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Stability of Al-bearing superhydrous phase B at the mantle transition zone and the uppermost lower mantle

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ABSTRACT

We determined the stability and chemical composition of Al-bearing superhydrous phase B at 20–24 GPa and 1400–2000 °C to discuss the mechanism of water transport in the mantle transition zone and uppermost lower mantle at temperatures close to the mantle geotherm. Superhydrous phase B contained significant amounts of Al_2O_3, from 14 to 32 wt%, and Al-bearing superhydrous phase B remained stable, even at 2000 °C and pressures of approximately 20–24 GPa. Moreover, two types of superhydrous phase B with different chemical compositions coexisted at 20–24 GPa and 1600 °C. The Al_2O_3 and H_2O contents increased, and the MgO and SiO_2 contents decreased as the pressure and temperature increased up to 1600 °C. Above 1600 °C, the MgO and Al_2O_3 contents increased, and the SiO_2 and H_2O contents decreased as the temperature increased. We found two substitution mechanisms: (1) $2Mg^{2+} + Si^{4+} \rightleftarrows 2Al^{3+} + 2H^+ + \square_{Mg}$ (Mg site vacancy) $(2Mg^{2+} = Al^{3+} + H^+ + \square_{Mg}):(Si^{4+} = Al^{3+} + H^+) = 1:1$, (2) $Si^{4+} + 16H^+ \leftrightarrows 4Mg^{2+} + 4Al^{3+}$. The maximum H_2O content of Al-bearing superhydrous phase B is 11.1(3) wt%, which is ~1.9 times larger than that of the Mg-end-member. The crystal structures of the two coexisting superhydrous phase B values are expected to be slightly different from each other. The present results indicate that Al-bearing superhydrous phase B can be stable in a subducted slab with a high Al content compared to pyrolite (e.g, chlorite) at temperatures typical of the mantle transition zone and the lower mantle. Thus, water can be transported to the lower mantle by Al-bearing superhydrous phase B in the subducting slab, even at the typical mantle geotherm.

Keywords: Superhydrous phase B, dense hydrous magnesium silicates, stability, substitution mechanism, hydrous mineral; Physics and Chemistry of Earth's Deep Mantle and Core