ATLA REGIO (VENUS) PLUME HEAD STAGE: INSIGHTS FROM ITS DYKE SWARM HISTORY. H. El Bilali[1,2], R.E. Ernst[1,2], K.L. Buchan[3], J.W. Head[4], [1]Department of Earth Sciences, Carleton University, Ottawa, Ontario, Canada; hafidaelbilali@cunet.carleton.ca, [2]Faculty of Geology and Geography, Tomsk State University, Tomsk, Russia, [3] 273 Fifth Ave., Ottawa, Ontario, Canada, [4]Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, Rhode Island, USA.

Introduction: Part of the BAT region, Atla Regio is the locus of triple junction rifting with the larger rifts extending to the ENE, SW and SE to connect with other regios. Dali Chasma is a 4000 km long rift system extending SW from Atla Regio (Fig. 1).

Atla Regio represents a major mantle plume concentration featuring multiple volcanic centres (notably Ozza, Maat and Ongwuti Montes, and likely also Sapas Mons), associated coronae, topographic highs, a geoid high and radiating rift system (Fig. 1), all classic signatures of Large Igneous Province (LIP)-style magmatism associated with an active mantle plume (e.g., [1-3]) (Fig. 1). Comparable LIP magmatism on Earth consists of major volcanism in the form of shield and plateau basalts, and giant radiating and circumferential dyke swarms (e.g. [4-5]). Dyke swarms on Venus are expressed as sets of long narrow grabens (and also pit chains) inferred to overlie blind dykes that were, for the most part, laterally emplaced (e.g., [6-7]). There have been several detailed studies of graben systems (interpreted in the context of dykes) in multiple regions of Venus (e.g., [8-11]) and other planetary bodies (e.g., [12-13]).

Dyke Swarms and Magmatic Centres of Alta Regio: We undertook detailed mapping of graben systems across Atla Regio in order to distinguish different radiating, circumferential and linear graben sets (interpreted to mark dyke swarms) and link them with their magmatic centres.

Initial mapping of the graben interpreted as dykes is shown in Figure 2, with about 34,000 lineaments traced to date. Preliminary analysis of the data (Fig. 3) suggests that there are giant radiating and circumferential graben (dyke) systems linked to the four mons (Maat, Sapas, Ozza, Ongwuti), Zemina corona, and unnamed magmatic centres. Grabens from Ongwuti Mons, Unnamed (labelled as such) magmatic centre, Maat and Ozza montes extend for hundreds to thousands of kilometers from the centres, with the Ozza Mons dykes reaching more than 2000 km.

Locating the Plume Centre and Plume Head Size: Based on the transition distance from radiating (due to the underlying plume head) to linear (due to dominance of the regional stress field), Ongwuti Mons has a similar plume head radius to that of Maat Mons (about 600 km), whereas the Unnamed centre south of Ozza Mons has an inferred plume head radius of 200 km. The inferred plume size for Ozza Mons is the largest, with an inferred plume head radius of 1200 km (Fig. 4) [e.g., 14-15]. The plume heads of the other three are all enclosed with the extent of the Ozza Mons plume head. In addition, Sapas Mons is located at the edge of the outer boundary of the Ozza Mons plume head and could therefore also be related to it. On this basis all could be related to a single large plume centered on Ozza.

Age Relationship Based On Cross-Cutting Relationships: Cross-cutting relationships between dykes and flows suggest that Ongwuti Mons is older than the Unnamed centre, which is older than Ozza Mons. All three centres are aligned along a SW-NE trend suggesting a rift link (Fig. 5). In addition, these age relationships suggest that Maat Mons is younger than Ongwuti Mons and the Unnamed centre. The grabens of Maat Mons appear older than Ozza Mons flows, but younger than the Ozza Mons dykes. Sapas Mons is interpreted to be younger than Maat Mons. More analysis is required to confirm the relative ages.

Discussion:

Testing Plume Tail Model:

The large size of the radiating swarms associated with Ozza, Ongwuti, Maat, and Unnamed centres are consistent with plume head, but not with plume tail magmatism (which consists of a protracted but lower flux of volcanism and corresponds to smaller volume flows and much shorter dyke swarms). Furthermore, the absence of any other candidates for plume tail magmatism would suggest that Atla Regio is still at the plume head stage (suggesting an age < 50 myr), consistent with the observed active volcanism along the Ganiki Chasma rift system [3] that extends northward from Atla Regio.

Explanation of Age Progression of Magmatic Centres: If all the magmatism is at the plume head stage, then an explanation is required for the presence of multiple distinct centres and their age progression. We consider possible models involving: 1) shifting of the lithosphere above a stationary plume, 2) shifting of a plume, 3) lithospheric controls (including zipper-style rifting [16]) on changing location of centres above a stationary plume, and/or 4) breakup of the plume head during ascent into smaller plumes/diapirs.

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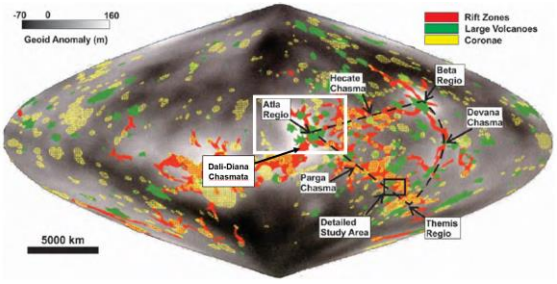

Figure 1: *Study area located in Atla Regio, the locus of triple junction rifting with the larger rifts extending to the ENE, SW and SE to connect with other regios. Base-map after [17].*

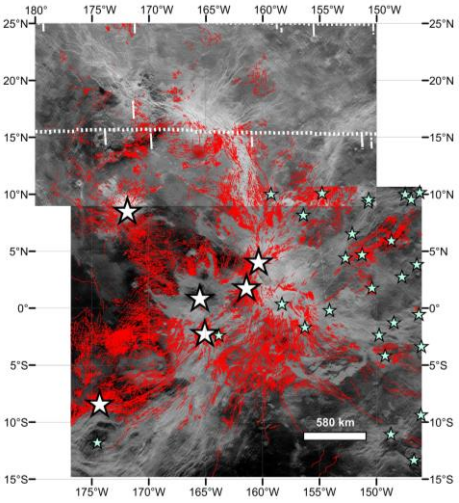

Figure 2: Radiating, circumferential and linear *graben systems of Atla Regio inferred from mapping of about 34,000 lineaments to date. Large /small stars mark major / minor magmatic centres.*

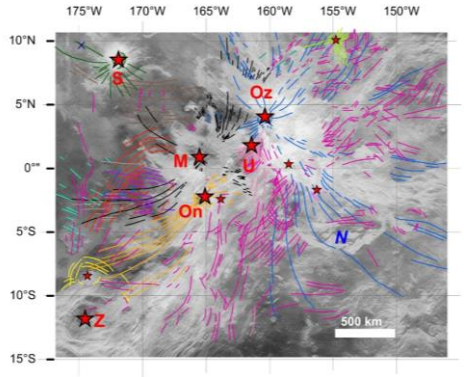

Figure 3*: Generalized distribution of graben systems (interpreted as dyke swarms) of Atla Regio. Stars represent known and unknown magmatic centres. S: Sapas Mons, M: Maat Mons, Oz: Ozza Mons, On: Ongwuti Mons. Z: Zemina Corona, and the remaining stars represent unknown magmatic centres. N: Ningyo Fluctus.*

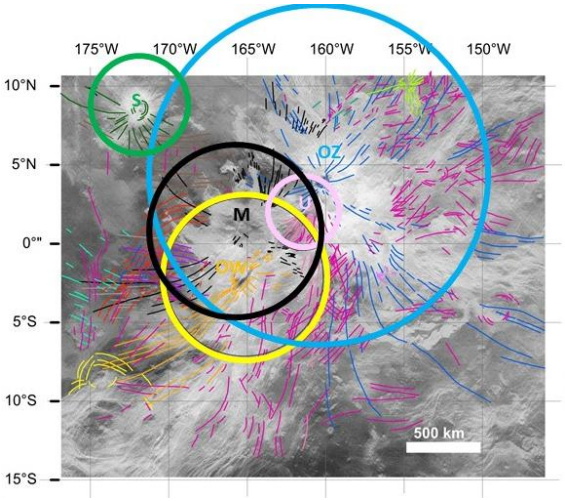

Figure 4*. Plume head size estimates for Maat Mons (M), Ozza Mons (Oz), Ongwuti Mons (On), Unnamed centre (U) and Sapas Mons(S) (from Fig. 3) showng that all can be approximately enclosed by the plume head for Ozza Mons.*

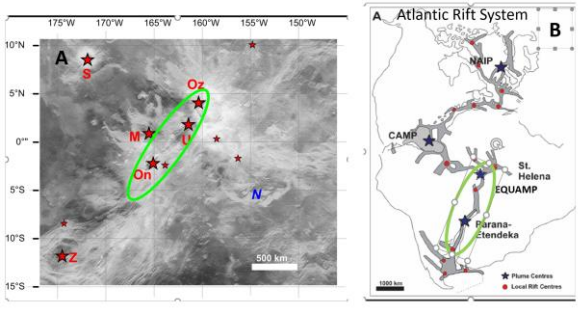

Figure 5: *A). Alignment of Ongwuti (On), Unnamed centre (U) and Ozza Mons (Oz). B) Comparison with incipient rifting of the South Atlantic in association with multiple ca. 130 Ma plume centres [11].*