POSSIBLE FORMATION MODELS OF VENUSIAN MULTIPLE CORONAE AND AGE RELATIONSHIPS BETWEEN THEIR COMPONENT STRUCTURES.
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Introduction: Coronae are volcano-tectonic structures with concentric and/or radial structures and associated volcanic features with diameters ranging from 100 km to more than 1000 km [e.g. 1-4]. Coronae are thought to form as a result of buoyant mantle diapirs deforming overlying lithosphere [e.g. 3-8]. Currently we identify 62 multiple coronae [9], including 8 multiple arachnoids. The numbers have changed during the course of this study (compare with e.g. [10, 11]), because we have dropped some structures out of the list and included new ones based on the closer study and mapping of the features. 43 multiple coronae are Type 1 and 19 Type 2 coronae (Type 1 and 2 as defined in [12]). We have looked more closely at the structural and geological characteristics of the multiple coronae and their relations to topography in an attempt to test different formation models. We have also attempted to establish age relationships between the component parts of each multiple corona. Here we present some preliminary results form this ongoing study.

Methods: We have analyzed the main structures and units of the multiple coronae, their relation to topography (e.g. how concentric and radial ridges and fractures are located with respect to topography (topographic rims, interior lows or highs, outer troughs etc.). We used Magellan left-left and left-right stereo images where available and synthetic stereo images elsewhere (if altimetry data was available and of reasonably good quality) [13]. We have done some coarse geologic mapping of about 50% of the multiple coronae (usually based on Magellan C1-MIDR radar images [13]) and more detailed geological mapping of representative coronae of each morphological class [9] using standard photogeologic methods and Magellan C1-MIDRs, F-MIDRs and F-MAPs (about 10 coronae to date). We are in the process of mapping more multiple coronae in detail.

We also tried to establish age relationships between component structures of the multiple coronae from structural and topographic observations, i.e. can we find out which component part of e.g. a 2-part multiple corona started forming earlier or evolved longer than the other.

Results and Discussion: *Formation models.* Multiple corona formation models include: 1) Movement of the lithosphere over a stationary mantle plume [3, 14], 2) migration of a mantle plume or diapir under the lithosphere [3], perhaps by lithospheric channeling of the diapir [14], 3) emplacement of several spacially close diapirs [15] either more or less synchronously or in succession (which may not be apparent from structures or topography of the resulting multiple corona) [3,15], 4) a secondary diapir arising from a larger diapir [15], 5) emplacement of an elongated diapir where diapir shape may have been influenced by the crustal/lithospheric structure, e.g. a zone of weakness, and/or stress field.

Model 1 can be ruled out because Venus appears to be a one-plate planet (at least for the past 500-1000 m.yr.) where surface horizontal movements have been small [e.g. 16].

Our observations and interpretations of the multiple coronae structures and geological histories give some (preliminary) results concerning possible formation models. For many multiple coronae, and especially for many coronae in morphological classes A, B, E and F [9], model 3 appears to be most simple and plausible formation mechanism. This is especially true for those multiple coronae where component structures have different topographic morphologies [10] (currently 28 (47%) multiple coronae out of 60; 2 multiple coronae are not covered by altimetry data and their topographical classification is therefore not possible [10]). However, there are multiple coronae where lithospheric channeling [14] could have played a role. We are still evaluating these models based on more detailed mapping and observations of the multiple coronae.

Lithospheric channeling and secondary diapirs may explain shapes and some topographic characteristics of Class D [9] multiple coronae. A few multiple coronae of Class C may be explained by model 5, but formation by multiple diapirs cannot always be ruled out.

Age relationships. We have also attempted to establish the age relationships of the component parts of the multiple coronae we have studied. In roughly about 45% of the cases the relative age sequence cannot be established with any confidence. In about 55% of the multiple coronae the age relationships can be inferred, although often with some considerable uncertainty, or at least partial age relationships can be established, for example in a 3-part structure we can say that one of the structures is younger than the other two, but we may not be able to tell which of the other two parts is older or younger than the other one.

Also, sometimes we may be able to tell that at least the latest volcanic or deformational activity in one part occurred later than in the other part(s), but we cannot say which component part started forming first. We anticipate that with more detailed mapping we may be able to establish age sequencies more reliably but not for all multiple coronae.

It is also interesting to note that most of the Class E and F multiple coronae (multiple coronae with 3 or more component structures, respectively) are not chains of structures but rather clusters. In more chain-like multiple coronae (Classes E2 and E3 [9]) where some age relationships can be seen, the age relationships do not imply systematic difference in the direction of the the chain, but rather the middle structure in a 3-part multiple corona is observed to be more likely of different age than the other two structures (often superposed on the other two and therefore younger). This also indicates that Venusian lithosphere has not moved significantly horizontally during the formation of these multiple coronae.

Conclusions: Observations and interpretations of the geological and topographical characteristics of the multiple coronae indicate that there are probably more than one formation mechanism for the multiple coronae. For each multiple corona we can constrain possible formation models, but in many cases we cannot definitely say that only one formation model is possible for the multiple corona in question. Formation by emplacement of several closely spaced diapirs seems to be the most common and simplest mechanism, although also lithospheric channeling may have played a role in several cases.

Morphological class of the multiple corona does not seem to correlate directly with a specific formation model, although multiple coronae of Classes C and D may have had more constrained formation mechanisms.

We have attempted to establish the age relationships of the component structures of the multiple coronae. In more than half of the multiple coronae this can be done, at least partly, but often with some uncertainty. We are continuing mapping the multiple coronae in more detail to try to constrain their formation mechanisms and evolutionary histories more fully. We are also looking at the relationships between the multiple coronae and local and regional geology (especially tectonic structures) in order to gain more insight into how local and regional characteristics (sress fields, earlier or contemporaneus crustal structures etc.) may have affected multiple corona formation.

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