SEARCHING FOR SURFICIAL DEPOSITS ON VENUS USING MULTI-POLARIZATION RADAR. Lynn M. Carter, *Department of Astronomy, Cornell University, Ithaca NY 14853, (lcarter@astro.cornell.edu)*, Donald B. Campbell, *Department of Astronomy, Cornell University, Ithaca NY 14853*, Bruce A. Campbell, *Center for Earth and Planetary Studies, Smithsonian Institution, Washington DC 20560*, Jean-Luc Margot, *Department of Geological and Planetary Sciences, California Institute of Technology, Pasadena CA 91125*.

Introduction. The Magellan spacecraft returned hundreds of images of craters, radar-dark halos, and wind features on Venus. It is clear that surficial layers are associated with some of these features; for example, 59 of the craters have parabolic shaped deposits that are thought to be a few centimeters to a meter in thickness [1],[2]. Magellan also revealed about 400 radar dark "splotches" that may be places where a smooth rubble layer was formed when the shock wave from an impactor hit the surface and crushed the rock [3]. Two dune fields and several areas of microdunes were identified in Magellan data, as well a few thousand windstreaks, so it is clear that dust is transported and re-deposited by wind. [4]. Thin surficial layers that are not clearly visible in the Magellan imagery may be present in other regions as well. In fact, many surfaces on Venus that were imaged by Magellan SAR may look much different when viewed at optical wavelengths, since radar waves penetrate surface layers and show details of the underlying terrain. A good example is the L-Band (24 cm wavelength) shuttle imaging radar (SIR-A) observations by McKauley *et al.* [5] who detected buried river valleys in the Arbain Desert in southern Egypt.

Surface layers with thicknesses of order centimeters can be detected with multi-polarization radar observations. If a circularly polarized radar wave refracts into a surface that is smooth at wavelength scales and is reflected by an underlying structure, the returned radar echo will have a linearly polarized component. The linear polarization occurs because the horizontally and vertically polarized components of the incident wave have different transmission coefficients into and out of the surface layer. The fraction of the echo that is linearly polarized depends on the amount of surface and sub-surface diffuse and quasi-specular scattering, as well as on the incidence angle and dielectric constant of the surface material. If there is no sub-surface scattering, there will be no linearly polarized component of the echo. Our goal was to use this dual-polarization technique to search for surficial deposits on Venus. This procedure has previously been applied to the Moon in order to compare properties of the lunar regolith in several different regions [6].

Arecibo Radar Observations. We observed Venus with the Arecibo S-Band (12.6 cm) radar system during two inferior conjunctions with different sub-radar latitudes (8.5° N in 1999 and 9.5° S in 2001). A circularly polarized wave was transmitted and the echo was received in both circular polarizations. For each epoch, we formed images of the surface in all four Stokes' parameters and used these to obtain maps of the degree of linear polarization. In order to reduce the ambiguity problem, we transmitted north and south of the planet on alternate runs. We combined runs from multiple days to build up signal-to-noise and also averaged spatially.

The final products are four Mercator projection maps of the degree of linear polarization over the observable surface of Venus; one northern hemisphere and one southern hemisphere map for each opposition. The resolution of the 1999 map (after the spatial averaging) is about 16 kilometers, while the resolution of the 2001 map is about 12 kilometers. In order to investigate the relationship between the degree of linear polarization features and the Magellan imagery, we created color overlays where the value of each pixel is the Magellan SAR image value, and the hue of each pixel is determined by the linear polarization stretched to a color scale. Because the sub-radar point moved between oppositions, and because very little linearly polarized echo is theoretically expected within about 25° of the sub-radar point, some of the features observed during one opposition were not visible during the other. However, features that could be observed at both epochs have a similar shape.

Craters and Associated Deposits. Many of the most distinctive linear polarization features that show up in the Arecibo maps are related to impact craters. There are six craters that have a very convincing connection with a specific region of linear polarization, and four additional craters where the association with linear polarization features is more ambiguous due to more complex terrain. The locations with higher degrees of linear polarization are areas where the SAR imagery shows a slightly higher cross section. These brighter patches have a diffuse appearance; the underlying terrain appears muted but is usually still visible. The features are also asymmetric with respect to the crater location, lying almost completely to one side of the crater or forming a partial ring around the crater.

Figure 1 shows the image of the degree of linear polarization for the region surrounding the crater Nelike (26.8° S, 329.2° E). Nelike was not previously classified as a crater with a parabolic deposit [1], but it seems to have a bright parabolic shape surrounding it in the Magellan SAR images. The area of high degree of linear polarization overlies the outer margin of the parabolic deposit in the SAR image. Other craters that have linearly polarized echoes that are clearly associated with their surrounding deposits are Carson, Xantippe, Anya, Barton, and Boivin. Carson crater is one of the more unusual parabola craters. It has a bright deposit west of the crater, as well as a small bright parabolic arc just east of the crater, which makes the crater seem like it has a "double parabola" surrounding it. The degree of linear polarization in the Arecibo map falls directly onto the bright areas just west and east of the crater, while the radar dark bands on either side of the bright deposits show no linear polarization. The most symmetric crater feature is the one surrounding Barton and Lachappelle craters (located at 27.4° N and 337.5° E). In this case the linear polarization feature is nearly circular, and it appears to fall in

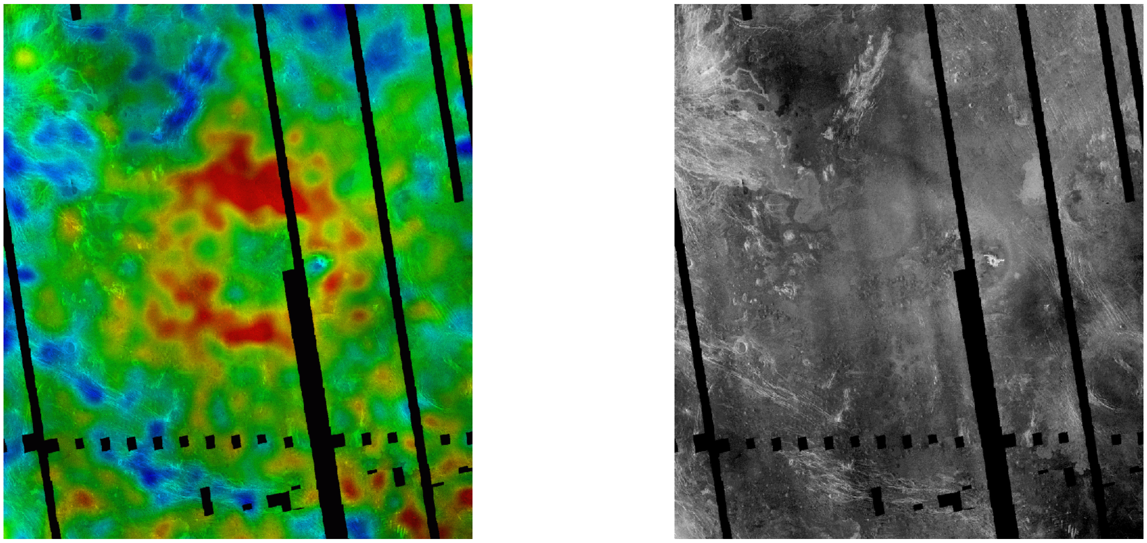

Figure 1: The image on the left is a Mercator map of the degree of linear polarization associated with the crater Nelike, which has been combined with a Magellan SAR image. The SAR image is shown on the right for comparison. The image is 678 km by 773 km. Red areas have the highest fraction of linearly polarized echo (18%), while darker blue areas have a very low fraction ($< 1\%$). Nelike is 6.1 km in diameter [9], which makes it the smallest crater with a parabolic deposit.

a topographic low surrounding the two craters. This may be a case where debris from an impact or material transported by wind was trapped in a depression. As with the other craters, the area with a high degree of linear polarization corresponds to a diffuse radar-bright ring in the SAR images.

All of the craters discussed above show linear polarization from their surroundings but not from the actual crater floors or bright ejecta blankets. The crater Stuart, however, shows a linearly polarized echo from the floor of the crater, but no appreciable linear polarization from the parabolic deposit associated with it. Stuart is a bright floored crater, located east of Alpha Regio, that has a low emissivity floor (0.69 compared with the global average of 0.845) [1], [7]. A high back-scatter cross section observed at oblique incidence angles usually indicates a surface that is rough at wavelength scales, but since emissivity also usually increases with roughness, the bright crater floor has been attributed to a combination of roughness and the intrinsic reflectivity of the crater floor material [1]. This feature is puzzling and is one area of future study.

It is also interesting that we do not see linear polarization associated with most of the parabolic craters in our viewing range. In particular, the crater Faustina, located east of Gula Mons, has an associated dark parabolic deposit that partially mantles a bright lava flow [1]. Modeling the Faustina parabola using a two-layer model gives deposit depths from 1-2 meters [1]. However, our maps show no evidence of the parabola, despite an incidence angle of almost 45° in the 2001 data set. The layer may be too thick or too lossy for there to be much sub-surface echo.

Future Objectives. In addition to the crater related linear polarization features, we also detect linearly polarized echoes from areas with wind streaks and from some small dome fields. These might be produced by wind-blown dust and by ash deposits. Our maps also show linear polarization around the edge of Maxwell Montes and around the crater Cleopatra on Maxwell Montes. The degree of linear polarization around the outer edge of Maxwell lies just off of the high reflectivity part of the mountain and seems to be primarily near the areas with steepest slopes. Part of the linear polarization signature surrounding Cleopatra falls on high reflectivity terrain. This is somewhat surprising since it implies that part of the echo comes from sub-surface scatter, but the Magellan/Goldstone bistatic experiment by Pettengill *et al.* [8] was consistent with scattering from a conducting or semi-conducting surface layer. Future work will focus on these areas with linearly polarized echoes that are not associated with distal crater deposits, particularly Maxwell Montes and Stuart Crater.

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