Decomposition of δ-(Al,Fe)OOH into an iron-rich hexagonal phase and δ-AlOOH : implications for water transportion into the deep lower mantle

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Water can be transported into the deep mantle through hydrous minerals in the descending slabs. The δ-AlOOH phase has a broad stability field which allows it carry water to the deep lower mantle [1], while the isostructural ε-FeOOH is transform to py-FeOOH under the deep lower mantle conditions [2]. The isostructural δ-AlOOH and ε-FeOOH phases can form δ-ε solid solutions [2,3]. To determine the stability of the δ-(Al,Fe)OOH solid solutions under the lower mantle conditions, we conducted high-pressure and high temperature experiments on the δ-(Al,Fe)OOH in laser-heated diamond anvil cells. We observed that the iron content in the δ-(Al,Fe)OOH starting material with the atomic ratio of Fe/(Fe+Al) >20% was reduced to 8%-10% and a new hexagonal phase (referred to as the H1 phase) appeared at 70-86GPa, 1800K-2300K. The H1 phase was found stable in the $MgO–Al_2O_3–Fe_2O_3–SiO_2–H_2O$ system coexisting with bridgmanite, δ-phase and Fe_2O_3 with a post-perovskite structure at 80GPa and 2100K. We determined its hexagonal lattice with a= 10.019 Å and c = 2.614 Å at 79GPa by the multigrain analysis and obtained its chemistry composition with a ratio of Fe/O similar to that of Fe_2O_3 by TEM analysis on the recovered samples. Formation of the H1 phase suggests that iron-rich δ-(Al,Fe)OOH is not stable at high temperature, which indicates that during the subduction of iron-rich slabs, the iron-rich δ-(Al,Fe)OOH is likely stable in the cold region (<1800 K), and will transform to the H1 phase and a nearly Fe-free δ-AlOOH phase beyond 1800 K in the deep lower mantle. The discovery of the H1 phase suggested complexities in the lower mantle mineralogy when water and other volatiles are involved.

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[2] Nishi, M., et al. Nature 547.7662 (2017): 205-208.

[3] Kawazoe, T., et al. American Mineralogist 102.9 (2017): 1953-1956.