Lower Mantle Storage of Water in "Anhydrous" High-Pressure Basalt Assemblages

W. R. Panero, L. R. Benedetti, R. Jeanloz
Department of Earth and Planetary Science,
University of California, Berkeley, 307 McCone Hall , Berkeley, CA 94720, USA

High-pressure experiments on natural mid-ocean ridge basalt (MORB) and calibrated amounts of H2O reveal that significant amounts of water can be incorporated as hydroxide into the perovskite + stishovite phase assemblage that is stable at lower-mantle pressures. Synchrotron-based infrared absorption (FTIR) spectroscopy combined with laser-heated diamond-cell experiments at pressures and temperatures of 30-65 GPa and 2000-4000 K show that hydrogen partitions strongly into the stishovite phase, with as much as 3000 hydrogens per million silicons (H ppm Si) relative to an upper bound of 100 H ppm Si in the coexisting perovskite phase (Fig 1). The hydrogen content in the stishovite phase increases by about a factor of 3-5 with the onset of partial melting, indicating that the stishovite phase is the solidus phase under these conditions, and that hydrogen partitions into the stishovite over the melt (Fig 2). Thus, as much as 350 H ppm Si can be sequestered in the high-pressure assemblage of "anhydrous" MORB at lower-mantle conditions. At current subduction rates, this corresponds to an accumulation of up to 100

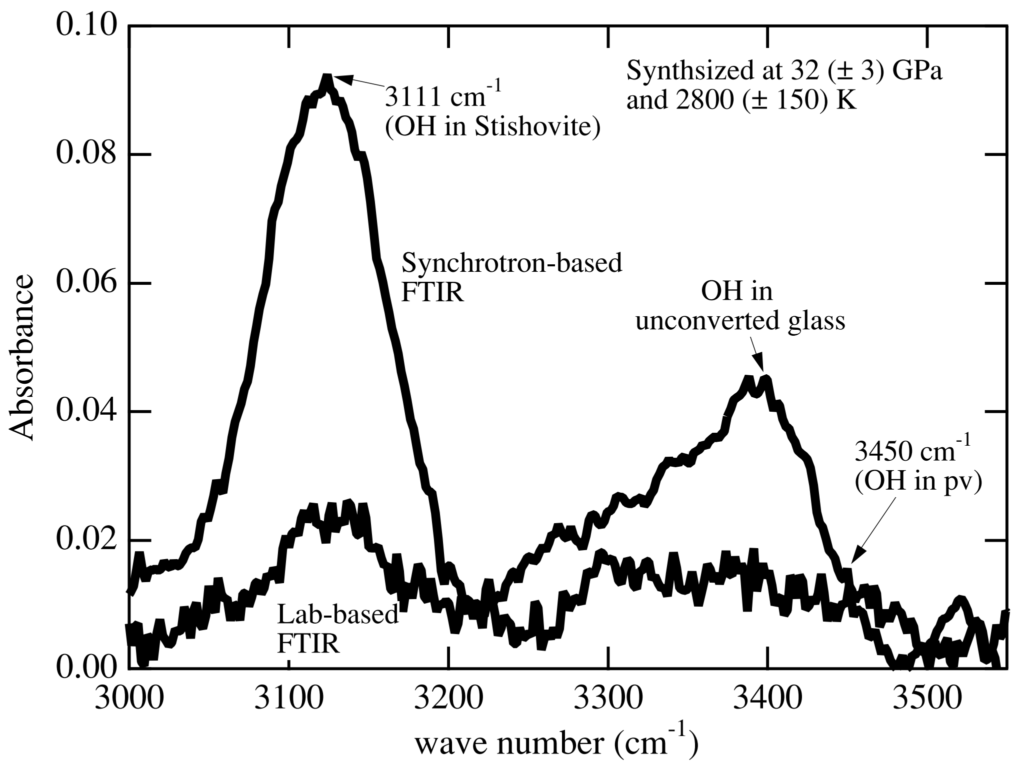

Figure 1. Comparison of a spectrum taken at ALS 1.4.3 (top, 256 scans) to one taken on a lab-based spectrometer (bottom, 60000 scans). While both show a distinct peak at 3111 cm-1 corresponding to OH vibrations in stishovite, the synchrotron-based spectrum has a much better signal-to-noise, as well as better spatial resolution, thereby avoiding problems of sample heterogeneity. Additionally, there is no detectable absorption at 3450 cm-1, where OH in perovskite is expected to absorb, indicating that the hydrogen in this assemblage enters entirely into the stishovite, while perovskite forms virtually hydrogen-free.

percent of the present hydrosphere over the age of the Earth. Thus, to the degree that subduction has extended into the lower mantle over geological history, a significant fraction of the planet's water may be stored at depth. Water in the lower mantle may locally lower the melting temperature, allowing for partial melt at the core-mantle boundary and providing a source for mantle plumes.

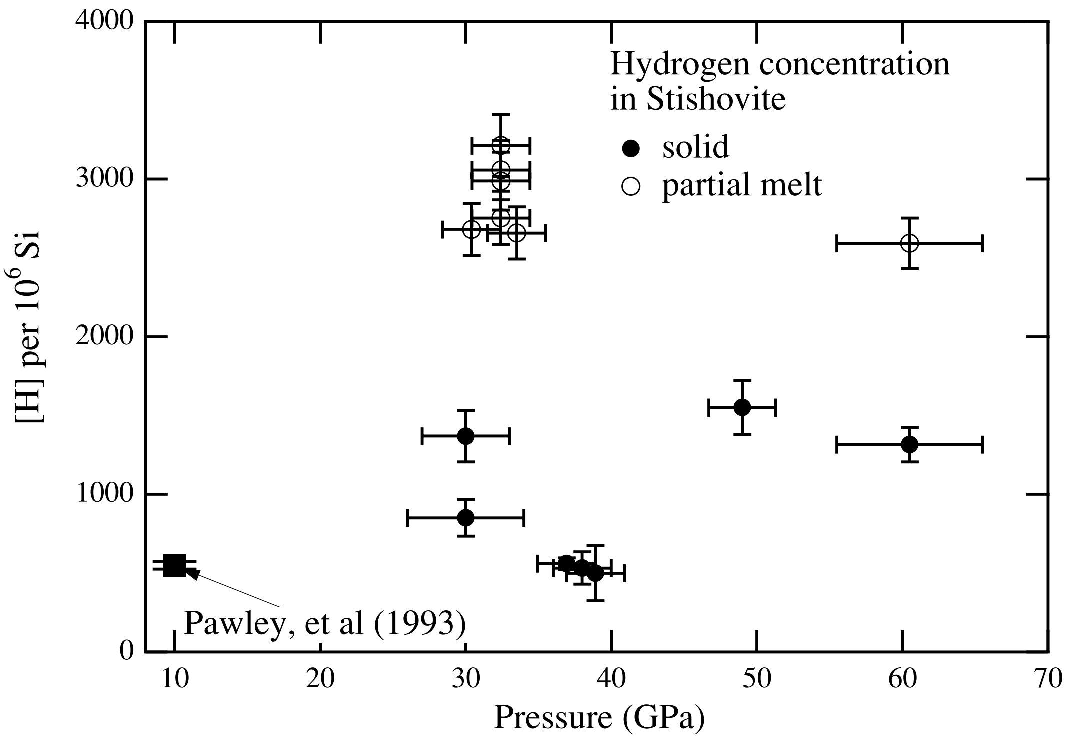

Figure 2. The hydrogen content in the stishovite phase shows a slight increase with pressure for those samples synthesized sub-solidus, and the concentrations are consistent with the concentration determined by Pawley, et al (1993) at lower pressures. Upon melting, the hydrogen concentration in the stishovite increases by a factor of 3-5, indicating that the hydrogen acts as a compatible element under these high-pressure, high-temperature conditions.

This work was supported by the National Science Foundation.

Principal investigator: Wendy Panero, Department of Earth and Planetary Science, University of California, Berkeley. Email: wpanero@seismo.berkeley.edu Telephone: 510-643-8325.