

In situ X-ray observations of phase transitions in KAlSi₃O₈ under lower mantle conditions

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It has been reported that radioactive isotope in potassium (⁴⁰K) is one of the elements related to the heat generation and thermal evolution in the Earth. Thus, it is important to identify the host of potassium in deep mantle. Feldspar (KAlSi₃O₈) is the strongest candidate for the host of potassium in the shallow part of the mantle. In this study, we investigated the phase relations in KAlSi₃O₈ under the lower mantle conditions using multi anvil apparatus combined with synchrotron radiation.

The experiments were conducted using Kawai-type multi anvil apparatus (SPEED-MKII) at BL04B1 beam line, SPring-8. We used two kinds of starting materials to assure the stability of high-pressure phases. One is a glass (+minor oxides) obtained from a mixed powder with K₂CO₃, SiO₂ and Al₂O₃ heated at 1273 K for 1 day. The other is KAlSi₃O₈ hollandite synthesized at 15GPa and 1473 K using this mixed powder. The sample temperature was monitored by a W3%Re/W25%Re thermocouple, while pressure was calculated from equation of state of Anderson et al. (1989) for gold powder mixed with the sample as forms of powders or a foil.

First, the glass starting material was loaded to 35.7GPa, and then heated to 1473 K at a constant ram load. At 1073 K, sample started to crystallize from the glass, and the transformation to a new phase (HollanditeII) was observed at 1473 K and 30.9GPa. After we confirmed the formation of hollanditeII at this P-T condition, we decreased temperature from 1473 to 300 K, at a fixed pressure of ~30GPa. As the result, hollanditeII was found unchanged under these conditions.

In the second experiment with hollandite starting material, we observed that hollandite transformed to hollanditeII at 21.7-25.4GPa upon compression even at the room temperature, which is consistent with what we observed upon quasi-hydrostatic compression of hollandite in a diamond anvil cell (Ferroir et al., 2003). After we compressed to 31.4GPa, the temperature was increased to 1473 K at a constant ram load, and we could observe the well-resolved X-ray diffraction pattern of hollanditeII. On the other hand, hollanditeII transformed to hollandite in decompression process, and was unable to be recovered at the ambient conditions.

Nishiyama et al. (2003) was studied the P-V-T relations of KAlSi₃O₈ hollandite, and reported hollandite is stable up to 26GPa and 1800 K. Thus, by combining this observation with our present results, we expect that the slope of hollandite-hollanditeII phase boundary is positive, and may approximately be expressed by $P(\text{GPa})=20.6+0.0044T(\text{K})$.