THE IMPORTANCE OF IMAGING IN SPACE EXPLORATION: LESSONS LEARNED FROM THE 2015 CANMARS MSR ANALOGUE MISSION.

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Introduction: The consideration of images as data and the importance of high-resolution imaging are often neglected. After the Viking mission, NASA originally did not intend to put a camera aboard the subsequent Mars Orbiter mission as "the Viking orbiters [had] already given us excellent maps of Mars" [1]. The higher resolution images from the Mars Global Surveyor's wide- and narrow-angle cameras however completely changed our view of Mars from that of the Viking era, revealing sedimentary rocks [2] and a complex aqueous [e.g., 3] and aeolian [e.g., 4] history. Recent discoveries such as potentially water-related present-day gully activity [e.g., 5–7] and recurring slope lineae [8] by the Mars Reconnaissance Orbiter Context Camera (CTX) and High-Resolution Imaging Science Experiment (HiRISE) have further emphasized the importance of high-resolution imaging in planetary exploration. Ground-based martian observations from image data such as rounded cobbles suggesting sustained flow of water [9] and examples of aeolian cross-bedding [10] take us a step beyond what is visible from satellite imaging. Combining orbital and ground-based image datasets helps to paint the overall picture of Mars, offering opportunities to study Mars from the grain-to-global scale.

Here we summarize the impact of high-resolution orbital and ground-based imaging in the geologic interpretations of a Mars analogue site in the desert of Utah during the 2015 CanMars Mars Sample Return (MSR) Mission. This was a Mars sample return analogue mission carried out in partnership with the Canadian Space Agency (CSA), MacDonald, Dettwiler and Associates Ltd. (MDA), and the Centre for Planetary Science and Exploration (CPSX) at the University of Western Ontario, as part of the NSERC CREATE project "Technologies and Techniques for Earth and Space Exploration." For a summary of the mission and its goals, see the companion abstract from this conference [11].

Landing Site: The CSA's Mars Exploration Science Rover (MESR) "landed" in an undisclosed (to the science team) location in the desert of Utah.

Interpretations from orbit. Before landing, the datasets available to the science team included a 60-cm/pixel visible-wavelength color image of the terrain in and around our landing ellipse (Fig. 1). Pre-mission analysis of this orbital image data led the science team to favor an interpretation of the features in our landing ellipse as inverted paleochannels—possibly capped by basalt—within a sedimentary basin. This interpretation was based on the geomorphology of the region combined with a digital elevation model [12].

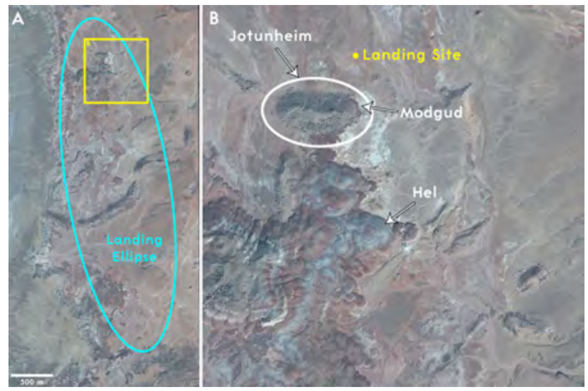

Fig. 1—(A) 60 cm/pixel Quickbird satellite image of the CanMars MSR Analogue Mission landing ellipse. (B) Closer view of the rover's landing site and key targets referenced in this abstract. ***Base image credit: DigitalGlobe.***

Ground-truthing. Ground-based imaging with MESR's Mast Cameras (Mastcam), coupled with geochemical analysis, revealed the capping unit to be a conglomerate rather than the basalt predicted from orbit. Pieces of the capping unit that had fallen to the base of Jotunheim allowed for direct access to the unit.

Panoramas acquired of our main target (a hill dubbed "Jotunheim") reachable from our landing site on the first few sols of driving showed layering within the hill. This was expected from the satellite image (Figs. 1 & 2). However, upon closer approach to Jotunheim, zoom images from the Mastcam revealed that some of the red-toned "layers" were in fact merely places where red material from the upper layers of Jotunheim had been transported downslope by mass wasting processes (i.e., gully activity, Fig. 2B).

The importance of high-resolution imaging was also highlighted with an area named "Modgud". Targeting for XRF and Raman measurements was initially done using a panorama where the resolution of the area of interest was not ideal for fine-scale targeting. When geochemical data for the 3 sites marked in Figure 2A were received, the results from Modgud 3 differed significantly from those of Modgud 1 and 2. However, the quality of the panoramic image was not sufficient to determine why at least Modgud 1 and 3 differed as they both appeared to be targeted on the white-toned material at the base of Jotunheim. The following sol, we drove closer to Modgud and took a zoom image of the region of Modgud 3. This higher-resolution image (Fig. 2B) was then used to more precisely target additional XRF and Raman data collection. Geochemical results from Modgud 4 were consistent with those from Modgud 3, confirming the composition of the white material. The science team agreed getting the additional data was worthwhile despite the use of time and data budget, which was limited. In this case, the zoom imaging was critical for context in interpreting the geochemical results.

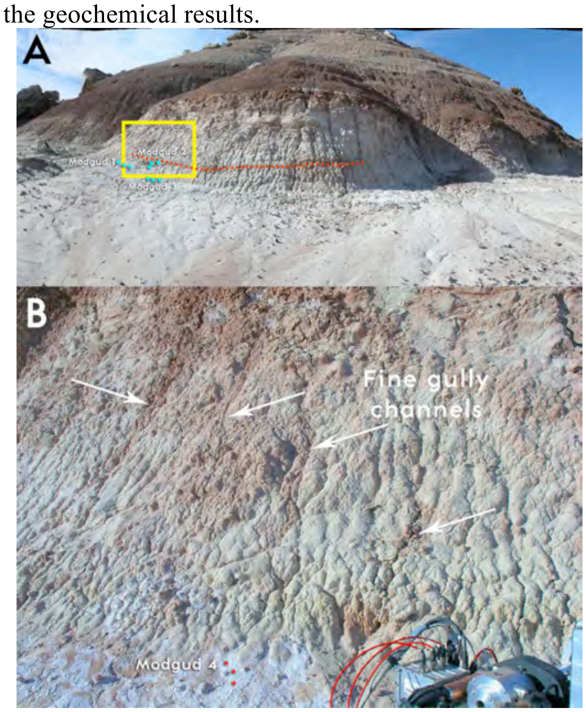

Fig. 2—(A) Subframe of sol 7 panorama from the MESR Mastcam. The red layer near the base of the slope of Jotunheim was identified as a possible target for MESR (dotted line). The three groups of teal dots represent 3-point rasters for Modgud 1–3 taken by XRF and Raman. (B) Upon arrival at the location denoted by the yellow box in (A), we found the red "layer" to be material mobilized downslope along fine gully channels (white arrows) rather than a distinct sedimentary layer within Jotunheim. The three red dots mark the 3-point XRF raster taken of Modgud 4.

Image data also allows for the analysis of areas not accessible by contact science instruments or the rover itself. This may be due to steep slopes, distant locales, or untraversable ground. A feature dubbed "Hel" for example was too distant to be reached by the rover during the analogue mission. A panorama acquired on sol 10, which included coverage of Hel, revealed possible massive layers within the finer-grained sedimentary layers. The zoom image of Hel acquired the following sol (Fig. 3) suggested these massive layers were conglomerates, very similar to the capping unit we had observed atop both Jotunheim and Hel, as well as other potential paleochannels visible in the satellite image of the region. This led the science team to the hypothesis that multiple episodes of high-energy channel-filling events occurred in the region, separated by periods of deposition of mudstones in a low-energy environment. Ground-based high-resolution image data was therefore a critical component in the science team's interpretation of the geologic history of our landing site and the wider landing ellipse region.

For a comprehensive discussion of the geologic interpretations of our landing site, please see the companion abstract from this meeting [13].

Figure 3—MESR zoom image of Hel. Conglomerate layers marked with white arrows.

Lessons Learned: Image data is critical to every planetary mission. The geomorphology revealed from imaging tells the first-order—at the very least—story of the geologic history of an area. Images give the initial context needed for interpreting any associated geochemical data. High-resolution images are also essential in identifying potential misconceptions from lower-resolution data. Images are more than simply pretty pictures of other worlds—they are data and are essential for scientific interpretation of other datasets, mission support, and overall understanding of geological context.

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