RECENT ATHENA MICROSCOPIC IMAGER RESULTS. K. E. Herkenhoff[1] (kherkenhoff@usgs.gov), J. W. Ashley,[2] N. A. Cabrol,[3] R. A. Yingst,[4] R. E. Arvidson,[5] and the Athena Science Team, [1]USGS Astrogeology Science Center, Flagstaff, AZ 86001; [2]Arizona State U.; [3]SETI Institute; [4]U. Wisconsin, Green Bay; [5]Washington U.

Introduction: The Athena science payload [1] on the Mars Exploration Rovers (MER) includes the Microscopic Imager (MI), a fixed-focus camera mounted on the instrument arm. The MI acquires images at a scale of 31 µm/pixel over a broad spectral range (400 to 700 nm). The MI acquires images using only solar or skylight illumination of the target surface. Early results of the MI experiment on both MER rovers (Spirit and Opportunity) have been published previously [2-5]. Highlights of more recent results are described below.

Spirit (MER-A) results: Soil materials at Gusev show texture down to the limit of MI resolution (~100 µm). Soil surfaces are typically rough at submillimeter scales but are molded to much smoother surfaces under compression by the Mössbauer contact plate and/or a rover wheel, suggesting the presence of a substantial fraction of particles too small to be resolved. It is unclear how much of this remolding was accomplished by compression of void space and reorganization of existing particles versus crushing of weak particles to even smaller sizes [6]. Sand-sized dust aggregates are observed on the Martian surface and on the rover [7], and are likely to be easily mobilized by winds. Therefore, saltation of solid sand grains may not be required to inject dust into the atmosphere, explaining the rarity of dune migration despite the frequency of dust storms on Mars [8]. MI and other observations of rover tracks show that both deposition and erosion act to erase the tracks, but fallout of atmospheric dust plays only a minor role [9].

Soil samples on the Gusev plains and in the "Columbia Hills" can be classified into two textural domains. One is heterogeneous, with a continuum of angular-to-rounded particles of fine sand to pebble sizes and is generally dust covered and locally cemented. The second shows the effects of dominant and ongoing eolian processes that redistribute a population of medium-size (270 µm) sand [10]. The finer fraction is more chemically homogeneous, consistent with a globally-mixed source [11]. Bright, coarse-grained ripples in Gusev crater are likely representative of bright, linear bedforms observed elsewhere on Mars [12].

Spirit MI observations of the rocks on "Home Plate" are consistent with a volcaniclastic origin. Clast-supported textures are observed in most rocks in the "Inner Basin" of the Columbia Hills, with only subtle sedimentary laminae in some cases [13]. The most well-rounded grains are interpreted as accretionary lapilli, which imply that water was present during volcanic eruptions. The rocks on Home Plate were covered by enough dust that Rock Abrasion Tool (RAT) brushing was required to allow textures to be seen by the MI, such as the dark, moderately sorted and rounded grains seen in "Pecan Pie" (Fig. 1) and many other rocks at Home Plate. The MI also monitored the MER magnets and solar panels at the 2008 winter haven on the north side of Home Plate. After solar power was sufficient to allow Spirit to drive again, the MI was used to examine the silica-rich rock "Stapledon" just north of Home Plate. The texture of Stapledon observed by the MI appears similar to that seen in the silica-rich rocks on the east side of Home Plate, suggestive of secondary mineralization through precipitation from hydrothermal fluids [14].

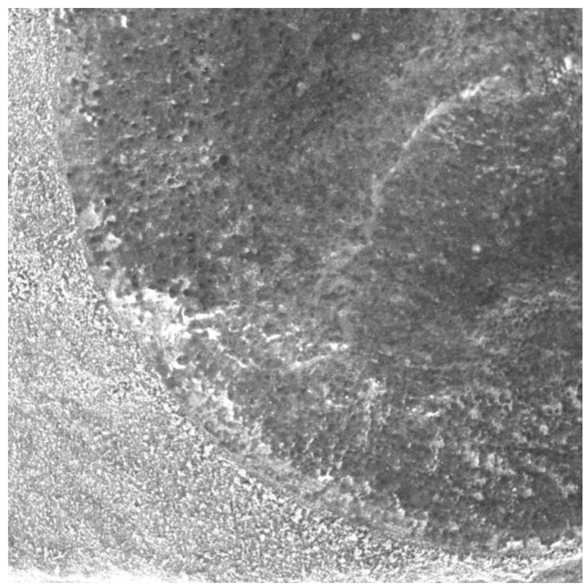

Figure 1. Merge of MI images of "Pecan Pie" acquired on Sol 1368. Area brushed by RAT (upper right) shows dark, rounded grains interpreted to be accretionary lapilli.

While plans for extracting Spirit from the sands of "Troy" were being made, the MI was extensively used to examine the rocks and soils accessible to the instruments on the arm. These data show that moderately sorted, salty aggregate soils at depth are overlain by a thin sulfate-rich crust near the present sandy surface. The angularity of the salty particles indicates that they were not transported very far before they were deposited, and their texture suggests that they were subjected to aqueous processes [15]. These observations, along with MI images showing Spirit's underbelly, were used to inform extraction testing in the MER testbed at JPL. While the MI was not designed to take images of objects under the rover, the out-of-focus data still showed what appeared to be a rock touching the belly. Fortunately, this rock did not impede efforts to extricate Spirit, and progress was made before waning solar power halted the extraction effort on Sol 2169 [16]. Spirit suffered a low power fault on Sol 2210 (March 22, 2010); no data have been received since.

Opportunity (MER-B) results: Opportunity MI observations in Victoria crater show that hematite concretions are generally smaller and less spherical than those observed farther north on Meridiani Planum, despite similarities in the chemical composition of the rocks [17]. This change in the concretions may be due to lateral differences in depositional environment or diagenesis, or may reflect vertical stratigraphic variations as Opportunity traversed up section.

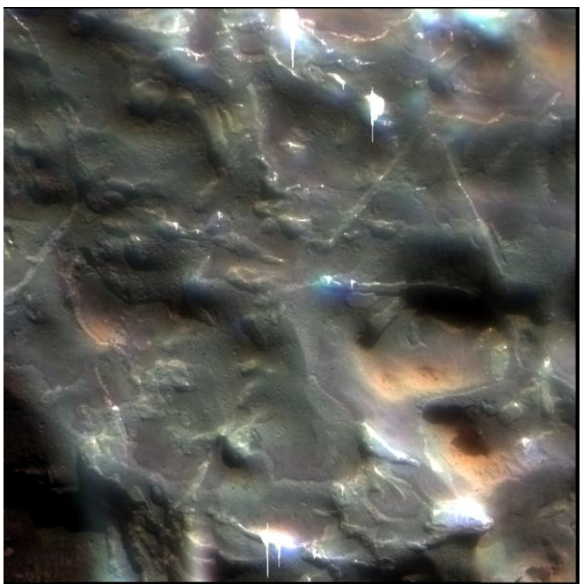

Figure 2. Merge of MI and Pancam color (L257) images of part of "Block Island" showing Widmanstätten pattern, represented as differentially-eroded taenite lamellae and kamacite plates, most easily recognized in the triangular arrangement at upper right, but present across the imaged surface. Vertical streaks are due to blooming of saturated pixels on specular sunlight reflections.

As Opportunity traversed across Meridiani Planum, the MI observed multiple outcrops and cobbles. Four of the cobbles, dubbed "Barberton," "Santa Catarina," "Santorini," and "Kasos," show textures that are consistent with the interpretation, based on chemical data, that they are members of a meteorite strewn field [18]. Opportunity has also studied four iron-nickel meteorites. MI images of "Block Island" show triangular features (Fig. 2) that are interpreted as Widmanstätten patterns, commonly observed in iron-nickel meteorites [19]. The MI has also imaged skeleton-like metal protrusions on the iron-nickel meteorite "Block Island" that appear to be the result of preferential weathering of interstitial material. Smooth patches of material with lobate margins have been interpreted as oxidized weathering rinds or coatings [20]. To date, Opportunity has found only one cobble that is similar to basaltic shergottites, "Bounce Rock" [21]. Other cobbles have brecciated textures and appear to be ejecta blocks, mixtures of sulfate outcrop and a basaltic component [22].

Many soils observed by the Opportunity MI are weakly cohesive at their surface, perhaps due to the presence of cementing salts [6]. However, motion of fine basaltic sand has been observed in some locations, including the dark streaks north of Victoria crater [23]. A survey of MI images of soils on Meridiani Planum shows no correlation with thermal inertia observed from orbit by THEMIS, but the MI sampling of soils is sparse. The THEMIS thermal inertia variations are likely caused by differences in coverage of the bedrock surface by fine-grained eolian bedforms [24].

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