

## DISCUSSION.

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This department has been established by the editors in order to afford to those interested in questions relating to economic geology an opportunity for informal discussion. Contributions are cordially invited either in the form of discussion of more formal papers appearing in earlier numbers or bearing upon matters not previously treated. Letters should be directed to the Editor, Sheffield Scientific School of Yale University, New Haven, Conn. The full name of the author should be attached to all communications.

### *MAGNETIC IRON ORES OF CLINTON COUNTY, NEW YORK.*

*Sir:* The paper by William J. Miller in the November number of *ECONOMIC GEOLOGY*, relating to the magnetites of Lyon Mountain and vicinity, is a concise and altogether faithful account of the geology of an important Adirondack mining district. With most of the statements and conclusions there can be little disagreement, if one accepts the viewpoint of the more recent workers in this field of Precambrian geology. On a few points, however, it appears the writer has taken a position which invites critical inquiry from the reader, for the evidences submitted seem scarcely adequate to warrant the deductions which he makes, particularly with regard to the derivation of the ores.

The explanation of the magnetites that occur in the Precambrian gneissic rocks is primarily dependent of course upon the methods of origin ascribed to the latter. If the wall-rocks are igneous then it is reasonable to suppose the ores are connected with some magmatic process, since all the evidences go to show they were in place when the gneisses assumed their present position and structures. On the other hand if the wall-rocks are sedimentary—as they undoubtedly are in certain Adirondack districts—it is possible to ascribe various methods of genesis to the magnetites, the easiest of which is perhaps to regard them as

contemporaneous accumulations metamorphosed along with the country rocks. Still the influence of igneous activity may not be excluded, as everywhere these sedimentary or Grenville formations have been powerfully affected by the igneous invasions of the early Precambrian and these not unlikely have been instrumental in the deposition of their contained magnetites.

The country gneiss in the Lyon Mountain area is described by Miller and earlier by Cushing as having the mineral composition of a low-quartz granite. It contains some admixture with other rocks like amphibolite, dark pyroxene gneiss, mica and pyritic schists, but on the whole it is remarkably uniform and simple in character throughout the area of probably several hundred square miles that it covers in the northern Adirondacks. Cushing regarded it as igneous and Miller concurs in this view by calling it Lyon Mountain granite. With this interpretation no issue will be made, for the present writer has expressed a similar opinion.

The derivation of iron ores then centers about some magmatic process. In his contribution Miller emphasizes the importance of the foreign inclusions within the granite, particularly those of more basic character, as a source of the iron. The existence of an older gabbro is predicated upon the presence of certain hypersthene-bearing materials, as well as hornblende gneisses, both of which are considered to have been invaded by the granite during its progress toward the surface. In this process it is held the granite took up magnetite from the older rocks but also secured additional and perhaps more important supplies of iron oxides by reaction upon the hypersthene and hornblende which through its influence underwent a paramorphic change to diallage of lower iron content. The corollary of the matter is that the magnetite of the ore bodies has come mainly from these foreign sources and not from the granite itself, although the concentration of the iron in its present form must have been brought about by magmatic action in some way.

A sample of gabbro, representative of the inclusions, but unaffected by the granite, on analysis showed 11.54 per cent.  $\text{Fe}_2\text{O}_3$  or 8.08 per cent. iron. A sample of diallage rock from near the

Lyon Mountain deposits returned 10.86 per cent.  $\text{Fe}_2\text{O}_3$ , or 7.60 per cent. iron, of which 8.16 per cent.  $\text{Fe}_2\text{O}_3$  was in the pyroxene mineral. On the basis of the mineral analysis of the gabbro it is reckoned that the three minerals—hornblende, hypersthene and magnetite making up 60 per cent. of the mass of the gabbro—contain by themselves 18.4 per cent.  $\text{Fe}_2\text{O}_3$ , but here a little error has crept in as the correct amount on the assumed basis would be 19.2 per cent. By deducting the iron in the form of magnetite it is concluded that the hornblende and hypersthene of the gabbro have lost much iron in conversion to diallage.

The figures afford little basis for a quantitative statement of the problem. So far as they go they indicate that the gabbro with 11.54 per cent.  $\text{Fe}_2\text{O}_3$  may have been transferred to a diallage rock with 10.86 per cent.  $\text{Fe}_2\text{O}_3$ , but not much else. There is no information vouchsafed about the equivalent volumes concerned in the operation, or the material additions or subtractions which, if the theory is correct, must have taken place. But even admitting that the gabbro contains several per cents. of iron more than the diallage rock, which is scarcely indicated by the analysis, is the mass of the gabbro that may have been ingested in the granite proportionate to the effects produced in the formation of the magnetite deposits? That is the crucial point.

The general character of the gneiss or granite does not give support to the view that it has absorbed large amounts of foreign material, except very locally. In the Palmer Hill district to the east of Lyon Mountain the rock is nearly a pure feldspar-quartz-magnetite mixture, and in the writer's observation that is the prevailing character of it. Admixture with foreign material seems to have no bearing on the distribution of the ores in general, although in the Lyon Mountain district some of the deposits do align themselves more or less with the hornblende and mica schists enclosed by the granite. Palmer Hill and many other mines exemplify their association with granite notable for its small amounts of the dark minerals, except magnetite which not infrequently runs up to 10 or 15 per cent.

Dr. Miller himself does not seem to hold that the granite has

actually absorbed much of the gabbro, as he states that the typical rock is a microcline—microperthite—quartz material with only 8–10 per cent. of plagioclase in the form of albite and oligoclase. Consequently the abstraction of iron has been a sort of lixiviation process, without notable incorporation of the other ingredients. In any case it must be held that a very large body of the gabbro was involved, that the magmatic solutions penetrated it very thoroughly, that the iron so taken up was later segregated in order to form ores of 30–50 per cent. iron content in very substantial bodies. With such large masses the chilling effect upon the solutions would be considerable and tend to block the migration of the iron oxide. It seems likely that the iron must crystallize out close to the source of supply, so that the total effect would be one of dilution rather, through addition of the magmatic material.

Such theory also fails to account for the iron content of the granite in its normal phases. This is a matter that has not been dealt with, but it needs to be taken into consideration. In its mineral and chemical properties the rock belongs to the general type of soda-rich granites and syenites that have come to be known as the predominant magnetite-bearing rocks the world over. If segregation of the iron in the granite itself may not explain the formation of ore bodies like those in question, then our theories of magmatic processes appear inadequate.

The late crystallization of the magnetite particles which Dr. Miller notes in regard to the ores is not exceptional; also it is not necessarily indicative of a later introduction of magnetite after the crystallization of the silicates; rather it seems to depend upon the proportion of iron to the other ingredients. Thus in ordinary gabbro the magnetite or ilmenite normally crystallizes first but in the segregated ores it is the last to form.

The Precambrian magnetites present very intricate problems and their solution requires close study, such as Dr. Miller has given to the present occurrence. My criticism is that he has over-emphasized certain features which really play a minor rôle in the ore-forming process.

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