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STUDIES IN IRISH QUATERNARY DEPOSITS: SOME LACUSTRINE DEPOSITS NEAR DUNSHAUGHLIN, COUNTY MEATH

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II.

STUDIES IN IRISH QUATERNARY DEPOSITS: SOME LACUSTRINE DEPOSITS NEAR DUNSHAUGHLIN, COUNTY MEATH.

By G. F. MITCHELL.

(Plate IV.)

[Read 22 January. Published 1 March, 1940.]

Contents.

I.—Preliminary.

The field-work, which forms the basis of this paper, was carried out during the summers of 1935–39. A grant from the Committee for Quaternary Research in Ireland in support of the field-work is gratefully acknowledged. Excavation of a crannog in the basin containing the deposits was the stimulus which started the investigation, and to Dr. Hencken, Director of the Harvard Archæological Mission, and the other members of his team my best thanks are due for much assistance and many facilities during the excavations. I am also very grateful to Professor K. Jessen of Copenhagen (who visited the site in 1935) for placing his field notes and pollen-samples at my disposal, as without these, as well as his generous instruction and advice, the work could not have been carried out. To Dr. L. A. T. Ballard, Messrs. T. H. Chillingworth, A. Farrington, J. Hand, A. W. Stelfox, and Professor L. B. Smyth I am indebted for assistance in field and laboratory.

II.—Topography of the Basin.

The village of Dunshaughlin is situated about twenty miles (*ca.* 32 kms.) north-west of Dublin, in the gently undulating landscape of County Meath. Immediately to the east of the village lies an oval depression about one mile and a quarter (*ca.* 2 kms.) in length and two-thirds of a mile (*ca.* 1 km.) broad at its widest part. The basin itself is divided between the townlands of Dunshaughlin, Grangend Common, Bonestown, Lagore Big and Lagore Little. The ring of higher ground at about 350 ft. O.D. which surrounds the basin sinks to its lowest level at the eastern end, and all drainage, natural and artificial, must have been led away towards the east. No streams enter the basin, which receives only the water that falls on the surrounding slopes. The basin is at present almost dry, but in the past, before drainage operations were carried out, held a considerable volume of water. In the waters of the lake a crannog had been

built, and its remains were discovered in the year 1838, when some drainage trenches were being deepened. This crannog, which lies in the townland of Lagore Big, and is usually referred to as the Lagore crannog, was the first to be discovered in the British Isles. A report of its excavation will be published by the Harvard Archæological Mission.

An attempt may perhaps be made to form a picture of the basin before drainage commenced. The original 6″ plan of the Ordnance Survey (surveyed in 1836) shows the area as marshy, and penetrated by several drains. There is a small detached area of open water in the north-east corner and two small rectangular cuts, possibly peat cuttings, are shown near the southern margin. The accompanying Survey Letter (1, p. 290) refers to the basin as *Múr Damhán*, the Bog of the Ox. At this period the water-level had already been lowered by several feet, as the lake deposits have a considerably greater extent than the area shown as boggy ground on that map. The extent of these deposits (as determined by probing), and, therefore, of the lake itself, is shown on the accompanying map (fig. 1), based on the 6″ O.S. plan (1924 printing), and reproduced here by kind permission of the Minister for Finance.

Wilde (2, p. 420), who was the first to describe the crannog, refers to the surroundings as "a 'cut-away' black bog"; from his statements it is obvious that the patch of open water referred to above was still in existence. This paper was published in 1840, so Wakeman (3, p. 325) is

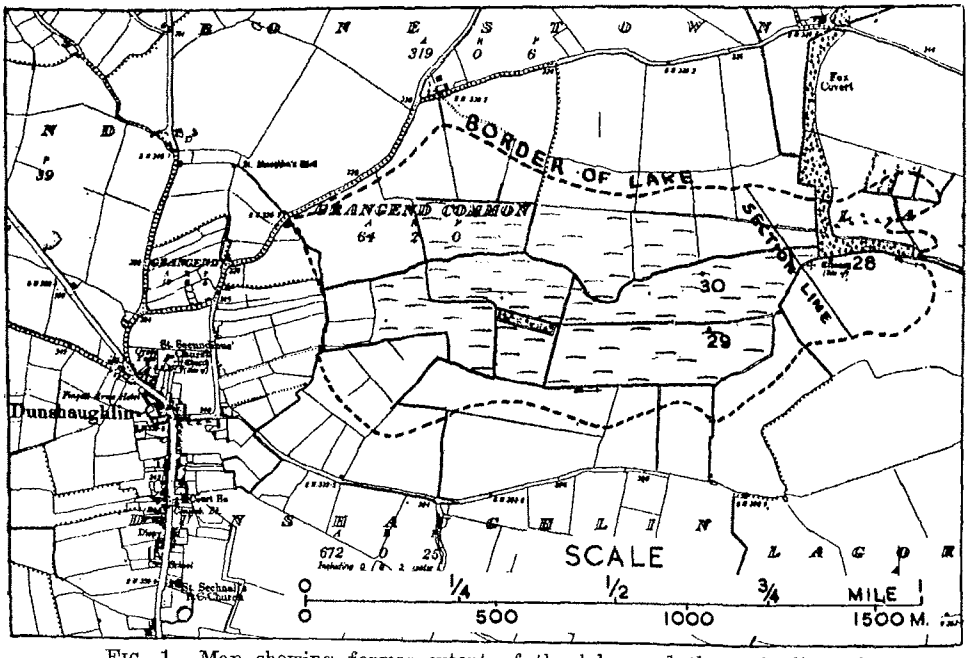

FIG. 1.—Map showing former extent of the lake, and the main line of section, together with Points 28, 29, and 30. Reproduced from the Ordnance Survey by permission of the Minister for Finance of Ireland.

in error when he says that the initial discovery was made in 1848, when workmen were "clearing a river-course through a bog." He states that further turf-cutting in 1849 gave him an opportunity of inspecting the site.

The main drain by which water is led away leaves the depression, as already mentioned, at the eastern end, and is cut through the drift which extends over the area, and into the underlying Carboniferous strata. Probably even before drainage the extent of open water was small, for the basin holds a large amount of lacustrine deposits. It is likely that the conception of a margin of rushes and sedges with a *Phragmites* association further out and possibly open water in the centre gives a fairly true impression of the undisturbed conditions.

At present in summer open water is confined to the drains (the water area in the north-east corner having disappeared), but in winter fairly extensive flooding takes place. Coarse grasses, rushes and sedges cover most of the old lake-floor to-day, with some *Phragmites* towards the centre, but even there conditions are dry enough for a small plantation of trees to succeed.

III.—METHODS OF INVESTIGATION.

By means of borings (made with a Djos drill of the Hiller type, kindly lent by the Committee for Quaternary Research) and profiles a section (shown in Plate IV), 330 metres long, running in a north-west–south-east direction and passing through the crannog, was established across the east end of the lake. To this another section (fig. 2), thirty-five metres long,

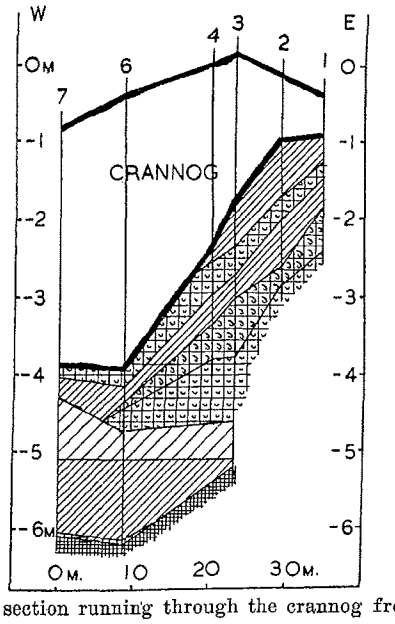

FIG. 2.—A line of section running through the crannog from west to east.

and running east to west through the crannog, was linked, Boring 7 being common to both sections. Twenty-six borings and profiles, not all of which reached the bottom of the deposits, were used to build up the sections; five of these profiles (nos. 1, 2, 3, 4, 5) were recorded by Professor Jessen. Samples for pollen-analysis were taken at points 3, 5, 12, 17, 18, 20. Boring 27 was near to the section line. In addition, borings and profiles were recorded in other parts of the basin to investigate features not well shown along the line of section. These points were numbered 28, 29 and 30; the positions of these points are marked on the map (fig. 1). A datum for levelling was established on the surface of the lacustrine deposits at Boring 8 at the northern end of the main section. This was the highest level to which the lake deposits were traced. This datum was 20 cms. higher than the datum employed by the archæologists in their excavation of the crannog. The key to the symbols employed in sections and diagrams is seen in fig. 3.

In preparing the pollen-diagrams from the samples taken, the method used by Jessen in his Ballybetagh diagrams (4, p. 247) has been followed in the main. No attempt, however, has been made to differentiate between the various kinds of NTP (non-tree-pollen), though the total NTP has been reckoned where significant. *Salix* has been estimated as a percentage of the other TP (tree-pollen), and not reckoned with them. This follows Godwin (5, p. 281), who considers that the results of confusing pollen of *Fraxinus* with that of *Salix* are thus minimised. Also, as the environmental range of the *Salix* species is much greater than that of the other forest trees, the genus should not be equated with the other trees, which (with the exception of *Betula*) are represented by one species only. Two existing indigenous Irish species of *Betula* are recognised. *Corylus* is reckoned as a percentage of the TP (without *Salix*). In preparing the diagrams where the percentage of *Corylus* exceeded 100, the appropriate number has been entered in the first column to the right of the diagram. The percentages of Ericaceous pollen, where present, and of NTP pollen, when reckoned, are entered numerically in the next column to the right. In every case, except where specially noted, the percentages are based on 150 TP. Solid black is used in the diagrams to indicate archæological horizons.

IV.—Zonation of the Deposits by means of Pollen-diagrams.

Though the deposits, especially near the margins of the basin, exhibited an apparently simple stratification, it soon appeared from the pollen-analyses that the chronological horizons did not coincide with the stratigraphical ones. As it is possible to recognise in the pollen-diagrams the zones set up by Jessen (4, p. 250; 6, p. 276), typical diagrams will first be discussed and the zones established with but brief reference to the stratigraphy.

Because a boulder-clay rich in limestone blocks was seen in all the drains around the margin of the basin, and was reached at the base of all those borings that penetrated the lacustrine deposits completely, it is probable that the whole basin is lined with boulder-clay. In the central parts of the basin the depth at which the boulder-clay occurred varied

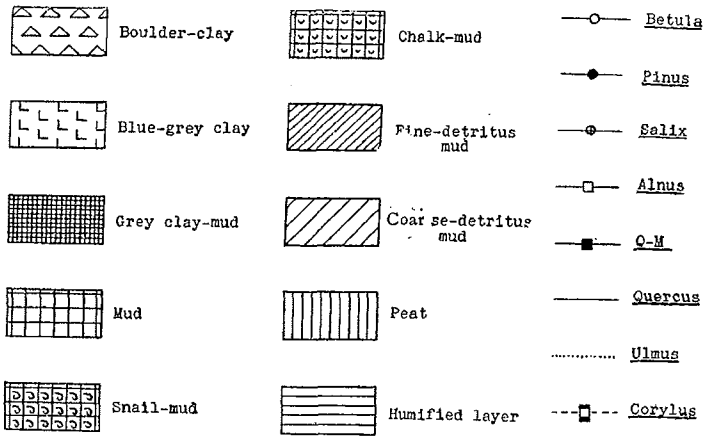

FIG. 3.—The key to the symbols used in the sections and the pollen-diagrams.

between 200 cms. and 1,000 + cms. below datum. Its surface is, therefore, irregular, and doubtless includes many smaller hollows. Over the central area of the basin the boulder-clay was succeeded upwards by a stone-free sandy clay, blue in colour and sticky in consistency. It contained, except for some moss-stems, no vegetable remains. Most borings revealed a blue-grey mud containing clay and sand, and, characteristically, leaves of *Salix herbacea* resting directly on the blue clay.

But at one point, No. 29, the lowest layers were as follows:—

500–525 cms.	Brown fine-detritus mud with leaf-fragments and scattered shells, including *Pisidium* sp.
525–532 cms.	Green-brown mud, with scattered shells, seed of *Potamogeton natans.*
532–750 cms.	Grey clay-mud, becoming darker in colour below, with some sand and leaves of *Salix herbacea.*
750–820 cms.	Grey chalk-mud, becoming lighter in colour below, with alternating light and dark bands. Some content of clay and scattered Ostracod shells.
820–900 cms.	Grey-brown chalk-mud, with less sand.
900–985 cms.	Light-grey mud, becoming darker in colour below.
985–1000 cms.	Blue clay, with some content of sand and mud. Scattered Octracod shells.

Below this level the chamber of the drill failed to open.

Pollen-samples taken here yielded the diagram seen in fig. 4. The changes in vertical scale in the diagram should be noted. In the blue clay at the base of the boring pollen was very scarce, only 5 TP and 7 NTP being noted in the sample from a depth of 995 cms. Though the clay was not penetrated completely at this point, it rests elsewhere in the basin, as previously noted, on the boulder-clay. It may be assigned to Jessen's Zone I. Even if its small pollen content is derived from the boulder-clay, as it may be (7), it is clear that the quantity of derived pollen involved in the higher zones cannot at most be very large.

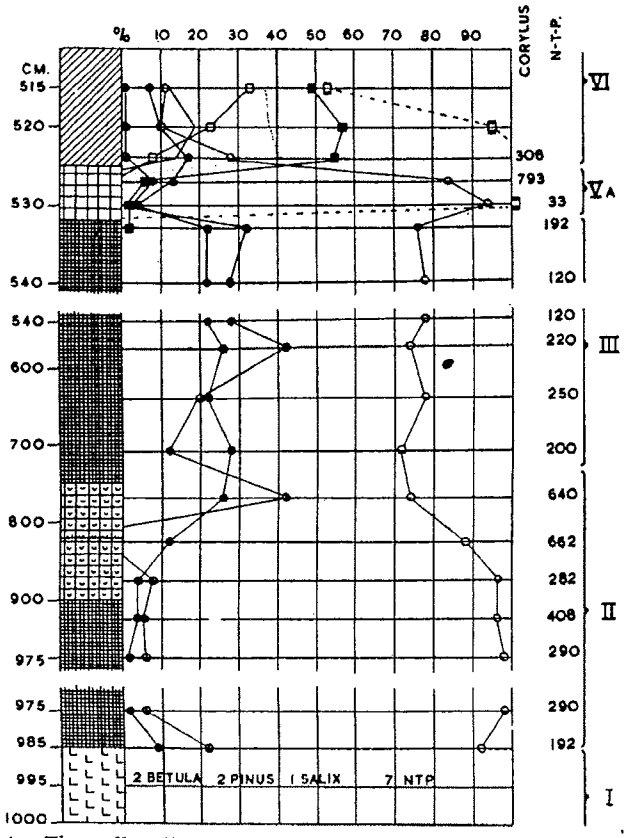

FIG. 4.—The pollen-diagram from Point 29 in the centre of the basin.

Zone II (late-glacial *Betula* period) extends from 750 to 985 cms. It is characterised by the presence of autochthonous chalk as well as allochthonous inorganic material. *Betula, Pinus,* and *Salix* alone are present; the predominance of *Betula* is very marked. The percentage of NTP is usually considerably greater than 250. Above 750 cms. the chalk dis-

appears, and the deposit becomes a grey clay-mud with sand and leaves of *Salix herbacea.* This zone, Zone III (late-glacial *Salix herbacea* period of Jessen), extends up to 532 cms. The predominance of *Betula* is not so marked, and the NTP percentage does not exceed 250.

In the samples analysed from Zones II and III it was only possible to count 50 TP, but above the stratigraphic change at 532 cms. from grey clay-mud to green-brown mud without sand, pollen was abundant, and 150 TP could be counted with ease. The two samples immediately above the transition represent Sub-zone Va, part of the *Corylus* maximum. The apparent absence of Zone IV is doubtless due to the very slow rate of accumulation in the early post-glacial zones in the centre of the basin. The three uppermost samples may be allotted to the beginning of Jessen's Zone VI. *Alnus* is established, *Betula, Pinus,* and *Salix* are unimportant in amount, *Corylus* has fallen away from its earlier levels.

There can be little doubt that the deposits described above illustrate the local response to the late-glacial climatic conditions already established from the Ballybetagh facies. All the other borings which penetrated the grey mud completely were marginal. There no chalky phase was observed. Therefore, this boring, No. 29, was the only one which revealed the complete late-glacial sequence.

A series of samples was taken at the north end of the section at Boring 13, where the stratigraphy was as follows:—

0– 30 cms.	Humified layer.
30– 76 cms.	Brown peat with some fibre.
76– 80 cms.	Brown peat-mud.
80–110 cms.	Yellow snail-mud, with some layers poorer in chalk.
110–135 cms.	Green-brown chalk-mud.
135–146 cms.	Grey-white chalk-mud.
146–158 cms.	Blue-grey clay.
	Drill on stone.

The diagram (fig. 5) illustrates two post-glacial zones, Zones IV and V. Zone IV is the post-glacial *Betula* zone of Jessen. "*Betula* is dominant, with a marked expansion in the upper part of the zone. The curves for *Pinus* and *Salix* have their greatest frequency in the lower portion of it" (4, p. 253). No significant amounts of *Corylus, Quercus, Ulmus* or *Alnus* are present. Zone V displays the *Corylus* maximum, which reaches a value of 2,400 per cent. at 99 cms. It may be divided into Jessen's two Sub-zones Va and Vb. "In Sub-zone Va *Corylus* is rising, *Betula* tends to fall . . . *Pinus* is beginning to rise" (4, p. 254). The upper limit is placed at the rational limit for *Ulmus.* In Sub-zone Vb *Quercus* and *Ulmus* become important for the first time.

Zone V is seen *in toto* in the diagram (fig. 6) constructed from samples taken at Boring 20 at the south end of the section. The details of the stratigraphy are—

0– 30 cms.	Humified layer.
30– 60 cms.	Black-brown crumbling peat.
60– 75 cms.	Brown fibrous mud-peat.
75–145 cms.	Yellow snail-mud.
145–180 cms.	Yellow chalk-mud, becoming browner below with few shells.
180–184 cms.	Grey chalky clay-mud.
184 + cms.	Blue-grey clay.

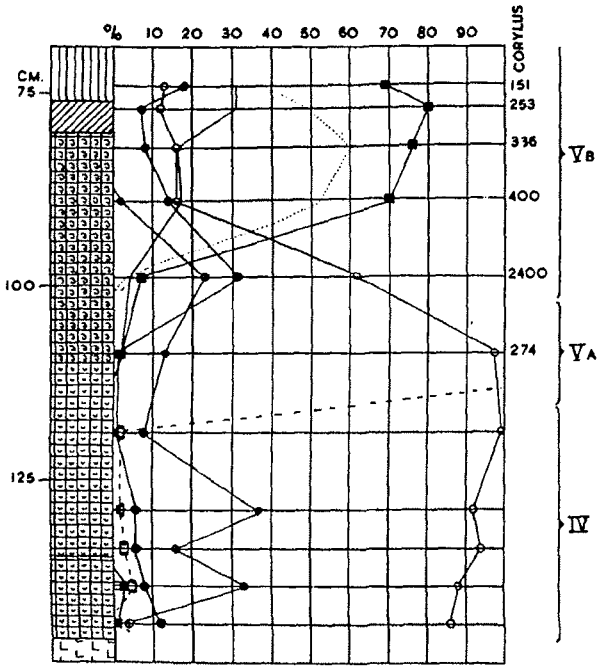

FIG. 5.—The pollen-diagram from Point 13 on the main line of section.

Only the basal post-glacial sample represents Zone IV. The next sample indicates Sub-zone Va. Sub-zone Vb shows considerable values for *Ulmus* and *Quercus*, and "covers the greatest portion of the *Corylus* maximum . . . In the upper part of the Sub-zone the *Corylus* curve falls inward. The main direction for the *Betula* curve is inward: *Salix* is without great significance. The *Pinus* curve, often containing its outward direction, may reach a rather high maximum, up to about 50 per cent.

near the top of the zone or a little above it" (4, p. 255). The highest sample belongs to the base of Zone VI, the first period in which *Alnus* reaches a dominant position.

To illustrate Sub-zone Vb in more detail, and to demonstrate again the extreme slowness of deposition in the central area in the early post-glacial stages, a diagram (fig. 7) has been prepared from samples taken at the base of Boring 30, where the stratigraphy was as follows:—

750–815	cms.	Dark-brown fine-detritus mud with scattered shells and Ostracod tests.
815–830	cms.	As above, but paler in colour.
830–856	cms.	Green-brown mud with traces of sand.
856–875 +	cms.	Grey clay-mud.

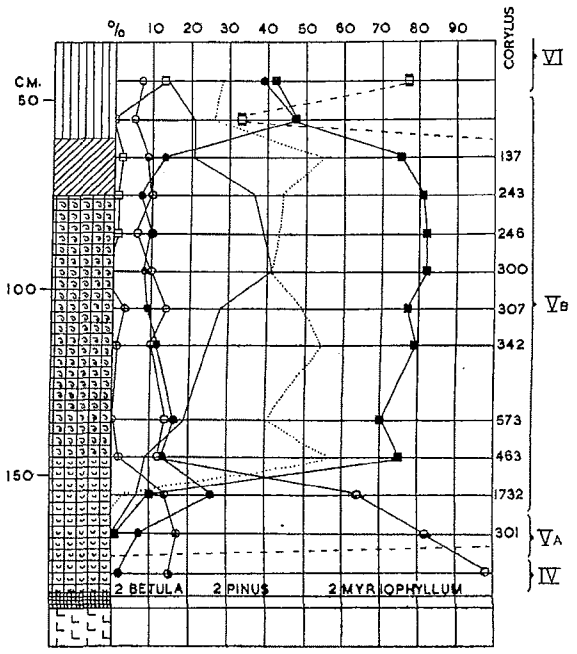

FIG. 6.—The pollen-diagram from Point 20 on the main line of section.

Near the transition from clay-mud to green-brown mud samples were taken at 1 cm. intervals, and for a considerable distance above the transition at 2 cm. intervals, but even so there is no record in the diagram of Zone IV or Sub-zone Va. Therefore, throughout the duration of these zones less than 1 cm. of deposit was accumulated here. Sub-zone Vb is illustrated in considerable detail. The beginning of Zone VI is also seen.

(The Irish diagrams which Professor Jessen has already published terminate at the beginning of Zone VI. In the Lagore diagrams the transition between Zone VI and Zone VII of the outlined scheme (6, p. 276) is clear, but the transition between Zone VII and Zone VIII is not so easily to be distinguished. Before publication, the manuscript of this paper was submitted to Professor Jessen for criticism, and he has confirmed the level of the transition between Zone VI and Zone VII. He

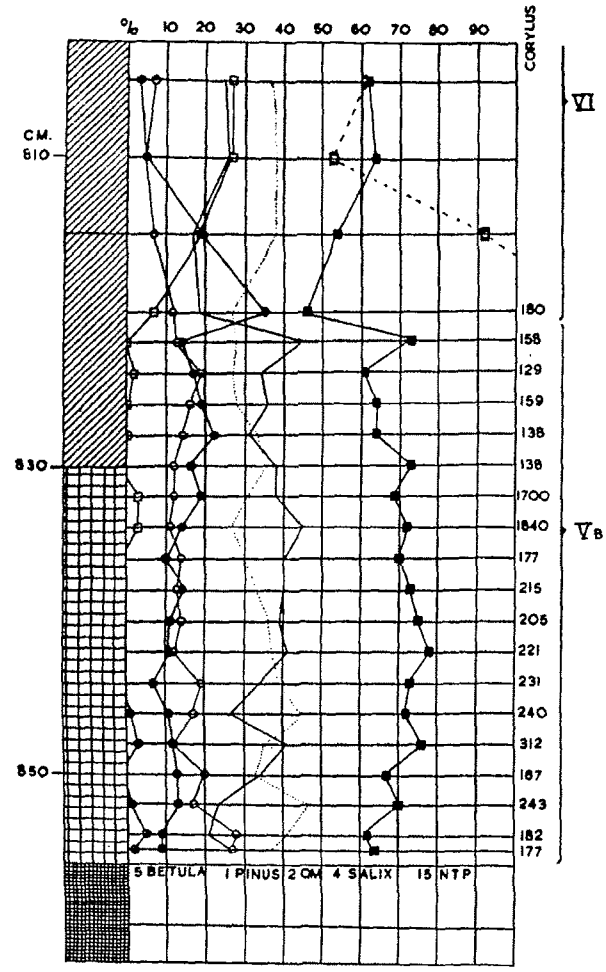

FIG. 7.—The pollen-diagram from Point 30 in the centre of the basin.

has also indicated the level of the boundary between Zone VII and Zone VIII in the pollen-diagram from Point 3 (fig. 8). It must be remembered that the characters that separate Zone VIII from Zone VII

are not as distinct as those that mark the lower zones. For this further expression of Professor Jessen's interest, I must express my thanks.)

Zones VI and VII, and a part of Zone VIII, are illustrated in the diagram (fig. 8) established from samples taken at Boring 3 directly beneath the crannog. The deposits here were—

0–200 cms.	Crannog material.
200–255 cms.	Dark-brown fine-detritus mud containing drifted material, especially in the upper part. Scattered bones throughout the layer.
255–290 cms.	Grey-yellow chalk-mud with horizontal twigs and shells.
290–317 cms.	Light grey-brown fine-detritus mud with many shells and many rhizome and radical fragments. At 307 cms. a human skull was found.
317–394 cms.	Yellow snail-mud with few radicels.
394–480 cms.	Dark-brown chalk-mud with many snails.
480–530 cms.	Black-brown coarse-detritus mud with scattered shell fragments.
530–540 cms.	Dark fine-detritus mud without shell fragments.
540–616 cms.	Grey mud, perhaps with some clay.
616–835 cms.	Grey-blue sticky clay with some sand. Drill among stones.

There is little doubt that the late-glacial zones are present here, but the pollen content below 540 cms. was too sparse for these to be easily established. In Zone VI, extending from 410 to 540 cms., *Quercus* overtakes *Ulmus,* and the total QM is about equal in amount to *Alnus,* whilst *Betula* and *Pinus* are insignificant. At the division between the zones the QM curve falls, due to a reduction in *Quercus,* the *Alnus* curve rises steeply above the QM curve, and is never challenged by the latter again. *Corylus* also rises sharply. Zones VII and VIII are rather featureless, but in Zone VIII *Betula* tends to rise.

This diagram terminates immediately below the crannog layers. At the western side of the crannog a shallow layer of chalk-mud rested on top of the crannog debris. Samples obtained at Profile 18, 12 metres west of the line of section, yielded the diagram seen in fig. 9. On account of its stratigraphical position this small diagram must be allotted to a later stage of Zone VIII.

The eight zones established by Jessen (6, p. 276) have been recognised in the pollen-diagrams. These zones have a regional significance in Ireland,

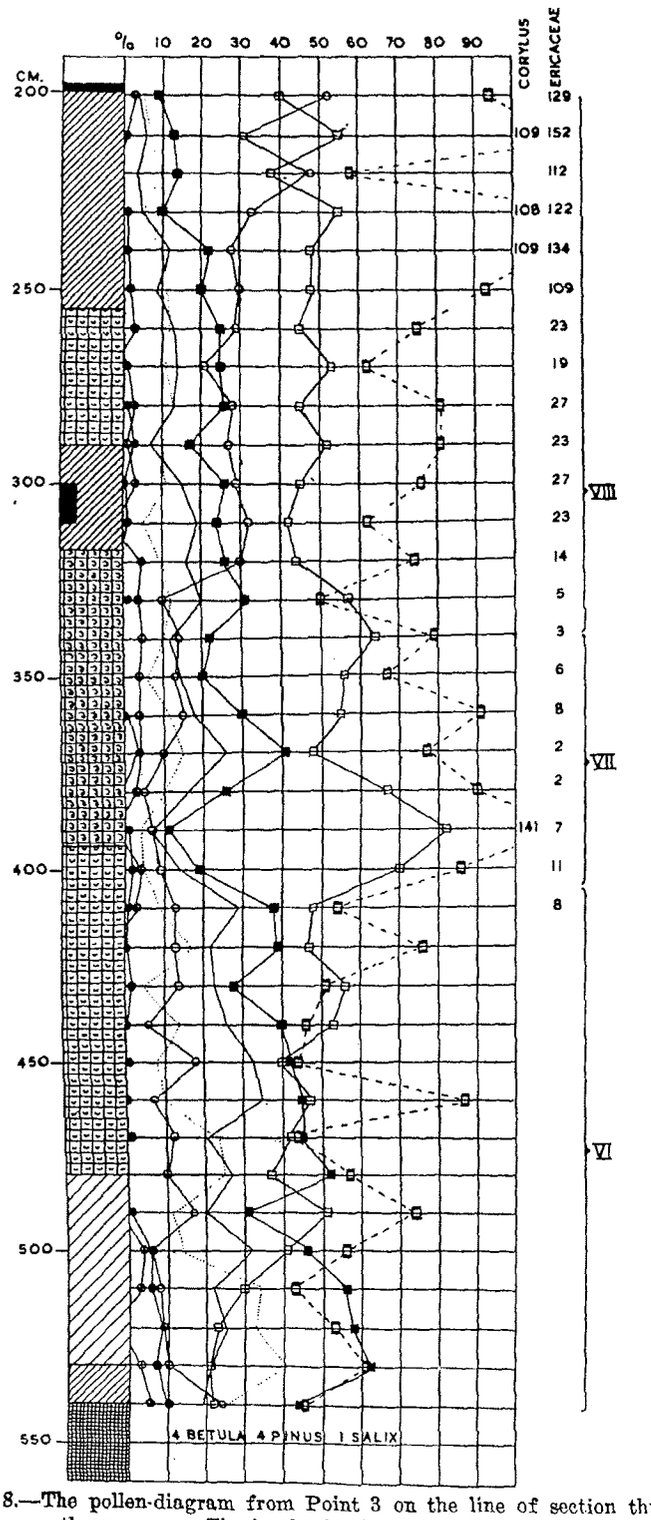

FIG. 8.—The pollen-diagram from Point 3 on the line of section through the crannog. The level of a human skull is shown.

and at least the earlier ones in Great Britain also (8, p. 453; 9, p. 170). These chronological zones will be referred to for dating purposes in the stratigraphical description.

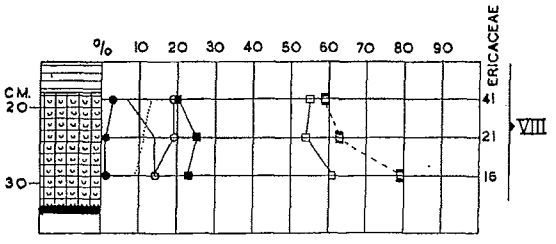

FIG. 9.—*The pollen-diagram from Point 18 on the main line of section.*

V.—GENERAL STRATIGRAPHY.

In describing the stratigraphy along the line of section (Pl. IV), the late-glacial deposits (blue-grey clay of Zone I, sandy chalk-mud of Zone II, blue-grey *Salix herbacea* clay-mud of Zone III) will not be considered further, beyond noting the shape of their upper surface on which the post-glacial deposits rested. From the northern margin the surface slopes gently down from datum level to a depth of 300 cms. below datum at a distance of sixty metres. In the next twenty-five metres there is a more abrupt fall of about 300 cms. to a level at which the surface becomes approximately horizontal. This level of 600 to 650 cms. below datum is maintained across the central parts of the basin till a point about one hundred and forty metres out from the southern margin is reached. From here to within sixty metres from this margin there is a rise to 300 cms. below datum. For some distance further this level is maintained, but then there is a slight fall to 350 cms. below datum about thirty metres from the margin above a deep depression in the boulder-clay. Twenty metres from the margin the 300 cm. level is reached again, and then there is a steep rise to the margin. By far the greatest part of the surface is composed of grey clay-mud, but as the margins are approached blue-grey clay and boulder-clay are present.

The post-glacial deposits at the margins of the basin, north and south, and in the central area will be described separately.

At the northern end of the section below 150 cms. below datum a yellow chalk-mud, referred to as the lower chalk-mud, rested on the earlier deposits. Above 150 cms. below datum yellow snail-mud rested on the late-glacial deposits and transgressed outwards across the upper surface of the lower chalk-mud. On the snail-mud rested a fine-grained peat. The uppermost deposit, referred to as the humified layer, capped this peat. As the humified layer extended over the whole basin it will be discussed in detail later. The diagram from Boring 13 (fig. 5) makes it clear that

the lower chalk-mud was deposited in Zone IV, and that the rest of the deposits, if we exclude the humified layer, were laid down before Zone V came to an end.

At the southern end of the section once more a yellow chalk-mud caps the late-glacial deposits. As the upper surface of these declines to lower levels about ninety metres from the shore, the lower chalk-mud takes on a browner colour, and has an increasing content of shells in the upper layers. Here, as shown by the diagram from Boring 20 (fig. 6), its deposition occupied the end of Zone IV and the first part of Zone V. It is succeeded by a thick layer of yellow snail-mud deposited in the beginning of Sub-zone Vb. Where the upper surface of the snail-mud lay more than 200 cms. below datum, it is capped by a thin band of fine-detritus mud with some chalk and scattered shells, on which rests a fine-grained peat. Where the upper surface of the snail-mud is higher, it is succeeded directly by the peat. The peat is covered by the humified layer. The formation of these upper deposits, again excluding the humified layer, took place in the later stages of Sub-zone Vb, and the beginning of Zone VI is seen in the highest sample of the diagram.

It is evident that in the shallow waters at both ends of the section the sequence of events was similar, and that before Zone VI commenced as much as 150 cms. of deposit had been built up, open water had been obliterated and replaced by a peat-forming vegetation. In the central area conditions were very different, accumulation in the stages that immediately succeeded the late-glacial period being very slow. At Boring 3 (figs. 2 and 8), where the upper surface of the late-glacial deposits lay about 550 cms. below datum, the sample taken 10 cms. above the top of the blue-grey mud clearly belongs to the beginning of Zone VI. At Boring 17 samples at this transition were taken at closer vertical intervals. Only the sample taken one centimetre above the top of the clay-mud indicated Zone V. The sample taken one centimetre higher up and those above it belonged to the beginning of Zone VI. At Boring 17 the basal post-glacial deposit was a yellow-brown mud of a fine grain and without macroscopic plant remains, nowhere more than 10 cms. in thickness. This deposit was also present in Borings 29 and 30. On the line of section this mud only occurred below 500 cms. below datum level, and appeared to merge laterally at about this level into the lower brown fine-detritus mud which lay on it in the central area, and extended up the sides of the basin beyond it to a level of about 450 cms. below datum. The fine-detritus mud contained seeds and scattered shells.

Capping this deposit was a brown coarse-detritus mud, which was very rich in fragments of wood, especially wood of *Betula*. Its thickness increased from 50 cms. on the south side of the basin to 250 cms. at the northern side. This greater thickness at the north may be due to a prevailing south-westerly wind, which would gather all floating debris to

this corner of the lake, the debris subsequently sinking to form the deposit. Seeds and a few shells were present.

The upper fine-detritus mud succeeded the coarser mud, and it had throughout some chalk content. This deposit filled the centre of the basin, and interdigitated with the marginal deposits. This arrangement was well seen in the vicinity of the crannog.

The yellow snail-mud, whose upper surface was last referred to at a depth of 200 cms. in Boring 20, dips outwards and downwards from this point towards the centre of the basin. As it does so, its thickness diminishes till the bed disappears below the crannog at a depth of 450 cms. below datum. This wedge-shaped deposit underlies the upper fine-detritus mud of the central area. Above the snail-mud this detritus mud retains its character, and merges into the fine-grained mud which lies between the peat and the snail-mud, where, as already noted, the upper surface of the snail-mud lies more than 200 cms. below datum. Below the snail-mud and the underlying lower chalk-mud the coarse-detritus mud and the lower fine-detritus mud of the central area are present. Below the crannog another thin layer of chalk-mud, the middle chalk-mud, was intercalated into the upper fine-detritus mud. It probably represents a local response to certain conditions of water depth.

Pollen-dating for these layers is provided by the diagram from Boring 3 (fig. 8). All the deposits below the snail-mud (*i.e.*, lower chalk-mud, coarse-detritus mud, lower fine-detritus mud) belong to Zone VI. The bulk of the snail-mud was deposited during Zone VII, and the rest of the snail-mud, where upper surface is here *ca.* 350 cms. below datum, and the upper fine-detritus mud during Zone VIII. In Boring 5 (fig. 12), where the snail-mud was deposited at a higher level, its age was assigned to the later part of Zone VI. The snail-mud, therefore, crept downwards and outwards away from the margin as the central parts became filled with deposit. Near the southern margin it was deposited in Sub-zone Vb, further out in Zone VI, and at its greatest depth in Zones VII and VIII.

The deposits of both the marginal and the central areas are clothed in vegetation, whose roots, penetrating to a depth of *ca.* 35 cms., have added humus to the upper layers and stained them to a rust-brown colour. This layer has been referred to above as the humified layer. In four borings, nos. 15, 18, 21 and 28, a further deposit, the upper chalk-mud, was discovered between the humified layer and the lower deposits. This upper chalk-mud was nowhere more than 25 cms. in thickness, and in Boring 15 it lay on the upper fine-detritus mud, in Boring 18 on the debris marginal to the crannog, in Borings 21 and 28 on the peat.

The pollen diagram (fig. 9) constructed from samples taken at Boring 18 has been assigned to Zone VIII. As the layer here overlay some of the debris marginal to the crannog, and as it contained some fragments of charcoal, it must be contemporaneous with the later stages of the crannog

occupation. Dr. Henceken stated that the layer was continuous in the vicinity of Boring 18. The diagram shown in fig. 10 was obtained from samples taken in 1937 at Point 28 on the side of a trench to the east of the crannog. This trench had been dug in connection with a division of a field, and along the sides of the trench the upper chalk-mud appeared at irregular intervals between the peat and the humified layer. It was clear that the humified layer had been formed at the expense of the upper chalk-mud, for it still retained in places traces of layers where shells had been numerous.

The stratigraphy was as follows:—

0– 30	cms.	Brown humified deposit with bands of chalk and layers of shells. Many pieces of charcoal.
30– 52	cms.	Black-brown peat-mud with scattered pieces of wood.
52– 66	cms.	Dark-brown laminated mud-peat, becoming lighter in colour below and increasing content of rhizomes.
94–100 +	cms.	Yellow snail-mud.

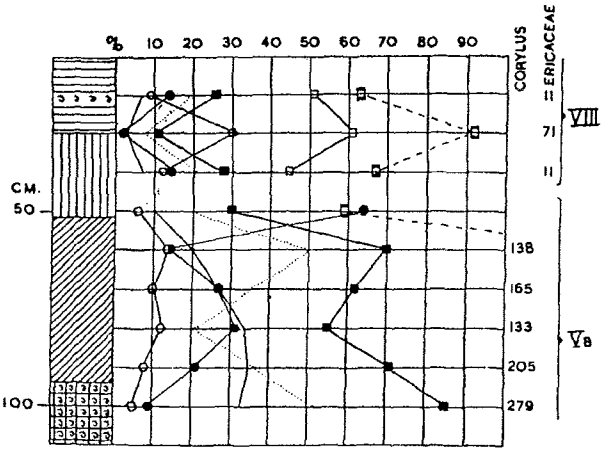

FIG. 10.—The pollen-diagram from Point 28 at the east end of the basin.

The uppermost three samples of the diagram were taken in the humified layer or in the upper layers of the peat; they have been allotted to Zone VIII. The remainder of the samples must be assigned to Sub-zone Vb, and the stratigraphy is the typical one of these early marginal deposits. Therefore, the upper chalk-mud and the humified layer are here, and doubtless along the line of section, resting unconformably on the earlier deposits. There must have been a rise in the level of the lake after the occupation of the crannog had begun.

VI.—ARCHÆOLOGICAL SIGNIFICANCE OF THE POLLEN ZONES.

During the course of the extensive excavation made by the Harvard Archæological Mission at and in the vicinity of the crannog, three finds were made which were not associated with the occupation site itself. These were a Neolithic sherd at Profile 27, fourteen metres south-east of Profile 7, a bronze spear-head at Profile 5, and a human skull at Profile 3.

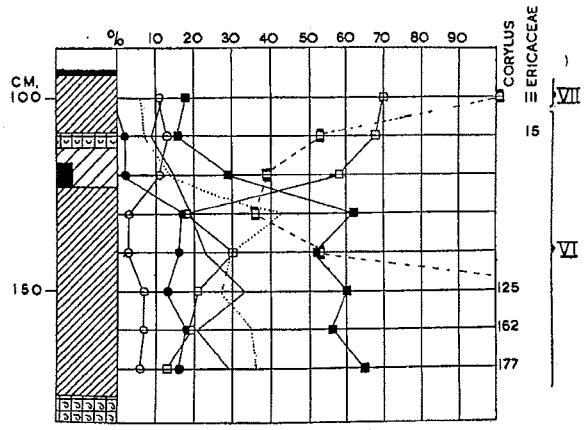

FIG. 11.—The pollen-diagram from Point 27, south-east of Point 7. The level of a neolithic sherd is shown.

Samples taken in the vicinity of the sherd yielded the diagram seen in fig. 11. The pottery lies below the transition from Zone VI to Zone VII. The spear-head (Profile 5, fig. 12), about which Dr. Hencken says in a private communication, "it cannot be earlier than middle Bronze Age, but may very well be considerably later," lies above this transition, and in the early stages of Zone VII. As the spear-head was standing in a vertical position it is probably slightly younger than the deposit which surrounds it. The diagram from Profile 3 (fig. 8) shows that the skull occurs in Zone VIII. In comparing these diagrams the different rates of accumulation must be allowed for, deposition at Profile 27 being very slow in the later zones.

The crannog and its circumjacent debris lie in Zone VIII. Unfortunately the bulk of the excavation had been completed before the significance of the upper chalk-mud was realised, with the result that the Zone VIII diagrams are interrupted by the crannog structure, and no continuous diagram is available.

As the occupation of the crannog is regarded by Dr. Hencken as extending from the latter part of the eighth century to the latter part of the tenth century A.D., three archæological horizons may be interpolated into the pollen zones—a Neolithic horizon in Zone VI, a Bronze Age

horizon in the early stages of Zone VII, and an early Christian horizon in Zone VIII. The skull belongs to the period between the Bronze Age and the building of the crannog.

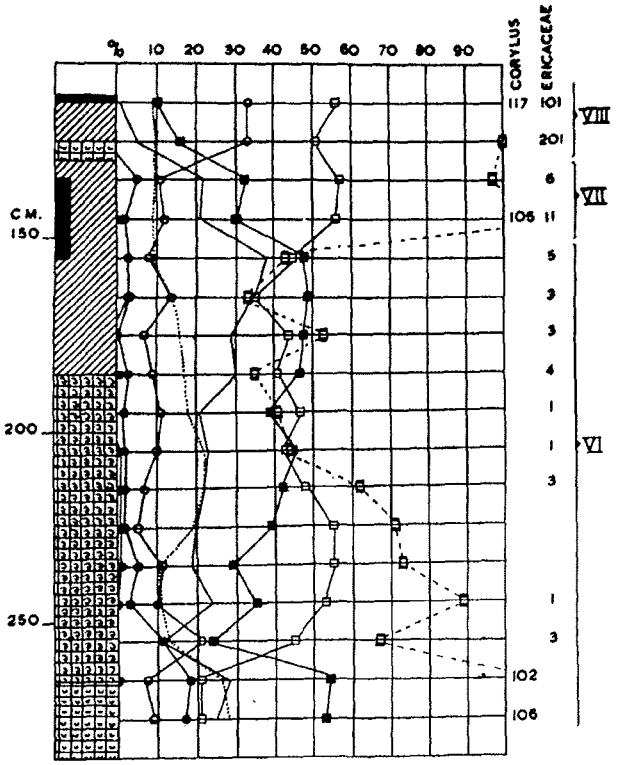

FIG. 12.—The pollen-diagram from Point 5 on the main line of section. The level of a bronze spear-head is shown.

VII.—DISCUSSION.

Of the boulder-clay that lines the depression it can only be said that it presumably belongs to the Newer Drift (10), and is, therefore, of the same age as the drift underlying the deposits at Ballybetagh and at Ralaghan (4). The deposit of Zone I at Lagore is similar to that of Zone I at Ralaghan, and the deposit of Zone II at Boring 29 at Lagore resembles in the main that of Zone II at Ballybetagh and Ralaghan. But in Zone III a difference arises. At both Ballybetagh and Ralaghan the slopes surrounding the small basins were rather steep. When solifluction set in, sand and gravel, together with clay, actively crept out to cover the entire floor of the basin. Remains of contemporary land plants were carried out along with the inorganic debris. But at Lagore

the basin was large and the slopes gentle; consequently, only the finer clay and sand and few remains of land plants reached the centre of the basin. Deposition in standing water seems to have been continuous throughout the late-glacial period. As the more genial conditions of Zone II followed the arctic conditions of Zone I and the plant cover became established, the quantity of inorganic debris reaching the lake was reduced, and an open-water chalk-mud with little sand succeeded the grey clay of Zone I. When the more rigorous conditions of Zone III set in and the plant cover deteriorated, inorganic matter once more appeared and the grey clay-mud of Zone III was deposited, large debris being completely absent. The absence of typical deposits of Zone II in the marginal areas may be due either to a continuous marginal supply of inorganic debris or else to a lower water level in the basin in late-glacial times.

No remains of the Irish Elk (*Cervus giganteus*) were found during the recent excavations and survey. Bones of this animal are frequently found in two adjacent basins, one to the north and one to the south-east. The deposits in the basin to the south-east are under investigation; but it may be said that bones of elk and reindeer occur in a solifluction clay with leaves of *Salix herbacea* (probably of Zone III age) which overlies a chalk-mud (probably Zone II). As the post-glacial deposits in this basin are very thin, the bones are frequently discovered. At Lagore the late-glacial deposits of Zones II and III are covered everywhere by at least two metres of post-glacial deposits, and no elk bones have been discovered in the basin in recent years. The statement of Du Noyer (11, p. 7) that in this basin "below the peat in the marl, were discovered the remains of *Megaceros hibernicus,*" should be accepted with reserve.

In the earlier post-glacial zones deposition was confined to the margins of the basin. Why so little accumulation should have taken place in the central parts is hard to understand. But it is definite that as much as 135 cms. of deposit had formed at the margins, and open water had been replaced by a peat-forming vegetation composed of Carices and *Cladium* before 10 cms. of deposit had accumulated in the central area. This marginal deposition occurred in Zones IV and V. The beginning of Zone VI saw the commencement of the deposition of detritus muds in the centre of the basin. As the basin filled up, the chalk-mud and snail-mud crept out further from the southern margin.

The ulna of a bear, not precisely localised, was discovered during the excavation in chalk-mud in the vicinity of the crannog. Beyond ascribing the bone to the post-glacial period no further reference can be made.

The transition from Zone VI to Zone VII is marked in the pollen-diagrams by a sudden increase in the value of *Alnus* at the expense of *Quercus,* and a sharp though temporary increase in *Corylus.* Somewhat above this level Ericaceous pollen assumes importance for the first time.

It is tempting to regard these changes as the local reaction to that deterioration of climate which is marked in the raised-bogs by an increase in the rate of growth, the onset of which occurs at the Grenz or Border-horizon. In his preliminary scheme of post-glacial development in Ireland (6, p. 276) Jessen places the VI/VII transition at the Grenz. As there was no formation of *Sphagnum* peat in the basin and as *Sphagnum* bogs are rare in the vicinity of Dunshaughlin, the increase in Ericaceous pollen may represent an extension of *Calluna* heath at the expense of the forest in the period following the deterioration of climate. Of the heath in West Jutland, Jonassen (12) says: "The facts seem to show that the heath has been wood-clad throughout the greater part of post-glacial time . . . The Ericales-curve seems to show that the first onset of the *Calluna* heath took place at the beginning of sub-Atlantic time" (*i.e.*, immediately succeeding the Grenz). The increase in the importance of *Alnus* was doubtless due to an increasing tendency for the ground to become waterlogged favouring this tree.

VIII. Flora List (established from macroscopic remains).

	Blue clay.	Grey-brown chalk-mud.	Grey clay-mud.	Lower chalk-mud.	Snail-mud.	Peat.	Lower Fine-detritus mud.	Coarse-detritus mud.	Upper Fine-detritus mud.	Middle chalk-mud.	Upper chalk-mud.
Zone I.											
Moss stems	×	·	·	·	·	·	·	·	·	·	·
Zone II.											
Chara oospores	·	×	·	·	·	·	·	·	·	·	·
Zone III.											
Arenaria ciliata (*K. Jessen det.*) ...	·	·	×	·	·	·	·	·	·	·	·
Betula pubescens ...	·	·	×	·	·	·	·	·	·	·	·
Myriophyllum sp. ...	·	·	×	·	·	·	·	·	·	·	·
Ranunculus cf. *Flammula* ...	·	·	×	·	·	·	·	·	·	·	·
„ sp. ...	·	·	×	·	·	·	·	·	·	·	·
Salix herbacea ...	·	·	×	·	·	·	·	·	·	·	·
Sparganium ramosum ...	·	·	×	·	·	·	·	·	·	·	·
Chara oospores	·	·	×	·	·	·	·	·	·	·	·
Moss stems	·	·	×	·	·	·	·	·	·	·	·
Zone IV.											
Betula pubescens ...	·	·	·	×	·	·	·	·	·	·	·
Populus tremula (*K. Jessen det.*) ...	·	·	·	×	·	·	·	·	·	·	·
Chara oospores	·	·	·	×	·	·	·	·	·	·	·
Moss stems	·	·	·	×	·	·	·	·	·	·	·

	Blue clay.	Grey-brown chalk-mud.	Grey clay-mud.	Lower chalk-mud.	Snail-mud.	Peat.	Lower Fine-detritus mud.	Coarse-detritus mud.	Upper Fine-detritus mud.	Middle chalk-mud.	Upper chalk-mud.
Zone V.											
Betula pubescens ...	·	·	·	×	×	×	·	·	·	·	·
Carex sp.	·	·	·	·	·	×	·	·	·	·	·
Cladium Mariscus ...	·	·	·	×	×	×	·	·	×	·	·
Corylus Avellana ...	·	·	·	·	×	·	·	·	·	·	·
Nuphar luteum ...	·	·	·	·	×	×	·	·	×	·	·
Nymphaea alba ...	·	·	·	×	·	·	·	·	·	·	·
Potamogeton natans ...	·	·	·	×	·	·	·	·	×	·	·
„ *praelongus* ...	·	·	·	×	·	·	·	·	·	·	·
Ranunculus repens ...	·	·	·	·	·	×	·	·	·	·	·
Scirpus lacustris ...	·	·	·	·	×	·	·	·	·	·	·
Chara oospores	·	·	·	·	×	×	·	·	×	·	·
Zone VI.											
Alnus glutinosa ...	·	·	·	·	·	·	·	×	·	·	·
Betula pubescens ...	·	·	·	·	·	·	·	×	·	·	·
Carex sp.	·	·	·	·	·	·	×	×	·	·	·
Cladium Mariscus ...	·	·	·	·	·	·	·	×	·	·	·
Menyanthes trifoliata ...	·	·	·	·	·	·	·	×	·	·	·
Nuphar luteum ...	·	·	·	·	·	·	×	×	·	·	·
Nymphaea alba ...	·	·	·	·	·	·	×	×	·	·	·
Potamogeton alpinus ...	·	·	·	·	·	·	·	×	·	·	·
„ *natans* ...	·	·	·	·	·	·	·	×	·	·	·
„ *praelongus* ...	·	·	·	·	·	·	·	×	·	·	·
Ranunculus aquatilis ...	·	·	·	·	·	·	·	×	·	·	·
„ *repens* ...	·	·	·	·	·	·	×	×	·	·	·
Rubus idaeus	·	·	·	·	·	·	·	×	·	·	·
Sambucus nigra ...	·	·	·	·	·	·	·	×	·	·	·
Scirpus lacustris ...	·	·	·	·	·	·	×	×	·	·	·
Sparganium ramosum ...	·	·	·	·	·	·	·	×	·	·	·
Moss stems	·	·	·	·	·	·	·	×	·	·	·
Fontinalis antipyretica (*K. Jessen det.*) ...	·	·	·	·	×	·	·	·	·	·	·
Cenococcum	·	·	·	·	·	·	·	×	·	·	·
Zone VII (identifications by Professor Jessen).											
Alnus glutinosa ...	·	·	·	·	×	·	·	·	·	·	·
Batrachium sp. ...	·	·	·	·	×	·	·	·	·	·	·
Betula pubescens ...	·	·	·	·	×	·	·	·	·	·	·
Cirsium palustre ...	·	·	·	·	×	·	·	·	·	·	·

	Blue clay.	Grey-brown chalk-mud.	Grey clay-mud.	Lower chalk-mud.	Snail-mud.	Peat.	Lower Fine-detritus mud.	Coarse-detritus mud.	Upper Fine-detritus mud.	Middle chalk-mud.	Upper chalk-mud.
Zone VII—(*Continued*).											
Nuphar luteum ...	.	.	.	.	×	.	.	.	.	.	.
Nymphaea alba ...	.	.	.	.	×	.	.	.	.	.	.
Potamogeton natans ...	.	.	.	.	×	.	.	.	.	.	.
„ *praelongus* ...	.	.	.	.	×	.	.	.	.	.	.
Sambucus nigra ...	.	.	.	.	×	.	.	.	.	.	.
Scirpus lacustris ...	.	.	.	.	×	.	.	.	.	.	.
Fontinalis antipyretica ...	.	.	.	.	×	.	.	.	.	.	.
Zone VIII (identifications by Professor Jessen).											
Ajuga reptans	.	.	.	.	.	.	.	.	×	.	.
Alnus glutinosa ...	.	.	.	.	.	.	.	.	×	.	.
Arctium sp.	.	.	.	.	.	.	.	.	×	.	.
Batrachium sp.	.	.	.	.	.	.	.	.	×	.	.
Betula pubescens ...	.	.	.	.	.	.	.	.	×	.	.
Caltha palustris ...	.	.	.	.	.	.	.	.	.	×	.
Carex inflata ...	.	.	.	.	.	.	.	.	×	.	.
Carex sp.	.	.	.	.	.	.	.	.	×	.	.
Ceratophyllum demersum ...	.	.	.	.	.	.	.	.	.	×	.
„ *submersum* ...	.	.	.	.	.	.	.	.	.	×	.
Cladium Mariscus ...	.	.	.	.	.	.	.	.	×	×	.
Corylus Avellana ...	.	.	.	.	.	.	.	.	×	.	.
Menyanthes trifoliata ...	.	.	.	.	.	.	.	.	×	×	.
Nuphar luteum ...	.	.	.	.	.	.	.	.	×	×	.
Potamogeton alpinus ...	.	.	.	.	.	.	.	.	.	×	.
„ *natans* ...	.	.	.	.	.	.	.	.	×	×	.
„ *obtusifolius* ...	.	.	.	.	.	.	.	.	.	×	.
„ *praelongus* ...	.	.	.	.	.	.	.	.	×	.	.
Potentilla erecta ...	.	.	.	.	.	.	.	.	×	.	.
Prunus spinosa ...	.	.	.	.	.	.	.	.	×	.	.
Ranunculus aeris ...	.	.	.	.	.	.	.	.	×	×	.
„ *repens* ...	.	.	.	.	.	.	.	.	×	.	.
„ sp. ...	.	.	.	.	.	.	.	.	.	×	.
Rubus fruticosus ...	.	.	.	.	.	.	.	.	×	×	.
„ *idaeus* ...	.	.	.	.	.	.	.	.	×	.	.
Rumex obtusifolius ...	.	.	.	.	.	.	.	.	×	.	.
Salix sp.	.	.	.	.	.	.	.	.	×	.	.
Sambucus nigra ...	.	.	.	.	.	.	.	.	×	.	.
Scirpus lacustris ...	.	.	.	.	.	.	.	.	×	.	.
„ sp. ...	.	.	.	.	.	.	.	.	.	×	.

	Blue clay.	Grey-brown chalk-mud.	Grey clay-mud.	Lower chalk-mud.	Snail-mud.	Peat.	Lower Fine-detritus mud.	Coarse-detritus mud.	Upper Fine-detritus mud.	Middle chalk-mud.	Upper chalk-mud.
Zone VIII—(*Continued*).											
**Sonchus asper* ...	·	·	·	·	·	·	·	·	×	·	·
Stellaria media ...	·	·	·	·	·	·	·	·	×	·	·
Urtica dioica	·	·	·	·	·	·	·	·	?	×	·
Fontinalis antipyretica ...	·	·	·	·	·	·	·	·	·	×	·

* A fruit *verisimiliter* from this layer.

With regard to the plant remains from Zones VII and VIII, Professor Jessen remarks: "They derive principally from the vegetation in the lake itself and from the swamps and meadows along its shores. Some of the plants found in the sample taken immediately below the crannog may owe their presence there in some way or another to the action of man. This concerns both the edible fruits, such as *Corylus* and *Prunus,* and also the group consisting of *Arctium* sp., *Rumex obtusifolius, Stellaria media,* and perhaps *Ranunculus repens,* which may have been introduced to and have grown on the crannog.

The presence of *Sambucus nigra* removes any doubt that this bush might not be truly indigenous in Ireland (13, p. 207).

In the middle chalk-mud some fruits of the genus *Ceratophyllum* were found. Three specimens belonged to the species *demersum,* being armed with long spines, while one fruit was completely without spines, and closely resembled the fruit of *submersum.* This species, though known in England, is not known as a living Irish plant. In future investigations it would be of interest to make a study of the *Ceratophyllum* fruits in Irish mud deposits to throw further light on the questions of the variation range of the two species (15) and of the former distribution of *C. submersum* in Ireland.

Besides the plant remains mentioned in the list, it may be noted that the poles used in building the crannog were mainly of *Fraxinus excelsior* and *Quercus* sp., while the fascines were usually branches of *Corylus Avellana.* Twigs of *Calluna* were abundant in the crannog material."

Of the earlier zones, it may be noted that seeds of *Cladium Mariscus* were abundant in the deposits of Zone V, and were still found, though in smaller numbers, in the later zones. With regard to this plant, the "Cybele Hibernica" (16, p. 392) remarks, "frequent in the west, rare in the east." Praeger (14) also notes its present distribution in Ireland as western. For remarks on the late-glacial status of *Arenaria ciliata* and *Salix herbacea* in Ireland, see Jessen and Farrington (4, p. 235).

IX.—FAUNA LIST (identifications by A. W. Stelfox).

Zone I.
Pisidium sp.
Ostracod tests.
Zone II.
Zone III.
Zone IV.
Cristatella.
Zone V.
Limnaea pereger.
Pisidium nitidum.
Planoribus fontanus.
„ *crista.*
Valvata cristata.
„ *piscinalis.*
Zone VI.
Bithynia tentaculata.
Limnaea palustris.
„ *pereger.*
Pisidium sp.
Valvata cristata.
„ *piscinalis.*
Zones VII/VIII.
Bithynia tentaculata.
Limnaea pereger.
Sphaerium corneum.
Zone VIII.
Bithynia tentalulata.
Limnaea pereger.

This list is not comprehensive; it merely lists the species identified in random samples from various points.

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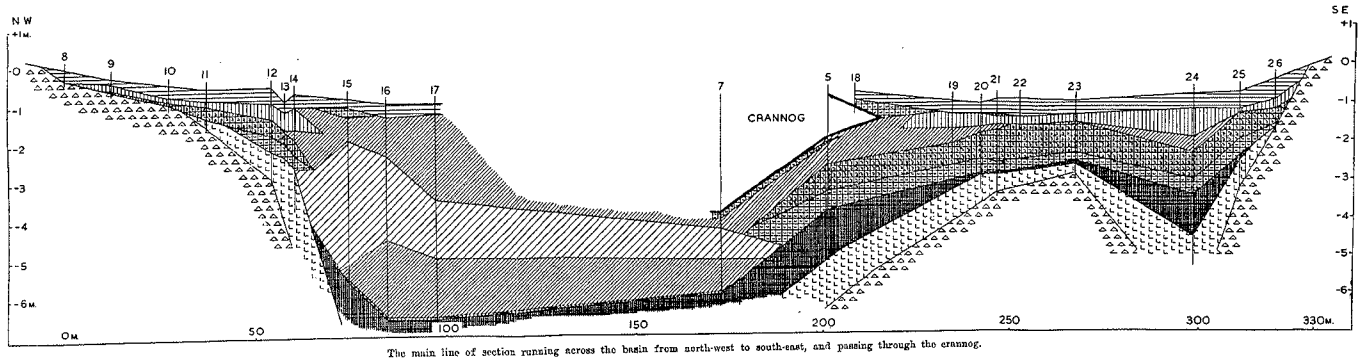

The main line of section running across the basin from north-west to south-east, and passing through the crannog.