

EXPLANATION OF PLATE V.

FIG. 1.—*Dithyrocaris ovalis*, W. and E., specimen having both valves preserved united along the mesial line.

FIG. 2.—*Dithyrocaris granulata*, W. and E., the left half of the carapace only preserved.

FIG. 3. ————— ditto.

FIG. 4. ————— *glabra*, W. and E., the left half of the carapace only preserved.

FIG. 5. ————— W. and E., the right half of the carapace only preserved.

FIGS. 1–5 were all obtained from the Black Carboniferous shales overlying the Calderwood cement-stone, E. Kilbride, Lanarkshire.

FIG. 6.—*Dithyrocaris ? striata*, W. and E., part of the left valve only preserved. Lower Old Red Sandstone, Carmichael Burn, S.E. of Lanark.

FIG. 7.—The small specimen of *Dithyrocaris tricornis*, Scouler, referred to in the former part of this paper, see GEOL. MAG. 1873, Vol. X. p. 485, as showing “the same infolding of the lateral margins as the larger example displays.” (See Vol. X. Pl. XVI. Figs. 2 and 3.)

III.—GLACIALOID OR RE-ARRANGED GLACIAL DRIFT.

By G. H. KINAHAN, M.R.I.A.

IN many places in Ireland, but conspicuous in the S.E. portion, there is a Glacialoid drift (that is, a drift very similar in aspect to some of the typical Glacial drift). This drift will be found in places above the shelly drifts of Wicklow and Wexford, and has led Prof. Harkness, F.R.S., to believe that in those counties there is evidence for two distinct periods of glacial drifts, one below and the other above the shelly drift. His classification has been adopted by Mr. A. Bell¹ and others; still there does not appear to be evidence in Ireland for two distinct ages of glacial drift, separated by an interval, represented by sub-aqueous accumulations (sand, gravel, marl-clay, &c.), and the reasons for this conclusion will be given in this paper.

There is reason for supposing that in Ireland since the great Glacial period there have been four marked changes in the level of the country:—

I.—During the first, the land sank from 250 to 350 feet lower than at present. This we will call the *Period of the 300 feet sea beach* or the *Esler sea period*.

II.—At the second the land was stationary for some time, while between 70 and 120 feet lower than it now is. This may be called the *Time of the 100 feet sea beach*.

III.—At the third there was a rest when the land was from 20 to 30 feet lower than now. This I propose to call the *Time of the 25 feet sea beach*.

IV.—At the fourth the land was at least 30 feet higher than it is now. The subsequent depression by which it was brought to its present level appears to be still in progress in certain places.

These changes seem to have been more or less prevalent over the whole country, but not always uniform, as since the Glacial period the drifts have been affected by faults, some of very recent date, and

¹ Palæontology of the Post-Glacial Drift of Ireland, by Alfred Bell, GEOL. MAG. 1873, Vol. X. p. 447.

on their downthrow sides the drift may be much lower than on the upthrow, on which account the ancient sea beaches are not universally at the same elevation.

I.—The evidence for this movement is very general throughout the island, as in many places below the 350 feet contour line, and in all places below the 250 feet contour line, the Glacial drift, whether Boulder-clay drift or Moraine drift,¹ is more or less washed and sorted into silt, sand, gravel, or shingle.

II.—This interval of rest at the level specified seems proved by the raised beaches in places near the coast, and in valleys between 70 and 120 feet above the level of the sea.

III.—That the land was stationary at this stage is proved by raised beaches and old sea cliffs found at or near the present coast line; while the subsidence

IV. is evident from the sub-marine bogs off the coast and the submerged bogs and land accumulations under the muds, etc., in the estuaries, lagoons, salt-marshes, and elsewhere.

The accumulations formed during the time included in Nos. I., II., and III. are very similar in aspect, and may be clays, marls, sands, gravels, or shingles. It does not appear improbable that if properly worked out they might be found to contain different suites of fossils; this, however, has not as yet been done, and the fossils collected from the different zones have all been grouped together. All the shelly drifts on the east and south-east of Ireland, with the gravels containing chalk flints on the coast of Cork, have been classed as one, by Prof. Harkness, while it is quite evident that portions of them, at the east and south-east are distinct, and belong to the three different periods, while all the Cork gravels containing chalk flints probably belong to the second or third period, as high up above them in the hills are the remains of the 300 feet sea beach.

The gravels mentioned by Mr. Du Noyer on the coast of Dublin and Louth belong to the second or third period, probably the latter, while those near Howth Harbour seem to belong to the second.

In the south-east portion of Wicklow, and in the co. Wexford, the marls, sands, gravels, and shingles of the time of the 100 feet beach in general contain fragments of shells; but as these drifts are made up of the re-arranged older shelly deposits, much cannot be learned from them, unless it shall be proved hereafter that they contain fossils which do not occur in the shelly drifts of the first period.

In the central plain of Ireland the gravels of the "Esker sea period," as a rule, are devoid of fossils. These have, however, been found in a few places, as Dr. Oldham, F.R.S., records them at Finglas, co. Dublin (200 feet); Clane, co. Kildare; Naas, co. Kildare (380 feet); between Athy and Castle Comer on the slopes of the high Coal-measure table land; and at Roscrea, co. Tipperary (400 feet). Sir R. Griffith has recorded fossils in the drift at Tarmon Hill, co. Mayo (250 feet); and the late General Portlock found them in the co. Sligo at 200 feet, and in the co. Londonderry

¹ *Moraine drift*, called Boulder drift in my early papers on the Irish drifts.

up to 300 feet. I found one shell in the Esker at Maryboro', Queen's co.; while Messrs. Bryce and Hyndman have found them near Belfast up to a height of 150 feet. All these localities, except, perhaps, those of Messrs. Bryce and Hyndman, are probably in gravel or sands belonging to the "Esker sea period," and the great height at which some of them are found will be hereafter referred to. From the above it is seen that although as a general rule the "Esker sea period" gravels are without fossils, yet in some places these do occur; and this peculiarity may be due to the conditions under which the drift was formed. As in places these gravels contain fossils, and as they occur at an elevation very similar to that of the shelly drifts of the co. Wexford, it does not appear unreasonable to suppose that all were formed simultaneously; and in support of this idea it should be mentioned that to the south-west, and north-west, the Wexford shelly drift seems to graduate into unfossiliferous accumulations, while in both localities they seem to merge into the "Esker sea period" gravels: from the first, through the valleys of the Suir, the Nore, and the Barrow; and from the latter, through the valley of the Slaney: while in places, both on the Esker gravels of the central plain, and on the Wexford shelly drift, there are perched erratics that seem to have been dropped from icebergs. If this suggestion is correct, the drifts of Wexford and south-east Wicklow must have accumulated under conditions more favourable than the other "Esker sea period" gravels to the growth and preservation of the shells now found in them.¹

It was at one time suggested that the ridges or eskers of the central plain of Ireland were the remains of a central gravelly member of the glacial drift, and that it had once been covered by a newer Boulder-clay. If such had been the case, it is scarcely possible but that in that portion of the island a part of the Upper Boulder-clay would have remained, to record its former existence. This suggestion, however, had to be abandoned, as the Officers of the Geological Survey in no place could find the remains of this Upper Boulder-clay, but, on the contrary, found that the "Esker sea period" gravels were always the highest member, whether the subjacent drift be the older Boulder-clay drift or the newer Moraine drift, the Esker-gravels stretching continuously over both. In the S.E. of Ireland, in the counties Wicklow and Wexford, over the shelly drifts is found in places a drift that sometimes contains ice-dressed blocks and fragments, and in places graduates into true glacial-drift.² This *Glacialoid* (or glacial-like) drift, however, also graduates into, and is interstratified with, the shelly gravels, marls, and clays, and does not always contain the ice-dressed blocks and

¹ Sir H. James records shells at a height of 400 feet on the Forth Mountains, co. Wexford. There would, however, seem to be a mistake in the figures, as Mr. Wyley, during his survey, did not observe them, but states they are not to be found above 250 or 300 feet, and the drift on the higher portions of those hills is a rock detritus in which shells could scarcely occur.

² On the borders of the counties Limerick and Tipperary, fringing the high land [Slieve Phelim], Glacialoid drift is found capping and interstratified with the Esker-period gravels.

fragments, these being more frequent where it approaches the true glacial drift than elsewhere, while ice-dressed blocks are also sometimes found in the marl or clay; and, what appears to be remarkable, many of the blocks in these argillaceous accumulations may retain a good polish, while the polish on the block in the *Glacialoid* drift is more or less obliterated, as if by the attrition of sand, etc.

The *Glacialoid* drift usually contains fragments of fossils, chalk, and flints, and shows other features characteristic of the typical shelly drift, often in lenticular patches of gravel; and, except in the immediate proximity to the true glacial drift, lenticular patches, layers, and partings of gravel, sand, marl, or clay, occur more or less frequently, the mass being more or less distinctly stratified. This drift is always at about the same elevation as the shelly drifts into which it graduates. A peculiarity of the contained blocks and fragments is, that in some places they all, in other places the majority of them, stand on edge, which seems seldom to be the case in typical Boulder-clay drift and rarely in Moraine drift.¹

The accumulations formed during the time of the 100 feet beach, near the east and south-east coasts, are similar in materials to those of the first, and may be shingle, gravel, sand, clay, or marl. They always contain fragments of fossils, but many of these evidently belong to the older gravels, etc., from which the newer drifts were formed. They are found in some of the valleys running inland, and seem to be more or less regularly distributed at heights under 100 feet. On the west coast, fossils have not been recorded in them; but these deposits, sometimes forming cliffs or shelves in the hill-sides, have been noted in places in the counties Cork, Kerry, Clare, Galway, and Mayo. Their limits and altitude, however, are very uncertain, on account of the gravels, etc., of which they are formed being similar to those of the "Esker-sea period." In the vicinity of Menlough, N.N.E. of the town of Galway, there is a "remarkable sea-beach-like bank." This in one locality is a well defined shingle beach, at an altitude of about 80 or 90 feet; but toward the N.W. and N.E. it seems to graduate into gravels, those to the N.W. being traceable onwards up to a height of 150 feet. In most of the low valleys in West Galway there are well developed tidal bars between the 100 and 120 feet contour lines. These probably mark the margin of the same sea-level as those at Menlough, but are at a higher level on account of the great Post-Glacial faults that traverse the valleys now occupied by Lough Corrib and its tributaries.

The third time, one of rest, is recorded by the raised beaches of shelly sand and gravel found in different places close to the coast-line, but especially near the north-east and south-west coasts. These were also observed on one of the Aran Islands, Galway Bay. In other parts of Galway, also in Mayo, there are terraces of gravel that appear to have been formed at this time; while in places in the co. Clare

¹ In typical Boulder-clay drift there may be subordinate portions in which the blocks stand on edge. This, however, seems always to occur in places where we may suppose an iceberg or shore-ice was aground on the Boulder-clay drift, and shoved the blocks up on end.

and in the co. Limerick there are well-marked low cliffs that are supposed to be contemporaneous. In south-east Ireland, near the coast, gravels of this period seem not to be recorded.¹ This, however, may be due to the great encroachment of the sea on its soft cliffs, which has obliterated all traces, except in the low places bordering the lagoons, estuaries, and inland bays. The shelly estuary gravel, on which a considerable portion of Dublin is built, seems to belong to this period.

Previous to mentioning the submerged bogs and forests that mark the fourth period, it appears necessary to vindicate their real significance, as it has been suggested that submerged and submarine bogs do not prove a subsidence of the land, as they may accumulate in lagoons or other places below the sea-level, and afterwards be submerged by the sea breaking through the enclosing barrier, or the bogs may become submarine by the sand bank being moved landwards. In some cases such a supposition may be correct; but in most cases (those of the Irish submerged and submarine bogs being among the number) it could not be the case, as the bogs contain roots, or "corkers," *in situ*, of such trees as the oak and pine—timber that would not grow except on drained ground; besides, the trees are of considerable size: consequently the land must have been above the sea-level for a long time, while the oak and pine forest was growing to maturity; while subsequently the land would seem to have begun to sink, and the drainage to have become defective, causing the decay of the forest, and afterwards marshes in which such trees as willows grew, with peat producing plants succeeding. The latter state must also have existed for a considerable time, when we notice the thickness of the peat found in the submerged and submarine bogs, and know the length of time that the vegetable matter required to form only a few inches of solid peat, took to grow before the peat had sunk gradually below the level of the sea. Fresh water or brackish water deposits must have accumulated in such places, which were succeeded by marine deposits. Subsequently the land seems to have risen slightly, as in most, if not all cases where these estuary lands have been reclaimed, there is a greater or less thickness of the surface portion, highly impregnated with iron, and in general separated from the purer marl underneath by a stratum of shells. This highly ferruginous portion seems to have been deposited in shallow water, the iron being due to the mineral in solution having been deposited from the water evaporated, while, when the water was deep, all such solid matter would have been carried away. The oxide of iron being deposited when the salts of iron, such as a sulphate or carbonate, common in many waters, are decomposed by decayed vegetable or animal matter, thus forming in the marginal or shallow portions of lakes, estuaries, etc. The layer or stratum of shells separating the two varieties of marl is evidently due to the change in the condition of the water, as, when it became charged with iron, it destroyed the animal life. Why this should have taken place suddenly is not

¹ Since the above was written, my colleague, Mr. E. T. Hardman, has drawn attention to a beach of this period near Tramore, co. Waterford.

apparent; but it may have been due to a sudden change in the level of the land, or, what seems more probable, to the formation of sand banks that dammed up portions of the slobes, causing the water on them suddenly to become brackish or even fresh.

These sunken and submarine bogs are as yet unexplored, consequently their depth beneath the level of the sea is unknown. Peat, however, from 10 to 16 feet deep, has been sounded in places off the south and west coast, below low water of spring tides; while during the works carried on for the reclamation of the estuary muds of Wexford Harbour, peat about 5 feet thick was found under 16 feet of the mud, the lowest portion being 21 feet below the surface; and these muds, before they were reclaimed, were covered at half-tide. It may also be mentioned that in places off the mouth of Wexford Harbour there are now tidal islands in places, which in the ancient charts were marked as "dangerous shoals."

A *résumé* has now been given of the movements that are known to have changed the level of the country, and a short description of the drifts and other deposits accumulated during these recent periods;¹ we may therefore return to the *Glacialoid drift*; and as we believe it is not a true glacial drift, we will give suggestions as to how it may have been formed, illustrating these by facts that can be observed at the present day.

The *Glacialoid drift* of south-east Ireland occurs over or interstratified with shelly drifts, while under the latter are typical glacial drifts. Beginning to the northward at Killiney-hill, co. Dublin, there is a shelly gravel overlying a Boulder-clay. The latter drift can be traced southward from that hill along the sea-cliff to Bray river, it appearing at the base of the cliff under the shelly drifts. It is nearly continuous all the way; but as the drifts have been moved up and down by recent faults, in a few places, where it has been let down below the sea-level, it is hidden from view. Over this Boulder-clay the drift may be sand, gravel, in a few places a shingle, or marl or clay, often a good brick clay; and all except the last are more or less shelly. There is also a sandy clayey accumulation, which in places contains subangular or rounded blocks and fragments, some of which are partially ice-dressed. The latter variety only occurs in very subordinate quantities, and always graduates into the gravels or clays, generally the latter. The division between the shelly drift and the Boulder-clay is in general well marked, and the change from one to another abrupt; but in a few places it is not so, one being a little southward of Shanganagh river, where near the base of the former there is a thin subordinate bed of Boulder-clay. Inland, in the country between Kingstown and Bray, similar varieties of the upper drift occur, with apparently the same relations to one another; while where the Boulder-clay drift is exposed, they always appear to lie on it.² In

¹ The *Æolian drift* or blowing sand has not been mentioned in connexion with these accumulations, as such sands may be of any age, some being as old as the later part of the *Glacial Period*, having been formed while the moraine drift was accumulating, while portions are forming at the present day.

² There is a section exposed in the old sea-cliff at Dunleary Harbour, east of the Salt-hill Hotel, in which, as seen from the railway, a Boulder-clay-like drift overlies

the railway cuttings north and south of Bray Head, up to a height of about 200 feet, there are shelly gravels interstratified with *Glacialoid drift*; portions of the latter drift being, apparently, in both places the uppermost member in the section. In the co. Wexford, according to the published geological maps, most of the country below the 250 feet contour line is occupied by shelly drifts; but in this area of shelly drift are rocky tracts or exposures of "Rocky" and Boulder-clay drift, while some of the land above the 250 feet contour line is also surrounded by it. The shelly drift in general is more or less gravelly on the south of these exposures, and to the north margin of the area; while marls and clays are found to the north of the exposures and in the wide open spaces. Associated with these arenaceous and argillaceous accumulations the *Glacialoid drift* occurs, but mostly with the latter, dovetailed into them or graduating into them, and in places overlying them. As this *Glacialoid drift* has previously been noticed, it is unnecessary here to repeat the description.

(To be concluded in our next Number.)

IV.—DESCRIPTIONS OF NEW FOSSILS FROM THE DEVONIAN FORMATION OF CANADA.

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(PLATE VI.)

(Continued from page 60.)

Genus *PRODUCTELLA*, Hall.

"Shells having the general form of *Productus*, but uniformly with a narrow area on each valve, a foramen or callosity on the ventral area, small teeth, and more or less distinct teeth-sockets. The reniform vascular impression, rising from between the anterior and posterior ocluser muscular impressions, curves gently outwards, and, following a curvature somewhat parallel with the margin of the shell to below the middle of its length, is abruptly re-curved, and the extremity, turned a little backwards, terminates about halfway between the margin and the anterior extremity of the mesial septum. The cardinal process, seen from the inner side, is bilobed, and from the exterior side each of these divisions is usually bilobed.

"These shells differ from *Strophalosia* in the extremely narrow linear cardinal area, greater extension of the hinge-line, more extreme arcuation or ventricosity of the vental valve in many or most of the species, and especially in the direction and termination of the reniform vascular impressions, which resemble those of *Anulosteges* and of some species of *Productus*. It differs from *Productus* in the constant presence of an area, hinge-teeth, and sockets." (Hall, Pal. N. Y. vol. iv. p. 153.)

Productella is considered by Hall as a mere sub-genus of *Producta*; a considerable thickness of gravel. The base of this cliff is a huge kitchen-midden. Consequently it could not be examined. Therefore I cannot say if the upper portion of this section is typical Boulder-clay drift, or if the underlying gravels are similar to the shelly gravels in the adjacent country to the south.