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TEXTURAL EVOLUTION OF PARTIALLY-MOLTEN PLANETARY MATERIALS IN MICROGRAVITY

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Scientific Rationale

Recent Earth-based experiments examining the textural evolution of partially-molten rocks have revealed two important ways in which surface energy considerations affect magma evolution. First, it is now clear that there exists a specific melt fraction (3-5% for partially-molten peridotite) that represents a bulk-system minimum in surface energy: In the absence of physical forces, this melt fraction stably persists along grain edges in a continuous, 3-dimensional network.

Secondly, in systems of initially free-floating grains, surface energy reduction may be achieved by welding together of like grains. In experiments on Earth, this process is drastically accelerated by gravitational settling of the generally denser mineral grains, which promotes grain-to-grain contact and eventual welding to form a continuous mat of crystals at the bottom of the crucible, from which most of the melt is expelled.

In microgravity environments, surface energy effects will also operate. The key point is that in low-g the surface energy effects will not be modified by gravitational considerations. Because of the energy gained by wetting of grain edges in a partially-molten rock, it may be impossible in the near-absence of gravity to extract small amounts of partial melt. Under circumstances of high melt fraction, initially dispersed crystals will make only random contact with one another; so the process of grain-to-grain welding will be slowed, perhaps giving way to some extent to grain coarsening.

For the reasons noted above, the evolution of partially-molten systems in low-g environments can be expected to be quite different from that occurring on Earth. Actual experimentation with systems experiencing low gravity is clearly needed, however, in order to appreciate fully the differences. The results of such experiments have direct applications to the magmatic evolution of small planetary bodies (and to the Earth as well in regions where neutral buoyance of crystals might occur); microgravity experiments would also provide a firm basis for interpreting the textures of such enigmatic meteorites as pallasites.

Experiments

An initial experimental program addressing surface-energy effects on partially-molten materials in microgravity would involve simple, isothermal treatment of natural samples (meteorites, peridotitic komatiite) at preselected temperatures in the melting range. Textural evolution would be assessed by time studies in which the only experiment variable would be run duration. Textural characterization of each sample would be done by quenching, recovery, and sectioning for generally later, computer-aided interpretation of features.

Requirements

A furnace capable of:

- temperature to 1800°C and control to ± 3° over entire sample

- controlled oxygen fugacity
- accommodating a 1 cubic centimeter sample
- experiment durations up to 1 month
- rapid sample quench (200^{o} - $500^{o}C$/sec)

Highly-desirable support facilities would include a scanning electron microscope with energy-dispersive analytical capability and and on-board sample sectioning/polishing capability.