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Glacial landforms: a teaching resource in maps and GIS

The authors describe a project to map the British-Irish ice sheet and suggests how the map, GIS and satellite imagery can be used with GCSE and post-16 geography students to investigate glacial landforms.

Accompanying online materials

Introduction

Geographical research means producing evidence that we hope makes our understanding 'less wrong' than previous versions of the 'truth'. The University of Sheffield's BRITICE project delivers landform evidence that tells us more about the huge, kilometres-thick ice sheet that once covered most of the British Isles.

The BRITICE map and GIS database of the glaciated landscape of the British Isles draw together over 170, 000 landforms from over one hundred years of field investigation, along with more recent mapping from satellite images and digital elevation models, both on- and offshore.

Thanks to this compilation, we now have an excellent picture of the distribution and pattern of Britain's glacial landforms. In our ongoing research, the pattern of retreat that we can interpret from these landforms acts as a sampling template, directing fieldwork to collect material (e.g. organics for radiocarbon dating) to date the timing and speed of ice retreat. This advances our knowledge of the ice sheet so we can assess how it responded to former climate change. The ultimate aim is to use our new knowledge to improve forecasting of the contribution of polar ice sheets to sea level rise in a warming world; here, however, we have given some examples of teaching activities to be used with the BRITICE map free poster and online resources (see below).

Free glaciated landscapes poster

To celebrate our glaciated landscape and its glacial geomorphology we have designed an educational poster version of the BRITICE map (Figure 1). This includes brief definitions and illustrations of moraines, drumlins, eskers, meltwater channels, trough mouth fans, crag and tails, glacially streamlined bedrock, cirques, erratics, subglacial ribs and ice-dammed lakes, all of which can be found on the map. The poster, which is A0 size, is being mailed out to geography departments in all UK secondary schools this term.

In partnership with Esri UK we have also launched a freely accessible online interactive BRITICE map, so you can zoom in to see the landforms in all their detail and situate them on base maps for your local area or fieldwork site (Figure 2). The GIS functions allow you to manipulate, measure and query landform data online without additional software. The interactive map, GIS data and PDF of the poster map are free to download via www.BRITICEmap.org

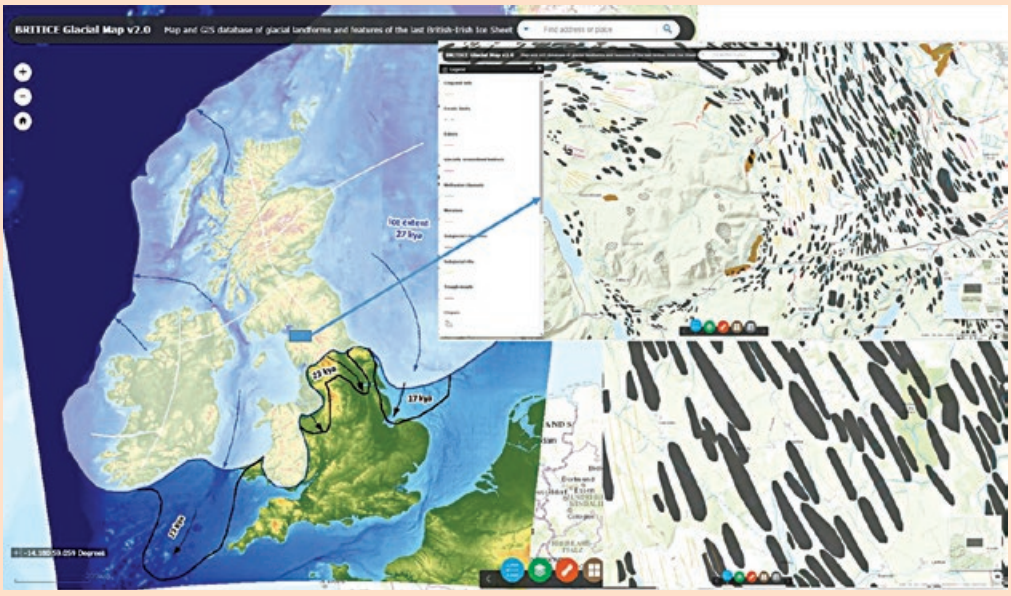

Figure 2: Example screen shots of the online map, showing progressively more detail as you zoom in – in this case, on drumlins in the Vale of Eden, Cumbria.

Figure 1: The educational poster version of the BRITICE map.

Figure 3: Two drumlins whose lush pastures, against the rougher grass of this part of County Galway, Ireland, clearly identify them in the landscape. These streamlined landforms shaped in subglacial sediment (till) record the orientation of ice flow (arrows).

Drumlins and ice-flow direction

Use the online interactive BRITICE map to locate landform features. Take their latitude and longitude and find them on aerial photographs in Google Earth, to see what they look like and teach students how to identify them. The drumlins from the poster (Figure 3), for example, are good to search out: they can be found at -9.618 degrees (i.e. W) and 53.450 N. Textbooks usually say that the blunter, stoss ends of drumlins point upstream and the tapering ends point downstream. However, we have recently discovered that this is usually not the case, with most drumlins actually being symmetrical. Those with stoss and lee ends have a very slight tendency to be shaped as described in textbooks and indicating ice flow direction: however a near-equal number are shaped 'backwards', including those illustrated here. If you look on the map the ice-flow direction had to be away from central Ireland in an offshore direction: we can clearly see that the stoss (higher and wider) end of the drumlins is at the downstream end. Drumlins and their cousins, subglacial ribs (see map), were formed by interactions and shaping between the base of the ice sheet and the underlying soft sediments. Their significance and how they are formed is described in a 4-minute video on the GA website (https://www.geography.org.uk/Subglacial-bedforms-videocast).

Moraines and the pattern of ice sheet retreat

Moraines are ridges of sediment recording former ice margin positions with numerous examples across the map. Especially significant are those discovered in the last ten years on the seafloor. A useful exercise would be to get students to plot the course of retreat of the ice sheet, from its maximum extent through to its final demise. See if they can take an area, or the whole ice sheet, and use moraine positions as a guide, interpolating between these and using other landforms such as drumlins to get the ice-flow directions correct. This could be achieved on printed-out maps, or using the online BRITICE map, or by downloading the data into GIS. Figure 4 is the answer we came up with by doing this exercise ourselves. Note that the ice sheet mostly retreated to high ground, as in Scotland; but not always, as shown by the margin withdrawing from the Cheshire-Shropshire plains into the Irish Sea. Using radiocarbon dating we now know that the ice sheet was at its maximum extent 27, 000 years ago, had retreated to the present day coastline by around 17, 000 years ago, and by 15, 000 years ago survived only as small ice caps in the main mountain regions.

Figure 4: The maximum extent and pattern of retreat, showing successive margin positions as the climate warmed, the ice sheet shrank, and sea level rose at the end of the last glaciation (27, 000 to 15, 000 years ago). This is the retreat pattern we reconstructed from the landform data (Clark *et al.*, 2012).

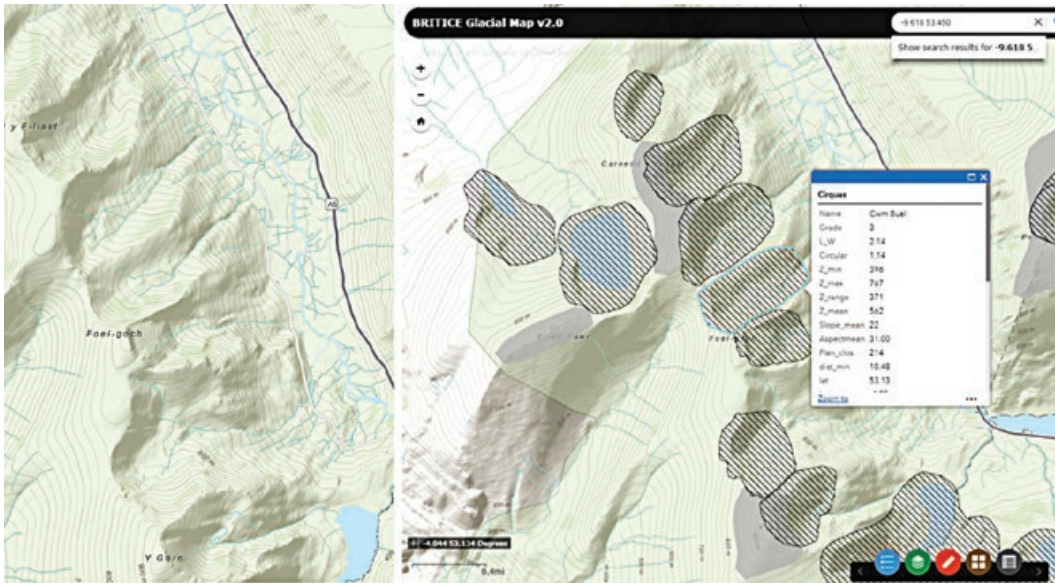

Figure 5: A series of north-east facing cirques (cwms) in the Carneddau Mountains of Snowdonia. Clicking on a cirque (or any mapped feature) opens up an attribute table that in this case provides measures such as the aspect (direction in degrees in which it faces).

Aspect and elevation of cirques

Cirques (also called cwms and corries) are glacially-eroded, armchair-shaped hollows cut into the flanks of mountains. They were formed by small glaciers eroding, mostly at the start and end of glaciations when the ice masses were restricted to the main mountain regions. At these times of marginal glaciations the glaciers are thought to have preferentially existed on the north and east flanks of mountains, where snow and ice surfaces received less intense solar radiation. An interesting exercise is to test this hypothesis by using the cirques recorded in the online BRITICE map (Figure 5) and extracting aspect data for plotting in Excel as a histogram. When we did this for all 2208 cirques in the British Isles we found a strong preference for north- and east-facing aspects, supporting the hypothesis. The mean direction was 41 degrees (Barr *et al*., 2018), but there are often quite large divergences caused by the geological influence on the structure of uplands for example. Use the GIS function in the online BRITICE map to query each cirque (just click on it), revealing in the attribute table the direction it faces (e.g. in Figure 5, Aspect mean 31 degrees). These values could then be transcribed into Excel for analysis. Why not choose a number of upland regions to conduct this exercise, then seek reasons as to why the mean aspect varies and is different from the mean for the whole of the British Isles? Other measures in the attribute table, such as elevation and range, could also be useful.

Further work

Esri has made ArcGIS software freely available to schools, and for teachers and groups of students who want to explore further, the full GIS files of all 170, 000 landforms can be freely downloaded as Esri shapefiles for use in ArcGIS. These data, and other resources (high-resolution pdf maps and the BRITICE poster map), are available at www.sheffield.ac.uk/geography/staff/clark_chris/britice_v2/index

The workshop presented by the University of Sheffield Geography Department at the 2018 GA Annual Conference in Sheffield – 'The BRITICE glacial mapping project' – showing how the map and GIS data could be used, can be downloaded from the Conference 2018 pages of the GA website. | **TG**

BRITICE

The aim of the BRITICE project is to bring together published information regarding the geomorphology (landforms) of the last British-Irish ice sheet. The compiled record will help us better understand how ice sheets work. Since 2012 the BRITICE-CHRONO project has spent over 1500 person-days of fieldwork, collecting samples from 914 sites across the land and beneath the sea, and we have now dated some 639 important sites. See www.britice-chrono.group.shef.ac.uk for further information.

References

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