GEOLOGIC MAPPING OF THE NORTH POLAR REGION OF VENUS (V1-SNEGUROCHKA PLANITIA): IMPLICATIONS FOR THE EVOLUTION OF VOLCANIC ACTIVITY. D. M. Hurwitz and J. W. Head, Dept. of Geological Sciences, Brown University, Providence, RI 02912, debra_hurwitz@brown.edu

Introduction: The north polar region of Venus, first viewed in detail by Venera 15-16, is comprised of a lowland plain (Snegurochka/Louhi Planitiae) surrounded to the south by the tessera regions of Ishtar Terra (Lakshmi Planum, Maxwell Montes, and Fortuna Tessera), an annulus of coronae (Tethus Regio), a major lowland region (Atalanta Planitia), a fan of deformation ridge belts that converges toward the pole (Vinmara Planitia), and a second annulus of coronae and volcanic edifices (Metis Regio). We are systematically mapping the geology of this critical region as part of the NASA-USGS Venus Mapping Program. Our broad goals include comparing the geological histories of Venus and the Earth's Archean, two settings that share many similarities in terms of geological features, structures, thermal conditions, and interpreted processes. We are focusing on several key questions common to both the Archean and Venus: 1) Crustal Thickening Environments and Processes: Over what range of environments does crustal thickening occur on Venus; what insight does this provide for the Archean? 2) Role of Diapirism: What are similarities/differences between coronae and diapiric structures on Venus and Archean basement-cored domes? 3) Nature and Origin of Deformation Ridge Belts: What is the geologic setting of Venus linear deformation belts; how do they compare to the Archean? 4) Origin and Context of Regional Plains: Do Archean komatiitic plains deposits bear similarities to the regional plains on Venus in terms of emplacement style and relationships? 5) Geodynamic Evolution: a) Archean-Venus: What insight does the Earth's Archean record provide to the nature and understanding of features, units and sequences on Venus? b) Venus-Archean: What insight does the local, regional and global geology of Venus provide for selecting the geodynamic processes thought to have operated during Earth's Archean (e.g, vertical or lateral crustal accretion, mantle/crustal overturn, diapirism, flood basalts, crustal thickening)? Here we report on our reconnaissance mapping and our assessment of the range of geologic units in the V1 quadrangle, their sequence, and implications for the volcanic history of the region.

Description of geologic units in Snegurochka Planitia (V1): Observations of Snegurochka Planitia were made using Magellan and Venera 15-16 radar images and are shown in Figure 1. The region consists of several units characteristic of Venus, including tesserae, deformational ridge belts (dorsae), small shield volcanoes, coronae, radar dark and bright regional plains (planitiae), large volcanoes with associated lobate flows, and impact craters. We describe the units in stratigraphic sequence, from oldest to youngest, as established by geologic mapping.

Tessera, generally the oldest unit in the region, lies mainly to the south (Itzpapalotl Tessera between longitudes 330E and 30E); tessera is characterized by radar bright, heavily deformed regions with at least two sets of intersecting ridges and grooves [e.g., 1-3]. This tessera belt merges with Fortuna Tessera and Lakshi Planum in the neighboring V2 and V7 quadrangles, forming a region that includes Maxwell Montes, the highest topography on Venus rising 8 km above the surrounding plains [4]. A second tessera belt lies at the poleward end of Sel-anya Dorsa, a ridge belt in eastern V1.

The deformational ridge belts, or dorsae, are characterized by closely-spaced, parallel lineaments. These belts are interpreted to be early volcanic plains materials compressed into ridge-like belts and fractured [e.g., 5-9]. The dominant two dorsae in the region appear to intersect near the pole, with Dennitsa Dorsa lying near 200E and Sel-anya Dorsa lying near 90E. A third belt, Semuni Dorsa, lies near latitude $+80^{o}$.

Meslenitsa Corona formed in the midst of Dennitsa Dorsa near $+75^{o}$, 200E, and two other coronae, Anahit and Pomona, formed on the western flanks of Itzpapalotl Tessera between 270E and 315E. Coronae are characterized by a raised circular plateau surrounded by a raised rim of concentric lineaments and bounded on at least part of the outer edge by a trench [10]. Radiating extensional lineaments cut across the surrounding plains, suggesting that at least parts of the coronae formed after the plains.

Small shield volcanoes (<20 km in diameter) are abundant in the V1 quad (Fig. 1) and tend to be embayed by later regional plains (note their association with the margins of the deformation belts and their lower density in the regional plains). Shields are observed both individually and in clusters across the region [e.g., 8, 11-13], leading some researchers to map shield plains as a distinct unit that largely predates the regional plains [e.g., 14]. A large cluster of small shields lies nearly parallel to Dennitsa Dorsa in Louhi Planitia near 180E. This shield field lies at a low elevation, and flows associated with individual shields superpose the surrounding plains. A second cluster of small shields lies between Meslenitsa Corona and Renpet Mons, a third between Anahit Corona and Renpet Mons, and a fourth, smaller cluster lies within Pomona Corona. The shields within Pomona Corona appear to have been embayed in the lower-lying regions of the corona's center. Other shield clusters not associated with coronae have also been embayed by surrounding plains units, suggesting that regional plains were emplaced more recently than the small shield volcanoes in many locations.

Surrounding and embaying the deformational belts and many shield clusters are the regional plains of Louhi and Snegurochka Planitiae. Regional plains are characterized by both radar dark (generally older) and radar bright (generally younger) subunits that are typically morphologically smooth but often contain structural features such as wrinkle ridges, fractures, and scattered shields. These plains are also referred to as smooth or ridged plains [9]. The largest volcano in the region, Renpet Mons, with a diameter of 300km located at $+76^{o}$ 235E, appears younger than the plains units [10]. This volcano fed extensive lobate flows that overlie the surrounding plains of Snegurochka Planitia.

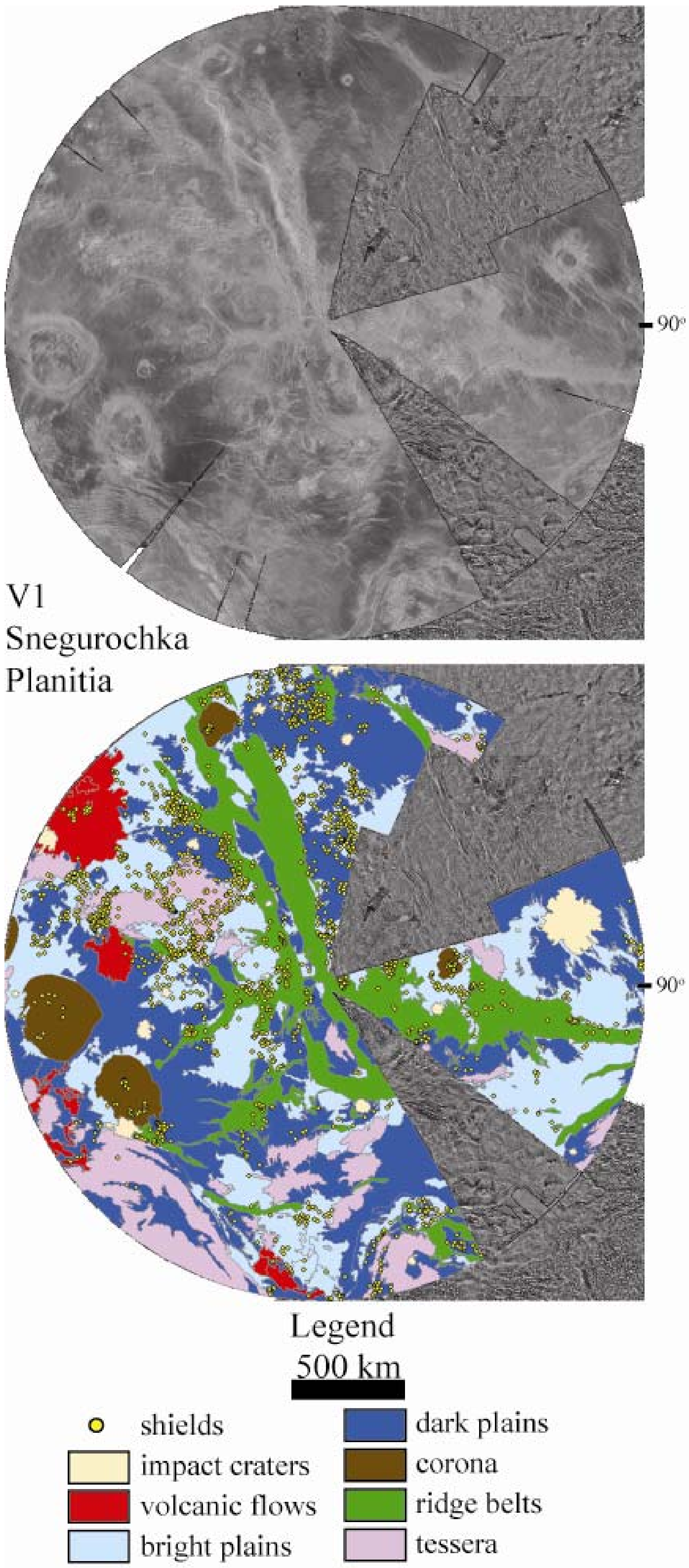

Figure 1: Magellan radar image superimposed on Venera 15-16 imagery (top) and geologic map (bottom) of Snegurochka Planitia (V1). This polar region contains tesserae, deformational ridge belts, suites of regional plains (planitiae), coronae, a large volcano and associated lobate flows, small shield volcano fields, and impact craters. The spatial and stratigraphic relationships of the features within this region are analyzed in an effort to compare the geologic histories of Venus and the Earth's Archean.

Impact craters, which generally appear as circular depressions surrounded by radar bright ejecta, are largely superposed on older units. Some impact craters have been embayed by the surrounding regional plains (e.g., near +81, 285E), but most craters appear younger than the plains, with relatively fresh secondary craters sometimes apparent (e.g., +78, 105E). Thus in V1, impacts have occurred both before and after the emplacement of the regional plains.

Discussion: The observations presented above indicate an approximate stratigraphy for Snegurochka Planitia, from oldest to youngest, of tessera, deformation ridge belts, corona, small shield volcanoes, large-scale volcanism forming radar dark plains followed by radar bright plains, and large shield volcanism and associated lobate flows, with impacts occurring at various times in the history of V1. This stratigraphy is not absolute, as more complicated relationships present themselves: for example, in most cases shields appear older than the surrounding plains, but in some cases they appear younger, and parts of the coronae superimpose the surrounding plains while other parts are embayed by the surrounding plains. In general, however, this stratigraphy suggests that the surface of Venus has been shaped by various modes of volcanism across its history. By studying the spatial and stratigraphic relationships of the volcanic features within V1, specifically of the large volcanoes, small shield volcanoes, and the volcanic plains, more insight can be gained as to the timing and mechanism of the shift between localized and regional volcanism in Snegurochka Planitia.

Implications for the Archean: 1) Crustal Thickening Environments and Processes: Some regional plains occur in what appears to be a flexural moat formed by underthrusting beneath Lakshmi Planum near 300E. 2) Role of Diapirism: Diapiric structures appear to be active throughout Venus' history, with more recent activity concentrated in radial dike emplacement and lobate lava flow emplacement. 3) Nature and Origin of Deformation Belts: In the V1 quadrangle, the deformation belts form the apex of a huge fan that radiates to the south, though their origins remain unclear. 4) Origin and Context of Regional Plains: Flood-basalt style regional plains indicate that broad resurfacing of the area occurred, but their origin is not clear, as few source vents have been identified. 5) Geodynamic Evolution: The volcanic record of V1 is characterized by early distributed volcanism (numerous small shields), followed by regional volcanism (the regional plains), followed by large point sources and lobate flows (coronae and large volcanoes).

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