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Water storage capacity in the Earth's upper mantle

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While it is well accepted that significant amounts of water can be stored as hydroxyl in nominally anhydrous minerals (NAMs) of the mantle, the storage capacity of the mantle remains unknown because the simultaneous effects of pressure, temperature and composition have never been investigated in the laboratory. The majority of studies has concentrated on the study of single phases and have established very important basis for our understanding of water incorporation in minerals. It has been shown that the solubility of water in NAMs increases with increasing pressure and water fugacity. The effect of temperature is more complicated. At low pressures water solubility in olivine increases with temperature, whereas at high pressures it follows a bell-shaped curve and decreases with increasing temperature above a critical temperature which corresponds to the onset of wet melting around 1100-1200°C. Concerning the effect of composition, it has been shown that water solubility in olivine increases with increasing iron content at 0.3 GPa. But this is contradicted by recent reports at high pressures of 8 to 14 GPa. Silica activity is an important parameter at low pressure, which could affect the OH infrared absorption spectra of olivine and then potentially help in diagnosis of the environment in which olivine formed. However, these spectral distinctions disappear at high pressures. Also, the correlation of some hydroxyl absorption bands in infrared spectra of olivine with aliovalent impurities such as Fe^{3+}, Al^{3+} and Ti^{4+} vanishes as water fugacity increases. This is logical since olivine does not incorporate much impurities, water fugacity will be the strongest effect with increasing pressure. Thus it appears that in olivine many behaviours due to environmental conditions measured at low pressures (< 3 GPa) are not occurring at high pressures, suggesting that extrapolation of solubility laws established at low pressures would yield misleading estimates at high pressures.
A review of the state-of the-art results will be presented as well as a model of water storage capacity in the upper mantle.