PYROCLASTIC DEPOSITS ON VENUS: REMOTE-SENSING EVIDENCE AND MODES OF FORMATION. B.A. Campbell[1], L. Glaze[2], and P.G. Rogers[3], [1]Center for Earth and Planetary Studies, Smithsonian Institution, Washington, DC 20560 (campbell@ceps.nasm.edu), [2]Proxemy Research, 20528 Farcroft Lane, Laytonsville, MD 20882, [3]NASA Headquarters, Washington, DC 20546.

The dense, hot atmosphere of Venus has a significant impact on effusive volcanism. Previous work has suggested that rapid crust formation will occur on lava flows, and that explosive eruptions require substantially higher abundances of magmatic volatiles than their terrestrial counterparts [1, 2, 3]. The transport of volcanic clasts by ballistic ejection from a source is impeded by the dense atmosphere, so simple air-fall deposits will be confined to relatively small areas about the central vent [4]. These models imply that extensive pyroclastic deposits on Venus are likely to be rare. In this work, we examine the morphology and remote-sensing properties of several rough surficial deposits which may be products of explosive volcanism, and the means by which such deposits may be produced under Venus conditions.

The largest areas identified thus far occur in the Sapho Patera region, associated with Anala (11^o N, 14.5^o E) and Irnini Montes (14.5^o N, 15.5^o E) [5]. Figure 1 shows a Magellan image of one such deposit, characterized by high radar return, feathery margins, and little internal texture. These materials appear to mantle the underlying plains, but have been embayed in several locales by later plains-forming eruptions. Unlike the crater-related haloes and parabolic ejecta surficial deposits, the radar-bright material is not the stratigraphically youngest feature in the region. Two additional areas of high radar return with wispy margins are associated with coronae south of Bell Regio (13^o and 17^o N, 37^o E). These deposits appear to emanate from the annular ridges of the coronae and trend W to SW. The southernmost deposit has been cut by a later dark plains unit (Figure 2).

The four areas share similar remote sensing properties (Table 1). All have backscatter coefficients analogous to those of terrestrial a'a flows, implying a surface with rms height at the 12-cm scale of at least 4 cm (the value needed to saturate the diffuse return) [6]. If these are fields of rocky debris, then individual clasts may range up to 8 cm in size or larger. The Fresnel reflectivity and 12.6-cm emissivity values suggest competent rock surfaces, with no evidence for enhanced dielectric constant or layers of porous material. Elevations of the bright areas range from 1.0-2.5 km above the mean radius.

A preliminary examination of the local stratigraphy and surface morphology suggests that these surficial layers are remnants of potentially much larger deposits which have been buried by later outpourings of low-viscosity magma. The central region of Irnini Mons (Sapho Patera) is filled by mottled to radar-dark lava flows and numerous small volcanic shields or domes. The source vent for the possible pyroclastic deposit is uncertain. While there are circular depressions in the northwest corner of the central floor, vents for the rugged clastic material may be buried beneath later flows. The areal extent of even the remnant pyroclastic deposits is quite large. At Irnini Mons, the furthest bright patches lie ~200 km from the start of the deposit along the arcuate inner fractures. The two corona-related deposits have maximum dimensions of ~150 km. This suggests a considerable volume of clastic debris, and in turn extended or violent eruptive events.

In an effort to constrain the possible formation mechanism for these deposits, we consider the development of eruptive plumes and the transport of clastic debris in the Venus atmosphere. While the upper-level winds are capable of carrying fine particles from a plinian (maintained and convecting) plume, or an impact crater ejecta curtain, in a preferred direction, it seems unlikely that 4-8 cm clasts could be transported in this manner. In addition, all work to date [1, 7, 8] indicates that the high surface temperature and pressure, coupled with the likelihood that CO_2 is the primary volatile component, will act to inhibit the ability of erupted material to rise buoyantly. A more reasonable scenario is that material is ejected from the vent as a gaseous jet and then collapses to form a pyroclastic flow.

We use the model for plume formation developed in [9], which differs somewhat from those presented in [7] and [8]. To model the eruption conditions at Irnini Mons, we assume a vent elevation of ~3 km, an atmospheric composition as defined by [10], and a temperature and pressure profile as defined by [11] for the central latitudes. We also assume a temperature of 1400 K for the erupted mixture of gas and pyroclasts. Fountain heights would be somewhat lower for lower eruption temperatures. The effects of CO_2 and H_2O as the driving volatile were considered.

The exit velocity of erupted material is dependent upon the volatile content of the magma. We allowed the volatile abundance to vary from 1.5-5 wt. %, corresponding to ejection velocities of 150-270 m/s. At lower volatile contents, the magma will not achieve explosive disruption [1]. For the ambient conditions at Irnini Mons, we can determine the maximum vent size for which a plume will rise convectively (Figure 3). If H_2O is the driving volatile, vents may be 50-300 m in diameter without creating a collapsing column. Low-moderate abundances of CO_2 as the driving volatile produce collapsing columns for even small (<100 m) vent diameters. The height of a collapsing column is greatest just above the maximum vent size for sustaining buoyant rise. Fountain heights of a few km are possible for moderate volatile abundances. Independent of vent radius, the maximum fountain height is directly correlated with the magma volatile content.

Such collapsing fountains could feed extensive surface flows of hot clastic material. Future work will focus on the stratigraphic relationship of the various rough deposits to their apparent source regions, and on estimation of the areal extent of the original mantling layers. We will also model the eruption process in more detail in an effort to constrain the possible volatile content and mass eruption rate required to emplace coarse-grained layers over such great distances.

Table 1. Remote sensing data for several possible pyroclastic deposits. Site location, radius R, incidence angle ϕ, radar backscatter coefficient σ^o, Fresnel reflectivity ρ, and 12.6-cm emissivity E_H are derived from Magellan data products. Range of possible dielectric constant ε based on assumption of plane- and rough-surface emission models [12]. Note the high radar backscatter coefficients for all of these sites, comparable to or greater than values for terrestrial a'a flows.

Location	R (km)	(ϕ, σ^o)	ρ	E_H	ε
14.9° N, 13.2° E	6052.09	(26°, -6.5 dB)	0.15	0.806	5.6-6.6
		(45°, -7.2 dB)			
15.3° N, 14.3° E	6052.51	(26°, -6.5 dB)	0.11	0.871	3.9-4.5
		(45°, -8.3 dB)			
16.6° N, 37.1° E	6053.13	(45°, -8.6 dB)	0.13	0.836	3.3-5.3
13.5° N, 37.3° E	6052.82	(45°, -7.9 dB)	0.13	0.852	3.0-4.7

Fig. 1. Magellan radar image of an outlying area of radar-bright terrain west of Irnini Mons. Image width 77 km. Portion of FMIDR-15N014; 1. Note the feathery margins of this mantling deposit.

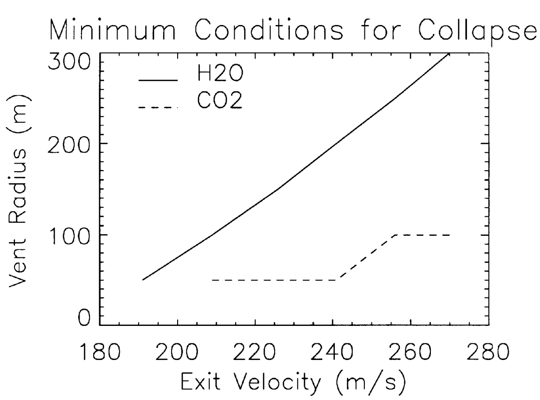

Fig. 3. Graph of minimum vent radius to permit column collapse in a Venus eruption.

Fig. 2. Magellan radar image of a rough mantling deposit south of Bell Regio. Image width 203 km. Portion of C1-MIDR-15N043; 201. Note that the deposit is bisected by plains-forming flows.

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