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BIIS: The Last British Ice Sheet, A Review of The Most Recent Major Glaciation of Great Britain and Ireland

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Geology Honors Thesis

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ABSTRACT

The British Irish Ice Sheet was a substantial ice mass covering the British Isles during the most recent glaciation that ended around 11,700 years ago. Oftentimes referred to as the BIIS, it is subdivided into two sections, a western and eastern side that covered Great Britain and Ireland, with the Irish basin in the middle. Some notable areas of study around Great Britain and Ireland include the 'Bizzle' in Northern England, which was transformed by the effects of the eastern margin of the BIIS, the Carstair Kames in Scotland, a locality known internationally for its esker system, The Minch region northwest of Scotland, known for its remnants of an important paleo ice stream, and Ireland to the west along with the Irish basin that contains a lot of marine floor evidence and important islands such as the Isle of Man. Various studies over the years have aimed at mapping and recording the geomorphology and ages of the landscape in this area to piece together the dynamics of ice sheets and glaciers that were active during the Devensian and Younger Dryas glacial periods. One of the most important recent studies, was a movement by academic and research organizations to compile a GIS map of glacially related features in Britain, Scotland, and Ireland. This map is one of the most impressive and complete records of geomorphology in this section of the world, and it is a work in progress that seeks to clean up and verify old data as well as add newfound discoveries to the map. The aim of this paper is to examine some of the vast records collected over the span of glacial study in the United Kingdom and put together a brief summary of key areas and how they have been interpreted to have evolved when the BIIS was active, as well as what they may indicate in regard to ice sheet modeling and the dynamics of paleo-ice flow.

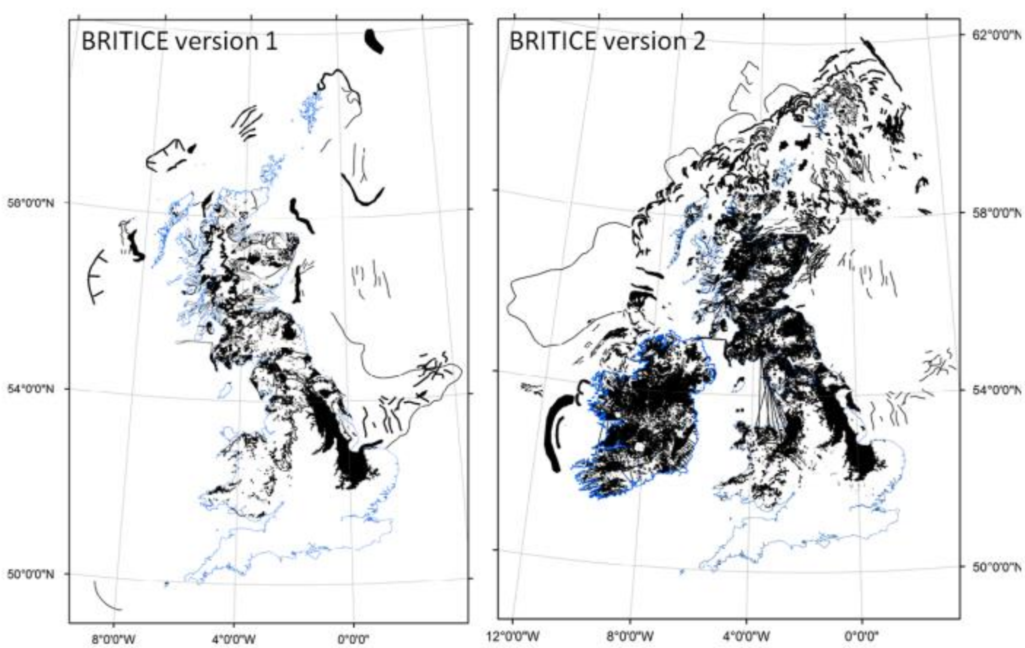
INTRODUCTION

Ice sheets are without a doubt the largest masses of ice that play a role in the glacial cycle. They are also in turn, the biggest influencers on the state of climate change and how it develops over time. Studying the fine details of past glacial cycles can provide invaluable input that can be used to make predictions in global warming, as well as help scientists understand the landforms that are left behind after long periods of glacial activity. The knowledge of glacial activity today, whether it is about the evolution of previous ice ages long past, modern glacial patterns, or predictions about glacial behavior in the future, is produced through the combination of 2 vast fields of study. Ice sheets today, whose properties and trends can be measured and modelled, provide important information about glacial activity in the maximum of a glacier's life span. The shortfall of this field however is that the glacial bed here cannot be directly observed, and the time-dependent variations that occur in the lifespan of a glacier have only been studied for about 70 years. This information however, combined with the evidence left by Pleistocene ice sheets, whose patterns cannot be directly measured but whose glacial beds are exposed, and longer-term variations interpreted from geological sequences, creates a much better view of how ice sheets evolve and move, and the large-scale aftermath they leave behind. The scope of this paper is to explore the discoveries and interpretations of the BIIS, or British-Irish ice sheet that covered the British Isles during the most recent glacial cycle from the end of the Eemian to the end of the Younger Dryas, encompassing the period 115,000 to 11,700 years ago, known in Great Britain as the Late Devensian glaciation. Many of the findings and speculations on the behavior of the BIIS have been up for debate and there is still a lot of data out there that may be incorrect or incomplete, and the use of new technology such as bathymetry imaging and more advanced geophysical methods are opening more doors to the past of this glacial event.

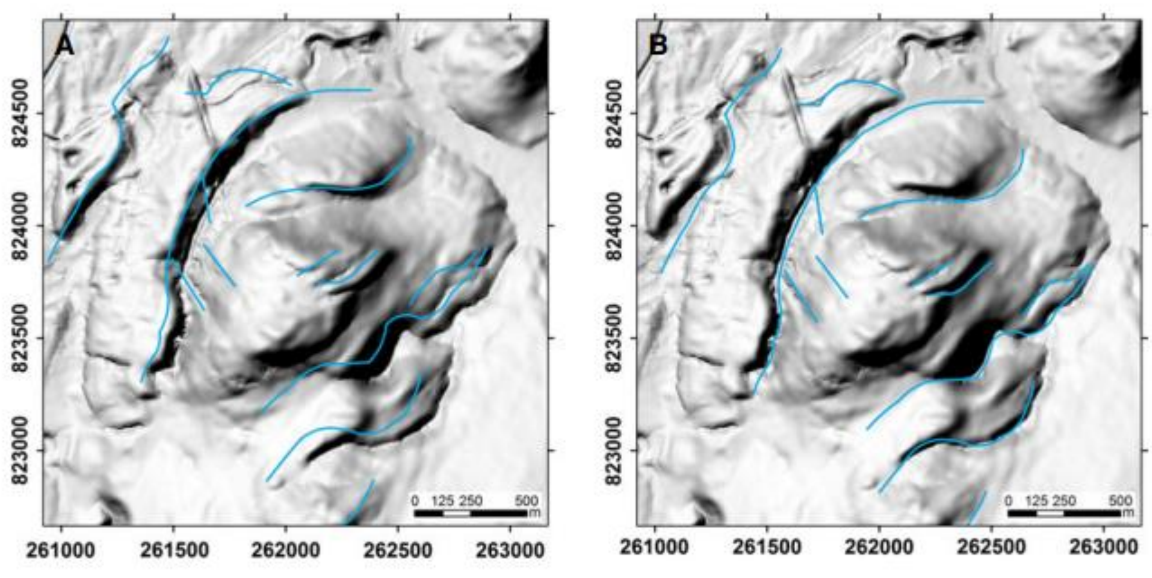
DISCUSSION

GIS:BRITICE Land Form Compilation:

The BIIS covered most of the British Isles and the surrounding continental shelf during the last major glaciation. It is assumed that most glacial landforms in the British Isles relate to the BIIS and the most recent glacial episode, but this is based on the presumption that glacial cycles destroy landforms from earlier cycles, which isn't always true. Landforms in the British Isles belonging to earlier glaciations are considered to be rare though. Leaps in technology over the decades have exposed much more landforms and features in the area. Bathymetry data has revolutionized what has been recorded regarding submerged glacial geomorphology, and many more structures like meltwater channels remain to be discovered and mapped for offshore areas. 2D and 3D geophysical surveying methods have proved very useful in revealing bedform patterns covered up by meters of post glacial sediments. Below is a generalized image of the compilation. This was built on the base of a previous collection which was the first version of this map; "The revised GIS database contains over 170 000 geospatially referenced and attributed elements – an eightfold increase in information from the previous version" (Clark, Bateman, et. al., 2017). Version 2 now also contains data on Irish landforms.



As this map has a massive number of features, a generalization process of filtering through landforms to remove duplicate data and improve resolution has made the new version a lot more concise. There were examples in the data that duplicated a landform up to five times based on different sources, so a 'landform reconciliation' process was necessary to make the data accurate. Following the example set by the glacial map of Canada, many landforms of the same type in close proximity to each other have been grouped under the same symbols, further improving the filtering processes for the map. Some GIS positioning errors may have also occurred as some of the earlier literature did not contain accurate information, and topographic maps with features such as coastlines and rivers were used to piece together the correct locations of the landforms, albeit still incurring positions off by 100 or so meters in the process. Below is an example of the corrective adjustment process to improve accuracy. (Clark, Bateman, et. al., 2017)



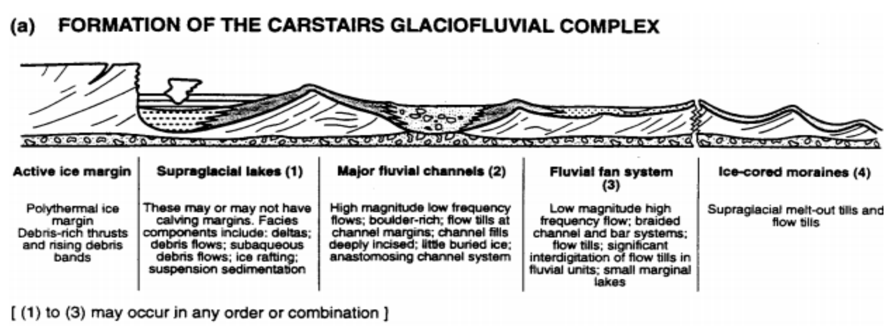
All features geo-rereferred from earlier works have been quarried with their original source to serve as a 'citation' and can be viewed via attribute table. One of the most important datasets in this compilation is the collection of moraine data, as it provides a clearer picture of continental shelf wide glacier retreat and can be used to understand the retreat of the entire shelf itself. An addition to V2 of this map were cirques, which are partly open hollows cut into mountain sides. Although cirques in Britain are well documented, this map marks the first nearly complete record of cirque distribution throughout the British Isles. An open topic in this compilation that has a lot of potential however is ice dammed lakes. “The evidence for ice-dammed lakes mostly comes from the elevation of sediments interpreted as being lacustrine found in sedimentary sections, from boreholes, by shorelines, or spillways” (Clark, Bateman, et. al., 2017). This map contains over 50 examples of these glacial lakes in GB, but none so far for Ireland despite records of them in earlier publications. The missing data on these lakes that is most difficult to achieve is their extents and lake levels.

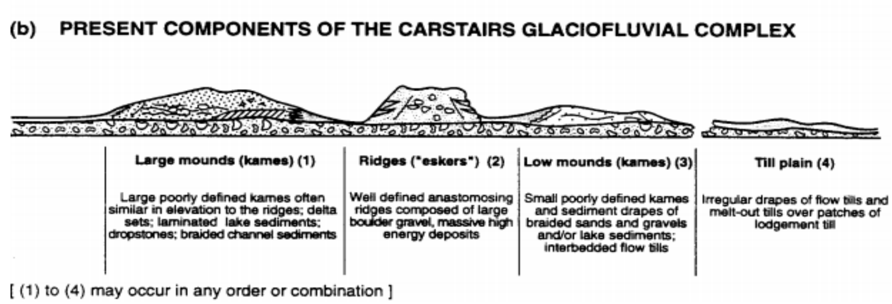
BRITICE V.2 is one of the most impressive collections of glacial landforms and descriptions published in 2015. The accumulation of glacial data in the field has been ongoing for more than a century so there is a lot of earlier works to draw from. However, this endeavor ran into a problem of sorts; the compilation issue. This issue stems from the notion that the processes and methods of interpretation for glacial information collected over the years have changed and evolved significantly, and managing data from different time periods and publications can get very complex and difficult. Gradually solving this issue will lead to illuminating the ‘bigger picture’ of past, present and future glacial landscapes and will be the next steppingstone to a better understanding of still debated glacial concepts. Although very extensive and impressive, this map should be considered a ‘renaissance-level’ database, as it still has a long way to go before it is complete and systematically accurate in landform identification/categorization, and it has been suggested that “it is likely that more channels and features could be found with analysis of higher resolution DEMs (e.g. from Lidar)” (Clark, Bateman, et. al., 2017)

Regions

Carstair Kames:

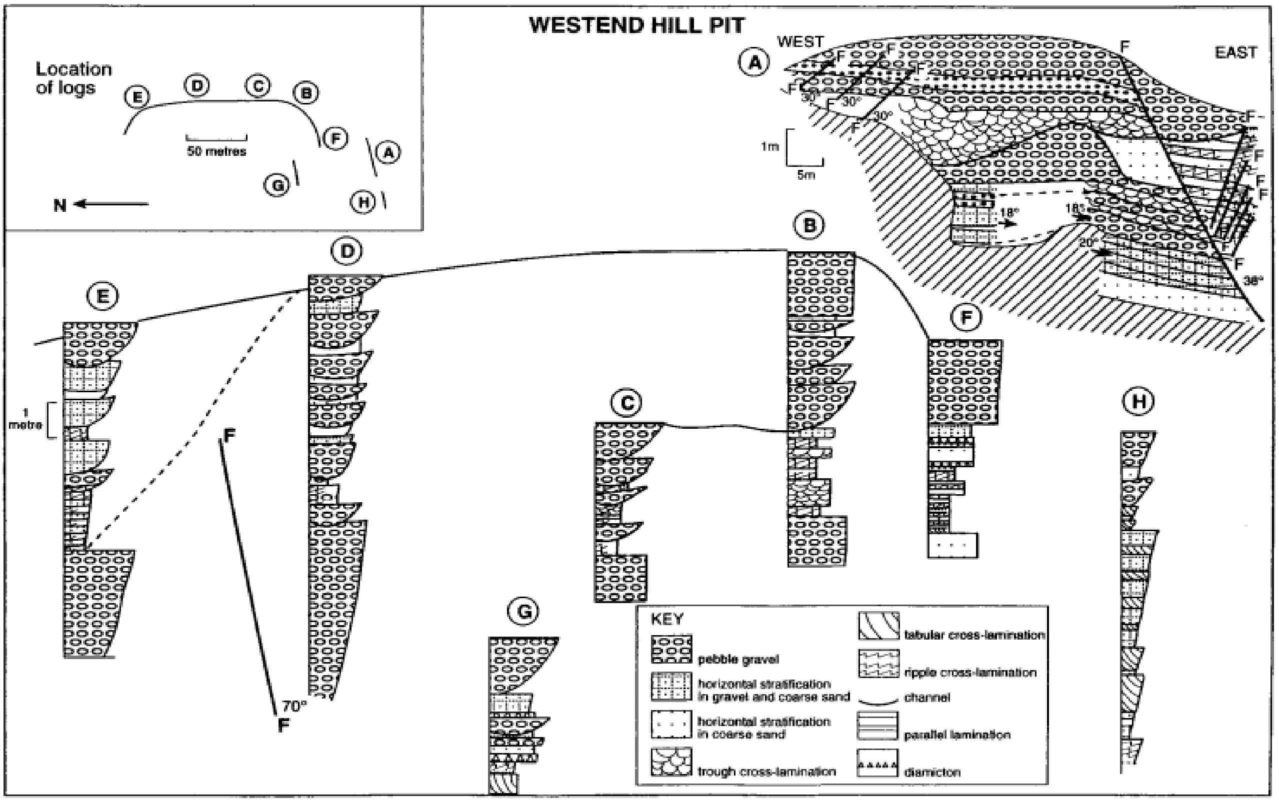
The Carstair Kames are a British esker locality known internationally for its classic examples of an esker system. It formed by sediment deposition from glacial melting. This site has been speculated upon for over 150 years. The exact origins of the deposits are not known, but studying them has been very important for understanding the evolution of Scotland's Quaternary landscape. The key landforms that characterize this include "large, sinuous and anastomosing ridges; large, irregular, linear mounds; and small, low and irregular mounds" (Huddart, Bennet 1997). The interpretation of these morphological elements is important in understanding paleo-glacial hydrology and subglacial processes. One of the most interesting esker types in this region are braided eskers. They can be best described as "sinuous, bifurcating ridges which split and rejoin to form anastomosing networks" (Huddart, Bennet 1997). Below is an array of visuals to describe the eskers that can be found at the Carstair Kames.





(Huddart, Bennet 1997)

The sedimentology within these deposits is usually fluvio-glacial. The sequence follows a trend of boulder/gravel beds underneath more fine gravels and sands, but these units are typically very discontinuous and faulting also heavily applies. Flow direction is apparent here as, "the gravels are imbricate with a flow direction that varies from the southwest at the west end of the pit to northwest at the eastern end" (Huddart, Bennet 1997). In the northeast sector of the Carstair system, finer sediments can be found, which are likely of glacial lake origin. These landforms go on for about 6 kilometers north along ridges and mounds that intertwine along a southwest/northeast trend. In-between many of the landforms, kettle-holes can be found. Similar formations exist in other parts of the region, and it could be possible that the Carstairs Kames could relate to a vaster system of glacial deposits. The ridges described near Lanarkshire are roughly 25 meters high and overlie a bed of till. These ridges can be interpreted as englacial or supraglacial and have a connection to the complicated terminal moraine left from the retreat of the BIIS. The ridges are more defined towards the SW, this is another indication of the direction of the glaciers' retreat, and can be confirmed by direction measurements taken from the sediment sequence recorded in pits excavated in the study area. One of the key elements of this study is the sequence recorded at the excavated pits. "The sediment sequence shows Carstairs illustrates the sedimentological diversity that may be present at such sites and emphasizes the possibility that they may represent supraglacial drainage Systems" (Huddart, Bennet 1997)

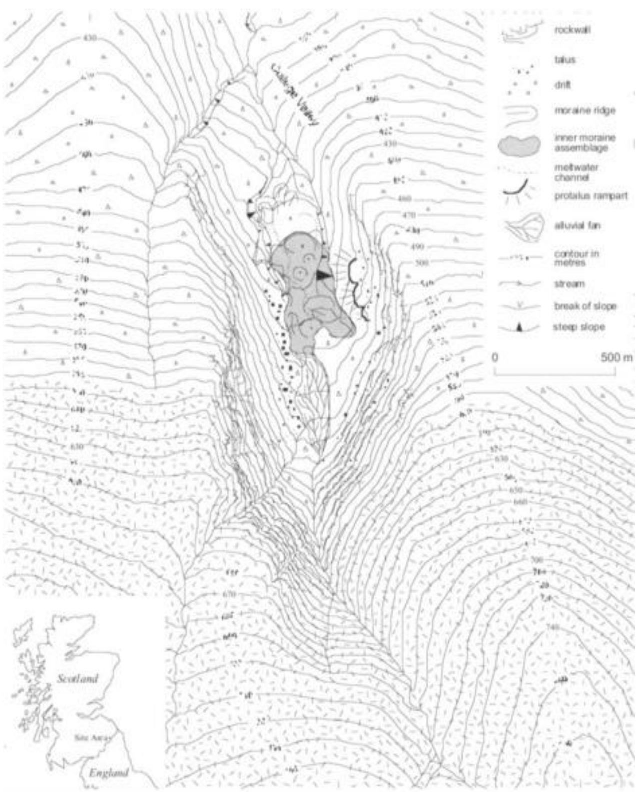


(Huddart, Bennet 1997)

This sequence is interpreted to be deltaic, mostly dominated by pebble gravel. It is consistent with a depositional environment underlain by buried ice. This sequence is split by a major fault, from an extensive sequence of rippled and parallel laminated sands, which are in turn also heavily faulted (Huddart, Bennet 1997).

Eastern Margin: The Bizzle

The Bizzle valley is an elongated glacial basin cut into the north flanks of the Cheviot Hills in northern England and southeastern Scotland (Harrison et.al. 2006). During the Younger Dryas (around 12,900 to 11,700 years ago) substantial ice masses accumulated in the western-most regions of the British Isles. Having the only cirque basin glaciation, this area received the majority of precipitation during this time and left the eastern Scottish uplands relatively glacier-less. Although the Bizzle is a seemingly very attractive site for paleo glacial research, it has not raised as much attention from glaciologists as it should have. In 2006, The environmental department at Oxford University in the UK set out to "(1) analyze the geomorphic evolution of the basin; (2) to discuss the evidence supporting Younger Dryas glaciation at the site; (3) and to examine the paleo-climate implications of cirque basin glaciation" (Harrison et. al. 2006).



(Fig.2) Periglacial and glacial environment of the Bizzle; comparisons of the 2 settings with respect to clast roundness

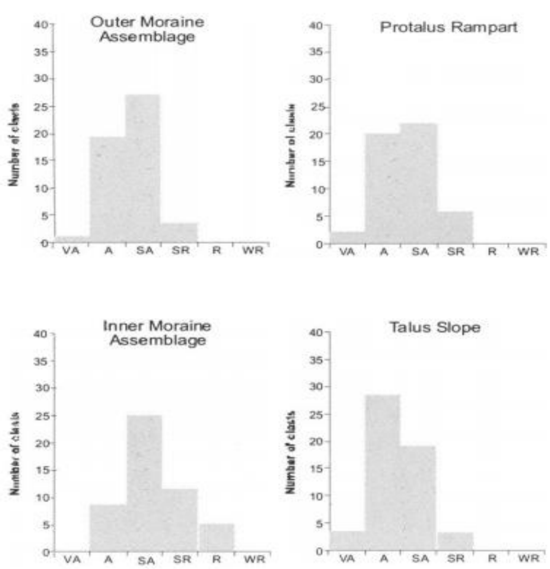


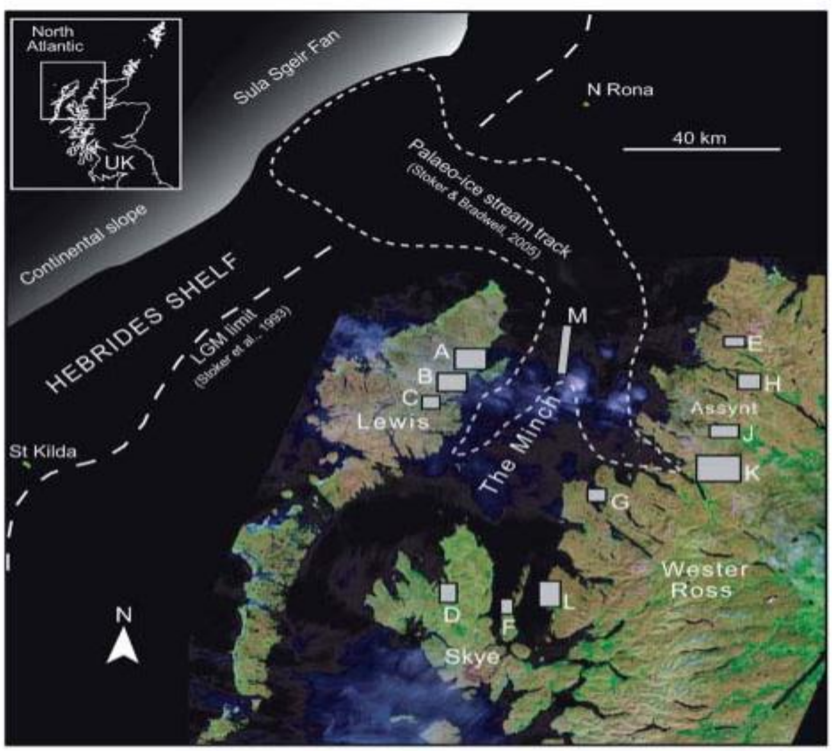
Figure 1Location and Geomorphological map of the Bizzle (Harrison et. al. 2006)

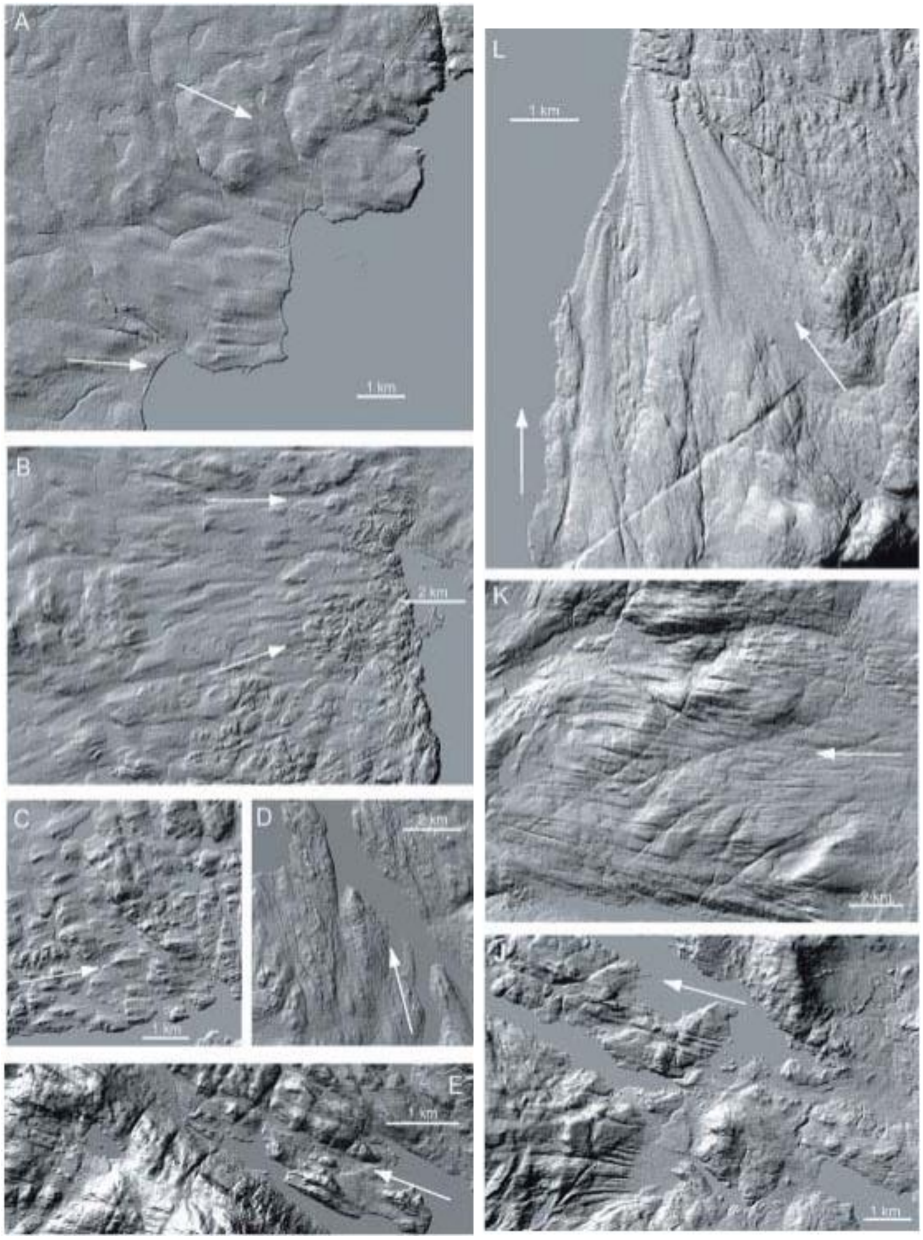
The Majority of the watershed in between England and Scotland lies underneath the Cheviot Hills. The uplands towards the center have Devonian granites as the bedrock which are surrounded by andesites forming the lower section. It is speculated by previous work that these hills sheltered their own ice cap that may have impeded in-coming ice from other regions before the deglaciation that occurred at around 15,000 years ago. If Younger Dryas glacial ice developed inside the Bizzle, then there would likely be evidence for variations in the extent of periglacial landform development including mass wasting of quaternary age deposits. There would also be a clear difference of frost weathering between the areas inside and outside of the Bizzle. Geomorphic mapping revealed a striking difference in the degree of periglacial landform development between the inner and outer glaciated areas (Harrision et. al. 2006). The outer regions of the Bizzle show well-developed periglacial features, which indicate that severe cold-climate conditions existed during that time frame following the retreat of the glaciers in the area. The landforms were comprised of frost-shattering in the bedrock and mountain top detritus, as well as a well-developed talus slope. The contrary is true for the inner glaciated part of the valley as it contains poorly developed tallus slopes. Despite having some scattered irregular spreads of rock, the most common findings in the area are “morainic debris, a glacially molded bedrock and an alluvial fan” (Harrison et. al. 2006). The highly variable environment left behind by the minor glaciation in this area is indicative of the role that the “steep precipitation gradient” played in the British Isles during the development of a minor glacier in the Bizzle valley and the far heavier glacial activity much farther to the west. The effect of this precipitation gradient could also be applied in similar regions farther west towards Ireland if they exist, as well other parts of the UK, and could also be potentially applied to earlier time frames such as the Devensian. As this area has received minimal research, revaluation of previous literature also has potential.

Minch-Paleo Ice Stream:

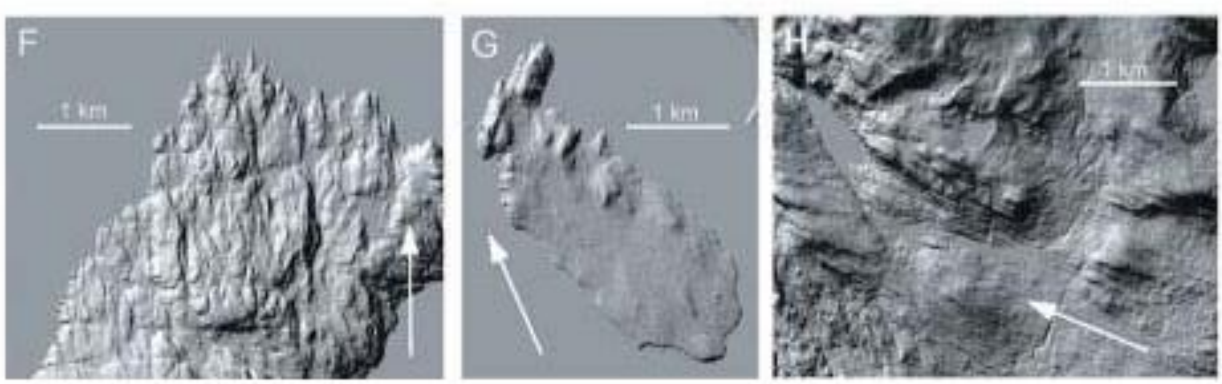
paleo-ice streams are rapidly moving sections of an ice sheet and are the outlet for the majority of moving ice; “ice streams play an important role as regulators in the behavior of modern ice sheets (e.g. Antarctica, Bamber et al., 2003) and take the form of corridors of fast flowing ice bounded by ice flowing up to an order of magnitude slower (Stokes and Clark, 2001; Bennett, 2003)” (Philips, Everest, Diaz, 2009). Ice streams are believed to be very important in understanding the paleo glacial dynamics, flow directions and overall stability of the BIIS as a whole, over the last glacial period. The Minch Paleo ice stream in the north western areas of Scotland, is believed to have been the dominant force in the assemblage of the northwest section of the BIIS during the late Devensian, and likely had a heavy influence on where the ice sheet split as well as the thickness across the whole sheet as a unit. As ice streams can be a major factor in sea level rise as well, the Minch paleo ice stream can likely also be identified as a driving force in connection with periods of abrupt climate change. Below is a map showing the flow track and extent of the ice stream.

(Bradwell et. al. 2006)





To the left are digital surface models (DSM) generated using NEXTMap elevation data stores of various locations in the study area. In the images, structures such as streamlined landforms, low-relief drumlins, large meltwater channels, crag and tails, bedrock-cored mega flutes, mega drumlins, whalebacks, ice-molded forms, elongate parallel lineation, and deeply etched groves all follow a northwestern trend synonymous with the movement of the Minch ice stream. Images A, B, & C all have eastward lineation, which would coincide with a eastward flow that curved around to line up with the overall NW flow trend (Bradwell et. al. 2006)



Similar trends were found in the underwater area at the center of the Minch; “swath bathymetry and side scan-sonar images reveal large-scale ridge-groove structures on the sea floor between the northwest Scottish mainland and Lewis. These strongly parallel, highly elongate features are developed in diamicton, as indicated by sub-bottom profiles and borehole data” (Bradwell et. al. 2006). These mega-scale underwater glacial lineations are very likely glacier “plough marks”. Due to the general NW to SE trend of these lineations and their enormous size (100–500 meters wide; 1–7 km long), lack of variation in direction, they could very well be the after math of the ground contact point of the Minch Paleo ice stream. The flow dynamics and characteristics of the Minch can be compared to ice streams studied in Antarctica; “Studies in west Antarctica have shown that fluctuations in ice-stream size and vigor can result in a regionally lowered ice-sheet surface, ice piracy and the migration of ice divides (Alley and Whillans, 1991; Truffer and Echelmeyer, 2003) (Bradford et. al. 2006). During the last glacial maximum, The Minch ice stream was likely the dominant force in the overall trend of ice flow in the northwest region of the BIIS. The Minch paleo-ice stream was probably last active around 22,000–25,000 years ago. The collapse and disintegration of the ice stream might have been due to sea level rise around 19,000 years ago, around the time of the North Atlantic iceberg-discharge event, which was part Heinrich events that marked the end of the last ice age (Bradford, Stoker, Larter, 2006). Although a good deal of evidence has been gathered on the operation of the Minch as it was retreating from the UK, its north-westward extent is still relatively unknown and subject to further research.

Northern Irish Sea Basin:

Over the course of the Late Devensian period, the BIIS stretched over the northern Irish Sea Basin from Ireland, eventually flanking in from the southwest region of Scotland. The sea basin in the middle, has a substantially uneven sea floor, with western regions reaching depths of up to 140 meters, and getting as shallow as 40 meters to the east (Chiverrell et al. 2018). Almost in the middle of the basin lies Isle of Man, which holds a wealth of terrestrial evidence on the movement and activity of the Irish sector of the BIIS. Below is a geomorphological map of the southern end of the Isle of Man (Chiverrell et al. 2018) which contains glacial landforms and sediments.

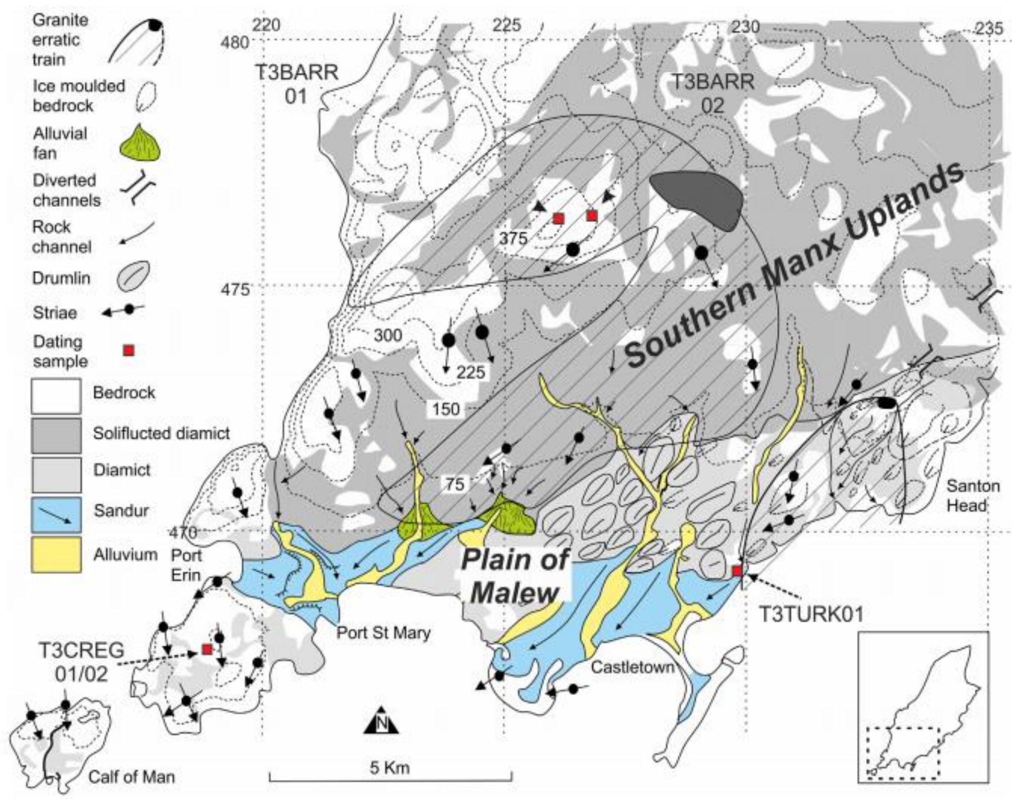
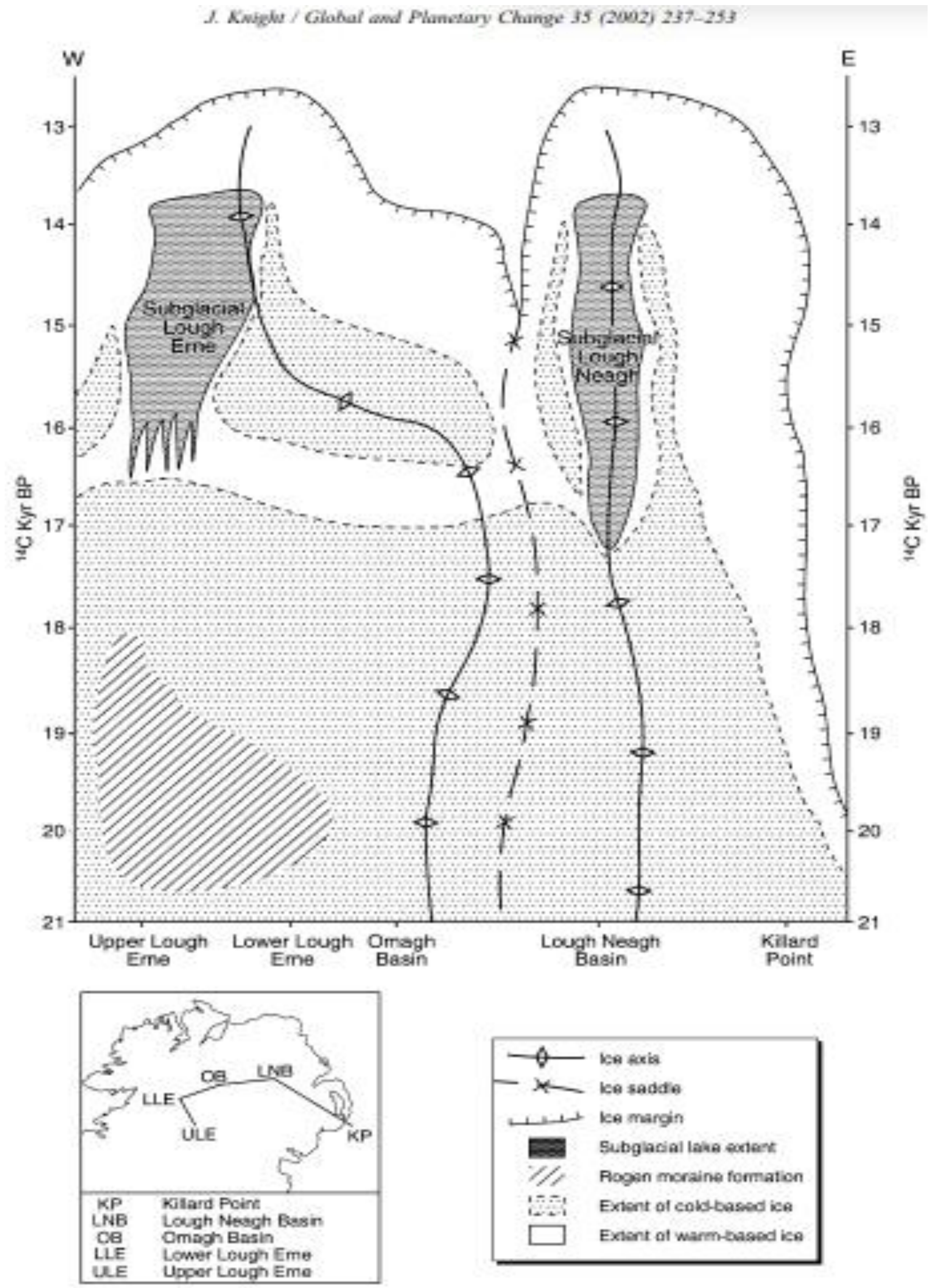


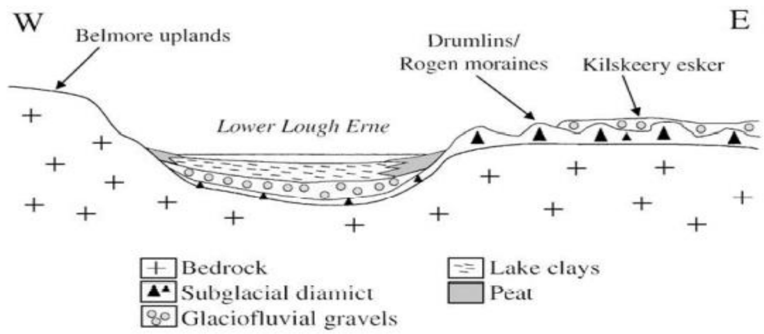
Figure 3. Glacial geomorphology of the south of the Isle of Man and a 5-km Ordnance Survey grid (Thomas *et al.*, 2006; Roberts *et al.*, 2007) showing the locations of samples T3CREG01 and T3CREG02, T3TURK01, and T3BARR01 and T3BARR02. [Colour figure can be viewed at wileyonlinelibrary.com]

Exposure ages obtained for the uplands on the Isle of Man and Cumbria to the east potentially limit the thinning of ice on the Irish sea basin to have happened during overall retreat. The boulder surface exposure ages there suggest that this ice thinning on the Isle of Man occurred at some time between 25,000 and 19,000 years ago, at an elevation of 385 m. (Chiverrell et al. 2018). The advance of the BIIS through the Celtic Sea has been predicted to have been relatively quick and short-lived (Chiverrell et al., 2013) and was followed by a rapid retreat (Smedley et al., 2017; Small et al., 2018). Such an advance and quick retreat was probably either driven by or quickened by significant activity of ice streams and could explain the changes in the retreat as recorded on the west lateral margin of the BIIS. The timeframe for ice thinning in the mountains of the Isle of Man and Cumbria on the mainland of England are much older than previously thought, ranging from 18,000 to 16,000 years for exposure above the ice in the Cumbrian Mountains. On the Isle of Man there is stratigraphical evidence for repeated still-stands and oscillations of the ice margin (Chiverrell et al. 2018). The Scottish readvance from the east seems to have happened either right before or a little earlier during the final deglaciation of the majority of the Lake District in England. The retreat of the BIIS in the northern Irish Sea Basin was a lot quicker in the regions to the south, when ice margins retreated northwards from the Llyn Peninsula in northern Wales to the central valley on the Isle of Man at around 20,000 years ago. Retreat rates then slowed to 13–20 meters during the ice margin oscillations to the north across the northern section of the Isle of Man and the lowlands of Cumbria and experienced both small and large-scale cycles of retreat/ readvance, before then retreating to the north towards south-west Scotland. Overall, this new retreat sequence highlights the importance of internal dynamics in controlling ice retreat rates in the Irish Sea, but also documents the final demise of the ice in the NISB which occurs at the same time as the climate warming of the very top of the N. hemisphere at around the 45-degree Mark (Chiverrell et al. 2018).

Role of Stored Subglacial Meltwater in Ice Stream Dynamics; North Central Ireland:

Meltwater Dynamics have a close connection to the basal thermal regime of glaciers, which is a balance between processes that cause a glacier's base to start melting. These processes include geothermal heat flux, heat produced at the base of a glacier via friction, and plastic deformation (Knight, 2002). Reconstructing these meltwater processes may uncover key details that would help understand the big picture of dynamic ice behavior. Several varieties of meltwater related features can be found throughout Northern Ireland including tunnel valleys, drumlin leeside sequences, eskers, and lag deposits. Earlier studies have mainly focused on short lived-high energy meltwater outbursts that would not be common along the entire ice front but might occur on a regional to continental scale (Knight, 2002). It is just as important to study lower magnitude meltwater events that occur over the course of years to decades, as they can be telling of subglacial conditions that persist over a longer period. The late Devensian ice sheet that covered Ireland is a source of great examples of these lower magnitude events as it was a "small, temperate, mid-latitude ice sheet subject to rapid (millennial-scale) climate oscillations affecting the northeastern Atlantic region during the last deglaciation." (Knight 2002) (McCabe and Clark, 1998; McCabe et al., 1999). An important study location for these meltwater events are the basins around upper and lower lake Lough Erne, which formed in a lowland depression occupied partly by subglacial ribbed moraine ridges, as well as the Lough Neagh basin a little farther to the east. Below is a generalized diagram showing the basins and lakes across Northern Ireland, and a reconstruction of the retreat of the Devensian ice sheet and the deposits it left behind. It is worth noting that the 2 major subglacial meltwater areas that are now lake Lough Erne and Lough Neagh began to develop right at the cusp of the transition from cold based ice to warm based ice at the 17 Kyr BP mark. The cold based ice persists around the lakes to nearly 14 Kyr BP, essentially creating a seal around them.





. Cross-sectional sketches through the Lower Lough Erne Basin showing basin asymmetry and distribution of generalised facies types.

The so called “sealed” subglacial lakes like lake Lough Erne and Lough Neagh in Northern Ireland may indicate that the behavior of smaller temperate ice sheets may have largely depended on meltwater events at a high as well as low magnitude. These smaller ice sheets also did not have a uniform temperature, as patches of cold and warm based ice traded places regularly during the glacial retreat (Knight, 2002). The variety of subglacial and proglacial features and sedimentology found around the 2 major lakes and the adjacent land in the Lough Erne basin in Northern Ireland is a link for sub glacially driven meltwater activity (Knight, 2002). Judging on the general layout and formation processes of the landforms and sediments in the Northern Ireland study areas, it is very likely that the lakes in the Lough Neagh and Lough Erne basins were indeed subglacial. When these subglacial lakes developed, the resulting meltwater pooled in low elevation areas near the ice sheet centers (centers to the west and east of the glacial saddle dividing the ice between the lakes) and was basically sealed in by cold-based ice near warm-based ice margins. The dividing saddle is located between latitude 48N–56N (Sejrup et. al. 2004).The upper and lower Erne lakes and lake Lough Neagh were drained mainly by flowing through dendritic networks of subglacial channels that had to have eventually burst through the cold based ice at the margins of the forming lakes. These channels include the Kilskeery eskers shown at the top of the page, the Glarryford eskers in Ulster, and the nearby Poyntzpass tunnel valley.

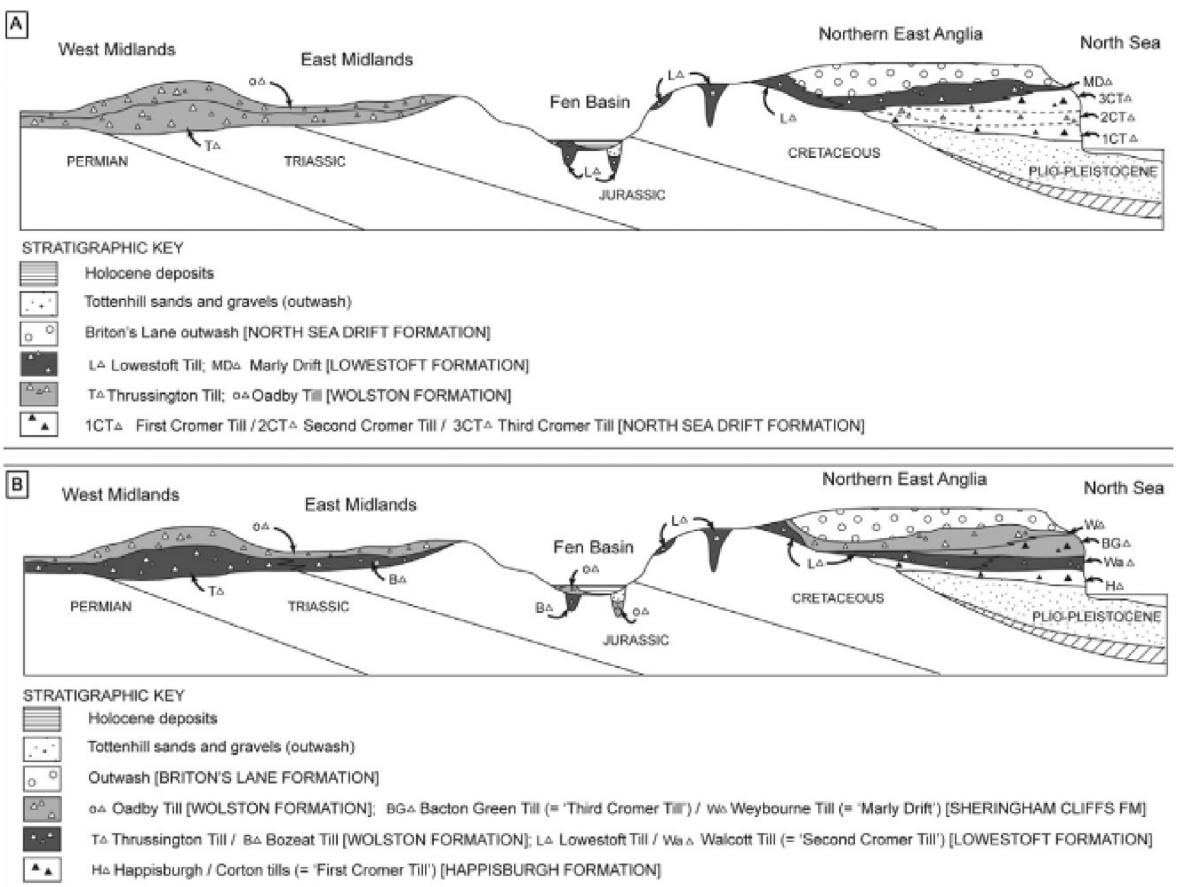
Overview

Long Term Development Implications:

Being active for up to 2.6 Million years over the course of the Pleistocene, the ice that existed over Britain saw its greatest extent during the Anglian glaciation. This glaciation marked the most extensive quaternary expansion of the BIIS and has had a major effect on Britain's landscape (Lee et. al. 2011). In addition to radically altering Britain's drainage and relief, it was also mainly behind the formation of the Strait of Dover at the southeast corner of Britain, separating it from mainland Europe during high sea level changes that occurred around the middle to late Pleistocene. The overall behavior of the BIIS over the glaciations of the Pleistocene was largely controlled by climate shifts on the global scale, which also had a close connection to other ice sheets in the northern hemisphere (Batchelor et. al. 2019). It is evident the 'climatically sensitive' north Atlantic region, which held ice sheets such as the Scandinavian ice sheet, the Laurentide ice sheet, the Greenland ice sheet, and other smaller surrounding ice sheets in close proximity, was subject to stage-oriented glacial change over the course of 1.25 to 0.7 million years ago. The exact way that the BIIS fits into this system is still unclear however, as its long-term development is still poorly understood (Lee et. al. 2011). Some of the many reasons for this include the discontinuity and vagueness of some glacial information to come out of Britain, as well as missed links between onshore and offshore data and mismatching interpretations of glacial sequences and geologic data collected farther inland of Europe. Offshore data has been used however to suggest that the glaciation of the British lowlands began during the Cromerian stage, which occurred over half a million years ago. The confusion and discontinuity from British and other European records likely resulted from the absence of glacial deposits in most Cromerian sequences analyzed in Northwestern Europe (Lee et. al. 2011). The main evidence for the BIIS is derived from the Glacial erosion surface that stretches across the Hebrides shelf. This surface first drew attention when it was discovered as a major seismic unconformity. Other evidence is drawn from ‘over-deepened’ subglacial tunnel valleys produced by contemporary glaciofluvial erosion and deposition during ice margin retreat (Lee et. al. 2011). Sedimentary sequence evidence for the BIIS’s expansion into Britain can be boiled down to glaciolacustrine and glacio-marine deposits of the Swarte bank in the North Sea and the Aberdeen ground formations which are characterized by sub horizontal, laterally continuous internal reflectors which represent bedding within this predominantly clay-rich unit (Cameron et. al. 1992, Gatliff et. al. 1994) (Lee et. al. 2011).

A close connection of the BIIS to the Scandinavian ice sheet indicated an explanation for the earliest encroachment of British ice into the northern margins of the North Sea. This initial expansion coincided with the Scandinavian expansion onto the continental shelf edge during the Fedje glaciation around 1.1 million years ago (Sejrup et al., 1987) (Lee et. al. 2011). The evidence for this consists of “large influxes of outwash derived pre-quaternary polymorphs, which are believed to be eroded from lowland bedrock strata along the western fringes of the North Sea, and offshore from northern Britain” (Eckman 1999) (Lee et. al. 2011). Some of these influxes of glacial outwash also came from the Jaramillo chronological subdivision spanning from 1 to 1.07 million years ago (Lee et. al. 2011). Glacial erratics are also key pieces of evidence to the evolution of the BIIS. Erratics and other heavy minerals have been located in coastal deposits around Northeast Britain. A popular and plausible explanation for these erratics indicates calving processes of the BIIS that resulted in ice rafting, which helps put together how the ice sheet fluctuated over different stages of a glaciation. This can only be seen however if the coastal ‘reworking’ processes that took effect on the erratics are factored in. Bore hole data from the British Geological Survey for the Hebrides slope (Geikie Slide) offshore to the northwest of Scotland, shows a drop stone sequence of Scottish origin. This sequence has been dated to between the early to mid-Pleistocene and Gauss-Matuyama paleomagnetic boundary, which was a geological event approximately 2.45 million years ago when earth's magnetic field reversed (Mcdougall, 1972). These drop stones in the Hebrides shelf are some of the first pieces of evidence for the birth of the Scottish section of the BIIS at the beginning of the Pleistocene, and their specific connection to the Gauss-Matyama event does make it plausible that the long-term behavior of glaciation in Britain can be strongly linked to orbital forcing (Lee et. al. 2011).

(Lee et. al. 2011)



Above is a before and after map of the northern and midland regions of Britain. Due to issues with chronology resulting from inaccurate interpretation, seen as “missed join ups” with data from other European countries, a new map for the area (B) was created to more precisely represent the Anglian geology. The main change from (A) to (B) on the maps, is the designation of the Thrussington and Odby tills as separate layers, and the re-classification of the Lowestoft till in A as predominantly Oadby till in B, underlain by the Thrusington till.

CONCLUSIONS

The study of the paleo-glaciology of the BIIS still has a long way to go before it is properly understood, albeit there is already a long history of glacial research in the UK. Scientific attention has been brought back to the BIIS and its history for a few reasons, chiefly due to the interest in paleo-ice streams, the publication of the second version of the BRITICE map and GIS data compilation, and the development of new and high-tech methods for data collection (such as LIDAR) and data interpretation. The glacial remnants left behind in the sections of the northern hemisphere that are underwater have been out of reach for most researchers during the early days of glacial study, but new developments in bathymetry methods have yielded a whole wealth of new information on seafloor topography. Reconstructing the margins of the BIIS could be crucial to understanding how global climate change ties into ice-sheet oscillations, and thus this information could be used for extrapolation of future sea level changes. The consensus on the dynamics of the BIIS is that it was dominated by steady south-westward expansion over Ireland from 35k to 30k years ago, transitioning to a more southern expansion for the next 6,000 years, and followed a similar backwards trend of retreat up to the end of the ice age. Data on this is still not conclusive however, as there is a good deal of discontinuity and ambiguity in the glacial and geological records of the UK, the finer details of which are still waiting to be worked out.

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