EXPERIMENTAL SHOCK DECOMPOSITION OF SIDERITE AND THE ORIGIN OF MAGNETITE IN MARTIAN METEORITE ALLAN HILLS 84001

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Introduction: ANSMET (Antarctic Search for Meteorites) has collected fifteen Martian meteorites over the forty year history of the program. Elephant Moraine 79001 was the first to be identified as Martian in 1983 by Bogard and Johnson [1] who found that trapped gasses within shock glass veins and pockets in the meteorite were present in the exact same proportions as gasses measured by the two NASA Viking spacecraft that landed on Mars in 1976. The Allan Hills meteorite ALH 84001 proved to be another auspicious find for the ANSMET program when in 1996 researchers led by David McKay [2] claimed that it contained proposed evidence for life on Mars about 3.6 Ga ago. The carbonates within Allan Hills 84001 indicate that liquid water was present on and within Mars 3.6 Ga ago, at a time when the first known microbial life was active on Earth. The debate over evidence for life in ALH 84001, particularly over the proposed magnetite biomarkers, has shown the process of scientific inquiry in action and has served to promote public, political and research interest in Mars. Since 1996, most of the lines of evidence for life in Martian meteorite ALH84001 have been shown to have alternative abiotic formation mechanisms. Golden et al. [3] were able to demonstrate inorganic synthesis of the carbonates from aqueous solutions of variable ion concentrations and the formation of magnetite from siderite upon heating at 470ºC. It is possible that the magnetite in ALH 84001 could have been formed by shock decomposition of siderite in one of the several impact events to which it was subjected [4], events in the meteorite's history known to have occurred unequivocally. That hypothesis is tested in a series of experiments the results of which are reported here.

Methods: Naturally occurring siderite was first characterized by electron microprobe, transmission electron microscopy (TEM), Mossbauer spectroscopy, and magnetic susceptibility measurements to be sure that the starting material did not contain detectable magnetite. Samples were shocked in tungsten-alloy holders (W=90%, Ni=6%, Cu=4%) to further insure that any iron phases in the shock products were contributed by the siderite rather than the sample holder. Each sample was shocked to a specific pressure between 30 to 49 GPa (see [5] for details of the experiments).

Discussion of Results: Transformation of siderite to magnetite as characterized by TEM was found in the 49 GPa shock experiment. Compositions of most magnetites are > 50% Fe^{+2} in the octahedral site of the inverse spinel structure. Magnetites produced in shock experiments display the same range of single-domain, superparamagnetic sizes (~50 to 100 nm), compositions (100% magnetite to 80% magnetite - 20% magnesioferrite), and morphologies (equant, elongated, euhedral to subhedral) as magnetites synthesized by Golden et al. (2001) or magnetites grown naturally by MV1 magnetotactic bacteria, and as the magnetites in Martian meteorite ALH84001. Fritz et al. [6] previously concluded that ALH84001 experienced ~32 GPa pressure and a resultant thermal pulse of ~100-110º C. However, ALH84001 contains evidence of local temperature excursions high enough to melt feldspar, pyroxene, and a silica-rich phase.

Conclusions: This 49 GPa experiment demonstrates that magnetite can be produced by the shock decomposition of siderite as a result of local heating to > 470º C. Therefore, magnetite in the rims of carbonates in Martian meteorite ALH84001 could be a product of shock devolatilization of siderite as well.

References: [1] Bogard and Johnson (1983) *Science* **221**, 651-654. [2] McKay et al. (1996) *Science* **273**, 924-930. [3] Golden et al., (2001), *Am. Min.* **86**, 370-375. [4] Treiman (1998) *MAPS* **33**, 753-764. [5] Bell (2007) *MAPS* **42**, 935-949. [6] Fritz et al., (2005), *MAPS* **40**, 1393-1411.