MICRO-SPECTROSCOPY AS A TOOL FOR DETECTING MICRON-SCALE MINERAL VARIATIONS ACROSS A ROCK SURFACE: AN EXAMPLE USING A THIN SECTION OF MARTIAN METEORITE ALH 84001.

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Introduction: Imaging spectroscopy is a powerful tool for mineral detection across broad spatial regions. A prototype micro-imaging spectrometer at NASA-Ames is tested in this study on a scale of tens to hundreds of microns across rock surfaces. Initial measurements were performed in the visible spectral region on a thin section of martian meteorite ALH 84001.

Martian Meteorite ALH 84001: Numerous detailed studies of ALH 84001 have been initiated since its identification as a martian meteorite [1], partly owing to its prominence as a potential carrier of evidence for life on Mars [2]. Bulk reflectance spectra of chip surfaces [3] and a particulate sample [4] of this meteorite have been completed. These and other studies confirm low-Ca pyroxene as the dominant mineralogy of this meteorite and have identified small grains of magnetite and Mg-Fe carbonate, plus a variety of organics.

Instrument: The Kairos Scientific Microscopic Digital Imaging Spectrometer (MicroDIS) is a high resolution infrared imaging microscope (HIRIM) and was developed for biological applications. It utilizes an Olympus BX60 microscope, a Peltier cooled CCD camera, and computer-interfaced monochromator [5]. CyberDIS software is provided with the instrument that enables sorting of spectra in the entire image in order to identify spectrally dominant signatures as well as problematic spectra.

Measurement Procedure: We selected a region of the martian meteorite ALH 84001 under 10X magnification that showed darker grains on the left and lighter grains on the right separated by what appears to be a fissure cavity (see Figures 1-3). The image was focussed using the 510 nm channel because this showed a good response for all areas of interest. Spectra were run of this region from 430 to 800 nm at 5 nm spectral resolution.

Using the Kairos software we selected groups of absorbance spectra from related regions in the magnified image. Figure 1 shows an image with the fissure cavity marked in red, Figure 2 shows an image with a pyroxene grain marked in red, and Figure 3 shows the rim of the fissure marked in red. Note that the rim in Figure 3 surrounds but does not include the material marked in Figure 1. Spectra were also acquired for the bright region shown in these images and the glass/epoxy layer outside the area of the sample in the thin section. Selected raw absorbance spectra of this sample are shown in Figure 4. The bright region and the fissure rim spectra look much like the glass/epoxy spectra and are distinct from the spectra of the pyroxene spot and fissure cavity region.

Spectral Processing: Additional spectral processing is required for this sample because of the glass and epoxy binding the meteorite in the thin section. Shown in Figure 5 are spectra of the regions marked in Figures 1 and 2 after normalizing to the fissure rim. This was attempted because the fissure rim exhibits some spectral characteristics similar to those of the outer glass region. This may represent the upper glass/epoxy layer above the meteorite sample in the thin section. Unfortunately we were unable to completely remove the signature of the glass/epoxy substrate by this method. For comparison, bulk reflectance spectra of two spots on the surface of ALH 84001, split 271 (from [3]) and a particulate magnetite sample measured at the Brown University RELAB facility are also shown here. Shown in Figure 6 are spectra from regions shown in Figures 2 and 3 that were first converted to reflectance, then normalized to a glass spectrum and then to the fissure cavity spectrum. Remnants of the glass bands at 550, 595 and 680 nm occur in many of the spectra even after these normalization attempts. Still, Figures 5 and 6 demonstrate the ability of micro-imaging spectroscopy to isolate and identify components which are not separable in bulk spectra.

Work in progress: We will continue to refine normalization techniques that will better enable separation of the spectral signatures due to minerals from those of the thin section glass and epoxy. We are also hoping to run some spectra on this ALH 84001 thin section in the infrared region. We are also planning to run spectra of a few grains from ALH 84001, split 92, in the hopes of simplifying and improving the spectral processing required. Our goal is to identify variations in the Fe mineralogy of this meteorite at the micro scale across broad spatial regions.

References: [1] Clayton R. N. (1993) *Antarctic Meteorite Newsletter* 16(3), 4; Mittlefehldt D. W. (1994) *Meteoritics* 29, 214. [2] McKay D. S. et al. (1996) *Science* 273, 924. [3] Bishop J. L. et al. (1998) *Meteorit. Planet. Sci. 33,* 693. [4] Bishop J. L. et al. (1998) *Meteorit. Planet. Sci. 33,* 699. [5] Yang M. et al. (1998) *Biotechnology et alia* 4, 1.

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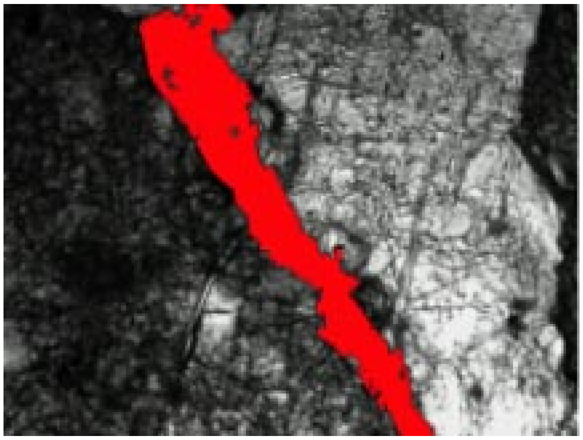

Fig. 1 10X Image of ALH84001 thin section with fissure cavity spectral region marked in red.

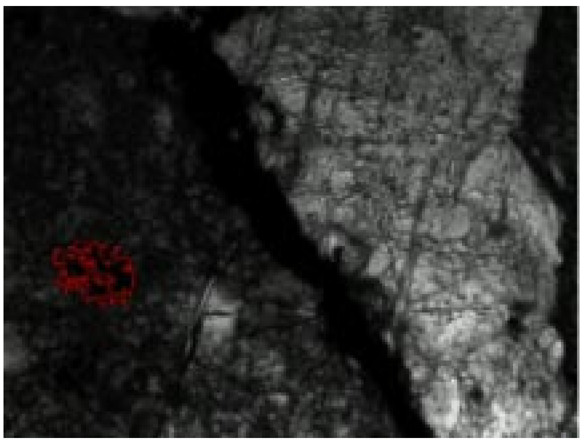

Fig. 2 10X Image of ALH84001 thin section with pyroxene spot spectral region marked in red.

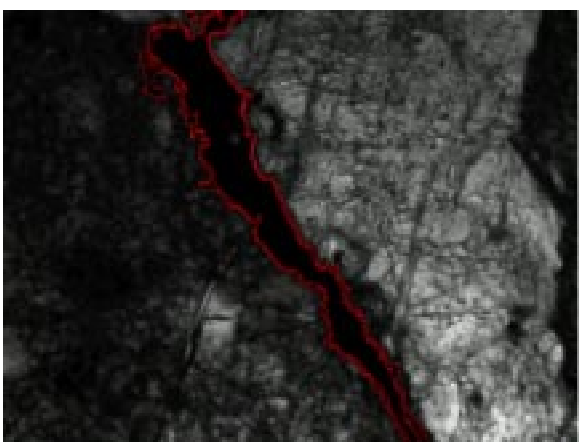

Fig. 3 10X Image of ALH84001 thin section with fissure rim spectral region marked in red.

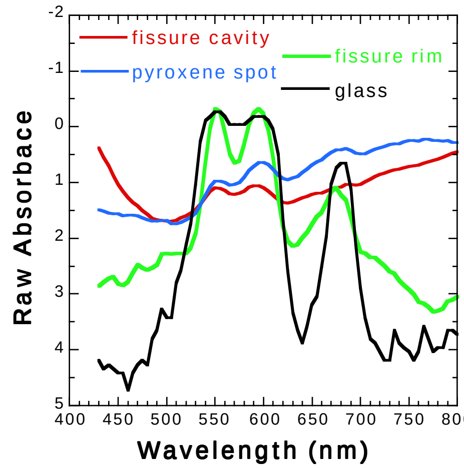

Fig. 4 Raw absorbance spectra measured using micro-visible spectrometer of regions shown in Figs. 1-3 on a thin section of ALH 84001, plus the thin section glass.

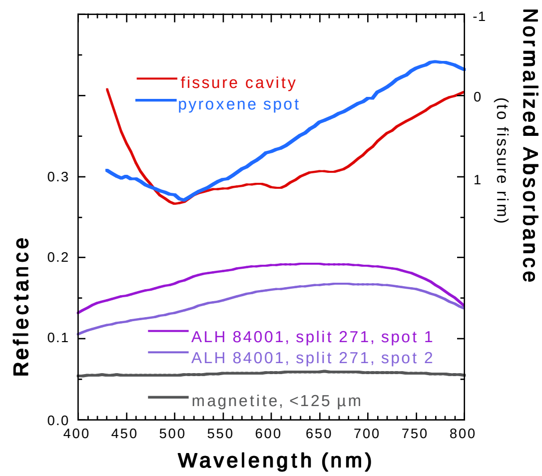

Fig. 5 Normalized absorbance spectra from Fig. 4 compared with bulk reflectance of ALH 84001 and magnetite.

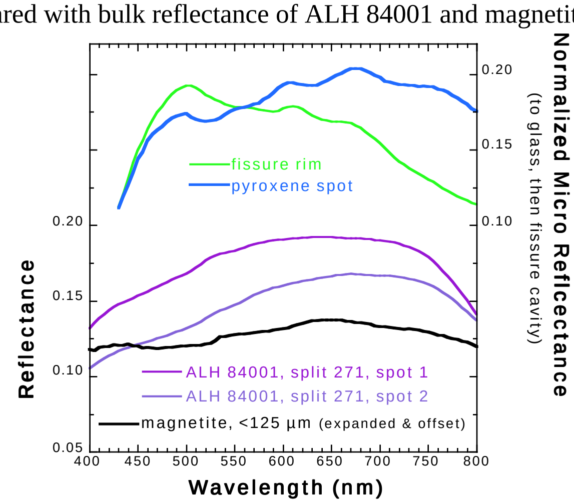

Fig. 6 Normalized reflectance spectra from Fig. 4, plus bulk reflectance of ALH 84001 and magnetite.