Magma chambers: Convection with spherical particles

Jan Verhoeven and Jörg Schmalzl

Abstract:

The dynamics of a convective magma chamber is driven by the presence of different concentrations of crystals and temperature gradients of the fluid. Crystal settling occurs because crystals are heavier than the fluid, leading to differentiation and layer formation. With our numerical model we investigate the characteristics of the crystals and want to find out whether they remain suspended or start to build a layered structure on the ground withing the convective lifetime of a magma chamber.

We present a newly developed algorithm that is a combination of a convection model by Trompert and Hansen and the Discrete Element Model (DEM) that describes the movement and acting forces in granular material. The interaction between the solid particles and the fluid is described on one hand by Stokes' law that influences particle movement and on the other hand by a particle concentration field that describes density variations in the fluid due to the presence of particles. The algorithm enables us to study crystal settling in non-dilute convective suspensions which are typical for magma chambers. The characteristics of settling are mainly controlled by the following two parameters: Rayleigh number and chemical Rayleigh number.

First results indicate that particles can influence convection in magma chambers considerably. We present an example of the behavior of a fluid that is cooled from above and heated from below with 2000 particles homogeneously placed in the whole area. The total number of sedimented particles is recorded over time. The settling velocity that is dependent on time can give hints whether the convection is driven by the particle concentration differences or by the temperature gradients.