Rheological constraints on the fate of subducted oceanic crust in the mantle

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Garnet and olivine are two minerals that are representative of two most important geochemical reservoirs of Earth's upper mantle. Garnet is the major mineral in the silica-rich, less depleted component (e.g., subducted oceanic crust), whereas olivine is the major mineral in the depleted component. The geodynamic behavior of such geochemically distinct reservoirs is largely controlled by the contrasts in density and viscosity with the surrounding mantle rocks. Although the density contrasts between these two components have been systematically investigated (e.g., Ringwood and Irifune, 1988), not much in known about the rheological contrast. Previous studies emphasized the high strength of garnet (Karato et al. 1995), but nothing was known about the influence of water. We have carried out laboratory experiments to determine the rheological contrast between garnet and olivine as a function of water fugacity. We found that the rheological contrast is sensitive to water content. Garnet (Mg-rich) will have similar strength with olivine under water-rich environment, whereas it is stronger than olivine under water-poor environment. This suggests that the separation of subducted crust in the deep upper mantle is possible when the oceanic crust is relatively water-poor, whereas the separation will not occur when it has a high water content.