DID THE POROUS CARBONATE REGIONS IN ALH 84001 FORM BY LOW TEMPERATURE INORGANIC PROCESSES? Lauren B. Browning[1], William L. Bourcier[2], [1]Hawaii Institute of Geophysics and Planetology/SOEST, University of Hawaii at Manoa, Honolulu, HI 96822-2219, [2]University of California, L-219, Lawrence Livermore Laboratory, Livermore, California 94550.

McKay et al. [1] argue that the meteorite ALH 84001 may contain fossilized evidence of life that existed in a low temperature aqueous environment on Mars. One of their arguments involves the interpretation of a petrologically distinct region within one of the carbonate globules (p. 927). This region contains several well-formed Fe-monosulfides and magnetite grains embedded in a fine-grained carbonate groundmass that is inferred to have formed by partial dissolution of the surrounding carbonate core. Because McKay et al. were unable to identify any simple inorganic model to explain their observations, they favor a biogenic origin for the carbonate globules in ALH 84001. Yet, a variety of simple inorganic models can readily explain their observations.

Thermodynamic analysis of the equilibrium reaction:

$$\text{Calcite} + 4Fe^{2+} + HS^- + 3H_2O + 1/2O_2(g) = \text{Magnetite} + \text{Pyrrhotite} + Ca^{2+} + HCO_3^- + 6H^+$$

at 25°C shows that the three minerals can co-exist over a fairly wide pH range, depending on the fluid composition [2]. There are at least two easy ways to explain partially dissolved carbonate: reducing the fluid pH, as noted by [1], and undersaturating the fluid with respect to calcite [2]. Thus, McKay et al.s observation (p. 927) that "the dissolution of carbonate is always intimately associated with the presence of Fe-sulfides and magnetite" in the meteorite suggests the possibility that the iron minerals precipitated during an episode of calcite dissolution. If the infiltrating fluid was undersaturated with respect to calcite and too acidic to stabilize magnetite and pyrrhotite, then the observed mineral assemblage and texture is nicely explained by reaction between calcite and a dilute sulfide and iron-bearing solution. The rise in pH due to calcite dissolution would cause precipitation of the two iron minerals. Other simple low temperature inorganic models can also explain McKay et al.s' observations. Therefore, McKay et al.'s petrologic argument based on observations of porous regions within the carbonate globules provides little support for biogenic activity in this rock.

ALH 84001 is volumetrically dominated by orthopyroxene [3], a mineral phase that quickly reacts with water at low temperatures to form phyllosilicates. Therefore, the absence of phyllosilicates in this meteorite also raises serious questions about the relevance of any model, either inorganic or organic, that explains the origin of carbonate globules in the context of a low temperature aqueous environment. The minerals in ALH 84001 globules form together over a wide range of temperatures and pressures in terrestrial environments [4], many of which are inhospitable to life, i.e. skarn deposits.

References:

1] McKay et al. (1996) *Science*, 273, 24-930. [2] Garrels and Christ (1990) *Solutions, Minerals, and Equilibria* , Jones and Bartlett, Boston. [3] Mittlefehldt (1994) *Meteoritics* **29**, 214. [4] Einaudi et al. (1981) *Econ. Geology 75th Anniversary*, 317.