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Modified magnetite and hydrothermal apatite in banded iron-formations and implications for high-grade Fe mineralization during retrogressive metamorphism

Kangxing Shi[1,2,†], Changming Wang[1,*], Leon Bagas[1,3], and Hongyu Duan[1]

[1]State Key Laboratory of Geological Processes and Mineral Resources, School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China
[2]College of Earth Sciences, Hebei GEO University, Shijiazhuang 050031, China
[3]Xi'an Center of China Geological Survey, Xi'an 710054, China

Abstract

Modified magnetite and hydrothermal apatite in banded iron formations (BIFs) are ideal minerals for studying hydrothermal and metamorphic processes and are applied to linking with high-grade Fe mineralization and metamorphism in iron deposits hosted by BIFs. In this study, we have investigated the geochemical composition of modified magnetite and hydrothermal apatite and in situ U-Pb geochronology on apatite from the Huogezhuang BIF-hosted Fe deposit in northeastern China. The magnetite in metamorphosed BIF is modified, locally fragmented, and forms millimeter- to micrometer-scale bands. The apatite is present surrounding or intergrowing with magnetite, has corroded surfaces, and contains irregular impurities and fluid inclusions, indicating that it has been partly hydrothermally altered. Original element compositions (e.g., Fe, Al, Ti, K, Mg, and Mn) of magnetite in BIFs have been modified during high-grade Fe mineralization and retrogressive metamorphism with temperature reduction and addition of acids. The hydrothermally altered apatite has been relatively reduced in the contents of Ca, P, F, La, Ce, Nd, δCe, δEu, and total REEs compared to non-altered apatite. The magnetite and apatite in low-grade BIFs are poorer in FeO_T than those from the high-grade Fe ores, indicating that Fe is remobilized during the transition from BIFs to high-grade Fe ores. The magnetite and apatite in high-grade Fe ores are overgrown by greenschist-facies minerals formed during retrograde metamorphism, suggesting that the high-grade Fe mineralization may be related to retrogressive metamorphism. In situ U-Pb geochronology of apatite intergrown with magnetite and zircon LA-ICP-MS U-Pb dating at Huogezhuang deposit reveals that the BIF-hosted magnetite was altered and remobilized at ca. 1950–1900 Ma, and deposition of the BIF began during the Late Neoarchean. The changes of elements in the modified magnetite and different geochemical compositions of the altered and unaltered apatite confirm that the modified magnetite and hydrothermal apatite can be effective in tracing high-grade Fe mineralization and retrogressive metamorphism in BIFs.

Keywords: Banded iron-formation, apatite, magnetite, high-grade iron ore, mineralization and metamorphism, Huogezhuang deposit