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Editorial: Water in the Earth's interior

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Editorial on the Research Topic
Water in the Earth's interior

It is well known that significant amounts of water are stored in the Earth's deep interior in the form of hydroxyl within the crystal structures of hydrous and nominally anhydrous minerals. By the incorporation of water, the physical and chemical properties of minerals can be dramatically changed; for example, water reduces the strength of minerals, accelerates the atomic diffusivity, enhances electrical conductivity, and produces dehydration melting. Therefore, water plays an important role in geodynamic and geochemical evolutions of the Earth's interior. Knowledge about the behavior of water in the Earth's interior can thus provide critical clues for Earth science research. Over the past 30 years, many geoscientists have spent plenty of efforts to investigate the water circulation between Earth surface and deep interior, water distribution in the mantle, how water affects the physical and chemical properties of minerals and rocks, and how water is substituted into the crystal structures of minerals. However, many problems related to water behavior in the Earth's interior remain unclear or still under debate.

The most fundamental question in this field is how much water exists in the Earth's interior. It is well accepted that the mantle transition zone (MTZ) is a potential water reservoir because its dominant minerals, wadsleyite and ringwoodite, can host up to 3.0 wt.% of water as point defects in their crystal structures. However, the actual water content in the MTZ is unknown. Previous studies reported estimations with significant discrepancies from very dry condition to nearly water-saturated MTZ (e.g., Yoshino et al., 2008; Kelbert et al., 2009; Pearson et al., 2014; Fei et al., 2017; Tschauner et al., 2018; Zhang et al., 2022). Here, by combining a global P- and S-wave isotropic velocity tomography and mineral physics modeling, Wang and Wang imaged the water distribution in the MTZ. They conclude that the water content in the upper part of MTZ is about 0.3–0.5 wt.%, whereas that in the lower MTZ is about 0.15–0.2 wt.%. In contrast, the regions near the subducting slabs contains much more water, i.e., 0.5–1.0 wt.% and 0.2–0.5 wt.% in the upper and lower MTZ, respectively. These results provide new seismic constrains on water contents and distributions in the Earth's interior.

Another fundamental question is how water is circulated in the solid Earth. Water could be transported from the surface to deep interior by subduction of slabs.

Nevertheless, it is uncertain about the carriers of water and amount of water transported by subducting slabs. Since the electrical conductivity of minerals is sensitive to its water content, in this Research Topic, Liu and Yang experimentally measured the electrical conductivity of eclogitic omphacite and garnet as functions of water content under high pressure and high temperature conditions. They found that the bulk conductivity of water-rich eclogite is more than one order of magnitude higher than water-poor samples. Considering the relatively low conductivity of subducting crusts at 70–120 km depth obtained by geophysical observation, omphacite and garnet in the eclogitized slabs should be water-poor, namely, the amount of water carried by eclogite in the subducting slabs is probably limited.

In contrast to the limited amount of water carried by eclogite, hydrous minerals such as diaspore (α-AlOOH) may potentially carry significant amount of water to the deep mantle. Huang et al. evaluated the equation of state and stability of diaspore using *in situ* synchrotron X-ray diffraction (XRD) and Raman spectroscopy. Their results indicate that the pressure and temperature stability of diaspore is up to ~10.9 GPa and 700 K. Therefore, diaspore could be maintained as a metastable state at depths of 390 km, corresponding to the bottom of upper mantle along the coldest subducting slab geotherm. It is thus a potential carrier in the cold subducting slabs to transport water into the deep regions of the upper mantle.

In addition to the general minerals in the Earth's interior, Hu et al. (2016) and Nishi et al. (2017) discovered that the high-pressure polymorph of the mineral goethite (FeOOH), which exists ubiquitously in our life as rust, may dominate the water circulation in the deep lower mantle. Following Hu et al. (2016) and Nishi et al. (2017), Hu and Tang in this Research Topic investigated the behavior of the hydroxyl bonding and structural transition in FeOOH under lower mantle conditions. Using first-principle calculations of molecular dynamics and simulations of nuclear magnetic resonance (NMR) spectroscopy, they tracked the structural transform of FeOOH from ordinary solid, *via* a plastic state to the superionic phase with increasing pressure. Their finding provides new insights about the states of hydrous phases in the Earth's interior such as ice, hydrides, and hydroxides.

Author contributions

HF organized the draft with input from all authors.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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