# Characterizing the Mineralogy of Potential Lunar Landing Sites

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**Abstract.** Many processes active on the early Moon are common to most terrestrial planets, including the record of early and late impact bombardment. The Moon's surface provides a record of the earliest era of terrestrial planet evolution, and the type and composition of minerals that comprise a planetary surface are a direct result of the initial composition and subsequent thermal and physical processing. Lunar mineralogy seen today is thus a direct record of the early evolution of the lunar crust and subsequent geologic processes. Specifically, the distribution and concentration of specific minerals is closely tied to magma ocean products, lenses of intruded or remelted plutons, basaltic volcanism and fire-fountaining, and any process (e.g. cratering) that might redistribute or transform primary and secondary lunar crustal materials. The association of several lunar minerals with key geologic processes is illustrated in Figure 1. The geologic history of potential landing sites on the Moon can be read from the character and context of local mineralogy.

FIGURE 1. Overview of mineral diversity associated with early crustal processes on the Moon.



The current suite of orbital missions to the Moon from Europe, Japan, India, China, and the United States will provide a wealth of global data for the Moon. Potential targets for future landing sites will be studied in detail by a complement of sophisticated sensors to be flown in lunar orbit.
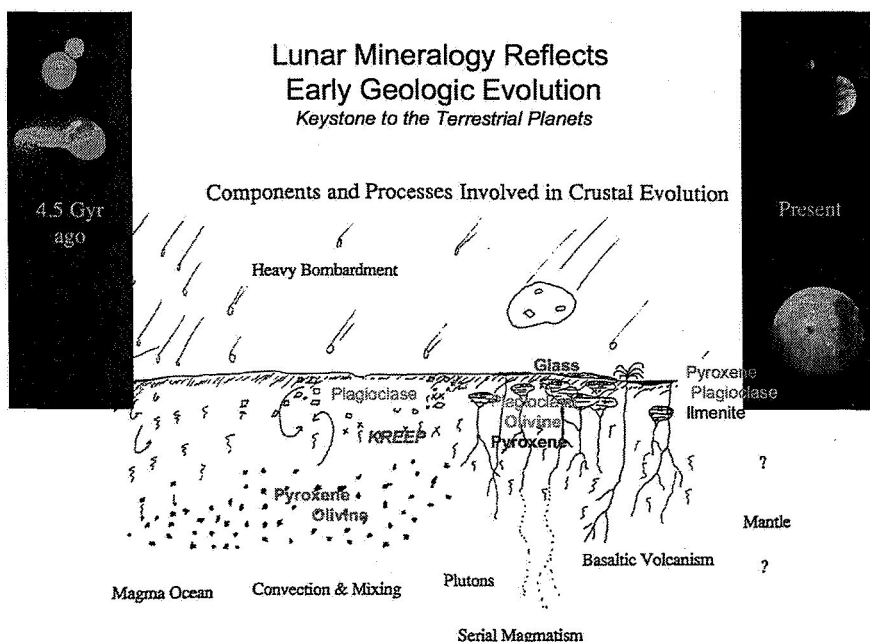
The Moon Mineralogy Mapper (M3, pronounced "m-cube") is a state-of-the-art imaging spectrometer that will fly on Chandrayaan-1, the Indian Space Research Organization (ISRO) mission to the Moon. M3 operates from 430 to 3000 nm with 10 nm sampling and acquires image cubes of data across a FOV of 40 km. We know from earth-based measurements of the lunar near-side, that a diversity of spectral features occur in the near-infrared that are highly diagnostic of mineralogy (e.g. Pieters 1993). An example for the central peaks of Copernicus is shown in Figure 2 along with a mare basalt and iron-rich pyroclastic material. The presence of such diagnostic mineral features, coupled with the high SNR of M3, allow M3 to map the mineralogy of the Moon in a spatial context globally.

One of the objectives of M3 is to characterize the mineralogy of the surface at high spatial resolution (70 m/pixel) to allow detailed geologic assessment of targets of interest to the science and exploration communities. We are compiling a list of prioritized landing sites for operational planning of data acquisition and invite suggestions from the community. These data will be of enormous value as this generation of explorers plans activities across the Moon.

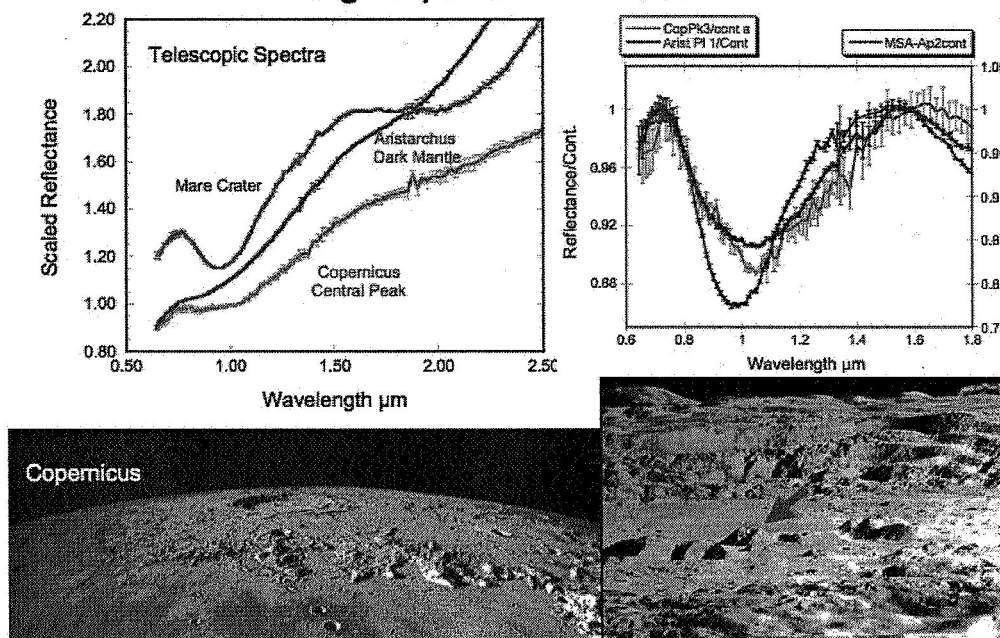## Mineral Characterization Requires High Spectral Resolution

FIGURE 2. Near infrared spectra of lunar areas acquired with earth-based telescopes provide examples of diagnostic absorption features present in lunar terrains observed remotely. High spectral resolution data are required to accurately measure the ubiquitous (red-sloped) continuum as well as to characterize the superimposed absorption bands. The small central peak of Copernicus (green arrow) exhibits a broad composite absorption band (green spectrum) characteristic of olivine. In contrast, the dark mantling material on the Aristarchus Plateau (Arist Pl1; red spectrum) exhibits absorption feature characteristic of pyroclastic quenched glass and a mare crater (blue spectrum) exhibits the properties of abundant high-Ca pyroxene. The central peaks of Copernicus remain a high priority science target.

## ACKNOWLEDGMENTS

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## PRINCIPAL AUTHOR'S BIO (~50 WORDS)

Dr. Carle M. Pieters is a Professor in the Department of Geological Sciences at Brown University. She began working on remote compositional analysis of the Moon during the Apollo program and continues lunar research in the laboratory with lunar samples.