EFFECT OF IN-SITU AQUEOUS ALTERATION ON THERMAL MODEL HEAT BUDGETS.

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Introduction: CM chondrites experienced relatively low-temperature aqueous alteration, at least some of which happened on their parent body. The conditions under which aqueous alteration occurred are: fluid temperatures of 0-25°C [1], from the time of asteroid formation up to 15 Myr [2-4] and mobility over scales of only tens of μm [5, 6].

Asteroid thermal models [7] have been successful in describing high-temperature parent-body processing, but no models yet completely characterize CM-type parent bodies. We continue to use our thermal model [8], which addresses the characteristics and physics of the liquid water phase, to develop scenarios that produce liquid water consistent with observed thermal and spatial constraints in CM meteorites.

In-situ alteration budgets: Exothermic alteration reactions (represented by a simple serpentinization reaction) are the chief cause of thermal runaway in our previous work. To further explore the effect of this heat source, we created scenarios that begin with serpentine in the parent body, which might be from aqueous activity in the nebula [9] or in previous parent bodies. We began these runs with 25%, 35%, and 45% initial serpentine by volume and included only enough initial reactants (forsterite and enstatite) to create ~50% total serpentine (the difference in initial serpentine among runs is made up in inert rock).

As expected, in all three cases, the peak temperature at the center of a 20-km parent body is lower than achieved previously (<330K). The peak temperature as a function of radius is shown in Fig. 1 for the 25% initial serpentine run. Since this run undergoes more reactions, it has the largest heat budget. However, even in this case, only the central 5 km reaches the melting temperature of ice so that the volume of the body further altered to ~50% serpentine is only approximately the central 1/6 of the asteroid volume. This total volume doesn't change significantly between these three scenarios. In addition, in all three cases, radial transport of water occurs over scales of kms rather than μms. This is due to the hydration reactions, which start in the center of the parent body, generating a strong enough temperature gradient to push both liquid and vapor upwards for kms through the rock pore space. The final serpentine and ice composition of the 25% initial serpentine case is shown in Fig. 2. Excess liquid water is pushed up to the outer radius of reactions where it meets the inward moving cooling wave and freezes, nearly filling up the pore space.

Conclusions: Hydration prior to final parent body formation and evolution is insufficient, in itself, to resolve the mismatch between thermal models and CM meteorite observations. Ongoing simulations are exploring parameters such as macroporosity and kinetics of heat release.

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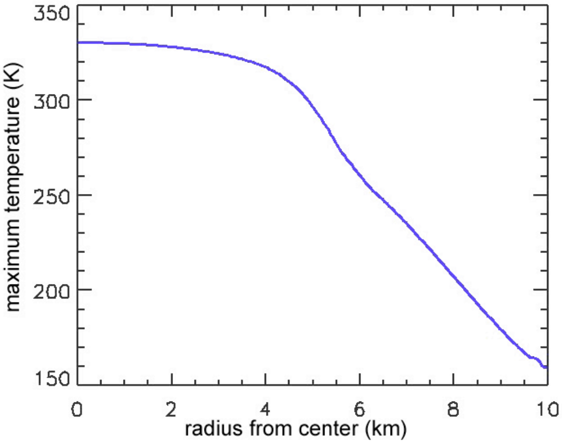

Fig. 1. Maximum temperature in the central region of a 100-km parent body starting 25% initial serpentine.

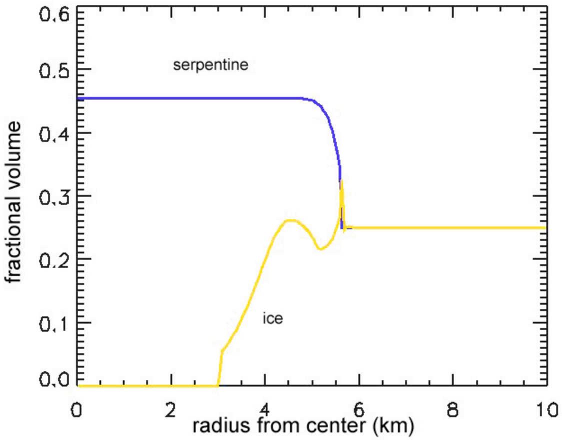

Fig. 2. Final volume fractions of serpentine and ice in the central region of the parent body.