GEOLOGIC HISTORY OF THE LAVINIA PLANITIA/LADA TERRA REGION, VENUS: RESULTS OF MAPPING IN THE V-55, V-61, AND V-56 QUADRANGLES. M. A. Ivanov1,2 and J. W. Head2,1 Vernadsky Institute, RAS, Moscow 119991, Russia; Mikhail_Ivanov@brown.edu; 2Brown University, Providence, RI 02912, USA.

Introduction: Lada Terra (V-61 and V-56 quadrangles) is a region of midlands (0-2 km above mean planetary radius, MPR) at high southern latitudes (~300-90°E, 55-80°S). It is dominated by a large dome-shaped structure, a swell, and hosts numerous coronae (e.g., Quetzalpetlatl and Boala [1,2]), and large complexes of lava flows, fluctuates (e.g. Mylitta and Cavillaca [3,4]). Belts of fractures and graben interconnect many coronae in Lada Terra [5]. The vast lowland of Lavinia Planitia (~330-0°E, 25-55°S, V-55 quadrangle) is adjacent to Lada Terra from the north. Deformational belts of ridges and grooves and vast moderately deformed plains characterize the floor of Lavinia Planitia [6,7]. The pattern of deformation, topography, and gravity signature are consistent with mantle downwelling under Lavinia Planitia [8] and with mantle upwelling in the region of Lada Terra [9,10]. Thus, Lada Terra and Lavinia Planitia apparently represent contrasting geodynamic provinces. Their close proximity suggests a genetically related history [4]. We studied these regions in detail through geological mapping at 1:5 M scale under the USGS planetary mapping program (combined area of the quadrangles V-55 [11], V-61, map in edit, and V-56, map in progress). The main goal of our study was to reconstruct the major episodes of geologic history of Lada and Lavinia and establish the timing and sequence of events during formation and evolution of these regions.

Topographic configuration of Lavinia Planitia and Lada Terra. Lavinia Planitia is a large lowland basin a few thousand km across, and is as deep as ~1.5 km below MPR. The general distribution of topography in Lavinia Planitia is asymmetric with the deepest portion of the basin toward its southern edge. Toward the north and northwest, the elevation changes ~1 km over a distance of ~1800 km while at the southern and eastern margins the same change in elevation occurs over a distance of ~500 km. Deformational belts on the floor of the basin form a radial pattern and topographically represent elevated zones several hundred meters high. The most prominent belts are concentrated in the deepest area of Lavinia Planitia.

The major portion of Lada Terra is within the 0-2 km interval (midlands). The largest topographic feature of Lada Terra is a broad (~1000 km across) symmetric swell, the summit of which reaches an elevation of ~3.5 km. The overall topographic shape of the Lada swell resembles that of other dome-shaped rises on Venus (e.g., Beta, Eistla Regiones). In contrast to these areas, which are topped by large volcanoes, the Lada swell hosts nested Quetzalpetlatl and Boala Coronae and lacks large volcanoes. Two regional-scale topographic features (thousands of km long, hundreds of km wide, a couple of km in amplitude), an elongated depression, and a topographic ridge, concentrically outline the swell of Lada from the north and east.

Regional geology: Units, structures, and their stratigraphic relationships. In our mapping, we used traditional methods of unit definition [12,13] appropriately modified for radar data [14]. On the basis of these approaches [14-18], we defined units and mapped relations between them and tectonic structures using F/C1-MIDR’s, images and altimetry data. All three mapped quadrangles display similar sets of material and tectonic units. Consistent age relationships among them allow stratigraphic correlations of the units in the broad mapped region. The oldest unit is Tessera. It has a unique pattern of deformation consisting of intersecting ridges and grooves [19-22, 7] and is consistently embayed by less deformed materials. The major occurrences of tessera in the area of our mapping are Alpha Tessera (to the east of Lavinia Planitia, V-55) and Cocomama Tessera (to the east of the Lada swell, V-56). Densely lineated plains (pdl) form the oldest plains unit. Its surface is cut by densely packed lineaments (some of them are fractures). Material of densely lineated plains embays tesseria where these units are in contact. Ridged plains (pr) are commonly deformed by broad (5-10 km wide) ridges tens of kilometers long. The ridges are arranged in linear belts and predominantly occur on the floor of Lavinia Planitia (V-55). Both emplacement and deformation of ridged plains postdate deformation of the unit pdl. Abundant small (a few km) shield-like features characterize Shield plains (psh). The unit occurs preferentially within Lavinia Planitia where it embays ridged plains. Psh is significantly less widespread within the elevated portion of Lada Terra (V-61) but is abundant around Cocomama Tessera (V-56). Regional plains (rp) form the most widespread unit with a morphologically smooth and homogeneous surface, which is typically cut by wrinkle ridges. Sources of the plains are not obvious. There are two units of regional plains. The lower unit (rp1) has relatively low radar backscatter and usually makes up the floor of the lowlands surrounding Lada Terra. Sometimes it occurs in stratigraphic windows on the slopes of the Lada swell. The upper unit (rp2) has a higher radar albedo and, sometimes, lobate boundaries. Both units of regional plains embay shields plains. Lobate and digitate boundaries (Lobate plains, pl) morphologically smooth surfaces (Smooth plains, ps), and clusters of small shields (Shield clusters, sc) similar to those of shield plains characterize units that are younger than
regional plains. These units preferentially occur on slopes of the Lada swell (V-61 and 56).

There are two types, scales, and ages of contractional features in the map area. The older are ridges and arches that deform ridged plains (unit pr). Regional plains embay these structures. The northern rim of Quetzalpetlatl Corona is morphologically similar to a typical ridge belt, and is related to the evolution of the corona. Regional plains embay the rim at its southern end. Thus, formation of the rim predates emplacement of regional plains. The younger contractional features are wrinkle ridges that form a regional network that deform regional plains and other older units and are embayed by smooth and lobate plains.

Numerous fractures and graben in the region studied are typically collected in zones of extensional structures (groove belts and rift zones). Groove belts preferentially occur on the floor of Lavinia Planitia (V-55) where they cut ridges of the unit pr and are embayed by shield plains and regional plains. Rift zones are concentrated in Lada Terra and appear to be contemporaneous with the youngest plains units (pl, ps, and sc). The largest of them is a rift-like zone of Kalaipahoa Linea (V-61) that outlines the Lada swell from the north. Another rift-like zone is within the V-56 quadrangle. It consists of a chain of coronae interconnected by graben and outlines the swell from the east. Within both zones there are prominent sources (coronae) from which emanate the youngest volcanic flows (e.g. Mylitta Fluctus).

Discussion and conclusions The V-55, V-61, and V-56 quadrangles cover a region that consists of two provinces, Lavinia Planitia and Lada Terra, contrasting in topography, gravity, and overall geologic history. Deformational zones of ridge and groove belts that form the bottom of the general stratigraphic column populate the floor of Lavinia Planitia. The most prominent belts preferentially occur at the deepest portion of the Lavinia basin and are embayed by units of intermediate stratigraphic position (psh and rp). An important characteristic of the basin is the absence of both young deformation and volcanic materials postdating formation of wrinkle ridges. The general topographic configuration of Lavinia Planitia and the radial pattern and topographic position of the deformational belts on its floor are consistent with subsidence of the surface during formation of the Lavinia basin [8]. The stratigraphic position of the deformational belts on the floor of Lavinia implies that the subsidence largely occurred relatively early and the topographic asymmetry of Lavinia suggests that the locus of the subsidence was near the southern and eastern edges of the basin. The vast plains units of intermediate stratigraphic position were emplaced on the floor of a lowland when it already was largely formed.

Lada Terra is in sharp contrast to Lavinia Planitia. It is an elevated region, which is dominated by the Lada swell and characterized by abundant young volcanism (lobate plains) and young extensional deformation (rift zones). The summit area of the swell (Quetzalpetlatl and Boala Coronae) and the Tarbell/Jord Coronae complex within the rift of Kalaipahoa Linea are the most important sources of young volcanism. Young lava flows flow down the regional slopes of the swell and the steeper southern and eastern edges of the Lavinia basin [11,23]. Magellan gravity data [24,25] show that the Lada swell is characterized by high values of both vertical gravity acceleration (up to 120 mGal) and geoid height (up to 40 m). These features together strongly suggest that the central portion of Lada Terra represents a region of mantle upwelling. The stratigraphic position of the most abundant units in Lada Terra means that much of the volcanism associated with the upwelling largely postdated the subsidence in Lavinia Planitia.

Thus, the geologic history of the region of Lavinia Planitia and Lada Terra appears to consist of two major phases. The earlier phase corresponds to formation of the vast basin in Lavinia. During the phase of broad upwelling, massive volcanism and extensional tectonics occurred in Lada Terra largely postdating the formation of Lavinia. The close geographic position of the lowlying Lavinia Planitia and elevated Lada Terra, their overall topographic configuration, and general sequence of events in these regions are consistent with and suggest a genetically linked evolution of these provinces [4]. In this model, the downwelling in Lavinia occurred together with upwelling under Lada, initiating the younger geologic activity within Lada Terra.