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# Water distribution in Earth's mantle during magma ocean crystallization

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Earth's habitability is inseparable from water, which not only distribute on Earth's surface but also hidden in deep mantle. Evidence has shown that Earth may acquire its water during the main stage of accretion, where magma oceans were prevailing due to the energetic impacts. Yet, how such early water is distributed and stored during magma ocean crystallization remains unclear. This is largely determined by how water is partitioned between mantle minerals and silicate melt. Bridgmanite (Brg) is the first mineral crystallized from Earth's deep magma ocean extend to lower mantle. Therefore, determining the water partition coefficient between Brg and silicate melt is of first order to understand the early evolution of deep water. Previous studies only focus on water solubility in Brg at conditions of topmost lower mantle. However, to our knowledge, it is still lack of direct experiment constraints on water partitioning between Brg and silicate melt at conditions of deeper lower mantle.

Here we use laser-heated diamond anvil cell to simulate deep magma ocean conditions and determine water partition coefficient between Brg and silicate melt. Water contents of the sample recovered from ~37−71 GPa and ~3600−4500 K are measured using NanoSIMS (**Fig. A1**). The results shows that Brg and quenched melt respectively contain ~175−1947 ppmw and ~2061−62647 ppmw water, yielding Brg/melt water partition coefficient in the range of ~0.026−0.086. In addition, we find that the incompatibility of water in bridgmanite strongly decreases with increasing temperature.

Given plausible magma ocean crystallization scenarios, our results suggest that lower mantle, rather than transition zone nor the upper mantle, is the major water reservoir in solid mantle right after magma ocean crystallization. Such primordial water in the lower mantle retained from magma ocean would be transported upward with mantle convection and then released to the shallow regions. This process may turn on the Earth's deep water circulation, facilitating Earth's evolution to a habitable planet.

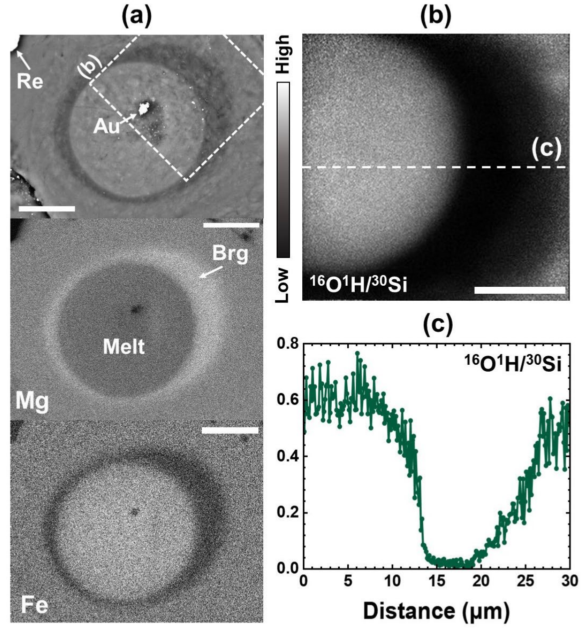


**Fig. A1. Compositional map of a recovered sample.** (**a**) BSE image and distribution map of Mg and Fe of a sample recovered from 56 GPa and 4088 K. Bright particles are Au remnants of the repolishing Au-coating sample after NanoSIMS measurements. (**b**) Distribution map of $^{16}O^1H/^{30}Si$ of a selected region in plane **a** performed by NanoSIMS. (**c**) Selected line profile of $^{16}O^1H/^{30}Si$ in plane **b**. The scale bars are 10 μm.