Icarus 277 (2016) 433–441

Contents lists available at ScienceDirect

Icarus

journal homepage: www.elsevier.com/locate/icarus

Geomorphology and volcanology of Maat Mons, Venus

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ARTICLE INFO

Article history:
Received 23 December 2015
Revised 8 April 2016
Accepted 13 May 2016
Available online 4 June 2016

Keywords:
Venus surface
Volcanism
Geological processes

ABSTRACT

Full-resolution (FMIDR) Magellan radar backscatter images have been used to characterize the geology and volcanology of the volcano Maat Mons on Venus. This volcano has often been identified by remote sensing techniques as one of the volcanoes on the planet that could have been recently active, and is the highest volcano on Venus with a relief of ~9 km. The summit of Maat Mons is characterized by a caldera complex ~26 × 30 km in diameter with at least six remnant pit craters ~10 km in diameter preserved in the walls of the caldera, suggesting that multiple small volume (<16 km^3) collapse events formed the caldera. Four lava flow types, described as "digitate flows", "sheet flows", "fan flows" and "filamentary flows", can be identified on the flanks. Three rift zones can be identified from the distribution of 217 pit craters >1 km in diameter on the flanks. These pits appear to have formed by collapse with no effusive activity associated with their formation. No evidence for explosive volcanism can be identified, despite the (relatively) low atmospheric pressure (~55 bar) near the summit. There is also a lack of evidence for lava channels, deformation features within the caldera, and thrust faults on the flanks, indicating that the physical volcanology of Maat Mons is simpler than that of typical martian and terrestrial shield volcanoes. Preservation of fine-scale (3–4 pixels) structures within the pit craters and summit pits is consistent with geologically very recent activity, but no evidence for current activity can be identified.

1. Introduction

Over the past 30 years, several investigations have hinted that Venus is volcanically active today, but none have been definitive. Episodic injection of sulfur dioxide into the atmosphere (Esposito et al., 1988), high radar emissivity at elevations >2.5 km above the 6051 km mean planetary radius (Robinson and Wood, 1993), visible and infrared emissivity measurements of the surface (Smrekar et al., 2010), and enhanced microwave thermal emission (Bondarenko et al., 2010) have all been proposed as indicators of recent eruptions. Maat Mons (194°E, 1°N) (Fig. 1) is possibly the best candidate for a recently active volcano on Venus, by virtue of the spatial variability of radar emissivity values at the summit (Klose et al., 1992; Robinson and Wood, 1993; Campbell, 1994), near-infrared spectra (Shalygin et al., 2012), and high (>8 km) topographic relief which suggests that the volcano is still being constructed. In addition, Magellan gravity data show that the Atla Regio region (~10°S to 25°N, 180° to 215°E), where Maat Mons is located, is one of the areas on Venus that could be situated over an active hot spot and thus is consistent with the hypothesis that Maat Mons could be active today (Smrekar, 1994; Shalygin et al., 2012).

Detailed geomorphic mapping of the summit area and flanks of the volcano extending up to ~100–120 km from the summit (Fig. 2) has been conducted here to better characterize the styles of volcanism at Maat Mons. Despite the importance of Maat Mons for investigating recent volcanism on Venus, the available data sets for such analysis are scarce, even by comparison with elsewhere on the planet. Only left-looking Magellan synthetic aperture radar (SAR) data are available for the entire volcano (right-look data are missing for the summit), and no stereo-derived topography (Lerberl et al., 1992; Gleason et al., 2010) is available. FMIDR Magellan radar backscatter images were used for this study; at the latitude of Maat Mons, these data have a spatial resolution of 108 m (cross track) and 110 m (along track) prior to projecting the data. Thus the intrinsic preserved resolution of the radar images is probably no better than ~150 m x 150 m. Topographic data come from the Magellan nadir-looking radar altimeter that has mapped the surface at a horizontal resolution of 10–30 km (Ford and Pettengill, 1992), so this has resulted in poor knowledge of the summit caldera geometry and the detailed shape of the upper slopes of the volcano (Fig. 3). Furthermore, Maat Mons is located on the Equator at 194°E, so that the volcano is never visible from Earth-based radar (Campbell and Campbell, 1992) thereby precluding any multi-incidence angle radar studies of the texture of lava flows. Magellan SAR data have an incidence angle of ~45° over Maat Mons.

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http://dx.doi.org/10.1016/j.icarus.2016.05.022
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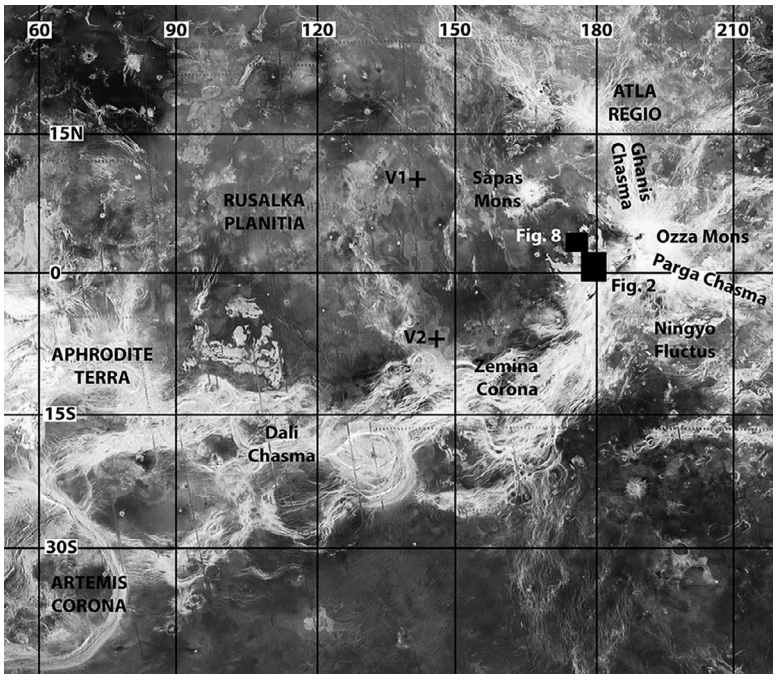

Fig. 1. Location map for Maat Mons. Study area of Maat Mons (Fig. 2) and the NW lava flow field (Fig. 8) are identified. "V1" and "V2" denote the Vega 1 and Vega 2 landing sites. Mosaic covers an area from 30°N to 45°S and 58° to 215°E. Part of JPL image PIA00256.

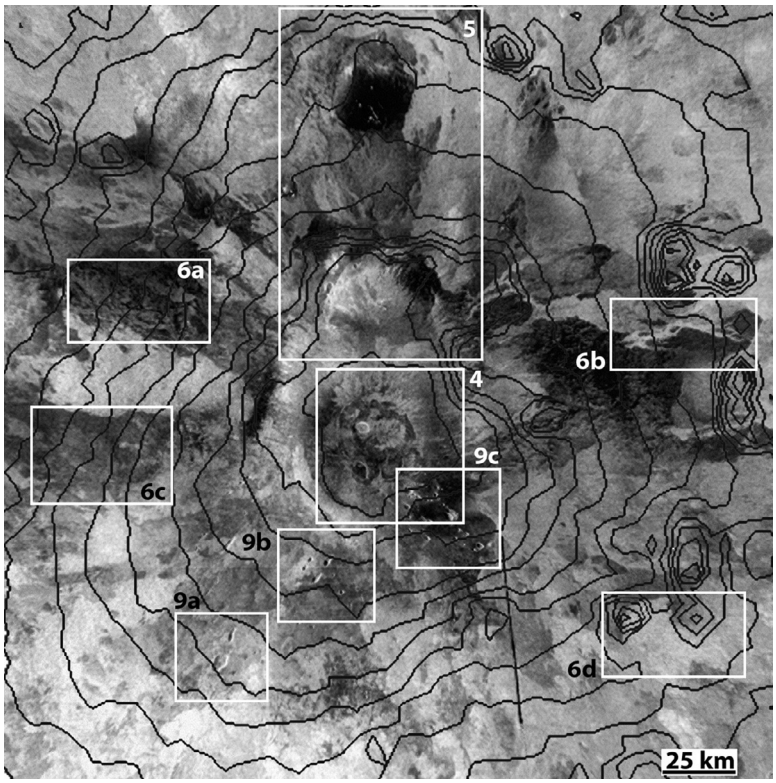

Fig. 2. Magellan SAR mosaic of Maat Mons. Superposed contours from the Magellan radar altimeter are at 500 m intervals. White boxes show the locations of subsequent figures. Geographic area extends from 0.3°S–2.2°N, 193.4°E–196.2°E. Topographic data from Ford and Pettengill (1992). Magellan image mg_0024/f00n194. See Fig. 1 for location.

2. New mapping

This study of Maat Mons has included an analysis of the distribution of pit craters on the flanks, the spatial distribution of lava flow fields (radar-bright and radar-dark flows), and the morphology of the summit craters. Collectively, the mapping permits insights into several characteristics of the volcano, including:

(a) An investigation of the role of elevation on the degassing of magmas on Venus. In particular, a search for evidence