The effect of potassium on the stability of NAL phase in the lower mantle

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High-Pressure (P) and high-temperature (T) experiments were conducted at \(P = 33\) to 144 GPa and \(T = 1,800\) to 2,700 K in order to examine phase relations on the join \(\text{Na}_{1.00}\text{Mg}_{2.00}\text{Al}_{4.80}\text{Si}_{1.15}\text{O}_{12} - \text{K}_{1.00}\text{Mg}_{2.00}\text{Al}_{4.80}\text{Si}_{1.15}\text{O}_{12}\). Stable phases were identified in-situ at high \(P-T\) in a laser-heated diamond-anvil cell (DAC), based on synchrotron X-ray diffraction measurements. The results show that K-rich new aluminous (NAL) phase forms continuous solid solution on the join \(\text{Na}_{1.00}\text{Mg}_{2.00}\text{Al}_{4.80}\text{Si}_{1.15}\text{O}_{12} - \text{K}_{1.00}\text{Mg}_{2.00}\text{Al}_{4.80}\text{Si}_{1.15}\text{O}_{12}\) at 30 GPa. And, NAL is formed as a single phase up to the lowermost mantle conditions in both \(\text{Na}_{0.75}\text{K}_{0.25}\text{Mg}_{2.00}\text{Al}_{4.80}\text{Si}_{1.15}\text{O}_{12}\) and \(\text{K}_{1.00}\text{Mg}_{2.00}\text{Al}_{4.80}\text{Si}_{1.15}\text{O}_{12}\) compositions. On the other hand, single-phase NAL is found only to 100 GPa at 2,500 K, and NAL coexists with calcium-ferrite type (CF) phase at 120 GPa and 2,300 K in \(\text{Na}_{0.75}\text{K}_{0.25}\text{Mg}_{2.00}\text{Al}_{4.80}\text{Si}_{1.15}\text{O}_{12}\). Considering the NAL phase with \(\text{Na}_{1.00}\text{Mg}_{2.00}\text{Al}_{4.80}\text{Si}_{1.15}\text{O}_{12}\) composition is stable only up to 45 GPa at 1,850 K, these results clearly indicate that the presence of potassium drastically expands the stability \(P-T\) field of NAL. In addition to hollandite, the NAL phase should be an important host of potassium in the deep lower mantle, formed in K-rich materials such as subducted continental crust.