

Elemental partitioning between high Mg andesite and aqueous fluids as functions of pressure and salinity

Tatsuhiko Kawamoto^{1*}, Kenji Mibe², Ken'iti Kuroiwa¹, Tetsu Kogiso³

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

1. Introduction

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 [1-3]. Partition between minerals and melts is relatively well known, while partition between aqueous fluids and melts remains to be investigated.

2. Experimental

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 (2.5 mol NaCl and 2.5 mol KCl per 1 kg water) in a metal tube + single-crystal-diamond lids 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 keV to 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 [4, 1]. SR-XRF spectra are collected from the melt globule and the aqueous fluid using an SSD detector placed with 6 degrees to incident X-rays.

3. Results

A series of experiments has been carried out at pressures of 0.5, 1, 1.5, 2 and 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.

4. Discussion

NaCl and KCl in aqueous fluids have large effects on elemental partition between melts and fluids as Keppler suggested [5]. He measured distribution coefficients between saline solution and andesitic melt based on quenched experiments and reported D Ba and D La at 0.3, 1, 1.5 and 2 GPa. The present observation is qualitatively consistent with reported values in his measurement [5]. Elliott and his colleagues 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 [6]. 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 (Figure 3 in [6]). 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 [1-3]. If this is the case, the melt should be characterized by less abundance of alkali elements and more abundance of alkali earth and rare earth elements than the aqueous fluid. The aqueous fluid and melt components suggested as slab-derived components in the Mariana arc show features consistent with a Cl-rich aqueous fluid and a melt formed through a separation of a slab-derived supercritical fluid [1]. In order to address this hypothesis, more data sets of elemental partition under HTHP conditions are required. Chemical fractionation of slab-derived supercritical fluids may play an important role in subduction zone magmatism.

References

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