THE ABSENCE AND PRESENCE OF OLIVINE IN THE COLUMBIA HILLS OF GUSEV CRATER, MARS: THE LATEST RESULTS FROM MINI-TES. S. W. Ruff[1] and the Athena Science Team, [1]Department of Geological Sciences, Arizona State University, Tempe, AZ 85287-6305, steve.ruff@asu.edu.

Introduction: At the time of writing, the Mars Exploration Rover Spirit had descended from the summit of Husband Hill in Gusev Crater via Haskin Ridge (Fig. 1) and is now crossing the South Basin en route to "Home Plate". The traverse up the north side of Husband Hill revealed a remarkable diversity of rock types as seen by the Miniature Thermal Emission Spectrometer (Mini-TES, ~2000-350 cm^{-1},[1]). The route down off the summit presented yet more spectral/lithological diversity. The variation in mineralogy that most distinguishes the different segments is that of olivine. Olivine dominates the rocks of lower Haskin Ridge but is diminished or absent on the West Spur and Husband Hill.

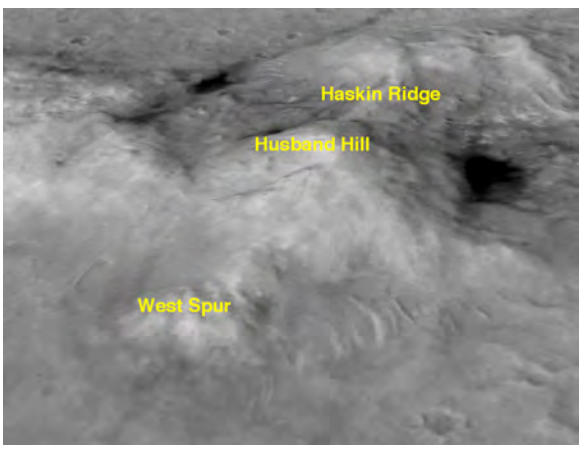

Figure 1. A view looking east across the portion of the Columbia Hills traversed by the Spirit rover. This perspective view was created from topography derived from MOC stereo imaging by the USGS, Flagstaff (courtesy L. Soderblom).

Spectral Measurements: The major rock/spectral classes encountered during the ascent [2] and descent of Husband Hill are shown in Fig. 2. Ascending from the basalt-covered plains of Gusev, the rover first encountered rocks on the West Spur collectively known as Clovis Class that appear to be dominated by basaltic glass. The north side of Husband Hill is covered in float rocks called Wishstone Class with the clear spectral signature of plagioclase that approaches 60% of the bulk mineralogy. Large outcrops called Larry's Lookout and Jibsheet Ridge on Husband Hill are home to Watchtower Class rocks that appear to be dominated by a basaltic glass component and show no obvious spectral features attributable to plagioclase or olivine. At the summit of Husband Hill, more plagioclase-bearing Wishstone Class float rocks were found along with a substantial outcrop of rock most similar to Watchtower Class (i.e., little to no olivine).

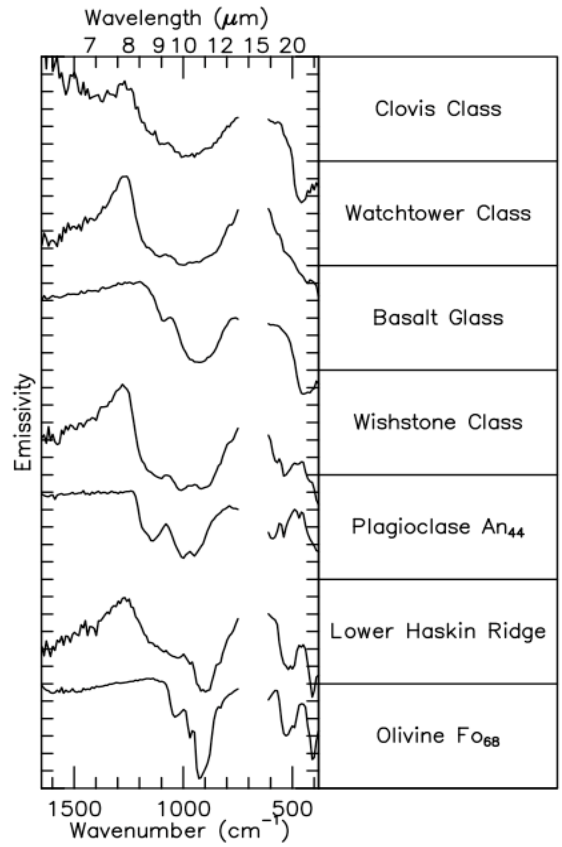

Figure 2. Example Mini-TES spectra of the major rock types observed in the Columbia Hills along with laboratory spectra of components that dominate each class (most evident at long wavelengths).

The descent from the summit involved a traverse across a region known as upper Haskin Ridge where a surprising diversity of rock types was encountered, most of which are distinct from the rocks observed during the ascent. The rover investigated one outcrop here known as Kansas. Mini-TES spectra of these rocks lack the distinctive feature of olivine that would come to dominate the majority of the rocks of lower Haskin Ridge. Beginning with the outcrop called Larry's Bench on lower Haskin Ridge and extending downhill through the greatest abundance of outcrop yet observed on the mission, spectral features

attributable to olivine have dominated Mini-TES spectra. Based on comparisons with laboratory olivine spectra, it appears that olivine with a composition of ~Fo_{60} is the norm. The ability to estimate Fo# from band position is being investigated by [3]. Formal deconvolution of Mini-TES spectra following sol 420 has been inhibited by dust contamination of the Mini-TES pointing mirror as described in the next section.

Dealing with the Dust: An aeolian event occurred sometime during sol 420 that incredibly, cleared much of the power-robbing dust that had accumulated on the rover's solar panels. But this same event appears to have deposited a film of dust on the Mini-TES pointing mirror housed in the top of the Pancam mast assembly. While far from opaque, the mirror dust does contribute spectral features to those of every target viewed by Mini-TES. The magnitude and sign of the dust artifacts depend on the temperature difference between the mirror and target (ΔT_{MT}).

We have developed a semi-quantitative correction for mirror dust that is based on use of the external calibration target as a known spectral reference. If we assume that the spectral shape of the external calibration target is that which was observed prior to sol 420, then any departure from this shape is due to the mirror dust. To correct the spectrum of a rock or soil target we can use a correction based on the spectrum of the external calibration target with a similar ΔT_{MT} as the surface target. For example, an observation of a Wishstone class rock called Rousseau (Fig. 3a) with a ΔT_{MT} of ~12° C can be corrected using the spectrum of the external calibration target with a comparable ΔT_{MT} according to the equation:

$$\varepsilon_{cor} = \varepsilon_{rock} - \varepsilon_{cal} - \varepsilon_{cal\ pre\text{-}dust} + 2 \qquad (1)$$

where ε_{cal} is the emissivity of the external calibration target with a comparable ΔT_{MT} and $\varepsilon_{cal\ pre\text{-}dust}$ is the average emissivity of the external calibration target prior to sol 420. The addition of the constant value 2 normalizes for the subtraction of the two other quantities. The result is shown in Fig. 3b. The corrected Rousseau spectrum is much more similar to the average Wishstone class spectrum. While not a perfect match, the mismatch in the middle wavenumber range may actually represent real variation between this rock and the average Wishstone spectrum. At this point, such a correction serves to better assess the spectral character of rocks that have no pre-sol 420 counterparts, which is the case for all of the olivine-rich rocks on lower Haskin Ridge. Future improvements to the correction likely will need to account for the different radiance terms associated with the target and mirror dust to minimize the potential for introducing slope into the corrected spectrum. Until then, deconvolution of spectra following sol 420 has been put off.

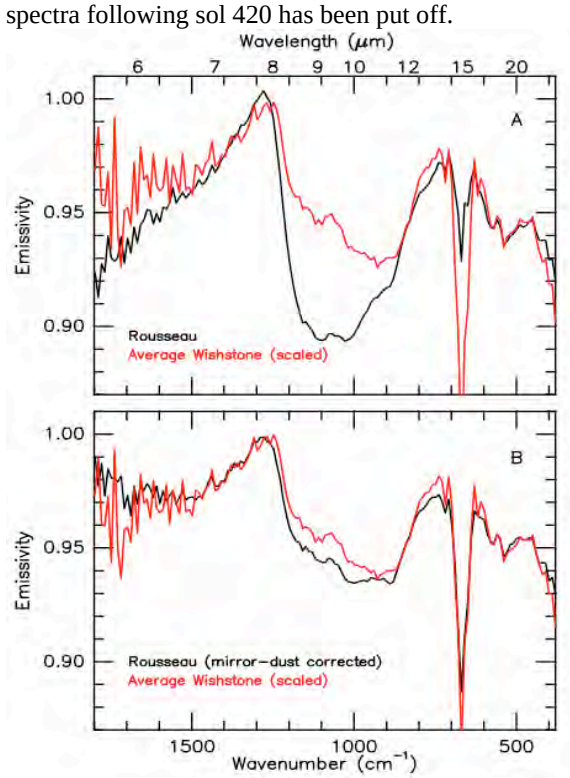

Figure 3. An example of a spectrum showing the effect of mirror dust (Rousseau) in A and a semi-quantitative correction shown in B.

Discussion: While the rocks encountered by the Spirit rover on the Gusev plains are rich in olivine, those in the Columbia Hills have shown notable variations. Outcrops on the West Spur and on the north side and summit of Husband Hill are lacking in olivine and other primary igneous minerals and instead appear to be dominated by basaltic glass. This is in contrast to the float rocks spread across the north side of Husband Hill that are dominated by plagioclase with a minor olivine component. The abundant outcrops encountered on lower Haskin Ridge display an olivine feature and abundance comparable to the rocks on the plains. If we assume that olivine can be used as an indicator of the interaction of water with the rocks of the Columbia Hills, the role of water has been highly variable.

References: [1] Christensen, P. R., et al., *Science* **305**, 837-842 (2004). [2] Squyres, S. W., et al., *Journal of Geophysical Research* (In press). [3] Lineberger, D. H., *LPSC* (2006)