EPSC Abstracts
Vol. 8, EPSC2013-686, 2013
European Planetary Science Congress 2013

Enhanced Compositional Analysis of the Moon using Diviner's Long Wavelength Channels

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Abstract

To date, the Diviner compositional investigation has been conducted using Diviner's three narrow band "8 µm channels" to model the position of the silicate Christiansen feature (CF) [1], the position of which is sensitive bulk silica content. In this work, we extend Diviner spectral analyses to include an additional broadband mid-infrared channel centered at 18 µm. Incorporation of this channel into compositional analyses enables the use of spectral indexing and spectral mixture analysis techniques that were not previously available using 3-point spectra. Here, we demonstrate the utility of these techniques for an olivine-bearing region of the Moon southeast of Aristarchus crater.

1. Introduction

Locations on the Moon with olivine-bearing, pyroxene-free lithologies have been detected by both the Moon Mineralogy Mapper (M^3) and Spectral Profiler (SP) [2-3]. These areas are generally associated with crater ejecta (Figure 1) on thin portions of the lunar crust [3]. Both M^3 and SP cover visible and near-IR wavelengths. While Diviner is capable of detecting pure olivine using the three "8 µm channels", very few of the sites identified by M^3 and SP as "olivine-rich" look different from average lunar mare composition in Diviner 3-point emissivity data. This suggests that either (1) olivine abundances at these sites are quite low, or (2) that a high abundance of olivine relative to plagioclase is necessary to produce CF values that are distinguishable from average lunar mare.

To address this issue, we acquired a set of simulated lunar environment (SLE) spectra of olivine/anorthite mixtures [4-5]. That work showed that for the CF position of an anorthite-forsterite mixture to be elevated above average mare (~8.3) [1], there must be greater than about 90 weight percent forsterite present. It is clear from this work that non-linear spectral mixing makes it difficult to determine the presence of olivine from the spectral shape of channels 3-5 alone. However, this series of spectra, convolved to the Diviner bandpasses (Figure 2) do reveal that with increasing olivine content, there is a concavity inversion between Diviner channels 4-6. We developed a concavity index using channels 4, 5, and 6 that is analogous to that used by [6] to map the presence of highly silicic materials on the Moon. We make use of this index to map the presence of olivine southeast of Aristarchus.

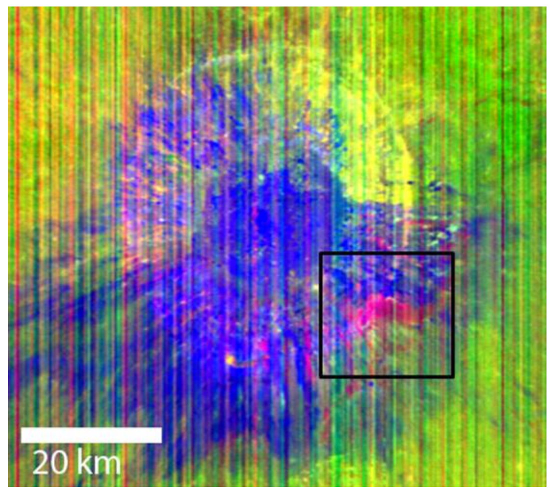

Figure 1. M^3 composite image of Aristarchus crater. Olivine-bearing materials are bright purple. The black box outlines Figs. 3 and 4.

2. Spectral Index Mapping

Figure 3 shows a Diviner band 4, 5, and 6 concavity index map of southeast Aristarchus overlayed on an LROC WAC mosaic. The map covers -47.3° to -46.3° E and 22.7° to 23.7° N. In this map, red and orange colors correspond to olivine-bearing surfaces while blue and green regions are relatively olivine-free. The distribution of olivine-bearing surfaces mapped by this technique corresponds well with that mapped by M^3.

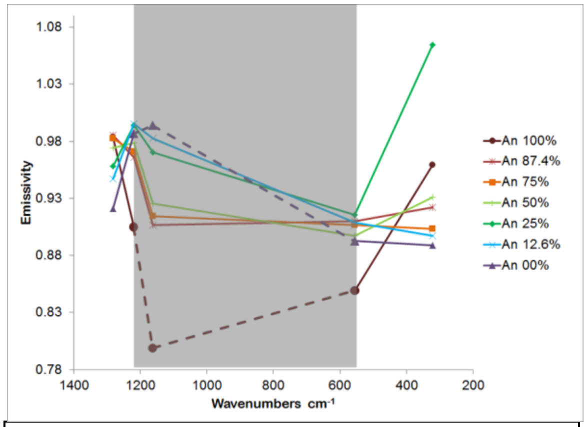

Figure 2. Laboratory spectra of olivine-anorthite mixtures acquired in a simulated lunar environment and convolved to the Diviner bandpasses. The spectral concavity between channels 4-6 (shaded region) inverts as the abundance of olivine increases.

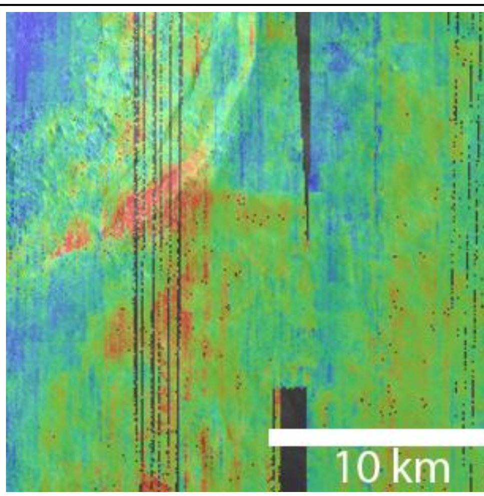

Figure 3. Diviner olivine index overlayed on LROC WAC mosaic of southeast Aristarchus crater. Red and orange colors indicate the presence of olivine.

3. Spectral Mixture Analysis

The addition of a fourth channel to Diviner compositional analysis enables rudimentary spectral mixture analysis. While the fine-grained nature of the lunar regolith likely precludes linear unmixing, spectral mixture analysis may prove to be a useful method to determine the presence and distribution of major silicate phases on the lunar surface. For this analsyis, we used laboratory spectra of anorthite, forsterite, and augite acquired under SLE conditions. We then used factor analysis and target transformation (FATT) [7] to determine scene-derived spectral endmembers from the laboratory data. The result of the spectral mixture analysis using the scene-derived endmembers is shown in Figure 4. The results generally correlate well with the spectral index mapping, although the modelled olivine distribution along the Aristarchus rim is not as strong as that seen in the index map (Figure 3). Future work will focus on correlation of deconvolution and index mapping methods and incorporating an additional Diviner broadband channel (band 7, centered at ~31 µm) into our analyses.

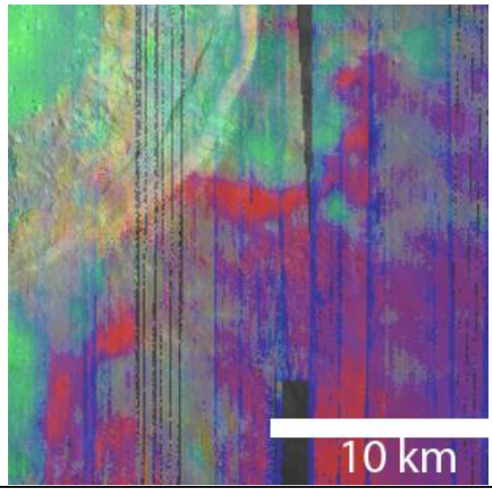

Figure 4. Spectral mixture analysis results. Red=forsterite; green=anorthite; blue=augite.

4. References

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