DISPERSION OF PLANETESIMAL IRON CORES DURING ACCRETIONAL IMPACTS. J. Kendall[1], and H. J. Melosh[1,2], [1]Physics Department, Purdue University, West Lafayette IN 47907 USA, [2]EAPS Department, Purdue University, West Lafayette IN 47907 USA. (kendallj@purdue.edu)

Introduction: The dispersion of planetesimal iron cores during accretional impacts plays a large role in understanding the Earth's present day mantle and core equilibrium. The abundance of moderately siderophile elements ("iron-loving"; e.g. Co, Ni, W, P) in the Earth's mantle is high compared to chemical separation of metal-silicate at 1 bar [1,2]. A current explanation, proposing chemical equilibration of metal and silicate at high pressures and temperatures, can explain the abundance in the Earth's mantle [3,4,5]. These studies propose equilibrium of liquid silicate and liquid metal at temperatures and pressures found in a deep magma ocean. The formation of magma oceans during late accretion is likely due to large and energetic impacts [6,7]. During late accretion, the bulk of the mass added to an accreting body is from large impactors with diameters on the order of 10 km to 1000 km [8,9,10]. However, it is now believed that most large planetesimals differentiated very early in our solar system's history due to radiogenic heating, primarily from ^{26}Al [9,11,12]. The melting caused by heat released from ^{26}Al allows the metal to separate from the silicate in planetesimals early, three million years before most chondrules [13]. For the case of undifferentiated meteorites, the metal is small, typically less than 1 mm, and chemical diffusion is quick in a silicate magma ocean. For all these reasons, it is important to understand the dispersion of differentiated planetesimals.

Dispersion through Entrainment: Recent models have concluded planetesimal iron cores of 10 km diameter or larger partially emulsify with the magma ocean [14]. If it is less than 10 km then the iron core will sufficiently disperse into centimeter scale fragments through turbulent entrainment and thus rapidly chemically equilibrate with the silicate in the magma ocean [14,15]. This is supported by recent laboratory experiments showing turbulent entrainment sufficiently mixes small planetesimals cores post-impact [16]. However, these studies assume the planetesimal iron core is a concentrated mass post-impact. The model then assumes the concentrated mass settles passively from a zero velocity [14,16].

Impact Process Disperses Iron: After the impact process, the core is not expected to be a concentrated mass. The impact process strips away the silicate mantle of the planetesimal and stretches the iron core. We use here a numerical model to determine how dispersed the iron core is after the impact. It is not possible to model both the scale of the impact (100 km) and the chemical separation (~1 cm). Instead, we propose a stretching model that gives insight to the final state of the iron core post-impact, as it stretches through a volume of mantle silicate larger than its initial diameter.

Methods: We test this by using the iSALE shock physics hydrocode [17,18,19]. Simulations were run for a 200 km diameter impactor of dunite with a differentiated 100 km diameter iron core. The target is chosen as Earth modeled as a half space target of dunite and as a liquid magma ocean. For the equation of state, we used ANEOS. We model vertical and oblique impacts in 3D with a resolution of 5 km. In 2D, the iSALE code uses a cylindrical symmetry to approximate vertical 3D impacts and allows higher resolution. We place Lagrangian tracers in each cell at a distance set by the resolution of the simulation. These tracers allow us to track the location of the iron material during the impact.

Conclusions: We simulated impacts of differentiated planetesimals with an iron core and dunite mantle impacting into a magma ocean of dunite material. For vertical impacts, we see the iron core dispersed into a region much larger than previously shown. Since a vertical impact is unlikely, modeling oblique impacts is important. For oblique impacts, the iron core is dispersed even more along the downrange region. The size and shape of the dispersed region is dependent upon the impactor diameter and impact angle. The dunite mantle is stripped from the impact and the iron is stretched into a region several times its initial diameter. This is larger than previously estimated by the entrainment models. After the impact has dispersed the iron core, the iron will then undergo entrainment and be further dispersed. As a result, we expect impactors on the range of 100 km diameter to be mixed more than previously expected.

References:

[1] Ringwood, A. E. (1966),*GCA* 30: 41–104. [2] Capobianco, C.J. et al. (1993) JGR. 98 5433-5443. [3] Murthy, V.R. (1991) *Science* 253, 303-306. [4] Righter, K. et al. (1997) *PEPI* 100, 115-134. [5] Li, J. et al. (2001) *GCA* 65, 1821-1832. [6] Melosh, H. J. (1990) *Origin of the Earth*, pp. 69–83. [7] Tonks W.B., and Melosh H. J. (1993) *JGR* 98: 5319–5333. [8] Chambers, J. E. (2004) *EPSL* 223, 241-252. [9] Bottke, W. F. et al. (2006) *Nature* 439:821-824. [10] Kokubo, E., and Ida, S. (1998) *Icarus* 131:171-178. [11] Yoshino, T. et. al. (2003) Nature, 422, 154-157. [12] Baker, J. et al. (2005) *Nature* 436: 1127-1131.

[13] Schersten, A. et al. (2006) *EPSL* 241: 530-542. [14] Dahl, T. and Stevenson, D. (2010) EPSL, 295,177-186. [15] Rubie, D. et. al. (2003) EPSL 205, 239-255. [16] Deguen R. et al., (2011) EPSL, 310 303-313. [17] Amsden A. et al. (1980) *LANL Report* LA-8095. [18] Collins G. S. et al. (2004) *Meteoritics & Planet. Sci.*, *39*, 217-231. [19] Wünnemann K. et al. (2006) *Icarus*, **180**, 514-527.