The Moon Mineralogy Mapper: Characteristics and Early Laboratory Calibration Results. Robert O. Green[1], Carle Pieters[2], Pantazias Mouroulis[1], Glenn. Sellars[1], Michael Eastwood[1], Sven Geier[1], and James Shea[3]. [1]Jet Propulsion Laboratory California Institue of Technlogy, Mail-Stop 306-431, 4800 Oake Grove Drive, Pasadena, CA 91109 (rog@jpl.nasa.gov), [2]Brown University, [3]Swales Inc.

The Moon Mineralogy Mapper (M3) was selected as a NASA Discovery Mission of Opportunity in February 2005. The M3 instrument is a high uniformity and high precsion imaging spectrometer of the pushbroom type. M3 measures spectra as images in the solar dominated portion of the electromagnetic spectrum. The basis for the use of imaging spectroscopy for mapping the mineralogy of the moon is shown in the diversity of lunar mineral spectral signatures illustrated in Figure 1. M3 is planned to be launched as a guest instrument on the Chandrayaan 1 mission of the Indian Space Research Organization (ISRO) in early 2008.

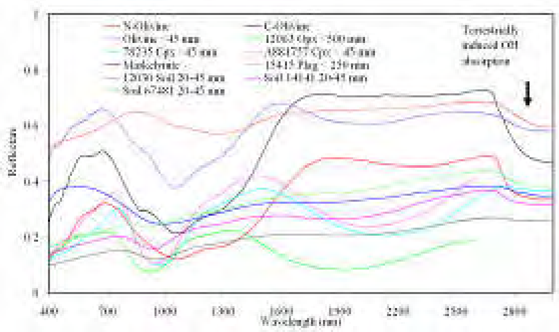

Figure 1. Selected reflectance spectra of lunar minerals.

As a guest instrument, M3 was required to be low mass, low volume and low power. Yet, the imaging spectroscopy science required a broad spectral range, excellent radiometric precision and unmatched uniformity. A high throughput and uniformity optimized Offner imaging spectrometer design[1] was selected and is shown in Figure 2. The design uses a compact three mirror telescope that feeds light through a uniform slit to spectrometer with one spherical mirror and a custom convex grating. The dispersed light from the spectrometer then passes through an order sorting filter to the detector array that is sensitive from 430 to 3000 nm. This design is enabled by the structured blaze convex grating in the core of the uniform full-range spectrometer. The mass and power of the M3 instrument are ~8 kilograms and ~15 Watts average. The volume of the optical and detector assembly is 25 X 18 X 12 centimeters.

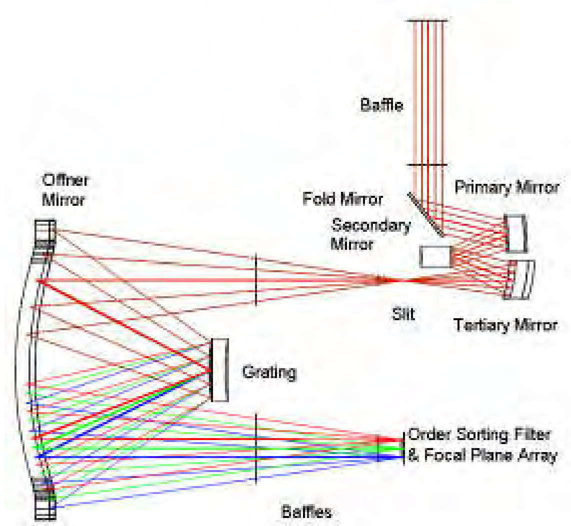

Figure 2. Optical layout of the M3 imaging spectrometer instrument.

A summary of the spectral, radiometric, spatial and uniformity characteristics of the M3 instrument are given in Table 1.

<u>Table 1. Key M3 Measurement Characteristics</u>

Spectral		
	Range	430* to 3000 nm *originally 700
	Sampling	10 nm constant
	Response	FWHM <15 nm
Radiometric		
	Range	0 to specified saturation
	Sampling	12 bits measured,
	Response	Linear to 1%
	Accuracy	Within 10% absolute
	Precision (SNR)	>400 @equatorial reference >100 @polar reference
Spatial		
	Range	24 degree field-of-view
	Sampling	0.7 milliradian
	Response	FWHM < 1.0 milliradian
Uniformity		
	Spectral-cross-track	< 10% variation of spectral position across the field-of-view
	Spectral-IFOV	< 10% IFOV variation over the spectral range

Funding for the fully space qualified M3 instrument became available in May of 2005. The first spectrum was measured during laboratory characterization and alignment work on the 15th of December 2006. The M3 instrument is scheduled to be fully calibrated and complete for delivery in March 2007.

The first spectrum is shown in Figure 2 and is from a neodymium spectral calibration panel. The M3 spectrum extends from 430 to 3000 nm. The corresponding laboratory spectrum runs from 400 to 2500 nm. This first spectrum provides end-to-end verification of M3 performance as a spectrometer.

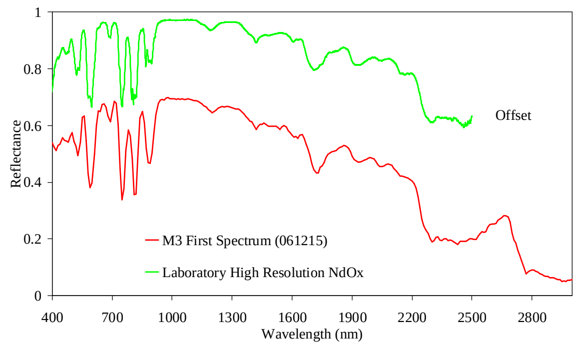

Figure 2. M3 first spectrum in the laboratory of Neodymium spectral calibration target.

An indication of the exceptional uniformity of the M3 design and implementation was provided by these early laboratory characterization and alignment measurements. Figure 3 shows the cross-track spectral centroid of a laser line near 2050 nm. The points in the plot show the centroid result for each cross-track sample range from 60 to 630 samples. Some variability is caused by use of pre-flight electronics and cables for these measurements. Never-the-less, this early cross-track spectral uniformity result shows less than a 1 nm spectral calibration variation across the entire swath.

This level of uniformity is essential for the advanced spectroscopic algorthims required to pursue the M3 science objectives.

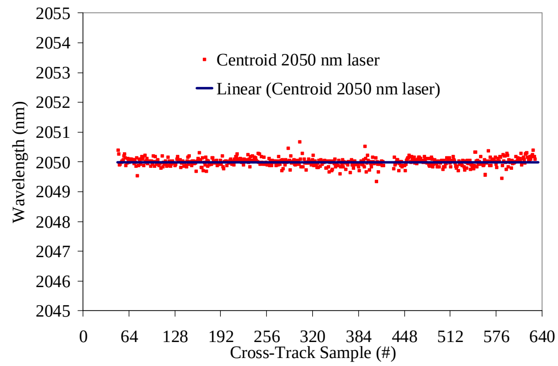

Figure 3. Cross-track uniformity of M3 at 2050 nm in early laboratory measurements.

A comprehensive suite measurements were acquired during this early laboratory characterization and alignment thermal vacuum cycle. Selected results are presented here. In total, these measurements show that when alignment is complete M3 will meet the full set of spectral, radiometric, spatial, and uniformity requirements.

Acknowledgment: We thank NASA Discovery Program for supporting M3 development and implementation. We are honored to be part of ISRO's Chandrayaan-1 mission.

References 1. Mouroulis P, Green RO, Chrien TG, "Design of pushbroom imaging spectrometers for optimum recovery of spectroscopic and spatial information," APPLIED OPTICS 39 (13) (2000)