Rare earth element behavior in subduction-zone fluids: the effect of T and ligands

ALEXANDRA TSAY[1], ZOLTAN ZAJACZ[1]
AND CARMEN SANCHEZ-VALLE[1]

[1]IGP, ETH Zürich, Switzerland
(*correspondence: alexandra.tsay@erdw.ethz.ch)

Understanding of rare earth element (*REE*) systematics has a broad application for subduction-zone processes. Particularly, arc-related magmas display a typical trace element abundance spectrum, characterised by the enrichment in light rare-earth element (*LREE: La, Ce, Nd*) and depletion in the heaviest rare earth element (*HREE: Yb, Lu*) relative to *MORB*. This particular geochimical signature may result from the influx of aqueous fluids and/or silicate melts derived from within the slab. Therefore, investigating the behavior of *REE* in fluids at high *P* and *T* conditions is crucial for constraining the composition of slab fluids, as well as for understanding subduction-zone processes in general.

In this study we present new experimental data on *REE* silicate ($REE_2Si_2O_7$) solubility in aqueous quartz-saturated fluids, containing various ligands (F^-, CO_3^{2-}, SO_4^{2-}, Cl^-), and in hydrous haplogranitic melt at conditions relevant for subducting slab (600-800 *°C*, 2.6 *GPa*). The experiments were conducted in an end-loaded piston-cylinder apparatus and the fluids were *in situ* sampled at *P-T* in the form of primary fluid inclusions in quartz. Gold capsules were loaded with a chip of synthetic $(La,Nd,Gd,Dy,Er,Yb)_2Si_2O_7$ – phase, various aqueous solutions (~ 20 *wt.%*) and a piece of natural quartz. In the case of experiments with melt, the capsule was loaded with a piece of $REE_2Si_2O_7$, a synthetic haplogranitic glass and water (~ 15 *wt.%*). Rb and Cs were added to the solutions as internal standards for LA-ICPMS analyses.

The solubility of *REE* in quartz-saturated H_2O, free of additional ligands, increases more than an order of magnitude as temperature is increased from 600 to 800 ºC. Addition of ligands, even in relatively small amounts (0.3-1.5 *m*), promotes *REE* solubility compared to pure H_2O. Each type of ligands leaves a characteristic *REE* pattern, reflecting the preferences of *REE* complexation: *e.g.*, efficient *LREE-Cl* and *HREE-F*, $HREE\text{-}CO_3$ complexation. The solubility of *REE* in the melt is moderate, comparable with the solubilities in pure H_2O.

Our results showed that *REE* can be effectively transported by aqueous fluid and the effect of temperature as well as fluid chemistry play an important role in REE mobility and *LREE*/*HREE* fractionation.

3D shapes of regolith particles: comparison between Itokawa and Moon

A. TSUCHIYAMA[1]*, T. MATSUSHIMA[2],
T. MATSUMOTO[3], T. NAKANO[4], D. AMEMIYA[1],
J. MATSUNO[1], T. NAGANO[3], A. SHIMADA[3],
K. UESUGI[5], A. TAKEUCHI[5], Y. SUZUKI[5]
AND M. OHTAKE[6]

[1]Grad. School of Sci., Kyoto Univ., Kyoto 606-8502, Japan
(*correspondence: atsuchi@kueps.kyoto-u.ac.jp)
[2]Grad. School of Systems and Information Engineering, Univ. of Tsukuba, Tsukuba, Japan
[3]Grad. School of Sci., Osaka Univ., Toyonaka, Japan
[4]AIST/GSJ, Tsukuba, Japan
[5]JARSI/SPring-8, Sayo, Japan
[6]JAXA/ISAS, Sagamihara, Japan

Hayabusa sample analysis elucidated a variety of surface processes on asteroid Itokawa: (1) regolith formation by impact [2], (2) solar wind implantation to uppermost regolith surface [3], (3) space weathering rim formation mainly by solar wind He implantation (~10^3 yr) [4,5], (4) grain abrasion probably by grain motion due to impact-induced seismic waves in a regolith layer (>10^3 yr) [1,2,6], and (5) final escape of particles from the asteroid by impact (<8 Myr) [3].

The grain abrasion was found based on the 3D shapes and surface morphologies of Itokawa samples using x-ray micro-tomography [2] and FE-SEM observation [6]. The 3D shapes of lunar regolith samples were also examine by tomography [7] but not grain-by-grain as performed for the Itokawa samples. In the present study, the 3D shapes of Apollo 16 highland (60501) and Apollo 11 mare (10084) regolith samples were examined by the same method as the Itokawa particles using micro-tomography at SPring-8.

The shape distribution shows that the lunar regolith is more spherical than the impact fragments although lunar regolith is the product of impact on the lunar surface, suggesting that the regolith was abraded. The cause may be grain motion during gardening by impacts. The degree of abrasion is larger than that of the Itokawa particles due to larger scale of impacts and longer regolith residence time.

[1] Tsuchiyama *et al.* (2013) *LPS* **XLIV**, #2169. [2] Tsuchiyama *et al.* (2011) *Science,* **333**, 1125-1128. [3] Nagao *et al.* (2011) *Science,* **333**, 1128-1131. [4] Noguchi *et al.* (2011) *Science,* **333**, 1121-1125. [5] Noguchi *et al.* (2012) *Meteor. & Planet. Sci.,in print.* [6] Matsumoto *et al.* (2013) *LPS* **XLIV**, #1441. [7] Katagiri (2010) *Proc. 12th Internat. Conf. Engin., Sci., Constr., Operat. in Challeng. Environ.*, 254–259.

DOI:10.1180/minmag.2013.077.5.20