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# Solubility of water in peridotite liquids and the formation of steam atmospheres on rocky planets

**Paolo Sossi**[1], Peter Tollan[1], James Badro[2], and Dan Bower[3]
[1]Institute of Geochemistry and Petrology, ETH Zürich, 8092 Zürich, Switzerland (paolo.sossi@erdw.ethz.ch)
[2]Institut de Physique du Globe de Paris, Université de Paris, 75005 Paris, France
[3]Center for Space and Habitability, Universität Bern, 3012 Bern, Switzerland

Atmospheres are products of time-integrated mass exchange between the surface of a planet and its interior. On Earth, the most significant of these events occurred when it existed in a magma ocean state, producing its earliest atmosphere. During this stage, both steam- and carbon-rich atmospheres may have been generated in equilibrium with a magma ocean [1, 2]. However, the nature of Earth's early atmosphere, and those around other rocky planets, remains unclear for lack of constraints on the solubility of major atmophile elements in liquids of appropriate composition.

Here we determine the solubility of water in 14 peridotite liquids synthesised in a laser-heated aerodynamic levitation furnace [2]. We explore oxygen fugacities ($fO_2$) between -1.5 and +6.4 log units relative to the iron-wüstite buffer at constant temperature (1900±50 °C) and total pressure (1 bar). The resulting $fH_2O$ ranged from nominally 0 to ~0.028 bar and $fH_2$ from 0 to ~0.065 bar. The total $H_2O$ contents were determined by FTIR spectroscopy of polished thick sections by examining the intensity of the absorption band at 3550 $cm^{-1}$ and applying the Beer-Lambert law.

We find that the mole fraction of dissolved water in the liquid is proportional to $(fH_2O)^{0.5}$, attesting to its dissolution as $OH^-$. The solubility coefficient fit to the data yields a value of ~500 ppm/bar$^{0.5}$, roughly 30 % lower than that determined for basaltic liquids at 1350 °C and 1 bar [3]. Therefore, more Mg-rich compositions and/or higher temperatures result in a significant decrease of water solubility in silicate melts. While the solubility of water remains high relative to that of $CO_2$, we hypothesise that steam atmospheres may form under oxidising conditions, provided sufficiently high temperatures and H/C ratios in terrestrial planets prevail.

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