VISIBLE/NEAR INFRARED SPECTRAL TRENDS BETWEEN MERIDIANI PLANUM SURFACE MATERIALS: COMPARISONS BETWEEN SPHERULES, BASALTIC SANDS, OUTCROP, RINDS, AND COBBLES. W.H. Farrand[1], B.L. Joliff[2], J.F. Bell III[4], J.R. Johnson[5], [1]Space Science Institute, 4750 Walnut St. #205, Boulder, CO 80301, farrand@spacescience.org, [2]Washington University, St. Louis, MO, [4]Cornell University, Ithaca, NY, [5]U.S. Geological Survey, Flagstaff, AZ.

Introduction: The Mars Exploration Rover Opportunity has been exploring a portion of Meridiani Planum and has encountered a number of surface materials. These include light-toned sulfate-rich outcrop (the Burns Formation), basaltic sand, hematite-rich spherules, and, less commonly, dark-toned cobbles and dark-toned rind and fracture fill materials. The nature of the outcrop has been extensively examined [e.g., 1,2,3,4,]. While addressed by [3], the nature of the rind/fracture fill material remains enigmatic. The cobbles encountered at various places on the Meridiani plains are also enigmatic and appear compositionally diverse [5]. Multispectral visible and near infrared images from Opportunity's Pancam [6] can be used to look for common color properties between these surface materials.

The Pancam Instrument and Data: Pancam consists of two digital cameras mounted on a mast over the deck of the rover. The two cameras enable stereo imaging. Each Pancam "eye" utilizes a 1024x1024 active imaging area frame transfer CCD detector array and has an 8-position filter wheel allowing multispectral imaging in the 400 to 1000 nm VNIR spectral range. Operational multispectral observations typically consisted of observations in 13 "geology" filters with spectral overlap between the eyes near 435 and 750 nm. Further details on the Pancam instrument are provided in [6].

Processing of Multispectral Data: Pancam data are calibrated to absolute radiance using pre-flight radiance coefficients derived from integrating sphere observations and corrected for detector and electronic temperature variations. The data are calibrated to radiance factor (I/F) by reference to measurements made of a calibration target mounted on the deck of the rover. An empirical correction for dust accumulation on the calibration target has been applied to the data [7]. By dividing by the solar incidence angle at the time of data acquisition, the data are converted to relative reflectance (R*). The R* spectra of materials of interest were decomposed to a number of spectral parameters discussed below.

Images and Spectra of Meridiani Surface Materials: As discussed in [8], there are two broad color classes that describe Meridiani outcrop. In Pancam L3,5,7 (673, 535, 432 nm) color composites these classes appear buff and red to purple colored and are referenced as such here. In true color renditions of the Meridiani outcrop [9], these color differences are more muted. We also draw a distinction between "rinds" which are oriented coplanar, or nearly so, to bedding (**Fig. 1a**) and "fracture fill" which are oriented perpendicular, or nearly so, to bedding (**Fig. 1b**). **Fig.2** shows Pancam spectra of representative Meridiani surface materials including two compositionally distinct cobbles (Antistazi and Perseverance).

Spectral Parameter Plots of Meridiani Surface Materials: Fig. 3 shows a plot of 535 nm band depth versus 535 to 601 nm slope for basaltic sand, hematite spherules, and different color units from the Shoemakers Patio region of Eagle crater (mapped as "Unit A" by [1]). There is a clear trend of increasing 535 to 601 nm slope and increasing 535 nm band depth from the spherules to the basaltic sand to the red rinds and then a split between the "purple" and "buff" surfaces of Unit A. A similar trend is observed for a plot of band depth at 535 and 600 nm among comparable surface materials from the "Fruitbasket" and "Olympia" areas (**Fig. 4**). These plots illustrate that the Meridiani spherules are dominated by gray, rather than red, hematite since they have such low 535 nm band depth values. The cobbles plotted in **Fig. 4** have even lower 535 nm band depths indicating surfaces relatively lacking in ferric oxide – rich components.

The basaltic sand has slightly higher values for these parameters, which could indicate inclusion of some of the highly oxidized windblown bright drift material. The rinds (from the "Fruitbasket" region) and fracture fill (from "Olympia") have higher values for these parameters, but are still lower than those of the outcrop. While the formation mechanism(s) for the rinds and fracture fill is/are still to be determined (the two features could have different origins), the position of these materials in the spectral parameter plots of **Fig. 3** and **4,** between basalt sands and outcrop, in conjunction with MB and APXS results, suggests a composition intermediate between outcrop and surface materials (eg., basaltic sands). Possibilities for the origin of the rind and fracture fill material include possibilities ranging from physical mixtures (eg. something akin to clastic dikes) to in place alteration due either to interaction with diagenetic fluids or with atmospheric constituents [10]. Color differences close to

the fracture in **Fig. 1b** are suggestive of diagenetic alteration in association with the fracture fill.

The very low 535 nm and 600 nm band depth of cobbles such as those plotted in **Fig. 4** suggests that these materials are very weakly oxidized. However, cobbles examined at Meridiani have proven to be variable both in terms of their VNIR spectral character and their chemical composition [5].

Conclusions: The spectral parameter plots of **Fig. 3** and **4** suggest trends of increasing oxidation from cobbles and spherules through basaltic sands, rinds and fracture fills to buff-colored outcrop. Since the spherules contain a substantial fraction of ferric oxide in the form of gray hematite, such a trend is not completely valid, but might have more to do with increases in the fraction of fine-grained ferric oxide phases such as red hematite and/or other ferric oxide or oxyhydroxide phases on material surfaces.

References: [1] Squyres S.W. et al. (2004) *Science, 306,* 1709. [2] Grotzinger J.P. et al. (2005) *EPSL, 240,* 11. [3] McLennan S.M. (2005) *EPSL,240,* 95. [4] Clark B C. (2005) *EPSL, 240*, 73. [5] Joliff, B.L. et al. (2006) *LPS XXXVII* [6] Bell J.F. III et al. (2003) *JGR,108, E12*. [7] Sohl-Dickstein, J. et al. (2005) *LPS XXXVI*, #2235. [8] Farrand, W.H. et al., *JGR*, in preparation. [9] Savransky, D. and J.F. Bell (2004) *EOS*, abstract P21A-0197. [10] Learner, Z.A. et al. (2006), *LPS XXXVII*, this conference.

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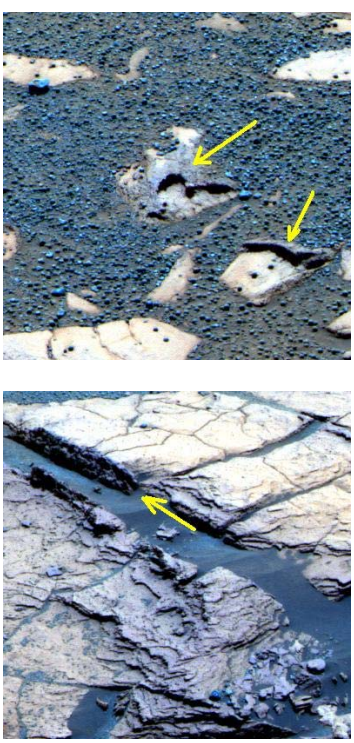

Figure 1. **A** (top). Sol 50 P2579 L357 composite of target Golf Hole at Shoemakers Patio, Eagle crater. **B** (bottom) Sol 675 P2542 L357 composite of target Roosevelt in the Olympia region, Erebus crater.

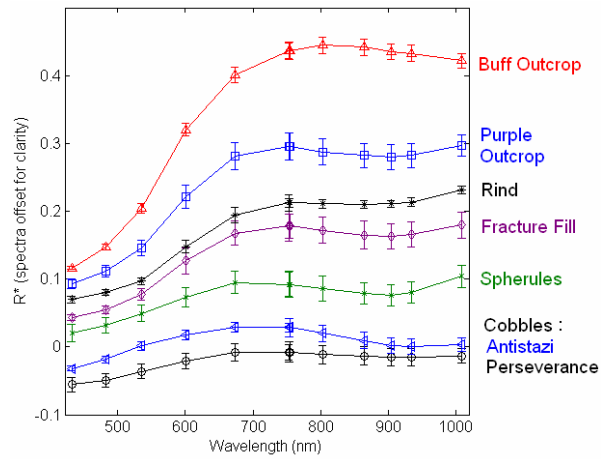

Figure 2. Representative Pancam spectra of Meridiani surface materials.

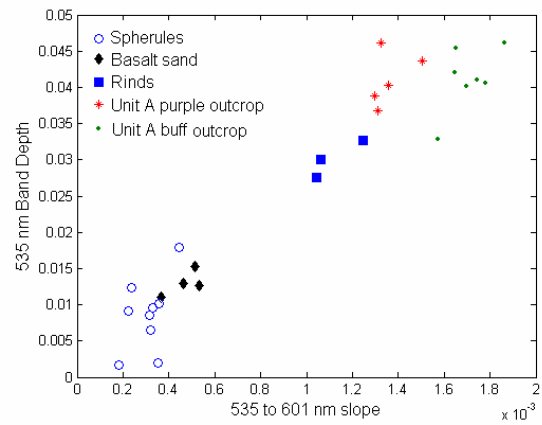

Figure 3. Plot of 535 nm band depth vs. 535 to 601 nm slope of Meridiani surface materials from Shoemakers Patio.

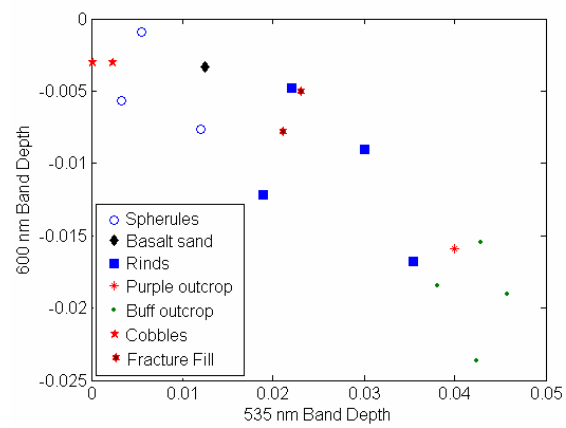

Figure 4. Plot of 535 nm band depth vs. 600 nm band depth for surface materials from the Fruitbasket and Olympia regions.