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Iron-titanium oxyhydroxides as water carriers in the Earth's deep mantle

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Abstract

We experimentally explored phase relations in the system FeOOH-TiO_2 at pressures of 16 GPa and temperatures of 1000–1600 °C, which corresponds to conditions of the Earth's mantle transition zone. Analyses of the recovered samples revealed that, in the studied conditions, there are two stable iron-titanium oxyhydroxide phases whose estimated composition is expressed by $(FeH)_{1-x}Ti_xO_2$. One is the Fe-rich solid solution ($x < 0.23$) with ε-FeOOH type crystal structure (orthorhombic, $P2_1nm$), and the other is the more Ti-rich solid solution ($x > 0.35$) with α-PbO_2 type structure (orthorhombic, *Pbcn*). The ε-FeOOH phase is stable up to ~1100 °C irrespective of chemical composition, whereas the α-PbO_2 type phase is stable up to 1500 °C for a composition of $x = 0.5$ and at least to 1600 °C for $x = 0.75$, and thus the α-PbO_2 type phase is stable at average mantle temperature in the Earth's mantle transition zone. Iron-titanium-rich phases found previously in basalt + H_2O system are estimated to be the ε-FeOOH and α-PbO_2 type phases where the phase with iron-rich composition found at relatively low temperature (<1100 °C) is ε-FeOOH phase and the phase with titanium-rich composition is α-PbO_2 type phase. The α-PbO_2 type and ε-FeOOH phases may be stable in the subducted basaltic crust at pressures in the mantle transition zone under water-rich conditions.

Keywords: Mantle transition zone, water, titanium, hydrous mineral, basaltic crust