PRELIMINARY ANALYSIS OF POLYCYCLIC AROMATIC HYDROCARBONS IN THE MARTIAN (SNC) METEORITE ALH 84001; Kathie L. Thomas, Chris S. Romanek, Simon J. Clemett, Everett K. Gibson, David S. McKay, Claude R. Maechling, and Richard N. Zare; 1Lockheed, C23, NASA Rd. 1, Houston, TX 77058, 2NASA/JSC, SN4, Houston, TX 77058, 3Dept. of Chemistry, Stanford University, Stanford, CA 94305, 4NASA/JSC, SN, Houston, TX 77058

Previous work has shown that pre-terrestrial organic compounds exist in interplanetary dust particles (IDPs) and certain meteorites [1-3]. Polycyclic aromatic hydrocarbons (PAHs) have been found in several IDPs [1,2] and numerous ordinary and carbonaceous chondrites [3]. We document, for the first time, the occurrence of PAHs in the newest member of the SNC meteorite clan, Alan Hills 84001.

This martian meteorite is an unusual orthopyroxenite which contains ~0.5 [4] - 0.1 vol.% [4, 5] carbonate spheroids, ~100-200 μm in diameter. These spheroids, which range in composition from magnesite to ferroan magnesite [5-7], are not the result of terrestrial contamination; rather carbon isotopic abundances are consistent with martian atmospheric CO₂ as the carbon source [5]. Oxygen isotopic composition of carbonates indicates that they probably precipitated from a low-temperature fluid within the martian crust [5]. We selected ALH 84001 to search for organic signatures because it is possible that PAHs may co-exist with other low-temperature carbon-bearing phases in a subsurface martian environment. Indeed, a recent report suggests that Mars may have been a wet and warm planet [5, 6].

Methods We fractured 3 fragments of ALH 84001 which range in size from ~2-8 mm in length. The fragments were processed in the meteorite clean lab at NASA/Johnson Space Center to minimize laboratory contamination. These freshly-fractured samples were sent to Stanford where their surfaces were analyzed for PAHs using a microprobe two-step laser mass spectrometer (μL²MS). Our μL²MS has a spatial resolution of 40 μm and selectively ionizes aromatic species from the plume of desorbed organic molecules. This instrument has been described previously [1]; however, the detection sensitivity was recently improved by replacing the 1-inch microchannel plate detector (MCP) with a 2-inch MCP. For PAH mapping studies of a freshly-cut surface, a single-shot mass spectrum was taken on a sample spot followed by translation of the sample by 50 μm. After the sample was analyzed, the infrared laser power was increased and position indicators were burned into the surface producing laser-fused beads of the SNC meteorite matrix. The samples were then returned to NASA/JSC for analysis with a turbo-pumped JEOL 35 CF scanning electron microscope (SEM) equipped with a PGT energy dispersive spectrometer (EDS). SEM micrographs and EDS analyses were taken of the sample to determine if the spatial concentration of PAHs corresponds to textural or mineralogical features on the surface. To date, we have analyzed one surface using both techniques.

Results We have determined that certain types of organic compounds are indigenous to ALH 84001 because their presence correlates with mineralogical features in the chips. A spatial map of the PAHs from a 1 mm x 0.5 mm region of one surface was prepared by taking mass spectra over a 20 x 12 array of spots. There was great variability in the signal strengths from the 240 spots. To illustrate this point, we prepared a contour plot (Fig 1a) of the most intense PAHs. For each spot, the signal intensity of phrenanthrene (C₁₄H₁₀; 178 amu), pyrene (C₁₆H₁₀; 202 amu), chrysene (C₁₈H₁₂; 228 amu) and benzoypyrene (C₂₀H₁₂; 252 amu) were summed and recorded. The data for the 20 x 12 array were spline fit to make the contours less jagged. In Fig 1a, there are three regions of the sample that are richer in PAHs than others. These are referred to as "hot" spots. SEM observations show that a correlation exists between one surface feature and a region with the highest PAHs concentration (Figs 1a, 1b). The surface feature is a magnesite core, ~30 μm in diameter, located within a carbonate spheroid. The diameter of the PAHs "hot" spot and the spheroid core are comparable suggesting that the core may be the hydrocarbon carrier. Two other regions of slightly enhanced concentrations of PAHs did not correlate with surface features. Not all spheroid cores in the analyzed chip contain PAHs excesses; in fact, some cores do not have PAHs concentrations above background.
PAHs in ALH 84001; Thomas, K.L. et al.

**Discussion** PAHs have been observed in ALH 84001 and have been correlated with specific surface features. The intensities for these signatures are much weaker than those observed in carbonaceous meteorites, however PAHs were not concentrated in acid residues as with some meteorites [3]. Although there may not be a correlation between bulk carbon and the presence of PAHs, the total carbon in ALH 84001 (~600 ppm [7]) is low compared to carbonaceous chondrites. PAHs have been previously measured in IDPs with bulk carbon ranging from 3-14 wt.% [1,2] and in chondrites [3] with bulk carbon abundances ranging from ~0.1-4.0 wt.% [e.g., 8]. Hydrocarbons were reported from another martian meteorite, EETA 79001 [9] and have been observed in bulk samples of ALH 84001 [7]. However, the presence of organic compounds in ALH 84001 has been interpreted as possible terrestrial contamination [7]. A portion of the bulk carbon in ALH 84001, which has been reported to combust at temperatures up to 450 °C [7], may be represented by the PAHs component in our study. The carbonates in this meteorite may have been formed from relatively low temperature circulating fluids [5,6]. If so, these fluids may also have contained dissolved hydrocarbons.


**Spatial Distribution Masses 178, 202, 228, 252 amu**

**Figure 1a.** Contour map showing regions of PAHs enrichments. PAHs are in two regions which are slightly above background. Region in upper left is > 4 x enriched in PAHs above background.

**Figure 1b.** Low magnification back scattered SEM image of ALH 84001 surface mapped in Fig 1a. Carbonate spheroid in dark circle corresponds to region with the highest PAHs enrichment. Scale bar is 100 μm.