

Mineralogy under the deep lower mantle conditions determined by in-situ X-ray measurements

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High-pressure and high-temperature in-situ X-ray diffraction measurements reveal the crystal structures of minerals stable under the deep lower mantle conditions. We report our recent results on the phase transitions of the mantle-relevant minerals based on experiments using a laser-heated diamond anvil cell at BL10XU of SPring-8.

Previous experimental studies on the phase transition of SiO₂ have been controversial. We made in-situ X-ray diffraction measurements up to 151 GPa and 2500-K (Murakami et al., 2003). Amorphous silica was used as starting material, and the sample was heated for more than 1.5 hour to examine the kinetic effects. The results demonstrated the CaCl₂-type silica is a post-stishovite phase and it undergoes further transition to the $\sqrt{2}$ -PbO₂-type structure above 121 GPa at 2400-K. The $\sqrt{2}$ -PbO₂-type SiO₂ can be present in the deep lower mantle in the silica-saturated bulk composition such as subducted former oceanic crusts. The presence of SiO₂ phase has been suggested also as a reaction product at the core-mantle boundary.

Recent both theoretical and experimental studies showed that the CaSiO₃-perovskite has an orthorhombic or tetragonal structure slightly distorted from cubic. We performed in-situ high-pressure and high-temperature X-ray observations at ~40 GPa on both Al-free and Al-bearing CaSiO₃-perovskite with changing Al₂O₃ content from 0 to 6 wt%. The results showed that Al-free CaSiO₃-perovskite had a tetragonal symmetry at room temperature (Shim et al., 2002) but became a cubic phase above ~700-K. Similar phase transition was observed for CaSiO₃ with 2 wt% Al₂O₃ composition. In contrast, CaSiO₃-perovskite phase containing 6 wt% Al₂O₃ was cubic even at room temperature. These suggest that the tetragonal to cubic transition in CaSiO₃-perovskite does not likely occur in the lower mantle even within the cold subducting slabs.

References

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The characteristics and petrogenetic relationship of mixing end-member magmas from Shirataka Volcano, Moriyoshi volcanic zone

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Following five geological units from Shirataka Volcano are related to magmatic eruption; these are the Kokuzo lava (KL), Numata pumice flow deposit (NPF), Hagino block-and-ash flow deposit (HBFD), Shiratakayama-Kitsunegoe-Nishikuromoriyama lava domes (SLDG), and Higashikuromoriyama lava dome (HLD) in the ascending order. Many petrologic features suggest that all rock from this volcano was formed by magma mixing. In this study, we clarify the petrologic characteristics and petrogenetic relationships among end-member magmas of mixing rocks in each units from Shirataka Volcano.

Most of the rocks from Shirataka Volcano are medium-K, calc-alkaline andesite to dacite and subordinate amount of low-K andesite are only recognized in the lower part of KL. Each phenocrysts is divided into three groups as follows, according to their chemical compositions; (1) Pl (An₃₈₋₅₀), Hyp (Mg-v=52-55), Aug (Wo₄₃En₄₀), Hbl (+/-), Qtz (+/-), (2) Pl (An₅₈₋₇₃), Hyp (Mg-v=ca.72), Aug (Wo₄₀En₃₈), (3) Ol (ca.Fo₈₀) (+/-), Pl (An₇₀₋₈₆). The phenocrysts of each groups may derive from low (ca.800-900 degrees C), intermediate (ca.1000 degrees C), and high temperature magmas (ca.1150 degrees C) respectively.

Whole rock compositions show following three linear trends on variation diagrams; medium-K defined by the upper part of KL, NPF (except for pumices), HBFD, SLDG, HLD, low-K defined by the lower part of KL, and the other kind of medium-K defined by pumices in NPF. These trends are parallel to one another in each diagrams.

Considering the mineralogical and geochemical data, intermediate magma was formed during the mixing process between high and low temperature magmas. The compositions of high temperature magmas (mafic end-member) are estimated to be 50-54wt%, and those of low ones (felsic end-member) are 65-66wt% in silica content. The trace element model calculations show that the felsic end-member cannot be derived through fractional crystallization of phenocrystic minerals from the mafic end-member (particularly Zr, Y). The other possibility is re-melting of solidified mafic end-member magmas. The felsic end-member could be produced through partial melting, if gabbroic residual was assumed. Consequently, we infer that each of felsic end-members may be formed by re-melting of solidified mafic end-members.