EPSC Abstracts
Vol. 7 EPSC2012-295 2012
European Planetary Science Congress 2012

Altered distal deposits near old craters on Venus

N. Bondarenko
Earth and Planetary Sciences, University of California - Santa Cruz, USA; Institute of Radiophysics and Electronics, National Academy of Science of Ukraine, Ukraine (nbondar@ucsc.edu)

Abstract

"Altered" parabolic features on the Venus surface were observed in association with five old craters (of 54 studied). Remnants of radar-dark parabolas are still present at their sites of initial deposition; aging processes result in brightening of dark parabola mantles. The limited number of candidates for thick weathered distant crater deposits means that mantling by ancient dark parabola material is not widespread on Venus.

1. Introduction

A number of impact craters on Venus are associated with extended radar-dark diffuse features (DDF), often shaped as parabolas. These features are thought to be airfall mantling deposits of loose material ejected by the impact event. Craters that do not exhibit any DDF in their immediate surroundings are usually considered to be old. The relatively older origin of such craters was confirmed on the basis of analysis of volcanically embayed and tectonically deformed craters [1]. The diversity of target terrains and the limited crater population on Venus do not allow a robust statistical approach to the study of DDF mantled surfaces hypothetically modified with age. At first glance, however, surroundings of old craters localized in plains do not exhibit any unusual properties. The efficiency of the actual aging process that could alter distal crater deposits is unknown yet. Thus, a study of the vicinity of old craters could help to assess the current state of surfaces covered by DDFs long ago. In the present work, the possibility that the mantle material remains at the sites of deposition but becomes radar-brighter (due to changes of mantle physical properties or structure) has been investigated.

2. DDF mantle alteration

Alteration of DDF mantle material could occur due to the interaction with the high-temperature, high-pressure chemically reactive Venus atmosphere. A variety of possible mechanisms of alteration can be suggested, for example, chemical modification and physical weathering as discussed, e.g., in [2]. Due to the presumably high porosity of the mantles, atmosphere-caused alteration could not only occur at the very surface of the mantle only, but also rather uniformly within its interior volume, and could lead to a change in the bulk properties of the mantle and the state of mantle-atmosphere interface.

Chemical weathering could lead to the lithification of loose mantles as suggested in [3]. This hypothesis is supported by the low bearing capacity of the uppermost layer of the Venus surface measured during landings of the Venera- 9, -10, -13, and -14 spacecraft, which point to porous material comparable with terrestrial tuff. Partly lithified DDF deposits also can be responsible for layered rocks seen in Venera panoramas [3].

It is possible that lithified extended deposits from the crater Sanger, modified by tectonic processes, are seen in the Venera-9 panorama. Within the known confidence circle [4], the Venera-9 landing site is closer than 100-500 km eastward from the crater Sanger (D = 83.8 km). Craters as large as Sanger, namely Stuart (D = 69 km), Boulanger (D = 72 km) and Greenaway (D = 92 km), have parabolas with eastward extensions of 198-468 km [5]. Thus, thick (> 10 cm) deposits are expected in close proximity to these craters.

Different ways of changing in the mantle bulk properties discussed for the aging of extended crater-related mantles remaining at the site of deposition [6] lead to a variety of possible appearances of old thick mantles, including bright, partly dark, or apparent invisibility.

In general, if we consider that old mantles are still located at their sites of initial deposition and that aging processes result in brightening of dark parabola

mantles, we can expect the presence of “altered” or “brightened” parabolic features on the Venus surface near old craters. If such a mantle is rather thick (at least thicker than 10 cm) and the mantle became bright, for example, due to a rough atmosphere-mantle interface and/or increased mantle volume scattering, then the underlying surface is expected to be unrecognizable in the radar images.

3. Approach and result

The surroundings of 31 large (>30 km) craters without any associated DDF nearby and 23 large craters having faint dark halos were systematically studied. The radar images in places, where a parabola would be expected, were used to search for diffused disappearance of boundaries of underlying volcanic units and any features that could be interpreted as "altered" or "brightened" parabolas considering that old mantles are still located at their sites of initial deposition. Only a few examples of such kind were found.

The surface near the crater Chiyojo is shown in Figure 1. Radar contrasts between lava flows at sites marked with C and D (1.4 dB and 1.2 dB, respectively) to the west of the crater are lower, in comparison with radar contrasts at A and B (2.4 dB and 2.2 dB, respectively). The surface shown in Figure 1 exhibits similar appearance and radar cross-section during the first and second Magellan cycles (24° and 25.2° incidence angles, respectively).

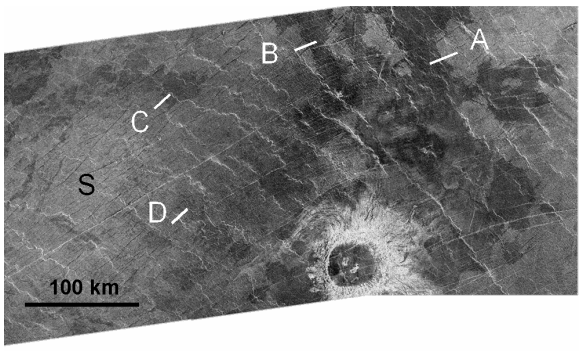

Figure 1: The crater Chiyojo (47.8°S, 95.7°E, D = 38.8 km). S marks the area with dark deposits accumulated along ridges.

Other examples include: (1) Volcanic shields located further from the crater Nijinskaya are brighter by 0.4 – 1.2 dB in comparison with the shields, which are located to the west of the crater (in the expected place of the extinct parabola). (2) Poorly resolved boundaries between lava flows are located ~400 km northwest from the crater Deken. (3) A dark area located southwest of the crater Agnesi has different radar contrasts along the boundary with the same flow. Its eastern part (closer to the crater) appears to be poorly resolved. (4) The large diffuse area south of the crater Rhys is consistent with the possible presence of aged distal crater deposits.

4. Summary and Conclusions

The limited number of candidates for thick weathered distant crater deposits (5 from 54) means that mantling by ancient dark parabola material is not widespread on Venus. Thick mantles seem not to retain their DDF properties over the whole area of initial mantle deposition. Terrains where parabolas formerly existed are now still characterized by different microwave properties. Thus, thick aged mantles seem not to remain in the sites of deposition.

References

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