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Crater-associated dark diffuse features on Venus: The nature of surficial deposits and their evolution

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Introduction. Analysis of Magellan radar images of Venus surface has shown that about 65% of large (>30 km) craters on Venus have associated radar-dark diffuse features (DDFs) [Basilevsky and Head, 2002], including well-expressed radar-dark parabolas [Campbell et al., 1992]. DDFs were interpreted as surficial deposits of loose material created and/or lifted by the crater-forming impact [Campbell et al., 1992, Bondarenko and Head, 2004]. Craters with parabolas are thought to be the youngest on the planet [Campbell at al., 1992]. Morphological sequence of DDFs from parabolas to halos to one or several faint radar-dark patches was interpreted as a degradation sequence of DDFs [Basilevsky and Head, 2002]. Particular mechanism of parabolas degradation is not well understood. Two end-members can be considered: (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. We analyze DDFs using several Magellan data sets in order to understand the relative role of these mechanisms.

Observations. Doppler-frequency analysis of the Magellan radar altimeter data had shown that the strongest surface echo systematically deflects from the nadir in many areas [Tyler et al., 1992]. Quantitative estimates of this deflection, so-called Doppler centroid, are available from the Planetary Data System (a part of GVDR or SCVDR data sets). In the plains, the Doppler centroid is a measure of the north-south (N-S) asymmetry of surface roughness at scales from centimeters to hundreds of meters [Bondarenko et al., 2005]. The effective spatial resolution of these data, although rather poor (~50 km in 20˚S – 40˚N latitude zone, where we used these data), allows the study of large DDFs.

Areas of zero Doppler centroid (N-S-symmetric roughness) are often associated with radar-dark parabolas and well-expressed halos. Decameter-scale surface roughness derived from Magellan radar altimeter measurements (both ARCDR data set [Ford and Pettengill, 1992] and SCVDR data set [Tyler et al. 1992]) 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.

It have been noted that DDF-associated microwave emissivity features, especially emissivty parabolas, are larger than DDFs seen in the radar images [Bondarenko and Head, 2004]. The DDF-associated areas of zero Doppler centroid are often larger than the radar-dark features too. There are several examples, where the boundary of zero Doppler centroid area coincides with the boundary of an emissivity feature. This gives additional evidence that the crater-related loose material deposits have wider extension that the DDFs in the radar images.

There are several examples, where there are bands of distinctively high degree of N-S roughness asymmetry along boundaries of the DDF-associated areas of zero Doppler centroid. The most plausible cause for the roughness asymmetry is the presence of eolian features (microdunes, rillpes, etc.) on the surface [Kreslavsky and Vdovichenko, 1999; Bondarenko et al., 2005]. The observed bands of increased asymmetry at the periphery of the crater-related deposit 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 by comparison of left- and right-looking radar images [Weitz et al., 1994; Kreslavsky and Vdovichenko, 1999]. All three areas of very strong E-W asymmetry interpreted as microdune fields [Weitz et al., 1994] are localized in the western parts of parabolas. This again is a sign of wind reworking of the DDF material.

We also studied surroundings of large “old” craters without any radar-dark features nearby. With the radar images, we were looking for any features that could be interpreted as “altered”, “brightened” parabolas. For example, we were looking for diffuse disappearance of boundaries of volcanic units in the places where the parabola edge would be expected. We did not find any evidence of this kind.

Conclusions. We found evidence for reworking of the loose material of DDFs by winds. This process is very slow, and thick DDF deposits remain flat for a long time. However, movement of loose material by winds can be the process responsible for degradation and removal of DDFs. Widespread roughness anisotropy outside the DDFs [Kreslavsky and Vdovichenko, 1999; Bondarenko et al., 2005] indicates the presence of eolian features and hence, some amount of loose material virtually everywhere. This material could have formed during old impact events and moved by winds from former DDFs. We do not see evidence for degradation of DDFs through induration and roughening of the deposits, though we still cannot completely rule out this process.

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