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A unique volcanic field in Tharsis, Mars: Monogenetic cinder cones and associated lava flows.

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Abstract

This study is focused on an unique unnamed volcanic field in Tharsis, where we observed several atypical small conical edifices. Our investigation suggests that these cones are monogenetic volcanoes. Their morphometric properties and a comparison to terrestrial analogues suggest that they are Martian equivalents of terrestrial cinder cones,.

1. Introduction

Mars displays a wide range of relatively young volcanic landforms [1]. Most of them are produced by effusive activity, like giant shield volcanoes, small and low shields, lava flows, and lava plains. Although the most common type of volcanic edifices on Earth are monogenic cinder or scoria cones [e.g., 2], the unambiguous identification of cinder cones on Mars is rare. Previous studies discussed the existence of cinder cones on Mars on theoretical grounds [3, 4], or used low-resolution Viking Orbiter images for putative interpretations. With the exception of morphologically similar pseudocraters [5], however, they were not analyzed in detail yet. We report on several possible cinder cones (**Fig. 1**) in an area situated north of Biblis and Ulysses Paterae.

2. Methology

This study uses images from the Context Camera (CTX), High Resolution Stereo Camera (HRSC), and High Resolution Imaging Science Experiment (HiRISE). CTX images have sufficient resolution (5-6 meters/pixel) to identify possible cinder cones and associated edifices. Topographic information (e.g., heights and slope angles) were determined from single shots of the Mars Orbiter Laser Altimeter (MOLA) in a GIS environment, and from stereo images (HRSC, CTX) and derived gridded digital elevation models (DEM).

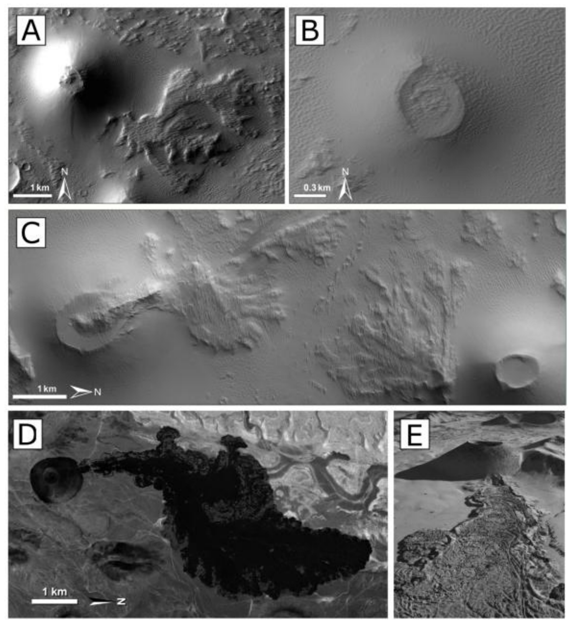

Figure 1: (A) Detail of lava flow starting on the base of cone (CTX, P22_009554_1858_XN_05N122W, centered 5.87°N/237.15° E), (B) summit crater of cone with well-developed rim and flat plato on the top (HiRISE, PSP_008262_1855_RED, centered 5.78°N/237.01°E) and (C) lava flow gravitating on the flank of cone (left) and next flow starting on the base of cone (right). Note transition between lava flows and surrounding plain covered by strong dust layer (HiRISE, PSP_008262_1855_RED, centered 5.65°N/237.02°E). D) Terrestrial cinder cone with associated lava flow (SP Mountain, Arizona, USA). E) Arial view of the same cinder cone with detail of lava flow in the foreground.

3. Comparison

Monogenic volcanic landforms on Earth were well described previously, and several basic ratios were established to classify them [2]. We calculate these ratios for the cones in the study area to test the hypothesis that they are Martian analogues to cinder cones, taking into account theoretically predicted differences in their morphology due to the specific Martian environment and its effect on eruption processes [2, 4]. Our measurements show that the investigated Martian cones have a mean basal diameter of 2,300 m, about ~2.6 times larger than terrestrial cinder cones. The crater diameter for Martian cones range from 185 to 1,173 meters. The WCR/Wco ratio has a mean value 0.28. The edifices are also higher (from 64 to 651 meters) than terrestrial cinder cones (on average: 90 meters). The Hco/Wco ratio is 0.12, which is less than that of pristine terrestrial cinder cones with a ratio of 0.18 (**Fig. 2**). The slope distribution of cone flanks is between 12° and 27.5° (the steepest sections reach >30°).

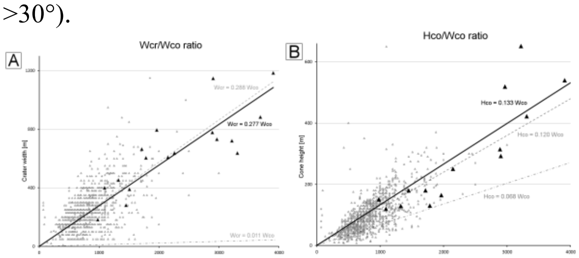

Figure 2: Morphometry of investigated cones in comparison with terrestrial cinder cones and stratovolcanoes with summit craters. Full triangles correspond to Martian cones; empty triangles to terrestrial cinder cones (~1060 edifices from [5-7]). (A) Crater width (WCR) versus basal cone width (Wco) of volcanic cones. The solid line represents the best fit using linear regression for Martian cones, dashed line for terrestrial cinder cones and dot-and-dash line for stratovolcanoes with summit craters. (B) Plot of the cone height (Hco) vs. basal width. Lines represent the same cones as in Plot A.

4. Summary and Conclusions

The evidence for physiological diversity of Martian volcanism is still growing (see also [9]). Based on our analyses, we interpret an assemblage of landforms in Tharsis as a cinder cone field. It is surprising that this is the only well-preserved field of this kind seen so far on Mars, given the fact that cinder cones are the most common volcanoes on Earth. These cinder cones provide the opportunity to study eruptions on Mars that were characterized by a higher degree of explosivity than the very recent effusive eruptions in the very late Amazonian (≤100 Ma) forming the widespread plain-style volcanism [10]. Possible causes for the explosivity are a higher volatile content of the magma, a slower magma rise speed, magma-water interactions, or a combination of these and other factors.

Acknowledgements

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