
Introduction: The investigation of the composition of mare-highland boundaries carried out by Mustard et al. [1] using multispectral images from the Galileo Solid State Imaging (SSI) instrument reveals the existence of three distinct mixing systematics across the mare-highland contacts in the region of southwestern Procellarum. The three basic types are narrow, moderate, and complex mixing gradients, and each implies a different set of fundamental processes that have contributed to the observed gradients. However, the 4 km resolution of the Galileo SSI data is too low to critically evaluate the exact properties of these boundaries, particularly in areas with rapidly changing abundances. The higher spatial resolution of Clementine UV/VIS data (≈200 m/pixel, 5 filters between 0.415-1.0 μm) allows the contact of mare-highland to be addressed in more detail. We have begun a series of studies to characterize and model mixing across mare-highland boundaries using these data, beginning with simple boundaries (sharp geologic contact, simple superposition of mare on highland). In this study, the contact between the Grimaldi mare and the highland on the southern edge (Fig. 1) is investigated through the spectral mixture analysis of Clementine UV/VIS data. Our preliminary analyses reveals the boundary consists of three mixing zones: moderate, steep, and moderate. The moderate zones on the mare and highland sides of the contact are approximately 30 km wide, while the steep zone is ≈6-8 km wide. We are currently examining other such simple boundaries to determine if the physical dimensions and properties are consistent across the moon, and thus a characteristic properties of simple boundaries.

Methods: 5-filter Clementine UV-VIS data were calibrated to reflectance using the methods developed by the Clementine Team [2], with modifications for merging low and high exposures developed at Brown. Filter sets covering 10° of latitude across the Grimaldi basin were calibrated and mosaicked into a strip. An image-based linear spectral mixing model [3] was performed using 3 endmembers representative of blue mare, highland, and highland fresh crater. The image data were deconvolved into the percent spectral contribution of the three endmembers (Fig. 2) using a least squares mixture model. The proportion of each endmember required to minimize the error of the fit, subject to the constraint that the sum of the fractional abundance of endmembers equals unity, determines the spectral abundance of that endmember. The distribution and spectral abundance of these endmembers were calculated with an average error of ≈0.5% reflectance.

Results and Discussion: The calculated endmember abundances provide a framework for interpreting the relative contribution of the surface components represented by the spectral endmembers to the Clementine UV/VIS data. Four profiles of mare abundance variation across the boundary of Grimaldi mare-highland (Fig. 3) were produced using the mare fraction image. It is evident in Fig. 3 that there are three distinct zones in the mixing profiles. A shallow mixing gradient from regions of pure mare leading up to the mare-highland contact, a zone of very steep changes in mare abundance across the geologic contact, and then another moderate mixing zone leading up to regions of pure highland. These profiles have been analyzed to determine the widths of these zones, and the change in mare abundance across each. These results are summarized in Fig. 4. The steep mixing zone averages 6-8 km in width with a change in abundance of ≈40%, where the geologic contact is at ≈60% mare. The moderate mixing zones on each side of the steep gradient are approximately 25-35 km in width and have typical abundance changes of 10-20%. The possible calibration difficulties due to scattered light have been considered as a contribution to these mixing profiles, and we have determined that they cannot account for the magnitude and symmetry of the changes observed.

The production of narrow mixing gradient has been attributed to the result of simple post-formation lateral mass transport of surface materials due to the time-averaged effects to impact cratering and regolith gardening [1,4]. These new observations, however, imply that there is a two-stage mixing across this boundary. One occurs very close to the boundary and may be adequately modelled by impact-generated lateral mixing and transport as presented by [5]. However, carried out to longer distances, this model should create a abundance profile that changes monotonically. The modelling of [4] only included the continuous ejecta facies, while the
distinct zones. The modelling of [4] only included the continuous ejecta facies, while the moderate mixing gradients in Fig. 2 and 3 imply some far-field effect that might be from discontinuous ejecta facies. We will be examining other simple mare-highland boundaries in the near future to assess the constancy of these observations, and begin modelling the basic dynamics. With a better understanding of simple mixing across boundaries, we can then begin to assess the relative importance competing processes (e.g. basin ejecta emplacement, volcanism, cryptomare [1]) involved in more complex boundaries.