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Newtonian flow of anorthite-diopside aggregates

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We have performed coaxial and torsion deformation of fine-grained (< 5 μm) synthetic anorthite-diopside aggregates at 950 ˚C - 1200˚C, 200 MPa - 400 MPa confining pressures and 5 MPa - 500 MPa flow stresses. We specifically addressed the effect of traces of water and the effect of shear strains up to ~ 5.

We found that Newtonian regime dominated with a stress exponent n = 1.0 $\pm$ 0.2. Increasing water content and confining pressure induces a gradual decrease in activation energy from Q = 570 $\pm$ 34 kJ/mol for nominally dry samples ($\sim$ 0.005 $\pm$ 0.002 wt.% H_2O) down to $\sim$ 279 $\pm$ 48 kJ/mol for samples containing $\sim$ 0.075 $\pm$ 0.25 wt.% H_2O.

The macroscopic flow laws derived from torsion and from coaxial deformation are comparable. However, the microstructures substantially evolved with strain. Starting samples and little strained samples contain numerous large single-phases clusters. Conversely, in highly strained samples the clusters are completely desegregated indicating mechanical phase mixing. In addition, highly strained samples also show cavitation and cavitation coalescence. Newtonian flow, mechanical phase mixing and cavitation coalescence are evidences for grain boundary sliding mechanisms. However, we also observed that the densities of dislocations, dislocation arrays and subgrains increase with strain. We suggest that at low strain grain boundary sliding is efficiently accommodated by grain boundary diffusion, but at high strain grain boundary dislocations contribute to the accommodation mechanism. Based on our data, we support Newtonian rheology as characteristic of ultramylonites in the lower crust.