REMOTE SENSING CONSTRAINTS ON THE FORMATION AND EVOLUTION OF THE MOON'S ANORTHOSITIC CRUST.
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Introduction: The formation of the Moon's primary anorthositic crust is still an outstanding science question as two major hypotheses have been suggested. The impetus for the hypothesis of a lunar magma ocean came from the analyses of pristine Apollo samples [e.g. 1-2] and suggests that the lunar primary crust was formed by the crystallization and flotation of plagioclase (anorthosite's most abundant mineral) in the late stages of a magma ocean. Serial magmatism models have also been suggested in which plagioclase crystallizes from several different plagioclase-rich diapirs and these models are based on the analyses of terrestrial anorthosites, lunar breccias, and feldspathic meteorites [e.g. 3-4]. Thus, examining the local and global distribution of anorthosite across the lunar surface and estimating its compositional variations is significant for better understanding lunar crustal formation processes. In this work we combine the strength of identifying Fe-bearing minerals in near infrared (NIR) remote sensing data with the strength of determining plagioclase composition using remote thermal infrared (TIR) observations to characterize the distribution of pure crystalline anorthosite and determine their composition.

Results: Analysis of Moon Mineralogy Mapper (M^3) NIR observations identified pure crystalline plagioclase (~99-100% plagioclase) widely distributed across the lunar surface. Spectrally pure, crystalline plagioclase was identified in the walls and ejecta of simple craters and in the walls, floors, central peaks, and ejecta of complex craters; most in association with the inner rings of near- and far-side impact basins [5]. While many of the anorthosite identifications are concentrated on the far-side and around impact basins, regions with the highest crustal thickness values [6], anorthosites are also identified within craters with intermediate and lower crustal thickness values [5]. Thus, pure anorthosite is found across large-scale surface features and throughout the crustal column suggesting large coherent zone(s) of anorthosite.

To better understand the compositional variability of plagioclase distributed across the lunar highlands, estimated Diviner Christensen Feature (CF, an emissivity maximum diagnostic of silicate mineralogy [7]) values were analyzed. A single distribution of CF values is observed with a mean CF value of 7.91 ± 0.05 μm suggesting that the average composition of plagioclase identified across the lunar highlands is similar [5]. The mean Diviner CF value can be compared to the wavelength position (7.84 μm) of the CF of high-Ca anorthite (An_{96}) measured under simulated lunar conditions to estimate the An# for the observed pure plagioclase units [5]. The mean Diviner CF value suggests the plagioclase composition across the highlands is relatively uniform in composition, highly calcic ($An_{\geq 96}$), and is consistent with plagioclase compositions found in the ferroan anorthosites (An_{94-98}) [e.g. 1-2] and feldspathic meteorites (An_{95-97}) [e.g. 4]. However, shorter CF values are observed in several craters, including Jackson crater, suggesting some anorthositic units may have less calic plagioclase corrobating earlier Diviner observations [8].

Conclusions: Our integrated remote sensing observations confirm that spectrally pure anorthosite is widely distributed across the lunar surface and most exposures of the primary anorthositic crust are concentrated in regions of thicker crust surrounding impact basins on the lunar near- and far-sides. The global nature of anorthosite identifications and the scale of the impact basins require a coherent zone of pure anorthosite of similar composition in the lunar crust. These considerations along with others including the (1) range in the ferroan anorthosites ages [e.g. 9], (2) geochemical differences observed in Apollo ferroan anorthosites and feldspathic meteorite anorthosites [e.g. 4, 10-11], and (3) the remotely observed differences in the Mg# on the near- and far-sides [e.g. 12-13] are important constraints to be considered in any model for the formation and evolution of the Moon's anorthositic crust.

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