EPSC Abstracts
Vol. 11, EPSC2017-440-2, 2017
European Planetary Science Congress 2017

Venus Monitoring Camera (VMC/VEx) 1 micron emissivity and Magellan microwave properties of crater-related radar-dark parabolas and other terrains

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1 Data description and the method of investigation

About 10 % of impact craters seen in the Magellan radar images of Venus have associated radar-dark parabolas [1, 2]. The aim of this work is a comparative study of several typical radar-dark parabolas, the neighboring plains and some other geologic units seen in the study areas, at two depths scales: the upper several meters of the study object are available through the Magellan-based microwave (at 12.6 cm wavelength) properties (microwave emissivity, Fresnel reflectivity, large-scale surface roughness, and radar cross-section), and the upper hundreds microns of the object are characterized by 1-µm emissivity resulted from the analysis of the near infra-red (NIR) irradiation of the night-side of the Venusian surface measured by the Venus Monitoring Camera (VMC) on-board of Venus Express (VEx).

Microwave parameters and 1-µm emissivity of the surface materials have been studied in five $\sim$ 1600 × 1600 km areas, which include craters Adivar, Bassi, Bathsheba, du Chatelet and Sitwell (see fig. 1), all with associated radar-dark parabolas (see an example in fig. 2). Selected for the analysis surface units include "homogeneous" and "heterogeneous" parabola parts, the non-parabolic halo of the crater Caccini (near the crater du Chatelet), plains, massifs of the tesserae terrain, and a locality of the rifted terrain in the area of crater Sitwell. The study addresses following questions about parabola formation: what is physical and geological states of various parts of parabolas; what physical and chemical changes of the material, being a source for the parabola (upper 100's meters of the plains-forming basalts), took place in the parabola formation process and their subsequent evolution [3].

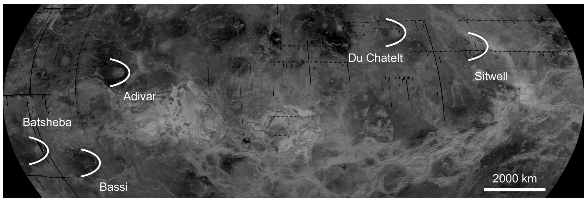

Figure 1: Locations of the dark-parabola craters under study in the Magellan synthetic aperture radar (SAR) image covering area 30°S – 40°N and 40°E – 220°E

For all mentioned above units and subunits the microwave parameters and 1-µm emissivity have been calculated and then compared. 1-µm emissivity depends on chemical and mineralogical composition of the studied materials and on the surface structure and grain size. Microwave emissivity and Fresnel reflectivity are controlled by dielectric permittivity of the surface material: the higher dielectric permittivity, the higher Fresnel reflectivity and the lower microwave emissivity.

2 Results

The comparative study of parabolas of five craters allowed coming to following conclusions:

1. 1-µm emissivity usually exhibits the dependence: the lower 1-µm emissivity, the lower Fresnel reflectivity, the higher microwave emissivity.

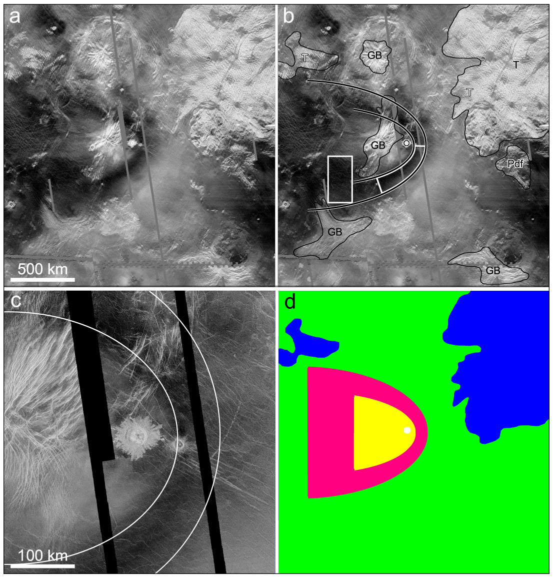

Figure 2: a) Magellan SAR image of the crater Bathsheba parabola and its vicinity; b) similar image with boundaries of the dark parabola, groove belt (GB) and tesserae terrain (T); homogeneous part of the radar-dark parabola (DHM) are outlined with white; c) Magellan SAR image of the crater Bathsheba and its close vicinity; d) simplified map of the units under study: the plains with groove belts included (green), the radar-dark part of the parabola (red), the radar-bright part of the parabola (yellow), the tesserae terrain (blue). The considered area is 1 600 km × 1 600 km.

2. Differences in bulk properties of parabola units having the same 1-µm emissivity appear to reflect differences in a packing style of mantle material consists of particles.

3. Radar bright inner parabola parts, observed within three of five studied parabolas possibly indicate more turbulent (comparing to radar-dark parts) deposition environment, thinner parabola mantles or partial coverage of the underlying surface.

4. 1-µm emissivity values of three dark parabolas remain the same over individual parabola subunits. This suggests that characteristics of the upper several hundred microns of the dark parabola mantle is very close to each other over the whole parabola area and do not depend on the bulk properties of the total parabola mantle.

5. The non-parabolic halo of the crater Caccini exhibits characteristics close to those of the dark parabolas suggesting that in a process of shrinking of the parabola into a non-parabolic halo the considered parabola parameters remain mainly unchanged. On the other hand, 1-µm emissivity of the Caccini halo based on the comparison with the Adivar parabola shows signs for the coarser Caccini halo mantle and can be treated as a degradation state.

6. The observed differences in microwave emissivity and Fresnel reflectivity between parabolas and adjacent plains may indicate that parabola materials are more weathered with oxidation of their iron into hematite since the subsurface plains material is not easily accessible for atmosphere gases.

7. Comparisons of properties for tessera terrain and plains confirmed suggestions of the earlier works on non-basaltic composition of the tessera material.

8. Distinctive (from plains) composition of the tessera material indicates also effective downslope movement of the surface material on a rough surface of the tesserae.

9. Comparisons of the rifted terrain in the area of the crater Sitwell and plains, assuming absence of the significant topographical changes between Magellan and VEx observations, showed that high tectonic deformation is the main factor that influenced the majority of rifted terrain properties including its microwave emissivity.

References

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