Cold Environments: Upland Glaciation Background Information
FSC Rhyd-y-creuau Field Centre

Ice in Wales

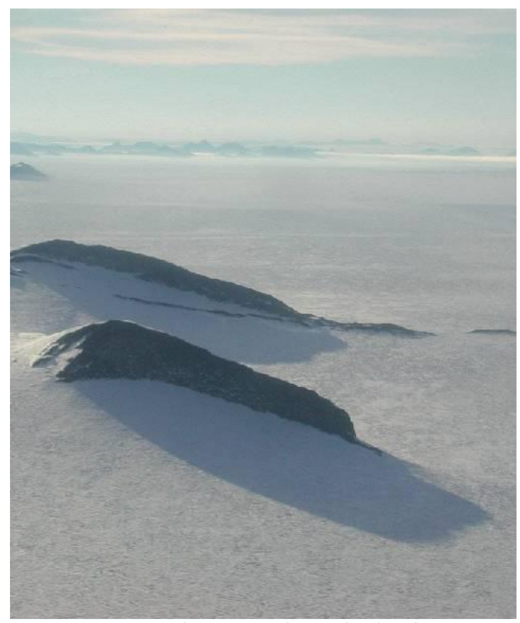
The Glacial landforms seen in the British Isles today are the product of glacial events throughout the Quarternary Period. Global temperatures began to fall 2.4 million years B.P. (Before Present). The British Isles had significant cold periods from around 2 million years ago until around 10,000 years ago when the warmer Holocene epoch began. Throughout the Quarternary there have been other short warmer events known as interglacials (when glaciers have retreated) and long glacials (when glaciers have advanced. Ongoing research is leading to revisions of the known timescale as evidence of yet undiscovered glacial events come to light (Richards, 2005).

Quarternary Period (based on Bowen, 1999)

Epoch	Approx start date (years B.P.)	Glacials	Interglacials
Holocene	10,000		
Late Pleistocene	80,000 125,000	Devensian (the cold period at the end of this, about 18,000 B.P. is sometimes called the Dimlington) Wolstonian*	Trafalgar Square (formally known as the Ipswichian)
Middle Pleistocene	300,000 500,000	?* ?* Anglian Beestonian	Hoxnian Strensham Purfleet Swanscombe Cromerian
Lower Pleistocene	2 million		

** the original framework (by Michell et al, 1973) has been much debated particularly with regards the glacial events between newly identified interglacials.*

During each glacial the furthest extent of the ice was different. In the Anglian period, most of the British Isles were covered by an enormous ice sheet which reached as far south as a line across England from the Severn Estuary in the west stretching to the Thames Estuary in the East. During the more recent Devensian ice reached its furthest extent around 20,000 years ago with ice sheets across most of Wales and the Midlands finishing in East Anglia. At this point North Wales would have been affected by an ice cap. One theory is that this would have been centred over Migneint Moor and glaciers flowed out along pre-existing river valleys. It has been suggested that in some places the ice grew so thick that it overflowed mountain passes and cut through watersheds creating diffluent troughs (Addison, 1997). More recently it has been argued that these features could have been created by ice originating more locally in the mountainous area around the Glyders and not from ice travelling through from the Mignient Moor area to the South West (McCarroll, 2005). North Wales would have looked similar to the Antarctic today; a sea of ice with only the highest mountain peaks exposed as nunataks.



Antarctica today, not a dissimilar landscape to North Wales 18,000 B.P.

Valley glacier in the Vanoise Swiss Alps. The smaller corrie glaciers are perched high above, similar to Nant Ffrancon 15,000 B.P.)

This was followed by a period of warming, and with rising temperatures the ice sheet melted. The Ogwen area of North Snowdonia would have had valley glaciers fed by smaller corrie glaciers. Gradually the snouts of these glaciers retreated back up the valley sides until only small corrie glaciers were left. We would have last had these conditions during the Loch Lomond re-advance, approximately 12,000 B.P. These too then would have disappeared as temperatures continued to rise.

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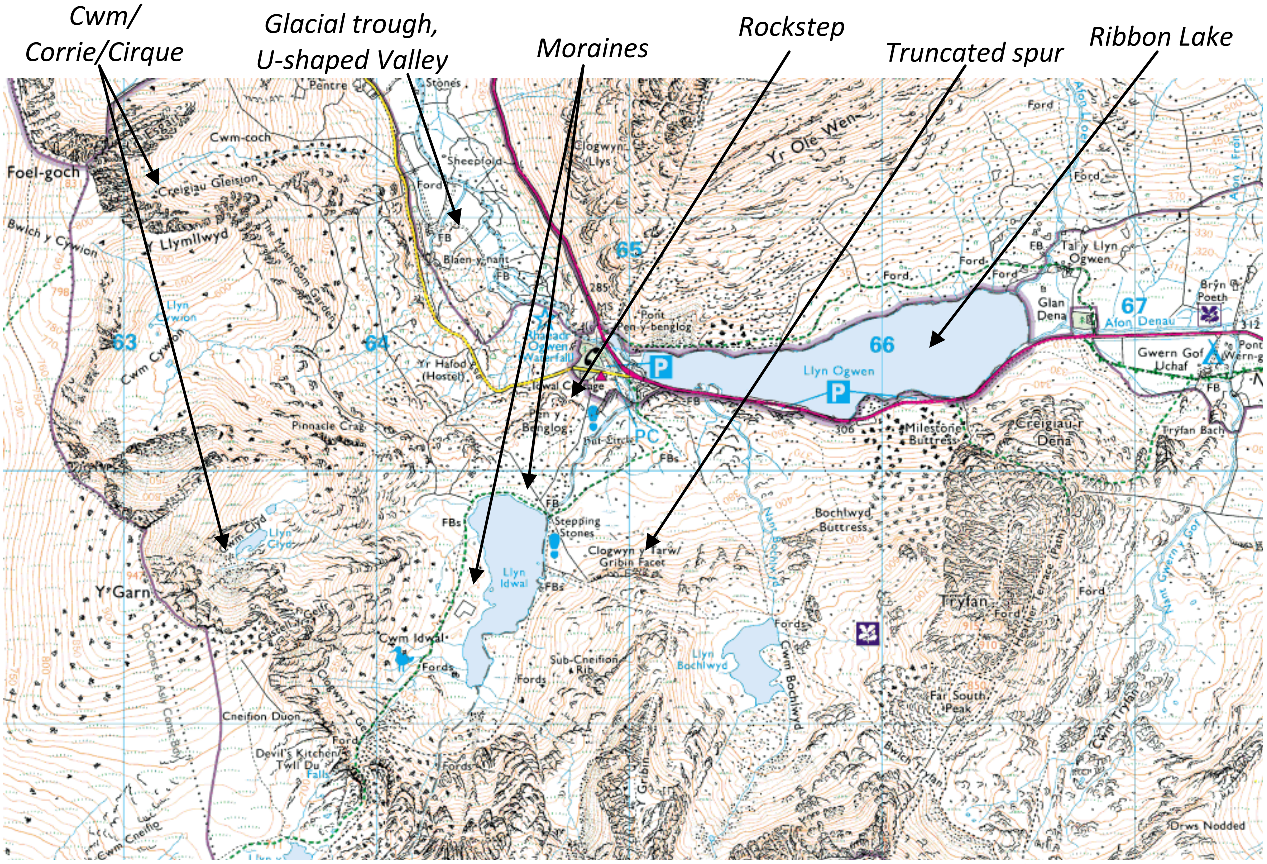
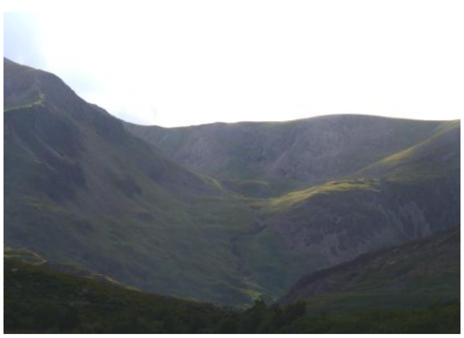
Nant Ffrancon Valley, Northern Snowdonia



Source: OS map Extract from Memory Map

Nant Ffrancon was carved by a glacier moving north-west towards what is now Anglesey. At the Nant Ffrancon rock step, or riegel**,** marked by the waterfall Rhaedr Ogwen there is a drop of 100m in height. The rock at the waterfalls is particularly hard, and resistant to erosion. The valley was widened, straightened and deepened by the glacier. Former interlocking spurs were truncated leaving vertical crags along the valley sides, and a U-shaped glacial trough.



*A hanging valley, joining Nant Ffrancon by the rock step. This would have added significant amounts of ice here leading to increased erosion and helping to form the rock step***.** (photo: Helen Morton)

After the ice melted, water filled the floor of Nant Ffrancon forming a ribbon lake. This lake filled the depression left by glacial erosion over-deepening the valley floor. It was dammed at its northern end by a rock barrier near to where the town of Bethesda stands today. Over time this lake filled in with sediments, leaving the flat valley floor we see today. A misfit stream meanders its way across the valley floor. In places it exposes striated rocks as it erodes away the lake sediments.

Right: Nant Ffrancon Valley

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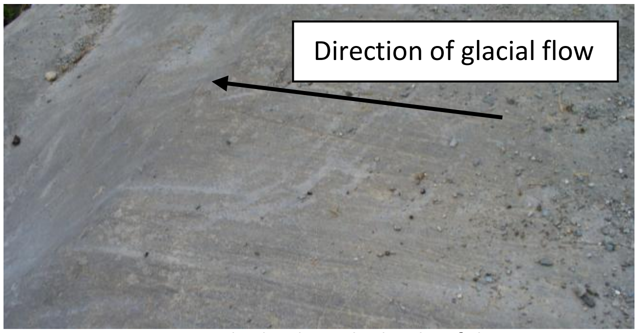


Striations in bedrock on the banks of the River Ogwen.
(photo: Helen Morton)

Glacial landforms	Examples in Ogwen area
Glacial trough	Nant Ffrancon
Arête	Y Gribin
Truncated spur	Bottom slopes of Y Gribin
Ribbon lake	Llyn Ogwen
Corrie/Cwm/cirque	Cwm Idwal or Cwm Clydd
Hanging valley	Cwm Cywion
Rock step	Rhaedr Ogwen
Misfit stream	Afon Ogwen
Infilled glacial lake	Floor of Nant Ffrancon
Corrie lake	Llyn Idwal

Terminal Moraine

There is an excellent example of a terminal moraine on the western side of Nant Ffrancon. This was formed by the glacier from Cwm Coch. Similar features can be seen in the Alps today. This is where material was deposited at the end of the glacier which flowed down from this corrie high up above the U-shaped Valley.

The Ogwen Valley

The Ogwen Valley has many glacial features. These include diffluent troughs, truncated spurs and a ribbon lake.

Diffluent Troughs or Breached Watersheds

Originally the Nant Ffrancon and Ogwen Valley would have been two individual stream valleys draining a high moorland area in opposite directions from around the area of Pen y Ole Wen directly above the Ogwen Cottage. The Ogwen would have drained to the east and Nant Ffrancon to the northwest. The erosion of this watershed has been explained by a glacier travelling north from Migneint Moor, as the valleys filled up with ice some ice was forced up into what is now called the Ogwen Valley. This ice became thicker and deeper until it was forced over the watershed between Ogwen and Nant Ffrancon. This was rapidly eroded to form a diffluent trough, breaching the watershed and eroding the high land. An alternative and more recent theory is that ice, from a more local origin (probably the Glyder cwms and area around Tryfan), eroded this old watershed away. The evidence of ice erosion in the u-shaped valley at Idwal Cottage can be explained by ice of local origin. No erratics from the Migneint area have been found here, which would support the theory that ice has travelled from this inland moor.

Truncated Spurs

Several truncated spurs can be seen down the length of the Ogwen and Nant Ffrancon Valley. One example is the end of Gribin ridge, by Cwm Idwal. These may once have been interlocking spurs of land sticking into the middle of a V-shaped valley, the glacier has since eroded the end of these spurs, shortening, or 'truncating' them.

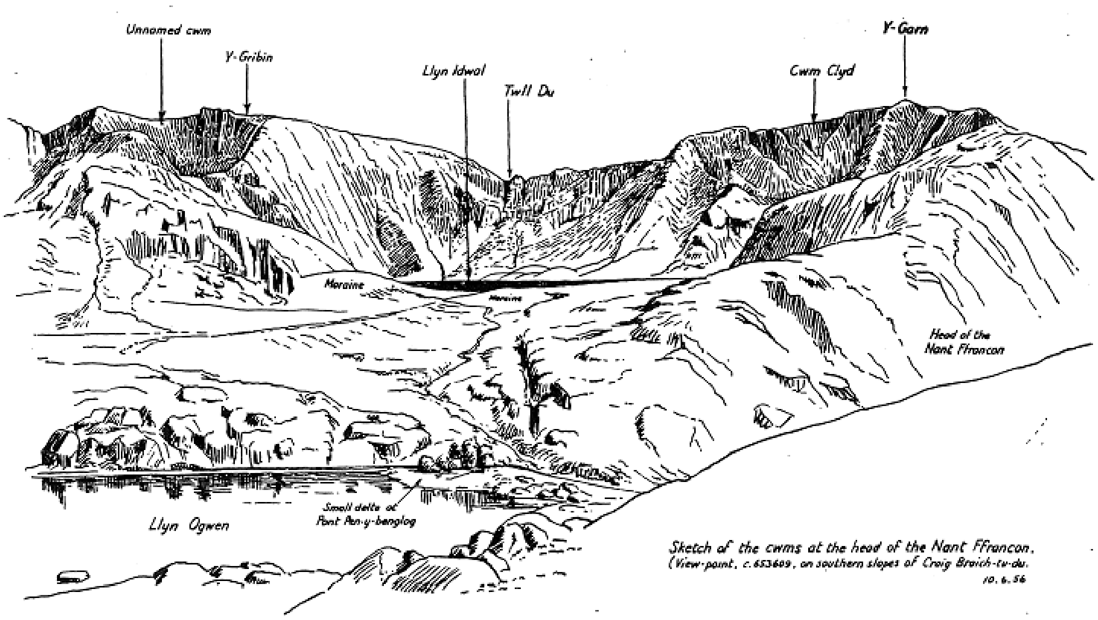
Ribbon Lake at Llyn Ogwen

Ribbon lakes occur where over-deepening of the glacial trough has occurred. This can happen for a variety of reasons:

- A softer rock is more easily eroded. When the glacier then reaches harder rock, this will resist erosion resulting in a deeper valley floor above it.
- Thicker glacial ice. Ice erosion is closely related to the thickness of the ice. If a glacier is joined by a tributary glacier, this will increase erosion immediately causing over-deepening.
- Compression flow. Glaciers flow in a sequence of extending and compressing flow. As a glacier speeds up down a steeper gradient it will be stretched and become thinner so reducing erosion. When it reaches flatter ground it slows down and concertinas becoming more bunched up and thicker. Erosion increases in these flatter areas leading to over-deepening.

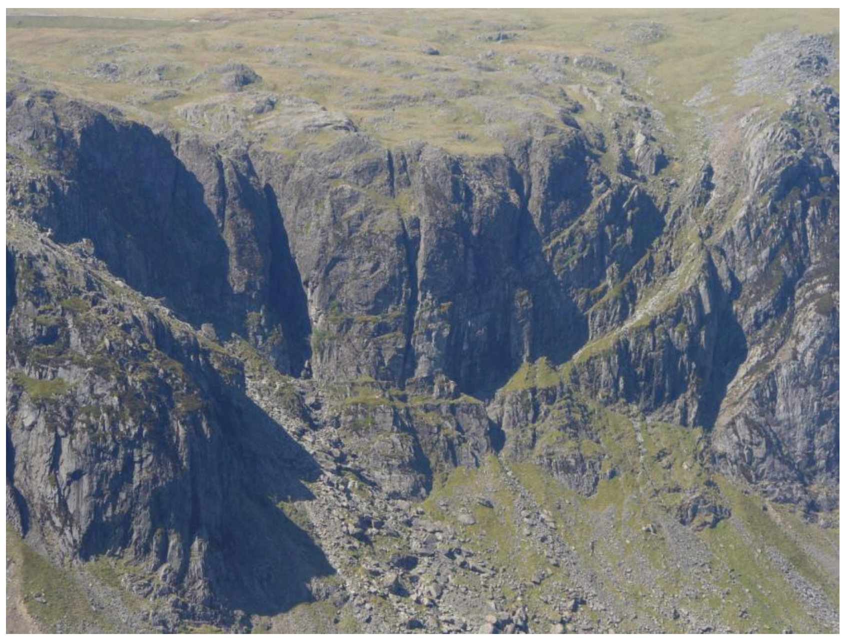
Once the floor has been over-deepened and the glacier melts, water fills the depression. The lake shape reflects the valley shape resulting in a long, thin linear lake known as a ribbon lake. Llyn Ogwen is an example of this.

Cwm Idwal

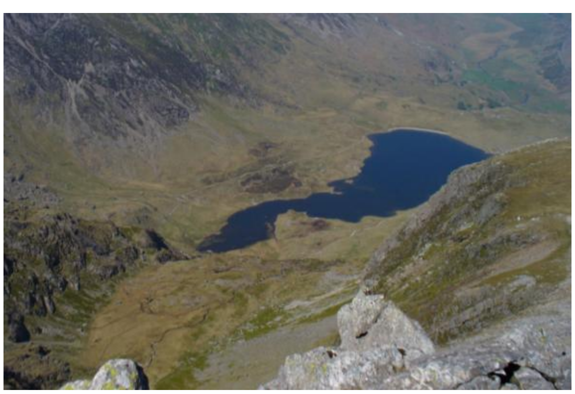


Shape: Most glacial corries are circular in shape, with round corrie lakes. In Snowdonia several corries do not fit in with this usual pattern. Cwm Idwal is one such example. It is linear being one and a half kilometres in length and only a kilometre wide from arête to arête.

Altitude: Cwm Idwal is a lot deeper and lower than the other Glyderau corries. Its floor is at an altitude of 375m. Compare this to the surrounding corries, Cwm Bochlwyd (550m), Cwm Cneifion (600m), Cwm Clyd (660m). There are several possible reasons for this. Cwm Idwal lies below the lowest point in the Glyderau range. The pass above it was low enough to allow ice to spill over from the Llanberis Pass. This meant that Cwm Idwal had greater volumes of ice and therefore would have been subjected to greater amounts of erosion. In addition, Cwm Idwal lies along a line ofgeological weakness. The bedrock here is part of a syncline.



The Devil's Kitchen (or Twll Ddu) on the backwall of Cwm Idwal, ice would have been able to spill over here from the valley behind. The syncline (a basin –like structure of rock layering where the rock has been folded) can be picked out in the picture.



Llyn Idwal, in Cwm Idwal North Wales.

Llyn Idwal

Unlike most corrie lakes which are circular, Llyn Idwal has a linear shape. In places the lake is also disrupted by rock obstructions and by hummocky moraines. Unusually for a corrie lake, it is surprisingly shallow with 10 metres at its maximum but with an average depth of 3 metres. Its mouth is dammed by a terminal moraine. Corrie lakes are often dammed by either a rock lip, terminal moraine or both.

Idwal Slabs

These are diagonally slanting rock slabs in Cwm Idwal. They are slanting because they are part of the syncline rock structure. Dilatation (pressure release) has added to the weathering of the slabs. Now this is area is very popular with rock climbers.

Y Gribin

Y gribin is an example of an arête. It is a knife-edged, jagged ridge separating Cwm Cneifion and Cwm Bochlwyd. Both these corries were eroded back into the Glyder mountains side-by-side. Over time the glaciers in these cwms would have increased in size and begun to erode backwards into the mountain plateau, leaving a sharp ridge between them.

Y Gribin with a jagged appearance along the skyline like a serrated knife. (Photo: Helen Morton)

Moraines

Several different types of moraines can be found in Cwm Idwal including terminal moraine, lateral moraine and hummocky moraine.

Terminal moraine: this can be found in the mouth of the corrie and lake as it falls away to the Ogwen valley below. This was formed at the end of the glacier, where it deposited the material it had eroded from further up the valley.

Hummocky moraines: These can be found on the east and west side of Llyn Idwal.

Lateral moraine: This runs parallel to Llyn Idwal along its western side. It has a classic triangular cross section and is around three hundred metres in length. However there are other theories put forwards about its formation. One is that it is a protalus rampart, another that it is the recessional moraine for a glacier that reached across Cwm Idwal from Cwm Cneifon.

A double lateral moraine running down the side of an Alpine valley. The larger moraine on the right is the older moraine (Photo: Helen Morton)

Stone stripes in Cwm Clyd above Cwm Idwal

Post Glacial Modification

The whole area has been subject to modification since the last glacier retreated. Other geomorphological processes have taken over including:

- **Periglacial processes.** After the ice retreated the landscape would still have been extremely cold. In many places the land would have been permanently frozen as permafrost. Many periglacial processes would have been at work (and still are), creating periglacial landforms such as stone stripes. These are formed due to freeze thaw bringing stones to the surface and creating 'patterned ground'.

- **Weathering.** Although Wales is no longer in the grip of a glacial, temperatures in the winter months regularly fall below freezing at night and rise in the day. Resulting freeze-thaw cycles attack rocks, when water freezes in the numerous cracks it weakens the rock as it expands. The main land forms resulting from this process are the blockfields or felsenmeer on the mountain summits and ridges. This is where the rock is weathered in situ, but being on a flat surface, can not roll away. As a result boulder fields build up. The second type of landform is scree, which line the valley slopes at their base. These are where the frost shattered boulders fall from steep slopes to the valley floor. The end result is that over time the mountain slopes become more gradual in their gradient. The large blockfields on the Glyder and Carneddau summits would have been above the glacial ice and were therefore shaped by extreme cold and periglacial processes but were not scoured by ice. The clear break between the ice scoured rounded ground (such as above the Devil's Kitchen) and these upland rocky blockfields indicated the thickness of ice. It suggests that it would once have been upto 820m-860m OD in the Nant Ffrancon area. The last time ice was that extensive in the area may have been 40,000 B.P. with slightly less ice 20,000 B.P. Though the evidence to create a clear timeline for this is poor and further research is needed (Bowen et al, 2002).

Frost shattered rock on the summit of the Glyders.

- **Sedimentation and lake infill.** The flat floor of the Nant Ffrancon indicates that it once contained a ribbon lake. This lake was dammed by an igneous intrusion (forming a band of resistant rock) running across the valley floor. Over thousands of years sediments and debris brought down by the many streams filled the lake in leaving the flat valley floor.

- **Alluvial fans –** these are triangular shaped build ups of sediment brought down from the mountains by the streams. On reaching the valley floor, the streams' velocity is abruptly slowed down causing the water to lose energy and deposit its load.

- **Fluvial erosion –** streams from hanging valleys are eroding vertically back into the hanging valleys creating deep and steep sided gorges on their way to the valley floor.

References and further reading

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