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MONTE CARLO MODELING OF THE RESURFACING OF VENUS. M. A. Bullock[1], D. H. Grinspoon[1], and J. W. Head[2], [1]Laboratory for Atmospheric and Space Physics and the Department of Astrophysical, Planetary and Atmospheric Sciences, University of Colorado, Boulder CO 80309, USA, [2]Department of Geological Sciences, Brown University, Providence RI 02912, USA.

The observed size-frequency distribution of impact craters on Venus is consistent with a production surface that is approximately 0.5 to 1.0 Gy old [1]. However, widespread volcanism on the surface suggests that some regions may be significantly younger than this, and the question of whether the surface is in production or equilibrium remains open. Recent results from the Magellan mission to Venus show that only a small number of impact craters are modified by volcanism [2]. Furthermore, statistical analyses of the placement of impact craters on the surface of Venus suggest a completely spatially random distribution [1]. The existing distribution of impact craters on Venus may be explained by three possible equilibrium models:

1. Global scale resurfacing occurred at some time in the past, followed by much reduced volcanic activity [2]. Impact craters would have accumulated since this time, and the surface of Venus would be of a single production age.
2. Resurfacing occurs on a regional level, with a characteristic length scale that is less than the scale of randomness of the crater population [3].
3. Volcanic activity is responsible for a slow vertical accumulation of lava, resulting in the eventual removal of craters [1].

We have developed a three-dimensional model of venusian resurfacing that employs Monte Carlo simulations of both impact cratering and volcanism. The model simulates the production of craters on Venus by using the observed mass distributions of Earth- and Venus-crossing asteroids and comets [4]. Crater rim heights are calculated from a power law fit to observed depth/diameter ratios. The growth of a variety of volcanic features is simulated in the model. The areal extent of shield fields, large volcanos, and lava floods is determined in the simulations by sampling the appropriate distributions for the feature type from Magellan data. Since a greater number of modified craters is found in the Atla-Beta-Themis region, the spatial distribution of volcanic activity is skewed in the model to represent regions of greater or lesser volcanism. Lava flows are modeled by an energy minimization technique to simulate the effects of local topography on the shape and extent of flows. Some mixture of the three endmember models described may be necessary to adequately explain the observed paucity and distribution of partially embayed impact craters. The model is run under a wide range of assumptions regarding the scale and time evolution of volcanism on Venus. Regions of the parameter space that result in impact crater distributions and modifications that are currently observed will be explored to place limits on the possible volcanic resurfacing history of Venus.

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DEBRIS AVALANCHES AND SLUMPS ON THE MARGINS OF VOLCANIC DOMES ON VENUS: CHARACTERISTICS OF DEPOSITS. M. H. Bulmer[1], J. E. Guest[1], K. Beretan[2], G. Michaels[2], and S. Saunders[2], [1]University of London Observatory, University College London, NW7 2QS, UK, [2]Jet Propulsion Laboratory, Mail Stop 230-225, Pasadena CA 91109, USA.

Modified volcanic domes, referred to as collapsed margin domes, have diameters greater than those of terrestrial domes and were therefore thought to have no suitable terrestrial analogue. Comparison of the collapsed debris using the Magellan SAR images with volcanic debris avalanches on Earth has revealed morphological similarities. Some volcanic features identified on the seafloor from sonar images [1,2] have diameters similar to those on Venus and also display scalloped margins, indicating modification by collapse.

Examination of the SAR images of collapsed dome features reveals a number of distinct morphologies to the collapsed masses. Ten examples of collapsed margin domes displaying a range of differing morphologies and collapsed masses have been selected and examined. Of these, five have more than one failure on their flanks. The aprons have distinct radar characteristics that reveal lobate boundaries, large radar-bright blocks, and hummocky terrain, features typical of landslide deposits [3], making them distinct from lava flows, which show a more constant radar backscatter and irregular boundaries. The morphologies vary (Fig. 1), from those that spread only toward their terminus to those that spread very early in their course and have a large lateral extent. Similar morphologies, seen in GLORIA images of landslides on the seafloor off the Hawaiian Ridge [1], are suggested to be two types, debris avalanches and slumps. The slumps are slow moving during emplacement, wide, and thick, with transverse blocky ridges and steep toes, while debris avalanches are fast moving, elongate, and thinner. While it is difficult to see small-scale surface detail from the SAR images, the comparison seems justified.

The distance the aprons have traveled from the base of the dome ranges from 8.6–68.8 km, making their runout distances comparable to large terrestrial volcanic debris avalanches, pyroclastic flows, and lahars. Data on the travel distance of the venusian avalanches (Table 1) as a function of vertical drop height (H/L), plotted against terrestrial mass movement features, demonstrates the great mobility of a number of them.

TABLE 1. Measurements of seven debris aprons from collapsed margin domes on Venus.

A	B	C	D	E
Name	Volume km^3	Height km (H)	Length km (L)	H/L
–26.3, 296.8		1.4	62	0.022
–29.7, 183.7	220	0.9	38.5	0.023
–16.8, 244.8	150	3.7	25.7	0.14
–7.6, 255	135	1.6	19	0.08
–25.4, 308		1.6	10	0.16
–25.4, 308		1.6	8.6	0.19
–0.2, 284.9		0.14	23	0.0061

Fig. 1. Mapped outlines of slump and debris avalanche aprons. The outline in the bottom right is that of a possible lava flow from the collapsed margin dome on Sapas Mons.

On Earth, landslides on volcanic edifices can be triggered by a number of different processes, including those occurring as a result of aseismical crustal deformation, such as oversteepening of slopes due to deformation (possibly resulting from dyke emplacement of magma rise), overloading of the slope (by lavas), excess weight at the top of the slope (due to a large cone or a large area of summit lava), removal of support by explosions on the flanks, and caldera collapse. Failure occurring coseismically can result from structural alteration of the constituent parts of the slope leading to failure, dislodgement of otherwise stable slopes, and fault movement resulting in an increased slope angle [4]. Seismic pumping may also be a major control on slope stability during an earthquake [5].

On Venus, similar processes may operate. The high ambient temperatures may result in development of a weak carapace, which in turn may allow relatively rapid dome growth to occur. If the effusion rates are high, as suggested by the size of the features, then oversteepening would be a likely consequence resulting in failure and collapse. Landslide scars may be modified by continued dome growth. The existence of fractures around the base of some of the collapsed domes and of debris aprons cut by fractures suggests that there has been seismic activity and surface deformation occurring during the period of modification of the dome.

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MIXED-VALENCE IRON MINERALS ON VENUS: Fe^{2+}-Fe^{3+} OXIDES AND OXY-SILICATES FORMED BY SURFACE-ATMOSPHERE INTERACTIONS. Roger G. Burns and D'Arcy W. Straub, Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge MA 02139, USA.

Background: The oxidation state and mineralogy of iron on the hot surface of Venus are poorly understood [1–3], despite qualitative *in situ* measurements of oxygen fugacity during the Venera 13/14 missions [4], some reflectance spectral data derived from the