Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.30980

Speciation of trace elements (Mn, Ni, Cu, and Zn) in C-type asteroid Ryugu related to their aqueous concentrations and the effect on the evolution of organic matters

AYU TAKEMOTO[1], TAKAHIRO KAWAI[1], TOMOHIRO OHNO[1], AKIKO YAMAGUCHI[2] AND YOSHIO TAKAHASHI[1]

[1]The University of Tokyo
[2]Japan Atomic Energy Agency

We investigate affinities of transition metals (TM: Mn, Ni, Cu, and Zn) for their possible host minerals (pyrrhotite and saponite) under euxinic conditions, which control TMs' distribution mechanisms via water-mineral interactions. Based on the results, the potential catalytic role of TMs in organic chemical reactions, particularly the Formose reaction, was discussed. To achieve this, we utilized XAFS analysis for the speciation of these elements in Ryugu, adsorption experiments, and Formose reactions. Our study is based on the analysis of Ryugu samples, which were returned by Japanese asteroid probe *Hatabusa-2*. Ryugu is an ideal sample for this study as the sample was not affected by any secondary alteration, preserving the information of aqueous alteration in its parent body. Initially, we conducted Ni-K edge bulk XANES measurements on Ryugu particles (A0477), which results indicate that Ni in Ryugu consists of (i) 90% of Ni incorporated into pyrrhotite and (ii) 10% of Ni adsorbed on saponite. Additionally, EXAFS revealed that Ni-S interatomic distance of 2.306 Å is closer to that of Fe-S in pyrrhotite (2.387 Å; Tokanami et al., 1952) rather than that of NiS. This suggests that TMs, including Ni, substitute for Fe in the pyrrhotite structure. In addition, Ni concentrations in pyrrhotite and saponite in Ryugu were determined by micro-XRF analyses. To further investigate the distribution of Ni in water in Ryugu, adsorption experiments were conducted to determine distribution coefficient (K_d) was defined as K_d (L/kg) = $[Ni^{2+}]$ / [Ni in mineral]. Based on the Ni concentrations in each mineral and K_d, we can estimate $[Ni^{2+}]$ from two minerals as follows:

- For pyrrhotite: $K_d = 2.4 \times 10^4$ L/kg, leading to $[Ni^{2+}]$ = 6.3 umol/L.
- For saponite: K_d = 134 L/kg, leading to $[Ni^{2+}]$ = 653 umol/L.

Based on these findings, $[Ni^{2+}]$ estimated in Ryugu are reasonable. Additionally, EXAFS analysis indicates that Ni was incorporated as solid solutions within pyrrhotite. The same methodology was extended to other TMs in this study. Based on the results, catalytic efficiency of these TMs during the progress of prebiotic organic synthesis such as Formose reaction (Ono et al., 2024) will be discussed.