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Earth shaped by primordial H2 atmospheres

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Earth's water, intrinsic oxidation state, and metal core density are fundamental chemical features of our planet. Studies of exoplanets suggest that hydrogen-rich atmospheres may be the source of these features. Planet formation and evolution models demonstrate that rocky exoplanets commonly formed with hydrogen-rich envelopes that were lost over time. These findings suggest that Earth may also have formed from bodies with H_2-rich primary atmospheres. We have applied a self-consistent equilibrium chemical thermodynamic model to show that Earth's water, core density, and overall oxidation state can all be sourced to reactions between H_2-rich primary atmospheres and underlying magma oceans in its progenitor planetary embryos. Water is produced from dry starting materials resembling enstatite chondrites as oxygen from magma oceans reacts with hydrogen. Hydrogen derived from the atmosphere enters the magma ocean and eventually the liquid metal core. The resulting ~ 0.5 wt % H in the core is the primary source of density deficits matching that of Earth's core. Oxidation of the silicate rocks from solar-like to Earth-like oxygen fugacities also ensues as Si, along with H and O, alloys with Fe in the cores, contributing further to the core density deficits. Reaction with hydrogen atmospheres and metal-silicate equilibrium thus provides a simple explanation for fundamental features of Earth's geochemistry that is consistent with rocky planet formation across the galaxy.

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