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A Semianalytical, three dimensional model of microstructure in multiparticle, multiphase flow

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The microstructure of a partially molten rock is determined by melt volume fraction and contiguity, the fractional area of intergranular contact. Various physical properties of a grain-melt system, such as the effective elastic moduli and seismic velocities, depend on the melt microstructure. In this study, a three dimensional, semianalytical model is developed to investigate the way the microstructure varies with perturbations in the surface tension along grain-grain and grain-melt contacts. The variation of surface tension excites a viscous flow in the interior of the grains, as well as the melt, and controls the steady-state shape of the grain and microstructure of the aggregate. The output of the model is analyzed to calculate the contiguity, melt volume fraction, and dihedral angle for the system. The measurement of contiguity and melt volume fraction allow for the calculation of the effective elastic moduli and seismic velocities, while dihedral angle measurements are used to compare our results with previous studies. The variation in contiguity reflects large variations in the corresponding seismic signature. When extrapolated to the conditions similar to Earth's core-mantle boundary, the results indicate that a relatively modest amount of melting can explain the presence of the observed ultralow velocity zones.