CLEMENTINE COLOR MOSAICS OF PROCELLARUM VOLCANIC COMPLEXES: EVIDENCE FOR DOME MORPHOLOGY LINKED TO VOLATILE CONTENT AND ERUPTION RATE.

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Variations in lunar dome morphology have been attributed to either variable eruption rates and different volatile content or to the fractionation of magma towards a more evolved composition. Clementine color composite images reveal that morphological dome constructs are not distinctive in color and by inference, composition. Therefore, we suggest that changes in dome morphology are attributable to physical processes of eruption.

Clementine multispectral data can provide information on the composition of units in and geologic constraints on the history of two major volcanic complexes, Marius Hills and Rümker Plateau, in the Oceanus Procellarum region of the Moon. The Marius Hills region in south-central Procellarum is composed of low and steep domes, cones and sinuous rilles. Variations in the morphology of Marius Hills domes have been explained by variable eruption rates and different volatile contents associated with eruption conditions [1] or changes in the composition of the magmatic material from which the domes formed [2,3]. The Rümker Hills in northern Procellarum are dominated by low, circular, smooth domes, often with summit pit craters. The diversity of construct morphology in the Marius Hills suggests that differences between the two areas can be explained by some interplay of overall length of volcanic activity of the complex, rates of magma supply, and viscosity of the lava. If, in fact, construct morphology is also dependent on compositional variations, then domes of similar morphology may have similar compositions.

At the Marius Hills, low domes are capped with irregular steep domes and cones. In Hawaiian volcanism, magma changes in composition with time; the younger lavas are more alkalic and silicic, gas-enriched, and contain more phenocrysts [2]. These changes can be attributed to lowering of the temperature of the magma chamber [4] and the changed composition of erupted lavas result in a change in morphology of landforms. For the Marius Hills, it has been suggested that the earliest low, broad domes are mafic whereas the steep-sided later features are intermediate to felsic in composition [5]. Walker [6] points out that because flow length is proportional to eruption rate in terrestrial lava flows, flows with steeper slopes could also be produced by decreasing eruption rates.

We have created preliminary calibrations and multicolor mosaics of the Marius and Rümker Hills regions with Clementine images from three band passes of the ultraviolet-visible (UVVIS) camera centered at 415, 750 and 950 nm. Spatial resolution of the images averages 200 m/pixel whereas the best previous digital multispectral imaging of this region has a resolution of ~4 km/pixel [7]. The images of Marius and Rümker Hills analyzed here are color ratio composites of 750/415-nm, 750/950-nm and 415/750-nm ratios represented as red, green and blue respectively. Ratioing the images from different filters eliminates brightness variations caused by topographic shadowing and albedo, and yields a color map of different spectral units based on mineralogy and soil maturity [8]. Compositional interpretations are based on Clementine spectra correlation with laboratory spectra. The compositional units mapped are at a much higher spatial resolution then previously possible, allowing us to see for the first time the relationship between dome morphology and geologic units. We discuss below only the Marius Hills; work on Rümker is continuing.

The excavation of the subsurface by impact craters and incisions by sinuous rilles to various depths, along with their spatial distributions and compositionally determined color, yield information necessary to reconstruct the stratigraphy of both regions [9,10]. Fresh exposures of mare basalts are spectrally bright in the 750/950 and 750/415 nm filter ratios. Mature mare soils are either spectrally bright in the 415/750 nm ratio, and flat in the 750/950 nm ratio (corresponding to "blue" maria, inferred to reflect high-Ti content [11]) or spectrally bright in the 750/415 ratio and flat in the 750/950 nm ratio (corresponding to

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"red" maria, inferred to indicate low-Ti content mare units [11]). Exposures of highlands materials and immature soils are bright only in the 415/750 nm color ratio.

South of the Marius Hills plateau, low-Ti mare flows predominate and craters expose fresh mare basalts in their walls, exemplified by a yellow color in the color composite image. To the north, over the major portion of the Marius Hills, the low-Ti mare unit is discontinuous giving way to a patchwork of low-Ti mare and highlands material. Craters and rilles within the low-Ti unit expose fresh mare basalt but craters >500 m in diameter have floors composed of highland rocks, suggesting that the mare basalt is thinner here. Craters and rilles that occur within these feldspathic highland areas excavate only highland material. The patchwork of lower Ti and highlands material grades into relatively higher Ti (blue) mare soil beyond the northern boundary of Marius Hills. Marius F, an impact crater 10 km in diameter, shows strong 415/750 nm reflectance, indicating highland material and Marius LA, an impact crater 6 km in diameter, just to the north has both weaker 415/750 nm and stronger 750/950 nm reflectance, suggesting that the highlands deposits are more deeply buried here, and mare basalt thickens to the north of the Marius Hills.

Highland material is the dominant subsurface unit at Marius Hills. These rocks are exposed by craters and by the steep-sided walls of sinuous rilles in the central and northern portions of the complex. The onlapping character of the two mare units, the high-Ti unit to the north and the lower Ti unit to the south, suggests that Marius Hills is a topographic boundary that separates the two different units. This concept is supported by the Clementine altimetry data which shows that Marius Hills is a symmetrical upwarp that stands about 1 km above the surrounding Oceanus Procellarum. The Clementine compositional data suggest that the volcanic construct of Marius Hills is built upon a pre-existing topographic rise of terra material.

The lack of correlation between the compositional boundaries in the color data with topographic domes and cones of Marius Hills suggests that the physical properties of volcanic eruptions here have been determined largely by the magma supply rates and the abundance and state of the volatiles in erupting lava. If the morphological units were dependent upon the fractionation of magma, compositional color unit boundaries would correspond to the volcanic structures. Viscosity of erupted lava probably has also been effected by the temperature of the liquid, the percentage of phenocrysts, the abundance of gas, and whether the gas is dissolved or in the form of bubbles in the magma. We suggest that the cones of Marius Hills are small stratovolcanoes formed by a series of low magma supply eruptions, possibly interlayered with pyroclastic deposits, and that the domes are shield volcanoes formed by a series of low viscosity eruptions..

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