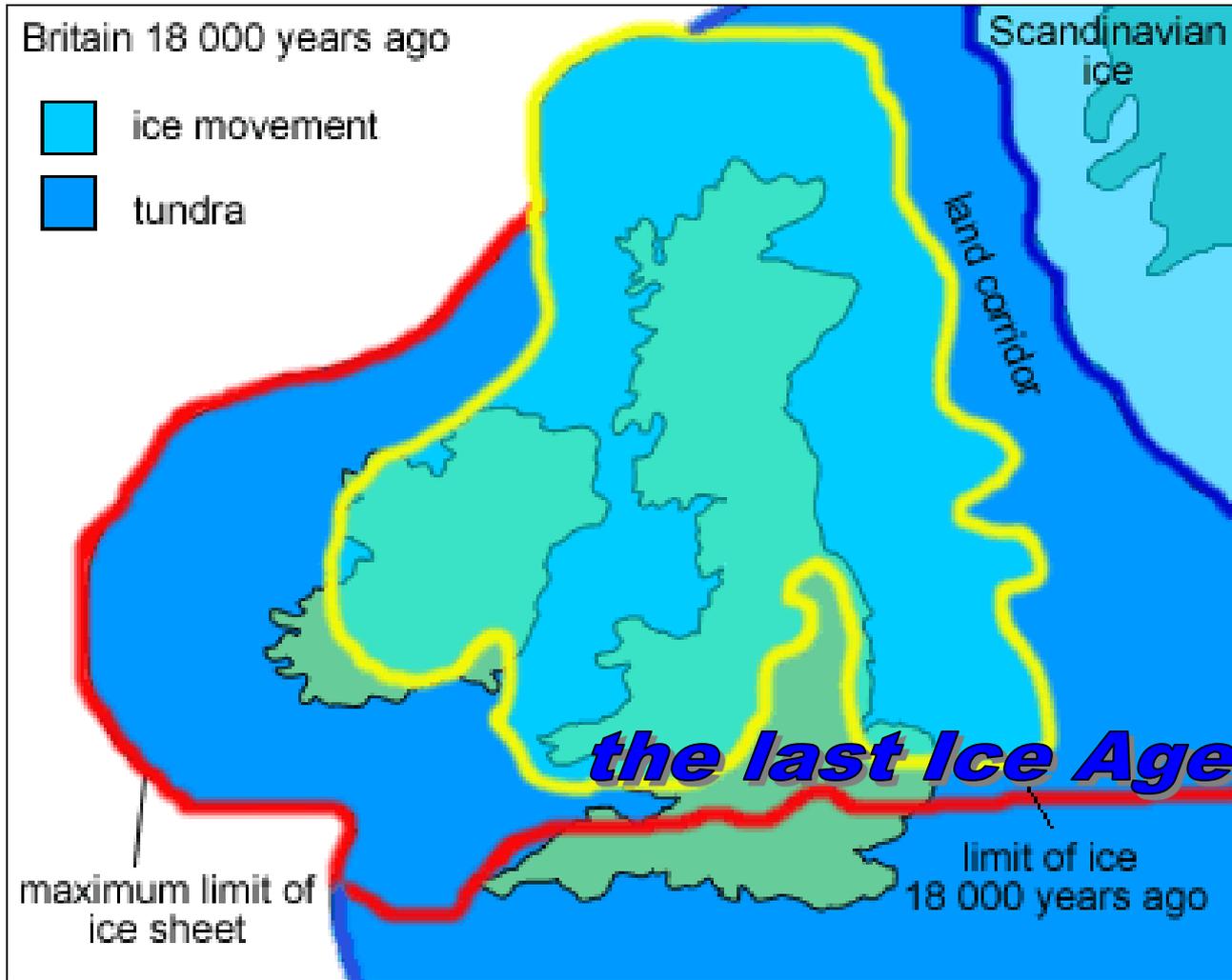


# Higher Geography



**LITHOSPHERE - glaciation**

# *the Ice Age*



The 'Ice Age' was a series of advances and retreats of the icecaps. It lasted from 1.7 million years to 10,000 years BP.

Most of Britain was glaciated as far south as the Severn-Thames line.





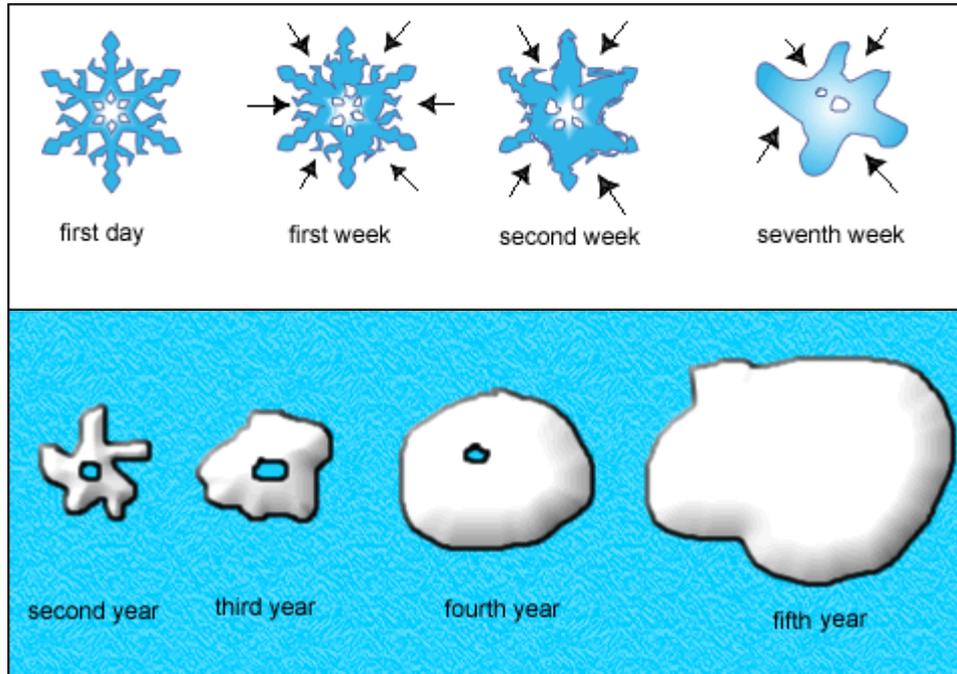
These occur at high altitudes, latitudes nearer the poles and often on the colder, north-facing slopes.

## ***formation of a glacier***

Glaciers form in areas of permanent snow called **snowfields**.



# formation of a glacier



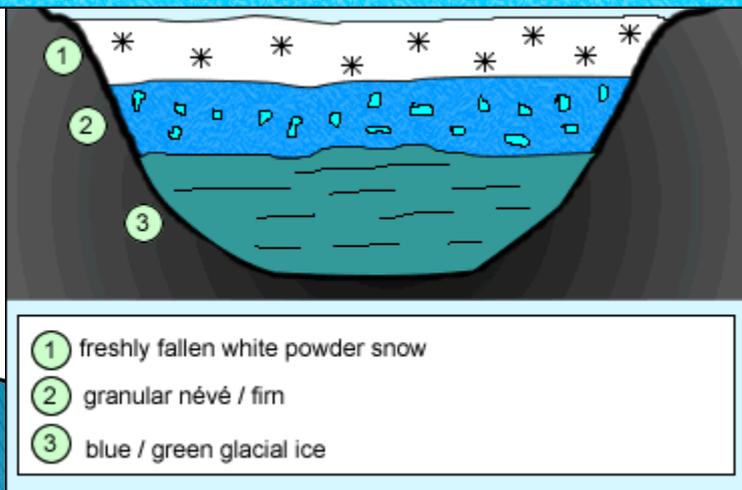
☁ As more snow falls the pressure makes the earlier snowflakes melt.

☁ Repeated melting and re-freezing forms granules called firn or névé.

☁ Further compression forms larger crystals of glacial ice.

☁ It can take 30 to 40 years for snow to form dense glacial ice.

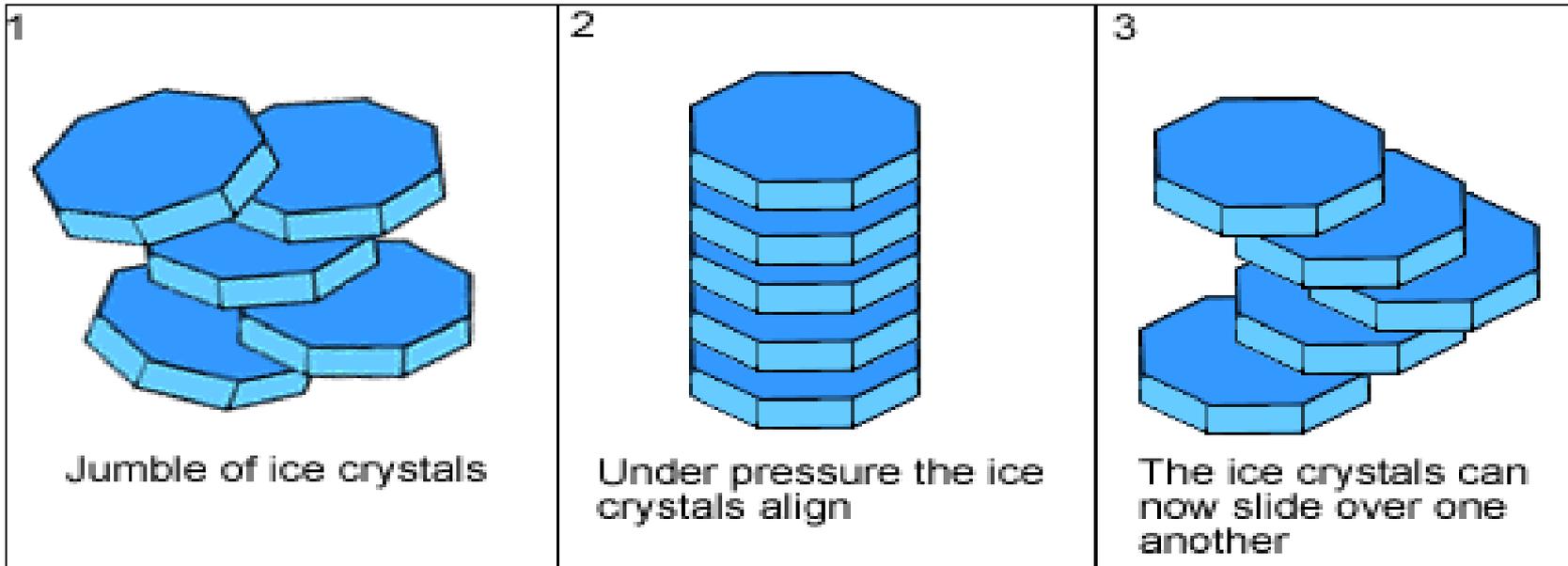
☁ It now moves downslope under its own weight.



# *glacier flow*

Despite being hard and solid, glacier ice flows because of:

- **internal deformation** - individual ice crystals within a glacier deform and slide across one another.

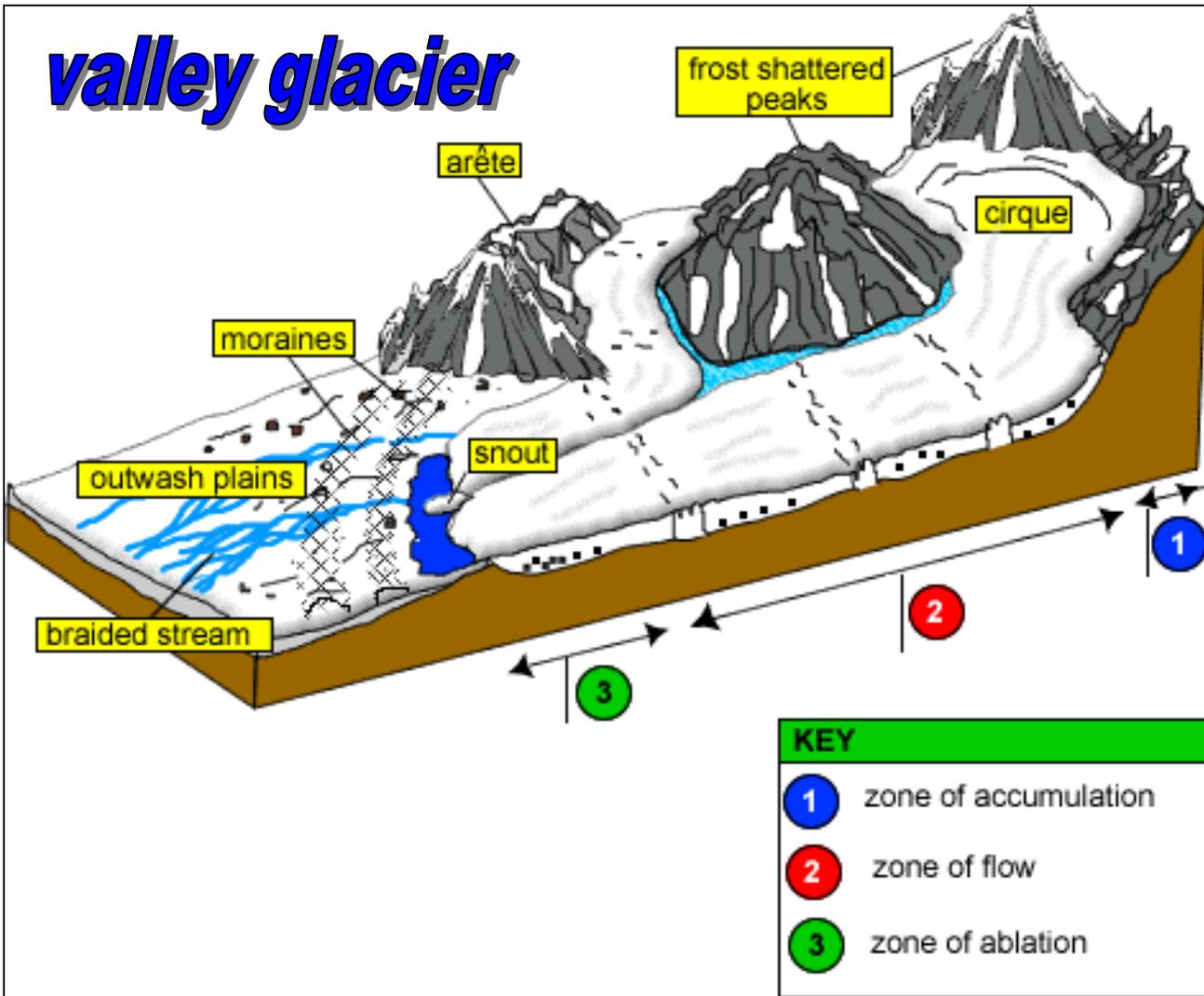


- **basal sliding** - meltwater at the base of the glacier lubricates the ice causing it to slide.

# *valley glacier*



# valley glacier



## Zone of accumulation

This is where the snow collects, turns into ice and forms features like cirques, arêtes and pyramidal peaks. The rocks above the glacier undergo frost shattering.

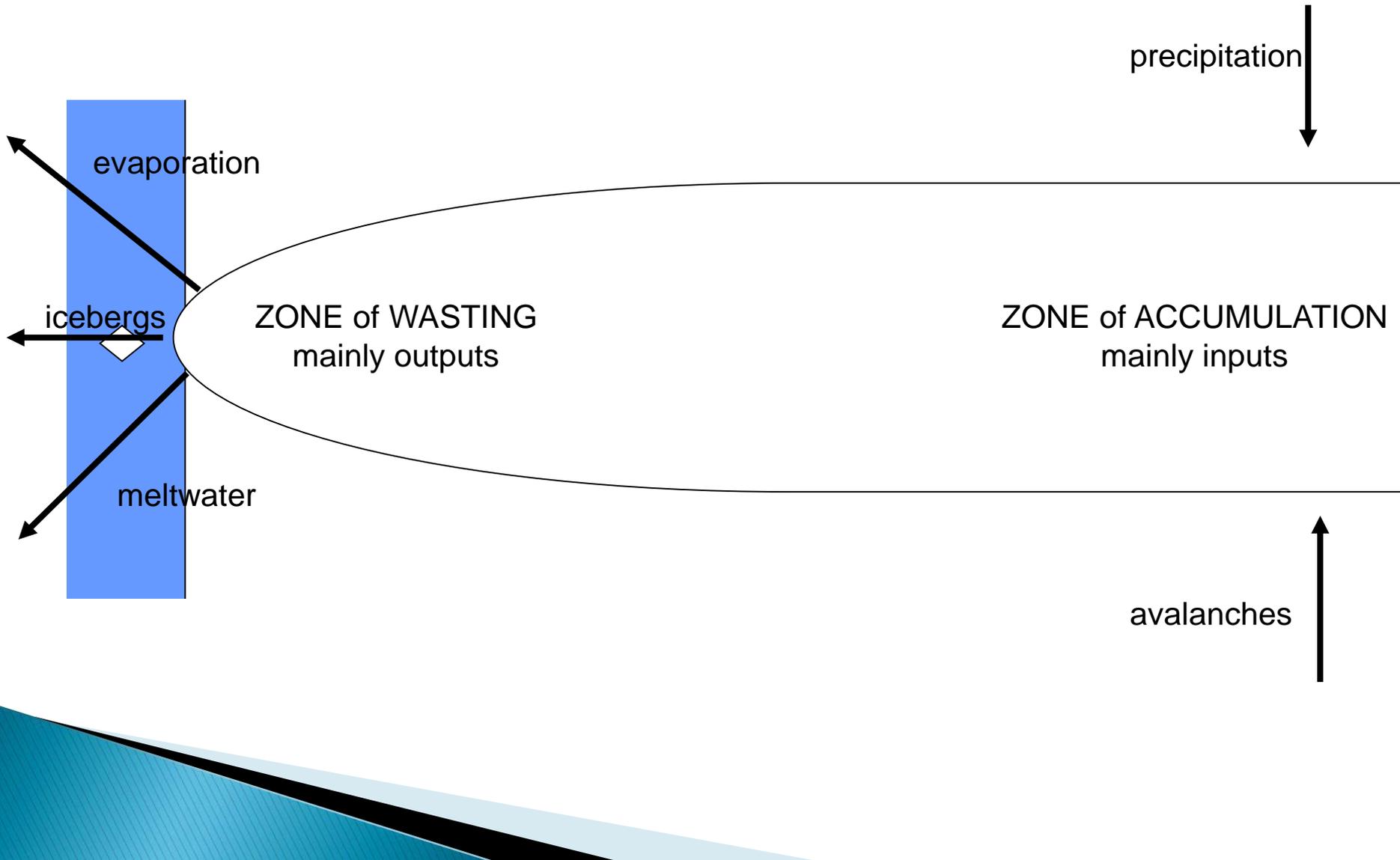
## Zone of flow

The ice moves under gravity. It erodes through abrasion and plucking. Glacial troughs, hanging valleys, waterfalls and lakes are formed in this zone.

## Zone of wasting (melting and evaporation)

This zone contains the terminal moraine ridge and outwash plain. It occurs at the snout of the glacier.

# A glacier is a *system* with *inputs* and *outputs*



## **Ice erodes by:**

### **1. Freeze Thaw (Frost Shattering)**

**Water in cracks in the rock freezes and expands.**

**After many cycles of freezing and thawing lumps of rock are broken off.**

### **2. Plucking**

**Glacier ice freezes into cracks in rocks and when the glacier moves it pulls out chunks to leave a jagged surface.**

### **3. Abrasion**

**Rocks stuck in the ice grind away the bedrock under the glacier.**



# freeze thaw



*Water expands when it freezes*

- ❄ Water from melted snow collects in cracks and crevices in rocks above glaciers.
- ❄ At night temperatures drop below freezing and the water changes into ice.
- ❄ Water expands when frozen and so exerts pressure on the sides of the crack.
- ❄ Eventually the rock shatters.
- ❄ Sharp, angular pieces of rock are formed called **scree**.



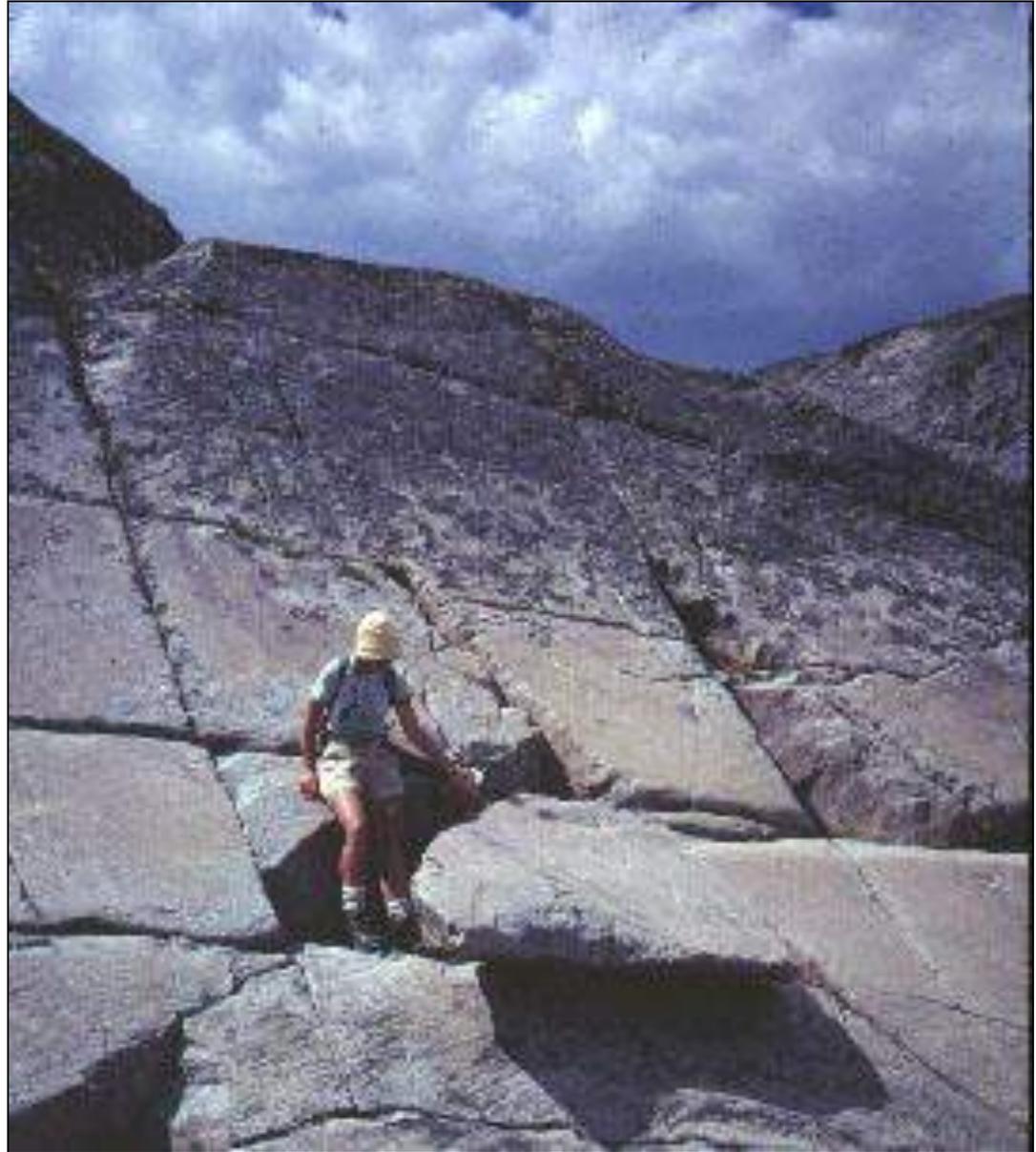
Scree - rock fragments broken off by freeze thaw (frost shattering)

# ***plucking***

↘ Glacial ice melts due to friction as it goes over an obstacle like a rock mass.

↘ This water will almost instantly refreeze because of the overlying pressure of the ice.

↘ It re-freezes into the cracks and crevices and as the glacier moves loose pieces of rock are pulled or torn out.



# ***abrasion***

This erosion process occurs when pieces of rock debris embedded in the ice wear away the rocks on the valley floor and sides.



# *abrasion*



The rock is scratched, polished, smoothed and eventually worn away by the scouring action.

The pieces of rock also become smaller through this rubbing action.

# *abrasion*



Striations are scratches made on the existing surface by rocks that are embedded in the bottom of the glacier as it moves forward.

# revision



**Freeze-thaw is a WEATHERING process.**

**Plucking and abrasion are processes of EROSION.**

- 1. Explain the difference between the processes of WEATHERING and EROSION.**
- 2. Explain each of the three processes using diagrams and notes.**

# *formation of a corrie*

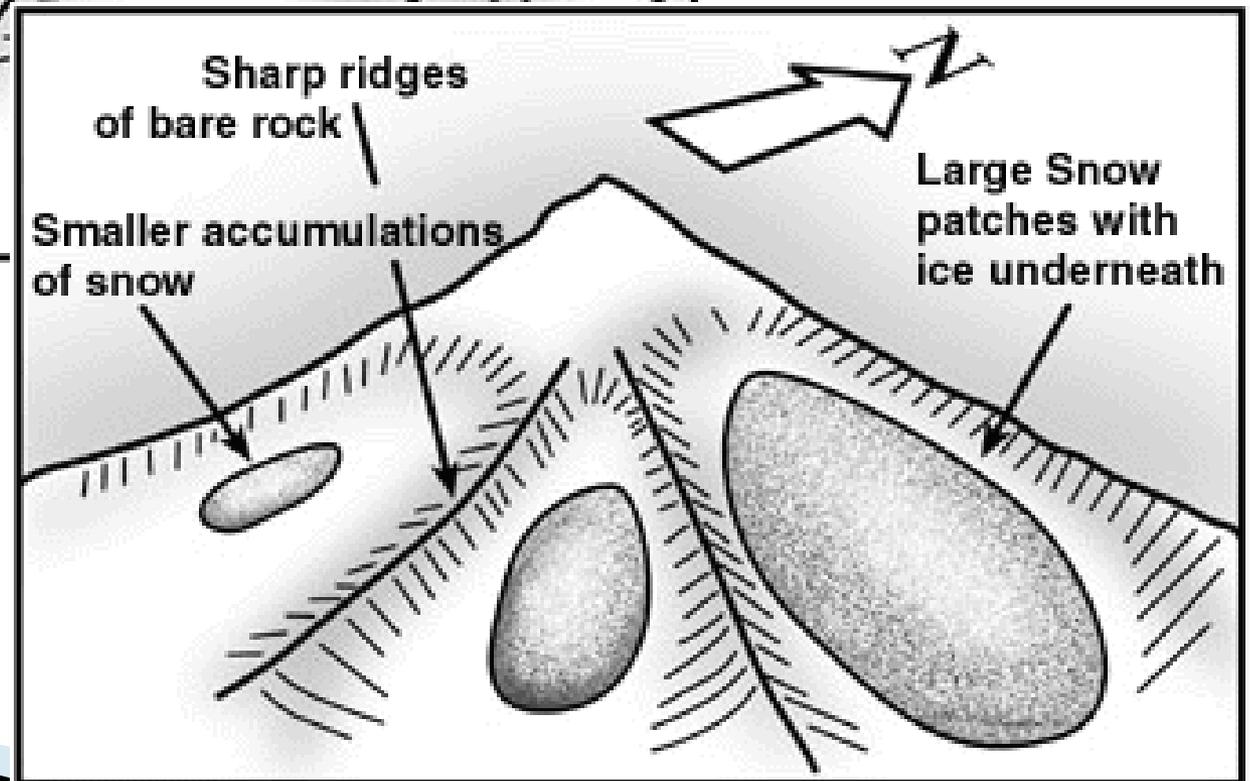
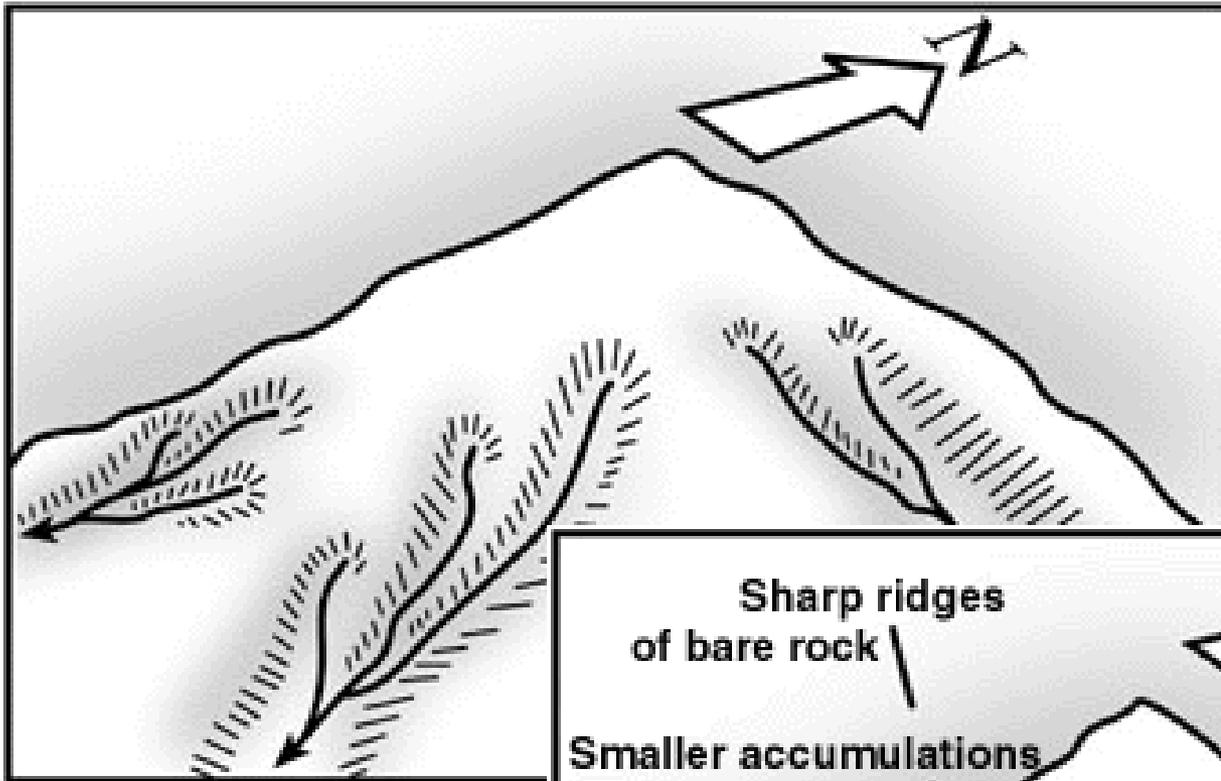


Snow collects in hollows, especially on the less sunny north and east facing slopes, turns to glacial ice and moves downwards under the force of gravity

Rocks are plucked out and the hollow is widened to become a **cirque or corrie**.

A corrie is a deep, rounded hollow with a steep head or back wall.

***formation of  
a corrie***

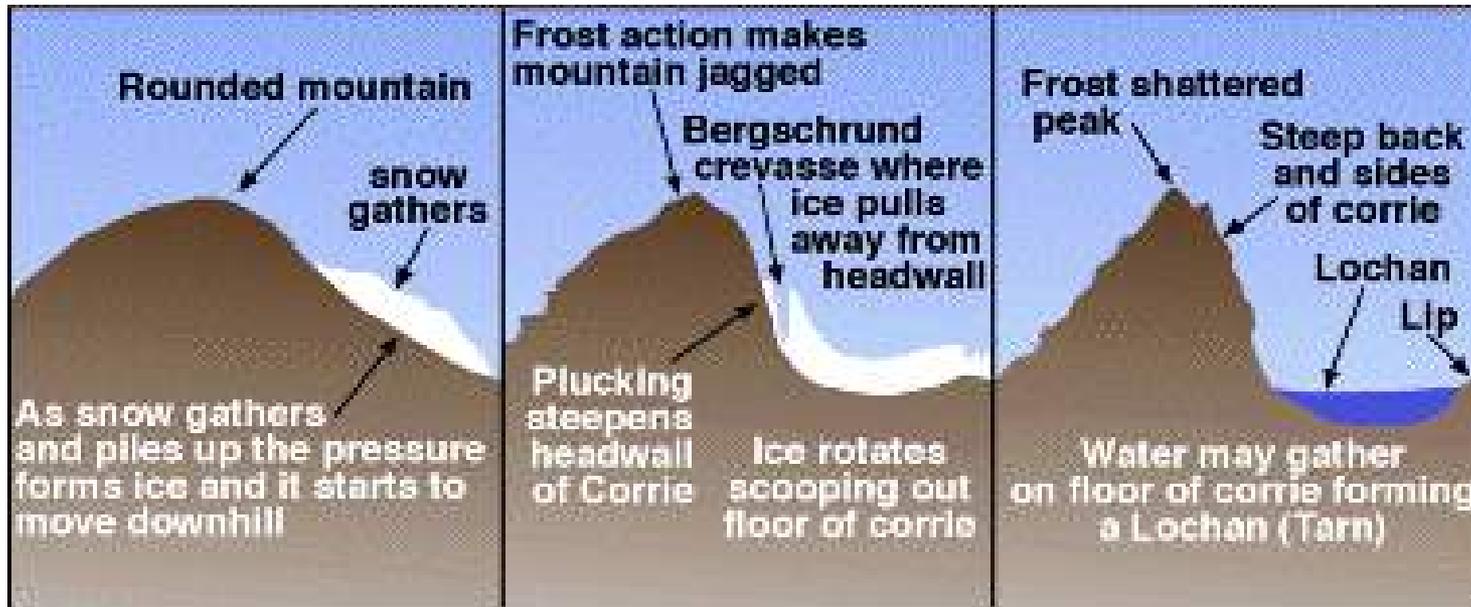


# *formation of a corrie*

**Before Glaciation**

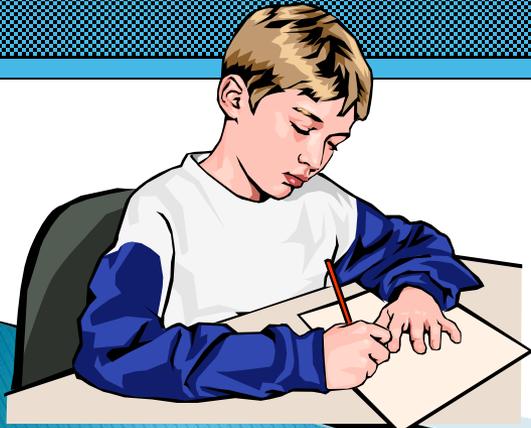
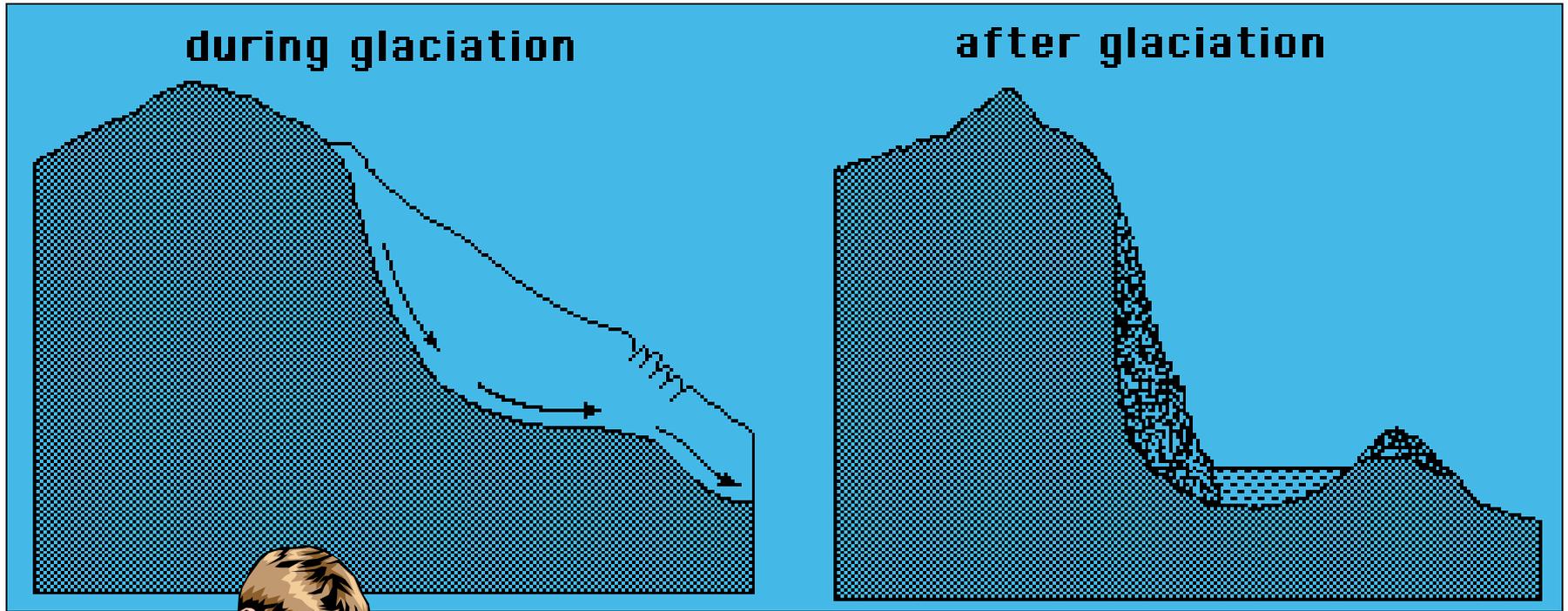
**During Glaciation**

**After Glaciation**



- a) snow collects in hollows
- b) snow compacts to ice
- c) ice moves under gravity, lubricated by meltwater
- d) ice rotates to lip
- e) abrasion deepens corrie
- f) plucking steepens back and sides
- g) corrie lochan (tarn) may fill hollow.

# *formation of a corrie*



Copy the diagram showing a corrie after glaciatiion.

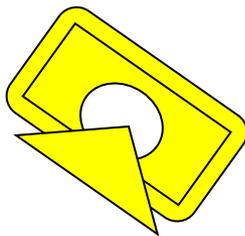
Label it to show:-

*corrie headwall lochan (tarn) lip scree*

***corrie***



Photo by R. Schukar.



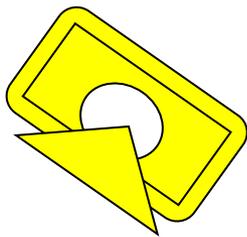
**Position photograph  
taken from**



Photo by R. Schukar.



# *corrie and tarn*



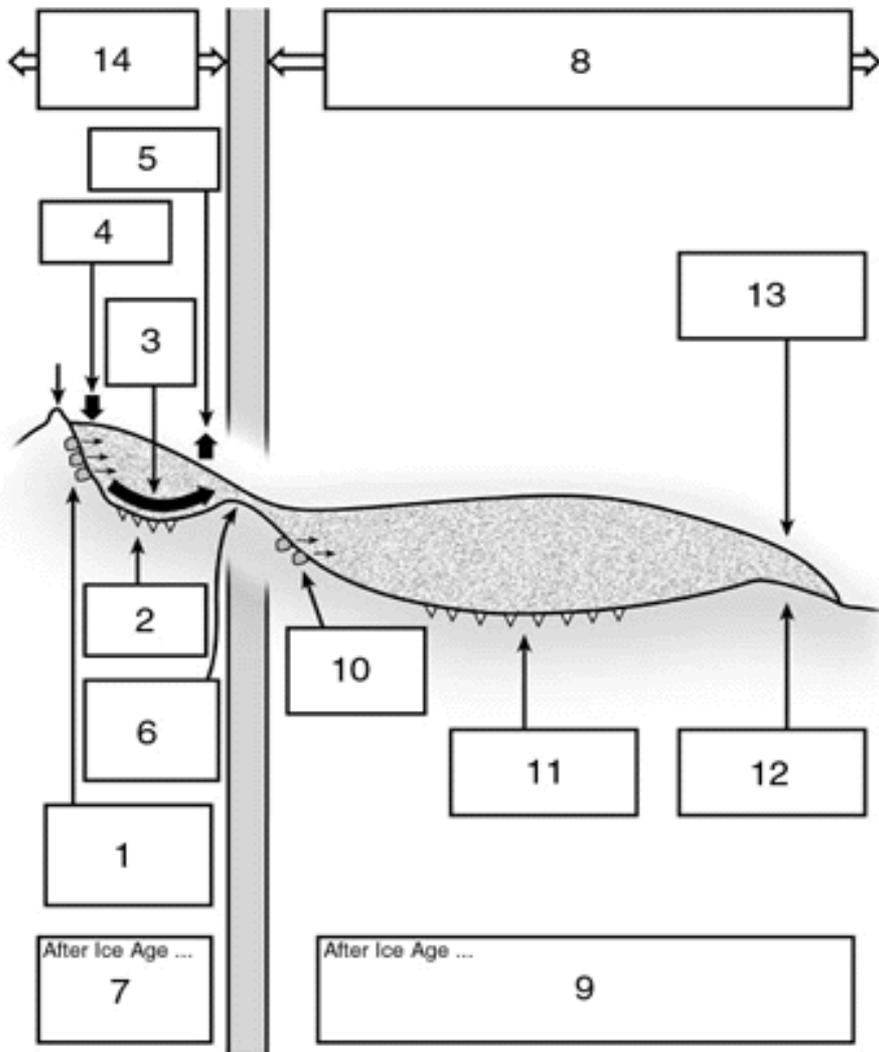
**Position photograph  
taken from**



# *corrie and tarn*

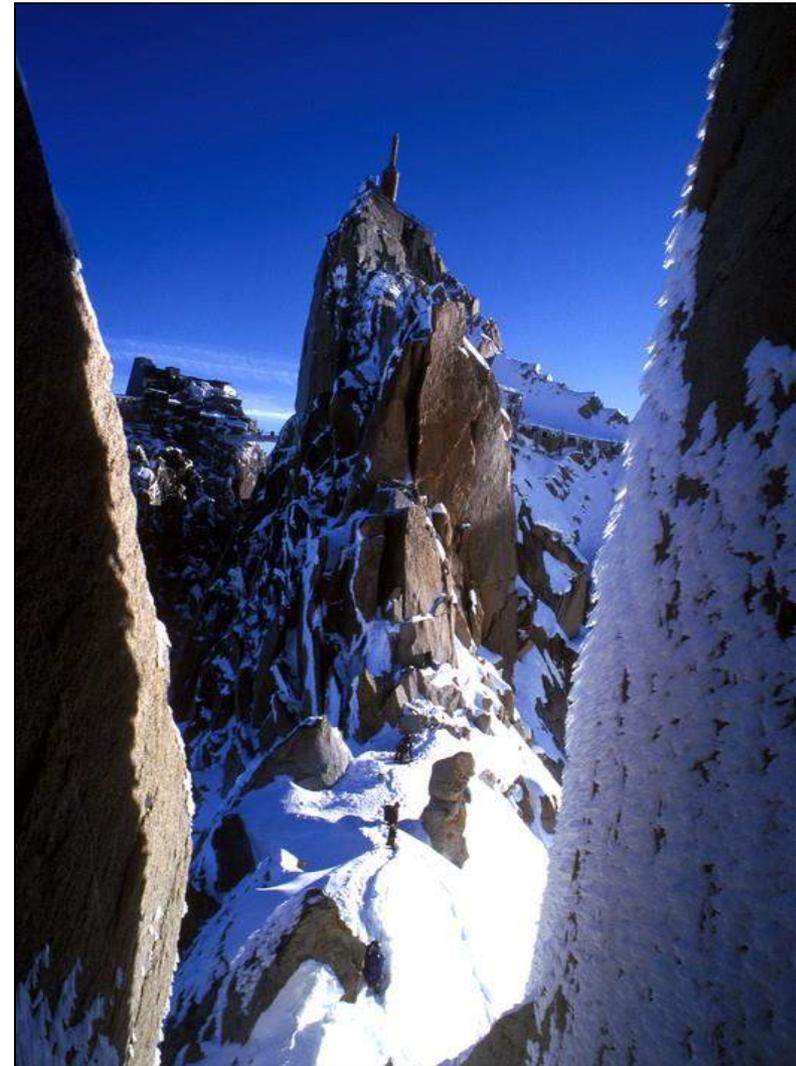
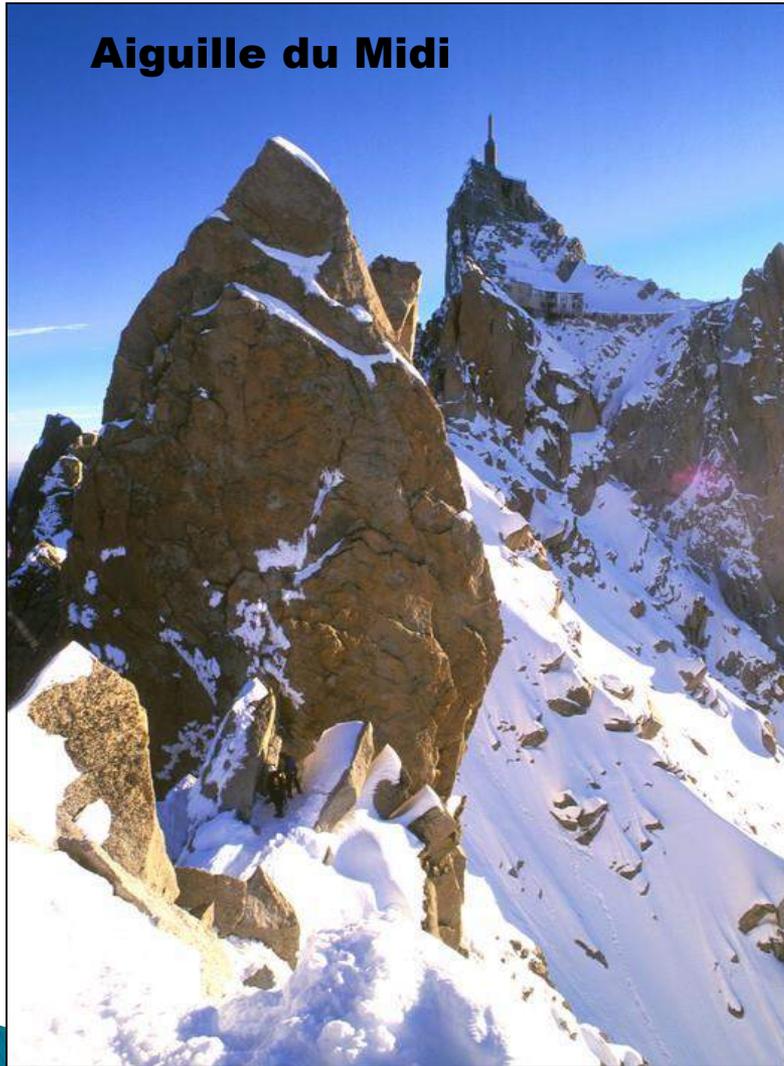


Once the glacier retreats, the cirque may be filled with water. A small, generally circular loch is formed. This is known as a **tarn** or **corrie lochan**.



1. Plucking: removes huge blocks from back wall.
2. Abrasion: sharp rocks embedded in ice erode the floor.
3. Rotation: the corrie glacier slides down and round in its basin.
4. Pressure from new snow.
5. Less pressure because less snow falls here.
6. Rock lip forms because corrie glacier is sliding upwards here and not eroding much.
7. After Ice Age corrie glacier leaves a basin-shaped hollow, often with tarn or corrie lake in floor of hollow.
8. Huge valley glacier fed by several corrie glaciers.
9. After Ice Age valley glacier leaves a glacial trough and often a long, narrow 'ribbon lake'.
10. Plucking under valley glacier.
11. Abrasion under valley glacier.
12. Rock bar at end of valley glacier.
13. Valley glacier thinner (farthest away from snow and ice supply, so less erosion).
14. Corrie glacier.

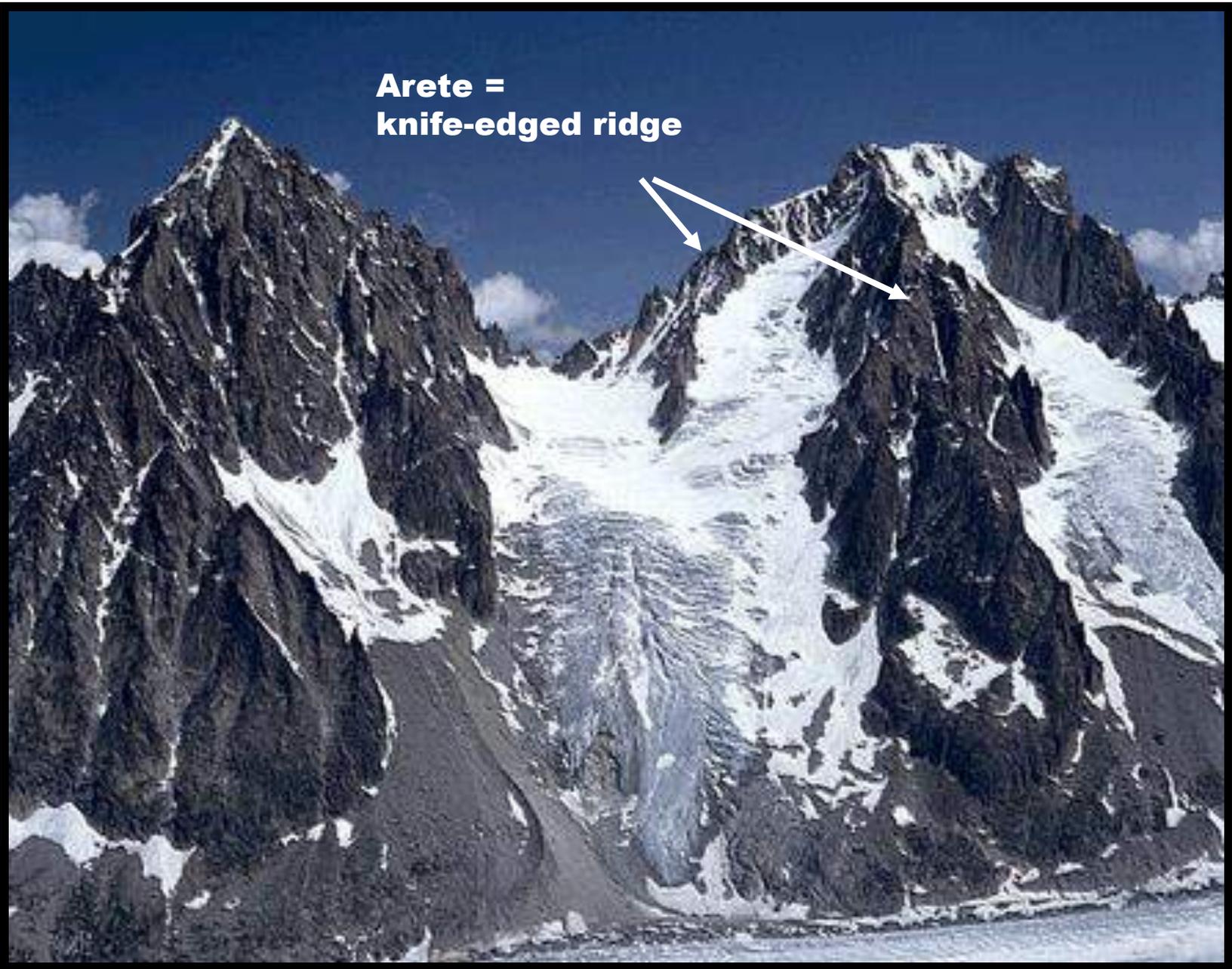
# *formation of an arete*



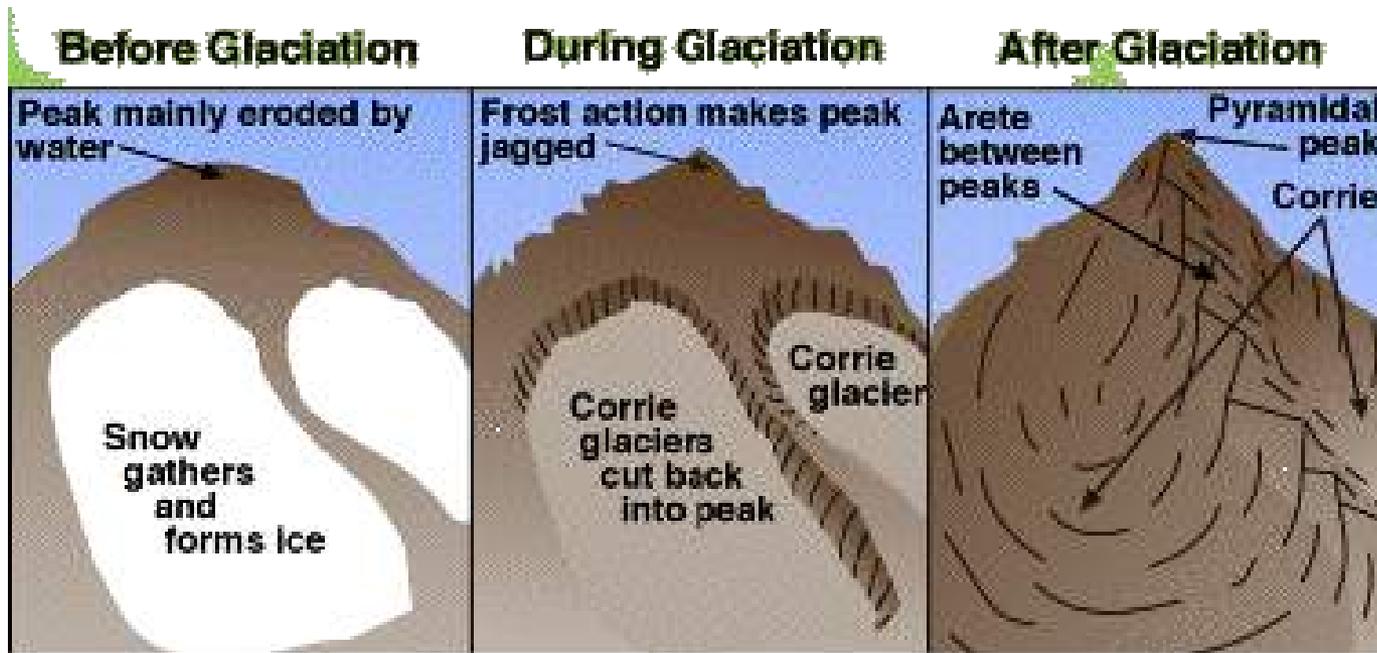
An arete is a narrow, sharp-edged ridge which forms the side walls of cirques and separates different glacial valleys.

# *arete*

**Arete =  
knife-edged ridge**

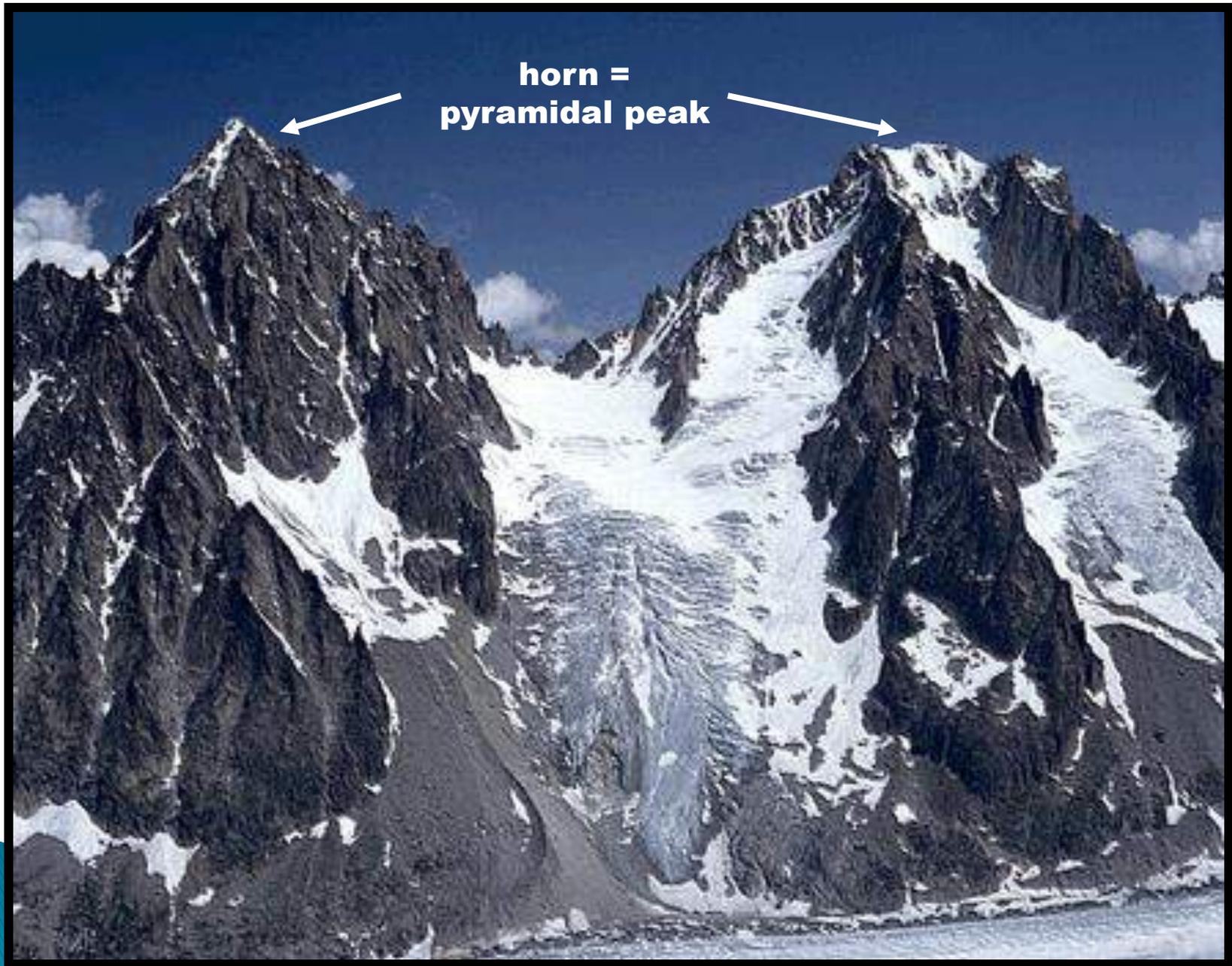


# *formation of a horn (pyramidal peak)*

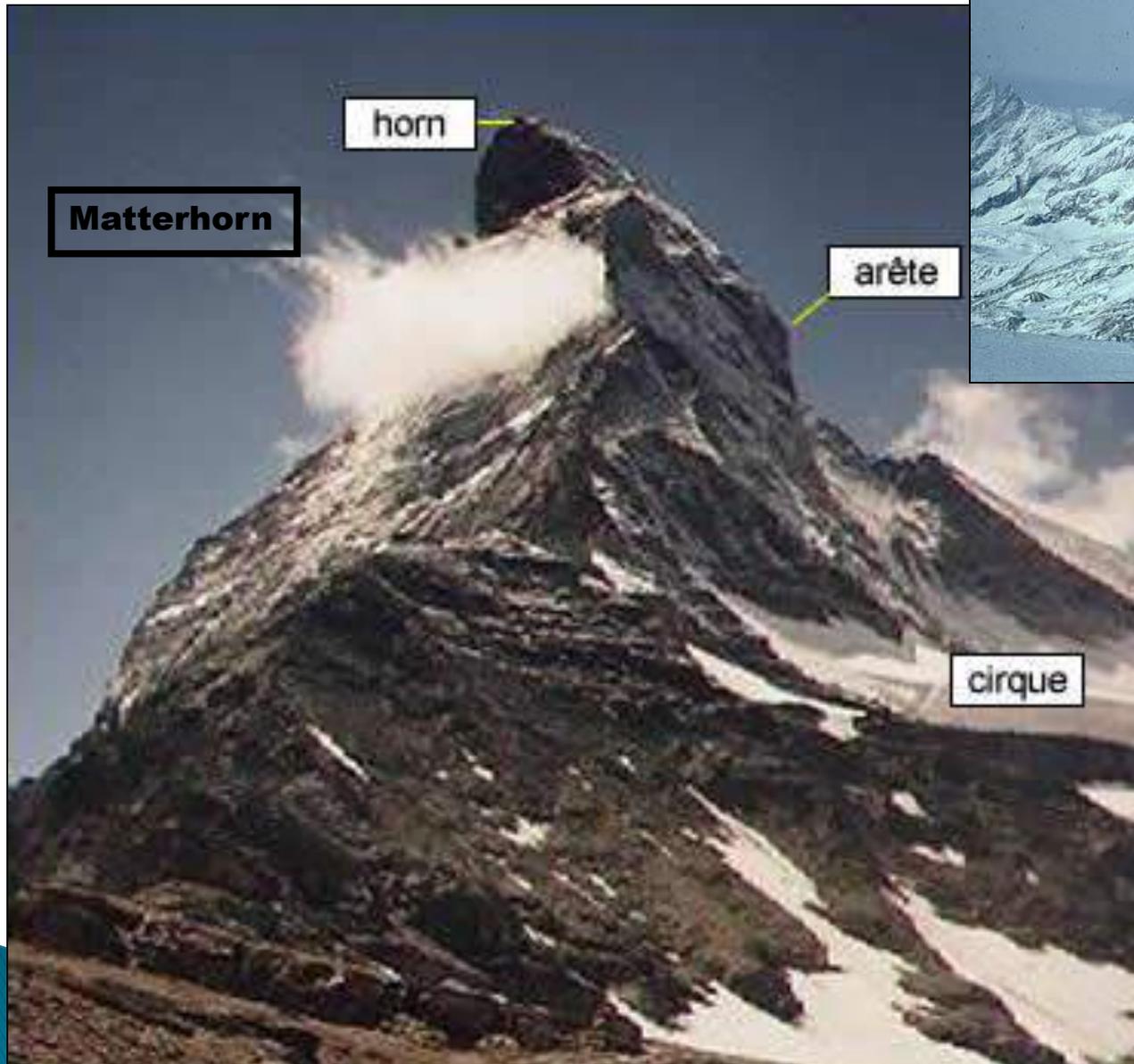


- three or more corries form around a peak
- where corrie sidewalls meet they form an arête (knife edge).
- arêtes meet to form a horn (pyramidal peak).

# *horn*



# *horn*



When three or more corries erode backwards a sharp pointed pyramid shape is created. This is called a Pyramidal Peak or Horn.

# revision



1. Write a definition of each of the following terms:-

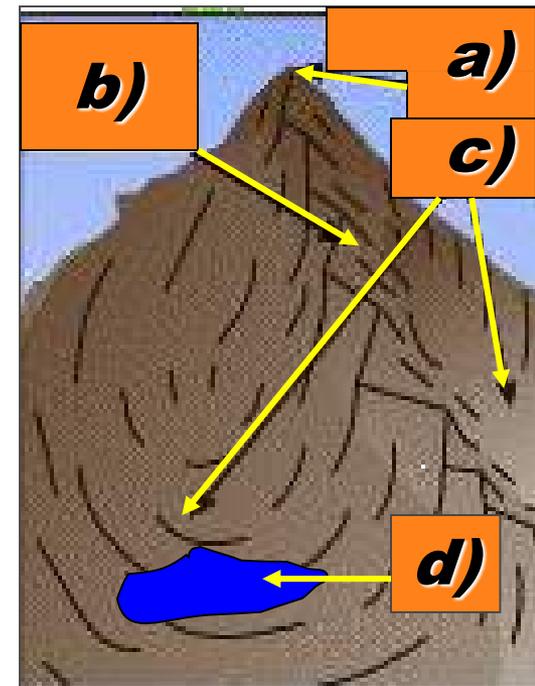
***corrie***

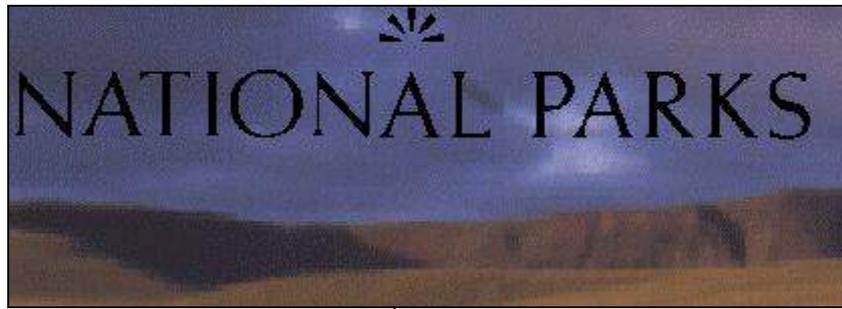
***arête***

***horn***

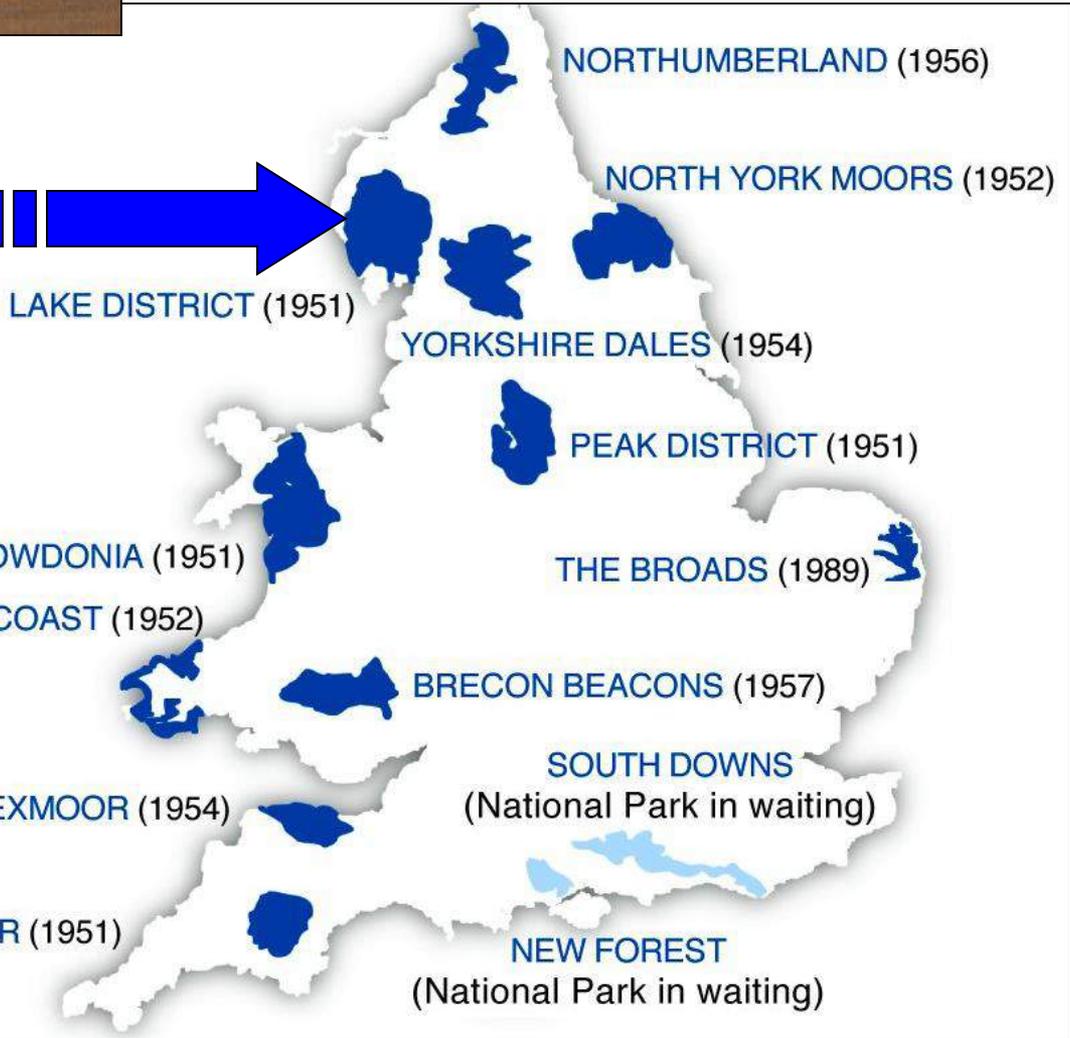
***tarn***

2. Which feature goes with which letter on the diagram?





Eleven National Parks have been designated in England and Wales.

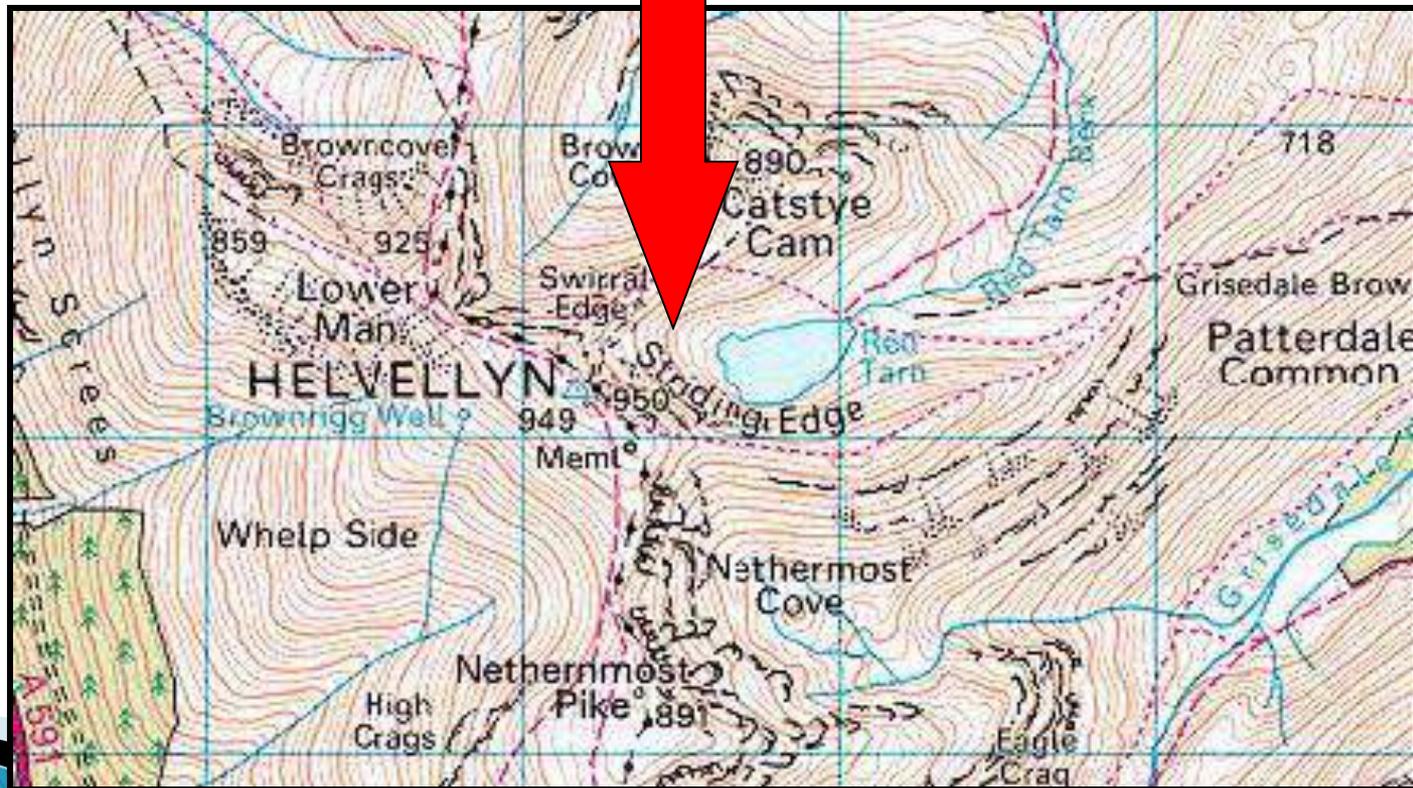
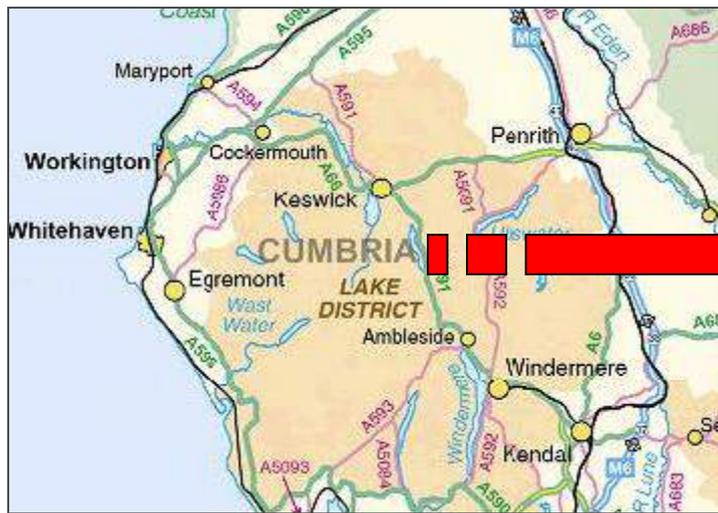


National Parks have two purposes:-

 to conserve the natural beauty of the countryside

 to promote public access to the countryside.

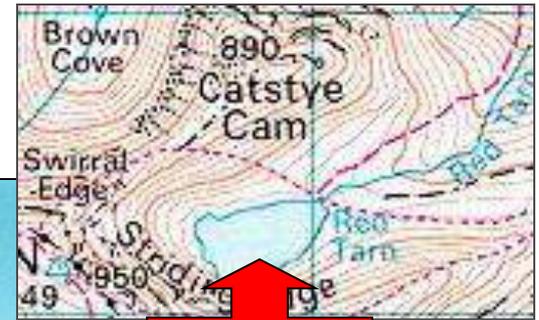




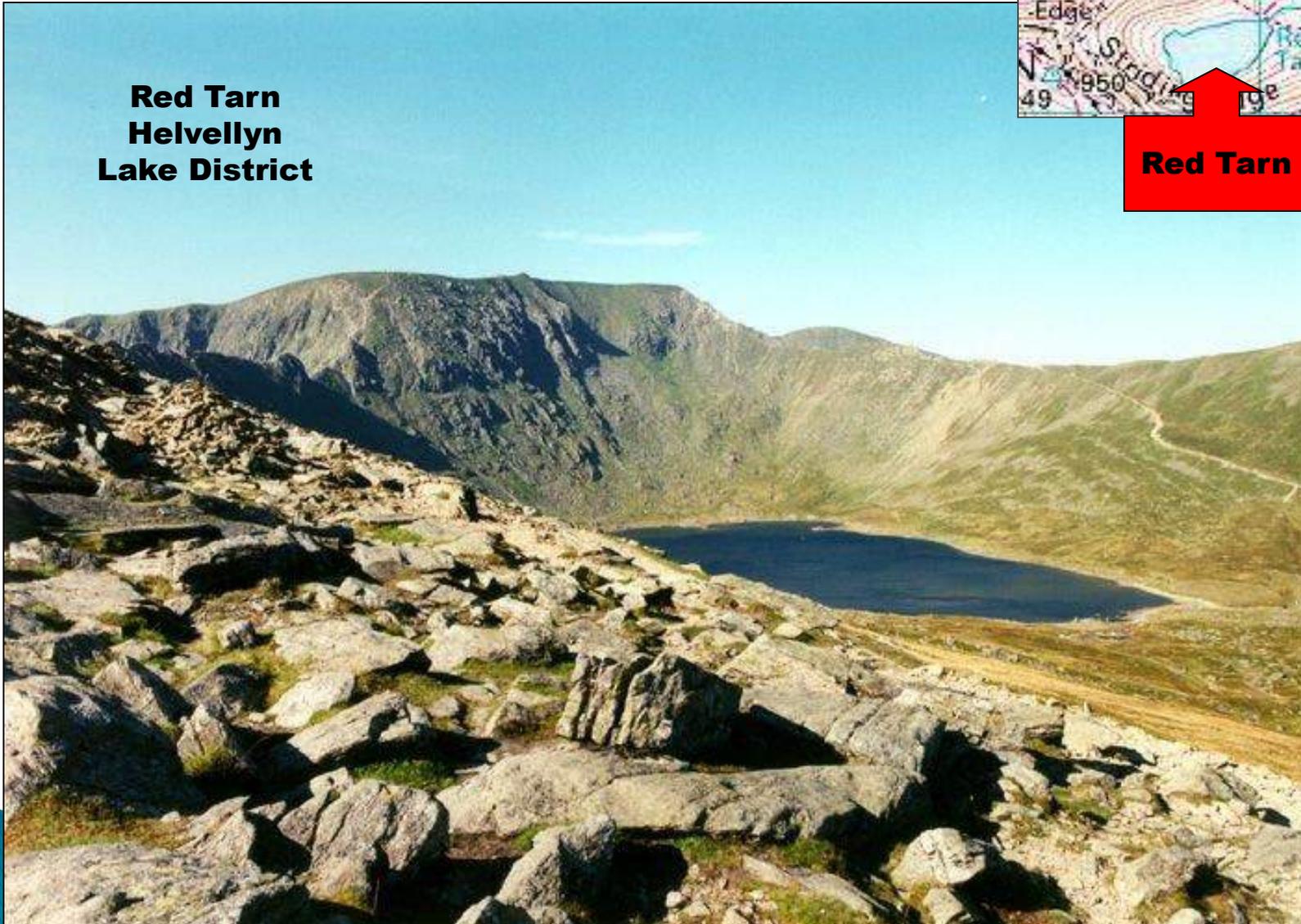
# *Helvellyn Lake District*

# *corrie and tarn*

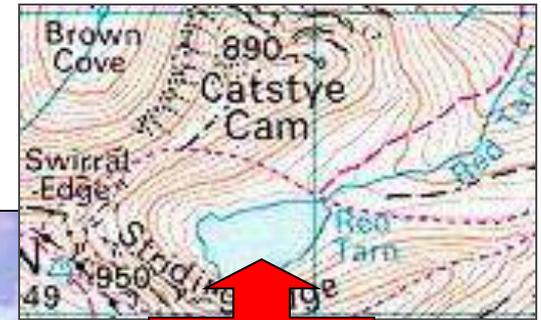
**Red Tarn  
Helvellyn  
Lake District**



**Red Tarn**



# *corrie and tarn*

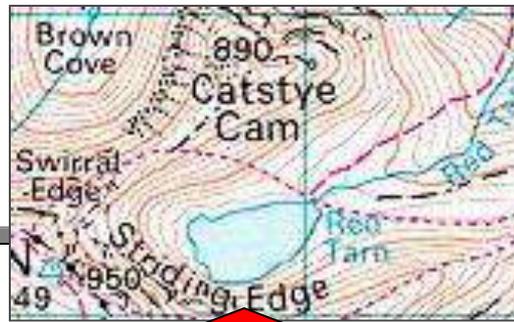


**Red Tarn  
Helvellyn  
Lake District**

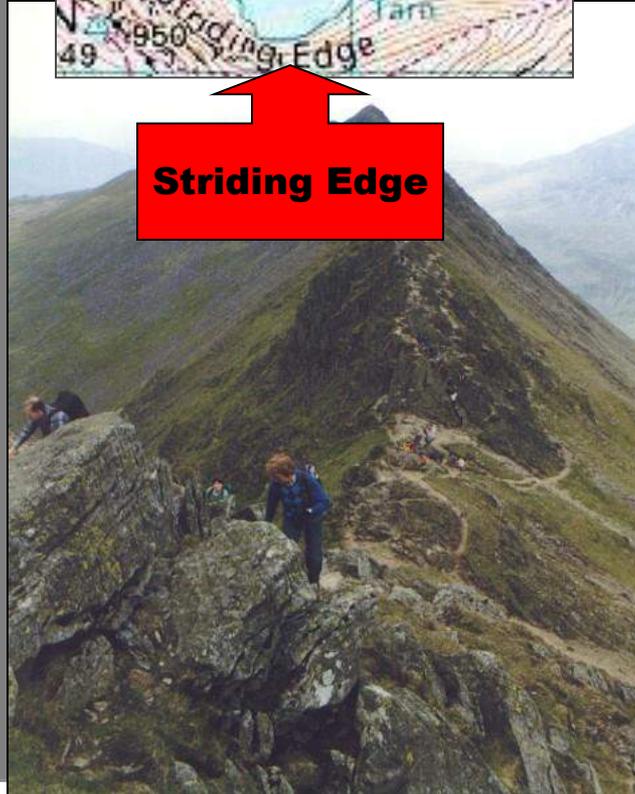


**Red Tarn**

**arete**



**Striding Edge**



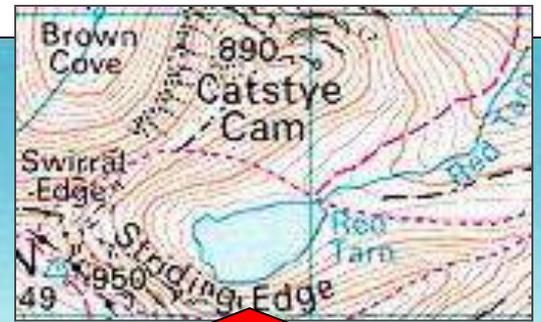
**Striding Edge  
Helvellyn  
Lake District**

When a corrie is formed, its back and side walls are steep. When two corries form next to each other a narrow rock ridge is formed. This is often likened to a knife edge, with near vertical sides and a sharp top edge.

This feature is called an **arête** or knife-edged ridge.

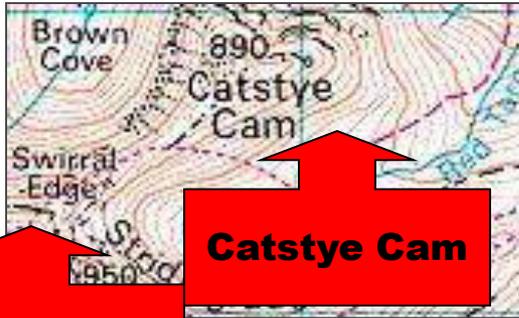
*arete*

**Striding Edge  
Helvellyn  
Lake District**



**Striding Edge**





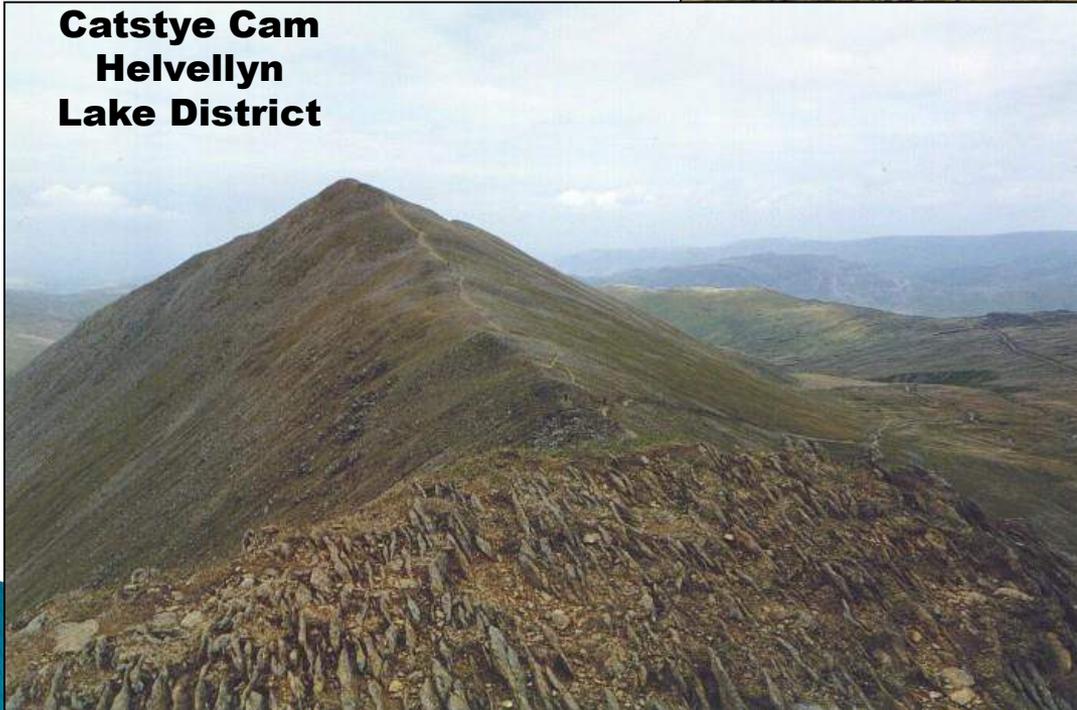
**Swirral Edge**

**Catstye Cam**

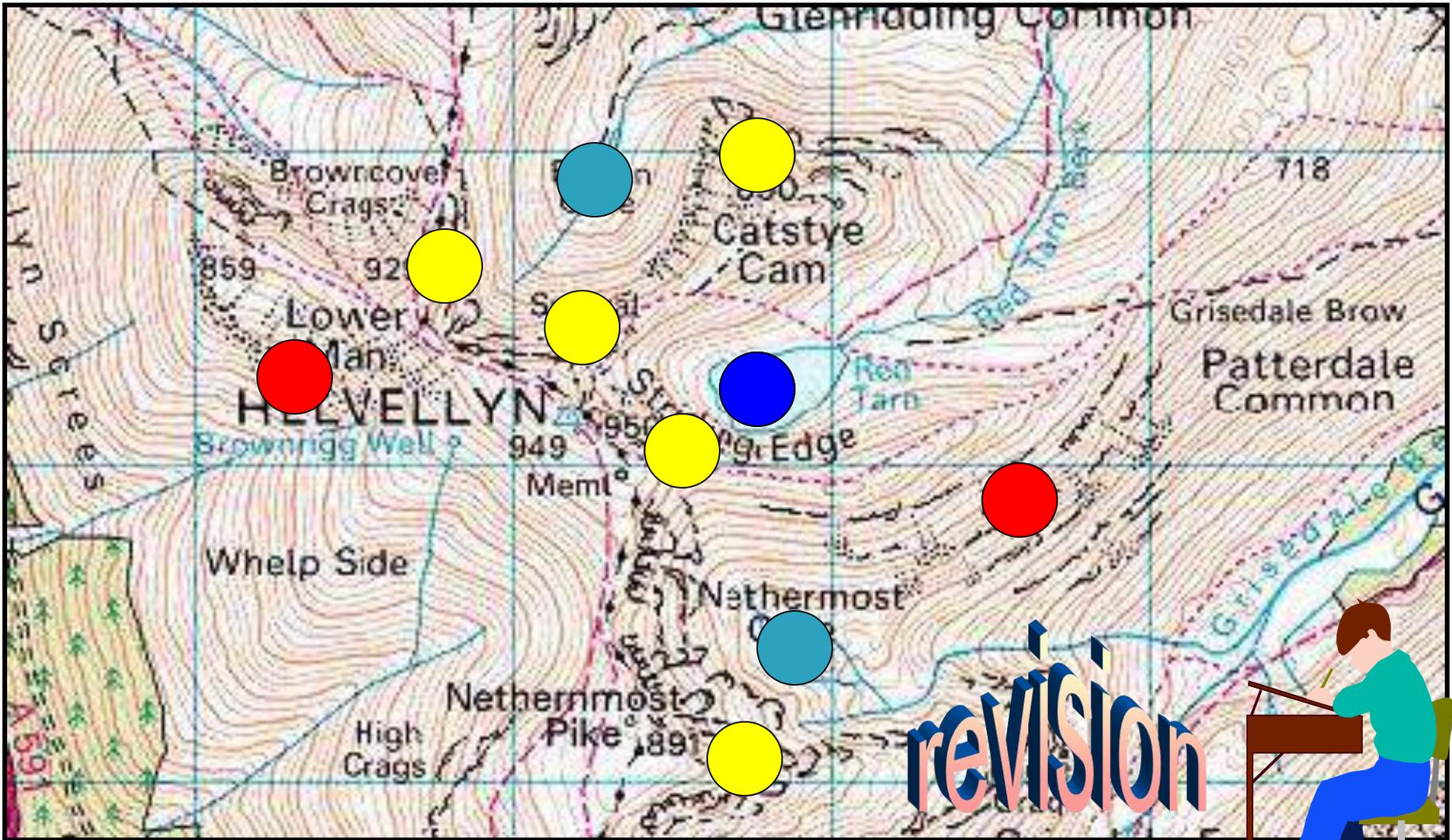
**Swirral Edge  
Helvellyn  
Lake District**



**Catstye Cam  
Helvellyn  
Lake District**



*arete*



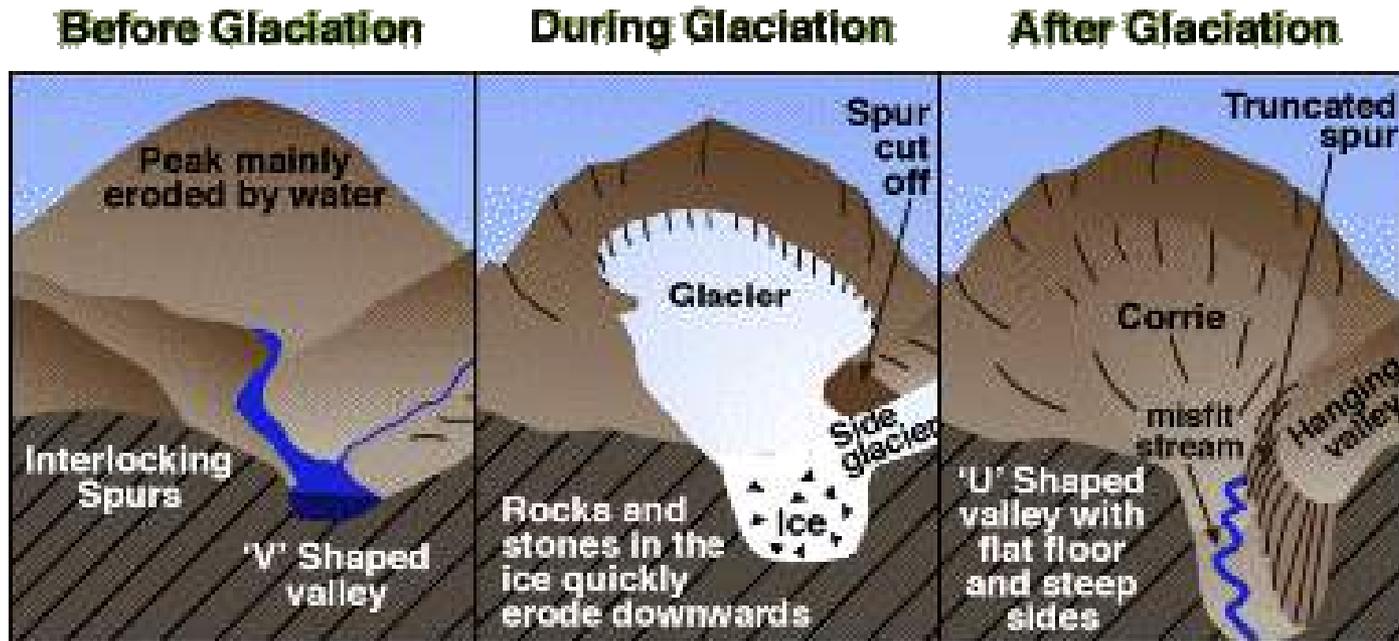
revision



-  **scree**
-  **cirque**
-  **tarn**
-  **arête**

Identify examples of glacial features on the map.

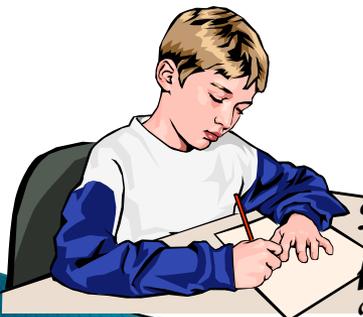
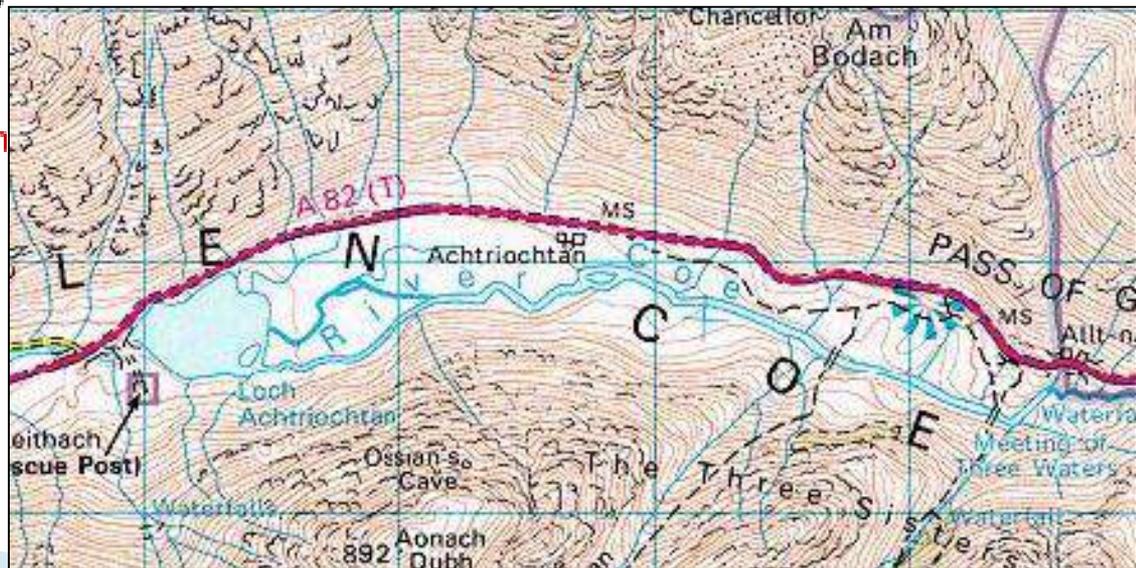
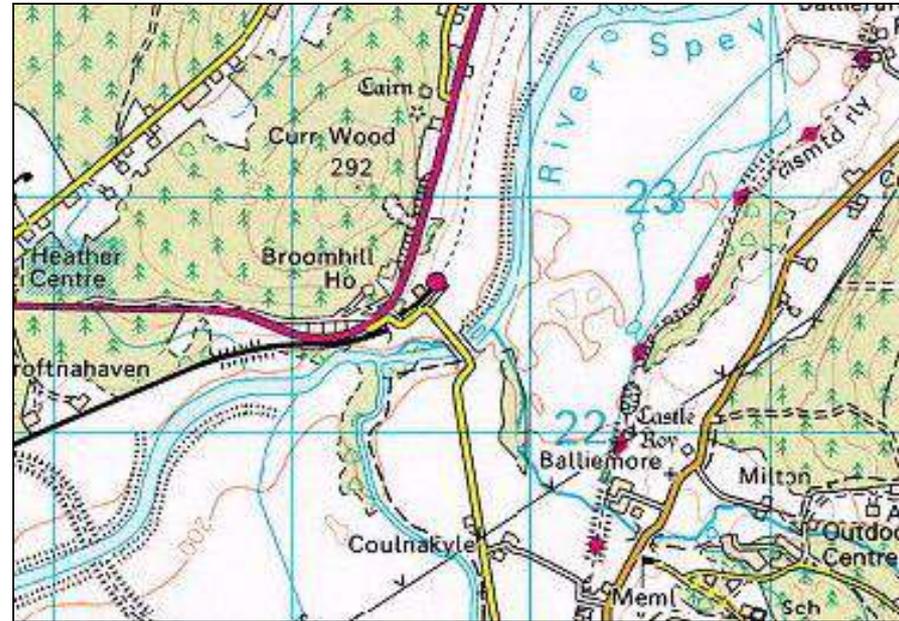
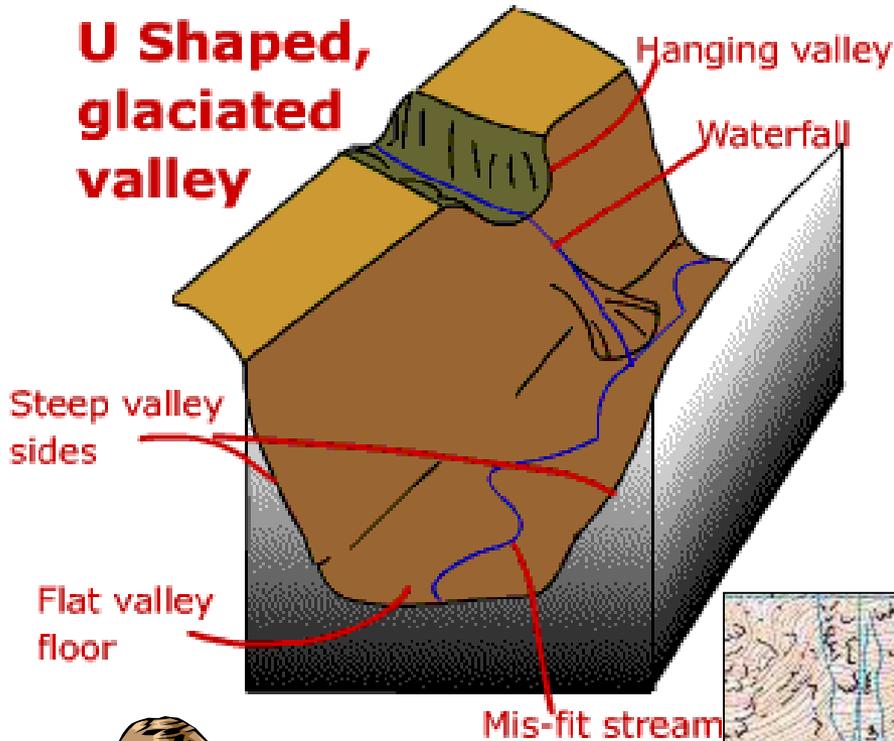
# formation of a 'U' shaped valley



- glacier flows in an earlier 'V' shaped valley,
- glacier abrades the sides and floor of the river valley,
- valley is greatly deepened, widened and straightened,
- when the ice melts the valley is 'U' shaped,
- it has very steep sides and a fairly flat floor,
- any later rivers are called 'misfit streams' because they are far too small to have cut the valley.

# 'U' shaped valley

**U Shaped, glaciated valley**



*Describe the main features of a glaciated U-shaped valley and its 'misfit' river.*

## ***'U' shaped valley***



Glaciers are very powerful agents of erosion: they reshape former V-shaped river valleys into wide, deep, steep-sided troughs by the processes of abrasion and plucking.

# *'U' shaped valley*

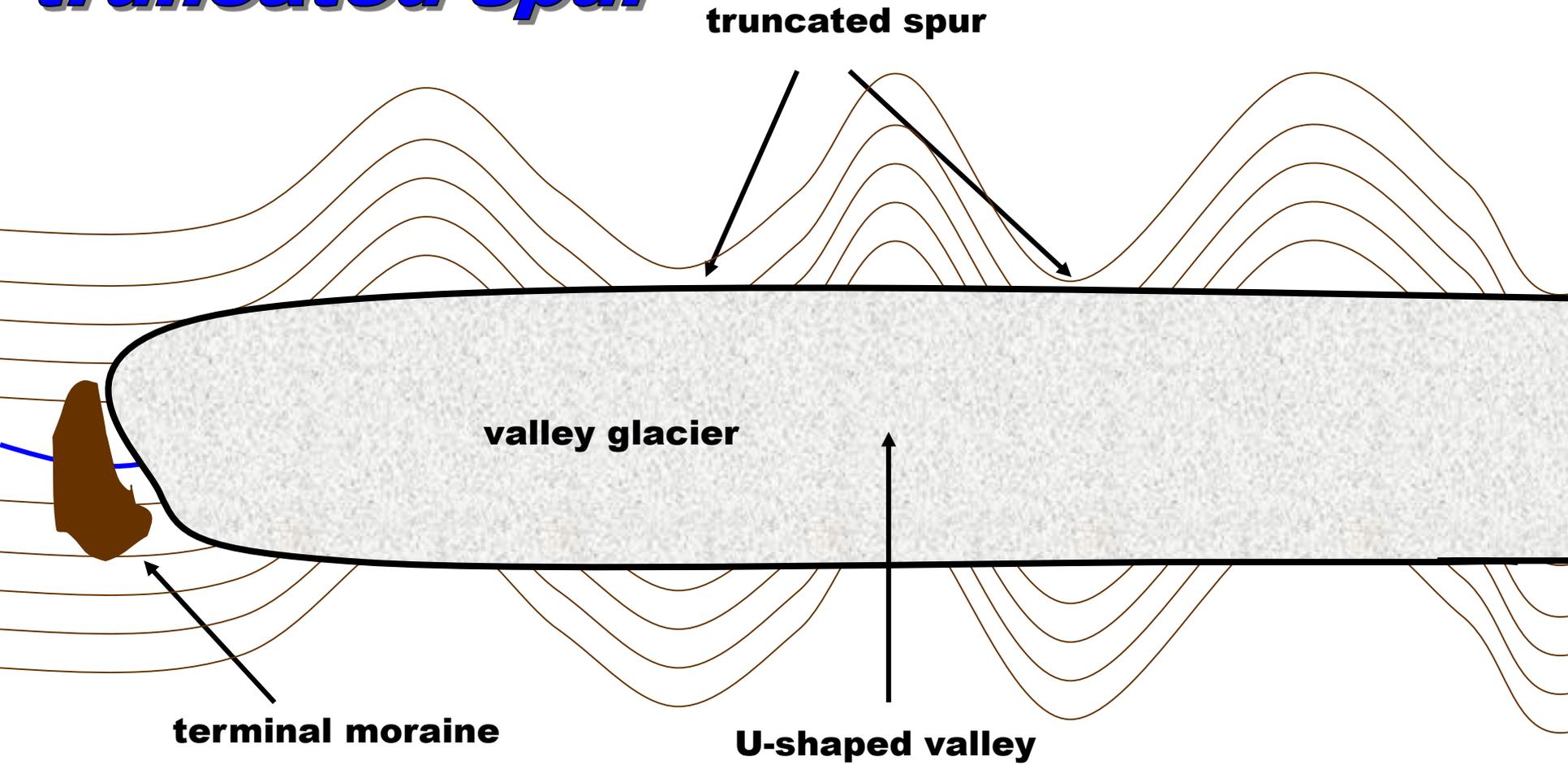


Former river spurs are truncated: their ends are cut off by the ice action to form steep, sheer cliffs.

# *'U' shaped valley*



# *truncated spur*

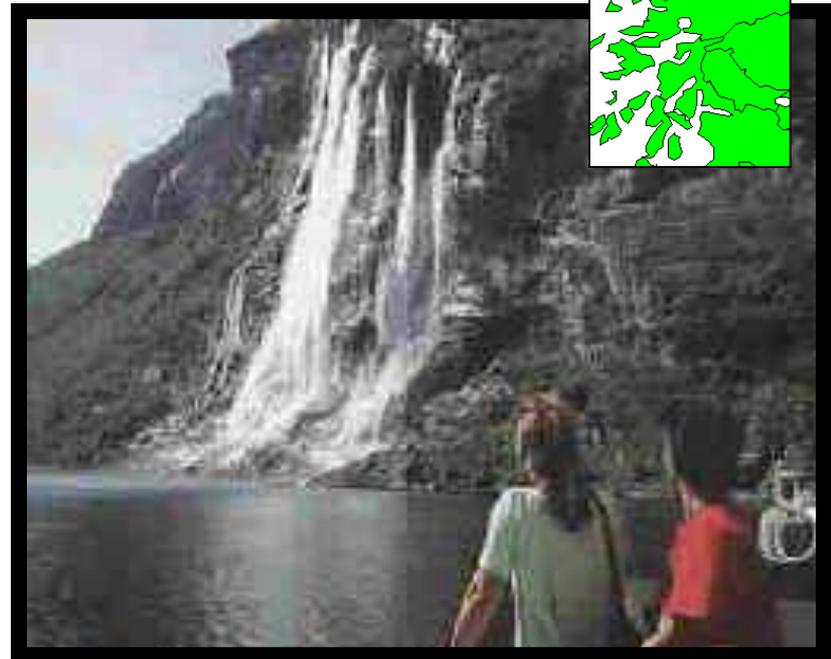




# ***fiord***

When a glaciated valley is submerged or drowned by a rise in sea level a fiord is formed.

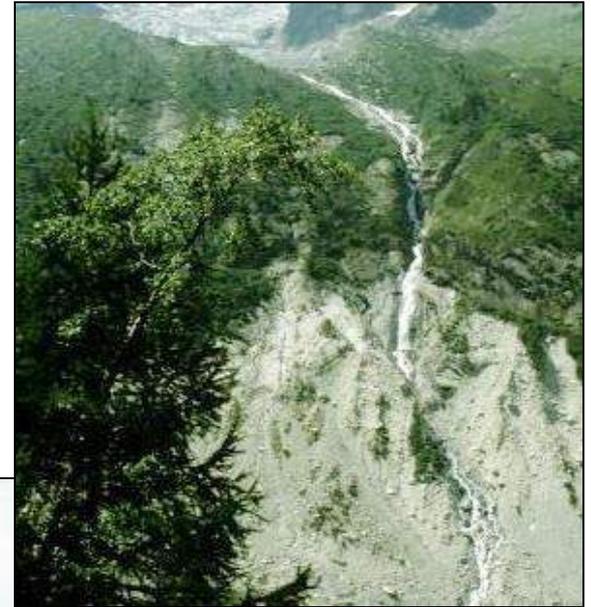
The sea lochs of western Scotland are the best examples of fiords in the British Isles.



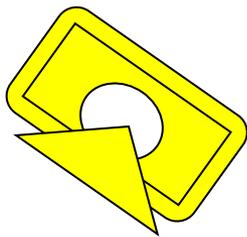
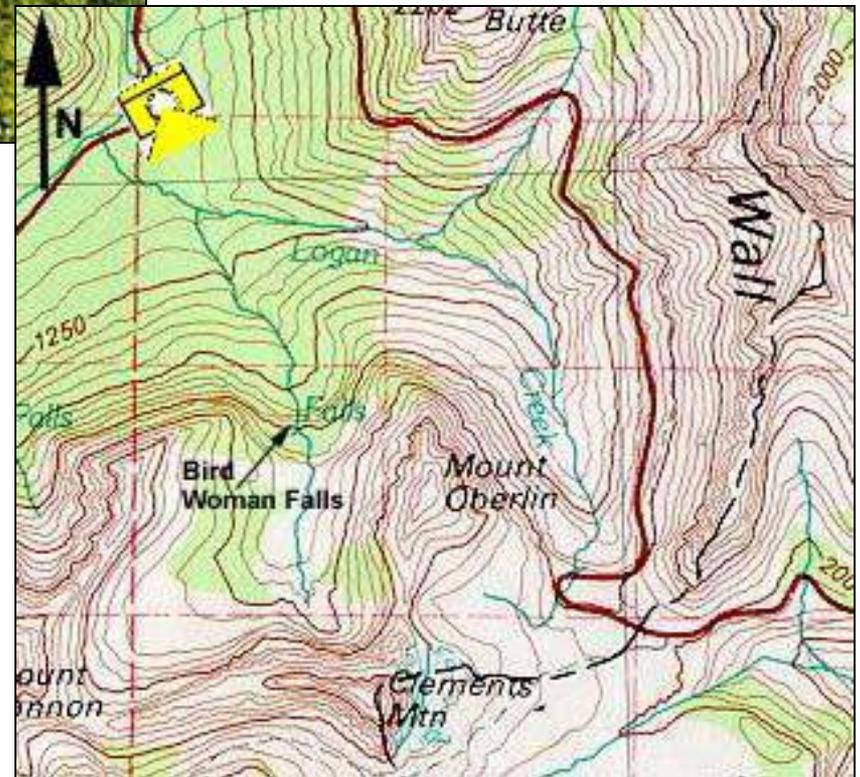
**Sognefjord Norway**

# *hanging valley*

Vertical erosion in the main glacier is far greater than in the tributary glaciers. Valleys are not the same depth and after the glacier has retreated rivers flowing down the tributary join the main trough via a waterfall

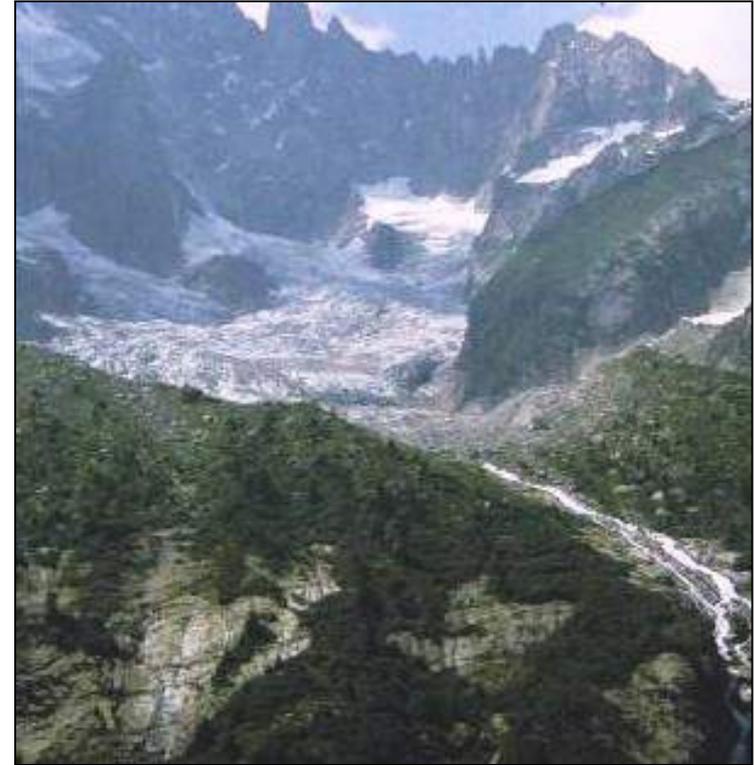


# *hanging valley*



**Position photograph  
taken from**

# *hanging valley*



At the base of a waterfall alluvial fans are sometimes found as a result of deposition.

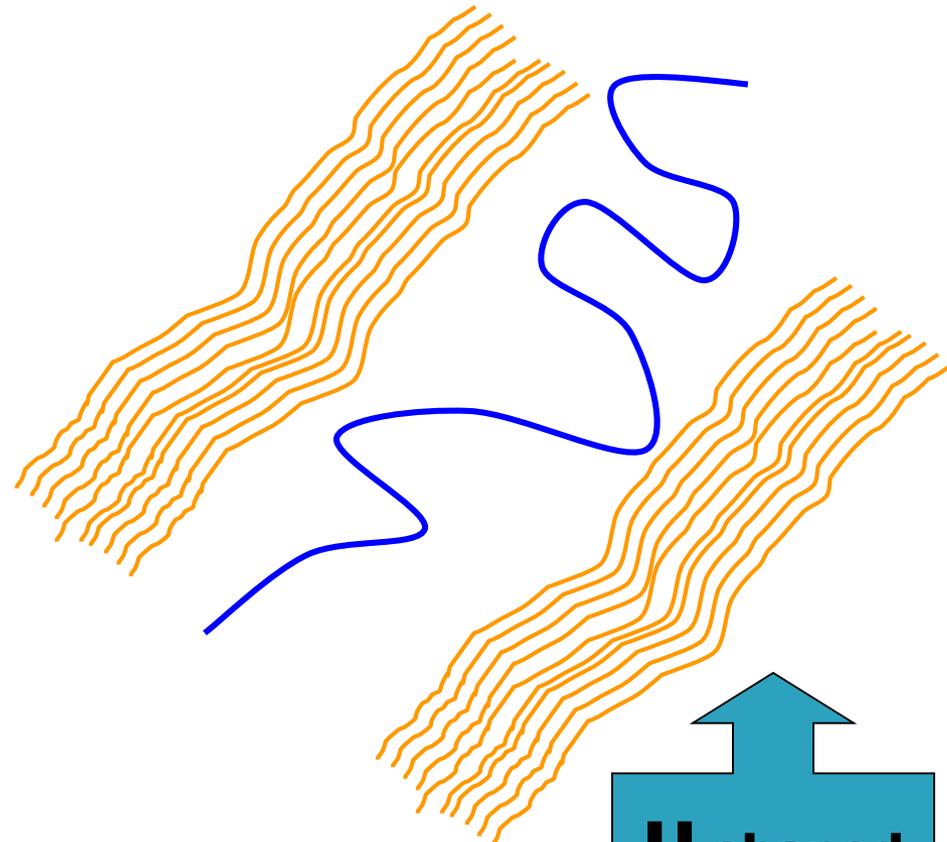
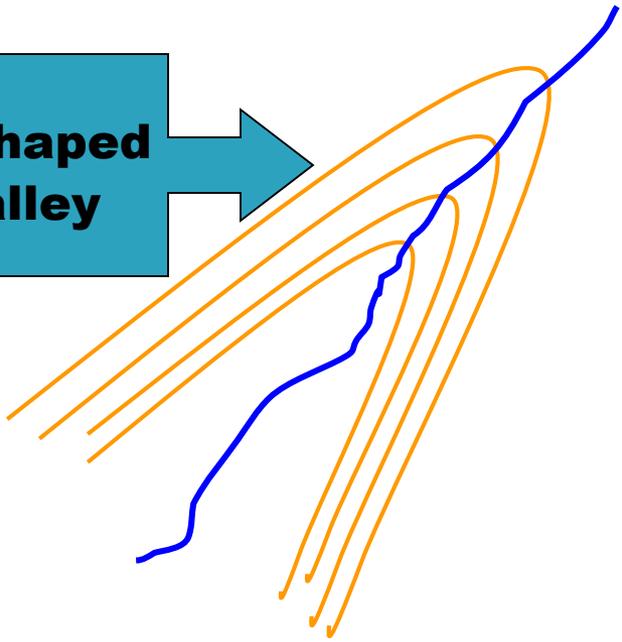
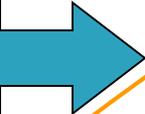


# ***alluvial fan***

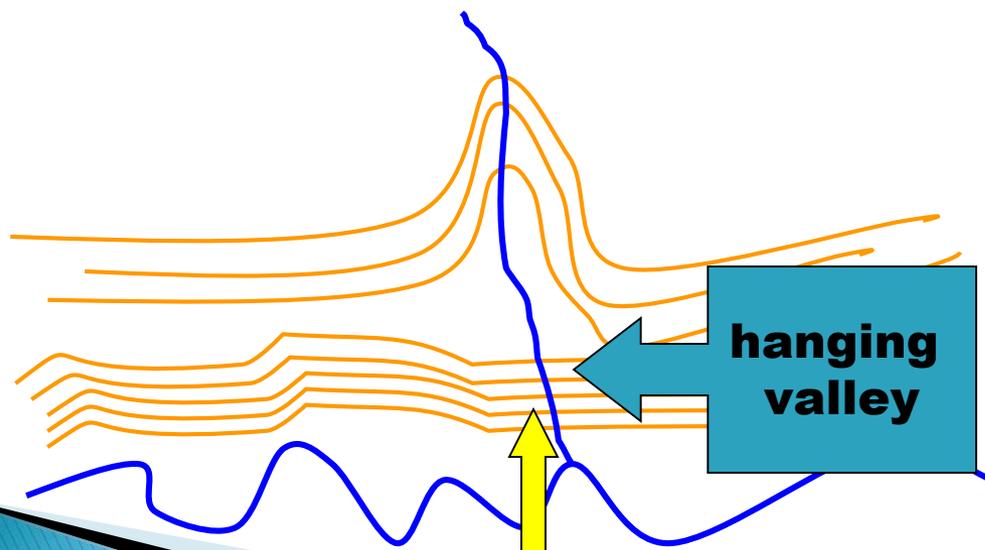


**alluvium = silt deposited by a river**

**V-shaped valley**



**U-shaped valley**



**hanging valley**



**waterfall**

**Ullswater  
Lake District**



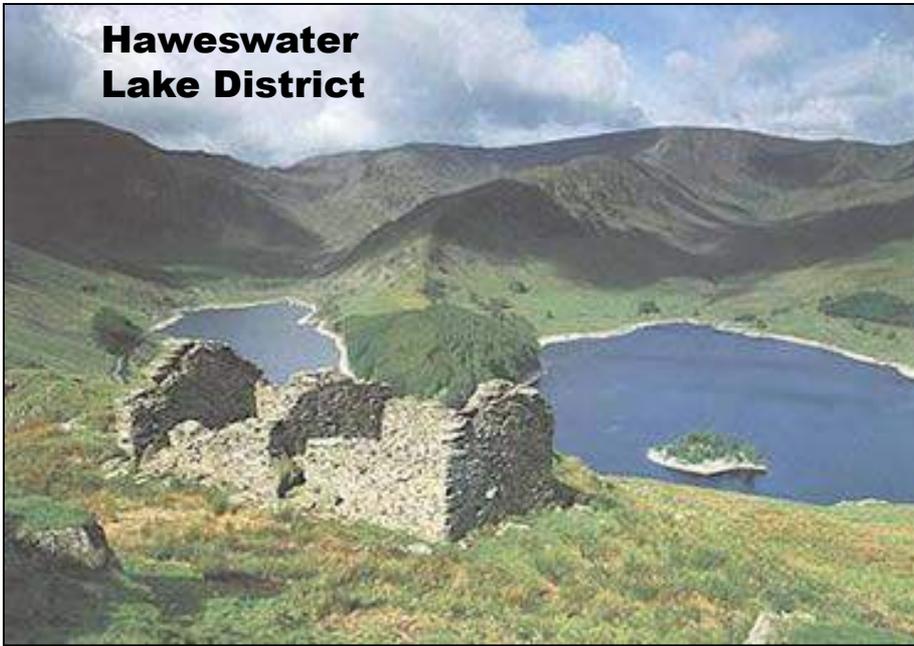
***ribbon  
lake***



When a glacier moves along its valley some parts are deepened more than others. When the glacier retreats the deepened sections fill with melt water and become lakes.

The English Lake district owes its character to these narrow ribbon lakes along its valley floors.

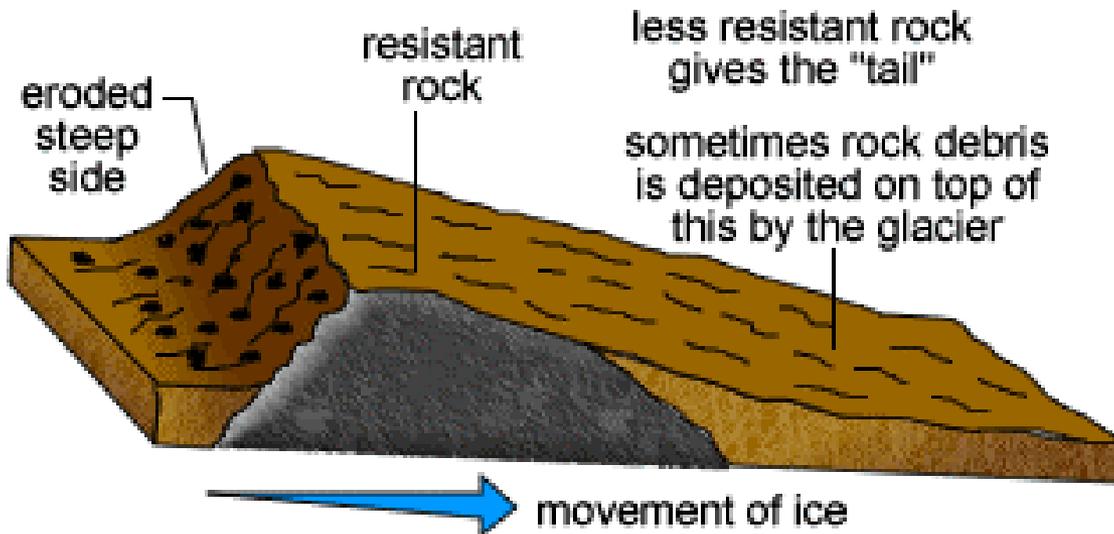
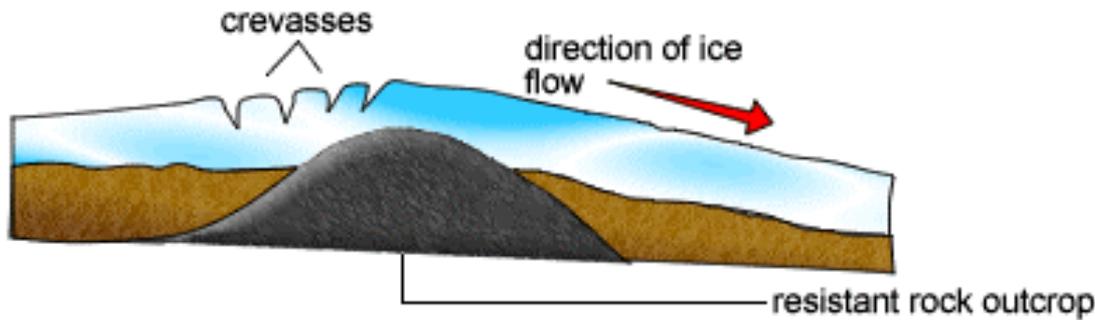
# *ribbon lake*



Ribbon lakes can also be formed when glacial deposits build a natural barrier across a glacial trough

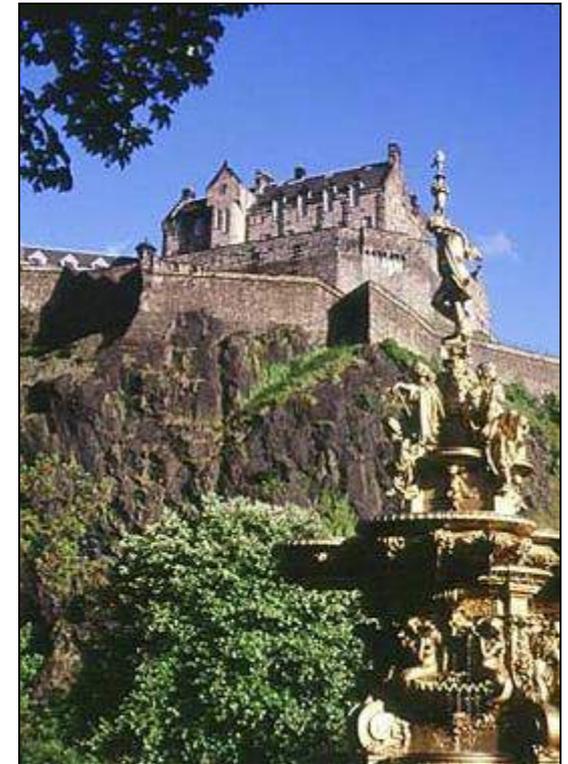


# *crag and tail*



These are partly erosional, partly depositional features  
The rock face facing the ice is steepened by glacial erosion.

Material is deposited on the opposite side to form a tail of boulder clay.

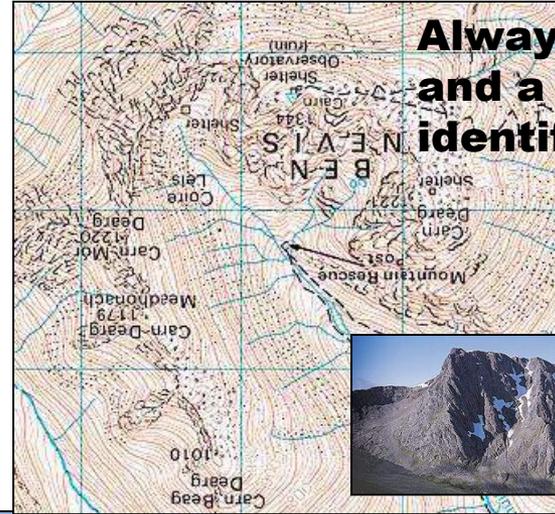
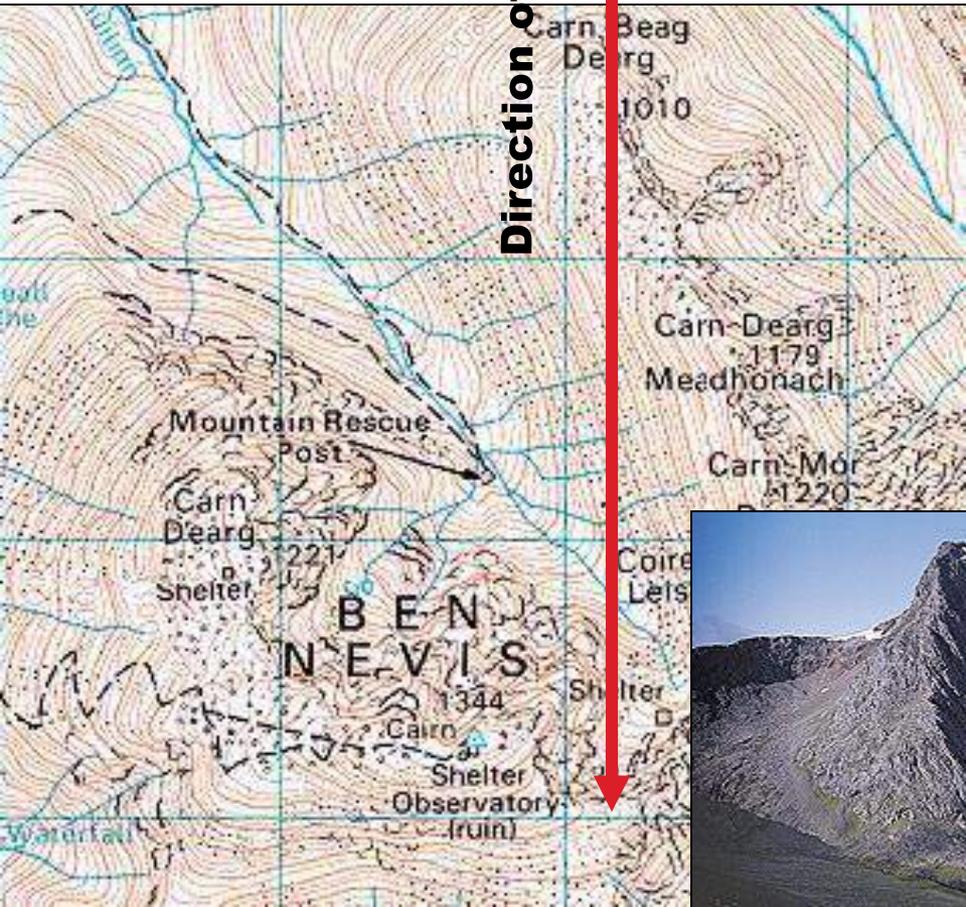


Edinburgh Castle

# Ben Nevis



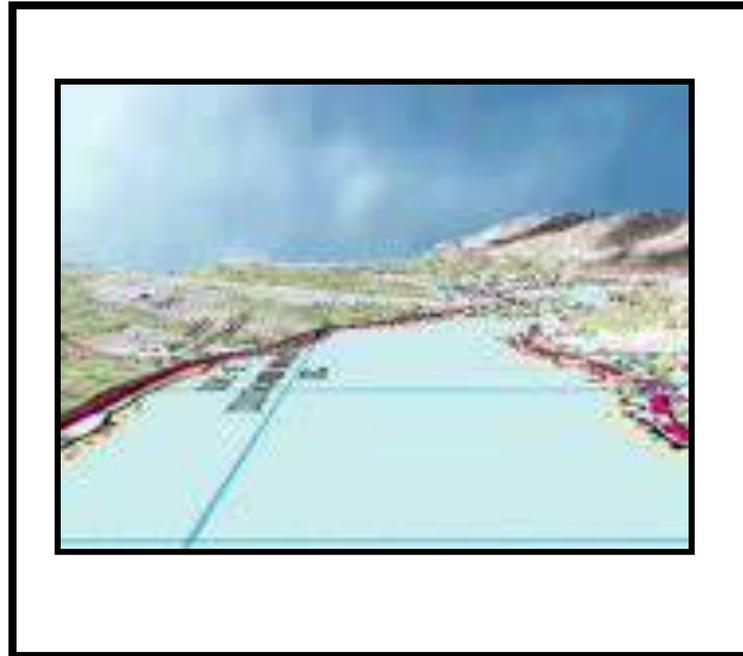
Direction of diagram



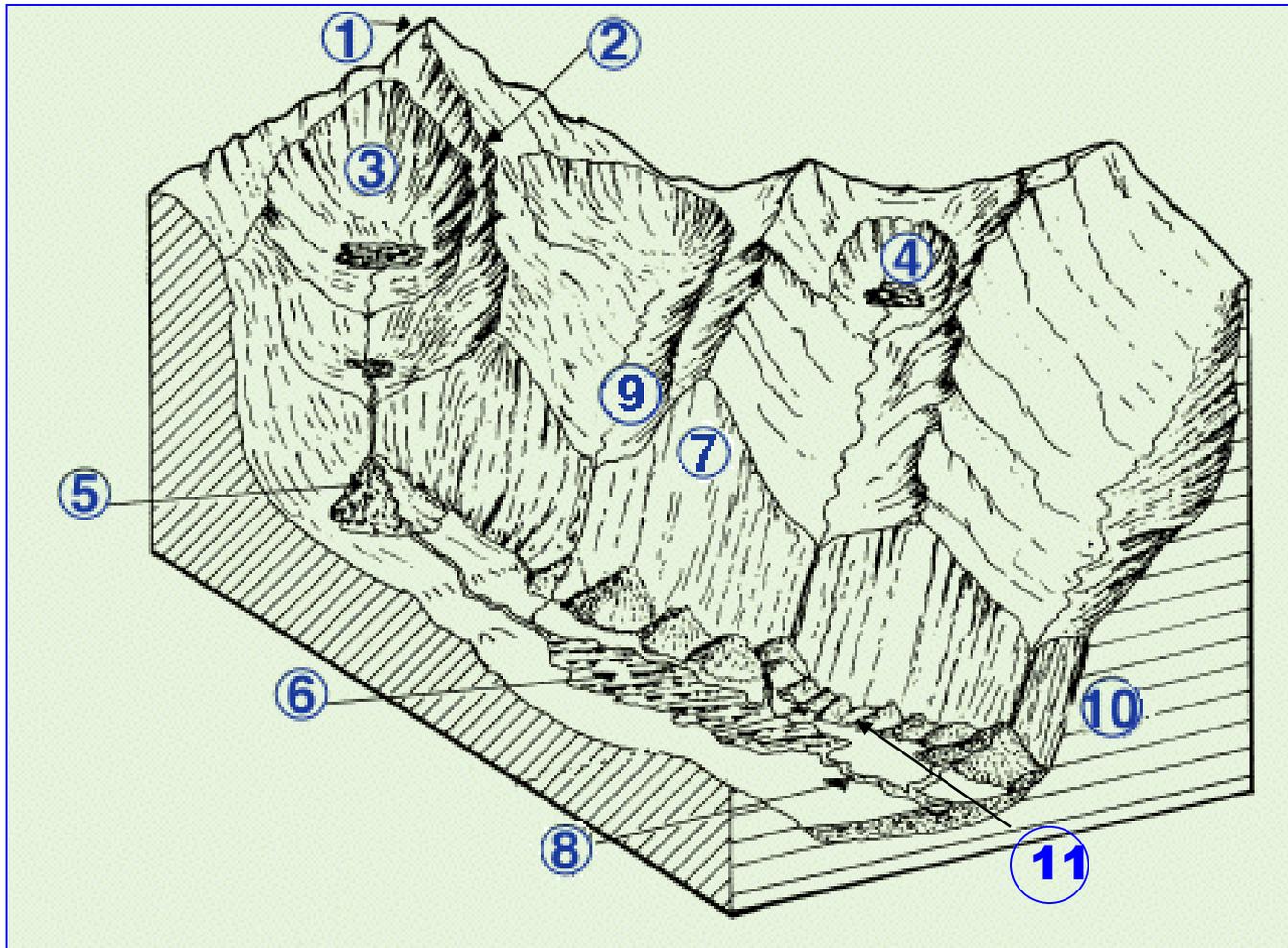
**Always align a map and a diagram before identifying features.**



# ***Ben Nevis***



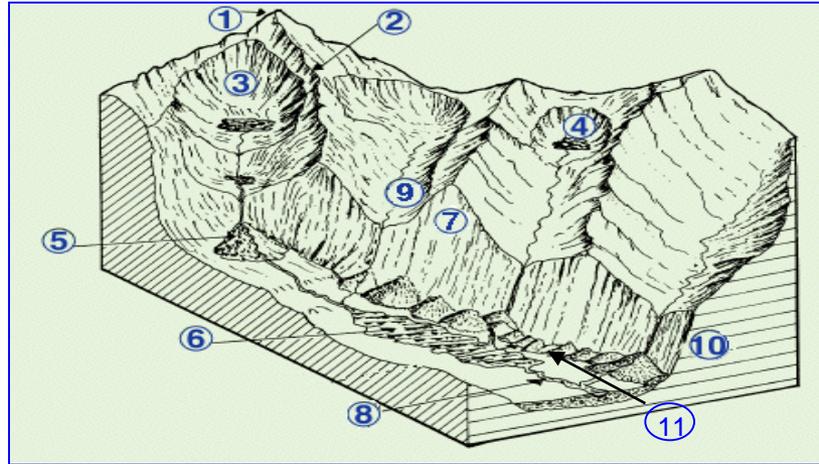
## *landforms of glacial erosion*



Identify the features marked on the diagram by matching them to the names of features listed below.

**Arête; Hanging Valley; Corrie (Cirque); 'U' shaped Valley; Alluvial Fan; Pyramidal Peak; Corrie Lochan (Tarn); Misfit Stream; Ribbon Lake; Truncated Spur; Screes.**

# *landforms of glacial erosion*



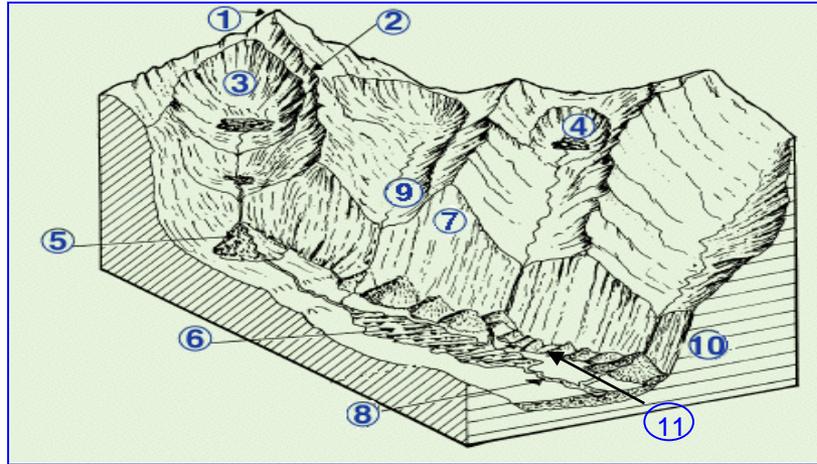
1 is a Pyramidal Peak because it has steep, triangular faces divided by sharp ridges or arêtes.

2 is an Arête, because it is a sharp ridge between corries.

3 is a Corrie or cirque, because it is an armchair shaped hollow with steep back and sides.

4 is a Corrie Lochan or Tarn, because water has gathered in the hollow in the floor of the corrie.

# *landforms of glacial erosion*

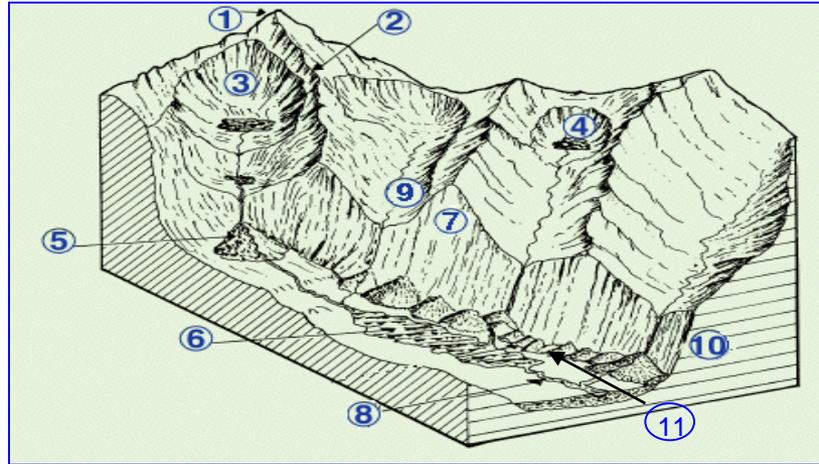


5 is an Alluvial Fan, because it is a fan shaped pile of rock material (alluvium) washed down by the stream.

6 is a Ribbon Lake, because it is a long narrow lake in a part of the valley cut deeper by the glacier.

7 is a Truncated Spur, because the ridge has been cut off sharply by the ice that flowed down the main valley.

# *landforms of glacial erosion*



8 is a Misfit Stream, because it is far too small to have cut the valley.

9 is a Hanging Valley, because the valley floor is much higher than the floor of the main valley.

10 is a 'U' Shaped Valley, because it has steep sides and a nearly flat floor. (The other side of the valley is missing in this cut-away diagram).

11 are Screens which are piles of loose rocks and boulders mainly formed by frost shattering.

# *glacial landforms*

**Landforms of weathering**

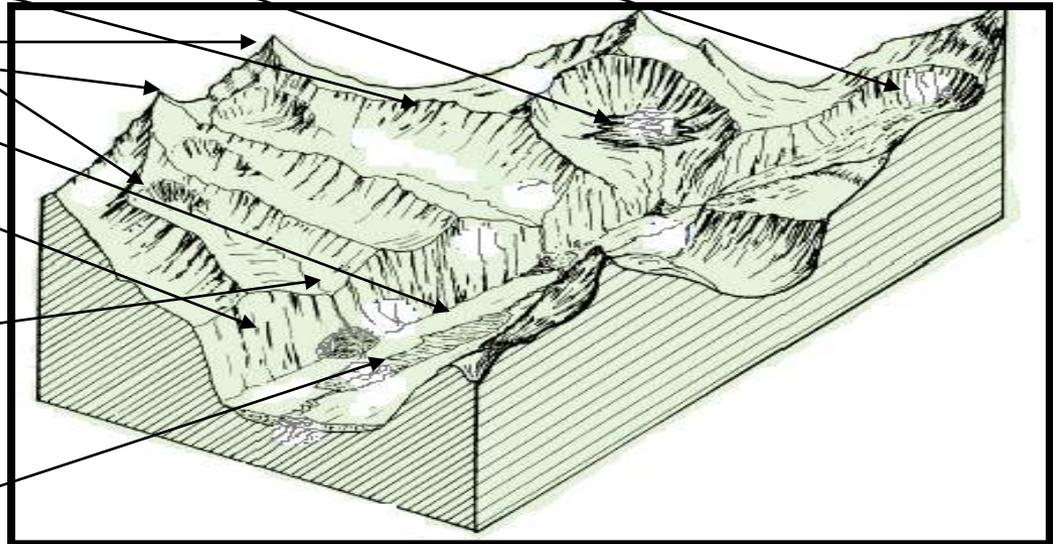
**Landforms of glacial erosion**

**Landforms of glacial deposition**

**Landforms of fluvioglacial deposition**

scree      corrie      crag and tail      moraine      esker  
tarn      erratic      kettle  
arête      drumlin      outwash plain

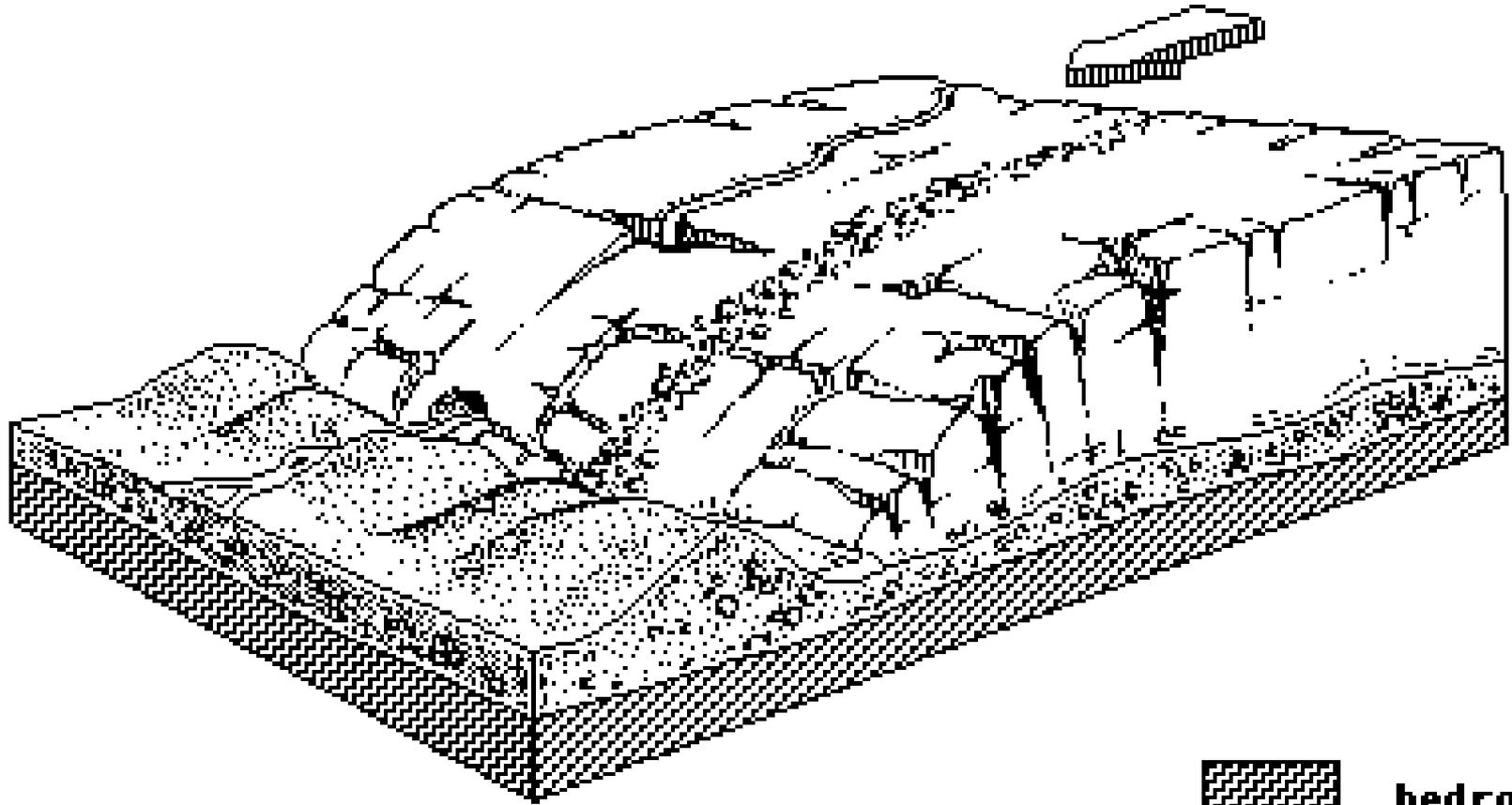
horn  
U-shaped valley  
truncated spur  
hanging valley  
fiord  
ribbon lake



# LANDFORMS of GLACIAL DEPOSITION

a lowland landscape during glaciation

direction of  
ice movement



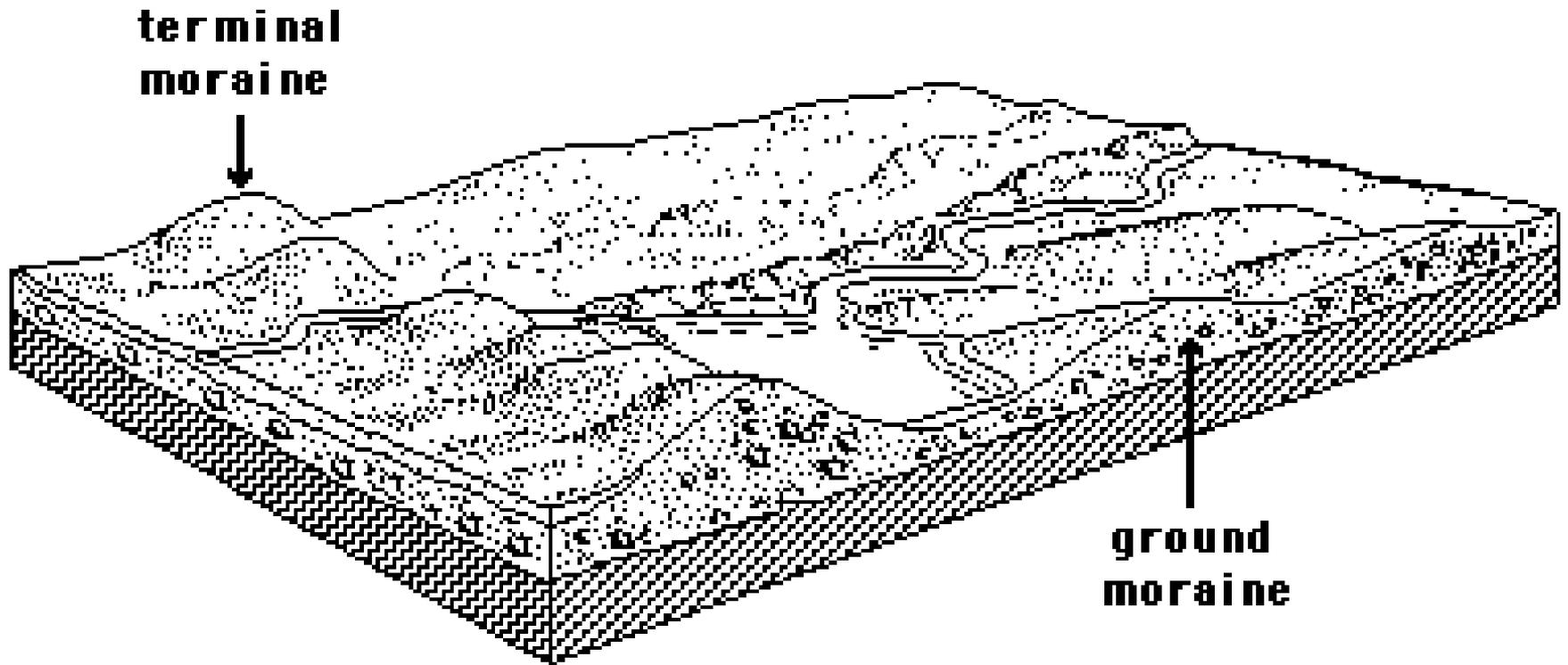
bedrock



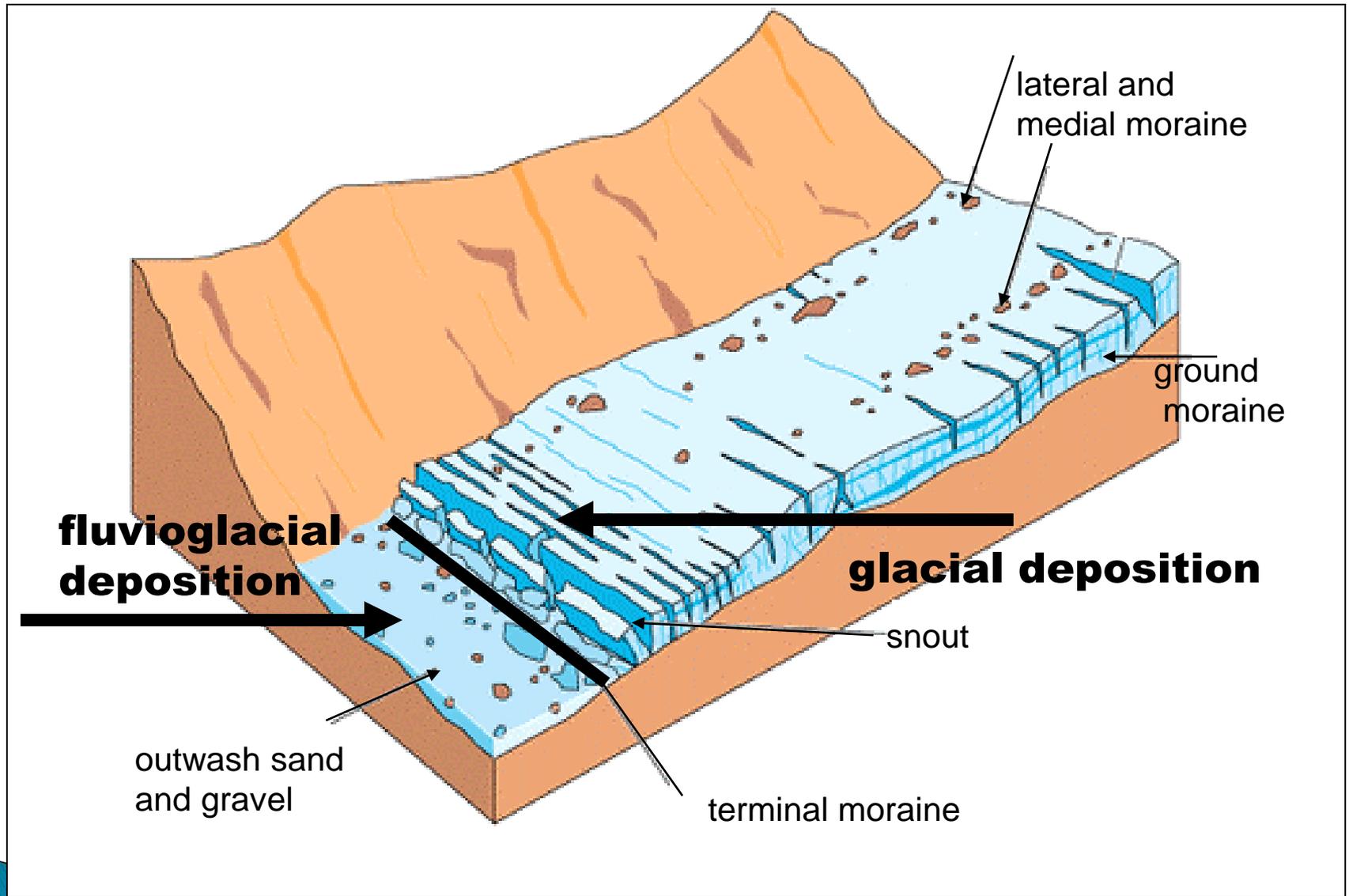
boulders, stones, sand and clays  
carried along or moved, by the ice

# LANDFORMS of GLACIAL DEPOSITION

the same lowland landscape after glaciation



# *glacial deposition*



# ***glacial deposition***

Materials carried by the glaciers are deposited in two main ways;

Glacial Deposits (unsorted) dumped from the melting ice, such as moraines and till. These are jumbled mixtures of broken rock material of many different sizes.

**boulder clay is a glacial deposit**

Fluvo-glacial deposits (sorted) washed out of the ice by meltwaters, such as eskers. These are more rounded and have been sorted by the action of the water, the heavier materials being laid down first.

**outwash sand and gravel is a  
fluvioglacial deposit**

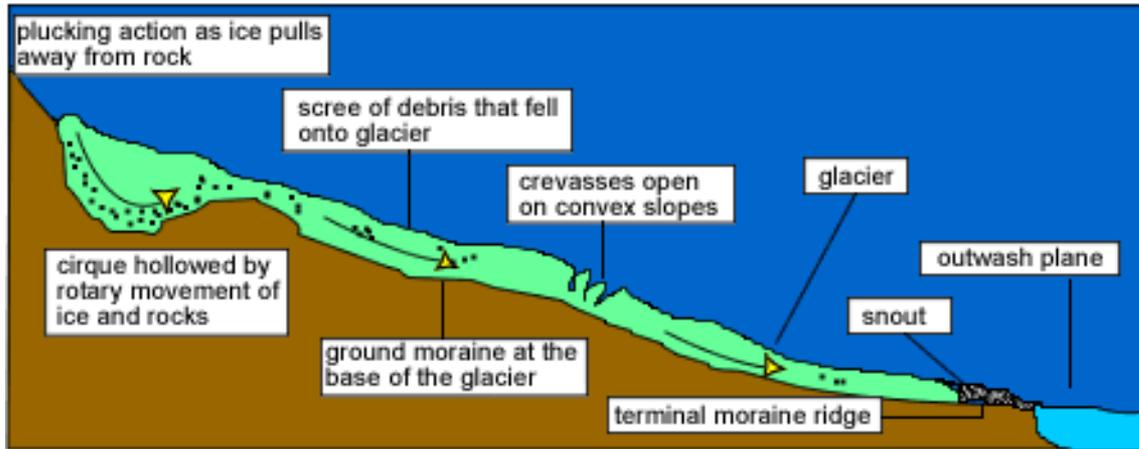
# ***moraine***



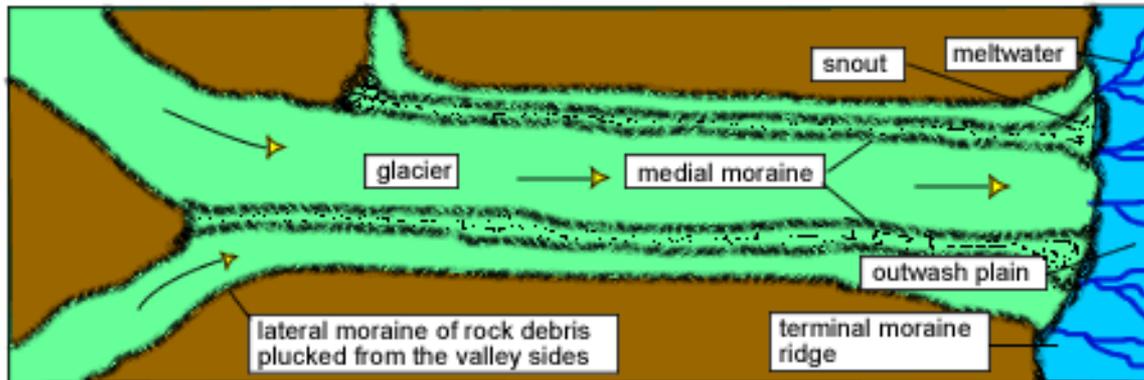
- Moraine is the waste material worn away and collected by the ice
- It is angular in shape
- Glacial deposits are poorly sorted, ie all different sizes and rock types are mixed together.

# ***moraine***

Side View



Plan View



- **Lateral moraine** is found on the sides of the glacier. Scree, from frost shattering, is an important source.

- **Medial moraine** is found down the middle of the glacial surface and occurs when the inner lateral moraines of two glaciers join.

- **Ground moraine** is found at the base (bottom) of the ice. It is also called till or boulder clay.

- **Terminal moraine** is found in front of the snout of the glacier if it is stationary. It represents the maximum advance of the ice.

# ***boulder clay***

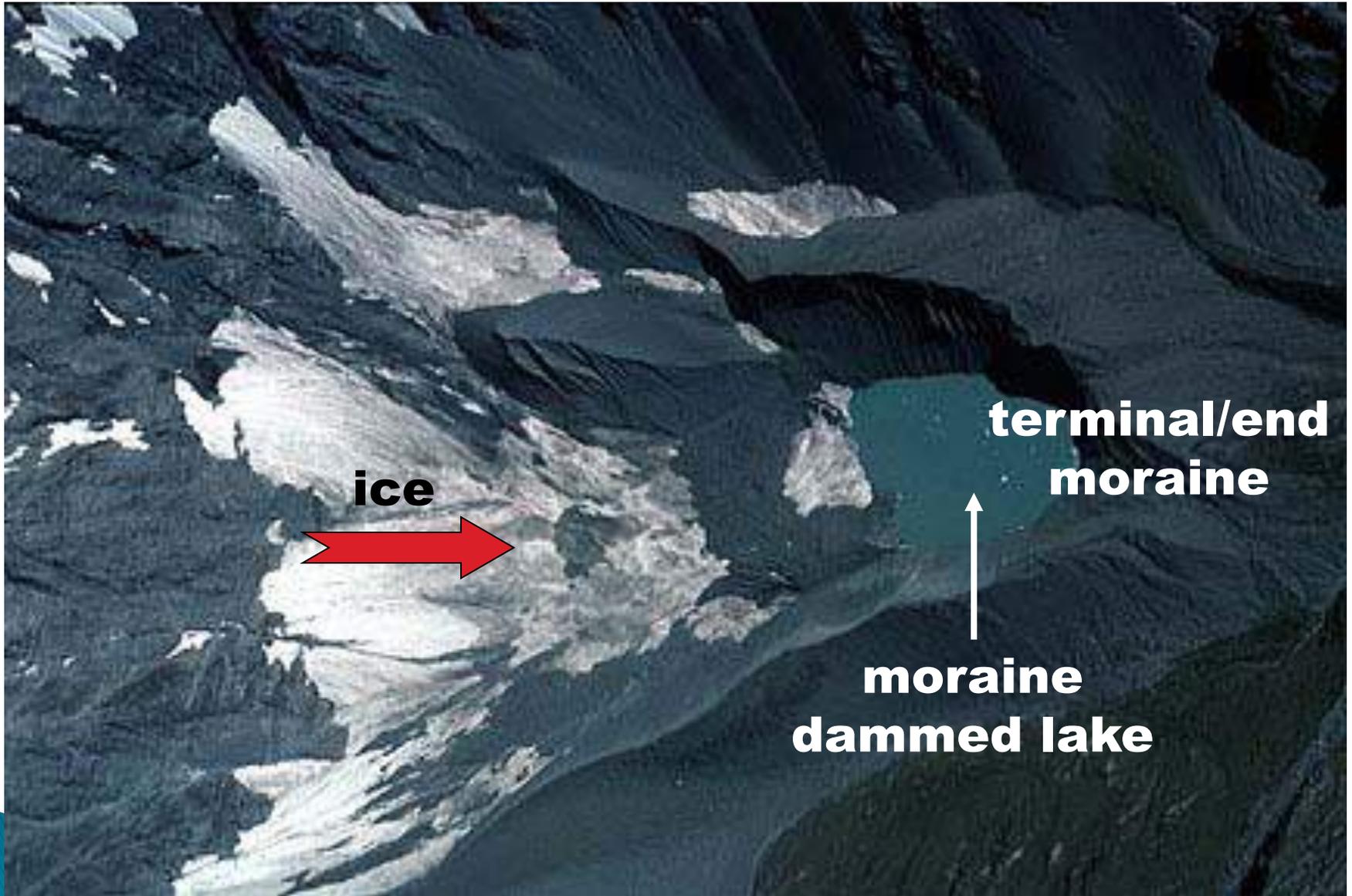


Boulder clay is glacial *moraine* consisting of thick clay with angular rocks. The exact composition will depend on the rocks eroded by the glacier. Boulder clay is sometimes called *till*.

# ***moraine***



# ***moraine***



# ***moraine***



# ***terminal moraine***

The line where the ice-sheets end is marked by a ridge of thick, unsorted glacial deposits. This is called the terminal moraine ridge.



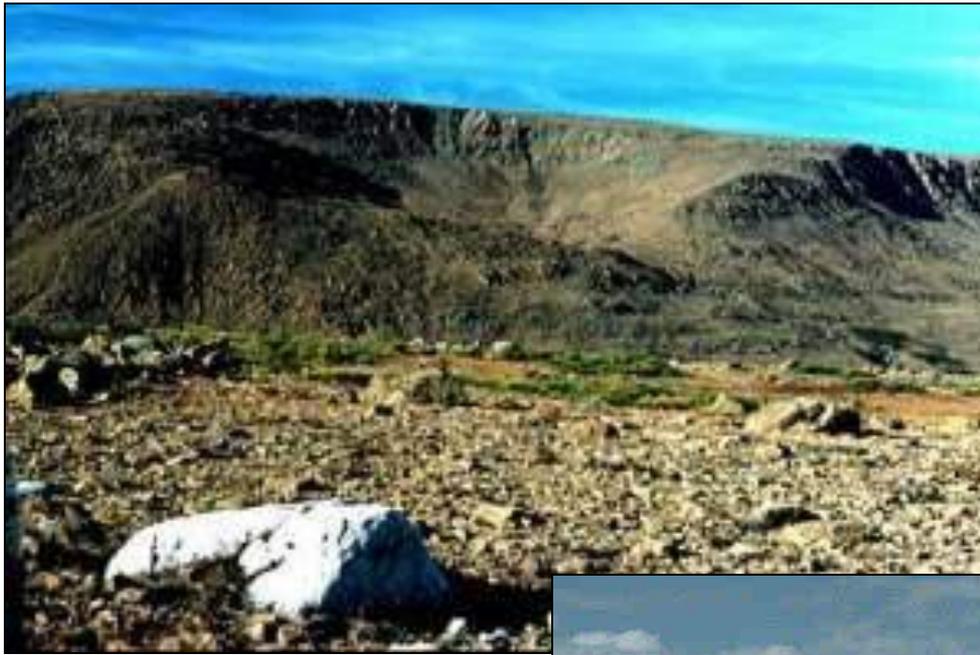
In front of this ridge, the melt water carries fine sand, silt and clay depositing it further on. This forms an outwash plain.

***erratic***

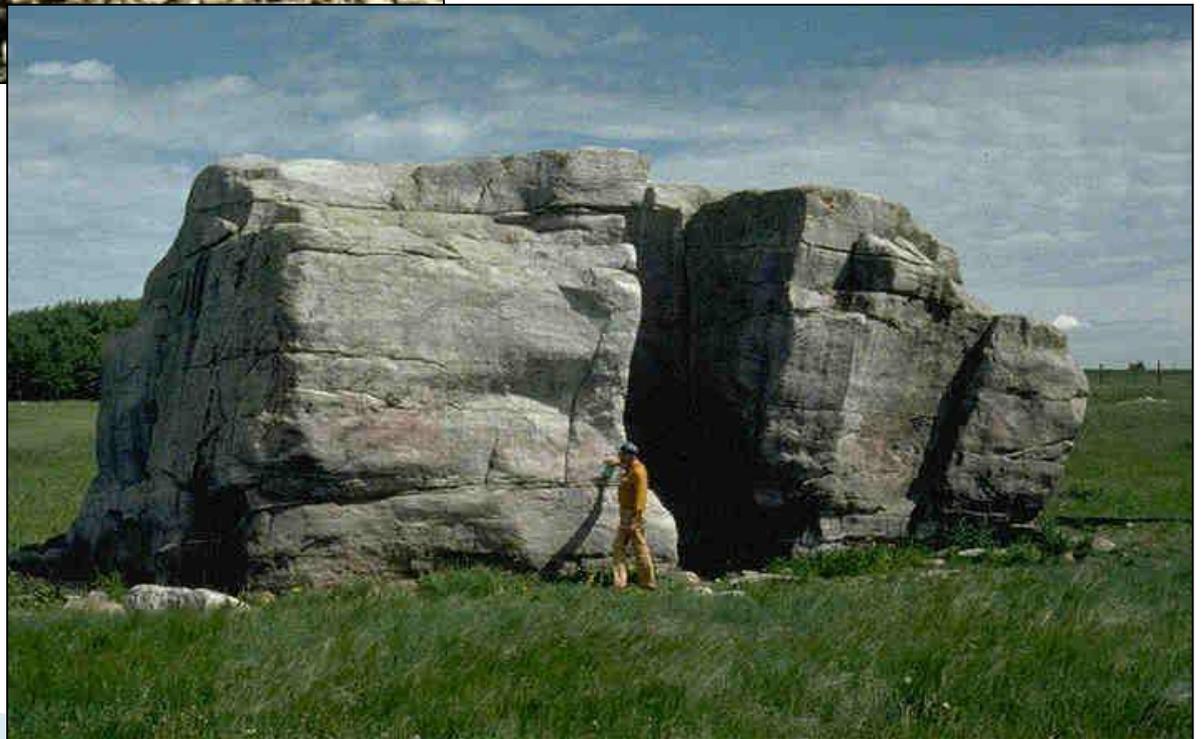


# *erratic*

Erratics are large rocks that are completely different from the type of rocks on which they rest



They were carried by the ice-sheet, sometimes for hundreds of kilometres and then deposited.

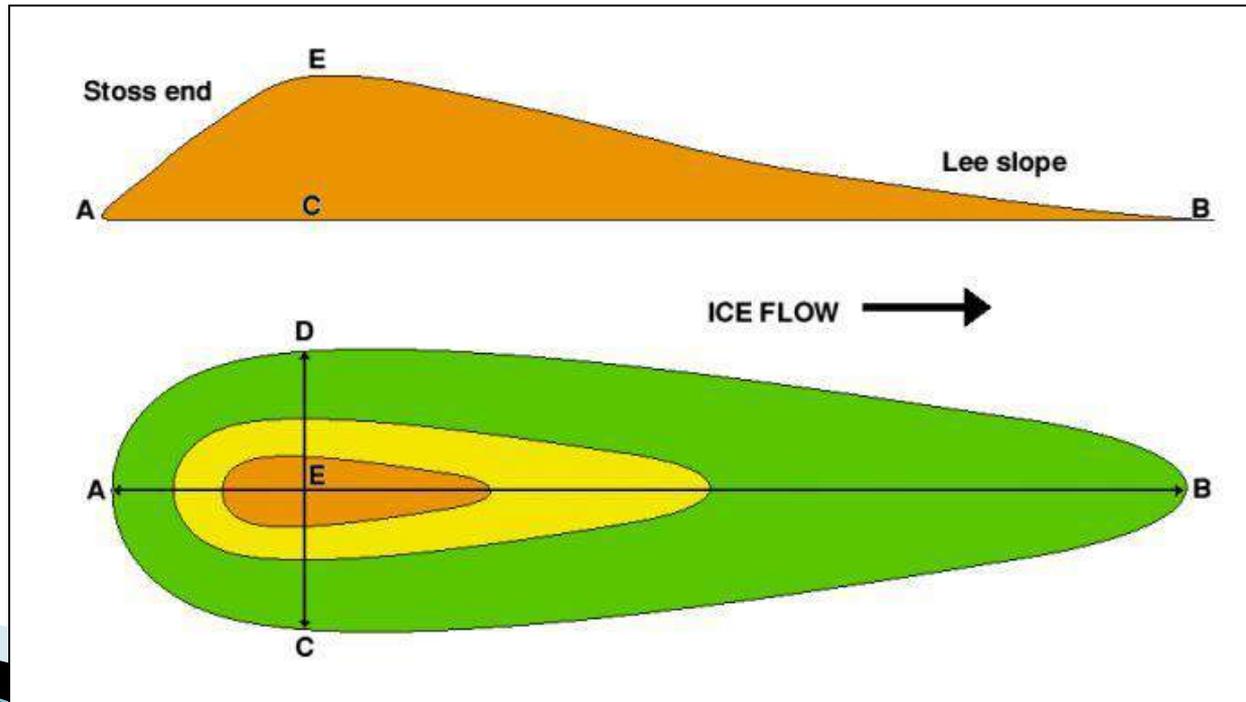




# ***drumlin***

Drumlins are smooth, rounded mounds of ground moraine. The steep side faces the ice movement.

Drumlins often occur in swarms or groups.

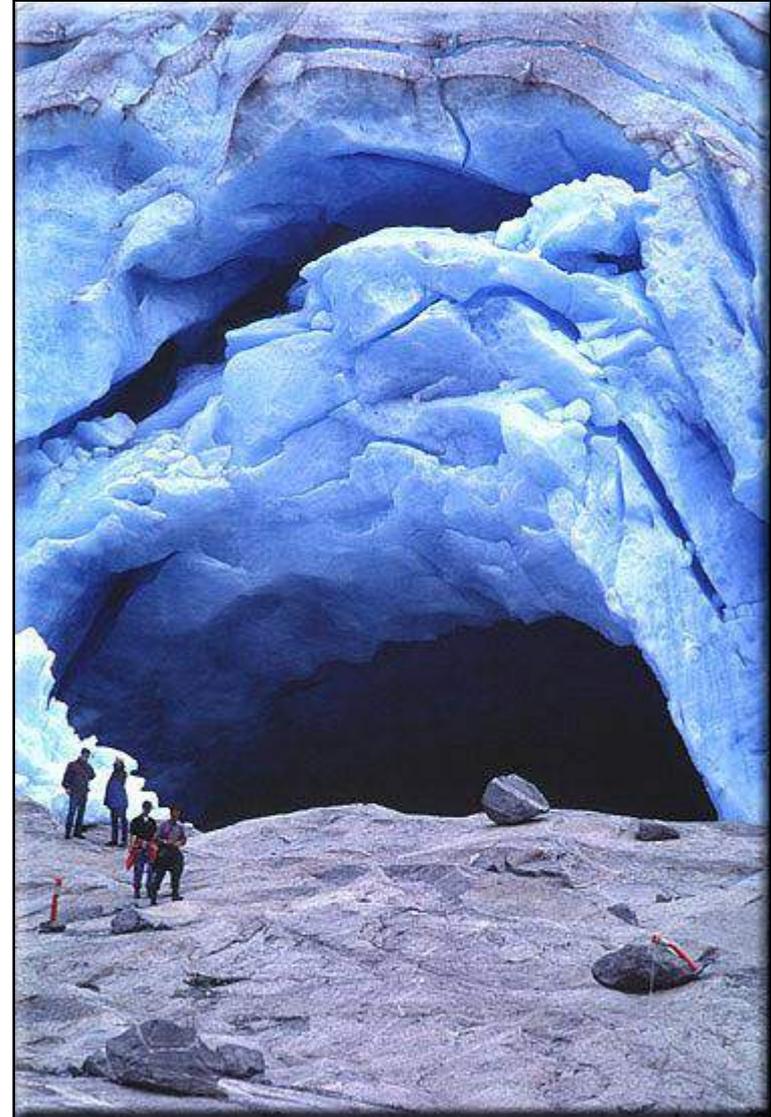
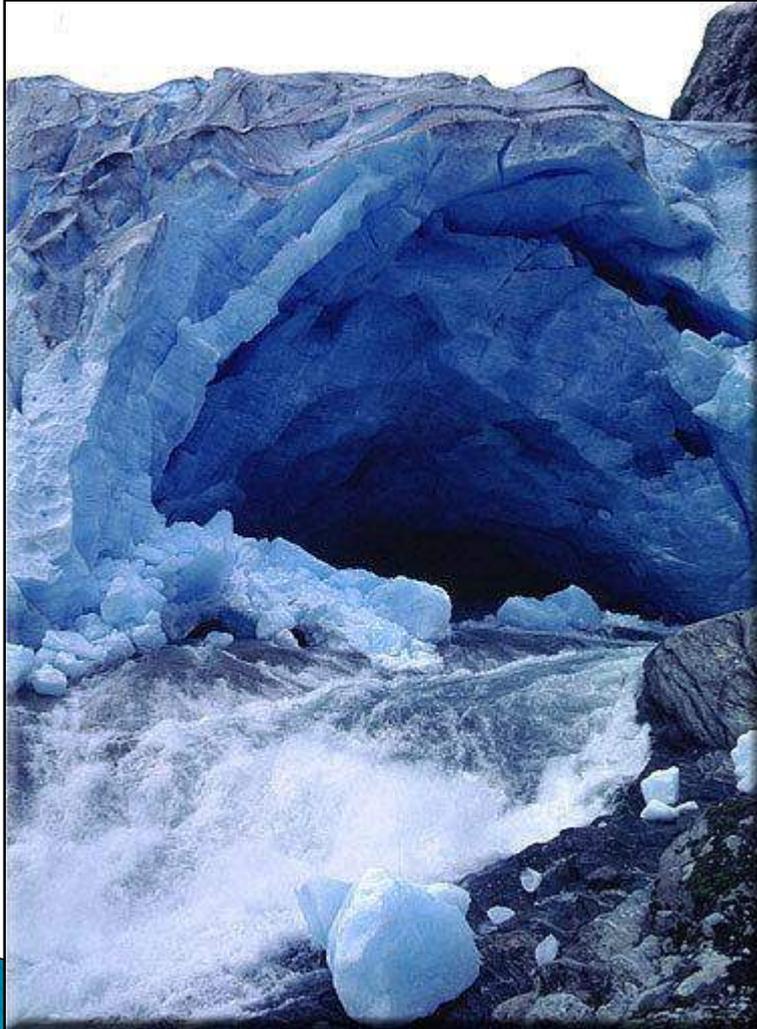


# ***drumlin***



# *esker*

Glacial streams are found under the ice-sheet. They are loaded with debris (sand and gravel) carried by the meltwater. As the ice-sheet retreats, the river deposits its load.



# *esker*

An esker is a steep-sided, long, winding ridge, made up of gravel and sand.



glacier

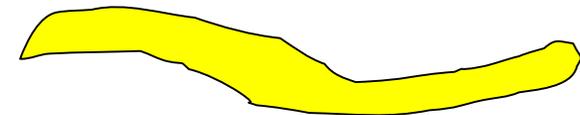


river flowing under ice depositing sand and gravel



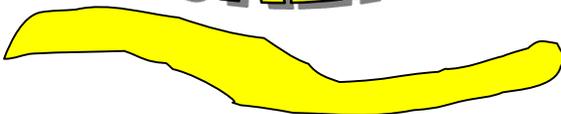


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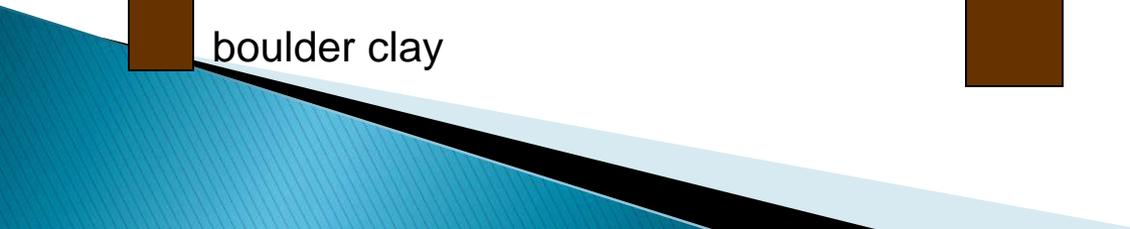
**ESKERS**

**KAMES**



sand and gravel

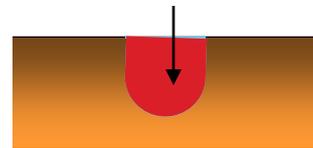
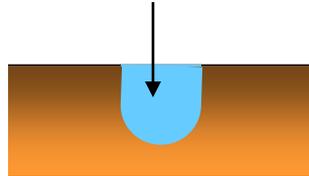
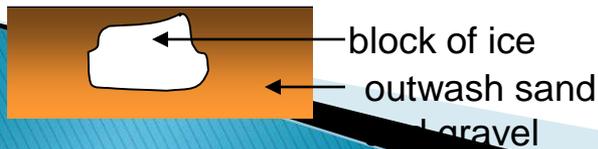
boulder clay



# *kettle*



depression formed when ice melts      depression filled with water to form kettle lake



# *outwash plain*



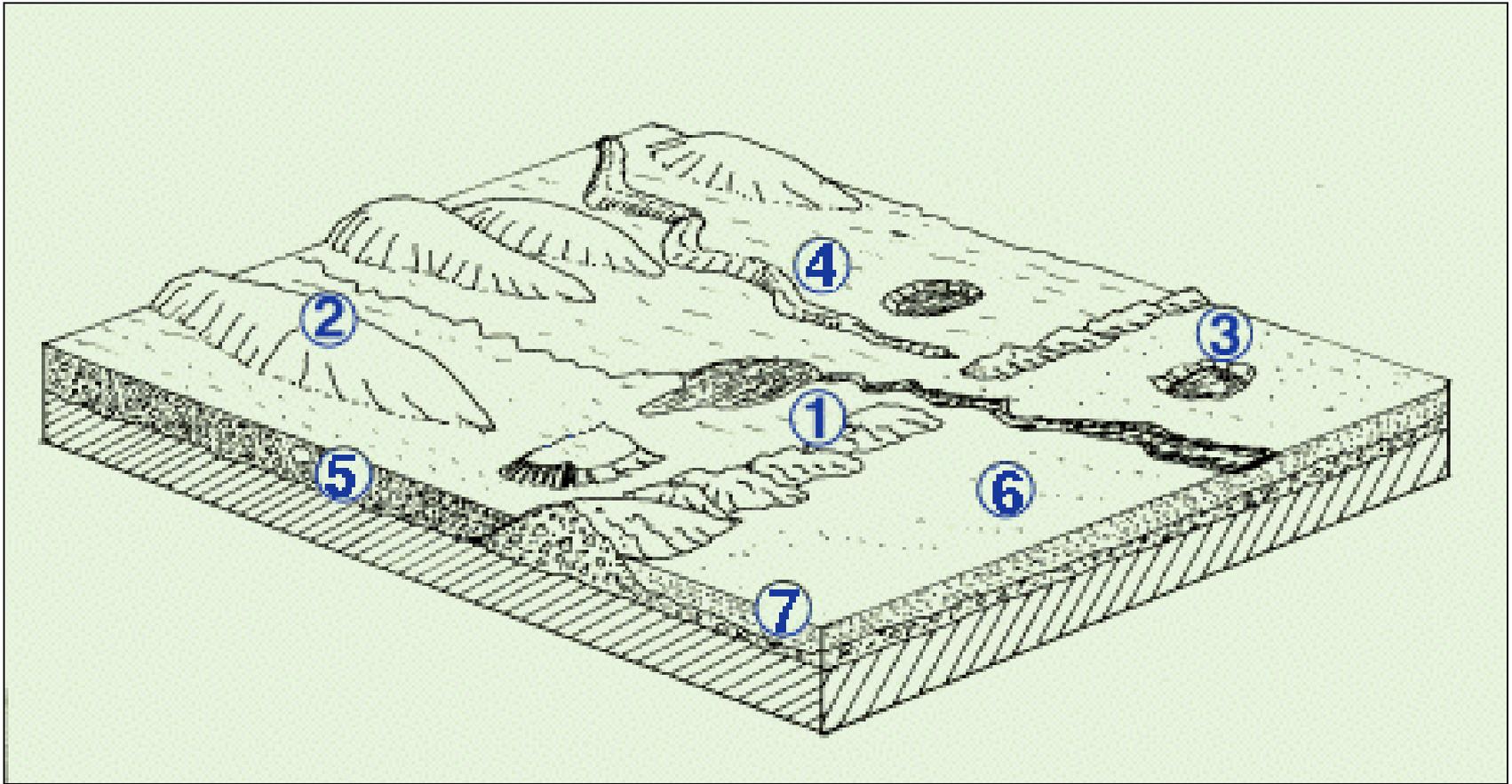
glacier



sorted sands  
and gravels  
spread out  
to form  
outwash plain

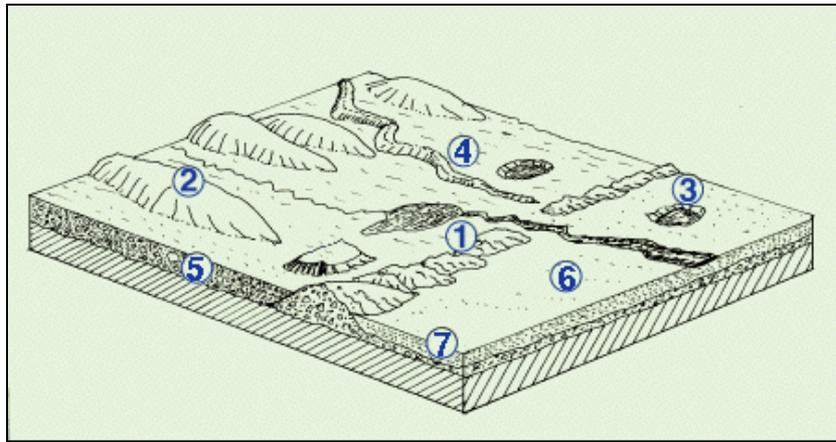


Infertile outwash often  
covered by bog or forest



Identify the features shown on the diagram by matching the numbers to the names given.

**Esker; Terminal Moraine; Till (Ground Moraine/Boulder Clay);  
Outwash Plain; Drumlin; Kettle; Outwash Sands and Gravels.**

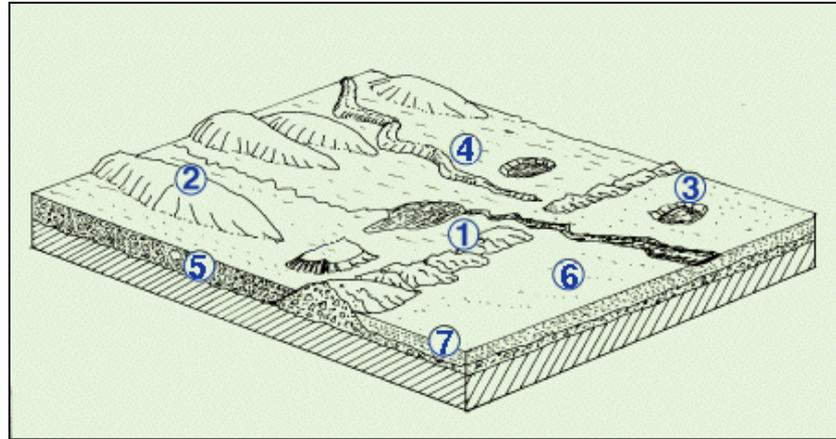


1 is a Terminal Moraine. A hummocky ridge of unsorted stones, boulders and clays dumped by the glacier at the furthest point it reached

2 is a Drumlin. A long, rounded mound of till, moulded under the flowing ice. Its narrower end points in the direction that the ice was moving. They usually occur in groups (swarms)

3 is a Kettle. A water filled hollow left when a block of ice in the till or outwash melted to leave a hollow

4 is an Esker. A long, winding ridge of sands and gravels left by a stream which ran in an ice tunnel under the melting glacier



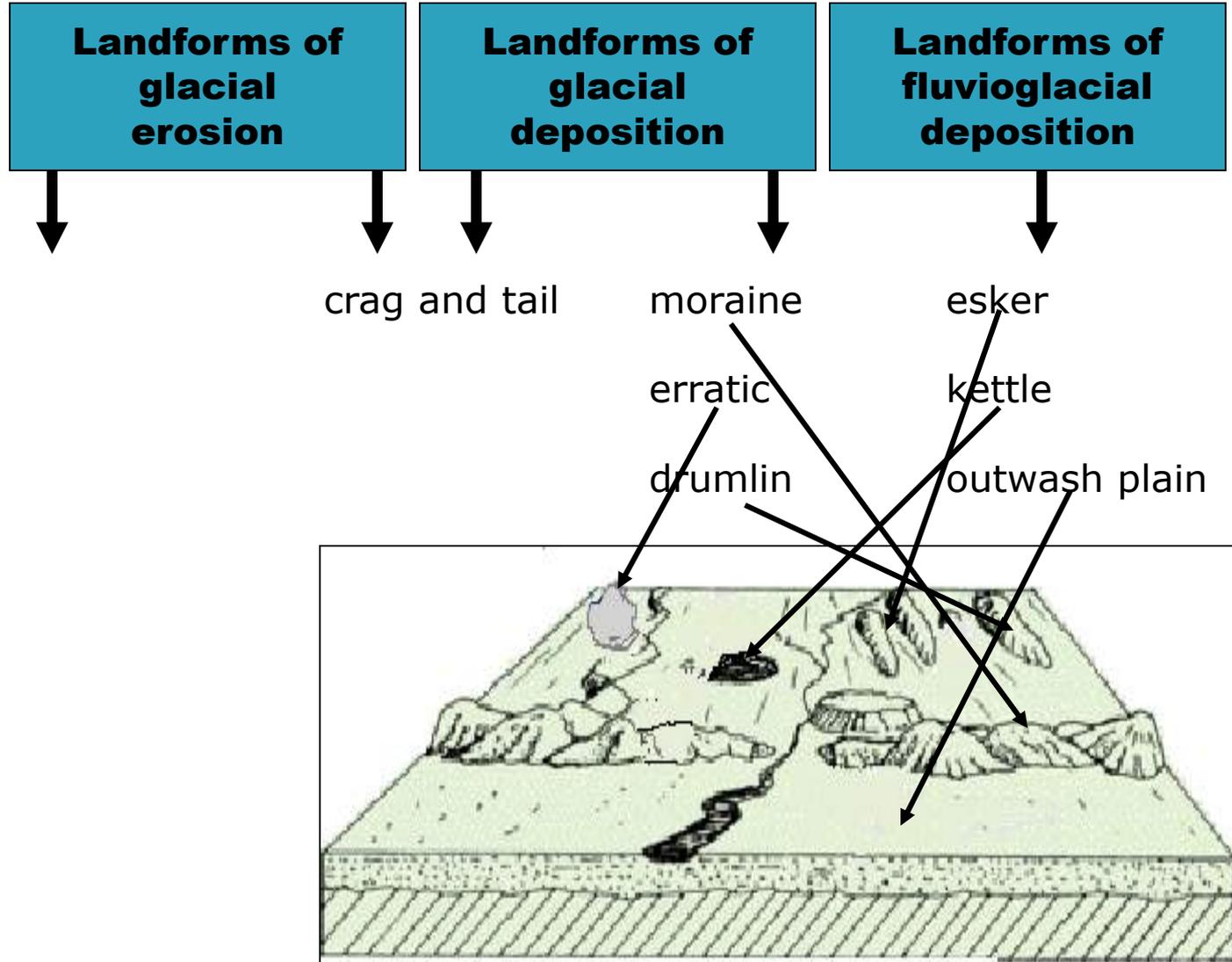
5 is Till (Ground Moraine or Boulder Clay). A mixture of broken rocks and clay plastered over the bedrock under the base of the glacier

6 is an Outwash Plain. A nearly flat expanse of sorted sands and gravels washed out of the glacier and carried beyond the terminal moraine

7 is Outwash sands and gravels. The meltwaters washed these away from the glacier, rounding off angular stones and depositing them in layers.

Glacial  
deposition  
=  
unsorted  
deposits  
=  
boulder clay

fluvioglacial  
deposition  
=  
sorted  
deposits  
=  
sands and  
gravels



|                            |   |
|----------------------------|---|
| <b>Ablation</b>            | melting and evaporation of glacial ice at its snout         |
| <b>Abrasion</b>            | sand-papering effect that smooths and polishes rocks        |
| <b>Alluvial fan</b>        | fan shaped deposit of silt when a river flows on to a plain |
| <b>Alpine glacier</b>      | valley glacier  |
| <b>Arête</b>               | sharp, knife-edged ridge between two corries                |
| <b>Boulder clay</b>        | ground moraine  |
| <b>Cirque</b>              | armchair shaped hollow at the head of a glacial valley      |
| <b>Continental glacier</b> | ice sheet   |
| <b>Corrie</b>              | cirque  |
| <b>Corrie lochan</b>       | tarn  |
| <b>Crag &amp; tail</b>     | steep rock face with a gentle slope of boulder clay         |
| <b>Crevasse</b>            | deep vertical crack formed in ice                           |
| <b>Cwm</b>                 | cirque  |
| <b>Drumlin</b>             | elongated mound of ground moraine                           |

|                               |  |
|-------------------------------|--|
| <b>End moraine</b>            | terminal moraine   |
| <b>Erratic</b>                | rock transported by ice and deposited on a different rock surface  |
| <b>Esker</b>                  | winding ridge of sand and gravel                                   |
| <b>Fiord</b>                  | glacial trough drowned by a rise in sea level                      |
| <b>Firn</b>                   | granular ice   |
| <b>Fluvio-glacial</b>         | formed by meltwater flowing in or off a glacier                    |
| <b>Freeze-thaw</b>            | weathering of rock by expansion of water in cracks when it freezes |
| <b>Frost shattering</b>       | freeze-thaw  |
| <b>Glacial deposition</b>     | sediment left behind when a glacier melts                          |
| <b>Glacial erosion</b>        | wearing away of rocks by abrasion and plucking                     |
| <b>Glacial ice</b>            | ice formed when snow is compressed                                 |
| <b>Glacial transportation</b> | movement of materials by glacial flow                              |
| <b>Glacial trough</b>         | glaciated U-shaped valley with steep sides and a flat bottom       |
| <b>Glacier</b>                | mass of ice which flows by gravity                                 |
| <b>Ground moraine</b>         | material deposited at the base of a glacier                        |

|                        |  |
|------------------------|--|
| <b>Hanging valley</b>  | valley above the level of the main valley often with a waterfall           |
| <b>Headwall</b>        | steep back wall of a cirque  |
| <b>Ice sheet</b>       | mass of ice not limited to a valley  |
| <b>Horn</b>            | pyramidal peak   |
| <b>Kettle</b>          | small shallow lake on an outwash plain formed by blocks of ice melting.    |
| <b>Lateral moraine</b> | moraine deposited along the sides of a valley glacier                      |
| <b>Medial moraine</b>  | moraine formed when two alpine glaciers flow together                      |
| <b>Meltwater</b>       | rivers formed by melting ice   |
| <b>Misfit river</b>    | winding river flowing in a valley it did not form                          |
| <b>Moraine</b>         | angular, unsorted waste material transported by a glacier                  |
| <b>Névé</b>            | firn   |
| <b>Outwash plain</b>   | sorted deposits of sands and gravels spread by meltwater                   |
| <b>Plucking</b>        | erosional process - meltwater freezes into cracks and pulls out loose rock |
| <b>Pyramidal peak</b>  | sharp, pointed peak formed by glacial action                               |

|                         |   |
|-------------------------|---|
| <b>Ribbon lake</b>      | long, narrow lake in a glacial trough                         |
| <b>Scree</b>            | sharp, angular material produced by frost shattering          |
| <b>Sea loch</b>         | fiord   |
| <b>Snowfield</b>        | area of permanent snow found above the snowline               |
| <b>Snout</b>            | end of a glacier  |
| <b>Striations</b>       | scratches on the bedrock made by moraine carried in a glacier |
| <b>Tarn</b>             | small circular lake in a cirque                               |
| <b>Terminal moraine</b> | moraine ridge deposited at the snout of a glacier             |
| <b>Till</b>             | ground moraine  |
| <b>Truncated spur</b>   | interlocking spur that has been cut-off by glacial erosion    |
| <b>U-shaped valley</b>  | glacial trough  |
| <b>Valley glacier</b>   | glacier confined to a valley                                  |