EVOLUTION OF THREE LARGEST CORONAE ON VENUS, HENG-O, QUETZALPETLATL, AND ARTEMIS: PRELIMINARY RESULTS: M.A. Ivanov[1,2], and J.W. Head[2]; [1]Vernadsky Institute, RAS, Moscow, Russia, mikhail_ivanov@brown.edu, [2]Brown University, Providence RI, USA

Introduction. The vast majority of coronae on Venus cluster around a diameter of ~200-300 km, but three extremely large examples also occur; coronae are thought to be the surface manifestation of rising mantle instabilities (plumes, diapirs, thermals) and the differences in geological features and history between the two sizes may reveal important information about the nature of interior thermal evolution and patterns of mantle convection [1-11]. The largest coronae, Quetzalpetlatl (Q), Heng-O, and Artemis, have dimensions ~1000-2500 km [2,5,10,11]. Analysis of such coronae will help to document the relative timing of any such instabilities, characterize interaction of large mantle diapirs with the lithosphere, and help distinguish between the origin of the larger and smaller features. In this study, we analyzed the stratigraphic relationships of the key material units, structures and topography in order to outline the key aspects of their evolution.

Characteristics. Heng-O (2.0N, 354.5E, D=~900 km) is in the southern part of Guinevere Planitia between Eistla Regio to the north and Alpha Regio to the south. Topographically, the area of the corona is a low (~1 km) rise surrounded from the west, north, and east by elongated lowlands. Heng-O is almost completely outlined by a distinct rim. The southern half of it is morphologically prominent and consists of narrow ridges and swarms of graben arranged in a single arc-like feature ~1600 km long and a few hundred meters high. Structures of this portion of the rim are embayed by regional plains from outside and inside of the corona. There are no outliers of older units within the northern half of the rim. This portion of the rim of Heng-O, which is up to 1.5 high and ~ 100 km wide, is outlined by arcuate swarms of wrinkle ridges, has a symmetric cross-section, and is surrounded from the outside by a moat, which is ~100 km wide and ~400 m deep relative to the surrounding plains. The interior is covered by regional plains with wrinkle ridges similar to those outside the corona. Inside the corona, regional plains embay fragments of groove belts and clusters of small shields, the two units that make up the rest of the corona interior. Some groove belts inside the corona appear as a continuation of the belts running toward Heng-O from the southeast. These exterior belts are also embayed by regional plains.

Q (68.0S, 357.0E, D=~800) dominates the highland (2 km above MPR) of western Lada Terra and is outlined from the west and north by a dense swarm of ridges (~5-10 km wide) that are arranged in an arcuate belt ~50 km wide and ~850 km long. The belt constitutes the corona rim, the mean elevation of which is ~1.3 ± 0.4 km. To the northeast and east, Q is in contact with Cocomama Tessera. The southern half of Q has no distinct morphological features outlining the corona. The exterior topographic moat (~100-150 km wide): 1) has an asymmetric cross-section and is characterized by a shallow (0.1-0.15^{o}) northern wall and steeper (up to 1^{o}) southern one. Thus, the apparent average depth of the moat is ~200-300 m relative to the surroundings of Q and ~600-800 m relative to the rim of the corona; 2) the floor is embayed by lava flows that now tilt toward Q; 3) about half the width of the corona rim is on the steeper southern wall of the moat.

Q as a whole is a large dome-like feature ~1700 km across the highest area of which (~2.9 km above MPR) corresponds to the rim of smaller Boala corona (D=220 km, 359.0E, 70.0S) that is completely inside Q. The S, W, and N portions of the rim of Boala, which is ~400-500 m high, hosts a set of narrow arcuate graben and there is a cluster of small shields on the eastern side of the corona. Q is a huge center of volcanism within Lada Terra. Morphologically distinct lava flows almost completely cover the corona interior, partly fill the moat, and extend far beyond Q. The flows have lobate fronts, are tectonically intact, and the shape of them indicates the source areas and paths of flow. The most obvious sources of the flows are Boala corona and the cluster of small shields on its eastern flank. Almost everywhere inside and outside Q, except for the moat, the flows follow the present-day topographic gradient. In a few places, older wrinkle-ridged plains form local highs (kipukas). Clear stratigraphic relationships among key structures and material units occur at the western edge of Q. The plains with wrinkle ridges there embay structures of the corona rim ridge belt and both the plains and the belt are flooded by lobate flows.

Artemis (35.0E, 135.0N, D=2600 km) is the largest corona on Venus [2,10,11], three-quarters of which is outlined by a very deep (~2-2.5 km) trough, Artemis Chasma, consisting of narrow (a few km wide) densely packed ridges. The whole corona is on a regional slope from the tessera highland of Thetis Regio toward the lowlands of Zhibek Planitia. Heavily embayed remnants of tessera occur within regional plains to the W of Artemis. Interiors of the corona are complexly deformed and are cut from SW to NE by a trough of Britomartis Chasma, which is ~1 km deep. Volcanic plains morphologically similar to regional plains of Venus and lobate lava flows occupy small portion of the corona interiors. Lobate flows that clearly postdate regional plains are related to two corona-like features in the SW and NE portions of Artemis.

The outermost ridges of Artemis Chasma appear to be embayed by regional plains on both sides of the chasma but there is no evidence for embayment inside it. Outside of the corona, two groove belts run toward Artemis from the SW and E. Their structures, graben and fractures, are embayed by regional plains. Where the SW belt comes to Artemis Chasma, its structures are mostly cut by the ridges of the chasma and only a few graben apparently deform the ridges. In the east, structures of Artemis Chasma completely destroy structures of the other groove belt. The surface of regional plains on both sides of Artemis Chasma is tilted away from the chasma rims, suggesting the regional plains surface was tilted after plains emplacement.

Discussion. Of the three studied coronae, Heng-O is characterized by the least volcanic and tectonic activity. Regional plains that embay relatively old units such as shield plains and groove belts within the corona mostly fill the interior of the corona. Regional plains also embay the material and structural units that make up the southern portion of the Heng-O rim. These relationships mean that Heng-O began to form before the emplacement of the regional plains. The evolution of the corona, however, continued after formation of the plains. The corona-related volcanism that post-dates vast regional plains is concentrated outside of Heng-O along its southern edge and forms extensive homogeneous lava plains and individual lava flows. These volcanic materials, although superimposed on the regional plains, are deformed by wrinkle ridges. Late tectonic deformation related to Heng-O occurs along the northern half of the rim, which is a topographic feature. There, regional plains are bent upward into a topographic ridge and displaced downward to form a moat that is attached to the rim. Wrinkle ridges that deform regional plains are conformal to the rim. This means that this portion of the rim continued to form after the emplacement of regional plains and regional stresses introduced by the growing rim probably governed the pattern of distribution of wrinkle ridges nearby. No young volcanism is related to the northern portion of Heng-O. The evolution of Heng-O appears to be a continuous process with a gradual shift of activity toward the northern half of the corona.

Minor tectonic activity characterizes Q. The most prominent tectonic features there are the ridge belt and the topographic moat along the northern edge of the corona. The ridge belt is embayed by regional plains meaning that Q as well as Heng-O began to form before emplacement of the plains. Q is an important center of young (post-regional plains) volcanism on Venus. The lobate flows are nearly tectonically intact and flow along the present topographic gradient. The surface of the plains, however, is tilted within the moat suggesting that it continued to form until recently in the evolution of the corona. The moat probably is not a complimentary structure to the northern ridge belt because formation of the belt apparently ceased before emplacement of regional plains. The youngest tectonic structures that deform lobate plains are concentric graben at Boala corona. The corona occupies the summit of a large dome-like highland and is the source of lobate plains in the area of Q.

The volcanic activity at Q apparently coincides in time with broad updoming of a large area within western Lada Terra. Probably synchronous to the updoming is the development of several large structural zones consisting of smaller coronae interconnected by dense swarms of fractures and graben [12]. The coronae of these zones are usually distinct sources of massive volcanism such as Mylitta and Kaiwan Fluctuses [13-15]. The late volcanic flows at Q cover up almost all evidence of the previous evolution of the corona. Thus, two alternatives are possibly: Either the corona evolved continuously or it was reactivated relatively recently.

Artemis is the most tectonically deformed corona and volcanic activity there was rather minor. The corona has complexly deformed interiors where the evidence for the formation of smaller additional coronae and possible spreading has been found [10,11]. Contrasting to the majority of coronae on Venus, Artemis is outlined by a deep trough, Artemis Chasma, which consists of densely packed narrow ridges and resembles a large zone of convergence [16,17]. Two observations suggest that Artemis started to form before the emplacement of regional plains: 1) Artemis appears to be an area at which large groove belts pre-dating regional plains converge. This suggests that before emplacement of regional plains the area of Artemis was a locus of convergence of belts of extensional structures, which appears to be typical for coronae on Venus [18]; 2) The outermost structures of Artemis Chasma are embayed from outside and, in places, from inside of the corona by regional plains. There is a set of observations, however, indicating that Artemis Chasma continued to evolve as a tectonic feature after emplacement of regional plains: 1) There is no flooding of any sort inside the chasma; 2) Structures of the chasma appear to destroy fractures and graben of the outside groove belts; 3) Regional plains on both sides of the chasma are tilted away from it; 4) Where young lobate lava flows inside Artemis corona are near Artemis Chasma, the flows are also tilted away from the chasma. Close spatial association of Artemis to the largest system of deep rifts and somewhat unusual feature of the corona (outlining trough instead of a ridge) suggest that characteristics of Artemis may be strongly affected by development of the system of rift relatively recently in the geologic history of Venus.

Conclusions. In each corona, the initial corona-related structures predate the emplacement of regional plains. Elsewhere [19-23] evidence has been found that these plains may represent a global-scale stratigraphic reference. In this case, the large-scale deep mantle or core-mantle instabilities have been originated relatively early in the preserved geologic history of Venus. We are currently working to correlate the stratigraphic relations of these features to the chronology of other major events in the preserved history of Venus and compare this history to the range of geodynamical evolutionary models [e.g., 6-9].

References: 1) A. Pronin and E. Stofan, *Icarus,* 87, 452, 1990; 2) E. Stofan et al., *JGR*, 97, 13347, 1992; 3) E. Stofan et al., *in: Venus II* U. AZ Press, 931, 1997; 4) S. Smrekar and Stofan E., *Science*, *277*, 1289 1997; 5) L. Crumpler et al *in: Venus II* U. AZ Press, 697, 1997; 6) A. Jellinek et al., *JGR*, 104, 7183, 1999; 7) A. Jellinek et al., *GRL*, 29, 2002; 8) A. Dombard et al., *LPSC 33* , #1877, 2002; 9) C. Johnson and S. Solomon, *LPSC 33* , #1952, 2002; 10) J. Spencer, *GSAB*, 113, 333, 2001; 11) V. Hansen, *GSAB*, 114, 839, 2002; V. Hansen, LPSC 32, #1036, 2001; 12) G. Baer et al., *JGR*, 99, 8355, 1994; 13) K. Roberts et al., *JGR*, 97, 15991, 1992; 14) G. McGill and N. Bridges, USGS, Map I-2747, 2002; 15) M. Ivanov and J. Head, *Micro 36*, #39, 2002; 16) C. Brown. and R. Grimm, *JGR*, 101, 12697, 1996; 17) C. Brown and R. Grimm, *Icarus*, 139, 40, 1999; 18) D. McKenzie et al., *JGR*, 97, 115977, 1992; 19) G. Schaber et al., *JGR*, 97, 13257, 1992; 20) R. Strom et al., *JGR*, 99, 10899, 1994; 21) A. Basilevsky and J. Head, *GRL*, 23, 1497, 1996; 22) M. Ivanov and J. Head, *JGR*, 106, 17515, 2001; 23) A. Basilevsky and J. Head, *Geology*, 30, 1015, 2002.