

PLAINS VOLCANISM ON THE LUNAR MARE. J. B. Plescia¹ The Johns Hopkins University, Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel MD (jeffrey.plescia@jhuapl.edu).

Introduction: The most obvious and volumetrically important aspect of post-heavy bombardment lunar volcanism is the eruption of the basaltic mare [1]. These large, presumably high-volume eruption rate basaltic plains fill topographic depressions of ancient impact basins and embay the surrounding highlands. In addition to the mare, other styles of lunar volcanism include pyroclastics [2-4] and what have been referred to as "lunar domes" [5-10]. Lunar domes include features that exhibit a variety of morphologies and presumably a range of compositions and/or eruptive styles. Recently, [11] has suggested the presence of huge, low-relief shield volcanoes on the mare.

Historically, the term "dome" has been used to describe all small-scale features suggested to be of extrusive (and possibly intrusive) volcanic origin. In terrestrial geology, the term "dome" (when used in a volcanic context) is applied to steeped-sided edifices having a silicic composition (e.g., Mono-Inyo Domes). While some lunar domes (e.g., Compton Belkovich and Hansteen Alpha [12-13]) have silicic compositions, the majority have compositions similar to the mare.

Here, a subset of lunar domes is discussed which are interpreted to represent a style of volcanism characterized by small-volume eruptions that built low-relief constructs with low slopes, small diameters (few kms) and low relief (few hundred meters) (Figure 1). This style of volcanism has been termed plains volcanism [14] and typical of Hawaii, Iceland and the Snake River Plains. Such a style is also common in the Tharsis region of Mars.

Background: Several studies have described areas characterized by "lunar domes" [10, 16-17]. Within each area, the number of individual domes can range from a single or a few to hundreds. Data from LRO now allow a more quantitative analysis of the morphology and morphometry of the domes and a differentiation of their individual characteristics. Head and Gifford [10] classified lunar domes into seven categories. Those that fall into their classes 1-3 are the types discussed here. They note that such domes have diameters of a few to <20 km, heights of tens to a few 100's m, slopes <5° and many have summit craters.

Analysis: Using the existing compilations, each of the previously dome features in each of the groups was examined. In addition to those previously recognized, a number of new features were identified. The characteristics and dimensions were determined for each. For some, the published coordinates differed slightly from those defined by LRO. In a few cases, no

feature could be recognized at the stated coordinates. Several, previously identified as domes, are not considered to be of volcanic origin based on new observations. Rather, they are pieces of the highlands embayed by younger mare or are isolated massifs near the highlands-mare boundary.

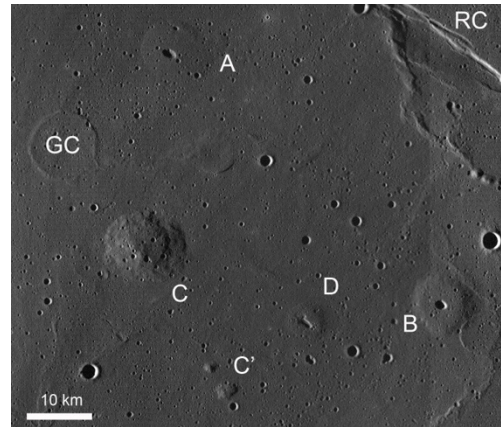


Figure 1. Small volcanic constructs southwest of Rupes Cauchy in Mare Tranquillitatis. A: low-relief, low-slope construct with central crater; B "pancake-shaped" construct; C and C': hummocky, steep-sided construct. Rupes Cauchy, GC: ghost crater / wrinkle ridge. LRO WAC images.

Morphology and Morphometry: The northeastern portion of Mare Tranquillitatis adjacent to Rupes Cauchy exhibits a number of volcanic vents and serves as an example. Figure 1 illustrates the typical morphologic range. Topographic profiles across three different types are illustrated in Figure 2.

One group consists of low-relief features with a summit crater (A in Fig.; Fig. 2 green profile). The contact with the surrounding plain is gradual and in some cases difficult to identify. Both the construct outline and the summit crater can be circular or elongate. Relief is of the order 100 m. A second type has a "pancake-like cross-sectional shape" [10] in which the summit region has gentle slopes and the margin is characterized by a steeper slope (B in Fig.1; Fig. 2 red profile). Upper slopes are <1° and the marginal slopes are steeper (2°-5°); they have an abrupt contact with the surrounding plains. Relief is of the order 100-200 m. The third type (C in Fig. and Fig. 2 blue profile) are relatively steep-sided and have an abrupt contact with the surrounding plains and typically lack a summit crater. The surface morphology is hummocky and

the slopes are of the order of a few degrees (2° - 5°). These features have relief of several hundred meters. Some examples of this type (e.g., C' in Fig. 1) are relatively small; they are not considered to be pieces of highlands based on their hummocky morphology.

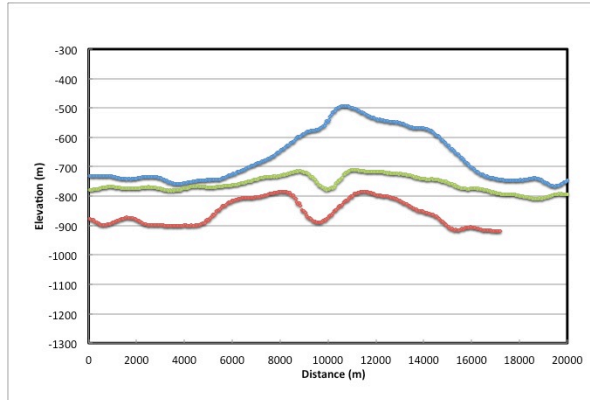


Figure 2. Topographic profile across different types of constructs (see text for discussion).

In addition, a small number of features have been identified that appear to be the result of spatter (Figure 3) or pyroclastic volcanism (i.e., cinder cone). They are characterized by irregular outline, summit craters, possible lava flows and may be localized along fractures.

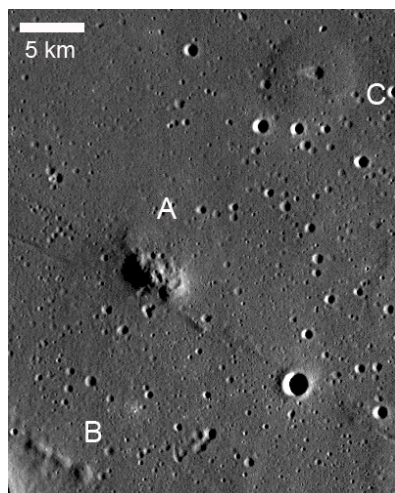


Figure 3. Steep-sided, irregular constructs localized along fractures (A and B). C: low relief-low slope construct with central crater. LRO WAC images

Some of the constructs have morphologies indicative of structural control. Construct boundaries and/or summit craters are elongate in common direction and that direction is parallel with local tensional fractures. For example, in northwest Mare Tranquillitatis, several

constructs have a northwest elongation, parallel to Rupes Cauchy (Figure 3).

Conclusions: Lunar domes consist of a variety of morphologic types. While the morphology and morphometry of some (and other aspects such as composition) can be associated with non-mare (i.e., more silicic) lavas, the vast majority are consistent with typical mafic compositions. The morphologic style of most is similar to terrestrial plains volcanism - low shields built by eruption of small-volume flows, isolated flows and occasional spatter. While local structural control of the location or morphology of individual vents is obvious, most appear to be randomly distributed within the individual groups.

The range of morphology and slopes for these features suggests that there are differences in either the eruption rate or composition of the lavas among the vents. The steeper features either represent more viscous lavas or much slower eruption rates compared with the constructs that have very low ($<1^{\circ}$) slopes.

These features represent the terminal stages of mare volcanism. Rather than the broad high-effusion-rate eruptions that formed the overall mare, 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 generally low slopes and paucity of features that have a morphology similar to spatter or cinder cones suggests that 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* (Chicago: 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., McGovern, P. J., and Kiefer, W. S., (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.