EXTENDED CRATER DEPOSITS ON VENUS: INTEGRATED ANALYSIS WITH MAGELLAN DATA. N. V. Bondarenko, Institute of Radiophysics and Electronics, National Academy of Science of the Ukraine, (12 Ak.Proskury, Kharkov, 61085, Ukraine, bndr@kharkov.ua).

Introduction: Extended radar dark diffuse features (DDF) associated with craters on Venus surface exhibit the diversity of shapes from roughly parabolic to nonuniform complex patterns on Magellan radar images and are observed for the majority of all impact craters on the planet (~ 65% of craters with diameter large 30 km have associated DDFs [1]). DDFs have been interpreted as deposits (mantles) of loose material ejected and lifted by the impact. Generally, all craters are divided into 4 types, namely, craters with: dark parabola (DP), dark halo (DH), patchy dark areas ("faint halo", FH), and no dark deposits ("no halo", NH). This sequence has been suggested to reflect an age progression of craters from young to old [2].

The presence of the mantles strongly affects the observable electromagnetic properties of the surface, as well seen in the Magellan data. In the present work DDFs of different type for craters with diameter > 30 km were analyzed and life cycle of radar dark parabolas was studied through two end-member scenarios of aging processes including (1) removal of the loose material by wind and (2) induration and subsequent roughening by eolian erosion, which diminishes the radar signature of the deposits.

The study of DDFs was made using results of Magellan mission including SAR images, ARCDR and SCVDR data sets [3-5].

Wind action - roughness asymmetry: Radar echo Doppler centroid f_D derived through Doppler-frequency analysis of the Magellan radar altimeter data is a measure of surface scattering asymmetry in north-south (N-S) direction ([5], SCVDR data set). Roughly, f_D represents the deflection of strongest surface echo from the nadir.

About 45 craters with associated DDFs in 20°S – 40°N latitude zone (the effective spatial resolution of f_D here is ~ 50 km) were studied. It was found that radar-dark parabolas and well-expressed halos are usually associated with areas of zero f_D (N-S symmetric roughness). As examples, dark parabola crater Bassi and dark halo crater Elena are shown in Fig. 1. Crater-related DDFs here have zero f_D, while the volcanic plains unit over which they are superposed has a pronounced N-S slope asymmetry.

Decameter-scale surface roughness derived from Magellan radar altimeter measurements (ARCDR [4] and SCVDR [5] data sets) is usually lower for the parabolas and halos than for surroundings. These observations support the interpretation of the DDFs as surficial deposits with flat upper surface [6, 7].

Crater-associated microwave emissivity features (Magellan radiometric observations [3]), especially emissivity parabolas, were shown to be larger than DDFs seen in the radar images [7]. The DDF-associated areas of zero f_D are often larger than the radar-dark features too. This gives additional evidence that the crater-related loose material deposits have wider extension than the DDFs in the radar images.

Bands of distinctively high degree of N-S roughness asymmetry along boundaries of the DDF-associated areas of zero f_D were found for DP craters Boleyn and du Chatele. Radar image of crater Boleyn and its appearance in the f_D map are shown in Fig. 2. High f_D band (marked with “2”) does not have any specific expression in the radar image. The most plausible cause for observed roughness asymmetry is the presence of eolian features (microdunes, ripples, etc.) on the surface [8, 9]. The observed bands of increased asymmetry at the periphery of the DDFs indicate wind reworking of the deposit material in the areas where the deposit is thin.

Surface roughness asymmetry in east-west (E-W) direction has been studied [8, 7] by comparison of left- and right-looking radar images. Three areas of very strong E-W asymmetry (difference is up to 8 dB) interpreted as microdune fields [8] are localized in the western parts of parabolas. In addition to [8] DDF areas with scattering asymmetry (difference is ~1 – 4 dB) were found westward from several small craters including Adaiah, Abigail, and Chiyojo. This again is a sign of wind reworking of the DDF material. However, the majority of DDFs associated with other studied craters are characterized by symmetric scattering in E-W direction.

Induration and roughening by eolian erosion: Surroundings of 31 NH craters and 23 FH craters were studied. The purpose was to find any features that could be interpreted as “altered”, “brightened” parabolas on radar images. For example, this could be diffuse disappearance of boundaries of volcanic units in the places where the parabola edge would be expected.

No any clear evidence of this kind was found. Only a few examples of weak changes in radar contrasts of lava flows boundaries were observed. For example, small lava flows located to the west from crater Nijinskaya are brighter than surrounding surface by 1.0 db, while radar contrasts for another flows looked very similar in the same area vary from 1.4 dB to 2.2 dB.

Many examples of radar-dark deposits in wind shadows at small topographic features westward from old craters were found.

DDFs aging sequence: Properties of radar dark areas were compared with properties of “typical” surfaces observed in the vicinity of DP, DH, FH and NH craters under study. Radar dark and “typical” were defined according to their radar cross-sections: lower than the planetary average and in the range of

± 2 dB from the planetary average, respectively. The dielectric permittivity of the surface was derived from the Fresnel reflectivity measurements in Magellan radar altimeter experiment [4].

90 crates under study (from 94) show higher average permittivity for dark surface in comparison with typical one. The difference is not high and varies from 0.01 up to 0.75. The other 4 crates show opposite relationship; the difference does not exceed 0.2. These cases include three FH craters and one NH crater.

Average Hagfors' roughness parameter <ξ> and dielectric permittivity <ε> of dark and "typical" surfaces for craters of different types are presented in Table. 1. Data show that, in general, dark surfaces are characterized by lower roughness compare with "typical" one. Roughness of typical areas near craters of different types (Table 1) is similar to each other. Dark material permittivity of NH craters seems to be lower than the permittivity of DP craters.

Table 1.

	Dark surface		Typical surface	
	<ξ>, °	<ε>	<ξ>, °	<ε>
DP	2.1±0.5	4.56±0.34	2.3±0.4	4.24±0.29
DH	2.2±0.4	4.38±0.49	2.5±0.5	4.18±0.44
FH	2.1±0.6	4.38±0.53	2.5±0.5	4.17±0.42
NH	1.9±0.6	4.37±0.45	2.7±0.6	4.11±0.35

Thus aging of dark parabola material on Venus is accompanied by the decrease of material dielectric permittivity.

Conclusions. No evidences for degradation of DDFs through induration and roughening of the deposits were found. Though this process still cannot be completely ruled out, roughening of DDFs seems to be not important for brightening of initially dark mantles.

The majority of radar-dark parabolas and halos on Venus are characterized by a smooth mantle-atmosphere interface. On the other hand, many evidences for reworking of the loose material of DDFs by winds were found. Together these mean that the mantle can preserve its smoothness for a geologically long time, the mantle material can saltate under wind action, and is mobile. Taking into account the expected decrease of mantle material permittivity, movement of loose material by winds seems to be the process responsible for degradation and removal of DDFs.

References: [1] Basilevsky A. T., and Head J. W. (2002) *JGR 107*, doi:10.1029/2001JE001584. [2] Izenberg N. R. et al. (1994) *Geophys. Res. Lett., 21*, 289–292. [3] Pettengill G. H., et al. (1992), *JGR, 97*, 13091- 13103. [4] Ford P. G., and Pettengill G. H. (1992) *JGR 97,* 13103-13114. [5] Tyler G. L. et al. (1992) *JGR 97*, 13115 – 13139. [6] Campbell D. et al. (1992) *JGR 97*, 16249 – 16277. [7] Bondarenko N. V., and Head J. W. (2004) *JGR 109*, doi: 10.1029/2004JE002256. [8] Bondarenko, N. V. et al. (2005) *LPSC. XXXV*I, abstract # 1236. [9] Kreslavsky M. A., and Vdovichenko R. V. (1999) *Solar System Res. 33*, 110. [10] Weitz C. M. et al. (1994) *Icarus 112*, 282 – 295.

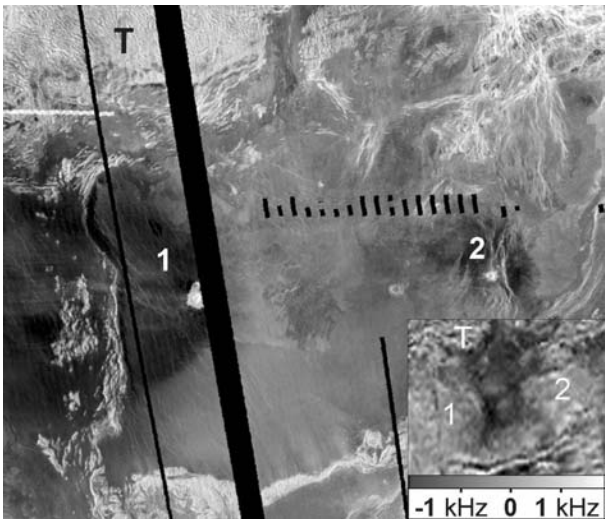

Fig. 1. Magellan SAR mosaic of craters Bassi (19°S 64.7°E, diameter - 35 km, marked with "1") and Elena (18.4°S, 73.4°E, diameter - 17 km, marked with "2"). Inset shows the Doppler centroid map of the same area, gray shades denote zero Doppler centroid, dark and bright shades mean deflection of the Doppler centroid from nadir. T - Ovda Tessera.

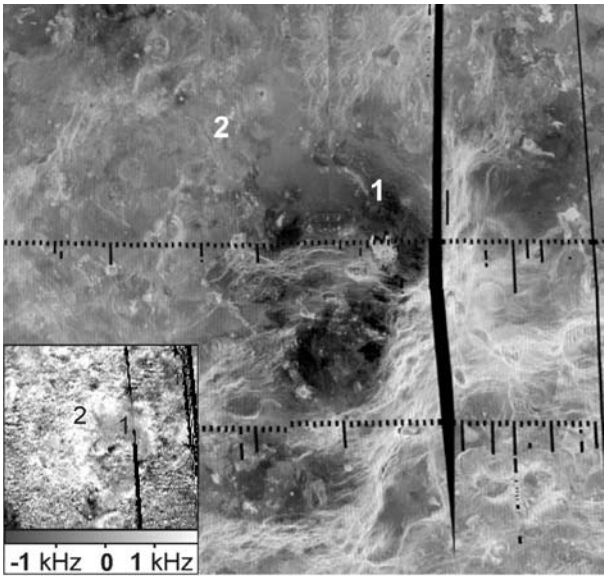

Fig. 2. Magellan SAR mosaic of crater Boleyn (24.4°S 220.1°E, diameter - 69.8 km). Inset shows the Doppler centroid map of the same area (see description in Fig. 1). "1" marks DDF-associated area of zero Doppler centroid; "2" marks band of distinctively high degree of N-S roughness asymmetry (1.4 kHz – 2.3 kHz).