Can a Benard-Marangoni Instability Play a Significant Role in Corona Formation Processes on Venus? A Preliminary Study

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Coronae are large-scale volcano-tectonic features with a nearly circular or elliptical shape and regarding their diameter are ranging between 60 and more than 2600 km. Nearly all of them rise up to 1.5 km above their surrounding terrain, possess a raised rim and have associated volcanic and tectonic structures: they include large numbers of small volcanoes and domes, flow deposits, radial, concentric, oblique or chaotic fractures, ridges and grooves. More than 500 Coronae and related structures (Arachnoids and Novae) are identified up to now and exist in a wide range of geologic settings regarding their environment and in relation to each other (double and triple Coronae and Corona-, Arachnoid- and Nova-multiples [1, 2, 3]).

The origin of Coronae and also of Arachnoids and Novae up to now is not fully understood, so a varity of different models based on mantle upwelling or downwelling, rising or sinking diapirism, surface uplifting, gravitational relaxation or a Rayleigh-Taylor instability exist in the literature, but each model only can explain one or two specifically associated features.

Our work investigates the possibility of the existence of a Benard-Marangoni instability in the upper mantle of Venus as a consequence of variations in the surface temperature and of the reheating process of the mantle. We further investigate the geologic consequences of such a Benard-Marangoni convection cell, which can take over the control of convective transport processes in lack of operative Rayleigh-Benard processes. A change in the ratio between these two forms of convection (expressed as the Rayleigh number of the mantle divided by the mantle's Marangoni number) in support of a Benard-Marangoini convection is in a good agreement with our present understanding of the Venusian mantle, the thermal parameters of which seem to inhibit active Rayleigh-Benard convection cells. We also show the evolution of this ratio with time as a consequence of the mantle-reheating [4]. The concept of Benard-Marangoni instability, known from fluid dynamics never before has been adapted to a solid planetary body and can only be used here, as time scales arising for geological processes, allow a planet to be considered as a viscous body.

Thus the presence of an operative Benard-Marangoni convection cell would pose an explanation for recent volcanism, which will be a matter of investigation of the ESA

Venus Express and of the ISAS Climate Orbiter Planet-C mission too. Furthermore the global surface temperature distribution, which is a subject of the surface-investigation plans of the Venus Express mission can be used to elaborate the analysis on the scale of Benard-Marangoni convection in the Venusian mantle and additionally pose an explanation for the presence of a raised interior in some Coronae, which is in agreement with [5], where the raised interior can be interpreted as an evidence for active Corona-volcanism.

References:

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