TEMMI: A Three Dimensional Exploration Multispectral Microscope Imager for Future Planetary Missions.

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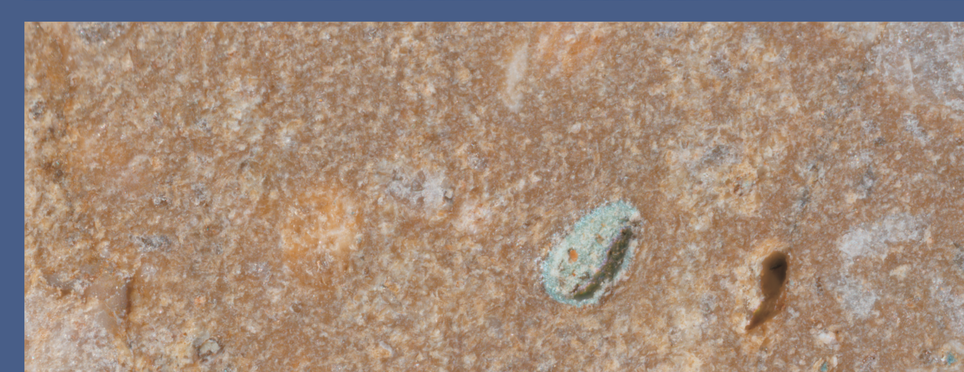
Introduction

Past, current and future missions to the surface of Mars and the Moon include high-resolution microscopic imagers. High-resolution three-dimensional (3D) microscopic images provide morphologic, structural, textural and chemical information that are of utmost importance for conducting field investigations of planetary surfaces. The noted chart summarizes the capabilities of the Three Dimensional Exploration Multispectral Microscope (TEMMI). We also demonstrate TEMMI's imaging quality on geologic materials, specifically impactites from various terrestrial impact structures, which may be analogous to structures found on both the Lunar and Martian surfaces.

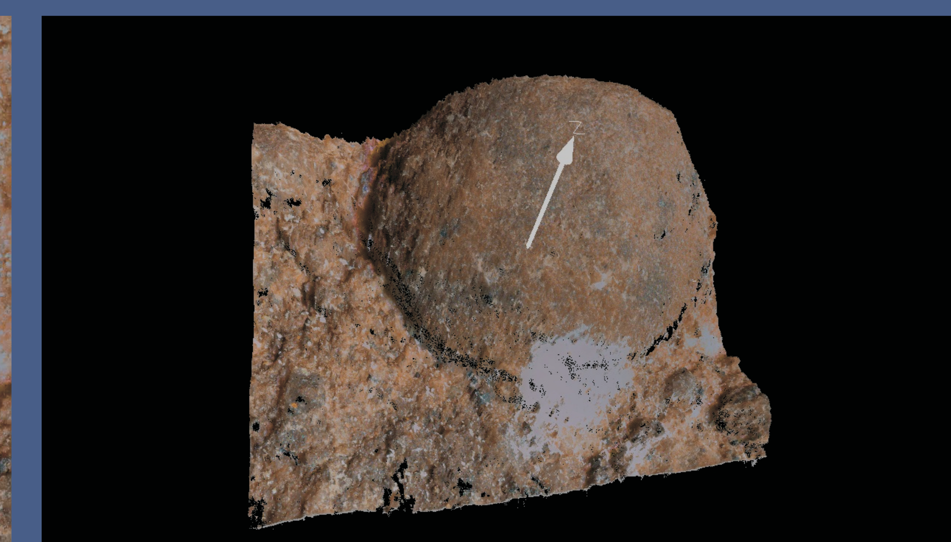
Parameter	Value	
Objectives	1, fixed focal length	
Imaging modes	Low resolution	High resolution
Resolution (pixel)	4.4 µm	2.2 µm
Resolution (optical)	≤ 10 µm	≤ 5 µm
Field of view	5.7×4.3 mm²	5.7×2.1 mm²
Depth of field	18 µm raw	
Focusing	Adjustable focus ≤ 25 mm, autofocus	
3D resolution	5 µm (x,y) × 2 µm (z)	
Working distance	≥ 25 mm	
Colour	yes	
Colour resolution	12 bit	
Illumination	8 wavelengths from 455 nm to 850 nm	
Fluorescence	Yes (365 nm)	
Mode	reflective	
Reflectance	quantitative	
Power consumption	< 35 W avg, < 50 W peak	
Mass	< 6 kg	
Exposure times	0.1 – 5 ms typical	

Image Quality



Top: low resolution image of an impact melt breccia with FOV of 5.7 x 4.3 mm and optical resolution of 10 µm (4.4 µm pixel resolution). Bottom: high resolution image with FOV of 5.7 x 2.1 mm with ≤5 µm optical resolution (2.2 µm pixel resolution).

3D Imagery

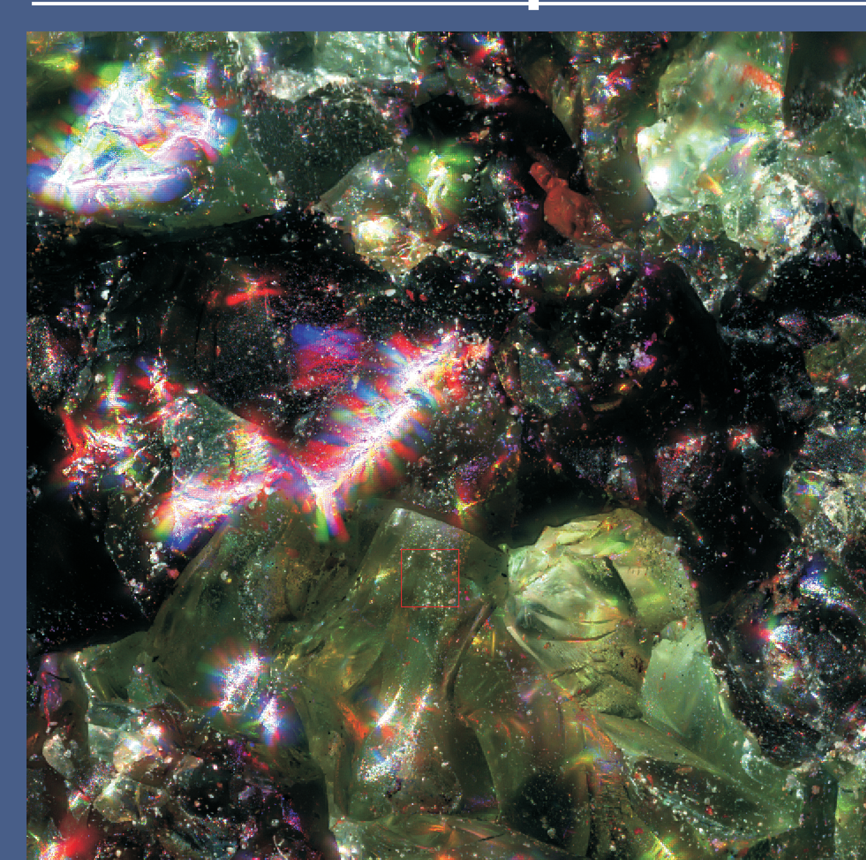


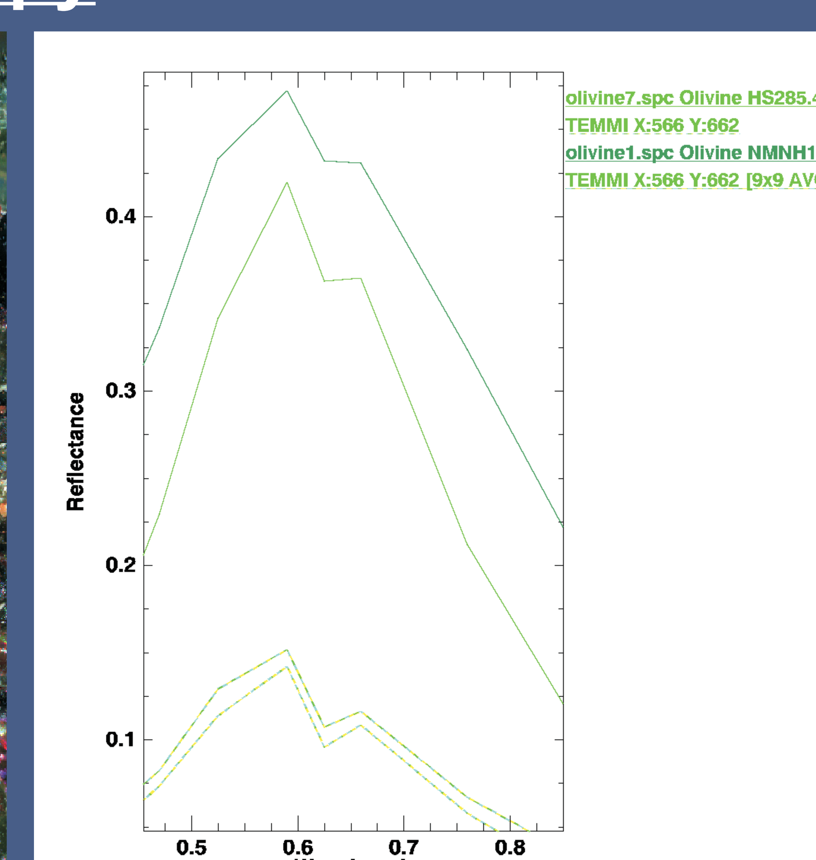
Left: low-resolution color images with a FOV of 5.7 x 4.3 mm. Right: 3D perspectives of the same images draped on their derived 3D models. Top: haemtite concretion resembling the Martin 'blueberries. Bottom: the characteristic conical and striated structure of a shatter cone.

Ultraviolet

Left: low-resolution color image with FOV of 5.7 x 4.3 mm of a fluorescent Ruby set in Zoisite. Right: The same image taken using only the ultraviolet wavelength at 365nm.

Reflectance Spectroscopy





Left: A reflectance image of olivine and pyroxene. The reflectance spectra is taken from the noted red square in the image. Right: TEMMI's 8 point spectra covering the wavelengths from 455 nm to 850 nm successfully matched olivine to the USGS mineral spectral library of 481 minerals. The results were obtained via visual matching and by utilizing three different methods: spectral angle mapping (SAM), spectral feature fitting (SFF), and Binary Encoding (BE).The plot clearly demonstrates a nice match between TEMMI's reflectance data to the two seperate USGS olivine spectra.

References: [1] Edgett, K. S. et. al. (2009) Work-shop on the Microstructure of the Martian Surface, 5-5. [2] Farmer, J. D. et. al. (2011) AGU Fall Meeting 2011, Abstract #P33D-1786. [3] NASA - Mission Highlights http://www.nasa.gov/missions/index.html. [4] Nuñez, J. I. et. al. (2010) 2010 GSA Denver Annual Meeting. [5] Tunstel, E. et. al. (2002) Automation Congress, vol. 14, pg. 320-327. [6] Schopf, J.W. and Kudryavtsev, A.B. (2009) Precambrian Research 173, 39-49. [7] Preston, L. J. et. al (2011) GAC/MAC - MAC/AMC - SEG - SGA Joint Annual Meeting. [8] Clark, R. N. et al. (2007) USGS digital spectral library splib06a: USGS, Digital Data Series 231. [9] Amir Sagy et. al. (2002) Nature 418, 310-213. [10] Mahaney, E. C. et al (2008) AGU Fall Meeting 2008, Abstract #P33B-1440.

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