

**Sharing Moon Mineralogy Mapper (M<sup>3</sup>) / Chandrayaan-1 with Students and the Public.** C. J. Runyon<sup>1</sup>, S. Shipp<sup>2</sup>, C. Shupla<sup>2</sup>, G. Tuthill<sup>3</sup>, K. Halau<sup>3</sup>, College of Charleston, Charleston, SC 29424, [runyonc@cofc.edu](mailto:runyonc@cofc.edu),<sup>2</sup> Lunar and Planetary Institute, Houston, TX, [shipp@lpi.usra.edu](mailto:shipp@lpi.usra.edu), [shupla@lpi.usra.edu](mailto:shupla@lpi.usra.edu),<sup>3</sup> Montana State University, Bozeman, MT, [Tuthill@g-mail.com](mailto:Tuthill@g-mail.com) and [khalau@montana.edu](mailto:khalau@montana.edu)

### **Moon Mineralogy Mapper/Chandrayaan-1.**

Moon Mineralogy Mapper (M<sup>3</sup>) is one of eleven instruments selected to fly onboard India's Chandrayaan-1 spacecraft in 2008. M<sup>3</sup>, selected as a NASA Discovery Mission of Opportunity in May, 2004, is a high spatial and spectral resolution spectrometer that will help scientists better understand the compositional variation of the Moon's surface.

M<sup>3</sup>'s overall science strategy to characterize and map the lunar surface composition in the context of its geologic evolution and exploration strategy to assess the Moon's mineral resources at high spatial resolution in support of NASA's "Vision<sup>1</sup> to Explore the Moon, Mars and Beyond ..."

### **M<sup>3</sup> Education & Public Engagement Plan.**

The education and outreach program shares the exciting results of the Chandrayaan-1 and M<sup>3</sup> mission in support of NASA's education goals and themes of this conference: *Of the Moon, On the Moon and From the Moon* through its hands-on activities with geologic samples, spectroscopy and review of lunar geology.

### **Three Unifying Themes for M<sup>3</sup> E/PO.**

Unlike NASA's Mars Public Engagement Program, within which exists a set of well vetted themes and strategies to share with the public, there is not yet an "official" Lunar Public Engagement Program, nor a fully vetted set of common lunar education themes. We have identified three themes as unifying threads between the M<sup>3</sup> science, engineering, technology and E/PO. Each theme may stand alone or support the others:

***Geology of the Earth-Moon System.*** The objective of this thematic strand is to promote and enable student use of authentic scientific data, spectra, and imagery leading to an understanding of the processes that formed the Earth-Moon system and evolved their surfaces. Resources from NASA's previous lunar missions (e.g., Apollo, Clementine, Lunar Prospector) will lay the foundation for understanding M<sup>3</sup> imaging spectra and Chandrayaan-1 data.

***Properties of Lunar Materials.*** The objective of this strand is to promote and enable student and public use of authentic scientific data and spectral imagery to analyze the physical properties of lunar materials. Resources from NASA's previous lunar missions (e.g., Apollo, Clementine,) and laboratory

data will lay the foundation for understanding M<sup>3</sup> imaging spectra and Chandrayaan-1 data.

***Science & Technology of Lunar Resources.*** The third thematic objective addresses a current void in science education by promoting the exploration and understanding of the physical, chemical, and geological properties of lunar surface materials that may permit their use as a future resource in support of extended human presence on the Moon.

The M<sup>3</sup> activities and programs designed within the themes are inquiry-rich; meet the national standards in science, math and engineering, and have all been educator vetted.

### **M<sup>3</sup> E/PO Activities and Toolkit.**

M<sup>3</sup> E/PO activities and resources will permit students to learn how the Moon and different planetary surfaces form and understand how scientists and engineers explore these worlds. M<sup>3</sup>/ Chandrayaan-1 mission E/PO activities largely build upon two highly acclaimed, teacher-vetted, educator guides: 1) "*Exploring the Moon: A Teacher's Guide*",<sup>3</sup> published by NASA to support the Lunar Education Sample Disk Program, and 2) the recent *Active Astronomy Program* generated by the SOFIA E/PO program.<sup>4</sup> All curricula, resources and activities generated are a part of the M<sup>3</sup> E/PO Toolkit.

Included in this toolkit are activities and resources related to the current Chandrayaan-1 mission, the M<sup>3</sup> instrument, spectroscopy, lunar history and more. These activities all support one or more of the above themes making them applicable for current and future missions such as Lunar Reconnaissance Orbiter (LRO) E/PO program and more<sup>5</sup>. Kit materials include formal curricular activities targeting Grades 4-12. Kit contents and curricula being developed include: *Seeing the Moon: Using Light to Investigate the Moon*, a series of educational activity modules developed by M3 E/PO partner, Lunar and Planetary Institute (LPI).

In these modules, 5th to 8th grade students investigate light and the geologic history of the Moon. Through the hands-on inquiry based activities, students experiment with light and color, collect and analyze authentic data from rock samples using an ALTA hand-held classroom reflectance spectrometer, map the rock types of the Moon, and develop theories of the Moon's history.

Additional kit materials include a Lunar Timeline: History of Lunar Exploration; Geologic History of the

Moon & Geologic Processes; Impacts / Cratering and Regolith Formation; Volcanoes; Mapping and Superposition; Rocks and Minerals; Activities with the Lunar Samples and Sample Education Disks; Hand-held ALTA Classroom Spectrometers / Spectroscopy; Observing and Exploring the Moon and Thematic Posters with graphics and activities.

The classroom toolkits will be made available for loan to educators who participate in the M<sup>3</sup> workshops on a short-term basis from the LPI. (More details to come).

More informal means of involving the public include the use of:

- M<sup>3</sup> website to engage families and students in lunar exploration and to share their photos & stories of the Moon
- Storytelling –stories of the Moon, coupled with scientific theories of lunar formation from cultures around the world will be made available via the web, M<sup>3</sup> exhibit(s), workshops and a CD when compiled.
- M<sup>3</sup>/Chandrayaan-1 exhibits at small venues

Professional development opportunities for both formal and informal educators include workshops with the M<sup>3</sup> scientists, engineers, and educators from across the country at the LPI and in association with various conferences. During these workshops participants receive background and content in lunar science, on M<sup>3</sup>, Chandrayaan-1 and upcoming missions such as LRO, hands-on experience with the mission E/PO activities, and a chance to begin planning an exhibit and/or education program for their own classroom or science center/museum.

In Fall, 2008 we will offer an on-line course on the Geology of the Moon using web-based Classroom Tools (WebCT) with Montana State University. WebCT is a distance learning program that will permit the M<sup>3</sup> E/PO team to continue supporting and working with participating educators while they are developing lunar curricula and follow-up education programs.

M<sup>3</sup> science and engineering team members are giving talks and presentations to local, state and national groups as well as reporting on their research results.

Formative and summative evaluations are fully integrated into the M<sup>3</sup> E/PO Program. Metrics for success are monitored by PERG, an external evaluator with assistance from the E/PO team.

**Figure 1:** Educator working on spectra with hand-held ALTA using M<sup>3</sup> E/PO tools.



In addition, the M<sup>3</sup> E/PO team is collaborating with the LPI and other lunar missions to develop and support joint educational resources for the broader community such as the new set of lunar posters.

**Acknowledgment:** We thank the NASA Discovery Program and Science Mission Directorate for supporting the development and implementation of the M<sup>3</sup> E/PO program. We are honored to be part of ISRO's Chandrayaan-1 mission.

**References:** [1] NASA HQ (2006) [2] Runyon, C.J. (2006) Proc. of Indo-US Wkshp on Util. of Space-based Res. to Enh. Sci Ed in India. p. 116-120., p. 187-195. [3] Taylor et al. (1994) <http://ares.jsc.nasa.gov/Education/activities/ExpMoon/ExpMoon.htm> [4] SOFIA E/PO Team (2004) Active Astronomy <http://www.sofia.usra.edu/edu/materials/activeAstronomy/activeastronomy.html> [5] Stockman S. (2007) LPS Abstract XXXVIII, 1997.