Evaluation of the influence of alkali elements on hydrogen solubility of clinopyroxene for estimating water content of lunar mantle

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In the early history of lunar exploration, lunar samples returned by the Apollo missions revealed that volatile elements are depleted on the Moon. Almost all volatile components were thought to be eliminated by the giant impact event that probably led to the formation of the Moon. However, recent microanalyses of lunar samples have discovered hydroxyl or water in the constituent minerals. These observations suggest that the lunar mantle may not be entirely dry and contain water to same extent as the Earth’s mantle. The lunar volcanic glasses of Apollo 15 and 17 were measured by SIMS and about 4-46 ppm water were detected (Saal et al., 2008). Hui et al. (2013, Nature Geosci.) detected up to 2.7 ppm water in plagioclase grains from the lunar highland crust sample. They suggest that the initial water content of the lunar magma ocean (LMO) reaches approximately 320 ppm water content. As a result of these studies, water content and the process that the moon got water has attracted a lot of attention. Since no indigenous hydrous minerals have been found in the moon, it is likely that anhydrous mineral possess water as a reservoir in the lunar mantle. Water exists in the Earth’s mantle as hydrous mineral, anhydrous mineral, silicate melt, liquid water, and their intermediate form. In the Earth’s mantle, hydrogen may be incorporated as defects in nominally anhydrous minerals (NAMs) such as Olivine, pyroxene and garnet. (e.g., Smyth et al., 1991). Especially, clinopyroxene (Cpx) shows the maximum water content in the upper mantle xenolith (Inglin and Skogby, 2000). Cpx has possibility of being water reservoir in the lunar mantle due to its crystal structure and chemical composition.
Nakamura et al. (2012) confirmed the presence of calcium rich pyroxene in the South Pole-Aitken (SPA). It is possible that the lunar upper mantle has been excavated and exposed in SPA (Cintala and Grieve, 1998; Lucey et al., 1998). Cpx is likely to be one of the major minerals of the lunar mantle as well as the earth.
Since there is less hydrous mineral in the Moon, water should concentrated in KREEPy basalt that assumed to be the final part of the lunar magma ocean solidification. In this study, we target the measurement of hydrogen solubility of Cpx crystallized from alkali-rich magma.
We conducted a high temperature and high pressure experiment at 1 GPa using a piston cylinder apparatus at Bayreiches Geoinstitut, Germany. Starting material is the natural alkali basalt powder (Haku-4 reported by Kuritani et al., 2009), adding ~5 wt. % water with a micro-syringe. For the Fourier Transform Infrared (FT-IR) analysis, it is necessary to produce Cpx crystals larger than 50 μm. Therefore, in order to considerate conditions suitable for sample synthesis, we conducted several experiments that the initial temperature, cooling rate, the temperature after cooling and the retention time were changed. We report the conditions that succeeded in creating the Cpx large enough for FT-IR analysis and the future plans.
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