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Residential field studies for GCSE and A Level Geography and Geology in the UK, Andorra and Spain.

VIRTUAL FIELDWORK ACTIVITY EIGHT

Studying features of glacial erosion and deposition in the North West Highlands of Scotland.

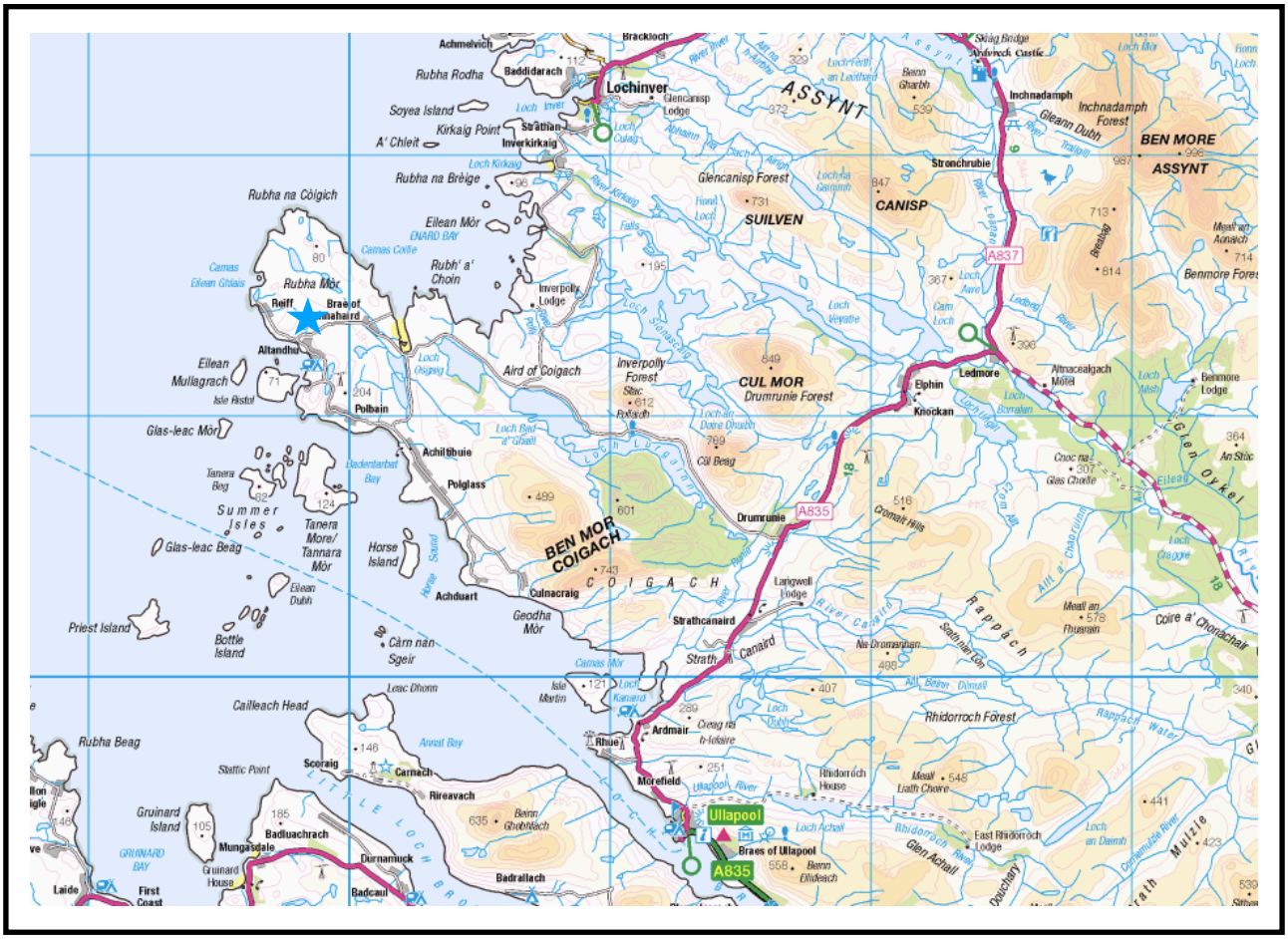
Location and background.

The aim of this study is to

1) use aerial photography, field evidence and GIS to help us understand the former direction of ice movement during the last glacial maximum (Devensian).

2) Use field evidence and a simple key to work out the origin of the deposits exposed in a small cliff at Camas Mor Beach.

Our field study area is a few miles north of the town of Ullapool in the North West Highlands of Scotland. It is an area that displays some truly impressive landforms associated with the processes of glacial erosion and deposition during the last glacial maximum.



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Using MACRO SCALE evidence to study the direction of ice movement.

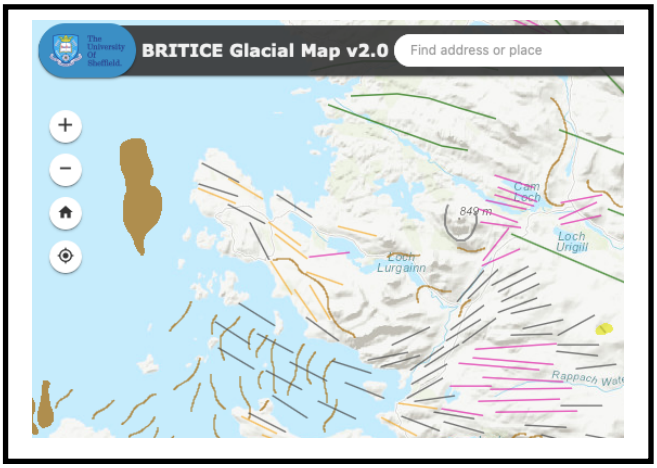
Our glaciation field study courses explore many places around the Ullapool area, in the Coigach Peninsula and the North West Highlands Geopark. We start every course with a journey to a viewpoint near Altandhu (NB 984 133 - marked with a blue star on the map above) where there is a superb view southwards to the Summer Isles.

What features can you see in this photograph that would suggest the direction of former ice movement?

The shape of the some of the islands is typical of ice-scoured bedrock - imagine huge roche-mountonees and you get the idea. This tells us that these islands were once underneath a vast ice sheet that was moving from east to west (left to right in this photograph). This was the Devensian Ice Sheet, often called the Last Glacial Maximum. This glacial period started around 28,000 years ago (28 ka BP) and ended around 14.7 ka BP.

Our interpretation of this photograph is supported by secondary data from the BRITICE website -

https://shefuni.maps.arcgis.com/apps/webappviewer/index.html?id=fd78b03a74bb477c906c5d4e0ba9abaf



You can see dark lines indicating the trend of ice-scoured bedrock, areas of terminal moraine out to sea (large brown patches) and the wavy brown lines indicating recessional moraines as the ice sheet retreated.

The bright pink lines indicate an area of intensely eroded terrain that is termed the “Ullapool Megagrooves” and this area is observed during our field study courses as we drive from site to site.

The Ullapool Megagrooves are best seen using aerial images - see next page.

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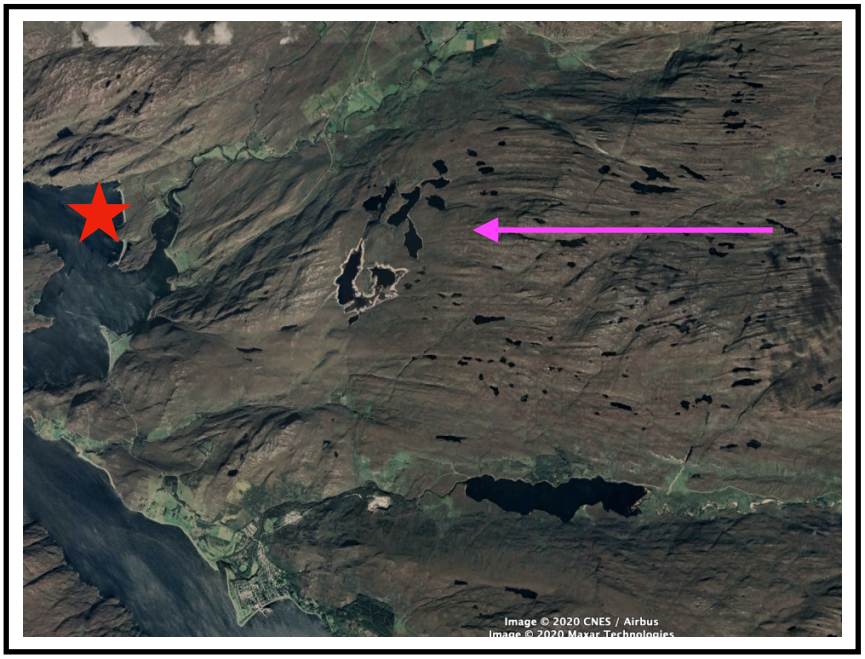


Google Earth image of the area known as the Ullapool Megagrooves - indicated on the BRITICE map above with parallel pink lines.

The importance and extent of numerous areas of megagrooves was first studied in a paper by Tom Bradwell in 2005:-

Bradwell, T., 2005: Bedrock megagrooves in Assynt, North West Scotland. Geomorphology, 65: 195 - 204.

Using MICRO SCALE field evidence and GIS to plot the direction of former ice movement.

Our field study courses also include opportunities to study micro-scale glacial features. Camas Mor beach in Strathcanaird (indicated with a red star in the Google Earth image above) has some outcrops of glacially eroded sandstone at either end of the beach. Both exposures show very distinctive evidence of erosion by moving ice in the form of striations.

Well preserved striations at NC 111 007 on Camas Mor Beach.

30 cm ruler for scale.

The striations are particularly well preserved here as they have only recently been exposed by the erosion of overlying superficial deposits by the sea.

We used a compass to measure the orientation of striations at both ends of Camas Mor beach and the field data is recorded in this table.

Site number	OS grid reference	Latitude	Longitude	Orientation of striations in degrees
1	NC 111 007	57.9560	-5.1925	**254**
2	NC 111 001	57.9510	-5.1914	**248**

Using ARCGIS to plot the orientation data.

ARCGIS is an extremely powerful GIS package but many people assume that one needs an account to use it. Although this is the case to use the more advanced features, many tools are still available on the free browser version, including the ability to plot arrows to indicate the direction of ice flow.

The first thing that you need to do is to create an excel or numbers spreadsheet with 3 column and 2 rows for site one and site two. You will need latitude, longitude and orientation of striations.

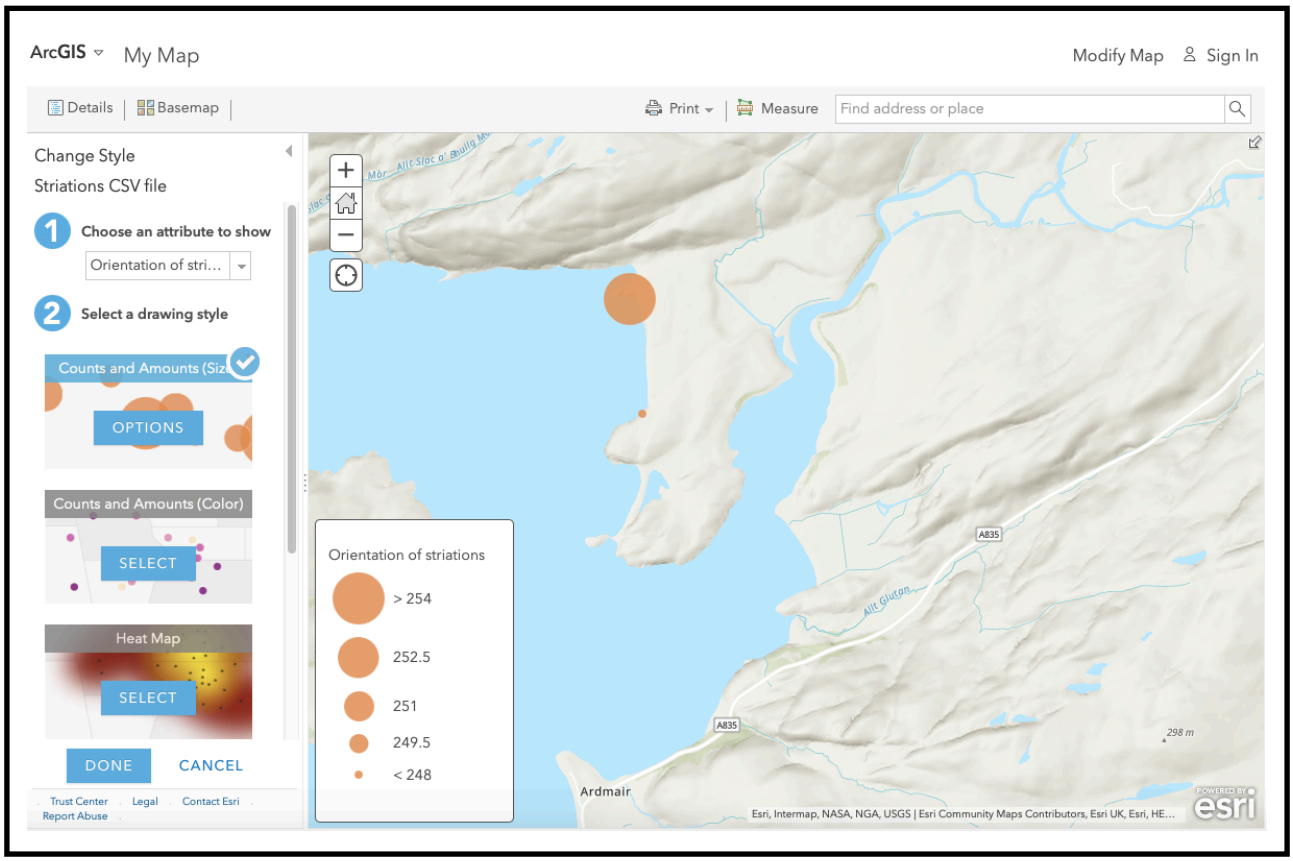
This spreadsheet needs to be saved as a CSV file.

There is a CSV file available to download on the website.

Then you need to open ARCGIS on your browser

https://www.arcgis.com/home/webmap/viewer.html

Drag and drop the CSV file onto the browser page and the result will look like this initially.



This has accurately shown the location of both the pieces of data, but is representing the value (the orientation) as a proportional circle and not as a direction.

A few simple adjustments within the various settings enable this to be changes to show data as arrows that are pointing in the correct direction - the orientation of the striations.

By going into the Details section and playing with the choice of symbols, choosing Rotate Symbols (degrees) and adjusting the size of the symbols you can end up with a map as shown on the next page.

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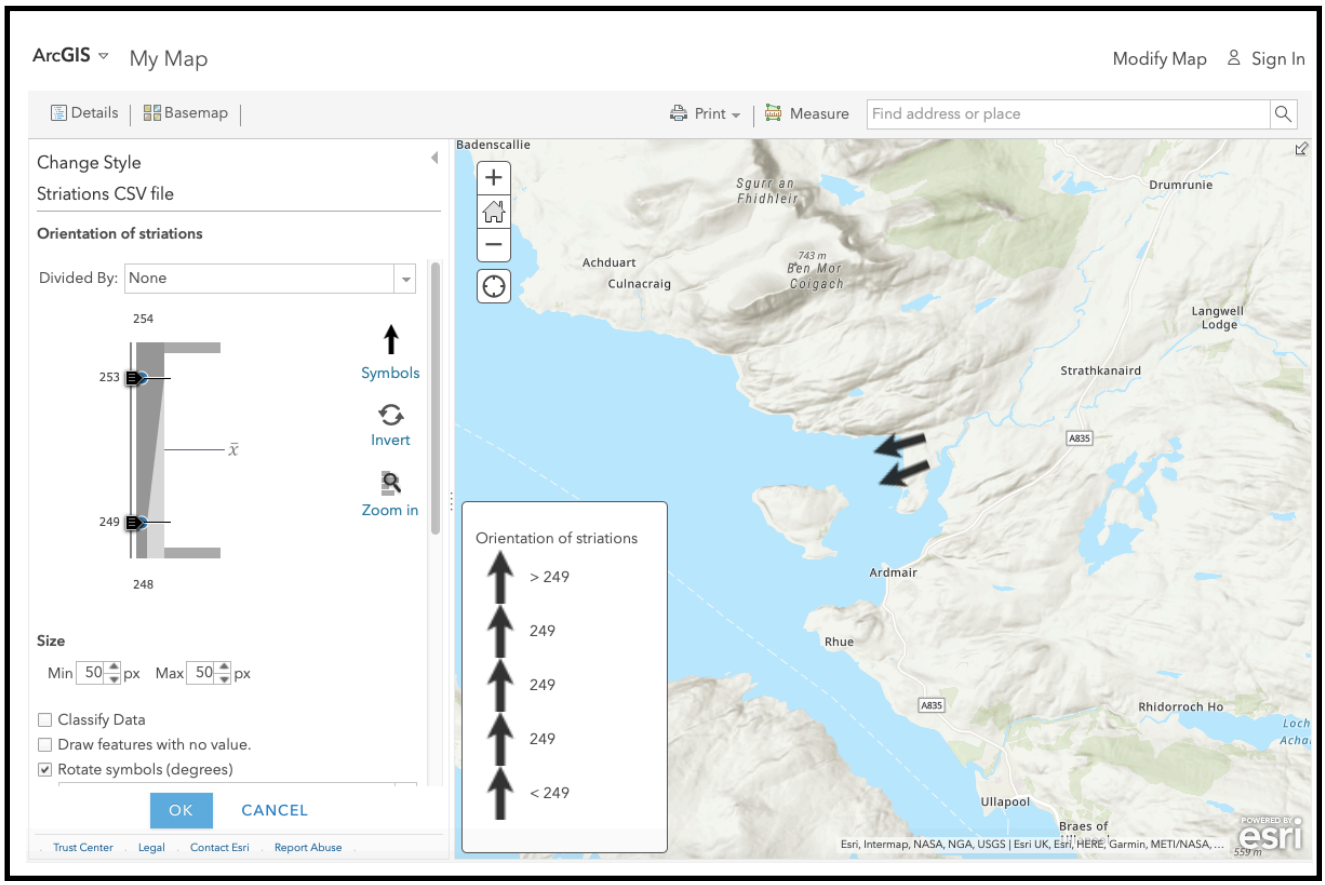
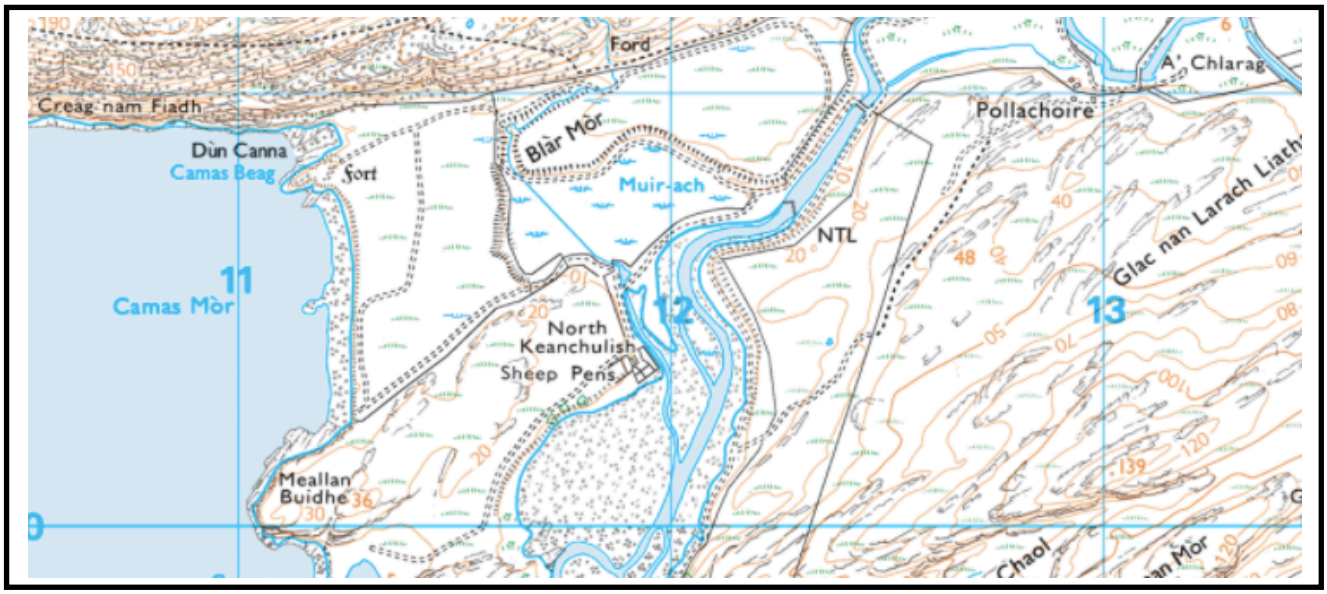


How does this map fit in with the MACRO SCALE evidence of ice movement?

It is clear that all the evidence points towards a major ice stream travelling east to west but being partially deflected south westwards by the mass of Ben Mor Coigach before rejoining the main east to west flow out over the Summer Isles.

If this is the case the Camas Mor beach should be within a U-shaped valley - a classic glacial trough? But look at this more detailed map - is this the case?



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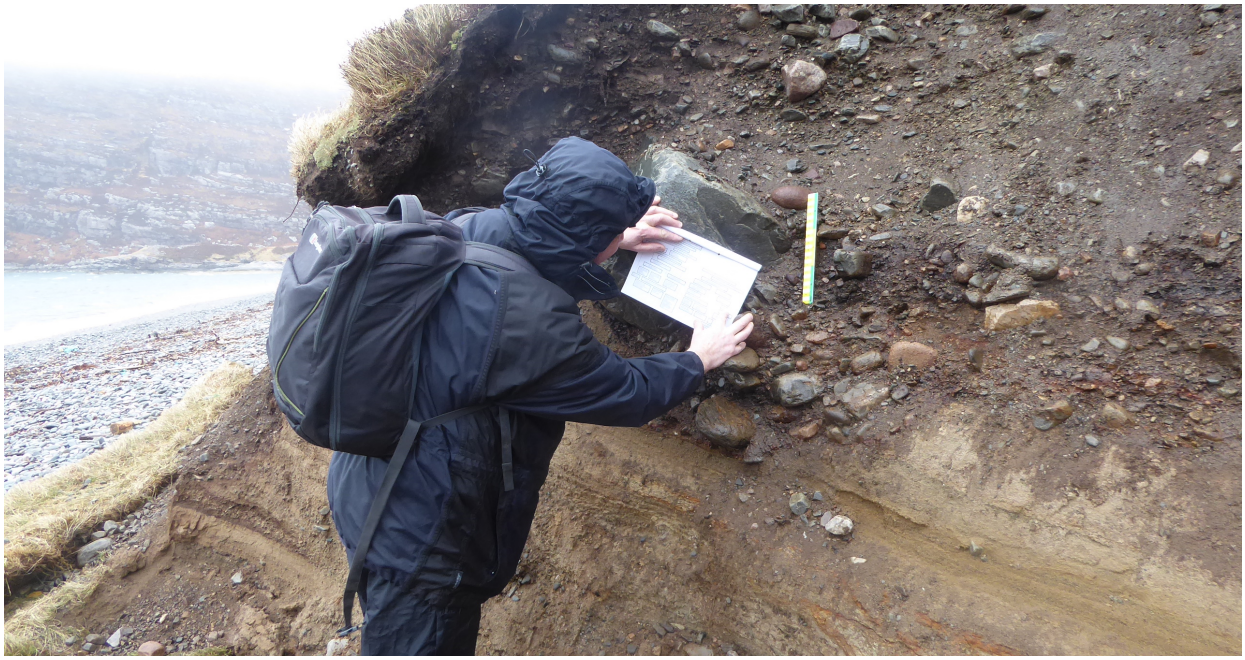
The valley floor inland of Camas Mor beach is a large flat terrace, with a meandering river valley cutting down into the terrace and with the sea eroding a cliff into the terrace at the back of the beach.

The cliff at the back of the beach gives us the chance to study this terrace, discover how it was formed and learn why what should be a deep U shaped glacial trough is a flat-bottomed wide valley.

Using a key to determine the origin of glacial sediments.

Study the photographs of the sediments that form the terrace filling the valley floor. The sea has eroded a cliff into the terrace exposing a section through the deposits. Use the simple key to try and determine the origin of these deposits. 30 cm ruler (and a person!) are included for scale. (don't be confused by the anomalously large boulder when answering question one on the key)



A simple key to determine the likely origin of glacial sediments.

Adapted from "Field exercises in the interpretation of Pleistocene Deposits"
by Peter Keene 1995.
Published by Thematic Trails, Oxford.
ISBN 0 948444 29 0
https://www.thematic-trails.org/index.htm

1. In the part of the section you are examining the material is sorted roughly into particles of the same size in any given layer or bed?

Yes - **2.**

No - **3.**

2. In the part of the section you are examining the stones are mostly rounded?

Yes - **4.**

No - **5.**

3. In the part of the section you are examining does the material consist of larger stones embedded in a much finer material?

Yes - **6**.

No - **7**.

4. You are probably looking at a deposit of Glacio-Fluival origins such as an outwash plain. The glacial meltwater transports the material and attrition causes them to become more rounded. Huge changes in discharge causes the streams to braid and deposit different particle sizes in different places - hence the sorting of size in different layers.

5. You are probably looking at ice-contact drift such as a kame terrace or within an esker. The meltwater varies in discharge causing rapid changes in particle size in the layers but stones have been transported a relatively short distance hence little attrition compared to fluvioglacial.

6. You are probably looking at a deposit of glacial moraine. Study the stones in detail. Is there a variety of different rock types all mixed up? This would indicate that the moraine has been deposited by a glacier that was eroding a large and geologically varied area.

7. You may be looking at a solifluction deposit. Check to see if all the stones are pointing in a similar direction - downhill?

What is your result? What do you think is the origin of the deposits filling the bottom of this glacial valley? Is there a single definitive answer?

The "correct"answer is 4 - glacio-fluival deposits. The rapid changes of particle size, the predominantly rounded shape and the degree of sorting all indicates that this is a section through an outwash plain.

But there is that singularly large boulder - how did that get there? Could it have been a piece of moraine that was then surrounded by the outwash as the glacier retreated up valley?

(Have a look at the full version of this key - a scanned pdf version will be available on the website very soon. This is a very detailed and comprehensive resource written originally to aid the identification of superficial deposits in SW England but has been successfully used by students across the UK)

Conclusion and evaluation.

This is a large piece of fieldwork and builds up a picture of a complex story on varying scales.

How would you improve the quality of the evidence to enable you to add more detail to this story?

Camas Mor beach on a particularly cold and dull March day, looking southwards.

Further reading

The Quaternary of Western Sutherland and adjacent areas - a field guide. Edited by Sven Lukas and Tom Bradwell, 2010.
Quaternary Research Association. ISBN 0 907780 80 6