SEARCHING FOR PYROCLASTIC DEPOSITS ON VENUS. L. M. Carter[1], M. M. Douglas[2], B. A. Campbell[3] and D. B. Campbell[4], [1]NASA Goddard Space Flight Center, Greenbelt, MD (lynn.m.carter@nasa.gov), [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Smithsonian Institution, Washington, DC [4]Cornell University, Ithaca, NY.

Introduction: Pyroclastic deposits are produced by degassing volatiles that fragment the ascending magma during an eruption, and they have a variety of forms depending on eruption characteristics. On Earth, pyroclastic deposits are produced in a variety of eruption types, including Plinian column eruptions (airfall deposits), explosive eruptions that generate ground-hugging density currents, and during fire fountaining [1]. On the Moon, pyroclastics are typically associated with rilles or floor-fractured craters that presumably allowed volatiles to escape from deep in the lunar interior [2].

On Venus, the thick atmosphere inhibits the development of convective plumes that create large airfall deposits [3]. Instead, pyroclastic flow deposits should be more common, and material may not travel as far from the vent source as it would on Earth. We currently know very little about explosive volcanism on Venus. For example, are pyroclastics more likely to be associated with summit volcanism or smaller rifts? What size and type of volcano is typically associated with pyroclastic deposits? How localized are pyroclastic deposits? In addition, based on the aeolian features mapped during the Magellan mission, sediment supply on Venus appears to be very low. Sediments can be replenished through impact cratering, weathering, and volcanism. If volcanism creates only a limited supply of widely distributed fine-grained ash, it is possible that impact crater ejecta dominate the Venus sediment supply.

Magellan mission data led to the identification of some possible pyroclastic deposits. For example, the radar dark terrain south of Tepev Mons and part of the eastern caldera has been interpreted as low-density deposits [4]. But it is very difficult to identify these deposits in single polarization radar data alone, because radar waves will penetrate through mantling deposits. Radar polarimetry can detect mantling layers and assess roughness, and many areas of diffuse, moderate backscatter on Venus have been shown to be associated with mantling deposits [5,6].

Methods: In an effort to do a systematic search for pyroclastic deposits, we used Arecibo polarimetry data to search for low circular polarization ratio (CPR) deposits associated with volcanoes. On the Moon, pyroclastic deposits have distinctly low CPR values due to the absence of wavelength-sized scatterers [7]. We also compared the CPR data with degree of linear polarization (DLP) images; high DLP values indicate that the radar wave penetrates into the surface. We conducted a multi-stage search for possible pyroclastic deposits over the ~1/3 of the surface of Venus visible to Arecibo. First, on a regional-scale we looked for areas that have low CPR values relative to the surroundings. Second, we used published lists of large- (>100 km) and intermediate-sized (>20 km, <100 km) volcanoes [7] and excerpted Arecibo polarimetry for all volcanoes in the available latitude/longitude range. We created overlays of the low-resolution (~12 km/pixel) polarimetry on Magellan data to determine whether any volcanic features were associated with smooth mantling deposits.

Results: We have found numerous examples of low-CPR mantling deposits associated with lava flows, shield fields, and small domes. There does not seem to be a certain class of volcanic feature that is more likely to be associated with mantling deposits, but the intermediate-sized volcanoes we investigated did not show any possible pyroclastic deposits on the summits or flanks.

The flanks of Sif Mons [8] and a flow field emanating from Nehalennia Corona (Fig. 1) both have low CPR flow fields, along with a higher degree of linear polarization that suggests that the radar is penetrating

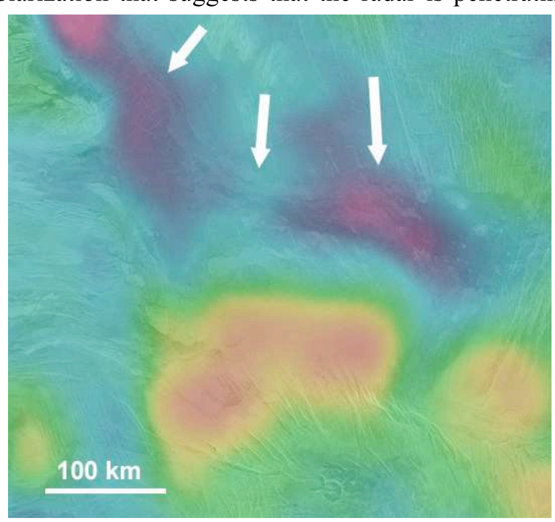

Fig. 1: A low-CPR flow to the north of Nehalennia Corona (14 N, 10 E). The Arecibo CPR data has been stretched to a color scale and overlaid on Magellan data. The average CPR of the low end (purple) of the scale is 0.2; the red area has an average CPR of 0.4.

into a mantling deposit. In both cases, the flows are radar dark compared to surroundings. It is not clear whether the mantling material originated at a single source region as part of the eruption that produced the flow, or whether there are smaller unresolved (in Magellan data) sources of material, for example at the end of the flow where the lowest CPR values are located.

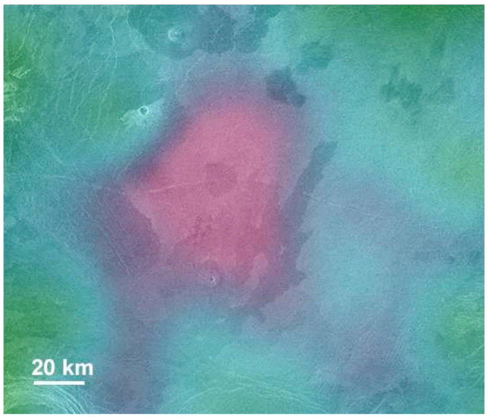

Fig. 2: A low-CPR region (average CPR of 0.3, only a couple of pixels) associated with a ~11 km dome, located at 8 N, 268 E.

In one case a small area of low CPR is associated with a dome straddling a rift (Fig. 2; Fig. 3). Many lunar pyroclastics are associated with rilles or fractures [7], but to date this is the most obvious such example on Venus. The ~11 km dome is at the center of the low CPR area, suggesting that it may have been a source region for fine-grained smooth deposits. This feature really pushes the limit of the resolution of the Earth-based polarimetry (and of the Magellan data), and it illustrates why higher resolution radar imaging polarimetry data are needed. Without the polarimetry, there would be no reason to suspect that this area was unusual.

Some radar-dark groups of small shield volcanoes also have a low CPR and higher degree of linear polarization that could indicate pyroclastic deposits. These include Tuli Mons and groups of shields at 5 N, 65 E. These areas contain dozens of small volcanoes spaced within kilometers of each other. In this study, smaller shield clusters (a few volcanoes) do not exhibit polarimetry characteristics that differ from surrounding plains.

The majority of volcanic plains, small volcanoes, and even intermediate and large edifices have moderate circular polarization ratios similar to pahoehoe lavas on Earth [10]. The lack of many large, low-CPR mantling deposits is consistent with modeling results that suggest that large pyroclastic deposits may be uncommon on Venus. However, the resolution of current data precludes detection of small (<10 km) mantling deposits that do not travel far from the vent, and the Earth-based data only covers a small fraction of the Venus surface. Some Venus pyroclastics (and other mantling deposits) may also be thin and transparent to the S-band radar (e.g. too thin to produce significant low CPR signatures because the radar reflects from underlying rougher terrain).

Future Work: The Arecibo images reveal clear variations in surface properties across volcanic terrains and many possible areas of pyroclastics, but interpretations are significantly limited by the resolution and coverage of the Earth-based data. Higher resolution orbital radar imaging, including polarimetry on the tens of meter scale, would lead to a significant improvement in our ability to understand the formation and evolution of volcanoes on Venus.

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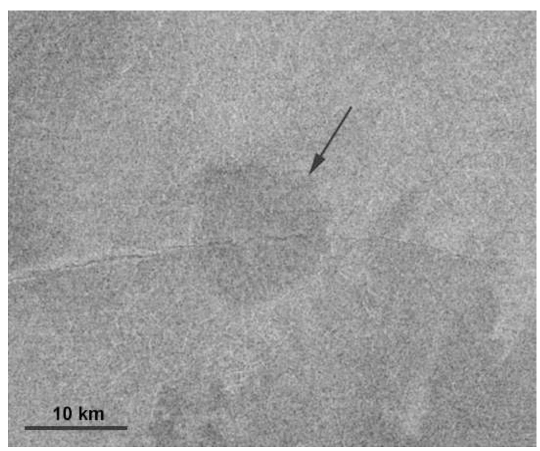

Fig. 3: A full resolution Magellan image of the dome in Fig. 2 (sampled at 75 m/pix), which straddles a fracture and has a central pit. The fracture extends over 200 km.