FIELDS OF SMALL VOLCANOES ON VENUS (SHIELD FIELDS): CHARACTERISTICS AND IMPLICATIONS

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OBSERVATIONS: Analysis of the Venera 15/16 data indicated the existence of abundant small volcanic edifices, each $\leq$20 km diameter, interpreted to be predominantly shield volcanoes [1,2] and occurring scattered throughout the plains terrain, most commonly in equidimensional clusters. In the Magellan data, these clusters of greater than average concentration of small volcanic edifices are called "shield fields". A typical shield field consists of volcanoes numbering $\approx 10^2$ and ranging in density from 4 to 10 edifices per 10^3 km^2 within an area that covers $\geq 10^4$ km^2. Most of these fields are roughly equant in outline but a small percentage are elongate or consist of diffuse concentrations of edifices over larger areas. Typical field diameters most commonly range from 60 to 300 km, with a mode at $\approx$100 km (Fig. 1). The volcanic edifices are generally $\leq$10 km in diameter, and are predominantly radar-bright and shield-shaped in profile with a single summit pit [3]. A small number of fields are composed predominantly of a less common edifice type such as radar dark shields, edifices with radar bright aureoles or halos, elongated "anemone"-type small shields, or domical profile edifices. The radar bright or radar dark material locally surrounding shield field edifices, which sometimes covers local structural lineaments, is interpreted to represent associated volcanic material, probably thin lava flow units, although minor amounts of ash or cinder may produce a very thin local veneer in some areas [3]. If the visible flow fields associated with some shield fields are of average size, then the area of resurfacing associated with a shield field appears to be comparable to that of the area of a single large volcano.

DISTRIBUTION: 553 shield fields have been identified in the catalog of volcanic features [4,5]. A contour map of shield field density is shown in Fig. 2. 70% of shield fields occur on 50% of the surface of Venus. Shield fields are somewhat more distributed over the surface than are larger volcanic features[4,5]; however, Magellan global analysis has confirmed the previous observation made from the Venera data set [1], of two dominant global concentrations. Density within these concentrations ranges from 2 to 7 fields per 10^6 km^2. These two regions also show high concentrations of all volcanic features [6,7] and have been informally named the Beta-Atla-Themis, "BAT" region, centered at longitude 250°, and the Alpha-Tellus-Tethus, "ATT" region, centered at longitude 80°. Large numbers of shield fields appear to define the margins of the BAT area, rather than the center; and occur east of the center of the ATT region. Magellan has also confirmed the previous observation based on Venera data [1] that small volcanoes do not occur in large numbers in the areas dominated by ridge belts or in the very lowest or very highest elevations on the planet. 59% of shield fields occur in elevations between mean planetary radius and 2 km above mean planetary radius, 36% occur in regions mean planetary radius in elevation, and only 5% occur in regions $\geq$2 km above mean planetary radius. Fields are commonly spatially associated with larger volcanic features. Shield fields frequently occur within the inner rings of corona; and those associated with large volcanoes often occur around the distal edges of, and occasionally are surrounded by, the radial lava flows forming the volcano flanks, but they also occur near the summit of a few large volcanoes.

IMPLICATIONS: Fig. 3 shows three possible models for the origin of shield fields: (1) they are "islands" of higher topography subsequently surrounded by later plains material; (2) they represent the area of a region of anomalous melting; and (3) they represent the area of a magma reservoir. Model 1 would imply that the fields represent portions of an abundant "layer" of small edifices produced globally in an earlier period of greater small shield productivity and that there has been a change in eruption style with plains formation occurring predominantly after the production of the small edifices. This would explain the equant aspect of most fields; however some fields show associated flows superimposed on surrounding plains and the manner in which shield fields appear to cover local structural patterns suggests that they are associated with plains-forming material themselves. In addition, local stratigraphic relationships show that there is a range of shield field ages in relation to the surrounding regional plains units and the associated larger volcanic features, implying that shield formation did not occur planet-wide as a single event. Models 2 and 3 imply that the fields represent areas of melting anomalies. Model 2 implies that the area of the field is controlled by the extent of the region of melting. A variation of Model 2 uses small reservoirs to explain

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local groups and alignments of edifices or differences in edifice type due to variations in eruptive style or melt chemistry. Model 3 implies that the area of the field is controlled by the areal extent of a magma reservoir. The areal shape and density of most shield fields could be explained by postulating a shallow regional reservoir or trap located between the melt source region and the surface and approximately equal in size to the areal extent of the field. Given the stratigraphic evidence of the range of shield field ages, models 2 and 3 are favored over model 1 for most cases. Whether the shape and size of a field reflects the area of the melt anomaly or the area of a reservoir is difficult to determine. The formation of a field of small volcanoes, rather than a single large volcano, must imply a difference in magma rates or reservoir characteristics.

[1]Aubele and Slyuta, 1990, E.M.P. 50/51, 493–532; [2]Garvin and Williams, 1990, G.R.L. 17(9), 1381–1384; [3] Guest, et al, 1992, submitted to JGR, Magellan issue; [4]Head, et al, 1992, Submitted to JGR, Magellan issue; [5]Crumpler, et al, 1992, (abstr) this volume; [6]Head, et al, 1992, (abstr) this volume; [7]Crumpler and Aubele, 1992 (abst) this volume.

FIGURE 1

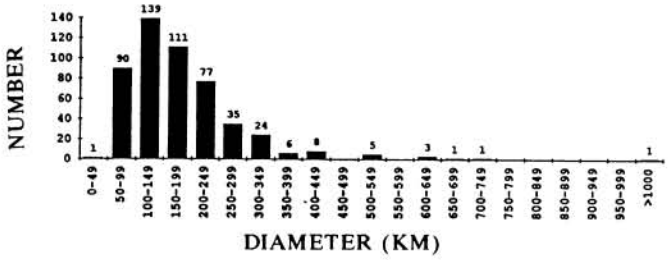


FIGURE 3

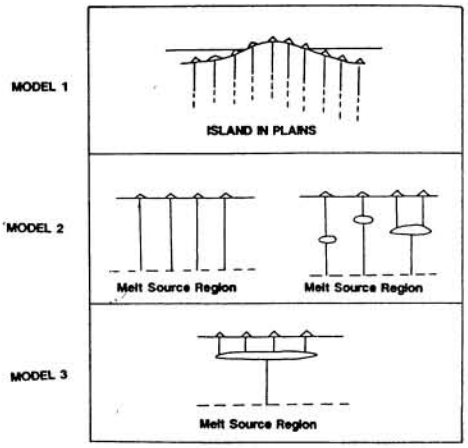
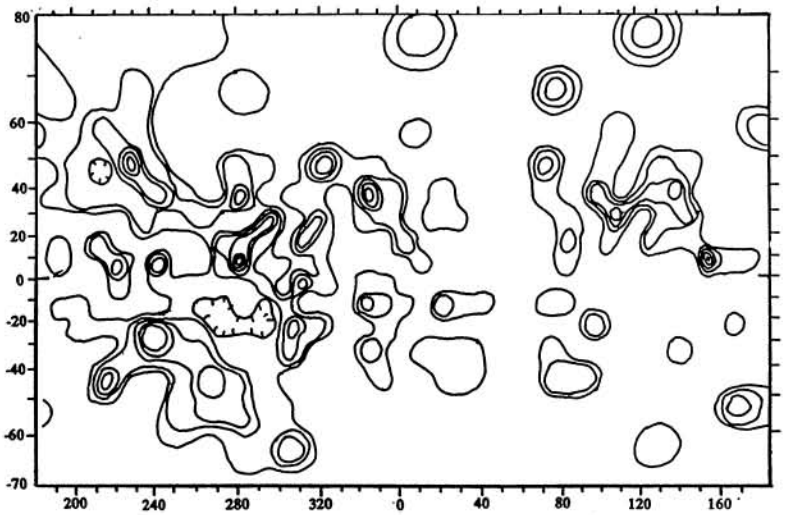


FIGURE 2

DENSITY OF SHIELD FIELDS



CONTOUR INTERVAL = 1 FIELD/10^6 KM^2
CONTOURS RANGE FROM 2 TO 7