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REPORT ON SOIL STUDY TOUR THROUGH IRELAND

1973

lh BODEMKUNDE EN GEOLOGIE

REPORT ON SOIL STUDY TOUR THROUGH IRELAND.

by students of the Agricultural University,

Wageningen, the Netherlands,

from 25 June - 5 July 1973.

Department of SOIL SCIENCE
and GEOLOGY

Composed by Th.Edelman,
with contributions of
the participants.

I. Preface.

The pedological excursion abroad for students in Soil Science brought us to Ireland in 1973. This very interesting study tour was organized by the Director and staff members of the National Soil Survey of Ireland.
The trip from the Netherlands to the Irish republic and vice versa was made by ferry to Harwich, by train to Holyhead, and again by ferry to Dūn Laoghaire, close to Dublin. At this place we were picked up by a rented coach and delivered again after 9 exciting days.
Looking back to this excursion we have to say first of all that we had a beautiful introduction in the geology, the geomorphology and especially in the soils of Ireland including their possibilities for agriculture and forestry. We got acquainted with the special difficulties of some soils in relation to the very wet climate and the way in which the difficulties are being overcome. For this purpose we visited several research stations on soil and land improvement for different agricultural purposes, and some cattle and sheep experimental stations where a.o. new breeds and farming practices adapted to the very special weather and soil conditions of this country are developed. The visits to the extensive lowland peats of central Ireland as well as to the blanket peat areas on the west coast, the crossing of the drumlin landscapes with their particular soils, the man-made soils of the pittoresque West coast and the soils with ironpans of many different shapes were highlights of the excursion. Besides we were impressed by the high potential grass and forest production of the majority of Irish soils. The different excursion leaders showed us sites on historical significance and told us much about the splendid early history of the country, as well as about the misery of the 19th century culminating in the Great Famine. In this respect nobody of us will forget the visit to the abandoned village on Achill Island.
In the first place we like to thank Mr. M.J. Gardiner, Head of the National Soil Survey, and Mr. E. Culleton of An Foras Talūntais, who did their utmost to organize this nice trip. Besides them we are greatly indebted to the coworkers of the Soil Survey of Ireland: Mr. P.J. Burke, Mr. T. Finch, Mr. B. Hammond, Mr. J. Kiely and Mr. M. Walsh for their excellent guidance on the different parts of the trip. We also thank the heads of the visited research stations and their coworkers, for their explanations. The participation of Mr. J. Stolp of the Dutch Soil Survey Institute and of Mr.L. Stroosnijder of the Laboratory of Soils and Fertilizers, who supported the

discussions considerably, was very much appreciated. A special word of thanks has to be passed to our Irish busdriver Charley, who guided us, sometimes with some difficulties, to many hardly accesible places. As a result of a wide range of interests of the participants attention was given to other subjects than soils too, e.g. forestry, vegetation, hydrology, and not forgetting Guinness and folk songs. Due to this and the opportunities to meet Irish people at night the atmosphere during the excursion was excellent and we thank everybody for his contribution to this. Mr. Th. Edelman composed this report in English, which we appreciate very much.

It is a great satisfaction for us that the sequence of successful excursions abroad could be continued in 1973.

Prof.Dr. L.J. Pons,

Ir. H. Rogaar.

II. List of participants.

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III. Introduction.

This report gives an account of a Soils Study Tour of Ireland, emanating from the Agricultural University in Wageningen, the Netherlands.
The first part of this report deals with general information confined to Irish circumstances and sometimes even to the Study Tour. It is based mainly on literature study and forms the requisite background for the second part of this report. In this part a description of the Study Tour is given in chronological sequence.

IV. Acknowledgements.

I wish to express my thanks to Prof.Dr.Ir. L.J. Pons and Ir. H. Rogaar for suggestions and critical remarks on the concept-report,to Mrs. R. Viezee for correcting the text, and to all students who made a contribution in reporting parts of the Study Tour.

Theo Edelman.

PART I

1. CLIMATE.

Ireland has a typical west maritime climate with relatively mild, moist winters and cool, cloudy summers. For the greater part of the year, warm maritime air, associated with the Gulf Stream, helps to moderate the climate (10).

1.1. Rainfall, evaporation and humidity.

The mean annual rainfall is 1016 mm;by general consent this is considered excessive. Rainfall is varying from 750 mm in lowlying areas to 2500 mm or more in various uplands (16). See fig.'s 1 and 21.

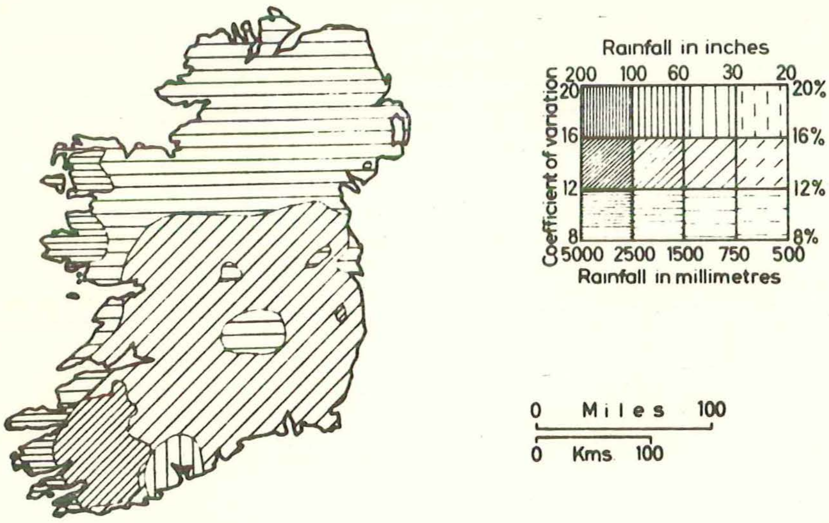


Fig. 1: Mean annual rainfall and its coefficient of variation, 1901-1930 (30).

In table 1 figures concerning mean precipitation have been listed. Maxima and minima have been underlined.

	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1 Birr	80.5	53.5	53.0	52.8	64.2	68.0	92.7	81.7	93.7	84.1	73.7	111.4	909.3
2 Claremorris	111.9	78.2	77.5	56.4	68.5	84.7	87.0	96.8	113.4	111.4	100.9	140.5	1127.2
3 Clones	83.3	64.2	53.5	41.6	58.1	77.2	95.1	99.6	84.1	88.2	81.3	109.9	936.1
4 Dublin	60.1	48.9	49.4	33.9	63.8	62.1	70.8	89.2	73.7	75.3	73.3	87.5	788.0
5 Malin Head	112.8	89.0	55.6	51.8	55.2	87.8	94.0	78.0	96.2	92.8	74.3	140.5	1028.0
6 Midleton	89.0	63.6	65.2	60.0	84.2	71.4	40.8	81.2	95.8	104.6	109.2	116.0	981.0
7 Mullingar	87.1	53.6	58.5	47.2	60.1	69.8	88.4	85.6	91.4	98.6	83.4	114.1	937.8
8 Roches Point	101.0	62.2	124.4	29.8	75.0	62.2	93.0	77.8	134.2	87.6	80.0	132.8	1060.0
9 Shannon	89.6	56.7	60.4	48.6	62.0	61.3	73.5	81.5	97.9	83.4	82.8	126.8	924.5
10 Valentia	152.6	109.6	122.7	72.6	84.6	73.5	99.7	93.6	131.4	143.3	143.6	178.6	1405.8

Table 1. Mean precipitation (mm). (29).

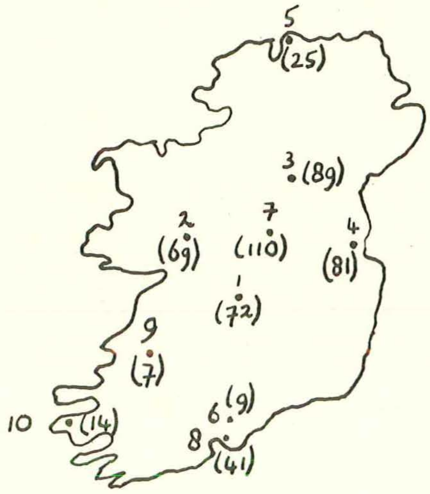


Fig. 2. Location and elevation of meteorological stations. The numbers correspond with those in table 1. Between brackets: the height above mean sea level (m).

The average calculated annual potential evaporation ranges from 420 mm in the north to 520 in the south (26). The ratio rainfall-evaporation is balanced well in favour of rainfall. The average maximum precipitation deficits were calculated on 25 to 50 mm in the south to 0 to 25 mm in the rest of the country (16).
Throughout the year the relative humidity is high, it ranges from 70 to 90% (9, 10, 14, 18).

1.2. Temperature

For figures concerning mean temperature see table 2. Maxima and minima have been underlined.

	Jan.	Febr.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1 Birr	4.2	4.2	6.8	8.6	11.2	13.7	15.2	15.0	13.5	10.4	7.0	5.7	9.6
2 Claremorris	3.8	4.2	6.3	8.0	10.8	12.9	14.4	14.1	12.4	9.8	6.8	5.5	9.1
3 Clones	3.4	3.8	5.9	7.8	10.8	13.0	14.4	14.1	12.4	9.6	6.5	5.0	8.9
4 Dublin	4.4	4.3	6.3	8.1	10.8	13.4	15.1	14.7	13.0	10.4	7.4	6.1	9.5
5 Malin Head	5.3	5.3	7.1	8.2	10.4	12.9	14.2	14.4	13.4	11.0	8.2	6.4	9.7
6 Midleton	4.9	4.6	6.1	8.3	10.9	13.4	15.6	15.2	12.8	10.3	7.6	6.9	9.7
7 Mullingar	3.7	4.0	6.2	8.1	11.1	13.4	14.9	14.5	12.7	9.9	6.6	5.2	9.2
8 Roches Point	6.4	6.3	8.2	9.3	11.8	14.1	15.2	15.1	14.2	11.8	8.8	7.5	10.7
9 Shannon	4.7	4.7	7.1	8.9	11.7	14.0	15.5	15.3	13.6	10.8	7.6	6.5	10.0
10 Valentia	6.6	6.4	8.1	9.3	11.5	13.6	15.0	15.2	13.9	11.6	9.0	8.1	10.7

Table 2. Mean temperature (^{o}C). (29).

Several stations along the coast never recorded temperatures below $0^{\circ}C$ from May or June to September. Inland areas are definitely frostless from June to August; at Markree, Co. Sligo, frost has been recordered every month except in July (16). For an average number of days with groundfrost see table 3.

Table 3: Average number of days with groundfrost. (9, 10, 15)

	Carlow	Lullymore	Shannon
Jan.	20.7	12.0	9.9
Febr.	16.8	10.0	11.7
March	13.5	7.8	8.9
April	12.9	3.8	6.9
May	8.5	1.4	2.8
June	2.5	0	0.6
July	0.3	0	0.0
Aug.	1.6	0.2	0.0
Sept.	4.0	0	0.2
Oct.	8.9	2.2	3.4
Nov.	15.3	11.4	6.5
Dec.	18.9	11.2	7.1
Totaal	123.9	60.0	58.0

1. Carlow
2. Lullymore
3. Shannon
4. Markree

1.3. Wind.

Westerly winds predominate, though a climate influenced by the passage of so many depressions counts winds from every quarter at some time of the year. Winds of gale force are most frequent in the northwest, where the average is 40 per year, against 36 in the southwest. Most of the gales come from a westerly direction (16).

Table 4. Strata of the British Isles

Era	*Period*	*General Lithology*
CAINOZOIC	**Pleistocene**	Alluvium, gravel, till, and minor littoral deposits.
	Pliocene	Thin littoral deposits in S.E. England.
	Miocene	Absent—Alpine folding in S. England.
	Oligocene	Largely lacustrine clays, sandstones and limestone in Hampshire Basin and Devon.
	Eocene	Predominantly clay, with sands and flint gravels in the London and Hampshire Basins. Clays in N. Ireland with basalt lavas, extending into the W. Isles.
MESOZOIC	**Cretaceous**	*Upper* Chalk mainly in S.E. and E. England and N.E. Ireland. *Lower* Clays and sandstone in S.E. England.
	Jurassic	Limestones and clays in S., S.E. and E. England, and S. Wales. Much sandier in N.E. Yorkshire and subsidiary ironstones in L. and M. Jurassic of E. Midlands and N.E. Yorkshire. Patches of sands, shales, limestones and thin coals on E. and W. coasts of the Scottish Highlands. Clays in N.E. Ireland.
	Triassic	Sandstones, conglomerates and mudstones in the Midlands, Pennine flanks, Solway Firth, S.W. England, N. and S. Wales, N.E. Ireland and scattered patches in W. Scotland.
UPPER PALAEOZOIC	**Permian**	Dolomitic limestone and sandstones E. of the Pennines; sandstones and breccias in N.W. and S.W. England. Dolomitic limestone in Ulster. Main Variscan folding. Granitic intrusions in S.W. England and Scottish Highlands.
	Carboniferous	*Upper* Sandstones, shales and coals in C. Scotland, N. England, Midlands, Bristol district, N.E. and S. Wales and C. Ireland. Shales and sandstones in S.W. Peninsula (Culm facies) *Lower* Massive limestone in C. and S. Pennines, N.E. and S. Wales, Mendips, C. Ireland, Isle of Man. Replaced in part by shales, sandstone and coals in N. England and Scotland. Shales and thin limestones in S.W. England (Culm) and S.W. Ireland (plus sandstones). Basic lavas in Scotland and Derbyshire.
	Devonian	Mainly sandstones in Scotland, Cheviots, Welsh borders and S. Wales (with marls) and Ireland. Transition to marine sandstones, shales and limestones between N. and S. Devon and Cornwall. Main Caledonian folding in L. Devonian. Lavas in Scotland, granitic intrusions in S.W. Highlands, S. Uplands, Cheviots and Leinster.
LOWER PALAEOZOIC	**Silurian**	Shales, sandstones and greywackes in S. Uplands, Lake District, N. and C. Wales, C. and N.E. Ireland. Some argillaceous limestones in Welsh Borders and Midlands.
	Ordovician	Shales and sandstones in S. Uplands, Lake District, N. and S.W. Wales, Leinster mountains and N.E. Ireland. Lavas and ash in Lake District, N. Wales and Ireland.
	Cambrian	Shales, sandstones and quartzite in N. and S.W. Wales, Shropshire, and Midlands. Slates and flagstones in I. of Man, Dolomitic limestone over sandstones in N.W. Scotland.
	Pre-Cambrian	Chiefly schists, gneisses, with quartzites, marmorised limestones and igneous rocks. Exposed in isolated inliers except in Scottish Highlands and N.W. Ireland. In Scotland the following sequence is recognised:
	Torridonian	Sandstones with shales, arkoses and conglomerates in Sutherland, Lewis and Skye.
	Dalradian	Schists, with slates, quartzites, arkoses and conglomerates in S.E. Grampians and Shetlands.
	Moinian	Schists and granulites mainly, in N.W. Highlands and N.W. Grampians.
	Lewisian	Gneisses in two groups, the younger Laxfordian and older Scourian separated by dolerite dykes, in Sutherland and Outer Hebrides.

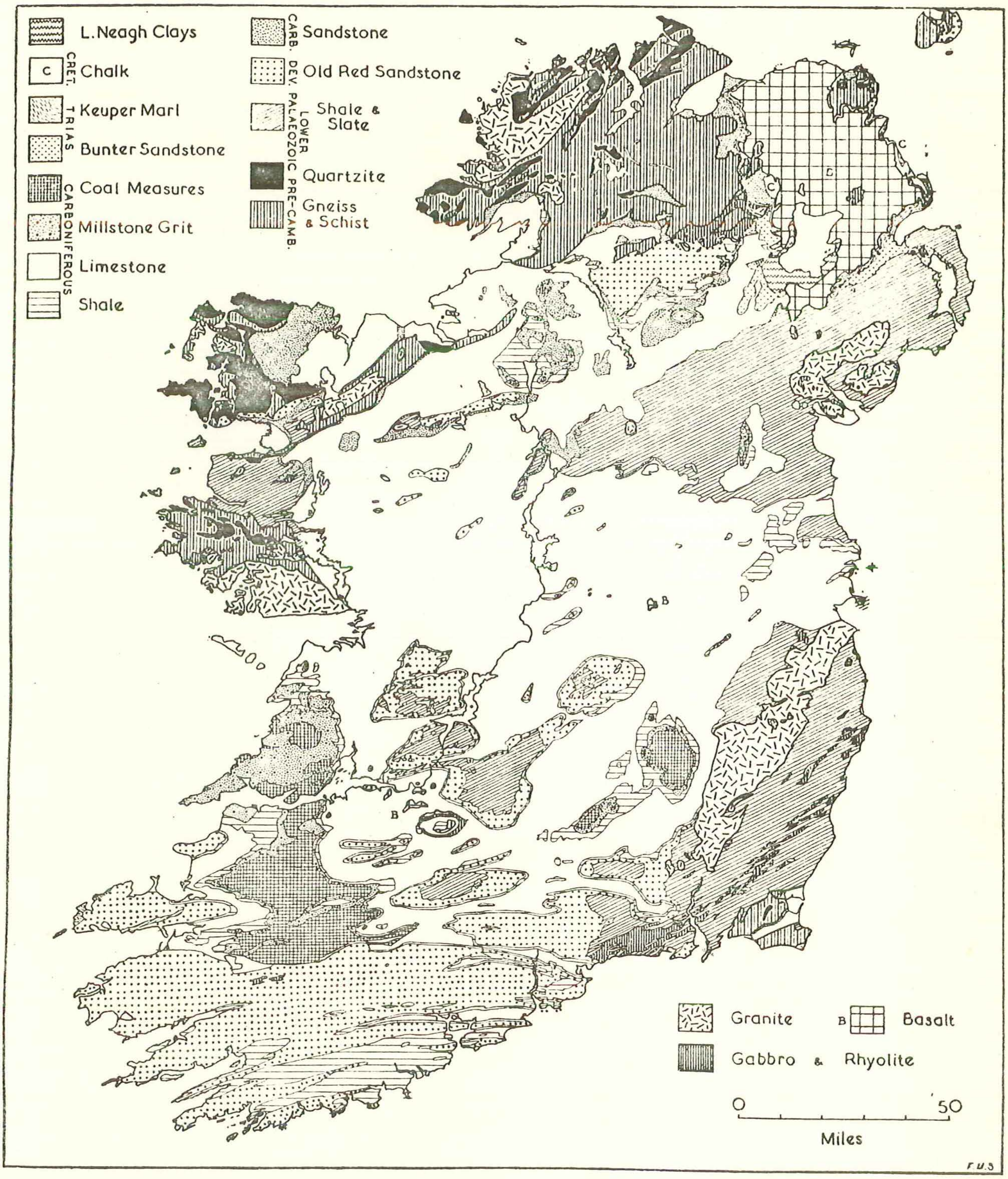


Fig.3:Geology(16).

2. GEOLOGY.

On the basis of table 4(p.10) and fig.3(p.11) the geology will be briefly outlined.
The bedrock-geology has been described in (3) and (30), for the glacial geology reference is made to (16), (25) and (30).

2.1. The Pre-Cambrian.

During Pre-Cambrian times Ireland was part of the continent; all rocks have been metamorphosed and deformed by succesive orogenic cycles. Pre-Cambrian rocks, consisting of gneiss, schist and quartzite, are widely distributed in the west and the north-west.

2.2. The Lower Palaeozoic.

Throughout much of the L. Palaeozoic Ireland was part of an area of marine sedimentation (see fig. 4). The rocks consist of shales and slates. Well folded L. Palaeozoic rocks are found in the south-west (see Itinerary, page 7) and in parts of the Central Plain. Strongly folded L. Palaeozoic rocks are widely distributed in the area north of Connemara and in north-east Ireland.
At the closure of the L. Palaeozoic the country was transformed by the Caledonian Orogeny, which effectively terminated marine geosynclinal sedimentation. Metamorphism was general: siliceous sediments were converted into quartzites, shales into slates.

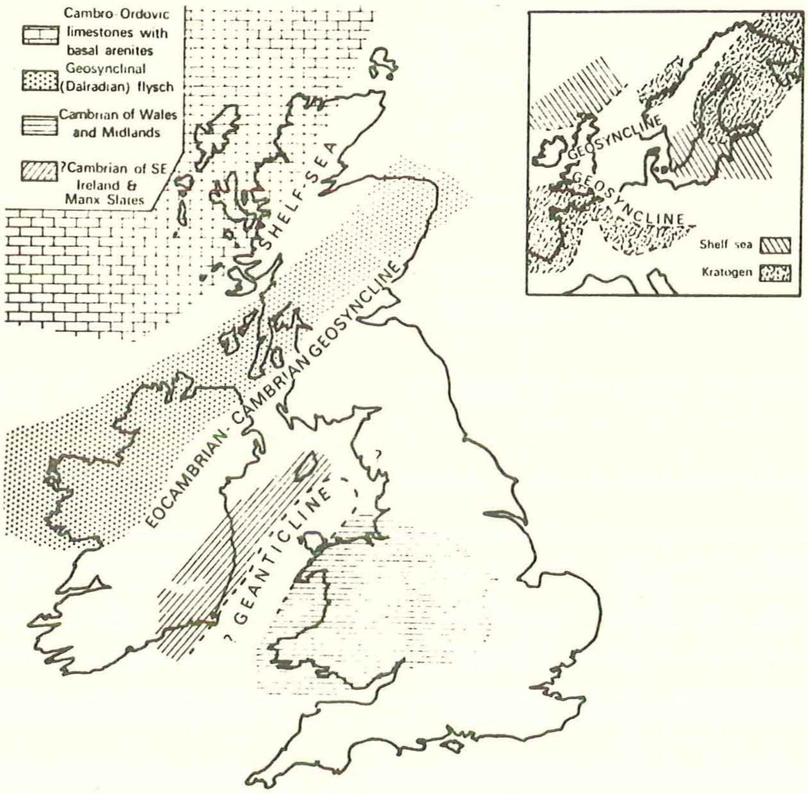


Fig. 4. The palaeography of Britain in Cambrian times (3).

2.3. The Upper Palaeozoic.

2.3.1. The Devonian.

During the Devonian Ireland was part of the Old Red Sandstone Continent (see fig. 5). Sediments were accumulated under fresh water and terrestrial conditions; the strata consist of grits and gritty sandstones. At the end of the Devonian the country was largely planed down. Because of their superior hardness the Old Red Sandstone rocks tend to dominate the landscape. There are extensive outcrops in the south-west, inliers in the Central Plain (see 2.3.2.) and some outcrops in the north.

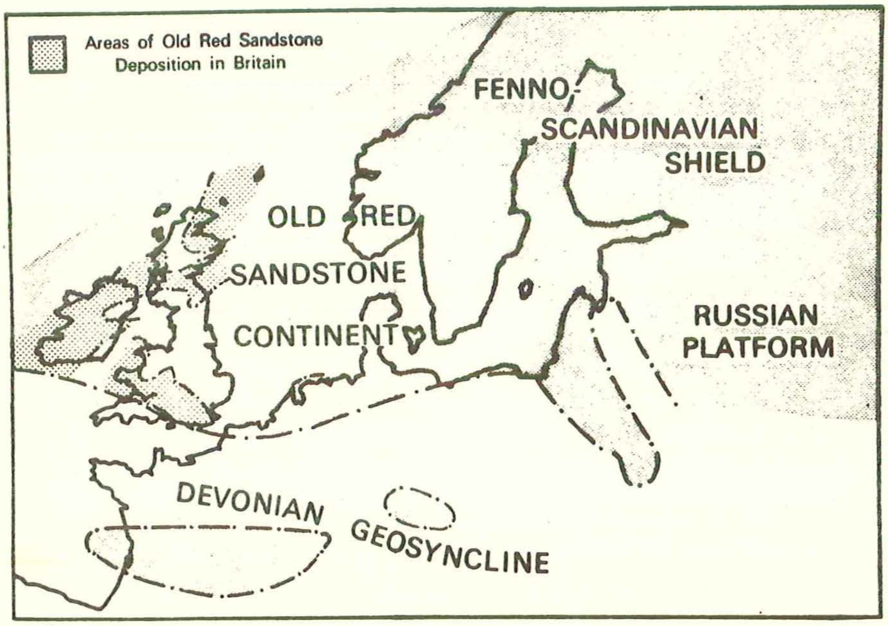


Fig. 5. The palaeography of Europe in Devonian times, showing the extent of the Old Red Sandstone Continent bordering the geosynclinal areas (3).

2.3.2. The Carboniferous.

During the Carboniferous the Old Red Sandstone Continent was inundated by generally shallow seas. In the south of Ireland Lower Carboniferous slates (called Culm strata) occur, which were deposited in the geosynclinal foredeep (see fig. 6). On the northern flank great thicknesses of reef limestones, known as Waulsortian Reefs, are found (see fig. 7). The Central Plain was covered by shallow shelf seas. Northwards the L. Carboniferous strata thin rapidly. In Co. Clare shales were laid down in a downwarping through, centred in the region of the Shannon Estuary (see fig. 8). Muds and sands from the surrounding land were laid down in the centre and up the sides of the through. These sediments are known as Millstone Grit. Coal forming conditions were fulfilled during the Upper Carboniferous. Coal Measures can be found in the south-west and in parts of the Central Plain.

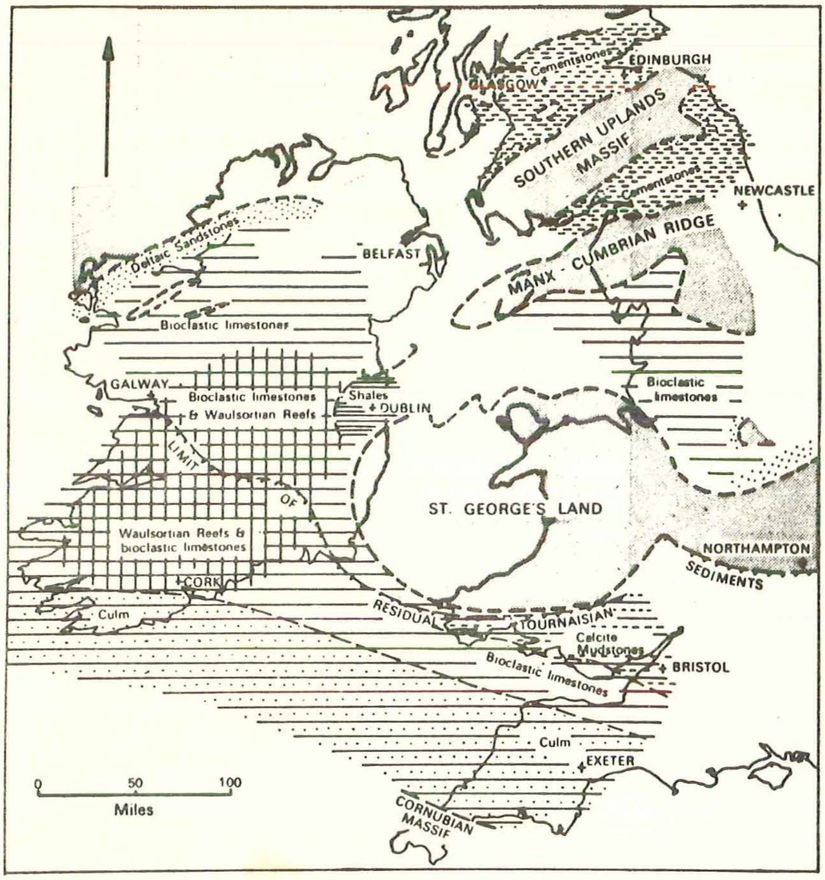


Fig.6: Early Visean palaeography of Britain(3).

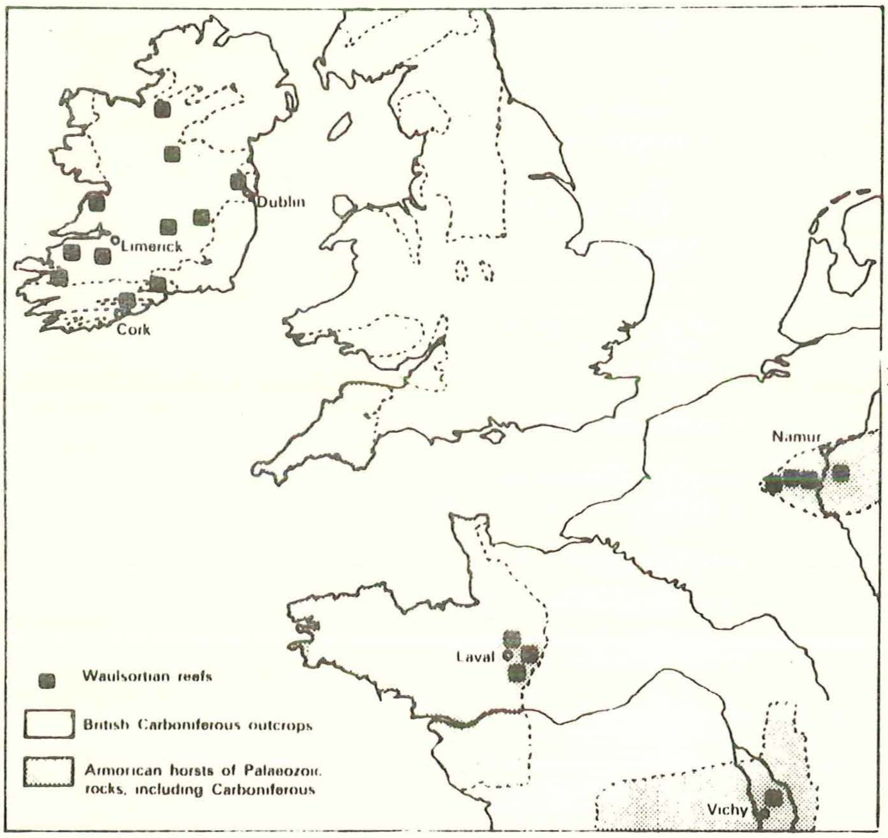


Fig.7: The distribution of Waulsortion Reefs in the Lower Carboniferous of N.W.Europe(3).

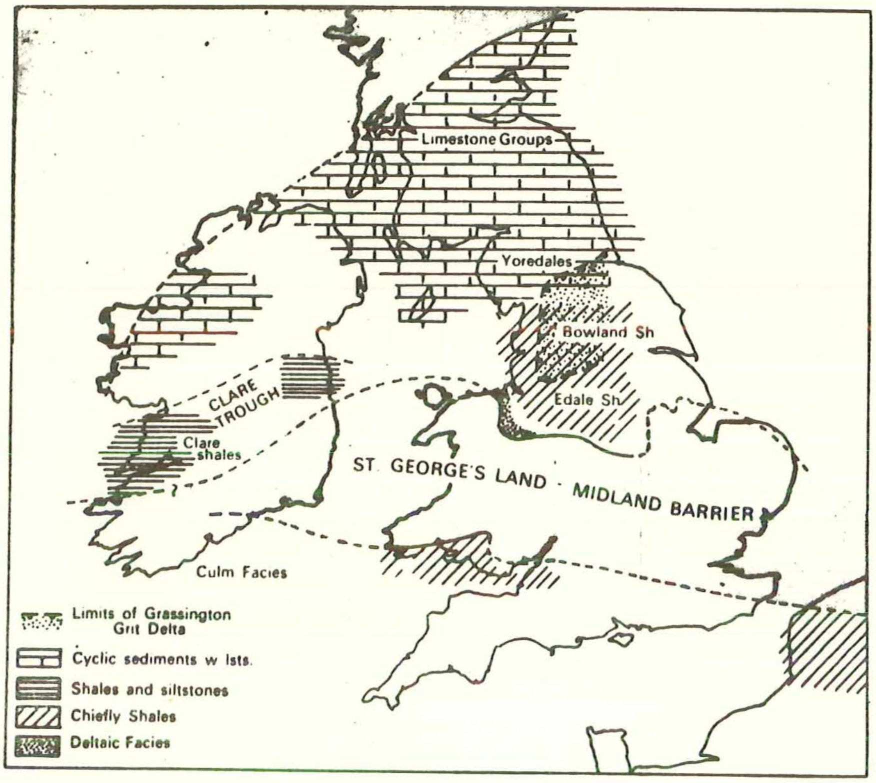


Fig.8:The palaeography of early Namurian times(3).

In late Carboniferous times earlier earth-movements culminated in the Variscan or Armorican Orogeny. The horizontal strata of the Devonian and Carboniferous were compressed and buckled into synclines and anticlines, which in general run east-west. The folding is most intens in the south. The gentle folds of the Central Plain have produced the Devonian inliers of the northern part of the plain. Metamorphism was general.

2.3.3. The Permian.

During the Permian Ireland became part of the continent (see fig. 9). Permian outcrops are not extensive in Ireland.

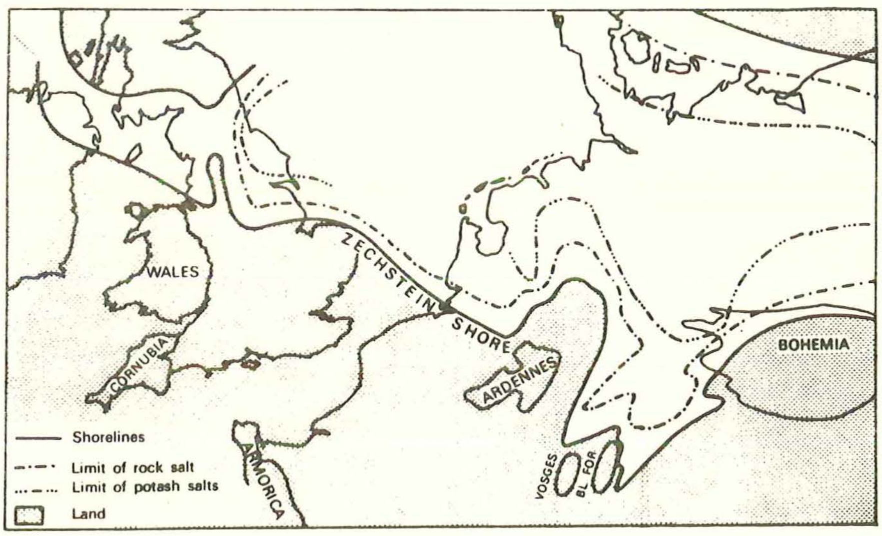


Fig.9:The palaeography of the Zechstein Sea and the distribution of salt deposits(3).

2.4. The Mesozoic.

Lower Trias (Bunter) sandstones and Upper Trias (Keuper) marl can be found in north-east Ireland, where minor outcrops of Lower Jurassic rocks occur too, Ireland being land for the other part (see fig. 10). In the Upper Cretaceous the Chalk sea covered all northern Ireland and spread far to the south-west. The white limestone from Ireland is from this period.

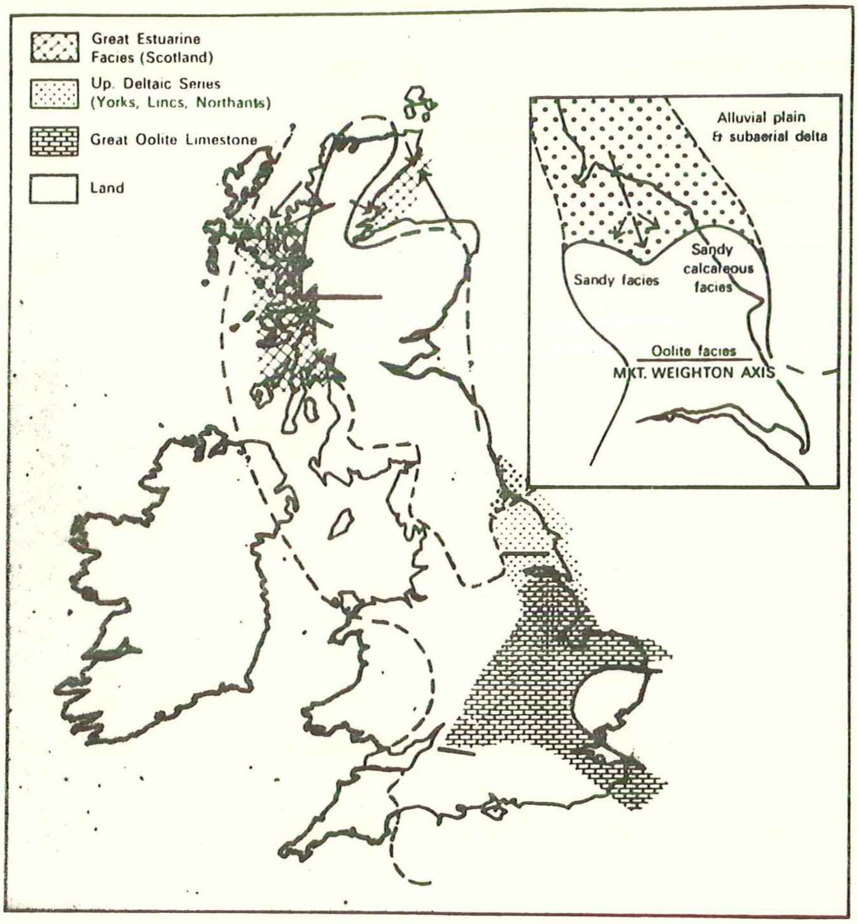


Fig.10:Middle Jurassic palaeography.

2.5. The Cainozoic.

2.5.1. The Tertiary.

Great changes in geography marked the closure of the Cretaceous Period. The Chalk sea withdrew from northern Europe and a long period of erosion followed, giving rise to denudation of the landscape resulting in a pediplain with deep soils. In Lower Tertiary times Northern Ireland was subject to severe igneous activity. Due to this extensive lava flows, chiefly basalts and intrusions are found there.

2.5.2. The Pleistocene.

During the Pleistocene large parts of Ireland were covered by icecaps, which were developed by heavy falls of snow rather than at low temperatures. By the action of the ice many of the landforms established during Tertiary times suffered major modifications; soils were taken off and the denudation of the landscape, started in the Tertiary, was continued.

2.5.2.1. Stages.

The stages of the Pleistocene are indicated by table 5.

	Stage	*Climate*	*Type site or area*	*Correlation of glacial stages with north-west Europe*
Upper Pleistocene	Flandrian (postglacial)	temperate	postglacial peats and lake deposits of Britain	
	Devensian (last glaciation)	cold, glacial	glacial deposits of Cheshire Plain	Weichselian (Würm)
	Ipswichian (last interglacial)	temperate	interglacial lake deposits at Bobbitshole, Ipswich	
	Wolstonian	cold, glacial	glacial deposits at Wolston, Warwickshire	Saalian (Riss)
Middle Pleistocene	Hoxnian	temperate	interglacial lake deposits at Hoxne, Suffolk	
	Anglian	cold, glacial	glacial deposits on the coast at Corton, Suffolk	Elsterian
	Cromerian	temperate	lake deposits at West Runton, Norfolk	
	Beestonian	cold	silts and fluviatile gravels at Beeston, Norfolk	
	Pastonian	temperate	tidal deposits at Paston, Norfolk	
Lower Pleistocene	Baventian	cold	marine sands and silts on the coast at Easton Bavents, Suffolk	
	Antian	temperate	marine deposits in borehole at Ludham, Norfolk	
	Thurnian	cold		
	Ludhamian	temperate		
	Waltonian		crag on coast at Walton-on-the-Naze, Essex	

Table 5: Stages of the Pleistocene (25).

2.5.2.2. Glaciated areas.

Evidence of the Anglian is poor, as the traces have been removed for the greater part by later glaciations.

The Wolstonian covered almost the whole of Ireland and part of the present seabed (see fig. 11).

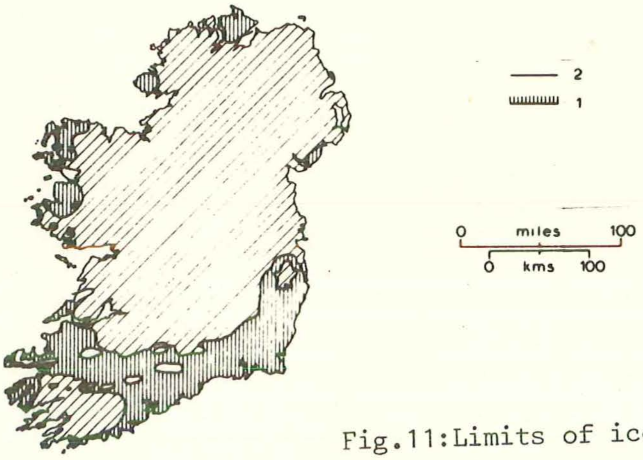


Fig.11:Limits of ice advances in Ireland(25).
1:limit of pre-last glaciation ice.
2:limit of Wolstonian.

Due to the elevation and the heavy precipitation the main ice centres were situated at the westcoast, whence ice moved over the Central Plain, meeting ice from the Irish Sea which originally derived from Scotland, and local glaciers from the Wicklow mountains (see fig. 12).

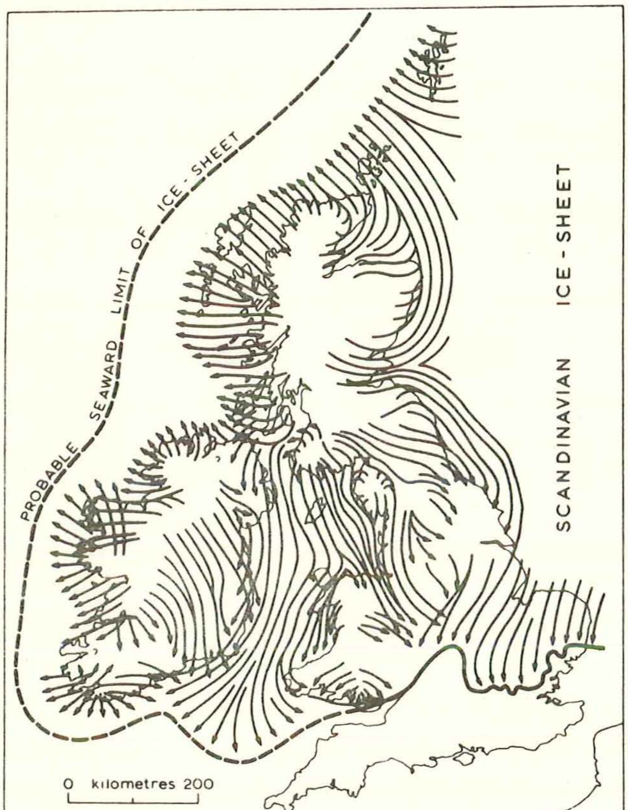


Fig.12:Centres of ice formation and directions of movement in the British Isles(25).

During the Devensian the ice readvanced twice in Ireland. At the York readvance much of the south-east remained icefree. The ice rose against the flanks of the Wicklow mountains, which possesed again their own valley glaciers, while a large mass of ice accumulated in the south-west. At the Lammermuir readvance only northern Ireland was covered by ice (see fig. 13). For the directions of the ice flow see fig. 14.

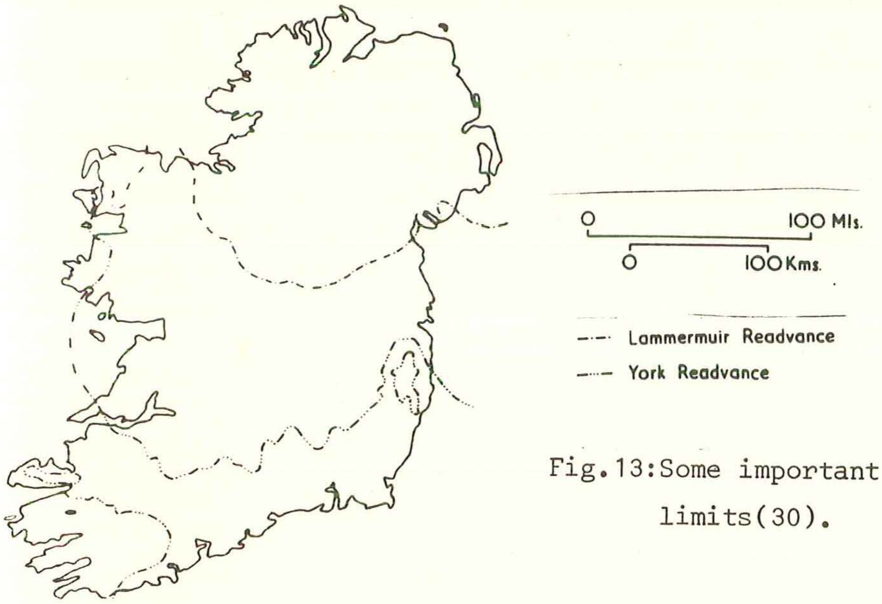


Fig. 13: Some important glacial limits(30).

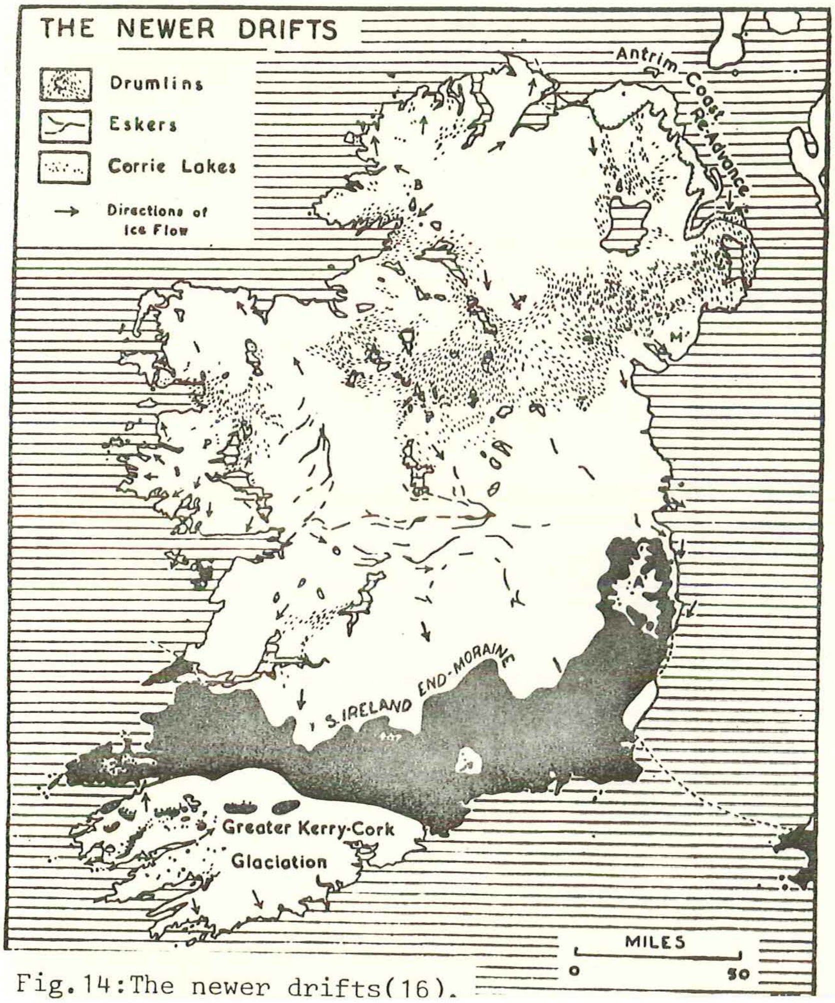


Fig. 14: The newer drifts(16).

2.5.2.3. Glacial features and landforms.

The mountainous areas above the ice level.

One of the typical features of these areas are the screes, which are slopes covered by debris which has been loosened by freeze-thaw processes.

The upland areas overrun by the ice.

These areas were subject to scouring, grinding and plucking, giving rise to bare rocks, which are often polished, scratched (roches moutonnées) and transformed to rock drumlins (see below at drumlins).

The lowlands.

In lowland areas a variety of glacial forms occurs. Moraines, kames and kettles, eskers and drumlins will be dealt with here.

Moraines: these are the natural concentrations of the material the ice was carrying, which result at thawing. Different types can be distinguished according to the margin where the ice melted (see fig. 15).

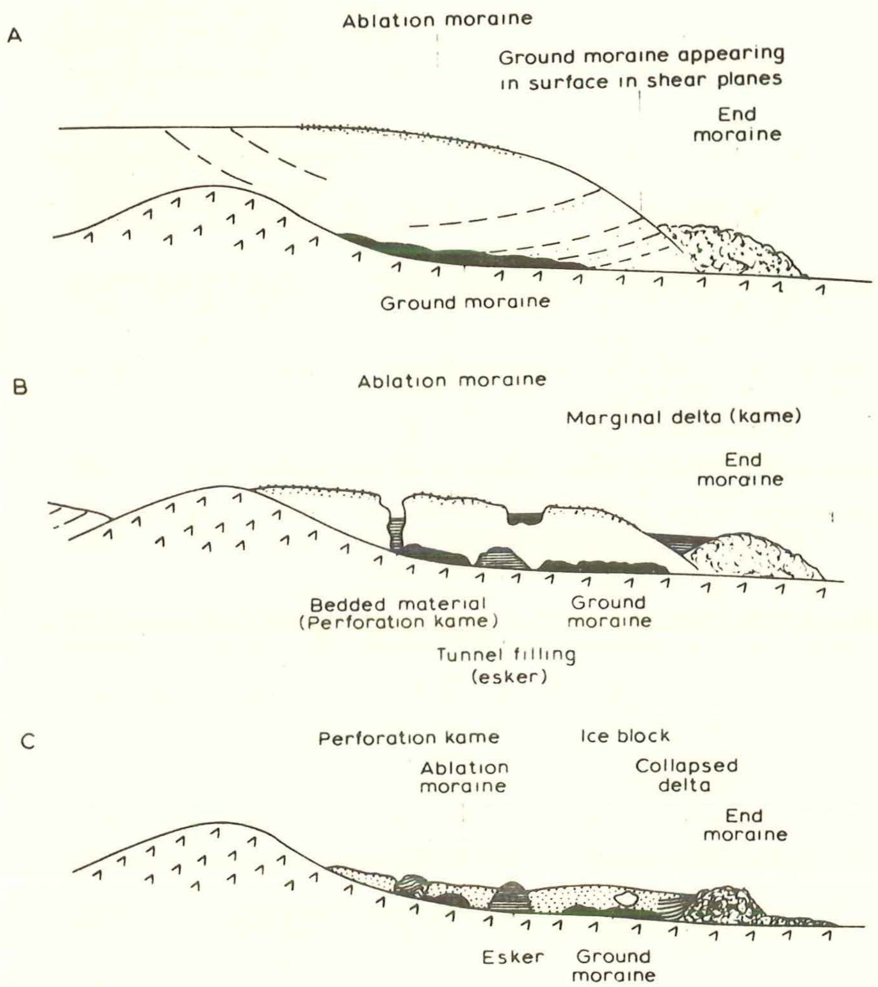


Fig.15:Formation of a moraine complex(25).

Groundmoraine is formed at the bottom of an icesheet and is found back as sheets of till or boulder clay. The majority of the till is reflecting the underlying bedrock, though obviously its character cannot change immediately passing from one outcrop to another; thus the icesheets from the westcoast left limestone bearing drift over large parts of the Central Plain and on mountain sides, while till in eastern Ireland contains muds and oozes from the Irish sea floor. The south-western icesheet deposited drift largely composed of sand and gravel.
Endmoraines are formed by melting of the fronts of icesheets, which remained stationary for long times. The limit of the York readvance is indicated by the endmoraine extending from the Wicklow mountains to the mouth of the Shannon. The Kells moraine indicates the extent of the ice during the Lammermuir readvance (see fig. 16).

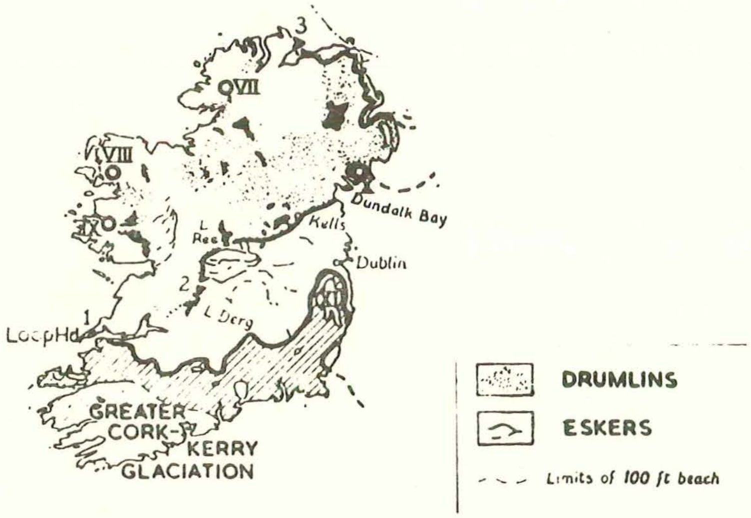


Fig.16:Retreat stages of the last ice sheet in Ireland(16).

Recessional moraines mark halts in retreat.
Ablation moraine is caused by the thawing of the surface. Finer constituents tend to be washed out of it by meltwater, sand and gravel staying back.
This material is irregularly let down on to the groundmoraine when the icesheet finally melts.

Kames and Kettles:

Kames are features produced by glacial rivers at the margins of the ice (see fig. 15). Kame terraces are formed by streams flowing along the edges of the ice, where it abuts against higher ground (see fig. 15). When the ice melts the terraces at the edges of the ice will slump while any included lump of ice melts to give kettle holes.

Eskers are long, more or less winding ridges mainly composed of sands and gravels which are normally bedded. They owe their existence to the action of glacial rivers beneath the ice (see fig. 15). Fig. 16 shows the occurence of eskers in Ireland. Near Dunmore we studied a beaded (i.e. an interrupted, due to sedimentation) esker on July 2nd . The esker had a position perpendicular on the recessional moraines. A layer of unsorted, stoney material, consisting of shaley limestone, was covered by some sandy and gravelly layers. The high silt-and the low claycontent suggest that water streamed rather fast here. No information was available about the extension of the esker under the groundmoraine in the lower surroundings. Somewhat furtheron we studied a cutting through the same esker. It's material, consisting of clear fluvial layers, was covered by glacial till. The boundary between these two materials was very sharp. This cover of glacial till commonly occurs at the sites of eskers. Much discussion followed about the waving fluvial layers. The cause of this might be that the depositions of a braided river endured afterwards, when the ice melted, a kind of "plumpudding-effect", by which the deposited materials flowed away to the sites.

Drumlins are widespread in Ireland (see fig. 16). They occur where ice from adjacent centres was still moving rapidly and were caused by some tendency inherent in an icesheet to streamline underlying relief: the general form is an elongated hill with a rounded blunter end towards the ice and a longer, tapering end in the down ice direction (see fig. 17). They are more elongated as a result of greater pressure, consequent on more rapid ice movement. The features may vary from pure drift forms to forms, entirely composed of rock. For the main drumlin areas see fig. 16.

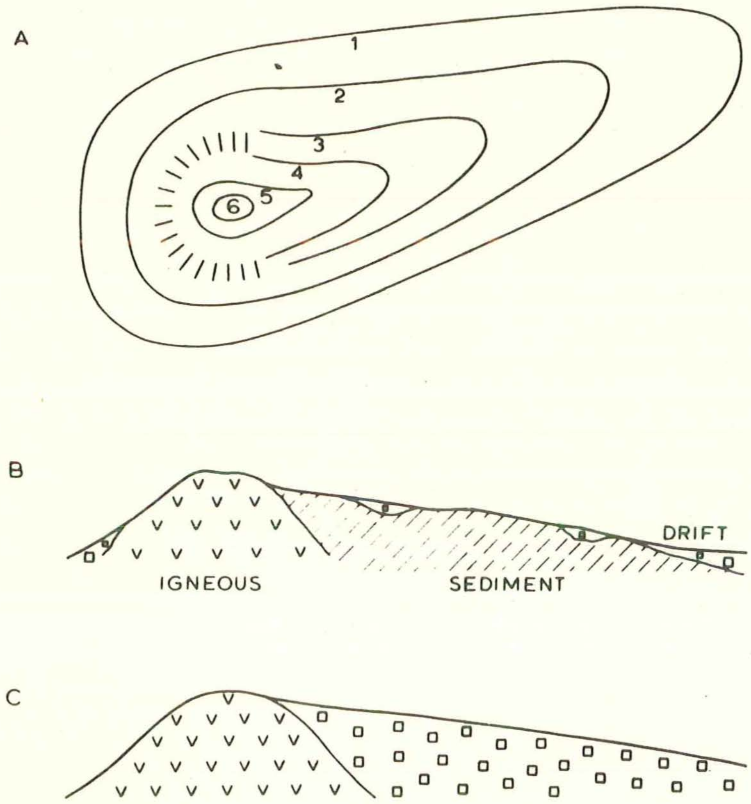


Fig.17:Possible compositions of crag and tail features(25).

2.5.3. The Holocene (30).

During the Holocene climatic conditions ameliorated, which had far reaching consequences.

Vegetation.

During the Pleistocene Ireland was cut off from England by the Irish Sea. Large tracts of the present seabed south-west of Ireland however made part of the country and were not covered by ice;most of the present plant species survived the last glaciation in the Atlantic fringe and from here Holocene plantgrowth originates.
The bare drifts were clothed with heath and grass, and later with dense forests. The plant succession has been summarized in table 6. During the climatic optimum peat was formed in swampy hollows (see 9.1.1.) and on the flatter mountain slopes (see 9 .1.3.).

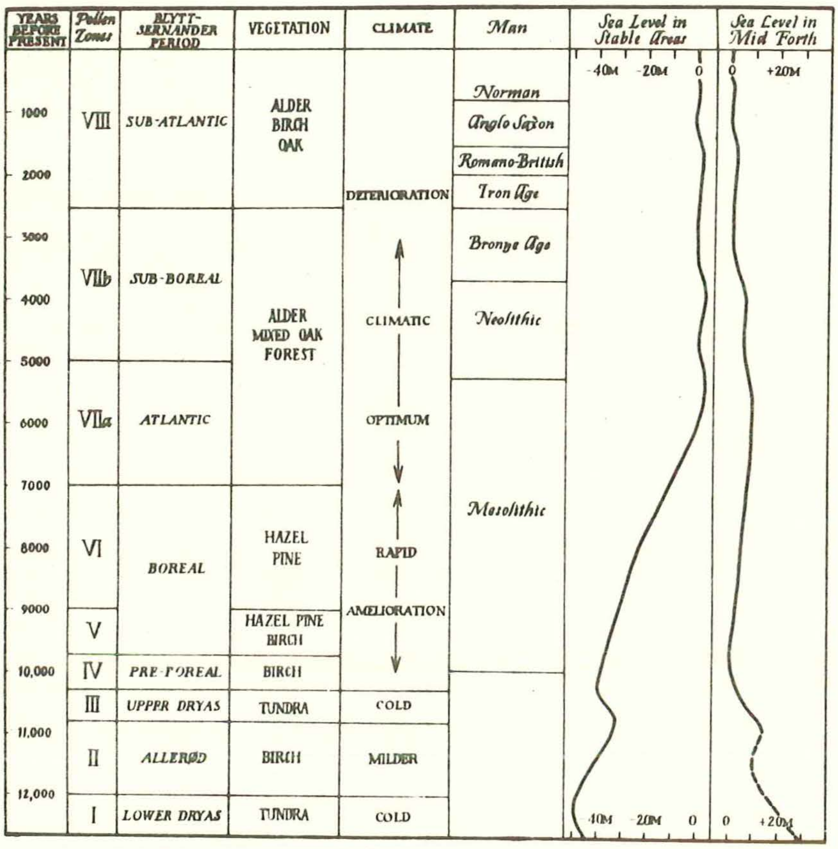


Table 6:Correlation of some aspects of late-glacial and post-glacial features(25).

Cultures (30).

After the melting of the icesheets Ireland was opened up for human occupation. The different cultures have been summarized in table 6.
During the Mesolithic people lived from hunting and fishing.
By late Atlantic times revolutionary cultural changes, accompanying the diffusion of food production, took place. The economy during the Neolithic was based on polished stone axes for forest clearance, which was necessary for the shifting cultivation system. During the Bronze Age evidence points to invasive movements, which has been attributed to soil exhaustion in Central Europe, following many centuries of shifting cultivation. The increasing range of use for heavy timber during the Iron Age, including the construction of massive timber-laced defences, speeded up the attack on the woodlands and especially on the oakwoods.

Uplift (25).

If thick ice is loaded on to a block of the earth's crust it gets out of balance and tends to sink (see fig. 18). Melting of the ice means lowering of the pressure and gives rise to a hinge-movement: rising of the centres where the ice was thickest and lowering of the areas which were covered by a thin ice-sheet. This occurs with a considerable lag effect. That is why Central Ireland is still rising, while other parts are still lowering. This, combined with a raising sealevel, stands for the extensive erosion of the blanket peat area in the western part of the country (see July 3rd).

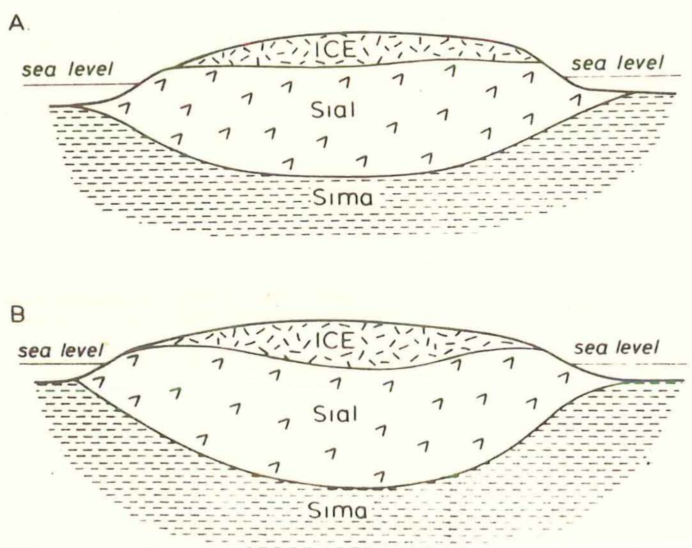
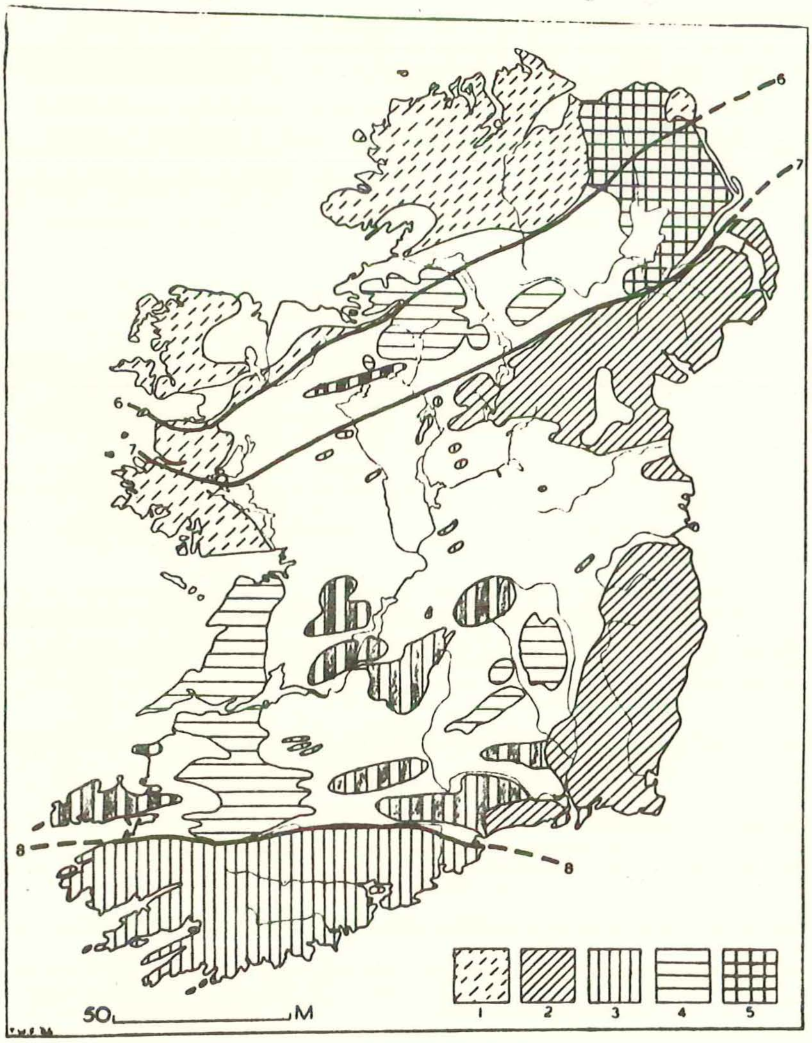


Fig.18:The effect of an ice cap on the equilibrium of the earth's crust(25).

3. STRUCTURE AND RELIEF.

3.1. Structure (16).

The structure of Ireland is strongly affected by the geology (see fig. 19 and fig. 3 .). The Irish landscape shows five main structural elements, each of distinct age and form (see fig. 19). Two main structural lines can be distinguished (see fig. 20).



1, Western Caledonian masses; 2, Eastern Caledonian masses (Newry axis and Leinster chain); 3, Armorican uplands with intervening lowlands in the south; 4, Carboniferous plateaus; 5, Basaltic plateaus and lowlands; 6 and 7, continuation (6) of Highland Boundary and (7) Southern Upland boundary faults

Fig.19:Structural elements(16).

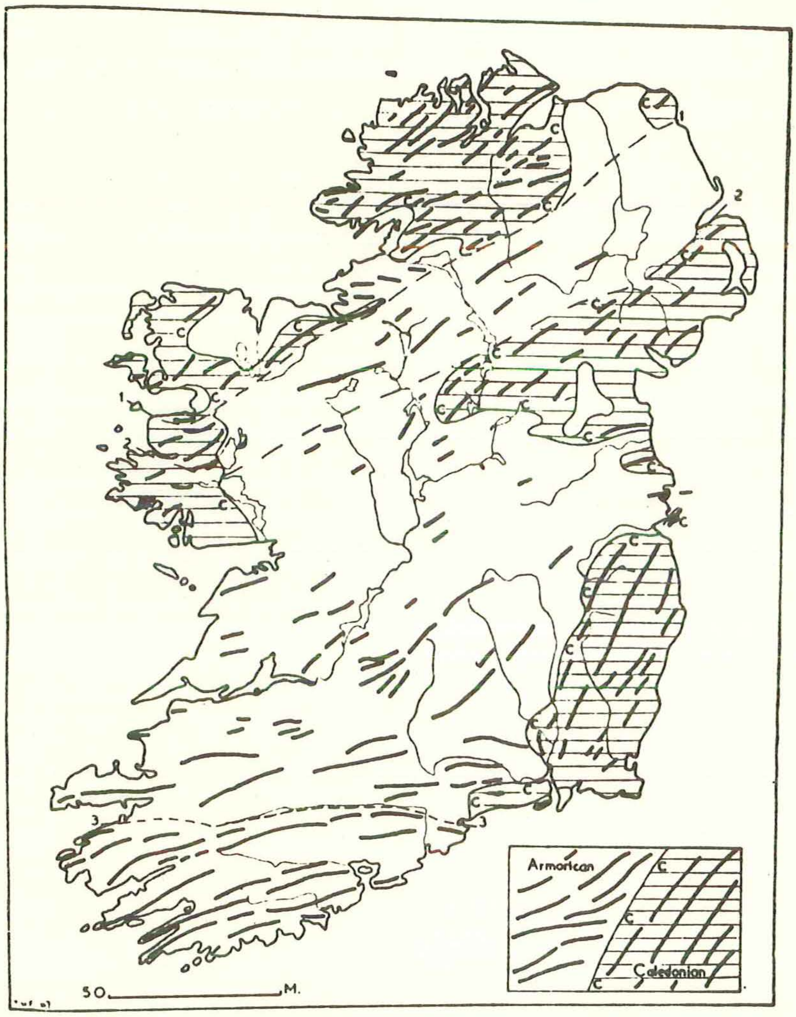


Fig.20:Trend lines in Caledonian and Armorican Ireland(16).

Various pedeplain levels exist. The highest level (around 600 m.) is said to be Devonian; it is seen on Slieve League, Donegal and on various hills in south Mayo. The second level (around 180-240m.) is called the South Ireland pepeplain. Another level is seen throughout the lowlying country (see 3.2.).

3.2. Relief (30).

The main relief types and their distribution are shown in fig. 21. A simplified grouping of these units (fig. 22) reveals the basic relief pattern. Ireland is frequently compared to a saucer, because many of the uplands lie near the coast while the interior is essentially a lowland.

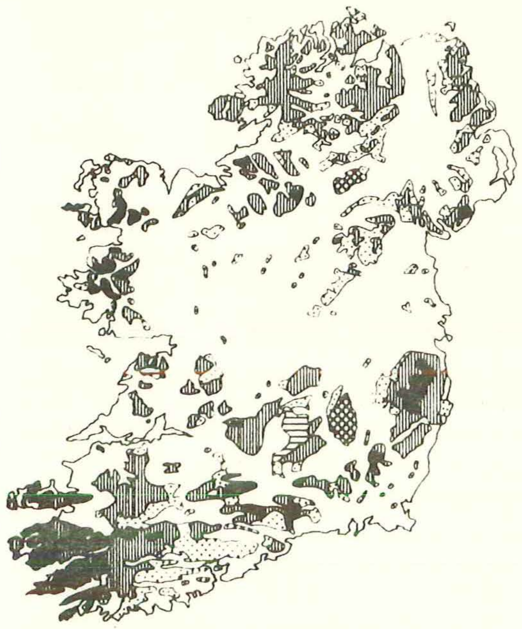


Fig.21:Relief types(30).

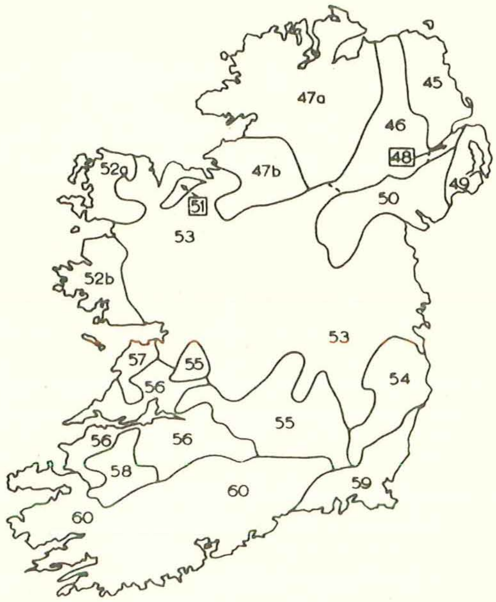


Fig.22:Relief regions(30).

The uplands are rather strongly dissected; the northern upland region is divided by lowlands into three parts, the southwestern region is cut by various streams. Much of the Central lowlands lies between 60 and 90m. Apart from isolated hills and drumlins, glacial drift forms the major relief; most of this area is very flat and boggy.

The morphological consequences of the wetness of Ireland (not so much residing in heavy annual amounts of precipitation but in the persistence of the rain and the feebleness of the evaporation), resulting in erosive processes being fast, are far reaching:

- Due to fragmentation of the relief there are no large upland areas. The most massive upland (the Wicklow mountains) covers barely 500 sq. km.
- Another consequence lies in the general lowering of the Irish uplands.
- Nothing of the older pediplanes, still forming plateaus in England and Scotland, has been left in Ireland.
- Relatively many valleys have been formed in Ireland.
- Corresponding geological landscapes in Ireland have been eroded relatively deep (compared with Scotland: 200-300 m. deeper).

4. SOIL FORMATION.

It has long been recognised that there are five major factors in soil formation, which strongly influence the kind and combination of processes which change the parent material into a soil. Before pointing out the relative influence of these factors on the main processes (restricted to Irish circumstances) a short description of the Great Soil Groups will be given.

4.1. The Great Soil Groups.

The vast majority of Irish soils can be represented by nine Great Soil Groups (17):

Great Soil Group	Main characteristic	Subdivision	Description
BROWN EARTHS	little differentiation into visible horizons	- Acid B.E.	-see June 27th, third stop
		- B.E. of high base status	-see July 4th, second stop
BROWN PODZOLICS	strong-brown subsurface horizon	-	see Itinerary page 13
GREY-BROWN PODZOLDICS	Bt-horizon	-	see It. page 3 and 4
PODZOLS	A2, B2h and/or B2ir	- Podzols	-see It. page 14 and 15
	idem + peaty surface layer	- Peaty Podzols	-see June 29th, first stop
		- Reclaimed Podz.	
GLEYS	effects of drainage impedance dominate, developed under conditions of waterlogging	- ground-water G.	-see It. page 17
		-surface-water G. (or pseudogley)	-see It. page 10 and 11
PEATS	soils of a highly organic nature	- Basin Peats	-see June 26th, first stop
		- Hill or Blanket Peats	-see July 1st
RENDZINAS	dark surface horizon weathered from material rich in lime	-	-see June 30th, seventh stop
REGOSOLS	immature mineral soils without distinct horizons	-	see It. page 6
LITHOSOLS	skeletal, stony soils, overlying solid or shattered bedrock		

4.2. The major factors in soil formation (22, 10).

4.2.1. Climate.

One of the most active agents in soil formation is climate. The main element of Irish climate is the rainfall-evaporation regime (see 1.1.) by which most of the soils tend to be leached (see 4.3.2.). Apart from this the humid climate is partially responsible for the extensive areas of gley soils and for much of the peat formation (the biggest percentage of bogland and especially of climatic peats is found along the westcoast).

4.2.2. Parent material.

Glacial drift is the most common parent material of Irish soils. It varies considerably in constitution and in geological composition, which is reflected in the soils derived from it. The chemically-mineralogical properties highly determine the results of the leaching process (see 4.3.2.) while the physical properties are important for the speed of soil formation.

4.2.3. Relief.

The position of a soil in the landscape is governed by the relief. For this reason relief is important in many respects; especially in its effect on water run-off and drainage. The effects on hydrology were demonstrated on the area of the Lullymore Cutover Peatland Experimental Station (see June 26th, third stop) and on the Cratloc hills (see June 30th, after first stop). Relief also influences the local micro-climate. For example: southerly slopes are drier than northerly ones, being exposed to stronger radiation and consequent higher temperatures, giving rise to a less extent of leaching.

4.2.4. Living organisms and mankind.

Living organisms,as plants as animals,play an important role in soil formation, a too complex role however to deal with here.
In old settled countries, like Ireland, it is difficult to find any arable soil which has not been influenced by human activity (8):
- In prehistoric times the sparse woodland was removed (see 2.5.3.), which led to soil degeneration (see June 29th, first stop).
- Many soils were reclaimed in the period immediately before the Great Famine. Reclamation consisted of ditch building, cultivation and the addition of a variety of liming materials and manures. Burnt lime and calcareous seasand (see July 3rd, second stop) were the main liming materials and the manures commonly used included dung, ashes and roas scrapings.
- More recent activity comprises the reclamation of cut-away peat (see 9.4.).

4.2.5. Time.

Considerable time is needed for the development of horizons in the soil profile. Soils developed on youngh deposits (like the Shannon Alluvial Series, see June 29th, fifth stop) show less distinct horizons, in general, than those developed on old materials over a longer period. Although Irish soils are young the influence of time could be demonstrated (see June 30th, first stop) in different soil depths as a result of the different age of parent material.

4.3. <u>The major soil forming processes</u> (22, 10).

In this chapter the processes of main importance for Ireland will be dealt with.

4.3.1. Accumulation of organic matter.

The establishment of a vegetative cover brings about the accumulation of organic matter. Under favourable conditions as regards a.o. hydrology, climate and chemistry, the organic matter is subject to severe alterations, resulting in the formation of humus. Under less favourable conditions the accumulation of organic matter can surpass the decay, and soils of a highly organic nature (ORGANIC SOILS or PEATS) develop (see chapter 9). In combination with the leaching (see 4.3.2.) PEATY IRON PAN PODZOLS developed.

4.3.2. Leaching.

Climatic conditions in Ireland give rise to a downward movement during part of the year of the liquid phase, which can act as a carrier for transport of different components through the soil. At first the water soluble salts, notably Ca- and Mg-carbonates are leached. In this stage there are still two major processes: weathering of primary minerals and formation of new products like clayminerals and sesquioxides. The continuous weathering and leaching cause a lowering of the electrolyte-content, notably of the stabilising Ca-ions, and a consequent lowering in pH. These conditions enable peptisation and migration of the clayparticles, which process proceeds at a large scale at pH 6.0-5.5. At a still lower pH (due to proceeding leaching, or due to the parent material being acid from the beginning) the primary minerals are more intensively weathered while certain compounds of the organic matter can be translocated, sometimes as metal-organic complexes, taking with them the metal-ions of the dissolved sesquioxides.

<u>BROWN EARTHS</u> posses a rather uniform profile, they have not been extensively leached or degraded. In many cases however a certain degree of leaching may have occured, resulting in the translocation and accumulation or removal of soluble constituents, such as (calcium carbonate) bases (hence the sub-division in Acid Brown Earths and Brown Earths of high base status) and Al. Characteristic for this group is the

intensively weathering, resulting in the formation of a.o. ironoxides which occur as cutants around the grains, colouring the soil brown and the accumulation of Al in some part of the B-horizon.

GREY BROWN PODZOLICS are associated with the leaching process too. The principal constituent accumulated in the B-horizon is finely divided and orientated clay. To qualify as a Grey-Brown Podzolic, a soil must have a B-horizon significantly higher in clay-content than either the A-or C-horizon (Bt-horizon). The occurence of clay skins on the structural ped surfaces within the Bt-horizon is a further characteristic.

BROWN PODZOLICS are a more intensely leached version of the Brown Earths.
The upper horizons are more depleted of bases and other constituents.
A characteristic feature of these soils is a sub-surface horizon of strong red-brown or yellowish-brown colour due to enrichment, principally by iron oxides leached from the upper horizons.

PODZOLS are more intensely leached than either the Grey-Brown Podzolics or the Brown Podzolics. They display well-defined horizons of depletion and accumulation and are considered to be degraded soils. They develop from parent materials of very low base reserves or from parts of the profile where the base reserves have been depleted. The acidity combined with a high rainfall promote a considerable leaching of soil constituents, principally bases,iron-and aluminium-oxides, and humus. In cases of advanced deterioration an iron-pan may be formed and poorly decomposed organic matter may accumulate on the surface (see June 29th, first stop).

4.3.3. Oxidation/reduction.

The redox-potential in soils is subject to alterations. When oxygen can enter the soil freely, the redox-potential is high, resulting in a.o. Fe-compounds being oxydated and immobile. When water replaces air and enough readily decomposable organic matter is present, the activity of anaerobic micro-organisms is furthered, resulting in a.o. Fe-compounds being reduced and mobilised. The presence of water may be due to the sucking power of organic matter (as is the case at the formation of an iron-pan podzol). Reduced conditions may also be caused by a high watertable (GROUNDWATER-GLEYS) or by impermeable nature of the whole or part of the soil-profile. In this case the soils are usually referred to as SURFACEWATER-GLEYS (Pseudo-gleys).

5. SOIL MAPPING.

5.1. History.

The history of Irish soil science is a long one (23, 24) and it is worth mentioning that the signal and direction of progress in soil mapping is given in Ireland. The first publication concerning soil mapping in Ireland dates from 1833, when Griffith wrote the principles on which the valuation of land was to be made. The work of Sir Robert Kane, a contemporary of Griffith, was strikingly: from data concerning the mechanical and chemical nature of soils he destilled their agricultural capability, he summed up results in agrological maps and represented the distribution of soils according to their financial values.

For the more recent history we must go back to 1959, when the National Soil Survey was established within the Soils Division of An Foras Talúntais (the Agricultural Institute) and was charged with the task of surveying, classifying and mapping the soils of Ireland. Such information is essential for the most efficient land use planning and practise, which is of the utmost importance in a country like Ireland, where agriculture occupies such a vital role in the economy (17).

5.2. Soil maps of the counties.

The main activities of the soil-surveys are being carried out on a county basis. For the counties Wexford, Limerick, Carlow, West Cork, Kildare and Clare soil bulletins and maps based on detailed-reconnaissance surveys have been published (18, 15, 10, 9, 14). In the counties Mayo and West Donegal field work is at an advanced stage, while in several other counties more generalised soil surveys have been completed.

Field mapping is carried out on a scale of 6 inch=1 mile (1:10,560), which detail is reduced to a scale of ½ inch=1 mile (1:126,720) for publication.

The next soil units are of importance:

Soil Series: the primary category used in mapping and classification is the Soil Series, which comprises soils with similar type and arrangement of horizons, developed on similar parent material (see fig. 23). A soil series is named usually after the location in which the particular soils are best expressed or occur most widely.

Soil Variants: variants are really separate soil series that are too small in extent to be shown at certain scales of mapping.

Soil Types: soils within a series may be sub-divided into soil types on the basis of textural differences in the surface soil.

Soil Phases: soils within a series may also be sub-divided into soil phases on the basis of variations in features like slope, depth or stoniness, features that are important in soil behaviour and land use.

<u>Soil Associations</u>: in order to relate soils to their environment and, in particular, to their geological parent materials, series may be grouped into larger mapping units or soil associations. A soil association is a grouping of series developed on similar parent materials but varying in profile character.

<u>Soil Complexes</u>: where soil series are recognised, but where their distribution pattern with contiguous series is so intricate as to defy clearcut delineation on the map, a soil complex is mapped.

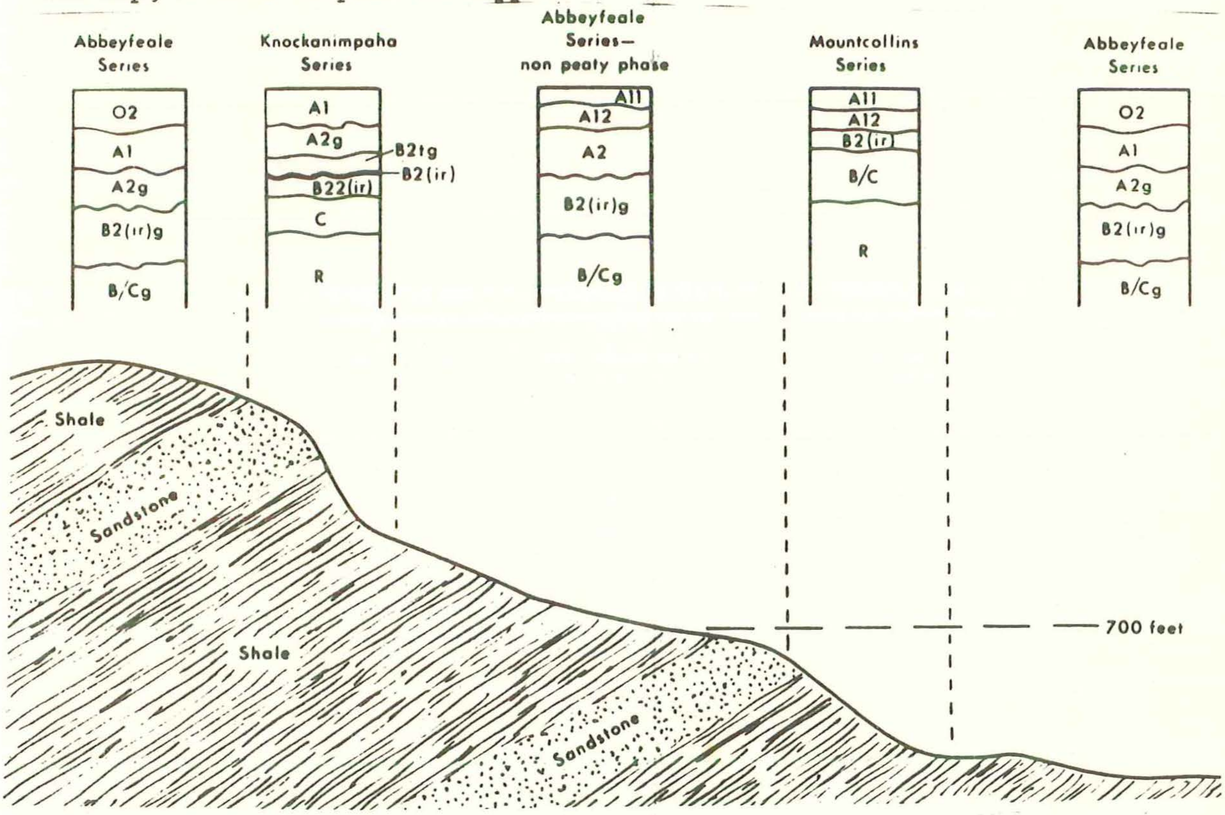


Fig.23:Abbeyfeale and associated soils in relation to topography and geology(15).

5.3. Soil map of Ireland (17).

In 1969 a new generalised soil map of Ireland (see Itinerary) at a scale of 1 inch=9 miles (1:575,000) was edited. As sources of information all available soil maps, mentioned in chapter 5.2., completed by special reconnaissance surveys in counties that had not yet been surveyed, were used.

5.3.1. Legend.

The map legend (see Itinerary) is based on the Great Soil Groups (see 4.1.). Each of these groups consists of a collection of closely related soil series, being comprised therefore of soils having a number of important profile characteristics in common.

There are 31 mapping units, consisting of geographic associations (see 5.2.) of the great soil groups. These associations were organised on the basis of both physiographic or land-form divisions and general drainage characteristics.

Each association consists of a principal soil and of one or more associated soils. The degree of dominance of the principal soils has been designated as 90, 75, and 60% of the association area. The associations have been grouped in five broad physiographic divisions, subdivided in a unit comprising the drier soils and a unit comprising the wetter soils.

5.3.2. Extent of different units.

The % of the total area occupied by each soil association and grouped by each major physiographic and drainage division has been computed (see table 7). Organic soils have been calculated at 7.0% (1.2 million acres). This only takes account of the large peatbogs; enclaves are included as associated soils in other associations.

Soil association[a]	% of total area	Physiographic and drainage division	% of total area
1	12.8	Mountain and hill soils	21.2
2	4.9		
3	0.3		
4	2.8		
5	0.4		
6	1.1	Rolling lowlands	19.6
7	1.9	(mainly dry mineral soils)	
8	8.1		
9	6.3		
11	2.2.		
12	0.9	Rolling lowlands	9.5
13	6.4	(mainly wet mineral	
14	2.2	and organic soils)	
15	3.4	Drumlins (mainly wet	7.8
17	4.4	mineral and organic soils)	
18	2.3	Drumlins (mainly drier	2.3
		mineral soils)	
20	4.1	Flat to undulating lowlands	26.6
21	3.7	(mainly dry mineral soils)	
22	3.9		
23	3.2		
24	11.7		
25	3.5	Flat to undulating lowlands	4.4
27	0.4	(mainly wet minerals soils)	
28	0.5		
29 + 31	4.8	Organic soils	7.0
30	2.2		
Other (towns, etc.)	1.6		1.6

[a]Association numbers 10, 16, 19 and 26 occur in Northern Ireland.

Table 7: Soil associations and physiographic and drainage divisions as percentage of total land (17).

Suitability Class	Use-Range	Type of Limitation**	Soil Series
A Mainly suitable for tillage crops, pasture or forestry	Wide use-range	No serious limitations	Ballybrood, Ballylanders, Ballynalacken, Derk, Elton, Kilfergus, Knockainy Variant, Mountcollins, Patrickswell.
B Mainly of moderate suitability for tillage crops, pasture or forestry	Somewhat limited use-range	Somewhat high elevations and steep slopes	Doonglara.
		Adverse soil physical conditions	Ballynamona, Rathcannon.
		Coarse texture; liable to periodic drought	Baggotstown, Ballyvorheen, Cooga, Kilbeheny.
		Weak structure	Cloverfield, Knockcommane Variant.
		Drainage slightly defective; weak structure	Ballydoole.
C Mainly of moderate to poor suitability for tillage crops; mainly of moderate suitability for pasture or forestry	Somewhat limited use-range	Drainage imperfect to poor; moderate to weak structure	Lyre, Rootiagh.
		Hazard of periodic flooding	Aherlow, Feale, Mulkear.
		Somewhat shallow soils; occasional bedrock outcrops; liable to periodic drought	Ballincurra (poor for forestry)
D Mainly of poor suitability for tillage crops; mainly of moderate suitability for pasture or forestry	Limited use-range	Drainage poor to very poor; adverse soil physical conditions	Abbeyfeale, Cluggin, Gortaclareen, Howardstown, Kilrush, Mountminnett, Puckane, Shannon.
		Drainage very poor; hazard of periodic flooding	Camoge, Darkisland.
		Serious drainage problem; high water-table	Griston.
		Shallow soils; frequent bedrock outcrops	Carrigogunnel,*** Rineanna,*** (very poor for forestry), Wonderhill.***
E Mainly unsuitable for tillage crops or intensive grazing; mainly of moderate and poor suitability for extensive grazing or forestry	Very limited use-range	Shallow soils, pan formation, steep slopes; high altitudes	Knockaceol, Knockanimpaha, Knockastanna, Seefin, Temple Hill variant.
		Very serious drainage problem, high water-table	Coolalough, Drombanny.
F Unsuitable for cultivation or intensive grazing; mainly unsuitable for forestry; mainly of poor suitability for extensive grazing	Extremely limited use-range	Very shallow soils, frequent rock outcrops, steep slopes, high altitudes	Slievereagh.
Unclassified (Variable suitability)	Variable use-range	Variable limitations from slight to serious	Ashgrove Complex, Rineanna Complex Basin Peat, Blanket Peat.

***These soils are borderline to Class E

Table 8: Suitability Classes(15).

6. SOIL SUITABILITY.

In Irish soil bulletins the classification of soils according to their suitability and limitations for different agricultural enterprises is strongly emphasized. As such a rational basis, on which optimum land-use practices can be planned, is provided. Because precise quantitative data on the productivity of the different soil series are not sufficiently available, soil suitability classification is a qualitative one, based on an evaluation of the significance of the more permanent characteristics of the soils.

6.1. Suitability Classes.

The soil series have been grouped into six suitability classes (see table 8,page 36a).

6.2. Use range.

Five categories have been distinguished (see table 9). A wide-use range means that limitations can be overcome by normal manurial and management practises. A limited use-range comprises soils mainly unsuited to tillage, suited to permanent grassland and mostly suited to forestry while an extremely limited use-range means that agricultural potentials are greatly restricted. In table 9 the soil associations in the different use-range categories are shown.

Use-range category	Soil association no.	% of Irish Republic
1. Extremely limited	1, 2, 5	18.1
2. Very limited	3, 14, 29, 30, 31	9.5
3. Limited	4, 12, 13, 15, 17, 18, 22, 25, 27	29.6
4. Somewhat limited	6, 11, 20, 23	9.0
5. Wide	7, 8, 9, 21, 24, 28	32.2

Table 9: Soil associations in different use-range categories (17).

6.4. Drainage conditions.

The soil series have been grouped into seven drainage classes, which refer to natural drainage condition (see table 11). The soils in Class a are not capable of holding sufficient moisture for normal growth of a wide range of crops throughout the average growing season; soils in Class b are capable of fulfilling this requirement whilst not suffering from excess moisture effects. Soils in Class c have slightly defective drainage but are not in need of artificial drainage for most purposes. In the soils in Class d drainage improvement is necessary to attain their full potential, whilst in those in Classes e and f drainage is a basic prerequisite to any form of sustained improvement and higher output. The soils in Class g have variable drainage characteristics; this is due to iron-pans that occur sporadically and to differences of component soils in complexes.

Natural Drainage Class	Conditioning Factors	Soils	Per cent of total area
(a) Excessively drained	Rapid permeability Deep water-table	Aherlow, Baggotstown, Ballincurra, Ballyvorheen, Cooga, Kilbeheny, Mulkear, Slievereagh	4.63
(b) Well drained	Moderate permeability Deep water-table	Ballybrood, Ballylanders, Ballynalacken, Ballynamona, Cloverfield, Derk, Doonglara, Elton, Kilfergus, Knockaceol, Mountcollins, Patrickswell, Rathcannon, Seefin	37.70
	Moderate permeability Temporary water-table on bedrock	Carrigogunnel, Rineanna, Wonderhill	0.23
(c) Moderately well drained	Slow permeability Deep water-table	Ballydoole, Feale	0.81
(d) Imperfectly to poorly drained	Moderate permeability Seasonal high water-table	Rootiagh	0.13
	Very slow permeability Deep water-table	Abbeyfeale, Cluggin, Gortaclareen, Kilrush, Puckane	19.16
(e) Poorly drained	Moderate permeability Seasonal high water-table	Mountminnett	0.10
	Variable permeability (slow to moderate) Seasonal high water-table	Darkisland, Drombanny, Lyre	0.98
	Very slow permeability Seasonal high water-table	Camoge, Howardstown	19.36
(f) Very poorly drained	Rapid permeability Seasonal very high water-table	Griston	0.23
	Slow permeability Very high water-table	Shannon	2.10
	Slow permeability Seasonal very high water-table	Coolalough	0.16
(g) Variable drainage	Complex of moderate-slow permeability Deep water-table	Knockanimpaha, Knockastanna	0.59
	Variable permeability Variable water-table	Ashgrove Complex, Rineanna Complex	5.58
Unclassified		Basin Peat, Blanket Peat	7.79

Table 11:Classification of the soils according to natural drainage conditions(17).

7. SOME ASPECTS OF AGRICULTURE.

During the excursion several aspects of Irish agriculture were dealt with. At the Moorepark Dairy Research Centre (June 28th) and the Herbertstown Economic Testfarm (June 29th) information was given about fatting-and dairy-cattle. At the Belclare Research Centre (July 2nd) sheep husbandry came up for discussion. The harvesting of peat was dealt with at the Lullymore Cutover Peatland Experimental Station (June 26th) and the Bellacorick peat-fired electricity generating station (July 3rd). Scattered information was given at Johnsown Castle (June 27th) and throughout the excursion.

7.1. History (27).

For ages Ireland has suffered under political complications attended by an insufficiently paying market for agricultural products. This has been fatal for the development of agriculture in all aspects. This impediment has been removed by the membership of the E.E.C., which provided Ireland a wide, stable and paying market for its agricultural products. The structural problems and the technological arrears, legacies of injury in the past, still rest however.

7.2. Place in the national economy (19).

Agriculture plays a vital role in the Irish economy:
Agriculture occupations support a good 30% of the employed population; it provides the main raw products for many branches of Irish industry, and raw agricultural produce makes up nearly 50% of the total year export.

7.3. Value and composition.

Table 12. indicates the value and composition of Irish agricultural production:

horned cattle	107,2	wheat	11,5
milk	79,8	oat	1,0
sheep and wool	14,7	barley	15,8
pigs	40,3	sugar beats	8,2
poultry and eggs	18,1	potatoes	11,2
horses	3,4	other crops and turf	17,5
other products	0,3		
+	263,8	+	65,2

total: 263,8
65,2 +
329,0

Table 12: value and composition of Irish agriculture in 1970 (in million pounds) (20).

Cattle is the main enterprise. Unless the enterprises being rather extensive and the cattle being of moderate quality, the value exceeds 50% of the total agricultural value. Only with a more rational grassproduction this value can be doubled (27).

7.4. Environmental factors.

The climate and nature of the soils in Ireland are strongly reflected by the composition of the arable area, of which 90% is covered by grass.
Climatic conditions result in a long growing season for grass (see fig. 24) and in cheap lodging of the cattle, while the rainfall is sufficiently variable to offer major problems for tillage, generally from excess rather than deficiency; the ripening of cereals is hindered in most years by the frequent spells of wet weather and low proportion of sunshine (16).
As pointed out in chapter 6 the greater part of Irish soils is affected with limitations for tillage, in a higher degree, than for grassland.
These factors, and the low costs of land give Ireland an enormous potential for beef- and dairy-production.

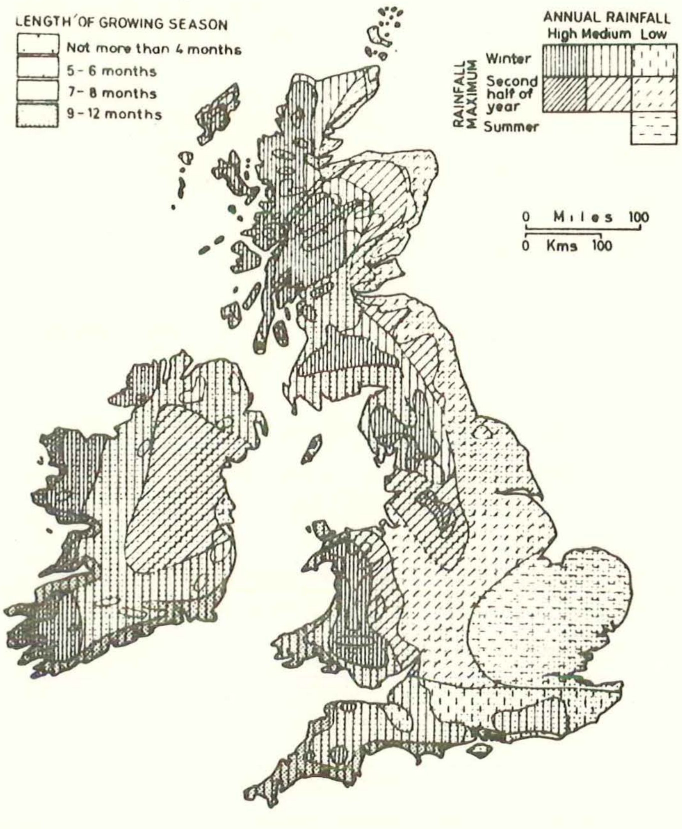


Fig.24:Regional climatic differences(30).

7.5. Structural problems (19, 27).

The greater part of Irish agricultural holdings is small (see table 13).

Percentage	seize
40	< 6 ha
20	6-12 ha
17	12-20 ha
23	> 20 ha

Table 13: farmseize in Ireland (19).

The mean farmseize is 18 ha (not included holdings smaller than 2.5 ha, including the extended, often submarginal hill-lands in the west).
This lies above Dutch- and E.E.C. level; store cattle breeding is the main enterprise however (see 7.3.) which is an extensive production form, demanding relatively much land. Most large enterprises occur in the east and southwest: 75% exceeds 20 ha. Especially in the north and the west problems exist, because employment outside agriculture is scanty. Under the schemes operated by the Department of Lands, numbers of farmers migrate each year to other parts of the country, their farms are available for re-distribution to those who remain. An extension of this activity would lead to greater farm seize and better income for the farmers.

8. SOME ASPECTS OF FORESTRY.

Only four procent of the Irish landscape (300.000 ha) is covered by wood; apart from Iceland, Ireland is thus the least forested country in Europe (see 2.5.3.). The area covered by wood is extended yearly with 10.000 ha at the advice of the Forest and Wildlife Service, which was founded in 1908 as the Forestry Commission. The main aim is the production of wood. The Irish State possesses two sawmills; the establishment of paperplants is left to private persons.

8.1. Species.

Due to favourable climatic conditions many species can be grown. Mainly Picea sitchensis (60%) and Pinus contorta (20%) and to a less extent Mediterranean species like Pinus insignis, Pinus radiata and Abies nobilis and nearly all softwood species occurring in the Netherlands are planted. The mild climate is reflected by the occurrence of Eucalyptus spp., Nothofagus obliga, Fuchsia magellana and Yucca spp.

8.2. Soils.

Forestry is thrown on soils less suitable for agriculture, like mineral soils which are easy poached (46% of the area) and blanket peats.
The blanket peats are oncely fertilized with 500 kg P/ha and, if necessary, 50 kg K/ha.

8.3. Productiveness.

Average production of Picea sitchensis in Ireland amounts to 22 m^3/ha/year; on mineral soils results are better than on organic ones (26 resp. 14 m^3/ha/year). Due to this very high production one can suffice with a medium long rotation. Calculations show that, on poorly drained drumlins, forestry is more paying than extensive cattle breeding; the profits are obtained on a much longer term however (11).

8.4. Natural woodland.

Few traces of natural woodland are to be seen, mainly on hill sides never cleared for grazing and cultivation; most woods have Quercus sessiliflora as the dominant tree with a subordinate layer of Ilex aquifolium. There is a marked absence of trees in some western districts on or near the coast, which is usually regarded as a direct result of the exposure to westerly winds (15).

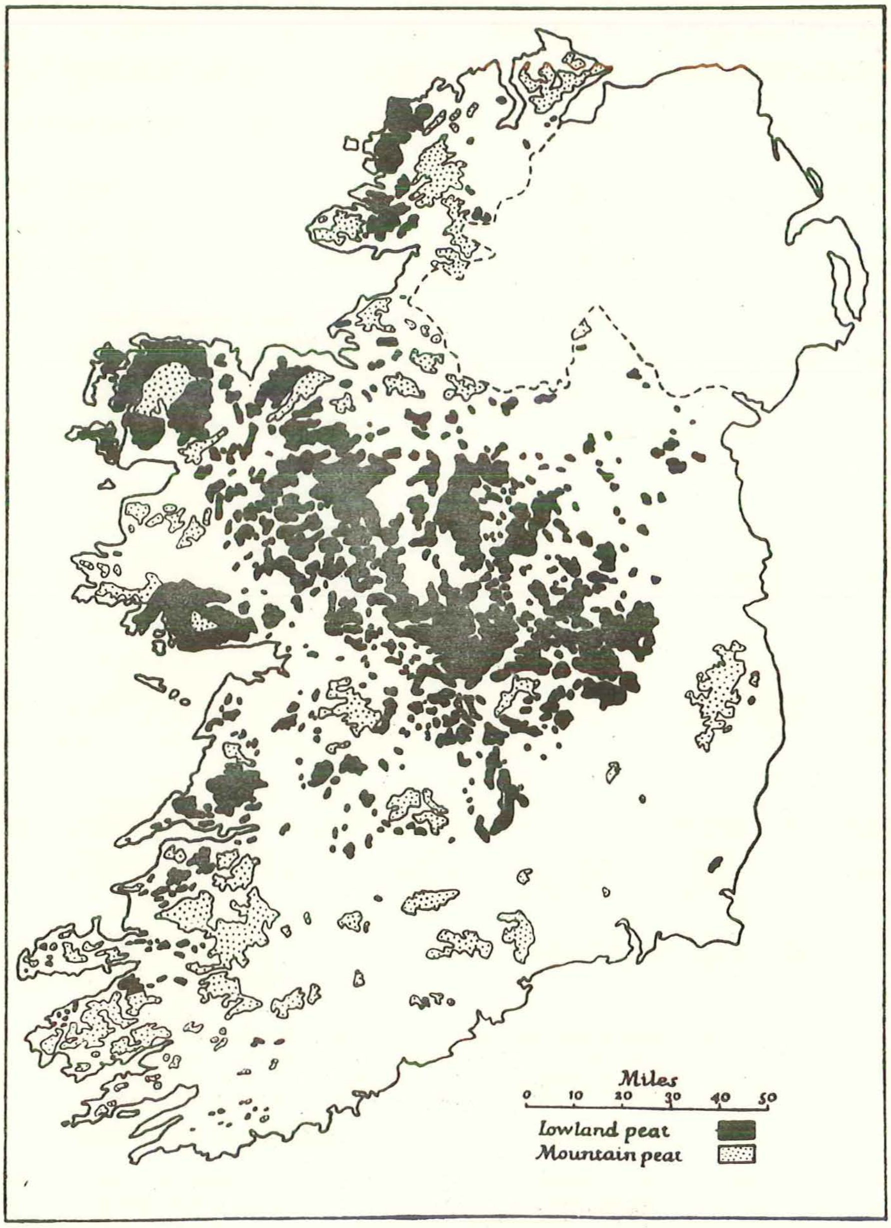


Fig.25:The peat deposits of the Republic of Ireland(12).

9. PEATBOGS.

Peatbogs cover about 600.000 ha of the Irish Republic. The biggest percentage is found along the westcoast, but large tracts also occur in the Central Plain, while pockets of peat soil are to be found in most counties (see fig. 25 ,page 43a).

9.1. Peatformation.

Peatgrowth started in the early Holocene and shows a peak in the Atlanticum because of optimum climatic conditions (see 2.5.3.). The growth started at places with extreme wet conditions.

9.1.1. Fenpeat.

Retreating ice had left standing water in deep and shallow depressions. In these depressions (the shallow ones are called fens) organic matter or gyttja accumulated. On top of these gyttjas reed started to grow, giving rise to the formation of reedpeat. After some time the pool is filled up and the peatformation continues at or slightly above the groundwater-level under alder and birch vegetation: a so called alderbog.

The reedpeat, the alderpeat and the birchpeat together are called fenpeat or topogenic peat (Dutch: rietveen and broekveen), characterised by the inflow of water which is rich to medium-rich in nutrients (eutrophic to mesotrophic).

9.1.2. Raised bog.

As soon as the bog is out of reach of water containing nutrients and the development is only controlled by rainwater (ombrotrophic) the vegetation changes completely. From this time on we have to do with a raised bog (Dutch: koepelveen or ombrogeen veen), with growth of mainly spagnum and ericaceae.

9.1.3. Blanket peat.

These bogs occur mainly in West-Ireland, where conditions are so wet that not only depressions, but also flat areas and mountains are covered with peat, but can also be found on some higher hills in the interior. The growth of the blanket or climatic peats (Dutch: spreiveen) started in the Atlanticum on the very moist hills.

9.2. Visited bogs.

During the excursion we visited a fenpeat (Newbridge fen), a raised bog (Bog of Allen) and a blanket bog (Connemara).

9.2.1. Newbridge fen.

At Tuesday June 26th (sixth stop) we studied an original fenpeat.
Water-inflow: the fen is fed by springwater containing carbonates, which is bubbling up at a high edge at one side of the fen. The area has been drained.
Vegetation: due to the alcalic water the vegetation is a special one. The species we found were: Cladium mariscus (Dutch: Galligaan), Schoenus nigricans (D: Zwarte knopbies), Molinia coerula (D: Pijpestrootje), Phragmites communis (D: riet), Menyanthes trifolium (D: Waterdrieblad), and Circium palustre (D: Moerasdistel). Drainage resulted in part of the area having lost its contact with the spring-water; this may be the reason also plants indicating a more acid environment, like Erica tetralix (D: Dophei), Succisa pratensis (D: Blauwe knoop), Polygala vulgaris and Potentilla erecta, can be found.

9.2.2. Bog of Allen.

At Tuesday June 26th (first stop) we studied a raised bog.
Profile: the thickness of the total bog is 6 metres. Little humified, young sphagnum peat overlies more humified, old sphagnum peat with remnants of pine. Underneath the raised bog fenpeat could be noticed.
Humification: the grade of humification can be estimated by pinching water out of the peat material; the measure of cloudyness is proportional to the measure of humification.
Pines: if there is a rather dry period during 20 to 30 years, Pinus can develop in the raised bogs. When the climate is getting wetter, the raised bog starts to grow again, the trunks rot and the trees fall down. This is the reason why one can find remnants of pine in the bogs.
Drainage: at this moment the bog is not so wet as originally due to the cutting of the surrounding bogs and the consequent lowering of the groundwater-level.
Surface: mostly the surface of an ombrotrophic bog is hummocky, with Ericaceae dominating on the small, about one foot wide hummocks and Sphagnum in the shallow basins around the hummocks. The Sphagnum in the basins grows up, forming a new hummock, slightly higher than the already existing ones, on which the Ericaceae are growing. These Ericaceae, preferring relatively dry conditions, are "drowned" by this process, being unable to build up a hummock by organic matter production, as quick as Sphagnum does. As soon as the recently formed hummock has grown high enough above the surrounding groundwater, Ericaceae start growing on these and Sphagnum growth starts again on the former hummocks, now forming pools, and so on. In the climatic peats in the western part of Ireland this type of hummocky growth was almost lacking.

Vegetation: in the pools we found Rhynchospora alba (D: Witte snavelbies), Eriophorum augustifolium (D: Eenarig wollegras), Drosera anglica (D: Kleine zonnedauw) and Sphagnum species; in the hummocks Calluna vulgaris (D: Struikhei), Erica tetralix (D: Dophei), Scirpus caespitosus (D: Veenbies), Narthecium ossifragum (D: Beenbreek) and Andromeda polifolia (D: Lavendelheide) were found.
Burning:in the surrounding we saw the traces of burning, which is done to further the regrowth of Molinea and Erica, which serves as food for sheep.

9.2.3. Connemara blanket bog.

At Sunday July 1st we climbed a hill covered by blanket peat.
Vegetation: save the species of the raised bog some other species could be notified: Schoenus nigricans and Potentilla erecta. In exploited areas woodroot-remnants of conifers were visible; heather species become dominant here.
Surface: in these bogs no pools and hummocks should occur; nevertheless we found some hummocks. This may indicate that there are transitions from a blanket bog to a raised bog.

9.3. Peat fuel production.

In Lullymore (Tuesday June 26th, second stop) and Bellacorick (Tuesday July 3rd, third stop) several aspects of peat fuel production were dealt with.

9.3.1. Turf production.

For centuries turf production in Ireland has been based on handwinning methods. The upper layer of moss and heather is stripped from the bogsurface and discarded. The raw peat is then cut into sods. The wet sods lying on the bogsurface are dried until they are solid enough to be built into small heaps for further drying. When fully dried the turf is stored in ricks, the outside sods being built into a protective wall against the weather (4).
On the establishment in 1946 of Bord na Móna, a semi-state body, a large scale turf production programme based on mechanical methods was adopted (12).
Two main methods are employed in the Irish Republic: the sod peat and the milled peat method. Sod peat: the bog is drained by ditches at intervals of 200 m. After removal of the vegetation and the bolsterlayer a cutting machine, called a bagger, excavates the peat by working along the vertical face of a trench, macerating and forming it into sods which are spreaded on the prepared bog surface to dry. After six or seven weeks drying the sods are built into small piles.
A sod-collecting machine later stacks them in ricks. Bord na Móna uses 43 baggers. During the season, which lasts from the beginning of April till early August, production proceeds day and night. Average output per machine is 13 tons per hour.

Milled peat: the bog is drained by ditches at intervals of 12 to 13 m. After removal of the vegetation the top half-inch of peat is stripped from the prepared surface of the bog by vehicles which use a large drum studded with spikes. The particles so produced are harrowed regularly to facilitate drying. Then the peat is scraped into ridges, which are taken up and moved across adjacent production areas and drainage ditches. The whole process from milling to harvesting is repeated about 18 times each season.

9.3.2. Economic and social aspects (5).

Mechanised turf production runs to more than 4 million tons annually, which represents an enormous saving in imported fuel. Turf-fired powerstations generate one third of the electricity requirements. In July 1973 electricity, generated with peat, was said to be a little more expensive than electricity obtained from oil. Probably it will be cheaper now.
Besides the purely economic aspect, the social weight was heavily because of the emigration problem. Bord na Móna employs up to 6000 workers on the bogs during the season and this work takes place where it is most needed, in the midland counties and the west.

9.4. Agricultural potentials.

9.4.1. Uncut peat.

The reclamation of peatland for agriculture has been practised for centuries; in many districts peatland is the only land available for agriculture. The potentials are restricted, however, by the excess of water, the low nutrient level and inaccessibility (7). A very intensive drainagesystem is needed for water-table control. With the blanket peats, difficulties arise because the surface is undulating in many cases as it follows fairly closely the contours of the mineral soil (6). Peat soils are generally deficient in many major and trace elements (19). Numerous combinations of Ca, N, P and K were used to determine optimum major element requirement (7). Cu is essential for the growth of cereals (13). Bo was required for sugar-beet, swedes and kale, Mo for brassicas. Mn has been found to be limiting in the growth of raspberries (19). Improvement can be obtained by replacing the existing vegetation with more productive species. Surface seeding (lime, fertilizers and seeds over the old vegetation) requires the minimum of equipment (7).

9.4.2. Cut-away peat.

The work of Bord na Móna has been responsible for renewing interest in agricultural possibilities of cut-away bogs (11). The Lullymore Cutover Peatland Experimental Station has carried out wide ranging experiments covering many aspects of grassland and horticulture for the past decade (1, 2). The experimental area increased from 10 ha

in 1960 to 65 in 1972. The data from this research are now being applied to commercial enterprises in beef, vegetable and nursery stock production on peat soils. In Bellacorick reclamation of cut-away bogs for agriculture has just been started. Each cut-away bog presents firstly a difficult problem by the excess of water, the deficiency in most of the major and minor elements, the subsiding of the peat by compaction, oxidation and loss of water, the occurence of hard wood, a.s.o. and secondly an essentially different problem because the variation in peattypes, the depth of peat remaining and the underlying soil considerably influence reclamation.
Generally spoken milled over bogs are more suitable for agricultural reclamation than cut over sod bogs.

Lullymore.

Soil: the soil in the visited experimental area consists of milled over peat on a subsoil of stoney, calcareous, glacial till. At many places the milling operations caused the complete disappearance of the sphagnum peat. At these sites the fenpeat, with an average depth of 0.6 to 0.8 m. lies at the surface. The peat has a pH of 5.2 to 5.8 and a base saturation of about 50%. At some places the sphagnum peat has not at all or has only partly been removed due to the presence of pinewood in the peat (see 5.2.2.), which is very hard and if it is abundant, it makes the peat unsuitable for milling. Dependant on peatdepth one distinguishes shallow (< 1 m.) and deep (> 1 m.) milled over peat.
Grassland: experimental work has shown that grass is the most suitable crop for shallow milled over peat (1). A rapid oxidation, the presence of stones in the subsoil and the layered nature of the fenpeat, giving rise to a low water transmission, make these soils unsuitable for tillage.
The conditions for good grassland are a good drainage and a sufficient fertilizer input.
Regarding the drainage: experiments have been done with several drainage systems. The visited field was drained by surface-grading (slope 1:100) to an open drain. Tile drainage would be satisfactory but it is too expensive due to the narrow distances required.
As to the fertilizers: N, P and K are given in amounts of resp. 300,40 and 225 kg/ha. These nutrients are recovered in the crop for 95%. In view of the decomposition of the peat it is not clear how this is possible. Besides the major elements one has to add Ca, Mg, Co, Fe and I. Cu is given directly to the cattle by injection; Mb, which occurs in relatively high amounts in the soil, would inactivate Cu in the soil. Liming is not necessary. Results are as good as those on the best mineral soils, treated with equivalent fertilizer inputs (1).

Horticulture: due to its physical properties humified sphagnum peat is very suitable for horticulture. The rapid oxidation requires a deeper than normal incorporation of lime and fertilizers. The old sphagnum peat shows a strong colloidal nature; it has a low rate of water movement and hazard of irreversibly drying is present. Without deep-ploughing good rooting is impossible. The pH is raised to 5.5. with 3.0 to 3.5 tons lime/ha. High yields of a good quality can be obtained with salad, carrots, sprouts, celery, French beans, onions, a.s.o. Due to night frosts early crops are impossible.

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PART II

Route of Tour: see Itinerary.

Tuesday June 26th. Accompanied by Dr. M. Gardiner and Mr. R. Hammond.

We drive from Dublin to Prosperous.

Route description: see page 1 of the Itinerary.
Geology: the route leads over Carboniferous limestone formations, covered by a 50-60 cm thick layer of Carboniferous limestone glacial till, consisting for 50% of lime.

West of Prosperous we enter the central flat area of Ireland with many raised bogs (see 9.1.2.).
Landscape: most of the peat bogs have been partly digged away. Because of the unsystematic way of handcutting the peat, a small-scaled landscape originated with a very irregular relief and a still worse drainage than the original raised bogs.
Reclamation: due to the very difficult reclamation, land in this area costs only 10 pounds/ha, reclamation costs on the contrary are over 350 pounds/ha. At some places reclamation for agricultural use was carried out on a private base. The calcareous drift material, with a loam to sandy loam texture, was used to raise pH and to strenghten the topsoil.
By this practise the ash-value raised from 2 up to 40%.
Farming: cabbage and potatoes are the most important crops, mainly grown on the base of part time farming. Part of the area is used as grassland.

First stop: the Bog of Allen.

A few miles west of Prosperous we stop to study a raised bog profile.
The bog at this demonstration point is part of a large bog system, known as the Bog of Allen, which runs in a south-west direction through the counties Kildare, Offaly and Tipperary. See chapter 9.2.2.

Second stop: the Lullymore Cutover Peatland Experimental Station.

Three subjects are dealt with:

1. Peat-monoliths: we get an explanation on how to make peat-monoliths by impregnating the peat material with polyethyleenglycol, which, heated to 80°C, mixes with water in all ratios. After 4 to 5 days the monolith gets dry, is rinsed with destilled water and fined to a board. By applying this method, the peat cannot oxidate or shrink and the colours are conservated.

2. Mechanical harvesting of peat: with the aid of some slides an idea is given about the way it is done. See chapter 9.3.

3. Reclamation of cutover bogs for agriculture: after lunchtime we visit some experimental fields of the station, where explanation is given concerning the reclamation. See chapter 9.4.2.

Third stop: Toposequence in Glacial Till.

On the area of the experimental station we study a toposequence in calcareous till of Weichsel age. Due to a different topographic position, which caused differences in drainage (see 4.2.3.), three different profiles developed in this parent material. The studied sequence is a common one in this area.

First profile : see page 5 of Itinerary for description and analyses.
Classification: Grey-Brown Podzolic of the Elton Series.
Land use : pasture with grass and clover.
Soil formation: from origin groundwater-level was relatively deep here, resulting in decalcification of the top 64 cm. According to Mr. Hammond profiles with a still higher position in the landscape show a deeper decalcification-limit.
After decalcification clay was mobilised, giving rise to an eluvation- and illuvation-horizon.
Suitability : due to a good porosity, the absence of compaction and a strong developed structure, the soil has good and deep rooting facilities, resulting in a wide ability. Difficulties can arise in forming a seedbed because of clodforming.
Vegetation : poor in species. Elytrigia repens (D: kweek) and Urtica dioica (D: brandnetel) were noticed, indicating a high nitrogen supply.
Remarks : the classification is tentative because distinct clayskins cannot be seen by the naked eye; micromorphological data are absent.

Second profile: see page 3 and 4 of the Itinerary for description and analyses.
Classification: Improved Gleysoil (not Grey-Brown Podzolic as mentioned in the Itinerary).
Land use : pasture with grass and clover.
Soilformation: the soil has been decalcificated down to 30 cm depth.
Drainage : this soil was imperfectly drained; due to the cutting of the peat in the surroundings and the digging of ditches, drainage is now moderately well.

Suitability : this soil is suitable for grassland; because of the improved drainage roots can enter the C-horizon.

Vegetation : many species, a.o. Briza media (D: trilgras) and Primula veris (D: slanke sleutelbloem). Some are indicating a high pH.

Remarks : differences with the first profile:
the solum is less thick (30-40 cm.), grayer colours, distinct mottling, a topsoil with higher % C.

Third profile :

Classification: Humic Gley; Haplaquept.

Land use : pasture.

Soil formation: decalcification down to a depth of 20 cm.

Drainage : poorly drained.

Suitability : this soil has too undeep rooting facilities and is too wet for tillage, resulting in grass as the most suitable crop.

Vegetation : many species. Some indication for wettness was found in the presence of Circium palustre (D: Moerasdistel) and Filpendula ulmaria (D: moerasspirea).

Remarks : differences with the first two profiles:
no mottling in the A1-horizon and again a higher % C.
The texture is somewhat heavier by the lower situation or by weathering in situ.
Some of us think to see a mole-passage. Mr. Hammond tells this is impossible, because there are no moles at all in Ireland (see 2.5.3.).

Fourth stop : Fontstown Series.

Midway between Lullymore and Kildare while staying in the bus, we studied a profile.

Classification: Grey-Brown Podzolic; Typic Hapludalf.

Parent material:calcareous, stoney till of Weichsel age, composed mainly of limestone.

Topography : this series is lying high in the landscape, giving rise to a lighter texture and a thinner solum than soils in the lower surroundings.

Soil formation: after decalcification, clay was mobilised resulting in a 20-80 cm. thick, tonguing B2t-horizon.

Drainage : due to a silt-content of 33% the structure of this soil is weak, resulting in grass as the most suitable crop.

Fifth stop: Gravelpit near Kildare.

Near Kildare we visited a gravelpit in an outwashplain of the Weichsel-glaciation, covered by glacial till. Layers of fine and coarse gravels and stones, often sloping, are alternating. The gravels are partly cementated to each other by lime, giving rise to huge blocks of hardened material. The lime infiltrated probably from above and is the result of the decalcification of the overlying soil-material. According to Prof. Pons such a cementation can occur within 10 years.
In the top of the gravels, soils of the Athy Complex with Grey-Brown Podzolics (a wavy B2t) and Brown Earths are found.

Sixth stop: Newbridge Fen.

Afterwards we had the opportunity to see some people of non fixed address and an original fenpeat (see 9.2.1.).

We return to Dublin and arrive in Broc House.

Wednesday June 27th. Accompanied by Dr. M. Gardiner.

We leave Dublin and drive southwards along the Irish Sea.
Route description and Geology: see page 7 of the Itinerary.

We arrive in the Kilmacanoque Valley. Evidence of Pleistocene activity associated with both the Saale and the Weichsel glaciations is abundant in the drift deposits, about which detailed information is given on the pages 8 and 9 of the Itinerary.

First stop: Grey-Brown Podzolic, Kilmacanogue Valley.

Near Kilmacanogue we study a profile developed in the Weichsel drift, represented by a terminal moraine behind which a fine recessional moraine of fluvio-glacial gravels occurs, (see 2.5.2.3.) left by the meltwater of a tongue of ice, which invaded the valley from the north. The profile has been developed in these gravels.
Description and analyses: see page 9 of the Itinerary.
Classification: Grey-Brown Podzolic.
Soil formation: an argillic horizon has been formed. Unfortunately micromorphological data are lacking.
Suitability : the soil has a wide use-range. Notwithstanding the presence of many stones, good crops can be obtained with barley, wheat, sugar-beat and pasture.
Remarks : there was some discussion how clay-mobilisation can occur while the pH-H_2O of the A2-horizon is 8.0.
Probably the soil has been limed or recycling of bases occured after the clay eluviated at a lower pH; or the clay weathered in situ (see 4.3.2.).

Second stop: Surface-water Gley of Macamore Series.

In the southern part of the valley, in the Macamore district, the Saale drift is located. For detailed information reference is made to page 10 of the Itinerary. After lunchtime we study a profile developed in this drift.
Description and analyses: see pages 10 and 11 of the Itinerary.
Drainage : poorly drained. The topsoil is soon saturated with water, giving rise to a high surface run-off (90%) and a dry subsoil. Artificial drainage consists of mole drains crossing tile drains in gravelbeds.
Soil formation: in the A- and B-horizon pseudo-gley features (see 4.3.3.) are noticed: the structure-elements are reduced at the outside and oxidated at the inside. The C-horizon is brown and oxidated.

Suitability : whilst the lime status of these soils is generally satisfactory, natural nutrient levels are very low.
Good management is needed to keep the rush short: only short rush is eaten by the cattle.

Remarks : the topsoil was very silty. According to Ir. Rogaar this could be due to the presence of two different parent-materials, i.c. an ablation till resting on a basal till (see 2.5.2.3.).

Third stop: Acid Brown Earth developed in Saale-till.

In the southern part of the Macamore district we study a soil developed in till of Ordovician shale composition.

Classification: distrochrept.

Texture : loam-clay loam.

Soil formation: the soil has always been acid, clay transport was not possible (see 4.3.2.); a homogenous brown profile with a cambic B-horizon developed.

Drainage : well-drained.

Suitability : this soil is very suitable for the growth of strawberries and raspberries.

Remarks : liming may cause clay migration (see 4.3.2.).

On entering the Screen area a drastic change in topography is evident.
This area has the characteristics of a young landscape. The kame and kettle pattern is demonstrated (see 2.5.2.3.).

Topography: see page 12 of the Itinerary.

Soils : see page 12 to 16 of the Itinerary.

Fourth stop: Acid Brown Earth developed in Coarse Textured Material

Near Curracloe we study an Acid Brown Earth developed in a deposit belonging to the South Irish End-moraine of the last glaciation (see fig.14).

Classification: Vorstvaaggrond or moderpodzol.

Soil formation: the parent material was calcareous in the beginning.
Due to continuous leaching the soil is quite acid now, for which reason we see features of clay illuvation (see 4.3.2.).
The narrow horizontal band of clay does not contain enough clay to be called a B2t-horizon and has been disturbed by biological activity.
Weak features of iron-and humus-migration are noticed.

Fifth stop: Johnstown Castle in Wexford.

We arrive at the headquarters of the Soils Division of An Fóras Taluntais. In front of the castle Mr. Ryann deals with several aspects of Johnstown Castle.
History : see page 15 and 16 of the Itinerary.
Acreage : the estate comprises 200 ha. About 80 ha is used for experiments on grassland. About 20 ha is in use for soil fertility experiments; barley and potatoes are the main objects. About 100 ha of woodland are included.
Research: investigations are done a.o. to fertilizers and to the relation soil-landuse concerning physical, chemical and biological aspects.
Field experiments are carried out here and on farms elsewhere.

In groups we visit the five departments located at the castle.

Soil Survey (Mr. Gardiner):
See chapter 5.

Soil Fertility and Chemistry (Mr. Brogan and Mr. Byrne):
The aim is to determine the chemical fertility of the different soils, especially with regard to N, P, K and pH.
Advises: if problems exist with soil-fertility farmers can insult an advisor, who studies the problem and takes samples. The samples are analysed at Johnstown Castle; results are given to the advisor, who draws his conclusion and advises the farmer. The insult, the analyses and the advise are free of charge.
Capacity: in one year about 50.000 plant- and about 100.000 soil-samples are examined. By the aid of an auto-analyser the capacity can be doubled.
Some findings: on soils derived from old red sandstone shortage of Mg may occur due to excessive amounts of K. On the same soils under grass there often is a shortage of Co. On various soiltypes a shortage of S occurs. There is too little air pollution to overcome this shortage; the use of gypsum is recommended. On soils derived from shales, Mb often reaches a toxic level inducing a shortage of Cu. In this case liming is advised.

Plant nutrition and Biochemistry (Mr. O'Sullivan):
Research is done in the field of plant nutrition, especially with respect to minor elements. In studies about ion-uptake great use is made of the activity of special enzymes, which may be explained in the beneath.
Iron-uptake: one of the studies in progress is the Fe-uptake by Timothee and Yorkshire Fog. A shortage of iron will be accompanied by a decreased activity of the enzyme reductase in the root. For this reason the activity of this enzyme is a measure for the amount of active iron.

The activity of the enzyme reductase is determined by the amount of Fe^{3+} which is reduced to Fe^{2+}, which gives a blue colour with potassium-ferricyanide and can be measured colorimetrically. In an equal way the uptake of Zn and Mn is studied with the enzymes aldolase resp. peroxidase.
Shortage of Cu, Mn and Zn: investigations learned that these elements tend to lack in lime-poor areas, what may be caused by a more intensive agriculture and the absence of the elements in normal NPK-fertilizers.

Soil Biology:

Research is done a.o. to the N-fixation by white clover. Some results:
- at a lower light intensity more N is fixated,
- most N is fixated between 21 and 17°C,
- between May and August less N is fixated; assimilation products are used for seed products in this period and are thus not available for bacteria,
- the most N is fixated on dry soils.

Grassland Nutrition and Ecology (Mr. Murphy):
Growth season: in the southern part of Ireland the growth season for grass lastst from mid or late April till early October. In the northern part the season is two months shorter due to the colder and wetter climate (see chapter 1).
Manuring: the average N-gift is about 20 kg/ha. According to Mr. Murphy reaction on N would be slight (20 to 25 kg d.m./kg N/ha) due to the high organic matter content of the soils. Clover is still very important.
On most grasslands P is in minimum.
Stocking rate: 1 cow/ha with a potential for 2 with a N-gift of 200 kg/ha.

Driving to Wexford we were dropped off at several hotels.

Thursday June 28th. Accompanied by Mr. T. Finch.

Driving from Wexford to Waterford we pass an old glacial landscape with only small differences in parent material, mainly consisting of long east-west and parallel running ranges and valleys.
Geology: in Ordovician times mainly clay sedimentated. On the clay sandy material was deposited in Devonian times. On this material lime sedimentated during the Carboniferous. The Variscan Orogeny caused folding which gave rise to the formation of synclines and anticlines and metamorphosis to resp. Ordovivian shales, Devonian old red sandstone and Carboniferous limestone (see chapter 2).
Glacial influence: during the Riss glaciation the land was covered by till consisting of a mixture of limestones, sandstones and shales. The melting of the ice caused erosion and solifluction. Thus on the ridges mainly old red sandstones and sometimes shales are found and in the valleys a mixture of limestones, sandstones and shales. The icetongues and the glacial meltwater streams formed big valleys, in which small rills are streaming nowadays.
Soils: from till, mainly composed of shales and sandstones, mainly Brown Podzolics and Acid Brown Earths developed. Where shales dominate, commonly Gleysoils are found. 70% of the soils in this area is well-drained; the main problem is the variation in soil-depth.
Farming: arable land covers only a small part of the area; the agricultural use is a mixed one. The average farmsize is 20 to 25 ha; the sizes increase now because many families die out or leave. Upto only a few years ago meat-production was very important, now being replaced by milk-production more and more. The arable cultivation is mainly directed on the production of cattle-feed. On the very shallow soils woods are growing.Fences of stones and trees or shrubs are abundant. The stonefences originate from the past when more land was used for tillage. The fences of trees and shrubs cover 10% of the grassland area, they originate from the 17th or 18th century and much of them are removed now.
Having crossed the long drowned estuary, known as Waterford harbour where the rivers Suir, Nore and Barrow join and reach the sea, we arrive at Waterford.
Farming: although the landscape and the parent material remain the same, leaving Co. Wexford and entering Co. Waterford, a more intensive agriculture is noticed. This would not be due to a change in climate or soils, but to the tradition of using more fertilizers.

First stop: Profile developed in Old Red Sandstone-till of Saale age.

A few miles west of Waterford we study a profile.

Classification: Brown Podzolic or Acid Brown Earth.

Topography : this profile is lying on a slope.

Texture : sandy loam (7 to 10% clay, 20% silt).

Soil formation: it is not clear whether the B-horizon is a cambic or a spodic one; probably we have to do with a transition.

Remarks : in the lower surroundings several types of Gleysoils are found, some of which are very grey-coloured.

We drive on to Fermoy.

Geology: on the ridges we mainly find old red sandstone, and in the valleys limestone.

Soils: the drainage of most soils is much better than in the area where shales dominated.

Farming: the limestone valleys are well-cultivated; due to the immigration of English colonizers during the past centuries less fences and more trees occur, giving the impression of an English landscape.

Second stop: the Moorepark Dairy Research Centre.

Following the River Blackwater lined with a strip of alluvial soils, we arrive at Fermoy. Mr. M.J. Mulcahy gives us information about the centre.

General: the centre was established in 1959 with the aim to further an efficient production of milk and pork.

Research: the complete production-sequence is multidisciplinary studied by the five operating departments: dairy microbiology, pig husbandry, dairy husbandry, dairy technology and dairy chemistry. Most research is done by graduate and post-graduate students. Research is financed by government and industry; individual as well as national problems are studied.

Testfarms: the centre ownes two farms in the surroundings and rents three farms elsewhere on different soiltypes. At the farms results can be tested on their practical value or reproduced under other circumstances (soil, climate).

The two farms near the centre were shown to us by Dr. Pheeley, head of the department of dairy husbandry.

First farm:

Improvements: the farm has been improved by (1) elimination of the tree/shrub fences and electric fencing (2) fertilizing with 250 kg N/ha in 5 to 6 gifts per growing season and (3) good management.

Number of cows: there are 250 milkcows on the farm, 3.1 cow/ha.
Production: 11,000 kg d.m./ha/year; 2750 liter milk/cow/year.
Milkstable: a walk-in-milkstable of the herringbone-type is used; its back is orientated to the south-west. With the 14 machines 2 man can milk 140 cows/hour. The stable should be placed in the centre of the area. Costs of the stable: 4500 to 5000 pounds.
Food: from the beginning of march till the end of november the cows are outside. In the stable-period the cows are fed with silage. After the calving the silage is replenished with concentrated food composed of soyabeans and mais, sometimes of barley and molasse. Concentrated food is given in amounts of 100 kg/year.

Second farm:

Stable: a laybox-stable is shown us, cheaply constructed of galvanised pipes, and with a corrugated iron roof for the comfort of the operator.
Slurry: the slurry is sammled in a 2 feet deep pit and is spread over the area after the second cut of the hay.

We drive on to our hotels in Fermoy.

Friday June 29th. Accompanied by Mr. Tom Finch and Mr. Jim Kiely.

The reclamation of rolling heatherland.

We leave Fermoy ascending an old red sandstone anticline, we move in south-west direction. The area consists of a rolling upland, which has been covered by glacial till; locally this cover has been eroded, on most places till has been covered by peat.

First stop: Peaty Iron Pan Podzol developed in Old Red Sandstone-till.

A few miles south-west of Fermoy we stop to study a profile.

Classification : peaty iron pan podzol; placaquod .

Parent material: compact, drab (D: vaalbruin), stoney old red sandstone-till.

Vegetation : burned heather vegetation with calluna, scirpus caespitosa.

Soil formation : the development of this soil can be divided into four stages (see 2.5.3.):

- development of an Acid Brown Earth in acid parent material under the Atlantic climate. This is a well-drained soil with deep rooting facilities. The natural vegetation is wood.
- the second stage starts by cutting the woods, which took place on a large scale from Neolithic times onwards on aid of shifting cultivation (see 2.5.3.).
  After cultivation was abandoned, the trees were unable to regenerate under the more unfavourable climatic conditions of the Iron Age, and heath becomes the dominant vegetation (3). The undeep rooting system causes an accumulation of organic matter in the topsoil. The soil is still well-drained. Sometimes, however, much water is stored in the topsoil, giving rise to a lowering of the redox-potential and consequent reduction and mobilisation of Fe and Al.
  In this stage a Brown Podzolic is formed.
- in the third stage as much iron has been reduced and mobilized that beneath the main rooting zone, where the organic matter content is low, giving rise to a lower water holding capacity and a higher redox-potential, an iron pan is formed. The pan is strongly cementated and divides the profile in two layers. The pan is nearly impermeable for water and roots.We are dealing dealing now with an Iron Pan Podzol.
- after the pan has been formed the topsoil becomes wetter. In this stage peat is formed, the soil changes into a Peaty Iron Pan Podzol.

Horizon	Depth	Characteristics
Ao	6-0	
A1 -A21h	0-4	peaty, 20-30% org. matter, 5-7% clay, densely rooted.
A2h-A22h	4-12	same amount of org. matter and clay; gley phenomena.
B2ir	12-15	wavy and branched iron pan; (and thus according to Soil Taxonomy not an iron pan); above the pan roots stagnate.
B22ir(t)	15-34	30-40% silt, 10-12% clay, orange-brown coloured, pH=5, free drained, this spodic B is the result of soil-formation in the second stage.
C	34+	5-8% clay, weathered from the limestone which makes up a small part of the till.

Suitability : this is a marginal soil.

Remarks : before the Big Famine the fragipan was broken with crowbars. After this time the area was left. Recently one started to reclaim the area for the growth of Pinus spp. Because of a changed economic situation however, the area will be used for grassland. Costs of reclamation: 70 pounds/acre (f 1150/ha), including costs of cultivation, seeds and fertilizers. Reclamation comprises breaking of the iron pan, ploughing and removal of the stones. Almost certainly this reclamation will strongly influence the soils in the lower surroundings by an increased water discharge. In fact all influences should have been studied. Due to the costs and the bad cooperation with soil-physicals, research on this subject has not been done.

Second stop: Peaty Podzolised Pseudogley developed in Old Red Sandstone-till.

In the lower surroundings of the peaty iron pan podzol we study a gleysoil.

Classification : peaty podzolised pseudogley; aquept.

Parent material: old red sandstone-till with a higher content of silt and clay, more compact and less stoney than the first profile.

Vegetation : a.o. spruce and sphagnum.

Soil formation : due to the compact, impermeable nature of the till the profile has always been wet. In contrast with the former profile a sharp boundary between reduced and oxidated soil is absent, for which reason an iron pan could not develop; as a result most of the iron has been removed.

Secondly the nature of the till caused the development of pseudogley features (see 4.3.3.).

Because of the low pH and the wet, reduced circumstances the clay material in the topsoil has partly been broken down.

In the A-horizon a weak B2h-horizon develops. A still lower pH will cause stronger podzolisation.

Suitability : during a long period each year this soil is too wet for grassland. Forestry is recommended.

Remarks : this area has been reclaimed one century ago. Some of us could see this at the disorderly nature of the top 30 cm of the profile or at the vegetation.

Third stop: Brown Earth at the Moorepark Dairy Research Centre.

We drive back to Fermoy to examine a profile.

Classification : Brown Earth with low base saturation; Dystrochrept.

Parent Material: old red sandstone till containing more limestone than parent material of former two soils. Clay-content: 10 to 15%. pH=6.0.

Land use : grassland.

Soil formation : -by weathering the clay-content of the Ap-horizon raised from 10 to 15 up to 20%; this was said to be very common for Ap-horizons of the Acid Brown Earths in Ireland.
-decalcification caused pH to go down from 6.0 to 5.4 (due to liming pH is 6.5 at present). It is not clear why this fall in pH was not accompanied by clay-mobilisation (see 4.3.2.).
-the A-horizon is overlying a cambic-B-horizon.

Remarks : -before liming this profile had to be classified as an Acid Brown Earth.
-the liming has consequences for the clay-mobilisation and, according to Prof. Pons, a textural B-horizon possibly may develop in future. Why however clay-mobilisation due to a rise in pH and not due to a fall in pH?
-the Ap-horizon is rather dark coloured. Probably this is due to the enrichment with manure; the soil has long been used for tillage before the Dairy Centre started experiments.

We drive from Fermoy to Herbertstown.

Landscape: near Fermoy we see an anticline-syncline system like the one between Wexford and Fermoy (see June 28th).

Endmoraine: against the mountains in the north the Weichsel endmoraine, consisting of small hills, is found (see fig.14). Due to the absence of permafrost, periglacial features lack.

Volcanism: near Herbertstown features of Carboniferous volcanism can be noticed: layers of lime are alternating with layers of ash, the eruptiva are acid; in the limestone instrusions of bazalt occur.

Fourth stop: the Herbertstown Economic Testfarm.

General: the farm was founded in 1959 by the Agricultural Institute with the aim to determine the stocking rate for milchcows on good grassland.
Improvements: ditches were filled up, tree- and shrub-fences were eliminated and the grassmixture was improved.
Stocking rate: the improvements resulted in a stocking rate of 1.9 cow/ha.
Present task: experiments were finished and nowadays the farm belongs to the Moorepark Dairy Research Centre. The main task is to grow heafers.
Slurry: by way of a pipeline the slurry is transported to the grassland and is spreaded over the surface.

The Elton Gravelly Loam Series.
On the area of the testfarm we study a profile.

Analyses	: see page 17 of the Itinerary.
Classification	: (minimal) Grey-Brown Podzolic.
Parent material	: limestone till with 20% shales, sandstones and andesitic, acid volcanic material.
Land use	: grassland.
Soil formation	: the profile shows an A1-, a grey A2-, a weakly developed B2t- and a C-horizon with free Ca. Throughout the solum clayskins and other features of mass-transport can be seen by the naked eye.
Drainage	: well-drained.
Suitability	: the soil has a well developed, but due to the high silt-content a very weak structure. Without addition of organic matter the structure would be degenerated within 4 years. In connection with this problem the soil has a limited use for tillage. With wheat special problems are to be expected because this cereal mainly uses water with a tension in the pF-range 2.5-3.0 and especially the B2t-horizon contains much water with this tension; the wheat would grow too fast and would be laid (D: legeren). Due to the drainage and the deep rooting facilities (3 feet) the soil has a wide use-range for pasture (stocking rate 1 cow/acre), for forestry and for the growth of hard fruits. However, the climate is rather moist, so it would be difficult to spray against illnesses; the low mean temperature, storms ,few sunshine and lack of a market organisation are other adverse factors for fruit growth. For these reasons the soil is not used as such.

Remarks : Someone questioned about the absence of gleyphenomena while Elipacuris, the best moist indicator under Dutch circumstances was present. Mr. Finch explained that the topsoil is saturated with water during wintertime and that gleysoils are found in the very near surroundings.

The Howardstown Clay Loam Series.

On the area of the testfarm we examine another profile.

Analyses : see page 17 of the Itinerary.

Classification : Mr. Finch calls this soil a Gley; low humic gley, groundwatergley; poldervaaggrond.

Parent material: same as former profile.

Topography : This soil is lying 2 or 3 meters lower than the former one.

Land use : grassland.

Soil formation : decalcification down to 25 cm. The B-horizon is prismatic.

Drainage/Hydromorphy : the soil is poorly drained. Rustmottles up to the surface, blue-grey C-horizon at 1 meter. In wintertime water reaches the surface. Mole-drainage would improve drainage; the drains will maintain during 4-5 years.

Suitability : the soil has rooting facilities down to 40 cm. The soil is too heavy to be ploughed and is consequently only suitable for grassland or forestry. The stocking-rate is 1 cow/2 acre, with fertilizing 1 cow/1.25 acre.

Remarks : this soil covers 15% of County Limerick.

From Herbertstown we drive to Shannon.

Endmoraine: another time we see hills of the Weichsel end-moraine.

History: from Neolithic times on people lived in this area (see 2.5.3.) a few miles west of Limerick we stopped at a circle of big stones, among which old red sandstones.

Museum: we visited the Open Air Museum, located midway between Limerick and Shannon.

Fifth stop: the Shannon Alluvium Series.

At Shannon we examine a profile.

Analyses : see page 20 of the Itinerary.

Classification : fluvaquent; poldervaaggrond.

Parent material: silty clay.

Soil formation : free Ca occurs throughout the profile. The topsoil is brown and ripened. In the B-horizon prismatic structures and gleyphenomena are noticed. The subsoil is grey and half to nearly ripened; pyrite is present.

Drainage : the soil is not flooded anymore. With a good artificial drainage cracks will develop giving rise to a good permeability.

Suitability : due to the high siltcontent this soil is difficult to utilize resulting in grass and poplar as the most suitable crops.

We drive from Shannon to Limerick and arrive at our hotels.

Saturday June 30th. Accompanied by Mr. Tom Finch.

We leave Limerick, drive westward along the norhtern side of the Shannon and enter County Clare. The southern boundary of this county is formed by the northern shore of the Shannon, which, westward of Limerick, widens in a 95 km long estuary to meet the Atlantic Ocean.
We are driving on limestone, along a ridge of old red sandstone. The farming and the houses look prosperous. Due to the danger of flooding the houses are built on drumlins.

First stop: Grey-Brown Podzolic developed in Limestone-till.

North of Limerick we stop at a roadcut to study a profile of the Patrickswell Series (see page 19 Itinerary for Profile Analyses).

Parent material: the upper 70 cm of the profile consists of Weichselian glacial drift of limestone origin mixed with some old red sandstone. The underlying bedrock consists of carboniferous shaley limestone.

Land use : grassland.

Soil formation : compaired with the Elton Series seen in Herbertstown (see June 29th, fourth stop) this soil is shallow since the parent material is 2000-3000 years younger.

Drainage : due to the development of solution cracks in the, in itself impermeable, shaley limestone, the soil has internal drainage.

Horizons	: Characteristics
IA1	
IA2	
IB2t	this horizon has a very good round blocky structure. Many biopores are noticed giving rise to good rooting facilities. At the sites of the structure elements dark-brown clayskins can be recognised. Few mottles.
IIB2b	this dark-coloured structure B-horizon has been weathered from the shaley limestone.
IIBD	transition from the IIB2b- to the D-horizon.
IID	fast weathering, impermeable limestone with many solution cracks.

Suitability : due to the high silt- and the low clay-content in the topsoil the structure is not stable; on the surface a crust can develop easily. Liming and application of organic matter is necessary to improve this soil.
Because of the good structure of the IB2t-horizon and the cracks in the subsoil the agricultural potentials are high with good tillage possibilities.

We pass the Cratloc hills, which bear handplanted oakforests of appr. 65 years old. The oaks were used for the roof of Westminster Hall in London and for the Royal Palace in Amsterdam. The forests grow on drumlins made up chiefly of Devonian old red sandstone material, left here by the Weichsel glaciation. There is no evidence that this area was previously used for agriculture.

Toposequence on the Cratloc hills.

In the development of the soils and in the natural vegetation a toposequence can be recognised (see 4.2.3.):

	at the foot	halfway	on the top
O-horizon	10 cm thick	thinner, due to better humification	lacking
A2-horizon	25 cm thick, fragipan-like, only few roots can penetrate this hor.	size and fragipan character have been decreased	lacking
B-horizon	orange-brown, no clay	low % of clay	?
size of trees	low	higher	high
vegetation	poor, acid Querceto-Betuletum	transition "	rich, less acid Querceto-Capinetum

Probably this toposequence has been caused by a large lateral waterflow to the foot of the drumlin.

Throughout the area we notice long low drumlins: the glacial ice moved relatively fast here (see 2.5.2.3.).

Second stop: Monastry in Dysert O'dea.

In Dysert O'dea, 8 km NW of Ennis, we visit the remnants of an old monastry: an imcomplete round tower dating from the 6th or the 7th century and a chiseled high cross from the 10th century. Among the remnants of the church there is a 12th century doorway with interesting sculpture. Near the monastry the O'dea castle dating from the 14th century is found. This castle has been renovated by the new Irish-American owner. The old monastry and the castle were built on a recessional moraine made up of large limestone boulders. The recessional moraines of the Weichsel glaciation consists of well-drained, coarse grained calcareous drifts.

Going westward the Carboniferous limestones are gradually disappearing under Carboniferous shales. Due to this the drumlins contain decreasing amounts of limestone and sand and increasing amounts of shales. The drumlins become higher and less numerious too. In the shale area rushes are commonly found. Between the drumlins fenpeat often developed, sometimes raised bogs are found.
Many boulders are found in the till and the fields are much smaller.
These areas are reclaimed with government grants. Great poverty is prevailing; the average size of the farms is less than 30-50 acres on mainly poor soil, only suitable for grazing. By comparison the minimum farmsize on good soils in eastern Eire should be 70-80 acres to have a reasonable income.
There is still another reason for the poverty: climatic suitability for agriculture deteriorates from east to west (see 7.4). Rainfall increases steadily from about 1000 mm near Limerick to over 1500 mm on the westcoast of County Clare. Also windvelocity increases and may be a limiting factor for agriculture.

Third stop: Surface-water Gley of the Kilrush Series.

Only one mile west of the limestone area we study a profile at the foot of a drumlin. Profile analyses on page 20 of the Itinerary.

Parent material: coal measure shales underlain by Millstone Grits (see 2.3.2.).
Soil formation : a cambic-B-horizon developed.
Drainage : in wintertime this soil is wet, during summer dry. Artificial drainage will give poor results because there is hardly percolation through the soil, due to the high clay- and silt-content. Run-off during the winter is great.

Horizon	Depth	Characteristics
A11	0-10	
A12g	10-20	
Bg	20-30	prismatic structure and mottling.
Cg	30-40	parent material derived from shales.
D	40+	parent material consisting of millstone grits.

Suitability : the land-use is inhibited by the high clay- and silt-content. This soil cannot be tilled. Strong winds form another limitation. Stocking rate: 1 cow/acre. Spruce would do well on this soil, estimated yield: 12-13 m^3/ha.
Roots, mainly from rushes, go down as far as the bedrock.

Remarks : -this soil occurs all over the drumlin; rarely and on isolated places on the sites and on the top Acid Brown Earths and Brown Podzolics are found.
-the Clare shales are notorious for containing considerable amounts of K, Mb and Se.

Fourth stop: Mountcollins Series.

About ten miles westward we study another profile.

Classification : Acid Brown Earth tending to Brown Podzolic; Distrochrept.

Parent material: Upper-Carboniferous shales.

Soil formation : the shales have been weathered to clay loam.
The acid parent material delivers free Fe and Al.
A homogenous Fe-rich subsoil is developing.

Drainage : well drained, due to the good structure and the occurence of many cracks in the bedrock.

Suitability : due to the occurence of free Fe and Al the structure is stable, unless the high siltcontent. The good structure furthers biological activity, which again increases the stability of the structure. The rooting facilities are excellent. If the climate was not so wet this soil would be very suitable for tillage. Stocking rate: 1-1.5 cow/acre.

Driving westward we ascend the North Clare Hills. The drumlins here ressemble kames, being almost circular. This kind of drumlins has been derived from nearly immobile ice (see 2.5.2.3.), which in this case was impeded by the mountains. Small kames and meltwater channels occur also in this hilly landscape. Over the whole area blanket peat occurs, from which much has been cut.

We arrive in the coastal area, where Saale till is underlain by Upper-Carboniferous coal measure shales. Due to solifluction of the drift material the soils are only 2-3 ft thick and dry, making this area unsuitable for farming. Employment is mainly found at the peat generated electricity plants.

Fifth stop: Surface-water Gley of the Kilrush-Alkaline Series.

At Spanish Point we study an Alkaline Surface-water Gley.

Parent material: Saale drift composed of shale and limestone, underlain by Upper-Carboniferous shales.

Horizon	Characteristics
A1	the changing thickness of this horizon is probably due to the dash of the waves, throwing material on the coast; on the surface and in this horizon rounded boulders are found. The dark colour of this horizon may be caused by the dark parent material or by the drying of seaweed, which is used as food for chickens.
B	in this rusty horizon weak features of clay-illuvation are noticed. Strongly prismatic structure.

Remarks : western winds carry fine drops of seawater up to one mile landinward. Consequently trees only grow in the lee of drumlins and show dead tops, due to the salt-effect.

We drive in northern direction through a kame and kettle landscape (see 2.5.2.3.).

Sixth stop: the Kliff's of Moher.

Here we buy some picture-postcards to enjoy the beautiful view on the Atlantic Ocean. Very clearly we see the spray of seawater, going up along the rocks. The kliff's raise 150 m. above sealevel and are composed of shales interrupted by some layers of sandstone. They were formed by glacial erosion; landinward a solifluction layer of shales could be noticed, indicating that the tops were situated above the ice.

Driving in north-eastern direction we soon re-enter the Carboniferous limestone area. At most places the probably thin layer of till has been washed away; the till can be found back in the cracks of the limestone bedrock. We notice the so-called karn weathering, finding its expression in horizontal as well as vertical fissures, in small rills and small gaps. As regards the vegetation, reference is made to page 18 of the Itinerary.

Seventh stop: Rendzina at Black Head.

Parent material: limestone till

Drainage : well-drained

Horizon	Depth	Characteristics
A1	0-15	20% lutum; brown coloured; good, very crumby structure.
C	15+	parent material, consisting of Carboniferous limestone, very fine grinded by the ice. Pockets with brown topsoil material.

Suitability : the A1- as well as the C-horizon allow very good rooting. Due to the dark colour this is an early, warm soil on which oat and barley can be cultivated. For Irish circumstances this is a good soil.

Remarks : Mr. Dinc mentiones that in Turkey hard limestone occurs and asks if Rendzina's will also develop there. This is not the case. Rendzina's will only develop on soft limestone with free drainage. This rendzina will change into a Brown Earth; from the Brown Earth a Grey-brown Podzolic will develop.

Along the coast we drive from Blackhead to Galway.

Sunday July 1st. Accompanied by Mr. T. Finch.

Route: we leave Galway and drive in western direction along the coast. Having past Inveran we go to Maam Cross and drive in western direction to the Twelve Pins. Via Maam Cross, Oughterard and Moycullen we return to Galway.

Geology: along the coast a strip of kame and kettle landscape occurs on granitic bedrock. From a few miles landinward to a line crossing Maam Cross in east-western direction an area extends with granit rock and glacial till. North of this line the parent material consists of mica-schist, gneiss and quartzite.

Soils: in the coastal strip we find poor peatland and very shallow or no soil (very acid, peaty podzols). Landinward climatic peats, rock outcrops and to a less extend shallow podzolised soils are noticed. The Twelve Pins form part of an area with peaty podzols and climatic peats.

Settlement: the kame and kettle landscape is hard to reclaim. It is cultivated however; the fields are much smaller and fertility is much lower than in the limestone area. Main employment is found in fishing and small scale farming (sheep, horticulture). Landinward remnants of settling are absent. The land is common property, everyone is free in cutting the peat.

Blanket peat: in Connemara we climbed a mountain and studied the vegetation in the blanket peat (see 9.2.3.).

Monday July 2nd. Accompanied by Mr. M. Walsh and Mr. P.J. Burke.

We leave Galway and drive in NE direction through almost featureless, gently undulating lowlands. On most places the Carboniferous limestone, an almost pure clear water deposit, is covered by a thin and heterogenous layer of limestone till.

On our route we notice different glacial features (see 2.5.2.3.):

First stop: Kames and Kettles.

Before reaching Tuam we pass a small kame and kettle landscape. On the higher parts only shallow soils can be found: Brown Earths, mostly less than 30 cm deep and with a high base saturation. In the lower parts somewhat deeper soils, up to 60 cm, with a weak argillic horizon:
Grey-brown Podzolics.

Second stop: Endmoraines.

North of Tuam, where the moraine cover can be up to 50 m. thick, a landscape with recessional or tempory endmoraines is found.
In the depressions between the long, low, parallel hills lakes were formed in which gyttja was formed by the fauna living in the lakes.
Gyttja is a kind of organic marl with 75% $CaCO_3$. On the 2 à 3 m. thick layer of marl, fenpeat developed and afterwards a raised bog.

Third stop: Esker.

Midway between Tuam and Dunmore we study an esker (for information concerning geology see 2.5.2.3.). As regards the soil:

Classification : Brown Earth
Texture : sandy loam
Parent material: young, unsorted material consisting of rounded, sometimes shaley limestone
Soil formation : decalcification up to 40 cm.
Drainage : well-drained. Due to a good porosity little or no run off.

Horizon	Characteristics
A1 B	the solum, consisting of an almost black, thin A1 and a structure B-horizon, varies in depth from 10-40 cm. Base saturation very high, pH 6 à 7.
C	unchanged parent material.

Suitability : these soils would be suitable for sugarbeets; due to the small sized fields (reclamation is complicated and expensive) they are used for sheep grazing.

Remarks : on the esker Rendzina's are found too, with more or less the same characteristics, and very seldom Grey-brown Podzolics.

Driving back via Tuam to Kilmaine, we enter another kame and kettle landscape, west of Kilmaine. The glacial drift is 5 to 6 feet thick and sometimes layered. Soils on the upper slopes are 10 à 20 cm deep, on the lower slopes up to 60 cm.

Fourth stop: The Belclare Research Station.

Mr. T. Holan and Mr. Quirke of Belclare Research Station, which is attached to the western research centre located at Creagh, are dealing with several aspects of sheep husbandry:

General: in this area 80% of the land is covered by grass, from which 80% is permanent grassland. Natural grass production is low: 5000 kg d.m./ha.

Stocking rate: 5 ewes/ha. With a low fertilizer gift it is possible to keep 15 ewes/ha, with a lambmeat production of 300 kg/ha.

Co-grazing: research is done to determine the best ratio between sheep and cows; there are indications the so-called co-grazing gives optimal returns.

Manuring: a fertilizer gift of 60 kg N, 20 kg P and 50 kg K/ha gives a yield of 12,000 kg d.m./ha; a gift of 150 kg N, 20 kg P and 50 kg K/ha gives a yield of 18,000 kg d.m./ha.

Stable period: in the months Dec., Jan. and Febr. the sheep are in the stable and are extra fed: silage and Mo.

Breeds: from the 1000,000 Irish ewes 700,000 are Galway ones. These sheep are big but have a moderate fertility: 1.4 lamb/ewe. The crossing of a Galway with a Finish Bread resulted in a slighty smaller animal, but with increased fertility: 2.0 lamb/ewe. With grants of the government the rams of this new breed are brought to the farmers. Crossing this new breed with Texel sheep resulted in a breed with a decreased amount of fat but a somewhat slower growth. This last breed has been crossed with Suffolk sheep to adapt it to Irish climatic conditions.

Lambtime: lambs are born in september and in march. 50,000 sheep are treated with hormones to change the lambtime in order to have fresh lambmeat also in the other months.

At the research centre we study 2 profiles:

First profile : description and analyses see page 23 of the Itinerary.

Classification : Brown Earth; Ochrept

Parent material: Carboniferous limestone glacial till

Land use		: grassland
Drainage		: well drained
Horizon	Depth	Characteristics
A11	0-16	
A12	16-26	a weak argillic horizon was noticed here. Perhaps due to biological homogenisation this horizon is weak.
A/C	26-42	
C	42+	black spots, caused by the weathering of the C-containing limestones.
Suitability		: due to the good, rounded blocky structure this soil has excellent rooting facilities. This is one of the best soils we saw, excellent for grassland.

Second profile		: description and analyses on page 24 of the Itinerary.
Classification		: Low Humic Gley; Broekeerdgrond.
Parent material		: lake deposit
Land use		: grassland
Drainage		: poorly drained
Horizon	Depth	Characteristics
A1	0-35	black spots
C	35+	rust mottles
Suitability		: this soil produces as much grass as the first soil does. The weak structure of the topsoil and the bad drainage however make it little accessible for sheep.

On the way to Achill Island we gradually see the limestone being replaced by old red sandstone.
Having passed Ballyhean the landscape is composed of drumlins. In the depressions inter drumlin peat is found. Along Macombe-bay we stop to have a look at the drowned drumlin landscape.
Drainage is getting worse: rushes and gleysoils.

Tuesday July 3rd. Accompanied by Mr. M. Walsh and Mr. P.J. Burke.

We drive from Achill to Dooagh.

Soils: the dominating rock on Achill Island is quartsite, some old red sandstone is found too. The soils are consequently very acid: mainly peaty podzols, peaty gleys and peats are found.

Employment: Achill Island is populated by a fishing community. Only from the early summer till september, however, the sea is quiet enough to fish. Complementary employment is found in agriculture. Average farmsize is only 10 acres; most of the farming is done by hand, sometimes horses are used. The main object is sheep, some potatoes and oat are grown.

Tourism: about 10,000 tourists visit Achill Island each year.

First stop: Peaty Iron Pan Podzol.

Just before Keel we study a profile.

Texture : sandy material, boulders through entire profile.

Parent material: acid, quartsitic glacial till.

Soil formation : see June 29th, first stop.

Horizon	Depth	Characteristics
0	20- 0	climatic peat, independant of the profile
A21	0-10	bleached horizon, no motting, no blue colours.
A22	10-20	bleached horizon, darker than A21. This horizon is a kind of B2h-, Mr. Walsh called it an A2h-horizon.
B21ir	20-25	branched iron pan. Few roots can penetrate this pan. This horizon is also found in boulders.
B22	25-45	brown, free drained, strongly oxidated cambic B-horizon.
C	45+	unchanged glacial till.

Suitability : breaking of the pan is necessary for cultivation.

Remarks : at some places the pan has been dissolved and developed again somewhat deeper in the profile. The part of the profile above the newly formed pan is getting deferralised.

The B2h-horizon keeps unchanged and shows the place of the former pan. The solution of the iron is probably caused by accumulation of organic matter as a result of waterstagnation above the pan, giving rise to reducing conditions.

Second stop: Left Village.

From Keel we drive to Dooagh to see a left village on the slope of a hill. Before the Famine at least 500 people lived here in very small houses.
Ridges: the inhabitants had a special way of growing potatoes: they made ridges on which 3 rows of potatoes were planted. The ridges follow the slope. Close to the village they show the next profile: a 40-50 cm thick plaggen epipedon, consisting of dark coloured, homogenous sandy material (seasand?), free of stones; then a brown B2ir, overlying an olive grey C-horizon. The parent material contains much gneiss with chlorites. Vegetation mainly grass. Higher on the slope we find young reclaimed land, also with ridges. The ridge material looks heterogenous, is stoney and the original soil material can be recognised. Traces of an ironpan podzol are noticed. Vegetation: grass with heather. Still higher we find a slope without ridges. We see a peaty ironpan podzol with a peaty A1, an A2h, a B21h (place of former ironpan), a purple B22 (weathering), a B2ir (ironpan) and a brown B3-horizon. Vegetation: tormentil, scirpus caespitosus, erica, juncus squarosis. On the valley floor we could recognise the former parcelling, forming a mosaic of small ridged fields. The stone walls of the recent parcelling cross these older fields.

From Dooagh we drive to Bellacorick through a blanket peat landscape.
Erosion: at some places the peat has strongly been eroded by the sea, who enters the area by tidal creeks. Possibly this is due to the raising sealevel and the downward movement of the Irish coasts (see 2.5.3.).
Cutting: much of the peat has been cut by hand, resulting in an irregular surface topography.
Drainage: along the roads the peat is strongly drained.

Third stop: The Bellacorick Peat-fired Electricity Generating Station.

Mr. Seamus O'Gorman deals with several aspects of harvesting peat (see 9.3.).

We leave Bellacorick and drive to Sligo. We leave the area with acid, quartsitic rocks and peats and enter, just before Ballina, an area with limestone and drumlins.

Wednesday July 4th. Accompanied by Mr. M. Walsh and Mr. P.J. Burke.

We leave Sligo and drive in northward direction.

Yeats: we stop at the grave of Yeats, the celebrated Anglo-Irish poet who won the Nobel Prize for Literature. Near the churchyard we see a Celtic Cross. These crosses date from the 6th to the 12th century and are probably a continuation of the standing stones from former times.

The eldest Celtic Crosses are smooth with only a few Celtic signs, in the younger ones biblical representations are chiseled.

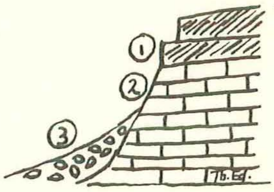
We drive on to the valley of the Benbulbin mountain.

Valley: the valley between the mountains was completely filled with ice in the Pleistocene. Many drumlins are found here, never exceeding the 200 meter level. The moraine material consists of limestones and shales.

Most soils are heavy textured surface-water gleys, at some places grey brown podzolics are found. The valley is used as grassland.

Mountain: we study the erosion forms of the Benbulbin mountain. We notice three different slopes:

1. a very steep, almost vertically slope with conglomerates of carboniferous limestone, without vegetation.
2. a less steep debris slope with limestone, shales and layers of flintstone. This slope is used for extensive sheep grazing.



3. a colluvial slope, used for intensive sheep grazing. The colluvial material consists for 35% of clay and for 50% of silt. Mainly gleysoils are found.

First stop: Iron Pan Podzol on Pre-Cambrian Rock Exposure.

In the neighbourhood of Glenade we study a profile.

Classification : placaquod; iron pan podzol; moerige veldpodzol.

Parent material: very acid, various glacial drift, containing gneiss, overlying pre-Cambrian gneiss.

Horizon	Depth	Characteristics
A1	0-20	peaty; deferralised coarse sandgrains with darkbrown coating.
B2ir	20-25	branching iron pan, in some places removed to appear deeper in the profile (see July 3rd, first stop).
B2	25-50	weathering horizon from the Acid Brown Earth stage (see June 29th, first stop).
C	50-80	unchanged till.
D1	80-120	rotten rock; the original structure is visible. The gneiss is chemically weathered, which is probably due to the leaching of the acid "podzolwater".
D2	120+	unchanged rock.

Second stop: Brown Earth with High Base Saturation.

A few miles SE of Glenade we study a profile.

Classification : Eutrochrept; Eutrofe Braunerde.

Texture : loamy sand.

Parent material: glacial drift derived from Carboniferous limestone, gneiss and schist, overlying Carboniferous limestone.

Soil formation : originally the entire profile was limerich. The topsoil has been decalcified. pH=5.8. Secondary lime has been precipitated on the rock subsoil.

Suitability : due to the good drainage and structure this is an excellent soil for grass and forestry. Tillage will give problems because of the stones in the profile.

Third stop: Farmvisit.

Mr. Tony Kilbane deals with several aspects of the farm.

Acreage: the farm covers 90 acres from which 65 acres are used for grazing and the remainder for growing winterfeed.

Stocking rate: 1 livestock unit/2 acres.

Production: the farm has specialized on meatproduction. The calves are suckled by the cows, thus there is no milkproduction for the factory.

Manuring: the grass is fertilised with NPK (100,65 and 70 pound/acre).

Stable period: because of the high rainfall there is an inwintering period of 6 months.

Fourth stop: Surface-water Gley in Monarhamilton.

After lunchtime we study a profile at the slope of a drumlin.

Classification : alfic haplaquept; surface-water gley (with pseudogley features).

Parent Material: glacial drift derived from Carboniferous, siliceous limestone and shales.

Vegetation : grass and rushes.

Horizon	Depth	Characteristics
A1	0-15	13% clay. Dark greyish brown.
A2g	15-30	this horizon consists of a greyish-brown chertlayer. (chert is limestone with a high Si-content). 20% clay.
Btg	30-60	41% clay.
Cg	60-100	35% clay.
CG	100+	blue-grey, reduced clay.

Suitability : this soil is very wet for a large part of the year and only suitable for extensive grazing and forestry (sitca spruce).

Remarks : -the coarse clay fraction consists for 90% of chemically and physically inactive quartz, giving rise to a lower CEC and less swelling and shrinking than would be expected.
-it is not certain if the high clay-content of the B-horizon is due to clay-illuvation. Micromorphological data are absent.

From Monarhamilton we drive in the direction of Lough Allen, through the drumlin area of Co. Leitrim. The word drumlin is a contraction of the two Celtic words leith and droim (= grey resp. drumlin). So Leitrim is the county of the grey drumlins, which we noticed during a heavy rainshower.
The drumlins consist of Carboniferous limestone drift with a high content of carbon and ironphospate. Between the drumlins peat and surface water gleys are found.

Fifth stop: Drumlin near Drumkeeran.

Having passed Drumkeeran we stop to have a nice view on the drumlins.
At the horizon we can see the Iron Mountains. At the other side of the road we study a profile in a drumlin.

Classification : alfic haplaquept; gley.

Parent material: glacial drift derived from Lower Carboniferous siliceous limestone with some sandstone and shale influence.

Texture : cherty loam to clay.

Vegetation : juncus, grass.

Drainage : poorly drained.

Horizon	Depth	Characteristics
A1	0-10	22% clay. 9% org. matter; pH=6.5; weakly structured
A2g	10-18	16% clay; a compact layer of angular chert gravel, known locally as channel; pH=6.5.
B1g	18-35	21% clay; pH=6.8; sticky.
B2tg	34-70	34% clay; pH=6.9; sticky, weak prismatic structure.
Cg	70-95	35% clay; pH=7.3.

Suitability : this soil has a limited use-range. Grassland is the most suitable. The clay is suitable for the fabrication of bricks (little shrink, see below).

Remarks : due to the high quartz content of the clay fraction the clay has a high plasticity and a low viscosity.

We cross the river Shannon and pass Drumshanbo. The shale drumlins give ground for limestone drumlins. Sometimes raised bog on fenpeat is noticed between the drumlins. Interdrumlin lakes occur too.

Sixth stop: the Agricultural Institute in Ballinamore.

At Ballimore we take a walk over a drumlin and drive to Dublin.