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Impact craters in structurally heterogeneous targets: Venusian case studies.

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Abstract

In this study, we complement our previous work by case studies of polygonal impact craters (PICs) and their surrounding tectonic environments, particularly the coronae by using full resolution SAR data (75 m/px) and Magellan altimetry (~4640 m/px). It seems that large, long-lived coronae with distinct topographic annuli favor the formation of PICs.

1. Introduction

On Venus, 121 impact craters with a diameter > 12 km were observed to have at least two straight rim segments and a clearly discernible angle between those segments, instead of displaying circular plan view, qualifying them as polygonal impact craters (PICs) [1–2]. As on other terrestrial planets, the formation of such PICs on Venus is controlled by dominating heterogeneities in the target [3–5]. Thus, the orientations of the straight crater rim segments are non-random, and were instead shown to have statistically significant positive correlations with the orientations of different tectonic structures [2]. In particular, the straight PIC rim segment orientations match the orientations of rift zones and the concentric, but to a lesser extent also the radial component of volcano-tectonic features, as well as the structural orientations measured from the underlying tessera terrain [2].

Much of our earlier work, while unravelling how different tectonic structures have different effects (or no morphologically observable effects at all) on subsequently forming impact craters, addressed the problematics of PICs and the pre-existing target structures mostly from the point of view of impact cratering mechanics [4–5]. In this work, we are taking a more detailed look on the types of tectonic structures affecting polygonal crater formation, and how the effects vary with the type, size, and location of the tectonic structure. Our study was carried out by using the Magellan SAR (Synthetic Aperture Radar) images, which cover 98% of the surface [6], with additional insight provided by Magellan topographic data.

2. Results and discussion

In our previous work [2], we studied the correlation between the orientation of the straight rim segments of PICs and the tectonic features on Venus. We showed that the straight segments of PIC rims are parallel (±7.5°) to structures of the nearby tessera terrain, young rift zones and especially the concentric components of volcano-tectonic features, usually coronae, far more often than is presumed if this was merely a random phenomenon. We also noticed that this dependence becomes notably less important with an increasing distance between the tectonic structures and PICs.

In the present work, we studied 15 PICs which are located near a corona (distance < 2 times the crater diameter) and whose rim segments show evidence of parallel orientation with concentric and/or radial components of the corona. We noticed that in most cases, the corona related to a PIC is rather large in diameter. In addition, it is relatively common that the annulus of the accompanied corona is clearly visible in topography. This can be seen as a prominent sign of uplift caused by a mantle diapir that rises close to the surface, and emphasizes the possible concentric deformation and stresses caused by the corona formation.

Our studied PICs also show that if one rim segment of the PIC matches the concentric or radial components of the nearby corona, the PIC rims very rarely show any correlation with other tectonic structures, except young rift zones.

3. Summary and Conclusions

While we previously showed that the orientations of the straight rim segments of polygonal impact craters match especially the concentric components of volcano-tectonic features, especially coronae, indicating that something in the environment of the corona enhances straight rim segment formation of the crater, our current studies show that there seem to be some systematics in those "PIC-related" coronae.

The studied coronae are mostly rather large in diameter, and their annuli are clearly visible in topography. Moreover, many of them show evidence of rather complex formation process, which may, therefore, suggest that the long evolutionary process of a corona has a vital role in creating favourable circumstances for PIC formation. This preliminary study also corroborates our earlier work [2] indicating that young rift zones and the concentric components of coronae form the dominant fracture pattern in the area, later "utilized" by the formation of polygonal craters. More detailed structural analysis and additional case studies form the basis of our future work on the interplay of Venusian tectonics and impact cratering.

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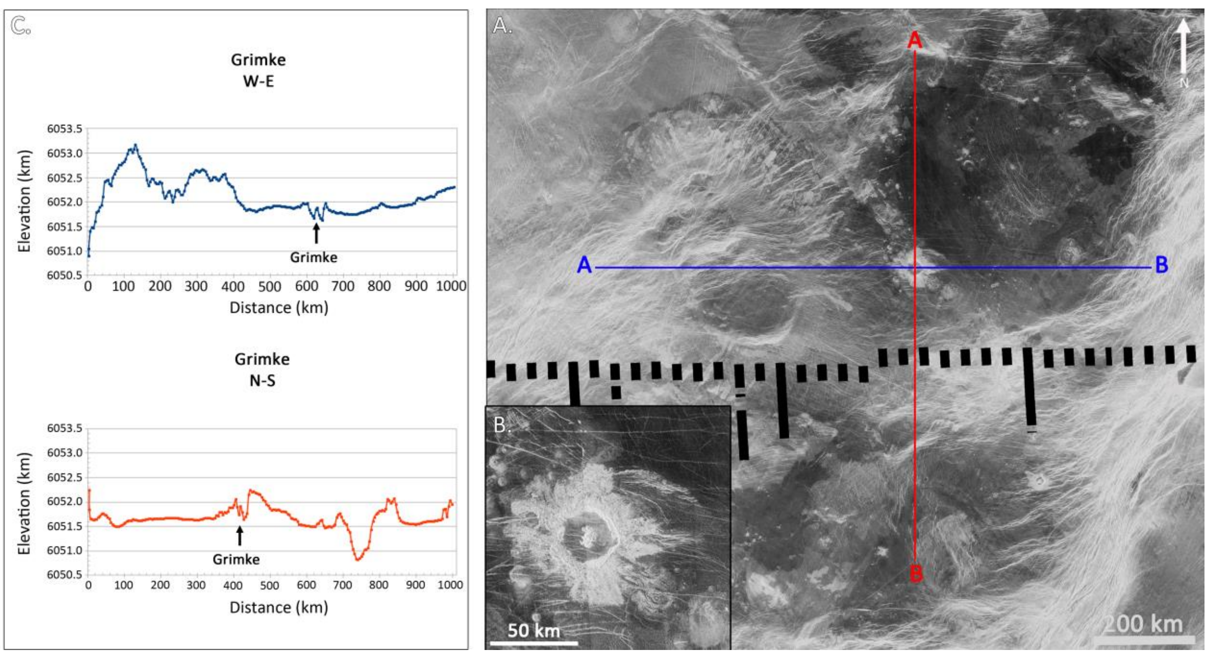

Figure 1: A) The Grimke crater (17.3°N, 215.3°E, D ~34.6 km; left-looking Magellan SAR image) is located close to the relatively small unnamed corona. B) A detailed Magellan SAR image shows the straight rim segments of the crater, which are parallel both to the concentric components of the nearby corona and the topographic rise which the crater is located on. C) The colored profiles show the topography of the region (from Magellan altimetry, extend from A to B). The corona has an uplifted annulus which is seen in the blue profile.