DETAILED MAPPING OF GRABEN-FISSURE SYSTEMS ASSOCIATED WITH FATUA CORONA, VENUS: IMPLICATIONS FOR MAGMATISM AND THE REGIONAL STRESS FIELD. E. M. Bethell[1], R. E. Ernst[1,2], C. Samson[1], K. L. Buchan[3], [1]Department of Earth Sciences, Carleton University, Ottawa, ON, Canada; erinbethell@cmail.carleton.ca, [2]Faculty of Geology and Geography, Tomsk State University, Tomsk, Russia, [3]Geological Survey of Canada, 601 Booth St., Ottawa, ON, Canada.

Introduction: Coronae are quasi-circular tectono-magmatic features on Venus that are generally hundreds of kilometers in diameter. They are characterized by complex topography and are typically associated with systems of extensional lineaments (i.e. graben-fissure systems) [e.g. 1]. Graben-fissure systems associated with coronae display two main geometries: circumferential systems that comprise the corona annulus, and radiating systems that can extend hundreds to several thousand kilometers beyond the center [2, 3].

Fatua corona is located in the V-32 (Alpha Regio) quadrangle and is centered at approximately 17.6° E, 16.1° S. The annulus has an arc length of 360° around the center. Fatua corona has been described as having a maximum diameter of 310 km and a maximum annulus width of 85 km [1]. However, our detailed structural mapping in the surrounding region using full resolution (~75 m/pixel) Magellan SAR images has revealed the maximum diameter and maximum width of the annulus to be 915 km and 316 km, respectively. Fatua corona is also associated with a radiating graben-fissure system that extends for ~1700 km, and includes the Brynhild fossae located in the V-44 (Kaiwan Fluctus) quadrangle (Figure 1) [4, 5]. Further south are the intersecting Alpha-Lada and Derceto-Quetzalpetlatl extensional belts [5].

Dyke Swarm(s) Associated with Fatua Corona: The extent of the radiating graben-fissure system associated with Fatua corona suggests a link with an underlying giant dyke swarm. This interpretation is supported by the observation of numerous volcanic flows and shield volcanoes clustered along the radiating graben.

Approximately 450 km south of the center of Fatua corona, the radiating graben-fissure system gradually changes trend to become a subparallel linear swarm oriented NE. This change of geometry is also consistent with the interpretation of an underlying radiating dyke swarm, with the dykes propagating perpendicular to the minimum compressive stress (σ_3). Proximal to the magmatic center of Fatua corona, the regional stress field is perturbed; σ_3 is the hoop stress and the formation of radially oriented dykes is preferred. At distances greater than ~450 km, the dykes propagate along the orientation of the regional stress field. In this case, the regional stress field is inferred from the dyke geometry to have the maximum compressive stress (σ_1) oriented NE.

The circumferential graben-fisssure system around Fatua corona may also be associated with an underlying dyke swarm, although this interpretation is more speculative [e.g. 6, 7]. The geometry of the circumferential system also appears to be influenced by the regional stress field. The innermost annulus structures are near-circular, whereas the outermost graben of the annulus form an ovoid geometry that is stretched to the south.

Regional Stress Field and the Alpha-Lada Extensional Belt: The Alpha-Lada extensional belt trends NW, with a total length of ~6000 km and a maximum width of ~200 km [8]. The Alpha-Lada extensional belt intersects with the Derceto-Quetzalpetlatl extensional belt at Astkhik planum [5]. The Derceto-Quetzalpetlatl extensional belt trends NNE, extends for ~2000 km and is over 300 km wide in some areas. Both extensional belts are associated with abundant coronae and volcanism. Cross-cutting relationships demonstrate that extension in the Derceto-Quetzalpetlatl belt initiated before the Alpha-Lada belt, but extension in the two belts more or less overlapped in time [8]. Bridges and McGill [5] determined that the formation of the Alpha-Lada extensional belt was likely broadly contemporaneous with the formation of the Fatua corona radiating graben-fissure system.

Radiating graben-fissure systems (likely underlain by dyke swarms) are commonly associated with coronae contained within the Alpha-Lada and Derceto-Quetzalpetlatl extensional belts, and in most cases, swing in trend to align with the main trend of the belts [5, 8]. Therefore, the orientation of σ_1 within the Alpha-Lada and Derceto-Quetzalpetlatl extensional belts was likely NW and NNE, respectively. This is consistent with observations of the geometries of giant dyke swarms in the Beta-Atla-Themis (BAT) region on Venus [9]. However, the southernmost portion of the radiating system extending from Fatua corona trends orthogonally to the main orientiation of the Alpha-Lada extensional belt; radiating graben are truncated near the NE margin of the belt by younger regional flood basalt plains [5]. The geometry of the Fatua corona radiating system suggests that σ_1 close to the Alpha-Lada extensional belt was oriented NE.

Based on the geometries of the graben revealed from our detailed structural mapping, we therefore hypothesize that extension in the Alpha-Lada belt was the dominant cause for the NE orientation of σ_1 at the time

of emplacement of radiating dykes from Fatua corona (Figure 2). This is in contrast to the rift-parallel stress field orientations observed within the Alpha-Lada belt, and those observed by [9] in the rifts of the BAT region, where broad-scale mantle plume upwellings were the proposed rifting mechanism. The regional stress field orientation outside the Alpha-Lada extensional belt instead resembles the intraplate stress fields away from Earth-like divergent plate boundaries, where σ_1 is oriented orthogonal to the main rifting trend [10]. The Alpha-Lada extensional belt may therefore represent a more Earth-like, insipient divergent boundary.

Estimates of Volume of Magma Emplaced in the Fatua Radiating Dyke Swarm and Comparison with the Mackenzie Radiating Dyke Swarm on Earth: The total volume of magma emplaced in a dyke swarm can be estimated if the cumulative length, average width, and vertical extent of the dykes can be approximated [11].

Located in northern Canada, the Mackenzie swarm is the largest currently recognized radiating dyke swarm on Earth. It was first compared to Fatua corona by [4]. It resembles the radiating swarm associated with Fatua corona both in size (the Mackenzie and Fatua corona swarms extend ~2500 and ~1700 km from the center, respectively) and in the gradual change in dyke trend from a proximal radial to a distal subparallel linear arrangement. Assuming an average dyke thickness of 30 m, and an average vertical dyke depth of 50 km, [11] estimated the Mackenzie swarm to represent ~80,000 km^3 of magma emplaced in the dykes. A similar estimate can be generated for the radiating swarm associated with Fatua corona, assuming similar geometric dyke parameters. This estimate yields a value of ~57,000 km^3 or 71% of the estimate for the Mackenzie swarm.

References: [1] Stofan, E. R., *et al*. (1992). *JGR* 97(E8), 13347-13378. [2] Ernst, R. E., *et al*. (2003). *Icarus* 164, 282-316. [3] Hansen, V. L., and Olive, A. (2010). *Geology* 38(5), 467-470. [4] McKenzie, D., *et al*. (1992). *JGR* 97(E10), 15977-15990. [5] Bridges, N. T., and McGill, G. E. (2001). *USGS Geologic Invest. Series* I-2747. [6] Bethell, E., *et al*. (2016). *LPSC XLVII*, Abstract #1471. [7] Buchan, K. L., and Ernst, R. E. (2016). *LPSC XLVII*, Abstract #1183. [8] Baer, G., *et al*. (1994). *JGR* 99(E4), 8355-8369. [9] Grosfils, E. B., and Head, J. W. (1994). *Geophys. Res. Letters* 21(8), 701-704. [10] Zoback, M. L. (1992). *JGR* 97(B8), 11703-11728. [11] Fahrig, W. F. (1987). *GAC Special Papers* 34, 331-348.

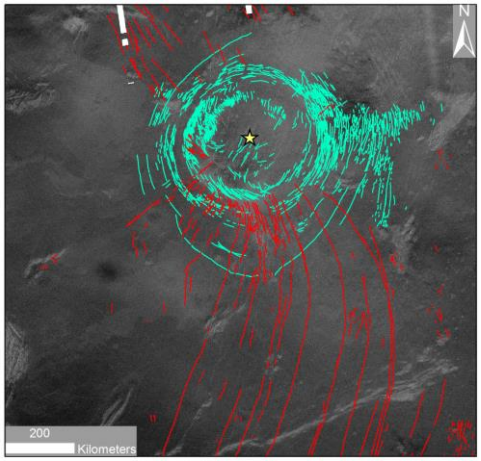

Figure 1: Detailed structural mapping of radiating (red) and circumferential (blue) graben-fissure systems associated with Fatua corona, superimposed on Magellan SAR image. Yellow star represents the interpreted location of the magmatic center, at 17.6° E, 16.1° S.

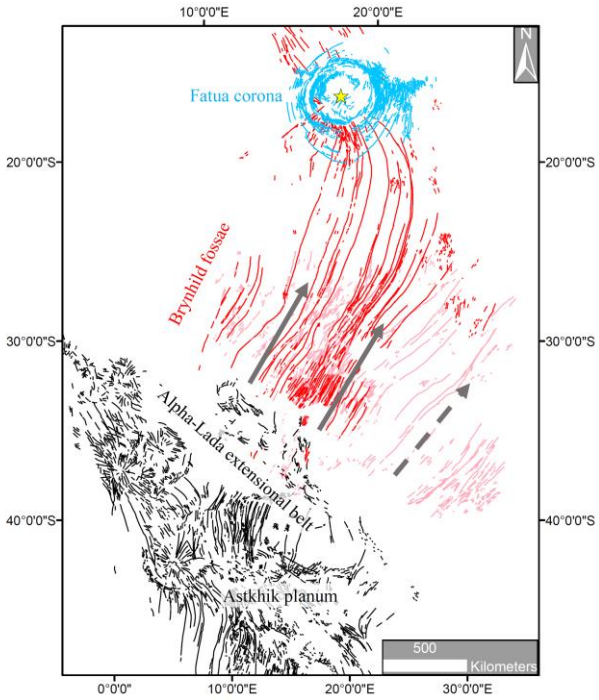

Figure 2: Mapping of radiating (red) and circumferential (blue) graben-fissure systems associated with Fatua corona, rift and corona structures associated with the Alpha-Lada extensional belt (black; after [5]) and NE-trending graben-fissures of unknown association (light red). Grey arrows represent the orientation of σ_1, interpreted from the geometry of the radiating system associated with Fatua corona; arrows are dashed in uncertain areas. Yellow star represents interpreted magmatic center of Fatua corona (17.6° E, 16.1° S).