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Geochemistry of the Furnace Magnetite Bed, Franklin, New Jersey, and the Relationship between Stratiform Iron Oxide Ores and Stratiform Zinc Oxide-Silicate Ores in the New Jersey Highlands

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Abstract

The New Jersey Highlands terrane, which is an exposure of the Middle Proterozoic Grenville orogenic belt located in northeastern United States, contains stratiform zinc oxide-silicate deposits at Franklin and Sterling Hill and numerous massive magnetite deposits. The origins of the zinc and magnetite deposits have rarely been considered together, but a genetic link is suggested by the occurrence of the Furnace magnetite bed and small magnetite lenses immediately beneath the Franklin zinc deposit. The Furnace bed was metamorphosed and deformed along with its enclosing rocks during the Grenvillian orogeny, obscuring the original mineralogy and obliterating the original rock fabrics. The present mineralogy is manganiferous magnetite plus calcite. Trace hydrous silicates, some coexisting with fluorite, have fluorine contents that are among the highest ever observed in natural assemblages. Furnace bed calcite has $\delta^{13}C$ values of –5 ± 1 per mil relative to Peedee belemnite (PDB) and $\delta^{18}O$ values of 11 to 20 per mil relative to Vienna-standard mean ocean water (VSMOW). The isotopic compositions do not vary as expected for an original siderite layer that decarbonated during metamorphism, but they are consistent with nearly isochemical metamorphism of an iron oxide + calcite protolith that is chemically and mineralogically similar to iron-rich sediments found near the Red Sea brine pools and isotopically similar to Superior-type banded iron formations. Other manganiferous magnetite + calcite bodies occur at approximately the same stratigraphic position as far as 50 km from the zinc deposits.

A model is presented in which the iron and zinc deposits formed along the western edge of a Middle Proterozoic marine basin. Zinc was transported by sulfate-stable brines and was precipitated under sulfate-stable conditions as zincian carbonates and Fe-Mn-Zn oxides and silicates. Whether the zincian assemblages settled from the water column or formed by replacement reactions in shallowly buried sediments is uncertain. The iron deposits formed at interfaces between anoxic and oxygenated waters. The Furnace magnetite bed resulted from seawater oxidation of hydrothermally transported iron near a brine conduit. Iron deposits also formed regionally on the basin floor at the interface between anoxic deep waters and oxygenated shallower waters. These deposits include not only manganiferous magnetite + calcite bodies similar to the Furnace magnetite bed but also silicate-facies deposits that formed by iron oxide accumulation where detrital sediment was abundant. A basin margin model can be extended to Grenvillian stratiform deposits in the northwest Adirondacks of New York and the Mont Laurier basin of Quebec. In these areas iron deposits (pyrite or magnetite) are found basinward of marble-hosted sphalerite deposits, such as those in the Balmat-Edwards district. Whether the iron and zinc precipitated as sulfide assemblages or carbonate-oxide-silicate assemblages depended on whether sufficient organic matter or other reductants were available in local sediments or bottom waters to stabilize H_2S.

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