SEEING THE SOILS OF MERIDIANI PLANUM THROUGH THE EYES OF PANCAM AND MICROSCOPIC IMAGER. C. M. Weitz[1] (weitz@psi.edu), R. C. Anderson[2], J. F. Bell III[3], N. A. Cabrol[4], W. M. Calvin[5], B. L Ehlmann[6], W. H. Farrand[7], R. Greeley[8], K. E. Herkenhoff[9], J. R. Johnson[9], B. L. Jolliff[6], R. V. Morris[10], L. A. Soderblom[9], S. W. Squyres[3], R. J. Sullivan[3]; [1]Planetary Science Institute; [2]Jet Propulsion Laboratory; [3]Cornell University; [4]NASA Ames; [5]University Nevada, Reno; [6]Washington University, St. Louis; [7]Space Science Institute; [8]Arizona State University; [9]U.S. Geological Survey, Flagstaff; [10]NASA Johnson Space Center.

Introduction: We are using data from the Pancam and Microscopic Imager (MI) on the Opportunity rover to characterize the soil grains at Meridiani Planum. We have traced individual grains in all MI images of the soils using the software application ImageJ distributed by NIH, and subsequently derived size and shape properties about the grains. The resolution of the MI is 31 microns per pixel [1] so we limit our measurements to those grains larger than about 0.3 mm in size. In cases where the grain is partially or substantially buried by other grains or finer soil particles, we do not make a measurement. False-color composites from Pancam images that cover the same location imaged by MI are made from the Left 2,5,6 (753, 535, 482 nm) filters or Right 2,7,1 (753, 1009, 430 nm) filters [2] in the Red, Green, and Blue channels, respectively. These color images are then merged with the MI images to illustrate color properties of particular grains. Pancam spectra are also extracted from grains when there is sufficient spatial coverage.

Background: The Opportunity rover has revealed a variety of soil grains at the Meridiani Planum site. The soils at Meridiani Planum are dominated by sand-size basalt particles <125 microns in size mixed with a lag deposit of larger grains of variable composition and size [3,4]. Spectrally, the soils show heterogeneity depending upon the grain types that dominate the soils at any particular location [5]. Whereas the soils at Gusev Crater are dominated by basaltic sand grains and basalt fragments [6], the soils at Meridiani have variable mixtures of sand size basalt grains, hematite-rich spherules and fragments, coated partially buried spherules, fragments of the evaporite sulfur-rich outcrop, and mm-to-cm size basalt fragments [3,4,5]. Soils at both sites also contain variable amounts of fine-grained dust.

MI and Pancam observations of the soils: Figure 1 shows the average length for the major axis of grains measured for each MI image taken inside Eagle crater. In general, the size of most grains within Eagle crater falls between 1.5-3.5 mm, with very few grains at the smaller sizes (0.3-1.0 mm). Exceptions include the location containing targets "Cookies 'N Cream" and "Vanilla" from Sol 53 that is dominated by spherical grains between 0.5-1 mm in diameter. Figure 2 illustrates the dominance of these small grains at this particular location, which happens to be on the southern wall of Eagle crater. The Pancam color merge with this MI image suggests that the small spherules are more consistent with the basalt grains than the "blueberries" (spherulitic concretions derived from outcrop rocks [7]). The resolution of Pancam images of this location is on the order of 0.5 mm so the grains are only barely resolved. A Mössbauer measurement taken on an adjacent soil (Sol 53 Vanilla) that is composed solely of these smaller spherules (Fig 1) is consistent with a basaltic composition for the grains. Their concentration at this particular location in a brighter, elongate patch along the southeastern wall compared to elsewhere inside Eagle crater suggests wind activity favored their transport and subsequent deposition here. Their spherical shape is also possibly the result of wind action rounding them during transport, though water action cannot be ruled out.

MI soil images dominated by blueberries, such as Sol 14 "Superwit" and Sol 46 "Berrybowl" targets, have typical grain sizes between 3-4 mm. Most blueberries are not perfect spheres but instead show some form of small elongation or denting, perhaps caused by weathering rather than from origin in the outcrop as concretions. The circularity of soil grains measured inside Eagle crater is shown in Figure 3. The majority of grains fall above 0.9 (a perfect circle is 1.0), which indicates the grains are very circular in cross section. Exceptions were found on Sol 9 and Sol 10 ("Tarmac") which were taken adjacent to the lander and are dominated by elongate and fractured grains of basalt. Sol 56 "Brian Choice" is also dominated by angular basalt grains with a few blueberries mixed into these soils. The circular nature of the soil grains at Meridiani is probably both a reflection of their original morphology formed as concretions, and also their transport and modification by wind activity.

Grains outside of Eagle crater and along the smooth plains do not show the range of sizes and shapes seen inside the crater. The average size of the blueberries on the plains is slightly below that of blueberries located in soils adjacent to the Eagle crater outcrop, reflecting possible degradation by

wind activity that causes the grains to become smaller and more elongate with time due to transport.

Eolian ripples seen ubiquitously on the plains have a monolayer of rounded grains that are hematite-rich in composition [3,4]. We measured the sizes of 206 grains for the Sol 89 "Fred Ripple" target, which is located on the crest of one of these plains ripples. The average major axis length for these grains is 1.7±0.4 mm, with a circularity of 0.9±0.06. For a similar ripple within Eagle crater (Sol 52 "Lanikai"), we measured the same average size and circularity. Although rounded in shape, the grains on these ripple crests are slightly elongate, even more so than the blueberries located adjacent to the ripples.

Scattered throughout the soils of Meridiani Planum are cobbles that range from a few cm's to many tens of cm's in size. The cobbles occur in several spectral types, as demonstrated in Figure 4. While some are spectrally similar to "Bounce Rock", which was determined by APXS and Mössbauer to be SNC-like in composition [8,9], others have a broad absorption at longer wavelengths, such as Sol 123 "Barberton." Still other cobbles appear smooth and rounded, and have an upturn in reflectance between 933(R6) and 1001(R7) nm, which is characteristic of the hematite-rich blueberries [1]. Their larger sizes and broader absorption around 850 nm (i.e., Sol 51 "Sharkcage") suggest additional material besides that typically found in the blueberries, however.

References: [1] Herkenhoff, K.E. *et al.*, (2003), *JGR, 108*, 10.1029/2003JE002076 [2] Bell III, J.F. *et al.* (2003) *JGR, 108*, 10.1029/2003JE002070. [3] Soderblom, L. A. et al. (2004) *Science, 306*, 1723-1726. [4] Herkenhoff, K. E. et al. (2004) *Science, 306*, 1727-1730. [5] Bell, J. F. et al. (2004) *Science, 306*, 1703-1709. [6] Herkenhoff, K. E. et al. (2004) *Science, 305*, 824-826. [7] Squyres, S.W. *et al.* (2004) *Science, 306*, 1709-1714. [8] Klingelhöfer, G. et al., (2004) *Science, 306*, 1740-1745. [9] Rieder, R. et al., (2004) *Science, 306*, 1746-1749.

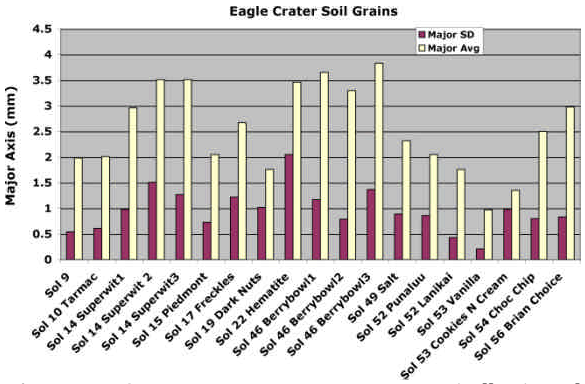

Figure 1. Average major axis grain size (yellow) and standard deviation (red) based upon MI images for soils inside Eagle crater.

Figure 2. Pancam Right eye filters 2,7,1 (750, 1009, 430 nm) in channels Red, Green, Blue, respectively, merged with MI image Sol 53 for target "Cookies'N Cream." Image is 3x3 cm in size.

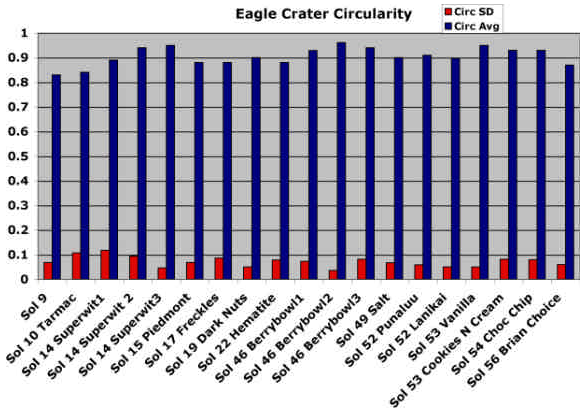

Figure 3. Average circularity of grains (blue) and standard deviation (red) within Eagle crater soils indicates most grains are very circular in shape.

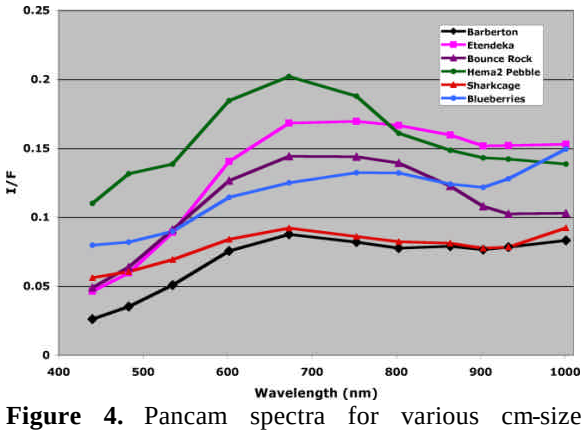

Figure 4. Pancam spectra for various cm-size cobbles seen at Meridiani Planum compared to a typical spectrum for the blueberries.