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Relationship between origin and evolution of life and deep carbon cycle

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Presence of life cannot be ignored when evolution of deep carbon cycle is considered. Two examples are shown in this presentation to demonstrate how life affected or was affected by deep carbon cycle in Hadean and Archean ages. During Hadean age, significant amounts of pre-biotic organic molecules were produced on the Earth surface, although origin of pre-biotic organics is still debated. Shock-recovery experiments were performed by our group in order to examine how to prepare pre-biotic organic molecules on the early Earth. In this experiment, Hadean oceanic impact events were assumed and experiments were performed under aquatic conditions. Results indicate that important pre-biotic molecules, including an amino acid, were produced by series of shock experiments (Furukawa et al., 2009, Nature Geosciences). Carbons in meteorites and/or atmospheric CO2 were carbon sources of organic molecules in this shock experiments. Estimation of total mass of organic molecules produced by impact events indicates the almost the same amounts of present biomass. Thus, the fresh pre-biotic organic molecules cannot be ignored for Hadean carbon cycles. A part of pre-biotic organic molecules were used for the chemical evolution of origin of life, and the rests must have been brought to mantle and/or core. If this was the case, pre-biotic carbon probably contributed as an important source of the late Hadean deep carbon.

Deep carbon in mantle and/or core was most likely returned to the surface. Such recycled carbon may have been affected to Archean biological activities. Organic carbon with extremely 12C-depleted feature is present in ca. 3.4 to 2.7 Ga sedimentary rocks. Significant activities of CH4-producing and -consuming bacteria were responsible for 12C-enriched organic carbon. Previous investigators considered that enhanced activities of CH4-producing bacteria between 3.4 to 2.7 Ga were responsible for 12C-enriched features. Alternative idea is possible if recycling of deep carbon is considered: recycled deep carbon could produce CH4 by interacting with hydrogen through submarine hydrothermal processes, and this CH4 was used for CH4-consuming bacteria rather than CH4-producing bacteria. This idea is supported by synchronized features between mantle-plume-like volcanic activities and occurrence of 12C-denriched organic matter. In other words, extreme depletion of 12C-enriched organic matter in Archean sedimentary rocks could be a signal of recycled deep carbon.

Keywords: origin of life, shock, methane, Archean