Edexcel A Geography GCSE

Topic 1c - Glaciated Upland Landscapes and Processes

Detailed Notes

Physical Processes in Glaciated Upland Landscapes

There are many different **physical processes** that influence glaciated upland landscapes, including: erosion, transport, deposition, weathering and mass movement.

These physical processes have shaped the UK **landscape in the past**, but some processes continue to **operate on relict (old) glaciated upland landscapes** that we see in the UK.

A glacier on James Ross Island, Antarctica
(Source: /www.antarcticglaciers.org/tag/mass-balance/page/2/)

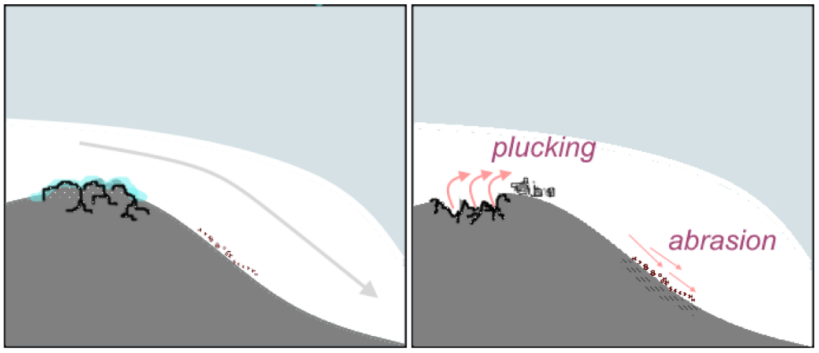
Physical Processes

When **glaciers and ice sheets cover the land**, they cause the erosion, transport and deposition of sediments within the glaciated landscape. These processes affected the upland landscapes of the UK **tens of thousands of years ago** when they were covered in ice.

Glacial Erosion

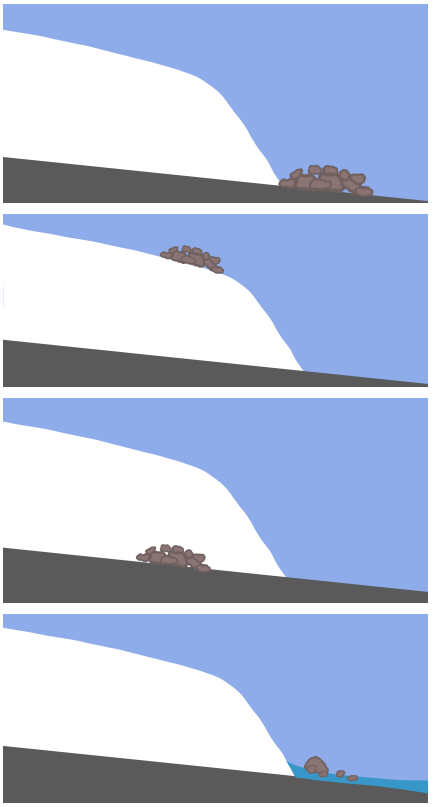
Glacial erosion is the breaking down and removal of rocks and sediment by **natural forces**. In glacial environments, there are two main forms of erosion.

- **Abrasion**
  - A **sandpapering** effect caused by small rocks embedded within the glacier rubbing on bedrock.
  - Abrasion usually leaves a smooth surface with scratches called **striations**.
- **Plucking**
  - **Meltwater** from glaciers freeze around broken or cracked parts of rock, breaking it off from the **bedrock or sides** as the ice moves down the slope.
  - Plucking is most prominent when there are many **joints** in the rock, as water can penetrate the rock and freeze in the cracks.



Transport

Sediments can be transported **within the ice**, **on top of the ice** or **around the ice**.



- Sediments such as rocks, boulders and debris are pushed along by the end of the glacier (**snout**) as ice flows from upland to lowland areas.
- Sediments broken off the sides of the valley or the back wall as a result of weathering processes such as **freeze thaw weathering** are transported **on top of the glacier**.
- Rocks embedded within the glacier as a result of **plucking** are transported **within** the glacier
- Sediments are transported away from the glacier by **meltwater** flowing from the snout. These sediments are usually deposited on the **outwash plain.**

Deposition

Glaciers and ice sheets deposit material when they melt or stop moving. The material deposited by a glacier is known as **glacial till**, or **moraine**.

When a glacier melts, there is a lot of **water** released from the glacier, creating streams, rivers and lakes that influence deposition. Rivers of **meltwater** flow out of the melting glacier, carrying and depositing lots of glacial sediments around the glacial landscape. This meltwater is known as **glacial outwash**.

Moraine in Greenland.

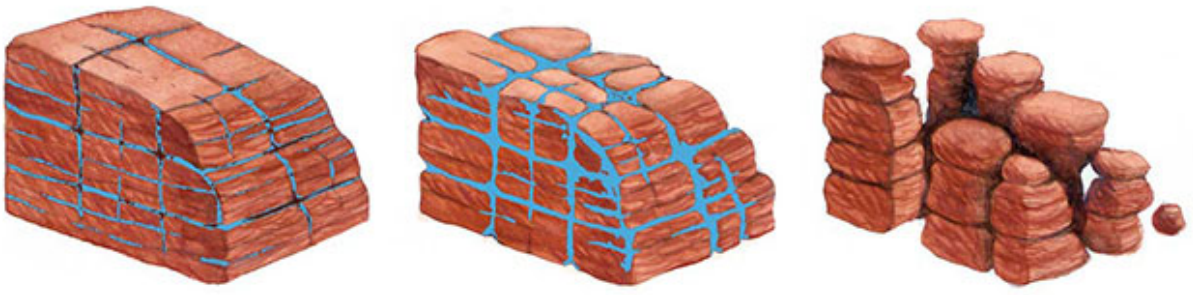
(Source: https://www.grida.no/resources/3584)

Physical Processes Operating on Relict Upland Glacial Landscapes

Glaciations affected many regions of the world during the last **ice age**. Upland landscapes that have been shaped by glaciers are still under influence from different **physical processes**:

Mechanical (Physical) Weathering: the breakdown of rocks due to exertion of **physical forces** without any chemical changes taking place.

- One example of mechanical weathering is **freeze-thaw** weathering, which occurs on rock surfaces above the surface of the ice in glaciated areas
    - **Rainwater** or **meltwater** enters the cracks in the bedrock above the glacier
    - As the temperature falls, the **water freezes and expands**, **widening cracks** in the rock. As the temperature rises, it **melts and contracts**. This process repeats, causing parts of the rock to break off



(Source: https://www.bgs.ac.uk/discovering-geology/geological-processes/weathering/)

- Freeze-thaw weathering in upland areas can result in the formation of **scree slopes** (large piles of rock covering the slope in upland areas) as shown below.

(Source:www.swisseduc.ch/glaciers/new_zealand/hooker_terrestrial/index-en.html?id=10)

Mass Movement

Mass movement is the **downhill** movement of sediment under gravity. It is influenced by:

- the **angle** of the slope/cliff
- the rock/soil type (**lithology**), including its weight and ability to flow downhill
- the **saturation** of the ground from previous rain or flooding

In **glaciated upland landscapes**, mass movement usually occurs through **soil movement** or **rock falls**/**slides**.

- **Soil Movement**
  The mass movement of soil occurs when soil becomes **waterlogged** (full of water), causing it to **flow downhill** due to gravity.

  This process, known as **solifluction**, is common in glaciated landscapes as frozen soils (known as permafrost) can thaw during summer.

Solifluction. (Source: /www.sciencedirect.com)

Soils may also move due to **frost creep**. Water underneath soil particles freezes and expands, pushing the particle **upwards**. Then when the ice **melts**, the soil moves back down, but because it's on a slope it **falls downhill**.

- **Rock falls/slides**
  On very steep slopes, rocks can become loose and eventually break off due **freeze-thaw weathering**.

  These can displace **large amounts of heavy material** and can therefore be very dangerous.

Rock fall (source: www.geostru.eu/rockfall-analysis/)

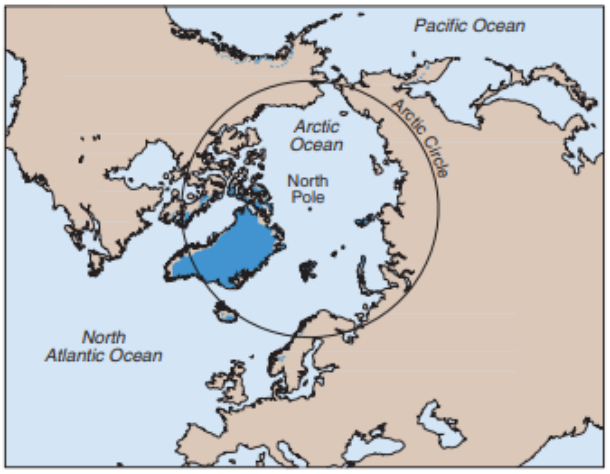
On rock slopes that are less steep, large areas may fracture and **slide** down the slope. Rockslides usually occur on **faults** within the rock slope, which can be affected by physical weathering.

Rockslide (source: blogs.agu.org/landslideblog)

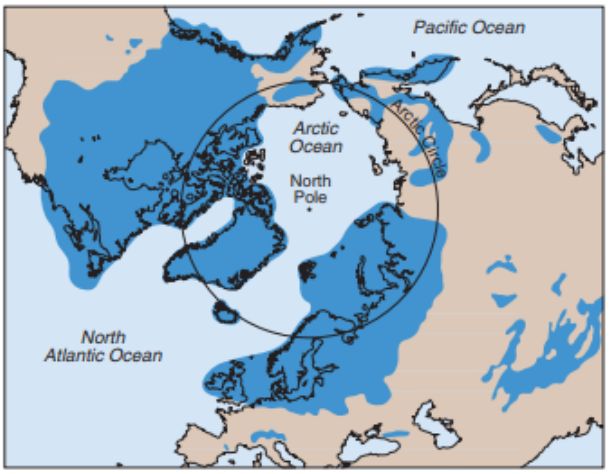
Past Climate

The Earth has experienced many periods in which temperatures were **much colder** than they are currently. The most recent period of glacial advance (**Last Glacial Maximum**) was around **21,000 years ago**, where a much larger area of the northern hemisphere was completely covered by ice, including the majority of the UK.

Present distribution of ice sheets.



Last glacial maximum distribution of ice sheets.



Source: http://www.open.edu/openlearn/ocw/pluginfile.php/614637/mod_resource/content/1/e500_11_sci_sk1_05t.pdf

This climate meant that glaciers and ice sheets affected the UK's **upland landscapes** through glacial **erosion**, **transport** and **deposition**.

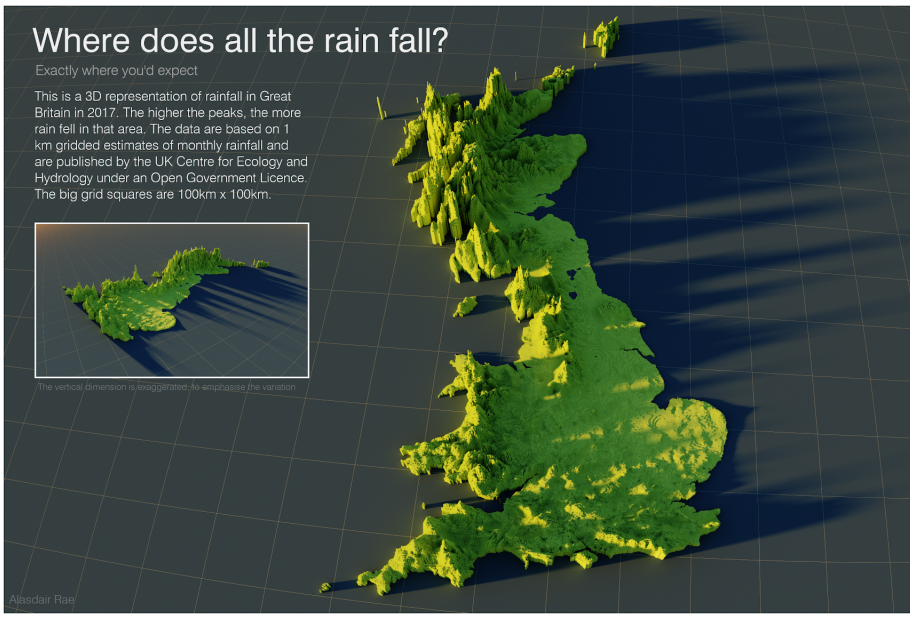
This interactive timeline outlines global temperature trends since the last **glacial maximum**.
(www.iflscience.com/environment/this-temperature-timeline-of-earth-shows-exactly-how-nonsensical-climatechange-deniers-really-are/)

Current UK Weather and Climate

The UK has a **temperate** climate:

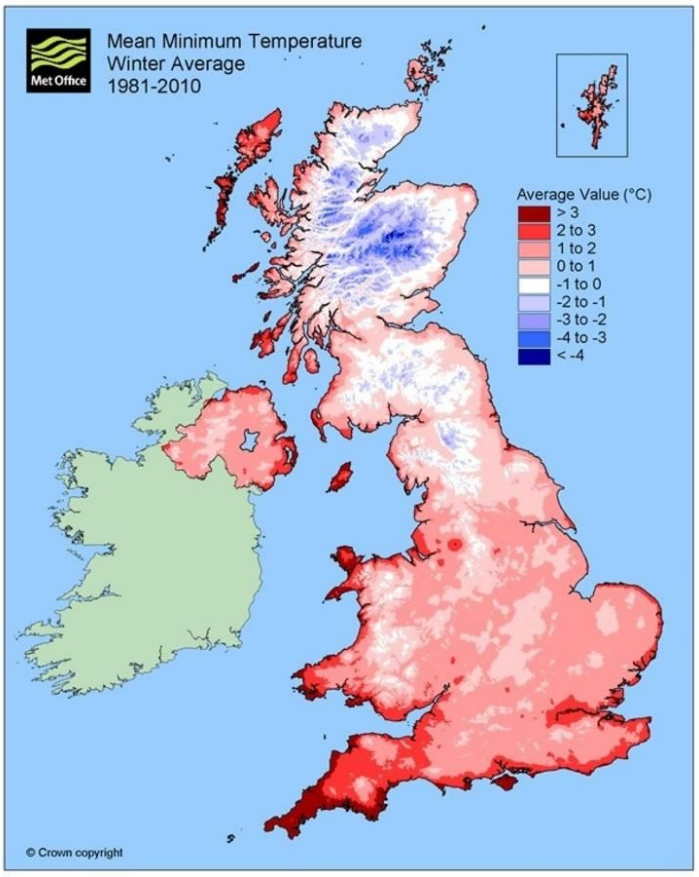
- A **temperate** climate experiences **warm summers** and cold, **wetter winters.**
- Temperatures can reach below freezing in winter. Colder temperatures in winter means the landscapes experience **freeze-thaw weathering**. In upland landscapes with steep slopes, this can trigger **rockfalls** and **rockslides**.
- Continuous rainfall in winter can trigger **mass movement events** such as **solifluction** or **landslides** in environments with steep slopes.
- The UK also frequently experiences **storms** in winter, bringing **heavy rain and high winds**. This means the UK can experience flooding events, which impact landscapes (e.g. enhanced river erosion).

The map below shows **average rainfall levels in Britain**. The areas with **high peaks** are areas that receive more rainfall. Notice high rainfall in the **uplands**, such as the Scottish Highlands, the Lake District, the Pennines, and parts of Wales (Cambrian Mountains).



(Source: http://www.statsmapsnpix.com/2020/08/rain-shadow-maps.html)

Below is a map that shows the average **lowest temperature in winter** throughout the UK. Hopefully you can spot similar trends to rainfall, where uplands experience colder temperatures, leaving them vulnerable to physical weathering like **freeze-thaw** for much of the winter.



Glacial Erosional Landforms

Erosional processes operating on glaciated uplands can create distinct **landforms** in these landscapes.

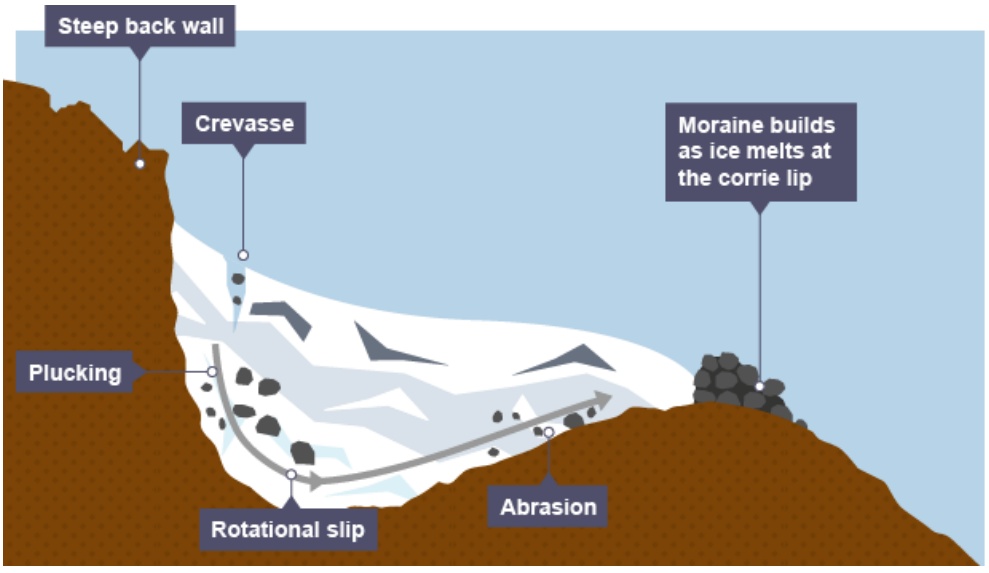
Corries

A corrie is an **armchair-shaped hollow**, located on the side of a mountain where a glacier forms.

Corries form by the following process:

- Snow falls and builds up in a **sheltered hollow** on the side of a mountain.
- The snow is eventually **compressed into ice**, forming a glacier.
- The back wall of the hollow becomes steeper due to **plucking** and **freeze-thaw weathering**.
- The weight of the glacier pushes it downhill, but it becomes trapped within the hollow, meaning the only way it can move is in a **circular motion** known as **rotational slip**.
- The base of the hollow is eroded by rotational **abrasion**, making it deeper.
- A **corrie lip** is formed at the front of the glacier due to deposition and less erosion.
- A **glacial lake** is formed in the hollow if the glacier melts, called a **tarn**.

(Source:www.living-art.org.uk)



(Source: https://www.bbc.co.uk/bitesize/guides/zy9ncwx/revision/2)

Arêtes

An arête is a narrow, **knife-edged ridge** formed between two corries (when the two steep back walls meet).

The image to the right shows **Striding Edge** in the Lake District. Notice the two hollows either side of the arête, and the **tarn** located to the left.

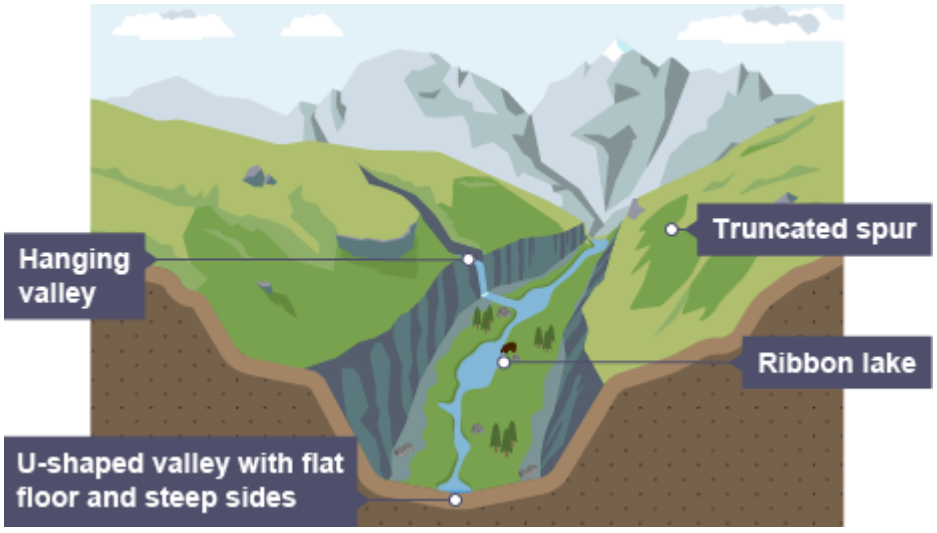
(Source:where2walk.co.uk/lake_district/classic_circuits/helvellyn-by-the-edges)

Glacial Troughs and Truncated Spurs

A glacial trough is a **u-shaped valley** formed by a glacier **bulldozing** and eroding through a river (v-shaped) valley. The glacier has enough force to erode away a river's **interlocking spurs**. This leaves smooth but steep **truncated spurs** on the valley sides and a wide, flat valley floor.

Glacial troughs are formed by the following process:

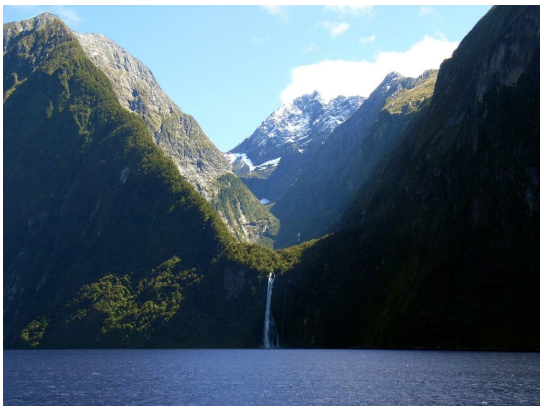
- **Interlocking spurs** (shown on the right) are eroded by the glacier through processes of **abrasion** and **plucking** at the spurs' bases, eventually forming a **truncated spur**.
- A glacier moves down a valley due to gravity.
- The glacier alters the shape of the **v-shaped valley** by eroding the valley sides through processes of **plucking** and **abrasion**.
- This creates a steep sided, wider valley in a 'U' shape, known as a **glacial trough** or **U-shaped valley**.



(Source: https://www.bbc.co.uk/bitesize/guides/zy9ncwx/revision/2)

Hanging Valleys

- There are both **main glaciers** and smaller **tributary glaciers** within glacial valleys.
- **Main glaciers** are **deeper, wider** and have a greater mass than **tributary glaciers**, meaning the main valley can be eroded more than the tributary valley/
- In tributary valleys, the glacier does not have enough **energy** to erode all the way to the valley floor.
- This results in the tributary glacier left hanging above the main valley.

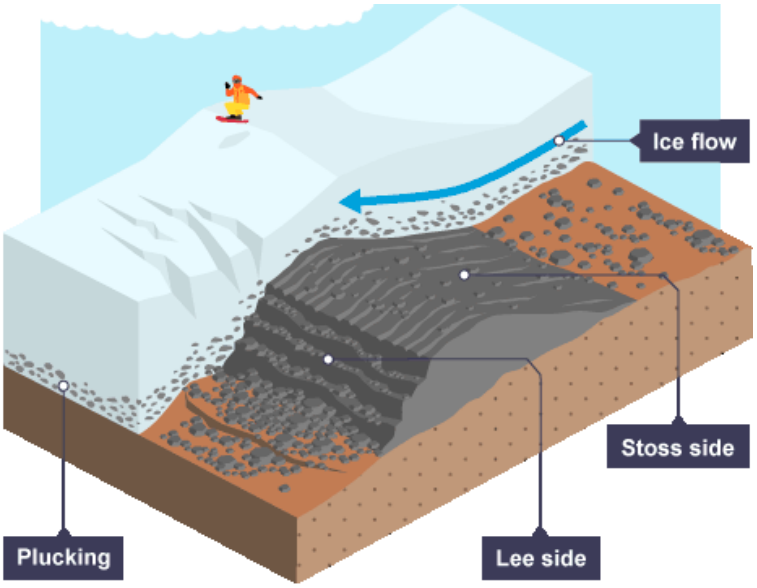


(Source: quizlet.com/gb/356089580/hanging-valley-diagram/)

Roche Moutonnées

A **roche moutonnée** is a **mass of resistant rock** which has a **smooth**, rounded up **(stoss)** slope facing against the direction of the ice flow and a steep, **jagged** face on the far **(lee)** side.

- As a glacier encounters a mass of rock, **pressure** builds up and causes **melting** of the glacier to occur, resulting in **basal sliding**.
- Rocks embedded within the ice **erode** the **bedrock** (by **abrasion**) on the up slope (which may form **striations** in the rock).
- On the far side, **water refreezes** as the **pressure falls**, and **plucking** occurs, leaving a steeper sided more jagged slope.



(Source: https://www.bbc.co.uk/bitesize/guides/zg36wxs/revision/4)

Glacial Depositional Landforms

Glaciers deposit sediment when they **melt** or **lose energy**, which can create distinct depositional landforms.

Ground Moraines

Ground moraine is material carried **under the glacier** that is **abraded** between the glacier and valley floor. It can be **deposited** when a glacier melts or when obstacles on the ground cause the material to build up.

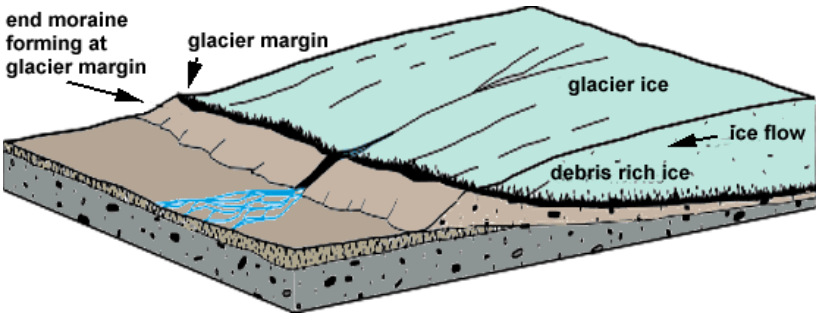
The material is eroded into smoother, smaller sediments via abrasion.

(Source: https://en.wikipedia.org/wiki/Moraine)

Terminal Moraine

Terminal moraine is formed when material being pushed at the **snout** of the glacier is deposited when the glacier stops moving.

Terminal moraine looks like a **large ridge of material** at the end of the glacier.

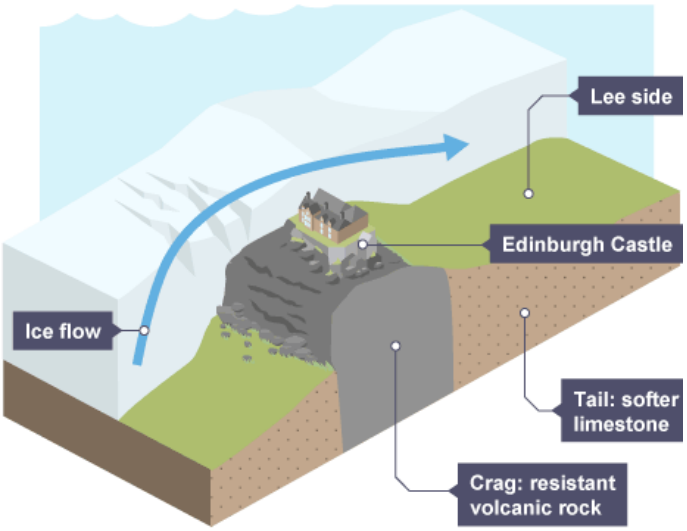


(Source:isgs.illinois.edu/outreach/geology-resources/end-moraines-end-glacial-ride)

Erosional and Depositional Landforms

Crag and Tail

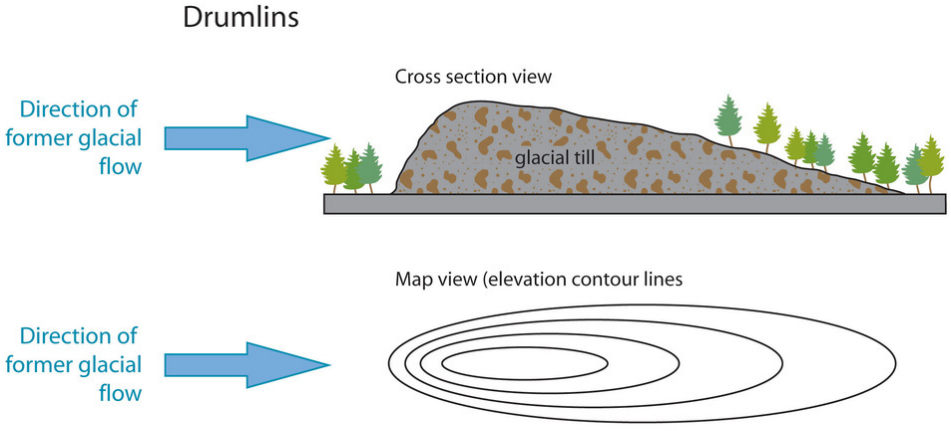
- A **large mass of resistant rock** on the **upslope (stoss) side** and a **gently sloping tail** on the **far (lee) side** made of **less resistant rock**.
- A glacier passes over an area of hard rock and softer rock.
- The stoss side is eroded by **plucking** and **abrasion**, creating a **steep sided, cracked** surface of resistant rock **(crag)**.
- **Moraines** are then **deposited** on the **far side (tail)**, giving it a gentler gradient.
- Edinburgh Castle was built on a crag and tail as shown in the diagram.



(Source: www.bbc.co.uk/bitesize/guides/zg36wxs/revision/4)

Drumlins

- **Drumlins** are **elongated hills** made up of material **deposited** by glaciers.
- Formed when glacial ice is moving forward and melting simultaneously.
- **Boulder clay** and **till** is **deposited** when the glacier encounters an **obstacle**.
- Most deposition occurs on the **stoss (blunt) end** of the drumlin, whilst the **lee slope (tapered end)** is shaped by **erosion** from the glacier as material is dragged down the slope by the moving ice.



(Source: https://surroundingtownsgeologytour.weebly.com/drumlin-hill-farms.html)

Impacts of Human Activity on Glaciated Upland Landscapes

Farming

Glaciated upland areas are frequently used for animal grazing in the UK, which has affected the glaciated upland landscape and the processes that act on it:

- **Farming** has shaped the landscapes in upland areas.
- **Deforestation** to create farmland has left land **unprotected from wind and rain**, which has resulted in increased **rates of erosion**. This can lead to **unstable slopes**, which makes **mass movement** more likely.
- **Overgrazing** and **trampling by livestock** leads to **soil erosion** and instability. This can disrupt wildlife, pollute water sources, and also cause **mass movement**.

Sheep grazing in the Lake District.

Forestry

For hundreds of years, UK woodlands in upland landscapes have been deforested to provide for the **timber industry**. Many places have now been **reforested** using fast-growing, non-native **coniferous trees** to protect areas with poor soil quality.

- Forests can help to bind the soil, which can stabilise slopes, reduce **water runoff** and lead to less **soil erosion** and **less mass movement**.
- Forests can change the **ecosystems** in upland landscapes, especially if they are non-native species like **coniferous trees**.

Conifer plantations in upland landscapes.

Settlement

Many upland landscapes in the UK have been shaped by **settlements**. Settlements in glaciated upland areas usually **displace vegetation and wildlife**, and can pollute areas. **Impermeable surfaces** around settlements alter **water runoff**, which may cause **erosion** and **mass movement**.

Development in Glaciated Upland Landscapes

Water Storage and Supply

In many areas of the world, glaciers provide **the majority of freshwater** to downstream communities. When glaciers **partially melt in summer**, meltwater is used for **drinking water, agriculture, and hygiene** among other things.

Dams can be constructed in **glacial valleys** to **store meltwater** so it is available throughout the year.

A glacial lake in a glaciated upland region.

Advantages	Disadvantages
Provides a **drinking water** supply for the region. **Dam construction** can improve access to water as supplies are less **seasonal** and are always available. Water supplies can support **agriculture**, improving **food supplies** as well as **employment opportunities**. Creates local **employment opportunities** through fish farming, construction, maintenance etc. Can generate renewable **HEP (hydroelectric power)** for locals and the country as a whole. **Improved access to water** supports overall **socioeconomic development** in a region.	Dams can be considered **visually unappealing**. Building of dams **disrupts** the **hydrological cycle** and involves the **flooding** of land, which can displace local communities. Damage to upland **habitats and ecosystems**. The **unpredictable nature** of glaciers means **large flooding events are common**. Dams can **fail** under these events which is dangerous. Climate change and rapid melting of glaciers makes this form of water supply **unpredictable** and **not dependable** in the long term in many regions. Building **dams** is very **expensive**.

Renewable Energy

Rivers flow down the steep slopes of glacial upland landscapes, carrying large amounts of **glacial meltwater** and **seasonal rainwater**. This flowing water carries a lot of **energy**, which can be **harnessed** and converted into **electric power**. **Hydroelectric power stations** (seen below) need to be built in order to harness this energy and supply it throughout the region.

(Source: /www.orfonline.org/research/hydropower-in-the-himalayas-the-economics-that-are-often-ignored/)

Advantages	Disadvantages
Improves **access to energy** in surrounding regions, which helps with **development** (especially in less developed areas that already struggle to supply energy). Renewable energy use can **reduce reliance on fossil fuels,** helping tackle **global warming**. Job creation in the region, including **construction**, **maintenance**, and **employees at the hydroelectric power station**. Hydroelectric power developments can **encourage infrastructural developments** in upland regions that would otherwise be **inaccessible**, e.g. roads, telecommunications, bridges.	Climate scientists predict that **global warming** will lead to **melting of glaciers in upland landscapes** as well as **reduced rainfall** in some regions. With **less meltwater and rainwater,** hydroelectric power stations will be **ineffective** because **river flow will be significantly reduced**. Building **hydroelectric power stations** is very expensive and requires **maintenance**. Poor understanding of river geomorphology can cause issues in rivers upstream and downstream of HEP stations, such as **drying out**. **Ecological damage** and disruption to **wildlife** in the area where the station is built.

Tourism and Recreation

The landscapes of glaciated upland areas attract many **tourists and locals** to embrace the scenery, wildlife, and take part in activities. This can bring **benefits** to the area and the local community, but can also create many **issues**.

Tourists struggle for parking in the Lake District, a glaciated upland landscape.

Advantages	Disadvantages
The high demand for forms of recreation in these areas (such as hiking, mountain biking etc.) provide **job opportunities** for locals in the **tourism industry**. **Local businesses** such as accommodations and shops benefit from tourists. This can bring **money into the area**, which can support locals. Money into the area can support conservation efforts etc. **Ecotourism** is becoming more popular, where tourists visit an area in order to **help conservation efforts**.	Tourists may cause **pollution** (e.g. from vehicles). Upland landscapes can be very fragile, so pollution can create issues. Developments for recreational activities increase **urbanisation** and **construction**, displacing wildlife and interfering with the ecosystem. Recreational activity may result in **environmental damage**. Locals often feel that tourism causes many issues, and conflicts can arise. For example, **tourists can leave field gates open** or **not keep their dogs on leads** which can put livestock at risk.

Conservation

Upland landscapes are **threatened by both natural processes** (e.g. erosion) and **human-induced processes** (climate change, environmental damage). Conservation efforts work to reduce these threats and protect the natural environment.

Fixing footpath erosion to conserve the area.

(Source:https://www.lakedistrict.gov.uk/caringfor/projects/fixthefells)

Advantages	Disadvantages
Successful conservation efforts means that generations to come can **experience the environment, culture and heritage** of a glaciated upland landscape. Conserving the environments can help **protect important past sites for scientific interest,** especially in glacial landscapes which are studied intensively as they show the **past environmental conditions**. Conservation efforts can provide **jobs for local people**.	Conservation can be **expensive** and require **lots of materials**. This may not be economically viable when **climate change** is continuing rapidly and conservation efforts would need to start again after future environmental degradation. Locals may disagree with conservation efforts, which can cause **conflict**. Many **glaciated upland landscapes** are difficult to access as they are **geographically isolated** (i.e. up hills, hard to reach). This can make conservation efforts difficult and sometimes **dangerous**.