IMAGING AT LONG DISTANCE WITH CHEMCAM REMOTE MICRO-IMAGER ONBOARD MSL.
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Introduction: Curiosity rover's ChemCam instrument includes a Remote Micro-Imager (RMI) intended to provide context for the laser-induced breakdown spectroscopy laser pits, document the changes induced by the laser shots on the target, and remotely study the martian rocks and soils at high resolution [1]. Here we report specifically on the latter type of imaging, especially at long distances in the rover driving direction toward the layers of Mt. Sharp.

ChemCam's RMI has the finest pixel scale on the rover with 19.6 µrad/pixel (1024x1024 grayscale CCD detector). Its small depth-of-field and field-of-view [2] have made it challenging to get an optimal focus on long distance targets, but a new autofocus algorithm based on an onboard analysis of the RMI images gives improved results. The smallest features that can be distinguished are of the order of 0.1 mm at 3 m [3], 4 cm at 1 km, and 0.5 m at 12 km (beyond which the spatial resolution of HiRISE orbital images is better than that of the RMI). These images are therefore a useful complement to MastCam color or multi-filter images (e.g. [4]). ChemCam can also take passive reflectance spectra (400-840 nm) at the center of the images providing long-range compositional information and its variability across the landscape [5].

Long distance RMI images: Atmospheric conditions can affect the image quality and long distance targets are preferably observed during the low-opacity season. Between mission days (Sols) 312 and 562, about 6 RMI mosaics were taken in the direction perpendicular to the rover traverse covering from the dark dune area toward the summit of the mound in the center of Gale crater (informally named "Mt. Sharp"). A similar number of mosaics were taken to cover the Bagnold Dune area, to the northeast of the current rover location.

One mosaic of Mt Sharp on Sol 1183 was dedicated to Light-Toned Yardang forming materials (LTY) described by Anderson et al. [6], and named the coarse yarding unit in [7]. The RMI confirmed the presence of fine-scale horizontal layers in LTY, and possibly angular beds too [8]. Finally, we describe here 5 other mosaics taken between Sols 327 and more recently, Sol 1126, of Mt. Sharp, in the general drive direction.

Sol 327 images. Known as Ameto mosaic (10x2 images, but only the top row is useful), the objective of this observation was to get a high resolution view of the layers of the Mt. Sharp "entrance" near our possible path, which was then 9 km away (Fig. 1). The foreground shows the typical undulating ridges of the phyllosilicate-bearing trough [7, 9] in front of a patch of sand. Behind, on the right hand of the image, a small butte is visible with bedding and meter-scaled boulders, possibly corresponding to fan materials transported into the channel. The background of the image may belong to the unit just below the LTY mentioned before.

Sols 467 and 475 images. Four vertical 1x10 mosaics aiming at the Hematite Ridge identified from CRISM data [10] at about 5 km from the rover. The images were taken along with passive spectra, which reveal likely hematite bearing materials beyond the dunes, and dune sands with variable amounts of olivine [11], which frequently cover the basal unit. It is apparent in the RMI images that the bedrock is indeed fractured in these areas.

Sol 1104 images: The target was a large-scale light-toned ridge at about 8 km from the rover, informally called "The Wall". Even though the image focus is not optimal, the mosaic clearly exhibits the occurrence of well developed canyons exposing sulfate-rich material detected from CRISM data [8].

Sol 1126 images: The aim was light-toned 10 m high mounds less than 4 km away. Stratigraphically, they are right above hematite ridge materials, and below the uppermost surficial materials of the fan shaped unit. ChemCam passive spectra and MastCam multispectral data are being analyzed and reveal distinctive spectral features [11]. A steep vertical outcrop is visible behind the mounds.

Perspectives: These few examples illustrate the type of science that can be addressed by RMI data. With improved pointing experience and focus capability, more high-resolution images will be acquired either to document geological units detected from orbit or to prepare the future rover waypoints. Building upon these promising results, the SuperCam instrument on the Mars 2020 rover will also be equipped with an RMI imager, using a CMOS detector with a Bayer filter to obtain color images [12].

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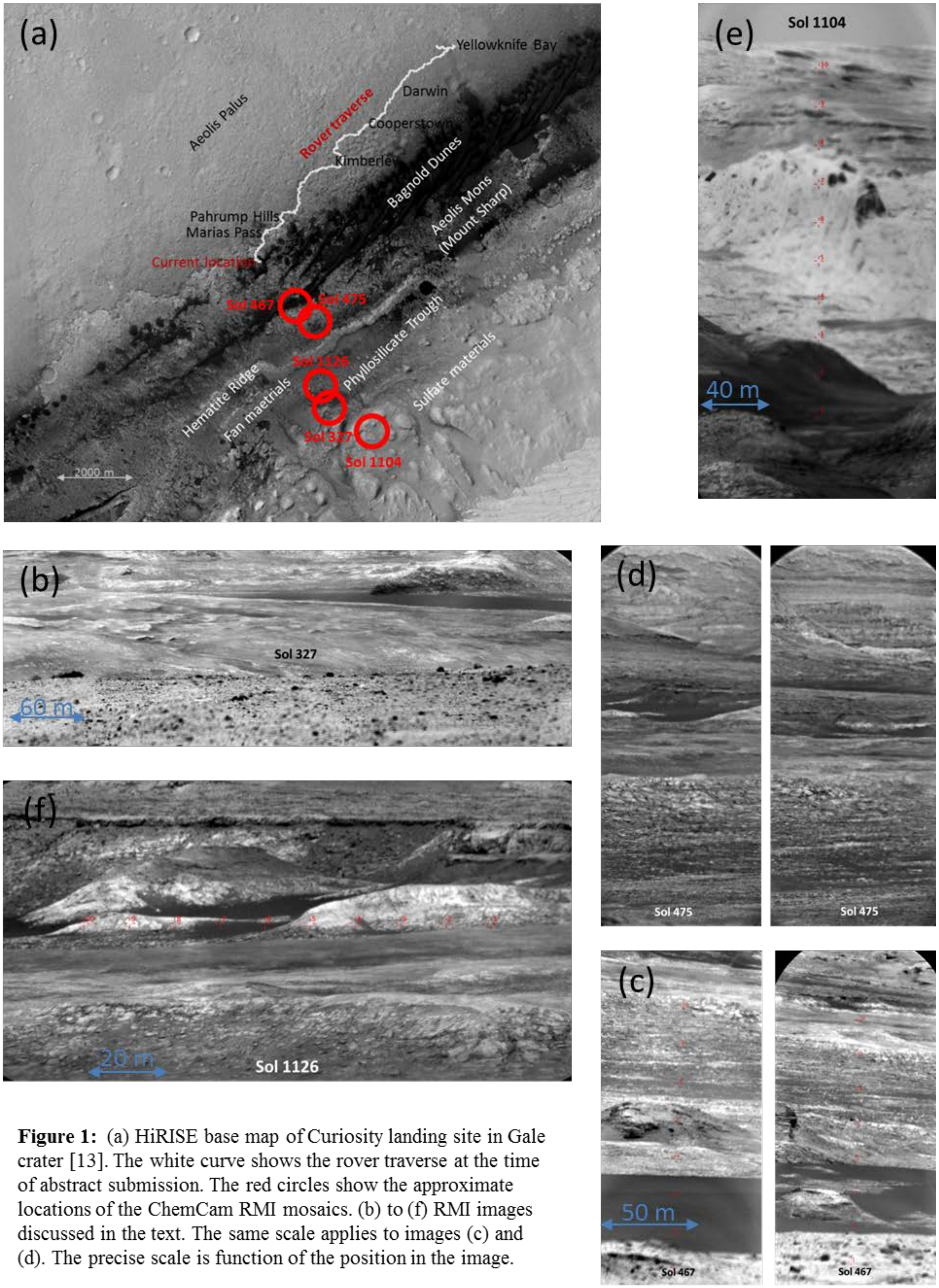

Figure 1: (a) HiRISE base map of Curiosity landing site in Gale crater [13]. The white curve shows the rover traverse at the time of abstract submission. The red circles show the approximate locations of the ChemCam RMI mosaics. (b) to (f) RMI images discussed in the text. The same scale applies to images (c) and (d). The precise scale is function of the position in the image.