

Post-hollandite phase in KAlSi_3O_8 as a host mineral of potassium in the Earth's lower mantle

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The behavior of potassium in the deep Earth is of great interest because potassium is one of the important heat source in thermal evolution of the Earth and might be recycled through the subduction of continental crusts, sediments, and K-rich basalts into the deep Earth. However, host minerals of potassium and the amount of K in the deep Earth remain uncertain. The KAlSi_3O_8 hollandite has a unique structure that large open tunnels are formed by double-chains of edge-sharing $(\text{Si,Al})\text{O}_6$ octahedra (Ringwood et al 1967; Yamada et al. 1984), and can accommodate large cations such as Na, Rb, Sr, Ba, and Pb as well as K in spite of its dense structure (Prewitt and Downs 1998). A high pressure polymorph of K-hollandite can therefore act as potential carrier of K, Na and trace elements into the deep Earth and may be important host phase of potassium in the Earth's upper mantle (Urakawa et al. 1994; Yagi et al 1994; Schmidt 1996; Wang and Takahashi 1999). The discovery of the K-hollandite in the melt vein of shocked meteorites supports the existence of K-hollandite at depths of 400–660 km in the transition zone of the Earth's mantle (Langenhorst and Poirier 2000; Ohtani et al. 2004). Tutti et al. (2001) proposed that the stability field of the KAlSi_3O_8 with hollandite structure extended to the depth of 2200 km in the Earth's lower mantle and the K-hollandite could be a K-host phase in deep Earth, based on their quench experiments. However, a new high-pressure phase of KAlSi_3O_8 , post K-hollandite phase with monoclinic structure of $I2/m$, at higher pressure of 22 GPa was discovered recently by in-situ X-ray diffraction measurements at high pressures and high temperatures (Sueda et al. 2004). Here, we report in situ X-ray observation of KAlSi_3O_8 composition at high pressures and temperatures up to 128 GPa and 3500 K corresponding to the conditions in the Earth's lowest mantle region. Powder X-ray diffraction spectra were collected by the angle-dispersive method at BL13A and BL18C of Photon Factory, High Energy Accelerator Research Organization (KEK), Japan. High pressure and temperature conditions were generated by laser-heated diamond-anvil cell (LHDAC). The natural sample of KAlSi_3O_8 was used as a starting material. Iron powder was mixed for laser absorber. Heating was achieved by a high power multimode Nd: YAG laser. Temperature was measured from both or one side by the spectroradiometric method (Kondo et al. 2004). Pressure was determined using the ruby fluorescence method (Mao et al. 1978) and/or the pressure dependence of the edge frequency of the first-order Raman mode at the culet of diamond anvil (Akahama et al 2004). X-ray diffraction patterns show the post K-hollandite with monoclinic structure of $I2/m$ is stable between 37 and 128 GPa below temperature of 3500 K, in contrast to the previous work (Tutti et al. 2001). The post K-hollandite phase has the same structure as original hollandite $\text{BaMn}_8\text{O}_{16}$, and shows a distortion that lowers the symmetry to the monoclinic space group. The structural distortion leads to the small deformation of tunnels in which large cations are placed. However, tunnel cations may not be affected significantly and could be kept in cation locations. Therefore, KAlSi_3O_8 would be the host phase for potassium in the whole Earth's mantle.