

DESCRIPTION
OF THE
GEOLOGICAL MAP OF SUTHERLAND.

BY PROFESSOR HEDDLE.

IT was with considerable reluctance that I felt myself compelled to discard the system of coloration adopted in the Geological Survey Maps; and this I did only after the strongly expressed opinion of several geologists.

It was not that I have any very intense desire to colour rocks after their natural tints, but I have an aversion to adopting a colour suite which departs markedly therefrom; or one which is in discordance instead of harmony therewith. One friend, a man of great scientific discretion, and himself an artist, writes me that when he looks at a recently published geological Map of Scotland, with its grey Torridon and its red Laurentian, he does not know whether he is standing on his head or his heels. I must say that I share the feeling intended to be therein expressed; and hold that, if there is to be an absolute departure from the tone presented by the rocks themselves, we, at least, should not have the incongruity of a bed of a sombre or dark hue, reposing upon one of a markedly lighter tint.

The colours, then, which have been adopted, if they differ from such as were formerly in use, have been selected upon the foregoing principles; namely, some resemblance to nature, and the keeping the graver tints for the more profound rocks.

There is what may be considered a departure from this, in the case of the lively tint given to the so-called "igneous rock." As this rock much resembles in many ways the Hebridian gneiss,—being only of a lighter tint,—a green was also chosen for it. While it may be urged that there is here too marked a distinction between it and the quartzite series to which it belongs, it has to be stated that a pronounced and brilliant colour was chosen, (to, perhaps, the detriment of the map as a whole,) in order that attention might be drawn in a forcible manner to *the* rock which the writer maintains will prove to be the key to the reading of the much-contested geology of the district.

In proceeding to direct attention to some of the features of the map, and to the facts which it evidences, the author has in the outset to state, that for all the lines laid down on the eastern side of the county, he is indebted to Dr. Joass, and to Professor Judd. To the first for much information imparted both by word of mouth and by letter;—to the latter for what is in fact almost a pantographed transcript of his published map of this eastern district.

The Old Red Conglomerate which caps the summit of Ben Armine, was inserted upon the authority of Mr. Crawford, of Tongue.

The author is responsible for almost every line of the rest of the map, (some few errors being corrected). It may be that certain of the lines are much the same as those which have appeared in former maps, especially in that of Cunningham;—if so, they have been verified.

The following are the points or localities which he has not verified, or has inserted chiefly on information derived from others.

The whole line of junction of the Torridon of the Rhu Storr with the Hebridian gneiss, is taken from Macculloch. The occurrence and the exact site of the upper limestone at Fier Loch Karstich, and at Loch Strathnashvish. The former he could not see from a height at a distance of a mile; the greenery of the latter he did see at the spot laid down, from the slopes of Ben Leod.

The position of the dolomite (and whether it was touched by the igneous rock) at the back of Craig Dionard.

The lines of junction of the upper quartzite with the "igneous rock" and with the upper gneiss, were not *walked along* between Loch More and the slopes of Ben Leod; though they were *seen* in their higher rolls from the summit of that hill;—and *portions* of the line of junction of the upper gneiss were not walked along at the back of Ben Uidh, and eastern Ben More; as also at the hill Arkle.

Every other line of junction was either walked along, or was so immediately under the eye of the writer, that he is, in all localities of importance at least, prepared to submit them as being nearly absolutely accurate.

As the amount of confidence which is to be placed in a geological map must in a great degree depend upon the extent of ground walked over,—and, as there is no better way in which to submit this than by enumerating the hills climbed, there is subjoined a list of the hills with their heights, which the writer ascended between Loch Torridon and the north shore. The whole of that district he explored with nearly equal care, before he considered that a sufficiency of data had been collected to entitle him to assume an assurance of expression equivalent to that which has been assumed by others.

| Torrion, Dumdounel, and Kinlochewe Districts. | | feet. |
|-----------------------------------------------|-------|--------|
| Leagach, south top | 3358 | 2824 |
| Ben Eay,—whole ridge | 3220 | 2644 |
| Fionn Bheinu | 3060 | 2410 |
| Benin a Mhuinidh | 2267 | 2394 |
| Slioch | 3260 | 1560 |
| Sgurr an Tuill Bhan | 3058 | 2541 |
| A'Mhaighdean | 2995 | 1745 |
| Benin Tharsuinn | 2965 | 2653 |
| Mullach Coire Mhic Fhearchair | 3300 | 1740 |
| Sgurr Dubh | 2950 | 1730 |
| Meallan Laoch | 1950 | 2597 |
| Sail Liath... .. | 2982 | 2461 |
| Corray Buidh | 3041 | 72445 |
| Scurr Fiona | 3474 | |
| Glass Meall Liath | 3082 | |
| Bidein, a Ghlas Thuil | 3483 | |
| Glas Meall Mhor | 3176 | |
| Sal Mhor | 2538 | |
| Beinn Dearg | 3547 | |
| Beinn Anachlair | 2915 | |
| | 60621 | |
| Coigach and Assynt District. | | feet. |
| Beinn Eiledeach | 1755 | 2864 |
| Ben More, Coignach; east top | 2265 | 2494 |
| Coul Beg | 2625 | 2613 |
| Stack Polly | 2009 | 2625 |
| Coul More | 2786 | 2483 |
| Cromalt Hill | 1265 | 2471 |
| Cnoc na Glas Cholle | 1008 | 2504 |
| Cnoc na Meallain | 1225 | 1780 |
| Cnoc na Stroine... .. | 1306 | 1018 |
| Cnoc Ledbeg | 1200 | 1020 |
| Cnoc an Leathaid Bhuidhe | 1205 | 1009 |
| Bræbag | 2670 | 3040 |
| Ben a Bhrachaidh | 2334 | 1543 |
| Bræbag Tarsuinn | 2338 | 2364 |
| Beinn nan Cnaimsheag | 1740 | 406 |
| Caisp | 2779 | 2996 |
| Suilven | 2399 | 503 |
| Sgonnan Beg | 1240 | 598 |
| Meall a Bhuiridh... .. | 1380 | 758 |
| Carn nan Conbhairean | 3190 | 523 |
| Ben More... .. | 3273 | 630 |
| Coineveall | 3234 | 2630 |
| | | 2537 |
| | | 603 |
| | | 740 |
| | | 43954 |
| | | 60621 |
| | | 72445 |
| | | 177020 |

Reay Forest, and the North.

| | |
|-----------------------------------------|------|
| Ben Hee | 2864 |
| Carn an Tionail | 2494 |
| Carn Dearg | 2613 |
| Meallan Lath Coire Mhic Dhughail | 2625 |
| Meallan a Loin | 2483 |
| Meall Garbh | 2471 |
| Beinn Leoghal | 2504 |
| Beinn Heil | 1780 |
| Meall Leathad na Cnaoibhe | 1018 |
| Beinn Bhræac | 1020 |
| Cnoc an Fhrecadain | 1009 |
| Ben Hope... .. | 3040 |
| Ben Strome | 1543 |
| Ben Stack | 2364 |
| Handa Island | 406 |
| Foinaven | 2996 |
| Cnoc Poll a Mhuraìn | 503 |
| Cnoc a Gheodha Ruadh | 598 |
| Sithean na h'Iolaire | 758 |
| Dìman Mor | 523 |
| Clo Mor | 630 |
| Meall Sgrìbhinn | 1216 |
| Crann Stacach | 2630 |
| Beinn Spionnaidh | 2537 |
| Cnoc ard an Tionail | 603 |
| Creag Mheirgeach | 740 |

The grounds upon which I base the sequence of rocks, which I believe to be the true one in this county, will be submitted elsewhere,* in describing *eighteen sections*, drawn between Kinlochewe and Loch Glen Coul. I must content myself at present with a few brief remarks upon the rock, which, from its having been generally designed as such, I have in the map termed the "igneous rock," of the quartzite.

This rock I find to occupy an unvarying position.

When it appears as a single bed, that position is immediately over the Dolomite. When more beds than this one appear, they are as invariably to be found intercalated in the upper quartzite.

This rock has given rise to an almost endless amount of controversy; an amount which the writer is satisfied would have been minimised, had only the twentieth part of the time been devoted to observation

* Transactions of the Royal Society of Edinburgh.

of it in the field, that has been frittered away in discussing it, upon all too narrow grounds;—indeed in many cases from an examination of it, at but a single locality.

According to some of the writers and disputants who have treated of this rock, it has broken through at various horizons, the junction rocks, along the whole line of strike from Whitten Head to Loch Maree; (indeed, according to one, as far south as Totaig on Loch Ailsh).

According to others, it only *appears* to have broken through these rocks; having in reality been so positioned through faulting. While, according to others, it is held to be conformably bedded with the other members of the higher formation.

We also find that petrologically it is, according to

| | |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------|
| Cunningham ... | Upper Gneiss. |
| Nicol ... | } Intrusive. |
| Murchison ... | |
| Harkness ... | |
| Hicks ... | |
| Geikie ... | |
| Hudleston ... | Upper Gneiss, metamorphosed in situ, from the near presence of lime. |
| Bonney ... | Old Gneiss, faulted up, and partly invaded by extravasated matter. |
| | Old Gneiss, faulted up, its upper portions crushed, especially when near lime; and sometimes granitoid from predominance of felspar. |

Of the above writers, Cunningham, Geikie, and Bonney, recognise or admit conglomeritic or brecciated structure, in this rock; while Nicol, Murchison, and Hicks, do not recognise, or overlook this.

Again Cunningham, Geikie, and Bonney vouch for a laminated structure, and a rude bedding, as being “sometimes to be seen,” or “apparent”; while Murchison and Hicks do not recognise this, and Nicol very seldom does.

Cunningham, Harkness, Ramsay, Geikie, and Murchison, hold that it does not “break up” the upward succession of the rocks; Nicol, Bonney, Hudleston, Hicks, and lately Callaway maintain that it does.

In presence of so great a turmoil of opinion as the above, is it any wonder that Mr. Hudleston, in a most successful endeavour to “act the part of an impartial historian,” should write—“Dr. Hicks, like all previous authors, is not a little troubled by the “igneous rocks,”—or that he should admit that he himself was “in a fearful fog as regards the merits of the whole controversy,”—and that the summing up of his critical sketch should be the finding, and there “was room for further examination.”

Sir Rhoderick Murchison writes:—“it in no way hinders the observer from developing a clear and conformable order of superposition.” The present writer goes a great deal further than this, and maintains, that,

while there are many sections where a clear order of superposition is developed without any material aid from this rock,—indeed, where it is not even present,—that still, in the more disturbed districts there is little hope of unravelling the *apparent* confusion which exists, without bringing in the aid which a thorough knowledge of the position or positions of this rock can afford.

Of the above authors, Cunningham, Nicol, Murchison, and Geikie, refer to the rock or rocks, as seen at several localities; the others at but few, or even at but one, and that one the locality where, perhaps of all others, it assumes the extreme of one of its appearances.

Had these authors walked along the strike of this rock—best at its lowest edge—picking up the dolomite along that strike, invariably in the same relative position, *one* if not all of the points at issue would have been rapidly resolved into a common stand-point of agreement.

As to the precise nature of the rock,—this has been pronounced upon by some of the more recent writers (after an amount of exploitation which their descriptions show to have had the proportions of a post-prandial saunter) with an amount of assurance which the present writer feels that even an extent of walking very inadequately vouched for by one hundred and seventy seven thousand feet of climbing, *does not entitle him to assume*. He would beg leave to refer to his paper before mentioned for his views; merely stating here that his opinion coincides with that of Cunningham and Geikie.

And he would submit the following facts, in controversion of the *two* views that it is the older gneiss,—and that it is an *eruptive* igneous rock.

First.—The invariability of its position throughout a stretch of over seventy miles; always *over* the dolomite, and if there be more beds than one *in* the upper quartzite; if there be only one bed, it underlies the upper quartzite, where present; the upper gneiss, where not present.

Second.—That along the whole line, at least from Loch Maree to Whitten Head, it at no spot shows a neck, or point of outflow.

Third.—That where it occurs in the upper quartzite, in five closely adjacent beds at Cama Loch, these beds never run into one another, or branch, to the smallest extent.

Fourth.—That where it is seen in highly-faulted localities, as at the east end of Mullach an Leathaid Riabhaich and elsewhere, it is never seen entering the rents, itself; but occurs in its proper place, as a layer or bed in the dislodged fragments.

Each of the above facts would throw doubt upon this being an eruptive igneous rock; taken collectively their evidence to such an effect could hardly be more complete.

There is, however, another fact connected with this rock, which has much significance. It is, that, apart from the constituents special to it, it contains *no* minerals. Imbedded crystals—druses—and veins, are alike unknown to it. Can a barrenness of such a nature be shown to occur in an eruptive igneous rock of equal bulk, elsewhere?

This feature also serves to distinguish it from the lower gneiss, which many contains accessory minerals.

The sequence of rocks, which the writer holds to exist in Sutherland, is as follows:—

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hornblendic Gneiss | | High dip to W.S.W. and S.W. |
| <hr/> | | |
| Conglomerates; small in grain, much attrited, no limestone fragments | | Along west shore dipping at 5° to 7° to W., or W. by N. Ten miles inland, dipping 5° to 7° E. by S. |
| <hr/> | | |
| Quartzite; with intercalated large-crystalline porphyry, and rarely fine grained beds | | Overlying <i>eastern</i> portion of the con- glomerate only; with dip to S.E., 10, to 30°. |
| Yellow flaggy argillaceous beds | | Conformable. |
| Fucoid beds | | Do. |
| Dolomite; with occasionally yellow quartz- ite layers, and a band of "trap" | | Do. |
| Fissile chloritic beds | | Do. |
| "Igneous rock;" sometimes cut vertically by dykes of dark-green "trap" | | Do. |
| Upper Quartzite; containing sometimes four intercalated beds of the "igneous rock;" and an albitic porphyry, which sometimes cuts it in thin dykes, and sometimes is intercalated. | | Do. |
| Limestone; of from two to several beds, sepa- rated by beds of flinty quartz-rock | | Do. |
| Beds of Quartz-rock, resembling "horn- stone" | | Do. |
| Gneiss of very varying features; sometimes plicated "chloritic;"—sometimes flaggy micaceous;—sometimes horn- blendic, crystalline, | | Do. but a few miles to the east, the dip in the north of the county, swings round to the north; while in the south, it swings round to the south. |
| <hr/> | | |
| Breccia; very angular, large in grain, with limestone fragments | | Unconformable; dip in the north, 5° to 15°, N. by E. |
| Conglomerates, not smoothly attrited | | Conformable. |

It is about forty-five years since one of the most conscientious and hard working of Scottish geologists told us that, in Sutherland, one gneiss was overlaid by conglomerates unconformably; that, in turn, by quartz rock, also unconformably; that, by a sequence of limestone,—quartz-rock,—a second limestone,—with a second gneiss, all conformable with one another. The same geologist described the "igneous rock," as a mere variety of the second gneiss.

The sequence now given, *is merely this old sequence*, stated in more detail. Chemistry has told us that the *first* limestone is Dolomite; and new traverses,—perhaps still more extended than those which the enthusiastic Cunningham was able to undertake,—rendered practicable through the open-handed hospitality of a *whole county*, at the behest of its noble proprietor,—enable the writer to state that the rock which Cunningham described as a mere variety of the upper gneiss, is to be regarded as such, and nothing else; if we are to be guided in our conclusions by such facts *as* its occurring among beds of rock which are conformable with that upper gneiss; *and as* its differing from the ordinary appearance of that gneiss to no whit a greater degree than do the beds of that rock itself which occur at the Whitten Head, and over the whole tract of ground which lies between Tongue and Farr.

The following errors have crept into the map.

At one or two points the colour of the upper gneiss has been swept too far westward; it has thus broken the continuity of the quartzite band; as between Foinaven and Arkle, and between Arkle and Loch More. At one or two points it has covered over ground intended to be left *uncoloured*, on account of its being concealed by swaddling and swarding.

The fault at Knoekan, and the quartzite tip on Suilven, should be removed.

The fault at Loch Borrolan has to be removed southward, *a quarter of an inch*; so as come in the line, and under the influence of the marks of doubt;—it being a very-doubtful fault.

A mark of doubt has to be inserted at the *middle* of the Ben Uarran fault; as this probably dies out, about the glen between Coineveall and Ben Uarran.

The anticline is placed too far up the slope of Ben Uarran.

The fault which cuts the limestone of Smoo off from the quartzite, should not extend west, so as to intersect the faults which let-in the gusset of upper gneiss. These faults of necessity must intersect to the south; but where is not known. The fault running from head of Loch Glen Coul (if it exists), dies out about two miles up the glen; and does not intersect the faults which bring up the great wedge of “igneous rock.”

There are some trifling errors in detail, but none which are vital.

Had the writer acted upon theory, even to what might be regarded as a legitimate extent, he would have connected the “igneous rock” of

Scannan, with that of east Ben More. He saw it at some intermediate spots, like stepping-stones, the whole way across; but he did not walk over the ground, at the stream side; and therefore the green band was not made continuous.

Agreeing as he does with Nicol (and lately Callaway) as regards the dolomite of Stronchrubie lying in a basin, he does not agree with either, as to the inferences to be drawn therefrom. A great semi-circular, anti-clinal-roll of the lower quartzite troughs the dolomite; which has thinned out before it plunges under the "igneous rock" of Ben Bhrachaid; but the *argillaceous beds* are there seen, dipping under the "igneous rock."

He also differs, altogether, from both of the above writers, as to the Cnoc-an-drian section; maintaining that the views of Murchison, Harkness, and Geikie as to it, are correct; though he cannot agree as to the *details* of the sections given by either Murchison, or by Harkness.

V.—*Note on Artificial crystals of "Specular Iron" formed in a Copper Works Slag.*

By W. TERRILL.

Read September 2nd, 1881.

SINCE my last communication on Artificial crystals (Min. Mag. No. 19), I have met with some very remarkable crystals formed in a Copper Works Slag which consisted mainly of Cuprous Oxide and Ferric Oxide with a little lime, a product from melting a charge of "copper precipitate."

The crystals are hexagonal plates, bounded on the edges by the faces of a rhombohedron which roughly measured gives an angle of $R:R=86^\circ$. They are iron black in color, with a splendid metallic lustre, and contain 50% Ferric Oxide with 45% copper.

Examined under the microscope or even with a strong lens, particles of copper and cuprous oxide are visible in a separate state.

I am of opinion that these are artificial crystals of "Specular Iron," which have separated out on cooling from the molten slag, and crystallized in a sort of skeleton network, the interstices mechanically imprisoning the particles of copper and cuprous oxide which are present.

A small quantity of lime was added to the charge for the purpose of combining with and fluxing the Ferric Oxide; but no lime was found in the crystals.