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The fluid dynamics of xenocryst formation in mafic enclaves

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Mafic enclaves produced by the mingling of felsic and mafic magmas commonly contain xenocrysts; crystals akin to those in the felsic host. These crystals are interpreted as having crossed the interface between the two magmas at some stage during the rock evolution. An understanding of the physical conditions that allow this exchange would give insight into the state of the system at the time of assimilation, providing information about the magmatic history of the rock. Using both numerical models and analogue experiments, the low Reynolds number gravitational settling of spheres on to fluid-fluid interfaces is studied as an analogue to this problem.

Theoretical treatment suggests that whether or not a particle sinks or floats at an interface depends on four dimensionless parameters; Bond number, the viscosity ratio, a modified density ratio and the contact angle. Spheres are allowed to settle onto an interface for different values of the dimensionless groups and the behavioural regime boundaries are determined. Experimentally this consists of dropping spheres of varying radii and density onto an interface between two density stratified fluids (silicon oil and polyethylene glycol solution), both of which are lighter than the sphere. The spheres are sputter coated in gold to ensure a constant surface interaction. The numerical models are used to validate these results and apply them in geologic settings. Early results suggest that the presence of even a small interfacial tension between the two magmas is sufficient to inhibit the passage of crystals across interfaces in magmatic systems.

An interesting feature of note in mafic enclaves is that the xenocrysts often occur in clusters. This can be compared with observations from the analogue experiments where 6mm nylon spheres were dropped onto the fluid interface. Although the spheres are light and small enough to individually be supported by the interface, the successive addition of spheres leads to the formation of an aggregate which, upon reaching a critical size or mass, sinks through the interface.