

counties, he will be liable to some such muttered interruption from an incredulous old farmer, as that of Edie Ochiltree to the Antiquary's far-fetched assertions—"Sea-beach here, sea-beach there; *I mind the bigging of 'em.*"

#### IV.—ON THE MIDDLE PLEISTOCENE DEPOSITS.

By Professor HARKNESS, F.R.S., F.G.S.

THE superficial deposits of the Co. of Wexford, containing a rich marine fauna, have been referred to in Professor E. Forbes's Memoir on "The Geological Relations of the existing Fauna and Flora of the British Isles."<sup>1</sup>

In an appendix to this memoir the several shells which have been obtained from the superficial deposits of this portion of Ireland are mentioned. A list of the fossil contents of these deposits had been previously given by Sir Henry James, who first pointed out the occurrence of these shell-bearing strata in the Journal of the Dublin Geological Society, Vol. III. The fossils mentioned in this list have been also determined by Professor E. Forbes.

The strata affording these fossil shells are described by Sir Henry James as very extensively developed in the Co. of Wexford, and occupying an area forty miles in length, by from eight to nine miles in breadth. They consist of sands and gravel and drift, and repose upon rounded pebbles." On the sides of the Firth Mountain they attain an elevation of 400 feet above the level of the sea. Their thickness near Blackwater is said to be 174 feet, and their base is nowhere seen.

On four of the sheets of the Geological Survey Maps of this part of Ireland (sheets 47 S.E., 47 N.E., 41 S.E., and 41 N.E.), these strata are referred to as follows:—"The low lands of this coast and the interior up to a height of between two and three hundred feet are covered by Pleistocene deposits, consisting of marls interstratified with sand and gravel, containing Arctic and other shells, chalk-flints, pebbles of Antrim chalk, jasper, coal, etc., and magnetic iron sand." Many of the species of shells which occur in these beds are in the Museum of the Geological Survey of Ireland, and the several localities from whence the specimens have been obtained are recorded on the underside of the slabs upon which they are mounted. By the kind assistance of Mr. Baily, Palæontologist to the Irish Survey, I have been able to give the following as localities from whence these specimens have been derived:—Ballyteige, Killiley, Rathaspick, Castle Ellis, Killisk, Ballyhuskard, Artramon, Ballyvaldon, Ballyknockan, Killmackridge, St. Margaret's, Killinkorley Clonmure.

The portion of the Co. of Wexford where these superficial deposits occur is marked by a circumstance which at once recalls, to the minds of those who have seen them, the Boulder-clays of Lancashire and Cheshire, and their associated strata. Great numbers of pits are seen scattered over the parts of Wexford where the superficial

<sup>1</sup> Memoirs of the Geological Survey, Vol. I.



deposits are formed; but by far the greater portion of these have been abandoned for many years, and are now full of water. From these pits have been derived materials used in the improvement of the land, and in every respect they are analogous to the marl pits in the English counties above alluded to. There are now very few dry pits in the northern portion of the area occupied by the superficial deposits in the Co. of Wexford; and those in the southern portion of the county afford very little evidence concerning the relative position of the strata which they exhibit.

Sir Henry James has stated that the base of the superficial deposits in this part of Ireland is not seen; and to this might be added, that for the most part we have little information as to the strata which are newer than the shell-bearing sands and gravels of the Co. of Wexford. There are, however, a few localities where strata of a different nature, and with well-pronounced features, are seen resting upon the shell-bearing deposits.

One of these localities is in Castle Ellis, about a quarter-of-a-mile north of the Post Office, in a field on the east side of the high road. Here there are two dry pits, one of which has recently been worked for material for the land. The sides of this pit exhibit a mass of reddish-brown Boulder-clay, about forty feet in thickness. This clay rests upon sandy and gravelly strata in some instances, almost consolidated by the infiltration of carbonate of lime. These sands and gravels forming the lower beds of the pit, are only exposed to the depth of about twelve feet.

The Boulder-clay above them abounds in angular, subangular, and rounded blocks of rocks, derived principally from the Cambrian and Silurian formations; and, in many instances, these blocks are beautifully striated.

Some of the sandy layers are very strongly impregnated with small particles of shells; and it is from these layers that the materials which are used for the improvement of land are obtained.

In Castle Ellis, on the same side of the road, a short distance south of the Post-office, there is another large dry pit, the upper portion of which also consists of Boulder-clay. Here, however, the Boulder-clay is not more than twelve feet in thickness, and the rest of the pit, which is of considerable depth, is made up of sands and gravels. A little further to the south, on the opposite side of the road, another dry pit occurs. The latter consists of sands and gravels exclusively, the Boulder-clay having thinned off before reaching this spot. The sands and gravels in the last mentioned pit are now largely worked, and, in common with the same deposits in other parts of the Co. of Wexford, they are known as "Manure gravels." It is to the abundance of fragments of shells, which occur in these deposits, that they owe their value for agricultural purposes.

Some other spots on the road from Castle Ellis to Wexford afford also "Manure gravels." One of these is at Pulregan, near Castle-bridge. Here, and in several other localities, the "Manure gravel" deposits exhibit a rounded outline, having much of the contour of Eskers. At Pulregan, besides numerous fragments of bivalve shells,



univalves are also found in the gravels, some of which are in a perfect state.

In the neighbourhood of the town of Wexford, and to the south thereof, the same deposits make their appearance; but here, as elsewhere, the strata on which they repose are not seen, and here they have no Boulder-clay above them.

Of the species of shells determined by the late Prof. E. Forbes from the "Manure gravels" of the Co. of Wexford, forty-three are common British forms, amongst which is *Fusus antiquus*, the variety *contrarius* being abundant among the specimens in the collection of the Irish Geological Survey. The specimens of this form, collected by myself from Castle Ellis, were of the ordinary variety and of small size. Nine of the species from the "Manure gravels" are forms which now occur in the northern British Seas; seven appertain to Boreal America, or to the coast of Greenland; and four are now found in seas south of the British Isles. Taking the whole of the shells, they appear to indicate a temperature somewhat colder than that which prevails in the present sea of the Wexford coast, but by no means such a rigorous climate as is represented by the shells which have been obtained from the deposits of Scotland and elsewhere reposing upon the Boulder-clays.

The occurrence of Boulder-clays above the shell-bearing sands and gravels of the Co. of Wexford, would, at first sight, induce the conclusion that these strata appertain to a horizon nearly allied to that of the Norwich Crag; and this inference is, to some extent, prevalent concerning them.

It is, however, necessary to look for their equivalents elsewhere, and to see the conditions under which those equivalents present themselves, before arriving at any conclusion as to the age and position of the "Manure gravels." There are two features in connection with these "Manure gravels" of the Co. of Wexford which are highly characteristic of them: one is, the presence of shells, and fragments of shells, which distinguishes them from Eskers, to which they are nearly allied in arrangement and in the general nature of their contents; the other feature which marks them is the constant occurrence in them of flint pebbles, which are almost altogether absent from the Eskers.

There are several localities in Ireland where beds, having the same nature and affording precisely the same contents as the "Manure gravels" of the Co. Wexford, are to be found.

One of these localities is the north side of the headland of Howth, the northern boundary of Dublin Bay. The strata, which are here well seen near the village of Howth, have been described many years ago by Dr. Scouler.<sup>1</sup> They consist of sands and gravels, the latter being limestone fragments, with which are associated flint pebbles. The section is about 200 feet in thickness; and Dr. Scouler states that the beds afford *Turritella terebra*, *Turbo littoreus*, *Nerita littoralis*, *Buccinum undatum*, *Cardium edule*, *Cyprina Islandica*, *Pecten varius*, and *Dentalium entale*, generally in a fragmentary con-

<sup>1</sup> Dublin Geological Journal, Vol. I., p. 270.



dition. These shell-bearing beds, with flint pebbles, rest upon a mass of Boulder-clay containing abundance of striated blocks, well seen at Balscaddan Bay; and this Boulder-clay reposes immediately upon the Carboniferous limestone.

The position of the shell-bearing beds, with flint pebbles, at Howth, resting on Boulder-clay, would at first sight appear to indicate a different and a higher horizon for these strata than for beds having the same nature in the Co. of Wexford, since the latter have Boulder-clay above them.

It must, however, be remembered that, in the Wexford area, the strata upon which the "Manure gravels" rest are not seen.

On following the gravels and sands of Howth, eastwards, they are found to be covered by Boulder-clay, which does not exceed more than three feet in thickness; and this Boulder-clay most probably represents the lower portion of the similar deposits which, in Castle Ellis, in the Co. of Wexford, covers the "Manure gravels."

Subsequently to the observations of Dr. Scouler on the shelly gravels and sands of Howth, Dr. Oldham has described beds of the same nature which occur in other parts of Ireland.<sup>1</sup> He also notices the appearance of flint pebbles in these strata; and he adds to Dr. Scouler's list of shells the following species:—*Ostrea edulis*, from Killiney and Bray; *Tellina solidula*, not uncommon; *Pecten opercularis*, from Killiney; *Pullastra decussata*, from Killiney and Bray; *Nucula oblonga*, *Astarte Gairensis*, from Killiney, Bray, and Sugarloaf; *Nucula nucleus*? and *Saxicava rugosa*, rare. Further observations in these beds also induced him to add to his previous list the following forms as occurring near Dublin:—*Rostellaria pespelicani*, *Fusus antiquus*, *Buccinum undatum*, *Nassa incrassata*, *Natica Alderi*, *Littorina neritoides*, *Trochus umbilicatus*, *T. ziziphinus*, *Triquetra* species of *Spirobis* sp., *Balanus* (impressions of).<sup>2</sup>

Since the observations of Dr. Oldham were made on these deposits, as they are seen in the districts around Dublin, they have attracted the notice of the Rev. Maxwell Close, who has paid special attention to the Glacial phenomena of Ireland. The Rev. Mr. Close has recognized the occurrence of the shell-bearing sands and gravels in the high ground to the south of Carrickmine's station, on the Dublin and Bray railway.

Here flint pebbles also make their appearance, and shelly fragments, the most abundant being portions of *Cyprina Islandica*.

The Rev. Mr. Close has also detected these shelly sands and gravels on the south side of the Three Rock Mountain, at an elevation of about 1,200 feet above the sea level.

The several species of mollusca, which have been obtained from the sands and gravels in the neighbourhood of Dublin, are such as are most common in the "Manure gravels" of the Co. of Wexford; and, like them, they do not indicate Arctic conditions in the seas in which they lived.

Sands and gravels of a nature similar to those of the neighbourhood of Dublin and the Co. of Wexford, have been found in other

<sup>1</sup> Op. Cit., *suprà*, Vol. III., p. 61.

<sup>2</sup> Op. Cit. *suprà*, Vol. III., p. 131.



parts of Ireland; and where they occur they are also marked by flint-pebbles and contain shelly fragments. A locality where they are well seen is at the south-eastern extremity of the Co. of Cork, near Youghal. Here they form on the coast a headland, called Clay Castle, having a height of ninety-one feet, consisting of sands and gravels and sandy clays, which make up the whole face of the cliff, the strata on which they repose not being visible.

These deposits and their shelly contents have been described by Mr. A. B. Wynne.<sup>1</sup>

I have not noticed these sands and gravels with flints west of Youghal; but I learn from Mr. G. H. Kinahan, of the Irish Geological Survey, that they are to be seen as far westward as Crookhaven, the extreme southwest portion of Ireland.

Strata of the same character as those of Ireland, which possess flint-pebbles and afford marine remains, have also been met with in several parts of Britain. Across the Irish Sea, and almost immediately opposite the sands and gravels of the high ground forming the sides of Dublin Bay, are the shell-bearing strata which lie on the eastern side of Moel Tryfaen. These strata of Moel Tryfaen have no Boulder-clay below them like those of Howth, for they repose directly on the Cambrian slates. In nature and arrangement these Welsh strata are almost identical with the "Manure gravels" of the Co. of Wexford, and they, too, contain the characteristic flint pebbles.

As regards the shelly contents of the Moel Tryfaen beds, these greatly resemble such as are afforded by the Irish sands and gravels, but on the whole they have somewhat more of an Arctic character.

There are also in the valley of the Severn, between Bridgenorth and Shrewsbury, deposits which seem to accord with the shell-bearing beds of Ireland. These have been described by Mr. Maw.<sup>2</sup> They consist of sands, gravels, and clays, which sometimes assume a rounded contour, as at Strethill; and in this respect they agree with the outline of many of the deposits of "Manure gravel" in the Co. of Wexford.

These strata of the valley of the Severn also contain flint-pebbles and afford marine remains. I am indebted to Mr. Maw for a collection of these remains; and they, together with others mentioned in Mr. Gwyn Jeffrey's list appended to Mr. Maw's paper, have a great analogy to the shelly contents of the Irish sands and gravels.

Many localities in Cheshire and also in Lancashire, have yielded a series of shells very nearly identical with the collections obtained from the several localities above named. The shelly deposits in these countries have been reached, in many cases by passing through a deposit of Boulder-clay, with well striated blocks identical with that which overlies the "Manure gravels" at Castle Ellis; and these shelly deposits, which effervesce freely in acids, are used for the same objects as their equivalents in the County Wexford, namely for

<sup>1</sup> Quart. Journal of the Geol. Soc., Vol. xxiv. p. 6.

<sup>2</sup> Quart. Journal of the Geol. Soc., vol. xx. p. 130.



agricultural purposes. Beds of sand are often found associated with the shelly marls; and in the neighbourhood of Preston in Lancashire where the shell-bearing strata are seen, they are described by Sir Roderick Murchison as consisting of porous loose gravel.<sup>1</sup> Mr. Binney has also described the shell-bearing strata associated with Boulder-clays, as these occur on the Lancashire coast, in the neighbourhood of Blackpool.<sup>2</sup> He mentions the association of flint-pebbles with these strata, and he gives a list of the shells, there being eleven forms of univalves, and eight forms of bivalves appertaining to species, all of which are found in the adjoining sea.

In the north-east of Scotland there are, in many spots, strata which seem to have a great affinity to the shell-bearing sands and gravels of Ireland, and to those of opposite districts of England and Wales. Before, however, we can determine the exact position of these Scottish beds, it will be necessary to know somewhat more about them. On the southern side of the Moray Firth, some of these deposits occur, and they have been described by Mr. Jamieson.<sup>3</sup>

In some cases the Aberdeenshire sands and gravels appear to be very nearly allied to the "Manure gravels" of the County of Wexford in their contour, for they occur in the parishes of Cruden and Slains in the form of mounds. They consist of water-worn pebbles, gravels, and sands, with broken shells, among which are fragments of *Cyprina Islandica*, the form most common in the sands and gravels near Carrick-mines, on the south side of Dublin Bay. These sands and gravels of Aberdeenshire have in some instances large erratic blocks resting on them, and sometimes a red clay hides them from view.

Strata of the same character as those of Aberdeenshire have been described by Mr. Prestwich as occurring on the south side of the Moray Firth, near Gamrie.<sup>4</sup> A section of these strata is seen on the coast; and Mr. Prestwich observes that flint-pebbles are found abundantly on the beach, which seem to have been derived probably from the upper beds of sand and gravel which here also afford shells; the species of Molluscs which occur in these sands and gravels, like those from the deposits of Lancashire and Cheshire, are not of a peculiarly Arctic type.

The county of Caithness, in the neighbourhood of Wick, appears likewise to furnish beds having the same position as those on the south side of the Moray Firth. Shells have also been collected from these strata by Mr. Peach.<sup>5</sup> Among the pebbles which enter into the composition of the shell-bearing deposits of Caithness, Mr. Peach mentions the occurrence of chalk flints as not uncommon.

The shells from these Caithness beds have been determined by Mr. Gwyn Jeffreys; and although they contain a few Arctic types, they are, on the whole, forms which have a wide geographical distribution.

<sup>1</sup> Silurian System, page 534.

<sup>2</sup> Mem. of the Lit. and Phil. Society of Manchester. Vol. x. page 121, *et seq.*

<sup>3</sup> Quart. Journal of the Geological Society 1858, page 523.

<sup>4</sup> Trans. of the Geol. Soc. Vol. v., p. 147. New series.

<sup>5</sup> Brit. Association Reports, 1862, 1864, and 1866.



Mr. Jamieson has also described the beds which yield shells in Caithness.<sup>1</sup> These beds, he states, consist of dark pebbly silt, or stratified pebbly clay, or gritty mud, and they are generally succeeded by reddish brown stony clay, possessing the ordinary characters of Boulder-clay. The strata in which the shelly fragments are most abundant are sometimes seen resting on the Old Red Sandstones, and the surfaces on which they repose frequently exhibit well marked glacial striation.

A list of shells, by Mr. Gwyn Jeffreys, is appended to Mr. Jamieson's memoir, and this list contains seventy-five species. Few of these shells are purely Arctic forms; and, taking the molluscs collectively from the Caithness beds, they exhibit a much less Arctic facies than those from some other localities in Scotland, among which is Gamrie.

With reference to the strata in the west of Scotland which have been so prolific in shells, and to which the attention of geologists was first directed by the researches of the late Mr. Smith, of Jordan Hill, these seem to possess very marked features which serve to distinguish them from the shelly sands and gravels above alluded to; and these west of Scotland strata also appear to occur in a different horizon.

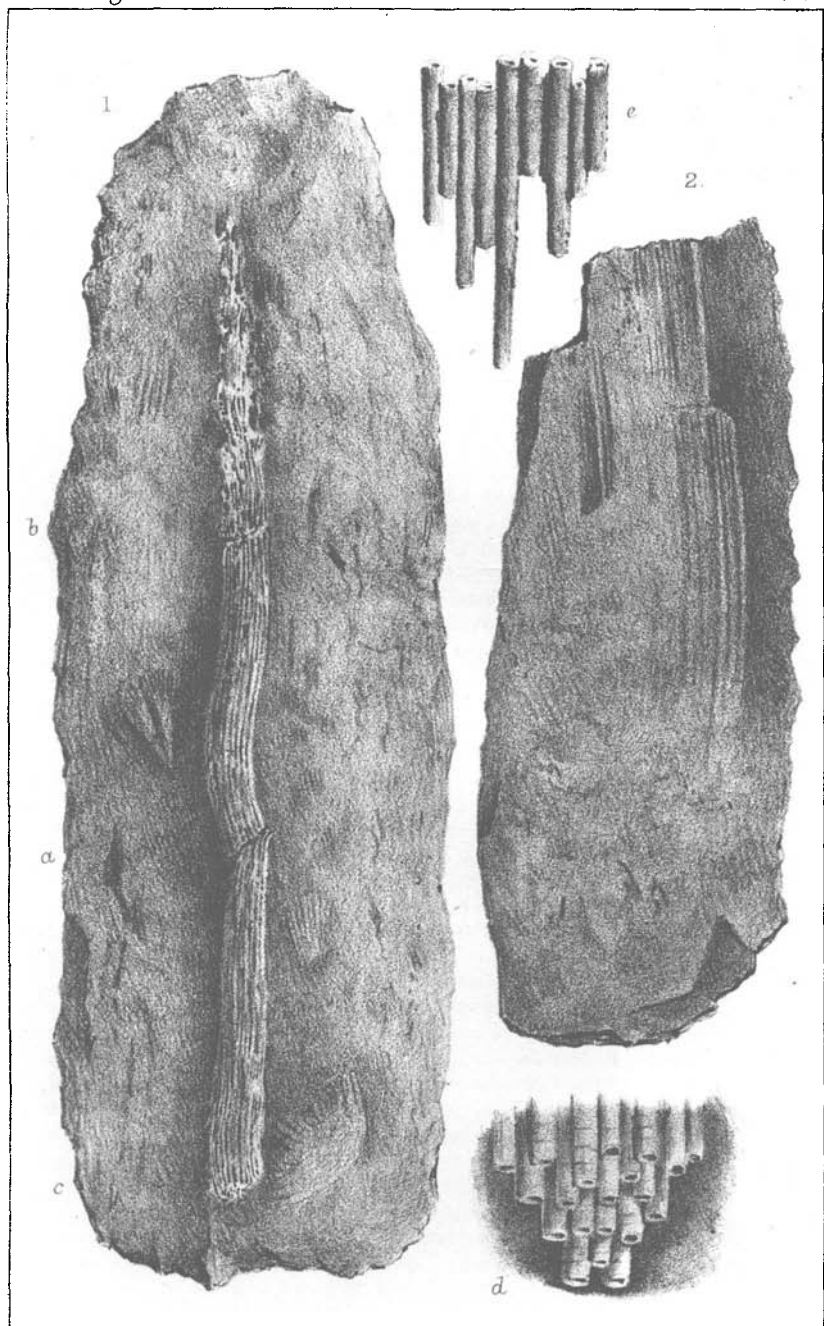
They are seen in the form of stratified beds which *overlie* the Boulder-clay, and they never appear with Boulder-clay above them. They bear about them, much more decidedly than the "Manure gravels," or their British equivalents, the impress of an Arctic climate. The west of Scotland shell-bearing strata belong to a more recent portion of the Pleistocene period than the beds of England, Wales, or Ireland, which contain shells and flint pebbles; for a well developed mass of Boulder-clay separates the two series from one another.

In England, the district which probably exhibits these shelly sands and gravels, with flint pebbles, in the greatest perfection, is the county of Norfolk; and the relations of these strata to the deposits above and below them in this county, have been well described by Messrs. Prestwich, Searles Wood, jun., F. W. Harmer, and J. E. Taylor. In some portions of this area, reposing upon the Norwich Crags, are grey sands with quartzose and flint gravels, from which Mr. Harmer has obtained, at Belaugh and Weybourne, a large number of shells, amongst which *Tellina solidula* is specially abundant.<sup>2</sup> These grey sands and gravels are succeeded by the lower Boulder-clay (Brick-earth) containing travelled and striated blocks. The fauna of this Boulder-clay is marked by an absence of all the mollusca of the Crags, except such forms as are of an Arctic or Boreal type. In position, this deposit seems to correspond with the Boulder-clay underlying the shell-bearing beds at Howth. At Howth, however, and elsewhere in Ireland, there have as yet been discovered no deposits which can be correlated with the grey sands and gravels that in Norfolk underlie the lower Boulder-clay. The lower Boulder-

<sup>1</sup> Quart. Journal of the Geol. Soc., Vol. xxii., p. 261, *et seq.*

<sup>2</sup> GEOLOGICAL MAGAZINE, Vol. VI., page 232.





G.R. De Wilde del. et lith.

W. West imp.

*Eophyton* ? *explanatum*. H. Hicks - Lower Arenig Rocks, St David's.



clays of Norfolk are succeeded by the "middle sands and gravels," which frequently attain a thickness of from 50 to 60 feet. These middle sands and gravels have yielded twenty-three species of shells. Amongst them is *Pectunculus glycymeris*, a form which Mr. Harmer says dies out in the newer part of the Red Crag, which is exceedingly rare in the Norwich Crag, but which is abundant in the middle sands and gravels. *Pectunculus glycymeris*, in a fragmentary state, is one of the most abundant of the bivalves at Pulregan, in the "Manure gravels" of the Co. of Wexford. Mr. Harmer also states that *Ostrea edulis* occurs in the "middle sands and gravels." This form disappears from the newer Crag beds, is not known to live within the Arctic circle; and the character of the fauna of the "middle sands and gravels" is decidedly less Arctic than that of the lower Boulder-clays.

The middle sands and gravels of Norfolk, like the shell-bearing beds in some portions of Ireland, are succeeded by an upper Boulder-clay, which possesses features showing that it originated, like the lower Boulder-clay, from Arctic conditions.

Judging from the fauna afforded by the three deposits, the lower Boulder-clay, the middle sands and gravels, or their representatives elsewhere in Britain or in Ireland, and the upper Boulder-clay, we arrive at the conclusion, that while, on the whole, there are distinct indications of the prevalence of Arctic conditions, there was, during the deposition of the middle portion of the Pleistocene deposits, a less rigorous climate.

There is another interesting circumstance in connection with the middle Pleistocene strata. This is the almost constant presence of chalk flints among the gravels which belong to this series. In the case of these deposits, as they are seen in the south-west of Ireland, there are at present no Cretaceous rocks nearer than the Co. of Antrim, which is at least 200 miles distant in a direct line from some of the spots where the middle Pleistocene strata are found. A transportation of flint-pebbles from Antrim would imply the agency of a northern current, a circumstance somewhat hostile to the evidence which the fauna of the "Manure gravels" affords; telling us, as it does, of a less rigorous climate than that which marks the earlier and later portions of the Pleistocene epoch.

South-eastern currents probably have had more influence in the transportation of these chalk flints, and they may perhaps have been derived from some source which extended from England to France before the greater portion of St. George's Channel was hollowed out; or before the Straits of Dover were formed.

The various members of the Pleistocene series have sustained, at different times, great losses from denudation.

In many cases the lower Boulder-clay is altogether absent. This is seen in some instances in Norfolk, where the middle sands and gravels repose upon the Crag group. At Moel Tryfaen the shell-bearing sands and gravels occur under somewhat similar conditions, as they rest upon the Cambrian rocks; and it is also probable that the inferior member of the Pleistocene series, the lower Boulder-



clay, is absent in the county of Wexford, having been removed by denudation.

The middle sands and gravels of Norfolk, have also been subjected to denuding influences. It is, however, in the south-east of Ireland, that this member of the series exhibits the influence of denudation in a high degree. Here the rounded outline of these deposits is the result of this influence; and here too we have evidence justifying the conclusion that the upper Boulder-clays have to a very great extent been removed by this cause, since we have this upper portion of the series preserved in a few localities only.

No doubt very considerable changes have been effected in the several deposits which constitute the Pleistocene group, since the period of their deposition, by the agency of atmospheric causes. These causes fail, however, to account for the entire absence of one or other member of the group in some localities; and it seems much more probable that the influences of marine currents, during changes in the relative level of land and sea, were the denuding agents, rather than atmospheric causes, such as are now in operation over the several areas where the Pleistocene deposits occur.

#### V.—ADDITIONS TO THE LIST OF BRACHIOPODA OF THE BRITISH SECONDARY ROCKS.

By RALPH TATE, Assoc. Lin. Soc., F.G.S.

SIXTEEN years have now passed since Mr. Davidson's Monograph of the British Secondary Brachiopoda appeared, and as numerous additions have been made from time to time, it is my present object to collate the scattered records of the additional species, and to supplement such information by notices of new or little known forms.

#### PART I.—LIASSIC SPECIES.

The number of British Liassic Brachiopoda known to Mr. Davidson was forty; of these *Leptæna granulosa* is now considered to be a *Placunopsis*, *L. Pearcei* is referred to the genus *Monotis*; *Discina Townshendi* finds a habitat in the Rhætic series, and *Discina reflexa* and *Lingula Beanii* should be removed to the Inferior Oolite; but this number has been greatly augmented, chiefly by the researches of Mr. Charles Moore. The fact of such a large number of species having been overlooked finds an explanation in the greater number of workers upon the Liassic formations; this is true not only for the Brachiopoda, but for other forms of animal life; thus the fauna of the Lias numbers 1,103 species, whereas 426 species only are catalogued by Professor Morris in his second edition of British Fossils, published 1854. The Lower Lias, which was somewhat characterized by a paucity of Brachiopodous shells—two or three species only being well known, has now yielded eighteen species.

1. WALDHEIMIA PERFORATA, Piette, sp. Bull. Soc. Geol. Fr., vol. xlii., 1856. *Terebratula strangulata*, Martin. *T. psilonota*, Quenstedt.