THE GENESIS AND DIAGENETIC EVOLUTION OF IRON OXIDES IN BANDED IRON FORMATION

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Minerals in banded iron formations (BIFs) are not primary. They more represent diagenetic to metamorphic overprinting. Understanding the formation and evolution of minerals in BIF is essential for using their various geochemical composition features to interpret oceanic, atmospheric and biological environments during the deposition of BIFs. We used electron microscopic, X-ray diffraction and Mössbauer spectroscopic methods to investigate the mineral and petrologic features of BIFs with their ages ranging from >3.76 Ga to ca. 2.2 Ga. Though they have wide depositional environments and post-depositional histories, their chemical and mineral compositions are alike. Magnetite, hematite, chert/quartz, Fe(II)-containing silicates and carbonates are the dominating minerals in all of them. Minor minerals include apatite and pyrite. However, the silicate species, mineralogical structures, banding and relative contents of each mineral phase vary from one to another. BIFs deposited before the great oxidation event (GOE, 2.45-2.32 Ga) contain more magnetite than those formed during or immediately before the GOE. Iron oxides (i.e., hematite and magnetite), regardless of their forming mechanism, could have undergone multiple redox alterations during sedimentary histories. Magnetite with euhedral crystallinity, homogeneous and pure chemical composition and primary hematite in the BIFs are more likely diagenetic products formed without the interference with external materials. They could largely represent the primary iron source in the ancient seawater, and geochemical data derived from these crystals may represent the environments and biological activities during their crystallization. In contrast, needle-like, fibrous and microplaty hematite distributed along fractures or bandings, irregularly-shaped massive magnetite with breccia structures, and magnetite replaced by carbonates and/or silicates probably have been altered in hydrothermal or supergene processes mediated by external fluids. Their geochemical features could no more represent the primary depositional environments of BIF. For silicates, their species and structures depend on the metamorphisms and deformations they have undergone, and thus mostly represent their metamorphic and tectonic histories. All minerals in BIFs including their mineralogical and petrologic features depend not only on their depositional geochemical conditions, but also on their post-depositional evolutions. Using geochemical data derived from minerals in BIFs to approach the ancient environments and biological activities should be combined with careful mineralogical examinations. The high-resolution electron microscopic observations on petrologic and mineralogical features of BIFs can provide reliable criteria for “primary” minerals bearing information on the oceanic and biological processes that could be further extracted by geochemical studies.