocean Floor

- Materials eroded from the earth which are not deposited by rivers or at the coast are eventually dropped on the ocean floor. The dominant process is slow sedimentation where the eroded particles very slowly filter through the ocean water and settle upon one another in layers. Generally speaking, we may classify all the oceanic deposits as **either muds, oozes or clays.**
  1. **The muds -** These are terrigenous deposits because they are derived from land and are mainly deposited on the continental shelves.
  2. **The oozes -** These are pelagic deposits because they are derived from the Oceans. They are made of the shelly and skeletal remains of marine micro- organisms with calcareous or siliceous parts. Oozes have a very fine, flour-like texture and either occur as accumulated deposits or float about in suspension.
  3. **The clays -** These occur mainly as red clays in the deeper parts of the ocean basins, and are particularly abundant in the Pacific Ocean. Red clay is believed to be an accumulation of volcanic dust blown out from volcanoes during volcanic eruptions.

Salinity of the Ocean

- Water contains large amounts of dissolved mineral matter of which sodium chloride or common salt alone constitutes more than 77 per cent. The other more important compounds include magnesium, calcium and potassium, while the rest are distinguishable only in traces of very minute quantities.
- Due to the free movement of ocean water, the proportions of different salts, remain remarkably constant in all oceans and even to great depths. But the degree of concentration of the salt solution in oceans does vary appreciably in different areas. This is expressed as salinity, the degree of saltness of water, either as a percentage or more often in parts per thousand. Variations are shown in salinity distribution maps by isohalines, lines joining places having an equal degree of salinity.
- Generally speaking, the average salinity of the Oceans is 35.2 ‰, about 35 parts of

salt in 1,000 parts of water. n the Baltic Sea, where there is much dilution by fresh water and melting ice, the salinity 15 much lower, only about 7 %o In the Red Sea whet there is much surface evaporation and fewer rive to bring in fresh water, the average salinity increases to 39 %o.

- The variation of salinity in the various seas and oceans is affected by the following factors.
  I. The rate of evaporation
  II. The amount of fresh water added by precipitation, streams and icebergs
  III. The degree of water mixing by currents

The Temperature of Ocean

- Since water warms up and cools down much more slowly than the land, the annual range OI temperature in any part of the ocean is very much smaller. It is less than 10°E for most of the open Seas.
- Generally, the mean annual temperature of the surface ocean water decreases from about 70°F in equatorial areas to 55°F at latitudes 45°N and S., and drops almost to freezing-point at the poles. The reduction of temperature with latitude is however never constant, because of the interference by warm and cold currents, winds and air masses.
- Water flowing out from the Arctic and Antarctic as cold currents, such as the Labrador Current of north-cast Canada, tends to reduce the **surface-water** temperature. Ports of eastern Canada even at 45°N are thus icebound for almost half the year.
- In the same way, coasts warmed by warm currents, such as the North Atlantic Drift, have their Surface temperature raised. The Norwegian coast, even at latitudes 60° to 70°N, is ice-free throughout the year.
- The highest water temperatures are found in enclosed seas in the tropics, e.g. the Red Sea which records a temperature of 85° to 100°F. The Arctic and Antarctic waters are so cold that their surface is permanently frozen as pack-ice down to a depth of several feet. In the warmer summer, parts of the **ice break off as icebergs** that both dilute the water and lower the surface temperature of surrounding ice-free seas.
- The temperature of the oceans also varies vertically with increasing depth. It decreases rapidly for the first 200 fathoms, at the rate of 1°F for every 10 fathoms, and then more slowly until a depth of 500 fathoms is reached. Beyond this, the drop is scarcely noticeable, less than 1°F for every 100 fathoms.
- In the ocean deeps below 2,000 fathoms (12,000 feet), the water is uniformly cold, just a little above **freezing-point**. It is interesting to note that even in the deepest ocean trenches, more than 6 miles below the surface, the water never freezes. It is estimated that over 80 per cent of all ocean waters have a temperature between 35° and 40°E

The Movements of Ocean Currents

Ocean currents are large masses of surface water that circulate in regular patterns around the oceans. Those that flow from equatorial regions poleward have a higher surface temperature and are warm currents. Those that flow from Polar Regions equatorward have a lower surface temperature and are cold currents

1) **The planetary winds -** Between the equator and the tropics blow the Trade Winds which move equatorial waters poleward and westwards and warm the eastern coasts of continents. For example, the **North-East Trade** Winds move the North Equatorial Current and its derivatives, the Florida Current and the Gulf Stream Drift to warm the southern and eastern coasts of U.S.A. Similarly, the South-East Trade Winds drive the South Equatorial Current which warms the eastern coast of Brazil as the warm Brazilian Current. The planetary winds are probably the dominant influence on the flow of ocean currents.
2) **Temperatures -** As warm water is lighter and rises, and cold water is denser and

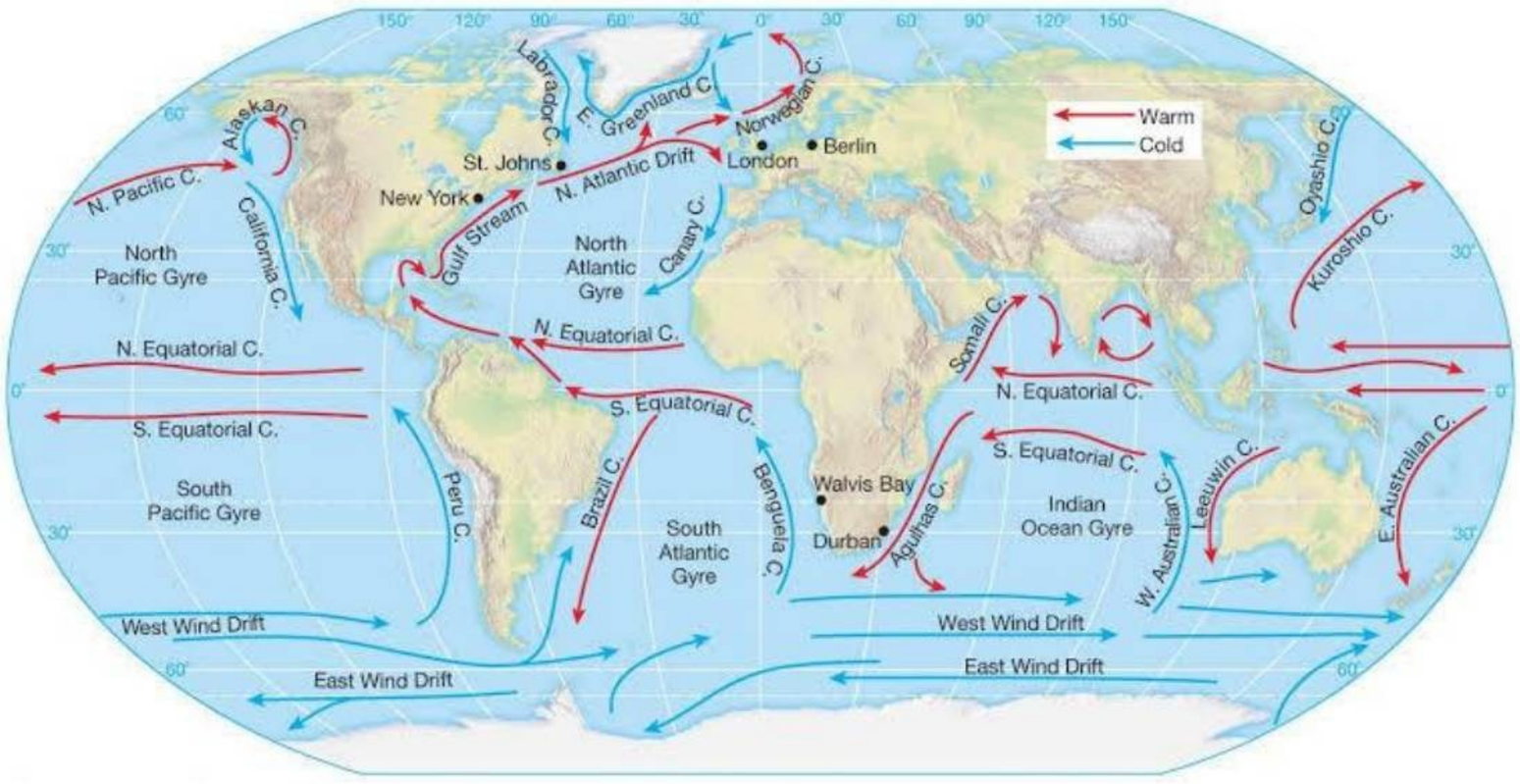
sinks, warm equatorial waters move slowly along the surface poleward, while the heavier cold waters of the Polar Regions creep slowly along the bottom of the sea equatorward.

3) **Salinity -** Waters of high salinity are denser than waters of low salinity. Hence waters of low salinity flow on the surface of waters of high salinity while waters of high salinity flow at the bottom to- wards waters of low salinity. For example, in the Mediterranean region, there is great difference in salinity between the waters of the open Atlantic and those of the partially enclosed Mediterranean Sea.
4) **The earth's rotation -** The earth's rotation deflects freely moving objects, including ocean currents, to the right. In the northern hemisphere this is a clockwise direction (e.g. the circulation of the Gulf Stream Drift and the Canaries Current). In the southern hemisphere it is an anti-clockwise direction (e.g. the Brazilian Current and the West Wind Drift).
5) **Land -** A land mass always obstructs and diverts a current. For instance, the tip of southern Chile diverts part of the West Wind Drift northwards as the Peruvian Current.

The Circulation of the Atlantic Ocean

- The steady Trade Winds constantly drift two streams of water from east to west. At the 'shoulder' of north-east Brazil, the protruding land mass splits the South Equatorial Current into the Cayenne Current which flows along the Guiana coast, and the Brazilian Current which flows southwards along the east coast of Brazil.
- In the North Atlantic Ocean, the Cayenne Current is joined and reinforced by the North Equatorial Current and heads north-westwards as a large mass of equatorial water into the Caribbean Sea. Part of the current enters the Gulf of Mexico and emerges from the Florida Strait between Florida and Cuba as the Florida Current. The rest of the equatorial water flows northwards east of the Antilles to join the Gulf Stream off the south-eastern U.S.A.
- The current hugs the coast of America as far as Cape Hatteras (latitude 35°N.), where it is deflected eastwards under the combined influence of the Westerlies and the rotation of the earth. It reaches Europe as the North Atlantic Drift. The Canaries Current flowing southwards eventually merges with the North Equatorial Current, completing the clockwise circuit in the North Atlantic Ocean.
- These cold waters are blown south by the out-flowing polar winds. The Irminger Current or East Greenland Current of flows between Iceland and Greenland and cools the North Atlantic Drift at the point of convergence. The cold Labrador Current drifts south-eastwards between **West Greenland and Baffin Island** to meet the warm Gulf Stream off Newfoundland, as far the south as 50°N. Where the icebergs carried south by the Labrador Current melt.
- The South Atlantic Ocean follows the same pattern. The of circulation as the **North Atlantic Ocean.** The major differences are that the circuit is anti-clockwise and the collection of sea-weed in the still waters of the mid-South Atlantic is not so distinctive.
- Where the South Equatorial Current is split at Cape Sao Roque, one branch turns south as the warm Brazilian Current. Its deep blue waters are easily distinguishable from the yellow, muddy waters carried hundreds of miles out to sea by the Amazon further north. At about 40°S. The influence of the prevailing Westerlies and the rotation of the earth propel the current eastwards to merge with the cold West Wind Drift as the South Atlantic Current.
- On reaching the west coast of Africa the current is diverted northwards as the cold Benguela Current (the counterpart of the Canaries Current). It brings the cold polar waters of the West Wind Drift into tropical latitudes.

The Circulation of the Pacific Ocean



- The North Equatorial Current flows westwards with a compensating Equatorial Counter Current running in the opposite direction.
- The North-East Trade Winds blow the North Equatorial Current off the coasts of the Philippines and Formosa into the East China Sea as the Kuroshio or Kuro Siwo or Japan Current. Its warm waters are carried poleward as the North Pacific Drift, keeping the ports of the Alaskan coast ice-free in winter.
- The cold Bering Current or Alaskan Current creeps' southwards from the narrow Bering Strait and is joined by the Okhotsk Current to meet the warm Japan Current as the Oyashio, off Hokkaido.
- The cold water eventually sinks beneath the warmer waters of the North Pacific Drift. Part of it drifts eastwards as the cool Californian Current along the coasts of the western U.S.A. and coalesces with the North Equatorial Current to complete the clockwise circulation.
- The current system of the South Pacific is the same as that of the South Atlantic. The South Equatorial Current, driven by the South-East Trade winds, flows southwards along the coast of Queensland as the East Australian Current, bringing warm equatorial waters into temperate waters.
- The current turns eastwards towards New Zealand under the full force of the Westerlies in the Tasman Sea and merges with part of the cold West Wind Drift as the South Pacific Current. Obstructed by the tip of southern Chile, the current turns northwards along the western coast of South America as the cold Humboldt or Peruvian Current.
- The cold-water chills any wind that blows on-shore so that the Chilean and Peruvian coasts are practically rainless. The region is rich in microscopic marine plants and animals that attract huge shoals of fish.

The Indian Ocean Circulation

- The Equatorial Current, turning southwards past Madagascar as the Agulhas or Mozambique Current merges with the West Wind Drift, flowing eastwards and turns equator wards as the West Australian Current
- In the North Indian Ocean, there is a complete reversal of the direction of currents between summer and winter, due to the changes of monsoon winds in summer from June to October, when the dominant and wind is the South-West Monsoon, the currents are blown from a south-westerly direction as the South- West Monsoon Drift.
- This is reversed in winter, North-East beginning from December, when the North-East Monsoon blows the currents from the north-east as the North-East Monsoon Drift.

CHAPTER: 13 - WEATHER

The Difference between weather and climate

- Any casual remarks about the atmospheric conditions of a certain place at a certain time are about weather. It is never static, and thus cannot be generalized.
- When we speak of climate, we mean the average atmospheric conditions of an area over a considerable time. For climatic averages, a minimum period of 35 years is desirable.

The importance of climate and weather

- The direction of winds once controlled the pattern of trading routes. Death rates are normally high in tropical countries and low in deserts, because germs are not transmitted readily in regions of high temperature and low humidity. Cool, fresh mountain air is always good for health.
- **Weather Bureaux** or Meteorological Stations are scattered all over the globe, including the oceans using some of the most up-to-date **weather instruments** to gather a wide range of data as raw materials for the construction of weather maps or synoptic charts
- The weather systems can often help to avoid or reduce the seriousness of the calamities. Professional meteorologists are able to forecast the weather fairly accurately from local observations.

The Elements of climate and weather

1) **Rainfall**
    - Rainfall including other forms of precipitation (snow, sleet and hail) is always measured by a metal instrument called a rain gauge.
    - An inch of rainfall means the amount of water that would cover the ground to a depth of 1 inch, provided none evaporated, drained off or percolated away. For meteorological recordings, a rain-day is reckoned as a period of 24 hours with at least 0.01 inch or more rain being recorded.
    - The daily records of rainfall will be added at the end of the month to find the total rainfall for that month. The total for each month is again added at the end of the year to find the annual rainfall.
    - The mean annual rainfall is obtained from the averages of annual rainfall taken over a long period of say 35 years. For plotting in rainfall maps, places having the same mean annual rainfall are joined by a line called an isohyet.
2) **Pressure**
    - The instrument for measuring pressure is a barometer. Variations in the atmospheric pressure on the mercury surface are balanced by the column of mercury in the glass tube.
    - Any liquid could be used for this purpose, but mercury has been chosen because it is the heaviest liquid known. If ordinary water were used, the corresponding column for normal atmospheric pressure would be 34 feet.
    - If the pressure increases, the air pressing on the surface will force up the mercury column to about 31 inches (high pressure).
    - On maps places of equal pressure are joined by lines called isobars.
    - Pressure readings vary with a number of factors. A sea-level reading of 30 inches will be halved on mountainous regions of 3:5 miles above sea level. This is **because** as one ascends there is less air above and so the weight, or pressure is less. The barometer is also sensitive to gravitational forces at different latitudes. The mercury itself also expands with an increase in temperature.
    - Since a mercury barometer that dips in liquid mercury is inconvenient for outdoor measurement, a more

portable but less accurate type known as the aneroid barometer is used.

- In aeroplanes, a modified type of aneroid barometer called an altimeter is used. As pressure decreases with altitude at an approximate rate of 1-inch drop in the mercury reading for every 900 feet ascent, the altimeter gives the reading in feet for height attained instead of millibars or inches.
- For a continuous record of pressure changes, as is sometimes required, the self-recording barogram is used.

3) Temperature

- The instrument for measuring temperature is the thermometer which is a narrow glass tube filled with mercury or alcohol. It works on the principle that mercury expands when heated and contracts when cooled. On t**hermometers, temperatures** are marked in one of two ways. In °F. (Fahrenheit) the freezing-point is 32°F, and the boiling-point is 212°F for most scientific purposes the Centigrade °C. Scale is preferred.
- A temperature taken in open daylight is very high, because it measures the direct insolation of the sun. It is better described as temperature in the sun. For agricultural purposes, earth temperatures are taken at various depths in the ground.
- To assess the possible damages done by ground frosts to crops in temperate latitudes, grass temperatures are also taken.
- But the temperatures that we are so accustomed to in climatic graphs are shade temperatures. That is the temperatures of the air. Precautions therefore must be taken to exclude the intensity of the sun's radiant heat. This is done by placing the thermometers in a standard meteorological shelter known as the Stevenson Screen.
- Maximum and minimum temperatures are measured by the maximum and minimum thermometers. They are either in the form of separate thermometers or joined in a U-shaped glass tube as in the Six's thermometer it pushes a metal indicator up the tube and this stays at the maximum level when the temperature drops.
- The minimum thermometer records the lowest temperature reached during the day; it probably occurs in the middle of the night or early in the morning.
- The mean daily temperature is the average of maximum and minimum eg. (87°FE + 73°F.) 2 80°F. The difference between the maximum and minimum temperatures of a day gives the diurnal range of temperature. The difference between the hottest month (i.e. July in the northern hemisphere) and the coldest month (i.e. January in the northern hemisphere) gives the annual range of temperature.
- In diagrammatic representations, monthly mean temperatures are shown in simple temperature graphs or in temperature distribution maps as isotherms. Temperatures decrease at the rate of 1°F drop in temperature for 300 feet ascent in altitude, so for highland stations a higher temperature is shown than was actually recorded.

4) Humidity

- Humidity is a measure of the damp-ness of the atmosphere which varies greatly from place to place at different times of day. The actual amount of water vapour present in the air, which is expressed in grams per cubic metre, is called the absolute humidity. But more important from the point of view of

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weather studies is the relative humidity.

- This is the ratio between the actual amount of water vapour and the total amount the air can hold at a given temperature, expressed as a percentage. Warm air can hold more water vapour than cold air. In the equatorial regions, over 80 per cent is common in the morning.
- When the relative humidity reaches 100 per cent, the air is completely saturated. The air temperature is said to be at dew-point. Further cooling will condense the water vapour into clouds or rain. It is thus clear that when relative humidity is high the air is moist, as in the equatorial regions; when it is low, the air is dry as it the deserts.
- The instrument for measuring relative humidity is the hygrometer, which comprises wet-and dry-bulb thermometers placed side by side in the Stevenson Screen. When the air is not saturated evaporation, which produces a cooling effect, takes place from the moist wick.

5) Winds

- Wind is air in motion and has both direction and speed. Unlike other elements in climate such as rain, snow or sleet, Winds are made up of a series of gusts and eddies that can only be felt but not seen.
- The instrument widely used for measuring wind direction is a wind vane or weather cock.
- Winds are always named from the direction they blow.
- The speed of wind is usually measured by an anemometer.
- The best guide is obtainable from the Beaufort Wind Scale which was devised by Admiral Beaufort in 1805 for estimating wind speed. Frequent reference to the table in your free time will help you to learn it quickly.

6) Sunshine

- The amount of sunshine a place receives, depends on the seasons, a factor determined by latitude and by the position of the earth in its revolution around the sun.
- In the meteorological station, sunshine duration is recorded by a sun-dial, 4 inches in diameter, on maps places with equal sunshine duration are joined by isohels.

7) Clouds

- When air rises, it is cooled by expansion. After dew-point has been reached cooling leads to condensation of water vapour in the atmosphere. Tiny droplets of water vapour which are too small to fall as rain or snow (less than 0-001 cm. approximately 0-0005 inches in radius) will be suspended in the air and float as clouds.
- For meteorological purposes, the amount of cloud-cover in the sky is expressed in eighths or oktas. On maps places with an equal degree of cloudiness are joined by lines known as isonephs.
- The classification of clouds is based on a combination of form, height and appearance. Four major cloud types and their variations can be recognised.
  - **a) High Clouds: mainly cirrus (Ci) of feathery form at 20-40,000 feet above ground.**
    - **Cirrus (Ci):** This looks fibrous and appears like wisps in the blue sky; it is often called **mares** tails. It indicates fair weather, and often gives a brilliant sunset.
    - **Cirrocumulus (Cc):** This appears as white globular masses, forming ripples in a 'mackerel sky.

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- **Cirrostratus (Cs):** This resembles a thin white sheet or veil: the sky looks milky and the sun or moon shines through it with a characteristic **'halo'.**

b) **Medium Clouds: mainly alto (Alt) or middle- height clouds at 7-20,000 feet.**

- **Altocumulus (Alt-Cu):** These are woolly bumpy clouds arranged in layers and appearing like waves in the blue sky. They normally indicate fine weather.
- **Altostratus (Alt-St):** These are denser, greyish clouds with a 'watery' look. They have a fibrous or striated structure through which the sun's rays shine faintly.

c) **Low Clouds mainly stratus or sheet clouds below 7,000 feet.**

- **Stratocumulus (St-Cu):** This is a rough, bumpy cloud with the waves more pronounced than in altocumulus. There is great contrast between the bright and shaded parts.
- **Stratus (St):** This is a very low cloud, uniformly grey and thick, which appears like a low ceiling or highland fog. It brings dull weather with light drizzle. It reduces the visibility of aircraft and is thus a danger.
- **Nimbostratus (Ni-St):** This is a dark, dull cloud, clearly layered, and is also known as a 'rain cloud. It brings continuous rain, snow or sleet.

d) **Clouds with great vertical extent mainly cumulus or heap clouds with no definite height (2-30,000 feet).**

- **Cumulus (Cu):** This is a vertical cloud with a rounded top and horizontal base, typical of humid tropical regions, associated with up-rising convectional currents. Its great white globular masses may look grey against the sun but it is a fair-weather cloud'. X.
- **Cumulonimbus (Cu-Ni):** This is, in fact, an overgrown cumulus cloud, extending for a tremendous vertical height from a base of 2,000 feet to over 30,000 feet. Its black and white globular masses take a fantastic range of shapes. Its cauliflower top often spreads out like an anvil. This is frequently seen in tropical afternoons.

8) **Other Elements pertaining to visibility** - Other elements affecting visibility include haze, mist and fog.

a) **Haze:** This is caused by smoke and dust particles in industrial areas or may be due to unequal refraction of light in air of different densities in the lower atmosphere. The term is usually used in connection with the reduction of visibility in regions of low humidity, less than 75 per cent. When visibility is less than 1 miles, haze is present.

b) **Mist:** The condensation of water vapour in the air causes small droplets of water to float about

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forming clouds at ground level called mist. It reduces visibility to about 1,000 metres or 1,100 yards. Unlike haze, mist occurs in wet air, when the relative humidity is over 75 per cent.

c) **Fog:** Ordinary fog is due to water condensing on dust and other particles like smoke from houses and factories. It only occurs in the lower strata of the atmosphere as a sort of dense ground cloud'. The visibility in fog is even less than 1,000 metres. In industrial areas, like those of the Black Country and northern England, very thick smoky fog is formed, called smog the visibility may be reduced to 220 yards or even less. Fogs that occur on hills are called hill fogs.

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CHAPTER: 14 - CLIMATE

The Atmosphere

- The atmosphere is made up of gases and vapour, and receives incoming solar energy from the sun giving rise to what we call climate.
- The lowest layer, in which the weather is confined, is known as the **troposphere**. It extends from the earth's surface for height of 6 miles, and within it temperature normally falls with increasing altitude.
- The **stratosphere** or the upper layer of the atmosphere. It extends upwards for another 50 miles or even more. It is not only very cold, but cloudless, with extremely thin air and without dust, smoke or water vapour but there are marked seasonal temperature changes.
- Beyond the **Stratosphere** is the **ionosphere** which goes several hundred miles up. It has electrically conducting layers which make short-wave radio transmission possible over long distances.

Insolation

- The only source of energy for the earth's atmosphere comes from the sun which has a surface temperature of more than 10,800°F. This energy travels through space for a distance of 93 million miles and reaches us as solar energy or radiant energy in the process called insolation. This radiation from the sun is made up of three parts, the visible 'white" light that we see when the sun shines and the less visible ultra-violet and infra-red rays.
- The infra-red rays can penetrate even dust and fog and are widely used in photography. Only that part of the sun's radiation which reaches the earth is called insolation.
- It is estimated that of the total radiation coming to us, 35 per cent reaches the atmosphere and is directly reflected back to space by dust, clouds and air molecules.
- Another 14 per cent is absorbed by the water vapour, carbon dioxide and other gases. Its interception by the air causes it to be 'scattered and diffused' so that the visible rays of the spectrum between the ultra-violet and infra-red give rise to the characteristic blue sky that we see above us.
- The remaining 51 per cent reaches the earth and warms the surface. In turn the earth warms the layers of air above it by direct contact or conduction, and through the transmission of heat by upward movement of air currents or convection.

Elements of Climate and Factors affecting them

- Of the various climatic elements, temperature, precipitation, pressure and winds are the most important because of their far-reaching global influences.
- these elements and their distribution, whether horizontal from equatorial to polar regions or vertical from ground to atmosphere, are in one way or another affected by some or all of the climatic factors: latitude, altitude, continentality, ocean cur- rents, insolation, prevailing winds, slope and aspect, natural vegetation and soil.

Temperature

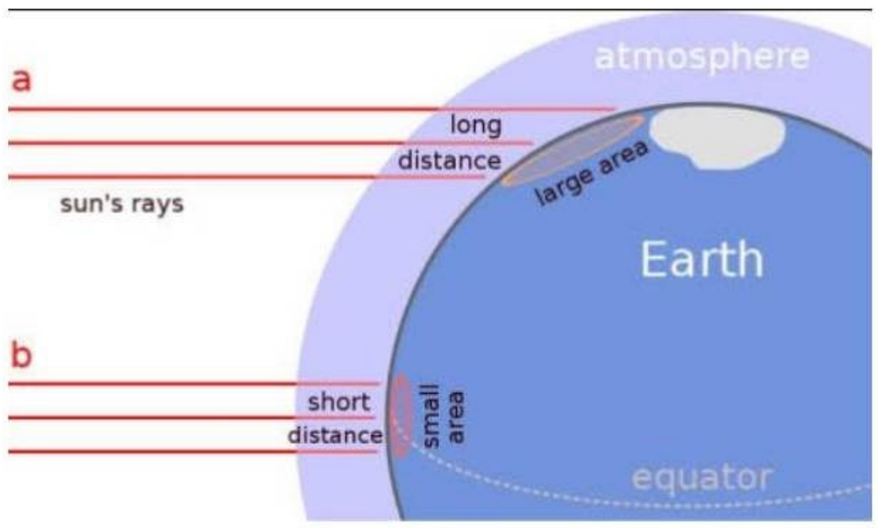
The Importance of Temperature

1. Temperature influences the actual amount of water vapour present in the air and thus decides the moisture-carrying capacity of the air.
2. It decides the rate of evaporation and condensation, and therefore governs the degree of stability of the atmosphere.
3. As relative humidity is directly related to the temperature of the air, it affects the nature and types of cloud formation and precipitation.

Factors Influencing Temperature

1) **Latitude -** Due to the earth's inclination, the mid-day sun is almost over- head within the tropics but the sun's rays reach the earth at an angle outside the tropics. Temperature

thus diminishes from equatorial regions to the poles. It shows two bands of rays coming from the sun to two different latitudes on the earth's surface. Band RI falls vertically over the equatorial latitudes on surface E.



2) **Altitude -** Thus temperature decreases with increasing height above sea level. This rate of decrease with altitude (lapse rate) is never constant, varying from place to place and from season to season.
3) **Continentality -** Land surfaces are heated more quickly than water surfaces, because of the higher specific heat of water. In other words, it requires only one-third as much energy to raise the temperature of a given volume of land by 1°F as it does for an equal volume of water.
4) **Ocean currents and winds** - Both ocean currents and winds affect temperature by transporting their heat or coldness into adjacent regions. Cold currents also lower the summer temperature, particularly when they are carried landwards by on-shore winds.
5) **Slope, shelter and aspect -** A steep slope experiences a more rapid change in temperature than a gentle one. Mountain ranges that have an east- west alignment like the Alps show a higher temperature on the south-facing 'sunny slope than the north- facing of facing 'sheltered slope'. The greater insolation of the southern slope is better suited for vine cultivation and has a more flourishing vegetative cover. Consequently, there are more settlements and it is better utilised than the 'shady slope'.
6) **Natural vegetation and soil** - There is a definite difference in temperature between forested regions and open ground. The thick foliage of the Amazon jungle cuts off much of the in-coming insolation and in many places sunlight never reaches the ground. It is, in fact, cool in the jungle and its shade temperature is a few degrees lower than that of open spaces in corresponding latitudes.

Precipitation

Types of Precipitation

- If air is sufficiently cooled below dew-point, tiny drops of water vapour will **condense** around dust particles.
- When they float about as masses of minute water droplets or ice crystals at a considerable height above sea level, they form **clouds**-cirrus, cumulus or stratus.
- When condensation occurs at ground level without necessarily resulting in rain, **haze, mist or fog** are formed. In higher latitudes or altitudes, where condensation of water vapour may take place in the atmosphere at temperatures below freezing-point, **snow falls.**
- If the moist air ascends rapidly to the cooler layers of the atmosphere, the water droplets freeze into ice pellets and fall to the earth as hail or **hailstones**.
- In a severe hail-storm the hailstones do great damage to crops and buildings Very often, the ice-pellets exist as **frozen rain-drops, melting and re-freezing** on their way down; this forms sleet. It is only when the droplets in clouds coalesce into larger drops between 0.2 mm. and 6 mm that rain falls.

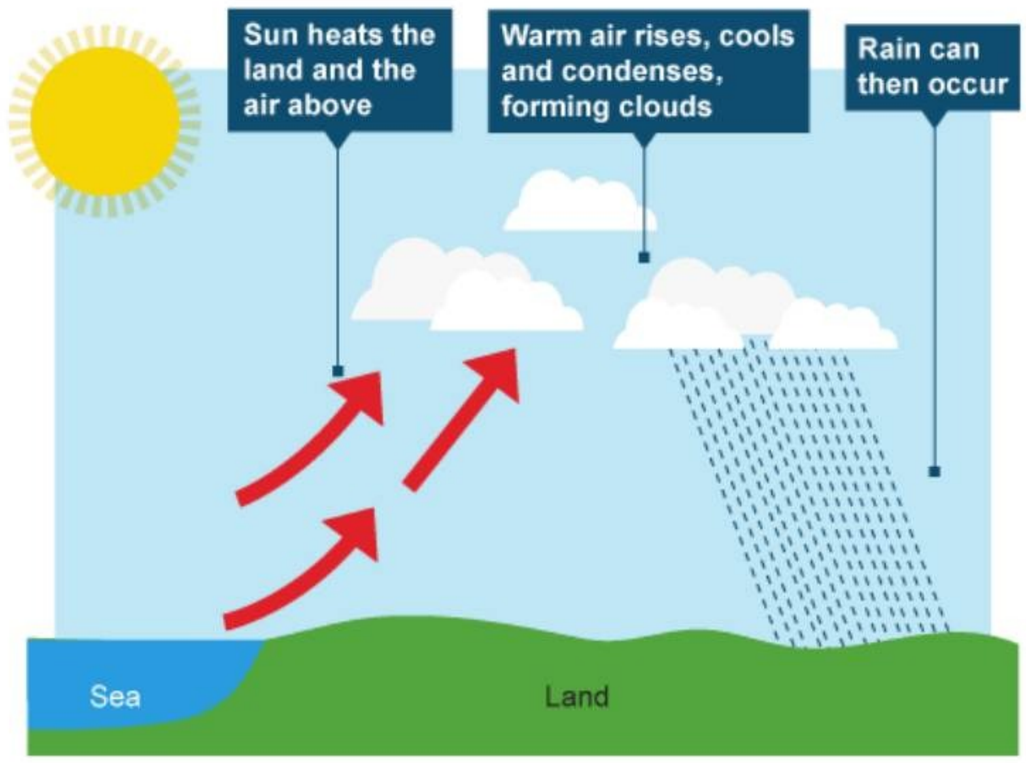
Rainfall

Types of Rainfall: There are three major types of rainfall.

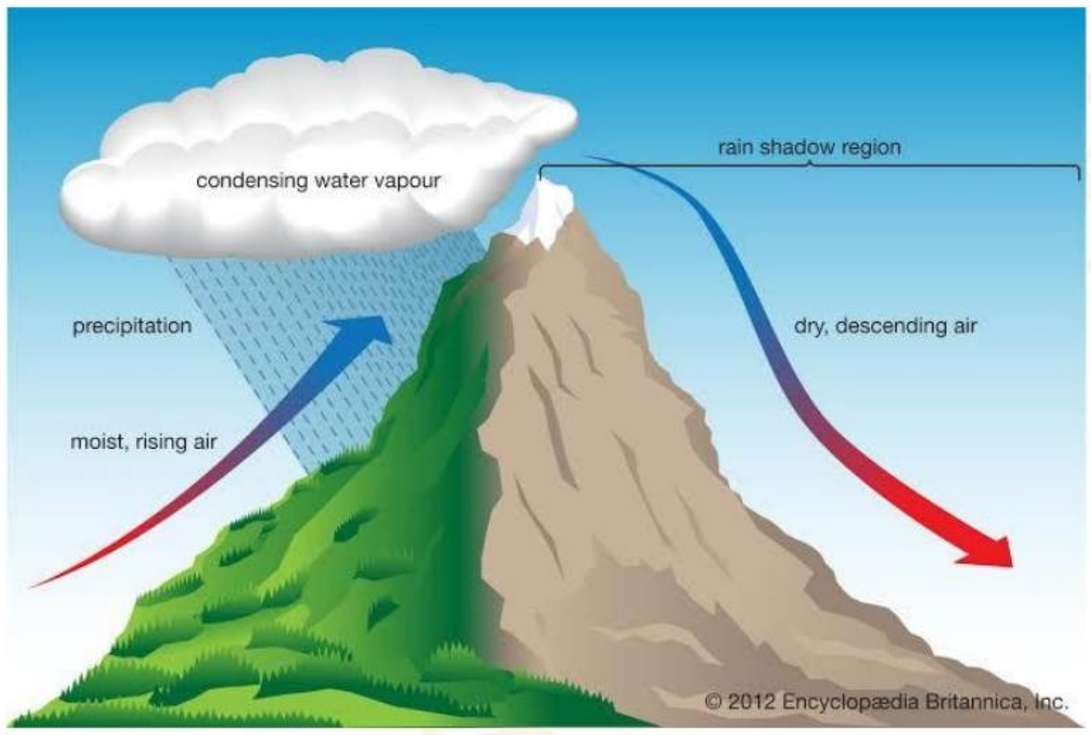
1. **Convectional rainfall**
   - When the earth's surface is heated by conduction, moisture-laden vapour rises because heated air always expands, and becomes lighter. Air rises in a convection current after prolonged period of intense heating. In ascending, its water vapour condenses into

cumulonimbus clouds with a great vertical extent.

- As the air rises it cools and when saturation point is reached torrential downpours occur, often accompanied by thunder and lightning. The summer showers in temperate regions are equally heavy with occasional thunderstorms.



2. **Orographic or relief rain**



- Unlike convectional rain which is caused by convection currents, orographic rain is formed wherever moist air is forced to ascend a mountain barrier. It is best developed on the windward slopes of mountains where the pre vailing moisture-laden winds come from the sea.
- Further ascent cools the air until the air is completely saturated (relative humidity is 100 per cent). Condensation takes place forming clouds and eventually rain. Since it is caused by the relief of the land, it is also known as relief rain.

3. **Cyclonic or frontal rain**
   a. This type of rainfall is independent of relief or convection. It is purely associated with cyclonic activity whether in the temperate regions (depressions) or tropical regions (cyclones). Basically, it is due to the convergence (meeting) of two different air masses with different temperatures and other physical properties.
   b. In ascent, pressure decreases, the air expands and cools, condensation takes place and light showers called cyclonic or frontal rain occur.

Pressure and Planetary

1. **Winds World pressure belts**
   - There is also a circulation of air over the Surface of the earth caused by the differences in pressure.
   - Along the equator and within 5 degrees north and south, is the Equatorial Low-Pressure Belt, where there is intense heating, with expanding air and ascending convection currents. This equatorial belt is often termed the Doldrums, because sailors in the olden days often found themselves becalmed here. It is a zone of wind convergence.
   - About 30°N and S. occur the Sub-Tropical High-Pressure Belts where the air is comparatively dry and the winds are calm and light. It is a region of descending air currents or wind divergence and anticyclones. It is frequently referred to as the Horse Latitudes.
   - Around the latitudes 60°N and S. are two Temperate Low-Pressure Belts which are also zones of convergence with cyclonic activity. The sub-polar low-pressure areas are best developed over the oceans, where

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temperature differences between summer and winter are negligible.

- At the North and South Poles 90°N and S. where temperatures are permanently low, are the Polar High-Pressure Belts. Unlike the water masses of the high latitudes in the southern hemisphere, high pressures of the corresponding latitudes in the northern hemisphere are a little complicated by the presence of much land. Some pressure differences between summer and winter can be expected.

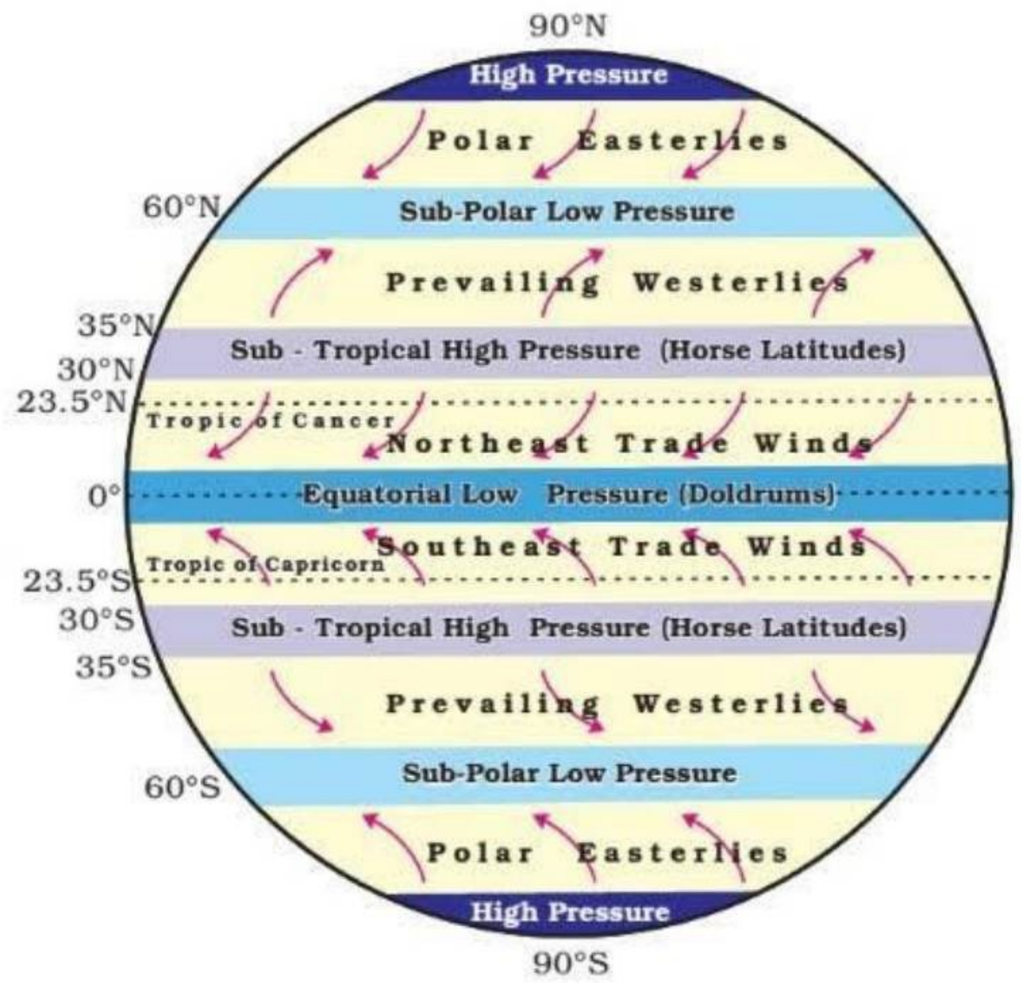
2. **The planetary winds**
    - Winds tend to blow from the high-pressure belts to the low-pressure belts as the planetary Winds. Instead of blowing directly from one pressure belt to another.
    - However the effect of the rotation of the earth **(Coriolis force)** tends to deflect the direction of the winds. In the northern hemisphere, winds are deflected to their right, and in the southern hemisphere to their left. This is know as Ferrel's
    - **Law of Deflection** - The Coriolis force is absent along the equator but increases progressively towards the poles.

Land and Sea Breezes and Monsoons

- Land and sea breezes are, in fact, monsoons on a smaller scale. Both are basically caused by differential heating of land and sea, the former in a diurnal rhythm and the latter in a seasonal rhythm.
- Warm air rises forming a region cool with a higher pressure. Its speed or strength is between m.p.h and it is generally stronger in tropical 5-20 than temperate regions. It is most deeply felt when one stands facing the sea in a coastal resort.
- At night the reverse takes place. A land breeze thus blows out from land to sea.

Fohn Wind or Chinook Wind

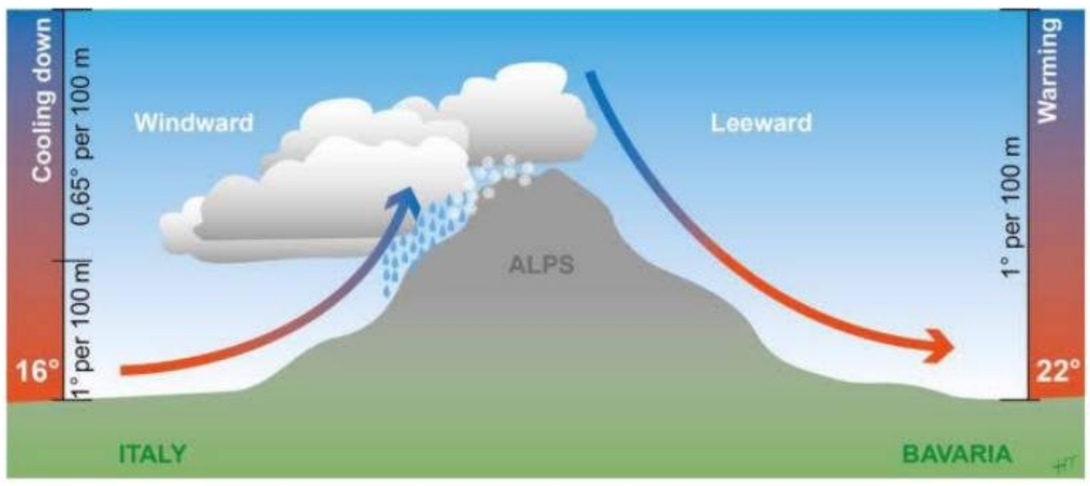
- Both the Fohn and Chinook winds are dry winds experienced on the leeward side of mountains when descending air becomes



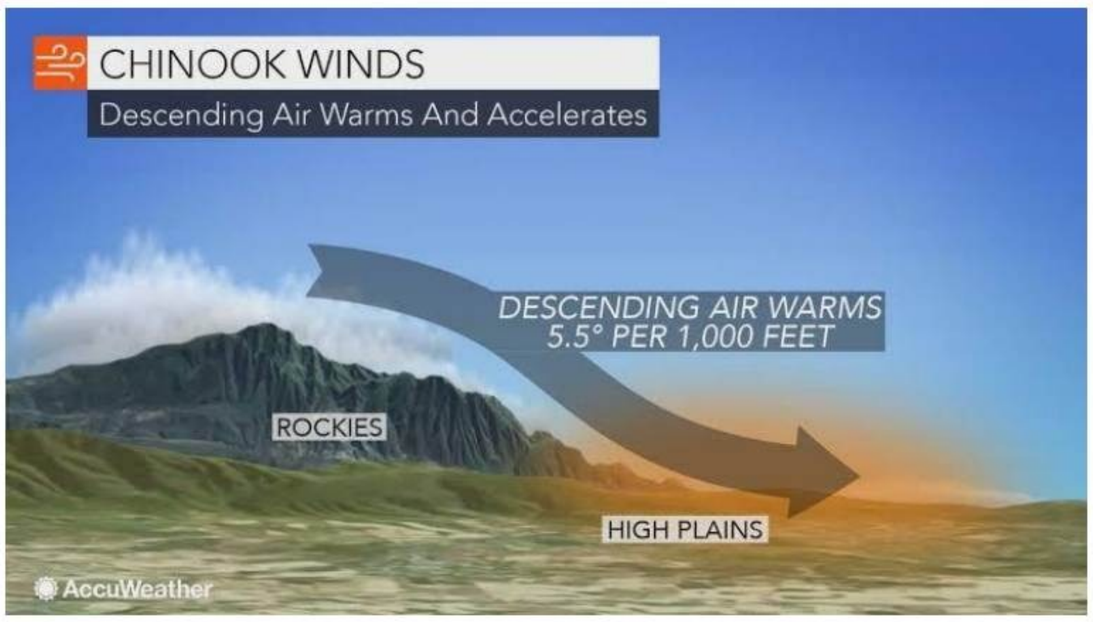
Major Pressure Belts and Wind System

compressed with increased pressure. The Fohn wind is experienced in the valleys of the northern Alps, particularly in Switzerland in spring. Chinook winds are experienced on the eastern slopes of the Rockies in U.S.A. and Canada in winter.

- It may raise the temperature by 15° to 30°F, within an hour! It melts snow and causes avalanches. In North America it is called Chinook, meaning the snow-eater. But it has its blessings too, it hastens the growth of crops and fruits and thaws the snow-covered pastures. In the Rockies, the Chinook has been known to raise



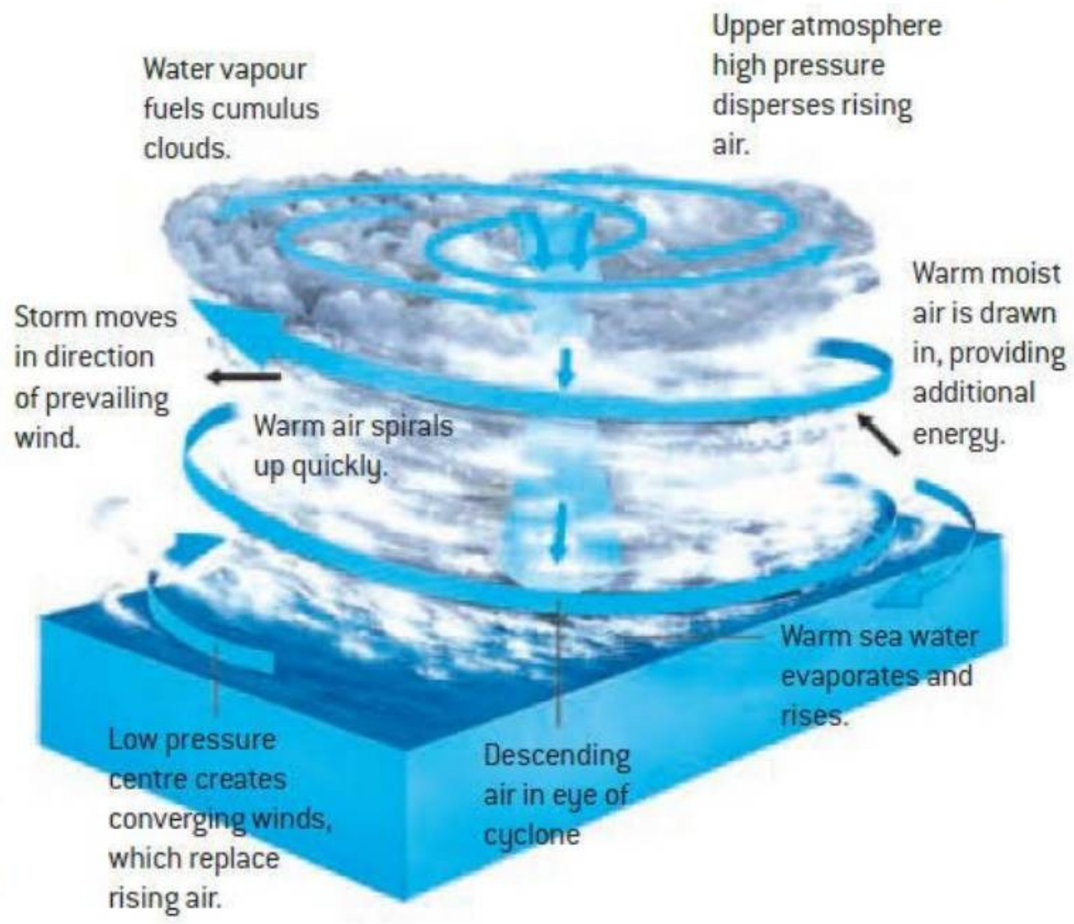
temperature by 35°E within 15 minutes. The occurrence of frequent Chinooks means winter is mild.



Cyclonic Activity

Tropical cyclones, typhoons, hurricanes and tornadoes

- All these are different kinds of tropical cyclones. They are well-developed **low-pressure systems** into which violent winds blow. Typhoons occur in the China Sea; tropical cyclones in the Indian Ocean; hurricanes in the West Indian islands in the Carib- bean; tornadoes in the Guinea lands of West Africa, and the southern U.S.A. in which the local name of Whirl-wind is often applied, and willy-willies occur in north-western Australia.
- **Typhoons** occur mainly in regions between 6 and 20 north and south of the equator and are most frequent from July to October. In extent, they are smaller than temperate cyclones and have a diameter of only so to 200 miles.
- The other tropical cyclones have similar characteristics and differ, perhaps, only in intensity, duration and locality. Hurricanes have calm, rainless centres where the pressure is lowest (about 965 mb.) but around this 'eye', the wind strength exceeds force 12 of the Beaufort scale (75 m.p.h.).
- **Tornadoes** are small but very violent tropical and sub-tropical cyclones in which the air is spiralling at a tremendous speed of as much as 500 m.p.h .A tornado appears as a dark funnel cloud 250 to 1.400 feet in diameter.
- **Cyclones -** The lowest pressure is in the centre and the isobars, as shown in climatic charts, are close together. Depressions vary from 150 to 2,000 miles in extent, circulating in anticlockwise direction in the northern hemisphere and clockwise in the southern hemisphere.
- **Anticyclones** normally herald fine weather. Skies are clear, the air is calm and temperatures are high in summer but cold in winter. Winds in anti- cyclones blow outwards and are also subject to deflection, but they blow clockwise in the northern hemisphere and anticlockwise in the southern hemisphere.



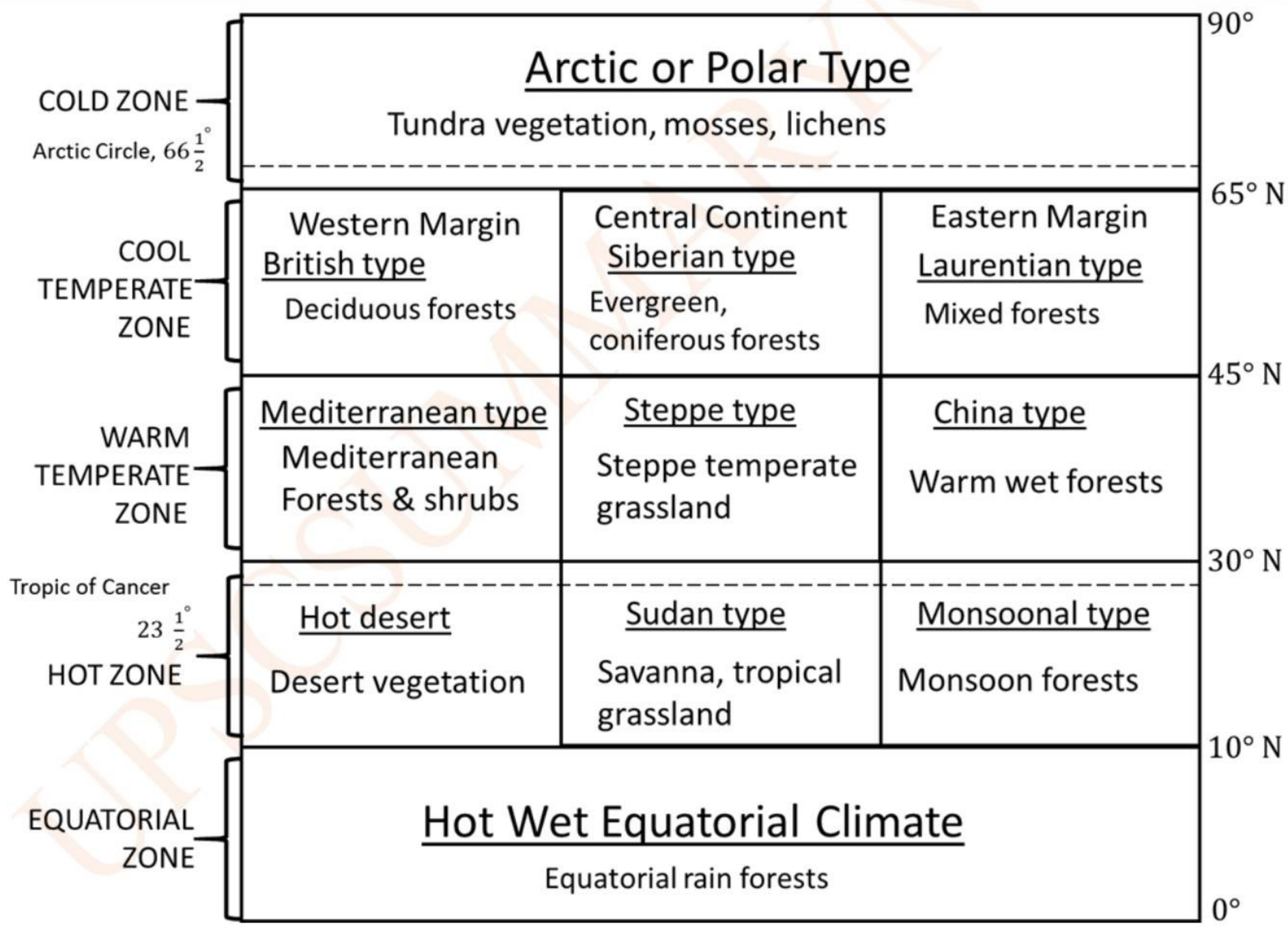
The formation of a tropical cyclone

Climatic Types and Natural Vegetation

- It is necessary to divide the world into several climatic zones, each with its own climatic characteristics, natural vegetation (forests, grasslands or deserts), crops, animals and human activities.
- Though the geographical characteristics may not be absolutely uniform in each climatic type, they have many things in common.

World Climatic Types

Climatic Zone	*Latitude (Approximate)*	*Climatic Type*	*Rainfall Regime (with approx. total)*	*Natural Vegetation*
Equatorial Zone	0°-10°N and S	1. Hot, wet equatorial	Rainfall all year round : 80 inches	Equatorial rain forests
Hot Zone	10°-30°N and S	2. a) Tropical Monsoon	Heavy summer rain: 80 binches	Monsoon forests
		b) Tropical Marine	Much summer rain: 70 inches	
		3. Sudan Type	Rain mainly in summer: 30 inches	Savanna (tropical grassland)
		4. Desert: a) Saharan type	Little	Desert vegetation and scrub
		b) Mid-latitude type	rain: 5 inches	
Warm Temperate Zone	30-°40°N & S	Western Margin (Mediterranean type)	Winter rain: 35 inches	Mediterranean forests and shrub
		6. Central Continental (Steppe type)	Light summer rain: 20 inches	Steppe or temperate grassland
		7. Eastern Margin: a) China type b) Gulf type c) Natal type	Heavier summer rain : 20 inches	Wawrm, wet forests and bamboo
Cool Temperate Zone	45°-65°N & S	8. Western Margin (British type)	More rain in autumn & winter : 30 inches	Decidous forests
		9. Central Continental (Siberian type)	Light summer rain: 25 inches	Evergreen coniferous forests
		10. Eastern Margin (Laurentian type)	Moderate summer rain : 40 inches	Mixed forests (coniferous and deciduous)
Cold Zone	65°-90° N & S	11. Arctic or Polar	Very light summer rain : 10 inches	Tundra, mosses, lichens
Alpine Zone		12. Mountain climate	Heavy rainfall (variable)	Alpine pastures, confiers, fern, snow



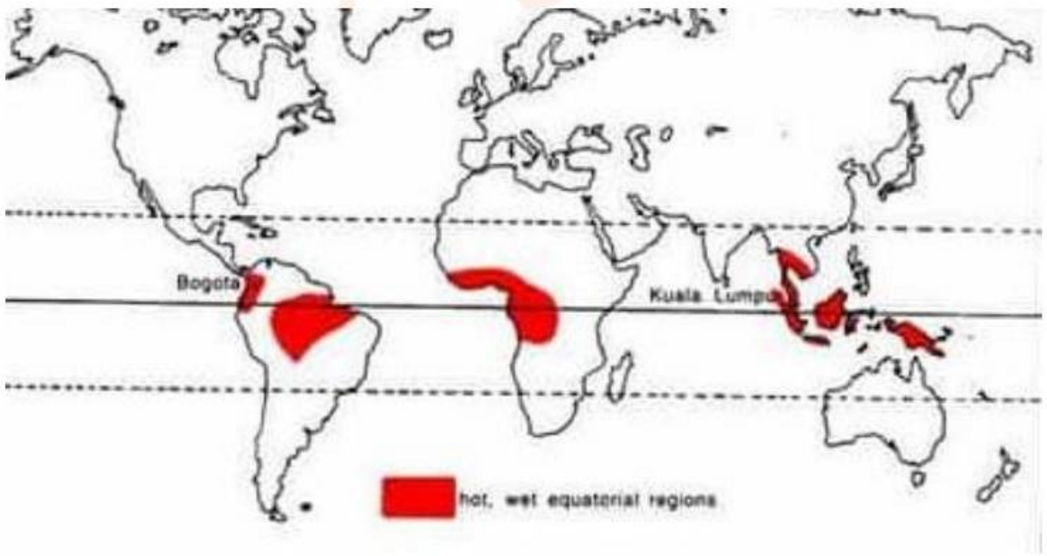
CHAPTER: 15 – THE HOT, WET EQUATORIAL CLIMATE

Distribution

- The equatorial hot, wet climate is found between 5 and 10° north and south of the equator. Its greatest extent is found in the lowlands of the Amazon, the Congo, Malaysia and the East Indies.
- Further away from the equator, the influence of the on-shore Trade Winds. Gives rise to a modified type of equatorial climate with monsoonal influences. Within the tropics, the equatorial highlands have a distinctively cooler climate, modified by altitude, such as the Cameron Highlands in Malaysia, the Northern Andes, and the Kenyan Highlands in East Africa.

Climate

- **Temperature**
  - The most outstanding feature of the equatorial climate is its great uniformity of temperature throughout monthly temperatures are always around 80°F with very little variation. There is no winter.
  - **Cloudiness** and heavy precipitation help to moderate the daily temperature, so that even at the equator itself, the climate is not unbearable. In addition, regular land and sea breezes assist in maintaining a truly equable climate.



- **Precipitation**
  - Precipitation is heavy, between 60 inches and 100 inches, and well distributed through- Out the year. There is no month without rain, and 4 distinct dry season like those of the Savanna or the Tropical Monsoon Climates, is absent. Instead, there are two periods of maximum rainfall, in April d October.
  - Which occur shortly after the equinoxes. Least rain falls at the June and December solstices. The double rainfall peaks coinciding with the equinoxes are a characteristic feature of equatorial climates not found in any other type of climate. But this Simple pattern may be upset by local conditions.
  - Particularly in coastal districts open to the influences of the trades, the tendency is towards a monsoon pattern with the heaviest rainfall coming in the summer months, i.e. June, July and August in the northern hemisphere and December, January and February in the southern hemisphere.
  - Due to the great heat in the equatorial belt, mornings are bright and sunny, followed by heavy downpours of convectional rain in the afternoons from the towering cumulonimbus clouds (see Chapter 13). Thunder and lightning often accompany the torrential showers.
  - Besides the convectional rainfall, mountainous regions also experience much orographic or relief rain. In addition, there are some intermittent showers from cyclonic atmospheric disturbances caused by the convergence of air currents in the **Doldrums.**
  - The relative humidity is constantly high (over 80 per cent) making one feel 'sticky' and uncomfortable.

Equatorial Vegetation

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- High temperature and abundant rainfall in the equatorial regions support a luxuriant type of vegetation-the tropical rain forest. In the Amazon lowlands, the forest is so dense and so complete in its vegetational extravagance that a special term 'selves is used.
- The characteristic features of the equatorial vegetation may be summarized as follows.
    1. A great variety of vegetation
    2. A distinct layer arrangement
    3. Multiple species
    4. Forest Clearings

Life and Development in the Equatorial Regions

- In the forests most primitive people regions generally sparsely are live as hunters and collectors and the more advanced one's practise shifting cultivation. Food is so abundant in such a habitat that many people worry very little about the life of the next day.
- In the Amazon basin the Indian tribes collect wild rubber, in the Congo Basin the Pygmies gather nuts and in the jungles of Malaysia the **Orang Asli** make all sorts of cane products.
- The most outstanding is natural rubber, called **hevea brasiliensis**. Malaysia and Indonesia are the leading producers, each accounting for more than a third of the world production. The home country, Brazil exports practically no natural very rubber.
- Tropical crop that has achieved an amazing success is cocoa. It is most extensively cultivated in West Africa, bordering the Gulf of Guinea. The two most important producers are ghana and Nigeria. There is a keen demand for the Op and acreages are rapidly on the increase.

Factors Affecting the Development of Equatorial Regions

1. **Equatorial climate and health** - Under conditions of excessive heat and high humidity, Man is subject to serious physical and mental handicaps. He exposes himself to such dangers as sun-stroke and to such diseases as malaria and yellow-fever.
2. **Prevalence of bacteria and insect pests** - As germs and bacteria are more easily transmitted through moist air, equatorial conditions are ideal for the survival of such organisms. Insects and pests not only spread diseases but are injurious to crops. They plague both men and animals.
3. **Jungle hinders development and maintenance** - The jungle is so luxuriant that it is quite a problem to clear a small patch of it and even more difficult to maintain it. Lalang
4. **Rapid deterioration of tropical soil -** It is a misconception that tropical soils are rich. In its virgin, untouched state, due to heavy leaf-fall and the decomposition of leaves by bacteria, a thick mantle of humus makes the soil fairly fertile. This is clear from the shifting cultivator's heavy cropping's in their newly cleared ladangs. The soil deteriorates rapidly with subsequent soil erosion and soil impoverishment.

Difficulties in lumbering and livestock farming

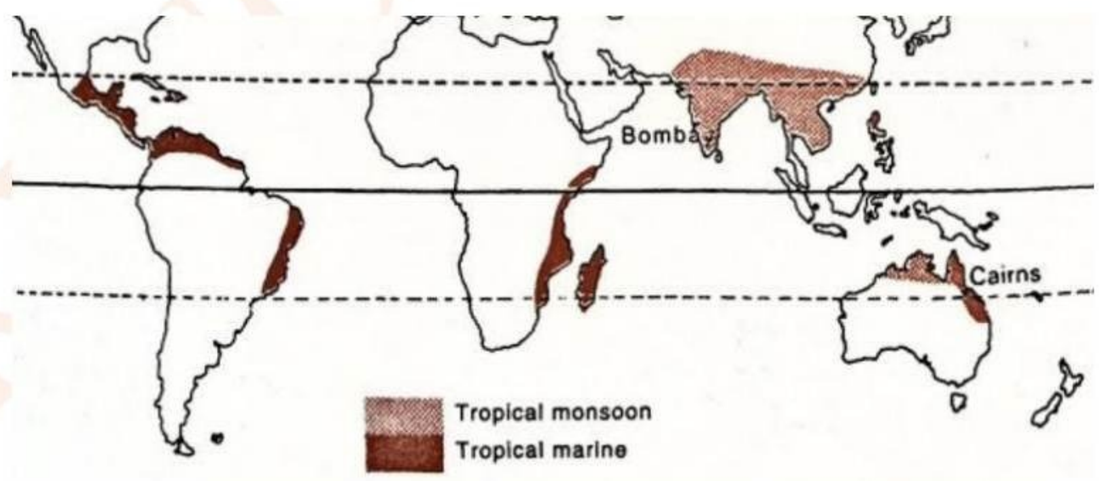
- The trees do not occur in homogenous stands, there are no frozen surfaces to facilitate logging and the tropical hardwoods are sometimes too heavy to float in the rivers, even if these flow in the desired directions.
- **Livestock farming** is greatly handicapped by an absence of meadow grass, even on the highlands the few animals like bullocks or buffaloes are kept mainly as beasts of burden. The grass is so tall and coarse that it is not nutritious. In Africa, domesticated animals are attacked by tsetse flies that cause ngana, a deadly disease.

Distribution

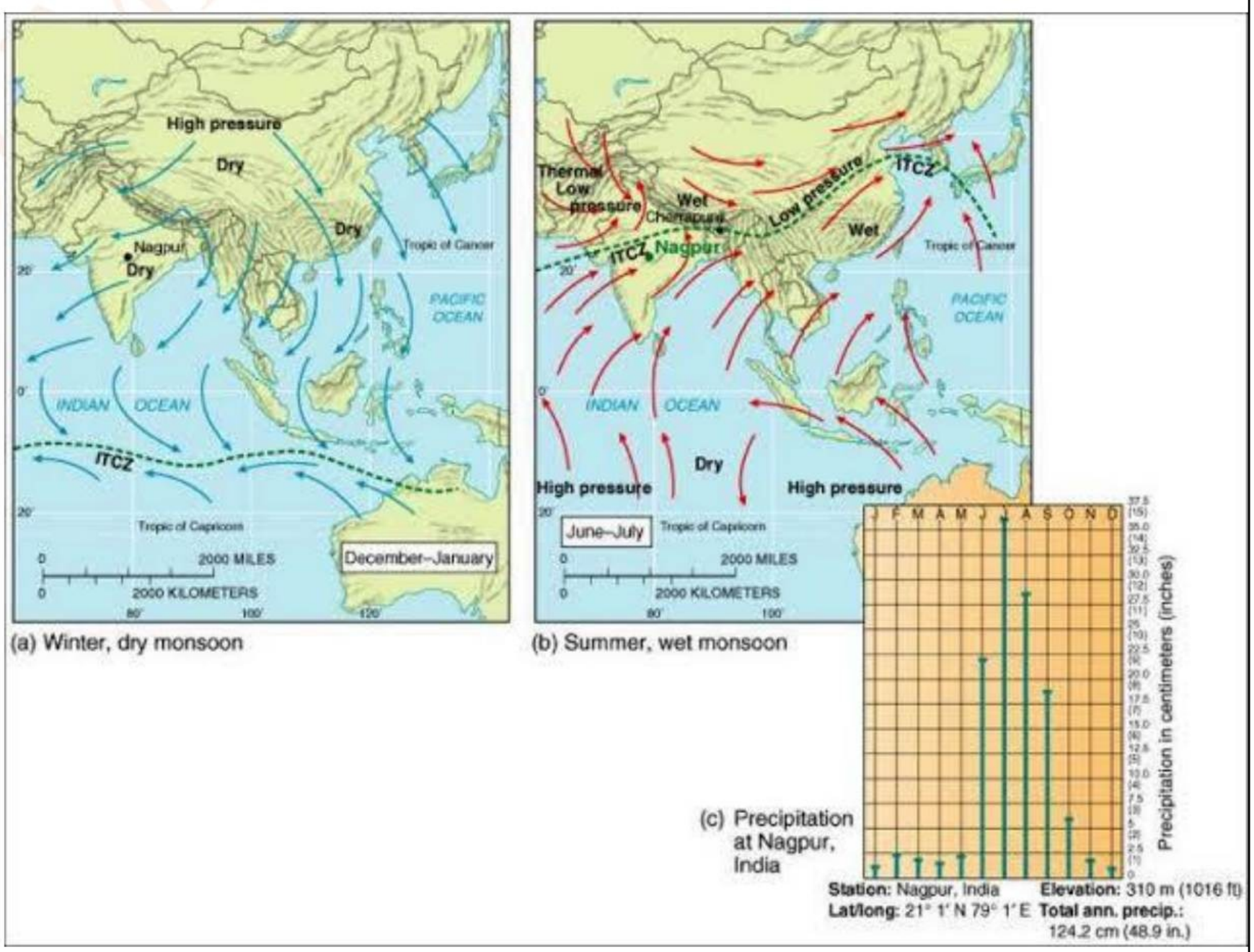
- On-shore wet monsoons in the summer and off-shore dry monsoons in the winter. They are best developed in the Indian sub-continent, Burma, Thailand, Laos, Cambodia, parts of Vietnam and south China and northern Australia. Outside this zone, the climate is modified by the influence of the on-shore Trade Winds all the year round, and has a more evenly distributed rainfall.
- Such a climate, better termed the Tropical Marine Climate, is experienced in Central America. West Indies, north-eastern Australia, the Philippines, parts of East Africa, Madagascar, the Guinea Coast and eastern Brazil.

Climatic Conditions in Tropical Monsoon Lands

- The basic cause of monsoon climates is the difference in the rate of heating and cooling of land and sea. In the summer, when the sun is overhead at the Tropic of Cancer, the great land masses of the northern hemisphere are heated.
- Central Asia, backed by the lofty Himalayan ranges, is more than 15°F hotter than its normal temperature and a region of intense low pressure is set up. The warm up much slower, remain comparatively cool. At the same time, the southern hemisphere experiences winter, and a region of high pressure is set up in the continental interior of Australia.
- Winds blow outwards as the South-East Monsoon, to Java, and after crossing the equator are drawn towards the continental low-pressure area reaching the Indian sub-continent seas, as the South-West Monsoon.
- In the winter, conditions are reversed. The sun s overhead at the Tropic of Capricorn, central Asia is extremely cold, resulting in rapid cooling of the land. A region of high pressure is created with outblowing winds- the North-East Monsoon.
- On crossing the equator, the winds are attracted the low pressure centre in Australia and arrive in northern Australia as the North-West Monsoon. In other parts of the world which experience a tropical monsoon climate a similar seasonal reversal of wind directions occurs.



The Season of Tropical Monsoon Climate



- **The Cool, dry season (October to February):-**
    - Temperatures are low 76°F in Bombay and only 50°F. in Punjab, with heavy sinking air. Frosts may occur at night in the colder north. The centre of high pressure is over the Punjab. Outblowing dry winds, the North-East Monsoon, bring little no rain to the Indian sub-continent.
    - However, a small amount of rain falls in Punjab from cyclonic sources and this is vital for the survival of winter cereals. Where the North-East Monsoon blows over the Bay of Bengal it acquires moisture and thus brings rain to the south-eastern tip of the peninsula at this time of the year.
- **The hot dry season (March to mid-June)**
    - The temperature rises sharply with the sun's northward shift to the Tropic of Cancer. Bombay has a mean May temperature of 86°F. Which is considered moderate, for many parts of India are even hotter. The heat is so great that schools and colleges are closed.
    - The stifling heat and the low relative humidity make outdoor life almost unbearable. Day temperatures of 95°F are Usual in central India and the mean temperature in Sind may be as high as 110°F. Coastal districts are a little relieved by sea breezes. There is practically no rain anywhere. By May, the temperature is so high that an intense low pressure zone is set up in north-west India.
- **The rainy season (mid-June to September)**
    - With the 'burst' of the South-West Monsoon in mid-June, in torrential downpours Sweep across the country to the delight of everybody. Almost all the rain for the year falls within this rainy season. For example, in Bombay 19.9 inches are recorded in June, 24 inches in July, 14.5 inches in August and a further 10.6 inches in September. As much as **95 per cent of the annual rainfall** is concentrated within four months.
    - This pattern of concentrated heavy rainfall in summer is a characteristic feature of the Tropical Monsoon Climate. The torrential down- pours have an immediate impact on the local temperature. They lower the temperature considerably. The mean temperature for Bombay is 86°E in May but only 81°E in July. In the north the drop is even greater, as much as 13°F.

The Retreating Monsoon

- The amount and frequency of rain decreases towards the end of the rainy season. It retreats gradually southwards after mid-September until it leaves the continent altogether.
- The Punjab plains which receive the south-west monsoon earliest are the first to see the withdrawal of the monsoon. The skies are clear again and the cool, dry season returns in October, with the outblowing North-East Monsoon.

The Tropical Marine Climate

- This type of climate is experienced along the eastern coasts of tropical lands, receiving steady rainfall from the Trade Winds all the time. The rainfall is both orographic where the moist trades meet upland masses as in eastern Brazil, and convectional due to intense heating during the day and in summer. Its tendency is towards a summer maximum as in monsoon lands, but without any distinct dry period.
- Its wettest months are in January (15-8 inches), February (l6 4). March (17-7) and April (12-1), which is summer in the southern hemisphere. Approximately 70 per cent of the annual rainfall is concentrated in the four summer months. There is no month without any rainfall.

- The range of temperature is typical of the tropical latitudes with a maximum of 82°F in January and a minimum of 70°F in July- a range of 12°F for the year.
- Due to the steady influence of the trades, the Tropical Marine Climate is more favourable for habitation, but it is prone to severe tropical cyclones, hurricanes or typhoons, as mentioned in Chapter 13.

Tropical Monsoon Forests

- Trees are normally deciduous, because of the marked dry period, during which they shed their leaves to withstand the drought.
- The forests are more open and less luxuriant than the equatorial jungle and there are far fewer species. Most of the forests yield valuable timber, and are prized for their durable hardwood. Amongst these teaks is the best known.
- Burma alone accounts for as much as three quarters of the world's production. It is such a durable timber that it is extensively used for ship building, furniture and other constructional purposes. Other kinds of timber include sal, acacia and some varieties of eucalyptus in northern Australia. To gather with the forests are bamboo thickets, which often grow to great heights.
- With a decrease in rainfall in summer, the forests thin out into thorny scrubland or savanna with scattered trees and tall grass. In parts of the Indian sub-continent, rainfall is so deficient that semi-desert conditions are found. Monsoonal vegetation is thus most varied, ranging from forests to thickets, and from savanna to scrubland.

Agricultural Development in the Monsoon Lands

- Much of the monsoon forest has been cleared for agriculture to support the very dense population. Wherever possible, crops are grown. The plains are ploughed, and the hills are terraced to provide farmland. Farms are small and the people are forever land hungry.' **In their quest for land**, they, have removed the natural vegetation, sometimes wantonly, resulting in acute soil erosion.
- Tropical agriculture dependent on natural rainfall and a large labour force, reaches its greatest magnitude in the monsoon lands. The soil provides the basis for the livelihood of millions. Farming is not only the dominant occupation of the greater part of the people, but also forms the mainstay to the economy of the **Indian sub-continent, China, South- East Asia, eastern Brazil and the West Indies**. The following types of agriculture are recognisable.

1. **Wet Padi cultivation**
    - Rice is the most important Staple crop and is grown in tropical lowlands wherever the rain exceeds 70 inches. It is perhaps the most characteristic crop of the monsoon lands.
    - There are two main varieties, the wet padi, which is mainly grown on lowlands in flooded fields or in terraced uplands, and the dry padi grown in regions of lower rainfall. A minimum of 50 inches of rainfall is required during the growing season.
    - Droughts and floods that are almost inseparable from a monsoonal type of climate can be very detrimental to its cultivation. Irrigation water from rivers, canals, dams or wells is extensively used in the major rice producing countries. They are cultivated in the drier or cooler areas where rice cannot be grown.
2. **Lowland cash crops**
    - The most important crop in this category is cane sugar. As much as two-thirds of world's sugar production comes from tropical

countries. Sugar is either grown on plantations or on small holdings wherever rainfall and sunshine are abundant. Some of the major producers include India, Java, Formosa, Cuba, Jamaica, Trinidad and Barbados. Jute is confined almost entirely to the Ganges Brahmaputra delta, in India and Bangladesh.

- It has long been a leading hard fibre for the manufacture of sacks (gunny). Manila hemp (abaca) is a product of the Philippines, particularly of Mindanao. It is used to make high quality rope indigo, still cultivated in India and Java; cotton, a major export of the Indian sub-continent and bananas, coconuts and spices.

3. **Highland plantation crops**
    - The colonization of tropical lands by Europeans gave rise to a new form of cultivated landscape in the cooler monsoonal highlands. This is the cultivation of certain tree crops in tropical plantations. Thousands of acres of tropical upland forests were cleared to make way for plantation agriculture in which tea and coffee are the most important crops.
    - Coffee originated in Ethiopia and Arabia, where it is still grown, but Brazil now accounts for almost half the world's production of coffee.
    - Tea originated in China and is still an important crop there, but as it requires moderate temperatures (about 60°F.), heavy rainfall (over 60 inches) and well drained highland slopes.
    - The best regions are thus the Himalayan foothills of India and Bangladesh, the central highlands of Sri Lanka and western Java, from all of which it is exported. In China tea is grown mostly for local consumption.
4. **Lumbering**
    - Wherever there are tropical forests which still have not been felled to make way for the plough, lumbering is undertaken in the more accessible areas. This is particularly important in continental South- East Asia. Of the tropical deciduous trees, teak, of which Burma is the leading producer, is perhaps the most sought after.
    - It is valuable on account of its great durability, strength, immunity to shrinkage, fungus attack and insects. It is grown in hilly districts up to 3,000 feet in altitude with a moderate rainfall.
    - Under government supervision, teak trees which are cut have to be replaced. This is the only way to ensure the steady supply of the timber which is the second greatest money-earner for Burma after rice.
5. **Shifting Cultivation**
    - This most primitive form of farming is widely practised. Instead of rotating the crops in the same field to preserve fertility, the tribesmen move to a new clearing when their first field is exhausted.

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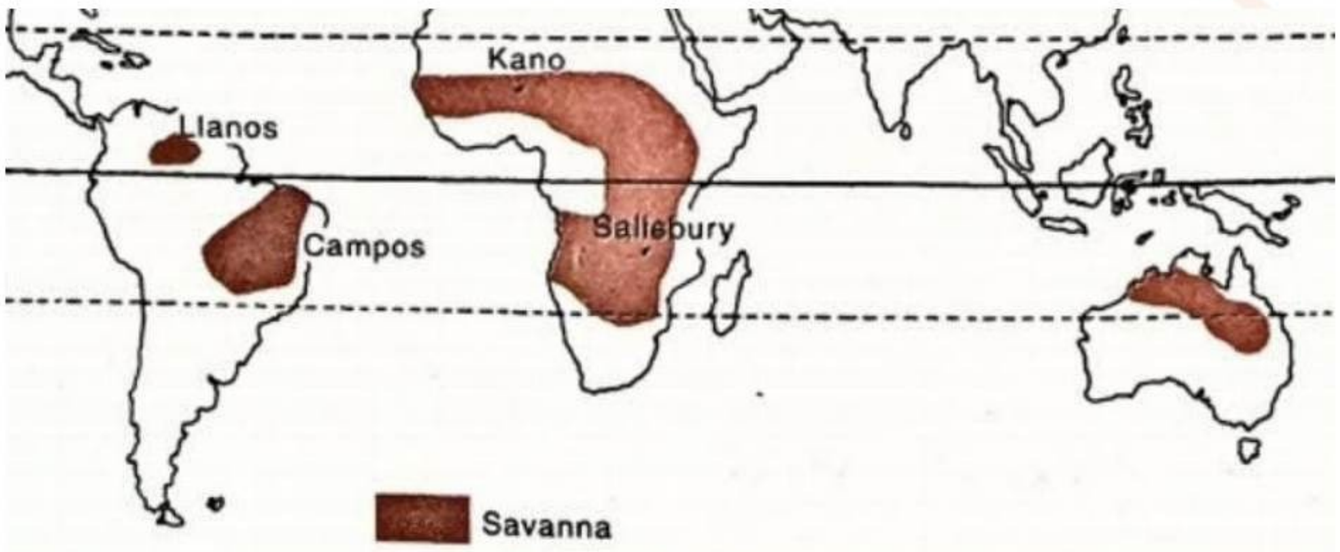
CHAPTER: 17 – THE SAVANNA OR SUDAN CLIMATE

Distribution

- The Savanna or Sudan Climate is a transitional type of climate found between the equatorial forests and the trade wind hot deserts. It is confined within the tropics and is best developed in the Sudan where the dry and wet seasons are most distinct, hence its name the **Sudan Climate.** The belt includes West African Sudan and then curves southwards into East Africa and southern Africa north of the Tropic of Capricorn.
- In South America, there are two distinct regions of savanna north and south of the equator, namely the llanos of the Orinoco basin and the campos of the Brazilian Highlands. The Australian savanna is located south of the monsoon strip running from west to east north of the Tropic of Capricorn.

Climate of the Sudan Type



- **Rainfall –**
  - The Sudan type of climate is characterized by an alternate hot, rainy season and cool, dry season. In the northern hemisphere, the hot, rainy season normally begins in May and lasts until September, as in Kano, Nigeria.
  - The rest of the year is cool and dry. The annual rainfall for Kano, which is located at a height of 1,539 feet above sea level, is 34 inches and is almost entirely concentrated in the summer.
  - Both the length of the rainy season and the annual total rainfall decrease appreciably from the equatorial region poleward towards the desert fringes. In the southern hemisphere, the rainy season is from October to March (the southern summer)
- **Temperature**
  - An annual temperature range of 20°F is typical, but the range increases as one moves further away from the equator. It is, however, interesting to note that the highest temperatures do not coincide with the period of the highest sun (e.g. June in the northern hemisphere) but occur just before the onset of the rainy season, i.e. April in Kano and October in Salisbury. There is also a distinct drop in temperature in the rainy period, due to the overcast sky and the cooler atmosphere.
  - Days are hot, and during the hot season, noon temperatures of over 100°E are quite frequent. When night falls the clear sky which promotes intense heating during the day also causes rapid radiation in the night. Temperatures drop to well below 50°E and night frost this time of the year. This extreme diurnal range of temperature is another characteristic feature of the Sudan type of climate.
- **Winds**
  - The prevailing winds of the region are the Trade Winds, which bring rain to the coastal districts. They are strongest in the summer but are relatively dry by the time they reach the continental interiors or the western coasts of the continents, so that grass and scattered short trees predominate.
  - In West Africa, the North-East Trades, in fact, blow off-shore from the Sahara Desert and reach the Guinea coast as a dry, dust-laden

wind, called locally the **Harmattan,** meaning 'the doctor. It is so dry that its relative humidity seldom exceeds 30 per cent.

- The doctor provides a welcome relief from the damp air of the Guinea lands by increasing the rate of evaporation with resultant cooling effects, but it is such a dry dusty wind that, besides ruining the crops, it also stirs up a thick dusty haze and impedes inland river navigation.

Natural Vegetation

- The savanna landscape is typified by tall grass and short trees. It is rather misleading to call the savanna tropical grassland, because trees are always present with the luxuriant tall grass.
- Trees grow best towards the equatorial humid latitudes or along river banks but decrease in height and density away from the equator. The trees are deciduous, shedding their leaves in the cool, dry season to prevent excessive loss of water through transpiration, e.g. **acacias**. Others have broad trunks with water-storing devices to survive through the prolonged drought such as baobabs and bottle trees.
- Palms which cannot withstand the drought are confined to the wettest areas or along rivers Vegetative luxuriance reaches its peak in the rainy season, when trees renew their **foilage and flower.**
- In true savanna lands, the grass is tall and coarse, growing 6 to 12 feet high. The elephant grass may attain a height of even 15 feet.
- The grass tends to grow in compact tufts and has long roots which reach down in search of water. The grass lies dormant throughout the long, rainless period and springs up again in the next rainy season. As the rainfall diminishes towards the deserts the savanna merges into thorny scrub.

Animal Life of the Savanna

- The savanna, particularly in Africa, is the home of wild animals. It is known as the 'big game country and thousands of animals are trapped or killed each year by people from all over the world. Some of the animals are tracked down for their skins, horns, tusks, bones or hair, others are captured alive and sent out of Africa as zoo animals, laboratory specimens or pets.
- The leaf and grass-eating animals include the zebra, antelope, giraffe, deer, gazelle, elephant and okapi. Many are well camouflaged species and their presence amongst the tall greenish-brown grass cannot be easily detected.
- The giraffe with such a long neck can locate its enemies a great distance away, while the elephant is so huge and strong that few animals will venture to come near it. It is well equipped neck with tusks and trunk for defence.
- Along rivers and in marshy lakes are numerous species of reptiles and mammals including crocodiles, alligators, monitors and giant lizards together with the larger rhinoceros and hippopotamus.

Human Life in the Savanna

- Within the savanna lands of the tropics live many different tribes who are either cattle pastoralists like the Masai of the East African plateau or settled cultivators like the Hausa of northern Nigeria.
- They are now mainly confined to the 15,000 square miles of Masai reserves in Kenya and Tanzania. Their old grazing grounds in the Kenyan Highlands were taken over first by the immigrant white settlers for plantation agriculture (coffee, tea, cotton) and dairy farming and later, after independence, by African farmers. They now occupy the less favoured areas of savanna.
- On the lower slopes of the East African plateau, where rainfall is as low as 20 inches and there are long periods of drought, the grass seldom reaches a foot high and is not nutritious. When there is a drought the Masai move upwards to the

higher and cooler plateau regions in which their herds can graze on the better pastures. They build circular huts with sticks, bushes and mud for temporary shelter.

- The cattle kept by the Masai are the zebu cattle with humps and long horns. The beef is only consumed when they die a natural death from old age or disease. They are never used as draught animals and are kept entirely for the supply of milk and blood.
- The milk is drunk either fresh or sour. Cheese-making is still not known to the Masai. Blood from both bulls and cows is drunk. This is obtained by tying a leather cord around the neck of an animal until the veins swell.
- Cattle are kept by every Masai family. They are considered far more valuable than anything else, and are symbols of wealth. Cattle are used in payment tor wives, and when the father of a family dies, the mother divides the livestock among the son's tribes such as the **Kikuyu of Kenya**, they obtain a small amount of millet, bananas, groundnuts and vegetables.
- The Hausa, settled cultivators. The Hausa are a tribe of settled cultivators who inhabit the savanna lands of the Bauchi Plateau of northern Nigeria. They number almost six million and have been organized in settled agricultural communities for hundreds of years.
- The Hausa live in towns or villages. The ancient Hausa city of Kano, with a population of 135,000 has long been a focus of routes and trade. They do not practise shifting cultivation as many tribes do. Some Hausa also cultivate non-food crops e.g. cotton and tobacco.
- In this manner, the Hausa rotate their crops between different fields at different parts of the year, which is a technique employed in advanced agricultural societies.
- Besides cultivation, the Hausa also make use of domesticated animals. Herds of cattle and goats are kept for both milk and meat, but they are only subsidiary to crop cultivation. Though they do not contribute much to the income of the Hausa, because of their small numbers, their manure is used to fertilize the fields. Sometimes fires may be caused by the dry, dusty Harmattan.

Problems, Prospects and Development of the Savanna

- The deserts or the freezing tundra form climatic barriers too 1ormidable for large scale human intervention to take place. But the savanna lands with an annual rainfall of over 30 inches and without any severe cold, should be able to support a wide range of tropical crops.
- Pioneer settlements in central Africa, northern Australia and eastern Brazil have shown that the savannas have immense agricultural potential for plantation agriculture of cotton, cane sugar, coffee, oil palm, ground- nuts and even tropical fruits.
- Tropical Queensland, despite its scarcity of labour force has been very successful in its attempts to develop its huge empty land. The newly independent states of Kenya, Uganda, Tanzania and Malawi have already taken to large-scale production of cotton and sisal hemp. Both crops thrive well in savanna conditions.
- But farming in the savanna land is not without natural hazards. Droughts may be long and trying as rainfall is often unreliable. During the rainy season, torrential downpours of heavy rain cause leaching, in which most of the plant nutrients such as nitrates, phosphates and potash are dissolved and washed away.
- Many savanna areas therefore have poor laterite soils which are incapable of sup-porting good crops. Unless the soil is properly conserved through regular manuring, weeding and careful maintenance, crop yields are bound to decline.
- The savanna is said to be the natural cattle country and many of the native people are, in fact, herdsmen or pastoralists. They often fall victim to tropical diseases, e.g. the ngana or sleeping sickness carried by the tsetse fly in Africa. The export of either

beef or milk from the tropical grasslands is so far not important.

- It seems necessary to introduce temperate cattle such as the English Shorthorn, Friesian or Guernsey to cross with the tropical zebu, if cattle rearing is to be successful in the savanna. In fact, a start has already been made in tropical Queensland which has become Australia's largest cattle producing state.
- In the African savanna, the attitude of such native herdsmen as the Masai who treat cattle as prestige animals, not for slaughtering, will pose many difficulties towards the commercialization of the cattle industry. But as an agricultural region, the savanna holds great promise for the future.

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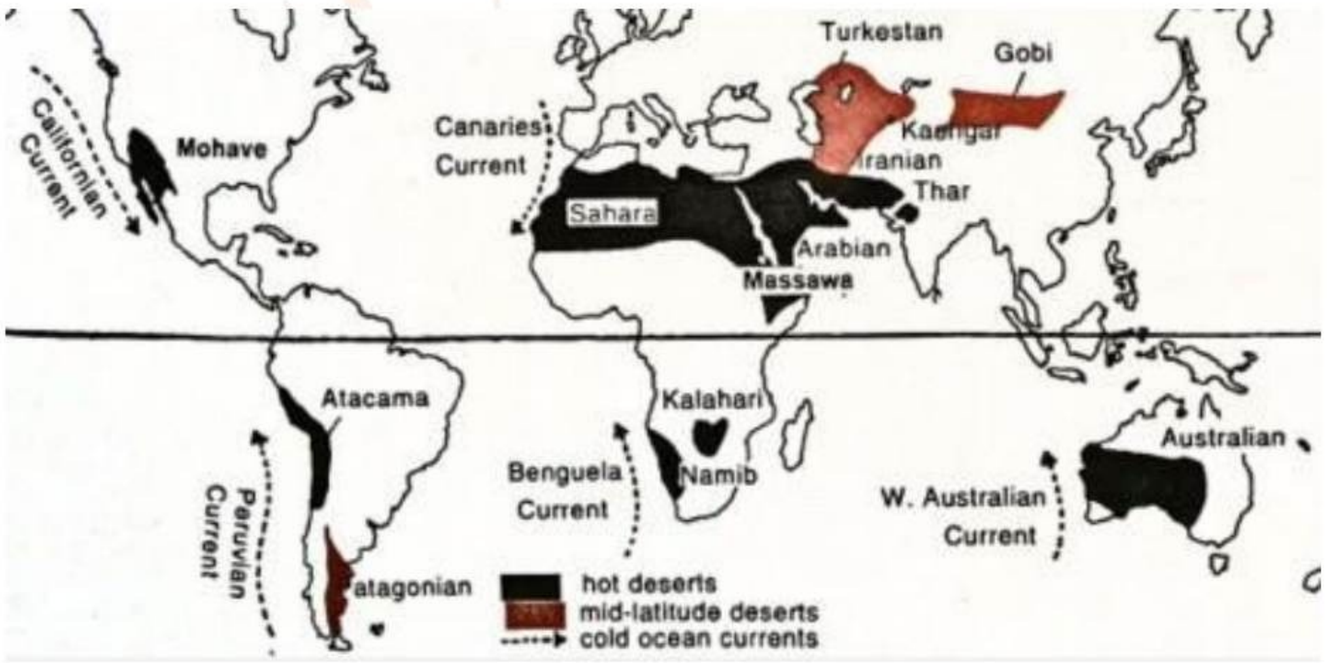
Distribution

- Deserts are regions of scanty rainfall which may be hot like the hot deserts of the Saharan type; or temperate as are the mid-latitude deserts like the **Gobi**. The aridity of the hot deserts is mainly due to the effects of off-shore Trade Winds; hence they are also called Trade Wind Deserts. The temperate deserts are rainless because of their interior location in the temperate latitudes, well away from the rain- bearing winds.
- The major hot deserts of the world are located on the western coasts of continents between latitudes 15° and 30°N and S. They include the Sahara Desert, the largest single stretch of desert, which is 3,200 miles from east to west and at least 1,000 miles wide. Its total area of 3.5 million square miles is larger than all the 50 states of U.S.A. put together. The next biggest desert is the Great Australian Desert which covers almost half of the continent.
- The other hot deserts are the Arabian Desert, Iranian Desert, Thar Desert, Kalahari and Namib Deserts. In North America, the desert extends from Mexico into U.S.A. and is called by different names at different places, e.g. the Mohave. Sonoran, Californian and Mexican Deserts. In South America, the Atacama or Peruvian Desert is the driest of all deserts with less than 0.5 inches of rainfall annually.



Climate

- **Rainfall**
  - In Salah in the mid-Sahara and Arica in the mid-Atacama have have practically no rain at all. In the latter, less than 0.02 inches fell within a period of 17 years in three light showers! In another station less than 150 miles away at Iquique, not a single drop of rain was recorded for four years and then a torrential downpour suddenly came one afternoon in which 2.5 inches of rain fell.
  - The hot deserts lie astride the Horse Latitudes or the Sub-Tropical High-Pressure Belts where the air is descending, a condition least favourable for precipitation of any kind to take place.
  - The rain- bearing Trade Winds blow off-shore and the Wester- lies that are on-shore blow outside the desert limits whatever winds reach the deserts blow from to warmer regions, and their relative humidity is lowered, making condensation almost impossible. There is scarcely any cloud in the continuous blue sky.
  - The relative humidity is extremely low, decreasing from 60 per cent in coastal districts to less than 30 per cent in the desert interiors. Under such conditions, every bit of moisture is evaporated and the deserts are thus regions of permanent drought.
  - Precipitation is both scarce and most unreliable Coastal stations. On the western coasts, the presence of cold currents gives rise to mists and fogs by chilling the on-coming air. This air is later warmed by contact with the hot land, and little rain falls.
  - The desiccating effect of the cold Peruvian Current along the Chilean coast is so pronounced that the mean annual rainfall for the Atacama Desert is not more than half an inch!

Rain normally occurs as violent thunderstorms of the convectional type. It "bursts suddenly and pours continuously for a few hours over small areas. The thunderstorm is so violent, and comes so suddenly that it has disastrous consequences on desert landforms.

- **Temperature**
  - The deserts are some of the hottest spots on earth and have high temperatures throughout the year. There is no cold season in the hot deserts and the average summer temperature is around 86°F. The reasons for the high temperatures are obvious-a clear, cloudless sky, intense insolation, dry air and a rapid rate of evaporation.
  - Coastal deserts by virtue of their maritime in- fluence and the cooling effect of the cold currents have much lower temperatures, e.g. Arica has a mean annual temperature of 66°F Iquique 65°F, Walvis Bay, South-West Africa, only 63°F. The desert interiors, however, experience much higher summer temperatures and the winter months are rather cold.
  - The diurnal range of temperature in the deserts is very great. Intense insolation by day in a region of dry air and no clouds causes the temperature to rise with the sun. The barren ground is so intensely heated that, by noon, particularly in summer, a reading of 120°F is common. But as soon as the sun sets, the land loses heat very quickly by radiation, and the mercury column in the thermometer drops to well below the mean temperature.
  - A daily temperature range of 30° to 40°E is common, though in the Death Valley of California, an exceptionally great diurnal range of 74°F has been recorded. Frosts may occur at night in winter.

Climatic Conditions

- The climatic conditions of the mid-latitude deserts are in many ways similar to those of the hot deserts. Aridity is the keynote. These inland basins lie hundreds of miles from the sea, and are sheltered by the high mountains all around them.
- As a result, they are cut off from the rain-bearing winds. Occasionally depressions may penetrate the Asiatic continental mass and bring light rainfall in winter, or unexpected convectional storms may bless the parched lands with brief showers in summer.
- Due to their coldness and elevation, snow falls in winter, it is clear that summers are very hot (80°F. in July at Kashgar) and winters are extremely cold with two months below freezing point. The annual range of temperature is 58°F, much greater than that of the hot deserts. Continentality accounts for these extremes in temperature.
- Winters are often severe, freezing lakes and rivers and strong cold winds blow all the time. When the ice thaws in early summer, floods occur in many places. The greatest inhibiting factors to settlement are the winter cold and the permanent aridity, besides remoteness from the sea.

Desert Vegetation

- The environment, so lacking in moisture and so excessive in heat, is most unfavourable for plant growth and a significant vegetation cannot be expected. But very rarely are there deserts where nothing grows.
- The predominant vegetation of both hot and mid-latitude deserts is xerophytic or drought-resistant scrub. This includes the bulbous cacti, thorny bushes, long-rooted wiry grasses and scattered dwarf acacias.
- Plants that exist in deserts have highly specialized means of adapting themselves to the arid environment. Intense evaporation increases the salinity of the soil so that the dissolved salts tend to accumulate on the surface forming hard pans. Absence of

moisture retards the rate of decomposition and desert soils are very deficient in humus.

- Most desert shrubs have long roots and are well spaced out to gather moisture, and search for ground water. Plants have few or no leaves and the foliage is either waxy, leathery, hairy or needle-shaped to reduce the loss of water through transpiration.
- Some of them are entirely leafless, with pricks or thorns. Others like the cacti have thick succulent stems to store up water for long droughts. There are still others that shed their leaves during droughts. The Seeds of many species of grasses and herbs have thick, tough skins to protect them while they lie dormant.

Life in the Deserts

Bedouin Arabs have fared quite well with their flocks of sheep, goats, camels and horses. The Bushmen of the **Kalahari and the Bindibu** of Australia remain so primitive in their mode of living that they barely survive. They are, in fact, a relic of the Old Stone Age in the modern world. The desert inhabitants may be grouped under the following categories.

1) **The primitive hunters and collectors**
    - Of the primitive tribes, the Bushmen and the Bindibu are the best known. Both the tribes are nomadic hunters and food gatherers, growing no crops and domesticating no animals. The Bushmen roam the Kalahari Desert with their bows and poisoned arrows, spears, traps and snares.
    - Bushmen either wear a loin cloth or go virtually naked. They travel in small family groups, and live together in open sherms. This is a hollow dug beneath a thorn tree, surrounded by bushes. At night a fire is lit to keep the family warm.
    - The **Bindibu or Aborigines** of Australia live in very much the same way as the Bushmen. They are lean and dark but healthy. They are skilled trackers and some of them use wooden throwing sticks or boomerangs and spears. They also domesticate the dingo, a wild dog that assists them in tracking down kangaroos, rabbits and birds.
    - But one distinct difference is that they always stay close to a water supply as they still have not devised a means of tapping and storing water. They live in wurlies, simple shelters made of branches and tufts and grass.
2) **The nomadic herdsmen**
    - These people represent a more advanced group of desert dwellers who pursue a livestock economy. They ride on animals instead of walking and are heavily clad against the blazing sun, the stormy winds and the chilly nights.
    - The Bedouin of Arabia ride on horses and live in tents; the Tuaregs of the Sahara are camel riders and dwell in grass zeriba, while the Gobi Mongols ride on horses to herd their yaks and live in portable yurts (a kind of tent).
    - Their wealth is their animals: sheep, goats, camels and perhaps a few horses. The animals provide them with all that they require, daily milk and cheese and on occasions meat as well. Their skin is used for hides or leather, for making tents, clothing, belts, footwear and water bags. From the hair and wool, the Bedouin make clothes, mats, ropes, rugs and carpets.
3) **The caravan traders**
    - These were the travelling merchants of the desert. Their journeys across the wastes of the Sahara or Russian Turkestan sometimes lasted months or even years. They travelled at night as a team and were well armed.
    - They carried a wide range of goods into remote interiors where their merchandise was highly sought after. These goods were sold or

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exchanged for hides, rugs, carpets and other valuable products of the deserts. Though profits were high, the risks were equally great.

4) **The settled cultivators**

- For crops to be cultivated in the desert, irrigation is indispensable. This is obtained either from oases, rivers or dams, through a network of canals.
- Nile flooded in summer, the overflowed water was caught in basins with raised banks and led into the fields to irrigate the crops. This was basin irrigate, which was widely practised by the **ancient Egyptian** farmers and is still employed by the Egyptians today.
- Rice and cotton are cultivated in summer, followed by wheat, barley, beans and another minor crops winter. Modern concrete dams constructed across the Nile e.g. Aswan and Sennar Dams are even more effective tor extensive irrigation works. Imperial Valley of California, and are able to irrigate millions of acres of arid land for crop production.
- In the deserts, wherever there are oases, some form of settled life is bound to follow. Tafilalet Oasis in Morocco which measures 5,000 square miles, supporting many settlements, including large towns.
- The Ghadames Oasis of Libya is only one square mile in size. Life in an oasis is secure and well organised. A wall is usually constructed around the oasis to keep out the violent dust storms called simooms.

5) **The mining settlers**

- It was gold that brought immigrants scrambling into the Great Australian Desert. Water and food supplies have to be brought 300 miles from Perth to keep the mines going.
- In the Kalahari Desert, the discovery of diamonds and copper has brought many white men to the 'thirst land' as it is called. Even in the most arid Atacama, in northern Chile, large mining camps have been established for the mining of caliche (cemented gravels) from which sodium nitrate, a valuable fertilizer, is extracted and exported to all parts of the world.
- Besides nitrates, copper is also mined. These two products have directly or indirectly contributed to the growing size of the Chilean towns of Arica, Iquique, The last named is the world's largest copper town. Similarly in the deserts of North America, silver is mined in Mexico, uranium in Utah and copper in Nevada.
- In recent years, the discovery of oil, in many parts of the Saharan and Arabian Deserts has transformed this forgotten part of the globe. In Algeria, oil wells have been sunk two miles deep to tap oil.
- Saudi Arabia to Saida (Lebanon) and Banias (Syria) on the Mediterranean coast. With still half of the world's reserves of oil untapped in this region, the deserts here will virtually be paved with gold. In Iraq, Kuwait, and Saudi Arabia the desert landscape is fast changing.

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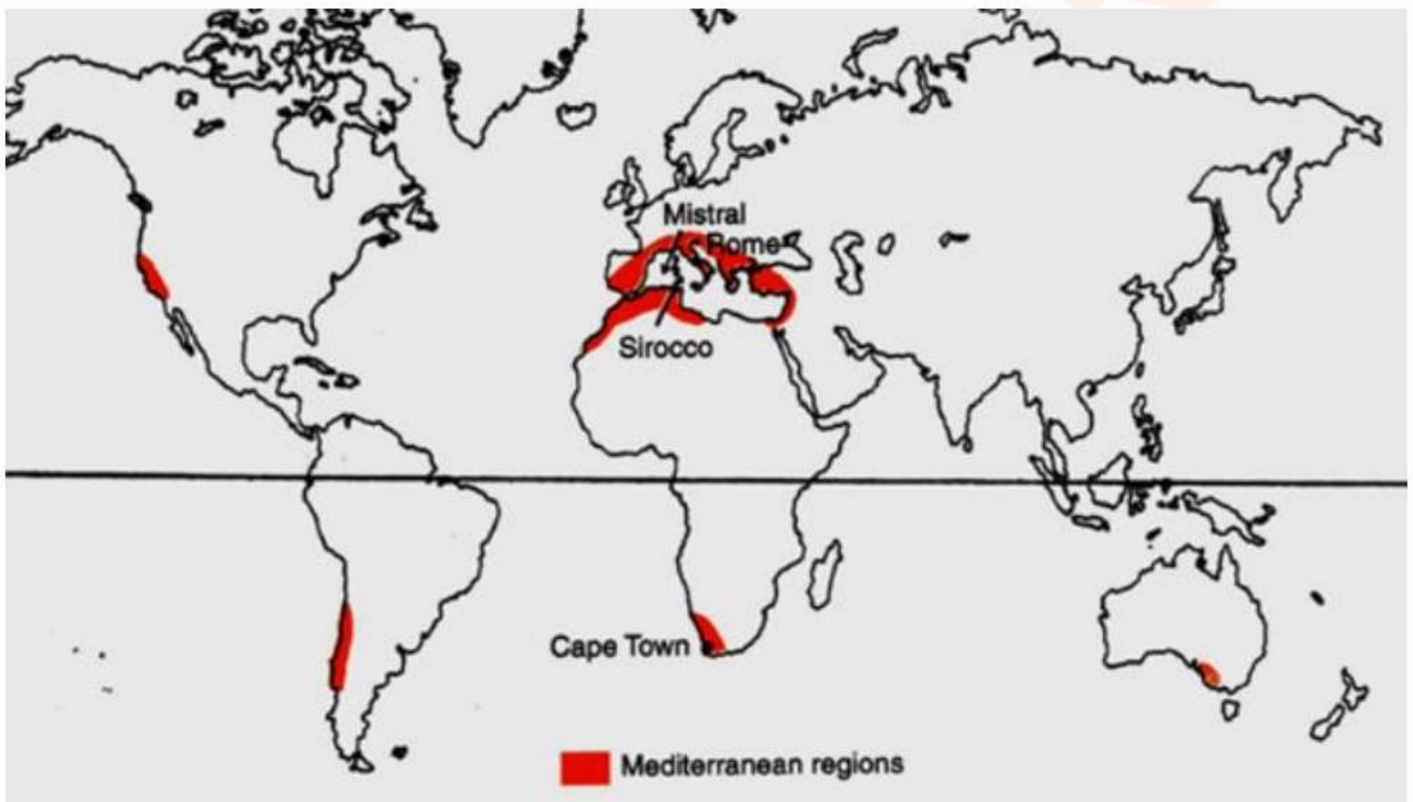
CHAPTER: 19 – THE WARM TEMPERATE WESTERN MARGIN (MEDITERRANEAN) CLIMATE

Distribution

- The Warm Temperate Western Margin Climate is found in relatively few areas in the world. They are entirely confined to the western portion of continental masses, between 30° and 45° north and south of the equator. The basic **cause** of type of climate is the shifting of the wind belts.
- Though the area around the Mediterranean Sea has the greatest extent of this type of winter rain climate, and gives rise to the more popular name Mediterranean Climate, the best developed form of this peculiar climatic type is, in fact, found in central Chile.
- Other Mediterranean regions include California (around San Francisco), the South-western tip of Africa (around Cape Town), southern Australia (in southern Victoria and around Adelaide, bordering the St. Vincent and Spencer Gulfs), and south-west Australia (Swanland).



Climate

The Mediterranean type of climate is characterized by very distinctive climatic features.

1. **A dry, warm summer with off-shore trades**
   - The summer months have a relatively high temperature (76°F. in July in Rome and 70°F. in January in **Cape Town**.) The highest temperatures are however experienced further away from the coast in the more continental eastern Mediterranean, in the interiors of the Balkan peninsula, the Anatolian Plateau and Mediterranean.
   - In summer when the sun is overhead at the Tropic of Cancer, the belt of influence of the Westerlies is shifted a little poleward. Rain bearing winds are therefore not likely to reach the Mediterranean lands. The prevailing Trade Winds are off-shore and there is practically no rain. The air is dry, the heat is intense and the relative humidity is low. Days are excessively warm and, in the interiors, prolonged droughts are common. At night, there is rapid radiation but frosts are rare.
2. **A concentration of rainfall in winter with on-shore westerlies**
   - The Mediterranean lands receive most of their precipitation in winter when the Westerlies shift equator wards. In the northern hemisphere, the prevailing on-shore Westerlies bring much cyclonic rain from the Atlantic to the countries bordering the Mediterranean Sea.
   - The mean annual rainfall is normally taken as 25 inches. Again, this differs greatly from place to place, depending on relief, continentality and the passage of the passing cyclones.
   - You will notice that the Mediterranean regions are often backed by mountains of some Iberia, the **central Meseta and other Sierras** of the peninsula present an effective barrier to the on coming Westerlies.
   - As a result, the Portuguese coast is much wetter than eastern Spain. Lisbon has annual rainfall of nearly

30 inches while Cartagena, along the eastern coast of Spain does not receive even half as much. Much heavier precipitation has been recorded in the highlands on windward slopes facing the Westerlies. The steep hills of the eastern Adriatic are rainiest part of Europe with 182 inches recorded at Crkvice, about 3,600 feet above sea level.

- Rain in Mediterranean Europe normally begins in September, reaching its peak somewhere in October (5 inches in Rome). Though the down- pours are infrequent they are often very torrential and in mountainous districts, destructive floods occur. The floods come so suddenly that there is practically no time to do anything about it. The disastrous **flood of Lisbon in 1967** came in the middle of the night and caused great damage and loss of life in a few hours!

3. **Bright, sunny weather with hot dry summers and wet, mild winters**
    - Considering its mid-latitude position, the Mediterranean regions have a very favour able climate, unrivalled by any other climatic regions. The climatic features are transitional between those of the Trade Wind Hot Desert in the south and the cool Temperate Maritime Climate in the north. Summers are warm and bright and winters are so mild and cool that many tourists come at all times of the year.
    - The sky is almost cloudless and sun-shine is always abundant. In July, Rome has as much as eleven hours of sunlight, and with the Mediterranean palm trees around, tourists feel very much as if they are in the tropics. Even in mid- summer, the intense heat is never sultry. The climate is so mild that many of the local people sleep in the open air.

4. **The prominence of local winds around the Mediterranean Sea**
    - Many local winds, some hot, others cold are common around the Mediterranean Sea. The causes are many and varied. The topography of the region with the high Alps in the north, the Sahara Desert in the south, continental interiors in the east and the open Atlantic on the west give rise to great differences in temperature, pressure and precipitation.
    - The passing cyclones from the Atlantic, the anticyclones from the north, and the cold air masses from the continental interiors are often interrupted or channelled by relief features, resulting in the birth of local winds around the Mediterranean. These winds varying in strength, direction and duration affect the lives, crops and activities of the people there indicates the location and direction of some of these local winds and the more important ones are described below.

    a) Sirocco
        - This is a hot, dry dusty wind which originates in the Sahara Desert. Though it may occur at any time of the year, it is most frequent in spring and normally lasts for only a few days. The Sirocco blows outwards in a southerly direction from the desert interiors into the cooler Mediterranean Sea.
        - It is usually associated with depressions from the Atlantic passing from the coast eastwards inland. After crossing the Mediterranean Sea, the Sirocco is slightly cooled by the absorption of the

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water vapour. Even then, it is still hot and dry with a temperature of over 105°F its sorching breathe withers vegetation and crops. The damage is particularly serious when it comes at the times during which vines and olives are in blossom.

- The Sirocco is so prominent that it is called by many other local names, such as Chili in Tunisia, Ghibli in Libya, Leveche in Spain, Khamsin in Egypt and Malta. In the Adriatic and Aegean Sea, this hot wind, better known as Gharbi, gathers much moisture causing fog, heavy dew and rain. This may be blood rain' because the wind is carrying the red dust of the Sahara Desert.

b) Mistral

- In contrast, the Mistral is a cold wind from the north, rushing down the Rhone valley in violent gusts between 40 and 80 miles per hour. The velocity of the Mistral is intensified by the funnelling effect in the valley between the Alps and the Central Massif, and in extreme cases trains may be derailed and trees uprooted.
- In winter when the Mistral is most frequent the temperature of the wind may be below freezing-point, though the sky may be clear and cloudless. As a protective measure, many of the houses and orchards of the Rhone valley and the Riviera have thick rows of trees and hedges planted to shield them from the Mistral.
- A similar type of cold north-easterly wind experienced along the Adriatic coast is called the Bora. Like the Mistral, it is caused by a difference in pressure between continental Europe and the Mediterranean. This usually occurs in winter, when the atmospheric pressure over continental Europe is higher than that of the Mediterranean Sea.
- The Bora thus blows outwards into the Mediterranean. This dry, icy wind is even more violent than the Mistral and speeds of over 100 m.p.h have been recorded. During strong Boras, ships may be blown aground and agricultural lands devastated.

Natural Vegetation

- In a land where half the year is dry, one cannot expect the natural vegetation to be luxuriant. Trees with small broad leaves are widely spaced and never very tall. Though there are many branches they are short and carry few leaves. The absence of shade is a distinct feature of Mediterranean lands. Growth is slow in the cooler and wetter season, even though more rain comes in winter.

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- Growth is thus almost restricted to autumn and spring when the temperature is higher and moisture is just sufficient. The long summer drought checks the growth.
- One fact is clear, plants whether trees or shrubs, evergreen or deciduous, have to devise ways of adapting themselves to a climatic environment with such a marked rhythmic recurrence of rain and drought.
- In many ways, the vegetational responses to climatic demands in the Mediterranean are similar to those of the adjacent deserts and the savanna further south.
- Plants are in a continuous struggle against heat, dry air, excessive evaporation and prolonged droughts. They are, in short xerophytic, a word used to describe the drought-resistant plants in an environment deficient in moisture.
- **Types of Mediterranean vegetation** - Various kinds of vegetation are found in the Mediterranean regions.
    1) **Mediterranean evergreen forests -** These are open woodlands with evergreen oaks, of which the cork oaks of Spain and Portugal are the best known. They are found only in the climatically most favoured regions with a rainfall of well over 25 inches, the trees are normally low, even stunted, with massive trunks, deeply fissured barks, small leathery leaves and a wide-spreading root system in Search of water. In Australia, the eucalyptus forests replace the evergreen oak.
    2) **Evergreen coniferous trees** - These include the various kinds of pines, firs, cedars and cypresses which have evergreen, needle-shaped straight trunks. They appear more on the cooler highlands and where droughts are less severe.
    3) **Mediterranean bushes and shrubs** - This is perhaps the most predominant type of Mediterranean vegetation. Summers are so dry and hot that in places forests give place to short, evergreen shrubs and bushes. The low bushes grow in scattered clumps and are often thorny. They are so different from the ordinary woodland or the true desert scrubland that special names have been given to them to distinguish their location in different parts of the Mediterranean lands. This type of vegetation is called **maquis** in southern France, and macchia in Italy. In California, the term chaparral is used and in Australia mallee scrub.
    4) **Grass -** Conditions in the Mediterranean do not Suit grass, because most of the rain comes in the cool season when growth is slow. Slow-growing vegetation, which cannot replenish its foilage readily, and which is without deep-penetrating roots, is least suited here. Even if grasses do survive, they are so Wiry and bunchy that they are not suitable for animal farming. Cattle rearing is thus unimportant in the Mediterranean. The grass, which is replaced by certain drought-resistant varieties of shrubs and flowering herbs, can however support sheep or goats.

Economic Development of the Mediterranean Regions

- Despite the semi-arid conditions over many parts of the Mediterranean lands, the climate as a whole is favourable. Its warm,

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bright summers and cool, crops to be moist winters enable a wide range of cultivated.

- One must not forget that the Mediterranean shore-lands were once the cradle of world civilization. Nowadays the area is important for fruit cultivation, cereal growing, wine-making and agricultural industries, as well as engineering and mining. We shall deal with some of them in greater detail below.
- **Orchard farming**
    - The Mediterranean lands are also known as the world's orchard lands. A wide range of citrus fruits such as oranges, lemons, limes citrons and grapefruit are grown. The fruit trees have long roots to draw water from considerable depths during the long summer drought. In exceptionally dry areas, irrigation helps to relieve the lack of moisture.
    - The thick, leathery skin of the citrus fruits prevents excessive transpiration and the long, sunny summer enables the fruits to be ripened and harvested.
    - The Mediterranean lands account for the olive tree is probably the most typical of all Mediterranean cultivated vegetation.
    - The olive can be eaten fresh or pickled with spices. The fleshy part can be crushed and olive oil extracted, a valuable source of cooking oil in a region deficient in animal fat. Soap and margarine can also be made with the oil.
    - Besides olives, many nut trees like chestnuts, walnuts, hazelnuts and almonds are grown and the nuts picked as fruits or for the chocolate industry. Other important fruits are peaches, apricots, pears, plums, cherries and figs.
- **Crop cultivation**
    - Cereals are by far the most important. Wheat is the leading food crop. Though conditions for extensive wheat cultivation are not as ideal as those of the cool temperate regions, the Mediterranean farmers have utilized the seasonal climatic rhythm to their best advantage. The wheat grown is mainly hard, winter wheat.
    - It is suitable for both bread- making and other food-products such as macaroni, spaghetti and vermnicelli. The farmers usually sow the seeds in autumn, so that they germinate and grow steadily with the coming winter rain. By spring there is still sufficient moisture for the wheat to mature. **Barley** is the next most **popular cereal.**
    - In the more fertile plains, vegetables, especially beans, and flowers are grown for the local market. A little cotton and tobacco are also grown. The mountain pastures, with their cooler climate, support a few sheep, goats and
- **Wine production**
    - This is another speciality of the Mediterranean countries, because the best wine is essentially made from grapes. Some 85 per cent of grapes produced, go into Wine. The long, sunny summer allows the grapes to ripen and then they are Medi hand-picked.
    - Viticulture is by tradition a Mediterranean occupation and the regions bordering the Mediterranean Sea account for three-quarters of the world's production of wine. In Spain, Portugal, France, and Italy, wine is the national drink.
    - Commercial viticulture is almost entirely confined to the Mediterranean regions. It has been estimated that 40 million tons of the world's total production of 46 million tons of grapes annually are being processed into wine.
    - The quality of the fermented grape juice is decided by a number of factors including the types of vines grown, the quality of the soil, the

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climate of the region, the method and extent of fermentation. Wine may be as cheap as any soft-drink or as expensive as brandy.

- The wine from southern Spain is called sherry from Portugal port wine. Chianti, asti and marsala come from different parts of Italy further north, e.g. Champagne in the Paris basin, Bordeaux in the Garonne basin, Burgundy in the Rhone-Saone valley.
- The world trade in fresh grapes is comparatively small mainly from Mediterranean South Africa. Most of the inferior grapes are preserved as dried grapes and exported. They are known by several names e.g. currants from the Levantine grapes, raisins from California, and sultanas from Asia Minor.

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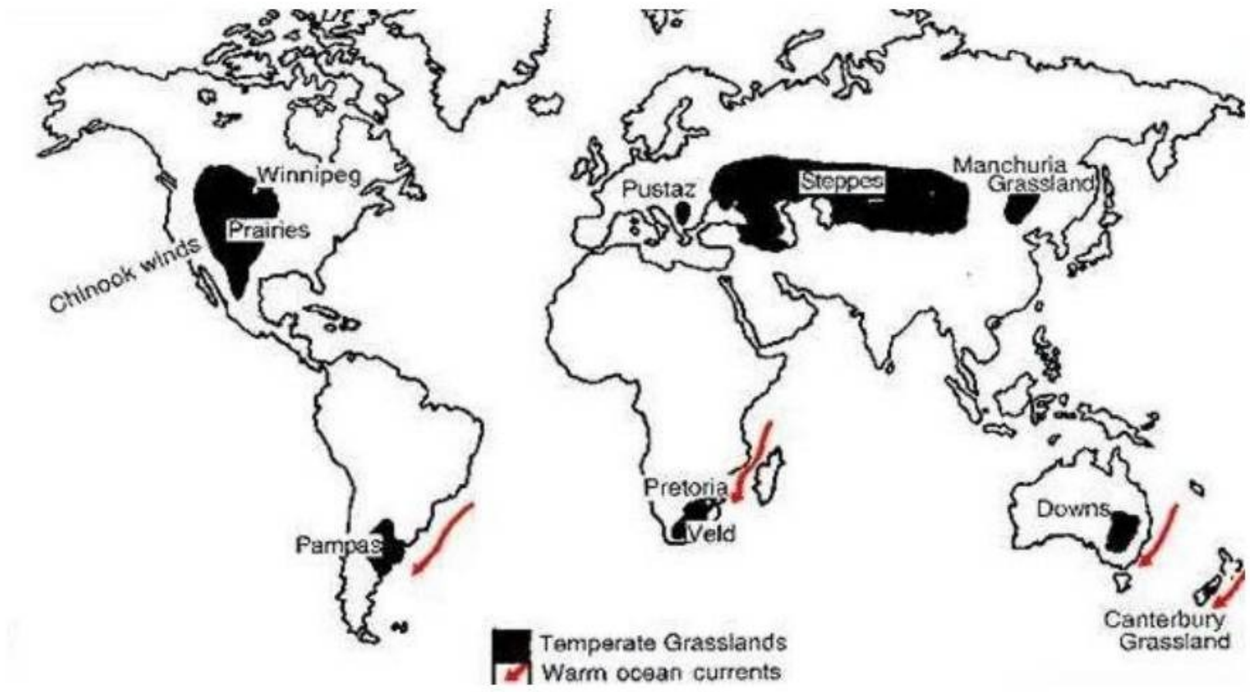
Distribution



- Bordering the deserts, away from the Mediterranean regions and in the interiors of continents are the temperate grasslands.
- These grasslands are so distinctive in their natural vegetation that, although those which occur in the southern hemisphere have a **much more moderate climate**, they are often dealt with together.
- In the northern hemisphere, the grasslands are far more extensive and are entirely continental. In Eurasia, they are called the Steppes, and stretch eastwards from the shores of the Black Sea across the great Russian plain to the foothills of the Altai Mountains, a distance of well over 2,000 miles.
- They are broken a few places, being interrupted by the highlands. There are isolated sections in the Pustaz of Hungary and the plains of Manchuria.
- In North America, the grasslands are also quite extensive and are called Prairies. They ie between the foothills of the Rockies and the Great Lakes astride the American-Canadian border.
- In the southern hemisphere, due to the narrowness of the temperate portions of the southern continents. The grasslands are rather restricted and less continental. In the case of the **Pampas of Argentina** and Uruguay, the grasslands extend right to the sea and enjoy much maritime influence.
- In South Africa, the grasslands are sandwiched between the Drakensberg and the Kalahari Desert; and are further sub-divided into the more tropical Bush-veld in the north, and the more temperate High Veld in the south.
- In Australia, the grasslands are better known as Downs and are found in the Murray-Darling basin of southern Australia.

Climate

- **Temperature**
  - Their climate is thus continental with extremes of temperature. Winters are very cold in the continental steppes of Eurasia because of the enormous distances from the nearest sea. The winter months are well below freezing and in Winnipeg the January reading is 4°E., 36° below freezing-point.
  - In contrast, the steppe type of climate in the southern hemisphere is never severe. The winters are so mild that the mean temperature for any of the winter months is usually between 35° and 55° F Temperatures below freezing point even in mid- winter (July in the southern hemisphere) are exceptional. These statistics establish the moderating effects of oceans on the climates of the southern hemisphere.
  - The annual range of temperature is great, a direct result of continentality. Winters are so cold that parts of the Eurasian Steppes are snow-covered for several months. The snow melts with the return of spring and by mid-summer, temperatures soar to over 65°F it is really hot for its latitude. For example, the mid-summer temperatures for Kiev is 67°F.
  - It is clear from the two selected stations given that there is a tremendous difference between the annual temperature range of the northern and southern hemisphere,

again a factor of continentality. The range in Winnipeg is 70°F nearly three times as great as that of Pretoria at 26°F.

- Readings taken in various other stations of the northern and southern hemispheres confirm this trend. The annual range for Mukden in Manchuria is 69°F. In comparison, the annual range of the more maritime stations of **Johannesburg,** Buenos Aires and Mildura in the southern hemisphere are very much smaller, 20°F., 25°F. 28°F respectively.

- **Precipitation**
  - In its continental position, the annual precipitation of the Steppe Climate can be expected to be light. Winnipeg has 20 inches with a distinct summer maximum from convectional sources, when the continental interiors are intensely heated.
  - The heaviest rain comes in the middle of the year with 3.1 inches each in June and July. Brought the occasional depressions of the Westerlies and coming in the form of snow.
  - The maritime influence in the steppe type of climate of the southern hemisphere is even better brought out by the rainfall regime. Its annual precipitation is always more than the average 20 inches because of the warm ocean currents that wash the shores of the steppe-lands here. Pretoria, has an annual precipitation of 26 inches with the wettest months in November, December, January and February, the summer season of the southern hemisphere.
  - This is the period of drought that may have such a disastrous effect on the sheep rearing industry here. The dry season is particularly pronounced in temperate grasslands adjoining deserts, for example in Australia.
  - On the eastern slopes of the Rockies in Canada and U.S.A. a local wind, similar to the Fohn in Switzerland, called the Chinook, comes in a south- westerly direction to the Prairies and has a consider- able effect on the local pastures.
  - It actually comes with the depressions in winter or early spring from the Pacific coast ascending the Rockies and then descending to the Prairies. It melts the snow-covered pastures and animals can be driven out of doors to graze in the open fields.

Natural Vegetation

- Though the term 'steppe vegetation geographically refers to the scanty vegetation of the sub-arid lands of continental Eurasia. In this connection, our reference to steppe grassland is taken to mean the temperate grasslands of the mid-latitudes, the Steppes, Prairies, Pampas, Veld and Downs.
- It is natural to expect the steppes to be grass covered, differing only in the density and quality of the grass. Their greatest difference from the tropical savanna is that they are practically treeless and the grasses are much shorter.
- Where the rainfall is moderate, above 20 inches, the grasses are tall fresh and nutritious and are better described as long prairie grass. This is typical of the grass of the wheat-lands in North America, the rich black earth or chernozem areas of Russian Ukraine and the better watered areas of the Asiatic Steppes.
- These areas are less suitable for arable farming and are used for some form of ranching as in the High Plains of U.S.A. The steppe grass can lie dormant throughout the prolonged drought. They sprout and come to life as soon as the temperature is warm enough for plant growth (43°E) and grow steadily with very little moisture.

- The appearance of the temperate grasslands varies with seasons. In spring, the grass begins to appear, green, fresh and blooming with small, colourful flowers. The light rainfall that comes in late spring and early summer greatly stimulates their growth and there is plenty for the animals to graze.
- Trees are very scarce in the steppes, because of the scanty rainfall, long droughts and severe winters. The rolling plain is an endless stretch of grass, whether green or brown, except along the water courses where a few low willows, poplars or alders break the monotony.
- Poleward, an increase precipitation gives rise to a transitional zone of Wooded steppes where some conifers gradually appear. Even then, the trees are very scattered and few in number. Towards the equator, the steppe grass becomes shorter and sparser, till it merges into the desert with thorny scrub.

Economic Development

- Nomadic and semi-nomadic peoples like the Kirghiz of the Asiatic Steppes. The Red Indians of North America were mostly hunters who moved around after the bison and other animals.
- The grasslands have been ploughed up for extensive, mechanized wheat cultivation and are now the granaries of the world.
- The tufted grasses have been replaced by the more nutritious lucerne or alfalfa grass for cattle and sheep rearing. These temperate grasslands are now the leading ranching regions of the globe. We shall now describe more closely each of these economic activities.
- **Nomadic herding**
    - This type of migratory animal grasslands. The herders were wandering tribes e.g. the Kirghiz, the Kazakhs, and the Kalmuk. The leather was used for making boots, saddles and belts, which were very essential in a country where the chief riding animal was the horse.
    - The harsh environment of the nomads, with long droughts and unreliable showers made the Kirghiz a tough and fearless people, the Tartars, and they long resisted subjugation by the Russians.
- **Extensive mechanized wheat cultivation**
    - The temperate grasslands are ideal for extensive wheat cultivation. The cool, moist spring stimulates early growth and the light showers in the ripening period help to swell the grains to ensure a good yield. The warm, sunny summer is not only advantageous for harvesting, but also enables the straw to be dried for farm use.
    - In addition, the levelness of the Steppes and other temperate grasslands all over the world makes ploughing and harvesting a comparatively easy job. One distinct drawback of this form of extensive mechanized farming is the consequent low yield.
    - But if we consider the yield per man, this is very much higher in the extensive farms. In this respect, the sparsely populated temperate grasslands of the mid-latitudes produce the greatest quantity of wheat per capita amongst the world's wheat-growing nations. They are, naturally the greatest wheat exporters.
    - Three-quarters of the **world's wheat is winter wheat,** i.e. wheat sown in winter or late autumn. It is a hard wheat with a low moisture contend, being ripened in the hot, sunny, continental summer. It is best for bread-making and is extensively traded. Poleward, where the winter temperatures are too cold for the wheat seedlings to survive, spring wheat is grown.
    - In North America, winter wheat is dominant south of the Great Lakes in U.S.A., while spring wheat is

sown mainly in the Canadian Prairie provinces of Alberta, Saskatchewan and Manitoba.

- Scientific plant breeding has now devised cold- resistant varieties that can mature within 110 days. This has resulted in the northward extension of the It is the less important soft wheat, more wheat cultivation into the Peace River region in Canada. In the warmer, wetter regions, maize is increasingly grown.

- **Pastoral farming**
  - When pioneer settlers first moved into the temperate grasslands, there were very few animals. The natural conditions suit animal farming. Where the winters are milder and the rainfall evenly distributed. The original tuft-grass was ploughed up and replaced by sown alfalfa.
  - Soon the **Pampas** became so involved with the **pastoral industry** that it took the lead in the world's export of beef. Large estancias (ranches) were established, linked to the frigorificos (meat-packing factories) in the coastal ports by a dense network of roads and railways. The growth ports was rapid and towns like Buenos Aires, Bahia Blanca, known Fray Bentos and Montevideo.
  - Much beef is produced in the Great Plains of U.S.A. and Australia became the world's leading wool exporter, accounting for a third of its total production. In the Eurasian Steppes.

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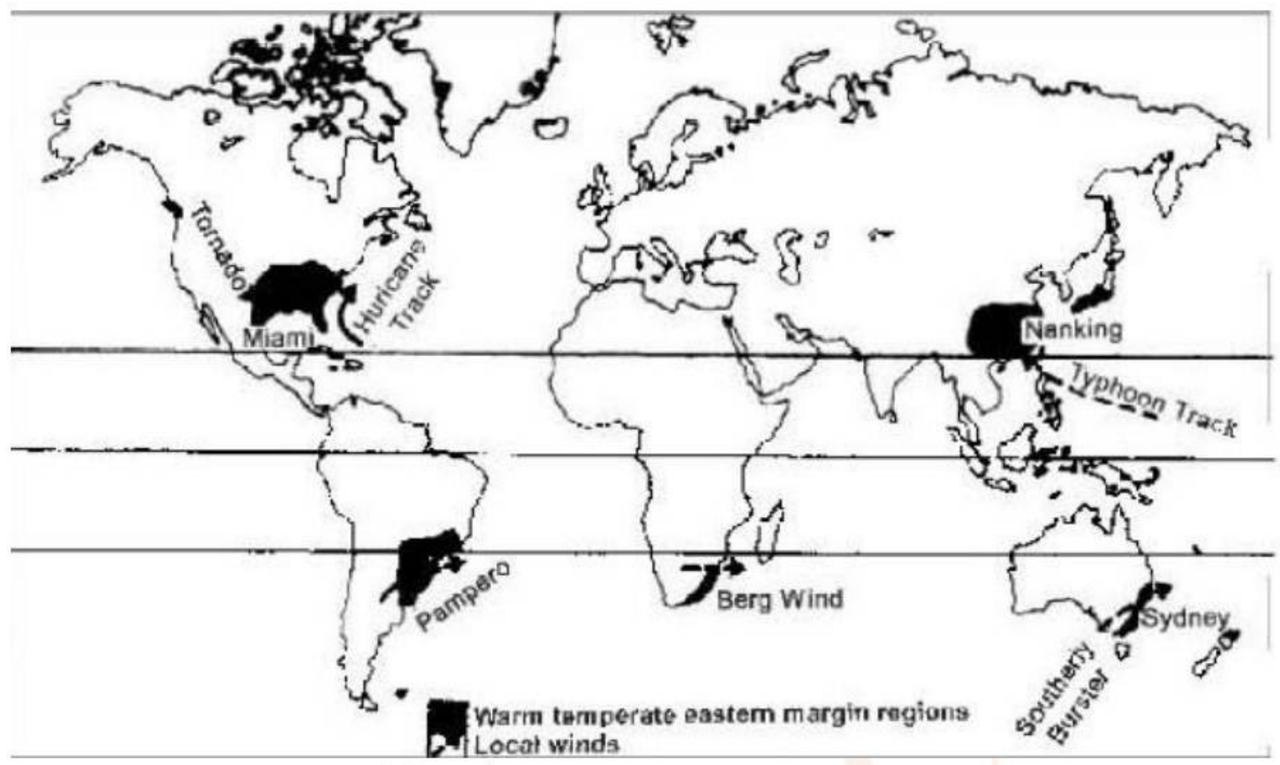
CHAPTER: 21 – THE WARM TEMPERATE EASTERN MARGIN (CHINA TYPE) CLIMATE

Distribution

- This type of climate is found on the eastern margins of continents in warm temperate latitudes, of just outside the tropics. It has comparatively more rainfall than the Mediterranean climate in the same latitudes, coming mainly in the summer.
- It is, in fact, the climate of most parts of China a modified form of monsoonal climate. It is thus also called the Temperate Monsoon or China Type of climate. In south-eastern U.S.A., bordering the Gulf of Mexico, continental heating in summer induces an inflow of air from the cooler Atlantic Ocean.
- In the southern hemisphere, this kind of climate is experienced along the warm temperate eastern coastlands of all the three continents: in New South Wales with its eucalyptus forests; in Natal where cane sugar thrives; and in the maize belt of the Parana-Paraguay-Uruguay basin.
- As the regions are influenced by the on-shore Trade Winds all the year round, without any monsoon variations, the climate cannot be described as temperate monsoon. It is sometimes referred to as the Natal type of climate

Climate

- The Warm Temperate Eastern Margin Climate is typified by a warm moist summer and a cool, dry winter. The mean monthly temperature varies between 40°E and 78°F and is strongly modified by maritime influence.
- Occasionally, the penetration of cold air from the continental interiors may bring down the temperature to freezing point. Though frosts are rare they occasionally occur in the colder interiors. For most of the time, it is pleasantly warm. The relative humidity is a little high in mid- summer when the heat becomes oppressive and can be very trying to the white settlers, e.g. in



Natal.

- Rainfall is more than moderate, anything from 25 inches to 60 inches. This is adequate for all agricultural purposes and the Warm Temperate Eastern Margin Climate supports a wide range of crops. Areas which experience this climate are very dense populated.
- Another important feature is the fairly uniform distribution of rainfall throughout the year. There is rain every month, except in the interior of central China, where there is a distinct dry season. Rain comes either from convectional Sources or as orographic rain in summer, or from depressions in prolonged showers in winter. Local storms, e.g. typhoons, and hurricanes, also occur.
- There is a good deal of variation in detail within the eastern margins and it is essential to examine them by reference to specific areas, where the local factors affect the climates. We shall sub-divide them into three main types.
    1) **The China type:** central and north China, including southern Japan (temperate monsoonal).
    2) **The Gulf type:** south-eastern United States, (slight-monsoonal).
    3) **The Natal type:** all the warm temperate eastern margin (non-monsoonal areas) of the southern hemisphere including Natal, eastern Australia and southern Brazil Paraguay-Uruguay and northern Argentina.

- **The China type**
  - The great land mass of the Asiatic continent with its mountainous interior induces great pressure changes between summer and winter. Intense heating in 'the heart of Asia sets up a region of low pressure in summer and the tropical Pacific air stream is drawn in as the rain-bearing South-East Monsoon.
  - Heavy precipitation occurs in most parts of China, decreasing inland. The wettest months of Nanking are in summer with more than a third of the annual rainfall falling in June and July (15.3 inches out of 42 inches), though the monsoon does not "burst as suddenly, nor 'pour as heavily as in India.
  - In winter, a steep pressure gradient is set up between the cold interiors of Mongolia and Siberia, and the warmer Pacific coastlands. The continental polar air stream flows outwards as the North-West Monsoon, bitterly cold and very dry. There is little rain but considerable snow on the windward slopes of Shantung as the cold winds are warmed and moistened.
  - Another climatic feature associated with the China type of climate in southern China is the occurrence of typhoons-intense tropical cyclones that originate in the Pacific Ocean, and move west- wards to the coastlands bordering the South China Sea.
- **The Gulf type**
  - The Gulf-Atlantic regions of the United States experience a type of climate similar to that of central China except that the monsoon characteristics are less well established. There is no complete seasonal wind reversal, for the pressure gradient between mainland America and the Atlantic Ocean is less marked.
  - The annual rainfall is heavy with 59 inches in Miami, and New Orleans; 52 inches in Montgomery and 41 inches in Charleston. There is no distinct dry period as in monsoon lands, and the abundant moisture has stimulated extensive cultivation of cotton and maize, in the Cotton and Corn Belts both of which are the world's leading areas for these crops. From the rainfall pattern.
  - It is clear that there is a tendency towards a summer maximum, brought by the on-shore Trade Winds which swing landwards from the Atlantic. The amount of rain is increased by the frequent thunderstorms in summer and by hurricanes in September and October.
  - Some stations, e.g. Montgomery in Alabama, also show a secondary maximum in late winter when cyclonic activities are greatest. Sometimes, violent tornadoes occur, due to intense local heating on land.
- **The Natal type**
  - The narrowness of the continents and the dominance of maritime influence eliminate the monsoonal elements which characterize the corresponding climates of the northern hemisphere.
  - The South-East Trade Winds bring about a more even distribution of rainfall throughout the year by the climatic graph for Sydney, Australia. It has a mean monthly precipitation of 4 inches, which is adequate for most agricultural activities. The annual amount of 48 inches is fairly representative of this climatic type in the southern hemisphere. The annual precipitation of Durban in Natal is 45 inches and that of Asuncion in Paraguay is 52 inches.
  - The passage of depressions across the southern edges of the warm

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temperate eastern margins results in a slight autumn or winter maximum, typified by Sydney which has its wettest months in March, April, May, June and July (the autumn-winter part of the year).

- Another feature to note is the small annual temperature range. However, the southern continents also have violent local storms, which, though not as severe as **the typhoon, hurricane or tornado,** are nevertheless, quite significant.
- The Southerly Burster a violent cold wind blowing along the coast of New South Wales, leads to a sudden fall in temperature. It is most frequent in spring and summer. The corresponding cold wind in Argentina and Uruguay is the Pampero, which is often accompanied by thunder and lightning besides the rain and dust.

Natural Vegetation

- The eastern margins of warm temperate latitudes have a much heavier rainfall than either the western margins or the continental interiors and thus have a luxuriant vegetation. The lowlands carry both ever green broad-leaved forests and deciduous trees quite similar to those of the tropical monsoon forests.
- On the highlands, are various species of conifers such as pines and cypresses which are important soft woods? As the perennial plant growth is not checked by either a dry season as in the Mediterranean, or a cold season as in the cool temperate regions, conditions are well suited to a rich variety of plant life including grass, ferns, lianas, bamboos, palms and forests.
- It is interesting to note that the warm temperate eastern margins are the homes of a number of valuable timber species. In eastern Australia the most important are eucalyptus trees, with scanty foliage and thick fern undergrowth.
- North-eastern Argentina come valuable warm temperate timbers such as the Parana pine, and the quebracho (axe-breaker, an extremely hard wood used for tanning) and wild yerba mate trees, from which the leaves are gathered for making Paraguay tea. Today, large yerba mate plantations have been established to produce Paraguay tea, an increasingly important export item of Paraguay.
- In Natal, the warm Mozambique current encourages heavy precipitation along the coast and many species of palm trees thrive. The highlands yield extensive forests of chestnuts, ironwood and Backwoods. An unusual occupation is the commercial cultivation of wattle trees in plantations for tanning extracts and for use in Natal's coal mines as pit-props.
- The forests of China and southern Japan also have considerable economic value and include oak, camphor, camelia and magnolia. Unfortunately, the tremendous population pressure in the two countries has caused much of the original forest to be cleared for fuel or crop cultivation. Deforestation has resulted in many barren hill-slopes that are still feeling the impact of soil erosion.
- The Gulf States of U.S.A. have lowland deciduous forests. The trees grow close together with thick undergrowth and leafy branches. Walnut, oak, hickory and maple are some of the more common species, while in the more sandy regions grow pines.

Economic Development

- Monsoon China together with southern Japan and other parts of the eastern margin climatic zone accounts for almost a **third of the world population.** Food has to be raised to feed the teeming population.
- The hills are terraced, fields are irrigated, and agriculture is extended to the limits of production. It is no exaggeration to say that the temperate monsoon lands are the most intensively tilled parts of the earth.
- e.g. cane sugar in Natal, coffee and maize in South America and dairying in New South

Wales and Victoria. Let us now examine some of the regions more closely.

- **Farming in monsoon China**
  - Undoubtedly this is the world's greatest rice growing area. A third of the world's rice is grown in China, though the huge population of 750 million leaves very little export. The Chinese peasants raise wet padi' or swamp rice. Farming is usually on a subsistence basis.
  - Monsoon China has all the ideal conditions for padi cultivation; a warm climate, moderately wet throughout the year, and extensive lowlands with fertile moisture-retentive alluvial soil, which if necessary, can be easily irrigated. The water is greatly enriched during floods, though these are far less frequent now.
  - The most intensively farmed areas are the basins of the Si-kiang, Yangtze Kiang and Hwang Ho. Besides rice the other important crops are tea, grown for home consumption and mulberry leaves gathered for feeding silk worms, though sericulture is declining.
- **Agriculture in the Gulf States**
  - It is grown only in a few areas in the southern coast- lands of the Mississippi delta. Americans are bread- eaters and one can well imagine how insignificant rice in the economy of the Gulf States is. The most important crops are corn, cotton and tobacco.
  - **Corn**
    - The chief food crop raised is, in fact corn or maize. The humid air, the sunny summer and the heavy showers suit the crop well. It is grown right from the Gulf coast to the Mid-west south of the Great Lakes, with the greatest concentration in the Corn Belt of Nebraska, Iowa, Indiana and ohio.
    - Region accounts for more than half the world's production of corn, but only 3 per cent of the world's export. This is because most of the corn is used for fattening animals, mostly cattle and pigs.
    - Many farmers do not harvest the corn but instead allow the cattle or pigs 'to hog the corn down in the field itself. The fattened animals are then sold to the meat plants in Chicago and Cincinnati to be slaughtered and processed into 'corned beef or frozen and chilled beef. Very little corn is consumed as a staple food in America.
  - **Cotton**
    - Of the cash crops grown in the Gulf States, none is comparable with cotton. In the Deep South, the fibre is so vital to the economic well-being of the southerners that 'cotton is king.
    - The Gulf type of climate is undoubtedly the best for cotton growing. Its long, hot growing season with 200 days frost free and a moderately high temperature of about 75°F permits the crop to grow slowly and mature within six months.
    - Like most fibres, cotton likes ample rain and an annual precipitation of around 40 inches is essential. In fact, an adequate moisture supply coming from frequent light showers with bright sunshine between them gives the highest yield.

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- The Cotton Belt is thus limited by the 20-inch isohyet on the west and 77°E isotherm in the north within which there are at least 200 days without frost. In the very south, in the Gulf-lands, the heavy rainfall damages the lint. This area is there-fore less suitable for cotton and is devoted to citrus fruits, cane sugar and market gardening, as in Florida.
- The commercial cultivation of cotton is now con-centrated only in the most favourable areas which are the **Mississppi** flood plains, the clayey Atlantic coastlands of Georgia and South Carolina, the Black Prairies of Texas and the Red Prairies of Oklahoma.
- The Sea Island cotton grown in the islands off the coast of Georgia and South Carolina is long-stapled (the fibres are between 1:5 and 2:3 inches in length) and is the best in the world. Further inland, the staples are shorter (about an inch long).
- This is typical of the bulk of the American cotton. Be-sides the problem of soil exhaustion and erosion caused by prolonged cotton cultivation, the most dreaded enemy of the Cotton Belt is the boll-weevil.
- The pest multiplies so rapidly that a pair of boll-weevils, if left unchecked, will breed over 10 million grubs within a single season! The pest is responsible for the westward migration of the Cotton Belt. When it first appeared in 1892 in the eastern U.S.A. it attacked the Sea Island cotton. Aerial spraying with insecticides and the thorough burning of old cotton stalks, have been found effective in eliminating the boll-weevil.

- **Tobacco**
  - Another interesting crop closely associated with the Gulf type of climate is tobacco, which incidentally is also a native crop of America. There is none so universally known as the Virginia tobacco. It is the raw material from which most of the world's cigarettes are blended to suit the smokers' taste.
  - The humid atmosphere, the warmth and the well-drained soils of the Gulf states, enable tobacco to be successfully cultivated in many of the eastern states of U.S.A., e.g. Virginia, Maryland, Georgia, North and South Carolina, Kentucky and Tennessee.
  - No less than half the tobacco that enters international trade comes from these states. Regardless of the views that doctors and school teachers may hold, cigar and cigarette-smoking has long been a universal habit that cannot be dispensed with. It is the basis of an industry and provides, through duty, a valuable source of income to the government.

- **Crop cultivation in the eastern margins of the southern hemisphere**
  - A close look at the economic map of the southern hemisphere will at once reveal the agricultural importance of its eastern margins which experience

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a Natal type of climate. The warm moist summers and frost-free winters not only the support many crops but also animals.

- In the coastlands of Natal, cane sugar is the dominant crop, followed by cotton and tobacco in the interior. Recent expansion of these crops has come about with improved irrigation. Maize is extensively cultivated for use both as mealie an important food item for Africans and silage', an animal fodder for cattle rearing.
- But in comparison with the maize yield of the Corn Belt of U.S.A., the African yield is rather low, often only half. Improvements can be made, if farmers attempt some form of crop rotation to arrest the rapid rate of soil exhaustion in regions of maize monoculture.
- In South America where rainfall is less than 40 inches there is much grassland on which many cattle and sheep are kept for meat, wool and hides. The products from these two kinds of domesticated animals account for over three-quarters of the annual exports of Uruguay. The remaining exports come mainly from wheat and flax.
- Further north in southern Brazil, the rainfall increases to more than 40 inches and forest gradually replaces grass. Here the important occupations are the cultivation of yerba mate (Paraguay tea) and the lumbering of and sheep are reared, and maize and cane sugar Cattle pine Parana araucaria or are grown.
- The region is now the chief source of Australia's milk, butter and cheese, besides cotton, cane sugar and maize which are increasingly grown in the north.

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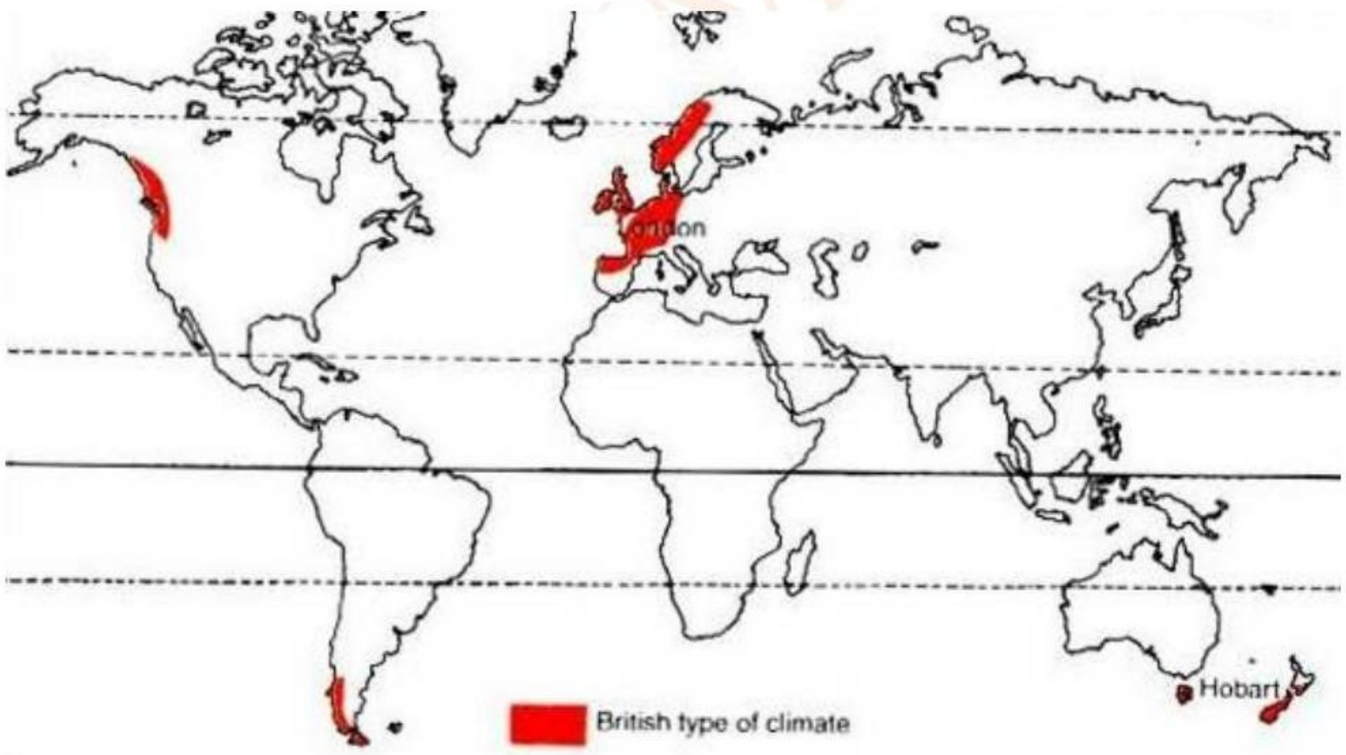
CHAPTER: 22 – THE COOL TEMPERATE WESTERN MARGIN (BRITISH TYPE) CLIMATE

Distribution

- The cool temperate western margins are under the permanent influence of the Westerlies all round the year. They are also regions of much cyclonic activity, typical of Britain, and are thus said to experience the British type of climate. From Britain, the climatic belt stretches far inland into the lowlands of North-West Europe, including such regions as of northern and western France, Belgium, and the Nether- lands, Denmark, western Norway and also north-western Iberia.
- There is so much oceanic influence on both the temperature and the precipitation that the climate is also referred to as the North-West European Maritime Climate. In North America, the high Rockies prevent the on-shore Westerlies from penetrating far inland and the British type of climate is confined mainly to the coastlands of British Columbia.
- In the southern hemisphere, the climate is experienced in southern Chile, Tasmania and most parts of New Zealand, particularly in South Island. The surrounding large expanses of water have increased the maritime nature of the climate here



Climate

- **Temperature**
  - The mean annual temperatures are usually between 40°F and 60°F. The warmest month in London as illustrated in the temperature graph of London (a) is 63°F and the coldest month is just around 40°F., thus giving an annual temperature range of only 24°F., which is comparatively small for its latitude (51°N.)
  - Summers are, in fact, never very warm. Monthly temperatures over 65°E even in mid-summer are rare. Heat of waves', as they are popularly called (that is a short spell of warm summer days) are a welcome feature in such cool temperate latitudes, where people do not often see enough of the sun.
  - This is attributable to the warming effect of the warm North Atlantic Drift and the prevalence of the South-Westerlies.
  - Sometimes, unusual cold spells, caused by the invasion of cold polar continental air from the interiors, may hit the western margins for a number of weeks. The climate of the maritime regions as a whole may be described as equable with moderately warm summers and fairly mild winters.
- **Precipitation**
  - The British type of climate has adequate rainfall throughout the year with a tendency towards a slight winter or autumn maximum from cyclonic sources. Since the rain-bearing winds come from the west, the western margins have the heaviest rainfall. The amount decreases eastwards with in-creasing distance from the sea.
  - Relief can make great differences in the annual amount. For example the western slopes of the Southern Alps of South Island, New Zealand have as much as 200 inches of rainfall

(mainly orographic rain) while the Canterbury Plain, in the rain-shadow area has as little as 25 inches.

- **The seasons**
  - As in other temperate regions there are four distinct seasons in the British climate type. Light snowfalls can be expected in the winter months normally only of short duration because of the comparatively mild weather.
  - But over the highlands such as the Scandinavian Mountains and the Ameri- can Rockies, snowfall is heavy and feeds the mountain glaciers that move down the valleys. Winter is the season of cloudy skies, foggy and misty mornings, and many rainy days from the passing depressions.

Natural Vegetation

- The natural vegetation of this climatic type is deciduous forest. The trees shed their leaves in the cold season. This is an adaptation for protecting frost themselves against the winter snow and frost. Some of the more common species include oak, elm, ash, birch, beech, poplar, and hornbeam. In the wetter areas grow willows, alder and aspen. Elsewhere are found other species, e.g. chestnut, sycamore, maple, and lime.
- Unlike the equatorial forests, the deciduous trees Occur in pure stands and have greater lumbering value from the commercial point of view. The open nature of the forests with sparse undergrowth is useful in logging operations. Easy penetration means much cost can be saved in the movement of the logs.
- The deciduous hardwoods are excellent for both fuel and industrial purposes. In Tasmania, the temperate eucalypts are also extensively felled for the lumbering industry. Higher up the mountains in the **Scandinavian highlands**, the Rockies, southern Andes and the Southern Alps of New Zealand, the deciduous trees are generally replaced by the conifers which can survive a higher altitude, a lower temperature and poorer soils.

Economic Development

- A very large part of the deciduous woodlands have been cleared for fuel, timber or agriculture. In Britain there is only 4 per cent of the original forest left. A large range of cereals, fruits and root crops are raised, mainly for home consumption rather than for export. North-West Europe.
- It is, in fact, a net importer of food- crops, especially wheat from almost all parts of the wheat lands for bread-making and other food items the region differs from many others in its unprecedented industrial advancement. Fishing is particularly important in Britain, Norway and British Columbia.
- **Market gardening**
  - Though market gardening is practised throughout the world wherever there is a large urban population, nowhere else is it so highly specialized as in North-West Europe. Several factors account for this. All the north-western European countries (Britain, France, West Germany, Benelux and Denmark).
  - Farms are normally small, Orated near large cities or industrial areas. Soils, whether silty, loamy or podzolic, are carefully maintained at a high degree of fertility. Very selective Fertilizers are applied depending on the type of crops in cultivation. Farming is carried out intensively, aiming at high yield and maximum cash returns. As the crops are perishable, a good network of trans- port is indispensable. The produce such as lettuces, cabbages, cauliflowers, tomatoes, onions, peas and fruits are seldom shipped but conveyed by high- speed conveyances such as trucks or vans. Perhaps a more appropriate term to use is truck farming, which is commonly used in the United States.

- Similarly, bulbs and flowers from the polder lands of the Netherlands and eggs, bacon and other dairy products from Denmark are sent to most of the major industrial centres of Europe in almost perfect condition for household consumption.
- In Australia, high-speed boats ply across the Bass Strait daily from Tasmania to rush vegetables, tomatoes, apples and beans to most of the large cities in mainland Australia. It is no wonder the Australians nicknamed Tasmania the 'garden state.

- **Mixed farming**
  - Throughout Britain and north-western Europe, farmers practise both arable farming (cultivation of crops on ploughed land) and pastoral farming (keeping animals on grass meadows). Crops may be raised for cash sales or as fodder for cattle or sheep.
  - Amongst the cereals, wheat is the most extensively grown, almost entirely for home consumption because of the very dense population in north-western Europe.
  - The next most important cereal raised in the mixed farm is barley. The better-quality barley is sold to the breweries for beer-making or whisky.
  - The most important animals kept in the mixed farm are cattle. North-western Europe was originally the home of many world renowned cattle breeds, e.g. Guernsey, Ayrshire and Friesian, which are first class dairy cattle for milk production.
  - Denmark comes high-quality butter, of which she ranks with New Zealand as one of the **world's greatest exporters**. In Devon and Cornwall clotted
- **Sheep rearing**
  - This is well developed in some parts of the British type of climate. Britain is the home of some of the best-known sheep breeds, eg. Leicesters, Lincolns and Southdowns' which are dual purpose, noted for mutton as well as wool.
  - With the greater pressure exerted on land by increased urbanization, industrialization and agriculture, sheep rearing is being pushed further and further into the less favoured areas. The principal sheep areas are on foothills, well-drained uplands, chalk and limestone Scarplands, and the light, sandy coasts.
  - In the southern hemisphere, sheep rearing is the chief occupation of New Zealand, with its greatest concentration in the Canterbury Plain. It has been estimated that for every New Zealander there are 20 sheep. Many factors have led to this unprecedented
- **Other agricultural activities**
  - Amongst the food crops, potatoes feature prominently in the domestic economy of the cool temperate regions. It is the staple food in supple menting wheat or bread for millions of people. In terms of starch, it yields far more food than any cereals and can be cultivated over a wide range of climatic and soil types.
  - But normally a cooler and more northerly latitude is preferred because the crop will be less prone to the attack of "**blight'**, a virus disease that is particularly infectious in warm and humid countries.
  - Today almost two-thirds of the world's annual production of potatoes comes from Europe, of which Poland, Germany, France and United Kingdom are the major producers. Besides its principal use

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as a substitute for bread, large quantities of potatoes are also consumed as animal fodder and as a source of industrial alcohol.

- Another interesting crop that is found almost exclusively in north-western Europe (including European U.S.S.R.) and parts of U.S.A. is beet sugar. The need for such a crop was greatly felt during the Napoleonic Wars around 1800 when military blockades caused a scarcity of sugar.
- The first beet sugar factory in Europe was established in 1801. The highest sugar yield is obtained when the autumn is both dry and sunny. Attempts to grow the crop in the colder north or the wetter west have so far been rather unsuccessful, except in some

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CHAPTER: 23 – THE COOL TEMPERATE CONTINENTAL (SIBERIAN) CLIMATE

Distribution

- The Cool Temperate Continental (Siberian) Climate is experienced only in the northern hemisphere where the continents within the high latitudes have a broad east-west spread. On its poleward side, it merges into the Arctic tundra of Canada and Eurasia at around the Arctic Circle. Southwards, the climate becomes less severe and fades into the temperate Steppe climate dealt with in Chapter 19.
- The predominant vegetation of this Siberian "sub-Arctic" type of climate is evergreen coniferous forest. It stretches in a great, continuous belt across North America, Europe and Asia. The greatest or single band of the coniferous forest is the taiga (a Russian word for coniferous forest) in Siberia.
- In Europe the countries that have a similar type of climate and forest are mainly in northern Europe, Sweden and Finland. There are small amounts of natural coniferous forest, due to high altitude, in Germany, Poland, Switzerland, Austria and other parts of Europe.
- In North America, this sub-Arctic belt stretches from Alaska across Canada into Labrador, and is found on the high Rocky Mountains farther south.
- The Siberian Climate is conspicuously absent in the southern hemisphere because of the narrowness of the southern continents in the high latitudes. The strong oceanic influence reduces the severity of the winter and coniferous forests are found only on the mountainous uplands of southern Chile, New Zealand, Tasmania and south-east Australia.

Climate

- **Temperature**
  - The climate of the Siberian type is characterized by a bitterly cold winter of long duration, and a cool brief summer. Spring and autumn are merely brief transitional periods. In comparison, the annual temperature range for Churchill is even higher, reaching 73°F (-19°F. in January and 54°F. in July). This is due to the more northerly position of Churchill. The extremes of temperature are so great in Siberia that it is often referred to as the 'cold pole of the earth'.
  - With such low temperatures in the cold season, heavy snowfall can be expected. Frosts occur as early as August and by September lakes and ponds are already ice-bound. All over Russia, nearly all the rivers are frozen. The number of days in which the rivers are frozen increases from south to north.
- **Precipitation**
  - The interiors of the Eurasian continent are so remote from maritime influence that annual precipitation cannot be high. Generally speaking, a total of 15 to 25 inches is typical of the annual precipitation of this sub-Arctic type of climate.
  - It is quite well distributed throughout the year, with a summer maximum from convectional rain when the continental interiors are greatly heated (mid-summer temperatures of 60° to 75°E. are quite usual and the maximum recorded in Siberia is a real surprise-102°F.).
  - The total precipitation of the Siberian climate is determined by such factors as altitude, latitude, proximity to the poles, amount of

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exposure to influences by Westerlies, (on western parts of continents), temperate monsoons (on the eastern parts of continents) and the penetration of the cyclones.

- Snow falls nearly everywhere in U.S.S.R. in the long, cold winter. The amount varies from place to place. It is heaviest in the northern tundra and in the Siberian taiga, where a thickness of several feet is common. Permanent snowfields like those of the Alps or the Himalayas are absent, because any accumulation of snow is melted with the return of spring and the warm summer. Frozen rivers are thawed, causing a rise in the water level and extensive floods occur.
- The lower courses of the Ob, Lena and **Yenisey** are marshy and ill-drained. Snow is a poor conductor of heat and protects the ground from the severe cold above, which may be as much as 30°-50°F colder. It also provides moisture for the vegetation when the snow melts in spring.

Natural Vegetation

- No other trees are as well adapted as the conifers to withstand such an inhospitable environment as the Siberian type of climate. The coniferous forest belts of Eurasia and North America are the richest sources of softwood for use in building construction, furniture, matches, paper and pulp, rayon and other branches of the chemical industry.
- The world's greatest softwood producers are U.S.S.R., U.S.A., Canada and the Fenoscandian countries (Finland, Norway and Sweden). In the production of wood pulp (by both chemical and mechanical methods), the U.S.A. is the leader. But in the field of newsprint, Canada has outstripped all other producers, accounting for almost half of the world's total annual production.
- There are four major species in the coniferous forests.
  1) Pine, e.g. white pine, red pine, Scots pine, Jack pine, lodgepole pine.
  2) Fir, e.g. Douglas fir and balsam fir.
  3) Spruce.
  4) Larch.
- Their presence in pure stands and the existence of only a few species are a great advantage in commercial forest exploitation.

Coniferous forests

1) **Coniferous forests are of moderate density** - The coniferous forests are more uniform and grow straight and tall, up to a height of about 100 feet. Where the poleward limit of tree growth is approached the trees are widely spaced, and give way to tundra vegetation.
2) **Almost all conifers are evergreen** - The low annual temperature with more than half the year below the growing-point temperature of 43°F, means that evergreens are at an advantage. Growth can begin as soon as growing-point is reached in spring. Food is stored in the trunks, and the bark is thick to protect the trunk from excessive cold.
3) **Conifers are conical in shape -** This is another adaption to survive the sub-Arctic climate. The sloping branches prevent snow accumulation which may snap the branches. It also offers little grip.
4) **Leaves are small, thick, and leathery and needle- shaped** - This is to check excessive transpiration. The leaf surface is reduced to the minimum, as the transpiration can be quite rapid in the warm summer due to intense continental heating.
5) **There is little undergrowth -** The podzolized soils of the coniferous forests are poor. They are excessively leached and very acidic. The evergreen leaves provide little leaf-fall for humus formation, and the rate of decomposition of the leathery 'needles' in a region of such low temperature is slow. Besides the continental interiors of the higher latitudes, coniferous forests are also found in other climatic

regions wherever altitude reduces the temperature.

Economic Development

- The coniferous forest regions of the northern hemisphere are comparatively little developed. Only in the more accessible areas are the forests cleared for lumbering.
- There is little agriculture, as few crops can survive in the sub-Arctic climate of these northerly lands. The long, cold winter, the frozen soils and the low mean annual temperature throughout the year exclude all but the hardiest crops.
- Only in the more sheltered valleys and the lands bordering the steppes are some cereals (barley, oats, rye) and root crops (potatoes) raised for local needs. Many of the Samoyeds and Yakuts of Siberia, and some Canadians are engaged in hunting, trapping and fishing. We shall deal with two of the major activities in greater detail.
- **Trapping**
    - Many fur-bearing animals inhabit the northerly lands of Canada and Eurasia. Wherever the cold is keenest, the quality and thickness of the fur also increases.
    - Consequently, the most severe winters produce the finest furs which fetch the highest prices. In Canada trappers and hunters, armed with modern automatic rifles, reside in log cabins in the midst of the coniferous forests to track down these animals.
    - Animals such as the silver fox and ermine are kept in captivity, and skinned when the furs reach a marketable stage.
- **Lumbering**
    - This is probably the most important Occupation of the Siberian type of climate. The trees are felled for many purposes.
        - **a)** Saw-milling
        - **b)** Paper and pulp industry
        - **c)** As a fuel
        - **d)** As an industrial raw material
    - **Is characterized by the following features: -**
        - **1)** The conifers are limited in species. Pine, spruce and fir are the most important in the northern forests, while larch is more predominant in the warmer south. They occur in homogeneous groups and not mixed as in the tropical forests.
        - **2)** In these northerly latitudes, agriculture is almost impossible and lumbering replaces farming in the continental interiors.
        - **3)** Lumbering is normally carried out in the winter felling when the sap ceases to flow. This makes felling much simpler. The snow-covered ground also makes logging and haulage a relatively easy job. The logs are dragged to the rivers and float to the saw- mills downstream when the rivers thaw in spring.

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CHAPTER: 24 – THE COOL TEMPERATE EASTERN MARGIN (LAURENTIAN)

Distribution

- The Cool Temperate Eastern Margin (Laurentian) Climate is an intermediate type of climate between the British and the Siberian type of climate. It has features of both the maritime and the continental climates. It is apparent from the **Laurentian type of climate** is found only in two regions.
- One is north-eastern North America, including eastern Canada, north-east U.S.A., (i.e. Maritime Provinces and the New England states), and Newfoundland. This may be referred to as the North American region. The other region is the eastern coastlands of Asia, including eastern Siberia, North China, Manchuria, Korea and northern Japan. It may be referred to as the Asiatic region.
- In the southern hemisphere, this climatic type is absent because only a small section of the southern continents extends south of the latitude of 40°S. Elsewhere in the southern hemisphere, the climate is so equable and the oceanic influence is so profound that neither the continental nor the eastern margin type of climate exists.

Climate

- The Laurentian type of climate has cold, dry winters and warm, wet summers. Winter temperatures may be well blow freezing-point and snow falls to quite a depth. Summers are as warm as the tropics (70°-80°F.) and if it were not for the cooling effects of the off-shore cold currents from the Arctic, the summer might be even hotter.
- Though rain falls throughout the year, there is a distinct summer maximum from the easterly winds from the oceans. Of the annual precipitation of 30 to 60 inches, two-thirds come in the summer. Winter is dry and cold, because the winds are dry Westerlies that blow out from the continental interiors.
- **The North American region**
    - The most remarkable characteristic of the Laurentian climate of the North. American region is its uniformity in precipitations (about 3 to 4 inches monthly) with a late summer maximum. New York has an annual precipitation of 41 inches with the wettest months in July and August (4.2 inches each).
    - No month is really dry, and the driest month, November, has 2.5 inches of rain. This uniformity of precipitation is largely due to the Atlantic influence and that of the Great Lakes. The warm Gulf Stream increases the moisture content of easterly winds from the open Atlantic.
    - The prevailing Westerlies which penetrate across the Rockies carry depressions over the Great Lakes to the New England states. These winds thus promote wet conditions especially in winter, which are vital for the agricultural activities of north- eastern North America.
    - The meeting of the warm Gulf Stream and the cold Labrador Current on coastal waters off Newfoundland produces dense mist and fog and gives rise to much precipitation.
    - In summer the Westerlies bring less depressions and extend their continental influence to the coast. Temperatures are normally high in summer for the latitude. New York has a mean July temperature of 74°F and sometimes even as high as 90°F.

- **The Asiatic region**
    - In contrast, the rainfall distribution of the Asiatic region is far less uniform. Winters are cold and very dry while summers are very warm and exceptionally wet.
    - The rainfall regime, is, in fact, similar to that of the tropical monsoon type in India, where the whole years rainfall is concentrated in the three summer months
    - The mountainous interior of China has such pronounced continental effects that the intense heating in summer creates a region of extreme low pressure, and moisture-laden winds from the Pacific Ocean and the Sea of Japan blow in as the South-East Monsoon. The Laurentian type of climate here is often described as the Cool Temperate Monsoon Climate.
    - The climate of Japan is modified by its insularity and also by the meeting of warm and cold ocean currents. It receives adequate rainfall from both the South-East Monsoon in summer and the North-West Monsoon in winter.
    - The latter is the dry, cold wind from mainland Asia, but after crossing the Sea of Japan it has gathered sufficient moisture to give heavy relief rain or snow on the western coasts of Japan. The rainfall is more evenly distributed, as in Tokyo, with two maxima, one in June, the Plum Rain (6.5 inches), and the other in September, the Typhoon Rain (9 inches).

Natural Vegetation

- The predominant vegetation of the Laurentian type of climate is cool temperate forest. The heavy rainfall, the warm summers and the damp air from fogs, all favour the growth of trees.
- Generally speaking, the forest tend to be coniferous north of the 50°N parallel of latitude.
- In the Asiatic region (eastern Siberia and Korea), the coniferous forests are, in fact, a continuation of the great coniferous belt of the taiga.
- South of latitude 50°N., the coniferous forests give way to deciduous forests. Oak, beech, maple and birch are the principal trees. Like their counter- parts on the western margins, the deciduous forests are fairly open.

Economic Development

- Lumbering and its associated timber, paper and pulp industries are the most important economic under- taking.
- Agriculture is less important in view of the severity of the winter and its long duration. Pota- toes thrive over large areas of the podzolized soils, while hardy cereals like oats and barley can be sown and successfully harvested before the onset of the cold winter. A number of other interesting crops are produced in the Asiatic region such as soya beans.
- The fertile Annapolis valley in Nova Scotia is the world's most renowned region for apples. Fishing is, however, the most outstanding economic activity of the Laurentian climatic regions.

Fishing

- **Fishing off Newfoundland, the Maritime Provinces and New England**
    - This is one of the world's largest fishing grounds. The reasons for its importance are particularly on the Grand Banks of Newfoundland geographical. Fish feed on minute marine organ- Isms, collectively called plankton, which is present in abundance only in shallow waters adjacent to land masses, where sunlight can penetrate through.
    - The gently sloping continental shelves (less than 600 feet deep) which stretch for over 200 miles

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south-east of Newfoundland, and off the coasts of the Maritime Provinces and New England contain rich collection of microscopic plankton.

- Fish of all types and sizes feed and breed here and support a thriving fishing industry not only in Canada and U.S.A., but also in countries like Norway, France Britain, Portugal, Denmark, Russia and Japan, who send fishing fleets to the Grand Banks.
- Cod liver oil is exported too. Other fishes caught are haddock, halibut, hake, herring, plaice, and mackerel. Various kinds of fishing craft and techniques are employed to obtain maximum harvests from the sea. Modern trawlers, dragging large conical-shaped nets, and drifters, carrying curtain-like rectangular nets, operate extensively off the Atlantic coasts.
- Off-shore fishermen also use traps, lines and nets to catch crabs, lobsters and shrimps for home consumption and increasingly for export. Further inland, in lakes and rivers, such as the St. Lawrence and the Great Lakes, freshwater fish, e.g. salmon, trout, eels and sturgeons are caught.

- **Fishing off Japan**
- In the north-west Pacific, fishing area of the world. The scarcity of meat (there is little pasture in Japan for livestock farming of any kind) and religious reasons have popularized fish as the principal item of diet and the chief protein food of the Japanese and the Chinese as well.
- The Japanese also make use of fish wastes, fish meal and seaweeds as fertilizers in their farms. Japan is one of the few countries that has taken to seaweed cultivation.
- Another interesting aspect of Japanese fishing is pearl culture. The divers of southern Japan dive down into the coastal waters and bring to the surface shell-fish called pearl oysters and extract the highly prized pearls for sale as ornaments.
- The Japanese interest in fishing is not confined to their own territorial waters, they venture far and wide into the Arctic, Antarctic and the Atlantic waters. Large whaling fleets complete with processing plants and experienced crews stay out in the open seas and return only occasionally for refuelling or replenishment of fresh provisions.
- **Let us find out why this is possible.**
  1) Japan is not well endowed with natural resources, for as much as 80 per cent of her land is classed non-agricultural.
  2) The continental shelves around the islands of Japan are rich in plankton, due to the meeting of the warm Kuroshio and the cold Oyashio currents
  3) The indented coastline of Japan, provides sheltered fishing ports, calm waters and safe landing places, ideal for the fishing industry.
  4) Lack of lowlands and pastures means that only a few animals can be kept to supply meat and other protein food. Fish, in all its varied forms, fresh, canned, dried, frozen, and in the form of fish pastes, fish sauce and spiced condiments takes the place of meat as Japan's primary source of protein food.

CHAPTER: 25 – THE ARCTIC OR POLAR CLIMATE

Distribution

- The polar type of climate and vegetation is found mainly north of the Arctic Circle in the northern hemisphere. The ice-caps are confined to Greenland and to the highlands of these high-latitude regions, where the ground is permanently snow-covered.
- The lowlands, with a few months ice-free, have tundra vegetation. In the southern hemisphere, the virtually uninhabited continent of Antarctica is the greatest single stretch of ice-cap where the layers of permanent ice are as thick as 10,000 feet.

Climate

- **Temperature**
  - The polar climate is characterized by a very low mean annual temperature and its warmest month in June seldom rises to more than 50°F. In mid-winter (January) temperatures are as low as -35°F and much colder in the interior. Normally not more than four months have temperatures above freezing-point.
  - Within the Arctic and Antarctic Circles, there are weeks very of continuous darkness. At the North Pole, there are six months without light in winter. Despite the long duration of sunshine in summer, when the sun does not set, temperatures remain low because the sun is low in the sky and much of the warmth of its faint rays is either reflected by the ground snow or used up in melting the ice.
  - The ground remains solidly frozen for all but four months, inaccessible to plants. Frost occurs at any time and blizzards, reaching a velocity of 130 miles an hour are not infrequent. In coastal districts, where warmer water meets cold land thick fogs may develop. They last for days, and in many instances, it is not possible to see for more than a few feet.
- **Precipitation**
  - Precipitation is mainly in the form of snow, falling in winter and being drifted about during blizzards. Snowfall varies with locality; it may fall either as ice crystals or large, amalgamated snowflakes.
  - As it takes **10-12 inches of snow to make 1 inch of rain**, precipitation in polar regions can be expected to be light, not more than 12 inches in a year. Convectional rainfall is generally absent because of the low rate of evaporation and the lack of moisture in the cold polar air. There is normally a summer maximum, and the precipitation is then in the form of rain or sleet.

Tundra vegetation

- The greatest inhibiting factor is the region's deficiency in heat. With a growing season of less than three months and the warmest month not exceeding 50°F. (The tree-survival line), there are no trees in the tundra. Such an environment can support only the lowest form of vegetation mosses, lichens and sedges. Drainage in the tundra is usually poor as the sub-soil is permanently frozen.
- Climatic conditions along the coastal lowlands are a little more favourable. Here are found some hardy grasses and the

reindeer moss which provide the only pasturage for the herbivorous animals like reindeer.

- In the brief summer, when the snows melt and the days are warmer and longer, berry-bearing bushes and Arctic flowers bloom. Though short-lived, they brighten the monotonous tundra landscape into Arctic prairies. Mammals like the wolves, foxes, musk-ox, Arctic hare and lemmings also live in tundra regions.

Human Activities

- Human activities of the tundra are largely con- fined to the coast. The few people who live in the tundra live a semi-nomadic life and have to adapt themselves to the harsh environment.
- In Greenland, northern Canada and Alaska live the Eskimos, numbering less than 28,000 today. They used to live as hunters, fishers and food- gatherers but in recent years more and more of them are settling in permanent huts.
- During winter they live in compact igloos and in summer when they move out to hunt they pitch portable tents of skins by the side of streams.
- Other Eskimos hunt caribou (the name given to reindeer in America) and other animals to secure a steady supply of their daily meat, milk, fat, skins and bones.
- Coastal villages have permanent wooden houses complete with modern facilities; speed-boats are replacing frail kayaks. Deadly rifles instead of traditional harpoons are used to track down animals and seals. Furbearing animals are being reared on a commercial scale and fishing, too, is being commercialized.
- In the Eurasian tundra are other nomadic tribes such as the Lapps of northern Finland and Scandina- via, the Samoyeds of Siberia (from the Ural Mountains and the Yenisey basin), the Yakuts from the Lena basin, and the Koryaks and Chuckchi of north-eastern Asia.

The Importance and Recent Development of the Arctic Region

- New settlements have sprung up because of the discovery of minerals. Gold is mined in Alaska, nickel, near petsamo U.S.S.R., petroleum in the Kenai Peninsula, Alaska: and copper at the Rankin Inlet, Canada. Coal has been mined in Spitsbergen for a long time and also in Alaska.
- More iron from large iron ore deposits in Labrador. New railway lines have been constructed to bring the ores to the St. Lawrence River for subsequent shipment to the major industrial districts. Rich deposits of iron ores at **Kiruna and Gallivare in Sweden.**
- With the establishment of ports on the Arctic seaboard of Eurasia, it is now possible to ship timber and fur from Siberia. Though the ports, such as **Igarka** at the mouth of the **Yenisey**, are not ice free, modern ice-breakers keep the passage open most of the time. It may not be long before the tundra is brought under greater agricultural, especially past- oral, use.