Abiotic nitrate reduction in hydrothermal environments and nitrogen cycle in early earth

*Manabu Nishizawa[1], Takuya Saito[1], Akiko Makabe[1], Takazo Shibuya[1], Ken Takai[1]

1. Japan Agency for Marine-Earth Science and Technology

Nitrogen is an essential element for life as a major component of biomolecules and a substance for energy metabolism. Currently, nitrogen cycle in surface environments is mainly driven by biological processes including nitrogen fixation, nitrification and denitrification. In contrast, little is known about nitrogen cycle in the pre-biotic Earth and its relation to chemical evolution. This study focuses on nitrate chemistry during water-rock interaction in deep-sea hydrothermal environments to understand the fate of atmospherically-derived nitrate in the Hadean ocean. In this study, artificial seawater with nitrate was reacted with synthetic komatiite at i) 250°C and 500 bar or ii) 350°C and 500 bar, using a closed system hydrothermal reactor reaction cell. To unravel the pathway and kinetics of nitrate reduction, time course measurements of chemical and nitrogen isotopic composition of fluid samples were conducted during the ongoing experiments. Our experiments show multi-step reduction of nitrate to ammonium and dinitrogen and temperature-dependence on the molar ratio of final products (NH_4^+/N_2). The experimental results imply that the Hadean deep-sea hydrothermal vents may have been favorable for chemical evolution in that both electron acceptor for energy metabolism (nitrate) and reduced nitrogen for organic synthesis (ammonium) were continuously supplied to the hydrothermal fluid-seawater mixing zone.

Keywords: Nitrogen, pre-biotic earth

