CHARACTERISTICS AND GEOLOGIC/TERRAIN ASSOCIATIONS OF SMALL DOME-LIKE HILLS ON VENUS;

J. C. Aubele, Dept. of Geological Sciences, Brown University, Providence, R.I. 02912

Introduction. Approximately 22,000 small dome-like hills have been recognized on the northern 20% of the surface of Venus imaged by Venera 15/16. These features have been described [1] as generally circular in planimetric outline, with a range in basal diameter from the effective resolution of the Venera images (1-2km) up to 20 km.

General Characteristics. The small hills have been called domes [1,2] following the lunar nomenclature, because of their broad apparent form. The nomenclature used here, "small dome-like hills", is preferred because of the strict volcanological definition of a dome and terrestrial lithologic connotations. Based on constraints on the appearance of features imaged by this radar system, individual slopes are less than 10°. Assuming these slopes, simple geometric models imply maximum height of approximately 1 km, and average height less than 1 km. Recent radar-clinometric data confirms these estimates [3]. Most of the small dome-like hills show no individually associated features; however, a small number exhibit summit pits, bright aureoles, low basal platforms extending beyond the basal diameter of the dome, and radial or lobe-like bright features interpreted to be volcanic flows. Summit pits are occasionally observed in dome-like hills larger in basal diameter than 8 km, and more frequently in ones larger than 15 km. Bright circular aureoles, without apparent topographic relief, appear to be associated with small dome-like hills northeast of Atalanta Planitia. Low basal platforms and bright features interpreted to be volcanic flows are rare but do occur in a few cases.

Dome Distribution. Slyuta, et al [2,4] have produced dome density contour maps and find that most dome-like hills occur in groups of several tens within areas of 10^3 km^2. Adjacent groups form clusters consisting of 10-20 groups within areas of 10^5 km^2. The greatest concentration of clusters of dome-like hills occurs in the general area of 60°N, 120°E. The outline of this region of cluster concentration generally corresponds to the Plains-Corona-Tessera Assemblage described by Head [10]. Major concentrations of clusters [2] are located in Tethus Regio (65°N, 110°E), Atalanta Planitia (60°N, 155°E), Ananke Tessera (55°N138°E), and Akkruva Colles (from Niobe Planitia, 35°N, 130°E, to Allat Dorsa, 65°N, 70°E).

Topographic Association. The cluster concentrations in Tethus, Ananke and Akkruva are associated with broad regional topographic highs. However, many small groups or clusters of groups occur on low plains or inside circular depressions and the cluster concentration in Atalanta occurs in the general area of the topographically lowest region of Venus.

Terrain Unit Association. Almost all of the areas of cluster concentration occur on mottled plains units designated as "rolling plains" interpreted to be of volcanic origin [5,10]. Major clusters frequently occur on such plains units at the margins of areas of tessera, while very small groups occasionally occur in intra-tessera plains near the margins of large tessera units. Smaller cluster concentrations occur in regions of predominant arachnoids, in the area between Sedna Planitia and Bell Regio and in the area south of the ridge belt province at 40°N, 215°E; and also occur at the northern end of Beta Regio (the only portion of this area imaged by Venera). No major concentrations of dome-like hills occur in areas of predominant ridge-belts or in the Mnemosyne area of predominant coronae, although very small groups and isolated dome-like hills occur associated with both of these types of geologic features.

Regional and Global Structure Association. As stated previously, major cluster concentrations of small dome-like hills are associated with the margins of tessera. A small number of dome-like hills occasionally occur at the ends of linear ridge belts. Individual groups of dome-like hills exhibit occasional minor alignments but, in most cases, there is no dominant trend direction. The general area of cluster concentration in Akkruva Colles, northeast of Niobe Planitia exhibits an overall NW-SE alignment. This zone, an area of topographic relief, is also the area of a linear positive gravity anomaly [4]. Although domes occur on the plains to the north and south of Ishtar Terra, Lakshmi Planum and the horizontal compressional fold belts [6] of Akna and Freyja Montes exhibit one of the lowest densities of small dome-like hills on Venus.

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Aubele, J.C.

Geologic Feature Association. Small groups of dome-like hills always appear to be associated with the following specific geologic features: coronae, arachnoids, intermediate (20-50 km) sized hills interpreted to be volcanic constructs, large volcanic centers and calderas, and large circular features of uncertain origin.

Coronae. Groups of dome-like hills (10-15 km diameter) occur predominantly inside the annular concentric ridges of coronae, while smaller groups occur on the surrounding plains. Flow-like features and domes in the interior of corona structures have been previously interpreted as evidence of volcanic activity occuring at various times throughout the evolution of the coronae [7].

Arachnoids. Arachnoids occur in clusters in lowland regions; and have been described as characterized by "central domes" ($\leq$10 to over 30 km in diameter, commonly with central pits) surrounded by rings and linear features interpreted to be tectonic in origin [8]. The central domes have been interpreted to be volcanic in origin [8]. Groups of small dome-like hills occur on the plains surrounding and between adjacent arachnoids.

Intermediate and Large Volcanic Centers. A few intermediate sized hills, commonly exhibiting summit pits and associated radial or lobate flow features, and interpreted to be small volcanic constructs, are generally found to be spatially associated with groups of small dome-like hills. These intermediate sized features are fewer in absolute number than the small dome-like hills and generally occur as isolated features scattered on plains units near groups or clusters of small dome-like hills. Groups and clusters of groups of small dome-like hills occur predominantly on the lower flanks, or beyond the distal edges, of the bright radial markings associated with large volcanic centers. This may imply that the spatially associated small dome-like hills pre-date final volcanic eruptions at these centers, or they may be difficult to identify in radar images on the, presumably, rough volcanic flows. Very few isolated domes occur on Lakshmi Planum, with small groups occurring on the rims and periphery of the calderas, Collette and Sacajawea [9].

Circular Features. Small groups of dome-like hills generally occur within large circular features of uncertain origin, particularly where the interior is lower in topographic elevation than is the surrounding plain.

Summary and Interpretation. The major cluster concentrations of small dome-like hills on Venus occur on rolling plains units interpreted to be volcanic, primarily around the margins of tessera terrain. Minor cluster concentrations occur in areas of predominant arachnoids. Small groups of dome-like hills always occur in association with the following individual geologic features: coronae, arachnoids, intermediate (20-50 km) sized hills interpreted to be volcanic constructs, large volcanic centers and calderas, and large circular features of uncertain origin. There appears to be a dominant association of small dome-like hills with geologic features generally interpreted to be volcanic in origin. An exception to this association is in the Lakshmi Planum (volcanic plains) area, where there are a small number of dome-like hills. Altitude and crustal thickness are two potential distinguishing characteristics of this area. The existence of small dome-like hills ($\leq$20 km), intermediate sized volcanic constructs (20-50 km), and large volcanic centers implies a continuum of volcanic edifices grading from less than 2 km to more than 100 km in diameter. The intermediate volcanic constructs may simply represent gradational diameters between the small dome-like hills and the large volcanic centers, and need not represent differences in eruptive style. There is a distinct distribution of number versus size range such that the number of edifices increases as the size decreases. This type of distribution is similar to that observed for volcanic edifices on Earth, both continental and oceanic. Detailed terrain, geologic and structural associations for the four major areas of cluster concentration are currently in progress.

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