

On the process of dihedral angle change

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Interstitial phases in igneous rocks commonly pseudomorph the residual porosity, with shapes inherited from melt-filled pores. The inherited angle at pore junctions may reflect either an impingement texture (e.g. Elliot *et al.*, 1997) or melt-present textural equilibrium. Since these are lower (median < 60°) than solid-state equilibrium values (~ 120°), such pseudomorphs are out of textural equilibrium. The solid-state texture will thus move towards one of larger dihedral angle. Interstitial clinopyroxene in cumulates from the Rum Layered Series shows variable approach to solid-state textural equilibrium from an initial inherited state. In contrast to the currently accepted model of dihedral angle change, which assumes an instantaneous establishment of the new angle at the pore corner with subsequent outwards propagation of the new surface curvature (Mullins, 1957), textural equilibration at pore corners actually occurs as a continuous process, with a gradual movement of the entire dihedral angle population towards the equilibrium final state. At any instant during this process, the static dihedral angle equation (Herring, 1951) does not hold.

References

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Quartz-H₂O dihedral angles and crystal misorientation

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The physical and chemical properties of deep-seated rocks are strongly influenced by the presence and intergranular geometry of fluids. At equilibrium, the latter is strongly determined by solid-solid interfacial energies.

In order to better understand the role of interfacial energies in determining fluid topology, we developed a new experimental technique for characterizing the 3-D geometry of individual pores. The technique involves introduction of H₂O along synthetic grain boundaries produced in a piston-cylinder apparatus by juxtaposing polished quartz disks at high P and T. H₂O trapped along the interface forms lenticular pores during the experiments as the grains weld together to form a grain boundary. After the experiment, grain boundaries were separated to expose half of each fluid-filled pore on complementary disks. Two advantages of this technique are that the: (1) 3-D pore geometry can be directly measured using atomic force microscopy thus removing effects caused by random sectioning of pores, and (2) solid-solid interfacial energy can be controlled by varying the amount of crystal lattice misorientation (determined by electron backscatter diffraction) between adjacent disks, and thus complementary dihedral angles can be measured as a function of variable lattice coincidence.

Ten synthetic quartz grain boundaries were exposed to pure H₂O over a range of induced crystal misorientations ranging from ~1° to 120° by rotations about the c-axis. It was expected that low-energy grain boundary configurations (e.g. 0° misorientation) would yield high dihedral angles. It was impossible to separate grain boundaries with misorientations <5° because the adjacent disks of quartz grew together to form a single crystal. Surfaces of quartz disks that were misorientated by values >5° yielded a narrow, normal distribution of dihedral angles ranging from 46° to 68° with a median value of 56°±4 (n=246). In natural quartzose rocks it is expected that there exists a large range of misorientations across grain boundaries. However, these results indicate that misorientation values >5° do not contribute to variable grain boundary energy or the spread of observed dihedral angles.