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Unique occurrence of organic matter in the banded iron formation of the Fig Tree Group, Barberton, S. Africa: implication to the middle Archean primary producer

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Archean banded iron formations (BIFs) are known to contain extremely small quantity of organic matter. Such rareness makes it difficult to examine the relationship between microbial activities and BIF genesis. Here, we report a discovery of microscopic organic matter in the BIF from the ca. 3.2 Ga Belvue Road Formation, Fig Tree Group, Barberton, South Africa.

Several BIF units were interbedded with clastic sedimentary rocks. Concentrations of Al, K and Ti are, correspondingly, high in the examined BIFs, suggesting BIFs were deposited at relatively shallow ocean environments with high flux of detritus. Oxide layers of examined BIFs were made of hematite, including submicron-sized hematite.

Aggregated organic matter (up to 5 µm in diameter) were found as inclusions of microcrystalline quartz in chert and oxide layers. In-situ Raman spectroscopic and chemical analyses indicate that organic matter were degraded before sedimentation by preferential loss of H and N, and then trapped in quartz during sedimentation. Organic matter were not detected in Fe oxides. The Raman spectroscopicgeothermometer using G- and D-peaks suggests that the examined organic matter were suffered from metamorphism with other minerals (up to 350 °C), supporting syn-sedimentary origin of organic matter. $\delta^{13}C$ values of kerogen from the chert layers ranged from -30.2 to -25.6 (average, -28 ‰), and the oxide layers ranged from -28.7 to -22.9 ‰ (average, -26 ‰). These carbon isotope data are explained by microbial fixation of atmospheric CO_2 by the Calvin-Benson-Bassham cycle in photic zones. The examined organic matter have no spatial association with Fe oxides, and such occurrence with geological circumstances do not support phototrophic Fe-oxidizing bacterial origin of organic matter. Therefore, oxygenic photosynthesizing bacteria were highly likely as primary producers at ca. 3.2 Ga Barberton oceans, and responsible for oxidation of Fe^{2+}.