PHYSICAL LANDSCAPES: Variety

Fig.52 Bealach na Ba, Applecross

Physical landscapes are a mixture of landforms of varying ages, origins and types. For example, a glaciated landscape could consist of a series of steep-sided, U-shaped valleys separated by a series of arete ridges, eroded by ice thousands of years ago.

The photo above (fig.52) shows part of the varied and beautiful landscape of the British Isles - the Bealach na Ba (the Pass of the Cattle) in the Applecross peninsula, deeply eroded by glaciers over millions of years.

Landscapes evolve through the influence of a variety of factors, including:

Internal forces - operating within the earth's crust:
Plate tectonics, the movement of the giant plates of the earth's crust can result in earth movements so powerful as to create major fault zones (see Fig.53), massive fold mountain ranges (such as the Alps), great rift valleys (such as the Central Lowlands of Scotland and the Rhine Valley) and volcanic eruptions such as those found in the Mediterranean Sea and in Iceland. (Fig.54)

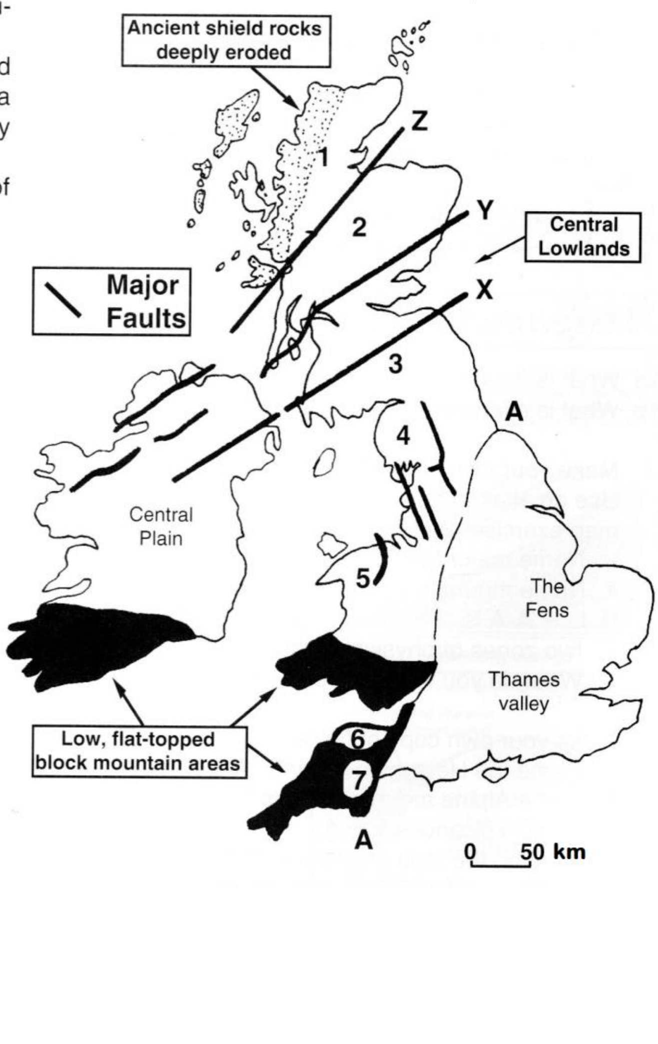
External forces - operating on the earth's surface:
These forces include weathering, mass movement, erosion, transportation and deposition as well as the influence of people.

Therefore, physical landscapes result from a combination of internal and external forces - as soon as the internal forces build up the land, external forces combine to wear it down. This balance is known as **Isostacy**.

The varied physical landscapes of parts of the earth's crust such as those of Europe (fig.54) are the result of what is known as **isostatic balance**.

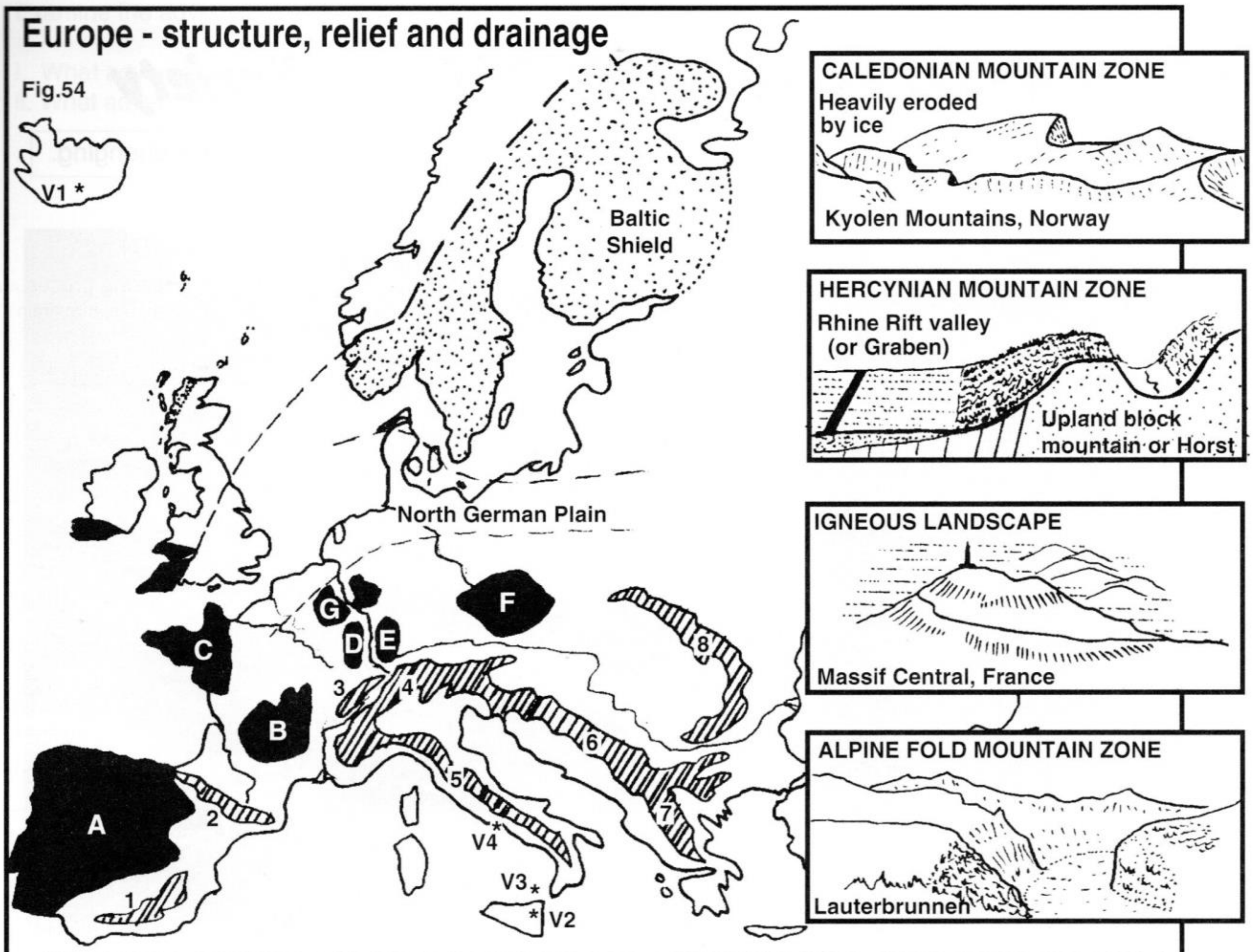
Selected physical features of the British Isles

Fig.53



Europe - structure, relief and drainage

Fig.54



EXPLANATORY KEY TO EUROPE MAP

- **The Baltic Shield** - the oldest part of Europe - a low undulating plain of old, hard metamorphic rocks.
- **The Caledonian Mountain Zone** - the remains of an old mountain chain dating back to 400 million years ago. Now a series of worn down plateaux.
- **The Hercynian Upland Zone** - another mountain building period occured about 280 million years ago. Hercynian Upland areas are a series of low, flat-topped uplands often with steep sides, and faulted or rift valleys.
- **The Alpine Mountain Zone** - Europe's highest mountain scenery formed between 85 and 30 million years ago. Many high areas, e.g. the Alps are still being glaciated.
- **The North German Plain** -a sedimentary lowland consisting of an undulating plain of a variety of deposits stretching from the North Sea to Eastern Poland.
- * **Volcanoes**, e.g. Mt.Etna, form spectacular mountain scenery along plate boundaries to the North and South of the continent.

Assignment Eleven

1a What is meant by the term physical landscape ?
1b What is a landform ?

2 Make your own copy of fig.53 - the British Isles. Use an atlas to help you complete the following map exercise. Write your answers on the map:
- i. Name major fault lines **X, Y** and **Z**.
- ii. Name mountain & upland areas **1** to **7**.
- iii. Line **A-A** is often used to divide Britain into two zones of physical landscape. What do you think these zones are ?

3 Make your own copy of fig.54
- i. Name the Hercynian Uplands **A** to **G**.
- ii. Name Alpine mountain areas **1** to **8**.
- iii. Name Volcanoes **1** to **4**.
- iv. Mark on the map the names of the main rivers; Danube, Rhine, Rhone, Seine & sea areas; Mediterranean, Baltic, North Sea, Bay of Biscay, North Atlantic, Norwegian Sea.

5 Europe has five main physical zones: the Baltic Shield, the Caledonian Mountains, the Hercynian Uplands, the Alpine Mountains and the North German Plain.
Write a brief description of each.

6 What are the main differences and similarities between
- i. the Caledonian and Alpine Mountain zones
- ii. the Central Lowlands of Scotland and the Rhine Valley ?

7 Design a simple diagram to explain the term isostatic balance.

PHYSICAL LANDSCAPES: Processes

Fig.55 Loch Torridon, Wester Ross, Scotland

Landscape processes

Time: 0 → Present day

Landscape Creating processes
Crustal movements, mountain building, earthquakes
Tens of millions of years

Landscape readjustments
Ice Ages, development of deserts
1-2 million years

Landscape modifications
by glaciers, rivers, seas, wind
Thousands of years

Landscape shaping processes
weathering, mass movements, human activity
Hundreds of years

Physical landscapes are shaped by a number of **processes** which act on the landscape and cause it to change.

In the photograph above (Fig.55) the landscape of the Loch Torridon area consists of a varied geology - different rock types including ancient sandstones interspersed with schists and gneiss originally formed over 1,000 million years ago. Crustal movements, resulting huge earthquakes, intense glaciation and recent human activity have all combined to shape the landscape shown. (Fig.56)

It is important to understand that the story of the shaping of any landscape is a never-ending one. The processes operating to shape a landscape include weathering, mass movement, erosion, transportation and deposition and depend on each other.

Weathering - is the small-scale breakdown of rock by physical, chemical and biological processes which produce rock debris known as **regolith** (fig.57).

Mass Movement - the movement of debris or regolith downhill is known as mass movement or **wasting** and occurs at a variety of speeds producing different effects (see fig.58)

Erosion - the removal of rock, soil and minerals carried out by **agents of erosion** which include ice (glaciers), water (rivers, seas), wind, people & animals. Erosion may be classified as Physical or Chemical (fig.59)

Transportation - all agents of erosion carry or transport eroded materials to other areas(fig.59)

Deposition - materials being transported will eventually be dropped or deposited as the agent of erosion loses energy.

All these processes act on a landscape over varying periods of time and at different rates depending on the resistance of the rocks being acted upon. This variation is known as **differential erosion**.

Fig.56 Main Rock Types

ROCKS AND SCENERY

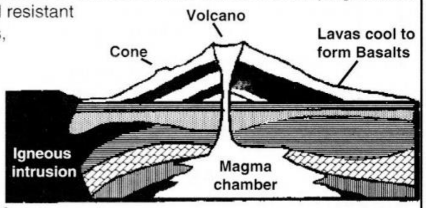
Landscapes and landforms are influenced by the type and structure of rock. The Highlands of Scotland are mainly composed of granite, schist and gneiss - they are harder than the sedimentary rocks which make up most of the Lowlands. Many hills in the Central Lowlands of Scotland (eg. Ochils, Pentlands) are composed of lavas and are harder and more resistant than surrounding rocks. Older rocks tend to be harder than young sedimentary rocks which tend to be soft and easily eroded.

IGNEOUS ROCKS derived from "Ignis" (Latin) - meaning fire

An **Igneous** rock is made up of material which was once molten. Igneous rocks can be classified into two main types:

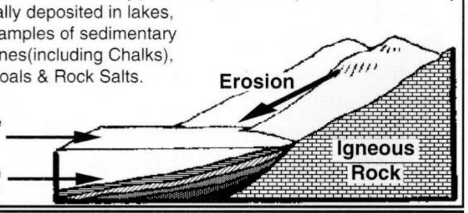
Extrusive rocks - lavas & ashes which cool on the surface developing smaller crystal structures. Hard and resistant rocks which include Basalts, Andesites, Obsidian, Pumice and Tuffs (ash).

Intrusive rocks - molten magmas which cool below the surface and develop large-medium crystals. Very hard and resistant rocks which include Granites, Dolerites, Pegmatites, Porphry (giant crystals).



SEDIMENTARY ROCKS derived from sediment - loose materials

Sedimentary rocks are formed from tiny particles (sediments) which are carried by rivers and are eventually deposited in lakes, seas and oceans. Examples of sedimentary rocks include Limestones(including Chalks), Sandstone, Shales, Coals & Rock Salts.



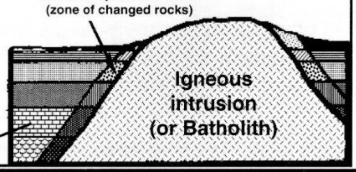
Over millions of years the lakes, seas and oceans are gradually filled in

Sediments are deposited in layers called strata or beds

METAMORPHIC ROCKS meaning change

A **Metamorphic** rock is an existing rock - an igneous, sedimentary or other metamorphic rock - which has been changed either by heat or pressure or both.

Often very hard and known as recrystalline, metamorphic rocks include Marble, Quartzite, Schist and Gneiss.



WEATHERING PROCESSES

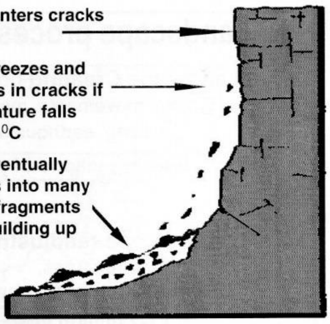
Fig.57

PHYSICAL WEATHERING

occurs where physical forces cause rocks to break up into smaller pieces.

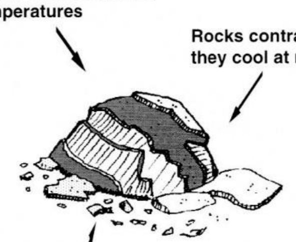
FROST-SHATTERING

occurs in high, cold wet areas



ONION WEATHERING

occurs in areas of high temperatures



CHEMICAL WEATHERING

occurs when there is a chemical reaction between water or a weak acid and rock.

Rainwater is a weak Carbonic acid which dissolves Calcium Carbonate($CaCO_3$)

Limestones consist of $CaCO_3$ and are dissolved slowly to form Limestone Pavements of clints & grykes(photo)

If a soil cover exists this process of chemical weathering is greater

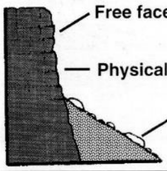
Fig.58

MASS MOVEMENT

is the name given to the movement of weathered material downhill and includes:

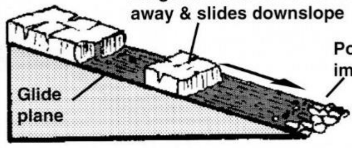
ROCKFALL

Broken rock falling downslope usually very suddenly and quickly. The material collects at the foot of the slope and is known as a **talus** (e.g. a scree slope).



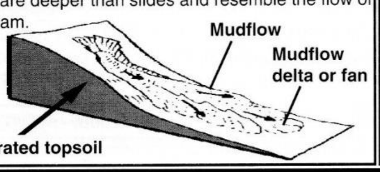
LANDSLIDE

Rapid movements of soil or rock on less steep slopes. Slides usually occur after heavy rain or snowmelt.



MUDFLOW

A flow of saturated materials downslope usually after torrential rainfall and in areas of sparse vegetation. They are deeper than slides and resemble the flow of a stream.



SOIL CREEP

A very slow process in which saturated soil expands at right angles to the slope. As the soil dries out it contracts in a vertical direction - the result is a creeping, downward movement.
Where soil cover or vegetation is removed the rate of creep is greatly increased.

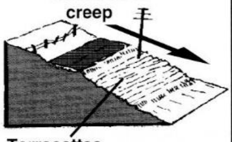
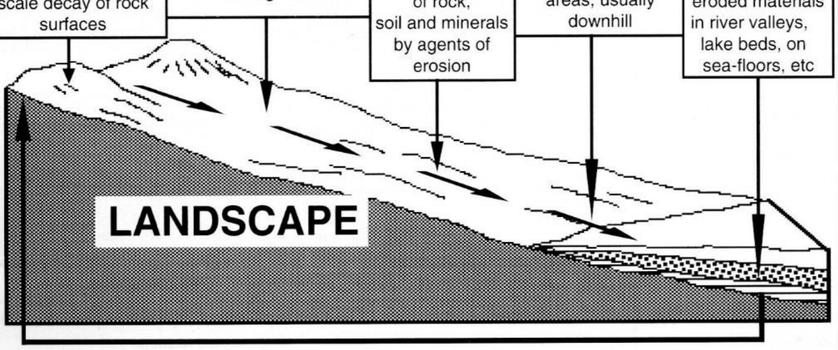


Fig.59

THE CYCLE OF EROSION

the processes which combine to shape the landscape

The **Cycle of Erosion** is the combination of the processes which operate on any landscape and takes place in 5 stages:



All physical landscapes have been formed by either erosion processes or deposition processes or a combination of both. The Cycle of Erosion above shows that physical landscapes are always changing. Humans often interfere with the cycle of erosion through actions which can speed up or slow down the processes involved.

Assignment Twelve

1 Make your own notes to help you revise the main Rock Types using the information provided on the previous page.

2 Explain the link between rock type and scenery.

3 Write full definitions (with illustrations) for each of the following terms: Weathering, Mass Movement, Regolith, Talus, Scree, Erosion, Transportation, Deposition.

4 Name the weathering processes responsible for the following:
i. Pot holes in roads in winter
ii. Wearing away of statues in towns and cities
iii. rainwater dissolving $CaCO_3$
iv. Piles of sharp-edged rocks at the base of high mountains in cold areas
v. Rocks heard to crack, with a noise like a pistol shot, in a desert area

5 Give two examples of biological types of weathering.

6 Describe a technique for measuring the speed of soil creep.

7a Make your own copy of the "Cycle of Erosion".

7b Give two examples of the ways in which humans interfere with erosion and deposition.

GLACIATED LANDSCAPES: Erosion

Fig.60 The Mer de Glace, near Chamonix, France

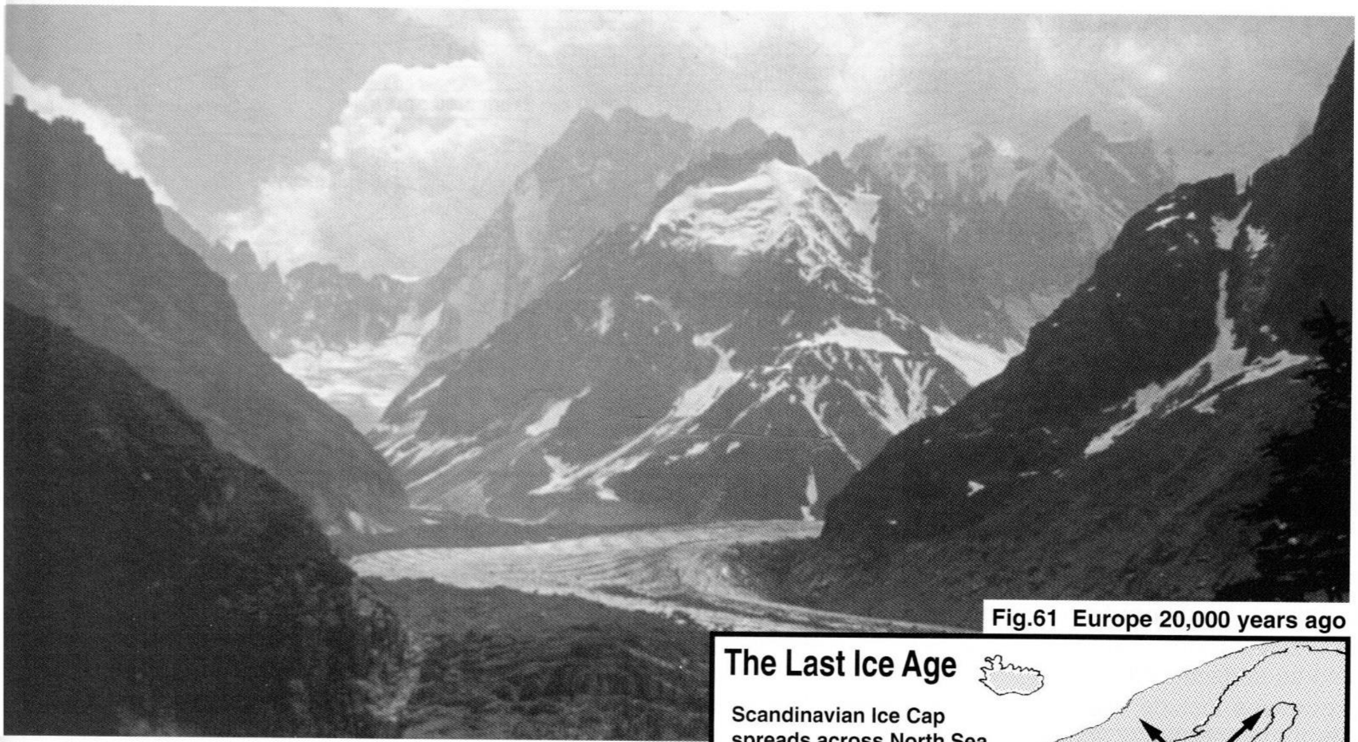
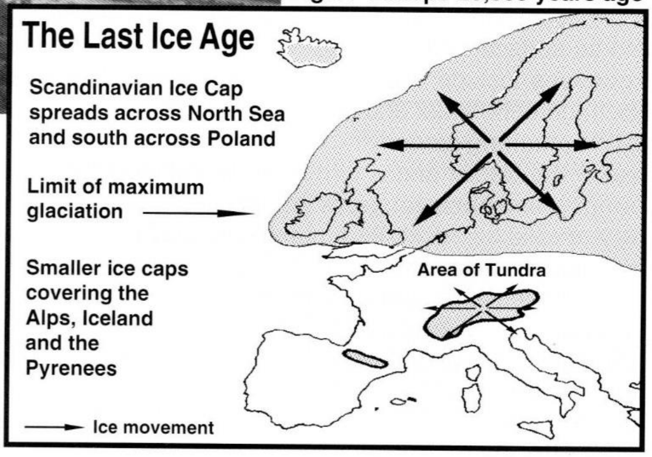


Fig.61 Europe 20,000 years ago

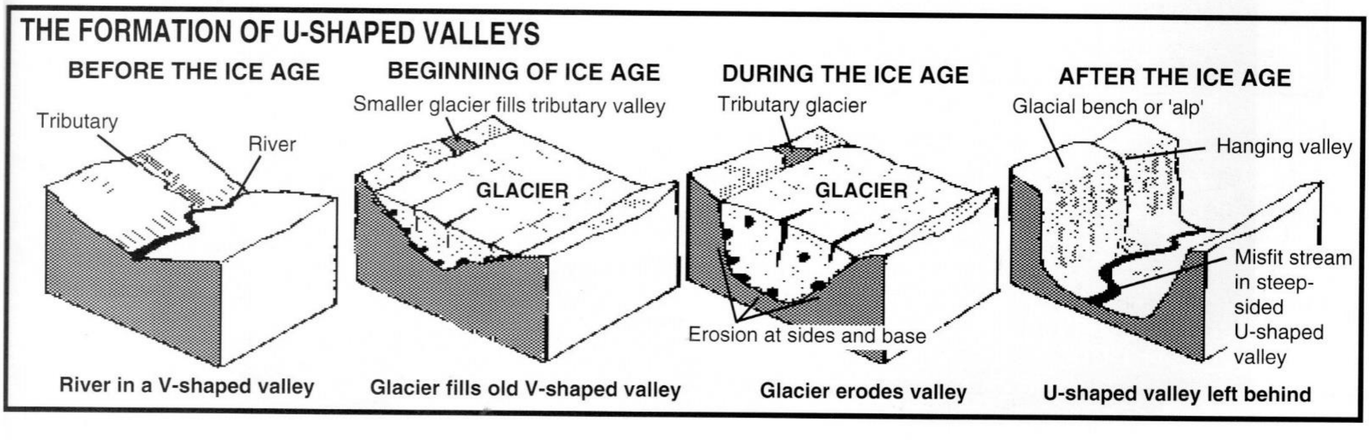


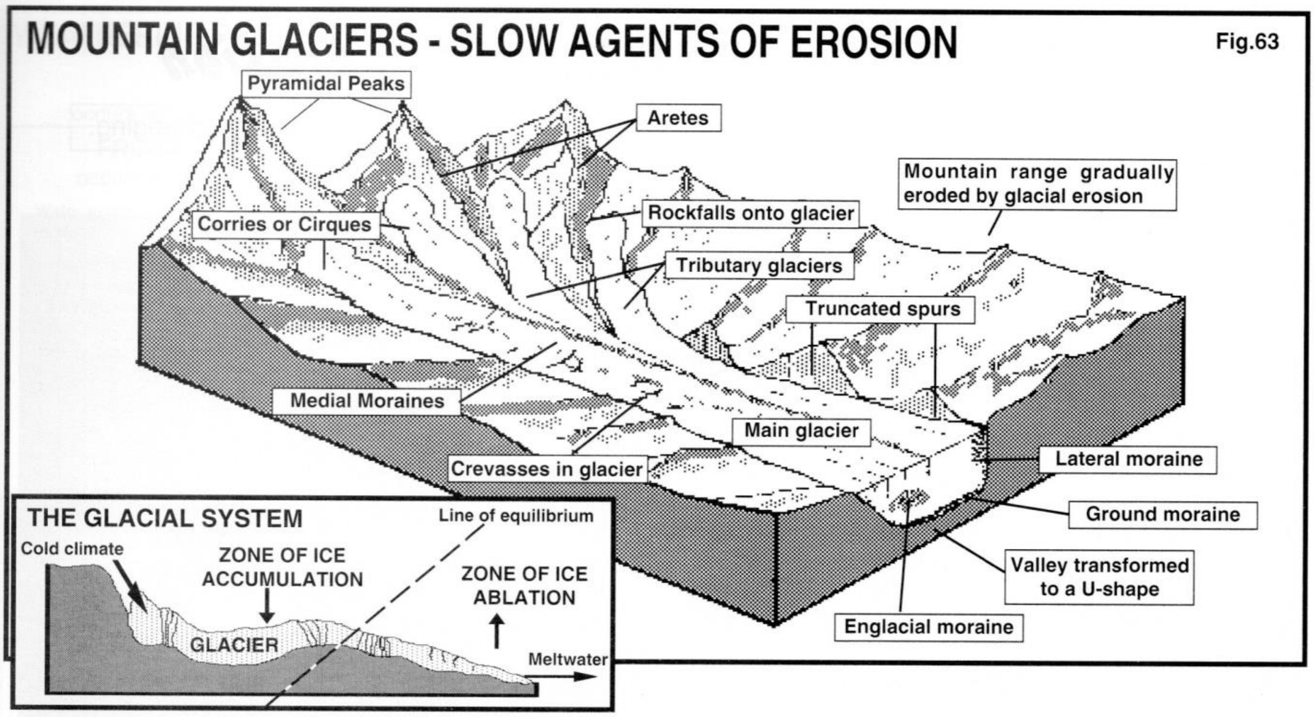
The climate of much of Europe, including the British Isles, over the last 2.5 million years has been cold enough to support the spread of ice sheets. Experts believe that there is evidence of as many as 20 different glaciations. The last major Ice Age (**Pleistocene**) ended about 10,000 years ago - although there are areas in the Alps where glaciers still exist (Figs 60-61). The ice advanced in sheets from mountainous areas such as Scandinavia and the Alps in colder periods known as **glacials**. As the climate warmed, the ice retreated in periods known as **interglacials**. The bad news is, many scientists think, that we are living through a short interglacial period and that the ice will return in about 3,000 years time!

Massive quantities of snow and ice built up at the beginning of each cold period. For millions of years, heavy snowfalls accumulated to impressive depths across large tracts of Northern Europe. Geologists believe that the scenery of much of the British Isles would have resembled that of present day Greenland: huge areas of ice covering all but the highest mountain tops. The majority of Northern Europe lay under hundreds of metres of ice. Even mountains such as Ben Nevis and Cairn Gorm lay buried by over 300 metres of ice just 15,000 years ago.

Underneath the ice, the landscape was slowly being shaped by the tremendous weight and erosive power of ice. Existing river valleys were gouged and deepened, leaving U-shaped valleys after the ice retreated (Fig.62).

Fig.62 Ice erosion processes

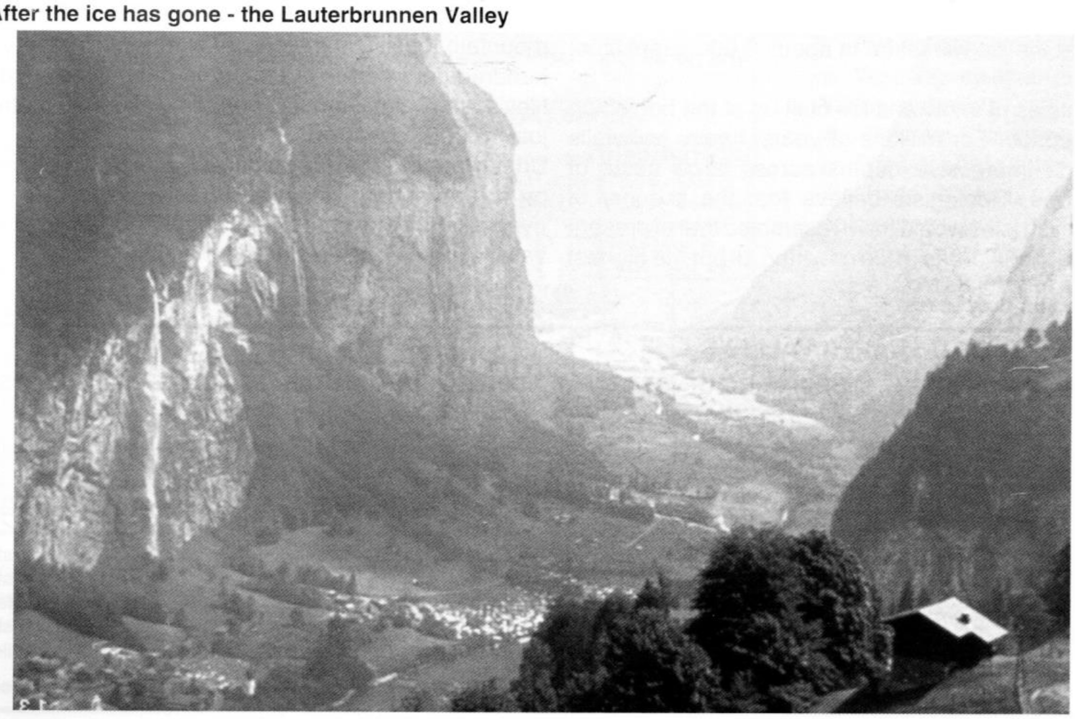


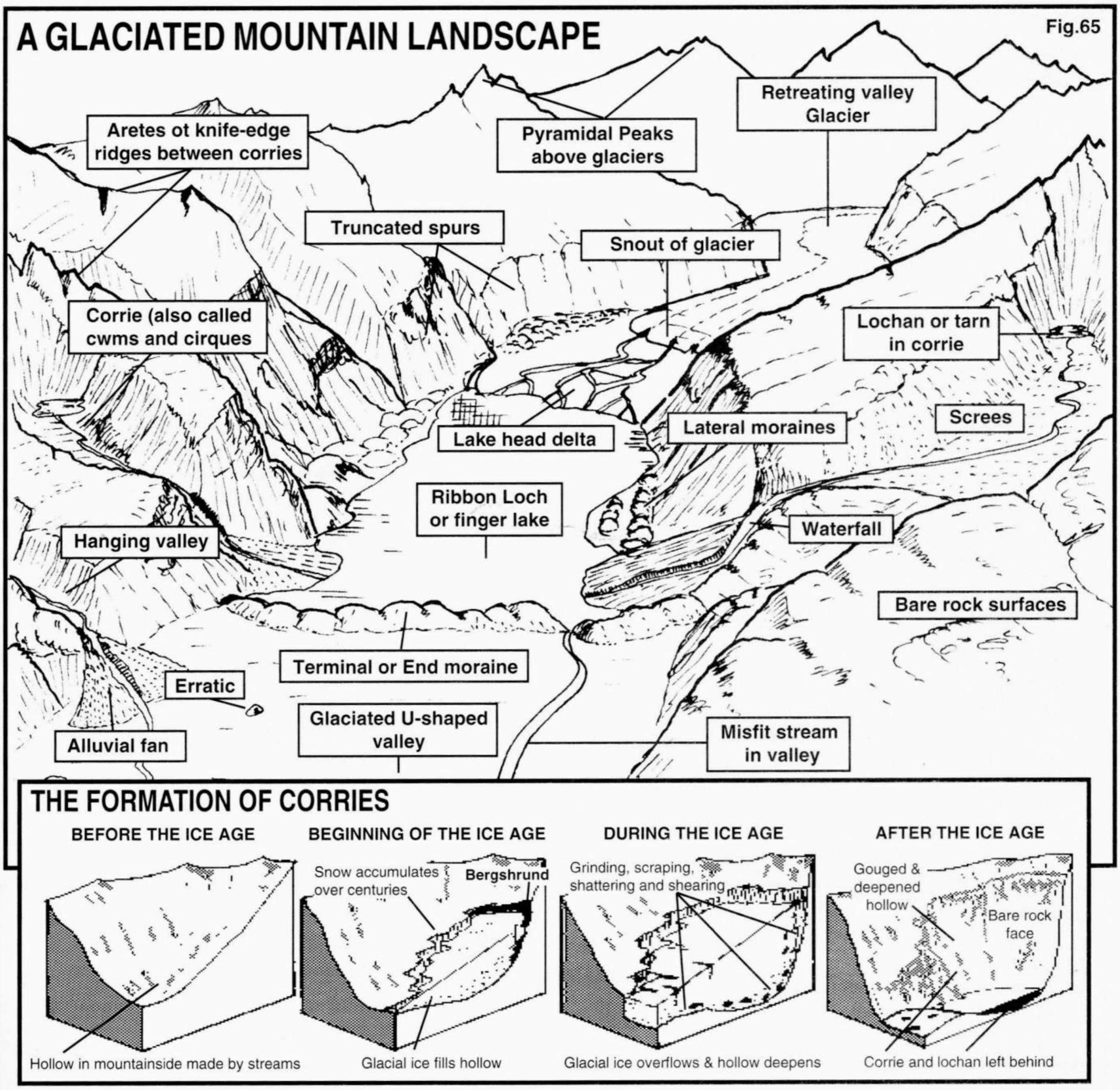


Glaciers, ice sheets confined to valleys, behave as a **system** (Fig.63). **Inputs** to the glacier include snow (falling as precipitation or from avalanches above), rocks falling onto its surface and rock fragments frozen into its base. **Processes** include transportation as the glacier carries rock fragments, water and ice downhill. Erosion processes include **plucking** (underlying rock becomes frozen into the base of the glacier and is torn away as the glacier moves downhill), and **abrasion** (rock embedded in the ice grinds away at solid bedrock). As a result, the glacier may leave scratches or **striations** in the bedrock beneath it. Frost-shattering above the glacier supplies rock fragments to the glacial system. **Outputs** from the system include water (as either meltwater or as water vapour, rock debris and ice trapped in hollows.

Where inputs exceed outputs, **accumulation** occurs and the glacier advances. **Ablation** occurs where there is an increase in temperature and the glacier (retreats) melts. As melting occurs, massive amounts of meltwater become a major agent of erosion, shaping the landscape. As a result of the glacial system, distinctive landforms are produced and spectacular scenery created (Figs.64-65). Mountain ranges are lowered. Glacial troughs are left behind, showing the scars of glacial erosion in the form of truncated spurs and corries. Moraines (debris excavated and transported by ice) are deposited on valley floors. Landscapes produced by ice are complicated since landforms created by one advance of ice may be wiped away by the next one.

Fig.64 After the ice has gone - the Lauterbrunnen Valley





Assignment Thirteen

1 Using an atlas, name two glaciated upland areas found in: Switzerland, Scandinavia, The British Isles.

2 Write full definitions for each of the following terms: Pleistocene, glacial, interglacial, ice sheet, glacier, ice ablation, ice accumulation, moraine.

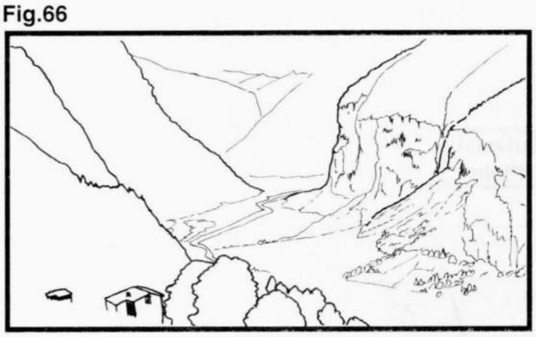
3 Describe the glaciated mountain landscape shown in Fig.65.

4 Describe the likely distribution of tourists and tourist-related developments in the area shown in Fig.65.

5 Explain using simple diagrams the formation of **two** of the following glacial landforms: U-shaped valleys, Corries, Aretes, Truncated spurs.

6 Describe in your own words the processes by which glaciers act as agents of erosion.

Fig.66



7 Draw a labelled diagram of a valley glacier.

8 Which factors influence the rate of glaciation of an area ?

9 Design your own diagram to help you explain the glacial system.

10 Label a larger copy of Fig.66 - the Lauterbrunnen Valley to show evidence of glaciation (use Fig 64 to help you).

GLACIATED LANDSCAPES: Deposition

Glaciers are able to transport huge quantities of materials (rock debris). The debris can be carried in three ways:-

Subglacial debris - moved along the floor of the valley either by ice (as ground moraine) or by meltwater streams **under** the glacier.

Englacial debris - carried **within the glacier** itself.

Supraglacial debris - carried **on the surface** of the glacier.

The collective name for all the materials (boulders, sands, gravels, clays, etc) deposited by glaciers is **drift**. These deposits can be classified into:-

Ground moraine (or **till**) including unsorted materials directly deposited by ice.

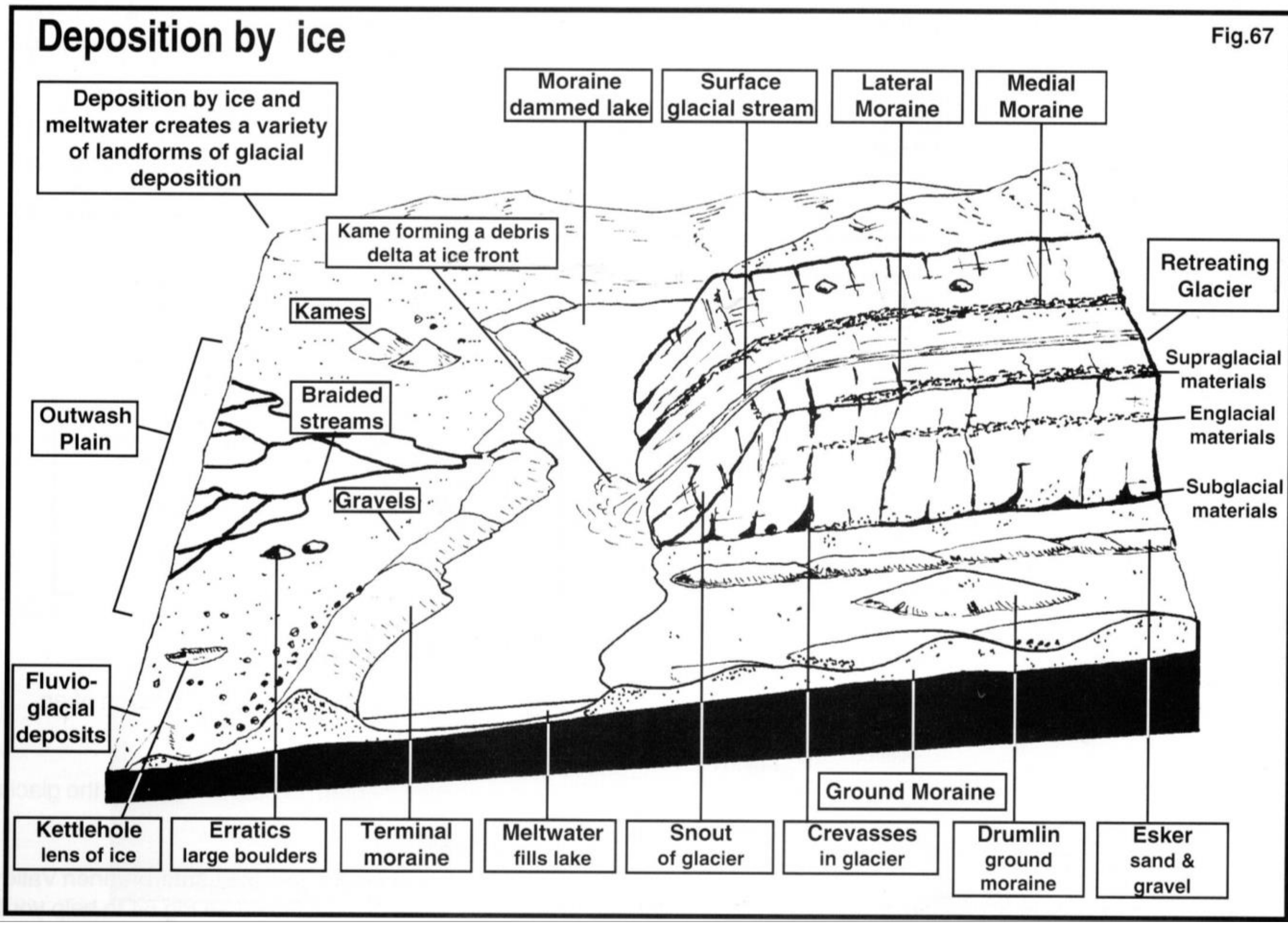
Fluvioglacial materials (or **outwash**) - including sorted materials deposited by meltwater streams.
Fluvioglacial deposits also include materials originally deposited by the ice and later picked up and redeposited by meltwater. Materials deposited by water are **sorted into layers** as deposition occurs - the heaviest debris being deposited first (at the bottom) and the lightest debris deposited last (at the top).

Landscapes produced by glacial deposition are very complex. Melting ice deposits moraine mainly at the ends and edges of retreating glaciers (fig.67). The later advances of ice (remember there have been as many as 20 Ice Ages affecting the British Isles) steamroller and bulldoze the earlier glacial deposits, reshape and redeposit them in new areas.
Glacial deposition takes place in two main ways:-

a. Debris carried in and on the ice is dumped on the surface of the land as the ice melts. The debris is unsorted with all sizes of rocks, stones and fine fragments mixed up and left on the surface. This material is known as ground moraine (or till) and it often contains evidence to indicate the main direction of ice flow. Elongated boulders are often left with their long-axes pointing in the ice movement direction.

b. As the ice melts, outflowing streams of meltwater flowing from the snout of the glacier carry away rock debris. The streams deposit this material, mainly sands and gravels, across the floor of U-shaped valleys. This fluvioglacial material is sorted - arranged in layers - as it is deposited.

Landforms characteristic of glacial deposition can therefore be classified as either those deposited by ice (glacial) or those deposited by meltwater (fluvioglacial) (Fig.70).



Features of glacial deposition include:-

Erratics are boulders transported by glaciers, often for many kilometres (fig.68). Boulders can be carried either inside the ice or on the glacier surface. Very often the erratic is of a different rock type to that of the area in which it is deposited.

Moraines, unsorted materials deposited by melting glaciers are of three main types:

Terminal or end moraine is often a high, narrow mound extending across a valley floor. The terminal moraine is deposited at right-angles to the direction of ice movement and mark the furthest extent of the ice advance.

Lateral moraine is debris dumped along the sides of a glaciated valley in the form of an embankment or hummocky ridges.

Medial moraine is usually found in the centre of a glaciated valley as a hummocky ridge. Medial moraines are formed as a result of the merging of two lateral moraines where two glaciers meet.

Drumlins are smooth, elongated mounds of ground moraine or till which has been deposited by the ice but shaped while the ice was still moving (Fig.69). The long axis of a drumlin lies parallel to the direction of ice movement.

Drumlins occur in groups or swarms and may be over 50 metres in height .

Features of Fluvioglacial deposition include:

Outwash plains are composed of gravels, sands and clays. These materials are deposited by meltwater streams during summer or when the glacier melts. Often up to 70 metres deep, outwash may be deposited on top of ground moraine following the retreat of a glacier (fig.71).

Fig.68 Slate boulder carried on top of a glacier

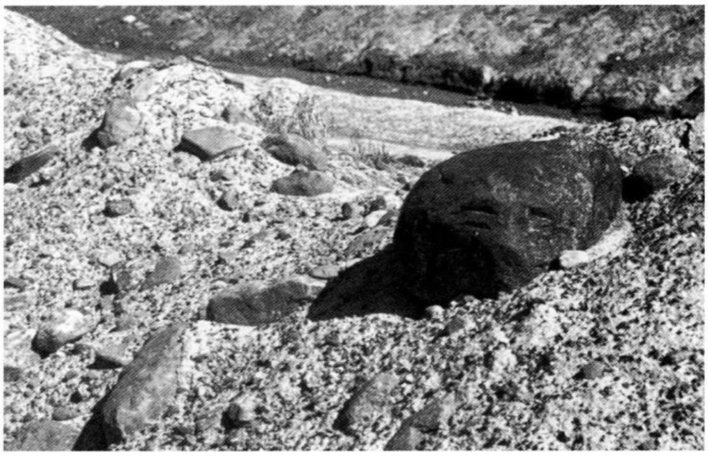


Fig.69 Forested drumlin in glacial lowland

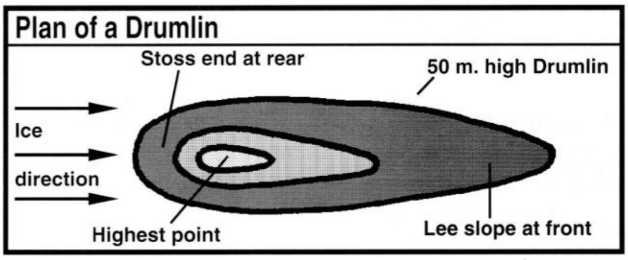
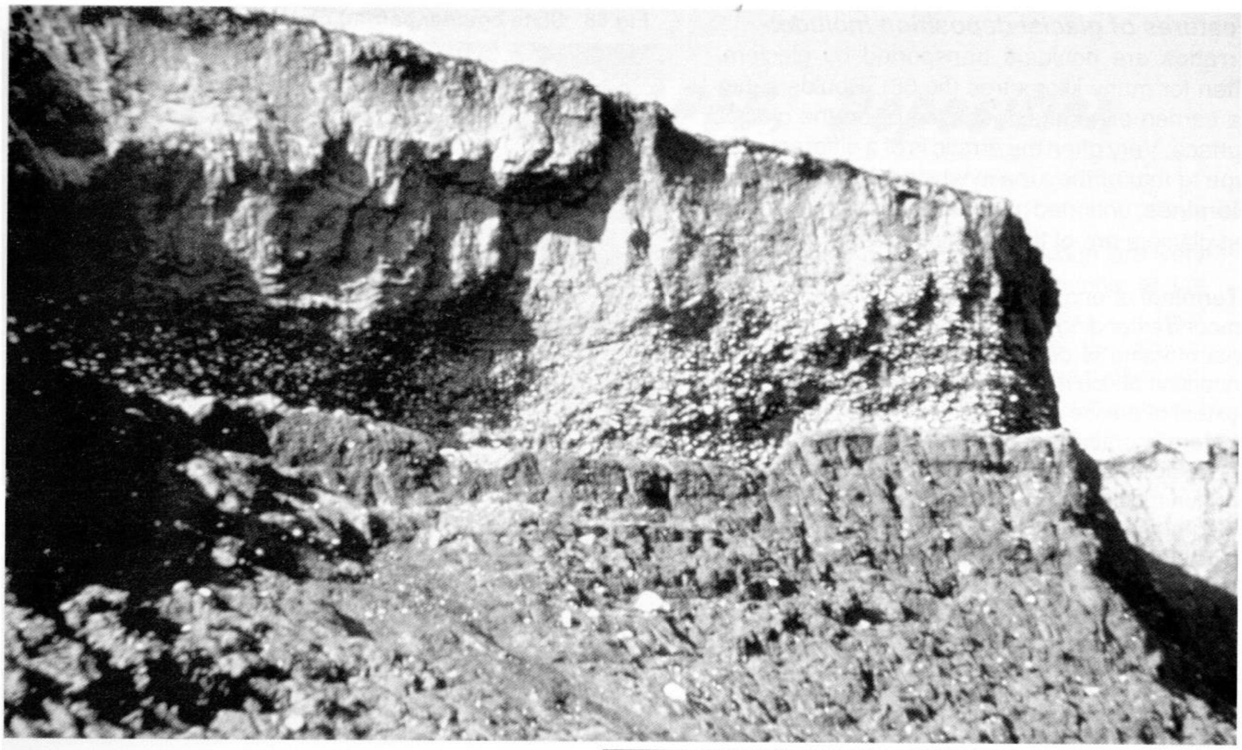


Fig.70 Depositional features and formation.

Deposition Feature	*Description*	*Formation of Feature*
Boulder clay or Till or Ground Moraine	Unsorted materials distributed across a valley. Stones often at an angle with long axes indicating ice direction.	Mainly unsorted subglacial materials deposited by melting glaciers.
Terminal moraine	A narrow ridge of unsorted materials extending across a valley.	Mounds of boulders deposited at the maximum advance of the ice.
Medial moraine	Mounds of material carried in the centre of a glacier.	Formed by the joining of two lateral moraines.
Lateral moraine	Unsorted materials found along the sides of glaciers and glaciated valleys.	Materials found along the sides of a glacier or a valley as a result of frost-shattering above.
Erratic	Rocks which are not normally found in the area in they are deposited.	Rocks transported by glaciers from their source to an area of different rock.
Drumlins	Streamlined, elongated mounds of unsorted materials with a steep end facing up the valley.	Till is deposited and shaped by moving ice.
Esker	Long, narrow sinuous ridges of unsorted materials crossing valley floors.	Material deposited by a subglacial stream.
Kame	Mounds of sorted materials deposited by meltwater across a valley or a delta in lakes at the edge of the ice	Material deposited where meltwater streams are in contact with ice.
Kettle-holes	Small shallow lakes containing sorted materials.	Dead ice surrounded by sand and gravel melts and forms a small lake.
Outwash Plain	Sorted deposits of sands, gravels and clays spread over a valley floor.	Meltwater streams deposit materials across a wide and low lying valley floor.
Moraine-dammed Lake	Shallow lake formed where a moraine dams a river.	Terminal moraine blocks the natural course of a river in a U-shaped valley.
Fluvioglacial deposits	Sorted materials or outwash (sands, gravels, clays).	Sands and gravels deposited by meltwater
Meltwater Channel	Shallow valley - often a dry valley today.	Valley carved by the erosive power of meltwater as a glacier retreats.

Fig.71



Eskers are low, narrow, sinuous ridges composed of sorted coarse sands and gravels. Eskers are thought to be the deposited courses of subglacial streams.
Kames are undulating mounds of sorted debris, sands and gravels washed into crevasses in stagnant ice. As the ice melts the debris is deposited on the ground. Kames may also be formed by the build up of deltas in lakes at the ice front (Fig.67).
Kettleholes form where a block of ice is detached from a glacier as it retreats. The ice may be partly buried by fluvioglacial deposits left by meltwater streams. When the ice block melts it leaves an enclosed hollow which often fills with water to form a kettlehole lake.
Kames and kettleholes are often found in the same depositional areas and give rise to the phrase 'kame and kettle' topography.
Braided streams form where channels of meltwater become clogged by coarse deposits, encouraging the stream to braid or divide in smaller streams.
Meltwater streams can be very powerful depending on the season or the rate of ice decay. Many meltwater streams are powerful enough to erode their own valleys. In some upland areas such as the Bathgate Hills in West Lothian, Scotland, streams from retreating glaciers not only carved their own channels (known as **meltwater channels**) but were powerful enough to flow uphill and over obstacles to their path.
On a wider scale, Europe's most fertile deposit is wind blown **loess**. The loess results from strong winds blowing at the end of the last Ice Age, picking up fine particles from glacial and fluvioglacial deposits. Large areas of northern France, Germany and Poland are blanketed with up to 20 metres depth of loess forming some of Europe's most fertile agricultural areas.

In summary, glacial erosion and deposition can affect both upland and lowland areas, creating landscapes of varying use to people.

Assignment Fourteen

1 In which ways are landforms produced by glacial deposition ?

2 Make your own simple copy of Fig.67 and add labels to each of the features of glacial deposition.

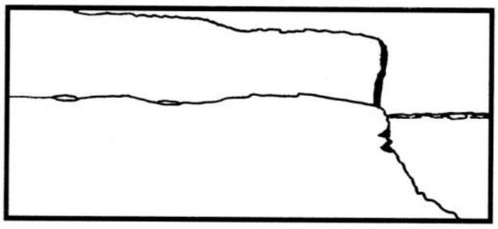
3 Study Fig.68.
   a. Which deposition feature is shown here ?
   b. Explain why it could not be the remains of a layer of rock eroded above the limestone below.

4 Study Fig.69. Explain how the landform was formed.

5 What are the differences between englacial, supraglacial and subglacial materials ?

6 Write full definitions of each of the following:-
   Esker, lateral moraine, outwash, kettleholes, Loess.

7 Label a larger copy of the sketch below (based on Fig.71) to describe the differences between the types of deposit shown.



8 Classify the features of glacial deposition listed in Figs.67 & 70 as either:
   Stratified (sorted) or
   Unstratified (unsorted) or
   Water features.

9 Make a list of glaciated landforms useful to people.

RIVER LANDSCAPES: Water Movement

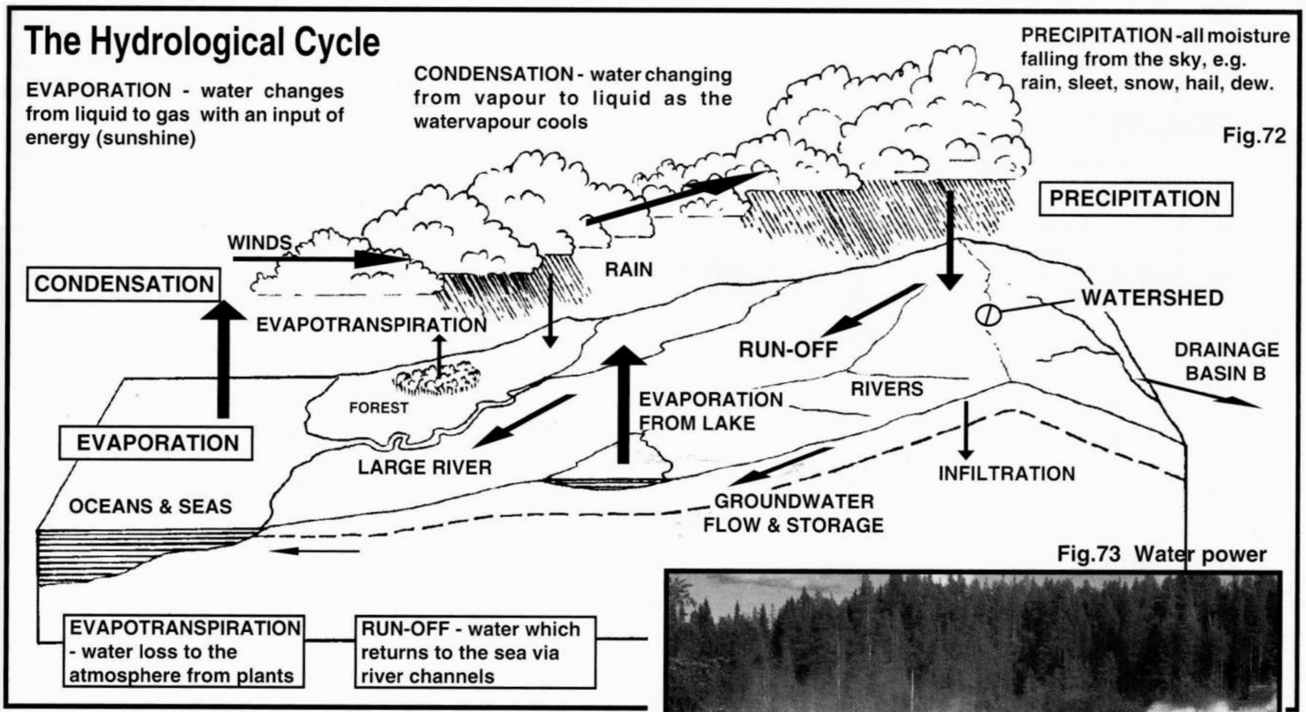


Fig.72

Fig.73 Water power

The water or **Hydrological Cycle** is another example of a **system** (with Inputs, Processes and Outputs) this time linking land, water and atmosphere (Fig.72).

Warm air passing over large water areas picks up water vapour or moisture by **evaporation**. As warm, moist air moves inland, pushed by the wind, it is forced to rise over higher land. As it does so, the air cools and the water vapour condenses, forming clouds. Some of the moisture will be dropped as **precipitation** - all forms of moisture which fall from the sky.

Three results are possible as precipitation falls to the ground:

- **a.** It may evaporate - returning to the air.
- **b.** It may soak into the ground due to the **permeability** (allows water to pass through it) of the local rock.
- **c.** It may run-off to join a stream or river and perhaps flow back into the sea again.

Water that soaks into the ground may soak deep down (**infiltration**) or may remain near the ground surface (**storage**) re-emerging later as a spring. Surface water will flow into a stream and then into a river (Fig.73). Rivers flow into lakes or back into the sea and in so doing are powerful agents of erosion, responsible for shaping scenery; eroding, transporting and depositing rock debris in other areas. (Figs. 74-77).

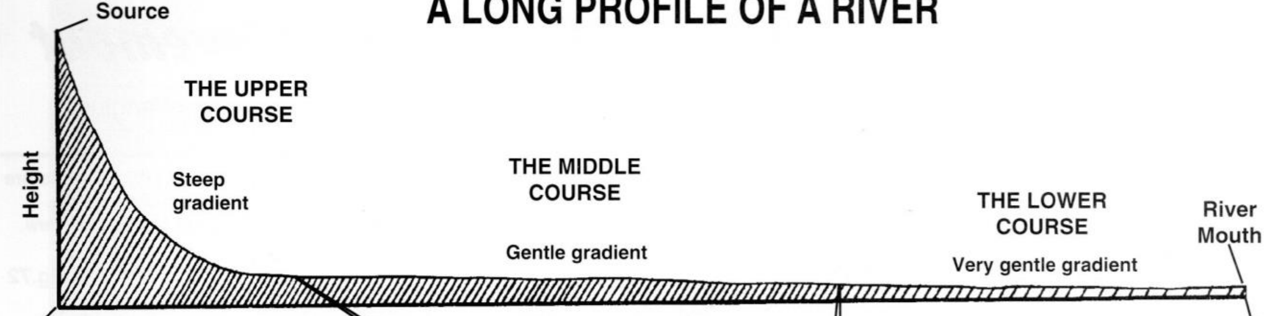
Examples of the movement of water within the cycle include rivers, ocean currents, winds (carrying clouds), evaporation, evapotranspiration (from vegetation), run-off, infiltration and precipitation.

THE MAIN RIVERS OF THE UNITED KINGDOM

Fig.74

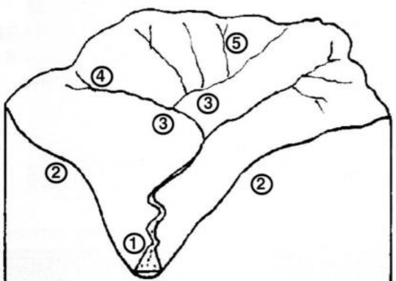
Fig.75

A LONG PROFILE OF A RIVER



The Upper Course

Many small tributaries or hillside 'burns' cut straight down into the landscape. Vertical erosion takes place.

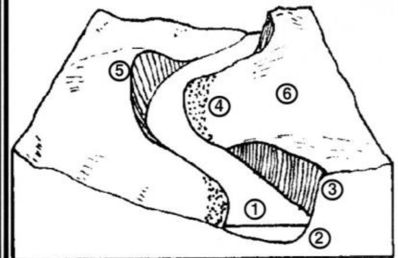


The river has no floodplain:

1. **Narrow river flowing like a torrent, through boulders.**
2. **Steep, V-shaped valley sides right down to the riverside.**
3. **Interlocking spurs.**
4. **Many tributaries feeding into the main river.**
5. **Waterfalls and rapids common**

The Middle Course

As the volume of water increases in the river, lateral (sideways) erosion begins to take place.

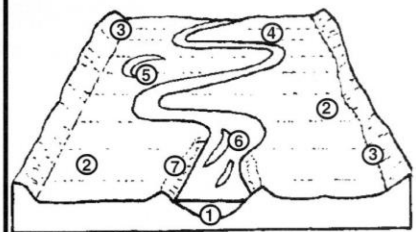


The river has a floodplain on one side:

1. **The river flows fastest on the outside of a meander.**
2. **The river is deepest on the outside bend.**
3. **The riverbank is undercut by a strong current creating river cliffs.**
4. **Mud, silt and sand are deposited by slower water on the inside of the bend.**
5. **Steep valley slope.**
6. **Gentle slope of valley.**

The Lower Course

The river meanders across a wide floodplain formed from silts, mud, gravels and sands deposited by the river.



The river has a floodplain on both sides:

1. **A wide river flowing down a very gentle gradient.**
2. **Wide flood plain on both sides of main river.**
3. **River bluffs indicate edge of floodplain.**
4. **Large meanders common in the lower course.**
5. **Ox-bow lake in abandoned river channel.**
6. **Eyots (silty islands in the river), show that river braiding is taking place.**
7. **Levees (raised river embankments) form during floods.**

Fig.76 Features of river valleys

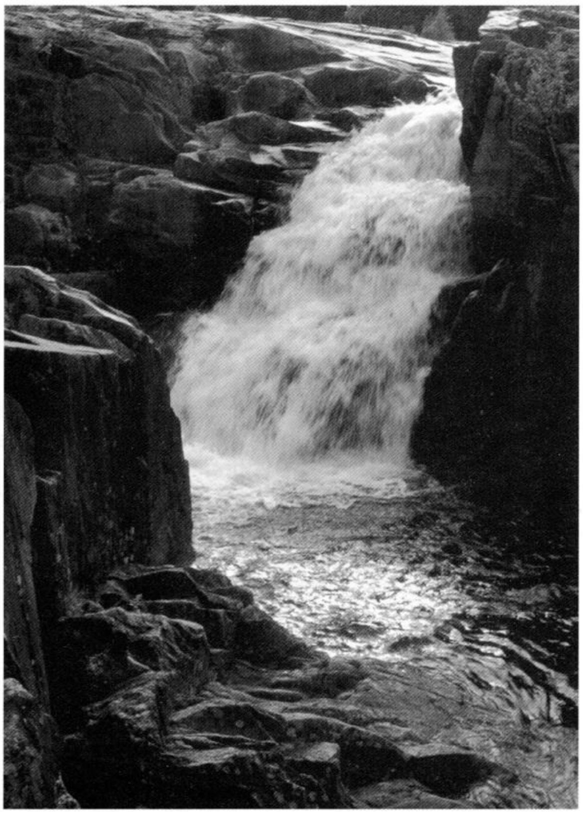
Rivers as agents of erosion and deposition use water power to carry out their task of modifying the landscape. The amount of water in a river is called its **volume**. A river's volume and speed generate **energy** which the river uses to erode the landscape. The velocity (or speed) of the flow of water is directly proportional to the degree of erosion and is partly determined by the gradient of the slope down which the river flows.

An idealised river (Fig.75) profile can be classified as having three main sections - The **Upper**, **Middle** and **Lower** courses, each with its own characteristic features (Fig.76). Other interconnected factors which influence the rate of erosion and/or deposition include **climate** (amount and distribution of annual precipitation), **Rock structure** and **type**, and **vegetation** (plants may help bind the soil together and stabilise the soil along the valley sides).

All rivers have a **source** (a starting point, - a marsh, a melting glacier, a lake, etc.) and a **mouth** where they enter the sea or ocean, join a lake or sink underground.

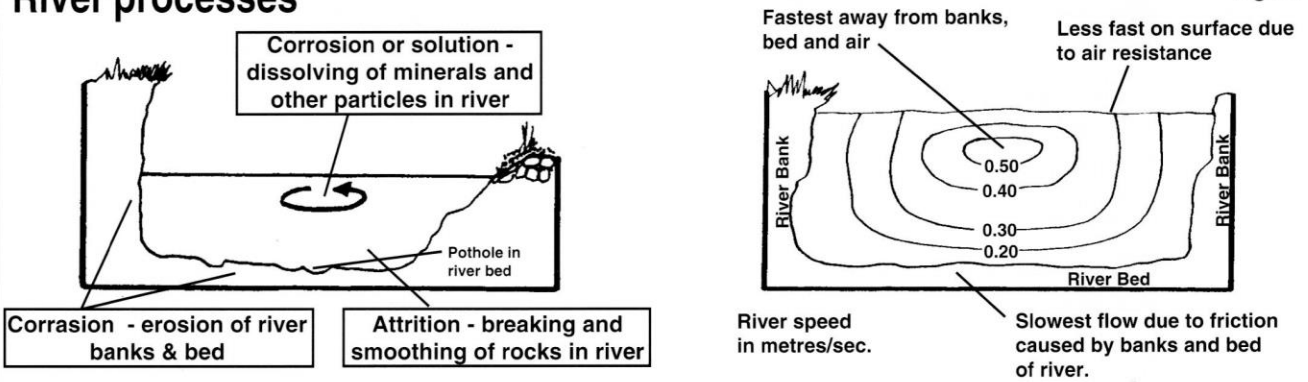
The hydraulic force of the water is not enough on its own to create massive erosion. Rivers carry a **load** which acts like teeth, wearing and tearing away at the banks and river bed (Fig.77). Rivers in **spate** (or flood) carry out their tasks at an increased rate, often carving new channels and changing their course in a very short space of time.

Fig.77 Rivers are powerful agents of erosion



River processes

Fig.78



There are four main processes of river erosion.

Hydraulic action or the sheer force of the water as the current hits river banks. Where the river is straight the point of maximum velocity may be found in midstream (Fig.78). But where a river flows around a meander, water is forced into cracks and any existing air within them is compressed. Pressure is increased and the bank may collapse.

Solution or corrosion occurs continuously and is influenced by the acidity level of the water and the local geology & soil cover.

Corrasion occurs where a river picks up material and uses it to abrade (sandpaper) its banks and river bed. Most effective during spate periods, corrasion also leads to the formation of potholes in river beds (Fig.79). Pebbles caught in the hollows in the river bed swirl around, grinding holes into the river bed.

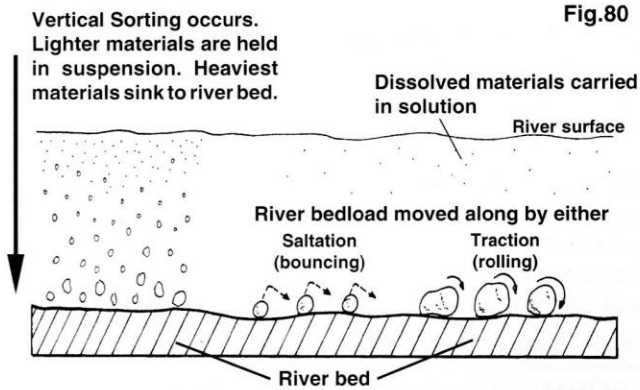
Attrition occurs where the materials in the river bed (called the **bedload**) collide with each other and break into smaller fragments. In time, the angular fragments become smaller and rounder as they are transported downstream.

As rivers transport their load downstream, the banks, riverbed and rock debris are eroded and this debris is used in the erosion processes (Fig.80). Rivers create many spectacular features - the most famous of which are waterfalls such as Niagara Falls. **Waterfalls** form where a river flows across a resistant layer of rock and fall onto a layer of softer rock below (Fig.81). The underlying layer of rock is eroded as water and bedload falls onto it. This creates a plunge pool and an overhang which eventually collapses. In this way a waterfall retreats upstream.

Fig.79 Potholes in a river bed.

TRANSPORTATION PROCESSES IN A RIVER

Fig.80



THE FORMATION OF WATERFALLS

Fig.81

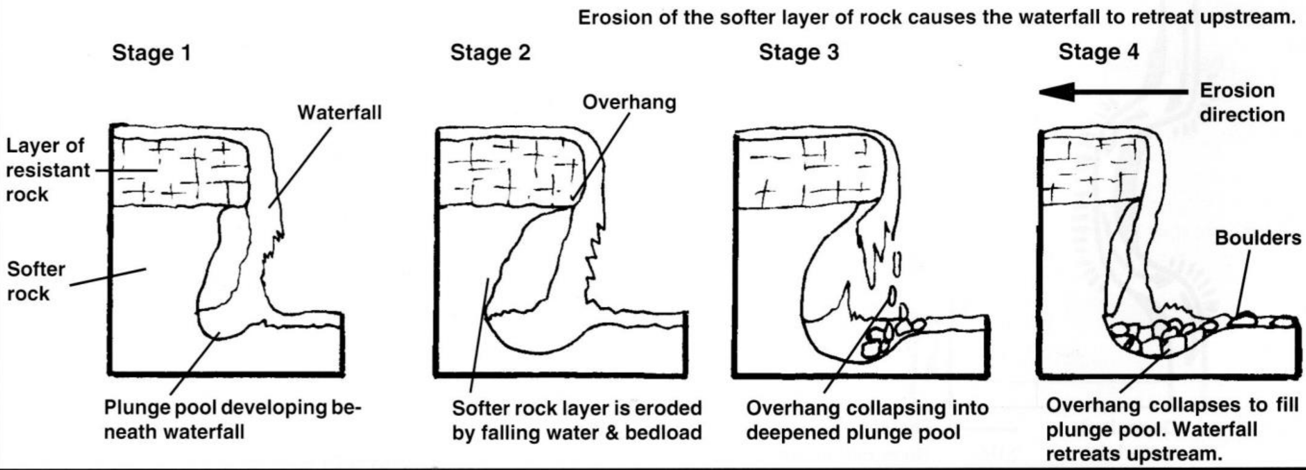


Fig.82 River Meander

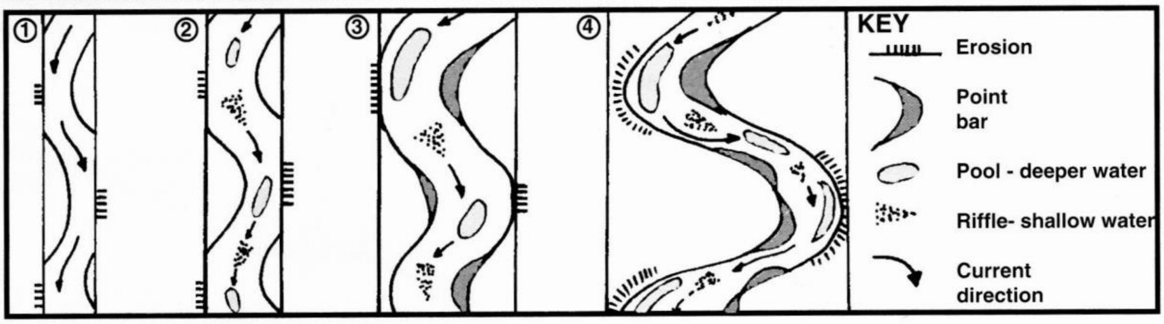


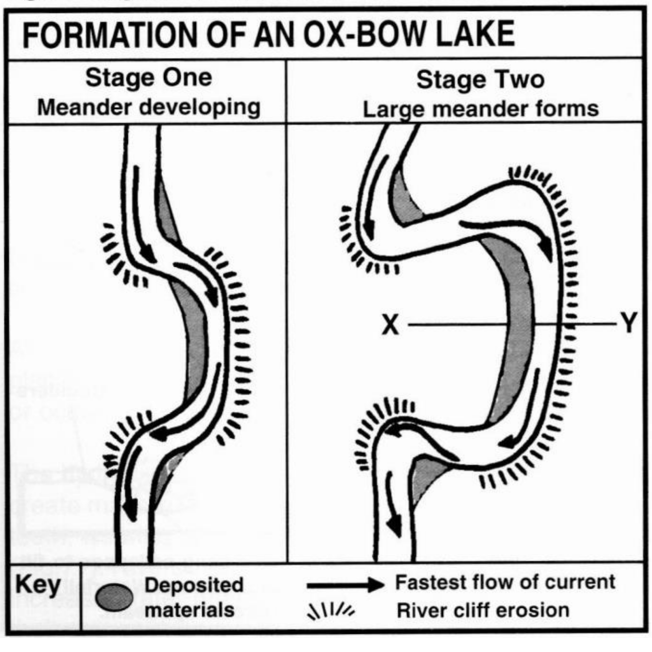
Fig.83 Stages in Meander formation

As the velocity of a river decreases it loses its capacity to carry all of its load. Deposition then occurs, starting with the largest materials. Deposition occurs where:-

a. A river widens and **meanders** as it begins to cross a break of slope or a flood plain (Figs.82 & 83)
b. A river enters the sea or a lake
c. A period of low precipitation is experienced.

Vertical erosion caused by a river in the upper course gives way to **lateral erosion** in the middle and lower courses. Ox-bow lakes form at large meanders where erosion undercuts the outside bank and shallow water aids deposition on the inside bank of a river (Fig.84).

Fig.84 Stages 1 & 2 of the formation of an Ox-bow lake



Assignment Fifteen

1a Make a simple copy of Fig.72 to illustrate the system called the Hydrological Cycle.
1b List the inputs, processes and outputs to this system.

2 Write definitions of each of the following terms:- Watershed, Precipitation, Run-off, infiltration, storage.

3 Make a key to Fig.74 -naming rivers 1-19. Use an atlas!

4a Give examples of water storage other than groundwater.
4b Give examples of water movement.

5a Describe, using simple diagrams, the features of a river in its Upper, Middle and Lower courses.
5b Describe at least four changes in a river as it flows downstream.

6 Is the river in Fig.77 in its upper, middle or lower course? Justify your answer.

7a Describe the ways in which a river erodes.
7b Explain why a river's load increases in amount but decreases in size as it flows downstream.

8 **Either** Explain the formation of any **two** of the following river features: meander, waterfall, floodplain **or** Complete the diagrams (Fig.84) to illustrate the formation of an Ox-bow lake.

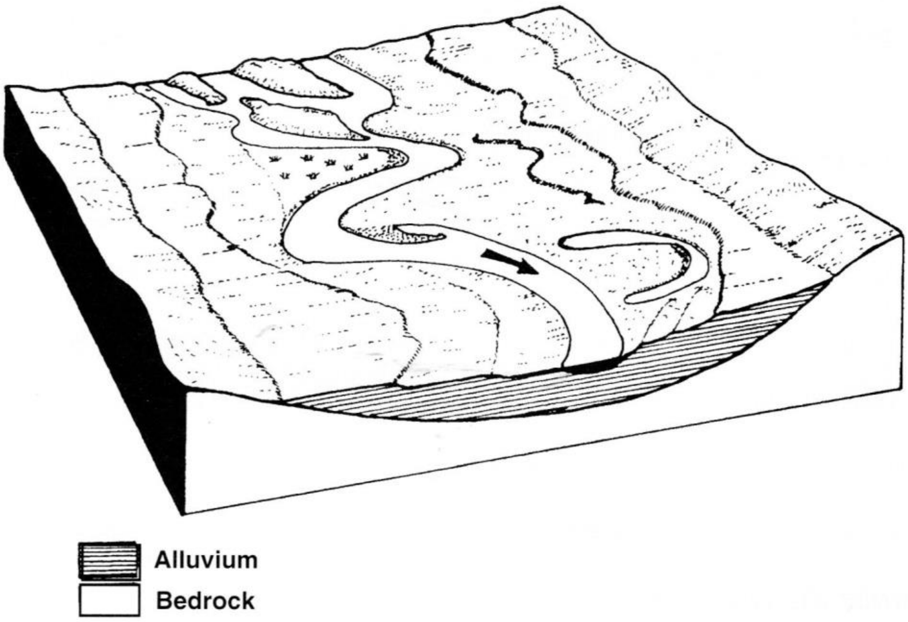
9 Explain vertical and lateral erosion.

10 Make a simple annotated fieldsketch of Fig.82 to describe the main features of a river meander.

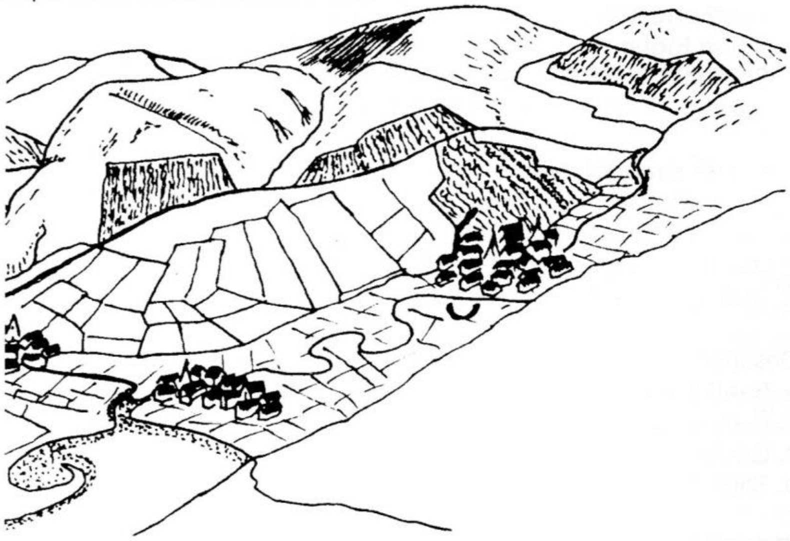
EXAM STYLE QUESTIONS

PHYSICAL LANDSCAPES

1 Explain the variations in erosion and deposition along the river valley shown in the diagram.



2 Describe fully the physical landscape shown in the sketch below.



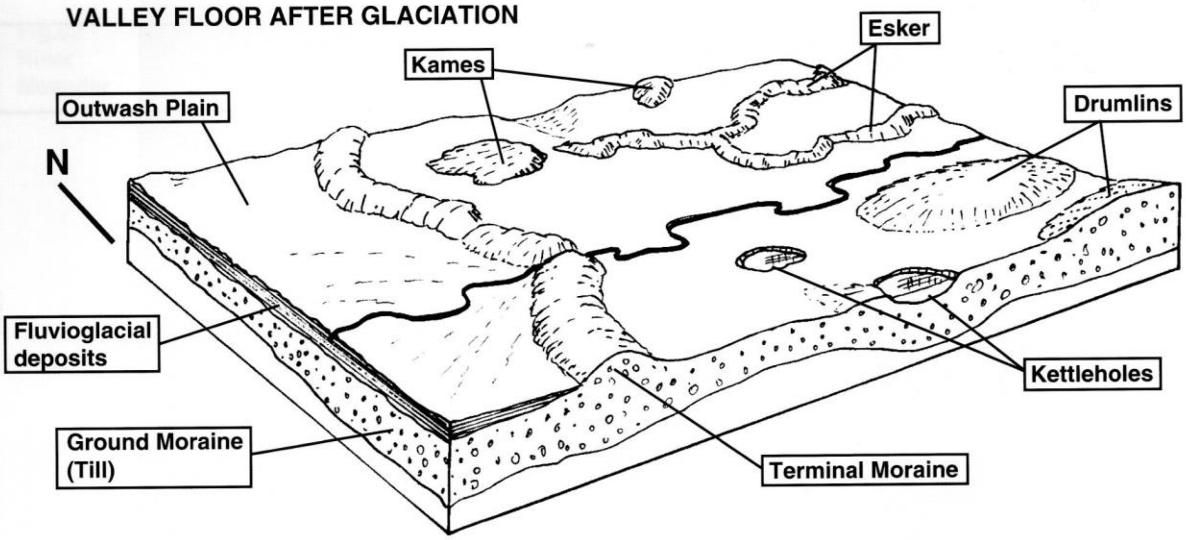
3 Select **one** landscape feature from the sketch. With the aid of a diagram explain how it was formed.

4 Select **two** of the following features and describe how they were formed:-

braided stream; ox-bow lake; meander; floodplain.

5 Describe one technique for measuring river velocity (speed) in some detail.

VALLEY FLOOR AFTER GLACIATION



Refer to the diagram above.

6 In which direction was the ice flowing when it formed this landscape? Explain your answer.

7 Explain how one of the labelled features in the diagram was formed.

8 What limitations can upland glaciated landscapes place on land use?

9 Indicate how upland glaciated landscapes can suffer from environmental damage through overuse.

Ordnance Survey Mapwork Questions

These questions can be answered by referring to any of the following map extracts:

a. **Banff and Macduff** 1:25 000 Extract No 830/0148-9
b. **Beinn Eighe** 1 : 50 000 Extract No 831/19 & 25
c. **Gairloch** 1 : 50 000 Extract No 826/19
d. **Stirling** 1 : 50 000 Extract No 732/57-58

10 Compare a **model river** to any of those listed below.
a. Banff and Macduff - River Deveron GR 6761
b. Beinn Eighe - River Grudie GR 9565
c. Gairloch - River Kerry GR 8272
d. Stirling - River Forth GR 8294

11 Describe the Physical features shown in the area indicated.
a. Banff and Macduff - GR 6761, 6861, 6762, 6862
b. Beinn Eighe - GR 9460, 9560, 9461, 9561
c. Gairloch - GR 8271, 8371, 8272, 8372
d. Stirling - GR 8496, 8596, 8497, 8597

12 Describe the relationship between physical landscape and land use in the area indicated.

13 Name the landscape feature in the following Grid Square and explain how it was formed.
a. Banff and Macduff - GR 6761
b. Beinn Eighe - GR 9465
c. Gairloch - GR 8573
d. Stirling - GR 8194

14 For the following Grid Reference, indicate which of the following land uses would be most suitable. Explain your answer, referring to the possible consequences of your chosen development.
Forestry; Arable Farming; Pastoral Farming; Recreation Centre

a. Banff and Macduff - GR 6760
b. Beinn Eighe - GR 9767
c. Gairloch - GR 7878
d. Stirling - GR 8195