CORE OR MANTLE? BREAKUP OF ASTEROID CORES DURING IMPACT IN THE LATE ACCRETION PHASE.

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Introduction: An important question related to the composition of Earth's present day mantle composition is the relatively high concentration of highly siderophile elements (HSE) [1]. However, this could be explained by the addition of metal cores of differentiated asteroids impacting during the late accretion phase [2]. At this time the Earth was most likely covered by a deep magma ocean as a result of the moon forming impact [3]. To better understand to what extent impactor material and in particular the impactor's core mix with the magma ocean more knowledge of the fragmentation and subsequent mixing is required. Are impactors completely dispersed upon the penetration process or do large fragments or the entire core remain more or less intact so that they almost directly settle into Earth's core and do not contribute to the HSE budget of the mantle? Experimental and numerical approaches have been used to answer this in the past [4,5]. To expand on the numerical work, we improved the treatment of fragmentation of impactor material in the Eulerian shock physics code iSALE. We developed and implemented a new method that allows determining the size frequency distribution of the impactor core as a function of different model parameters, such as impactor size, velocity and the magma ocean depth.

Methods: We use the grid-based Eulerian shock physics code iSALE-2D [6,7] to perform simulations of impacts of differentiated impactors into a magma ocean. However, since such codes are primarily optimized to accurately produce large scale features of the impact process, like the size or depth of the resulting crater, artifacts may occur when looking at behavior close to the resolution limit. The fragmentation of the impactor, here we focus on the metal cores, may be considered as a multi-scale process, which causes artifacts if the fragment size is of the order of the grid resolution. To reduce the influence of such resolution-controlled effects, we developed and implemented a new method to improve the fragmentation in our simulations. The idea is to identify when a fragment as a whole or in part approaches the resolution limit and use petrophysical criterions to determine if fragmentation occurs. If it is the case, we replace the material by a particle with size and mass of a given fragment. This particle then represents the fragment for the rest of the simulation.

The setup of our simulations consists of a differentiated impactor hitting a magma ocean target. The radius of the impactor is on the order of hundreds of kilometers and varies between simulations. The impact velocity ranges between 5 and 20 km/s and we assume different depths of the magma ocean.

Results: We analyze the size-frequency distribution of the impactor core fragments for different simulation setups to understand how these parameters influence the fragmentation. The preliminary results show that the impactor core breaks apart quite significantly during impacts. The higher the impact velocity the smaller the average fragment sizes. Larger impactor radii also result in larger fragment sizes. A comparison between simulations with and without the new method also shows that its usage generates significantly more and smaller fragments, which is expected since regular iSALE has the tendency to artificially clump material which results in larger fragments.

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References: [1] Walker R. J. (2009) *Geochemistry* 69:101-125. [2] Wood B. J. et al. (2006) *Nature* 441:825-833. [3] Tonks W. B. et al. (1993) *Journal of Geophysical Research: Planets* 98:5319-5333. [4] Daguen R. et al. (2014) *Earth and Planetary Science Letters* 391:274-287. [5] Kendall J. D. et al. (2016) *Earth and Planetary Science Letters* 448:24-33. [6] Collins. G. S. et al. (2004) *Meteoritics & Planetary Science* 39:217-231. [7] Wünnemann K. et al. (2006) *Icarus* 180:514-527.