Microstructural change and mechanical properties of experimentally deformed partially molten aggregates

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An experimental study was performed to investigate the effects of deviatoric stress on the microstructure of partially molten polycrystalline aggregates. Borneol (organic crystal) + melt system having an eutectic temperature of 43^oC and a moderate dihedral angle (about 20 degrees) was used as a partially molten rock analogue. Large samples (70mm cube) having a melt fraction of 0.089-0.22 were deformed ductilely under a uniform pure shear stress (shear strain rate = about 10^-7 s^-1), while monitoring the sample microstructure in situ using ultrasonic shear waves. Each sample was deformed repeatedly by changing the principal stress direction, resulting in the microstructural changes well detectable under the microscope. The most remarkable features of the stress and/or deformation-induced microstructural changes are significantlly enhanced grain-boundary wetting, significantly enhanced grain coarsening and a formation of large (sample scale) melt sheet in the direction of the shear plane, whose microscopic view is an assembly of completely wette two-grain boundaries. Changes in the elastic, anelastic, and viscous properties associated with these microstructural changes were measured quantitatively. Detailed quantitative analyses of both equilibrium and dynamic microstructures were performed through measurements of grain size, grain aspect ratio, and grain-boundary contiguity. Also, the microstructural effects on the bulk mechanical properties were investigated quantitatively through application of existing models clarifying the relationships between contiguity and the bulk mechanical properties. The microstructural changes observed in this study have many similarities with the `dynamic wetting' reported for the partially molten peridotite [Jin et al., 1994].