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NSF Award Abstract - #0405709

Collaborative Research: Rheology of Altered Oceanic Lithosphere

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Abstract

The rheology of altered oceanic lithosphere, and its evolution during subduction, plays an important role in numerous processes. The interpretation of thermal models for subduction zones, a goal of the MARGINS Subduction Factory initiative, depends on good constraints for both the strength of the down-going slab and the slab-wedge interface. Both of these physical properties may be controlled by the rheology of serpentine. The increase in pressure and temperature of the slab during subduction induces the dehydration of serpentine, releasing water to the surrounding environment, at depths greater than 50-100 km. These dehydration reactions are invoked to explain the double-seismic zone observed in some subduction zones, and the occurrence of intermediate depth seismic events (50-300 km). The released water can also be incorporated in the mantle wedge above the slab, promoting further serpentinization of part of the overlying mantle, or inducing melt production under the volcanic arc, depending on P-T conditions and the geometry of the subduction zone and mantle wedge. To understand the distribution of earthquakes in subduction zones it is important to constrain the rheological properties of altered lithosphere, how they evolve during dehydration reactions, the rheology of reaction products, and the feedbacks between metamorphic reactions and transport properties of the down-going slab. All of these issues are being explored as part of the MARGINS Seismogenic Zone initiative.

Deformation experiments are being conducted on serpentinites, talc, and fine-grained olivine aggregates at high pressure and temperature. The experiments are designed to: (1) Determine the strength and mode of deformation of serpentinites at high pressure and temperature, to further characterize the conditions of the transition from brittle to plastic deformation, and to measure for the first time the plastic rheology of antigorite if this regime is obtained in the laboratory. These data provide important constraints needed to understand the end-member mechanical aspects of deformation of altered lithosphere and fluid transport in serpentinites. (2) Study the feedbacks between permeability, reaction progress and rheology during dehydration of serpentinites to constrain conditions where reaction induced seismicity may occur. (3) Constrain the rheological properties of the fine-grained reaction products (olivine+talc+water) of dehydration reactions. This experimental work provides insights on the fate and transport of water released during dehydration of serpentine, on the relationship between dehydration and seismicity, and on the changes in rheology associated with phase changes during subduction.

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