Water and ice in asteroids: Connections between asteroid observations and the chondritic meteorite record

observations and the chondritic meteorite record

B. Schmidt[1] and K. Dyl[2]

[1]Georgia Institute of Technology
[2]Curtin University

The mid-outer main belt is rich in possible parent bodies for the water-bearing carbonaceous chondrites, given their dark surfaces and frequent presence of hydrated minerals (e.g., Feierberg et al. 1985). Ceres (Thomas et al. 2005) and Pallas (Schmidt et al. 2009) possess shapes that indicate that these bodies have achieved hydrostatic equilibrium and may be differentiated (rock from ice). Dynamical calculations suggest asteroids formed rapidly to large sizes to produce the size frequency distribution within today's main belt (e.g., Morbidelli et al. 2009). Water-ice bound to organics has now been detected on the surface of Themis (Rivkin and Emery 2009, Campins et al. 2009), and indirect evidence for ice on many of the remaining family members, including main-belt comets (Hsieh & Jewitt 2006, Castillo-Rogez & Schmidt 2010), supports the theory that the "C-class" asteroids formed early and ice-rich. The carbonaceous chondrites represent a rich history of the thermal and aqueous evolution of early planetesimals (e.g., McSween 1979, Bunch and Chang, 1980, Zolensky and McSween 1988, Clayton 1993, Rowe et al., 1994). The composition of these meteorites reflects the timing and duration of water flow, as well as subsequent mineral alteration and isotopic evolution that can constrain temperature and water-rock ratios in which these systematics were set (e.g., Young et al. 1999, Dyl et al. 2012). Debate exists as to how the chemical and thermal consequences of fluid flow on carbonaceous chondrite parent bodies relate to parent-body characteristics: small, static water bodies (e.g., McSween 1979); small, convecting but homogeneous bodies (e.g., Young et al. 1999, 2003); or larger convecting bodies (e.g., Grimm and McSween 1989, Palguta et al. 2010). Heterogeneous thermal and aqueous evolution on larger asteroids that suggests more than one class of carbonaceous chondrite may be produced on the same body (e.g., Castillo-Rogez & Schmidt 2010, Elkins-Tanton et al. 2011, Schmidt & Castillo-Rogez 2012) if the chemical consequences can be reconciled (e.g., Young 2001, Young et al. 2003). Both models (Schmidt and Castillo-Rogez 2012) and experiments (e.g., Hiroi et al. 1996) suggest that water loss from asteroids is an important factor in interpreting the connections between the C-class asteroids and meteorites. The arrival of the Dawn spacecraft to Ceres will determine its much-debated internal structure and finally answer the following question: did large, icy planetesimals form and thermally evolve in the inner solar system? Even if Ceres is not icy, Dawn observations will shed light on its surface composition, and by extension on the surfaces of objects with similar surface properties. This presentation will focus on tying the observational evidence for water on evolving and contemporary asteroids with detailed studies of the carbonaceous chondrites in an effort to synthesize physical and chemical realities with the observational record, bridging the gap between the asteroid and meteorite communities.