going on all *around*, and very probably a new centre was produced along quite the south-eastern edge of England. In Oolitic times the two former had probably united to form one western stretch of land, which gradually extended itself eastwards towards the close of that period, while the south-eastern mass of land was depressed, and received deposits upon it.

In Cretaceous times the land had retreated somewhat westwards, occupying rather more than the present western half of England, and then again during Tertiary ages increased slowly eastwards, until the whole of the present England was represented.

Lastly, during the Glacial period, such a submergence took place as to leave only parts of the original Welsh and Cumbrian centres above water, with perhaps a southern mass of land, thus, as it were, restoring the embryonic condition of England for a brief space at the close of its long history.

In the case of English geological history we have then to observe the following points:—

1. The geological records date back to Cambrian times, and there is clear evidence of land-centres as far back at least as the Mid-Silurian.

2. The early land-centres of Wales and Cumberland received depositions of strata *around and upon* them until the close of the Carboniferous, since which time they have been completely above water, with the exception of the partial submergence of the Glacial period. Thus, England may be considered a much older country than Italy, and to have had a more complex origin.

3. The long periods during which these two centres have remained as dry land, explains the enormous amount of sub-aerial denudation which seems to have taken place[1] in these districts.[2]

The study of ancient physical geography, which hitherto has received so little attention, is becoming daily of more and more importance and interest, inasmuch as by its consideration alone shall we probably be able to work out the great question of the succession and distribution of life upon the globe.

IV.— On the Transport of the Wastdale Crag Blocks.

By James Croll, of the Geological Survey of Scotland.

CONSIDERABLE difficulty has been felt in accounting for the transport of the Wastdale Granite Boulders across the Pennine chain to the east. Professors Harkness[3] and Phillips,[4] Messrs. Searles Wood, jun.,[5] Mackintosh,[6] and I presume all who have written on the subject, agree that these blocks could not have been

[1] "On the Denudation of the Lake District," Geol. Mag., January, 1870.

[2] It is curious to think how much older our English mountain districts are than the great ranges of the Alps, the Apennines, the Himalayas, the Andes, and the Rocky Mountains.

[3] Quart. Journ. Geol. Soc. xxvi., p. 517.

[4] British Assoc. Report for 1864 (Sections), p. 65.

[5] Quart. Journ. Geol. Soc., xxvi., p. 90.

[6] Geol. Mag., VII., p. 349.

transported by land-ice. The agency of floating ice under some form or other is assumed by them all.

We have in Scotland phenomena of an exactly similar nature. The summits of the Ochils, the Pentlands, and other mountain ranges in the east of Scotland, at elevations of from 1,500 to 2,000 feet, are not only ice-marked, but are strewn over with boulders derived from rocks to the west and north-west. Many of them must have come from the Highlands distant some 50 or 60 miles. It is impossible that these stones could have been transported, or the summits of the hills striated, by means of ordinary glaciers. Neither can the phenomena be attributed to the agency of icebergs carried along by currents. For we would require to assume not merely a submergence of the land to the extent of 2,000 feet or so,—an assumption which might be permitted,—but we should have to assume that the currents bearing the icebergs took their rise in the elevated mountains of the Highlands, a most unlikely place, and that these currents radiated in all directions from that place as a centre.

In short the glacial phenomena of Scotland is wholly inexplicable upon any other theory than that, during at least a part of the glacial epoch, the entire island from sea to sea was covered with one continuous mass of ice of not less than 2,000 feet in thickness.

In my paper on the Boulder-clay of Caithness,[1] I have shown that if the ice was 2,000 feet or so in thickness, it must, in its motion seawards, have followed the paths indicated by the curved lines in the diagram accompanying that paper. In so far as Scotland is concerned, these lines represent pretty accurately not only the paths actually taken by the boulders, but also the general direction of the ice-markings on all the elevated mountain ridges. But if Scotland was covered to such an extent with ice, it is not at all probable that Westmoreland and the other mountainous districts of the North of England would have escaped being enveloped in a somewhat similar manner. But if we admit the supposition of a continuous mass of ice covering the North of England, all our difficulties regarding the transport of the Wastdale blocks across the Pennine chain disappear. An inspection of the diagram above referred to will show that these blocks followed the paths which they ought to have done upon the supposition that they were conveyed by continental ice.

That Wastdale Crag itself suffered abrasion by ice moving over it, in the direction indicated by the lines in the diagram, is obvious from what has been recorded by Dr. Nicholson and Mr. Mackintosh. They both found the Crag itself beautifully moutonnéed up to its summit, and striated in a W.S.W. and E.N.E. direction. Mr. Mackintosh states that these scorings run obliquely up the sloping face of the crag. Ice scratches crossing valleys and running up the sloping faces of hills and over their summits are the sure marks of continental ice, which meet the eye everywhere in Scotland. Dr. Nicholson found in the drift covering the lower part of the Crag, pebbles of the Coniston flags and grits from the west.[2]

[1] Geological Magazine for May and June, 1870.

[2] Trans. Edin. Geol. Soc., vol. i., p. 136.

The fact that in Westmoreland the direction of the ice-markings, as a general rule, corresponds with the direction of the main valleys, is no evidence whatever that the country was not at one period covered with a continuous sheet of ice; because, for long ages after the period of continental ice, the valleys would be occupied by glaciers, and these, of course, would necessarily leave the marks of their presence behind. This is just what we have everywhere in Scotland. It is on the summits of the hills and elevated ridges, where no glacier could possibly reach, that we find the sure evidence of continental ice. But that land-ice should have passed over the tops of hills 1,000 or 2,000 feet in height is a thing hitherto regarded by geologists as so unlikely that few of them ever think of searching in such places for ice-markings, or for transported stones. Although little has been recorded on this point, I hardly think it likely that there is in Scotland a hill under 2,000 feet wholly destitute of evidence that ice has gone over it. If there were hills in Scotland that should have escaped being overridden by ice, they were surely the Pentland Hills; but these, as was shown on a former occasion,[1] were completely buried under the mass of ice covering the flat surrounding country. I have no doubt whatever that if the summits of the pennine range were carefully examined, say under the turf, evidence of ice-action, in the form of transported stones or scratches on the rock, would be found.

Nor is the fact that the Wastdale Boulders are not rounded and ice-marked, nor found in the Boulder-clay, but lie on the surface, any evidence that they were not transported by land-ice. For it would not be the stones *under* the ice, but those falling on the upper surface of the sheet, that would stand the best chance of being carried over mountain ridges. But such blocks would not be crushed and ice-worn; and it is on the surface of the clay, and not imbedded in it, that we should expect to find them.

It is quite possible that the dispersion of the Wastdale Boulders took place at various periods. During the period of local glaciers the blocks would be carried along the line of the valleys.

All I wish to maintain is that the transport of the blocks across the pennine chain is easily accounted for if we admit, what is very probable, that the great ice covering of Scotland overlapped the high grounds of the North of England. The phenomenon is the same in both places, and why not attribute it to the same cause?

There is another curious circumstance connected with the drift of England which seems to indicate the agency of an ice-covering.

As far back as 1819, Dr. Buckland, in his Memoir on the Quartz Rock of Lickey Hill,[2] directed attention to the fact, that on the Cotteswold Hills there are found pebbles of hard red Chalk which must have come from the Wolds of Yorkshire and Lincolnshire. He pointed out also that the slaty and porphyritic pebbles probably came from Charnwood Forest, near Leicester. Mr. Hull, of the Geological Survey, considers that "almost all the Northern Drift of this

[1] Geol. Mag. for June, 1870.

[2] Trans. Geol. Soc., vol. v., p. 516 (First Series).

part of the country had been derived from the débris of the rocks of the Midland Counties."[1] He came also to the conclusion that the slate fragments may have been derived from Charnwood Forest. In the Vale of Moreton he found erratic boulders from two feet to three feet in diameter. The same northern character of the drift of this district is remarked by Professor Ramsay and Mr. Aveline, in their Memoir of the Geology of parts of Gloucestershire. In Leicestershire and Northamptonshire the officers of the Geological Survey found in abundance drift which must have come from Lincolnshire and Yorkshire to the north-east.

Mr. Lucy, who has also lately directed attention to the fact that the Cotteswold Hills are scattered over with boulders from Charnwood Forest, states also that, on visiting the latter place, he found that many of the stones contained in it had come from Yorkshire still further to the north-east.[2]

Mr. Searles Wood, jun., in his interesting paper on the Boulder-clay of the North of England,[3] states that enormous quantities of the chalk débris from the Yorkshire Wold are found in Leicester, Rutland, Warwick, Northampton, and other places to the south and south-west. Mr. Wood justly concludes that this chalk débris could not have been transported by water. "If we consider," he says, "the soluble nature of chalk, it must be evident that none of this débris can have been detached from the parent mass, either by water action, or by any other atmospheric agency than moving ice. The action of the sea, of rivers, or of the atmosphere, upon chalk, would take the form of dissolution, the degraded chalk being taken up in minute quantities by the water, and held in suspension by it, and in that form carried away; so that it seems obvious that this great volume of rolled chalk can have been produced in no other way than by the agency of moving ice; and for that agency to have operated to an extent adequate to produce (a quantity that I estimate as exceeding a layer 200 feet thick over the entire Wold), nothing less than the complete envelopment of a large part of the Wold by ice for a long period would suffice."

I have already, on a former occasion, assigned my reasons for disbelieving in the opinion that such masses of drift could have been transported by floating ice.[4] But if we refer it to land-ice, it is obvious that the ice could not have been in the form of local glaciers, but must have existed as a sheet moving in a south and south-west direction, from Yorkshire, across the central part of England. But how is this to harmonize with the theory of glaciation, which is advanced to explain the transport of the Shap boulders?

The explanation has, I think, been pointed out by a writer in the "Glasgow Herald," of the 26th November last, in a review of Mr. Lucy's paper.

[1] Quart. Journ. Geol. Soc., vol. xi., p. 492. Memoir of the Country around Cheltenham. 1857. Geology of the Country around Woodstock, 1859.
[2] Geol. Mag., Vol. VII. p. 497. [3] Quart. Journ. Geol. Soc., vol. xxvi. p. 90.
[4] Philosophical Magazine for November, 1868.

In my paper on the Boulder-clay of Caithness, I had represented the ice entering the North Sea from the east coast of Scotland and England, as all passing round the North of Scotland. But the reviewer suggests that the ice entering at places to the south of, say, Flamborough Head, would be deflected southwards instead of northwards, and thus pass over England. "It is improbable, however," says the writer, "that this joint ice-sheet would, as Mr. Croll supposes, all find its way round the north of Scotland into the deep sea. The southern uplands of Scotland, and probably also the mountains of Northumberland, propelled, during the coldest part of the Glacial period, a land ice-sheet in an eastward direction. This sheet would be met by another streaming outward from the south-western part of Norway—in a diametrically opposite direction. In other words, an imaginary line might be drawn representing the course of some particular boulder in the *moraine profonde* from England met by a boulder from Norway, in the same straight line. With a dense ice-sheet to the north of this line, and an open plain to the south, it is clear that all the ice travelling east or west from points to the south of the starting-points of our two boulders, would be 'shed' off to the south. There would be a point somewhere along the line, at which the ice would turn as on a pivot—this point being nearer England or Scandinavia, as the degree of pressure exercised by the respective ice-sheets should determine. There is very little doubt that the point in question would be nearer England. Further, the direction of the joint ice-sheet could not be *due* south, unless the pressure of the component ice-sheets should be exactly equal. In the event of that from Scandinavia pressing with greater force, the direction would be to the south-west. This is the direction in which the drifts described by Mr. Lucy have travelled."

I can perceive no physical objection to this modification of the theory. What the ice seeks is the path of least resistance, and along this path it will move, whether it may lie to the south or to the north. And it is not at all improbable that an outlet to the ice would be found along the natural hollow formed by the Valleys of the Trent, Avon, and Severn. Ice moving in this direction would no doubt pass down the Bristol Channel and thence into the Atlantic.

Might not the shedding of the North of England ice-sheet to the north and south, somewhere not far from Stainmoor, account for the remarkable fact pointed out by Mr. Searles Wood, that the Boulder-clay, with Shap boulders, to the north of the Wold is destitute of Chalk, while on the other hand, the chalky Boulder-clay to the south of the Wold is destitute of Shap boulders? The ice which passed over Wastdale Crag moved to the E.N.E., and did not cross the Chalk of the Wold; while the ice which bent round to the south by the Wold came from the district lying to the south of Wastdale Crag, and, consequently, did not carry with it any of the granite from that Crag. In fact, Mr. Searles Wood has himself represented on the map accompanying his Memoir this shedding of the ice north and south.

These theoretical considerations are, of course, advanced for what

they are worth. Hitherto geologists have been proceeding upon the supposition of an ice-sheet and an open North Sea; but the latter is an impossibility. But if we suppose the seas around our island to have been filled with land-ice during the glacial epoch, the entire Glacial problem is changed, and it does not then appear so surprising that ice should have passed over England.

V.—On *Dicellograpsus*, a New Genus of Graptolites.

By John Hopkinson, F.G.S., F.R.M.S.

(PLATE I.)

THE Graptolites for which the name *Dicellograpsus* is here proposed are usually included in the genus *Didymograpsus*, which is thus made to comprise two groups of species which are not only generically distinct, but belong to entirely different sections of the Graptolite family, the species properly belonging to *Didymograpsus* (*D. Murchisoni* for example) having hydrothecæ similar to those of *Graptolithus*, while the species erroneously included in the genus (*D. Forchhammeri* and others) have hydrothecæ of the type of *Climacograptus*. This was first pointed out by Prof. James Hall. In his "Graptolites of the Quebec Group" (p. 57) he removed these species from *Didymograpsus*, and placed them in his new genus *Dicranograptus*; the species previously known as *Diplograpsus ramosus* being considered the type of the genus. To this species, and to another then first described, the genus was afterwards restricted by Mr. Carruthers, the remaining species being again included in *Didymograpsus*.[1] Though fully agreeing with Mr. Carruthers in thus restricting *Dicranograptus*, I cannot consider the species removed from it as having any alliance to *Didymograpsus*. I therefore propose to consider these species as forming a distinct genus, the diagnosis of which is as follows:—

Genus *Dicellograpsus*, gen. nov. (from δίκελλα, a fork; γραφω, I write).

Polypary, consisting of two simple monoprionidian branches, united only at the proximal end, and bearing hydrothecæ on their outer aspect; radicle, or initial process, on the same side of the polypary as the hydrothecæ.

From a slender radicle, flanked by two lateral spines, the simple monoprionidian branches immediately diverge in elegant symmetrical curves; usually very divergent at their origin, they soon become less so, then spring out again, and continue with a slight inward curve, until, towards their extremity, they are almost straight. They do not appear to be divided by any septum at their origin,—the cœnosarc of one branch most probably having been continuous with that of the other. The solid axis, commencing as the initial process, or radicle, bifurcates in the axil of the branches, on the inner or dorsal aspect of which it may in some species be detected. In others it cannot be made out beyond the axil, but from analogy

[1] Geological Magazine, Vol. V., p. 129.