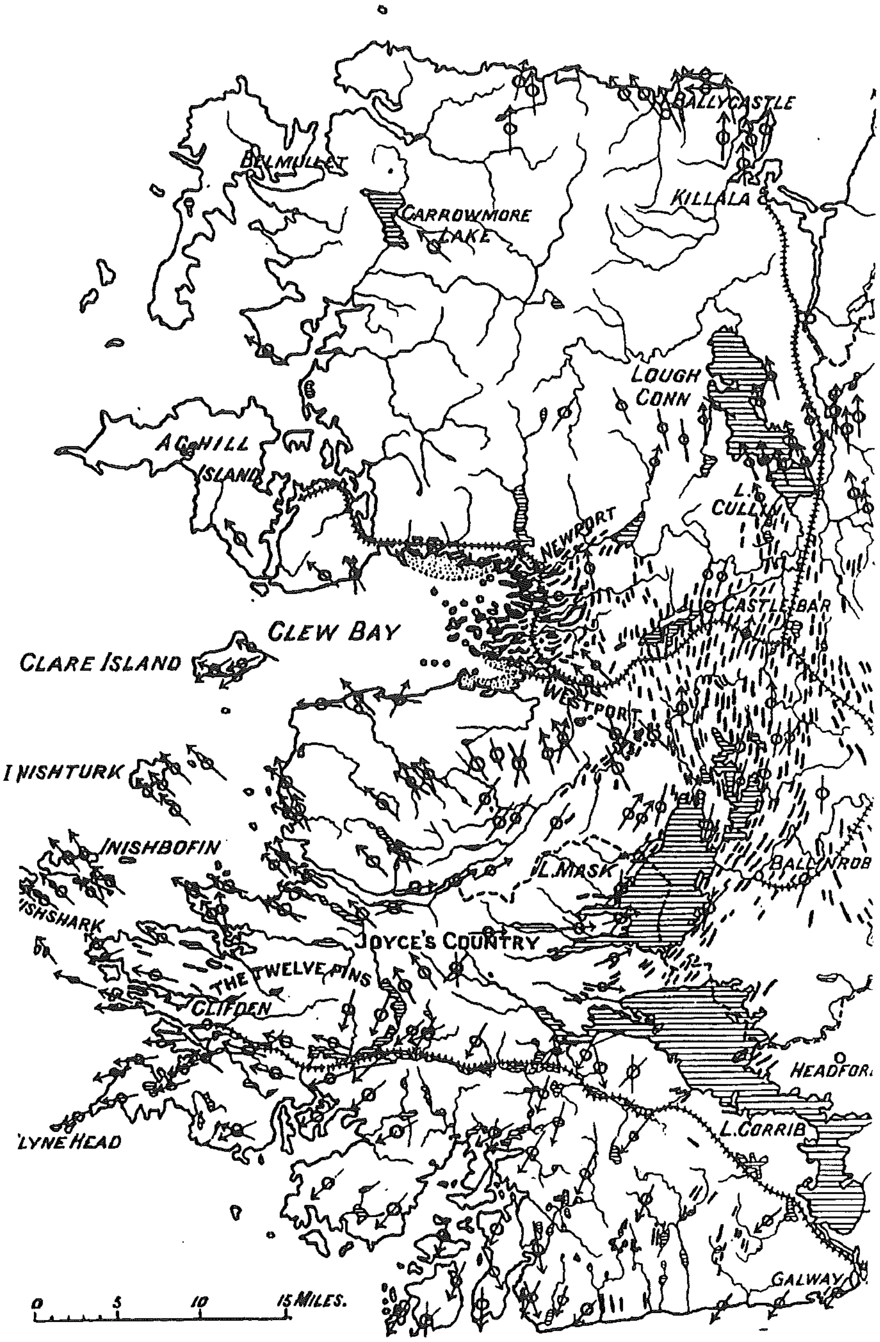
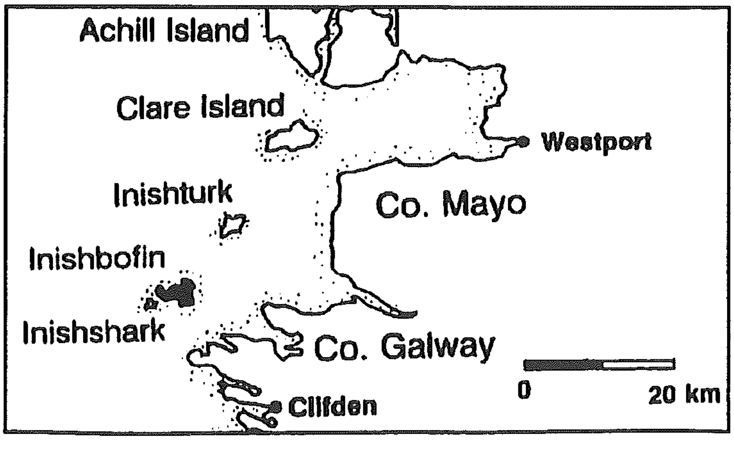
Clare Island
Inishbofin



IQUA

Field Guide No. 17



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Cumann Staidéar Ré Cheathartha na h-Éireann
Irish Association for Quaternary Studies

Oileán Cliara agus Inis Bó Finne
Clare Island and Inishbofin

á eagrú ag/edited by

Peter Coxon and Michael O'Connell

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CONTENTS

page

Section A. Clare Island

Section B. Inishbofin

LIST OF FIGURES

Preface.

This guide is intended to complement a weekend field meeting (Friday September 16th to Sunday 18th, 1994.) of the Irish Association for Quaternary Studies (IQUA). Clare island and Inishbofin contain a remarkable amount of information relating to Quaternary environmental change. Especially important is the record relating to the later Quaternary when both climate change and human impact have interacted to give large scale and fundamental change. The latter will be receiving particular attention in the course of the meeting.

Given the richness of the record this Guide cannot be regarded as comprehensive either with respect to each island as a whole or indeed to the individual sites covered. However, it is hoped that it will serve as an adequate field guide to the sites that will be visited and provide a useful guide to information on recent and, in several instances, still on-going research. Because of difficulties of inter-island travel, Inishbofin will not be visited. However, lectures will be provided on the archaeology and palaeoecology of the island.

This guide is also intended as a preliminary report on research relevant to the New Survey of Clare Island', a five-year programme of research launched by the Royal Irish Academy in 1991 to commemorate the Clare Island Survey (1909-1911) which was directed by R.Ll. Praeger on behalf of the Royal Irish Academy.

Please note that some of the sites referred to in this guide are private property and permission should be sought before entering.

Material in this guide has been drawn from a number of sources which are attributed in the text.

The area that we will cover during this trip is part of the OS 1:126,760 (1/2 ") sheet number 10 of Connemara and some of the sites that we will visit are shown on Figures in this guide.

Section A

Clare Island

(PC)

1. General Introduction

Clare Island (Oileán Cliara) is situated in the mouth of Clew Bay, County Mayo. The island is some 7.5km long (east to west) and 2.5km wide (north to south) and Figure 1 is a sketch map of the island showing its general topography and the sites that we are to visit . The island possesses two areas of high ground, Knockmore (462m) and Knocknaveen (223m) and it has magnificent cliffs along its northern coast as well as beautiful views of the mainland. The island's history is best known for its associations with Grace O'Malley (Granuaile) whose clan used the castle by the harbour. After Grace died in about 1601 the island went over to Ulick Burke. In the 17th century Clare Island was confiscated by the Crown and granted to an "English Adventurer", who, failing to get to the island, sold it for 30 guineas and a horse. In the 19th century Sir Samuel O'Malley mortgaged Clare Island to a London insurance company and the land was leased to a land agent. The last private owner was James MacDonnell whose nieces inherited Clare Island and sold it to the Congested Districts Board (one of their first buys) for £5486 in 1895. The work of the CDB in providing extensive and massive walls across the island can still be seen.

The interest of naturalists in island and remote habitats in the 19th and early 20th century was to put Clare Island on the scientific map for ever. In particular, work by Forbes and Darwin had shown that the flora and fauna of isolated islands can be of great interest and a survey of Clare Island was suggested in 1908. The island was chosen for its compact size, it was convenient for access and it contained a variety of habitats for study (mountain, bog, shore, cliff...). The Clare Island Survey's work on the island was commenced in 1909 and the area saw visits by scientists every month throughout that year with some comparative work being carried out on adjacent islands and on the mainland (Praeger, 1915). Praeger was the Survey's secretary and he played a large part in its organisation and was present on many of the trips. Over 100 people were involved with the survey and the scale of the original project can only be appreciated by browsing through the published material from these scientists. The work appeared as a series of papers which form Volume **31** of the *Proceedings of the Royal Irish Academy*. Sixty eight papers were published in all between 1911 and 1915 (part 39 was in two sections) but one part, Part 8, Peat Deposits, was never published.

The absence of the latter section dealing with the peat deposits led Professor Frank Mitchell to suggest that IQUA should hold their Annual Field Meeting on the island in 1982 and this author and Dr.J.R.Creighton of the Geological Survey of Ireland visited the island in June 1982 to carry out a preliminary choice of sites to be visited. Clare Island was visited again by the author, Catherine Coxon and Gina Hannon in July of 1982 when cores for palaeobotanical work were collected. These two visits provided the basis for the 1982 IQUA *Fieldguide to Clare Island* (Coxon, 1982).

However, a substantial amount of material of interest to IQUA has come to light since 1982 and it is hoped that this information will form the basis of the Clare Island part of the 1994 field excursion. Clare Island is mantled with a variety of Quaternary deposits which have been mapped by this author and by Browne (1991). A map of these deposits, and of the geomorphology of the island, is presented in the guide. The discovery of important archaeological features has meant that research in this area has blossomed and a real understanding of the

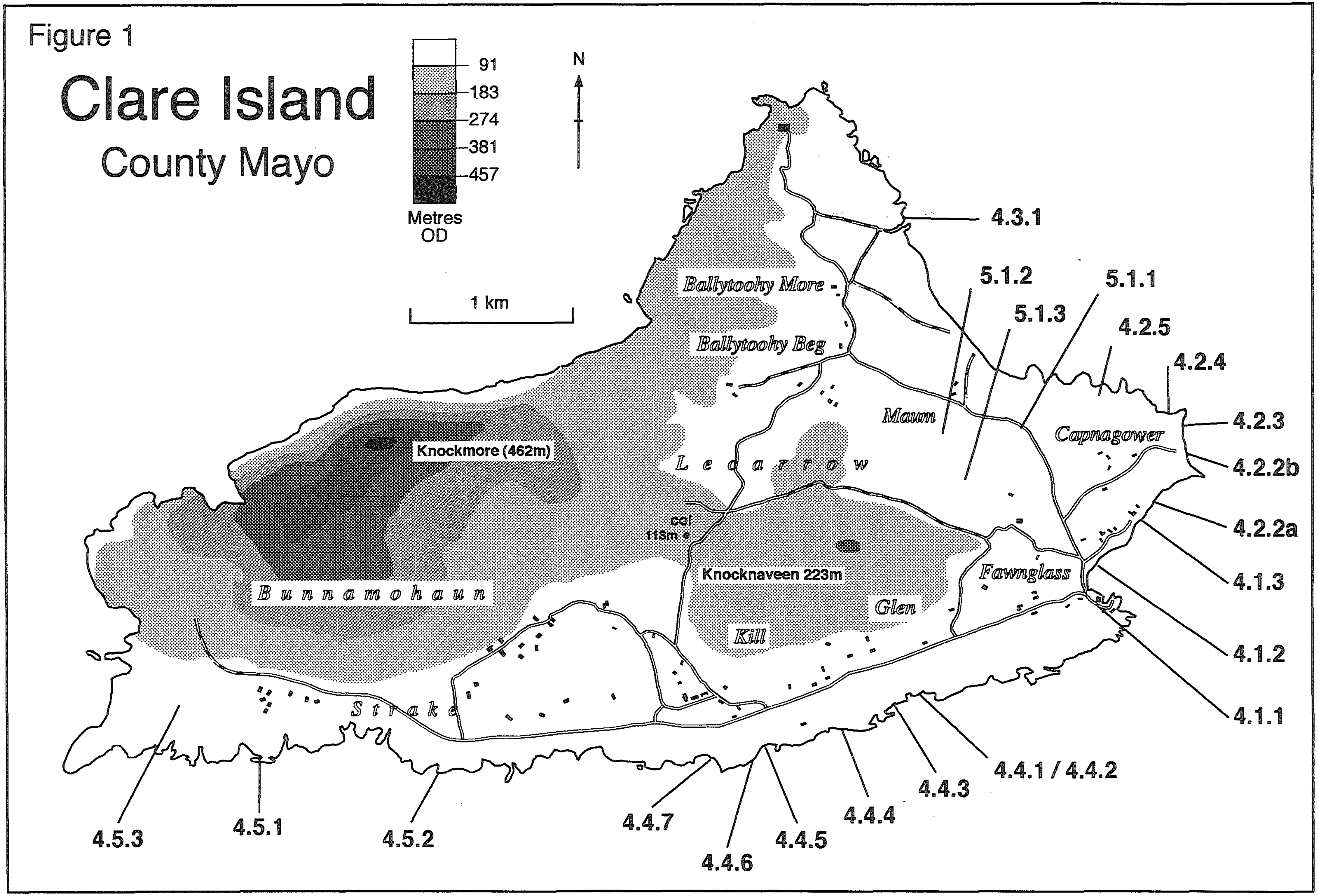


Figure 1
Clare Island
County Mayo
91
183
274
381
457
Metres
OD
N
1 km
Knockmore (462m)
Ballytoohy More
Ballytoohy Beg
Maum
Capnagower
Lecarrow
col
113m
Knocknaveen 223m
Fawnglass
Glen
Kill
Bunnamohaun
Strake
4.3.1
5.1.2
5.1.1
5.1.3
4.2.5
4.2.4
4.2.3
4.2.2b
4.2.2a
4.1.3
4.1.2
4.1.1
4.4.1 / 4.4.2
4.4.3
4.4.4
4.4.5
4.4.6
4.4.7
4.5.2
4.5.1
4.5.3

way that the island landscape has been produced is beginning to emerge. Hopefully this guide will bring some of this work into perspective.

A modern survey of Clare Island is currently being carried out (1991-1996) under the auspices of The Royal Irish Academy. Further information on this modern survey can be obtained from: Ms.Sara Whelan, Royal Irish Academy, 19, Dawson Street, Dublin 2.

2. Pre-Pleistocene geology of Clare Island

(JRG)

The bedrock geology of Clare Island is extremely varied and the present disposition of rocks is controlled by some major faults which extend through much of the Clew Bay area (Figure 2) The stratigraphy comprises four major subdivisions:

youngest	4. Lower Carboniferous
	3. Silurian
	2. Clew Bay Cambro-Ordovician
oldest	1. Deer Park Complex

Key to geological map of Clare Island

Lower Carboniferous	17	Lower Carboniferous clastics Quartzose conglomerates and sandstones White/red sandstone, conglomerate, breccias
Silurian	15	Glen Pebbly Arkose Formation Polymict granule, pebble and cobble conglomerates and sandstones. Minor red siltrocks.
	14	Bunnamohaun Siltstone Formation Laminated red and green siltrocks with lenticular sandstone beds.
	13	Knockmore Sandstone Formation Buff-green sandstones with thin mudrocks and intraformational conglomerates.
	12	Strake Banded Formation Laminated red and gray siltrocks with interbedded sandstones and acid tuffs.
	11	Kill Sandstone Formation Conglomerates with rounded clasts and cream and red sandstones.
Dalradian	6	Ballytoohy Formation Psammites, pelites, cherts, minor spilite, limestone
Pre-Dalradian?	2	Deer Park Complex Semipelite, pelite, amphibolite, serpentinite

High angled faults

Unconformity

The Leck Fault, which runs from the harbour almost due west to the Atlantic cliffs, has a significant post-Carboniferous displacement and differential erosion along this line has produced a major feature in the landscape.

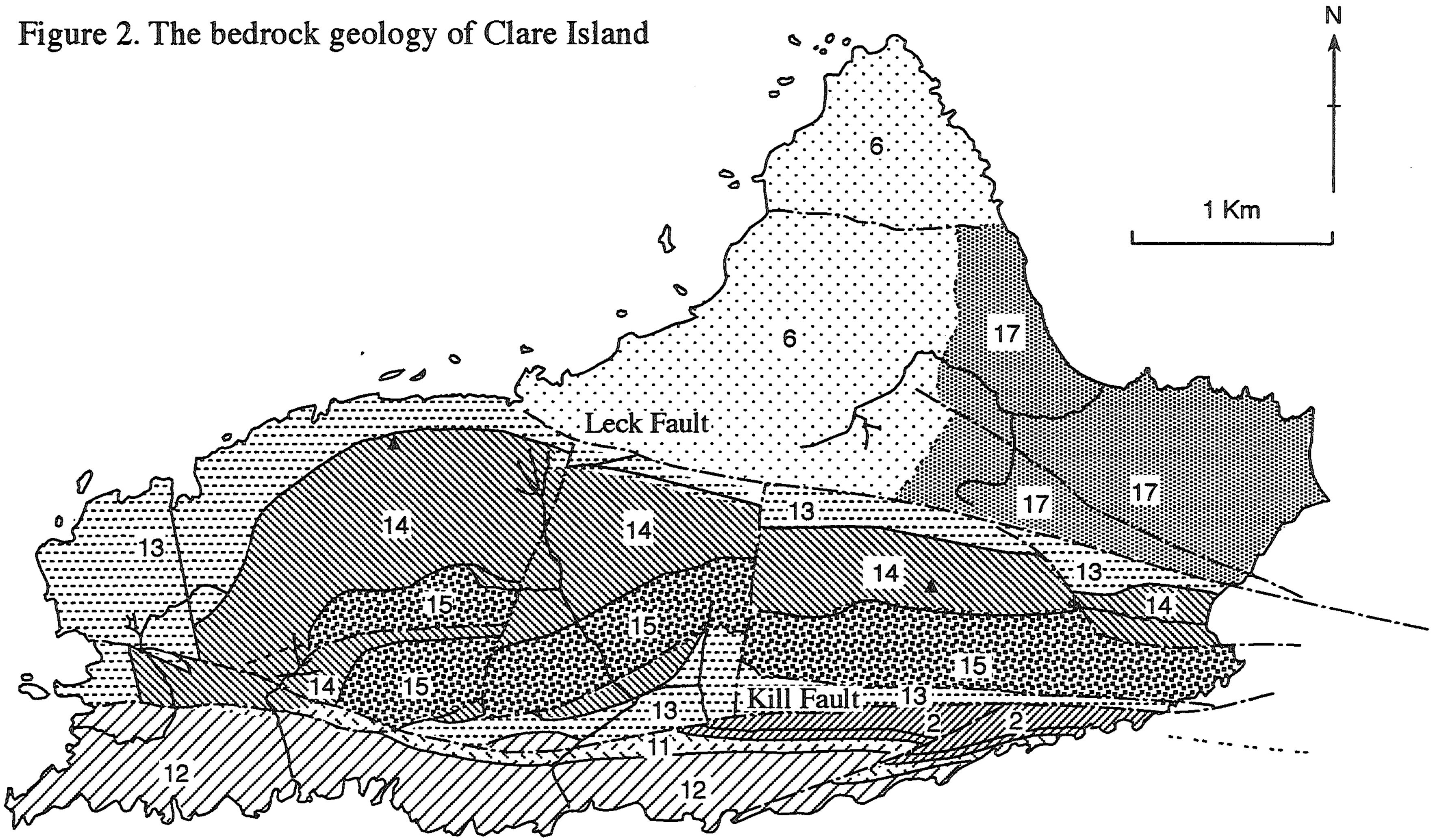
The Deer Park Complex comprises a varied assemblage of metamorphic rocks, some of which appear to have been metamorphosed to amphibolite grade. The main lithologies are serpentinites, pelitic and psammitic schists. Some of the meta-igneous rocks in this complex represent former ocean floor material. The complex extends along the southern shore of Clew Bay and is exposed in the southern part of Clare Island, south of the Kill Fault.

The Clew Bay Cambro-Ordovician rocks are still the subject of much debate. They were originally assigned to the late Precambrian Dalradian Supergroup which crops out extensively in North Mayo and Connemara. It is now clear that they are younger than this and have yielded Ordovician fossils on Clare Island. The lithologies seen in Clare Island in the Ballytoohy Formation (psammites, pelites, cherts, altered volcanic rocks and minor limestones) have very irregular outcrop patterns. These were explained as being due to complex refolding and faulting by Phillips (1973). It has recently been claimed that most of the lithologies occur as large blocks in a melange unit formed in Silurian times (Williams *et al.* 1994).

The bulk of Clare Island is formed of Silurian rocks, although in detail these remain poorly dated. The formations within the Silurian succession are characterised by differing percentages of sandstone and mudrock with pebbly sandstones and conglomerates being common in the uppermost Glen Pebbly Arkose Formation. The outcrop pattern is complicated by both low angle and vertical faults. Colours vary from mainly red in the Strake Banded and part of the Bunnamohaun Siltstone formations to green and grey. Some distinctive dark grey laminated mudrock bands occur at various levels but with a concentration at the base of the Bunnamohaun Siltstone Formation. A variety of small, localised gas rich intrusions cut this succession. The same stratigraphic succession of Silurian rocks also crops out on the mainland in the Louisburgh area.

The north east of the island is underlain by Lower Carboniferous rocks which are mainly red sandstones and mudrocks in the lower (western) parts and rather finer grained and greyer in the upper parts. The upward transition to limestones seen throughout the Clew Bay region is likely to occur just offshore to the north-east.

Figure 2. The bedrock geology of Clare Island



3. Regional Pleistocene Geology

Figure 3 is a map of Ireland showing the general distribution of glacial landform elements within the country. This map (reproduced from McCabe, 1987) is a generally accepted model showing deposits predominantly formed during the Last Glaciation (Midlandian) but also including areas which have been considered as ice free during the Midlandian (i.e. those areas marked as "Older drift"). The ice movement directions (based on numerous studies of till content and erratics) are depicted on Figure 4 and although the timing of these glacial events is the subject of some controversy this general pattern is one that must have predominated for major glacial episodes. The Irish Quaternary succession used in this guide is depicted on Figure 6.

Figure 5 shows the pattern of glacial deposits in central and western Ireland and the position of the two islands we are to visit. The map shows the extensive glacial deposits of the region which are characterised by drumlin swarms and large spreads of sand, gravel and moraine. The upland areas show evidence of mountain glaciation (on both a large and a small scale). It is clear from the work of Synge (1968, Figure 7 this guide) that during the last glaciation massive lobes of ice pushed along outlets like Clew Bay and that at the same time mountain ice masses accumulated in the uplands of Achill Island and in the Nephin Beg Range.

The pattern of glaciation in the west of Ireland is predominantly one of extensive ice streams pushing westwards along structural corridors from major centres of accumulation. In the area we are dealing with in this guide the accumulation centres lie in central Ireland, Achill, the Nephin Begs and in Connemara. The abundant evidence of such ice movements had been recognised very early on in the study of Ireland's glacial history (e.g. see Hallissy, 1914 -Clare Island Survey, front cover of this guide) and the general pattern of movement can be clearly identified on satellite imagery (Coxon and Browne, 1991 -Figure 5).

Our understanding of the sequence of glacial events in western Ireland is clouded by the lack of a firm stratigraphic basis for correlation. Synge's 1968 chronology (reproduced below) is left in doubt for a number of reasons.

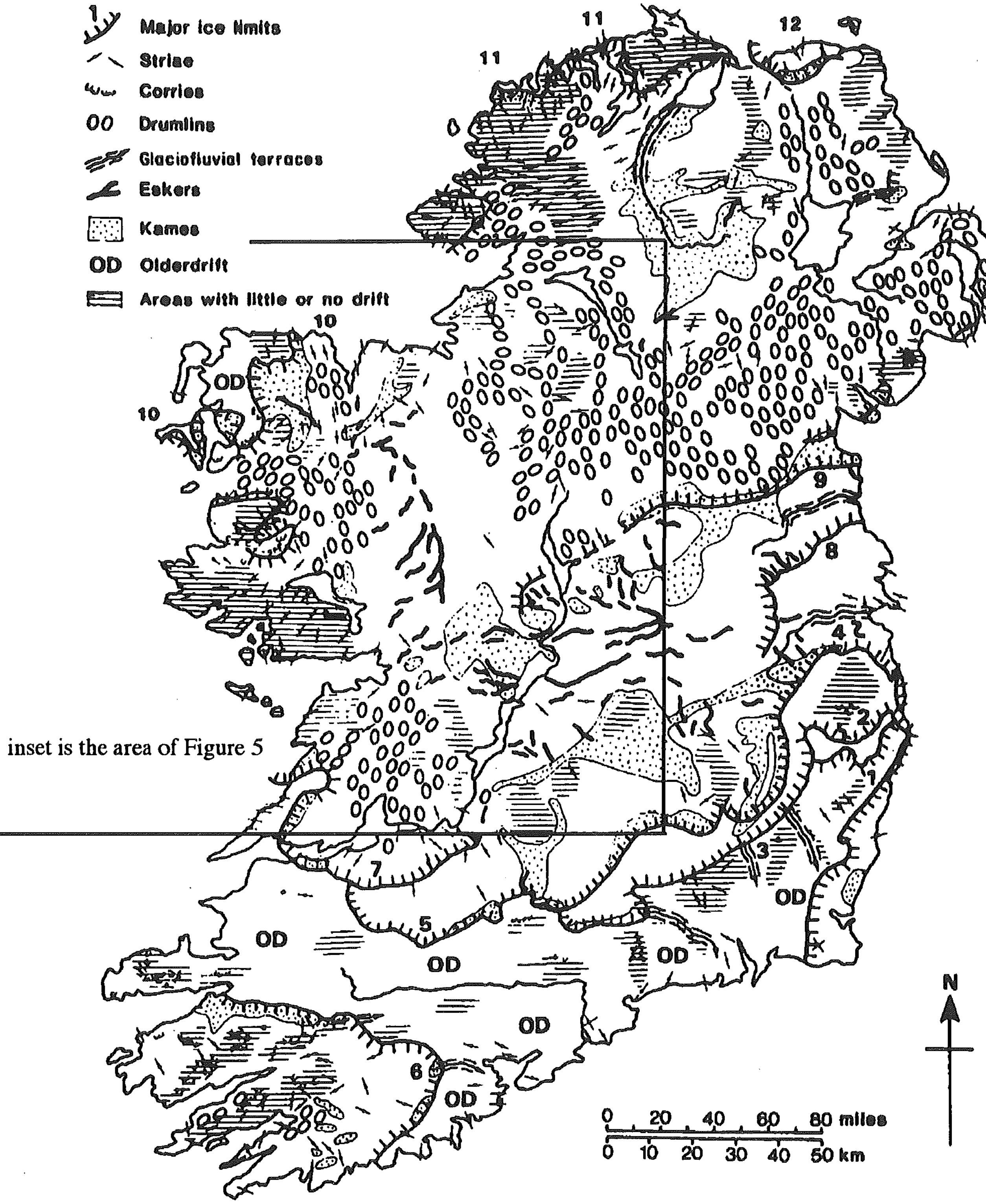
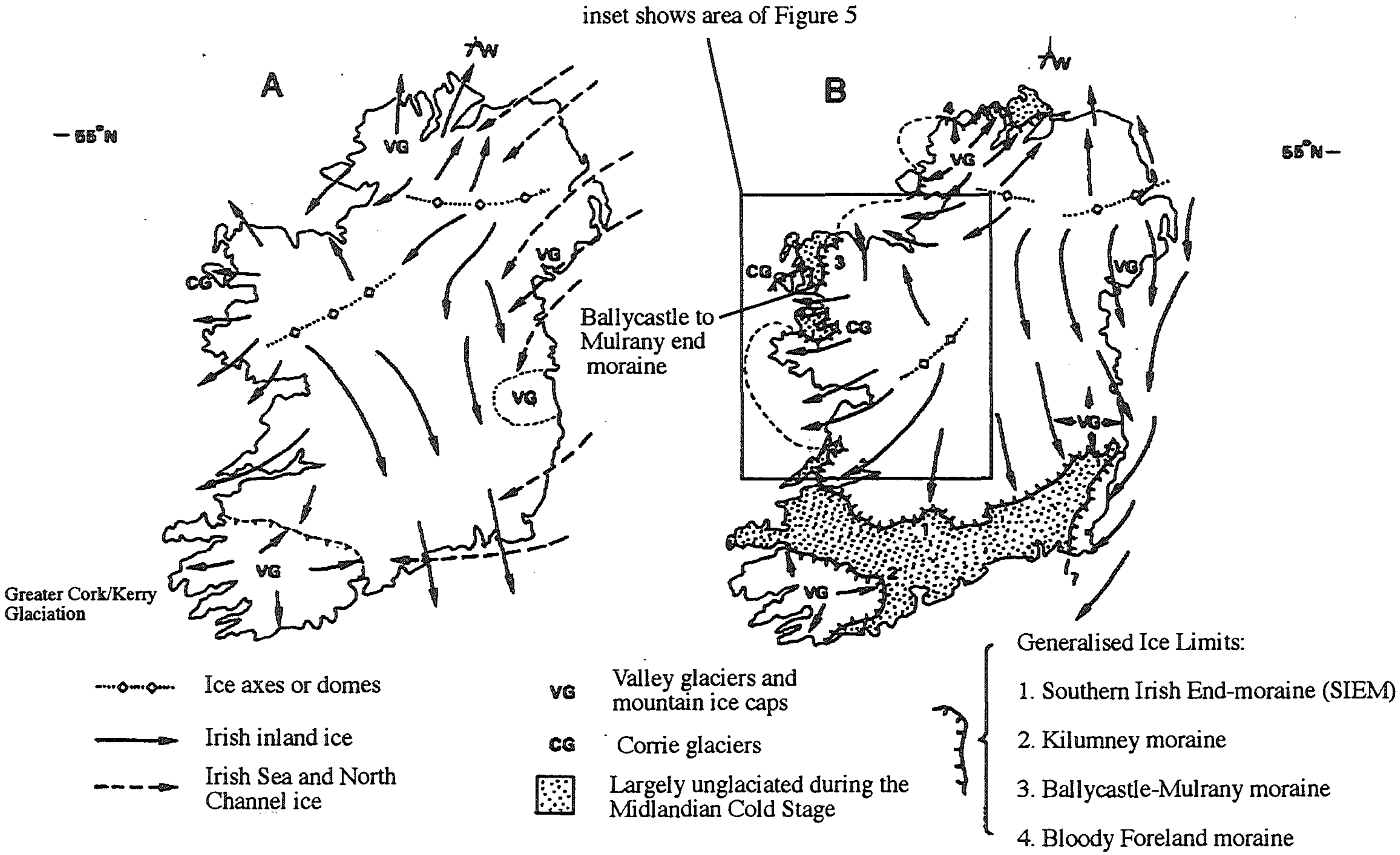


Figure 3. The Quaternary geology of Ireland (from McCabe, 1987)

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



A -Munsterian Glaciation
B -Late Midlandian Glaciation

Table 1. The chronology of tills in western Ireland. From Synge, 1968 (and Synge in Herries Davies and Stephens, 1978).

	General	Local Mountain
Midlandian glaciation	Ballycastle-Mulrany End-Moraine Newport till Roscahill till Killadoon till	Four stages of young corrie development on Achill Accorrymore moraines, Anaffrin moraines in Nephin Beg mountains
Last interglacial	Cartron River deposits in Corraun?	
Munsterian glaciation	Belderg shelly till Erris till Gort Upper Solifluction gravel	Several stages of old corrie development on Achill-Nakerroge moraines
Gortian Interglacial	Gort polleniferous mud	

There are a number of reasons that this stratigraphy can be considered unreliable. Firstly, the status of the Cartron River deposits is uncertain and cannot be reliably used as a deposit belonging to the last temperate stage (Coxon, 1993). Secondly, the dating of valves of *Macoma baltica* from shelly glaciomarine muds at Ballycastle to 16,940 ± 120 and 17,300 ± 100 years BP has called into question the age of the so-called "shelly tills" of north Mayo. This age of 17ka dates the maximum limits of ice advance in north Mayo within the Drumlin Event of the Glenavy Stadial (McCabe *et al.*, 1986, Figure 6).

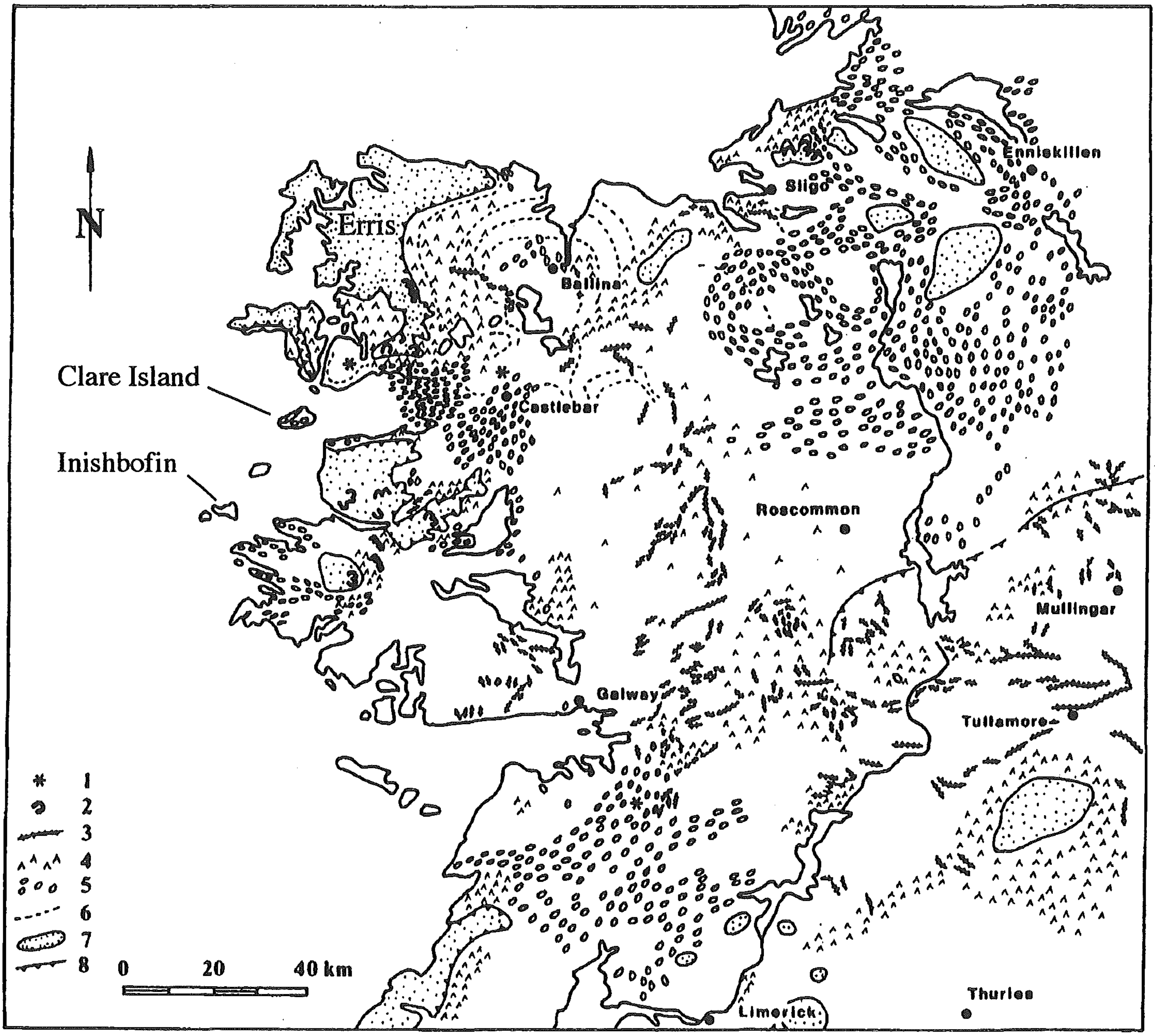
Synge (1968) suggested that the Ballycastle to Mulrany end moraine (Figures 4 and 7) represented " a younger drift series" and that it corresponded to the termination of the drumlin belt. The moraine flanks the eastern side of the Nephin Begs to a height of 380m and the ice that produced it pushed northwards through the Mulrany gap and through Achill Sound spreading as a lobe as far as Ballycroy and Dugort. In fact Synge was able to map the gradient of the ice mass that produced the Ballycastle-Mulrany end moraine throughout the region. Outside of this limit he identified "Older Drifts" on the basis of their weathered appearance and lack of fresh glacial landforms. This limit can be identified on both Figures 4 and 7 and the unglaciated region comprises of much of north western Mayo (Erris on Figure 5).

Synge (1968) comments that the shelly Belderg till overlies the older deposits (Erris till) but is older than the Ballycastle moraine which it lies below. This observation led the Belderg Till to be placed in the Munsterian Glaciation by Mitchell et al. (1973), a view reiterated in Herries Davies and Stephens (table 6.4, 1978) and Mitchell (1981) who used the term "Belderg Lobe" to account for Munsterian deposits in the area. In other publications it has been classed as (Early) Midlandian (e.g. Finch, 1977). The problem is that, until recently, there has been no evidence at all on which to date most of these sedimentary sequences in an absolute way. The lack of stratigraphical evidence that the "shelly tills" belong to an older glaciation and the dating of the north Mayo glacigenic sediments to late in the Midlandian leaves the sequence of Quaternary events in the region still very open to question. (McCabe, 1987). Recent research in the area has looked at the detailed sedimentology of the glacial sequences in and around the bays and coastal areas of western Ireland (e.g. McCabe 1993 and McCabe and Dardis, 1994). This work has concentrated on the drumlins and has raised many new questions about the behaviour and disposition of the ice sheet. Some of these points will be discussed below.

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

Although the details of the timing of Pleistocene events remain a mystery this part of western Ireland is one of the best places to appreciate the scale of the Late Pleistocene ice sheets and to appreciate the role they played in sculpting so much of the Irish landscape.

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



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

Figure 6.— The subdivision of the Quaternary Period in Ireland

(after Mitchell *et al.* 1973 and McCabe 1987, from Coxon, 1993)

Series	Stage	Age	Substage	Comments
Holocene	Littletonian	10,000	Nahanagan Stadial	Named after glacier activity at Lough Nahanagan in the Wicklow Mountains (Colhoun and Synge 1980). Extensive glaciation has not been recognised in Ireland but many periglacial features and the evidence of small glaciers are found (Gray and Coxon 1991).
		Late-glacial 11,000	Woodgrange Interstadial	This complex interstadial (with an early phase of climate amelioration and containing at least one period of erosion and climate deterioration) is recorded in many biogenic sequences from Irish Late-glacial sites (Watts 1977; 1985).
Pleistocene	Midlandian: Late	13,000 17,000	Drumlin Event	A distinct event (within the Drumlin Readvance Moraine of Synge 1969) producing drumlins. Recent evidence from north Mayo dates this event to around 17ka and the period is discussed in detail by McCabe (1985; 1987).
		Glenavy Stadial	Main Event	The maximum ice advance of the last glaciation peaking by 20–24ka. Sequences of till and organic sediments from Aghnadarragh (McCabe, Coope *et al.* 1987) allow this phase of glaciation to be put into context within the framework of the Midlandian cold stage.
	Midlandian: Middle	*c.* 25,000	Derryvree Cold Phase	Organic silts found between two tills at Derryvree (Colhoun *et al.* 1972) show a treeless, muskeg environment. The mammal remains from Castlepook Cave (Mitchell 1976; 1981; Stuart and van Wijngaarden-Bakker 1985) date from this period (34–35ka).
		c. 40,000	Hollymount Cold Phase	Organic muds found at Hollymount (McCabe, Mitchell *et al.* 1978), Aghnadarragh (McCabe, Coope *et al.* 1987) and Greenagho (Dardis *et al.* 1985). Fossils suggest cold, open, treeless environments. Possibly a continental climate with high seasonality.
		> 48,000	Aghnadarragh Interstadial	Pollen and beetle evidence from Aghnadarragh (McCabe, Coope *et al.* 1987) suggests cool temperate conditions with woodland, similar to that of Fennoscandia today. Dated to >48ka and tentatively correlated to the Chelford Interstadial (McCabe 1987).
	Midlandian: Early		Fermanagh Stadial	Till pre-dating organic beds at Derryvree, Hollymount (McCabe, Mitchell *et al.* 1978) and Aghnadarragh (McCabe, Coope *et al.* 1987) are believed to have covered most of Ulster. Evidence (from the presence of certain tree taxa in the subsequent interstadial) suggests that the glaciation may have been short-lived (Gennard 1986; McCabe 1987).
		c. 115,000	'Kilfenora interstadial'	UTD dates place cool temperate organic deposits at Fenit in Co.Kerry early within the Midlandian Glaciation (Heijnis *et al.* 1993). These biogenic sediments were originally thought to represent the termination of the Gortian temperate stage (Mitchell 1970) but there appears to be no firm correlation with that interglacial.
	Last Interglacial	*c.* 120,000		The recent discovery by Marshall McCabe of a reworked ball of organic sediment within the sands and gravels of the Screen Hills moraine (500m north of Blackwater Harbour within the Screen Member of Thomas and Summers 1983) gives hope of finding deposits of last interglacial age, as here for the first time in Ireland a *Carpinus* -rich pollen assemblage has been recorded (McCabe and Coxon, in press). The fact that the Gortian Interglacial may be last interglacial in age (Warren 1985) has to remain a possibility worth consideration but as yet no evidence points to this conclusion.
	Munsterian	*c.* 132,000		Widespread glacigenic sediments in the southern part of Ireland (Munster) have long been regarded as belonging to an 'old' glaciation on the grounds that they show distinct assemblages of erratics, striae and glacial limits as well as exhibiting subdued relief, deep weathering profiles and a lack of 'fresh' glacial landforms (Mitchell *et al.* 1973; Synge 1968; Finch and Synge 1966; McCabe 1985; 1987). The lack of (any) stratigraphic control has meant that although the Munsterian deposits exhibit certain unique characteristics the relative age of the cold stage is unknown. A distinct possibility is that some 'Munsterian' deposits are in fact Midlandian (including Early Midlandian) in age, but this theory awaits further verification.
	Gortian	estimated minimum age *c.* 302,000 rapid termination	Gn IV Gn IIIb Gn IIIa Gn II Gn I Pre-Gn l-g	Eleven sites have been described from around Ireland that record part of a characteristic temperate stage deposit with a biostratigraphically identifiable record. The Gortian is represented by a unique record of vegetational succession and by a number of fossil assemblages that represent stages which have been described in a number of ways (e.g. by Mitchell 1981; Watts 1985; Coxon, this paper). One particularly noticeable aspect of the Gortian is its sudden truncation (see text). Opinion is divided as to the age of the Gortian (Watts 1985 and Warren 1985 give the basis of the two arguments). Biostratigraphically it resembles the Hoxnian of Britain and the Holsteinian of Europe. Recent amino-acid racemisation results on marine Gortian sediments from Cork Harbour (Scourse *et al.* 1992) confirm this suggestion. The dates on this chart are tentative and are referred to in the text.
	Pre-Gortian	estimated maximum age *c.* 428,000		Prior to the Gortian are sediments of late-glacial aspect, suggesting the temperate stage was preceded by a cool/cold stage.This stage is not represented by long or datable sequences, and the age is unknown.
	Ballyline	age unknown possibly > 428,000		A deposit of laminated, lacustrine, clay over 25 metres thick was discovered in 1979 by the Geological Survey of Ireland filling a solution feature in Carboniferous Limestone below glacial sediments near Ballyline, Co. Kilkenny (Coxon and Flegg 1985). From the evidence available the pollen assemblages can be seen to be typical of Middle Pleistocene sequences in Europe, but a firm correlation to a particular stage is not possible.
Pliocene	Pollnahallia (? or Early Pleistocene)	*c.* 1.7–2.5 Ma		Geological investigation of a complex network of gorges and caves in Carboniferous Limestone at Pollnahallia, Co.Galway, located lignite deposits —now covered by superficial material including wind-blown silica-rich sands (Tertiary weathering residues) and glacigenic deposits. Palynological results (Coxon and Flegg 1987) suggest that the lignite infilling the base of the limestone gorge is Pliocene or Early Pleistocene in age. Since the original study a further continuous core through the lignite has been taken.

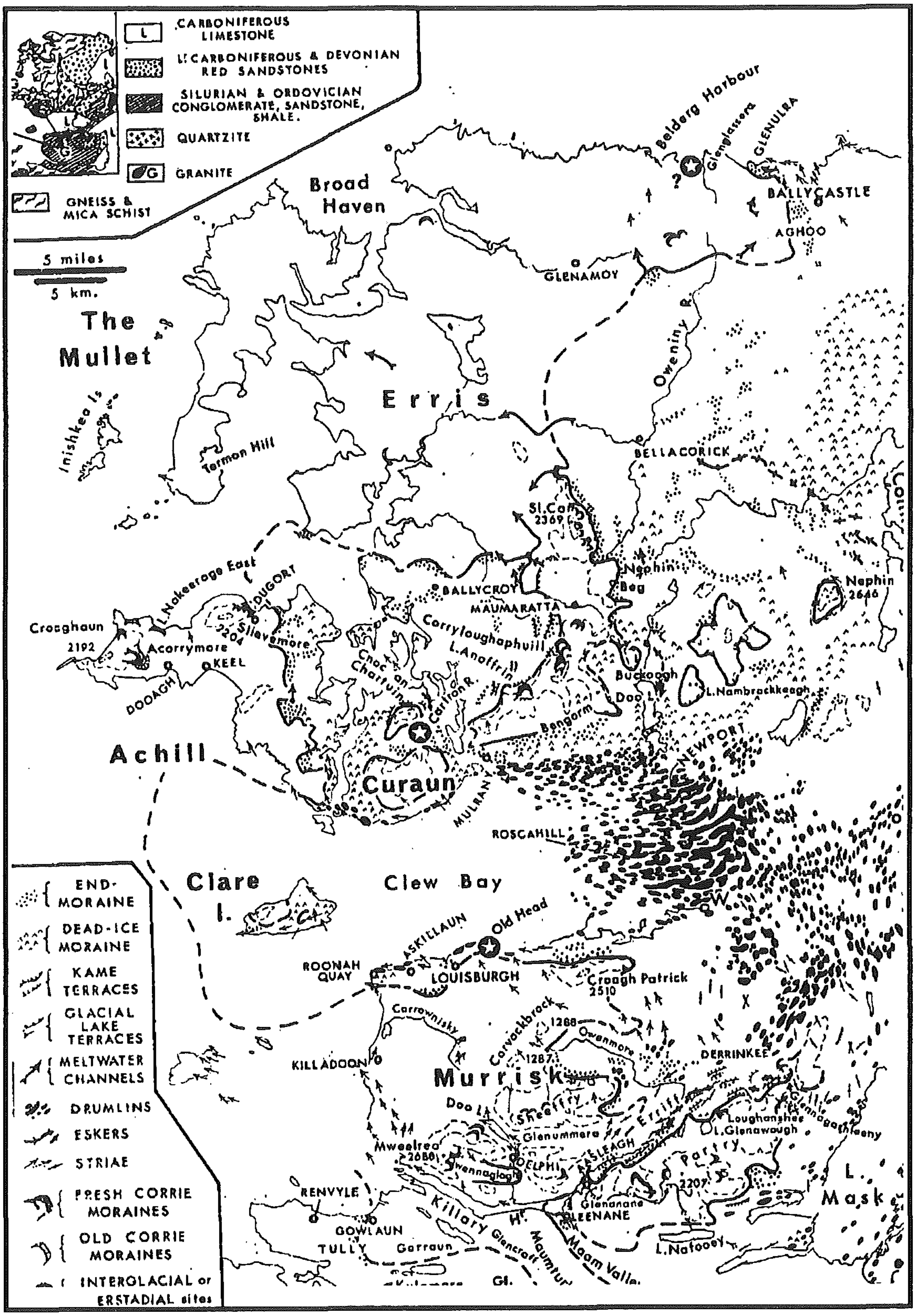


Figure 7. The glaciation of west Mayo showing the Ballycastle to Mulrany end moraine. From Synge, 1968.

4. The glacial geology of Clare Island

Against an uncertain stratigraphical backdrop it is not possible to place the glacial sediments of Clare Island within a firm framework. However, it is possible to characterise the glacial sediments and to assess the Pleistocene geomorphology of the island as a whole.

The Ballycastle-Mulrany end moraine, as mapped by Synge (1968), passes across Clare Island from NE to SW suggesting that the island was at or near the limit of the Drumlin Substage of the Glenavy Stadial some 17,000 years ago (Figure 7). This makes the drumlins and associated glacigenic sequences of particular interest as it suggests we may be looking at the margins of a large outlet glacier that produced the drumlin swarm in Clew Bay. The Drumlin Substage is associated with the widespread deposition in Clew Bay of the Roscahill and Newport Tills which are described below.

Modern work around the Irish coast has suggested that the drumlins associated with the Drumlin Substage were formed under unique conditions as fast-flowing ice uncoupled from the underlying sediment and moved towards the continental shelf. Such flow was generated by intense marine downdraw and lowering of ice sheet profiles during rapid deglaciation around 17,000 years ago (McCabe 1993).

The Quaternary geology of the area was first described by Cole *et al.* (1914). Synge (1963 and 1968 and IN Herries Davies and Stephens, 1978) summarised the glacial history and his observations of the tills provide a useful summary (Synge's stratigraphy of these tills is given in Table 1 above). The predominant glacial sediments of the Clew Bay area can be summarised as follows:

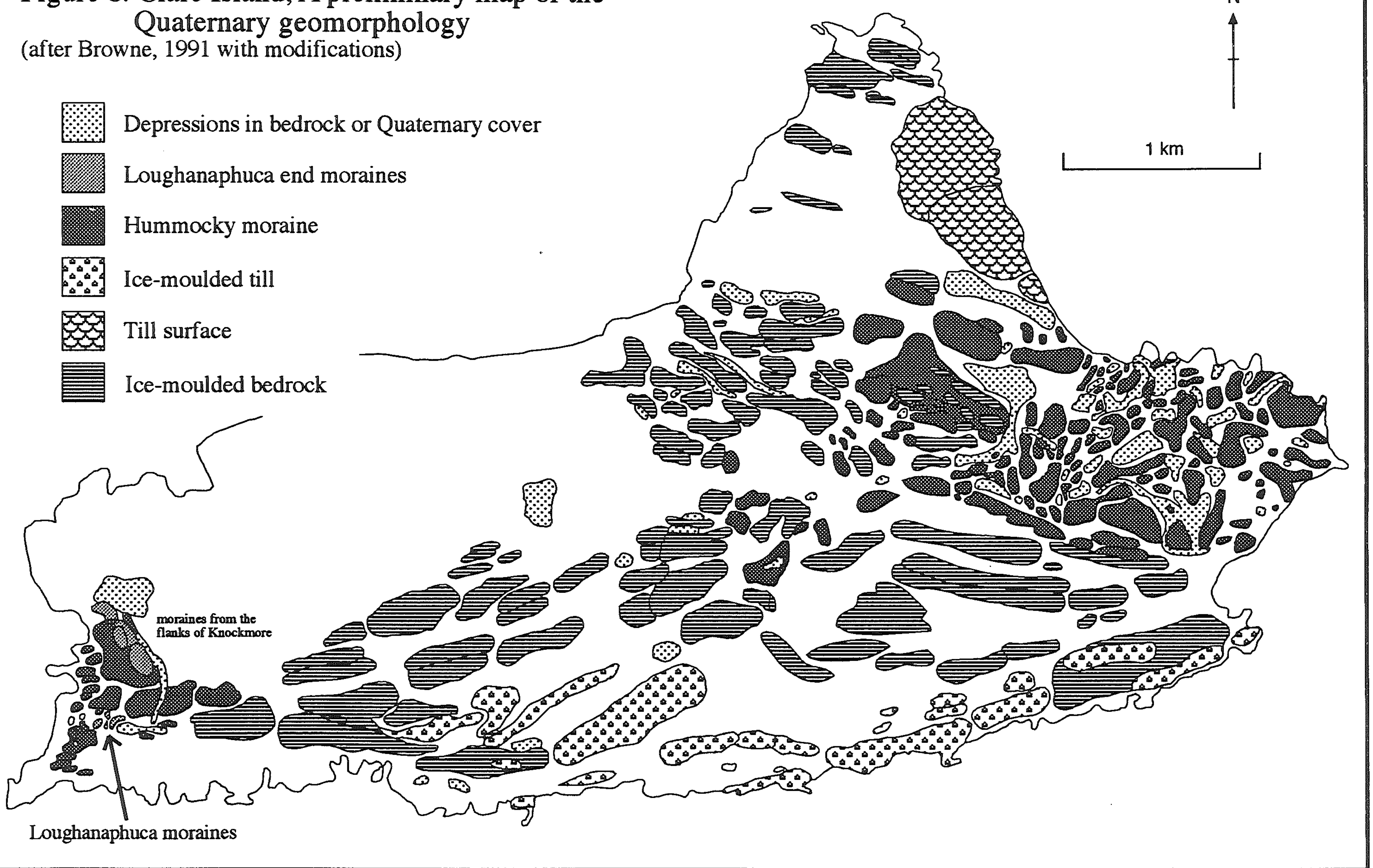
Newport Till (Glenavy Stadial)	Sandstone-rich diamicton frequently containing large angular and sub angular boulders in a matrix of shattered Old Red Sandstone.
Roscahill Till (Glenavy Stadial)	Massive, limestone-rich diamicton containing striated, sub-rounded to sub-angular cobbles and boulders in a sand/silt matrix of crushed limestone. frequently found lying on ice-moulded and/or striated bedrock. Contains local and regional erratics.
Killadoon Till (unknown age)	Ice movement north or NNW across Clew Bay from Murrisk. Till contains shale and sandstone as well as granite from Corvockbrock.
Erris Till (unknown age)	Extensive in lowlands of NW Mayo. Ice moved towards the NW leaving only higher mountains uncovered.

The movement of the ice across Clare Island has had a profound effect on the landscape, both moulding the underlying bedrock, and depositing glacigenic sediments across the eastern and southern parts of the island. We shall visit sites that will put the possible sequence of events and the sedimentary environments that produced the deposits into perspective.

The glacial geomorphology of Clare Island is depicted on Figure 8 which has been modified after the work of Browne, 1991. This map shows the major glacigenic landforms and the extent of the principal till types. The main sequence of events was as follows:

Glacial striae and erratics suggest that much of the island has at some time been overrun by ice with erratics found on the ridge of Knocknaveen at 200m O.D. (Hallissy, 1914). The sequence of glacial events is a bit more difficult to define.

Figure 8. Clare Island, A preliminary map of the Quaternary geomorphology
(after Browne, 1991 with modifications)



The earliest phase of extensive glacial activity (rather than piecemeal evidence) that can be recognised is from the thick deposits of limestone-rich till which are smeared across the eastern, northeastern and entire southern parts of the island. The till (which can be correlated to the **Roscahill Till** of Synge, 1968 but see the discussion below) is a predominantly poorly-sorted, massive and compact diamicton containing a mixed erratic assemblage of limestone, sandstone, siltstone and quartzite. It varies locally and to the west contains abundant local clasts. To the northeast of the island it reaches thicknesses of 20m+. The diamicton contains numerous large shear planes at some sites and many smaller ones and it has a strong fabric orientation suggesting it is a lodgement till. Fabrics indicate that the ice that deposited this till was moving from the east as do striae on bedrock surfaces and ice-moulded bedrock along the south coast which all show a direction of 260-280^{o}. Such an ice movement direction would be concomitant with a large outlet glacier flowing along Clew Bay onto the continental shelf towards the west. The distribution of ice -moulded bedrock and limestone-rich till suggests that the ice that deposited the Roscahill Till on Clare Island crossed the eastern end of the island, ran along the northern and southern flanks of Knocknaveen, along the southern coast and extended part way into the northeastern end of the col between Knockmore and Knocknaveen. Ice-moulded bedrock to the southwest of the col suggests that ice did cross between the two hills at some stage but diamictons with a local origin obscure the extent of the Roscahill Till on the flanks of Knockmore, Knocknaveen and within the col itself. It is uncertain whether these diamictons are local facies of the Roscahill Till, whether they represent a separate glacial episode, are remobilised glacigenic deposits or are solifluction deposits. The ice that deposited the Roscahill Till may have crossed the col into the western part of the island (the col reaches 110m O.D., see Figure 1) and that ice may also have crossed some of the upper slopes of Knocknaveen.

Overlying the Roscahill Till in the eastern part of the island are less massive diamictons containing sub-angular, and angular boulders within a sandy matrix. The till contains lenses and beds of better sorted sediment which is stratified in places This reddish-brown till has a high component of sandstones and quartzites with less limestone and this material is comparable to that described by Synge as the **Newport Till**. The Newport Till has produced a notable landscape element of hummocky moraine in the northeastern part of the island where it is best developed. This landscape (Maum and Capnagower Townlands) is truly spectacular with kame and kettle topography producing the hummocky appearance of an area where ice has recently stagnated and wasted *in situ* . Some sections within the hummocky moraine are chaotic mounds of large boulders within a sandy matrix. To the east and southeast of Knocknaveen the ice that deposited the Newport Till appears to have been relatively unimpeded and has formed a veneer over the Roscahill Till, formed stratified deposits in the lee of drumlinised Roscahill Till and formed lee-side deposits behind local rock protuberances. However to the north and northwest of Knocknaveen the ice appears to have been restricted by high ground the south and east and to have come to a halt against the side of Knocknaveen. Indeed, the sloping hummocky surface on the northern side of Knocknaveen is a trim line of this glacier and this ice did not breach the col but stagnated against its northeastern slope

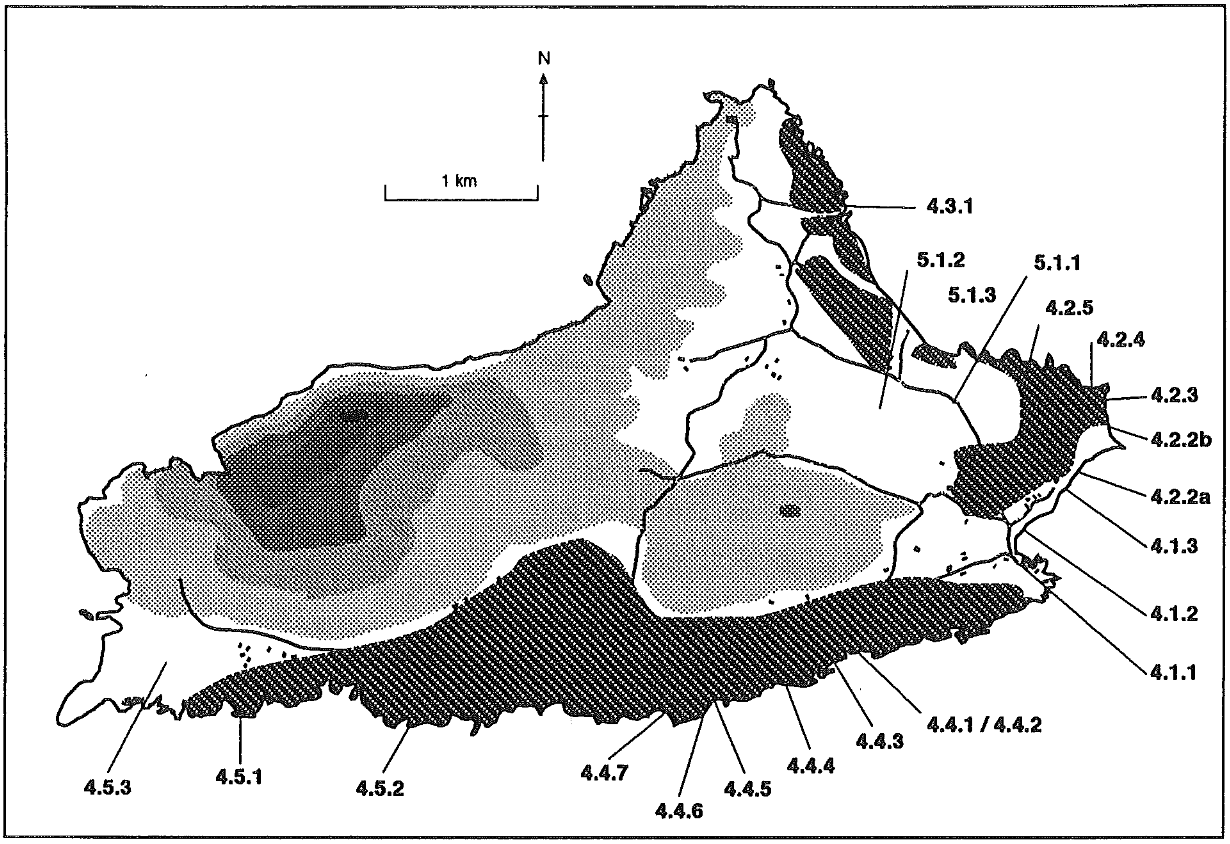


Figure 8a.1. Distribution of limestone containing diamictons

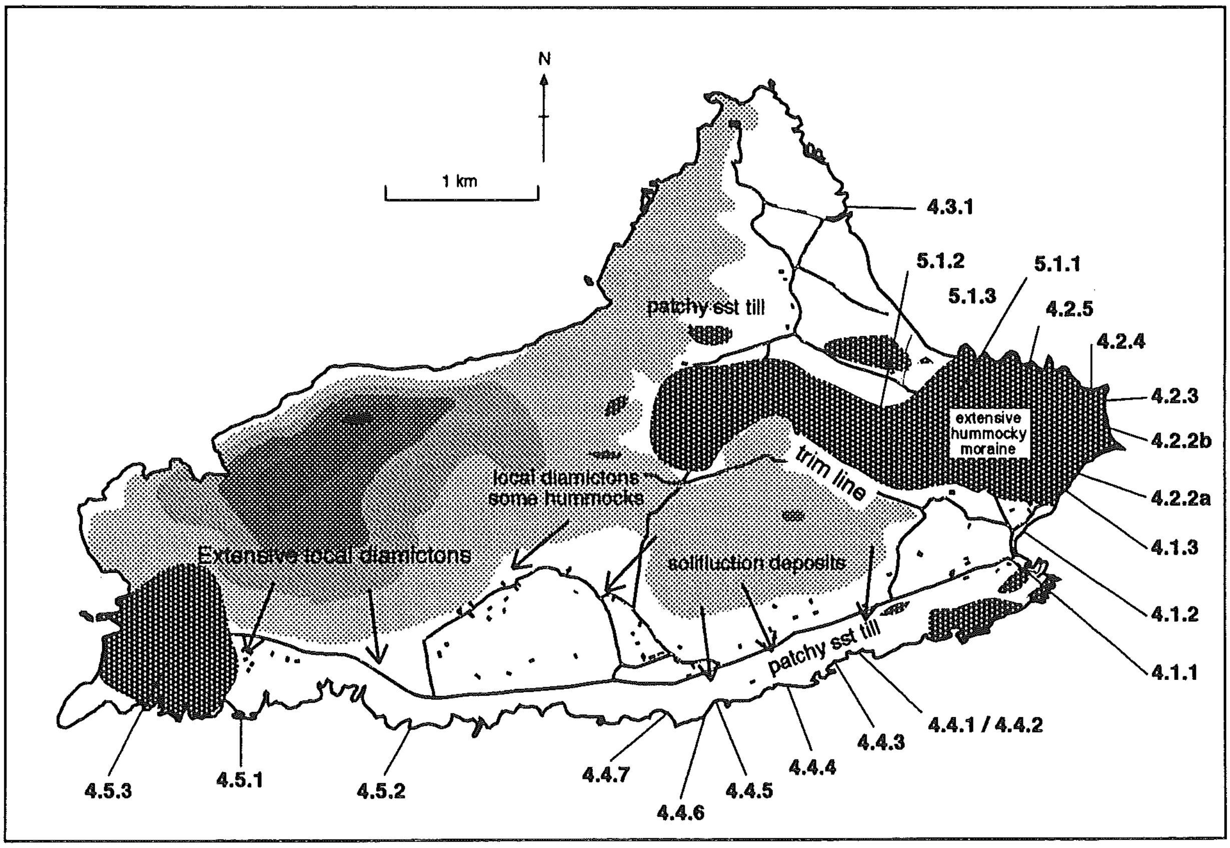


Figure 8a.2. Main distribution of sandstone containing diamictons

It is probable that the two tills are very closely related. Certainly the upper, Newport Till, has the appearance of melt-out , supra- or en-glacial material and may have come from a different part of the same glacier system as the Roscahill Till. it is also possible that the Newport Till represents the last advance (or surge) of a rapidly thinning outlet glacier during the latter part of the Drumlin Substage. The Roscahill Till, widespread lodgement of debris and associated ice-moulding could then be seen as being formed during the main phase of glaciation during the Glenavy Stadial. Such a relationship between the two tills would explain the limited extent of the Newport Till relative to the more widespread Roscahill Till and it would explain the draping of the former over the latter and their close association in drumlin forms along the southeastern coast of the island. Such close association of the two tills highlights the problems in using lithostratigraphic subdivisions in glacigenic sediments.

It is very important to realise that the two till lithologies are not always readily distinguished. Assigning complex diamicton units that are spatially very variable to type localities brings inherent problems and Clare Island is no exception. Although some sections appear to present clear examples of each type there are very prevalent local variations and the likelihood is that much of the observed till variation reflects changing sediment source area and facies. The principle difference between the Roscahill and Newport Till is one of depositional environment (reflected in the landform association) and genetic origin. Whether this also reflects a difference in age is open to question.

There is evidence for a small glacier having formed on the southwestern flank of Knockmore and the small arcuate moraines at Loughanaphuca (20m long 1-2m high) are shown on Figure 8. A locally derived diamicton overlies one containing limestone at this locality. These are described in more detail below.

Elsewhere on the island there is a widespread cover of soliflucted sediment which can be seen particularly clearly in stream sections and along parts of the south coast.

Glacial geology, sites to visit:

(A stroll around the coastal sections armed with Figures 1 and 8 will provide the reader with much to see. **Please note** that if wet or weedy the wave cut platform is incredibly slippery.). The sites are located on Figure 1 and the locality names are from the Ordnance Survey 1:10,560 scale maps.

4.1 Harbour area, Fawnglass.

Sections between the Bayview Hotel and the harbour show a poorly sorted diamicton containing angular cobble and boulder clasts in a sandy matrix. The lithologies are predominantly sandstones and quartzites. This diamicton is glacigenic and has evidence of some resedimentation and water sorting in the form of stratified and laminated horizons. There is an absence of fines and the fabrics are not particularly strong although they do suggest ice movements towards the west. The stronger fabrics indicate a movement towards 280° (4.1.2, Figure 9). The clast lithologies suggest that the tills in this area are similar to those described as Newport Till elsewhere and these are shown on Figure 12 (the clast composition data are all from Browne, 1991 and are based on a count of 200 pebbles in the 8-32mm size range after methods outlined in Bridgland, 1986).

4.1.1 Glen drumlin.

Here the sandstone rich till (diamicton with angular clasts in a sandy matrix) has three distinct units The diamicton is draped over ice-moulded bedrock that has a drumlin form and the clasts from the central unit show a preferred orientation towards 250^{o} (Figure 9).

4.1.2. North harbour, and 4.1.3 Bayview Hotel

The diamictons contain angular and sub-angular clasts, in part clast supported, with plucked local bedrock in places. There are distinct stratified and sorted units within these sediments, particularly in the middle and upper parts of the sequences. I suggest that they, in part, represent basal tills with evidence of bedrock erosion and resedimentation at the lower contact with bedrock or underlying till and with melt-out facies higher in the sections evidenced by weaker fabrics and by water sorting. The fabric shows a general westerly movement (Figure 9) and the pebble lithologies are mixed (Figure 12) The draping of much of this unit with angular clasts in a sandy matrix was probably due to a cover of supra-glacial sediment lowered onto the surface during deglaciation. It is this ice stagnation that has formed the hummocky terrain in the eastern and northeastern part of the island.

It is interesting that in the harbour area the sandstone-rich diamicton that resembles the Newport Till can be seen have a number of distinct forms:

a. Locally derived rock debris taken into basal transport
b. Local and regional rock debris, including some limestone, forming a massive till unit.
c. A drape of angular, clast supported, and partly stratified debris overlying till
d. A drape of angular, clast supported and chaotically arranged boulders.

The changing nature of the diamicton makes it hard to assign a correlation to any particular lithostratigraphical unit and it is better to simply describe the material objectively. The diamictons in the harbour area appear to be both:

1. Possible lateral equivalents of the limestone-rich diamictons to the west.
2. Overlying the limestone-rich diamictons as drapes and melt-out deposits.

We can discuss the pebble counts, fabrics, the facies associations and the landform elements produced by the sandstone-rich diamicton in the field.

4.2 The eastern coastal sections

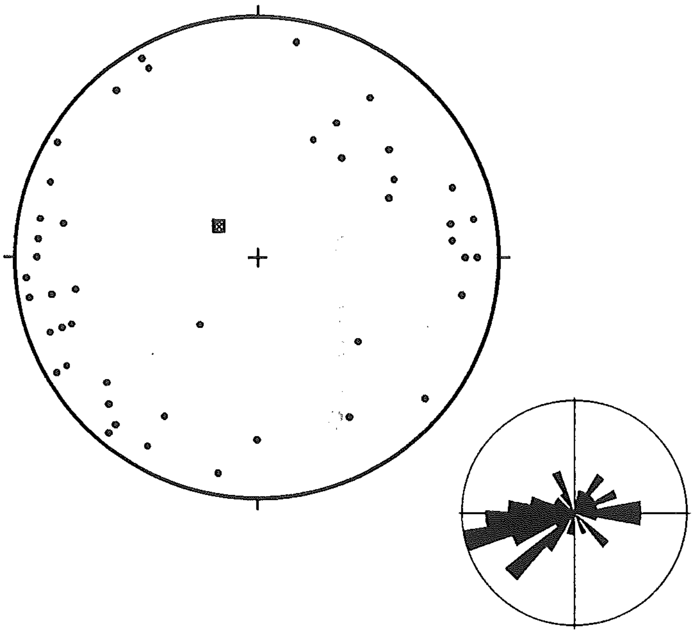
Low cliffs along the eastern end of the island provide sections within the glacigenic sequences and these have been described briefly by this author (1982) and by Browne, 1991. There are a number of interesting units along this stretch but access is not possible in wet weather due to the slippery nature of the rock. We may walk along here and the following sections are worth noting:

Figure 9. Fabrics from Diamictons, Clare Island (after data from Coxon, 1982)

Equal area lower hemisphere diagrams and rose diagrams

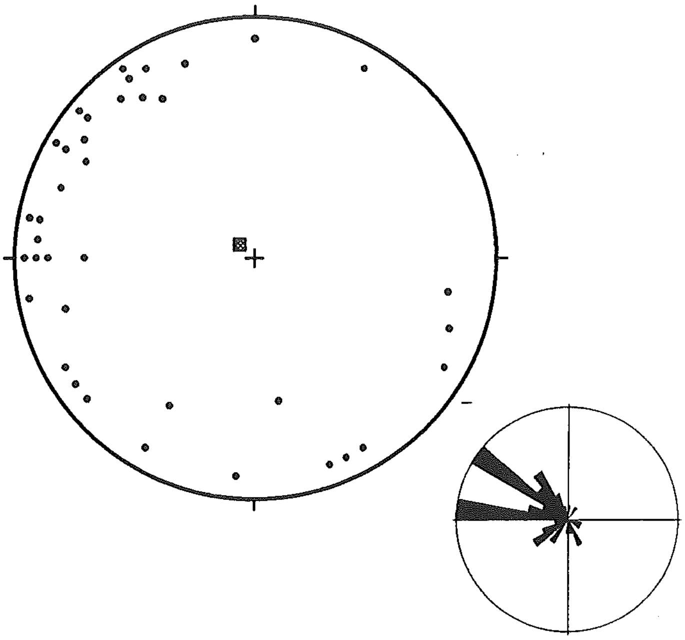
4.1.1. Glen drumlin

n=50, trend and plunge = 252.9°, 54.7°
length (max-1) =.3611
value too low to calculate concentration factor and confidence



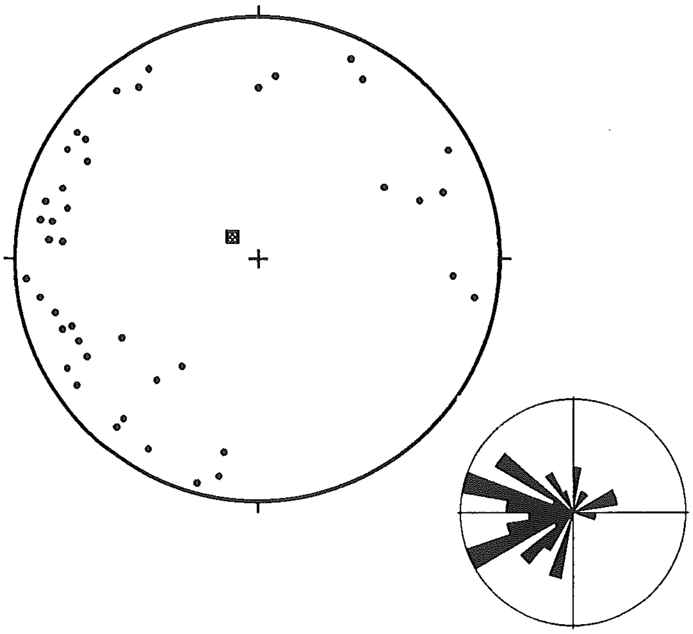
4.1.2. North harbour

n=50, trend and plunge = 279.4°, 21.1°
length (max-1) =.5958
value too low to calculate concentration factor and confidence



4.1.3. Bayview Hotel

n=45, trend and plunge = 271.1°, 32.6°
length (max-1) =.5318
value too low to calculate concentration factor and confidence



4.2.2a. West of Kinnacorra

n=45, trend and plunge = 332.4°, 26.2°
length (max-1) =.6133
value too low to calculate concentration factor and confidence

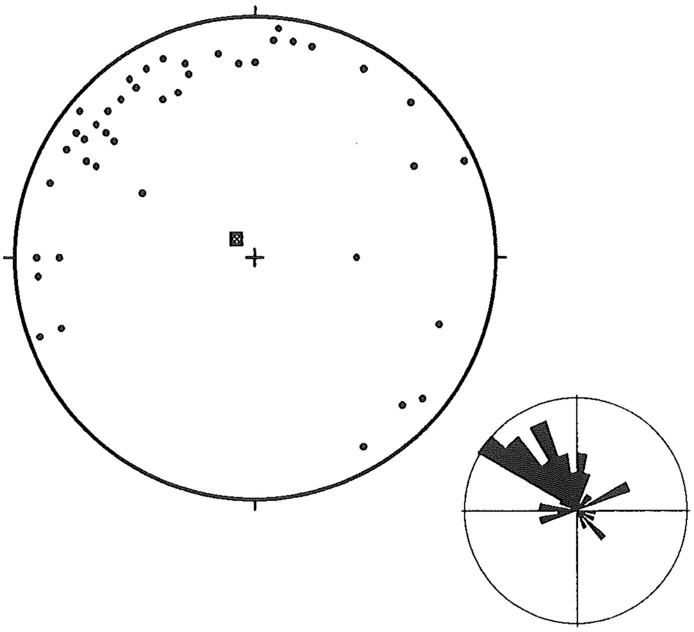
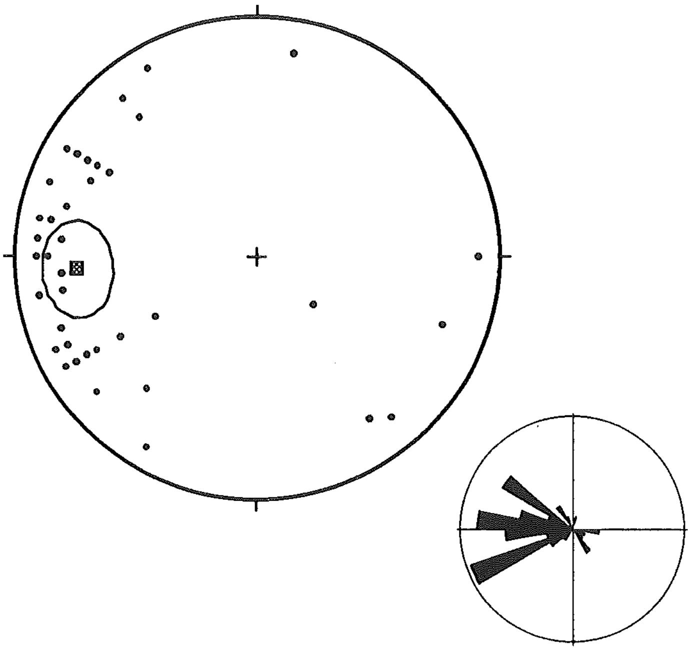
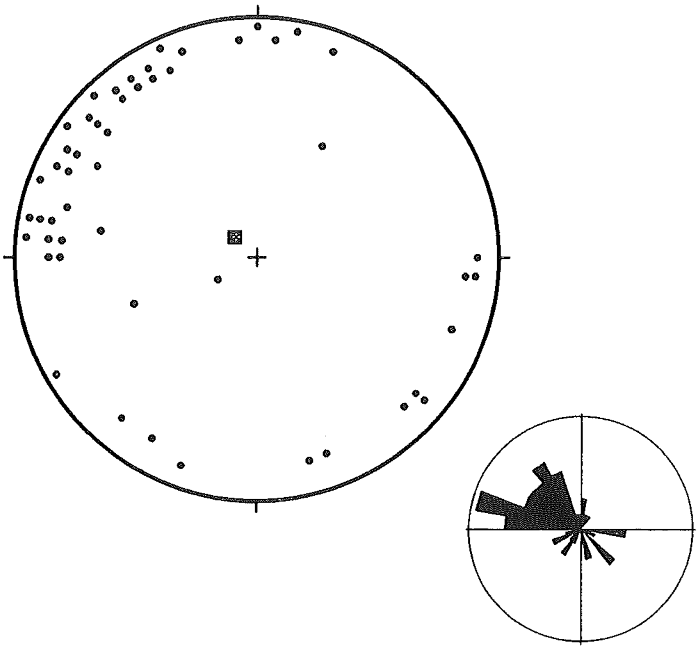


Figure 10

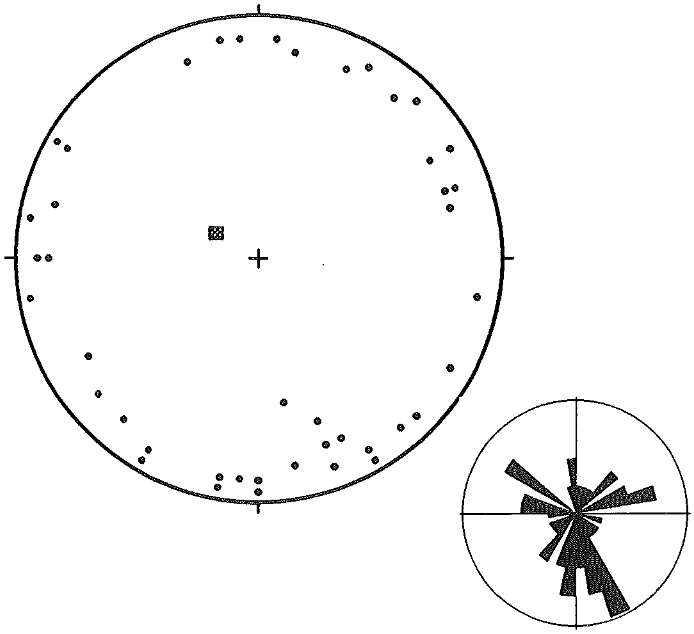
4.2.2b. Capnagower
n=50, trend and plunge = 266.1^{o}, 26.3^{o}
length (max-1) =.6927
99% confidence cone =17.4^{o} (not accurate)



4.2.4. Lacknacranny
n=56, trend and plunge = 299.7^{o}, 27.8^{o}
length (max-1) =.5237
value too low to calculate concentration factor and confidence



4.2.6. Maum Townland
n=45, trend and plunge = 167.3^{o}, 54.4^{o}
length (max-1) =.2650
value too low to calculate concentration factor and confidence



4.4.1. Ooghgubamonemeen
n=45, trend and plunge = 187.2^{o}, 28.3^{o}
length (max-1) =.5064
value too low to calculate concentration factor and confidence

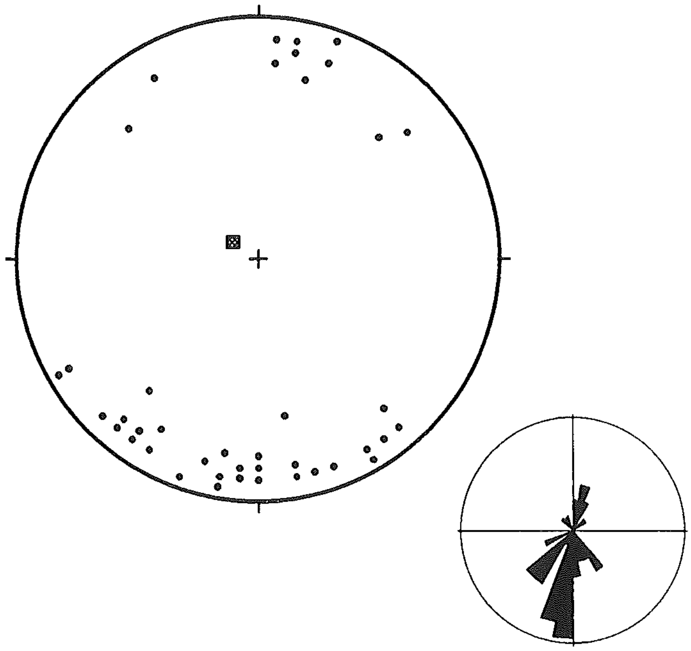
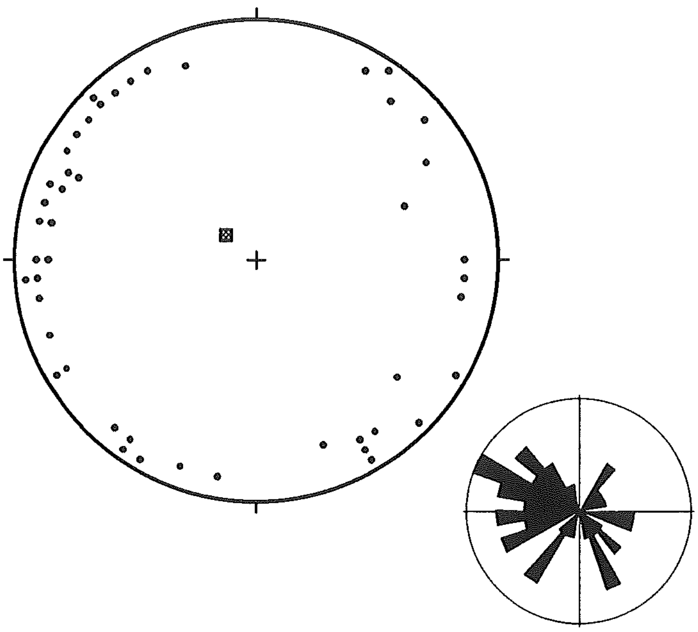
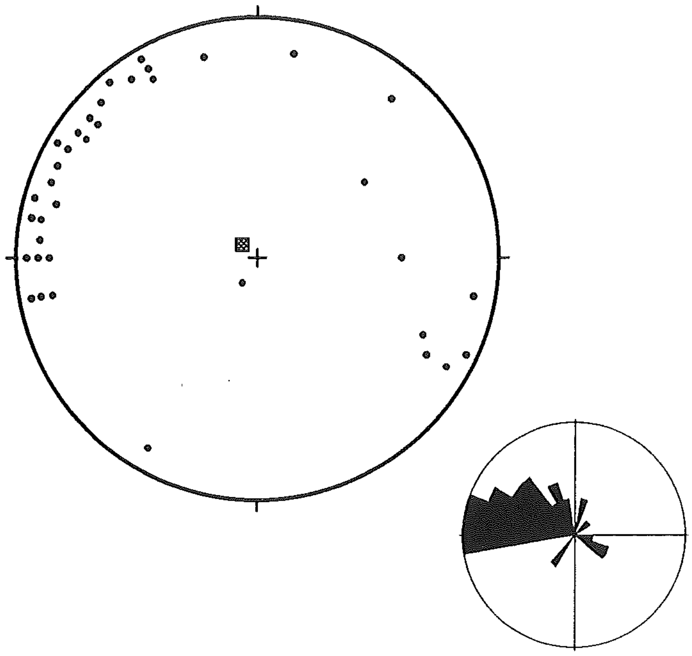


Figure 11

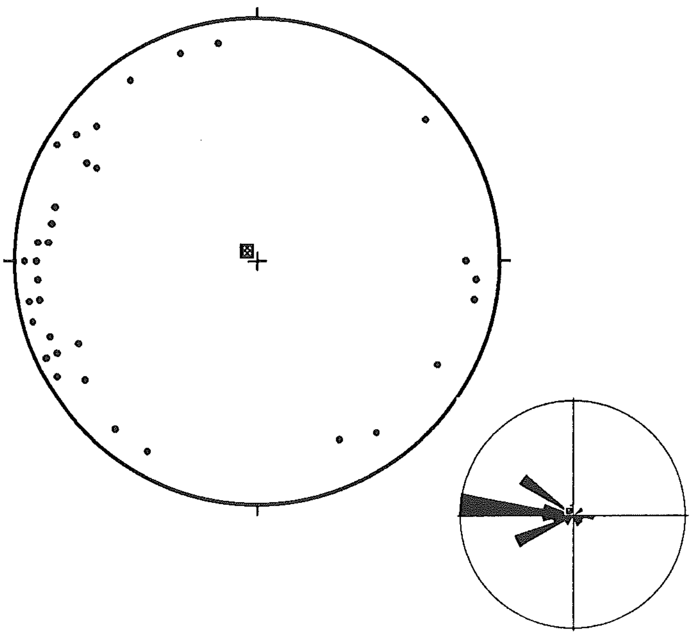
4.4.2. Ooghkeel
n=50, trend and plunge = 261.4°, 40°
length (max-1) =.3139
value too low to calculate concentration
factor and confidence



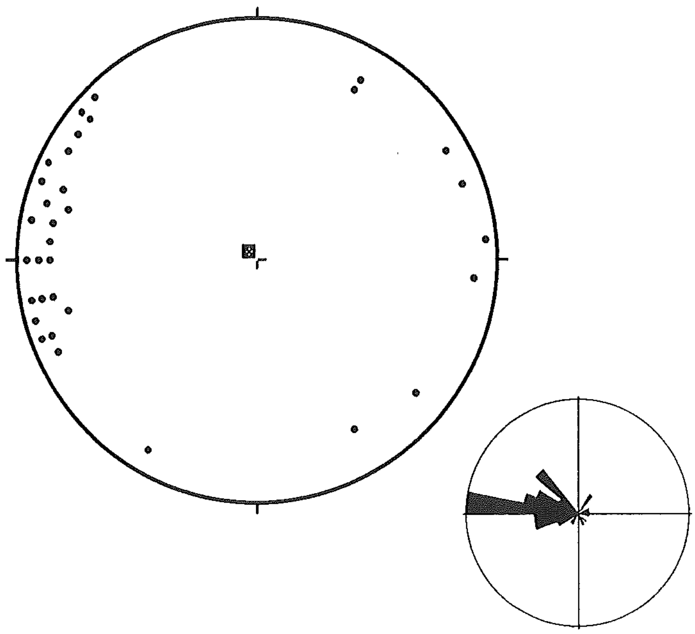
4.4.4. Barnasallagh
n=45, trend and plunge = 297.1°, 22°
length (max-1) =.6136
value too low to calculate concentration
factor and confidence



4.4.5. Peter Salmon's Cove
n=45, trend and plunge = 269.8°, 17.8°
length (max-1) =.6294
value too low to calculate concentration
factor and confidence



4.4.7. Portacoolia
n=45, trend and plunge = 279.1°, 15.7°
length (max-1) =.6461
value too low to calculate concentration
factor and confidence



4.2.1. Cliff between Bayview Hotel and Kinnacorra

Diamicton composed of angular/subangular cobbles and boulders in a sandy matrix. Sorting and laminations are apparent as are loading structures disturbed laminated units and some folding. These structures suggest that the upper part of the diamicton is a till deposited from melting ice. The diamicton contains clasts of limestone (9%) as can be seen on Figure 12.

Along this part of the coast sections in the hummocky moraine topography can be seen to consist of this type of material. The fabric has a notable trend towards 330^{o} suggesting ice movement on shore from the south east (Figure 9, 4.2.2a).

4.2.2b. Capnagower

Angular-subangular cobbles and boulders in a sandy matrix. Massive unit with crude stratification and sorting. The clast content suggests that the material is predominantly local in origin (Figure 12). The strong fabric of this till shows an orientation towards 266^{o} (i.e. westwards, see Figure 10).

As we walk along the shore towards the north the lower, limestone-rich till, can be observed below the upper one.

4.2.3. Carricknaportaun (Alnahaskilla of Browne, 1991)

Here high cliffs in till show a basal unit of limestone-rich (Roscahill?) till 2-3m thick overlain by the sandstone-rich (Newport?) till. The important point here is the nature of the boundary between these two units and the differences in the environment of deposition. The lower till contains limestone and local bedrock(Figure 12) and appears massive whilst the upper part of the section contains well-stratified (and in places channelised with poorly sorted horizons) horizons. Clearly the apparent lithostratigraphic change is being controlled here by the change in depositional environment.

4.2.4. Lacknacranny and westwards

The sections from the Alnahaskilla headland westwards show a clear division between the lower and upper tills. However, the relationship between the two deposits is not altogether simple. The lower till is limestone rich and has cobbles and boulders in a silt/clay rich matrix (the fabric suggesting ice movement towards 300^{o} , 4.2.4., Figure 10). The lower unit grades up into a more sandstone -rich deposit of pebbles, cobbles and boulders in a sandy matrix. Shear planes project down through both of these deposits suggesting that as the upper of these two units was deposited the sediment was being sheared (northwestwards). Although the boundary of these two units can be seen the junction is not sharply erosional but a gradual change in the clast content and matrix type. I would suggest that the two facies have been moulded together as the upper one was smeared over the lower. The shear planes being formed during the remobilisation of the lower till by the upper, perhaps during a later phase of ice movement. The source and depositional origin of the sediment may also have been different with the lower till resembling a lodgement till and that above a melt-out till suggesting they have come from different parts of the glacier system.

The sequence here is capped by angular boulders in a coarse matrix which is probably the supra-glacial sediment laid down as the glacier stagnated to form the hummocky topography.

4.2.5. Intermorainic boulder streams

Within the hummocky moraine (see below) there are impressive hollows and in some of these large boulders have collected in boulder streams. The widespread scatter of large, supra-glacially transported, clasts that were left lying across the landscape as the ice melted have soliflucted from topographic highs into the intermorainic hollows and valleys forming lines along the troughs. Some form ploughing blocks on the steeper slopes.

4.2.6. Maum and Capnagower Townland, hummocky moraine

As we head back inland to the southwest we cross the undulating surface of the upper glacigenic sediments that mask the underlying (and possibly glacially streamlined as on the southern coast) topography. The hummocky moraine is very impressive with an amplitude of over 15m and can be seen across the whole of the northeastern corner of the island (Figure 8). It is clear that a large lobe of ice stagnated within this corner of the island and it is likely that this was the last readvance of the Clew Bay outlet glacier at the end of the Drumlin Substage. The moraine reaches up the side of Knocknaveen where a trim line extending northwestwards can be identified at an altitude of around 90m. The hummocky terrain stretches into Lecarrow and part of the way into the Knockmore-Knocknaveen col but does not pass through it suggesting that the ice was not thick enough to encroach above 100m.

4.3 The northeastern coastal sections

4.3.1. Ooghcorragaun

Thick diamicton sequences are found along this part of the coast but are not very well exposed. The diamicton is massive, contains limestone (Figure 13) and has a strong fabric suggesting that is a lodgement till deposited by ice movement towards the west. The till forms a broad expanse (bench) of sediment banked against the northern section of the island but not reaching much above 60m (see Figure 8) suggesting the ice was flowing along this coast and around it to the north rather than across the northern end of the island. Channels cut through bedrock in Ballytoohy More may have acted as meltwater outlets from the ice at this stage although their origin is probably far older (as palaeochannels from a former drainage basin to the northwest, now gone?).

4.4 The southern coastal sections

Nearly the whole of the southern coast provides sections in Quaternary sediments. The general succession is that of a heavily striated and ice-moulded rock surface overlain by a limestone-rich diamicton which appears to be a lodgement till. This till has been ice-moulded producing extensive drumlinised topography along the southern coast. At the eastern end of the island this diamicton is overlain by a sandstone-rich one. This succession is suggestive of the Roscahill Till overlain by the Newport Till. The lower diamicton, and indeed the glacigenic sediments as a whole, thin out towards the west of the island and are sporadic beyond Craigmore. Along much of the coast the limestone-rich diamicton is overlain by local soliflucted sediment that has travelled downslope forming a drape over the glacigenic sediments. The ice-moulded bedrock, rafts of glacially transported bedrock and the drumlinised lodgement till are all impressive and worth a visit.

Figure 12. Clast lithological analyses (data from Browne, 1991)

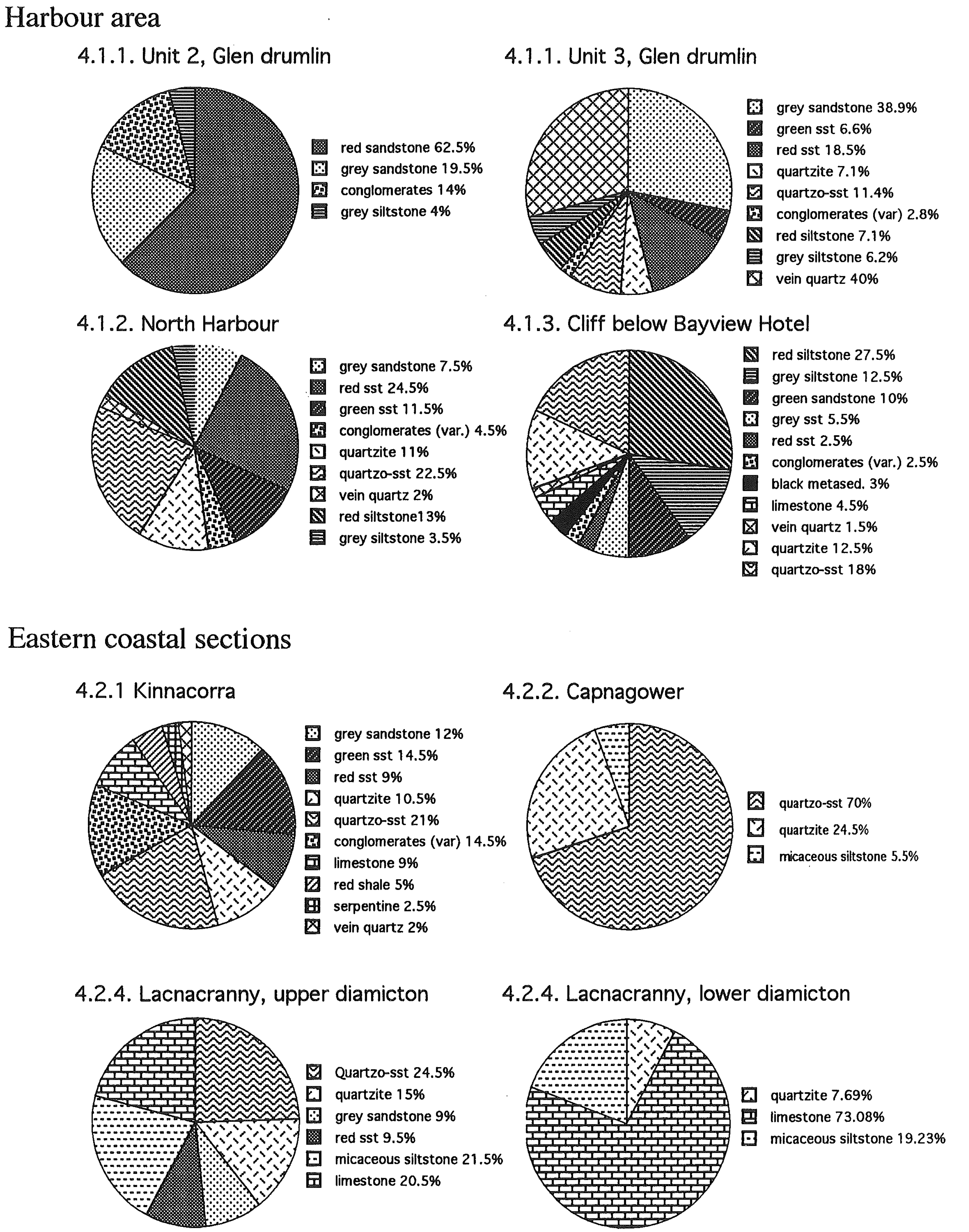
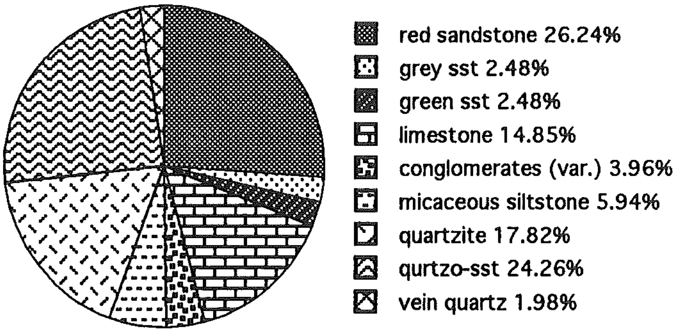


Figure 13.

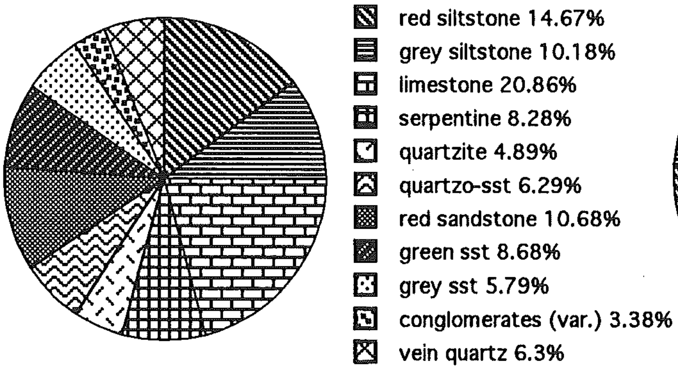
Northeast coast

4.3.1. Ooghcorragaun

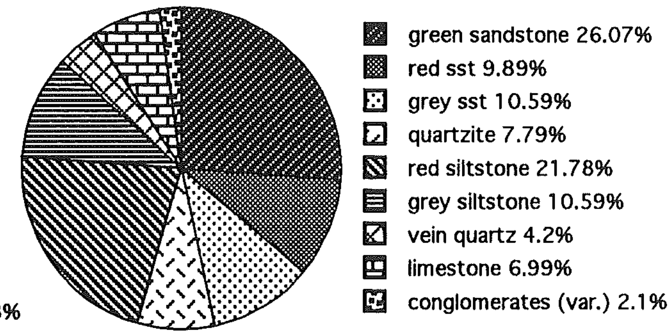


South coast

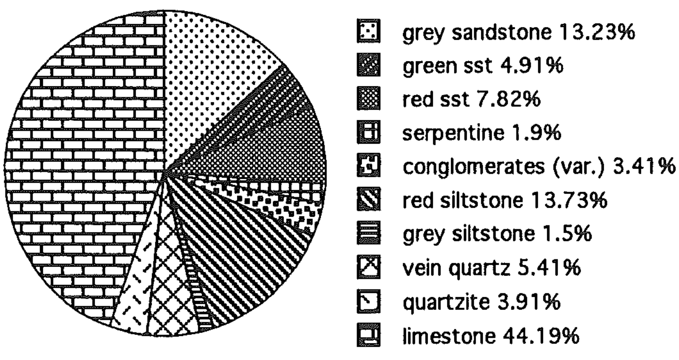
4.4.4. Barnasallagh



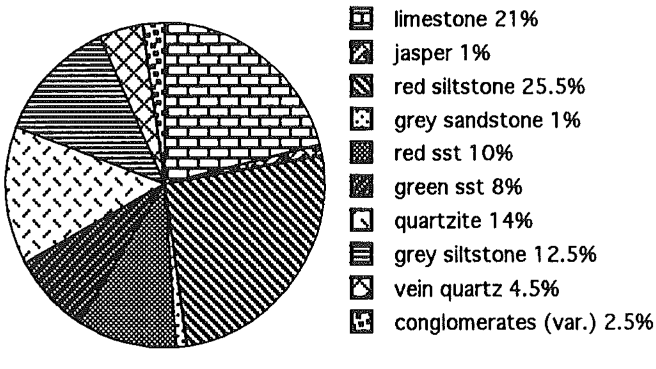
4.4.7. Portacoolia, upper diamicton



4.4.7. Portacoolia, lower diamicton



4.5.2. Ooghnageeragh



4.4.1. Ooghgubamonemeen

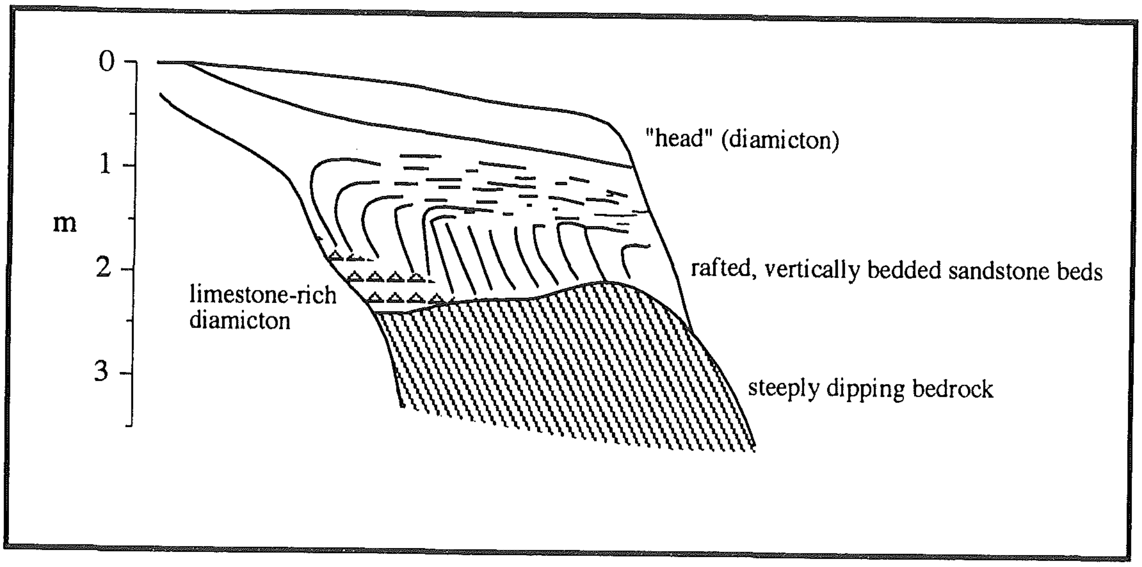
Sections in a diamicton composed of local rock types. Some of the clasts are striated and the fabric is very weak (Figure 10). This sediment is probably a reworked till that has been solifluncted downslope (towards 180°). It is tempting to use a place with a name like this as a type locality.

4.4.2. Ooghkeel

The bedrock surface here is striated and grooved (250°). The lowermost sediment in the section is a diamicton containing limestone. The fabric indicates ice movement

4.4.3. Oomernakineel

This site shows a section of rafted bedrock lying on limestone till. This may be an ice-rafted block or it may represent downslope slide under the effect of gravity. Overlying the raft are solifluncted sediments that show nice soil creep structures including overturned bedding. There is a further layer of solifluncted diamicton on the surface.



4.4.4. Barnasallagh

This site shows 4-5m of limestone-rich lodgement till. The till contains varied lithologies (Figure 13) including 21% limestone within a grey (tinged with pink) silty matrix (of crushed limestone and sandstone). The till fabric shows a clear dip towards 300°. The steeply dipping siltstones at this site have a clear erosional bench cut across them. Again at this site there are overlying remobilised (solifluted) sediments.

There are impressive sections in ice-rafted bedrock (they have travelled a short distance and some are 50m long) and till along this part of the coast showing that the ice-moulding of the bedrock, the emplacement of the lodgement till and substantial bedrock movement were all occurring locally.

4.4.5. Peter Salmon's Cove

5-6m of lodgement till with a matrix of grey/pink silty sand with clay. The clast lithology is again variable with over 20% limestone. The till contains a marked fabric with a strong orientation facing due west. The diamicton is predominantly massive with no apparent lamination except in the upper part of the sequence where some weak sorting has occurred. However, to the west of the section laminated muds and clays are draped over underlying lodgement till. These laminated sequences may be lee-side sequences. At the western end of the high section there are large shear planes running down through the entire thickness of till and there are marked, oriented, boulder accumulations along the lines of shear which stretch for 25m.

4.4.6. Portnakilly

This stretch of coast exhibits large whaleback ridges produced by ice-moulding. There are also p-forms in the rock surface which exhibit noted channel meandering and asymmetry. The ice-moulded forms show an orientation towards 265-270°.

4.4.7. Portacoolia

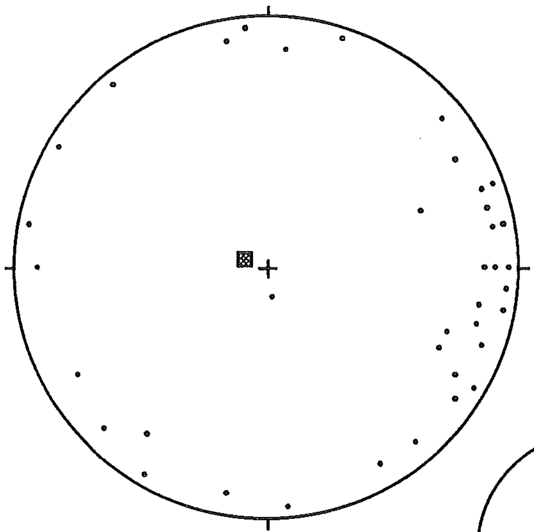
Hallissy noted three sets of striae at this locality (in Cole *et al.*, 1914) oriented 240, 300-305 and 195°. The lodgement till again shows a strong fabric towards the west (280°, Figure 11. There is an overlying diamicton at this site which can be seen to be more sandstone -rich than the lower, limestone dominated, one (Figure 13). I would suggest that the lower part of the sequence is a lodgement till resting on bedrock and that the upper material represents sediment deposited by melt-out as the ice decayed. Again this site shows a clear relationship between an upper and lower till and suggests a strong link between the two.

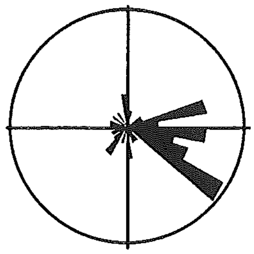
4.5. The south western coast and the western end of the island

4.5.1. Ooghganny

The site at Ooghganny shows local material predominating within a diamicton. I think that these sections may represent an ice advance from the corrie on Knockmore

n=45, trend and plunge = 101.8^{o}, 23.6^{o}
length (max-1) =.5030
value too low to calculate concentration factor and confidence





4.5.2. Oognageeragh

A clast analysis from this site (Browne, 1991, Figure 13) gives an impression of the content of the diamictons at the western end of the island. The sediment is poorly sorted with a strong fabric (dipping westwards) and is probably a lodgement till. There are laminated fines at the base and shear planes within the matrix. Much of the surface at this end of the island is mantled by local materials possibly originating from ice on the side of Knockmore.

4.5.3. Loughanaphuca.

The moraines at this end of the island are fascinating. They are small (*c.* 2-3m high and 20m long) arcuate moraines and represent a late ice advance. Hallissy (in Cole *et al*, 1914) described the small curved ridges at Loughanaphuca as moraine ridges representing successive retreat of a small glacier. On the grounds that they may have been Late-glacial (*s.s.*) in age the author took cores from behind the small arcuate moraines (Coxon, 1982) and recovered what are probably early Holocene sediments from above grey-blue clays in the depression behind the ridges. The lack of a complete Late-glacial sequence (i.e. the lack of pre-Nahanagan Stadial sediments) may indicate a Nahanagan age for the moraine system. However, this is by no means certain and further research would be needed at this site to confirm such an age. A glacier of this size reaching sea-level during the Late-glacial would be of considerable interest and would suggest a large accumulation of snow on the western flank of Knockmore.

The western end of the island also has a large hummocky moraine complex which is probably the product of an older glacier within the corrie on the flank of Knockmore. This moraine complex appears to contain both limestone and local material suggesting the small local ice mass fed into the larger Clew Bay outlet glacier. The geomorphology of these moraines is complex and also requires further work to assess their relative ages.

5. Vegetation history of Clare Island

One of the original purposes of the IQUA visit in 1982 was to make a preliminary analysis of the peat deposits (see introduction). In order to do this a number of sites were investigated including a number of peat hollows in Maum Townland. One of these sites proved to contain five metres of sediment and provided a pollen record which has subsequently been published (Coxon, 1987). The following is an account taken from that publication.

Vegetation history, sites to visit:
5.1.1. Maum Townland

The site investigated is within intermorainic hollows in the northeastern side of the island and is shown on Figure 1. The pollen analysis was carried out using standard procedures (see Coxon, 1987; Moore *et al.* 1991) and a relative percentage pollen diagram was produced (Figure 14).

Sediment description from core at Maum Townland

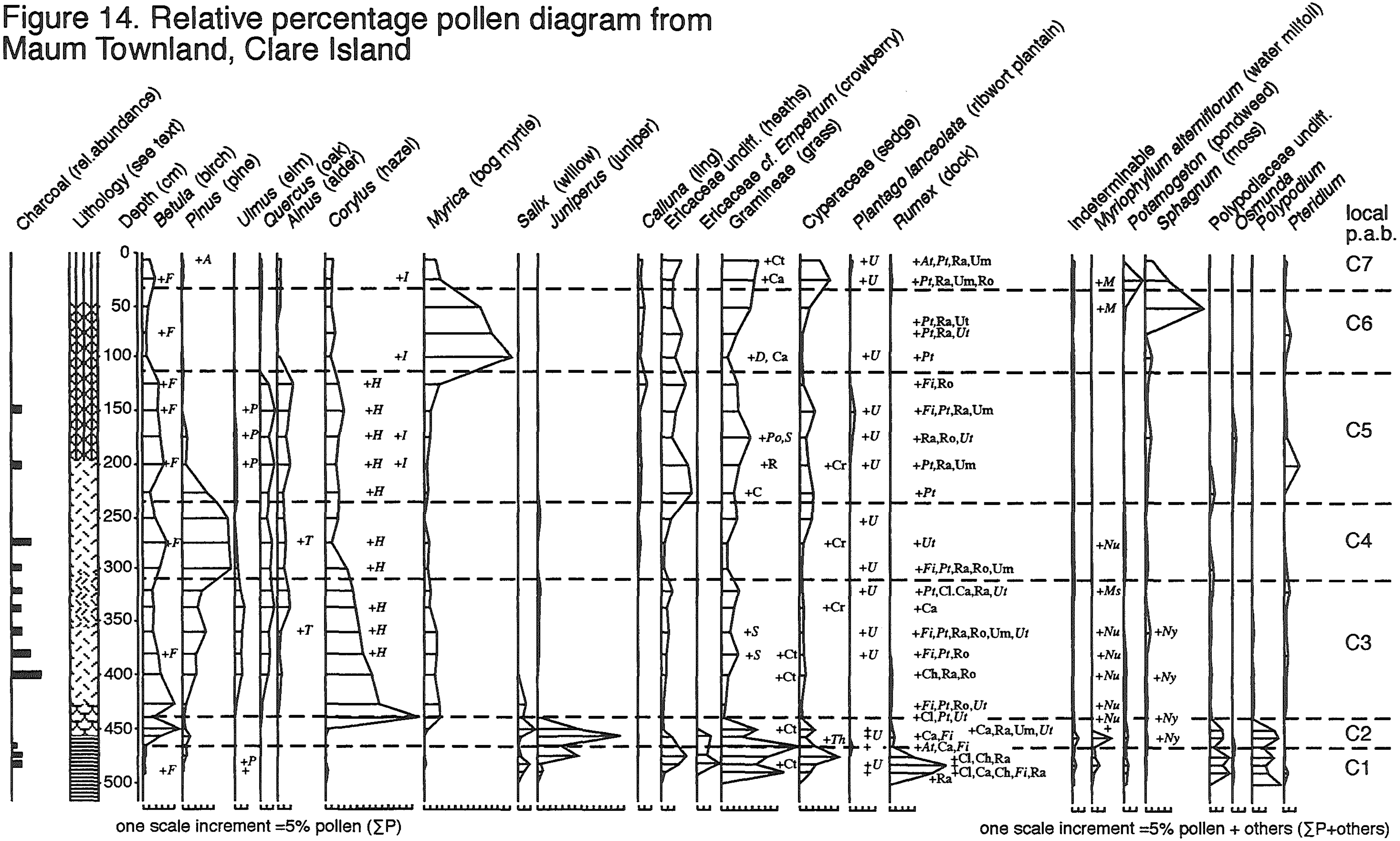
0-47cm	Coarse herbaceous peat with roots, stems and plant detritus	461-474.5cm	Light yellow mud with organic bands
47-200cm	Coarse homogenous herbaceous peat	474.5--490cm	Light grey mud
200-305cm	Very coarse detritus and occasional wood fragments	474.5-490cm	Marl with organic bands
305-360cm	Fine detritus, some clay	490-491cm	Dark grey clay
360-378cm	Coarse herbaceous peat and wood fragments	491-494cm	Laminated olive green clay and plant detritus
378-426cm	Coarse herbaceous peat, detritus and wood fragments	494cm-500cm	Laminated olive green clay with sand
426-460cm	Downward transition into yellow/grey, sticky marl with mud and organic bands (0.5mm thick)	500-520cm	Sand and angular pebbles with some clay
460-461cm	Yellow/grey clay		

The earliest sediments recovered were barren sands with pebbles indicative of unstable ground and cold conditions combining to infill part of the intermorainic hollow. lying on these are laminated sediments laid down in standing water that was surrounded by open vegetation of Gramineae, Cyperaceae, *Empetrum* and *Rumex*. Such pollen assemblages are widely known from the end of the Nahanagan Stadial some 10,200-10,000 years ago (Watts, 1977, Cwynar and Watts, 1989 and Gray and Coxon, 1991).

The open water conditions prevailed as the climate ameliorated and the landscape became colonised by *Juniperus*. This peak of *Juniperus* is ubiquitous in the Irish early Holocene and has been widely dated to between 10,000 and 9,500 years BP. At Lough Feeagh, 27km to the northeast, a similar assemblage has been dated to 9600 years BP (Browne, 1986). After the local peak in *Juniperus*, during pollen assemblage biozone (pab) C2, *Betula* and *Corylus* dominate the vegetation as these trees migrate and expand into the landscape, probably between 10,000 and 8,000 years BP.

The stabilisation of the landscape is evident from the nature of the sediment accumulating within the hollow by the end of C2 (i.e. increasing organic sedimentation replacing the initial deposition of organic-poor chalk and inorganic inwash) indicating stable soils. Following the peak of *Corylus* other tree types appear including *Quercus* and *Alnus*, while *Pinus* steadily increases in importance. The expansion of *Alnus* can probably be dated to between 6,500 and 7,500 years BP (Browne, 1986). At this level charcoal fragments become common in the pollen

Figure 14. Relative percentage pollen diagram from Maum Townland, Clare Island



key to abbreviated taxa:

F =*Fraxinus* (ash)
A =*Acer* (maple)
P=*Populus* (poplar)
T=*Taxus* (yew)
H=*Hedera* (ivy)
I=*Ilex* (holly)

C=*Centaurea*
Po=*Polygonum*
Ct=Compositae tubuliflorae
D=*Drosera*
S=*Succisa*
R=Rubiaceae
Fi=*Filipendula*
Ca=Cereals

U=*Plantago* undiff.
Th=*Thalictrum*
Cr=Cruciferae
At=*Artemisia*
Cl=Compositae lig.
Ca=Caryophyllaceae
Ch=Chenopodiaceae

Pt=*Potentilla*
Ra=Ranunculaceae
Ro=Rosaceae
Um=Umbelliferae
Ut=*Urtica*

M=*Menyanthes*
Ms=*Myriophyllum spicatum*
Nu=*Nuphar*
Ny=*Nymphaea*

Analyst: Pete Coxon, August, 1982

residues (see Figure 14) and remain so until pab C4 indicating frequent burning of the local vegetation.

Before *Pinus* comes to dominate the landscape the levels of pollen of *Ulmus* decline at around 330cm in the core. this appears to be the elm decline dated from many sites around Ireland to *c.* 5,000±300 years BP (Edwards, 1985). In the nearby Nephin Beg mountains the elm decline has been dated at three sites to between 4,200 and 5,000 years BP.

Subsequent to the decline of elm, *Pinus* becomes the dominant pollen contributor and this tree appears to have been the main forest component along with *Betula*. Many stumps of pine are found in and around Maum Townland and indeed Forbes (1914) constructed a map of the pine and oak stumps and of the probable former extent of these trees showing the northeastern part of the island to contain the highest concentration of these fossils. The frequent fires suggested during C4 by the high charcoal concentrations are also evident in the burnt nature of many of the pine stumps within the cut bog of Maum Townland. The period of pine domination post dates the elm decline and it is probable that the fossil stumps and the decline of pine at the start of C5 dates to 4,000 years BP or later.

In C5 *Betula, Quercus* and *Alnus* woodland and open heath communities replace *Pinus.* Phases of open ground development occurred with Gramineae and *Plantago lanceolata* becoming important. These phases, associated with burning, probably represent human clearances but the detail from this work is not detailed enough to say much more. The final two pab record the local importance of *Myrica* and the growth of *Sphagnum* as well as decreasing tree cover and an opening of the vegetation.

In the absence of radiocarbon dates from this site we can estimate the age of important phases in the vegetation record by reference to radiocarbon dated sites elsewhere in Ireland

Gramineae, Cyperaceae and *Rumex*	10,200-10,000 years BP	*Ulmus* decline	5,300-4,700 years BP
Juniperus peak	10,000-9,500 years BP	*Pinus* domination	4,500-4,000 years BP
Corylus expansion	9,000-8,500 years BP	*Pinus* decline	4,000-3,000 years BP
appearance of *Alnus*	7,500-6,500 years BP		

These dates are only estimates based on other sites around Ireland but they provide a framework within which we can visualise the vegetation of Clare Island developing.

5.1.2. Lough Avullin, Maum Townland.

5.1.3. Pollabrandy, Lecarrow Townland (Poirtín Fuinch of page 45...)

After a preliminary investigation of potential sites for further study during the Clare Island Symposium (15-18th June 1990) a week long period of fieldwork (16-20th July 1990) was carried out by Dr John Graham (Geology, TCD) and myself during which time a number of sediment cores were taken. This work was part of the Clare Island Study Feasibility Work organised by the Royal Irish Academy.

The sites were former lake basins chosen to complement the site at Maum Townland previously published (section 5.1 above) and in proximity to sites of archaeological importance. The sites were both sampled using a Livingston square rod piston sampler (Wright, 1967) taking one metre long overlapping cores in order to retrieve a continuous sediment column. The first site, Lough Avullin (in Maum Townland), is a large boggy area which is the site of a former lake, partly drained and partly infilled by sediment. The lake basin, which is over 100m in diameter and contains sediments over 10m deep, is an ideal site for producing a Post-glacial (10,000 years to present) "master" pollen diagram for the island as a whole which can then be used for biostratigraphical correlation from other organic sequences.

The second site is located in Lecarrow Townland near the head of a stream called Pollabrandy. Here there is a small, partly infilled, lake (in a depression in hummocky moraine) which is about 25m in diameter and contains 6m of sediment. The lake at Pollabrandy is immediately adjacent to a court cairn and therefore the sedimentary and palaeobotanical record should be of great interest as they should contain a record of prehistoric activities around the lake's edge.

It is hoped that the larger site with the greater resolution (Lough Avullin) will provide a picture of regional (i.e. island) vegetational history whilst the smaller site (Pollabrandy) will give a greater insight into local vegetational disturbances.

The work at both sites is under way and the preliminary results will be discussed in the field. The core from Lough Avullin is 866cm long and bottoms in sediments of the Nahanagan Stadial. The core contains numerous charcoal horizons some of which have been thin-sectioned and will be dated in due course with a grant from the Royal Irish Academy. The core from Pollabrandy is 610cm long and again bottoms in Late-glacial sediment. Work on this core has been carried out by Ulrike Huber.

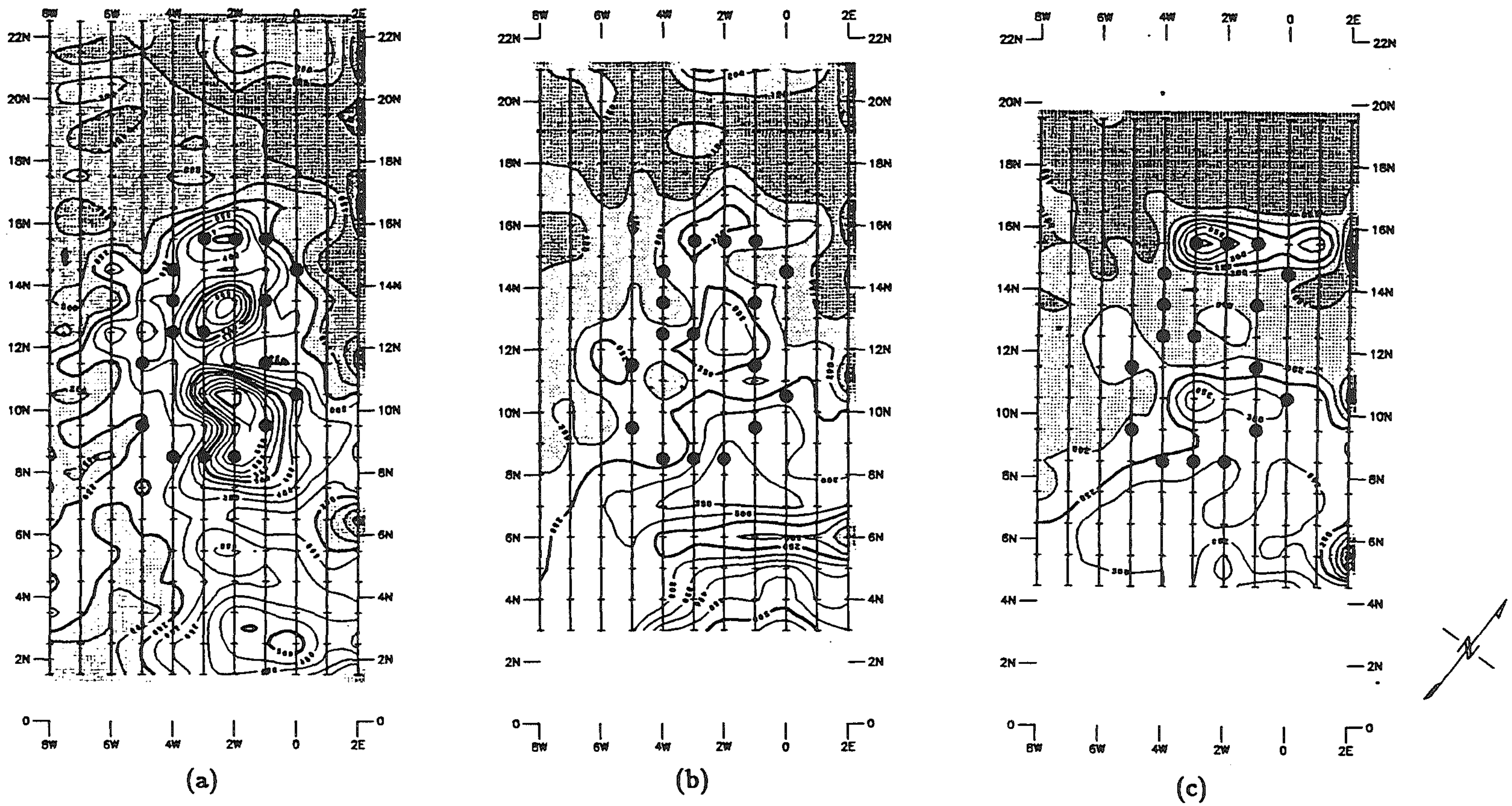
6. Geophysical Images of a Fulacht Fia at Capnagower, Clare Island

(K.J.B. and B.K.)

As part of a geophysical appraisal of a number of archaeological sites on Clare Island (Barton et al (1993), Kulessa (1993) and Slater (1993)) a fulacht fia (numbered 101 in Gosling (1993)) was surveyed using resistivity and magnetic susceptibility methods. Geophysical methods can often provide a non-invasive means of mapping sub-surface features in order to locate trial pits and trenches in the optimum position for excavation. In the case of the fulacht fia discussed here the survey objectives were to map the extent of the mound, to locate the trough and hearth and to position a possible excavation trench.

Resistivity surveying is good at discriminating between stone and soft sediments. Stone will tend to have a high resistivity due to its composition and general lack of moisture content whilst soft sediments will have a lower resistivity largely due to their clay and moisture content. In the case of the fulacht fia we wish to map the extent of the burnt stone in and surrounding the monument. The resistivity survey used an Imager cable which was configured as a Wenner array. This allowed a series of traverse lines which were spaced one metre apart to be run over the monument. Measurements were made at one metre intervals along each traverse line. The Imager system allows the Wenner electrode separation to be varied and this allows the depth of investigation to be controlled. The separations used in this survey were one, two and three metres corresponding to depths of investigation down to approximately 0.45, 0.90 and 1.35 metres respectively.

Figure 15 shows the results of the survey. Each contoured map shows the traverse lines; closed circles represent the surface outline of the fulacht fia. In Figure 15a the data for the one metre spacing (level 1) are shown. There are three main anomalous zones which differentiate the high resistivity burnt stone from the surrounding low resistivity sediments. A low resistivity area within the confines of the mound maps the limits of the trough between 0W/12N and 2W/12N.



New Survey Of Clare Island 1991–1995

Capnagower Townland, Fulacht Fia Nr.101

Resistivity Survey Using The Wenner Array

Contoured At 50, 250, And 500 Ohm-Metres

Circles Roughly Represent Visible Contours Of Fulacht Fia

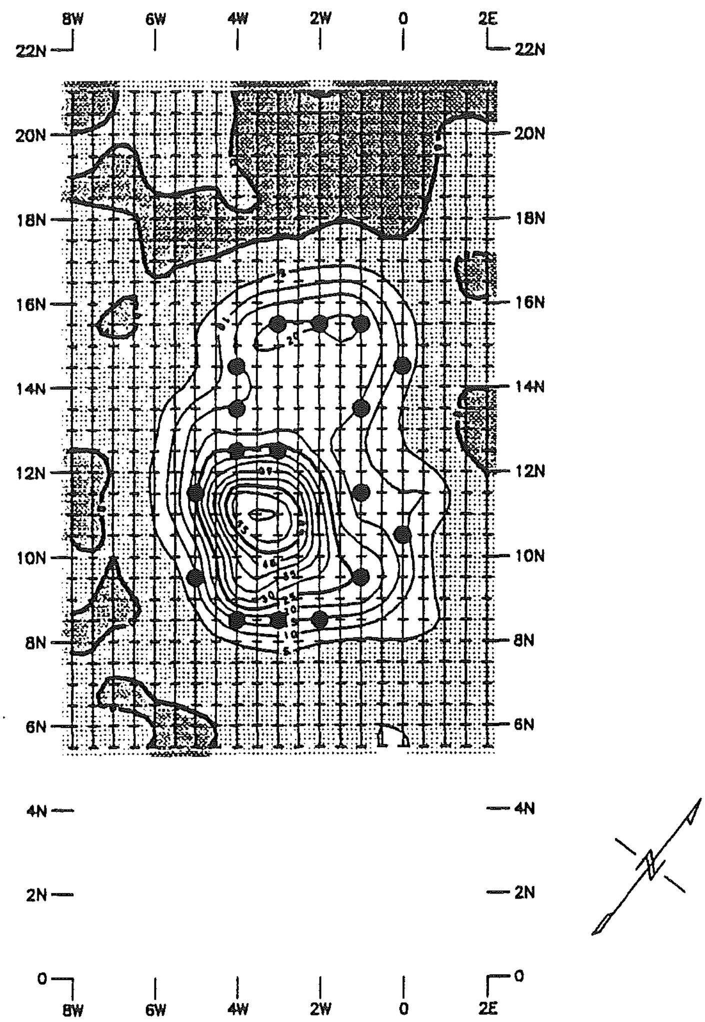
Figure 15. Results of the resistivity survey (after Kulessa, 1993)

The first zone, centred on 1.5W/10N, corresponds to one of the two 'lobes' of the fulacht fia and is displaced slightly to the south of it. This anomaly is located over the thickest part of the mound. The second and third anomalies (2.5W/13.5N and 2.5W/15.5N) show some differentiation of the second lobe. When we examine the data from the two metre separation (Figure 15b) we see that the three anomalous zones are now weaker relative to the background resistivity due to the soft sediments. This indicates that at depths below approximately 0.45 metres the resistivity contribution of the high resistivity burnt stone is diminishing and the influence of the low resistivity sediments is more dominant. In Figure 15c it is interesting to note that the anomaly at 1.5W/10N, although weak, can still be resolved but the feature at 2.5W/15.5N now appears stronger and has a linear form. This 'new' anomaly may relate to a spread of burnt material at depth or a bedrock controlled feature such as a gravel lens. The anomaly at 2.5N/13.5W has virtually disappeared at this depth. None of the anomalies found are thought to relate to the hearth.

The magnetic susceptibility survey was carried out on the same grid as the resistivity measurements with traverse lines 0.5 metres apart and a 0.5 metre measurement interval. The method relies on the fact that most materials have a certain ability to be magnetised. This property is called magnetic susceptibilty. Susceptibility varies with mineral composition with iron minerals such as magnetite exhibiting higher values. Rocks containing iron minerals lying in the Earth's magnetic field can be magnetised and burning of these rocks generally enhances their magnetic susceptibility. The magnetic susceptibility meter has a field loop with a 20 cm diameter which is used to measure the in-situ susceptibility of any material within its radius of investigation. This radius, or depth, of investigation is related to the diameter of the field loop and is approximately equal to it.

The results of the survey are shown in Figure 16. There is a very pronounced anomaly centred on 3.5W/11N with a weaker one at 2W/16N. The anomaly at 2.5W/13.5N seen in the resistivity data is not apparent using this method. The strong anomaly shows the mound to be asymmetric from a geophysical point of view and this could be related to the degree and period of burning of the stone or to the thickness of sediment cover on the mound being greater than the depth of investigation of the instrument. The cover being thinner (less than 20 cm) over the main anomaly and thicker (greater than 20 cm) at 2W/16N thus reducing the intensity of the anomaly. This may also explain why the resistivity anomaly at 2.5W/13.5N is not seen. It is interesting to note that the anomaly at 2W/16W corresponds to that seen in the resistivity data and this may rule out the possibility of a bedrock source for the resistivity anomaly. The trough is less easy to discern with the magnetic susceptibility method. A slight inflection of the contours indicates its presence. There is no evidence for the location of the hearth from the susceptibility data.

The results from the two surveys indicate the greatest thickness of mound material to lie in the area of 2W/10N where a trench could be located. A second pit or trench could be opened at 2W/16N to investigate the coincident resistivity and magnetic susceptibilty anomalies. The trough is apparent in Figure 15a whilst it was not possible to locate the hearth within the survey area.



New Survey Of Clare Island 1991–1995

Capnagower Townland, Fulacht Fia Nr. 101

Magnetic Susceptibitity Map

Contoured At 5,25, And 100
Smoothed Twice By Hanning Filter
Circles Roughly Represent Visible Contours Of Fulacht Fia

Figure 16. Results of the magnetic susceptibility survey (Kulessa, 1993)

7. Clare Island: An introduction to the prehistoric settlement
(PG)

Introduction

When the Royal Irish Academy launched the new interdisciplinary survey of Clare Island, in Co. Mayo, in 1991, funding for the archaeological work was fortuitously forthcoming in the form of a generous grant from The Discovery Programme. With this dedicated funding, archaeological fieldwork was initiated early in 1992 with the compilation and circulation a preliminary list of the island's monuments (Gosling 1992). Since then, programmes of fieldsurvey and monument prospecting have been undertaken each Easter. Arising from this work, a number of monuments have been targeted for geophysical survey and limited archaeological excavation. A report on the 1992 season was circulated in July 1993 (Gosling 1993), and further reports on the 1993 and 1994 seasons are now in preparation.

The archaeological section of the New Survey of Clare Island is being monitored by a sub-committee consisting of Mr Con Manning (convenor), Dr John Waddell and the present writer. The field research is being carried out under the direction of the writer, assisted by a team of archaeologists and archaeological students on a seasonal basis.

The archaeological research for the original survey was carried out by Thomas Johnson Westropp (1911), whose 78 page report also included sections on the archaeology of Caher Island, Inishturk, Inishbofin and Inishshark, as well as parts of the mainland around Clew Bay. It was one of the first Survey reports to be published and provided details on a total of 37 archaeological items ranging from the first detailed survey of the "Abbey" at Kill, to very brief notes on the standing stone at Ballytoohymore. While Westropp's work was a comprehensive piece of research, the increases in knowledge, particularly in relation to chronology, have overtaken his findings. Furthermore, the advances in archaeological techniques over the intervening 80 years, when coupled with a series of new discoveries on the island (Gosling 1990), suggested that new study would reveal significant new data regarding the island's early human settlement.

Even before fieldwork began, Westropp's total had been increased to over 90 archaeological monuments and items (Gosling 1992) Most of these new sites were fulachta fia discovered during casual fieldwork between 1988 and 1991 (Gosling 1990). The results of the archaeological survey, to date, are far beyond expectation with almost 200 monuments and items of archaeological interest now identified. When coupled with radio-carbon determinations from excavations, and the results of the palaeoecological section, our understanding of the early history of the island should be much clearer by the completion of the Survey in 1995.

Prehistoric Settlement

The opening pages of Thomas Johnson Westropp's report on the archaeology of Clare Island (1911, 11, 18-9) is liberally sprinkled with the negative article. Its presence arose from his perception that there was a marked absence of evidence for 'early settlers' on Clare Island. For Westropp's field research , though thorough, had yielded a lean harvest: a 'pillar stone', a 'bronze spear head' and a 'cist-like group of flat stones' along with some hut sites forms the sum total. Only in the case of the 'cliff forts' did he find solid settlement evidence, though in his accounts of the forts he wisely does not assign them to any specific period.

Today, these 'cliff forts' or promontory forts as we would now term them, still form an intractable problem in terms of their age and function. Six of them are

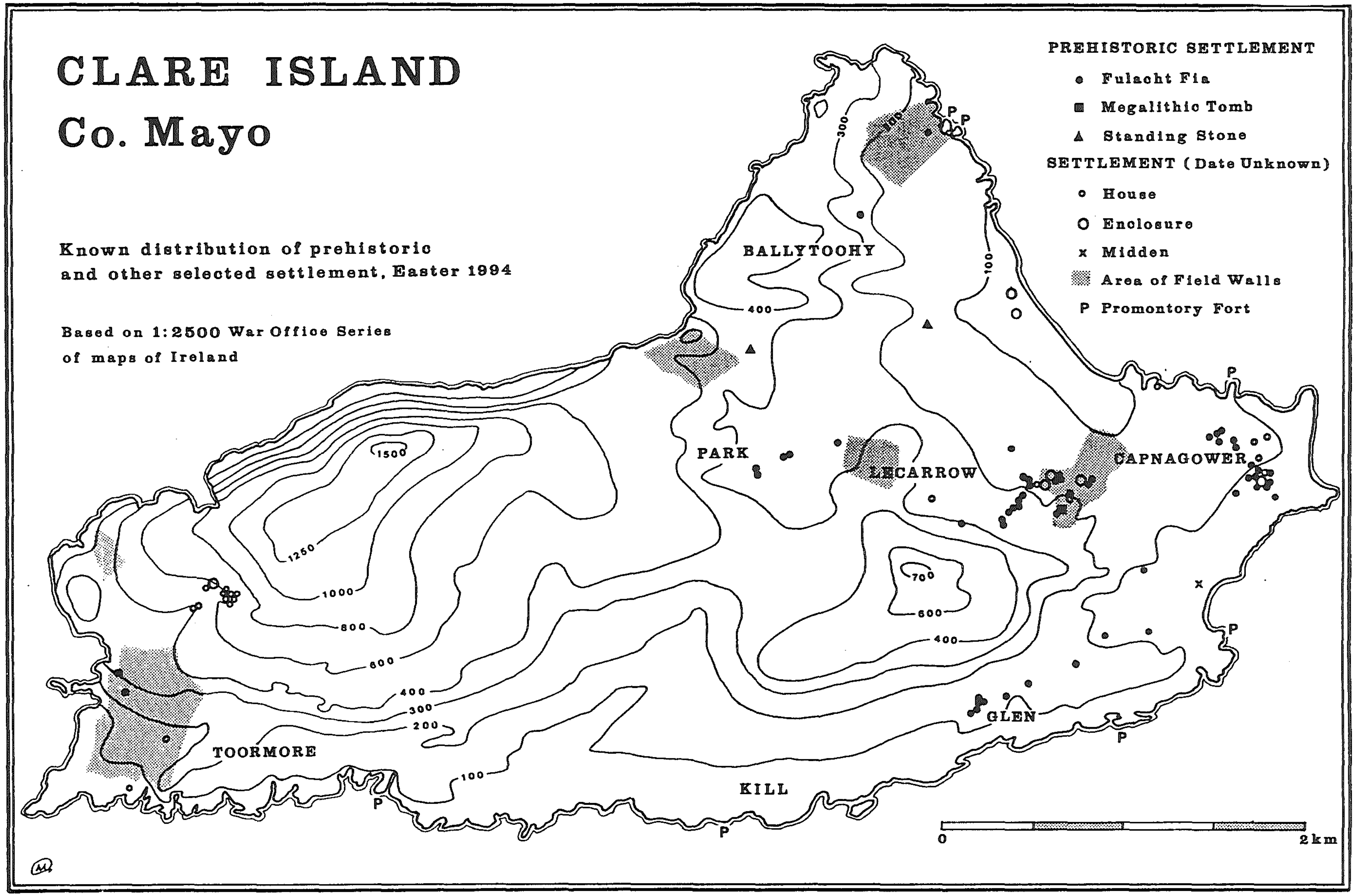


Figure 17 Known distribution of prehistoric and other selected settlement, Easter 1994

known on Clare Island strung out along the south and eastern coasts (Figure 17). A limited archaeological excavation conducted on one of them ('Doonagappul', in Strake td.) by Markus Casey in 1992 as part of the New Survey indicated that the construction of the monument was abandoned before its defences had been completed (Casey 1993). The five areas of possibly prehistoric field walls identified to date (Figure 17) present similarly unanswered problems.

In all other regards, however, there is now a relative abundance of field evidence for 'early settlers' on the island, ranging from a megalithic court-tomb at Lecarrow, to a barbed and tanged arrowhead from a midden at the harbour. Detailed accounts of these monuments and artifacts are offered below followed by an evaluation of their significance for understanding the prehistoric settlement of the island. It must be noted, however, that this is very much an interim statement, given the ongoing nature of the research and the absence, as yet, of any radio-carbon determinations. Only when these and the results of the palaeobotanical section of the New Survey are completed, will an authoritative account of the island's early settlement be possible.

Megalithic Tomb

This existence of this tomb was confirmed by the writer in August 1989, having been first identified by Dr Peter Gill, of Maum, Clare Island, as a possibly ancient structure some time before. It was surveyed by Paul Walsh, Megalithic Survey of Ireland, Ordnance Survey Office, Phoenix Park, Dublin in 1991 (Figure 18). With its discovery, we can now discern a definite Neolithic horizon of activity on Clare Island, probably dating back to the mid-third millennium before Christ (c. 3800-3,000 BC).

The monument occupies a saddle between two hillocks amidst the stark hummocky moraine topography to the E of Glan Hill (Knocknaveen on OS map). While thus sheltered from the prevailing winds, the site offers wide views to the north and east over the Lough Avullin basin and the north-eastern part of the island (Figure 17). Immediately to the E of the tomb is a small peat basin known locally as "Poirtín Fuinch" (Figure 21).

The tomb itself is a jumble of large stones, mantled, in the summer months, by a dense growth of bracken (Figure 18). An examination of the structural stones reveals that the tomb is of the court-tomb type, comprising one long and slightly wedge-shaped chamber (L 5.6m, Wth 2m max.) aligned ENE-WSW. Outside it, at the eastern end there was once a court, only four set slabs of which survive amid the mass of loose stone. From the extent of the latter, it would appear that the tomb was contained within a large cairn which now survives as a low oval cairn c. 19.25m long by c. 12.3m in maximum width. Though none of the original capstones survive a number of the massive corbel slabs are still in evidence along the SSE side of the chamber (Figure 18: shown in outline).

Court-tombs are one of four main types of megalithic tombs known in Ireland (Ó Ríordáin 1979). Over 300 of these tombs are now known, and their distribution is generally confined northern part of Ireland. Along with the less numerous portal-tombs their presence is thought to represent an early horizon of Neolithic settlement. From excavated examples, we know that the burial rite in these tombs frequently took the form of what is known as collective burial. This often involved the burial of the cremated remains of a number of individuals. Collective deposits of disarticulated unburnt bones also occur occasionally, suggesting the dead were left 'exposed' for some time before burial. The human remains were accompanied by fragmentary remains of pottery vessels, simple ornaments, and stone implements. Apart from their role as burial monuments, megalithic tombs are also likely to have

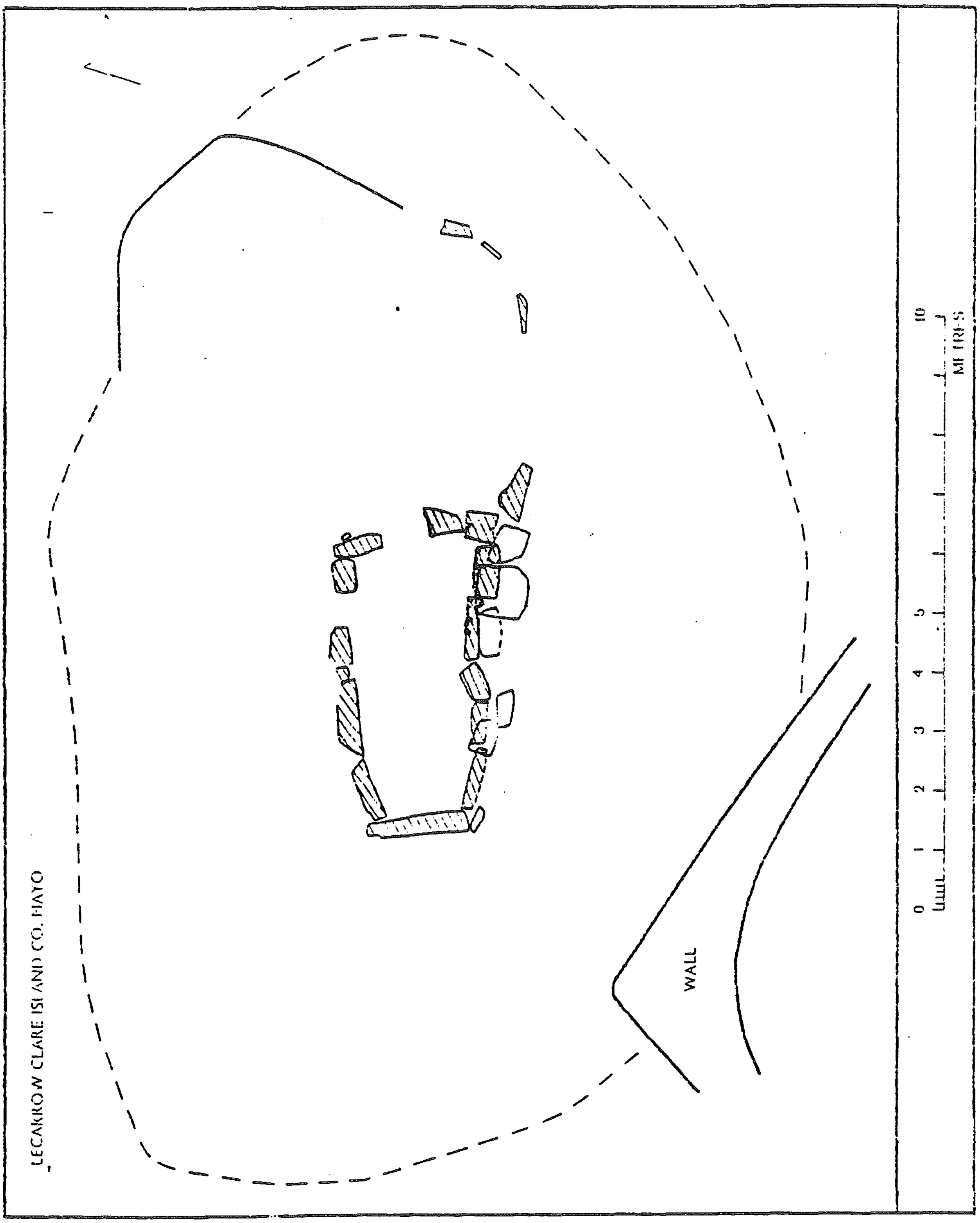


Figure 18 Megalithic court-tomb at Lecarrow, Clare Island (after Paul Walsh, Megalithic Survey of Ireland, Ordnance Survey Office, Phoenix Park, Dublin.

acted as focal points for the communities who built them, possibly fulfilling roles as places of assembly for law-making, games, and rituals connected with the cycle of the seasons.

Standing Stone

This diminutive stone was the only prehistoric monument identified by Westropp (1911, 16-17, 19). However, despite his clear description of its location, it has been consistently misplaced on the OS maps: initially on the OS six-inch map of Co. Mayo, (edition of 1920, sheet 85) and again on the recently published 1:50,000 Discovery Series maps (Government of Ireland 1993, sheet 30). The stone is situated immediately W of the roadside wall on the road from the harbour to the lighthouse close to the Centre for Island Studies. Standing only 1.35m in height, it is almost rectangular in plan (L 1m, Wth 0.7m). It does not appear to be deeply bedded; rather it sits on an area of rock which is mantled only by a thin soil cover.

The erection of large, more or less unhewn stones, often in prominent locations, was a widespread custom in prehistoric Ireland and elsewhere in western Europe. These can take the form of stone circles, stone rows (e.g. three or more stones forming a straight line), stone pairs (two adjacent stones) and single or isolated standing stones. The date and function of these often striking monuments are often far from clear. Single standing stones appear to have been erected over a long period, possibly from the Early Bronze Age (c. 2500 BC) to the Iron Age and even later. Single standing stones may have had a wide variety of uses; it has been claimed that some may have been boundary and route markers, and that others were burial monuments and memorials (Ó Ríordáin 1979). The location of this particular standing stone on a roadside close to the southern boundary of Ballytoohymore td. is thus interesting. Furthermore, its location is also close to a geological boundary (pers. comm. A. Phillips) which is reflected by the contrasting quality and uses of the land on either side of the road at this point.

Midden

Westropp recorded the existence of a 'kitchen midden' at the northern end of the bay to the N of the harbour (1911, 17, 28: Figure 17). This was relocated in 1992 at the northern end of the beach where it is exposed in the low cliff. It consists of bands of dark sand which can be traced for *c.*10m in the cliff face and are up to 0.9m in thickness. At least two horizons can be distinguished; an upper one of brown sand containing the shell of winkle, limpet and small stones, and a lower horizon of generally stone-free, light orange-brown sand. Fortuitously, a diminutive barbed-and-tanged arrowhead of chert was recovered from the lower horizon (figure 20). It lay at the junction of the sand and the boulder clay sub-strata. Though broken in antiquity, it originally measured at least 16mm in length and it was 15mm in width. It was made from a fine black chert. Its presence suggests that the midden was active in the Early Bronze Age (c. 2500-1500 BC) when arrowheads of this type were current.

A waste flake of chert was also recovered from disturbed soil on a house building site on the N side of the valley to the W of the beach in Easter 1994. Its find spot is less than 250m W of the midden.

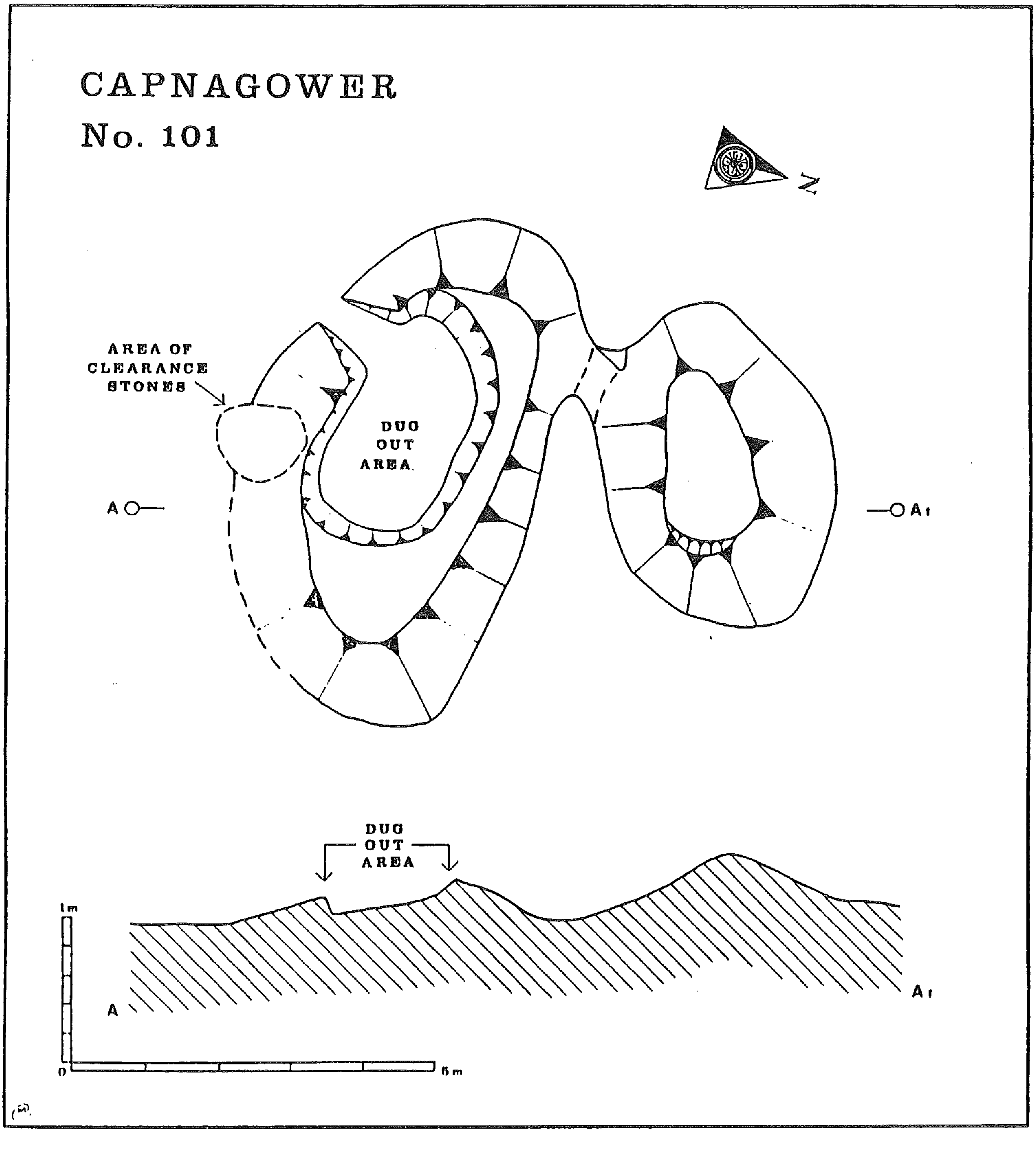


Figure 19 Plan of a fulacht fia at Capnagower, Clare Island.

Fulachta Fia

By far the most numerous prehistoric monuments on Clare Island are the fulachta fia, or burnt mounds. To date, a total of 49 definite and four probable mounds of burnt stone have been identified. As a group, they represent by far the largest number of such monuments identified on any of Ireland's offshore islands. Of these fulachta fia, only 23 survive as intact, or partially intact, mounds. Of the remainder, 16 were noted as layers of burnt stone exposed in the section faces of drainage trenches or stream banks, four in turf cuttings, four as spreads of burnt stone in animal rubbing hollows, three as spreads of burnt stone in recently reclaimed/ploughed fields, two as spoil from road building and field clearance, respectively, and one as a spread of burnt stone on a lakeshore.

Distribution: Figure 17 shows the known distribution of fulachta fia on Clare Island. It will be noted that the distribution displays a markedly eastern bias. This may, in part, be due to the incomplete nature of the fieldwork, which has yet to be completed for the western part of the island. However, many of the stream and peat basins in the western half of the island, including the Owenmore catchment, have already been subjected to preliminary reconnaissance. The failure to locate even one fulacht fia in these areas was notable. Thus, while the final distribution must await the completion of the fieldwork, the present distribution pattern is unlikely to alter greatly.

A number of questions arise regarding the topographical factors which may be affecting the distribution of the fulachta fia on Clare Island. In particular, there is the question of visibility of surviving remains. Of the 24 fulachta fia recorded to date in Lecarrow Townland, for instance, only 12 have any surface remains. The rest have been uncovered by chance during drainage operations (nine), turf-cutting (one), (?)wall building (one) and animal rubbing (one). Similarly in Glen Townland, all bar one of the ten fulachta now known were brought to light by land reclamation work, principally in the form of drain cutting (six). The exception in this case was again noted in an animal rubbing.

With regard to the Glen sites, it should also be noted that prior to 1989, seven of them were obscured by old spade cultivation ridges. This raises the question that the distribution of fulachta fia, as indeed the distribution of all archaeological monuments on Clare Island, is being heavily distorted by later periods of human activity, and in particular the tillage ridges associated with 18th and 19th century settlement. If this is the case, then it may go a long way towards explaining the total absence of evidence for prehistoric settlement along the south side of the island, particularly in the catchment area of the Owenmore River (Strake Townland) and in the area around Kill to the east of it. As the extensive series of the tillage ridges which mantle this area indicate, this part of the island witnessed intensive and continuous settlement during the population boom of the 18th and 19th centuries. Moreover, the location of the "Abbey" at Kill also suggests that the area may also have been a focal point for settlement since the Early Historic Period. Even today, it contains the deepest and most fertile soils on the island. The concentration of settlement activity in this area, and in particular the widespread spade cultivation of the 18th and 19th centuries, may well have obliterated many archaeological monuments including fulacht fia mounds.

Siting: Arising from their use of hot stones to heat water, the fulachta fia of Clare Island are obviously to be found close to water sources. However, a study of their siting pattern reveals certain preferences for particular locations. These have been summarised in Table 1, which shows that 49% favour locations on the banks of streams or rivers. However, a significant proportion (38%) are also situated in peat basins. These basins may have had areas of open water in the past. Where associated with basins, the fulachta tend to favour locations along the edges of the peat. Furthermore, within the basins, a tendency is also discernible to locate the fulachta at or close to the outflow point from the basin.

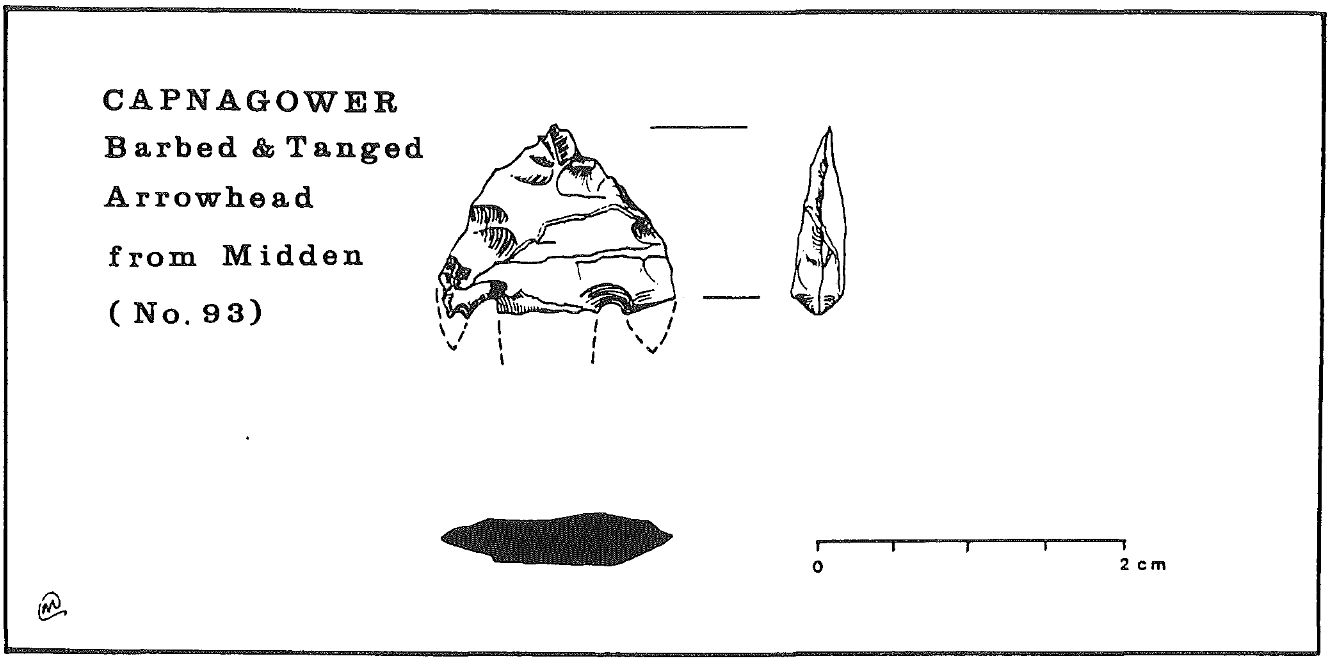
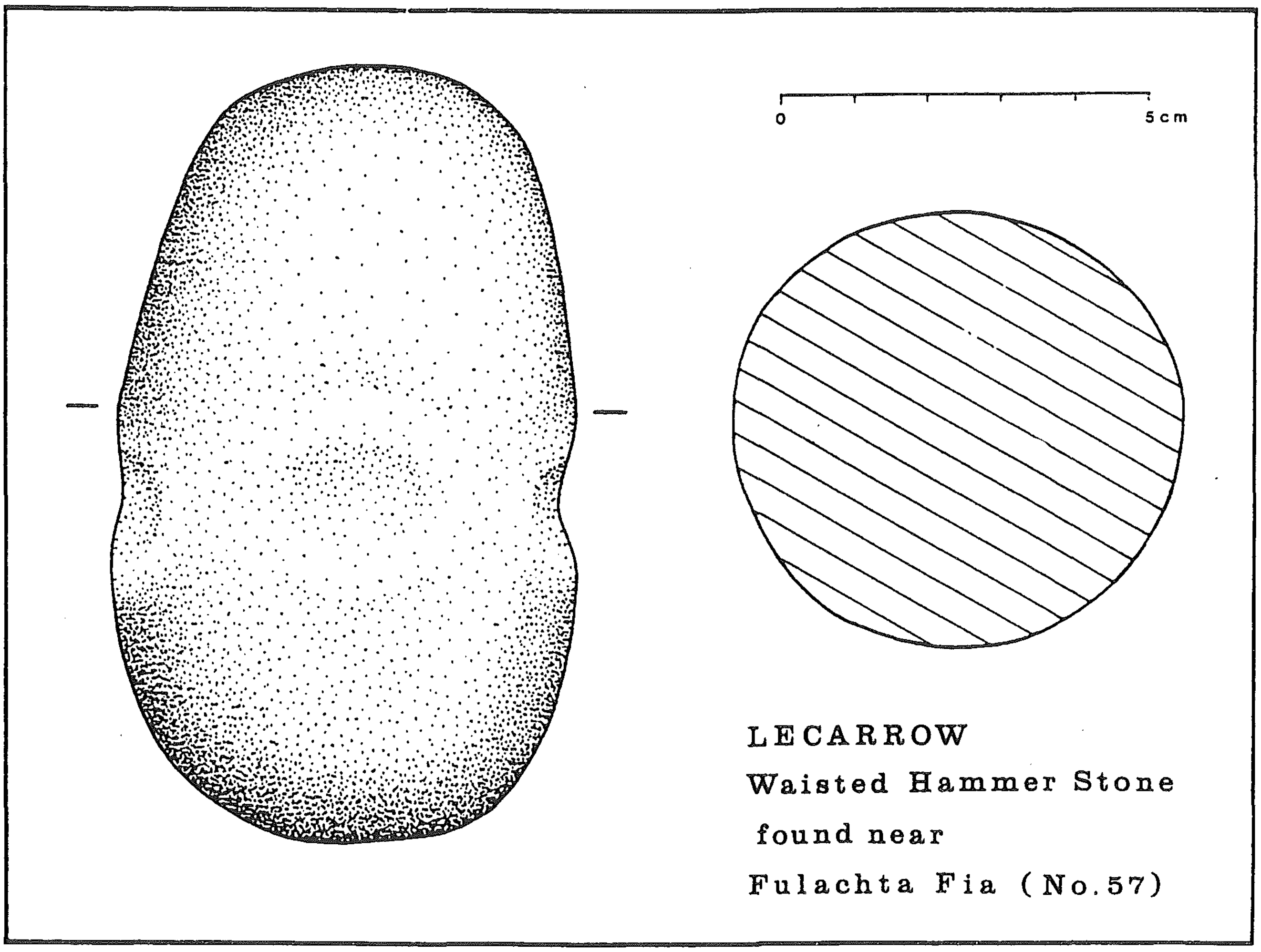


Figure 20 Arrowhead and hammer stone from Capnagower and Lecarrow Townlands, Clare Island



Given the consistency of the above siting pattern, there is a notable absence of fulachta fia around the fringes of any of the present lakes on the island. To date, only one fulacht fia has been identified in a lakeside location: a badly disturbed mound close to the reed beds at S extremity of Lough Avullin, in Maum Townland. This is the largest of the island's lakes and one might have expected more fulachta fia here. While this may be due to problems of identification resulting from water level changes and/or the partial drainage of the lake in the late 18th/ early 19th century, it is notable that the only fulacht located here to date is situated just above the present flood line.

Topographical Siting	**No. of examples (n=53)**
Stream/river bank	26
Peat basin - edge of	15
Peat basin - in peat	5
Surface run-off	3
lakeshore	1
unclear	3

Table 1: Siting preferences amongst fulachta fia on Clare Island

Mound Size and Shape: As outlined above, only 23 or 43% of the fulachta fia recorded to date have intact, or partially intact, mounds. These mounds range from the diminutive which measure only 3 to 4 metres across and are less than 0.5m in height, to one almost monumental example which measures almost 13m NE-SW and stands up to 1.7m in height. The vast majority of the mounds, however, lie within the 5-11m range, and average 0.5m to 1m in height (Figure 19).

mound shape	**frequency**
ovate	6
lunate	1
U-shaped/horseshoe	13
Irregular	3

Table 2: Mound shape amongst fulacht fia of Clare Island (N=23)

As Table 2 shows, the mounds also display a recurrent ground plan, with U-shaped or horseshoe-shaped forms predominating (59%). Furthermore, in some of the latter, the mound actually consists of two almost separate mounds linked by a saddle-like feature. A distinctive sub-group of roughly ovate mounds was also identified (27%). These tended to be relatively small mounds (3-6m across). Though ovate in plan, most of them had traces of an indentation in one side, possibly indicating the position of the trough.

Fulacht a Fia Groups: As Figure 17 shows, the principal feature of the distribution of the fulachta fia, apart from their bias towards the eastern part of the island, is their tendency to concentrate in particular areas. When studied in conjunction with the local topography, four major groups have been identified. The principal topographical and morphological characteristics of these major groups can be summarised as follows:

The Capnagower Group: This group comprises 15 definite and one probable fulachta fia, all situated in the NE part of the townland of Capnagower, close to the easternmost tip of the island. The area is one of hummocky moraine, here characterised by low ridges and hillocks interspersed with small peat basins. It is drained by a number of small streams which flow generally towards the east.

Though all the fulachta are situated on enclosed land, 11 mounds have survived largely intact. However, a number show evidence of minor interference. Of the remainder, two are visible in drainage trenches, one is visible in a turf cutting, one has been destroyed during the construction of a trackway, and the probable example has been extensively disturbed by tillage ridges

Three of the mounds are situated close to a very ruined, medium sized enclosure. The foundations of a circular house have also been identified nearby. The early ecclesiastical site associated with St Brigid lies at the E edge of the group.

The Glan/Fawnglass Group: This group comprises eleven fulachta, ten of which are situated in the townland of Glen in the SE part of the island, approximately half way between the harbour and modern church at Kill. This area forms part of the long settled southern coast of the island. It was certainly heavily cultivated in the recent past as is evidenced by the widespread traces of ridge and furrow cultivation.

The fulacht group are situated around the sides of the valley to the W of the harbour and a large peat basin immediately to the WSW. The sites are characterised by the fact that none of the mounds are intact. In fact, the only reason that seven of them were discovered at all was due to the levelling of the old ridges in preparation for the drainage and reclamation of the basin in 1989-90.

No other associated monuments are known in the area. Two of these sites (Nos. 71 and 95) were excavated by Paula King in 1992. (King, 1993).

The Lecarrow Group: (Figure 21) This group of 18 definite and one probable fulachta fia is situated in the eastern part of the townland of Lecarrow, *c.*1km to the NW of the harbour. It is the largest of the four groups identified to date. The fulachta are situated along streams and in small peat basins amongst the hilly, hummocky moraine topography at the eastern foot of Glan Hill (Knocknaveen on OS). The area is now part of the island's commonage. From the numbers of ruined peat-drying stacks visible on the summits of the hillocks, it has evidently been intensively exploited in the recent past for turf, and the whole area appears to have been extensively cut over within the past three hundred years.

Of the 19 fulachta in the group, 12 have intact or partially intact mounds. Of the remainder, five were uncovered during the cutting of a new channel for the stream called Pollabrandy on the OS maps. It is possible that some at least of the latter may have been intact mounds before the drainage work began. A sixth was uncovered during turf-cutting.

A number of the fulachta fia in this group also have potentially significant spatial associations with other monument types (Figure 21). One of the fulachta, a possible burnt stone mound (No. 111), is situated very close to the megalithic court-tomb (No. 2), while a second (No. 6) is sited immediately to the east of a circular house site (No. 7). Furthermore, three enclosures have been identified on hillocks overlooking streams or peat basins containing small clusters of fulachta (Figure 21). These enclosures are either roughly oval or irregular in plan and medium-sized in extent (Ds. 20-40m). They are defined by very low outlines of boulders and stones, parts of which have been robbed out to provide material for the later turf-drying stands. Finally, associated with the enclosures themselves are a series of intermittent and meandering fieldwalls (Figure 21). One group of these monuments (Nos. 28-9, 113-4) are to be archaeologically excavated by Paula King in 1994.

The Park Group: This group is situated in the western part of the townland of Lecarrow close to the centre of the island. It is the smallest of the four major groups, and comprises four definite and one probable fulachta fia. Four of the mounds are located in the eastern part of a large peat basin at Park, which is one of the principal turf-cutting areas on the island today. They were uncovered in the course of excavating drainage trenches c.1988. The fifth site was noted in an animal rubbing on the banks of the Dorree River to the east of Park.No other associated monuments are known in the area. One of these sites (No. 68) was excavated by Paula King in 1992-3 (King, 1993)

Fulacht Fia Clusters: During fieldwork it was observed that within these major groups, the fulachta tend to occur in small clusters. However, because of the density of sites in some of the major groups, i.e. Capnagower and Lecarrow, it was often difficult to decide visually where one cluster ended and another began. In order to quantify this pattern, an parameter of 50m was accepted as the maximum distance between any two fulachta of the same cluster. Of the 53 mounds identified to date, 20 or 38%, were thus deemed to be isolated examples. Amongst the remaining 62%, the tendency varied from two to five mounds per cluster (Table 3), the most common being clusters of two or three mounds (57.5%).

number of mounds per cluster	number of clusters
5	2
4	1
3	3
2	5

Table 3: Cluster size and frequency amongst the fulachta fia of Clare Island (N=33)

Finally, amongst the five clusters with three or more mounds each, a tendency towards a hierarchy of mound size was noted. In three instances, this took the form of one large mound and two or three smaller mounds. However, as intact mounds survived in only three out of five of these clusters, this pattern may be more apparent than real, and confirmation of its existence must await further analysis of mound size.

While much attention has recently been drawn to Irish fulachta fia as a monument type, this has been predominantly focused on national overviews of their function (Ó Drisceoil 1988), as well as their dating (Brindley *et al* 1990), associated finds and their distribution within particular counties (see Buckley 1990). Consequently, detailed analyses of the fulachta fia of a particular region, such as that presented above, has few Irish parallels with to compare and contrast it.

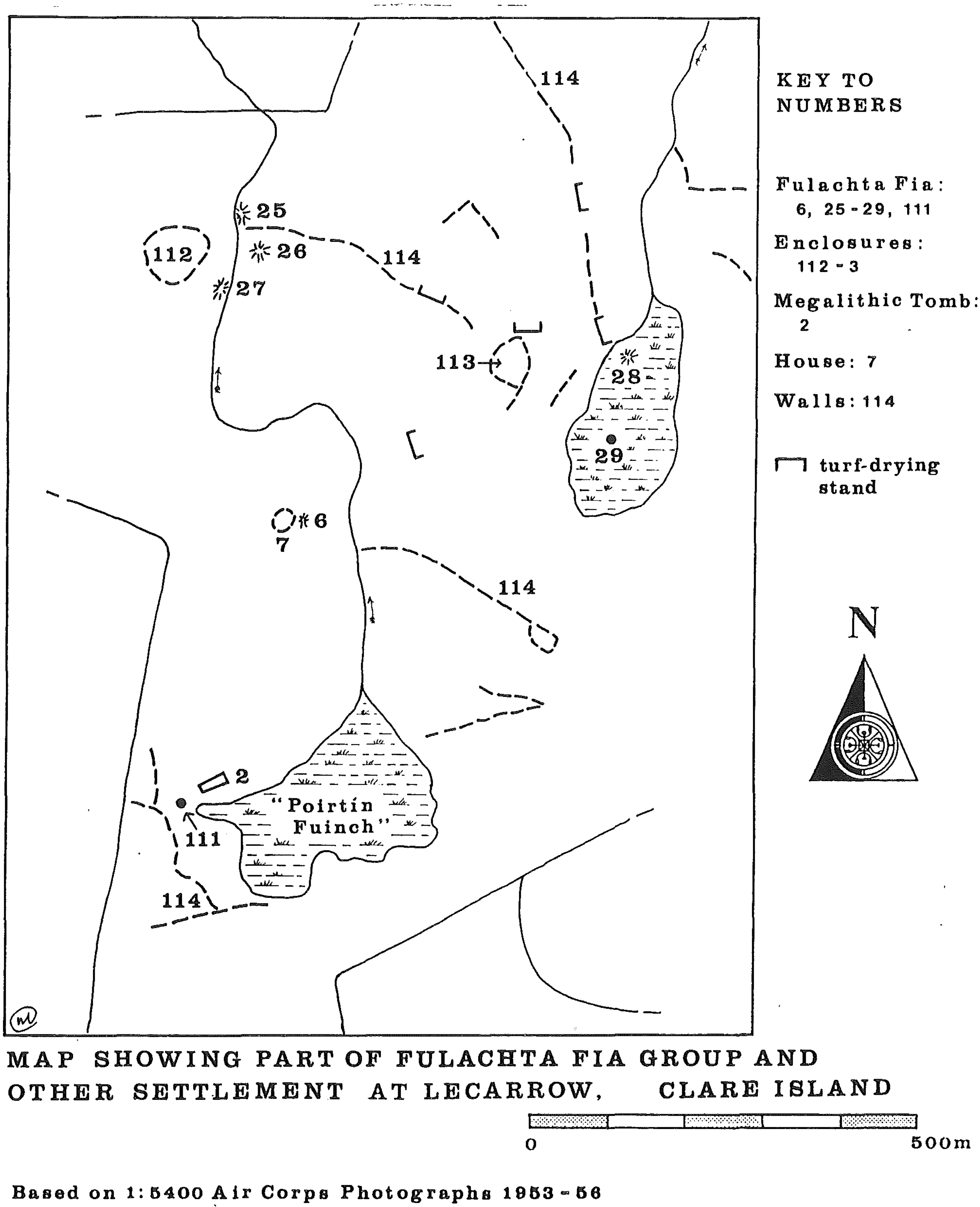


Figure 21 Prehistoric and other settlement at Lecarrow, Clare Island.

Summary & Conclusions

Though the data presented here is preliminary, a number of observations can now be made regarding the prehistoric settlement of Clare Island. Firstly, there is the megalithic tomb whose presence indicates the existence of a Neolithic farming community in the eastern part of the island in the 3rd millennium BC

However, the large numbers of fulachta fia on Clare Island suggests that the most significant period of prehistoric human activity was during the Bronze Age. Though we, as yet, await results from the radio-carbon samples taken during the excavations, the general consensus is that the construction and use of Irish fulachta fia dates to the middle and later parts of the Bronze Age (c.2,000-800 BC: Brindley *et al* 1990).

This impression, of significant settlement in the Bronze Age, is underlined by the albeit small number of artifacts recovered to date. Firstly, there is the chert arrowhead found protruding from the basal layers of a midden at the harbour (figure 20). There is also the find of a bronze spearhead from Cummer, at the west foot of Glan Hill (Knocknaveen on OS maps) and the discovery of a waisted stone maul in a stream bed near the island's largest fulachta fia (figure 20). A decorated rim-sherd of pottery was also found stratified within a fulacht fia mound at Park (King 1993). This is certainly of prehistoric vintage, and is probably of Bronze Age date (pers. comm. J. Waddell). Finally, there is also a standing stone in Ballytoohy More which is also likely to be of Bronze Age date.

As to the function of the fulachta fia, opinion is currently divided between their use for cooking and bathing (see Ó Drisceoil 1988). What is beyond dispute, however, is their utilisation of hot stones to heat troughs of water, and in this respect Irish fulachta fia can be regarded as reflecting patterns of Bronze Age settlement. This is important, for the distribution pattern of the fulachta fia within the island is marked by their concentration in particular areas (Figure 17). As already discussed, a number of relatively modern landuse factors may be affecting the distribution picture. However, there is also the possibility that the distribution is limited by other factors, such as the availability of suitable rocks for heating. Preliminary examination suggests that sandstone is the favoured rock type, and Dr M. Williams of UCG has agreed to carry out a geological report on the surface samples collected from each site, in order to examine this hypothesis.

This leads us to the spatial associations noted between some of the fulachta fia clusters and a number of medium-sized enclosures (Figure 21). Four examples of this have so far come to light, three in the Lecarrow Group and one in Capnagower. In each case, the enclosure is situated on low rise or hillock overlooking a peat basin or stream with a cluster of two to four fulachta fia. In each instance, the fulachta are not more than 150m from the enclosure and most are considerably closer (<100m). The presence of these enclosures in close proximity to clusters of fulachta fia raises the possibility that they could represent the foci of habitations of which the fulachta once formed a part.

In conclusion, these monuments and artifacts indicate a significant horizon of activity in the eastern part of Clare Island during the Neolithic and Bronze Ages. However, they also raise many questions regarding the origins and culture of the people who used them. As yet, these must remain unanswered, but the presence of the megalithic tomb and the numbers of fulachta fia and their pattern of clustering hints at the existence of relatively large communities of people regularly using them. Whether the prehistoric settlement was on a seasonal or permanent basis is just one of the many questions which remain unanswered as is the date of the extensive series of field walls currently under excavation at the extreme west end of the island.

Section B

INISHBOFIN

1. Archaeology and history of Inishbofin

(MG)

Introduction

The islands of Inishbofin (Inis Bó Finne), Inishlyon (Inis Laighean) and Inishshark (Inis Airc) lie within 10 km of the north-west Connemara coast. Of the three, Inishbofin is the largest, measuring 6.5 x 3.5 km, and also the only inhabited island.

The islands are strategically located midway along Ireland's western sea routes. The origin of their initial colonisation is still obscure. According to one local tradition, Inishbofin was once enchanted, uninhabited and hidden in thick fog. Eventually two fishermen lost in a sea haze landed on the island and lit a fire. This broke the spell and the fog lifted, revealing an old woman driving a white cow down on the lake. As it reached the water, she struck it with a stick and it turned into a rock. The island took its name from the white cow.

Whatever the basis of the legend, it is likely that the islands have drawn fishermen, farmers, monks, soldiers and adventurers for over 6000 years. The population has fluctuated widely over the millennia, reaching 1600 prior to the Great Famine in the mid-nineteenth century. In the meantime, it has fallen steadily so that at present it stands at an all-time low of about 180.

Early settlement

In contrast to the Connemara mainland, the islands have yet to produce diagnostic evidence of a Mesolithic presence and there is only circumstantial archaeological evidence for a significant Neolithic presence. There is a marked absence of typical Neolithic and Bronze Age ritual and burial monuments such as megalithic tombs and stone alignments. Recently, however, two standing stones have been identified on a low knoll over-looking Lough Bofin. The pollen analytical data from Church Lough indicate substantial Neolithic and Bronze Age populations on the island (O'Connell and Ní Ghráinne, this volume). The apparent absence, apart from the standing stones referred to above, of megalithic tombs or bronze age burial monuments suggests that social, economic and religious conditions may have been quite different from those pertaining on the adjacent mainland where there is a concentration of megaliths.

The islands possess an abundance of natural resources, large fish stocks, at least a modicum of fertile soils, a plentiful supply of fresh water and, in the case of Inishbofin, a superb and easily defended mile-long natural harbour. In addition, substantial deposits of valuable soapstone or steatite, an invaluable non-food resource for trade and exchange, are present, particularly on the west end of Inishbofin and on Inishshark. This easily worked rock was a highly prized material and is commonly found in Early Christian and Viking-age sites. During the Bronze Age, it was used to make moulds for bronze axes at Culfin on the north Connemara coast. An old soapstone quarry can still is seen on the shore in Westquarter, Inishbofin, and, until recently, fishermen used soapstone to make weights for their fishing nets.

The islands possess a number of midden sites, though they remain undated as yet. However, in a group of kitchen middens in Knock Townland, Inishbofin, a number of hammer stones were identified by Dr. Fogarty during the course of the original Clare Island Survey. This hints at a possible early date for these sites (Neolithic or Bronze Age). Unfortunately, most of these middens sites have been lost through erosion. In midden sites on the south side of Inishbofin harbour, a few worked pieces of flint have been found. A saddle quern in Knock Townland provides archaeological evidence for early cereal cultivation on Inishbofin.

The scarcity of monuments, which might be regarded as being of significance in terms of Bronze Age ritual, is in marked contrast to the wealth of well-preserved settlement evidence. Recent fieldwork in the marginal and rough land (*c.* two thirds of total area) has uncovered a profusion of substantial house sites with coeval field systems and fulachta fiadh. The more important settlement complexes discovered to date on these islands are located on the south side of Inishlyon, which lies immediately to the east of Inishbofin, and on the north-west and south-west shores of Inishshark and in Fawnmore and Middlequarter on Inishbofin. In a peat-filled basin on Inishlyon, fieldwork has revealed pre-bog field walls, a hut site, terraces and two fulachta fiadh. In Fawnmore and Middlequarter, Inishbofin, similar features are found in profusion. At least twenty house sites and enclosures are known from the islands.

A characteristic feature of the archaeology of Inishbofin are the well-constructed ancient stone terraces that dot the landscape. These were built, it would seem, in an attempt to utilise and consolidate every bit of suitable land for cultivation and to prevent soil erosion. They are sometimes found in close proximity to pre-bog enclosures and house sites, particularly in Fawnmore and Middlequarter Townlands, Inishbofin, and on Knock hill on the south-east side of the island. It is not yet possible, however, to ascribe them to a particular period.

The widespread distribution of terraces, field systems and fulachta fiadh may be interpreted as evidence for a large expansion of population during the later Bronze Age. This would have necessitated taking more marginal areas into cultivation, which in turn may have resulted in the exhaustion of the more fragile soils and perhaps to their abandonment and subsequent envelopment in peat.

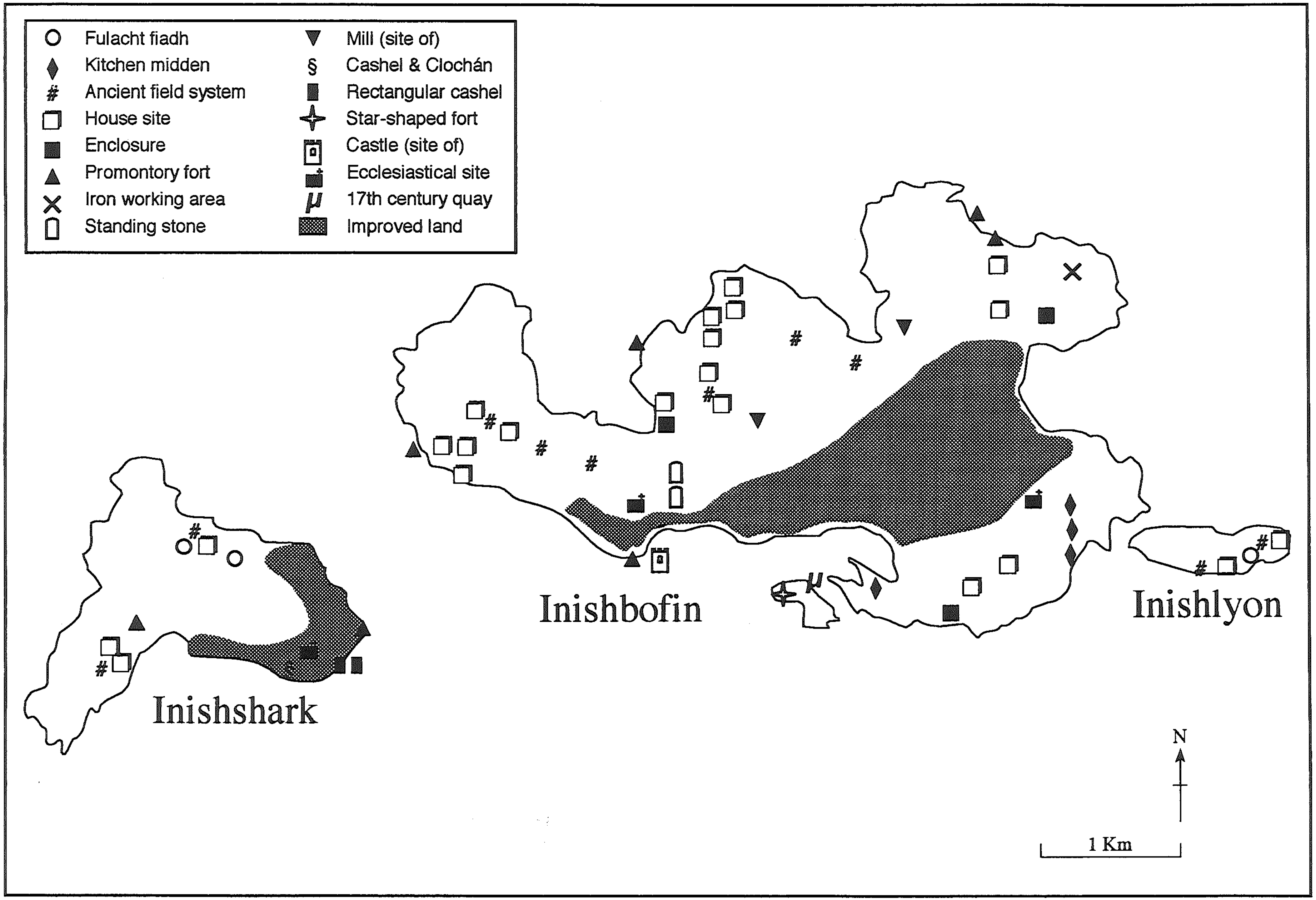
A particularly notable piece of evidence for Bronze Age settlement is the recently found pottery shard, datable to the Bronze Age, from a large eroding circular enclosure that abuts onto the north beach strand on Inishbofin.

Coastal promontory forts, thought to be of Iron Age, are common on these islands. The most dramatic is Dunmore in Westquarter, Inishbofin. It projects outwards into the stormy waters of Shark Sound like the prow of a great ship. It has two well defined hut hollows within. To the east of the fort, on the north side of Cnoc Mór hill are numerous hut/house sites and enclosures with adjoining field systems. There are at least four other coastal promontory forts, including Dooneennapisha, on Inishshark (opposite Dunmore), Dunnahineen in north-west Inishbofin and Dún Gráinne on an islet at the mouth of Inishbofin harbour. Dún Gráinne, according to tradition, was refurbished by the O'Malleys as a castle in the later medieval period. The bulk of Dún Gráinne has fallen into the tide, save for the remains of a few hut sites.

Early Christian Period

The presence of two early ecclesiastical sites on Inishbofin, and at least one on Inishshark, indicates that the islands were settled in the Early Christian period. The standard ringfort is unknown on the islands, though two unusual rectangular enclosures with house sites on Inishshark may be an island variety of ringfort. The monastic sites perhaps provided convenient foci for an increasingly nucleated population. The division of Inishbofin into five separate townlands may have taken place in the early Christian period.

The most famous of the island saints is undoubtedly St. Colman, Bishop of Lindisfarne, a monastic exile who retreated to these islands with a like-minded group of Irish and Saxon monks following the rejection of his defence of the Celtic



Fulacht fiadh
Kitchen midden
Ancient field system
House site
Enclosure
Promontory fort
Iron working area
Standing stone
Mill (site of)
Cashel & Clochán
Rectangular cashel
Star-shaped fort
Castle (site of)
Ecclesiastical site
17th century quay
Improved land
Inishshark
Inishbofin
Inishlyon
N
1 Km

custom for dating Easter at the Synod of Whitby in the mid 7th century. On Inishbofin, the remains of their early monastery beside Church Lough now lies largely beneath centuries of later burials and a medieval church. However, faint traces of an enclosure, a number of early crosses, a bullaun and two holy wells are tangible reminders of the early Christian site. The raised platforms above a number of burials, beautifully decorated with white quartz pebbles, are a striking feature of the graveyard at this site.

St. Scaithin is also associated with the island. Little is known locally about the saint's background though a Scaithin is well known in County Kilkenny. Little trace remains of his monastery but his house and holy well are pointed out in the vicinity of the lonely children's burial ground that now occupies the site of the original monastic foundation in Westquarter Townland.

On Inishshark, close to the tiny harbour, there are a number of features associated with the monastic settlement founded by St. Leo. Modern settlement on the island was clustered in and around this site. The visible remains of this settlement consist of a small monastic cashel with a well-preserved beehive hut, Clochán Leo. Traces of a medieval church, Teampall Leo, are incorporated within the crumbling remains of the modern church. A narrow inlet 'Fo Leo', contains a small holy well, Tobar Leo. St. Leo's bell survived on the island until the middle of the last century, before it was broken up to provide immigrants with a good luck charm for their dangerous Atlantic crossing to America.

The Medieval Period

In Medieval times these islands, like most of Connemara, lay beyond direct Norman influences and were held alternately by the O'Flaherty and the O'Malley sealords. The islands no doubt participated in the extensive business of trading and raiding that typified maritime pursuits in the medieval period along the western seaboard. A large anchor, though to be medieval in date, was dredged up some years ago between Inishbofin and Davillaun Island by Mr Paddy O'Halloran, skipper of the mail boat. This may relate to an Armada wreck which is documented as being lost off the east end of the island.

The strategic importance of the islands ensured that they attracted the attention of both National and English forces during the major upheavals caused by the 1641 rebellion. During this time Inishbofin became a pivotal stronghold in the west and was one of the last to fall. Royalist forces held out here with French aid from the Duke of Lorraine and made a last-ditch campaign of resistance. After some initial success, which included re-capturing the Aran Islands, the resistance finally crumbled and the islands surrendered in somewhat controversial circumstances. The Cromwellian regime built the imposing star-shaped artillery fort on Port Island at the mouth of the harbour, *c.* 1656. It is known locally both as Cromwell's Barracks and Don Bosco's Fort (he is reputed to have been a Spanish pirate and ally of Granuaile).

To the east of the star-shaped fort, an impressive crescent-shaped medieval harbour has been discovered. It consists of a harbour wall, 3 m in height, which is visible at low tide. It was probably used by smaller row boats which would have serviced larger boats anchored in the harbour. A number of possible medieval or post medieval houses are being eroded in a section on the shingle beach, landward from the harbour.

With the Cromwellian occupation, the islands entered a new and somewhat bizarre phase. The island was used as a penal colony for Catholic clergy and many remained until the restoration of Charles II. During the Jacobite wars the fort was once again in Irish hands and held out until after the battle of Aughrim in 1691, when they surrendered on good terms to the Williamite forces.

In the eighteenth century the islands, then owned by the Burkes, entered a period of relative tranquillity and benign neglect. The islanders resorted to the age-old practice of ship-wrecking and smuggling. A surviving warrant of 1741 gives a fascinating description of the wrecking of a ship, the Kitty Brigg, which was bound for England with a rich cargo from Antigua, the West Indies. She was wrecked in Inishbofin harbour by three O'Flaherty brothers, one being a priest. Stranger still, during the American War of Independence, a ship loaded with colonial troops from Canada was blown thousands of miles off-course and wrecked on the island. In the nineteenth century, fishing (which included the hunting of seals and basking sharks) supported an enormous population of over 1600 people.

During the latter part of the nineteenth century the congested district boards and the last English landlord, Allies, carry out much improvement. Allies, however, is credited with suppression of the Irish language which finally died out in the early 20th century The Irish language, however, continued to be spoken on Inishshark up to the 1940s when it was gradually replaced by English. In recent years the growth of a small tourist industry has brought fresh life to Inishbofin and the building of a new pier should revitalise the economic life of this most picturesque of islands.

2. Palaeoecology

(M.O'C. and ENG)

Introduction

Inishbofin, from the Irish 'Inis Bó Finne', i.e. 'Island of the White Cow', lies just over 5 km from the mainland of north-west Co. Galway and 20 km to the south of Clare Island. It has an area of 735 ha and forms a low-lying (highest point only 89 m O.D.), windswept and almost treeless landscape (Fig. B1).

The island is surrounded by relatively deep Atlantic waters (Fig. B1). The shallowest waters are to be found along a line connecting Inishbofin-Davillaun-Lecky Rocks-Rinvyle Point. Along this line, water depth just exceeds 20 m in two stretches of 1.6 and 0.6 km, respectively. Along the line Inishbofin-Cleggan Point water depths are greater, depths exceeding 30 m being recorded over a stretch of 1.8 km (Admiralty Charts, Sheets 2707 (1983) and 2706 (1982). If sea-levels of 16-10 m below present are accepted as pertaining at *c.* 9000 B.P. (Carter *et al.* 1989), then a landbridge as such may not have connected the island to the mainland even in the early post-glacial, i.e. before the early post-glacial isostatic rise in sea level had run its course. Part of the aims of the investigations reported on here, which were carried out towards a Ph.D. (Ní Ghráinne 1993), was to examine the effects of an offshore location on early post-glacial plant colonisation.

The bedrock geology of Inishbofin consists of metamorphosed sediments of Dalradian age and minor igneous intrusions (Cruse and Leake 1968). The Renvyle-Bofin fault effectively divides the island into a northern and southern region from the point of view of geology and present-day vegetation and land use. In the northern part, the rocks are predominantly siliceous grits and granulites, and also include pelites and semi-pelites. The pelitic rocks are typically metamorphosed sandy shales. Essentially, the pelites are similar to the rest of Connemara except that they are slightly more siliceous and calcareous. On the south of the island there is a thick exposure of pebble conglomerates which consists of large, rounded and flattened quartz pebbles set in a muddy or sandy matrix. Quartz-muscovite phyllites occur to the north and south of this bed. The main drift deposits also occur in the southern part of the island especially from Bofin harbour to Church Lough in the east. Here the best farming land is to be found which today is devoted almost exclusively to pasture and hay.

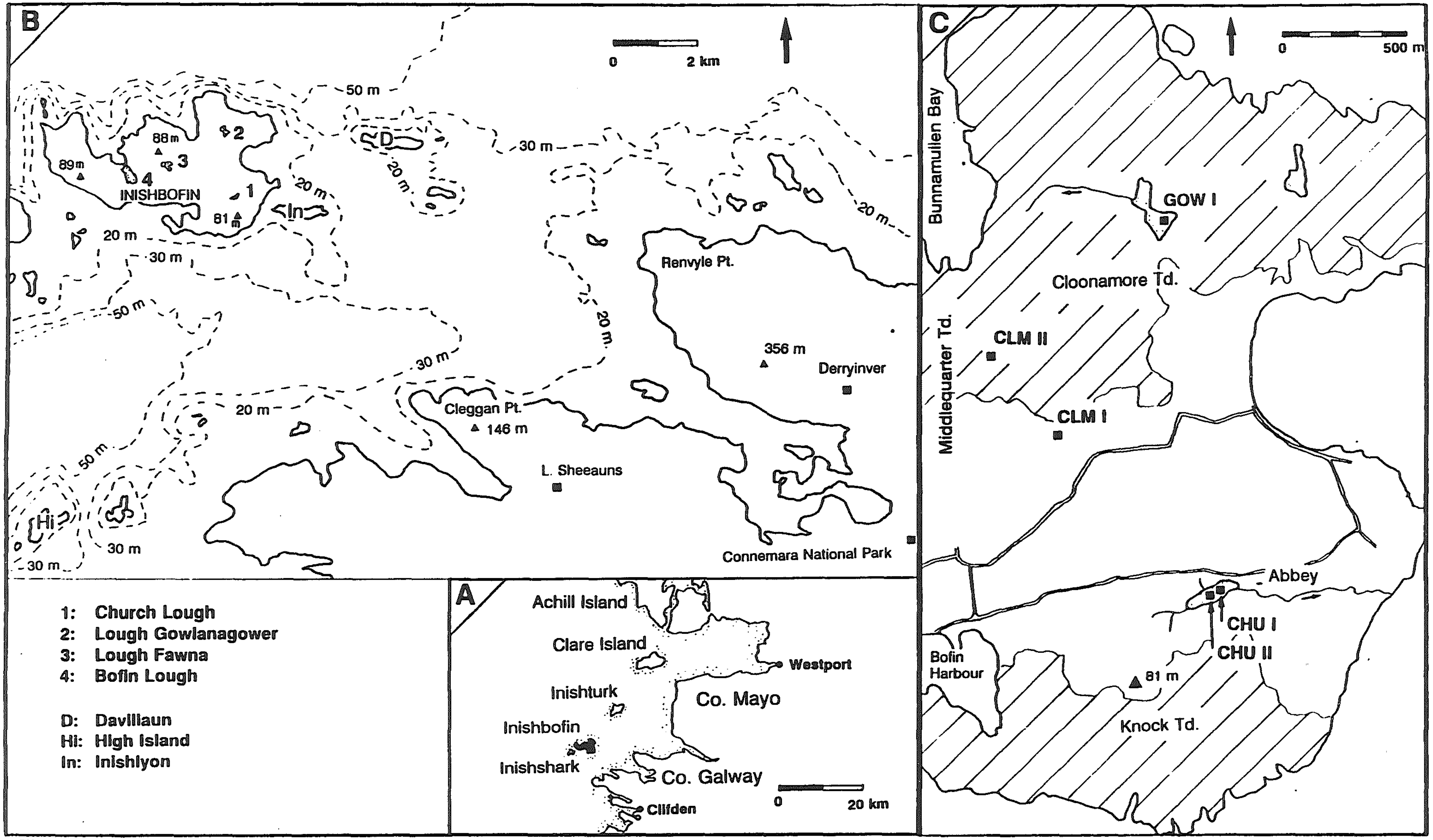


Figure. B1.

A. Map showing the location of Inishbofin and neighbouring islands.

B. Map of Inishbofin and the nearby Galway/Mayo coast. Sea floor contours, elevation of peaks (filled triangles) and pollen sites in Connemara are indicated (filled squares). The main lakes on Inishbofin (1-4) and some smaller islands are labelled.

C. Map of eastern Inishbofin showing the sites where palaeoecological investigations have been carried out (filled squares), early Christian site near Church Lough (Abbey), Knock Hill (filled triangle), main bog/heath areas (parallel lines) and road network.

In selecting sites that might provide long post-glacial records, lakes were the obvious and, indeed, the only choice since most of the peat has long since been cut away as a source of fuel. The lakes chosen, namely Church Lough and L. Gowlanagower, lie at the eastern side of the island but in contrasting settings. The former lies in a depression in what is the most fertile and possibly the most sheltered part of the island where a substantial drift cover forms a fertile soil. We know from historical records (see below) that this was also the site of an important early monastic settlement founded by St. Colman in 665 A.D. The rich archaeological record which survives at this site also attest to its important over at least six centuries (see Gibbons in this volume). In contrast to this, L. Gowlanagower lies in an area of heath and bog, with little or no drift and no obvious remains of human settlement in the vicinity. The lake, however, harbours what must be among the most thriving present-day European populations of *Eriocaulon aquaticum*, a North American element of the north-west European flora (in Europe the species is confined to W. Ireland and W. Scotland). On the northern part of the island, along the boundary between Cloonamore and Middlequarter Townlands, there is a relatively deep peat body (*c.* 3 m deep) which represents the remnants of a once widespread peat-covering that ran more or less the length of the northern part of the island. Investigations were carried out in this area on the only fossil tree stumps that were noted on Inishbofin.

Laboratory methods

After detailed stratigraphical examination, the cores were X-rayed. The X-ray image was examined for variations in density, the lighter image helping to pinpoint the more minerogenic parts of the core.

Samples for pollen analysis (1 cm thick and 1 cm^3 volume) were taken from the centre of the cut-open cores (CHU I and GOW I) and prepared following standard methods. *Lycopodium* spores were added as an exotic to enable pollen concentration to be estimated. The material retained in the 100 μm sieves used in preparing the pollen samples was examined for identifiable remains. A qualitative estimate was made of the frequency of the individual elements identified using the following abundance scale: + = rare; 1 = occasional; 2 = frequent; and 3 = abundant. The frequency of charcoal in these preparations was also noted. This is referred to as macro-charcoal to distinguish it from the smaller charcoal pieces (pieces greater than *Lycopodium* spores, i.e. *c.* 37 μm, were only counted) encountered in the pollen slides. The latter is referred to as micro-charcoal and, in contrast to the macro-charcoal which is probably of local origin, can be expected to reflect fires mainly at a regional local scale.

Whole core volume susceptibility in cores CHU I, CHU II and GOW I was measured using a Bartington Magnetic Susceptibility Meter, model MS2, fitted with a loop sensor. This equipment only became available after sampling for pollen had been carried out in core CHU I. Reading from these levels, however, did not depart from overall trends in the particular part of the core (only 1^+ cm^3 of material removed; also the signal is integrated from over *c.* 2 cm length of core).

Samples were taken from selected levels for ^{14}C dating and also for examination of χ (mass specific magnetic susceptibility; CHU I only) and ash content. The ash content determinations in the case of CHU I are considered unreliable and hence are not presented. In addition, a limited number of samples (15), 2-cm-thick, were taken from CHU I at points where the pollen and/or the lithological data suggested changes in vegetation and/or land-use history. Magnetic investigations were carried by Prof. F. Oldfield, Department of Geography, University of Liverpool, which included: χ (mass specific magnetic susceptibility), χ_{fd} (frequency dependent susceptibility), SIRM (saturation isothermal remnant magnetisation), ARM (anhysteretic remanent magnetisation), and IRM_s and IRM_h ('soft' and 'hard' isothermal remanent magnetisation). Five samples, also 2cm-thick, were investigated from the core GOW I. For ease of reference these are referred to in the text as the detailed magnetic investigations.

All samples are referred to by the depth of the upper sampling level. Thus the sample from 567-569 cm, on which detailed magnetic measurements were carried out, is referred to as 567 cm.

Church Lough, Inishbofin

Site description and sampling

Church Lough (grid ref. L 551 651; 10°13.3'W 53°37'N) is located near the east coast of Inishbofin, close to sea level. The lake is approximately 150 x 50 m in size and is fed by a number of small streams that enter the western part of the lake (Fig. B1). These drain the heath-covered Knock Hill to the south and the fertile farmland to the west and north-west. A small outflow stream flows eastwards to the sea through what appears to be an artificial cutting in the drift deposit at the eastern end of the lake.

On the north and especially the western side of the lake, there is much *Phragmites australis*. Aquatics include *Nuphar lutea* and *Persicaria amphibia (Polygonum amphibium)*, the former forming a wide band near the shore so that only a relatively small area in the centre is open water. Observations by locals and also the overall appearance suggest that the lake is rapidly in-filling. Two water samples collected on 10th September 1986 gave pH and conductivity readings of 7.1 and 7.2, and 292 and 289 μS cm^{-3}, respectively.

In the central part of the lake, where water depth is *c.* 3 m, two cores were taken, CHU I and CHU II (see Fig. B1), using a modified 5-cm diameter Livingstone corer in September 1986. In the case of CHU I there was almost 100% recovery in all drives while in CHU II, drive 3.5-4.5 m, there was incomplete recovery. As possibly representing the more complete record, CHU I was selected for detailed analysis.

Results of palaeoecological investigations

Stratigraphic descriptions, and x-ray analysis and whole-core magnetic susceptibility

The main stratigraphic features of the cores CHU I and CHU II are summarised in Table B1. While there appears to be a greater thickness of sediment at coring position CHU II, this may reflect, at least partly, a difference in the depth at which coring commenced (i.e. depth at which resistance to the corer was first noted, which was taken as 0 cm).

In both CHU I and CHU II, a late-glacial deposit, *c.* 1 m thick, was recorded at the base. This has not been palynologically investigated but is recognisable as pertaining to the late-glacial on the basis of a tripartite stratigraphy. The post-glacial sediments consist mainly of fine brown, organic-rich material with several distinctive bands of silt/sand and also distinctly darker layers, the darker colour being ascribed to much fine charcoal. The main features in the Holocene part of core CHU I are as follows:

1. X-ray analysis of the core showed a distinctly denser layer between 555-545 cm. A noticeable increase in the silt/clay content was independently noted while making stratigraphic descriptions of the core (Table B1) and high positive whole core magnetic susceptibility values (κ) were also recorded in this interval (Fig. B5).
2. High susceptibility values are also recorded between 4.28 and 4.18 m but there is no corresponding change in stratigraphy.
3. The other pronounced mineral-enriched layer occurs at 1-1.31 m which corresponds to high positive κ values. This also showed up clearly in the X-ray image.
4. Layers with obvious charcoal enrichment are recorded only in the upper part of the core, i.e. above 4.17 m.

Radiocarbon determinations and pollen stratigraphy

The ^{14}C dates, taken in conjunction with the pollen stratigraphy, provide a reasonable chronological control though considerable uncertainty remains regarding the chronology of the lowermost and uppermost parts of the core (Table B2). The points that follow are based on a comparison of the results of the ^{14}C determinations and the chronological implications of the pollen and lithological stratigraphy:

1. Sedimentation leading to the deposition of late-glacial sediments presumably began shortly after deglaciation. Sediments with the first noticeable increase in organic content (654.5 cm in CHU I) may be ascribed to the beginning of the late-glacial interstadial and probably date to *c.* 13 000 B.P.

2. On the basin of pollen (low arboreal pollen (AP) and substantial *Juniperus*) and also the stratigraphy, the base of the present profile CHU I (Fig. B3) may be confidently placed shortly after 10 000 B.P. (all dates, unless otherwise indicated, are in non-calibrated years), i.e. shortly after the end of the late-glacial.

3. In the lower part of the profile, palynological control of chronology such as a well defined rise in *Alnus* (dates to *c.* 6700 B.P. in Connemara, *cf.* O'Connell *et al.* 1988) and the Elm Decline (*c.* 5100 B.P.) is lacking.

4. The date 4200±100 B.P., which marks the rise in *Taxus*, is as expected insofar at it corresponds to the date for the expansion of *Taxus* at L. Namackanbeg, Spiddal (O'Connell *et al.* 1988).

5. The dates associated with the regeneration of tall shrubs (1760±80 and 1700±60), which bears all the hallmarks of the so-called late Iron Age lull, are acceptable.

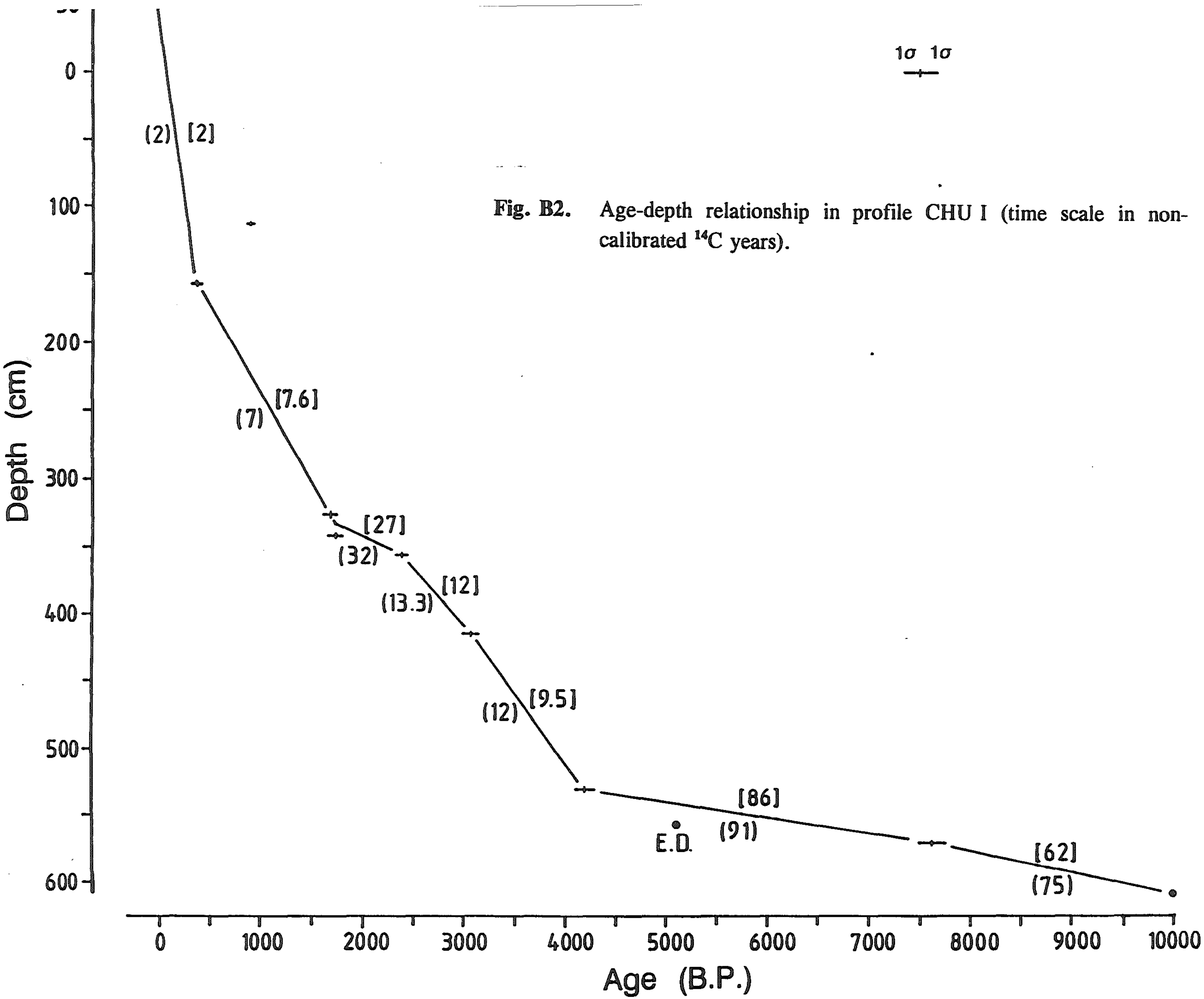


Fig. B2. Age-depth relationship in profile CHU I (time scale in non-calibrated ^{14}C years).

6. There is no palynological control available for the date 390±65 B.P., which corresponds to the mid sixteenth century. The most likely source of error is inwashed organics deficient in ^{14}C. However, taking into consideration the depth of the sample from the top of the core, it is unlikely to be much younger than the given date.

A plot showing the time/depth relationship and sediment accumulation rate is given in Fig. B2. From this it follows:

1. In the early Holocene, sediment accumulation is exceptionally slow (86 y cm^{-1}, i.e. 0.12 mm y^{-1}, between the two lowermost ^{14}C dates). Subsequently, sedimentation increases dramatically so that for most of the mid part of the profile values of *c.* 10 y cm^{-1}, i.e. 1 mm y^{-1} are achieved while in the uppermost part sedimentation increases still further to an estimated average of 2.5 y cm^{-1} or 4 mm y^{-1}.

2. The date 2400±65 B.P. lies in the so-called 'Hallstatt disaster' where the calibration curve is exceptionally flat. The age in calendar years may lie any place within a 360 year interval (at 1s confidence level).

3. Given that the dates 1760±80 and 1700±60 are statistically inseparable, a single point (334.5 cm; 1730 B.P.) is used to construct the time/depth relationship in this part of the core.

4. There is some uncertainly attaching to the depth relationship of core segments -60 to 0 cm and 0 to 100 cm (see Table B1). In the whole core susceptibility traces, the uppermost parts of cores CHU I and CHU II are characterised by high values showing characteristic twin peaks (Ní Ghráinne 1993). This suggests that there is no serious overlap or hiatus in the pollen profile CHU I. The micro- and macrofossil records from this part of core CHU I also supports this conclusion.

In the reconstruction of the palaeoenvironment at Church Lough (see below), the dates cited in the various (sub)headings relate to the end pollen samples of the particular PAZs or subzones, and are based on the assumption of constant sedimentation rates between the dated points. A constant sedimentation rate is rather unlikely, but in the absence of a better chronological control, the derived dates provide at least a reasonable approximation. Where there are good grounds for alternative date(s), this is signalled by a question mark and the alternative chronology is discussed in the text that follows.

Table B1. Stratigraphic descriptions of cores CHU I and CHU II from Church Lough.

CHU I			CHU II			
Depth (cm)	Stratigraphic description	Stratigraphic details (CH: charcoal)	Depth (cm)	Stratigraphic description	Stratigraphic details (CH: charcoal)	Comments
	Depth of water: 300 cm	Drives: 0-100; 100-200 cm etc.		Depth of water: 340 cm	Drives: 0-50; 50-150 cm etc.	
100 to 0 to -60*	Lake mud with high water content					
270-100	Silty lake mud with a conspicuous fibrous component	Silt/sand: (131)-125-100 CH: 155-131, especially 151-147 *Betula* twig, 1 cm Ø, at 148-147	350-150	Silty lake mud with a conspicuous fibrous component	CH: 165-150 Stone: 257-254	Holocene
609-270	Mainly dark, organic-rich lake mud with conspicous silt/sand layers and dark charcoal-enriched layers	CH: 318-290, especially 318-316; 378-350; 417-403 Silt/sand: 299; 403-402; 466-465; 543.5-539.5; 554-550 (incl. mica and schist flakes); 609-605	710-350	Mainly dark, organic-rich lake mud	Between 710-705 increasingly silty	
626-609	grey silt with many small stone fragments; low in organics		735.5-710	grey silt with gravel fragments, low in organics		Younger Dryas
654.5-626	lake mud with high organic component from 652 upwards	Silt/sand: 638; 645-644; 654.5-652	771-735.5	lake mud with high organic component from 757 upwards	Silt/sand: 745.5-743; 752-751 (incl. stone)	Interstadial
7-655	clayey silt		815-771	dauby blue silty clay and bands of sand		Pre-Interstadial

* Sampling commenced at 0 cm which, however, did not include the H_2O/sediment interface. This was subsequently sampled in a drive that began 100 cm above 0 cm, i.e. -100 to 0 cm; the uppermost sediment at the sediment/water interface was at 60 cm, i.e. -60 cm, above datum or 0 cm. All depths are in cm.

Table B2. Results of radiocarbon determinations, profile CHU I.

Gal. no. (CHU I)	^{14}C lab. no. (GrN-)	Depth (cm)	Age (B.P.)	Age[1] (cal. years)	Age[2] (cal. years)
8	17617	117-120	915±60	inverted	
7	17616	157-160	390±65	1574-1626 A.D. 1446-1520 A.D.	1536 A.D.
6	17615	325-328	1700±60	322-418 A.D. 256-290 A.D.	337 A.D.
5	17614	341-344	1760±80	214-400 A.D. 152-156 A.D.	276 A.D.
4	17613	357-360	2400±65	532-394 B.C. 754-694 B.C.	574 B.C.
3	17612	413-416	3080±85	1246-1206 B.C. 1430-1252 B.C.	1318 B.C.
2	17611	529-532	4200±100	2830-2620 B.C. 2900-2850 B.C.	2760 B.C.
1	17610	569-572	7630±150	6330-6240 B.C. 6560-6340 B.C. 6590-6570 B.C.	6415 B.C.

[1]Age range (1σ) in calibrated years; [2]Mid-point of 1σ age range

Church Lough, Inishbofin (CHU I)

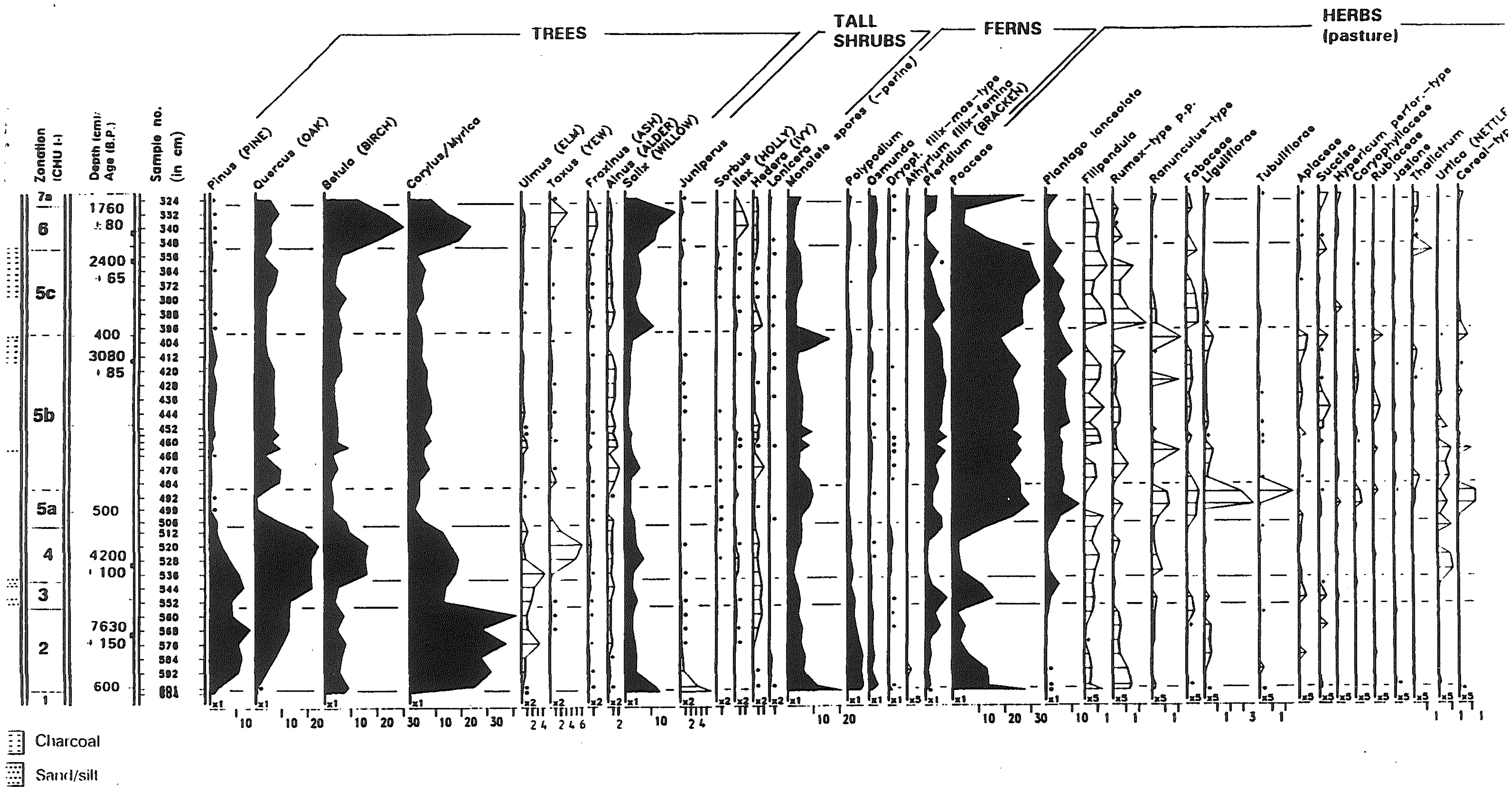


Fig. B3. Percentage pollen diagram from Church Lough (CHU I), lower part of profile (1 of 2 parts).

Church Lough, Inishbofin (CHU I)

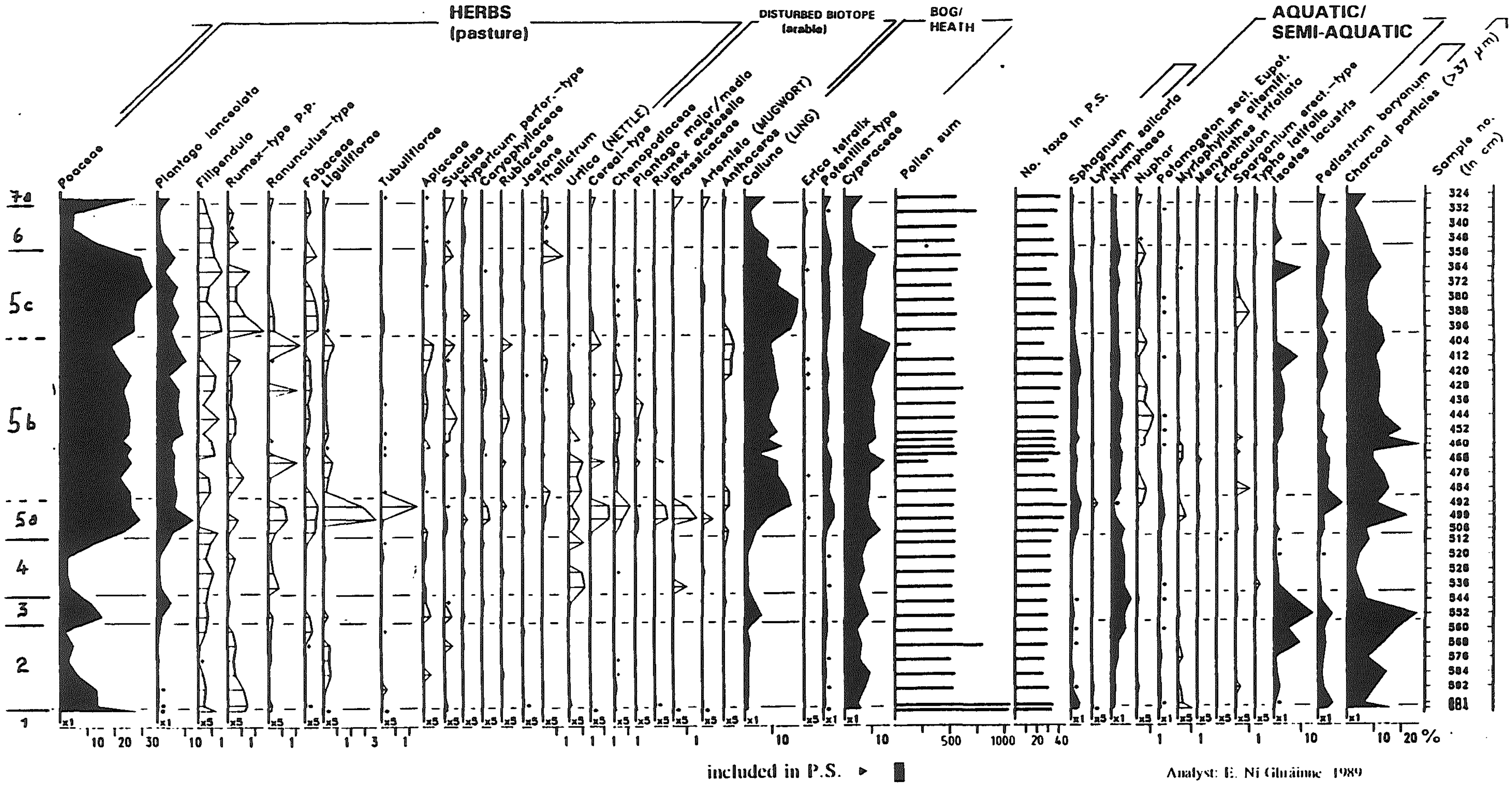
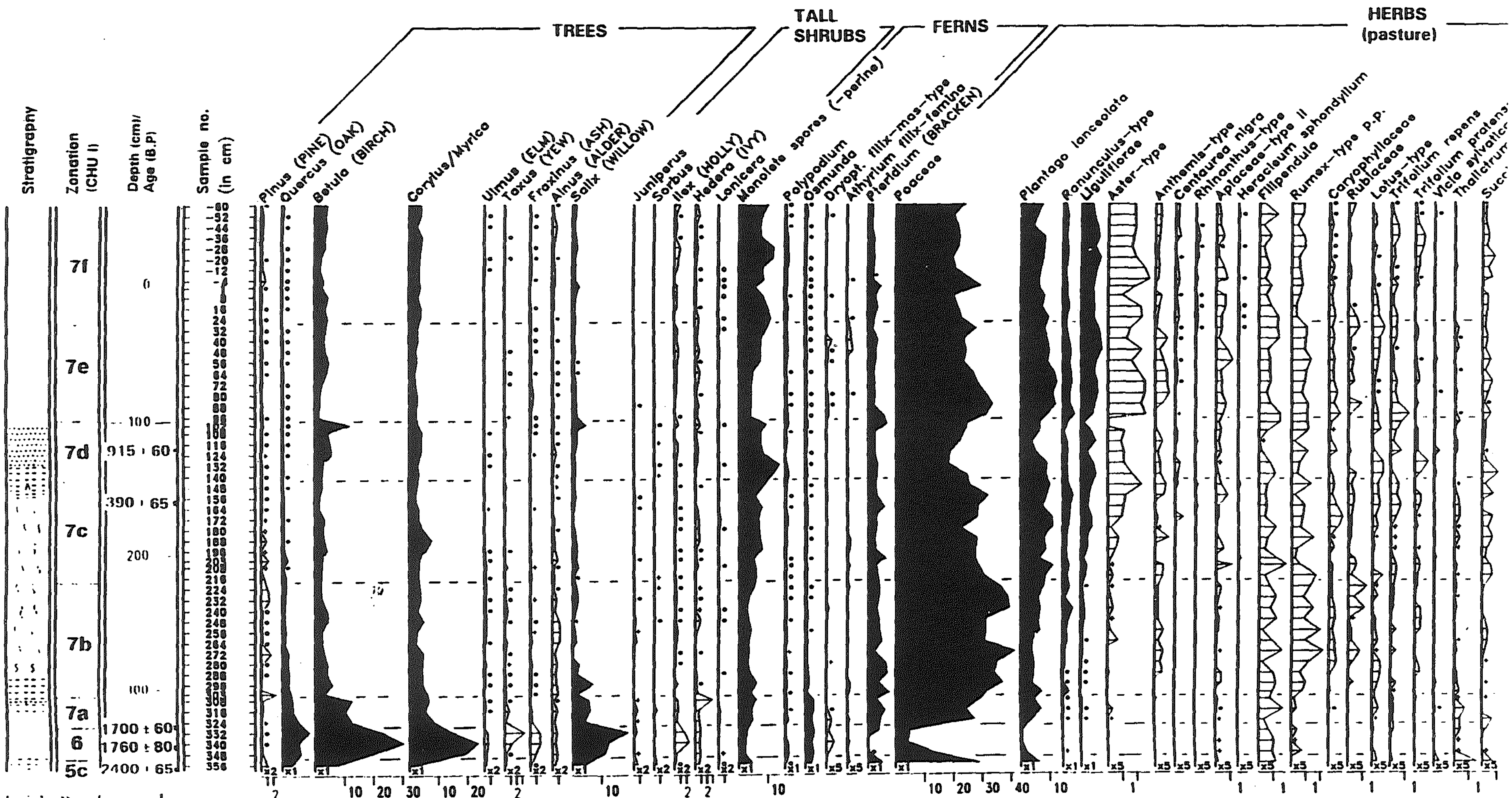


Fig. B3. Percentage pollen diagram from Church Lough (CHU I), lower part of profile (2 of 2 parts).

Church Lough, Inishbofin (CHU I)



Betula wood

Charcoal

Sand/silt

Fibrous sediment

Fig. B4. Percentage pollen diagram from Church Lough (CHU I), upper part of profile (1 of 3 parts).

Church Lough, Inishbofin (CHU I)

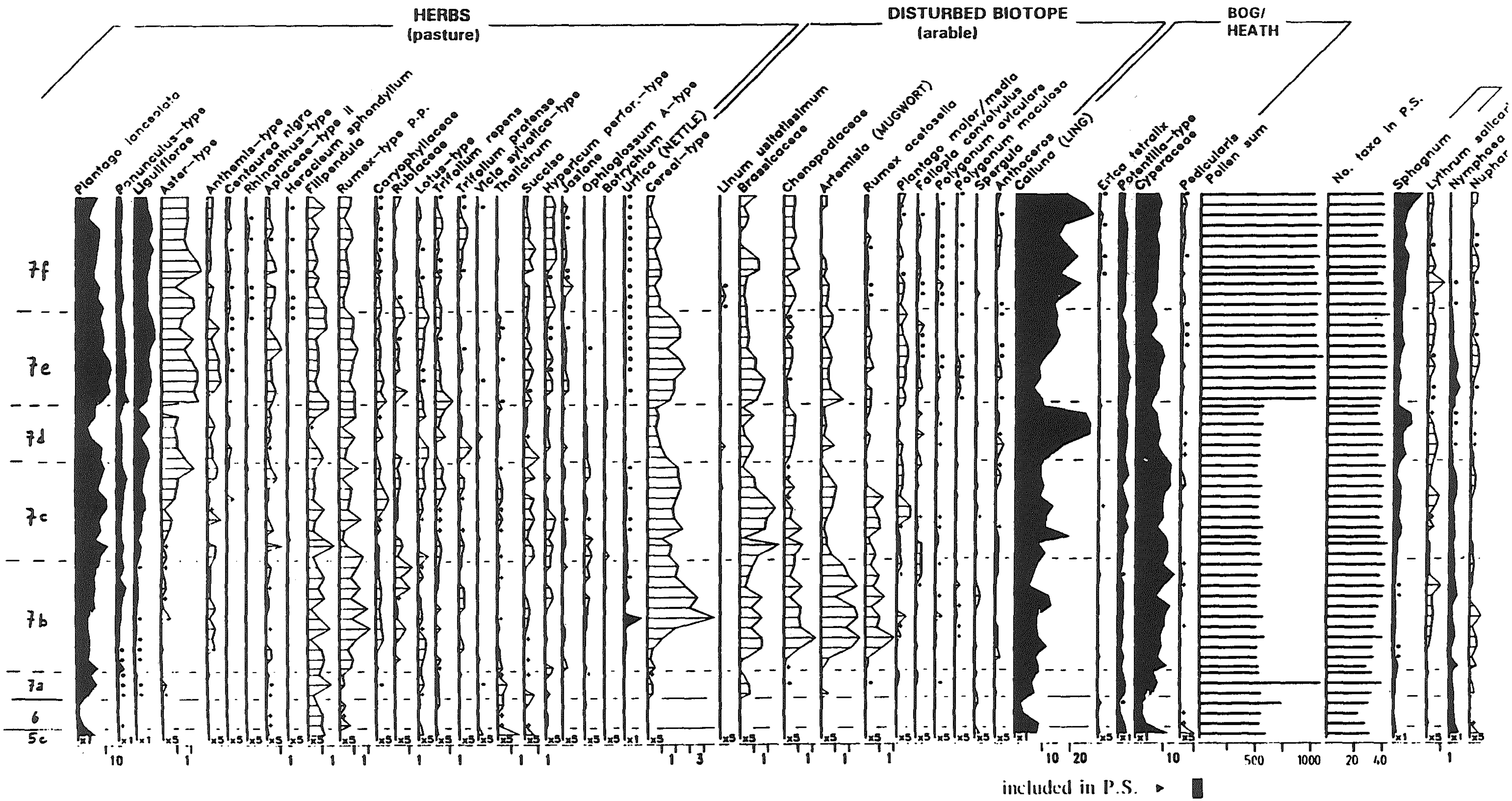


Fig. B4. Percentage pollen diagram from Church Lough (CHU I), upper part of profile (2 of 3 parts).

Church Lough, Inishbofin (CHU I)

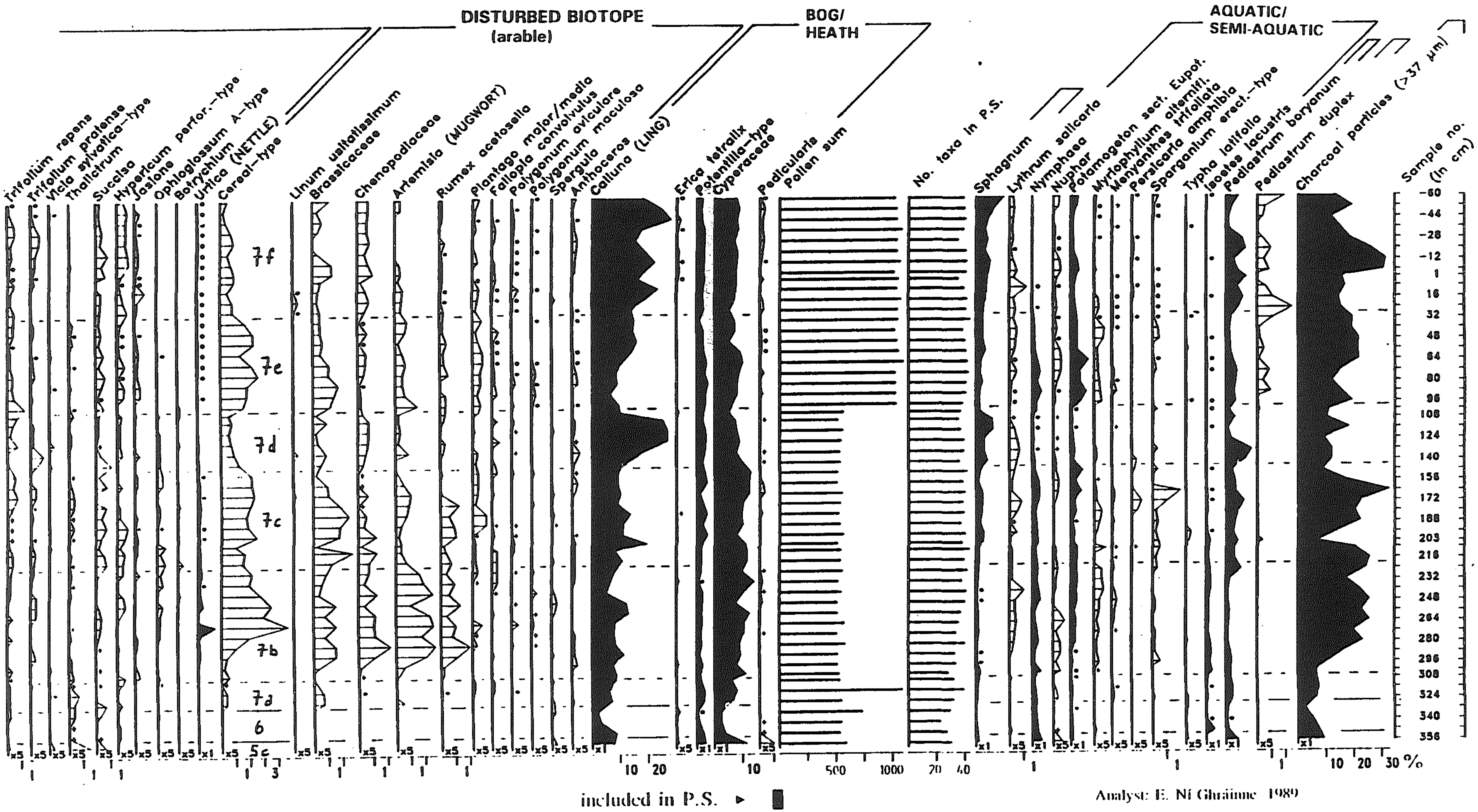


Fig. B4. Percentage pollen diagram from Church Lough (CHU I), upper part of profile (3 of 3 parts).

Church Lough, Inishbofin (CHU I)

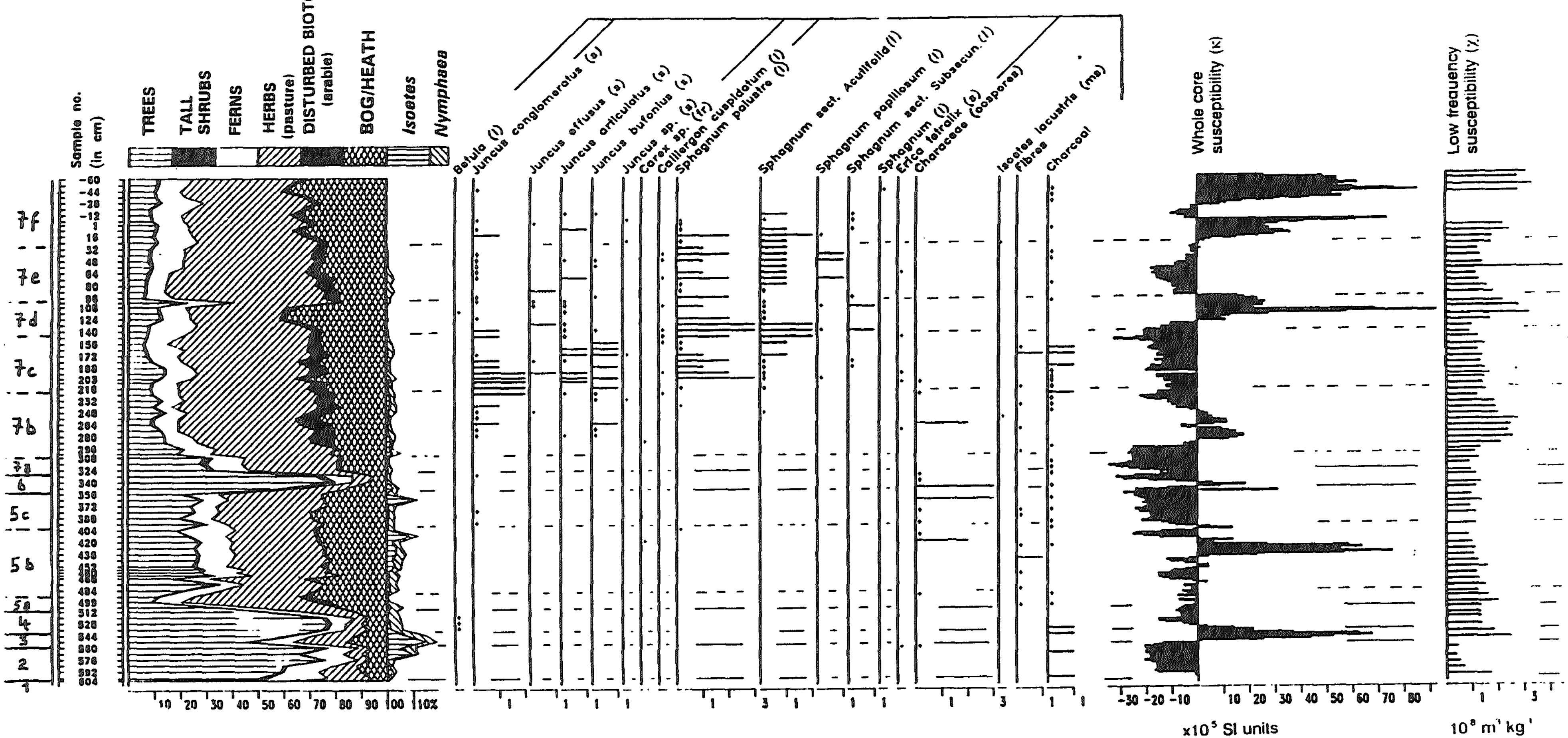


Fig. B5. Profile CHU I, Church Lough. Composite percentage pollen curves, macrofossils recorded in the coarse fraction (>100 μm) from the pollen samples, whole core susceptibility (κ), mass specific low frequency susceptibility (χ). The horizontal scale (macrofossils) is as follows: +, rare; 1, occasional; 2, frequent; 3, abundant. (l), leaves; (ms) *I. lacustris* macrospores; (s), seed/fruit.

Pollen analytical and macrofossil analyses, profile CHU I

The pollen and macrofossil data are presented in Figs. B3 and B4, and B7, respectively. Study of the *Corylus/Myrica* pollen led to the conclusion that *Myrica* is rare in profile CHU I. In the interpretation the assumption is made that this taxon reflects mainly the abundance of hazel. A small number of *Isoetes echinospora* spores were recorded. These most likely represent *Isoetes*-type spores produced by *I. lacustris* but outside the usual size range of *I. lacustris* spores, i.e. less than 30 μm (*cf.* Birks 1973). Cereal-type are based on maximum size ≥40 μm, a pore diameter ≥3 μm and pore+annulus diameter ≥8 μm. A total of 489 cereal-type pollen, with average maximum size of 47±8 μm (one standard deviation quoted), were identified and measured in profile CHU I.

In the macrofossil record, *Juncus conglomeratus* and *J. effusus*, and *J. acutiflorus* and *J. articulatus* was attempted. Where no epidermal cells remained, *Juncus* seeds are referred to as *Juncus* sp. In the case of *Betula* leaves tree birches are involved; these are most likely *B. pubescens.*

Post-glacial environmental reconstruction at Church Lough

1. *Succession in the early post-glacial*
   CHU I-1: 604 cm; c. 9700 B.P.

A single spectrum (604 cm) constitutes the basal zone. Relatively high *Juniperus* representation (5.9%) and a low AP/NAP ratio suggest that the final stages of a rather typical late-glacial/post-glacial transition is represented here. The substantial representation of Poaceae, Filicales (including *Osmunda* at 1%) and *Salix*, and lower values for *Juniperus* and *Betula* suggest that the vegetation was largely herb-dominated but with some shrub and perhaps tree willows.

2. *Early post-glacial woodland development*
   CHU I-2: 601-560 cm; c. 9335-6775? B.P.

In CHU I-2 *Corylus/Myrica* dominates the assemblage and tall canopy trees such as *Pinus* and *Quercus* are well represented. On the other hand, the NAP component is low, though Poaceae, Filicales (-perine) and Cyperaceae have substantial values.

The transition from herb/shrub vegetation, which was presumably low and open, to hazel-dominated woody vegetation (includes some *Juniperus*), takes place between samples 604 and 601 cm. This rather abrupt change in the pollen spectra does not necessarily signify rapid succession since sediment accumulation in this part of the profile may be as low as *c.* 75 sidereal years per cm (see Fig. B2).

In the tall canopy woodlands (spectra 592-560 cm, i.e. from *c.* 8840 B.P. or earlier), *Pinus* initially made a greater contribution than *Quercus* but, in the upper part the zone (from *c.* 7500 B.P.), the latter becomes more important. *Ulmus* is only a minor component (average representation (AR) 1.2%) and, indeed, may not have been locally present. *Corylus* is of considerable importance (AR 32%) but *Betula* and *Alnus* (AR 0.5%) played only a minor role. The failure of *Alnus* to expand is noteworthy.

The low but consistent presence of NAP such as *Filipendula*, *Rumex* and Liguliflorae suggests that woodlands were rather open. This is also supported by the continuous records for *Juniperus*, the substantial Filicales representation (including *Pteridium* and also *Osmunda*).

Taxa indicative of bog development are poorly represented (*cf.* low *Calluna* and *Sphagnum*). The substantial curves for Cyperaceae and *Potentilla*-type may represent lake-edge species such as *Carex rostrata* and *Potentilla palustris*, respectively. The main floating aquatic is *Nymphaea*, which presumably represents *N. alba*.

Whole core susceptibility values (κ) are negative which suggests that diamagnetic materials, such as organic matter and water, dominate. Mass specific susceptibility values (χ) are also low which suggests that there is low concentration of ferrimagnetic minerals. The detailed investigation of the magnetic properties of samples from 567 and 559 cm show a high hard remanence component. This suggests that, in these samples, haematite is making an important contribution to the magnetic mineralogy. Low ARM values suggest that the magnetic grain size is course. Inwash of unweathered bedrock is suggested. At 559 cm upwards, κ values change from being negative to positive which suggests increased inwash of minerogenic material. In the pollen data, indicators of instability in the woodlands include higher *Pteridium* values from 568 cm upwards, i.e. from *c.* 7600 B.P., and also higher *Isoetes lacustris* values. The latter feature may be interpreted as a response of the *I. lacustris* population to increased mineral input (Vourela 1980).

3. *Environmental change in the mid-Holocene PAZs CHU I-3 and 4: 552-512 cm; c. 6085?-4025 B.P.*

3.1. *Decline in* Corylus *and expansion of herbaceous, including bog/heath, vegetation (CHU I-3)*

At 552 cm, *Corylus/Myrica* representation falls to 13% (previously 41%) and subsequently fails to exceed 19% in this part of the profile. Several NAP taxa, including Poaceae, *Pteridium*, *Calluna* and *I. lacustris* rise sharply and *P. lanceolata* peaks at 544 cm. These changes bear all the hallmarks of Neolithic Landnam though cereal-type pollen is not recorded nor is an Elm Decline but then the *Ulmus* values are exceptionally low.

The rise in *P. lanceolata* suggests expansion of grassland while the rise in *Calluna* and also Cyperaceae is indicative of heath/bog development. The substantial records for micro- and also macro-charcoal suggest that fire, presumably in part at least deliberate, assumed increased importance. Regarding the chronology, it should be noted that the date given above for the base of the zone, which is based on the assumption of a constant sediment accumulation between the two relevant ^{14}C dates, is probably too old. It is likely that sedimentation in the lower part of the zone was slower than postulated by the straight line joining the ^{14}C-dated points (Fig. B2). It may be assumed that sedimentation increased due to more inwash from the catchment in the upper part of the interval.

There is strong evidence that the changes in vegetation and land-use in the catchment led to considerable soil erosion. High positive κ values are recorded in the interval 556-540 cm with highest values at 550 and 548 cm. The κ values (samples 552 and 544 cm only measured) have sharply increased (Fig. B5). A sample from 551 cm (only sample selected for detailed magnetic investigations) has particularly high values for χ , SIRM and especially 'hard' IRM while the ARM value is rather low. This suggests that haematite is important and that the magnetite grain size is coarse. Inwash of both primary and secondary minerals is probably taking place. The high micro-charcoal value at 552 cm suggests that fire was of importance and may have contributed to the production of secondary minerals.

The lithology indicates inwash of clastics. A pronounced silt/sand layer with bits of mica schist flakes was noted between 550 and 554 cm, i.e. the lower part of the zone (see Table B1). A particularly dense layer between 555-545 cm in the X-ray image suggested increase in mineral matter. The sharp rise in *I. lacustris* at 552 cm is probably in response to this.

3.2 Woodland regeneration including the expansion of Taxus *(CHU I-4; also includes top of CHU I-3)*

Though *P. lanceolata* has its highest percentage representation at 544 cm (CHU I-3), most of the other pollen curves (percentage and concentration) suggest that woodland regeneration has already commenced at this level in the profile. At 544 cm, *Quercus* has become the dominant tree. This continues until the top of CHU I-4. The *Pinus* population also expands with *Quercus* but declines earlier. *Corylus* and, in particular, *Betula* also expand, the latter presumably in the vicinity of the lake (*cf. Betula cf. pubescens* leaves recorded in samples 536, 528 and 520 cm; see Fig. B5). In CHU I-4, *Ulmus* falls to exceptionally low values from which it does not recover but *Taxus* expands and achieves 4.9%. Elm, if present, appears to have extinct at least in the vicinity of Church Lough by 4200 B.P., at which time yew was beginning to make a substantial contribution to the woodlands in the vicinity of the lake. At the time of maximum development of these secondary woodlands (*c.* 4100 B.P.; 520 cm) the NAP component, including the bog/heath taxa, make only a small contribution to the pollen rain. It is assumed that this more or less 100% woodland regeneration was facilitated by much reduced human activity.

In zone CHU I-4, κ values are negative which suggests a decline in minerogenic input. χ values are rather low and in the one sample that was investigated in detail (527 cm), the results suggest that a fine grained magnetite was the main contributor to the magnetic signals (moderate values for ARM and SIRM and low 'hard' IRM). This fits in with the stable conditions, including absence of fire, that would be expected in a period of woodland regeneration and little or no human disturbance.

4. Environmental change in later prehistory (post c. 4000 B.P.)
PAZ CHU I-5: 506-356 cm; c. 3970-2345 B.P.; 2450-466 cal. B.C.

The evidence from CHU I-5, which represents the greater part of the Bronze and Iron Ages, suggests considerable and sustained levels of human activity. This resulted in a relatively open landscape with greatly reduced trees/tall shrub cover and considerable amount of bog. The environmental record is discussed in the context of three distinct subzones, CHU I-5a to 5c.

4.1. Woodland clearance and farming (including pasture and arable)
Subzone CHU I-5a: 506-492 cm; 3970-3833 B.P.; 2450-2275 cal. B.C.

The pollen analytical evidence at the end of CHU I-4 (*cf.* decline in AP, including *Taxus*, and increase in *Pteridium* and also *P. lanceolata*) suggests that woodland clearance in the context of renewed human activity had already commenced prior to the beginning of subzone CHU I-5a, i.e. by *c.* 4000 B.P. or earlier. The evidence for woodland clearance in CHU I-5a is, however, particularly strong. Oak appears to have been completely removed and also hazel and birch. *Pinus*, which was increasingly less important since the beginning of CHU I-4, falls to such low levels as to suggest that pine no longer grew in the vicinity of the lake. Tall shrubs such as *Betula*, *Corylus* and *Ilex* may have been totally cleared.

The evidence for human activity during this subzone is particularly strong. NAP increase in diversity and also percentage representation. Noteworthy is the rise in Poaceae and *P. lanceolata* (had already commenced in the previous zone) and the substantial representation of Asteraceae (Tubuliflorae and Liguliflorae), Fabaceae and Caryophyllaceae. This probably reflects widespread pasture. There is also evidence for substantial arable farming in the form of cereal-type pollen, Brassicaceae, Chenopodiaceae, *Rumex acetosella* and *P. major/media*. Fire was also important (*cf.* micro- and also macro-charcoal records).

At the base of the subzone the percentage representation of Cyperaceae, *Potentilla*-type (probably reflects mainly *P. erecta* but may include *P. palustris*) and *Sphagnum* increases and *Calluna* representation rises to 17% at the top of the zone. Similar changes are recorded in the concentration diagram so that there may have been a real increase in the input of pollen by these taxa. The record suggests that bog/heath was important in the lake catchment from shortly after 4000 B.P. onwards.

Rather surprisingly in view of the evidence for more or less total woodland clearance and arable farming, the evidence for soil instability is rather weak. There are no obvious changes in the lithology, κ are negative though less so than in other parts of the profile (Fig. B5). χ values, however, rise which suggests that there is increased input of coarse and/or fine grained magnetic minerals. Unfortunately, there are no detailed magnetic measurements in this subzone.

There are also some biological indicators of change in the aquatic environment. *Nymphaea* declines, a more or less continuous but slender curve for *Nuphar* begins near the top of the subzone, and *Potamogeton* sect. *Potamogeton* and especially *Pediastrum* expand. These changes may be caused by a variety of factors such as changes in pH and nutrient content of the run-off, soil erosion (*cf.* rise in *Pediastrum* but the *I. lacustris* curve is interrupted) and lake level change.

4.2. Limited woodland regeneration in the context of sustained pastoral farming
Subzone CHU I-5b: 484-404 cm; 3755-2960 B.P.; 2175-1172 cal. B.C.

Increased representation of *Quercus*, the continuous though slender *Pinus* curve and the somewhat increased *Corylus/Myrica* representation suggests some regeneration of woody vegetation. The substantial NAP component, including consistently high percentage values for Poaceae and *P. lanceolata* (AR: 31 and 6.8%, respectively), and low and interrupted representation of cereal-type, Chenopodiaceae and also *P. major/media* suggest a considerable level of farming activity in which, however, the arable component is of reduced importance compared with CHU I-5a. It is assumed that farming rather than local climatic or edaphic conditions prevented a more complete regeneration of woodland.

The substantial micro- and also macro-charcoal (upper part of subzone) values and the darker sediment noted between 403 and 417 cm (see Table B1) suggest that fires, presumably anthropogenic in origin, were frequent in the catchment, especially in the later part of the subzone.

During this subzone, bog/heath taxa including *Sphagnum* have a sustained high representation. This suggests that bog/heath expanded locally and probably covered much of Knock Hill as it does today.

Again in this subzone, evidence for substantial soil erosion is weak. Increased silt/sand was noted at 466-465 cm. Otherwise, the sediment appeared to be highly organic. κ values are generally not as negative as in other parts of the core and high positive values are recorded in the interval 444-430 cm. χ values are higher in the lower part of the subzone. Detailed measurements carried out on samples from 469 and 421 cm gave low measurements for all variables which again supports the view that erosion of magnetic minerals is low. Given the high sediment accumulation rate and the apparently low mineral input, productivity in the aquatic environment must have been high. In this connection, the substantial representation of both *Nuphar* and *Nymphaea* might be noted. The increase in *I. lacustris*, especially in the upper part of the profile, may be indicative of increased mineral input (*cf.* also higher κ values).

4.3. Regeneration of willow and decline in farming, especially arable farming Subzone CHU I-5c: 396-356 cm; 2860-2345 B.P.; 1065-466 cal. B.C.

The differences between subzones CHU I-5b and CHU I-5c are qualitative rather than quantitative. *Salix* representation is distinctly higher, *Pinus* falls to very low values and *Calluna* (lower part of subzone) and Poaceae are better represented. Many of the indicators of farming activity decline (e.g. *P. lanceolata*) or are recorded mainly in the lower spectra of the subzone (e.g. cereal-type, Chenopodiaceae and *P. major/media*). *Osmunda*, a fern which in the west of Ireland today is normally to be found where there is some protection from grazing, has increased representation in the upper part of the profile.

Consistently negative κ values suggests the diamagnetic substances such as organic matter and water predominate in the sediment. A sample from the base of the subzone (395 cm) yielded a low χ value and a high SIRM/χ ratio (94.4) which raises the possibility that authigenic iron sulphite (greigite) may be involved (Oldfield, pers. comm.). Reduction in mineral input is suggested by the low *I. lacustris* representation and sedimentation rates have also declined (Fig. B3 and B2).

The overall evidence points to lower farming intensity. There was an expansion of heath (at least initially; *cf.* higher *Calluna* values) and also of woody vegetation especially in the vicinity of the lake (*cf. Salix*; also *Hedera*). In the upper part of the subzone, there appears to have been a cessation of arable farming though fire appears to have continued to play an important role locally (*cf.* micro- and macro-charcoal and also dark sediment noted in interval 350-378 cm).

5. *Regeneration of tall scrub and severe reduction in farming, especially arable farming*
   Zone CHU I-6: 348-332 cm; 2120-1715 B.P.; 179 cal. B.C.-cal. A.D. 323

This zone is characterised by high AP and low NAP. Regeneration of woody vegetation at the expense of pasture (*cf.* exceptionally low *P. lanceolata* values) and also heath is signalled by these changes. Tall canopy trees such as *Quercus* did not respond but there may be some regeneration of trees/tall shrubs such as *Fraxinus*, *Taxus* and *Ilex*. It is interesting that there is no response in the *Pinus* curve which would suggest that pine was already extinct in the island. The decline in *Calluna* (also Cyperaceae) suggests that heath had now a reduced role and hence the possibility exists that Knock Hill at this time carried tall scrub.

The available evidence points to soil stability during this period. Whole core susceptibility (κ) values are, apart from at the base of the zone, highly negative and χ values also decline. Sample 339 cm gave low values for all magnetic variables measured; these results suggest low erosive input. Low *I. lacustris* and *Pediastrum* values support this view. Low micro-charcoal representation suggest that fire was unimportant.

It is clear that there is a distinct lull in farming activity which, presumably, facilitated the regeneration of woody vegetation. This corresponds with the late Iron Age lull which finds expression in most western Ireland pollen diagrams (*cf.* Molloy and O'Connell 1993; O'Connell 1994).

6. *Demise of woody vegetation in the context of intensive farming (zone CHU I-7)*

Zone CHU I-7, which includes all of the historical period, is characterised by low AP and high NAP, especially Poaceae, *P. lanceolata* and cereal-type. Four subzones are recognised as follows:

6.1. *Clearance and resumption of farming (mainly pastoral)*
   Subzone CHU I-7a: 324-303 cm; 1654-1495 B.P.; cal. A.D. 379-526

This subzone is transitional in character between CHU I-6 where there is strong evidence of regeneration and CHU I-7b in which more or less total woodland clearance is reflected. The sharp fall in *Betula* and *Corylus/Myrica* suggests that most of the tall shrub vegetation in the vicinity of the lake has been cleared while the steep rise in *P. lanceolata* and the records for cereal-type, Brassicaceae (all *Hornungia*-type) and *Fallopia convolvulus* indicate that this is taking place in the context of renewed pastoral and arable farming. The dark colour of the sediment between 300 and 318 cm suggests higher charcoal concentration though the macro- and micro-charcoal curves are not particularly high.

Whole core susceptibility values are decidedly negative but χ values are somewhat higher and the magnetic properties of sample 307 cm (near top of subzone) suggest inwash of some unweathered bedrock. The rise in *Pediastrum* and in *I. lacustris* to a lesser extent may also be in response to increased mineral input.

According to the chronology suggested above, this subzone relates to the early part of the Christian period prior perhaps to the establishment of a monastery at Church Lough.

6.2 Intensive farming, mainly arable, in a totally cleared landscape
Subzone CHU I-7b: 296-224 cm; 1440-895 B.P.; cal. A.D. 575-1079
Subzone CHU I-7c: 216-148 cm; 830-370 B.P.; cal. A.D. 1136-1557

Subzone CHU I-7b spans what was probably the period of most intensive cereal cultivation in the vicinity of Church Lough. High cereal-type representation (peak of 2.5% which is the maximum for the profile) is accompanied by a suite of weed taxa indicative of arable farming including *Artemisia*, Brassicaceae (mainly *Hornungia*-type), Chenopodiaceae, *R. acetosella*-type, *Polygonum aviculare*, *P. convolvulus*-type and *Anthoceros* (both *A. punctatus* and *A. laevis*). The peak in *Urtica* coincides with the peak in cereal-type and in this part of the diagram, at least, it may also reflect arable rather than pastoral activity. Noteworthy is the substantial *Artemisia* representation (maximum 2.8%).

This assemblage provides exceptionally strong evidence for cereal cultivation. Most of the cereal-type pollen were assignable to *Triticum*-type. It is also noteworthy that only three *Secale* pollen were counted (1.6% of the total cereal-type pollen) in CHU I-7. Given the high pollen productivity and dispersal capacity of *Secale*, it is clear that it was not widely sown in the vicinity of Church Lough and presumably on Inishbofin generally. The high Poaceae representation presumably indicate grassland rather than *Phragmites* or bog/heath. It is interesting, however, that *P. lanceolata* is not exceptionally high. Unfortunately, information on how land-use in the past influenced flowering of this species is lacking. In the macro-fossil record, *Juncus* seed are recorded consistently for the first time. These were probably components of the wet grasslands and are another indication of the open landscape now almost completely devoid of tall woody vegetation.

The main stratigraphical feature is the high charcoal levels at the base of the subzone. Macro-charcoal is also recorded at the base and there is a substantial micro-charcoal curve throughout. Fire appears to have been an important element in the farming economy. No silt/clay layers were noted but κ values are mostly positive in the interval 292-252 cm which more or less coincides with maximum arable activity as deduced from the arable indicator taxa. Substantial input of minerals is also suggested by high χ values throughout the subzone. Details magnetic measurements for samples 271 and 247 cm show increased values for all magnetic variables measured. Input of fine grained magnetite is inferred. This appears to have been especially pronounced at 271 cm (coinciding with the sharp rise in the cereal-type curve).

On the basis of the ^{14}C-based chronology, this subzone spans approximately the second part of the first millennium A.D. According to historical records St. Colman founded his monastery at this site in 665 A.D. (Neary 1920). This monastic site was of sufficient importance to warrant a record of its abbots from its foundation to A.D. 918 in the Annals of the Four Masters.

Subzone CHU I-7c is distinguished from the previous subzone by changes in the relative importance of the various NAP components in comparison to the previous subzone. Poaceae percentages are lower while *P. lanceolata* is consistently higher. Towards the top of the subzone there is increased percentage representation of *Aster*-type and Liguliflorae, and Filicales (-perine) is higher throughout than in the previous subzone. With respect to the arable indicators, the values for cereal-type, Chenopodiaceae and especially *Artemisia* are lower while Brassicaceae (mainly *Hornungia*-type) and *P. major/media* are better represented. In the upper part of the subzone, however, Brassicaceae values decline and the *R. acetosella* curve ceases.

There is little doubt but that substantial levels of arable farming activity persisted until almost the end of this subzone. However, the change in the arable weed component suggests that the nature and/or intensity of the arable activity differed from that recorded in subzone CHU I-7b. The single record of *L. usitatissimum* from 164 cm (*c.* cal. A.D. 1500 or later) suggests local cultivation of flax. Probably the acreage under cereal and fallow declined (fall in cereal-type and *Artemisia*) while communities of the class Plantaginetea majoris were more frequent. These are communities of disturbed habitats where perennial rather than annual species dominate (e.g. *P. major*; *P. media* is not native to the Irish flora; see White and Doyle 1982; Webb 1977).

Towards the top of the subzone there are a number of indicators of increased emphasis on pastoral farming. The *P. lanceolata* curve is consistently high and *Ranunculus*, Liguliflorae and *Aster*-type rise. *Aster*-type includes several genera including *Bellis*, *Bidens*, *Eupatorium*, *Filago*, *Gnaphalium*, *Pulicaria*, *Senecio*, *Solidago* and *Antennaria* (*A. dioica* grows on the lower slopes of Knock Hill beside Church Lough), which are primarily grassland species. The same is true for Liguliflorae which includes mainly grassland taxa such as *Crepis*, *Taraxacum* and *Hieracium*. The occasional records for *Centaurea nigra* and *Rhinanthus*-type (first records for both taxa in the profile) suggest that there were now meadows in the vicinity of the lake. Meadowing may also have favoured species such as *Senecio jacobea*, *S. aquaticus* and Apiaceae species.

The macrofossil record also provides some important clues as to land use at this time. *Juncus* is well represented especially in the lower part of the subzone and include *J. conglomeratus*, *J. effusus* and *J. articulatus*. These species have a relatively wide ecology but are mainly associated with damp pastures and meadows. *Sphagnum* leaves are also common (also increased representation of *Sphagnum* spores), especially *S. palustre* and *S.* sect. *Acutifolia* in the upper part of the subzone. These moss leaves may have been carried in by water from the bog/heath communities to the south of the lake. Alternatively, they may have been growing at/near the lake margin which is quite likely in the case of *S. palustre*, a species of small-sedge (Caricion Curto-nigrae) communities (*cf.* also records for *Calliergon cuspidatum*, a species of similar habitat). The records of *E. tetralix* seed show that this species was a constituent of the bog/heath vegetation which also had much *Calluna*. It is noteworthy that the Characeae oospore record ceases near the base of the subzone (at 206 cm) which may be due the influence of the acid runoff from the bog/heath vegetation in the catchment.

At the top of the subzone, the sediment is dark, presumably due to charcoal. The macro- and micro-charcoal record, however, suggests that charcoal (and therefore fire) is more frequent in the lower part of the subzone. Throughout the subzone, κ values are decidedly negative but χ values are relatively high except at the top of the zone where the arable weed taxa decline. A sample from 195 cm gave a similar magnetic profile as that from 247 cm except that 'hard' ARM is exceptionally low. Inwash of fine grained magnetite is suggested.

It is interesting that *I. lacustris* remains at extremely low values from 196 cm onwards which may reflect the increasingly organic nature of the substrate and growth of *Phragmites*, and *Sparganium* and *Typha* (*cf.* the *Sparganium erectum*-type curve; *Phragmites* not distinguished from other Poaceae) at the margins of the lake rather than absence of minerogenic inwash. *Pediastrum*, on the other hand, which also normally responds to mineral input, is best represented in this part of the profile.

6.3 *Reduction in cereal production and possible introduction of the potato as a field crop*
Subzone CHU I-7d: 140-102 cm; 355-280 B.P.; cal. A.D. 1574-1639?

In this subzone there appears to be some regeneration of woody vegetation but this may consist almost entirely of birch and willow in the vicinity of the lake (*cf.* rise in *Betula* and *Salix* curves; *Betula* wood at 147-148 and *Betula cf. pubescens* leaf at 116 cm). The substantial rise in *Calluna* (also *Sphagnum*) from less than 10% to over 26% might be interpreted as an expansion of *Calluna* onto former cultivated areas (*cf.* fall in most NAP curves including Poaceae, *P. lanceolata* and cereal-type). On the other hand, this may be the result of secondary pollen in inwashed peat, a hypothesis which is suggested by the reversal in the ^{14}C date from 117-120 cm (Table B2). The increase in pollen concentration may also be largely reflecting input of secondary pollen.

Features of the lithology include charcoal enrichment up to 131 cm and increasingly silty sediment above 131 cm, i.e. coinciding with the rise in *Calluna*. The decline in *Potamogeton* sect. *Potamogeton* and the interruption of the curves for *Nymphaea* and *Nuphar* suggests that floating aquatic vegetation was of reduced importance.

Apart from the base of the subzone where organics dominate, κ values are highly positive and χ values are also high. A sample from 115 cm gave high χ, χ_{fd}, and 'soft' reverse field ratios, and low remanence susceptibility quotients, characteristics typical of burnt material (F. Oldfield, pers. comm.). Macro-charcoal was not recorded so the material providing the magnetic signal may consist partly of ash originating perhaps in domestic fires.

The probability that inwash is affecting the pollen record complicates the interpretation. The overall evidence, however, points to some decline in cereal cultivation (note: though cereal-type declines arable weed taxa are well represented, especially Chenopodiaceae). Some regeneration of woody species may also have taken place at least around the lake.

According to the chronology as presented above, the late sixteenth/early seventeenth century is represented here. In arriving at these estimates a constant sediment accumulation rate between 159 cm and the top of the profile is assumed. If allowance is made for the unconsolidated nature of the uppermost sediment (hence faster apparent accumulation), then sediment accumulation in the lower part of this interval should be lower than the average for the interval. Taking this into account, it is suggested that the upper date for the subzone may be too old by about a century. If this is so, then the initiation of potato cultivation may be recorded here. One of the main advantages of the potato as a crop was the possibility of using poor peaty soils

(Bell 1984). Today, abandoned cultivation ridges, the traditional way in which potatoes were cultivated, run down to the lake from the lower slopes of Knock Hill (*cf.* Fig. 8.4 in O'Connell 1994). It is likely that these ridges were initially formed on a thin covering of peat. This is also the most steeply sloping ground in the vicinity of the lake so that cultivation could be expected to result in severe soil erosion (see above).

The potato is largely silent in the palynological record (Hall 1989), so that it cannot be readily detected. However, Chenopodiaceae, which includes species associated with potato crops such as *Chenopodium* and *Atriplex* species, are well represented. Noteworthy also is the greatly reduced frequency of *Juncus* seeds from the base of this zone to the top of the profile. This may reflect less rushy fields, possibly the result of increased drainage.

6.4 *Increased emphasis on arable farming*
Subzone CHU I-7e: 96 to 32 cm; 270 to 145 B.P.; cal. A.D. 1663?-1793?

In this subzone pastoral indicators, and especially Poaceae, *P. lanceolata*, Liguliflorae, Tubuliflorae (mainly *Aster*-type), *Ranunculus* and Apiaceae have increased representation. The values for the arable indicators, including cereal-type, are comparable to those in CHU I-7c. This suggests that cereal cultivation was of considerable importance and no doubt also potato growing though this is not reflected in the pollen record.

In this interval κ values are generally negative which is unexpected but χ values are relatively high. The detailed magnetic record from samples 96 and 55 cm suggest continuing soil inwash similar to that in subzones CHU I-7b and 7c.

Floating aquatics are important (*cf. Nymphaea*, *Nuphar* and *Potamogeton* sect. *Potamogeton*) and a curve for *Pediastrum duplex* is initiated. *P. duplex* is normally associated with more eutrophicated water than *P. boryanum* (Jankovská and Komárek, 1982) and its appearance at the beginning of this sub-zone may be indicative of increasing eutrophication which also favoured the floating aquatic communities.

Applying a correction of 100 years to the chronology given above (see CHU I-7d) then this subzone would correspond to the nineteenth century. Agricultural statistics for the Clifden Poor Law Union, which includes Inishbofin, indicate a strong recovery in arable farming (both cereals and potatoes) in the interval 1850-1880.

6.5. *Reduction in farming and especially in arable farming*
Subzone CHU I-7f: 24 to -60 cm; 130 to -30 B.P.; cal. A.D. 1809?-1980

In this, the uppermost part of the core, Poaceae and *P. lanceolata* representation decline somewhat (but *Centaurea nigra* and *Rhinanthus*-type fairly consistently recorded) and the arable indicators decline, especially cereal-type and *Artemisia*. *Calluna* and *Sphagnum* increase substantially and *Pedicularis* is also consistently recorded. Decline in tillage is inferred and overall grazing pressure probably also declined resulting in more profuse flowering of *Calluna*.

The twin peaks in κ values suggest varying levels of mineral input. The available χ values also suggest substantial input of detrital minerals to which *Pediastrum* (*P. boryanum* and *P. duplex*) is responding favourably.

The records for *Nymphaea*, which cease at 24 cm, and *Nuphar*, which continues to the top are interesting in that *Nymphaea* has not been recorded in the island (earliest floristic survey dates to 1875, More 1876; most recent survey is that by Brodie and Sheehy Skeffington 1990), while *Nuphar* is common in Church Lough today. The extinction of *Nuphar* at Church Lough may be relatively recent and is probably associated with infilling and lowering of watertable levels (see also L. Gowlanagower). The so-called secondary rise in *Pinus* can also often serve as a useful chronological marker in the uppermost part of Holocene profiles. Here, however, the response in the *Pinus* curve is weak though a slight rise is detectable from near the base of the present zone. Given the extreme western position of the site, the weak and probably delayed response of the *Pinus* curve is not surprising. It is concluded that the palynological evidence supports assignment of this subzone to *c.* 1880-1980.

Lough Gowlanagower, Inishbofin

Site description and sampling

Lough Gowlanagower (grid ref. L 548 665; 10°13.2'W 53°37.8'N) lies 1.4 km north of Church Lough in Cloonamore Townland at *c.* 100 m O.D. It is a long, rather narrow lake (*c.* 200 x 100 m, narrowing in the centre to *c.* 30 m) with long axis running approximately north/south. At the southern side, the bedrock (siliceous grits and granulite) rises rather steeply but not to a great height (*c.* 20 m). Elsewhere, the terrain is hummocky but rather flat. On flat terrain at the western side the most extensive development of peat occurs; this is now being actively cut. Elsewhere, the bare bedrock is largely exposed, the peat presumably having been cut over for fuel in earlier times.

Inflow/outflow is confined to a small stream that enters the lake at the north-western end. The lake is shallow, the greatest depth of water appears to be at the southern end (*c.* 1 m). According to local information, rapid infilling appears to be taking place to which the peat cutting at the western side is undoubtedly contributing. The main aquatic species is *Eriocaulon aquaticum* which forms a more or less even cover over most of the lake. Other aquatics include *Juncus bulbosus*, *Lobelia dortmanna*, *Myriophyllum alterniflorum*, *Isoetes echinospora* and *Potamogeton natans*. Two water samples collected on 10th September 1986 gave pH and conductivity readings of 7.5 and 8.7, and 198 and 215 μS cm^{-3}, respectively. The high pH readings are rather surprising given that the lake catchment carries only heath and bog.

A single core (GOW I) was taken near the southern end of the lake where the thickest sediment was expected on the basis of the overall geomorphology of the lake and its immediate catchment.

Table B3. Stratigraphic description of core GOW I from L. Gowlanagower.

Depth (cm)	Stratigraphic description	Stratigraphic details (CH: charcoal)
	Water depth: c. 100 cm	Drives: 0-100, 100-200 cm etc.
48-0	Watery sediment	
272-48	Fibrous peat-like sediment with dark bands	Dark bands c. 2 cm thick, presumably due to charcoal, centred on 215, 223, 226, 237, 242 and 251
300-272	Organic-rich lake mud with fine fibrous material.	283-287: distinct iron-rich layer; upper and lower boundaries very sharp
314-300	brown lake mud with sand	
318-314	grey lake mud but not obviously silty or sandy	
400-318	dark brown, organic-rich lake mud with fibres; much iron precipitate on outside of core	fine fibres particularly conspicuous between 342-343 and 362-363; 384-386
439-400	grey-brown lake mud with fine fibrous material	Silty layer at 406-409
439-478	lake mud with dark charcoal-rich bands and white silt layers. Iron precipitate most conspicuous in intervals with high charcoal concentration	Silt/sand most obvious at 464 (0.5 cm thick) and 467; charcoal most conspicuous at 439-45 and 463-473
500-478	grey-brown lake mud with poorly developed silt and charcoal layers	CH: 481 and 484-486
569-500	Lake mud with some fine fibrous material	sandy: 504-505 plant remains conspicuous: 513-514; fibres obvious: 535-569
586-569	clayey silt with some organic matter	higher clay content: 569-57 increase in organic content: 575-577 sandy clayey silt: 577-586

Table B4. Results of radiocarbon determinations, profile GOW I, L. Gowlanagower.

Gal. No. (GOW I)	Gr. No. (GrN-)	Depth (cm)	Age[1] (B.P.)	Expected age[2] (B.P.)	$\delta^{13}C$ (‰)
7	20026	177-179	3290±100 (R)	1600	-27.30
	20241		2670±150 (E)		-27.56
6	20025	232-237	3600±110 (R)	2000	-27.48
5	20024	288-295	3330±130 (R)	4500	-28.33
	20089		3450±110 (E)		-29.05
4	20023	332-337	8090±220 (R)	5500	-27.85
	20240		7910±230 (E)		-27.95
3	20022	363-369	8070±160 (R)	6000	-28.92
2	20021	482-489	11690±140 (R)	8600	-27.88
	20091		9830±150 (E)		-26.31
1b and	20020	529-534	10480±130 (R)	9600	-25.90
1a[3]	20242	537-542	10250±150 (E)		-26.31

[1] R: residue; E: extract;
[2] Expected age provided when submitting samples to ^{14}C laboratory; in the mid and upper pa of profile, the non-standard pollen stratigraphy made estimation of age extremely difficult;
[3] Samples 1a and 1b were combined to give sufficient material for dating; 535.5 cm, i.e. the n point, was taken when contructing time/depth relationships (Fig. xx).

Results of palaeoecological investigations

Stratigraphic descriptions and whole-core magnetic susceptibility

The main stratigraphic features of core GOW I are summarised in Table B3. The base of the core (586-569 cm) is mineral-rich and gave the highest κ values and low loss-on-ignition values. Well developed bands of dark charcoal-rich sediment and light coloured silt layers are most frequent between 478 and 439 cm. Consistently positive κ values were recorded between 492 and 422 cm. Grey coloured lake mud was recorded between 300-314 cm but silt/clay enrichment was not obvious. In this part of the core, loss-on-ignition is particularly low and κ values form a pronounced peak. In the interval 314-300 cm sand particles were recorded in the brown sediment. From 272 cm to 48 cm, the sediment was fibrous and peat-like. Here κ values are consistently negative and loss-on-ignition very high and approach values usually associated with ombrogenous peat (*c.* 90%).

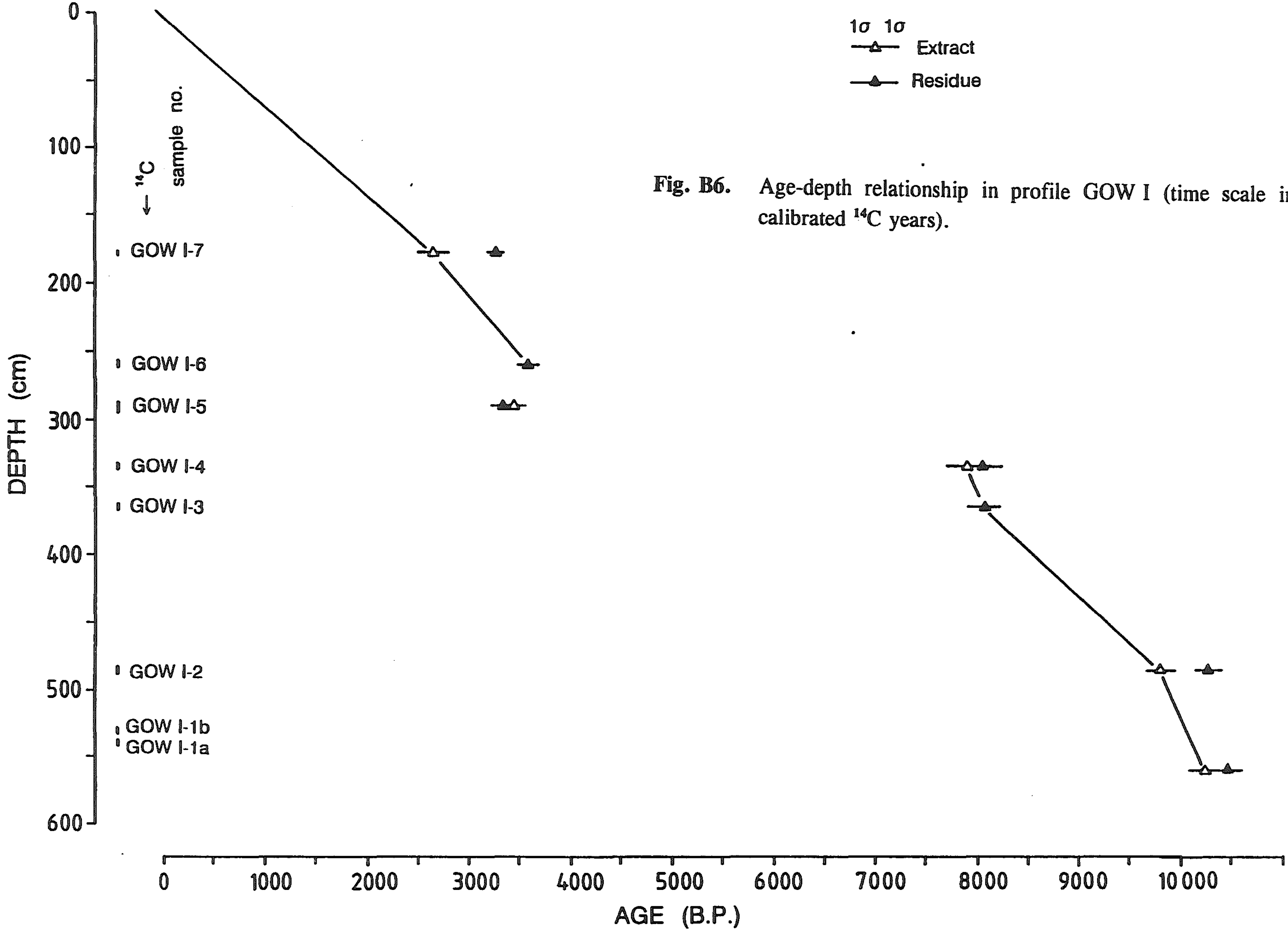


Fig. B6. Age-depth relationship in profile GOW I (time scale in non-calibrated ^{14}C years).

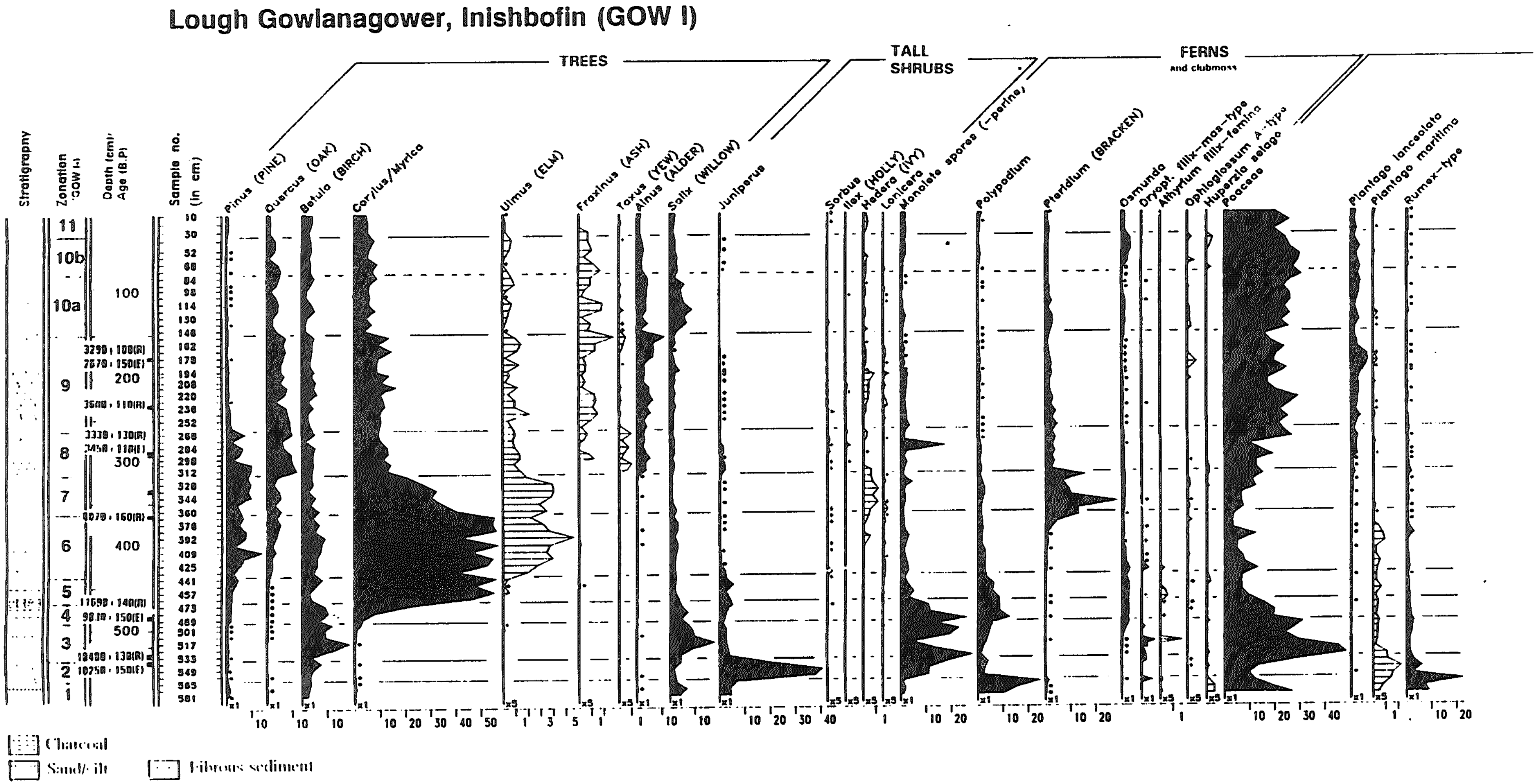


Fig. B7. Percentage pollen diagram from L. Gowlanagower (GOW I) (1 of 3 parts).

Lough Gowlanagower, Inishbofin (GOW I)

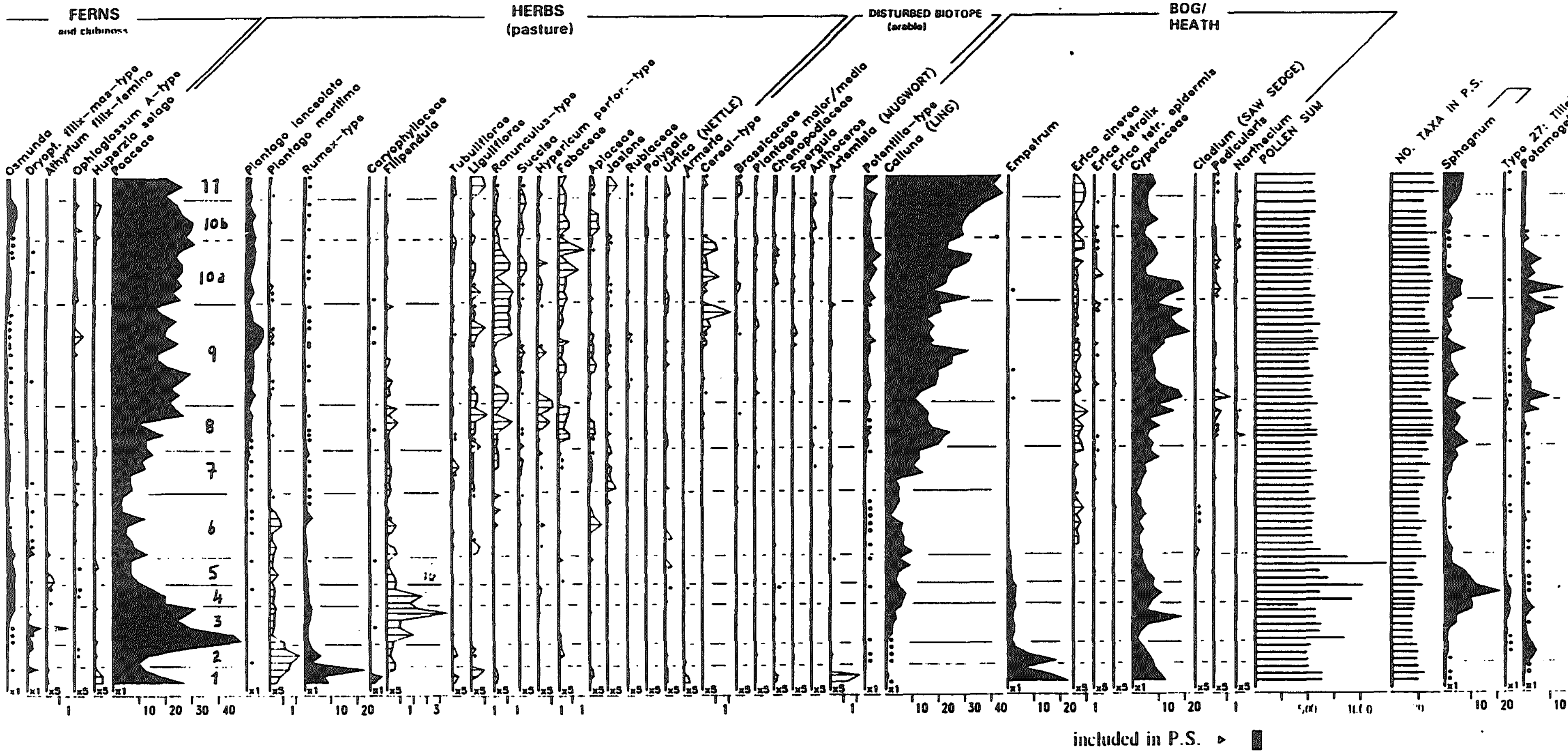


Fig. B7. Percentage pollen diagram from L. Gowlanagower (GOW I) (2 of 3 parts).

Lough Gowlanagower, Inishbofin (GOW I)

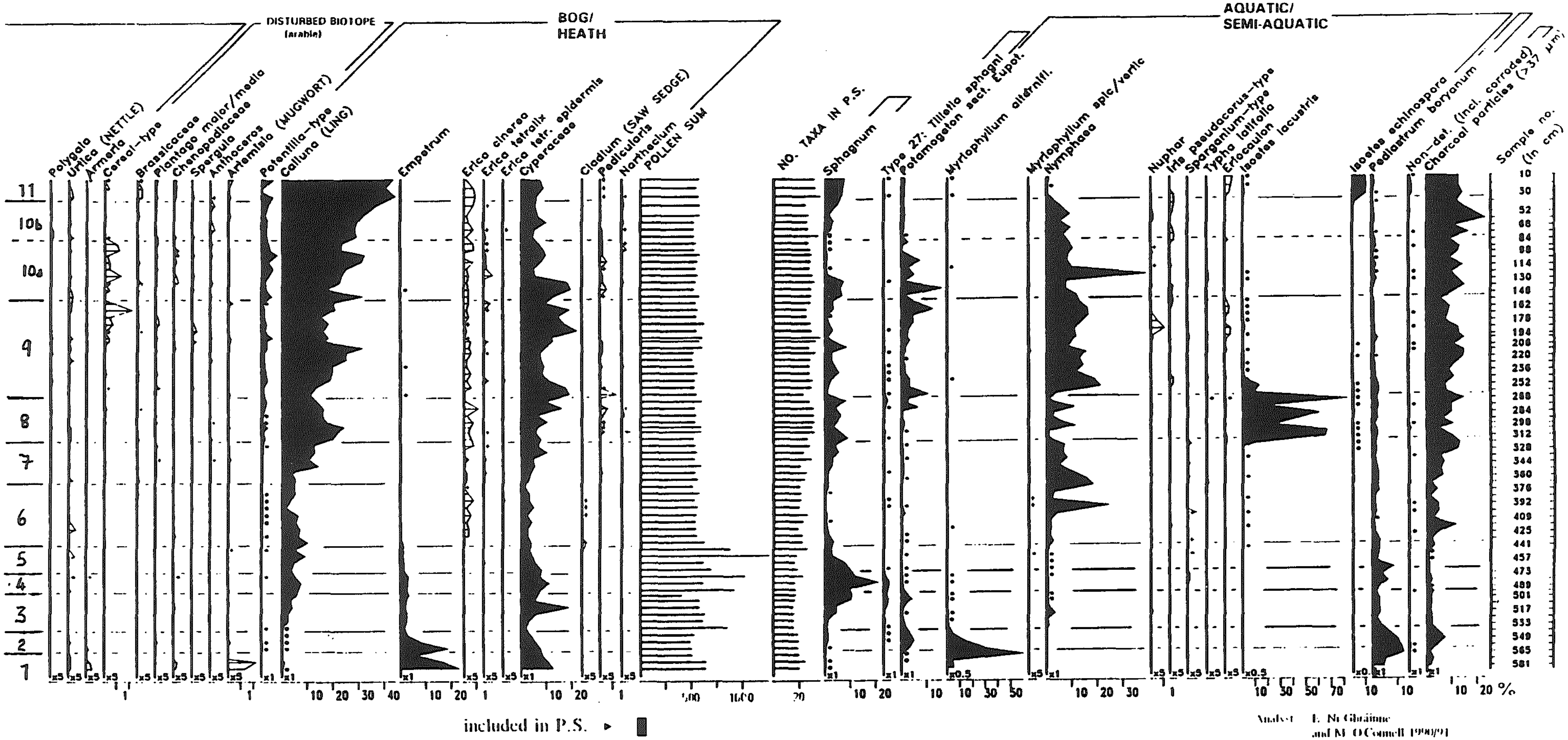


Fig. B7. Percentage pollen diagram from L. Gowlanagower (GOW I) (3 of 3 parts).

Radiocarbon determinations and pollen stratigraphy

Samples were given an acid/alkali/acid (AAA) treatment in the ^{14}C laboratory and the alkali soluble fraction, i.e. the humic acids referred to here as extract, and the residue, i.e. humin, were separately dated in five out of the seven samples submitted (see Table B4). In four samples the humin gave an older date than the extract but it is only in sample GOW I-2 that the difference is substantial (the humin is older by 1860 years). As is usually the case where the ages of the fractions deviate, the extract probably provides the more acceptable date (but *cf.* Walker and Harkness 1990). Taking the pollen analytical results also into account, the following points regarding chronology may be made:

1. The base of the profile, which on pollen analytical criteria opens at the late-glacial/Holocene transition, may date to earlier than 10 250 B.P.

2. At 481 cm *Corylus/Myrica* is at 7% and sample GOW I-2 (489-482 cm) gave a date of 9830±150 B.P. Like the preceding date, this is somewhat older than expected; clearly the humin fraction, which gave a date of 11 690±140 B.P., is unacceptable.

3. The two dates 8070±160, and 7910±230 (E) and 8090±220 (R), probably give a correct indication of age within the limits of the ^{14}C method. It follows that the sediment accumulation time in the lower part of the profile is at *c.* 10 y cm^{-1}, i.e. almost ten times faster than in the case of the corresponding part of CHU I.

4. Between pollen zones GOW I-7 and 8 there must be a hiatus. Indications of severe mineral inwash from the catchment include change in lithology (grey lake mud between 314-318 cm), high positive κ values between 316 and 300 cm, and expansion of the *I. lacustris* curve (≥10% between 320 and 268 cm). There is also an abrupt change in several other curves including *Alnus*, *Taxus* and *Quercus*.

5. At the top of GOW I-7 (beginning at 170 cm) there is an indication of tall shrub regeneration (*cf.* rise in *Corylus/Myrica* and *Alnus* from the previous spectrum) and decline in *P. lanceolata*) followed by severe reduction in AP at the beginning of PAZ GOW I-8. The lull in farming and the consequent regeneration of tall shrub followed by renewed farming activity, as seen in the CHU I profile, may be reflected here. If this is so, then the age as suggested by the ^{14}C dates (GOW I-6 and 7; Fig. B7) is too old.

6. The low AP representation, especially *Pinus* and *Quercus*, the decline in *Nymphaea* and the expansion in *I. echinospora* suggest that recent period (last 100 years or so) is represented. There is possibly a break in sedimentation at the GOW I-10b/11 boundary.

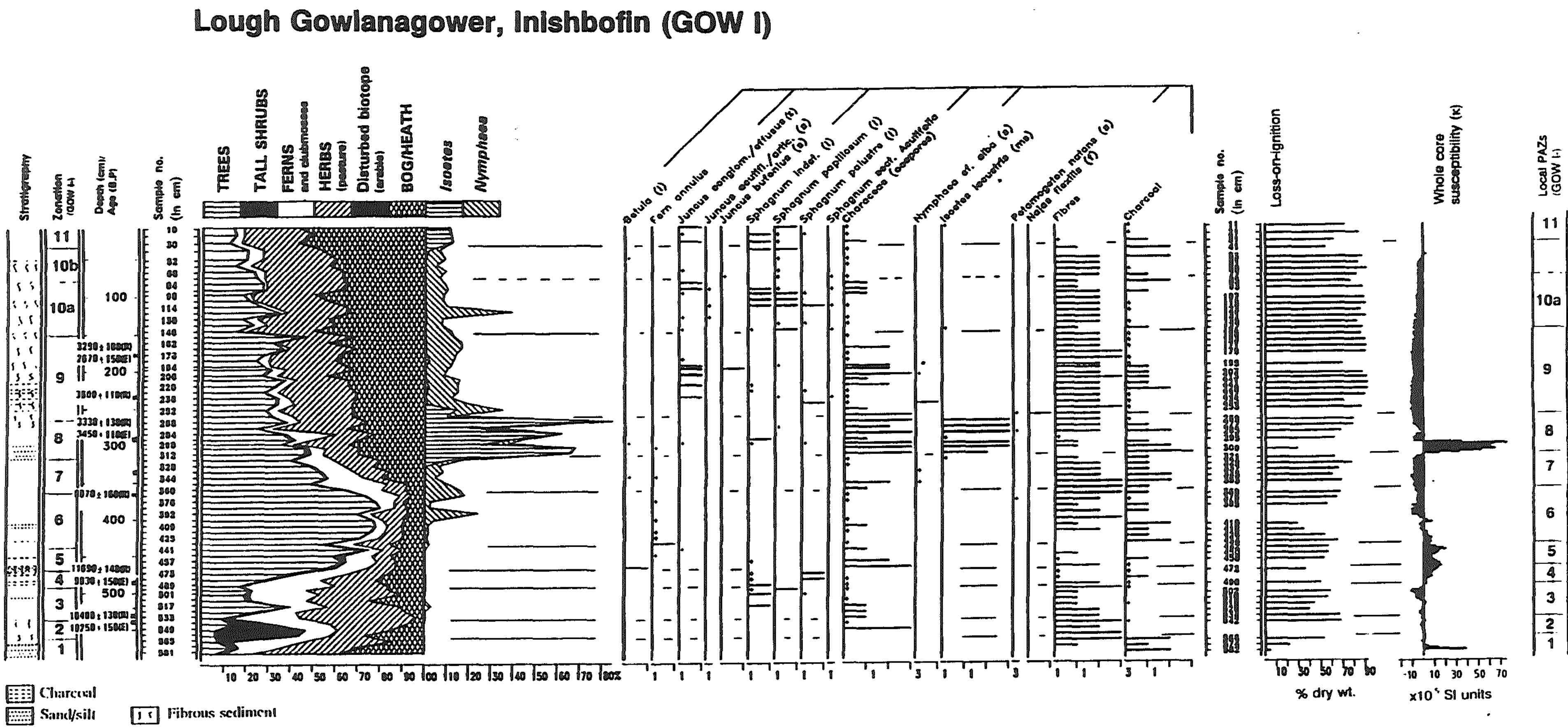


Fig. B8. Profile GOW I, L. Gowlanagower. Composite percentage pollen curves, macrofossils recorded in the coarse fraction (> 100 μm) from the pollen samples, loss-on-ignition values and whole core susceptibility (κ). The horizontal scale (macrofossils) is as follows: +, rare; 1, occasional; 2, frequent; 3, abundant. (l), leaves; (ms) *I. lacustris* macrospores; (s), seed/fruit.

Pollen analytical and macrofossil analyses, profile GOW I

The pollen and macrofossil data are presented in Figs. B7 and B8, respectively. *Myrica* forms a considerable proportion (20% or more) of the taxon *Corylus/Myrica* in much of the profile, even in the lower part. Unlike in the profile CHU I from Church Lough, the assumption that the *Corylus/Myrica* curve is primarily reflecting the abundance of hazel should not be made. *Isoetes* microspores are separated on the basis of size, the larger microspores (>30 μm) being assigned to *I. lacustris* and the smaller to *I. echinospora*. Where there are particularly high values of one taxon, there are invariably consistent but low records for the other taxon. Birks (1973) has shown that there is an overlap in the sizes of the microspores of these two species. Rather than indicating the presence of both species, the minor records may be more appropriately interpreted as spores that lie outside the size range of the majority of microspores of the dominant taxon (as in CHU I).

In the macrofossil record, no attempt was made to separate *Juncus conglomeratus* and *J. effusus*, or *J. acutiflorus* and *J. articulatus*. *Betula* leaves are most likely referable to *B. pubescens*.

Post-glacial environmental reconstruction at L. Gowlanagower

1. Succession in the early post-glacial
GOW I-1, 2, 3 and 4: 581-473 cm

The PAZs at the base of this profile are characterised by a considerable movement of the curves of several shrub and NAP, including aquatic, taxa. The main features are as follows:

GOW I-1: 581-565 cm

Empetrum, *Rumex*-type, *Polypodium*, and Poaceae are the main taxa. In the uppermost spectrum, *Myriophyllum alterniflorum* expands to reach 60% and *Pediastrum* also rises. Two loss-on-ignition values are available which show a rise from 21% (574 cm) to 53% (566 cm) and κ values decline (note: the lowermost highly minerogenic sediment where loss-on-ignition was 4% and κ values exceeded 200 SI units are omitted, Fig. B8).

Herbs, especially grasses, *Rumex* species (probably also includes *Oxyria digyna*) and *Cerastium*, are important, the main shrubby species is *Empetrum nigrum*, and at the end of the zone the aquatic species *M. alterniflorum* and the alga *Pediastrum* expand. The expansion of aquatics is normally one of the first indicators of the rise in temperature at the beginning of the post-glacial. Given the highly minerogenic nature of the sediment and hence the possibility of re-worked pollen (*cf.* high *Polypodium* representation) and the large sampling interval (8 cm), caution should be exercised in interpreting the significance of fluctuations within this zone in terms of vegetation and climate change.

GOW I-2: 557-541 cm

The main feature in this zone is the high *Juniperus* representation (20-41%). The minerogenic component in the sediment is no longer conspicuous (LOI greater than 65% and low κ values). This suggests that temperatures have risen sufficiently to enable soils to stabilise. The strong expansion of *Juniperus*, which follows a much less pronounced rise in *Empetrum*, may be interpreted as indicative of rising temperatures and soil stabilisation and maturation. Such changes are also suggested by the decline in *Rumex* and the poor representation (usually only single pollen) of taxa such as *Artemisia* and Chenopodiaceae. In the aquatic environment, *M. alterniflorum* is still important (percentage curve declines but concentration values are high) and broad-leaved *Potamogeton* and Characeae species assume some importance. *Littorella* is also well represented. These changes and the fibrous nature of the sediment suggest that the lake level may have been rather low.

GOW I-3: 533-495 cm

This zone is characterised by high Poaceae, ferns (including *Osmunda*), *Salix* and *Betula*, and consistently low *Juniperus* (≤4.1%) and *Empetrum* ≤3.5%) representation. There is an expansion of bog/heath taxa, including *Sphagnum*, *Calluna* and Cyperaceae.

In the lithology, plant fragments were conspicuous at 514-513 cm and a sandy layer was noted at 505-504 cm. LOI values are somewhat lower than earlier and κ values are positive in samples from 522 to 516 cm. There seems to be no overall pattern in these observations.

The usual early post-glacial succession involving juniper being replaced by tree birches has not occurred here. Instead, juniper is largely replaced by grass-dominated communities, which included *Filipendula*. This gradually gave way partially to bog/heath. Rather surprisingly, *Empetrum* played only a minor role in the latter vegetation type. Tall shrub vegetation appears not to have achieved any importance, the minor expansions of the *Salix* and *Betula* curves may well be the result of expansion of low shrubs (e.g. *S. herbacea* and *B. nana*) which usually are rather poorly represented in the pollen record. In the aquatic environment, *M. alterniflorum* is no longer important but *Nymphaea* becomes established in the lake. In the upper part of the zone, Characeae decline in importance which may be connected with the establishment of bog/heath in the catchment and inwash of acidic organic matter into the lake (*cf. Sphagnum* leaves in the macrofossil record).

GOW I-4: 489-473 cm

In this PAZ *Corylus/Myrica* increases from 2.5 to 22.8% and achieves 46.7% at the base of GOW I-5. *Pinus*, which was mostly less than 0.5% now exceeds 1.6%, *Quercus* is consistently present (<0.5%) but *Ulmus* is unrecorded. NAP, and especially Poaceae, decline.

The local expansion of hazel is recorded here (*Myrica* is also probably present but the available observations suggest that *Corylus* is the major contributor to the *Corylus/Myrica* curve at this point). In evaluating this expansion, the possibility that sediment accumulation rate is high in this part of the profile should be borne in mind (*c.* 0.1 mm y^{-1}; Fig. B6). *Pinus* and perhaps *Quercus* have also arrived but fail to expand. The absence of records for *Ulmus* suggests that its arrival was delayed until hazel had achieved full expansion (GOW I-5). Bog/heath continues to be important (*cf.* high percentage and concentration values for *Sphagnum*; also *Sphagnum* leaves).

The lithology suggests that mineral erosion is still occurring. This is supported by positive κ values and low LOI (35.8% at 472 cm). The presence of *Sphagnum* leaves and the difference in the age of the humin versus the residue fractions in the

^{14}C date GOW I-2 (this and also ^{14}C date GOW I-1 are older than expected; see above) also suggests that inwash of old organic matter is taking place at this time.

2. *Early post-glacial woodlands*
GOW I-5, 6 and 7: 465-320 cm

GOW I-5: 465-441 cm

In zone GOW I-5, *Corylus/Myrica* achieves its highest representation (both percentage and concentration), *Pinus* increases to 4.7% at the end of the zone, and *Quercus* and *Ulmus* are poorly represented (*Quercus* <1%; *Ulmus* <0.5%).

Hazel now constitutes the main component of the vegetation. The pine population has also expanded (*cf.* concentration diagram) but *Quercus* remains a minor element and *Ulmus* may be present. Tree and tall shrub vegetation has not, however, completely replaced herbaceous and low shrub communities. The pollen evidence indicates that *Juniperus*, *Empetrum* and also grass and sedge-dominated communities, including bog/heath vegetation, persisted throughout this zone.

In the lithology, dark charcoal-rich bands (but little micro-charcoal recorded) and white silt layers suggest that fires and soil inwash continued to play an important role. LOI values have increased (52.6-56.3%) but increase in ferrimagnetics is suggested by the rather high positive κ values especially towards the top of the zone.

GOW I-6: 433-368 cm

In this zone, *Corylus/Myrica* representation remains as in the previous zone, i.e. normally in excess of 50%, and the curves for *Pinus*, *Quercus* and *Ulmus* rise by a few percent. Overall NAP representation falls but NAP diversity increases and includes taxa such as *P. lanceolata* (also *P. maritima*).

Tall canopy trees now appear to be well established in the vicinity of L. Gowlanagower but they probably played a relatively minor role. Apart from the increased diversity of NAP, there is physical evidence for soil instability in the catchment. The grey-brown colour below 400 cm probably reflects higher silt content (also low LOI values; 34 and 28% in samples 418 and 410 cm, respectively) though κ values remain low.

In subzone GOW I-6b (392-369 cm), the *Pteridium* curve rises steeply which suggests an opening-up of the woodland cover (note: fern annuli recorded mainly in subzone GOW I-6a). Prior to the rise in *Pteridium*, pollen concentration declines (417 cm). This is probably connected with the changes in the sedimentation regime rather than input of pollen. The rise in the *Nymphaea* curve in subzone GOW I-6b is probably connected with a change in the aquatic environment.

GOW I-7: 360-320 cm

In this zone, *Corylus/Myrica* declines from greater than 55% (top of previous zone) to 21%. Apart from *Pinus* which shows increased representation, other AP curves remain more or less constant (both percentage and concentration values). *Pteridium* achieves a peak of 28.5% near the base of the zone and there is the steady increase Poaceae, Cyperaceae and *Sphagnum* curves.

The lithology is rather uniform in this interval, LOI values are high (59-77%) and κ values are decidedly negative. This suggests that the mineral soils in the catchment remained rather stable during this interval. The rise in *I. lacustris* at the top of the zone (320 cm) suggests an increase in mineral inwash (see GOW I-8). The first record for *Eriocaulon* is also recorded at this level and *Nymphaea* falls to low values. Since *Eriocaulon* is severely underrepresented in the pollen record (unpublished data), presence in the lake from this time onwards, though possibly with interruptions (only one record in GOW I-9 and 10a), is postulated.

According to the ^{14}C dates, the base of the zone dates to *c.* 8000 B.P. The curve for *Alnus* begins only at the uppermost spectrum (0.2%). Though *Alnus* is not a reliable guide to age, the lack of an *Alnus* curve does support the ^{14}C-based chronology. On the basis of the *P. lanceolata* curve a younger age might be argued. However, *P. lanceolata* is commonly recorded, normally only as single pollen (as here) in pre-Elm Decline levels, in several profiles from Connemara. Hence, reliance cannot be placed on this observation, especially since the vegetation was rather open in this and in the previous zone (see above).

In view of the early date, Neolithic farming can be ruled out. In the absence of archaeological evidence for a Mesolithic presence, disturbance by hunter/gatherers is also unlikely, though it should be noted that both micro-and macro-charcoal are well represented. This leaves the possibility that soil deterioration and/or climate change may have played a role in the decline in woody vegetation. On the available evidence, further deductions as to the processes involved are not warranted.

3. Perturbations in the terrestrial and aquatic environments GOW I-8: 312-268 cm

In this zone changes in the AP representation include a decline in *Pinus*, continuing low *Corylus/Myrica* percentages, a sharp increase in *Quercus* and the initiation of slender curves for *Alnus*, *Taxus* and *Fraxinus*. NAP continue to increase, especially Poaceae and Cyperaceae but the most dramatic increase is in *I. lacustris* microspores and megaspores.

In the lithology, there is a colour change from brown to grey in the interval 318-314 cm (no pollen data from these levels) and above this (to 300 cm) sand was conspicuous. LOI values are low in samples 309 and 302 cm (<31%) but then increase to reach 79% at the top of the zone. Corresponding changes can be seen in the κ curve (from highly positive to negative) which supports the idea of substantial inwash of inorganic soils. Above *c.* 300 cm, mineral inwash was greatly reduced.

On the basis of the ^{14}C dates and also the pollen stratigraphy (see above) a hiatus is postulated between GOW I-7 and 8. It appears that shortly after 8000 B.P., sediment accumulation ceased or perhaps more likely sediment deposited in the interval *c.* 8000 to 4000 B.P. has been reworked. The latter date is based on the presence of *Taxus* (≤1%) which expands in Church Lough at *c.* 4200 B.P. *Pinus* probably survives in the locality until the top of the zone. The CHU I profile suggests that *Pinus* was rare in the vicinity of Church Lough from ca. 3900 B.P. onwards (see also Cloonamore below).

The factors that brought about the disruption in the sedimentation regime cannot be reconstructed with confidence. Since it appears to predate the beginning of the Neolithic (*c.* mid fourth millennium B.P.), human activity can probably be excluded. On the other hand, it is clear that during the period represented by the zone under consideration, farming was important (*cf. P. lanceolata* in range 0.3 to 2.9% and also the occasional cereal-type pollen).

3. *Vegetation and land-use changes from later prehistory to modern times GOW I-9, 10 and 11: 260-10 cm*

In view of the evidence for incorporation of old organic matter (*cf.* reversal in the age of sample GOW I-6 and the large discrepancy between ages of the humin and residue extracts of sample GOW I-7), considerable caution is required in the interpretation of the pollen and other data from the upper part of the profile. Open grassland (*cf.* Poaceae and *P. lanceolata*) and bog/heath communities, which were already widespread from the beginning of GOW I-8, continue to expand. Pine is probably extinct locally from shortly after the opening of GOW I-9 but some oak and perhaps alder survives.

Features that might correspond to the late Iron Age lull and the subsequent rise in indicators of pastoral and arable farming are not readily identifiable. Changes at GOW I-9/10 boundary (*cf. P. lanceolata* and also the AP curves) may represent this period. Since bog/heath was the main component in the landscape about L. Gowlanagower, the profile can only be reflecting changes that are occurring at a distance. Changes at a distance are normally only weakly, if at all, expressed in pollen diagrams.

Of considerable interest is the record of changes in the aquatic environment. For most of this long period, there is a substantial *Nymphaea* curve which suggests that the white water lily was, together with broad leaved *Potamogeton* species, the dominant aquatic species. At the top of the profile (assumed to date to the present century) the *Nymphaea* curve drops to less than 1% and *I. echinospora* rises sharply while *I. lacustris* is at less than 1.7%. Neither *Nymphaea* or *I. lacustris* have been recorded growing on the island (Brodie and Sheehy Skeffington 1990; Webb and Hodgson 1968) though from the data presented here both were common at various times in the past. The *I. lacustris* records probably represent large *I. echinospora* microspores while the *Nymphaea* records may be due to re-working of older sediment which can be expected to contain much *Nymphaea* pollen.

Cloonamore, Inishbofin

Radiocarbon dating of pine stumps and pollen analytical investigation of associated peat

In partly cutaway peat within the wide basin that straddles Cloonamore and Middlequarter Townlands (grid ref. L 541 663; 10°13'W 53°38'N; for ease of description the area is referred to as Cloonamore) several pine stumps have been exposed or partially exposed by peat cutters. Preliminary stratigraphical and pollen analytical investigations were carried out in two sites, referred to as CLM I and CLM II (Fig. B1).

At site CLM I, a pine stump lay on *c.* 1 m of peat (with much *Phragmites* remains). Samples were taken from the peat at 10, 20 and 30 cm below the main body of the pine stump. Site CLM II lies *c.* 250 m north-north-west of CLM I, in a partly cutover peat mass where, at the time of the initial investigations (1987/88), several pine stumps lay exposed on or near the cutover peat surface. Samples were taken at a point CLM IId which lay *c.* 1 m from a peat face where a large pine stump was exposed (the stump was at 30 to 80 cm below the cutover peat surface). Pollen analysis was carried out on samples from 30, 40, 50, 60 70 cm, and 285 cm (deepest peat at sampling point).

Table B5. Results of radiocarbon determinations of pine wood from Cloonamore.

Gal. no./ ^{14}C lab. no.	Details of sample	Age B.P.	Age[1] (cal. B.C.)	Age[2] (cal. B.C.)
CL-2 GrN-20711	Approx. 13 rings taken from near the centre of a large stump; at least 40 rings to outside.	4140±25	2866-2612	2739
CL-1 GrN-20710	Twelve rings, each c. 5 mm wide, from near centre of stump. 30$^+$ wide rings followed by 1$^+$ cm with 10$^+$ narrow rings were noted; partly rotten so it was not possible to determine the total number of rings.	4150±25	2866-2624	2745

[1]Age range (1σ) in calibrated years; [2]Mid-point of 1σ age range

The pollen analytical results from CLM I (see Ní Ghráinne 1993 for details) show low *Pinus*, *Alnus* and *Taxus*, no *Ulmus* and *P. lanceolata* in the three samples (>6% in bottom sample; total terrestrial pollen sum, bog taxa excluded). This suggests that the pine stumps post-dates the Elm Decline. At CLM II, *Alnus* is absent in the lowermost sample which suggests that peat (not blanket bog peat) accumulation predates the expansion of *Alnus*. In the remaining samples, *Alnus* and *P. lanceolata* are in the ranges 4.4-11% and 1.8-8.9%, respectively. *Alnus* is normally over-represented in pollen diagrams but this representation is sufficiently high as to leave no doubt as to the local presence of alder. The high *P. lanceolata* representation serves to confirm a post-Elm Decline date. *Pinus* values in samples 70, 60, 50, 40 and 30 cm are at 11.8, 9.6, 22.3, 1 and 0.3%, respectively. The peak at 50 cm presumably reflects the local growth of pine on peat which was followed by extinction of the tree at least in the general vicinity of the sampling site.

In 1994, samples were submitted for ^{14}C from two pine stumps that lay close to CLM II. These samples, referred to as Cl1 and Cl2, were from stumps that lay *c.* 12 m apart. Details of the samples submitted and the results obtained are given in Table B5. The results that trees in question were growing at about 4150 B.P. and died at *c.* 4100 B.P. The evidence from the pollen analysis at CLM I and CLM II and also the lake profiles indicate that *Pinus* was unimportant from *c.* 4000 B.P. onwards. It probably became extinct on the island at that time but may have survived into the beginning of the next millennium (Fig. B3).

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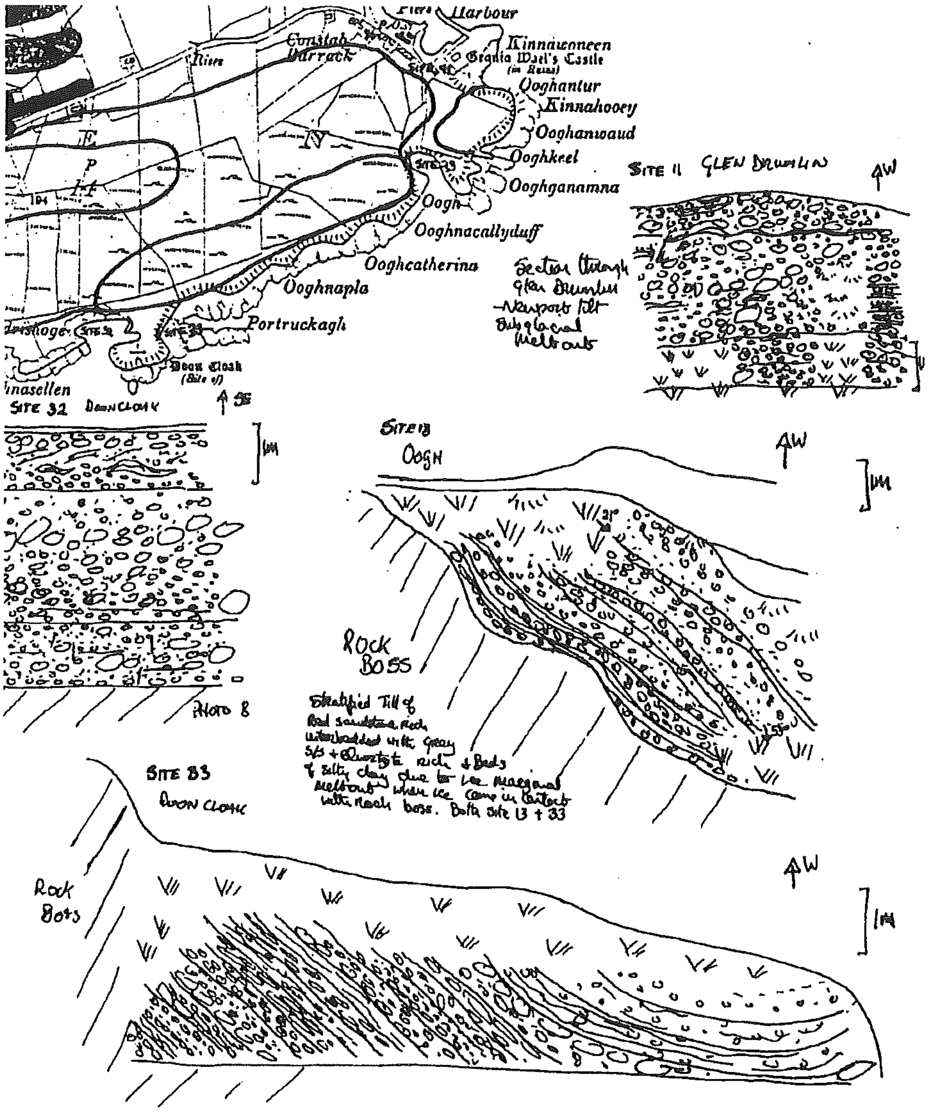
Software

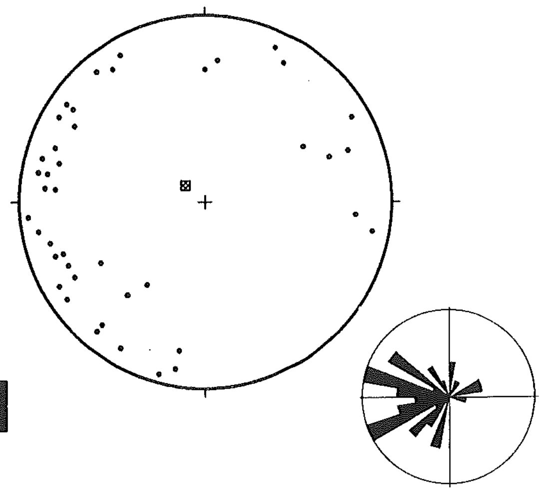
PC would like to acknowledge the use of the following program for the production of figures 9, 10 and 11:

Allmendinger,R.W. (1988-1992) *Stereonet Version 4.5. A plotting program for orientation data for the Macintosh™ Plus and II computers.*



Detail from Browne's (1991) Quaternary map

4.1.3. Bayview Hotel
n=45, trend and plunge = 271.1°, 32.6°
length (max-1) =.5318
value too low to calculate concentration
factor and confidence



IQUA

Clare Island Inishbofin

Field Guide No. 17