Implications of talc and dehydrating serpentinite rheology at HP-HT for subduction zone dynamics

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Subduction zones are the cold boundary of mantle convection, in which the shear zone at the interface between the descending slab and the mantle wedge accommodates most of the strain. Therefore the rheology of materials at this interface is likely to govern dynamics and evolution of subduction zones, including their initiation. Fluids released by subducting slabs hydrate peridotites within the mantle wedge, and can form talc and serpentine in significant quantities (1). These phyllosilicates have an exceptionally low strength at shallow levels of subduction zones.

Flow laws of phyllosilicates are critical for numerical modeling of subduction zone dynamics and force balance within the wedge; however, only few experimental data are available on the rheology of these materials at pressures relevant to intermediate depths (50 - 250 km) (2, 3). Extrapolation of low pressure measurements to high pressure may be hazardous because different deformation mechanisms are involved. Advances in high-pressure - high-temperature (HP-HT) deformation apparatuses coupled with synchrotron light (4) now allow in-situ investigation of the rheology of these phases within and outside of their stability fields. Deformation experiments on antigorite, the serpentine variety present at depths within subduction zones, showed that its low strength at HP can strongly localize deformation at the slab interface, and thereby could modify the mantle wedge convection, heat fluxes and seismic anisotropy (2). Antigorite viscous relaxation may also govern silent earthquakes that release elastic energy in subduction zones.

We will present the latest results from HP-HT deformation experiments on talc and talc-bearing assemblages produced by dehydrating antigorite, conducted at GSE-CARS (APS sector 13) with the D-DIA (4) apparatus. Strain and stress were measured in-situ using monochromatic X-ray imaging and X-ray diffraction (XRD), respectively. Stress-strain data were obtained between appx. 2 to 5 GPa and 300 to 700 C, at strain rates between 7.10-5 s-1 to 2.10-6 s-1, and on dehydrating serpentine around 4 GPa and 10-5 s-1.

Preliminary results suggest that within the conditions investigated the behavior of talc is not strongly dependent on strain rate and temperature, and that antigorite dehydration products are weaker than antigorite and talc. Antigorite dehydration rate is ~5 times slower under deformation at these strain rates, compared to static dehydration by (5). This has major implications for water transfer within fast deforming shear zones at the slab-mantle interface and within the slab, compared to water transfer in the slower deforming mantle wedge.

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