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Role of hydrogen on composition, structure, and dynamics of the lower mantle

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Seismological observations and experimental evidence suggest stagnant slabs transport hydrogen into the lower mantle. Hydrogen storage capacity in the lower mantle including in bridgmanite and real hydrogen abundance in the lower mantle, however, are still debated matters. Recent experimental works revealed that the most important hydrogen carrier into the lower mantle is hydrous phase δ (AlOOH)–phase H ($MgSiO_4H_2$) solid solution. This phase coexists with bridgmanite, i.e., it exists to the top of the peridotite lower mantle, whereas it is stable to the bottom lower mantle in MORB [1, 2].

Hydrogen and aluminum partitioning between the δ-H solid solution and bridgmanite revealed that bridgmanite is depleted in aluminum under the wet conditions, whereas it contains almost no hydrogen even under the wet conditions. The partitioning of H and Al can provide significant effects on lower mantle dynamics through changes of the phase boundary from garnet to bridgmanite and that from bridgmanite to post-perovskite, and the spin-transition pressure of these phases [3, 4]. Thus, hydrogen can modify physical properties such as seismic velocities and thermal conductivities of lower mantle minerals, and thus dynamics of the lower mantle.

Supply of hydrogen by slab subduction can create a reaction at the core-mantle boundary between water (H_2O) or hydroxyl (OH) in the slabs and iron in the outer core to produce FeO_2H pyrite and its high temperature decomposition product, Fe_2O_3 post-perovskite. These phases together with δ-H solid solution can account for the sound velocity and density anomalies at the base of the lower mantle such as ULVZ and LLSVP [5].

References:
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