DISCUSSION

AND

INFORMAL COMMUNICATIONS

*NASON ON "THE SEDIMENTARY PHASES OF THE ADIRONDACK MAGNETIC IRON ORES."*¹

Sir: It is a pleasure for me to discuss the paper by F. L. Nason, appearing in this number of your journal, in which evidence supporting the theory of the sedimentary origin of Adirondack nontitaniferous magnetic iron ores is presented. The problem of the origin of these ores is anything but a simple one, involving almost endless petrological considerations. For a good many years the igneous origin of these ores has been very generally accepted by workers in Adirondack geology. Mr. Nason renders a well worth-while service in questioning such a mode of origin. In this brief discussion many important phases of the whole subject must of course be omitted, my purpose being to confine attention mainly to the most significant issues raised in Nason's paper. It is assumed that the interested reader is either acquainted with, or has ready access to, Newland's "Geology of the Adirondack Magnetic Iron Ores,"² Kemp's "Geology of the Elizabethtown and Port Henry Quadrangles,"³ my paper on the "Magnetic Iron Ores of Clinton County, New York,"⁴ the discussion of my paper by Newland,⁵ and my answer to Newland's criticisms.⁶

Both Kemp and Newland have regarded the nontitaniferous

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² D. H. Newland, *N. Y. State Mus. Bul.*, 119, 1908.

³ J. F. Kemp, *N. Y. State Mus. Bul.*, 138, 1910.

⁴ W. J. Miller, *ECON. GEOL.*, vol. 14, 1919, pp. 509-535.

⁵ D. H. Newland, *ECON. GEOL.*, vol. 15, 1920, pp. 177-180.

⁶ W. J. Miller, *ECON. GEOL.*, vol. 16, 1921, pp. 227-233.

magnetite ores as magmatic differentiation or segregation masses of the syenite-granite series. Kemp has suggested that the ore at Mineville may possibly be thought of as "more or less akin to pegmatites in its formation."

More recently I have advocated a different magmatic theory of the origin of the ore, according to which a gabbro or metagabbro, older than the syenite-granite series, was the principal, or possibly the only, source of the magnetite whose derivation from the gabbro and its concentration into ore deposits were brought about by the intrusion of the great syenite-granite magma, more especially its pegmatitic and silexitic portions rich in hot gases, vapors, and fluids.

One of Nason's most important arguments in support of the theory of the sedimentary origin of the nontitaniferous ores is their general lack of titanium. The titaniferous magnetites are, he says, derivatives of the gabbros of the region, while the nontitaniferous ores either occur as a part of, or are directly associated with, a "gray gneiss" of sedimentary origin. Now, as Newland⁷ has said: "The term nontitaniferous, it may be noted, is hardly an accurate one to apply to any of the Adirondack magnetites, since titanium has been shown to be almost universal in these ores." The ores are, therefore, not so free from titanium as Nason's paper seems to imply.

As a result of field work in all of the principal magnetite mining districts—Lyon Mountain, Hammondville, and Mineville—I believe that the ore is directly associated with a more or less intimate combination of granite (or syenite) and an older gabbro (or metagabbro), the granite, or pegmatitic phases of it, having intruded and more or less injected the gabbro, giving rise to a crude-banded effect, parallel with the magmatic flow-structure foliation. The same is almost universally true of many smaller nontitaniferous magnetite deposits observed by the writer throughout the Adirondacks. Nason's logs of drill holes No. 181 and No. 296 are excellent examples of just such combinations of rocks in which his "gray gneiss" bands are, in my judgment,

⁷ D. H. Newland, *N. Y. State Mus. Bul.*, 119, 1908, p. 23.

merely zones or belts of magmatic origin closely associated with bands of an older more or less injected or assimilated gabbro. In this connection it should be stated that there is also probably gabbro of later age than the syenite-granite series, as for example in the vicinity of Mineville, and Nason may be confusing these two as I gather from reading his paper. His "gray gneiss" seems to be identical with the great body of what I have called the Lyon Mountain granite which encloses the ore bodies at Lyon Mountain. This country rock of the ore at Lyon Mountain is certainly of igneous origin as proved not only by its more or less intimate penetration of an older dark gneiss (metagabbro), but also by its noteworthy development of pegmatitic and silexitic facies.

Analyses of various samples of the Adirondack syenite-granite series and of the older gabbro show that the gabbro is rich in iron oxide, carrying an average of over 15 per cent., which is about three times as much as is contained in the syenite-granite. It is also true that the gabbro analyses show a little over 3 per cent. of oxide of titanium. In my original paper it is suggested that the iron-rich gabbro was the principal (or possibly sole) source of the ore, the iron-oxide having been extracted from the injected gabbro and deposited in zones by the granite magma or magmatic juices. Nason says it is difficult to understand how the iron could have been thus removed and deposited as ore almost free from titanium. This is a point not taken up in my paper, but it is no serious difficulty in the way of acceptance of my theory. Various important chemical and mineral rearrangements took place during the processes of injection of the gabbro and the concentration of the ores. Among such changes was the development of very considerable quantities of titanite in the rocks directly associated with the ores and to some extent in the ores themselves. As Newland⁸ says, the titanium of the ore and directly associated rocks "is traceable to the mineral titanite which is a common constituent of the wall rocks, and is often intergrown with the magnetite. Its proportion is generally

⁸ D. H. Newland, *N. Y. State Mus. Bul.*, 119, 1908, p. 23.

higher in the crude ore than in the concentrates." This is true of all three principal mining districts. Typical members of the syenite-granite series carry little or no titanium, but an analysis of the average ore-bearing syenite (or grano-syenite) of the Mineville district published by Kemp⁹ shows 3 per cent. oxide of titanium. It is, therefore, easy to understand what became of the titanium.

In support of the view that his "gray gneiss" is of sedimentary origin, Nason stresses the occurrence of a wide band of the gneiss, containing ore, intercalated with Grenville beds at the Cheever Mine. This "gray gneiss" I consider to be merely a layer-like mass of granite or grano-syenite which was locally intruded between beds of the Grenville series, this being a mode of occurrence which may be observed in many parts of the Adirondacks.

In arguing for the sedimentary origin of the "gray gneiss" with its ore, Nason emphasizes the practical absence of titanium from the rock, but he fails to take into account another point which I believe strongly militates against the sedimentary origin of the rock. I refer to the fact, brought out by Newland, that considerable quantities of pyrite almost never fail to be present in those nontitaniferous magnetite deposits which are directly associated with undoubted Grenville strata in various parts of the Adirondacks, while little or no pyrite occurs in the ores associated with the undoubted syenite-granite series. The rocks, including Nason's "gray gneiss," inclosing the ores at Mineville, Hammondville, and Lyon Mountain do not contain notable quantities of pyrite, and so we have another kind of evidence for the igneous origin of these ores and their wall rocks. My theory readily accounts for this difference in the pyrite content of the ores because the ore-bearing magma or magmatic juices absorbed the pyrite from the strata.

The facts that the ore bodies often show considerable linear extent and have "foliation planes no less strongly developed than those in the containing rocks, and these foliations are exactly conformable to those of the rock host" are, according to

⁹ J. F. Kemp, *N. Y. State Mus. Bul.*, 138, 1910, p. 50.

Nason, strong evidence for the sedimentary origin of the ore. In my original paper I interpret the parallelism of strike and dip of the ore zones and their foliation as due to magmatic flowage when both the syenite-granite (country rock) and ore-zone magmas were subjected to moderate pressure during the process of intrusion and crystallization. Under such conditions, is it any more surprising that the ore zones of magmatic origin often show considerable linear extent than that, commonly throughout the Adirondacks, long belts or zones of the syenite-granite series, different in composition from the general rock, developed under magmatic conditions?

W. S. Bayley, in the Raritan, New Jersey, Folio of the United States Geological Survey, states that an old dark gneiss, rich in iron-bearing minerals, was invaded and all cut to pieces by great bodies of granite magma. He suggests that, after the intrusion and partial cooling of the gneissoid granites, "they were invaded by masses of magma rich in iron, some of which were afterward enriched by iron-bearing solutions or vapors rising from the same subterranean source. Some of the ore layers may be merely injected bodies of the magma that had been segregated or differentiated from the parent magma at great depth." He further suggests that "some of the magnetite may have been deposited by hot solutions which penetrated the rocks before they were completely crystallized." Considering these rock relations, it seems reasonable to think that the iron of the magnetite ores, instead of having differentiated from the granite magma, may have been derived from the old iron-rich gneiss by magmatic (pegmatitic) solutions after the manner suggested by me for most, if not all, of the Adirondack nontitaniferous magnetite ores. If Bayley had emphasized his idea of hot solutions as ore carriers rather than that of differentiation of the ore from the granite magma, his explanation and mine would be much alike. In any case, these New Jersey ores are remarkably like those of the Adirondack region.

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