MICROWAVE PROPERTIES AND THE 1-MICRON EMISSIVITY OF CRATER-RELATED RADAR-DARK PARABOLAS AND OTHER SURFACE FEATURES IN FIVE AREAS OF VENUS.

N.V. Bondarenko[1,2], A.T. Basilevsky[3,4], E.V. Shalygin[3], W.J. Markiewicz[3]; [1]University of California – Santa Cruz, 95064 Santa Cruz, USA; [2]Institute of Radiophysics and Electronics, National Academy of Sciences of Ukraine, 61085 Kharkiv, Ukraine; [3]Max-Planck-Institut für Sonnensystemforschung, 37077 Göttingen, Germany; [4]Vernadsky Institute RAS, 119991 Moscow, Russia; nbondar@ucsc.edu.

Introduction: This work presents a comparative study of the Magellan-based microwave properties and the 1-micron emissivity of the surface for five crater-associated radar-dark parabolas, the neighboring plains and some other geologic units. The 1-micron emissivity was derived from the measurements done by the Venus Monitoring Camera on board the Venus Express spacecraft. The craters under study are Adivar, Bassi, Batsheba, du Chatelet (plus located nearby crater Caccini with non-parabolic radar-dark halo) and Sitwell. All these craters are located in the latitude belt from 25°S to 25°N where the geometry and other conditions for the VMC mapping are optimal.

Data description and approach: Used for our analysis microwave properties include microwave emissivity, Fresnel reflectivity, surface roughness presented as root-mean-square slopes, and radar cross-section. These parameters depend on surface dielectric permittivity and surface roughness at different spatial scales. Dielectric permittivity at radio waves range of observation [see, e.g., 1] is dominantly controlled by the material bulk density. The latter is determined by material porosity and by chemical-mineralogical characteristics of the solid materials [1, 2]. The values of 1-micron emissivity of the surface material depend on chemical / mineralogical composition of the Bbstudied materials and on their surface textures, in particular on the grain size [e.g., 3].

Figure 1 shows the parabola associated with crater Adivar as an example of our work approach. In SAR images the parabola outer part is prominently dark and called as "parabola dark" while its inner brighter parabolic area is called as "parabola bright". Homogeneously dark areas within dark part of the parabola (outlined with white in Figure 1a) are called "parabola-dark-good", the rest parts exhibiting some local brighter spots are called as "parabola-dark-not-good". Also plains, tessera terrain and groove belts are seen in Figure 1. Grooves are relatively old linear zones of tectonic deformation; they are mostly graben in the plains materials [4]. Taking this into account and along with relatively small percentage of the area occupied by the groove belts comparing to the plains, we included groove belts into the plains unit (Figure 1b).

Three of five considered crater-associated parabolas have the inner brighter areas, parabolas bright. Four of investigated craters are superposed on plains and the fifth one (Sitwell) is superposed on rifted terrain which in this place is tectonically deformed plains. Thus in all five areas under study the source material for dark parabolas is the plains material. In three areas massifs of tessera terrain are also observed and studied. In the Sitwell area the observed there rifted terrain is additionally studied. And in the crater du Chatelet area the non-parabolic radar-dark halo of crater Caccini is also included into analysis. Non parabolic radar dark haloes are considered to be associated with craters older than those having the radar-dark parabolas [e.g., 5, 6, 7].

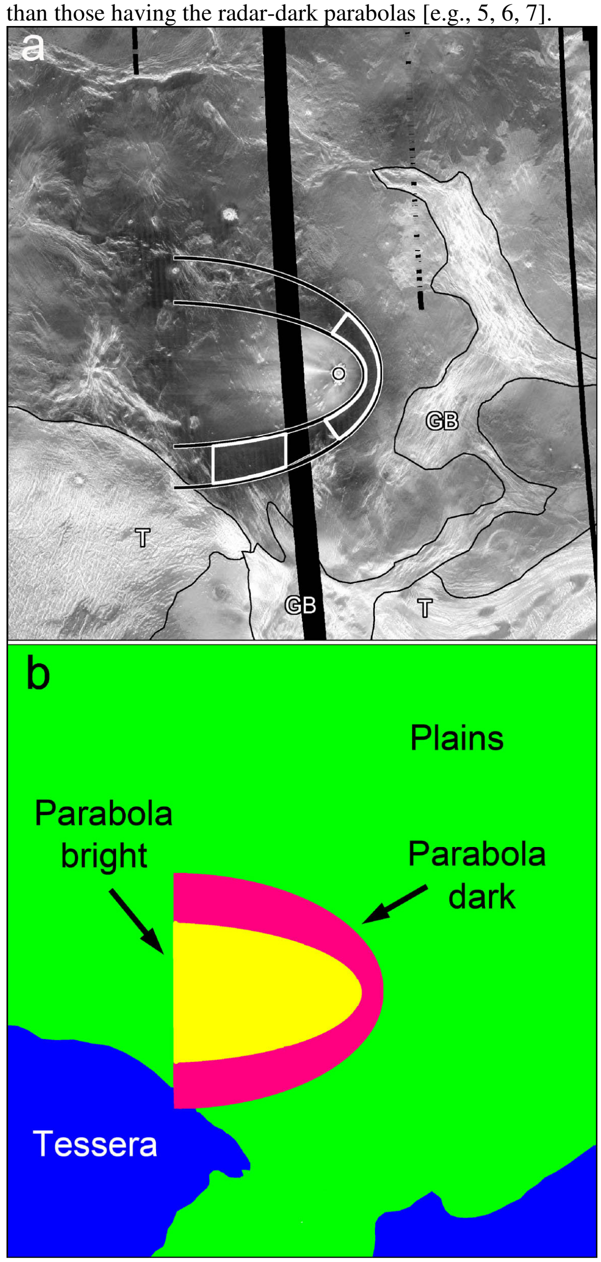

Figure 1. a) Magellan SAR image of the parabola crater Adivar and its vicinities with boundaries of the dark parabola, groove belts (GB) and tessera terrain (T), parabola-dark-good parts are outlined with white; b) simplified map of the units under study. The image area is 1680 x 1680 km.

For all mentioned above units and subunits the microwave parameters and 1-micron emissivity have been calculated and then compared.

Landing sites: In our analysis the observations and measurements made at the Venera 9, 10, 13, 14 and Vega 1 and 2 landing sites were also considered. At these sites evidence of the presence of crushable highly porous material has been found. In TV panoramas this crushable material is seen as centimeter-scale layered rocks [8, 9]. Particles composing the layered rocks are not distinguishable in the images so they should be finer than the image resolution: a few millimeters for the rock outcrops close to the cameras. This agrees with the observed sharp layer to layer boundaries. The measurements of electrical resistivity of the surface materials in the Venera 13 and 14 sites made by [10] showed that it is unexpectedly low: 89 and 73 ohm·m. This may be due to a presence of hematite whose occurrence on the surface of Venus was suggested by the thermochemical calculations of [11, 12] and agrees with the surface color measurements [13] using optical color images taken by Venera 13-14, and is supported by the experiments by [14] and [15]. Electrical resistivity of hematite at 750K is 20 ohm·m [16] so its admixture could be a cause of the low resistivity at the Venera 13, 14 sites.

It was suggested by [17] that the finely layered high-porous surface materials seen at the Venera sites are lithified deposits of previous parabolas whose surface with time became relatively rough so they lost the radar-dark appearance. Work [18] also suggested that lithified extended deposits from the crater Sanger, modified by tectonic processes, are seen in the Venera 9 panorama. So the described above properties of the material at the Venera-Vega landing sites may be applied to observed now parabolas.

Summary. As a result of these comparisons and analyses the following conclusions have been made:

The 1-micron emissivity which characterizes the uppermost hundreds-microns-thick layer of the parabola mantles usually show some correlation with the microwave parameters over the parabola area: the lower 1-micron emissivity, the lower Fresnel reflectivity, the higher microwave emissivity. For the parabola mantles having the same composition the lower 1-micron emissivity indicates smaller mantle particles.

Differences in bulk properties of parabola units having the same 1-micron emissivity appear to reflect differences in the mantle material packing style in the particles mix if the particles have the same sizes.

The parabola mantle porosity could be the key point to explain variations of microwave properties over the whole parabola area including inner bright parts. Particular values of mantle porosities cannot be estimated based on data available but observed variations of Fresnel reflectivity over the single crater parabola area (considering the same ejecta material) can occur due to differences in parabola mantles porosity of 7.1%, 6.3% and 9.7% for craters Adivar, Batsheba and du Chatelet, respectively.

The 1-micron emissivity alone cannot provide direct answers on particular properties of the mantles but it is a useful parameter in comparative studies involving mantles' microwave properties and characteristics of particular impacts.

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

Non-parabolic halo of crater Caccini exhibits characteristics close to those of the dark parabolas. Because non parabolic radar-dark haloes are considered to be older than the parabolic ones this suggests that in the process of shrinking of parabolic halo into non-parabolic one the considered parabola parameters remain mainly unchanged.

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

If the finely layered rocks seen in TV panoramas of Venera 9, 10, 13, 14, represent the material of past parabolas, the parabola mantle granulometry should be of millimeters scale and finer.

Comparisons of properties for tessera terrain and plains showed that in all studied cases tessera material has higher microwave emissivity, lower Fresnel reflectivity, significantly higher surface roughness and radar cross-section and lower 1-micron emissivity. This confirms suggestions of earlier works on non-basaltic composition of tessera material.

Distinctive (from plains) composition of tessera material indicates also effective down-slope movement of surface material on the rough surface of tessera bringing to the surface new portions of the pristine tessera material.

Comparisons of rifted terrain in the area of crater Sitwell and plains showed that high tectonic deformation is the main factor that influenced the majority of rifted terrain properties including its microwave emissivity.

Acknowledgments. We appreciate discussions and help of Mikhail Zolotov, Bruce Fegley and Yuri Shkuratov. ATB is thankful to Alexander von Humbold Foundation for partial support of this study. NVB gratefully acknowledges support from the NASA Planetary Mission Data Analysis Program, grant NNX11AQ46G.

References: [1] Carrier et al. (1991) In: *Lunar Source-Book.*. Cambridge Univ. Press, NY, 475–594. [2] Campbell and Ulrichs (1969) *JGR, 74,* 5867–5881. [3] Moroz et al. (2007) *Lunar Planet. Sci.* 1741. [4] Ivanov and Head (2011) *PSS, 59,* 1559–1600. [5] Arvidson et al. (1992) *JGR, 97,* 13,303– 13,317. [6] Izenberg et al. (1994) *GRL, 21,* 289–292. [7] Basilevsky and Head (2002) *JGR, 107, (E8),* 5061. [8] Florensky et al. (1983) *Science, 221, No. 4605,* 57–59. [9] Basilevsky et al. (1985) *Geol. Soc. Amer. Bull, 96,* 137–144. [10] Kemurdzhian et al. (1983) *Kosm. Issled. 21,* 323–330. [11] Zolotov (1991) *LPSC-22,* 1567–1568. [12] Zolotov (2007) In: *Treatise on Geophysics.* Elsevier, Amsterdam, 349–369. [13] Pieters et al. (1986) *Science, 234*, 1379–1383. [14] Fegley et al. (1995) *Icarus, 118,* 373–383. [15] Klingelhoffer et al. (1996) *PSS, 44, No. 11,* 1277–1288. [16] Ito et al. (2010) *Materials Transactions.* 5*1, No. 6*, 1163–1167. [17] Basilevsky et al. (2004) *JGR, 109*, E12003. [18] Bondarenko and Head (2009) *JGR,* 114, E03004.