The early biosphere in Marble Bar Chart, Pilbara, Western Australia

Masamichi Hoashi[1]; Aya Yamaguchi[2]; Munetomo Nedachi[3]; Hiroshi Naraoka[4]; Yusuke Suganuma[5]; Kazue Tazaki[6]; Hiroshi Ohmoto[7]

[1] Nature System Sci., Kagoshima Univ; [2] Fac. Sci., Kagoshima Univ.; [3] Space Sci., Kagoshima Univ.; [4] Dept. of Earth Sci. Okayama Univ.; [5] AIST; [6] Dept. Earth Sci., Kanazawa Univ.; [7] PSARC,Penn State

The Marble Bar Chert contains abundant hematite-rich bands, and has been interpreted that the hematite was produced by modern weathering. On the other hand, some geologists have pointed the bio-oxidation should be considered. To understand the contribution of bioactivity to precipitation of the iron oxides in Marble Bar Chert, we have examined mineral assemblage, texture and the existence of organic carbon in ferruginous band. Further, to consider biological activity of 3.5Ga we have measured carbon isotope ratios of organic carbon and extracted hydrocarbon in fresh core which obtains by Archean Biosphere Drilling Project (ABDP).

The ABDP core of the Marble Bar Chert is composed of carbon-rich black (banded and massive) chert, silicified white chert, and ferruginous banded chert in order of sedimentation. As a whole, banded cherts are chemical precipitations in situ, and massive ones are of hydrothermal. Ferruginous banded chert consisted of white, red and black band. Only the ferruginous banded chert has high magnetic susceptibility by numerous hematite and magnetite grains. Euhedral grains of pyrite of micron size are observed in the ferruginous bands as well as in hydrothermal veins. This texture suggests that the pyrite in the ferruginous banded chert is of syngenetic. Red bands in the ferruginous banded chert contain numerous hematite grains, which are accumulated as spherical grains of about 100 nm in diameter to euhedral grains up to 500 nm in quartz with the size of 10-30 micrometer in diameter. The quartz with hematite grains shows botryoidal texture. Black bands also contain numerous euhedral magnetite grains of about 1 micrometer in diameter, and the occurrence is similar to that of red bands. These botryoidal textures resemble that of modern bacterial mat of benthic coccoid cyanobacteria.

SEM images show bacteria-like cells connecting with and enveloping hematite grains in the botryoidal quartz. The intensity of cathodoluminescence from the botryoidal quartz is heterogeneous, and its two-dimensional image shows bacteria-like texture. The X-ray photoelectron spectra from ferruginous banded cherts contain a peak at about 285 eV, suggesting C-C and C-H bonding. Furthermore, the Raman spectrum from this chert exhibits the peaks at about 1300cm-1 and 1600cm-1. The Raman scanning image reveals that the organic carbon is closely associated to iron oxides. Carbon isotope ratio ranges from -21 to -28 permil. All data suggest that the carbon is of organic, and bio-activity is closely related to iron precipitation.

We also examined the organic carbon from iron free cherts; banded black chert and massive black chert. They show the range of -27 to -23 permil and -33 to -23 permil, respectively. The rather wide isotopic ratios of the massive black chert suggest that this chert contains the fragments of banded black chert, as well as organic carbon from different organisms. Additionally, we extracted hydrocarbons from these cherts, and identified by GC/MS. Hydrocarbons compose mainly of n-alkane of the range of n-C11 to n-C21 with a peak at n-C16. This composition differs from drilling contaminant such as libricant and modern organisms, and is derived from the organism in situ. Further identification needs for our extracted biomarker.

As a conclusion, the occurrences of mineral and organic carbon suggest that the ferruginous banded cherts have not been affected by hydrothermal alteration, metamorphism or modern weathering, but suggest that the original texture has remained unchanged. The occurrences suggest further that the precipitation of iron oxides was related with bioactivity. The isotopic ratios suggest the existence of photosynthetic bacteria in banded black chert, methanogen in massive black chert, and photosynthetic iron oxidizing bacteria in ferruginous banded chert.