PYROCLASTIC FLOW DEPOSITION ON VENUS.

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Introduction: Pyroclastic Density Currents (PDCs) are hot, gravity-driven flows composed of volcanic material and gases that accompany explosive volcanic eruptions. PDCs have been known to form by the collapse of eruption columns [1], by the collapse of a lava dome [2], or by lateral blast [3]. For magma compositions similar to Earth, the high atmospheric pressure on Venus influences explosive eruptions in the following ways: (i) inhibition of bubble exsolution and growth resulting in low injection velocities [4], and (ii) reduced expansion of the eruption column due to low density contrast with the atmosphere [5]. Both these processes act to restrict plume growth and buoyancy, leading to conditions conducive for plume collapse and subsequent PDC generation. The dense lower portion of the PDC is referred to as a pyroclastic flow and the resulting deposit is termed a pyroclastic flow deposit [6]. The largest pyroclastic flow deposits on Earth have runout lengths >100 km [7,8].

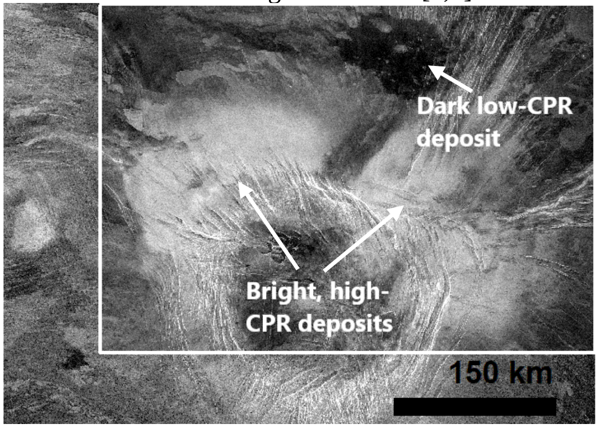

Fig. 1 Magellan SAR image of Irnini Mons. The white rectangle marks the boundary of the simulation grid.

Proposed pyroclastic deposits on Venus: Previous workers have mapped likely pyroclastic flow deposits with large runouts (70-120 km) using Arecibo and Magellan SAR images of Venus's surface [9,10]. The radar backscatter and polarimetry vary greatly between these proposed deposits. On one hand, deposits with high backscatter in Magellan SAR and high circular polarization ratio (CPR) in Arecibo data have been suggested to be pyroclastic flow deposits (Fig. 1) [10]. However, pyroclastic flow deposits are expected to be radar-dark owing to the small grain size of ash. Accordingly, low-CPR regions of fine-grained mantling deposits have also been suggested to be pyroclastic flow deposits (Fig. 1) [11]. We use 2D gravity-flow models to recreate the runouts of both types of deposits at Didilia Corona, Irnini and Tepev Mons. Results from the simulations at Irnini Mons are presented here.

Irnini Mons (14.3°N, 15.65°E) is a volcano-tectonic feature in Western Eistla Regio with SAR-bright, high-CPR deposits in the northern flank, separated by a dark, low-CPR flow in the lower section of the flank (Fig. 1). Both deposits have been suggested to be of pyroclastic flow origin [10,11]. The diffuse, SAR-bright deposit also appears to have flowed down the shallow slope (<2.5°) of Irnini Mons. The runout of these deposits range from 70 km in some places to >100 km in others.

Model: We implement a 2D granular flow model by solving depth-averaged shallow water equations on an XY grid [12]. The method of using granular flow models to simulate pyroclastic flows have been shown to be effective for terrestrial PDCs [13,14]. High particle concentration flows are expected to be primarily gravity driven even under high ambient pressure conditions [15]; hence using this model is appropriate to test out a purely gravity-driven endmember case. The depth-averaged model takes as input the topography of the area [16], friction angle (which is a property of the flowing material), and initial flow velocity and simulates the change in flow depth and velocity over a specified time period. Following previous studies [12], our model uses a 1st order Godunov scheme with an HLLC Riemann solver to calculate the flux across the grid cell interfaces; the source terms are solved separately using an explicit Euler method. Simulations were run to match the extent of the bright and dark deposits on the northern flank of Irnini Mons with the parameters listed in Table 1. To increase flow runout, high values for initial velocity and pore fluid pressure, and low values for friction angle were necessary. The initial flow velocity used is close to the speed of sound on Venus and the ratio of pore pressure to total basal normal stress was set to 0.98. The friction angle employed here is also low compared to most terrestrial studies [14], but given the shallow slopes of Irnini Mons, low friction angle is needed to initiate flow.

Total volume	~2.5 km^3
Initial velocity	400 ms^{-1}
Friction angle	12°
Simulation time	10 minutes

Table 1 Parameters used in 2D mass flow simulation

Results and Discussion: The simulated flow runs out to ~45 km for the bright deposit and ~35 km for the dark deposit (Fig. 2). For the bright deposit, the lateral

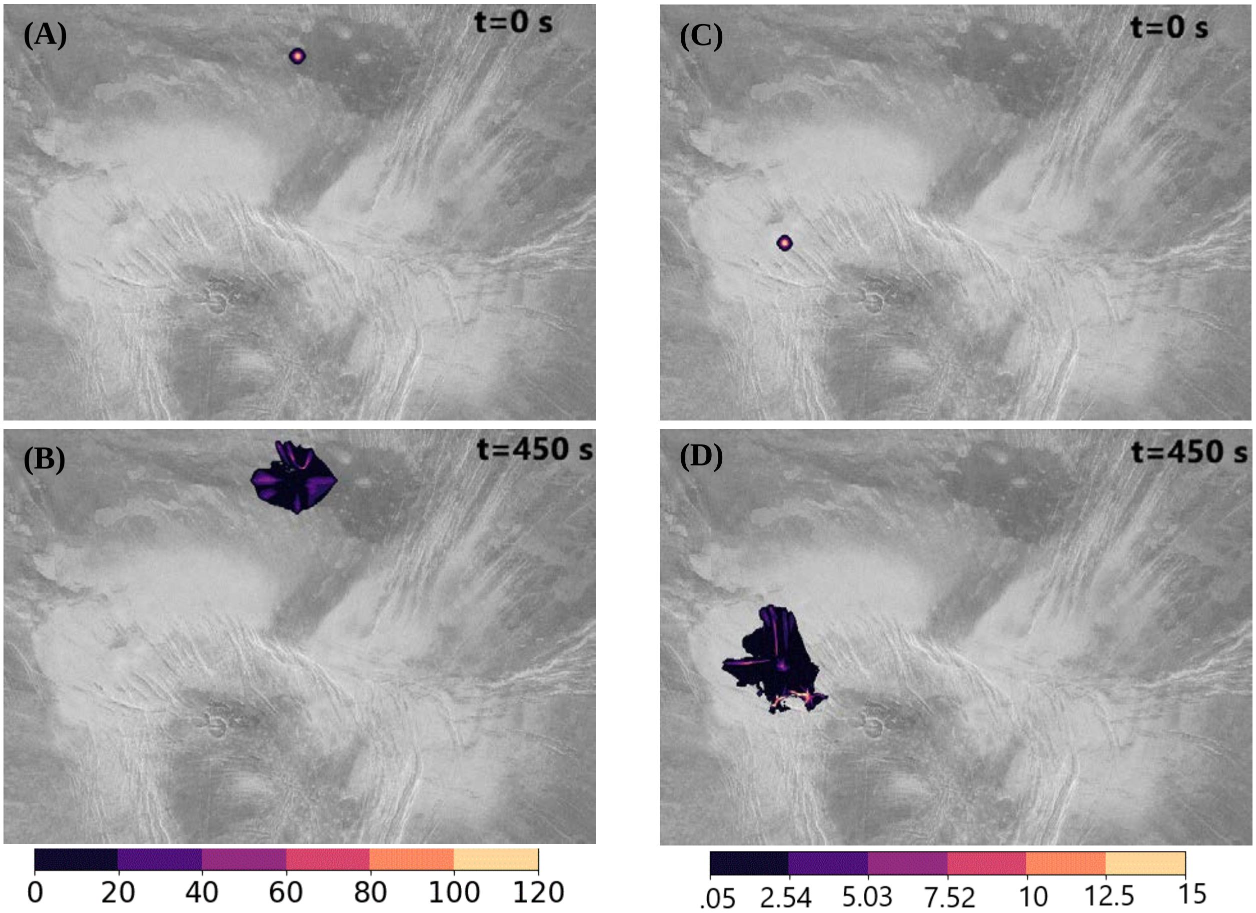

Fig. 2 Flow thickness (in meters) after 9 min. **(A)** Initial location and **(B)** final flow thickness for dark deposit. **(C)** Initial location and **(D)** final flow thickness for bright deposit. Streaks of localized thickness in (B) and (D) are artifacts caused by coarse resolution and data gaps within the stereo topography.

extent of the simulated flow is small compared to the observed unit; however, multiple sources of PDC could explain the areal extent. After 10 minutes, local deposit thickness is as high as 12.2 m for the dark deposit and 70.5 m for the bright deposit. Average final thickness is ~2.4 m for both flows. It is clear that the gravity-driven flow models are unable to produce the observed runouts for both deposits after 10 minutes of flow (flow thickness after 9 mins are shown in Fig. 2).

Future work: We intend to add the effects of diffusing pore pressure and variable basal friction to the current model. However, including the effects of pore pressure diffusion would only act to increase flow resistance and reduce runout. We will also explore models outside the purely gravity-driven regime which take into account processes analogous to subaqueous flows, such as sliding on a thin film of ambient fluid (as with marine debris flows) or transport by turbidity currents (like turbidites), which can result in longer runout of pyroclastic flows on Venus.

Acknowledgments: This study was supported by a FINESST award to I. Ganesh and partly by an SSW grant to L. M. Carter. Magellan SAR images were processed using USGS Astrogeology Science Center's Map-A-Planet 2 (MAP2).

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