# SHIELD FIELDS AND SHIELD PLAINS ON VENUS: CONTRASTING VOLCANIC UNITS EXEMPLIFIED IN SHIMTI TESSERA (V-11) AND VELLAMO PLANITIA (V-12) QUADRANGLES.

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**Introduction:** The geologic features "shield fields" and "shield plains" (or "shield terrain") have been used by a number of Venus researchers and authors of Venus geologic quadrangle maps. However, there has been occasional confusion concerning the two terms and the geologic units they define. Stratigraphic interpretation may vary due to the identification of clusters of small shields as either shield fields or isolated patches of shield plains [1]. Vellamo Planitia Quadrangle (V-12) includes the originally defined type example of shield plains [2]. Shimti Tessera Quadrangle (V-11) [3] includes a shield field that is younger than the regional wrinkle-ridged plains as well a regional shield plains unit (with partially buried outliers) that is older than the regional wrinkle-ridged plains. Detailed analyses of these quadrangles provide a useful contrast and comparison between the two geologic units and their interpretations.

**Shield Fields:** Enhanced concentrations of small Venus volcanoes distributed over a quasi-circular region from 100 to 150 km in diameter are called "shield fields" [4], following terrestrial volcanological usage of the term "volcanic field" that may contain clusters of 10s to 100s of vents. Shield fields have vent densitiers of >10,000 vents/$10^6$ $km^2$. Shield fields have been considered to be a distinct type of volcanic center on Venus, possibly arising from conditions of low magma supply rates in which the magma flux from a melting anomaly is less than that necessary to sustain shallow magma reservoirs [5], analogous to the current interpretation of terrestrial volcanic fields with clustered monogenetic vents [6].

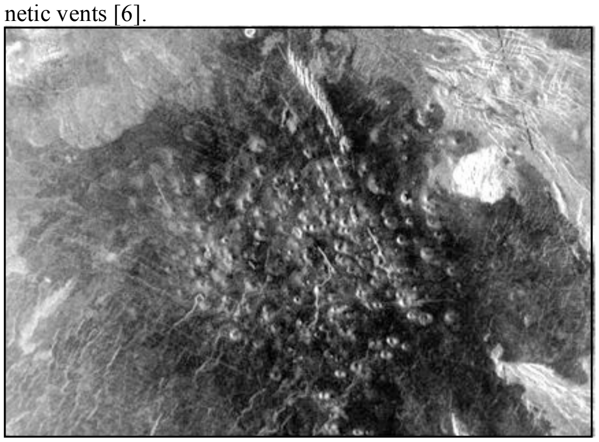

**Figure 1.** A typical shield field MVC-52/302.5SF [5,8]; small shield volcanoes clustered in a 150-km in diameter circular region.

The shield fields of Venus were identified globally (647 fields) in the Magellan Catalog of Volcanic and Magmatic Features [5,8]; and classified into three types [5]: (1) simple, a cluster of randomly scattered edifices with no apparent association between the edifices and the surrounding plains or other volcanic features, and with no associated lobate or digitate flow(s) or flow field(s); (2) apron shield fields, clusters of small volcanoes spatially associated with patterns of radar-bright or radar-dark material interpreted to be volcanic flows erupted by, or associated with, the small shield volcanoes; and (3) companion shield fields, spatially associated with another type of volcanic or tectonic center, usually a large volcanic center or corona.

Globally, shield fields occur that are stratigraphically older than the surrounding plains, stratigraphically younger than the surrounding plains, and apparently contemporanous with (or the source of) the surrounding plains [5,8,9].

It is probable that the formation of shield fields has occurred locally throughout Venus geologic history, produced by anomolous melt source regions of limited extent.

**Shield Plains:** Shield plains (or shield terrain [10]) represents one of the more unusual plains surfaces of Venus. During preliminary mapping of Vellamo Planitia Quadrangle, large regions of shields were recognized that appear uniformly distributed rather than clustered as are shield fields, and interpreted as a distinctive plains unit [2]. The volcanoes of the shield plains occur distributed over regions of the surface that extend for thousands to millions of square kilometers, at ~4500 shields/$10^6$ $km^2$ [2,10]. Within the plains the individual shields occur in assoication with plains material of intermediate radar backscatter and may appear to form small clusters that give the plains a hilly appearance. The plains unit displays consistent characteristics and stratigraphic relationships, directly and consistently overlying tessera and densely lineated plains, and directly and consistently overlain and embayed by wrinkle-ridged plains material. The unit has been described here and elsewhere on the planet as a thin, locally discontinuous layer that is lace-like

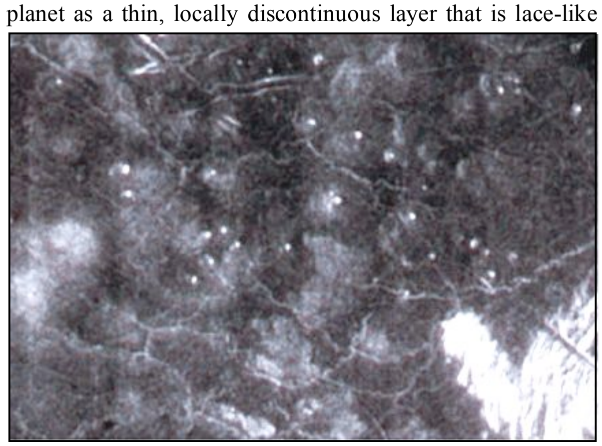

**Figure 2**. Typical shield plains; widely separated small shield volcanoes . Image width is 90 km.

in appearance [10]. Following the initial reports of the Akkruva shield plains, authors of other Venus quadrangles also identified and mapped similar shield plains or shield terrain units. These quadrangles include V-3, 4, 8, 13, 20, 23, 24, 37, 43, 44, 52, 54, 55, 56, and 59 [11].

**Shield Fields and Shield Plains: Different Volcanological Processes:** The shield plains represent a style of resurfacing of Venus that is clearly different than that of the wrinkle-ridged plains [1,10,12], and in these quadrangles, the contact and stratigraphic relationships between the two is clear. Any model of resurfacing for the planitiae of Venus must take into consideration the formation of shield plains [10]. The shield plains have been described and interpreted by a number of researchers in different ways: (1) as a volcanically emplaced unit, possibly comparable in morphology and abundance of vents to terrestrial seamounts [13]; (2) as a global stratigraphic unit that represents a systematic change in dominant style of volcanic activity [1]; (3) as a thin, discontinuous mechanically coherent “shield paint” [10] possibly emplaced as flood type lava flows, mud volcanoes, or in situ point source volcanism; and (4) as local-scale volcanic resurfacing throughout Venus geological history [14].

It may be that the style of volcanism represented by the shield plains is closely allied with the late stages of tessera formation or its obliteration, or it may represent a stratigraphic unit that is particularly preserved near tessera owing to higher topography and less inundation by later plains events. Contacts and stratigraphic relationships with these units in this quadrangle are generally consistent with estimates [10.15] of shield associated deposits that are probably tens of meters or less in thickness; however they are clearly thick enough to cover and flood some preexisting structure. There is also evidence that the shield associated deposits are thick enough (confirmed in other locations [10]), to show wrinkle ridges continuing across the contact and deforming (or reactivating and following old structural patterns within) the shield plains.

Based on the results from quadrangles V11-12, shield plains are interpreted as having formed by the eruption of multiple small shields, and associated flows, over a discrete period of geologic time. Because there are few constraints on emplacement rates of Venus surfaces, it is not determined whther shield plains surfaces are produced in a punctuated, catastrophic, or continuous formation [16]. For thermodynamic considerations alone, it is unlikely that all of the small shield volcanoes were active simultaneously or that the unit formed geologically instantaneously as, for example, vallis-related flood basalt plains may have formed [17]. Instead, shield plains probably accumulated over some finite geologic time interval such that small shield volcanoes were “accumulated,” either over a specific geologic time period individually, or in an anomalous period of shield field formation [1]. Hansen [10] also confirmed that shield terrain formed in a time-transgressive manner. Since each edifice or cluster of edifices acts as a point source, it is not surprising that a patchy, lace-like aspect is identified within the context of a larger regional unit.

The map area (V11-12) provides evidence that confirms a major peak of small shield volcanic activity prior to the formation of the vast regional plains [1]. There is local evidence in this quadrangle for older tectonic and volcanic structures within the shield plains; their presence may support the possibility of a relatively long time period of formation for the shield plains. Regardless of the duration of the geologic time period, it is a consistent and constrained time period in the stratigraphy of the mapped area, and therefore it provides evidence for a change in the mechanism of formation of plains units within this region.

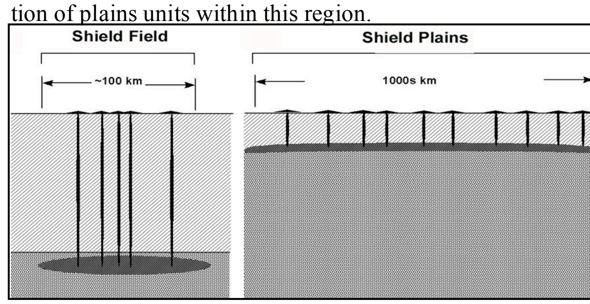


**Figure 3**. Model for shield field versus shield plains.

**Conclusions:** Shield fields can be compared to terrestrial volcanic fields; melt areas of limited extent, possibly deep magma sources, and low magma rates delivered to the surface. The difference between large volcanoes and shield fields on Venus is a change in magma volume ascent rate [5]. Shield plains, however, may be more analogous to terrestrial oceanic seamounts; volcanism associated with a widespread melt source and relatively shallow magma sources. Shield fields and shield plains appear to represent different volcanic styles and may represent different temporal associations in Venus geologic history.

**References:** [1] Ivanov&Head, JGR 109, 2004; [2] Aubele, LPSC 25, 1994; 26, 1995; 27, 1996; [3] Aubele, Geol Maps V11, V12, in review; [4] Aubele&Crumpler, LPI Contrib. 789, 1992; Aubele et al, LPSC 23, 1992; Aubele&Crumpler, 1994; [5] Crumpler et al, Venus II, 697-756, 1997; [6] Shaw, JGR 90, 1985; [8] Crumpler&Aubele, Volc on Venus *in* Encycl. Volcanoes, 2000; [9] Kreslavsky&Head, JGR 104, 1999; Addington, LPSC 30, 1999; Icarus 149, 2001; Ivanov&Head, JGR 109, 2004; [10] Hansen, GSA Bull 117, 2005; [11] Bender et al, USGS I-2620, 2000; Bridges&McGill, USGS I-2747, 2002; Hansen&DeShon, USGS I-2752, 2002; Ivanov&Head, USGS I-2684, 2001; USGS I-2972, 2004; I-2870, 2005; V-56, in prep; Johnson et al, USGS I-2610, 1999; Lang&Hansen, LPSC 24, 2003; V-24, in prep; Lopez&Hansen, LPSC 24, 2003; Hansen, GSA Bull 117, 2005; V-23, in prep; McGill, USGS I-2637, 2000; USGS I-2794, 2004; [12] Basilevsky&Head, Geol 30, 2002; [13] Aubele&Slyuta, EMP 50, 1990; Ernst&Desnoyers, Phy of E&P Int 146, 2004; [14] Stofan et al, LPSC 35, 2004; [15] Guest et al, JGR 97, 1992; [16] Campbell, JGR 104, 1999; [17] Basilevsky & Head, GRL 23, 1996.