Carbon isotope of Archean organic matter (3.46-2.76 Ga) from six drilling cores at Pilbara Craton, Western Australia

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Archean biological activities have played an important role for the evolution of the surface environment, and there are still many arguments on the evolution of Archean life and environment. We determined carbon isotopic compositions of the Archean clastic sediments and volcanics (3.46-2.76Ga) from six drilling cores at the Pilbara craton, Western Australia to consider the evolution of life and environment. The results are as follows.

The isotopic composition of organic carbon from 3.46Ga to 2.9Ga decreases from -26.1 to -31.9permil with much less variation, suggesting normal photosynthesis by algae and/or cyanobacteria. At the 2.77Ga black shale interbedded in Mount Roe basalt, organic matter is extremely 13C-depleted (-49.6 permil), suggesting abundant methane assimilation. At the 2.76Ga Hardey formation, carbon isotopic composition gradually recovers to normal photosynthesis. However, these data should be evaluated from various aspects such as alteration of isotopic ratios by metamorphism, hydrothermal alteration and modern weathering.

The isotopic compositions of the clastic sediments (shale, sandstone and conglomerate) in Mount Roe Basalt, collected from surface, are from -45.7 to -26.3permil with an average of -39.4permil with standard deviation of 4.3permil (N=20), which are much heavier than those from un-weathered core, suggesting extremely 12C-depletion during weathering. On the other hand, the pyroclastic rocks from Salgash contain numerous fragments of black shale, of which the isotopic compositions are heavier than those of the overlying black shale, suggesting the thermal effect to deplete the 12C.

Pilbara Craton has been affected by 2.1Ga metamorphism of prehnite-pumpellyite facies to green schist facies. As the P-T condition can not be determined accurately from ordinal mineral assemblage, however, we evaluate the P-T conditions, using sphalerite geobarometer, fluid inclusion and rock magnetism. Zinc and other transition metals are generally dominant in the Aechean rocks, and sphalerite is often observed as segregation, dissemination and hydrothermal precipitation in the core. We applied the geothermometer by Lusk et al. (1993) to sphalerite buffered by pyrite and pyrrhote. The FeS contents of sphalerite from the Salgash segregation veins are almost constant for whole the core, and the FeS content suggests about 6.5Kb and 180 to 250 degree centigrade from filling temperature. Mount Roe Basalt contains also sphalerite coexisting with pyrite and pyrrhotite. The FeS content is also uniform, and suggests less pressure than that of Salgash, if the temperature is assumed from the fluid inclusion. Contrast to the Salgash sphalerite, as the sphalerite in Mount Roe Basalt is disseminated or occurs in hydrothermal veins, the estimated temperature might not be suitable to be applied.

The remanent magnetization of volcanics and sediments in Pilbara Craton preserves the primary and secondary components, and various experiments suggest that the secondary components were added at the 2.1 Ga metamorphic stage. Thermal demagnetization suggests that the secondary components were attached at 150 to 250 degree centigrade on the Mount Roe Basalt and at 200 to 300 degree on the Marble Bar Chert which is near the Salgash. Hence, it is suggested that the rather highly metamorphosed rock preserved the heavier carbon isotopic composition. The carbon isotopic compositions of rather older formation might be lighter than measured values. If so, the biota with much lighter carbon such as methanotroph might be more predominant in the early Archean Era.

The variation width of isotopic compositions in each drilling site has an important information, suggesting the variety of bio-activity. The wide variation since 2.8Ga suggest the increase of the kinds of organisms.