CHARACTERISTICS OF DOMES ON VENUS AND A COMPARISON WITH TERRESTRIAL CINDER CONES AND OCEANIC VOLCANIC EDIFICES: J.C. Aubele, J.W. Head, Dept. Geol. Sci., Brown Univ. Prov., RI 02912, E.N. Slyuta, A.T. Basilevsky, Vernadsky Inst., USSR Acad. Sci., Moscow.

INTRODUCTION A fundamental question of Venus is the nature of surface volcanic processes; that is, the importance and extent of volcanism, the eruptive styles of volcanism, and the modification of topography by volcanism. In addition to some large-scale volcanic structures, areas of dome-like features which occur in clusters on the plains of Venus have been reported by Barsukov et al. [1,2]. These features are generally circular and range from 2 to 15 km in basal diameter. Over 21000 small domes have been recognized; and global distribution patterns suggest that the domes may be related to or controlled by patterns of Venus global tectonics [3]. If the domes are volcanic features, then their characteristics, abundance and density distribution are important indicators of the nature and significance of volcanic activity on Venus and its relationship to global geologic and tectonic processes.

Barsukov, et al. [2] has commented on the similarity in morphology of these features to volcanic domes or cinder cones on Earth and Mars. Head and Wilson [4], in their theoretical treatment of volcanic processes and resultant constructs on Venus, state that these features could represent edifices produced by effusive activity, explosive activity, or a combination of the two; and that size-frequency data would be useful in attempting to narrow the possible mechanism of formation. A range of information, including the heights of the features, profile and planform, local geologic relationships, existence and abundance of visible central pits, dome spacing and alignment, and the existence of visible associated flow features would help to assess the type of volcanism represented by these features. In this study we begin to assess the domes by comparisons of basal diameter size-frequency and number density information.

OBSERVATIONS A typical region of dome concentration on Venus occurs in an area of approximately 110,000 km^2 centered at 110° and 65° N in Tethus Regio. Using Venera radar mosaics, over 400 domes have been mapped, ranging in basal diameter from 1 km to 8 km, with a predominant size range of 2–5 km and a mode of 3–4 km (Fig.1). Domes smaller than 1 km may be difficult to recognize in the radar imagery; and, at the present resolution, it is impossible to differentiate between conical and domical profiles. Few summit craters or associated flow features can be identified in this area with certainty. The area occurs along the southern edge of Meshkenet Tessera where it contacts a mottled plains unit which appears to overlie or embay the tessera in some areas. The domes occur on the plains unit, with only a few exceptions mapped in the tessera. More domes may occur in the tessera, but recognition may be difficult due to the ridged nature of the terrain. In general the domes appear relatively evenly scattered over the plains unit, however local groups frequently occur in clusters of 10 to 20 domes and about 15% of the domes occur in aligned patterns of apparently contiguous features. These alignments appear to be oriented along major trend directions in the tessera and may reflect some local structural control in the distribution of the domes. Overall dome density in the area is approximately 0.4 domes/100 km^2 and maximum density is 1 dome/100 km^2.

COMPARISON TO TERRESTRIAL FIELDS One typical concentration of volcanoes on Earth occurs in the form of cinder cone fields. These fields commonly consist of 100's of vents scattered over 1000's of km^2. Cinder cones are the dominant vent type, however a small number of other vent eruptive styles usually also occur. Vent basal diameters range from 0.2 to 2.5 km with modes from 0.7 to 1 km [5]. Vent density ranges from 3 to 10 vents/100 km^2 and, in areas of maximum vent concentration within fields, 10 to 30 vents/100 km^2 [6,7]. The Springerville volcanic field in east-central Arizona has been field mapped in detail and extensively studied over the last few years [8,9,10] and can be used to compare to the region of dome concentration in Tethus Regio described above. The Springerville field consists of approximately 300 vents, predominantly cinder cones, and associated flows covering an area of about 3000 km^2. Vent size range and frequency distribution is similar to other cinder cone fields which have been studied. Vent basal diameter in the Springerville field ranges from 0.2 to 1.9 km with a mode from 0.5 to 1.0 km. Since the field was mapped from the ground, vents smaller than 0.2 km would have been recognized if they occurred. The size ranges and modes are very different for the Springerville vents and the Venus domes (Fig. 1). The Springerville vents occur singly or in clusters of 3 to 7 vents, and about 17% occur in aligned patterns of adjoining vents. Overall density is 10 vents/100 km^2 and in the area of maximum density 28 vents/100 km^2. The overall density of vents in the Springerville field is an order of magnitude larger than the area of maximum density of the Tethus Regio domes.

The most abundant volcanic features on Earth occur on the sea floor in the form of seamounts interpreted to be dominantly effusive lava constructs. These submerged oceanic volcanoes are estimated to occupy approximately 6% of the Pacific seafloor area [11]. Seamounts generally occur clustered in groups or aligned in chains. Basal diameters are estimated to be in the range of 2 to 30 km and, although estimates of seamount abundance vary, densities of 0.1 to 0.4/100 km^2 have been calculated for the Pacific [11,12,13]. This is comparable to the overall density estimate of the dome field studied in Tethus Regio, and an order of magnitude greater than the average density of all domes over the entire surface area of Venus north of 30° N imaged by Venera. Basal diameter measurements of volcanic seamounts from the GLORIA sonar imagery [14] in the East Pacific, along the west coast of the U.S., are compared with the dome field in Tethus Regio (Fig. 1). Basal diameters of volcanic seamounts visible in the sonar imagery in this area range from 0.7 to 18.0 km, with a predominant size range from 1 to 13 km and a mode of 2 to 3 km. As plotted in Figure 1, the size range and distribution of the ocean floor volcanic features and the dome field studied in Tethus Regio are relatively similar. Domes larger than 8 km do not occur in the Meshkenet Tessera area, but do occur elsewhere on Venus, where the general diameter range extends from 2 to 15 km.

CONCLUSIONS The comparisons discussed above indicate that, in size range, mode and possibly, density, Venus domes are more similar to terrestrial ocean floor volcanic seamounts than to terrestrial cinder cone fields. Theoretical analysis of eruption conditions on Venus and a preliminary assessment of Venus domes [4] showed that they could be produced by: 1) predominantly *effusive activity* which would create small dome-like shield volcanoes similar to those observed in the Snake River Plain on Earth [15] and on the lunar maria [16]; 2) *strombolian activity*, which could theoretically result in localized volatile enhancement and the production of pyroclastic cones on Venus even in the presence of the dense Venus atmosphere, although this latter factor would strongly suggest that cone diameters would probably be less than terrestrial cinder cones and certainly should not consistently exceed them; 3) more evolved magmas and higher volatile content magmas producing *Pelean activity* and *pyroclastic deposits and cones*, which would be expected to be less than a few kilometers in diameter. Comparison of the size range, mode, and density of Venus domes in general and the Tethus Regio dome field in particular, and terrestrial cinder cone fields and oceanic seamounts suggest that the Venus domes are more similar to oceanic seamounts than to cinder cone fields. On the basis of the combination of theoretical analyses [4] and the morphological/morphometric comparisons reported here, we conclude that Venus domes in the Tethus Regio area are most likely to be small shield volcanoes built up from effusive eruptions. This implies that the physical mechanism of eruption may be similar in both the Venus and terrestrial cases. Larger implications depend upon the global tectonic environment of Venus. For those areas of stable crust and lithosphere, heat transfer is conductive and advective and represents the local thermal environment. The presence of numerous small shield volcanoes could be indicative of the regional and global distribution of advective heat transfer. If Venus has regions of laterally mobile lithosphere [17], then the origin of the abundance and distribution of many volcanoes on the plains of Venus may be comparable to terrestrial oceanic seamounts generated at or near the axis of spreading, and added during intra-plate activity. We are presently examining new terrestrial seamount data to further define similarities and differences between the Venus and oceanic data.

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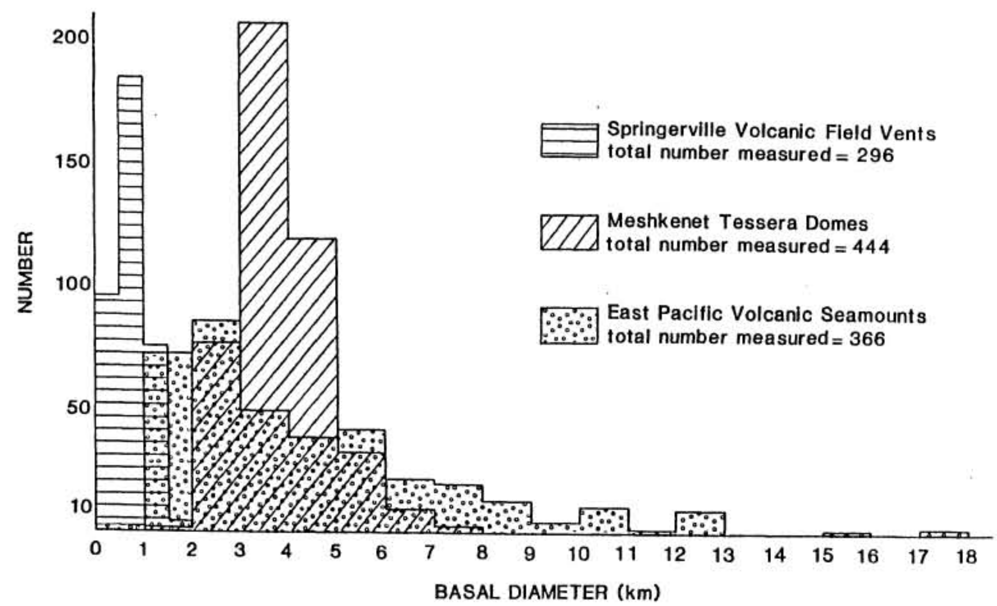

Figure 1