Geological and geochemical study of organic-rich sedimentary rocks in the Matachewan area, Abitibi Greenstone Belt, Canada (2.7 Ga)

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Late Archean biosphere are believed to be formed by complex of photosynthesizing and chemoautotrophic microorganisms. On the other hand, it has been uncertain as to which microorganisms were the major primary producers in the late Archean age. Therefore, geological and geochemical studies were carried out on 2.7 Ga organic-rich sedimentary rocks from the Matachewan area of the Abitibi Greenstone Belt, Canada to constrain the above problem.
Geological survey in the studied area revealed the presence of sandstone/shale sequence and hydrothermal sulfide-rich shale/chert sequence, respectively. The sandstone/shale sequence mainly made of clastic components with occurrence of a granular sedimentary organic matter. The sulfide-rich shale/chert sequence are rich in hydrothermal pyrite and silica with abundant organic matter. The sulfide-rich shale/chert sequence underlain by pillow lavas. Significant amounts of hydrothermal chert/carbonate veins developed in pillow lavas, associated with various sulfides, such as pyrite and chalcopyrite. Bulk Cu concentrations of these rocks are found to be very high near the pale-surface of pillow lavas. This suggests that rapid cooling of submarine hydrothermal fluids near the surface of pillow lavas resulting preferential precipitation of chalcopyrite in the vein. This further suggests that the hydrothermally altered pillow lava locality was the venting site. It is found in the present study that hydrothermal veins in pillow lavas contain significant amounts of organic matter. This indicates the incorporation and circulation of sedimentary organic matter in submarine hydrothermal systems.
The carbon stable isotopic composition of organic matter ($\delta^{13}C_{org}$) in the sandstone-shale sequence, -29‰ (PDB), and the depositional environment indicate that photosynthetic microbial organic matter is preserved in this sedimentary rock. The $\delta^{13}C_{org}$ values in the sulfide-rich shale/chert sequence are ranging from -32 to -17‰ (PDB). The $\delta^{13}C_{org}$ value of -32‰, which is thought to be the least pyrolytically decomposed, were not significantly different from those in the sandstone-shale alternation. The $\delta^{13}C_{org}$ values in pillow lavas show slightly heavier values, suggest loss of isotopically light carbon during early diagenesis. This indicates that the thermogenic methane production in the hydrothermal systems. All results suggest that (1) deposition of organic matter derived from photosynthetic bacteria, (2) there recycling by hydrothermal activity, and (3) possible methane production by thermal decomposition of organic matter. In other words, the methane supply that supported the chemosynthetic bacteria at that time was probably caused by the cycle of photosynthetic bacteria-derived organic matter. This close relationship between chemosynthetic bacteria and photosynthetic bacteria is a major characteristic of this study area.

