EPSC Abstracts
Vol. 6, EPSC-DPS2011-1369-1, 2011
EPSC-DPS Joint Meeting 2011

An integrated NIR and TIR approach to the plagioclase-rich regions on the Moon using M^3 and Diviner data

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Abstract

Recent near infrared (NIR) observations from SELENE [1], [2] and M^3 [3] have uniquely identified Fe-bearing crystalline plagioclase regions on the Moon. These results are significant because they validate earlier NIR observations [4], [5] as well as characterize the widespread distribution of crystalline plagioclase across the lunar surface. The identification of Fe-bearing crystalline plagioclase in the NIR comes from a broad absorption band at approximately 1.3 μm due to electronic transitions of Fe^{2+} in the crystal structure. While previous NIR lab studies of plagioclase have suggested that the band depth and center position of the 1.3 μm feature may vary with Fe and An content [6], [7], the relationship between NIR spectral properties of plagioclase and its composition (An#) has yet to be quantified.

Regions of nearly pure crystalline plagioclase (<5% olivine and pyroxene) as identified in NIR spectra are ideal areas to investigate the utility of thermal infrared (TIR) Diviner data to constrain plagioclase compositions. Diviner has three spectral bands near the 8 μm region chosen specifically to measure the peak of the Christiansen Feature (CF), an emissivity maximum indicative of composition [8]. New lab measurements of varying compositions of the plagioclase solid solution series demonstrate that the CF position is diagnostic of composition and linearly related to An# even when measured under a simulated lunar environment [9]. Thus an integrated NIR and TIR approach will enable plagioclase compositions to be mapped across the lunar surface and is significant for identifying rock types (e.g. ferroan anorthosites versus Alkali-suite rocks) and may ultimately constrain their method of formation (e. g. magma ocean crystallization or plutons).

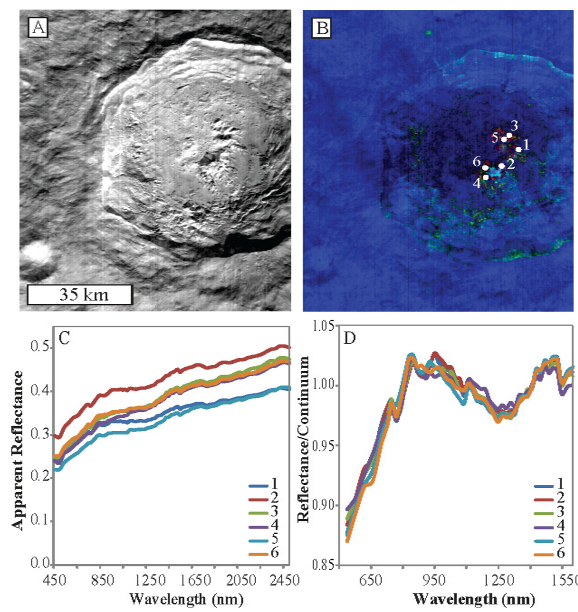

Figure 1: (A) M^3 2936.3 nm reflectance image of Jackson crater. (B) M^3 band parameter map where R = band depth at 1250 nm, G = band depth at 1050 nm, and B = band depth at 1900 nm. Red areas indicate regions rich in plagioclase. White circles indicate 5 x 5 pixel locations at which spectra are extracted and plotted in (C). (D) Reflectance spectra where a continuum (anchored at 749 nm and 1579 nm) has been removed.

1. Data and Methods

A systematic study of the plagioclase-rich regions identified by SELENE [1] will be performed. M^3 data covering each of the regions will be identified and NIR band parameters will be calculated to highlight specific plagioclase-rich areas. M^3 NIR spectra will also be extracted of the regions with the strongest absorptions and analyzed to confirm the identifications of crystalline plagioclase and the absence of mafic minerals (e.g. Figure 1). Diviner radiance data for the same regions will be analyzed, converting radiance to emissivity, from which a map of the CF position will be generated [10]. The areas within the Diviner data exhibiting CF values between 7.4 and 7.9 µm indicate they are plagioclase-bearing and will be examined in detail including a comparison of the TIR distribution of plagioclase with the NIR distribution of plagioclase in the M^3 band parameters map. The calculated CF positions will be compared with the CF positions from the full resolution laboratory spectra of the plagioclase solution series measured under SLE conditions to determine the An# for the identified plagioclase.

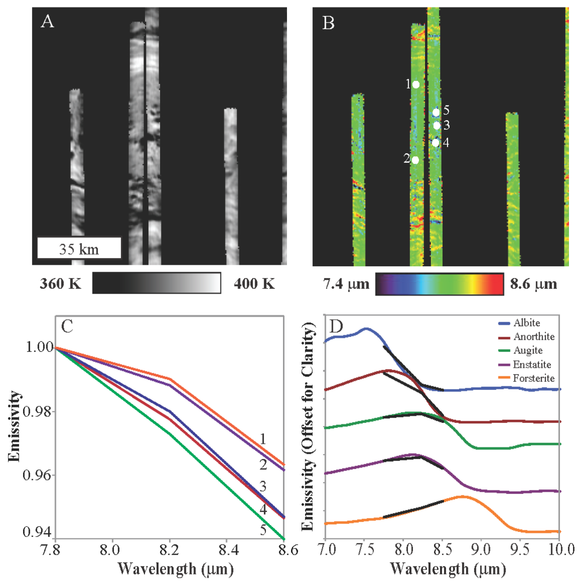

Figure 2: (A) Diviner band 8 temperature map of Jackson crater. (B) Diviner CF map where purple and blue areas indicate low CF values (plagioclase-bearing) while green to red areas indicate higher CF values (mafic-bearing). (C) Diviner spectra extracted from the identified white circles in (B). (D) Full resolution and Diviner resolution mineral spectra of the major silicate minerals on the Moon.

2. Results

Initial analysis of M^3 data over Jackson crater (a 71 km crater on the lunar farside) clearly identifies crystalline plagioclase in the central peak and floor of the crater (Figure 1) as mapped by [1]. The 1.3 µm electronic transition band is well developed implying very little shock effects. The correlation between the M^3 band parameter map and the Diviner CF map is strong (Figures 1 and 2). To understand the compositional diversity of plagioclase within these units, we examine only the pixels with CF values between 7.4 and 7.9 µm and we find that the mean CF value is 7.83 µm with a standard deviation of 0.07 µm. This indicates that there is very little plagioclase compositional variation within Jackson crater and that the composition is anorthite and/or bytownite.

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