EVALUATION OF PRESSURE DURING AQUEOUS ALTERATION AND METAMORPHISM OF ASTEROIDS.

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Alteration of asteroids during the first 10-15 Ma could have caused increase in pressure (*P*) and destruction of some bodies [1,2]. Production of H_2 through oxidation of Fe, P, C, S, Ni and Si by H_2O and its separation into the gas phase was likely to be the major reason for rising *P*. Production of gases, increasing temperature (*T*) and evaporation of aqueous solution led to increase in *P*. On the other hand, elevated porosity and permeability, dissolution, chemical consumption, condensation (H_2O gas), diffusion and escape of gases reduced *P* buildup and could have caused *P* to decrease. We modeled alteration of chondrites with thermochemical equilibrium and mass balance calculations in closed isochoric-isothermal systems [3] in order to evaluate the effects of degree of alteration, water/rock mass ratio (*W/R*), porosity, rock composition and *T* on pressure in specific zones inside asteroids.

Results show that *P* can potentially reach several hundred bars and is proportional to the amount of aqueously altered rock (degree of alteration). Maximum pressures are observed at the aqueous to metamorphic transition. Complete consumption of aqueous solution is followed by decrease in *P*, which could be accounted for by H_2 use via reduction of previously formed phases. If occurred, further metamorphism causes minor variations in *P* owing to the interplay of dehydration and redox reactions. Dehydration releases $H_2O(g)$ and increases porosity. In redox processes, $H_2O(g)$ and $H_2(g)$ are consumed due to oxidation and reduction, respectively. Lower porosities lead to higher *P* over the course of aqueous and metamorphic processes. At each degree of alteration, highest *P* values correspond to water/altered rock ratio (local *W*/*R*) of ~0.2. That *W/R* value also represents the aqueous to metamorphic transition. At lower *W/R* ratios, H_2 production and *P* are limited by the amount of water; at higher *W*/*R*, they are limited by the amount of rock and affected by H_2 dissolution in water.

We evaluated specific *T*-*W/R*-porosity-alteration progress conditions at which explosive destruction of typical asteroids can occur at $P > 10^2$ bar [1,2]. For example, at 100 ^{o}C and original porosity of 50%, that *P* can be achieved at bulk *W/R* of 0.1-1 and at the degree of alteration above ~0.2. Lower original porosity and/or higher *T* can cause destructions of asteroids at earlier stages of aqueous alteration. At the metamorphic stage, destructions are less likely.

Finally, abundances of oxidized minerals in chondrites [e.g., 4] were used to evaluate the amount of H_2 produced and corresponding upper limits for *P* in localized regions of their parent bodies. For CM2 chondrites, ~6 moles H_2 per kg of water-free rock, 20 ^{o}C and 50-20% porosity lead to *P* of 0.7-1.8 kbar. For CI chondrites (~3.5 moles H_2, 150 ^{o}C, 50-20% porosity) maximum *P* is 0.6-1.5 kbar. These estimations demonstrate the need for H_2 removal via diffusion into peripheral asteroidal zones and escape, consistent with oxidizing nature of CM2 and CI chondrites.

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