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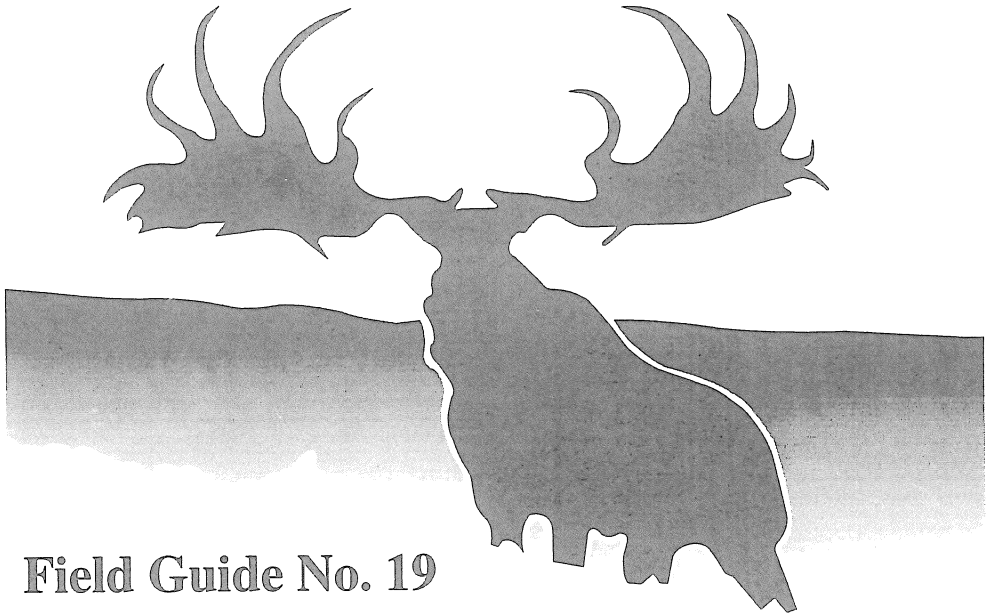

Field Guide No. 19

NORTH-WEST DONEGAL

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1995

Edited by

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PREFACE

This Field Guide complements the Annual Field Meeting of the Irish Association for Quaternary Studies (IQUA), held in north-west Donegal 30th September-1st October 1995.

IQUA previously visited Donegal in 1984, in conjunction with visits to sites in Co. Londonderry (Wilson & Carter, 1984). On that occasion time restrictions only allowed work at the Clonmass Estuary and on the Inishowen peninsula to be considered. On this occasion the entire meeting was based in Donegal, although emphasis was placed on a relatively small area of the county (Fig. 1). Nevertheless, the area is one in which recent work has demonstrated the presence of a wide range of interesting landforms and sediment sequences that facilitate the reconstruction and understanding of Quaternary environmental change and human impact on the landscape during the last few thousand years.

It is probably true to state that prior to 1980 Donegal was somewhat neglected by Quaternary scientists. Few radiocarbon dates had been obtained (Edwards, 1985), limited pollen analysis had been undertaken (Telford, 1977), sea-level changes and coastal evolution were not well documented, modern concepts relating to glaciation had not been applied, and very few periglacial features had been identified (Lewis, 1985). Several things have changed since then, but in certain disciplines there is great scope for even more work to be undertaken. There is much potential within the county for obtaining additional information pertaining to Quaternary landscape evolution.

If this Field Guide stimulates interest and subsequent research into the Quaternary history of Donegal then it will have served a useful purpose.

Sheets 1 and 2 of the Ordnance Survey of Ireland 1:50,000 Discovery Series are recommended for use with this Field Guide.

Peter Wilson
Coleraine, June 1995

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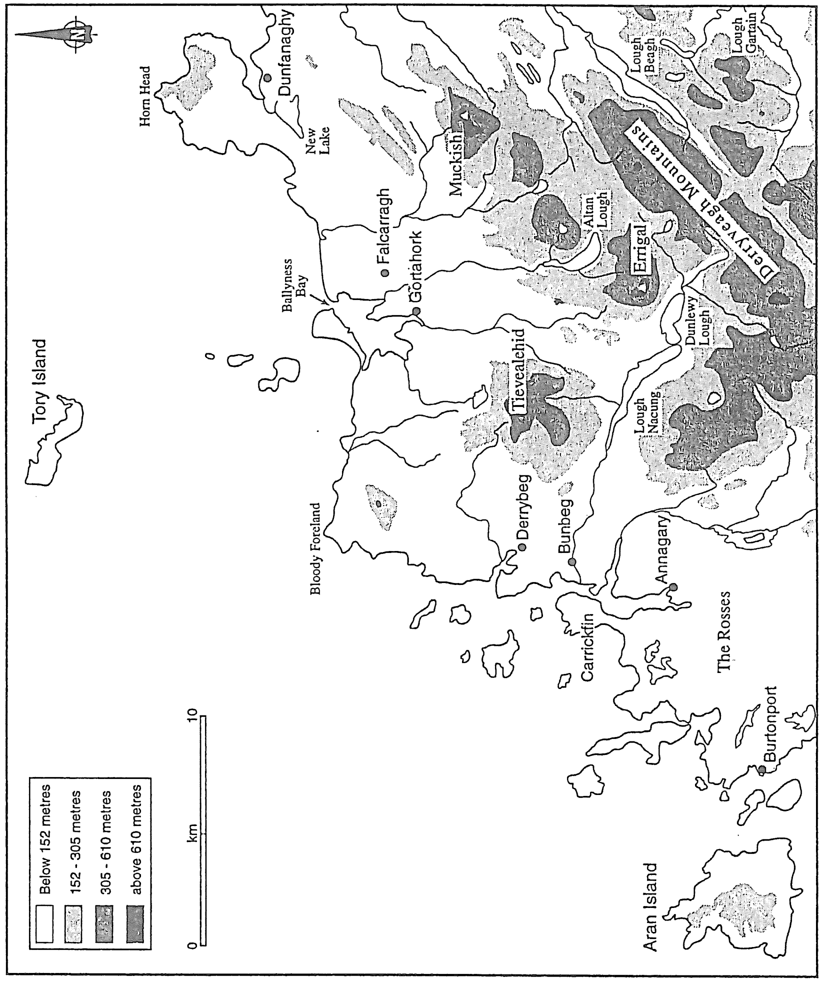

Figure 1. Topography and drainage of north-west Donegal.

INTRODUCTION

Pre-Quaternary Geology (*John Roberts*)

The geology of much of north-west Donegal has been long investigated from the work of Grenville Cole (1902), on the Donegal granite, to the in-depth studies of the Pitcher research school in the 1950s, also centered mainly on granite, to the stratigraphic-structural studies in the Creeslough area (McCall, 1954), and to the ongoing tectonic studies of Hutton (1977).

The area is bounded by the Gweebarra Fault in the south-east, Horn Head in the north, and Burtonport in the west (Fig. 2), and is well known for many different aspects of geological research. Indeed, the University of London was very active in the area for almost 30 years, with the thrust being led by Wallace Pitcher. Nowadays, interest has waned, other than for the continuing structural work of Hutton with respect to the tectonic slides and metasediment-granite relationships. The scenic beauty of the area owes much to its pre-Quaternary geology and structure, whilst the coastal area has been influenced strongly by the inheritance of glacial sediments, and the development of subsequent landforms.

The geological succession: The geological succession of north-west Donegal comprises a thick pile of quartzites, pelites and limestones which were laid down under a variety of sedimentary environments in Late Pre-Cambrian times (Harris & Pitcher, 1975). In a regional sense they can be correlated with the Appin Group of the standard Scottish succession, which is ascribed to a lower Dalradian age. The thick sedimentary pile has been metamorphosed to the mid-Greenschist facies as a result of protracted deformation and thermal events associated with the Grampian Orogeny, about 500 million years ago.

The succession in the Creeslough area was established by McCall (1954), and later revised by Pitcher & Berger (1972). The accepted sequence is:

6. Falcarragh Pelites
5. Sessiagh-Clonmass Formation (here not subdivided)
4. Ards Quartzite
3. Ards Pelite
2. Altan Limestone
1. Creeslough Formation

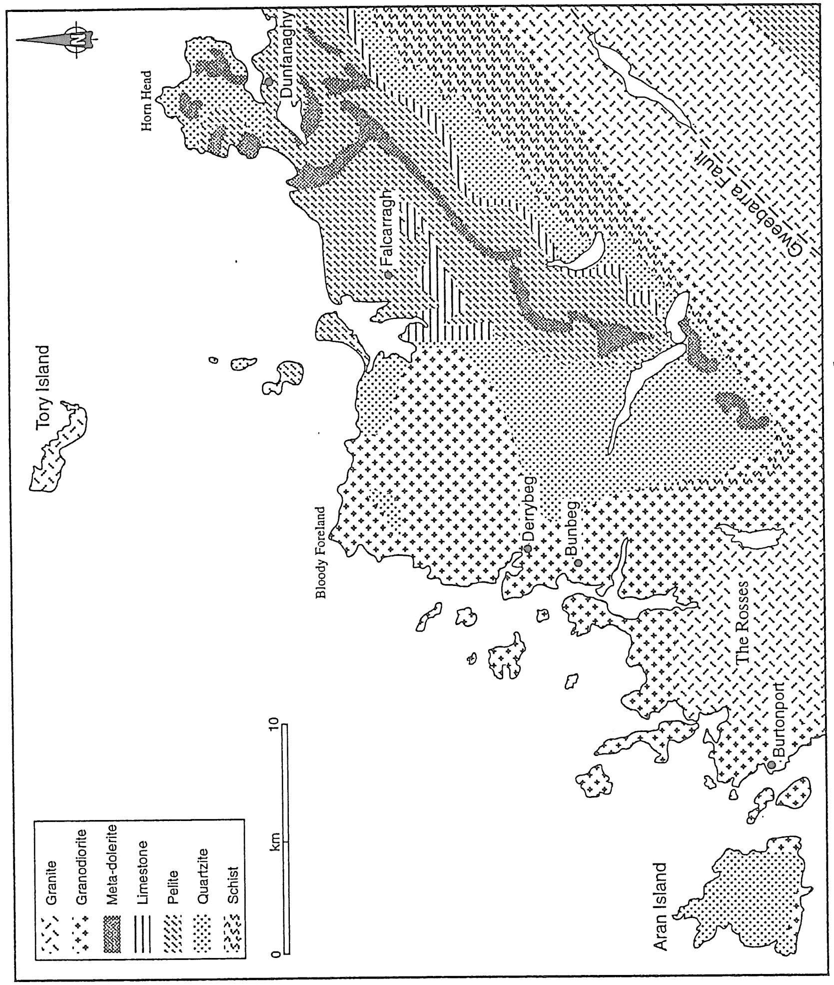

Figure 2. Pre-Quaternary geology of north-west Donegal.

The obvious lithological variations in the succession give rise to different topographic expressions. The extremely hard quartzites form the highest ground in the Donegal Highlands, i.e. Errigal, the Aghlas and Muckish, and prominent coastal cliffs, as at Horn Head. The pelitic and calcareous lithologies usually form the lower ground and give rise to hummocky terrain, often with steep scarp-like features. Such forms can be seen south of the Dunfanaghy-Falcarragh road and can be attributed to either quartzite leaves in the pelites, or, more commonly, to the presence of metadolerite sills. These sills are hard, dark-coloured rocks which in places achieve the metamorphic grade of garnet amphibolite, but, more usually, are little more than altered quartz dolerites. The sills also vary considerably in thickness; many are 20-30m thick, but one, the Mam Sill, which forms a prominent topographic feature southwards from Dunfanaghy towards the west flank of Errigal, attains a thickness of 120m.

Structural influences: The lithological variations in the sedimentary pile are not in themselves sufficient to account for the landscsape diversity. Many aspects of the landscape are controlled by tectonic structures which developed at different times and at different scales within the rocks. The alignment of peninsulas, drainage nets and loughs all depict the very strong north-east - south-west so-called Caledonoid grain, a grain initiated during the Grampian Orogeny, and subsequently modified by the later Caledonian movements. The grain follows the trend of the major fold axes, whilst the corresponding topographic features exhibit a simplicity of trend which belies the complexity of the fold pattern, e.g. the overturned north-west facing syncline of Errigal.

If the folding has played a big part in controlling the alignment of landforms, so has fracturing. A cursory glance at a topographic map will show that in the metasedimentary areas there is also a strong linear direction which trends north-west - south-east, a direction which has had a profound influence on the development of geomorphological features in this part of Donegal. This direction coincides with the strike-normal trend and in many places is a well-developed joint trend, e.g. all the gaps cutting the Errigal-Muckish ridge take this alignment, and, importantly so, this is also the trend of the Tertiary dyke swarms which affect a large part of this area.

At a different scale, the major fault systems also trend north-east - south-west. As already stated, the Gweebarra Fault is an important structural feature in the area, being responsible for initiating a zone of weakness in the Main Donegal Granite and the location of Glen Veagh. This fault is just one of many left-handed strike-slip Caledonian shears, many of which display lateral displacements measured in kilometers.

The Caledonian Granites: North-west Donegal is famous internationally as an important area of granite emplacement studies. The plutons have also had a strong influence on the development of the landforms. The contact of the Main Donegal Granite with the Creeslough Formation at the head of the Poisoned Glen being a good example. The principal effect of the granites is that because they are lithologically more homogeneous, they produce more rounded landforms, but the different granites also produce characteristic topographies, e.g. the Older Granodiorite against the outer granite of the Rosses Ring Complex. Finally, the granites too have been affected by episodes of fracturing, and the emplacement of late-stage dykes has produced linear patterns in these plutonic bodies.

Quaternary Geology (*Marshall McCabe*)

Geographically north Donegal is sited in a marginal sector of the last composite ice-sheet which covered the British Isles. It therefore occupies a critical zone, adjacent to the continental shelf, where ice-sheet responses to marine effects and climatic oscillations/cycles should be recorded in the geological record. However, in recent times no detailed research has been undertaken on the glacial geology of the area. As a result, many of the current problems surrounding ice-sheet activity, glacial cycles, land/ocean interactions, deglacial mechanisms, offshore/onshore correlations, and the timing of glacial events cannot be fully answered.

There seems little doubt from the patterns of surficial moulding and directional lineations created by moving ice, that the entire area of north-west Donegal was covered by the last or Late Midlandian ice masses (Fig. 3). Most of the leading topographic features of the area, or at least their visual image, can be attributed directly to the erosive effects of ice acting on the structural grain of the country, which must also have been exploited by an amalgam of preglacial weathering and erosive episodes. Charlesworth (1924) has captured the essential glacial character of the region which has all the erosive attributes of a mid-latitude glaciated western highland margin:

> "The severe glaciation to which the north-west of Ireland has been subject has produced by erosion and deposition profound modifications in the topography and physical relief. Over the greater part of the area the ice drowning the hills from top to bottom was powerful and capable of free outward movement. The mountain tops and ridge summits are characterised by beautifully-rounded outlines, e.g., the Barnesmore and Derryveagh mountains; crags and projecting bosses have had their asperities removed, while the flanks and summits have been dressed and rounded. By ice-moulding the valleys of the upland

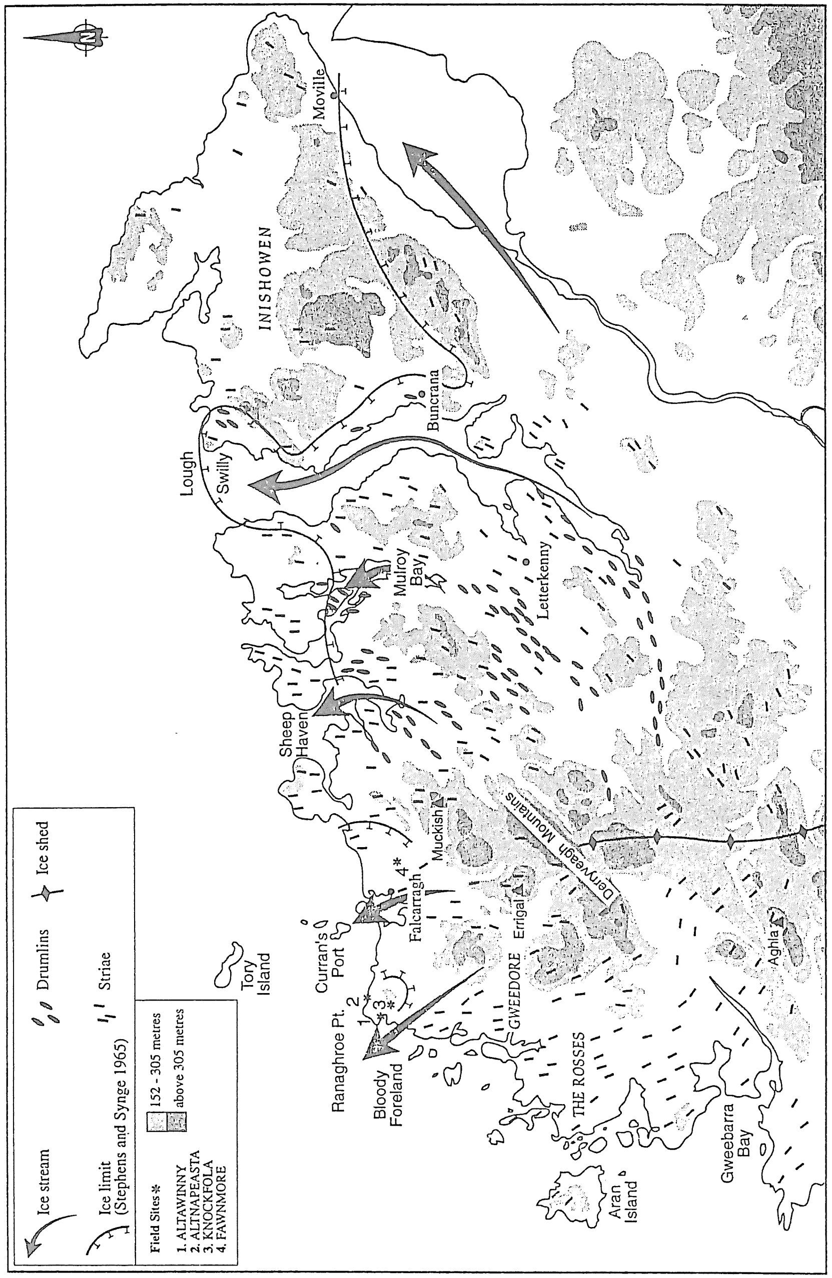

Figure 3. Glacial features of north Donegal and location of field sites (1-4).

region have been simplified, widened and deepened, their profiles reduced or modified, and the ends of their projecting spurs destroyed by lateral erosion with the evolution of straightened and steep-sided valleys. These are prevalently trough-shaped, especially in the granite and mountainous region, or wide and open in the country composed of schist."

Glacial stratigraphy: Many early workers including Officers of the Geological Survey (1908), Dwerryhouse (1923), and Charlesworth (1924) have identified drifts containing a range of Cretaceous and basalt erratics across Inishowen and north Co. Londonderry. Traditionally, this evidence has been used to identify either a readvance of Scottish ice onto the north coast of Ireland or a major expansion of ice during the penultimate cold stage (Munsterian?). Recent work by the author on the north coast suggests that the phase relationships between Scottish and Irish ice masses are more complex. The shelly diamicts identified by former workers provide a range of ages from early to late in the Midlandian and were deposited in a variety of glacial depositional settings. Deposits of this type have not been identified west of Lough Swilly and therefore will not be evaluated here.

On morphological evidence most of the patchy tills in north-west Donegal are associated with deposition during the last glacial cycle. Thick till deposits are mainly confined to drumlin bedforms which are concentrated along the structural lineaments leading from the Sheep Haven, Mulroy, and Swilly inlets into the mountains (Fig. 3). Other till bodies are either thin or discontinuous and confined largely to valley axes and lower hill slopes. A major exception to this general pattern of drift distribution is the extensive bank of diamict exposed along the coast of Bloody Foreland between Altawinny Bay and Curran's Port (Fig. 3).

Late Midlandian ice flow: The general ice flow patterns shown in Figure 3 have been reconstructed from striae observations (Charlesworth, 1924), drumlin long axes and erratic carriage. The range of field evidence demonstrates that ice dispersal northwards occurred from an ice axis extending between Lough Barra and Lough Derg (Charlesworth, 1924). Directional indicators show that ice moved east from this dispersal zone then north-east in a gentle sweep along Inishowen, Lough Swilly, Mulroy Bay, and Sheep Haven (Fig. 3). During the glacial maximum, ice moved north-east and north across the structural grain of the Owencarrow and Owenwee troughs. It is stressed that during the initial and final glacial phases topography would have provided a much stronger control on ice-sheet and ice marginal configurations in the form of valley glaciers, ice streams, and ice-sheet lobes (see deglacial section). Many of the ice-breached cols of the Errigal-Muckish ridge and Derryveagh Mountains were undoubtedly used or partially breached by northward moving ice. Charlesworth (1924) identified at least three zones of erratic carriage which support the ice flows outlined above:

1. North and north-east carriage of Barnesmore granite.

2. Northward carriage of metasediments onto granite bedrock around Drumfin.

3. Northward and north-west carriage of granite onto quartzite along the Errigal-Muckish ridge.

West of the postulated ice divide, ice fanned northwards and north-west across Aghla Mountain and Slieve Snaght, across the coast and onto the continental shelf. Ice flow indicators show a consistent pattern across the Rosses and Gweedore into the eastern Atlantic which acted as a major ice sink for these ice streams. Similar patterns of offshore ice flow occur in all the bays of western Ireland. It is argued on directional evidence alone that the Late Midlandian ice-sheet limit lay well beyond the present coastline. Little offshore evidence has been published on these limits though Peacock *et al.* (1992) have shown that ice from western Scotland reached St. Kilda and morainal banks are known 30km west of Achill Island.

In many general accounts, the Late Midlandian ice limit is shown by a line stretching west from Moville (Inishowen) to Bloody Foreland. This ice limit was proposed by Stephens & Synge (1965). The basis of the limit centred on five concepts:

1. That the Moville - Bloody Foreland line marked the limit of fresh drift features.

2. That drumlin forms occurred only within (i.e. south of) this morainic limit.

3. That drifts outside (i.e. north of) this limit were disturbed by cryoturbation features and did not exhibit fresh morphological forms.

4. That outwash associated with the push moraines (e.g. Moville) was also associated with high relative sea level (HRSL) and high (*c.* 26m OD) raised, late glacial strandlines.

5. That the moraines and outwash at Glencrow (Moville) are contemporaneous with red marine clay and HRSL.

Here it is argued that the discontinuous glacial efflux sequences mapped by Stephens & Synge (1965) do not represent the limit of Late Midlandian ice but are more representative of a retreat stage as ice withdrew from the continental shelf. This

hypothesis is supported by several lines of field evidence and arguments:

1. There is abundant offshore evidence that Late Midlandian ice extended onto the continental shelf (Peacock *et al.*, 1992).

2. The pattern of ice directional indicators inside and outside of the proposed ice limits demonstrate a fairly strong ice flow directly onto the shelf.

3. It is unlikely that the Late Midlandian maximum was associated with HRSL. At this time eustatic sea levels were considerably lowered.

4. HRSLs are more likely associated with the ice decay cycle when isostatic compensation was at a maximum (e.g. Boulton, 1990). This pattern of events is well documented from other sectors of the ice sheet around Ireland (Stephens, 1963; Synge, 1977) and south-west Scotland (Walker *et al.*, 1992).

Deglacial cycle: Evidence for the pattern and nature of ice decay is fragmentary and is confined to cross-valley moraines, isolated morainic ridges, and point efflux deposits. In general these features show that topography strongly influenced the configuration of ice streams as they withdrew from the Atlantic seaboard and retreated into the structural grain of the mountains. During this phase, the ice had thinned or downwasted and individual frontal morainic accumulations probably reflect equilibrium situations, re-equilibration points, and short-lived efflux deposits. Several features are recognised and probably represent short-lived halts in ice retreat. Overall, their patchy distribution suggests that ice retreat was rapid and may have been a reflection of intense ice loss onto the continental shelf, possibly following marine downdraw (e.g. McCabe *et al.*, 1984). The evidence of HRSL at a time when the main structural depressions were occupied by thick ice streams tends to support this viewpoint. Field evidence includes:

1. Ice-pushed efflux deposits occur at Glencrow (Moville), Dunaff Bay, Buncrana, Mulroy House, and Fawnmore (Falcarragh). These gravelly sequences record subaqueous outwash from ice tongues retreating to the south (i.e. they have been linked or correlated to define a major ice limit across the north Donegal inlets).

2. The line of boulders and gravelly debris around the western flanks of Bloody Foreland probably represents ice marginal deposition as ice downwasted around the headland. This line of gravelly mounds may be traced east along the southern flank of Bloody Foreland to Ferry's Lough.

3. Recessional cross-valley moraines were recorded by Charlesworth (1924) two miles west of Muckish Gap. Further upvalley, retreat is marked by morainic mounds

within the Gap itself.

4. Charlesworth (1924) also noted that retreat phases of the Sheep Haven glacier occur immediately below Glenveagh Bridge and at the entrance to Ashelleen Burn.

5. There is little field evidence for phased ice retreat across Gweedore and the Rosses. Retreat phases are marked, however, near the mouth of the Gweedore valley and between Lough Nacung Upper and Dunlewy Lough (The Cung) in the form of cross-valley moraines.

Most of these cross-valley features and outwash fans are small relative to the size of the glaciers which occupied the valleys. It is therefore concluded that they represent temporary halts of the ice margin after most of the Donegal ice had wasted away. A possible mechanism for rapid environmental change of this type, other than climatic forcing, is marine downdraw of the ice cap and catastrophic ice wastage. The paucity of retreat phenomena along the fringe of north-west Donegal can hardly be explained either by the small size of the ice cap or climatic forcing. The latter cannot be invoked alone as a causative mechanism because periglacial evidence suggests that the regional climate was still extremely cold in the Lateglacial period which would have slowed down ablation rates.

Coastal Evolution *(Peter Wilson)*

Our knowledge of coastal evolution in north Donegal is limited to the period since the decay of the last (Midlandian) ice-sheet *c.* 15 ka BP. High level raised beaches, up to *c.* +25m OD, were reported in the latter years of the last century but it was Stephens & Synge (1965) who provided the first detailed description of these features, related them to Midlandian drift limits, and constructed a shoreline diagram demonstrating that the beaches are at progressively lower altitudes as one proceeds west. No Lateglacial beaches were mapped west of Dunfanaghy. The interbedding of outwash and red clay, of probable marine origin, and geomorphological evidence were taken to indicate contemporaneity of these beaches with a Late Midlandian ice limit (*cf.* McCabe, this volume). The best of these high level beaches occur around Malin Head and are outside the area covered by this guide. However, the beaches indicate north Donegal has been influenced by substantial isostatic recovery.

From this Lateglacial high stand, sea level fell rapidly so that by 12 ka BP the shoreline must have been some distance seaward of the present coast. Carter (1982) suggested a sea-level minimum of -30m OD along the north coast of Northern Ireland. More recently Peacock *et al.* (1992) have indicated water depths on the

shelf off western Scotland may have been 90-100m below present during the Late Pleistocene and Early Holocene. Whatever the minimum sea-level position, much of the Malin Shelf was either exposed or covered with much shallower water at that time.

This low-stand sea level lasted until about 8.5 ka BP when sea level began to rise rapidly due to the declining degree of isostatic adjustment and a eustatic increase of ocean volume. Shaw (1985) and Shaw & Carter (1994) have discussed the evidence for Holocene sea-level changes from peats and organic-rich sediments at several coastal location in north-west Donegal. Their data suggests that relative sea level had attained levels close to that of today by the mid-Holocene but never exceeded present datum, in contrast to the evidence from the north coast of Northern Ireland (Fig. 4).

One consequence of the transgression was the transfer of coarse clastic debris from the shelf towards the coast as the glacial debris was eroded and sorted. The accumulation of coarse material at the shoreline provided anchor points for other deposits, notably sand beaches and dunes. Carter & Wilson (1993) have discussed the origins of coastal dunes in north-west Ireland and, on the basis of radiocarbon dating evidence, have argued that the dunes did not begin to form until after the peak of the transgression.

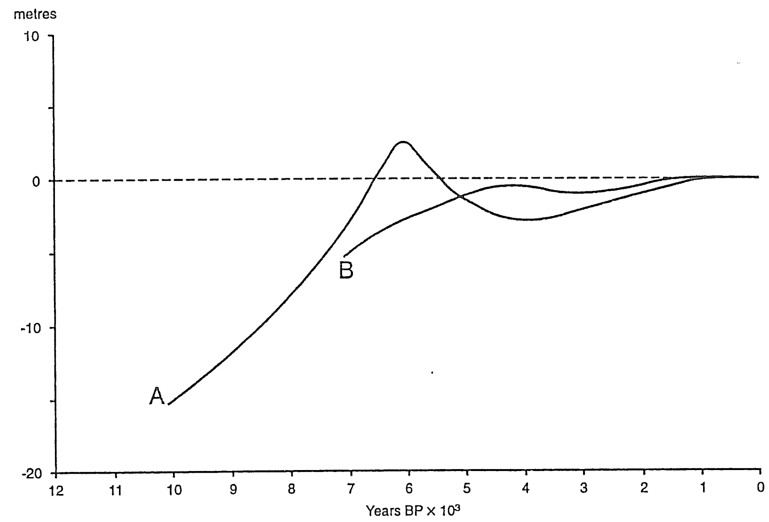

Figure 4. Sea-level curves for: (A) the north coast of Northern Ireland, after Carter (1982), and (B) north-west Donegal, after Shaw (1985).

Archaeology (*Eamon Cody*)

An archaeological survey of county Donegal carried out in 1980-1 (Lacy, 1983) identified some 2,500 monuments dating from the Mesolithic to about 1700 AD. These, arranged in rough chronological order and described in almost 2,000 entries, include those monuments, almost one-fifth of the total, that have been levelled or destroyed since the county was first mapped at a scale of six-inches to one-mile by the Ordnance Survey in the 1830s.

Mesolithic (*c.* 7,000 BC - *c.* 4,000 BC): The hunter-gatherer phase of Irish prehistory left no monumental remains and traces of the period depend for their recognition on distinctive stone tools which may come to light by chance or as a result of intensive fieldwork in those locations, usually coastal, lake-side or riverine, favoured for settlement. In Donegal, a flint-working site on a raised beach at Dunaff Bay on the Inishowen peninsula (C 310 460) dates to the later Mesolithic (Addyman and Vernon, 1966) as do stray finds of distinctive "Bann-flakes" at five locations, one on Horn Head and the others in the general Raphoe area of east Donegal.

Neolithic (*c.* 4,000 BC - *c.* 2,200 BC): The long lived hunter-gatherer phase of Irish prehistory came to an end sometime around 4,000 BC when the practice of farming reached Ireland from abroad. Thus ensued the clearance of the forested countryside and its sub-division into fields. This period saw the first appearance of pottery and the development of regional styles helps chart the archaeological record. The enduring monumental legacy of Ireland's early farmers, as of their counterparts along Europe's Atlantic coastline, are the large communal megalithic tombs that still survive today. There are some 140 such monuments, almost 10% of the country's total, in Donegal. These, along with numerous stray finds of diagnostic stone implements (e.g. Ó Ríordáin, 1935; Flanagan, 1966, 1968), represent the Neolithic period in the county today.

The four main classes of megalithic tombs known in Ireland are represented in the county. There are 46 court-tombs, about half that number each of portal-tombs and wedge-tombs, a small number of passage-tombs and a considerable number of ruined tombs. Court-tomb galleries in the county usually consist of two chambers, a feature of the type in western areas of the country, and as is the norm, the majority face approximately eastwards. The variant forms of court-tombs are represented by the central court-tombs at Ballymunterhiggin (G 878 592) and Farranmacbride (G 535 854), the dual court-tomb at Roosky Upper (H 207 975) and the twin-galleried example at Malin More (G 519 826). Portal-tombs, like the court-tombs, also favour an eastern orientation. In Donegal the distribution of

these two types is remarkably similar. Passage-tombs are represented by the cemetery at Kilmonaster Middle (H 273 976) in east Donegal though only one tomb there now survives in recognisable form (Ó Nualláin, 1968) and by a few examples near Bundoran.

Though many more dates are required to establish anything like a satisfactory chronology for Irish megalithic tombs, it is clear that court-tombs and passage-tombs were already under construction in the fourth millennium BC and, though reliable dating evidence is scant, so also it would seem were portal-tombs. Wedge-tombs are a later development than the other types and do not seem to have been built until about 2,500 BC, continuing in use into the early Bronze Age. The Donegal examples maintain the western orientation of the type, all facing approximately west or south-west.

The megalithic tombs in Donegal are absent from the extensive tracts of mountain land in the county. Outside the mountainous areas the earlier types, the court-, portal- and passage-tombs, in aggregate, display a widespread distribution of varying intensity and reflect extensive human settlement in the region either side of *c.* 3,000 BC. This widespread occurrence of tombs does not extend to the low-lying coastal area, largely coinciding with the Rosses and Gweedore, extending northwards from Dungloe to Bloody Foreland where no megalithic tombs and indeed few other prehistoric or early medieval monuments are known, excepting only coastal midden sites of largely indeterminate date. This area more or less coincides with the main Donegal granite and where not under peat consists of a bare rocky landscape dotted with boulders.

Activity in the county in the later Neolithic, as indicated by the distribution of wedge-tombs, is more restricted geographically than during the earlier part of the era and shows a preference for more upland locations. Some two-thirds of wedge-tombs in the county are found either side of Lough Swilly, to the east on the Inishowen peninsula and to the west as far as Kilmacrenan, all on higher ground than the court- and portal-tombs in the area. The remainder, save one in the middle of the county near Ballybofey, are found on two low-lying coastal strips, one to the south of and the other to the west of Donegal Bay, in both of which areas other tomb types are relatively numerous.

Traces of ancient field walls noted at or close to a handful of megalithic tombs are undated but could perhaps be the remains of the man-made landscape of the tomb-builders. More extensive remains of ancient field systems, probably of prehistoric origin, have been exposed by peat-cutting at Kindroghed (C 556 469) on the Inishowen peninsula and in Knockfola townland (B 812 336) at Bloody Foreland.

Bronze Age (*c.* 2,200 BC - *c.* 500 BC): The new technology of metal-working became widespread in Ireland in the centuries prior to 2,000 BC and this convenient technological division of prehistory between the periods of stone and metal broadly coincides with the appearance of new monument types. Again as in the Neolithic period, it is the funerary and/or ritual aspects of the society that are primarily evidenced in the surviving monuments of the period.

Communal burial in megalithic tombs now gave way to the tradition of single burial in cists or simply in pits. The remains, burnt and unburnt, were accompanied by or placed in varying styles of funerary pottery vessels. Burials in this tradition, sometimes grouped in small cemeteries, remained in vogue until *c.* 1,200 BC. They were sometimes inserted in the chambers and particularly the cairns of the earlier megalithic tombs. Such occurrences lend themselves to considerable socio-cultural speculation. There are some 30 or more early Bronze Age graves known in county Donegal (Waddell, 1990). It is noticeable that the majority of these share the broad Lough Swilly centred distribution of two-thirds of the wedge-tombs. There is also a small concentration of early Bronze Age graves in the south of the county near Ballyshannon where megalithic tombs of all classes are known.

Though the practice of building large megalithic tombs had come to an end large stones continued to be used to construct less elaborate ritual monuments such as stone circles. The most impressive in Donegal is the large but atypical Beltany stone circle on a hill in Tops townland (C 255 005) near Raphoe. Here a ring of large contiguously-placed slabs encloses a low cairn. More typical of the type are relatively small gapped rings of stone as found at Carrowreagh (C 494 406) and Glackadrumman (C 544 475) while the stone circle complex at Cashelenny (H 171 748), revealed by turf-cutting, is the westernmost of the distinctive mid-Ulster group of circles. To be included in the same building tradition as stone circles are stone alignments of which there are perhaps five examples in the county. It is also likely that many of the standing stones in the county date to this period. As of *c.* 1980 some 140 standing stones survived in county Donegal and the evidence of Ordnance Survey maps is that a like number have been demolished since about 1840.

A series of cup-marks is carved on one face of one of the large stones forming the Beltany stone circle. The same motif, and embellished versions of it, sometimes accompanied by a variety of other motifs are found on a number of standing stones in Donegal and also on rock outcrops. This style of decoration is known as "rock art". There are extensive and splendid displays of the style on exposed sheets of rock in Magheranaul townland, Doagh Isle, at the northern end of the Inishowen peninsula (Van Hoek, 1987).

The distribution of the numerous standing stones is heavily weighted to the good agricultural lands of east Donegal. They were especially concentrated, perhaps significantly, in the Raphoe area in the general vicinity of the Beltany stone circle. The distribution extends northwards from there to the inner reaches of Lough Swilly and beyond to Inishowen on one side of the Lough and Fanad on the other side. Likewise, the small numbers of stone circles, stone alignments and instances of rock art are in the main scattered over this wide area.

Iron Age (*c.* 500 BC - *c.* 500 AD): This period, characterised by the use of iron for making tools and weapons is distinguished by the appearance of new artifact types, notable examples being the rotary quern, distinctive horse-bits and also a new art style, the La Téne, which has its origin in mainland Europe. Hillforts, long considered Iron Age sites, are increasingly seen to have their origin in the later Bronze Age, though continuing as functioning tribal or regional centres into the Iron Age. Four examples are identified in Donegal, the multi-vallate example known as the "Grianán of Aileach" on the Inishowen peninsula (C 366 198), a univallate enclosure at Croaghan in east Donegal (H 299 975), and two close together south-west of Ballintra in south Donegal, one a small hill-top enclosure at Glasbolie (G 895 685) and the other a substantial D-shaped example at Lurgan (G 898 673). Linking the four hillforts is the presence in each of a mound or cairn, such as could be expected to cover a burial of the Neolithic or Bronze Age period, though that in the "Grianán" no longer survives.

Coastal promontory forts, narrow cliff-edged headlands defended on the landward side by a fosse and bank arrangement or by a stone wall, may be of Iron Age date though there are also indications that an early medieval date is also possible. The paucity of finds at the small number of excavated examples suggest they may have been places of temporary resort whether for security or otherwise. They share with hillforts a potential for defence but most of them, unlike hillforts, are quite small and could only have catered for small numbers of people. Of the 30 or so along the Donegal coast, the biggest and most impressive as to defensive capability is that at the east end of Tory Island (B 876 458) where a peninsula flanked by sheer cliffs is protected by four substantial banks and intervening fosses.

Mention may be made here of ring-barrows, a relatively close-knit group of a dozen or so of which are known in the Ballyshannon area. Some ring-barrows, on excavation, have been found to contain Iron Age burials, others Bronze Age, and some might be of Neolithic date.

Early Medieval period (*c.* 500 AD - *c.* 1200 AD): Increased agricultural activity is reflected in the palynological record for this period which witnessed the construction of thousands of ringforts all over the country. The introduction of Christianity led to the appearance of new monument types, cross-slabs, crosses, and churches. With the appearance of writing, largely the preserve of the monks of the new religion, the tales, lore and pseudo-history of the country came to be written down and enables us to begin to put names on the people and places of the time.

Some 650 ringforts, the most numerous monument type in the county, are known in Donegal. These monuments, round, sub-circular or oval in outline contained the dwelling houses and out-buildings of farm families. A distinction can be made on the basis of building material between those built solely of stone, known as cashels, of which there are some 200 and those built largely of earth, some 230 of which are known. Constructional details of the remainder are uncertain as they have been levelled during the years since about 1840.

In Donegal, less than 5% of ringforts are found above 150m OD with 70% occurring at 90m OD or lower. Outside the higher areas peat-grown land appears also to be largely avoided. The area of Rosses and Gweedore is all but devoid of ringforts as it is, as noted above, of prehistoric monuments. In marked contrast, ringforts are especially numerous on the limestone lands of south Donegal stretching northwards from Bundoran to Ballintra. There is a broad distinction between the distribution of earthen ringforts and cashels with the latter in the main confined to the shallow glacial tills of north and west Donegal and earthen forts predominating on the deeper soils of the east and south of the county.

The great majority of both types are of univallate construction. At only a handful of sites is there a second or outer enclosing wall or fosse. As well as the differing distributions of the two types, they also contrast in size. Some 80% of earthen forts range from 15m to 35m in mean internal diameter with 30% between 25m and 30m. Just over 75% of cashels range from 10m to 25m in mean internal diameter with fully 35% between 15m and 20m. Perhaps the smaller sizes of cashels might be a reflection of their occurrence on less favoured lands or might it be that the labour involved in quarrying and/or collecting stones was more onerous and time consuming than digging the fosse of an earthen fort.

Entrances to ringforts in Donegal, as elsewhere in Ireland, are more likely to be at the eastern side of the enclosure and by a factor of some two and a half to one on the basis of some 60 sites where information is available. This may be but the obvious response to the prevailing westerly winds of Ireland. Souterrains, underground chambers, have been identified in some ringforts although a good number of the type occur in isolation, the enduring remnant of a ringfort or perhaps of a simple unenclosed house site.

Analogous to the ringfort is the crannóg, artificial islands built in lakes, where security seems to have been a significantly greater priority than in ringforts. Such examples as are known in Donegal were built by dumping a great heap of stones on a lake bed to form a platform.

The ringforts, in their scattered distribution, reflect the rural character of Irish society and this trait is also seen in the religious monuments of the period. The monastic settlements of the Christian religion stood in enclosures of earth or stone similar to the ringforts of secular society. Many of these sites remained in ecclesiastical use for centuries during which early churches were replaced by later ones in the medieval and early modern eras. Others survived in use as burial grounds long after the church fell into disuse. In all, just over 100 such sites in Donegal would appear to belong to this early period of Christianity. The most oft-occurring feature at such sites, and frequently the only reasonably reliable indication of its early date, is the presence of a cross-slab. These survive in considerable numbers in the county with important examples in Carndonagh (C 466 450) and Fahan (C 345 261) on the Inishowen peninsula, at Conwal (C 139 105) near Letterkenny, in south-west Donegal at Inishkeel Island (B 706 001) and especially in the Glencolumbkille area where they are known in considerable numbers. This area thus preserves a rich legacy of the ritual monuments of two distant eras, the Neolithic with its megalithic tombs and the ecclesiastical remains of the early Christian period. Notable also from this period are the decorated high crosses of north Inishowen at Clonca (C 526 470), Carndonagh and Carrowmore (C 516 456) and the strikingly tall undecorated example in Ray churchyard near Falcarragh. A feature of the early Irish church was the adoption by some of the ascetic ideal leading to monastic settlement in difficult locations. Perhaps the most striking manifestation of this was the establishment of a monastery atop Slieve League in south-west Donegal at about 500m OD. The island monasteries of Rathlin O'Birne and Tory Island seem to have been a response to the same motivation. Of particular note at the latter site is the round tower, the sole surviving example in Donegal, and the T-shaped or tau-cross carved from a single block of stone.

Medieval period (*c.* 1200 AD - *c.* 1600 AD): Influences reaching Ireland during the 12th century AD were reflected in changes in church organisation which saw the adoption of the universal diocesan model and the introduction of new architectural styles in church building. The enduring influence of the Normans on all aspects of Irish life and society is reflected in the landscape by the widespread castle building they initiated. These architectural innovations in the fields of both ecclesiastical and military architecture made a relatively modest impact on Donegal. In the ecclesiastical realm the new romanesque style of 12th century Ireland is represented only by a few fragments of stonework at Conwal (C 139 105) and by a window head in the same style incorporated in the early 17th century church at Ramelton (C 235 209). The fortunate survival of these fragments only illustrates what may have been lost to us. Of the great continental monastic orders that established houses in Ireland only the Cistercians are known in Donegal where one house, Assaroe Abbey (G 868 622), was founded in 1178 and possibly a second some years later at Kilmonaster Lower (H 274 991). There are no identifiable remains at the latter site. A Norman military presence in the county is represented singly and dramatically by Greencastle (C 653 403) on the west shore of Lough Foyle. This was built by the "Red" Earl of Ulster, Richard de Burgo, in 1305. It was the principal Norman centre in north-west Ulster and compares with the great Edwardian castle of Caernarvon in Wales. With the collapse of the de Burgo influence in Ireland and the contraction of the Norman colony there was little or no castle building in the county until the 15th and 16th centuries when the ruling Gaelic families, the O'Dohertys, O'Donnells and MacSweeneys, began to build for themselves the typical tower-houses of the period, some dozen or so of which survive. These, for the most part, are centred on two strategic coastal locations, in the north-east around the shores of Loughs Foyle and Swilly and in the south of the county around Donegal Bay. It is these same families whose patronage ensured the noteworthy success of the Franciscan friars, especially those of the Third Order Regular. Some eight friaries were built in the late 15th and 16th centuries in the same two areas, around Lough Swilly and Donegal Bay, as the tower-houses of their patrons.

Following the upheavals of the early 17th century, which saw the flight of the Earls and the plantation of Ulster, land, castles and churches changed hands. Some earlier castles were refurbished and extended. For example, Sir Basil Brooke added a manor house to the O'Donnell tower-house in Donegal town and Bishop Knox converted the Carmelite friary at Rathmullan into a residence. Other grantees, under the terms of their land allocation, built substantial houses within fortified walled enclosures of which Faugher House (C 053 362) near Dunfanaghy is the best preserved example. Similarly, the churches of the old religion were suppressed and fell into lay hands or were re-modelled and new churches built to cater for the needs of the Protestant faiths.

Archaeology of Coastal Dunes (*Joanna Nolan*)

Maritime resources have always formed an important part of the subsistence base in Ireland, and Donegals' long coastline provides rich archaeological evidence for the importance of such resources during several periods of our history and prehistory. Large deposits of Neolithic material in the form of chipped stone tools are known from several coastal locations in the county, the preceding Mesolithic is as yet poorly represented. Bronze Age artifacts are quite common in coastal con-

texts. Several Bronze Age cist burials have been discovered in sand dunes and one rare Iron Age burial was found at Lough Swilly. Finds of Early Christian metalwork are also known from several sites in the county and small Medieval spun pins along with material to manufacture them have also been found.

Settlement at coastal locations would not have been permanent and was rarely extensive, instead these areas were probably visited periodically. During the Mesolithic, coastal resources provided an important part of the seasonally available food supply and short term camps would have been set up when they visited these areas. Although farming replaced hunting and gathering during the Neolithic period, finds of artifacts from this and later periods show that coastal resources continued to play a part in these later economies. These people probably only made short term stays when they visited coastal areas, which would not generate extensive or obvious archaeological sites. Instead, their presence at these locations is mainly attested to by chance finds of artifacts.

The shifting patterns of sand dunes reveal traces of these visits but often whatever contexts originally existed for such artifacts is destroyed during these denuding episodes. Favourable extraction locations would have seen repeated use through time and the varied pattern of sand dune formation and denudation tends to create chronologically mixed groups of archaeological artifacts from such sites. Archaeological deposits in sand dunes can rarely be considered as closed contexts and they provide only limited evidence for the processes which created them.

The way archaeological material has been recovered from coastal contexts has often contributed to the confusion that surrounds these sites. Many coastal areas in Donegal were visited by the Northern collectors during the latter part of the last century and the early part of the present century. While these hobbyist antiquarians gathered much of the evidence we have from these sites, they were mainly concerned with artifact recovery. They gave very sketchy information on the provenances and types of locations from which such material was recovered (*cf.* Knowles 1891, on the 50 hut sites at Horn Head). They also concentrated on recognisable artifacts, so the samples they generated must be regarded as biased.

Although we know of rich deposits of archaeological material from sand dunes right around the Donegal coast, their usefulness in fleshing out the archaeological record is very limited.

Vegetation History (*Julie Fossitt*)

Much of the present land surface of north-west Donegal is dominated by blanket peat and heathland. Trees are rare but small pockets of deciduous woodland (mainly oak and birch) can be found in scattered locations. Historical records indicate that Donegal was more extensively wooded in the past; the distribution and demise of these woodlands is outlined in McCracken (1958).

Subfossil wood remains confirm that, at some time during the Holocene, trees were considerably more widespread in Donegal than they are today. Pine stumps are a common feature in peat deposits throughout the county, including the north-west (Fig. 5a). Radiocarbon age determinations for samples of subfossil wood suggest that these pine trees colonised the landscape between 4,600 and 3,800 years BP (Telford, 1977; Fossitt, in prep). Subfossil wood remains of birch, oak, hazel, alder and yew have also been reported from Donegal (Harte, 1867; Hull *et al.*, 1890, 1891a, 1891b; Jessen, 1949; Mitchell, 1951; Flanagan, 1977; Shaw, 1984).

The history of vegetation development can be traced from palynological records. Pollen diagrams have been produced from four sites in Donegal (Fig. 5b), three small lakes from the western lowlands (Fossitt, 1994), and an infilled lake basin from the Glenveagh area (Telford, 1977; see also Watts, 1977). All sites have complete Lateglacial and Holocene records.

Lateglacial vegetation changes: Plants started to colonise the newly deglaciated landscape at about 13,000 years BP. Vegetation development was a gradual progression from open, species-rich herbaceous communities with some *Salix* scrub, to widespread *Empetrum* heath and juniper scrub. As ground cover increased, soils stabilised and began to accumulate. Scattered areas of birch scrub may have developed in the most sheltered locations.

Renewed soil erosion and a break up of the vegetation cover indicate a reversion to colder climatic conditions during the Lateglacial stadial. *Empetrum* heath continued to dominate the vegetation in association with patches of herb-rich grassland.

Holocene woodland development and decline: All sites record a gradual transition from widespread juniper scrub to open birch woodland with *Salix* at the beginning of the Holocene (10,000-9,000 years BP). *Corylus avellana* expanded rapidly at about 9,000 years BP. Regional variation emerged as woodland diversity increased. *Ulmus*, *Quercus* and *Pinus sylvestris* invaded the western lowlands between 9,000 and 8,200 years BP. Pine stomata confirm local presence of pine populations at 8,600 years BP (Fossitt, 1994). Time lags of up to 1,000 years were experienced in the spread of these trees to upland and inland sites (Telford, 1977; Fossitt, 1994; see also Pilcher & Larmour, 1982); *Pinus sylvestris* did not invade the Glenveagh area until 7,500 years BP.

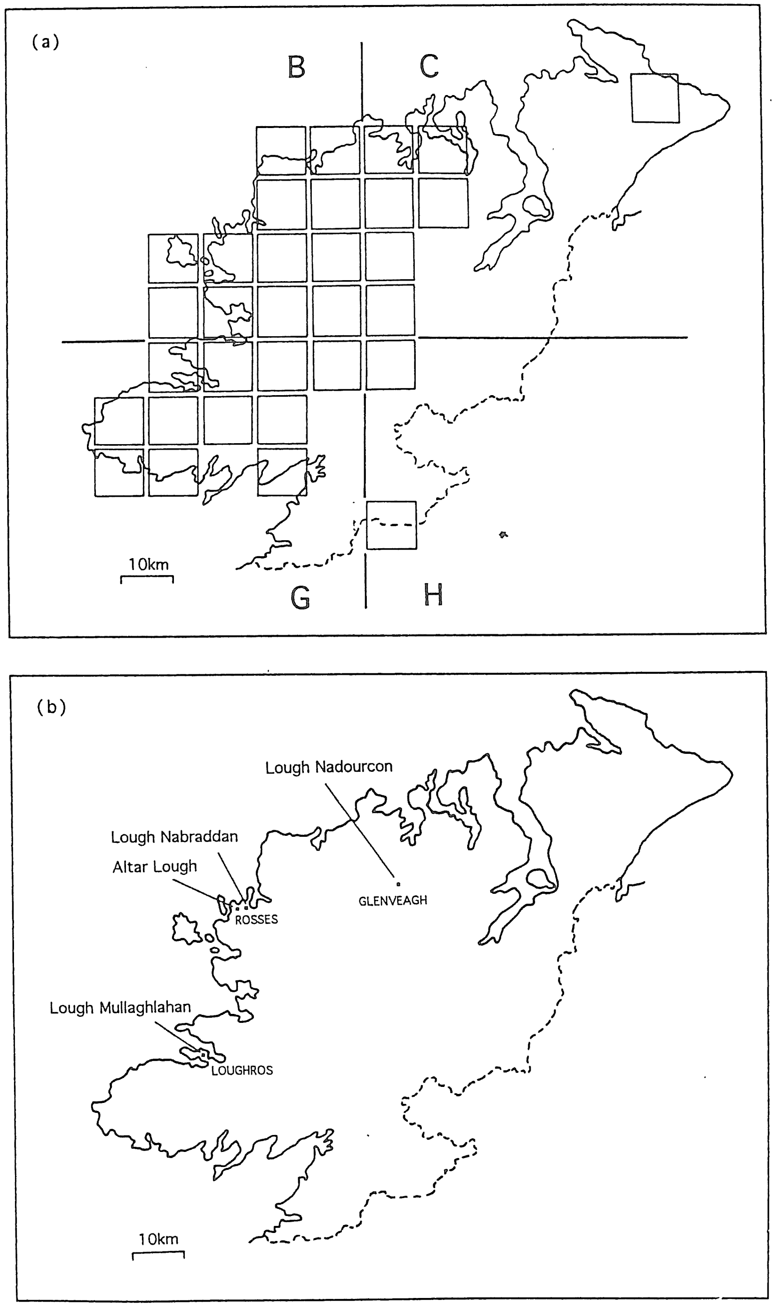

Figure 5. Donegal showing (a) the distribution of macrofossil remains of *Pinus sylvestris* in 10km squares of the National Grid (after Bennett, 1995), and (b) the location of palaeoecological sites.

Mixed woodland with *Betula, Corylus avellana, Ulmus, Quercus, Pinus sylvestris, Populus, Sorbus aucuparia* and *Salix* developed throughout north-west Donegal. *Alnus glutinosa* became established between 7,200 and 6,600 years BP; an interpolated date of 4,800 years BP for its arrival at Lough Nadourcon is anomalously young (see Bennett & Birks, 1990). *Pinus sylvestris* was more abundant in upland areas, including Glenveagh, than in the coastal lowlands. Canopy cover was at a maximum in the early Holocene (9,000-8,000 years BP). As woodland diversified it became more open in the Rosses, Glenveagh and in other areas that were marginal for tree growth. Continuous woodland cover persisted only in the most fertile and sheltered locations in the north-west (Fossitt, 1994).

Unwooded lowland areas and mountains supported heathland and herb-rich grassland communities, with ferns and patches of birch and juniper scrub. Blanket peat developed as a natural process in marginal areas, including the lowlands, from as early as 9,000 years BP.

A phase of woodland disturbance or instability in the mid-Holocene included the elm decline (5,300-5,100 years BP), the expansion of *Pinus sylvestris* (5,000-4,500 years BP), the invasion of *Fraxinus* and *Taxus* (*c.* 5,000 years BP), and the onset of the final woodland decline in north-west Donegal. The main expansion of blanket peat began between 5,000 and 4,500 years BP, and continued gradually until the landscape was predominantly treeless at about 2,500 years BP. Woodland decline and blanket peat expansion have been attributed to persistent low levels of disturbance relating to human activity and domestic animals.

Pollaguill - Aeolian and Alluvial Sands (*Peter Wilson*)

Of the 155km^2 of coastal dunes in Ireland, approximately 43% (67km^2) occur in Co. Donegal. Although these dunes are a conspicuous element of the coastal zone, recent reviews have highlighted our limited knowledge of dune morphodynamics and age structure (Wilson, 1990a; Carter & Wilson, 1993). None of the Donegal dune systems have yet been studied in any great detail; this is surprising given the fundamental role of dunes in acting as a buffer against catastrophic coastal change and their anticipated vulnerability to predicted near-future changes in sea level and wind/wave climates.

Two substantial areas of aeolian sands (Pollaguill and Tramore-Anloge Hill) occur on the western side of the Horn Head peninsula (Figs. 1 & 6) and have been the subject of recent research designed to elucidate something of their evolution and age structure.

At Pollaguill, aeolian sand covers an area of *c.* 1km^2 (Fig. 6). The sand extends east and north from Pollaguill Strand and over the crest of Croaghadara (107m). Numerous blowouts and gullies dissect the sand and reveal buried soils that testify to sand accumulation in several phases. The oldest sand unit occurs as a broad belt around the flanks of Croaghadara and reaches a thickness of 4-5m. Buried podzolic soils, deep leaching of $CaCO_3$, and an absence of sedimentary structures characterise this sand unit. The podzolic soil horizons can be traced laterally over long distances and indicate that the sand unit takes the form of a sand sheet with low-amplitude ridges and depressions rather than true dunes. Radiocarbon dates from the base of the peaty topsoils of the buried podzols at sites 1 and 4 respectively indicate that the sand was deposited prior to 2,830$\pm$45 years BP (SRR-5074) and 3,320$\pm$40 years BP (SRR-5069) (Figs. 6 & 7). Dates from the top of the peaty horizons indicate soil burial occurred after 715$\pm$40 years BP (SRR-5073) at site 1 and after 1,420$\pm$40 years BP (SRR-5068) at site 4. The overlying sand is up to 2m in thickness, has a low $CaCO_3$ content and possesses weakly developed soils.

In more recent times these sand accumulations have been dissected by deep water-cut gullies and blowouts. At least two phases of gullying are evident from examination of gully wall stratigraphy at site 3 (Fig. 6). The first phase of gullying was relatively shallow and channels were infilled by sand containing quartzite and metadolerite clasts, and fragments of peat and iron pan. In the second phase, gullies were cut through the infilled channels and underlying sand to bedrock. Because of the inclusion of peat and iron pan fragments (presumably from the buried podzols upslope) within the channel fills, both phases of gullying are probably

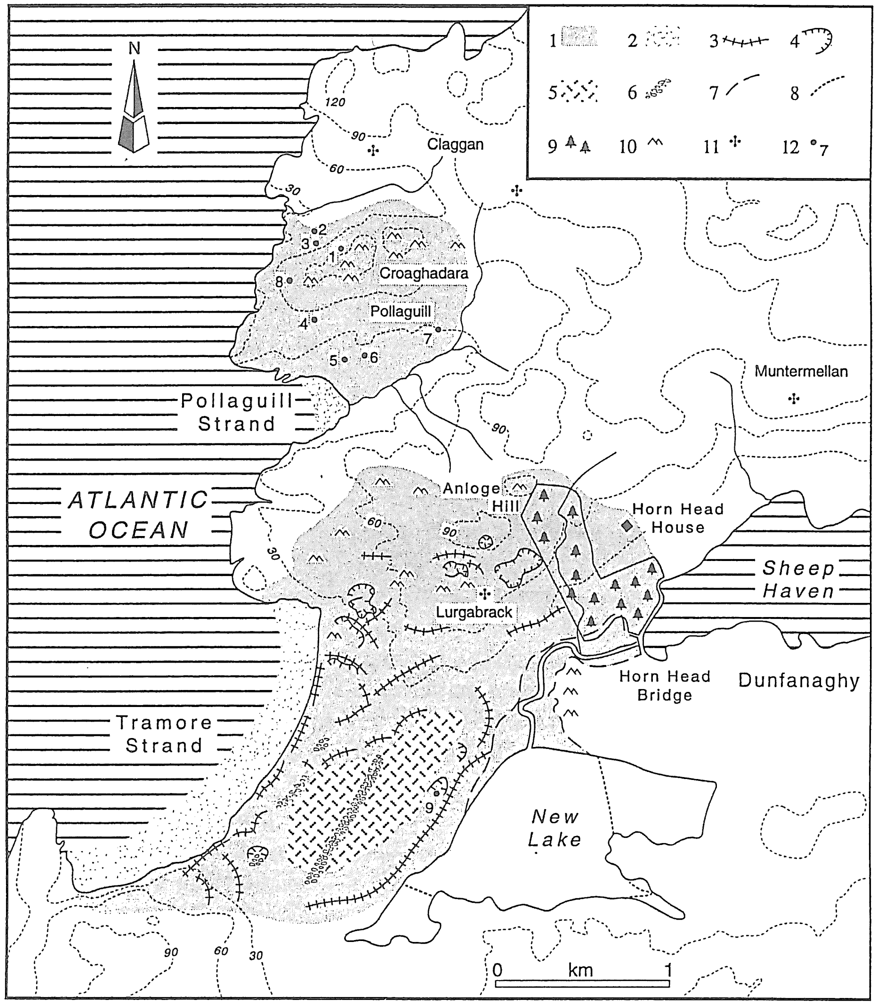

Figure 6. Aeolian sands and archaeological sites, Horn Head. 1, aeolian sand. 2, beach sand. 3, dune crests. 4, blowouts. 5, flooded deflation plain. 6, gravel ridge. 7, margins of estuary, pre-1920s. 8, embankments of reclaimed land, now submerged. 9, conifer forest. 10, bedrock. 11, archaeological monument. 12, sand exposures investigated.

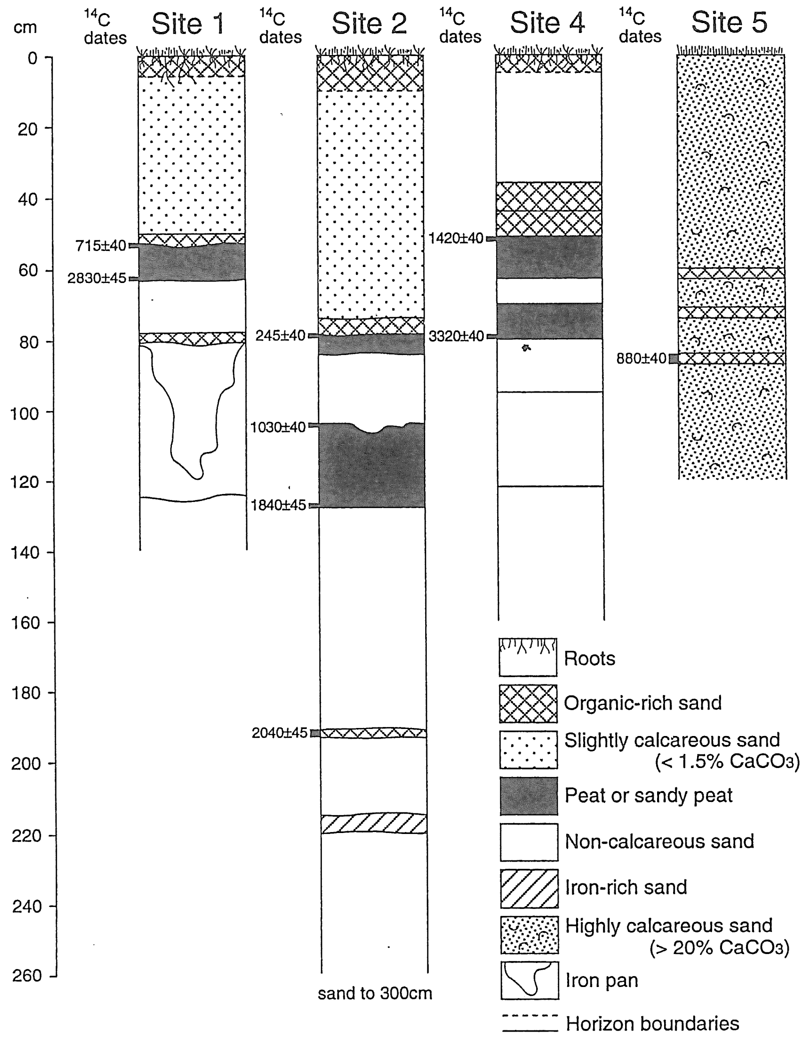

Figure 7. Stratigraphy and radiocarbon dates from sites at Pollaguill, Horn Head.

younger than 700 years BP.

At the northern foot of Croaghadara alluvial sands, derived from the gullies, are present. Sand stratigraphy and radiocarbon dates from site 2 (Figs. 6 & 7) reveal that peat accumulation was terminated by sand deposition after 1,030±40 years BP and again after 245±40 years BP (SRR-5070). Prior to these depositional events, some sand had accumulated at the site before 2,040±45 years BP (SRR-5072) and again between this date and 1,840±45 years BP (SRR-5071). Whether these earlier sands are aeolian or alluvial is not known.

The underlying causes of such intensive gullying are unclear and, in the context of coastal aeolian sands, the gullies are rather unusual features.

At the southern foot of Croaghadara, inland of Pollaguill Strand, a low-angle sand sheet extends along the valley axis. Shallow blowouts show that the sand is thin (<1.5m) and buried soils indicate that it accumulated in several phases. At site 5 (Figs. 6 & 7) a radiocarbon date of 880±40 years BP (SRR-5067a) was obtained from the oldest of three buried organic-rich horizons. At site 7, buried soils are less evident in the sections, but erosion of the sand is revealing the walls of a former field system. It is believed to be from this general area that Knowles (1891, 1901) described numerous 'hut-sites'. The high $CaCO_3$ content of this sand (20-45%) contrasts with that of the other sands on Croaghadara and lends support to a more recent age for sand deposition.

The Pollaguill sand deposits contain a valuable and important record of stability and instability phases in sand accumulation. Interestingly, this record of events stands in marked contrast to that available at Tramore-Anloge Hill (see below). Further work, geared towards the archaeological record, would probably assist in producing an even more detailed understanding of aeolian events and their products.

Claggan - Portal Tomb (*Eamon Cody*)

This portal-tomb is situated at the north-west end of the Horn Head peninsula some 400m from the coast (Fig. 6). It is a single-chambered structure now partly-ruined, and stands towards the broad eastern end of a long cairn of stones (Fig. 8). The cairn, its perimeter somewhat ill-defined and obscured by vegetation creep, is 33m long (E-W), narrows from about 13m wide near its E end to about half that at the W, and is 70cm or so high.

The chamber is represented by four orthostats. Two tall portal-stones at the E,

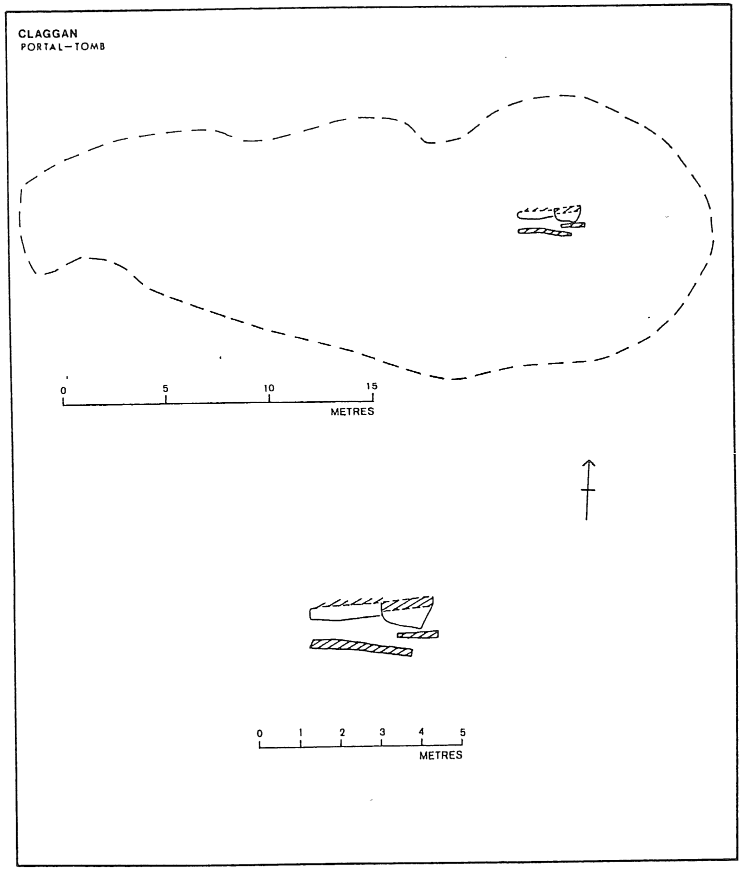

Figure 8. Plan of Claggan Portal Tomb.

60cm apart, identify the front of the tomb. A long sidestone adjoins each portal-stone. The southern sidestone overlaps and leans against the outer face of the adjoining portal-stone. There is no trace of the backstone of the chamber which would have stood transversely between or just beyond the ends of the sidestones. Another transversely-set stone may have stood between the portal-stones; sometimes the stone at this position is quite low-sized and, conceivably, could be concealed by cairn stones which occupy the chamber area. The chamber would have been roofed, probably by a single large slab. An original chamber length of 2.5m to 3m is indicated and it is about 1m wide.

Claggan - Court Tomb (*Eamon Cody*)

This court-tomb stands on a more-or-less level patch of ground on a hill-slope towards the north end of Horn Head peninsula (Fig. 6). It consists of the remains of a U-shaped court at the NNW leading to a ruined gallery, now 8.5m long, divided into two chambers (Fig. 9). It seems likely that the gallery was originally somewhat longer. A field-wall has been built along the western side of the structure. West of this wall and on the slightly downhill side of the site there is the low remains of a cairn some 20m in length. There is no trace of cairn remains to the E of the gallery though two set stones, positioned 2m beyond the E arm of the court and parallel to it, may be part of a stone kerb that would have delimited the cairn. A third stone alongside these two may not be *in situ*.

The court is 4.5m or so wide and was at least 5m long. Four stones of its eastern arm, averaging 1 m in height, are in place and a fifth lies fallen beyond these. Cairn remains hinder identification of the W arm of the court but one large stone close to the gallery entrance would appear to be a courtstone. Just beyond this is another likely example. The status of three other low stones here is uncertain.

Two transversely-set jambs, as is usual in court-tombs, mark the entrance to the gallery. These, each about 70cm high, stand 80cm apart, and lie on the perimeter of the court. A thin slab stands at the inner end of the western jamb. Just beyond the eastern jamb there is another stone set parallel to it which seems to be mirrored on the opposite side of the gallery by a stone protruding from the wall crossing the site. These stones represent a "doubling" of the entrance jambs, a feature of only occasional occurrence.

The first chamber of the gallery is some 3.2m long and 2.3m wide. A single orthostat survives on either side of the front half of this chamber, both about 1m high. A leaning slab at the inner end of the E side of this chamber is of uncertain status.

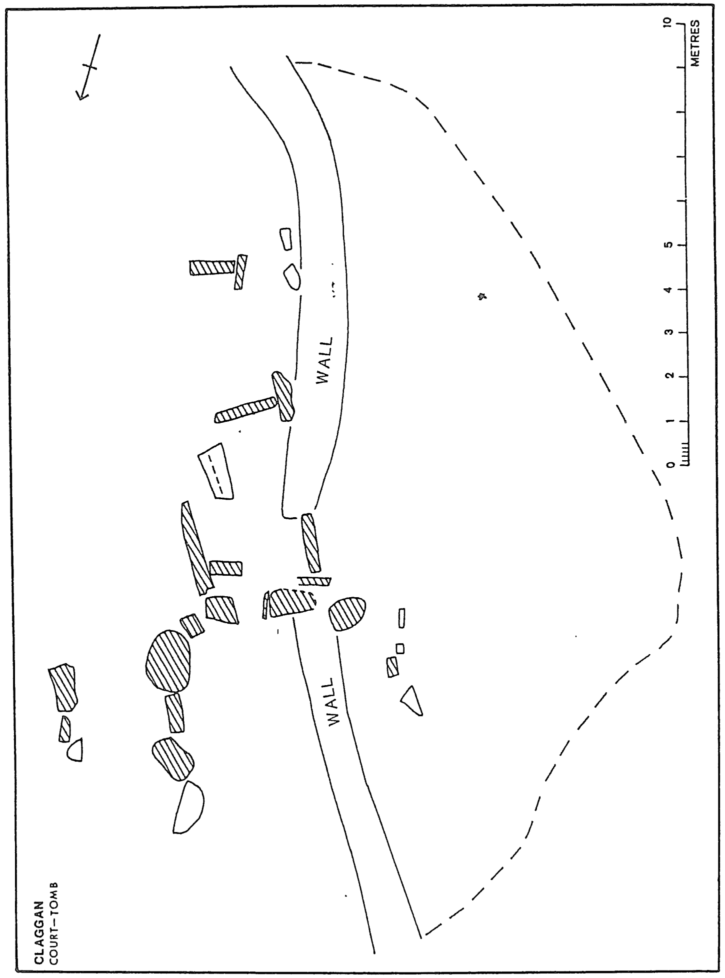

Figure 9. Plan of Claggan Court Tomb.

A sill-stone with a longitudinally-placed jamb at its W end marks the division between the first and second chambers. The jamb is about 1m high and the sill about half that height. The sides of the second chamber are missing but another jamb and sill arrangement similar to the last marks its southern end indicating a chamber length of about 3m. The jamb and sill arrangement at this point represent a further division of the gallery and so it does appear that originally there was at least one more chamber here, though no trace of it is apparent.

Muntermellan - Portal Tomb (*Eamon Cody*)

This monument, a portal-tomb, located towards the E side of Horn Head, stands at the foot of a rocky ridge (Fig. 6). It consists of a well-preserved chamber, 1.8m long and not more than 1m wide, built with thin slabs, standing towards the northern end of a quite substantial cairn of stones (Fig. 10). The cairn is 24m long (N-S), some 10m wide and 1m or so high.

A doorstone at the front or N end of the chamber is flanked by two tall portal-stones. The eastern portal-stone is 2.5m high and the other, which may have lost a piece from its top, is 2.3m high. These rise 1m or so above the top of the doorstone which blocks entry to the chamber. Single stones form the sides and back of the chamber and each is about the same height as the doorstone. As is usual in portal-tombs the long sidestones overlap and lean against the outer faces of the portal-stones. The backstone is inset between the ends of the sidestones. An horizontally-laid slab, the subsidiary roofstone, covers that part of the chamber behind the portal-stones. A gap between the base of this roofstone and the top of the eastern sidestone is blocked by a slab set outside of and rising above the sidestone. A corbel has slipped from the top of the western sidestone and, now split, lies against it. Forward of this a large displaced slab, some 3m long, rests against the front of the chamber. This is the main roofstone and would have overlain the entire structure with one end raised skywards on the tall portal-stones and its opposite end resting on the subsidiary roofstone.

Lurgabrack - Souterrain (*Peter Wilson*)

The souterrain is situated on the southern slopes of Anloge Hill overlooking the sand dunes that back Tramore Strand (Fig. 6). It was discovered in 1968 and is described in Lacy (1983) as consisting of a gently curving SW-NE passage at least 12m in length. It is 1m high, 1.09m wide and has walls constructed of stone and the roof of flags. Two trap points consisting of projecting jambs and lintels 6.1m apart were also recorded. The roof of the souterrain has collapsed at several points

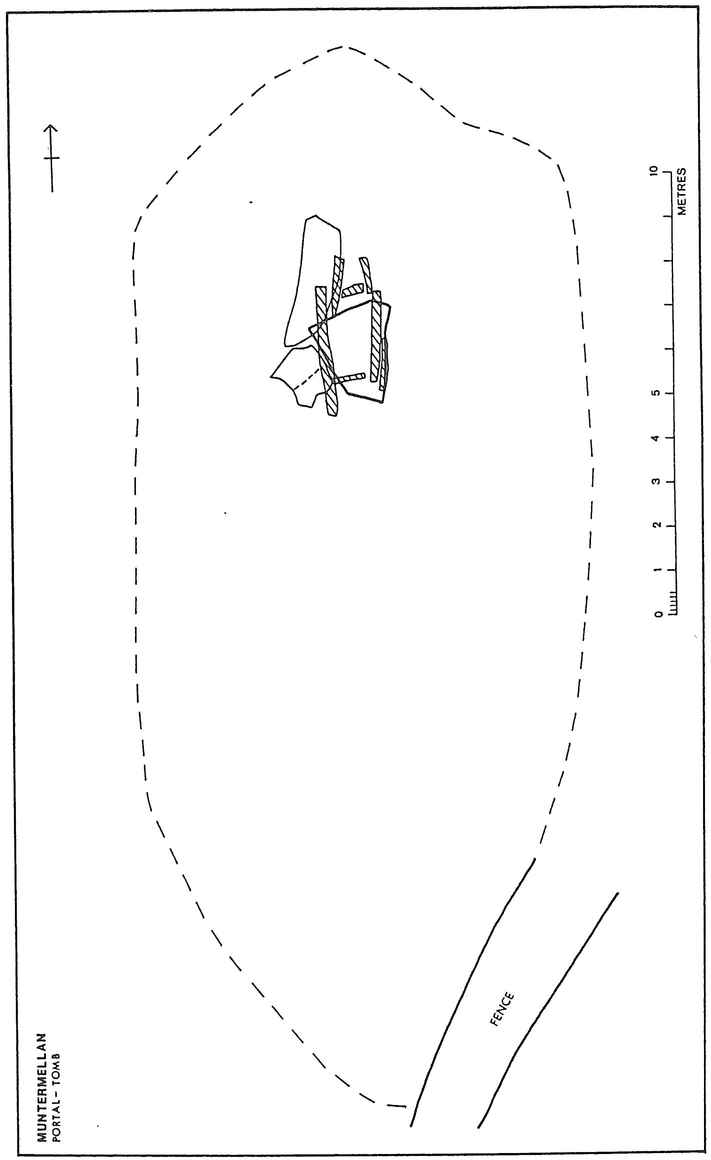

Figure 10. Plan of Muntermellan Portal Tomb.

and the whole structure must be regarded as in a dangerous condition. Entry is not advised.

Souterrains are usually explained as being for refuge and/or storage and are frequently associated with farmsteads (raths, ringforts, cashels) of the Early Medieval period (Mallory & McNeill, 1991). The position of Lurgabrack, in an area of extensive sand dunes that are currently of limited agricultural value, suggests that the dunes are probably younger than the construction of the souterrain. Within a short distance of the souterrain, where dune sand is either thin or absent, low walls can be seen passing beneath the dunes. Their age is not known but they may represent boundaries of enclosed areas laid out at the time of souterrain construction. If so, the massive dunes that cover Anloge Hill are relatively recent features and their movement across the hill may have been the cause for abandonment of the site.

Tramore-Anloge Hill - Aeolian Dunes *(Peter Wilson)*

Approximately 4km^2 of aeolian dunes extend east and north from Tramore Strand to the shores of New Lake and Sheep Haven, and over the crest of the east-west trending Anloge Hill (Fig. 6). Immediately inland of Tramore Strand the dunes rest on a framework of gravel ridges oriented sub-parallel to the present shoreline. The gravels may represent a tombolo linking the former island of Horn Head to the mainland (Shaw, 1985) and are exposed at several location within the dunes and across the floor of a large deflation plain that is frequently flooded.

Presently, these dunes are well-vegetated and stable, although sparsely vegetated blow-over plumes and rim dunes indicate that several blowouts remain active. Soil development is restricted to sand pararendzinas (A-C horizon sequences), the $CaCO_3$ content of the dunes is high throughout (20-40%), and large-scale sedimentary structures extend virtually to the surface of the dunes. These characteristics are taken as indicating that dune stabilisation by vegetation occurred relatively recently.

The age and evolution of this large dune field is not known in detail. No buried, organic-rich soil horizons by which to date the system have been found, even though several blowouts extend to the underlying gravels or bedrock and reveal the entire stratigraphy. However, at least two periods of large-scale transgressive dune activity have occurred.

First, in the walls of a blowout in the dunes alongside New Lake (site 9, Fig. 6), a distinctive pale brown sand horizon, containing numerous disarticulated valves

and fragments of *Cerastoderma (Cardium) edule* (Cockle), occurs beneath 6-10m of sand. This sand horizon has a sharp upper and diffuse lower boundary, possesses slightly more organic matter than the sand above and below, and has shells of land snails immediately beneath its upper boundary. It is interpreted as a former vegetated surface that existed before the large dune ridge developed. The cockles are thought to have been collected locally (most likely from the area now occupied by New Lake which was formerly an extension of Sheep Haven estuary) by earlier settlers, 'processed' at the site and the valves discarded. A radiocarbon date of 1,220±45 years BP was obtained on a sample of the *Cerastoderma* valves and provides a maximum age for emplacement of these dunes. The sand was probably derived from the deflation plain immediately west of the dunes.

Second, documentary evidence indicates that from 1700 until the early 20th century, the Stewart family managed the dunes largely as a rabbit warren and rigidly controlled the cutting of marram. On the death of the resident landlord, in 1917, the estate passed to his son who preferred to be an absentee landlord. As a result, the system of estate management broke down and dune instability prevailed. The story is well told by Brennan (1925) and Murphy (1980). Between 1918 and 1930, marram cutting became more common and the regular rabbit shoots ceased. As a consequence, the rabbit population rose and associated burrowing activities increased and, along with the removal of marram, sand drifting became a major problem. Agricultural land in the vicinity of Horn Head House was engulfed and sand blocked many of the arches of Horn Head Bridge, preventing tidal water from penetrating into the upper part of the estuary and creating the New Lake (Fig. 6). Sand stabilisation was eventually achieved during the 1930s and 1940s after the Land Commission took over the estate and embarked on a programme of marram planting. The final stage in sand fixation was begun in 1946 with the planting of conifers.

Despite the close geographical proximity and similar topographic settings of the two dune areas of Horn Head described above, the details presented reveal that they do not appear to share similar histories. At Tramore-Anloge Hill, all the available evidence points to relatively recent dune development, while at Pollaguill, aeolian sand deposition began prior to *c.* 3,300 years BP. and several depositional phases have occurred since that time. The application of luminescence dating techniques to the Tramore-Anloge Hill dunes would undoubtedly assist in establishing more detail of their age structure.

Ray - High Cross (*Eamon Cody*)

This high cross, remnant of an early monastic foundation, was erected on a concrete plinth some 15 years ago by the Office of Public Works. It now stands at the inner face of the N wall of a ruined parish church. The church, unroofed but with walls standing to full height, is built of rubble with ashlar quoins and is a 17th century re-building of an earlier church. The W doorway with stop-chamfered jambs and pointed head as well as some punch-dressed blocks incorporated elsewhere in the building may have come from the earlier church. On the interior face of the W gable there is the remains of the 1754 aedicule of the local landowning Olphert family, its inscribed tablet now missing.

The high cross had lain broken on the ground in the graveyard which surrounds the church since at least 1835 until its restoration and re-erection. Carved from a single stone it stands 6.2m high with an arm-span of 2.3m. The shaft is 66cm wide narrowing to 55cm at the top and an open-work ring describing a space 1m to 1.2m across occupies the angles of the cross. The only embellishment apparent on the cross are two panels in light relief, each approximately 24cm square, one on each arm. A hole in the base of the shaft to aid its original erection is now concealed by the supporting plinth.

A large stone with a rounded hollow or basin cut into its surface lies in the graveyard close to the church. Such stones (bullaun stones), though of uncertain function, are a feature of early ecclesiastical sites.

In the NE corner of the graveyard there is a large upright stone standing some 2m high. This could pass for an ancient feature but according to Ordnance Survey records marks the grave of Rev. Charles Leslie who was incumbent of the parish in 1780.

Muckish - Fossil Rock Glacier (*Peter Wilson*)

A massive ridge of quartzite debris occurs at the foot of the south-southwest facing slopes of Muckish (Figs. 1 and 11). First termed "a series of morainic mounds" by Charlesworth (1924) and later regarded as the product of a cirque glacier by Dury (1957), the feature has recently been interpreted as a fossil rock glacier by Wilson (1990b).

The ridge is arcuate in plan form and has an estimated volume of $2.8x10^6m^3$. However, this figure includes debris removed by quarrying, and an unknown volume of bedrock and sand and gravel buried beneath the ridge. The true volume of

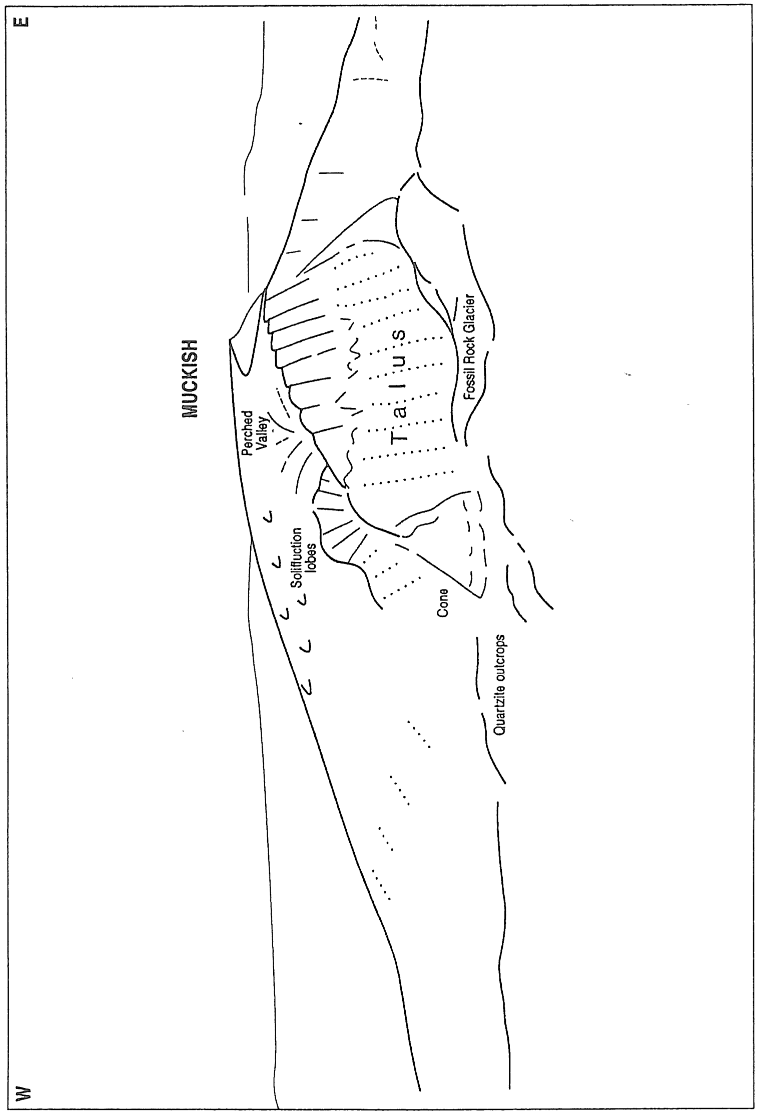

Figure 11. The southern aspect of Muckish showing the fossil rock glacier, talus, and alluvial cone.

debris is probably somewhat less than the figure given. Slopes of rockfall talus and degraded cliffs of Dalradian quartzite rise above the ridge. The lateral extent of the ridge corresponds closely with the lateral extent of the cliffs. Ice-moulded outcrops of quartzite occur to the west of the ridge and a large mass of bedrock or displaced bedrock occupies a substantial area towards the eastern end of the ridge and has been partly overridden by debris.

In Figure 12 ridge morphology is depicted by four surveyed profiles. From west to east the ridge increases in size from a relatively low and broad feature with a double crest (profiles A-B and C-D) to a much higher, wider and thicker ridge with a single crest (profile E-F). The ridge has a crest length of 770m; the double crest extends for 220m. At its eastern end the ridge descends steeply and obliquely from the talus to a distinct notch or col in the crest; this section of the crest has a maximum gradient of 27°. Beyond the col the crest curves north, undulates gently and terminates at the talus foot. The distal slope is both longer and higher than the proximal slope and has greater maximum gradients. On profiles E-F and G-H a gradient exceeding 30° is maintained for 120-140m. Ridge dimensions and gradients based on the four profiles are listed in Table 1.

The base of the distal slope forms an abrupt break of slope with the surrounding ground. However, near the western end of the ridge the base of the distal slope is poorly defined due to small hummocks of quartzite clasts that lie adjacent to the ridge. These may represent bedrock covered by a veneer of quartzite clasts or reworked ridge debris derived from shallow embayments on the distal slope.

A prominent backing depression up to 21m deep occurs between the ridge and the talus foot. In the east, the depression is linear for *c.* 300m and descends as a series of steps to an elongate basin behind the central and western sectors of the ridge. This basin contains six enclosed hollows separated by transverse ridges of quartzite debris. The ridges have amplitudes of up to 9m.

The distal slope of the ridge has been quarried and allows partial assessment of the internal characteristics and composition of the ridge. The upper part of the exposure comprises coarse, openwork debris to a depth of 0.5-1m. Below this the debris remains clast-supported and predominantly openwork but finer material occurs as a loose infill. Isolated concentrations of clasts lacking in fines are occasionally visible. Overall the debris is extremely poorly-sorted; clasts range in size from granules to boulders 4m in length. Quartzite is the sole component of the debris. Other lithologies (schist and granite) occur in the underlying sand and gravel. Crude bedding is sometimes visible in the upper part of the quarry face; beds are poorly defined but appear to form broad and shallow troughs.

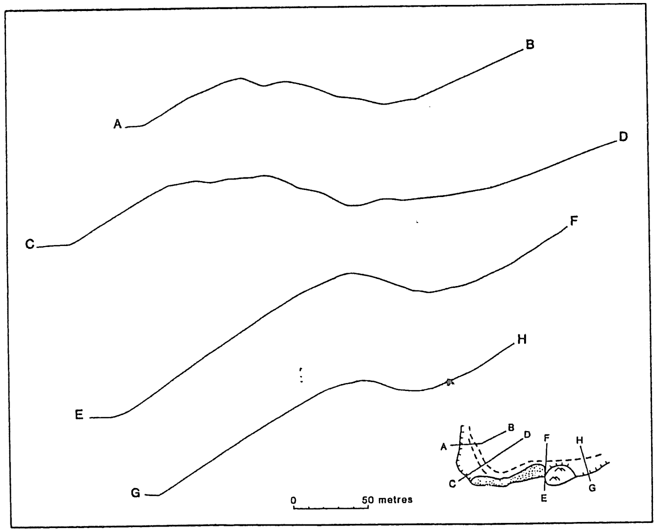

Figure 12. Surveyed profiles across the Muckish fossil rock glacier.

Table 1. Dimensions and gradients for the four profiles surveyed across the Muckish fossil rock glacier.

Profile	L_d	h_d	L_p	h_p	w	t	$\alpha_{max.}$	$\beta_{max.}$
A-B	73	33	67	19	160	30	32°	20.5°
C-D	96	47	60	21	186	37	33°	26.5°
E-F	186	95	55	14	213	55	36°	18.5°
G-H	157	77	39	7	175	40	34°	19.5°

L_d length of distal slope, h_d height of distal slope, L_p length of proximal slope, h_p' height of proximal slope, w ridge width, t ridge thickness, $\alpha_{max.}$ maximum gradient of distal slope, $\beta_{max.}$ maximum gradient of proximal slope.

The plan form and composition of the ridge indicate clearly that the feature is related to the slope below which it occurs. Based on the morphological and sedimentological characteristics of the debris accumulation and the adjacent terrain and sediments, Wilson (1990b) argued that the debris represented a fossil lobate rock glacier rather than a moraine ridge, protalus rampart or large-scale slope failure accumulation.

The talus-foot location of the debris accumulation and the close correspondence between the sedimentological characteristics of the talus and the debris strongly support a talus origin for the debris. Therefore the feature probably has an origin similar to rock glaciers that have been termed 'talus-derived rock glaciers', 'talus-foot rock glaciers', 'protalus rock glaciers' and 'talus rock glaciers'. Active forms of these features contain interstitial ice and ice lenses and move downslope by the deformation of the ice within them.

Figure 13 outlines a simple model of the major stages in development of the fossil rock glacier. Stage A represents talus accumulation in cold climate conditions through a range of processes. Interstitial ice and ice lenses develop within the talus by the burial of snowbeds and percolation of meltwater from upslope. The talus now represents a permafrost body or perennially frozen debris mass. Some debris may have accumulated as a protalus rampart or bench. In stage B, thickening of the debris/ice mixture has resulted in threshold conditions for downslope movement being exceeded and the frozen debris has begun to flow as a lobe-like extension to the talus foot into the depression between the bedrock ridge and the talus. A critical thickness of *c*. 15m before movement commences has been estimated for such features in the Alps. The processes causing movement are not well understood but are attributed to permafrost creep and sliding due to plastic deformation of the contained ice. With further debris accumulation and flow, the rock glacier passed over the crest of the bedrock ridge and moved down the outer slope, burying the ridge over most of its length (stage C). With climatic amelioration, rock glacier flow ceased and the melting of internal ice caused collapse and settling of the debris (stage D).

The fossil rock glacier is thought to date from the Nahanagan Stadial (*c*. 11-10 ka BP). It clearly post-dates the decay of the last Irish ice sheet, which deposited numerous granite boulders on the surrounding slopes, and must pre-date the start of milder conditions in the Holocene. Permafrost development implies a period of pronounced renewed cooling following deglaciation and the only period for which there is widespread evidence of such cooling is the Nahanagan Stadial. Rock glacier movement is believed to have occurred during the Stadial but the debris probably began to accumulate as talus earlier in the Lateglacial period as a result of rockfalls from glacially steepened rockwalls. A Nahanagan Stadial age is con-

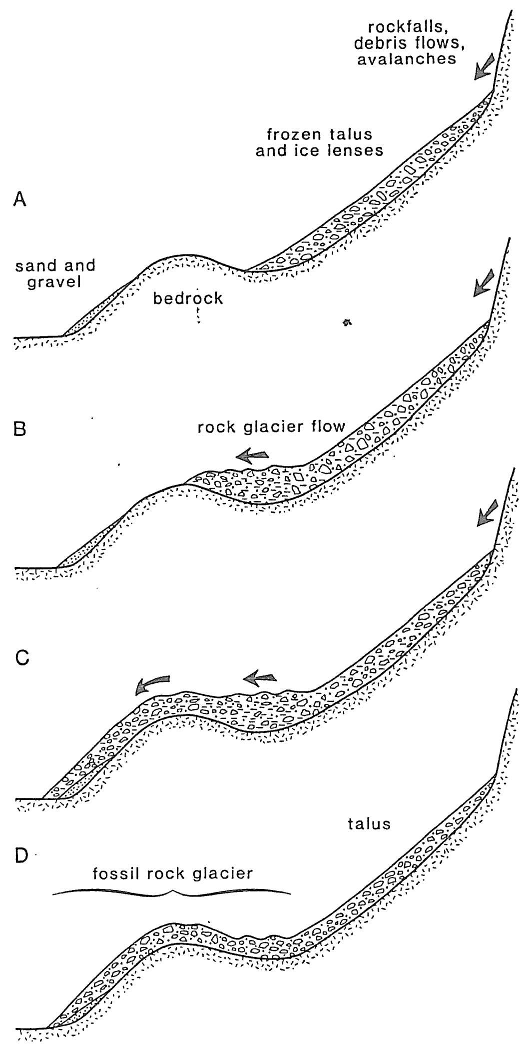

Figure 13. Stages in development of the Muckish fossil glacier.

sistent with widespread evidence for severe climatic conditions elsewhere in Ireland at this time.

Muckish - Talus (*Peter Wilson*)

The talus that rises above the fossil rock glacier forms a broad sheet of debris accumulation parallel to the cliff (Fig. 11). Talus of this nature is usually found beneath featureless or non-gullied cliffs, but on Muckish the 'cliff' comprises a series of tapering and degraded rock buttresses or ribs separated by shallow vegetated gullies of various widths. Features usually associated with talus below indented cliffs (e.g. single or compound talus cones) are absent. The talus probably accumulated during the Lateglacial and Early Holocene periods and is essentially a relict deposit. Some limited modification by debris flow and shallow talus sliding is currently occurring.

An interesting features of this talus is the series of alternating longitudinal zones of very coarse clastic debris below buttresses and less coarse material below gullies. Numerous studies have documented the downslope changes in clast size on talus but very few have described marked lateral (cross-slope) variations such as those visible on Muckish.

Two sampling strategies were adopted in order to assess the nature of these clast-size patterns. First, clasts were sampled at each of ten sites along a 250m cross-slope traverse of the talus at mid-talus height; five sites were located below buttresses and five below gullies. Second, on an upslope traverse, adjacent coarse and less coarse debris zones, below buttress and gully respectively, were sampled at 30-50m intervals; this gave five paired sites. At each site *b* axis measurements of 50 clasts were made and local slope angles recorded (Wilson, 1990c).

Results of the size measurements are presented as clast dispersion diagrams in Figure 14. The pattern of size variation confirms the visual impression of alternating longitudinal zones of very coarse debris below buttresses (B1-5 samples) and less coarse material below gullies (G1-5 samples) (Fig. 14a). Each sample is significantly different from adjacent samples at the 0.001 level. Individual clasts range from 13-85cm for B samples and 6-50cm for G samples. The degree of clast sorting, as indicated by the interquartile range, is generally good for G samples but moderate to poor for B samples. Slope angles at B sites are in the range 32-39° and at G sites 33.5-37.5°; these values are statistically indistinguishable at the 0.05 level.

Clast size data for each of the five pairs of samples obtained on the upslope traverse

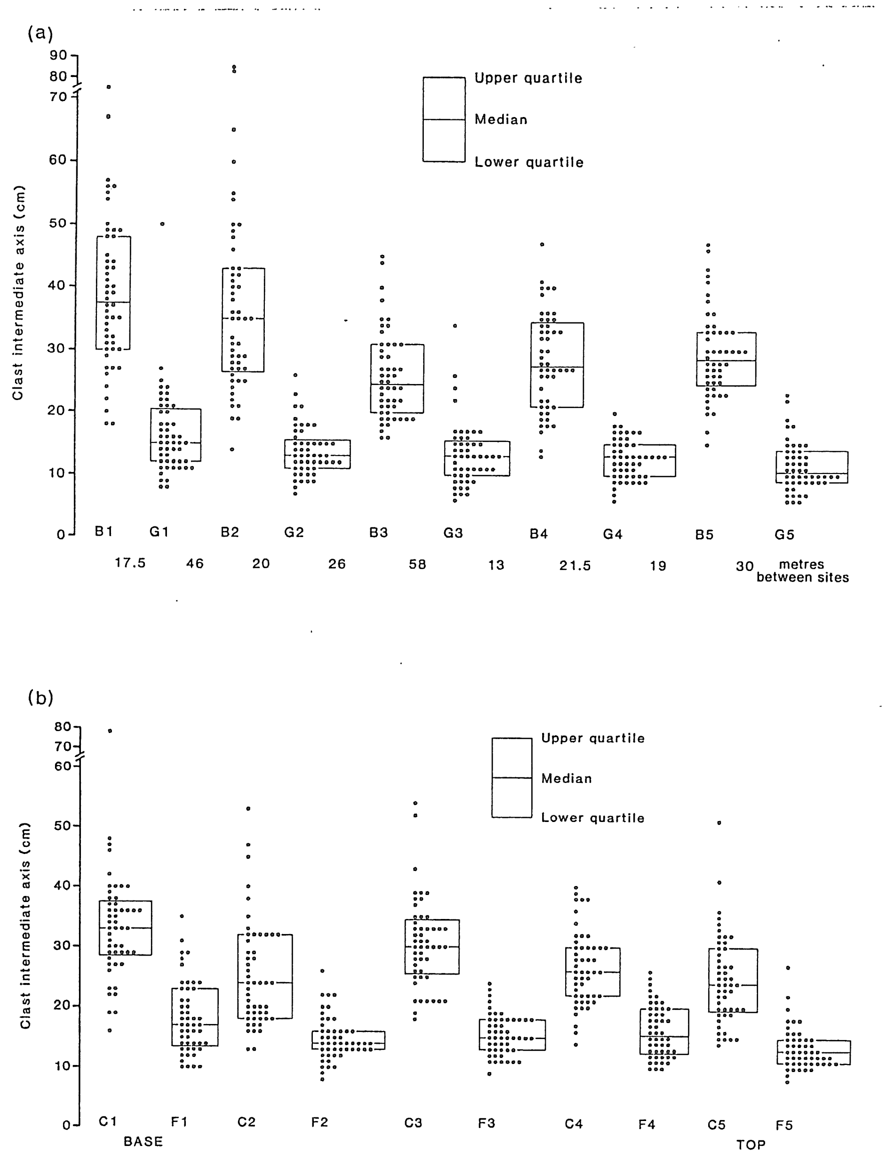

Figure 14. Clast dispersion diagrams for the Muckish talus: (a) sites along a 250m cross-slope traverse; (b) sites along an upslope traverse of adjacent coarse and less coarse debris zones.

are also significantly different at the 0.001 level, indicating that the lateral variation in clast size is maintained along the entire upslope length of the talus. Clast sorting is generally better for F samples (less coarse material below a gully) than for C samples (coarse material below a buttress) (Fig. 14b). At C sites, slope angles of 33.5-39^{o} were recorded and at F sites 31-39^{o}; there is no significant difference between these groups at the 0.05 level.

The nature of longitudinal clast size variations within the F and C debris zones are also indicated by Figure 14b. Each category of samples displays a complex pattern of size variation. Samples from the base and top of individual debris zones (i.e. C1 and C5; F1 and F5) are significantly different at the 0.001 level and indicate an overall decrease in clast size upslope. However, intermediate samples show that this is not a simple progressive size decline. Samples from the coarse debris zone display the best sequence of upslope decrease in clast size. The less coarse debris zone possesses a weaker pattern of upslope size decrease.

Clast size variations on talus are usually associated with the processes leading to talus accumulation. The tendency for clasts to decrease in size with increasing distance up talus is considered to be a characteristic of those slopes dominated by the process of rockfall. Cross-slope variations in clast size are regarded as the product of other processes (e.g. snow and slush avalanching, debris flow, fluvial activity). Such processes usually originate in gullies or chutes above the talus which serve to localise the movement of snow, water and falling debris. Accordingly, on Muckish the distinctive pattern of very coarse debris below buttresses and less coarse debris below gullies could be attributed to rockfall from buttresses and the operation of 'other' processes in gullies, but talus morphology suggests that this is unlikely to be the case. Talus that accumulates by processes other than rockfall possesses very different characteristics to talus produced by rockfall alone. In particular, lower slope gradients, boulder lobes and tongues, conical talus forms, channels and levees, hummocky debris flow deposits, absence of upslope decrease in debris size, basal accumulations of fine material; and a wider range of clast sizes resulting in poor sorting at a given point, are generally considered to be indicative of these 'other' processes. The absence of these features from the Muckish talus implies that their formative processes were not operative during talus accumulation. Thus, the clast size patterns are thought to reflect predominantly the process of rockfall and there is some evidence to suggest that the patterns originate in the following ways:

1. The less coarse and better sorted debris below gullies is probably related to closer and more regular joint spacing in the talus source area. Gully beds are currently vegetated and bedrock outcrops are rare, but where outcrops occur and along gully walls, joint systems are more closely and regularly spaced than on buttresses from which larger clasts with a greater size range have been released.

2. The weaker pattern of upslope decrease in clast size in the less coarse debris zones may be a function of more regularly sized clasts produced in the gullies, but in addition talus sliding may have influenced these size arrangements to some degree. A few fresh scars occur on the upper part of the talus and these are located below gullies. Material in these zones is particularly susceptible to small-scale disturbance, while in the coarse debris zones this occurs with much less frequency. Talus sliding in the less coarse debris zones was probably effective during talus accumulation as a result of rockfall impacts and this may have modified the size grading produced by rockfall alone.

Muckish - Alluvial Cone (*Dominique Sellier & Peter Wilson*)

A large alluvial cone occurs to the north-west of the fossil rock glacier (Fig. 11) and in terms of its size is an exceptional feature in the landscape around Muckish. At its base, the cone extends across the hillside for over 200m, filling a broad embayment between bedrock outcrops. Along its northern margin the cone forms a sharp break of slope with the surrounding ground and rises steeply (maximum gradient 33^{o}) to a distinct crest with a short backslope of 3^{o}. In its central area the base of the cone is not clearly defined; a series of lobes extend away from the cone and shallow gullies occur on the slope above. The maximum gradient in this area is 28^{o} and there is no crest/backslope as found further north. Above this steep frontal slope, the gradient decreases to *c.* 20^{o} and the cone tapers towards a prominent gully in the cliff. Surface exposures on the cone show it to be composed of coarse quartzite clasts.

Above the gully, a deep valley cuts into the mountain and has acted as the source of the cone debris. Valley-side slopes are convex and of low gradient at higher levels and rectilinear and steep at lower levels, suggesting two phases of incision.

Debris cones are usually considered to be composite landforms in that debris flows and fluvial activity have contributed to their accumulation. In parts of upland Britain, many debris cones have been shown to be relict features while others have seen significant accumulation in the recent past (Harvey *et al.*, 1981; Brazier *et al.*, 1988; Brazier & Ballantyne, 1989). The Muckish debris cone is essentially a relict feature. It is well vegetated and, in part, covered by blanket peat deposits. Only at the apex of the cone is there evidence of fresh debris being added. If debris flows were involved in building the Muckish cone, it seems likely that these flows reworked glacial and periglacial debris from the gully and valley upslope. In this respect the cone is essentially a paraglacial feature (*sensu* Ryder, 1971) that was dependent on an abundant supply of pre-existing glacial and periglacial material.

However, cone morphology indicates two phases of accumulation. The first phase is indicated by the steep frontal slope and short backslope, suggesting that an arcuate ridge of quartzite debris accumulated first. The origin of this ridge is unclear but it may have been a Nahanagan Stadial protalus rock glacier, as occurs nearby. The second phase is represented by the bulk of the cone that has filled the depression behind the ridge. A Nahanagan Stadial age for the ridge implies a Holocene age for the cone. It is interesting to note that the valley above the gully appears to have undergone two phases of incision.

Muckish - Summit Plateau (*Peter Wilson & Dominique Sellier*)

Muckish rises to 666m above sea level and has an extensive gently-sloping plateau above 600m, most of which is covered by coarse and angular quartzite debris that Charlesworth (1924) ascribed to Late Midlandian frost action. He also considered that the mountain had been either totally or substantially covered by ice from the Derryveagh Mountains (granite) during the last glaciation. Although granite erratics occur on the lower ground around Muckish and to a height of 550m on the neighbouring Aghla Mountains (Wilson, 1993), no erratics have been found on the plateau. Most of the plateau debris constitutes a blockfield, but in some places relict and active patterned ground features are present within the debris and on the western slopes the debris is arranged into large boulder lobes and terraces. Also present is a thin and dissected sheet of aeolian sand.

Wilson (1989) discussed the nature, origin and age of the aeolian sand. It occurs as a narrow vegetated zone along the northern edge of the plateau and is of medium to fine grain size and moderately sorted. Erosion has produced a number of vegetation-free scarps which show that the sand is underlain by peat and also contains thin peat horizons. Radiocarbon dating of these organic layers indicates that one phase of sand deposition post-dates 5,300±70 years BP (SRR-3319) but pre-dates 2,650±50 years BP (SRR-3318), while statistically inseparable dates of 1,910±60 years BP (SRR-3320) and 1,760±60 years BP (SRR-3317) provide a maximum age for a second phase of sand accumulation

The sand is derived from beds of friable quartzite exposed immediately below the northern rim of the plateau that were quarried as a source of glass sand from the latter part of the last century until the 1950s. The lateral extent of the sand along the plateau edge corresponds with the lateral extent of the friable quartzite beds in the scarp. Transfer of sand from the scarp to the plateau has entailed upslope transport and must have been achieved by northerly winds. The location of the

sand deposits is consistent with the pattern of airflow and sand movement over a windward-facing escarpment. The greatest thickness of sand occurs close to the plateau edge and thins rapidly away from the edge. Sand deposition began during the mid-Holocene, indicating that the friable quartzite beds were sufficiently weathered at that time to yield sand for aeolian transport.

To-date, these sands are the only aeolian deposits described from the uplands of Ireland. They testify to the geomorphic importance of wind action when coupled with conducive lithological characteristics.

Relict and active patterned ground features occur at several locations on the summit plateau of Muckish and were described by Wilson & Sellier (1995). The relict features comprise networks of roughly circular to elongate cells of relatively small quartzite clasts surrounded by borders of larger quartzite clasts. Cell mean diameters range from slightly less than 1m to slightly more than 2m. Many of the cells are raised 10-15cm above the adjacent coarse borders. These features probably relate to severe frost-action processes during the last glaciation and/or the Nahanagan Stadial. For the most part they are inactive as indicated by lichen-covered clasts, scanty vegetation and a thin and discontinuous peaty topsoil.

Active patterned ground features are associated with the relict features in that the sorted nets display both surface and sub-surface evidence for recent disturbance (partial activity). The active features - termed stony earth circles - occur on the raised cells of the sorted nets and comprise irregular patches of brown soil devoid of vegetation; the largest forms cover 600cm^2. Trenches dug across the patterns showed the coarse borders and flanks of the raised cells to be underlain by podzolic soil horizons, suggesting stability over a considerable period of time. Beneath the stony earth circles the podzolic soil horizons are both deformed and truncated (Fig. 15); subsoil horizons have been injected upwards and laterally and resemble cryoturbations produced through the differential frost heave of adjacent sediments possessing a negative frost-susceptibility gradient. Soil samples analysed for their grain size distributions revealed sand (43-66%) and silt (29-46%) to be the dominant components with considerably smaller clay contents (2-15%). The samples are classed as frost susceptible and negative frost-susceptibility gradients are demonstrated by the greater amounts of silt plus clay and organic matter in the B and C horizons of the soils relative to the E horizons.

The presence of active patterned ground in quartzite regolith is unusual as this normally comprises openwork blockfields lacking in fines. The presence of fines on Muckish is thought to be due to the weathering of occasional thin and soft beds of mica-schist within the quartzite.

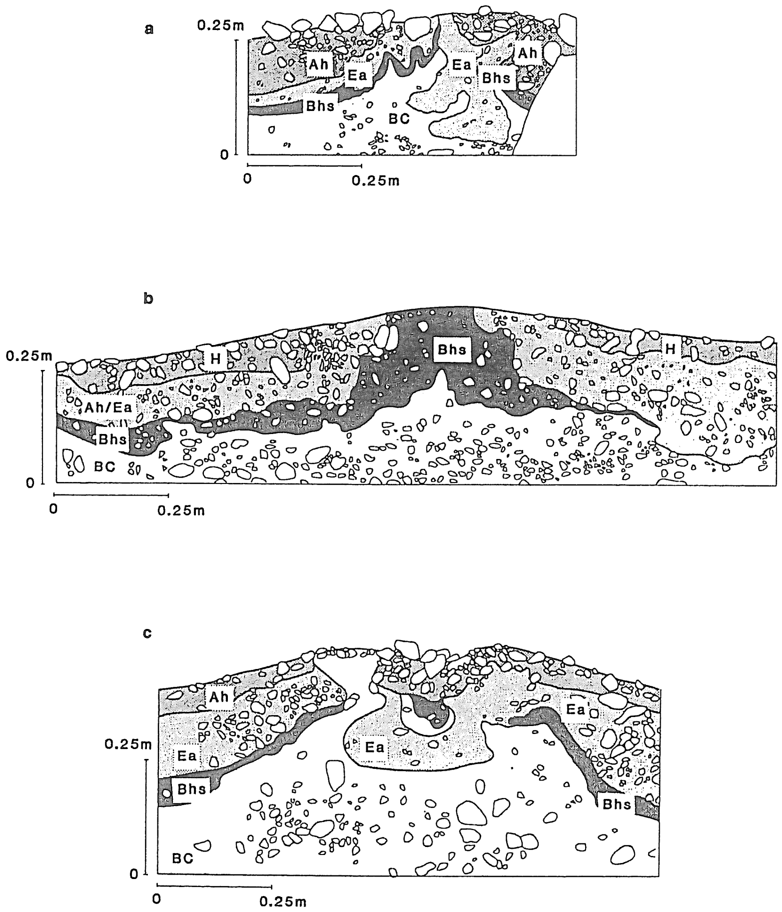

Figure 15. Excavated sections across three raised cells and stony earth circles on Muckish. Disturbed podzolic soil horizons are evident.

The stony earth circles are evidence for recent and/or current differential frost heave on Muckish. It is not known when activity was initiated or whether several phases of activity have occurred. Differential frost heave may have been more important during the most severe years of the 'Little Ice Age' than at present. Alternatively, the great storms within this period may have stripped some vegetation and soil from the plateau and permitted the more effective operation of frost heave.

The stony earth circles represent only the second example of active patterned ground in Ireland. In the Comeragh Mountains, 320km south of Muckish, Wilson (1992) identified small-scale, active, sorted nets and stripes at 730-760m above sea level. The implication from these widely separated sites is that most if not all upland areas in Ireland above 600-700m elevation have climatic conditions favouring frost-related soil processes although lithological/regolith controls or accumulations of thick blanket peat may prevent patterns from forming in some locations.

Derryveagh Mountains - Glacial Evidence (*Dominique Sellier*)

The granite landforms of the Derryveagh Mountains stand in marked contrast to those of the quartzite ridge running from Errigal to Muckish. In terms of scale, three categories of feature highlight the differences.

1. General slope profiles - on the granite these carry a strong imprint of glaciation, but less so on quartzite.

2. Medium size features such as ice-moulded outcrops and *roches moutonnées* are very common on the granite but are uncommon on the quartzite.

3. Polished and striated surfaces, which are common on quartzite, are virtually absent on the granite probably because of the coarse grain size or because they have been destroyed by Holocene weathering. Other small-scale features (e.g. hyperbolic cracks, crescentic gouges (convex chattermarks) and truncated planes, see Sellier & Bossière, 1993 for examples of these) which are again common on the quartzite, are rare on the granite but do exist and are of interest for determining ice movement directions and the vertical extent of the last ice sheet. Erratic blocks are also useful features for establishing the extent and movement of the last ice sheet.

Hyperbolic cracks have been observed in about 10 locations on the northern side of the Derryveagh Mountains at elevations between 140-480m above sea level.

They occur as individuals and as hyperbolic crack strings. Crack chord lengths range from 10-35cm, and lengths of the perpendicular bisector to the chord range from 2-5cm. Crescentic gouges of similar size to the hyperbolic cracks also occur but are less common. These micro-scale features are probably of Midlandian age because Holocene weathering of 1-5cm on the granite, as determined by the protrusion of aplite veins, suggests they are unlikely to have survived from an earlier glacial phase. Ice movement directions during the Midlandian, as indicated by these features, are to the north and north-west (*cf.* Charlesworth, 1924).

The vertical extent of the last ice sheet in the Derryveagh Mountains is rather difficult to determine but several lines of evidence suggest it to have been about 550m above sea level. First, the highest undoubted glacial features (truncated planes) have been identified at 520m on Dooish. Second, many old ice-moulded surfaces exist above this altitude but have been deeply fractured by frost action. Third, below this limit erratics are common; above this limit erratics are present but are less common and may be older than the last glaciation. Fourth, weathering pits and granitic sand deposits are better developed above the limit. Thus, the Derryveagh Mountains with the exception of the summits of Dooish and Slieve Snaght and plateau areas above 550m were probably ice covered during the Midlandian. This vertical ice limit is similar to that reported by Wilson (1993) on the basis of granite erratics on the quartzite Aghla Mountains to the north.

Errigal - Fossil Rock Glaciers (*Peter Wilson*)

Errigal is a superb talus-mantled quartzite mountain rising to 751m above sea level. Approximately one half of its basal circumference is occupied by large-scale talus-foot debris accumulations (fossil rock glaciers and protalus ramparts). The presence of granite erratics on the slopes of Errigal led Charlesworth (1924) to conclude that the mountain had been overridden by ice from the Derryveagh Mountains during the Pleistocene. Brief reference was made to the debris accumulation at the foot of the north-east talus by both Kinahan (1894) and Charlesworth (1924), but apparently neither author recognised the equally, if not more, spectacular debris landforms that occur along the western slopes of the mountain. These features are best appreciated from a light aircraft at 600m!

Wilson (1990d) was the first to provide a detailed description and explanation for these features. Five debris accumulations exist (Fig. 16) and to visit all would take several hours and some rather strenuous walking across very rough ground. Only one of the features is easily accessible from the road at Dunlewy (I on Fig 16) and forms the basis for this site visit.

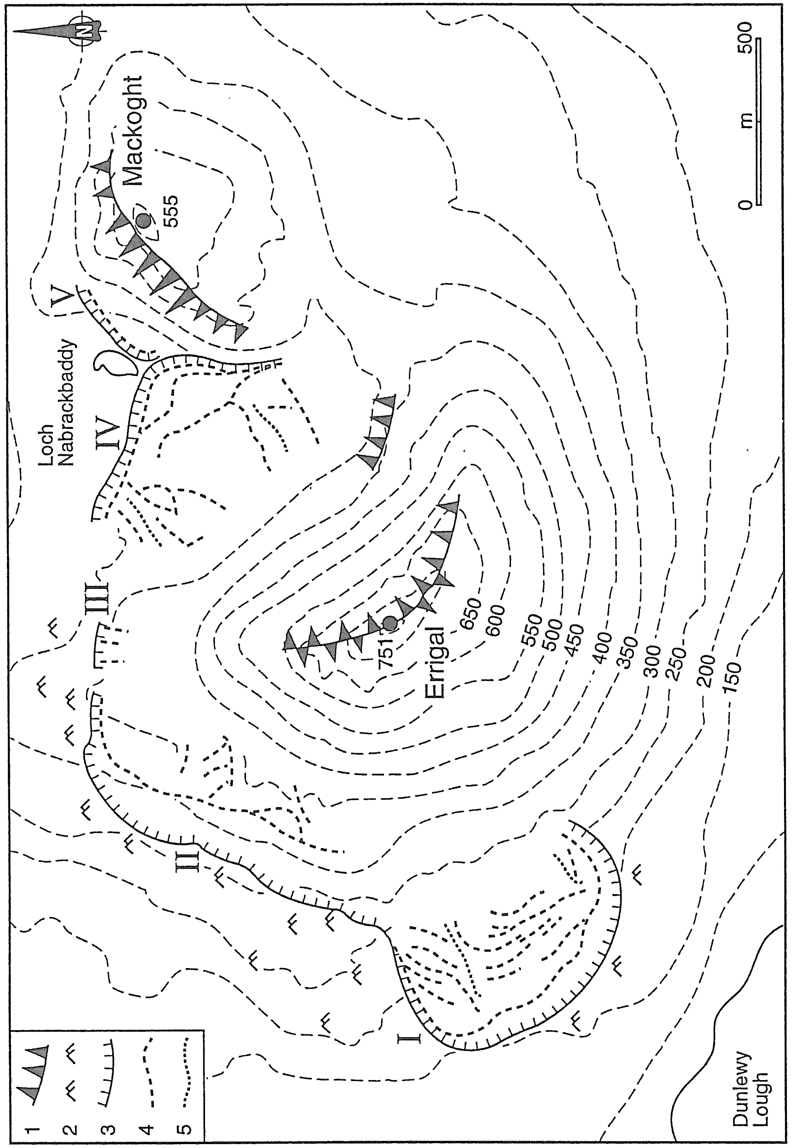

Figure 16. Talus-foot debris accumulations (fossil rock glaciers and protalus ramparts) on Errigal. 1, cliffed slopes. 2, rock benches on lower slopes. 3, base of distal slopes on debris accumulations. 4, crest lines. 5, longitudinal depressions.

The feature is located between *c.* 150-275m above sea level at the base of the steep south-western slopes. It forms a massive lobate accumulation of quartzite debris with an area of 295,000m^2 and an estimated volume of $3.8 \times 10^6 m^3$. The feature extends for 730m across the hillslope and 450m downslope. Although now covered by peat and vegetation, two distinctive morphological units are apparent: (1) the terminal ridge and (2) the interior, composed of smaller ridges and depressions. The morphology is indicated by the surveyed profiles in Figure 17.

The terminal ridge is the most prominent component of the feature and measures *c.* 1500m along the base of the distal slope and *c.* 1300m along the crest. It comprises two lateral ridges 250-300m in length that broaden and thicken downslope before curving across the slope to form the large frontal ridge. Maximum facet angles for the distal slope lie within the range 24.5-34^{o}; the corresponding range for the proximal slope is 17.5-35^{o}. The distal slope attains its maximum length (101m) and height (44m) along the front of the ridge. Maximum ridge thickness (36m) and width (196m) also occur in this area. A rock bench of quartzite and metadolerite underlies the terminal ridge along approximately half its frontal length (Fig. 16). To the north this bench is replaced by a low-angle slope with an isolated limestone outcrop. Extensive peat erosion in front of the ridge has revealed numerous granite boulders.

The interior of the feature is divided by a distinct longitudinal depression. North of this, a series of ridges branch from the lateral ridge and run obliquely across the hillslope, terminating at the longitudinal depression. A second, shorter, longitudinal depression occurs alongside the southern lateral ridge. Transverse ridges and depressions displaying slight downslope convexity occupy the central and southern parts of the interior. The ridges have amplitudes of up to 10m and widths not exceeding 60m. An average debris thickness of 13m has been estimated for the interior.

The upslope termination of the interior is delimited by a discontinuous transverse depression. Above this a steep heather-clad slope, interrupted by several narrow, low-angle, bench-like surfaces, rises for *c.* 200m. Talus occurs at a higher level.

Very few areas of debris are exposed because of the peat and vegetation cover. However, where peat erosion has occurred the debris is coarse and openwork with no evidence of fines in the surface layers. The bulk of the debris is quartzite with minor quantities of metadolerite derived from dykes in the quartzite rockwalls.

The most plausible explanation for this and some of the other debris accumulations on Errigal is that they represent fossil rock glaciers that developed during the Nahanagan Stadial as a result of permafrost creep (as described for the Muckish

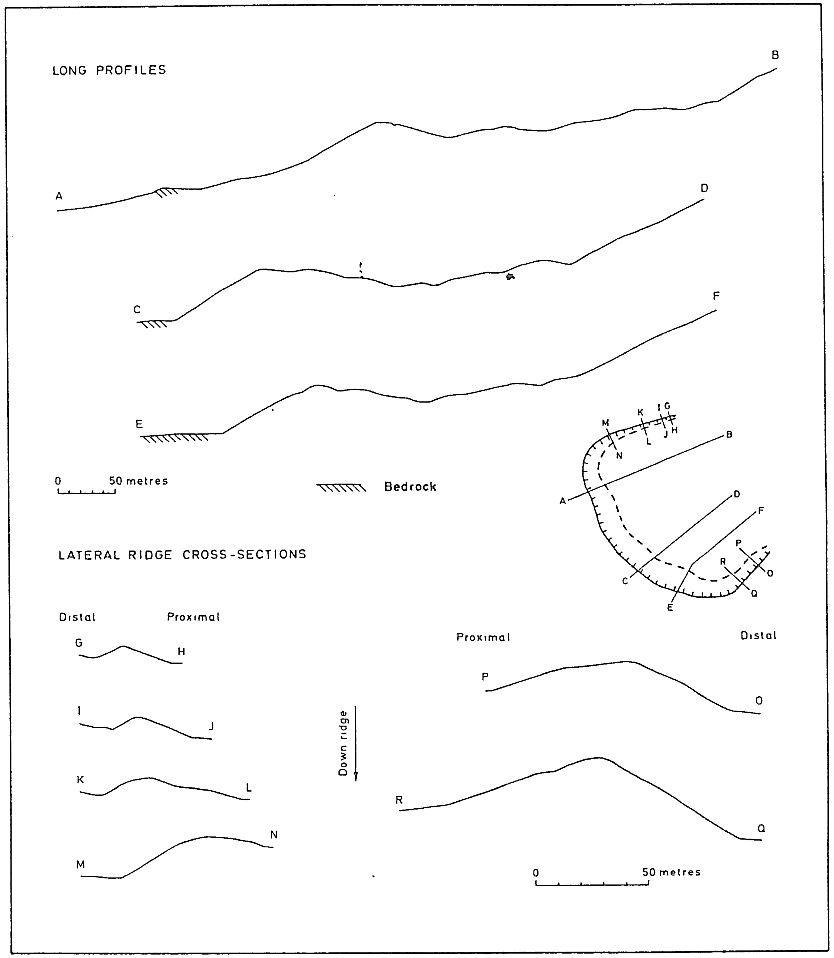

Figure 17. Surveyed profiles across Errigal I.

fossil rock glacier). Other possible origins were considered and rejected by Wilson (1990d). If a fossil rock glacier origin is accepted, then some palaeotemperature inferences can be drawn based on the fact that active rock glaciers can develop where mean annual air temperature is slightly below 0°C. The lowest fossil rock glacier on Errigal (feature I) extends down to 150m above sea level. Applying a lapse rate of 0.6°C/100m, a mean annual air temperature no higher than 1°C at sea level is implied for the Nahanagan Stadial. This represents a temperature depression of *c.* 8.5°C relative to the present day and compares with an estimated temperature depression of 7.2°C at Lough Nahanagan (Colhoun & Synge, 1980).

Fossil rock glaciers have also been identified on Aghla More and Aghla Beg (quartzite mountains between Errigal and Muckish) (Wilson, 1993). All these landforms testify to significant slope modification following the decay of the last Irish ice sheet by geomorphic processes that either no longer operate or operate at vastly reduced rates. The well-jointed character of the quartzite cliffs made them especially susceptible to frost wedging under the severe climatic regimes at the end of the last glaciation and during the Nahanagan Stadial.

Errigal - Talus (*Dominique Sellier*)

The Errigal talus has been more affected by debris flows than that on Muckish, but it is still possible to see areas of talus that are unmodified. As with Muckish, coarse debris is seen to occur below buttresses and less coarse material occurs below gullies. Two adjacent profiles (G69 and G70) were surveyed below a gully and buttress respectively (Figs. 18 & 19) and clast size (*a* axis) was measured from photographs taken at intervals of 40m along the profiles. Prior to photography, a 1m grid sub-divided at 10cm intervals was laid across the talus.

The results obtained are similar to those presented by Wilson (1990c and this volume) for talus on Muckish. Mean clast size is greater at all positions on profile G70 (buttress) than profile G69 (gully) and there is an overall decrease in clast size with increasing distance up-slope, although on both profiles the decrease is not regular (Fig. 20). The percentage of clasts in various size categories is shown in Figure 21. Clasts with an *a* axis greater than 50cm only occur at the base of profile G69, but are found along the entire length of profile G70. Clasts with an *a* axis less than 4cm only occur at the top of profile G69 and are absent from profile G70. Clasts within the size range 10-49cm are the dominant component at most sites on both profiles.

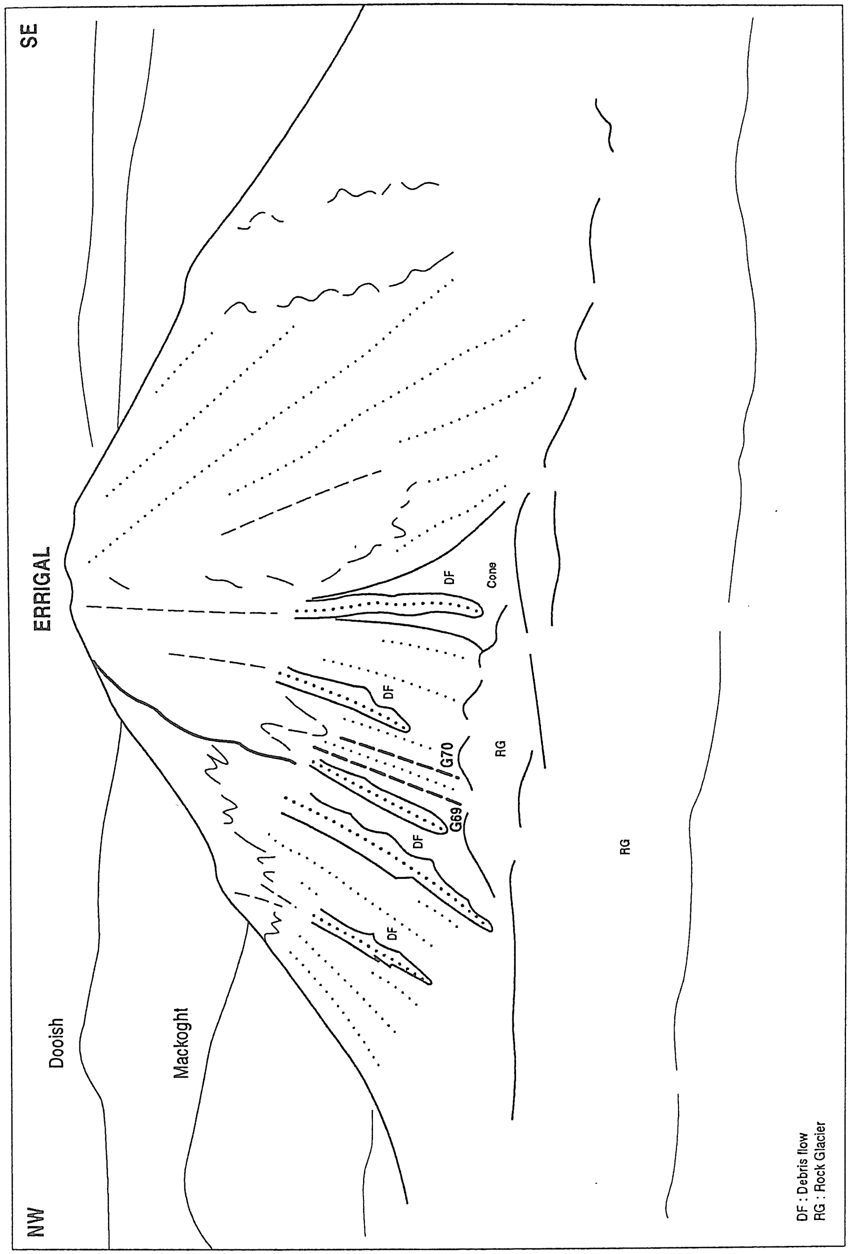

Figure 18. The western aspect of Errigal showing debris flows on talus and locations of profiles G69 and G70.

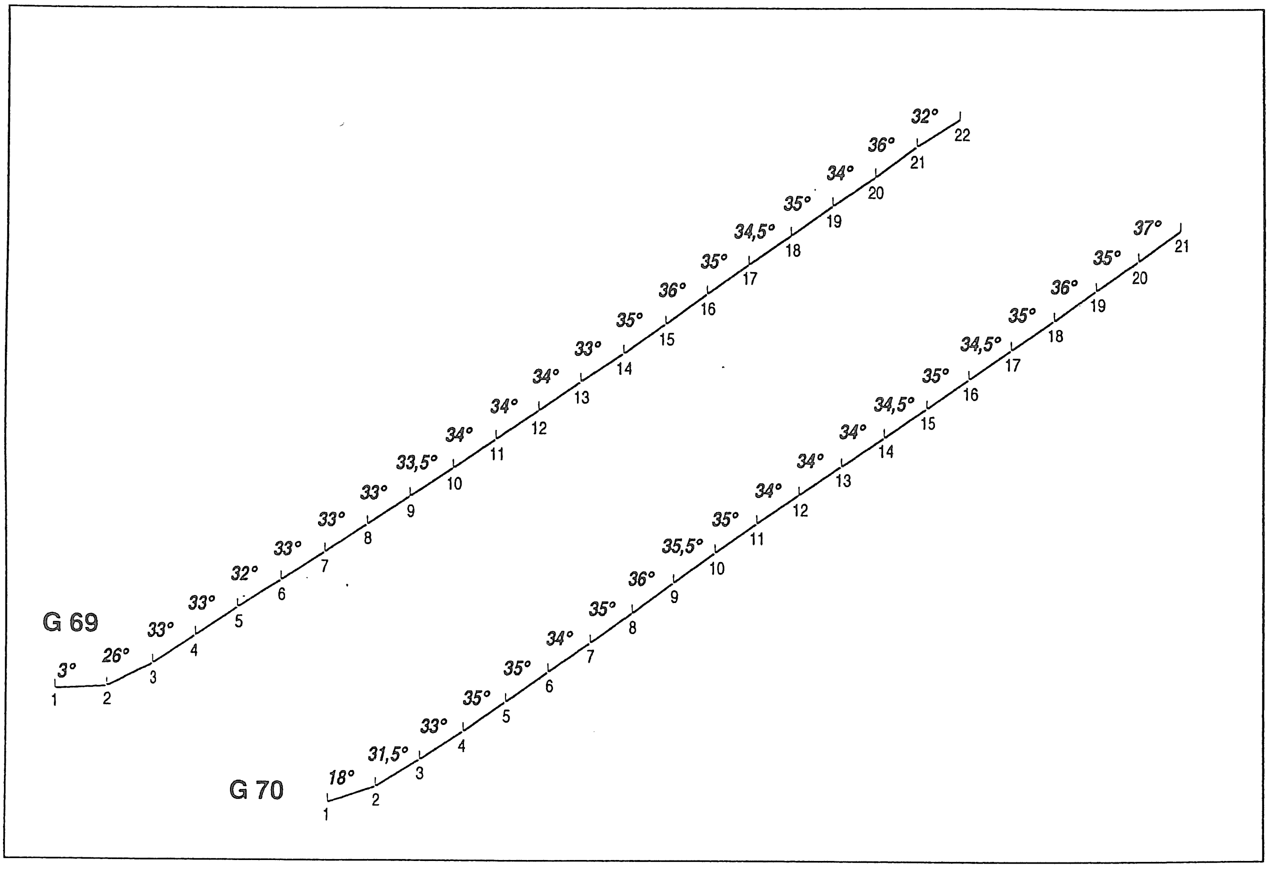

Figure 19. Profiles G69 and G70 from the Errigal talus with gradients and site numbers indicated.

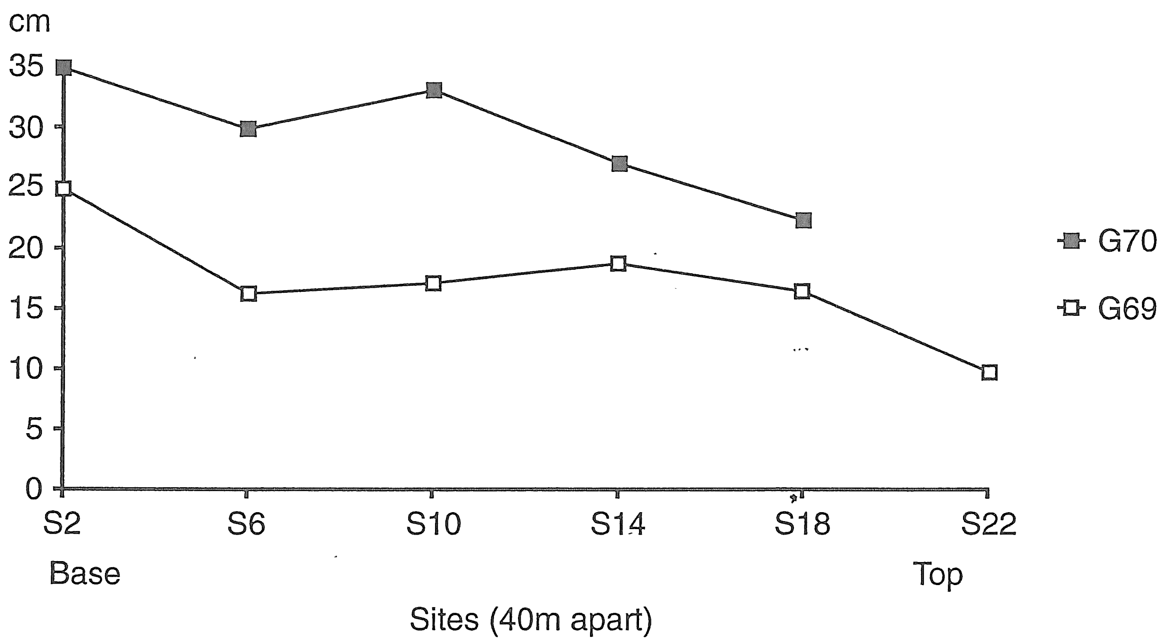

Figure 20. Mean clast size variations (a axis) along profiles G69 and G70.

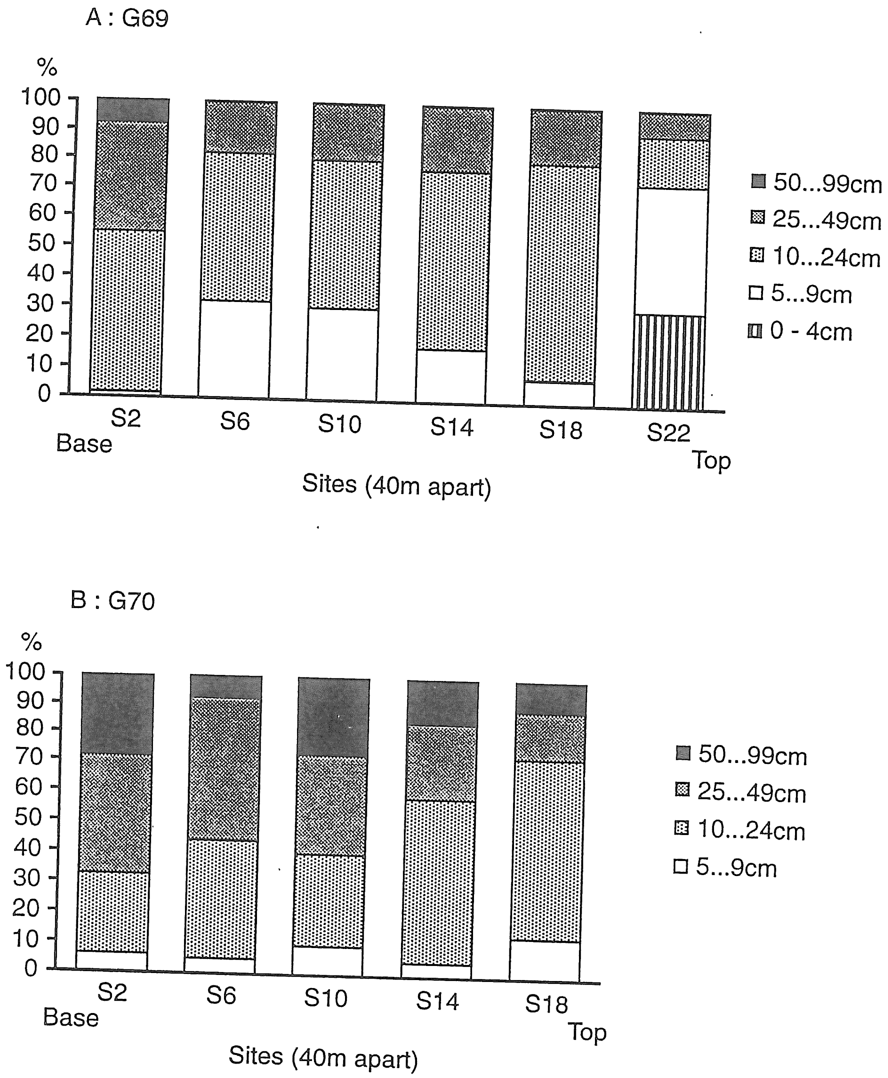

Figure 21. Distribution of clast size (*a* axis) in different size ranges along profiles G69 and G70.

Gortahork - Head Deposits (*Peter Wilson*)

A stony diamicton, up to 3.5m in thickness, is exposed in a small roadside excavation on the northern outskirts of the village of Gortahork. The material is matrix-supported and dominated by angular clasts of the local bedrock, the Upper Falcarragh Pelites. Rounded and sub-rounded clasts of other lithologies, including metadolerite, granite, quartzite, and vein quartz, are also present suggesting that the diamicton contains some material that is probably derived from glacial sediments. The matrix (i.e. material <2 mm diameter) is poorly sorted and comprises 77% sand, 21% silt, and 2% clay. Medium sand (+1 to +2ø; 500-250µm) and fine sand (+2 to +3ø; 250-125µm) are the major components of the size distribution with 20% and 22% by weight respectively.

The diamicton is considered to be a head deposit formed as a result of mass wasting processes (frost creep and gelifluction) in a periglacial environment following the withdrawal of the last Irish ice-sheet from the coast of Donegal. Several lines of evidence support this interpretation. First, the abundance of angular clasts of the local bedrock set in a poorly-sorted matrix. Second, the grain size distribution of the matrix (Fig. 22) is sufficiently fine-grained to be within the frost susceptible range as defined by Beskow (1935). Third, a sample of 50 elongate pelite clasts display a strong preferred downslope orientation and clast dips are also downslope (Fig. 23). Together these attributes are regarded as characteristic of non-argillaceous head deposits (Ballantyne & Harris, 1994).

The age of head accumulation is not known with certainty although it probably occurred within one of two periods. First, as the last Irish ice-sheet withdrew from the coast of Donegal (*c.* 15-13 ka BP), periglacial conditions may have existed marginal to the retreating ice. Second, the Nahanagan Stadial (*c.* 11-10 ka BP) was characterised by severe periglacial conditions and permafrost, and it is argued above that the Muckish and Errigal fossil rock glaciers formed at that time. Head accumulation was probably restricted to one of the above periods as there are no obvious stratigraphic breaks in the sediments to indicate more that one phase of accumulation.

Fawnmore - Ice Marginal Terrace (*Marshall McCabe*)

Commercial pits 2km east of Falcarragh have exposed sections in a terrace-like feature which may be traced eastwards on the south side of the main road. The surface of the terrace is at about 30m OD though its original morphology at this site is difficult to reconstruct.

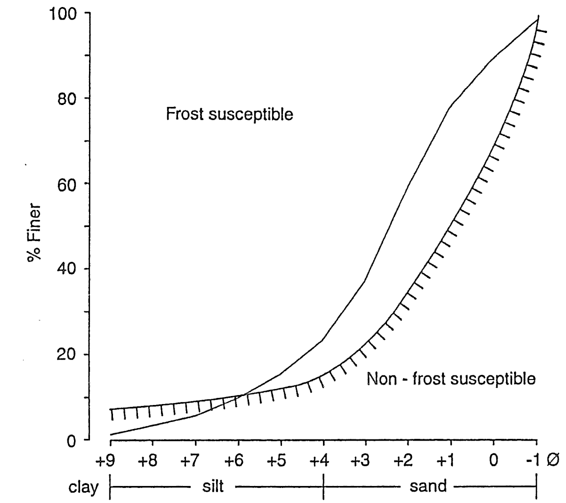

Figure 22. Cumulative grain size curve for the Gortahork head deposits plotted against the frost-susceptibilty limit of Beskow (1935).

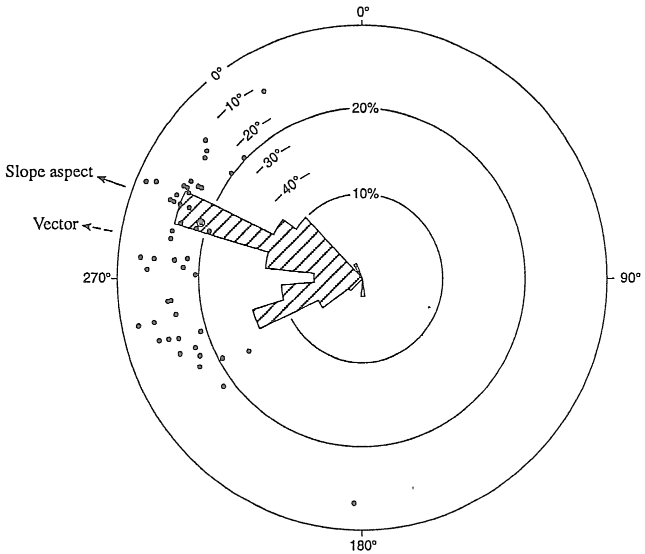

Figure 23. Three-dimensional fabric diagram for 50 clasts from the Gortahork head deposits.

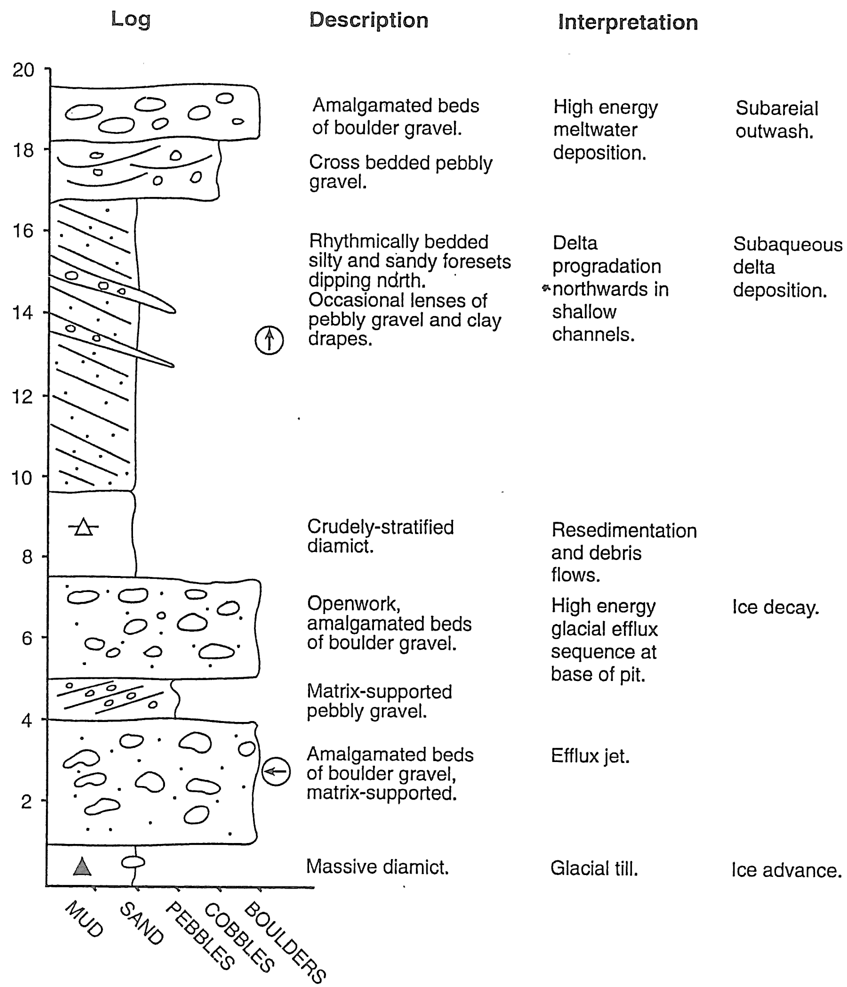

Figure 24. Generalised log of the Fawnmore efflux complex.

The gravels and sands are related to ice wastage southwards as the ice margin retreated along the Ray River valley. Two discrete events are recorded in the sediments (Fig. 24). Overconsolidated diamict, occasionally exposed in the base of the pit, has most of the characteristics of a basal till and is associated with deposition during ice movement northwards. An excellent section in a similar schist-rich till is exposed in the roadside at Moyra, 1km to the south.

The stratified sediments in the pit consist of a wide range of lithologies. Amalgamated beds of boulder gravel are similar to high energy, jet efflux systems recorded from many ice proximal sites in Ireland. Clast imbrications suggest palaeoflow to the west and north-west. These gravels are overlain by a crudely-stratified diamict recording debris flow activity and a switch in the location of the jet. The large-scale foresets overlying the diamict indicate delta progradation northwards in shallow water up to about 30m OD. Palaeoflows are recorded from channel foresets dipping to 40-60° at angles up to 15°. In general these foresets are sandy rhythmites with occasional lenses of pebble gravel. The foresets are truncated by flat-lying beds of matrix-supported gravel representing topset beds.

The overall geometry of the gravel/sand sequence records ice contact and deltaic sedimentation. The basal boulder gravels record high energy pulses driven by high hydrostatic pressures and jet sedimentation. Debris flow from unstable slopes is probably recorded by the stratified diamict when the jet closed down or switched location. Foreset deposition indicates subaqueous deposition related to a water plane around 30m OD. It is possible that this water plane was controlled by HRSL though there is no other known evidence, in the form of raised beaches or fossiliferous glaciomarine deposits, to substantiate this.

Ballyness Bay - Spit and Estuary System (*John Shaw*)

Generally, not much is known of coastal landforms during the period of Holocene marine transgression because most of the evidence has been destroyed, or is submerged and has not been investigated. However, there is a large amount of evidence regarding how the coast developed as the transgression waned, and relative sea level came within several metres of its present level. The barrier - estuary system at Ballyness is typical of a number of similar coastal systems that formed in the final phase of the transgression.

The Ballyness coastal system is comprised of three parts. The first is east of the estuary, where coastal dunes lie behind a north-facing dissipative, sandy beach. The second part is the shallow, sandy estuary with extensive flood deltas, a single

deep inlet channel, and an ebb delta flanked by swash bars. Megaripples are common in the vicinity of the inlet and flood deltas. The third part of the system is a large spit (Dooey Peninsula) that lies behind a wide, northwest-oriented, dissipative beach. The substructure of the spit is a splayed complex of drift-aligned, gravel beach ridges (Fig. 25) that indicates sediment transport from the west. In places, the gravel ridges are overlain by dunecrete with aeolian cross-bedding. The superstructure of the barrier is a large volume of aeolian sand forming a curving ridge parallel to the west coast and deeply notched by blowouts. Behind this ridge, extensive areas have been deflated down to the water table. Perhaps the most striking part of the spit is at its eastern extremity, where a large sandhill slopes steeply down to the inlet channel.

This is one of the most exposed parts of Ireland, and high wave energy, strong winds, together with tidal energy, result in high rates of sediment transport in the system. Some sediment transport is cyclical. For instance, sand is moved through the inlet by flood tides, deposited on flood deltas, remobilised and carried by ebb channels into the main inlet channel, back onto the ebb delta, then moved landward by waves onto flanking subtidal and swash bars, and back into the ebb channel. It is unclear how much of this sand bypasses the inlet to reach the east beach and dunes. Several other pathways may not be cyclical, however. Sand blown from the west-facing beach is trapped in the dunes by vigorous marram. Sand moving down the east face of the large sandhill reaches the ebb channel and enters the cyclical estuary pathway.

Among the questions that can be asked about the evolution of Ballyness are: (1) how old is the system; (2) where did the sediment come from; and (3) what accounts for the division of the spit architecture into a gravel substructure and a sand superstructure? An estimate of the age of the spit has been determined by data from the west end of the estuary, where freshwater peat exposed on the foreshore is underlain by salt-marsh peat (Shaw, 1985; Shaw & Carter, 1994). The upper part of the peat is highly organic, but in the lower 25cm, the organic content decreases downwards. The pollen assemblage of this lower zone has high amounts of pine pollen, and relatively large amounts of types that could be interpreted as indicative of a salt-marsh environment. In addition, pollen preparations contained the linings of foraminifera tests. The radiocarbon age of the base of the organic zone was 4,530$\pm$60 years BP, and a sample from the top was dated to 3,340$\pm$30 years BP. The brief period of salt-marsh conditions that commenced at *c.* 4,500 years BP shows that the western part of the spit had formed by that time.

As relative sea-level rise decelerated, and reached a level almost the same as that of today, the spit began to form. The source of sediment is unknown at present but is almost certainly west of the spit, and most likely to have been a seaward exten-

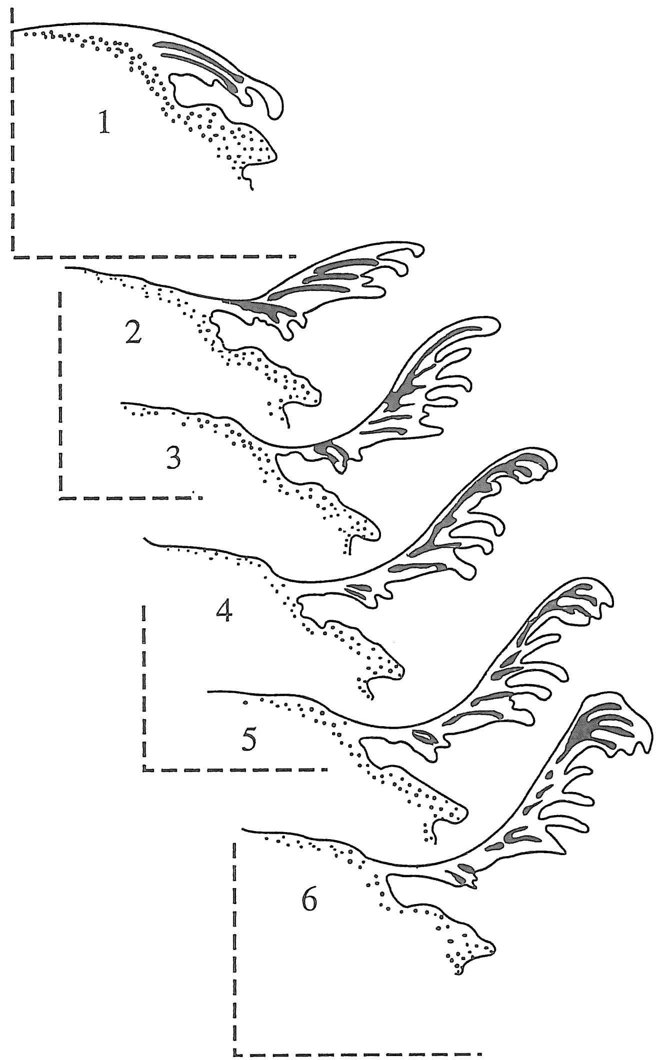

Figure 25. Stages in the development of the gravel ridge substructure, Dooey Peninsula.

sion of the till that is exposed in coastal bluffs west of the pier. In the early growth phase the spit was comprised of gravel beach ridges (Fig. 25), with small amounts of aeolian sand. After emplacement of the gravels, the barrier entered a long phase during which sand moved onshore and was blown into dunes. During this phase it is likely that human activity played a strong role in causing instability, resulting in the deflation corridors, the large sandhill, and the many blowouts that notch the frontal dune ridge.

Early (gravel-dominated) and late (sand-dominated) growth phases occurred elsewhere in Donegal, for example at Horn Head, where the underlying gravel ridges have been exposed by deflation. Could it be that in glaciated settings, barriers are invariably gravel-dominated in the early progradational phase and become sand-dominated later? In eastern Canada, where relative sea level rose throughout the Late Holocene, prograded swash and drift-aligned barriers are almost invariably composed of gravel beach ridges; they rarely show signs of a subsequent period of sand-dominance. So perhaps the rate of sea-level rise, and the consequent relative youth of barriers, is linked to the relative volume of sand that has moved onshore. In south-west Newfoundland, many barriers that formed after 3,000 years BP consist of gravel beach ridges, they have almost no aeolian sand, and rest on large, sandy submerged platforms. In this case, 95% of the sediment in the coastal system is stored below sea level, in sandy platforms that continue to prograde into a deep (90m) coastal basin. Thus, nearshore morphology can also be important in determining the ratio of sand to gravel.

Bloody Foreland - Glacigenic Sediments (*Marshall McCabe*)

Coastal erosion has exposed a thick (*c.* 20m) glacigenic sequence (Fig. 26) which forms cliff sections for about 3km from Altawinny Bay to Ranaghroe Point, Altnapeaste and Curran's Port (Fig. 3). Three main stratigraphic units occur in these sections:

A: Near Altnapeaste remnants of a horizontal rock platform occur between 1m and 3m above present beach level. The condition of the platform is highly variable ranging from rocking core stones set in a weathered growan to unweathered rock. Nearby, horizontal beds of sand and gravel are characterised by well rounded clasts, clast sorting, size sorting, and shape sorting. These parameters suggest deposition in an upper beach face setting (Fig. 26). Overlying laminated silts and sands may represent deposition in open water. Samples examined by P. Coxon were devoid of plant remains.

B: The laminated silts and sands are overlain unconformably by a thick (< 12m)

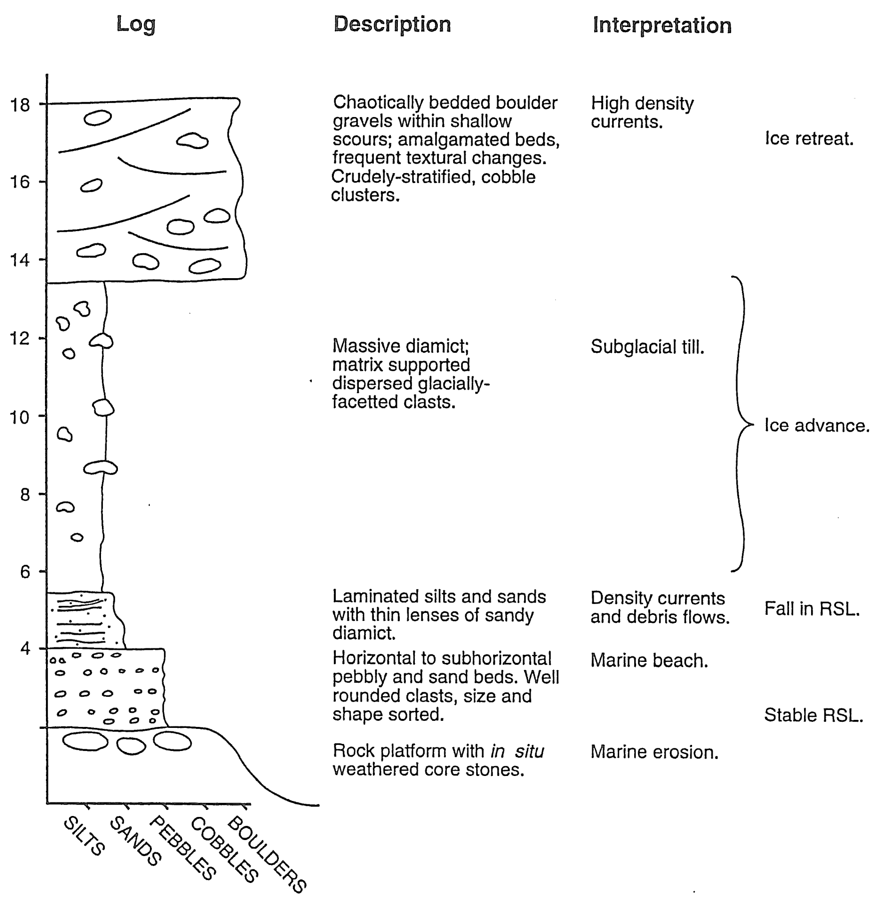

Figure 26. Generalised log of coastal sequences, Altnapeaste.

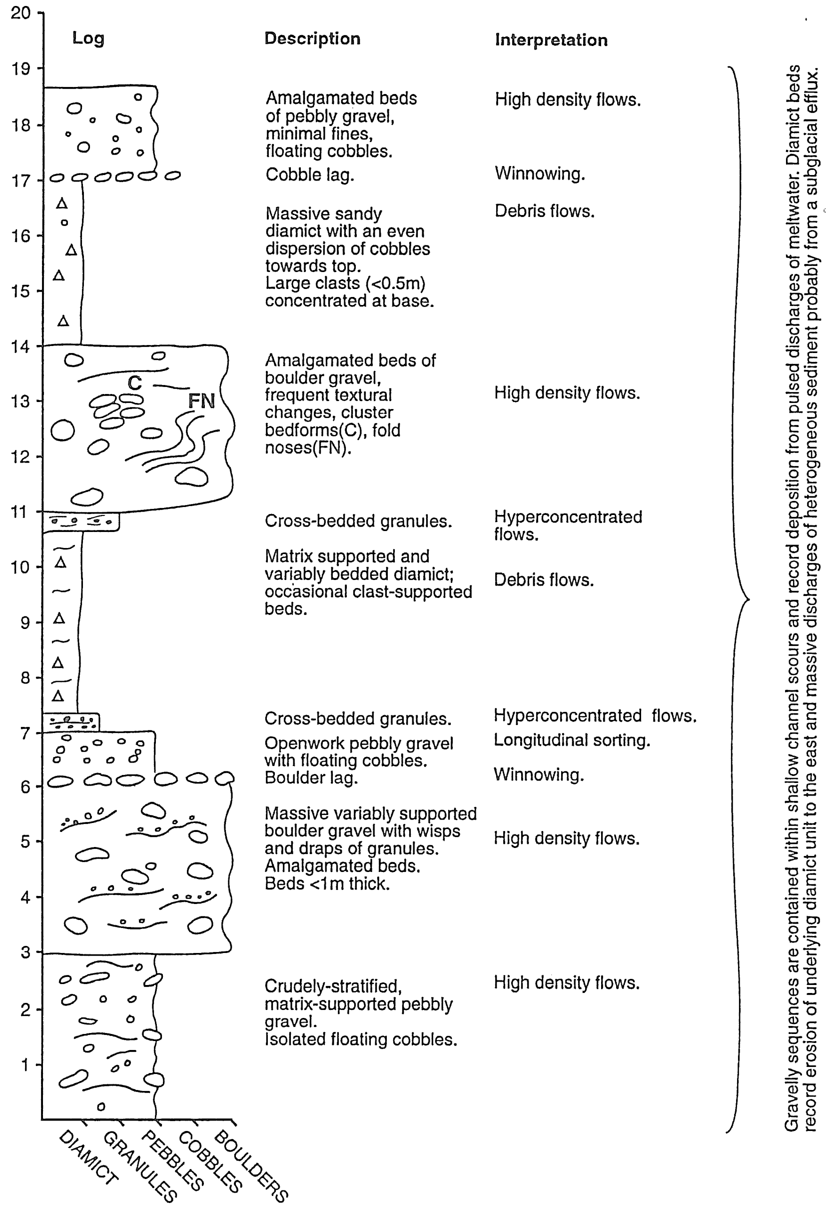

Figure 27. Log of coarse-grained gravels, Altawinny Bay.

wedge of massive, overconsolidated diamict (Fig. 26). The diamict extends continuously for about 3km along the northern margin of the Bloody Foreland ridge and seems to underlie an area of about 3km^2. Geometrically, it is a wedge-shaped body tapering to a feather edge west of Curran's Port. The presence of striated clasts, a wide range of clast sizes, predominance of local rock lithologies, overconsolidation, and a range of minor sedimentary structures suggests it is a basal till. Its age is unknown though its distribution and geometry suggest it to be a lee-side deposit associated with divergence of the last, northward moving ice-sheet on either side of the Bloody Foreland ridge.

C: The surface of the diamict is irregular having been deeply channelled by fluvioglacial meltwater. The overlying polymodal gravels are typical of high density sediment suspensions which were deposited in shallow multi-storied channel systems and are well exposed at Altawinny Bay (Fig. 27). The general palaeoflows were to the north and west. It is likely that the gravels were deposited as the ice withdrew southwards across the coastline from the continental shelf. At present their precise depositional setting cannot be evaluated with any precision. They may simply be part of a formerly more extensive fan system with only the more proximal parts preserved. Alternatively they may record incision at a time of lowered sea level followed by aggradation during sea level rise.

The well-defined block moraine which skirts the western and southern flanks of Bloody Foreland formed in a lateral position with respect to the ice margin. This ice margin post-dates the gravels at Altnapeaste. Internally the moraine is composed of angular to subangular blocks of granite, some of which are up to 2m across. Deep sections near Knockfola school show that the boulders are set in a coarse sandy to gravelly matrix which has been washed out from the upper parts of the sequence. It is thought that most of the blocks are derived from local deglaciated slopes with the variable matrix added by meltwater either from the ice or local slopes.

Knockfola - Pre-bog Fields and Promontory Fort (*Eamon Cody*)

Turf-cutting has exposed the entire length of two ancient stone walls on ground sloping towards the coast at Rinardalliff Point, Bloody Foreland at the NW tip of county Donegal. The N and W sides of a broadly right-angled bend in the coastline are linked by two curving field walls. The western of the two, nearer the bend in the coastline, is some 75m in overall length and isolates a sub-rectangular field measuring about 55m N-S and 50m E-W. The second wall, 180m in overall length, forms the eastern and southern limit of a second larger field which curves round the landward side of the first to open on to the coast at either end. Each wall

consists of a line of contiguously-placed large stones set in the ground though many are now dislodged. Further investigation would be required to establish if the exposed walls are part of a more extensive network.

Within the smaller field a slight projection of the coast is isolated by an arc, 15m long, of low stones and there is a similar feature just S of the larger field. Between these two features there is a small promontory fort formed where a narrow neck of land, cliff edged, is isolated on the landward side by a deep fosse. Traces of walling indicate that a rectangular structure occupied the greater part of this promontory fort. This may be the "Old Castle" identified here on the original OS six-inch map and might well post-date the construction of the promontory fort. Just E of the promontory fort and where the shorter of the two ancient field walls meet the cliff there are two rectangular stone-built hut sites, the larger 7m by 3m in size.

The chronological relationships of the various features here are not known. The two field walls may well be prehistoric in origin but they remain to be precisely dated. The chronology of small coastal promontory forts, such as that found here, is quite uncertain. Dates ranging from the later prehistoric to the second half of the first millennium AD have been advanced for the type.

Annagary Strand - Submerged Forest (*Peter Wilson*)

At Annagary Strand (Fig. 1) an impressive collection of *Pinus* stumps embedded in up to 1m of *Phragmites* peat occurs in the upper part of the inter-tidal zone. Peat thickness varies due to an irregular granitic basement. The stumps are at *c.* HWMS or *c.* 4.3m OD (Shaw, 1985). No dates for the remains are available but palaeoecological investigations of nearby lake sediments (Fossitt, 1994 & this volume) have demonstrated that *Pinus* began to decline after 4,500 years BP and became extinct at different sites in western Donegal between 3,700 and 2,400 years BP.

Carrickfin - Aeolian Dunes (*Peter Wilson*)

Carrickfin (Fig. 1) was formerly an island at the mouth of the Gweedore River, but is now linked to the mainland of the Rosses by a low dune barrier on which Donegal Airport has been built. Shaw (1985) notes that on the Admiralty chart of 1833 most of this area is shown as being covered by high spring tides, suggesting that the dune barrier must be relatively recent.

At the northern end of the airstrip, high dunes with blowouts occur. In one of the blowouts there is an extensive surface spread of animal bones, marine shells, charcoal and rock fragments. These midden materials also underlie the surface, being embedded in 30-50cm of dark brown sand. A shallow trench, excavated across this surface, demonstrated that the materials pass beneath 10-15m thickness of aeolian dune sand. A radiocarbon date of 810±60 years BP (Beta-62956) was obtained from charcoal fragments picked from a small fire site amongst the debris. Although caution is often advised regarding the interpretation of radiocarbon dates on charcoal obtained from archaeological sites, a tentative preliminary interpretation is that the date provides a maximum age for development of the overlying dunes.

Knowles (1901) recorded occurrences of bones and shells at Carrickfin, but the locations of his sites are unknown and may not have been in the dunes.

Carrickfin - Archaeology *(Barry Raftery)*

The Site: The following account is based on excavations carried out in 1985. On initial inspection, the midden consisted of a narrow platform of irregular width extending for a minimum length of 35m in a roughly north-south direction. Along the east, the occupation platform disappeared under the sand dune so that its extent in this direction could not be ascertained. In the west the edge of the midden was defined by a ragged scarp, vertical in some places, deeply undercut in others, which rises for a height of from *c.* 40cm to *c.* 1m above the sloping ground alongside. Extending westwards from this scarp is a broad area of sand 11-12m wide which contains numerous shells, bones and stones. Further to the west is a grassy hollow which rises before falling sharply to the sea some 400m distant.

The surface of the midden slopes gently from south to north and more steeply from west to east. The impression is that originally the site was in the form of a low, rounded mound. The exposed width of the midden varies considerably according to the degree of erosion suffered. In the north it is little more than 1.5m wide while in the south it expands in a westward direction to a maximum width of about 14m. Bones and shells are strewn along its entire length, sometimes in noticeable concentrations. Everywhere areas of grey, brown and black organic material are visible on the surface and in several areas there is evidence of burning. Similar occupation layers can be seen in the exposed section along the west.

According to local people, the site first appeared in the early 1970s when a large section of the dune was blown away. It is said that at that time the foundations of a rectangular, stone-built structure (since dismantled) were revealed. In the intervening years a number of bronze pins have been picked up from the surface of the

midden by local people.

The Excavation: It soon became apparent that the writer had underestimated the importance and complexity of the site and the extent of the excavation required there. Thus, the details presented can be regarded no more than a preliminary reconnaissance.

In the time available the surface of the midden was cleared and features planned, the western scarp was cut back into a series of straight, vertical sections to give an initial indication of the nature of the occupation layers, and four east-west cuttings, averaging 2m in width, were made into the midden and excavated down to natural sand.

Initial analysis of the stratification suggests that one major phase of occupation took place, followed by several minor periods of activity. There is no suggestion that any significant interval of time elapsed between the phases and all seem to belong to the same cultural horizon. Roughly in the centre of the midden, at the edge of the scarp, the remains of a rectangular setting of stones, enclosing a surviving area 54cm by 46cm, was uncovered. Reddened, burnt material in the base of this, and a layer of charcoal, confirmed that this was a hearth. Extending eastwards from this (and disappearing under the dune), was a narrow stretch of paving 60-90cm in width. This was composed of specially-selected slabs of stone carefully placed to provide an even walking surface. The slabs were embedded in a mottled, grey occupation layer in which large quantities of shells and animal bones, as well as a few artifacts, were found. In one area, a portion of the paving was covered by a thin layer of shells and charcoal. A thick grey occupation layer underlay both paving and hearth but no obvious stratigraphical break between upper and lower phases of activity could be detected.

South of the excavated area (where the midden is at its widest) traces of extensive human activity are visible on the surface in the form of thick clusters of shells, bones, charcoal and other organic debris. In the section there, a concentration of charcoal and burnt red layers indicates the presence of a hearth which appears to have been enclosed by a rectangular stone setting similar to that described above. There are also some large stones *in situ* which could be remnants of the stone structure first revealed when the sand dune moved. Unfortunately there was no time to excavate this potentially interesting area but further investigation is clearly required.

The Finds: In 1978 the writer picked up a fragmentary saddle quern and a pronged bone implement from the surface of the midden. Only a handful of finds was brought to light in the course of the 1985 excavations but these give some indica-

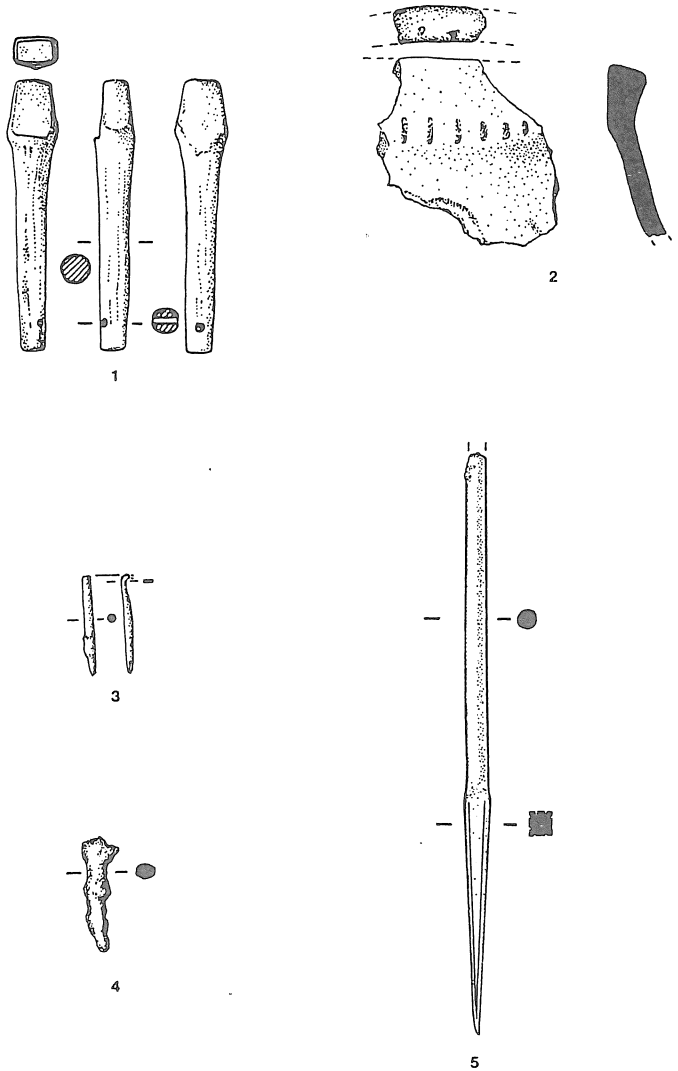

Figure 28. Finds from excavation at Carrickfin: 1, harp-peg of bone or horn. 2, decorated rimsherd. 3, bronze buckle. 4, iron nail. 5, bronze pin. Scales - 1-4, 1/1; 5, 2/1.

tion of the date of the site. Apart from a waste flint flake, a few crumbs of bronze, an iron nail and an amorphous lump of the same metal, the principal artifacts recovered are a straight-shafted bronze pin, a bronze fragment, possibly from a buckle, a decorated rimsherd of handmade pottery and a finely-carved harp-peg of bone or horn (Fig. 28). The pin is of medieval type but is, as yet, difficult to date closely. The potsherd, too, is not clearly datable but may be part of a medieval cooking pot. The harp-peg is more amenable to closer dating: it is likely to have been made in the 13th or 14th century.

Faunal Remains: Detailed analysis of the faunal remains is currently in progress. Finbar McCormick of Queen's University, Belfast, spent four days on the excavation and supervised the collecting and recording of bones and shells from the site. Every single item, numbering many thousands of specimens, was retained for study. So far it can be stated that the bones of cattle, sheep, pigs and horse are present. There are some bird bones and a single fragment of red deer antler. At least six species of fish have been found as well as a whale bone. A wide range of shell fish has also been recognised including cockles, mussels, oysters, periwinkles, limpets, scallops, razorfish and crab. When the work is finished an extensive picture of the dietry habits of the occupants of Carrickfin will be available and it may be possible to attempt an estimate of the size of the population involved. Information from the shells and fish might help to determine if the site was seasonal or permanent.

Radiocarbon Dates: Five samples were submitted for radiocarbon dating. Three of the samples were from animal bones and gave ages of 879±35 years BP (UB-3615), 832±35 years BP (UB-3616) and 1,018±35 years BP (UB-3617). Two samples of limpet shells gave ages of 1,169±35 years BP (UB-3622) and 1,199±35 years BP (UB-3623). These dates, plus that of 810±60 years BP (Beta-62956) obtained from charcoal, suggest that the site was in occupation during the latter part of the first millennium AD and that occupation continued for several centuries.

Comment: The limited investigations at Carrickfin have shown that the midden represents an archaeological find of some significance. The paving, the carefully-constructed hearths and the reported house suggest for the site a degree of permanence and it may be that an important open settlement existed at Carrickfin in Medieval times. Though middens are common around the Donegal coast, there is as yet no example which has been comprehensively excavated and published. Carrickfin thus offers an ideal opportunity to rectify this situation and to shed light on a little-known aspect of Irish life in Medieval times.

The Rosses - Palaeoecology *(Julie Fossitt)*

Lough Nabraddan and Altar Lough are situated approximately 3km apart on the northern fringe of the Rosses district in western Donegal (Fig. 29). This low-lying region was formed by intrusion and subsequent erosion of a circular granitic outcrop, or ring-complex (Whittow, 1974). The present undulating surface is dominated by low, rocky hills, innumerable lakes and small, peaty fields. Land was intensively cultivated in the past and population densities have remained high over the last few centuries (see Micks, 1925; Freeman, 1940).

Details of all procedures relating to core collection and the production of pollen and associated diagrams are given in Fossitt (1994). Selected palaeoecological results are presented in Figures 30 & 31. Dates are given as conventional radiocarbon years before present (0 BP = AD 1950).

Lough Nabraddan (B 777 195; altitude 20m): Lough Nabraddan is a small lake (0.6ha) which occupies a deep valley on a fault-line to the west of Annagary. A minor stream flows northwards along the valley and through the lake from the southern end. At the coring point there was 5.6m of water and 7.4m of sediment.

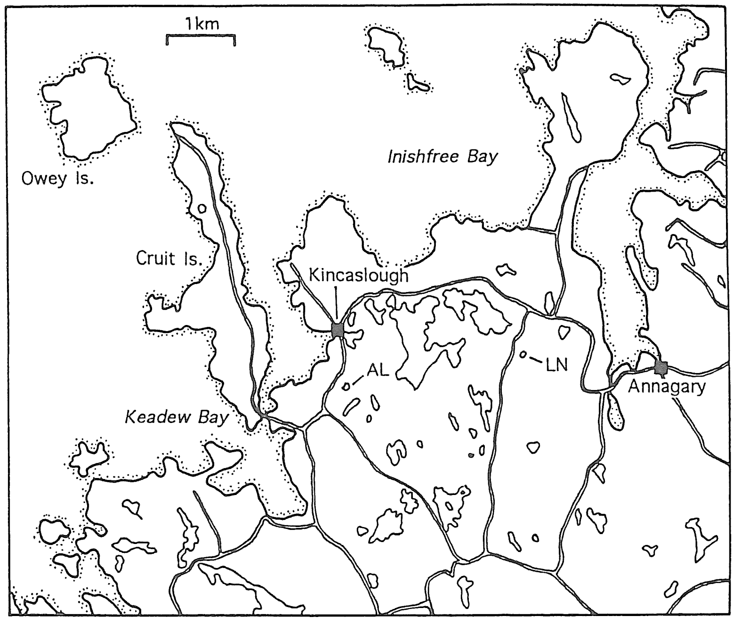

Figure 29. The Rosses showing location of Nabraddan (LN) and Altar Lough (AL).

Differences in geology, exposure and land-use have given rise to east-west contrasts in the catchment. Blanket peat and abandoned farm land dominate the exposed eastern side (felsite and microgranite). The western side (granodiorite) is sheltered and supports most of the trees and all of the land currently under cultivation. Trees include *Quercus petraea, Corylus avellana, Alnus glutinosa, Populus tremula, Sorbus aucuparia, Salix cinerea, Acer pseudoplatanus* (planted) and *Ilex aquifolium*, with a small coniferous plantation at the roadside. Overgrown fields, collapsing field walls and three deserted houses indicate that the catchment was more intensively cultivated and more highly populated in the past.

Lateglacial vegetation changes: Herb-rich grassland communities started to colonise the barren, rocky landscape around Lough Nabraddan at about 12,700 years BP. *Rumex, Artemisia*, Saxifragaceae and Cruciferae were prominent amongst the pioneer taxa, and patches of *Salix* scrub developed. Ground cover was incomplete and raw mineral soils were actively eroding into the lake. Successional changes resulted in the expansion of pteridophytes (mainly *Polypodium* and *Huperzia selago*), and a reduction in the abundance of herbs. *Empetrum nigrum* and *Juniperus communis* became established at about 12,000 years BP and spread to form extensive areas of heathland and scrub. Vegetation cover increased and catchment soils stabilised.

The Lateglacial stadial (LN-1c) is characterised by renewed erosion in the catchment and disruption of the vegetation cover, beginning at about 11,000 years BP. A band of grey-brown silty clay (1193-1186cm) represents a phase of severe catchment erosion. Juniper scrub was greatly reduced in abundance and may have disappeared from the surrounding hills. *Empetrum* heath persisted in abundance and *Polypodium* re-expanded.

Holocene woodland development and decline: The beginning of the Holocene (10,050 years BP) is marked by a second major expansion of *Juniperus communis*, and the decline and disappearance of *Empetrum* heath. Juniper scrub reached its maximum distribution when *Betula* started to expand at 9,900 years BP. Open birch woodland with *Salix* and *Populus* developed and dominated the landscape from 9,700 to 9,000 years BP. Juniper scrub contracted as shade and competition from trees increased.

Corylus avellana became established at 9,100 years BP and spread rapidly to replace *Betula* as the dominant tree taxon. *Ulmus, Pinus sylvestris* and *Quercus* invaded the local vegetation between 8,500 and 8,200 years BP. Mixed woodland developed. Diversity increased with the arrival of *Alnus glutinosa* at 7,000 years BP. Canopy cover was at a maximum in the early Holocene. Woodland became more open after 8,000 years BP; tree and shrub pollen frequencies decline from

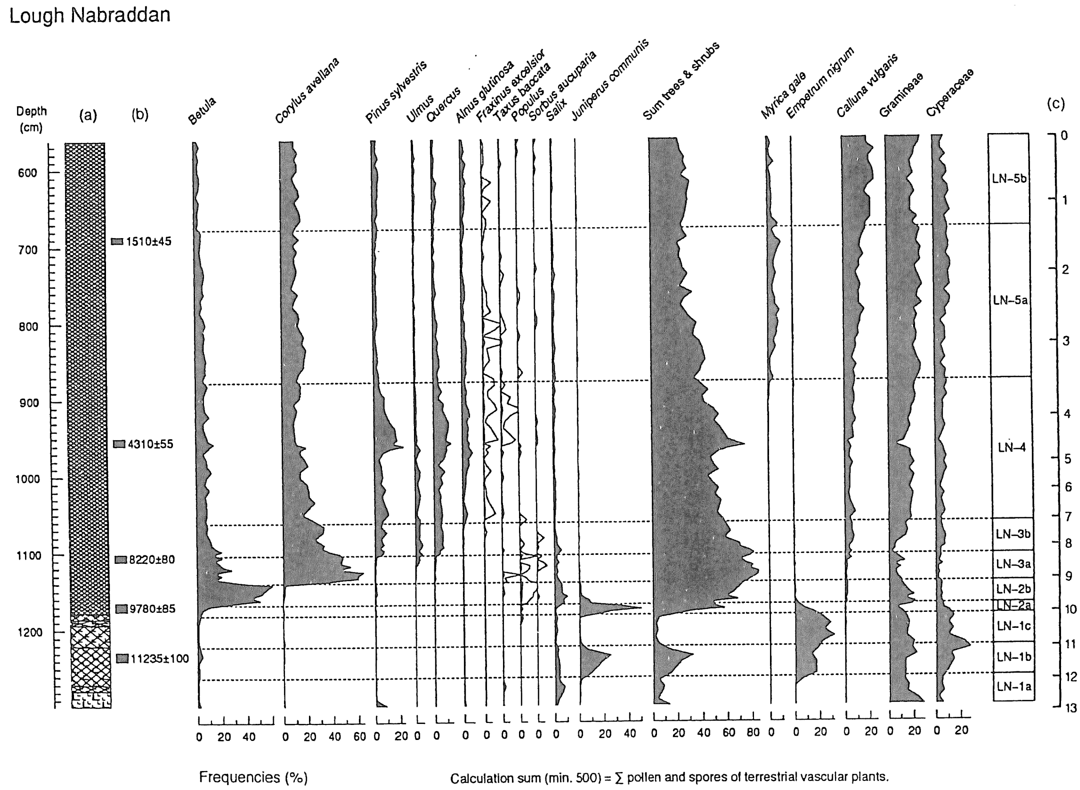

Figure 30. Selected palaeoecological results from Lough Nabraddan, plotted against (a) Troels-Smith (1955) stratigraphic column, (b) ^{14}C samples and age determinations (yrs BP), and (c) an approximate timescale (^{14}C yrs BP x 10^3). Outline curves represent an exaggeration of x10 for minor taxa.

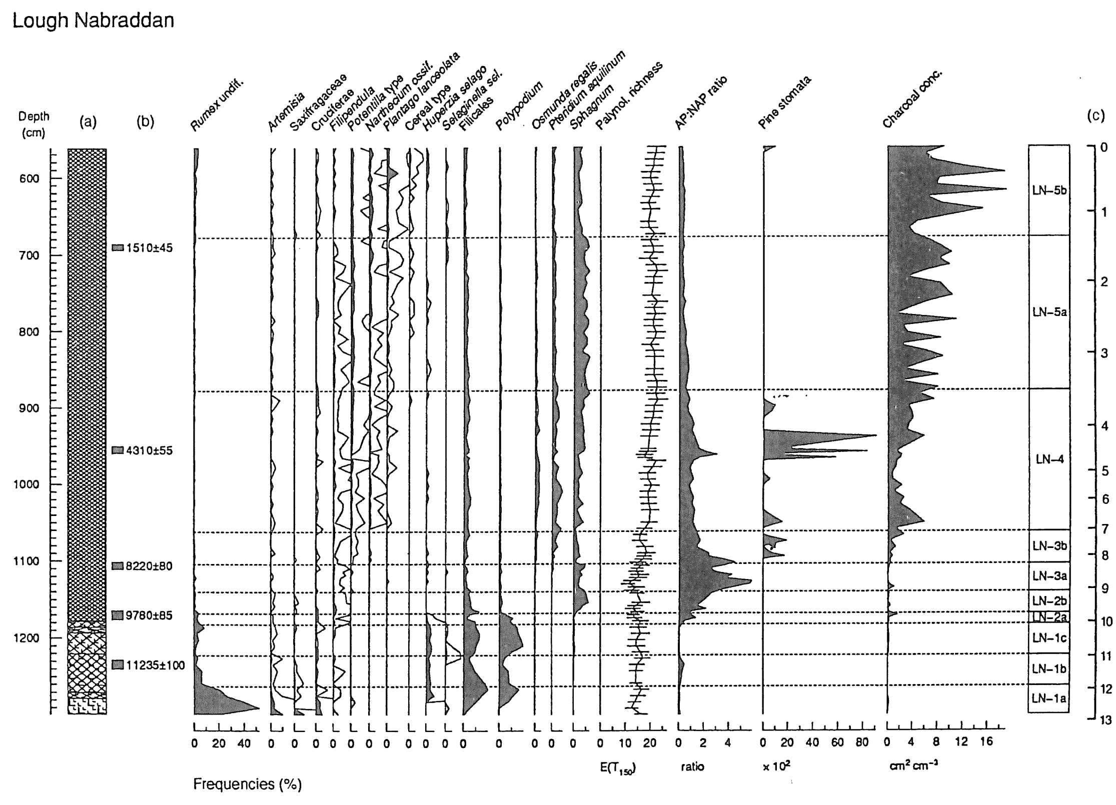

Figure 30. continued.

over 80% in LN-3a, to less than 60% from 7,000 to 5,000 years BP. *Calluna vulgaris*, grasses, sedges, *Pteridium aquilinum* and herbs were prominent in unwooded areas.

Open mixed woodland continued to dominate the landscape with little change until the elm decline at 5,300 years BP. A phase of woodland instability ensued and tree populations fluctuated. *Plantago lanceolata* pollen may be associated with local disturbance or tree clearance at around 5,000 years BP. *Fraxinus* and *Taxus* invaded the area at this time. *Pinus sylvestris* started to expand at 4,700 years BP and reached its maximum distribution at 4,500 years BP. This resulted in a temporary increase in the overall extent of woodland cover. Local presence of pine trees is confirmed by pine stomata (4,600-4,100 years BP).

The final woodland decline began immediately after 4,500 years BP and was concurrent with the demise of *Pinus sylvestris*. Pollen and stomata records indicate that *Pinus sylvestris* was locally extinct or extremely rare at 3,500 years BP. Woodland was replaced by blanket peat and, by 2,500 years BP, the landscape was predominantly treeless. The beginning of a continuous curve of *Plantago lanceolata* pollen coincides with the earliest records of cereal type pollen at 2,700 years BP. Cultivation of the surrounding catchment was most intensive from about 800 years BP onwards. Cereal type pollen is abundant (>1%) in sediments which represent the last 200 years.

Altar Lough (B 751 190; altitude 30m): Altar Lough is a small lake (1.2ha) with an irregular outline. It is surrounded by low, rocky hills and derives its name from an altar site, no longer in evidence, on the western shore. There are no inflowing streams; a minor outflow leaves via the northwestern arm of the lake. Water was 2.5m deep at the coring point and, below this, 5.4m of sediment had accumulated. Blanket peat dominates the catchment. Trees are absent but scattered shrubs of *Salix cinerea, Juniperus communis, Ulex europaeus* and *Ilex aquifolium* can be found on the surrounding hills. Local peat deposits contain numerous pine stumps. Field boundaries suggest that land was used for extensive grazing of stock and not for cultivation. Two abandoned cottages lie within 200m of the lake shore.

Lateglacial vegetation changes: Plant colonisation began at about 12,700 years BP. High *Pinus sylvestris* pollen frequencies in the basal samples are interpreted as exaggerated long distance pollen inputs (Fossitt, 1994). Pioneer communities were dominated by grasses, herbs (mainly *Artemisia*, Saxifragaceae and Cruciferae), and *Salix* scrub. Ground cover increased as *Rumex* and *Polypodium* expanded. *Empetrum nigrum* and *Juniperus communis* became established at about 12,000 years BP and spread to form extensive areas of heathland and scrub (AL-1b).

Vegetation changes in the Lateglacial stadial (AL-1c) include a major reduction in the abundance of juniper scrub, and increased representation of *Artemisia* and *Polypodium*. *Empetrum* heath continued to dominate the vegetation. Sedimentary changes are indicative of renewed erosion in the catchment and inwash of minerogenic material to the lake.

Holocene woodland development and decline: Successive expansions of *Juniperus communis, Betula* and *Corylus avellana* characterise the beginning of the Holocene. *Empetrum* heath declined and gradually disappeared as juniper scrub spread to dominate the vegetation. *Betula* started to expand at about 10,000 years BP. Juniper scrub contracted as birch woodland with *Salix* became more extensive and shade and competition increased. *Corylus avellana* was the next tree to arrive and spread rapidly to become the woodland dominant at 9,000 years BP. *Ulmus, Quercus* and *Pinus sylvestris* invaded the area at about 8,800 years BP, and *Alnus glutinosa* expanded at 6,400 years BP. Other trees included *Sorbus aucuparia, Populus* and *Ilex aquifolium*.

Open mixed woodland developed. Canopy cover was at a maximum in the early Holocene (9,000-8,000 years BP) but was never continuous; tree and shrub pollen frequencies rarely exceed 80%, and range from 60-70% for the period 8,000-5,000 years BP. Unwooded areas supported a mixture of peatland, heathland and grassland communities which were rich in *Calluna vulgaris*, ferns and herbs.

Woodland disturbance dates from the mid-Holocene. The elm decline at 5,100 years BP preceded a phase of woodland re-expansion attributable mainly to the advance of *Pinus sylvestris*. Tree populations fluctuated and diversity increased as *Fraxinus* and *Taxus* became established. *Pinus sylvestris* expanded and reached its maximum distribution at 4,700 years BP; stomata confirm that pine trees were growing in the catchment at 4,500 years BP. The advance was short-lived and, as *Pinus sylvestris* declined, pine stumps were preserved by the expanding peat deposits. Evidence suggests that pine populations persisted locally until 2,400 years BP. However, changes in AL-4a (3,700-3,400 years BP) are indicative of catchment erosion resulting from disturbance or tree clearance (Fossitt, 1994). There is a possibility that disturbance continued throughout AL-4b and that the final woodland decline has been masked by reworking of sediments.

The *Plantago lanceolata* curve suggests human disturbance may have begun at 5,400 years BP. Cereal type pollen indicates that there was some local crop-growing at 2,500 years BP. By 2,400 years BP the landscape was dominated by treeless blanket peat.

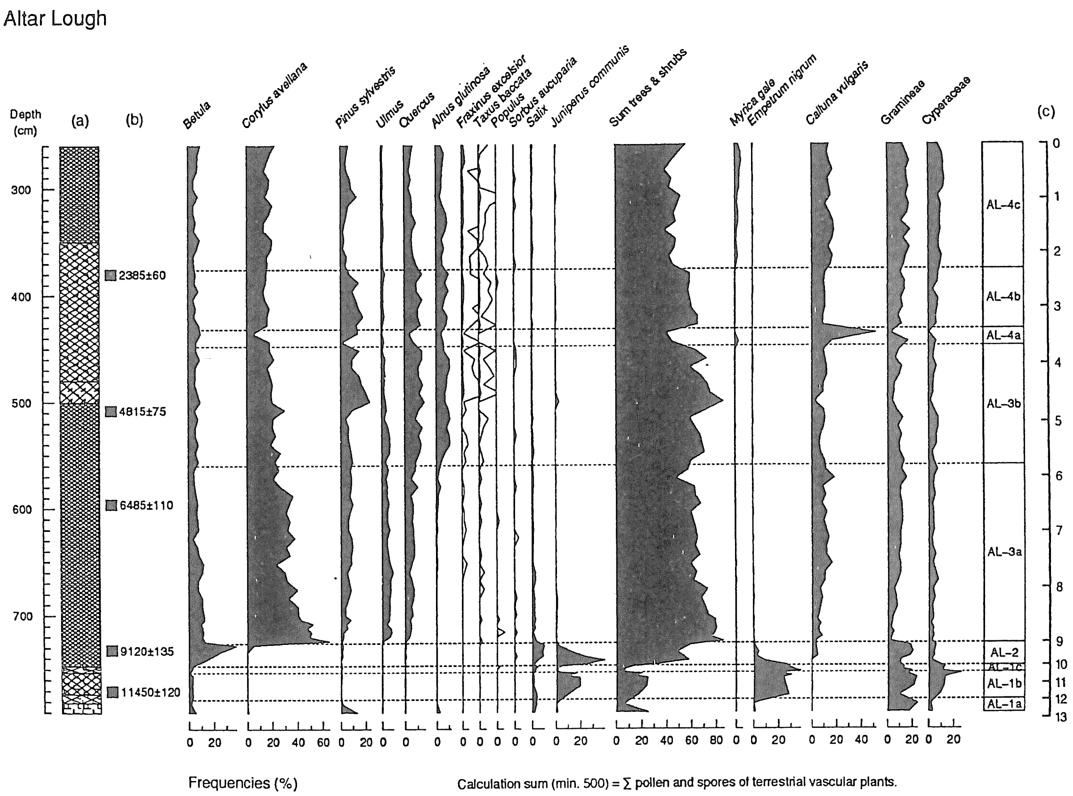

Figure 31. Selected palaeoecological results from Altar Lough, plotted against (a) Troels-Smith (1955) stratigraphic coloumn, (b) ^{14}C samples and age determinations (yrs BP), and (c) an approximate timescale (^{14}C yrs BP x 10^3). Outline curves represent an exaggeration of x10 for minor taxa.

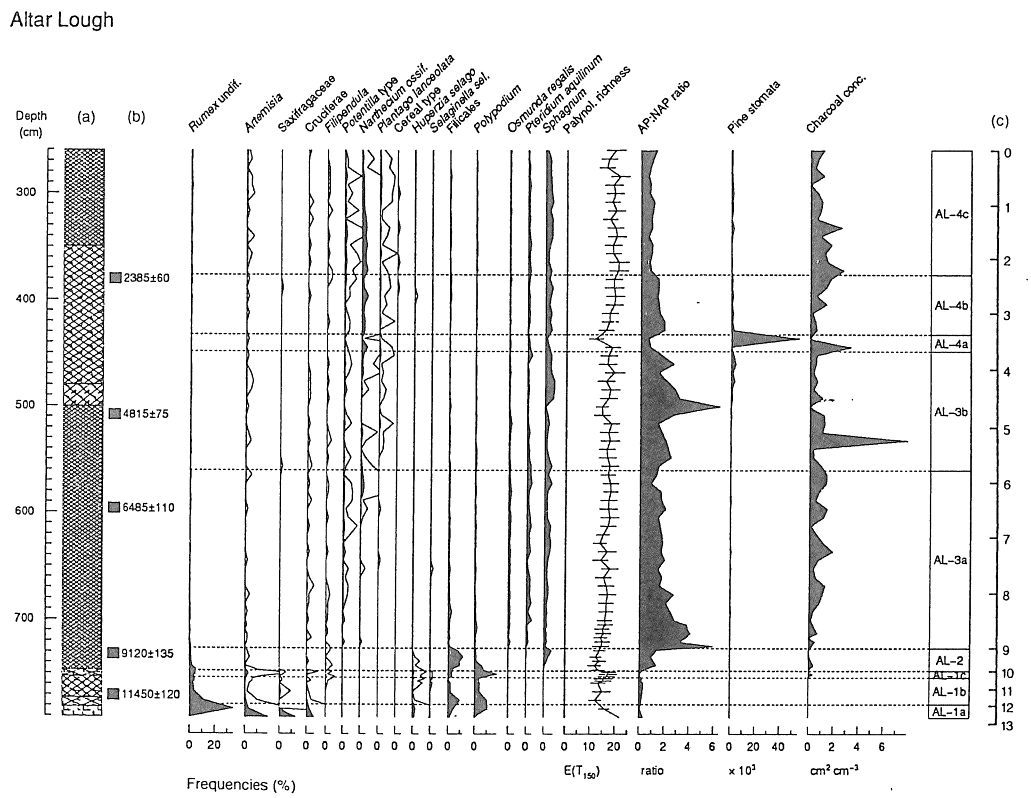

Figure 31. continued.

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