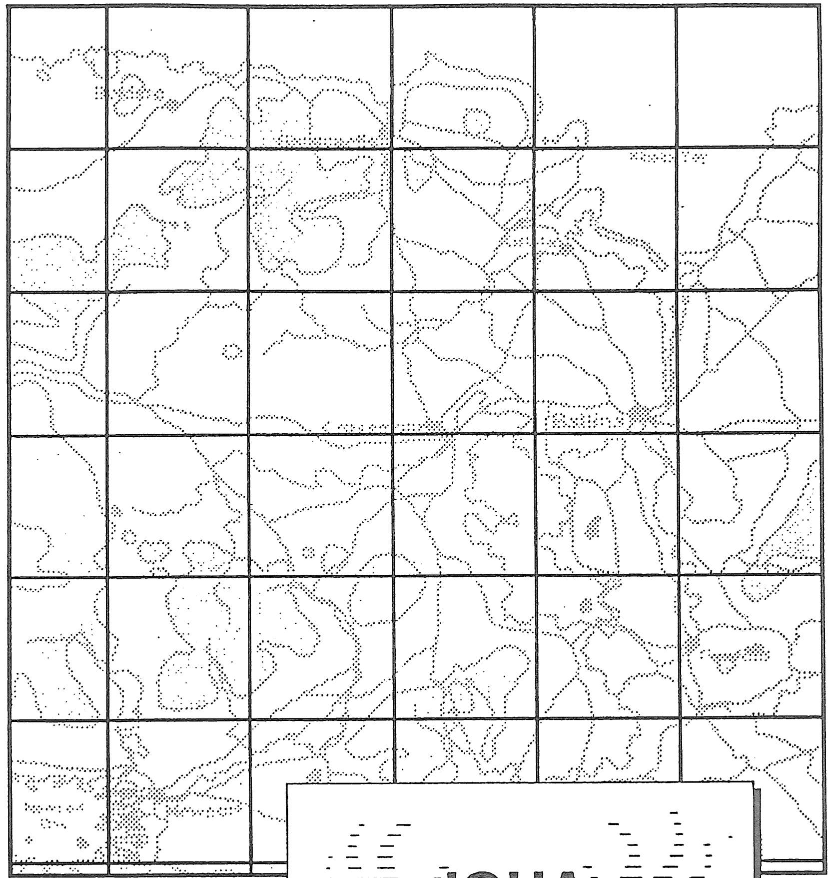
North Mayo



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Coxon,P and Hannon,G. 1991. The interglacial deposits at Derrynadivva and Burren Townland. in: Coxon,P. (ed.) *Fieldguide to the Quaternary of north Mayo.* Irish Association for Quaternary Studies (IQUA), Dublin.
Gibbons,M. and Condit,T. 1991. Lake promontory forts in County Mayo. in: Coxon,P. (ed.) *Fieldguide to the Quaternary of north Mayo.* Irish Association for Quaternary Studies (IQUA), Dublin.
Coxon,P. and Browne,P. 1991. The Nephin Beg Range and the Late-glacial. in: Coxon,P. (ed.) *Fieldguide to the Quaternary of north Mayo.* Irish Association for Quaternary Studies (IQUA), Dublin.

A fieldguide to the Quaternary of North Mayo

by

Peter Coxon,
Department of Geography,
Museum Building,
Trinity College,
Dublin

with contributions from

P.Browne, T. Condit, M.Gibbons, G.Hannon and J.Stone

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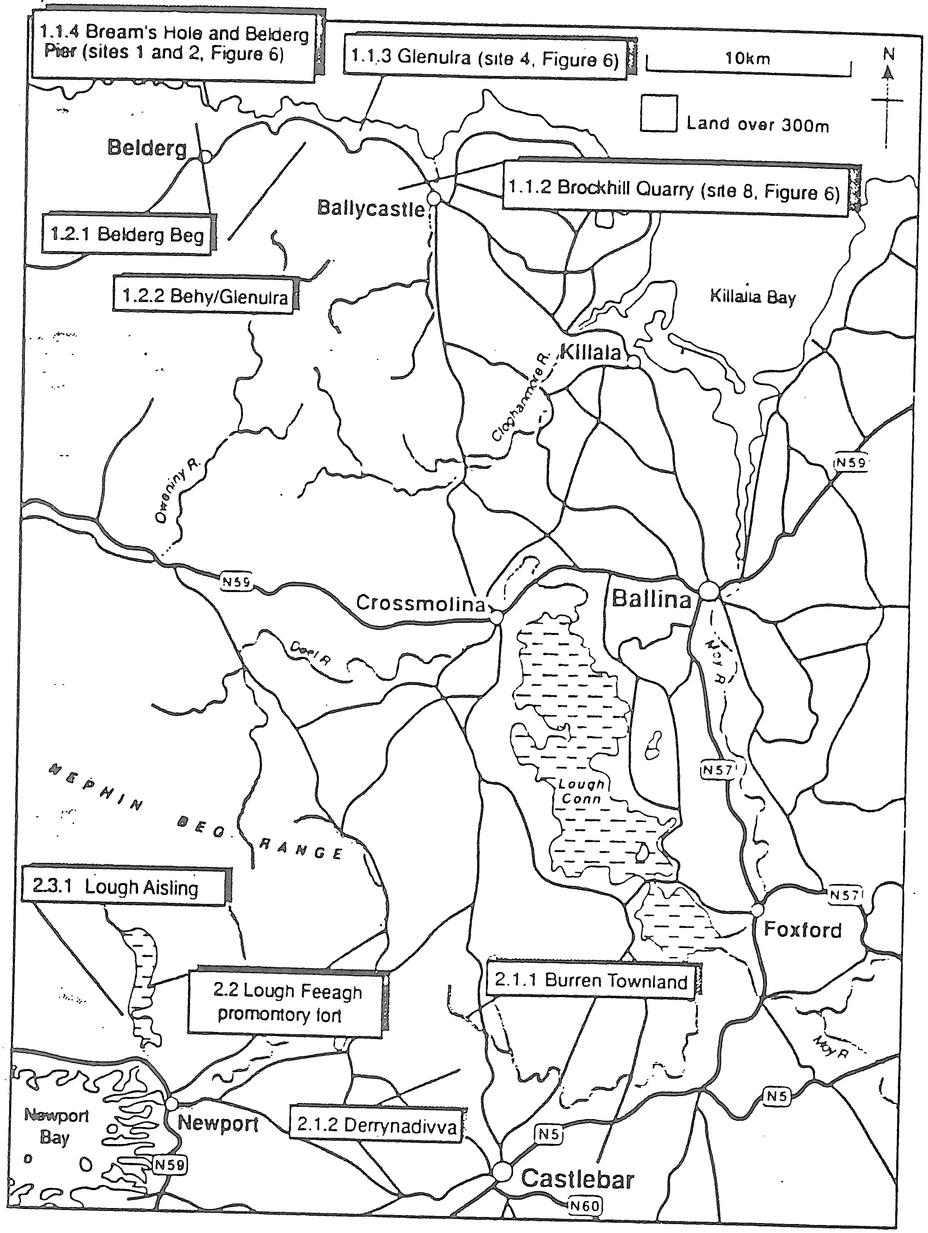
Figure 1. Location of sites to be visited during IQUA 1991 Fieldmeeting.



Preface

This guide is intended to complement a weekend field meeting of the Irish Association for Quaternary Studies (IQUA) and as such it is not a comprehensive guide to all of the area mentioned in the title but a guide to selected sites. Our visit will be concentrating on the glacial and interglacial geology as well as aspects of the archaeology and our omission of, for example, sites looking at blanket peat or particular sets of glacial moraines does not mean that their importance in the landscape has been overlooked. We cannot look at all of the important sites relating to the Quaternary and the following sections tend to cover themes within the landscape as a whole. North Mayo contains a treasure trove of information relating to climatic and environmental change on a large and small scale as well as containing abundant evidence of early human settlement and its influence on the scenery.

Many of the diagrams and tables have been reproduced not to reinforce existing dogma but to facilitate discussion about spatial trends and geological events. It is the author's opinion that the area of north Mayo would warrant further analysis and that new ideas about the glacial history of the region would be welcome.

I have attempted to compile published (and some unpublished) information referring to the places that we will visit on the excursion that will help in their understanding in the field. The reader is directed to the original publications (where available) for the full details. Although the guide is predominantly concerned with the Quaternary (but basically pre-Holocene) geology and the archaeology an attempt to provide information regarding other areas of interest has been made.

Please note that some of the sites are private property and permission should be sought before entering.

Material in this guide has been drawn from a number of sources which are attributed in the text. I would like to thank Jeremy Stone, Michael Gibbons, Tom Condit and Philip Browne for providing additional material for inclusion within this guidebook and Matthew Stout for the cover design and for drafting a number of the diagrams in this guide book and Colm O'Cofaigh and Stephen O'Connor for assistance in preparing the guide.

Introduction and outline of the field trip

The area that we will cover during this trip is part of the OS 1:126.760 (1/2 ") sheet number 6 of North Mayo and some of the sites that we will visit are shown on Figure 1.

Outline of the IQUA 1991 excursion

Our field trip is intended to visit and discuss sites that have been more recently discovered or reassessed rather than to look into every aspect of north Mayo. Thus we can only hope to look at selected sites and topics but if participants know of other quarries, sections etc. that would be worth including then please let me know.

Saturday 5th October
1.1 The glacial deposits of the north-Mayo coast
1.2 The Céide Fields
Sunday 6th October
2.1 The interglacial deposits at Derrynadivva and Burren Townland
2.2 The promontory fort at Lough Feeagh
2.3 The Nephin Beg Range and the Late-glacial

North Mayo -regional geology

The underlying geological framework of north Mayo is extremely varied and includes some of the oldest rocks in Ireland. Some of the original igneous rocks of the Annagh Gneiss Complex are thought to have been erupted roughly 1,900 million years ago (1,900 Ma). These rocks occupy the central part of the Mullet Peninsula and the mainland south of the road from Belmullet to Bangor. Moving inland there is a progressively younger series of Dalradian metasediments (roughly 700 Ma to 500 Ma), and further east lie Carboniferous clastics and limestones (around 350 million years old). To the south of the limestone lowlands, the Ox Mountains (and associated Devonian rocks) form a SW-NE ridge of schists, granites and clastics. Igneous rocks are also found at the southern tip of the Mullet Peninsula, and basic intrusives crop- out all along the coast - notably at Belderg, and just north of Killala.

The rocks of the Annagh Gneiss Complex are thought to have originated as a mixed sedimentary and igneous sequence into which a series of basic dykes and granitic sheets were intruded in two separate phases of igneous activity, late in Pre-Cambrian times (probably associated with the Grenvillian orogeny). A period of amphibolite facies metamorphism, between approximately 1,070 Ma and 1,000 Ma, created the gneissose banding, and this was followed by intrusion of a series of smaller granite sheets prior to the Caledonian orogeny. Today these rocks are largely covered by extensive blanket bogs, but clasts derived from the complex are found in glacial deposits throughout the region.

The metasediments and intrusives of the Ox Mountains form an inlier of higher land running north-east south-west within the Lower Carboniferous. Granitic rocks of the Slieve Gamph igneous complex (487 Ma) form the spine of the inlier, and are surrounded by high grade (at least amphibolite facies) metamorphosed sandstones, silts and mudstones. The age of these metasediments is uncertain, but further north the major phase of metamorphism is dated at approximately 700 Ma.

From late Pre-Cambrian to early Ordovician times, North Mayo was situated on the southern margin of the Dalradian marine basin, which extended across to northern Scotland. Dalradian schists and quartzites underlie much of the western

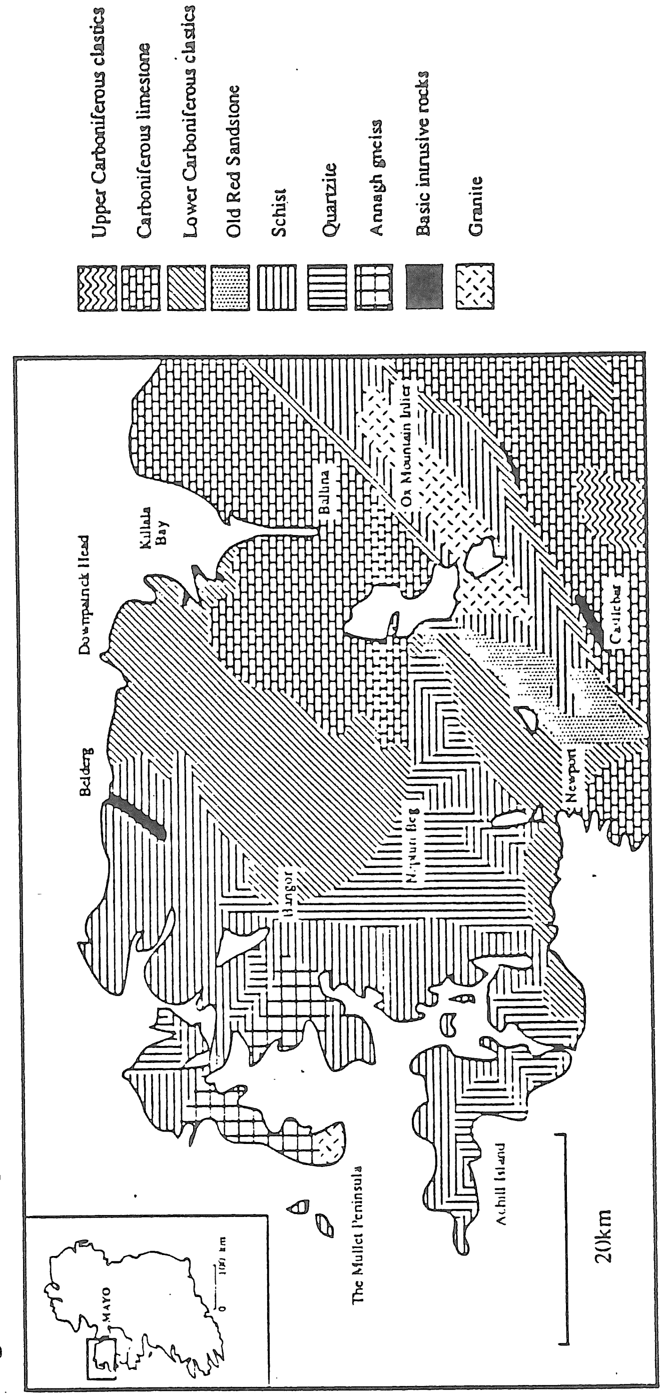


Figure 2. Simplified geology of the north Mayo region.

part of North Mayo, where the more resistant quartzites form areas of high land running north south from Slieve Fyagh down to the Nephin Beg range, and along the northern margin of Clew Bay. The earliest Dalradian rocks in the area are psammites of the Grampian Group, which were probably laid down in fluviatile to marginal marine environments. The quartzites, psammites and pelites of the Appin Group were deposited following a transition to more stable marine shelf conditions - which in turn were followed by a variety of shelf and deeper water deposits of the Argyll Group, including some quartzites which may represent tidally reworked post-glacial outwash sands. The youngest Dalradian rocks, of the Southern Highland Group, include: turbidites, localised tuffs and basic volcanics, and occasional limestones. The Dalradian rocks all show signs of folding, faulting and high grade metamorphism resulting from the Caledonian orogeny, which developed during the closure of the Proto-Atlantic (Iapetus) ocean during late Cambrian to middle Ordovician times.

The Blacksod Granite, at the southern tip of the Mullet Peninsula, is a late Caledonian stock about 5 km in extent, which has been dated radiometrically at around 383 Ma.

Lower and Middle Old Red Sandstone deposits are found in fault- bounded blocks at the western end of the Ox Mountain inlier. The rocks comprise folded and faulted conglomerates and sandstones, and may locally be associated with andesitic volcanics.

During Lower Carboniferous times North Mayo was situated near the equator and, following the ORS terrestrial regime, shallow marine conditions were established. A belt of deltaic clastics lies to the north and west of a broad expanse of shelf limestones. The clastics comprise alluvial conglomerates, sandstones and red and green siltstones with some shales. A small outlier of Namurian shales and sandstone occurs at Slieve Carna just west of Kiltamagh, to the south of the Ox Mountain complex.

The opening of the North Atlantic Ocean was associated with a phase of Tertiary intrusive activity which resulted in emplacement of the Killala gabbro, followed by the east-west trending Killala Bay dyke swarm. Part of the latter crops-out spectacularly at Belderg Harbour where dolerite intrusions are seen deforming Appin Group Dalradian metasediments.

(J.J. Stone)

Regional Pleistocene geology

Figure 3 is a map of Ireland showing the general distribution of glacial landform elements within the country. This map (reproduced from McCabe, 1987) is a generally accepted model showing deposits predominantly formed during the Last Glaciation (Midlandian) but also including areas which have been considered as ice free during the Midlandian (i.e. those areas marked as "Older drift"). The ice movement directions (based on numerous studies of till content and erratics) are depicted on Figure 4 and although the timing of these glacial events is the subject of some controversy this general pattern is one that must have predominated for major glacial episodes.

Since the early work of Charlesworth (1928) which covered the area of north

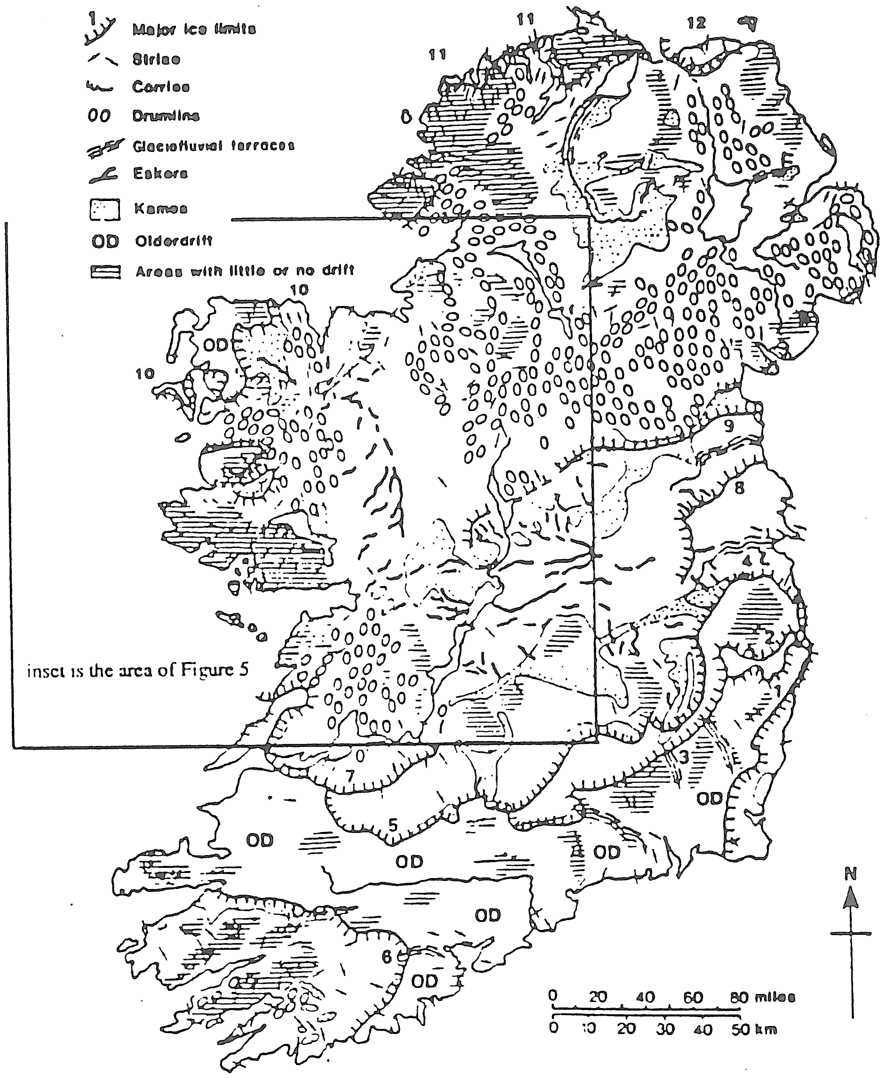
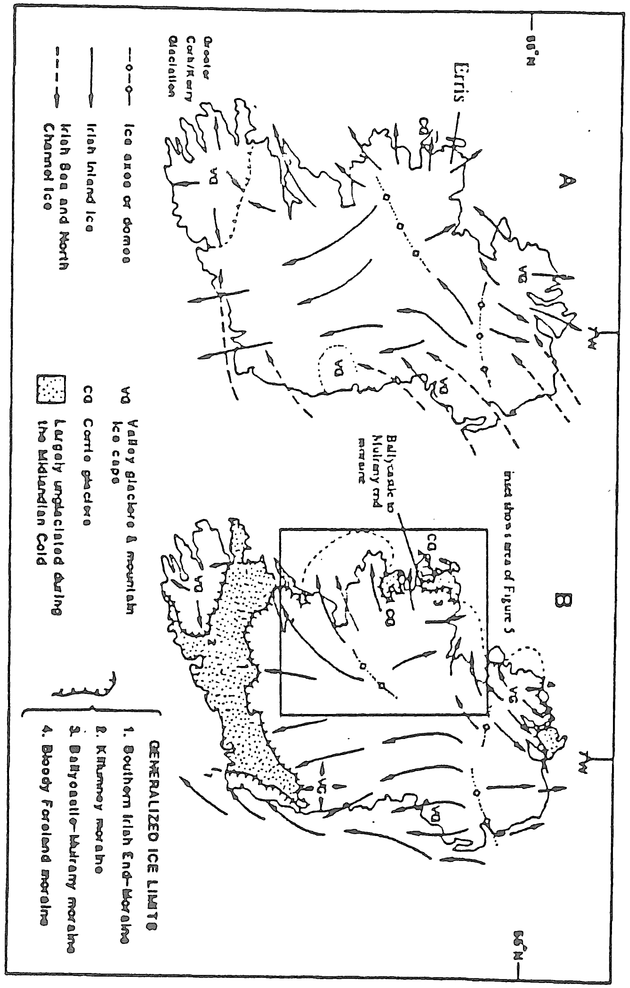


Figure 3. The Quaternary geology of Ireland from McCabe, 1987

Figure 4. General directions of ice-sheet movement in Ireland (after McCabe, 1985).



A -Munsterian Glaciation
B -Late Midlandian Glaciation

Mayo and west Sligo as a whole and the more comprehensive work of Synge (1963) the region has attracted little attention from Quaternary geologists. The area to the south (South Mayo and Connemara) has been more extensively visited by Quaternary scientists and yet we still have little evidence of the actual sequence of glacial events (Table 1, page 50). The problem with the correlations proposed in such schemes as Table 1 is that they are (at best) of local value only and are not dated.

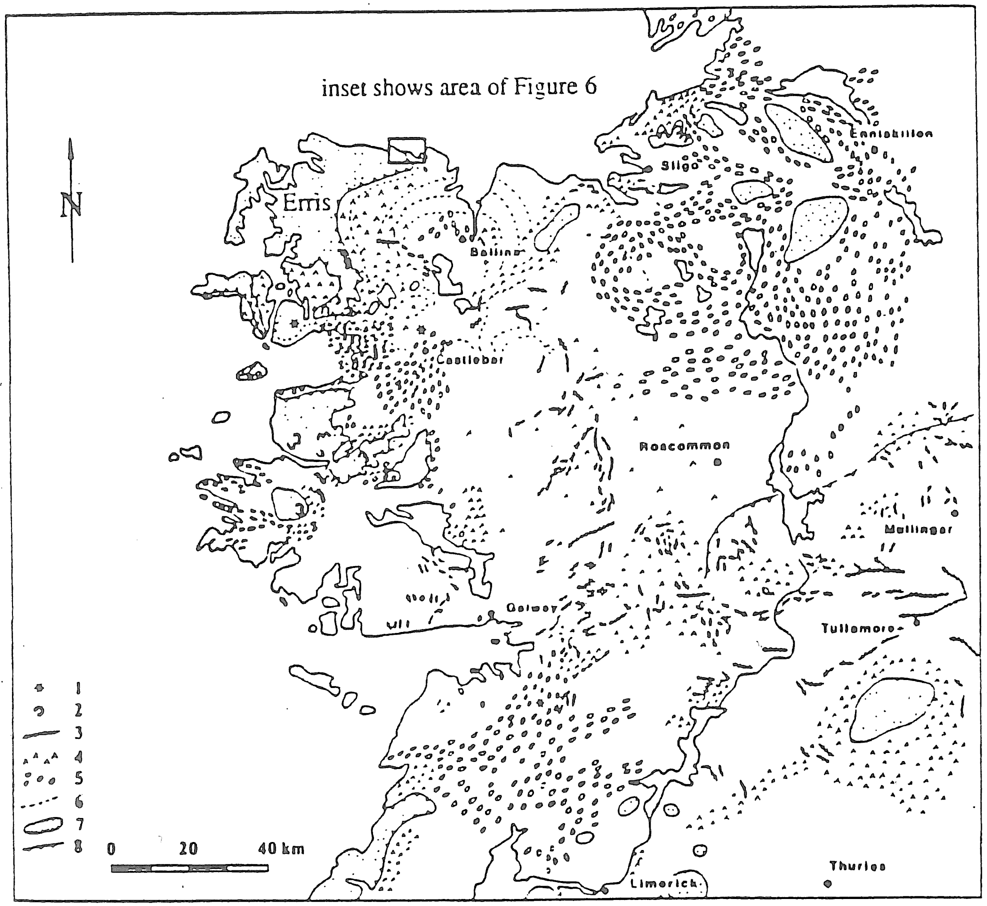
The extensive glacial deposits of the eastern and southern part of the region which are characterised by drumlin swarms and large spreads of sand, gravel and moraine are complemented by the upland areas with their evidence of mountain glaciation (on both a large and a small scale). It is clear from the work of Charlesworth and Synge that during an extensive glacial period large ice masses pushed from the axis identified in Figure 4 north westwards towards north Mayo and that at the same time mountain ice masses have accumulated in the uplands of Achill Island and in the Nephin Beg Range. These glaciers have left a suite of landforms and deposits in the west of Ireland that can be summarised as on Figure 5. The extensive till and moraine drapes of the eastern part of north Mayo sweep around to the north (towards Killala Bay and the north Mayo coast) and to the south of the Nephin Begs to form the drumlin belts most beautifully represented by the drumlins in Clew Bay. The moraines and deposits of sand and gravel including eskers that were formed during deglaciation are also found in eastern north Mayo. Synge (1968) identified an ice limit (the Ballycastle-Mulrany moraine) outside of which he identified "Older Drifts" on the basis of their weathered appearance and lack of fresh glacial landforms. This limit can be identified on both Figures 4 and 5 and the unglaciated region comprises of much of north western Mayo (*Erris* on Figure 5).

Interglacial deposits have been identified at a number of localities in north Mayo and we shall visit two of these that are very close together and represent a glacially disturbed interglacial surface. These are the sites of Derrynadivva and Burren Townland which were known from the 1960s and have been referred to in a number of publications (e.g. Finch, 1977 and Watts, 1985). This fieldguide contains some new observations on these sites which are Gortian in age. The interglacial sediments are contained within or are under thick till deposits on the flanks of hills to the south east of the Nephin Begs. Unfortunately the interglacial deposits do not assist in dating the glacial deposits. The interglacial deposit described from Curaun (Corraun) by Synge (1968) have not been unequivocally shown to be of interglacial status and as such their relevance to the stratigraphy of western Ireland is in some doubt (but see Table 1). I have been unable to relocate this deposit which is a shame considering its potential importance.

In recent years work by Coudé (1983 and 1985), Kenyon (1986), Browne (1986) and McCabe *et al.* (1986) has brought to light the fact that much of interest lies within this northern part of Mayo.

Research by McCabe *et al.* (1986) has identified ice limits associated with glaciomarine sediments in the Belderg area (Site 1.1 Figure 1) adding a fascinating dimension to the proposed ice free area proposed by Synge in Erris. As we can discuss in the field (and see section 1.1 below) the ice limits described by Synge are attributed to a large scale Late Midlandian ice advance (The "Drumlin Readvance"). Glaciomarine muds associated with the ice limit provide the only core

Figure 5. Map of central and western Ireland (from Coxon and Browne, 1991, after numerous sources.



1. interglacial deposits
2-cirque moraines
3-esker
4-sand and gravel spreads including kames
5-drumlins
6-moraines (after Charlesworth, 1928)
7-areas with little or no Midlandian deposits
8-major ice limits

Late-glacial) dated glacigenic sediment in the area as McCabe *et al.* obtained dates of *ca.* 17,000 years BP from shells in the muds.

The mountain glaciation, principally in the Nephin Begs and on Achill Island, was extensive and most research has concentrated on the corrie glaciers that produced numerous moraine limits. Synge (1963 and 1968) created a classification of the corrie glaciations based on the appearance of moraines (i.e. whether they were weathered or not etc.) and on their local juxtapositioning -see *cirque glaciations* on Table 1. Work by Coudé (1983) has looked at the size, altitude and aspect of the Nephin Beg and Achill corries whilst Kenyon (1986) has, in a detailed geomorphological study of the area, reassessed the age of the Nephin Beg corrie moraines and the regional stratigraphy. Browne's work (1986) has also added to our picture of the Late-glacial activity of the Nephin Beg glaciers and carried out work on the Post-glacial (Holocene) vegetational development.

The overall picture of north Mayo is of an area with a rich and varied Pleistocene history where large ice masses from the south east have pushed up and around the mountains of north Mayo whilst mountain glaciation has produced large corries with multiple moraines. The timing of the glacial events is speculative but the presence of interglacial sequences may hold promise for more detailed research into the glacial stratigraphy. Recent research has highlighted the need for a reassessment of both the stratigraphic relationships between glacial deposits and, far more importantly, the depositional history of the deposits themselves has to be viewed in a modern and regional context.

1.1 The glacial deposits of the north Mayo coast

The summary I have prepared of this topic for our site visits and this fieldguide is principally based on the research of McCabe, Haynes and MacMillan (1986). I have listed a number of sites from their paper and we will visit those sections that are available at the time of the trip. The opportunity to visit this area where glacial sea levels are claimed to have reached up to 80m O.D. provides us with a chance to air many views on the Quaternary of Ireland as well as this area in particular. Hopefully we can visit other sites during the excursion that will allow us to discuss the "Older Drifts" and the general problem of identifying glacial limits in western Ireland.

Introduction

The fascinating shelly drifts of north Mayo have been the subject of analysis for over one hundred years with the research of Traill (1875) reporting in detail on the area around Glenulra and Beiderrig (Belderg). (It is interesting to note that it was the occurrence of arctic and northern shells in tills on Clare Island -found during the Clare Island Survey- that triggered Hinch's quest for cold marine faunas). Traill noted that a "... hard blue compact clay (*till*) with shells .../ occurred in Glenulra, Fiddawntawnanauneen, and at Belderrig Harbour, and at the last two places *Tellina calcarea* was found in considerable abundance, and with valves unbroken." (Hinch, 1913). Hinch's paper gives faunal lists for a number of sites in the area and he suggested the following local sequence of glacial deposits:

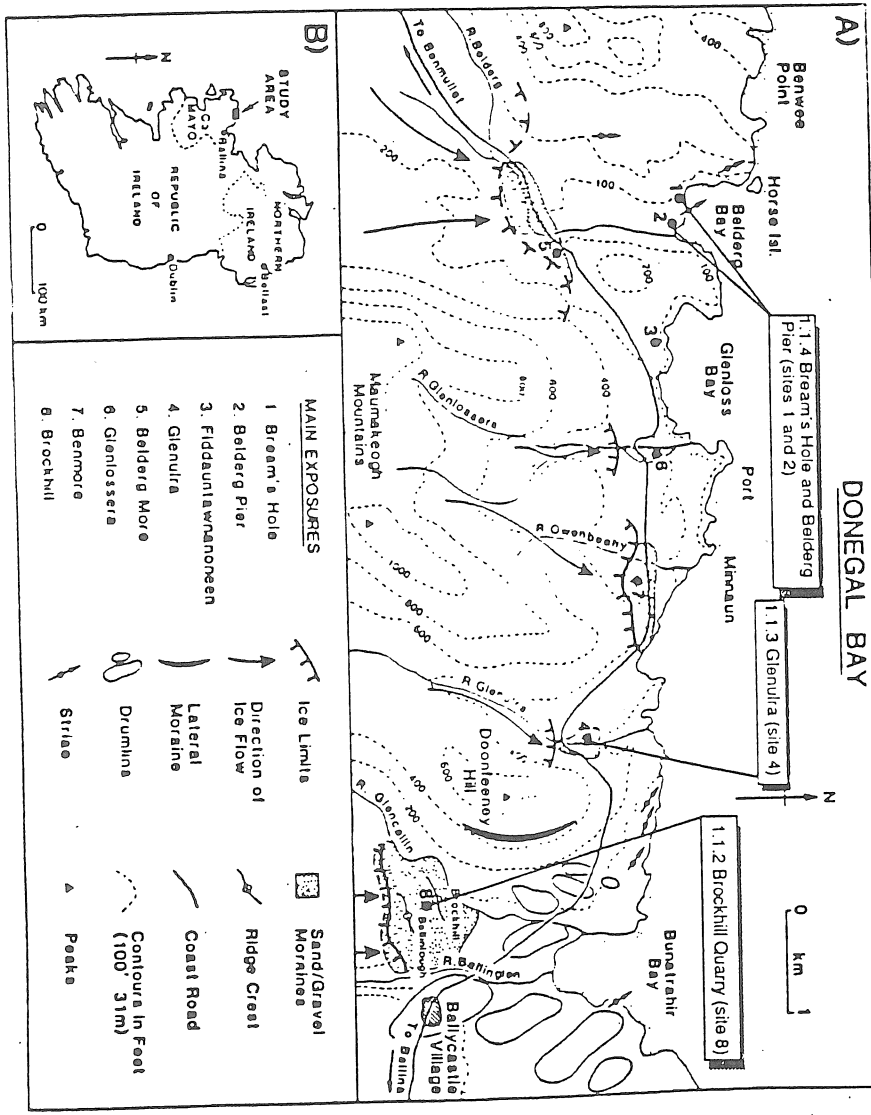


Figure 6. The location map of McCabe, Haynes and MacMillan's (1986) study areas.

5. Sands and gravels
4. Belderrig Boulder-clay with *Tellina calcarea*
3. Brown Boulder-clay, mostly of local origin
2. Stiff blue Boulder-clay (Till)
1. Boulder-bed in the Owenbehy

Hinch considered that the "brownish Boulder-clay" (3) came from the south whilst the origin of the "Glenulra Till" (2) and the "Belderrig Tellina-clay" (4) was obscure but that it was clear that "... they both come from the northward". Hinch's search for diagnostic erratics from the north failed and he concluded:
"...the possibility that the Belderrig Tellina-clay was brought by floating ice must not be overlooked. This deposit is so limited in extent, and occurs so near the present coast-line that even one large berg could have swept the Tellina-clay into its present position."
Charlesworth (1928) recognised landform features which stretched from Ballycastle along the foot of the "Corslieve Range" (eastern flank of the Nephin Begs) as a moraine laid down during a major ice retreat, a theme continued by later researchers. Charlesworth also noted the shelly drifts around Ballycastle, which had been described by Traill and subsequently by Hinch, observing that they provided a problem because the erratic content and "form of the moraine" suggested ice movement from the south east. Charlesworth explains the shelly drifts as the effect of:
"...local ice only advancing from the south-east and east and impinging upon the coast".

Since this early work Synge (1968) suggested that the Ballycastle to Mulrany end moraine (apparent on Figures 3, 4 and 5) represented " a younger drift series" and that it corresponded to the termination of the drumlin belt. The moraine flanks the eastern side of the Nephin Begs to a height of 380m and the ice that produced it pushed northwards through the Mulrany gap and through Achill Sound spreading as a lobe as far as Ballycroy and Dugort. Synge (1968) comments that the shelly Belderg till overlies the older deposits (Erris till) but is older than the Ballycastle moraine which it lies below. This observation led the Belderg Till to be placed in the Munsterian Glaciation by Mitchell *et al.* (1973), a view reiterated in Hernes Davies and Stephens (table 6.4. 1978) and Mitchell (1981) who used the term "Belderg Lobe" to account for Munsterian deposits in the area. In other publications it has been classed as (Early) Midlandian (e.g. Finch, 1977, see Table 1). The problem is that there has been no evidence at all on which to date these sediments in an absolute way.

The origin of this shelly till is still problematic with a northerly provenance, from across Donegal Bay, being held as one way to incorporate the marine fossils (Hernes Davies and Stephens, 1978 and Warren, 1985).

The shelly till of the north Mayo coast is clearly problematic with authors believing it to be from a number of sources, both local and extra-regional, the depositional environment not having received careful attention since the early part of the Century and the age of the deposit being far from resolved. Up until recently the analyses of the Belderg Till have been far from satisfactory in terms of its dating, sedimentology and relationship to other deposits (including the Ballycastle-Mulrany end moraine).

The evidence for the origin, depositional setting and age of these shelly deposits will be the focus of the sites that we will visit.

1.1.1 Regional setting

Figure 6 shows the area that we will be visiting to investigate the Ballycastle end moraine and its associated shelly sediments. The site numbers refer to sites discussed in more detail in McCabe, Haynes and MacMillan (1986). The coastal fringe along which these sediments lie is composed of Dalradian metasediments to the west of Port and Carboniferous shales and sandstones to the east. McCabe *et al.* studied glacigenic sequences that are exposed along the coast and in valley floors and flanks and identified ice originating from two major sources during the deposition of the Ballycastle end moraine complex and deposits to the west which are:

A. An ice mass in the lowlands around Ballycastle moving north into Donegal Bay (Synge, 1968). This ice produced drumlins in the lowland and ice marginal deposits along the flanks of the Ballinglen Valley (area around site 8, Figure 6). The ice marginal deposits form the northern extension of the Ballycastle-Mulrany end moraine which is the local limit of the "Drumlin Readvance" in the west of Ireland (Synge, 1968).

B. Local ice from the Maumakeogh Mountains to the south which formed outlet glaciers in the north facing valleys of the coast (e.g. The Glenulra and Owenbeahy valleys -sites 7 and 4 on Figure 6).

The critical findings and subsequent points raised by McCabe *et al.* include the following which, if correct, dramatically change our perspective of the glacial sequences in this area. (It must be remembered when looking at this evidence that substantial proof now exists around the Irish coast for raised glaciomarine sequences and that these sequences are frequently associated with Drumlin Substage (McCabe, 1987) ice (e.g. Synge, 1977, McCabe, 1986; 1987, McCabe, Dardis and Hanvey, 1987, McCabe and Dardis, 1989, McCabe and Eyles, 1988 and Eyles and McCabe, 1991) and the topic awaits much further investigation.)

1. Drumlins and basal tills were deposited by ice moving from the Irish lowlands and local ice masses north into Donegal Bay.
2. Deltas formed with tops at heights of up to 80m O.D. on the lowlands and subaqueous moraines formed within valleys where floating (marine) ice grounded.
3. In front of the grounded ice mass (along the current coastal fringe) a drape of glaciomarine mud was deposited which contains an abundant cold water fauna characteristic of those found near tidewater glaciers. This change from glacial to glaciomarine conditions is crucial to an understanding of the behaviour of the Midlandian ice sheets.
4. Valves of *Macoma baltica* from these glaciomarine muds have been dated to 16,940 ± 120 and 17,300 ± 100 years BP. This age of 17ka dates the maximum limits of ice advance and the flooding of large areas by a glacial sea prior to unloading as the ice mass decayed.
5. The mechanism for producing such a dramatic height for glaciomarine deposition is one of localised crustal deformation due to ice sheet loading.

1.1.2 Brockhill Quarry (site 8, Figure 6)

This site is a good one from which we can get an overall feeling for the enormous palaogeographic significance of large scale Pleistocene glaciation. The sands and gravels lying here were deposited along the flank of the Maumakeogh Mountains above the low ground of the Ballinglen Valley. The deposit has the appearance of a delta kame lying against the valley flanks. McCabe *et al.* note that the sand and gravel accumulation, which they call the Brockhill moraine, is "...typical of prograded Gilbert type deltas" and they also note that it is extensive and believed to be at least 40m thick . The morphology of the feature, with its steep ice contact slopes, surface ridges and kettled topography, as well as its internal structure suggest it is indeed an ice marginal feature formed at the edge of the main lowland ice sheet.

The sections that we should see in the quarry are typified by the schematic outline on Figure 7. The key to the lithofacies types is given on table 2, page 52. The sediment sequence is as follows:

3. Crudely- bedded matrix supported beds of cobble and pebbly gravel (Gms). Bed traces near horizontal but some cross-bedding is present.
2. Up to 13m of planar crossbeds dipping northwards. The lower part of this unit is predominantly matrix supported, pebbly gravel (Gms) which are neither massive or normally graded. The ice proximal beds (those to the south of the pit) are planar but grade upwards and northwards into trough crossbeds. The upper part of the section is stacked sets of parallel bedded and rippled sand (Sp and Sr) also dipping north.
1. The basal 6-7m consists of alternating sets of horizontally bedded and rippled sand. Small lenses of pebbly gravel (Gt) and pebbly sand are also present.

Some undergraduate fieldwork carried out by TCD's Geography and Earth Science students (Glacial Geomorphology course) in February 1991 confirmed palaeocurrent analyses of both large and small scale foresets showing predominant flow to the north and north west whilst other analyses carried out allow a graphic representation of the clast lithological content and the particle size of the sediment. McCabe *et al.* noted that Carboniferous limestone was the most predominant lithology (70%) followed by Carboniferous sandstone (20%) and metasediments and granite (5%). Figure 8 shows three examples of results obtained from pebble counts which, like the original authors' results (and Charlesworth over 60 years before!), do not indicate any material inconsistent with a southerly or south easterly provenance.

The three examples of particle size graphs (Figure 7) are given merely to give the reader an impression of the type of material present in each unit. In fact the individual beds are so variable that such analyses are of little value to characterise the units as a whole.

The occurrence of a delta at Brockhill with sediment originating from the south or south east suggests a very high water levels. McCabe *et al.* note that there is no evidence of an ice lobe from the east (in Donegal Bay) or any topographical feature that could impound water in front of the northerly moving ice and so the delta must

Figure 7. Log from Brockhill Quarry with a selection of psa graphs from the main units

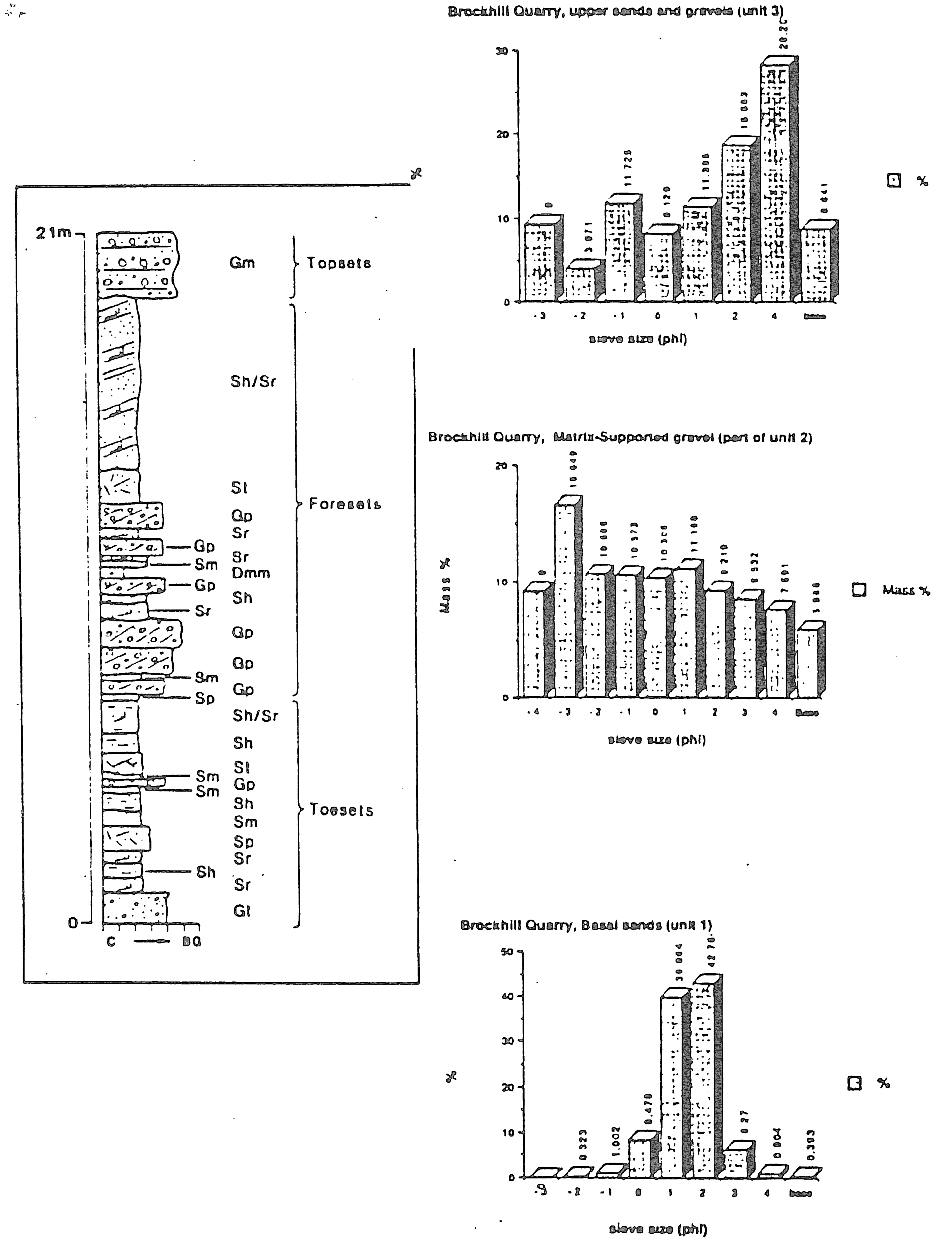
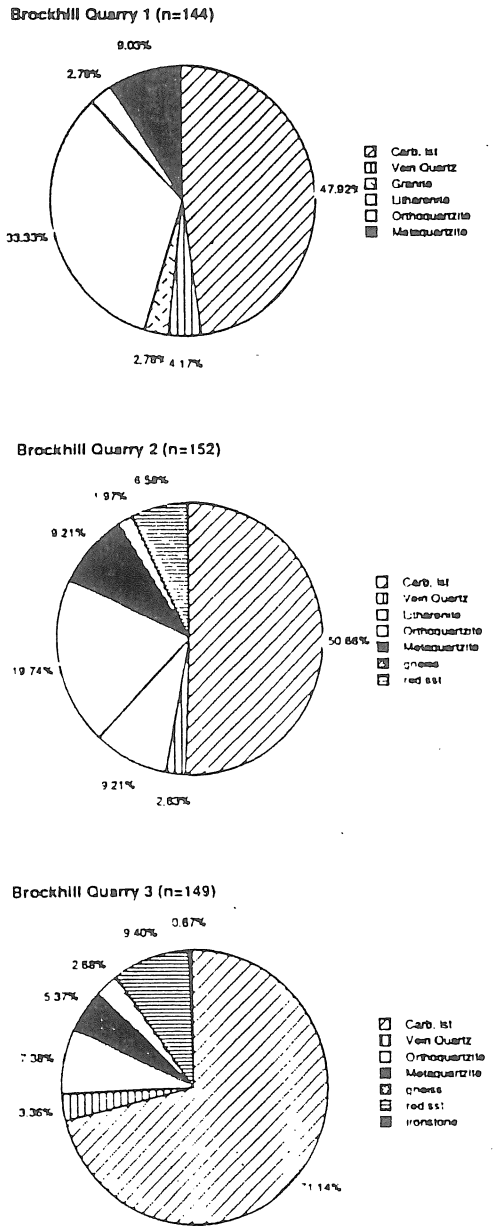


Figure 8 . Representative clast lithological analyses from Brockhill Quarry (n>140, 8-32mm size range)



be associated with higher sea level and the glaciomarine sediments to the north west.

1.1.3 Glenulra (site 4, Figure 6)

The valley of the Glenulra River cuts into bedrock and along its flanks we should see 2 crucial successions of deposits that include important fossiliferous muds.

1.1.3.A This site is close to the road and is >20m in height. The section includes the following sequence which is generally coarsening gradually upwards:

5. 8m of matrix supported and crudely stratified gravels. (Gm/Gms). Occurs up to 82m O.D. as flat shoulders on the flanks of the valley.
4. Medium and coarse sand.
3. 2-3m of parallel laminated sand. (Sh)
2. 2m of parallel laminated silt and fine sand. (Fl)
1. 8m of a massive diamictic mud (75% silt/clay) that contains shell fragments, dispersed clasts and stringers of fine silt and sand. (Fm)

1.1.3.B This impressive section is well worth a visit but it is prone to massive slumping and it may be unavailable due to its dangerous nature. The following succession is present (Figure 10):

4. A coarsening up sequence of cross bedded planar gravel beds (dipping north) coarsening from pebble to cobble grade gravel and containing occasional boulders.
3. 3m of cross-bedded sand containing lenses of trough bedded sand and pebbly sand.
2. 5m of stacked beds of cross stratified, planar, gravels that dip northwards. (Gp)
1. 3m of diamictic mud. The mud is massive but contains crude bedding. (Fmd) Thin sand stringers increase upwards (Fmd(r)).

The Glenulra sections are similar to those described by McCabe *et al.* from Glenlossera (McCabe *et al.*, 1986, site 6, Figure 6) and the two show stacked coarsening up sequences which are compared by the authors to "...prograded toeset/foreset sequences commonly found in subaqueous glacial environments (Cohen, 1979; Gustavson *et al.*, 1975; Shaw, 1975)".
The implications of this interpretation are that standing water must have been present to allow for the aggradation of a delta to 82m O.D. at Glenulra. The presence of a fossil marine fauna with cold-climate affinities from the mud facies at the site shows that this aggradation occurred under glaciomarine conditions.

1.1.4 Bream's Hole and Belderg Pier (sites 1 and 2, Figure 6)

We shall visit this area to look at the Quaternary sections (which have unfortunately slumped over the last few years) and at some interesting (but considerably older) dolerite intrusions in the local psammites to the east of the bay.
The principal sites of interest here are the ice moulded rock platform to the west of Belderg Pier which is overlain by a massive diamicton (Dmm) 3-5m in thickness. The diamicton is in part crudely stratified and contains clast clusters. The upper

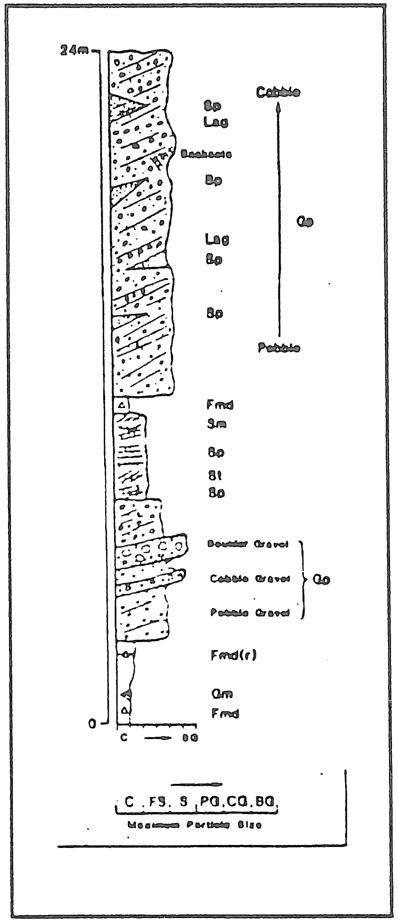


Figure 10. Graphic log from Glenulra (site 4, Figure 6). After McCabe et al. , 1986.

surface of the Dmm unit is overlain by a lag of pebbly gravel which is draped by an extensive unit (5-9m thick) of diamictic mud (Fmd). This unit is variable and in places well sorted. It stretches eastwards to the pier and some facies contain a micro- and macrofauna including paired and separated valves of *Macoma calcarea* . The latter were so abundant in sections near top the pier that they were collected by McCabe *et al.* and a radiocarbon date of 16,940 ±120 BP was obtained.

The importance of the interpretation of these north Mayo sections is obvious. The glacial stratigraphy of the north Mayo coast is one that has attracted considerable attention in the past and these new insights are likely to attract further interest. The dating of the glaciomarine succession at Belderg settles many contradicting views on the regional stratigraphy but the interpretation of these glacial sediments, with the associated high stand of sea level, is not likely to go unchallenged. One possible model for producing such changes in sea level is shown as Figure 11 and the consequences of such wide reaching concepts are suggested in Figure 12.

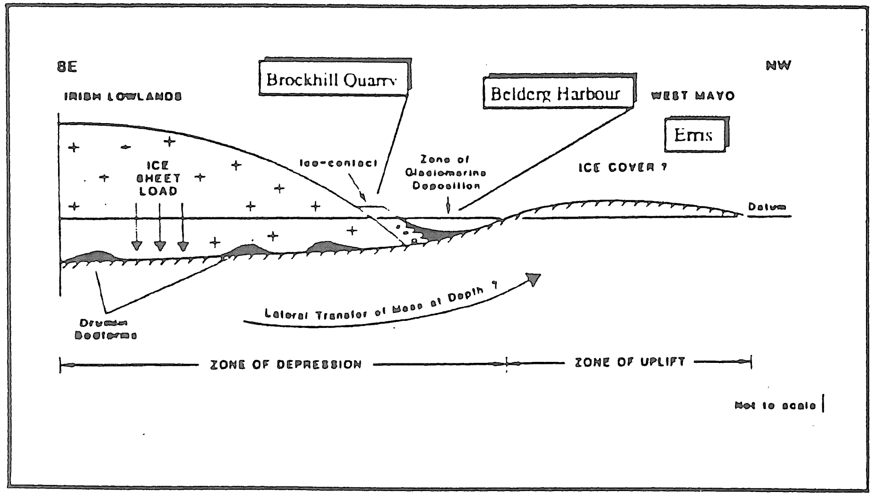


Figure 11. Postulated crustal depression adjacent to an ice mass in north Mayo. After McCabe *et al.* , 1986.

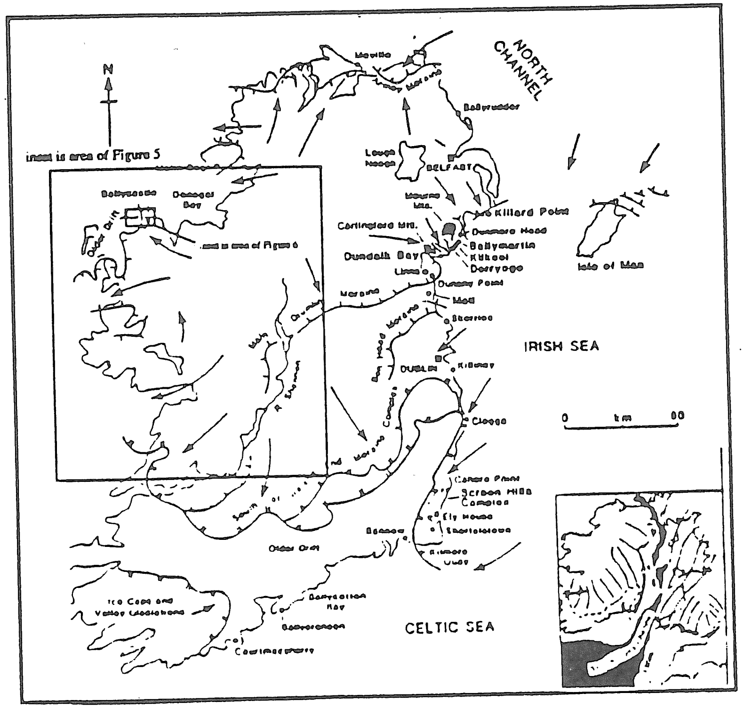


Figure 12. Ice flow in the Irish Sea Basin (after McCabe, 1987)

1.2 The Céide Fields

Introduction

The summary I have prepared of this topic for our site visits and this fieldguide is based on the research of Caulfield (1983 and 198?).

The high concentration of court tombs in north Mayo has indicated an intensive neolithic settlement in that area (de Valera and O'Nuallain, 1964). Caulfield (1983) has noted that the rapid blanket bog growth in the area has preserved sites within and below the bog itself. Megaliths are buried below peat and they are associated with extensive field boundaries which include stone walls and earthen banks. Cutting of the blanket bog for fuel has exposed field boundaries near to 20 tombs and archaeological excavations at two sites, both of which are shown by radiocarbon dates to be primarily of neolithic age, are recorded by Caulfield.

1.2.1 Belderg Beg

At this site (Figure 1) large stone walls were built directly on the mineral soil before the blanket peat initiation. A stump of a pine tree which grew in the bog close to one wall gave a radiocarbon date of 2270±95 bc giving a minimum age for the wall building. The site is complicated by later occupation, one dated to the 13th century bc.

1.2.2 Behy/Glenulra

This famous site has, through diligent archaeological survey using an ingenious probing method and by mapping exposures at peat faces, revealed over 6km of boundaries below blanket peat (Figure 14). Dates are available giving a minimum age for the boundaries as follows:

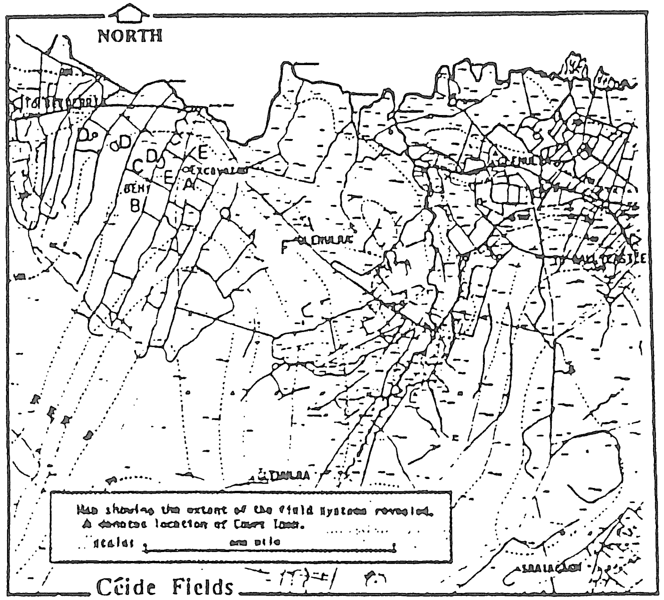
2510±115 bc (date from an enclosure in one of the fields
1940±110 bc |
1680±70 bc | from peat close to the Behy tomb (Smith *et al.*, 1973)
1980±105 bc |
4460±115 bp | from a hearth in an enclosure
(3200 bc)

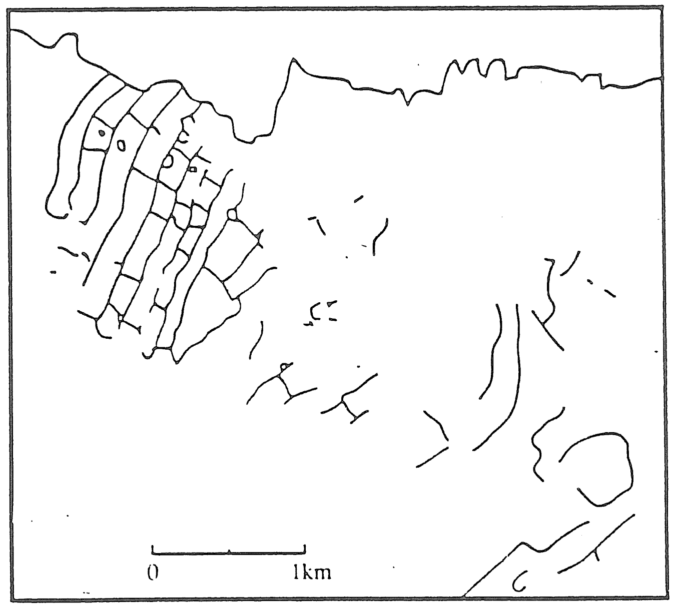
Many other sites have been noted in the Belderg area of north Mayo and boundaries are frequently associated with megalithic tombs. Caulfield also notes that areas with few pre-bog walls may have been covered by peat before extensive population occurred. For example the area to the west of Belderg is devoid of sites and radiocarbon dates of 2390±65 bc and 5160±75 bc (Hakansson, 1974, reported in Caulfield, 1983) from pine stumps 1km west of Bellanaboy Bridge lend this theory support.

The field boundaries themselves at Behy/Glenulra are shown on Figure 14 and as shown the area they cover is 1 km^2 divided into strips 150m wide by curvilinear parallel walls. The long fields are divided by off-set cross walls. Probing of the blanket peat has shown the walls run for a considerable distance. Caulfield makes three fascinating observations regarding the Behy/Glenulra fields:

1. The layout of the field pattern has a unity that suggests it was planned and

Figure 14. The Behy/Glenulra field system. From Caulfield, 198?. The upper image is scanned from the printed version and the lower is an attempt to highlight the prehistoric fields





organised carefully as a single decision.
2. The walls would have been high enough to keep in (or exclude) cattle but not sheep or deer.
3. The fields are of a size suggesting they were used for a grass crop and thus animal husbandry was being practised.

2.1 The interglacial deposits at Derrynadivva and Burren Townland

Introduction

Organic sediments lying below and within glacial diamictons have been briefly described in the literature from two sites in the foothills of Croaghmoyle, at the southwestern end of the Ox Mountains Inlier, to the north of Castlebar (Finch, 1977 and Watts, 1985). The localities, shown on Figure 1 (and in detail on Figures 15 and 17) are within Burren and Derrynadivva Townlands and they were relocated by the author using the original field sheets of Prof. G.F.Mitchell. The full details of the pollen (including the SEM work) and the macrofossil analyses have been written up and will be presented elsewhere (Coxon, Hannon and Foss, in prep.)

The extensive nature of the interglacial fragments in the area of Burren and Derrynadivva Townlands suggest that extensive erosion of a pre-existing (Gortian) land surface must have taken place by the ice that deposited the overlying till.

2.1.1 Burren Townland (M135973)

At this locality organic materials are exposed in river sections along a 1.5km stretch of the Clydagh River between *ca.* 150 and 180 m O.D.

The organic sequences are scattered and variable in extent and for the most part represent ice-rafted material contained within glacial diamictons. As it is only fragmentary the interglacial material on the whole does not warrant detailed analysis. However at one site (BT 1 on Figure 15) the thickness and preservation of organic interglacial material is particularly good.

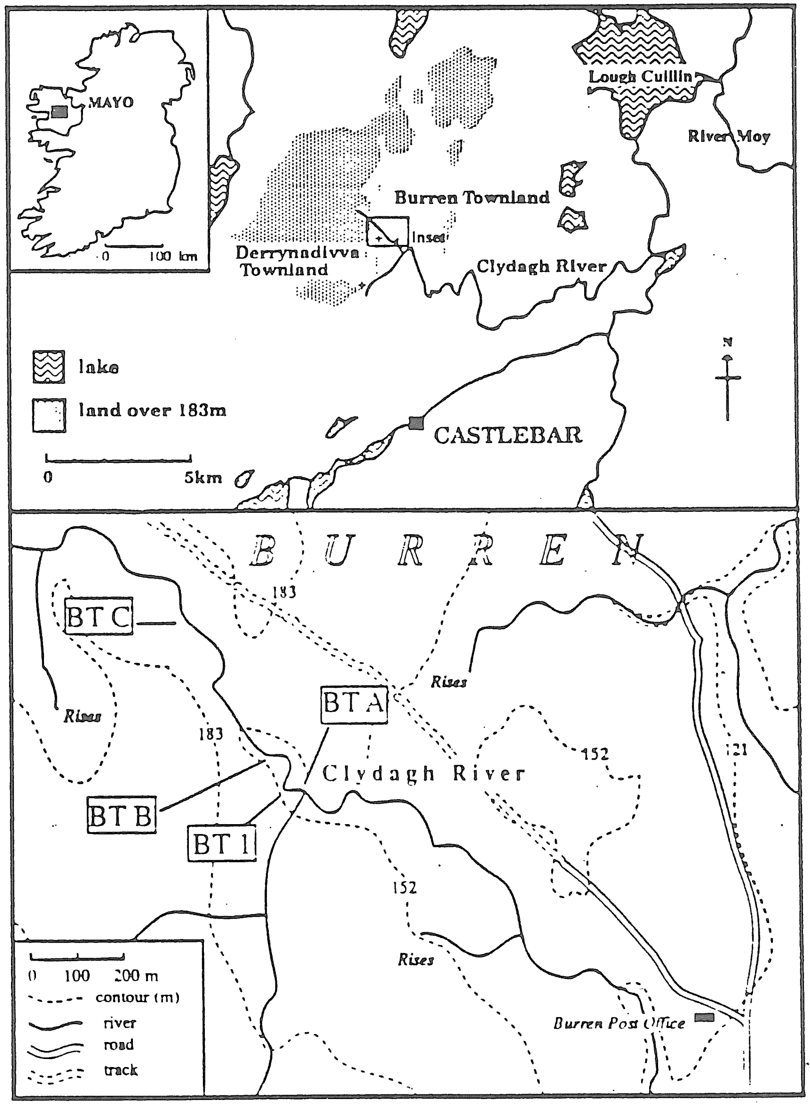
The later parts of a Late Pleistocene interglacial sequence can be recognised at the site and they are similar to late Gortian sediments described from Derrynadivva (see 2.1.2 below). In turn the sequence at Derrynadivva can be compared to the type locality and other sites of Gortian Interglacial age (Watts, 1985).

Stratigraphy

The organic sediments in the valley of the Clydagh River in Burren Townland appear to have once covered a wide area and they have been extensively glacially reworked, presumably from a palaeo-land surface of Gortian age. Some sediment rafts are 1 to 2m long and 30-40cm thick and they have been smeared out within glacial till. The till is of variable thickness and reaches 25m in places. For example at site BT C (Figure 15) a number of thin lenses of organic sediment are smeared out within a thick till sequence. Pollen analyses of the organics at BT C show that they are similar in composition to the main sequence described here (at BT 1). Other remnants of interglacial sediments that also contain pollen assemblages similar to those at BT 1 are found at BT A and BT B (Figure 15) within the Clydagh River valley.

The section at BT 1 is the most complete at Burren Townland and it is composed

Figure 15. Location map of the interglacial site at Burren Townland. From Coxon, Hannon and Foss, in press.



BURREN TOWNLAND

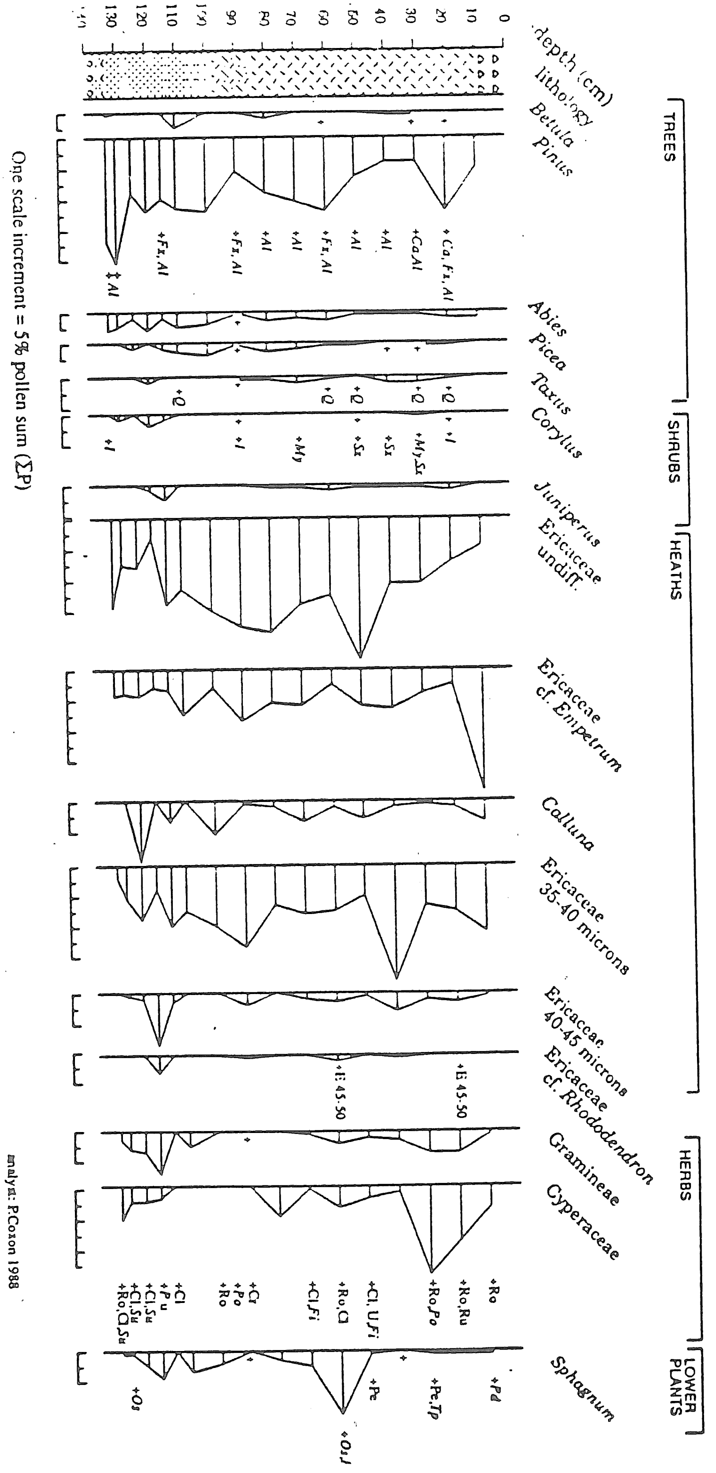


Figure 16. Percentage pollen diagram from the interglacial deposit at Burren Townland. From Coxon, Hannon and Foss, in press.

primarily of a wood peat which has been disturbed (it is folded in part) either by solifluction or glacial rafting. The extent of the deformation makes it difficult to judge where the upper and lower boundaries of the interglacial unit lie and the upper surface appears unconformable with the overlying till. The interglacial deposit appears to be a wood peat that was probably extensive and formed on a water-logged surface. Unlike Derrynadivva (Coxon *et al.* in press) the field relationship of the organic sediments to the surrounding diamictons is not clear.

The pollen assemblage zones and the vegetational history

In order to maintain clarity the pollen diagram (Figure 16), which shows the relative percentages of taxa, is of selected pollen types only. The percentages are of the sum of terrestrial pollen types (ΣP) and occurrences of less than 1% P are shown on the diagram as a +.

The pollen diagram is relatively uniform throughout with only limited degrees of change identifiable. The pollen spectra suggests a dominance by ericaceous vegetation (including *Rhododendron ponticum*, *Empetrum* and *Calluna*). The problems of identifying ericaceous pollen using a light microscope only allows speculation that this heathland was diverse because there is a range of pollen of different sizes. (SEM studies (Coxon *et al.* in press) show that *Rhododendron ponticum* was indeed present). Associated with the heath were *Pinus* with lesser amounts of *Alnus*, *Abies*, *Taxus*, and *Juniperus* pollen. Open ground is represented by Gramineae and Cyperaceae along with a small number of herb taxa. Towards the end of the organic deposition at BT 1 *Empetrum* becomes more important as does Cyperaceae whilst *Pinus* becomes less important. It is difficult to tell whether these subtle changes have much palaeoenvironmental significance.

The flora is a limited one by Gortian Interglacial standards and the same taxa are recorded in a number of the isolated within-till fragments suggesting that the material is all the same age.

Discussion

The interglacial sequence at Burren Townland appears to record a portion of the latter part of the Gortian Interglacial as outlined by Mitchell (1981) and Watts (1985). Taxa associated by Watts (1985) with the Gortian Interglacial are present at Burren Townland including *Rhododendron ponticum*, *Abies* and Type X. The Burren Townland pollen assemblage is different to the typical records of the end of the Gortian Interglacial in that it is incomplete and does not record the dramatic truncation of the "cryocratic" stage of the interglacial. However the ericaceous wood peat is similar to one recorded at Derrynadivva and it is probable that the Burren Townland sites represent a fragment of the late interglacial (post-temperate) vegetation of upland heath in an exposed site. The nature of the depositional record does not allow further speculation on the end of the Gortian Interglacial because the site is incomplete but it does give a picture of late Gortian vegetational history and provides an insight into the palaeoenvironment of upland Ireland in the Gortian Interglacial.

2.1.2 Derrynadivva (M131954)

At Derrynadivva organic materials are intermittently exposed along an 80 metre section in the banks of a small tributary of the Clydagh River at *ca.* 135 m O.D. (The organic sequences are diverse and represent the middle and later parts of a Late Pleistocene interglacial sequence which can be compared to the type locality and other sites of Gortian Interglacial age (Watts, 1985).

Stratigraphy

Like Burren Townland the organic sediments at Derrynadivva appear to extend over a wide area and glacially transported rafts of similar organic material are widespread in stream sections in the area between Burren Townland and Derrynadivva where they can be found within and below extensive thicknesses (up to 25m) of streamlined till. The section at D1 (Figure 17) is the most complete at Derrynadivva and it records a transition from coarse clast supported gravels at the base through organic silts into wood peat which becomes intercalated with inorganic horizons towards the top (Figure 18). Although disturbed in places the organic sediments appear to be conformably overlain by a diamicton. The initial sequence most probably represents a fluviatile environment where a backwater has formed to allow quiet water deposition. Occasional flooding of the backwater is evidenced by horizons of medium and fine sand as well as isolated pebble clasts. Sporadic drying out of the backwater is demonstrated by horizons of intense mottling and oxidation of the organic silts. Eventually the organic silts filled the backwater and a wood peat formed on the water-logged surface. Soil instability towards the end of the biogenic deposition caused layers of inorganic material to flow across the wood peat. Eventually organic deposition ceased and the interglacial was capped by a diamicton. This change from organic to inorganic sedimentation is a gradual one that appears to be conformable although, in places, some of the interglacial sediment has been rafted and reworked by either solifluction or glacial rafting.

The pollen assemblage zones and the vegetational history

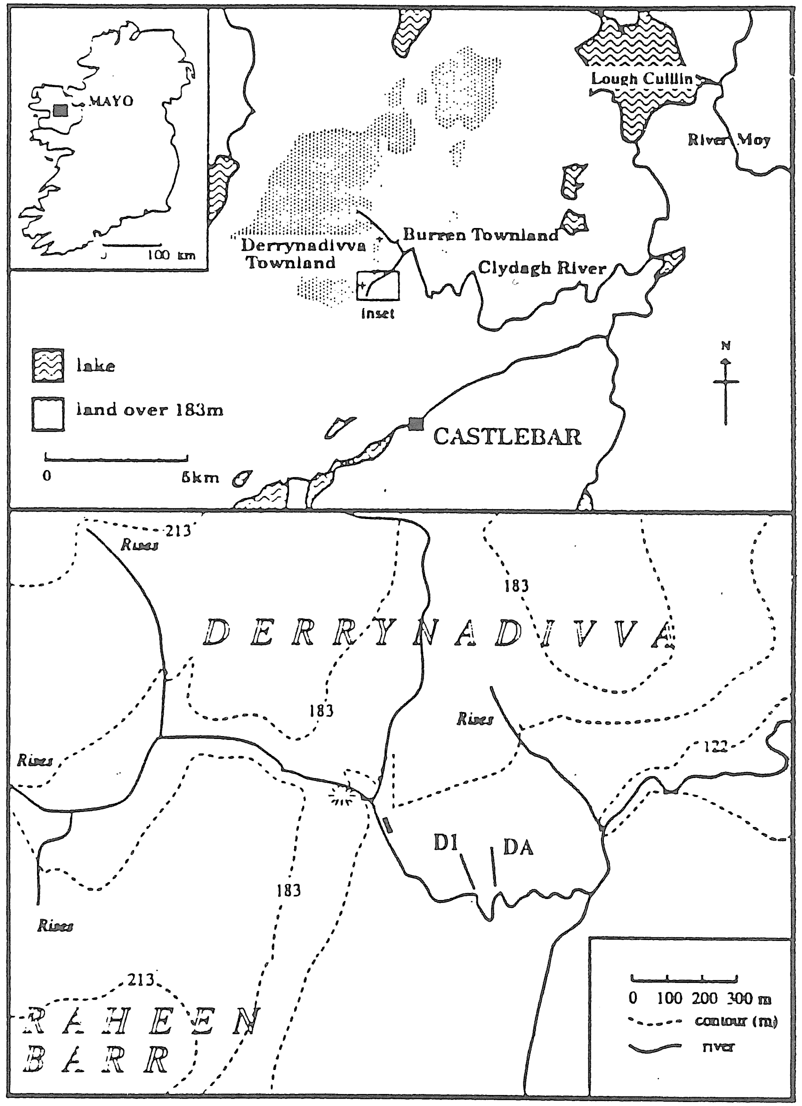
A selection of the pollen and macrofossil records are summarised on Figure 18 which shows the relative percentages of taxa. The percentages are of the sum of terrestrial pollen types (ΣP) and occurrences of less than 1% P are shown on the diagram as a +.
The pollen diagram can be subdivided into 4 local pollen assemblage biozones (p.a.b.) to facilitate description:

DV 4	*Pinus -Alnus - Abies* - Ericaceae p.a.b.
DV 3	*Pinus -Betula -Quercus* p.a.b.
DV 2	*Betula -Pinus -Quercus* p.a.b.
DV 1	*Betula -Quercus -Pinus* p.a.b.

DV 1 *Betula -Quercus -Pinus* p.a.b. (330-350cm)

The lowermost sediments lie unconformably on sands and gravels and so the early part of the interglacial is missing. The pollen record suggests oak and birch woodland with pine being an important component of the vegetation. Open areas

Figure 17. Location map of the interglacial site at Derrynadivva. Coxon, Hannon and Foss, in press.



were also present with numerous herb taxa, Gramineae and Cyperaceae. Macrofossil remains of *Betula pubescens* and *B. pendula* show the presence of these trees locally and *Quercus* sp. is also recorded from this zone. Other macrofossils associated with this mixed thermophilous woodland include *Ajuga reptans* along with waterside plants such as *Ranunculus flammula* and *R. batrachium* indicating a shallow water environment. The oak woodland probably surrounded the open water of the channel backwater with open ground being maintained by occasional flooding that occurred there.

DV 2 *Betula -Pinus -Quercus* p.a.b. (280-330cm)

The fall in importance of the pollen of *Quercus* is combined with increasing percentages of pollen of *Betula, Pinus* and *Salix*. Macrofossils include both *Betula* species recorded in DV 1 as well as numerous buds of *Quercus* sp., bracts of *Corylus avellana* and, later in the zone, leaves, seeds and wood of *Pinus sylvestris*. This zone is also characterised by the appearance of charcoal fragments both on the pollen slides and in the macrofossil samples. Fire frequency may be influencing the vegetation and pine, which can withstand fire events more successfully than the other trees present, may be expanding at the expense of the more fire sensitive taxa.

Open areas, shallow water environments and shrub vegetation remain with Gramineae and numerous herb taxa, *Ranunculus* spp. and *Corylus* and *Salix* being important components.

DV 3 *Pinus -Betula -Quercus* p.a.b. (190-280cm)

The beginning of the zone is marked by increases in the pollen representation and macrofossil occurrence of *Pinus* as well as a continuing decline in levels of pollen of *Quercus*. However, macrofossils of *Quercus* sp. show that this tree is still locally present. *Betula pendula* is not recorded after the start of the zone although *B. pubescens* remains frequent.

Halfway through the zone (at *ca.* 240cm) macrofossil records of *Sorbus acuparia*, *Salix* sp. and *Quercus* end and those of *Pinus* become less frequent whilst the pollen diagram shows the appearance of *Alnus*, *Abies*, and a number of Ericaceous types and leaves of *Empetrum nigrum* are noted. The change in the vegetation indicates environmental alteration possibly due to increasing fire frequency or soil acidification (or both).

DV 4 *Pinus -Alnus - Abies* - Ericaceae p.a.b. (140-190cm)

The last zone contains major changes in the vegetational composition with *Betula*, *Quercus* and *Salix* becoming less important and *Alnus*, *Abies*, *Picea* and *Ilex* increasing in frequency along with a dramatic rise in the pollen of Ericaceae including *Empetrum* - type, *Calluna* and cf. *Rhododendron*. Macrofossils of *Calluna vulgaris* and *Abies alba* attest to the changes in the pollen diagram.

The changing vegetation in DV 4 and the lack of charcoal in the sediments possibly represent increasing oceanicity and damper conditions. The fall in frequency of macrofossils of aquatic taxa can be attributed to a facies change from shallow water deposition to a detrital and wood peat.

Towards the end of the zone the frequency of potentially reworked pollen

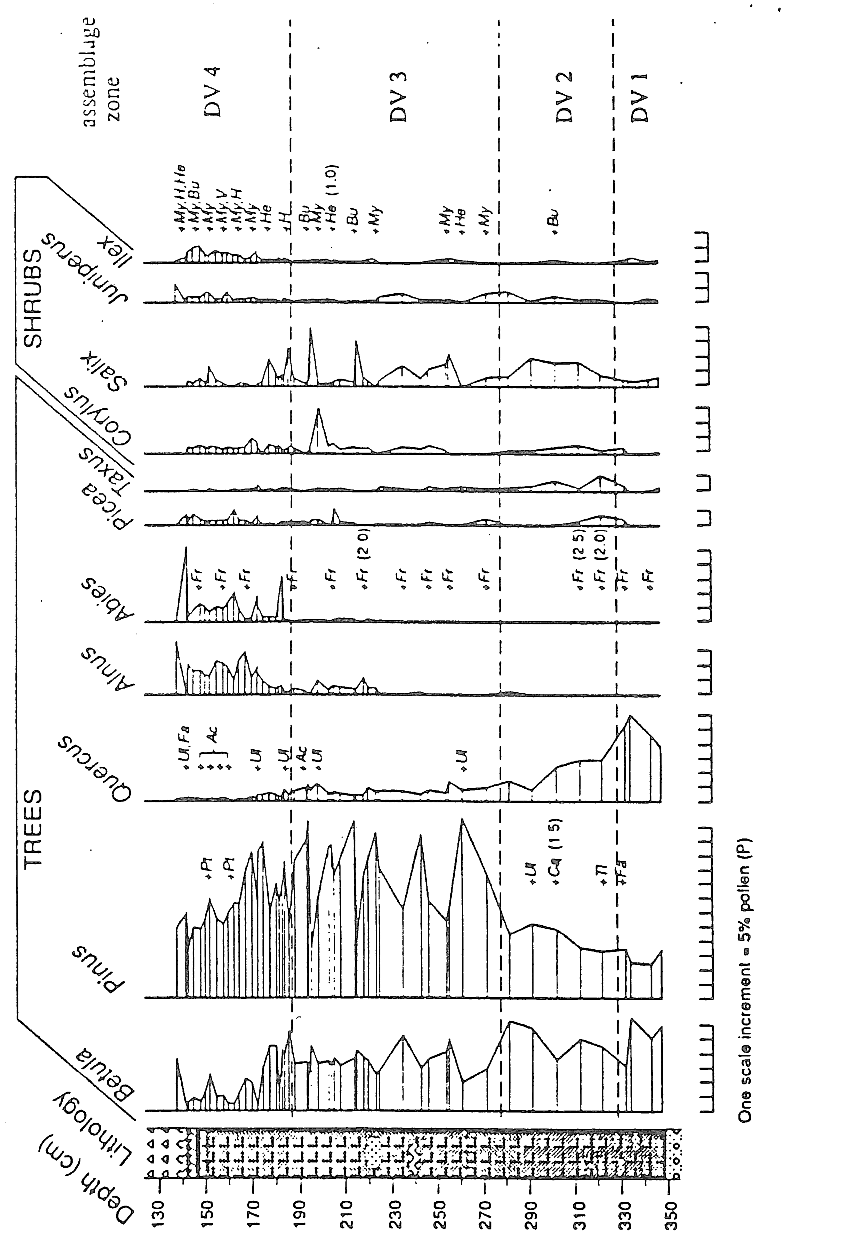


Figure 18a. Percentage pollen diagram from the interglacial deposit at Derrynadivva. From Coxon, Hannon and Foss, in press.

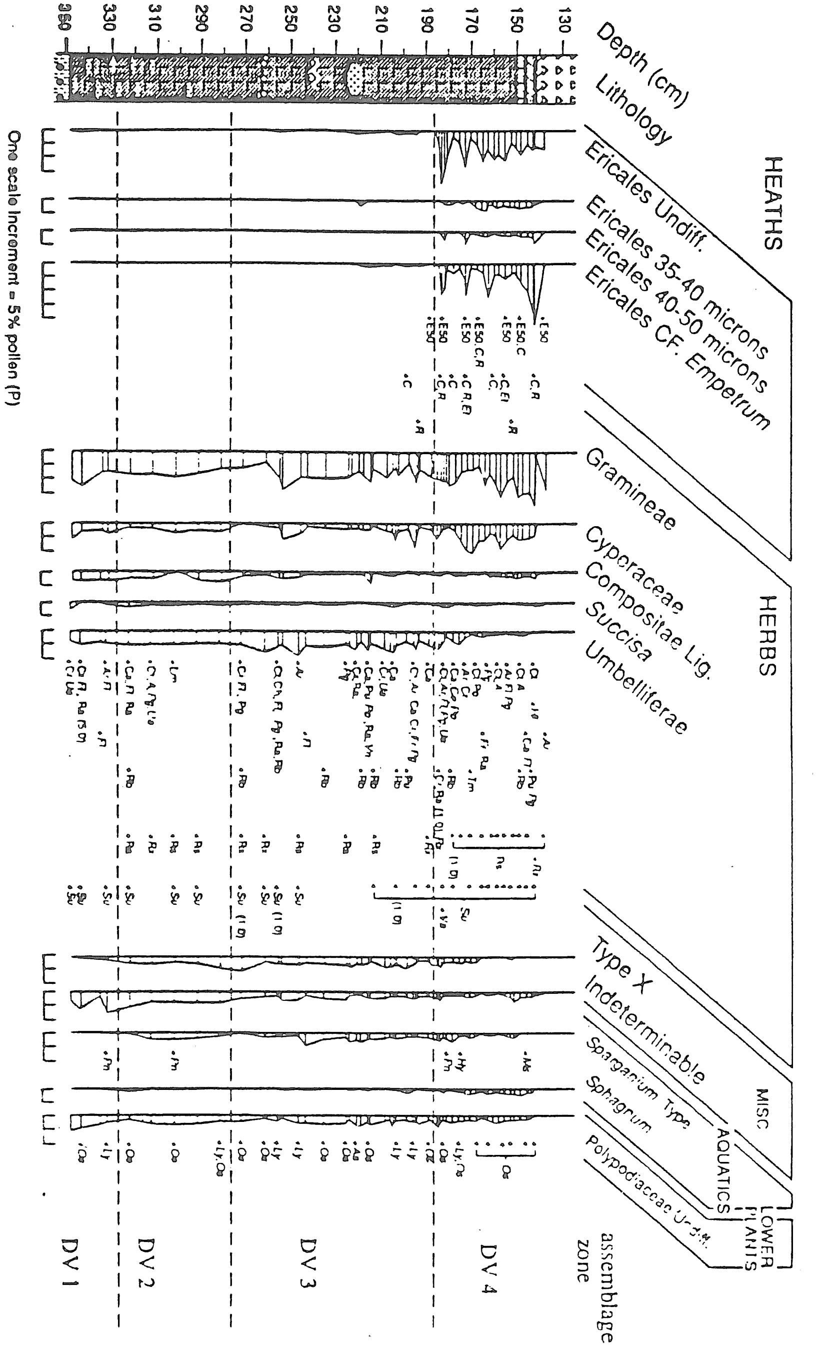


Figure 18b. Percentage pollen diagram from the interglacial deposit at Derrynadivva. From Coxon, Hannon and Foss, in press.

(damaged, corroded, crumpled and degraded) increases markedly for some taxa (Figure 19). This reworking is affiliated with the progressive rise of inorganic horizons in the upper part of the interglacial. Some taxa are not reworked to the same extent (e.g. *Empetrum* , *Pinus* , Gramineae, Cyperaceae and *Juniperus*) whereas others show marked reworking (e.g. *Abies* , *Alnus* and *Betula*). This differential change in pollen preservation suggests a severe climatic deterioration affected some elements of the vegetation towards the end of DV 4 and also caused widespread soil instability evidenced by the inorganic horizons in the upper section of the wood peat.

Discussion

The interglacial sequence at Derrynadivva appears to record the latter part of the Gortian Interglacial as outlined by Mitchell (1981) and Watts (1985). The earlier, late glacial, part of the interglacial is not preserved at the site. The following correlation to established Gortian Interglacial zones can be suggested:

Derrynadivva	Watts 1985	Mitchell 1970
DV 4	Atlantic-climate forest stage (telocratic)	IGWD
DV 3	High forest stage (mesocratic)	IGWC
DV 2	High forest stage (mesocratic)	IGWC
DV 1	High forest stage (mesocratic)	IGWC

Taxa associated by Watts (1985) with the Gortian Interglacial are present at Derrynadivva including *Rhododendron ponticum* , *Buxus* and *Abies* . Also present are *Pterocarya* (although only a single grain occurrence was recorded), *Fagus* (two grains) and a continuous curve of Type X (Turner, 1975 and Phillips, 1976). The latter palynomorph is restricted in its occurrence in Britain to the Hoxnian Interglacial.

The Derrynadivva pollen assemblages strongly resemble those from a number of Irish sites (see Figure 20) including Kildromin (Watts, 1967), Kilbeg (Watts, 1959) and Baggotstown (Watts, 1964 and 1985). The truncation at the top of Gortian pollen diagrams, which can be seen at a number of the sites on Figure 20, has led to the suggestion that the "cryocratic" stage of the interglacial is not preserved in Irish sites (Watts, 1985). However all of the Gortian sites with substantial records appear to end abruptly in the "Atlantic-climate forest stage" (or "telocratic") stage. One problem at some Gortian Interglacial sites is that it is hard to tell whether the observed end of the interglacial sequence is conformable with overlying sediments due to glacial disturbance and /or a lack of field data (e.g. Baggotstown, Watts (1964) where the borehole material was disturbed and Benburb, Gennard (1984) where the field relationship of the interglacial are unclear). Another problem is that detailed sediment descriptions of the upper parts of the interglacial sequences do not exist. Where photographs of good sections are available (e.g. the excavations at Boleyneendorrish (Gort) in the 1930s, Mitchell (pers.comm.)) or reasonable sediment descriptions exist (e.g. Kilbeg, Watts (1959)) then it is apparent that there is evidence of conformable sedimentation throughout the latter part of the interglacial although undoubtedly glacitectonic disturbance has occurred. The sedimentary and palaeobotanical evidence suggests that the Derrynadivva site is

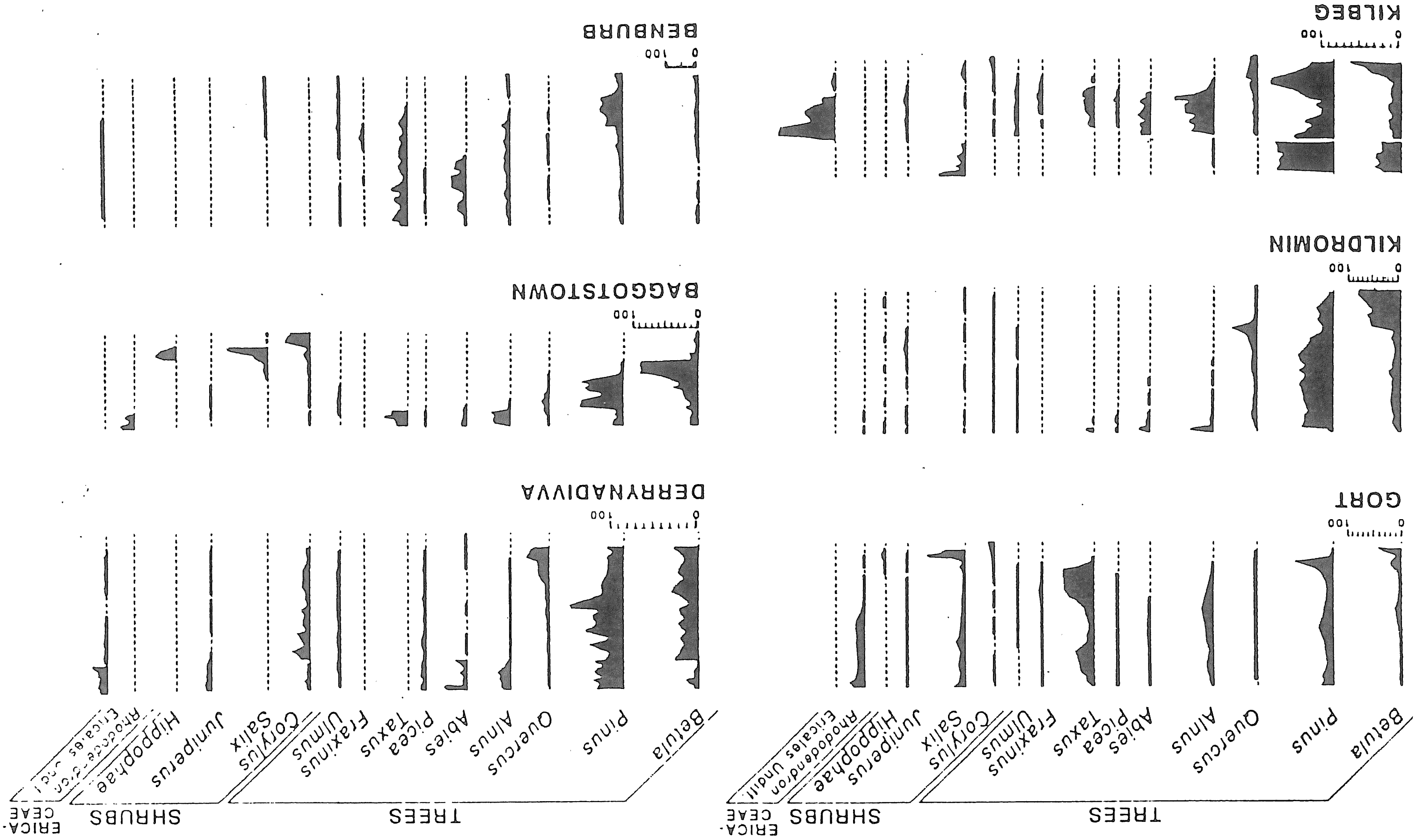
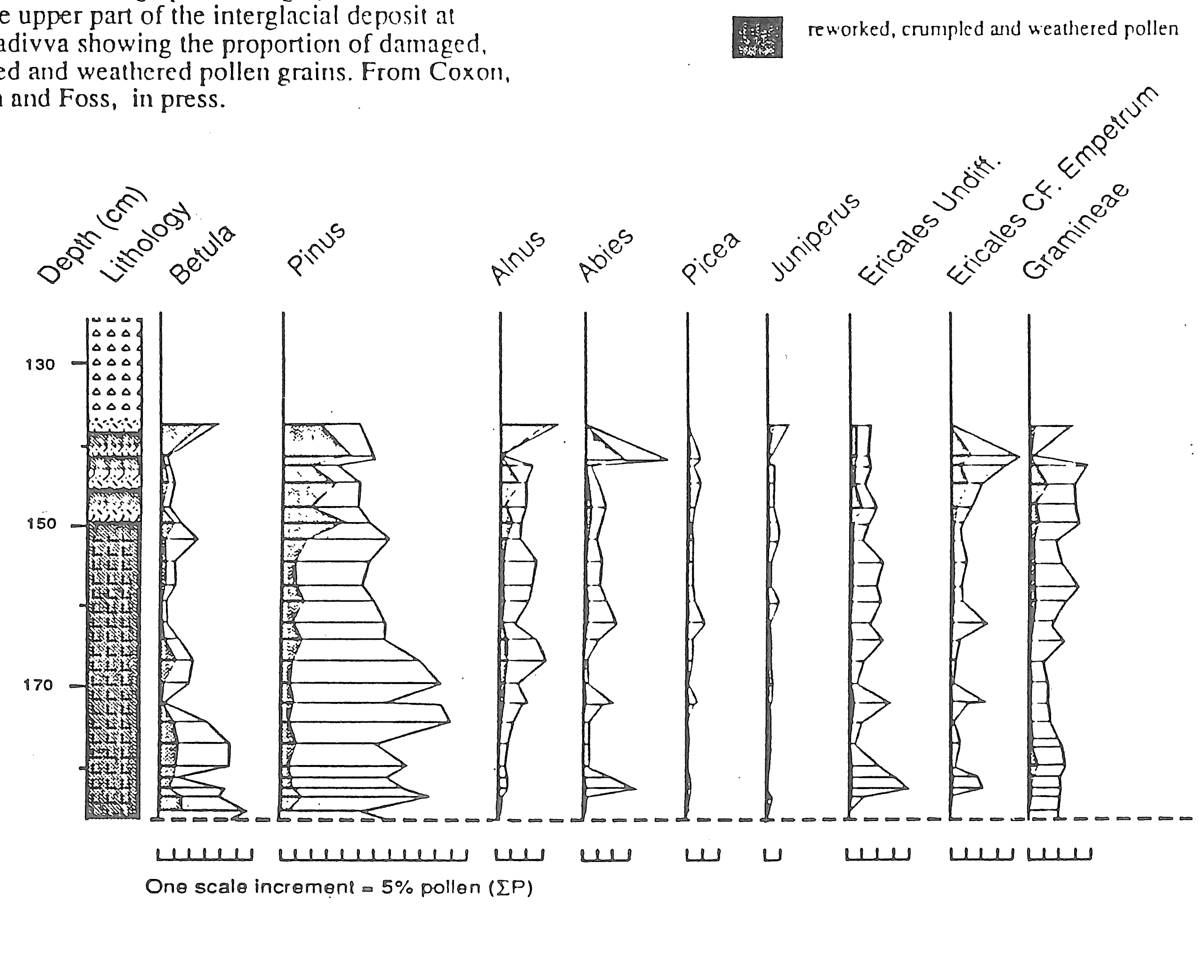


Figure 20. Abbreviated pollen diagrams from selected Gortian sites enabling between site comparison. After Ruddock, 1990.

Figure 19. Percentage pollen diagram for selected taxa from the upper part of the interglacial deposit at Derrynadivva showing the proportion of damaged, crumpled and weathered pollen grains. From Coxon, Hannon and Foss, in press.



similar to those at Gort and Kilbeg and that it provides continuous sedimentation through this critical period.

This record of the closing stages of the Gortian Interglacial at Derrynadivva is a remarkable one as it shows a sudden climatic deterioration that would be difficult to detect as continuous from standard pollen data because of the extensive reworking of pollen and spores. Likewise a careful analysis of sedimentary change is required if the full import of the termination of the interglacial is to be recognised. There is a clear need to reinvestigate the upper sections of other Gortian Interglacial sites in order to analyse this termination in more detail.

The age of the Gortian Interglacial is subject to debate. It is agreed that it represents a Late Pleistocene temperate stage but it has proved hard to correlate with other sites in Europe. Watts (1985) summarises some of the arguments that have been made regarding the age of the Gortian and concludes that the interglacial is probably equivalent to the Hoxnian of Britain and the Holsteinian of Continental Europe. It is however a possibility that the Gortian Interglacial is last interglacial in age as suggested by Warren (1979 and 1985) although the reasoning given has been questioned (e.g. McCabe, 1987). Recent research suggests a penultimate interglacial age for the Gortian Interglacial based on a study of amino acid racemisation of shells from a borehole in Cork Harbour (Scourse *et al.* , in press) whilst work at Fenit (Heijnis, Ruddock and Coxon, in prep.) following on earlier research by Mitchell (1970) suggests that the organic deposits there are not Gortian but belong to an Early Midlandian interstadial (Kilfenora Interstadial) that has been dated using the Uranium-Thorium disequilibrium method.

Whatever the age of the Gortian Interglacial the deposits at Derrynadivva record a truncated interglacial sequence that represents a rapid climatic deterioration not seen in European penultimate and last interglacial records. It is suggested that Ireland's proximity to the Atlantic Ocean may be the reason for this severity of climate change with the influence of a cooling Atlantic at the onset of glaciation being a major factor in the control of the European climate. It is therefore important to analyse the latter parts of more Irish interglacial sequences in detail as they may hold important information about vegetational response in Western Europe to the onset of global cooling.

(P.Coxon and G.Hannon)

2.2 Lake promontory forts in County Mayo.

During the course of the first ever comprehensive if still preliminary survey of the county a type site (or at least sub - type) new to Irish archaeology has been recognised i.e. the lake promontory fort. As the name suggests promontory forts are found on projecting promontories of land where artificial defences are necessary along one side only. Promontory forts have long been recognised, but until now only two types were commonly identified. These are the coastal and inland promontory forts respectively. The identification of a third type site of this class - the lake promontory fort - is an important dimension to these intriguing but little researched sites.

As with coastal promontory forts, the most numerous type of promontory with several hundred examples, various combinations of earthen banks, fosses and stone ramparts span the necks of these promontories and isolate them from the mainland. Lake forts are located on lowlying promontories in complete contrast to coastal and inland forts where steep natural cliffs provide additional protection.

There is considerable variation as regards the scale and layout of the defences and the extent of the area enclosed. The Lough Feeagh site being unusual in having multiple defences with a double stone rampart and intervening rock cut fosse (see Figure 21b). The size and scale of the fortification can from the massively defended headland at Doon Point on Lough Carra to the relatively small site at Castlecarra on the same lake (for locations see Figure 21a).

While their impressive fortifications would suggest that they are primarily defensive sites built in response to unstable social, political and economic conditions, some may have had a ritual dimension. The Lough Feeagh site has an unusual oval stone-built enclosure at the tip of the promontory (see Figure 21b) which may be of ritual significance. As none of the Mayo sites have been excavated it is impossible to say whether or not they were major settlement sites. Barry Raftery has included both inland and coastal promontories as part of the suite of monuments belonging to a hillfort category. These sites, if they are indeed related would then be seen not simply as fortified homesteads but as major tribal centres in their own right. One is tempted to pick out the site at Doon Point on Lough Carra as being one such tribal centre on account of the huge area enclosed and the scale of the defensive rampart. From the distribution of such sites on the larger Mayo lakes it would appear that the lakes themselves were of considerable strategic and military importance in the later Bronze Age and Iron Age when these sites are considered to have been built. As yet we have no reliable constructional dating evidence for promontory forts, but if they are related to hillforts a date from as early as 1,000 BC seems likely. Only a handful of promontory forts have been excavated producing dates from the 6th century BC to the 11th century AD.

Re-use and re-fortification of lake promontory clearly took place in Mayo. At Errew the monks seem to have re-used an earlier earthwork and on the Moy estuary at Castleconnor the Normans re-fortified an existing estuarine promontory fort (SMR No.22:85) by building a town wall outside it. At Castlecarra the Normans re-occupied or re-fortified a small rock cut headland. Settlement continued on both these sites well into the 17th century. A similar picture can be seen at the great lake promontory fort of Rindoon, Co. Roscommon on the Shannon. Below is a preliminary of known and suspected lake promontory forts in Co. Mayo. Numerous

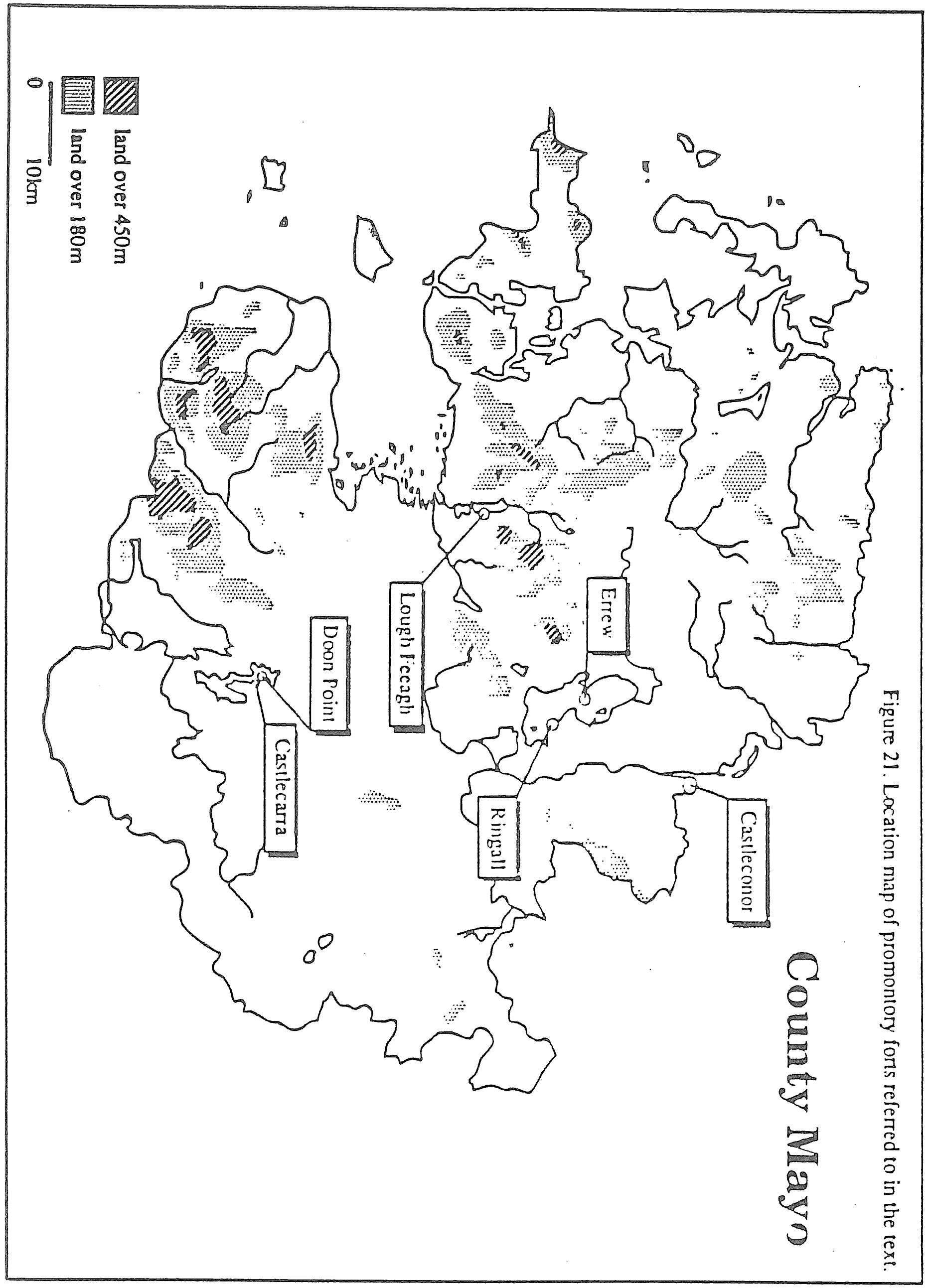
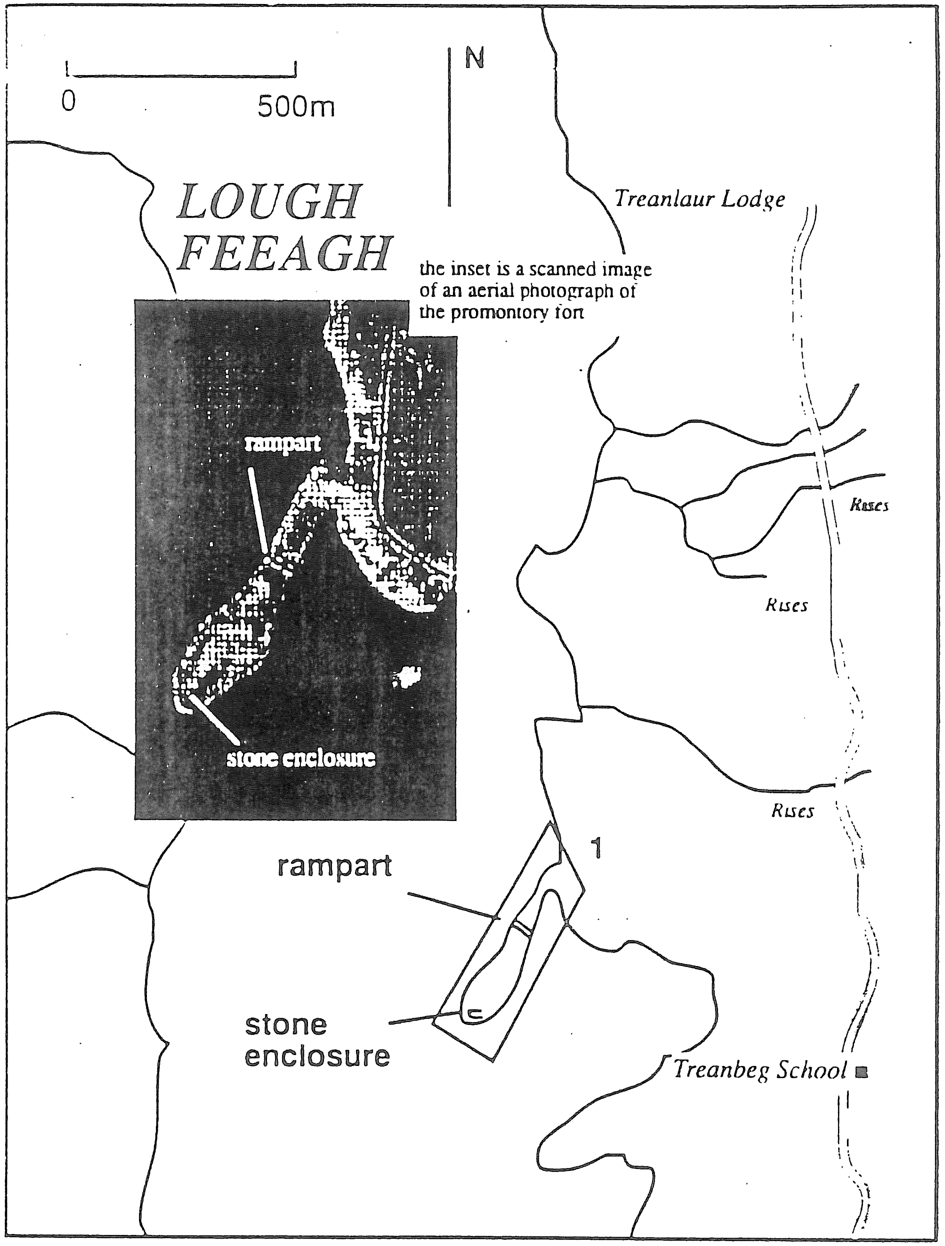


Figure 21. Location map of promontory forts referred to in the text.

Figure 21b. The promontory fort at Lough Feeagh



other examples await confirmation.

PRELIMINARY LIST OF LAKE PROMONTORY FORTS IN COUNTY MAYO
(see Figure 21a for locations)

1. Lough Feeagh, SMR No. 57:1. A narrow promontory knifing into the side of the lake, fortified at its narrowest part by a double rampart of stone with intervening rock-cut ditch. Area within ramparts measures approx. 250m by 70m. Modern entrance apparently on the site of the original entrance. On the southern tip of the peninsula there is an unusual ovoid shaped stone enclosure, partially peat covered. The approach to the site from the northeast is quite difficult due to the uneven nature of the underlying rock surface (poor man's chevaux-de-frise!).

2. Errew Point, Lough Conn, SMR No. 38:129. Large low-lying peninsula jutting northwards into the lake. A straight 110m long rampart cuts off the northern two thirds of the peninsula, an area of approx. 400m by 100m. Site re-used in Early Christian and Medieval times, fine complex of monastic remains still surviving within. Two other boundaries crossing the peninsula are possibly early in date.

3. Rinagall Point, south eastern side of Lough Conn. SMR No. 48:72. Pear shaped promontory jutting southward into the lake. Cutting off the neck of the promontory is a largely defaced rampart approx. 40m in length. The area within the rampart widens to a maximum of 170m. The western side of this rampart can be seen as a collapsed rubble mound on the shore of the lake. This rampart still serves as the present townland boundary and was marked as a significant boundary as early as 1683 during Petty's survey of the barony of Tirawley.

4. Doon Point, Lough Carra, SMR No. 99:18. Aerial photography has revealed a massive stone rampart 110m long, 10-13m in width and up to 3m in height cutting off the promontory. It is slightly curved and is cut through by a modern track possibly on the line of the original entrance. The promontory itself measures over 600m in length and up to 300m in width.

5. Castlecarra, Lough Carra, 400m due east of Doon Wood, SMR No. 100:82. A rock-cut ditch over 100m long cutting off a relatively small peninsula, approx. 110m by 150m. Site re-fortified by the Normans who built a bawn wall and a gatehouse along its line and a castle within.

(Michael Gibbons and Tom Condit)

2.3 The Nephin Beg Range and the Late-glacial

The nature of this IQUA fieldtrip necessitates that our visit to the Nephin Begs will be limited (access is difficult for groups) and the coverage in this guide cannot cover all of the aspects of Quaternary research that have been carried out in this area. This section is simply designed to give readers an introduction to the relevant literature and to Late Midlandian (Late-glacial ~13000-10000 years BP) events in the mountains. I can recommend Kenyon's (1986) research paper, the air photograph coverage and hill-walking in the Nephin Beg Range, much is yet to be discovered here.

Introduction

In his papers of 1963 and 1968 Synge proposed a stratigraphy for the Munsterian, Midlandian and Late-glacial of the area of north Mayo which in part covers the Nephin Beg Range. This research attempted to characterise the relationship between the mountain glaciers and those of the main ice caps to the east and the result has contributed to the compiled stratigraphy outlined on Table 1 in this guide.

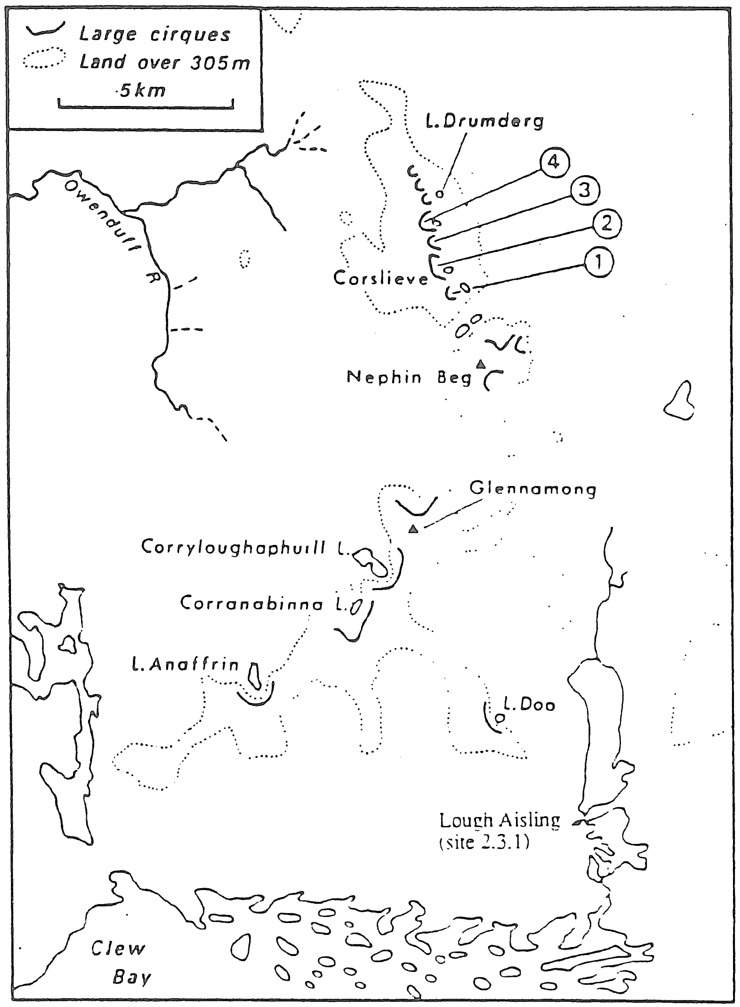
As outlined in an earlier section of this guide (*Regional Pleistocene geology*) the sequence of events proposed by Synge included an early glaciation (producing the Erris Till), an interglacial (Corraun (sometimes Curaun) Interglacial) and a succession of 4 corrie glaciations (Achill I to IV, based on Charlesworth's earlier research on Achill) during the Midlandian Glaciation with large ice masses only fringing the eastern and southern sides of the Nephin Beg Range.

In a carefully researched and well argued piece of geomorphological research Kenyon (1986) identified numerous moraines and other glacial and periglacial features within the Nephin Beg Range corries and he concluded that the broad (stratigraphic) relationship of the features assigned by Synge was not substantiated by the field evidence. In particular Kenyon noted that periglacial features could not be used as evidence of limits to the Midlandian Glaciation as they could have formed during the Nahanagan Stadial and hence could be found within Midlandian limits. Briefly, Kenyon suggests 4 phases can be recognised in the Midlandian Glaciation and he uses morphological evidence and erratic contents to correlate glacial sequences and features. Kenyon's phases are:

A. Development of a local (Nephin Beg Range) ice cap possibly coalescing with ice from Connemara and forming the Erris Till.
B. Reduction in size of the local ice cap and its coalescence with an inland ice sheet.
C. A halt in down wasting (or readvance) of inland ice as drumlins are formed.
D. Corrie glaciation during the Nahanagan Stadial on a larger scale than previously recognised.

Kenyon places some doubt on the validity of the stratigraphic position of the Corraun Interglacial (suggesting it may belong to the Late-glacial (Woodgrange) Interstadial) but, like Synge, he can provide no evidence to date any of the glacial sediments. The proposal for extensive mountain glaciation, both during the Midlandian and, to a lesser extent, during the Nahanagan Stadial, is an interesting one that will require further research. Kenyon's conclusion is that his work cannot

Figure 22. Corries and Browne's (1986) coring sites in the Nephin Beg mountains. Lough Clevala is just to the east (see text for grid ref.).



disprove the earlier stratigraphic framework. However his research identifies important aspects of the glacial geology of the area that would warrant further investigation and may eventually lead to the dating of the various phases of glaciation.

One aspect of the work of Browne (1986) looked at Late-glacial (for details of the current Late-glacial stratigraphy see Table 3, page 52) sequences from lake sediments within the area of the Nephin Begs in an attempt to identify sites of Nahanagan Stadial glaciation and to compare vegetation sequences at high and low altitudes. In all he studied 4 sites; Lough Anaffrin, Corslieve 1, Lough Clevala and Lough Aisling (three of which are marked on Figure 22). This project was a difficult one logistically as it involved transporting coring equipment and boats to relatively inaccessible sites (including Lough Anaffrin and Corslieve 1 (Figure 22)). The sites studied by Browne were very varied in altitude, soil type, size and aspect:
Lough Aisling, L957977, 15m O.D.
Lough Clevala, G060110, 73m O.D.
Lough Anaffrin, F870015, 184m O.D.
Corslieve 1, F927125, 320m O.D.

High level corrie lakes proved inaccessible but the southern end of L.Anaffrin contained a complete Late-glacial sequence suggesting that no glacier formed at or below the present lake level during the Nahanagan Stadial. The lake sediments in Corslieve 1 (Figure 22) did not contain a full Late-glacial record and Browne considered that this was because of local solifluction into the lake basin. The pollen records at three of Browne's sites (Loughs Clevala, Aisling and Anaffrin) do not show a marked change to extreme cold conditions during the Nahanagan Stadial and he suggests that conditions were not intensely cold here during this period and that extensive glaciation of the Nephin Begs at this time was unlikely.

The latter point will only be proved by further work on sediments in the higher corrie lakes, something suggested by Kenyon (1986) and Browne (1986) that will take considerable effort to achieve especially as sediment focussing requires the cores to be taken from the deepest part of the basin and most of these lakes are >30m deep.

2.3.1 Lough Aisling (L957977)

We shall visit this site as it is the most accessible of the lakes studied by Philip Browne although as this is a lowland site the setting is not as spectacular as the corrie lakes. The site name is taken from a gatepost not the Ordnance Survey map.

The location is a small freshwater lake some 300 X 100m at an altitude of 15m O.D. The lake has an inlet and outlet stream and some of the stream's catchment is as high as 200m O.D. The basin is on the southern flanks of the Nephin Begs, between two lateral moraine ridges. the upper reaches of the catchment are developed on Pre-Cambrian schists and gneisses, and is a sheltered southerly facing site. The core was taken from the central part of the basin where the water is deepest (5m) and a 4m core was recovered.

The maximum depth of approximately 5m is to be found in the central portion of the lake and it gently shallows around the periphery, shelving more steeply to the sides, north and south. A small stream flows through the basin entering it at the western end and exiting at the centre of the southern flank.

Sediment description

Depth. Description

130-200 cm: Dark reddish brown detritus mud. Firm, nig 3, strf 0, elas 3, sicc 3, calc 0. Ld3Dg1Dh+. Colour: 5YR 2.5/2. Contacts: gradational. *Phragmites* leaves present.

200-215 cm: Very dark brown detritus mud. Firm, nig 3, strf 0, elas 3, sicc 3, calc 0. Ld3Dg1Dh+. Colour: 10YR 2/2. Contacts: gradational.

215-412 cm: Very dark brown detritus mud. Firm, nig 3, strf 0, elas 3, sicc 3, calc 0. Ld4Dg+. Colour: 10YR 2/2. Contacts: gradational.

412-414 cm: Brownish grey silty detritus mud. Firm, nig 2, strf 0, elas 2, sicc 3, calc 0. Ld2As/Ag2. Colour: 5YR 5/1.Contacts: sharp.

414-415 cm: Dark reddish brown sand. Firm, nig 2, strf 0, elas 2, sicc 4, calc 0. Ga2Gs1As/Ag1. Colour 5YR 3/2. Contacts: sharp.

415-420 cm: Brownish grey silty detritus mud. Firm, nig 2, strf 0, elas 2, sicc 3, calc 0. Ld2As/Ag1Ga1. Colour 5YR 5/1. Contacts: gradational.

420-446 cm: Dark reddish brown sandy clay. Firm, nig 2, strf 0, elas 1, sicc 3, calc 0. As/Ag2Ga2. Colour: 2.5YR 4/2. Contacts: gradational.

446-484 cm: Blackish brown silty detritus mud with laminae of sand. Firm, nig 3, strf 3, elas 2, sicc 3, calc 0. As/Ag2Ld2Dg+. Colour: 5YR 2/2. Contacts: sharp to gradational.

484-499 cm: Black-brown silty detritus mud. Firm, nig 3, strf 1, elas 3, sicc 3, calc 0. Ld3As/Ag1Dg+. Colour: 7.5YR 2/3. Contacts: sharp.

499-502 cm: Brown-grey silty clay. Firm, nig 1, strf 0, elas 0, sicc 3, calc 0. As/Ag4Ga+. Colour: 7.5YR 5/1. Contacts: gradational and irregular.

502-520 cm: Light brown-grey silty clay. Firm, nig 1, strf 0, elas 0, sicc 3, calc 0. As/Ag4Ga+. Colour: 7.5YR 7/1. Contacts: gradational.

520 cm: Impenetrable due to stone or gravel layer.

Loss on ignition tests were carried out and there are two phases represented in the results of these tests. Firstly there is a period of low organic content between 520 cm and 410 cm which is interrupted at 500-483 cm by a sharp rise from 2-3%, to 20% organic content. Subsequently there is a rapid drop to the previous levels of 3-6%. Secondly there is a phase from 410 cm to the top of the core where organic content of the sediment is often an order of magnitude greater than that of the first phase. Values range from 22% to 68% organic content and show a general rising trend from 410 cm up to the top of the core. This trend is broken at 229 cm when there is a sharp drop from 63% to 27% at 214 cm with an equally sharp rise in values following this event. At the very top of the core another drop in organic content seems to be initiated.

An abbreviated version of the pollen diagram (main taxa only, low percentages of these taxa not depicted) appears as Figure 23 in this guide and the following pollen assemblage zones (p.a.z.) were recognised by Browne:

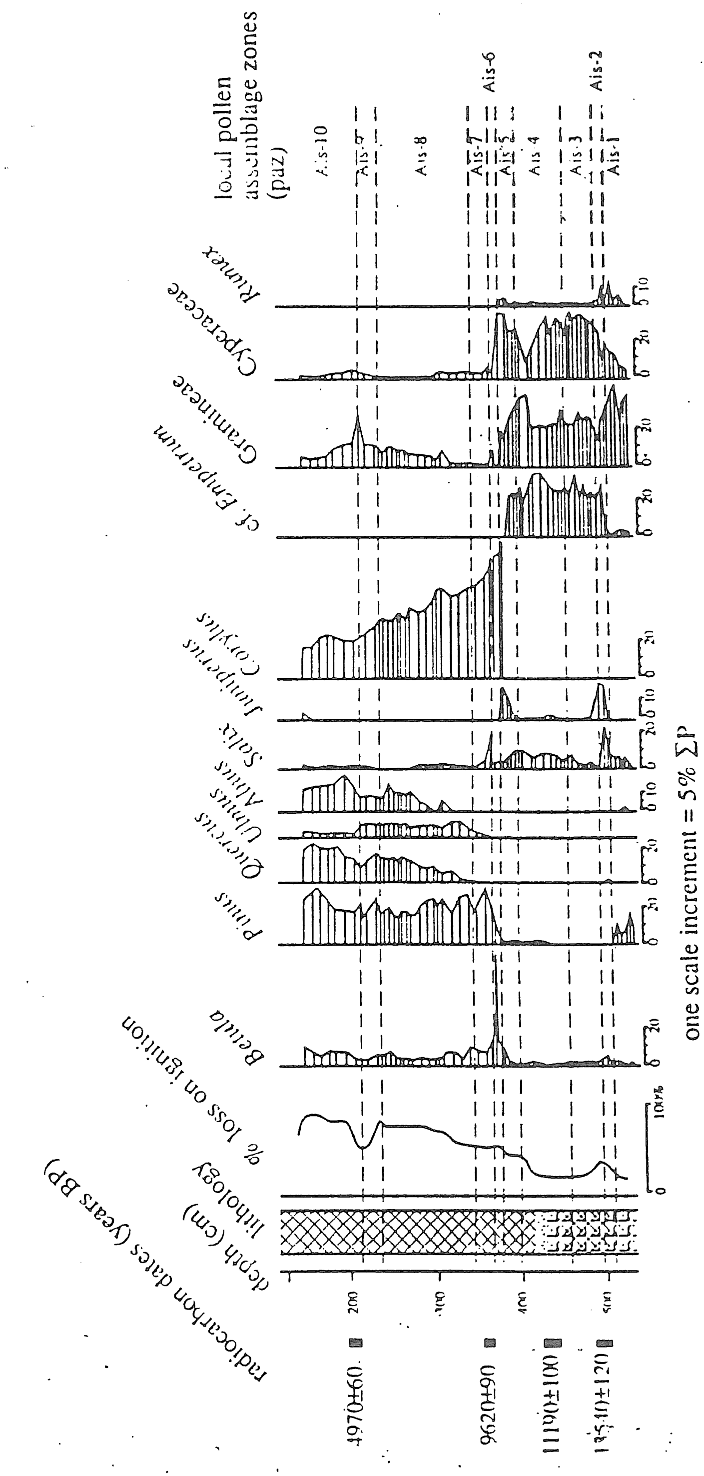


Figure 23. An abbreviated pollen diagram from Lough Aisling after Browne (1986).

Ais-1 GRAMINEAE-*PINUS* -CYPERACEAE p.a.z., 520-497 cm.
Ais-2 *JUNIPERUS -SALIX* -CYPERACEAE-*EMPETRUM* p.a.z., 497-480 cm.
Ais-3 *EMPETRUM* -CYPERACEAE-GRAMINEAE p.a.z., 480-425 cm.
Ais-4 *EMPETRUM* -GRAMINEAE-CYPERACEAE-*SALIX* p.a.z., 425-383 cm.
Ais-5 *JUNIPERUS -EMPETRUM* -CYPERACEAE-GRAMINEAE p.a.z., 383-368 cm.
Ais-6 *CORYLUS-BETULA* p.a.z., 368-358 cm.
Ais-7 *CORYLUS-PINUS* p.a.z., 358-313 cm.
Ais-8 *CORYLUS-PINUS-QUERCUS-ALNUS-ULMUS* p.a.z., 313-205 cm.
Ais-9 *ALNUS-QUERCUS-PINUS-CORYLUS* p.a.z., 205-180 cm.
Ais-10 *PINUS-QUERCUS-CORYLUS-ALNUS* p.a.z., 180-140 cm.

The site provides a radiocarbon dated, low resolution, picture of the Late- and Post-glacial vegetation development in the lowland of the Nephin Beg Range area. The full scope of Browne's work (which covered the Late-glacial and Holocene vegetational history of the Nephin Begs) is too wide to include in this fieldguide but some of the pertinent findings include the following:

The Late-glacial

The problem of glacial stratigraphy in the Nephin Begs corries is at present unresolved with two opposing hypotheses put forward by Synge (1963) and Kenyon (1982; 1986). Whilst Synge suggested that there was negligible corrie glacier activity during the Nahanagan Stadial, Kenyon put forward the hypothesis that Late-glacial corrie activity was much more extensive than previously thought. This problem could effectively be resolved by an investigation of Late-glacial sediment in the corries themselves.

As a result of Browne's project it is clear that in the corrie at L. Anaffrin there is a nearly complete sequence of Late-glacial pollen bearing sediments, including material obviously deposited during the Nahanagan Stadial. This certainly indicates that at L. Anaffrin there was little or no build up of ice during the stadial and protalus ramparts at the corrie backwall were probably the only features formed during the climatic change. The evidence from Corslieve 1 is not so conclusive and it was found that the pollen record only started at the Nahanagan Stadial /Holocene transition and below this level there were only barren sands. There are two possible explanations for this sedimentary sequence; either the basin was ice filled during the stadial in which case the sands are a glacial deposit, or else the sands are a solifluction deposit produced by slope wash within the basin during periglacial conditions. The first suggestion can probably be discounted because there are clearly no fresh morainic features within the basin (Synge, 1963; Kenyon, 1986) and secondly the sandy material would appear to be too fine a deposit to be derived at a glacier source. Therefore it seems more likely that the deposit is a result of solifluction but why is it barren of pollen when at L. Anaffrin solifluction clay deposits contain a pollen flora?

Kenyon suggested that the fresh moraines at Corslieve 2, 3, 4 (see the photograph of Corslieve 2 moraines in Coxon and Browne, 1991) and Coranabinna (Kenyon, 1986) may be of Nahanagan age because they lack periglacial features behind them, yet they occur outside the moraines. Unfortunately the evidence presented here precludes any confirmation of this

hypothesis as access to these sites with coring equipment was too difficult. Therefore it is difficult to dismiss Kenyon's statement that "...during the Nahanagan Stadial glaciers were much more extensive than previously thought" as there is only positive evidence against this at L. Anaffrin. However there are secondary sources of evidence which can be used to clarify the problem.

The pollen content at Loughs Aisling, Anaffrin and Clevala shows that conditions were not very extreme in the region. It is clear that during the interstadial birch trees and copses may have been present as evidenced by the macrofossil record at L. Aisling. More importantly the main effect of the stadial climatic change appears to have been only a change in the extent of the pre-existing vegetation rather than any change in the composition of the vegetation. This suggests that there was not a marked change to extremely cold conditions and this is further supported by the insignificance of pollen of open tundra conditions normally associated with ice proximal environments. At L. Aisling the presence of *Empetrum* throughout the stadial also suggests that conditions may not have been very extreme. The pollen content supports the evidence from L. Anaffrin showing that extensive glaciation in the Nephin Begs did not occur during the Nahanagan Stadial.

The sediment stratigraphy shows that the Late-glacial was basically divided into three and this tripartite sequence is found through Britain and Ireland. To a certain degree this is reflected in the pollen assemblages which can be broadly placed within a pre-interstadial, interstadial and stadial framework. However in reality the situation is much more complex than this. This change from the strict tripartite pollen zonation to a more flexible framework is a relatively new feature in Irish pollen stratigraphy (Watts, 1977). The pollen record itself shows that, as in other parts of Ireland notably the southeast (Craig, 1978), the maximum pollen concentration and pollen influx occurs during the early part of the interstadial with a gradual decline to the low values found during the stadial. This indicates that the early part of the interstadial was perhaps the warmest and most productive period and this complements Coleopteran evidence from Britain (Coope, 1977). Lough Anaffrin however provides an anomaly as in the early stage of the interstadial there is clearly a period of very low pollen concentration and influx. This event may well be similar to that found at Coolteen (Craig, 1978) and at some other Irish sites (Watts, 1977) and probably represents a period of soil erosion. In Britain similar events have been correlated to the Older Dryas (Pennington, 1977). This soil erosion may have been a result of a climatic deterioration though Watts suggests the reasons may be more complex. Certainly the event is well marked at L. Anaffrin and there are complementary increases in pollen of open ground taxa as well as a decline in the organic content of the sediment. The event only seems to have been effective at altitude in the Nephin Begs as it is not recorded at L. Aisling.

The main feature of the Late-glacial pollen record is the abundance of Gramineae and Cyperaceae throughout the period and open grass-heath must have dominated the region particularly during the interstadial when the grassland may have been quite productive. The lag between the changing lithology in cores and the later vegetational change during the Late-glacial is also very notable and can even be seen on the summary pollen diagram from L.Aisling (Figure 23).

Of special interest is the macrofossil record of *Betula pubescens* at L. Aisling during the interstadial. This shows that even though birch percentages were low, tree birch was present locally and Mitchell has used a similar macrofossil record of

Betula pubescens to indicate an interstadial birch copse at Littleton Bog in Tipperary (Mitchell, 1981b). This indicates that conditions were cool and the characteristic high percentages of *Empetrum* at L. Aisling would confirm this. At L. Anaffrin, at higher altitude, *Empetrum* is not important and this can be regarded as a response to severe conditions at altitude. At L. Clevala *Empetrum* is also not important but probably for a different reason. The base rich soils at L. Clevala would not have been suited to *Empetrum* which prefers acidic conditions and thus at L. Clevala it was not present in any quantity.

The stadial is marked mainly by a drop in pollen concentration and organic content at the relevant sites and as already mentioned there is not a significant change in the composition of the vegetation. There are small increases in pollen types typical of more open conditions, soil instability and snow patch development, however they collectively amount to a very small component of the vegetation. The sediment record shows that there was a significant increase in minerogenic deposition and there must have been solifluction and slope wash throughout the area.

Unfortunately the radiocarbon dating of the Late-glacial proved to be ineffective for a number of reasons including the need to use long pieces of core for conventional dating and contamination by old carbon. The problem of contamination by older inert carbon in metamorphic rocks is not unique to the Nephin Begs (Lowe and Walker, 1980) and is aggravated by the low organic content of Late-glacial sediment. In general it is clear that the Late-glacial was dominated by herbaceous pollen and there are only very small amounts of shrub and arboreal pollen. It is also clear that the species diversity during the Late-glacial was quite rich though at some eastern sites a greater diversity has been recorded.

The Holocene

In terms of pollen stratigraphy there is a broad similarity between that found in the Nephin Begs and the general Irish model. The pollen record shows the development of woodland and forest conditions, its subsequent decline and then the development of peat and bog growth. There are some major differences especially with regard to the dominance of hazel throughout the Holocene. This is similar to other western sites but is clearly different to midland and eastern sites. The importance of pine is also much greater than in sites in the midlands and to a lesser extent the east of Ireland. Man has clearly played a role in the Nephin Begs in that his grazing animals and fire probably accelerated deforestation and helped initiate and maintain bog development. However there is no evidence of arable agriculture or Landnam phases seen else where in Ireland.

At all four sites the sediment accumulation rates from 10,000 - 5,000 B.P. are considerably slower than after 5,000 B.P.. This is frequently the case in Irish pollen sites and the faster sediment accumulation seems to have been initiated after the 'elm fall'. At Corslieve 1 there is evidence for periods of high sedimentation occurring after 5,000 B.P. probably due to peat and humus erosion. The higher sedimentation rates are supported by the decline of *Isoetes* particularly at the 'elm fall' as it is intolerant of sediment charged water.

The Nephin Beg regional stratigraphy hides some interesting information on variation within the region between the four sites. In particular there is a clear distinction between the sites at altitude and those at lower levels. At Corslieve 1 the

pollen record shows that right from the start of the Holocene Gramineae were an important component of the vegetation and there are much lower percentages and concentrations of arboreal pollen. This indicates that at Corslieve 1 the landscape was considerably more open and relatively treeless compared to lower altitude. L. Anaffrin appears to hold an intermediate position with trees being more important than at Corslieve 1 but less so than at lower sites. The exception to this rule is during the *Betula* phase in the early Holocene. This phase is particularly well marked at Corslieve 1 where birch was able to expand to a greater extent than at the lower sites because the hazel expansion probably occurred later at altitude. At lower altitude the birch peak is not as distinct as it merges with the preceding juniper peak and subsequent hazel expansion.

The hazel expansion at the low sites was clearly a very marked event and the hazel maximum occurs almost at its arrival. At altitude the hazel expansion is somewhat more gradual, particularly at Corslieve 1, and the concentration and percentages of hazel pollen are considerably less than those at the two low sites. Superficially it seems to be due to altitude but is probably more a reflection of soil differences with hazel intolerant of the thin soils at altitude, preferring the richer soils particularly at L. Clevala. As can be seen on Figure 23 the hazel rise is interrupted at L.Aisling by a dramatic, short-lived drop in hazel values. This event is found in only one sample, in both the concentration and percentage diagrams and is therefore not likely to be an artifact of the percentage calculations. It suggests that for some reason the hazel population suffered some major set-back which allowed the re-expansion of birch and willow and some grassland. It is difficult to put much emphasis on this event as it is recorded in a single sample. It is not likely to be due to an artifact, contamination or sampling error. It may be that hazel, which is particularly susceptible to frosts as it flowers early in the year, suffered from a small scale climatic deterioration resulting in later frosts. This could have reduced the reproductive potential of hazel, allowing an opening up of the vegetation though there is no associated sedimentary evidence to support this. The event occurred around 9600 years B.P. and it may show early Holocene climatic oscillation. If such an event did occur it was shortlived as the event only occurs over 1 cm of the core and therefore little emphasis is put on it. This event was not found in any of the other cores taken in the Nephin Begs.

The expansion of oak, elm and pine occurs soon after the hazel maximum at the two lower sites but again it is clear that the expansion of pine in particular is delayed at Corslieve 1, with pine preferring the better drained soils at low levels and at L. Aisling in particular. Oak and elm pollen occurs at altitude but the extent to which it is derived from local stands or from updraughting from the adjacent lowlands is hard to determine. It is probable that elm was not very important at altitude as it favours good soils which were not present at altitude. This is supported by the low concentration of elm pollen at Corslieve 1 especially.

Alder also seems to have been affected by altitude to a certain extent as indicated by the alder maximum. At L. Aisling and L. Clevala (the low sites) the alder maximum occurs after the 'elm fall' when there is a considerable expansion of alder. However at the two higher sites the alder maximum occurs prior to the 'elm fall' and occurs at lower values after that event. Therefore a limitation appears to have been imposed on alder by altitude.

The importance of the woodland components is clearly dependent on altitude.

This is to a certain extent as much due to soil type and species competition as due to altitude. Pine appears to be a more important component of the woodland at altitude than at lower levels but it disappears earlier (Bradshaw and Browne, 1987). This is probably the result of less competition from the deciduous trees at higher altitude and pine was able to exploit this advantage whereas at the low sites, particularly on the rich soils of L. Clevala, pine was not able to compete effectively with the other tree types. Hazel is not as important at altitude compared to the lower sites this being due to the thin soils found at higher elevation which are not favoured by hazel and similarly elm favours the richer soils at low levels.

The "elm fall" is ubiquitous at all of the sites, though less well marked at the high sites where elm is not as important. The wide range of radiocarbon dates for the event reflects errors in the dating and the 'elm fall' can be regarded as synchronous as shown by Edwards (1985). Of special interest is the subsequent pine record at L. Aisling which shows that there was a major regeneration and expansion of the local pine population. This is not apparent elsewhere in the Nephin Begs and suggests that L. Aisling may well have become a late Holocene pine refugia. This is contrary to the usual hypothesis that pine survived latest at higher altitude and at L. Aisling there is clear evidence that pine was present at a well drained lowland acidic site well after the 'elm fall' (Bradshaw and Browne, 1987).

After the 'elm fall' at the higher sites, particularly Corslieve 1, there is a significant increase in *Calluna* and grass-heath whilst shrub and arboreal pollen are lower. This indicates the development of peat in the region and it clearly was initiated much earlier at altitude than in the lowlands. At Corslieve 1 there is also evidence of associated peat erosion in the form of peaks in organic content and increases in the pollen of heath pollen types. According to the radiocarbon dates it is probable that peat development started at Corslieve 1 prior to 3,000 B.P. whilst it only occurred after 2,100 B.P at lower altitude at L.Clevala.

Apart from the effects of altitude on the pollen record there are also variations due to soil type which have been mentioned in passing. Pine in particular seems to have been affected by soil type in that on the richer limestone soils of L. Clevala pine was unable to compete with the deciduous trees that favour those conditions. This effectively meant that pine became restricted to the poorer soils such as the acidic soils of L. Aisling. At altitude the poor acidic soils also meant less competition allowing pine to become a more important component of the woodland. Hazel and elm also seem to have been affected by soil type, both preferring the richer soils at low level sites in particular the rich soils at L. Clevala. Browne's (1986) project showed that in both the Late- and Post-glacial in the Nephin Begs there is a broad similarity between the sites but there are also strong variations due to both altitude and soil type and these variations are evident in the pollen record.

(P.Browne and P.Coxon)

General glaciation	Cirque glaciation
Midlandian	
1. Roundstone Upper *Salix herbacea* Clay	Acorrymore Innermost Moraines – Achill IV (Nahanagan Stadial)
2. Roundstone Mud	
3. Roundstone Lower *Salix herbacea* Clay	
4 Ballycastle-Mulrany Moraine	Achill III
5. Newport Till	
6. Roscahill Till	
7. Oldhead (Louisburgh) Peat	
8. Ballycroy Moraines	Annafrin Outer Moraine – Achill IIb (Athdown)
9. Killadoon Till	
10. Belderg Shelly Till	
11.	Achill IIa (Bnnas)
12.	Acorrymore Outer Moraine – Achill I (Aughrim)
13. Curraun (Corraun) Inter-glacial	
Munsterian	
14 Erris Till	
15. Gort Upper Solifluction Till	
Gortian	
16. Gort Mud, Derrynadivva Mud	
17. Gort Fine Sandy Clay	
18. Gort Lower Solifluction Gravel	

Table 1. Quaternary stratigraphy in western Ireland (from Coxon and Browne, 1991, after Mitchell *et al.*, 1973 and Finch, 1977)

Table 2. Lithofacies types and their sedimentary characteristics based on Miall (1977) and Eyles *et al.* (1983) as covered in this guide. The lower table contains the predominant lithofacies found along the north Mayo coast. (after McCabe *et al.*, 1986)

Code	Lithofacies Type	Sedimentary characteristics
Dmm	Diamicton, massive	Structureless, very-poorly sorted mud/sand/gravel admixture; dispersed pebbles, cobbles and boulders; glacially bevelled clasts present
Dms	Diamicton, stratified	Matrix/clast supported; stratification is pronounced and more than 10% of unit thickness; often graded; generally stacked beds; pronounced winnowing
Gc	Gravel, clast-supported	Massive or imbricated (See text and logs for grain size and grading characteristics)
Gms	Gravel, matrix supported	Massive (See text and logs for grain size and grading characteristics)
Gm	Gravel, crudely bedded	Horizontal/inclined bedding (See text and logs for grain size and grading characteristics)
Gt	Gravel, stratified	Trough crossbeds (See text and logs for grain size and grading characteristics)
Gp	Gravel, stratified	Planar crossbeds
Sm	Sand, massive	Silty-sand; mean grain size −1Ø
Sh	Sand, horizontal lamination	Stratified; generally normally graded; mean grain size +2Ø; well sorted
St	Sand, trough-cross beds	Low angle crossbeds (<10°)
Sp	Sand, planar crossbeds	Coarse to medium sand
Sr	Sand, rippled	Type A, B and 'S' ripple drift, cross-lamination
Fl	Mud, laminated	Alternating clay, silt and fine sand laminae
Fm	Mud, massive	Clast deficient
Fmd	Mud, diamictic	Massive; clasts dispersed
Fmd(r)	Mud, diamictic	massive; winnowing structures; crude stratification; lags, folding; deformed drape laminae

Site	Main Lithofacies	Minor Lithofacies	Inferred depositional palaeoenvironments
1. Bream's Hole	Dmm	-	Basal till
	Fmd Fmd(r)		Iceberg zone mud, plume deposits
2. Belderg Pier	Fm Fmd	Fl	Iceberg zone mud and density currents
3. Fiddauntawnanoneen	Dmm	-	Basal till
	Fm Fmd	Fmd(r)	Iceberg zone mud
4. Glenulra	Fm Fmd Fl Sh	-	Iceberg zone mud
	Gp	Sh Sr Sp Fmd(r)	Ice marginal delta prograded over mud
5. Belderg More	Gms Gm	Gc	Ice marginal subaqueous outwash
6. Glenlossera	Gp Sh	Sm Dmm	Ice marginal delta
7. Benmore	Gms Dms Dmm	Fl Sh	Ice marginal subaqueous debris flows
8. Brockhill	Gp Sr Sh	Gt Gms	Ice marginal Gilbert-type delta

Table 3. Correlation table for the Late Midlandian Glaciation (from Coxon and O'Callaghan, 1987)

Continental north west Europe: Stage	Substage	Years	Chronozone	Ireland: Stage	Substage			Years	Pollen assemblages	Jessen's (1949) tripartite scheme the Late Glacial
		8,000			8,000	8,000				
Flandrian	Early Flandrian	9,000 – 8,000	Boreal	Littletonian	Early Littletonian	Early Post Glacial		8,500 –	*Corylus* phase	
								9,500 – 8,500	*Salix – Betula* phase	
		10,000 – 9,000	Preboreal					10,000 – 9,500	Second Juniper peak	
		10,000			10,000	10,000				
Weichselian	Late Weichselian	11,000 – 10,000	Younger *Dryas*	Midlandian	Late Midlandian	Late Glacial	Nahanagan S	10,200 – 10,000	Gramineae – *Rumex* peak	
		11,800 – 11,000	Allerød				Nahanagan S	10,900 – 10,200	*Artemisia* phase	III
		12,000 – 11,800	Older *Dryas*				Woodgrange I.S	11,800 – 10,900	Oxalis phase	II
							Woodgrange I.S	12,000 – 11,800	Erosion phase	II
							Woodgrange I.S	12,400 – 12,000	First Juniper peak	
		13,000 – 12,000	Bølling				Woodgrange I.S	13,000 – 12,400	*Rumex – Salix* assemblage	I
		13,000				13,000				
	Middle Weichselian				20,000					
					Middle Midlandian					

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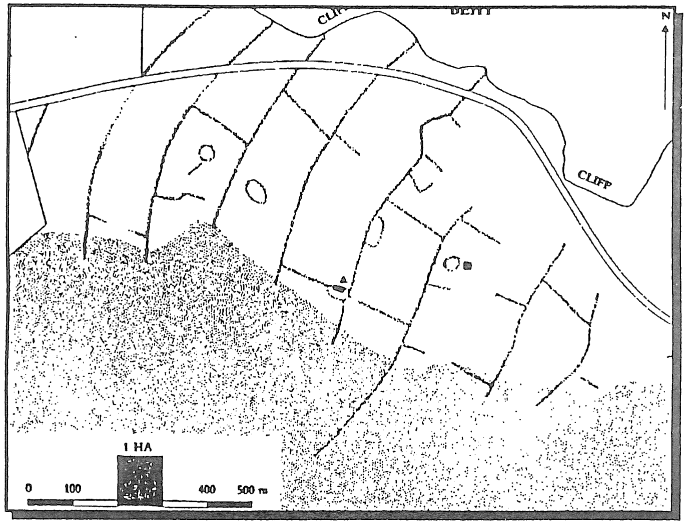

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