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Modelling the radar scattering behaviour of possible Venus pyroclastic deposits

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Abstract

Pyroclastic deposits have been proposed in several places on Venus, but these deposits have a wide variety of morphologies and radar backscatter and polarimetry properties. Radar models of the scattering behaviour of different volcanic profiles can provide insight into the structure of the deposits observed on Venus.

1. Pyroclastic Volcanism on Venus

Venus is clearly a volcanic planet, but we do not know much about the styles of volcanism that are present today and how volcanic processes may have changed over time. This information is critical to understanding how the planet loses heat, how tectonics has evolved on Venus, and how much water has been permanently lost.

Explosive eruptions require significant amounts of volatiles. Measured D/H ratios suggest that the planet's interior is very dry [6]. Modelling suggests that for explosive eruptions to occur with the dense Venus atmosphere, magma volatile contents must be much higher than they are on Earth, around 5% H_2O or CO_2 by mass [1]. These pieces of evidence suggest that pyroclastic volcanism should be rare.

However, numerous papers have identified possible Venus pyroclastic deposits, some of which are associated with areas identified as potentially younger volcanic terrains in Venus Express data [3, 4, 7, 8]. Together these observations suggest that pyroclastic deposits may be more common than expected given the atmospheric conditions, and may even be recent features that would indicate availability of volatile-rich magmas in the present era.

Currently the best way we have of studying these deposits in detail is using Magellan spacecraft data and Arecibo Observatory radar observations that also measure polarimetry. The proposed pyroclastics have a wide range of morphologies and backscatter properties. For example, both radar-bright and radar-dark features have been proposed as pyroclastic deposits (Fig. 1), and the features can be flows or have irregular outlines. In order to better understand these deposits, measurements of backscatter and polarization properties can be combined with radar scattering models of different types of surface and subsurface structures.

2. Models of Radar Backscattering

There are two questions to be addressed with modelling of the radar scattering properties of pyroclastics. First, what pyroclastic deposit types

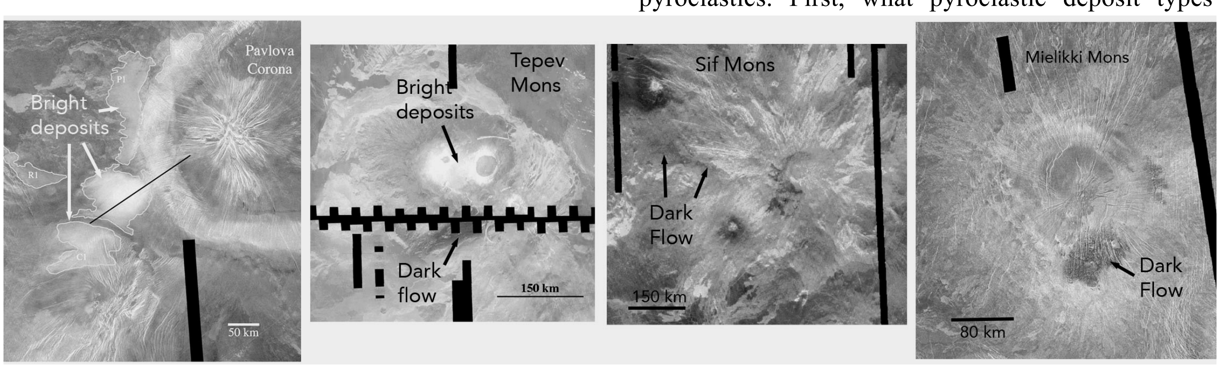

Figure 1: Some features that have been proposed as pyroclastic deposits on Venus [3, 4]. These deposits include both bright and dark deposits. Some proposed deposits have flow morphologies, while others are diffuse patches.

could lead to the diffuse radar-bright features observed near some vents? Second, radar dark flows with low CPR values can also be created by lavas with high amounts of absorbing materials such as ilmenite [5]. Radar dark flows can also display a high degree of linear polarization if the radar can penetrate into the lava flow and reflect from air gaps within the flows [4, 5]. How can we distinguish between dark pyroclastic flows and dark effusive lava flows?

The modeling will consider a range of possible deposit structures (Fig. 2). There are two basic types of scattering that need to be accounted for in the models: near-specular scattering from the smooth surfaces, and diffuse scattering from wavelength-scale structures such as embedded rocks or surface roughness elements. Specular scattering depends on the transmission and reflection coefficients of the horizontal and vertical components of the wave, as well as the attenuation through the medium.

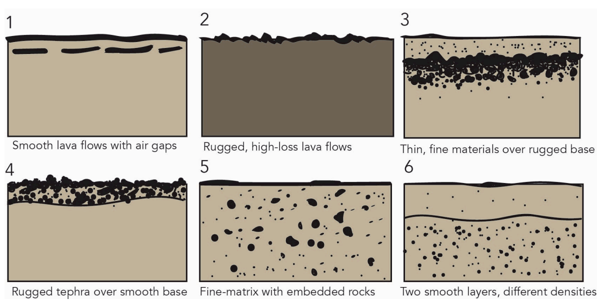

Figure 2 : Stratigraphic profiles of volcanic terrains to be considered in the modelling.

There are multiple models for rough scattering, including Mie scatterers (often used for cases with few scatterers) and the Small Perturbation Model (assumes a smooth surface). In this case, the model will use a collection of small dipole scatterers, which has successfully been used before to reproduce CPR values (e.g. [2]). The Stokes matrix terms can then be derived for diffuse and specular scatter from each of the volcanic deposit profiles. At the meeting, results will be presented for the cases of layered pyroclastic deposits with embedded rocks.

3. Summary

The radar modelling will help to quantify the relationship between the different features that have been proposed as pyroclastic deposits, and will provide a guide for how different types of pyroclastic deposits will look to radar. On Earth, close study of pyroclastic deposits provides key clues about eruption that produced them, and new higher-resolution imaging, polarimetry, and topography data of Venus are important to providing the quantitative information needed for comparison with these types of models in the future.

Acknowledgements

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