Postscript.—On referring to Mr. James Geikie's "Note on the Occurrence of Erratics," I see that Forbes thought there was evidence in the Swiss glaciers of stones being "actually introduced into the ice by friction at the bottom of the glacier." Of course, if there is positive evidence in Switzerland of this sort of thing, the presence of stones in the Till ceases to be a difficulty.

V.—NOTE ON MR. GOODCHILD'S THEORY OF THE SUB-GLACIAL FORMATION OF GRAVELS, ETC.

By EDWARD T. HARDMAN, F.C.S., etc.;
Of the Geological Survey of Ireland.

IN the paper on "Drift" in the *GEOLOGICAL MAGAZINE* for November, 1874,¹ Mr. Goodchild, in proposing his new theory, appears to invite discussion on it. I therefore beg to contribute my *quota* towards upholding the marine, as against the exclusively glacial, deposition of certain gravels belonging to the Drift.

According to the last paragraph of his paper,² this theory is, that all the glacial deposits were formed under ice, and with the assistance of sub-glacial streams; and that neither stratification nor the presence of marine remains proves the former agency of the sea in their formation.

Whether this idea will meet with general acceptance I shall leave to others to determine, on the various merits. It is certainly ingenious, and would no doubt serve to explain the presence of lenticular patches of sand, gravel, and laminated clays, such as are frequently found in the Boulder-clay; but its application in the case of the masses of sand and gravel that are often spread out over large tracts of country appears to be hardly tenable. I shall, however, confine myself to a point which I noticed in connexion with the Drift of the North of Ireland during my work for the Geological Survey, and which seems to me to have a legitimate bearing on the question. Besides bringing forward a new link in the chain of evidence, it refers to a matter not likely to be observed in any other district.

As every one is aware, one of the chief features in the geology of the North of Ireland is the existence of the Upper Chalk with Flints, covered by a very thick sheet of Basalt, the two formations being in effect co-extensive; for there is hardly any part of the area occupied by the Chalk which has not its protecting cap of Basalt.

The Drift, for the purposes of this note, may be divided lithologically into Till,³ and stratified sands and gravels with brick-clays, in some of which fragments of shells have been found. Now the contents of these Drifts differ very widely. The "Till" contains invariably a very large per-centage of the local rock, whatever it may happen to be—Limestone when that rock prevails; Sandstone and shale near Coal-measure ground; and a plentiful supply of Basalt, both in large blocks and small pebbles, when over or within reasonable reach of it, together with igneous and metamorphic rocks

¹ On Drift, by J. G. Goodchild, F.G.S.

² *Loc. cit.* p. 510.

³ In a few places patches of Boulder-clay (Upper Boulder-clay) resting on the sands and gravels occur in the district with which I am acquainted.

from some distance; but in no case Chalk or Chalk-flints to the amount of more than about three or four per cent., even when in the Chalk country, unless where in very close proximity to unprotected Chalk exposures.

On the other hand, the gravels, as a rule, contain perceptibly less of the local rock, plenty of travelled or foreign pebbles, and a great abundance of chalk and flints; of the last two so much that the ground is often white with them; and this often when at a distance of 100 feet from, or sometimes underlying them, is Boulder-clay, on which a considerable amount of time and trouble should be expended before anything from the Chalk would turn up.

The district to which I refer is that comprising the south of Derry and Antrim, great part of Tyrone, and the northern part of Armagh. In those places, I have examined a great number of exposures in "Till," together with equally many gravel-pits, and always found the distinction noticed above to obtain.

Portlock¹ gives a list of gravel-pits in the counties Derry, Tyrone, Armagh, and Fermanagh, noticing those of 52 parishes, the gravel of 35 of which contained chalk or flints; and in 25 of these chalk is *not* the local rock. They comprise from two to three exposures per parish on an average. I mention this to show how general the occurrence of chalk is in the gravel of this large district.

Now if all the Drift of these parts had been deposited first by ice, and almost simultaneously re-arranged in places by glacial river-action, should we not expect to find in the re-arranged part the same constituents as in the so-called Till? or, to put it more clearly, must not all the pebbles of the gravels have previously existed in the moraine matter of the glacier, and would they not, therefore, be found in all parts of the Drift in nearly the same relative proportions? According to the hypothesis, the gravels would be merely the Boulder-clay minus the clay, and I see no reason why the *chalk débris* should become concentrated by washing. Were the proportion of chalk, etc., in the "Till" very variable, it might indeed be supposed that these gravels had their origin in some such chalky Drift. But this is not consistent with the facts. The "Till" is, as I have mentioned, remarkably free from such pebbles, and in the extensive district I have examined hardly any difference in this respect could be observed.

This difference may be easily accounted for on the usual theory of the glacial formation of the "Till," or Boulder-clay, and the later marine deposition of these gravels. The glaciers, or ice-sheet, which gave rise to the former had, in order to reach the chalk, to work through the hard basalt overlying it, and this attempt was in but few instances successful, as will be at once seen on looking at the geological map. Beyond the basaltic sheet the ice passed over schists and other metamorphic rocks, Old Red Sandstone, Carboniferous Limestone, and the older Mesozoic strata.² While, therefore,

¹ Geological Report on Londonderry, etc., pp. 747-8.

² There is evidence that the general Physical Geology of this district just before the Glacial Epoch was not very different from that which prevails there at the present day. This I have given in a paper read at the late meeting of the British Association at Belfast, "On the Age and Mode of Formation of Lough Neagh."

we find all the last-mentioned rocks in great plenty in the Till, together with basalt, thanks to this last we get little or no chalk, or flints; for even in the rare cases where the chalk was cut down to, or was already exposed, the proportion of chalk to other rocks would be very insignificant.

Now let the land be submerged, and the sea come into play around the chalk escarpments. It would soon form cliffs, and not content with that, would undercut, and eat into the comparatively easy-worn and well-jointed chalk, as it is now doing all along the northern coast, tearing out large blocks, rounding them, and wearing them into pebbles. The overhanging basalt would soon be brought low, and the result would be a gravel composed largely of basalt, chalk, and flints, together with such pebbles as might happen to lie in the Drift—if there were any—previously deposited, overlying the cliffs, and perhaps some others drifted round from distant parts of the then coast. There can be no difficulty on this point, for as the chalk is found at all heights from the present level of the sea up to 1400 or 1500 feet, any amount of submergence between these limits would bring it under the influence of the sea. Such a gravel, then, being swept away over the sea-bottom, would cover the former Drift; if then the ground emerged at any given point of this area, the "Till" or Boulder-clay would be found to contain most local rocks, and but little chalk; while the gravel would contain few local rocks, but a great amount of chalk and basalt.

I find, on referring to Portlock's exhaustive Report, that he had somewhat the same idea as to the formation of the shelly clays of the northern part of county Derry, namely, that they were formed in a sea which cut away the chalk and basaltic cliffs, hence the occurrence in them of so many chalk and basalt pebbles.¹ There can be little doubt that these clays belong to the Drift, although Portlock considered them to lie beneath it: for not only are similar clay-beds found everywhere in the gravels of the district, but these particular beds contain the characteristic shell of the Clyde beds, *Nucula oblonga*, as well as the usual drift shells, *Cyprina Islandica*, *Turritella terebra*, and *Astarte multicostata* (?).

With relation to these beds the following point occurs. Portlock mentions, and remarks on the fact, of "the delicate *Nucula* being uninjured, as if deposited on the spot, while the strong *Cyprina* has been almost destroyed." If then all these beds had been brought into their present position, from 100 to 450 feet above sea-level, by moving ice, why should one genus be shattered, and the other preserved? They should have all been either preserved without distinction, or broken up indiscriminately.

The chalk and flints to which this note refers are not only found in the gravels of the North of Ireland, but also—more sparingly—in the midland and southern counties. I have noticed them in the gravels of county Meath frequently, also occasionally in those of counties Carlow² and Kilkenny, but more rarely. Still, however, the

¹ *Op. cit.* p. 737.

² In the gravels of Carlow I have found shell fragments; in one near the town, I

distinction noticed in the north holds good—comparative abundance in the Gravels, and greater rarity in the Boulder-clay. It appears as well that they have been seen in the gravels of Wexford and of Cork.¹

It must be borne in mind that the Irish Chalk is of a very hard texture, almost as hard as ordinary Limestone, and much harder than the Coal-measure Shales, Bunter Sandstone, and Keuper Marls, all of which occur so plentifully in the "Till" of the northern district; so that its absence cannot be ascribed to crushing and pulverization by the ice-sheet, nor can it be laid to the score of solution by water containing carbonic acid, for this would also affect the Limestone. Besides, neither of these suppositions would account for the scarcity of Chalk-flints.

VI.—ON SOME OF THE MASSIVE FORMS OF *CHÆTETES*, FROM THE LOWER SILURIAN.

By H. ALLEYNE NICHOLSON, M.D., D.Sc., F.R.S.E.,

Professor of Biology in the College of Physical Science, Newcastle-on-Tyne.

CHÆTETES PETROPOLITANUS, Pander.

The typical forms of *Chætetes petropolitanus*, Pander, are free in habit, and are invariably furnished with a flattened or concave base, which is covered with a thin concentrically-wrinkled epitheca. The general shape of the corallum is typically a cone or hemisphere when full-grown, and a concavo-convex disc when young; but its adult form is liable to great variations; and even the young examples are not constant, being sometimes plano-convex, or slightly bi-convex. The calices are exclusively carried upon the upper surface of the mass, and are thin-walled, polygonal in shape, and destitute of intermediate tubuli. Very often the surface exhibits minute tubercles, carrying corallites of a slightly larger size than the average; but this phenomenon does not appear to be constant. Young examples may have a diameter at their base of four or five lines, and a height of three lines; adult specimens may have a long diameter of four inches or more at the base, and a height of an inch and a half; but the majority of individuals exhibit dimensions intermediate between these measurements.

Stenopora patula, Billings (Canadian Naturalist, vol. iv. p. 427), as hinted by Mr. Billings himself, is to be regarded as only a well-marked variety of *C. petropolitanus*. It agrees with the typical examples of the latter in its free habit, in its surface-characters, and in its possession of a concentrically-wrinkled epitheca. It is peculiar only in its shape, having the form of an approximately circular disc, the basal surface of which is flat, or slightly concave, and is covered by an epitheca; whilst the upper surface is got two perfect shells. One a *Purpura lapillus*, the other a small bivalve which I have not been able to identify with certainty, but it appears to be *Tellina solidula*.

¹ On Re-arranged or Glacialoid Drift, by G. H. Kinahan, M.R.I.A., GEOLOGICAL MAGAZINE, Decade II. Vol. I. No. 3, pp. 112 and 119.