Morphological and spectroscopic characteristics of organic matter in Banded Iron Formation, Barberton Greenstone Belt, South Africa

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The emergence of cyanobacteria has been postulated to cause an increase in Earth’ s atmospheric oxygen concentration ~2.45 Ga and oxidation of ferrous iron in a seawater, facilitating the formation of Banded Iron Formations (BIFs) in the Proterozoic era. On the other hand, iron precipitation process in the Archean is still controversial. Previous studies suggest that anoxygenic iron-oxidizing bacteria and/or free oxygen produced by cyanobacteria, was responsible for iron oxidation before ~2.45 Ga. Organic matter preserved in BIFs may provide insights into the iron oxidation process and biological evolution in Archean. However, authenticity of Archaean organic matter has to be first clarified for further investigations due to possible later contamination. Here, we investigated morphological and spectroscopic characteristics of organic matter in ~3.2 Ga BIFs in Sheba mine, Moodies Group, Barberton Green stone Belt, South Africa to estimate the chemical structure combined with a contamination check using Raman spectroscopy.

Organic matter was collected by two different methods: extraction by acid treatment of powder samples and pick up with a micro-manipulator from thin sections. When Raman spectra were obtained using 532 nm wavelength laser, acid-treated organic matter showed two peaks ~1350 and ~1580 cm^{-1} corresponding to disordered and ordered carbon structures, whereas micro-sampled organic matter shows no detectable peak with a high background. Because yellow-green fluorescence was observed in micro-sampled organic matter using a Fluorescence microscope, the fluorescence likely causes a high background in the Raman spectra. Therefore, 785 nm wavelength laser was applied for micro-sampled organic matter. Calculated metamorphic temperature from the Raman spectra obtained by acid-treated and micro-sampled organic matter was from 400 to 540˚C, which is consist with greenschist facies of the Barberton Greenstone Belt. This indicates that the organic matter is not a later contamination. Chemical mapping with an Electron Probe Micro Analyzer shows that micro-sampled organic matter is predominately comprised of carbon with slight contribution of nitrogen (< 0.1wt%). Infrared spectra of the organic matter show absorption peaks corresponding to N-O, C-O, and C=O bonds, suggesting that organic matter remains their functional groups in the structure. Based on the morphology and microstructure observed by Field Emission- Scanning Electron Microscope, the organic matter may have been derived from biofilm because of similarity in the morphology as well as the large size (20 –50 μm). Furthermore, the micro-sampled organic matter has a rough surface while the acid-treated organic matter has a smooth one, which may be due to damages by acid-treatment. Our results suggest that micro-sampling is suitable to observe the detailed morphological and structural features of organic matter preserved in Archean sedimentary rocks.

Keywords: Archean, Microfossils, Barberton Greenstone Belt, Raman spectroscopy, Infrared spectroscopy

