# New evidence of biogenic origin of 3.2 Ga banded iron formations at Fig Tree Group, Barberton, S Africa

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The microbial oxidation has been a popular model for the genesis of Precambrian banded iron formations (BIFs). It has been uncertain as to if oxygenic or anoxygenic photosynthesizing bacteria were responsible for the oxidation of $Fe^{2+}$ in Archean oceans. Currently, non-biological origin of BIFs has been proposed, expanding the possibilities of BIF's genetic models. Most Archean BIFs do not contain organic matter (OM). This makes it difficult to evaluate the biogenic or non-biogenic origin of BIFs. Here we report the discovery of OM in the ca. 3.2 Ga BIFs from Fig Tree Group (FT BIFs) in Barberton. The detailed study on such organic matter will constrain the contemporary microbial activities during BIFs deposition.
Examined $Al_2O_3$ concentrations in FT BIFs were relatively high compared to Archean BIFs, ranging from 0.2 to 3.4 wt% (N=37). Ti and Zr concentrations are high and correlated with those of $Al_2O_3$. Those chemical characteristics and geological constraints indicate the shallow depositional environments of examined BIFs where the input flux of detrital materials was high.
Iron layers in FT BIFs are dominated by hematite (up to 100 $\mu$m in diameter) and microcrystalline quartz. Fine particles of OM, approximately 1-micron meter in diameter, were discovered in the microcrystalline quartz of iron layer. Such OM particles are commonly found in several iron layers of examined BIFs. The homogeneous metamorphic temperature up to 350 ˚C was estimated by the Raman spectroscopic analyses on those OM, consistent with lower-green schist phases suggested from other mineral assemblages. These results suggest that those OM were syn-depositional with BIFs, and most likely represent the OM of primary producers in shallow photic zones. The $\delta^{13}C$(kerogen) values of FT BIFs samples were -30.2 to -22.9 ‰(VPDB) (N=30). The $\delta^{15}N$(kerogen) values of those were -8.1 to -1.8 ‰ (AIR) (N=5). It is found that the $\delta^{13}C$(kerogen) values are correlated with the $\delta^{15}N$(kerogen) values ($R^2$ =0.79).
Both $\delta^{13}C$ and $\delta^{15}N$ values of OM in FT BIFs showed the excursions. Such excursion was most likely caused by switching nutrient reservoirs from deep water column reservoirs to shallow reservoirs for microbial carbon and nitrogen fixation. In particular, the deep reservoirs contained $^{12}C$-enriched $HCO_3^-$ and $^{14}N$-enriched $NH_3$, yielding light $\delta^{13}C$ and $\delta^{15}N$ values of OM. Such deep reservoirs only can be formed by degradation of OM supplied from surface photic zones where photosynthesizing bacteria were acting as the primary producer. There was no correlative occurrence of Fe oxides and OM suggesting that OM in shallow reservoirs were not derived from anoxygenic Fe-oxidizing bacteria. Therefore, FT BIFs were considered to be formed by oxidation of ferrous iron reactions with free oxygen produced during oxygenic photosynthetic bacteria. Our results provide a new evidence of the biogenic origin of middle Archean BIFs, and oxygenic photosynthesizing bacteria that were responsible for the oxidation of $Fe^{2+}$. This conclusion is not consistent with the currently popular non-biogenic BIF genesis models.

Keywords: Banded Iron Formations (BIFs), Barberton, Archean, Organic matter