# SPATIAL DISTRIBUTION OF VOLCANOS IN THE MARIUS HILLS AND COMPARISON WITH VOLCANIC FIELDS ON EARTH AND VENUS

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**Introduction** The Marius Hills volcanic field is the largest volcanic dome complex on the Moon. Located in central Oceanus Procellarum, it is about 200 by 250 km across. It includes about 300 volcanic domes and cones, which is roughly half of the total number of volcanic domes on the Moon's surface [1,2]. The unusual concentration of volcanism in this small region of the Moon makes it an important study target. Here, we discuss the spatial distribution of volcanos within the Marius Hills and contrast our results with volcanic fields on Earth and Venus. This work complements a gravity study of the Marius Hills, which images details of the subsurface structure related to the magmatic plumbing of the volcanic field [3].

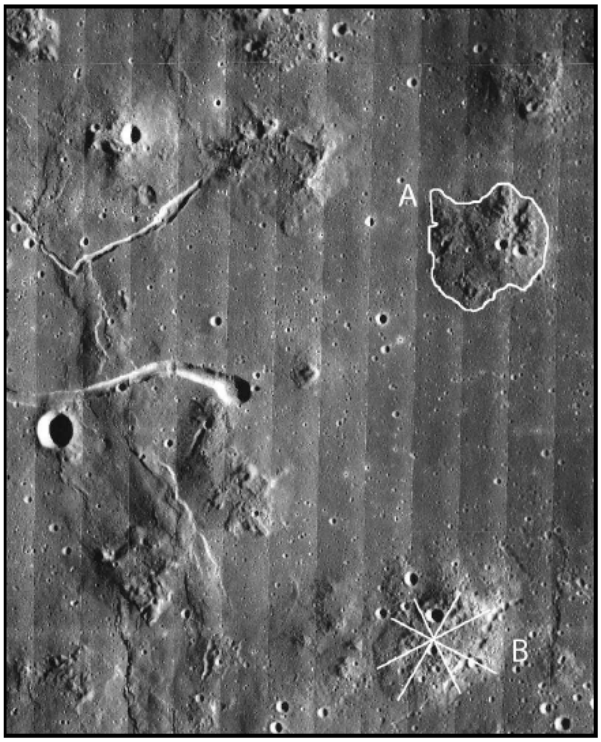


**Figure 1:** A representative image of volcanic domes in the Marius Hills, showing how we defined the boundary of volcanic domes (A) and the mean diameter of the domes (B).

**Results** Figure 1 shows a representative region of the Marius Hills, including a number of volcanic domes and two sinuous rilles. Using Lunar Orbiter images IV-150-H2 and IV-157-H2 and the USGS image analysis software package ISIS, we measured the location and diameters of volcanic domes within the Marius Hills. We defined the edge of each volcano based on changes in surface texture and changes in surface brightness, which were assumed to reflect changes in slope (Figure 1a). Due to the irregular shape of many of the volcanos, we drew 4 chords across each structure (Figure 1b). The average length of the chords defined each volcano's diameter, and the center of the chords defined the volcano's center.

We measured a total of 239 domes, ranging in diameter from 1 to 12 km, with a median diameter of 3.9 km. A previous study of this region [1] counted multiple volcanos in a given location when there was a change in morphology, particularly when a "steep-sided dome" sat on top of a "low dome". In our work, we considered such structures to be segments of a single volcano. This explains the difference in number of volcanos identified (239 here versus 321 in [1]). Also, our study omitted a few very small structures that may be volcanic cones but which could not be confidently identified on the available imagery.

We calculated the concentration of volcanos as a function of location using the kernel weighting function method [4]. We used a Gaussian weighting function, $\exp[-0.5(d/h)^2]$, where d is the distance from a map point to a given volcano and h is a smoothing lengthscale. We chose this form because it provides high weight to volcanos near a map point and smoothly decreases the weight applied to volcanos at larger distance from the map point. Varying the magnitude of h controls the resolution of the resulting map. For small values of h, the calculated concentration considers only volcanos at small distances from the calculation point, whereas larger values of h smooth the results over larger distances. For $h \leq 20$ km, our concentration maps show numerous local concentrations of domes within the Marius Hills. On the other hand, larger values of h emphasize a smaller number of broad concentrations. Figure 2 shows results for h=30 km, which is useful for comparing with the results of gravity models of this region [3].

The maximum concentration of volcanic domes in Figure 2 is $3.0 \cdot 10^{-5}$ km$^{-2}$ at 14 N, 307 E. A secondary concentration maximum of $4.8 \cdot 10^{-6}$ km$^{-2}$ occurs at 7 N,

309 E (white diamond in Figure 2). These concentration maxima are close to the locations of the two gravity anomaly maxima measured by Lunar Prospector [5]. The gravity anomalies have been interpreted as the solidified magma chambers that fed volcanic activity within the Marius Hills [3].

For comparison, a recent study of the Snake River Plains volcanic field in Idaho using the same kernel weighing function method found volcano concentrations of $3 \cdot 10^{-6}$ to $1 \cdot 10^{-4}$ km$^{-2}$ [6]. We have also used the methodology described here to study 6 volcanic shield fields on Venus selected from the fields mapped by Addington [7]. The Venus fields each had between 71 and 116 domes, with maximum concentrations (for h=30 km) of $2.5\text{-}8.9 \cdot 10^{-5}$ km$^{-2}$. These values both for the Snake River Plains and for the Venus shield fields are comparable to the concentration observed in the Marius Hills.

**References** [1] Whitford-Stark and Head, LPSC 8, 2705-2724, 1977. [2] Head and Gifford, Moon and Planets 22, 235-258, 1980. [3] Kiefer, this conference. [4] Weller et al., pp. 77-87 in *Statistics in Geology*, ed. Mader et al., Geological Soc. London, 2006. [5] Konopliv et al., Icarus 150, 1-18, 2001. [6] Wetmore et al., pp. 431-453 in *Volcanic and Tectonic Hazard Assessment for Nuclear Facilities*, ed. Connor et al., Cambridge University Press, 2009. [7] Addington, Icarus 149, 16-36, 2001.

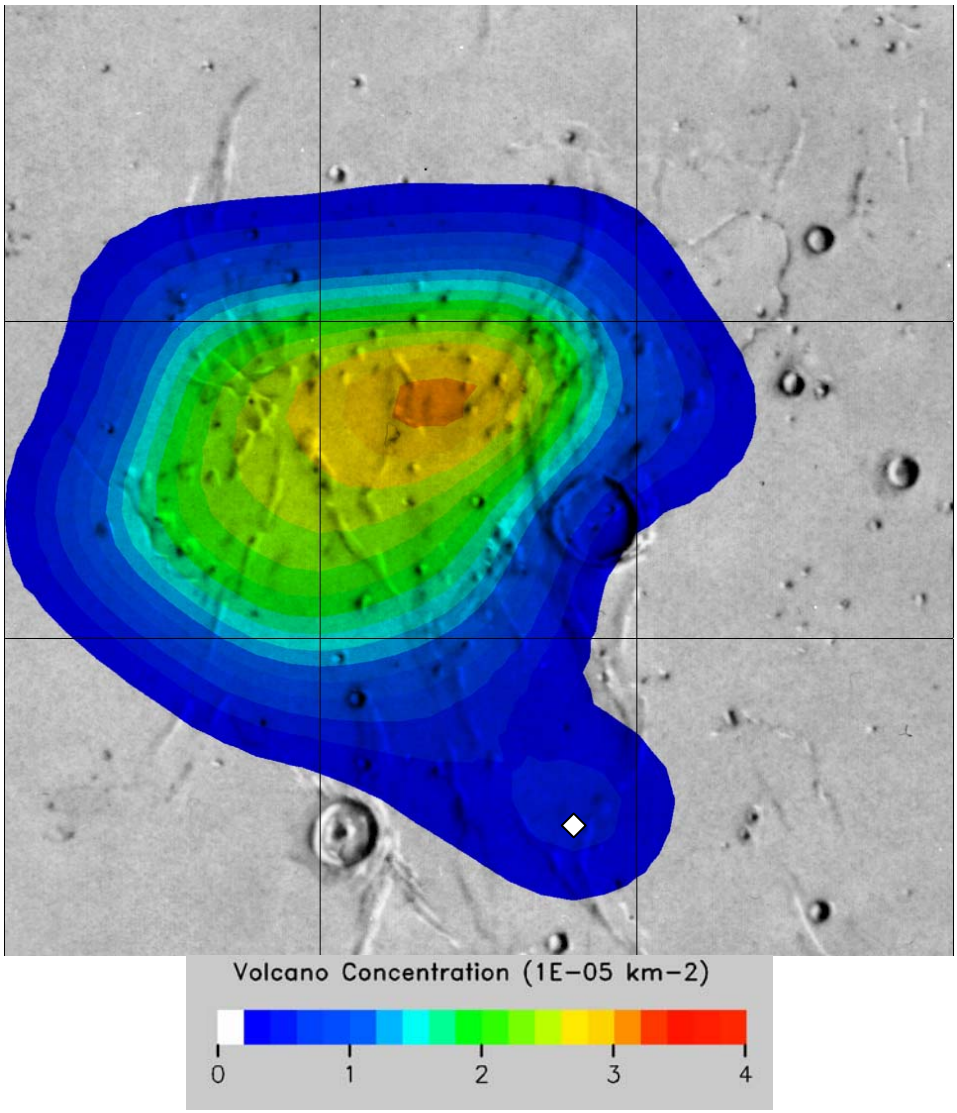


**Figure 2.** The concentration of volcanos in the Marius Hill, assuming a kernel bandwidth of h=30 km. Simple cylindrical projection. The region shown is 445 km across at map center (12.5° North) and uses a shaded relief image as the base map. The white diamond shows the location of a secondary maximum in the volcano concentration.