ORIGIN OF CLOSELY-SPACED PIT CLUSTERS ON LUNAR SILICIC VOLCANIC COMPLEXES, Joseph M. Boyce[1], Peter Mouginis-Mark[1], Tom Giguere[1], [1]Hawaii Institute of Geophysics and Planetology, Univ. of Hawaii, Honolulu, HI 96822.; jboyce@hawaii.edu.

Introduction: Enigmatic clusters of pits, so closely-spaced that their rims touch, or overlap are found on some (Fig. 1), but not all silicic volcanic complexes on the Moon [1-10]. McCauley [1] suggested that the pit clusters on Mons Hansteen are of volcanic origin because some of them have elongate or irregular shapes, while, Boyce et al., [10] proposed that they also represent a new style of volcanic eruption on the Moon. However, to date, no detail model has been proposed for the origin of these closely-spaced clusters of lunar volcanic pits, or the processes(s) responsible for producing them. In this abstract, we propose a conceptual model for their formation.

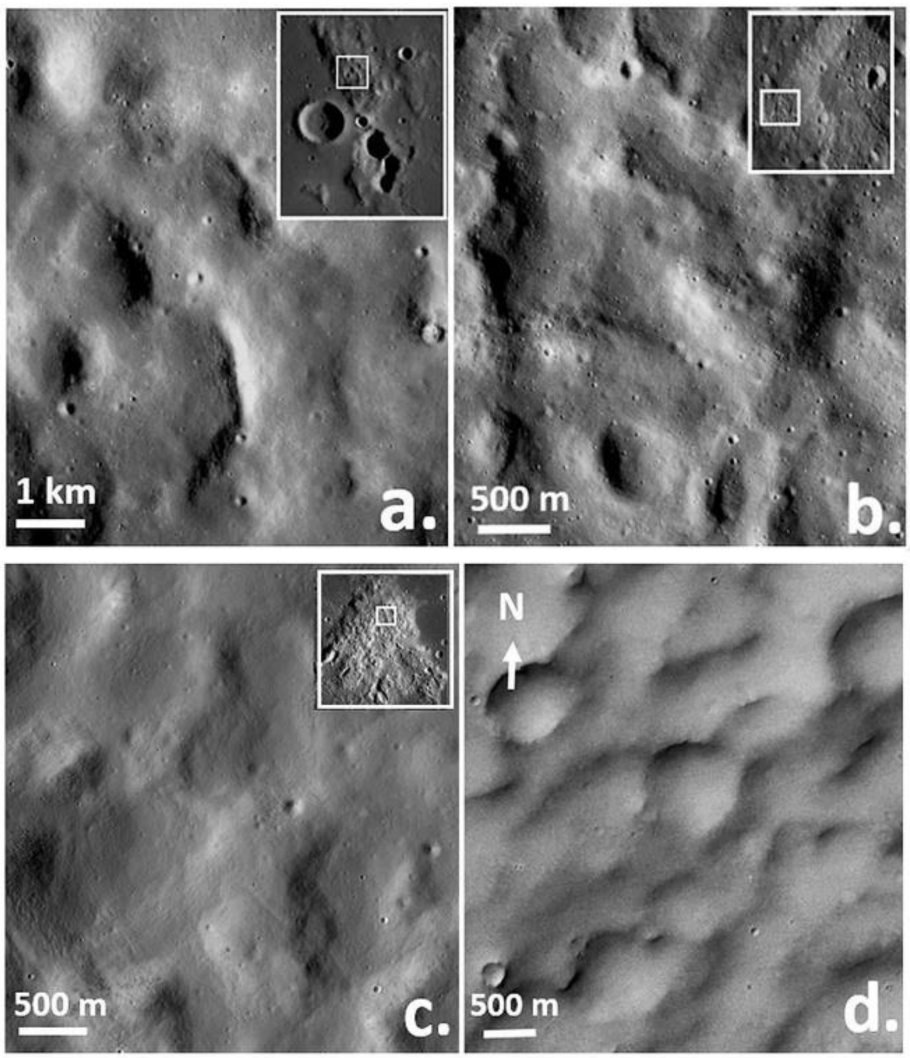

Fig 1. High resolution images of pit clusters on Lassel Massif (a); the northwest side of Gruithuisen Gamma dome (b); the north central part of Mons Hansteen (c), and (d) is CTX image CTX G21_026250_1606_XN showing the pits in a portion of the floor of a 93 km dia. Martian crater at 19.4 S, 180 E. Lunar images are from LROC Quick Map.

Observations and Background: The size of the area covered by pit clusters varies greatly from one lunar silicic volcanic complex to the next. The pit clusters on Mons Hansteen occur across most of its surface, while those on Lassell Massif complex, and Gamma Gruithuisen dome occur only in small patches. A few larger pits, interpreted as volcanic, are also found on these complexes [1 – 10]. Pit clusters have not been identified on Marian domes, or Compton-Belkovich Volcanic Complex suggesting that the process that produced pit clusters may not operate, or not as vigorously on these complexes, or if it did, then the pit clusters could have been buried by younger volcanic material.

The average diameter of the individual pits is < ~ km, and their size distribution appears to be relatively narrow. The individual pits in the clusters commonly are subdued circular to irregular-shaped depressions so close together that their rims sometimes share straight segments suggesting: 1) they formed simultaneously, 2) their sources (vents) were also closely-packed and likely shallow (within the flows). The ridges between the pits in the clusters are relatively smooth and rounded, although their interior slopes can be relatively steep (20° to 25°). The floors are typically broad, gently rounded to nearly flat suggesting that the surface is blanketed by particulate material (e.g., ash). Morphologically, these traits are similar to those of pit clusters associated with Martian impact craters (Fig. 1 d), as well as those formed in experimental fluidized beds, and some terrestrial ash deposits [11 - 14]. The mechanism that produce these analog features involves the rapid escape of gas through particulate material resulting in development of multiple vent pipe that act as conduits to facilitate rapid escape of the gas. We suggest that the morphologic similarity of the lunar pit clusters and Martian pits provide a clue to the mechanism for the origin of the lunar pit clusters.

Models for emplacement of terrestrial silicic flows can also provide further insight into the possible origin of the lunar pit clusters. For example, Fink and Manley [15] and Manley and Fink [16] proposed that as silicic lavas are extruded, the upper surface vesiculates because of low pressure, creating finely vesicular pumice. The central part of the flows remains hot long enough to allow crystallization releasing water vapor. The water vapor migrates upward through the flow by way of microcracks formed by shear stresses transmitted from the base of the advancing flow. However, the microfracturing is unable to reach the uppermost part of the flow resulting in an unfractured level in the flow, below which the rising volatiles accumulate. However, the relatively high water content and low density of this volatile-enriched layer allow it to rise to the surface as flow lobes, and, in certain conditions, can generate local explosions that blast through to the surface of the flow covered by fine vesicular pumice and ash to produce explosion craters. Production of such explosion craters on terrestrial silicic flows are isolated events, which appears to be similar to lunar silicic domes where a few large individual pit is also common.

Proposed origin: Considering this model and our observations, we propose that during emplacement into the low gravity and low pressure lunar environment, cooling and cracking of the silicic flow releases water vapor accumulated in the volatile-rich layer of the flow. The cracking allows these volatiles to escape through the fine vesicular pumice and ash surface materials where it produces closely-spaced vent pipes. The closely-spaced pits were excavated by the rapidly escaping gas through these pipes. We also suggest that whether pit clusters form or not could be controlled by such factors as the initial dissolved gas content and/or silica content, and/or the cooling history of the flows.

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References: [1] McCauley, J., 1973, USGS, Geol. Survey Invest. Ser. Map I-740; [2] Head, J., McCord, T., 1978. Sci. 199, 1433-1436; [3] Chavrel et al., 1999. JGR. 104, 16515–16529; [4] Wagner et al., 2010. JGR. 115, E06015; [5] Jolliff, B., et al., 2011, Nat. Geosci. 4, 566-571; [6] Hawke, B., et al., 2014 JGR 108 (E7), 5069.doi: 10.1029/2002JE0 02013; [7] Chauhan et al., 2015. Icarus 253, 115–129; [8] Ashely et al., 2016, Icarus 273, 248–261; [9] Ivanov, B., et al., 2016; Icarus 273, 262–283; [10] Boyce et al., 2017, Icarus 283, 254–267; [11] Boyce, J., et al., 2012, Icarus, 221, 262-275; [12] Tornabene, L., et al., 2012. Icarus, http://dx.doi.org/10.1016/j.icarus. 2012.05.022.; [13] Kuni R., Levenspiel, O., 1969. Fluidization Engineering. John Wiley & sons, NY; [14] Rhodes, J., 1998; John Wiley & Sons, Chichester; [15] Fink, J., Manley, C., 1987; *in* Fink, J.H., ed., GSA. SP 212, p. 77–88; [16] Manley, C., Fink, J., 1987. Geol., v. 15, p. 549–552.