Composition of the Lunar Crust as seen by the Moon Mineralogy Mapper on Chandrayaan-1

C. M. Pieters1, P. J. Isaacson1, J. F. Mustard1, L. A. Taylor2, and the Moon Mineralogy Mapper Team

[1]*Department of Geological Sciences, Brown University, Providence, RI 02912 (Carle_Pieters@brown.edu)*

[2]*Planetary Geosciences Institute, University of Tennessee, Knoxville, TN 37996*

The canonical characterization of the lunar crust, based principally on Apollo, Luna, and meteorite samples analyzed in Earth-based laboratories, is formulated around the concept of an anorthosite-rich float cumulate (FAN) produced by crystallization of an extensive lunar magma ocean (LMO). Portions of this initial FAN crust were likely infused with and assimilated by secondary magmatism to form the Mg-suite and gabbronorite rocks that are recognized in the lunar samples. Much of the upper crust was mixed and redistributed as breccias during the late heavy bombardment and basin-forming events. The deeper, mafic LMO mantle cumulates were the source of the mare basalt volcanism that filled low-lying areas across the surface, particularly on the nearside.

Within this context, the Moon Mineralogy Mapper (M3) on Chandrayaan-1 was designed to map and characterize lunar surface mineralogy at high spatial resolution (70-140 m/pixel) and high spectral resolution and range (460 – 3000 nm). During the Chandrayaan-1 mission, M3 acquired data for ~90% of the surface at 140-280 m/pixel. We have assessed the overall nature of the highland crust and dark mare. As expected, the high-albedo crust is low in mafic minerals and is very feldspathic. The maria are basaltic in nature and exhibit a diverse range of mafic-mineral compositions.

Craters of all sizes provide probes to the composition of the interior. At the Orientale Basin we have identified massive remnants of the LMO anorthosites along the exposed and uplifted Inner Rook Mountains (innermost ring). The relation of anorthosites to prominent noritic blocks seen in the Outer Rook Mountains and in external basin deposits indicates that the lower crust (below the anorthosite) is noritic

in nature. At the Moscoviense Basin on the farside of the Moon we identify a new rock-type that occurs as one of several discrete unusual compositions detected along the uplifted western inner ring of the basin. The new rock type is dominated by Mg-spinel with no detectible pyroxene or olivine present (<5%), and may represent a cumulate portion of a magmatic system from the lower farside crust. However, the Mg-spinel rock type area, and several small areas along the inner basin ring that also exhibit unusual compositions relative to their surroundings, are invisible morphologically and exhibit no evidence for distinct processes that would lead to their exposure.

The Moon Mineralogy Mapper on Chandrayaan-1 also documented the presence of widespread water and hydroxyl-bearing phases across the surface of the Moon. Broad absorptions near 3000 nm were observed at higher latitudes where surface temperatures are lower, and at small, localized outcrops at all latitudes, often associated with fresh feldspathic craters. A temporal relation to lunar day/night appears to exist, leading to speculation that the source of a component of this H2O/OH is linked to solar-wind proton bombardment, although the precise origin of the water/hydroxyl presently is unclear.