Geophysical observations reveal the water distribution and effect in Earth's mantle

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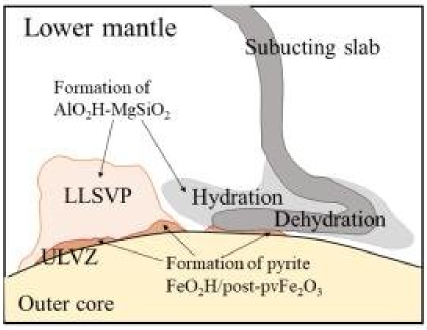

The cartoon of the core-mantle boundary shows dehydration of slabs and hydration of surrounding mantle. Credit: ©Science China Press

Professor Eiji Ohtani from Tohoku University, Japan, summarized the content, distribution and effect of water in the Earth's mantle, published in *National Science Review*.

What is "water in the mantle"?

Hydrogen is the most abundant element in our solar system. In the Earth, hydrogen exists as vapor in the atmosphere, water and ice in the ocean, super-critical fluids in volcanoes and the Earth's crust, hydroxyls in hydrous and nominally anhydrous minerals in the Earth's crust and mantle, proton and hydroxyl (OH) in magmas, and hydrogen in metallic iron in the Earth's core.

Hydrogen and water play important roles in dynamics of the Earth's interior. They lower the internal friction of rocks and cause earthquakes and fracturing. Water generates magmas by lowering the melting temperature of silicates in the mantle. Water softens rocks and enhances mantle convection.

How much "water in the mantle" is there? How does it work?

Seismic and electrical conductivity observations combined with experimental mineral physics data on sound velocity and electrical conductivity of minerals suggest a transition zone that is hydrated at least locally. Continental and oceanic sediment components together with the basaltic and peridotite components might be stored in the mantle transition zone. Low seismic velocity regions have been reported at around 410 km beneath some plate convergent regions. These regions might be caused by the existence of dense volatile rich magmas.

Water can be carried further into the lower mantle by descent of the slabs due to gravitational instability. The anomalous Q and Vs regions may be created at the top of the lower mantle. Dehydration from the slabs produces fluids or hydrous melts in this region due to a large difference of the water solubility between the transition zone and lower mantle assemblages. Although hydrous magmas without density crossover can escape upwards, continuous descent of the slabs causes dehydration from the slabs and produces low Q and Vs regions at the shallow part of the lower mantle. The ?-H solid solution $AlO_2H-MgSiO_4H_2$ is a major carrier of water into the lower mantle. The hydrogen bond symmetrization could occur in various hydrous phases stable in the mantle.

The core-mantle boundary (CMB) is a region where extensive reaction between water and iron could occur. The ?-H solid solution is stable to the CMB conditions. Therefore, this hydrous phase carries water into the base of the lower mantle and also into the core. Pyrite FeO_2Hx can be formed due to a reaction between the core and hydrated slabs at CMB. This phase could be a potential candidate existing at ULVZ. Formation of FeO_2Hx and its decomposition due to its thermal instability at CMB could cause global geodynamical events.

More information: Eiji Ohtani, Role of water in the Earth's mantle, *National Science Review* (2019). DOI: 10.1093/nsr/nwz071

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