

THE PETROGENETIC RELATIONSHIP BETWEEN CARBONATES AND PYRITE IN MARTIAN METEORITE

ALH84001. C.K. Shearer, M.N. Spilde, M. Wiedenbeck, and J.J. Papike. Institute of Meteoritic, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico, 87131.

INTRODUCTION. Understanding the development, timing and setting of the precipitation of carbonate and sulfide in fracture-filling lithologies is critical to interpreting potential biomarkers in ALH84001. For example, to properly interpret S isotopes as a marker for biogenic activity [1], it is important to understand the relative precipitation sequence of carbonate and sulfides, the temperature of precipitation, and the open-closed system behavior of S species during precipitation. This abstract focuses upon the precipitation history of carbonates and sulfides. Another [2], focuses upon the effect of open-closed system behavior of S species on S isotopic systematics in the system represented by ALH84001.

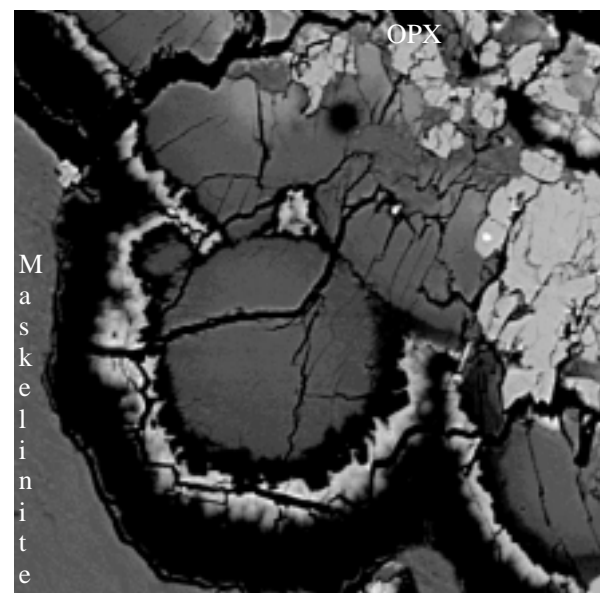
APPROACH. Using electron microprobe techniques, carbonates were imaged, mapped and analyzed along traverses. A carbonate "stratigraphy" was established into which pyrite precipitation could be related. Distribution of pyrite was determined using optically microscopy. For more statistically relevant information regarding pyrite distribution in ALH84001, we have initiated automated electron microprobe search techniques [3]. Trace element analyses of the carbonates, maskelinite, and orthopyroxene were performed using a Cameca ims 4f ion microprobe at the University of New Mexico. The carbonates and silicates were analyzed under the following conditions: Analyses were performed using an O- primary beam accelerated through a nominal potential of 10kV and focused into a 20 micron diameter area. For the carbonates, positive secondary ions (B, Mn, Sr, Y, REE) were counted and normalized to ^{44}Ca and $\text{CaO}\%$. A suite of carbonate standards were used to establish ion yields for each element and each bulk composition [4]. For the silicates, positive secondary ions (Sr, Y, Ba, REE) were counted and normalized to ^{30}Si and $\text{SiO}_2\%$. A suite of silicate standards were used.

DATA. Compositional zoning in the carbonates in ALH84001 have been previously described to varying degrees of detail [5,6,7]. FIGURES 1 and 2 illustrate detailed growth morphologies and compositional zoning in the carbonates through backscatter and compositional (x-ray) images. Clearly, these two images indicate multiple episodes of carbonate precipitation, changing fluid compositions and perhaps different mechanisms of carbonate growth. Similar types of textures observed in minerals from terrestrial settings have been attributed to growth from a supersaturated fluid within open-space [8]. FIGURE 3 illustrates the compositional zoning in the carbonate in terms of its end-member components (CaCO_3 , MgCO_3 , FeCO_3 , and MnCO_3), along a traverse from the maskelinite-carbonate interface to the orthopyroxene-carbonate interface. At least 7 distinct compositional zones can be distinguished in FIGURES 1, 2 and 3. Although not all of these individual zones could be analyzed for trace elements by ion microprobe, zones that were analyzed have REE patterns that were slightly HREE enriched (FIGURE 4). Interior carbonate zones were slightly more enriched in

REE, Sr, and Y. These zones also have slight negative Eu anomaly. Outer zones have lower abundances of Sr, REE, and Y. These zones have either no inflection at Eu or have a small positive Eu anomaly. Orthopyroxene is LREE depleted, HREE are approximately 1 times chondrite and has a small negative Eu anomaly. The Sr content is less than 0.2 ppm. The maskelinite is LREE-enriched (4 to 7 times chondrite) with a large positive Eu anomaly. Sr ranges from 230 to 280 ppm. Preliminary observations based on optical microscopy suggest that the pyrite formed during an early stage of carbonate precipitation. However, this observation should be taken with caution at this time. Observations based on only two thin sections using only optical microscopy obviously have a statistical bias. Additional optical and electron microscopy studies of additional thin sections are required to prove or invalidate this interpretation

CONCLUSIONS. Based on our preliminary textural and chemical observations, the following conclusions can be made: (1) The textures exhibited by the carbonates imply a low temperature environment in which the carbonates grew into an open space containing supersaturated fluid(s). (2) The extensive zoning in the carbonates probably makes any attempt to use carbonate geothermometry suspect. (3) Some of the components in the carbonates may be locally derived from the orthopyroxenite lithology. (4) Pyrite may have precipitated along with the early carbonate. The ALH84001 system remained open with regard to S species [2] or the S was locally derived.

FIGURE 1. Backscatter image of carbonate in ALH84001.



Carbonates and Pyrite in ALH84001: C.K. Shearer et al.

FIGURE 2. Mg x-ray map of carbonate (reverse color image; dark=high Mg).

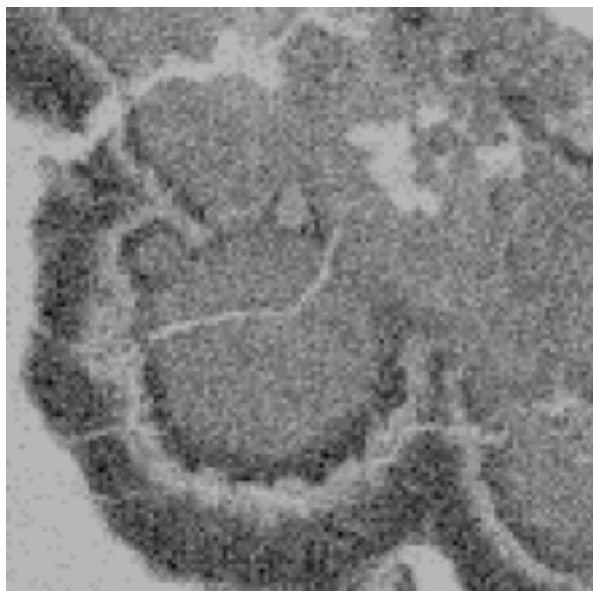


FIGURE 3. Electron microprobe traverse across carbonate in Figure 1. The traverse extends from the carbonate-maskelinite interface to the carbonate-pyroxene interface.

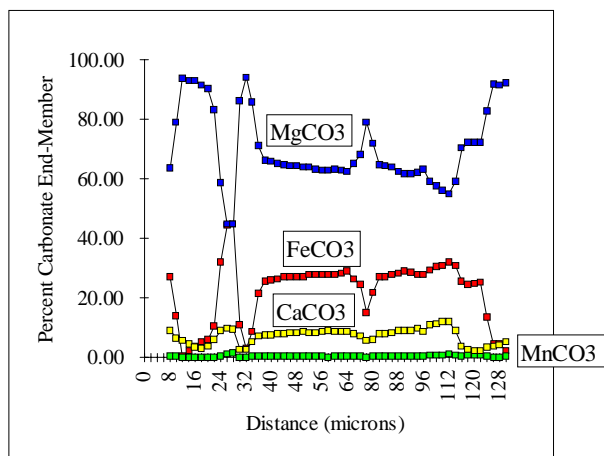
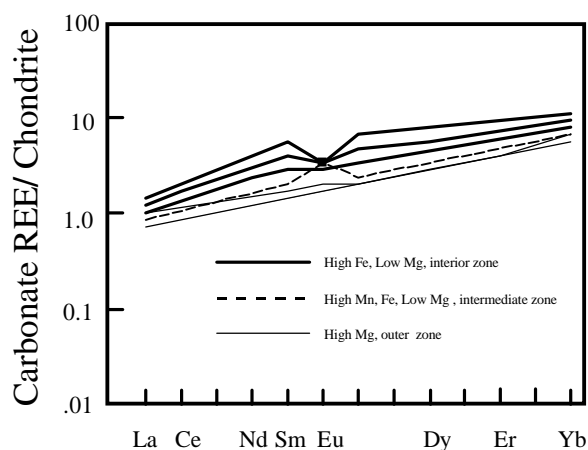


FIGURE 4. REE patterns for the carbonate zones shown in Figure 1.



REFERENCES. [1] Shearer et al. (1996) GCA 60, 2921-2926. [2] Shearer (1997) LPSC XXVII, this volume. [3] Adcock et al. (1997) LPSC XXVIII, this volume. [4] Denniston et al (1997) GCA 61, in press. [5] Mittlefehdt (1994) Meteoritics 29, 214-221. [6] Treiman (1995) Meteoritics 30, 294-302. [7] Harvey and McSween (1996) Nature 382, 49-51. [8] Roedder (1968) Economic Geology 63, 451-471.