Experimental investigation on geo- & biochemical interactions among ultramafic rocks, hydrothermal solution, H2 and primitive life

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We propose a hypothesis that Ultra-H3 (Ultramafic rock, Hydrothermal activity, Hydrogen, and Hyper SLiME) linkage was responsible for the development of primitive life on the early Earth (for additional information on this hypothesis, see an abstract of Takai et al. in this session). HyperSLiME represents hyperthermophilic subsurface lithoautotrophic microbial ecosystem dominated by hyperthermophilic methanogens beneath an active deep-sea hydrothermal field. This ecosystem is driven by hydrogen which is possibly generated from hydrothermal reaction between ultramafic rocks and/or gabbros and seawater at high temperature. The important and unique property of HyperSLiME is that it is based on chemolithoautotrophic primary producers utilizing completely photosynthesis-independent energy generation and carbon sources. These facts described above lead us to propose that Ultra-H3 linkage is a key to understanding the first sustainable ecosystem as well as the origin of life on the early Earth.

In order to establish Ultra-H3 linkage hypothesis, we plan experimental investigations of hydrothermal reactions among hydrothermal solution, ultramafic rocks, and microorganisms related to HyperSLiME. The hydrothermal experiments will be performed to resolve the following issues: 1) relationships between HyperSLiME activity and hydrogen concentration of hydrothermal fluid, 2) hydrothermal hydrogen-generation under the specific condition of the early Earth (e.g., low-O2, low-SO4, high-CO2, low-pH, and komatiitic rocks), and 3) probability of formation of organic compounds such as amino acids that are essential to cellular life during the hydrothermal reaction. High-temperature and high-pressure (up to 120oC/600bar) microbial culture apparatus will be employed for the incubation experiments related to the issue 1. Experiments in water-rock interaction (temperatures and pressures up to 600oC and 500bar) for the issues 2 and 3 will be conducted using newly designed hydrothermal apparatus with both flexible reaction-cell and fluid-flow systems. For better understanding of the reaction processes, we are establishing systems of direct analysis of gasses in hydrothermal solutions through tandem-gas chromatography and trace element analysis of ultramafic and mafic rocks through ICP-MS equipped with a collision cell. In our poster contribution, we will discuss our experimental strategies and the details of our facilities and methods for these laboratory experiments.