FESEM IMAGING REVEALS PREVIOUSLY UNSEEN DETAIL AND ENHANCES INTERPRETATIONS OF ALH84001 CARBONATE PETROGENESIS. C. S. Schwandt,[1] G. A. McKay,[2] and G. E. Lofgren[2], [1]Lockheed Martin, 2400 Nasa Road 1, C23, Houston, TX 77058, craig.s.schwandt@jsc.nasa.gov, [2]Johnson Space Center, SN2, Houston, TX, 77058. gordon.mckay@jsc.nasa.gov, gary.e.lofgren@jsc.nasa.gov.

Introduction: Much controversy has continued regarding the petrogenesis of the carbonate in the ALH84001 Martian meteorite. Several factors contribute to the continued discussion, including: the observation that each time a sample is examined new information can be gleaned; most of the thin sections which were extensively examined have significant thin-section preparation damage; and the fact that the number of samples available for inspection is limited. However, this last factor is intentional in that the majority of the meteorite is being reserved until technological advances occur that will offer new understanding. Using a new JEOL 6340F field emission scanning electron microscope (FESEM), particles as small as 2.5 nanometers can be observed at low kV on uncoated samples. Examination of the ALH84001,6 thin section with the FESEM reveals exciting new detail, which was previously not observable. These details significantly impact previously proposed carbonate petrogenetic hypotheses.

Observations: Figures 1 a & b show feldspathic glass which cuts across and intrudes pyroxene and intrudes into an interstitial carbonate occurrence. The feldspathic glass clearly intrudes the pre-existing carbonate, as demonstrated by the fractures that terminate at the carbonate and glass interface.

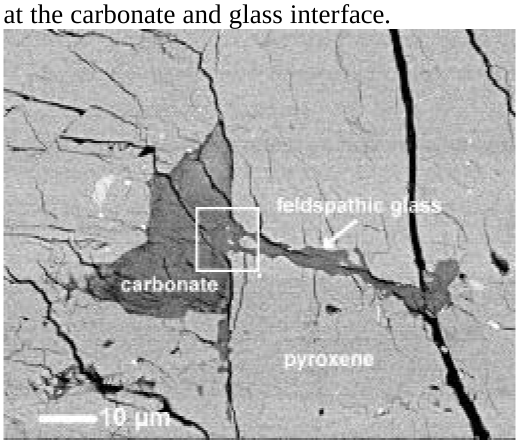

Figure 1a

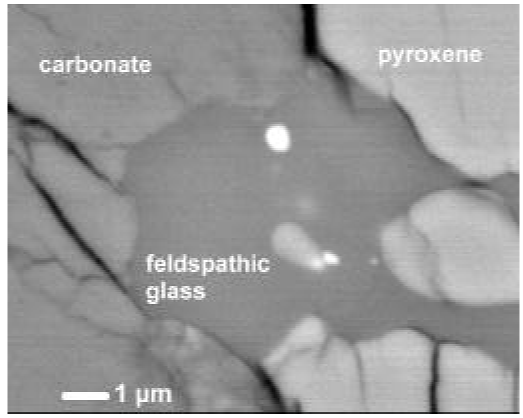

Figure 1b

The higher magnification image (Fig. 1b) shows how the feldspathic glass has eroded the pyroxene and carbonate along the interface.

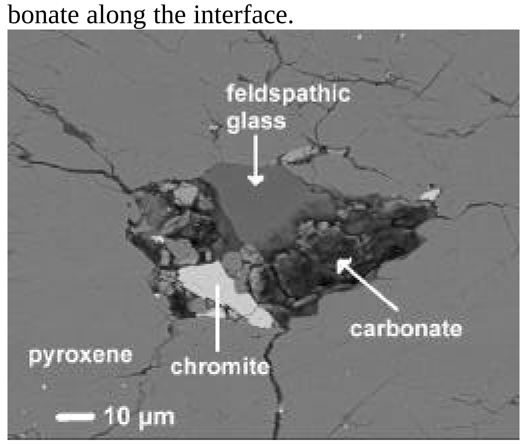

Figure 2

Figure 2 shows feldspathic glass and unmelted small fragments of pyroxene, chromite, and carbonate surrounded by pyroxene. This two dimensional image gives the impression that the feldspathic glass may have entrained and slightly moved some of these fragments from earlier locations. It is not clear whether the fracturing present in the carbonate of Figure 2 is the result of that movement or whether it is due to thin section preparation.

The FESEM will prove invaluable for addressing further the issue of the apparent meta-stable carbonate compositions [1]. Figure 3 clearly reveals compositional boundaries that are present in the carbonate which previously were not observable with broaderbeamed instrumentation. The magnesite bands in the figure are only about 125 nm wide.

The FESEM will provide new exceptional information, because the instrument is capable of using conventional size samples but can resolve very small features. The important contrast with TEM is that with the FESEM one can observe more completely the petrogenetic relationships. With TEM, it is often difficult to understand observed micro-features in the context of larger-scale features, and this lack of context often leads to confusion about petrogenetic relationships.

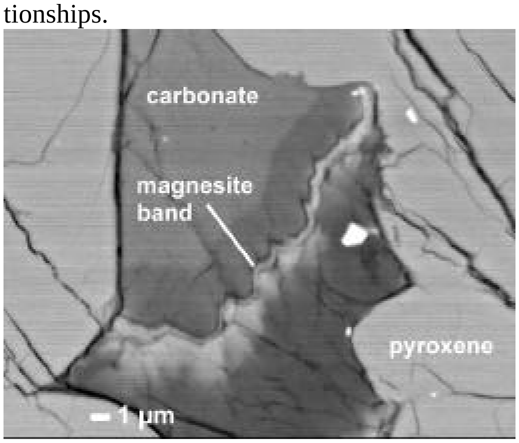

Figure 3

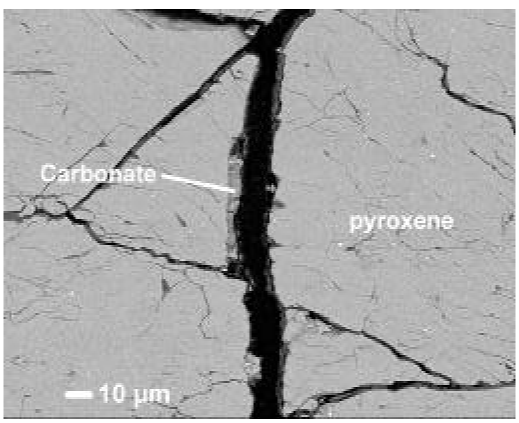

Figure 4

Figure 4 shows one of the fracture filling type carbonate occurrences. The zoning is similar in two dimensions to the zoning in the carbonate globules. It is clear that the siderite and magnesite zoning did not develop in the direction normal to the fracture surface.

Interpretations: The new observations of the fine-scale compositional zoning further substantiate the importance of kinetic mechanisms during formation of the carbonate occurrences as indicated by [2]. Further investigation with this new FESEM of the compositionally zoned carbonate globules at the nanometer scale may shed more understanding on the relationship of the carbonate, magnetite, and iron sulfides.

Figures 1 and 2 clearly demonstrate that the feldspathic glass intruded and mobilized small solid carbonate fragments. This provides further evidence that the carbonate was not melted by the impact event. [3, 4] suggested that the carbonate was shock melted and that the zoning in the carbonate was formed by rapid cooling. This new observational capability along with the carbonate analog experiments of [5,6] clearly indicate the carbonate in ALH84001 was not shock melted. Also, [3,4,7] concluded independently that the three main types of carbonate occurrences (globules, interstitial, fracture filling) formed by the same process. This conclusion is based primarily on the similarity of carbonate composition and zoning, despite a broad range of grain sizes and the three types of occurrences. Therefore given this constraint, along with the images above, the scenario proposed by [8] is improbable. Their model requires shock melting of carbonate followed by injection into fractures and crevices, while crystallizing within seconds to the same compositions everywhere, regardless of the size and shape of the carbonate body, followed by subsequent minor disruption and mobilization of crystallized carbonate by yet molten impact-produced feldspathic glass. Our images are inconsistent with a model having shock melted carbonate.

References: [1] Romanek C.S. et al. (1994) *Nature, 372*, 655-657. [2] McKay, G.A. and Lofgren, G.E. (1997) *LPS XXVIII*, 921-922. [3] Scott E.R.D., Yamaguchi A., and Krot A.N. (1997) *Nature 387*, 377-379. [4] Scott E.R.D. and Krot A.N. (1998) *LPS XXIX*, #1786(CD-ROM). [5] Jones J.H. and Schwandt C.S. (1998) *LPS XXIX*, #1425, (CD-ROM). [6] Schwandt C.S., Hörz F., Lofgren G.E., McKay, G.A. (1998) *Meteoritics and Planetary Science, 33*, A139. [7] McKay G., Mikouchi T., Lofgren G., and Schwandt C. (1997) *Annual Meeting Japanese Mineralogical Society*. [8] Scott E.R.D. and Krot A.N. (1998) *Workshop on Martian Meteorites*, 44.