FRACTURE FILLINGS IN ALH84001 FELDSPATHIC GLASS: CARBONATE AND SILICA. G. McKay[1], T. Mikouchi[2], C. Schwandt[3], and G. Lofgren[1], ([1]SN2, NASA-JSC, Houston, TX 77058; [2]Mineralogical Institute, University of Tokyo, Tokyo 113, JAPAN; [3]Lockheed Martin, 2400 NASA Rd 1, Houston, TX 77058; gordon.mckay@jsc.nasa.gov).

Introduction. ALH84001 is the well-known martian meteorite in which evidence for possible biogenic activity has been reported [1], especially in the carbonates. The issue of biogenic activity is of great philosophical and scientific importance, and yet remains highly controversial. Understanding the origin and history of the carbonates and related materials in this sample is one key to resolving this controversy.

[2,3] described the general petrography of ALH84001, and many workers have studied the petrography and chemical compositions of carbonates [e.g., 4,5,6]. The sample is an igneous orthopyroxene and chromite cumulate with interstitial plagioclase. Subsequent to its igneous history, the sample suffered mechanical granulation along sheared zones (probably from shock), possible recrystallization of the granular material, and at least one shock event after the recrystallization. The plagioclase was melted and quenched to glass, as suggested for other shergottite meteorites by [7]. At some point during these events, carbonates were introduced into the sample. However, the age of the carbonates is not yet well understood [8,9], and even the timing of their formation relative to other events affecting this sample is unclear, as is the mechanism of carbonate formation. We are using petrographic and textural information to try to understand the relationship of the carbonates to other minerals in this sample.

In this abstract we report two different types of filled fractures cutting feldspathic glass. Although interpretation is complex, these fractures and the material that fills them contain important clues to the sequence of events affecting ALH84001. Understanding the timing and origin of these fracture fillings is essential to understanding the history of this sample and the carbonates therein.

Samples and analytical methods. We studied three polished thin sections of ALH84001 (,64 ,82 ,88) that were allocated to the consortium led by Duck Mittlefehldt. We performed petrographic studies, elemental mapping, and chemical analyses of the samples using optical microscopes, electron microprobes (the Cameca SX-100 at JSC and the JEOL 8100 at the University of Tokyo), and FEG-SEMs (the Philips XL-40 at JSC and the Hitachi S4500 at the University of Tokyo).

Results and discussion. ALH84001 has many interesting and complex textural features. In this abstract we describe three of them. Fig. 1a shows a fracture running from top to bottom, across pyroxene and feldspathic glass. We traced this fracture for several mm in the pyroxene "above the top" of the image. In some places, it is manifested as a simple "crack", as in the top portion of Fig. 1a. In other places, as in most of its length in Fig. 1, it is filled with carbonate. This carbonate has typical Ca-Fe-Mg zoning (Fig. 1b) like that in other carbonate occurrences [e.g., 2-5]. We have seen similar thin traces of carbonate in other areas feldspathic glass, including some leading to globules. We believe these veins may be "feeder dikes" for the globules.

The vein in Fig 1 has two horizontal branches, one in each direction, a little below the center of the image. The location of these branches does not seem to be random. Fig. 1c is a K map. A striking feature of this map is the heterogeneous distribution of K in the feldspathic glass. In other areas (e.g., Fig. 2), it is clear that these K-rich zones are fragments of pre-existing feldspar "floating" in a matrix of less K-rich feldspar melt. Thus, the history of the

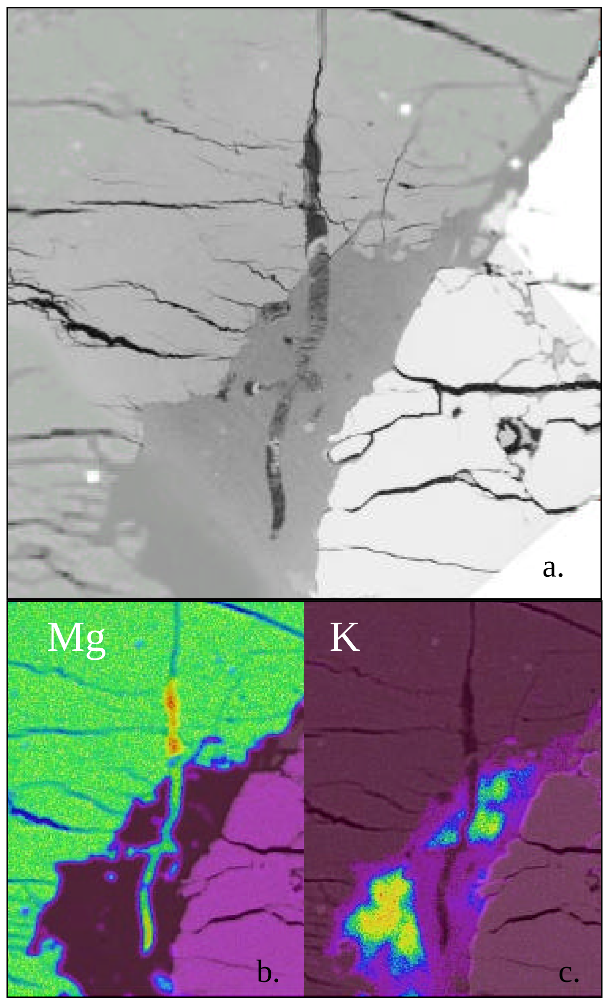

Fig. 1. Carbonate-filled fracture cutting across pyroxene and feldspathic glass. **a.** BSE image. Entire image is 125 µm in width. **b.** Mg map. Warmer colors indicate higher concentrations. Note zoning along vein. **c.** K map. Note that vein has branches extending into glass at the boundary between the upper K-rich area and the K-poor area.

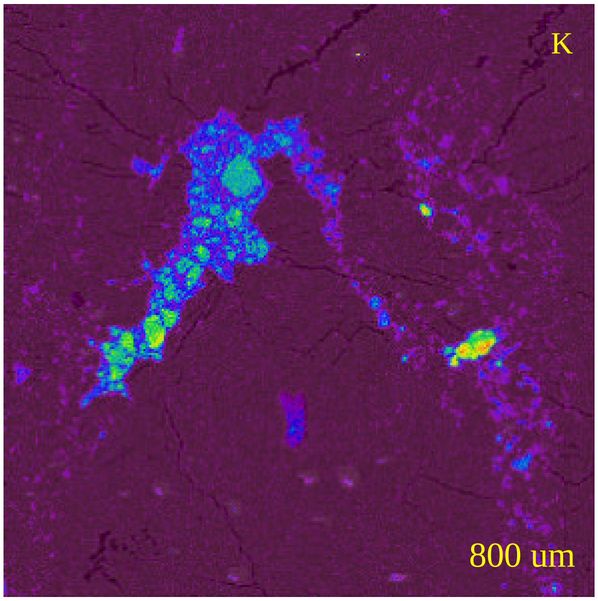

Fig. 2. K map of feldspathic glass region showing fragments of K-rich feldspar in matrix of K-poor feldspar. Width is 800 µm.

feldspathic glass zones is complex, involving fragmentation of heterogeneous feldspar, melting of at least portions of this feldspar, and quenching. This melting must have occurred during or after the shock event that fractured the surrounding pyroxene, as pointed out by [7]. Note that the horizontal branches of the carbonate-filled vein in Fig. 1 lie on the boundary between K-rich and K-poor fragments. The most likely interpretation of this texture is that the carbonates filled fractures between K-rich and K-poor feldspar fragments that existed before the feldspar was melted by the impact. A corollary is that there was a **previous** event (impact or tectonic) that fragmented the feldspar, probably the same event that granulated the pyroxene [2,5,11].

Fig. 3 shows another very important feature in ALH84001 feldspathic glass. About 10-20% of the feldspar grains show a pervasive network of lower-Z material that is only obvious in very high-contrast BSE images (Fig 3a). High-resolution images reveal that this network consists of a set of web-like veins occupying the interstices between angular or slightly rounded fragments of feldspar (Fig. 3b). The veins are typically less than 1 µm thick, and the boundaries between the veins and the feldspathic material are distinct and sharp (Fig. 3b).

The veins are too thin for quantitative analysis. Moreover, elemental mapping has inadequate spatial resolution to clearly show the chemical composition of the veins, although it indicates that they are richer in Si and poorer in Al and Ca than the feldspar fragments (Figs. 3c and 3d). Moreover closely spaced line analyses on feldspar regions yield compositions that can be interpreted as overlapping analyses of stoichiometric and SiO_2. Thus, we believe the veins are probably nearly pure silica. Moreover, the textures in Figs. 3a and 3b seem completely incompatible with the idea that this silica was injected as an impact melt [6]. It is much more likely that the vein-filling material precipitated from a fluid that permeated the granulated feldspathic zones. Thus, along with abundant larger filled fractures, these veins point towards a sample that was heavily fractured and highly permeable, through which fluids of varying compositions moved freely, leaving behind a variety of minerals as evidence of their passage.

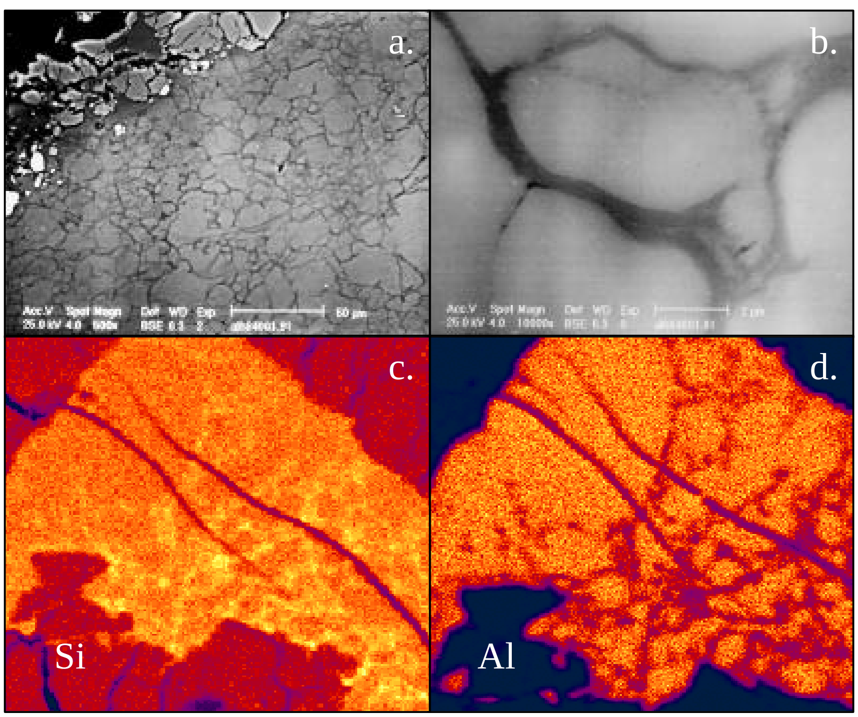

Figure 3. Filled fractures in feldspathic glass. **a.** BSE image. Scale bar is 50 µm. Width of image is 200 µm. **b.** Enlargement of region from 3a. Scale bar is 2 µm. **c.** Si map of different grain. **d.** Al map of same grain as 3c.

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