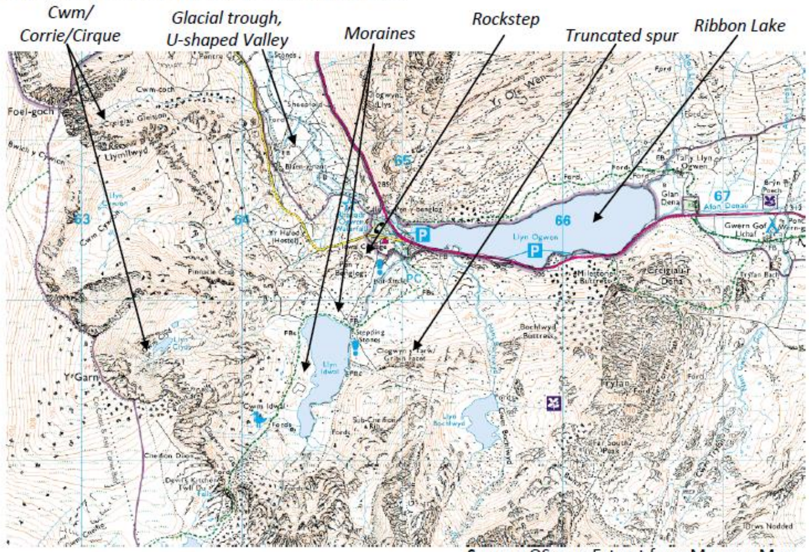
Glaciated Landscapes

1. Context and planning – what is the geographical enquiry process?

Prepare to investigate a geographical question in the field; make and justify decisions on the task including data collection methods and how to use them; define and refine the research question(s) that underpin the context of the field investigation; risk and ethical issues.

Nant Ffrancon Valley, Northern Snowdonia



Source: OS map Extract from Memory Map

Preparing to investigate a geographical question starts with an area of study that interests you. What would you like to know that would involve doing some research on your own?

Possible research areas:

- Characteristics and patterns of the assemblage of landforms within the landscape.
- Transport pathways and ice-flow directions identified within the landscape.
- Variations of glacial and/or fluvial sediments across landscape.
- Scope and scale of the glacial erosion / deposition in region X.

The **next steps to designing your investigation** might include:

- Internet research on locations that are appropriate for your area of interest.
- Researching fieldwork methods and techniques.
- Familiarising yourself with the key concepts and theories that relate to your research area.
- In designing your enquiry it can be helpful to consider the What, Who and How of the enquiry.

What	Who	How
What Geographical theory and context are you interested in researching? *What do you intend to do?* *What evidence would address your research aims?*	*Who would be involved?* *Who will provide consent to participate in your enquiry?*	*How will you carry out your enquiry?* *How will you ensure the ethics of your enquiry?* *How much time do you have?*

Once you have found your research area, you will want to find your **aim** and/or hypothesis. Aims are a statement of what you are trying to find out. In Geography there are broadly two kinds of aims:
Are things different from each other?
e.g. “How does the orientation of deposits vary between sediments sites A and B?”
Are things associated with each other?
e.g. “Is there a relationship between corrie back wall height and altitude in area X?”

Hypothesis is an idea or explanation that can be tested through study and experimentation.
e.g. A hypothesis could be: There is a significant difference in the angle of dip of clasts within glacial till deposited by ice sheet A and ice sheet B.

Written in partnership with Field Studies Council (FSC).
FSC is an environmental education charity established in 1943. It is the leading provider of fieldwork with over 50% of all A Level geography students visiting its network of centres each year. For further information please visit: http://www.field-studies-council.org/outdoorclassroom

Decide on the **location for the investigation** and develop your knowledge of the place(s) being studied, using O.S maps, local knowledge, aerial photographs and Google earth. Accessibility, safety considerations and considerations of scale will all be important. Ensure that you acquire a 'sense of place' about the glacial or post glacial landscape that you will be investigating: Where is it? What size is it? Which settlements are situated within in? Which ice sheets were important in terms of shaping the landscape? A clear appreciation of timescales is important here. You will need to have a knowledge and understanding of which glacial and interglacial periods you are seeing evidence of.

Justification of the reasons for selecting the location and the type and amount of data you plan to collect can be based on accessibility, safety considerations and considerations of scale and the time available to complete the data collection and the suitability of the location in terms of the features or material that you are wanting to investigate. Describe your field area with words and an annotated base map; you could also give some background information about the area.

Thinking like a geographer involves being **ethical in your research.** Give due care and attention to the impact and possible harm that your enquiry may have upon the environment and the people in it. Specifically for physical glacial studies this may involve conducting an environmental impact assessment regarding removing till or considerations in your research questions on a questionnaire. You will also need to identify potential risks and how they can be minimised. Weather conditions are more critical to the success of some fieldwork methods than others, but should always be considered in a risk assessment and in a dynamic way during the course of an investigation.

You will need to use a wide ranging set of sources to provide a contextual background to your study, which might involve information and data from National Parks, internet, University research papers and other student's previous data sets.

2. Data collection – how is data and information (evidence) collected?

Acquire field data (primary) and relevant literature (secondary data / information) pertinent to the research question; observe and record in the field and understand the theory / context for the research question, using quantitative and qualitative methods and field (primary) and secondary data / information.

A wide range of relevant data collection approaches should be used, both qualitative and quantitative methods. Record both your individual fieldwork methods and highlight any data you have used which you have not collected or has been collected as a group.

You will need to check on the availability of **suitable equipment** and be shown how to operate it, checking that it is in working order and complete with batteries/chargers. This will ensure that you maximise both the quality and quantity of data you will be collecting. You should also **design your own recording sheets and/or questionnaires** in the classroom before undertaking fieldwork. Pilot recording sheets and/or questionnaires should be tested either with your teacher and/or peer support. This stage involves a revision of sampling strategies studied during the AS course. Selected sampling strategies need to be justified and decisions for the non-use of others need to be given.

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Types of primary data you might collect for example could be:

- Corrie Survey

Altitude The height above sea level of the floor of the corrie could be measured using a GPS as well as secondary sources. The height of the backwall could be gathered in a range of ways ranging from the use of GPS at the base and the top or using a range finder and clinometer from the corrie floor as well as secondary sources from OS maps and google earth. *Aspect* The orientation of the corrie could be measured using a compass and both northings and eastings could be recorded. *Width and Length* Latitude and longitude points could be measured out in the field using specific Apps and this could then be used in the classroom to work out the width and length from secondary sources. *Field Sketches and Photographs* You could draw and annotate field sketches and photographs in the field to highlight the processes in action on the features. *GPS Log* The location of particular features or sample site could be logged.

- Glacial and/or fluvial glacial depositions

Orientation Which way has a clast within till or a boulder on the surface been deposited by the glacier (particularly useful if it has an elongated shape), this could be measured using a compass. *Size* This could be measured using callipers or rulers of varying length. A broad view of sustainability should be taken here in terms of removing clasts from till deposits, and where possible size could be determined from material that has already fallen from the till to minimise group erosion of sites. *Roundness* Roundness could be measured on a scale such as Power's scale of roundness or by first measuring its size, using the Callieux calculation. *Shape* Shape could be categorised using Zingg shape classification. *Dip* The angle of dip of clasts within till could be measured using a compass clinometer. *Field Sketches and Photographs:* You could draw and annotate field sketches and photographs in the field to highlight the processes in action on the features of deposition and cross-sections of deposited material. *Geomorphological mapping:* to show the extent of the feature or deposit.

- Succession studies

With Scree Analysis and lithosere succession:

Slope angle is measured with clinometers and ranging poles

Degree of sorting through measuring the size of material to see if here is a relationship between this and altitude.

Vegetation colonisation- This could be measured in a range of ways such as presence or absence, percentage cover, frequency of different species, diameter of one species e.g. map lichen, and location or one species e.g. in terms of variation in terms of preferences regarding angle, aspect and geology.

Geomorphological mapping of the extent of scree combined with GPS log to get specific location of features.

With Hydrosere succession along a transect:

Identifying plant species along a transect.

Frequency of each species could be recorded to give a measure of diversity.

Plant height could be measured using rulers of varying sizes.

Abiotic factors such as light, wind speed and temperature could be recorded.

Detailed resources on fieldwork techniques:

Antarctic Glaciers http://www.antarcticglaciers.org/students-3/geography-a-level-2/

Field Studies Council http://www.geography-fieldwork.org/

Secondary data can be found in a range of places and a good study is backed up with a range of secondary data.

Geology maps: Provide information on the underlying rocks which will give information on how resistant to erosion those rocks are and how this may have been important in determining the size and shape of erosional features in a specific area.
http://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/geoBritainMap/home.html?src=topNav
http://mapapps.bgs.ac.uk/geologyofbritain/home.html

GlacierHub
http://glacierhub.org/
Information and scientific research about glaciers and information about the people connected with them.

Glacier Photograph Collection
Historical record of the glacial change in photographs.
http://nsidc.org/data/glacier_photo/

Glaciers, Climate and Society
http://glaciers.uoregon.edu/index.html
Information sources ranging from research data on the resource pages to links to supporting sites on climate, hazards and human dimensions of glacial research.

Historical Climatic Data

- http://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/iceAge/home.html?src=topNav
- https://www.ncdc.noaa.gov/cdo-web/

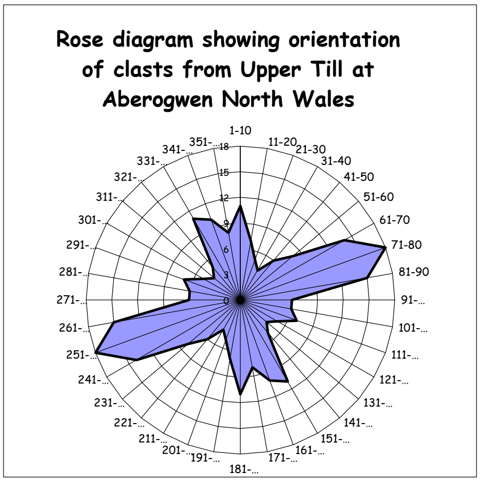
BRITICE – The British Ice Sheet
https://www.sheffield.ac.uk/geography/staff/clark_chris/britice
Maps and GIS database of the glacial landforms and features related to the last British Ice Sheet.

3. Presentation and display – how is the collected data and information presented?

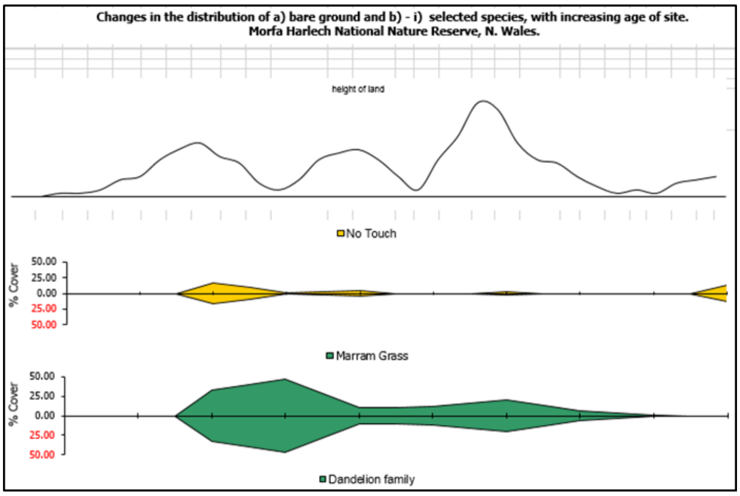
Process a range of field and any relevant secondary data / information using quantitative and qualitative methods in order to lead to appropriate analysis.

Bar charts to show till clast roundness, dip or shape in different deposits and possibly relative to other variables such as clast size.
Field Sketches and Photographs: These could be annotated and located on an OS or Geological map. The annotations should clearly show why students think that these features are found where they are and how they fit into the wider landscape.
Scatter graph: To show for example the relationship between corrie backwall height and altitude of the top of the backwall.
Long profile: Using a map or digital mapping, a long profile of a glacial trough can be drawn.
Valley cross-sections: Using a map or digital mapping, valley cross-sections can be drawn. These can be located on a base map of the area.

Flow Maps could be created to show the deduced movement of ice. Proportional arrows could be used to extend this to show the number of clasts found of a particular rock type and then link this to the inferred origin of the deposited material.
Rose Diagrams to show feature aspect or alignment within an area.



Kite diagrams to represent the observation of plants at regular intervals to show one type of vegetation cover along a transect in a hydrosere (edge of a kettle hole for example) or a lithosere (on rocks on a scree slope).



4. Analysis and interpretation of findings – how can the evidence be analysed?

Interrogate (interpret and analyse) data / information from field (primary) data, and, as relevant, secondary data / information; describe patterns, trends, relationships; apply knowledge and understanding of geographical knowledge, concepts and processes and theory to specific evidence collected to understand field observations.

This section requires a critical analysis of your findings, showing why they were appropriate to your aims/questions. It is also where you can draw out the uniqueness of your research. There are two main sections, the first is to analyse your data, ensuring you are using appropriate techniques. The second part relating to the interpretation is where you make sure that accurate results have been extracted from the data you have collected and you interpret what you have found in the wider context of geographical theories and existing research.

You might:

- Describe your results and the way the data has been presented.
- Suggest and identify reasons for the results.
- Compare and discuss the relationship between your results and geographical theories and models.
- Consider anomalies and how expected your results are.

You might use specific methods such as:

Cailleux Index

The raw data needed for each pebble are:

- the length of the longest axis (l)
- the radius of curvature of the sharpest angle (r)

For each stone, calculate Cailleux Index as follows

Ci = (2r/l)x1000.

Ci=100 for a perfectly spherical pebble. The lower Ci is, the more angular the pebble.

Krumbein's Index of Sphericity

The raw data needed for each pebble are the lengths of the a, b and c axes.

For each stone, calculate Krumbein's Index as follows

K = cube root of bc/a2

K = 1 for a perfectly spherical pebble. K must be between 0 and 1. The lower K is, the less spherical the pebble.

Examples of statistical test might include:

Chi- squared test: Using data on corrie aspect you could determine whether there is a preferred orientation for corries in the area studied. The null hypothesis would be there is no preferred orientation of corries in area x.

Spearman's Rank: Using data on corrie highest backwall altitude and backwall height. The null hypothesis would be that there is no significant correlation between the height of corrie backwalls and the altitude of the top of the backwall.

Chi- squared test: Using measurement of clasts within two layers of glacial till of different origins, students could determine if there is a significant difference in the angle of dip within the two layers. A null hypothesis could be: There is no significant difference in the angle of dip of clasts within glacial till deposited by ice sheet A and ice sheet B.

5. Conclusion – what conclusions can be drawn and how do these relate to the initial aim of the enquiry?

Synthesise findings to draw conclusions based on evidence and theoretical research.

This is an opportunity to summarise the main findings from your results. What do the main results say? Refer back to the research aim/question and explain to what extent they have been met. Use the descriptions of the results from the previous section to build linkages between the different data sets, explaining the patterns in your data.

6. Evaluation of the whole investigation – what evaluative techniques should be applied to the enquiry process?

Critically reflect on every stage of the whole investigation in order to appreciate the strengths and limitations of the primary and secondary data, links to original question; note strengths and limitations (accuracy, validity and reliability) and anomalies and / or errors or misuse of data; evaluate the methodology including, if relevant, sampling techniques; suggest improvements for further research.

In this section the aim is to reflect on the process of the investigation and how that process may have an impact on the quality of your conclusions. This section may include:

- Evaluation of each stage of the investigation.
- Consider the validity of methods and the limitations of your conclusions.
- Improvements that could be made to the way the data were collected.
- Identify possible extensions to the study, or other data that could be collected.

Validity is the suitability of the methods to answer the question that it was intended to answer. Reliability is the extent to which measurements are consistent.

Example of Research Project

How does the glacial system change over time on glacier X?

Primary Data may include:

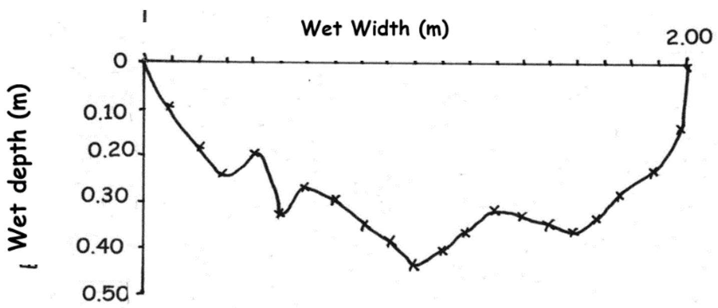
Discharge in a meltwater channel calculated using the equation cross section x velocity
Cross section is calculated by width (bank to bank measured using a tape measure) x depth (a number of depth measurements across the channel taken with a ruler to allow an average depth to be calculated)
Velocity can be measured using specialist equipment such as a hydroprop or digital flow meter. Alternatively,
Glacier velocity can calculated using known points (e.g. marked rocks) on top of a glacier. Ideally, a set of stones are marked and laid in a transect across the glacier and GPS marked at their initial location. Finding the stones after a year and re-marking their location with GPS will allow an annual velocity to be calculated for the glacier.
Glacier Mass Balance can be calculated if the inputs (falling and avalanched snow) and outputs (meltwater, icebergs, avalanches) are known. Primary data to collect this information would need to rely on an academic establishment to provide long term datasets. Some suggestions on how to take such measurements can be found here:
https://www.nichols.edu/departments/glacier/mb.htm

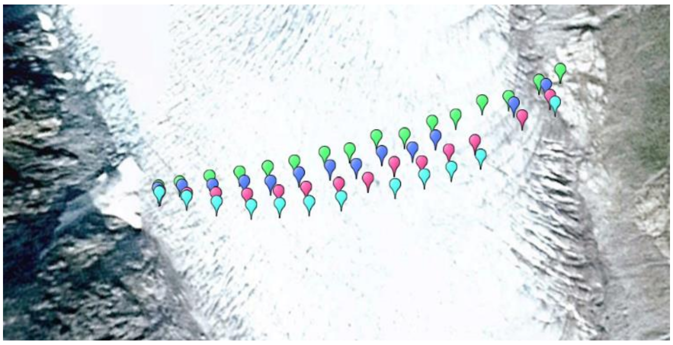
Secondary Data may include:

Old photographs / maps/ aerial photographs: Can be used to compare past and present glacier positions.
Historical climate data for the Alps, including temperature and precipitation:
http://www.zamg.ac.at/histalp/

Data presentation may include:

Cross section diagrams of a channel can give an idea of width and depth of the channel, and may be compared for different locations.
Line graphs can be used to show the variation in meltwater during the course of a day, or a season.
Geo-located points: locations of stones found on subsequent years can be presented as points overlaid onto a basemap or aerial image.





Statistical Analysis may include:

Spearman's Rank:
Using data on meltwater discharge and temperature, the null hypothesis would be that there is no significant relationship between meltwater discharge and temperature, or for annual glacier velocity and distance from valley side, a null hypothesis that there is no significant relationship between annual glacier velocity and distance from the valley side.