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生命惑星の地球化学
Biogeochemistry of life-inhabited planets: Lessons from Early Earth

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Among planets so far we know, only the Earth is known to harbor life. Therefore, environmental condition of early Earth must have been essential for origin of life as well as for subsequent evolution of biosphere. Chemistry of the early atmosphere and ocean is still largely uncertain, though recent geochemical investigations allow us to understand redox state of the early Earth. The anomalous isotopic ratio (S-MIF) recorded in sedimentary rocks only before 2.3 billion years ago indicate that the pre-2.3 Ga atmosphere was virtually devoid of molecular oxygen (Farquhar et al., 2000). Photolysis of SO2 in an O2-poor atmosphere has been the only known process that produces the large sulfur isotopic anomaly. Atmospheric model calculation has indicated that a reducing atmosphere (pO2 $<$1 ppm) is required for preserving the atmospheric isotopic anomaly into geological record, otherwise all the atmospheric sulfur species can be oxidized into sulfate before deposition and thus erase the isotopic anomaly (Pavlov and Kasting, 2002). Based on isotopic fractionation factors determined by a series of our laboratory experiments, we have suggested that the preservation of the S isotopic anomaly requires low CO2 well below 1 bar, instead including other reducing gasses like H2, CH4 or CO (Danielache et al., 2008; 2012; Ueno et al., 2009; in press). In such a reducing atmosphere, photochemistry should have been an important source of simple organic compounds like aldehydes and carboxylic acids that can drive prebiotic synthesis. The organic species and their flux are changed by redox condition of the system. The presence of ocean together with its reducing capacity from dissolved ferrous iron may have played a key role for chemical evolution before origin of life.