COMPLETE
PHYSICAL GEOGRAPHY WITH MAP WORK ELEMENTS

STUDENT'S BOOK 3

Hudson Kelvin Gareta (MEDLM, BAED)

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INTRODUCTION

"*Complete Physical Geography with Map Work Elements, Student's Book 3*" is a book that is based on the current secondary education curriculum of Malawi. This is an outcome based curriculum that seeks to demonstrate what students should be able to do at the end of the course. Outcome-based education is an approach to education in which decisions about the curriculum are driven by existing outcomes that the students should display at the end of the course. This publication tackles such units as Map Work and Interpretation of Geographical Information, Understanding the Earth, Environmental and Natural Resource Management and Interdependence between Malawi and the World. Therefore, rely on it, you will find it very helpful.

TOPIC 1

Map Work and Statistical Methods in Geography

Success criteria:

By the end of this topic, the student should be able to:

- Interpret map symbols in relation to land use.
- Explain factors that affect land use patterns.
- Identify various landforms on topographical maps.
- Draw cross-sections of selected landforms from topographical maps.
- Identify riverine features on a topographical map.
- Identify coastal features on a topographical map.
- Measure distances between points.
- Calculate areas on a map.
- Draw cross-sections and river profiles.
- Reduce and enlarge maps.
- Calculate gradient between two points.
- Identify various ways of collecting geographical data.
- Design data collection instruments.
- Collect data using appropriate instruments.
- Analyse data using appropriate procedures.

Background

In Form One, you learnt about the following: Maps and their components, types and uses of maps, map symbols and conventional signs, location and grid reference, direction and bearing. In Form Two, you learnt about: Longitudes and latitudes, contour patterns, relief, gradient, land use, drainage patterns, cross-sections and long profiles, riverine and coastal features. In Form Three, you will learn about important map reading and interpretation skills which include land use, landforms, riverine and coastal features. You will further look at map work in line with measurement of distance, calculation of area, cross-sections and river profiles, reducing and enlarging maps as well as calculating gradient.

MAP WORK

Measurement of distance between two points on a topographical map

(a) Methods used for measuring straight distances

In order to measure distance between two points on a straight line, the following methods are recommended:

1. Using a strip of paper with straight edges

Procedure:

Step one: Place the strip of paper along the straight line of the distance between the two points.

Step two: Mark off the distance between the two points on the paper, and place it onto the linear scale and read off the actual measurements.

2. Using a pair of dividers or compasses

Procedure:

Step one: Span the distance with a pair of dividers or compasses.

Step two: Place the span against the line or linear scale in order to obtain actual measurements. Refer to the figure below:

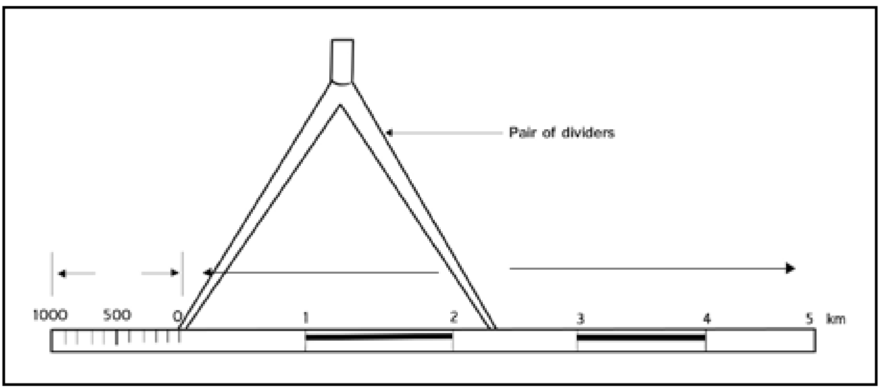


Fig. 1.1.1: A pair of dividers on a straight line distance

3. Using a thread

Procedure:

Step one: Stretch the piece of thread between the two points on the topographical map. Mark the string at the point where the line ends.

Step two: Take this piece of thread and place it against the linear scale.

Step three: Measure the distance beginning from zero to the right.

4. Using a ruler

Procedure:

Step one: Put the ruler between the two points on the topographical map in order to read the distance.

Step two: Take this distance onto the linear scale for measurements.

(b) Methods used for measuring curved or winding distances

In order to measure curved distances, the following methods are recommended:

1. Using a pair of dividers or 'Cut and measure them all' method.

Procedure:

Step one: Identify the distance and mark the end points with capital letters on the topographical map.

Step two: Mark off the nearly straight portions of the road, railway line or river with a sharp pencil. Join these portions together with a smooth line.

Step three: Using a pair of dividers, transfer the distance from the winding road, railway line or river to a piece of paper starting from the first to the last point.

Note: In order to avoid measuring one of the portions twice, put a mark, tick, number or indicate with an alphabet letter every measured section as shown below.

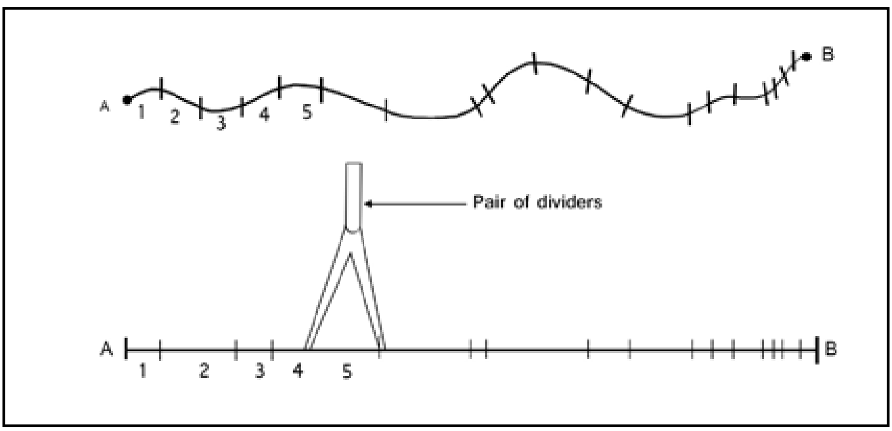


Fig. 1.1.2: How to transfer distance of winding rivers, railway lines and roads from the topographical map onto a piece of paper

Step four: Take a ruler and measure the distance of the portions on the piece of paper.

Step five: Convert this distance to the actual length using the linear scale given.

2. Using a string or thread

Procedure:

Step one: Lay or place the string or thread along the route between two points.

Step two: Using a pen, mark on the string or thread the starting point. Follow the route up to the second straight point and mark this point on the string or thread.

Step three: Using the second point as your starting point, straighten out the string or thread and measure the distance of the next straight portion (These straight portions can be marked on the paper before measuring). Continue with this process until you reach the final marked point. Mark the end point on the string or thread.

Step four: Put the string or thread on the linear scale to measure the marked points. Read off the distance.

How to read off the distance onto the linear scale

Points to remember:

1. Always start from zero on the linear scale and not from 1. Then move to the right side of the zero.
2. All whole numbers are measured to the right side from zero.
3. All fractions are measured to the left hand side from zero.
4. The final answer is the total of the whole number plus that of fractions.

Activity 1.1.1:

In pairs, measure the length of M17 road on the topographical map extract of Salima (page 28), using the methods that you have learnt.

CALCULATION OF AREA ON THE MAP

Ways of calculating area of regular and irregular shapes

In order to calculate area of any feature, it is important to categorise the feature as either regular or irregular.

(a) Calculating area of a regular shaped-feature

Regular-shaped features include squares, rectangles, circles and triangles. These features have specific formulae that can be used to calculate their areas.

Area of a square = Side × Side (S^2).

Area of a rectangle = Length × Width/breadth (L×W).

Area of a circle = Pie × Radius × Radius (πr^2).

Area of triangles = ½ Base × Height (½bh)

Example:

Calculate the area that is between the East of Easting 54 and North of Northing 72 on the topographical map extract of Salima on page 28.

Solution:

Count the number of boxes or squares available in the area given.

Measure the length of one side of the square on the map in centimetres. Then convert this length to the actual length on the ground using the linear scale, that is, 2 cm represents 1 km.

Area of 1 full square = 1 km × 1km

= 1 km^2

Number of squares = 8 (Actual area of 1 square = 1 km^2)

Therefore area covered by this section

= 8 squares × 1 km^2 = **8 km^2**

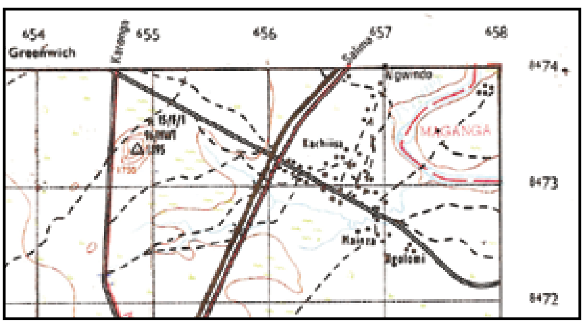


Fig. 1.1.3: Calculating the area of a regular shaped feature

Activity 1.1.2:

Individually, calculate the area to the East of Easting 56 and North of Northing 68 on the topographic map extract of Salima.

(b) Calculating area of an irregular-shaped feature

Irregular-shaped features are those that have no distinct shape. They have irregular boundaries. Examples of irregular features include natural forests, game reserves and national parks. In order to calculate their areas, you should subdivide the feature into equal squares. Complete or full squares are counted as one, while incomplete squares are counted as halves.

$$\text{Area of any irregular-shaped feature} = \left(\text{Number of full boxes/squares} + \frac{\text{Number of half boxes/squares}}{2}\right) \times \text{Actual Area of 1 full square}$$

Note: A full or square box is the one that is fully covered without leaving any space. A half box is any box or square that is incomplete. It does not imply that half boxes should be exactly half, that is, they can be one third, three quarters, two fifth, and so on.

Example:

Calculate the area covered by Kachere Forest Reserve in the figure below.

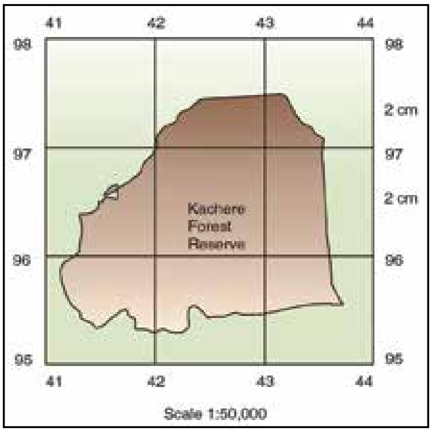


Fig 1.1.4: Kachere Forest Reserve

$$\text{Area covered by Kachere Forest Reserve} = \left(\text{Number of full boxes/squares} + \frac{\text{Number of half boxes/squares}}{2}\right) \times \text{Actual Area of 1 full square}$$

Total number of squares $= 1 + \frac{7}{2} \quad = 1 + 3.5$

$= 4.5$ full squares

Area of 1 full square $= 1 \text{ km} \times 1\text{km} = 1\text{km}^2$

(Each square is 2 cm by 2cm on the topographical map which is equivalent to 1 km × 1 km)

Therefore, area covered by Kachere Forest Reserve $= 4.5 \text{ full squares} \times 1 \text{ km}^2$

$= 4.5 \times 1 \text{ km}^2$

$= \mathbf{4.5\ km^2}$

Activity 1.1.3:

Individually, calculate the area covered by Livunzu estate on the topographical map extract of Nkhate (page 27).

DRAWING CROSS-SECTIONS AND RIVER PROFILES

Meaning of a cross-section

A cross-section is a side view of a piece of land between two points. It is used to determine the gentleness or steepness of land between two points. It is a graphical representation of landforms between two points.

Ways of drawing a cross-section

A cross-section is drawn by using two scales namely:

1. Vertical scale

- It is used to plot values on the Y-axis.
- It is used to determine the height of the Y-axis.
- It is indicated on the Y-axis after drawing it.
- It can either be reduced or enlarged.

2. Horizontal scale

- It is used to plot values on the X-axis.
- It is indicated below the X-axis.
- It is taken from the topographical map, that is, the Representative Fraction scale on the map is the one that is indicated below X-axis.
- It is therefore the same as the one used on the map extract because it represents the same distance between two points on the map.

Procedure for drawing a cross-section

There are steps to be followed as one draws a cross-section. These steps are:

Step one: Join two points on the topographical map with a straight line.

Step two: Place a straight edged paper along the line on the map and mark the start and the end points, noting the altitudes of the two points. Mark points where each contour line crosses the line. Note the altitudes of such points.

Step three: Plot the Y-axis and indicate values on it corresponding to the height of contour lines. It is advisable to use the vertical scale and vertical interval in order to determine height or the highest value of the Y-axis. For example, if the vertical scale is 1 cm represents 50 ft and the vertical interval (difference between highest and lowest is 7) then 350 ft will be represented by 7 cm, 150 ft by 3 cm and 200 ft by 4 cm. That is,

If 50 ft $\rightarrow$ 1 cm

Then 200 ft $\rightarrow$?

$$\rightarrow \frac{200 \text{ ft} \times 1 \text{ cm}}{50 \text{ ft}} = \mathbf{4 \text{ cm}}$$

This means that a vertical line or a Y-axis whose height is 4 cm is required for a cross-section having 200 ft.

Step four: Plot the X-axis or baseline. This X-axis should be of the same length as the distance between the two points on the map. The length of the X-axis does not change as doing so can distort the meaning.

Step five: Place your straight-edged paper along the X-axis or baseline and mark the values of each point.

Step six: Plot your graph line joining all coordinate points. This line shows the way land can be seen physically.

Step seven: Then shade the area under the graph line.

Ways of indicating rivers and roads after drawing a cross-section

Rivers are indicated by drawing a winding line with a black arrow pointing exactly where the river is passing on the X-axis. On the other hand, roads are indicated by putting a mark above the graph line and not on the X-axis. Note that the mark has to be exactly above the point marked on the X-axis.

Example:

In pairs, using pencils, rulers and strips of papers, follow the procedure above to draw a cross-section of the area along Northing 65 from Easting 58 on the map extract of Salima. On it show M17 road, M5 road, the railwayline and the river. Use a vertical scale of 1cm represents 50ft.

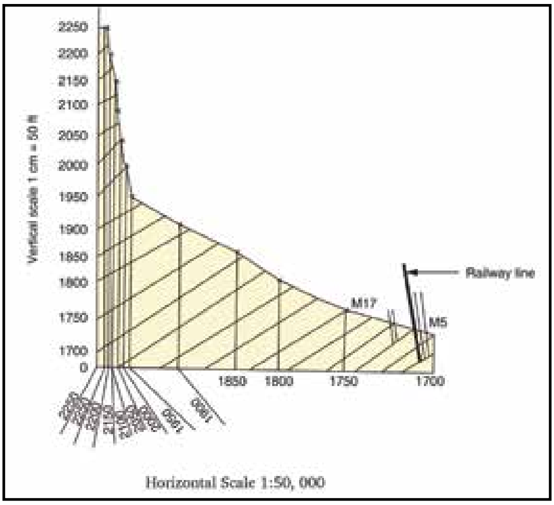


Fig. 1.1.5: Cross-section of area between Easting 53 and 54 along Northing 66

Activity 1.1.4:

In pairs, use the following diagram to draw a cross-section of area between points S and T. On it show Kamwendo River. Use the vertical scale 2 cm rep. 50ft.

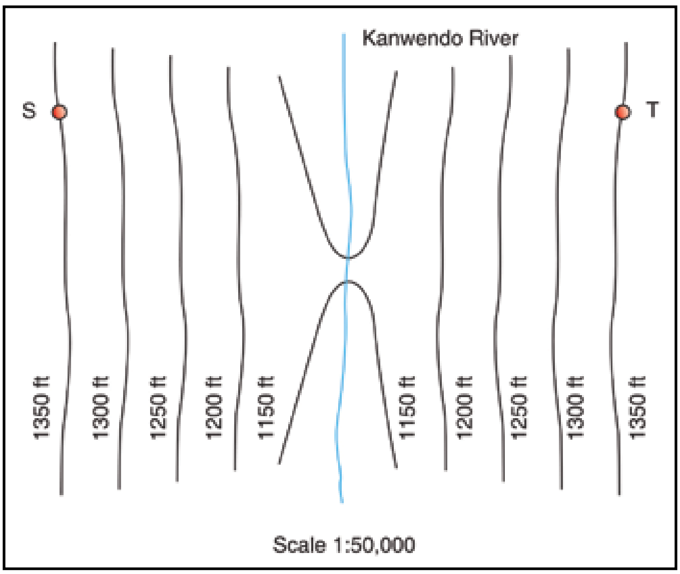


Fig. 1.1.6: Various heights between points S and T

DETERMINATION OF INTERVISIBILITY

Meaning of the term intervisibility

Intervisibility is the ability to see one place from another place. This simply means that if one point is visible from another, then the two points are said to be intervisible.

Ways of finding intervisibility between two points

Example:

Find out whether points S and T in Activity 1.1.4 are intervisible.
Explain your answer.

Procedure for finding intervisibility

Step one: Identify the two points on the topographical map.

Step two: Find their altitudes.

Step three: Join the two points with a straight line using a pencil.

Step four: Note the values of all points where contour lines cut the line joining the two points, that is, S and T.

Note: If one or more contour lines have values which are higher than those of points S and T, then the two points are not intervisible. This is because there is a highland in between them. However, if there is none, then the two points are intervisible. This is because there is no barrier in between them.

Therefore, S and T are intervisible because there is no barrier in form of a hill or a mountain in between them. The values between S and T are lower than those of these two points.

If it is not possible to determine intervisibility by following the procedure above, then this may be done by drawing a cross-section between the two points. After drawing the cross-section join the two points by a straight line referred to as a *visibility line*. If all or part of the cross-section is above the visibility line, then the two points are not intervisible. However, if the cross-section is below the line, then the two points are intervisible.

Activity 1.1.5:

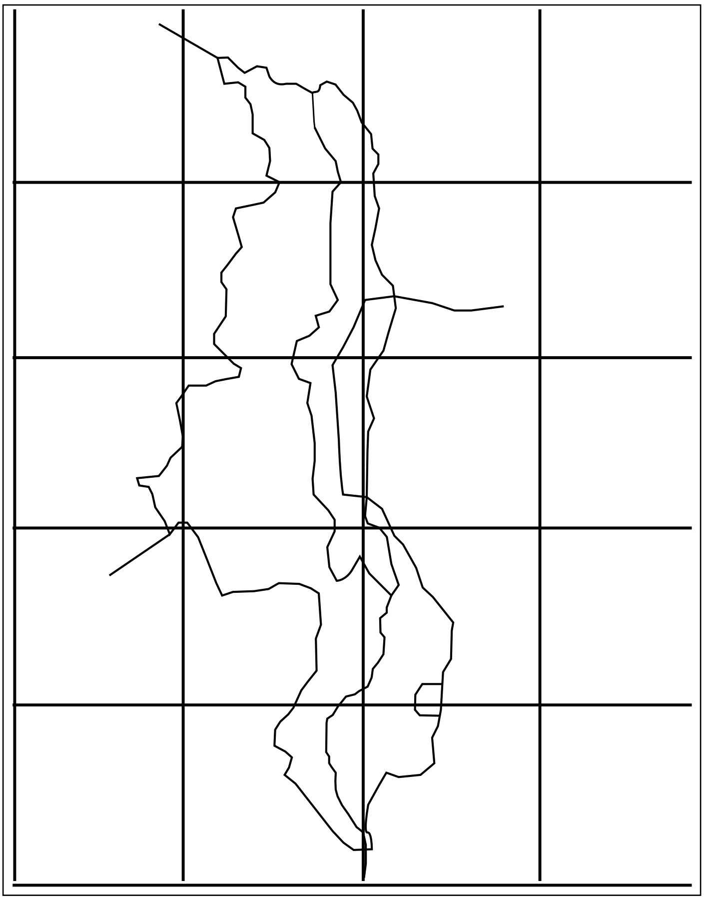
In pairs, find out whether Chiwaya borehole BHY105 and Ngolomi F.P. School are intervisible on the topographical map extract of Salima. Explain your answer.

MAP REDUCTION AND ENLARGEMENT

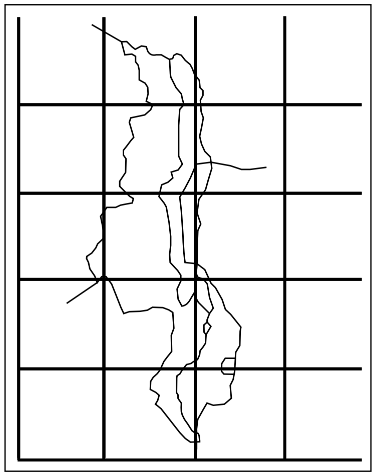
(a) Map reduction

In order to reduce a feature on a topographical map or part of the map, follow the procedure below.

Example: Reduce the map of Malawi below by half.



Scale 1:50,000



Scale 1:100,000

Fig. 1.1.7: Reduced and enlarged map of Malawi

Identify the boundary of the feature → Draw the reduced boundary on the space provided → Draw the new grid → Copy new details from the original grid → Reduce the scale

Fig. 1.1.8: A flow diagram showing the procedure for map reduction

Procedure:

Step one: Identify the boundary of the feature or part of the map under consideration. Use a piece of ruler in order to reduce the boundary by half. Then draw the reduced boundary on the piece of paper. This drawing of the reduced boundary will help you to reduce the grid.

Step two: Draw the reduced new grid for the map of Malawi. Make the side of each square or block exactly half the original one.

Step three: Copy the details of the map from the original grid to the new one.

Step four: It is important to reduce the scale that is below the original grid. You learnt in Form One how to reduce the scale. The scale that is on the topographical map must be multiplied by ½. This will increase the denominator by exactly twice its original size.

Activity 1.1.6:

In pairs, reduce part of the topographical map of Salima by half between Eastings 53 and 58 and Northings 70 and 74. On the reduced part of the map, show the two roads M17 and M5 as well as all villages.

(b) Map enlargement

In order to enlarge the feature on the topographical map or part of the map twice its original size, follow the procedure below.

Example:

Enlarge the map of Malawi twice its original size.

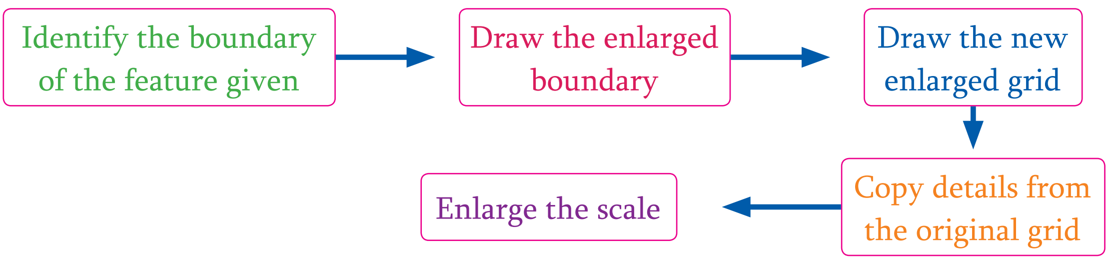


Fig. 1.1.9: A flow diagram showing the process of map enlargement

Procedure:

Step one: Identify the boundary of the feature or part of the map under consideration. Use piece of ruler in order to enlarge the boundary twice its original size. Then, draw the enlarged boundary on the piece of paper. This drawing of the enlarged boundary will help you to enlarge the grid.

Step two: Draw the enlarged new grid for the map of Malawi. Make the side of each square or block exactly twice the original one.

Step three: Copy the details from the original grid to the new one.

Step four: It is important to enlarge the scale that is below the original grid. You learnt in Form One how to enlarge scales. The scale that is on the topographical map must be divided by ½. This will reduce the denominator by exactly half.

Activity 1.1.7:

Individually, enlarge Kachere Forest Reserve twice its original size.

Advantages of the reduced maps

- They enable a relatively large part of the earth to be squeezed on a small part. Hence the information of such a large part is ably shown on a small space on paper.
- They are useful in showing fewer features.

Advantages of enlarged maps

- They show more details in that many features can easily be seen.

CALCULATION OF GRADIENT

Terminologies:

- Gradient: Gradient is the angle of slope of land. It is also expressed as a ratio of the height between two points on land to the distance between them.
- Vertical Interval (V.I.): This is the difference in height between two points (highest and lowest points) on a topographical map.
- Horizontal Equivalent (H.E.): This is the actual distance between two points on the actual ground.

Procedure for calculating gradient

Step one: Draw the line joining the two points on the topographical map given.

Step two: Find the vertical interval (V.I.) by finding the difference between the highest and lowest points. (Find altitudes of the two points given to know which point is the highest and lowest).

Step three: Find the horizontal equivalent (H.E.) by measuring the length of the line that you have drawn joining the two points. Thereafter, transfer this length from the topographical map onto the linear scale in order to convert it to actual distance on the ground.

Step four: Substitute the values into the formula given below.

$$\textbf{Gradient (AB)} = \frac{\text{Vertical Interval (BC)}}{\text{Horizontal Equivalent}}$$

Mathematically,

Hypotenuse

$$= \frac{\text{Opposite}}{\text{Adjacent Side}}$$

$$\textbf{AB} = \frac{BC}{AC}$$

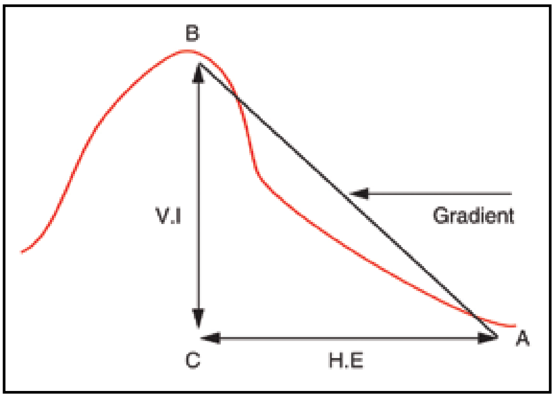
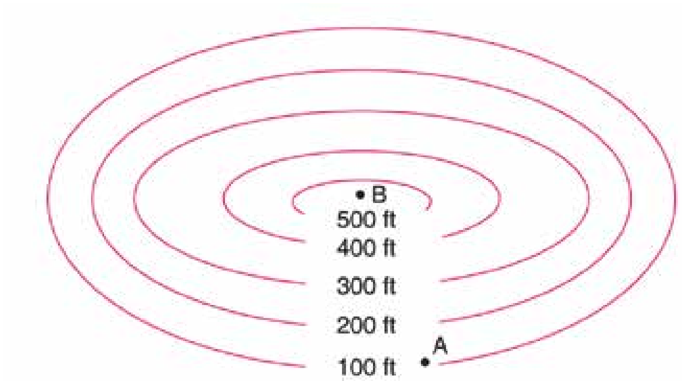


Fig. 1.1.10: How to calculate gradient between two points

HOW TO FIND VERTICAL INTERVAL

We simply subtract the lowest value at the lowest point/ place in altitude from the highest value at the highest point given.



Scale 1:50,000

Fig. 1.1.11: How to find the vertical interval

From Fig.1.1.11, the Vertical Interval = 500 ft – 100 ft = **400 ft**

WAYS OF FINDING HORIZONTAL EQUIVALENT

There are several ways of finding horizontal equivalent. These include the following:

(a) Take a ruler to measure the distance between the two points given. Then, convert to the actual length on the ground by using the scale or simple mathematical solving.

(b) Use a string to transfer the distance between the two points given. Later on transfer the distance to the linear scale.

(c) Use a piece of paper to measure the distance and transfer it to the linear scale in order to convert it to the actual length on the ground. One centimetre between points A and B will give us half a kilometre on the linear scale since 1 centimetre represents $\frac{1}{2}$ km if the scale is 1:50,000.

Ways of converting distance on the topographical map to actual length on the ground

1. Using the linear or line scale

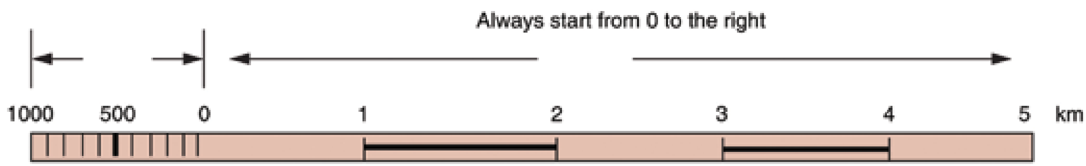


Fig. 1.1.12: A linear or line scale

Take the measured distance from the topographical map onto the linear scale. Then, begin from zero and move to the right and take note of the whole number that you have found. If there is a fraction remaining, bring it to the fraction side and begin from zero to the left. The answer will be given by the sum of the whole number and the fraction.

2. Using simple mathematical method

Normally, there is a scale given for uniformity purposes and the value of the horizontal equivalent is always larger as compared to the value of vertical integration. This is because H.E relates to the actual distance on the ground. Therefore, the units must be made the same by proper conversion. The answer has no values because the units cancel out each other at this stage. The answer can be a fraction, ratio or a decimal number.

Note: It is important to always remember to make the numerator 1. This can be done by dividing the numerator by itself and then divide the denominator by the same numerator.

Interpretation of results of gradient

The answer which is found as a fraction or ratio or a decimal number shows the steepness or gentleness of the slope. The smaller the denominator of the fraction, the steeper the slope. The bigger the denominator, the more gentle the angle of slope between two points. For more information, refer to the information in the table below.

Table 1: Interpretation of results of gradient.

Angle of slope	Degree	Gradient
Steepness	Extremely steep	$^1/_1$
	Very steep	½
	Steep	$^1/_3$
	Fairly steep	$^1/_5$
Gentleness	Gentle	$^1/_{30}$
	Almost flat	$^1/_{120}$
	Flat	0

This means that any fraction which is more than $^1/_5$ indicates a steep gradient, while any fraction which is less than $^1/_5$ reflects a flat or gentle slope.

Activity 1.1.8:

In pairs, calculate the gradient between the highest point of Mkanga Hill and borehole BHW 277 on the topographical map of Salima. Use the scale 1m:50ft. Then interpret your answer in relation to the angle of slope.

FUNDAMENTAL MAP READING AND INTERPRETATION SKILLS

It is important to understand and possess skills on how to read and interpret maps. The three main aspects that can help us in map reading and interpretation include land use, economic activities and occupations of people in a particular area.

1. LAND USE

Land use refers to the way land is utilised for the survival of human beings and other living organisms. Land can be used for various purposes such as settlement, agriculture and provision of social services. In order to relate these various purposes to land use, it is important to know how to interpret map symbols that you observe on the topographical map. Relief or topography has an influence on how land is used. Hilly areas for example, will discourage many activities such as settlement while flat ones will encourage them.

(a) Interpretation of map symbols in relation to land use

It is advisable to identify symbols on the topographical map and find out their meanings from the key. Interpretation is done after verifying the meanings of the symbols in the key. You can also begin by noting symbols in the key and checking their meaning, before referring to the main map extract for verification.

(b) Ways of identifying a particular type of land use on the topographical map using map symbols

(i) Agriculture or farming

Whenever you identify symbols indicating that there is cultivation on a topographical map, it means that the land is used for agriculture. Presence of water bodies on the same land such as rivers, may indicate that the land is used for irrigation agriculture.

(ii) Settlement

Settlement symbols present on the topographical maps mean that the land is used for settlement. These include symbols for huts or villages.

(iii) Livestock farming

In order to find out if livestock farming is carried out, you can check for symbols indicating grasslands, boreholes, water pumps, dams and cattle dips.

(iv) Forestry

Presence of symbols indicating that there are forest reserves mean that the land is used for forestry.

(v) Lumbering

Presence of saw mills, tracks or minor roads ending in the forest mean that land is used for lumbering or timber industry.

(vi) Mining or quarrying

Presence of mining symbols such as quarries will indicate that mining activities are being carried out in an area.

(vii) Fishing

Presence of symbols of water bodies like rivers, lakes, fish ponds and marshes reflect fishing activities in the area.

(viii) Tourism

Presence of symbols of areas of interest such as historical sites, game reserves and national parks indicate that tourism is carried out in the area.

(ix) Provision of social services

Presence of symbols for schools, hospitals, roads, banks, post offices and churches indicate availability of social services in the area.

Activity 1.1.9:

Using the topographical map extract of Salima, Nkhate or any other topographical maps available at your school, identify any landforms that you observe on them.

FACTORS THAT AFFECT LAND USE PATTERNS

Activity 1.1.10:

Brainstorm the factors that affect land use patterns

Some of the factors that affect land use patterns include type of drainage system, altitude, natural resources, water masses, social services and places of interest as shown in Fig. 1.1.13 below.

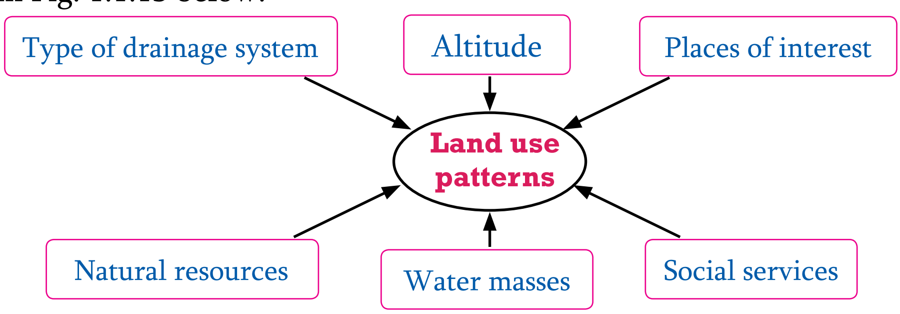


Fig. 1.1.13: Factors that affect land use patterns

(a) Altitude

Hilly or mountainous areas discourage settlement while flat areas encourage settlement.

(b) Type of drainage system

People are likely to be attracted to settle in areas where soils are well-drained as these are suitable for growing crops. Poorly drained soils discourage cultivation of crops and discourage settlement. Gentle slopes are usually well-drained and tend to attract settlement. Steep slopes and valleys are usually poorly drained and may be left for forests or may be covered by swamps.

(c) Natural resources

Presence of natural resources on land like minerals allows mining to be carried out.

(d) Water masses

Presence of water masses like rivers, lakes, marshes, dams and cattle dips as well as grassland areas encourages people to carry out activities like fishing and livestock farming.

(e) Social services

Presence of social services encourages settlement while absence of social services discourages settlement.

(f) Places of interest

Presence of places of interest such as game reserves, national parks, historical sites and lakes encourages tourism which in turn attracts people. On the other hand, absence of these places of interest may discourage settlements.

2. ECONOMIC ACTIVITIES

An economic activity refers to any activity that people carry out in order to earn a living. In order to find out economic activities carried out in an area on a given topographic map, it is vital to interpret the symbols by checking their meanings on the key.

Factors that determine economic activities

1. Presence of water bodies

Presence of water bodies encourages fishing activities which in turn attract people.

2. Location of settlements

Coastal settlements also encourage fishing and in turn attract many people.

3. Social services

Presence of social services such as markets, shops and trading centres encourages business or commercial activities which attract many people. On the contrary, absence of such social services may indicate that there is little or no commercial activities in the area.

4. Secondary industries

Presence of manufacturing industries attracts many people. This is because people will move there to look for employment opportunities. On the other hand, absence of manufacturing activities may discourage settlement in a particular area.

5. Agricultural activities

Presence of agricultural activities encourages settlements while absence of agricultural activities discourages them.

6. Forest reserves

Presence of forest reserves encourages the establishment of timber industries which in turn encourages settlements.

Ways of identifying economic activities

- Lumbering: Look for symbols of saw mills or minor roads ending in forests.
- Mining: Look for symbols of mines or quarries.
- Agriculture or farming: Look for presence or symbols of cash crops, ginneries or general cultivation.
- Pastoralism: Look for presence of grassland areas, boreholes, dams, water holes or quarantine camps.
- Fishing: Look for presence of coastal settlements and water bodies such as rivers and lakes.
- Trade: Look for symbols of trading centres, markets or shops.
- Manufacturing: Look for presence or symbols of factories or manufacturing industries.

3. OCCUPATION

You can predict the occupations of people living in any topographical map by interpreting symbols that you observe on the map. Such occupations include the following:

(a) Teachers or teaching: Look for presence or symbols of schools.

(b) Nurses, doctors and nursing: Look for presence or symbols of hospitals.

(c) Fisherpersons or fishing: Look for presence or symbols of rivers, streams or part of the lake.

(d) Miners: Look for presence or symbols of quarries or mines.

Activity 1.1.11:

In pairs, using the topographical map extract of Salima, Nkhate or any other topographical map available at your school, identify the economic activities and occupations of people living in these parts.

IDENTIFICATION OF VARIOUS LANDFORMS ON TOPOGRAPHICAL MAPS

There are several landforms that are displayed on the topographical maps. These landforms include the following:

1. Bay

A bay is an indentation or curve in the coastline where the lake meets the land between two headlands. Examples in Malawi include Domira, Chitimba, Monkey and Nkhata Bays.

2. Beach

A beach is a lake, ocean or sea-related feature formed by sand or pebbles. It is often found in many of the bays.

3. Estuary

An estuary is a drowned river mouth or the mouth of the river where it meets a lake or sea. The river enters the lake or sea in a single stream.

4. Peninsula

A peninsula is a piece of land almost completely surrounded by water but still joined to the mainland by a narrow neck called Isthmus. The word 'pen' comes from a Latin word meaning 'almost' and 'insula' means island, thus peninsula means 'almost an island'.

5. Strait

A strait is a narrow stretch of water which connects two bodies of water. An example is the Strait of Gibraltar connecting the Atlantic Ocean and the Mediterranean Sea.

6. Lagoon

A lagoon is a shallow stretch of water which is partly or completely separated from the sea or lake by a narrow strip of land.

7. Confluence

A confluence is the point where a tributary (branch of the river) joins the main river.

8. Headlands or points

A headland or point is a part of the land which sticks out into the lake. Every bay has two headlands, one on each side of the bay.

9. Tombolo

A tombolo is a bar of shingle and sand which joins an island to a mainland or an island to another island.

10. Cliff

A cliff is a vertical or near-vertical mass of very steep rock.

11. Cape

A cape is a piece of land that sticks out into the sea, ocean, lake or river. Capes are also called headlands and they extend into a body of water, usually the sea.

RIVERINE FEATURES ON TOPOGRAPHICAL MAPS

Examples of riverine landforms

There are several riverine landforms. Examples include the following:

1. Rapids and waterfalls

These are sudden vertical falls cascading over the edge of a hard rock layer, plateau or high level side valley.

2. Gorge

A gorge is a narrow valley often formed in the upper course of a river due to the fast flow of water.

3. Meanders

The term '*meander*' was derived from the winding river called *Meanderez* in Asia Minor. It means that the river is slowly and gently following a winding course.

4. Ox-bow lakes or horse-shoe lakes or cut-offs

These are lakes that form in the lower course or the flood plain of the matured river. The continuous erosion and deposition that occurs on the bends of meanders lead to isolation and cutting off of part of the river to form an ox-bow lake.

5. Delta

A delta refers to the fan-shaped streams at the mouth of a river where the load is deposited after entering the lake. A river forms a delta when it enters the lake through several river channels.

6. Flood plain

A flood plain is a gentle undulating plain where large deposits build up in the lower course of the river.

7. Levees

Levees are ridge-like features or raised banks produced by the river which overflows its channels. The river allows deposition to take place in the banks of the channel. There is an accumulation of deposits and materials on the sides when the river flows normally.

Activity 1.1.12:

Below is a figure showing riverine features. Use it or any topographical map available at your school to do the following activity:

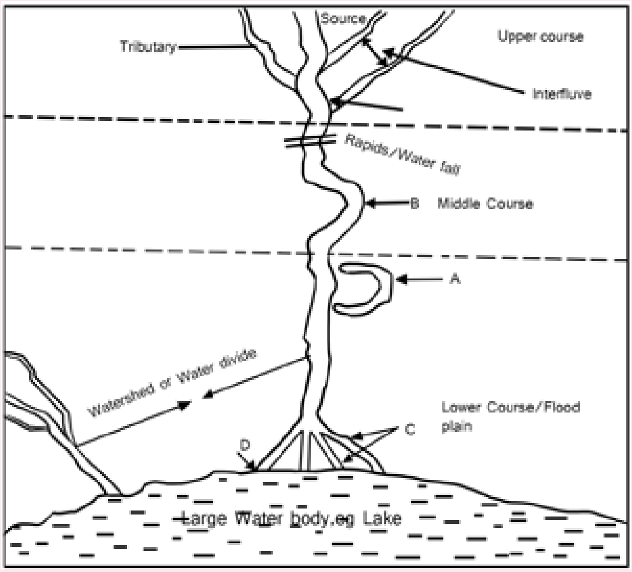


Fig. 1.1.14: Figure showing various riverine features

In pairs, identify any of the riverine features marked A, B, C and D. Then describe how each of the feature identified is formed.

COASTAL FEATURES ON TOPOGRAPHICAL MAPS

Coastal features can be formed through deposition or erosion.

(a) COASTAL FEATURES FORMED THROUGH DEPOSITION

1. Beaches

A beach is a deposit of loose sediments of sand and gravel brought by waves adjacent to a body of water on its shore.

2. Spits

These are long narrow ridges of sand and shingle which project from the coastline into the sea. A sand spit is a linear accumulation of sediments that is attached to land at one end.

3. Tombolos

A tombolo is a bar that connects two land masses. It is a seaward deposition of sediments linking the mainland to an island.

4. Bars

Bars are offshore accumulation of sediments due to wave erosion, transportation and deposition.

5. Marine dunes

A marine dune is an accumulation of sand deposited by wind in ridges, mounds or hills.

(b) COASTAL FEATURES FORMED THROUGH EROSION

1. Capes

Capes are barrier islands that project into the open sea to form a right angle shoreline. These are generally large features that are exposed to wave attack on each side, but one side is accreting while the other is eroding.

2. Bays

Bays are indentations in the shoreline that form pockets of a sheltered sea.

3. Cliffs

A sea cliff is a very steep rock face adjoining the coast.

Activity 1.1.13:

Below is a figure showing coastal features. Use it or any topographical map showing coastal features available at your school to do the following activity:

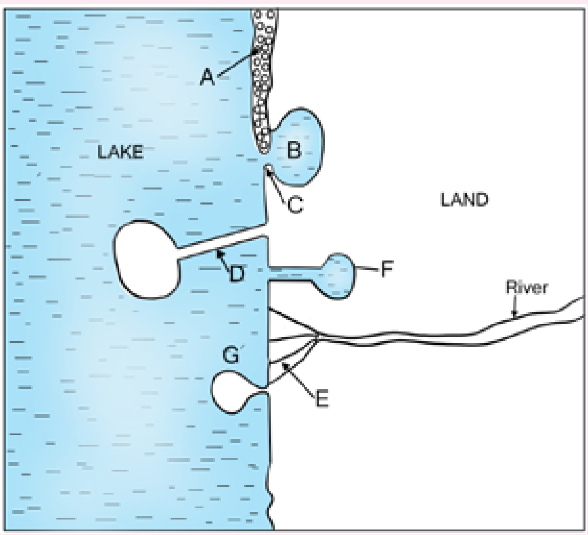


Fig. 1.1.15: Figure showing coastal features

In pairs, identify any of the coastal features A, B, C, D, E and F on the figure above. Then describe how each of them is formed.

Activity 1.1.14:

The following is a table with a Geography word scramble. Test your knowledge by using it to do the activity below.

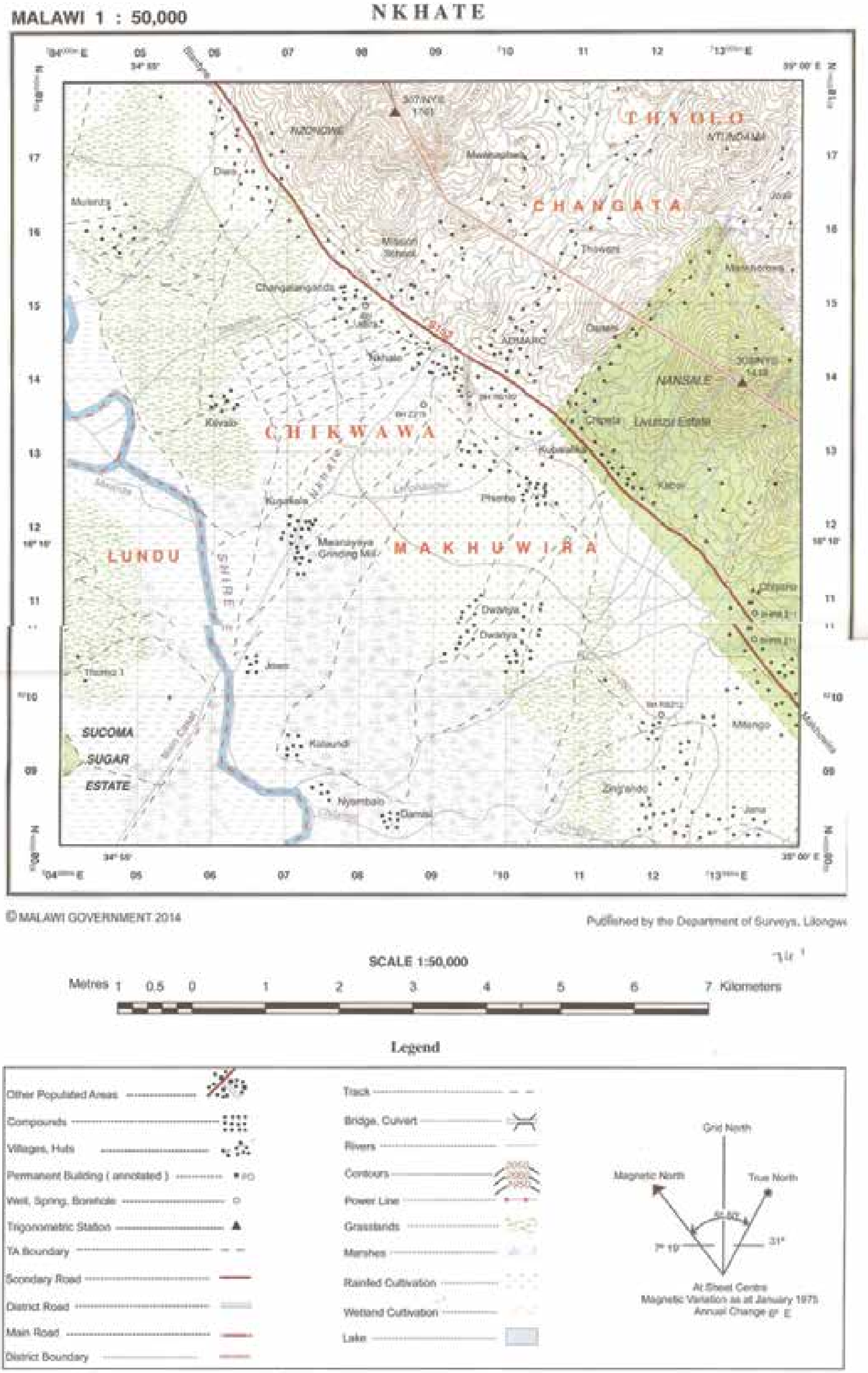
On your left are scrambled letters representing examples of riverine and coastal features. On your right are blank spaces for their answers.

Individually, write the correct word on the spaces on the right for the riverine and coastal features in the left column.

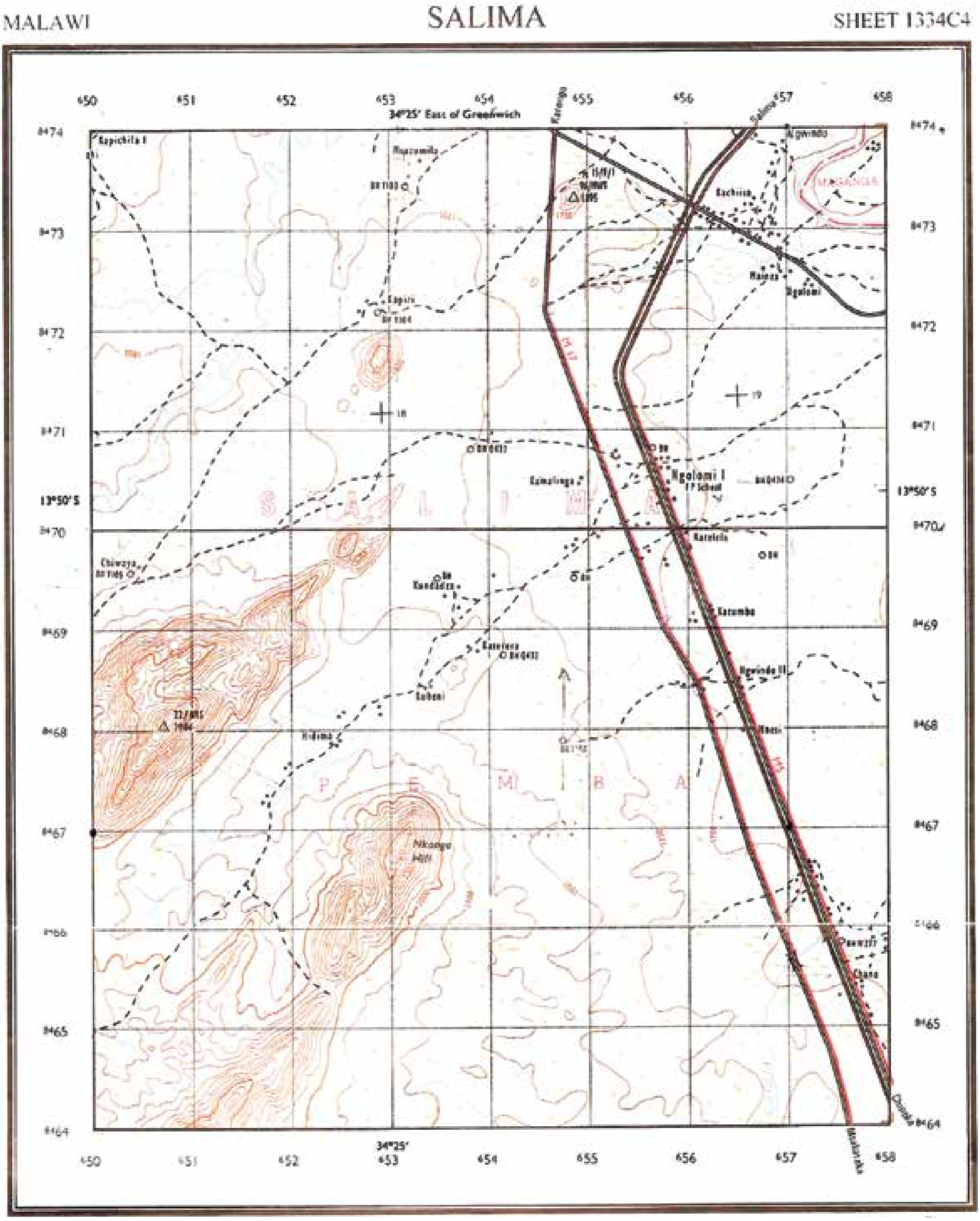
Table 2: Examples of riverine and coastal features.

Question	Answer
Egrog	
Resemand	
Gonalo	
Wobox kale	
Seleev	
Dloof napil	
Cheab	
Tsip	
Bolomot	
Sarb	
Nerima nude	
Pace	
Yabs	
Liffc	

MAP EXTRACT OF NKHATE



MAP EXTRACT OF SALIMA



KEY TO MALAWIAN SERIES OF 1: 50,000

Town or areas with permanent buildings ....

Other populated areas ....

Compounds ....

Huts. Villages ....

Main Road (with number) M10

Secondary Road S23

District and Other Road D49

Bridge. Culvert ....

Track ....

Aerodrome, Landing Area ....

Railway Station or Halt, Level Crossing .... Sta LC Siding

Light Railway ....

Permanent Building (annotated) .... PO

Telephone Line .... Along Road

Power Line 33kV

Forest ....

Light Forest ....

Orchard Bush ....

Scrub ....

Grass and Scrub ....

Grassland ....

Palms ....

Marsh ....

Seasonal Marsh or Dambo ....

Rice ....

General Cultivation ....

Estates and plantations ....

Boundaries:

International ....

Regional ....

District ....

Traditional Authority .... ZULU

National Park ....

Township ....

Game Reserve, Forest Reserve controlled Area ....

Cadastral, Plane .... SD/1000 or SP43/75

Trigonometrical Station ....

International Boundary Pillar BP6A

Spot Heights in Feet 5653

Bench Mark (with number) 11/M/20

Air Photo Principal Point with Film No 050 MW15/72F12

Radio Telephone Mast ....

Rest House ....

Church, Mosque, Temple ....

Lighthouse ....

Mine ....

Well, Spring, Borehole .... OW OS OBH

Furrow, Pipeline .... F P

Watercourse, Waterfall, Rapids, Dam .... WF R

Watercourse (Wide), Waterfall, Rapids ..

Watercourse, disappearing, indefinite .....

Contours 2050 2000 1950

Depression ....

Sand or Mud .... Inland Coastal

Quarry ....

Cliff ....

Outcrop Rock, Flat Rock ......

Boulder Rock ....

STATISTICAL METHODS IN GEOGRAPHY

Introduction

Statistics relates to the gathering of information involving numerical data, organising the gathered information, presenting it in a meaningful way, then analysing it and drawing valid conclusions from it. In this sub-topic, we will learn about the methods of collecting data and their advantages and disadvantages. We will further look at ways of designing data collection instruments and how to collect data by using appropriate procedures. We will learn how to organise, analyse, interpret and present data using various methods.

Terminologies:

- **Data:** This refers to raw and unprocessed information.
- **Primary data:** This is the name given to the data that is used for specific purposes for which they were collected. Primary data will contain unknown quantities with respect to the method of collection, accuracy of measurements or the members of the population that were investigated. Sources of primary data can either be censuses or samples. *Censuses* are surveys that examine various details of the members of the population. Examples of censuses include population, distribution and production censuses. Samples are representative subjects of population.
- **Secondary data:** This is the name that is given to data that is being used for some purpose other than for which they were originally collected. Summaries and analyses of such data are sometimes referred to as secondary statistics.
- **Data collection:** It can be defined as the means by which information is obtained from selected subjects of an investigation.
- **Sample:** This is an examination or representative subset of the population.
- **Discrete data:**This is the type of data that can be counted.
- **Continuous data:**This is data that is weighed and measured like that of rainfall and temperature.

DATA COLLECTION METHODS

Activity 1.1.15:

Brainstorm on the methods of collecting data.

Activity 1.1.16:

In groups of five, discuss the methods brainstormed in Activity 1.1.15.

There are several methods of collecting data. The main ones are questionnaires, interviews, observations, measurements and carrying out experiments.

1. QUESTIONNAIRES

A questionnaire is a means of eliciting the feelings, beliefs, experiences, perceptives, or attitudes of a sample of individuals. A questionnaire is a form or prepared device that is distributed to the respondent so as to collect feedback or responses concerning the questions set. It is a systematic compilation of questions that are submitted to a sample population from which information is desired.

Purpose of questionnaires

The purpose of the questionnaire is to gather wide information from scattered sources. It is mostly used in cases where one cannot personally and readily see all of the people from whom he or she desires responses. It is also used where there is no particular reason to see them personally.

Advantages of questionnaires

(i) They are cheap.

(ii) They are practical.

(iii) They provide an easy way of obtaining large amounts of data from many respondents within a short time.

(iv) There are minimal chances of asking leading questions.

(v) The researcher does not have the chance of influencing the responses.

(vi) They can be analysed more scientifically and objectively than other forms of data collection.

(vii) When data has been quantified, it can be used to compare and contrast other researches and may be used to measure change.

(viii) Positivists believe that quantitative data can be used to create theories and/ or test existing hypotheses.

(ix) They can be administered by the researcher or by a number of people with limited effect to validity and reliability.

(x) There is uniformity of questions as each respondent receives the same set of questions phrased in exactly the same way.

(xi) The questions in the questionnaires are standardised. Some questions are highly structured to an extent that conditions under which they are answered are controlled.

Disadvantages of questionnaires

(i) Low response rate because some respondents may not know what to write.

(ii) Questionnaires may be answered by the wrong group of respondents.

(iii) There is no room to clarify the questions.

(iv) Some questions may not be answered.

(v) There is a high tendency of telling lies.

(vi) The Data collection does not give in-depth information.

(vii) They lack validity.

(viii) Some information in the questionnaires may not be understood or interpreted easily by the respondent.

(ix) The respondent may be forgetful or may not give an answer within the full context of the questions asked.

(x) Respondent's motivation is difficult to assess, affecting the validity of responses.

(xi) Unless a random sampling of returns is obtained, those returned may represent biased samples.

2. INTERVIEWS

Interviews are direct, face-to-face attempts to obtain reliable and valid feedback or responses from one or more respondents. They are conversations in which the roles of the interviewer and the respondent change continually.

Note: The person asking or leading the interview is called an interviewer or researcher. The person responding or being asked the questions in the interview is called an interviewee, respondent or informant.

Advantages of interviews

(i) Clarity on responses

Interviewees can clarify on their responses.

(ii) High response rate

Interviews ensure high response rate. This is because interviews are generally pre-arranged and scheduled for a convenient time and location.

(iii) In-depth information

There are high chances of soliciting detailed and in-depth information in an interview. It is possible and easy to probe subjects and follow up issues over a relatively long time.

(iv) Room for clarity

The researcher is able to probe further and clarify responses given in order to obtain important information.

(v) Validity

Data can be checked for accuracy and relevance as as it is being collected through direct contact at the point of the interview.

(vi) Insights

The researcher is likely to gain valuable insights based on the depth of the information gathered.

(vii) Therapeutic

Interviews can be a rewarding experience for the informant, compared with questionnaires or experiments. Interviewees have the chance to talk about their ideas at length to a person whose purpose is to listen and note the ideas without being critical.

(viii) Information priorities

Interviews are a good method of producing data based on the informant's priorities, opinions and ideas. Informants have the opportunity to expand their ideas, explain their views and identify what they regard as crucial factors.

Disadvantages of interviews

(i) Language barrier problems

Sometimes, the use of a language that cannot be easily understood by either the interviewer or interviewee may hinder the whole exercise.

(ii) Interviews are time consuming

Analysis of data can be difficult and time consuming.

(iii) Difficulty in data analysis

This method produces non-standard responses. Semi-structured and unstructured interviews produce data that is not pre-recorded and has a relatively open format. This data becomes difficult to analyse.

(iv) Less reliability

Consistency and objectivity are hard to achieve. The data collected is, to an extent, unique, owing to the specific content and the specific individuals involved. This has an adverse effect on reliability.

(v) Interviewer effect

The identity of the researcher may affect the statements of the interviewee. They may say what they do or what they prefer to do and the two may not tally.

(vi) Inhibitions

The tape recorder or video recorder may inhibit the effectiveness of the interview. Some respondents may not feel free to go on with the interview. The interview is an artificial situation where people are speaking for the record and on the record. This can be daunting for some people.

(vii) Invasion of privacy

Interviewing can be an invasion of privacy and may be upsetting for the informant.

(viii) Interviews are expensive to conduct

The cost of the interviewer's fee, the travelling and transcription fees, can be relatively high if the informants are geographically widespread.

TYPES OF INTERVIEWS

There are many types of interviews. They can be structured, semi-structured, unstructured, single, individual or personal interviews, street or informal. One may also carry out telephone interviews.

(a) Structured interview

- A structured interview involves organising formal questions and answers. It is like a questionnaire which is administered face to face with a respondent.

- The researcher has a predetermined list of questions. Each respondent is faced with identical questions.
- The choice of alternative answers is restricted to a predetermined list. This type of interview is rigidly standardised and formal.

(b) Semi-structured interview

- The interviewer has a clear list of issues to be addressed and questions to be answered.
- There is some flexibility in the order of the topics.
- The interviewee is given chance to develop his or her ideas and speak more widely on the issues raised by the researcher.
- The answers are open-ended. More emphasis is on the interviewee elaborating points of interest.

(c) Unstructured interview

- Emphasis is placed on the interviewee's thoughts.
- The role of the researcher is to be as unintruisive as possible.
- The researcher introduces a theme or topic and then allows the interviewee to develop his or her ideas and pursue his or her line of thought. Allowing interviewees to speak their minds is a better way of discovering things about complex issues.
- It gives an opportunity for in-depth investigations.

(d) Single interview

- It involves a meeting between one researcher and one respondent.
- It is easy to arrange this type of interview.
- It helps the researcher to locate specific ideas with specific people.
- It is also easy for the interviewer to control the situation.

(e) Group interview

- It involves more than one informant or respondent or interviewee.
- The numbers involved ranged between four to six people.

(f) Individual or personal interviews

These are face to face conservations that involve asking and answering questions orally and recording the responses. It is a method used to collect data that involves interviews by trained interviewers. It can be used together with random or quasi sampling. Random sampling ensures that each and every member of the population has an equal chance of being selected. Quasi sampling is used when random sampling is not possible.

Advantages of individual or personal interviews

(i) They are cheap to carry out.
(ii) They are fast.
(iii) Interviewees are able to clarify their responses.
(iv) The interviewer has the advantage of observing body language.
(v) Questions can be altered in order to obtain more useful data.
(vi) They can be used with young children and illiterate individuals.
(vii) They allow informants to respond to any matter they see fit.
(viii) They allow the interviewer to observe verbal and non-verbal behaviour of the respondents.
(ix) They are a means of obtaining personal information, attitudes, perceptions and beliefs.
(x) They reduce anxiety so that potentially-threatening topics can be studied.

Disadvantages of individual or personal interviews

(i) Interviewers may ask leading questions.
(ii) Sometimes, there are language barrier problems.

(g) Street or informal interviews

It is a method of interviewing the respondent where the interviewer is just one of the team. There are often differences in the way the individual interviewer will ask questions to respondents and the way replies are recorded.

Advantage of street or informal interviews

- They are accurate and complete.

Disadvantage of street or informal interviews

- The methods of collecting data are expensive.

(h) Telephone interviews

These are used in conjunction with systematic sampling. An interviewer makes a telephone call to the interviewee and guides him or her through the questions that require feedback.

Advantage of telephone interviews

- They are time-saving as the interviewer needs not to travel to every place or location where the respondent is.

Disadvantage of telephone interviews

- They can cause aggravation and the interviewer needs to be skilled because there is no eye contact.

3. OBSERVATION

Observation method is a technique in which the researcher records what he or she observes (it should be related to the research). The behaviour of the research subject is watched and recorded without any direct contact. It involves the systematic recording of observable phenomena or behaviour in a natural setting. It involves visiting the field or area of study, viewing all features related to the topic of discussion and recording the details observed. Items are sampled from work study, that is, geographical data.

Purpose of observations

The purpose of observation technique includes:

(a) To collect data directly.

(b) To collect substantial amount of data in a short time span.

(c) To get eye witness first hand data in a real life situation.

(d) To collect data in a natural setting.

Advantages of observation method

(i) Information is collected quickly.

(ii) The method is cheap to use.

(iii) It saves on time.

(iv) Accurate data is collected.

(v) It is possible to minimise chances of data distortion or misinterpretation.

(vi) Observations are made in a natural setting.

(vii) It allows the researcher to experience the reality of emotions of those who are being observed.

(viii) Virtually all data collected is useful.

(ix) It is suitable when explaining what is going on in a particular setting.

Disadvantages of observation method

(i) It is affected by weather conditions.

(ii) Inaccessibility or a harsh environment hinders this method.

(iii) Data collected is biased to the researcher.
(iv) Incorrect data may be collected if natural setting is changed.
(v) It is time consuming.
(vi) It can pose difficult ethical dilemmas for the researcher.
(vii) Data recording is often difficult for the researcher.

4. MEASUREMENTS

Geographers can also collect data through measurements. They can take or estimate distances. They can also count objects in the sample by means of taking census, use of tape measures and instruments such as rain gauges and thermometers.

Advantages of using measurements

(i) They provide accurate data.
(ii) They are fast.
(iii) It is easy to collect data using measurements.
(iv) Data cannot be easily misinterpreted.

Disadvantages of using measurements

(i) Some of the instruments can be expensive to acquire.
(ii) Data collection can be slow where counting of large volumes of data is required.
(iii) Incorrect data can be obtained through estimation.

5. CARRYING OUT EXPERIMENTS

This involves carrying out an investigation or test in order to provide evidence supporting or opposing a given hypothesis (a tentative theory).

Advantages of using experiments

(i) They are accurate and correct.
(ii) They provide a key to further research.

Disadvantages of using experiments

(i) They are time consuming.
(ii) They are expensive to conduct.
(iii) Incorrect data can be obtained by faulty instruments.

DESIGNING DATA COLLECTION INSTRUMENTS

1. QUESTIONNAIRES

Questionnaires are designed to be used with most forms of sampling. It is important to know how to design a questionnaire. Poorly designed questionnaires can cause many administrative problems and incorrect results from the respondents. As a result, wrong conclusions may be made. The questionnaire should be as short as possible. The questions should be simple and unambiguous, not personal or offensive. The questions should not be leading and they should not involve calculations or tests of memory.

In designing questionnaires, the following steps should be included:

Step 1 : Draft the content of the questionnaire based on pre-determined information needs.

Step 2 : Pay attention to language being used in the questionnaire.

Step 3 : Draft the questions carefully.

Step 4 : Optimise the sequence of questions.

Step 5 : Make format of the questions as easy as possible to enhance easy flow.

Step 6 : Check consistency between instruments.

Step 7 : Pretest the instrument to be used.

Step 8 : Revise the above determined steps.

AN EXAMPLE OF A QUESTIONNAIRE

How to write the introduction

- It should be written in a way that it is inviting but also professional.
- It must clearly state the purpose and goals of the survey or research.
- It needs to clearly state the duration for the survey (optional).
- It must contain brief information about the one conducting the survey.
- Confidentiality should be guaranteed in the introduction part.
- Information about any incentive you are willing to provide should also be provided.

I. Introduction

The Chimbalame Restaurant is dedicated to improving customer satisfaction. Through this brief survey, you answers will be helpful in enhancing our services and meeting your needs. Your response will only be used for survey purposes.

II. Questions

Instructions:These should be given to guide the respondent.

(i) Please indicate your level of agreement or disagreement with each of the statements below regarding Chimbalame Restaurant.

(ii) Place a ✓ or an ✗ in the box of your answer.

Q1. How many times per day do you visit Chimbalame Restaurant?

☐ Once ☐ Twice ☐ Thrice

Q2. Do you visit Chimbalame Restaurant with family or friends?

☐ Yes ☐ No

Q3. Respond to the statements in the first column by using any of the following terms: Strongly agree, Agree, Neutral, Disagree, Strongly disagree.

Table 3: Rating of statements related to Chimbalame Restaurant.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. The restaurant is accessibly located.					
2. Restaurant hours are convenient for my daily needs.					
3. Advertised dish was in stock.					
4. A good selection of dishes was present.					
5. The meals sold are good value for the money.					
6. The restaurant has the lowest prices in the area.					
7. Meals sold are of the highest quality.					
8. Restaurant atmosphere and décor are appealing.					

Q4. How would you rate your overall experience at the Chimbalame Restaurant?

☐ Highly satisfactory ☐ Satisfactory ☐ Neutral ☐ Unsatisfactory ☐ Highly unsatisfactory

Q5. What could we do to make Chimbalame Restaurant a better place for you and other customers?

____
____
____

III. Demographic data

Name (optional): ______________________________

Age : ____________________ Gender: ☐ Male ☐ Female

E-mail address (optional) : ______________________________

Note: *This section is optional. The questions asking for demographic data should be relevant to the survey goal and must point to the characteristics of the target.*

IV. Thank you for sharing your thoughts with us. Enjoy your dining at Chimbalame Restaurant.

Note: *This section should include further information regarding how to claim the incentive that you wish to provide to the respondent.*

Activity 1.1.17:

In pairs, choose one of the following statements and design a questionnaire to find out if it is true:

- *Older students do more homework than younger students.*
- *Women spend more time shopping than men.*
- *Time students take to travel to school.*

2. OBSERVATION CHECKLIST

The process of designing an observation checklist involves the following steps:

Step one: Identify the types of observation that will be conducted in the study to decide on what type of observation checklist to create.

Step two: Make a list of different categories to use on the observation checklist to obtain the necessary data during the observation. These categories can include characteristics of a person or object.

Step three: Create a second list of sub-categories to take place under each category. Select sub-categories that aim at obtaining important data about the subject, rather than collecting needless information.

Step four: Put a checklist together on a clean sheet of paper. Write the type of observation or project name at the top of the page as well as the date of the observation. Then list each observational category below the project name. Include the sub-categories under the corresponding categories as well.

Step five: List different subject names across the top page, if observing more than one subject at the same time. An example would be the names of different students in the classroom. Draw vertical lines between each subject name using a ruler, to separate each name on the sheet of paper. Separating each name prevents confusion after observation is complete.

An example of an observation checklist

Table 4: An example of an observation checklist

Observation	Yes	No	Comment
Ability to be a playmate			
Ability to be playful Ability to use a toy approximately			
Joint attention with others during play			
Ability to use ideation (what to play)			
Ability to understand that specific toys are used for specific games			
Ability to play independently			
Ability to tease and joke			
Need for other structures for optimum play performance			
Sensory preferences during play			
Eye contact during play			
Interaction during play			
Ability to expand on a familiar play activity and to change it			

Source: *http://www.ehow.com/how8749579make-own-observation-checklist.html*

Activity 1.1.18:

In groups of five, create a behavioural checklist to note how students in your classroom are behaving during delivery of lessons or instruction. Write the purpose of the observation on a sheet of paper.

3. INTERVIEW GUIDES

The following are guidelines for interview guides:

Step one: Find out the main goal of the interview. Write down measurable objectives. Translate these objectives into evaluation objectives. Ensure that each question is connected to your goal.

Step two: Write questions that encourage dialogue and description. Questions should ask concrete situations and yield descriptive responses. For example, What did you experience? How did it make you feel?

Step three: Avoid questions that begin with 'Why?' This is because such questions are open- ended and leave multiple interpretations.

Step four: Use follow up questions that ask respondents to clarify their responses, ideas, thoughts and feelings.

Step five: Avoid dichotomous questions that solicit simply Yes or No answers.

Step six: Use simple vocabulary and not bombastic, hard, complex or difficult words.

Step seven: Begin the interview with a general, non-threatening question. Move from simple to complex questions.

Step eight: Keep questions short and precise.

Step nine: Do not mix ideas. Instead include only one idea per question.

Step ten: Avoid leading questions that give the respondent hints about what would be a desirable or appropriate kind of answer. Keep questions neutral.

Step eleven: Use presumption questions that assume the respondent has something to say and increase the likelihood that the respondent will have something to say. Such questions include the implication that what is presupposed is the natural way for things to occur.

An example of an interview guide

Some of the questions that can be included in the interview guide include:

An Interview Guide

(a) Tell me about yourself.

(b) Why did you leave the last job?

(c) What can you offer us that others cannot?

(d) What are your strengths or best skills?

(e) What are your major weaknesses?

(f) What are your career goals?

(g) What are your hobbies?

(h) What salary are you expecting?

(i) Why should I hire you?

Activity 1.1.19:

In groups of five, prepare an interview guide based on the following information:

- *Hobbies of your friends.*
- *Careers your friends would like to pursue.*
- *Subjects your friends like.*
- *Type of sports your friends like.*
- *The kind of food your friends like.*

COLLECTING DATA USING APPROPRIATE INSTRUMENTS

Collecting data using appropriate instruments requires consideration of the following points:

(i) Establish a good rapport with the respondent.

(ii) Recording devices should be used without distracting the interviewee.

(iii) Descriptive information should be collected with a stimulating and encouraging discussion.

USING INTERVIEW GUIDES

Areas to consider when conducting semi-structured and in-depth research interviews

(i) Opening the interview: The researcher needs to establish a good rapport with the respondent to help them feel at ease before the interview begins.

(ii) Use of appropriate language: The researcher should choose simple vocabulary for the respondent to easily and quickly understand.

(iii) Developing appropriate questions: The researcher should ask questions based on relevant themes.

(iv) Developing good listening skills: The researcher should listen keenly to the respondent. Failure to listen can pose problems of collecting correct information.

(v) Testing and summarising understanding: The researcher should identify key points from explanations.

(vi) Recording and dealing with difficult participants: The researcher should reframe the questions to ensure that even the difficult respondents give clear and relevant feedback.

(vii) Recording data: The researcher should record the information collected correctly.

COLLECTION OF DATA ON A CHOSEN TOPIC

Activity 1.1.20:

In groups of 5, formulate a questionnaire, interview guide or observation checklist and collect the required information on the following topics;

(a) Causes and effects of rapid population growth.

(b) Causes and effects of water, land and air pollution.

(c) Causes and effects of climate change.

Using these data instruments, collect data on the topics highlighted. Then write a report to be presented to the whole class.

WAYS OF ORGANISING DATA

Data organisation is important because it helps clarify relationships between data items. This is done by putting related items in one folder. Furthermore, it also helps when we need to find the information later.

Fig. 1.1.16: A flow diagram showing questions to be considered when organising data

(a) Chronological

Information presented in time sequence, either forward or backward, is chronological. Chronological ordering is also desirable to describe history or development. Chronological sequencing of ideas is necessary to show time relationships. However, it is overused by individuals who sequence their writing to reflect their thinking about a problem. Whatever was thought about first is written about first. Such organisation prevents flexibility in the writing process and ignores the techniques of emphasis.

Activity 1.1.21:

In groups of five, organise the following data in chlonological order:

- *Chimwemwe takes her supper at 6:30 p.m.*
- *She goes to the football ground for sporting activities at 3:30 p.m.*
- *She takes her breakfast at 6:30 a.m.*
- *She goes to class at 7:00 a.m.*
- *Chimwemwe wakes up at 5:00 a.m.*
- *She begins her preparation at 5:30 a.m.*

(b) Value or size

The logical order for some topics begins with the most valuable or the largest item first.

(c) Geographical or spatial

Data can be organised geographically. Geographical sequencing of ideas is less usable than other methods because of its rigidity.

(d) Simple to complex

Data can also be organised with regard to its simplicity or complexity, for easy understanding.

(e) Inductive (indirect)

Facts are presented first and then conclusions drawn from them. Inductive organisation is useful when readers are uninformed or when resistance or antagonism is expected.

(f) Deductive (direct)

The main idea or conclusions and recommendations should come first. Examples, reasons and clarifications should then follow.

DATA ANALYSIS USING APPROPRIATE PROCEDURES

There are basically two methods of analysing data collected by various methods. These include qualitative and quantitative data analysis techniques.

(a) Qualitative data analysis

- It is based on meanings expressed through words.
- Collection results in non-standardised data requiring classification into categories.
- Analysis is conducted through the use of conceptualisation.

(b) Quantitative data analysis

- It is based on meanings derived from numbers.
- Collection results in numerical and standardised data.
- Analysis is conducted through the use of diagrams and statistics.

Approaches to qualitative data analysis processes

Qualitative data analysis involves three processes. These processes include the following:

(i) Summarising (condensation) of meanings

- This involves producing a summary of the key points that emerge from the data collected.
- Long statements are compressed into brief statements, that is, words are rephrased.
- It involves condensing the meanings of large amounts of text into few words.
- Principle themes are noted through the process of summarising.

(ii) Categorisation (grouping) of meanings

- Categories are developed and subsequently attaching them into meaningful chunks of data.

(iii) Structuring (ordering) of meanings using narrative

- Meanings are derived from categorised data.
- Relevant bits of data are attached to the appropriate categories that have been devised.

Approaches to quantitative data analysis

(i) Using a deductive approach

- This applies when an existing theory has been used to formulate research questions and objectives.
- Theoretical propositions may be used as a means to devise a framework to help appraise and direct data analysis.

(ii) Using an inductive approach

- An alternative to deductive approach is where data is first collected and then explored to see which themes or issues can be followed up and concentrated on.

INTERPRETATION AND PRESENTATION USING VARIOUS METHODS

When data has been collected and organised, it has to be presented so that we are able to derive meaning from it.

Checklist for constructing data presentation instruments

When presenting data using various data presentation instruments, it is important to follow the checklist provided below.

- Use pencils and not pens as pens can be difficult to erase in case of inaccurate writings.
- All diagrams should be neat and attractive to the eye.
- Diagrams should be easy to read, without excessive detail.
- Always try to locate the diagram centrally on the paper, using as much of the paper as possible.
- A general title must always be given. The title should describe what is being portrayed. It should be as brief as possible and to the point.

- Axes, if used, should be clearly labelled, giving the units of data and a note of any break of scale.
- Shading or colouring, if used, must be lightly done.
- Avoid overcrowded maps and diagrams.
- Every statistical map should have the following:
  (i) Title (ii) Key (iii) Scale (iv) Frame (v) Compass direction

Ways of presenting data

There are various ways of presenting data. Some of the ways include the following:

(a) Using line graphs

Line graphs are used to show continuous data.

How to plot line graphs

In order to plot line graphs, follow the procedure given below:

(i) The horizontal axis is normally used to represent an independent variable such as time in hours, days, months, years or any period of time.

(ii) The vertical axis represents the dependent variable, that is, quantity of values and sometimes percentages.

(iii) The base of the vertical scale should be at zero, the top should be slightly higher than the maximum value to be recorded on it.

(iv) Two different sets of values may be marked on the two axes, provided that the relationship between them is constant.

(v) Plot the pairs of X on the X-axis and Y on the Y-axis.

(vi) Join the points with a smooth line.

Example:

Table 5 below shows goals scored in a number of matches during a tournament. The number of matches is represented by the frequency column.

Table 5: Number of goals scored in a tournament.

Number of goals	Frequency
0	4
1	8
2	12
3	16
4	20
5	24
6	28
7	32

Draw a line graph using the information from the table above. Use the vertical scale of 1 cm represents 4 (frequency) and the horizontal scale of 1 cm represents 1 goal.

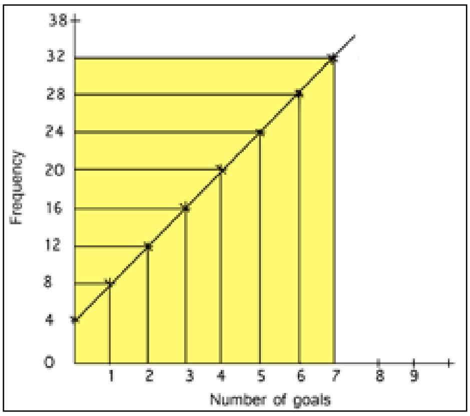


Fig. 1.1.17: Line graph

Activity 1.1.22:

The number of attempts a darts player made one evening before he hit the 'bull's eye' were recorded as shown in Table 6 below.

Table 6: Number of attempts of a darts player.

Number of attempts	Frequency
1	0
2	5
3	10
4	15
5	20
6	25
7	30

Individually, plot the line graph using the data given above.

Activity 1.1.23:

Cahill Motors hires out vans and their charges are shown below. Use the information in the table to answer the question that follows.

Table 7: Distance covered (km) and hire charges of Cahill Motors.

Distance covered (km)	50	150	250
Hire charge	45	55	65

Draw a straight line graph to illustrate the information above.

(b) Using curve graphs

Example: Plot a simple curve to illustrate the data for Valencia in the table below.

Table 8: The climate of Valencia.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Temp. (°C)	5	6	6	7	8	10	11	13	13	10	7	6

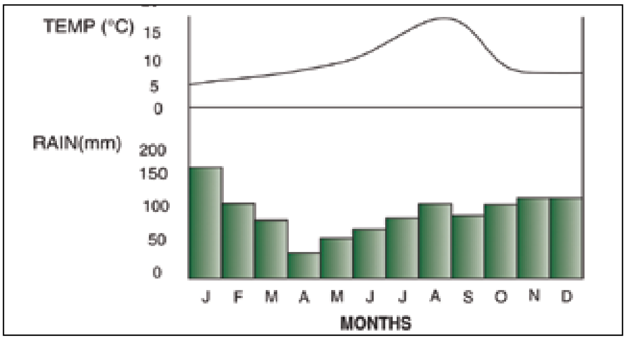


Fig. 1.1.18: Graph showing the climate of Valencia

Activity 1.1.24:

In pairs, plot a simple curve graph to illustrate the data for station M below.

Table 9: Temperature data for station M.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Temp. (°C)	24	23	22	21	20	18	17	18	20	23	24	24

(c) Using bar graphs or charts

Types of bar charts

1. Simple bar charts

A simple bar chart is a chart consisting of a set of non-joining bars. It has a grid and some vertical or horizontal columns (bars). A separate bar for each class is drawn to the height proportional to the class frequency. The width of the bars for each class is always the same and if desired, each bar can be shaded or coloured differently.

How to draw a simple bar chart

Step one: Draw the Y-axis by using the class frequencies and scale given. Class frequencies are always indicated on the Y-axis.

Step two: Draw the X-axis whose length will depend on the number of categories and the width of each bar.

Step three: Draw a separate bar for each class since each class is drawn to the height proportional to the class frequency. The width of the bars drawn for each is always the same according to the scale given in the question under study. If desired, each bar can be shaded or coloured differently.

Example:

Teachers at a certain school were asked how they travelled to school one day, and their replies were recorded as follows:

Table 10: Mode of transport and frequency of movement of teachers at a certain school.

Mode of transport	Frequency
Walking	13
Train	2
Cycling	8
Horse	1
Car	12

Draw a bar chart to display this information. Use 1 centimetre to represent a frequency of 2 on the Y-axis and 1 cm to represent the width of each bar.

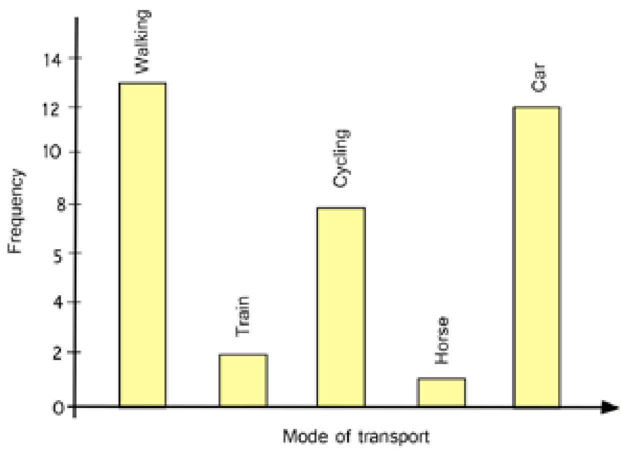


Fig. 1.1.19: A bar chart

Activity 1.1.25:

A survey of the occupation of the men in a certain club produced the following information:

Table 11: Occupation of the men in a club.

Occupation	Frequency
Accountants	1
Engineers	7
Bankers	3
Lawyers	4
Doctors	3
Salesperson	5

Draw a bar chart to display this information. Use 1 centimetre to represent a frequency of 2 on the Y-axis and 1 centimetre to represent the width of each bar.

Activity 1.1.26:

The table below shows the budget for a certain Local Government Authority estimation in a certain country. Use it to do the activity below.

Table 12: Budget for a Local Government Authority estimation in a certain country.

Item	Amount (MK)
Agriculture	2,250,000
Education	5,000,000
Health	4,400,000
Water supply	3,500,000
Development	1,650,000

Using a scale of 2 cm to represent a frequency of 1,000,000 on the Y-axis and a scale of 1 cm to represent bar width, draw a bar graph to illustrate the information above.

2. Histograms

Histograms are bar charts that display the observed frequencies of data that have been binned (divided into continuous, equally spaced intervals). The bars are attached to each other.

Ways of constructing histograms

(i) Each bar represents one class, bar width corresponds to the class width and the bar height generally corresponds to the class frequency.

(ii) The vertical axis (representing frequency) and horizontal axis (representing data values) must both be scaled and labeled clearly.

(iii) The chart as a whole must have a title.

Example: Draw a histogram using the data in the table below.

Table 13: Number of days when employees were late for work.

Number of days (X-axis)	Number of employees (Y-axis)
1	30
2	50
3	20
4	10
5	40
6	25
7	5
8	2

KEY: Take 2 cm to represent 10 employees on the Y-axis and 1 cm to represent the width of each bar on the X-axis.

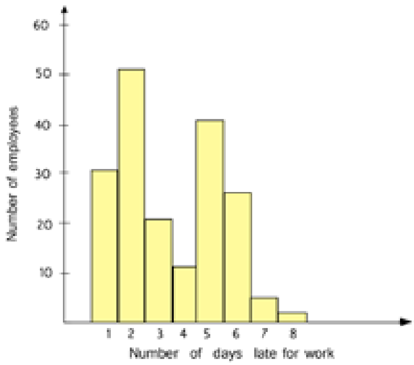


Fig. 1.1.20: A histogram showing number of days employees were late for work

Activity 1.1.27:

50 cooks were asked how long they boiled maize and their replies were recorded as below.

Table 14: Time taken boiling maize by cooks.

Time in minutes (to the nearest minute)	Number of cooks
Under 5	5
5-9	20
10-14	5
15-19	10
20-59	10

In pairs, take 2 cm to represent a period of 5 minutes on the Y-axis and 1 cm to represent bar width. Then draw a histogram to display this data.

(d) Using pie charts

A pie chart is a circular chart that is divided into slices by radial lines. Each slice represents the relative contribution of each part to the whole. It shows the totality of the data being represented using a single circle. The circle is split into sectors, that is, pieces of pie, the size of each one drawn into proportion to the class frequency. Each sector can be shaded or coloured differently if desired.

How to construct a pie chart

In order, to construct a pie chart, the size of each sector needs to be calculated in degrees. The procedure is:

Step one: Calculate the proportion of the total that frequency represents.

Step two: Since a complete circle has 360 degrees, multiply the proportion by 360 degrees, giving the sizes of relevant sectors (in degrees) that need to be drawn.

Step three: Using the compass, draw a circle by using an appropriate radius given in the question.

Step four: Indicate the sectors by using figures of sizes of degrees that you have found. In each sector, indicate the category that you are dealing with.

Example:

The table below shows the life expectancy data of some countries in southern Africa in 1995. Use it to answer the questions that follow.

Table 15: Life expectancy data for some countries in southern Africa in 1995.

Country	Life expectancy
Malawi	43
Mauritius	71
Mozambique	47
Namibia	59
South Africa	64

Question: Using the radius of 5 cm, draw a pie chart to illustrate the data above.

First, add all the life expectancy frequency values, that is, 43+71+47+59+64=284

Then, calculate the proportion of the total that the frequency represents.

Malawi $= {}^{43}/_{284} \times 360° = 54.5°$

Mauritius $= {}^{71}/_{284} \times 360° = 90°$

Mozambique $= {}^{47}/_{284} \times 360° = 59.6°$

Namibia $= {}^{59}/_{284} \times 360° = 74.8°$

South Africa $= {}^{64}/_{284} \times 360° = 81.1°$

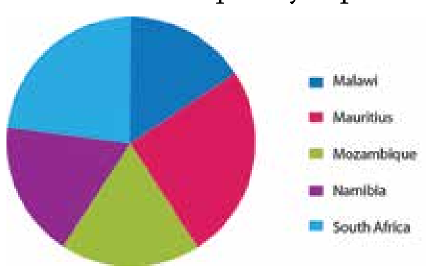


Fig. 1.1.21: A pie chart showing life expectancy of some countries in southern Africa

Activity 1.1.28:

Below is a table showing areas of protected lands in Malawi and their percentages. In groups of five, use it to answer questions that follow.

Table 16: Areas of protected lands and their percentages.

Category	Area of protected land	Percentage of protected land
Game reserves	?	19.4%
National parks	6, 960.926 km^2	?
Forests reserves	8080.6456 km^2	43.3%
Grand total	18, 662 km^2	100%

(a) Calculate the area covered by the game reserves in Malawi.

(b) Calculate the percentage of land covered by national parks in Malawi.

(c) Using a radius of 5 cm, draw a pie chart to display the information in the table.

Activity 1.1.29:

In a certain school, the lessons in each week are allocated as shown in the table below.

Table 17: Allocation of lessons according to subjects in a certain school.

Subject	Number of lessons
English	4
French	4
Maths	5
German	4
Science	6
Others	13

Using a radius of 5 cm, in pairs, draw a pie chart illustrating this data.

Activity 1.1.30:

In a certain class, 20 students were asked to give the number of children in their family. Use the information on the table below to answer questions that follow:

Table 18:Total number of children in the families of 20 students.

Number of children in family	Number of families	Angle subtended
1	*11*	*198°*
2	*5*	
3	*1*	
4	*2*	
5 or more	*1*	
Total	*20*	*360°*

In groups of five,

(a) Copy and complete the table above which shows the results.

(b) Using a radius of 4 cm, draw a pie chart accurately to show this information.

(e) Using age-sex pyramids

Age-sex pyramids display demographic data. As such, these pyramids will be constructed by using information regarding the following:

(1) **Age ranges**: This relates to how many people in the population are between a given age range, for example, 0-14, 15-24, 25-54 and so forth. This can be expressed as a percentage of the population.

(2) **Sex**: This involves the number of females and males in the population with regard to the age range given. The number of females and males within a certain age range can also be expressed as a percentage of the total number of people within the same age range.

Example: Below is the demographic data profile of Lesotho in the year 2014. Use it to construct the age-sex pyramid.

Table 19: Demographic data profile of Lesotho in the year 2014.

Age range	Percentage of total population	Males	Females
0-14yrs	32.9%	321,017	318,265
15-24yrs	19.9%	184,006	203,336
25-54yrs	36.8%	349,365	364,970
55-64yrs	4.9%	51,274	44,847
65 yrs and over	5.4%	55,955	51,973

Source: www.indexmund.com/namibia/demographics-profile.html

From the figures in the table above, the percentages of males and females can be calculated as follows:

Table 20: Demographic data showing percentages of males and females.

Age range	Males	Females
0-14yrs	15%	16%
15-24yrs	9.5%	10%
25-54yrs	18%	18%
55-64yrs	2.6%	2.3%
65 yrs and over	2.8%	2.6%

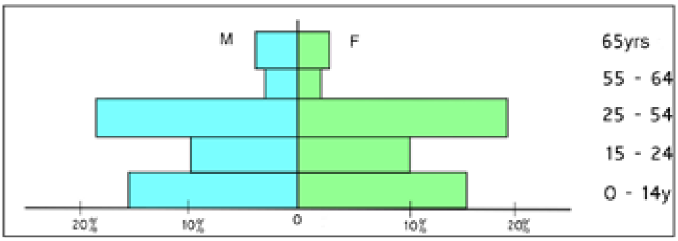


Fig. 1.1.22: An age-sex pyramid of Lesotho in 2014.

(f) Using statistical maps

A statistical map is a special type of map in which the variation in quantity of a factor such as rainfall, population, or crops in a geographical area is indicated. Examples of statistical maps are chloropleth maps, proportional symbol maps and dot maps. Refer to Fig. 1.1.23 below.

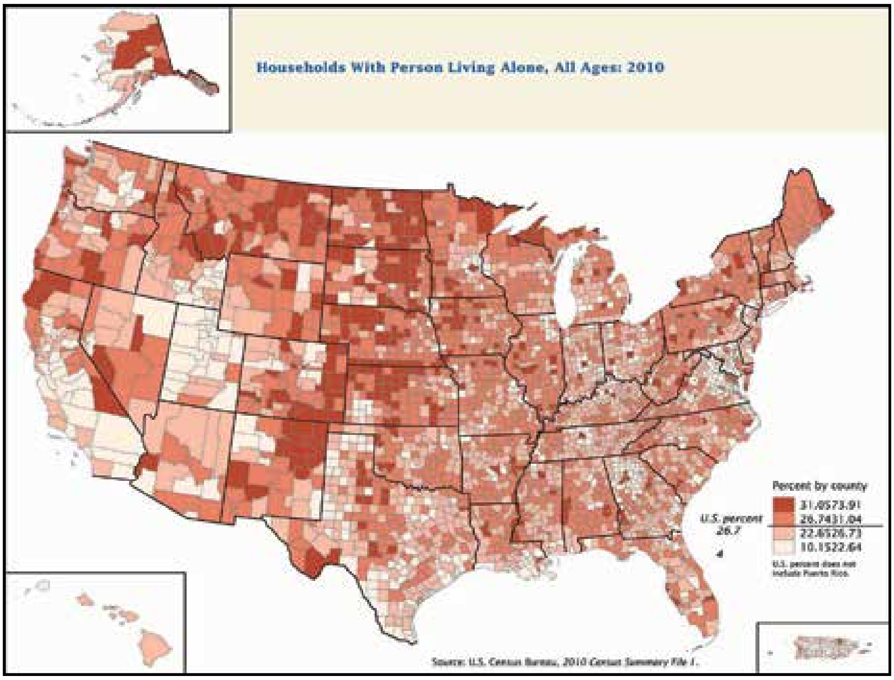


Fig. 1.1.23: A statistical map

(g) Using tables

One way of organising and presenting data is by using tables where data is put in rows and columns.

Example:

Zoya has decided to classify her music collection. She has a total of 84 cassettes and CDs. Out of these, 58 are pop music. Only two of her 50 cassettes are classical.

Organise this information in two-way table by finding the following:

(i) The number of classical CDs that Zoya has in her collection.

(ii) The total number of CDs for both classical and pop music owned by Zoya.

(iii) The number of CDs for pop music with Zoya.

(iv) The number of cassettes for pop music that Zoya is having.

(v) The total number of classical CDs that Zoya is organising.

Draw the table as shown below.

Table 21: Zoya's musical collection

	Cassettes	CDs	Totals
Classical			
Pop			
Totals			

Using the information given, put the data in the rows and columns.

(a) The total cassettes and CDs is 84.

(b) The total pop music cassettes and CDs is 58.

(c) There are 2 classical cassettes out of 50 cassettes.

Table 22: Showing Zoya's musical collection

	Cassettes	CDs	Totals
Classical	2		84-58=26
Pop	50-2=48		58
Totals	50	84-50=34	84

Table 23: Showing Zoya's musical collection

	Cassettes	CDs	Totals
Classical	2	26-2=24	84-58=26
Pop	50-2=48	58-48=10	58
Totals	50	84-50=34	84

Table 24: Showing Zoya's musical collection

	Cassettes	CDs	Totals
Classical	2	24	26
Pop	48	10	58
Totals	50	34	84

Activity 1.1.31:

In groups of five, complete the activity using the information in the table below:

Table 25: Activities chosen by 74 youngsters on an adventure holiday.

	Rock climbing	Mountain walling	Totals
Boys	**?**	**?**	5
Girls	**?**	**?**	20
Totals	**?**	**?**	?

Copy and complete the two-way table.

Activity 1.1.32:

Below is information on the boys and girls at a certain school.

Table 26: Levels and subjects taken by boys and girls at one school.

	Levels	1	2	3	4
Mathematics	Boys	2	5	13	32
	Girls	2	6	11	35
	Totals	**4**	**11**	**24**	**67**
English	Boys	3	7	14	31
	Girls	1	5	15	36
	Totals	**4**	**12**	**29**	**67**
Science	Boys	4	6	13	35
	Girls	3	7	13	34
	Totals	**7**	**13**	**26**	**69**

In groups of five, present the information in the table above in another format as shown below.

		Mathematics	English	Science
Level 1	**Boys**			
	Girls			
	Total			
Level 2	**Boys**			
	Girls			
	Total			
Level 3	**Boys**			
	Girls			
	Total			
Level 4	**Boys**			
	Girls			
	Total			

(h) Using flow diagrams

Flow diagrams are used to describe data that involves processes which occur at a certain point in time. A flow chart will always describe progression of data in a form of connected circles, boxes and any other geometric shape. This shows relationships that exist among the various steps.

Example of a flow chart

Draw a flow chart showing stages involved in cement making as provided in the paragraph below.

"Raw materials, namely shale and limestone are crushed and later on mixed. Water is then added and the mixture is put in a kiln where heat is applied to allow the water to evaporate. The result is called clinker which is then transported to Blantyre where gypsum is added to the it. The mixture is ground to powder which gives us cement as a product. This product is then stored to await distribution."

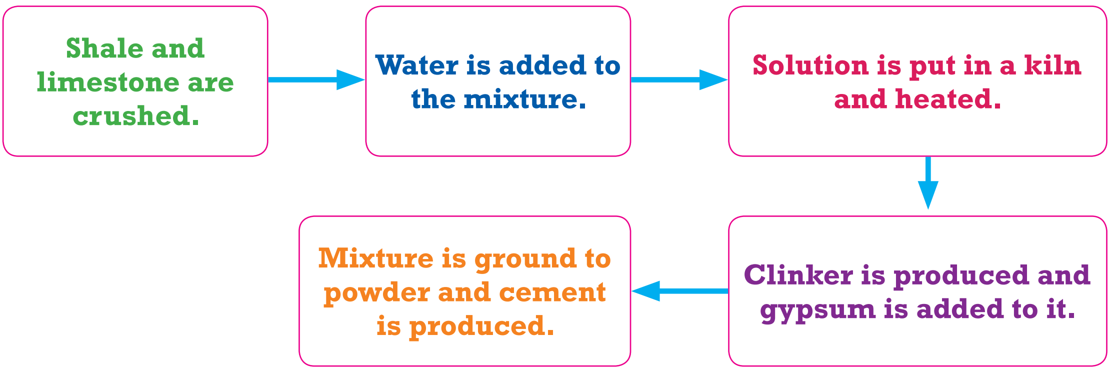


Fig. 1.1.24: A flow diagram showing production of cement

Activity 1.1.33:

In groups of five, analyse the following process of extracting aluminium from bauxite and then come up with a flow diagram.

"Bauxite ore is crushed and then caustic soda solution is added. Heat is applied under pressure. The end result is a combination of both dissolved silica and aluminium in solution leaving behind undissolved iron oxide. This substance is not necessary and therefore it is removed by filtration process. Aluminium hydroxide is then added to form aluminium precipitate which is heated to produce alumina or aluminium oxide. Molten crylite is added to the alumina and the mixture is smelted or electrolysed to allow molten aluminium to form at the cathode".

Review Questions

Q1. (a) Measure the length of S152 road on the topographical map extract of Nkhate.
(b) Calculate the area covered by Livunzu estate on the topographical map extract of Nkhate.
(c) Mention any two economic activities that take place in this part of Nkhate.
(d) Identify any three land uses on the topographical map of Nkhate.
(e) Explain any two factors that affect land use patterns.

Q2. Calculate the gradient between the trigonometrical station 308/NYS and the borehole BHZ219 on the topographical map of Nkhate. Use a scale 50 ft represents 200 metres.

Q3. (a) Look at the map extract of Nkhate area between Eastings 08 and 13 along Northing 12. Are these points (Eastings 08 and 13) intervisible? Give a reason for your answer..
(b) Determine intervisibility between points A and B below, then give a reason for your answer.

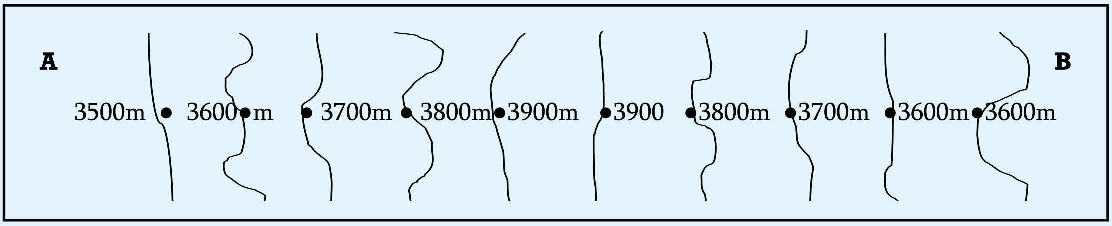


Fig. 1.1.24: Intervisibility between two points A and B

Q4. (a) Reduce Livunzu estate by half.
(b) Describe one advantage of reduced scale.

Q5. (a) Identify the riverine features that you observe on the topographical map extract of Nkhate.
(b) Explain how such riverine features form.

Q6. (a) Mention any three methods of collecting data.
(b) State any two advantages and disadvantages of the above-mentioned methods of collecting data.
(c) Describe how you can design the instruments of collecting data that you have mentioned in Q6 (a) above.
(d) Explain the procedures of collecting data.

Q7. (a) Describe two appropriate procedures for analysing data.

Table 27 below shows daily temperatures for New York City, recorded for 6 days, in degrees Fahrenheit. Use it to answer Q7 (b) that follows.

Table 27: Daily temperatures for New York City.

Day	Temperatures
1	43° F
2	53° F
3	50° F
4	57° F
5	59° F
6	67° F

(b) Plot the line graph using the information in the table above.

Q8. Table 28 below shows the number of visitors by purpose to Malawi in the year 1984. Use it to answer the questions that follow:

Table 28: Number of visitors by purpose to Malawi in 1984.

Purpose	Number of visitors
Holiday	?
Business	18, 196
Visiting friends and relatives	12, 916
Total	**45, 095**

(a) Find the number of visitors who came to Malawi for holiday.

(b) Using the radius of 5 cm, draw a pie chart to illustrate the information above.

Q9. One hundred people arriving home from holiday were asked what type of accommodation they had taken up. Part of the information is given in the table below. Use it to answer the questions that follow.

Table 29: People arriving home from holiday

	Hotel	Caravan	Camping	Others	Totals
July	11	4	3	?	?
August	?	14	?	06	?
Sept	?	?	4	03	30
Totals	**49**	?	**15**	**11**	**100**

(a) Copy and complete the table.

(b) How many of these people;

(i) Went on holiday in August?

(ii) Stayed in a hotel in September?

Q10. Below is the data regarding Namibia demographics profile of 2014. Use it to draw the age-sex pyramid.

Table 30: Namibia demographics profile in 2014.

Age range	Percentage of total population	Males	Females
0-14yrs	31.7%	352,368	345,593
15-24yrs	23.1%	256,965	251,276
25-54yrs	35.9%	410,736	378,678
55-64yrs	4.8%	47,832	58,602
65 & over	4.4%	41,697	54,659

Q11. Below is a table showing petrol consumption of a car in litres at various speeds. Use it to answer the questions that follow.

Table 31: Petrol consumption of a car in litres at various speeds.

Speed km/h	20	30	40	50	60	70	80	90	100
Consumption	5.5	4.8	4.4	4	4	4.3	4.9	5.8	7.2

(a) Draw a pair of axes with speed on the horizontal axis and petrol consumption on the vertical axis.

(b) Plot the nine points from the table and draw a smooth curve.

(c) From your graph, estimate the most economical speed for the car.

(d) Estimate the consumption in litres per 100 km at a speed of 95 km/h.

Q12. Draw a flow diagram from the information below regarding the process of desalination.

"Saline water is subjected to low temperatures so that it freezes inside a freezing chamber. Ice mixed with water forms which are later on separated and ice crystals are finally washed to remove brine (salty water). The washed ice particles are put in a container where they are heated so that they change to liquid (fresh water)."

TOPIC 2

The Lithosphere

Success criteria

By the end of this topic, the student should be able to:

- Explain the theory of 'continental drift'.
- Explain the evidence supporting the continental drift theory.
- Examine the weaknesses of the continental drift theory.
- Explain the plate tectonics theory.
- Explain the causes of plate tectonics.
- Explain the different types plates and boundaries.
- Identify features formed along plate boundaries.
- Explain the formation of geological features.
- Explain the effects of geological features on the environment and human activities.
- Explain the main processes of mountain building in relation to plate tectonics.
- Explain the different features formed from mountain building process.
- Analyse the effects of mountain building on life and human activity.
- Explain the term 'volcanism'.
- Explain the formation of a volcano.
- Explain extrusive and intrusive features formed from a volcano.
- Assess the effects of volcanic activity.
- Explain the term 'earthquake'.
- Explain the causes of earthquakes.
- Explain the effects of earthquakes.
- Explain the relationship among fold mountains, volcanoes and earthquakes.
- Describe the main types of rocks.
- Explain the formation of rocks.
- Identify characteristics and samples of each type of rock.
- Examine the importance of rocks to life and human activities.

Background

In Form One, you learnt about the shape of the earth, its movements and their related effects. In Form Two, you looked at the internal structure of the earth and formation of different features on the earth's surface. In Form Three, you will learn about the theories of continental drift and plate tectonics. You will also tackle the mountain building process, volcanism, earthquakes as well as rocks.

Terminologies:

Activity 2.2.1:

Brainstorm on the meanings of the terms 'theory' and 'continental drift'.

Explanations:

- **Theory:** A theory is an explanation for observed phenomena that has a high possibility of being true. It is a concept that has been highly tested and in all likelihood, it is true. In common usage, it is for what scientists call ***hypothesis,*** that is, a ***tentative answer*** to a question or ***solution*** to a problem.
- **Continental drift:** This refers to the idea that continents move freely over the earth's surface, changing positions relative to one another.
- **Continental drift theory:** This is the theory that suggests that at one point in time, the earth was a single continent called ***Pangea***. This single continent was surrounded by a single super ocean known as ***Panthalasa*** or ***Tethy Sea***. The proponent of the theory (Alfred Wegener, a German meteorologist) suggested that this single supercontinent later split into the present day continents.

SPECIFIC PHYSICAL OCCURRENCES WITHIN CERTAIN PERIODS

There were specific physical occurrences that took place within certain periods, millions of years ago. These include the following:

(A) Permian Period (225 million years ago)

Physical occurrences: There was a single supercontinent called ***Pangea*** which was surrounded by a single super ocean called ***Panthalasa*** or ***Tethy Sea***.

(B) Early Triassic Period (200 million years ago)

Physical occurrences: The Pangea broke apart and the land blocks separated slowly in a sideways direction.

(C) Late Triassic Period (180 million years ago)

Physical occurrences: The land blocks formed two major landmasses namely Luarasia in the north and Gondwanaland in the south. Luarasia later broke into North America, Greenland, Madagascar, India, Australia and Antarctica. Gondwanaland broke into Africa and South America.

(D) Late Jurassic Period (135 million years ago)

Physical occurrences: Landmasses formed from Luarasia and Gondwanaland gradually moved apart.

(E) Late Cretaceous Period (65 million years ago)

Physical occurrences: India moved northwards to join Asia. South America drifted northwards to join North America, that was moving westwards. Australia detached itself from Antarctica and drifted eastwards. Antarctica moved southwards.

(F) Quaternary Period (Less than 1 million years ago)

Physical occurrences: The continents attained their present position but still continued to drift apart.

Fig. 2.2.1 below shows the continental drift process.

Illustration of the continental drift process

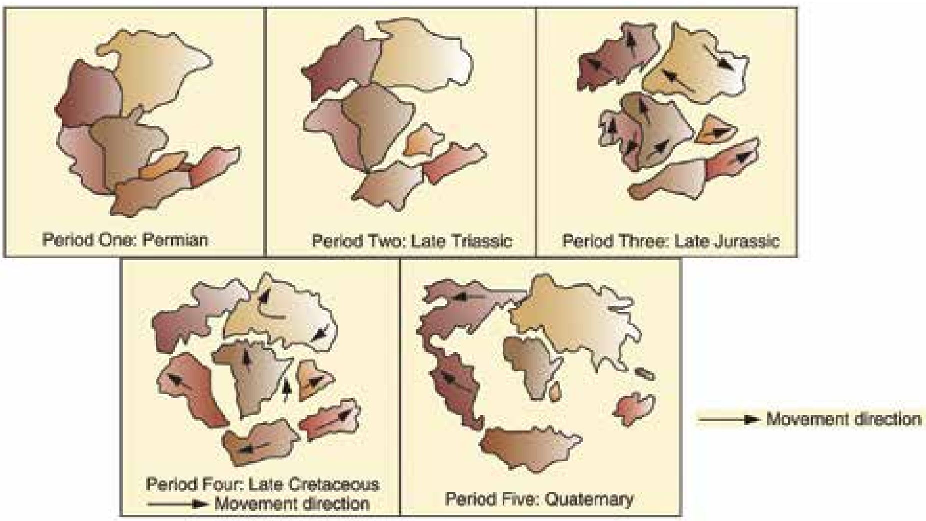


Fig. 2.2.1: The continental drift process

Activity 2.2.2:

In pairs, study the diagram showing the continental drift process. Redraw it in your notebooks in order to demonstrate how continents drifted apart.

Note: The waters of the super ocean (Panthalasa or Tethy Sea) formed the various oceans Atlantic, Pacific and Indian Ocean that we see today.

Activity 2.2.3:

In groups of five, discuss the theory of continental drift.

Evidence supporting the theory of continental drift

(a) The southern continents fit in a gigantic jig-saw puzzle, that is, they can easily fit if brought together.

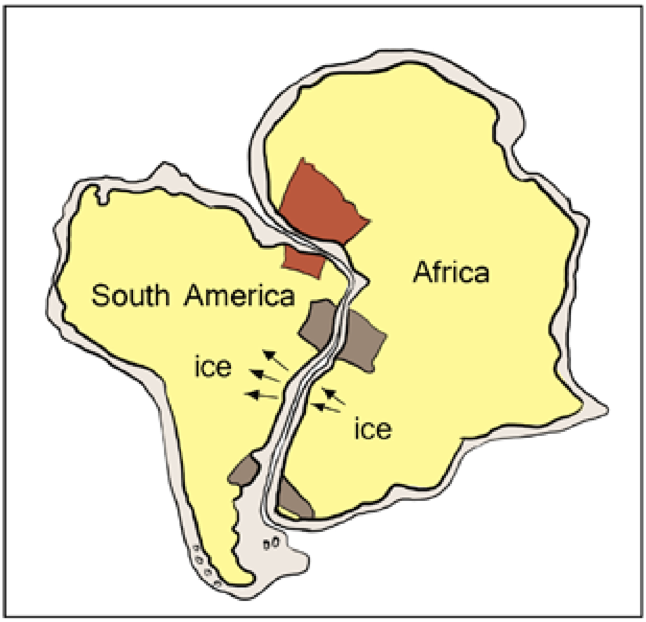


Fig. 2.2.2: How southern continents fit if brought together

Activity 2.2.4:

In pairs, redraw the model above and see how the South American and African continents can easily fit if brought together. Then analyse figure 2.2.3 and identify similarities of fossils in different continents.

(b) There is an almost identical geological sequence of rock layers in South Africa, Deccan plateau (India), Plateaux of South America and Antarctica.

(c) Folded ranges of Argentina are similar in structure and age to the folded Cape Ranges of South Africa.

(d) Magnetism of ancient rocks (paleomagnetism) indicates that continents were once a single continent. Rocks are magnetised in the direction of magnetic north when solidifying. All ancient rocks on all continents show a similar magnetism pattern.

(e) West African rocks and those of Brazil are similar in their structure. This shows that the two regions were once joined.

(f) Some continents have similar climates such as the eastern part of South America and the south western part of Africa.

(g) Fossils in different continents appear similar. For example, the fossil remains of land-dwelling reptiles *Lystrosaurus* and *Cynognathus* are found on all continents in Triassic age rocks. The plant *Glossopteris* is found in Pennsylvanian and Permian-age rocks on all the continents.

(h) Some identical species exist on certain continents. Earthworms exist in both Africa and South America.

(i) Mineral specimens along the supposed breaklines of the continents are nearly identical.

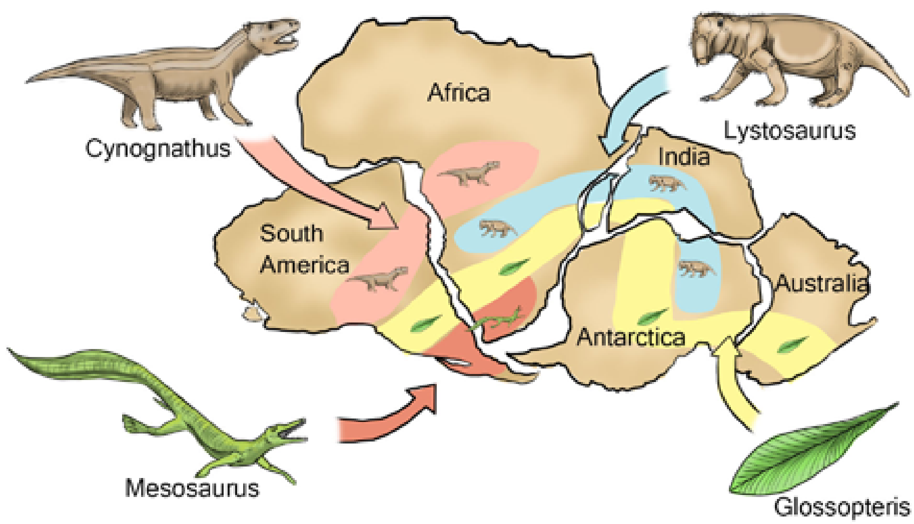


Fig 2.2.3: Fossils on the continents of South America, Antarctica, India and Australia

Weaknesses of the theory of continental drift

Activity 2.2.5:

Brainstorm on the weaknesses of the theory of continental drift.

Explanations

(a) The theory does not explain what caused the drifting process.

(b) The separation of continents (continental drift process) has been strongly opposed on physical grounds. Alfred Wegener for instance, proposed that the continental layer of less dense rocks had moved like a great raft through a 'sea' of dense oceanic crust rock. This process is physically impossible because the rigid crustal rock could not behave in such a fashion.

(c) Critics have argued that fossil plants might have been spread throughout the drifted continents by wind or ocean currents and not by the drifting continents.

(d) It is difficult to match some of the continents, for example, northern continents.

(e) The driving mechanism proposed by Alfred Wegener for continental drift was a combination of centrifugal force from the earth's rotation and gravitation force that cause tides. But careful calculations of these forces showed them to be too small to move continents.

(f) The presence of land-dwelling reptiles throughout the scattered continents was explained by land bridges, which were postulated to somehow rise up from the sea floor and then subside again. The existence or non-existence of land bridges was difficult to prove without data on the topography of the sea floor.

(g) Apparent movement of poles or polar wandering.

What is polar wandering?

This is the apparent (seemingly) movement of the earth's poles.

Explanation

Polar wandering might have been caused by moving poles rather than moving continents. The position of magnetic poles seems to have wandered all over the earth. A group of geophysists who first measured the poles for polar wandering in the 1950s discovered that the magnetic poles move a little but still always remain close to the poles of rotation. They also discovered and were surprised to learn that the path of the apparent polar wandering measured in North America was different from that measured in Europe. They arrived at a conclusion from which originates one of the weaknesses. They concluded that because the poles could have moved, then it must be continents and magnetic poles which had moved. However, a mechanism to explain the movement that occurred was still lacking.

Activity 2.2.6:

Organise the class into proposers and opposers so as to debate on the following questions related to the weaknesses of the theory of continental drift.

- *Is it possible for the continental crust to break in the way Alfred Wegener suggested?*
- *Is it true that fossils have been spread over the continents by the drifting process?*
- *Is it possible to match continents?*
- *Is it true that continents drifted apart due to the rotation of the earth as Alfred Wegener suggested?*

THE THEORY OF PLATE TECTONICS

Introduction

The main challenge with Alfred Wegener's theory was that it contained no explanation of how entire continents could move. Wegener's explanation of continental drift in 1912 was that the drifting occurred because of the earth's rotation. This explanation and theory was not widely accepted. In 1968, the theory of plate tectonics attempted to solve this problem.

The theory of plate tectonic was proposed as a hypothesis in the early1960s. The idea of this theory was based on the earlier hypothesis of continental drift. The concept of plate tectonics was born by combining two pre-existing ideas namely continental drift and sea floor spreading. Continental drift is the idea that continents move freely over the earth's surface, changing their positions relative to one another. Harry Hess, a geologist from Princeton University, further put forward a hypothesis of sea floor spreading. He suggested that the sea floor moves away from the ridge crest and toward the trenches as a result of mantle convection.

Terminologies:

- Plate: This is a large, mobile slab of rock that forms part of the earth's surface. It is found along the imaginary line, known as the moho discontinuity, which separates the mantle and the crust. In order to know where plates move inside the earth's crust, refer to the Fig. 2.2.4 below.

- Tectonic activity: This refers to how the entire lithosphere, including the crust, breaks and bends.
- Tectonics: This is the study of tectonic activity.
- Asthenosphere: This is the region of the earth's outer shell beneath the lithosphere. It is of indeterminate thickness and has plasticity as part of its characteristics.
- Plate tectonic theory: This is a theory that suggests that the earth has six large and several small lithospheric slabs or plates. These plates are continuously in motion, floating on the asthenosphere. Refer to Fig. 2.2.4 below.

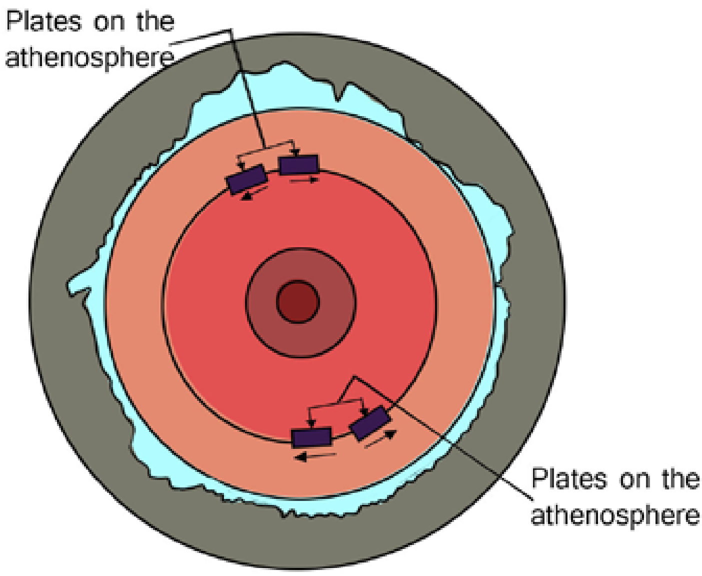


Fig. 2.2.4: Diagram showing the plate tectonics theory

Activity 2.2.7:

In groups of five, discuss the meaning of the term 'plate tectonics'.

Relation of the theory of continental drift to plate tectonics

Activity 2.2.8:

In groups of five, discuss the similarities and differences between the continental drift theory and the plate tectonics theory.

Table 33: Differences and similarities between continental drift and plate tectonics theories.

	Continental drift theory	**Plate tectonics theory**
Similarity	Continents move because of convectional currents in the upper part of the mantle.	Plates move continuously because of convectional currents in the upper part of the mantle.
Differences	It is the continents which drift apart.	It is the plates that move.
	Continents only move in one direction, that is, sideways; only tensional force determines the movement.	Plates move in three ways depending on the force that applies and the way magma moves in the mantle.

CAUSES OF PLATE TECTONICS

Activity 2.2.9:

Brainstorm on the causes of plate tectonics.

Convectional currents that operate within the upper part of the mantle cause this tectonic activity. These currents are responsible for plate spreading or divergence, collision or convergence and plates moving past each other.

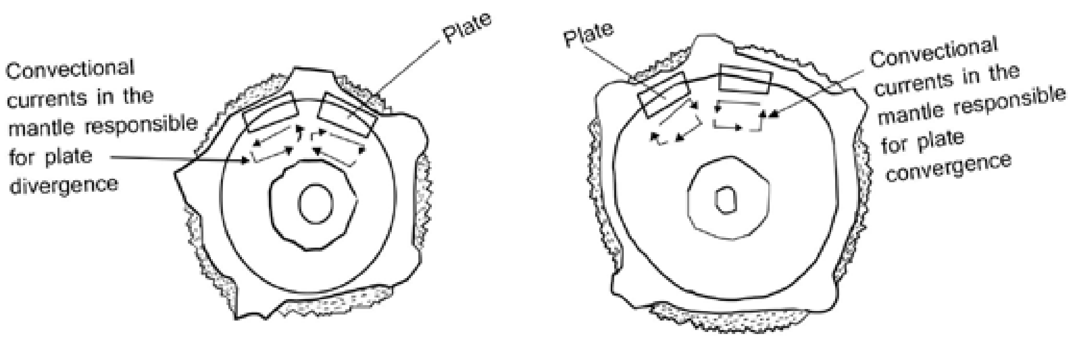


Fig. 2.2.5: Convectional currents that determine plate movements

Activity 2.2.10:

In groups of five, analyse the figures showing convectional currents that determine plate movements. Discuss the causes of plate movements.

Description of convectional currents and mantle plumes

Convectional currents in the upper part of the mantle occur because of loss of heat from the most inner part of the earth (core) that heats the mantle, causing it to overturn. W. Jason Morgan of Princeton University suggested and proposed that convectional currents occur in the form of mantle plumes. These mantle plumes are narrow columns of hot mantle rock that rise through the mantle, (much like smoke rising from a chimney). Mantle plumes are thought to have mushroom-shaped heads above a narrow rising hail (see figure below). When the large head of plume nears the surface, it causes uplift and the eruption of a vast field of flood basalt. As the head widens beneath the crust, the flood basalt area widens and the crust is stretched.

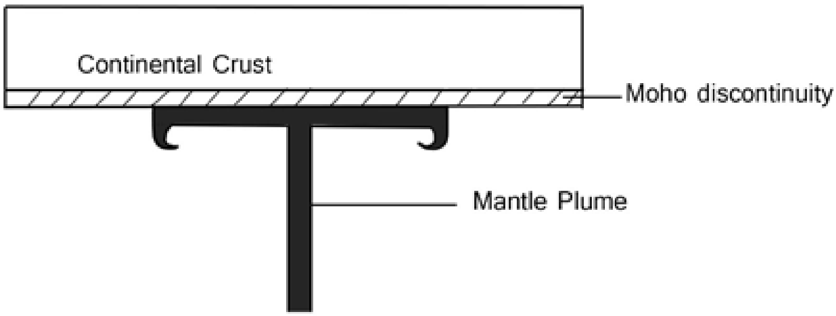


Fig. 2.2.6: Mantle plumes

TYPES OF PLATES AND BOUNDARIES

The earth is divided into a number of plates which are also referred to as lithospheric slabs. These plates move and are carried on a soft layer between the crust and mantle called asthenosphere. The plates are moved by horizontal-moving convectional currents (refer to Fig. 2.2.5 showing convectional currents that determine plate movements).

There are two types of plates, namely:

(a) Continental plates

These are lighter plates which carry the continents. Examples of such plates include: North American Plate, South American Plate, African Plate and the Eurasian Plate.

(b) Oceanic plates

These are denser plates which contain heavier basaltic rocks that form the ocean floor. Examples of such plates include the Pacific Plate and the Antarctic Plate.

Location of the main tectonic plates and their boundaries

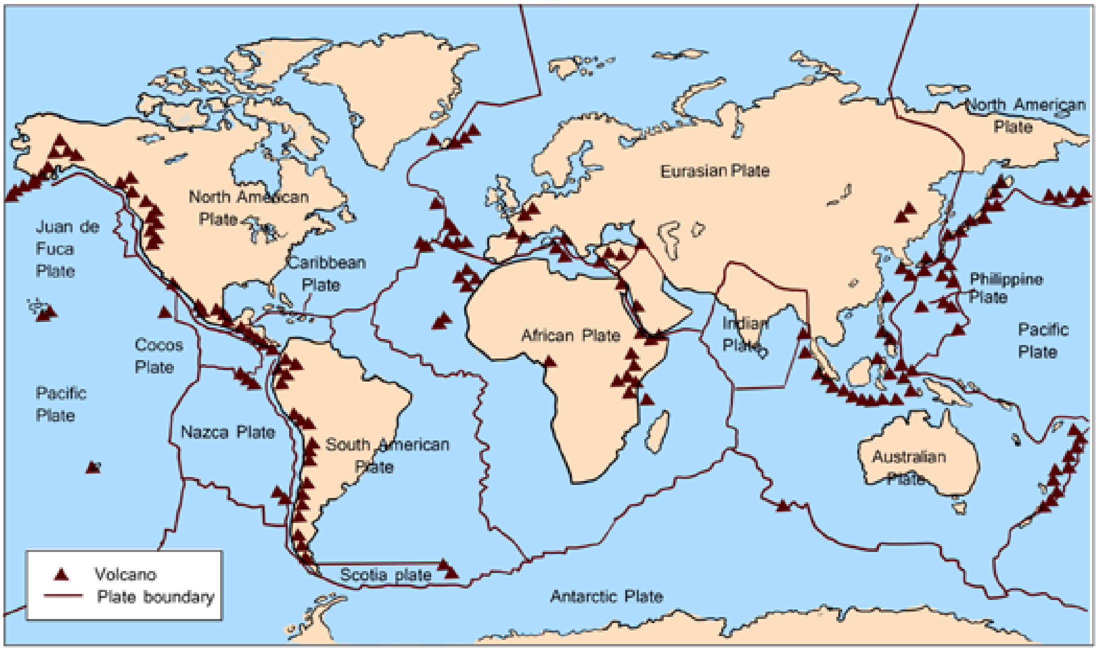


Fig. 2.2.7: Main tectonic plates and plate boundaries

Activity 2.2.11:

In pairs, draw the world map in your notebooks and indicate the following on it:

(a) ***Main tectonic plates***

- *Nazca oceanic plate.*
- *South American plate*
- *Philippines plate*
- *Pacific oceanic plate.*
- *North American plate*
- *African plate*
- *Australian plate*
- *Eurasian plate*

(b) ***Plate boundaries***

Direction of movement of main tectonic plates

Table 34: Direction of movement of main tectonic plates

Name of tectonic plate	Direction of movement
NAZCA	Eastwards
PACIFIC	Westwards
AUSTRALIAN	North eastwards
EURASIAN	Eastwards
SOUTH AMERICAN	Westwards
NORTH AMERICAN	Westwards
PHILIPPINES	Eastwards
AFRICAN	North eastwards

PLATE BOUNDARIES

Meaning of plate boundaries

Plate boundaries are zones of instability. The changes that take place in the margins of continents lead to the formation of the world's major landforms such as rift valleys, plateaus, block mountains, oceanic ridges, oceanic islands, volcanic mountains and fold mountains.

The main plate boundaries include:

(a) Destructive margins or convergent plate boundaries

These are margins of converging plates. They are called destructive margins because this is where the crust is destroyed.

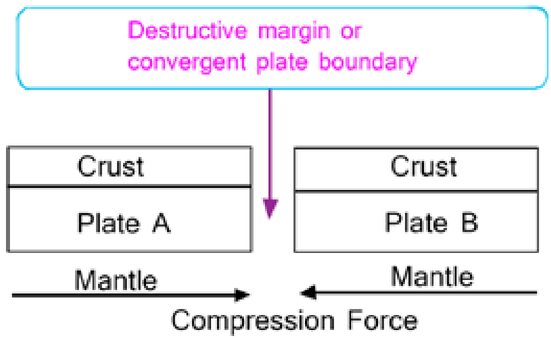


Fig. 2.2.8: Destructive margin or convergent plate boundary

(b) Constructive margins or divergent plate boundaries

These are margins of diverging plates. They are called constructive margins because these are places where a new crust is formed.

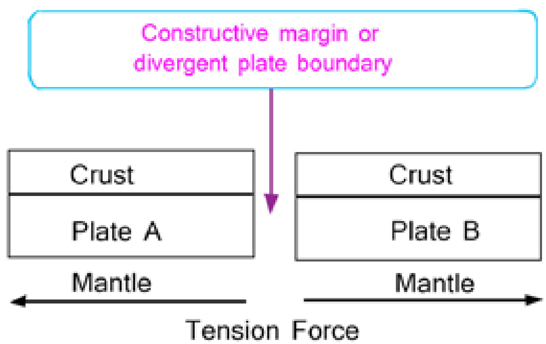


Fig. 2.2.9: Constructive margin or divergent plate boundary

(c) Conservative margins or transform plate boundaries

These are margins that occur where two plates move past one another.

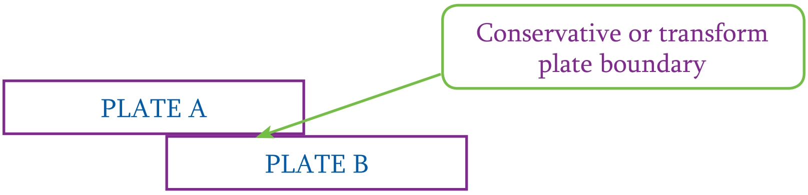


Fig. 2.2.10: Conservative or transform plate boundary

Activity 2.2.12:

In pairs, draw diagrams to demonstrate the following plate margins or boundaries:

(i) Destructive margin or convergent plate boundary

(ii) Constructive margin or divergent plate boundary

(iii) Conservative margin or transform plate boundary

Then show each other what you have drawn.

TYPES OF PLATE MOVEMENTS

There are three types of plate movements. These include the following:

1) Spreading or diverging plate movement

In this type of movement, plates move apart. This movement of plates is caused by a kind of convectional current that moves away from the centre of plumes outwardly as shown in the diagram below. Such movement of convectional currents creates tension force.

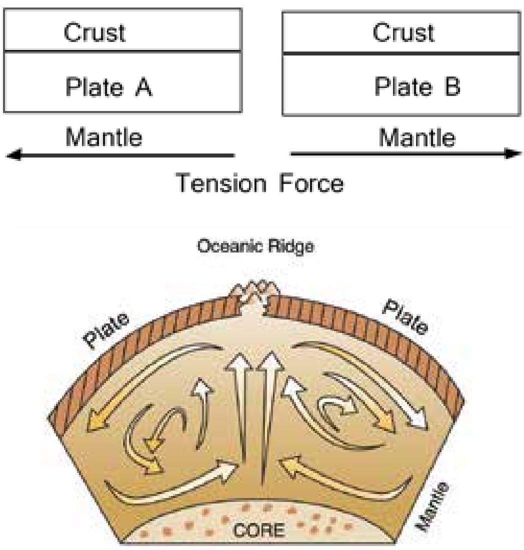


Fig. 2.2.11: Spreading or diverging plate movement

Effects of spreading or diverging plate movement

This type of plate movement results into the formation of various physical features such as marine/oceanic ridges, volcanic mountains, volcanic islands, rift valleys and block mountains, which are formed due to tension force. Earthquakes and volcanic activities are very common where there are diverging plate movements.

Convectional currents originate from the centre outwards laterally. → Convectional currents create tension force. → Plates are subjected to tension force and they eventually break. → Plates begin to diverge and move away from each other. → Magma comes out of the earth's surface and forms such features as oceanic ridges, volcanic islands, rift valleys, block mountains and volcanic mountains.

Fig. 2.2.12: Flow diagram showing spreading or diverging movement

2) Converging or colliding plate movement

In this type of plate movement, plates move towards each other under compression force and finally collide. It is caused by convectional currents that originate from different areas of plumes and come together as shown in the figure below.

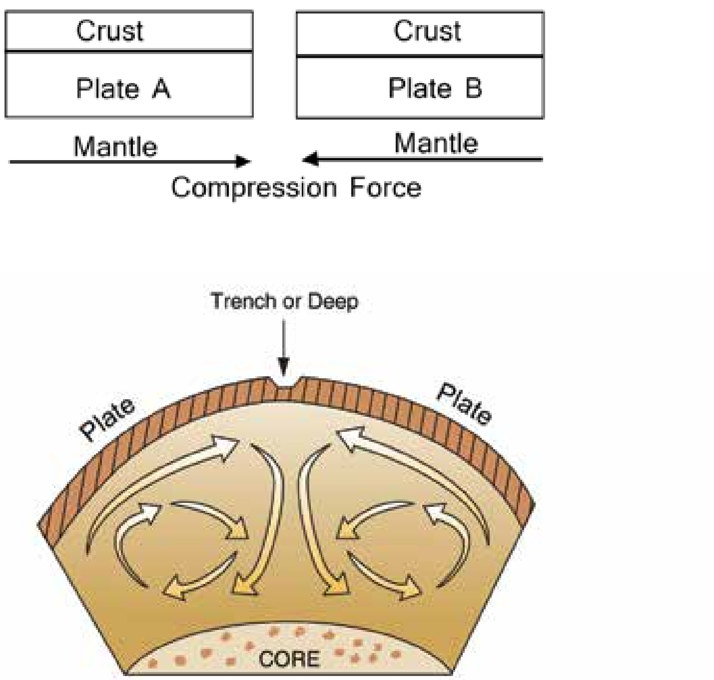


Fig. 2.2.13: Converging or colliding plate movement

Effects of converging or colliding plate movement

This type of movement of plates results in the formation of such features as trenches, oceanic islands, fold mountains, block mountains and rift valleys under compression force. It also results into earthquakes and volcanism.

Convectional currents originate from different points and move towards the same point. → Convectional currents create compression force. → Plates are subjected to compression force and they eventually bend or fold. → Plates begin to converge and move towards each other. → Plates bend or fold upwards forcing lower and upper crust to also bend upwards. Features produced include fold mountains and oceanic islands. In some cases, some sections of the earth are raised with respect to the others, forming rift valleys and block mountains.

Fig. 2.2.14: Flow diagram showing converging or colliding plate movement

3) Shearing or sliding plate movement

In this type of movement, plates move past each other. This is caused by convectional currents that operate in the opposite direction. The boundary that separates the two plates is called a fault boundary. The San Andreas Fault in California is a very good example of this boundary and earthquakes are very common.

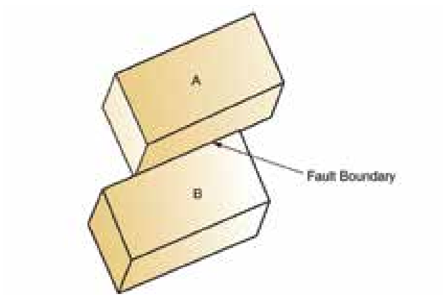


Fig. 2.2.15: Sliding or shearing plate movement

Effects of shearing or sliding plate movement

(i) It results into earthquake activities and their associated effects.

(ii) It results into volcanism.

Convectional currents flow in opposite direction. → Plates move in the opposite direction. → Earthquakes, volcanoes are common along the fault boundary.

Fig. 2.2.16: Flow diagram showing shearing or sliding plate movement

Activity 2.2.13:

In pairs, using good diagrams, demonstrate the following types of plates:

- *Converging or colliding plate movement*
- *Diverging or spreading plate movement*
- *Shearing or sliding plate movement*

CASE STUDY 1: THE SAN ANDREAS FAULT

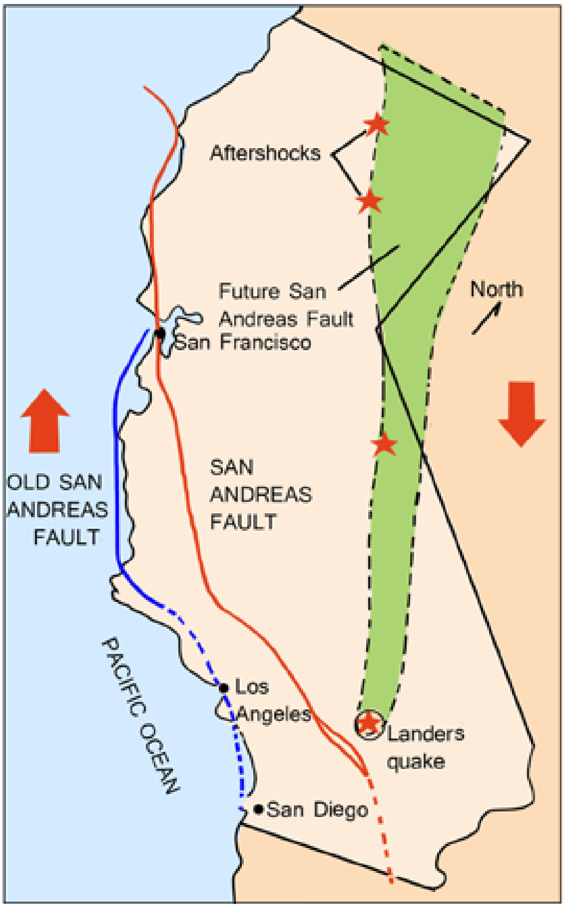


Fig. 2.2.17: The San Andreas Fault boundary

The San Andreas Fault is a 'master' fault of an intricate fault network that cuts through rocks of the California coastal region. It is more than 800 miles long and extends to a depth of 10 miles within the earth. It forms a continuous narrow break in the earth's crust that extends from northern California southwards to Cajon Pass near San Bernardino. This fault is characterised by such surface features as long straight escarpments, narrow ridges, and small un drained ponds formed by settling of small blocks within the zone. Many stream channels characteristically flow sharply to the right where they cross the fault.

Blocks on the opposite sides of the San Andreas Fault move horizontally. During the 1906 earthquake in the San Francisco region, roads, fences and rows of trees and bushes that crossed the fault were offset several yards. The road across the head of Tomales Bay was offset almost 21 feet, the maximum offset recorded.

Source: Schulz S.S. and Wallace R.E. from http://pubs.usgs.gov/gip/earthq3/safaultgip.html.

Activity 2.2.14:

In groups of five, answer the following questions:

Q1. Identify the kind of plate movement in the San Andreas Fault.

Q2. What evidence is there in the case study that backs up your answer to Q1?

Q3. What do you think can be the cause of the movement of blocks in the San Andreas Fault?

Q4. Mention the effects caused by the movement of the blocks in the San Andreas Fault.

GEOLOGICAL FEATURES THAT ARE FORMED ALONG PLATE BOUNDARIES

It is important to note that geological features can form under both tension and compression forces. This occurs through diverging or spreading plate movement and converging or colliding plate movement respectively.

(a) Features formed under diverging or spreading plate movement

These features form when convectional currents move in the opposite direction from one centre and generate tension force. These features include the following:

1. Volcanic islands

A volcanic island is formed when plates diverge or move apart due to tension forces. This happens on the sea floor of water masses which are found inside continents. As plates move away from each other, it forces the lower crust and the mantle to break, thereby creating a vent (a hole through which magma passes). Later on, the magma originating from the core eventually seeps above the surface of the water. It cools and solidifies to form a feature called a volcanic island.

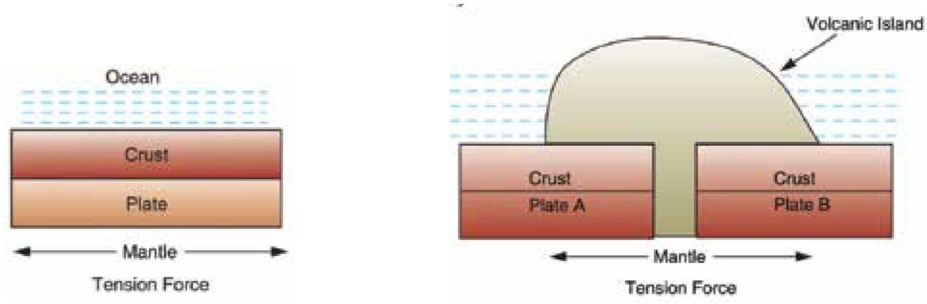


Fig. 2.2.18: A volcanic island

2. Oceanic or marine ridges

Meaning of the term 'oceanic or marine ridge'

This is a giant mountain range that extends on the sea bed or ocean floor. Though it does not protrude above the hydrosphere, it rises 2 to 3 kilometres above the ocean floor. It is made up of mostly basalt.

How does it form?

A marine or oceanic ridge is formed when there is tension force which causes two plates to diverge or move away from each other, under the lower crust, below the sea or ocean. The tension force breaks the crust above the plates, the plate itself and the mantle, thereby creating a vent. This allows magma to leave the core and come out to the bottom part of the ocean. At this point, magma just spreads on the ocean floor or sea bed, forming a solid rock which is a new crust. This solid rock is referred to as an oceanic or a marine ridge.

The zone between the diverging plates is sometimes called a spreading zone. An example of such a zone is beneath the Atlantic Ocean where the African plate and the American plate diverge. The magma outpourings in this zone have resulted in a ridge called the Mid-Atlantic ridge. Other examples of ridges include Chagos-Laccadive, South West and South East Indian Ridges (refer to diagram of main tectonic plates (Fig.2.2.7). See the figure below for an illustration of the marine or oceanic ridge.

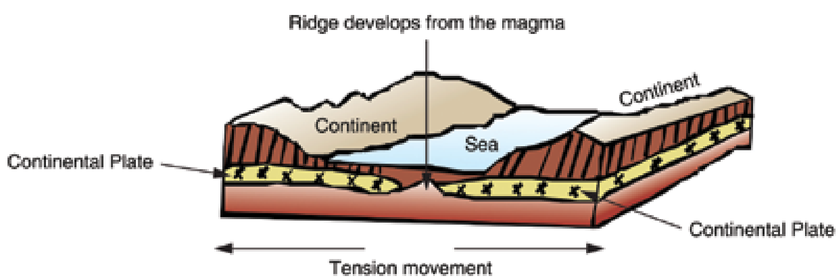


Fig. 2.2.19: An oceanic or marine ridge

3. Volcanic mountains

These are mountains that are formed when plates move away from each other under tension force. When this happens, magma comes out through vents as well as fissures cools and solidifies on the earth's surface and forms volcanic mountains.

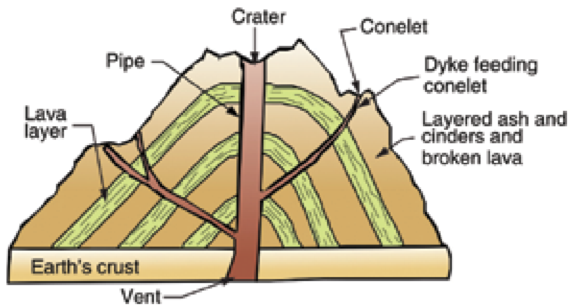


Fig. 2.2.20: Volcanic mountains

4. Block mountains and rift valleys under tension force

When tension force applies on a section of the earth, cracks or faults develop as shown in stage one in Fig. 2.2.21 below. When the force continues to apply, the middle section subsides or sinks leaving the two blocks on either side. This creates a rift valley or graben which when filled by water becomes a rift valley lake. The remaining blocks of land form mountains known as block mountains or horsts.

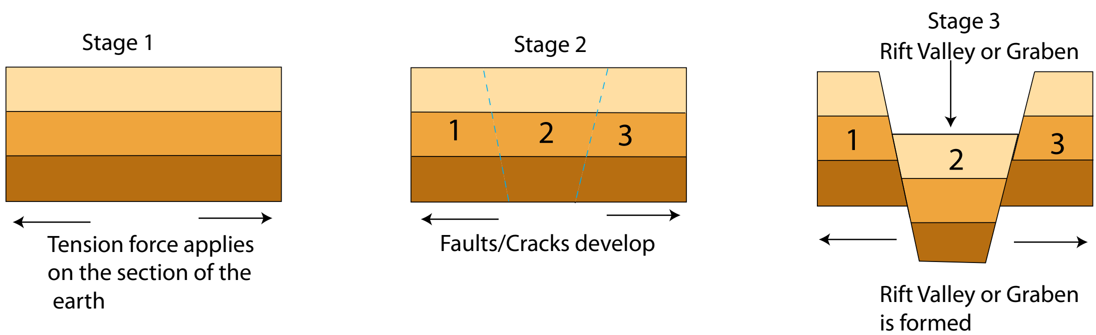


Fig. 2.2.21: Formation of rift valleys and block mountains or horsts under tension force

(b) Features formed under converging or colliding plate movement

1. Rift valleys and block mountains under compression force

When compression force applies on a section of the earth, cracks develop in a manner shown in stage one in Fig. 2.2.22 below. When the force continues to apply, the blocks on the sides are raised above the central block. This creates a rift valley or graben which when filled by water becomes a rift valley lake. The blocks of land on the sides that are raised over the central block form mountains that are called block mountains or horsts.

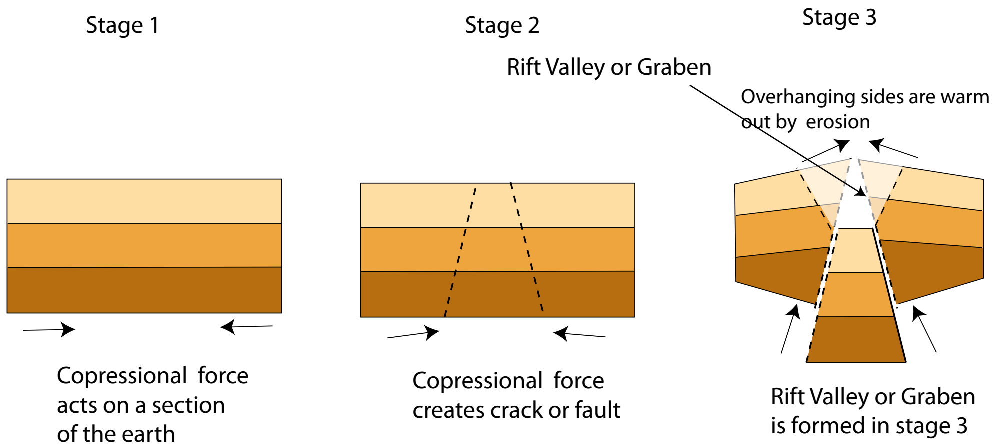


Fig. 2.2.22: Formation of block mountains and rift valleys under compression force

2. Trenches

Meaning of the term '*trench*'

This is a narrow, deep trough that is parallel to the edge of the continent or an island arc (a curved line of islands like Aleutians or Japan).

Formation of trenches

Trenches form when an oceanic plate and a continental plate collide when there is compression force. The margin of the oceanic plate is drawn beneath the continental plates because it is heavier than the continental plate. This forms a V-shaped feature called a trench. Examples of trenches include Peru, Aletian, Java, Marianas and Tonga.

The rocks of the oceanic plate are absorbed in the mantle. The destructive margin is called zone of subduction. Examples of active subduction zones are found off the coast of Japan, California and West Coast of South America.

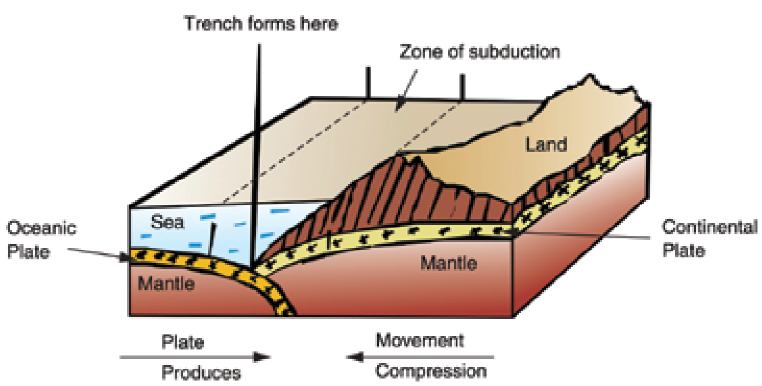


Fig. 2.2.23: Formation of trenches

3. Formation of fold mountains

Fold mountains form when there are compression forces on the rocks in the trench. The sedimentary rocks in the trench are eventually folded or pushed up to form fold mountains.

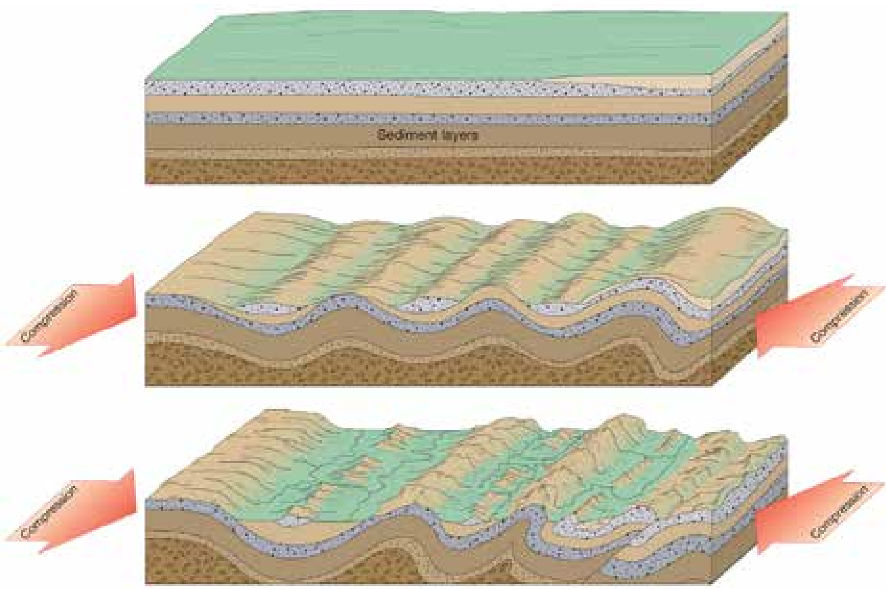


Fig. 2.2.24: Formation of fold mountains

4. Formation of oceanic islands

Oceanic islands are formed when compression forces operate under the plate, such that folding occurs. When the plate folds upwards, it forces the crust to bend upwards. As a result, it protrudes above the surface of the ocean water to form an oceanic island.

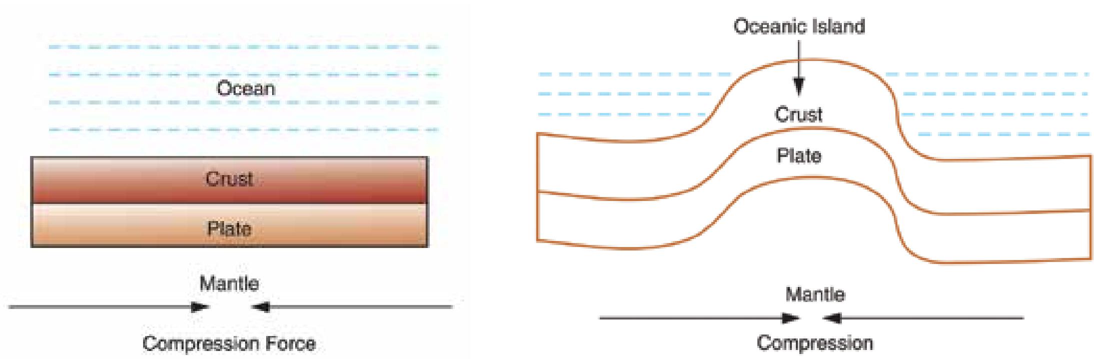


Fig. 2.2.25: Formation of oceanic islands

(c) Activities that dominate through shearing or sliding plate movement

(i) Earthquakes are a dominant characteristic where plates shear or slide past each other.

(ii) Volcanoes are very common in the zones where plates slide past each other.

Activity 2.2.15:

In groups of five, identify any five features that form along plate boundaries and the forces that cause them. Discuss how these features form by using good diagrams.

IMPACT OF FORMATION OF GEOLOGICAL FEATURES ALONG PLATE BOUNDARIES ON THE ENVIRONMENT AND HUMAN ACTIVITIES

Activity 2.2.16:

In groups of five, describe the effects of geological features on the environment and human activities.

Explanations:

Geological features can either have positive or negative effects on both the environment and human activities.

Positive effects

(i) Volcanic, fold and block mountains are tourist attractions.

(ii) Volcanic mountains are sources of precious minerals like gold, copper, tin, diamond and silver.

(iii) Windward sides of mountains receive heavy orographic or relief type of rainfall. This rainfall encourages the formation of rivers that promote agricultural activities and the production of hydro-electric power.

(iv) Some mountains have forests which are a source of timber.

Negative effects

(i) Mountains act as a barrier to communication and transportation. They make construction of roads and railway lines difficult.

(ii) Leeward sides of mountains are known as the rain shadow. They receive little or no rain. This has a negative effect on agricultural activities.

CASE STUDY 2: THE EFFECTS OF GEOLOGICAL FEATURES ALONG PLATE BOUNDARIES IN ICELAND

"…….In Iceland, one of the most geologically active locations on earth, the divergence of the North American and Eurasian plates along the Mid-Atlantic Ridge can be observed as the ridge rises above the sea level. At the convergent boundaries, plates collide with one another. The collision buckles the edge of one or both plates, creating a mountain range or subducting one of the plates under the other. This leads to the formation of a deep seafloor trench. At convergent boundaries, a continental crust is created and an oceanic crust is destroyed as it subducts, melts, and becomes magma. Convergent plate movement also creates earthquakes and often forms chains of volcanoes. The highest mountain range above sea level, the Himalayas, was formed 55 million years ago when the Eurasian and Indo-Australian continental plates converged. The Mediterranean Island of Cyprus formed at a convergent boundary between the African and Eurasian plates. Hardened mounds of lava, called pillow lavas, were once on the bottom of the ocean where this convergence occurred, but have been pushed up and are now visible at the surface….."

Source: http://education.nationalgeographic.com/education/media/plate-tectonics/?ar_a=1

Activity 2.2.17:

In groups, read case study 2 above and answer the following questions:

(a) What kind of plate movement takes place in Iceland?

(b) Mention the features that have been formed as a result of such plate movements.

(c) Identify activities that are associated with the kind of movement highlighted.

THE PROCCESS OF MOUNTAIN BUILDING ASSOCIATED WITH PLATE TECTONICS

Meaning of the term 'mountain building'

Mountain building refers to the construction of mountains. The mountain building period is also referred to as orogenesis. The term orogeny simply refers to an episode of intense deformation of rocks in a region. This deformation is usually accompanied by metamorphic and igneous activity.

Types of movements involved in mountain building

There are two movements involved in mountain building, namely:

(a) **Vertical movements** which are also called epeirogenic movements.

Effect: These movements lead to the formation of rift valleys and block mountains.

(b) **Horizontal movements** which are also called orogenic or lateral movements.

Effect: Horizontal movements result in the formation of marine ridges, trenches, fold mountains and volcanic mountains.

Mountain building periods

There have been several mountain building periods during the earth's history. The three most recent ones are the ***Caledonian***, the ***Hercynian*** and the ***Alpine*** which took place 310, 240 and 30 million years ago respectively.

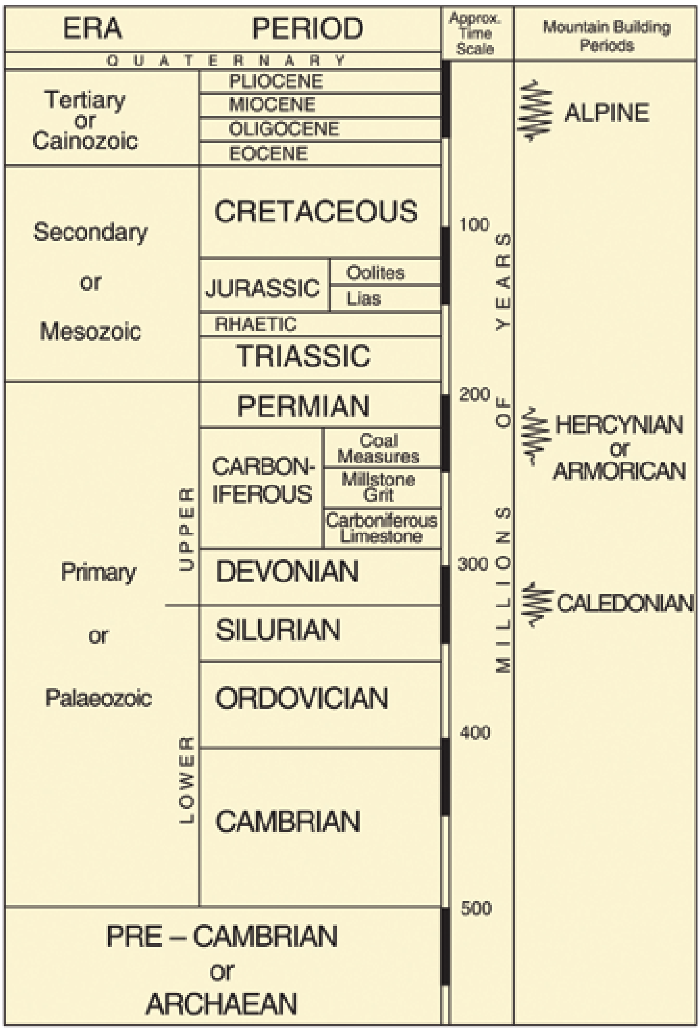


Fig. 2.2.26: Mountain building periods

Orogenic belts involve a sequence of events which together form what is known as an orogenic cycle. It involves the following sequences of events or stages.

Stage one

Development of geosynclines. This is an elongated down-warping of the crust of the earth, forming the deep trough in which great thicknesses of sediments accumulate especially in the central zone.

Stage two

This stage involves compression of the belt by a first orogenic phase. This phase involves root formation, in-depth folding and over thrusting superstructure, as well as uplifting of the compressed zone in response to the buoyant (isostatic) effect of the root.

Isostatic theory asserts that equilibrium exists on the earth's surface; equal mass must underlie the earth's surface.

The concept of isostacy

Isostacy is the balance or equilibrium of adjacent blocks of brittle crust 'floating' on the upper mantle. Since crustal rocks weigh less than mantle rocks, the crust can be thought of as floating on denser mantle, much as wood floats on water.

Blocks of wood floating on water rise or sink until they displace an amount of water equal to their own mass or weight. The higher the wood block appears above the water surface, the deeper the block extends under the water. Thus a tall block has a deep root. In a greatly simplified way, crustal rocks can be thought of as tending to rise or sink until they are balanced by the weight of displaced mantle rocks. This concept of vertical movement to reach equilibrium is called isostatic adjustment.

Stage three

This involves the lateral growth of the geosynclines by the development of new subsiding tracts outside the rising mountain. As the mountains are crushed into peaks and valleys deepened by denudation, they provide much of the sediments which fill up the depression.

Stage four

In this stage, there is renewed orogenic compression of the whole belt. Stages three and four may occur twice or even thrice in the more complex belt.

Stage five

During the more vigorous orogenic phases and particularly during the climax of revolution, the deeper rocks are intensely metamorphosed. Since the dawn of geological time, at least nine orogenic movements have taken place, folding and faulting the earth's lithosphere. The folding and faulting of the lithospheric rocks is called the diastrophism. Some of them took place in pre-Cambrian times while others have taken place quite recently, that is, about 30 million years ago.

Generally, the evolution of a mountain belt typically begins when sediments are deposited. The history of a mountain belt can be described in three main stages, namely:

(a) Accumulation stage
In this stage, a thick sequence of sedimentary and volcanic rocks accumulates.

(b) Orogenic stage
There is intense deformation of the layered rocks into folds and reverse (including thrust) faults, along with metamorphism and igneous activity.

(c) The uplift and block-faulting stage
The area is subjected to a long period of uplift, often with block-faulting and erosion. Eventually, the mountain belt is eroded down to a plain and it incorporates into the ***craton*** (region of the continent that had been structurally stable for a prolonged period of time).

PROCESSES OF MOUNTAIN BUILDING

FOLDING AND FAULTING

The process of mountain building involves folding and faulting which are associated with tectonic activity.

1. FOLDING

Definition of the term 'fold'
A fold is simply a bend in the crust, caused by compression forces exerted by the earth's movements.

Nature of folds

There are four types of folds, namely:

(a) Simple folds
(b) Asymmetrical folds
(c) Overfolds
(d) Overthrust folds/thrust folds

(a) Simple folds

The rock layers bend upwards and downwards under compression force. The ones that bend up form an ***upfold*** or ***anticline***; those that bend down form a ***downfold*** or ***syncline***. The sides of the fold are called ***limbs***.

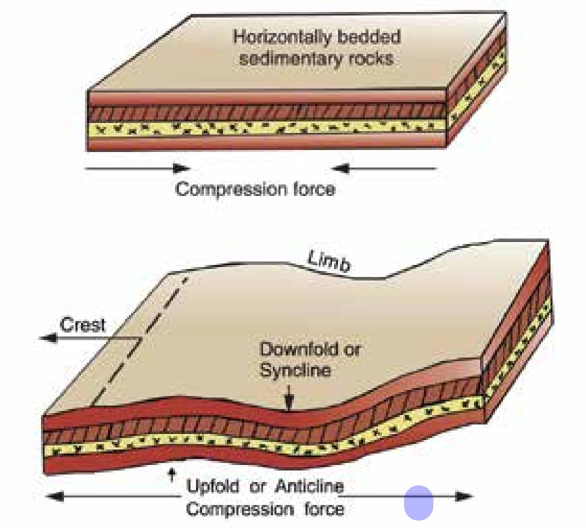


Fig. 2.2.27: Formation of a simple fold

(b) An asymmetrical fold

If compression force continues to apply on the section of the earth, a simple fold is changed into an asymmetrical fold. One side of the asymmetrical fold is steeper than the other as shown in Fig. 2.2.28 below.

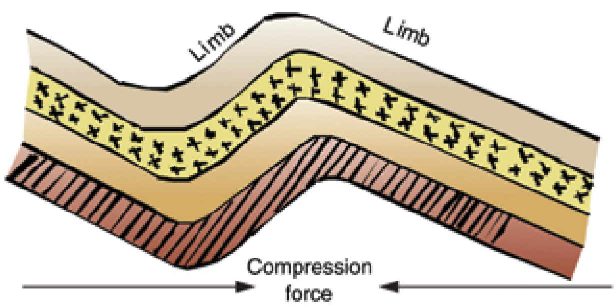


Fig. 2.2.28: Formation of an asymmetrical fold

(c) Overfold

If the compression force continues, an asymmetrical fold is changed into an overfold, where one limb is pushed over the other. An overfold is formed when the compression force is greater on one side of the rock than the other.

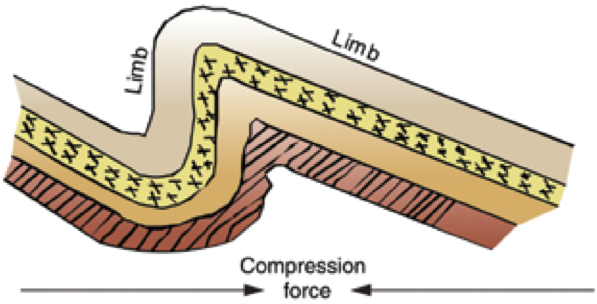


Fig. 2.2.29: An overfold

(d) An overthrust fold/thrust fold

Further pressure on the overfold causes the rock to fracture. The upper limb of the fold is thrust forward or pushed over the lower limb. This forms an overthrust or a thrust fold as shown in Fig. 2.2.30 below.

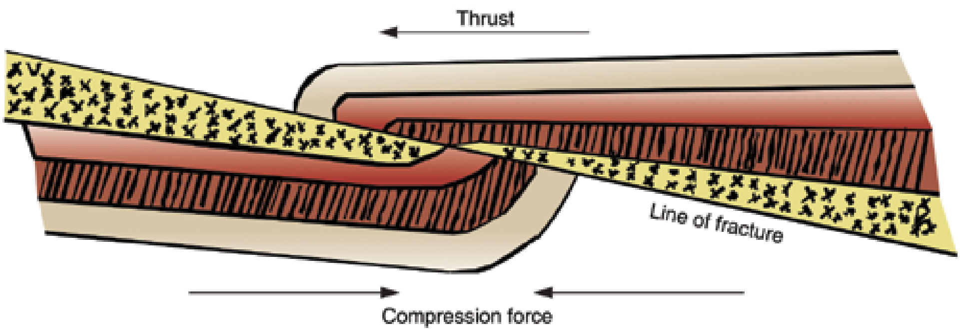


Fig. 2.2.30: An overthrust fold or thrust fold

FEATURES WHICH FORM AS A RESULT OF FOLDING

The features which form as a result of folding include fold mountains, escarpments, syncline valleys and depressions.

(a) Fold mountains

Description of fold mountains

Fold mountains consist of masses of folded sedimentary rocks which have a thickness of 12 km or more.

What are the causes of fold mountains?

Large-scale earth movements lead to the formation of these mountains when stresses are set up in the earth's crust. Such stresses may be due to the increased load of overlying rocks, flow movements in the mantle, magnetic intrusion into the crust, or expansion or contraction of some parts of the earth. When such stresses are initiated, rocks are subjected to compression forces that produce folding along the fault lines.

Formation of fold mountains

There are four stages in the formation of fold mountains.

Stage one

In this stage, two continental blocks move towards each other under forces of compression. When the two blocks collide, they create a trench that becomes a site for the sea. Sediments brought about by erosion accumulate in the trench leading to the formation of sedimentary rocks.

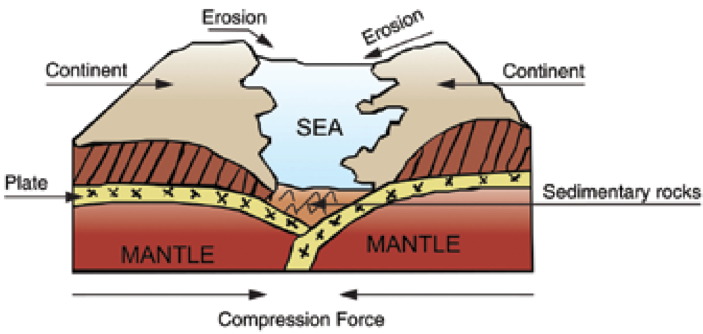


Fig. 2.2.31: Stage one in the formation of fold mountains

Stage two

Further compression forces is exerted on the continental blocks. This eventually causes the sedimentary rocks in the trench to be pushed up or folded as seen on Fig. 2.2.32.

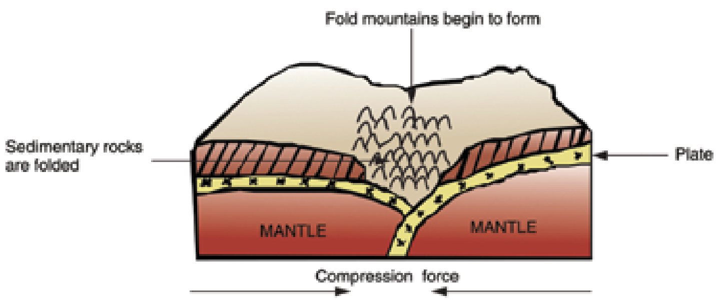


Fig. 2.2.32: Stage two in the formation of a fold mountain

Stage three

As compression forces continue to apply, intense folding takes place. Sometimes, one continental block rises up over the other. The folded rocks continue to rise.

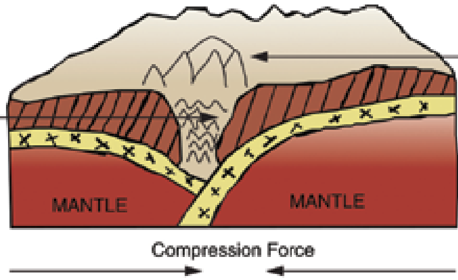


Fig. 2.2.33: Stage three in the formation of a fold mountain

Stage four

The folded, uplifted sedimentary rocks now form lofty fold mountains. Volcanic activity often takes place, producing intrusive features like batholiths.

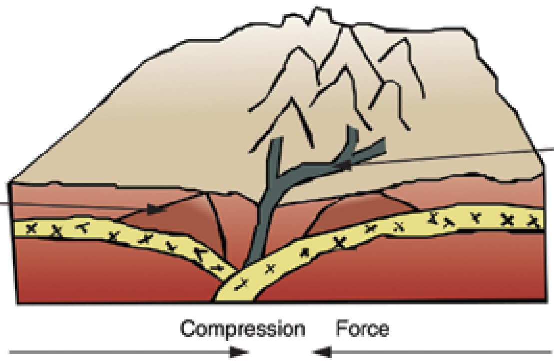


Fig. 2.2.34: Stage four in the formation of a fold mountain

Activity 2.2.18:

In groups of five, discuss the process of folding through the different stages. Present your findings to the whole class using well-labelled diagrams.

2. FAULTING

Terminologies:

- **Faulting**: This is the process that involves cracking or fracturing of rocks in the earth's crust along the lines of weaknesses. It is caused by forces of tension and compression which cause both vertical and horizontal earth movements.
- **A fault**: This is the fracture or crack in the earth's crust along which displacement of rocks occurs.

Types of faults

(a) Normal fault

This fault results from stresses in the crust. It originates from tension in a vertical or an inclined fault plane. One side of the rockblock drops downwards relative to the other along the fault plane. It produces a very steeply-inclined fault zone with a block of sand on the sides being pushed up or upthrown, relative to the downthrown block on the other side. A prominent scarp is formed. See Fig. 2.2.35 below.

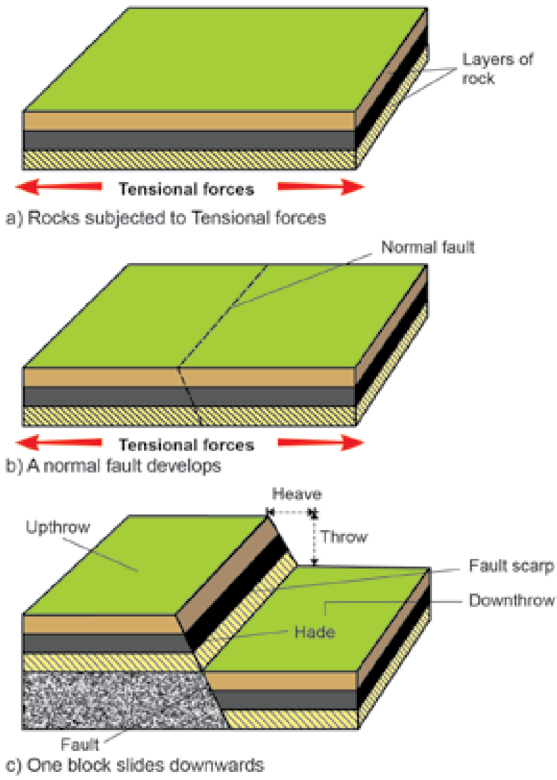


Fig. 2.2.35: A normal fault

(b) Reverse fault

The reverse fault is produced when compression forces push a block of rock on one side of a fault upward in relation to the other along the line of fault plane. One block is thus thrust over the other. The upthrown block is steeply above the down thrown block so that the fault scarp would be severely oversteepened if erosion did not occur to smooth out the slope.

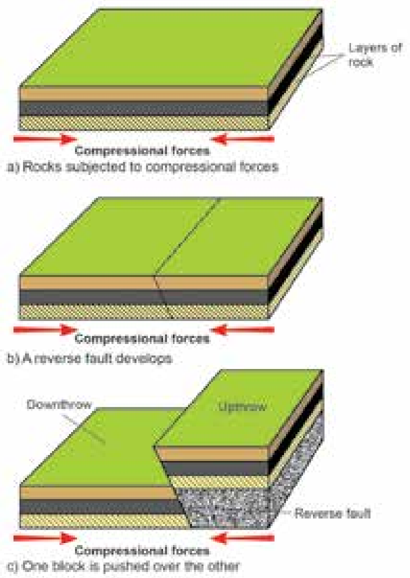


Fig. 2.2.36: A reverse fault

(c) Tear/shear/ transform or strike-slip fault

This type of fault is caused by two opposing parallel forces that cause two blocks of land to slide past each other. The rock strata remain at the same level on the surface but their structural position is altered as two adjacent portions slide against each other. The movement is horizontal, with adjacent blocks being displaced laterally relative to each other.

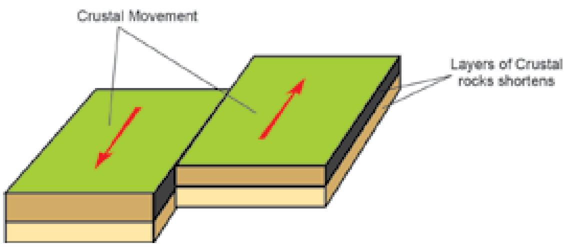


Fig. 2.2.37: A shear fault

4. Overthrust fault

Compression forces cause the upthrown block to move up and over the downthrown block at a relatively low angle, sometimes for many miles. Overthrusting occurs frequently in mountain building. This results in unusual geological relationships such as older strata being piled on top of younger rocks.

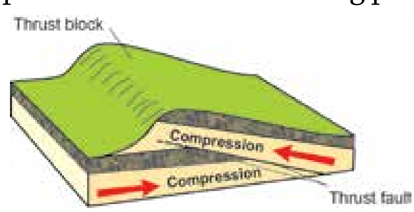


Fig. 2.2.38: An overthrust fault

RELATION BETWEEN MOUNTAIN BUIDING TO MOVEMENT OF TECTONIC PLATES

It is interesting to note that mountains form in areas where plates are either diverging/spreading or converging/colliding. According to the theory of plate tectonics, thin layers of the crust slowly move in different directions; laterally or towards each other. Most of the familiar mountain ranges have been formed where the net movement of two plates is towards each other. For example, the Andes fold mountains formed due to the converging of the South American continental plate and the Nazca oceanic plate.

FEATURES FORMED FROM MOUNTAIN BUILDING PROCESS

Several features that are formed during the mountain building process include fold, residual, block and volcanic mountains.

(a) Volcanic mountains

Volcanic mountains are formed when tension forces break the crust, plates and mantle. This paves way for molten materials which are ejected from fissures; the molten materials then solidify on the earth's surface. These materials include molten lava, volcanic bombs, cinders, ashes, dust and liquid mud. They fall around the vent (hole through which molten lava passes) in successive layers, building up a volcanic cone.

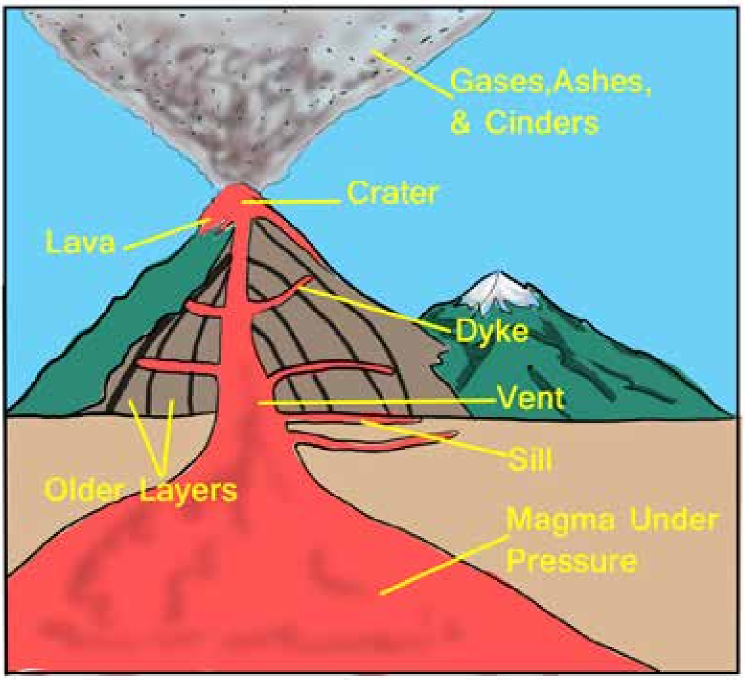


Fig. 2.2.39: Formation of a volcanic mountain

Volcanic mountains are also called mountains of accumulation. They are very common in the Circum-Pacific belt (this is the belt where volcanic activity and earthquakes are common). Volcanic mountains are also common in such volcanic peaks as Mt. Fuji (Japan), Mt. Mayon (Philippines), Mt. Merapi (Sumatra), and Mt. Agung (Bali).

(b) Residual mountains

Residual mountains are formed when agents of denudation such as water and wind erode an already existing mountain. The height of less resistant rocks is lowered by these agents of denudation overtime. The resistant rocks stand out as residual mountains. An example is Mount Monadnock in the USA.

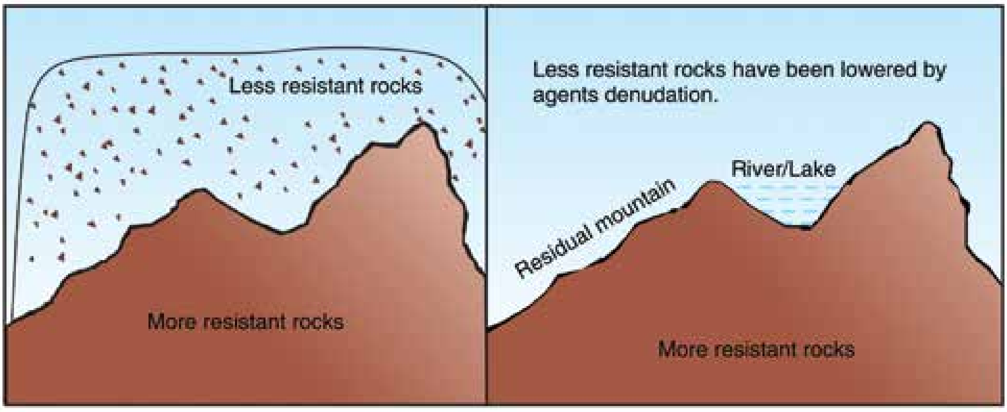


Fig. 2.2.40: Formation of a residual mountain

(c) Block mountains

Block mountains can be formed when the earth's crust is subjected to either tension or compression forces. When tension forces are exerted on the earth, faults occur and blocks of land are pulled away from each other. The land at the centre of the fault will sink and the overhanging blocks on either side will form block mountains. When compression forces are exerted on the earth, faults still occur. Continued compression may cause the block of land in the middle to be pushed up to form a block mountain.

(d) Fold mountains

Fold mountains are formed when compression forces are exerted on the earth's crust. Sedimentary rocks in the earth's crust are bent upwards while others are bent downwards when further compression forces are exerted from two opposite directions. As we learnt earlier, the parts of the sedimentary rock that bend upward are known as upfolds or anticlines and they form the fold mountains.

Activity 2.2.19:

In groups of five, discuss how the following mountains form from the mountain building process:

(a) Fold mountains

(b) Block mountains under both tension and compression forces

EFFECTS OF MOUNTAINS ON LIFE AND HUMAN ACTIVITIES

Positive effects

(i) Mountains act as a tourist attraction.

(ii) They are sources of precious minerals such as gold, copper, tin, diamond and silver.

(iii) They are rich agricultural belts.

(iv) They contain valuable timber resources for example the coastal ranges of Western America (coniferous soft woods), the foothills of the Himalayas (teak).

Negative effects

(i) Mountains act as a barrier to communication and transportation.

(ii) They act as a barrier to favourable climate in that, regions on one side of the mountain can have an entirely different climate from that of the other side. For example, to the west of the Rockies, the coastlands of British Columbia have mild winters, warm summers and rains throughout the year. To the east of the Rockies, the Prairies have cold winters, hot summers and maximum rain in summer.

(iii) Ascending and descending winds cause destruction of vineyards in Alpine ranges.

DISASTER RISK MANAGEMENT STRATEGIES

Terminologies:

- **Hazard:** A hazard is a dangerous condition or event that threatens or has potential for causing injury to life or damage to property or the environment. Examples of geological hazards include earthquakes, tsunami, volcanic eruption and landslides.

- **Vulnerability:** This refers to the extent to which a community's structure or geographical area is likely to be damaged or disrupted by the impact of a particular hazard. It may be on account of their nature, construction and proximity to hazardous terrains of a disaster prone area.

- **Risk:** This is a measure of the expected losses due to a hazardous event occurring in a given area over a specific time period. The level of the risk depends on :
  (i) Nature of hazard.
  (ii) Vulnerability of the elements which are affected.
  (iii) Economic value of these elements.

  A community is said to be at risk when exposed to hazards and it is likely to be adversely affected by its impact.
- **Capacity:** This can be defined as the 'resources, means and strengths' which exist in households and communities and which enable them to cope with, withstand, prepare for, prevent, mitigate or quickly recover from a disaster. For example, people whose houses have been destroyed by an earthquake can salvage things from their homes and farms. Some have skills which enable them to find employment if they migrate either temporarily or permanently.

  How to determine level of risk

$$\text{Risk} = \frac{\text{Hazard} \times \text{Vulnerability}}{\text{Capacity}}$$

  Therefore, the risk will be great when the society, organisation or the community has inadequate capacity to deal with the occurrence of the disaster.
- **Disaster Risk Management:**

  Aim of Disaster Risk Management (DRM)

  – It aims to reduce or prevent the potential losses broguht about by hazards, assure prompt and appropriate assistance to victims of disaster and achieve rapid and effective recovery.

THE DISASTER RISK MANAGEMENT (DRM) CYCLE

Fig. 2.2.41: The Disaster Risk Management (DRM) cycle

1. Risk identification and assessment

This involves analysis and monitoring of hazards, vulnerability analysis and determination of risk.

2. Prevention and mitigation

Prevention includes all activities that are taken to avoid negative effects of the disaster. Mitigation is aimed at minimising effects of the disaster. This includes vulnerability analyses, public education, land management and land use planning among others.

3. Preparedness

This involves preparations on how to respond to a disaster. It may include early warnings, evacuation and emergency planning.

4. Recovery

This involves restoring the community back to normal status. This includes immediate intervention such as search and rescue missions, and provision of security, food, water, shelter, sanitation, clothes, medical and trauma care. The duration is normally short term. Recovery also includes rehabilitation that involves restoration of basic services and functions in the community. The duration can range from a few weeks to several months. Finally, it also includes reconstruction where services fully resume to normal and where preventive measures are observed. This may take several months to a few years.

How Disaster Risk Management (DRM) knowledge and skills could be applied in mountain building zones

The knowledge and skills of disaster risk management ought to be applied in areas regarded as mountain building zones. This is because such zones are often associated with such geological natural disasters as earthquakes, volcanoes and landslides.

There is need to identify and assess risks to the communities within such zones. This involves analysing the community's capacity to deal with the occurrence of earthquakes, volcanoes and landslides. In order to determine the risks in these areas, there is need to weigh the vulnerability of the community and the geological hazard that affects the area. Then, there is also need to look at the capacity of the community to cope with the disaster.

Activities that will enable the community to avoid the effects of the disaster should be put in place. These activities may include monitoring and maintaining records of the geological structure of hills near settlements to detect any possibility of occurrence of landslides and avalanches. In addition, monitoring and checking records of shock waves in areas prone to earthquakes and volcanoes is advisable. Definitely, any increase in the number of shock waves can indicate the possibility that an eruption or earthquake is going to take place in the near future. Therefore, people can be warned to move to safer places.

Furthermore, tall buildings should be constructed with strong earthquake resistant materials which could help mitigate the effects of the disaster in case an earthquake occured. Awareness campaigns could also be very helpful to people living in the disaster prone areas. If people are aware of what to do and at what time, they can keep themselves from harm.

More importantly, people should be taught how to prepare to respond to earthquakes, volcanoes and landslides. They can prepare well if they are warned in advance. They must know how to temporarily evacuate from affected areas. Planning for the emergency therefore becomes very vital.

In cases where the volcano, earthquake or landslide has taken place, there is need to work towards getting everything back to normal. Ways of recovering from earthquakes, volcanoes and landslides include mobilising resources for rehabilitation, providing psycho-social support to children and traumatised persons, rebuilding the damaged infrastructure better and safer than before, among others.

Activity 2.2.20:

*Below is a short play entitled "**On the Eve of 18th June, 1956**". It is a story of a dream by Mr. Chigwembe, an old man in a remote village. In the evening of the following day, he begins to narrate his dream to his grandchildren as they are seated around the fire place. Choose actors or actresses depending of the nature of your school and stage it in front of the whole class. Use the play to do the activity that follows.*

SCENE ONE

(Around the fire place)

Grandfather: (*soliloquy*) My son, my daughter, I know that you have not seen many things but you need to know what this life brings forth.

Grandchild: What do you mean?

Grandfather: I have experienced many things in my life. Lend me your ears so that you may hear. I had a dream about an earthquake in one of the mountains in our land.

Grandchild: What happened grandfather?

Grandfather: I dreamt that people had been told about risks in the area that was affected by the earthquake. They had been earlier informed about using safe construction materials for their houses. Contingency plans were made by the departments that deal with disasters in the country.

Grandchild: Are these things necessary?

Grandfather: Absolutely yes! In addition, people were told to identify the safest places in their homes. Most importantly, an emergency bag was prepared in readiness for first aid.

Grandchild: What happened when the earthquake occured?

Grandfather: People took cover under heavy objects, stayed away from walls and objects that could fall on them like buildings and electric cables. They also helped those who got injured by administering first aid.

Grandchild: What happened afterwards?

Grandfather: People were advised to be careful as they moved about since earthquakes are known to cause standing buildings and structures to collapse. People drove slowly and avoided bridges. They stayed away from unstable structures.

Grandchild: That was a very frightening dream!

Grandfather: Indeed, it was absolutely frightening but we can learn a lot from it. Nowadays, the world is prone to many disasters. Some of these disasters include earthquakes, floods, volcanoes, fires and droughts. As such, one needs to be aware of the disaster risk management skills that ought to be applied in areas affected by such disasters.

In groups, read the short play above and answer the following questions:

(a) Identify the disaster risk management techniques that were followed during the earthquake in Mr. Chigwembe's dream.

(b) If the earthquake was taking place and you happened to be in the affected area, suggest what you would do during and after the earthquake.

(c) What lessons have you picked from the short play?

VOLCANISM OR VOLCANICITY

Meaning of the term 'volcanism'

Activity 2.2.21:

Brainstorm the meaning of the term 'volcanism'.

Volcanism refers to the process through which molten rock or gases are forced onto the earth's surface. When the molten rock solidifies in the crust after failing to reach the earth's surface, intrusive features such as batholiths, sills, dykes, laccoliths and lopoliths are formed. When the molten rock reaches the earth's surface, extrusive features such as volcanoes, acid lava cones, lava plateaus, ash and cinder cones, craters and calderas, hot springs, geysers and steam jets are formed.

Types of volcanism

There are two types of volcanism: Intrusive or plutonic volcanism and extrusive volcanism.

(i) Intrusive or plutonic volcanism

This refers to the igneous activity where molten material fails to reach the surface of the earth but remains and solidifies within the earth's crust. This results into the formation of intrusive features.

(ii) Extrusive volcanism

This refers to the process where magma is ejected onto the earth's surface in a volcanic eruption. This results into the formation of extrusive features.

Formation of a volcano

Rocks below the crust are usually under very high temperatures. High pressure is also exerted on them by the crust, keeping these rocks in a semi-solid state. Friction along the rock surfaces at the boundaries of tectonic plates raises the temperature further. Reduction in pressure caused by faulting and folding together with the high temperature causes these rocks to become molten and semi-fluid. This hot, molten rock within the earth's interior is known as magma.

As the magma rises, it forces its way through the cracks of the crust. The magma may stay in the crust where it forms internal features such as batholiths, sills and dykes or it may reach the surface either quietly, or with great violence.

If the magma contains a lot of gases, especially steam, then the magma will be ejected to the surface under pressure. This causes the gases to expand quickly, giving rise to violent explosions. When the magma reaches the earth's surface, it is called lava.

STAGES IN THE VOLCANIC LIFE CYCLE

A volcano usually passes through three main stages in its life cycle. Notably, eruptions are frequent in the beginning and hence the volcano is said to be active. The frequency of eruption declines as the volcano passes through the second stage with time. In the second stage, eruptions become less frequent. The volcano at the second stage is said to be dormant. This stage is followed by a long period of inactivity. Volcanoes at the third stage are said to be extinct. This means that the volcano will no longer erupt, but will still retain its features as a volcano.

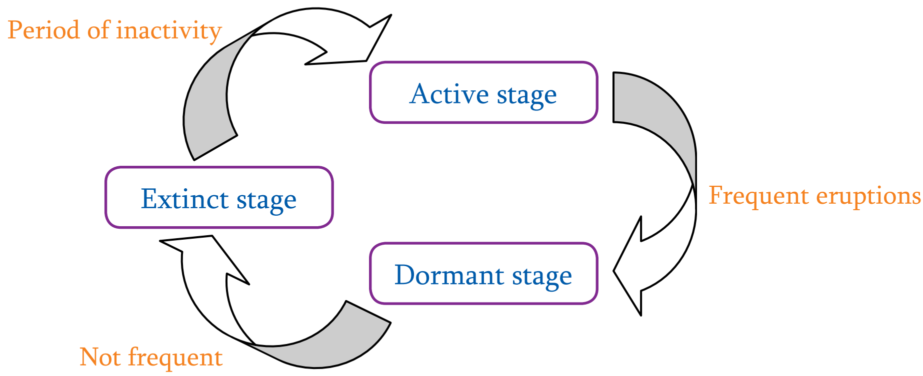


Fig. 2.2.42: Stages in the volcano's life cycle

Activity 2.2.22:

In groups of five, discuss the stages of a volcanic life cycle. Draw a diagram to illustrate the stages of a volcano.

Explanations:

There are three types of volcanoes namely:

(a) Active volcanoes

(b) Dormant volcanoes

(c) Extinct volcanoes

(a) Active volcanoes

Volcanoes are said to be active when they erupt frequently, or when they have erupted within recent times. Examples include Mt. OlDoinyo Lengai in Tanzania, Mt. Cameroon and Mt. Nyamlagira in DRC.

(b) Dormant volcanoes

These are volcanoes that are known to erupt and show possible signs of eruption in the future. Examples include Mt. Menengai, Mt. Longonot and Mt. Suswa in Kenya, and Mt. Kilimanjaro in Tanzania.

(c) Extinct volcanoes

These are volcanoes that have not erupted at all in historic times. Examples include Mt. Kenya and Mt. Elgon in Kenya and Mt. Ngorongoro in Tanzania.

LAVA

When magma reaches the earth's surface, it is called lava. There are two types of lava: acidic lava and basic lava.

(a) ACIDIC LAVA

Characteristics of acidic lava

- It is highly viscous with a high melting point.
- It is light in colour.
- It has a low density.
- It has a high percentage of silica.
- It flows slowly before solidifying.
- The resultant cone is steep-sided.

Effects of acidic lava

- It mainly explodes loudly, throwing out many volcanic bombs or pyroclasts. This is because the accumulation of lava in the vent obstructs the flow of the outpouring lava.
- Acidic lava is very violent. The lava is so viscous that it can form a spine or plug.

(b) BASIC LAVA

Characteristics of basic lava

- It is very hot, about 1000 °C (1830°F).
- Basic lava flows with a speed of 16-48 km/h.
- It is dark in colour, like basalt.
- It is rich in iron and magnesium but low in silica.

- It flows quickly and therefore it is not very explosive.
- The resultant volcano is gently sloping with a wide diameter. It forms a flattened shield or dome.

Effects of basic lava

- It affects extensive areas, spreading out as thin sheets over great distances before solidifying.

LOCATION OF MAJOR AREAS OF VOLCANIC ACTIVITY

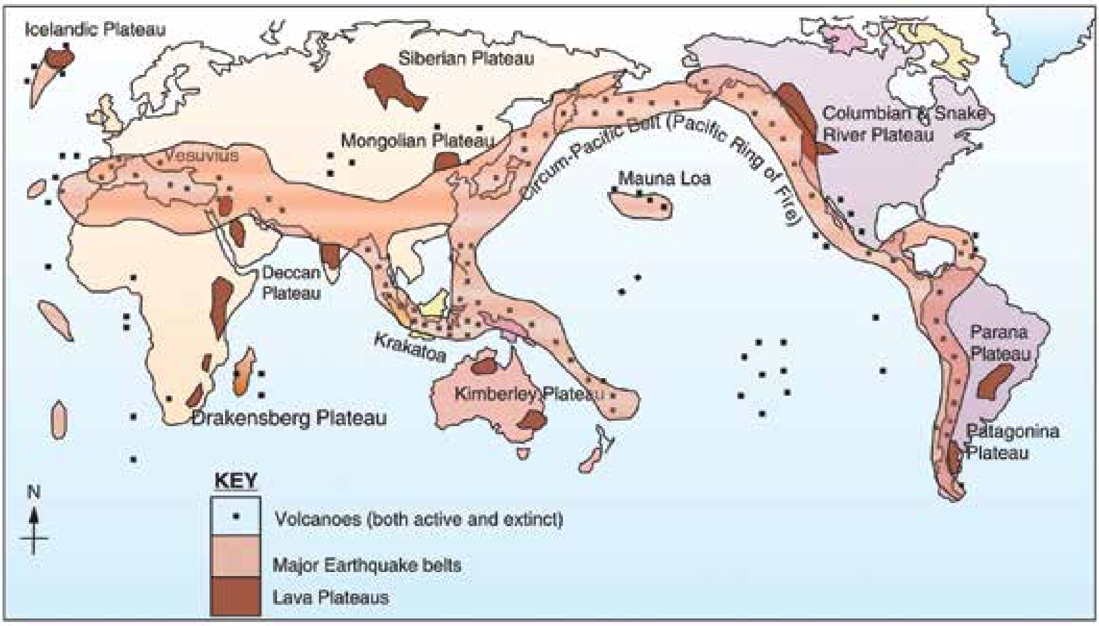


Fig. 2.2.43: Major areas of volcanic activity and lava plateaus

Activity 2.2.23:

In pairs, draw the world map in your notebooks and locate the Circum-Pacific Ring of Fire on it.

EXTRUSIVE AND INTRUSIVE FEATURES FORMED FROM A VOLCANO

(a) EXTRUSIVE FEATURES

These are features formed on the earth's surface. They are formed when lava reaches the earth's surface. They include the following:

(i) Basaltic lava domes or shield domes

These form from basic lava which has low viscosity and flows over a wide area.

(ii) Acid lava cones

These are cone-shaped hills that have a narrow base and steep sides. They are formed from highly viscous acidic lava.

(iii) Composite volcanoes

These are volcanoes consisting of layers that alternate in the form of pyroclasts and lava. They are formed from successive vent eruptions. They normally have craters at the top. Examples include Mt. Kilimanjaro, Mt. Meru and Oldonyo Lengai in Tanzania, and Mt. Tibesti in Chad.

(iv) Lava plateaus

These features form when lava escapes different fissures and spreads over a large area and long distance. It forms a flat sheet of lava.

(v) Plug dome

A plug dome is a hard cylindrical plug formed from very viscous acid lava. It forms a heap-like dome immediately above the surface of the earth and it is resistant to erosion. It is also known as a plug volcano.

(vi) Ash and cinder volcanoes

These are volcanoes that form when cinder, ash and other pyroclasts are released through the vent. Mt. Teleki is an example of an ash and cinder volcano.

(vii) Volcanic plugs or necks

These are volcanoes formed when lava solidifies within the vent and is later exposed through denudation due to removal of the surrounding softer rocks.

(viii) Hot springs, geysers and steam jets

A hot spring refers to superheated water that gushes from inside the earth's surface. Geysers refer to superheated water that comes out from the earth's crust explosively together with steam. A steam jet is a mixture of steam and other gases reaching the earth's surface through cracks. Examples of hot springs in Malawi include Liwonde and Chawina in Nkhotakota.

(ix) Craters and calderas

Craters are round, funnel-shaped features found at the mouth of a volcanic vent. Calderas are enlarged craters that are formed when subsequent explosions blow off the existing crater.

(x) Fumaroles, solfatara and moffette

A fumarole is a subsidiary vent on a volcano or a hole in the ground which mainly emits gases or steam. A solfatara refers to a fumarole that mainly emits sulphurous compounds like sulphur dioxide in gaseous form. A moffette is a fumarole that mainly emits carbon (IV) oxide, a compound that is used in the bottling industry.

Note: Emission of gases and steam periodically takes place from dormant volcanoes. Similar emission of gases and steam takes place in some volcanic regions where active lava eruptions have long since ceased.

(b) INTRUSIVE FEATURES

(i) Batholiths

A batholith is a very large mass of magma which accumulates in the crust. Sometimes, it forms the root or core of the mountain. Batholiths are made of granite. They form surface features only after they have been exposed by agents of denudation such as water (through erosion) and air (through moving wind).

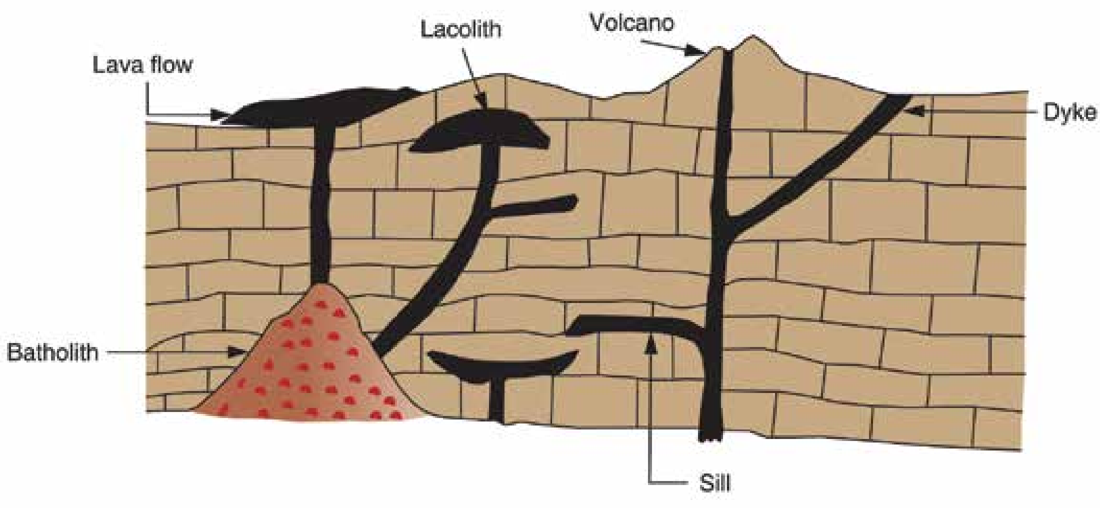


Fig. 2.2.44: Formation of a batholith

(ii) Sills

A sill is formed when a sheet of magma lies along the bedding plane. Some sills form ridge-like escarpments when exposed by erosion. Others, through erosion, remain as carps on top of the hill and they protect it from erosion. An escarpment formed by the sill has dimensions which are similar to those of a dyke.

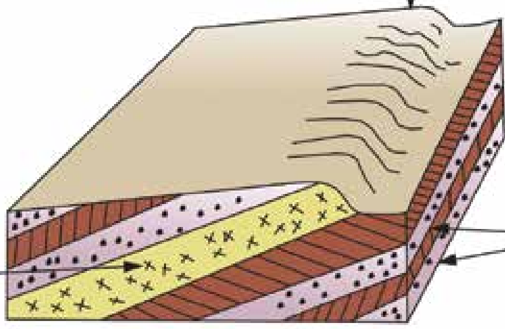


Fig. 2.2.45: A sill

(iii) Dykes

When a mass of magma cuts across the bedding plane, it forms a wall-like feature known as a dyke. Some dykes are easily eroded to form shallow trenches. Other dykes resist erosion and stand up as wall-like ridges. Like sills, dykes sometimes give rise to waterfalls and rapids.

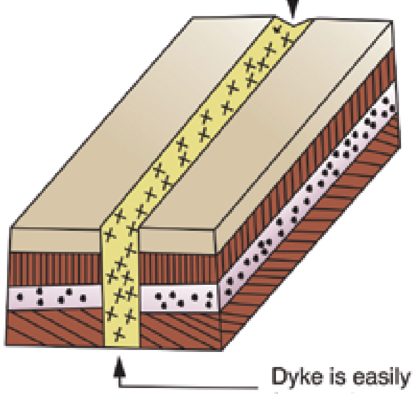


Fig. 2.2.46: A dyke

(iv) Laccolith or laccolite

This refers to a mass of magma which has forced up overlying layers of rocks. It is mushroom-shaped and it lies between the bedding planes.

(v) Lopolith

This is a large saucer-shaped intrusion of igneous rocks. It forms a shallow basin.

(vi) Phacolith or phacolite

This is a strip of lens-shaped igneous intrusion. It looks like lopolith and forms near the crest of an anticline or the bottom of a syncline.

Activity 2.2.24:

Below is a Geography word scramble. Test your knowledge by using it to do the activity below.

On your left are letters representing intrusive and extrusive features formed through volcanism. On your right are blank spaces for their answers.

Individually, write the names of the intrusive and extrusive features formed through volcanism correctly in the spaces on the right. Then classify the answers as intrusive and extrusive features.

Table 35: Names of intrusive and extrusive features formed through volcanism

Questions	Answers
Kyed	
Ladacer	
Lilatecco	
Lliss	
Tecrsra	
Thablosith	
Segerys	
Leromafu	
Clothipha	

RELATIONSHIP BETWEEN VOLCANISM AND MOUNTAIN BUILDING

The process of mountain building involves both vertical and horizontal movement of the earth's crust. These movements are initiated by tension and compression forces that are generated by convection currents in the mantle. These processes are associated with faulting and folding which eventually creates vents through which magma passes. Volcanism thus results from both tension and compression forces. This means that volcanism occurs in all processes through which mountains evolve.

EFFECTS OF VOLCANISM

Volcanism has both positive and negative effects:

(a) Positive effects

(i) *Volcanism is a source of geothermal power*: Hot springs and geysers supply *hot water* which provides *energy for use in buildings*. In New Zealand and Iceland, hot springs and geysers are widely used and are very beneficial. Geysers are also used in the production of geothermal energy.

This is done when the steam is trapped and led to turbines which rotate, enabling the generators to produce electricity.

(ii) *It enhances tourism*: This is because volcanism gives rise to scenic features of great beauty.

(iii) It results in the *formation of precious stones* and *materials* which act as raw materials in industries.

(iv) Some lava outpourings *have weathered to give fertile soils*. Examples include Java, the North Western part of Deccan Plateau and the plain around Etna. These regions are of important agricultural value.

(v) *Carbon (IV) oxide* produced from magma is used by the *bottling industries*.

(vi) *Craters* and *caldera lakes* provide *water for domestic purposes*. They also create a *good fishing environment*.

(vii) ***Volcanic mountains*** provide *timber resources* and serve as *habitats for a variety of animals*.

(viii) The mountains are ***catchment areas*** hence are *sources of rivers* and *springs*.

(b) Negative effects

(i) Some eruptions produce poisonous gases which kill people. For example, Mt. Pélee erupted in 1902 and killed 30,000 people.

(ii) Some eruptions cause great sea waves that can cause destruction to coastal areas.

(iii) Some eruptions cause great damage to property. Mt. Pélee caused destruction of St. Pierre and Vesuvius which buried Herculaneuma and Pomeii with ash, during its eruption in 1902.

(iv) Volcanism leads to pollution of the environment. The emission of toxic gases such as sulphur (IV) oxide and carbon (II) oxide into the atmosphere cause pollution and can cause acid rain.

(v) Volcanic mountains discourage settlements and are barriers to transport networks.

(vi) Leeward sides of mountains are rain shadow areas and discourage agricultural activities.

Need for applying disaster risk management knowledge and skills in areas that are vulnerable to volcanic activities

Activity 2.2.25:

In groups of five, discuss the need for applying disaster risk management skills in areas prone to volcanic activity.

People living in volcanic-prone areas need to apply disaster risk management knowledge and skills. There is need to identify level of risk in areas which are prone to volcanic eruption. The volcano, as a geological hazard, should be analysed and monitored. The volcanic hazard involves effects of ash, gas and mudflows. In addition, the extent of vulnerability should also be analysed. The characteristics and circumstances of the community that make it prone to the damaging effects of the volcano should be analysed. The level of risk can be identified by weighing the hazard and vulnerability and looking at the capacity of the community to cope with the effects of the volcanic eruption. If there is a high level of risk, then it is advisable that people should move to safe places.

People ought to be sensitised on how to act quickly to avoid getting hurt in the event of a volcanic eruption. Proper preventive and mitigation measures such as land use planning and land management should be followed.

People living in these volcanic-prone areas should be prepared in advance for the volcanic eruption. In this respect, early warning systems are necessary. Scientists can predict possible occurrences of volcanoes. They can study changes in the earth's surface that might give clues to possible volcanic eruptions. By doing so, many of these events can be detected by sensitive instruments or by satellite technology. Early warning of a likely eruption can then be given. Governments and different humanitarian groups should prepare to temporarily evacuate people and property from volcanic-prone areas.

In addition, people must know how to recover from the effects of volcanic eruption. This might involve provision of rescue services, rehabilitation and reconstruction. Provision of services and public assistance during or immediately after a disaster is necessary. The aim is to save lives, reduce negative impacts on health and ensure public safety. Relevant stakeholders should ensure that important services are provided during or immediately after a volcano has erupted.

CASE STUDY: VOLCANO AT MT. MERAPI

Mount Merapi is located in south east Asia in Indonesia. It is north of Yogyakarta and west of Solo on the Island of Java. It is 1,700 metres high. This mountain has been erupting regularly since the 1500s.

The volcano and its eruptions were caused by the Indo-Australian plate being subducted beneath the Eurasian Plate. The volcano is located on a destructive plate margin at a subduction zone. The volcano is part of the Circum-Pacific Ring of Fire.

There are both primary and secondary effects of this volcano. Primary effects include volcanic bombs and hot gases (up to 800°C) which spread over a distance of 11 kilometres away from the point of origin. In addition, flow of pyroclasts spread 3 km down the mountain of Merapi. Sulphur (IV) oxide was blown across Indonesia and as far south as Australia. Ash fell up to 30 kilometres and 5 kilometres into the sky. Villages which were 15 kilometres away were under 30 centimetres of ash. Secondary effects resulted from primary ones and these included an increase in prices of vegetables because of the damage to crops. Emergency shelters had to be moved over 15 kilometres away. Planes were grounded in Western Australia because of the risk of damage to aircrafts from the ash cloud. Danger areas extended to 20 kilometres from the mountain. A total of 278,000 people living in this area had to flee their homes. Ashes, rocks and lava deposited on the sides of the volcano are still being washed down into towns by rainfall, creating a mudflow that flows along the river valleys.

There were 273 people who were killed and 577 people who got injured as a result of the volcano. About 360,000 people became homeless. Some people, particularly farmers, lost their livelihoods and homes. The evacuation sites were overcrowded leading to poor sanitation, no privacy and serious disease risk. However, the volcano has brought some positive impacts. A conservation area has been set up around the volcano where it is unsafe to live. In addition, the ash from the volcano will eventually lead to more fertile soils in the area.

Notably, in the short term, 210 evacuation centres were set up either as tents, in schools, churches, stadia or government offices. There were 1,600 people who were either volunteers or military. These people were part of national aid response. International aid was offered from organisations such as Red Cross. In the longrun, formal evacuation centres were eventually set up because buildings such as schools and government offices, were need for their official uses. Furthermore, 2,682 people had to be moved to new and safer houses permanently. The government is making money available to farmers to help replace their livestock. The government set up a special task force to support people affected by the volcano either by family issues, or because they had lost their jobs.

Source://handygeography.wordpress.com/gcse/the-restless-earth-revision-materials/volcano-case-study-mt-merapi/

Activity 2.2.26:

Read the case study and in pairs answer the questions that follow.
Q1. Identify the cause for the Mt. Merapi volcanic eruption.
Q2. Describe the effects of the Mt. Merapi volcanic eruption.
Q3. What disaster risk management skills were applied during the Mt. Merapi volcanic eruption?

EARTHQUAKES

Activity 2.2.27:

In groups of five, discuss the meaning of the term 'earthquake'.

Terminologies:

- **Earthquake:** This refers to sudden earth movements or vibrations in the earth's crust.
- **Focus:** This is the point at which an earthquake originates. It is sometimes several kilometres below the earth's surface.
- **Epicentre:** This is the point on the earth's surface immediately above the focus. This is where shock waves first hit the surface. It is the shock waves that give rise to an earthquake.
- **Seismometer:** This is an instrument that is used to measure seismic waves.
- **A seismograph:** A recording device that produces a permanent record of earth's motion detected by a seismometer.

Location of Areas or Zones where Earthquakes Occur in the World

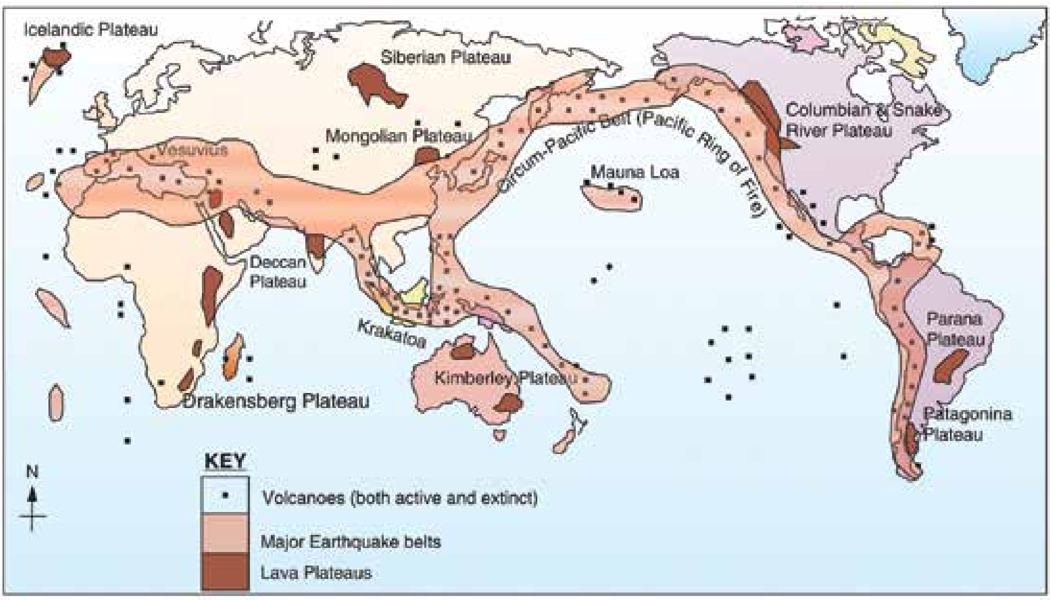


Fig. 2.2.47: Areas or zones where earthquakes occur in the world

Where do the majority of earthquakes occur?

The majority of earthquakes occur in narrow belts which mark the boundaries of tectonic plates. The main types of regions where they occur are:

1. The mid oceanic ridges.
2. The ocean deeps and volcanic islands.
3. The regions of crustal compression.
4. The Mediterranean-Himalayan belt.
5. Earthquakes largely occur in the *Circum-Pacific Ring of Fire*.
6. Along fault boundaries for example the Californian fault boundary.

Activity 2.2.28:

In pairs, draw the world map in your notebooks. Locate the above highlighted regions where earthquakes occur on it.

CAUSES OF EARTHQUAKES

Activity 2.2.29:

Below is a tree diagram showing causes and effects of earthquakes. The roots of the tree represent the causes; the tree trunk is the main idea (earthquakes) while the branches represent the effects. In groups of five, analyse the tree diagram and discuss the causes (F, G and H) and effects of earthquakes (A, B, C, D, E, I, J and K). Then suggest the disaster risk management skills that could be applied to minimise the adverse or negative effects of earthquakes.

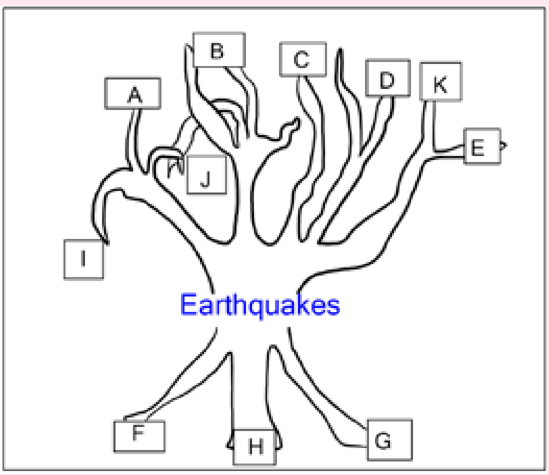


Fig. 2.2.48: Tree diagram showing causes and effects of earthquakes

Write a short summary of the causes, effects and suggested disaster risk management skills that could be applied to reduce the disastrous effects of earthquakes. Then present your findings to the whole class through your group representative.

Explanations:

Earthquakes are generally caused by the following:

1. Natural causes

(i) Tectonic plates sliding past each other along the line of fault, that is, shearing or sliding movement of tectonic plates.

(ii) Diverging or spreading movement of tectonic plates caused by tension force that results into volcanic eruptions.

(iii) Converging or colliding plate movement caused by compression forces.

(iv) Isostatic adjustment.

The term 'Isostacy' refers to the process of long range, slow adjustment of the earth's crust due to changing pressures. Isostacy can force crustal materials out of an area which is being uplifted or depressed, resulting into faults that cause waves leading to earthquakes.

2. Human causes

(i) Underground nuclear tests: Underground nuclear bombs trigger off immense vibrations within the earth in the region they take off.

(ii) Movement of trains generates vibrations of waves as they roll.

(iii) Use of explosives causes shock waves.

(iv) Construction of large reservoirs causes shock waves.

DETECTION AND MEASUREMENT OF EARTHQUAKES

Earthquakes are measured in terms of the magnitude or energy as well as intensity that they release.

(a) Measurement of magnitude or energy released by an earthquake

Magnitude is a measure of the amount of energy given off by an earthquake. This energy released by an earthquake is measured by a Richter scale. The Richter scale ranges from 0 to 10 or 0 to 8.9. This means that an earthquake measuring 3.0 on the Richter scale is ten times stronger than the one that measures 2.0. The Richter scale uses the seismograph as a measuring tool. The amount of energy released by an earthquake is measured by the height (amplitude) of one of the wiggles on the seismograph. The larger the earthquake, the more the ground vibrates and the larger the wiggle.

Table 36: The Richter scale

Richter scale unit	Destruction level for nearby earthquakes
2-3	Hardly noticed
3-4	Slightly noticed
4-5	Minor
5-6	Damaging
6-7	Destructive
7-8	Major destruction
8 +	Enormously destructive

(b) Measurement of intensity of an earthquake

Intensity of an earthquake refers to how strong or hard an earthquake shakes the ground. It determines how much and what kind of damage it has caused. The earthquake's intensity can be known by the effect it has on people and buildings. This intensity is measured on the Mercalli scale which uses Roman numeral numbers ranging from I to XII; the higher the number, the greater the damage.

Modified Mercalli Intensity Scale

I Not felt except by very few under especially favourable circumstances.

II Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognise it as an earthquake. Standing motor cars may rock slightly; vibration like passing of truck. Duration estimated.

IV During the day felt indoors by many, outdoors by a few. At night some awakened. Dishes, windows, doors disturbed, walls make cracking sound. Sensation is like heavy trucks sticking on buildings. Standing motor cars rocked noticeably.

V Felt by nearly everyone; many awakened. Some dishes and windows broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles and other tall objects sometimes noticed. Pendulum clocks may stop.

VI Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys; slight damage.

VII Everybody runs outdoors. Damage is negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. It's noticed by people driving motor vehicles.

VIII Damage is slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; in poorly built structures. Panel walls are thrown out of frame structures; fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in smaller amounts; changes in well water. Persons driving motor cars disturbed.

IX Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously; underground pipes broken.

X Some well-built wooden structures destroyed; most masonry and frame structures with foundations; ground badly cracked. Rains bent; considerable landslides from river banks and steep slopes; shifted sand and mud. Water splashed (slopped) over banks.

XI Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures form in the ground; underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rain bent greatly.

XII Total damage. Waves are seen on ground surface. Lines of slight and level distorted; objects thrown upward into air.

Adopted from McGeary, Plummer and Carlson (2004)

Differences between the Mercalli scale and Richter scale

These differences are shown in the table below.

Table 37: Differences between the Mercalli and Richter scales

Parameter of comparison	Mercalli scale	Richter scale
Item to be measured	It measures the intensity of an earthquake, by observing its effects on people, environment and earth's surface.	It measures energy released by an earthquake by using a seismograph. A base-10 logarithm scale is obtained by calculating the logarithm of amplitude of waves recorded by the seismograph.
Measuring tool	Through ***observation***	Through ***seismograph***
Calculation	Quantified from observation of effect on the earth's surface, human objects and human-made structures.	Base-10 logarithm scale obtained by calculating logarithm of amplitude of waves.
Scale	**I** (not felt) to **XII** (total destruction)	From **2.0** to **10.0+(**never recorded. A 3.0 earthquake is 10 times stronger than a 2.0 earthquake.
Consistency	It varies depending on distance from the epicentre.	It varies at different distances from the epicentre, but value is given for the earthquake as a whole.

WAVES

The shock waves set up vibrations that may be as high as 200 per minute from the focus. Such waves may be categorised into three types namely:

(a) Primary waves which travel in solids, liquids and gases. These waves travel at great speed.

(b) Secondary waves which travel in solids. These waves cause rocks to vibrate in a direction perpendicular to their path.

(c) Longitudinal or long waves which have long amplitude wiggles. These waves cause rocks to move in a horizontal manner at right angles to the direction of the wave. These rocks can also move in elliptical orbits.

EFFECTS OF EARTHQUAKES

1. They can cause vertical and lateral displacement of parts of crust.
2. They can raise or lower parts of the sea floor. In Sagami Bay (Japan) in 1923, parts of the bay were uplifted by 215 metres.
3. Earthquakes in oceans give rise to waves known as ***tsunamis or tidal waves***. These waves are also called ***seismic sea waves***.

What are tsunamis or tidal waves?

These are sudden movements of the sea floor upward or downward during a submarine earthquake that can generate very large sea waves, popularly called 'tidal waves'. However, ocean tides have nothing to do with generating huge waves. The Japanese term '***Tsunami***' is preferred by geologists.

Effect of Tsunamis

Tsunamis are extremely dangerous as they cause a lot of destruction to the coastal areas. This is so because they travel so fast that there is little time to warn people of their impending arrival. A tsunami formed in Hawaii will take only hours to reach Japan, Alaska and Washington. Reaching heights of 100 feet (30 metres), tsunamis can remove all the water away from the beach as they approach the shore.

Did you know?

Tsunamis or seismic sea waves are caused when a large section of the sea floor suddenly rises or falls during an earthquake. All the water over the moving area is lifted or dropped for an instant. As the water returns to sea level, it sets up long, low waves that spread very rapidly over the sea.

4. Earthquakes cause the raising or lowering of coastal regions, for example, in Alaska when some of the coastal rocks were uplifted by 16 metres in 1899.
5. They also cause natural disasters such as landslides as in the Loess Country of North China in 1920 and 1927.
6. They can cause destruction of cities when fires break due to the sparking of fallen electrical lines. Fire is also set off because of broken gas lines.
7. They lead to loss of life and destruction of property.
8. They may lead to the spread of water borne diseases like dysentery, cholera and bilharzia especially when tsunamis occur.
9. Many roads might be destroyed and communication lines might be badly damaged.
10. There will be need for relocation of people where the earthquakes make them homeless.

Activity 2.2.30:

In groups of five, observe the figure showing the effects of earthquakes below and answer the following questions:

Fig. 2.2.49: Effects of earthquakes

1. *What effects of earthquakes do you observe in the picture above?*
2. *What precautionary measures could be taken to avoid such devastating effects of earthquakes?*
3. *What do you think could be done to recover from effects of the earthquake?*

DISASTER RISK MANAGEMENT SKILLS APPLIED IN AREAS PRONE TO EARTHQUAKES

(a) Preparedness measures to take before an earthquake

- Be informed about risks in your area.
- Be informed about the safety of the construction materials used in your house.
- Think about contingency plans.
- Identify the safest areas in your house.
- Make sure the furniture, lamps, pictures and utensils in your house are in a secure place.
- Move any inflammable materials away from the heat sources.
- Find out where the main electricity and gas connections are and who could operate them in case of an emergency.
- Prepare an emergency bag.

(b) During an earthquake at home

- Remain calm because panic hinders your action towards safety.
- Open the doors since movement may cause jams.
- Do not rush towards exits.
- Move away from windows, mirrors and heavy objects.
- Do not use machines or candles. Shut off all possible sources of fire.

If you are outdoors

- Stay away from walls, buildings and electric cables.
- Move away from objects that may fall on you.
- Be careful of objects such as electrical wires and glass on the ground.
- Move towards an open place.
- While escaping, try to avoid narrow streets. Avoid those streets that are overcrowded with people.
- Help others as much as possible by giving first aid.

(c) After the earthquake

- Ensure you keep to open places as tremors may cause buildings to collapse.
- Do not go to the beaches because tsunamis may occur.

- When in a car, drive slowly; careful of what is lying on the road and avoid bridges. Stay away from unstable structures.
- Before moving away, see if people need your help.
- Wear shoes if possible, to avoid being cut by objects such as glass.
- Check on the injured; do not move those who are seriously injured unless it is an emergency.
- Check if there is any risk of fire.

Source: WHO (1989), African Disaster Handbook, OAU Printing Press

CASE STUDY: JAPAN EARTHQUAKE AND TSUNAMI (11/03/11)

A massive 9.0 magnitude earthquake struck Japan, Friday afternoon, on 11 March, 2011 at 0546. The earthquake was centred 130 kilometres to the east of the prefecture's capital, Sendai. A tsunami was sent crashing into the country's north-eastern coast. It was originally reported at a magnitude of 7.9, but later was upgraded to 8.9 and then to a 9.0. It lasted six minutes making it the fifth largest recorded worldwide since 1900, according to the U.S Geological Service. It had 10, 000 times more energy than the magnitude 6.3 earthquakes in Christchurch and New Zealand which struck 17 days earlier.

Japan is located on the east edge of the Eurasian Plate. In this zone, the oceanic Pacific plate subducts (sinks under) the Eurasian plate. This plate margin is destructive. Plates collide and stick due to compression force. When pressure builds up and is released, it causes a rapid shift in the plates and a lot of energy of is released.

Japan was largely prepared for the earthquake and many buildings remained standing afterwards. However, Japan was not prepared for the subsequent tsunami. A tsunami warning extended to at least 50 nations and territories in the far south. Local television showed smoke rising from a Tokyo port building, fire in the capital's water front Odaiba district and oil finery ablaze in Ichihara, near Tokyo. In Iwate building, a bridge collapsed and a building was washed away, with boats and cars swirling around in the rising waters.

Traders said that most of the selling took place off-shore as Tokyo traders were evacuated. Tokyo's major airports halted flights and all Tokyo areas were halted. Radiation releases caused large evacuations, concern over food and water supplies, and treatment of nuclear workers. 2000 people were confirmed dead, 2,000 were injured while 530,000 were displaced, staying in 2,500 evacuation centres, such as schools and public halls.

A tsunami warning was issued three minutes later after the earthquake. A Meteological Agency official appeared on TV urging those affected by the earthquake not to return home because of the possible tsunami. He said:

"In some areas, we have issued a warning of a tsunami of higher than 10 metres and we expect these areas will experience the high water levels soon; please stay on high alert."

The Governor of Miyagi Prefecture asked for Japanese military forces to be sent in to help. The Defence Ministry sent eight fighter jets to check the damage. The bank of Japan set up a disaster control team to assess the impact of the earth on financial markets and financial institutions. In response, 91 countries offered aid in form of blankets, food, search dogs and military transport. A British rescue team arrived in Japan to join the search for survivors of the earthquake and tsunami.

Source: //joeblakey.com/geography/case-study-japan-earthquake-tsunami-110311/

Activity 2.2.31:

In groups of five, read the case study and answer the following questions:

Q1. Describe the nature of the earthquake that occurred in Japan in terms of magnitude and intensity.

Q2. Identify the cause of the Japan earthquake and tsunami.

Q3. Explain any ten effects of the Japan earthquake and tsunami.

Q4. What disaster risk management skills and knowledge were applied before, during and after the earthquake and tsunami?

Q5. In your own view, do you think the disaster risk management skills and knowledge applied were satisfactory or not? Give a reason for your answer.

RELATIONSHIP AMONG FOLD MOUNTAINS, VOLCANOES AND EARTHQUAKES

Activity 2.2.32:

In groups of five, discuss the relationship that exists among fold mountains, volcanoes and earthquakes.

Fold mountains are formed in the zones where earthquakes and volcanoes occur. For example, Rocky Mountains and Andes Mountains were formed within the Circum-Pacific Ring of Fire where volcanoes and earthquakes are common. This is where plates converge or collide, thereby creating sudden vibrations of the earth's crust. The process of folding is generally associated with faulting where cracks develop. Therefore, magma is likely to leave its reservoir and force itself into these cracks. This eventually results into the kind of volcanism which is likely to form intrusive features like batholiths, laccoliths, sills, and dykes, among others.

IDENTIFICATION OF SHIELDS

Meaning of the term 'shields'

A shield is a stable part of the earth which is not prone to sudden vibrations in the crust. Such areas happen to be away from the boundaries or margin of tectonic plates.

Examples of shields

1. Laurentian shield
2. Brazilian shield
3. Baltic shield
4. African shield
5. Arabian shield
6. Siberian shield
7. Deccan shield
8. China shield
9. Australian shield

Location of shields on the world map

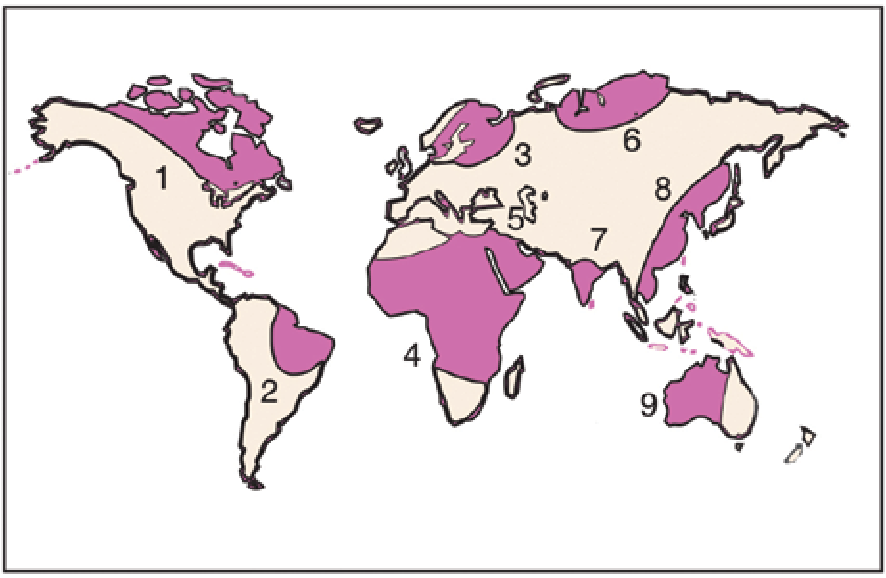


Fig. 2.2.50: Shields on the world map

ROCKS

Meaning of the term 'rock'

Activity 2.2.33:

Brainstorm on the meaning of the term 'rock'.

A rock is a combination or an aggregate of two or more mineral particles. It can also be defined as a naturally-formed, consolidated material usually composed of grains of one or more minerals.

Composition of rocks

The earth's crust consists of rocks which comprise a combination of different minerals. All minerals are formed from one or more of the eight main elements. These elements include the following:

- Oxygen } Quartz
- Silicon }
- Potassium
- Sodium
- Calcium
- Magnesium
- Iron
- Aluminium

Examples of minerals

1. **Quartz** (sometimes called silica) is a compound of silicon and oxygen. It is a very common mineral. Other common minerals are micas and feldspars. Granite, a fairly common rock, is a mixture that contains quartz, micas and feldspars.
2. **Feldspars**

   These are compounds of potassium, sodium, calcium and aluminium.
3. **Micas**

   These are compounds of potassium, magnesium, silicon and aluminium.

Classification of minerals

Some minerals are crystalline while others are non-crystalline.

(i) Crystalline minerals

Atoms of these minerals are arranged in a definite manner.

(ii) Non-crystalline minerals

Atoms of these minerals are not arranged in any definite manner.

Table 38: Common rocks and their minerals

ROCK	MINERALS
Limestone	Quartz, feldspar and micas
Sandstone	Quartz, calcite and feldspar
Granite	Feldspar, augite
Basalt	Calcite, dolomite
Shale	Quartz, micas and feldspar

TYPES OF ROCKS

Generally speaking, all rocks may be classified into three groups namely:

1. Igneous rocks
2. Metamorphic rocks
3. Sedimentary rocks

1. IGNEOUS ROCKS

Meaning of 'igneous rocks'

The term 'igneous rock' refers to those rocks that are formed through igneous activity; original rocks become molten and the magma cools and solidifies to produce igneous rocks.

Formation of igneous rocks

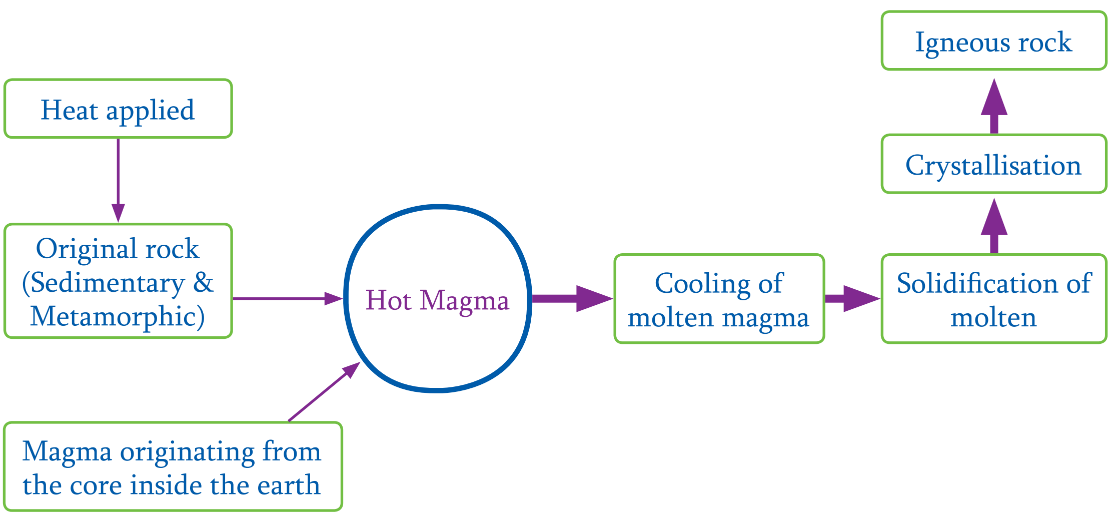


Fig. 2.2.51: Flow diagram showing formation of igneous rocks

Activity 2.2.34:

In groups of five, discuss how igneous rocks form.

The name igneous comes from the Latin word Ignis which means 'fire'. This means that there is melting of original rocks after being heated. This produces molten material that eventually cools and solidifies on the earth's surface. The molten material remains in channels connecting the molten magma reservoirs and the wells below the earth's surface. This means that features form in these three areas.

When rocks solidify after reaching the earth's surface, they are called lava, volcanic rocks or extrusive rocks. When they solidify in channels connecting the molten magma reservoirs with the exterior, they are called hypabyssal rocks. When they solidify well below the surface under the influence of pressure, they are called intrusive or abyssal rocks.

In terms of origin, there are two main classes of igneous rocks: plutonic and volcanic rocks.

(a) Plutonic igneous rocks

These are rocks formed at some depth of the earth's crust. They have cooled and solidified slowly to an extent that large, easily recognised crystals have been able to form. Examples of these intrusive rocks include *granite*, *diorite* and *gabbro*. They can be exposed to the surface by the processes of denudation and erosion.

(b) Volcanic igneous rocks

These are molten rocks poured out of volcanoes as *lava*. They solidify rapidly on the earth's surface and their crystals are small.

Activity 2.2.35:

In groups of five, discuss the process that leads to the formation of igneous rocks.

Characteristics of igneous rocks

Igneous rocks are characterised by the following:

(i) They contain large crystals thus they are crystalline.

(ii) They are non-stratified. This means that they do not appear in layers.

(iii) They are non-fossiliferous. This means that they do not contain fossils. Indeed, it is very hard and impossible to find remains of dead plants and animals in these rocks, since they cannot exist in the magma in the core.

Gabbro igneous rock

Rhyolite igneous rock

Granite igneous rock

Andesite igneous rock

Fig. 2.2.52: Examples of igneous rocks

Table 39: Examples of igneous rocks

Origin	Texture	Rock Name	Dominant Minerals
Extrusive	Glassy	1. Obsidian	Orthoclase, Amphibole, Quartz
		2. Pumice	Orthoclase, Amphibole, Quartz
	Fine grained	3. Scoria	Plagioclase, Olivine, Pyroxene
		4. Rhyolite	Orthoclase, Mica
		5. Andesite	Plagioclase
		6. Basalt	Plagioclase, Olivine, Pyroxene, Mica
Intrusive	Coarse grained	7. Granite	Orthoclase, Amphibole, Quartz, Mica
		8. Diorite	Plagioclase, Pyroxene, Amphibole, Mica
		9. Gabbro	Plagioclase, Pyroxene
		10. Peridorite	Olivine, Pyroxene

2. METAMORPHIC ROCKS

Meaning of metamorphic rocks

These are rocks which were originally igneous or sedimentary but they later changed in terms of their structure (arrangement of rock layers) and chemical composition. The appearance of these rocks changes due to the influence of heat, pressure, air and water

How do metamorphic rocks form through these conditions?

(a) **Heat:** Heat cause the igneous and sedimentary rocks to melt, as the magma cools and solidifies. It is this process of cooling and solidification that makes minerals re-crystallise. This changes the structure of the affected rocks. For sedimentary rocks, crystallisation happens for the first time, while for igneous rocks, it will happen for the second time.

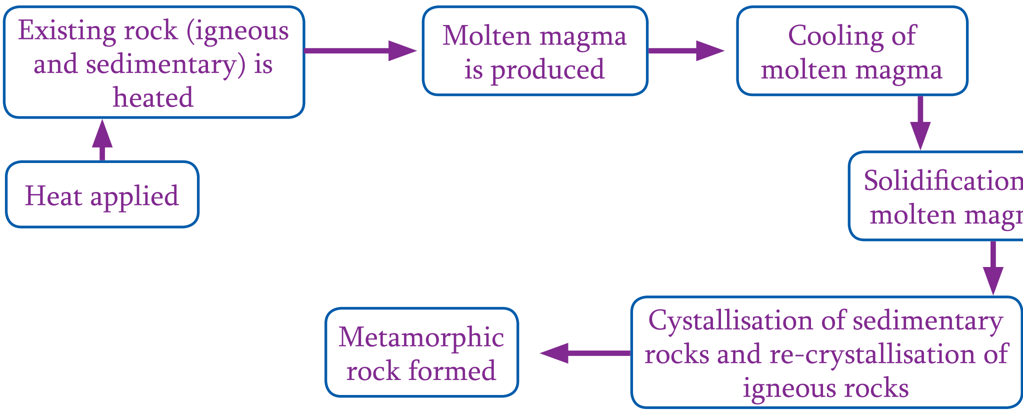


Fig. 2.2.53: Flow diagram showing how heat determines formation of metamorphic rocks

(b) **Pressure:** When igneous and sedimentary rocks are subjected to great pressure, their structure can be altered.

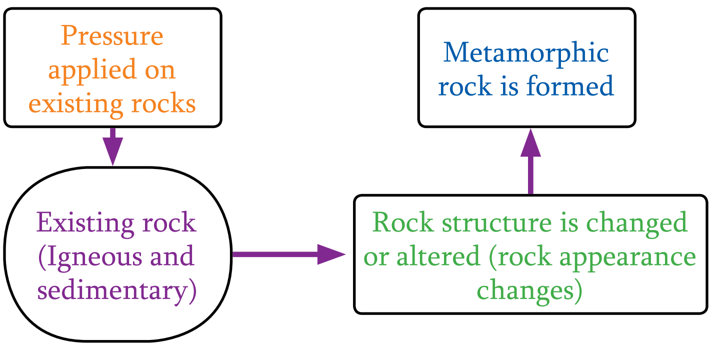


Fig. 2.2.54: Flow diagram showing how pressure determines formation of metamorphic rocks

(c) **Water:** Water dissolves some rock materials and deposits other materials inside rocks. This catalyses a chemical reaction between the materials brought by water and the minerals which are already inside these rocks. Water molecules (H_2O) can also react with mineral elements to produce other compounds. This chemical reaction changes the chemical composition.

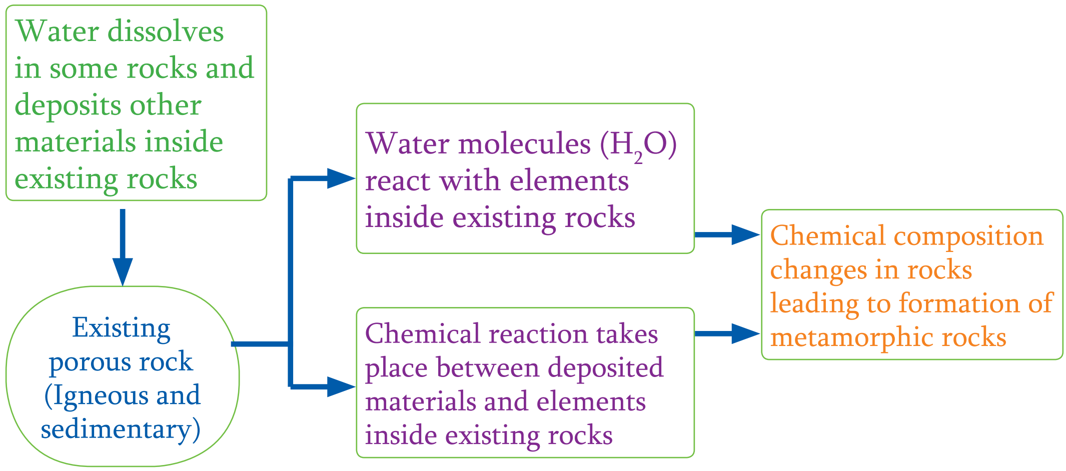


Fig. 2.2.55: Flow diagram showing how water determines formation of metamorphic rocks

(d) **Air:** When air molecules of a particular gas enter a porous rock, there is a chemical reaction between the minerals which are found inside the rocks and the gas molecules which have entered the rock. For example, when oxygen enters a porous rock having iron mineral inside it, there is a chemical reaction between the two compounds. This chemical reaction eventually changes the rock's chemical composition.

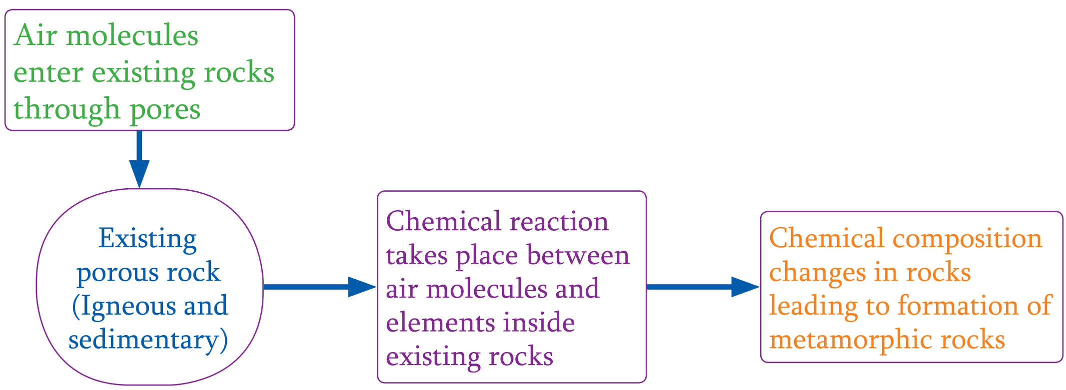


Fig. 2.2.56: Flow diagram showing how air determines formation of metamorphic rocks

Activity 2.2.36:

In groups of five, discuss the process that leads to the formation of metamorphic rocks basing on the following factors:

- *Heat*
- *Pressure*
- *Air*
- *Water*

Types of metamorphism

Metamorphism refers to the changes that take place in rocks on the earth. These changes may lead to new textures, new assemblages or both.

(a) Dynamic or cataclastic metamorphism

When metamorphic changes are due to changes in pressure, the process is called *dynamic* or *cataclastic metamorphism.* When rocks undergo metamorphism, new minerals are produced. Sometimes, they re-crystallise and become more compact and resistant to erosion. The first sign of metamorphism is the arrangement of minerals in bands or layers. This structure is known as *foliation*.

(b) Thermal or contact metamorphism

Sometimes, heat can determine the changes that take place. When this happens, the process is called *thermo* or *contact metamorphism*.

(c) Regional /thermo-dynamic metamorphism

This happens where pressure and heat operate together on rocks over a large area.

(d) Metasomatism

Sometimes gases move through rock pores and come into contact with different rock elements. Chemical reactions take place hence new minerals are formed. This kind of metamorphism is called *metasomatism*.

Table 40: Examples of metamorphic rocks

Name of rock	Original rock	Arrangement of grains
1. Slate	Shale, siltstone	Layers almost invisible
2. Phyllite	Shale, siltstone	Layers almost invisible
3. Schist	Impure limestone, shale, siltstone	Layer visible from 1 cm to 1 m apart.
4. Gneiss	Granite, slate, conglomerate, siltstone	Layers from 1 cm to 1 m apart
5. Marble	Pure limestone	No layer
6. Quartzite	Pure Sandstone	No layer
7. Serpentine	Basalt, Peridotite	No layer

Phyllite metamorphic rocks

Gneiss metamorphic rock

Fig. 2.2.57: Examples of metamorphic rocks

Characteristics of metamorphic rocks

(i) Most metamorphic rocks are sufficiently coarse-grained to permit recognition of individual minerals.

(ii) Rocks are almost invariably layered. In some cases, the layered arrangement is probably inherited from sedimentary bedding. In other cases, layering is probably developed by metamorphic processes.

(iii) These rocks are considerably harder than equivalent sedimentary rocks.

(iv) They contain grains which are generally quite intergrown with each other.

(v) Some rocks contain fossils that have been greatly distorted out of their original shape. These can originate from sedimentary rocks.

3. SEDIMENTARY ROCKS

Meaning of the term 'sedimentary rocks'

These are rocks formed from sediments that have been transported and deposited either by water, wind or ice. The most common sediments are those transported and deposited by water.

Classification of sedimentary rocks

A solid rock is broken into small particles called *sediments* or *clastics*. Others may be formed by chemicals and organic processes and they are known as *non-clastics.* The chemically formed rocks are often referred to as *hydrogenic* particularly if they are formed in water. Organic ones are called *biogenic carbonaceous rocks*.

Therefore, sedimentary rocks are classified into two categories: clastic and non-clastic rocks.

(a) Clastic sedimentary rocks

Existing rocks undergo the process of weathering. The produced sediments are transported and later on deposited in a geosyncline (sea and ocean bordering the continents). In the geosyncline, they are compacted (squeezed) and lithified or connected together to form hard rocks. Sometimes, these rocks are said to be mechanically formed. Clastic rocks are named according to the size and shape of sediments.

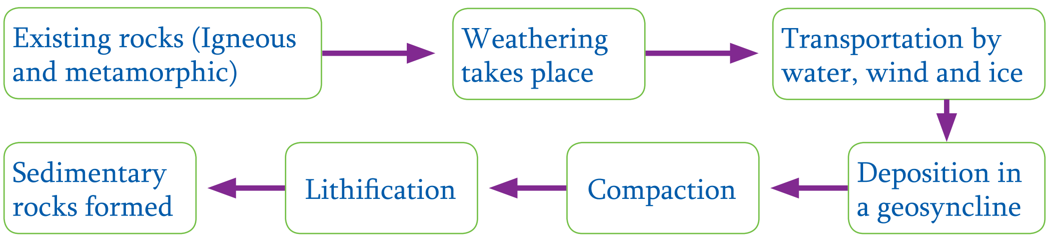


Fig. 2.2.58: Formation of clastic sedimentary rocks

(b) Non-clastic sedimentary rocks

These are rocks that are formed through a chemical reaction between two solutions where precipitation occurs. These include precipitates such as calcite, evaporates such as salt and organic deposits such as coal and limestone. Non-clastic rocks are named according to composition. All of them have interlocking crystals except peat, lignite and coal sequence.

Table 41: Examples of sedimentary rocks

Category	Examples	Texture	Composition	Remarks
CLASTIC	Conglomerate	Round pebbles	Any kind of rock	Pebbles held together
	Breccias	Angular pebbles	Any kind of rock	Sand, clay and cement
	Sandstone	Sand-sized grains	Quartz	Grains may be calcite
	Siltstone	Very fine grains	Mostly quartz	Gritty feel
	Shale	Microscopic grains	Mostly clay and Mica	Occurs in layers

NON-CLASTIC	Limestone	Coarse to small crystals	Calcite, small shells	Texture
	Chert (Flirt)	Microscopic crystals	Chalcedomy	Cement in rocks
	Alabaster	Microscopic to coarse	Gypsum	Evaporate
	Rock salt	Cubic crystals	Halite	Evaporate
	Peat, lignite	Coarse to microscopic plant fragments	Fragments	Products of plants decay without oxygen.

Characteristics of sedimentary rocks

The following are the characteristics of sedimentary rocks:

1. They are layered or stratified (particularly the clastic rocks).
2. They are fossilised (they contain fossils).
3. They are non-crystalline.

Types of sedimentary rocks

There are three types of sedimentary rocks. They are classified according to their origin and composition. These include:

(a) Mechanically formed sedimentary rocks

These are rocks which have been formed from the accumulation of materials derived from other rocks. These include clays, gravel and alluviums (all deposited by water), moraines, boulder clay and gravel (deposited by ice), and loess (deposited by wind).

Examples of mechanically formed sedimentary rocks

(i) Sandstones

These are made from sand grains, often quartz fragments derived from granite. Their texture or composition and colour vary tremendously.

(ii) Conglomerates

These are large pebbles firmly cemented to form a rock known as conglomerate. Pebbles in the rock are rounded.

(iii) Breccia

These are formed when the fragments are angular.

(iv) Clay

These are formed from finer sediments. Clay is used for brick-making.

(v) Shale or mudstone

These are formed from sediments that are much finer than those of clay.

Activity 2.2.37:

In groups of five, discuss the process that leads to the formation of clastic or mechanically formed sedimentary rocks.

(b) Organically formed sedimentary rocks

These are formed from the remains of living organisms.

Examples of organically formed sedimentary rocks

Organically formed sedimentary rocks from animals include:

(i) Chalk
(ii) Coral

Organically formed sedimentary rocks from plants include:

(i) Peat
(ii) Coal
(iii) Lignite

(c) Chemically formed sedimentary rocks

These rocks are formed as a result of evaporation of water from salt precipitates leaving behind layers of salt which are compacted into rocks. They are precipitated from chemical solutions of one kind or another.

Examples of chemically formed sedimentary rocks

(i) Borax
(ii) Potash
(iii) Gypsum
(iv) Nitrates
(v) Rock salt

Activity 2.2.38:

Let the whole class go outside and collect rock samples from the field, then identify sedimentary rocks from them.

RELATIONSHIP BETWEEN AND AMONG THE DIFFERENT TYPES OF ROCKS

The Rock Cycle

There is a relationship between and among the three types of rocks. This relationship can best be described by the rock cycle. The rock cycle simply means that rocks can change from one form to another under different conditions. Sedimentary and metamorphic rocks may change to igneous rocks, only when they are exposed to great heat such that melting occurs. The molten materials cool and solidify to form these igneous rocks. Igneous and sedimentary rocks may change to metamorphic rocks, only when subjected to heat, pressure, water and air. Finally, metamorphic and igneous rocks can change to sedimentary rocks when they undergo the weathering process and sediments are transported to the lower valley where they get compacted and they lithify (get connected together). See Fig. 2.2.59 below.

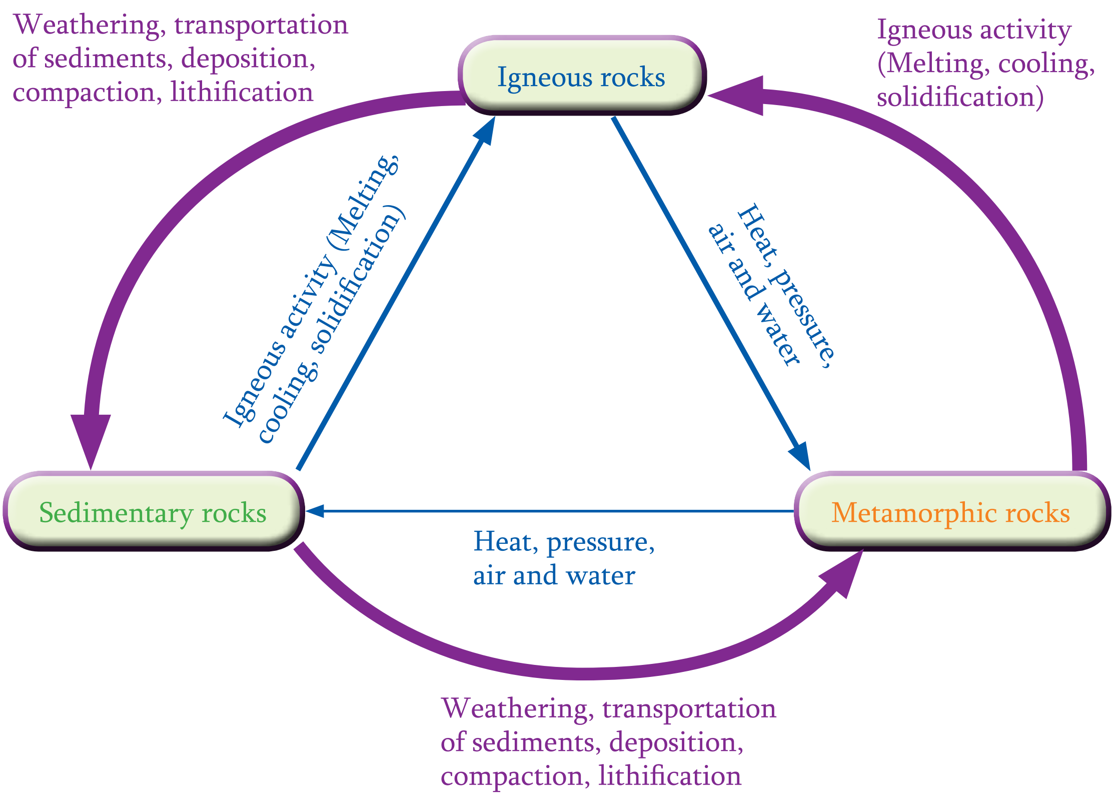


Fig. 2.2.59: The rock cycle

IMPORTANCE OF ROCKS TO LIFE AND HUMAN ACTIVITY

Activity 2.2.39:

Brainstorm on the importance of rocks to life and human activities.

Explanation:

- Limestone is used in cement making.
- Rocks break down to give fertile soils.
- Rocks are used as decorations.
- Rocks are sources of valuable minerals like zinc, lead, bauxite, bauxite and copper among others.
- They also act as water reservoirs through aquifers.
- They provide salts for both domestic and industrial purposes such as soda ash in Lake Magadi.
- Clay is used in brick making.

Review Questions

Q1. (a) Define the following terms: 'theory', 'continental drift' and 'continental drift theory'.

(b) Account for evidences of continental drift.

(c) Why is it that the theory has received a lot of criticisms? Explain any two ways.

Q2. (a) What do you understand by the term 'plate tectonics theory'?

(b) Explain the cause of plate movement.

(c) Mention the types of plates that you know.

(d) Give examples of the types of plates mentioned in (c) above.

Q3. Below is a world map showing main tectonic plates. Use it to answer the questions that follow:

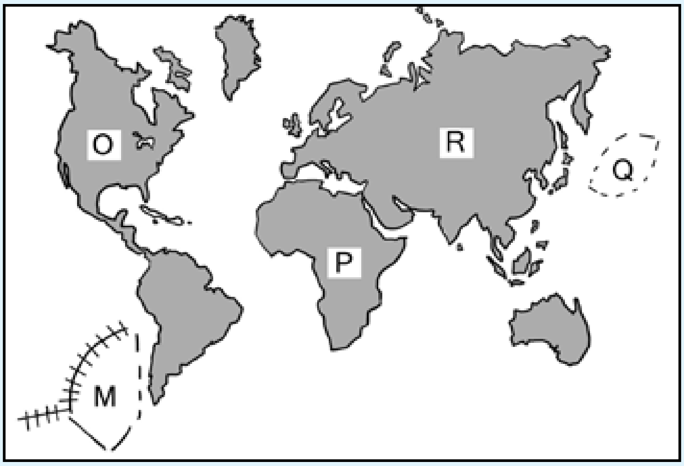


Fig. 2.2.60: Map showing main tectonic plates

(a) Name the plates labelled M, N, O, P, Q and R.

(b) (i) With the aid of diagrams, describe the three types of plate movements.

(ii) Using the diagrams drawn in (b) (i) above, identify the plate boundary or margin that is associated with each plate movement.

Q4. (a) Mention any geological features that are formed along the plate boundaries.

(b) Explain how each of these features form.

(c) Using well labelled diagrams, explain how each of the following types of mountains evolve:

(i) Residual mountains

(ii) Fold mountains

(iii) Volcanic mountains

(iv) Block mountains

(d) Explain any three effects of geological features on the environment and human activities.

Q5. (a) Define the term 'fold'.

(b) Using well labelled diagrams, describe the four types of folds.

Q6. (a) Define the term 'faulting'.

(b) Describe the types of faults that you know.

Q7. List the features that were formed through the mountain building process.

Q8. (a) What do you understand by the term 'volcanism' or volcanicity?

(b) Explain how a volcano forms.

(c) Describe the stages of the volcano's life cycle.

Q9. The figure below shows a volcano. Use it to answer the questions that follow.

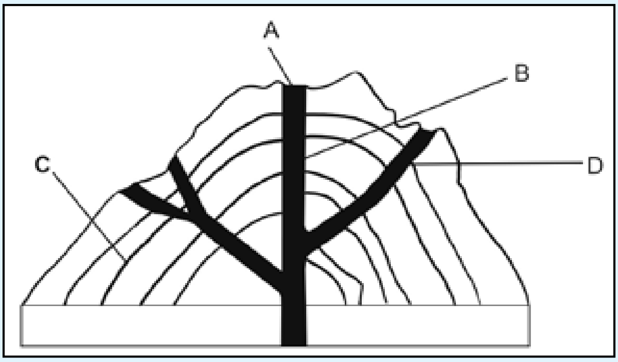


Fig. 2.2.61: A volcano

(a) Name the parts labelled A, B, C and D.

(b) List five examples of intrusive and extrusive features.

(c) Draw the world map in your notebook. Name and locate on the world map areas which are prone to volcanic activity.

(d) Describe the relationship between volcanism and mountain building.

(e) Explain any four positive and three negative effects of volcanic activity.

(f) Suggest strategies that can be put in place to manage volcanic activities.

Q10.(a) Define the term 'earthquake'.

(b) Explain any four causes of earthquakes.

(c) List the major regions where earthquakes commonly occur.

(d) Explain any five effects of earthquakes by citing relevant examples.

(e) Explain what happens when a continental plate collides with an oceanic plate.

Q11. (a) What is meant by the term 'rock'?

(b) Mention any four minerals that are contained in rocks.

(c) Mention any three types of rocks.

(d) Explain how each of the rocks you mentioned in (c) above is formed. Cite relevant examples in each case.

(e) State the characteristics of each type of rock.

(f) Describe the relationship that exists between and among the three types of rocks.

Q12. Below is a figure showing the rock cycle. Use it to answer the questions that follow.

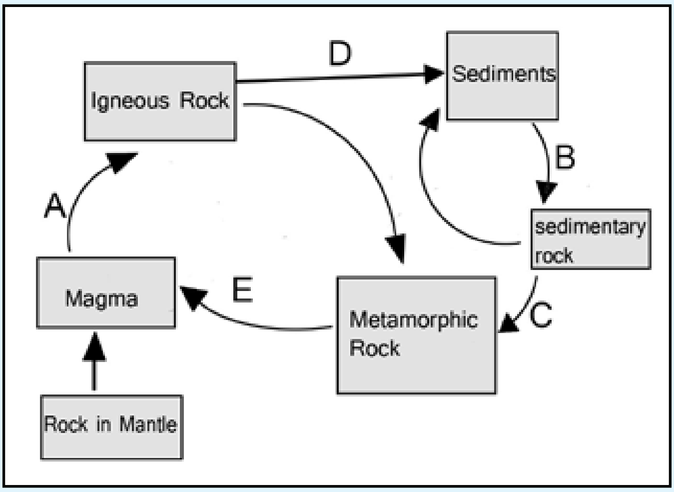


Fig. 2.2.62: The rock cycle

(a) (i) Identify the processes A, B, C, D and E.

(ii) Describe the processes identified in 12 (a) (i) above.

(iii) Briefly describe the rock cycle.

(b) State four economic importance of rocks to human beings.

TOPIC 3

The Hydrosphere

Success criteria:

By the end of this topic, the student should be able to:

- Explain the term 'landform'.
- Explain the formation of riverine features.
- Explain the importance of riverine features.
- Explain how coastal landforms are formed.
- Explain the importance of coastal landforms.
- Explain relief features of ocean basin.
- Explain the terms 'ocean currents', 'drifts' and 'streams'.
- Identify major ocean currents of the world.
- Explain causes of ocean currents.
- Explain the factors that influence the direction of ocean currents.
- Suggest the effects of ocean currents.

Background

In Form One, you looked at the meaning of the term 'hydrosphere', the main features and processes of the hydrological cycle. You further learnt about the importance of the hydrological cycle and ways of maintaining it. In Form Two, you looked at the internal structure of the earth and the internal and external processes that shape the landscape. You also looked at the Shire River with regard to its importance and the socio-economic challenges it faces. In Form Three, you will look at riverine, relief and coastal features.

RIVERINE LANDFORMS

Meaning of the term 'landform'

Activity 2.3.1:

Brainstorm on the meaning of the term 'landform'.

A landform is a specific feature on the earth's surface. Landforms range from large-scale features such as plains, plateaus and mountains to minor features such as hills, valleys and alluvial fans.

Examples of riverine landforms

There are several riverine landforms. Some of these include:

Ox-bow lakes, deltas, confluences, gorges, catchment areas or basins, levées, watersheds or water partings or divides, meanders and flood plains.

FORMATION OF RIVERINE LANDFORMS

1. RAPIDS AND WATERFALLS

How do rapids and waterfalls form?

These occur where the river's slope suddenly becomes steep causing water to flow over the edge of a hard rock layer, plateau or high level side valley. This steep slope can be caused by a hard rock that lies vertically, horizontally or dips upstream. See Fig.2.3.1 below.

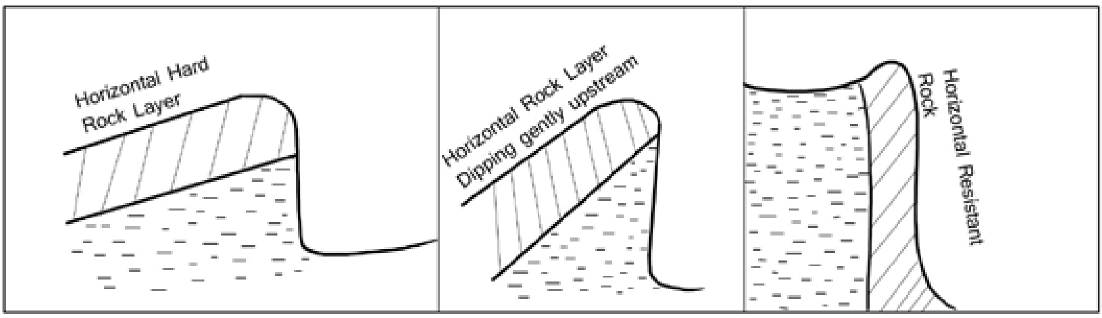


Fig. 2.3.1: Formation of rapids and waterfalls

Waterfalls can also be caused by the uplifting of land, land slides, lava flowing, presence of a cliff on the river's course into the sea, presence of a hanging valley over a glacial trough and presence of fault scarps. They can also form due to plunging of water due to the presence of rejuvenation heads or knick points in the river channel.

2. GORGES

How does a gorge form?

A gorge is formed when there is a vertical erosion of the river bed.

Characteristics of a gorge

- The valley floor is very narrow.
- The valley floor is almost flat.
- It has steep sides.

Note: Rivers that follow through gorges are characterised by waterfalls and rapids.

Examples of gorges

(i) Mpatamanga gorge along the Shire River valley in Malawi.
(ii) The Pungwe gorge in the Inyama mountains in Zimbabwe.
(iii) Kafue gorge in Zambia.

3. MEANDERS

How do meanders develop?

First, rivers flow slowly due to a flat or gentle slope of land, deposition of sediments or load transported from upper and middle courses. It is the deposition of sediments that blocks water and subsequently causes the river to change its direction of flow from a straight to a winding channel. These winding paths are called meanders.

4. OX-BOW LAKES, HORSE-SHOE LAKES OR CUT-OFFS

Formation of ox-bow lakes, horse-shoe lakes or cut-offs

Ox-bow lakes form in the lower course or flood plain of the river because of the flatness or gentleness of land. This creates a good platform for the deposition of sediments which have been transported from the upper course. Erosion takes place in the upper course thereby allowing sediments to collect in the lower course. With reference to the figure below, load deposits at M and N block water that flows through the meander, taking a more direct course. The meander detaches itself from the main river and forms the type of lake known as an ox-bow lake, horse-shoe lake or cut-off.

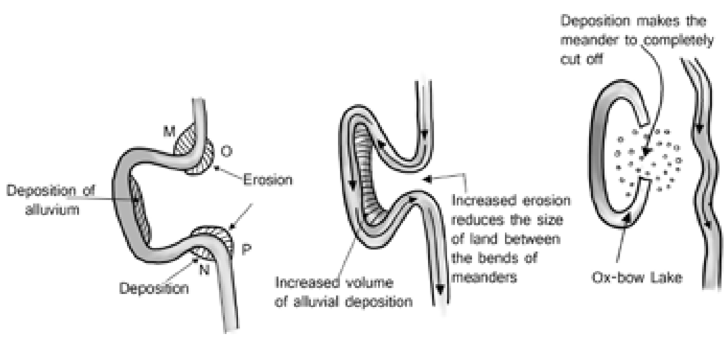


Fig. 2.3.2: Formation of an ox-bow lake

5. DELTA

Formation of a delta

A delta is formed when the river is entering a large body of water at its mouth. As the river flows from its source, it carries a load (sediments) which is deposited by running water after erosion has taken place. This load moves from the upper to the lower course of the river,before being deposited at the mouth of the river. It is therefore difficult for the river to follow a more direct course. Instead, it is sub-divided by the load into several channels called ***distributaries***. At this stage, spits and bars arise and lagoons are formed. These lagoons begin to get filled with sediments and get swampy. This is the stage when the delta assumes its real appearance. Plants grow in the old part of the delta and swamps slowly disappear thus leaving this part of the delta dry.

Conditions necessary for delta formation

- Low speed or velocity of water in the river.
- Gentle or flat gradient, or angle of slope.
- No obstacles along the river channel to prevent filtering of the materials.
- Large load (sediments) in the river to slow down velocity of water in the river.
- Faster deposition of the load than the rate it is removed by the action of the tides or ocean currents.

Types of deltas

There are various types of deltas. The main ones are arcuate delta, birdsfoot or digitate delta, estuarine delta and cuspate delta.

(a) Arcuate delta

The term 'arcuate' is a Latin word meaning 'curved'.

Characteristics of an arcuate delta

(i) It has a large number of tributaries.
(ii) It is composed of coarse sediments such as gravel and sand.
(iii) It is triangular in shape, resembling an inverted pyramid.

How does it form?

It is formed when the density of water in the river and sea are similar. As a result, sediment deposition takes place in the area. It is also known as a fan-shaped delta.

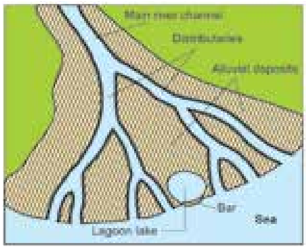


Fig. 2.3.3: Arcuate delta

(b) Birdsfoot or digitate delta

Characteristics of birdsfoot or digitate delta

(i) It is composed of very fine sediments called silt.

(ii) The river is sub-divided into few distributaries.

How does it form?

It is formed when the less dense river water carrying large volumes of fine materials like silt, flows into denser sea water.

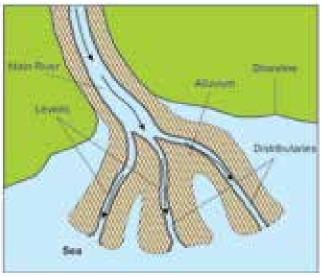


Fig. 2.3.4: Birdsfoot or digitate deltas

(c) Estuarine delta

Characteristics of estuarine delta

(i) It resembles a funnel shaped layer of deposits at the mouth of the river.

(ii) Deposits form an island.

How does it form?

It is formed at the mouth of a submerged river when the river deposits its load on the coast. Strong waves and currents sweep much of the sediments along the shoreline.

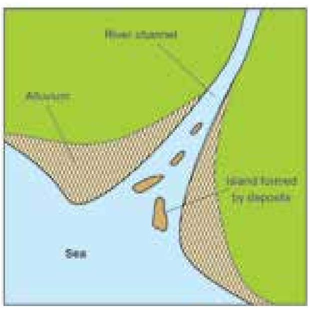


Fig 2.3.5: Estuarine delta

(d) Cuspate delta

Characteristics of cuspate delta

- It is shaped like a tooth.

6. FLOOD PLAINS

Flood plains develop in the lower course of a river when the river carries large quantities of sediments. During annual floods, these materials are spread over the low-lying adjacent areas. There is deposition of large sediments during each flood. This eventually builds a flat area called a ***flood plain***.

7. LEVEES

These are ridge-like features or raised banks produced by the river which overflows its channels. The river allows deposition to take place in the banks of the channel. There is an accumulation of deposits and material on the sides when the river flows normally.

Activity 2.3.2:

Below is a figure showing riverine features. Use it or any other topographical maps available at your school having riverine features, to do the following activity:

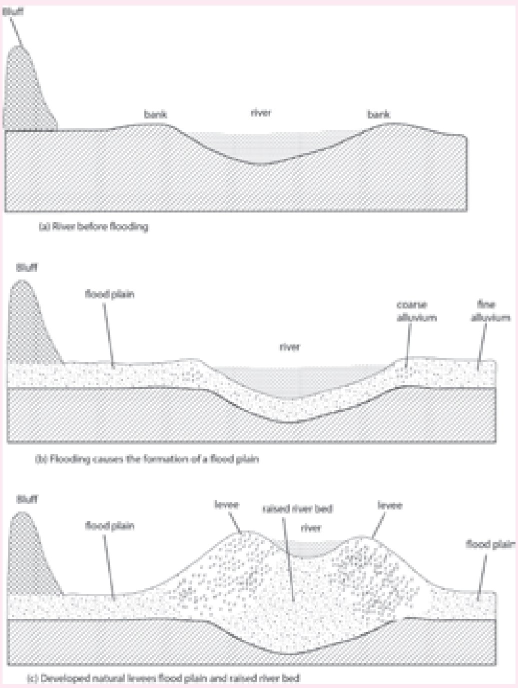


Fig. 2.3.6: Riverine features

In pairs, identify any of the riverine features, and then describe how each of them is formed.

IMPORTANCE OF RIVERINE LANDFORMS

Activity 2.3.3:

Brainstorm the importance of riverine landforms.

(a) Waterfalls and rapids help in the production of hydro-electric power.
(b) Flood plains are fertile areas for agricultural activities.
(c) Fishing activities are carried out in ox-bow lakes.
(d) Riverine landforms are good habitats for marine animals like fish.
(e) Deltas provide a good environment for irrigation agriculture.

COASTAL LANDFORMS

Coastal features can be formed through deposition or erosion.

(a) COASTAL FEATURES FORMED THROUGH DEPOSITION

1. BEACHES

Formation of beaches

Beaches are formed when sand and gravel, which have been loosened from land, are taken and moved by waves. They are eventually deposited along the shores as beaches.

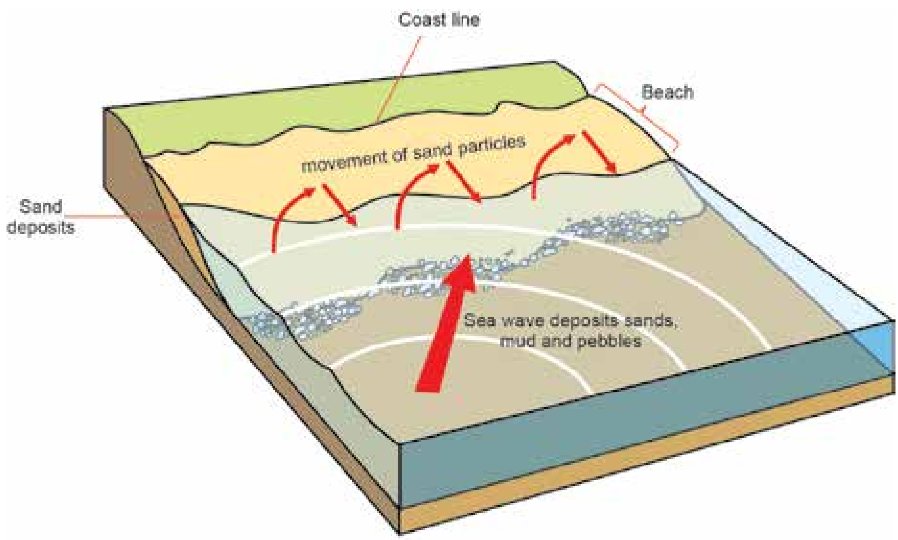


Fig. 2.3.7: A beach

Characteristics of beaches

Beaches are characterised by the following:

- A remarkable diversity of sediment size, from boulders to fine silt.
- Larger particles and steeper slopes are found where wave action is high.
- Fine particles and gentle slopes are characteristic of beaches exposed to low wave action.

2. SPITS

Formation of spits

Spits form as a result of deposition of sand and shingles. Sediments in form of sand are carried parallel to the shore by long shore drift (wind and waves) where it may extend across a bay or between two headlands. This especially happens where water is relatively calm. Eventually, sand particles are deposited on the bend of a coastline or at the mouth of an estuary to form the coastal feature called *spit*.

Fig. 2.3.8: A spit

Characteristics of spits

- Spits are typically elongated, narrow features.
- They are extended several dozen feet by wind and waves.

Examples of spits

Examples of spits on our coastline include ***Shell Ness spit*** on the Isle of Grain, Pagham, ***Castle Coote*** at Seasalter and Shoreham.

3. TOMBOLO

Formation of a tombolo

Tombolos are formed where a spit continues to grow outwards, joining land on the offshore. It continues to grow until it reaches an island, forming a link with the main land, just like a bridge.

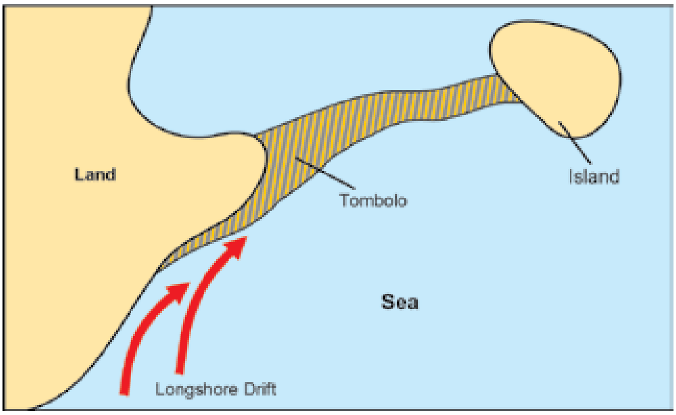


Fig. 2.3.9: A tombolo

Examples of tombolos

Examples of tombolos include Holy Island, Northumberland, St. Michael's Mount, Cornwall, and the Isle of Portland.

4. BARS

Formation of bars

A bar forms when a ridge of shingle is formed across the mouth of a river or entrance to a bay as seen in Fig. 2.3.10 below.

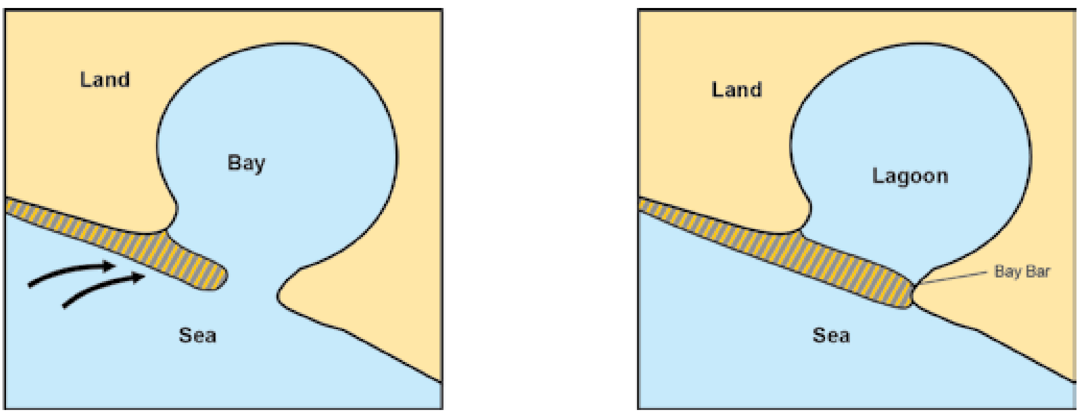


Fig. 2.3.10: A bar

5. MARINE DUNES

Formation of sand dunes

Sand accumulation in the backshore creates sand dunes when it is formed from wind-blown sediments. With the force of onshore winds, a large amount of coastal sand is driven landwards, forming extensive marine dunes that stretch into dune belts.

Characteristics of sand dunes

- Dunes usually run parallel with the coastline. They protect the hinterland from coastal erosion and flooding.
- Dune systems such as marram grass are relatively unstable, unless vegetated, as the roots hold the dunes in place.

(b) COASTAL FEATURES FORMED THROUGH EROSION

1. CAPES

Formation of capes

Capes are formed when waves act on rocks of varying resistance, where erosion of the coastline takes place irregularly. The softer rocks are worn out while harder ones persist as capes.

2. BAYS

Formation of bays

Bays are formed in two ways namely:

(a) By continental drift

Bays were formed as the super continent Pangea broke up along curved and indented fault lines. Examples include Bay of Bengal, Gulf of Mexico, Gulf of Alaska, Persian Gulf and Gulf of Guinea.

(b) By glacial and river erosion

Sheltered inlets formed due to the preferential erosion of soft rock. Bays are formed over hundreds or thousands of years due to the erosion of soft rocks such as clay or sandstone. Soft rocks erode much faster than hard rock such as chalk or limestone, creating headlands. Bays formed by glaciers are called ***afjords*** while ***rias*** are created by rivers.

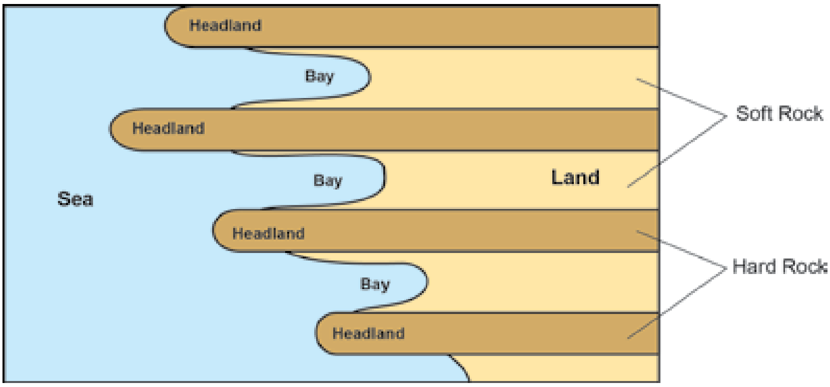


Fig. 2.3.11: Formation of bays

3. CLIFFS

Formation of cliffs

Cliffs are formed as a result of erosion and weathering processes. Weathering happens when natural events like wind or rain, break up pieces of rock. In coastal areas, strong winds and powerful waves break off soft or grainy rocks from harder rocks.

The process of cliff erosion

1. Weathering weakens the top of the cliff.
2. Sea waves continuously hit the base of the cliff forming a wave-cut notch.
3. The notch increases in size causing the cliff to collapse.
4. Backwards waves carry the rubble towards the sea forming a wave-cut platform.
5. The process is repeated and the cliff continues to retreat.

4. CAVE, ARCH, STACK, STUMP AND GLOUPS

(a) ***Sea caves*** form along lines of weakness in cohesive but well-jointed bedrock. Sea caves are prominent headlands where wave refraction attacks the shore. Prolonged wave attack on the base of a cliff excavates holes in regions of local weakness.

(b) ***A sea arch*** forms when sea caves merge from opposite sides of a headland.

(c) ***Sea stack:*** If the top of the arch collapses, a pillar of rock remains behind as a *sea stack*.

(d) ***Sea stump:*** Continued erosion into a headland takes place undermining the foundations. The stack collapses, forming the stump. This is usually seen in hard rock landforms such as chalk.

(e) ***Gloup:*** A gloup is an opening in the roof of a sea cave. Incoming waves sometimes force air to rush upward or water to spout intermittently.

Activity 2.3.4:

The figure below shows coastal features. Use it or any topographical maps showing coastal features available at your school to do the following activity:

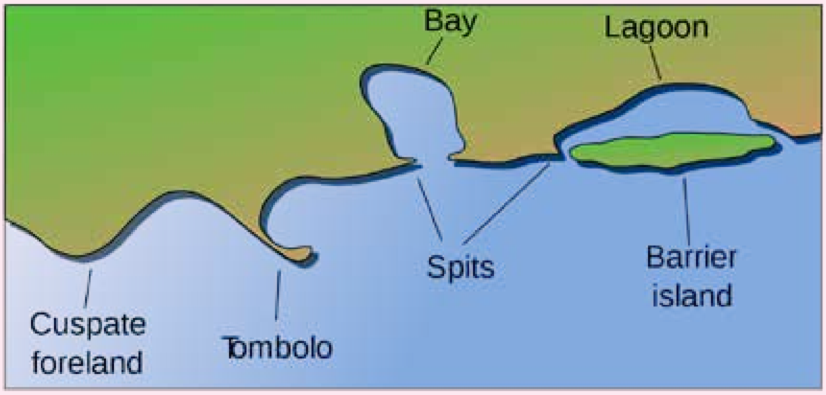


Fig. 2.3.12: Coastal features

In pairs, identify any of the coastal features, then describe how each of them is formed.

Importance of coastal landforms

(a) Coastal landforms are tourist attractions thus are a source of foreign exchange when visitors come to see them.

(b) They are good breeding areas for fish.

(c) Corals are raw material for the cement industry whose products are used in the construction industry.

(d) Coastal landforms such as lagoons, coastal marshes and coral reefs are good habitats for marine animals.

(e) Ports are developed when deep, well-sheltered harbours develop from submerged coastlines.

Activity 2.3.5:

In groups of five, discuss the importance of coastal landforms.

RELIEF FEATURES OF OCEAN BASINS

Nature of relief features of ocean basins

The ocean basins have several relief features. These features include the continental shelf, continental slope, ocean deeps, trenches, ocean bed or plain, oceanic islands and oceanic ridges. The cross-section below illustrates the sub-marine relief features.

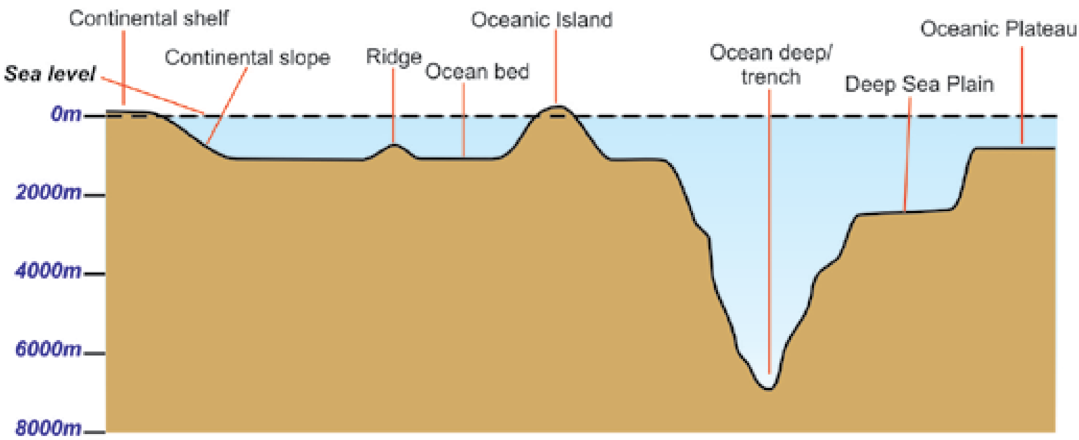


Fig. 2.3.13: Relief features of oceanic basins

Activity 2.3.6:

In groups of five, draw the ocean basin profile in your notebooks. Indicate on it the relief features of ocean basins.

(a) Continental shelf

A continental shelf forms when the edge of the continental slope gently downwarps under the surrounding oceanic waters. The seaward extension of the continental edge is marked approximately by 100 fathoms (180 metres) isobaths (these are contours making the depths below sea level).

Characteristics of continental shelves

- They are shallow (depth of between 120m to 370m).
- Width varies greatly (between a few kilometers to more than 100 kilometres).

Examples of continental shelves

(i) Eurasia in the northern hemisphere

- Along the coast of North West Europe.
- Along the coast of Siberia.

- The floor of Yellow Sea.
- The floor of Java Sea and southern part of South China Sea.

(ii) North America in the northern hemisphere

- Along the North East coast of North America.
- The floor of Hudson Bay.
- Along the Gulf Coast of North America.

(iii) Australasia in the southern hemisphere

- The floor of the Australian Bight.
- The floor of Gulf of Carpentaria.

(iv) South America

- Along the coast of Patagonia.

Significance of continental shelves

- They enable sunlight to penetrate due to their shallowness. This allows planktons to photosynthesise and multiply abundantly. They are therefore good fishing grounds.
- They have limited depth and gentle slope which keep out cold water currents and increase height of tides. This can sometimes hinder shipping and other marine activities.

Disadvantage of continental shelves

- They can hinder shipping and other marine activities since ships can only enter and leave a port on a tide.

(b) Continental slopes

A continental slope refers to the steep edge of the continental shelf showing an abrupt change in gradient to about 1 in 20. This is the continuously sloping portion of the continental margin, seaward of the continental shelf extending down to the deep sea floor. It separates the continental shelf from the continental rise.

(c) Deep sea plain or abyssal plain

This is a gentle and undulating plain lying 2 or 3 km below the sea level. It covers two thirds of the ocean floor and is generally called *abyssal plain*. It has a depth of 3,000 metres to 6,000 metres. The floor of the abyssal plain is covered by sediments. Although it was thought to be featureless, it has been revealed by modern sounding devices as having submarine plateaus, ridges, trenches, basins and oceanic islands.

(d) Oceanic deeps

These are long narrow trenches or troughs that plunge as great ocean deeps, a depth of 5,000 fathoms or 9,000 metres. They are the deepest parts of the sea. Sometimes, they are known as submarine trenches. They are found adjacent to the areas of volcanic and earthquake activity. Examples of such ocean deeps include the following:

Atlantic Ocean

- Romanche deep (8,060 metres approximately)
- Puerto Rico deep (9,625 metres approximately)
- South Sandwich Trench (9,090 metres approximately)

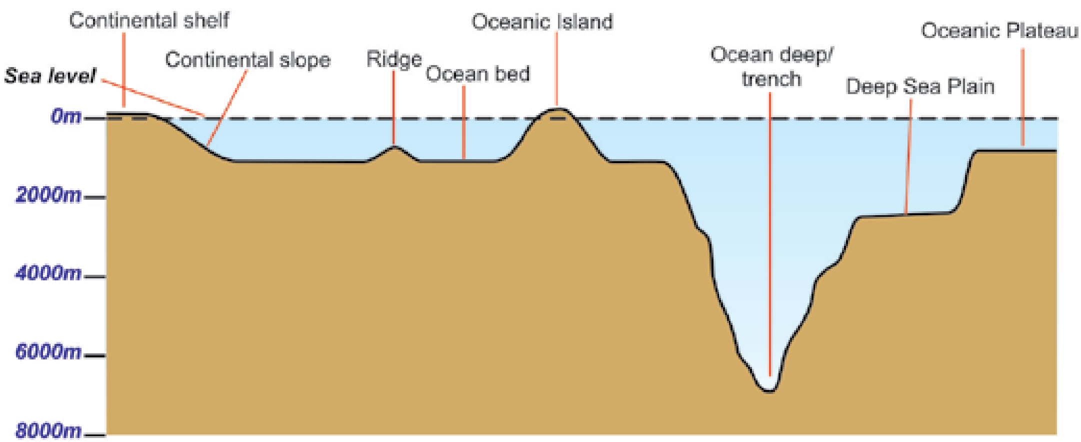


Fig. 2.3.14: Ocean deeps and trenches

(e) Trenches

Trenches are narrow troughs which are V-shaped. They form where oceanic plates meet continental plates. Refer to what we learnt earlier on geological features that form under compression force. Examples of trenches include the following:

Pacific Ocean

- Mariana trench (12,000 metres approximately)
- Tonga trench (10,300 metres approximately)
- Aleutian trench (8,380 metres approximately)
- Philippine trench (11,980 metres approximately)
- Japanese trench (9,300 metres approximately).

Indian Ocean

- Sunda Trench (8,140 metres approximately)

(f) Submarine or oceanic ridges

Oceanic ridges are giant mountain ranges that extend on the sea bed or ocean floor. They form under tension forces that break the lower crust, plate and mantle, allowing magma to come out. This magma spreads on the sea bed where it cools and solidifies to form the solid rock or mountain range known as the *oceanic ridge*.

Examples of oceanic ridges

- Mid Atlantic Ridge
- Hawaiian Ridge in Pacific Ocean
- South West and South East Indian Ridges

(g) Sea mounts

These are submerged volcanoes with sharp tops. They sometimes rise above the sea as *isolated islands*. Examples include Hawaii and Tahiti islands.

(h) Guyots or tablemounts

These are volcanoes which rise above the ocean floor whose tops have been flattened by erosion. They are covered with water. Flat top seamounts are called *guyots*.

(i) Continental rises

These are provinces of gentle slopes between the continental slope and abyssal plains. They are made of piles of sediments that have been delivered to the deep sea from the continental shelf.

(j) Submarine canyons

These are steep sided valleys cut into the sea floor of the continental slope. They sometimes extend into the continental slope. When the continental slope and shelf are cut in many places, they give rise to features called *canyons*. Canyons resemble river canyons on land, housing steep, rocky walls.

(k) Tolls

These are central and circular lagoons fringed by coral islands.

(l) Abyssal hills

These are small hills that rise from the floor of an abyssal plain. They are sea mounts that are less than 100 metres in length. They are sometimes called *sea-knolls*.

MATERIALS DEPOSITED ON THE OCEAN FLOOR

Erosion that takes place in the upper courses of rivers causes materials to be eventually deposited into larger water bodies like oceans. This results in accumulation of some deposits like muds, oozes and clays.

1. Muds

- These are derived from land and hence are referred to as terrigenous deposits.
- They are mainly deposited on continental shelves.
- Muds have different colours depending on their chemical content. For example, they can be blue, red or green in colour.

2. Oozes

- These are derived from the ocean and hence are referred to as pelagic deposits.
- They are made of shelly and skeletal remains of marine micro-organisms with calcareous or siliceous parts.
- They have very fine, flour-like texture.

3. Clays

- Clays occur as red clays in the deep parts of the ocean basins.
- They are abundant in the Pacific Ocean.
- Red clay comes from volcanic dust blown out from volcanoes during volcanic eruption.

Activity 2.3.7:

In pairs, put a ✓ in the box provided if the statement is true and an ✗ if the statement is false.

Table 42: Statements related to riverine, relief features of oceanic basins and coastal features

Statement	True	False
Guyots are submerged volcanoes with sharp tops which sometimes give rise above the sea as isolated islands.		
Tombolos are formed where a spit continues to grow outwards joining land on the offshore.		
A leeve is a narrow valley often formed in the upper course of the river due to the fast flow of water.		

Continental slopes are gentle and undulating areas lying 2 or 3 km below the sea level.		
Tolls are central and circular lagoons fringed by coral islands.		
Oozes are derived from the ocean and hence are referred to as pelagic deposits.		
Continental shelves form when the edge of the continental slope gently downwarps under the surrounding oceanic waters.		
Abyssal hills are sea mounts less than 100 metres in length.		
Muds are derived from land and hence are referred to as terrigenous deposits.		

OCEAN CURRENTS

Terminologies:

Activity 2.3.8:

Brainstorm on the meaning of the following terms; Ocean currents, drifts, convectional currents and streams.

Explanations

- **Ocean currents:** These are large bodies of water that circulate in regular patterns around oceans.
- **Drifts:** These are ocean currents caused by prevailing winds.
- **Convectional currents:** These are ocean currents caused by temperature.
- **Streams:** These are bodies of running water that are confined in channels and move downhill under the influence of gravity. Streams are smaller than rivers.

Major types of ocean currents

There are two types of ocean currents:

1. Warm ocean currents
2. Cold ocean currents

1. Warm ocean currents

Definition of warm ocean currents

These are ocean currents that flow from the equatorial region or belt polewards. They have a higher surface temperature.

Examples of warm ocean currents

(a) Brazilian Current
(b) North Pacific Drift Current
(c) Mozambique or Agulhas Current
(d) Cayenne Current
(e) Florida Current
(f) South Indian Ocean Current
(g) North equatorial Current
(h) Kuroshiwo (Japan) Current
(i) South Pacific Current
(j) East Australia Current
(k) South Atlantic Current
(l) Equatorial Counter Current
(m) South Equatorial Current

2. Cold ocean currents

Definition of cold ocean currents

These are ocean currents that flow from the polar regions equatorwards. They have a lower surface temperature.

Examples of cold ocean currents

(a) Benguela Current
(b) Canaries Current
(c) California Current
(d) Peruvian or Humboldt Current
(e) Labrador Current
(f) Irmiger/Eastern Greenland Current
(g) Falkland Current
(h) West wind drift Current
(i) West Australia Current
(j) Oyashio-bering Current
(k) Okhaotsk Current
(l) Kamchatka Current

Activity 2.3.9:

Below is a Geography word scramble. Test your knowledge by using it to do the activity below.

On your left, are letters representing examples of ocean currents in both the northern and southern hemisphere. On your right, are blank spaces for their answers.

Individually, write the correct names of the ocean currents and their types on the proper columns provided on the right.

Table 43: Examples of ocean currents and their types

Questions	Answers	Type of ocean current
Ricasena		
Daflori		
Thorn Ficicap		
Mbodhult		
Osworukhih		

Tchakamak		
Dorrabal		
Labenuge		
Gimerri		
Rabinazil		
Yenneca		
Quzamebimo		

Location of the major ocean currents of the world on the world map

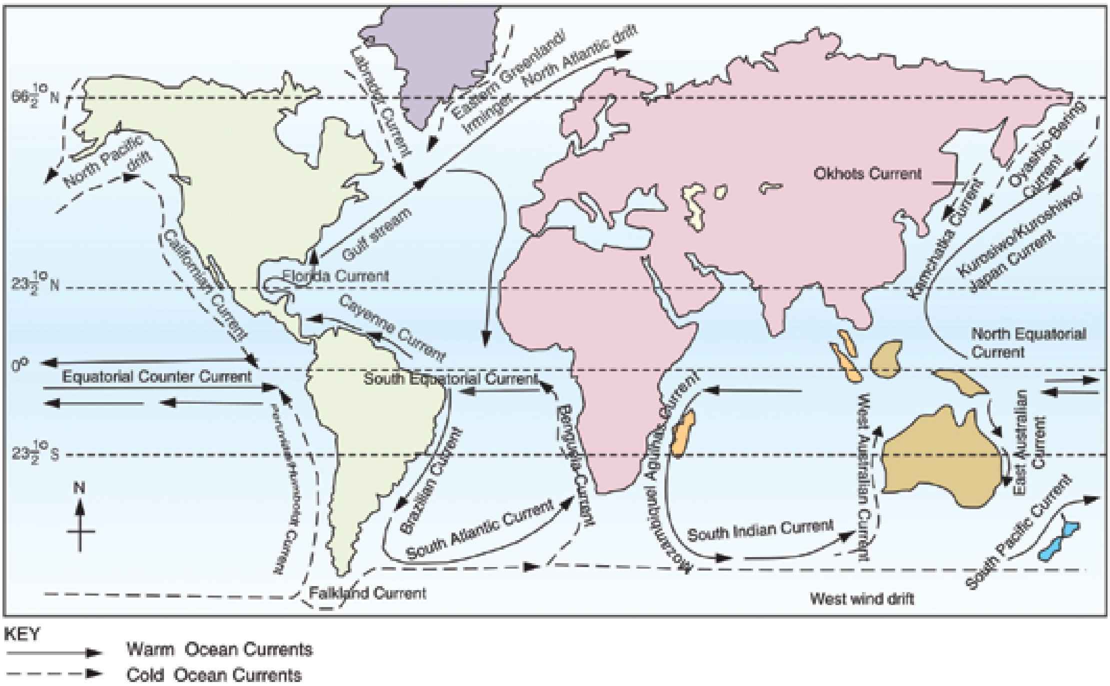


Fig 2.3.15: Major ocean currents on the world map.

Activity 2.3.10:

In groups of five, draw the world map in your notebooks. Indicate the following warm and cold ocean currents on it:

- Brazilian Current
- North Pacific Drift Current
- Mozambique or Agulhas Current
- Kuroshiwo (Japan Current)
- Benguela Current
- Canaries Current
- California Current
- Peruvian or Humboldt Current
- Labrador Current
- Kamchatka Current

CAUSES OF OCEAN CURRENTS

Activity 2.3.11:

Brainstorm on the causes of ocean currents.

There are four causes of ocean currents. These include:

1. Temperature
2. Rotation of the earth
3. Planetary winds
4. Salinity

1. Temperature

There is a large difference in the temperature of ocean waters at the equator and at the poles. Warm water being light rises, while cold water, being denser sinks. Warm water from the equatorial region moves slowly along the surface polewards while the heavier cold waters of the polar regions creep slowly at the bottom of the sea or ocean equatorwards. This type of movement creates friction that causes a wave of water to develop on the surface of the water. This wave creates a current that moves in one direction as seen in Fig. 2.3.16 below.

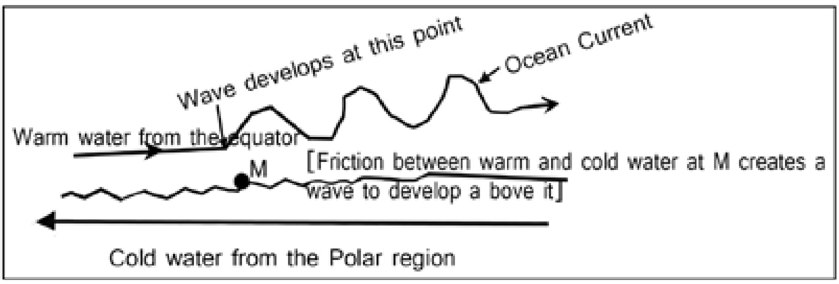


Fig. 2.3.16: How temperature causes an ocean current

2. Rotation of the earth

When the earth is rotating on its own axis at an angle of 23½°, it creates a force known as ***coriolis force*** (centrifugal force). This force pushes surface water in one direction and creates a water wave that begins to move towards a particular direction, thereby creating an ocean current. See Fig. 2.3.17 below.

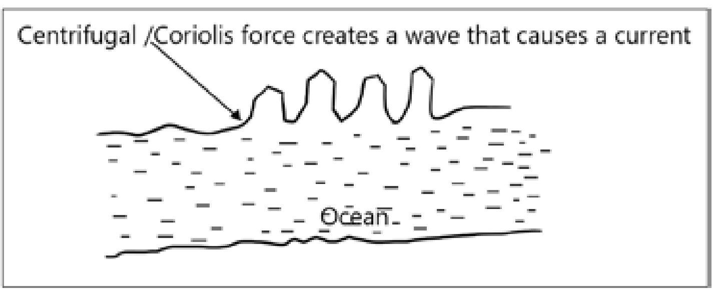


Fig. 2.3.17: How rotation of the earth causes an ocean current

3. Planetary or prevailing winds

When planetary or prevailing winds blow over the surface water of an ocean, they push surface water in one direction. This creates a regular pattern of movement of large masses of water around oceans.

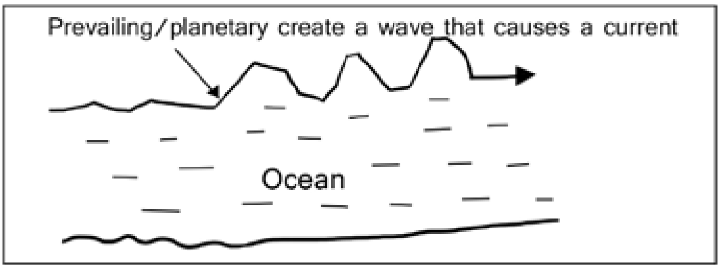


Fig. 2.3.18: How planetary or prevailing winds cause an ocean current

4. Salinity

Meaning of the term 'salinity'

It is the degree of saltiness of the water. Salinity is caused by dissolved salts like sodium chloride, calcium, magnesium and potassium, salt deposits by rivers, salts dissolved from the ocean bedrock and volcanic activities on the sea floor.

How salinity causes ocean currents

Water with high salinity (high concentration of salts) is denser compared to water with low salinity. Therefore, water with high salinity will sink while water with low salinity will rise because it is lighter. This type of movement creates friction which eventually creates a water wave. These water waves move in one direction, thereby creating an ocean current.

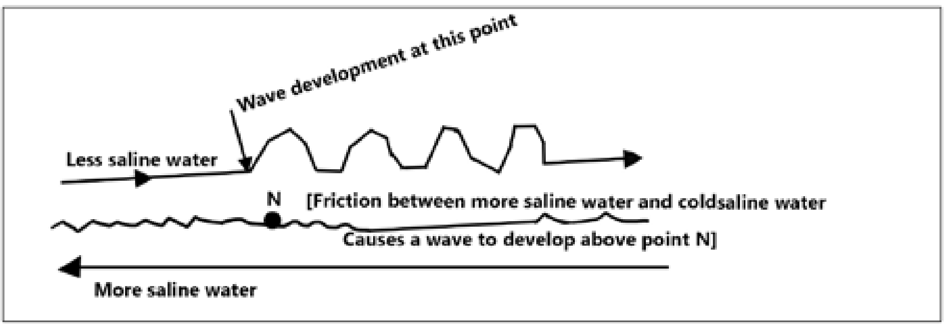


Fig. 2.3.19: How salinity causes an ocean current

Activity 2.3.12:

Individually, write an essay describing four factors that cause ocean currents.

FACTORS THAT INFLUENCE THE DIRECTION OF OCEAN CURRENTS

There are several factors that determine the direction of ocean currents. The main ones include:

(a) Shape of continents or landmass
(b) Rotation of the earth
(c) Planetary or prevailing winds
(d) Temperature

(a) Shape of continents or landmass

A landmass always obstructs and diverts a current. For example, the South West African landmass diverts the Benguela cold ocean current northwards as seen in Fig. 2.3.20 below.

Fig. 2.3.20: How landmass diverts an ocean current

(b) Rotation of the earth

Meaning of the term '*Ferrel's Law of Deflection*'

This is a law that states that all freely moving objects such as ocean currents and prevailing winds change direction because of *coriolis* or *centrifugal force* created by the rotating earth. The change in direction is referred to as *deflection*. When deflection takes place in the northern hemisphere, ocean currents and prevailing winds are deflected to the right in a clockwise direction. On the contrary, ocean currents and prevailing or planetary winds are deflected to the left in an anticlockwise direction in the southern hemisphere.

How rotation of the earth influences the direction of ocean currents

When the earth rotates, it creates a force called ***coriolis*** or ***centrifugal force***.This force deflects ocean currents to the right in a clockwise direction in the northern hemisphere and to the left in an anticlockwise direction in the southern hemisphere.

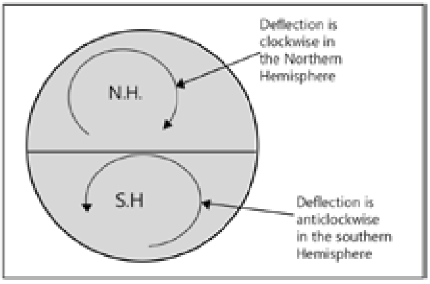


Fig. 2.3.21: How rotation of the earth influences direction of an ocean current

(c) Planetary or prevailing winds

The direction taken by the prevailing or planetary winds on the globe will be the same as the direction to be taken by an ocean current in one a particular area. Ocean currents will thus follow the direction of the three types of prevailing winds namely trade winds, westerlies and easterlies as seen in Fig. 2.3.22 below.

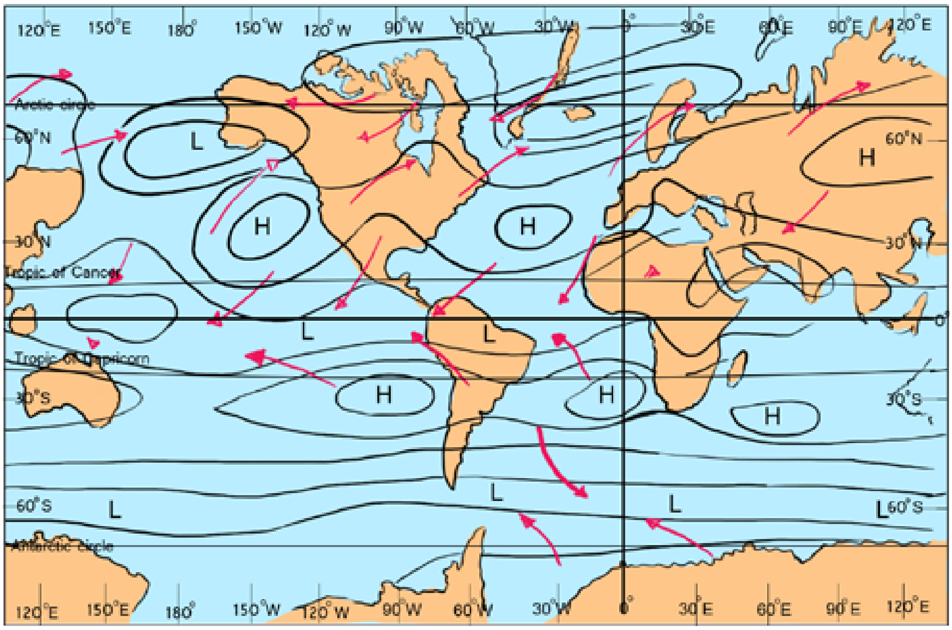


Fig. 2.3.22: How prevailing or planetary winds influence direction of an ocean current

(d) Temperature

Water that has high temperature is lighter and therefore it will move from the equatorial belt towards the poles. Water that has low temperature is denser and therefore it will flow from the polar regions to the equatorial belt creeping slowly at the bottom of the ocean or sea. All warm ocean currents will therefore flow from the equatorial belt polewards while all cold ocean currents will flow from the polar regions equatorwards.

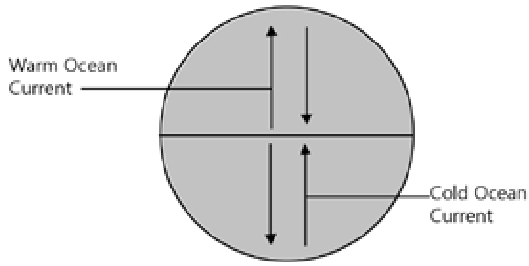


Fig. 2.3.23: How temperature influences the direction of ocean currents

Activity 2.3.13:

In pairs, using good diagrams, illustrate how the direction of ocean currents is influenced by temperature, rotation of the earth, shape of the continents and prevailing or planetary winds.

EFFECTS OF OCEAN CURRENTS

Activity 2.3.14:

Brainstorm on the effects of ocean currents on climate, shipping and fishing.

Ocean currents have various effects on climate, fishing and shipping.

(a) On climate

(i) As warm ocean currents move polewards, they distribute heat from the tropics to the poles, thus influencing the climate. For example, the North Pacific Drift warm ocean current warms the west coast of Alaska and British Columbia, melting the winter ice. Hence, Vancouver port is ice-free during winter and the winter season generally becomes very mild. In addition, winds blowing over a warm current onto a cooler land surface usually bring heavy rain.

(ii) On the contrary, cold ocean currents from the polar regions distribute cool temperatures to the tropics thus influencing the climate. For example, Benguela cold ocean current lowers temperatures off the coast of Namibia (Kalahari) where fogs are common. In addition, winds blowing over a cold current onto a warmer land surface usually bring little or no rain.

(iii) When cold and warm ocean currents meet, they produce mist and fog. For example, near New Foundland, the Gulf Stream warm ocean current meets Labrador cold ocean current and produces fog. Sometimes, they also create storms.

(b) On fishing

(i) The meeting of cold and warm ocean currents creates major fishing grounds. Examples include the North Western Pacific or North East Asia fishing ground (where Kamchatka cold ocean current and Kurosiwo or Kuroshiwo warm ocean current meet) and the North Western Atlantic or Eastern Canada (where Labrador cold ocean current meets the Gulf Stream warm ocean current).

(ii) When cold and warm ocean currents meet, there is precipitation of minerals. This precipitation facilitates the growth of microscopic plants called planktons which are food for fish. As a result, fish increase abundantly.

(iii) The major fishing grounds are found in continental shelves where water is shallow and enables sunlight to penetrate. Hence, planktons are able to photosynthesise and multiply abundantly.

(c) On shipping

Positive effect

(i) There is ease in movement of ships sailing in the same direction as the ocean currents. Less fuel is spent, thereby reducing expenses and transit time.

Negative effects

(i) The meeting of cold and warm ocean currents creates fog. Fog causes visibility problems for ships.

(ii) Ocean currents increase the height of tides and can make ship loading and offloading difficult.

(iii) Ships moving in the opposite direction to that of the ocean current are likely to capsize.

What is the impact of each of the following ocean currents?

(a) Brazilian Warm Ocean Current

This current encourages fishing along the coast of Uruguay and Argentina.

(b) North Pacific Warm Ocean Current

This current warms the west coast of Alaska and British Columbia, thereby melting the winter ice hence Vancouver Port is ice free in winter and the winter is very mild.

(c) Benguela Cold Ocean Current

It lowers temperatures off the coast of Namibia (Kalahari) where fogs are common. Fogs are formed when onshore winds blow over the current.

(d) Mozambique or Agulhas Warm Ocean Current

It modifies the climate of Eastern Coast of Africa by raising temperatures. Generally, temperatures are higher than on the western coast where the cold Benguela current flows.

(e) The meeting of Gulf Stream Warm Ocean Current and Labrador Cold Ocean Current

It encourages precipitation of minerals for the growth of planktons and creating fishing grounds around North West Atlantic or Eastern Canada. It also produces dense fogs off New Foundland.

Effects of warm and cold ocean currents towards the coast they flow to

1. Warm ocean currents

- They bring higher temperatures to areas they flow to. As a result, they raise temperatures of coastal areas.
- They bring rain to the coast when evaporation and condensation of the water vapour has taken place. Winds passing over warm ocean currents absorb a lot of moisture which can condense and form a cloud.
- They provide warmth for growth of planktons.

2. Cold ocean currents

- They generally decrease coastal temperatures and lower evaporation rates.
- They bring little or no rainfall to the coast. This is due to the fact that winds blowing over cold ocean currents are cool and dry, thus carry no moisture. Remember that it is the moisture that brings about rainfall.
- They cause deserts after producing a *desiccating effect* in the affected areas. As a result, there is little moisture for vegetation to grow which leads to the formation of a desert.

Review Questions

Q1. (a) Define the following terms:

(i) Hydrosphere

(ii) Ocean currents

(iii) Drifts

(iv) Streams

(v) Convectional currents

(b) Differentiate between warm ocean currents and cold ocean currents.

Q2. Explain any four factors that can cause ocean currents.

Q3. Explain any four factors that influence the direction of ocean currents.

Q4. Why are some ocean currents cold and others warm?

Below is a world map showing ocean currents. Use it to answer the questions that follow:

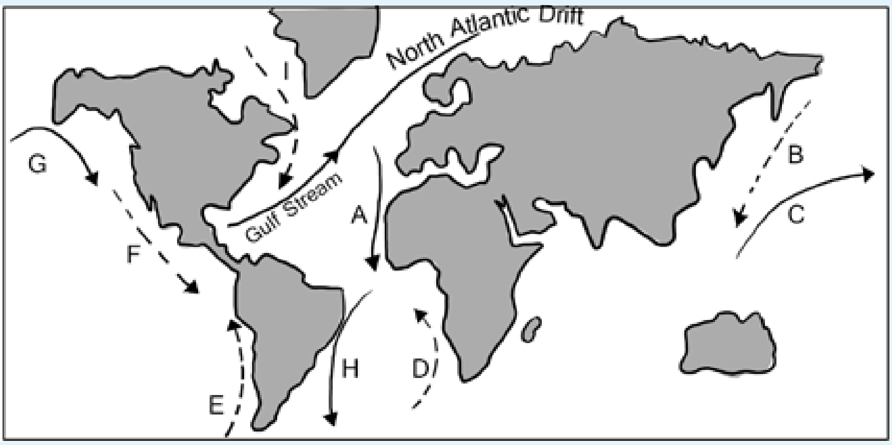


Fig. 2.3.24: Ocean currents on the world map

Q5. (a) Identify the ocean currents labelled A, B, C, D, E, F, G and H.

(b) Describe the effects of the following:

(i) Meeting of ocean currents B and C.

(ii) Ocean current H to the adjacent landmass.

(iii) Ocean current G to North America.

(iv) Ocean current D to the nearby African landmass.

(c) Explain the effects of ocean currents on the following:

(i) Climate

(ii) Fishing

(iii) Shipping

Q6. With the aid of good diagrams, explain how the following riverine features form:

- Ox-bow lakes, deltas, confluences, gorges, catchment areas or basins, levées, watersheds or water partings or divides, meanders and flood plains.

Q7. With the aid of good diagrams, explain how the following coastal features form:

- Beaches, spits, tombolos, bars, marine dunes, capes, bays and cliffs.

Q8. (a) Describe the importance of relief features of the ocean floor.

(b) Distinguish between the following terms:

(i) Continental shelf and continental rise.

(ii) Submarine trench and submarine ridge.

TOPIC 4

The Atmosphere

Success criteria:

By the end of this topic, the student should be able to:

- Explain the term 'air pressure'.
- Explain the factors that influence air pressure.
- Locate the main air pressure belts on the world map.
- Account for the distribution of pressure belts in the world.
- Explain the term 'prevailing winds'.
- Explain the different types of prevailing winds.
- Explain how prevailing winds are influenced by air pressure belts.
- Explain how Ferrel's law of deflection (Coriolis force) affects prevailing winds.
- Interpret isobars on an air pressure map.
- Explain the term 'air mass'.
- Explain the main types of air masses.
- Explain the type of weather associated with air masses.
- Explain the term 'front'.
- Explain the formation of fronts.
- Identify characteristics of different types of fronts.
- Describe the type of weather associated with each type of front.
- Explain the Inter-Tropical Convergence Zone (ITCZ) and its impact on weather.
- Explain the meaning of the term 'local winds'.
- Explain the characteristics of local winds.
- Explain the occurrence of local winds.
- Explain the occurrence of land and sea breeze.
- Explain the influence of land and sea breezes on local weather and human activities.
- Explain the development of cyclones and anti-cyclones.
- Explain the weather that is associated with tropical and temperate cyclones.
- Explain how clouds are formed.
- Identify the main types of clouds.
- Explain the forms of precipitation.
- Explain how precipitation is formed.
- Explain the different types of rainfall.
- Identify areas in the world receiving different types of rainfall.
- Interpret rainfall data from various sources.

Background

In Form One, you learnt about elements of weather such as air pressure, wind, temperature and rainfall. You also learnt about factors that affect these elements and how they can be measured. In Form Three, you will look at these elements in depth. You will learn about their meaning, types of occurrence and the areas that experiences them on the world map. You will also learn about fronts, that is, their meaning, formation and characteristics and the weather that is associated with them. You will also tackle occurrence of land and sea breezes as well as cyclones and anticyclones; in addition, you will look at their influence on weather.

WORLD PRESSURE BELTS

Meaning of the term 'air pressure'

Activity 2.4.1:

Brainstorm on the meaning of the term 'air pressure'.

Explanation:

Air pressure is simply the outward force that a parcel of air exerts in order to support another parcel of air around it. It is basically the weight exerted by overhead atmosphere or air on a unit area of surface.

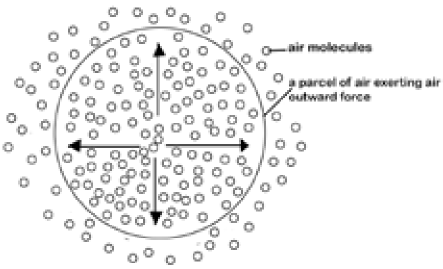


Fig. 2.4.1: A parcel of air exerting outward force

Air molecules have weight. They therefore exert pressure called *atmospheric pressure*. This air pressure is not the same for all regions. Air pressure is also always the same for any one region all the time. In some regions, the pressure is higher for one part of the year than it is for another part of the year.

Activity 2.4.2:

Below is a figure showing rising and descending air. Use it to answer the questions that follow.

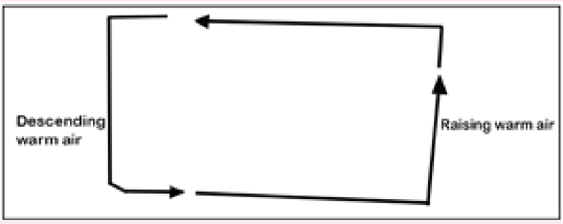


Fig. 2.4.2: Rising and descending air

In groups of five, discuss why air is rising and descending in the above diagram.

FACTORS THAT INFLUENCE AIR PRESSURE

There are several factors that influence air pressure. The main factors include the following:
(a) Altitude (b) Temperature (c) Rotation of the earth (d) Humidity

(a) ALTITUDE

Altitude refers to the height above sea level. Air pressure is bound to be different at different heights. In the figure below, air pressure at Q is higher than it is at the top of the mountain, P. Why is it so?

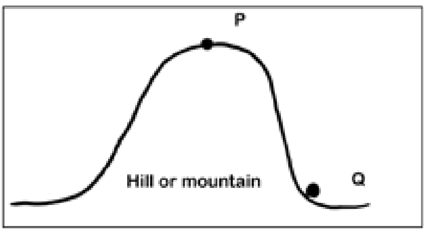


Fig. 2.4.3: Effects of altitude on air pressure

Explanation:

When air rises, its molecules move further apart. As a result, outward pressure decreases. The air molecules are spread over a large area thereby increasing their volume. This results into decreased weight, which leads to a decrease in air pressure. It should be known that the number of molecules remains the same. On the other hand, when air descends, its molecules get closer together and more concentrated. Its weight is likely to increase. This in turn will increase the outward force or pressure. The volume of air also decreases but the number of molecules remains the same. The outward pressure of the molecules is spread over a smaller area.

At sea level, air has to support a greater weight of air than at the top of the mountain. The molecules of air at sea level push outwards with a force equal to that exerted by the air above it. On the contrary, air molecules at the top of the mountain push outwards with much less force because the weight of the air above it is less. This explains why air pressure increases when air descends.

Conclusion:

The higher the altitude, the lower the air pressure. Similarly, the lower the attitude the higher the air pressure.

Activity 2.4.3:

Below is a graph showing changes in air pressure with changes in altitude. In groups of five, use it to answer the questions that follow:

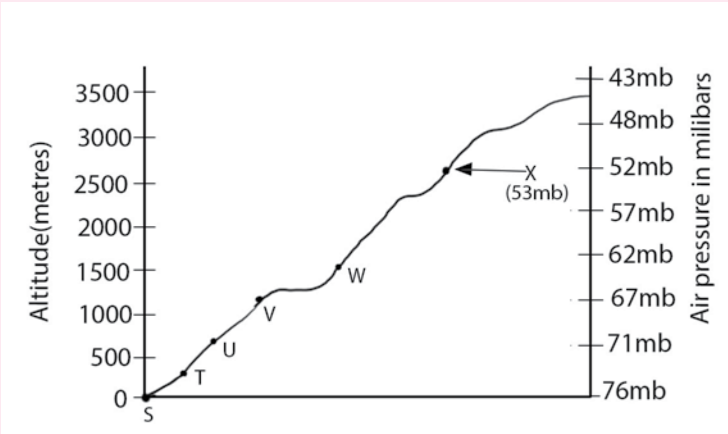


Fig. 2.4.4: Graph showing changes in air pressure with changes in altitude

(a) What is happening to air pressure from S to W?

(b) Why is it so?

(c) Find air pressure for points T and U.

(b) TEMPERATURE

Note: In order to explain temperature as a factor that affects air pressure, you should keep in mind that surface area and air pressure relate in the following way. The larger the surface area, the lower the air pressure, consequently the smaller the surface area, the higher the air pressure. Furthermore, it is important to keep one factor (number of air molecules) constant.

Explanation 1:

Any decrease in temperature makes air molecules to be cooled and eventually contract. When this happens, the outward pressure of its molecules is spread over a smaller area. Since air molecules are now concentrated at one point, they begin to push outwards with great force. Consequently, this increases the pressure of air.

Conclusion

The pressure of air increases when its temperature falls.

Explanation 2:

When temperature increases, molecules of air get heated and expand. They eventually begin to rise because they lose weight. They occupy a larger surface area and exert a less outward force. This eventually decreases the pressure of air.

Conclusion

Air pressure decreases when its temperature rises.

Activity 2.4.4:

In groups of five, use the figure below showing the pressure belts of the globe to answer the questions that follow.

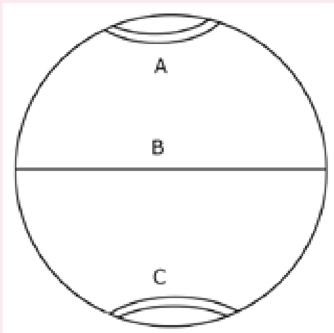


Fig. 2.4.5: Creation of air pressure belts

(a) Describe air pressure at regions A, B and C.
(b) Give reasons why it is so.

(c) ROTATION OF THE EARTH

Explanation

The rotation of the earth causes the air at the poles to be deflected or pushed towards the equator. In theory, this should result in air piling up along the equator to produce a belt of high pressure. Low pressure will be expected to develop at the poles. However, what actually happens is much more complex. Therefore, it is important to examine how both temperature and rotation affect the air pressure pattern.

Temperature

Low temperature at the poles causes the air to contract. This creates high pressure at the poles.

High temperatures along the equator cause the air at the equator to expand. This creates low pressure at the equator called the Doldrums Low Pressure.

Rotation

As a result of the earth's rotation, the air blowing away from the poles crosses the latitudes that keep getting longer. This causes the air to spread out to occupy a greater space towards the equator. As a result, the air expands and its pressure falls. These low pressure belts are noticeable along 60°N and 60°S. They are known as the Temperate Low Pressure Belts.

Activity 2.4.5:

Using the same groups, use the figure below to answer the questions that follow:

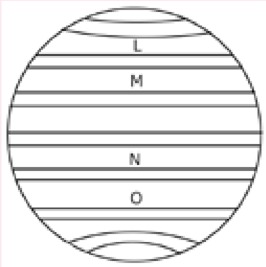


Fig. 2.4.6: How rotation of the earth affects air pressure

(a) Describe air pressure in the zones L, M, N and O.

(b) Give reasons for your description in (a) above.

(D) HUMIDITY

Humidity refers to the amount of water molecules or water vapour available in the atmosphere. The amount of water vapour or moisture in the air compared to the saturation point at a given temperature is referred to as relative humidity. Humidity can cause air pressure to increase or to decrease.

Explanation

When water vapour moves in the atmosphere, it collides with other air particles such as gases like oxygen and nitrogen. The faster the collisions, the higher the air pressure will be. In addition, these particles are pulled near the earth's surface, due to the earth's force of gravity. As a result we experience higher air pressure near the earth's surface, than in the atmosphere.

When water molecules become compact, air pressure increases. These molecules are kept closer to the earth's surface due to gravity. At the same time, increase in temperature helps in the evaporation process from the lakes, rivers, oceans and other water sources. Hence the moisture in the air increases.

When molecules rise up due to evaporation, they spread out and this creates lower air pressure. The rising air reaches a point known as saturation point, it starts to cool. As a result, the water molecules present in the air lose energy and form larger particles. With time, due to temperature drop, these water molecules fall back to the earth in form of rain, snow, mist, fog, dew or any other form of precipitation. Low air pressure therefore brings stormy weather, precipitation and cooler temperatures.

LOCATION OF THE MAIN PRESSURE BELTS ON THE WORLD MAP

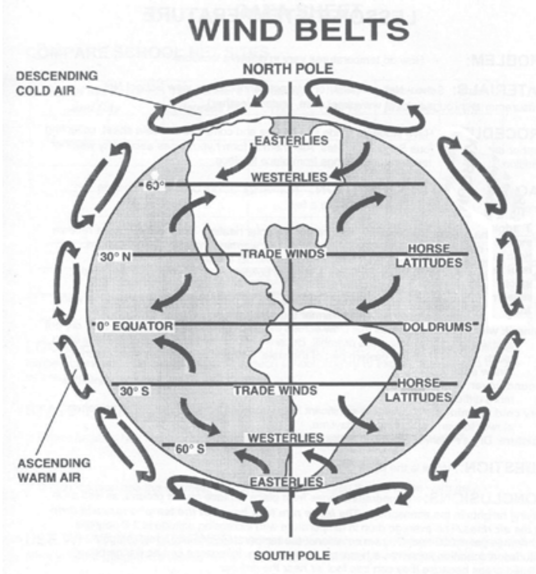


Fig. 2.4.7: Main pressure belts on the world map

DISTRIBUTION OF THE MAIN AIR PRESSURE BELTS

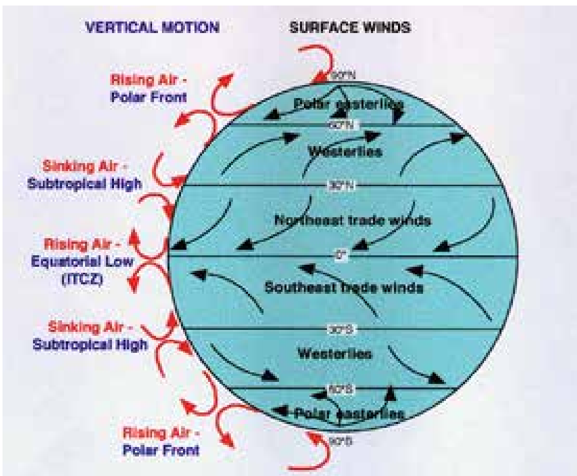


Fig. 2.4.8: World air pressure belts on the globe

Activity 2.4.6:

In groups of five, explain the causes of the following pressure belts on the globe:

(a) Doldrums Low Pressure belt
(b) Horse Latitude or Sub-Tropical High pressure belt
(c) Temperate Low Pressure belt
(d) Polar High Pressure belt

Interpretation of temperature and altitude data in relation to air pressure

(a) Altitude

Activity 2.4.7:

In pairs, use the information in the table below to answer the questions that follow:

Table 44 showing altitudes of areas V, W, X, Y and Z

Area	Altitude
V	1, 427 m
W	856 m
X	5, 039 m
Y	2, 745 m
Z	10, 338 m

Q1. At which point is air pressure:

(i) highest?

(ii) lowest?

Q2. Give reasons for your answer in Q1 (i) and (ii) above.

(b) Temperature

Activity 2.4.8:

Using the same pairs, below is a graph showing temperatures of towns A, B, C, D and E. Use it to answer the questions that follow:

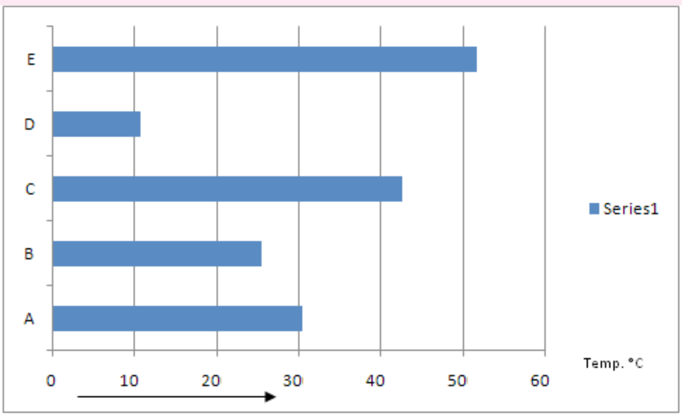


Fig. 2.4.9: Graph showing temperatures of towns A, B, C, D and E

(i) Where is air pressure high? Explain.

(ii) Where is air pressure low? Why?

PREVAILING WINDS

Meaning of the term 'prevailing winds'

These are winds that blow more frequently than any other type of wind on the globe.

Activity 2.4.9:

Below is a table showing winds blowing in one month within a certain area. In pairs, use it to answer the questions that follow.

Table 45 showing frequency of winds.

Direction of winds	NE	S	W	SE	NW	E	SW	N	Calm
Frequency	5	2	-	3	4	2	1	3	10

Q1. Identify the prevailing wind according to the information in the table above.

Q2. Give a reason for your answer.

DIFFERENCES BETWEEN PREVAILING AND LOCAL WINDS

Table 46 showing differences between prevailing and local winds.

	Prevailing winds	Local winds
Time frame	• They blow for a long time	• They blow for a short time
Area coverage	• They affect large areas	• They affect small areas

TYPES OF PREVAILING WINDS

There are three types of prevailing winds: polar winds, westerlies and trades.

1. POLAR WINDS

Characteristics of polar winds

- They blow from the Polar High Pressures to Temperate Low Pressures.
- They are better developed in the southern hemisphere than in the northern hemisphere.
- They are deflected to the right to become North East Polar Winds in the northern hemisphere and to the left to become the South East Polar winds in the southern hemisphere.
- They are irregular in the northern hemisphere.

2. WESTERLIES

Characteristics of westerlies

- They blow from Horse Latitudes to the Temperate Low Pressures.
- They are deflected to the right to become South Westerlies in the northern hemisphere and to the left to become the North Westerlies in the southern hemisphere.
- They vary in both direction and strength.

- They contain depressions (masses of air whose isobars form an oval or circular shape, where pressure is low in the centre and increases towards the outside).

3. TRADES

Characteristics of trades

- The word 'trade' originates from the Saxon word *tredan* which means to *tread* or follow a regular path.
- These winds blow from the Horse Latitudes to the Doldrums.
- They are deflected to the right to become the North East Trade Winds in the northern hemisphere and to the left to become the South East Trade Winds in the southern hemisphere.

LOCATION OF PREVAILING WINDS ON THE WORLD MAP

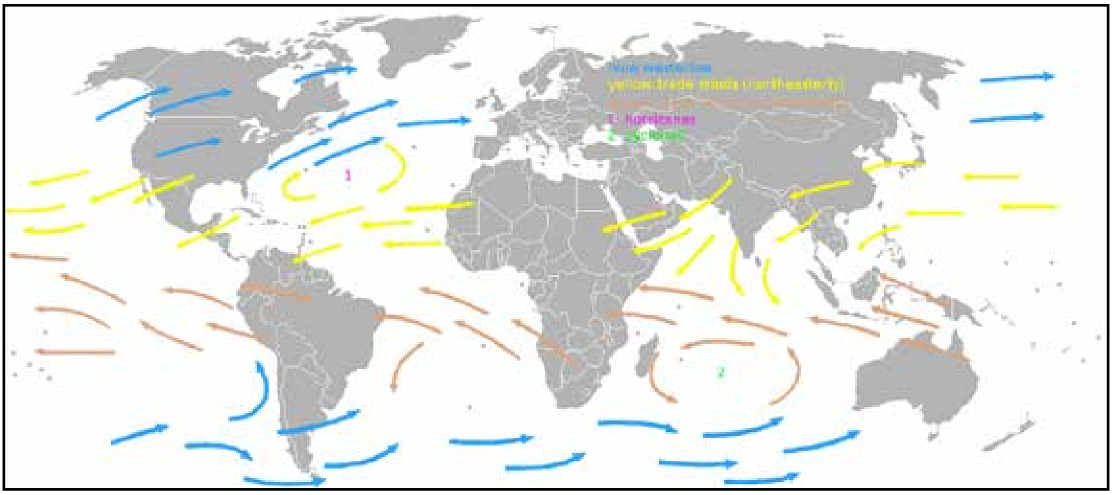


Fig. 2.4.10: Prevailing winds on the world map

How prevailing winds are influenced by air pressure belts

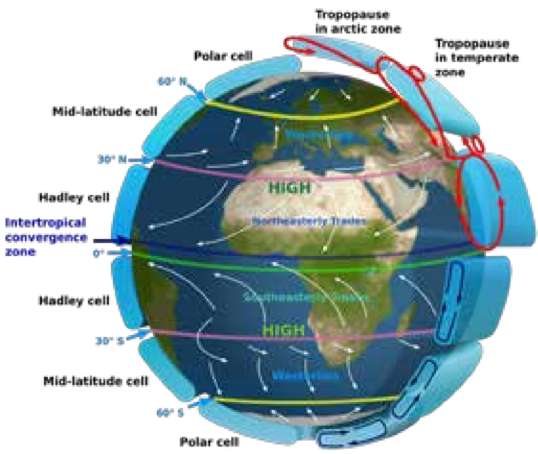


Fig. 2.4.11: Air pressure belts

Activity 2.4.10:

In pairs, draw the world map in your notebooks. Locate the prevailing winds on it.

How prevailing winds are influenced by pressure belts

The direction of these winds is influenced by pressure belts (high or low) because air always moves from an area of high pressure to an area of low pressure.

RELATION OF AIR PRESSURE TO CHARACTERISTICS OF PREVAILING WINDS

(a) Polar winds

- They blow from the Polar High Pressure belts to the Temperate Low Pressure belts.

(b) Westerlies

- They blow from the Horse Latitudes or Sub-Tropical High Pressure belts to Temperate Low Pressure belts.

(c) Trades

- They blow from the Horse Latitudes or Sub-Tropical High Pressure belts to the Doldrums Low Pressure belts

Meaning of the term 'Ferrel's Law of Deflection'

This law states that when the earth is rotating, it creates ***coriolis force*** or ***centrifugal force*** which deflects (changes direction of) all freely moving objects to the right in a clockwise direction in the northern hemisphere and to the left in an anticlockwise direction in the southern hemisphere.

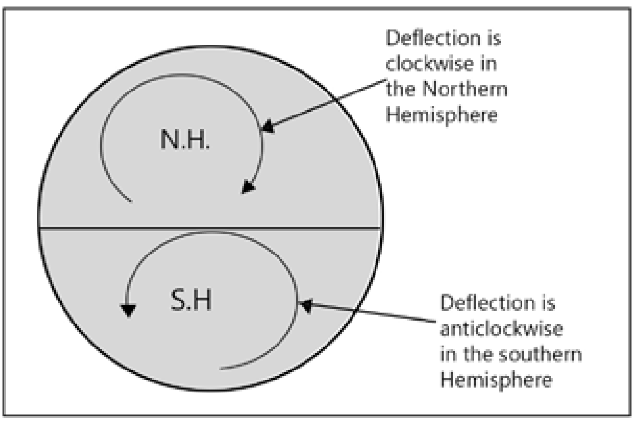


Fig. 2.4.12: Ferrel's law of deflection

HOW FERREL'S LAW OF DEFLECTION AFFECTS PREVAILING WINDS

It is important to note that all winds are affected by Ferrel's law of deflection.These winds are deflected to the right in a clockwise direction in the northern hemisphere and to the left in an anticlockwise direction in the southern hemisphere.

HOW PREVAILING WIND DIRECTION IS AFFECTED BY USING NON-ROTATING AND ROTATING GLOBES

(a) By rotating globes

On the rotating globe, prevailing or planetary winds are deflected to the right in a clockwise direction in the northern hemisphere and to the left in an anticlockwise direction in the southern hemisphere. Refer to the figure below.

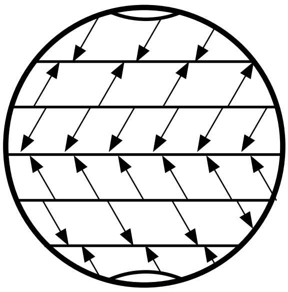


Fig. 2.4.13: Prevailing wind direction on a rotating globe

(b) By non-rotating globe

If the earth was not rotating, it is obvious that there would be no deflection of winds. Thus, Ferrel's law of deflection would not apply in this case. Therefore, winds would blow in a straight fashion as demonstrated in the figure below.

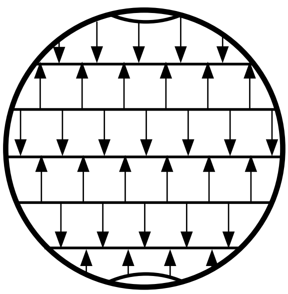


Fig. 2.4.14: Prevailing wind direction on a non-rotating globe

Activity 2.4.11:

Individually, draw the globe and indicate prevailing winds if the globe was:

(a) rotating (b) non rotating

Give an explanation in each case.

INTERPRETATION OF ISOBARS ON AN AIR PRESSURE MAP

Isobars are lines that are drawn on an air pressure map connecting places of the same air or atmosphere or barometric pressure. Air pressure is measured by a barometer and expressed in millibars (mb). Wind speed and direction is influenced by pressure gradient.

ISOBARS AND PRESSURE GRADIENT

What is pressure gradient?

This is the rate at which the atmospheric pressure changes horizontally in a certain direction on the earth's surface.

Interpretation of pressure gradient using isobars on an air pressure map

When the isobars are close together, it means that there is a fast change of pressure from point to point. This is shown at right angles. The gradient is steep and air is quickly drained (the movement of air or wind is great). On the contrary, when the isobars are far apart, the gradient is slight and wind speed is slow.

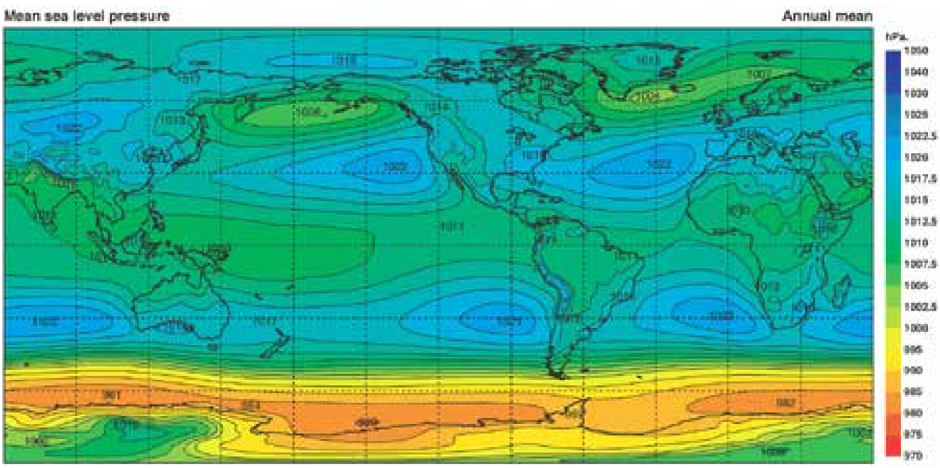


Fig. 2.4.15: Air pressure map

How to find pressure gradient

Example:

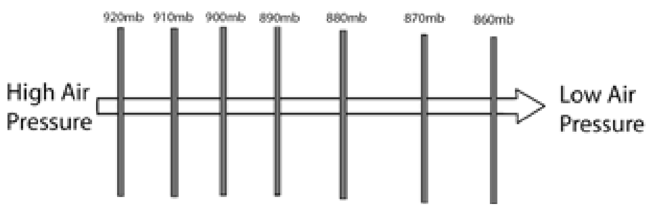


Fig. 2.4.16

Calculate the pressure gradient in the figure above.

Solution:

Pressure gradient = Difference in value (millibars) between two adjacent isobars

= 920 mb – 910 mb = **10 mb**

This means that air pressure is changing at the rate of 10 mb horizontally to the East on the earth's surface.

Activity 2.4.12:

Individually, calculate the pressure gradient between points S and T in the figure below

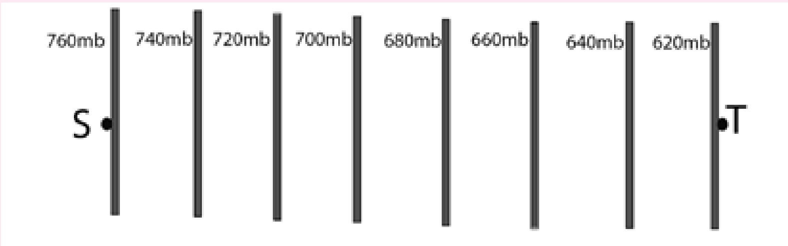


Fig. 2.4.17: Pressure gradient between S and T

Drawing isobars on an air pressure map

In order to draw isobars on an air pressure map, you need to develop some important drawing skills.

Tips on drawing isobars

(a) Always draw an isobar so that the air pressure readings that are greater than the isobar's value are consistently on one side of the isobar and lower values are on the other side.

(b) When positioning isobars, assume a uniform pressure change between neighbouring stations. For example, 840mb would be drawn between 830 mb and 850 mb.

(c) Adjacent isobars tend to be shaped alike.

(d) Continue drawing an isobar until it reaches the boundary of the plotted data or close to the form of loop by making its way to its starting point.

(e) Isobars never stop or end within the data field. They never fork, touch or cross one another.

(f) Isobars cannot be skipped if their values fall within the range of air pressures reported on the map.

(g) Always label all isobars.

Source:*www:amestoc.org/amsedu/online/info/samplecourse/In*

Activity 2.4.13:

In pairs, draw isobars on the sketch of the air pressure map below.

●840 mb

●840 mb ●820 mb ● 840 mb

●840mb ● 820 mb ●800 mb ●820mb

●820mb ●800mb ●800mb ●820mb ●840 mb

●840 mb●820mb

●840 mb●800mb ●800mb ● 820mb

● 820 mb ● 840 mb

●840 mb

Fig. 2.4.18: Sketch of an air pressure map

DETERMINING WIND STRENGTH AND DIRECTION FROM AN ISOBARIC MAP

(a) Wind strength

When the isobars are closer to each other, it means that the wind is stronger. On the other hand, when they are far apart, it implies that wind is weaker.

(b) Wind direction

Winds always blow or originate from areas characterised by close isobars to areas where isobars are far apart.

Activity 2.4.14:

In pairs, observe the figure below and do the activity that follows:

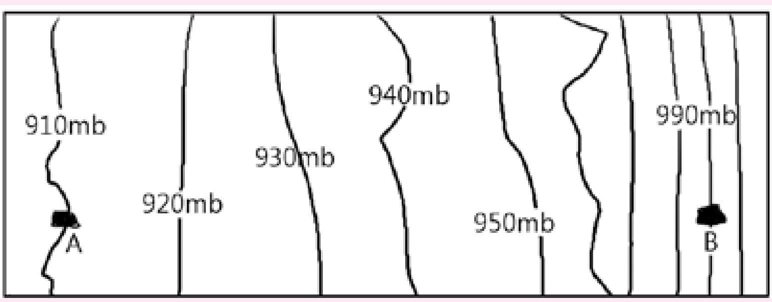


Fig. 2.4.19: Isobars determining wind strength and direction

(i) Where is the wind blowing from in the figure above? Use the eight cardinal point figure that you learnt in Form One.

(ii) Determine the wind strength by using the isobars.

AIR MASSES

Meaning of the term 'air mass'

This is an extremely large body of air whose properties of temperature and moisture content (humidity), at any given altitude, are fairly similar in any horizontal direction. This air mass can cover hundreds of thousands of square miles.

Classification of air masses

Air masses are classified according to:

1. Latitude
2. Temperature

1. Latitude

Basing on latitude, there are three air masses namely:

(i) Polar Air Masses

These air masses originate from the poles and hence they are called polar air masses.

(ii) Equatorial Air Masses

These originate from the equatorial belt.

(iii) Tropical Air Masses

These originate from the tropical belt.

2. Temperature

The two main air masses with regard to temperature are cold and warm air masses.

Main types of air masses

There are two main types of air masses: polar air mass and tropical air mass.

(i) Polar air mass

This is divided into two categories namely:

1. Maritime Polar Air Mass (mP)

These originate from the poles but within the oceans.

2. Continental Polar Air Mass (cP)

These originate from the tropics but within the land.

(ii) Tropical air mass

This is divided from the tropics but within the land.

(a) Maritime Tropical Air Mass (mT)

These originate from the tropics but within the oceans.

(b) Continental Tropical Air Mass (cT)

These originate from the tropics but within the land.

Note: Air masses can be either stable or unstable.

Stable air masses

When an air mass rises and becomes cooler than the surrounding air, it tends to sink back to the ground if it is no longer forcibly carried upward. Such an air mass is likely to produce convectional rise because the air resists lifting. Such air is stable.

Unstable air masses

An air mass in which rising updraft tends to increase in intensity with time is said to be unstable. An unstable air mass continues to rise as long as its temperature is higher than the temperature of the surrounding air. Such an air mass yields heavy showers and thunderstorms. It is most likely to be found in warm, humid areas such as equatorial and tropical oceans and their bordering lands throughout the year. It is also found in the middle latitude regions during the summer season.

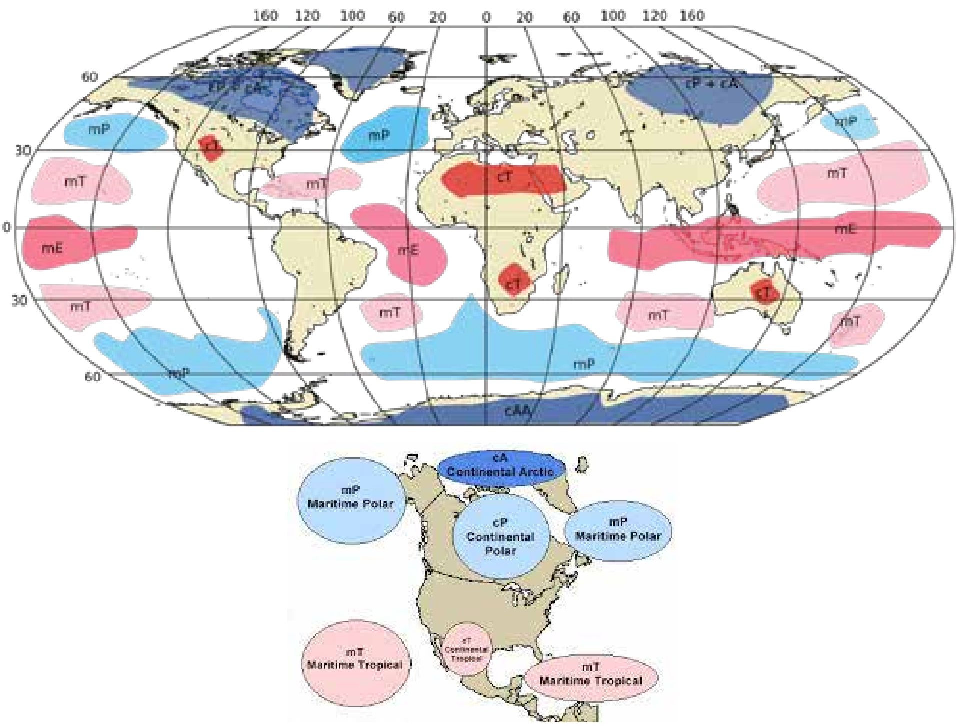


Fig. 2.4.20: Main types of air masses on the world map

Note: The formation of air masses is normally associated with *source regions*. This means that certain parts of the earth's surface are particularly well-suited to generate air masses. Such regions must be extensive, physically uniform, and associated with air that is stationary or anticyclonic.

Examples of source regions

- Ocean surfaces
- Extensive flat land areas that have uniform covering of snow, forest, or desert.

Table 47: Types of air masses, their codes, source regions and properties

Type of air mass	Code	Source Regions	Properties of source regions
Arctic/Antarctic	**A**	Antarctica, Arctic Ocean, fringes, and Greenland	Very cold, very dry, very stable
Continental polar	**cP**	High latitude plains of Eurasia and North America	Cold, dry and very stable
Maritime polar	**mP**	Oceans in vicinity of 50°C to 60°C latitude	Cold, moist relatively unstable
Continental tropical	**cT**	Low altitude desert	Hot, very dry, unstable
Maritime tropical	**mT**	Tropical and subtropical oceans	Warm, moist, variable stability
Equatorial	**E**	Ocean near equator	Warm, very moist, unstable

Source: Mc Knight T.C. and Hess D. (2005), Physical Geography, 8th Ed., Upper Saddle River, New Jersey 07458, Pearson Education Inc.

WEATHER ASSOCIATED WITH EACH AIR MASS

a. Polar air masses

The maritime polar air mass has a bit of moisture. However, this moisture does not lead to heavy precipitation, although it can bring about changes in weather. This airmass lowers the temperature of a particular region causing the weather to become cold. The weather can also be foggy or rainy as the air mass passes nearby.

The continental polar air mass is drier than the maritime polar air mass. This is because the continental polar air mass originates from the land. Being dry, the continental air mass does not bring about precipitation. However, it has the capacity to lower temperatures of the affected areas rendering the areas cold.

b. Tropical air masses

Tropical maritime air masses tend to have a lot of moisture because they originate from the oceans. This aspect brings about a heavy precipitation since humidity is always high. For example, Chiperoni local winds are warm and moist, bringing persistent low clouds (stratus). These bring a form of precipitation called ***drizzle*** in the southern region of Malawi.

Tropical continental air masses have less moisture because they originate from the land. They however have the ability to induce heavy precipitation. This is because the incoming air is generally warm, having a higher temperature originating from the tropical belt. This eventually increases evaporation rate in the affected areas. For example, the Harmattan local winds which originate from the Sahara Desert, blowing towards the western coast of Africa, are capable of bringing about heavy precipitation in the affected areas. This is because by being hot, they increase the rate of evaporation. Guinea benefits more from the kind of precipitation that is induced by these local winds.

Air masses which influence weather types on the African continent

1. North East Trade winds which are generally warm, dry and unstable. These winds affect the weather of North Africa.
2. South East Trade winds which are warm and moist affect the southern east part of Africa.
3. Warm, moist, unstable air from the Atlantic Ocean blowing towards the south western parts of Gabon, Congo and Angola.
4. Cool, moist, unstable air, blowing towards north eastern parts of Morocco and Mauritania.
5. The Harmattan local winds blowing towards the western coast of Africa. Guinea is mostly affected where evaporation increases due to its high temperature hence it brings heavy rainfall.
6. Chiperoni local winds that affect the south eastern parts of southern Africa. These winds affect the southern part of Malawi.

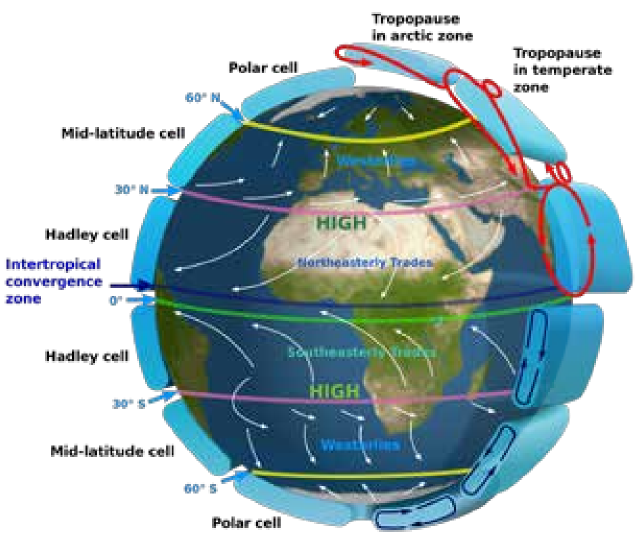


Fig. 2.4.21: Air masses which influence the weather types on the African continent

FRONTS

Introduction

When large masses of warm air and cold air meet, they do not mix. Instead, they form a *front*. A front is usually hundreds of metres long and when it passes, the weather changes. In this section, you will look at the meaning, types of fronts, their characteristics and their associated weather.

Meaning of the term 'front'

This is the boundary or line of separation between cold and warm air masses. It is a transition zone between air masses with distinct properties. The differences of air masses are mainly due to densities.

Types of fronts

There are several types of fronts which include the following:

(i) Warm front
(ii) Cold front
(iii) Occluded front
(iv) Stationary front
(v) Inter-tropical front
(vi) Polar front

Characteristics of different types of fronts

(a) Warm front

- There is a gentle slope to the front, averaging about 1: 200.
- Warm air ascends over retreating cool air with temperature of warm air descending without losing or gaining weight as air rises.

(b) Cold front

- There is a steep frontal boundary with warm air that is forced up and over.
- There is also a faster advancement of air.

Note: A combination of steep slope and faster advancement of air leads to rapid lifting of the warm air over the cold front. This rapid lifting often makes the warm air very unstable. The result is blustery and violent weather along the cold front.

(c) Occluded front

An occluded front is indicated on the line by alternating purple triangles and semi-circles on the same side of the line and pointing in the direction of the cold front symbols on the cold front.

(d) Stationary front

- A stationary front line is indicated by blue triangles on one side of the line alternating with red semi-circles on the opposite side of the line. The triangles point away from the colder air while the semi-circles point away from the warmer air.

- Stationary fronts are found where the cold and warm air masses are moving parallel to the front (not moving with respect to one another). Stationary fronts are also found if the cold and warm air masses are meeting directly with comparable wind speeds.

(e) Polar front

Symbols are used on surface weather maps to indicate the characteristics of this type of front.

FORMATION OF DIFFERENT TYPES OF FRONTS

(a) Warm front

It forms when moist, warm air mass moves up and over a cold air mass. This front develops when a warm air mass uplifts over a cold air mass.

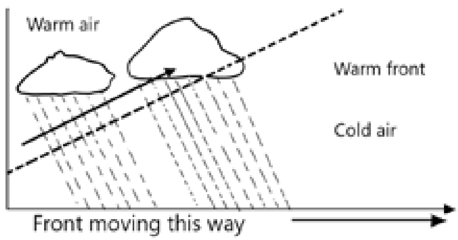


Fig. 2.4.22: Warm front

(b) Cold front

It forms when a cold air mass pushes under a warm air mass, forcing the warm air to rise. This front develops when a cold air mass uplifts a warm air mass.

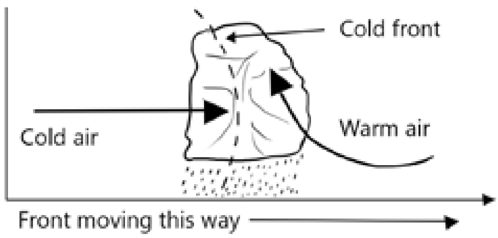


Fig. 2.4.23: Cold front

(c) Occluded front

This front develops when cold and warm air masses uplift each other. It also develops when a cold front overtakes a warm front. The warm air mass rises over the cool air masses, pushing and meeting in the middle. As the cold front moves in more quickly than the warm front, it eventually overtakes the warm sector. This is called ***occlusion***. The boundary between the uplifted air and cold air is called an ***occluded front***.

Types of occluded front

(i) Cold front occlusion

The air on the leading edge of an advancing cold front is warmer than the air on the rear edge. The result is that both the warm air mass behind the warm front and the cooler air mass in front of the cold front are uplifted above the advancing cold front.

(ii) Warm front occlusion

The air ahead of the warm front is cooler than the air behind the advancing cold front. As the cold air overtakes the warm air, the advancing cold air rises above the cooler air ahead of the warm front air.

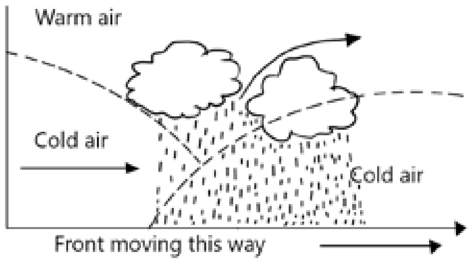


Fig. 2.4.24: Occluded front

(d) Stationary front

It forms when a warm air mass meets a cold air mass and neither air mass has the force to move the other. They remain stationary or '*stand still*'. This front develops when warm and cold air masses remain stationary where they meet.

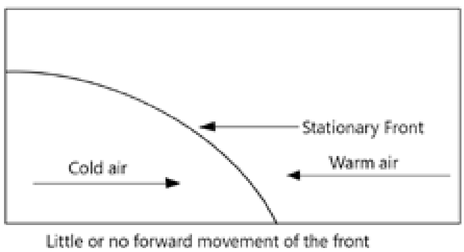


Fig. 2.4.25: Stationary front

(e) Inter-tropical front

This front forms between the trade wind belts of the Northern and Southern Hemispheres.

(f) Polar front

The *polar front* is the general name given to the boundary separating the polar air masses from tropical air masses that extends around the world. This front develops between polar and tropical air masses.

Activity 2.4.15:

In groups of five, observe each front diagram and examine the characteristics based on it. Report your findings to the whole class for further discussion.

Location of different types of fronts on the world map

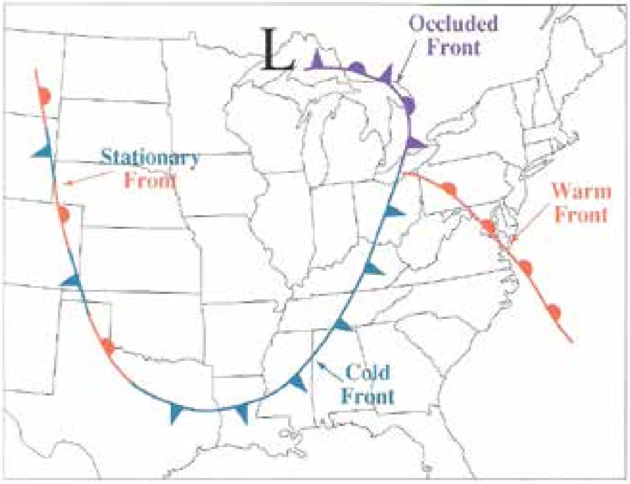


Fig. 2.4.26: Different types of fronts on the world map

Activity 2.4.16:

In pairs, draw the different types of fronts in your notebooks; then show each other what you have done.

WEATHER ASSOCIATED WITH EACH TYPE OF FRONT

(a) Warm front

As the warm air mass rises, it condenses into a broad area of clouds. A warm front brings gentle rain or light snow, followed by warmer and mild weather. It is associated with cirrus, nimbostratus clouds and steady gentle rains.

(b) Cold front

Thunderheads can form as the moisture in the warm air mass rises, cools and condenses. As the front moves through, cool, fair weather is likely to follow. Vertically-developed clouds are common with turbulence and showery precipitation. Precipitation is usually of higher intensity, but with a short duration that is associated with a warm front. It is often accompanied by cumulonimbus clouds and organised thunderstorms.

(c) Occluded front

The temperature drops as the warm air mass is occluded or cut off from the ground and pushed upwards. This can bring strong winds and heavy precipitation.

(d) Stationary front

Clouds and fog form where warm and cold air masses meet. As a result, it can rain or form snow. There is high probability of having prolonged clouds and precipitation.

(e) Inter-tropical front

There is heavy rainfall and strong violent winds.

(f) Polar front

There is clear sky but with little cirrus clouds that bring light showers. The polar front is associated with cyclonic storms.

THE INTERTROPICAL CONVERGENCE ZONE (I.T.C.Z) AND ITS IMPACT ON WEATHER

Meaning of the term 'Inter-Tropical Convergence Zone (I.T.C.Z.)'

I.T.C.Z. is an area of low air pressure and marks the point of trade winds convergence. This is an area or zone where air masses meet in a low air pressure zone and is indicated by the apparent movement of the sun.

The Inter-Tropical Convergence Zone (I.T.C.Z.) as a pressure belt

The Inter-Tropical Convergence Zone (I.T.C.Z.) is considered as a pressure belt. It has low pressure due to the high temperature it experiences. This belt shifts position from southern to the northern parts of Africa. Being a belt of low pressure, different air masses flow towards it.

Isobaric maps of Africa according to seasons

(a) In January

Winds blow towards this low pressure zone, that is, the warm dry stable air from the land, north of the pressure zone (North East Trade Winds) and the moist unstable maritime air from the Atlantic and Indian Ocean (South East Trades) and the Congo air. Such a meeting causes the moist air to rise over the warm stable one resulting in rainfall.

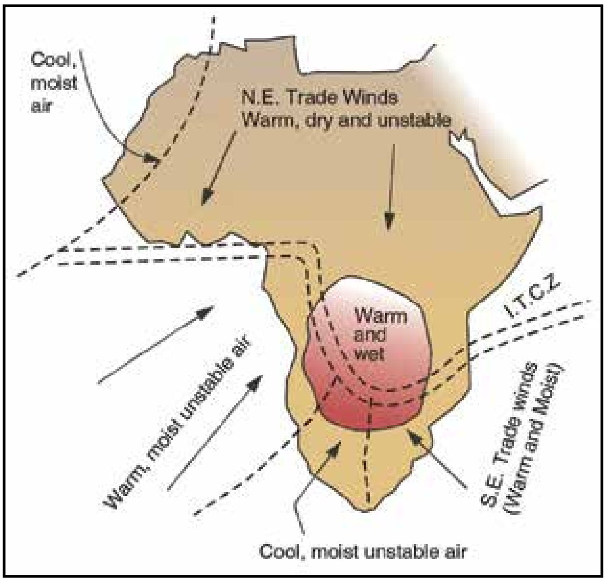


Fig. 2.4.27: Position of I.T.C.Z. in January

(b) In July

The I.T.C.Z. shifts to the North. The warm moist air from the Atlantic (West Coast) meets the warm dry stable air from the land (North of Africa including Sahara).

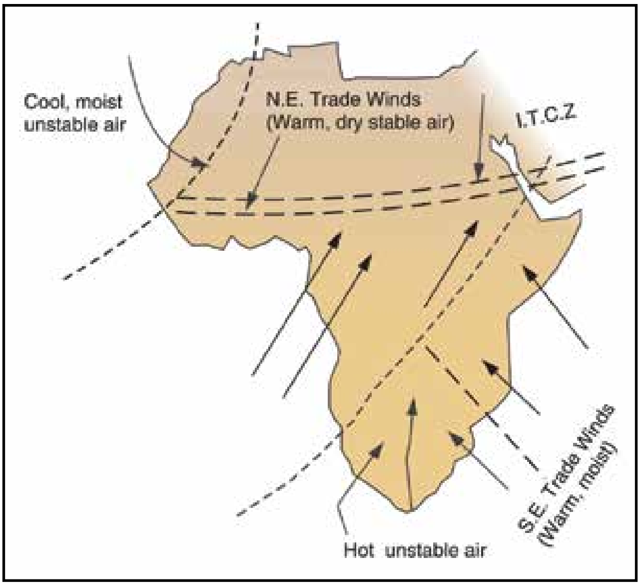


Fig. 2.4.28: Position of I.T.C.Z. in July

Activity 2.4.17:

In groups of five, discuss the movement of the I.T.C.Z. on weather patterns on the African continent during the year.

General effects of the I.T.C.Z. on weather patterns

The most important climate control with regard to tropical climatic types relates to the position of the I.T.C.Z. Variations in the location of I.T.C.Z, drastically affects rainfall in many equatorial nations. As a result, wet and dry seasons of the tropics follow.

- Temperatures drop slightly and skies fill with small white cumulus clouds.
- Winds veer from the north-east to south-west direction, bringing rain showers.
- Cumulonimbus clouds accompanied by lightning, thunder and heavy rains develop.

The impact of I.T.C.Z on the weather patterns in Malawi

The I.T.C.Z. marks the onset of rainfall in Malawi. When it is over Malawi moving from south to north, it becomes very cloudy and rainy. During this time, there is persistent rainfall where it can rain for a number of days without stopping.

Activity 2.4.18:

In groups of five, discuss the impact of I.T.C.Z. on weather patterns of Malawi.

LOCAL WINDS

Meaning of the term 'local winds'

These are the kind of winds that blow for a short period of time affecting a smaller area.

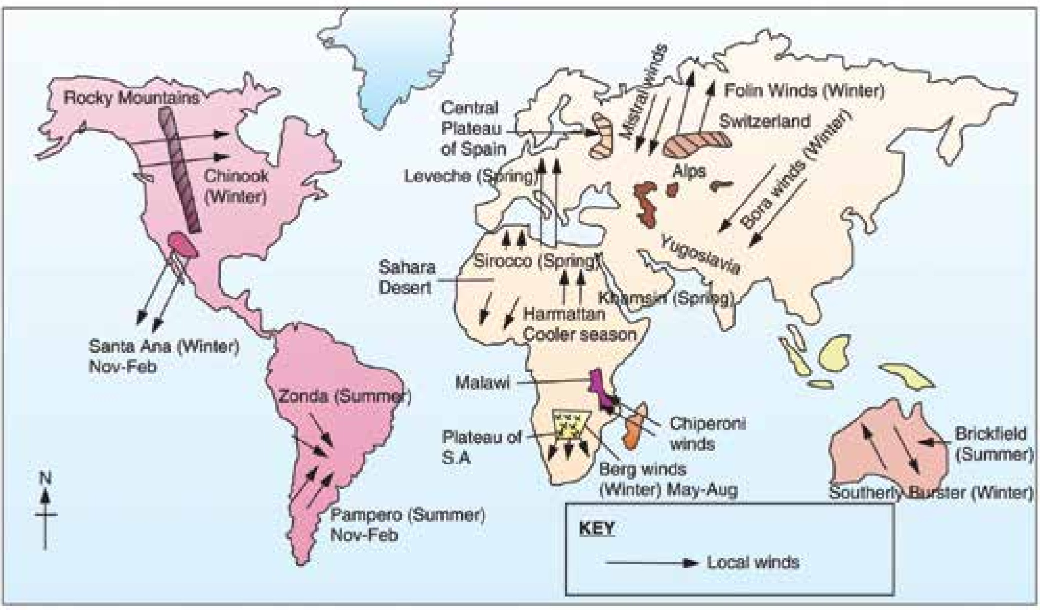


Fig. 2.4.29: Location of local winds on the world map

Activity 2.4.19:

In pairs, draw the world map and locate the following local winds.

(i) Harmattan (ii) Chiperoni (iii) Fohn (iv) Chinook

CHARACTERISTICS AND EFFECTS LOCAL WINDS

1. CHIPERONI

Where does it blow?

It originates from Mozambique. It affects the Shire Highlands. See Fig. 2.4.30 below.

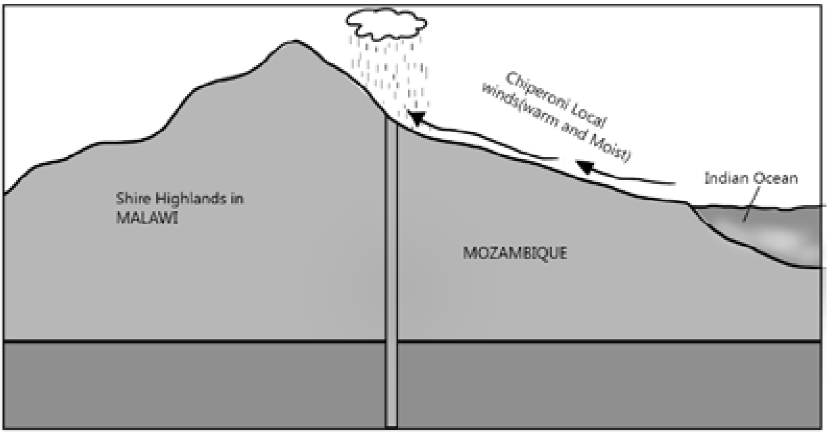


Fig. 2.4.30: Chiperoni local winds

Characteristics of Chiperoni winds

(i) They are warm.

(ii) They are moist.

(iii) They originate from Mozambique.

Effects of Chiperoni winds

- They bring persistent stratus clouds which lead to a form of precipitation called drizzle**.** The precipitation is experienced in the southern region of Malawi, particularly Mulanje, Thyolo and Blantyre.

2. CHINOOK

Where does it blow?

It originates from the Pacific Ocean. It blows across the Rockies Mountains in Canada and U.S.A. See Fig. 2.4.31.

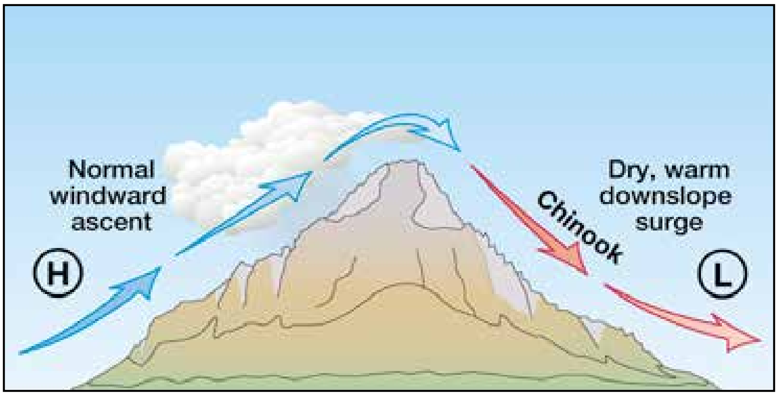


Fig. 2.4.31: Chinook local winds

Characteristics of Chinook local winds

(i) They are warm.
(ii) They are very common in spring and winter.
(iii) They bring heavy orographic or relief rainfall.
(iii) They descend over the Rockies Mountains.
(iv) They blow from the Pacific Ocean and across Rockies Mountains.

Effects of Chinook local winds

(i) They raise temperature by 19°C within a period of 15 minutes. As a result, they can melt and dry winter snow. It is for this reason that they are called Snow Eater. It is thus of economic value in pastoral regions such as areas from Southern Colorado (U.S.A.) to Mackenzie River.
(ii) They bring precipitation in form of rain to the West of Rockies.

3. HARMATTAN

Where does it blow?

It blows from the Sahara Desert to the western coast of Africa. See Fig. 2.4.32 below.

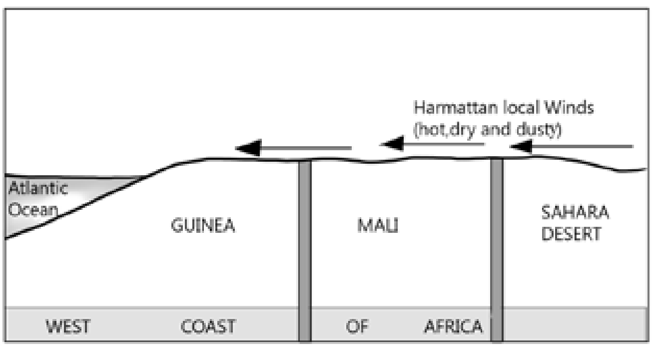


Fig. 2.4.32: Harmattan local winds

Characteristics of the Harmattan local winds

(i) They are hot, dry and dusty.

(ii) They are capable of splitting trunks of trees and also damaging crops.

(iii) They blow from the Sahara Desert to the western coast of Africa.

Effects of the Harmattan local winds

(i) They bring hot air towards Guinea. This encourages evaporation hence it brings about heavy rainfall which enables crops to grow. This is why the Harmattan wind is called ***the Doctor***.

4. FÖHN LOCAL WINDS

Where does it blow?

It blows down the leeward slope of Northern Alps (a fold mountain in Switzerland). See Fig. 2.4.33 below.

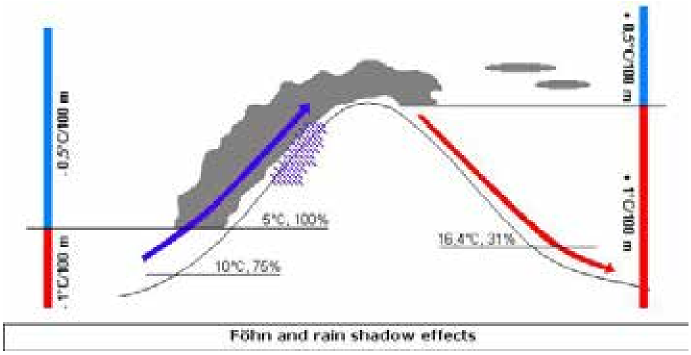


Fig. 2.4.33: Föhn local winds

Characteristics of Föhn local winds

(i) They are warm.

(ii) They are dry.

(iii) They blow down the leeward slope of Northern Alps Mountain.

Effects of Föhn local winds

(i) The winds are capable of melting snow because they can raise temperatures by 8°C to 11°C.

(ii) They can cause avalanches.

(iii) Trees and houses become excessively dry.

(iv) They melt snow in winter and spring in northern Switzerland. This helps to provide moisture for growing pastures.

(v) The winds are useful in the ripening of crops.

OCCURRENCE OF LOCAL WINDS

Generally, local winds are developed by depressions. The air circulation in these is such that air is drawn in from tropical regions in the front of the depression and hot winds develop. Also air is drawn in from polar regions in the rear of the depression and cold winds develop.

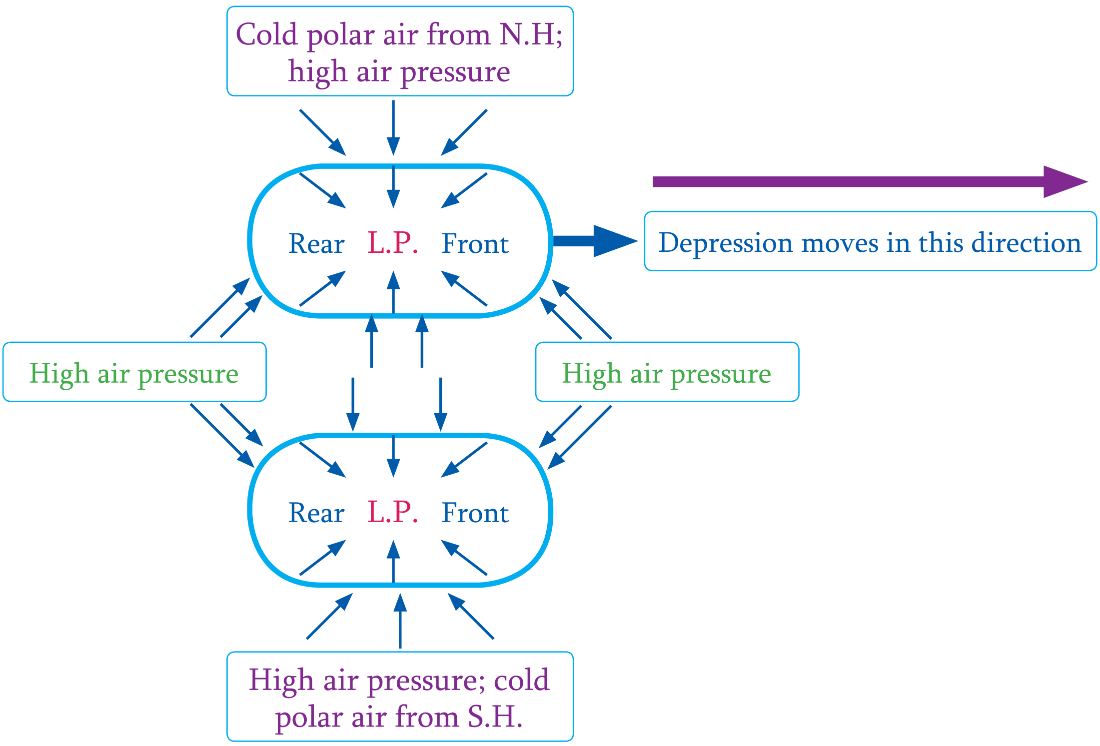


Fig. 2.4.34: How local winds develop

Small-scale convection currents arise from the uneven heating on the smaller scale. This kind of heating occurs along the coast and in mountains. Indeed, small scale convectional currents cause local winds.

OCCURRENCE OF LAND AND SEA BREEZES

The occurrence of land and sea breezes is determined by air pressure which is basically caused by differential heating of land and water masses. The slow-moving air masses which are simply called breezes will always move from areas of high pressure to areas of low pressure. Areas of high pressure have a high concentration of air molecules than areas of low pressure. It is also important to note that land heats up and cools down faster than the water in the sea.

(a) Sea breeze

During the day or summer, land heats up faster than water in the sea. Consequently, this will make air molecules above the land to expand thereby occupying a large space. Air molecules will rise up because they lose their weight. This will make a parcel of air exert less outward force. The weight of air will be less hence air pressure will be low.

The opposite is also true. The sea heats slower than land during the day. As a result, the temperature above the water in the sea is relatively lower than above the land. This means that air molecules above the sea will contract and occupy less space, leading to high air pressure. Therefore, air will move from the area of high pressure (sea) to the area of low air pressure (land) thereby creating a ***sea breeze*** (slow-moving air from the sea). See Fig. 2.4.35 below.

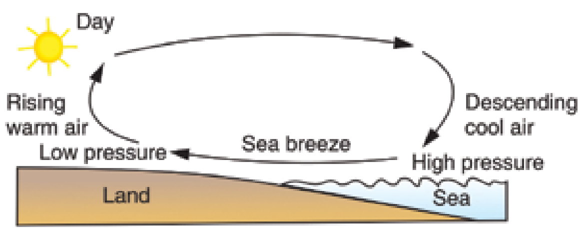


Fig. 2.4.35: Sea breeze

(b) Land breeze

During the night or winter season, land cools faster than water in the sea. Consequently, air molecules above the land contract. This air occupies less space and gains weight. Air pressure thus increases over land. On the other hand, air molecules over the sea water surface expand, rise up and occupy a large space because they are heated by the heat absorbed by the water. As a result, air pressure decreases over the sea where the concentration of air molecules is lower than that of the land. Air thus moves from land where air pressure is high to the sea where air pressure is low. This creates what is referred to as a ***land breeze*** (air from land). See Fig. 2.4.36 below.

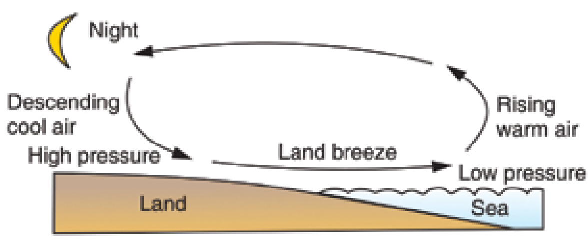


Fig. 2.4.36: Land breeze

Activity 2.4.20:

In groups of five, discuss the occurrence of land and sea breezes.

INFLUENCE OF LAND AND SEA BREEZES ON LOCAL WEATHER AND ENVIRONMENT

(i) Sea breeze

The sea breeze has a cooling effect on the adjacent landmass. This eventually lowers the temperatures of the adjacent landmass. Tourists and local people enjoy this sea breeze.

Upon reaching the landmass, air molecules begin to get heated and consequently rise up. This causes the air to circulate and descend when subjected to low temperatures. However, this parcel of air has a partially high temperature, which has a heating effect over the ocean water. The water in the ocean has a slightly higher temperature than land.

(ii) Land breeze

The land breeze has a cooling effect over the ocean surface. This is because its air molecules have absorbed the low temperature released by the land. Fisherpersons are mostly affected by this low temperature over the sea, lake or ocean water at night. These air molecules are heated by the high temperature released by sea, ocean or lake water. Consequently, they rise up and circulate to descend onto land where they have a warming effect. This explains why it becomes absolutely hot at night along the lake shore which may affect people's sleep.

CYCLONES AND ANTICYCLONES

A. CYCLONES

Terminologies

- **Cyclone:** A cyclone is a strong storm that originates from a region of low atmospheric pressure at the centre and increases outwards.
- **Buys Ballot's Law:** This law states that cyclones are deflected to the right in a clockwise direction, in the southern hemisphere.

Types of cyclones

There are two types of cyclones namely:

(a) Tropical cyclones such as typhoons, hurricanes, cyclones and Willy willies.

(b) Temperate cyclones (also known as depressions).

(a) TROPICAL CYCLONES

Meaning of tropical cyclones

These are intense, low pressure weather systems that build up near the equator, where ocean temperatures are generally high, creating a low pressure zone. They develop over oceans and move towards the continent.

Area of occurrence

These develop along the doldrums low pressure belt between the sub-tropical high pressure belt and the equatorial belt. At this point, the South East trade winds meet North East trade winds. Refer to Fig. 2.4.37.

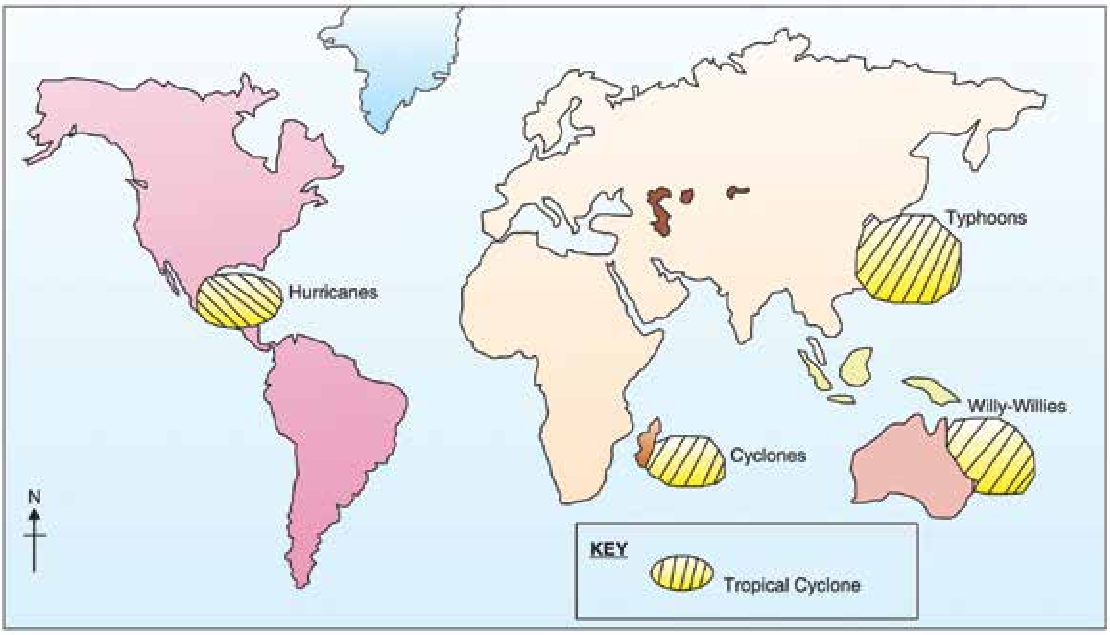


Fig. 2.4.37: Areas of tropical cyclone development

General characteristics of a tropical cyclone

(i) It originates over oceans in the tropics in summer.

(ii) It does not occur in the regions within 5° North and South of the equator because of the weak Coriolis force. It develops between 5° and 20° North and South of the equator.

(iii) It is smaller than a frontal depression. It is centred around an area of extremely low atmospheric pressure.
(iv) Once formed, it moves westwards.
(v) It rotates clockwise in the southern hemisphere, in line with Buys Ballot's Law.

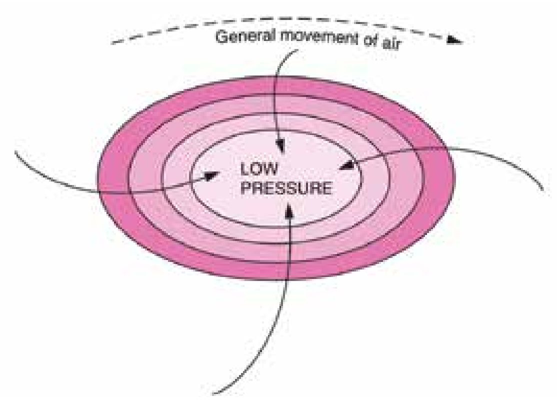


Fig. 2.4.38: Rotational direction of a tropical cyclone in the southern hemisphere

(vi) It is accompanied by heavy rains and showers which cause a great deal of damage due to the strong winds and floods.
(vii) A source of energy in a tropical cyclone is latent heat which is freed as moist tropical air condenses.
(viii) Warm, moist air is drawn into the low pressure centre from a large area over the oceans.
(ix) Air spirals upwards with great low pressure in the centre.

A cross-section of tropical cyclones

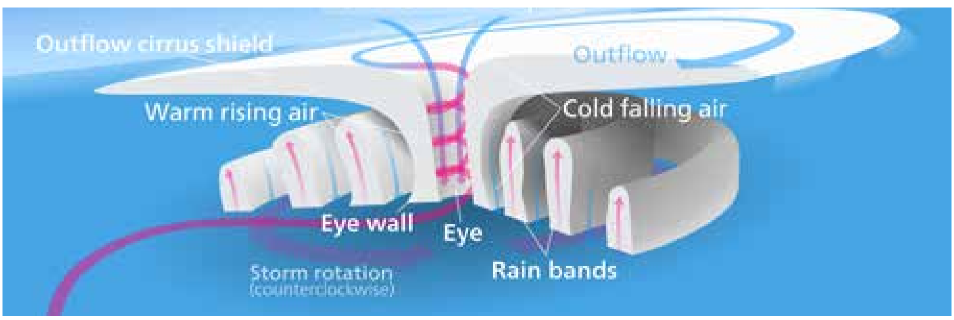


Fig. 2.4.39: Cross-section of a tropical cyclone

Conditions necessary for the development of a tropical cyclone

Certain conditions have been identified as common characteristics in the development of a tropical cyclone. These include the following:

(i) An abundant source of warm, moist air with temperatures of about 27°C or more, near the surface.

(ii) High level of heat causing updrafts of air.
(iii) High levels of humidity.
(iv) Major winds blowing in the same direction.
(v) Air must be blowing inwards towards the centre and rising rapidly.
(vi) Nimbostratus clouds must form to give heavy rainfall.
(vii) There must be an inward flow of air in the upper level of the atmosphere.

How does the tropical cyclone develop?

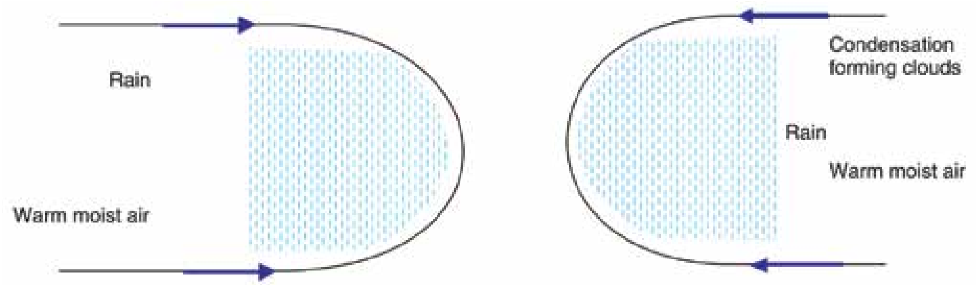


Fig. 2.4.40: Development of a tropical cyclone

Explanation:

Tropical cyclones develop when South East trade winds meet North East trade winds along the inter-tropical front. When they meet, one is uplifted over the other. As a result, the moisture of the uplifted trade winds condenses to form clouds that bring about heavy rainfall. As warm air rises, more air is sucked in to take its place. This provides energy for the storm to move. The storm begins to spiral because of the rotation of the earth. The air is thrown outwards from the centre while the eye remains calm as warm air descends. This storm develops over oceans and where air masses have travelled, absorbing a lot of moisture. It is this moisture that supplies energy to the cyclone. This is why once the tropical cyclones reach landmasses, their life span ends, due to insufficient moisture.

WEATHER ASSOCIATED WITH A TROPICAL CYCLONE

(i) **Heavy rainfall:** As the front of the vortex arrives, gusty winds develop and thick clouds appear, resulting in heavy rainfall.

(ii) **Strong winds:** When the vortex arrives, the wind becomes violent reaching speeds of over 240km/h.

(iii) **Storm surges:**The low pressure and strong winds means that the sea level is very high; this is referred to as a storm surge. The strong winds create huge waves which push towards the coastal areas. This causes extensive coastal flooding.

(iv) Calm conditions return when the 'eye' arrives. The 'eye' means that air moves with a speed of between 16 to 32 km/h.

(v) The arrival of the rear (back) of the vortex brings in violent winds. The vortex refers to dense clouds, violent winds and thunderstorms which are rough. The vortex moves with a speed of between 32 to 64 km/h.

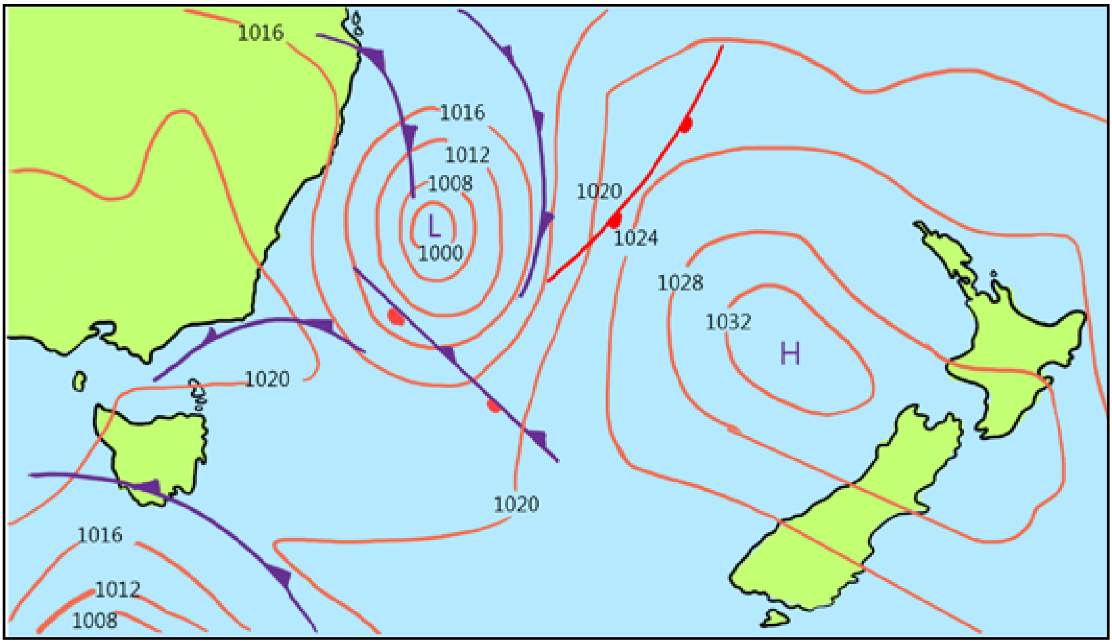


Fig. 2.4.41: A synoptic chart

Location of tropical cyclones on world maps

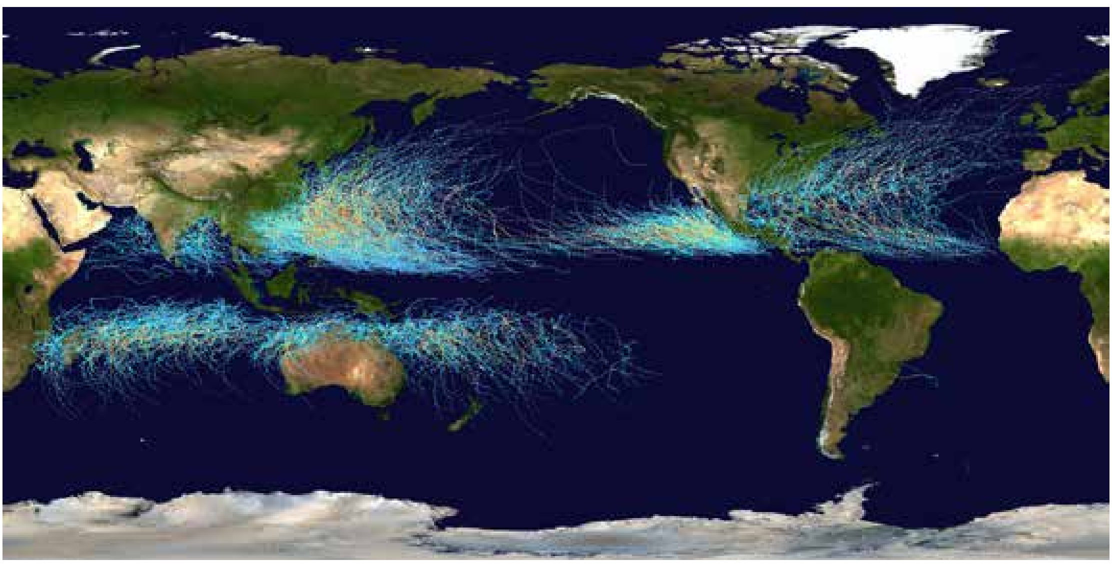


Fig. 2.4.42: Tropical cyclones on the world map

(b) TEMPERATE CYCLONE OR DEPRESSION

Meaning of the term 'depression'

A depression or a temperate cyclone refers to a strong storm which originates from an area of low air pressure whose isobars are very close at the centre, forming an oval shape.

Movement of air in the depression

Air moves or circulates in an anticlockwise direction in the northern hemisphere and in a clockwise direction in the southern hemisphere, according to Buys Ballot's Law. Normally, winds move from areas of high pressure to the central part of the cyclone. Depressions are rarely stationary. They generally move in an easterly direction.

Where do depressions develop?

They develop in temperate latitudes (60 degrees North and South of the equator) where westerly winds meet polar winds. Humid air from the tropics meets cold air from polar regions along the boundary line called polar front.

Characteristics of depressions

(a) They are associated with changing weather with continuous rain, caused by the uplifting of warm, moist tropical air by the cold polar air which is a bit drier.

(b) They vary in their size (some are large while some are small).

DEVELOPMENT OF THE DEPRESSION OR TEMPERATE CYCLONE

Cold air from polar region meets warm air from tropics along the polar front. → Friction occurs and causes a wave to develop in the front. → The wave bulges into cold air and gets larger. → Air pressure falls at the tip of the wave and winds blow around it in an anticlockwise direction. → The bulge causes warm air to rise over cold air at the warm front. → The cold air forces itself under the warm air at the rear (back) where the cold front develops.

Fig. 2.4.43: Flow diagram illustrating how a depression develops

Firstly, cold air from the polar regions starts moving in a general westerly direction along the polar front. Warm tropical air moves in a general easterly direction. When the two meet, there is always friction which causes a wave to develop in the front. This wave bulges into cold air and gets larger. Then air pressure falls at the tip of the wave and winds blow around the tip in an anticlockwise direction. The development of the bulge causes the warm air to rise over the cold air at the warm front. The cold air forces itself under the warm air at the rear (back) where the cold front develops. When this happens, the temperate cyclone has been formed and is ready to move. The warm air between the two fronts is called the warm sector. See Fig. 2.4.44 below.

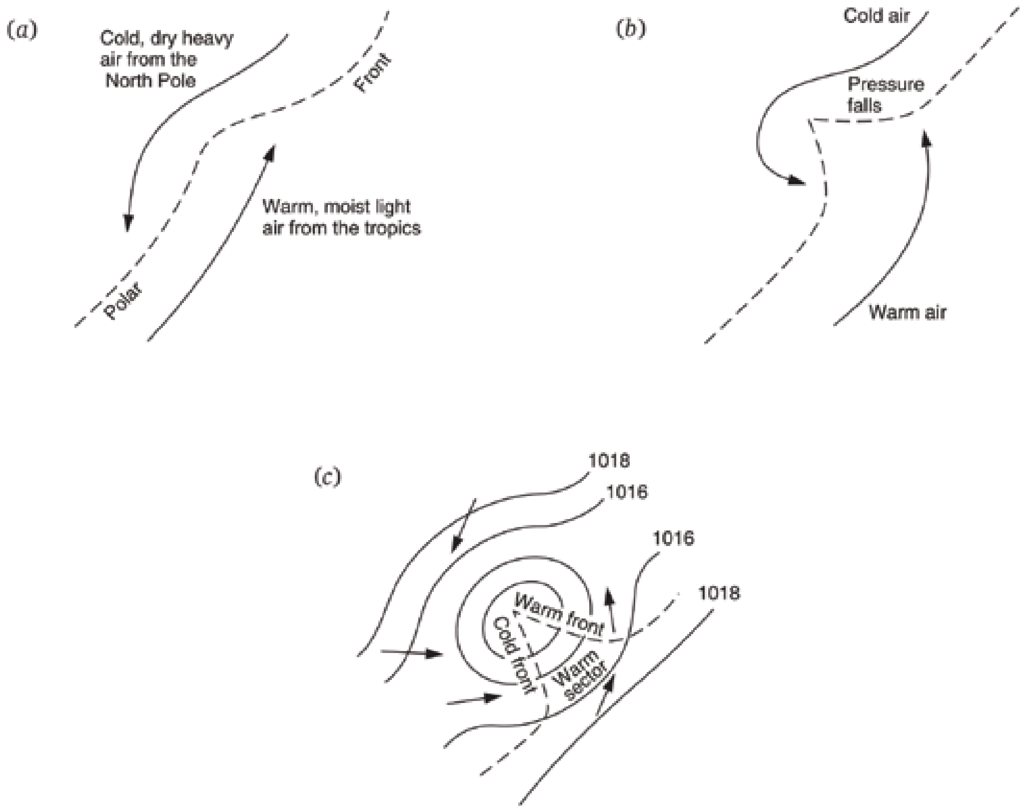


Fig. 2.4.44: Development of a temperate cyclone

Weather associated with a depression

1. Clear sky but often with little cirrus clouds.
2. Definite cloud cover develops as winds blow from the South East, causing occurrence of light showers.
3. The rain stops and the wind changes direction from South East to South West.
4. Temperatures rise and the air is humid because the warm sector lies over the centre.
5. Weather changes very quickly causing wind to blow from the North East; temperature falls. The sky remains clear and cool with the passage of a depression.

Similarities and differences between temperate and tropical cyclones

Similarities

- They both circulate in an anticlockwise direction in the northern hemisphere and clockwise direction in the southern hemisphere (This is **Buys Ballot's Law**). See Fig. 2.4.45 below.

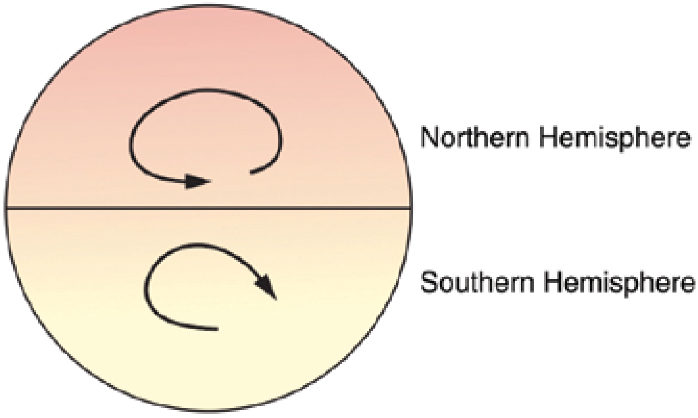


Fig. 2.4.45: Circulation of temperate and tropical cyclones

Differences between tropical and temperate cyclones

The differences between these two cyclones can be summarised in the table below:

Table 48: Differences between tropical and temperate cyclones

	Tropical cyclone	**Temperate cyclone**
Size	• It is smaller	• It is bigger
Extent of violence	• It is more violent	• It is less violent

B. ANTICYCLONES

Meaning of anticyclones

These are strong storms which develop in regions of high atmospheric pressure which decreases outwardly. The pressure gradient is gentle and winds are light.

Characteristics of anticyclones

(i) They bring about fine weather.

(ii) Skies are clear, the air is calm.

(iii) Temperatures are high in summer but low in winter.

(iv) In winter, great cooling of the lower atmosphere may result into thick fogs.

(v) Winds blow outwards, as opposed to inwards in tropical cyclones.

(vi) They observe ***Ferrel's law of deflection*** in that; they blow in a clockwise direction in the northern hemisphere and anticlockwise direction in the southern hemisphere.

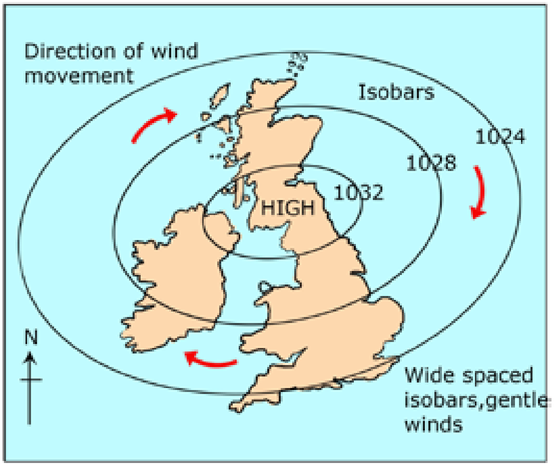


Fig. 2.4.46: Anticyclones

Examples of anticyclones

The main examples of anticyclones are:

- South Atlantic High
- Indian Ocean High

CLOUDS

Meaning of the term 'clouds'

Clouds are masses of small water droplets or ice crystals, formed by condensation of the water vapour in the atmosphere.

Formation of clouds

Clouds are formed when the processes of evaporation and transpiration take place. These processes release water vapour into the atmosphere. The water vapour then rises and eventually cools when subjected to low temperatures. Water vapour begins to condense around different condensation nuclei which include small particles of dust, salt and other particles of matter. Tiny water droplets are formed when the dew point (the temperature at which water vapour begins to condense) is reached. These droplets enlarge and combine to form a cloud. See Fig. 2.4.47.

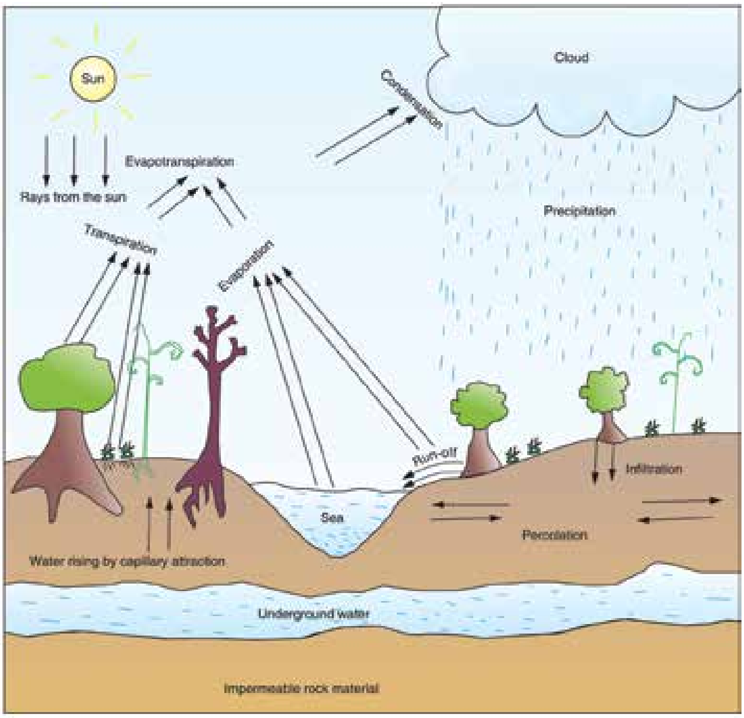


Fig. 2.4.47: The hydrological or water cycle

Activity 2.4.21:

In groups of five, study the diagram of the hydrological cycle above and relate it to cloud formation. Then discuss how clouds form.

MAIN TYPES OF CLOUDS

Criteria used to classify clouds

Clouds are classified according to their appearance, form and height. Basing on height, clouds are classified into four groups. These include the following:

1. High clouds
2. Medium clouds
3. Low clouds
4. Clouds of great vertical extent

Table 49: Cloud chart

Type or category of clouds	Examples
High clouds	Cirrus, cirrocumulus and cirrostratus
Middle clouds	Altostratus and altocumulus
Low clouds	Stratus, stratocumulus and nimbostratus
Clouds with vertical development	Cumulus and cumulonimbus

With regard to appearance, clouds are grouped into cirrus, cumulus, nimbus and stratus.

1. HIGH CLOUDS

These clouds exist between 6,100 metres to 12,200 metres above the ground. There are three categories of high clouds namely cirrus, cirrocumulus and cirrostratus.

(i) Cirrus (Ci) clouds

Characteristics of Cirrus (Ci) clouds

- They look fibrous and appear like wisps in the blue sky.
- They are thin, white and icy.

Weather associated with Cirrus (Ci) clouds

- They indicate a fine and fair weather.
- They give a brilliant sunset.

(ii) Cirrocumulus (Cc) clouds

Characteristics of Cirrocumulus (Cc) clouds

- They appear as white globular masses.
- Sometimes they look like scales of fish, hence the sky filled with cirrocumulus is called a '***mackerel sky***'.
- They are thin, white and icy.

Weather associated with Cirrocumulus (Cc) clouds

- Cold air at high altitudes causes small cloud droplets to freeze into ice crystals.

(iii) Cirrostratus (Cs) clouds

Characteristics of Cirrostratus (Cs) clouds

- They look like a thin white sheet or veil.
- The sky looks milky.

Weather associated with Cirrostratus (Cs) clouds

- The sun or moon shines through cirrostratus and often form a '***halo***'. ***Haloes*** are circular shapes resembling the sun or moon.

2. MEDIUM CLOUDS

These are clouds which are found between 2,100 metres and 6,000 metres. There are two types of medium clouds namely altocumulus (Alt-Cu) and altostratus (Alt-St).

(i) Altocumulus (Alt-Cu) clouds

Characteristics of Altocumulus (Alt-Cu) clouds

- They are woolly, bumpy and are arranged in layers.
- They appear like waves in the blue sky.

Weather associated with Altocumulus (Alt-Cu) clouds

- They bring about fine weather.

(ii) Altostratus (Alt-St) clouds

Characteristics of Altostratus (Alt-St) clouds

- They are denser than altocumulus clouds.
- They are layered or puffy.
- They are greyish in colour with a watery look.
- They have fibrous or striated structure through which the sun's rays shine faintly.

3. LOW CLOUDS

These occur below 2,100 metres. They fall in three categories:

(i) Stratocumulus
(ii) Nimbostratus
(iii) Stratus

(i) Stratocumulus (St-Cu) clouds

Characteristics of Stratocumulus (St-Cu) clouds

- They are round and bumpy clouds.
- They have more pronounced waves or a more wavy form than the altocumulus.
- There is a great contrast between the bright and shaded parts.

(ii) Nimbostratus (Ni-St) clouds or rain clouds

Characteristics of Nimbostratus (Ni-St) clouds

- They are dark and dull clouds.
- They are clearly layered.
- They have grey colour.

Weather associated with Nimbostratus (Ni-St) clouds

- They bring continuous rain, snow or sleet as forms of precipitation.

(iii) Stratus (St) clouds

Characteristics of Stratus (St) clouds

- These are very low clouds that are uniformly grey in colour.
- They are thick.
- They look like a low ceiling or highland fog.

Weather associated with Stratus (St) clouds

- They bring dull (not clear or bright) weather which is associated with drizzle (form of precipitation).
- They reduce visibility of aircrafts, and affect their movement.

4. CLOUDS OF GREAT EXTENT

These clouds have no definite height. They are found between 6,100 metres to 9,000 metres above sea level. There are two types of these clouds: cumulus and cumulonimbus.

(i) Cumulus (Cu) clouds

Characteristics of Cumulus (Cu) clouds

- These clouds have round tops.
- They are tall, narrow and puffy.
- They have flat bases and look like the globe They are mainly white and grey.
- They are common in tropical regions where humidity is high.

Weather associated with Cumulus (Cu) clouds

- They are associated with uprising convectional currents.
- They bring fair weather.

(ii) Cumulonimbus (Cu-Ni) clouds or thunder clouds

Characteristics Cumulonimbus (Cu-Ni) clouds

- These are found within a height of between 600 metres to over 9000 metres.
- They have black and white globular mass.
- They have a cauliflower top that spreads out like an anvil.
- They are common within the tropics in the afternoon hours after a lot of evaporation in the morning.

Weather associated with Cumulonimbus (Cu-Ni) clouds

- They bring about heavy convectional rainfall.
- They are accompanied by thunder and lightning.

Table 50: Cloud summary

Cloud type	**Associated weather**
Cirrus (Ci)	Nil
Altostratus (Alt-St)	Light rains which may or may not reach the ground.
Altocumulus (Alt-Cu)	Nil
Nimbostratus (Ni-St)	Heavy continuous rain or snow.
Cumulus (Cu)	Usually nil unless large sometimes which may be associated with showers of rain or hail.
Cumulonimbus (Cu-Ni)	Thunderstorms, lightening, showers of rain, snow or hail.
Stratocumulus (St-Cu)	There may be a drizzle, usually associated with reduced visibility.
Stratus (St)	There may be a drizzle, usually associated with reduced visibility

Source: *http://www.bribanehotairballonscom.au/images/cloud*

Activity 2.4.22:

In groups of five, discuss the types of weather associated with different types of clouds.

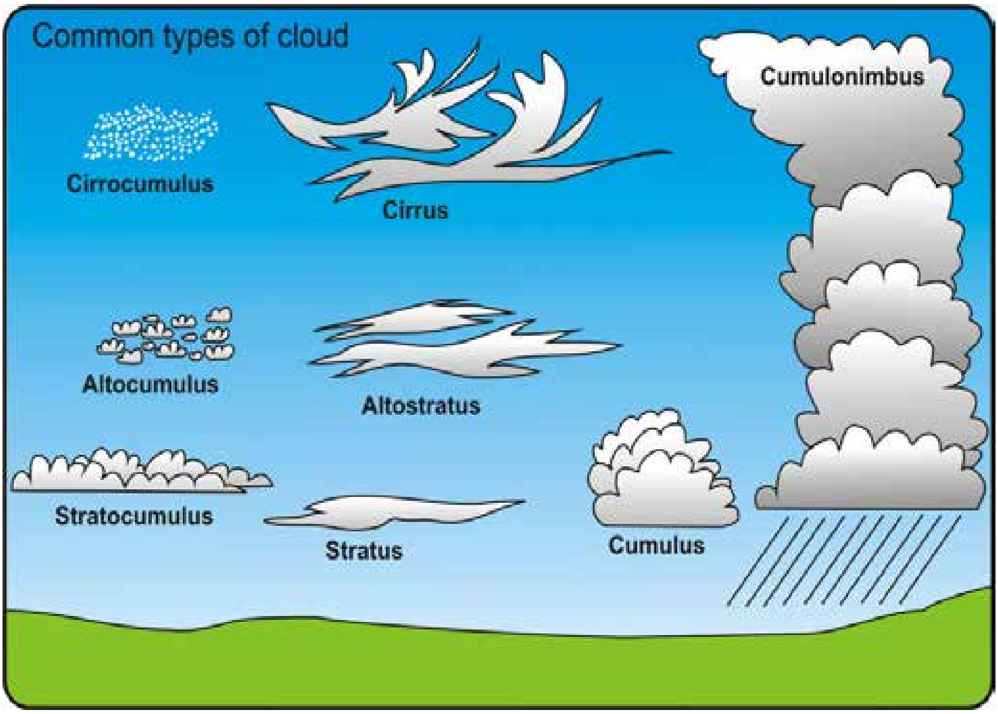


Fig. 2.4.48: Cloud types and heights

Activity 2.4.23:

In pairs, observe the figure showing cloud types and heights above and identify the following cloud types:

- *High clouds*
- *Medium clouds*
- *Low clouds*
- *Clouds of great vertical extent*

PRECIPITATION

Meaning of the term 'precipitation'

Precipitation refers to all forms of moisture originating from the clouds which fall on the earth's surface. The concept entails water in liquid or solid state falling from the clouds due to condensation of airborne water vapour. It also entails water precipitation in a solid or liquid form that falls from clouds to the earth's surface under the influence of gravity.

Major forms of precipitation

There are different forms of precipitation.The main ones are rain, hail, snow, mist, fog, frost, sleet and rime.

(a) Rain

Rain is liquid water drops that fall mostly from nimbostratus and cumulonimbus clouds. It only forms when the droplets in clouds coalesce into or combine to form larger drops between 5 mm and 6 mm in diameter.

(b) Mist

Mist refers to small water droplets suspended in the air. It is formed when warm, moist air suddenly meets cool and cold air. Visibility in mist is higher as compared to visibility in fog.

(c) Fog

This is a thick cloud which forms close to land and water masses. It is formed when moisture is cooled and condensed to its dew point near the ground. Since fog is dense, there is very poor visibility. In foggy weather, a person can only see up to about 100 metres.

Types of fog

There are various types of fog. These include radiation fog, frontal fog, steam fog, hill fog and advection fog. The most dominant is advection fog.

Advection fog forms when warm air passes over or meets cold air, resulting into rapid cooling. Advection fog occurs when a relatively humid air mass moves over relatively cold ground and condensation occurs. It can also form when a warm humid air mass encounters a somewhat cold lake or ocean. An example is the warm air over the cooler Great Lakes during the summer.

(d) Hail

Hail refers to raindrops that have frozen in the sky and fall to the earth's surface as crystals, pellets or ice. They take long before they fall enabling them to grow in size. They are made of frozen raindrops which exceed 5 mm in diameter. Hail usually forms in cumulonimbus clouds, resulting from the uplift of air by convectional currents or at a cold front. They are very destructive because of their size. Hail is common in mid latitude areas.

(e) Rime

Rime is formed when fog is moved up by wind against objects when temperatures are below freezing point. It is a white, thick, heavy and opaque mass of tiny crystals.

This is normally formed on the surface of such objects as trees, poles, wires and roof tops of houses. It is common in high latitude areas.

(f) Snow

Snow is formed from solid water ice crystals that agglomerate together becoming flakes. Big ones form near freezing points and small ones form at colder temperatures. Snow is formed when water vapour freezes and condenses at a temperature below freezing point. This forms ice particles. If hygroscopic or freezing nuclei are present, they coalesce to form snowflakes on further condensation. If dew point temperatures are under 0°C, then vapour condenses directly into a solid (sublimation).

(g) Sleet

Sleet is a mixture of ice and snow which falls as frozen raindrops. It is formed when the upper air temperature is below freezing point, allowing snowflakes to form. Lower air temperatures are around 2°C to 4°C. This temperature allows their partial melting. It is formed in high latitude areas.

(h) Glazed frost

It is the reverse of sleet. It occurs when water droplets form in the upper air but turn to ice when in contact with a freezing surface. When it forms on the roads, it is called black ice.

(i) Frost

Frost is a thin layer of ice which looks like powder. Frost forms on the surface of objects like bushes. The condition of the atmosphere must be cold for frost to form.

(j) Dew

It is formed if dew point is above freezing point. It is formed on the earth's surface on buildings, rocks, vegetation and other objects during warm periods of the year. It is formed when condensation occurs close to the ground such that water droplets are able to form. Furthermore, dew arises mostly with clear and calm weather during the evening hours and at night when there is no fog. Snow falls from clouds of different shapes, mostly stratocumulus, high stratus and cumulonimbus during cold periods of the year.

(k) Hoar frost

This forms when dew point is below freezing point. Frost may also be frozen dew. If the lower air is relatively warm, moist air contains hygroscopic nuclei and if the ground cools rapidly, radiation fog may form.

(l) Drizzle

Drizzle is somewhat smaller droplets that drift slowly towards the surface of the earth. It has the diameter of between 0.2 to 0.5 mm. Mostly it falls from low stratus clouds. It is frequently accompanied by fog and poor visibility.

CONDITIONS NECESSARY FOR PRECIPITATION TO OCCUR

- Evaporation has to take place from both land and water masses so as to release water vapour into the atmosphere.
- Transpiration should take place from vegetation so as to release water vapour into the atmosphere.
- Evaporation and transpiration saturate the air causing it to have high humidity.
- Air must contain small particles of matter such as dust around which the moisture droplets form.
- The air must be cooled below its dew point.

Explanation of how precipitation is formed

Precipitation is formed through different processes such as evaporation, transpiration, condensation and sublimation. When water present on both land and water masses (such as streams, rivers, lakes, seas and oceans) is heated by energy from the sun, it breaks into hydrogen and oxygen atoms. This gives rise to vapour. The process whereby water changes from liquid state to gas (vapour) is called ***evaporation***. Additionally, vapour is also lost from vegetation through openings found underneath the leaves called ***stomata***, through a process known as ***transpiration***. The combined loss of vapour from vegetation, land and water masses is referred to as ***evapotranspiration***.

When vapour has been released into the atmosphere, is starts losing its temperature to the air that surrounds it. This follows a decrease in temperature because the higher one goes, the cooler it becomes. It reaches a point that this vapour cools below its dew point. This point is also called ***adiabatical cooling***. Water droplets cling around the condensation nuclei such as small particles of matter like dust. When this happens, tiny water droplets start forming. The droplets eventually enlarge as more and more water droplets join them through a process called ***condensation***.

When the diameter of water droplets enlarges, they combine to form a cloud which can no longer be held in the atmosphere. Eventually, it is pulled by the gravitational force emanating from the core, the most interior part of the earth. This process whereby water droplets fall onto the earth's surface is called ***precipitation***. This takes such forms as rain, fog, snow, hail, drizzle, rime, frost and sleet.

Activity 2.4.24:

In groups of five, complete the flow diagram below. Later, discuss the stages of the processes through which precipitation is formed; write a short essay to describe the process of precipitation formation. Present your findings to the whole class.

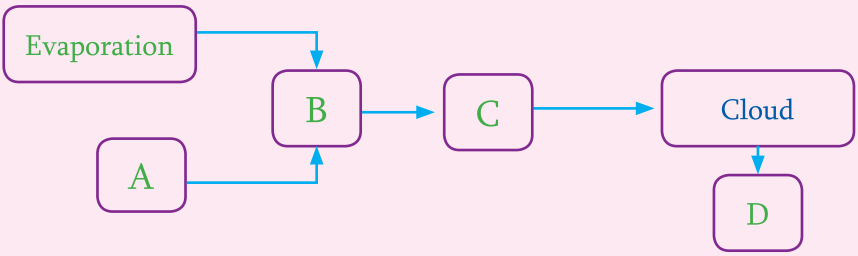


Fig. 2.4.49: Flow diagram showing stages in the formation of precipitation

RAINFALL

Types of rainfall

There are three basic types of rainfall. These are convectional, cyclonic and relief rainfall.

(a) CONVECTIONAL RAINFALL

How does convectional rainfall form?

Study the flow diagram below illustrating how convectional rainfall forms.

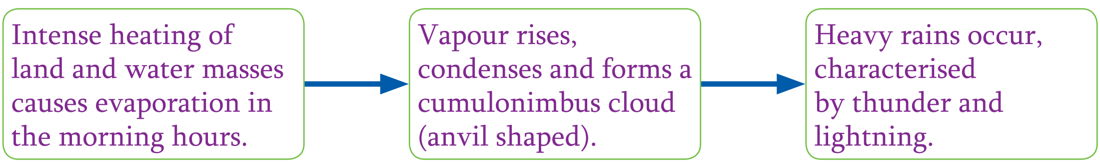


Fig. 2.4.50: Flow diagram showing how convectional rainfall forms

Explanation

Convection rainfall forms when there is intense heat originating from the sun reaching land and water masses during morning hours. This causes a lot of evaporation from both land and water masses. As a result, more water molecules are broken down by the solar energy into hydrogen and oxygen atoms. These atoms give rise to water vapour. This water vapour is transported by air upwards as it rises to form a big cumulonimbus cloud that is anvil shaped. Heavy rains occur often characterised by thunder and lightning. See Fig. 2.4.51 below.

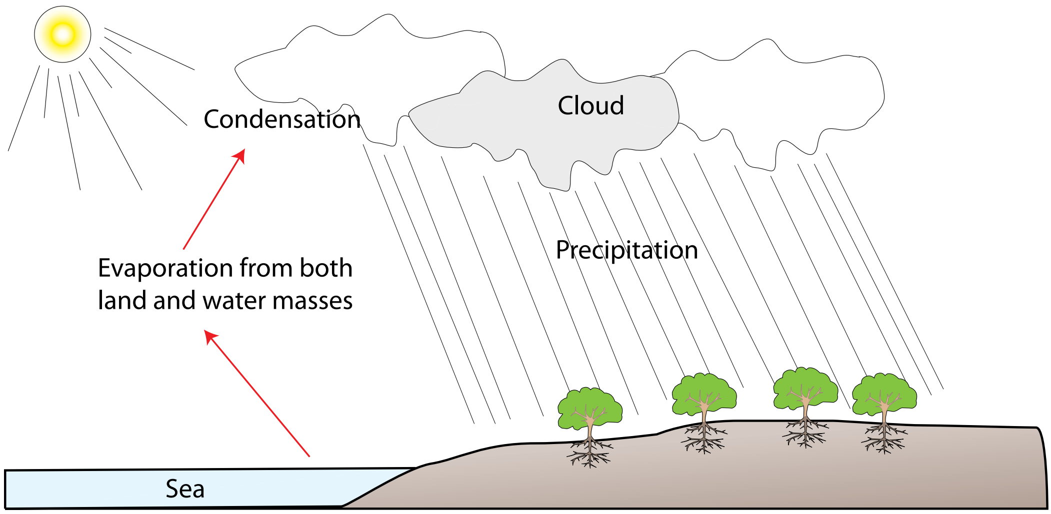


Fig. 2.4.51: Formation of convectional rainfall

Characteristics of convectional rainfall

Convectional rainfall is characterised by the following:

1. Thunder
2. Lightning
3. An anvil shaped cloud
4. It usually falls in the afternoon.

Areas where convectional rainfall is common

- It is the most common type of rain in equatorial regions, and in regions having a tropical monsoon climate. This is because the sun is directly overhead in these areas.
- In humid tropical regions of Indonesia, Malaysia, Central and West Africa, Amazon Basins and Central America.

(b) CYCLONIC, FRONTAL OR DEPRESSION RAINFALL

How does cyclonic, frontal or depression rainfall form?

Two air masses of different temperatures meet along the front. → Warm air mass rises up over cold air mass because it is lighter. → Warm air condenses, clouds form bringing about rainfall.

Fig. 2.4.52: Flow diagram illustrating how cyclonic or depression rainfall forms

This type of rainfall is formed when two air masses of different temperatures (one warm and one cold) meet along a line of separation called a front. The result of this meeting is that the warm air mass rises over the cold air mass because it is lighter. The rising warm air has a lot of moisture within it that cools when subjected to low temperatures. Condensation takes place and clouds form. This consequently brings about rainfall which is called cyclonic, frontal or depression rainfall. See Fig. 2.4.53 below.

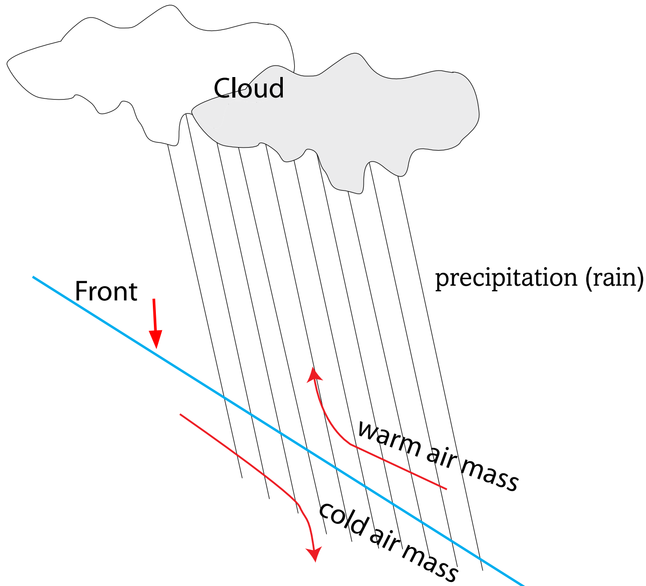


Fig. 2.4.53: Formation of cyclonic, frontal or depression rainfall

Characteristics of cyclonic, frontal or depression rainfall

- In tropical cyclones, the rainfall is often very heavy but it lasts for only a few hours.
- In temperate depressions, the rainfall is much lighter but it lasts for many hours or even days.
- Cyclonic rainfall is common throughout the doldrums where trade winds meet.

Areas where cyclonic, frontal or depression rainfall is common

- It occurs in temperate areas, especially between the Arctic and the continental air masses.

(c) OROGRAPHIC OR RELIEF RAINFALL

Terminologies

- **Windward side**: This is the side that receives rainfall because it faces the rain-bearing winds.
- **Leeward side**: This is the side that receives little or no rainfall because it receives dry air.

How does orographic or relief rainfall form?

Onshore winds rise up over hilly or mountainous regions lying at right angles to the direction of onshore winds. → Winds rise up and the vapour in it cools and condenses to form a cloud on the *windward side*. → Precipitation (rainfall) results on the windward side. → There is little or no rainfall on the *leeward side* because descending air is dry.

Fig. 2.4.54: Flow diagram showing how orographic or relief rainfall is formed

Explanation

Orographic or relief rainfall is formed when onshore winds rise up over hilly or mountainous regions lying at right angles to the direction of unsaturated, warm maritime air. These winds rise up and the vapour they carry eventually cools, because temperature decreases the higher they rise. A cloud is formed on the windward side. Consequently, this side receives heavy rainfall and has evergreen vegetation. On descending to the leeward slope, a decrease in altitude increases both pressure and the temperature. Air is compressed and warmed. Consequently, the relative humidity will drop. As the maritime air crosses the hill or mountain; it becomes dry. This is because it has lost moisture in form of rainfall on the windward side. This is why it bears little or no rainfall on the leeward side.

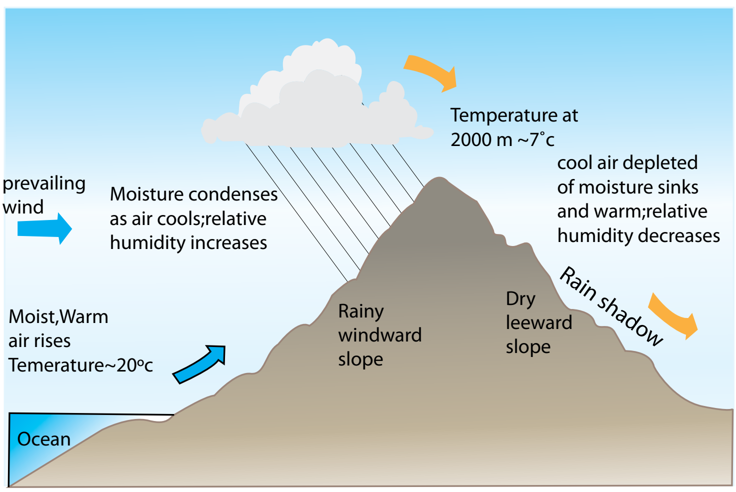


Fig. 2.4.55: Formation of orographic rainfall

Characteristics of orographic or relief rain

- It occurs in all latitudes.
- It mainly forms on the windward slopes of mountains which face rain-bearing winds.

Examples of areas which experience orographic rainfall in Malawi and beyond

- South east facing slopes of the Nyika Plateau where winds originate from Lake Malawi.
- Southeast facing slopes of Viphya Plateau where winds originate from Lake Malawi.
- Southeast facing slopes of Mulanje Mountain where winds originate from the Indian Ocean.
- Western side of the Rockies fold mountain where onshore winds originate from the Pacific Ocean.
- Northeast of Peninsular Malaysia, western New Zealand, western Scotland and Wales.
- The Assam Hills of India and Bangladesh.

AREAS IN THE WORLD RECEIVING DIFFERENT TYPES OF RAINFALL

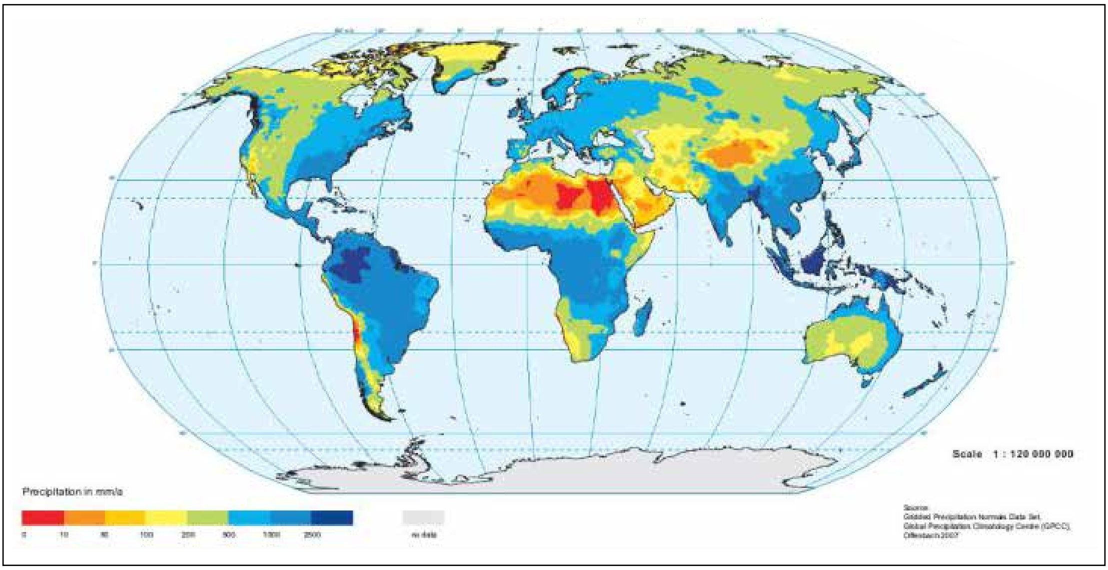


Fig. 2.4.56: Areas in the world that receive different types of rainfall

INTERPRETATION OF RAINFALL DATA FROM VARIOUS SOURCES

It is extremely important to be able to interpret rainfall data from various types of graphs and tables.

Example 1: Observe the graph showing the tropical monsoon climate of Darwin and interpret the annual trend of rainfall. Organise the rainfall data in form of a table.

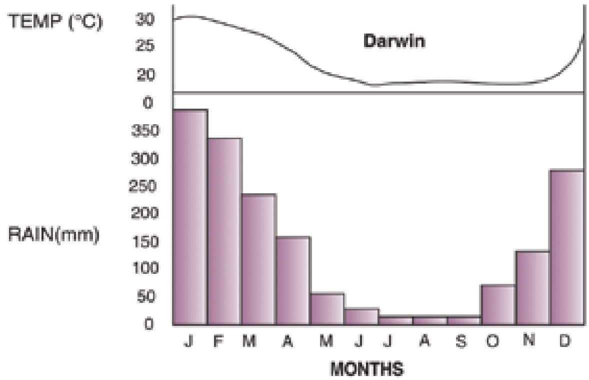


Fig. 2.4.57: Tropical monsoon climate of Darwin

This information can be put in the table as indicated below:
Table 51: Annual trend of rainfall of Darwin

	J	F	M	A	M	J	J	A	S	O	N	D
Rain (mm)	400	325	230	150	50	25	10	10	10	60	125	275

Implication of the data above

- There is heavy rainfall in summer in Darwin from November to April, but it decreases in the month of May. This is because of the decreasing amount of temperature.

Example 2: Below is the climatic graph of Havanna. Organise the information in a table.

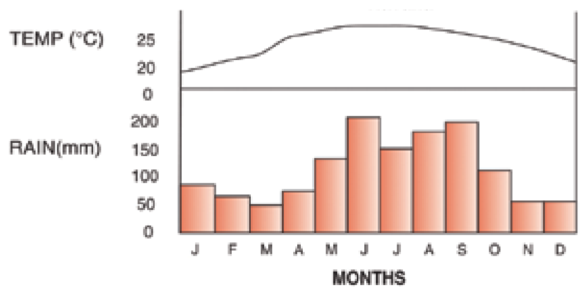


Fig. 2.4.58: Climatic graph of Havanna

This information can be put in the table as indicated below:
Table 52: Annual trend of rainfall of Havanna

	J	F	M	A	M	J	J	A	S	O	N	D
Rain (mm)	90	65	50	75	140	230	160	195	200	120	65	65

Implication of the data above

- There is heavy rainfall in summer in Karonga District in Malawi from November to April. The rainfall decreases in the month of May because of decreasing amount of temperature.

Activity 2.4.25:

In pairs, observe the rainfall graph of Darwin below and interpret it to give meaning of the rainfall data.

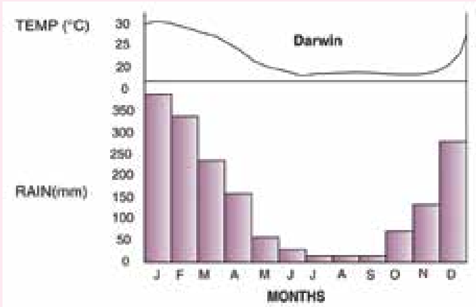


Fig. 2.4.59: Climate of Darwin

Activity 2.4.26:

Below is the map of Malawi showing rainfall distribution. Use it to do the activity that follows.

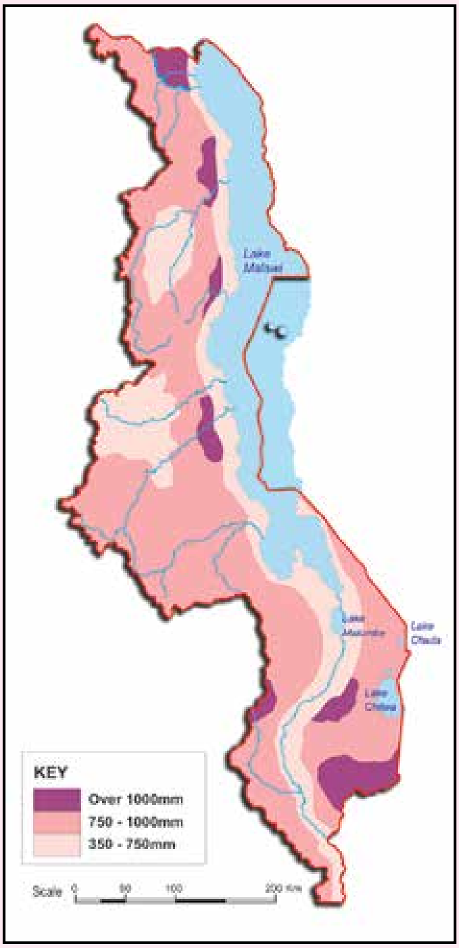


Fig. 2.4.60: Rainfall distribution of Malawi

In groups of five, observe the map of Malawi above and answer the following questions:

(a) Which areas receive the highest amount of rainfall in Malawi?

(b) Which areas receive the lowest amount of rainfall in Malawi?

(c) What could be the possible reasons for the answers given in (a) and (b) above?

Review Questions

Q1. (a) Define the term 'air pressure'.

(b) How do the following factors influence air pressure?

(i) Altitude

(ii) Temperature

(iii) Rotation of the earth

(iv) Humidity

Q2. (a) Draw the globe and indicate the following pressure belts on it:

(i) Polar high pressure belts

(ii) Temperate low pressure belts

(iii) Sub-tropical high or horse latitude pressure belts

(iv) The Doldrums low pressure belts

(b) Account for the distribution of such air pressure belts.

(c) Observe the temperature and altitude data in the table below and answer the questions that follow:

Table 53: Temperature and altitude data of areas E, F, G, H and I

Area	Altitude (m)	Boiling temperatures of water (°C)
E	0	100
F	300	99
G	900	97
H	1,500	95
I	3,000	90

(i) At which point is air pressure highest? Give a reason for your answer.

(ii) At which point is air pressure lowest? Give a reason for your answer.

(iii) If you were to boil water quickly, at which point would you choose? Explain your answer.

Q3. (a) What do you understand by the term ‘prevailing winds’?

(b) Differentiate between prevailing winds and local winds.

(c) Give examples of prevailing winds and their characteristics.

(d) Draw the globe and indicate prevailing winds on it.

(e) Explain how prevailing winds are influenced by air pressure in terms of their movement.

(f) Draw the globe and illustrate how prevailing winds would behave if the earth were non-rotating and rotating.

(g) Plot isobars on the air pressure map below.

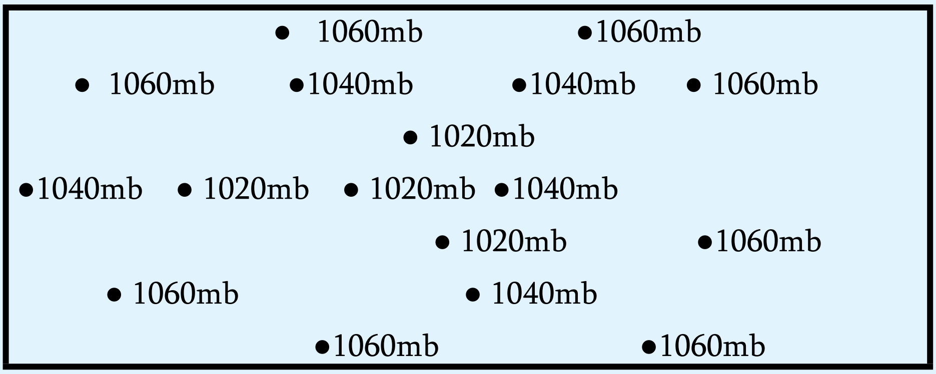


Fig. 2.4.61: Air pressure map

Q4. (a) Define the term ‘air mass’.

(b) Mention the main types of air masses.

(c) Explain the weather that is associated with each type of air mass mentioned in Q4 (b) above.

(d) Identify any four air masses that have influence on weather patterns on the African continent.

Q5. (a) What do you understand by the term ‘front’?

(b) Observe the following diagrams and then identify the types of fronts related to each one of them.

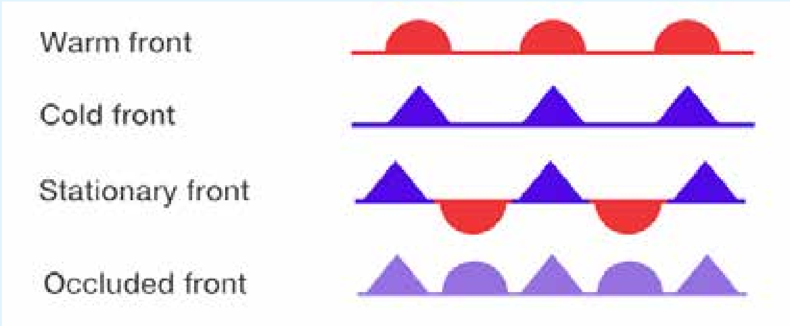


Fig 2.4.62: Fronts

(c) Explain how each type of front identified is formed.

(d) Give any one characteristic of each of the types of fronts.

(e) Draw the world map and locate the different types of fronts on it.

(f) Describe the weather that is associated with each type of front.

Q6. (a) Define the term 'Inter-Tropical Convergence Zone (ITCZ)'.

(b) Explain the impact of the Inter-Tropical Convergence Zone on the weather patterns of Malawi.

Q7. (a) What does the term 'local winds' mean?

(b) Below is a world map showing local winds. Use it to answer the questions that follow:

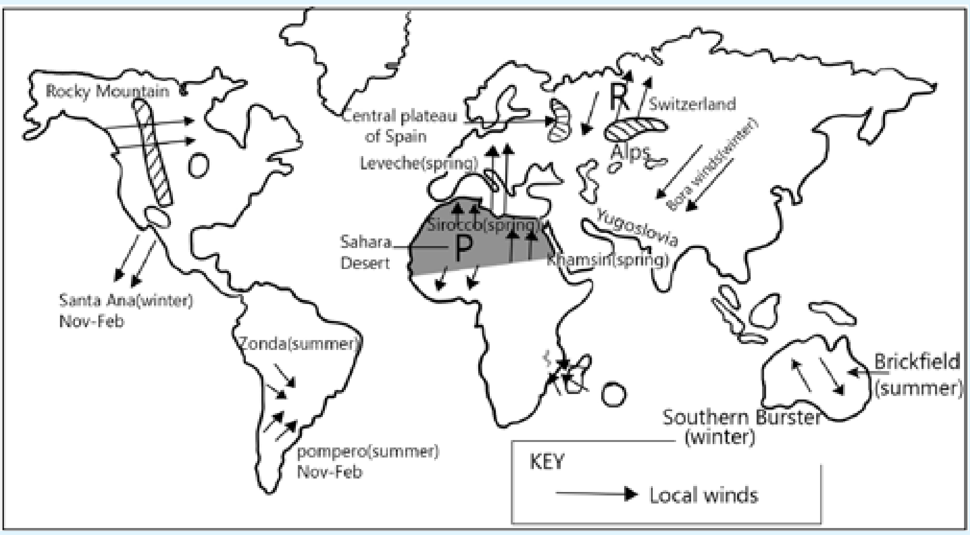


Fig. 2.4.63: Local winds

(i) Identify the local winds labelled O, P, Q and R.

(ii) List any two characteristics of each one of these local winds.
(iii) Explain any one effect of each one of these local winds.
(iv) With the aid of a diagram, describe how local winds occur.

Q8. (a) With the aid of good diagrams, describe how land and sea breezes occur.

(b) Explain the influence of land and sea breezes on local weather and human activities.

Q9. (a) Differentiate between cyclones and anticyclones.

(b) With the aid of a good diagram, explain how a tropical cyclone develops.

(c) Below is a diagram showing development of a temperate cyclone. Use it to answer the questions that follow.

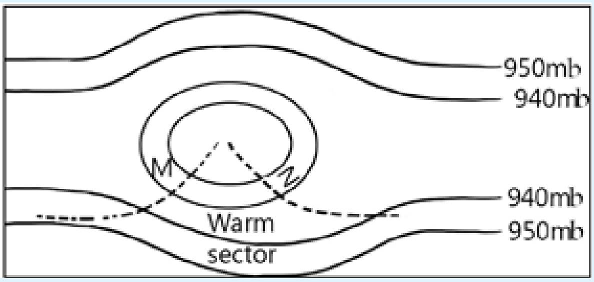


Fig. 2.4.64: Development of a temperate cyclone

(i) Identify the parts labelled M and N.
(ii) Describe how the temperate cyclone or depression develops.

(d) Explain the weather that is associated with tropical and temperate cyclones.

Q10.(a) Define the term 'clouds'.

(b) With the aid of a good diagram, explain how clouds form.

(c) Copy and complete the table below:

Table 54: Categories of clouds

Type or category of clouds	Examples
High clouds	
Middle clouds	
Low clouds	
Clouds with vertical development	

(d) Explain the type of weather that is associated with each example of the categories highlighted.

Q11. (a) Explain the meaning of the term 'precipitation'.

(b) Below is a Geography word scramble with jumbled up letters on the left representing various types of precipitation. Write the correct term on the blank spaces on your right.

Table 55 showing examples of forms of precipitation

Questions	Answers
Gof	
Nira	
Tims	
Mire	
Wons	
Leset	
Wed	
Rildezz	
Lahi	

(c) State any four conditions that are necessary for precipitation to form.

(d) Explain how precipitation is formed.

Q12. (a) Below is a figure showing the formation of orographic or relief rainfall. Use it to answer the questions that follow.

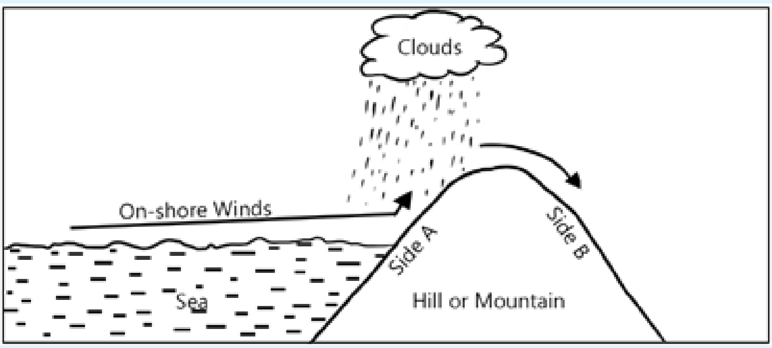


Fig. 2.4.65: Formation of orographic or relief rainfall

(i) Identify the sides A and B.

(ii) Explain how orographic rainfall is formed.

(b) List any two characteristics of the following types of rainfall.

(i) Orographic or relief rainfall

(ii) Frontal, cyclonic or depression rainfall

(iii) Convectional rainfall

(c) Give any two examples of areas which receive the types of rainfall listed in Q12(b) above.

(d) With the aid of good diagrams, explain how cyclonic, depression or frontal, and convectional types of rainfall are formed.

Q13. Below is the rainfall graph of Vancouver. Use it to answer the questions that follow:

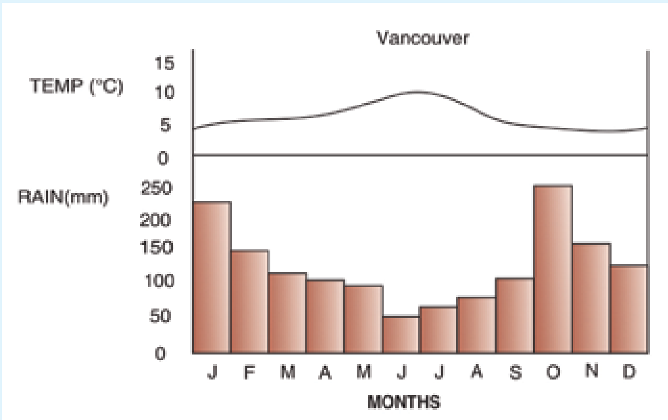


Fig. 2.4.66: Rainfall pattern of Vancouver

(a) In which months is the rainfall highest and lowest?

(b) In which hemisphere is this station? Explain your answer.

TOPIC

5 World Climate and Climatic Regions

Success criteria

By the end of this topic, the student should be able to:

- Explain the climatic regions.
- Identify world climatic regions.
- Explain characteristics of climates and associated vegetation.
- Explain the influence of climate and vegetation on economic activities.

Background

In Form One, you looked at the differences between weather and climate, and the elements of weather which include temperature and rainfall. In Form Three,we will learn about, world climate in terms of the characteristics of different types of climate, their associated agricultural activities as well as factors that hinder agricultural development in areas affected by these climates.

Meaning of the term 'climatic region'

Activity 2.5.1:

Brainstorm on the meaning of the term 'climatic region'.

A climatic region refers to a particular area having average atmospheric conditions for a considerable period of time.

IDENTIFICATION OF WORLD CLIMATIC REGIONS ON THE WORLD MAP

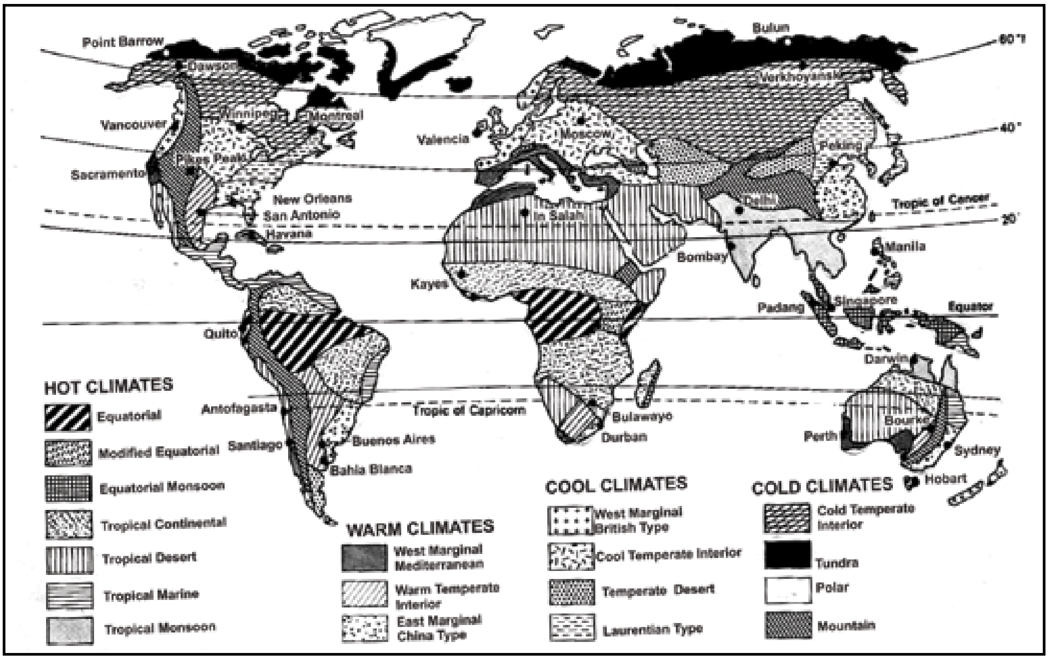


Fig. 2.5.1: World map showing different climates

CRITERIA THAT IS USED TO CLASSIFY WORLD CLIMATE

Activity 2.5.2:

Brainstorm on the criteria that are used to classify world climates.

Classifiers of world climates have chosen temperature and precipitation as the most significant and understandable features of climate. Initially, Greeks spoke of three climatic zones namely:

(i) Temperate zone of the mid-latitudes
(ii) Torrid zone of the tropics at the South
(iii) Freed zone to the North

Today, we recognise five climatic zones in the world. These are:

(a) Equatorial warm wet zone
(b) Tropical hot-dry zone
(c) Sub-tropical warm temperate zone
(d) Mid-latitude cool temperate zone
(e) High latitude cold zone

Activity 2.5.3:

In groups of five, identify the world climatic regions highlighted above.

THE KÖPPEN SYSTEM

How does the Köppen system work?

The Köppen system uses a numerical basis of classification (either average temperature or average rainfall) and zone boundaries are determined by vegetation.

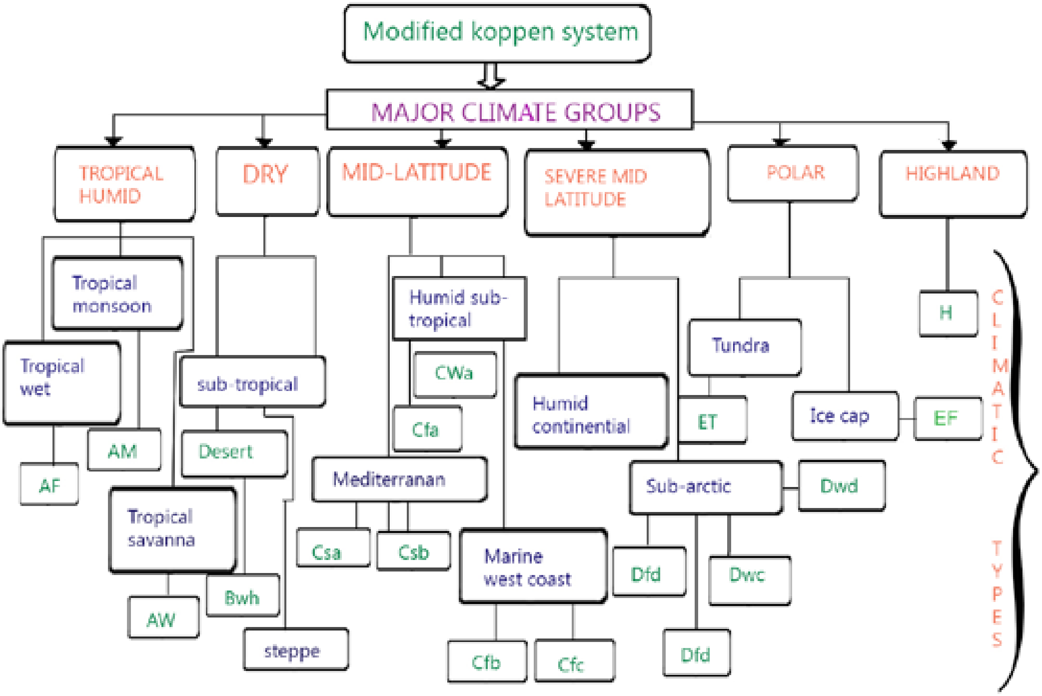


Fig. 2.5.2: Modified Köppen system of classification

Source : Mcknight, T.L. and Hess, D. (2005)

Criteria or attributes of the Köppen system

- They are relatively simple to comprehend and use.
- They show some sort of an orderly pattern over the world.
- They give some indication of zone genesis.

A. TROPICAL CLIMATES

These climates are dominant within the tropical belt. They include the following:

1. Equatorial climate
2. Tropical continental (Sudan) climate
3. Tropical desert climate

1. EQUATORIAL CLIMATE

Location of Equatorial Climate

- It is located between latitudes 5° North and 5° South of the equator. Areas that experience this climate include the Amazon Basin (South America), the Congo Basin, Southern Ivory Coast, South Western and Central Ghana, and Western and Coastal Nigeria.

Climatic characteristics of Equatorial Climate

(a) There are no definite seasons because there is low pressure throughout the year.

(b) Average daily temperatures are 26°C and annual temperature range is 3°C. This is caused by an almost constant length of the day all year with the mid-day sun being always near-vertical.

(c) Heavy convectional rainfall accompanied by thunder and lightning comes usually in the afternoon. Annual rainfall is about 2000 mm.

(d) Humidity is always high due to high evaporation.

(e) Mid-day sun is always near-vertical. It is overhead twice a year, at the equinoxes.

Table 56: Climate of Entebbe-Uganda

	J	F	M	A	M	J	J	A	S	O	N	D
Temp. (°C)	27	27	27	26	25	25	25	26	27	27	26	26
Rain (mm)	65	85	150	250	225	125	75	75	75	112	125	125

Table 57: Climate of Libreville, Gabon Coast

	J	F	M	A	M	J	J	A	S	O	N	D
Temp. (°C)	30	31	31	31	30	29	28	28	29	29	29	30
Rain (mm)	250	250	325	300	213	25	25	25	100	275	380	200

Activity 2.5.4:

In groups of five, discuss the characteristics of equatorial climate.

Agricultural and economic development

(i) People earn their living through hunting and gathering.

(ii) Shifting cultivation is practiced because of the presence of evergreen tropical rainforests.

(iii) Plantation agriculture is also practiced. For example, cocoa growing in Ghana, sugarcane cultivation in Cuba, oil palm growing in Malaysia and Zaire, among others.

(iv) The timber industry (lumbering), whose valuable trees include mahogany, ebony and green heart (hardwood trees), thrives in those areas experiencing equatorial climate.

Things that retard development in the Equatorial Climate

(a) Diseases and insect pests are common. This is because of the prevalence of a hot and wet climate that creates a conducive environment for multiplication of a variety of insects. For example, tsetse flies (*katsembe*) that transmit trypanosomiasis in cattle and sleeping sickness in human beings are a dominant characteristic of the equatorial climate. Consequently, animal rearing is adversely affected because of this and other related diseases.

(b) Since the areas affected are densely forested, transportation becomes a problem. Roads and railway lines are difficult and expensive to construct.

(c) There is loss in soil fertility due to leaching.

(d) While the tropical areas have the potential in timber resources, commercial extraction is difficult. This is because of the absence of frozen surfaces to facilitate loggings. Tropical hardwoods are sometimes too heavy to float in rivers.

2. TROPICAL CONTINENTAL (SUDAN) CLIMATE

Location of Tropical Continental (Sudan) Climate

- It occurs between 5° and 15° North and South of the equator.
- It is mainly experienced in Africa and east, central and South America.
- In Africa, it is called ***Savanna***.

Characteristics of Tropical Continental (Sudan) Climate

(a) There are definite wet and dry seasons which coincide respectively with the hot and cooler seasons. A hot rainy season alternates with a cool, dry season.

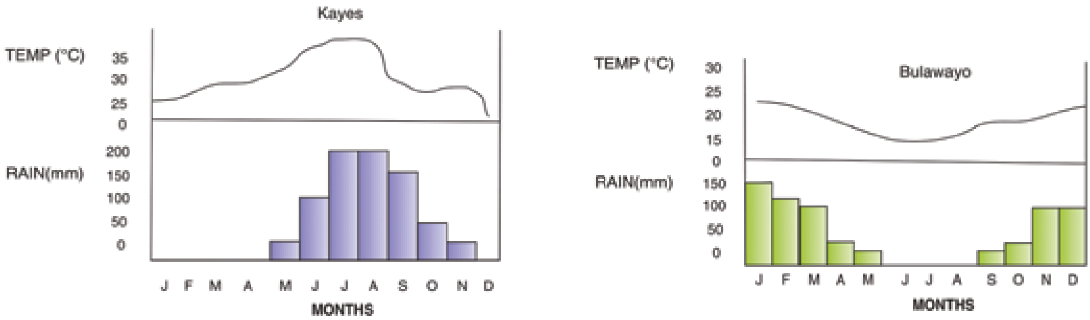


Fig. 2.5.3: Sudan climate

Climate of Chileka

Table 58: Climate of Chileka

	J	F	M	A	M	J	J	A	S	O	N	D
Temp. (°C)	28	27	27	26	25	24	23	24	25	27	29	30
Rain (mm)	220	185	140	45	08	-	-	-	-	10	75	190

Climate of Salima

Table 59: Climate of Salima

	J	F	M	A	M	J	J	A	S	O	N	D
Temp. (°C)	28	28	29	27	26	25	24	25	29	33	32	30
Rain (mm)	340	290	275	80	10	-	-	-	-	03	35	225

(b) Summers are hot with temperatures around of 32°C. Winters are cooler about 21°C. Annual temperature range is about 11°C.

(c) Heavy convectional rainfall is common in summer. Winters are usually dry.

(d) The annual rainfall if often around 762 mm. This amount of rainfall may be more in coastal regions and less near the hot deserts.

(e) The highest temperatures occur just before the rainy season begins. This includes the months of April in the northern hemisphere and October in the southern hemisphere.

(f) Humidity is high in summer.

Activity 2.5.5:

In groups of five, discuss the characteristics of tropical continental climate.

Agricultural and economic development

Agriculture is not well developed in the Africa Savanna because some farmers still follow primitive agricultural practises.

(i) Nomadic pastoralism is practiced, especially by the Maasai community of Kenya in East Africa.

(ii) In some areas like Nigeria, crops are grown. For example, the Hausa and Agikuyu communities of East Africa grow millet, maize, bananas, groundnuts and beans.

(iii) Commercial plantation agriculture is also carried out, for example in Kenya and Malawi, where tea is grown in plantations.

Factors preventing further expansion of agricultural development

(a) Unreliable rainfall (droughts are common).

(b) Diseases and insect pests

(c) Loss of soil fertility

3. TROPICAL DESERT CLIMATE

Location of Tropical Desert Climate

- The main areas experiencing this climate are the Sahara Desert, the Arabian Desert, the Iranian Desert, the Thar Deserts, the Australian Desert, the Namib Desert, Atacama Desert, the California and Mexican Deserts.

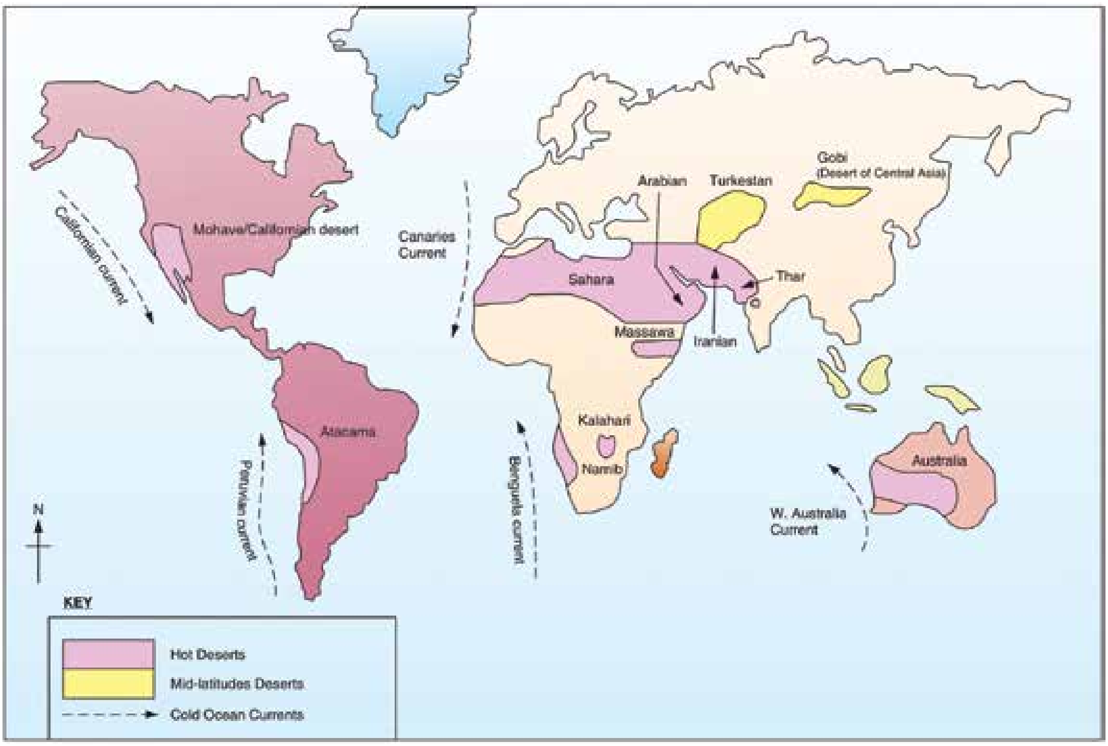


Fig. 2.5.4: World map showing location of deserts

Characteristics of Tropical Desert Climate

(a) Rain rarely falls. Average annual rainfall is about 120 mm.

Table 60: Climate of Walvis Bay, Namibia Coast

	J	F	M	A	M	J	J	A	S	O	N	D
Temp. (°C)	18	19	19	18	17	16	16	14	15	17	18	17
Rain (mm)	3	3	7	3	-	-	-	-	-	-	-	3

Table 61: Climate of CapeJuby, Morrocan Coast

	J	F	M	A	M	J	J	A	S	O	N	D
Temp. (°C)	16	16	17	18	18	20	20	20	21	20	18	16
Rain (mm)	13	13	13	-	-	-	-	13	13	13	13	25

(b) The climate is common in tropical high pressure belts.

(c) Temperatures vary from 29 °C in hot seasons to 10°C in cool seasons.

(d) Day temperatures often go over 38°C. This is because of absence of clouds. Temperatures fall to 15°C in cool seasons at night mainly because of clear skies. Diurnal (daily) temperature range is very high.

Activity 2.5.6:

In groups of five, discuss the characteristics of desert climate.

Agricultural development

1. Irrigation agriculture can take place. Crops grown include wheat, dates, vegetables and fruits.
2. Nomadic herding takes place in Sahara and Arabian deserts. For example, Tuaregs of North Africa and Bedouins of Saudi Arabia practice nomadic herding.

Factors that prevent further agricultural development

- Very limited quantities and distribution of available fresh water. This can be solved through ice towing from the Antarctic to the hot desert areas.

B. TEMPERATE CLIMATES

These are experienced within the temperate regions. They include the following:

1. Mediterranean or warm temperate western margin
2. Cool temperate interior

1. Mediterranean or Warm Temperate Western Margin Climate

Location of Mediterranean Climate

- This climate occurs between 30°N and 45°N, and 30°S and 45 °S, on the western side of continents.
- The climate is mainly experienced around the shores of the Mediterranean Sea, South Africa, central Chile, central California, Southwest and southern Australia.

Characteristics of Mediterranean Climate

(a) This is a unique type of climate because it receives rainfall in winter. It receives both cyclonic and convectional rainfall. Annual rainfall is between 500-900 mm.

(b) Temperature ranges from 21°C in summer. These winds are dry and thus bear no rains.

(c) Onshore westerly winds blow in winter bringing cyclonic rainfall.

(d) Areas affected experience local winds. A local wind like Sirocco is hot, dusty and dry. This wind blows in summer across the Mediterranean Sea from the Sahara desert. Mistral (strong and cold wind) blows in the winter from the north down the Rhone Valley. Bora blows in winter and develops because of pressure difference.

(e) Soils are generally low in humus, neutral to alkaline in pH, low in biological activity, low in nitrogen and phosphorous, and slow in the decomposition of organic matter. The rugged topography generally leads to a mosaic of old and new soils, with extensive areas of deep alluvial soils (particularly in California), thin soils on slopes due to extensive erosion, and a general susceptibility to erosion, degradation and desertification.

(f) Majority of the regions experiencing this climate are located between 32° and 41° North or South of the equator.

(g) All regions are situated along the coast of oceans or the Mediterranean Sea.Apart from the large portions of the Mediterranean Basin, all other regions are on the west coasts. Strong, cold, up-welling currents bathe the coastal regions with cool marine air and moderate winter temperatures, except for the Mediterranean Basin and South and Western Australia.

(h) Summers are warm and hot, while winters are cool but mild, with one month averaging below 59° F (15 °C); sub-freezing temperatures do not occur more than 3% of the total time.

(i) Rugged mountains, frequently parallel to the coastline (except in Australia), influence and modify climatic patterns, forming distinct rain shadows and micro-climates.

Activity 2.5.7:

In groups of five, discuss the characteristics of Mediterranean Climate.

Agricultural development of Mediterranean climate

(a) This climate suits growth of crops such as fruits and cereals.

(b) Citrus fruits (oranges, lemons, grapes and limes) are extensively grown. This is made possible through irrigation.

Important agricultural activities in the Mediterranean Climate

- Olive trees are grown. They are useful for making cooking oil.
- Growing of grapes (viticulture)- used for making wine.
- Growing of wheat and barley-for making flour used for baking.

Dominating Industries in Mediterranean climate

- Wine-making, flour-milling, fruit-canning and food-processing.

2. Cool Temperate Interior Climate

Location of cool temperate interior

- It occurs in the interior of North America and Eurasia, between latitudes 35°N and 60°N.
- It is mainly experienced in the provinces of Alberta, Saskatchewan and Manitoba in Canada; North Central and mid-west of the U.S.A.; in central and eastern Europe and western USSR.

Characteristics of Cool Temperate Interior Climate

(a) Winter temperatures often fall to as low as -19°C with summer temperatures rising to 18°C. Annual temperature range is 37°C.

(b) Convectional rainfall falls in summer. Annual total rainfall rarely exceeds 513 mm. Rainfall decreases towards the East in Eurasia and towards the West in North America. Rainfall intensity decreases as one moves towards the poles.

Note: This climate is not found in the southern hemisphere.

Table 62: Characteristics of Cool Temperate Interior Climate

Months	Temperature (°C)	Rain (mm)
J	– 20	10
F	– 17	17
M	– 9	29
A	3.6	34
M	11	53
J	16	82
J	19.1	79
A	17.3	56
S	12	53
O	4	34
N	– 6	28
D	13.9	23

Activity 2.5.8:

In groups of five, discuss the characteristics of cool temperate interior climate.

Agricultural development in Cool Temperate Interior Climate

(a) Growth of wheat is important in both America and the Eurasian regions.

(b) Mixed farming is practiced in some regions. For instance, cattle are reared alongside growing wheat and other temperate cereals in the European and Soviet regions.

Review Questions

Q1. Below is a map showing world climates. Use it to answer the questions that follow.

Fig. 2.5.5: World climates

(a) Identify the climates marked A, B, C, D, and E.

(b) Describe any two characteristics of each of the climates identified in Q1 (a) above.

(c) Explain any three factors that promote agricultural development in the regions identified in A, B, C, D and E.

(d) Of what economic importance are the climates A and B?

(e) Explain any factors which hinder economic and agricultural development in the climatic regions A, B, C, D and E.

Q2. Below is a table showing the climate of Chitedze in Malawi. Use it to answer the questions that follow.

Table 63: Climate of Chitedze in Malawi

	J	F	M	A	M	J	J	A	S	O	N	D
Temp. (°C)	26	27	28	27	26	24	23	24	27	30	29	27
Rain (mm)	220	185	148	45	04	-	-	-	-	05	75	190

(a) Identify the type of climate that is associated with the climatic data above.

(b) Describe any three characteristics that are associated with the climate identified above.

(c) What types of agriculture dominate in this region?

(d) Mention the challenges that are faced by agriculture in this region.

Q3. Below is a figure showing location of deserts on the world map. Use it to answer the questions that follow.

Fig. 2.5.6: Location of deserts on the world map

(a) Identify the deserts marked A, B, C, D and E.

(b) Give any two characteristics of desert climate.

(c) Mention any two agricultural activities that are associated with desert climate.

Q4. Below is a table showing the type of climate in a certain region. Use it to answer the questions that follow:

Table 64: Climate Data

	J	F	M	A	M	J	J	A	S	O	N	D
Temp. (°C)	9	10	11	12	19	20	22	22	21	18	12	9
Rain (mm)	99	81	81	49	35	10	-	-	5	11	80	98

(a) Identify the type of climate that is associated with the climatic data above.

(b) Describe any three characteristics that are associated with the climate identified above.

(c) What types of agriculture dominate in this region?

(d) Mention the challenges that are faced by agriculture in this region.

TOPIC 6

The Biosphere (World Climatic Biomes)

Success criteria:

By the end of this topic, the student should be able to:

- Explain characteristics of vegetation associated with different types of climates, that is, equatorial, tropical continental, tropical desert, cool temperate interior and Mediterranean (warm temperate western margin).
- Explain the influence of vegetation associated with different climates on economic activities.

Background

In Form Two, you learnt about forestry in Malawi. You looked at the meaning of the term 'forestry', distribution of forest reserves in Malawi and importance of this natural vegetation. In Form Three, you will look at the characteristics of vegetation associated with different types of climates. You will also look at the influence of vegetation associated with different climates on economic activities.

Natural vegetation refers to the different types of plants (trees, grass and shrubs) that grow on their own, without any interferance or modification by the human beings. This kind of vegetation can be modified or interfered with through agro-forestry, urbanisation, animal rearing, desertification and fire.

DESCRIPTION OF VEGETATION

Vegetation can be described according to its structure and physical properties. The following are the features one would look at to describe vegetation.

(a) Life forms

(i) Trees (with main trunks and branches) and shrubs (with branches and stunted in growth).

(ii) *Lianas* (those that climb upon other plants).

(iii) Herbs (they do not have a woody structure).

(iv) Epiphytes (those that live on other plants).

(v) Flowerless plants (those that have no flowers on them).

(b) Size

- Whether the plant is tall, medium or short in height.

(c) Coverage

- Sparsely covered (as in deserts), in groups and continuous (as in equatorial forests).

(d) Their response to annual climatic cycle

Trees may be *deciduous* (losing leaves seasonally) or semi-deciduous (those that shed leaves but not seasonally. They shed within shot periods of time). Others may be *evergreen* (have leaves all year round). Others are *xerophytic* or *drought resistant* (can survive without water), while others are *succulent* (have broad trunks in order to store excessive water). Some plants are *halophytes* (salt lovers), while some are *phreatophytes* (develop long roots).

(e) Leaf size and shape

- Leaves may be broad or needle-shaped.

(f) Leaf texture

- Leaves may be thick, thin and delicate. Others are hard, thick and leathery, thick and spongy.

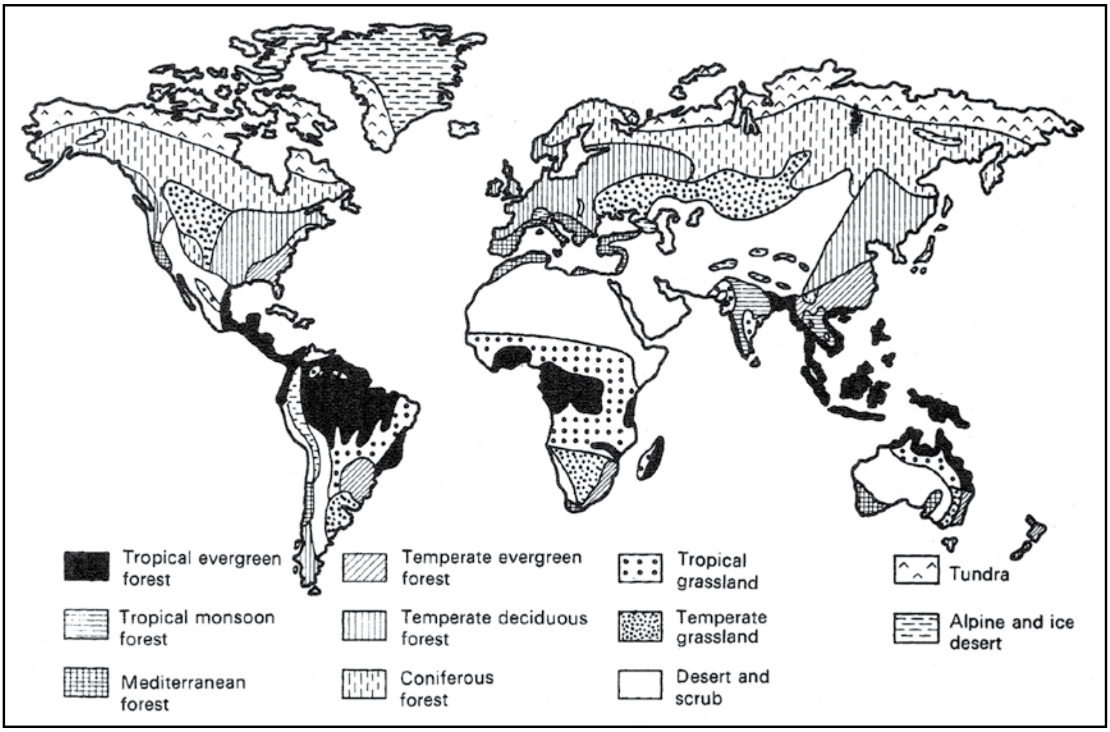


Fig. 2.6.1: World natural vegetation

TYPES OF VEGETATION

1. Tropical Vegetation/Tropical Rainforest/Equatorial Forest

Location of tropical vegetation/tropical rainforest/equatorial forest

- In equatorial climatic regions.

Characteristics of tropical vegetation/tropical rainforest/equatorial forest

(a) Has a wide variety of plants and animals.
(b) The forest consists of three layers; upper layer, middle layer and bottom layer. The bottom layer is mainly dominated by *ferns* and *herbaceous plants* which can grow well in the shade.
(c) Trees grow closely.
(d) Growth is continuous (flowering, fruiting, and shedding takes place throughout the year) because of abundant moisture (over 2000 mm annually) and high temperature, averaging 26°C.
(e) Most trees have *broad leaves* to ensure that there is *enough transpiration* since trees absorb a lot of water.
(f) Trees have *long roots* that ensure *strong support*.
(g) Some trees are *epithytic* and *parasistic* (live on other plants).
(h) Trees are tall forming a canopy. This leads to little or no undergrowth. A thick canopy of foliage develops and it is broken only where there are rivers or where the forest has been cleared for cultivation. Tall trees have a wide variety of *creepers, ferns, orchids* and *lalang* growing on them.
(i) Trees have leaves with *drip tips* so that *rain can drain off easily* since the area receives heavy rainfall.
(j) New trees shoot up quickly so as to reach out for sunlight.
(xi) Most of the *trees are evergreen* because of *abundant moisture*. See Fig. 2.6.2 below.

Fig. 2.6.2: Tropical evergreen forests

Activity 2.6.1:

In groups of five, discuss the characteristics of tropical evergreen forests.

Trees found in tropical forests

- Mahogany, ebony, orchids, rosewood, ironwood and greenheart. These are hardwood trees.

Economic importance of tropical evergreen forests

(a) Trees such as mahogany are used for lumbering.

(b) Shifting cultivation is practiced.

(c) Trees such as ebony are used for creating sculptures.

(d) They trees are used for making poles.

Note: When land is abandoned after its vegetation has been removed, a secondary vegetative cover grows. This vegetation is characterised by short trees and very dense undergrowth.

2. Tropical Grasslands

Location

This vegetation is found in areas that experience tropical continental climate (savanna climate).

Characteristics of tropical grasslands

(a) Trees are *deciduous*. They shed their leaves in order to prevent excess loss of water through transpiration.

(b) Trees have *long roots* to search for ground water.

(c) Trees are *succulent*. They have broad trunks in order to store excess water. For example, the baobab tree has a thick water-storing trunk with minimum leaves to reduce transpiration.

(d) Trees are *umbrella-shaped* to shield their roots from the scorching heat and to expose only a narrow edge to strong trade winds that blow all year round.

(e) Tropical grasslands have tall grass with scattered trees.

(f) Grass dries out in the hot and dry season.

(g) There is a luxuriant growth of both trees and grass.

Did you know?

Tropical Grassland vegetation is succulent, umbrella-shaped, deciduous and has long roots. Find out why it is so.

Activity 2.6.2:

In groups of five, discuss the characteristics of tropical grasslands.

Examples of vegetation in areas that experience tropical continental climate

- Baobab, palm, gum, acacia and elephant grass are found in this region.

Fig. 2.6.3: Tropical Grasslands

Names of different grasslands

(i) Campos (Tropical grassland in Brazil).

(ii) Llanos (Guinea highlands).

(iii) Savanna (Africa and Australia).

Difference between vegetation in the equatorial climate and in savanna climate

(a) Equatorial vegetation is dominated by trees while the savanna type is dominated by grass.

(b) Equatorial vegetation has a continuous canopy while that of savanna is not continuous. This is because in most cases, vegetation in savanna is spiced by grass.

(c) Growth, flowering and fruiting of trees takes place all the time in the equatorial climate while in the savanna climate, it is seasonal.

(d) There are more species of plants in the equatorial climate than in the savanna climate.

(e) Trees in the equatorial climate are evergreen while trees in savanna climate are deciduous.

3. Desert Vegetation

Location of desert vegetation

- It is found in tropical desert climate regions.
- Desert vegetation differs from one part of the world to another. For example, in some cold deserts like Mohave, plants are notably big with some scattered bushes of shrubs and grass. In hot deserts like the Sahara, most areas are bare and without vegetation.

Characteristics of desert vegetation

(a) The vegetation has long roots which are well spread out to gather moisture. The roots get great depth where they can reach water.

(b) Many plants are succulent. This means they can store water in their tissues to be used during dry seasons. An example is the cacti. They have very thick leaves and stems in order to store water.

(c) Stems have a thick waxy cuticle in order to prevent transpiration.

(d) Vegetation is xerophytic or drought-resistant. Examples include scrub vegetation such as bulbous cacti, thorn bushes, long-rooted wiry grasses and scattered dwarf acacias.

(e) The plants produce sleepy seeds (those that lie dormant when it is dry and germinate when water is available). The seeds of many species of grasses and herbs have thick skins to protect them while they lie dormant.

(f) The vegetation is scattered; drought resistant species of plants are dominant.

Fig. 2.6.4: Desert vegetation

(g) Plants have few or no leaves and the foliage is waxy, leathery and hairy or needle-shaped to reduce the loss of water through transpiration.

(h) Some plants shed their leaves during drought.

(i) Some plants are halophytes. These plants are adapted to survive in saline conditions.

Did you know?

Desert vegetation is succulent, xerophytic, and have thick waxy cuticle, long roots and some of them are halophytes. Find out why it is so.

Activity 2.6.3:

In groups of five, discuss the characteristics of desert vegetation.

General plant adaptations in areas that experience desert climate

(i) Plants produce seeds that can lie dormant for long periods of time. When the rains fall, the seeds then germinate and begin flowering.

(ii) Most plants store water in their roots.

(iii) Most of these plants have long and deep roots in order to tap water under the ground. Such vegetation is referred to as *phreatophytes.*

(iv) The plants are *Drought resistant*, that is, they are adapted to surviving with minimum water. Such plants are referred to as *xerophytes*.

Examples of vegetation found

- Cacti, thorn bushes, date palms and shrubs.

Note: There are very few food chains due to lack of grass and limited number of green plants. Indeed, the desert ecosystem is very fragile because organisms do not have alternative sources of food which are available in more complex ecosystems.

4. Temperate Vegetation

Location of temperate vegetation

This vegetation is found in areas that experience Mediterranean climate.

Characteristics of temperate vegetation

(a) Many of the plants are evergreen, maximising potential for photosynthesis.

(b) Trees such as oaks have thick and often gnarled barks to help reduce transpiration.

(c) Others such as olive and eucalyptus have long tap roots to reach underground water supplies. In some cases, many trees have bulbous roots that store water.

(d) Most trees only reach 3 to 5 metres in height.

(e) They provide little shade as they grow at widely spaced intervals.

(f) They have needle-shaped leaves in order to reduce transpiration.

(g) Where natural woodland has been replaced, scrub vegetation develops. For example, chaparral in California, maquis or garrigues in Europe, fynbus in South Africa and malle in Australia.

Characteristics of maquis

- It is taller, denser and has more tangles.
- It grows in areas of impermeable rock (granite).
- It consists of shrubs such as heather and broom.

Characteristics of the garrigue

- It grows on drier and more permeable rocks (limestone).
- It is shorter and less dense than maquis.

Examples of common plants include aromatic shrubs such as thyme, lavender and rosemary.

(h) Native vegetation is dominated by arboreal, shrubby, evergreen and sclerophyllous plants. These plants are adapted to climatic stresses of heat and aridity. A well-developed annual and herbaceous (often bulbous) flora is also common.

(i) Native plants often experience a period of summer dormancy, induced by heat and lack of soil moisture, except in some cool, foggy coastal zones.

(j) Frequent summer and autumn fires, brought on by months without rain, serve as a natural means of renewing vegetative growth and maintaining the health and vitality of the native plant communities.

(k) They are pyrophytic (fire resistant).

(l) There is very little natural vegetation.

(m) They are adapted to summer drought.

Activity 2.6.4:

In groups of five, discuss the characteristics of temperate vegetation.

How vegetation withstands the dry summer

(a) Water is stored in their thick barks and leaves.

(b) The plants have spreading and deep roots that easily trap water.

(c) They have needle-shaped leaves to ensure that there is less transpiration.

Examples of vegetation found in areas that experience Mediterranean climate

- Cedars, conifers, eucalyptus, maquis, chaparral, malle and oaks. Refer to the figure below.

Fig. 2.6.5: Temperate vegetation

5. Coniferous Forests

Location of coniferous forests

These forest are found in areas that experience cool temperate interior climate.

Characteristics of coniferous forests

(a) They have needle-shaped leaves so as to reduce the rate of transpiration.
(b) They have an umbrella-shaped structure.
(c) Trees grow at a reasonably slow rate.
(d) They are composed of evergreen coniferous trees.
(e) They have a bigger area or mass of wood than leaves.
(f) There is no undergrowth.

Activity 2.6.5:

In groups of five, discuss the characteristics of coniferous forests.

Examples of coniferous trees

- Hemlock, spruce, pine and fir which are all softwoods.

Fig. 2.6.6: Coniferous trees

Economic importance of coniferous trees

1. They are used for making paper.
2. They are used for making furniture.
3. They are used for making matchsticks.
4. They are used for making synthetic fibres such as rayon.

Review Questions

Q1. Below is a type of vegetation that is associated with a certain climate. Use it to answer the questions that follow.

Fig. 2.6.7: A type of vegetation

(a) Identify the type of vegetation shown above.

(b) Which climate is associated with the type of vegetation identified in Q1 (a) above?

(c) Explain why the vegetation identified above develops broad leaves.

(d) Give a reason why this vegetation has long roots.

(e) Why is it that the growth of this vegetation is continuous?

(f) State any two examples of trees found in this type of vegetation.

(g) Why does this vegetation have little undergrowth?

(h) Of what economic value are the trees identified in Q1(f) above? Explain any two of those values.

Q2. Below is a type of vegetation that is associated with a certain climate. Use it to answer the questions that follow.

Fig. 2.6.8: A type of vegetation

(a) Identify the type of vegetation shown above.

(b) Mention the type of climate that is associated with this type of vegetation.

(c) Give one reason why this vegetation is deciduous.

(d) Explain one reason why it has long roots.

(e) State one reason why this vegetation is succulent.

(f) Why is it that this vegetation is umbrella-shaped?

(g) List three other examples of plants found in this vegetation.

(h) Explain any two economic importance of this vegetation.

Q3. Below is a type of vegetation that is associated with a certain climate. Use it to answer the questions that follow.

Fig. 2.6.9: A type of vegetation

(a) Identify the type of vegetation shown in Fig. 2.6.8 above.

(b) Mention the type of climate that is associated with this type of vegetation.

(c) Why is it that this type of vegetation has a thick waxy cuticle?

(d) Give one reason why it produces sleepy seeds.

(e) Mention one reason why trees develop long roots.

(f) State one reason why some trees are halophytes or salt lovers.

(g) Explain one reason why such vegetation is xerophytic.

(h) List any four examples of this type of vegetation.

Q4. Below is a type of vegetation that is associated with a certain climate. Use it to answer the questions that follow.

Fig.2.6.10: A type of vegetation

(a) Identify the type of vegetation above.

(b) Mention the type of climate that is associated with this type of vegetation.

(c) How do trees ensure that they are pyrophytic or fire resistant?

(d) Why do they have a thick and often gnarled back?

(e) Give a reason why the trees develop long roots.

(f) State one reason for their needle-shaped leaves.

(g) List any three examples of trees found in this type of vegetation.

Q5. Below is a type of vegetation that is associated with a certain climate. Use it to answer the questions that follow.

Fig. 2.6.11: A type of vegetation

(a) Identify the type of vegetation above.

(b) Mention the type of climate that is associated with this type of vegetation.

(c) Why do such trees have needle-shaped leaves?

(d) Give a reason why such trees are umbrella-shaped.

(e) List any two examples of trees that are found in this vegetation.

(f) Of what economic importance does such vegetation have in areas where it is found?

TOPIC

7 Environmental Issues

Success criteria:

By the end of this topic, the student should be able to:

- Explain environmental issues.
- Explain the meaning of the term 'pollution'.
- Describe causes and effects of pollution.
- Suggest ways of controlling pollution.
- Explain the meaning of the term 'desertification'.
- Describe the causes of desertification.
- Assess the effects of desertification.
- Explain the meaning of the term 'climate change'.
- Examine the causes and effects of climate change.
- Explain climate change mitigation and adaptation measures.

Background

In Form Two, you learnt about human activities such as deforestation, poor waste disposal and setting bush fires that endanger the environment. You further looked at their related effects. In Form Three, you will learn about such environmental issues as pollution, desertification and climate change in terms of their meanings, causes, as well as effects. Furthermore, you will tackle climate change mitigation and adaptation measures.

Terminologies:

- **Environmental issues:** These refer to the harmful aspects of human activity on the biophysical environment.
- **Environmental problems:** These refer to the difficulties that are caused by human activities that result in changes in the environment. These changes have disastrous effects on certain aspects of the environment.
- **Pollution**: This refers to unfavourable alteration and contamination of the natural conditions of the environment.

Activity 3.7.1:

In groups of five, discuss the meanings of the terms 'environmental issue' and 'environmental problem'.

Examples of environmental issues

The following are examples of environmental issues:

(a) Climate change

Climate change is triggered by human activities such as deforestation and emission of greenhouse gases. Although human beings are part of the biosphere, their activities greatly affect climate. It is evident that the effects of climate change affect the same environment. Global warming results into either high or low rainfall which eventually affects the flora (plants), fauna (animals) and people alike. Climate change is therefore an environmental issue.

(b) Destruction of ecosystems

The ecosystem, that is, plants and animals living in an inter-dependent relationship forms the environment. Human activities such as cultivation of forested areas may lead to the extinction of plant and animal species, which poses a threat to the environment.

(c) Energy crisis

Energy mainly originates from natural resources in the environment. These resources include the sun, water, wind, vegetation, fossil fuels and radio-active materials like uranium. Conservation of energy begins with target energy source conservation measures. When energy is not conserved properly, an energy crisis occurs.

(d) Environment degradation

The environment can be destroyed in many ways. For example, soil can be degraded through rampant erosion. Erosion washes away soil nutrients and fertilisers. Soil erosion is largely caused by deforestation, which takes place when there is rapid population growth. Mining activities lead to land dereliction (a situation whereby land becomes completely useless and unproductive), in addition to leaving the land ugly. Furthermore, air can also be polluted by human activities.

(e) Overpopulation

Overpopulation is a situation where the number of people exceeds the available resources such as land, water and social services. This leads to depletion of resources which cause the extinction of various species in the environment. The effects of overpopulation affect the biosphere and other components of the environment.

(f) Waste management

Waste is produced by human activities. It should thus be managed properly to avoid posing a threat to the environment. Indeed, failure to manage waste well can be disastrous to the environment.

(g) Ozone depletion

The ozone is an important resource in the environment because it protects us from harmful solar rays such as infrared, X-rays and gamma rays. The ozone layer is being depleted through the emission of greenhouse gases. Protection of the ozone from further depletion and later on recovery requires human intervention. The effects of ozone depletion include flooding and droughts.

(h) Intensive farming

Intensive agriculture practiced today sometimes negatively affects our environment. This happens when a piece of land is over-cultivated or when very many animals are kept in a small piece of land. This may mean diverting water for irrigation which poses a threat to acquatic ecosystems, and the use of chemicals which may cause the soil to lose its fertility. This system of agriculture is practiced in areas that are highly populated such as the Monsoon Lands of Asia. The very small piece of land available has to be used maximumly in order to feed the growing population. As a result, soil is bound to lose its fertility and fertiliser or manure application becomes very vital. It is important to remember that soil is also an important resource in the environment and that it needs to be conserved.

(i) Soil depletion

Soil supports animal and plant life as well as human beings. If the soil is not well conserved, it can affect animal and plant communities as well as human population.

Examples of environmental problems

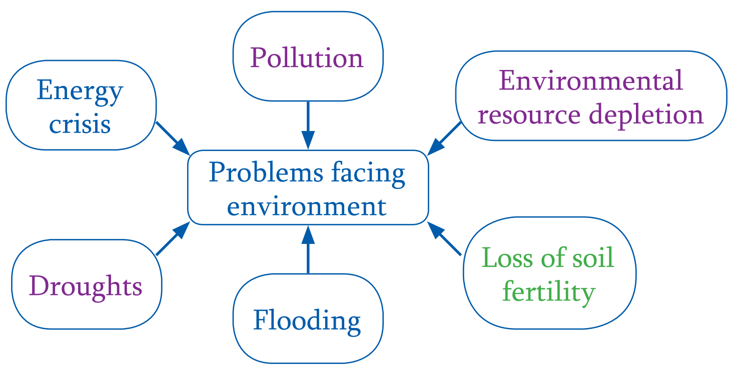


Fig. 3.7.1: Environmental problems

(a) Pollution

Most human activities contribute to pollution of such resources as land, water and air. The causes and effects of pollution are discussed later in this topic. The negative effects of pollution on land, air and water make it necessary to strategise on ways of preventing it.

Solutions to pollution

- **Treating industrial waste**: Chemicals and other types of waste released from industries such as wastewater should be treated. This helps to control excess gases that could be released in the atmosphere or toxic water.
- **Recycling waste products**: Reusing or turning waste products into new, useful products helps reduce pollution.
- **Proper waste disposal**: Dangerous waste products should be burnt in a protected environment or burried deep in the ground.
- **Control industrialisation**: Before setting up new industries, a thorough assessment of the impact on the environment should be done by the concerned parties. Control measures should also be put in place well in advance.

(b) Droughts

Droughts are a product of climate change caused by deforestation and emission of gases into the atmosphere. The tendency of human beings to cut down trees disturbs the hydrological cycle. This is because it reduces the rate of transpiration and more carbon (IV) oxide gas will be emitted into the atmosphere. This eventually leads to little or no rainfall. Persistent lack of rainfall leads to occurrence of a drought. In addition, the release of such gases as chlorofluorocarbons (CFC's), nitrous oxide, methane and carbon dioxide into the atmosphere causes global warming. In case of rainfall, the water will be acidic. Insufficient amounts of precipitation can adversely affect many aspects of the environment such as plant and animal growth. It may lead to poor yields, poor quality animals and animal products like milk and meat. This eventually affects the health of human beings. It may even lead to death of people and animals.

Solutions to droughts

- **Afforestation**: Planting trees on land that had no trees before helps in attracting rainfall. Areas having forests or trees receive rainfall more often than bare areas.
- **Re-afforestation**: This refers to the exercise of planting trees in areas where trees have been cut. This too helps in rain attraction.

- **Avoidance of emission of greenhouse gases into the atmosphere**: Depletion of the ozone layer in the atmosphere allows intense sun rays to reach the earth. As a result, the land dries up faster. Therefore, there is need to control gases released into the atmosphere. This is because these gases, especially carbon dioxide, lead to the depletion of the ozone layer.
- **Civic education**: People should be enlightened on the dangers of drought. Similarly, people should be educated on the possible ways to curb drought.
- **Preventing occurence of bushfires**: Bushfires destroy vegetation and the land is left bare and exposed to erosion. Ensuring bushfires do not occur retains the soil nutrients and vegetation that in turn attracts rainfall and enables the land to be useful economically.

(c) Flooding

Flooding is caused by many factors which may include deforestation and emission of greenhouse gases. Deforestation entails the removal of vegetative cover leaving the land bare and exposed to agents of soil erosion. Emission of greenhouse gases, causes global warming, which can either lead to high or low rainfall. Notably, high rainfall leads to flooding which has become common in different parts of the world. Flooding leads to loss of life and damage to property and may call for urgent demand for relief.

Solutions to flooding

- **Afforestation**: Planting trees on bare land, which provides a cover for the soil and makes it harder for the floods to take place and cause destruction.
- **Re-afforestation**: Planting trees where others had been cut helps to balance oxygen and carbon dioxide gases in the air.
- **Avoidance of emission of greenhouse gases into the atmosphere**: This can be done through treating waste before releasing to land, water sources or air.
- **Civic education**: People should be enlightened on the effects of and solutions to flooding.
- **Prevention of occurrence of bushfires**: Burning bushes increases carbon dioxide gas in the atmosphere. Therefore, the practice should be stopped to avoid destroying the ozone layer.

(d) Loss of soil fertility

The soil tends to lose fertility through overuse, poor farming practices, ridging and planting along the slope, careless cutting down of trees, among others. These are mainly caused by rapid population growth. When vegetation is removed, soil particles lack support and become loose. The soil now becomes prone to erosion. Rain water easily takes away soil particles which may end up in water masses. Consequently, flooding can occur, leading to death of living things and damage to property. Soil erosion can negatively affect plant growth and lead to low yields. This eventually affects the health and economy of people. Furthermore, the ecosystem may be disrupted when certain species of vegetation are lost.

Solutions to loss of soil fertility

- **Afforestation**: Planting trees where there are no trees helps to create a vegetative cover that protects soil particles from being eroded away.
- **Re-afforestation**: Planting trees where they have been cut down enables the soil particles to be bound together. This eventually protects them from being carried away by running water and air.
- **Good farming practices**: Implementing good farming practices such as contour ploughing, avoiding overstocking and overgrazing and terracing helps to reduce floods.
- **Controlling population growth:** This reduces pressure on vegetation that helps prevent the soil from erosion.

(e) Environmental resource depletion

If resources in the environment such as fish and wildlife species are not properly taken care of in protected areas such as fish ponds, game reserves and national parks, they can become extinct. Extinction breeds many problems which are related to the environment. These problems include the following:

- Malnutrition in people due to scarcity of the much needed minerals such as iron, copper, calcium, iodine, magnesium, and vitamins. This can also lead to death of people, disruption of the food web, an imbalance in the ecosystem and loss of foreign exchange earnings.
- Disturbance of the water cycle when vegetation is removed. Insufficient rainfall can affect plant and animal growth. Subsequently, human beings will also be negatively affected. It can also lead to the following:
  - Disruption of the food chain.
  - Lowering of the level of water masses creates problems for hydro-electric power production.
  - Domestic and industrial activities that require water will be adversely affected.

Solutions to environmental resource depletion

- **Controlling population growth**: This minimises pressure on environmental resources and in turn protects them.
- **Civic education**: Teaching people about the importance of environmental resources such as wildlife, fish and vegetation can help to protect such resources.
- **Legislation**: Enactment and enforcement of laws that protect the environment and its resources can prevent depletion and extinction of such resources.

(f) Energy crisis

Due to an increase in population, there is unnecessary pressure of world's environmental energy resources. The reserves of non-renewable resources such as fossil fuels are declining. Oil and natural gas in the known reserves, for example, are likely to be exhausted within less than 100 years and coal within less than 250 years. In view of this, it is evident that these resources will become scarce in future. Additionally, the supply of energy originating from fossil fuel does not match the demand. This mismatch and likelihood of becoming scarce in future together pose a big threat of energy crisis.

Solutions to energy crisis in the world

The problem of energy crisis can be solved by using alternative renewable sources of energy such as biomass, wind, water and solar.

Activity 3.7.2:

Imagine that you are the guest speaker at an annual environmental day event which centres on environmental issues and problems. Prepare the speech that you will present at the ceremony that highlights five important environmental issues and problems. In your speech, include the following:

- *Description of the five environmental issues.*
- *Description of causes and effects of five environmental problems.*
- *An elaboration of suggested ways of solving environmental problems highlighted.*

TYPES OF POLLUTION

Activity 3.7.3:

In groups of five, discuss the meaning of the term 'pollution'.

There are four types of pollution namely: Air, water, land and noise pollution.

(a) AIR POLLUTION

Causes of air pollution

(i) Removal of vegetative cover.

- Vegetation purifies air. It can be removed through desertification and bushfires. The removal of vegetation allows the increase of air pollution.

(ii) Emission of harmful gases and smoke by industries.

- The release of harmful gases such as carbon dioxide in the air destroys the ozone layer. Harmful gases also contaminate air in the atmosphere.

(iii) Smoke from burning garbage and rubber waste.

(iv) Fumes such as nitrous oxide released by moving vehicles.

(v) Volcanic eruption in form of gases and dust particles. Mount Pelée volcanic eruptions, for instance, released gases which killed thousands of people. Such gases are bound to pollute the air.

(vi) Setting of bushfires which pollute the air.

(vii) Bursting of sewages: Sewages release harmful gases into the atmosphere which pollute the air.

(viii) Spraying of chemicals, insecticides and pesticides can also pollute air.

Effects of air pollution

(i) Air pollution can lead to respiratory problems for animals and human beings.

(ii) Acid rain will be formed. This rain destroys vegetation, especially the leaves, and reduces the rate of transpiration. In addition, acid rain also leads to chemical weathering when it enters rocks that contain calcium carbonate such as chalk and limestone.

(iii) It results into global warming when greenhouse gases are released into the atmosphere.

(iv) It causes ecological imbalances.

(v) It cause eye, throat and lung diseases.

(vi) It causes smog when fog mixes with smoke and this affects visibility.

(vii) It causes suffocation and death of human beings and other living things when gases are inhaled.

Ways of combating air pollution

1. Creating awareness on the dangers of air pollution.
2. Using alternative sources of energy that do not pollute the air.
3. Enacting and enforcing laws to protect the environment.
4. Establishing measures and policies in factories in order to control the level of air pollution.
5. Dispersing and diluting pollutants in the upper layers of the atmosphere with the aim of reducing concentration at the lower levels.
6. Preventing occurrence of bushfires.
7. Carrying out afforestation and re-afforestation practices.
8. Monitoring levels of air pollution regularly.
9. Using clean energy at home and in industries.

Activity 3.7.4:

Below is a Futures Wheel showing causes and effects of air pollution. Complete it in pairs.

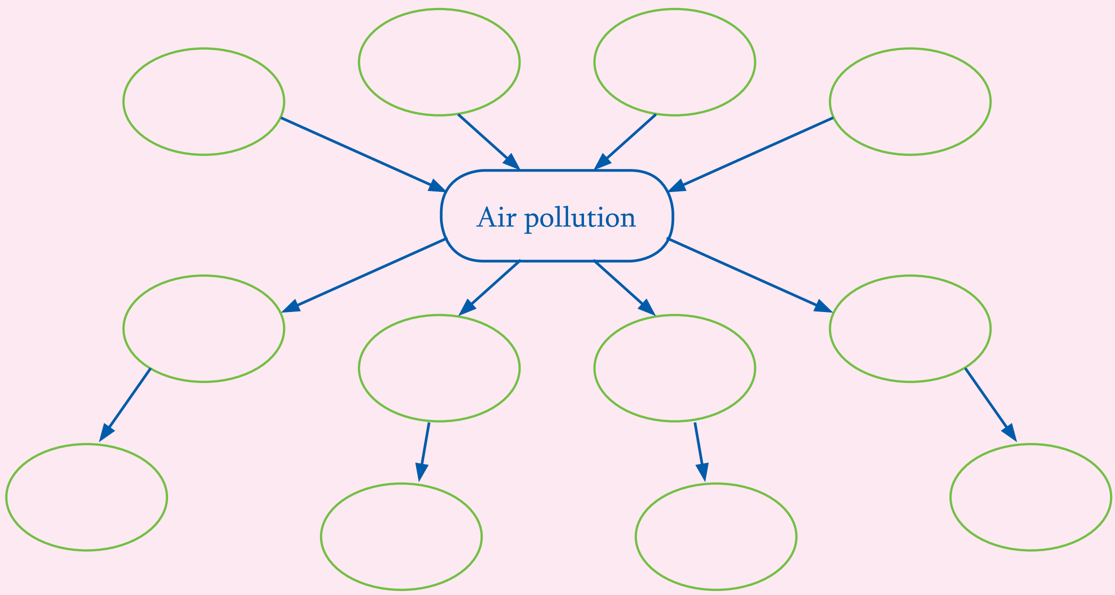


Fig. 3.7.2: Futures Wheel showing causes and effects of air pollution

(b) WATER POLLUTION

This refers to the contamination of water masses with toxic soluble chemicals, industrial waste, sewage, garbage and salts.

Causes of water pollution

(i) Waste discharge

The disposal of waste in water by industries causes water pollution.

(ii) Oil spills

Oil leakages into water masses pollute water.

(iii) Fishing methods

Some methods of fishing such as use of chemicals pollutes water.

Effects of water pollution

(i) Loss of *aquatic* or *marine life*.

(ii) *Eutrophication* in water masses such as lakes and rivers through high concentration of organic and inorganic nutrients. *Eutrophication* is the buildup of large amounts of minerals such as nitrates and phosphates in fresh waters. This leads to an imbalance in the ecosystem resulting into death of many organisms.

(iii) Polluted water leads to pollution of the soil and kills *soil micro-organisms* such as nitrogen-fixing bacteria. This in turn, interferes with soil fertility.

(iv) *Spread of water borne diseases* such as cholera, diarrhoea, dysentery and typhoid.

(v) Water polluted with fibres such as asbestos causes cancer and stomach diseases like asbestosis.

(vi) Polluted water can *damage crops* leading to *low crop yields*.

Ways of combating water pollution

1. Creating awareness on the dangers of water pollution.
2. Proper treatment of sewerage and industrial effluents before being discharged into water masses.
3. Using good agricultural practices that prevent water pollution from occurring, for example, planting along contours.
4. Controlling soil erosion through afforestation, re-afforestation, strip cropping, terracing, fallowing and mulching.

Activity 3.7.5:

Below is a Futures Wheel showing causes and effects of water pollution. Complete it in pairs.

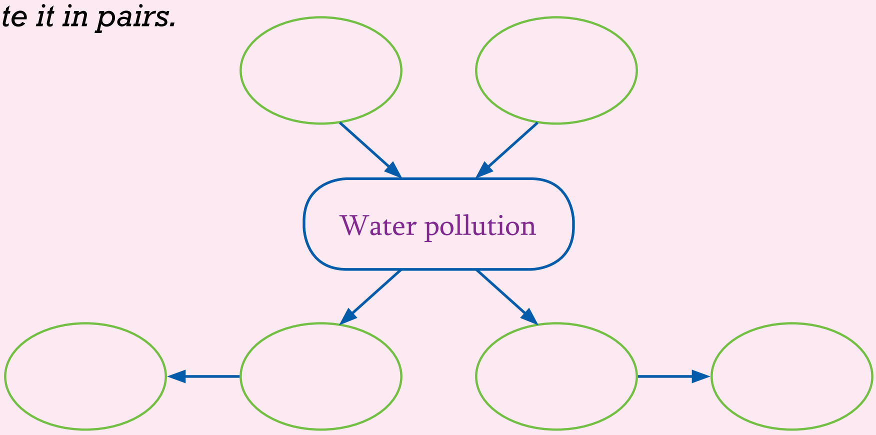


Fig. 3.7.3: Future's wheel describing causes and effects of water pollution

(c) LAND POLLUTION

Causes of land pollution

The natural state of land can be altered or polluted by several factors which include the following:

(i) Waste discharge

When people discharge waste on land masses, it eventually leads to land pollution.

(ii) Nuclear testing

The tendency of testing nuclear materials such as explosives leaves dire consequences on land because these materials are hazardous.

(iii) Excessive use of chemical fertilisers, insecticides, herbicides and fungicides.

These chemicals react with soil and may destroy the top soil, rendering it useless for agriculture.

(iv) Extreme cases of soil erosion

Soil erosion leaves the land bare and unproductive.

Effects of land pollution

(i) *There is loss of biodiversity*: Land pollution causes loss of life of living organisms in the soil. Plant species also reduce in number or become extinct. Other living organisms may migrate to other favourable areas.

(ii) It causes *diseases in human beings* and *animals*.

(iii) It results into agricultural *low productivity*.

(iv) It creates *wastelands*.

Ways of controlling land pollution

1. Following good agricultural methods.
2. Treating solid waste before being dumped on land.
3. Using pesticides and insecticides properly.
4. Controlling soil erosion.

Activity 3.7.6:

Below is a Futures Wheel showing causes and effects of land pollution. Complete it in pairs.

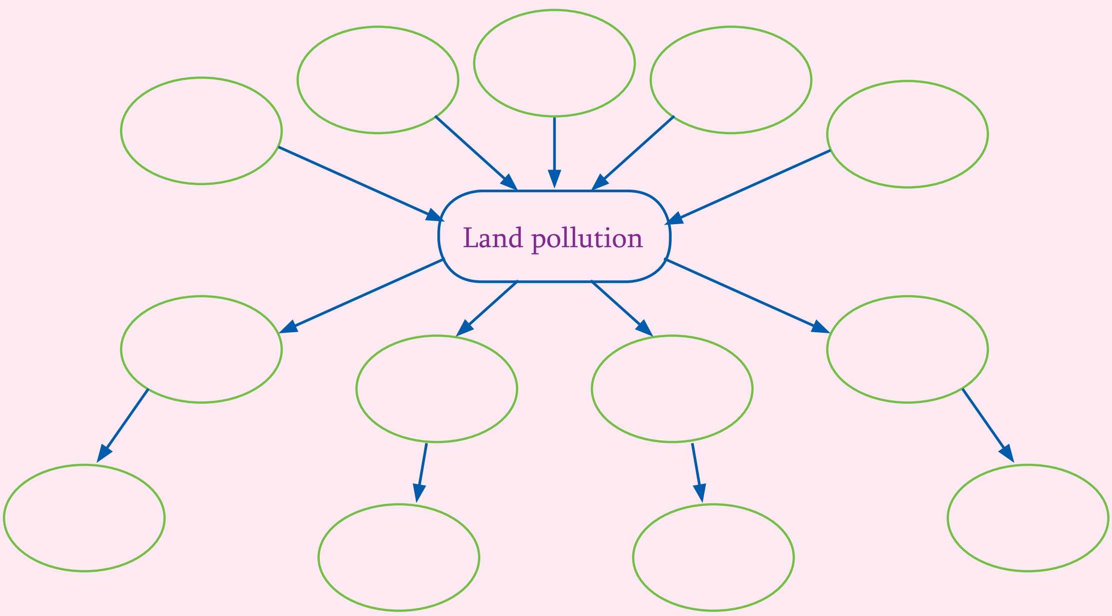


Fig. 3.7.4: Futures Wheel showing causes and effects of land pollution

Activity 3.7.7:

Conduct a survey of the nearby water and land masses around your school. Identify cases of pollution. Suggest the causes, effects and ways of combating cases of pollution. Write a letter explaining these to the minister who deals with environmental issues.

DESERTIFICATION

Meaning of the term 'desertification'

Activity 3.7.8:

Brainstorm on the meaning of the term 'desertification'.

Desertification is the process of land degradation where the available vegetation and moisture (water) gets depleted, increasing the bareness and dryness of a piece of land. It is a steady process that turns good fertile land into a barren one.

CAUSES AND EFFECTS OF DESERTIFICATION

Factors that lead to desertification

Activity 3.7.9:

Below is a tree diagram showing causes and effects of desertification. The roots of the tree represent the causes, the tree trunk is the main idea (desertification) while the branches represent the effects. In groups of five, analyse the tree diagram and discuss the causes (F, G and H) and effects of desertification (A, B, C, D and E). Then suggest ways of controlling it.

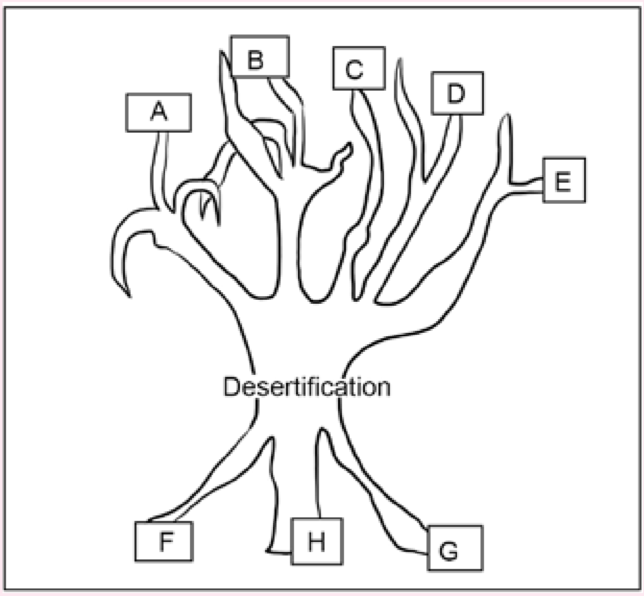


Fig. 3.7.5: Tree diagram showing causes and effects of desertification

A. HUMAN CAUSES

1. Population growth through high birth rates and immigration

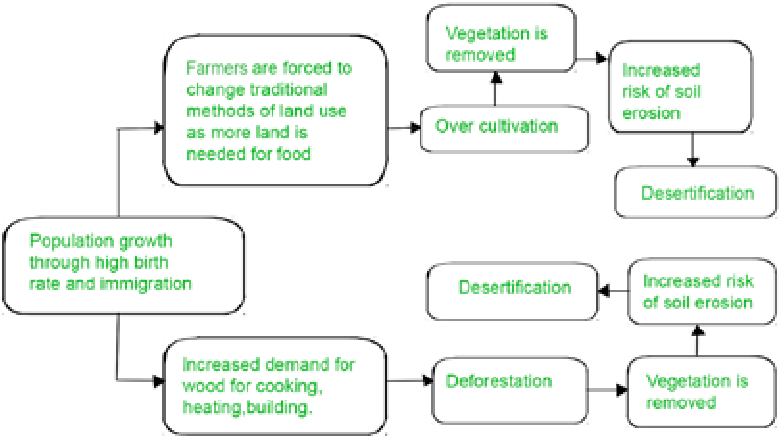
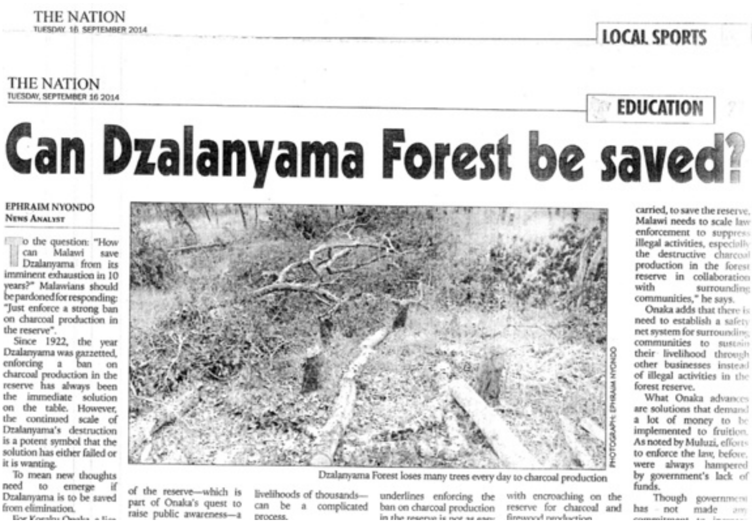


Fig. 3.7.6:Flow diagram showing population growth through high birth rate and immigration

Explanation:

When the population grows through high birth rates and immigration, there is an increased demand for food and wood for cooking, heating and building. This eventually leads to deforestation where vegetation is removed to create more farming land. Soil is left bare and therefore, there is an increased risk of soil erosion. Ultimately, this causes desertification. There is an increasing pressure on vegetation in Malawi due to rapid population growth. Pressure has mounted, for instance, on the Dzalanyama Forest Reserve in Lilongwe where trees are being cut mainly for charcoal production. This may, if not checked, lead to desertification.



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TUESDAY, SEPTEMBER 16 2014
EDUCATION

Can Dzalanyama Forest be saved?

EPHRAIM NYONDO
News Analyst

To the question: "How can Malawi save Dzalanyama from its imminent exhaustion in 10 years?" Malawians should be pardoned for responding: "Just enforce a strong ban on charcoal production in the reserve".

Since 1922, the year Dzalanyama was gazzetted, enforcing a ban on charcoal production in the reserve has always been the immediate solution on the table. However, the continued scale of Dzalanyama's destruction is a potent symbol that the solution has either failed or it is wanting.

To mean new thoughts need to emerge if Dzalanyama is to be saved from elimination.

Dzalanyama Forest loses many trees every day to charcoal production

PHOTOGRAPH: EPHRAIM NYONDO

of the reserve—which is part of Onaka's quest to raise public awareness—a ...

livelihoods of thousands—can be a complicated process.

underlines enforcing the ban on charcoal production ...

with encroaching on the reserve for charcoal and firewood production ...

carried, to save the reserve, Malawi needs to scale law enforcement to suppress illegal activities, especially the destructive charcoal production in the forest reserve in collaboration with surrounding communities," he says.

Onaka adds that there is need to establish a safety net system for surrounding communities to sustain their livelihood through other businesses instead of illegal activities in the forest reserve.

What Onaka advances are solutions that demand a lot of money to be implemented to fruition. As noted by Muluzi, efforts to enforce the law, before, were always hampered by government's lack of funds.

Though government has not made any ...

Fig. 3.7.7: A newspaper cutting highlighting on the deforestation in Dzalanyama Forest Reserve

2. Poor agricultural practices

(a) Poor farming techniques such as shifting cultivation, over cultivation and excessive use of fertilisers and chemicals can also cause desertification. These activities lead to removal of vegetation, thereby increasing chances of desertification. Overgrazing mainly occurs when there is overstocking on a piece of land and this also leads to desertification.

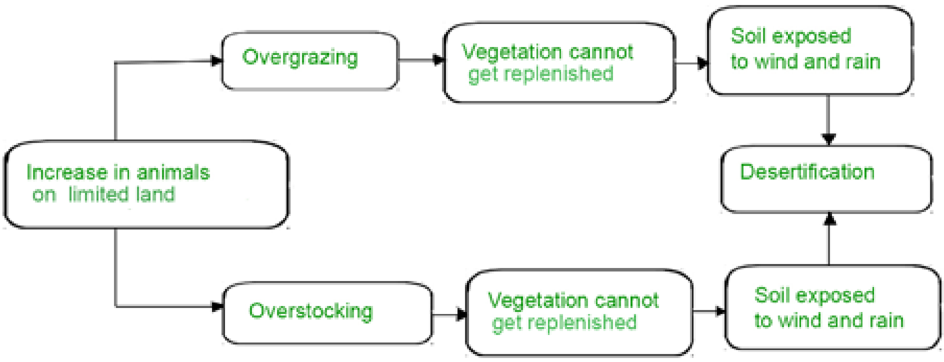


Fig. 3.7.8: Flow diagram showing overstocking and overgrazing as causes of desertification

(b) *Accidental burning of semi-arid vegetation* can also destroy vegetation, leading to desertification.

(c) *Poor irrigation practices* in arid areas can cause *salinisation* (building up of salts in the soil) that prevents plant growth.

3. Climate change

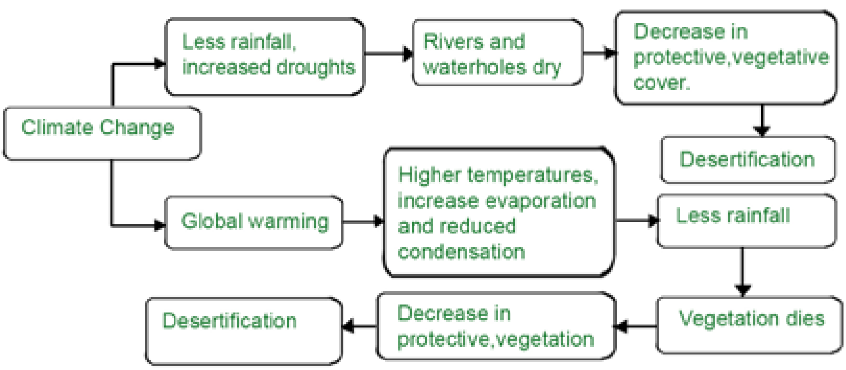


Fig. 3.7.9: Flow diagram showing climate change as a cause of desertification

Explanation:

Climate change can also cause desertification. This occurs when there is global warming which in turn increases temperatures, raises rates of evaporation and reduces condensation rates. Eventually, this leads to less rainfall for vegetation. Vegetation will be adversely affected due to lack of rain and it will dry up leading to desertification. In addition, insufficient rainfall leads to drying up of water masses like rivers, lakes and waterholes. Vegetation will dry up and die when there is no water, and this will significantly reduce the plant species. Reduction of vegetation may cause extinction of such species with time. This ultimately causes desertification.

4. Policy factors

There are certain policies that lead to unsustainable use of resources. An example includes policies that favour nomadic herding over sedentary farming can also contribute to desertification.

B. NON-HUMAN CAUSES

5. Desiccating effects of cold ocean currents along the coasts of continents

Deserts can also develop on tropical coasts next to cold ocean currents. Cold ocean currents blow along western edges of continents, cooling the air above them. The cold marine air warms up as it moves over land, causing high evaporation and little rain on the coast. Cold ocean currents produce *a desiccating effect* when they blow over the affected areas so that moisture is not easily condensed. These conditions make it difficult for vegetation to survive, resulting into desertification. The Benguela and Peruvian or Humboldt cold ocean currents, for example, have contributed to the formation of Namib Desert and Atacama Desert respectively.

6. Rain shadow effects of mountains

When moist air passes over a mountain, it cools down, condenses and forms clouds. Thereafter, there is heavy rainfall on the windward side. As air descends on the leeward side, it is usually dry because it has deposited all the moisture on the windward side. It therefore brings little or no rainfall. Some parts of the desert in the south western region of the U.S.A, that is, Nevada and Northern Arizona largely experience the rain shadow effect of Sierra Nevada range in Eastern California.

7. Great distance from the ocean

Aridity (dry conditions) are experienced in places that are far from the ocean. This is because most rainfall comes from the water masses. The dry climate of the large arid region in China, which is 30° North latitude, is due to its location in the continental interior and also the rain shadow effect of mountains like the Himalayas.

8. Rain shadow effects of easterly trade winds

Most of the trade winds blow from the North East in the northern hemisphere and from South East in the southern hemisphere. They tend to drop most of the moisture they are carrying on the eastern edges of the land masses that they come in contact with. As a result, they are fairly dry by the time they reach the continental interiors. The western sides of the continents thus experience a greater effect of the rain shadow. In North and South America, the main mountain ranges, Rockies and Andes respectively, lie towards the western sides of the continent. Therefore, the rain shadow effect covers a fairly narrow area of these mountain ranges as well as the Sonora and Atacama Deserts.

9. Formation of the sub-tropical high pressure belt

Since rays from the sun are mostly concentrated close to the equator, air molecules around this region get heated up quickly. The hot air contains large amounts of vapour thus has high humidity. This heated air rises in form of convectional currents and then cools, causing thick clouds to form and heavy torrential rains to fall.

The air that had risen in the convectional currents stops when it reaches the layer in the atmosphere called *troposphere*. At this level of the atmosphere, it is forced to flow towards the North Pole or South Pole. As air flows away from the equator, it cools. This is because it loses its main source of heat. This cooling process makes the air to become denser. Much of it sinks back towards the earth's surface at about 30° North or South of the equator. The sinking produces high pressure air belt which is characterised by the following:

- It is dry because most of the water vapour it contains was dropped in the convectional rainfall near the equator.
- It is warm because it is heated by the compression as it sinks.
- It is stable, with skies that are generally clear and cloudless.
- Winds blow outwards from areas of high pressure, while some winds blow towards the equatorial doldrums of low pressure belt. Some winds blow polewards to bring warm westerly winds to the mid latitudes.

These conditions make it difficult for vegetation to survive resulting to desertification.

Activity 3.7.6:

In groups of five, discuss the process of desertification.

EFFECTS OF DESERTIFICATION

(i) It disturbs the hydrological cycle since the rate of transpiration is tampered with. This may in turn lead to drought and famine.

(ii) It prevents regeneration of various valuable plant species.

(iii) It causes the land to be prone to landslides.

(iv) It encourages soil erosion and contributes to the silting of river beds.

(v) It causes climate change.

(vi) It leads to poor crop yield leading to food shortage.

(vii) It leads to drying up of water bodies and water catchment areas.

(viii) It triggers the migration of people.

(ix) It leads to loss of vegetation and animal species resulting into extinction of plant and animal species.

WAYS OF CONTROLLING DESERTIFICATION

(a) Afforestation

- Planting trees where there were none before can help to control desertification.

(b) Re-afforestation

- Planting of trees where they have been cut also helps to combat desertification.

(c) Good land husbandry

- Good agricultural techniques will prevent and control desertification. Some of these techniques include contour ploughing, avoiding overgrazing and overstocking.

(d) Civic education

- Teaching people about the dangers of deforestation and desertification as well as the importance of retaining vegetation cover can also help to control desertification.

(e) Controlling rapid population growth

- This reduces pressure on vegetation thus controlling desertification.

(f) Provision of alternative sources of energy

- Use of alternative sources of energy will reduce pressure on vegetation. This will help in controlling desertification.

CLIMATE CHANGE

Introduction

It is important to note that the world climate has changed due to various reasons. The main ones are air pollution and deforestation. The change brought about by climate has several effects. Examples include global warming, increasing storms, changing ocean currents and the shrinking of the Antarctic ice cap. Climate change is a global issue which requires joint action to solve it. International agreements are necessary where all countries would agree on a joint proper remedial action to solve this problem.

Meaning of the term 'climate change'

The term '*climate change*' refers to a change in the state of climate, that can be identified by the changes in the mean or the variability of its properties, and that it persists for an extended period, typically decades or longer. Climate change may be caused by natural internal processes or external forces, or persistent human-influenced changes in the composition of the atmosphere.

CAUSES OF CLIMATE CHANGE

(a) Deforestation

This is the cutting down of trees. It is mainly caused by rapid population growth. When trees have been cut down carelessly, the rate of transpiration is reduced leading to little or no rain. The water cycle is adversely affected resulting into drought which can cause famine conditions. In addition, the removal of vegetation means that there will be more carbon dioxide in the atmosphere. Vegetation helps to reduce carbon dioxide concentration in the atmosphere through the process of photosynthesis.

(b) Emission of various gases into the atmosphere (greenhouse effect)

The release of greenhouse gases into the atmosphere causes global warming. Examples of such greenhouse gases include the following:

1. *Carbon dioxide*: It originates from burning of fossil fuels used in the industries and power stations. It is also produced when bushfires occur, and the carbon dioxide levels in the atmosphere increase when there is deforestation.
2. *Chlorofluorocarbons (CFC's)*: These are gases released from aerosols and by refrigerators.
3. *Methane*: It originates from farming, waste disposal, mining and rice fields.
4. *Nitrous oxide*: It is emitted from power stations, vehicles, and from the use of fertilisers.

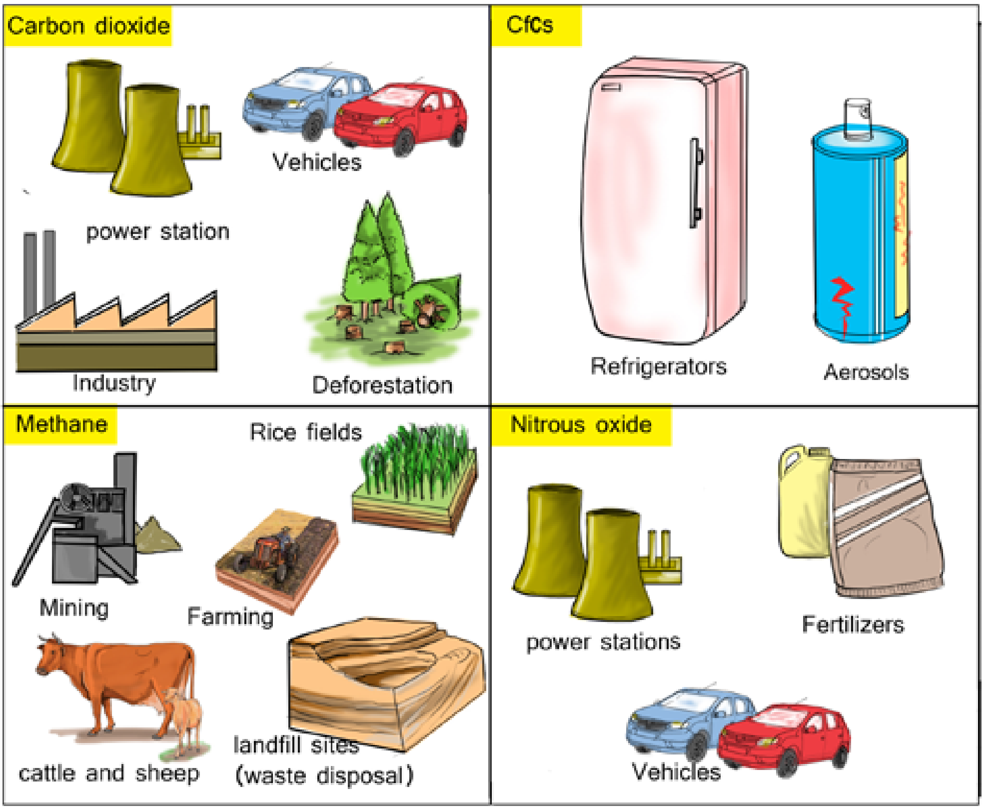


Fig. 3.7.10: Various sources of greenhouse gases

GENERAL EFFECTS OF CLIMATE CHANGE

1. POSITIVE EFFECT

- Higher temperatures and more carbon dioxide lead to more photosynthesis and more food production.

2. NEGATIVE EFFECTS

(i) Global warming

Meaning of the term 'global warming'

This is the most recent phenomenon which has affected the whole globe. It is caused by greenhouse gases which are released into the atmosphere. When these gases have been emitted into space, they absorb the outgoing infrared radiation which has been sent back by the earth's surface through terrestrial radiation. A large percentage of the amount of energy is absorbed by clouds and greenhouse gases and radiated back towards the earth's surface. This means that there is less heat that escapes into space. This eventually warms the lower atmosphere and the globe in turn hence global warming.

Indicators of global warming

- Global sea level has risen.
- Glaciers are melting.
- Ocean currents are changing.
- The Arctic and Antarctic Ice caps are thinning and shrinking.

Impact of global warming

- Heavy rains, flooding, blizzards and storms.
- Droughts in Africa and India have caused famine and breakdown in farming.
- Desertification has also increased due to evaporation of water from fertile areas that makes plants to be deprived of water.
- Changes in the location of plants and animals. Plants are becoming extinct in their natural habitat and animals keep relocating to where they can find food when drought and famine strike.

(ii) Increasing storms

Notably, increasing temperatures as a result of global warming have led to the differential heating of land and water masses. This in turn has affected the air pressure of these masses in that in some areas, it is high while in others it is low. Low atmospheric pressure developing over oceans creates tropical and temperate cyclones that have a negative effect over the land mass they blow to. Therefore, the probability of having more storms is becoming increasingly higher than before following rising temperatures brought about by global warming.

(iii) Changing ocean currents

It has already been highlighted earlier that temperature affects air pressure. High temperature leads to low air pressure whereas low temperature leads to high air pressure. Normally, warm ocean currents flow from the equator polewards while cold ocean currents flow from the poles towards the equator. Increasing temperatures as a result of global warming especially in regions around the poles can change the direction of flow of ocean currents.

(iv) Shrinking of the Antarctic Ice cap

Global warming increases temperature in different places on the earth's surface. Within the Antarctic belt, normal temperatures are low, thus leading to the formation of the ice cap. However, due to the high temperature, part of this is melting resulting into the shrinking of the Antarctic ice cap. This also leads to flooding as molten ice which has turned into water gets into nearby land masses.

Effect of sea level rising

- Low level land is at risk of flooding.
- Salt water will spread further inland.
- There will be a change in the types of plants, animals and ecosystems.
- Coastal erosion will increase.
- Increase in replenishing costs of beaches due to coastal erosion.

SPECIAL EFFECTS OF CLIMATE CHANGE IN MALAWI

Malawi has experienced adverse climatic hazards over the last decades. The most serious ones are dry spells, seasonal droughts, intense rainfall, riverine floods and flash floods. Refer to the information in the table below:

Table 65: Frequency of natural disasters over the last seven decades.

Type of hazard	1940-49	1950-59	1960-69	1970-79	1980-89	1990-99	2000-2009
Cyclones	1	4	-	-	-	1	1
Droughts	1	-	-	-	1	2	1
Floods	-	-	-	5	29	44	61
Hailstorms	-	-	-	-	1	1	-
Landslides	1	-	-	-	1	2	-
Avalanches	1	-	-	-	1	-	-
Strong winds	-	-	-	1	2	8	6
Total	**4**	**4**	**-**	**6**	**35**	**58**	**69**

Source: Njewa, E.D. (2011). Handbook on Climate change, Origins, Current Science and Negotiations, City Printing and Publishing Company Ltd

Explanation of effects of climate change in Malawi

1. Malnutrition

Climate change is always linked to agricultural production. This is because changes in the amounts of rainfall and temperature affect crop production and animal husbandry. Droughts often lead to poor crop yield which lead to malnutrition.

2. Occurrence of diarrhoea and cholera

Diarrhoea and cholera cases are likely to increase. This is due to excess rainfall brought about by climate change. This rainfall leads to flooding eventually increasing the prevalence of such diseases.

3. Occurrence of malaria

Climate change influences all the three components of the life cycle of the parasite that causes malaria. This is because the large amounts of rainfall experienced will create waterlogged conditions or flooding pools which will create favourable conditions for mosquitoes to breed. In addition, hot weather may encourage people to sleep outdoors or discourage them from using mosquito nets.

4. Frequent disruption of production of hydro-electric power

Production of hydro-electric power has been negatively affected by droughts and floods. These conditions lead to the fluctuation of water in the Shire River that consequently affects the production of power. In addition, flooding has led to siltation in the Shire River, resulting into inability of turbines to rotate at Nkula A and B as well as Tedzani power stations.

5. Loss of biodiversity

Droughts are responsible for the drying up of water masses. This in turn leads to loss of animal species, especially fish. Droughts have been responsible for the drying up of lakes in Malawi such as Lake Chilwa in 1995 where a lot fish species died.

6. Loss of forests through fires

Droughts lead to land degradation and loss of soil fertility. The intense heat at times causes natural fires in forests. For example, during the drought in 1995, some 5550 hectares (36%) of Chongoni Forest was destroyed by forest fires caused by human activities. This also resulted into loss of biodiversity and seedlings and caused a lot of pollution.

Activity 3.7.7:

In pairs, complete the Futures Wheels below showing the effects of deforestation and emission of greenhouse gases (GHGs).

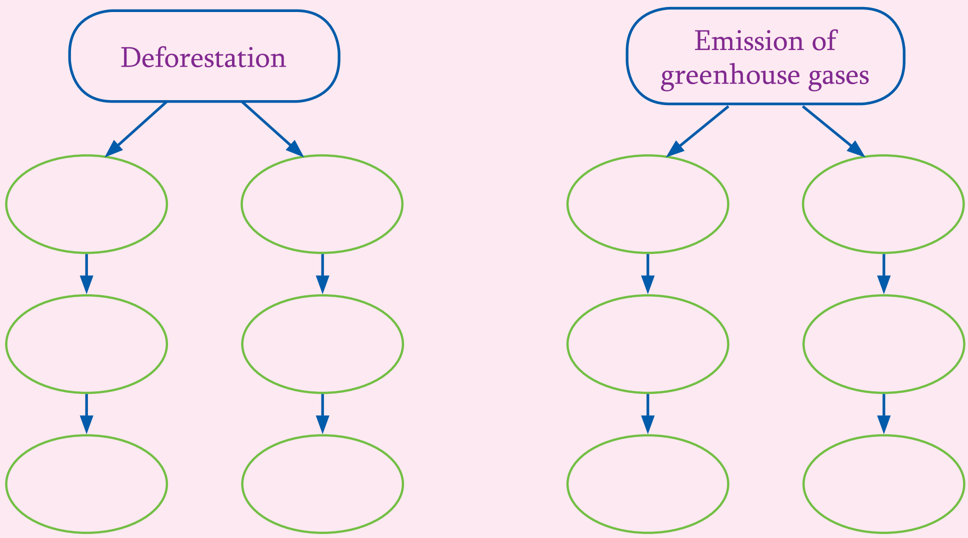


Fig. 3.7.11: Futures Wheels showing effects of deforestation and greenhouse gases (GHGs)

CLIMATE CHANGE MITIGATION AND ADAPTATION PRACTICES IN MALAWI

Introduction

There is evidence to show that climate has indeed changed in Malawi. In view of this, there is need to mitigate and adapt to such a change in climate. In Malawi, there are several climate change mitigations and adaptation practices. You will learn more about these in this sub-topic.

Differences between climate change mitigation and climate change adaptation

Climate change mitigation refers to structural and non-structural measures undertaken to limit the adverse impacts of climate change. On the other hand, *climate change adaptation* is an adjustment in natural human systems in response to actual or expected climate change or its effects.

General climate change mitigation and adaptation procedures in Malawi

(i) *Biomass energy conservation* through use of *"Chitetezo Mbaula"* or *"The Protective Stove"*, with the aim of reducing carbon emission into the atmosphere. There are various programmes going on in the country that target the use of the protective stove. These include the following:
- MAEVE project which is a Non-Governmental Organisation (NGO). This project aims at protecting the environment through reduction of carbon emission into the atmosphere. This project sells the "Chitetezo Mbaula" or "The protective stove" at affordable prices.
- Public Private Partnership Programme (PPP) in T/A Mabuka in Mulanje. This programme encourages people to use the energy-saving stove "Chitetezo Mbaula" or "The protective stove".

(ii) *Changes in crop choice* and *farming techniques*.

(iii) *Diverting water from major sources* like rivers to areas where irrigation and fish farming can take place.

CASE STUDY 1: MULANJE MOUNTAIN FOREST RESERVE AND ITS SURROUNDINGS

Introduction

The climate of Mulanje is affected by the presence of Mulanje Mountain in Malawi and partly by Chiperoni Mountain in Mozambique. The climate is warm or hot and humid throughout the year. Annual temperatures average between 21°C to

23°C. Maximum temperatures are often around 32°C to 35°C during November and December (the beginning of hot and wet season). During the dry season (from July to mid-August) as a result of Chiperoni winds from Chiperoni Mountains in Mozambique, the Phalombe Plains and those of South Mulanje experience cooler weather. Temperatures drop on Mount Mulanje to freezing point.

Mulanje has experienced a lot of changes in climate. The amounts of rainfall and temperature have increased. A number of studies have been conducted by the Mulanje Mountain Forest Reserve (MMFR) to assess the local communities' understanding of climate, the causes and impact of climate change in the area.

In 1991, the Mulanje and Phalombe districts experienced continuous rains on Mount Mulanje and Michesi, which led to flash floods across nine villages. This was followed by a number of droughts and extremely poor crop harvests. The worst of these droughts occurred in 2005. Today, rainfall is very unpredictable as evidenced by the shifting of the onset of the first rains which used to come in October. Indeed, locals identified changes in climate of Mulanje. Through this study, one of the workers in the Mulanje Mountain Forest Reserve had this to say;

"From January to June every year, there were heavy rains in Mulanje. A hot, dry season started in August and lasted until October when the first rains known as Chzimalupsya (the fire extinguisher) started. Chzimalupsya no longer preceedes the main rains because the rain season starts very late, sometimes as late as December. June and July were extremely cold months with frequent fogs, but it is now difficult to tell cold and hot seasons apart. Many rivers coming from Mount Mulanje had large pools and never used to dry. Now they frequently dry up as early as June," said R. Seven, aged 50.

Recent observations of the local weather have also indicated this climate change. For instance, temperature and rainfall data from Mimosa Tea Research Foundation show a steady increase in maximum and minimum temperature over the past twenty years.

In addition, there have been a lot changes in water and land resources. These changes are mainly due to population pressure on them. In the past, villagers used to dig wells and the water table was well tapped. Overtime, however, the wells dried up and people have turned to the rivers for water. Since there is a high demand for land, people have been forced to encroach into the Mulanje Mountain Forest Reserve. The energy need and demand for bio-fuel are major threats to forests in Mulanje Mountain. The 1999 state of the environment report sites deforestation as the major environmental problem facing Malawi, with about 3% of forest lost every year. Wood is the most commonly used source of energy among the rural poor in Mulanje.

Adaptation and mitigation procedures in Mulanje Mountain Forest Reserve

Since the communities of Mulanje are aware of the change in climate, there are several adaptation and mitigation strategies that are taking place in the district. Some of them are:

1. The T/A Njema Community-based Irrigation Project

This project was started to divert water from Nanchidwa River into fish ponds and the small vegetable gardens surroundings the ponds. The success of the project convinced other members of the community to imitate the same efforts. Later, the supply could no longer provide the much needed water into the community fields. A committed village sought external help to build a strong and bigger structure (a weir) to assist in diverting water and also improve on the irrigation canal. Today, these communities are happily irrigating a larger piece of land and generating income from of-season crop sales and fish production in 45 fish farms.

2. The Chisongoli Catchment and Watershed Management Project

The Chisongoli Catchment and Watershed Management Project, also in T/A Njema, came about after the Mulanje Mountain Conservation Trust and COMPASS research realised that people were encroaching into the reserve, destroying the forest's ecosystem, and jeopardising water for people downstream. Founded by the United States Agency for International Development (USAID) and the Coca-Cola Company, this project helps communities around the T/A Njema area to withdraw from the forest reserve and gain employment in other areas such as tea growing sector. The tea industry has committed to helping these individuals establish small scale tea farms by donating tea seedlings and supporting other agricultural activities.

3. Changes in crop choice and farming techniques

Communities in Mulanje have responded to rainfall's unpredictability by employing intercropping and relay cropping as farming techniques. Farming households are often planting a minimum of two crops in their gardens, including cereals, legumes, pulses and tuber or root crops. Fast-maturing pigeon peas, which fix nitrogen in the soil, are a source of proteins. These peas are commonly used in intercropping and are grown as a cash crop in the district. There is, however, potential for loss of genetic resources with these adaptations as farmers prefer them to the old practices.

4. The Mkhumba Boundary Communities Livelihoods Improvement Project

The objective of the Mkhumba Boundary Communities Livelihoods Improvement Project in Phalombe (a drier area of the MMFR) is to improve the lives of impoverished communities in Phalombe district. These communities live close to and interact with the MMFR. At the same time, the project encourages the sustainable management of the reserve's natural resources and the survival of its biodiversity. The project focuses on agricultural adaptation since the area is predominantly agricultural. It assists farmers to use wetlands (*dambos*), small-scale irrigation and drought sensitive crops in order to improve their harvest. The emphasis is on supplementing their household incomes rather than simple food production and food security.

5. The Biomass Energy Conservation- A Public-Private Partnership Programme

In T/A Mabuka, eighteen stove producer groups from Nkuta and neighbouring villages have partnered with the Lujeri Tea Estates Company, in collaboration with IFSP/GTZ-ProBEC, in a project to conserve biomass energy. The Public Private Partnership Programme (PPP) encourages people to switch from cooking in an open fire place, which consumes a lot of firewood, to cooking on low cost, energy saving stove called "*Chitetezo Mbaula*", which is as a protective stove. The protective stove uses less firewood than open firewood because it produces more heat energy and less smoke from the same amount of wood. In addition, the stove runs on any form of fuel available around the home, such as cassava stems, tea stems, pigeon peas stems and maize stalks.

Activity 3.7.8:

Read the Mulanje Mountain Forest Reserve (MMFR) case study above and in groups of five, do the following activity.

Q1. What evidence is there in Mulanje District that shows that climate has indeed changed?

Q2. Identify the climate change mitigation and adaptation techniques that are being followed in Mulanje District.

Q3. If you were in Mulanje, suggest what you could do to contribute to climate change mitigation and adaptation in the district.

CASE STUDY 2: THE LAKE CHILWA BASIN

Malawi has experienced a number of adverse climatic events in recent years. Lake Chilwa, a major lake in the country has dried up nine times in the 20th century due to low rainfall in the basin. It is predicted that the events of this nature will become more common with increased climate variability. Some studies suggest that temperatures in the Lake Chilwa Basin will increase by up to 5°C by 2075.

The area around the basin is highly populated, thus posing a big threat on environmental resources. There is increased environmental degradation and an anticipated but predictable climate change in the basin that is causing food insecurity and famine.

In the past, sector specific strategies worked towards solving problems of food insecurity, overfishing, deforestation, soil erosion and siltation of rivers. However linkages between these sector strategies have been weak and have failed to address the wider impacts of climate variability and change on food production, the environment and livelihood vulnerability. In addition, there is lack of capacity at the local and district level within the sectors to plan for and manage the impact of climate change.

As a matter of adaptation to climate change, the Lake Chilwa Basin Climate Change Program (LCBCCP), implemented by WorldFish, in partnership with Leadership for Environment and Development (LEAD), The Forestry Research Institute of Malawi and the University of Malawi and funded by the Norwegian Ministry of Foreign Affairs, is developing a range of climate change adaptation solutions. These will be implemented in support of the country's national adaptation program so as to enhance the capacity of communities to adopt sustainable livelihoods and natural resource management. Attention is focusing of human-environment relationship in ten hot spots in the Lake Chilwa Basin, each of which has been identified by local community members. One of the key tools to be used will be the International Union for Conservation of Nature's Ecosystem-based adaptation model. This builds on traditional knowledge and generates a range of social, economic and cultural benefits while helping to conserve biodiversity. The project will also conduct studies on critical ecological systems, processes and components such as water resources, soil erosion and vegetation.

Source: *http:www.worldfishcenter.org/our-esearch/ongoing-projects/climate-change-adaptation-lake-chilwa-basin*

Activity 3.7.9:

Read the case study above and in groups of five, answer the following questions:

Q1. What evidence is there to show that there is climate change in the Lake Chilwa Basin?

Q2. Identify the causes of climate change in the Lake Chilwa Basin.

Q3. What climate adaptation measures are being undertaken in the Lake Chilwa Basin?

Q4. If you were a resident of Lake Chilwa Basin, suggest the proper climate adaptation measures that could be put in place.

Review Questions

Q1. (a) Define the following terms:

(i) Environmental issue

(ii) Environmental problem

(b) List examples of environmental issues and environmental problems.

Q2. (a) Define the term 'pollution'.

(b) Mention the types of pollution that you know.

(c) Explain any causes of each types of pollution that you have mentioned.

(d) State any three effects of each type of pollution.

(e) How can the types of pollution mentioned in Q2 (b) above be controlled? Suggest any three ways.

Q3. (a) What do you understand by the term 'desertification'?

(b) Mention the causes of desertification.

(c) How do the causes mentioned in Q3 (b) above cause desertification?

(d) Explain the effects of desertification.

(e) Suggest measures for controlling desertification.

(f) Complete the flow diagrams below:

(i)

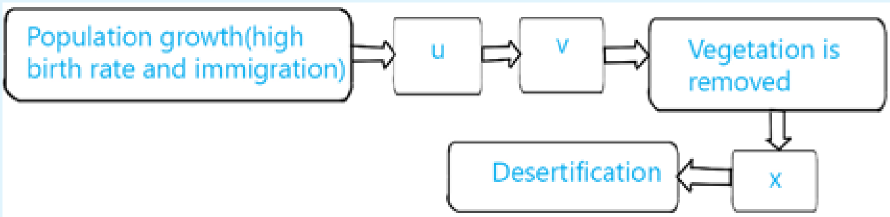


Fig. 3.7.12: Flow diagram showing causes of desertification

(ii)

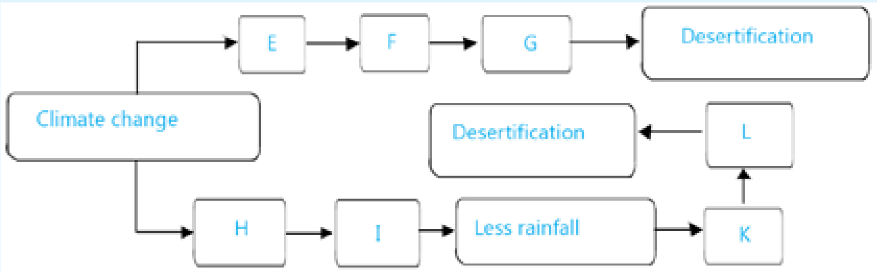


Fig. 3.7.13: Flow diagram showing causes of desertification

Q4. (a) Define the term 'climate change'.

Below is a tree diagram showing the causes and effects of climate change. The roots of the tree represent the causes of climate change, while the branches represent the effects of climate change. The trunk represents the main idea which is climate change. Use it to answer questions that follow.

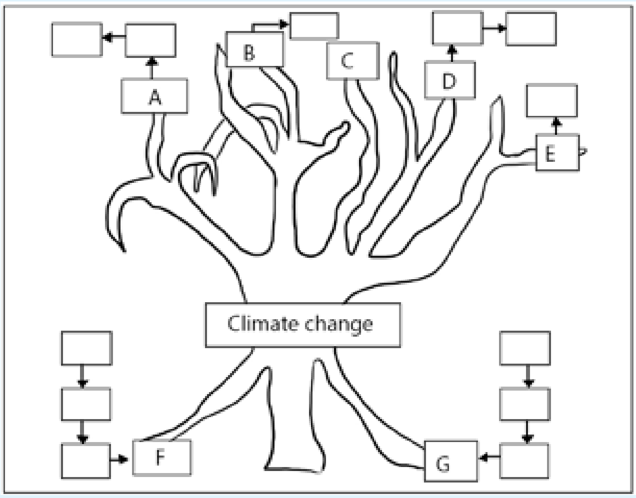


Fig. 3.7.14: Tree diagram showing causes and effects of climate change

(b) Describe the causes of climate change F and G.

(c) What do you think could have led to the causes described in Q4 (b) above?

(d) Describe the effects of climate change A, B, C, D and E.

(e) Fill in the gaps in the branches of the tree diagram.

(f) Suggest measures or solutions to problems of climate change.

Q5. (a) Differentiate between climate change mitigation and climate change adaptation.

(b) Give examples of climate change mitigation and adaptation practices in Malawi.

TOPIC 8

World Fishing

Success criteria:

By the end of this topic, the student should be able to:

- Explain the development of the world fishing industry.
- Identify major fishing grounds.
- Explain the main fishing methods used in world fishing.
- Explain the importance of the fishing industry.
- Explain other resources from the sea apart from fish.
- Examine challenges faced by the fishing industry.
- Suggest possible solutions to the challenges faced by the fishing industry.

Background

In Form Two, you looked at fishing in Malawi with regards to its importance and the human activities that endanger fish resources. You further learnt about ways of preserving fish and methods of catching fish in Malawi. You also located the major fishing grounds on the map of Malawi. In Form Three, you will identify the major fishing grounds on the world map. You will further look at the main fishing methods used in world fishing, the importance, challenges and possible solutions to the challenges faced by the fishing industry.

Terminologies

- **Fishing:** This is a primary industry activity involving the catching of aquatic animals from a water source.
- **Fishing piracy:** It refers to the illegal fishing of endangered species.

FACTORS THAT INFLUENCE DEVELOPMENT OF THE FISHING INDUSTRY

Activity 3.8.1:

In groups of five, discuss the factors that influence development of any industry.

1. Human factors

(i) Presence of a large population which provides labour to carry out fishing and a market for the fish.

2. Physical factors

(i) The meeting of warm and cold ocean currents which encourages the growth of planktons (This is food for fish).

(ii) Presence of good natural harbours.

(iii) Availability of shallow water on the continental shelves which allow planktons to grow properly.

(iv) Availability of planktons (green, microscopic plants) on which fish feed.

(v) Existence of a cool climate. Fish are cold-blooded animals and they survive in temperatures lower than 20°C. This climate also helps in the growth of planktons.

(vi) Favourable nature of the coastline: Indented coastlines are good for fishing because they offer good natural harbours.

(vii) Presence of mountains, infertile soils and absence of minerals.

These conditions force people to undertake fishing as a means of livelihood.

(viii) Planktons require water with little to high concentrates of salts. Saline water favours plankton growth.

3. Economic factors

(i) Market availability: Areas which are highly populated offer a wide market for the fish caught.

(ii) Transport facilities: Since fish is highly perishable, it requires readily available and fast means of transport.

(iii) Capital: Fishing is a capital-intensive activity requiring large sums of money, since fishing equipment has to be bought.

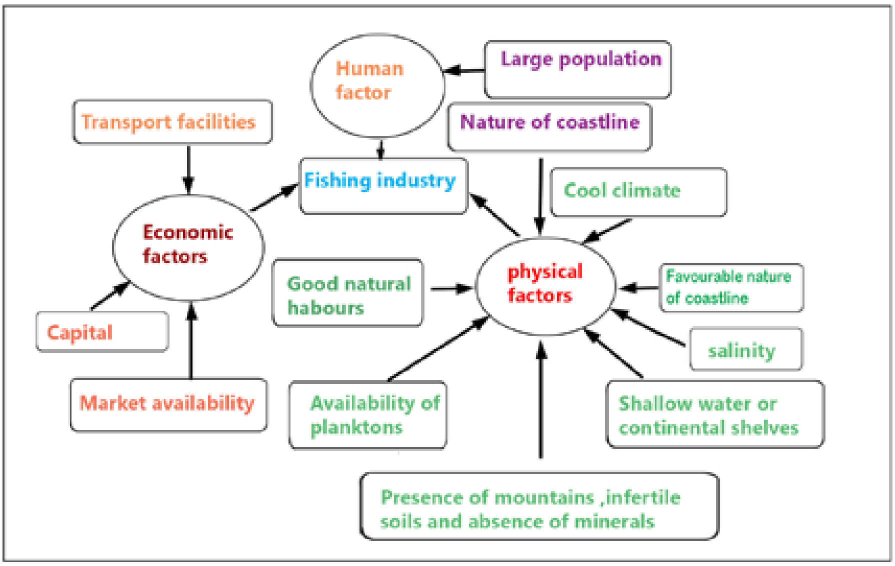


Fig. 3.8.1: Flow diagram showing factors that influence the development of the fishing industry

LOCATION OF THE MAJOR FISHING GROUNDS ON THE WORLD MAP

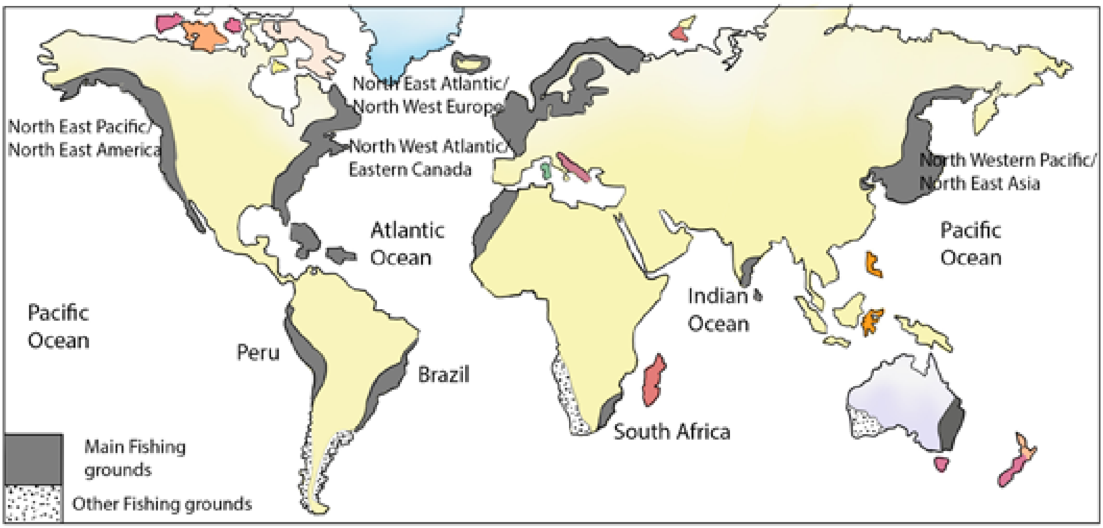


Fig. 3.8.2: Map showing location of major fishing grounds of the world

Activity 3.8.2:

In pairs, draw the world map in your notebooks. From the world map, locate the following major fishing grounds:

- *North East Pacific or North East America.*
- *North East Atlantic or North West Europe*
- *North West Atlantic or Eastern Canada*
- *North Western Pacific or North East Asia*

NORTH WESTERN PACIFIC/NORTH EAST ASIA

Location

This is one of the major fishing grounds of the world. Fishing takes place in areas surrounding Japan (major fishing country). It extends from Bering Sea to East of China.

Reasons for large scale fishing

- High demand for fish and its products both locally and internationally due to high population.
- Good transport network.
- Advanced technology.
- Presence of indented coastlines, for example, Japan provides shattered fishing ports, calm waters and safe land places which are ideal for the fishing industry. Hakodat and Kushiro are large fishing ports.
- Absence of lowlands and pastures which mean that only a few animals can be kept to supply meat and other protein foods. Therefore, there is increased demand for fish.
- The continental shelves are rich in planktons because of the meeting of Kuroshiwo Warm Ocean current and Katchatka Cold Ocean current.
- Industrialisation has enabled fishing to be scientific.

Examples of fish caught

The types of fish that thrive in cold waters include:

(a) Cod (b) Halibut (c) Herring (d) Salmon

The types of fish that thrive in warm waters include:

(e) Sardine (f) Tuna (g) Mackerel

NORTH WESTERN ATLANTIC/EASTERN CANADA

Location

This fishing ground extends from Cape Cod to Newfoundland, off the coast of Canada in South America. The major problem is overfishing.

Reasons for large scale fishing

- It has indented coastlines with good natural harbours.
- Presence of a harsh climate and infertile soils has forced people to look for alternative sources of income such as fishing.
- The meeting of North Atlantic Drift warm current and Labrador Cold Ocean current facilitates precipitation of nitrates which in turn creates a good condition for plankton growth.
- Presence of shallow waters which catalyses the process of photosynthesis in planktons.
- Availability of capital.
- Availability of advanced technology.
- Nearness to markets which are found close to densely populated areas of the North Eastern part of the United States of America.
- Cool temperate climate.
- Availability of temperate forests which provide timber for the manufacture of sailing boats and fishing crafts, as well as parks for floating nets.

Examples of Fish caught

(a) Cod
(b) Sardines
(c) Hake
(d) Mackerel
(e) Haddock
(f) Halibut
(g) Flounder

NORTH EAST ATLANTIC/NORTH WEST EUROPE

Location

This is one of the major fishing grounds of the world. Fishing grounds in this area include Barents Sea, Iceland, North Sea and Bay of Biscay. Norway is the leading fishing nation in this region. Other fishing countries include France, Denmark, Spain and Great Britain.

Reasons for large scale fishing

- Ideal cool climate for plankton and fish growth.
- Presence of ports and fish breeding places.

- Large markets for the fish because the fishing ground is close to densely populated areas of the world.
- Improved technology enabling mechanisation to take place.
- Good and wide continental shelves.
- The mixing of the North Atlantic Drift (warm current) with cold waters of the Arctic ocean over shallow waters above continental shelves.
- Highly mechanised fishing floats.

Cod and herring dominate Norway's fishing industry although whaling in the Antarctic is of great significance.

Did you know?

Norway is the leading fishing nation in N.E. Atlantic fishing ground because of:

(a) Harsh climate which makes farming unfavourable and hence people focus on the sea for their livelihood.

(b) Absence of extensive minerals and forest resources has forced Norway to turn to the sea.

Examples of fish caught include:

(a) Mackerel	(b) Haddock	(c) Halibut	(d) Hake
(e) Herring	(f) Plaice	(g) Sole	(h) Skate

NORTH EAST PACIFIC/NORTH WEST AMERICA

Location

This fishing ground extends from California to Alaska.

Reasons for large scale fishing

- Advanced technology enabling modern methods of commercialisation.
- Indented coastline with safe sheltered harbours.
- Cool climate which encourages plankton growth.
- Unfavourable climate and presence of steep slopes prevents people from carrying out other agricultural activities. This has forced people to divert to the ocean for their livelihood.
- Presence of mountain rivers such as Fraser and Skeena where fish like salmon can easily multiply.
- Upwelling of ocean waters along the coastline encourages plankton growth.

Examples of fish caught

(a) Halibut	(b) Cod	(c) Herring	(d) Salmon

Salmon fishing is the main type of fishing activity that takes place from Bering Strait to Oregon.

Fig. 3.8.3: Salmon

Description of salmon fish

To begin with, young salmon fish hatch from eggs laid in mountain streams and lakes. When they are about one year old, the young salmon fish swim downstream to the sea. When they are about four years old, the salmon fish return to the rivers to lay their eggs (this is when they are caught). Salmon fish are caught by trawls and seine nets in coastal waters. Dams across rivers prevent the fish from swimming up rivers unless special ladders are built to bypass the dams.

MAIN TYPES OF FISH CAUGHT

There are two types of fish caught. These are:

(1) Pelagic fish

These are fish which live, breed and feed near the surface of the sea water. These include tuna, pilchard, mackerel, sardines, anchovies and menhaden.

(2) Demersal fish

These are fish that live, breed and feed on the sea bed on the continental sea. These fish include sole, cod, haddock, halibut, hake, skate and garoup.

MAIN FISHING FISHING METHODS

Activity 3.8.3:

Brainstorm on the various methods used to catch fish.

1. METHODS THAT ARE USED TO CATCH PELAGIC FISH

(a) Drift nets

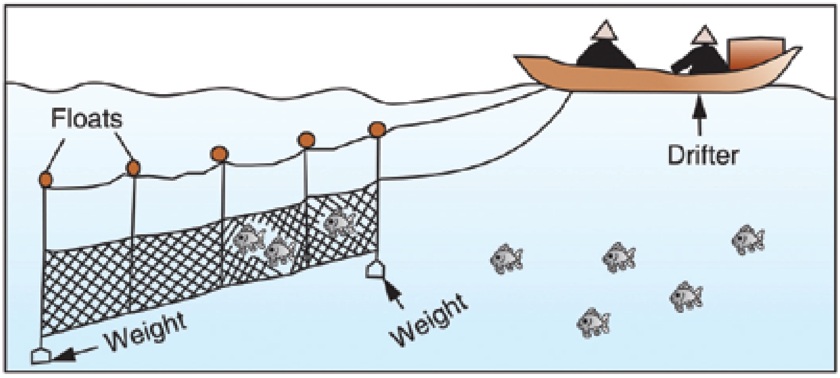


Fig. 3.8.4: Drift net

How does it operate?

These nets are hung vertically in the water. The nets are weighted along the bottom edge and supported along the top edge by floats. Fish are caught by their gills in the mesh of the nets.

(b) Purse seine net

These are nets whose mouths are kept wide open by a system of floats and sinkers. They are weighted along the bottom edge by weights and floated by corks on top. They are pulled by their ends to surround a shoal of fish. These nets are stretched between two fishing boats. Sometimes, they are pulled by two fishermen with one end attached to a small boat. They are similar to drift nets.

2. METHODS THAT ARE USED TO CATCH DEMERSAL FISH

(a) Trawl nets

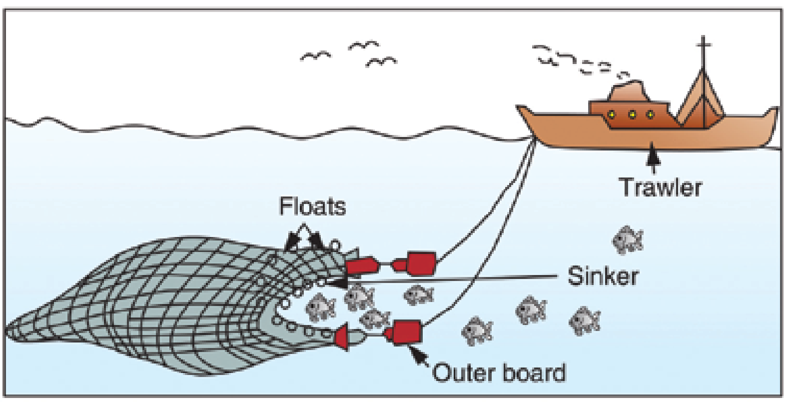


Fig. 3.8.5: Trawl net

How does it operate?

This type of net has a conical shape which is open at the base. The mouth is kept wide open by system of floats on the top part and weights at the bottom. The fish is caught by dragging the net along the sea bed by trawlers.

(b) Haul seine nets

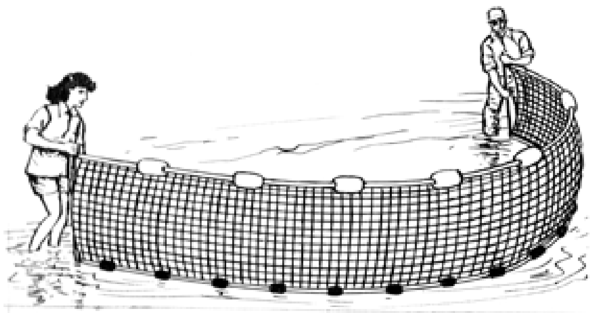


Fig. 3.8.6: Haul seine net

How does it operate?

These are nets which have an oval mouth with a conical shape. The net is stretched between fishing boats. Sometimes they can be pulled by fishermen with one end being attached to and pulled by a small boat or from the shore.

IMPORTANCE OF THE FISHING INDUSTRY

Activity 3.8.4:

Brainstorm on the importance of the fishing industry.

Explanations:

(i) It is a source of raw materials for production. Fish provide us with fertilisers, fish meals, glue and oil.

(ii) It provides the much needed proteins and minerals such as iron, calcium, iodine, copper, phosphorus and magnesium as well as vitamins.

(iii) It attracts tourists who normally study or do research on the various species of fish.

(iv) It is a source of employment.

(v) It is a source of income to fisherpersons.

(vi) It helps in the development of related industries such as fertiliser manufacturing as well as boat and net making.

Why is fishing also known as a robber industry?

This term is used because the catching of fish is not balanced by replacing the stock. This arises because of rapid population growth.

OTHER RESOURCES OBTAINED FROM THE SEA APART FROM THE FISH

(i) *Fresh water*: This is produced through desalination process (removal of salts).

(ii) *Sand* and *gravel*: These are brought by erosion.

(iii) *Oil*: These form from dead marine plants and animals.

(iv) *Natural gas*: It originates from dead marine plants and animals.

(v) *Food*. It comes in form of *prawns* and *shells*.

(vi) *Metals*: The sea gives us metals such as iron, gold, tin, manganese and gold.

(vii) *Sea weed*: This is a *raw material* for *ice cream*, *malted milk*, *cheese*, *chocolate milk*, *salad dressing*, *jellies*, *puddings* and *mayonnaise*.

(viii) *Minerals*: We obtain minerals such as *potassium*, *magnesium*, *sulphur, sodium chloride* and *phosphorus* from the sea.

(ix) *Salts*: They are mainly obtained from saline water.

(x) *Whales*: These are large fish that are caught in the sea.

SOCIAL AND ECONOMIC IMPORTANCE OF OTHER RESOURCES OBTAINED FROM THE SEA

Activity 3.8.5:

In groups of five, discuss how resources from the sea can be important socially and economically.

1. **Natural gas**

   This is a good fuel for domestic and industrial purposes.

2. **Prawns and shells**

   These provide food for the people. They are very nutritious.

3. **Sea weed**

   This is a raw material for ice cream, malted milk, salad dressing, jellies, puddings and mayonnaise.

4. **Sand and gravel**

   These materials are used in the construction industry.

5. Crude oil

This can be separated and purified to produce such products as kerosene, gasoline, bitumen or asphalt, petroleum gases, lubricants and other by-products.

6. Fresh water

This can be used for domestic and industrial purposes as well as irrigation.

7. Minerals

(a) Sodium chloride
- It is used to flavour food.
- It is used in the manufacture of sodium carbonate and sodium hydrogen carbonate.
- It is used as a raw material for the chloralkali industry.

(b) Magnesium
- It is used in alloys to build space shuttles and racing cycles.
- As a compound, it is used in the manufacture of ingestion remedies and toothpaste.
- Compounds of magnesium are also used in medicines.

(c) Bromine
- It is used in the manufacture of fuel additive tetraethyllead(IV).
- Bromine compounds are used in photography ($AgBr$), medicines (KBr) and herbicides as well as flame retardant materials.

(d) Sulphur
- It is used to vulcanise rubber, a process that makes rubber harder and increases its elasticity.
- It is also used in manufacture of matches, fireworks and fungicides.
- It is used as a sterilizing agent and in medicines.

8. Salts

(a) Ammonium sulphate
- It is used in the manufacture of fertilisers.

(b) Sodium carbonate
- It is used in glass making, softening water and making modern washing powder.

(c) Magnesium sulphate
- It is used in medicines as a laxative.

(d) Calcium sulphate
- It is used for making plaster boards and plaster cards for injured limbs.

(e) Ammonium chloride

- It is used in torch batteries.

(f) Calcium carbonate

- It is used in the extraction of sodium, drying agent (anhydrous).

(g) Potassium nitrate

- It is used in fertiliser and gun powder manufacture.

(h) Sodium chloride

- It is used in making hydrochloric acid, for food flavouring, hospital saline and in the Solvay process for the manufacture of sodium carbonate.

9. Metals

You may refer to uses of minerals in Topic 3: Natural Resources for gold and iron.

Activity 3.8.6:

In groups of five, match the resource obtained from the sea on the left, to their social and economic importance on the right.

Resource obtained from the sea	Social and economic importance
Crude oil	*This can be used for domestic and industrial purposes as well as in irrigation.*
Fresh water	*They provide food to the people and they are very nutritious.*
Sand and gravel	*This is a raw material for ice cream, malted milk, salad dressing, jellies, puddings and mayonnaise.*
Natural gas	*This can be separated and purified to produce such products as kerosene, gasoline, bitumen or asphalt, petroleum gases, lubricants and other by-products.*
Prawns and shells	*These materials are used for construction.*
Sea weed	*This is good fuel for domestic and industrial purposes.*

CHALLENGES FACED BY THE FISHING INDUSTRY

Activity 3.8.7:

Brainstorm on the challenges facing the fishing industry.

(i) Pollution of the sea

Pollution of water masses is worsened by the disposal of waste by industries. Polluted water can therefore kill fish and other marine species. Oil leakage can deprive fish of oxygen, leading to their death.

(ii) Overfishing

This is as a result of rapid population growth which exerts pressure on people to try to look for alternatives to the scarcity of meat as well as a source of income.

(iii) Destruction of fishing grounds

Most of the fishing grounds are used for various activities which include sporting and recreation. When such activities are taking place, the habitat for aquatic or marine animals is destroyed. Most of these marine animals eventually die or reduce in number and become extinct with time.

(iv) Indiscriminate fishing

This is the catching of immature fish when fishermen use nets whose mesh size is very small. The population of mature fish will consequently be reduced when fishermen catch the fingerlings or young fish. This will negatively affect the supply of fish which will not be adequate to meet the demand.

(v) Lack of knowledge

Some people lack knowledge on how to manage and conserve fish. This ignorance contributes to death of most marine species that in turn adversely affects fishing.

RELATION OF THE CHALLENGES FACED BY THE FISHING GROUNDS

(a) North West Pacific

(i) Overfishing: This is the greatest problem brought about by high population.

(ii) Fisheries conflicts: These arise from excessive fishing efforts due to increasing population and economic motivations.

(b) North East Atlantic

(i) Lack of enforcement of regulations, for example compliance with permitted quota.

(ii) Catching fish during breeding season.

(iii) Overfishing

(c) North East Pacific

(i) Water pollution

(ii) Overfishing

(iii) Lack of enforcement of regulations

(d) North West Atlantic

(i) Overfishing

(ii) Lack of enforcement of regulations applying to foreign fleets.

SOLUTIONS TO THE CHALLENGES FACED BY THE FISHING INDUSTRY

(a) Removal of all poisonous and harmful chemicals from industrial waste before it is discharged into rivers and seas.

(b) Instituting laws against industries that pollute fishing grounds in order to reduce pollution.

(c) Enacting and enforcing international law convections and agreements that protect fish in the fishing grounds.

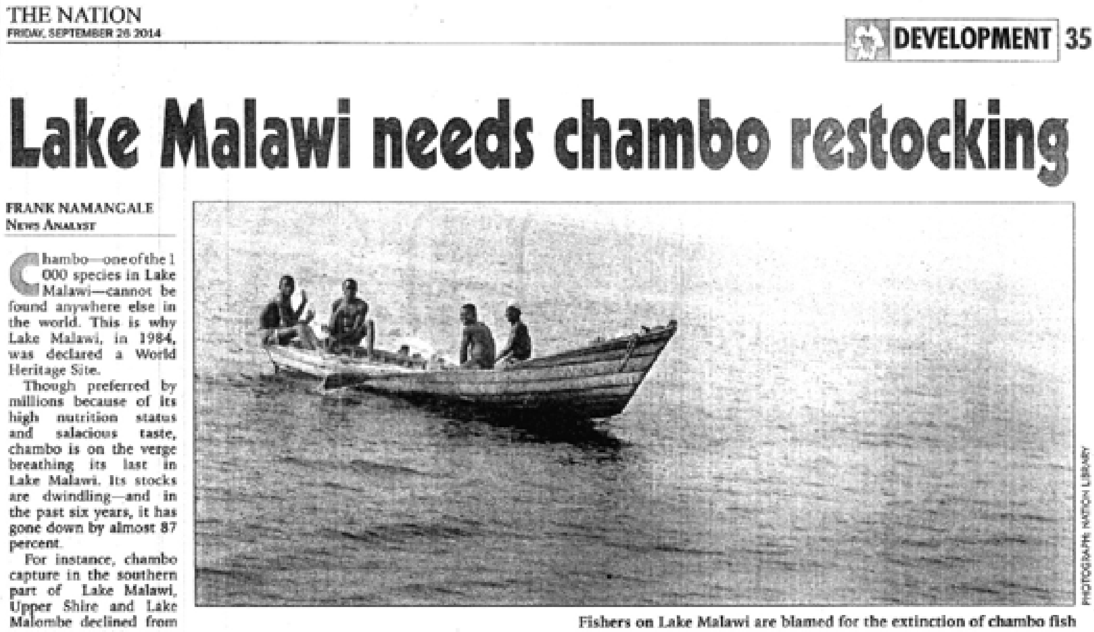
(d) Relocating the fish from highly populated areas to overfished waters.

(e) Introduction of new species in the overfished waters.

(f) Imposing tough measures on those that catch small fish, for instance, by fining them.

(g) Fish farming after thorough research of the many species of fish in terms of the types of food they eat, how they move and their habits.

(h) Restocking fish species in the overfished waters. In Malawi, for instance, *Chambo* fish has been overfished and needs restocking.



THE NATION
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DEVELOPMENT 35

Lake Malawi needs chambo restocking

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News Analyst

Chambo—one of the 1 000 species in Lake Malawi—cannot be found anywhere else in the world. This is why Lake Malawi, in 1984, was declared a World Heritage Site.

Though preferred by millions because of its high nutrition status and salacious taste, chambo is on the verge breathing its last in Lake Malawi. Its stocks are dwindling—and in the past six years, it has gone down by almost 87 percent.

For instance, chambo capture in the southern part of Lake Malawi, Upper Shire and Lake Malombe declined from

PHOTOGRAPH: NATION LIBRARY

Fishers on Lake Malawi are blamed for the extinction of chambo fish

Fig. 3.8.7: A newspaper cutting highlighting the need to restock the *chambo* fish

Proposal of measures to ensure that the solutions are successfully implemented

Activity 3.8.8:

In groups, propose measures to ensure that the solutions are successfully implemented.

Explanations:

1. Developing policy guidelines that will help people to know how such solutions should be implemented.
2. Regulations should be laid down that describe the size of mesh to be used by fisherpersons in fishing grounds. In Malawi, the Fisheries Act does emphasise on the mesh size to be used.
3. Putting in place small committees in fishing areas to check on people who practise indiscriminate fishing. In Malawi, village beach committees have been set up by the Malawi Government to allow fish to spawn and build stocks.
4. Civic education on fish farming in terms of how it should be done will enable it to be successful. This awareness campaign can also be done in the area of management and conservation.
5. Periodic checking of waste disposal by industries. There should be a link between industries and authorities who manage fisheries in major fishing grounds. This can help to verify that there are no poisonous and harmful chemicals from industrial waste before it is discharged into rivers and seas.

Review Questions

Q1. Below is a world map showing major fishing grounds. Use it to answer the questions that follow:

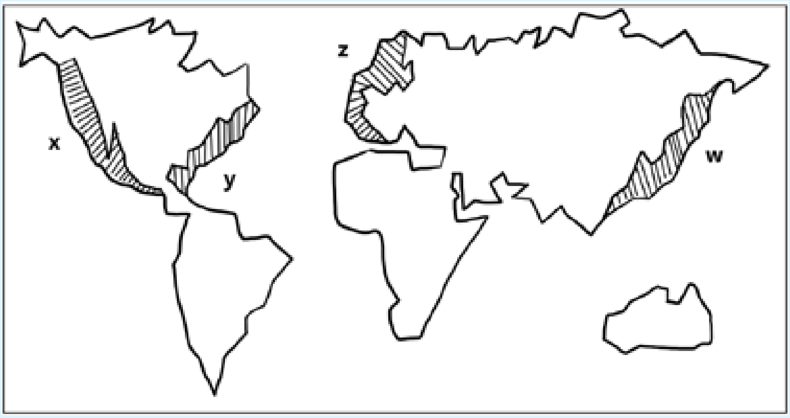

Fig. 3.8.8: Major fishing grounds of the world

(a) Mention the fishing grounds W, X, Y and Z.

(b) Explain any five factors that have helped in the development of the fishing grounds mentioned in Q1 (a) above.

(c) Give any two examples of fish caught in each of the above-mentioned fishing grounds.

Q2. (a) (i) Differentiate between **pelagic** and **demersal** types of fish.

(ii) List any three examples of **pelagic** and **demersal** types of fish.

(b) With the aid of diagrams, describe the methods that can be used to catch pelagic and demersal types of fish.

Q3. (a) Explain any four importance of the fishing industry.

(b) State any five resources that can be exploited from the sea apart from fish.

(c) Explain the social and economic importance of these resources obtained from the sea.

Q4. (a) Describe any four challenges faced by the fishing industry.

(b) Suggest three solutions to the challenges faced by the fishing industry.

(c) Suggest any measures that can be taken to ensure that solutions are successfully implemented.

TOPIC 9

International Trade

Success criteria:

By the end of this topic, the student should be able to:

- Explain the term 'trade bloc'.
- Explain the aims of regional and international trade blocs.
- Explain the benefits and challenges of trade agreements.
- Explain the role of customs in international trade.

Background

In Form Two, you learnt about trade in Malawi. You specifically learnt about the definitions of imports and exports, balance of trade in Malawi and factors that influence it. In Form Three, you will look at international trade in line with regional and international trade groupings. You will also learn about the aims, benefits and challenges of trade agreements as well as the role of customs in the international trade.

REGIONAL AND INTERNATIONAL TRADE BLOCS

Meaning of the term 'trade bloc'

Activity 4.9.1:

In groups of five, discuss the meaning of the term 'trade bloc'.

A trade bloc refers to an organisation of various countries within a given geographical region aimed at achieving similar economic goals for each member state.

Examples of regional and international trade blocs

(i) Regional trade blocs

- The Common Market for Eastern and Southern Africa (COMESA).
- The Southern African Development Community (SADC).
- The Economic Community of West African States (ECOWAS).

(ii) International trade blocs

- World Trade Organisation (WTO).

AIMS OF REGIONAL AND INTERNATIONAL TRADE BLOCS (COMESA)

Activity 4.9.2:

In groups of five, discuss the aims of SADC, COMESA and WTO.

1. THE COMMON MARKET FOR EASTERN AND SOUTHERN AFRICA

Introduction

COMESA was established on 8th December, 1994. It replaced the Preferential Trade Area (PTA). Its headquarters are in Lusaka, Zambia.

Member countries of COMESA

Angola, Burundi, Comoros, Democratic Republic of Congo, Djibouti, Eriteria, Ethiopia, Egypt, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Namibia, Rwanda, Seychelles, Somalia, Sudan, Swaziland, Uganda, Zambia and Zimbabwe.

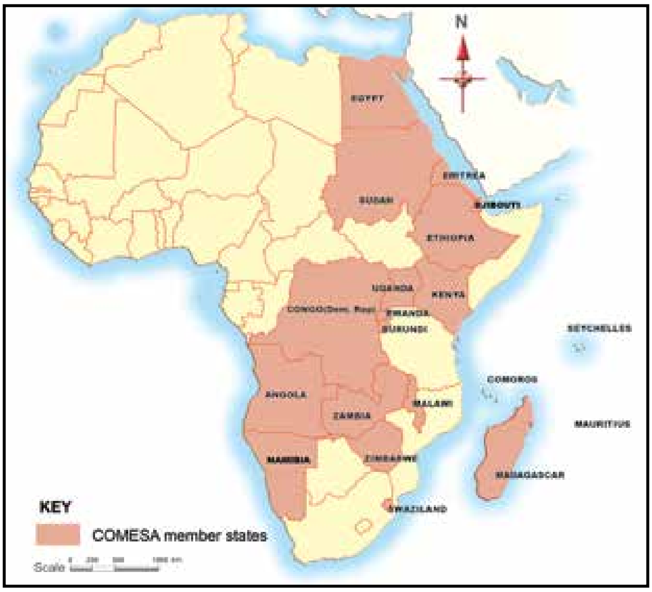

Fig. 4.9.1: Member countries of COMESA

Aims of COMESA

- To create a conducive environment for both domestic and foreign investment.
- To enhance cooperation in economic activities.
- To foster peace, security and stability in order to enhance economic growth.

Roles played by COMESA

- It widens the common market for member countries.
- It increases productivity and specialisation because of increased competition.
- It promotes rational exploitation of natural resources.
- It establishes a good network of transport (road and railway).
- It abolishes some taxes thereby increasing volume of trade.

2. THE SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC)

Introduction

This regional trade grouping was formed in 1922 in Windhoek in Namibia. Its headquarters are in Gaborone, Botswana. It has fourteen member countries.

Member countries of SADC

Lesotho, Tanzania, Swaziland, Angola, Democratic Republic of Congo (DRC), Zambia, Malawi, Namibia, Botswana, Mozambique, South Africa, Madagascar, Seychelles, Zimbabwe and Mauritius.

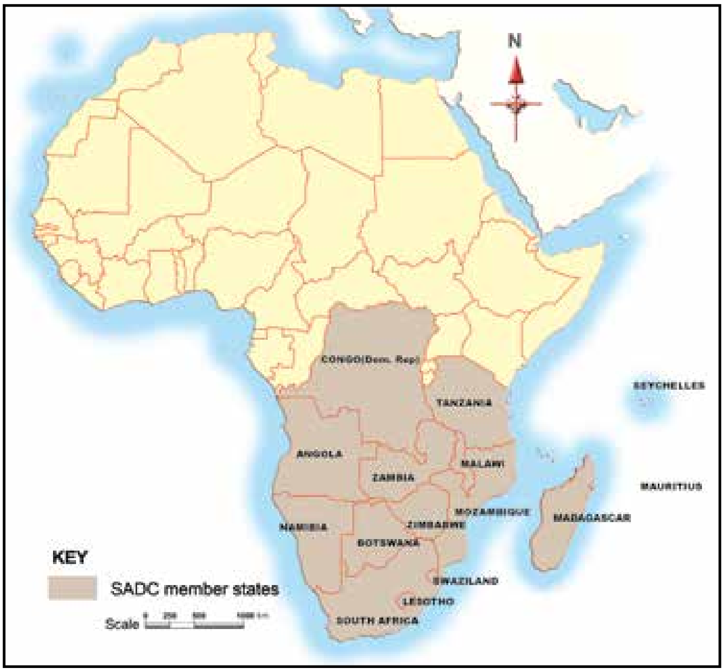

Fig. 4.9.2: Member countries of SADC

Aims of SADC

- To achieve sustainable utilisation of natural resources.
- To promote and defend peace and security in the region.
- To alleviate poverty through economic development and growth.
- To set up common political values, systems and institutions.

Roles played by SADC

- It has consolidated and maintained peace among the member countries.
- It has uplifted the living standards of people of member countries.
- It has fostered and promoted regional and international cooperation and integration.
- It has established the common market for the member countries.

3. THE ECONOMIC COMMUNITY OF WEST AFRICAN STATES (ECOWAS)

Introduction

It was established on May 28th, 1975 by a treaty in Lagos. Its headquarters are in Abuja, Nigeria.

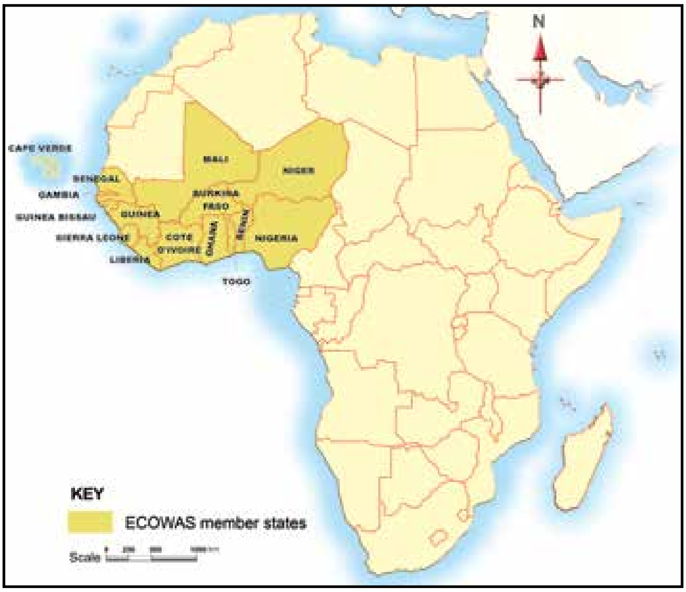

Fig. 4.9.3: Member countries of ECOWAS

Member countries of ECOWAS

- Nigeria, Burkina Faso, Niger, Guinea, Senegal, Sierra Leone, Benin, Cape Verde, Gambia, Guinea Bissau, Cote D'Ivoire, Mali, Togo, Ghana and Liberia.

Objectives of ECOWAS

- To enhance economic stability of member countries.
- To improve the living standards of member countries.
- To promote economic cooperation.
- To promote free movement of goods, people and services, from one member country to the other.

Roles of ECOWAS

- To uplift the living standards of member countries.
- To create economic stability of member states.
- To create and promote free trade.
- To improve relationships among member countries.

Activity 4.9.3:

Organise the class into proposers and opposers and debate on the question: ***Should Malawi belong to SADC and COMESA?***

BENEFITS OF REGIONAL TRADE INTEGRATION OR REGIONAL TRADE BLOCS

(i) It promotes peace and stability among member countries.
(ii) It encourages specialisation of production and increased productivity.
(iii) It promotes more rational exploitation of natural resources.
(iv) It improves living standards of people of member countries.
(v) It eliminates trade barriers which in turn increases opportunities for trade.
(vi) It promotes free flow of goods and people among member countries.
(vii) It improves transport and communication networks among member countries.
(viii) Member countries are able to bargain for better prices as a bloc and increase in supply in the world market.
(ix) It promotes economic growth and development of member countries.

CHALLENGES OF TRADE AGREEMENTS IN TRADE BLOCS

There are several challenges that are associated with regional trade agreements. These include the following:

1. International Cross Boarder Traders (ICBTs) experience obstacles such as high cost of goods entering neighbouring countries and reduced returns to their investments. This is because of the taxation system which is often punitive. Most countries depend on trade as a source of revenue. Therefore, it is difficult to implement a low and uniform common external tariff. Wide disparities among the trade regimes of member countries in SADC and COMESA make it hard to harmonise trade tariffs.
2. Women traders have complained of excessive harassment especially at ports of entry to the member countries.
3. Visa restrictions: International Cross Boarder Traders (ICBTs) often complain about visa restrictions, which stifle their businesses. In some countries, even when visa has been given, authorities allow entry for a maximum number of days. Botswana and South Africa for example, restrict visits to a maximum of 90 days only.
4. Women-owned small and medium enterprises face well documented gender-specific barriers that constrain their potential growth in business. This includes barriers in access to markets, including tourism, information and technology, as well as training needs (management and information technology), among others.

5. Disparities in the trade regimes of the member states make it difficult to harmonise common external tariff.
6. Protectionism: The proposed three or four band common external tariff structures are based on the classification of products into four categories. These categories are raw materials, capital goods, intermediates and finished products. The proposed tariff structure would lower the degree of protection for some countries but increase it for others. Past experiences suggest that classification of commodities gives ample opportunity for special interests to assert themselves.

Activity 4.9.4:

Individually, write a short essay describing the benefits and challenges of regional trade groupings.

CASE STUDY: THE ALASKA COMPANY IN DRC

Background

This company has its headquarters in Bukavu, capital of the South Kivu Province in eastern DRC, with branches in Goma and Beni. ALASKA was created in 1997. Since 2005, it has specialised in the import of wines from Stellenbosch in South Africa. The company imports paper, brand "ROTATRIM MUNDI" from Johannesburg and will soon start the import of sugar from Mauritius. ALASKA has 11 employees and about USD 2 million of turnover per year.

Barriers encountered

For ALASKA, the banking culture is still quite new in DRC and businessmen do not trust the Congolese banks. According to this company, banking fees are affordable but the transfer of money abroad takes long and slows down the running of the business. Often, the company's partners (sellers) urge them not to use Congolese banks for money transfers. This is why on the suggestion of its South African partners, ALASKA uses the Bank of Kigali (Rwanda) for its international banking transactions (for the payment of vendors in South Africa for example).

It has recently become increasingly possible to get loans from local banks, thanks to the establishment of branches in Bukavu. The company thinks, however, that the interest rate is still high. The micro-finance institutions (which are commonly used in the eastern part of the DRC) charge an interest rate of around 3% per month or 36% per annum. The interest rate charged by commercial banks varies but is currently between 1.5 and 2% per month or 18 to 24% per annum. It is important to note that loans are mainly given in USD and rarely in the local currency (Congolese franc).

Moreover, the long banking procedure for obtaining credit does not encourage businessmen to borrow money from the banks. They prefer to work with the local Savings and Credits Cooperatives although their interest rates are higher than those of the banks.

Small and medium enterprises pay a flat income tax of $250 per year in the DRC. If the fiscal administration discovers that the company's value has been under-estimated, the administration will apply the normal rate of 40% plus a fine of 25% of the profit. This creates uncertainty and a temptation to under-report on earnings in order to avoid the steep penalties for under-estimating turnover. There is also an issue with multiple levels of taxation. The company pays many taxes that it does not fully understand. Some of these taxes include: Tax EAD (tax collected by the local government), VAT, tax collected by the International Trade Office, Tourism, Economic Affairs, IPMEA (office of Small and Medium Enterprises, industries and craft industry), environment tax, health service tax, etc.

The political and economic environment in the DRC is not conducive for business. As a result, it cannot attract new investors. The investment code is old and cumbersome: to register a new company, one needs to travel to Kinshasa, 2000 kilometres away from Bukavu. The procedure is costly and can take more than one year. All licenses and permits need to be applied for in Kinshasa. This results in a high level of corruption of public agents and contributes to delays. Corruption is beyond tolerable limits. When paying customs duties, the amount, which appears on the official clearing document, is only a half or a third of what in effect is payable by the company. It is not possible to obtain services needed from the government without bribing the agents. Otherwise the service will take unjustifiable longer to be delivered.

Furthermore, the company contends that customs clearing procedures are expensive and are not consistent in DRC. They change every two or three months. This implies supplementary costs for the company. Congolese customs agents are competent but the lack of equipment limits them: their services are not computerised; they do not have checking equipment; they have no access to the Internet and cannot communicate with the customs administrations of neighbouring countries. Good infrastructure is lacking in the DRC. However the infrastructure in the rest of the region is generally acceptable.

Differences in traffic laws are a challenge. Maximum weight loads differ from 50T in Tanzania to 45T in Rwanda with Zambia and other countries having their own laws.

Quality and standard controls are weak in the DRC and officials are easily bribable. The difficulties arise when entering South Africa where strict rules apply.

Impact of barriers

The lack of credit is a barrier for many businessmen in the DRC. It makes it difficult to sustain a steady cash flow and make timely payments to partners in other SADC countries.

The company estimates that its business is highly affected by the tax system in DRC. It is difficult to develop and expand the business with all the taxes it pays. To avoid being ripped off by tax agents, the company employs a consultant at an additional cost.

In other countries in the region, it is possible to know the content of a container without taking a long time to check the whole container by hand. The lack of required equipment (a scanner for example) in DRC's customs administration leads the customs agents to check all containers and this affects the costs of the business.

The lack of useable roads in DRC increases the cost of doing business for the company. The following example was provided: from Tanzania to the Congolese border, Bukavu, a truck takes 6 days (about 2000 km). However, during the rainy season the same truck takes between 4 and 5 days from the border to Bukavu (only 3 km), with a high risk of accident and losing the goods. The consequence is that the stay of Tanzanian drivers in DRC is too long; there is a high risk of their visa expiring.

Furthermore, given the impassable nature of roads in DRC, many small cities are not accessible and the company is obliged to use aircrafts to transport its goods to those cities. This increases the selling price of the commodities.

Moreover the lack of electricity limits the importation capacity of the company in frozen products. The company is the exclusive reseller of DISTELL's products in eastern DRC, except Katanga. However, due to the poor quality of transportation infrastructure, the company is not able to deliver products in provinces such as Maniema, Eastern Province and other remote cities.

The multiplicity of people to bribe for obtaining services affects the profitability of the company. The company considers that for an issue to be actioned by public agents, one has to bribe several people and several times without being sure that the problem will be sorted out in time and effectively. This implies many additional costs that the company did not budget for.

Lastly, differences in the traffic laws in regional countries (most of them being members of SADC) concerning the maximum weight a truck can transport generate supplementary costs for the company since it has to pay fines in three to four countries where its trucks transit. The lack of harmonisation of these laws generates an important loss of profit for the company.

Comments and suggestions

The company has the following recommendations for the Congolese government:

1. Decentralise the administration: The country is too large and businessmen do not need to travel to Kinshasa to obtain business permits and licenses.
2. Improve the quality of roads.
3. Revise and update the investment code.
4. Reduce the number of agents and state departments operating at the border.
5. Equip the customs administration with the necessary tools and equipment so that time spent at the border can be reduced.

Source: http://www.thetradebeat.com/sadc-business-case-studies/alaska

Activity 4.9.5:

In groups of five, read the case study of ALASKA company in the Democratic Republic of Congo and do the following activity:

(a) Identify the challenges faced by Alaska company in DRC.

(b) How are these challenges connected to regional trade groupings or blocs?

(c) What are the suggested measures to minimise such problems?

What are the benefits of abolishing taxes or import duties within trade groupings?

- It increases volume of trade in the member countries.
- It ensures economic growth of member countries.
- It improves living standards of the people of the member countries.

Factors that influence the type of trade that is to be followed within a particular region such as SADC members

(i) Presence of natural resources such as gold (South Africa), copper (Zambia) and uranium in Malawi, among others.

(ii) The degree of industrial development, for example South Africa which manufactures many products.

(iii) Geographic location of a particular country. A country can participate in trade with countries of contrasting economies because of its geographical position. This type of trade is called *entrepôt*.

(iv) Tariffs and import duties often tend to reduce volume of trade among countries.

ROLE OF CUSTOMS IN INTERNATIONAL TRADE

Meaning of the concept of 'customs'

This refers to the place at the port, airport, or frontier where officials check incoming goods, travellers or luggage. It is a government department entrusted with the enforcement of laws and regulations to collect and protect import revenue, and regulate and document the flow of goods in and out of the country.

Activity 4.9.6:

In groups of five, discuss the role of Customs in trade.

Explanation:

Customs has become the hub around which the wheel of globalisation turns. The hub must be both strong and flexible in order for global trade to operate efficiently while society remains safe.

Primary role of Customs

- Customs focuses on revenue collection as its primary task.

Changing role of Customs

- Customs has changed its role from revenue collection to trade facilitation.

How does the department of Customs achieve this role?

This is done by ensuring that there is a balance between effective control measures and facilitation of trade.

CHALLENGES FACED BY CUSTOMS DEPARTMENT

Activity 4.9.7:

In groups of five, discuss the challenges faced by the Customs department.

1. The major challenge is to strike a balance between seemingly conflicting objectives which include the following:
   (i) Quick clearance for trade facilitation.
   (ii) Enforcement of control measures in the process of trade facilitation.
2. Increase in cost of administration of Customs through implementation of trade facilitation and requirements.

Review Questions

Q1. (a) What is meant by the term 'regional trade bloc'?

(b) List any three examples of regional trade groupings in Africa.

(c) Name any two members of each of the regional trade bloc listed in Q1 (b) above.

(d) Mention any two aims of each of the regional trade bloc listed in Q1 (b) above.

(e) Mention one example of an international trade bloc.

(f) What is the aim the international trade bloc mentioned in Q1 (e) above?

Q2. (a) Explain any four benefits of trade agreements among member countries within a regional trade grouping.

Q3. Describe any three challenges that trade blocs face regarding their trade agreements.

Q4. (a) Explain the role of Customs in international trade.

(b) Describe any challenges that Customs face in international trade.

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