THE HISTORY OF TOPOGRAPHY ON VENUS; M.A. Ivanov[1,2], J.W. Head[2], and A.T. Basilevsky[1,2]. [1]Vernadsky Institute, Russian Academy of Sciences, Moscow, Russia; [2]Dept. Geol. Sci., Brown University, Providence, RI 02912 USA (mikhail_ivanov@brown.edu).

Introduction: The topography of a planet can date from different parts of planetary history. Venus is the most Earth-like of the terrestrial planets (e.g., in size, density, position in the solar system) but displays no current plate tectonics and aqueous erosion. It is presently a one-plate planet, is losing its heat largely by conduction, and yet has an Earth-like average surface age (<~1Ga), and is characterized by a unimodal hypsogram. When did the major components of the current global topography of Venus form? We investigated this question through a synthesis of geological mapping over 99% of the surface of Venus, an assessment of the stratigraphic relationships and ages of the main units, and a comparison of their distribution and age to the present topography of Venus. Here we report on our interpretation of the sequence and timing of the global topography of Venus.

Major geologic units: Photogeologic analysis of radar images of Venus has revealed the major surface features, their general origin, and their sequence of formation. Initially identified stratigraphic sequences [e.g. 1,2] have been followed by systematic quadrangle mapping and global stratigraphic assessments [e.g. 3-11]. Ivanov [12-13] recently completed a synthesis of geological mapping from the 82.5°N to 82.5°S, ~99.1% of the planet.

Five Venus terrain types/units make up about 95.8% of the mapped area and appear to be the most important. Heavily tectonized terrain (*tessera, **t**, densely lineated plains, **pdl**, ridged plains, **pr**, and groove belts, **gb***, ~20.3% of the map area) is exposed mostly as large plateaus, small outliers, and belts standing as much as several km above the surrounding plains [14]. These units are heavily tectonized and always embayed by surrounding plains. *Shield plains, **psh*** (~18.5%) form units a few hundred kilometers across characterized by numerous small (5-15 km) volcanic shields. Stratigraphic analyses show that shield plains largely predate regional plains [e.g. 15-18]. *Regional plains **rp*** (~42.8%) typically have radar-dark and radar-intemediate, smooth surfaces, which are interpreted to be solidified lava flows, and cover large contiguous areas [e.g. 19]. The plains are deformed by a network of narrow wrinkle ridges, a result of deformation of the surface by moderate horizontal contraction [e.g. 20]. The large areas, sinuous channels, flow fronts, and very gentle slopes, all suggest high-rate, low-viscosity eruptions of basaltic lava. *Lobate plains, **pl*** (~8.8%) are observed in two partly overlapping environments: adjacent to rift zones and covering the slopes of volcanic edifices, often at the nexus of rift zones. The flows are often bright, ~10-~100 km long, and a few to ~10 km wide. They overlie regional plains and embay other preexisting units. *Rift zones, **rt***; (~5.3%) are usually topographic troughs a few km deep with raised flanks; walls and floors of the troughs are heavily deformed by fractures. Rift zones are generally contemporaneous with lobate plains.

Topographic configuration of the units: The distribution of the topography of the major map units shows that the oldest, tessera, is the highest (Fig. 1). The younger shield plains are concentrated at intermediate hypsometric levels and regional plains are the lowest unit hypsometrically (Fig. 1), primarily occurring in the current lowlands. Stratigraphic relationships show that the majority of shield plains underlie the regional plains and thus they are probably also present in the low areas below the regional plains. The surface slope of the shield plains away from the tessera, and evidence that they underlie the regional plains in the present topographic basins, strongly suggest that the lowlands topography formed before regional plains, perhaps in broad concert with the formation of the tessera highlands. Rift zones and associated lobate flows form predominantly at intermediate to high elevations (Fig. 1). Rift zones are interpreted to be due to relatively recent upwelling and associated rifting-related crustal and lithospheric thinning. Lobate lava flows, emerging from rift margins and volcanic rises, trend down-slope into the adjacent midlands and lowlands, covering regional plains and shield plains.

Ages of the units: Magellan data revealed only ~970 impact craters, leading to the interpretation that the mean age of the surface of Venus, T, was ~750 Ma (300 Ma to 1 Ga) [21]. The mean age is usually expressed as T and the age of surface units as fractions or multiples of T. A synthesis of the mean ages assigned to the units under consideration is tectonized terrain: 1.09 (±0.09, 1s) T, shield plains1.04 (±0.09) T, regional plains 1.05 (±0.06) T, lobate plains: 0.54 (±0.09) T, rifts: 0.63 (±0.13) T. These age estimates show that Venus was not resurfaced at a uniform rate. The deformation that characterizes the tessera terrain and other tectonized units occurred over a relatively short time and was rapidly followed by globally distributed small centers of volcanism (shield plains) and then by flood-basalt-like regional plains. All of this activity resurfaced

~81.7% of the mapped area in a short time interval (5-22% of the total preserved surface history of Venus). During the rest of the history, rifting, volcanic rises, and associated volcanism were the dominant processes, resurfacing only ~18.3% of the planet. Using a different approach (counting craters superposed on post-regional plains volcanic units and rifts) [22] found that the general rates of volcanism and rifting during post-regional plains time were close to constant and were much lower than rates of volcanism and tectonism prior to the deformation of the regional plains by wrinkle-ridges.

The History of Topography on Venus: These data now permit us to assess the age of the topography of Venus: what portion remains from its earlier history and how much is attributable to more recent activity? Comparison of the areal, altimetric, and age distributions of the units (Fig. 1) strongly suggests that the vast majority of the current topography dates from the first few tens of percent of the observable (since tessera formation) history of Venus. Tessera occupies topographic highlands, shield plains occur preferentially on midland surfaces sloping toward the lowlands, and regional plains predominantly occupy lowlands and the lower parts of the midlands. The fact that volcanic regional plains occupy lowlands is evidence that these lowlands were present at the time of their emplacement.

In the main portion of the morphologically recorded history that postdates regional plains emplacement, the major contributors to the current topography were rift zones, and the volcanic rises. Lobate lava flows emanating from these places flow downhill into pre-existing surrounding midlands and lowlands, resurfacing regional plains and older units. The fact that this combined activity resurfaced only ~14% of the mapped area strongly suggests that: 1) the level of interior activity of Venus manifested by integrated volcanic/tectonic activity decreased significantly following the emplacement of regional plains, and 2) the style of resurfacing changed dramatically from intense crustal deformation (tessera) and global high-flux volcanism (shield and regional plains), to local centers of volcanism interconnected by rift zones with associated local volcanism. We concur with other workers [e.g. 23] that this distinctive change is consistent with the early phase (tessera to regional plains) representing a major period of enhanced heat loss, while the later phase represents a prolonged more stable period of lithospheric thickening. We interpret the origin of the long-wavelength topography of Venus to be a remnant of the geodynamical forces related to tessera formation and the global volcanic aftermath represented by shield and regional plains emplacement. The preservation to modern times of the ancient topography of Venus is believed to be due to rapid lithospheric thickening following the emplacement of regional plains.

References:

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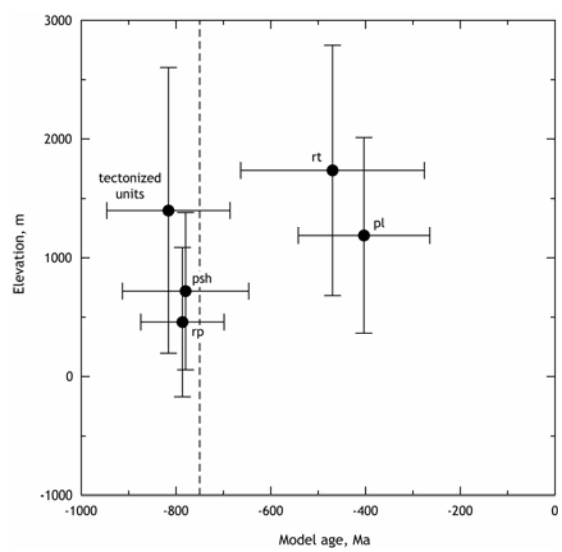

Fig. 1. Altimetric distribution of topography of geologic units and structures as a function of model age (T=750 Ma).