Discovery of primary hematite-silica clusters in Kukatash Banded Iron Formation at 2.7 Ga Abitibi Greenstone Belt

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Banded Iron Formations (BIFs) are widely recognized in Archean era, although it is still controversial whether dissolved Fe (II) in the seawater was removed by oxic or non-oxic seawater, and which microbial activities were present in such environment. To examine these problems, we examined BIFs and associated black shales at the Kukatash area in 2.7 Ga Abitibi Greenstone Belt, Canada. Geological survey revealed that the total thickness of BIF at the Kukatash area was up to 100 meters, containing ferruginous cherts, oxide- and carbonate-BIF. Black shales were interbedded in several stratigraphic positions of BIFs. The $\delta^{34}S_{pyrite}$ values in black shales were ranging from -5.4 to 10‰, suggesting that activities of sulfate-reducing bacteria in sulfate-bearing environments. The $\delta^{13}C$ values of kerogen, ranging from -31.2 to -30.2‰, support photosynthetic based ecosystem in upper water column. Our findings do not support methanogen dominated ecosystem in the reduced ocean but support oxygenated biosphere in 2.7 Ga.

Major iron-bearing minerals in BIFs were magnetite, Fe-carbonate and iron silicate. Their paragenetic relationships suggested non-primary feature of them, meaning secondary formed during diagenetic or metamorphic stages. We discovered rounded-shape clusters, which sizes were a few mm in diameter, appeared in the oxide BIFs. They contained submicron-sized euhedral hematite in the microcrystalline quartz matrix. Fe-bearing minerals other than hematite were not observed in these clusters, by detailed TEM and micro-Raman spectroscopic analyses. Therefore, those hematite crystals were interpreted as the early oxides, formed by interaction between Fe^{2+} and oxic seawater. Primary hematite was survived from late diagenesis and metamorphisms by protection from cemented microcrystalline quartz. All data found in the present study consistently suggests that 2.7 Ga Kukatash oceans were oxygenated, although it is still uncertain if such feature represent global phenomena.