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The influence of water on the Peierls stress of olivine at high pressures

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To investigate the influence of water on the low-temperature plasticity of olivine under lithospheric conditions, we carried out a series of creep experiments on polycrystalline olivine at high pressures ($\sim$6 GPa), relatively low temperatures ($873 \leq T \leq 1173$ K), and hydrous conditions using a deformation-DIA. Samples were fabricated from fine powdered San Carlos olivine under hydrous conditions. In the experiments, a sample column composed of a sample and alumina pistons was assembled with a talc sleeve and graphite resistance heater into a 6.2-mm edge length cubic pressure medium. Experiments were carried out at the National Synchrotron Light Source at Brookhaven National Laboratory. In a run, differential stress and sample displacement were monitored in-situ using synchrotron x-ray diffraction and radiography, respectively. The low-temperature plasticity of olivine under hydrous conditions is constrained by our data with a Peierls stress of 4.2 ± 0.3 GPa. This value is much lower than those reported the Peierls stress for olivine under anhydrous conditions ($\sim$ 6 – 15 GPa, Evans and Goetze, 1979; Raterron et al., 2004; Mei at al., 2010), indicating a significant influence of water on the low-temperature plasticity of olivine. The low-temperature flow behavior of olivine under hydrous conditions quantified in this study provides a necessary constraint for modeling the dynamic activities occurring within lithospheric mantle especially for those regions with the presence of water such as beneath a mid-ocean ridge and along a subducting slab.