dredging nearer the shore, and from this I inferred that the fossiliferous bed, which seems to stretch along the coast at a distance of from six to fifteen miles, does not extend beyond this deep water to the "Long Forties." On examination of the materials brought up by the dredge from the top of the bank, there were found shells of the following species in a worn and semi-fossil condition, namely:—

Purpura lapillus, one specimen.
Litorina rudis, one specimen.
Solen siliqua, two specimens.
Mytilus edulis, one large broken valve and several fragments of smaller specimens.

Before it occurred to me that these fragmentary fossils might be interesting in a geological point of view, the greater part of the dredgings had been examined. It is quite possible, therefore, that other specimens may have escaped notice.

Now as *Litorina rudis* is generally found on rocks above high-water mark, and never beyond low-water, and as all the other species are highly characteristic of the shore, or very shallow water, it seems a fair conclusion that at the period when these were living, the relative levels of land and sea were very different from what they now are, and that the bank had then formed the shore of the German Ocean. If only one specimen had been found it might have been accounted for by some of the many accidents which occasionally bring even a foreign shell into the dredger's bag; but four species having been found in the course of one day's dredging, it appears very probable that they lived and died where they were found.

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3. *On the* Glacial phenomena *of* Caithness.

By T. F. Jamieson, F.G.S.

Contents.

1. *Introduction.*—In August 1865 I paid a visit to Caithness, in order to study the last geological changes in that north-eastern corner of Scotland. Mr. Peach has lately given us an excellent account of the fossil-contents of its glacial beds, from which he enumerates seventy-five species of Mollusca, besides various other forms of Invertebrata. The object, however, of my visit was not so much to look after the fossils as to satisfy myself about the conditions

under which the beds containing them had been accumulated, and to compare them with those of other districts with which I was already acquainted.

In the neighbourhood of Glasgow, and along the east coast from Aberdeen to Edinburgh, we find the beds containing Arctic shells lying on the top of a rough boulder-clay destitute of such fossils; and these marine fossiliferous beds are often of great depth and finely laminated, presenting all the features of tranquil and regular deposition. The remains of mollusca and starfishes in them are, in many instances, quite entire and uninjured, as if they had been gradually enveloped in the fine mud in which the animals lived and died, while the crust of large barnacles on some of the stones points to a like stillness of the sea-bottom. In Caithness nothing of this sort has been observed; no distinction has been made of a rough boulder-clay destitute of fossils and an overlying marine fossiliferous bed; the shells, according to all observers—Dick, Cleghorn, Hugh Miller, Peach, and others—are described as being scattered in a broken state all through a mass of rough boulder-clay, and no such thing as a bed of tranquilly deposited marine sediment containing entire shells has been reported. This seemed to me to indicate that the conditions under which the glacial beds of Caithness were accumulated must have differed in some way from those that prevailed in the other districts, and I was therefore desirous of studying the locality in order to make out, if I could, the cause of the difference.

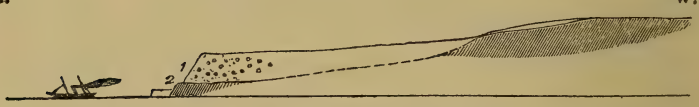
2. *General distribution of the Drift, its colour, texture, and contents.*—Viewed from a distance, Caithness has the appearance of a bare undulating plain, sloping very gently to the north and north-east, and terminating in lines of rocky cliff which are battered by a restless and stormy sea. Along the southern border of this plain there is a fine group of hills, of which Morven (2331 feet), the Scarabins (2048 feet), and the Pap of Caithness (1229 feet) are the most conspicuous; there are, also, some straggling heights of lesser importance along the western side of the county. These hills form a sort of separation or boundary between the low district of Caithness and the more mountainous region of Sutherlandshire. Geologically it is a country of Old Red Sandstone. The hills just mentioned consist of quartzose mica-schist and granite, on the flanks of which repose thick masses of conglomerate and grit forming the base of the Old Red in this region. These beds of conglomerate and grit pass up into a great series of thin-bedded shales, flags, and sandstones, generally of a dark-grey colour, which stretch away in billowy undulations over the surface of the country to its north-eastern corner, as has been well shown by Sir Roderick Murchison.

It is in the low troughs and winding hollows which form the beds of the various streams that we find any quantity of glacial débris; on the higher ground the rocks are either bare and devoid of earthy cover, or hidden by a growth of peat and heather. Some of these low tracts run across the country from side to side, as, for example, from Wick to Thurso by way of Loch Watten, and between

Fig. 1.—*Sketch Map of Caithness, showing the boundary of the dark-grey drift, and the direction of the glacial markings.*

Dunnet Bay and Sinclair Bay. Another low tract passes up the bed of the Thurso water and along to the east coast by way of Dunbeath. The drift is spread in sheets filling up these troughs and levelling the irregularities of the rocky strata so as to impart a smoother and softer outline to the surface. So far as I saw, it does not form irregular mounds and hillocks, neither is it very rough on the surface with erratic blocks; it seems confined in a great measure to the lower levels, thinning out at altitudes of 100 or 150 feet. The thickness, therefore, varies much, being greatest in those depressions which descend nearly to the sea-level. Thus at Scrabster harbour, in Thurso bay, there are banks of it more than 100 feet high, and in some of the troughs of the south branch of the Dunbeath water it is nearly as thick. Deep masses occupy the hollow from Watten to the Bay of Wick, and also stretch along the Thurso river into the very centre of the county. There is also a good deal of it in the bed of the Forss and at Lybster, but at the Freswick Burn it is comparatively thin. In all these places it is of very much the same hue, being of a deep leaden-grey or slate-colour, very dark when moist, and considerably paler when dry, similar, in fact, to the colour of the Caithness flags on which it rests. Occasionally the upper portion is of a browner, more ferruginous tint, which may be owing to the influence of the atmosphere, the percolation of surface-water, or to some other cause.

Fig. 2.—*Scrabster Harbour.*



1. Unstratified pebbly clay with very few broken shells.
2. Old Red Sandstone.

The texture, however, varies a good deal in different places. At Scrabster harbour, where it reaches a thickness of more than 100 feet, no difference can be perceived from top to bottom; it is just the same at the base, where it is in contact with the ice-worn surface of the subjacent rock, as it is 100 or 150 feet higher up. It shows no stratification nor traces of gradual deposition. It is a coarse gritty mud, exceedingly firm and difficult to pierce, and thickly charged with small stones, which are dispersed very uniformly throughout all parts of the deposit. Pebbles of all sizes below that of a man's fist or foot are the prevailing dimensions, but stones of from two to three feet in length also occur; I saw no great erratic blocks. The stones are more or less worn and rubbed, and many of them show the glacial scratches. A few small fragments of shells are dispersed through all parts of the bank, from the bottom to within at least 15 feet of the top, but are by no means common. Such is the character of the section at Scrabster, and it is very much the same along the banks of the Thurso water for several miles up

its course; but for a mile or two above Halkirk pieces of shells are more common, and occasionally an entire valve may be met with. So thickly packed is this drift with small stony rubbish that in many places almost every handful of mud contains several fragments.

Along the banks of the Haster Burn, near Wick, large stones are more common in the drift, and there are even some considerable boulders; but notwithstanding the coarse stony nature of the deposit, this is one of the best localities for fossils, fragments of shells being of frequent occurrence dispersed in the unstratified rough stony mud; and in the course of a single visit to this stream, in company with Mr. Joseph Anderson of Wick, I got an entire valve of *Astarte borealis*, and one or two specimens of *Turritella* and *Natica* nearly perfect.

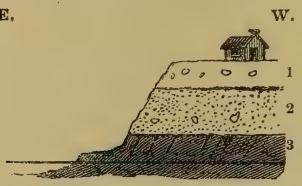
At the south branch of the Dunbeath stream, the sections are similar to those on the Thurso river, and pieces of shells about equally common. In the bed of the Forss the drift is very full of stones, and shells are exceedingly rare; otherwise it resembles that of the localities just mentioned.

Fig. 3.—*Section at Wick Bay.*

1. Reddish-brown clay with boulders.
2. Dark pebbly silt with broken shells.
3. Old Red Sandstone.

At Wick, however, it is somewhat different; in the banks beside the harbour (at Pulteney town) the drift is 50 or 60 feet deep. The lowermost two-thirds of it are a sandy mud, or silt, of a very dark grey colour, solid and firm as if much compressed; and although there are a good many small pebbles dispersed through it, yet they do not form a large proportion of the mass, and there is an absence of big stones. Fragments of shells are in many places not uncommon, and are scattered through it in an irregular manner, not occurring in horizontal lines or seams. There is, in short, no distinct stratification, although in some places there is an approach to it, owing to patches of a more sandy nature occurring; it is an unstratified pebbly silt, the greater part of the mass consisting of fine sand. The upper part of the bank, on the other hand, is of a browner, more ferruginous colour, much coarser in quality, with more muddy sediment and few or no shells; it is also full of stones and large ice-worn boulders of sandstone, quartzose, mica-schist, and granite, on which the glacial scoring is well marked. One of these granite blocks is 12 feet in length. I cannot say that there is any clear sharp line of separation between this coarse upper stuff and the dark siltier matter beneath; for although in some places the distinction is pretty well marked, in others they seem to graduate into each other. Where the rock rises in the cliff, the dark silty portion thins out, and the coarse brown mud full of boulders rests immediately upon the ice-worn surface of the Caithness flags.

Fig. 4.—*Section at Keiss Harbour.*



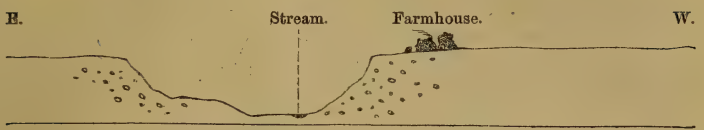
1. Reddish-brown stony clay.
2. Dark-grey pebbly silt with broken shells.
3. Sandstone, iceworn.

At Keiss harbour, which lies seven or eight miles further to the north, the character of the section is very much the same as at Wick. The total thickness of the drift near the harbour is about 40 feet. The lowermost 23 feet consist of an unstratified mass of dark sandy mud, with a few broken shells and some stones dispersed through it, which reposes directly upon the ice-worn surface of a red sandstone rock, without the intervention of any other deposit. The scratches and grooves point N. 35° to 40° W., and some of the imbedded stones are likewise scratched. The upper 17 feet of the bank consists of a browner coarse mud with more stones, and, so far as I observed, no shells. Although the lowermost sandy portion of the drift at Keiss and Wick has no distinct stratification, it is nevertheless more like an ordinary marine deposit than what I saw in the other sections throughout Caithness.

3. *Character of the Stones imbedded in the Drift.*—The stones imbedded in the Caithness Drift consist for the most part of the débris of the Caithness flags—those beds which Murchison terms the middle division of the Old Red Sandstone of this part of Scotland—and accordingly the general hue of the drift closely resembles the prevailing dark bluish-grey tint of these strata. There is, however, always a mixture of other sorts; fragments of quartzose mica-schist, and granite occur, so far as I observed, very frequently in the drift of all parts of Caithness. I noticed them at the Burn of Freswick, which is only a few miles from Duncansby Head, also at Keiss, and all about the neighbourhood of Wick, and along the whole of the Thurso water. There are likewise generally some fragments of sandstone and conglomerate, and occasionally one of hornblende-schist; this latter, however, is not common. Mr. Peach also mentions the occurrence of porphyry, gneiss, Oolite, Lias, and Chalk-flints. Mr. Dick told me that fragments of Oolite are not uncommon; I myself observed many pieces of it in the drift at the mouth of Berriedale.

I did not see many large erratic blocks, but Mr. Peach tells me that some big ones of conglomerate are scattered across the country, more particularly between Weydale and Stonegun, near Thurso. He saw *very* few on the Scarabin hills. Mr. Dick told me he had not observed any large blocks which might not have been derived

Fig. 5.—*On the Thurso Water, near Thurso.*



The high banks on both sides of the stream consist of unstratified pebbly clay or gritty mud with a few traces of broken shells.

from rocks in some part of the county, with the exception of one of granite near Castletown, which he thought was different from any of the Caithness granites, and had probably come from Sutherland, where a similar quality of rock is known to occur.

4. *State of the Shells.*—The shells, as a rule, occur in broken fragments. The most common kinds are the *Cyprina Islandica*, *Turritella ungulina*, *Astarte borealis*, *A. elliptica*, *Tellina calcaria*, and *T. Balthica*. Although broken pieces are the rule, yet exceptions sometimes occur. Thus, during the search that I myself made, I found one entire valve of *Astarte borealis*, another of *A. elliptica*, and two small ones of *A. compressa*, likewise a specimen of *Natica nitida* and another of *N. Islandica*, both almost perfect. And in the collections of Mr. Joseph Anderson and Mr. Robert Dick I saw several entire single valves of *Astarte* and *Leda*, on which there were occasionally small portions of the epidermis or skin remaining, also entire specimens of *Mangelia* and *Nassa*. Mr. Peach has even got a specimen of *Anomia* with both valves compiete, in a fine state of preservation, and this was in the drift containing the usual assemblage of ice-worn stones and broken shells, the only instance of an entire bivalve that I have heard of. The *Turritella*, which is one of the most common of all the species, although always more or less imperfect, yet frequently occurs in large pieces, some of them not far from being entire. I nowhere observed any instance of the shells being found in an undisturbed condition, nor could I hear of any such having been found; there seems to be no such thing as a bed of laminated silt with shells *in situ*. Even the *Foraminifera*, when seen through the microscope have a rubbed, worn appearance. No clay suitable for the manufacture of bricks and tiles or drain-pipes has been got in Caithnes, it is all too sandy and full of stones. The laminated brick-clays are, in short, entirely absent.

Many of the shell-fragments show marks of glacial action. It is generally on the stouter pieces of *Cyprina* and *Astarte* that these are to be seen, but I found some fragments of *Tellina calcaria* distinctly marked. Now this is rather a delicate fragile shell, and the fact of its being so marked and yet not crushed to powder, shows how gentle, in some cases, the action must have been that imprinted these markings. Where the shell-fragments are of an elongated form, the scratches run lengthways along them, just as they do on the pebbles. I have one piece of shell, which I picked up myself, not quite an inch long, most beautifully marked with a multitude of fine parallel scratches as if done by the point of a needle, and quite polished even

on the broken edges. The fragments of *Turritella* somehow seldom show these markings.

5. *The Glaciation of the Rocks and Boulders.*—One of the objects I had particularly in view was to note the direction of the glacial markings on the rocks, and to ascertain whether they could be accounted for by a movement of ice proceeding from the interior of the country towards the coast. I therefore lost no opportunity of noting the bearings of the scratches wherever I saw them. The result showed a pretty uniform direction over the whole district, the lines running N.W. and S.E. Thus:—

At Reay	N. 45° to 55° W.
Ditto at another place	N. 50° W.
About halfway between Forss and Reay	N.W.
In the bed of the Forss water	N. 45° W.
On the top of Leurery hill (about five miles S.W. of Thurso)	N. 55° to 60° W.
At Scrabster harbour	N. 30° W.
On the top of a cliff near Skirza Head	N. 65° W.
In the bed of the Freswick stream	N. 35° to 40° W.
At Keiss harbour	N. 35° to 40° W.
At the new pier at Pulteney (Wick)	N. 15° W.
On the top of the cliff near the old castle of Wick	N. 15° W.
Some cross markings here pointing W. 15° S.	
In the bed of the Milton Burn (near Wick)	N. 43° to 45° W.
In the bed of the Haster Burn (near Wick), in several places finely displayed	N. 55° W.
On a hill-slope between the streams of Dunbeath and Berriedale, on conglomerate, well marked	N. 60. W.
On the roadside, near Berriedale Church	N. 60° to 65° W.
Ditto, one mile south of Berriedale inn	N. 45° W.
Ditto, two miles south of Berriedale inn	N. 40° W.
On Lumps of conglomerate (having an evident *stos-seite* on the N.W.) about two miles south of Berriedale	N. 34° to 40° W.

In the above the correction for compass variation has been applied. Mr. Peach in reference to this subject says, "All the grooves that I have met with on the rocks below the clay in Caithness run N. and S. with deviations to the E. and W.; I have found them almost all over the county." Upon inquiring of Mr. Peach, I find that his bearings are by compass. Remembering, therefore, that the compass in that district at present points fully 25° to the west of north, it will be seen that his account of the matter nearly corresponds with my own.

The impression left upon me by all I saw was, that the movement had been *from* north-west to south-east; for where I observed any indication of a *Stosseite* it was on the north-west side. In order to obtain further evidence on this point, I endeavoured to trace the boundary of the dark-grey drift; for I thought that, had the movement come from the north-west, the dark-grey mud derived from the Caithness flags should overlap the red grit and conglomerate towards Dunbeath and Berriedale, while the flags themselves should be overlapped at their north-western boundary towards Reay by a different-coloured drift. This I found to be the case. The dark-grey mud fills the bed of the Forss water, but does not extend beyond the watershed between that stream and the Burn of Isauld; and at Reay, the drift

covering the grey flags is of a reddish brown colour. On the other hand, the dark-grey mud stretches south-eastward, past Lybster, into the bed of the water of Dunbeath, and lies in heavy masses even in the south branch of that stream. I also traced it to the mouth of Berriedale water, where it mingles with the reddish-brown drift that prevails from there to the Ord; but further up the Berriedale Glen to the base of the Scarabin hills the colour is reddish brown. The distribution of the dark-grey mud therefore harmonizes with the supposition that the transport had been from the north-west; and a movement of ice from north-west to south-east across Caithness is totally at variance with the notion of the scratches having been caused by glacier-action proceeding from the interior of the country towards the present coast.

I have already mentioned that the stones imbedded in the drift of Caithness very often show the glacial striæ. When examining the sections along the Haster Burn, in company with Mr. Joseph Anderson, I remarked that the striæ on the imbedded fragments generally agreed in direction with those on the rock beneath. The scratches on the boulders, as usual, run lengthways along the stones when they are of an elongated form; and the position of these stones, as they lie imbedded in the drift, is, as a rule, such that their longer axes point in the same direction as do the scratches on the solid rock beneath, showing that the same agency that scored the rocks also ground and pushed along the drift. Interspersed amongst these ice-worn stones were many fragments of shells—themselves also scratched—and some univalves almost entire.

This coincidence of direction between the scratches on the stones and those on the subjacent rock I also observed in the section along the Milton Burn; and I am inclined to think it is a characteristic feature, and will be found of general occurrence. In my paper "On the last Geological changes in Scotland," I have described it as a feature of the boulder-earth or glacial-mud which lies beneath the marine beds in the midland region of Scotland. The appearance of the drift along the Haster Burn and in many other places in Caithness is, in fact, precisely the same as that of the Old Boulder-clay of the rest of Scotland, except that it is charged with remains of sea-shells and other marine organisms*. Mr. Anderson told me that

* The glacial drift of Caithness is particularly interesting as an example of a boulder-clay which, in its mode of accumulation and ice-scratched débris, very much resembles that unstratified stony mud which occurs underneath glaciers—the '*moraine profonde*' as some have called it. But the presence of marine organisms, and the direction of the glacial striæ, which indicate a movement of ice from the north-west, where there is now nothing but open sea for an immense distance, together with the absence of moraines, are all suggestive of marine conditions having prevailed during the deposition of the Caithness drift. It would therefore seem that sea-borne ice can in some places accumulate a mass of unstratified stony mud so like that which is found underneath a glacier as to be undistinguishable from it, except by containing remains of sea-animals. The scratched boulders used to be looked upon by some as a certain test of glacier-action. "Ces cailloux," says Ch. Martins, "sont, pour ainsi dire, *le fossile caractéristique* de la présence d'anciens glaciers."—Bull. Geol. Soc. of France, 2 ser. iv. 1191, 1847. In the Caithness drift, however, not only the stones, but the very sea-shells are glacially scratched, a circumstance which I have also observed in some of the glacial marine beds of Aberdeenshire.

specimens of this drift from the Haster Burn had, upon microscopical examination, yielded him abundance of *Foraminifera* and other minute remains of animal life. Mr. Anderson was the first to apply the test of washing and microscopic examination to the Caithness Drift, and Mr. Peach says that all the samples tried from between John O'Groats and Wick had yielded them in this way more or fewer *Foraminifera*, *Entomostraca*, &c.

6. *Absence of Moraines and Gravel-hillocks.*—I saw no abrupt mounds of gravel and boulders in Caithness, nothing like the Kaims or Esker ridges, nor anything like a moraine. Mr. Dick told me he had noticed some gravel-hillocks near Dirlet, but nowhere else. Circumstances prevented me from exploring the neighbourhood of Morven and the adjoining hills, but in a walk along the Berriedale Glen, from the base of the Scarabins to the sea, I observed no moraines. This part of the glen is deep, narrow, and winding. There is a good deal of unstratified reddish-brown stony earth in some places along the foot of the hills, in which some ice-scratched stones occur, and where the mouth of the glen opens upon the sea there is a great depth of it on the south bank. Large boulders of many different kinds—granite, sandstone, conglomerate, quartzose mica-schist—occur here, also fragments of shelly limestone, and bits of dark sandstone containing lignite. Most of this accumulation of drift has a reddish-brown colour, but there is also a mixture of dark bluish-grey stuff, in which after some search I got nine or ten small pieces of shell and a bit of a *Balanus*. This drift is likewise to be seen on the face of the sea-cliffs on the north side of the stream.

There is also, so far as I observed, very little valley-gravel; indeed I am inclined to think that the valley-gravel, such as we find it in the midland region of Scotland, is not developed in Caithness. That which occurs in the ruts of the various streams is merely what might be produced by the long-continued action of currents such as we see flowing in them at present. The gravel in these channels seems to be merely the stones derived from the banks of drift along their course, the finer sediment having been washed away by the current. So far as I saw, these beds of gravel are not extensive, and are confined to the bottom of the channels in which the streams run. These watercourses are trenches which appear to have been cut out of the drift by ordinary river-action.

7. *Relation of the Caithness Drift to that of the rest of Scotland.*—Caithness, therefore, differs from the midland region of Scotland in regard to its glacial phenomena:—

1st. In that the glaciation of its rocks seems to have been produced by a movement of ice proceeding, not from the interior of the country, but apparently from an external region to the north-west.

2nd. In its covering of drift, which resembles the Old Boulder-clay of the middle of Scotland in regard to its physical arrangement, but differs therefrom in the prevalence of marine organisms scattered through it.

3rd. In the absence of glacial-marine beds deposited with the

indications of tranquillity that we observe in the regions further to the south.

4th. In the deficiency of valley-gravel, and the absence of moraines and gravel-hillocks.

It is very desirable to ascertain the area over which these features prevail. From what Mr. Peach says of Shetland, I am inclined to think it will embrace both these islands and the Orkneys. I did not examine the north coast of Sutherlandshire, and cannot say how far in that direction the same characters extend; but in passing rapidly along the east coast of Sutherland and Ross it seemed to me that there was a change after going south of the Ord of Caithness, the shelly drift vanishing, while great moraine-like heaps of gravel make their appearance at the mouths of the several valleys. At Brora, for example, there is a remarkable assemblage of hillocks which come down close upon the shore, and at Dornoch Frith I noticed similar deposits on the north side near Clashmore, and on the south side along the base of Struie hill. At Muir of Ord, between Beauly and Dingwall, I examined another fine range of gravel-hillocks, extending from the neighbourhood of the railway-station westward up the flank of the hill to a considerable height. But the finest of all is a most remarkable series of ridges commencing at a place called Kildrummy, about two miles from Nairn, and ranging south-westward by the Loch of the Clans and Loch Flemington towards Culloden moor, in the neighbourhood of Inverness.

The direction of the glacial scoring in Caithness, if produced south-eastward, would pass the corner of Aberdeenshire near Fraserburgh; and here I may mention that I have recently observed traces of glacial action at a few places in the neighbourhood of that town, and it is interesting to remark that their direction corresponds with that in Caithness, being N.W. and S.E., and produced by an agency which seems to have come from the north-west. Thus :—

On a rock surface newly exposed in a railway-cutting near Rathen	N. 65° W.
At another spot in the same cutting	N. 45° W.
At Fraserburgh quarry	N. 40° to 65° W.
On the coast at St. Colms, about five miles south-east of Fraserburgh, there are some rocks which have a strong appearance of glaciation and a north-west *Stosseite*, while long fluted hollows point	N. 65° W.; but there are no trustworthy scratches.
The rocks also on the south side of Fraserburgh harbour have an appearance of glaciation coming from the north-west or west-north-west, and beside the turntable at the railway-station there are some scratches on the rock in varying directions.	

Again, it is worthy of remark that along the coast from Banff to Peterhead, the prevailing colour of the glacial clay is dark bluish-grey, quite like that of Caithness. This, however, may be owing to the sediment from the clay-slate of Banffshire having drifted eastward; but it may also be partly due to a drift of fine muddy matter from Caithness. The dark bluish-grey clay ranges south to Peterhead, where it thins out and is interstratified with the red clay

which prevails thence all along the east coast as far south as Fifeshire. In the neighbourhood of Peterhead, as for example, at the Invernettie brickwork (See Quart. Journ. Geol. Soc. vol. xiv. p. 518, 1858), there are many boulders of red and grey sandstone, and also of a tough greenish-coloured stone, all of which resemble rocks that occur in Caithness, but, so far as I know, not in the adjoining parts of Aberdeenshire. I have always been at a loss to account for these boulders near Peterhead, and also for the dark-grey tint of the clay between that town and Fraserburgh, seeing that the rocks of the district consist of mica-slate and granite. But looking at the direction of the glacial markings, I am somewhat inclined to think that both the boulders and the dark muddy sediment in this low projecting corner of Aberdeenshire may have drifted from Caithness.

8. *Place of the Caithness Drift in the history of the Glacial period.*—I have now to consider the relation in time of the glacial phenomena I have been describing to those of the rest of Scotland. In the parts of Caithness which I examined, it seems to me that we have only one glacial deposit, and I am further of opinion that we cannot separate, in point of time, the period of its accumulation and present arrangement from that of the scratching of the rocks on which it lies: for the coincidence in direction of the scores on the rocks with those on the stones imbedded in the drift shows that it was one great movement—long-continued probably—that marked the rocks and carried along the mass of stony mud that now rests upon them; in fact it was the movement of the drift across the surface of the rocks that scratched them. Now in the midland region of Scotland we have evidence of three well-marked stages in the Glacial period—1st, the great glaciation of the surface and deposition of the Old Boulder-clay or till; 2nd, the finely laminated glacial-marine beds; 3rd, the overlying gravels and moraines. To which of the divisions represented by these three are we to refer the Caithness drift? or is it the equivalent of any two of them, or of all the three?

The Caithness Drift contains remains of sea-shells all through it, often from top to bottom, and these shells are broken, rubbed, and scratched, evidently by the same agency that marked the rocks and boulders. This is an important fact, for it gives us a date for the action. The scratching and breaking of the shells was an event at least as late as the time when the Mollusca lived that formed the shells; and, seeing that the shells extend to the bottom of all the sections of the drift, it is further evident that none of it was lodged in its present position at a more remote date. Indeed, it is in the lower part of the sections that the fragments of shells chiefly occur; in some cases, as for example at Wick and Keiss, they are scarcely to be found in the upper portion. If, then, we could find the date of the shells, we should have a clue to the age of the drift itself. In the midland region of Scotland the Old Boulder-clay, and the scratching of the ice-worn surface of rock on which it rests, evidently preceded the time when the mollusca lived whose remains we find in the marine beds above it. At Loch Gilphead, in Argyleshire,

rows of *Mya Uddevallensis*, entire in their burrows, are found in the fine marine sediment overlying the Boulder-clay, and many other facts of a like nature might be cited. Now if the Caithness Drift is the equivalent of the Old Boulder-clay of the rest of Scotland, why do we not find some fine laminated clay above it, as we do in other places?

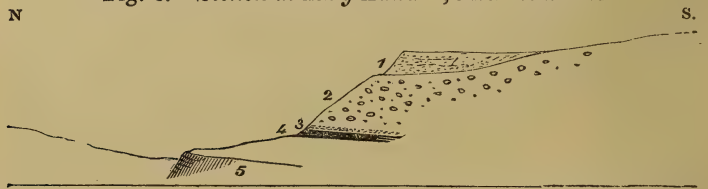
It may be said that the mollusca of the Caithness Drift are an older group than those found in the marine clays of the other parts of Scotland, and therefore, although these mollusca lived during the Caithness Drift, it does not necessarily follow that the latter deposit is more recent than the Old Boulder-clay of the rest of Scotland. An inspection, however, of the list given in the Appendix to this paper does not suggest an older age, but the contrary. In order to place this in a clearer light I have drawn up Table 2, in which the geographical relations of the Caithness shells may be compared with those of groups from the glacial beds of other parts of Scotland. Thanks to the efforts of Mr. Peach, we have a very good list from Caithness; moreover, the specimens have been all examined and named by Mr. Jeffreys, an eminent authority in these matters, so that the list may be used with all confidence.

I think it is a fair inference that the more nearly a group of British fossil mollusca resembles the assemblage of species now living upon the shores of Britain the more recent is the period to which that group belongs. I have accordingly ranged the groups in a series, those which show the lowest percentage of British forms being reckoned oldest. From this Table it will be seen that the Caithness group is the most modern, except that of Fort William, which in a former paper I had referred to the very close of the Glacial-marine period (Quart. Journ. Geol. Soc. vol. xxi. p. 174, 1865), while the proportion of Arctic species is less at Caithness than at any of the other localities—less even than at Fort William. It is not pretended that all these groups represent distinct stages in the Glacial period; several of them I have no doubt were contemporaneous, but I think we are entitled to suppose that the Errol, Elie, and other groups at the beginning of the list are older than the Caithness and Fort William ones. Here, then, we have further evidence to show that the accumulation, or at least the final arrangement, of the Caithness Drift was a comparatively late affair; it therefore ought not to be confounded with the Old Boulder-clay. It seems to me that it ought to be referred to the Glacial-marine period. A set of marine beds containing Arctic shells were probably deposited over the low part of Caithness; and much drifting ice seems to have passed over the district from the north-west, which crushed and destroyed these marine beds, broke the shells, and mixed them up with other superficial débris into that mass of rough pebbly mud which now overspreads the surface. These marine beds were probably of different ages, the older containing Arctic species, the later containing chiefly Boreal and southern forms. This would account for that mixture of species which we observe in the Caithness list.

At Invernettie, near Peterhead (see Quart. Journ. Geol. Soc. vol. xiv. p. 518, 1858), the base of the section shows fine stratified clay and sand free from stones, above which there is a thick mass of rough pebbly clay like that of Caithness, containing well-scratched boulders of granite, sandstone, &c., with some broken sea-shells, which also show traces of glacial scratching. Here, then, we have a mass of unstratified drift closely resembling that of Caithness, and from its position above the fine laminated clay apparently later than at least a part of the glacial-marine beds.

But the glacial deposits at King-Edward, in Aberdeenshire, throw still more light upon the relations of the Caithness beds. Some sections recently laid open there have enabled me to understand their arrangement far better than formerly. At this locality there are deep masses of unstratified pebbly mud of a dark-grey colour, very hard and firm, containing stones (some of which are ice-worn and striated) and fragments of shells, which are likewise occasionally scratched. It is, in short, so like the Caithness Drift in every respect—in colour, texture, and organic contents—that I can perceive no difference between them. It has been called "*the Boulder-clay*" by Mr. Robert Chambers, who visited the locality in 1855*. Besides this coarse stony mud there are some beds of fine stratified sand, which often contain remains of shells in considerable abundance, most of them broken, but many of them entire. The bivalves always occur in detached pieces and want the epidermis, as if they had been washed about by water. This, I believe, is the bed that yielded Hugh Miller's specimens, and from which I have obtained most of the species enumerated from King-Edward in my paper on the last geological changes in Scotland. But there is another bed of fine dark-grey silt, free from stones, containing Arctic shells entire, and apparently *in situ*, with the epidermis on. The *Tellina calcaria* occurs here of large size, with both valves connected by the ligament and shut, also *Leda*, *Natica*, and others; they are very sparingly dispersed in the silt, which contains streaks of black carbonaceous matter, proceeding probably from the decay of seaweed. It also contains *Foraminifera*. This bed of silt I noticed in 1857;

Fig. 6.—*Section at King-Edward, Aberdeenshire.*



1. Valley-gravel.
2. Pebbly clay.
3. Fine sand with shells.
4. Fine silt with shells *in situ*.
5. Rock.

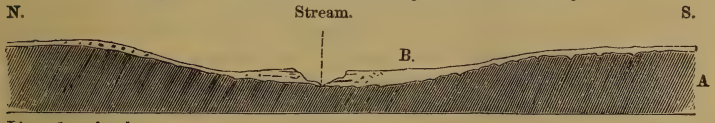
* See 'Proceedings of Royal Society of Edinburgh,' Dec. 17, 1855.

but, owing to the want of good sections, the arrangement of these various deposits was then obscure. It is, however, as follows:—

Commencing at the surface we have—	Thickness in feet.
1st. Water-worn gravel and sand, stratified, often rather coarse and pebbly, and somewhat ferruginous. Contains no fossils, so far as I have seen	10 to 25
2nd. Unstratified pebbly mud of a dark-grey tint, hard, and difficult to pierce. The stones in it are of small size, but numerous, and some of them glacially scratched. In the upper part I could see no shells; but shell-fragments occur in the lower part, increasing in numbers towards the base. Some of the shell-fragments show distinct traces of glacial action	20 to 30
3rd. Fine brownish sand, in some places rich in shells. This sand is interstratified with the upper part of the subjacent bed	1 to 2
4th. Fine dark-grey silt, free from stones, containing Arctic shells complete, and apparently *in situ*; they are, however, mostly decayed and somewhat crushed, so that it is difficult to extract them. This silt is very firm, as if much compressed, and the greater proportion of it consists of fine muddy sand. The base of this bed has not been exposed, but it has been excavated by Mr. James Runciman (who was so good as to lay it open at my request) to a depth of 10 feet. No difference in the quality is to be seen to this depth; no stones. The upper surface of this silt is about 150 feet above the sea.	

Here, then, we have a thick mass of drift, exactly like that of Caithness, clearly overlying a glacial-marine silt, with shells *in situ*. The broken shells in this coarse upper drift seem to have been derived from the beds below. In one part of the bank I found, at the bottom of the coarse pebbly mud, beds of fine silt with broken shells and confused stratification; these seemed to be ordinary marine beds disturbed from their original position by the agency that lodged the overlying drift. Where this disturbing action was so great as to completely break up and destroy the fine silty layers then we should have sections like those of Caithness, where the mass is unstratified from top to bottom, and I believe in many places of the King-Edward banks this will be found to be the case. Large boulders are rare in the King-Edward district, but I saw one of Greywacke from 3 to 4 feet in length, which seemed to have dropped out of the coarse pebbly mud.

Fig. 7.—*Section across King-Edward valley.*



A. Greywacke and clay-slate,
B. Glacial deposits.

In a notice of these King-Edward (the name is a corruption of *Kinedart*) beds in the 14th vol. of the Quart. Journ. Geol. Soc. 1858, p. 525, I remarked that the shells in the fine silt were often crushed in a remarkable way, as if by sudden pressure from above.

The glacial beds of the south of Arran (first described by the Rev. R. B. Watson, and more recently explored by Dr. Bryce and the Rev. H. W. Crosskey) seem to have many points of resemblance to those of King-Edward. There are beds of fine clay containing Arctic shells, sometimes in a broken or crushed state, but occasionally entire and apparently *in situ*. This fossiliferous stratum is covered by a great thickness of what Mr. Watson calls "*Boulder-clay*," but which Messrs. Bryce and Crosskey term "*Upper Drift beds*." If I understand Mr. Watson rightly, this upper stuff occasionally contains broken shells. The fine fossiliferous clay sometimes rests immediately on the older rocks, at other times, according to Messrs. Bryce and Crosskey, there is a mass of clay beneath it of harder, coarser texture than what lies above, and containing stones and boulders on which glacial action is more apparent, and they would restrict the term "*boulder-clay*" solely to this lower stuff. Mr. Watson mentions the occurrence of glacial beds beneath the fine shelly clay, but, according to him, they vary a good deal in character, and he does not draw the same strict distinction between them and the upper beds.

If want of stratification, hardness of texture, and abundance of well-glaciated stones and boulders are to be the tests for what we should call genuine Boulder-clay, then much of the Caithness Drift will stand the ordeal, and, moreover, the shells are as well glaciated as the boulders. The upper pebbly mud of King-Edward is also often very hard and firm.

If the Old Boulder-clay or till has been produced, not in the sea but by glacier-ice moving on the land, it ought to be devoid of marine fossils. What we now want is a microscopic examination of our various so-called Boulder-clays. Messrs. Anderson and Peach have made a commencement with those of Caithness, and find them full of minute organisms. This was to be expected from the presence of the sea-shells. The Boulder-clay, however, which lies beneath the beds of Arctic shells in the midland region of Scotland is remarkable for the absence of fossils, but it yet remains to be seen how it will stand the test of washing and microscopic examination.

9. *The post-Glacial period in Caithness.*—So far as I observed, the post-glacial conditions in Caithness do not appear to have differed much from those in the rest of Scotland. Some indications of a submerged forest, or old land-surface, occur at Sinclair Bay. The peat bed, close upon the shore at Ackergill, contains clusters of seeds of land-plants and also some remains of trees or bushes. Mr. Cleghorn, of Wick, thinks this peat bed is a marine deposit of matter carried into the sea by the rivers. After examining it in company with him I am inclined to differ from this opinion. The peat is covered by a mass of blown sand, which has insinuated itself into some of the crevices and openings of the peat, but I saw nothing to induce me to believe that there was any interstratification of peaty matter with marine sediment.

Mr. Dick told me that at Thurso some peat, containing hazel-nuts and twigs, had been got near the beach on the west side of the town, but I could not learn whether it was *in situ* or transported.

There are some traces of a recent change in the relative level of sea and land along the coast, but only to a very slight extent. The elevation of beds of coast-shingle cannot be depended on with much exactitude as evidence of the former level of the sea, for storm-waves fling up banks of pebbles to various heights, according to the nature of the coast. Even large boulders and great heavy blocks are moved in this way far above the reach of the tide in calm weather. A remarkable instance of this may be seen a little to the south of Wick, which has been cited by some as an example of iceberg-action. But I was assured by Mr. Joseph Anderson that within the last four or five years some of these blocks have been tossed about by the great waves which occasionally break upon the coast during severe gales, a statement which is confirmed by the observations of Mr. Peach. Mr. Cleghorn also told me that he had seen blocks of thirty tons' weight turned over by the surf 15 or 20 feet above the present level of the sea. Beds of estuarine silt, that have been accumulated in well-sheltered positions, afford a better means of determining the former sea-level. There are, however, no estuaries in Caithness, and I therefore cannot speak with confidence as to the amount of this recent change of level, but from all I saw I should think the present position of the land is only a very few feet higher than formerly. The beds of old estuarine mud at the firths of Dornoch, Cromarty, and Beauly attain no great height above the present sea-level—not so much as in the firths of Tay and Forth, or even at the Montrose basin.

Later than this last rise, as shown by their position, are two ancient tumuli in Sinclair Bay, known as "*the Birkle Hills*;" they are of large size and of a bee-hive form. They seem to contain some internal chambers, or stone structures of some sort, but have not been properly explored. One of them was partially opened last year by Mr. Laing. The bases of both are only a few feet above the present reach of spring tides; one of them, at least, is not more than 4 or 5 feet above it. The fact of these old remains being later than the raised beach agrees with my observations at the Estuary of the Ythan, in Aberdeenshire.

Kjokken-möddings, or heaps of edible shells mixed with burnt stones and the teeth and bones of various animals, abound along all the sandy bays of Caithness; I observed them in great numbers at Reay, at Freswick, and at Sinclair Bay. They are often covered by a considerable thickness of blown sand. At Reay I noticed a great quantity of the shells of *Helix nemoralis* in these heaps, as if it had been eaten there along with the limpets and periwinkles. Several teeth which I picked up from these heaps were examined by Dr. Turner, Demonstrator of Anatomy in the University of Edinburgh, who pronounced them to belong to the Pig, Horse, Ox, Deer, and Sheep.

Appendix.

In regard to the following Tables I have again to acknowledge the kind assistance of Mr. Jeffreys, who has done me the favour of revising the Caithness list, as well as the lists from which the abstract, Table no. 2, has been prepared.

The list of Caithness shells combines Mr. Peach's two lists (for which see 'Brit. Assoc. Report' for 1862, Trans. of the Sections, p. 83, *ibid.* for 1864, p. 61), and also some additional species enumerated in a paper lately communicated by him to the Physical Society of Edinburgh.

For the Fort William list see Jeffreys in the 'Brit. Assoc. Report' for 1862, Trans. of the Sections, p. 73. For that from Elie see the Rev. Thomas Brown in the 'Proceedings of the Royal Society of Edinburgh' for March 2nd, 1863. The others will be found in the Appendix to my paper in the 'Quart. Journ. Geol. Soc.' vol. xxi. p. 161, 1865.

In the two following Tables

Southern means species living on the west coast of Europe, to the south of lat. 50°.
British means species living on the coasts of Britain.
Northern means species living on the west coast of Europe, south of lat. 60° and the Arctic circle.
Arctic means species living within the Arctic circle.
N. E. American means species living on the east coast of North America.

TABLE I.—*List of Mollusca whose Shells are found in the Glacial Drift of Caithness.*

No.		Southern.	British.	Northern.	Arctic.	N. E. American.
1	Anomia ephippium, var. squamula	*	*	*	*	*
2	Aporrhais pes-pelecani	*	*	*	*	
3	Astarte borealis=A. arctica, of *Forbes & Hanley*	..	..	*	*	*
4	—— compressa	..	*	*	*	*
5	—— sulcata	*	*	*	*	
6	—— sulcata, var. elliptica	..	*	*	*	*
7	Buccinum undatum	*	*	*	*	
8	Cardium echinatum	*	*	*	*	*
9	—— edule	*	*	*	*	
10	—— exiguum=C. pygmæum, *F. & H.*	*	*	*	*	
11	—— fasciatum	*	*	*	*	
12	—— Grœnlandicum	..	..	..	*	*
13	—— Norvegicum	*	*	*	*?	
14	Cerithiopsis costulata=Turritella? costulata, *Möller.*	..	*	*	*	*
15	Chiton cinereus	*	*	*	*	*
16	Crenella decussata	..	*	*	*	*
17	Cyprina Islandica	*	*	*	*	*
18	Cyrtodaria (Glycimeris) siliqua	..	..	..	*	*
19	Dentalium abyssorum	..	..	*	*	*
20	—— entalis	*	*	*	*	*
21	Donax vittatus=D. anatinus, *F. & H.*	*	*	*	*	
22	Fusus antiquus	?	*	*	*	
23	Lacuna divaricata=L. vincta, *F. & H.*	*	*	*	*	*
24	Leda minuta=L. caudata, *F. & H.*	..	*	*	*	*
25	—— pernula, var. buccata	..	..	*	*	*
26	—— pygmæa	?	*	*	*	*
27	Littorina litorea	*	*	*	*	*

TABLE I. (*continued*).

No.		Southern.	British.	Northern.	Arctic.	N. E. American.
28	Littorina obtusata = L. littoralis, *F. & H.*	*	*	*	?	
29	Lucina borealis	*	*	*	*	
30	—— spinifera	*	*	*	*	
31	Mactra solida	*	*	*	*	
32	Mangelia lævigata = M. nebula, *F. & H.*	*	*			
33	—— Leufroyi	*	*			
34	—— pyramidalis	..	..	*	*	*
35	—— Trevelliana	..	*	*	*	
36	—— turricula	*	*	*	*	*
37	Mya truncata	*	*	*	*	*
38	—— ——, var. Uddevallensis	..	..	..	*	*
39	Mytilus edulis	*	*	*	*	*
40	—— modiolus = Modiola modiolus, *F. & H.*	..	*	*	*	*
41	Nassa incrassata	*	*	*	*	*
42	Natica affinis = N. clausa, *Brod. & Sow.*	..	..	*	*	*
43	—— Islandica = N. helicoides, *F. & H.*	..	*	*	*	*
44	—— nitida	*	*	*	*	
45	—— pallida = N. Grœnlandica = N. pusilla, *F. & H.*	..	*	*	*	*
46	—— sordida	*	*			
47	Nucula nucleus	*	*	*	*	
48	—— sulcata = N. decussata, *F. & H.*	*	*	*		
49	Odostomia acicula = Eulimella acicula, *F. & H.*	*	*	*		
50	—— albella (see *F. & H.* vol. iii. p. 286)	*	*	*		
51	Ostrea edulis	*	*	*	..	*
52	Patella vulgata	*	*	*	*	
53	Pecten Islandicus	..	..	*	*	*
54	—— maximus	*	*	*		
55	—— opercularis	*	*	*	*	
56	Purpura lapillus	*	*	*	*	*
57	Rhynchonella psittacea	..	..	*?	*	*
58	Rissoa parva, var. interrupta	*	*	*	*	
59	Saxicava Norvegica = Panopæa norvegica, *F. & H.*	..	*	*	*	*
60	—— rugosa. Large form	..	..	..	*	*
61	Solecurtus candidus	*	*			
62	Tellina calcaria = T. proxima, *F. & H.*	..	..	*	*	*
63	—— Balthica = T. solidula, *F. & H.*	*	*	*	*	*
64	Tornatella fasciata	*	*	*	*	
65	Trochus Grœnlandicus = T. undulatus, *F. & H.*	..	*	*	*	*
66	—— Vahli	..	..	..	*	*
67	—— zizyphinus	*	*	*	*	
68	Trophon clathratus = Fusus scalariformis, *Gould*	..	..	*	*	*
69	—— ——, var. Gunneri	..	..	*	*	*
70	—— truncatus = T. clathratus, *F. & H.*	..	*	*	*	*
71	Turritella ungulina = T. communis, *F. & H.*	*	*	*	*	
72	Venus casina	*	*	*		
73	—— gallina = V. strictula, *F. & H.*	*	*	*	*	
74	—— lincta = Artemis lincta, *F. & H.*	*	*	*		
75	—— ovata	*	*	*	*	
		46	60	66	63	41
	= per cent.	61	80	88	84	55

Of the above shells the *Turritella* and *Cyprina* are probably the most common. *Astarte*, *Natica*, *Tellina*, *Saxicava*, and *Mya* are also pretty frequent, and so likewise are *Dentalium entalis*, *Leda pernula*, *Cardium echinatum*, and *Mangelia turricula*. The scale of frequency, however, differs in different localities. Some of the species have been determined from single fragments, as, for example, *Venus ovata* and *Trochus zizyphinus*.

Patella vulgata is a shell I have never myself found in any of our Scotch glacial beds, but Mr. Peach informs me he got one pretty perfect specimen, besides two or three fragments. Mr. Dick also told me he had found it. In regard to some of the other species Mr. Peach has supplied me with the following information:—"*Pecten maximus* and *opercularis*, in fragments, occur frequently. *Cardium Norvegicum*, two or three hinge-pieces. *Fusus antiquus*, two pillar-lips. *Ostrea edulis*, one pretty large shell and several fragments"; and he says there can be no doubt whatever that these occur in the very same deposits as the more Arctic forms.

TABLE II.—*Showing the Geographical relations of groups of Mollusca whose Shells occur in some of the Scottish Glacial beds.*

Localities.....	Errol.	Elie.	King-Edward.	Paisley.	Kilchattan.	Gamrie.	Caithness.	Fort William.
Total number of species at each locality	13	14	27	26	16	25	75	47
Southern, per cent.	8	14	44	38	50	52	61	55
British, " ..	38	43	59	61	69	72	80	85
Northern, " ..	62	57	93	100	100	96	88	96
Arctic, " ..	100	100	100	100	100	100	84	89
N.E. American, "	100	100	89	85	87	88	55	70

Some interesting information may be gathered from the foregoing Table.

The Errol and Elie groups, it will be seen, are intensely Arctic; the shells are just such as we might find in the sea of Spitzbergen at the present day, many of the species not ranging south of the Arctic circle. In them the proportion of British species is less than 50 per cent., while that of the Southern has dwindled down to a very small fraction. These two groups I take to represent an early stage of the glacial-marine beds when the rigour of the climate was at its height.

The groups from King-Edward, Paisley, Kilchattan, and Gamrie probably belong to a somewhat later stage, for although the general character is still Arctic, yet it is less strictly so than in the two preceding. The proportion of Southern forms is far greater, and the British exceed 50 per cent.

The Fort William group is probably the latest of all; it is no longer Arctic but Northern, and the British species exceed 80 per cent.

The Caithness group seems to be a mixture of species from glacial beds of both earlier and later date.

The high percentage of North American forms in all the groups, but more especially in the first six, is a feature of much interest.

February 21, 1866.

William Henry Corfield, Esq., B.A., Fellow of Pembroke College, Oxford, University College Hospital, Gower Street, W.C.; Henry Lee, Esq., The Waldrons, Croydon; Henry Skiffington Poole, Esq., B.A., Cape Breton, Nova Scotia; Alexander Ramsay, jun., Esq., 45 Norland Square, Notting Hill, W.; Charles Pearce Serscold, Esq., Taplow Hill, and 24 Oxford Square; George Suche, Esq., 77 Grosvenor Street, W.; and James Maurice Wilson, Esq., M.A., Fellow of St. John's College, Cambridge, Rugby School, were elected Fellows.

The following communications were read:—

1. *On the* Tertiary Mollusca *of* Jamaica.

By R. J. Lechmere Guppy, Esq., Civil Service, Trinidad.

(Communicated by Henry Woodward, Esq., F.G.S., F.Z.S.)

[Plates XVI.–XVIII.]

§ 1. The Relationships of the Miocene of Jamaica.

In 1862 Mr. Lucas Barrett, Director of the Geological Survey of the West Indies, brought over from Jamaica and deposited in the British Museum a collection of Miocene fossils. In 1863 Mr. Carrick Moore communicated to the Geological Society the results of his examination of the shells, Dr. Duncan described the corals, and Prof. Rupert Jones gave an account of the Foraminifera *. In 1864 Dr. Duncan and Mr. Wall gave a sketch of the geology of a part of Jamaica, showing the relations of the Cretaceous and Tertiary formations exposed in that island †. In the same communication Dr. Duncan described several new and interesting corals from the Cretaceous, Eocene, and Miocene strata; but beyond the general results given in Mr. Carrick Moore's paper above referred to, the shells have remained untouched. It was, I believe, the intention of Mr. Barrett to have worked out this portion of the subject, and, indeed, he had already had one plate engraved, which has since been destroyed for want of instructions; but as his untimely and lamented death has intervened to prevent our receiving the benefit of his illustration of the fossils alluded to, I have undertaken to furnish an account of these remains ‡.

* Quart. Journ. Geol. Soc., vol xix. p. 510.

† *Ibid.*, vol. xxi. p. 1.

‡ The following extract from a letter of Mr. Barrett was published by Dr. Woodward in an obituary notice of that naturalist: "The Tertiary system of