

Glacial History of Wales



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Y Drindod Dewi Sant
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Trinity Saint David

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ACNA4007 – Physical Landscape and the Geosphere

Objective

- To explore the glacial history of Wales with particular reference to erosional and depositional landforms
- To recap key glacial terms introduced during the last lectures
- Begin to map and explore glacial or remnant glacial features from aerial imagery.

Definition and Relevance...

- ... large, perennial accumulation of ice, snow, and sediment that originates on land and moves downslope (USGS, 2019)

- Almost 10 percent of the world's land mass is currently covered with glaciers

- $\frac{3}{4}$ of Earth's freshwater stored in glaciers

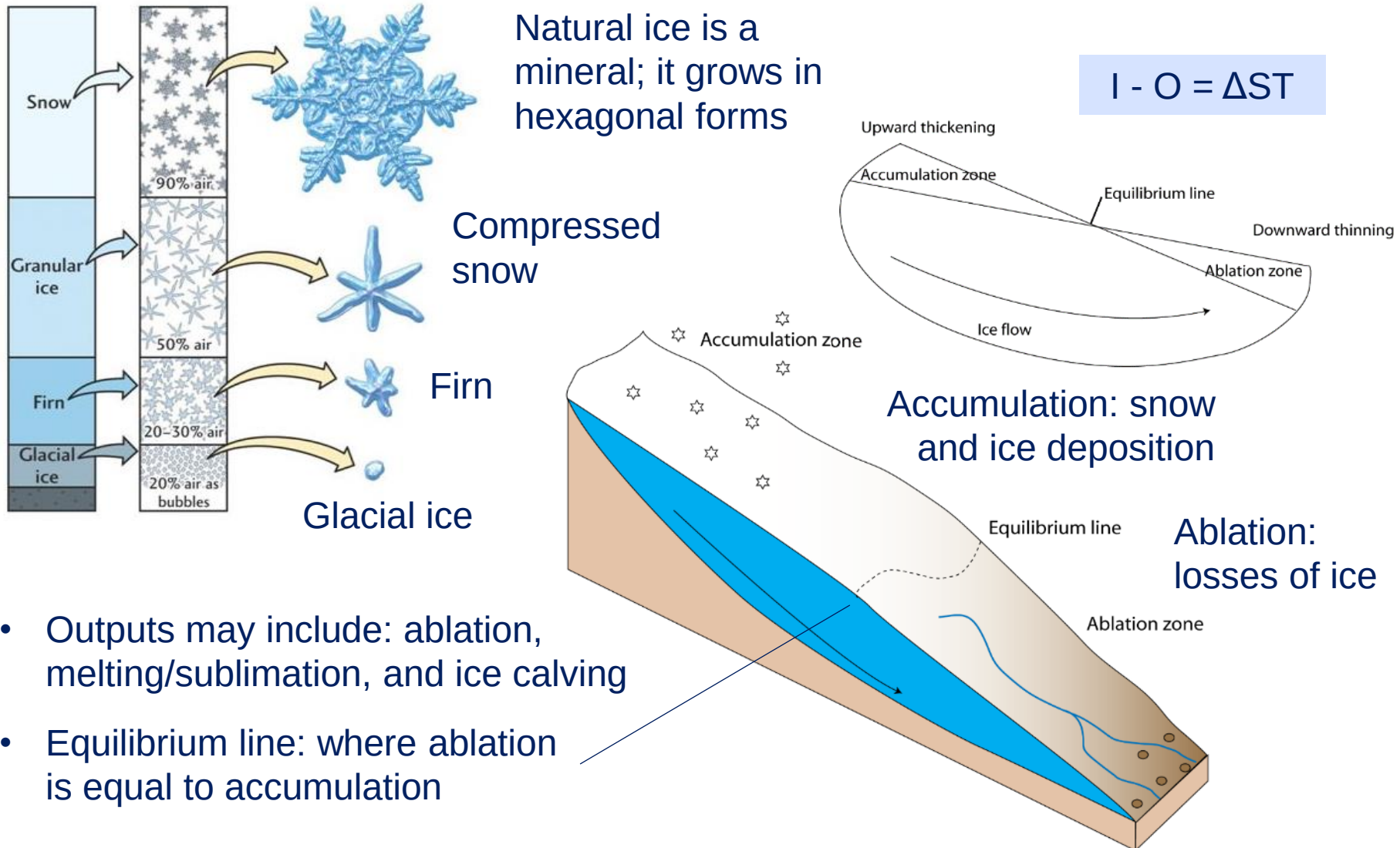
- In the (recent) past, glaciers have covered more than one third of Earth's surface...

... providing invaluable information about past climates

<https://www.youtube.com/watch?v=C3Jwnp-Z3yE>

A glacier...

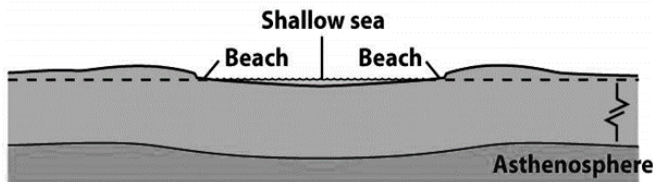
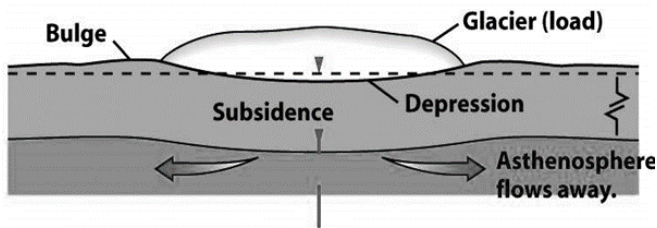
- ... large, perennial accumulation of ice, snow, and sediment that originates on land and moves downslope (USGS, 2019)



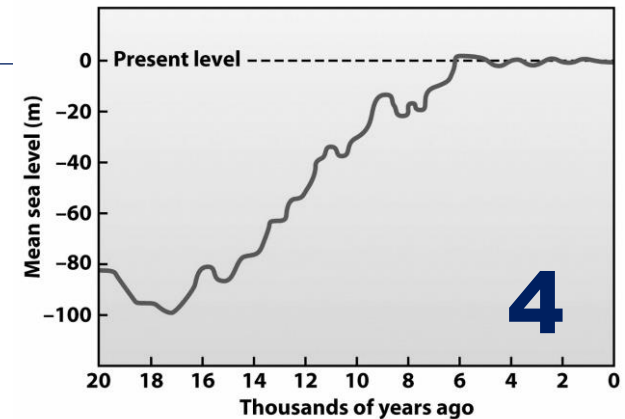
- Outputs may include: ablation, melting/sublimation, and ice calving
- Equilibrium line: where ablation is equal to accumulation

Consequences of glaciations

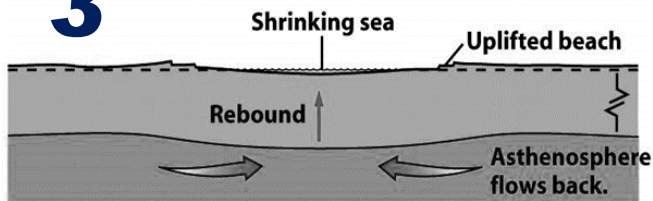
1 • Re-shaping of landscapes...



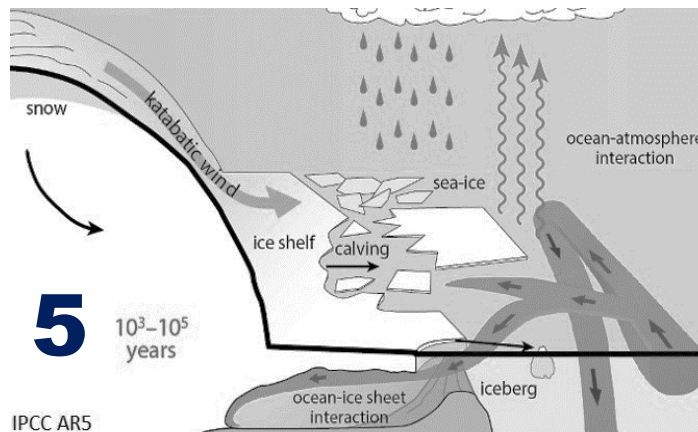
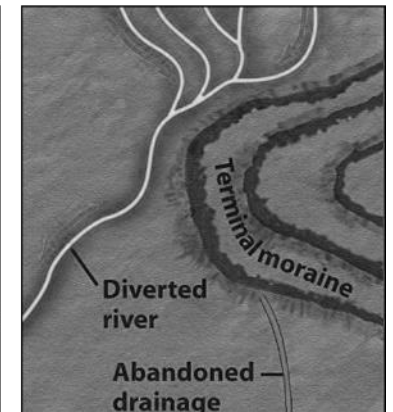
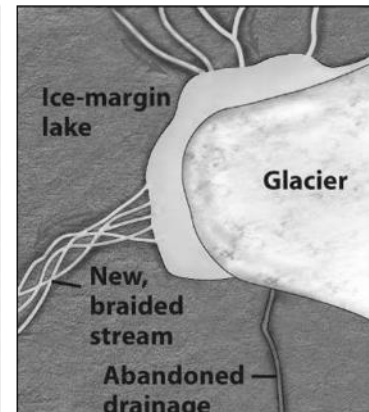
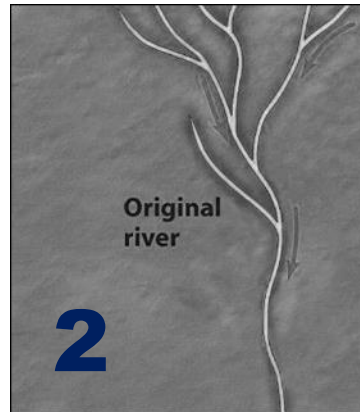
- Sea level – Ice ages cause sea level to rise and fall



3



- Subsidence and isostatic rebound (until today = 10s of ka)
- Interaction of ice sheets and atmosphere-ocean system, weather patterns change



- Drainage:
 - re-plumbing river systems
 - large glacial lakes
 - mega-flooding

How is this expressed in the UK...

1 • Re-shaping of landscapes...



Ribbon lakes formed by glacial erosion, Buttermere, Lake District.



U-shaped glacial valley, Glencoe, Scotland.



Newtondale, Yorkshire, formed rapidly by glacial meltwater.



Cirques (Cwms) formed from snow hollows at glacier head, Snowdonia.

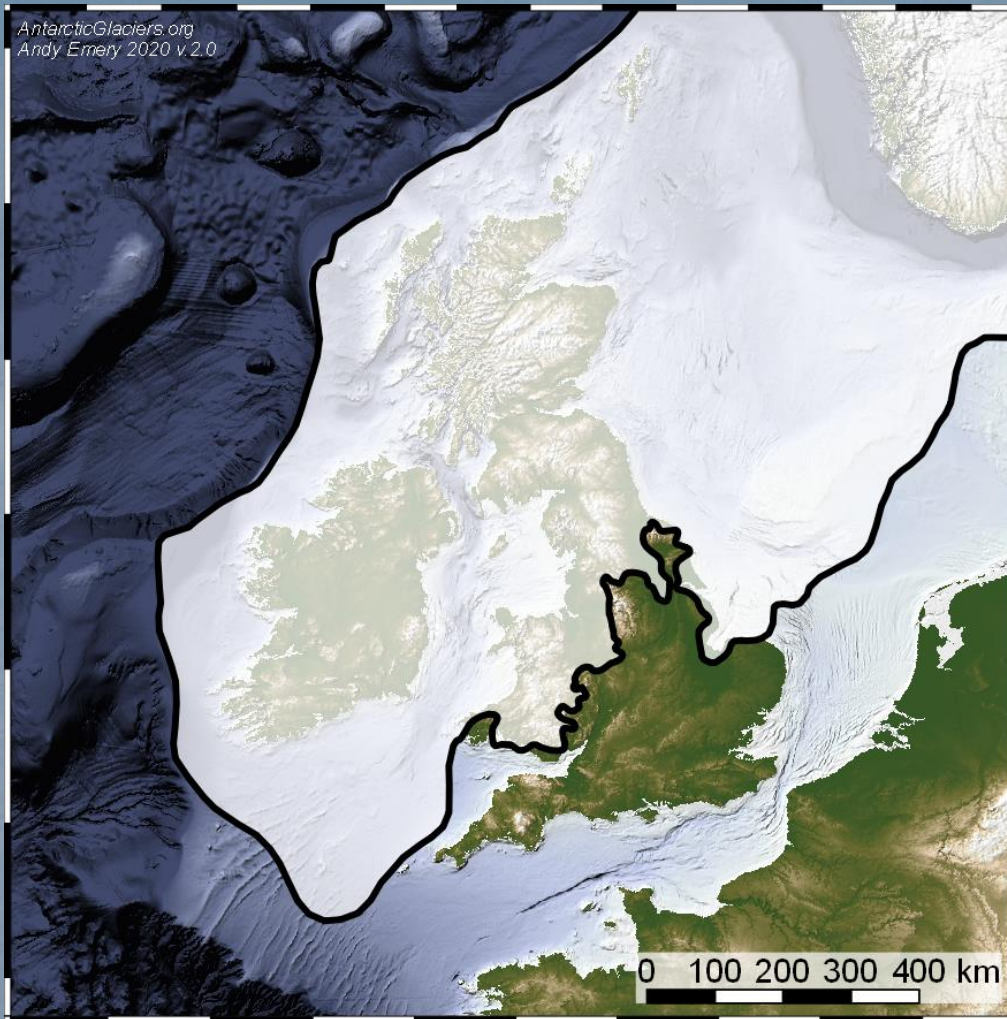


Boulder clay laid down by ice sheets in much of eastern England.

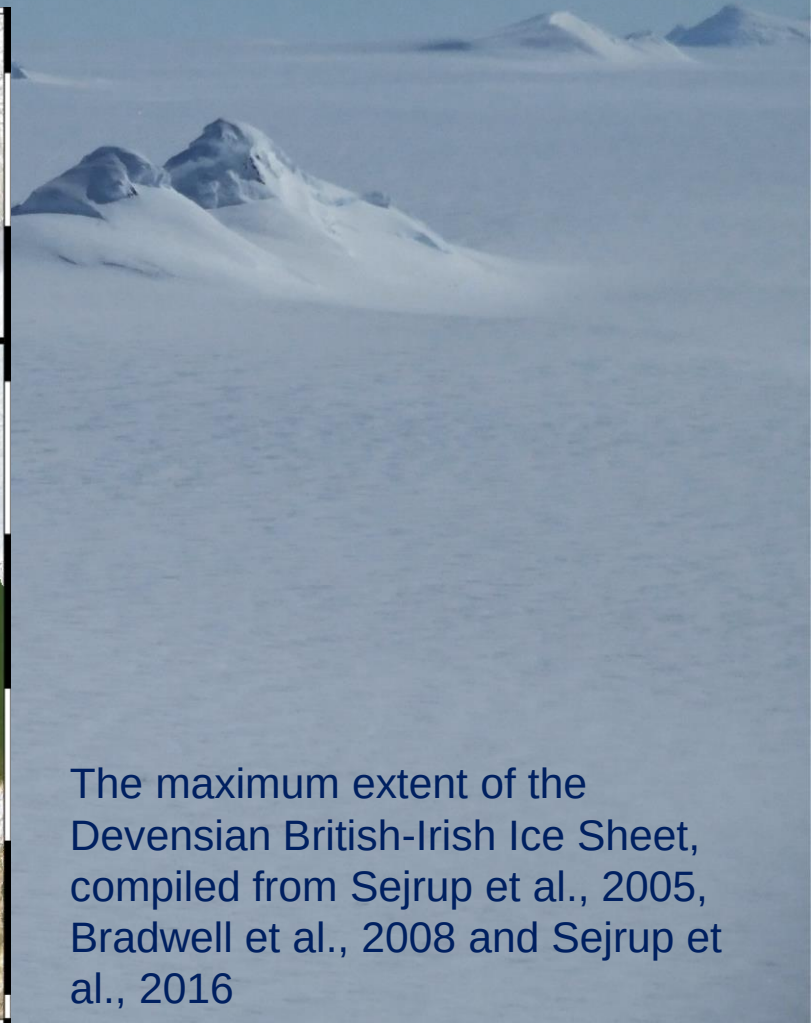
[Geological Society - Glaciation in Britain \(geolsoc.org.uk\)](http://geolsoc.org.uk)

Ice Sheets (recap)

- **Ice sheets (continental glacier):** Largest glaciers: ice mass over land
- Greenland + Antarctica = 95 % of all glacial ice currently on Earth
- If melted, they would raise global mean sea level by about 66 m

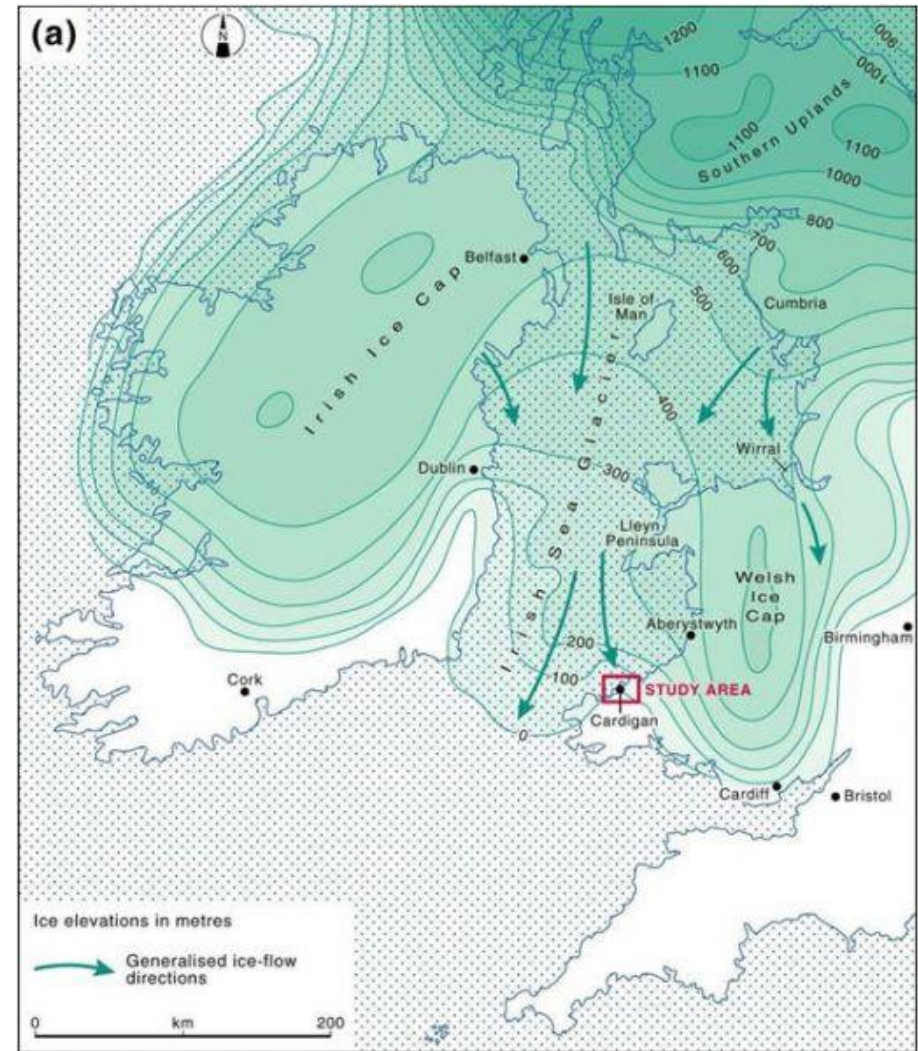


The maximum extent of the Devensian British-Irish Ice Sheet, compiled from Sejrup et al., 2005, Bradwell et al., 2008 and Sejrup et al., 2016



British-Irish Ice Sheet

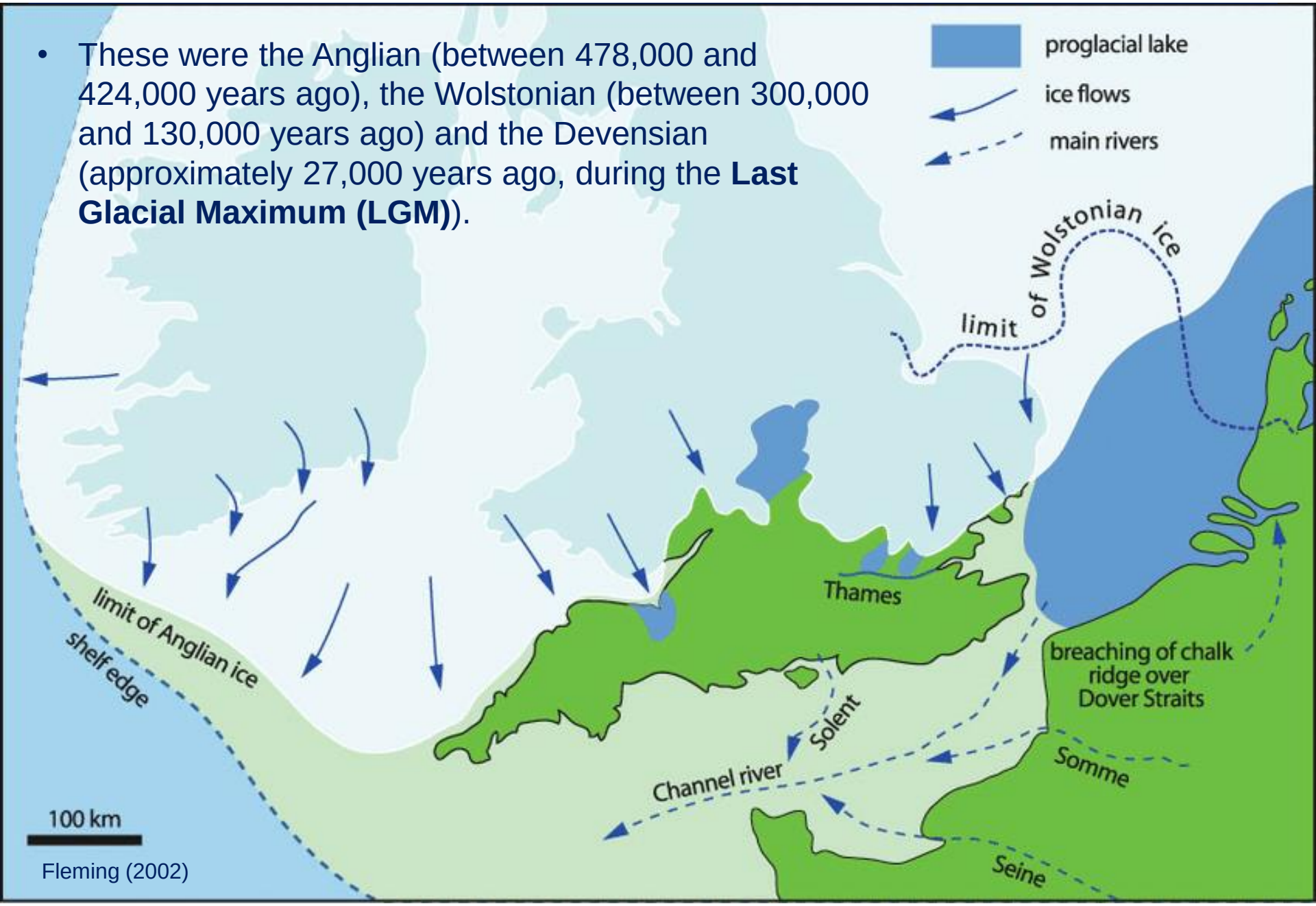
The British-Irish Ice Sheet is a name given to ice sheets that covered Britain and Ireland at different times during the **Quaternary Period**. Evidence for at least three major ice sheets is preserved in the sedimentary record on land in Britain and Ireland.



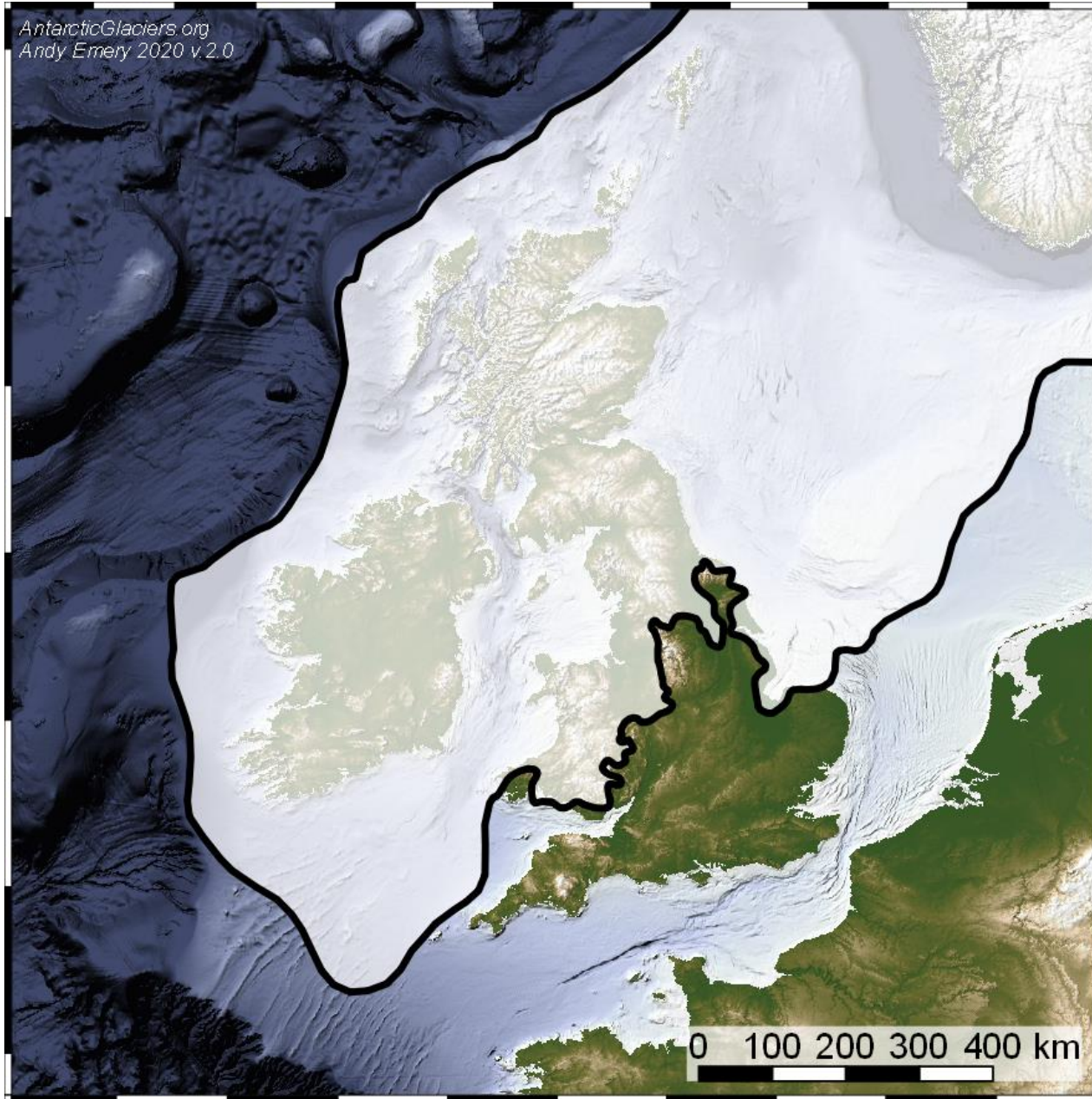
[Welsh Glacial Palaeoenvironments : Department of Geography & Earth Sciences , Aberystwyth University](#)

British-Irish Ice Sheet

- These were the Anglian (between 478,000 and 424,000 years ago), the Wolstonian (between 300,000 and 130,000 years ago) and the Devensian (approximately 27,000 years ago, during the **Last Glacial Maximum (LGM)**).



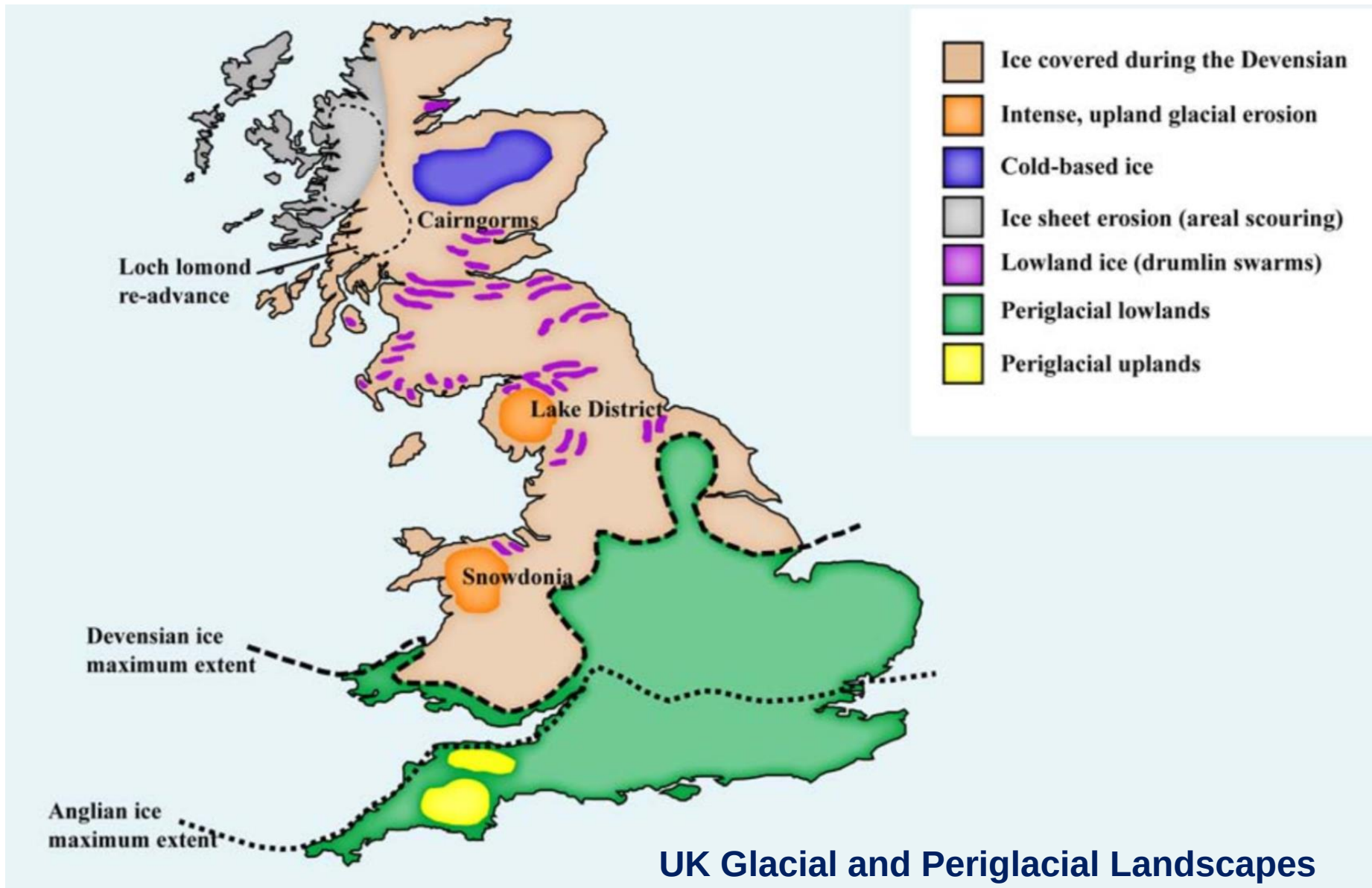
British-Irish Ice Sheet during LGM



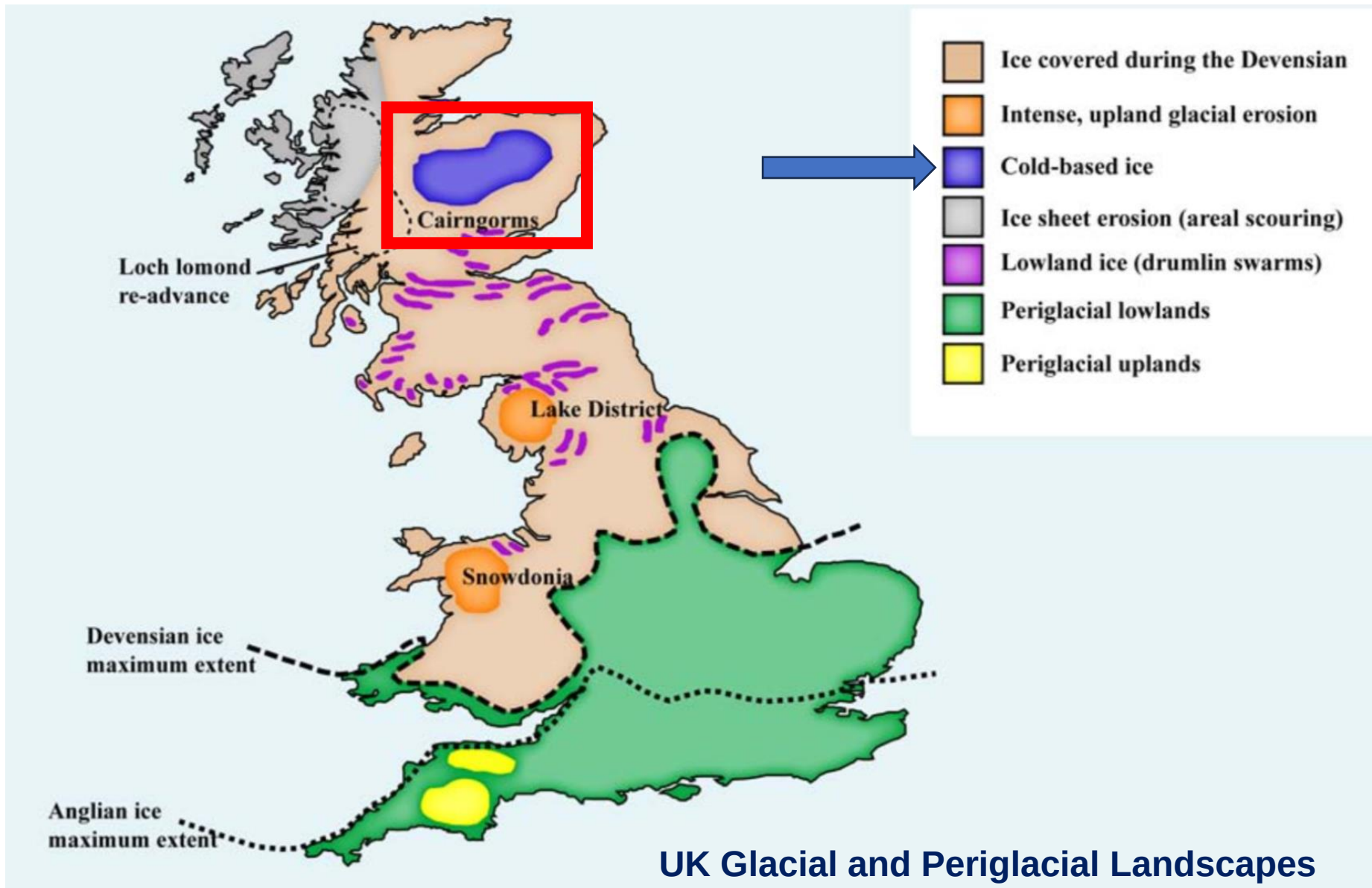
The **Devensian** British-Irish Ice Sheet was a large mass of ice that covered approximately two thirds of Britain and Ireland around 27,000 years ago.

This ice sheet retreated and shrank after 27,000 years ago and had completely disappeared by 11,300 years ago.

Ice Sheet extent during the LGM

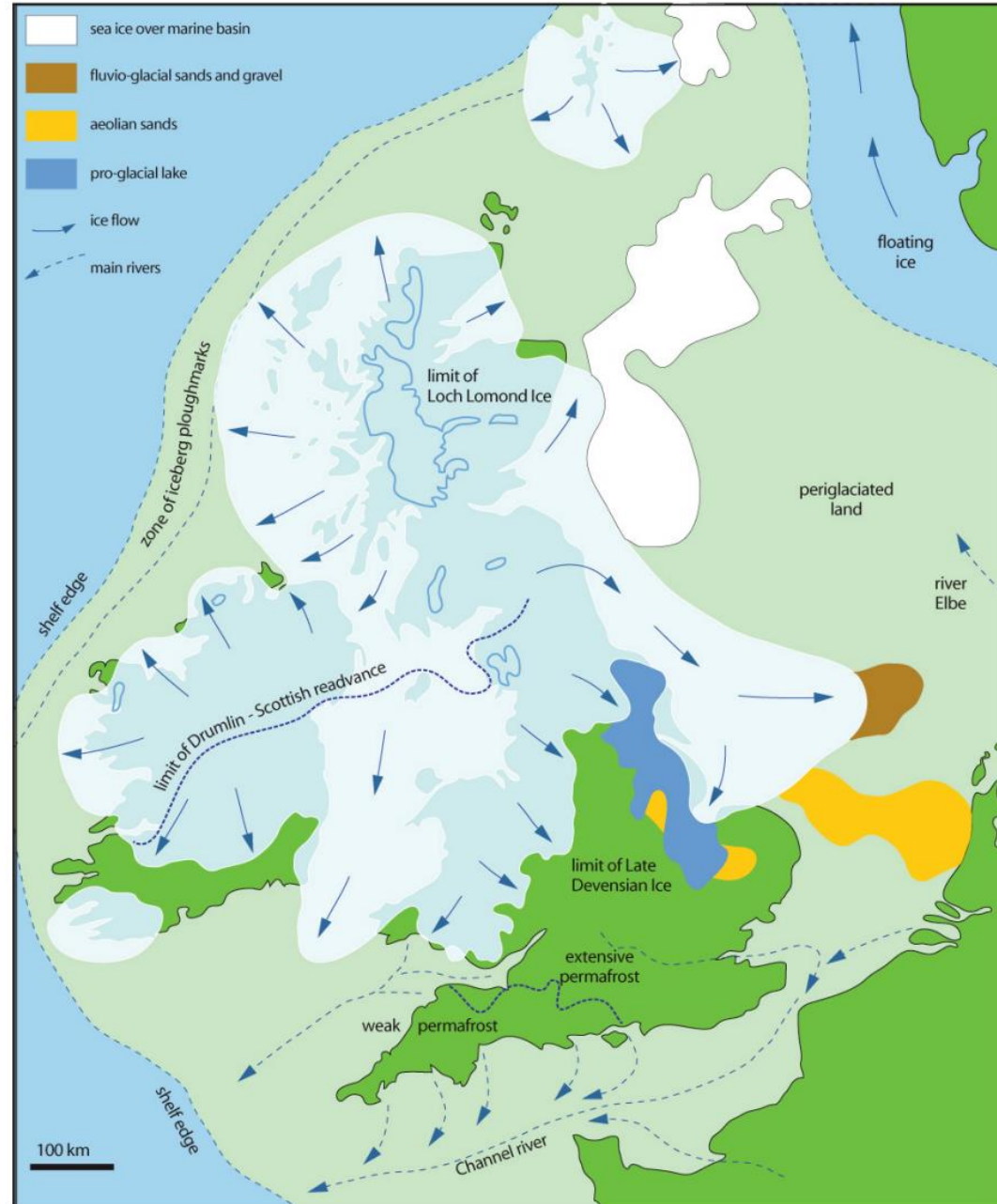


Ice Sheet extent during the LGM



Ice Sheet extent during the LGM

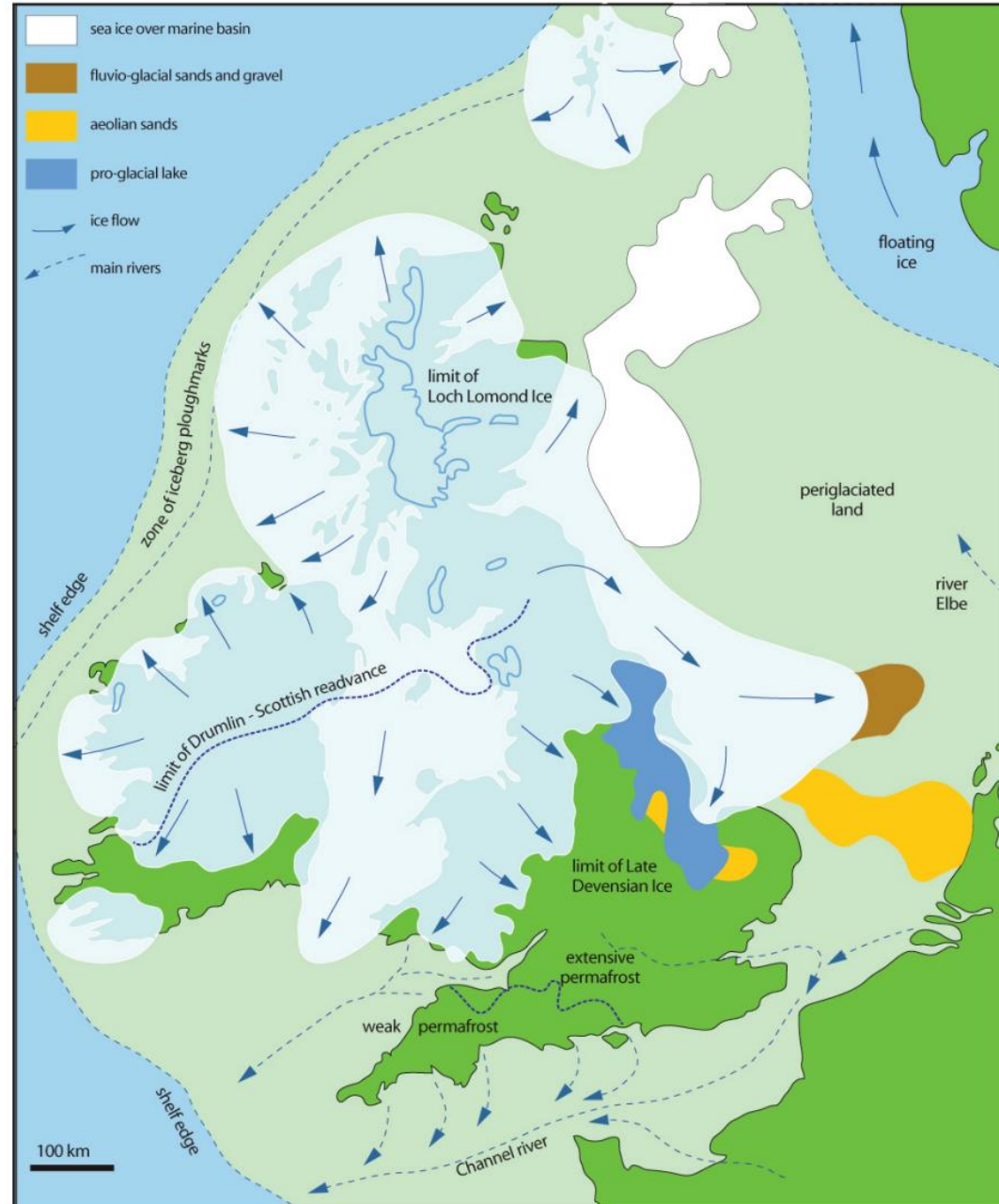
Palaeogeography during the
Devensian glaciation (After
Woodcock and Strachan 2000)
from **Fleming (2002)**



Ice Sheet extent during the LGM

Periglaciated = landscapes that undergo seasonal freezing and thawing, typically on the fringes of past and present glaciated regions.

Palaeogeography during the Devensian glaciation (After Woodcock and Strachan 2000) from **Fleming (2002)**

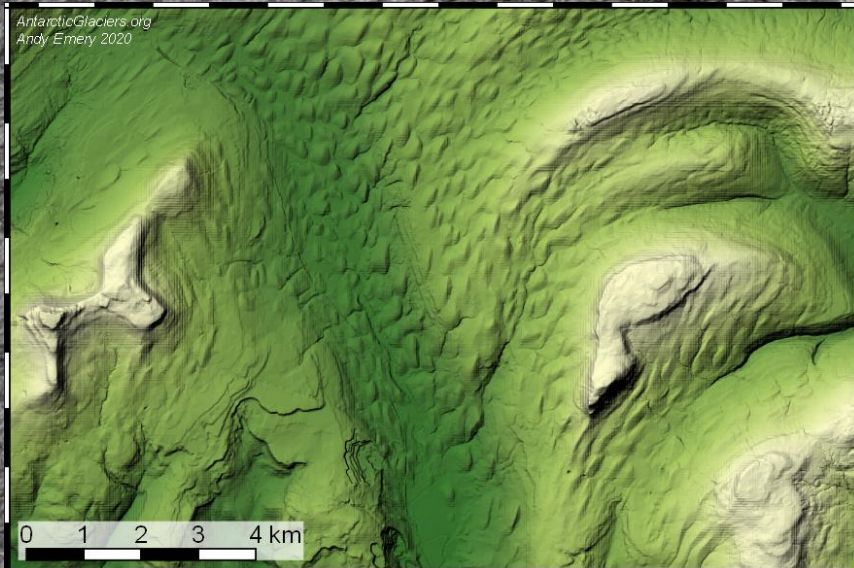


Devensian Ice Sheet (LGM)

- The Devensian ice sheet is the best-understood of the past British-Irish Ice Sheets. Because it is the most recent, evidence for the Devensian ice sheet is well preserved.

1 There is a strong imprint of this ice sheet in the glacial geology of Britain. Many glacial landforms record the story of movement of ice.

2 In the mountains, erosional landforms, such as cirques and roches moutonnées, are common.

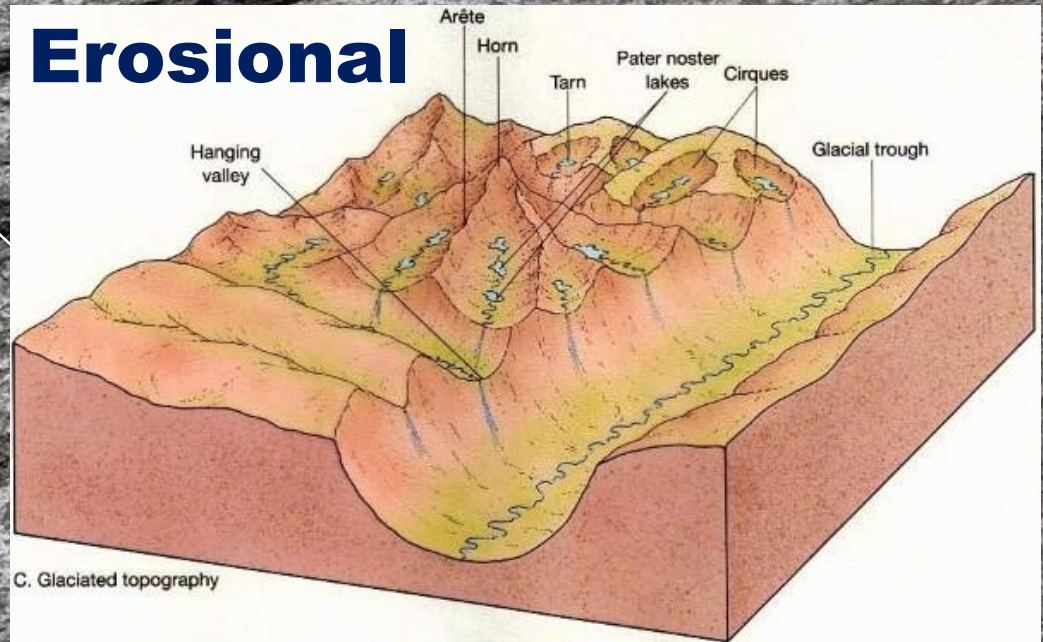


3 In the lowlands, the ice sheet has left behind sediment deposits, such as tills, and depositional landforms, such as drumlins and moraines

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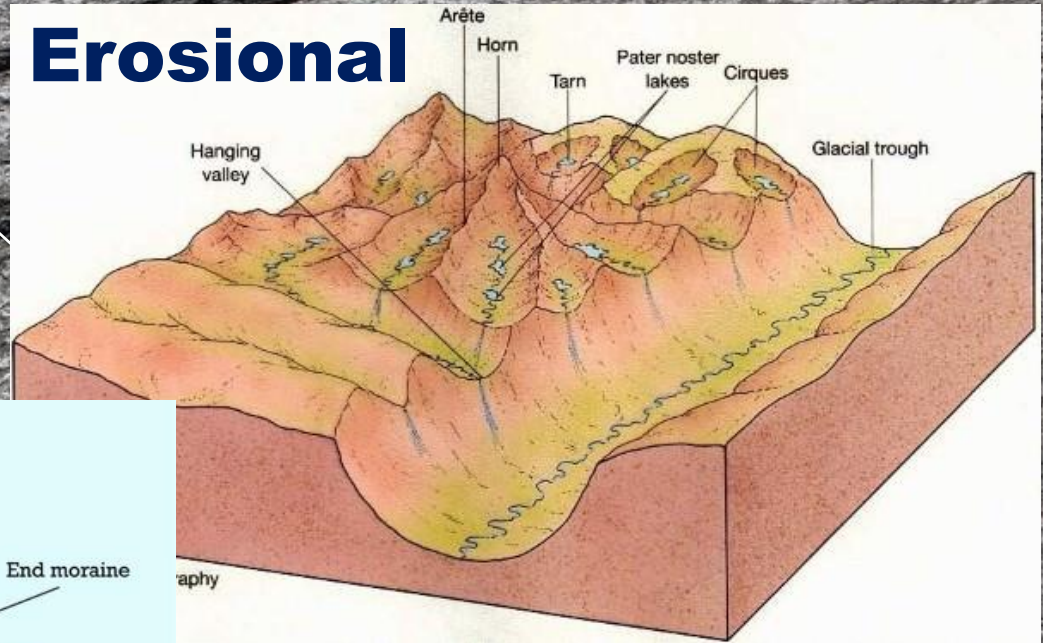


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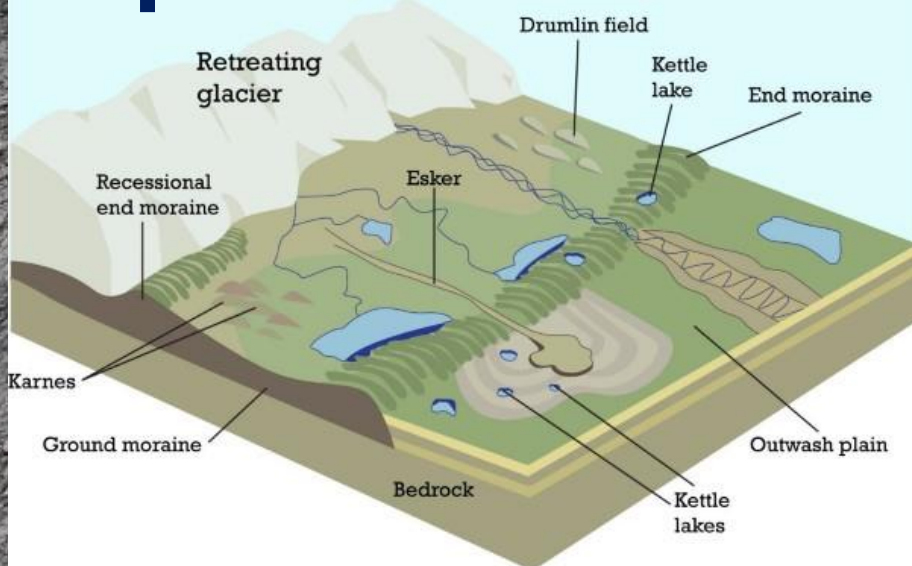
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Erosional



Depositional



Erosional Landforms – Cirques (cwms)



Classic glacial cirque basin. Cwm Clyd in the Glyderau mountains of Snowdonia.

Classic cirques take the form of armchair-shaped hollows with a steep headwall (which often culminates in a sharp ridge, or arête) and a gently-sloping or overdeepened valley floor.

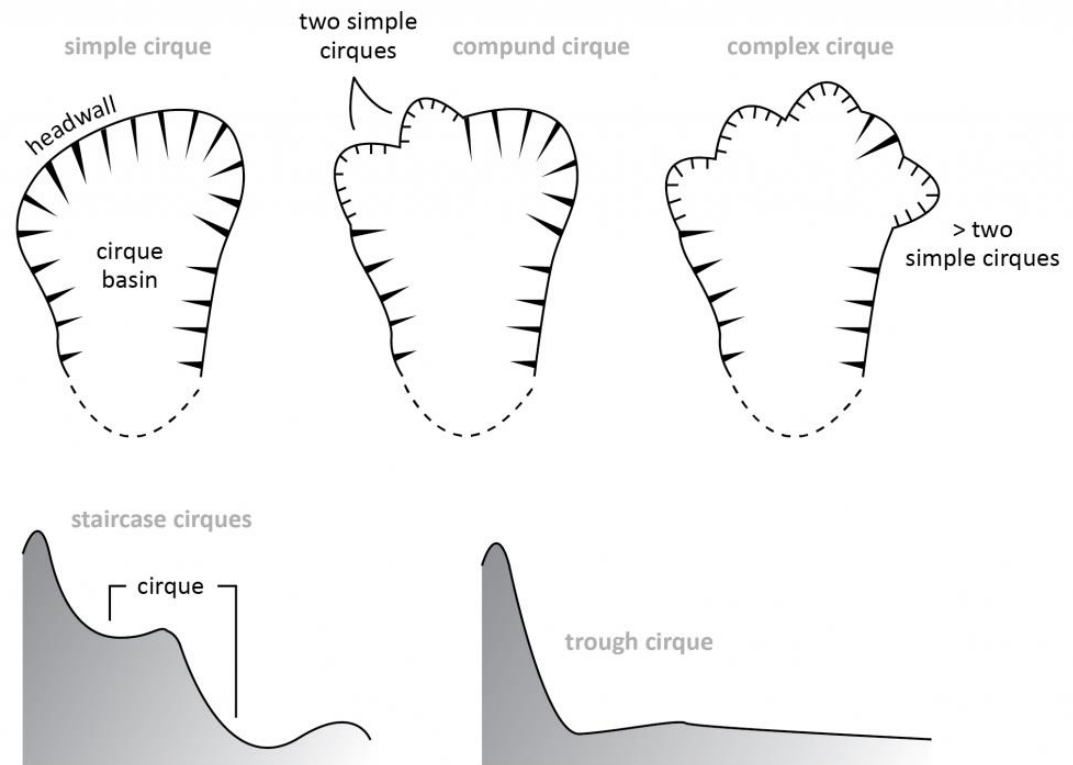
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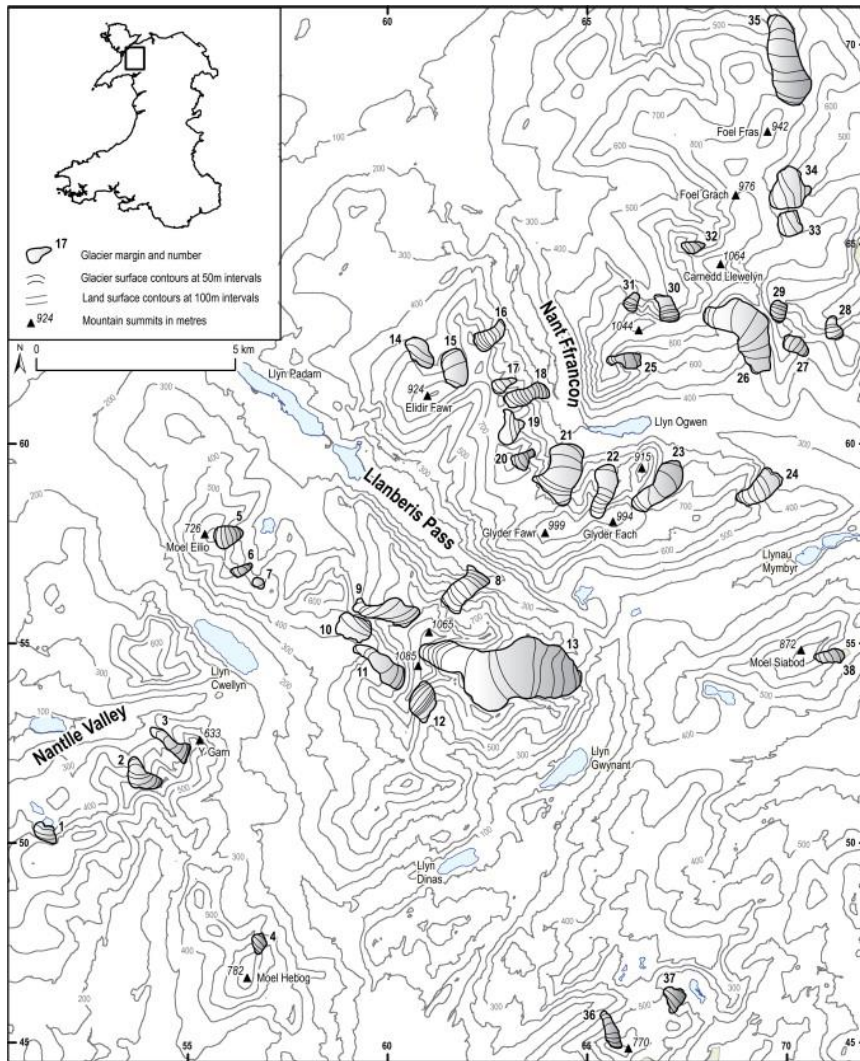
Erosional Landforms – Cirques (cwms)

- **Simple cirques**, which are distinct and independent features
- **Compound cirques**, where the upper part of a cirque basin contains two similarly sized simple cirques
- **Cirque complexes**, where the upper part of a cirque basins contains more than two similarly sized simple cirques
- **Staircase cirques**, where one cirque occurs above another
- **Cirque troughs**, where a cirque basin occurs at the upper end of a glacial trough



Cirque Glaciers in Snowdonia (LLS)

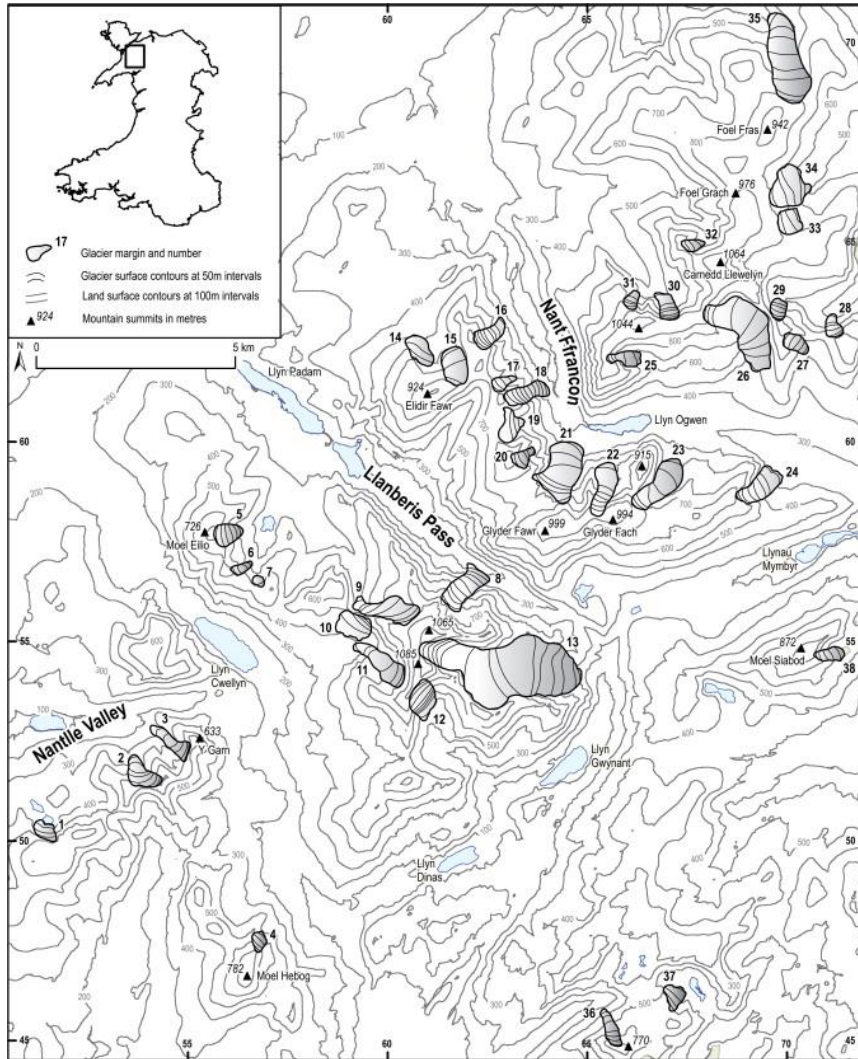
Because cirques are areas of snow accumulation, the direction in which they point (their aspect) can tell us something about the links between climate and glacier growth in the past.



Map of Loch Lomond Stadial cirque glaciers in Snowdonia, North Wales, showing a strong preference for northeasterly facing ice masses. Image from Bendle & Glasser (2012; ref. 5)

[Younger Dryas Glacial Map \(arcgis.com\)](http://arcgis.com)

Cirque Glaciers in Snowdonia (LLS)

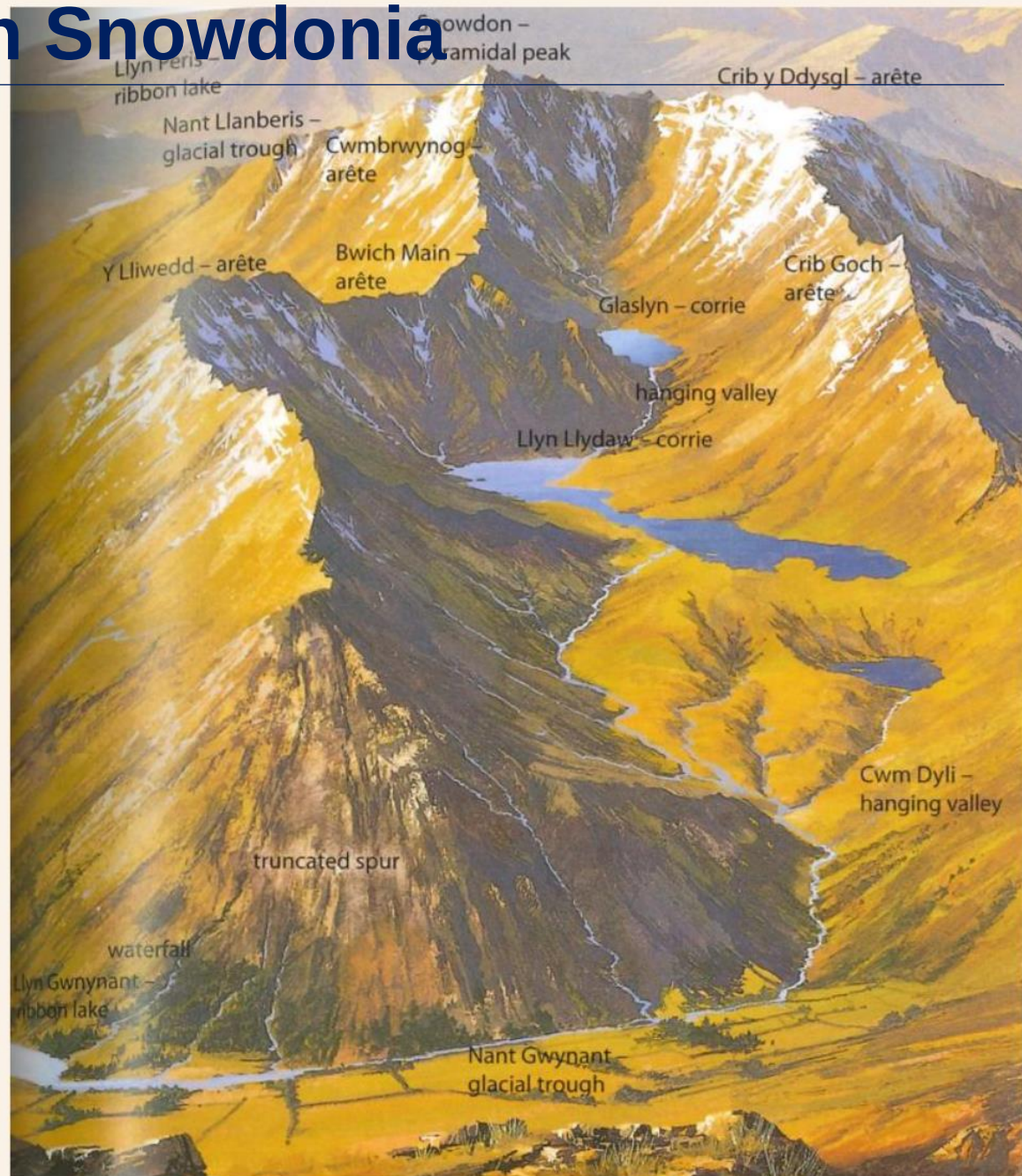


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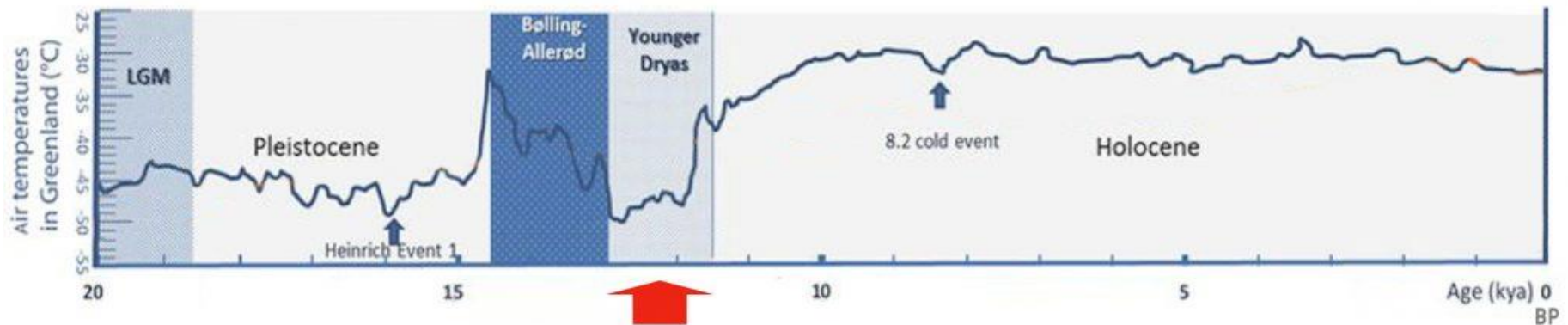
If looking from above, an interesting observation is that most cirques in Snowdonia face to the **north or east** and these also held most (as well as the largest) Loch Lomond Stadial glaciers.

Glacial features in Snowdonia



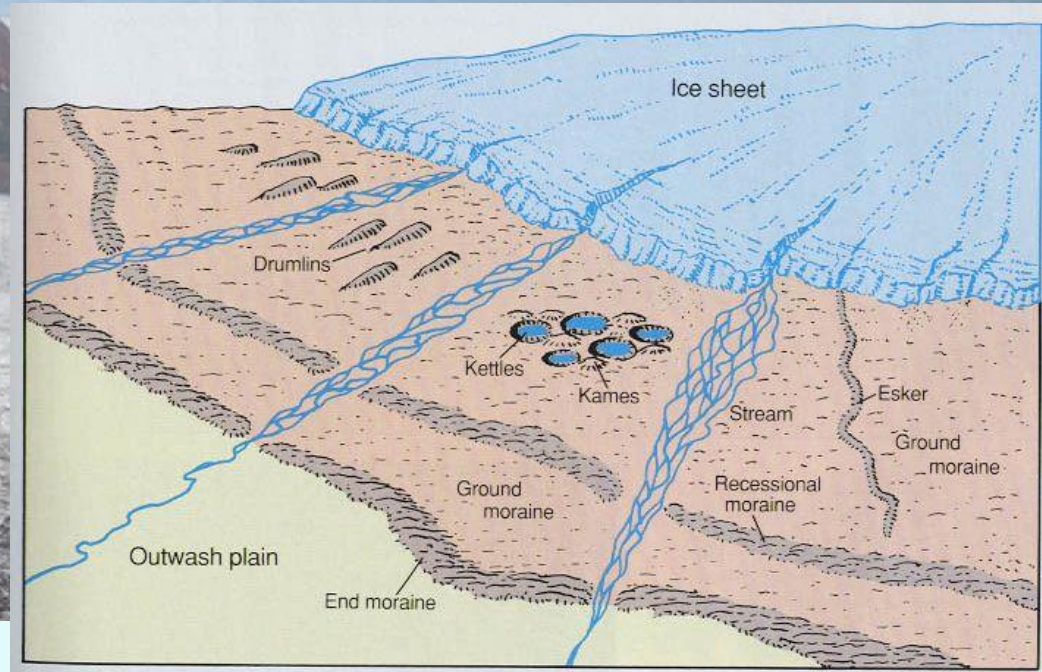
Loch Lomond Stadial in Britain

- Between around 13 and 11 thousand years ago, the climate cooled abruptly. This short-lived cold period temporarily reversed the general pattern of warming that drove the retreat of ice sheets after the Last Glacial Maximum, causing glaciers to readvance in many mountain regions.

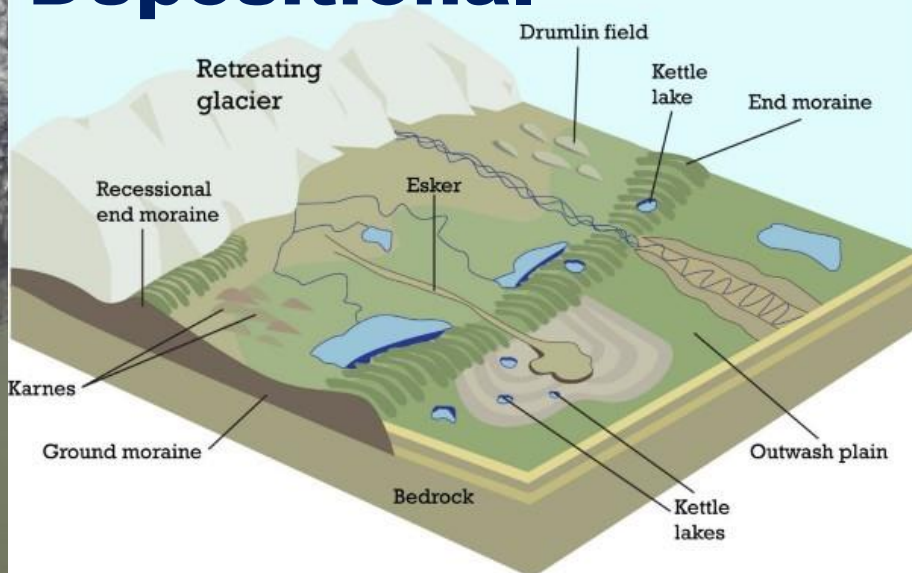


- In Britain, this cold snap is known as the Loch Lomond Stadial. In the Loch Lomond Stadial, an ice cap grew over the western Highlands of Scotland along with other smaller icefields, valley glaciers, and cirque glaciers that formed in the mountains and uplands of Scotland, England (e.g. Lake District) and Wales (e.g. Snowdonia).

Depositional Landforms



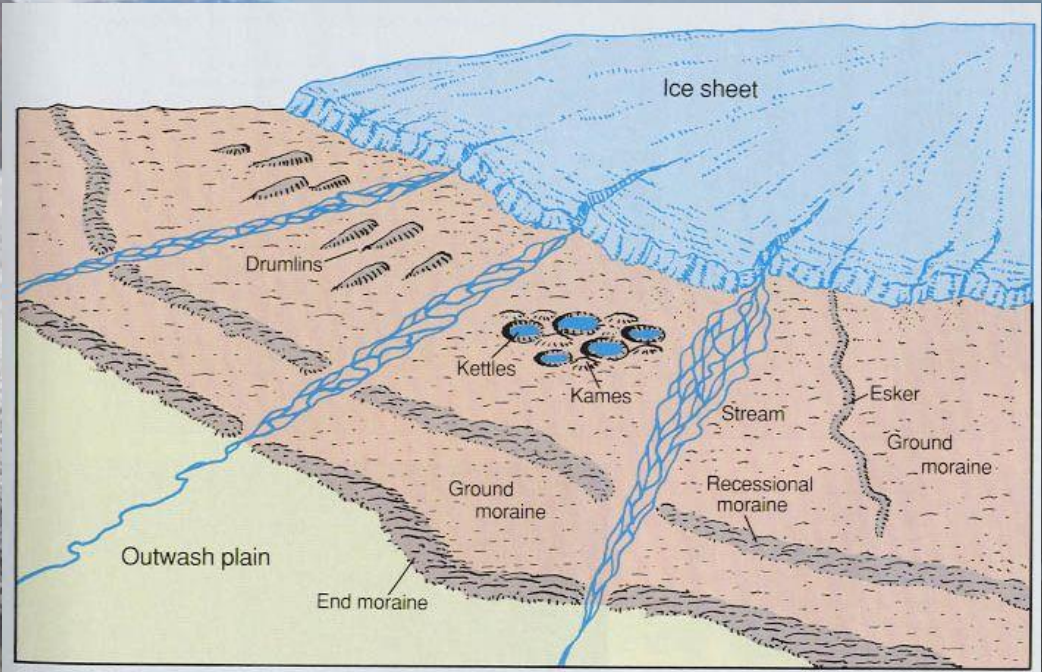
Depositional



In the lowlands, the ice sheet has left behind sediment deposits, such as **tills**, and depositional landforms, such as drumlins and moraines

Depositional Landforms: Drumlins

A drumlin is an elongated hill in the shape of an inverted spoon or half-buried egg formed by glacial ice acting on underlying unconsolidated till or ground moraine.



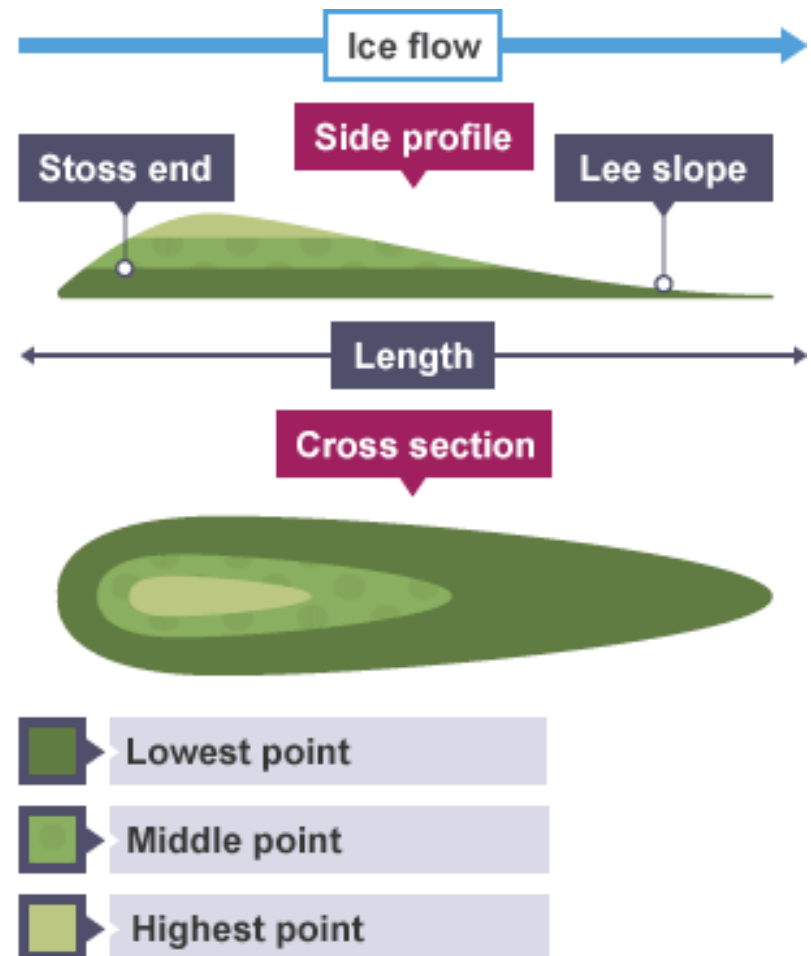
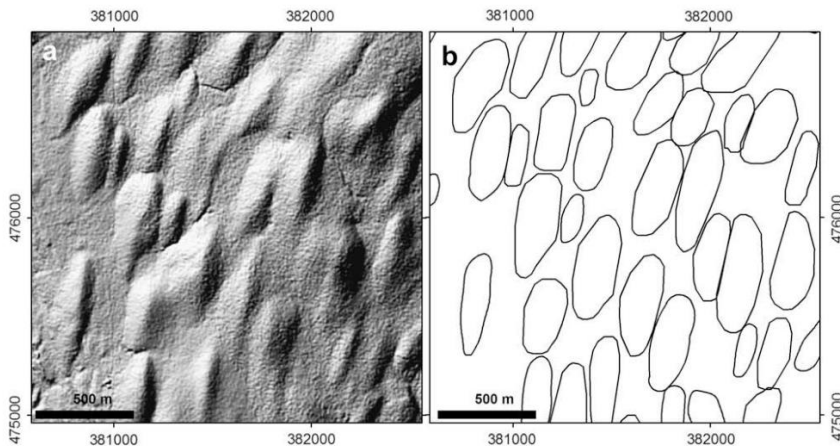
Drumlins and drumlin clusters are glacial landforms composed primarily of glacial till. They form near the margin of glacial systems, and within zones of fast flow deep within ice sheets, and are commonly found with other major glacially-formed features (including tunnel valleys, eskers, scours, and exposed bedrock erosion).

Depositional Landforms: Drumlins

Ice sheets flowing across a sedimentary bed usually produce these blister-like landforms that are streamlined in the direction of the ice flow and with each bump of the order of 10 to 10m in length and 10m in relief.

Cross section of a typical Drumlin

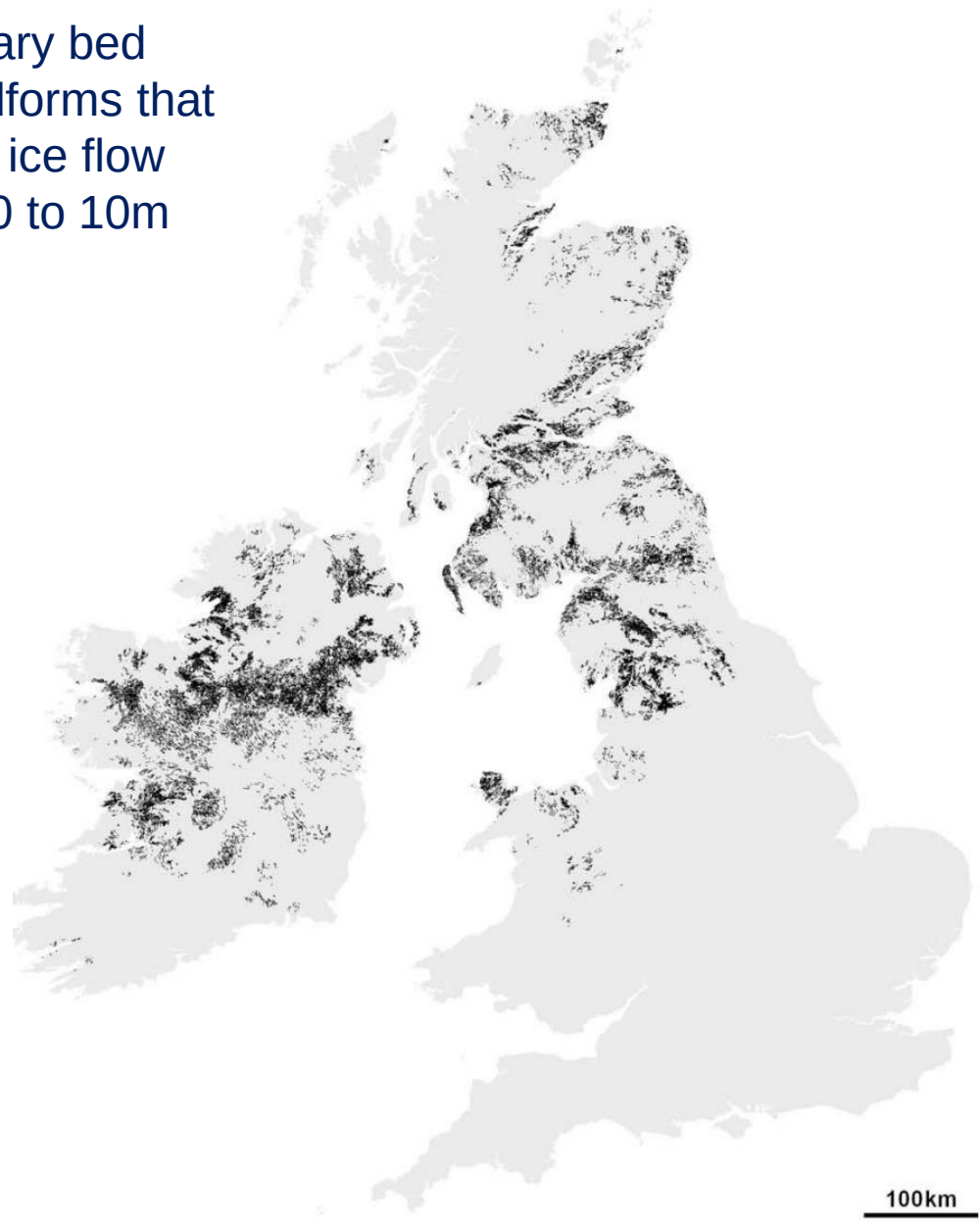
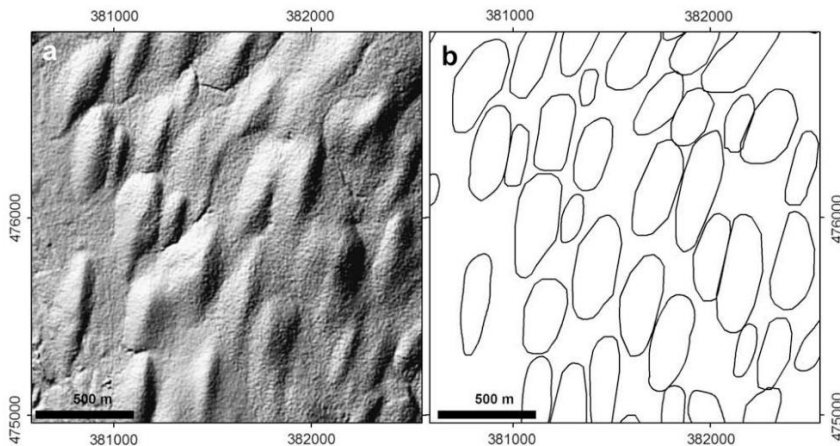
Below: Delineation of drumlins showing DEM and outline.



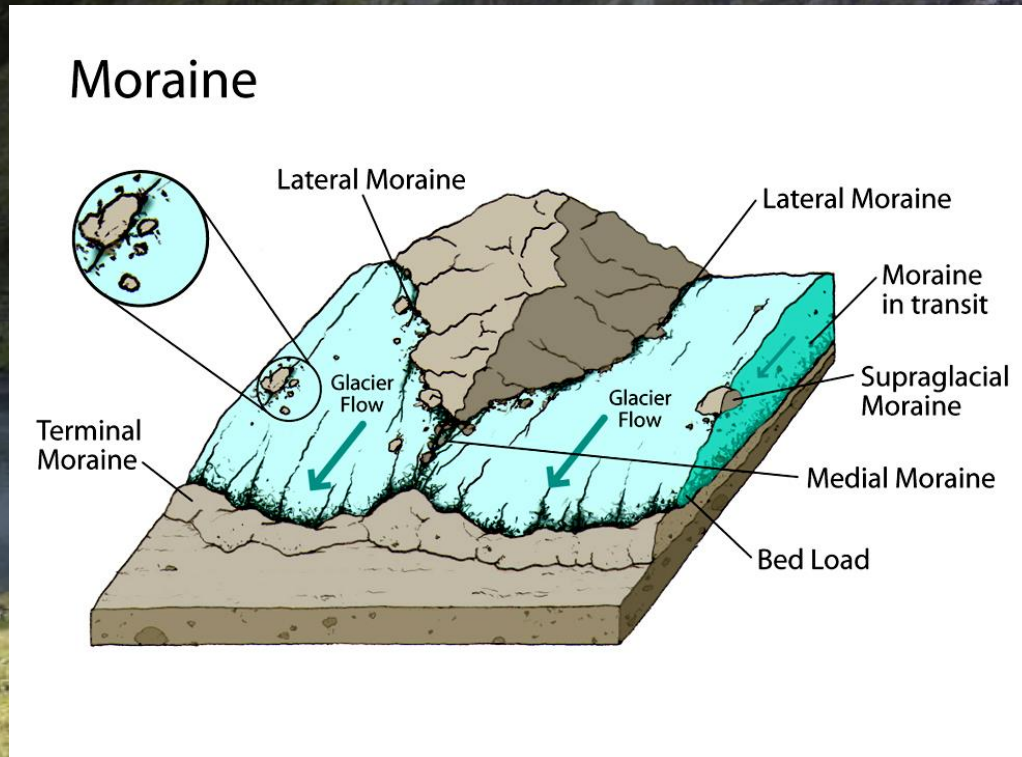
Depositional Landforms: Drumlins

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Mapped extent of drumlins in the UK (from Clark et al., 2009). **Below:** Delineation of drumlins showing DEM and outline.



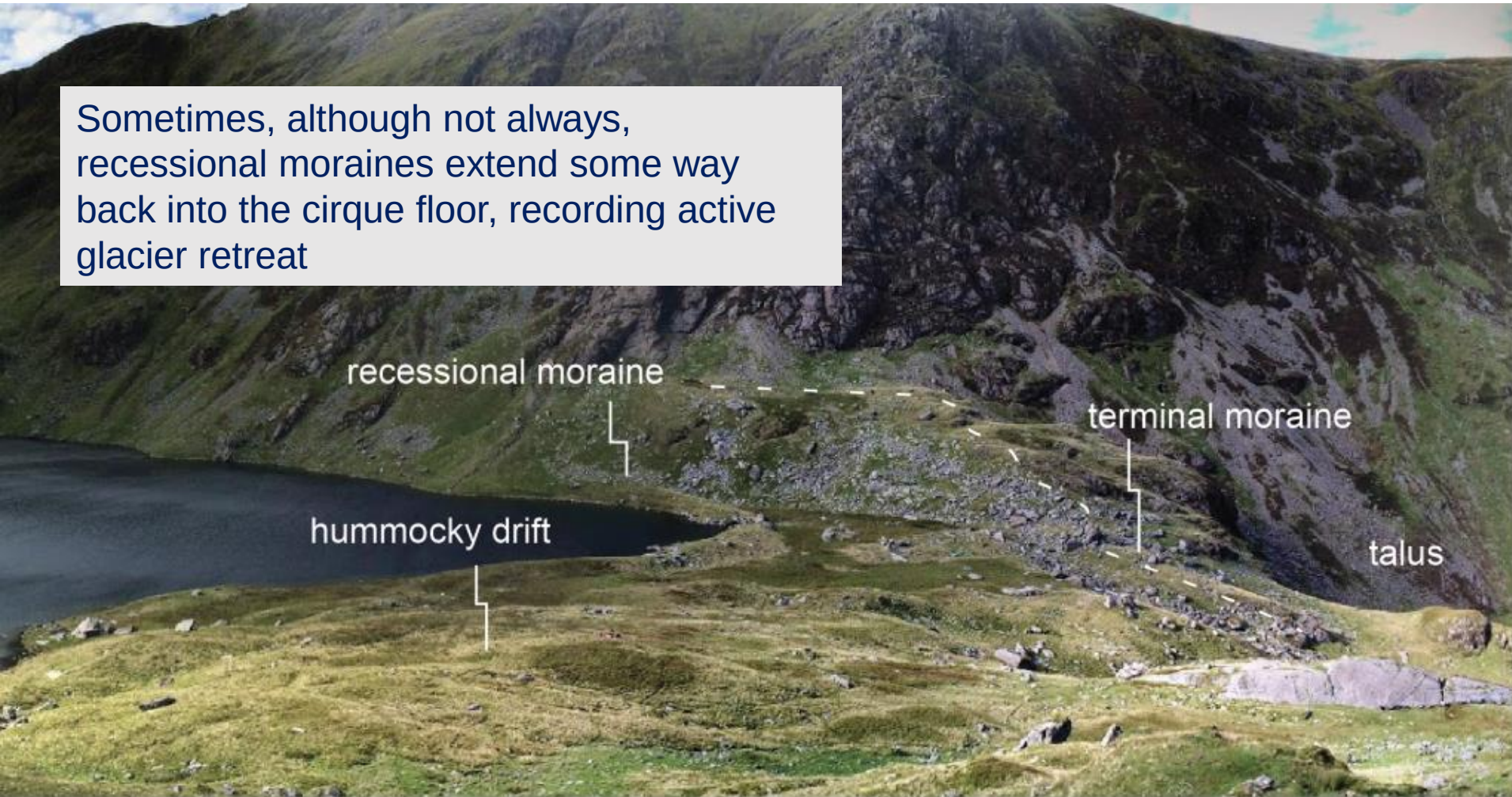
Depositional Landforms: Moraines



There are many different types of moraines that form as a glacier carves its way across a landscape: **lateral** moraines, which form on the side of the glacier; **supraglacial** moraines, which form on top of the glacier; **medial moraines**, which form in the middle of the glacier; and **terminal moraines**, which form at the end of the glacier.

Depositional Landforms: Moraines

Sometimes, although not always, recessional moraines extend some way back into the cirque floor, recording active glacier retreat



Arcuate, boulder-covered moraine ridges marking the limit of a former cirque glacier in Cwm Cau, mid-Wales. Note the hummocky drift enclosed inside the outer terminal moraine. Note also, talus slopes formed outside the limit of glaciation. Photo: J. Bendle.

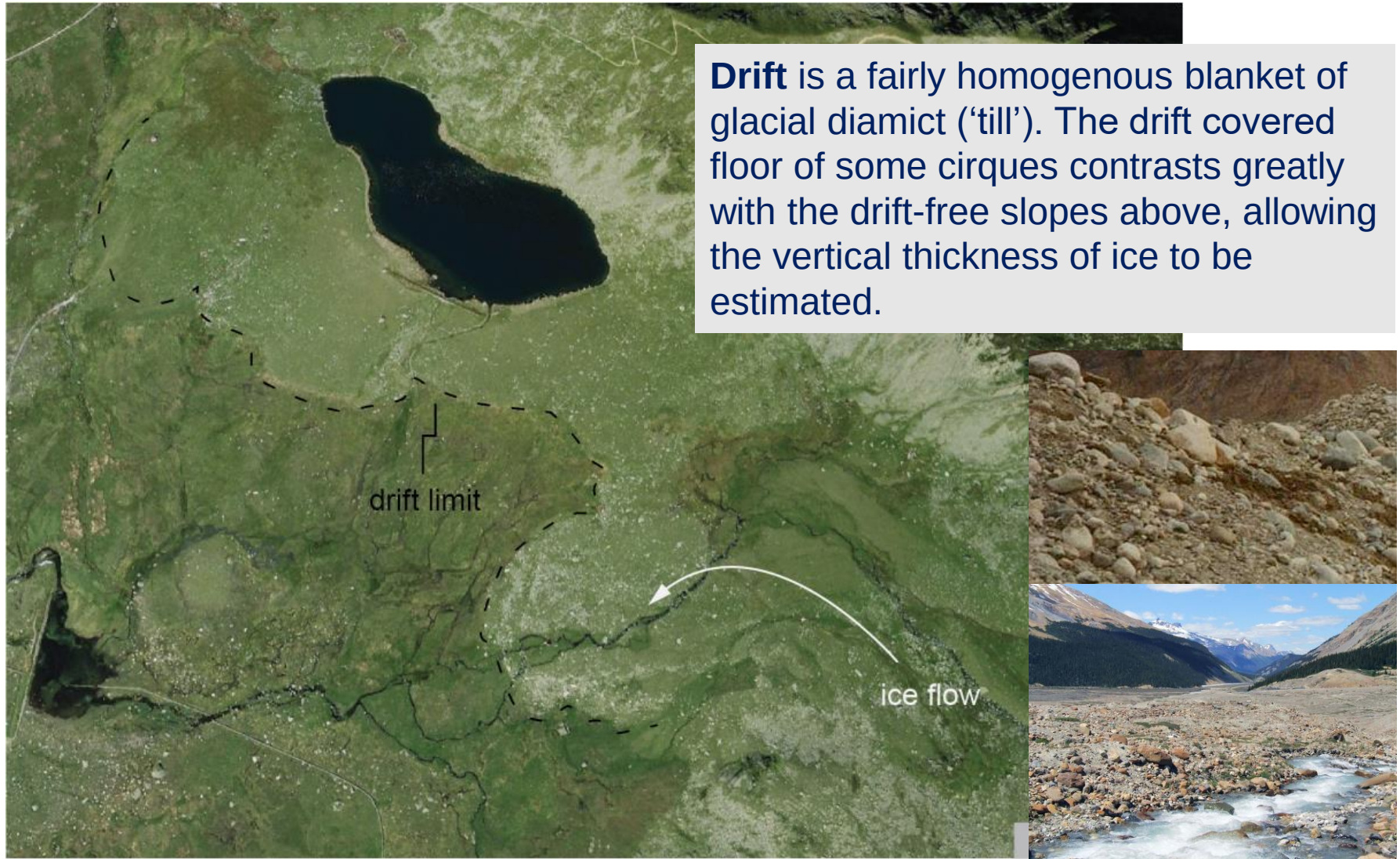
Drift/Till in Snowdonia



The limit of cirque glaciers is not always marked by moraine ridges. Sometimes, glacial extent is recorded by **'drift'**.

Glacial drift (the light-coloured ground dotted with boulders) marking the limit of cirque glaciers in Snowdonia, North Wales. Image from Google Earth

Drift/Till in Snowdonia

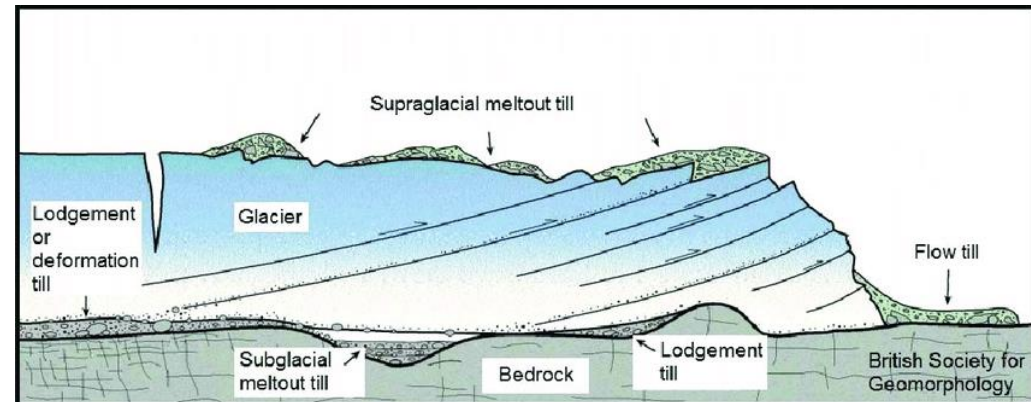
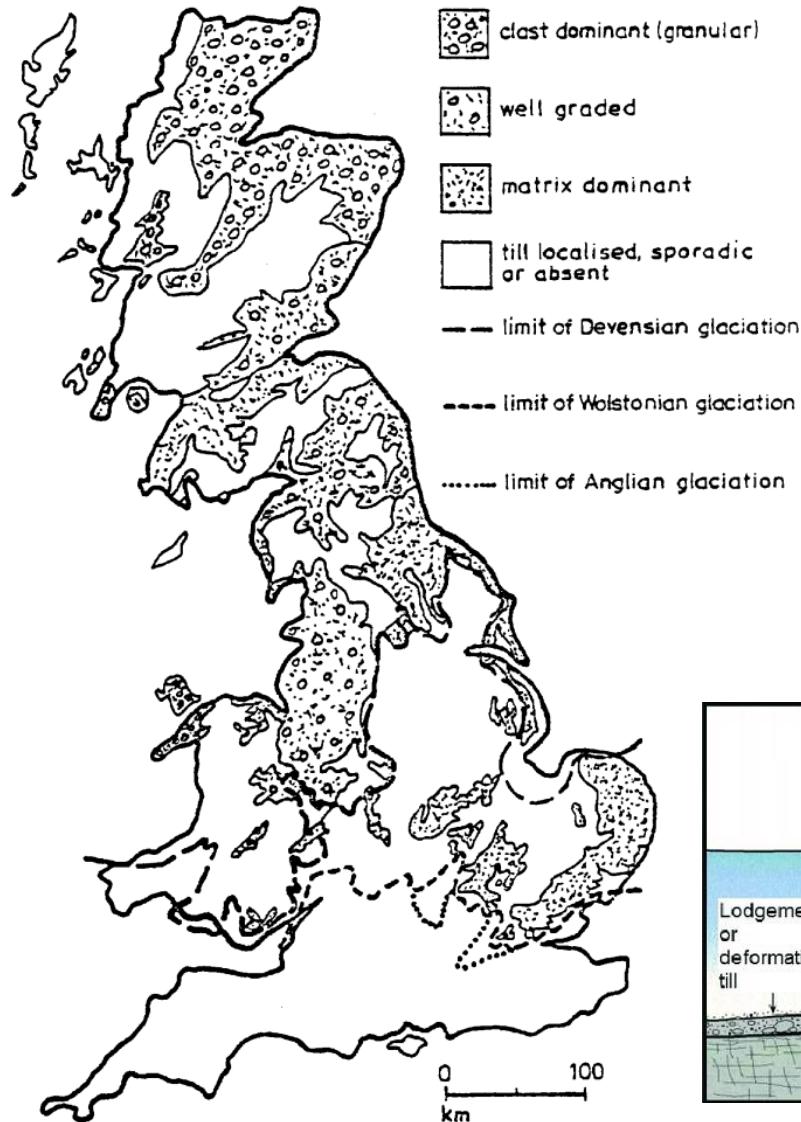


Drift is a fairly homogenous blanket of glacial diamict ('till'). The drift covered floor of some cirques contrasts greatly with the drift-free slopes above, allowing the vertical thickness of ice to be estimated.

Glacial drift (the light-coloured ground dotted with boulders) marking the limit of cirque glaciers in Snowdonia, North Wales. Image from Google Earth

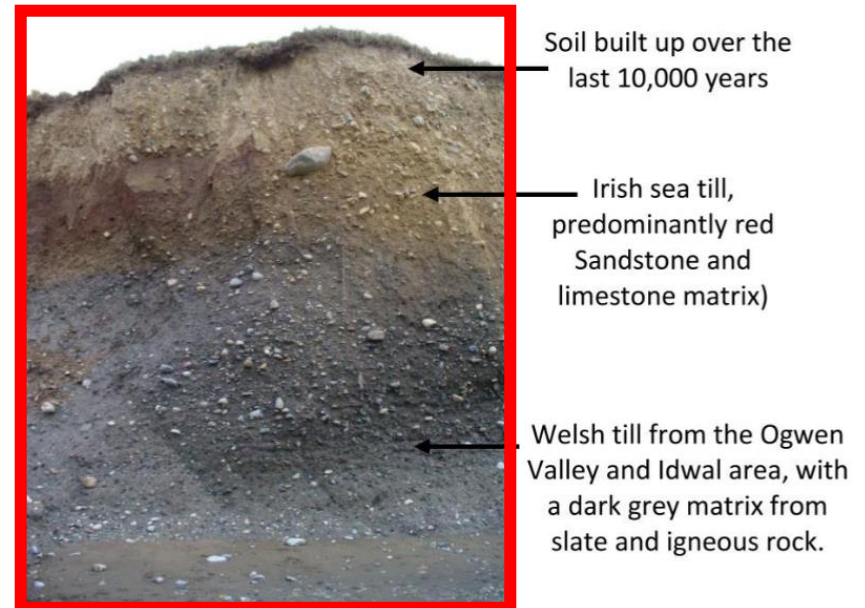
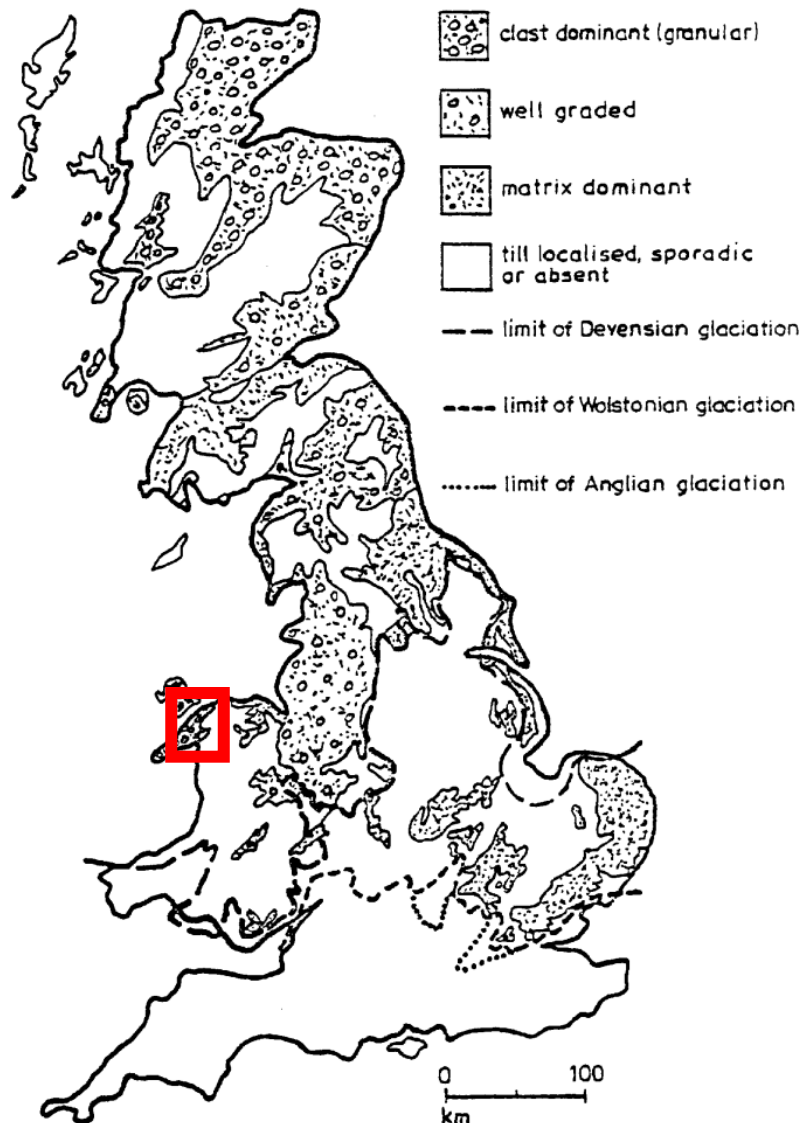
Glacial Till in the UK and Wales

- Map of Till in the UK (from Lewis, 1983)



Glacial Till in the UK and Wales

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Glacial evidence in Wales

-  Drainage channel
-  Late Devensian Welsh Ice Readvance
-  Irish Sea ice
-  Welsh ice
-  Arvon Advance
-  Drumlin field
-  Iced dammed lake

[P916210.jpg \(1011×1400\) \(bgs.ac.uk\)](#)



- Rivers usually braided - abundant sediment supply - rivers coalesce and deposit large volumes of material - **form outwash plains**

Glacial evidence in Wales



[P916210.jpg \(1011×1400\) \(bgs.ac.uk\)](#)

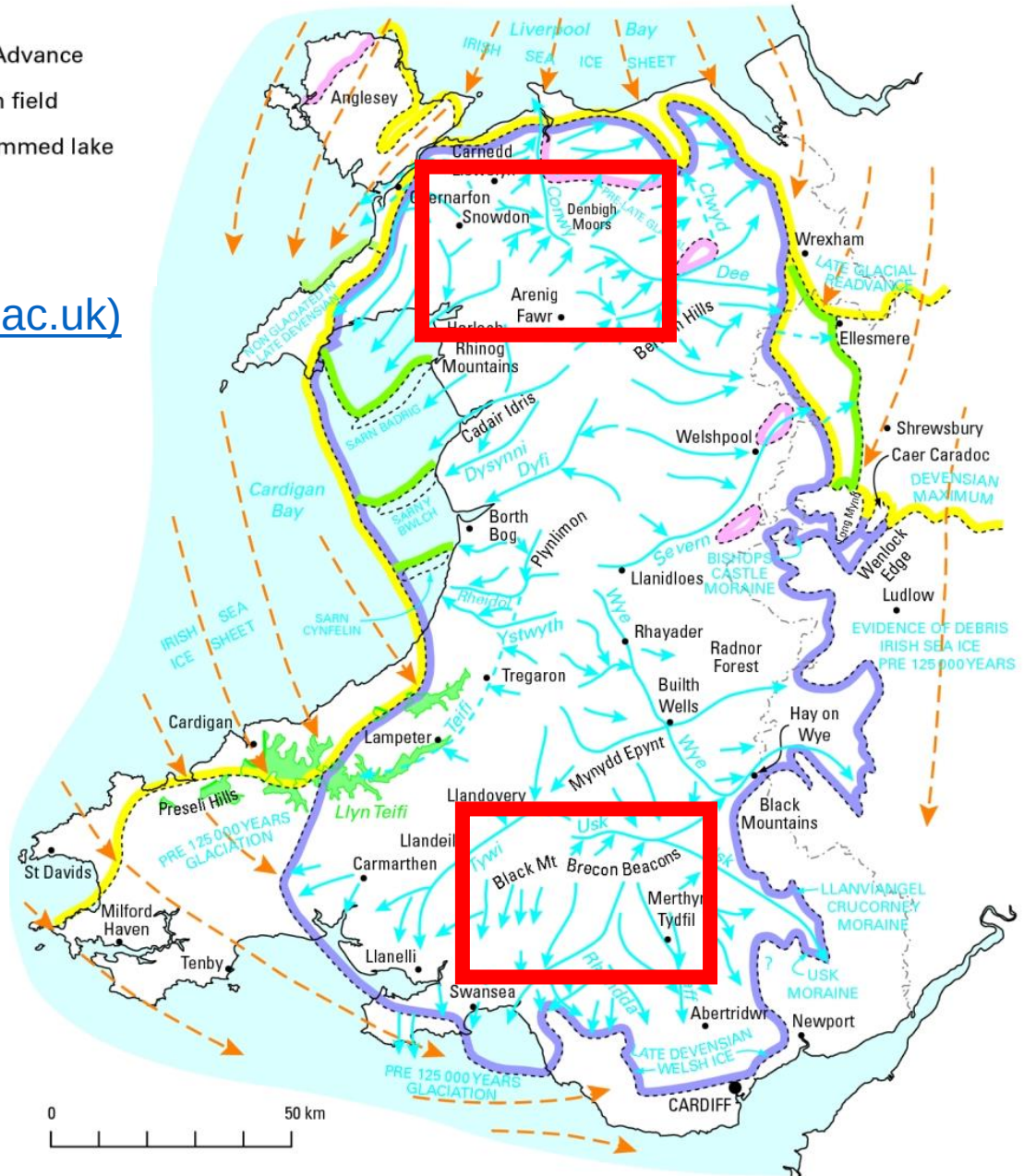


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Devensian Ice Sheet extent in South Wales?

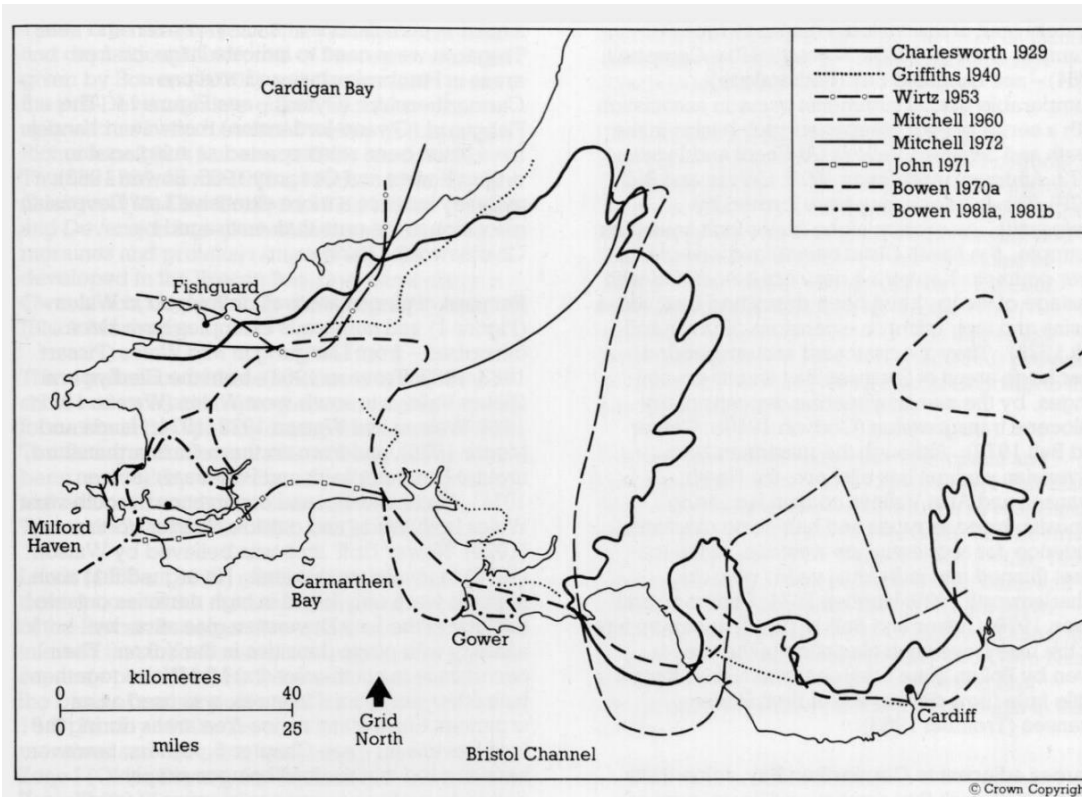
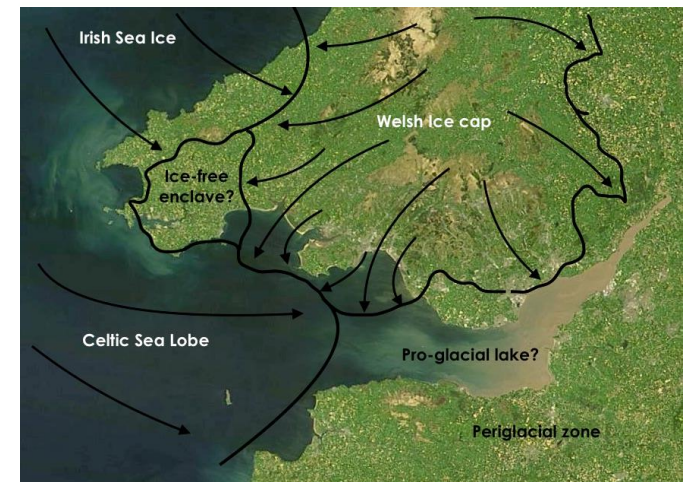
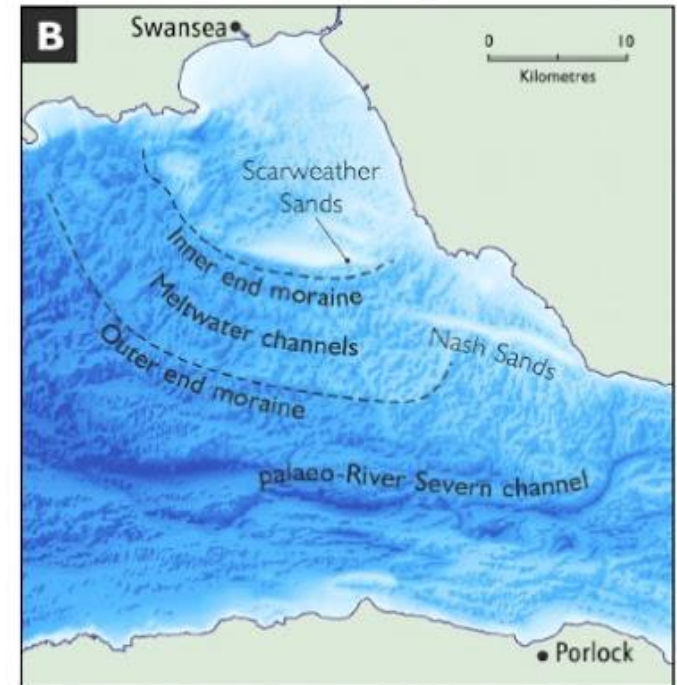


Figure 14 Some suggested Late Devensian ice limits in South Wales (from Bowen and Henry 1984; Campbell 1984)

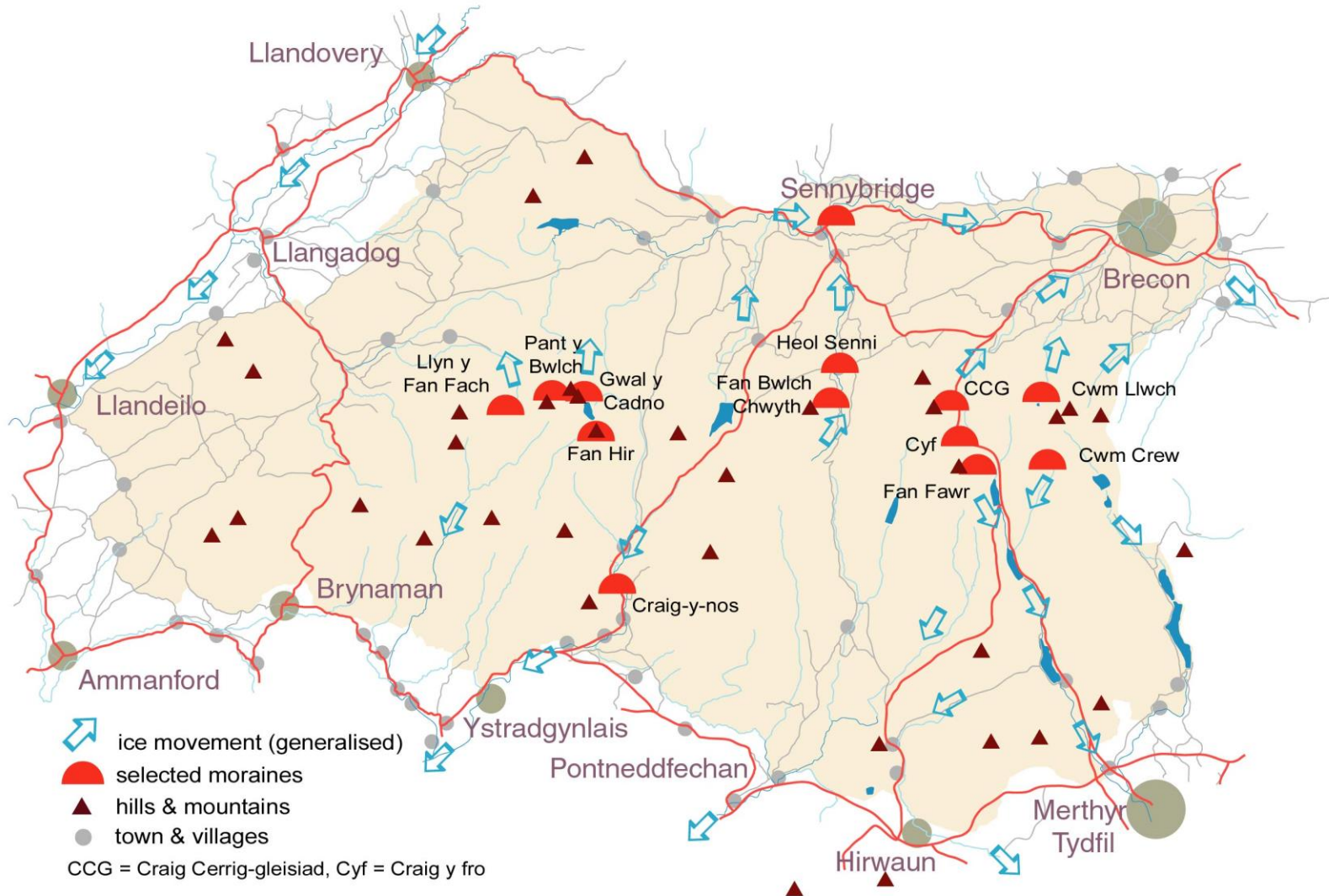
- Glacial extent in South Wales has been largely debated!

[Stonehenge and the Ice Age: The Glaciations of Gower \(brian-mountainman.blogspot.com\)](http://brian-mountainman.blogspot.com)



Glacial evidence in Brecon Beacons

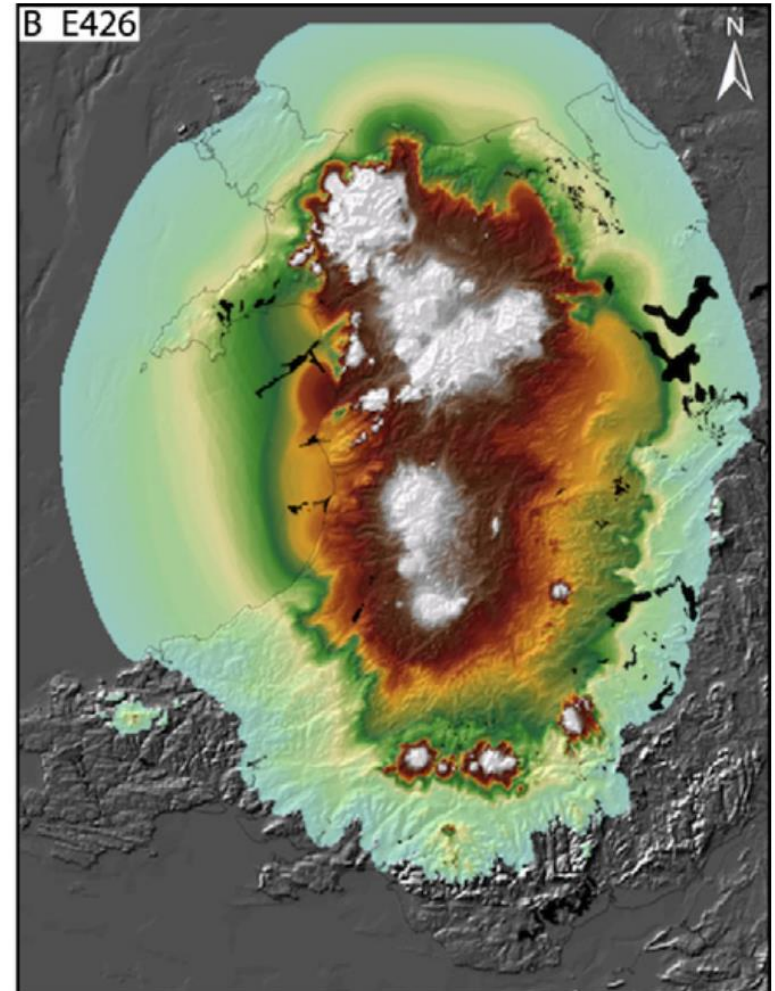
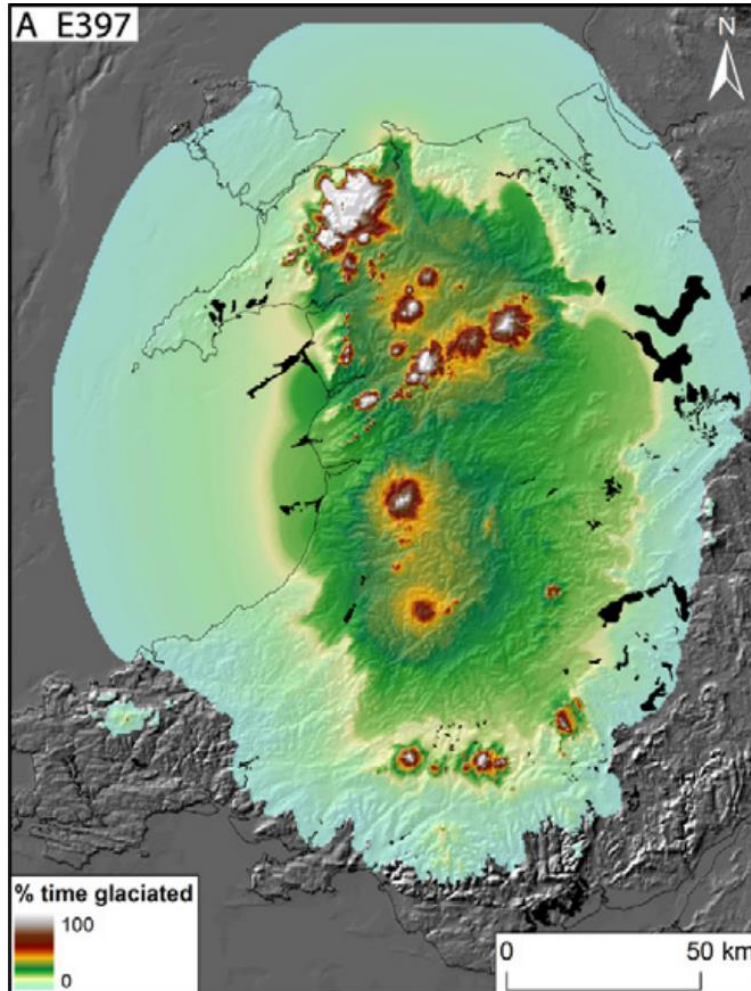
- [Quaternary Period | Fforest Fawr \(fforestfawrgeopark.org.uk\)](http://fforestfawrgeopark.org.uk)



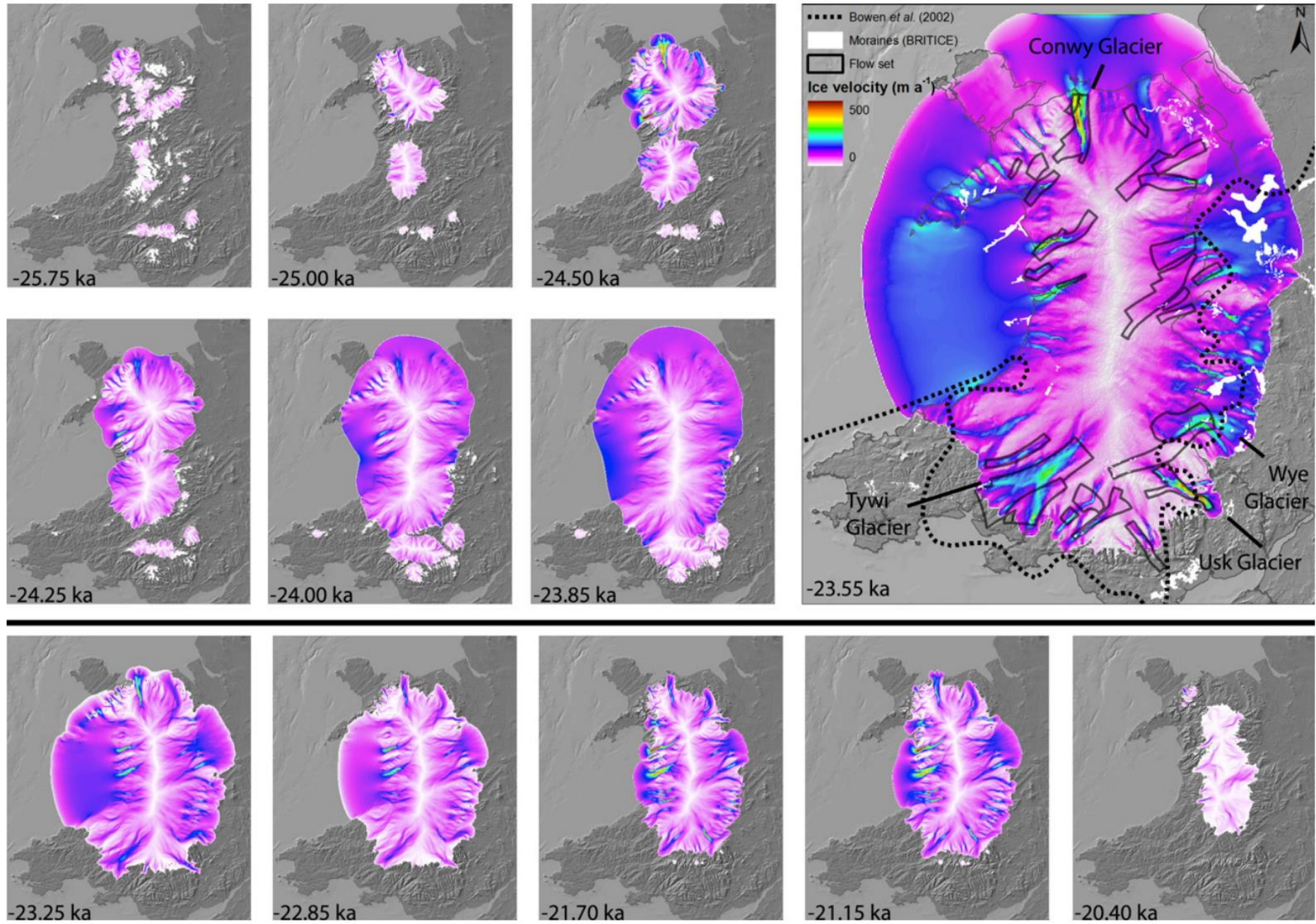
Glacial evidence in Brecon Beacons

Modelling LGM glacial extent in Wales

- Figure shows % of time glaciated (Patton et al., 2013). Model uses a suppressed LGM model (left) and a stronger LGM (with additional cooling pre-LGM). Black areas show moraines mapped in the BRITICE database (which we will explore later).



Glacial evidence in Brecon Beacons



Glacial evidence in Brecon Beacons

- Modelling LGM glacial extent in Wales
- Figure shows ice velocity (from Patton et al., 2013).

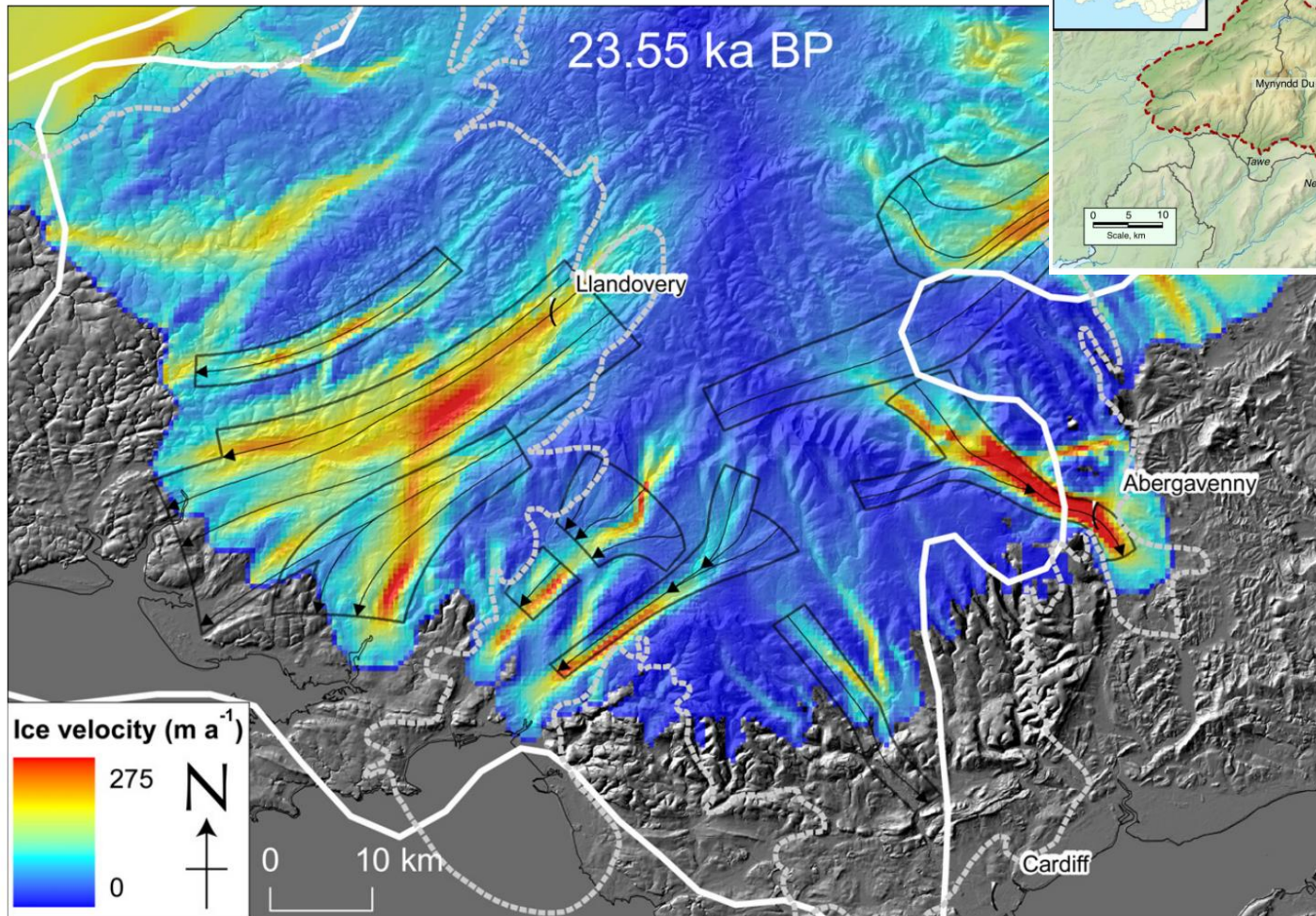
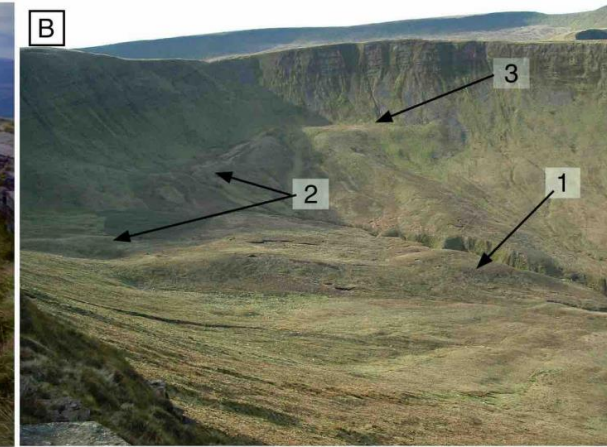


Fig. 9. Time-slice from the optimum experiment LGM, overlain by flowsets mapped from remotely sensed imagery. The bearing of major ice streams around the Brecon Beacons reflects the obstacle it provided for southward-flowing ice. Empirically derived ice limits are also shown by a solid white line (Bowen *et al.* 2002) and dashed grey line (Charlesworth 1929). Black arrows show empirically derived flow directions, determined from flowsets shown in Fig. 1. This figure is available in colour at <http://www.boreas.dk>.

Glacial evidence in Brecon Beacons

Upland Geomorphology: a) Long ridge running north-south beneath Fan Hir. This feature continues to be of interest, having been interpreted as a pronival rampart or terminal moraine of Younger Dryas age and even as a lateral moraine emplaced during the LGM. The current consensus is that this feature is a Younger Dryas terminal moraine.



b) Series of ridges within Cwm Oergwm interpreted by Coleman and Carr (2008) as terminal moraines associated with the maximum (feature 1) retreat phases (features 2) of a Younger Dryas glacier, and a contemporaneous pronival rampart (feature 3).

c) Complex of ridges within Cwm Sychlwch, beneath Fan Foel, Mynydd Du. Note also the well-developed talus accumulations described by Curry and Morris (2004).

Glacial evidence in Brecon Beacons

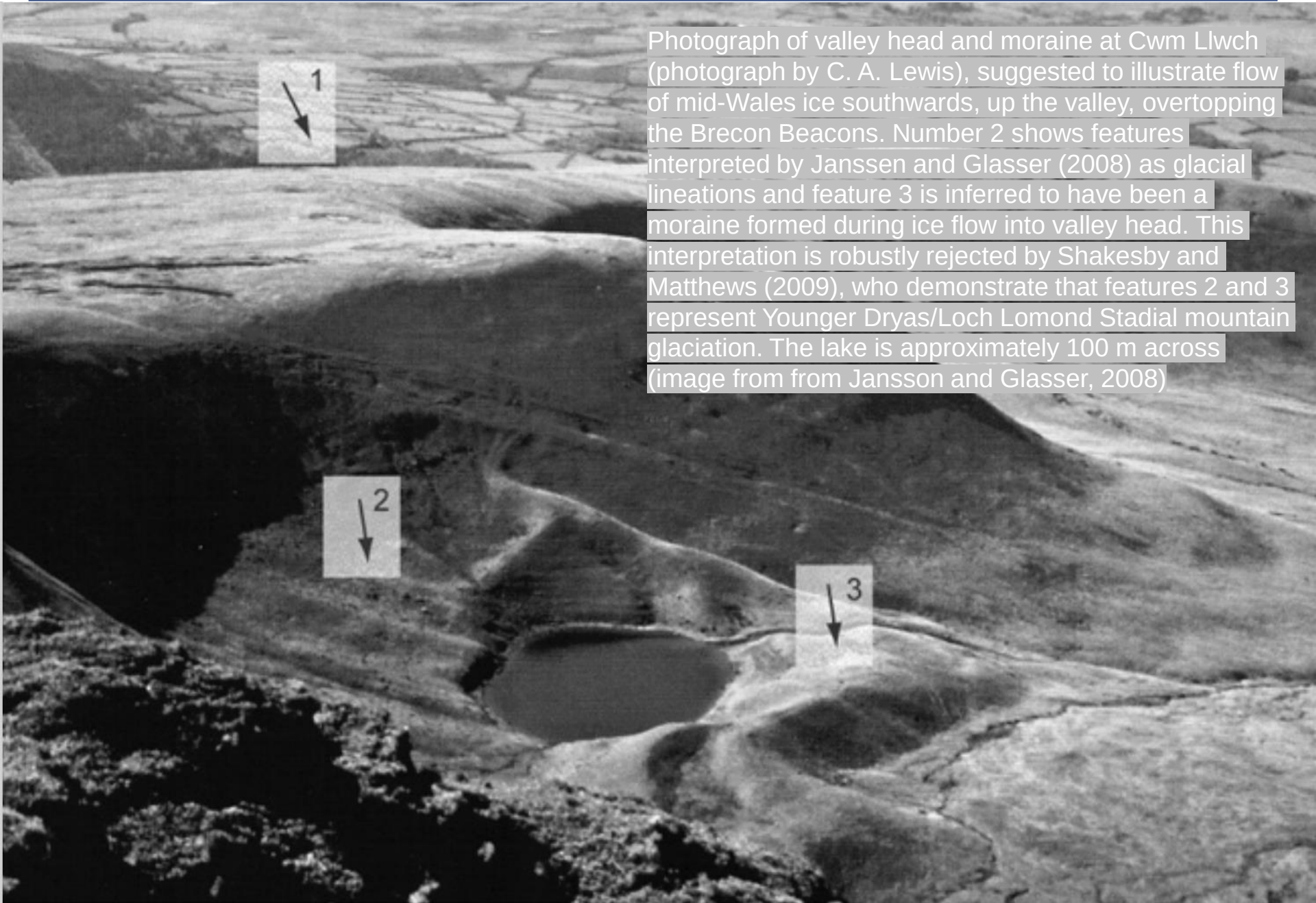
Scar exposed by Rock Slope Failure

Rock Slope Failure

Un-named and previously unreported rock slope failure beneath the Waun Rydd plateau, central Brecon Beacons. Large-scale paraglacial mass-movements are common in the region, albeit not commonly reported.



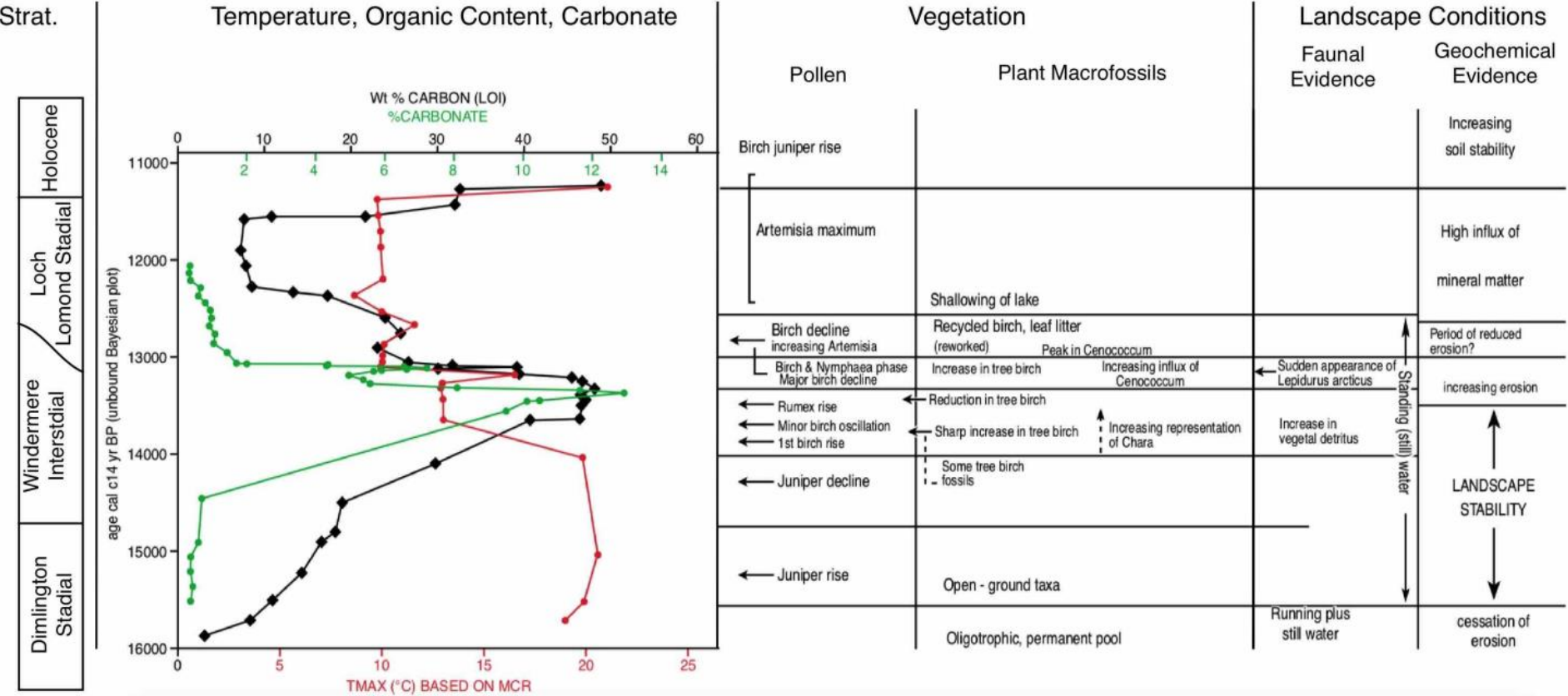
Glacial evidence in Brecon Beacons



Photograph of valley head and moraine at Cwm Llwrch (photograph by C. A. Lewis), suggested to illustrate flow of mid-Wales ice southwards, up the valley, overtopping the Brecon Beacons. Number 2 shows features interpreted by Janssen and Glasser (2008) as glacial lineations and feature 3 is inferred to have been a moraine formed during ice flow into valley head. This interpretation is robustly rejected by Shakesby and Matthews (2009), who demonstrate that features 2 and 3 represent Younger Dryas/Loch Lomond Stadial mountain glaciation. The lake is approximately 100 m across (image from Jansson and Glasser, 2008)

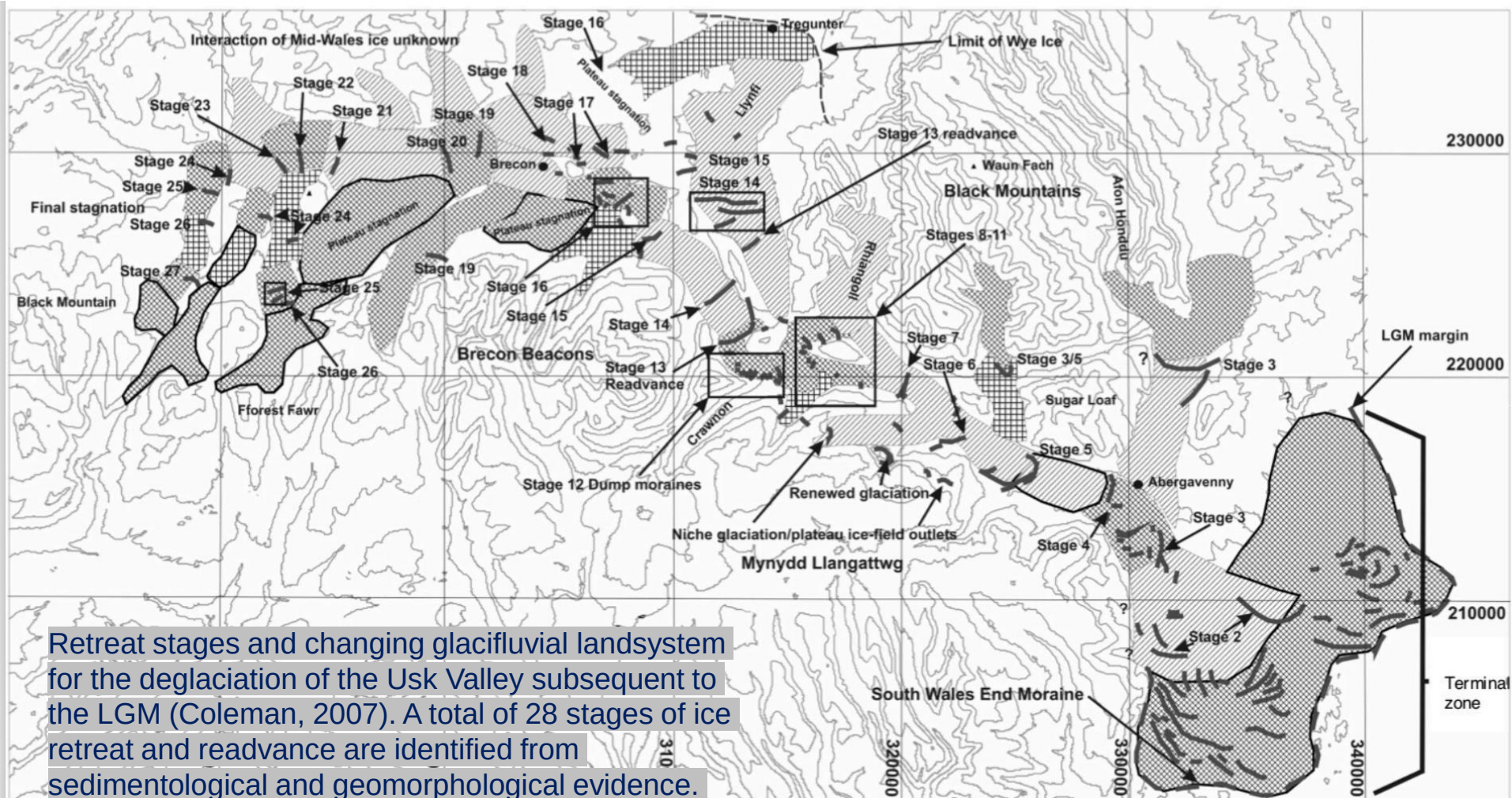
Glacial evidence in Brecon Beacons

Synthesis of the palaeoenvironmental record from Llanilid (adapted from Walker et al., 2003), showing the **dramatic temperature shifts** (derived from coleoptera mutual climatic range data), vegetation and ecology of South Wales and the Brecon Beacons associated with the Last Glacial-Interglacial Transition (LGIT)



Glacial evidence in Brecon Beacons

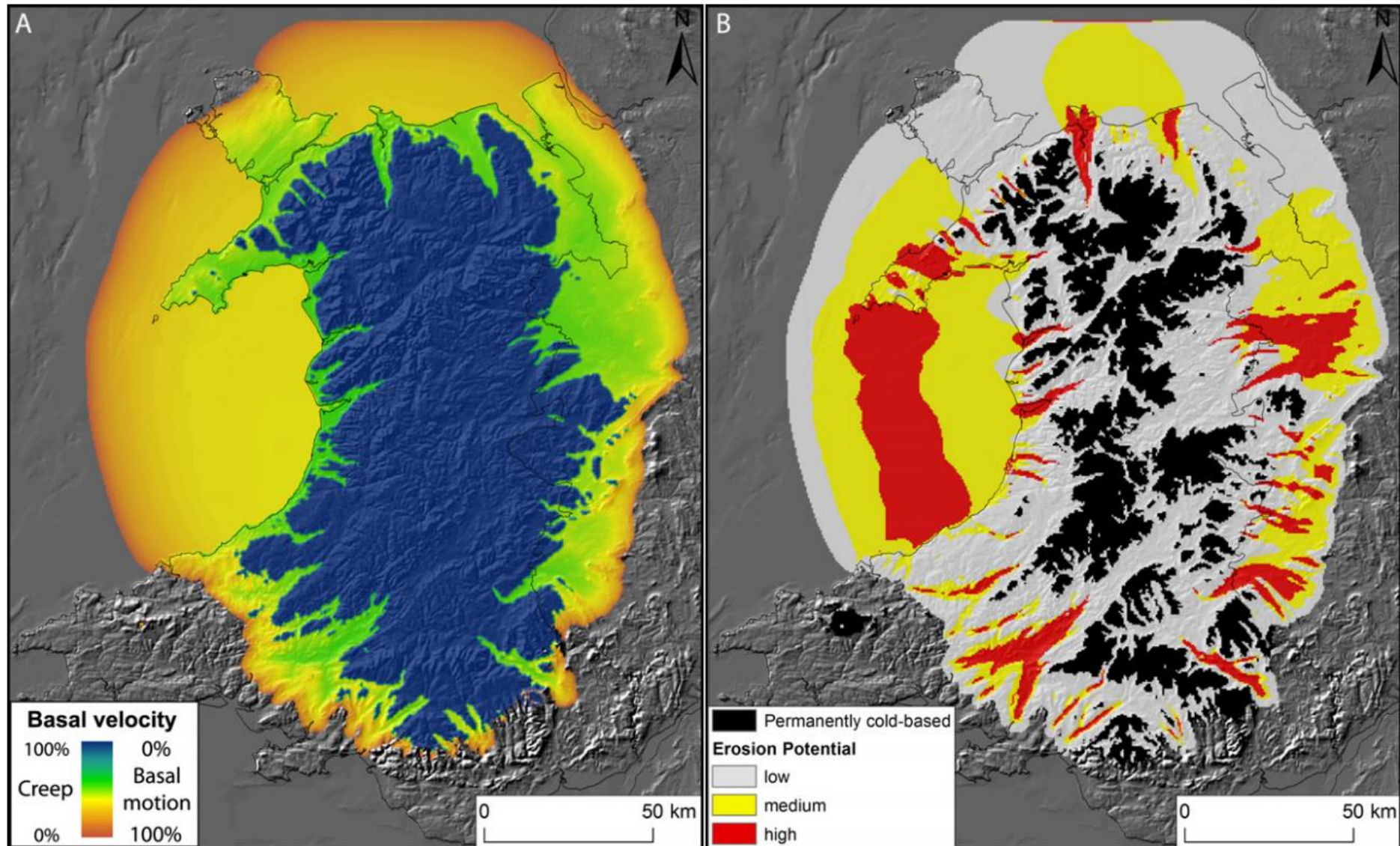
- Modelling LGM glacial extent in Wales
- Figure shows geomorphic mapping of Brecon Beacons (Carr)



Retreat stages and changing glacialfluvial landsystem for the deglaciation of the Usk Valley subsequent to the LGM (Coleman, 2007). A total of 28 stages of ice retreat and readvance are identified from sedimentological and geomorphological evidence. Bold black lines mark moraines. Active glacier retreat is marked by diagonal lines, and rapid wastage or stagnation is marked by cross-hatches.

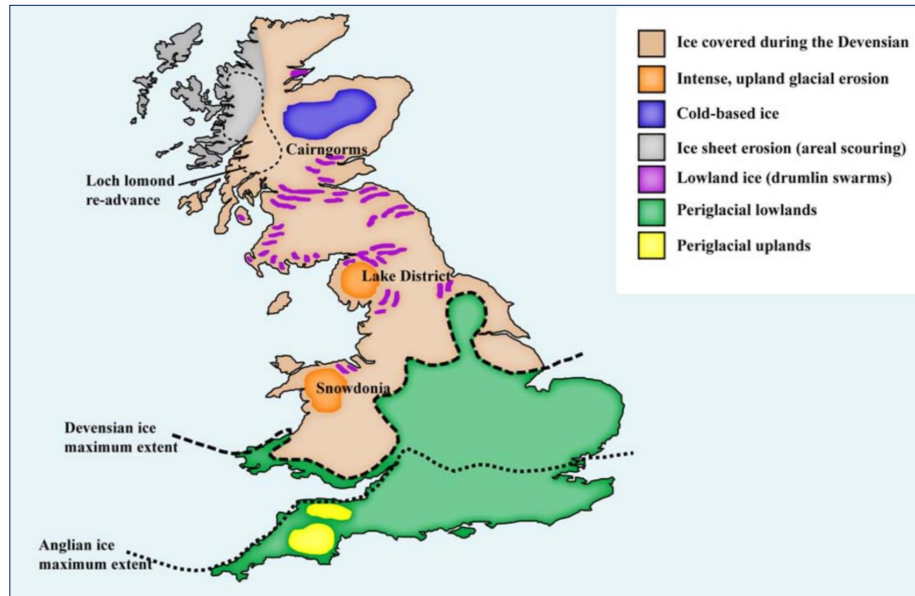
Glacial evidence in Brecon Beacons

- Figure shows basal velocity and erosion potential (Patton et al., 2013).



Glacial evidence in Brecon Beacons

- Figure shows basal velocity and erosion potential (Patton et al., 2013).

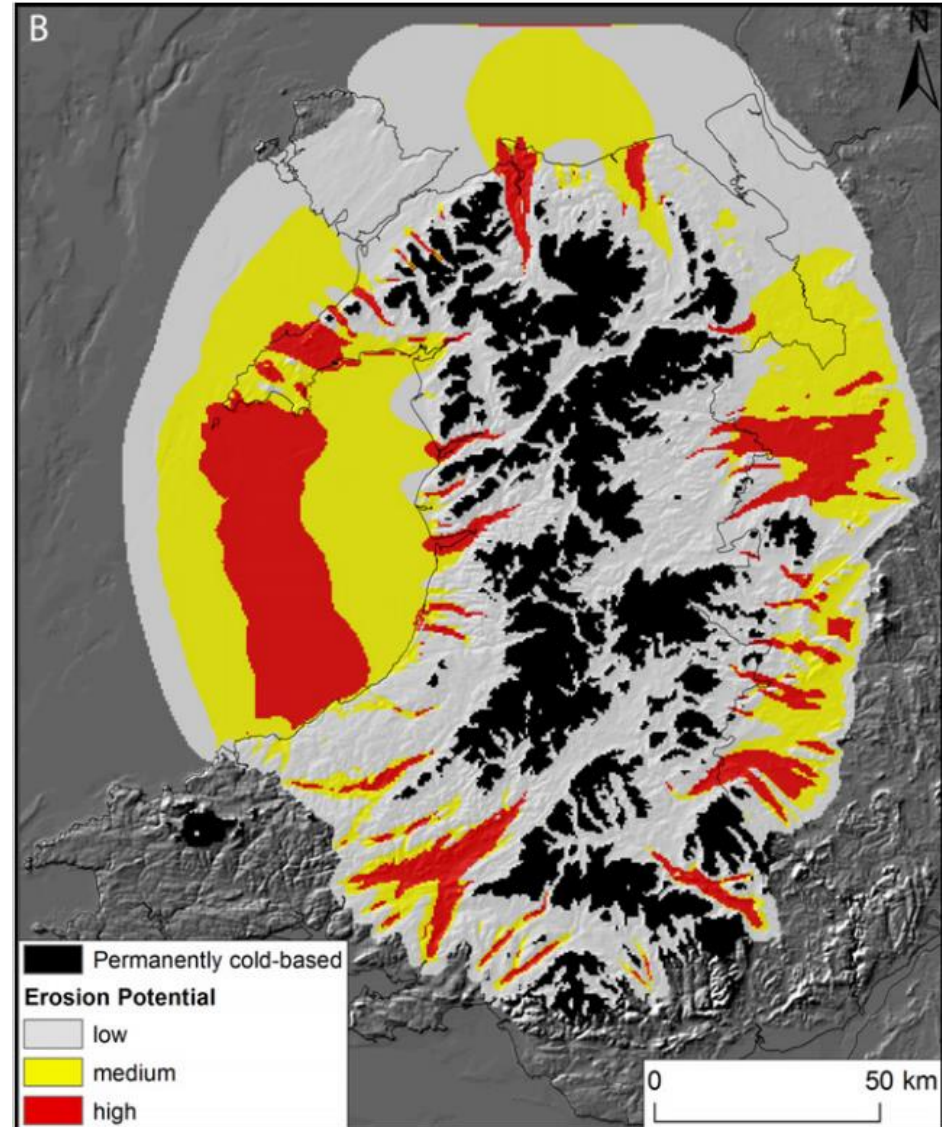


Further reading on Temperate and Cold-based glaciers:

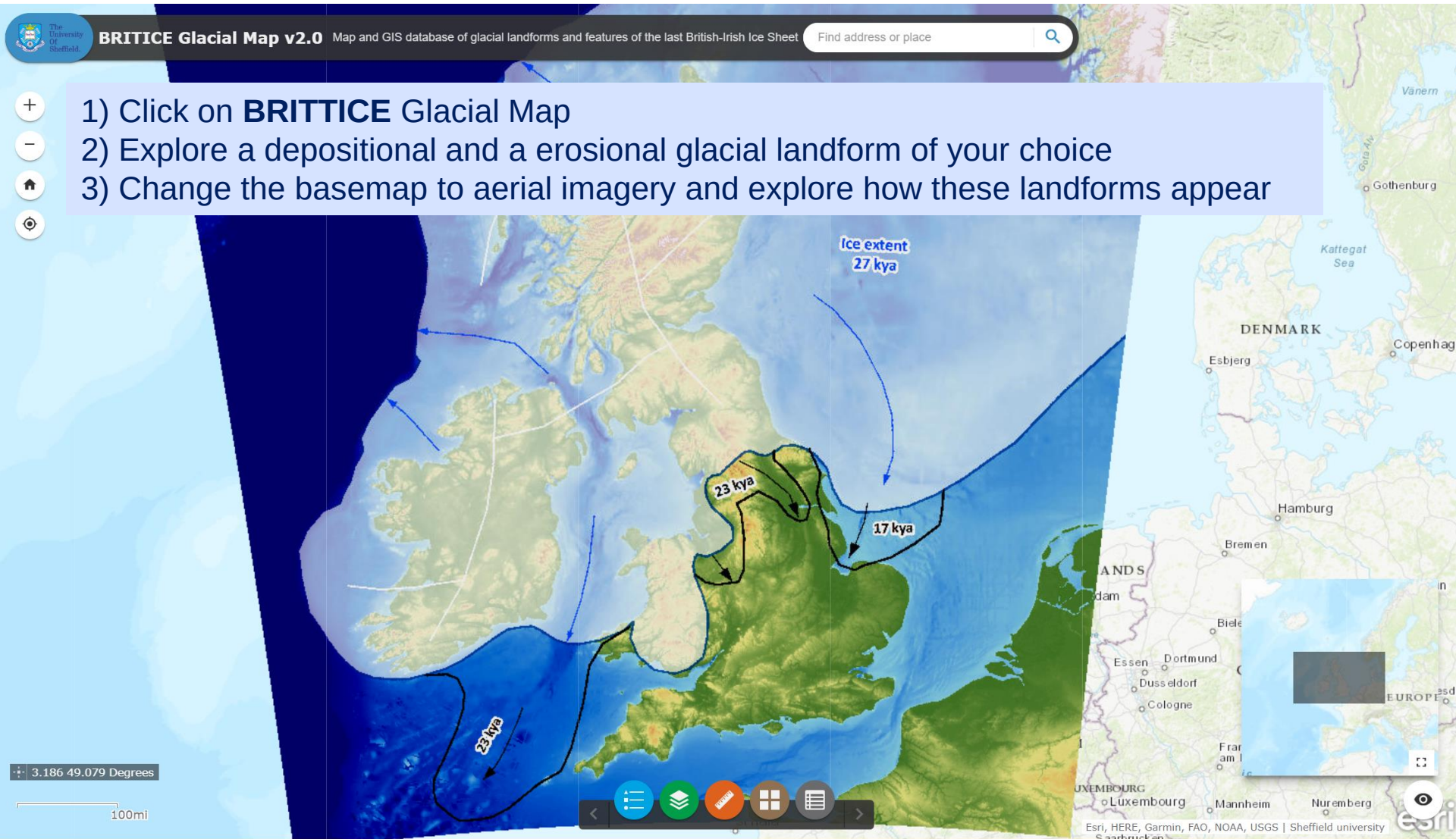
[Glacial thermal regime \(antarcticglaciers.org\)](http://antarcticglaciers.org)

[Glacial processes \(heartofavalonia.org\)](http://heartofavalonia.org)

[Science of Glaciers | National Snow and Ice Data Center \(nsidc.org\)](http://nsidc.org)



Glacial Mapping Activity



[BRITICE Glacial Map v2.0 \(arcgis.com\)](https://arcgis.com)

Report writing clinic

- 1) Structure
- 2) Writing effective paragraphs
- 3) Providing Feedback + Receiving Feedback
- 4) Referencing
- 5) Effective Figures
- 6) Submission process