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Strain localization and ductile failure of mixed and layered anorthite-diopside aggregates

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Strain localization in rocks at high temperatures and pressures depends on mineral composition and distribution of phases. To study the mechanical effect of varying phase distribution on strength and strain partitioning, we deformed synthetic fine-grained anorthite-diopside aggregates composed of either homogeneous mixtures or layered composites in high-strain torsion experiments at high temperatures and pressures. The results help to constrain the mechanical behavior of ultramylonites from high temperature shear zones.

Starting materials were fine-grained as-is glass-powders of anorthite (An) and diopside (Di), first cold-pressed at 150 MPa axial pressure and subsequently hot-isostatically pressed at 300 MPa pressure and 1100˚C temperature. To fabricate homogeneous mixtures we mixed 50vol% of An and Di powder in alcohol. Layered composites were manufactured by cold-pressing 2-3 alternating layers of An and Di with $\approx$ 1.5-3 mm thickness. Mean grain size is about 3 μm. Average water content is about 0.1wt% H_2O. A total of 8 homogeneous and 11 layered cylindrical samples of 10 mm in diameter and length between 3.5 and 9 mm were twisted in torsion at 400 MPa confining pressure and temperatures of 950-1100˚C using a Paterson-type deformation apparatus.

Most specimens were deformed at constant twist rate such that constant bulk shear strain rate is achieved for the different aggregates. Few samples were also deformed at constant torque. Resulting shear stresses are below 130 MPa. Creep behavior is linear viscous at stresses below about 80 MPa. At low shear strain rate ($\approx$2x10^{-5}s^{-1}) and temperatures above 950˚C samples exhibited continuous hardening, possibly owing to dilatancy and grain growth. At temperatures less than 1100˚C the strength of homo-

geneous mixtures is higher than that of layered aggregates (and of pure An). Strain in layered samples is partitioned into An-layers, which are weaker than Di-layers at $T < 1100^{\circ}C$, but no phase mixing occurred at the boundaries. Two-phase mixtures show pronounced strain localization at low stresses, likely due to inhomogeneous phase distribution, porosity, and grain size. Mixtures (and pure An) deformed at low T and all layered samples failed abruptly at shear strains of 1.3 - 6.7. Ductile failure occurred by nucleation, growth, and coalescence of cavities related to grain boundary sliding.