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Phase relations and formation of K-bearing Al-10 Å phase in the MORB+H_2O system: Implications for H_2O- and K-cycles in subduction zones

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Abstract

The potassium (K) and water (H_2O) cycles in subduction zones are predominately controlled by the stability of K- and H_2O-bearing minerals, such as K-mica, lawsonite, and dense hydrous magnesium silicates (DHMS). K-micas (muscovite or phlogopite) are the principal H_2O and K hosts in subduction zones and Earth's upper mantle and play a significant role in the deep H_2O and K cycles. The Mg-10 Å phase, normally appearing in hydrated peridotite in high-pressure experiments, has been considered as an important water-carrier in subducted hydrated peridotite. In this study, we found a K-bearing Al-10 Å phase in the MORB+H_2O system (hydrated basalt) at high pressures according to X-ray diffraction and stoichiometry. We experimentally constrained its stability field at high pressure. By considering newly and previously documented compositions of the 10 Å phase and micas, we confirmed a continuous solid solution or mixed layering between the 10 Å phase and K-mica at the interlayer site, suggesting that the K cycle and the H_2O cycle in subduction zones are coupled. From the discussion of the effect of f_{H_2O} on stability of the Al-10 Å phase, we conclude that a cold subduction zone can host and carry more bulk H_2O and K into Earth's deep mantle than a hot one. This work expands the stability regions of the 10 Å phase from the ultramafic system (Mg-10 Å phase) to the mafic system (Al-10 Å phase), and emphasizes the significance of the 10 Å phase for the deep H_2O and K cycle in subduction zone.

Keywords: H_2O- and K-cycle, Al-10 Å phase, K-mica, high pressure, subduction zone