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# Gwydir Bay

## Highlights

This is a key site for the study of the glacial and fluvioglacial sediments deposited in Llŷn by Irish Sea and/or Welsh ice. It is a reference locality for Devensian glacial stratigraphy in North Wales.

## Introduction

Glacial sediments derived from the Irish Sea Basin are commonly exposed along the north Llŷn coast. Sections at Gwydir Bay, however, provide an unusually complete and detailed sequence that can be used to reconstruct Late Pleistocene glacial events in north-west Wales. The site was studied by Reade (1893) and Jehu (1909), and more recently was described by Synge (1964), Saunders (1968a, 1968b, 1968c, 1968d, 1973), Simpkins (1968) and Whittow and Ball (1970).

## Description

The sections at Gwydir Bay run from near Porth Trevor northwards to beyond Mon Hen. Three main units occur - 1) a lower till, 2) intervening gravels and sands and, 3) an upper till. These typify the tripartite succession widely described in northern Llŷn by Jehu (1909). The sequence is shown in (Figure 29) and the beds correspond to the Trevor Till, Aberafon Formation and Clynnog Till, respectively. of Simpkins (1968).

The Trevor Till is a homogenous Irish Sea till. the base of which is not seen in central Caernarvonshire (Simpkins 1968). It attains a maximum exposure height in Gwydir Bay of some 30m. It is argillaceous and contains shell fragments and distantly derived erratics. The Trevor Till was, however, described as purple and stoneless by Synge (1964), although others have described it as red (Reade 1893), blue-grey (Jehu 1909) and dark grey-brown (Simpkins 1968). It is prone to slumping, and sections through it in Gwydir Bay are stepped, with individual exposures rarely amounting to more than 6m (Saunders 1968d). The Trevor Till is highly calcareous — up to 42.5% carbonate (Simpkins 1968).

The junction between the Trevor Till and the overlying sands, silts and gravels of the Aberafon Formation is not clearly exposed. The latter thickens to the north-east and comprises a series of almost horizontal beds of sorted, olive brown sands, silts and gravels. Near Mon Hen (Figure 29), the coastal cliff is cut almost entirely in these deposits, which average between 12 and 15m height. In places, the upper 2m of sand reveals elaborate convolution and festoon structures, a series of possible frost wedges, indurated zones and iron-pan formations. Collapse structures caused by the melting of buried ice have also been noted in the Aberafon Formation which, like the Trevor Till, contains Irish Sea erratics. Conversely, the sands and gravels are only slightly calcareous. Dislocated masses of Trevor Till occur within the sands and gravels of the Aberafon Formation (Simpkins 1968).

The Aberafon Formation is replaced laterally and vertically by a stony deposit, the Clynnog Till (Simpkins 1968). Towards Clynnog Fawr, the Clynnog Till forms most of the cliffline and the Trevor Till and Aberafon Formation are only seen sporadically towards the base of the cliff. The texture of the Clynnog Till is variable and, in places, shows a degree of fluvial sorting. It is yellow-brown and slightly calcareous (up to 4.7%) and it contains a mixture of Irish Sea and Welsh rock types (Simpkins 1968). Where the surface of the till is exposed, it is cryoturbated to the same degree as the Aberafon Formation and leached to a depth of 1–2m (Simpkins 1968). A thin development of cryoturbated sands and gravels has been described overlying the Clynnog Till in places (Synge 1964; Saunders 1968d) — see (Figure 29).

This tripartite sequence has been consistently recognised by successive workers (for example, Reade 1893; Jehu 1909; Saunders 1963, 1968a, 1968b, 1968c, 1968d, 1973; Simpkins 1968; Whittow and Ball 1970), but disagreement as to the presence or absence of a weathering horizon at the top of the Aberafon Formation at the site has led to radically different interpretations of the sequence of Late Pleistocene events in the area. (Figure 29) illustrates the stratigraphic context of the weathering horizon described by Saunders (1968d).

## Interpretation

Reade (1893) was the first to study the Pleistocene deposits of the north Llŷn coast in detail. He described a range of northern rock types from the Trevor Till, his Lower Boulder Clay, and established a source from the Irish Sea Basin. A microscopy study of sand grains from the overlying sands and gravels (Aberafon Formation) led Reade to suggest that the beds had been deposited, at least in part, by marine submergence.

Jehu (1909) identified two tills separated by fluvioglacial sands and gravels. He confirmed that the lower or Trevor Till contained rock types from sources in Anglesey and in the Irish Sea Basin, and interpreted the sequence in terms of two glacial events separated by warmer, possibly interglacial conditions.

More recent studies at Gwydir Bay fall into two main categories and have established the source and patterns of movement of the invading ice-sheets, and allowed a reconstruction of the sequence and chronology of Late Pleistocene events.

Early studies established an Irish Sea origin for the sediments at Gwydir Bay (Reade 1893; Jehu 1909), when a range of exotic rock types, including Ailsa Craig microgranite and porphyrites from the Dalbeattie area of Scotland, was described. Recent studies have applied pebble lithology measurements and till fabric analyses to try to determine the sediment provenance at Gwydir Bay (Saunders 1963, 1968b, 1968d; Simpkins 1968; Whittow and Ball 1970). Saunders confirmed that the Trevor Till contained a predominance of rocks from Anglesey and more northern (Irish Sea) sources, and showed that the Clynnog Till contained a more varied pebble lithology, with an assemblage indicating derivation from local sources in Anglesey and Snowdonia. Irish Sea pebble lithologies, however, were still common in the Clynnog Till. These findings were broadly confirmed by Simpkins (1968) who demonstrated that many pebbles in the Clynnog Till were relatively local in origin, including Cambrian grit, felsite, feldspar porphyry from Porth Trevor and slates and Ordovician volcanic rocks from Snowdonia. She suggested that the variable lithological and textural characteristics of the Clynnog Till indicated deposition as an end-moraine, whereas the more homogenous properties of the Trevor Till indicated deposition as ground-moraine or lodgement till.

Till fabric studies, however, proved less conclusive (Saunders 1963, 1968b, 1968d; Simpkins 1968). Although Saunders' measurements suggested that the Trevor Till was deposited by ice moving from north-west to south-east, and the Clynnog Till by ice moving almost due south, a considerable degree of fabric variability within units did not allow precise differentiation between the tills. However, the lithological and fabric evidence from Gwydir Bay have together been widely taken to indicate that the Trevor Till was deposited by Irish Sea ice which pushed across Anglesey before invading Llŷn. Comparable evidence from the Clynnog Till has also been used to suggest that during the second glacial advance, the area was invaded by confluent Irish Sea and Welsh ice moving almost due south (Saunders 1963, 1968b, 1968d; Syngé 1964; Simpkins 1968; Whittow and Ball 1970).

Although the source of the invading ice-sheets at Gwydir Bay is reasonably well established, their age is poorly understood. Early attempts to integrate stratigraphic evidence from the north Llica' coast into a chronology of Pleistocene events were made by Mitchell (1960) and Syngé (1963, 1964), who used evidence from Gwydir Bay and elsewhere on Llŷn. Syngé recognised Jehu's tripartite division of deposits along the north Llŷn coast and used Irish stratigraphic evidence to derive a framework for Pleistocene events. He suggested that raised beach gravels at Porth Oer (north-west Llŷn) were Hoxnian in age, and consequently that the two tills found along the north Llŷn coast including Gwydir Bay, belonged to the succeeding Saalian and Weichselian (Devensian) glaciations. The limited occurrence of the upper (Clynnog) till, between Clynnog Fawr and Bryncir, led Syngé (1963, 1964) and Mitchell (1960, 1972) to regard this area as being at the limit for Late Devensian ice. Indeed, Mitchell (1960) suggested that his Late Devensian limit could be traced offshore, and extrapolated right across St George's Channel to Wexford. The Trevor Till and associated sands and gravels (Aberafon Formation) exhibited signs of weathering and cryoturbation according to Syngé (1964), and this weathering was thought to have occurred during the

## Ipswichian Stage.

The views of Mitchell and Synge on Pleistocene events in north-west Wales have not been accepted by subsequent workers (for example, Saunders 1968a; Whittow and Ball 1970; Bowen 1974), who have suggested that the glacial succession at Gwydir Bay was deposited largely during the Late Devensian. Later workers have generally considered the limited occurrences of raised beach sediments, which occur at Porth Oer and Red Wharf Bay, to belong to the Ipswichian Stage, thereby fixing the glacial successions firmly in the Devensian Stage.

Saunders (1968a, 1968b, 1968d) reconstructed the following sequence of events from the evidence at Gwydir Bay and from other sites in north LI■n. He suggested that the Trevor Till was deposited during the principal thrust of the Late Devensian Irish Sea ice-sheet. In support of this view he cited radiocarbon dates from the Trevor Till and associated Aberafon Formation deposits elsewhere in north and west LI■n which, he believed, constrained the maximum age of the first recorded ice advance to around 30,000 BP. He argued that the sands and gravels of the Aberafon Formation overlying the Trevor Till at Gwydir Bay, were fluvio-glacial in origin and that they were related to wastage of the Late Devensian ice. Saunders placed much emphasis on the weathering horizon which he reported affected the surfaces of both the Aberafon Formation and the Trevor Till — see (Figure 29). Unlike Synge, Saunders (1968b, 1968d) attributed this weathering to interstadial conditions in the Devensian. He argued that a return to periglacial conditions should be inferred from the cryoturbation and frost-cracking of this weathered surface, and a return to fully glacial conditions was marked by deposition of the Clynnog Till at Gwydir Bay and northwards to Dinas Dinlle. The Clynnog Till he suggested, was deposited by a later advance of the Irish Sea and Welsh ice-sheets which impinged on northern LI■n, and extended as far south as Bryncir, where the maximum limit was marked by prominent moraines. At Bryncir, organic material disseminated within gravels of the moraine was dated by Foster (1968, 1970a) to 16,830 ± 970 – 860 BP (1–2801). Saunders (1968a) tentatively correlated the later expansion of Late Devensian ice with the Scottish Readvance. Although Bowen (1974) disputed the validity of the radiocarbon date from Bryncir because he felt there was no evidence that the deposit sampled was in fact organic, he accepted the concept and other evidence for a Late Devensian readvance in this area.

Simpkins (1968) did not recognise a weathering horizon at Gwydir Bay and therefore defined an alternative sequence of events for the area. Some of the structures attributed to frost-action by Saunders (1968d, 1973) were instead interpreted by Simpkins as due to tectonic disturbances caused by the melting of buried ice. No significant time interval was therefore envisaged between deposition of the three main units at Gwydir Bay and she suggested that the whole sequence was Late Devensian in age with the Clynnog Till representing only a minor oscillation of the ice-sheet.

Gwydir Bay provides the most detailed and extensive exposure through the typical tripartite sequence of northern LI■n. It can be regarded as a reference site for the Trevor Till, the Aberafon Formation and the Clynnog Till. Although individual members of this sequence are extensively exposed elsewhere in LI■n, Gwydir Bay is particularly important for showing the stratigraphic relationship between these deposits in a single section. It is the type locality in northern LI■n for the Trevor Till, which is much better exposed than at Dinas Dinlle to the north.

The sequence provides an important record of changing environmental conditions in north-west Wales during the Late Pleistocene, showing evidence for two separate glacial advances. It is widely held that the sequence is Late Devensian in age, and the stratigraphic detail at Gwydir Bay together with well developed glaciotectonic structures at nearby Dinas Dinlle, provide evidence for a possible readvance of the Late Devensian ice-sheet in north-west Wales.

Gwydir Bay is one of the most intensively studied sites in north-west Wales and has provided significant data for charting the patterns of movement and interaction of Irish Sea and Welsh ice masses. The Trevor Till was deposited by Irish Sea ice which moved across Anglesey before invading LI■n, while the Clynnog Till may have been deposited by confluent Irish Sea and Welsh ice masses. The weathering horizon described at Gwydir Bay by Synge (1964) and Saunders (1968a, 1968d) is important for interpreting the sequence, particularly in determining a possible ice-free interval between deposition of the Trevor and Clynnog Tills.

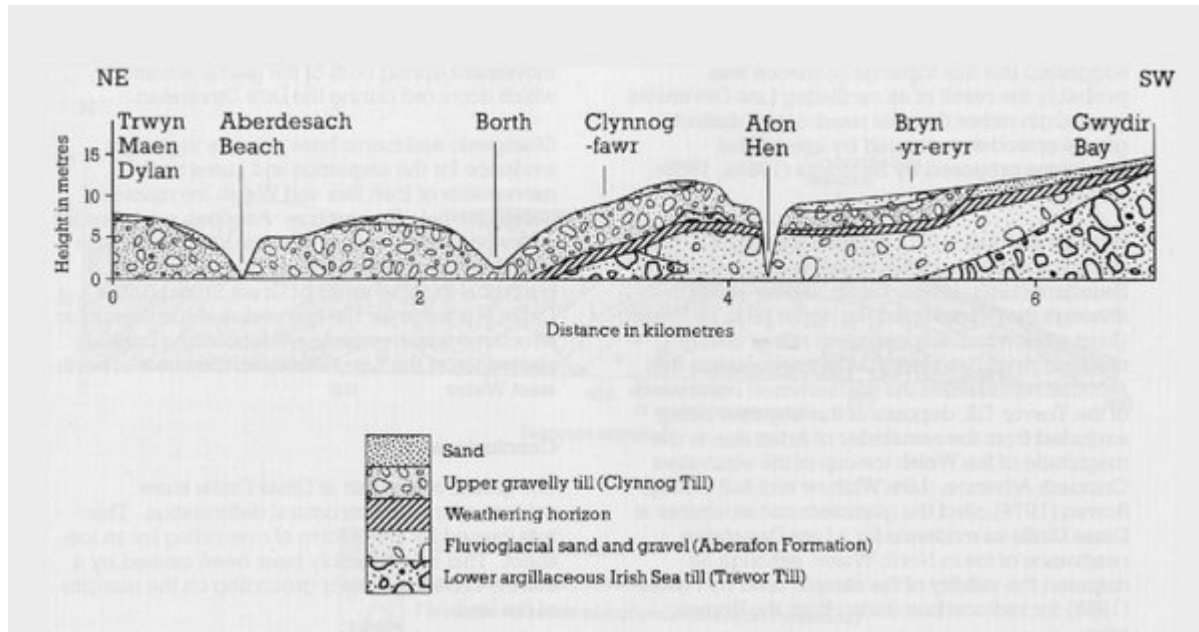
This is a reference site for the three principal sedimentary units found along the northern LI■n coast — the Trevor Till, the Aberafon Formation of sands and gravels and the Clynnog Till. The site demonstrates the stratigraphic relationships of these deposits and shows important evidence for the timing and interaction of the Irish Sea and Welsh ice masses which affected north-west Wales during the Late Pleistocene. The evidence suggests that the coastal margin was first

invaded by Irish Sea ice which moved across Anglesey into Llŷn, and then by a confluent Irish Sea and Welsh ice stream. The detailed lithostratigraphic evidence at Gwydir Bay is complementary to the glaciotectonic structures at Dinas Dinlle which have been used as evidence for a readvance of the Late Devensian ice-sheet in north-west Wales.

## Conclusions

Gwydir Bay is a reference site for three major units of glacial deposits. These are the Trevor Till (boulder clay), the Aberafon Formation consisting of sands and gravels, and the Clynog Till. Their mutual relationships show how the Irish Sea ice-sheet and Welsh ice-sheet interacted on the margins of north-west Wales.

## References



(Figure 29) Pleistocene sequence at Gwydir Bay (from Saunders 1968d)