Water transport and the evolution of CM parent bodies

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Extraterrestrial water-bearing minerals are of great importance both for understanding the formation and evolution of the solar system and for supporting future human activities in space. Asteroids are the primary source of meteorites, many of which show evidence of an early heating episode and varying degrees of aqueous alteration. The origin and characterization of hydrated minerals (minerals containing H_2O or OH) among both the main-belt and near-Earth asteroids is important for understanding a wide range of solar-system formation and evolutionary processes, as well as for planning for human exploration.

Current hypotheses postulate asteroids began as mixtures of water ice and anhydrous silicates. A heating event early in solar-system history was then responsible for melting the ice and driving aqueous alteration. The link between asteroids and meteorites is forged by reflectance spectra, which show 3-μm bands indicative of bound OH or H_2O on the C-class asteroids, which are believed to be the parent bodies of the carbonaceous chondrites in our collections [1]. The conditions at which aqueous alteration occurred in the parent bodies of carbonaceous chondrites are thought to be well-constrained: at 0–25°C for less than 15 Myr after asteroid formation [2]. In previous models, many scenarios exhibit peak temperatures of the rock and co-existing liquid water in more than 75 % of the asteroid's volume rising to 150°C and higher[3,4], due to the exothermic hydration reactions triggering a thermal runaway effect. However, even in a high-porosity, water-saturated asteroid, very limited liquid water flow is predicted (distances of 100's µm at most) [5]. This contradiction has yet to be resolved. Still, it may be possible for water to become liquid even in the near-surface environment, for a long enough time to drive aqueous alteration before vaporizing or freezing then subliming.

Thus, we are using physics- and chemistry-based models that include thermal and fluid transport as well as the effects of relevant chemical reactions to investigate whether formation of hydrated minerals can occur in the surface and near-surface environments of carbonaceous type asteroids. These models will elucidate how the conditions within the parent body that cause internal aqueous alteration play themselves out at the asteroid's surface. We are using our models to determine whether the heat budget of 20–100-km bodies is sufficient to bring liquid water to the near-surface and cause sufficient mineral alteration, or whether additional heat input at the surface (i.e., by impacts) is needed to provide a transient liquid-water source for mineral hydration without large-scale liquid-water transport.

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