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Influence of giant impactors on the terrestrial core formation

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Knowledge about the mechanism of terrestrial core formation is still poorly understood. Current thinking indicates the importance of giant impacts [e.g. Tonks and Melosh, 1993; Rubie et al., 2003] on this process. However it is not clear whether the impactors will be emulsified [Rubie et al., 2003] or will penetrate on a short timescale to the center of the planet [Dahl, 2005; Stevenson, 2008]. In our model we explore the implications of the second mechanism as until now most numerical models of core formation neglected giant impactors. We perform 2D cylindrical simulations using the code I2ELVIS applying the newly developed "spherical-Cartesian" methodology [Gerya and Yuen, 2007]. The code combines finite differences on a fully staggered rectangular Eulerian grid and Lagrangian marker-in-cell technique for solving momentum, continuity and temperature equations as well as the Poisson equation for gravity potential in a self-gravitating planetary body. In the model the planet is surrounded by a low viscosity, massless fluid ("sticky air") to simulate a free surface [Schmeling et al., 2008]. We apply a temperature- and stress-dependent viscoplastic rheology inside planets ranging from Mars- to Earth-size and include heat release due to radioactive decay, shear and adiabatic heating. As initial condition we use randomly distributed iron diapirs with random sizes in the range 50 to 100 km radius inside the accreting planet, which represent the iron delivered by predifferentiated impactors. Additionally we add a giant impactor into the model. For simplicity we neglect the heating of the planet by the impact itself. Additionally we assume the impactor to be at rest at the beginning of the simulation. A systematic investigation of the influence of giant impactors with varying radius on different-sized planets is being performed.

Results indicate that for Mars-sized bodies a giant impactor can induce due to shear heating effects a runaway differentiation process limited to one hemisphere only. This may have implications for the formation of the Martian crustal dichotomy as the limited release of potential energy on one hemisphere will cause a thermal asymmetry. It would lead to more crust formation on one hemisphere. Therefore results indicate that giant impactors on Earth-sized planets will be probably already predifferentiated. Our observations show that the presence of these giant impactors on Earth-sized planets triggers a fast differentiation of the whole planet as suggested by Ricard et al. [2008]. Even under the above mentioned restrictions, the results indicate that core formation on large terrestrial planets will be dominated by the largest impactors and be a very fast process on a timescale shorter than 0.1 Ma.