GRUITHUISEN DOMES REGION: A CANDIDATE FOR A LARGE EXTENDED LUNAR NONMARE VOLCANISM UNIT

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While the lunar mare volcanism appears to be relatively well documented, little is known about the emplacement of lunar nonmare volcanic geologic units before and during the period of mare volcanism. As it is for the mare volcanism, the existence of nonmare volcanism has equally major implications for the thermal history and crustal evolution of the Moon. Small lunar areas known as red spots may represent good candidates for such nonmare volcanic geologic units predating or contemporaneous of the period of mare volcanism (1). These anomalous areas are primarily characterized by a relatively high albedo and a strong absorption in the UV relative to the visible (2,3). They are located in a variety of geological settings, exhibit a wide range of morphologies (domes, smooth plains units, rugged highland patches)(1), and show some spectral variations interpreted as differences in composition (2,4). Many red spots are embayed by younger mare deposits, suggesting that they have originally covered a greater proportion of the lunar surface.

In this study, we present both telescopic CCD (sampling: 0.7 km/pixel) and Clementine orbital multispectral imaging of the Gruithuisen region which contains Imbrian age domical features of likely volcanic origin, presenting spectral characteristics of red spots areas (5). The images have been calibrated to telescopic spectra taken from previous work (5,6) and corrected to absolute reflectance. A principal component analysis (PCA) has been applied to both the spectral UV-VIS-NIR telescopic and orbital dataset of this region, which permits to map in detail the areal extent of the dome material within the region and to document its relation with other spectral units we have identified. The extended spectral mapping for this region represents an improvement with respect to the very few reflectance spectra (only two) available in the past for these volcanic features of particular interest.

Several domains with a high spectral homogeneity have been selected within the statistical cloud in the PCA diagrams (7). One spectral unit is found to coincide with the d, g et NW domes, almost outlining their morphological boundaries mapped by (8). Reflectance spectra for these units typically show a strong positive slope in the UV-VIS domain, indicating an absorption in the UV for the surface material corresponding to the domes. Reflectance spectra relative to MS2 also display a strong positive UV-VIS slope with very low 0.40/0.75 mm ratios (ranging from 0.84 to 0.92). The spectral characteristics for these dome unit are typically those of red spot spectra. The d dome and the Northwest dome appears to be spectrally similar one to each other and more homogeneous than the g dome. The cause of the significant spectral heterogeneities within the domes, particurlarly for the g dome is not determined presently. They might be due to optical effects (such as soil maturation processes), and/or compositional differences (such as TiO_2 content, or differences in mineralogical abundances). The morphology of the flows that are on the domes indicates that these flows are highly viscous in their emplacement and may also have been explosive in places. The Gruithuisen domes are similar in shape and surface texture to many terrestrial domes of dacitic and rhyolitic composition characterized by extrusions of more viscous lavas at low rates (5,8). Some of the observed spectral heterogeneities are clearly associated with morphological units on the domes, such as lava flows mapped by (8), on the southern flank of the dome g and possibly d.

Two mare units are spectrally identified within the image. The mare unit surrounding the domes is characterized by very low to low TiO_2 contents (< 3 wt%), while the mare unit located deeper within Mare Imbrium shows higher TiO_2 content values (2.5 to 6 wt%).

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Embaying the dome units and extending in their surrounding in relatively high albedo areas previously mapped as highland terrains (8), we mapped a widespread unit refered here as the dome-like unit. This unit presents spectral characteristics close to those of the dome unit material (red spot). Clearly the domelike unit is spectrally close to the dome unit, but different from the surrounding mare units and the background highland materials. Although the spectral characteristics of the dome material are not explained in terms of composition at the present time, it thus appears that this material is present in significant proportion in a large area outside the morphological boundaries of the domes, in the domelike unit. This would imply that the specific style of eruption which is inferred for the formation of the domes (i.e., high viscous flows of possible silisic composition)(5) might have occurred at a large regional scale in this region of the Moon. This observation might be supported by the fact that other similar volcanic features (the Mairan domes)(1,5,8) exist in this region, about 200 km northwest of the Gruithuisen domes. The dome-like unit we identified extends northwest and north of the Gruithuisen domes, towards the Mairan dome region.

The eruption of volatile-bearing silicate magmas, which is commonly very explosive on Earth, is expected to be more extreme on the Moon because of the external environment. Consequently, the products of silisic explosive eruptions (pumiceous pyroclasts) could be so finely-grained and widely dispersed that they produce no positive construct around the vent and no well-defined ejecta deposit (9). This may account for the wide areal extent of a dome-like material component around the domes. Under these conditions, the pyroclastic material may have been emitted from the domes themselves or from other source vents located wihin the dome-like unit. This scenario would imply the presence of volatile elements in the magma. However, it is also possible that the formation of the Gruithuisen domes results from more or less viscous magmas extruded at lower extrusion rates than mare basalts. In this case the wide extent of the dome-like unit would be more difficult to explain. However, source vents for this kind of magmas may have also occurred within the dome-like unit, but at a much lesser importance than in the dome region. The presence of the domes might be due to their position on top of the Imbrium ring fractures which might have also favored the supply of magmas for a longer span of time.

The presence of a widespread silisic material has some implications concerning the composition of the crust in this region of the Moon. A key point in the understanding of the volcanic history of this region is the definition of the real spatial extent and the limits of the dome-like unit, and particularly to see if there is a relation between the two Gruithuisen and Mairan domes complexes through a unit such as the dome-like unit. Ages of the dome materials and the surrounding mare basalts deposits need also to be precised. On the basis of morphological studies, we need also to determine more precisely what are the relations (surface mixing, distribution and stratigraphy), within the dome-like unit, between the dome-like material and the background material (Imbrium and Iridum ejecta) and/or local patches of mare material. An important point is also to determine whether we have or not morphological evidences of mantling deposits of volcanic origin in the dome-like unit. These investigations are currently being undertaken.

References. (1) Wood C. A. and J. W. Head (1975) Conf. Origin of Mare basalts, The Lunar Science Institute, Houston, 189-192. (2) Bruno B. C. et al., (1991) Proc. Lunar and Planet. Sci. Conf. 21st, 405-415. (3) McCord T. B. et al., (1976) Icarus, 29, 1-34. (4) Müller A. et al., (1986) Lunar Planet. Sci. Conf., XVII, 577-578. (5) Head J. W., and T. B. McCord (1978), Science, 199, 1433-1436. (6) Pieters C.M. (1978) Proc. Lunar Planet Conf., 9th, 2825-2849. (7) Chevrel S. D. et al., (1995) Lunar Planet. Sci. Conf., XXVI, 241-242. (8) Head J.W. et al., (1978) Lunar Planet. Sci. Conf., IX, 488-489. (9) Wilson L. and J. W. Head (1983) Nature, Vol. 302, 663-669.