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Finite element simulations of the deformation mechanisms of two-phase silicate aggregates subjected to large shear

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Synthetic aggregates of diopside-anorthite have been prepared by hot isostatic pressing in order to produce specimens with a controlled microstructure: a fine grained matrix (<5μm) of anorthite containing coarser diopside inclusions (< 45 μm). The specimens are subjected to torsion at T= 1000 to 1200 °C, confining pressure of 400 MPa and constant twist rates up to large shears. SEM (scanning electron microscope) observations have been made to characterize the microstructure. Samples exhibited Newtonian flow (stress exponent n=1). The fine grained matrix also showed evidences of grain boundary sliding (GBS) mechanisms, such as cavitation coalescence leading to microcracking and ductile failure. However, we have also identified substantial local stress enhancement and localized dislocation creep in the vicinity of the diopside inclusions. These observations provide data for modeling the deformation of the samples using a finite element code which accounts for the rheology of the constituents. Several models can be implemented, from linear elasticity to elasto-viscoplasticity. A few representative volume elements (RVE) are chosen for which the local distributions of strains and stresses are computed incrementally. One studies in particular the influence of the shapes of the inclusions on the local fields and also the interactions between neighboring inclusions. The stress concentrations which may thus appear in the structure can lead to local damage and other local deformation mechanisms, in addition to GBS (e.g. twinning, dislocation creep, grain refinement).