Microstructure and geochemistry of organic matters associated with iron minerals in 3.2 Ga banded iron formations, Moodies Group, Barberton Green stone Belt, South Africa

*Ryo Nakajima[1], Yoko Ohtomo[3], Tsubasa Otake[2], Takeshi Kakegawa[4], Tsutomu Sato[2]

1. Division of Sustainable Resources Engineering, Graduate School of Engineering, Hokkaido University, 2. Division of Sustainable Resources Engineering, Faculty of Engineering, Hokkaido University, 3. Faculty of Engineering, Hokkaido University, 4. Graduate School of Science, Tohoku University

The iron oxidation process in Banded iron formations (BIFs) is still controversial especially before the Great Oxidation Event. Previous studies suggest that microbial activity, either free oxygen produced by cyanobacteria or anoxygenic iron-oxidizing bacteria was involved in the formation of BIFs. Therefore, geochemical characteristics and occurrence of organic matters relating to the iron mineralogy may give an insight to the oxidation process. Here, we performed geological, petrological, and geochemical investigations on ~3.2Ga BIFs deposited in a shallow ocean, where high microbial productivity were expected, in the Sheba gold mine, Moodies Group, Barberton Green stone Belt, South Africa. Rock samples were classified into the MT type (magnetite-rich sandstone, 13-50 wt% Fe_2O_3) and SD type (magnetite-poor silty clastics, 10-30 wt% Fe_2O_3) based on the dominant iron mineral. MT type consists of alternating magnetite-rich layers and silicate-rich layers, containing euhedral magnetite, carbonates, quartz, biotite and chlorite. SD type is subdivided into SD-1, which consists of alternating carbonates (siderite, ankerite and dolomite)-quartz-rich layers and biotite-chlorite-rich layer, and SD-2, which contains the smaller grains of quartz, chlorite and biotite.
These samples contain 0.03-0.29 wt% of carbonaceous matters, which are observed as aggregates of 20 μm round or oval flakes in diameter. Wrinkles and folding structure are often observed on the surface of the flake structures. Carbon stable isotope ratio of the carbonaceous matters shows -26~-27‰, suggesting that it is likely to be derived from organisms. Microfossil-like strucstures in Moodies shales observed by Javaux et al., (2010) have the similar characteristics to this study, though they shows the wider range in the size distribution (31-298 μm in diameter). Organic matters extracted by acid dissolution has ~0.002 of N/C ratio, which is consistent with that of kerogen in Archean rocks that were subjected to a similar metamorphic grade. Raman microspectroscopy of the extracted organic matters indicates that they have experienced ~500 ˚C metamorphic temperature, which is slightly higher than the regional metamorphism in Moodies group. This may be due to an influence by the later hydrothermal fluids involving gold mineralization.
In both sample types, the iron content show a negative correlation with the organic carbon content, but a positive correlation with the carbonate carbon content. Most SD-1 samples show higher carbonate carbon to iron ratios than that of siderite. The carbon stable isotope ratios of carbonates in MT and SD-1 samples were ~-4‰. These results suggest that most carbonates in SD-1 and MT samples were ankerite and/or dolomite derived from mineralizing fluids. Previous studies indicate that organic matters in BIFs can be consumed as CO_2 or converted to siderite by a reaction with primary iron oxides during diagenetic and metamorphic process (Perry et al., 1973, Kohler et al., 2013). However, SD-2 samples showing high organic carbon contents are poor in carbonates and iron. Moreover, considering carbonate carbon stable isotope ratio in MT and SD-1 type samples and relatively high organic carbon contents in MT type samples (0.03-0.26 wt%), we suggest that the negative correlation between the organic carbon and iron contents is a primary signature during the deposition of BIFs. Assuming that a model proposed by Kohler et al. (2013) can be applied to this study, SD-2 samples, which are organic carbon-rich and iron-poor, and MT samples, which are carbon-poor and iron-rich, may reflect the activities of cyanobacteria and

iron-oxidizing bacteria, respectively, in different depositional settings. Then, our results imply that cyanobacteria would flourish nearby coast, whereas iron-oxidizing bacteria would be active relatively far from the coast, or below the cyanobacteria in 3.2Ga shallow ocean.

Keywords: Banded Iron Formations, Barberton Green stone Belt, organic matters

