Rheology of Earth's Interior

Summary

The objective of this proposal is to investigate the strength of olivine, the dominant mineral in the lithospheric mantle, under the relatively low-temperature, high-stress conditions in order to quantify the rheological properties of Earth's lithosphere. While extensive studies have been carried out on the rheological properties of olivine at high temperatures and low differential stresses appropriate for the asthenosphere of the Earth, relatively little is known about the deformation behavior at lithospheric conditions, where flow occurs by mechanisms not sampled in high-temperature experiments. Current flow laws describing deformation under lower temperature, higher stress conditions are based on a very limited set of data. Uncertainties are very large. Furthermore, the influence of water on the low-temperature plasticity of olivine has never been systematically studied. Important unresolved issues in geodynamics demand a better understanding of the rheological strength of lithosphere (e.g., what is the relative strength of crust and lithospheric mantle?; what role does lithospheric strength play at convergent plate margins?). Therefore, we propose here to use the deformation-DIA (D-DIA), an apparatus designed for conducting deformation experiments at high pressures, to carry out deformation experiments of olivine at low temperatures. Specifically, we will perform a series of experiments on polycrystalline samples of olivine in a D-DIA at temperatures between 673 and 1273 K and confining pressures of 6 to 12 GPa under both hydrous and anhydrous conditions. D-DIA experiments will be carried out at a synchrotron x-ray beam line, which provides the technology needed for measurement of pressure, differential stress, and sample displacement in deformation tests. With our extensive experience in investigating rheological properties of rocks and minerals combined with specific experience over the past several years with the D-DIA and high-pressure deformation techniques, we propose to make measurements for the purpose of developing a flow law appropriate for the lithospheric mantle. 04.