Possible Weathering Features in ALH84001. Susan J. Wentworth [1], Kathie L. Thomas-Keprta[1], Anne E. Taunton[1], Michael A. Velbel[2], and David S. McKay[3]; [1]Lockheed Martin, Mail Code C-23, NASA/JSC, Houston, Tx, 77058, 2 Dept of Geological Sciences, Michigan State University, East Lansing, MI 48824, [3]NASA/JSC, SN, Houston, TX 77058

Secondary Minerals. Previous work has documented terrestrial weathering products in Antarctic meteorites including the martian meteorite ALH84001 [*e.g.*, 1, 2]. The fusion crust of ALH84001 was described as remarkably free of salts and clay mineraloids, with only one grain of Ca-sulfate that was a clear indicator of terrestrial weathering [2]. Here we describe additional grains and surface textures on the fusion crust and interior of ALH84001 that may be further evidence of minor terrestrial weathering, as well as possible weathering features that may have formed on Mars.

We have studied several chips (including uncoated, carbon-coated, and AuPd-coated samples) of ALH84001 using a JEOL-35CF scanning electron microscope (SEM) and Philips XL-40 field emission gun SEM (FEG-SEM). Chemical analyses were performed using a PGT System IV and a Link ISIS both equipped with windowless energy dispersive x-ray spectrometers.

On the fusion crust, we found traces of terrestrial secondary minerals in addition to the single Ca-sulfate occurrence described in [2], including several small regions (each up to ~10 μm in across) of Mg-sulfate on one chip (Fig. 1; arrows). Several patches of amorphous(?) silica, ~10-15 μm in size, and micrometer-sized grains of NaCl mixed with silicates, were also present on the fusion crust. These secondary minerals were found by searching a total of ~8 mm^2 of fusion crust. This relative lack of secondary minerals on the fusion crust confirms that ALH84001 is among the least weathered Antarctic meteorites examined to date [2].

In interior chips of ALH84001, as well as below the fusion crust surfaces of exterior chips, blade-like to rhombohedral Mg-carbonate crystals are found occasionally near carbonate globules. Light-element EDX analyses indicate very high oxygen contents; these grains may represent a hydrated form of Mg-carbonate (*e.g.*, nesquehonite, hydromagnesite). Individual regions of these carbonate crystals range from ~10-70 μm in size; at low magnifications these regions appear to be in very close proximity to each other, suggesting that they are part of a much larger carbonate region. It is unclear if these crystals grew on Mars or in Antarctica.

Possible Weathering Textures. We also found several examples of unique carbonate and pyroxene textures that may have formed on Mars. In Fig 2, the edge of a carbonate globule has been exposed, showing that the globule has a pancake-like morphology (~200 μm in diameter with a width of < 10 μm) as suggested by others [*e.g.*, 3, 4]. An impression of the part of the carbonate globule that was removed remains in the pyroxene (Fig 2). Part of the globule has been removed revealing the underlying pyroxene texture which displays loosely-oriented botryoidal features (Figs 3-4). This texture is in contrast to other regions of the pyroxene, which typically have a ridged appearance (Fig 5). Almost certainly, the texture of the pyroxene directly under the carbonate was produced on Mars. The geologic location where the ridged pyroxene texture was produced is uncertain, but this texture may have also have been formed on Mars. This texture may be the result of differential weathering of pyroxene lamellae or exsolution zones.

Wispy (Fig 6) to fibrous textures (Fig 7) are present on some totally uncoated (without a conductive coating) pyroxene surfaces. We interpret these textures as thin layer lattice silicates. Individual nm-scale packets and relatively large regions (~ 500 nm^2) of phyllosilicates have been observed and examined in microtome thin sections using a transmission electron microscope (Fig 8) [technique described in 5]. The basal spacings measure 1.0-1.1 nm suggesting that this is a smectite-type clay. None of these pyroxene surface textures look like freshly fractured pyroxene. The botryoidal features are unlike any known terrestrial weathering textures for pyroxene; common terrestrial pyroxene dissolution features include distinctive parallel, lens-shaped etch pits [6].

Pitting of carbonate globule surfaces is commonly observed in ALH84001 as shown in Fig 9 (backscattered electron image). Some of the larger pit bottoms are composed of the underlying pyroxene (Fig 9, arrows). Dissolved or finely crystalline regions of carbonate have also been reported in thin sections examined by transmission electron microscopy [3].

In summary, ALH84001 carbonates and pyroxenes display a wide variety of unique surface textures which can be interpreted as weathering features. Additionally, the presence of minor clays indicates that, at some time in the history of this meteorite, an aqueous fluid was present. Further detailed analysis of these textures, as well as comparison to terrestrial analogs, may allow us to determine whether they formed on Mars or on Earth, and in what kind of geologic environment.

References:

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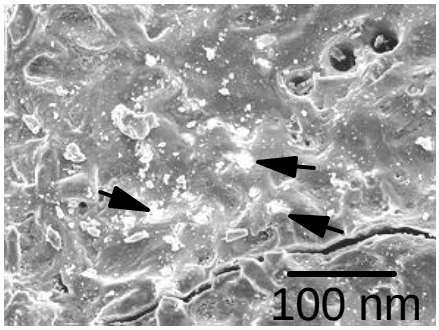

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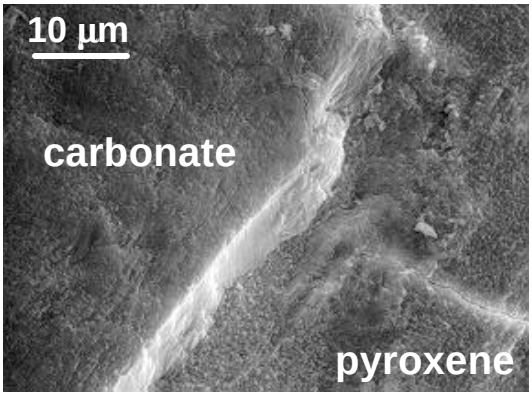

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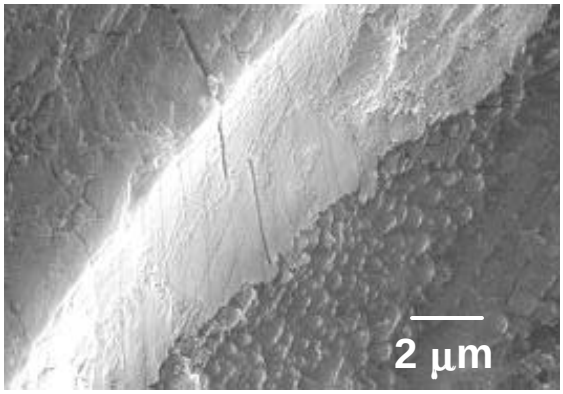

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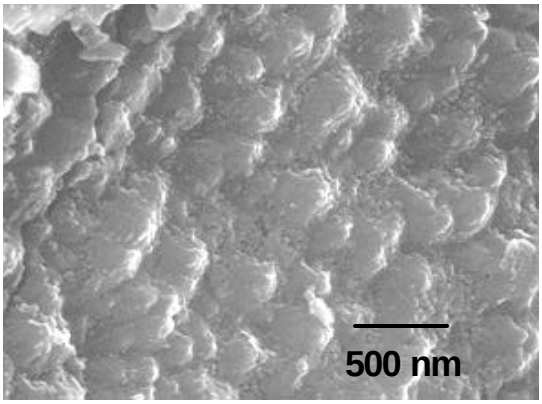

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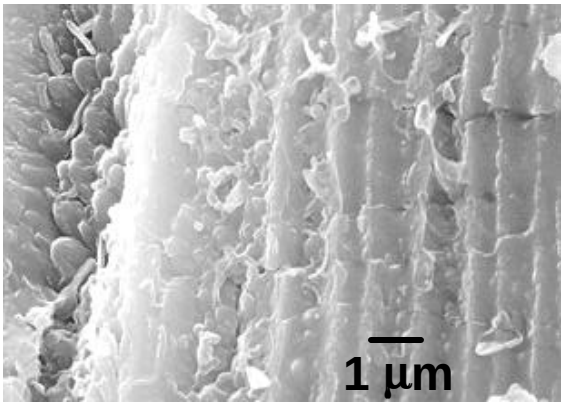

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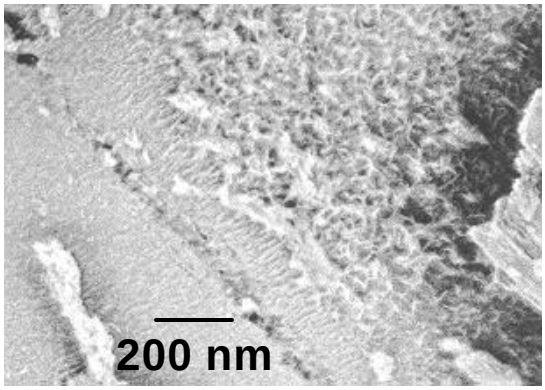

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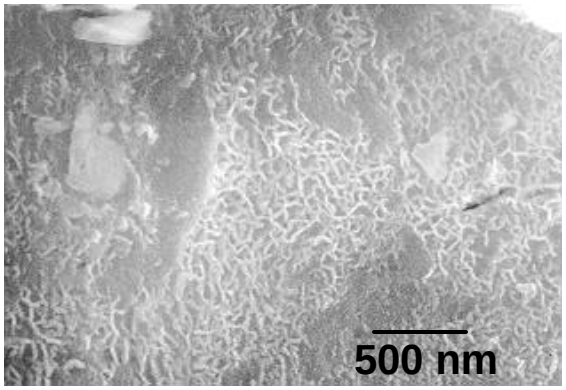

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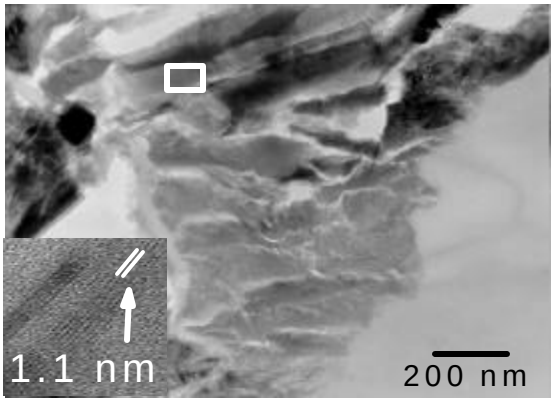

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