Grains on ripples are dominated by hematite-rich spherules of a remarkably homogeneous size distribution (1.3–1.8 mm diameter) with finer basalt sand and dust interspersed between the spherules [*Weitz et al.*, 2006]. The spherules display high levels of rounding and sphericity (seen at the target "RippleCrest_2" in Figure 33) and act as an armoring agent [*Soderblom et al.*, 2004; *Sullivan et al.*, 2005]. This size range is significantly smaller than that observed for spherules in the immediately underlying outcrop material and may indicate derivation from overlying outcrops that formed under a differing hydrodynamic diagenetic regime.

[84] Soils that are not located on the ripples are a mixture of spherules, rock fragments, basalt sand, and dust. Many of the millimeter-size rock fragments and larger centimeter-size cobbles are interpreted as pieces of meteorites, impact ejecta, or the outcrop lithology [*Weitz et al.*, 2006; *Squyres et al.*, 2006].

[85] Examination of the soils within Endurance Crater reveals grains not seen on the plains or at Eagle Crater. Rounded grains informally termed "popcorn" are found in association with outcrop lower down the walls of Endurance Crater (Figure 34). They are interpreted as originating within the outcrop rocks from a secondary generation of cementation and recrystallization formed around a variety of nucleation sites, including, but not restricted to the spherules [*McLennan et al.*, 2005].

[86] MI images of the outcrop near the floor of Endurance Crater also include cracks and depressions filled with small granules and basaltic sand (Figure 35). *Weitz et al.* [2006] measured the sizes of these grains to be 0.61 ± 0.22 mm, which represents the smallest population of grains resolved by the MI (i.e., >0.1 mm) thus far at Meridiani. There are actually two different types of grains seen at "Escher," with the larger, more irregularly shaped and brighter grains interpreted to be pieces of the outcrop while the smaller, darker grains appear to be basalt granules mixed in with the finer basalt sand. Additional soils near the floor of Endurance have spherules similar in size to the 4.5 mm diameter spherules still embedded in the outcrop (Figure 36). MI images of these soils also show centimeter-size rock fragments that are more angular in shape than the spherical spherules, perhaps representing impact ejecta or meteorite fragments now mixed into the soils.

[87] Examination of the ripples and interripple plains encountered after egress from Endurance Crater shows similar grains to those seen earlier in the plains soils. The main difference between these more southerly soils appears to be in the sizes of the grains that compose the lag deposit of the interripple plains. Figure 37 shows a plot of the average size of soil grains measured in each MI image. The size of the grains in the northerly plains between Eagle and Endurance craters is slightly larger than the grains seen in the soils as Opportunity drove south away from Endurance Crater. The size difference is most obvious in the spherules that compose the interripple plains, with those to the south being about 1 mm smaller. *Weitz et al.* [2006] attribute the smaller sizes of spherules in the southerly soils to smaller sizes of spherules observed in the local outcrop rocks that are weathering out and mixing into the soils as windblown sand grains erode the outcrop.

[88] The size of spherules that compose the soils on the ripples (Figure 33) remained similar even though the ripples are larger in overall size [*Sullivan et al.*, 2007]. Opportunity spent a significant amount of time studying "Purgatory Ripple," where the rover was stuck for several weeks in the fine-grained soils of the ripple interior (Figure 38).

Figure 38. Radiometrically calibrated MI image 1M173193890 of target Track, acquired on sol 507 in full shadow. Soil within track created by rover wheels is composed of fine grains and appears relatively high in reflectance, suggesting a high proportion of dust. Mössbauer imprint into soil (lower left) is well preserved, indicating that soil becomes consolidated when force is applied. Area shown is 31 mm square.

5. Conclusions

[89] The data returned by Opportunity's Microscopic Imager have provided key constraints in the interpretation of MER observations of various types of rocks and soils on Meridiani Planum. Evidence for both primary sedimentary structures and secondary mineralization is seen in MI images. Digital elevation models of MI stereo observations of the rock target Overgaard support the previous conclusion that liquid water once flowed across the surface of Meridiani Planum. The grain size and lamina thickness distributions observed in sandstones in the Burn formation indicate that they were formed by eolian deposition. Soil grain sizes and shapes are more homogeneous on the Meridiani plains than in Eagle Crater, with well-sorted spherules dominating ripple surfaces. The size of spherules between ripples decreases by about 1 mm from north to south along Opportunity's traverse.

[90] The relative (pixel-to-pixel) radiometric calibration accuracy of typical MI data acquired during the first three extended missions is 1.5%, and the absolute radiometric calibration accuracy is 20% or better. The MI continues to acquire good images as the rover explores Victoria Crater. MI data acquired after sol 900 will be described and discussed in future publications.