O Water, Where (in Nominally Anhydrous Minerals in a Convecting Mantle) Art Thou?

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Abstract: The viscosity of mantle rocks is governed not only by pressure and temperature but, importantly, also by water content. Thus, both water transport and heat transport are critical in determining mantle dynamics. Water is removed from the mantle through eruptions of volcanoes and is returned to the mantle by subduction of hydrated plates, all part of the deep water cycle. The fluxes of outgassing and ingassing water are governed by plate tectonics and simultaneously influence the vigor of tectonic processes. On the one hand, a greater concentration of water in the mantle promotes more vigorous convection, which, in turn, enhances melting and thus the flux of outgassed water. On the other hand, a hotter mantle supports faster convection, which, in turn, cools the interior more rapidly. The thermal evolution of the planet is, therefore, controlled by the tradeoff between the effects of water and temperature on the vigor of plate tectonics. The magnitude of that feedback on Earth's large-scale internal dynamics depends on the microscopic influence of trace concentrations of H ions on the physical properties of nominally anhydrous minerals in the mantle. Our research focuses on high-pressure, high-temperature experiments designed to explore two aspects of this problem. First, at the microscopic level, we investigate the mechanism(s) of incorporation of H ions in the nominally anhydrous minerals. Second, from a macroscopic perspective, we study the influence of H ions on the viscosity of mantle minerals and rocks. The results of these experiments are central to understanding the mechanism by which water influences mantle viscosity and thus the evolution of our planet.