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The rheology of altered oceanic lithosphere

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The rheology of altered oceanic lithosphere, and its evolution during dehydration reactions plays an important role in numerous subduction processes. The interpretation of thermal models for subduction zones 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 alteration products of peridotite, such as serpentine and talc. 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. Constraints on the rheological properties of alteration products of oceanic mantle are also important for understanding the strength of faults during flexural deformation in the fore-arc. Experiments on dehydrated serpentinites indicate that a significant portion of the weakening may occur owing to differences in the rheology of serpentine and the fine-grained olivine produced during the reaction [e.g., Rutter and Brodie, 1988]. However, extrapolation of olivine flow laws appears to contradict this interpretation. We have conducted suites of experiments on talc aggregates at temperatures up to 600oC and confining pressures up to 400 MPa. Similar to serpentinite, talc aggregates exhibit a nominally non-dilatant style of brittle deformation. Deformation localizes on parallel and cross cutting shear zones that form ~45° from the shortening direction. Strain remains localized at the highest temperatures and pressures tested, despite the fact that sample strength is considerably lower than the applied confining pressure. The coefficient of friction deduced from differential stress during stable sliding varies between 0.12 and 0.26. Microstructural observations indicate that the physical properties of talc are influenced by the weakness of the (001) plane during both brittle and plastic deformation. These results demonstrate that even small amounts of talc - a reaction product from dehydration of serpentine - may strongly influence the rheological properties of the subducted slab.