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I.—*On the Non-Meteoric Origin of the Masses of Metallic Iron in the Basalt of Disko in Greenland. Selected and translated from the original Danish paper of K. J. V. Steenstrup,*

BY J. G. ROHDE, *Travelling Companion to the author on his expedition in* 1872.

SCARCELY in any case has the meteoric origin of any iron been more doubtful than that of the Greenland masses found by Professor Nordenskjöld in 1870, for although they contain about 2 per cent. of nickel, and, when etched, show the Widmanstätt's figures, the fact that iron is imbedded in the basalt, on which the so-called meteorites were lying, bespeaks that the loose masses of iron originally belonged to the basalt.

"The Blue Rocks" (Danish, Blaafjeld, Greenland, Ovifak), on the southern coast of Disko, where the iron was found, are about 1800 feet high; the foot up to 600 or 700 feet is covered by loose stones forming a slant of 30 or 40°, above which, in the almost perpendicular rock, 13 or 14 horizontal seams of trap are seen. At the foot of the slant, in a declivity of about 50 feet high, immediately at the water, one or two of these seams are laid open, and it may thus be observed that each seam consists of 3 layers. The lowermost is fine-grained basalt, which, without distinct boundaries, but still visible at a distance, passes into a grey or brown amygdaloid, which again passes into a layer only a couple of inches thick, of clay strongly hardened with iron-oxide; above follow again with distinct boundaries, fine-grained basalt, &c. The layers of basalt and amygdaloid of the declivity, partly separately and partly both together appear in spots between the pebbles on the shore up to and past the iron, and it is in such a spot of basalt, *i.e.* in a basalt-layer, and not as stated by Professor Nordenskjòld, in a dyke that the iron occurs. It is the perpendicular direction on the water-line of the cliffs of this basalt that makes it look like a dyke. Basalt of the same peculiar appearance, jointed in the same directions, also occurs in several other places on the shores of Disko. It is impossible to trace any dyke or iron upwards in the slant or in the rocks; it is only on the low shore, and westwards from the iron imbedded in the basalt that fragments of native iron and of basalt containing iron have been found. That none are found eastwards is most likely due to the direction of the current at the shore. The greatest distance, westwards, from the imbedded iron, at which I found any of those fragments, was 2500 feet.

I have twice stayed for some time on the spot; in 1871 with the Swedish expedition of Friherre v. Otter, and in 1872 together with Mr. Rohde. I found not only that the iron occurs partly in veins, partly in larger and in smaller lumps and plates, principally standing in the direction of the cliffs of the basalt, but also by breaking the basalt to depths of 1 to 3 feet, I found that blocks or plates of iron were imbedded horizontally. Of one strongly oxidised mass measuring about 15 by 12 inches, I broke a piece of 6 or 8 inches thickness without getting to the bottom of it. It is only the strong oxidation of the iron that renders it so easy to separate these masses from the basalt and makes them look as if they did not originally belong to it. I further found that the iron, where in the largest quantities, penetrates the basalt in all directions, and when I succeeded in cleaving a piece of basalt along a fine crack, I found native iron deposited dendritically inside.

The basalt, which has a peculiar appearance, is coarse-grained and contains Spinel and Graphite. Microscopic sections show that some iron-grains are surrounded by and reticularly traversed by a black or greenish, Hisingerite-like, hydrous silicate of iron protoxide, whilst others are enclosed in a crust of Troilite in which again small bits of the Hisingerite-like mineral are seen.

In the report which I sent home with the Swedish expedition in 1871, I declared myself convinced that the manner in which the iron appears in the basalt only leaves room for one explanation, viz., that the iron belongs to the basalt, whether we suppose that it has been carried up with it or produced by chemical action, and that the loose ironblocks were more or less rounded fragments. I found the correctness of this opinion still further confirmed next year, and saw that the proof should be based more on geognostical than on chemical arguments—not analysis, but observation was wanted.

On my journeys in the Waigat (the sound between Disko and the Greenland continent), I therefore constantly watched the appearance of the basalt, expecting it to show some peculiarity which might throw some light on the subject.

At Assuk (on the north-east coast of Disko) on the most southerly of the 4 points in Rohde's and my map of the Waigat (Petermann's Mittheilungen, 1874), my attention was attracted by the red-rust colour of many of the rounded masses; but although I stayed for a couple of hours on this spot and broke many of the stones, I did not find native iron in any of them, as I had expected. On my way back I passed a little projecting basalt-rock, and as the basalt had a peculiar appearance, I took a piece of it for microscopical examination. From the latter, I conclude that the rusty rounded stones originate in that basalt, as they are both alike in composition, varying essentially from that of the basalt in most other places. Already by polishing the first specimens, my attention was attracted by the many iron-coloured stripes. These stripes precipitated copper, and under the magnifying glass they were seen to arise from small shining iron-grains equally distributed throughout the stone. Mr. Winther, A.M., examined a preparation and found that the diameter of the largest iron-grains was 0·105 $^{m}/_{m}$, but that many exceeded this measure either in length or width. Many were or 0·12 $^{m}/_{m}$ diameter, and almost circular. On a square of 0·21 $^{m}/_{m}$ 3 or 4 larger and half a score smaller iron-grains were observed, and in a less rich place of the same area, a score of small iron-grains of not more than 0·021 $^{m}/_{m}$ diameter were found. Later, I found iron-grains of 0·45 $^{m}/_{m}$ length and half as wide. They are surrounded by a black *opaque* crust, stated by Mr. Winther to be 0·010 $^{m}/_{m}$ thick, frequently much thinner, seldom thicker.

In the basalt several rather large crystals of Olivine, and most likely of Augite, as well as small grains of Graphite are seen, besides many crystals of Felspar. To ascertain the chemical composition of the iron-grains a part of the basalt was powdered, the iron extracted by a magnet and treated with hydrochloric acid; the developed hydrogen, estimated as water, showed 66·6 per cent. of pure iron and 0·4 per cent. of sulphur. The hydrochloric solution contained, besides iron, distinct traces of copper and cobalt, and a very slight trace of nickel. The insoluble residue digested with *Aqua Regia*, gave a solution containing a rather considerable amount of phosphoric acid.

As regards the estimation of metallic iron, I must add that, besides its not being possible to avoid some basalt-powder adhering, the fine iron-powder had been kept and exposed to the air for about a month before it was analysed.

Although I have examined 200 preparations of basalt from 40 different places in North Greenland, I have hitherto not succeeded in finding native iron in others than those from Assuk and Ovifak. Polishing almost all the others, I have always tested them with a solution of sulphate of copper and frequently got a precipitate of copper, partly on the preparation, partly on the powder, but I could never see what mineral produced this effect; and having seen by the preparations from Assuk, that even iron-grains of only 0·021 $^{m}/_{m}$ diameter under the microscope may easily be distinguished from the magnetic oxide; I must say I do not attribute any great signification to the testing with sulphate of copper only.

It is thus proved with full validity, and not indirectly as by Andrews, that native iron does occur in basalt, and under such circumstances, that there cannot be the slightest doubt about its telluric origin; for it may be supposed that nobody in earnest would maintain the opinion that this iron has fallen as "meteoric matter" during the formation of the basalt; and I therefore consider the principal obstacles removed to explain Nordenskjöld's iron-blocks as being telluric iron. The Widmanstätt's figures are no doubt due to crystallization, and might therefore be expected to appear in telluric iron when found in larger quantities; and I venture to add that this is proved by the Greenland iron-masses. As regards their meteorite shape a comparison between the many loose iron-blocks on the shore at Ovifak cannot convey any other idea than they are fragments, more or less rounded off, which are not more like each other than rounded stone in general, especially when it is considered that they consist of quite a peculiar material, which has a most varying faculty to withstand the influence of the air and the ice.

Finally, I shall only intimate how the iron may be supposed to have been produced. I have said that the iron must have been either carried up with the basalt or produced by chemical action in the latter, and it is probable, that both methods of origin have supported each other. The great difference between the specific gravity of the iron and the basalt does not render such an origin impossible, as the consistence of the basalt, when it was erupted, may have been very thick. Besides, the similar occurrence of another mineral in the Greenland basalt, in another place, shows that it is possible; for it is only the chemical composition of that mineral that forbids to explain it as being of meteoric origin, to which its mysterious occurrence would otherwise entitle it just as well as the iron at Ovifak. This mineral is a nickeliferous magnetic pyrites, which occurs in a dyke of basalt, 10 to 16 feet wide, at Iglakunguark in the Waigat, partly in small grains and round balls, but especially in a large lump in the middle of the dyke, the visible dimensions of which are: length 10 feet, width 5 feet, and thickness 4 feet, so that it measures at least 200 cubic feet, and weighs about 28,000 kilograms. The basalt in this dyke, though somewhat different from the basalt with the native iron, containing more Olivine, is just as the basalt near the iron, coarse-grained, and has a peculiar appearance, so that it is clear also in this instance, that the presence of such a strange mineral, or at least the unusual quantity of it, has had an effect on the basalt when the latter was formed. As now the chemical composition of this magnetic pyrites mass forbids us to call it a meteorite or a part of one, nothing else is left but to suppose it to have been carried up with the basalt, and the possibility of the theory that the ironblocks at Ovifak may have been carried up in the same way, is thus proved. Still, it is possible that the native iron as well as the magnetic pyrites may have been carried up with the basalt in smaller particles, and that the condensation of larger concretions has not taken place until the basalt was about hardening. Anyhow, the manner in which the iron occurs along the joints, indicates that a part of it must have been formed after the hardening of the basalt. To support my opinion that the iron may have been produced by chemical action through the disoxidation of some iron-ore by organic matter, I will refer to the occurrence of Graphite, together with the native iron in the basalt from Assuk, as well as to the fact that the basalt with the iron at Ovifak also contains a considerable amount of Graphite.

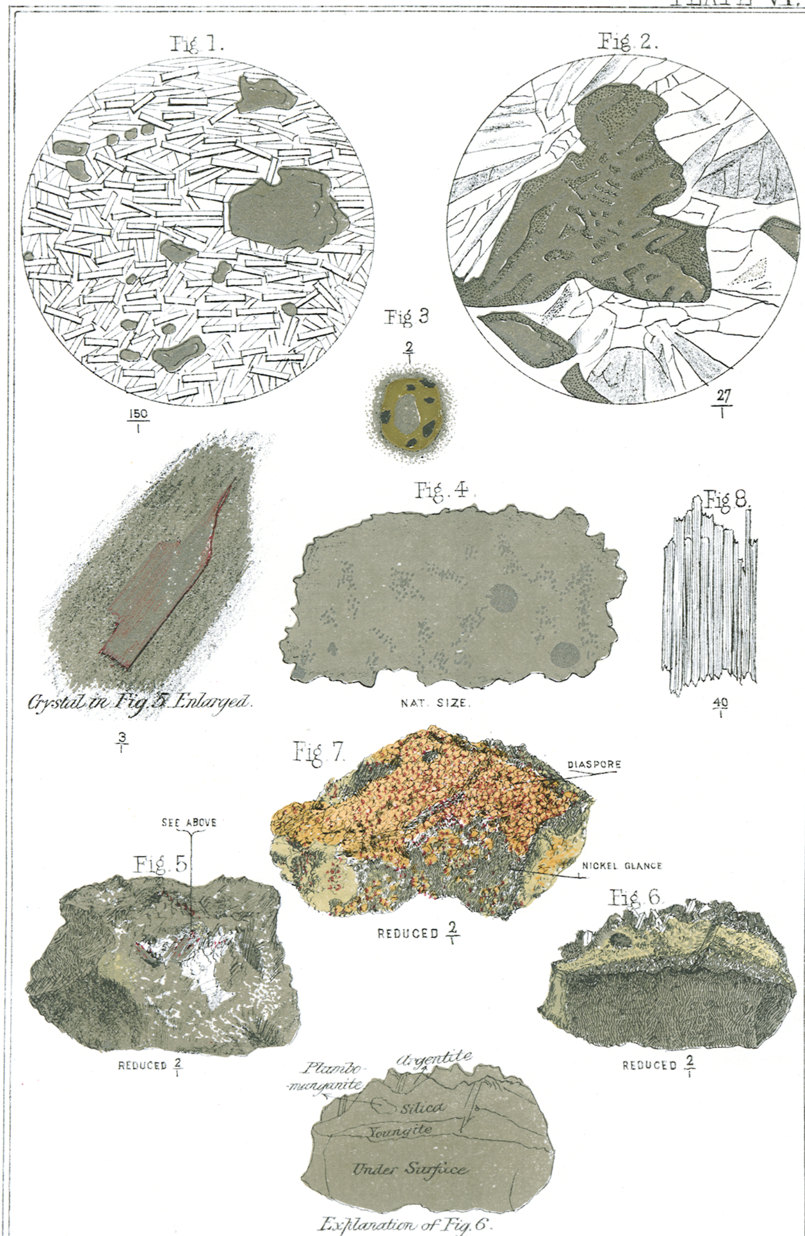
Fig. 1, plate IV, is from a photograph and represents a section of the basalt from Assuk, magnified 150 diameters. The native iron is surrounded by a dark substance, which, when more strongly magnified appears like a network, the meshes of which cover the iron as shewn in fig. 2. The *fluidale* structure which is presented by many of the sections, and the little colorless *microlites* of felspar or augite are not shewn.

Fig. 2 is a grain of metallic iron as seen in a section of the Blaajfeld basalt, magnified 27 diameters As in fig. 1 the felspar and augite are only indicated, but the grain of iron and its surrounding black network is faithfully represented.

Fig. 3 is a single grain, magnified 2 diameters, surrounded by a crust of triolite containing little grains of hisingerite.

Fig. 4 is a fragment of the basalt natural size, shewing the distribution of the iron grains.

PLATE VI.



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