Geophysical Research Abstracts, Vol. 7, 08401, 2005
SRef-ID: 1607-7962/gra/EGU05-A-08401

Metal droplets settling in a terrestrial magma ocean

T. Höink, J. Schmalzl and U. Hansen
Institut für Geophysik, Westfälische Wilhelms-Universität Münster, Germany

Most planetary formation models for Earth suggest one or more giant impacts during its accretion period. A mars-sized body impacting onto proto-Earth causes substantial melting. This leads to the formation of a magma ocean. Metal becomes finely dispersed as small droplets, even for already differentiated impactors. The stable droplet diameter is estimated to be ~ 1 cm, which is very small compared to the estimated depth of a magma ocean. While the droplets settle towards the bottom of the magma ocean they chemically equilibrate with the surrounding silicate.

This model explains the observed concentrations of siderophile elements in the mantle using a simple kinetic model for droplets settling in the magma ocean. However, parameter estimates place the extreme conditions of an early terrestrial magma ocean into the regime of hard turbulence under strong rotation.

Our objective is to investigate metal droplets settling in a magma ocean scenario. We recently developed a settling algorithm for the numerical study of finite-sized droplet settling in non-dilute suspensions. We have implemented this algorithm into a 2D and a 3D numerical convection model. Our approach considers a consistent settling velocity and the density contribution due to metal droplets.

In two dimensional simulations we vary the buoyancy ratio B, which is the ratio of the density variation due to metal droplets to the thermal density variation, for five different Rayleigh numbers, covering a range of four orders of magnitude. We find B to be a critical parameter and its critical value to depend on the Rayleigh number. The three dimensional simulations are used to consider the effect of rotation. We vary the relative strength of the Coriolis force compared to the buoyancy force. We also vary the overall buoyancy force.

Two scenarios can be found: suspension (where metal is entrained indefinitely) and layering (where metal is delivered downwards). Only one of the scenarios (layering) agrees with the fact that Earth developed a core. This scenario is characterized by the formation of a droplet-free top layer that grows over time. The flow is forced into two convection cells with only little vertical flux across their horizontal interface. This results in a lowered Nusselt number. The system develops a stable stratification with a metal-depleted top layer.