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Small-scale post-Noachian volcanism in martian highlands? Insights from Terra Sirenum

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Abstract

Volcanism on Mars was globally widespread in the early history, but was localized to a few main volcanic provinces [1]. Evidence for post-Noachian volcanism in the Martian highlands is rare outside these main provinces (e.g., Tyrrhena and Hadriaca Montes) and, to our knowledge; no such edifices have been reported so far. Here we report on our observations of several promising edifices in Terra Sirenum that might change this view.

1. Introduction

It is generally thought that highland volcanism occurred early in Mars` history and stopped not later than ~1 Ga after planet formation [2]. This activity produced large-scale volcanic edifices (paterae) and fine-grained pyroclastic deposits sometimes without clear associations to the known volcanic landforms. Several candidate locations were suggested as volcanic centres in western Gorgonum and south-eastern Atlantis basins [3], where extensive accumulations of deposits exist, however these volcanic centers were not confirmed by later studies ([4], [5]). It is not known where the pyroclastic material came from and whether volcanism was actually active in these areas.

Our study area is south of Gorgonum basin and about 150x50 km wide. It contains two spectacular cones with outgoing flows-like and 3 enigmatic dome-like structures (Fig. 1a). As far we know these landforms have not been described in previous studies.

2. Methology

We use images from CTX, HRSC, HiRISE and THEMIS-IR (day and night). Absolute model ages were determined from the crater size–frequency distributions, utilizing the software tool ‘cratertools’ and ‘craterstats’ applying the production function coefficients of [6] and the impact-cratering chronology model coefficients of [7].

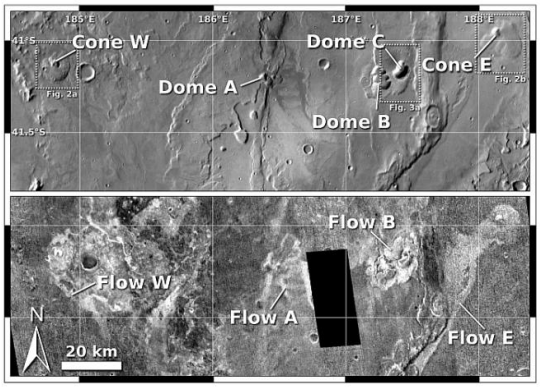

Figure 1: Themis-IR day- (above) and night-time (below) images of study area. Note the considerable thermal contrast between images, suggesting the presence of flow-like structures associated with cones and domes (visible in the night-time image).

3. Morphology

The study area is located in the Terra Sirenum region, where the crust is fractured by ~E-W-trending Tharsis-radial graben systems propagating from Syria Planum [8] and a series of older (thrust?) faults trending ~N-S. In the central part, three dome-like structures associated with flows are visible in day and night THEMIS images (Fig. 1b). Two well-developed breached cones (Fig. 2a, b) with outgoing flows partly covering cones themselves (Fig. 2c, d) are situated at the western and eastern margin of the investigated area. Overlapping flow margins (Fig. 2e) suggest a repetitive process of their formation. Flow thickness appears variable: Older/stratigraphically lower flows are less thick than younger/stratigraphically higher flows. The edges of the youngest flows seem to be relatively steep, based

on shadow lengths, which is in strong contrast to basaltic flows in Tharsis that typically display low relief. Based on HiRISE image inspection, the surface of one flow associated with a dome-like structure is built by boulders up to several meters large, and filled by eolian deposits forming small dunes. The surface of flows does not correspond to that of possible Martian glacial flows [9] and bears more resemblance to terrestrial ‘A’ā lava flows.

Preliminary age determination results based on crater counting suggest that some cones (Fig. 2) were formed between 0.5 to 1 Ga ago.

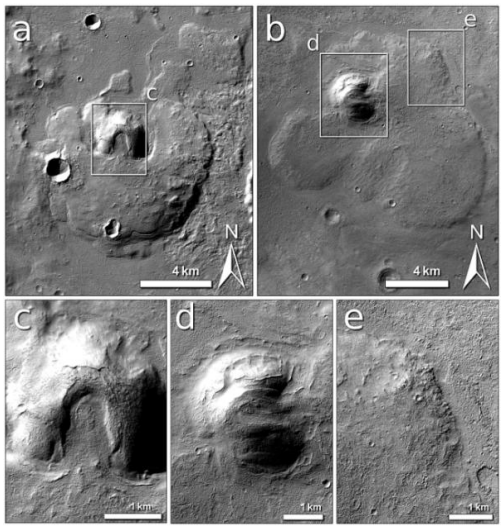

Figure 2: Two cones (a,b) with associated flows, note the details of cones (c,d) with central vent from material erupted to the surface. (e) is showing edge of overlapping flows. See the Fig. 1 for position.

5. Summary and Conclusions

Based on our observations and the similarities to terrestrial obsidian flows, we conclude that these surface features are probably volcanic in origin and post-Noachian in age. The observed cones represent Martian small-scale pyroclastic cones with outgoing lava flows, different in morphological comparison with previously observed Martian cinder cones ([10], [11]) or tuff rings/cones [12]. The Martian volcanic diversity is still growing.

The differences in flow thickness and the steepness of flow margins suggest changes in flow viscosity during cone formation and associated flow emplacement. If true, these observations raise the question whether these flows are composed by more evolved lava than characteristic for most other lava flows on Mars. However, further investigations are needed, and these cones and flows might represent ideal candidates for spectroscopic observations.

Acknowledgements

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