MAPPING RECENT ACTIVITY ON VENUS: STRESS FIELD ANALYSIS AND MODELS OF EVOLUTION FOR TECTONO-MAGMATIC FEATURES IN SW PARGA CHASMA

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Introduction: Detailed mapping and analysis of Magellan imagery at a south-easterly segment of the Parga Chasma Rift System (PCRS), proximal to Themis Regio, has unveiled a series of coronae associated with rift development, which have a complex geological history. The earliest evidence of volcanism includes cold, inactive coronae with thickened margins which are difficult to rift, causing the PCRS to deflect around them and over thinned lithosphere at active corona centres. The simultaneous emplacement of younger tectono-magmatic features and rifting causes interactions between radial magmatic stress fields and regional extensional stress fields, which create distinct sinuous graben-fissure morphologies.

Methods: Previous mapping efforts have often focused on grouping lithologic units by their geomorphology and likely formation process, e.g., rift zone and lava flows, or by separating coronae by their morphology [1, 2], or by classifying coronae according to activity level [3]. Much has been learned through geophysical modelling of the topography associated with coronae [4] as well as their connection with mantle plumes [5]. Detailed stratigraphic and structural analyses employed here, facilitated by mapping primary material units separately from the secondary structures that deform them, have proven successful in deriving a geological history of Parga Chasma on a regional scale and in developing evolutionary model cartoons to explain tectono-magmatic feature variability across the region.

Tectono-magmatic evolution: These analyses are consistent with published models [6] which predict radial graben-fissures to increasingly propagate, orthogonal to the regional stress field, with increasing distance from the magmatic centre as the strength of the radial magmatic stress field decreases and that of the regional stress field increases. Additionally, graben-fissures between neighbouring tectono-magmatic features preferentially align parallel to the strike line connecting the centres of the two features, due to interaction of the radial compressive stress fields associated with the centres [7].

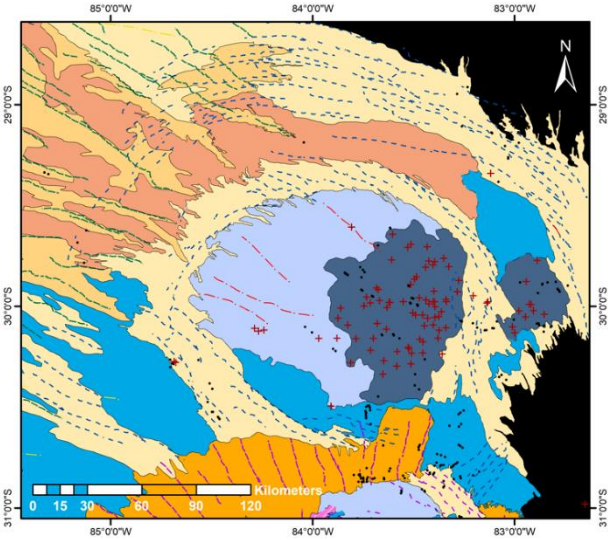

Figure 1: *A subset of the geological map depicting Gertjon Corona. Blue units are plains and shield clusters; yellow-orange units are deformed volcanic terrain; red crosses mark the centres of shield volcanoes; black dots mark the centres of pit craters.*

Central topographic highs are observed at five tectono-magmatic features, indicating an active stage of evolution and ongoing geological activity. Pre-rifting formations are suggested at Obiemi and Gertjon Coronae (Figure 1). Flux from a plume tail connecting to a secondary magma reservoir is proposed to keep the observed central highs supported at these coronae. A decreasing flux is hypothesised at Gertjon Corona, leading to preferential edifice eruptions which become increasingly centralised as the underlying plume freezes (Figure 2) [8]. Contrastingly, stratigraphic and stress field analyses attribute the sinuosity of graben-fissures to the post- or coeval formation of Xmukane Corona, UC1 and Ts and Nu Mons with the PCRS. Extrusive volcanic activity at Gertjon Corona is thought to be waning, whilst radar dark (young) lava flows occupying the circumferential troughs at Obiemi and Xmukane Coronae are interpreted to be sites of ongoing activity. The central high and early evolutionary stage of Ts and Nu Mons suggest current extrusive magmatic activity.

Coronae evolutionary models: The region is characterised by very few mappable lavas, but its complex and variable network of fractures and lineaments are evidence of a complex stress-field which may be indicative of waning or incipient activity. Analysis of the distributions and patterns of lineaments and tectonic units has permitted the construction of evolutionary models for Gertjon Corona, Xmukane Corona and UC1, and the development of a relative chronology for the region. These indicate that plume development may be past its peak but that, despite this, more centralised minor lava eruption could still be expected. The topography, geomorphology, and structure of PCRS along with its proximity to Themis Regio [9] suggests that we should expect recent activity and that higher resolution imaging by the forthcoming missions, some 40 years after Magellan, could reveal new lava flows and/or ongoing activity. Better DEMs (Digital Elevation

Models) and repeated imaging, at multiple polarisations, and at high resolution are needed to provide a detailed picture of the geology, surface conditions and topographic variations of this dynamic region of Venus.

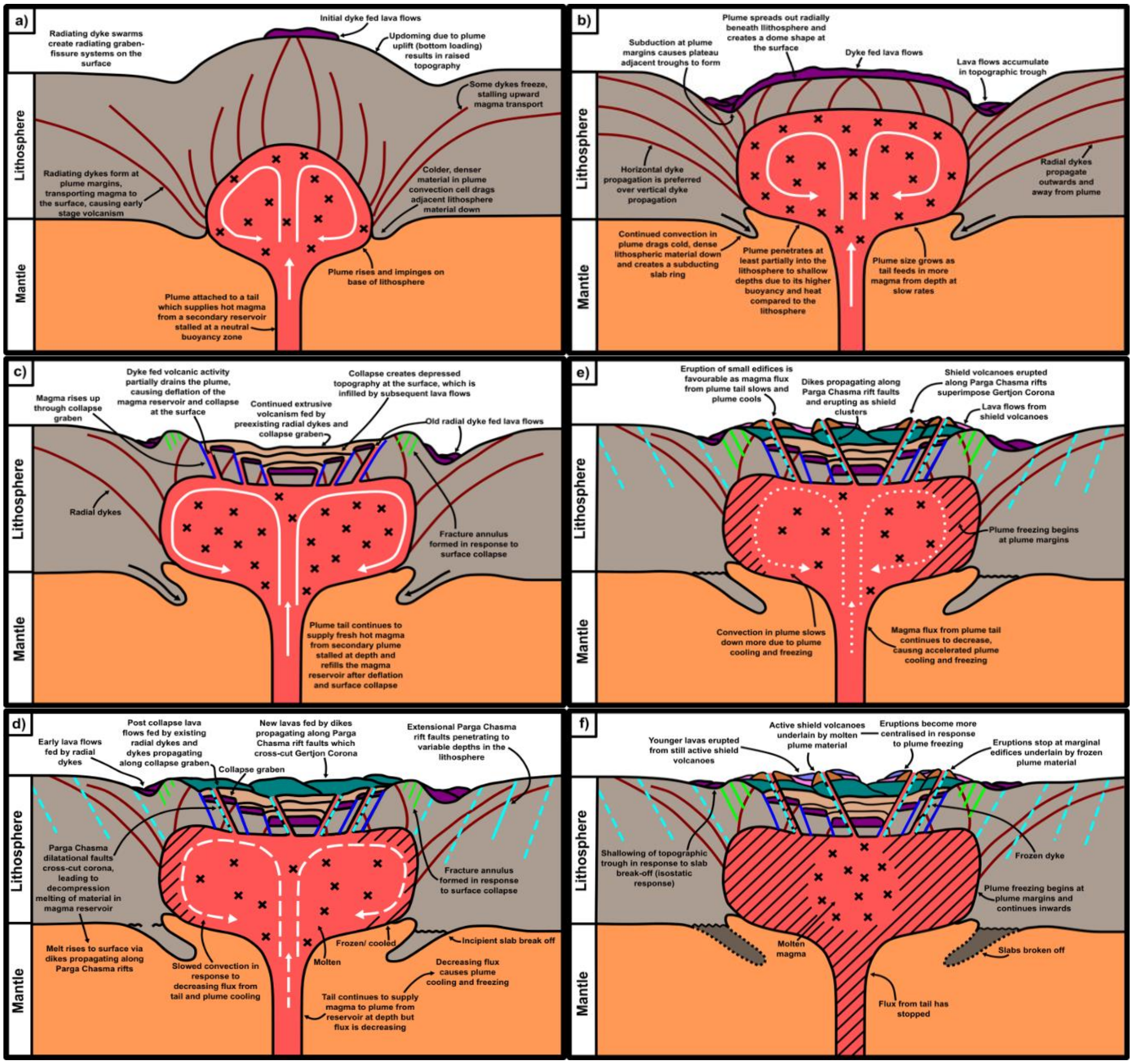

Figure 2: *The evolution of Gertjon Corona: a) Plume impingement and partial penetration into the lithosphere, generating updoming and radial dyking. The tail connects plume to a secondary magma reservoir stalled at depth. Flux from plume tail is decreasing with time; b) Plume spreads out radially, creating a plateau-like topography at the surface. Dyke fed surface volcanism occurs; c) Plume becomes drained due to dyke fed surface eruptions, causing surficial collapse. Plume reflates due to magma flux from tail and eruptions continue via collapse graben and pre-existing radial dykes; d) Parga Chasma rifts over Gertjon Corona. Dykes propagate along rifts, causing surface eruptions. Flux from tail decreases further, causing the onset of plume freezing; e) As flux from plume tail decreases and plume freezing continues, edifice eruptions along Parga Chasma rifts are favoured; and f) Plume tail freezes/ is cut off from secondary magma reservoir. Plume freezing continues, causing eruptions at edifices overlying plume margins to cease and eruptions towards the plume centre to continue. Edifice eruptions therefore become more centralised with time.*

References: [1] E Stofan et al. (1991) *Journal of Geophysical Research*, *96*, *20,933-20,946*. [2] M. Ivanov and J. Head (2015) *Planetary and Space Science* 113-114, 10-32. [3] A. Gulcher (2020) *Nature Geoscience* 13.8, 547–554. [4] S. Smrekar and E. Stofan (1997) *Science*, 277, 1289-1293. [5] E. Stofan and S. Smrekar (2005) In *Plumes, Plates and Paradigms*, G. Foulger, J. Natland, D. Presnail and D. Anderson Eds. [6] K. Nakamura (1977) *Journal of Volcanology and Geothermal Research*, 2.1, 1–16. [7] D. McKenzie et al. (1992) *Journal of Geophysical Research: Planets,* 97, 15977–15990. [8] J. Head and L. Wilson (1992) *Journal of Geophysical Research: Planets* 97, 3877–3903. [9] E. Stofan et al. (2012) *AGU* (invited talk), abstract P24B-01.