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Small Shield Volcanism on the Lunar Mare

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Abstract

Small shield volcanoes having low relief and gentle slopes are scattered across the lunar mare. These features represent the terminal phases of mare volcanism and are formed by short-duration, low-volume eruptions. Composition and eruption dynamics may have varied as the morphology and color of the shields vary. There appears to be regional correlations of morphometric properties indicating larger-scale organization of the eruptions.

1. Introduction

The most volumetrically important post-heavy bombardment volcanism is the basaltic mare [1]. These high-eruption rate basalts fill the depressions of ancient impact basins. In addition to the flood basalts, other volcanic styles include pyroclastics [2-4] and what have been referred to as "lunar domes" [5-10]. Lunar domes include features exhibiting a variety of morphologies and possibly a range of compositions and/or eruptive conditions. Recently, [11] suggested the presence of large low-relief shield volcanoes on the mare.

Historically, the term "dome" describes all small-scale features suggested to be of extrusive or intrusive volcanic origin. In terrestrial cases, "dome" (in a volcanic context) is applied to steeped-sided edifices having silicic compositions (e.g., Mono Domes). While some lunar domes (e.g., Compton Belkovich [12-13]) have silicic compositions, the majority have compositions similar to the mare.

Several studies compiled data for lunar domes [10, 16-17]; within each area, the number ranges from a few to hundreds. Data from LRO and other missions now provide the ability to characterize each dome in terms of areal extent, topography, morphology, and color properties in unprecedented detail allowing for an analysis of their origin.

Here, a subset of the domes are interpreted to represent a volcanic style characterized by small-volume eruptions that built low-relief constructs (Fig. 1). This style of volcanism has been termed plains volcanism [14] and is common in the Tharsis region.

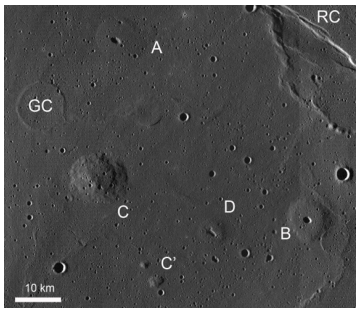

Figure 1. Constructs in Mare Tranquillitatis. A: low-relief, low-slope with central crater; B "pancake-shaped"; C and C': hummocky, steep-sided. Rupes Cauchy, GC: ghost crater. LRO WAC images.

2. Analysis

Using existing compilations, each site was examined and the characteristics and dimensions of the features were determined. For some, published coordinates differ slightly from those defined by LRO. In a few cases, no feature was recognized. Several previously identified domes, are not considered to be of volcanic origin. Rather, they are pieces of highlands embayed by mare. In addition a number of new features have been identified.

The northeastern portion of Mare Tranquillitatis adjacent to Rupes Cauchy exhibits a several vents and serves as an example. Figure 1 illustrates typical morphologic examples. Topographic profiles are illustrated in Figure 2.

One type has low-relief and a summit crater (A in Fig. 1; Fig. 2 green profile). The contact with the surrounding plain is gradual. The construct and the summit crater can be circular or elongate; relief is ~100 m. A second type has a "pancake-like cross-

sectional shape" [10]; the summit region has gentle slopes (<1°) and the margin steeper slopes (2°-5°) (B in Fig.1; Fig. 2 red profile). They have an abrupt contact with the surrounding plains; relief is ~100-200 m. The third type (C in Fig. 1 and Fig. 2 blue profile) is relatively steep-sided with an abrupt contact with the surrounding plains and lacks a summit crater. The surface is hummocky and the slopes are a few degrees (2°-5°); relief is several hundred meters. Similar features (e.g., C' in Fig. 1) may be volcanic or highland kipukas.

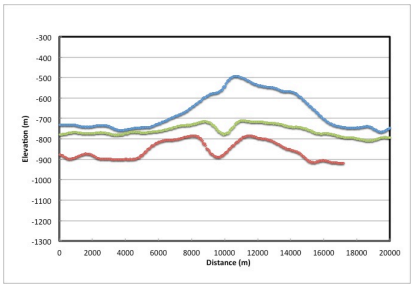

Figure 2. Topographic profile across different types of constructs (see text for details).

A few features appear to be the result of spatter or pyroclastic volcanism. They are characterized by an irregular outline, summit craters, possible lava flows and may be localized along fractures. At a few, short flows extend from low topographic mounds. Flows are up to 100 m thick and 15 km long. The mounds are 2 km diameter and may be cinder cones.

Some constructs have morphologies indicative of structural control. Boundaries and/or summit craters are elongate parallel with local tensional fractures. For example, in northwest Mare Tranquillitatis, several constructs have a trend parallel to Rupes.

Although there is considerable scatter in the morphometric data, the data suggest that shields in Mare Tranquillitatis become taller (87-158 m), have larger bases (5211-13682 m), summit elevation decrease (-764 to -1593 m), and summit craters deepen westward across the mare. Flank slopes are similar. These observations may indicate long-lived, hence larger volume, eruptions in the western mare at lower elevations compared to volcanism in the eastern mare.

3. Conclusions

Lunar domes exhibit a variety of morphologies. While the morphology and morphometry of some (and other aspects such as chemistry) can be associated with non-mare lavas, the majority are consistent with mafic compositions. The morphology of most is similar to terrestrial plains volcanism - low shields built by eruption of small-volume, isolated flows and occasional spatter. While local structural control is evident, most appear to be randomly distributed within the individual groups.

The variable morphology and slope suggest there are differences in either lava eruption rate or composition. The steeper features represent either more viscous lava or slower eruption rates compared with the constructs having very low slopes. Color differences between the shields and the surrounding mare also suggest compositional differences.

The small shields features represent the terminal stages of mare volcanism. Rather than the broad high-effusion-rate eruptions, these eruptions were localized and only small volumes were erupted before the conduit was abandoned. This suggests the magma sources were limited in terms of volume and/or pressure; perhaps the residuum from the original flood eruptions. The low slopes and paucity of features having a morphology similar to cinder cones suggests there was little volatile-rich magma.

References

[1] Head J. (1976) *Rev. Geophys. Space Phys*., *14*, 265-300. [2] Gustafson J. et al. (2012) *JGR, 117,* E00H25, doi:10.1029/2011JE003893. [3] Coombs C. and Hawke B. (1992) *Proc. Lunar Planet. Sci., 22nd*, 303-312. [4] Gaddis L. et al. (2003) *Icarus, 161*, 262-280. [5] Arthur D. (1962) *Comm. Lunar Planet. Lab. 1*. [6] Baldwin, R. (1949) The Face of the Moon, University of Chicago Press. [7] Salisbury J. (1961) *Astrophys. J., 134*, 126-130. [8] Fielder G. (1962) *British Astron. Assoc. J., 72*, 24. [9] Smith E. (1973) *The Moon, 6*, 3-31. [10] Head J. and Gifford A. (1980) *Moon and Planets, 22*, 235-258. [11] Spudis, P. et al. (2011) *42nd LPSC Abstract 1367*. [12] Jolliff B., et al. (2011) *Nature Geosci., 4,* 566-571. [13] Hawke B. et al. (2003) *JGR, 108*, E7, 5069, doi: 10.1029 / 2002JE002013. [14] Greeley R. (1977) NASA CR 154621, 41-53. [15] Lawrence S. et al. (2012) *43rd Lunar Planet. Sci. Conf., Abstract 2432*. [16] Wöhler C. et al. (2006) *Icarus, 183*, 237-264. [17] Lena R. et al. (2007) *Planet. Space Sci., 55*, 1201-1217.