ANALYSIS OF CORONAE IN THE PARGA CHASMA REGION, VENUS. P. Martin[1], E. R. Stofan[2] and L. S. Glaze[2]. [1]Department of Physics, University of Cambridge, Cavendish Laboratory, Madingley Road, Cambridge CB3 0HE, UK (paula.martin@phy.cam.ac.uk), [2]Proxemy Research, 20528 Farcroft Lane, Laytonsville, MD 20882 USA (ellen@proxemy.com; lori@proxemy.com).

Introduction: Parga Chasma is a 10,000km long fracture and trough system extending from Atla Regio to Themis Regio in the southern hemisphere of Venus [1, 2]. The Parga system consists of a main NW-SE trending chasma with 14 branching segments, each of the segments having coronae along their length. The trough, fractures and coronae of the Parga system form a zone of deformation that ranges from ~150 to >400km wide. Parga and other chasmata systems are thought to result from regional extension accompanied by upwelling to form coronae [1-4]. As most coronae are located along rift systems [2], analysis of chasma coronae may further constrain the origin and evolution both of coronae and of the chasma systems. Following an earlier preliminary study [5, 6] we examine the variations in size, topography, annulus characteristics, associated volcanism, relative location and relative timing of corona formation with respect to rifting along the Parga system. We analyse 131 coronae, including coronae along the chasma as well as those up to 1,500km away from the rift.

Spatial analysis: Parga Chasma forms one of the boundaries of the "BAT" (Beta-Atla-Themis) region, which has a high concentration of volcanic features, including coronae [1, 2]. While it has been noted that many coronae form along chasma systems [2], we wanted to analyze whether coronae in the Parga region were simply concentrated regionally, or whether they are actually concentrated along the fracture and trough system. We performed a statistical analysis of the Parga corona distribution, to determine whether the rift trends could be uniquely identified, or if the corona were randomly located within the region, as described below.

A statistical study can be used to investigate whether coronae form in a spatially systematic way or whether their relative locations are essentially random. All that is needed to perform the statistical analysis is a planform map of the region of interest with the locations of each and every corona within the region clearly identified. Based on simple visual inspection of the Magellan FMAP data, it appears that coronae may tend to cluster along the rift and trough system of Parga Chasma. However, truly random spatial distributions should exhibit some clustering; uniformly spaced features are not randomly distributed. In order to test whether the apparent clustering of coronae is significant we compared corona locations to the Poisson probability distribution. If the spatial distribution of coronae within the region of interest is significantly different from the Poisson distribution, we can conclude that there is some systematic behaviour controlling their occurrence. Alternatively, if the spatial distribution is indistinguishable from the Poission distribution, we must conclude that coronae occur randomly. This technique is described in greater detail elsewhere [7]. We have found that the locations of coronae within the Parga region are very well described by the Poisson distribution, and must therefore conclude that they are randomly located.

Corona timing: We examined the relationship between the coronae along Parga Chasma and any local segments of the Parga rift system, using Magellan FMAP and stereo images, to determine whether the formation of each individual corona pre-dates, post-dates, or is synchronous with the formation of the rift segment. Our aim was to use the available evidence to further develop our understanding of the evolution of the surface in this region. The relative timing of 55 of the coronae could not be determined because they are located off the rift, and that of a further 7 coronae could not be determined because they are located on Themis Regio and are not directly in contact with a rift segment. Of the remaining 69 coronae for which the relative timing could be determined, the vast majority (86%) are clearly active synchronous with the rift. However, almost half (48%) of the coronae located along the rift show some activity that pre-dates the rift. Only 26% of coronae along the rift show evidence of activity that post-dates rifting. No clear trend in relative timing of corona formation with respect to rifting is identified.

Corona volcanism: We examined the coronae in the Parga region using Magellan FMAP and stereo data to determine the amount of volcanism that could be clearly associated with each of the coronae. 61% of the coronae in this region have small amounts of associated volcanism, while 21% have moderate amounts, and 18% have high amounts. There is some correlation between corona topography and amount of associated volcanism: domes and plateaus generally have high amounts of associated volcanism; depressions and rimmed depressions generally have low amounts of associated volcanism. Volcanism in this region is dominated by flows from 10 large coronae, with volcanism highest on Themis Regio. Only 2 large volcanoes have been identified within the Parga system.

Discussion: It has been suggested [8] that volcano chains such as those in the Pacific can form in the presence of tectonic tensile stress by magmatic hydrofracture at local tensile maxima of flexural and membrane stresses. The process can be initialized by flexural stresses associated with a single volcano, and will continue as long as the region is underlain by a large source of partial melt. Without an applied tectonic stress, a wide pattern of volcanoes is seen. With an applied tensile tectonic stress, a narrow chain of volcanoes is produced [8]. In a thin plate case, where the amount of deflection is significant compared to the elastic thickness, that membrane stresses must be taken into account. In this case, multiple lines of volcanoes tend to be produced [8]. It has been found that the size of the eruptive region is controlled by the elastic response to magma overpressurization, with single, narrow lines of volcanoes indicative of narrow magma source regions [9]. Our statistical analysis of the distribution of coronae has not identified any distinct chains of volcanoes or coronae. The random distribution of the coronae in the Parga region may therefore be interpreted as the result of the absence of an applied tectonic stress and the absence of any significant membrane stresses.

The fracture patterns at coronae have been modelled as resulting from stresses produced by an upwarp or a cylindrical surface load [10]. Each model produced a distinctive set of fracture patterns, with upwarp under extension producing graben that would bow in towards the feature and a surface load in extension producing interior compression accompanied by graben that bow around the feature. Both models under compression predicted associated compressional lineaments. We compared each of the Parga coronae to the patterns predicted by these models [10]. 51% of coronae analysed in this study showed patterns of surface fracturing that are consistent with those predicted to result from upwarp and regional extension. Only 6% of coronae analysed in this study showed patterns of surface fracturing that are consistent with that predicted to result from a surface load. Unfortunately, the remaining 43% of coronae analysed in this study could not be compared with model predictions because of the complexity of the local surface geology.

Conclusions: Coronae occur randomly within the Parga region. The locations of individual coronae within the Parga region are not constrained by the location of the rift. Similarly, the location of the rift does not appear to be constrained by the location of coronae. As there is no spatial relationship between the coronae and the rift, we find no evidence that rifting controlled corona formation or vice versa. By comparison with models [8, 9], the random distribution of the coronae in the Parga region may be interpreted as the result of the absence of either an applied tectonic stress or the absence of any significant membrane stresses.

However, we do find some evidence for regional extension. The patterns of surface fracturing observed for the majority of coronae in this study are consistent with those produced by stresses resulting from model upwarp and regional extension [10]. Previous studies have suggested that coronae forming along rift zones have increased amounts of volcanism [e.g. 11]. Along Parga Chasma, we find that the amount of volcanism at coronae varies widely.

Analysis of 131 coronae in the Parga Chasma region suggests that these coronae differ in both annulus characteristics and topography from the total corona population [12]. As at topographic rises [14], there are coronae both along the chasma and in the surrounding plains that have shapes that are consistent with those predicted by models of corona formation that include delamination of the lower lithosphere [13]. Although there is no clear correlation between size, annulus characteristics or relative timing with respect to local rifting and location, general trends in topography and volcanism are associated with some rift segments. In addition, domes and plateaus generally have high amounts of associated volcanism, while depressions and rimmed depressions generally have low amounts of associated volcanism. There is no clear progression in age along the Parga Chasma system, consistent with findings at Hecate Chasma [3].

Although coronae are randomly distributed within the Parga region, they are clearly concentrated in the BAT region with respect to the rest of the planet. This concentration of coronae suggests that some broad-scale process has influenced the surface evolution of the entire BAT region. Further work on this is required.

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