

Preface to the *Hydrous Minerals at High Pressure* Special Issue

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The behavior of hydrous phases at non-ambient conditions is an important topic in the Earth sciences because the water stored in their structures as OH or H₂O can dramatically affect geological processes. For example, it is well known that the release of structural water during subduction is responsible for metasomatism and partial melting of the overlying mantle wedge, and associated volcanic activity at the surface. There is also a good correlation between the location of intermediate depth earthquake foci (~70–300 km) and the occurrence of hydrous minerals in subducted slabs. Many of the hydrous phases in subduction zones are “sinks” for water and can contain several wt% H₂O. However, even trace amounts (ppm levels or defect concentrations) of water in minerals can significantly affect physical properties. Dehydration of nominally anhydrous minerals may explain the increased strength and seismicity of the lower crust beneath ancient shield areas. The presence of OH defects decreases the viscosity of olivine, which has important implications for convection of peridotite beneath mid-ocean ridges. Small amounts of structural water also affect the preferred orientation of olivine aggregates, producing seismic anisotropy in the upper mantle. On a larger scale, the study of hydrous minerals can reveal important insights into the evolution of the Earth. Degassing of the mantle occurs primarily at the mid-ocean ridges and hot spots; the volatiles lost from the crust and upper mantle are replenished by hydrous phases during subduction. Therefore, the evolution of our planet is intimately linked to the recycling of water between the crust and mantle.

This special issue of *American Mineralogist* on *Hydrous Minerals at High Pressure* arose from a session of the International Mineralogical Association’s meeting at Edinburgh, Scotland in September 2002. The aim of that session was to provide a timely update on recent progress and future trends in the study of hydrous minerals at high pressure. The papers presented in this special issue reflect the broad range of interests and expertise that Earth scientists have developed in this fascinating and rapidly evolving area of research.

The techniques used include X-ray and neutron diffraction, vibrational spectroscopy and computational methods, all of which are very complementary. Equation-of-state studies on

structurally related mineral series, primarily using single-crystal X-ray diffraction, continue to provide important insights into the effects of structural topology upon physical properties—a major theme in modern mineralogy. However, while it is now possible to locate H atoms approximately from high-quality single-crystal X-ray diffraction data, this technique cannot be used to study details of the structural behavior of H at high pressure. A key development over the past 5–10 years in the study of hydrous minerals at high pressure has been the use of neutron powder diffraction (NPD) at pressures up to 10 GPa. It is now quite routine to perform NPD experiments under hydrostatic conditions to 8 GPa. Furthermore, cells for the study at simultaneous pressure (up to 7 GPa) and temperature (up to 1200 °C) by neutron powder diffraction have been used successfully in the past year or so.

With the advent of high-quality high-pressure data from neutron powder diffraction, it is now possible to make meaningful correlations between high-pressure spectroscopic data and H behavior. High-pressure studies of hydrous components (OH, H₂O) by vibrational spectroscopy have tended to race ahead of any detailed structural interpretation of H behavior, due to a dearth of corresponding high-pressure neutron data. The recognition of key correlations between spectroscopy and structure for hydrous components at high pressure can, in principle, also allow us to make significant interpretations of spectra collected well above the current limit of neutron-diffraction technology. For example, the spectroscopic signatures associated with H···H interactions and the reorganization and deformation of hydrogen bonds may be shared by a wide range of minerals.

Two exciting innovations will make it possible in the near future to extend the neutron measurements to phases with more complex structures. (1) The construction of a high-pressure beam line at the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory. The higher neutron flux and instrumental resolution at SNS will have a significant impact on the application of neutron powder methods to high-pressure crystal chemistry of hydrous phases. (2) The development of pressure cells for single-crystal neutron diffraction studies.

We are now at an exciting point in time with respect to understanding how the hydrous components of minerals behave at high pressure. Spectroscopic, diffraction, and computational studies are now poised to converge upon our favorite hydrous minerals!

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