

## Manganese and ferrous iron oxide inclusions in stromatolites from the 3.0 Ga Steep Rock Group Ontario, Canada

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How and when the early oceans of the Earth became oxygenated has been debated vigorously. The history of ocean oxygenation is strongly linked to antiquity of aerobic microorganism. Lipid biomarker studies suggest the existence of cyanobacteria, oxygen-producing photosynthesizing microorganism, as early as 2.7 Ga. On the other hand, no clear evidence for oxygenated microorganism has shown before 2.7 Ga.

Steep Rock Group of northwest Ontario is situated in the Wabigoon Subprovince of the Superior Province, Canada. The Steep Rock Group includes an assemblages of intrusive igneous rocks and sedimentary rocks, comprises five formations: Wagita formation (clastics), Mosher Carbonate, Jolliffe Ore Zone, Dismal Ashrock, and Witch Bay Formation (metavolcanic). Six Zircons from the basal fluvial Wagita Formation gave ages of approximately 2999 Ma (D. Davis, pers. comm. cited in Fralick and King, 1996). Mosher Carbonate contains diverse stromatolites morphologies.

The elemental distribution patterns of stromatolite samples were examined by electron microprobe and X-ray scanning microprobe analysis. Stromatolite samples consist mainly of carbonate minerals; calcite and dolomite but no rhodochrosites ( $\text{MnCO}_3$ ) and siderites ( $\text{FeCO}_3$ ). Manganese and ferrous iron oxide inclusions (5 to 30 micrometer in diameter) were found in organic matters in the stromatolite. This shows shallow ocean, stromatolite formed in, was oxygenated environment.

Raman spectra of organic matters show two absorbed bands. One is at 1600 to 1610  $\text{cm}^{-1}$ , is characteristic of well-crystallized carbonaceous material like graphite. Another is at 1300 to 1350  $\text{cm}^{-1}$ , representing existence of less well-crystallized carbonaceous material. This spectrum is corresponding to that of kerogen. Concentrations of total organic matter in stromatolite samples are ranging from 0.00 to 0.39 wt % C (19 samples analysis). Their carbon isotope compositions are ranging from -26.1 to -23.5 per mil (7 analysis). Carbon isotope compositions of organic matter in stromatolite are lighter than by about 25 per mil compare to carbonate minerals in the same samples (-1.7 to 2.1 per mil: 13 analysis). These carbon isotope fractionations are typical kinetic isotope fractionations by cyanobacteria. In addition, carbon isotope compositions of 3.0 Ga stromatolites are identical modern carbonate, suggesting that the carbon isotope composition of atmospheric  $\text{CO}_2$  was also similar to modern counterparts. Accompanied with mineralogy, the above geological date support that stromatolites in Steep Rock Group were formed by cyanobacteria.