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Numerical Verification of the Stokes Velocity for the Settling of Iron Droplets in a Terrestrial Magma Ocean

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The formation of magma oceans on at least the major terrestrial planets is widely assumed even if the full accretion history and early evolution of terrestrial planets is discussed rather controversial. Various processes occur within these magma oceans, among them the settling of small iron drops and their chemical equilibration with the silicate environment. Different models were proposed to explain the differentiation within a magma ocean. In order to model a magma ocean and give constraints about settling time of iron droplets, a constant velocity is used in most models, which is calculated using Stokes' famous formula. Because there is a large number of iron drops to handle, it is impossible so solve the flow around each single iron drop. According to the other model parameters this assumption is invalid, since Stokes' assumption of a creeping flow is violated. We introduce a model, in which the flow around iron drops in a molten silicate environment is computed using the appropriate hydrodynamic equations. We investigate the terminal velocity of a single drop descending through a magma ocean and additionally study the effects of the presence of other obstacles in the neighbourhood. We determine a new mean velocity, which may serve as an input parameter for the existent models of magma oceans. Although we used a full fluid–dynamical approach, the velocity computed with our model is not very different from the simple Stokes case and thus proves that the former assumptions were legitimate and can be used in future as well as the new velocity presented here.