METEORITE PARENT BODIES: WHAT CAN THEY TELL US ABOUT THE FORMATION AND EVOLUTION OF THE ASTEROID BELT?

Edward R. D. Scott. Hawai`i Institute of Geophysics and Planetology. University of Hawai`i. Honolulu, HI 96822, USA. Email: escott@hawaii.edu.

Groups of related meteorites provide clues to the numbers and sizes of the meteorite parent bodies and their thermal and impact histories. Combining this information with astronomical and spacecraft observations of the current asteroids and with results from dynamical models allows us to understand better how the asteroids formed and evolved.

Many meteorite and asteroid properties appear consistent with a primordial asteroid belt that was only a few times more massive than the existing belt and was gradually ground down over 4.5 Gyr. For example, the onion-shell model for H chondrites and the survival of Vesta's basaltic surface imply that parent bodies were relatively undisturbed while they were heated and cooled. Most differentiated bodies were relatively small—only 20-200 km across assuming that iron meteorites cooled inside intact differentiated asteroids.

By contrast, the standard model for accreting planets leads naturally to a situation where the initial mass of the asteroid belt was $10^{3\text{-}4}$ times the current mass and included Moon-to-Mars sized protoplanets. Such a model can explain the mass depletion of the belt, the inclined orbits of asteroids, the mixing of diverse types of asteroids, and their size distribution. Protoplanets would have excited the orbits of planetesimals leading to a period of intense collisional evolution until Jupiter reached its current mass and rapidly ejected all but a few lucky survivors, which were decimated during the Late Heavy Bombardment. In this model, the demolition of meteorite parent bodies would have peaked during ^{26}Al heating and subsequent cooling, and to a lesser extent during the LHB. In addition, differentiated asteroids and meteorites may have formed from impact debris generated by protoplanetary collisions.

Meteorites with thermal histories or other properties that appear to require a more massive asteroid belt with an early period of intense bombardment include both chondrites and differentiated meteorites. Protoplanetary collisions have been invoked to form CB chondrites from an impact plume and to allow group IVA irons to cool at diverse rates in a 300 km metallic body. Ureilites formed in a 200 km body that was catastrophically disrupted so that rocks at 1100°C cooled in days. Group IAB and IIE irons are best explained by impact disruption of partly molten bodies to mix chondritic and achondritic clasts and silicate melt with molten metal. Pallasites probably formed in impacts that disrupted differentiated bodies making offspring composed of olivine mantle fragments and molten metallic Fe,Ni from cores. Mesosiderites formed in an impact that scrambled molten Fe,Ni from a core with basalt and other igneous rocks making a 300 km ball of breccia.

Major unsolved problems for the more massive asteroid belt model include the following. How can we understand H chondrite thermal histories and Vesta's intact crust? Why did planetesimal accretion last for 5 Myr? Did protoplanets form throughout the asteroid belt? How did protoplanetary debris accrete in the disk if protoplanets prevented nearby planetesimals from accreting?