Fluid flow in small bodies induced by hydrogen gas pressure

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Physicochemical models on thermal history and material evolution of hydrous asteroids have been explored [e.g., 1,2]. A few models considered fluid flow to reproduce the characteristic O isotopic compositions of aqueously altered meteorites like CM and CI chondrites [e.g., 3,4]. These fluid flow models predicted convective or exhalation flow induced by temperature gradient or vapor pressure. Although these models involved hydration reactions, gas phases such as H_2 produced by the reactions were not taken into account.

Here I present a model on fluid flow in hydrous asteroids induced by H_2 gas pressure generated by oxidation of metallic iron. The model is 1-D spherically symmetric and includes thermal conduction of heat generated by ^{26}Al decay, phase transition of water/ice, a simplified aqueous alteration reaction, and fluid flow. I assume that the asteroids accreted 2.7 Myr after CAI formation, resulting in their initial ^{26}Al/^{27}Al ratio of 3.7 x 10^{-6}. The velocity of fluid flow is derived from the Darcy's low. The radii of the asteroids are between 30 and 100 km. The asteroids initially consist of 70 vol% rock, 5 % water/ice, and 25 % void space.

The simulations suggest that fluid (H_2 gas and liquid water) flows outward soon after ice melts and water reacts with rock. However, water stops flowing at ~8 km depth because the temperatures are lower than the freezing point of water. Thus, an icy shell forms near the surface, and liquid water accumulates just below the icy shell. As a result, water distributes heterogeneously in the asteroids in spite of its initially homogeneous distribution. Water consumed by the alteration reaction amounts to 1.7-3.1 vol% around the center of the asteroids and to 5.5-16 % below the icy shell, depending on the asteroid sizes. The peak temperatures range from ~800 K around the center to ~370 K in heavily altered regions. These combinations between alteration degrees and peak temperatures are consistent with those inferred for CO and CM chondrites. This may imply that CO and CM chondrites originated from the same parent body.

[1] Grimm R. E. and McSween H. Y. Jr. (1989) *Icarus* **82**, 244-280. [2] Cohen B. A. and Coker R. F. (2000) *Icarus* **145**, 369-381. [3] Young E. D. (2001) *Phil. Trans. R. Soc. London* **A359**, 2095-2109. [4] Palguta J. et al. (2010) *EPSL* **296**, 235-243.