

**TIDAL DISRUPTION OF PRIMORDIAL ASTEROIDS: A NEW PATHWAY FOR METEORITE PETROGENESIS.** E. Asphaug<sup>1</sup>, C. Agnor<sup>1</sup>, J.-M. Petit<sup>2</sup>, A.S. Rivkin<sup>3</sup> and Q. Williams<sup>1</sup>, <sup>1</sup>Earth Sciences Dept., University of California, Santa Cruz CA 95064 USA, asphaug@es.ucsc.edu, <sup>2</sup>CNRS, Obs. de Besancon, BP 1615, Besancon, France F-25010, <sup>3</sup>MIT, Dept. of Earth and Planetary Sciences, 54-418, Cambridge MA 02139 USA

**Introduction:** We evaluate the tidal disruption of planetesimals by planetary embryos from dynamical, geophysical and meteoritical perspectives. It is widely believed that the present population of asteroids (and thus most meteorites) derive from material that survived intense (99.9%) mass depletion in the protoplanetary disk between Earth and Jupiter. According to this scenario, about one in a thousand bodies survived scattering, close encounters and mergers to become the ancestors of the present main belt and the precursors of meteorites. Close tidal encounters with embryos were inevitable.

**Process and Implications:** This “long march” took its toll on the survivors, which begat the present asteroids. The rate at which planetesimals accrete onto planets is comparable to the rate at which planetesimals come inside the Roche limit of a dominant embryo [1]. Specifically, for very weak bodies (rubble piles, or those with half their mass in regolith) and for gravity-dominated bodies of fairly low viscosity ( $v_{\text{lim}} \ll \sqrt{G\rho}^{3/2} R^2 \sim 10^{11}$  poise for 100 km radius), periapsis  $\ll 0.5 R_{\text{roche}}$  results in catastrophic disruption as defined by removal of half the original mass. Note that even partially molten silicate bodies have sufficiently low viscosity to undergo disruptive tidal deformation, especially if water was abundant at this phase of planetary accumulation.

Our dynamical calculations show that a few percent of the surviving primordial asteroids underwent catastrophic tidal disruption during encounters with the transitory main-belt embryos [*c.f.* 2], if a majority were either partially molten or rubble piles during the first  $\sim 3$  Ma. Melting and differentiation of asteroid parent bodies is known to have occurred during this time [3], so planetary mantles may have been ripped from cores in several instances, a process which could even have been relatively common.

Tidal disruption produces a symmetric chain of fragments; comet Shoemaker-Levy 9 was an example. In models of tidal disruption [1], differentiated bodies pull apart into one or more central cores almost devoid of mantle rock, flanked by core-free bodies of diminishing size away from the center. The process need only occur a few times to resolve several dilemmas associated with iron and stony-iron meteorites and their parent bodies.

**Thermodynamics:** Tidal disruption induces pressure-release melting and brings core and mantle material into sudden close association across wide surface area. Silicate and iron mix as the core and deep mantle are brought abruptly (in the course of hours) to low pressure. Melts degas abruptly and generate turbulence. The shock-free disruption and mixing of parent materials can explain highly varying cooling rates within a single taxonomic type, and mantle-removal of classic M-type asteroids such as Psyche and Kleopatra without invoking intense impact bombardment of a sort that would have easily removed Vesta’s crust.

**Results:** We shall present dynamical models showing that this process is likely to have occurred for a significant fraction of the asteroid precursor population, together with detailed hydrodynamical calculations of the process, using SPH with the revised ANEOS equation of state tracking the thermodynamics.

**References:** [1] Asphaug, E. and W. Benz 1996, *Icarus* **121**, 225-248. [2] Morbidelli, A. *et al.* 2000, *MAPS* **35**, 1309-1320. [3] Keil, K. 2000, *P&SS* **48**, 887-903.