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Fate of Earth's volatiles during magma ocean crystallization

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Recent geochemical observations from deep-sourced lavas reveal a possible presence of primordial volatiles [e.g., Hallis et al., 2015, Williams and Mukhopadhyay, 2018]. In parallel, planetary formation models indicate such volatiles were likely delivered to the Earth during the main stage of accretion [e.g., O'Brien et al., 2014], when magma ocean(s) were thought prevalent. It raises an important, but largely unexplored question: how were early volatiles retained in Earth's mantle during and after magma ocean crystallization? This, in turn, requires the precise knowledge of how volatiles would behave in the mantle minerals and silicate melt at equilibrium. Unfortunately, experimental data available is limited to shallow mantle conditions or theoretical calculations are inadequate to simulate realistic atomic systems. Here we set to establish a protocol by combining high-pressure experiments with micron-scale and trace-level volatile analysis using secondary ion mass spectrometry. This allows us to systematically examine the chemical properties of silicate melt and mantle minerals throughout Earth's mantle conditions. With our extended dataset, we are hoping to better understand how Earth's volatiles are retained, distributed and re-mobilized from the early magma ocean stage to the present day.