Synchrotron Radiation X-Ray Fluorescence Analysis of Aqueous Fluids and High-Magnesian Andesite Melt Under High-Temperature And High-Pressure Conditions

Tatsuhiko Kawamoto[1], Kenji Mibe[2], Ken-ichi Kuroiwa[1], Testu Kogiso[3]

[1]Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, Japan, [2]Earth Research Institute, The University of Tokyo, Japan, [3]Graduate School of Human and Environmental Studies, Kyoto University, Japan

E-mail: kawamoto@bep.vgs.kyoto-u.ac.jp

Silicate melts and aqueous fluids are major fluids in subduction zones. Elemental partition among minerals and these fluids is a key to understand the elemental transfer from subducting slab to mantle wedge [Kawamoto et al. 2012 PNAS].

Synchrotron radiation X-ray fluorescence analysis is conducted to know elemental distribution between aqueous fluids and high magnesian andesite melt under high-temperature and high-pressure (HTHP) conditions. We put Cs, Ba, La, Sm, Gd, Ho, and Yb-doped high-Mg andesite with water or a saline solution and brought it under HPHT conditions. We achieved HTHP conditions with SPEED 1500 Kawai-type large-volume press installed at BL04B1, SPring-8, Japan. Incident X-ray is a white beam with energy ranging from 20 -150 keV. During heating at a given pressure, synchrotron X-ray radiography technique allows us to observe a melt globule surrounded by aqueous fluids through the diamond windows. SR-XRF spectra are collected from the melt globule and the aqueous fluid using an SSD detector.

A series of experiments has been carried out at pressures of 0.5-2.2 GPa. The spectra show characteristic X-ray peaks of the doped elements superimposed on a continuous X-ray background. At 1 GPa, no characteristic X-ray peak from any doped element is observed in Cl-free fluids and all the doped elements are partitioned into melts. At 1.5 GPa and greater pressures, only Cs is found in Cl-free fluids, with one exception of small X-ray peak of Ba at 2 GPa. In contrast, X-ray peaks of Cs and Ba are observed in saline solutions at 1 GPa. In addition to Cs and Ba, a small peak of La is also found in the saline solutions at 1.5 GPa and greater pressures. The other elements (Sm, Gd, Ho, Yb) are found only in melts at all conditions.

NaCl and KCl in aqueous fluids have large effects on elemental partition between melts and fluids as Keppler suggested [1996 Nature]. The present observation is qualitatively consistent with reported values in his measurement. Elliott et al. [1997, JGR] suggested two slab-derived components: a melt component and a fluid component in order to explain trace element characteristics of basalts and basaltic andesites in the Mariana arc. Both components are characterized by enrichment of alkali and alkali earth elements. The fluid component shows rare earth element abundances relatively similar to MORB, while the melt component shows more light rare earth element rich pattern. Such features can be consistent with a Cl-rich aqueous fluid and a melt that can be formed through a separation of a slab-derived supercritical fluid during its migration to the surface. Chemical fractionation of slab-derived supercritical fluids may play an important role in subduction zone magmatism.