MARS HAND LENS IMAGER (MAHLI) OBSERVATIONS OF ROCKS AT CURiosity’S FIELD SITE, SOLS 0–100. M.E. Minitti1, R.A. Yingst2, K.S. Edgeth, W.E. Dietrich3, V.E. Hamilton4, C.J. Hardgrove4, K.E. Herkenhoff4, L. Jandura4, L.C. Kah2, M.R. Kennedy3, S. Le Mouélic4, L.J. Lipkaman5, M.L. Robinson7, S.K. Rowland10, J. Schieber11, V. Sautter12 and the MSL Science Team, 1Applied Physics Laboratory (Johns Hopkins University, Laurel, MD 20723, michelle.minitti@jhuapl.edu); 2Planetary Science Institute, Tucson, AZ; 3Malin Space Science Systems, San Diego, CA; 4University of California, Berkeley, CA; 5Southwest Research Institute, Boulder, CO; 6US Geological Survey, Flagstaff, AZ; 7Jet Propulsion Laboratory, Pasadena, CA; 8University of Tennessee, Knoxville, TN; 9Lab. de Planétologie et Géodynamique, CNRS UMR-6112, Nantes, France; 10University of Hawai’i at Mānoa, Honolulu, HI, 11Indiana University, Bloomington, IN, 12LMCM, MNHN, Paris, France.

Introduction: The Mars Hand Lens Imager (MAHLI), located on the end of the robotic arm of NASA’s Mars Science Laboratory (MSL) Curiosity rover, is used to characterize stratigraphy and grain-scale morphology, structure, texture and mineralogy of rocks and fines encountered at Curiosity’s Gale crater field site [1]. MAHLI is a color, focusable camera capable of imaging targets at working distances from 2.1 cm (pixel scale ~14 µm/pixel) to infinity. From Sol 0–100, MAHLI imaged various rover and geologic targets, including five rocks [2]. The goal of this work is to describe, compare and contrast the properties (e.g., shape, texture, grain size, structure) of these five rocks as observed in the MAHLI data. These observations can then be combined with geochemical data from these rocks (where available) to explore their origin.

Rock Targets: The five rocks imaged by MAHLI were informally named Jake Matijevic, Bathurst Inlet, Cowles_5, Et Then and Burwash.

Jake Matijevic (Jake M.): Jake M. was selected as Curiosity’s first contact science rock target because it appeared dark and uniform (mafic?) in Mast Camera (Mastcam) images. These characteristics, and the size of the rock (~40 cm tall with a flat face), made Jake M. a suitable target for the first cross-comparison of results from the Alpha Particle X-Ray Spectrometer (APXS) and Chemistry and Camera (ChemCam) instruments, both of which provide information about elemental composition. Given that Jake M. was the first rock MAHLI observed, we employed a full suite of imaging techniques to test camera operations and maximize science return from the target. This suite included imaging from working distances intended to provide context (pixel scale = 102 µm/pixel) and medium (22 & 31 µm/pixel) resolution images. Two different locations on Jake M. were analyzed by MAHLI, APXS and ChemCam to assess textural and chemical heterogeneity.

Bathurst Inlet and Cowles_5: Bathurst Inlet and Cowles_5 (hereafter called Cowles) were encountered on the drive toward a scoopable material (ultimately the Rocknest sand shadow [e.g., 3]). They are angular with smooth fracture surfaces suggesting they are of considerable strength. Bathurst Inlet was an attractive target because it exhibited cm-scale banding in Mastcam images. The Mastcam images also suggested that both rocks were fine-grained, but they were unable to resolve whether the rocks are inherently fine grained or appeared to be fine grained due to eolian smoothing and polishing. Bathurst Inlet was imaged at two locations that differed in the amount of dust cover using the same imaging suite applied to Jake M. A single location on Cowles was imaged from working distances that provided context (pixel scale = 102 µm/pixel) and medium (38 µm/pixel) resolution images.

Burwash and Et Then: These targets were two of the very few rocks accessible to MAHLI during the eolian sediment analysis campaign at Rocknest [e.g., 3]. They were imaged at pixel scales of ~50–70 µm/pixel because they exhibited morphologic similarity to larger rocks nearby that were observed by ChemCam and Mastcam but were out of reach for Curiosity’s robotic arm instruments. Stereo imaging campaigns over the targets from larger working distances (40–80 cm) were acquired to begin development of the engineering use of MAHLI 3D meshes for future robotic arm placements [2].

Observations: Jake M.: In the context images, Jake M. is gray with a glassy luster that causes certain
surface orientations to reflect light from the Sun and the MAHLI white light LEDs. In the medium resolution images obtained when the surface was completely shadowed by the turret, the apparent contrast of the scene is reduced (Figure 1). Small-scale (<0.5 mm) surface reflections are observed to change with changing LED illumination at the highest-resolution imaging, and there are limited examples of phenocryst-like features at the surface of the rock. Jake M. exhibits a scalloped surface texture, small (<~1 mm) vesicles, and dust particles/clumps collected in surface recesses. The two different surfaces of the rock that were studied on different sols appear similar in color, luster and texture.

**Bathurst Inlet:** This target is gray and the cm-scale banding observed by Mastcam appears to be caused by variations in surface roughness between layers (Figure 2a,b). Darker gray, angular and lath-shaped features, up to 0.8 mm in size, are apparent (Figure 2c) on both surfaces observed by MAHLI. The bulk of the rock is so fine-grained that MAHLI cannot resolve grains or crystals in images with a pixel scale of 22 µm/pixel. This means that the grains or crystals, if there are any at all, are smaller than about 80 microns. Analysis of Bathurst Inlet by the ChemCam remote micro-imager (RMI) interprets its grain size to be <120 µm [4].

![Figure 2: A] Mosaic enhanced color image of Bathurst Inlet providing context for B) and C). B) Roughness variations between layers could be an expression of variable grain size. (C) Arrows point to angular features that could be crystals, crystal fragments or shards of volcanic glass.

**Cowles:** Cowles is likely gray like Jake M. and Bathurst Inlet, but it is coated with a thin veneer of dust that obscures its true color. However, even at pixel scales of 38 µm/pixel, irregular gray patches like those seen in Bathurst Inlet are apparent (Figure 3a).

![Figure 3: A] Subframe (~4 mm x 6 mm) of Cowles with black arrow pointing to an irregular gray patch, b) Burwash (image ~76 mm wide) and c) Et Then (image ~88 mm wide).

**Burwash and Et Then:** The surface of Burwash is uniformly covered with muted pits; dust, dust clumps and sand have collected in low points on the surface (Figure 3b). MAHLI observed surfaces that reflect incident sunlight, and small (<1 mm) gray, irregular features that appear to be dust-free are visible. Et Then was not imaged under lighting or at resolutions conducive to studying its texture in detail. Its surface contains muted pits like Burwash but also more sharply-defined voids. Et Then appears to exhibit parallel grooves or fractures across one of its faces (white arrows, Figure 3c).

**Interpretations:** Reflective surfaces on Jake M. and Bathurst Inlet by the ChemCam remote micro-imager (RMI) interprets its grain size to be <120 µm [4].