Late Archean Diversity of Microorganisms: Evidence from Carbon Isotopic Analyses

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The timing of the emergence and prosperity of oxygenic photosynthetic organisms, and formation of community of oxygenic and oxygen-trophic organisms is still controversial. However, it is one of the key issues of the evolution of the biosphere in early Earth. Presence of stromatolite over the world (Buick, 1992; Holland, 1994) and mass deposition of banded iron formation from 2.8 to 2.5 Ga (Cloud, 1973) indicate emergence of oxygenic photosynthesis and oxygenation of seawater in the late Archean. In addition, c.a. 2.7 Ga sedimentary rocks exhibits a negative anomaly in carbon isotope ratios ($d^{13}C$) up to -60 permil(Hayes, 1994; Schidlowski et al., 1983; Schoell and Wellmer, 1981), suggesting presence of an aerobic environment and the symbiosis of methanotrophic and methanogenic bacteria in the ancient sea. However, the detailed occurrence of the symbiosis and its timing are sill ambiguous.

Sakurai (2003) carried out carbon isotope analyses of organic materials in 37 samples of the Fortescue Group in Redmont area, Western Australia and found a large negative anomaly of -51 permil in the upper part of the Mingah Tuff Member of Tumbiana Formation.

We analyzed carbon isotopic compositions of 60 samples in the Mingah Tuff and Meentheena Carbonate Members of Tumbiana Formation, in order to reconstruct more detailed secular change of organic carbon isotope ratios, especially from mudstones, sandstones and stromatolites, and to determine the occurrence of the organic carbons with the large negative anomaly of carbon isotopes. The detailed chemostratigraphy shows the small variation of the $d^{13}C$ around the member boundary. The relationship between $d^{13}C$ and TOC is different in their lithologies, and shows that $d^{13}C$ of mudstones are lighter than those of sandstones. The difference can be explained by the mixing of organic carbons from two sources with their different isotopic values and contents, supporting two components model and the emergence of methanotrophic bacteria before the significant deposition of thick stromatolite carbonate of the Tumbiana Formation (Sakurai, 2003).