Report for the Joint Use/Research of the Institute for Planetary Materials, Okayama University for FY2024

05/14/2025

Category: ☑International Joint Research ☐General Joint Research ☐Joint Use of Facility ☐Workshop

Name of the research project: Biogenicity and preservation of trace metals in hot spring deposits: preparing for a Mars sample return mission

Principal applicant: Michael Rowe

Affiliated institution and department: University of Auckland, School of Environment

Collaborator

Name: Tak Kunihiro, Tsutomu Ota, Ryoji Tanaka

Affiliated institution and department: Institute for Planetary Materials, Okayama University

Research report:

Purpose

This research is to conduct isotopic analyses on hot spring silica samples to understand the potential bio-utilisation of trace metals. This specific application seeks to examine hot spring sinter deposits. The overarching outcome of this collaboration between Kunihiro, Ota, Tanaka, and Rowe is to identify geochemical tracers of microbial activity that may be implemented on samples returned from Mars for the identification of potential evidence of ancient of life. Specifically, this project aims to examine the extent to which gallium isotopes are biologically fractionated in hot spring/geothermal environments.

Conducted Research and Outcomes

The research was conducted remotely during 2025/02/25—2025/02/28. On this project, we plan to determine Ga isotopic analyses of silica sample in two different techniques. One approach is whole-rock precise isotope determination using ICP-MS and the other approach is in-situ isotope determination using SIMS. For the latter technique, standardization is necessary. After the remote discussions, we decided to synthesize glasses by dissolving hot spring silica samples with significant Ga, and determine their Ga isotope composition the glass using ICP-MS. During the research period, we initiated attempts to synthesize such reference materials. We tried to dissolve four hot spring silica samples with significant Ga in an open furnace; however, we failed to dissolve the glass fully because of purity of the samples. After the trial, we found that addition of a chemical flux is necessary to dissolve the silica sample and synthesize the reference materials. We continue to synthesize the reference materials.

In addition, over the course of the year we wrote a successful collaborative funding proposal to the New Zealand government (Marsden Fund) supported by the preliminary outcomes from our joint research.

"Gallium as a new indicator of biogenic processes in geologic materials" (Rowe PI)
New Zealand Marsden Fund. (2025-2028).

Proposal summary:
Trace metal biosignatures may be one of our best chances of finding evidence of ancient life on early Earth and elsewhere in the Solar System, such as Mars, where conditions favoured habitats for extremophiles >3.5 billion years ago. Gallium is an exciting new, and potentially robust tracer of microbial activity due to its potential substitution for Fe^{3+} in microbial processes. Pilot work reveals gallium association with microbes in terrestrial hot springs, but the how and why remains a mystery. Thus, gallium isotopes and chemical bonding will be measured in microbes preserved in hot spring silica using state-of-the-art instruments and new methodologies to determine why this biosignature exists. Microbial growth experiments will determine how widespread, and under what conditions gallium enrichments occur and therefore the breadth of application of this new biosignature. This integrated approach also has potential further application to medical and bioremediation industries, where gallium serves as an antibacterial agent and a bioleachate, respectively. Postgraduate students will train with international collaborators to bring advanced techniques and knowledge to NZ, while engagement activities with Rotorua school teachers will help inspire 'next-gen' scientists. Our international team has a proven track record of excellence, developing the tools necessary for research success.