The Equation of State of Silicate Melts at Lower Mantle Pressure

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Understanding the density of silicate melts at pressures above ~100 GPa is essential for describing the evolution of early terrestrial magma oceans and for interpreting the state of the modern core mantle boundary (and for deciding whether there is any connection between them). Unfortunately, the critical quantity is not so much the absolute density of melts, which can be modeled or measured to within a few percent, but the density *difference* between melts and their coexisting solids, which requires substantially better precision. This is a complex question involving multicomponent phase equilibria (to identify which solids are stable in a given liquid at particular conditions), partitioning (to distribute light and dense elements between phases), and high-precision densities of both melts and solids in a multidimensional, evolving pressure-temperature-composition space. The question is sufficiently complex that the latest computational, thermodynamic, and experimental efforts to define sink/float relations on the magma ocean liquidus do not agree, and further refinement involving cooperation among practitioners of these various methods is needed.

Talks in this session are likely to discuss a variety of experimental and computational efforts to constrain the structure, dynamics, and properties of melts. In this keynote, I will focus on the shock wave approach to silicate lqiuid equations of state developed in the 1980s for upper mantle pressure and extended more recently to all mantle pressures. Shock compression is uniquely suited to study liquids at high pressure because it provides absolute measurements of pressure and density without reference to calibrated pressure scales or diffraction. However, it provides data along the Hugoniot, a P-T curve that rises steeply and lies well above even magma ocean geotherms at lower mantle pressure. Accurate thermal pressure corrections are possible in energy space, because the shock experiments define the Grüneisen parameter. But to express density at a given temeprature requires knowing the heat capacity, which is complicated, or measuring shock temperature. Our latest efforts are focused on achieving high-precision absolute temperature measurements in shocked silicate melts in order to define the heat capacity and allow the shock wave-based equation of state to be confidently applied to crystal/liquid buoyancy questions at actual lower mantle liquidus and solidus temperatures.