RELATIONSHIP OF CORONAE, REGIONAL PLAINS AND RIFT ZONES ON VENUS. A. S. Krassilnikov[1,2,3], V.- P. Kostama[2], M. Aittola[2], E. N. Guseva[1,3] and O. S. Cherkaschina[1,3], [1]Vernadsky Institute, 119991, Moscow, Russia, kras@geokhi.ru, [2]University of Oulu, Astronomy, Department of Physical Sciences, P.O. Box 3000, FIN-90014, Finland, [3]Moscow State University, 119992, Geological Department, Moscow, Russia.

Introduction: Coronae are large radial/concentric volcano/tectonic structures on Venus [1-4] with diameters of 100 to over 1000 km. Coronae have varied topographical shapes; radial and concentric fracturing and compressional tectonic structures for their annulae are common, as well as massive volcanism [1-4]. Coronae are interpreted to be the result of updoming and fracturing on the surface due to interaction of hot mantle diapirs with the lithosphere and its subsequent gravitational relaxation [1-9]. According to the most detailed catalog [10] there are 514 coronae on Venus. Coronae have been classified into two types [10]: Type 1 - coronae that have annuli of concentric ridges and/or fractures, and type 2 that have similar characteristics to type 1 but lack a complete annulus of ridges/fractures. Few authors interpreted, that most coronae predate formation of regional volcanic plains with wrinkle ridges (PWR) [11,12], which have been argued to be usable as a general stratigraphic marker for Venus [13-16].

Two types of rift structures on Venus were subdivided [17-18]: 1) rifts (chasmata) and 2) fracture belts. Both of them were mapped as “fracture belts” or “rifts” by *Price* [19]. *Basilevsky and Head* [20] determined that chasmata cut PWR and fracture belts are mostly embayed by them.

Goals of the study: 1) To specify geology of rift zones on Venus. 2) To study the geology of sample of coronae of both types, we studied 20% of the whole population, each 5th structure from the list [10]. Altogether, 82 coronae of type 1 and 22 of type 2 were studied, in total 104 coronae. 3) To study styles of tectonic and volcanic activity of these coronae and also ages of these activity relative to time of PWR emplacement. 4) To determine time and tectonic relationship of coronae activity with rift zones.

1. Rift Structures.

Our analysis includes: (1) Global and regional photogeological mapping of rift zones at scale 1:50,000,000 [21]. (2) Study of relationship of time of rifts zones activity with time of PWR emplacement.

Interpretation of Key Observation. Our observations are in detail shown in [21], here we present mostly interpretation. Two different age groups of rift zones were subdivided and mapped: (1) old rift zones that predate emplacement of PWR and (2) young rift zones that postdate this event. In most cases young rifts inherit strikes of old rift zones, and old rifts zones are reworked by young rifts. That may imply that axis of rift produced by lithospheric extension were changed in some areas only, and dynamic of mantle upwelling during formation of both types of rifts were approximately the same; consequently rifts are long-lived structures that have period of activity which is comparable with age of PWR. More widespread distribution of old rift zones may be of evidence for two possible interpretation: (1) more active mantle dynamic before formation of PWR and/or (2) lithosphere has reduced thickness before plains formation and it becomes thicker with time decreasing rift activity after PWR formation. This may be circumstantial evidence of the thickening of the Venusian lithosphere with time [22-25].

2. Coronae Structures.

Methods of Study. We studied 20% of the whole population of coronae. Detailed geological maps of 34 typical examples of coronae of both types were also done [26]. For analysis of relationship of coronae with rift structures we used following criteria the same way as previously for novae analysis [6]. In our study we consider corona as rift-connected only if structural association is observed.

Summary of Key Observations. Period of Coronae Tectonic Activity: We used tectonics as primary characteristic for definition of age of corona because these are most determinative processes by corona formation. We estimated the age of all studied coronae using four categories based on relationship of tectonics of coronae with position of PWR: 1) Coronae that tectonically predate PWR (46 coronae, 44%). 2) Coronae that tectonic activity mostly predates PWR (29, 28%). 3) Coronae with tectonics that both predates and postdates PWR, approximately in equal proportion (26, 28%). 4) Coronae with tectonics that postdate PWR: there are no traces of corona tectonic activity before PWR formation (3, 3%). Because single coronae may have had a long period of formation, the most important phase for us is the most active period of them. Thus we have merged the two first types in our analysis. In total 97% of coronae started to form before PWR formation, 72% of coronae were most active before PWR emplacement, 3% of coronae have no traces of activity before PWR. Type 1 coronae (82 structures): 96% started to form before PWR, 69% were most active before PWR emplacement, only 4% started to form after PWR formation. Type 2 coronae

(22): all of them started to form before PWR, 82% were most active before PWR formation.

Time Relationship of Coronae with Rift Zones Activity: We subdivided all studied coronae into two groups: 1) coronae and rifts that were formed simultaneously and have genetic association; 2) coronae which predate or postdate rift zones formation that do not have genetic association with rift formation. Type 1 coronae (82 structures): 10% are associated with young rift zones and 16% are associated with old rift zones. In total 26% of type 1 coronae have association with rift zones and 74% are located outside of rift or predate/postdate rift zones formation. Type 2 coronae (22 structures): There are no coronae associated with young rift zones while 14% are connected to old rift zones. Altogether 14% of type 2 coronae have association with rift zones while 86% are located outside of rift or predate/postdate rift zones formation. Therefore, from all the coronae studied, 8% have genetic association with young rift zones, 15% have genetic association with old rift zones, indicating that 23% have genetic association with rift zones and 77% are located outside of rift or predate/postdate rift zones formation.

Type of Corona-related Volcanism: Shield volcanoes and/or their clusters associate with 77% of coronae of both types, 72% of coronae have shield volcanoes that predate formation of PWR and 10% - shield volcanoes that postdate PWR. Lobate lava flows formation associate with 47% of all coronae and smooth volcanic plains with 40% of coronae.

Stratigraphic Sequence: In all local areas studied the sequence of geological units is generally similar. Our findings are consistent with the model of regular changes in style of predominantly regional to global geological processes in the observed history of Venus [15-16].

3. Interpretation of Results and Conclusions.

Relationship Between Coronae and Rifts. Majority of coronae (77 %) of both types has no genetic association with rifts. That means that coronae–producing mantle diapirism and uplift of mantle material in rift zones are not well correlated in most cases at least in time. Part of coronae (23%) has genetic association with rift formation; it shows, that this part of structures may be formed due to prominence of both types of mantle material uplift – isometric corona-related on background of rift-related linear.

Periods of Activity of Coronae and Rifts. Majority of coronae (72%) were most active before formation of PWR, only 3% begun to form after PWR emplacement. That may have two reasons – decreasing of corona-producing diapirism activity with time and/or the thickening of the Venusian lithosphere with time [22-25]. Evolution of distribution of rift systems with time (decreasing of distribution and localization of rift zones [21]) is also evidence for this model of Venus evolution, caused by lithosphere thickening. Our observation also showed that rift-produced uplift zones probable were mostly stable at least from period of formation of PWR. According to our observations, type 2 coronae are in general older than type 1 coronae and less prominent in tectonics and relief [10]. That may indicate that type 2 coronae may be more covered by later volcanic events, e.g., regional plains formation and/or more gravitationally relaxed than type 1 coronae.

Coronae and Coronae-related Volcanism. Majority of coronae were most active before PWR formation, but almost half of all coronae has traces of post PWR volcanism. It shows that coronae are long-lived structures with complex evolution and some of evolution processes (e.g., tectonics and volcanism) may be distributed in time. Three types of volcanic activity connected to coronae were observed. Shield volcanoes during coronae evolution were mostly active before PWR emplacement. Decreasing of shield volcanoes activity with time supports model of "directional" model of evolution of Venus by *Basilevsky and Head* [15-16], this is in correspondence with the global study of shield volcanoes on Venus [27].

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