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Volatile retention during pebble accretion: A combined shock and spectroscopy study

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The origin and evolution of Earth's primordial water is at the forefront of geological and planetary science. The leading theory suggests delivery in the late cometary bombardment but Hydrogen's heavy isotope, deuterium, measured in D/H ratios from Earth's surface and mantle do not agree with each other nor that of comets. Geophysical observations indicate abundant water in the mineral and melt structures of Earth's mantle. The origin of this could be significantly earlier than previously thought, possibly during initial planet formation. Water trapped in mantle silicate material would need to survive collisions and bombardment of early Earth by impactors. To this end, we present results from dynamic compression experiments to test how water can alter the chemical and physical properties of hydrated amorphous silicates during simulated impact experiments.

We use experimental results to constrain calculations of Earth's primordial water reservoir. We compute mass fraction of water as a function of velocity as Earth forms using experimentally derived constraints. An example of an Earth forming process which we can experimentally match is pebble accretion. The volatiles retained after impact were measured with FTIR spectroscopy on samples after being impacted at relevant speeds with a 3" compressed-gas driven gun. Quantifying volatiles during dynamic compression will help to understand the origin of Earth's water, how Earth retained its water during accretion, and reveal details about planetary formation, particularly the evolution from planetesimal to planet within a protoplanetary disk.

Ultimately, our spectroscopy results show if volatiles were present during Earth's formation, the primordial reservoir in the mantle could be explained by the pebble accretion theory. Future and ongoing work related to this project are to first measure bulk hydroxyl concentrations of each impact to compare with the current results. Additionally, we will calculate what incoming volume of volatiles would lead to the current geochemical observations. Ultimately, this data can be compared with estimates of water in Earth's mantle from geophysical observations. Then models can be developed to determine what percentage of Earth's water came from pebble accretion.