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Core-mantle differentiation in a hydrous magma ocean

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Water's role in planetary composition is profound, with recent research suggesting its involvement in crucial chemical reactions with silicon and/or iron within magma oceans during core-mantle differentiation. However, accurately quantifying the effect of water on metal-silicate reactions under extreme conditions of high temperature and pressure poses significant challenges in both experimental and computational domains. To address this, we first train machine learning potentials of *ab initio* quality for the H-O-Mg-Si-Fe system and then conduct large-scale molecular dynamics simulations of metal-silicate coexistence to investigate the water content dependence of the metal-silicate partitioning behavior of these elements. Integrating our findings with experimental data on metal-silicate partitioning, we construct a thermodynamic model capable of describing the partitioning of H, O, Mg, Si, and Fe in a wide temperature, pressure, and compositional space. We find that water affects the metal-silicate partitioning behavior of these elements to different extents. This offers us a chance to constrain Earth's initial water content during the magma ocean stage and Earth's core and mantle compositions (e.g., Mg/Si ratio) simultaneously. Our results are also fundamental for interior modelling of water-rich exoplanets and have direct consequences on inferred water mass budgets from mass-radius data of exoplanets.