

カンラン石 - 斜方輝石間の水の分配に与える Al 濃度および酸素 fugacity の効果 Effect of Al content and oxygen fugacity on water partitioning between olivine and orthopyroxene

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Water affects physical property of minerals (e.g. elemental diffusion rates, melting points). Because small amount of water plays key roles in mantle rheology, precise knowledge on partitioning of water among mantle minerals is very important in understanding the earth dynamics. Rauch and Keppeler (2002) investigated effect of Al content on water solubility in orthopyroxene. Al solubility of orthopyroxene decreases with increasing pressure above 3 GPa. Thus water partitioning coefficient may change significantly above 3 GPa. Moreover, Nishihara et al. (2008) indicated that substituting mechanism of OH in a mineral changes considerably with concentration of OH. Although water partitioning has been studied by many workers under water saturated conditions, experiments under low OH concentration are very limited.

In order to investigate the partitioning coefficient of water between olivine and orthopyroxene under low OH concentration (4~200 ppm), we performed high-temperature and high-pressure experiments using Kawai-type multi-anvil apparatus (SPE-1000) and piston-cylinder apparatus at the Magma Factory, Tokyo Institute of Technology, using starting materials of natural olivine (Ol; KLB-1) and synthetic orthopyroxene with various Al content (Opx; $(\text{Mg,Fe})_{2-x}\text{Al}_{2x}\text{Si}_{2-x}\text{O}_6$ ($x=0, 0.025, 0.05$)). Powdered minerals were enclosed in metal foil capsule (Ni, Mo) to form monomineralic layers with more than 300 micron meters in thickness each and put it in a $\text{Au}_{75}\text{Pd}_{25}$ capsule at pressures of 1, 3 GPa and temperature of 1300 °C. Oxygen fugacity was controlled by Ni-NiO and Mo-MoO₂ buffers. Water contents were obtained with a vacuum type Fourier transform infrared spectrometer (FT-IR6100, IRT5000). Water content of minerals was calculated based on Paterson's (1982) calibration. Run products were polished down to doubly polished slab. After polishing and prior to FT-IR analysis, samples were stored in a vacuum oven at ~120 °C over night. Detection limit in the IR spectra at 3200-4000 cm^{-1} is typically less than 1 ppm due to very low background of vacuum type FT-IR.

Water partitioning coefficient between Ol and Al free Opx are $D_{(\text{Al free Opx/Ol})} = 1 \sim 2.3$. On the other hand, that between Al bearing Opx and Ol are $D_{(\text{Al bearing Opx/Ol})} > 4.1$. Thus $D_{(\text{Opx/Ol})}$ becomes larger with Al content of Opx. At constant temperatures, Al solubility of orthopyroxene stays nearly constant at 1~3 GPa but becomes smaller with increasing pressure above ~3 GPa. Results of this study shows that amount of water in Opx is much larger than that in coexisting Ol below ~3 GPa. On the other hand, water content of Ol would become much larger than that of Opx above ~3 GPa. The IR spectra of Al bearing Opx show peaks broader than those of Al free Opx. Peak shapes of Al bearing Opx are similar to those of natural samples. The IR spectra of Ol in recovered samples under Ni-NiO buffer show additional OH band (3700 cm^{-1}) that are not seen in the spectra of run products under Mo-MoO₂ buffer. We are performing further high pressure experiments using Ol single crystal to avoid grain-boundary effects on adsorbing water.

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