

The Falémé Iron District, Senegal

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Abstract

The Falémé iron district in the Kedougou-Kéniéba inlier of the Paleoproterozoic Birimian Supergroup of West Africa consists of nine major and 19 minor orebodies, distributed in a belt 65 km long and 15 km wide. Two major exoskarn orebodies have total reserves of 320 million metric tons (Mt) magnetite ore with 42 percent Fe, and seven major supergene-enriched orebodies, which overlie endoskarn, have reserves of 310 Mt with 59 percent Fe. Previous workers advocated an (exhalative)-sedimentary origin for the primary ore. In this paper, however, we present strong evidence for contact-metasomatic skarn mineralization associated with microdiorite intrusions, with an emphasis on the Karakaene-Ndi and Goto deposits.

The ore deposits of the Falémé district are the only major Precambrian magnetite skarn deposits worldwide that have not been subjected to postore metamorphism. The deposits of the Falémé district have many similarities to Phanerozoic magnetite skarn deposits that are associated with dioritic intrusions and also lack postore metamorphism.

The endoskarn of the Karakaene-Ndi deposit is hosted by microdiorite with pervasive albitization. Garnet ($\text{And}_{56-100}\text{Grs}_{0-43}\text{Alm}_{0-2}\text{Sps}_{0-1}\text{Pyr}_{0-1}$) and clinopyroxene ($\text{Di}_{58-100}\text{Hed}_{2-42}$) are early phases. Individual grains of garnet and clinopyroxene commonly are inhomogeneous, with Fe being concentrated at the margin of the grains rather than in the core. Fe-rich zones in clinopyroxene are also enriched in Na. Biotite and magnetite precipitated relatively late, followed by pyrite (2 vol %) \pm chalcopyrite \pm pyrrhotite \pm iss. Aqueous-carbonic fluid inclusions in quartz from one sample have CO_2 concentrations of 5 to 14 mol percent and indicate pressures of 300 to 900 bars and temperatures of 281° to 373°C at total homogenization.

The magnesian exoskarn of the Goto deposit is hosted by dolomitic and calcitic marble, which locally contains graphite. Magnetite is associated with prograde clinopyroxene ($\text{Di}_{89-100}\text{Hed}_{0-11}$) and phlogopite-rich biotite ($\text{Mg}/(\text{Mg} + \text{Fe}) \sim 0.89$) as well as retrograde serpentine. Garnet is scarce. Sulfur concentrations average 1 wt percent. Pyrrhotite and subordinate pyrite \pm chalcopyrite \pm arsenopyrite \pm pentlandite \pm cobaltite postdate most of the magnetite. The exoskarn formed under more reducing conditions and at lower temperatures than the endoskarn. Magnetite in the exoskarn has trace element concentrations similar to those of magnetite in the endoskarn but is distinguished from igneous magnetite in granodiorite and magnetite in andesite (possibly of igneous origin) by low concentrations of Cr_2O_3 and V_2O_5 .

Microdiorite is the most likely source of iron although no igneous magnetite in microdiorite could be identified. Microdiorite with only moderate hydrothermal alteration has lower iron concentrations (1.6–4.5% $\text{Fe}_2\text{O}_{3(\text{total})}$) than unaltered granodiorite and weakly altered andesite in the area (avg $\sim 7\%$ $\text{Fe}_2\text{O}_{3(\text{total})}$). Iron was probably leached from the moderately altered microdiorite and transferred into zones of intense alteration in microdiorite and host-rock marble. The low degree of hydrothermal alteration of granodiorite and small areal extent of andesite argue against a granodioritic or andesitic source of iron.

The supergene ore is derived from endoskarn with about 30 percent Fe and consists of hematite and hydrous iron oxides. The largest orebodies have a thickness of 100 m and are located in the central part of hills that rise 250 m above the surrounding peneplain; the bottom of the enrichment zone usually is centered deep below the top of the hills. The absence of supergene enrichment in exoskarn orebodies probably is due to unfavorable structural conditions. Supergene enrichment of endoskarn was probably not exclusively by residual enrichment, in which Ca, Mg, Na, and Si were removed from the orebody, but also involved addition of Fe from descending solutions to the site of enrichment.

Exploration for new supergene iron ore should be focused outside the exoskarn belt between Goto and Safa, as the deposits in this area are unlikely to have experienced major supergene enrichment. The Falémé district has some similarities to the geologic setting of iron oxide-copper-gold districts in which the deposits are hosted by dioritic rocks and may be representative of an iron oxide-rich end member of the iron oxide-copper-gold class. However, only about 3 t of gold have been mined from alluvial deposits in the area and the district is relatively poor in copper.

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