OVDA FLUCTUS, THE FESTOON LAVA FLOW ON OVDA REGIO, VENUS: MOST LIKELY BASALT.

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Introduction: Whether Venus' tesserae and the high plateau and mountains of Ishtar Terra and Maxwell Montes contain granitic (silica-rich) igneous rock is a fundamental question about the planet's history, with implications concerning ancient liquid water, paleoclimate, and habitability [1]. On the Venusian highland of Ovda Regio is a distinct lava flow, Ovda Fluctus, with a rumpled (festooned) surface. Ovda Fluctus, or the Festoon Flow, has been interpreted to be a flow of silica-rich lava [2,3]. Here, we have mapped Ovda Fluctus in detail, using all available data and emphasizing properties that might be diagnostic of its chemical composition and its interactions with the underlying terrain. The available data are consistent with Ovda Fluctus being of basaltic lava, not silica-rich lava.

Methods: All data are from the Magellan Venus orbiter mission [4], downloaded from the USGS "Map-a-Planet" site. Elevation data include a stereo radar DEM [5], augmenting Magellan altimetry. Images were processed and interpreted in ArcGIS and JMARS. Fractal dimensions of lava flow margins were calculated using the "ruler" method [6,7]. Festoons were recognized in left-look synthetic aperture radar (SAR) images as multiple, continuous, arcuate ridges with radar-bright peaks and layover in between.

Results: We evaluated several properties of Ovda Fluctus that are affected by the flow's rheology.

Roughness. Silica-rich lava flows are rough at meter-scales because of their high viscosity [8]. Ovda Fluctus is relatively smooth in comparison to the surrounding tesserae at this scale (Fig. 1).

Fractal Dimension. The fractal dimension of a lava flow margin is dependent upon its effective viscosity; less viscous flows tend to have more sinuous margins and thus higher fractal dimensions [7]. The flows we measured have fractal dimensions from 1.15 to 1.42, averaging 1.26 (Fig. 2). Fractal dimension can be influenced by the underlying topography, but there is no systematic difference here between flow lobes on flat and rough surfaces (Fig. 2) – compare lobes 1, 6, 7, & 16.

Altimetry. Ovda Fluctus sits near the crest of Ovda Regio, which has relief of over several kilometers. DEM data across the flow's northern margin give a thickness of ~200m. However, the center of the flow is at ~500m lower elevation than its northern margin. The fluctus straddles a critical elevation where radar properties change abruptly, with the low-backscatter portion of the flow being higher in elevation than the high-backscatter portion [9].

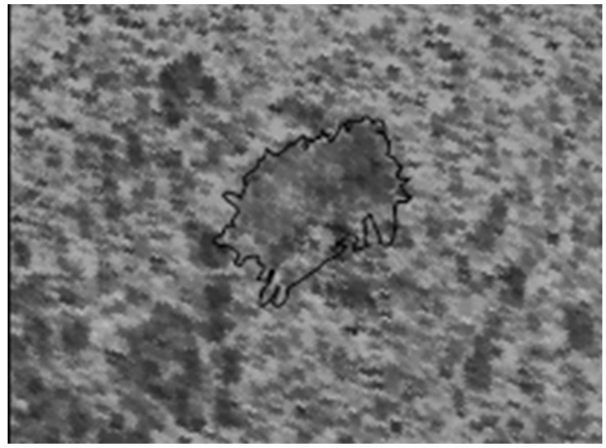


Figure 1. Ovda Fluctus region (outlined), in Magellan meter-scale roughness map. Darker tone is lower roughness; the flow is distinctly smoother than the surrounding tessera. Image spans 3–10S, 91–100E (950 km across); north to top.

Festoons. The surface of Ovda Fluctus is decorated with festoons, arcuate ridges that are inferred to form as the stiff, cooler, surface of a lava flow is deformed by the flowing lava beneath [2]. As such, festoons arc in the direction of flow, and those on Ovda Fluctus are consistent with outward flows toward its margins. Where these festoons are adjacent to kipukas (land surrounded but not covered by the flow), their orientations are skewed. These festoons likely represent interactions between the flow and underlying tesserae [2]. Festoon density is higher in the radar-bright portion of the flow. Where the bright and dark flow portions meet, moderately radar-dark sections of the flow seemingly overlap the festoons with less festoon-dense lava.

Overall Morphology. Ovda Fluctus' area (~60,000 km^2) and volume (~6,000 km^3) are more consistent with terrestrial basaltic effusions [10,11,12] than silicic. Topographic depressions, like that at the center of Ovda Fluctus, are known for flows of basalt lava on Earth, but not for silica-rich lava flows [13]. Because the flow fills troughs in the Ovda tessera, its estimated volume is uncertain. DEM data does not cover similar troughs in the tesserae, but the troughs could be kilometers deep.

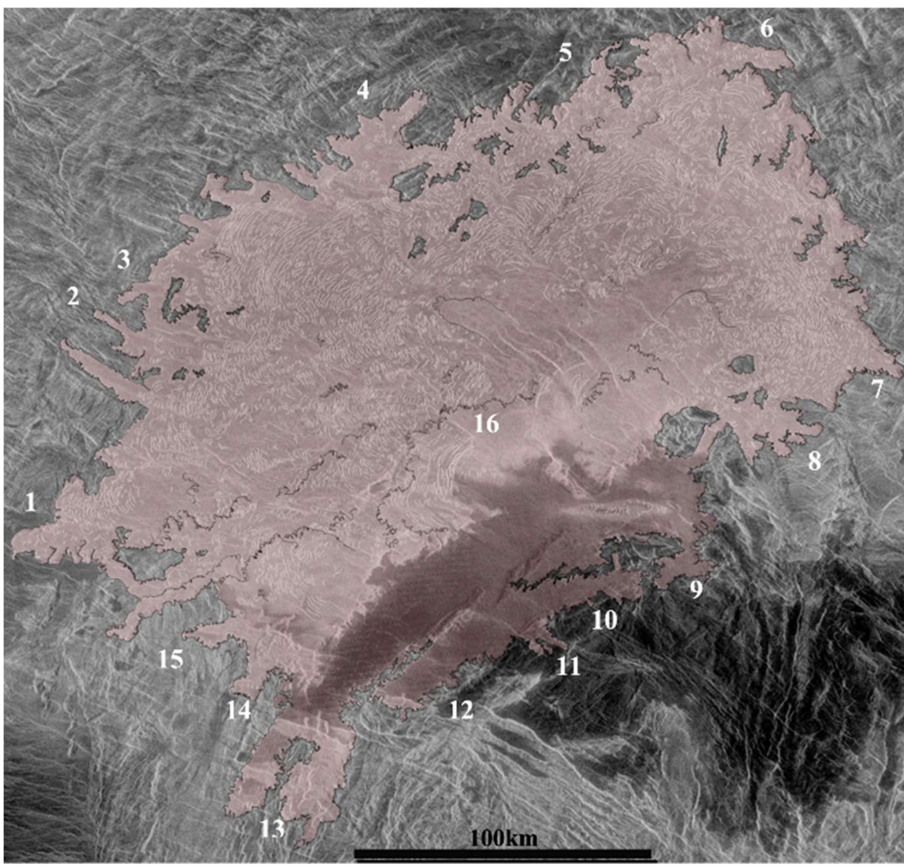
Discussion: The overall extent of Ovda Fluctus is slightly larger than previously mapped [2], see Fig. 2.The southern and eastern margins of the flow are ambiguous due to low contrast in SAR backscatter and numerous cross-cutting ribbon faults that obscure earlier geomorphic boundaries. It is possible that Ovda Fluctus superposes earlier flows. Radar emissivity and backscatter of the fluctus are similar to that of the surrounding tesserae, providing no evidence that Ovda Fluctus is of different material than the tesserae.

The fractal dimensions of Ovda Fluctus' flow lobes average 1.26 (Fig. 2), which is consistent with pahoehoe basalt flows, and well above dimensions measured for a'a basalt and silica-rich lavas [6]. Emplacement onto the rough tessera surface does not affect this inference, because interaction of a flow lobe with underlying terrain tends to decrease its fractal dimension [14].

Generally, the flow lobes are elongated NE-SW along the regional topographic trend of the surrounding tessera. This NE-SW trend is apparent within other features atop Ovda Fluctus (Fig. 2), such as the boundary between radar-bright features; flow lobe boundaries on the main flow surface (e.g., lobe 16); and orientations and alignments of the kipukas (Fig. 2). These features may represent rootless flows interacting with elevated tesserae [15].

Conclusions: All available evidence is consistent with Ovda Fluctus being composed of basaltic lava, and not of silica-rich lava. Because Ovda and its surrounding tessera have generally similar radar emissivity, it seems reasonable that the tessera could also be of basaltic material. This inference, of a basaltic tessera composition, can perhaps be tested using near-infrared optical emissivity [1].

References: [1] Gilmore M. et al. (2017) Space Sci. Rev. 212, 1511-1540. [2] Schenk P. & Moore H. (1992) LPSC 23rd, 1217-1218. [3] Saunders et al. (1992) JGRP 97, 13,067-13,090. [4] Head J.W. & Hess P.C. (1996) LPSC 27th, 513-514. [5] Herrick R. et al. (2012) EOS 93, 125-126. [6] Kappraff J. (1986) Computers Math. Applications 12, 655-671. [7] Bruno B.C. et al. (1992) GRL 19, 305-308. [8] Plaut J.J. et al. (2004) JGRP 109, E03001. [9] Treiman A.H. et al. (2016) Icarus 280, 172-182. [10] Permenter J. & Nussbaum R. (1994) LPSC 25th, 1067-1068. [11] Bryan S.E. et al. (2010) Earth Sci. Rev. 102, 207-229. [12] Swanson D. et al. (1975) Am. J. Sci. 275, 877-905. [13] Deschamps et al. (2014), GGG 15, 2128-2150. [14] Bruno B.C. et al. (1994) Bull. Volcanol. 56, 193-206. [15] Bleacher J.E. et al. (2017) JVGR 342, 29-46.



Lobe	D	R^2
1	1.22	0.88
2	1.28	0.98
3	1.28	0.98
4	1.15	0.94
5	1.21	0.98
6	1.28	0.91
7	1.25	0.98
8	1.18	0.97
9	1.30	0.94
10	1.25	0.99
11	1.42	0.97
12	1.20	0.97
13	1.22	0.94
14	1.39	0.85
15	1.30	0.99
16	1.21	0.97
Mean D	1.26	
σ	0.07	

Figure 2. New geomorphic map of Ovda Fluctus (left, North is up) and comparison table (right) of fractal dimension for numbered lobes. The flow (pink) is mapped with terminal and inner margins (black lines). Festoons (white lines) are generally convex in the flow direction. Numbers denote lobes that were analyzed for fractal dimension, D [5,6]. R^2 is goodness of linear fit in calculating each D.