

Geochemical study on the sulfide and organic matter at the Potterdoal deposit in Abitibi Greenstone Belt in Canada

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The early Archean seafloor hydrothermal vents are often considered as a cradle of early life [1]. The seafloor hydrothermal activities, in particular, became intensive at ca. 2.7 Ga and they formed volcanogenic massive sulfide (VMS) deposits, possibly containing organic matter [2]. However, it is poorly constrained that what was the original source of hydrothermal sulfur to form VMSs in ca. 2.7 Ga and whether the organic matter was originated by chemoautotrophs around hydrothermal vents or by the other possibility. Although the high activity of methane-oxidizing bacteria has been proposed in ca. 2.7 Ga oceans [3], ambiguity still have existed for production of methane in the ocean at that time. To reveal the biosphere and hydrosphere associated with the hydrothermal activity at that time, geological survey was conducted on the Munro township area located in the 2.7 Ga Abitibi Greenstone Belt in Canada. It hosts Potter and Potterdoal VMS deposits. The purposes of the present study are (1) to reconstruct ore forming processes and the source of sulfur at the Potterdoal deposit; (2) to constrain the microbial activity in relation to the ambient ocean water and hydrothermal activities at the Potterdoal deposit; (3) to propose the generalized microbial activities in the entire area of 2.7 Ga Munro oceans in comparison to our previous geochemical data from the Potter deposit.

At the Potterdoal VMS deposit, massive sulfides were dominantly composed of CuFeS_2 , ZnS and FeS_2 . Massive sulfides showed layered structures suggesting that sulfide precipitation on the ocean floor. Chemical compositions of ZnS suggest that all sulfides were precipitated at constant f_{S_2} conditions (around 10^{-10}) under thermodynamically equilibrium conditions. Chert and sandstone appeared in the distal area from VMSs and those sedimentary rocks were often brecciated by veining by of the hydrothermal fluids following VMS. The sulfur isotope composition ($d^{34}\text{S}$) values of the bulk VMSs ranged from -0.1 to +2.0 ‰(CDT) and those values of pyrite in chert and sandstone were from +5.0 to +6.9 ‰(CDT). So total variation of $d^{34}\text{S}$ values was 7 ‰ and this range suggests the sulfur source of VMSs was seawater sulfate. Since $d^{34}\text{S}$ values of sulfate cannot be lower than those of pyrite, they were at least larger than +6.9 ‰(CDT) at that time.

The organic carbon concentration of examined bulk samples were 0.0 to 0.5 wt. %C for VMSs, and 0.2 to 1.0 wt. %C for sedimentary rocks, respectively. Raman spectroscopic analyses on isolated kerogen from VMSs and sedimentary rocks showed constant metamorphic grades of all samples and the thermal alteration temperature was estimated as 291 ± 30 °C based on the full widths of half maximum of the D1 band in the Raman spectra of kerogen from VMSs, which indicates less altered features for the Archean rocks.

The carbon isotope composition of organic matter ($d^{13}\text{C}_{\text{org}}$) values of all Potterdoal samples ranged from -43.1 to -31.8 ‰(PDB). Those values suggest the presence of methanotrophs in the ambient ocean water. $d^{13}\text{C}_{\text{org}}$ values of Potter samples ranged from -48.6 to -39.6 ‰(PDB), which are lower and relatively constant than those of Potterdoal samples.

The estimated total mass of VMS at the Potter deposit is about three times as large as the Potterdoal deposit [4]. This probably suggests that a larger hydrothermal system existed at the Potter site. Such

difference may have affected thermal degradation of organic matter at both sites. The organic matter at the Potter site suffered additional degradation by thermal decomposition of it, producing more methane to the ocean than the Potterdoal site. Such process may have promoted activities of methanotrophs resulting more ^{12}C -rich feature of organic matter at Potter samples.

References

[1]Baross and Hoffman, 1985, *Origins of Life and Evolution of the Biosphere*, [2]Bekker et al., 2010, *Economic Geology*, [3]Hayes et al., 1994, *Early Life on Earth*, [4]Epp, 1997, *unpublished MSc thesis, McMaster University*.

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