THE PLAINS OF APHRODITE: GEOHISTORY AND MODES OF VOLCANIC RESURFACING, VENUS.

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Introduction: Resurfacing mechanisms are critical to the understanding of:: the evolution of the Venusian surface [1], implications of impact crater distribution and density [2, 3], possible climatic fluctuations [4], possible affects of climate on tectonic structures [5, 6], and evolution scenarios of lithosphere-atmosphere interactions and dynamics [7, 8]. We are in the process of mapping four contiguous VMAPs (V23, V24, V25 [in review], and V37 [9]) that cross the planitiae of Northern Aphrodite with the goal to establish the detailed geologic history of these planitiae. Our mapping does not accept *a priori* differentiation of "plains" material; but rather, focuses on the overall history of a planitiae regions with attention to spatial and temporal evolution of flows and flow sources, primary and secondary structures, topography, and tectonism. Documentation of the geologic history of extensive planitiae leads to a better understanding of the resurfacing mechanisms that have operated within the Venusian plains. To date two modes of volcanic resurfacing have emerged: relatively long and extensive flows sourced dominantly from coronae, and regional formation of a thin, lacey layer composed of coalesced small volcanic shields.

Map area: The map area extends from 15S-25N and 090-120E which encompasses portions of Rusalka, Llorona, Sogolon, and Niobe planitiae that are bounded to the south—from west to east—by crustal plateaus Ovda and Thetis regiones, and the Diana-Dali chasmata-coronae belt. Due to the vast size of the study area, comparison of regional map patterns to average surface age (ASA) provinces derived from the global crater density distribution is viable. The surface of Venus is divisible into three ASA provinces based on crater density *and* crater halos [10]; in contrast to other crater density studies, this study [10] differentiates an *average composite surface age*, not the age of an individual class of geomorphic features. The study area encompasses an "old" ASA province to the west and "intermediate" ASA province to the east and southeast. These old and intermediate ASA provinces display spatial point densities of between 2.73 and 2.53, and 1.45 and 2.53 craters/10^6 km^2, respectively.

The planitiae host a series of north-trending elongate basins and rises with wavelengths of 1000-1500 km. Gravity highs generally correlate with elevated topography, which preserves variably sized ridge belts, tracts of ribbon-bearing tessera terrain [11], and pervasively fractured terrain. Ridge belts trend both NE and NW in V25 and E V24; Numerous small to large ribbon-bearing tessera terrain occur across V23/V24. A ~28,000 km^2 exposure cut by pervasive NW-striking fractures outcrops in SE V24. Secondary structures including fractures and wrinkle ridges describe broad patterns across the map area. Fractures strike N-NNW across V23/V34, and strike NE in V25 and V37. Wrinkle ridges trend E-ENE across V23, V24, and V25, and exist locally as inversion structures [12] where earlier formed fractures were filled by lava and later contracted. V25 and V37 also host NW-NNW trending wrinkle ridges that parallel a chain of small coronae.

Rusalka Planitia, bounded by coronae to the west and south and by Atla Regio to the east, encloses a coronae chain that divides Rusalka into two NNW-trending basins. Coronae-sourced flows, which can extend >500 km from individual corona centers, dominate the volcanic resurfacing of the Rusalka basins, although dense shield fields contribute locally. Northeastern Llorona Planitia, bounded to west, north and east by coronae, and to the south by ribbon-bearing tessera and an extensively fractured terrain, hosts expansive coronae-sourced flows with local shield fields. Shields within the fields are so pervasive they locally mask evidence of an earlier geological history. Ridge belts, which display time transgressive histories as documented by others [13], generally sit topographically above corona flows, but host local small shields. Coronae flows both predate and post date wrinkle ridge formation; locally corona flows fill NE-striking fractures which are later inverted into wrinkle ridges, and corona flows deformed by wrinkle ridges locally buttress new corona flows. Between Rusalka Planitia and Llorona Planitia is an assemblage of undifferentiable flow members. A coronae-sourced origin for much of this unit is suspected, but cannot be robustly demonstrated due to the subdued, discontinous nature of the submembers. Channel forms indicating extended surface or near-surface lava distribution (cannali, rilles, etc) are prominent in both coronae-associated flows and undifferentated flows.

To the west in V24 and V23, within southwestern Llorona, Sogolon, and Niobe planitiae, low circular topographic ridges and radial to concentric fractures mark isolated corona structures, but recognizable long corona-source flows are rare. Instead an extensive layer of small shields covers the surface. The shields, small (1-15 km diameter) quasi-circular to circular radar-dark or -bright features with or without topographic expression, form a sort of lacey volcanic veil with varying visibility of underlying tectonic structures. The shields coalesce into a thin layer that we refer to as "shield paint". Small ribbon-bearing tessera inliers outcrop throughout the region; tessera structures trend consistently NW and/or NE across even the smallest inliers. Shields are variably to extensively developed at the edges of, and within, tessera inliers; locally tessera structures are masked by shields, yet coherent trends are still visible across large areas, preserved in a patchwork-like fashion. Shields also veil regionally developed secondary structures including pervasively fractured terrain in southwestern Llorona Planitia, associated with isolated coronae, and regionally developed N-striking fractures. Corona-related structures and N-striking fractures are locally reactivated cutting the shield paint layer; in some regions filled fractures have been inverted to N-trending ridges, presumably during more recent contraction.

The regional preservation of tessera inliers with coherent structural trends, as well as the coherence and preserved details of delicate, regionally extensive tectonic structures indicate that the shield paint layer, though developed over some $10x10^6$ km^2, forms a thin discontinuous layer. Detailed mapping of several individual SAR F-tiles shows that shield density is locally >10,000 shields/10^6 km^2, and that shield emplacement was time transgressive with reactivation (or formation) of tectonic structures [14]. Shields represent regionally distributed point-source volcanism. The spacing and size of the shields and their lack of recognizable patterns or trends indicates that melt for individual shields formed at relatively shallow levels across the entire region affected by shields.

Results. The map area covers ~$21x10^6$ km^2 of Venusian plains. Across this region there is no evidence of resurfacing by regional flood lava that escaped from local plains fractures. There is strong evidence, however, that long extensive flows that cover local planitiae are sourced from coronae. Fractures within the plains have leaked melt to the surface, but the melt emerged in the form of tens to hundreds of thousands of individual shields across much of V23 and V24 representing regionally distributed point-source volcanism, not flood lava. Thus, the Northern Aphrodite plains display two very different modes of volcanic resurfacing: by extensive corona-sourced flows to the east (V25/V37) and, by a thin volcanic veil comprised of numerous individual shields to the west (V23/V24).

These regions also show different ASA as determined by Phillips and Izenberg [10]. The region marked by corona-sourced flows, as well as the region of major coronae—the Diana-Dali chasmata-corona system, show intermediate ASA, whereas the shield-surfaced plains show old ASA. Adjacent regions occupied by crustal plateaus Ovda (western central and eastern) and Thetis to the south and Tellus to the northwest also show intermediate ASA. The old ASA shield-dominated plains also hosts numerous small ribbon-bearing tessera inliers that display regionally coherent tessera structure trends. The coherence of these trends is most simply explained if a coherent layer of ribbon-tessera under lays much of this old ASA province. Ribbon-terrain forms due to the interaction of globally thin lithosphere with a deep mantle plume [7, 11, 15-17]. As the plume interacts with the overlying lithosphere pre-existing craters are annealed, ribbon structures, folds and later graben form with or without local volcanism, resulting in the thickened crust of crustal plateaus. With time (during thin lithosphere time) crustal plateaus (ribbon-terrain) will topographically decay [7, 18]. The shield-dominated plains of V23/V24 hosts a decayed crustal plateau (now marked by ribbon-terrain inliers), the formation of which predated the formation—and related crater annealing—of the high-standing crustal plateaus. These relations provide evidence that craters can be annealed by lithosphere-deep mantle plume interactions, and that the overall surface history recorded within V23/V24 is older than that recorded in the adjacent crustal plateaus.

In summary our mapping indicates that not all plains surfaces are created in the same manner, and that some large tracts of plains are older than the major crustal plateaus, contrary to global stratigraphic models [19]. It is important to understand that a surface age is not necessarily the time of formation of individual geomorphic features. We must recognize that craters can be destroyed by annealing from below, as well as (?) through a combination of tectonic and volcanic processes from above. Intermediate ASA provinces might record a range of such mechanisms.

References: 1. JE Guest, ER Stofan (1999) *Icarus* **139**, 55-66. 2. GG Schaber *et al* (1992) *JGR* **97**, 13257-13302). 3. RJ Phillips *et al.* (1992) *JGR* **97**, 15923-15948. 4. MA Bullock, GH Grinspoon (2001) *Icarus* **150**, 19-37. 5. SC Solomon, MA Bullock, DH Grinspoon (1999) *Sci.* **286**, 87. 6. FS Anderson, SE Smrekar (1999) *JGR* **104**, 30743-30756. 7. RJ Phillips, VL Hansen (1998) *Sci.* **279**, 1492-1497. 8. VL Hansen, HR DeShon (2002) USGS map I-2752. 9. RJ Phillips, NR Izenberg (1995) *GRL* **22**, 1517-1520. 10. VL Hansen, JJ Willis (1998) *Icarus* **132**, 321-343. 11. HR Deshon (2000) DA Young, VL Hansen, *JGR* **105**, 6983-6995. 12. EM Stewart, JW Head (2000) *LSPC XXXI*, 1692.pdf. 13. VL Hansen, LF Bleamaster (2002) *LPSC XXXIII*, 1061.pdf. 14. VL Hansen, BK Banks, RR Ghent (1999) *Geol.* **27**, 1071-1074. 15. VL Hansen, RJ Phillips, JJ Willis, RR Ghent (2000) *JGR* **105**, 4135-4152. 16. RR Ghent, VL. Hansen (1999) *Icarus* **139**, 116-136. 17. RJ Phillips, VL Hansen (1994) *AREPS* **22**, 597-654. 18. AT Basilevsky, JW Head (1998) *JGR* **103**, 8531-8544.