Numerical Simulations of High Pressure Falling Sphere Experiments.

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The physical properties of silicate melts are studied because they control numerous differentiation processes. Specifically, silicate melt viscosity and density control crystal growth kinetics, crystal settling and suspension, fractional crystallization and melt convection dynamics. These differentiation processes facilitate fractionation and ultimately influence the mantle's evolution and the petrology observed at the Earth's surface. There are many methods to determine density and viscosity of silicate melts at 1 atm. At high pressures, however, the viscosities of geologically relevant melts are widely determined experimentally using the falling sphere technique based on Stokes' Law. Density may also be determined through this method. Stokes' Law assumes that a rigid sphere falls slowly and steadily through a stationary and infinite Newtonian medium of uniform properties. High-pressure falling sphere experiments however, usually involve a dense refractory sphere falling through a liquid contained by a cylindrical capsule of finite size. The sphere velocity is influenced by the walls and the ends of the capsule, and possible convective motion of the fluid. We have used GALE to assess the limitations and assumptions of the high-pressure experiments by numerically simulating the conditions of these laboratory experiments. Models were set up to investigate the effects of the capsule's walls and ends (Figure 1), non-centered sphere trajectories (Figure 2), the presence of multiple spheres, varied cell geometries reflecting laboratory experimental innovations, and the consequences of thermal gradients on the sphere's velocity and trajectory.

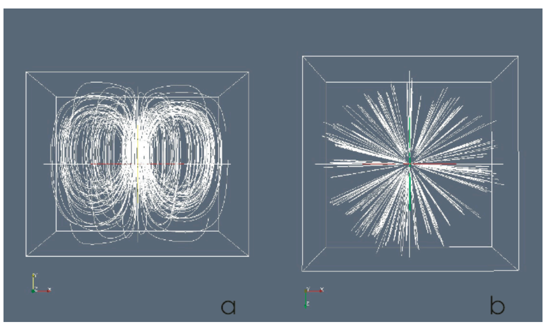

Figure 1a Streamlines of a 150 μm sphere falling along the central y-axis of a cylinder, viewed from z-axis.

Figure 1b Streamlines of a 150 μm sphere falling along the central y-axis of a cylinder, viewed from top of cylinder, down the y-axis.

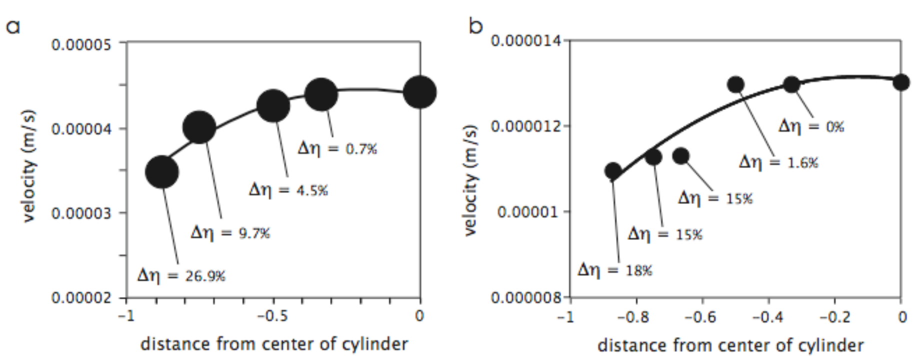

Figure 2a
Velocities of 100 μm spheres falling at various distances form the central y-axis of a cylinder.

Figure 2b
Velocities of 50 μm spheres falling at various distances form the central y-axis of a cylinder.

Reference: O'Dwyer L. Kellogg L.H., Lesher C.E. (2007), Numerical Simulations of Falling Sphere Viscometry Experiments, Eos Trans. AGU, 88(52), Fall Meet. Suppl., Abstract MR13A-1257.