Redox conditions and the corresponded microbial activity in Paleoproterozoic sea recorded in the 2.0 Ga Gunflint Formation, Canada

Akizumi Ishida[1]; Takeshi Kakegawa[2]

[1] Inst. Min. Pet. Econ. Geol. Tohoku Univ.; [2] IMPE., Tohoku Univ.

The age of ca. 2.0 Ga has been considered by previous investigators as an important age for rise of atmospheric oxygen. The atmospheric rise of oxygen was connected to the oxidation of early oceans and catastrophic for many anaerobic microbial life forms. Such anaerobic microbes would have 'isolated' in deeper parts of anoxic sea or sediments during the oxidation of the early oceans, creating more complicated ecosystem in the same sedimentary basin.

Geological survey was conducted at the Gunflint and the Rove Formations in Ontario, Canada during summer of 2006. Sedimentary rocks, probably representing shallow to hemi-pelagic environments, from Gunflint Formation were collected together with sedimentary rocks of Rove Formation, represented deeper marine environments. Almost all of Gunflint Formation samples contain oolite and mainly consisted of carbonates. Samples of Rove Formation were typical black shale.

In addition to geological survey, detailed petrographic and electron microprobe analysis were performed to identify constituent minerals and elemental distributions in thin section scale. Total organic carbon and sulfur concentrations of 55 samples were determined. Kerogen was extracted from 22 samples for further compositional and isotope studies.

It is found that S(py)/C(org) ratios of the Gunflint Formation are similar to modern marine sediments, suggesting that sulfate-reducing bacteria were active in the Gunflint sedimentary environment. In addition, different morphology of pyrite was found in the Gunflint samples. A framboidal-like pyrite, one of the minor morphology, has a characteristic of As enrichment. Majority of other type of pyrite did not contain As. Such contrast in As concentrations suggest the different origin of pyrite, probably syngenetic and diagenetic origins. The local enrichment of phosphate is also found in the Gunflint carbonate samples. High productivity of microbes followed by high sedimentation rates may have a responsibility for the phosphorous enrichment. The above phenomena are explained by the high microbial activities at the redox boundary of the shallow Gunflint sea.

The results of kerogen analysis indicate that difference in N concentrations. Such N concentrations may be reflecting aerobic N2-fixiation or anaerobic N2-fixiation. Stable carbon isotope compositions (d13C) of kerogen were ranging from -33.6 permil to -31.4 permil.d13C vs. H/C ratio diagram suggests that kerogen suffered from the composite diagenetic effects. Simulating the several models using the Rayleigh distillation equation, the following possibilities are suggested: (1) initial kerogen (when H/C ratio was ˜1.5) have had already variety of d13C values and had same diagenetic process, or (2) that initial kerogen have had same d13C and had different diagenetic process (for example petroleumgenetic or metanogenetic). All of above data suggest the existence of the aerobic-anaerobic microbial complex in the Gunflint sedimentary basin.