CIRCUMFERENTIAL GRABEN-FISSURE SYSTEMS OF VENUSIAN CORONAE AS POSSIBLE ANALOGUES OF GIANT CIRCUMFERENTIAL DYKE SWARMS ON EARTH. E. Bethell[1], R.E. Ernst[1], C. Samson[1], K.L. Buchan[2], [1]Department of Earth Sciences, Carleton University, Ottawa, ON, Canada; Erin-Bethell@cmail.carleton.ca, [2]Geological Survey of Canada, 601 Booth St., Ottawa, ON Canada.

Introduction: Giant circumferential dyke swarms are increasingly being recognized on Earth [1,2,3]. They are typically hundreds of kilometers in diameter and are distinct from small circumferential dyke systems associated with individual volcanoes. It is hypothesized that these giant terrestrial circumferential dyke swarms are potential analogues to coronae on Venus [1,2,3].

Coronae are sub-circular tectono-magmatic features that are widespread on Venus; at least 515 have been recognized [4]. They are typically 200-300 km in diameter, but some examples approach 1000 km (the largest is Artemis, with a diameter of approximately 2400 km) [4,5,6,7]. Coronae are defined and classified by their annulus of circumferential extensional (graben-fissure) lineaments and/or ridges and their topographic expression, which typically includes a raised rim [6,7]. Radiating graben-fissure systems can also be present.

Multiple lines of evidence suggest that radiating graben-fissure systems are underlain by dyke swarms [e.g., 8]. It is also proposed that circumferential graben-fissures can be underlain by dykes [2,9]. We provide a preliminary summary of the characteristics of circumferential graben-fissure systems associated with coronae on Venus and consider implications (e.g. magma chamber location) if the graben-fissure systems are underlain by dyke swarms. In addition, our summary of the characteristics of circumferential systems will be a predictive guide for the expanded identification of giant circumferential dyke swarms on Earth as analogues of coronae.

Methodology: A database of the key characteristics of circumferential graben-fissure systems associated with coronae is being developed from full resolution (~75 m/pixel) SAR images from the Magellan mission, USGS quadrangle maps and tabulations [e.g. 4,7] (Figures 1-2).

Preliminary Observations:

1) *Arc length*: Arc lengths can extend to 360° and are generally at least 90°. Arc lengths less than 360° may be the result of primary processes of corona formation (such as asymmetry of the underlying diapir or magma chamber), but in many cases are explained by partial volcanic flooding of the annulus.

2) *Minimum and maximum radii*: The morphology of coronae and their associated circumferential graben-fissure systems are often asymmetric. A non-circular circumferential graben-fissure system may reflect the size and shape of an underlying magma chamber / magmatic underplate.

3) *Minimum and maximum annulus width*: The width of circumferential graben-fissure systems often varies along the corona annulus. Variations in the width (e.g., from 10 to 195 km) of an individual circumferential graben-fissure system may represent variations in the width of the feeding zone off a deep magma chamber.

4) *Distribution with respect to corona topography*: Circumferential graben-fissure systems are usually concentrated in the uplifted rim of coronae [6]. However, in some cases circumferential graben-fissure systems can extend significantly (up to 250 km) beyond the uplifted rim. This suggests the generation of circumferential graben-fissure systems might not be entirely controlled by the same mechanisms that generate corona topography.

5) *Relationship with radiating graben-fissure systems*: According to models of corona formation involving mantle upwelling and/or diapiric uplift, radiating systems are thought to be generated during the uplift and magmatic construction phase [7,10,11]. Circumferential systems are thought to be generated during gravitational relaxation of the diapir [11]. This suggests that the circumferential systems are mostly younger than the radiating systems. When radiating and circumferential systems occur together, their respective foci are commonly offset, which further indicates a time lapse between their formation. However, in some cases, mutual cross-cutting relationships suggest broadly contemporaneous formation [7].

6) *Association with magmatic features*: Circumferential graben-fissure systems are commonly associated with pit crater chains (Figure 2A) which have been linked to underlying dyke injection [12]. However, purely extensional modes of origin have been proposed for pit crater chains on other terrestrial bodies [13]. Some circumferential graben-fissure systems are spatially associated with shield volcanoes, and occasionally, steep-sided domes (Figure 2B). Volcanic lobate flows and channelized flows (e.g sinuous rilles or canali-like features) have been observed to originate from circumferential graben-fissures (Figure 2C).

Concluding Remarks: The recognition that giant circumferential dyke swarms occur on Earth and are of similar scale to the annuli of Venusian coronae suggests these features may be analagous [1,2,3]. If so, circumferential graben-fissure systems would be un-

derlain by dykes and their distribution should be linked with an underlying magma chamber. The dip of the dykes would depend, in part, on the depth and size of the magma chamber (within the crust, or at the base of the crust as a magmatic underplate).

Our improving characterization of circumferential graben-fissure systems on Venus will be a predictive guide for the expanded identification of proposed terrestrial analogues of coronae, giant circumferential dyke swarms [3].

References: [1] Ernst, R.E., Buchan, K.L. (1998) LPSC XXIX, Abstract #1021. [2] Ernst, R.E., et al. (2014) GSA Ann. Mtg [3] Buchan, K.L., Ernst, R.E. (2016) LPSC XLVII, Abstract #1183. [4] Stofan, E.R., et al. (2001) Geophys. Res. Lett. 28(22), 4267-4270. [5] Stofan, E.R., et al. (1991) J.Geophys. Res. 96, 148-227. [6] Hansen, V.L., Olive, A. (2010) Geology 38(5), 467-470. [7] Stofan, E.R., et al. (1992) J. Geophys. Res. 97(E8), 13347-13378. [8] Ernst, R.E. et al. (1995) Earth Sci. Rev. 39(1-2), 1-58. [9] Ernst, R.E., et al. (2003) Icarus 164, 282-316. [10] Stofan, E.R., Head, J.W. (1990) Icarus 83, 216-243. [11] Squyres, S.W., et al. (1992) J. Geophys. Res. 97(E8), 13611-13634. [12] Davey, S.C., et al. (2012) LPSC XLIII, Abstract #1681. [13] Wyrick, D., et al. (2004) J. Geophys. Res. 109(E6), 1-20.

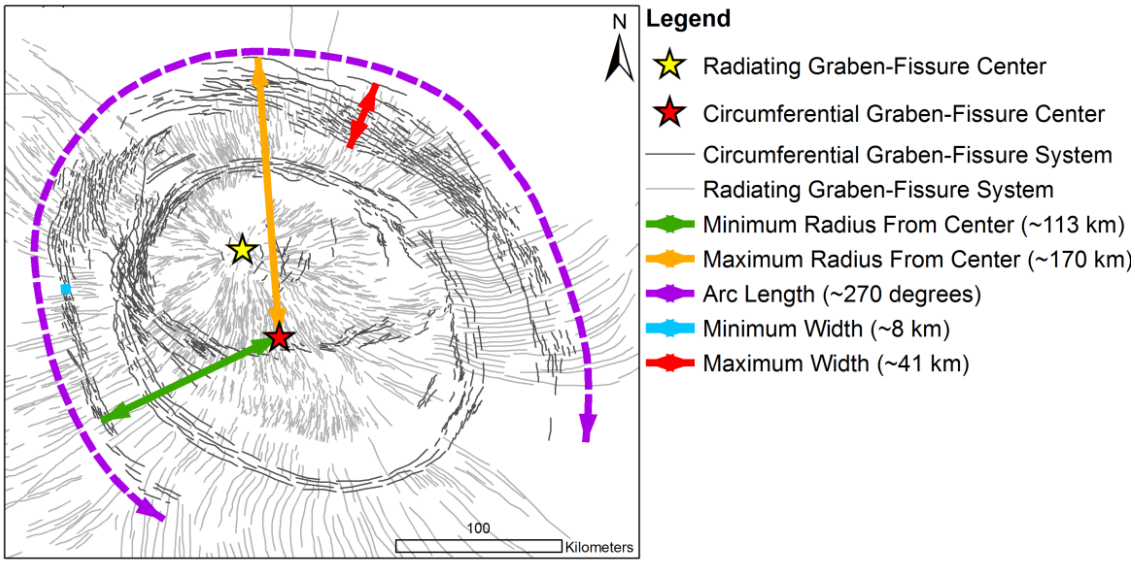

Figure 1. Schematic drawing of measurements taken on the outer ring of the circumferential graben-fissure system associated with Gashan-Ki corona (centered at 11.7° N, 243.7° E). Base map of graben-fissures by J. Graff (unpublished).

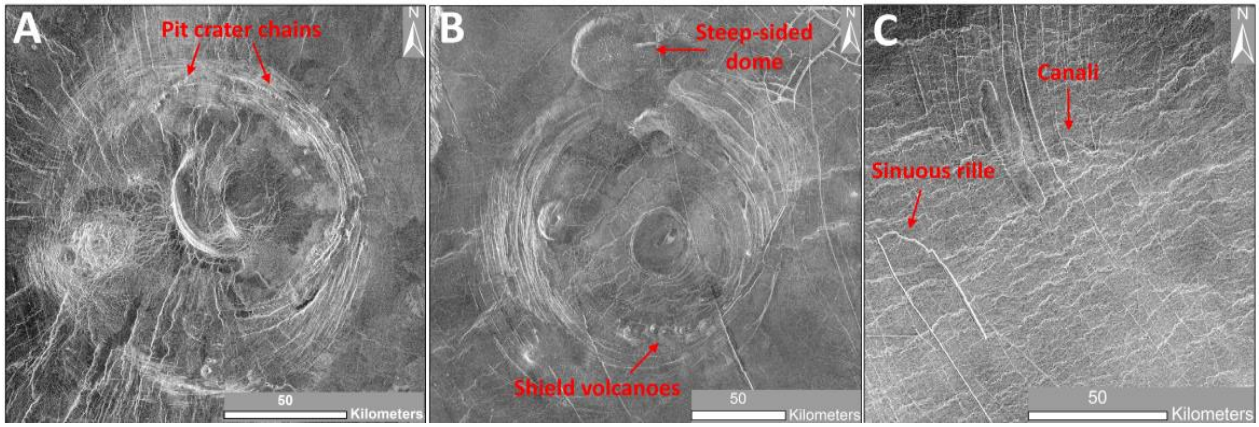

Figure 2. Examples of potential magmatic features associated with circumferential graben-fissure systems. A) Pit crater chains associated with the circumferential system around Qakma corona (centered at 35.5° N, 207.1° E). B) A few steep-sided domes appear to be spatially associated with the annulus of Fotla corona (centered at 58.5° S, 163.5° E), as well as a chain of shield volcanoes that occurs along the southern portion of the circumferential system. C) Sinuous rilles and canali-like features appear to emanate from graben that may be related to a circumferential system around Cybele corona (centered at 7.5° S, 20.7° E).