TEXTURAL EQUILIBRIUM IN ANORTHITE MELT SYSTEMS: PRELIMINARY RESULTS. A.B. Finnila, M.J. Rutherford, and P.C. Hess. Department of Geological Sciences Brown University Providence, RI 02912

We've begun an experimental program to determine the wetting characteristics of silicate melts in an anorthite-bearing crystalline matrix. Such data are needed because the physical properties of partially molten rock, for example, their rheology, electrical conductivity or permeability towards melt flow, are critically dependant upon the spatial distribution of melt within a texturally equilibrated rock. Several geologically relevant systems have been tested for their equilibrium melt morphology; olivine-basalt, enstatite liquid, lherzolite, granite, and quartz-albite. (1,2,3,4,5,6) The purpose of these studies was to determine whether the melt morphology was an interconnected network or was relegated to grain junctions leaving melt-free grain boundaries. Either melt morphology was observed in different systems.

There are no experimental data pertaining to rocks containing calcic plagioclase. This is unfortunate because the permeability of partially molten gabbro, norite, troctolite, or even anorthosite are of particular relevance to problems of melt infiltration and migration within the lunar crust.

A system at fixed temperature and pressure containing a single isotropic crystalline phase and a low melt fraction will attempt, by textural adjustments, to minimize the interfacial energy. The energy balance between various interfaces is given by

$$\cos\frac{\theta}{2}=\frac{\sigma_{SS}}{2\sigma_{SL}}$$

where σ_{SS} and σ_{SL} are solid-solid and solid-liquid interfacial energies, respectively and θ is the dihedral angle. If the dihedral angle is $0°< \theta< 60°C$, melt wets all the grain edges and corners but not the flat interfacial surfaces. The melt forms a connected network and the system is permeable even at low melt fractions. If $60° < \theta< 180°C$, the liquid does not wet the grain boundaries but is isolated at grain corners provided that a critical melt volume is not exceeded. The system at low melt fractions is impermeable and under hydrostatic conditions is closed with respect to melt flow.

In principal, then, the needed experimental data is obtained by annealing a small amount of melt with a large mass of finely crystalline anorthite and measuring the dihedral angle. The anorthite system, however, introduces some formidable problems.

1) The development of textural equilibrium is driven by diffusional processes (7), the kinetics of which are given by

$$Z=(Dt)^{\frac{1}{2}}$$

where Z is the characteristic diffusion distance, D the diffusivity and t is the time. If Z is taken as the grain size and $D= 10^{-15} cm^2/sec$ the NaSi-CaAl diffusivity in anorthite at 1400°C, then a 10 micron grain requires about 30 years to reach textural equilibrium! Since the flat interfacial regions are dry even if $\theta <60°C$, it is clear that textural equilibrium will be governed largely by solid state diffusional processes. Systems with a large volume of melt to anorthite will induce solution-precipitation processes, however, and thereby hasten the kinetics of grain boundary adjustments.

2) Anorthite is not isotropic and we expect that the surface energy is also highly anisotropic, thereby causing the wetting behavior of anorthite to be anisotropic. This will cause a range of true dihedral angles to the extent that certain favorably oriented grain boundaries will not be wetted whereas others might be. A distribution of true dihedral angles can be recognized by comparing theoretical and measured values (8).

Our experiments run at temperatures at or below 1370°C show very little anorthite recrystallization and textural equilibrium was not achieved within a period of 6 days, regardless of melt composition or melt fraction. We have annealed, varying quantities of KREEP-like basalt with 2-20μm size anorthite crystals at 1400°C for 6 days (in addition to 3 days at 1100°C) and obtained significant textural changes. At high melt fractions, the anorthite crystals increased in size by one order of magnitude with length:width ratios of approximately 2.5. These textures are currently being analyzed to determine the characteristic dihedral angle; preliminary measurements show a range between 30°-120° degrees. The true dihedral angle will have to be determined statistically using the methods described by (4) and (8). We also added various quantities of $MgSiO_3$ to anorthite and annealed these for periods up to 8 days at temperatures ranging from 1320°C-1450°C. Promising results were obtained from an experiment held at 1450°C for 6 days with a 5% $MgSiO_3$ melt fraction. The textures again approach equilibrium with increased crystal size. The length to width ratio of the crystals in this experiment is 3.8.

We also plan a new series of experiments in the Mg_2SiO_4-SiO_2-$CaAl_2Si_2O_2$ system. Olivine-rich bulk composition will be melted at about 1300°C to obtain an olivine-anorthite-melt assemblage. Since the melt must initially occur along anorthite-bounded junctions, the distribution of melt in texturally equilibrated troctolite will indicate the relative values of surface energies. If the equilibrated melt exists only on olivine grain boundaries, it will be clear that anorthite-melt surface energies are high and the melt does not wet anorthite. If melt is distributed at anorthite and olivine grain boundaries, it will be necessary to measure the value of dihedral angles to establish the wetting systematics. It is hoped that the kinetics of grain boundary adjustments will be enhanced by the necessity of melting a large fraction of the original anorthite crystals in the system.

1) Waff, H.S. and Bulau, J.R. (1982) Adv. Earth Plnt Sci, 12, 229-236. 2) Cooper, R.F. and Kohlstedt, D.L. (1982) Adv Earth Plnt Sci, 12, 217-228. 3) Cooper, R.F. (1990) JGR 95, 6979-6992. 4) Toramaru, A and Fuji, N. (1986) JGR 91, 9239-9252. 5) Jurewicz, S.R. and Watson, E.B. (1985) Geoch. Cosmo. Acta 49, 1109-1121. 6) Jurewicz, S.R. and Watson, E.B (1984) Contrib. Mineral Petrol 85, 25-29. 7) Cooper, R.F. and Kohlstedt, D.L. (1986) JGR 91, 9315-9323. 8) Jurewicz, S.R. and Jurewicz, A.J.G. (1986) JGR 91, 9277-9282.