SIZE DISTRIBUTION OF YOUNG AND OLD CORONAE ON VENUS,

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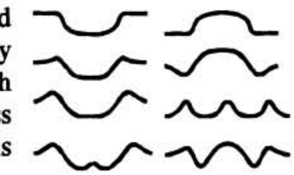
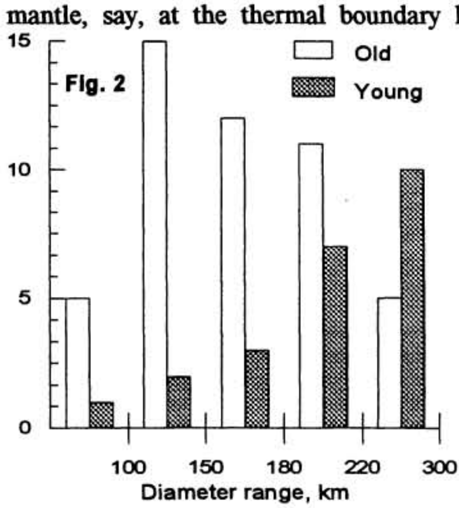
Topography of small coronae (<300 km in diameter) in planes of Venus was surveyed to assess whether each corona is young or old according to conventional scenario of corona formation. Size frequency distribution of young and old coronae was obtained. It was compared with a model for corona population. The model was based on the supposition that the flux of corona-forming diapirs was steady during population formation. Observations showed shortage of small young coronae in comparison with the model under any reasonable set of parameters. It points that convection style of upper mantle has been changing during formation of aparent surface.

Observations. Coronae on Venus are usually thought to be a surface expression of mantle diapirs or plume heads. Ascending of diapirs cause updoming of the surface, so at early stages of their formation coronae have generally elevated topography [1]. Then the diapirs flatten beneath the lithosphere and cool. This cooling causes thermal shortening, which leads to formation of generally depressed topography of coronae. So, studying topography it is possible to distinguish "young" and "old" coronae. In this study coronae listed in [2] were surveyed to assess whether they are young or old. Typical topographic profiles of coronae classified in this study as young and old are schematically shown in **Fig. 1.**



Old **Fig. 1** Young

Aiming to apply statistics of young and old coronae for the resurfacing history we need an estimation of coronae youth duration, that is duration of preservation of uplifted topography. It is possible only unless coronae were supplied with additional portions of overheated material during this period. Estimations [3] showed that diapirs forming large coronae probably originate at the core-mantle boundary, where liquid core can provide effective continuous supply of a mantle plume with heat. Morphology of some large coronae bears evidences of continuing episodes of tectonic activity. The estimations showed that small coronae cannot be formed by plume heads ascended from the core-mantle boundary. Their sources are located somewhere inside the mantle, say, at the thermal boundary layer above upper/lower mantle discontinuity. Sources of overheated material inside the mantle cannot provide continuous feeding of diapir body in contrast with sources at the core-mantle boundary. To be sure in absence of additional portions of heat supply I considered only coronae of diameter of 300 km or less.



Coronae genetically related to rift zones barely can be described by the simple scenario of formation. Therefor only coronae located in plains were included into the survey. Topography of some coronae showed no correlatiòn with features observed in SAR images. In these cases original topography apparently was destroyed or distorted by some later tectonic processes. These coronae also were excluded. Finally, assessment of a few coronae was impossible because of gaps in Magellan topography data. Among remained 71 features 23 were assessed as young and 48 as old. **Fig. 2** shows number of young and old coronae in 5 diameter bins. Note that the first bin (100 km in diameter and less) contains few features and statistics are poor.

Model of corona population. Existing models of corona formation [1, 4, etc.] do not describe the process quantitatively and in details. However very rough estimations of time scale of corona evolution can be made. Early stages of corona formation include intensive tectonics and heat loss through volcanism and take short time in comparison with following gradual conductive cooling of the diapir body. Duration of this cooling actually gives the time scale t of preservation of general uplift associated with the corona. For this time scale following dimension estimation could be applied: $t = H_e^2 / k$, where H_e is typical depth of overheated material and k is thermal conductivity. The depth scale H_e consists of depth H of a layer that separates the surface and overheated body (say, thickness of the lithosphere) and typical thickness of the overheated body itself. Laboratory

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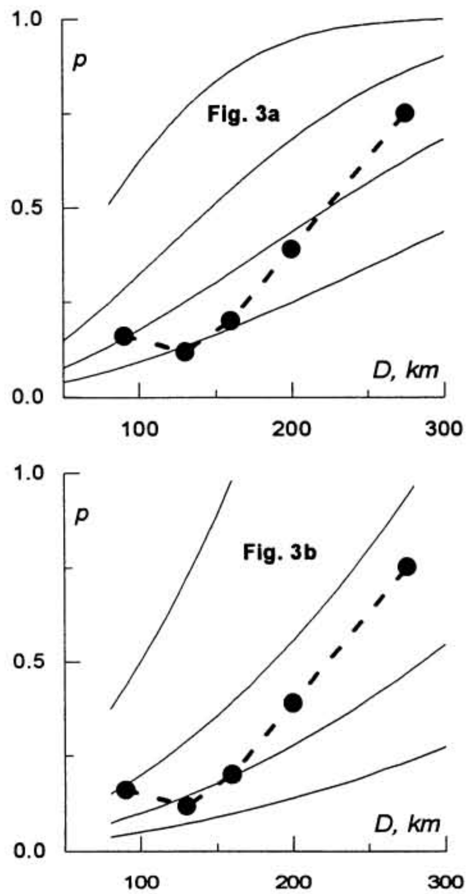
experiments [5] have showed that a diapir stalled by a lid spreads twice, that imply the thickness of flattened diapir to be about 1/8 of corona diameter D. It gives the final estimation:

$$t(D) \approx (H + \tfrac{1}{8}D)^2 / k \qquad (1)$$

Let diapir flux and frequency distribution of diapir diameters were stable during entire time T of formation of the apparent surface and initially the surface had borne no coronae. Assume the probability $g(D)$ to be erased during certain period does not depend of corona age and on time. Under these assumptions the fraction of young coronae $p(D)$ does not depend on corona formation rate and can be expressed as:

$$p(D) = \frac{1 - \exp(-g(D)\,t(D))}{1 - \exp(-g(D)\,T)} \qquad (2)$$



In **Fig. 3** fractions of young coronae in each of 5 diameter bins are plotted against average diameter of coronae in the bins. In **Fig. 3a** observations are compared with a family of curves of the dependence $p(D)$ according to formulae (2) and (1). In calculation it was supposed that $H = 5$ km, $T = 500$ Ma, $k = 0.005$ cm^2/s, g does not depend on D. Different curves correspond to different values of g. It is seen that observed dependence $p(D)$ is steeper than predicted by the model under taken set of parameters. Increasing of H makes the model dependence much less steep. Rate of corona erasing $g(D)$ hardly can increase with increasing of D. If $g(D)$ decreased with increasing of D, the model dependence $p(D)$ would also be less steep in comparison with constant g. The only possibility to make the model dependence $p(D)$ steeper is to take smaller T and g.

In a limit case $g = 0$ (corona erasing is turned off) $p(D) = t(D) / T$ (when $t(D) < T$). In **Fig. 3b** observed $p(D)$ is compared with this limit case for $H = 5$ km and different T. Some agreement between observed and modeled dependence is seen, meanwhile, taking reasonable values of H, say, $H = 10$ km makes model curves much less steep. To fit observed data in Fig. 3b it is necessary to adopt low values of T, say, $T = 100$ Ma or less. It would mean that whole corona population is rather young and corona formation would have started much later than most of plains had formed. It contradicts global stratigraphic relations on Venus [6].

Discussion. Comparison of observations with the model led to conclusion that rate of corona formation could not be stable during the last 500 Ma. Prominent shortage of young small coronae is observed. Main imperfection of our observations is that the list of coronae [2] is incomplete. However among coronae and corona-like features that are not included in the list fraction of young coronae is not likely to be higher than among listed features. Main imperfection of our model is very rough estimation of degree of flattening of diapirs beneath the lithosphere, because the results are sensitive to this quantity. Moreover, this degree can depend on diapir size. However, if the dependence does exist, the degree is higher for larger diapirs, that leads to excess of young small coronae. The same results from stronger thinning of the lithosphere above larger diapirs.

Shortage of young small coronae can result from general ceasing of corona-forming diapir flux. Another possibility is changing of size distribution of the diapirs. Both means that thermal regime or convection pattern of upper mantle has been changing since formation of observed corona population began. For example, general decreasing of superadiabatic thermal gradient across upper mantle can cause both general decreasing of diapir flux and shift of diameter distribution toward larger diameters.

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