THE “CORONATED” SURFACE OF VENUS. H. El Bilali¹, R.E. Ernst¹, K.L. Buchan², J.W. Head³
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Introduction: Through our geological observations, combined with detailed mapping (1:500,000 scale) of graben-fissure systems in 40+ areas across Venus, by members of our International Venus Research Group (IVRG) [1-3], the population of coronae of all ages and in all geological settings have increased, leading to an expanding importance of coronae in the evolution of Venus.

Coronae Overview: Coronae are quasi-circular or quasi-elliptical tectono-magmatic features, typically consisting of an annular rim and/or an annular trough, which often have circumscribing lineaments, typically extensional (grabens), but can also include compressional lineaments (wrinkle ridges) and a central region that can be depressed or elevated [4-8]. Coronae range in diameter from <50 km to over 2600 km, but have a mean diameter of 270 ± 190 km (https://planetarynames.wr.usgs.gov/Page/VENUS/target). Many coronae also have an associated radiating graben system (or novae). Such coupled systems have been termed corona-nova systems [9]. Both the circumferential and radiating grabens are thought to be underlain by dykes [3, 9-17]. Recent studies have suggested that Venus coronae are analogues of terrestrial giant circumferential dyke swarms, and are thus interpreted to represent the sites of Venus mantle plumes [9, 18], and thus to be emplaced above plumes or diapirs [19-23].

Coronae are common features on the surface of Venus, with 341 currently identified and named by the International Astronomical Union (IAU). However, a comprehensive compilation that includes unnamed coronae [20, 24] identified 513.

While this is an impressive number of coronae, we describe evidence for an even greater abundance of coronae of all ages in a variety of geological settings.

In addition, we discuss criteria for the recognition of coronae through detailed geological mapping, as well as implications of a more corona-rich (‘coronated’) surface of Venus.

Approaches for recognizing additional corona: Importance of circumferential graben-fissure systems. The main characteristic which has been used to recognize coronae on Venus is their annular rim (and/or trough) and associated fractures, since the interior topography is so variable [5, 20, 24]. It has been shown in recent years (e.g., [1-3]) that full resolution Magellan images can reveal subtle circumferential graben-fissure systems that are visible even when partially flooded. This has resulted in a significant increase in the number of coronae identified in the different age groups and settings (see discussions below). Moreover, such detailed mapping has resulted in a dramatic expansion of the estimated size of many individual coronae. For instance, Themis Coronae, which was previously thought to have a diameter of 330 km [4], has been shown to have a diameter of 1250 km when the circumferential grabens are included [15-16]. Similarly, detailed mapping of Heng-o Corona has resulted in its diameter being increased from 1060 km to >1800 km [25].

Another benefit of identifying circumferential graben systems of coronae is that their presence, and detailed mapping, can be used to rule out an impact origin, which can be important in assessing cryptic circular feature origin. In addition, the recognition of subtle radiating grabens can help in the identification of the cryptic corona-nova systems. Another possible setting for cryptic coronae is lava lakes. The 900 km long Itoki Fluctus in the Quadrangle V-39 [26] has been mapped in detail by [27] revealing that a lava lake fills a central depression associated with a prior magmatic feature, likely a corona.

Detailed mapping of circumferential grabens has also shown that irregular-shaped coronae are often composed of multiple overlapping sub-circular graben-fissure systems, indicating a complex geological history.

Expanded corona record: Here we describe the expansion of the corona record back through time in the following settings: young rifts and volcanic rises, post-plains, post-tessera/pre-plains, and syn-tessera.

Coronae in chasmata: Coronae are a key component of chasmata (rift zones) (e.g., [7, 28-31]). [32-33] noted that coronae (and corona-nova systems) are typically located at the foci of local triple junction rifts which are distributed along the major chasmata of the BAT region. Detailed (1:500,000 scale) mapping of graben-fissure systems along Parga Chasmata [3, 30-31, 34-36], and Dali-Diana Chasmata [3, 37-38] revealed additional coronae, and has helped to establish their relative ages and their association with rifting in the chasmata.

Corona dominated volcanic rises: As noted by [39] there are volcano-, rift- and corona-dominated volcanic rises. The latter include Themis, Eastern Eistla and Central Eistla Regio. Detailed mapping in Central
Eistla Regio [17, 40], and Eastern Eistla Regio [41] has revealed numerous additional coronae.

Post- or late- plains: Important examples are Derceto Corona [42] and Heng-o Corona. [25, 43-44].

Pre-plains: There are coronae in plains which have been partially flooded, and can therefore be determined to be pre or syn-plains. One example is an unnamed corona (225 km in diameter) located at the western end of Jokwa linea, which has been largely flooded by plains lavas [45] south of Jokwa linea, in Wawalag planitia, there are numerous partially flooded magmatic centres (mostly coronae, or corona-nova systems) recognized through detailed mapping [46]. Recognition that this portion of Wawalag planitia has a similar abundance of coronae (as partially flooded features) [47] as the adjacent elevated and unflooded Jokwa linea [45] suggests that abundant additional coronae may underly Wawalag (and other) planitia and only be visible when the plains lava flooding is thin.

Coronae superimposed on tesserae: There are numerous coronae superimposed on tesserae in crustal plateaus. For example, in Western Ovda Regio numerous coronae have been identified as having been emplaced after or during the late stage of tessera development but prior to the flooding of adjacent plains [47].

Cryptic circular features in tesserae. There are also cryptic circular features in tesserae that could represent remnants of coronae. This is particularly clear when faint circumferential and/or radiating grabens can be observed. If corona are an important component of tesserae, then they could represent an important source of heat loss during tesserae time.

Implications: Detailed mapping of graben-fissure systems at 1:500,000 scale using the full resolution Magellan images (in 40+ areas of Venus by members of the IVRG [1-3] has resulted in recognition of many new coronae (and corona-nova systems) in all the major geological settings: young rifts and volcanic rises, post-plains, pre-plains/post-tessera, and syn-tessera.

Better estimates of the overall density and relative age of coronae in various geological settings on Venus is important for understanding their possible roles in processes such as mantle convection patterns, scales and timing, rifts, regional uplift, and tessera development. Evidence of cryptic syn-tessera coronae would be particularly important and perhaps most controversial, as such features suggest significant coronae emplacement as early as the time of tessera formation.

References: