

Saswata Hier-Majumder, Perry H. Leo, David L. Kohlstedt

May 17, 2004

Abstract

In this work, we analyze wetting of grain boundaries in a polycrystalline aggregate by fluid in triple grain junctions in response to an applied shear stress. We evaluate the local stress concentrations near fluid-filled triple grain junctions and along the grain boundaries. The fluid pressure at the solid-fluid interface is evaluated in terms of the local stress concentration and the solid-solid and solid-fluid interfacial energies. In this model, the applied stress results in a pressure gradient within the volume of the fluid, which drives the pore fluid down the pressure gradient. We also discuss the coupling between the rate of relaxation of normal stress by diffusion along the grain boundaries and the velocity of fluid penetration along grain boundaries, as well as the extent to which wetting of grain boundaries is controlled by both diffusive stress relaxation and wetting. In this formulation, we define the non-dimensional fluid mobility number β . For systems with low values of β , stress relaxes entirely by diffusive transport without wetting. For systems with high values of β , partial to complete wetting of grain boundaries is achieved, depending on the net interfacial energy at the tip of the fluid.

The results from our numerical experiments indicate that fluid is expelled from the boundaries under localized compressive normal stress and penetrates into the boundaries under localized tensile normal stress to relax the stress. As a result, a pore fluid network of tubules along grain edges transforms into a network of fluid planes along grain boundaries, altering the permeability of the aggregate. Such a coupling between the stress tensor and the permeability tensor in deforming polycrystalline solid-fluid aggregates needs to be further investigated in order to model fluid segregation and demixing in the planetary interiors.