OVERVIEW OF RECENT ATHENA MICROSCOPIC IMAGER RESULTS. K. E. Herkenhoff[1] (kherkenhoff@usgs.gov), S. Squyres[2], R. Sullivan[2], R. Arvidson[3], A. Yingst[4], and the Athena Science Team, [1]U. S. Geological Survey, Flagstaff, AZ 86001; [2]Cornell Univ.; [3]Washington Univ., [4]Univ. Wisconsin-Green Bay.

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 microns/pixel over a broad spectral range (400 to 700 nm). The MI acquires images using only solar or skylight illumination of the target surface. Initial results of the MI experiment on both MER rovers ("Spirit" and "Opportunity") have been published previously [2,3,4]. Highlights of these and more recent results are described below. The 2007 Mars global dust storm resulted in contamination of the camera optics on both rovers, otherwise the cameras continue to perform well.

Spirit (MER-A) results: As examined by the MI, soil materials at Gusev show texture down to the limit of resolution (~100 microns). Soil surfaces are typically rough at submillimeter scales but are molded to much smoother surfaces under compression by the Mössbauer (MB) 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.

Some MI images of soil and dusty rocks show linear textures that likely reflect partial scouring by recent winds, particularly involving movement of dust aggregates. Bedforms at Gusev have coarser particles at their crests and finer grains in the troughs, like aeolian ripples on Earth [5]. Particle-size frequencies of sampled ripple surfaces typically are bimodal, with one mode centered between 1 and 2 mm (coarse sand to very fine granules) and the other below 500 µm (medium to very fine sand). The thermal inertia of aeolian bedforms derived from Mini-TES observations is consistent with MI observations of grain sizes [6]. Surfaces of "El Dorado" bedforms have finer (200-300 µm) sand, less dust, and appear to have been more recently active. Multiple MI images of "Innocent Bystander" show that sand grains were mobilized by strong winds during the 2007 dust storm.

MI observations of rocks on the Gusev plains that were abraded by the Rock Abrasion Tool (RAT) reveal evidence for thin coatings on the rocks, which may be products of alteration by water. The images show mineral grains, probably phenocrysts, beneath the coatings. MI images of basaltic rocks in the Columbia Hills do not show evidence for phenocrysts, but were obtained after it was no longer possible to grind into the rocks with the RAT and expose unweathered interiors [7].

MI observations of RAT holes in other rocks on Husband Hill show a variety of sedimentary textures, with clasts of sizes ranging down to the MI resolution limit. These images, along with observations by the other Athena instruments, suggest that these rocks are altered volcaniclastics or impact ejecta.

MI images at and near "Home Plate" show well-rounded and sorted grains 200–900 microns in diameter that are consistent with predictions for accretionary lapilli formed by hydrovolcanic activity on Mars [8]. These and other Spirit observations suggest that Home Plate was formed by a volcanic explosion, followed by aeolian and/or base surge reworking of the volcaniclastic debris [9].

MI observations of silica-rich soils on the east side of Home Plate show evidence for dark sand grains in a fine, bright matrix (Fig. 1), suggesting precipitation from hydrothermal fluids rather than bleaching of basaltic clasts. These and other recent MI observations will be presented and discussed at the conference.

Figure 1. Part of MI image of silica-rich soil "Kenosha Comets" acquired on sol 1189. Area shown is 6 mm high, with illumination from top.

Opportunity (MER-B) results: MI observations of soil-like materials within Eagle crater and on the surrounding plains have been used to assess cohesion and cementation of very fine-grained (<125 μm) material, based upon soil morphology after disturbances caused by the rover wheels and by the MB contact plate. Granules on the surface typically are pressed into the underlying very fine sand by MB contact; cohesion between grains is indicated where this results in very short, near-vertical walls in the surrounding soil. Some MI observations of soils disturbed by the MB contact plate show apparent fractures, suggesting that cementation of surface particles has formed a crust. The thickness of this crust is estimated to be at least 1 mm (the penetration depth of the MB contact plate) based upon images taken after the surface was disrupted. Cementation caused by precipitation of various salts (e.g., Cl- and SO_4-bearing) that bridge soil particles may be responsible, consistent with APXS results. Salts in the dust (unresolved by the MI) may dissolve and migrate into voids between soil particles via extremely thin films of briny water adsorbed onto soil particles. These water films may occur in soils whenever planetary spin axis obliquity and atmospheric relative humidity are high enough to cause precipitation or condensation of water. During warming events, salts may precipitate on soil particles as thin liquid films evaporate, weakly cementing the upper soil surface.

In the investigation of sedimentary rocks exposed at Meridiani Planum, the MI has provided essential data for integrating multispectral Pancam observations with chemical analyses made by APXS, MB, and Mini-TES [10]. MI images indicate that outcrop rocks have four principal components: (i) moderately rounded medium to coarse (0.2 to 1 mm) sand grains (probably reworked heterogeneous evaporites—mixtures of sulfates and very fine-grained siliciclastic material) that form mm-scale laminations; (ii) fine grained and coarser crystalline textures of subsequently precipitated cements and areas of recrystallization; (iii) centimeter-size vugs that record the early diagenetic growth and subsequent dissolution of crystals similar to sulfate crystals in terrestrial evaporites, and (iv) mostly 3-5 mm spherules distributed throughout the outcrops. MI images document spatial relationships among these constituents, recording a complex history of deposition and diagenesis [11]. In places, fine-grained evaporite muds appear to have been ripped up, transported and redeposited. Sandy laminae have been cemented, probably by sulfate minerals, during earliest diagenesis. The large vugs cut across bedding, indicating that the minerals that once filled them also formed diagenetically within the sediments. Where present, the vugs are found to continue into the rock for at least as deep as the RAT was able to grind (~5 mm) and commonly are seen to increase in size with increasing abrasion depth. Accordingly, they are interpreted to represent an intrinsic feature of the outcrops. Vugs exhibit prismatic to discoidal geometry, characteristically with maximum width (1-2 mm) near their midpoints and tapering toward their ends. This morphology is consistent with precipitation of certain evaporite minerals within the rock matrix, either displacing or replacing the matrix grains during growth. Vug geometry is most consistent with a monoclinic precursor mineral. Subsequently, these minerals were either dissolved by percolating fluid or abraded by wind activity to produce the vugs.

MI images and mosaics provide evidence for the presence of small-scale cross bedding with festoon geometry at Meridiani Planum. An MI mosaic of part of the outcrop dubbed "Overgaard" shows festoon cross-lamination similar to that observed in Eagle crater (Fig. 2). The MI images confirm two key features that lead to the interpretation of water having flowed at times across the surface at the landing site: centimeter-scale cross-stratification and festoon geometry of cross-lamination. Stereo images of the Overgaard outcrop have been used to generate a digital elevation model of the surface, which shows that the features interpreted as festoons are not correlated with topographic undulations [12]. These and more recent MI images will be shown and discussed at the conference.

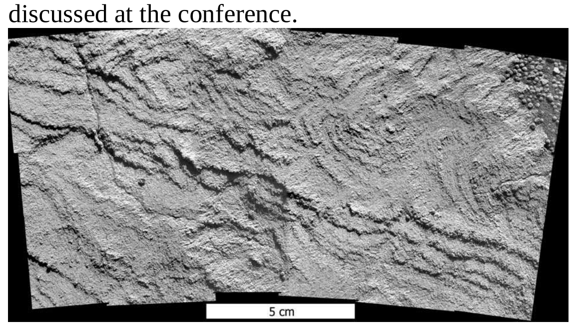

Figure 2. Mosaic of 18 MI images of outcrop "Overgaard", acquired on Sols 721 and 723 with illumination from top.

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