The Multispectral Microscopic Imager (MMI) with Improved Spectral Range and Resolution.

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Introduction: The Multispectral Microscopic Imager (MMI) is intended as an essential tool for use by robotic rovers or an astronaut in future Moon and/or Mars missions for traverse characterization, documentation, and mapping the distributions of a broad variety of geologic materials, including igneous and sedimentary materials (e.g lavas, impact ejecta and soil/regolith materials, aeolian, fluvial and hydrothermal deposits, as well as weathering alteration surfaces or rocks, soil crusts, etc.). Microtextural features of rocks and soils, herein defined as the micro-spatial interrelationships between constituent mineral grains, pore spaces and secondary (authigenic) phases (e.g. cements) minerals when used in combination with mineraogy, provides essential data for inferring both primary formational processes and secondary (diagenetic) processes. The MMI provides color microscopic views of rock surfaces where each pixel is a composite VNIR spectrum of the materials imaged. Such observations are similar to microscale views of rocks and soils routinely acquired by geologists in the field using a handlens which provide a basis for inferring their origin. The ability to quickly assess petrogenesis in the field significantly enhances field-based interpretations to support real-time hypothesis-driven exploration. In the context of Astrobiology, such observations enable broadly-based paleoenvironmental interpretations during exploration for assessing past or present habitability.

Multispectral Microscopic Imager: Development of the MMI was achieved through the addition of spectrometric capabilities to the highly-successful Microscopic Imagers (MIs) currently in operation on the Mars Exploration Rovers (MERs). The MMI, with its multiple spectral bands and spectral range extending into the infrared, has a demonstrated capability to discriminate and resolve the spatial distribution of minerals and textures at the microscale [1, 2, 3]. The MMI advances beyond the capabilities of current and planned microimagers such as Phoenix' Robotic Arm Camera (RAC) and Mars Science Laboratory's Mars Hand Lens Imager (MAHLI) by extending the spectral range into the infrared, and increasing the number of spectral bands. The MMI design employs multispectral light-emitting diodes (LEDs) and an uncooled focal plane array to achieve the low-mass (<1kg), low-cost, and high reliability (no moving parts) required for an arm-mounted instrument on a planetary rover [3].

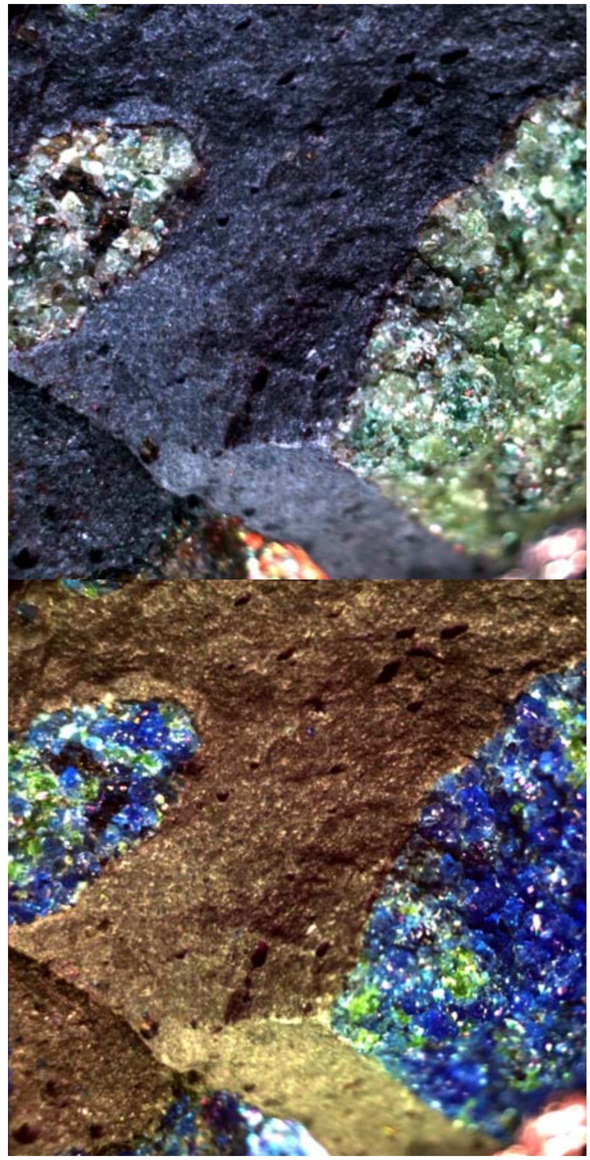

Fig. 1: *Multispectral images of San Carlos basalt with Lehrzolite xenoliths using a CCD-detector configuration of the MMI; field-of-view = 3cm x 3 cm, 30 µm per pixel. Top: Red = 0.660 µm, Green = 0.525 µm, Blue = 0.470 µm. Bottom: Red = 0.975 µm, Green = 0.810 µm, Blue = 0.660 µm.*

Investigation of samples with the MMI: Moon- and Mars-relevant samples were analyzed with the MMI to demonstrate its microtextural and mineralogical capabilities. Figure 1 shows two images of San Carlos basalt (Arizona) acquired with the MMI. The upper image is a “true-color” composite consisting of blue, green, and red bands. The lower image is a “false-color” composite consisting of visible- and near-infrared bands. Both images provide important microtextural information by distinguishing the Lherzolite xenoliths from the vesicular basanite (feldspathoid-bearing basalt) matrix [4]. The addition of the near-infrared spectral bands allows for further distinction based on composition, wherein olivine crystals (blue-color) are distinguished from the green-color clinopyroxene (chromium diopside). Figure 2 illustrates the improvement in ability to identify mineral classes provided by the MMI’s larger number of spectral bands and extended spectral range.

Conclusion: Data sets acquired with the MMI provide highly desirable geologic and contextual information for: 1) the detailed in-situ rover-based analysis of rocks and soils, 2) to guide the sub-sampling of geologic materials for sample return missions and 3) for use by astronauts during EVAs or in a lunar base laboratory.

References: [1] Sellar R. G. et al. (2007) *Seventh Internat. Conf. on Mars,* Abstract #3017. [2] Sellar R. G. et al. (2006) *Proc. SPIE 6309, 63090E*. [3] Sellar R. G. et al. (2008), *Joint Ann. Meet. LEAG-ICEUM-SRR*, Abstract #4075, [4] Righter K. and I. S. E. Carmichael (1993) *Am. Mineralog*. 78: 1230-1245.

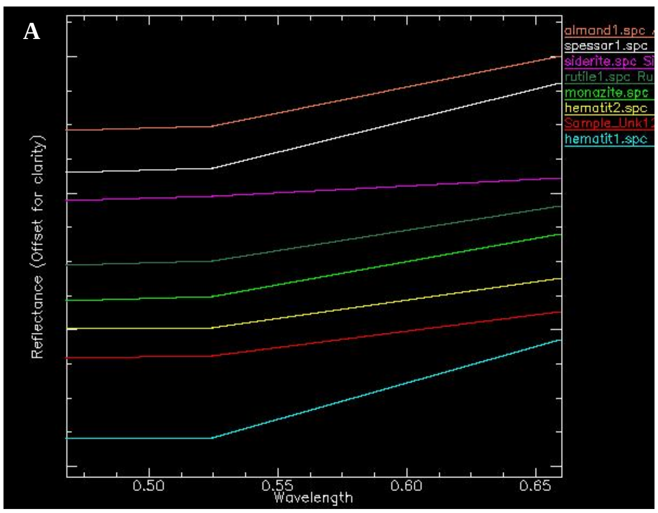

__Fig. 2:__ (A) 3-band (0.470, 0.525, 0.660 µm) reflectance spectra of a sample, extracted from a 19-band spectrum (acquired by an InGaAs-detector configuration of MMI) to simulate RAC or MAHLI capability, compared to library spectra of almandine, spessartine, siderite, rutile, monazite, and hematite. Sample spectrum (red) is good match to almandine, spessartine, siderite, rutile, monazite, or hematite; (B) 19-band, 0.47 – 1.55 µm spectrum of sample (red) compared to library spectra. Sample spectrum is a good match to hematite (light blue, yellow), poor match to the other five minerals; Sample confirmed as hematite by petrographic thin-section microscopy and XRPD.