Phase D as a major water carrier in the subducting oceanic crust into the lower mantle

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The distribution of water in the mantle and its effects on mantle dynamics are significant to understand the evolution of the Earth. It's believed that the water is transported from the surface into deep mantle via a variety of hydrous minerals in the subducting oceanic slabs (Ohtani, 2015). However, stability of hydrous mineral(s) in basaltic system at the pressure and temperature conditions equivalent to cold slabs in the transition zone, remains unclear.

High-pressure and high-temperature experiments were conducted in a hydrous basalt (JB-2 basalt plus brucite, water content=3.5wt.%) at 17–25 GPa, and 800–1200°C using multi-anvil apparatus. We used Au/Pt double capsules as sample containers, and the oxygen fugacity was buffered at ~NNO. The run products were analyzed by FE-EPMA. The water contents in hydrous phases were estimated from total deficits in FE-EPMA analyses.

The phase assemblages of the run products include majorite, stishovite, perovskite(s), hollandite, silicate melts and hydrous phase(s). The hydrous phase is Fe-Ti hydroxide at pressures lower than 18GPa or Al-bearing phase D at pressures higher than 18GPa. These two hydrous phases coexisted in one experiment (18GPa, 900°C). Our results show that the phase D is stable at pressures of 18–25 GPa, 800–1000°C. The Al_2O_3 content and (Fe+Mg)/Si ratio of phase D increase with increasing pressure. It is important to note that wadsleyite coexisting with Al-bearing phase D seemed to be nearly anhydrous in our experiment suggesting the importance of the subducting basaltic crust as a water carrier in mantle transition zone.

We propose that the phase D is one of major water reservoir in cold subducting oceanic crust at the mantle transition zone. Moreover, if the subducting slabs stagnate at the bottom of the transition zone and warmed up, the water would be released from phase D in the subducting former oceanic crust, which may be the dominant way to hydrate the transition zone or to cause magmatism in back arc hot spots.