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The Effect of Water on the Strength of Ringwoodite Spinel
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Beamline: X17C

Introduction: The transition zone between the Earth's upper and lower mantle helps govern the scale of mass and heat transport throughout the Earth. Low-pressure experiments suggest that the presence of water may influence the rheology of this region. Here we examine how the presence of small amounts of water affects the high pressure strength of a key transition zone material, ringwoodite spinel (Mg_2SiO_4).
Methods and Materials: A small piece (50μm x 50μm x 20 μm) of OH-bearing polycrystalline ringwoodite was loaded in the diamond anvil cell within a Be gasket. A radial x-ray diffraction geometry was used to collect x-ray diffraction patterns at different angles with respect to the principal stress directions by rotating the diamond cell about the axis defined by the incoming x-ray beam and the diamond cell loading direction [1,2].
Results: Hydrous ringwoodite supports a shear stress of 2 to 4 GPa in the pressure range of 5 to 15 GPa, representing a 50% decrease over the strength of anhydrous ringwoodite (Figure 1). Both hydrous and anhydrous ringwoodite show a small, positive elastic anisotropy (Figure 2). In addition, significant lattice-preferred orientation was induced in the hydrous ringwoodite as pressure was increased, such that above 15 GPa, most of the intensity was lost at most angles. The anhydrous ringwoodite, on the other hand, showed no evidence of preferred orientation as pressure was increased. This suggests the possibility that the presence of deformed hydrous minerals in the lower mantle may be detected seismically.

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References:
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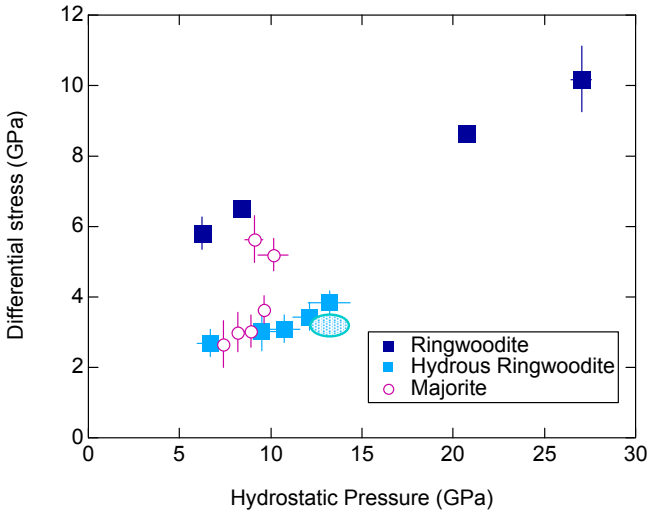

Figure 1. Room temperature strength of mantle minerals: ringwoodite [3], hydrous ringwoodite, and majorite [4]

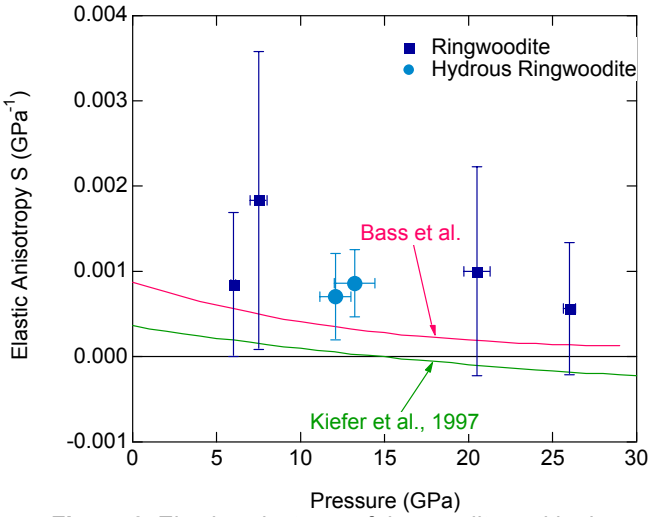

Figure 2. Elastic anisotropy of ringwoodite and hydrous ringwoodite at high pressure.