Partitioning of potassium between Fe-S melt and magam at high pressure and temperature

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It has been suggested that there are heat sources in the Earth's core. One of the candidates is potassium (^{40}K). Partitioning of potassium between liquid iron and silicate melt at high pressure and temperature is important to estimate the amount of potassium in the Earth's core (e.g. Ito et al., 1993; Gessmann and Wood, 2002; Murthy et al., 2003). The effect of pressure on the solubility of potassium into metallic iron is uncertain until now. In the previous works, experiments were performed below 26 GPa using a large volume press (e.g. Ito et al., 1993; Gessmann et al., 2002; Murthy et al., 2003), except for the work by Hirao et al. (2006) using diamond anvil cell (DAC). The aim of this work is to examine the solubility of potassium into metallic iron, and to clarify the effects of pressure, temperature and sulfur content on the solubility using Laser heated DAC.

The partitioning experiments were performed at 50 - 75 GPa and 2500 - 3500 K using a LHDAC. The starting materials were foiled Fe or Fe-13.2wt.%S which was sandwiched by natural Aduralia ($K_{0.973}Na_{0.020}Al_{0.998}Fe_{0.0006}Si_{3.003}O_8$). Powder X-ray diffraction was carried out to identify the reaction phases at beamline 13A Photon Factory, KEK. Chemical analysis was performed using EPMA and ATEM (Institute for Materials Research, Tohoku Univ.). Since Murrell and Burnett (1986) and Murthy et al. (2003) reported that polishing of samples using water or oil lubricants results in substantial potassium loss from Fe-S phase, the recovered samples were prepared in dry polishing for the EPMA in this study. The preparation of thin foil for the ATEM analysis was performed using Focused Ion Beam (FIB) system. Then the low energy Ar ion milling was employed for final thinning.

The solubility of potassium into metallic iron increased from 0.12 to 0.80 wt.% with increasing temperature (2500 K - 3000 K) at 50 GPa. This trend is consistent with previous studies (e.g. Gessmann and Wood, 2002; Murthy et al., 2003). Gessmann and Wood(2002) and Murthy et al.(2003) reported rapid increase of solubility of potassium with temperature. On the other hand, the effect of temperature on the solubility of potassium was not so sensitive in this study comared with previous reports. The solubility of potassium at 50 GPa in this study is smaller than the results of previous studies performed at much lower pressures, even if the effect of the temperature is considered. This result shows that the solubility of potassium decrease with pressure, and its effect is small.