THE EFFECT OF LIQUID TRANSPORT ON THE MODELING OF CM PARENT BODIES.

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Introduction: In our continuing development of an asteroid thermal model [1,2,3], we now include the radial transport of liquid water via capillary action. We also include the effect of gravity on both vapor and liquid transport and explicitly model the permeability as a function of pore size and porosity. Our goal is to determine constraints on the duration and temperature of the liquid water phase in a 100-km diameter CM-type parent body since this is critical in determining the evolution of organic materials on such bodies [4]. We solve the one-dimensional heat-flow equation and include a suite of radionuclides as the heat source. The parent body is modeled as consisting of forsterite, enstatite, inert rock, and water in the solid, liquid, and vapor phases. We use up-to-date temperature-dependent expressions for the heats of transformation, thermal conductivity, heat capacity, density, vapor pressure, and viscosity. We include serpentinization, dehydration, vapor diffusion, gas and ice fracturing, and convection.

The Models: We use a canonical model for an asteroid which accretes 3 Ma after the collapse of the solar nebula at a heliocentric distance of 3 AU. The initial void and ice fractions are taken to be 16$\%$ and 30$\%$ by volume, respectively. We assume a pore size of $D = 50$ μm and a permeability given by the Kozeny coefficient [5]

$$k = \frac{D^2 \epsilon^3}{150(1-\epsilon)^2} \;, \tag{1}$$

where ϵ is the porosity. Overall, this results in a lower permeability than previously used.

We treat the transport of liquid water as a Darcy flow with a velocity given by

$$v = \frac{-ks}{\mu}\left(\frac{\mathrm{d}P}{\mathrm{d}r} - \rho g\right) \;, \tag{2}$$

where s is the ratio of the volume taken up by liquid water to the porosity, μ is the viscosity of liquid water, ρ is the density of liquid water, g is the local acceleration due to gravity, and $P = P_{\mathrm{vapor}} - P_c$. The "capillary pressure" is [6]

$$P_c = \sqrt{\frac{\epsilon}{k}}\sigma J(s) \;, \tag{3}$$

where σ is the surface tension of the liquid water and $J(s)$ is an empirically determined function [7].

Results: We present the results of models with and without the radial transport of liquid water and compare them to previous models. The effect of Eq. (1) and updated physical constants is minor, increasing the central temperature by $\sim$ 10 K compared to model 2 of [3]. Liquid transport results in a significant movement of liquid water towards the center of the asteroid, raising the peak central temperature from 365 K to 400 K as heat is initially carried inwards more rapidly than thermal conduction carries it outward. Except in the central $\sim$ 10 km and where steep gradients are present, gravity dominates capillary action. However, while reactions are proceeding, steep gradients result in oscillations as liquid water moves back and forth. Eventually, water is drained from the mid-regions (25-35 km), lowering the effective heat capacity, heating them up, and pushing the outermost reaction zone out to 35 km rather than only 30 km. Fracturing occurs near 34 km as inward-flowing liquid freezes and fills up the void spaces at smaller radii. However, our model still produces only a narrow band near 35 km which matches CM meteorite characteristics.

References: [1] Cohen, B.A. and Coker, R.F. (2000) *Icarus* 145, 369-381. [2] Cohen, B.A. and Coker, R.F. (1999) *Met. Planet. Sci.* 34, A26. [3] Cohen, B.A. and Coker, R.F. (2000) *LPSC XXXI*, Abstract # 1935. [4] Cohen, B.A. and Chyba, C.F. (2000) *Icarus* 145, 272-281. [5] Batten, G.L. (1984) *J. Coll. & Inter. Sci.* 102, 513. [6] Wang, C.Y. and Beckermann, C. (1993) *Int. J. of Heat and Mass Transfer* 36, 2747-2758. [7] Udell, K.S. (1983) *ASME J. Heat Transfer* 105, 485-492.