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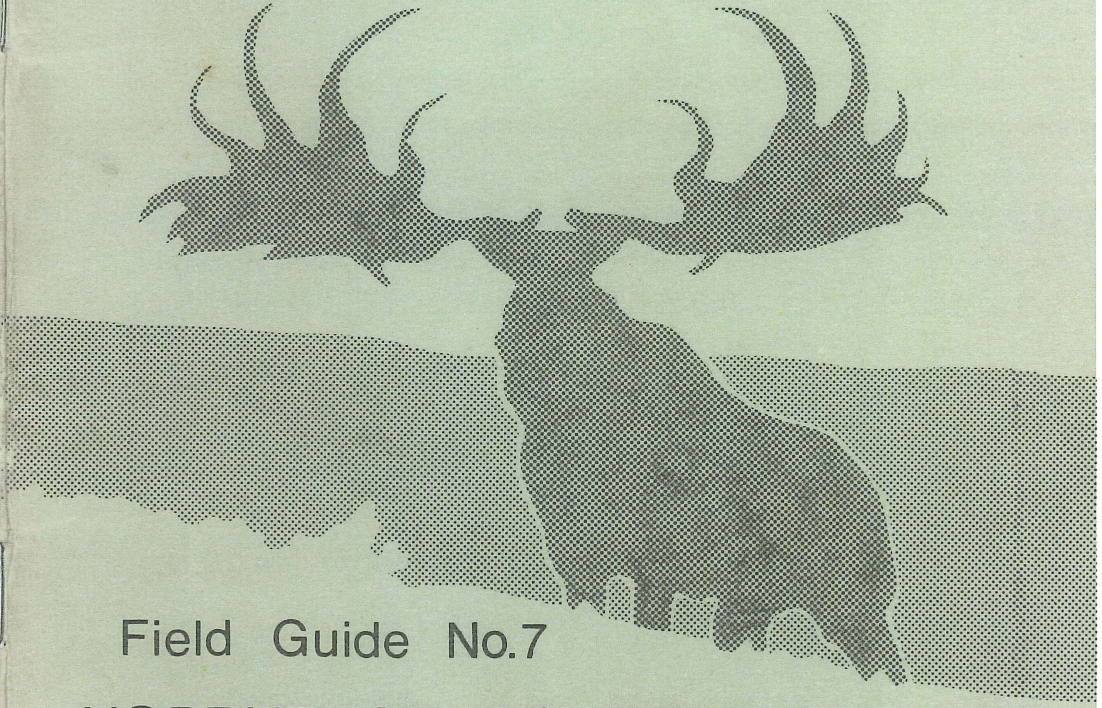

Field Guide No.7

NORTHEAST CO. DONEGAL AND NORTHWEST CO. LONDONDERRY

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Field Guide No. 7

North East Co. Donegal and North West Co. Londonderry (1984)

Compiled and edited on behalf of IQUA

by

P. Wilson and R.W.G. Carter

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IRISH ASSOCIATION FOR QUATERNARY STUDIES

1984 Field Meeting 28th-30th September

North East Co. Donegal and North West Co. Londonderry

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N.I. Ordnance Survey ½" sheets 1&2 are recommended for use in conjunction with this Guide.

PREFACE

This Guidebook has been compiled as part of the IQUA Field Meeting in North East Co. Donegal and North West Co. Londonderry from 28th-30th September 1984. The basic aim of the trip was to examine exposures and structures of Quaternary age along with archaeological sites in the north-west of Ireland and to promote discussion in the light of recent fieldwork. Much of the material included in the Guide is of an informal and unpublished nature and should be treated as such in future citations. Readers and users of this Guide should note that heights given in m OD for Day 1 of the meeting relate to OD Dublin and for Day 2, OD Belfast.

We would like to acknowledge the technical assistance provided by Shirley Tinkler, Kilian McDaid and Nigel McDowell in the production of diagrams for this Guide. We also thank the Natural Environment Research Council (NERC) for providing ^{14}C dating facilities and the British Geomorphological Research Group (BGRG) for a grant towards the cost of one ^{14}C assay.

Peter Wilson & Bill Carter
August 1984.

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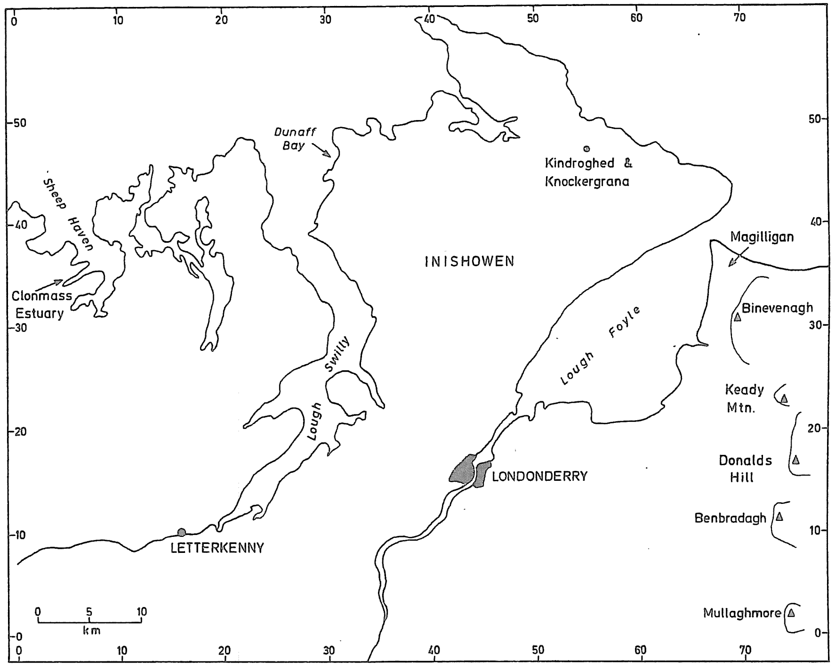

Fig. 1. Location map showing sites visited and others mentioned in the text. Scale given by 10 km Irish Grid.

NOTES ON THE QUATERNARY HISTORY OF NORTH WEST IRELAND

(Bill Carter)

Glacial geomorphology and sedimentology

It is sixty years to the month since Prof. J.K. Charlesworth published his seminal study of the glacial geology of north-west Ireland. Charlesworth was not the first to study the superficial deposits of the north-west, notably both Hull and Kilroe had gone before, describing and mapping the glacial landscape. However, Charlesworth brought to bear a hitherto unmatched objectivity, and his papers still provide an important basis for contemporary research. Charlesworth was a forthright advocate of mountain centred glaciations, spreading out to coalesce in the surrounding lowlands. He was ruthless with those who had thought otherwise. For example, in discussing Lamplugh's concept of a central lowland Irish ice sheet he concludes (Charlesworth, 1924, p. 179);

"There would appear to be no evidence whatsoever that ice in this pool ever assumed such thickness and dimensions as to raise its surface above that covering the ring of hills and cause reversion of the ice-flow."

Thus the Donegal highlands, and to a lesser extent, the Sperrins, were considered to be ice centres, with ice moving south and east into Tyrone, Londonderry, Monaghan and Antrim. Ice sinks formed in the Lough Erne and Lough Neagh basins. These events could be traced by the erratic trains of Donegal granites. Charlesworth did recognise the influence of invading ice sheets from Scottish centres, but considered that they made little impact on the

bastion of Donegal highland glaciers.

Charlesworth envisaged a complex pattern of deglaciation, involving numerous glacial lakes and spillways, forming at progressively lower levels as the ice retreated. Most of the meltwater was thought to have drained south or east, through the west bank tributaries of the Bann, into the greatly enlarged Lough Neagh, and then south into Co. Armagh and Co. Down. Further discussion of these events is given in Dardis (1980) and Carter (1985).

Charlesworth's views prevailed for many years. The sheer thoroughness of his investigations, together with his pre-eminence in Irish glacial geology did not engender much competition. However, in the 1960's and 1970's a number of new studies were undertaken, mainly under the direction of Prof. N. Stephens, then at QUB. Central to this fieldtrip is the work of Colhoun (1970, 1971a, 1971b, 1972), who investigated the glacial geomorphology of the Sperrins and the area to the north around Lough Foyle. Colhoun's approach is based in part on ideas put forward a decade earlier by Synge & Stephens (1960), which questioned the interpretation of some of the morainic ice-limits, and reopened the debate about lowland versus highland Irish ice centres so emphatically closed by Charlesworth 36 years earlier.

Colhoun (1970, 1971a) showed that the glacial stratigraphy of the Sperrin-Foyle region, a transitional one in terms of Charlesworth's 1924 schema, was indeed divided between ice of radically different origins. However, the dominance of Donegal ice was queried, with more attention being paid to extensions of basinal ice sheets from the Bann and Erne valleys.

The proposed glacial stratigraphy of Colhoun is given in Table 1. Two major glacial episodes are recognised, the Sperrinian and the Roeian. These correspond to the Midlandian and Munsterian Stages from Mitchell et al. (1973).

Table 1. Glacial Stratigraphy of North West Ireland (After Colhoun, 1971a and Mitchell et al., 1973).

Stage	North West
Littletonian:	
Late	Coastal dunes
Middle	Beach ridges
Early	Estuarine infill
Midlandian:	
Late	Late-Sperrin Glaciation/Malin raised beaches
Middle	Unknown/Derryvee Interstadial
Early	Unknown
Last Interglacial	Unknown
Munsterian	Dunaff Till/Spincha Till Bovevagh Till/Burnfoot Till Early Sperrin Glaciation
Gortian Interglacial	Unknown

The Roeian - The Roeian is represented by at least three formations. The earliest deposits are local tills associated with small ice centres in the Sperrins and Donegal. These were succeeded by a major ice incursion from the north-east, which crossed the coast and penetrated inland through the Bann, Foyle and Swilly corridors, at least as far south as the Sperrins and

Strabane. Colhoun assumes, via litho-facies similarities (particularly the presence of comminuted shell) and relative chronology, that this deposit is the equivalent of the Irish Sea Till commonly encountered along the eastern Irish seaboard. In the north-west, type sites are found at Burnfoot (C 378 232) at the south end of Lough Swilly, and Bovevagh (C 678 138) in the Roe valley.

The Roeian is concluded by the two local glaciations, represented by the Spincha Till Formation in Co. Londonderry and the Dunaff Till Formation in Co. Donegal. The Spincha is interesting inasmuch as it appears to be the product of basinal ice moving north out of the Lough Neagh-Lough Erne depression and overtopping the Sperrins. The Dunaff is the product of the local Donegal highland ice centre.

The Sperrinian - Of the Midlandian Stage most of the evidence concerns the last 30000 years. The prominent end-moraine that traverses north Londonderry and Donegal marks the outer limit of what Synge & Stephens (1960) termed the Drumlin Readvance Phase, and Colhoun called the late-Sperrin Glaciation. In north Londonderry it is characterised by the Gelvin Till after the type site east of Dungiven (C 749 120). The ice radiated from central Ulster, passing over the Sperrins and the Basalt Scarp and terminating, possibly as sea ice, in the north of the Swilly and Foyle valleys. The Swilly was almost certainly overdeepened by ice scouring at this period (Evans, 1973), assuming the character of a true fiord. The retreat phases of this glaciation are well-marked by a series of retreat moraines and associated glacio-fluvial deposits southward down the Roe and Foyle valleys (Colhoun, 1972;Davies & Stephens, 1978). The overall retreat may have been interrupted by occasional small readvances, as evidenced by the road section at Killyverry, Co. Donegal described by Carter et al. (1979). There is no evidence of the glacial-dammed lakes along the edge of the Basalt Plateau as postulated by Charlesworth (1924). In fact Colhoun (1972) suggests meltwater drained from the ice via the west bank tributaries of the Bann valley over the escarpment into the Roe valley. The morphological evidence for this may be two abandoned waterfalls at Legavannon (C 762 153) and Legananam (C 752 123). The retreat phases were accompanied by intense periglaciation of north-west Ireland (Colhoun, 1971b; Lewis, 1978), resulting in the development of blockfields, stone polygons and structural cryoturbations. The initial stages, at least, of this period are marked by extensive local solifluction deposits, derived from frost shattered material plus earlier glacigenic debris.

There is no direct evidence of the later Scottish Readvance phase in north Londonderry or Donegal, although products of this ice incursion may have been dumped in the vicinity of Magilligan, forming the sediment supply for the Littletonian beach ridges.

Coastal changes

Late- and post-glacial shoreline studies in the north-west have recently been reviewed by Carter (1982a) and covered by Devoy (1983). The former represents the only attempt to date to draw a sea-level curve for the area (Fig. 2). A brief summary of

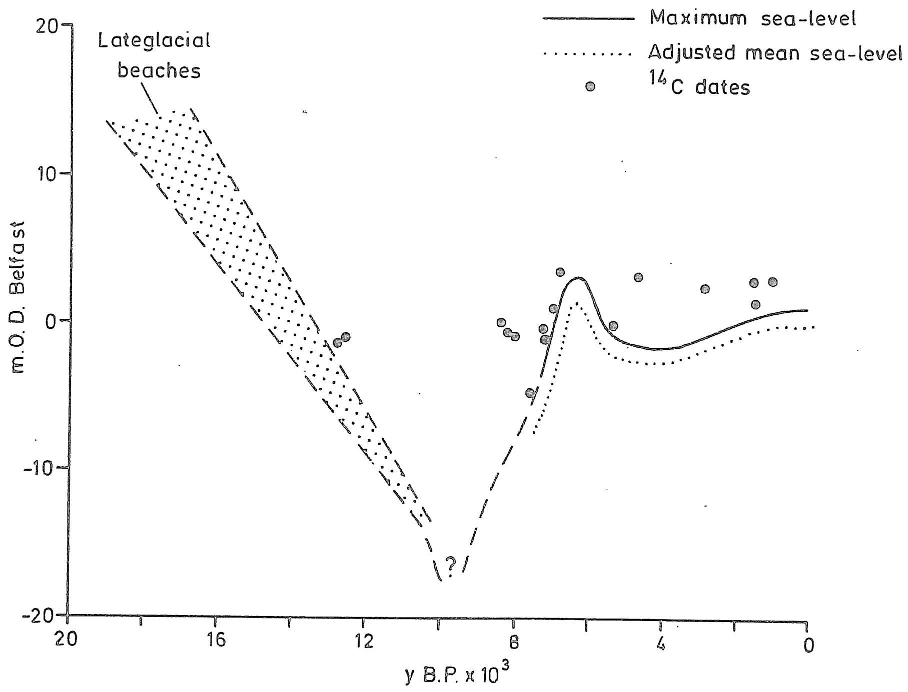

Fig. 2. Late- and post-glacial sea-level curve for the north coast of Ireland (modified from Carter, 1982a).

events will be outlined.

During the Sperrinian, isostatic depression of north-west Ireland led to high stands of sea-level along the north coast. These shorelines, probably contemporaneous with the presence of ice, remain as raised features up to 20 m above present sea-level, especially around Malin Head and Fanad Head (Stephens & Synge, 1965) and caused deposition of muddy estuarine sediments in a number of localities. During and after deglaciation the land rose, so that sea-level fell away to an unknown lower limit around 11000-10000 yr BP. This isostatically controlled marine regression involved a vertical drop of at least 30 m off the north coast, and would have exposed a wide area of the Malin shelf. About 10000 yr BP - the commencement of the Littletonian Stage - the rate of eustatic sea-level rise began to exceed the declining isostatic sea-level fall. The net result was that the sea rose again, eventually crossing the present coast about 8500 yr BP. The maximum transgression occurred about 7000-6500 yr BP (Colhoun et al., 1973; Carter, 1982a), and is marked by a widespread near-horizontal, raised shoreline around the coast. After 7000 yr BP the isostatic rate again outstripped the, now waning, eustatic rate. In the north this resulted in quite a definite 'peak' in the sea-level curve (Fig. 2), which has been dated, in the Bann Estuary, by Battarbee et al. (in press) and Hamilton & Carter (1983) to around 7500-5500 yr BP. The subsequent fall in sea-level away from this peak has had important sedimentological consequences. Falling wave base, over a shelf strewn with clastic glacigenic debris, led to the feeding onshore of massive amounts of material. In such conditions of sediment abundance, beach ridges and, later, dunes formed. We know that dunes were forming in the Bann Estuary as early as 5300 yr BP (Hamilton & Carter, 1983). The adjustments of the estuarine environments to this sediment supply, has resulted in infilling, and the gradual exclusion of sub- and even intertidal influences. The final stage of supra-tidal marsh and then alluvial cover is recorded at some sites like Clonmass.

The post-5000 yr BP history of sea-level is not well-known. There are virtually no ^{14}C assays on unequivocal index points.

A pragmatic assessment would be that sea-level may well have fallen and then risen to present level over a 2 or 3 m range, although there are severe difficulties in discerning former sea-levels on high energy coasts (Carter,1983). The end of the sea-level fall may be marked by the cessation of beach ridge formation at Magilligan and within Sheep Haven. Interestingly, present sea-level also appears to be falling. Data from the Malin Head tide gauge indicates a fall of 2.4 mm/yr since 1960 (Carter, 1982b). This trend may be very local, but could indicate the last vestiges of isostatic delevelling in Ireland.

Recent coastal changes must be viewed in the context of a slowly evolving sediment system. The coast is 'mature' inasmuch as there is very little longshore transfer of material, and the little there is, tends to form part of circulatory estuary mouth/near-shore exchanges.

CLONMASS ESTUARY (John Shaw)

The estuary is situated within Sheephaven (Fig. 1). Refracted Atlantic swell approaches from the north-east after initially entering Sheephaven from the north-west. Sediment, typically medium quartz sand with a spatially varying content of biogenic carbonate, passes seaward in an ebb channel and is returned landwards on relatively shallow areas exposed to strong flood flows late in the tidal cycle. Clonmass Bay is, however, relatively small and lacks some of the tidally generated features such as flood and ebb deltas which characterise larger Donegal estuaries such as Ballyness Bay, Loughros More and Trawbrega Bay.

At Clonmass, a documented ebb channel migration has allowed wave action at the estuary mouth to erode a dune system (Fig. 3). The sediment transport system which was set up deposited the sand a short distance away as a series of dune ridges. The cause of the ebb channel shift may have been a reduction in the tidal prism due to reclamation of land in the upper estuary c. 1820.

Upper Clonmass Estuary (C 060 345)

Enter the Ards Forest Park via the main access point which is approximately 5 km from Cresslough on the Cresslough-Dunfanaghy road. Follow the access road as far as the bridge. The site is about 100 m north of the bridge in a low lying area flooded by high spring tides.

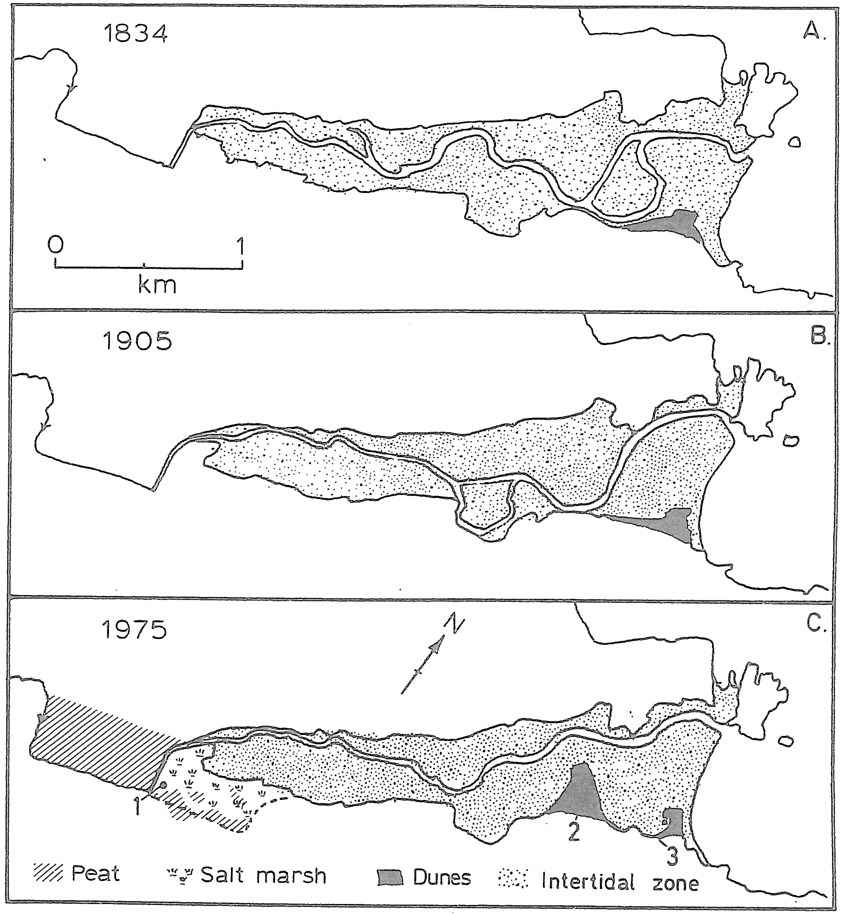

Fig. 3. Clonmass Estuary in 1834, 1905 and 1975. The shift of the main ebb channel to the north was accompanied by the erosion of pre-existing coastal dunes and the growth of a new dune system.

A vibrocorer core was retrieved from a peat covered area (1 on Fig. 3C) and a second core was retrieved at a slightly lower elevation about 40 m to the north-west. The stratigraphy indicated by the two cores is shown in Fig. 4.

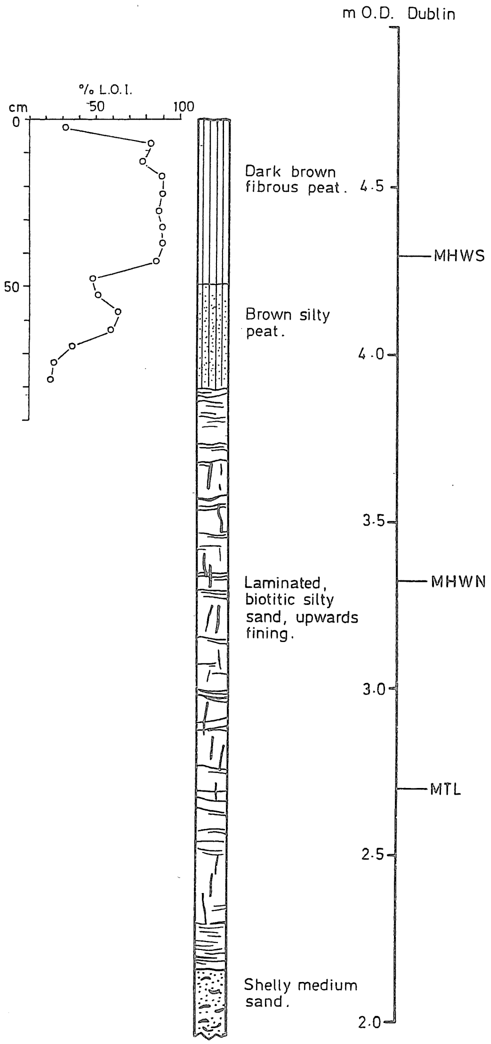

Fig. 4. A regressive sediment sequence in the upper Clonmass Estuary. Fibrous and silty peat overlie upwards fining silty sand with vertically oriented monocot roots.

About 50 cm of dark brown fibrous peat grades into 30 cm of brown silty peat. This rests on 1.64 m of laminated biotite-rich silty sand with frequent vertically oriented monocot roots. Calcium carbonate is absent from this silty sand and the silt content increases from 10% at the base of the unit to 50% at the top. Foraminifera are present and the unit was probably deposited in the upper part of the inter-tidal zone in an estuarine environment.

The basal unit consists of medium sand with biogenic carbonate. The whole sequence is interpreted as regressive in the sense of a lessening of marine influence at the site, so that the upper fibrous peat formed in an environment free from salt water inundation.

A sample for ^{14}C assay was taken from the base of the brown silty peat but the date is not yet available.

Fig. 5 is a relative pollen diagram constructed using data from samples taken at 2 cm intervals. The lower peat unit has high values of <u>Plantago maritima</u> and Chenopodiaceae are present, while the upper peat has increased values for Ericaceae. During its formation, the lower peat was subject to flooding by estuarine water while the upper peat was probably free from this kind of influence. The pollen evidence seems to substantiate the sedimentological evidence that a regression occurred, due either to a fall in relative sea-level or to sediment accumulation and peat growth.

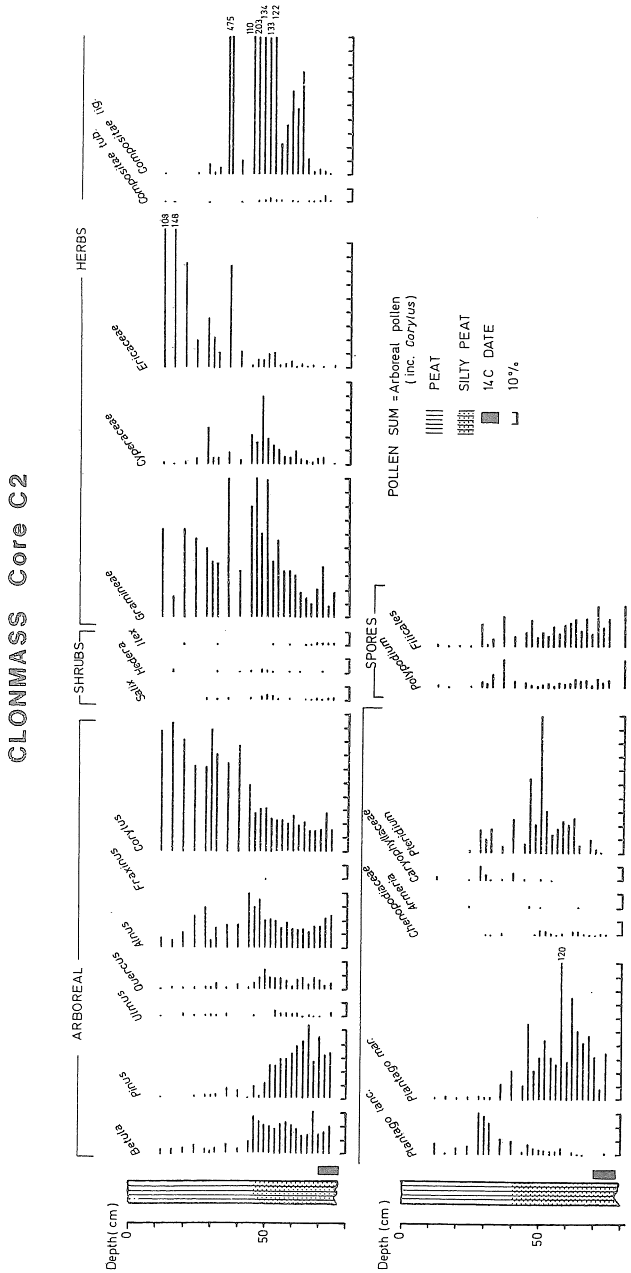

Fig. 5. Relative pollen diagram for the fibrous and silty peat at the upper Clonmass Estuary site.

The arboreal section of the diagram gives some indication of the site chronology. The decline of Pinus pollen is a reasonably synchronous event in Ireland (Smith & Pilcher, 1973) and typically occurs around 4000 yr BP. Pinus pollen is absent from another site (3 on Fig. 3C) at Clonmass by 3600 yr BP at the latest but Telford (1978) dated the event at 2550 yr BP at Glenveagh, 12 km to the south. The problem is that Pinus disappearance may be due to the lessening of marine influences at the boundary of the fibrous peat and silty peat, since over-representation of Pinus pollen in estuarine sediments is well documented (Godwin, 1956, p. 259). Since there are indications that at 3600 yr BP relative sea-level in the area was at least 1 m lower than at present, it seems that the Pinus decline here may be the natural decline, dated to about 4000 yr BP, and not an artifact of lessened marine influence. The commencement of silty peat accumulation was therefore before 4000 yr BP but probably after 5200 yr BP, the date of the Ulmus decline (Smith & Pilcher, 1973), since Ulmus values are very low throughout the sequence. The pollen evidence thus indicates a regression due to a fall in relative sea-level post-5200 yr BP and pre-4000 yr BP.

Clonmass Dunes (C 075 354)

Enter Ards Forest Park and leave vehicle in the main car park. After consulting the guide-map in the car park, follow the coastal path northwards. The path leaves the shore and climbs through an area of mixed forest. Keep left at the Y junction and follow the path as it descends. Where the path leaves the forest, turn left to enter the dunes.

Fig. 6 traces the growth of a cuspate foreland since 1905, and is based on evidence from maps and air photographs. A simple sediment transport cell caused erosion in the east and deposition a short distance westwards. The foreland is composed of a series of dune ridges whose average elevation is approximately +9.5 m OD (MHWS for the area is +4.3 m OD). A distinction is drawn between these aeolian features and the swash formed beach ridges which comprise the cuspate foreland at Magilligan, Co. Londonderry.

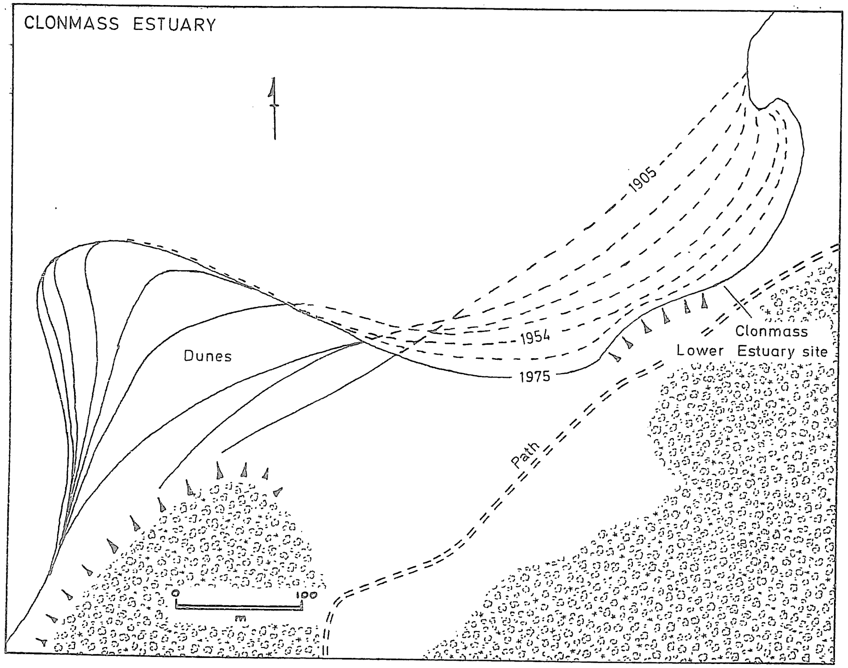

Fig. 6. Evolution of the dune ridge system at Clonmass since 1905.

The reason why dune ridges should form rather than beach ridges is uncertain. What is apparent is that each new ridge was more adjusted to the prevailing north-easterly swell than its

predecessor. It is unlikely that the growth of the foreland will close the estuary completely since the mean velocity of the ebb jet will increase if the exit is constricted.

The cause of the growth of the foreland is speculative. It is possible that an equilibrium existed, with sediment moving landward by swell wave action and being carried seaward in the ebb channel. If the tidal prism was reduced by land reclamation in the upper estuary, the ebb channel may have been forced to migrate, allowing erosion of the dunes by wave action.

<u>Lower Clonmass Estuary</u> (C 075 355)

Access is as for the dune site but continue further along the path until a small embayment with dune cliffs is visible to the left. Leave the path and descend to the beach.

Erosion of coastal dunes at this site has exposed a sequence of organic-rich sediments. Fig. 7 shows the positions of eight pits dug to investigate these sediments. A simplified stratigraphy with the location of five ^{14}C dated samples is shown in Fig. 8.

The upper sedimentary unit consists of up to 5 m of cross-bedded carbonate-rich aeolian sand. The deposition of this sand post-dates 800$\pm$40 yr BP (SRR-2399). This date was obtained from the uppermost of a number of thin organic-rich layers located within a unit of greyish brown (10YR5/2-4/2) carbonate-free sand (Fig. 8). Below this sand a thicker organic-rich unit was dated to 3600$\pm$50 yr BP (SRR-2398). This layer dips to the north-east and

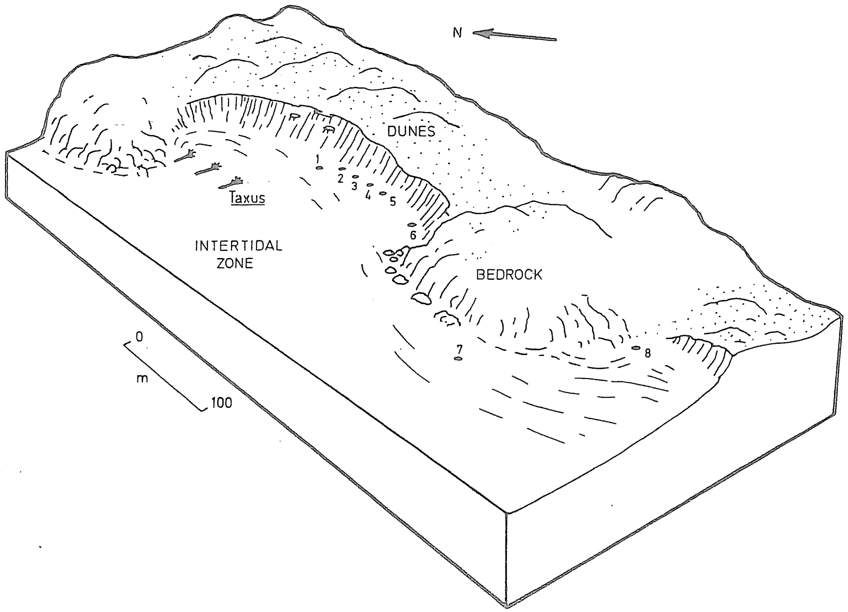

Fig. 7. A diagrammatic view of the eroded dunes at the lower Clonmass Estuary site, showing the location of pits dug to investigate the sediments.

thickens to a maximum of 20 cm before rising in height further along the beach and finally wedging out. The thickest part of this unit consists of compacted fen peat with disseminated sand grains throughout. A Taxus seed was found in this material as were fragments of Taxus and Alnus wood. A pollen diagram for the peat indicates a wooded environment. Herb values are highest at the base and top of the peat, suggesting that coastal dunes stabilized and became wooded with peat forming in inter-dune depressions. Of note is the absence of Pinus pollen, indicating the disappearance of this tree from the area by 3600 yr BP. Peat accumulation ceased with a return to drier conditions and an increase in the influx of aeolian sand.

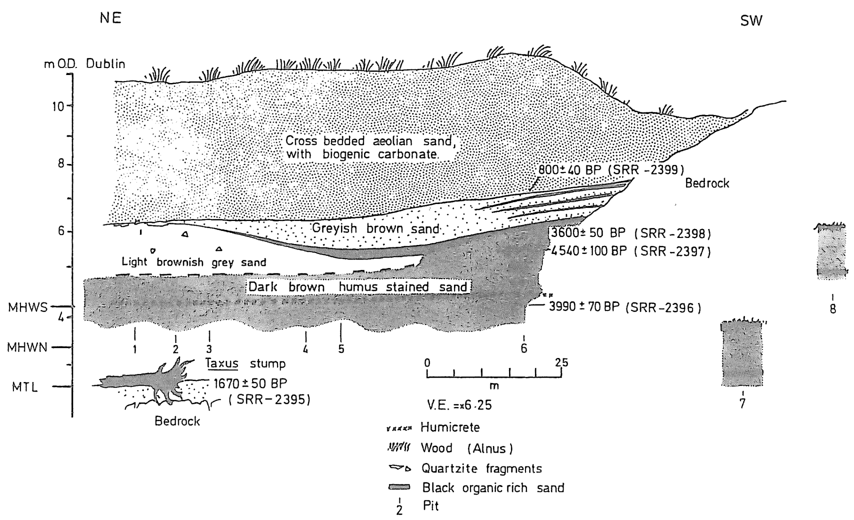

Fig. 8. Simplified stratigraphy at the Lower Clonmass Estuary site.

Underlying the peat are medium sands lacking in carbonate. Towards the north-east the sand has a bleached appearance (10YR5/1) and contains scattered angular fragments of quartzite and small pieces of charcoal. Closer to the bedrock outcrop it is very dark brown (10YR2/2) due to organic staining and contains abundant vertically oriented Alnus fragments typically 2-4 cm in diameter. A concentrated zone of these remains occurs in pits 6, 7 and 8 and a sample yielded a ^{14}C date of 4540$\pm$100 yr BP (SRR-2397). Other Alnus fragments taken from 75 cm below this zone returned a date of 3990$\pm$70 yr BP (SRR-2396) (Fig. 8). The simplest explanation for this inversion is that the younger sample consists of in situ root fragments while the overlying sample is allochthonous material. However, since the older Alnus remains are generally vertically oriented it may also be suggested that they too represent in situ fragments. This anomaly is not easy to resolve and the possibility of sample contamination cannot be ignored.

10 cm above the lower Alnus fragments is a black (10YR2/1), lustrous, 1 cm thick layer of cemented sand (Fig. 8). This resembles a humicrete, similar to those described by Pye (1982). The iron content of this material is low (0.13%) but %Loss-on-Ignition is relatively high (10.44%). Cementation of the sand grains probably occurred at the water table. The formation of the humicrete layer most likely post-dates 3990 yr BP, the age of the lower Alnus material, even if this material is a root (since it is judged unlikely that roots could have penetrated the humicrete zone). Because the humicrete is found at +3.00 m OD, in Pit 7 (i.e. more than 1 m below MHWS), a depression in mean relative sea-level of at least 1 m at the time of humicrete development is indicated. This assertion rests on the assumption that the water table was at least at MHWS.

Tree trunks lying on the beach below +3.00 m OD were identified microscopically as Taxus baccata and the outer wood of one trunk was dated to 1670±50 yr BP (SRR-2395). Considering the presence of Taxus fragments and a seed in the layer dated at 3600 yr BP, a long presence is indicated at the site. Initially it was believed that the trunks were in situ and had merely toppled over (some of the roots are wedged into rocky crevices which contain organic-rich sand). If this were the case, a depression in mean relative sea-level at the time of tree growth would be indicated. It is possible, however, that the trees were growing at a higher elevation and dropped vertically to their present position when the dunes were eroded.

Most of the sediments at the site are believed to be of aeolian origin and coastal dunes were probably in existance at 4540 yr BP. Periods of stability alternated with periods of increased aeolian activity. The deposition of the upper carbonate-rich sand was very rapid and may be due to the erosion of dunes further seaward. A depression of mean relative sea-level of at least 1 m seems likely at 3990 yr BP.

Table 2.

Profile Data - Pit 4 Lower Clonmass Estuary

m OD	Colour	% Loss-on-Ignition	Fe (ppm)	%$CaCO_3$	Unit Description
5.94-6.04	10YR6/4	1.48	1.91	37.68	Carbonate-rich sand
5.87-5.90	10YR4/2	0.55	1.01	0.25	
5.75-5.85	10YR5/3	0.42	0.86	0.41	Greyish brown sand
5.55-5.65	10YR5/2	0.20	0.33	0.37	
5.38-5.46	10YR2/1	38.71	0.36	0.89	Organic-rich sand
5.30-5.38	10YR3/1	1.45	0.05	0.50	Very dark grey sand
5.10-5.20	10YR6/2	0.10	0.00	0.16	Light brownish grey sand

Profile Data - Pit 6 Lower Clonmass Estuary

m OD	Colour	% Loss-on-Ignition	Fe (ppm)	%$CaCO_3$	Unit Description
6.68-6.78	10YR6/4	1.17	1.82	33.93	Carbonate-rich
6.66-6.68	10YR5/2	1.05	1.66	27.77	sand
6.63-6.66	10YR2/1	8.18	-	-	
6.40-6.50	10YR5/2	2.40	0.38	0.45	Greyish brown sand with
6.30-6.33	10YR2/1	12.19	1.02	0.68	organic-rich layers
6.15-6.25	10YR4/2	0.48	0.00	0.44	
6.00-6.10	10YR2/1	18.45	-	-	Organic-rich sand
5.90-6.00	10YR2/1	8.10	0.64	0.59	
5.70-5.80	10YR2/1	3.05	0.94	0.52	
5.50-5.60	10YR2/1	2.78	0.88	0.26	
5.33-5.43	10YR2/2	2.83	0.90	0.29	Dark brown organically
5.13-5.23	10YR2/2	3.08	0.64	0.41	stained sand
4.93-5.03	10YR2/1	2.08	0.63	0.37	
4.73-4.83	10YR2/2	2.03	0.38	0.36	
4.53-4.63	10YR2/2	1.82	0.26	0.26	
4.34-4.43	10YR2/2	2.31	0.50	0.21	
4.33-4.34	10YR2/1	10.44	0.13	0.62	Humicrete layer
4.23-4.33	10YR2/2	1.81	0.26	0.60	Dark brown organically stained sand

INISHOWEN (Brian Lacy)

Although Woodman (1978) has suggested that "the inlets of north Donegal would have been admirable areas for settlement" during the Mesolithic, few remains of that period have as yet come to light in the county. Prof. Woodman has documented a number of Mesolithic objects from the county including a collection from the Finn valley, among which was a group of flint implements which could be early Mesolithic in age. A probable Bann flake was found at Horn Head and what was possibly an early Mesolithic axe is said to have been found at Dunfanaghy, although it cannot now be identified. More recent palynological analysis of samples from Aranmore Island, by John Shaw of NUU, suggests possible early human occupation there. However, only one site in the county can be definitely assigned to the Mesolithic.

Dunaff Bay (C 310 460)

The site is located in the townland of Urrismenagh and lies on the slope between the coast road and the beach, almost at the mid-point of the bay.

Dunaff Bay (Fig. 1) lies near the mouth of Lough Swilly on the north-west side of Inishowen. There are numerous traces of post-glacial raised beaches around the bay and during the course of geological investigations of these in the 1960's, Stephens & Synge found "an almost complete section of the lowest ancient beach exposed in a disused gravel pit". Flints were found in the upper levels of the section and the site was subsequently re-examined by Addyman & Vernon (1966). A number of stratified

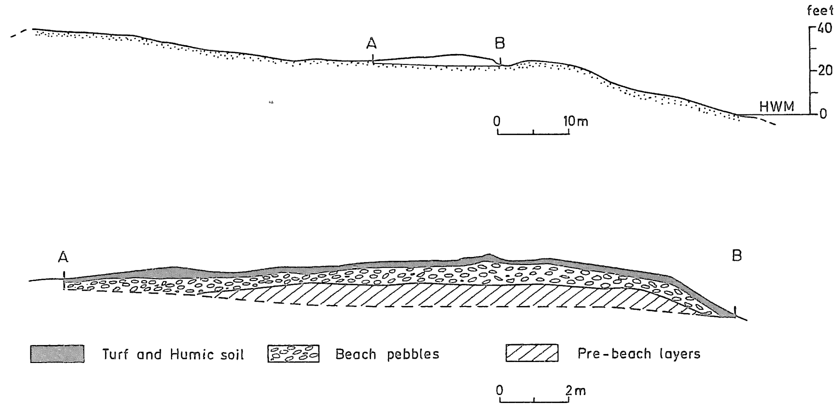

Fig. 9. Dunaff Bay. Profile and section of beaches (After Addyman & Vernon 1966).

flints were systematically collected from the section as well as loose finds from the surface of the gravel pit and three small hills to the east and south of the site. The stratified material came from the shingle layers of the ancient beach and from the overlying soil (Fig. 9). No significant differences were noted between the finds from the individual layers or between stratified and unstratified material. The flints, which for the most part consisted of waste material, were recently re-examined by Prof. Woodman. They were mainly derived from "uniplane single-platformed cores". Four rough scrapers or spokeshaves were discovered in the collection. Most of the flints were unabraded and unrolled and thus their deposition was deemed to have been contemporary with the formation of the beach. The raw material for the production of the objects consisted of "well rounded light grey flint beach pebbles from 2 to 8 ins. in diameter". It is most likely that these were humanly imported to the site from the adjacent chalk areas in counties Antrim and Londonderry.

The age of the beach is uncertain. It could be an ancient, high storm beach but, according to Addyman & Vernon (1966) was most likely formed by the post-glacial maximum marine transgression, contemporary with the Atlantic pollen zone. Pollen analysis, carried out on a sample from a nearby bog (by J.R. Pilcher), showed heavy afforestation and milder conditions in the area during the Atlantic period. The site has been interpreted as the location of a small flint industry, perhaps the part-time activity of a group of offshore fishermen who had the capacity to return with cargoes of flint as well as fish. Alternatively the site could represent the similar industrial activity of a group drawn to the location for the annual salmon run up Lough Swilly, in May or June, or for seal hunting.

<u>Kindroghed and Knockergrana</u> (C 556 469)

Follow the road north-east through Kindroghed "houses". The standing stone, which marks the site, can be seen from the road three fields in on the left on a slight rise.

Since the 1st edition of the OS 6" sheets (1835) a standing stone has been marked in this position. However, recent turf cutting has revealed an extensive collection of monuments some of which at least appear to pre-date the growth of the blanket bog (Fig. 10). Some of these monuments have been revealed by the complete removal of the turf, others are partly concealed and

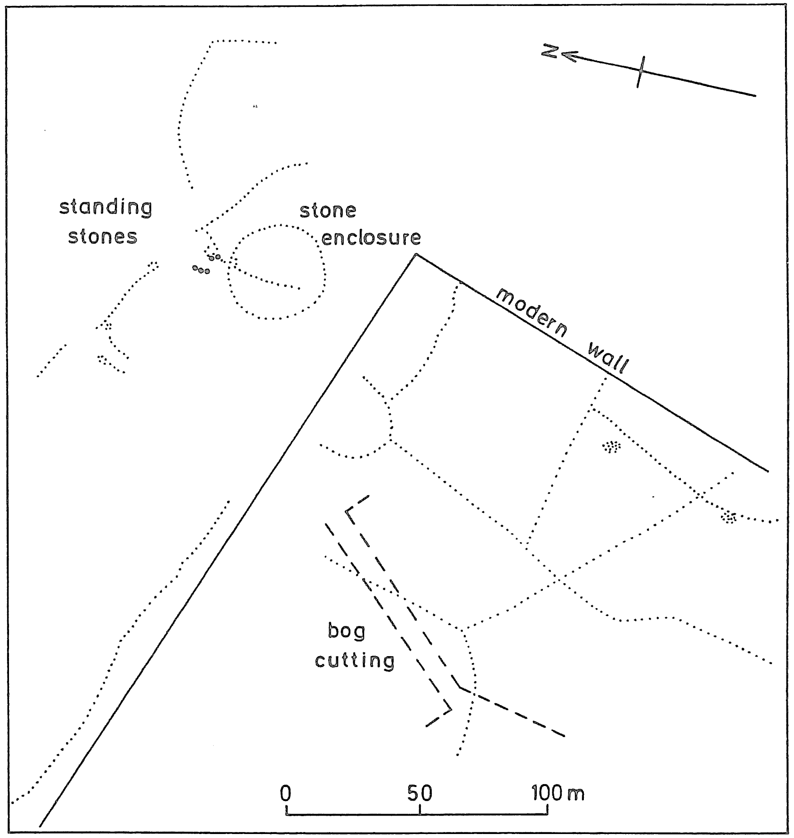

Fig. 10. Plan of Kindroghed and Knockergrana pre-bog remains.

others still, invisible on the surface, have been traced using the system of bog probing devised by Dr. Seamus Caulfield (UCD) at similar sites in north Mayo. The collection of monuments includes: stretches of wall,"field" enclosures, cairns, large circular enclosures, small sub-rectangular or sub-circular enclosures and standing stones. These latter may originally have formed part of a more complex structure such as a megalithic tomb. A Neolithic court-tomb, consisting of a mound 31 m long with a three chambered burial gallery, is located c. 400 m to the west of the pre-bog complex. Also some 250 m west of the site is a flat-topped natural boulder, on the top surface of which are carved 8 cup-marks. The general location of this complex and its association with the nearby monuments is suggestive of a pre-historic date, in the Neolithic or Bronze Age periods. This would be in line with the dates demonstrated by excavation for similar monuments in other parts of western Ireland. Similar pre-bog complexes have been found in other parts of Donegal, and Donegal is exceptionally rich in megalithic monuments of the Neolithic and early Bronze Age. In 1981 pupils from the Carndonagh Community School, with the advice of Dr. Alan Hamilton (NUU), carried out an investigation of the site including some pollen analysis. The results were successfully submitted to the Young Scientist of the Year competition.

MAGILLIGAN (Bill Carter, Alan Hamilton, Jim Mallory & Peter Wilson)

The Giant's Walk (C 662 303)

The site is on private land to the west of the main A2 road at Ballycarton, about 1 km north of the Roe Bridge and 1 km south of Bellarena station. The ridge runs parallel to the minor road leading west to Ball's Point. There are no sections currently exposed in the ridge.

The Giant's Walk is a gravel beach ridge complex formed at the time of the maximum transgression about 6500 yr BP (Carter, 1982a). The ridges comprise a wide range of rounded and sub-rounded clasts, including granites, quartzites, pelites and basalts, almost certainly derived from outcrops of late-Midlandian boulder clay which form the now abandoned cliffs to the north and east around Gort and Duncrun. Marine shells (mainly *Patella* sp. and *Littorina* sp.) were found some years ago during excavations for a septic tank at Bellarena Lodge. Unfortunately none were submitted for isotope analysis, and attempts to locate more shells in 1982 proved fruitless.

It is assumed that an estuary margin spit developed at the time of the maximum transgression fed by a southerly moving littoral current. The maximum height of the ridges is 12 m OD, but the gravel cores are covered by a veneer of blown sand of variable thickness. There are great difficulties in judging the heights of marine gravels in respect of sea-levels (Carter, 1983), and it is assumed the spit formed when sea-level was eroding the

Duncrun cliffs around 7 m OD (present sea-level in the area is 0.1 m OD, and the Spring tide range is 2.7 m). The spit almost certainly extended further seaward than its present truncation point of Ball's Point. The Giant's Walk forms the nucleus of the Magilligan beach ridge plain.

Gort/Duncrun cliff (C 680 320)

The minor road at Glebe (opposite Bellarena school) traverses the raised beach/cliff at Gort.

The Littletonian raised shoreline may be traced from north of the Giant's Walk for almost 10 km until it merges with the modern beach at Downhill. The cliff is cut into boulder clay, but is now badly degraded, with only occasional exposures. A marine notch associated with this shoreline falls at a constant altitude between 6 and 8.5 m OD throughout its length.

Tircrevan Burn Bridge (C 707 318)

The bridge is on the minor road between Lower Ballyleighery and Gortmore townland at c. 200 m OD. The section is visible in the gully to the south of the bridge, but cannot be approached on foot.

The small stream culvert under the road on Tircrevan Burn has eroded a deep gully in a thick matrix-dominated boulder clay overlain by soliflucted material. The stone composition is mainly basalt. No fabrics or stone counts have been made on the section, but it would appear to be related to an early retreat phase of the late-Sperrin Glaciation (late-Midlandian) in Lough Foyle, described by Colhoun (1972). Colhoun does not

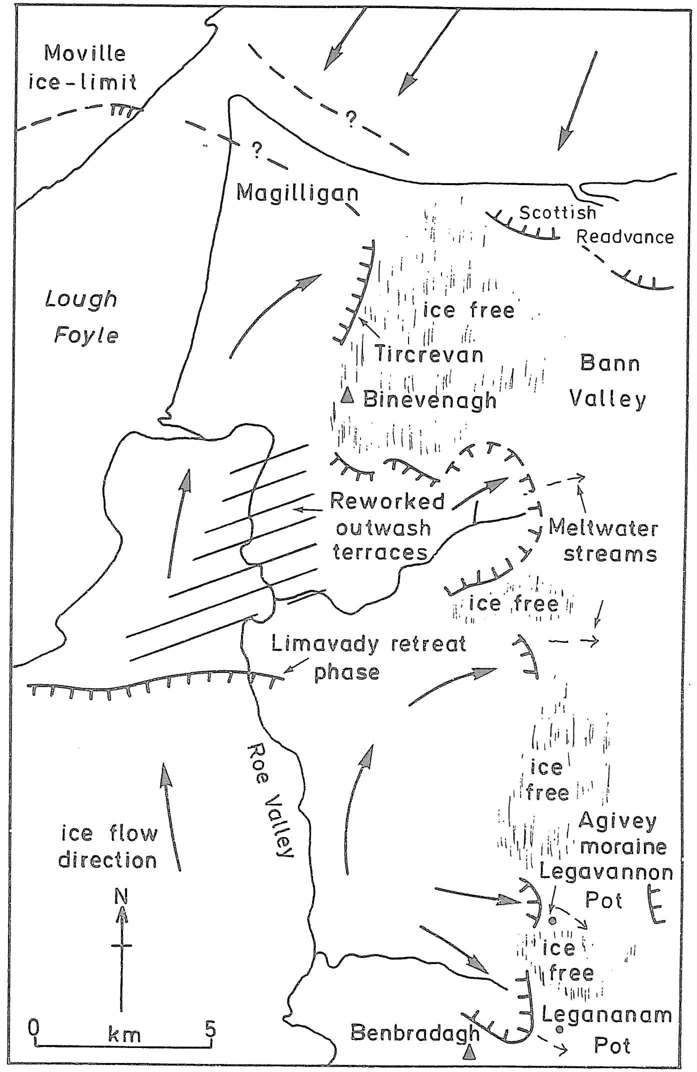

Fig. 11. Late-Midlandian ice-limits in the Roe valley and Lough Foyle. The northerly moving ice formed part of the late-Sperrin Glaciation of Colhoun (1972), the southerly moving ice part of the Scottish Readvance of Charlesworth (1924).

discuss this particular site, but does record similar scarp flank glacial diamicts at the same height (200-270 m OD) on Keady Mountain about 7 km to the south, and again on the southern side of Binevenagh itself at Largantea Burn at 200 m OD.

Gortmore Viewpoint (C 716 343)

Prominent viewpoint on the Bishop's Road from Limavady to Downhill. A path leads 100 m from the car park to a cliff top viewing site.

From Gortmore a panoramic view of the Magilligan beach ridge plain and Lough Foyle is available.

Both Charlesworth (1924) and Colhoun (1972) suggest that Magilligan marks the site of the maximum late-Midlandian ice-limit (Fig. 11). Charlesworth drew the limit of the Scottish Readvance along the line of the foreland, while Colhoun suggested it may indicate the northerly limit of the late-Sperrin Glaciation. Although the inner foreland is underlain by thin glacigenic deposits, there is no prima facie case for accepting either of these suppositions. However, it is likely that the bulk of the foreland sediments are of glacial origin.

The beach ridge plain, the best example in Ireland, occupies the north-eastern corner of the Lough, and comprises at least 35 Atlantic shore-parallel ridges between 150 and 300 m in width (Fig. 12). The inter-ridge depressions have provided shallow basins for the accumulation of lacustrine and marsh deposits (see site M/LF 2). The ridges maintain a constant width along-

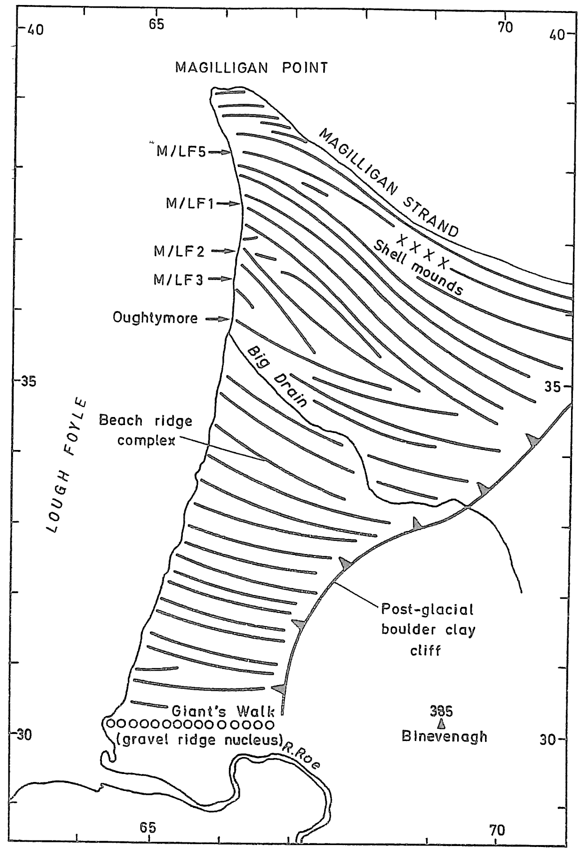

Fig. 12. Magilligan Foreland with locations of some of the sites mentioned in the text.

shore indicating that they are not the result of an east-west longshore drift. Rather they appear to have built up in response to a gradually falling wave base-level after the peak transgression about 6500 yr BP. The ridges have been covered by aeolian dunes. To the south the dunes are merely decoration, perhaps only a few centimetres thick, but to the north the dunes are 15-17 m above the beach ridge tops. The development of these higher northerly dunes is almost certainly associated with the cessation of sea-level rise and the inevitable erosion of the seawardmost ridges. The dunes are underlain in places by marine shell banks (Carter, 1975a). A shell sample from one of these banks has been recently ^{14}C dated to 1190±50 yr BP (SRR-2439). The banks are not anthropogenic shell middens.

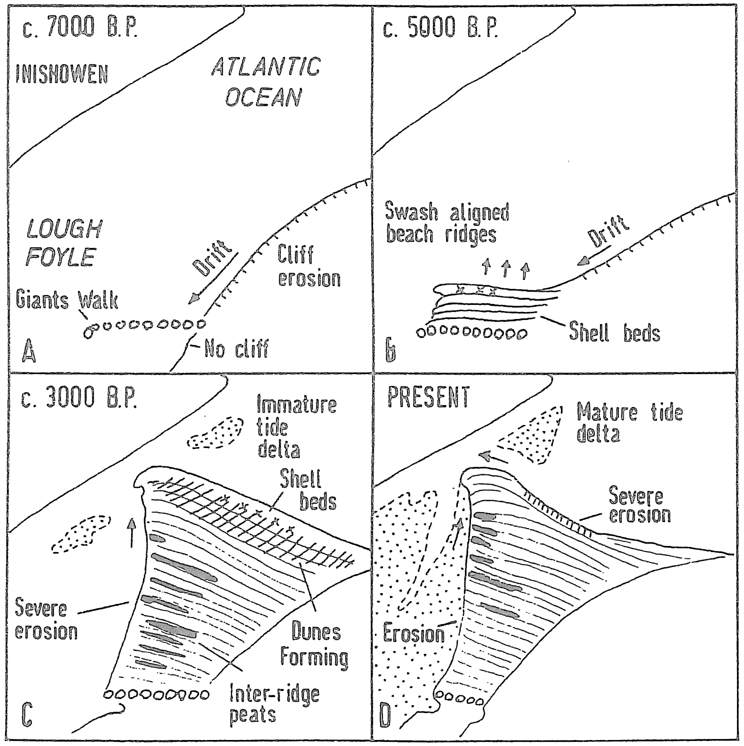

Fig. 13. Littletonian evolution of Magilligan Foreland (After Carter 1982a).

The main tidal channel of the Lough runs along the line of the Foyle Fault (an Irish extension of the Highland Boundary Fault). The distal extremity of the beach ridge plain advances and retreats as part of a sediment budget embracing the adjacent Atlantic and Foyle shorelines and the ebb residual shoal to the north-east. The budget displays a crude cyclicity of around 40 years (Carter, 1975b). The Littletonian evolution of Magilligan is necessarily speculative (Fig. 13). The beach ridge plain was substantially formed between 6500 and 2500 yr BP. It is postulated that ridges formed somewhat further seaward than the present coastline, only to be cut back by later erosion. Carter <u>et al</u>. (1982) suggest that the gradual development of the ebb shoal was partly responsible for onset of ridge erosion, via the perturbation of the incident wave field. Continuing erosion of the ridge structures is feeding the periodic fluxes monitored at the distal point but the overall trend is one of gradual redistribution of sediment from the shore onto the shelf or into the Foyle.
(RWGC)

The Lough Foyle Shoreline

The shoreline is reached by a minor road that leaves the main A2 at the Big Drain Bridge. The road passes Magilligan Prison and security checks are common. Road-side parking is available only when the road turns parallel to the shore.

Much of the evidence for the evolution of Magilligan Foreland is visible in cliff sections along the Lough Foyle shoreline (Fig. 12). Buried soils, peat lenses, marls and archaeological remains occur in many of the exposures and have yielded extremely valuable data for palaeoenvironmental interpretations.

Site - M/LF 1 (C 662 374)

Zones of strongly colour-differentiated sand that resemble horizons of a podzol sensu stricto (Avery, 1980) are buried by c. 50-80 cm of sand containing the modern soil. The buried profile has the following characteristics:

Table 3. Profile Data - M/LF 1 Buried Humus Podzol.

Horizon	Depth (cm)	Colour	pH	% Loss-on-Ignition	% Fe	% $CaCO_3$
bAh/Ea	66-69	10YR2/2	7.3	8.35	0.63	0.02
bEa	69-77	2.5Y6/2	7.1	0.35	0.03	0.06
bBh	77-82	10YR4/4	7.3	1.24	0.13	0.06
bBw1	82-102	10YR5/3	7.5	0.38	0.14	0.10
bBw2	102-112	10YR6/4	7.6	0.27	0.22	1.79
bCu	112-180+	10YR6/3-10YR6/4	8.0	0.34	0.24	10.53

The top of the bAh/Ea horizon has been levelled to +3.75 m OD and a ^{14}C date of 1290$\pm$40 yr BP (SRR-2066) was obtained (Fig. 14).

Following Avery (1980) this buried profile qualifies as a humus podzol. It possess an iron-deficient Bh horizon and lacks a Bs horizon. Leaching of shell fragments ($CaCO_3$) has extended for 30 cm below the bBh to give bBw1 and bBw2 horizons. Since burial the pH is believed to have increased due to the percolation of base rich water from the overlying calcareous sand.

Particle size analysis shows that there are no major pedological or stratigraphical trends in size distributions within or between

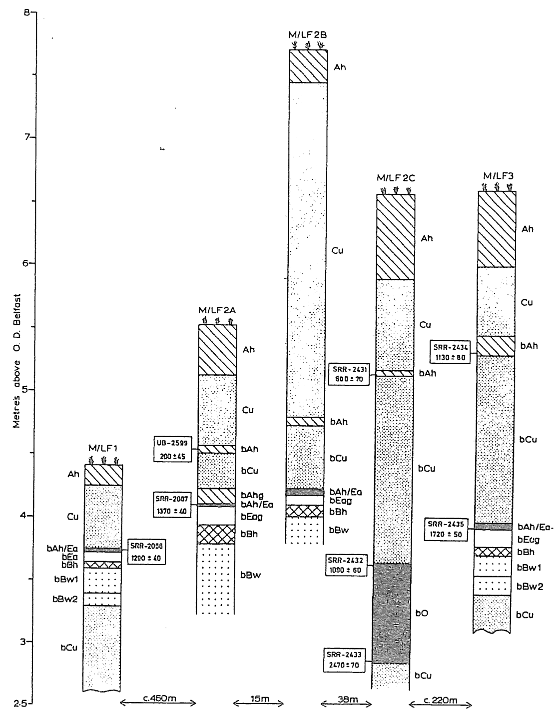

Fig. 14. Soil stratigraphy and ^{14}C dates.

the buried and modern profiles. Fine sand (+2 to +3ø) is the dominant component (>83%) of all the horizons examined. Silt and clay (>+4ø) contents are negligible (<2.0%). Textural uniformity is confirmed by the textural parameters; ranges in mean size (+2.49 to +2.59ø) and sorting (0.30 to 0.36ø) are small and show that all samples are either well sorted or very well sorted fine sand.

Site - M/LF 2 (C 661 369)

This is a composite section in a sand cliff some 6 m in height. Depending on the extent of erosion/slumping up to six exposures of buried soils/peat may be visible.

At the north end of the section (M/LF 2A) a buried humus podzol with physical and chemical characteristics similar to that at M/LF 1 can be traced for 15 m south (M/LF 2B). The levelled height at 2A for the bAh/Ea horizon is +4.11 m OD and organic matter from the same horizon returned a ^{14}C date of 1370±40 yr BP (SRR-2067). The levelled bAh/Ea height at 2B is +4.23 m OD. Approximately 40 m south of 2B (M/LF 2C) a thick (c. 79 cm) bed of peat outcrops in the same stratigraphic position as the podzol, although lateral continuity from podzol to peat cannot be demonstrated due to excessive slumping. The peat base is at +2.85 m OD and gave a ^{14}C age of 2470±70 yr BP (SRR-2433), the top of the peat was dated to 1090±60 yr BP (SRR-2432) (Fig. 14). The altitudinal difference between the podzol at M/LF 2B and the peat base at M/LF 2C represents an average slope angle of c. 2 deg.

The peat/podzol landsurface is buried by up to 3.5 m of calcareous aeolian sand and deposition apparently took place in at least two phases. The first phase is represented by up to 1.5 m of sand in which a thin organic horizon occurs. This unit has all the characteristics of a typical sand-pararendzina (Avery, 1980) and therefore once formed the topographic surface.

Table 4. Profile Data - M/LF 2A Buried Sand-Pararendzina.

Horizon	Depth (cm)	Colour	pH	% Loss-on Ignition	%Fe	$\%CaCO_3$
bAh	96-102	10YR4/3	7.2	1.53	0.36	0.54
bCu	102-130	10YR5/4	7.6	0.41	0.36	7.03

These sand-pararendzinas show relatively weak horizon development. A zone of organic accumulation and $CaCO_3$ depletion (bAh) occurs directly above calcareous parent sand (bCu) (Table 4). Former acidic conditions and free drainage are indicated by $CaCO_3$ depletion from the bAh horizons which, since burial, have undergone base resaturation. Lateral continuity of the sand-pararendzinas across the section cannot be shown although they occur in the same stratigraphic position in each profile. If these soils are contemporary features then they form an almost horizontal palaeolandsurface that rises from north to south at an average slope angle of 1 deg. ^{14}C dating of these soils has yielded ages of 200±45 yr BP (UB-2599) for M/LF 2A and 680±70 yr BP (SRR-2431) for M/LF 2C (Fig. 14).

Site - M/LF 3 (C 662 366)

The profile sequence here is similar to that at M/LF 2A and 2B, the main difference being the thickness of the bAh horizon of the sand-pararendzina.

The bAh/Ea horizon has been levelled to +3.97 m OD and gave a ^{14}C age of 1720±50 yr BP (SRR-2435) (Fig. 14). A ^{14}C date of

Table 5. Profile Data - M/LF 3 Buried Soils.

Horizon	Depth (cm)	Colour	pH	% Loss-on-Ignition	%Fe	% $CaCO_3$
bAh	115-131	10YR4/2	7.4	1.43	0.34	0.12
bCu	131-263	10YR6/4	7.8	0.82	0.24	8.25
bAh/Ea	263-268	10YR4/1	7.4	3.57	0.17	0.04
bEag	268-282	10YR7/2	7.2	0.19	0.04	0.08
bBh	282-289	10YR3/6	7.4	1.71	0.38	0.10
bBw1	289-305	10YR4/4	7.3	0.42	0.24	0.09
bBw2	305-320	10YR5/3	7.6	0.25	0.19	2.32
bCu	320-350+	10YR5/3	8.0	0.26	0.18	7.61

1130±80 yr BP (SRR-2434) was obtained for the bAh horizon of the overlying sand-pararendzina. This horizon is more than twice as thick as any of the bAh horizons at M/LF 2. It occurs in the same stratigraphic position and may indicate either a longer period of pedogenesis at M/LF 3 or partial erosion, prior to burial, of the bAh horizons at M/LF 2.
(PW)

Oughtymore (C 662 361)

Oughtymore (Fig. 12) was the site of an Early Christian shell midden discovered in 1979 by Dr. Alan Hamilton (NUU) and excavated in the same year by Prof. Peter Woodman (UCC) and Dr. Jim Mallory (QUB). The site is fairly typical of a series of coastal sand dune and cave sites that appear along the north Antrim coast and into Co. Londonderry and Lough Foyle. The midden itself was little more than a narrow band of cultural material ranging from 10 to 30 cm thick and was located mid-way

up the face of the sand cliff. Despite the extremely small area excavated (only seven square metres in a rushed rescue excavation) the site yielded a surprising amount of cultural and organic remains.

The cultural material from the site included about 20 sherds of souterrain ware (which now marks its westernmost extension on the north coast), fragments of a blue-glass and a lignite bracelet, a bone comb, an antler spindle whorl and an antler ring. The faunal remains included a minimum of four cattle, five sheep/goat, three pigs and one horse. In addition, remains of eel, salmon (or salmon trout), cod, haddock and plaice (or flounder) were recovered along with several bird bones. The molluscan remains included 22 species, primarily Littorina littorea, Cerastoderma edule and Mytilus edulis. The carbonized remains of both rye and barley were also discovered. Charcoal from the midden yielded a ^{14}C date which after dendro-calibration would fall somewhere within the range of the 7th through to the 9th centuries AD (UB-2442: 1295±35 yr BP). About 20 cm below the midden was another thick charcoal lens which dated to c. the 5th century ad (UB-2443: 1480±30 yr BP). Unfortunately, there were no accompanying remains within the band of charcoal.

Although about half a dozen small midden sites have been discovered along the Magilligan sand ridges, Oughtymore is the only one so far to have received any serious archaeological attention. It would appear to have been one component in a settlement system which was established in this region by the Early Christian period. During this time it is probable that

Magilligan had become church lands and that families settled here held their tenancy through the church. The most likely territorial arrangement would be that still preserved in the present townland pattern (which may itself go back to the Early Christian period though not without some subsequent modification). Here we find long strips of land comprising from 100 to 150 acres that extend from the shore inland. This means that each townland has a small coastal fronting for access to marine resources and also access to possible common grazing lands (a common bog is noted from the 17th century onwards) or upland pastures. The archaeological evidence all indicates a mixed economy. The discovery of rye in the botanical samples correlates very well with data from the later historical period since rye was the basic crop on Magilligan before the introduction of the potato. Naturally, its predominance here was due to its tolerance of sandy soils. Livestock, of course, played the primary economic role in Early Christian society where wealth was computed in terms of cattle. The importance of the marine component in the diet is difficult to assess although Magilligan's shoreline was highly valued during the Plantation period where fishing rights were a constant matter of contention between the Bishop of Londonderry and the Irish Society. Finally, despite naming the site a shell midden, it must be admitted that the total caloric value of all the shells excavated was probably less than that which might be gained from several kilogrammes of beef. Of some interest is the fact that the major shell fish (winkles) is not found in the immediate vicinity of the site and may have been collected as far south as the Roe valley or across the lough on the Donegal coast where a more rocky shoreline occurs.
(JM)

"Lost" Sites

An additional five ^{14}C dates are known to have been obtained on material collected from shoreline exposures. Unfortunately, precise site details are lacking although general site locations are known.

In 1971 a Salix log taken from the base of a peat bed at c. +2 to +2.5 m OD was dated to 1535±40 yr BP (UB-547) (Smith et al., 1973; Carter, 1975b). This log was partially incorporated in the underlying sand and may have represented allochthonous material. The site is a few hundred metres north of the Big Drain (Fig. 12).

From an exposure believed to be south of the Big Drain the Institute of Geological Sciences have obtained ^{14}C dates of 1055±100 yr BP, for a Pinus (?) log embedded in peat at c. +3 m OD, and 1655±100 yr BP, for an overlying Chara marl (Bazley et al, in press). The latter date is considered incorrect due to contamination.

McMorris (1979) conducted a palynological study of a 46 cm thick peat bed levelled to +1.84 m OD. Samples from the top and bottom of the peat were subsequently submitted for ^{14}C assay by Dr. Alan Hamilton (NUU) and returned dates of 808±40 yr BP (UB-2440) and 1022±40 yr BP (UB-2441) respectively. This site is thought to be in the vicinity of M/LF 2 - M/LF 3. The peat contains fossil wood, mosses, beetles and pollen and has only been superficially examined so far. The basal layer is a thin horizon of Acrocladium moss peat. Acrocladium is a genus characteristic of base-rich wet environments such as calcareous dune slacks. This is overlain by a narrow band rich in Typha pollen and seeds followed by the bulk of the peat which contains much wood. Wood identifications include Betula, Alnus and Corylus and fossil seeds of Corylus and Taxus are abundant, mainly towards the base of the peat. Taxus is an interesting find since it is not usually regarded as characteristic of peatland. However, it has been shown to have been common in the fenland forests of East Anglia and the genus must be considered a natural member of more base-rich swamp forest.

The pollen diagram contains rather low percentages of tree and shrub pollen, especially at its base (McMorris, 1979). The landscape must have been very open initially and, even later, woody plants might well have been restricted to the inter-ridge depressions. Common herbaceous pollen types include Gramineae, Cyperaceae, Filipendula, Umbelliferae, Urtica and Equisetum. Some of this must have been derived from fen vegetation.

Two pollen/spore types, Pteridium and Calluna, were unlikely to derive from the fen vegetation, given the types of plants present, and probably originated from acidic grassland on surrounding raised ground.

The absence of Plantago is anomalous and not explained. Urtica values are exceptionally high. This is normally regarded as a sign of cultural eutrophication. The genus does grow in fens, but the values are so high as to suggest anthropogenic influence. (AH, PW)

Site - M/LF 5 (C 662 380)

A buried soil/peat bed that displays lateral continuity occurs here (Figs. 12 & 15). The peat reaches a maximum thickness of 59 cm at point A and its base rests at +2.45 m OD. ^{14}C dates of 620±50 yr BP (SRR-2437) and 1790±50 yr BP (SRR-2438) were obtained for the top and bottom of the peat respectively. The peat thins northwards and passes into an organic soil horizon which rises sharply over a distance of c. 12 m to give an average slope angle of 10 deg.

At point E (Fig. 15) the soil horizon fades but reappears some 5 m to the north and falls steeply at an angle in excess of 12 deg. to point G, from where it continues north as an almost horizontal horizon. The organic matter at point G returned a ^{14}C date of 990±70 yr BP (SRR-2436).

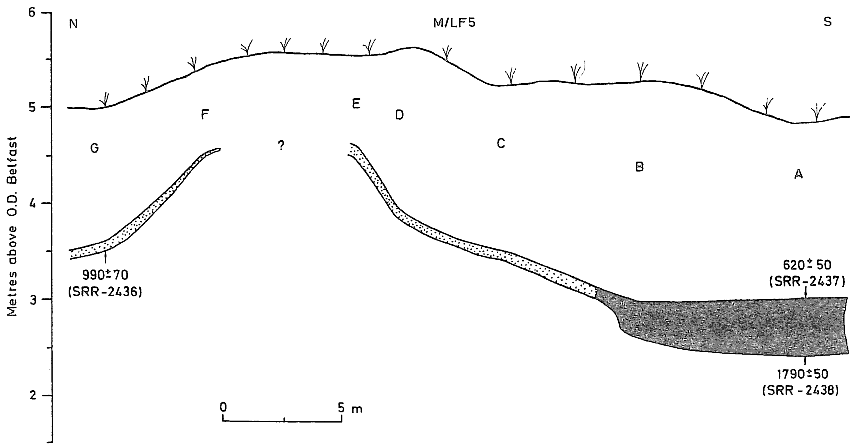

Fig. 15. Buried soil/peat at M/LF 5.

Discussion

Three major phases of sand deposition and pedogenesis are preserved at Magilligan Foreland and enable tentative palaeo-environmental reconstructions to be made (Fig. 16).

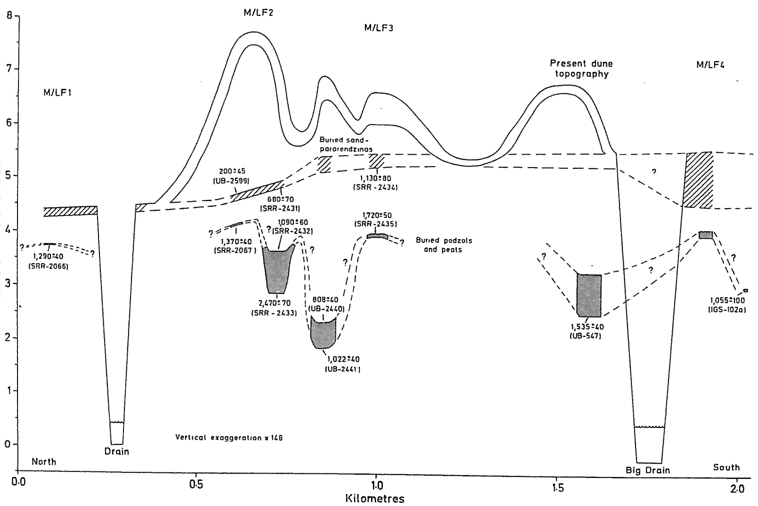

Fig. 16. Topographic reconstruction and locations of some ^{14}C dated samples.

The earliest preserved palaeotopography is a beach ridge plain whose soils constitute a buried palaeocatena. It comprises several podzolised beach ridge crests separated by inter-ridge depressions of various depths that contain peat. The plain was gradually raised above marine influences by isostatic rise and/ or eustatic regression. The beach ridge crests would have been elevated first and the deepest inter-ridge depressions last. Peat formation in shallow depressions began as early as c. 2500 yr BP and resulted in thicker seams than in deep depressions

where peat formation began as late as c. 1000 yr BP (Fig. 16). Pedogenesis on the elevated beach ridge crests should have begun before peat formation, probably between 2500 and 3000 yr BP. Palynological evidence suggests the peats developed as base-rich fens while the presence of <u>Calluna</u> indicates acidic soils close by. It may be assumed therefore that the podzolised beach ridge crests supported this <u>Calluna</u>. The Oughtymore archaeological site is contemporary with the peat/podzol landsurface and man's agricultural activities may be responsible for the high <u>Urtica</u> values found in the peat. It is also worth noting that podzolisation of soils has frequently been attributed to early agricultural practices.

All peat formation and podzolisation ceased at c. 1100-600 yr BP as indicated by ^{14}C dating. However, in the vicinity of M/LF 2 - M/LF 3 (Fig. 16) two ^{14}C ages for the top of peat outcrops (UB-2440:808±40 yr BP and SRR-2432:1090±60 yr BP) are younger than a date obtained for a stratigraphically younger buried sand-pararendzina (SRR-2434:1130±80 yr BP). Two of these dates are statistically inseparable at the 95% level but it is more difficult to reconile UB-2440 with SRR-2434. Sample contamination cannot be ruled out and is it also possible that burial of the peat/podzol landsurface occurred at different times over such short distances ? At M/LF 5 peat burial occurred c. 600 yr BP but this is 1.5 km to the north (Fig. 12).

The beach ridge plain was buried by aeolian sand, presumably derived by erosion of the lower/seaward parts of the beach ridges. Ah horizons of sand-pararendzinas developed on the near-horizontal planar surface of this sand, suggesting that this surface is either a primary feature or formed an erosion surface prior to pedogenesis. The Ah horizons in this sand are thin but severely weathered of certain minerals, indicating partial erosion followed by burial over much of Magilligan by dune sands of various thicknesses, which then formed sand-pararendzinas with thicker Ah horizons. Three ^{14}C dates obtained for the bAh horizons of the buried sand-pararendzinas at M/LF 2 and M/LF 3 show wide age variation (Figs. 14 & 16). Sample UB-2599 (200$\pm$45 yr BP) was a bulk sample for the 6 cm thick bAh at M/LF 2A and preparation included both an acid and an alkali wash. Samples SRR-2431 (680$\pm$70 yr BP) and SRR-2434 (1130$\pm$80 yr BP) represent the basal 3 cm of respective bAh horizons at M/LF 2C and M/LF 3 and preparation involved acid digestion and removal of rootlets. These sampling and preparation differences may account for the younger age at M/LF 2A but cannot account for the M/LF 2C - M/LF 3 discrepancy.

Although the buried podzols are visually striking with strongly colour-differentiated horizons, they are chemically and mineralogically immature. Organic matter translocation has been barely sufficient to produce the (b)Bh horizons that are a diagnostic feature of humus podzols and iron translocation has been even less effective. The visually distinctive podzol horizonation at Magilligan has resulted not from large-scale translocation but from a lack of silt and clay in the sands, which has meant that the small amount of translocated material is unusually obvious. Differences between profiles in the degree of podzolisation probably reflect variations in local

environments. The translocation of humus and iron suggest that podzolisation occurred in acidic conditions. The present-day neutral/alkaline pH of the podzols has resulted from base resaturation by percolating waters. The relatively low degree of weathering in these podzols is in accordance with the short soil-forming interval indicated by the ^{14}C dates. The overlying typical sand-pararendzinas have formed in similar parent materials to the podzols but probably over shorter time periods.
(PW)

Magilligan Point (C 660 390)

Magilligan Point is a Nature Reserve managed by the Conservation Branch, Department of the Environment (N. Ireland) for its geomorphological, botanical and ornithological interests. It is probably the best example of a prograding dune system in Ireland. The surrounding lands are all owned by the Ministry of Defence and access is forbidden - and inadvisable. The Point is reached by continuing along the minor road used to reach the Lough Foyle shoreline. Defence and prison personnel cannot deny access to the Point, but it is essential to keep to the road.

Only at Magilligan Point is it possible to see active development of beach ridges and dunes, something that must have been common in Ireland 5000 yr BP. Since 1950 five major beach ridges have welded onto the Point (Carter, 1979). The ridges act as a source for blown sand, and a series of low dunes have formed (Fig. 17). Dune growth is rapid at first (up to 0.5 m yr^{-1}) but then tails-off exponentially as either the source becomes depleted or sealed beneath a lag deposit (Carter, 1976), or a new foredune begins to form. The beach ridge/dune contact is often marked by a shell lag, which may be traced over wide areas.
(RWGC)

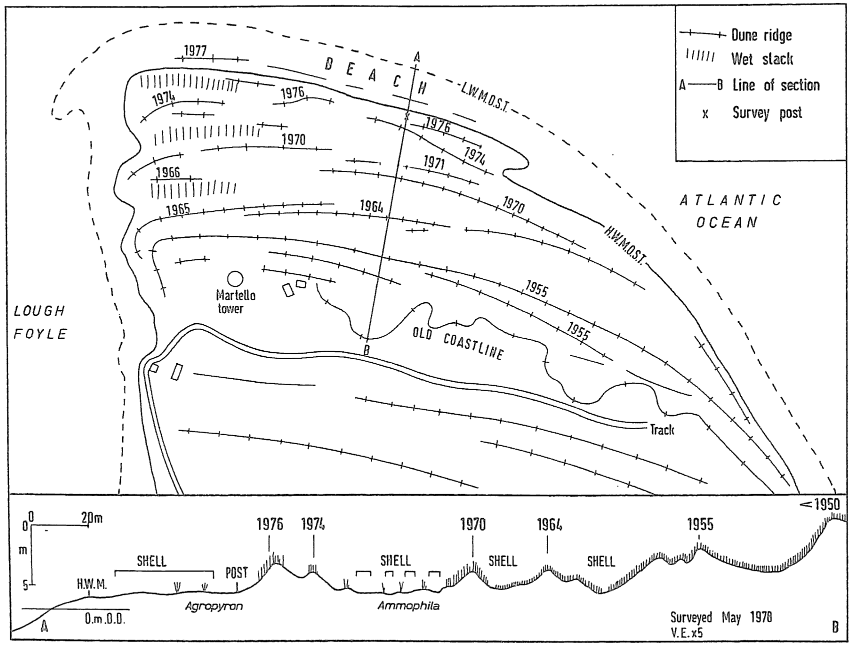

Fig. 17. The prograding dune system at Magilligan Point (After Carter, 1979).

THE BASALT SCARP (Richard Clark)

Along the western edge of its outcrop, the north Ulster basalt caps a west-facing escarpment for 35 km south from the coast at Downhill to Mullaghmore (550 m) (Fig. 18). The base of the basalt rises irregularly from below sea-level at the coast to over 400 m in the south. The basalt is a strong cap rock over the Cretaceous limestone and the less-competent Triassic strata. In plan, the scarp is divided into bastions and recesses in which spreads of glacial tills extend to the summit levels. On several of the bastions, Binevenagh (385 m) and Benbradagh (465 m) particularly, the escarpment is cliffed as are the Gortmore section overlooking Magilligan Point and the south end of Mullaghmore.

The cliffed sections are associated with a variety of undercliff features. Especially prominent are block slips, some obviously rotational, with a wide range in size and coherence. They extend up to 1500 m from the present cliff line and to about 200 m below the base of the basalt. Two groups of slumps are identifiable, most easily on Binevenagh, sharply-defined blocks close to the cliff-face and large, 'less fresh', generally lower blocks. The former group is clearly younger than the last glaciation; the age relations of the latter to the end of ice-cover are not yet completely clarified. On Binevenagh, blocks of the second type occur below both gully-fretted cliffs and fresher, steeper cliffs. Those of the former group intervene between the lower blocks and the steeper cliffs: the fronts of some of the upper rotational blocks are gully-fretted.

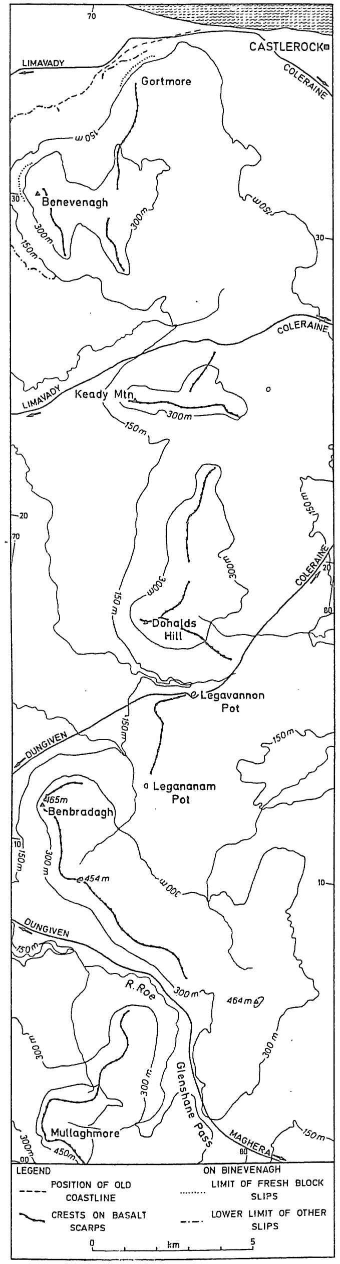

Fig. 18. The Basalt Scarp of North West Co. Londonderry showing location of places mentioned in the text and the limit of block slips on Binevenagh.

At the north end of Benbradagh and on Donald's Hill (399 m) the uncliffed scarp carries a blockfield cover and elsewhere, as on Keady Mountain (337 m), there are spreads of finer-textured head. Although the largest slipped blocks are on Binevenagh, the Benbradagh escarpment presents a great variety of landforms including what seems to be a major scarp-failure - debris flow feature on the south side of the hill (C 731 087). This created a scarpface niche and, outlined by marginal ramparts and depressions, the released debris extends 700 m from and descends c. 100 m below the niche.

Benbradagh

Access to the site is by minor roads/farm lanes that lead from the B64 Dungiven-Garvagh road. The site is on private land and permission to visit should be sought from the farmers at Derryduff and/or Tirgoland.

The west-facing scarp of Benbradagh is about 2.5 km long and an area up to 1 km west of and 300 m below the crest displays a complex assemblage of landforms. Profiles across the scarp face are conveniently considered in terms of three units, headslope, intermediate slope and footslope. The lateral diversity in each unit ensures considerable variety among profiles. The headslope includes cliff reaches, several on slump scars, active rock-fall scars, narrow slipped blocks still perched on the steep headslope, mobile and relatively stable scree varying from fine to coarse. Lobes, benches and pipe depressions occur locally on the scree. At the north end of the unit there are also block terraces and associated arcuate niches.

The upper part of the intermediate slope carries a number of large rotational slump blocks of various degrees of coherence. On one profile there is a sequence of three such blocks and below them nine benches probably of slump origin. Scars behind some of the highest blocks truncate thick scree at the bottom of the headslope. Below and to the north of the large slipped blocks there are large convex bulges of broken basalt. Discrete rubble 'streams' are aligned downslope below slipped blocks, bulges, and block terraces though in the north the veneer of debris is less accidented. On the lower parts of the intermediate slope the debris cover is arranged in a series of benches, arcuate or lobate in plan. The rubble streams terminate in this way. On the profile noted above there is a sequence of sixteen such steps though in that vicinity bench flights are more highly developed than elsewhere.

Several debris facies have been recognised, at least three in one profile. Cavernous clast-supported fresh, sharply-angular, generally matrix-free basalt rubble is commonly 1-2 m thick over a more matrix-rich head. However, in places there is at least 12 m of cavernous rubble (C 717 106). Sides and fronts of lobes and debris streams range up to c. 7 m high. In many cases these slopes are diversified by smaller benches which also occur in broken rubble at the lower edges of some of the slipped blocks as well as on the scree of the headslope. Enclosed depressions, singly and in downslope chains, occur on bench surfaces and on debris streams probably testifying to 'piping'. There are indications of the inner surfaces of some debris streams having sustained or regained mobility when the margins were stable. The

sites of previous slope failures on debris streams and lobe fronts have restabilised, but there have been very recent slope failures with the appearance of small lobes, mud flows, etc.

The footslope width varies, reaching about 300 m at most. At its lower edge it merges into till spreads. Its outer slopes, generally 3-7 deg., are characterised by large boulders, mainly basalt with some chalk, in and on a matrix largely derived from Trias and, locally, probably till. On its inner margin the slopes are 7-11 deg. and the surface is largely arranged in low arcuate terraces 1-3 m high. Springs and seepage occur at the inner margin of the footslope and in recesses between its lobes. There is some evidence of surface wash having occurred and of accumulation, possibly in phases, of material washed or 'sludged' from the fronts of the large lobes at the foot of the intermediate slope.

In short, landforms and materials on the scarp face of Benbradagh indicate a complex time-site-process continuum since the decline of the late-Midlandian ice-cover.

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