# High Pressure Crystal Chemistry of Hydrogen and Water on Planetary Surfaces

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In order for liquid water to exist on planetary surfaces, hydrogen must approach saturation in the nominally anhydrous silicate phases at least somewhere in the silicate mantles of terrestrial planets. Hydrogen is perhaps the least well constrained compositional variable of the Earth's interior. Although Earth's oceans dominate most of the surface geological processes, they constitute only 0.023 percent of the planet's mass. Because the surface oceans are such a small fraction of the total mass, they are unlikely to comprise the bulk of the planet's total hydrogen, the most abundant element in the cosmos.

Over the past two decades experimental mineralogists have explored the solubility of H in the major minerals of the interior including olivine, pyroxenes, wadsleyite, ringwoodite, garnets, akimotoite, and silicate perovskite. In the upper mantle and transition zone, where Si is in tetrahedral coordination and Mg and ferrous iron in octahedral coordination, the major hydration mechanism appears to be by protonation of oxygen atoms adjacent to octahedral vacancies. In the lower mantle where Si is in octahedral coordination, one major mechanism appears to be protonation of oxygen atoms on sites where Al substitutes for Si as has been observed in both stishovite and $MgSiO_3$-perovskite. Although more work is required at high pressure on more realistic hydrous pyrolite compositions, it appears that hydration of nominally anhydrous minerals will, in most cases, decrease both density and elastic moduli throughout silicate mantles.

Because protons (H-atoms) are mobile they can facilitate deformation by propagation of defects thus decreasing effective viscosity. H is also very soluble in Fe metal, and the H content of the core is poorly constrained. H therefore may be as important as heat in controlling convection in planetary interiors. Deep cycling of H may thus control the existance of liquid water and thus carbon-based life on planetary surfaces.