NO. III.—ON THE ORIGIN OF CERTAIN GRANITE BOULDERS IN THE
CLYDE VALLEY. By DUGALD BELL, F.G.S. With a Sketch
Map.

[Read 8th December, 1892.]

MORE than fifty years ago, the late Mr. Smith of Jordanhill—one of the founders of Glacial Geology—noted the occurrence of a certain number of granite boulders in the "Till" around Glasgow, and estimated their proportion as about 1 per cent. of the whole stony contents. About 60 per cent., he observed, were of sandstone and shale derived from the subjacent Carboniferous rocks; 30 per cent. were of trap from the Kilpatrick hills, about ten miles to the north-west; 9 or 10 per cent. of clay-slate and "greywacke" from mountains in Dumbarton and Argyle shires, about twenty miles away in the same direction; while "the granite blocks must have been transported from still greater distances. Beyond the Kilpatrick hills," he added, "the trap and white sandstone boulders disappear and are replaced by greywacke, clay-slate, and red sandstone, while those of granite and mica-slate become numerous," and also increase in size. The inference was, therefore, in all respects well supported that "the cause which produced the diluvial covering of the great coal-field of Scotland must have had its origin to the westward." *

As to the exact locality from which these granite boulders had been brought, Mr. Smith at first thought of Inveraray for some, and even of Ardnamurchan for others; but ultimately seemed to prefer Ben Cruachan as the most likely source. Thus, finding a small granite boulder in the "Till" at Chapelhall, near Airdrie, he remarked that to the east and south of Glasgow such boulders are comparatively rare and small, "but as we go to the north-west they increase both in number and in size. The nearest granite rock in that direction is at Cruachan about sixty miles to the north-west of Airdrie." †

The obvious difficulties regarding their transport from any of the localities named (by "violent floods," as was then supposed, or by any other agency that could be suggested) led Mr. Smith for a

* "On the Last Changes in the Relative Levels of Land and Sea." read to the Wernerian Society, 1838; republished in "Researches in Newer Pliocene and Post-tertiary Geology," 1862. Pp. 12, 13.

† "On the Occurrence of Marine Shells, &c.," read 1850, *Ib.*, p 141.

time to suppose that the "Till" might be as ancient as the elevation of the intervening mountain ranges (!) and "was most probably caused by the violent geological action by which it was accompanied."† Such conjectures belong to the infancy of every science.

From that day to this, though the supposed agency of transport has been changed, the locality from which these Clyde granites have come has been generally believed to be the same, viz., Ben Cruachan. It was the best known granitic area within what seemed to be a reasonable distance in the direction required, the rock near Inveraray not being a true granite, but a quartz-porphry; while if it be "a far cry to Loch Awe," it is a much farther one to Ardnamurchan or the Ross of Mull. Accordingly, at the various excursions of the Glasgow geologists and naturalists, whenever the members came upon a granite boulder, they were usually content to note it as "probably from Bunawe or Ben Cruachan."

Gradually, however, doubts have intruded. The majority of these boulders are of a grey, rough-grained granite, with large flesh-coloured crystals of felspar, easily recognisable, and differing distinctly from any granite known to belong to the Bunawe or Ben Cruachan district. Besides this, it became increasingly difficult to see how, by any conceivable means, the boulders in question could be transported from that quarter.

At this time of day we may dismiss "floods" and also "icebergs" and restrict ourselves to land-ice, as the only probable or possible agency of transport. But the difficulty which Mr. Smith pointed out, that "the intervening space is intersected by deep arms of the sea and steep precipitous mountain ranges," and which is fatal to the first two of these agencies, applies with sufficient force also to the third.

For, when the country was enveloped in land-ice, with great sheets or streams of it descending by all the principal valleys to the sea—such being the admitted conditions—the ice from Ben Cruachan and the surrounding granite district would evidently find its way seaward, partly by the Loch Etive branch of the great ice-sheet on the one hand and partly by that of Loch Awe on the other. There is every proof that Loch Etive was filled from side to side by an immense glacier, originating in the mountainous region at the head of it, which carried all boulders

† *Op. cit.*, p. 13.

on that side out westward towards Oban and the Sound of Lorne. Bunawe is therefore out of the question. On the other, or eastern, side of Ben Cruachan, there is equally clear evidence that Glen Strae, Glen Orchy, and Glen Lochy, were each filled with ice from the same region, which, coalescing, filled the channel of Loch Awe, and moved south-westwards by Ford and Kilmartin, out to the Sound of Jura. Similarly it can be proved that the channel of Loch Fyne was occupied by a great mass of ice from the eastern part of the same region, moving south-west in such volume, that at Ardrishaig, instead of conforming to the bend of the loch there, it went, in great part at least, straight across the isthmus of Knapdale, and so out to sea.* It is impossible, therefore, to imagine boulders first crossing the south-westward moving body of ice in Loch Awe, and finding their way eastward into Loch Fyne, then crossing the south-westward moving body of ice there, and still finding their way eastward into this part of the Clyde valley.

Judging from the marks of glaciation over the district generally, it has long appeared to me that the parent locality of the boulders in question was most probably somewhere in that mountainous tract which lies between the head of Loch Fyne on the one hand, and of Loch Lomond on the other. Many years ago the late Professor James Nicol of Aberdeen, in his Geological Map of Scotland (1858), indicated two small areas of granite in that district; and the fact that so careful an observer had done so lingered in memory as supplying the most likely solution of the problem. One or two visits to the locality, however, failed, from not traversing it sufficiently, to verify Nicol's indications. Meantime, Murchison & Geikie's "First Sketch of a Geological Map of Scotland" (1861), and Geikie's own larger Map (1876), contained no sign of granite in that locality; so that the origin of the boulders appeared to be still to seek.

Some years ago, being at St. Catherine's on Loch Fyne, opposite Inveraray, I was struck by the immense number of granite boulders strewn about the hillside and along the shore, quite resembling those of whose origin we are in search. These boulders, it was apparent, could not have come across the loch, there being no such rock *in situ* there; while the entire drift and movement of the ice in the locality had evidently been southward. Clearly, there must be an area of granite northward, somewhere about the head

* T. F. Jamieson, *Quart. Jour. Geol. Soc.*, vol. xviii,

of the loch or beyond it, probably in that little-known region already indicated, extending between the upper part of Glen Fyne and Glen Falloch. In that conclusion I rested till circumstances should enable me more fully to explore the locality, or should furnish some additional confirmation, or some distinct proof of the accuracy of this inference.

That confirmation or proof has now been furnished. The officers of the Geological Survey have lately described a remarkable "area of plutonic rock" on the eastern side of upper Glen Fyne, extending from that glen over to, and in one part somewhat beyond, the watershed between it and Glen Falloch. This plutonic area is about twelve or thirteen square miles in extent, of which ten are occupied by granite, chiefly by a "porphyritic granite," so named from the presence of "large crystals of orthoclase, measuring often two inches across." A stripe, however, on the eastern side is occupied by "granite not porphyritic," by tonalite (or quartz-diorite), and lastly, adjoining the mica-schist, there is a broken belt of diorite. These particulars are taken from a valuable paper by Messrs. Dakyn and Teall of the Survey, published in the *Quarterly Journal of the Geological Society* for May, 1892. The paper does not refer at all to the *dispersion* of boulders, its sole object being to exhibit the chemical and mineralogical proofs that we have in this area, the results of the "consolidation of a vast subterranean reservoir of molten rock.*"

I have since spent a long summer day amid the solitudes of this mountainous region, where I found the granite *in situ*, and have no doubt of its being the true origin of the boulders referred to. I need hardly point out how entirely it accords with all the known facts of their distribution, and of the glaciation of the district. By Loch Fyne, Loch Eck, and the Holy Loch, a large number reached the opening of the Firth of Clyde, and some were carried right across the Channel to the neighbourhood of Gourrock. By Loch Sloy and Loch Long many also found their way into the Gareloch, and along the northern shore of the Clyde near Helensburgh and Ardmore, and on towards Cardross and Dumbarton. Some were also carried from Garelochhead over into Glen Fruin, in the upper part of which they are numerous, becoming fewer down towards the school house, near which, however, there are two or three, and at

* "On the Plutonic Rocks of Garabal Hill and Meall Breac," *Quart. Jour. Geol. Soc.*, vol. xlviii., p. 104.

least two reached the "moraine." A more limited number from the eastern side of the watershed appear to have passed into the Loch-lomond valley, scarcely, if at all, by Glen Falloch, but chiefly by some of the side-glens further south, as at Upper Inveruglas, Tarbet, &c., and ultimately contributed their quota to those strewn on the flanks of the Kilpatrick hills, or imbedded in the

→ STRIÆ   ... GRANITE BOULDERS

Sketch Map showing distribution of the Granite Boulders.

“Till” around Glasgow (see Sketch Map, p. 20). Further details will be found in the following “Appendix.” But it may here be added that boulders of the other rocks in the “plutonic area” described—the finer granite, diorite, &c.—are frequently found associated with the porphyritic granite, and so furnish additional confirmation of the conclusion now stated.

Since reading this paper I have learned, from a reference kindly furnished by Mr. Jamieson of Ellon, that the late Mr. Hopkins, of the Royal Society and the Geological Society of London, indicated the same locality as has now been specified for the origin of these granite boulders. In a paper read to the Geological Society in 1851,* Mr. Hopkins states that his attention was directed to the matter by his friend Mr. Smith of Jordanhill, and that “the source of those blocks presented a great apparent difficulty.” Ben Cruachan was the nearest known source to which they could be referred; but “at the same time the nature of the country intervening is such as presented the greatest difficulty in any explanation of the dispersion of these blocks which should refer their origin to that mountain.”

Mr. Hopkins goes on to narrate that, accompanied by Mr. Montgomery of Ayr, he devoted several weeks of the summer of 1850 to a more detailed investigation of the subject. The conclusions he was led to form were, that certain blocks of dark-grey granite were derived from Ben Nime [Ben Ime], a mountain near Loch Sloy, to the north of Loch Long; but that those of light-grey granite, “with large crystals of felspar,” which are very numerous about the head of Loch Fyne, “proceeded from a great mass of granite about 4 or 5 miles north of the loch,” and extending eastward to the north of Loch Sloy. This is evidently the tract now more particularly described by Messrs. Dakyns & Teall; and it was doubtless from Mr. Hopkins’s paper that Prof. Nicol inserted the two little areas of granite in that quarter in his Map of 1858.

It is perhaps remarkable that Mr. Smith in publishing his well-known little volume of “Researches,” eleven years afterwards,

* *Quart. Jour. Geol. Soc.*, vol. viii., p. 20.

took no notice of Mr. Hopkins's observations, though they were due to his own suggestion, and removed what he had felt to be a difficulty. The explanation probably is, that Mr. Smith, being then an old man, allowed his papers to be reprinted very much in their original form, and except a few casual notes, made no attempt to bring them up to date. Thus, Mr. Hopkins's observations seem to have been largely overlooked even by professional geologists, as the Maps we have mentioned show, till now happily recalled in connection with this paper.*

* I may add that Mr. Hopkins also gave a Sketch Map of the district, showing the distribution of the boulders, which I had not seen when drawing up my own. The following are the principal points of difference between them :—

1. On *Loch Fyne*, Mr. Hopkins showed boulders to opposite Inveraray, but no further ; none at Loch Goil, Strachur, Loch Eck, or the Holy Loch.
2. On *Loch Long*, only at Arrochar, and thence across to Lochlomond ; none at Garelochhead, but the line resumed at the foot of the Gareloch and at Kilcreggan, and continued uninterruptedly up the Clyde to near Renfrew.
3. On *Lochlomond*, a continuous line from the head to the foot of the loch (west side) and down the Vale of Leven, joining the Clyde line at Dumbarton.
4. None marked on the opposite shore, near Gourcock.

[The greater part of this paper was also read to the Glacialists' Association in August, and appeared in the *Glacialists' Magazine* for September, 1893. Specimens of the granite from the various localities named were also exhibited at the meeting of the British Association for the same year.]

APPENDIX.

NOTES ON THE LOCAL DISTRIBUTION OF THE GRANITE BOULDERS.

(1) LOCH FYNE GROUP.—Towards the head of the loch, at St. Catherines, and downwards to Strachur—very numerous and often large.

Loch Long.—About 10 or 12 near the head of the loch.

Loch Eck.—Several, not large, along the eastern shore of the loch and on the hillside.

Holy Loch.—Around the head of the loch and along to Hunter's Quay—a good many. Beyond Kilmun on the one side and Hunter's Quay on the other—none observed.

(2) LOCH LONG GROUP.—Near Arrochar and up towards Loch Sloy—very numerous and often large. At the Arrochar end of the cross valley to Tarbet, and for some distance along it—several; fewer towards Tarbet.

Cove to Kilcreggan.—Fairly numerous, 12 to 15 observed (none seen on the western side opposite, near Blairmore).

Gareloch.—About Garelochhead and on towards Shandon—very numerous (only a few seen on the west side of the loch, near the head).*

Glen Fruin.—Part of the same series as Garelochhead. Numerous in the upper part of the glen, diminishing towards the lower part. One of good size, however, on a knoll more than half way down; a few near the school; and at least two on the "moraine."

Helensburgh and Ardmore.—A few at the west end: one of fair size on the shore near Ferniegair, and three or four at the east end near Craigendoran. At the projecting point of Ardmore, they again become numerous, over 40, large and small, having been counted within half a mile. A few found higher up, also, on the western side of Benbui.

Cardross to Dumbarton.—A few; sufficient to mark the continuity of the line.

(3) OPPOSITE SIDE OF THE CHANNEL.

Gourock to Inverkip.—From Kempoch Point to Cloch Lighthouse—about 20, mostly of moderate size. From the Cloch to Lunderston Bay, about 10, some large.

* Many of these boulders have been built into dykes and the sea-wall.

Fairlie to beyond Hunterston.—10 or 12, some of good size (not Arran granite, as some have curiously imagined, but distinctly north-east Argyleshire).

Cumbræ.—A good many at the north end, and 2 of good size at Millport.

(4) LOCHLOMONDSIDE.

Glen Falloch.—Few, if any. Mr. Hopkins records he found *none* in the glen. From the position of the granitic area, it is evident that Loch Fyne and Loch Long would be the principal channels of dispersal. Further down, however, they appear, but not very numerous, as if brought in by some of the side-glens from the west.

Below North Inveruglas, and near Tarbet and Luss, some are found; then very few, if any, along the lower part of the loch, on its western side; and none have been observed in the upper part of the Vale of Leven.

Near the foot of the Vale of Leven, however, they appear on the hillside near Overtoun, and behind Dumbuck, near Bowling, apparently where the Loch Long or Gareloch ice, in its eastward progress, would impinge on the hills there. A few were also found in the recent railway excavations near Bowling, and some near Bishopton on the opposite side of the river; and so on into the Glasgow district, where no considerable excavation can be made without discovering some of them. (At Partick, Jordanhill, Garscube Road, and Hamilton Hill a good many have been unearthed.)

Eastern Side of Lochlomond.—In its lower part 2 or 3 have been observed. And in the Strathendrick Valley, near Killearn and Balfron, several have been found, clearly proving that the Lochlomond ice had the same easterly trend which the distribution of the boulders along all the lochs mentioned shows was the prevailing, or general, direction over all this adjacent part of the Clyde Valley.