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Volcanism inside Valles Marineris? A field of small pitted cones in Coprates Chasma

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Abstract

We present observations of a field of more than 100 pitted cones and mounds situated insight Coprates Chasma (part of Valles Marineris; Fig. 1), which bear many morphological and morphometrical similarities to terrestrial and martian scoria cones. If these cones are indeed volcanic in origin, they will significantly expand our knowledge about the morphometry of pyroclastic cones on Mars. A magmatic origin, which would necessarily post-date the opening of the main troughs, would contribute to our understanding of the volcano-tectonic evolution of Valles Marineris.

1. Introduction

Based on Viking images it has been suggested that volcanism play a role in formation of Valles Marineris [1, 2]. Recent high resolution data acquired by the CTX camera (~5-6 m/px) reveal the existence of several fields of small pitted cones, mainly associated with chaotic terrain regions in the eastern part of Valles Marineris [3,4] and also in Coprates Chasma [4,5]. Coprates Chasma is a linear trough extending in west-east direction for ~1000 km as part of the large Valles Marineris system of topographic depressions. Based on morphological similarities, Harrison [4] suggested that these cones might represent scoria cones, i.e. small volcanic edifices composed of pyroclastic material. Most recently, the whole area was coved by CTX images that enable analysis of the entire field. One cluster of pitted cones is covered by a HiRISE stereo pair, allowing the production of a HiRISE DEM. Based on these new data, we studied the cones in unprecedented detail.

2. Methology

We used images from CTX, HRSC, and HiRISE. High-resolution topographic data were based on single MOLA shots, HRSC DTM, HiRISE and CTX stereo-derived DEM, which were computed from HiRISE and CTX stereo pairs [6] using the methods described, e.g., in [7]. HiRISE and CTX DEM reach a spatial resolution of ~1 m/pixel and ~10 m/pixel and a vertical accuracy of roughly a few decimeters and a few meters, respectively.

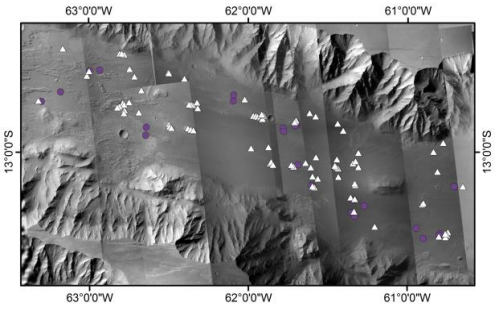

Figure 1: Location of investigated cones (triangles) and mounds (circles) in eastern Coprates Chasma (CTX mosaic). The edifices are spread over the entire trough.

3. Morphology and morphometry

The cones and mounds are widely spread over the entire area of about 155 × 35 km. Some edifices form small clusters containing up to ten edifices (Fig. 2), others stand alone. In plan view, the cone and mound morphology is characterized by circular to elongated outlines with steep flanks reaching up to 25°, but generally with lower values. Cone basal diameters vary from 0.5 km up to 2.2 km, with a mean of 1 km (based on 23 cones). Most of them have summit craters (as visible on Fig. 2a), which have diameters from 0.15 km up to 0.8 km (mean 0.3 km). In some cases craters are superposed by other craters suggesting the lateral migration of explosion site or feeder dike. Typically, the cones are not breached, but there are two exceptions which seem to result from explosion and/or collapse of the cone. In some cases cones are superposed on units with a rough texture that forms local bulges (Fig. 2b,c). In an attempt to compare the investigated cones with martian and terrestrial analogues, we measured the basal diameters of the cones (W_{CO}) and the crater diameters (W_{CR}). The W_{CR}/W_{CO} values range between 0.22 and 0.5 with

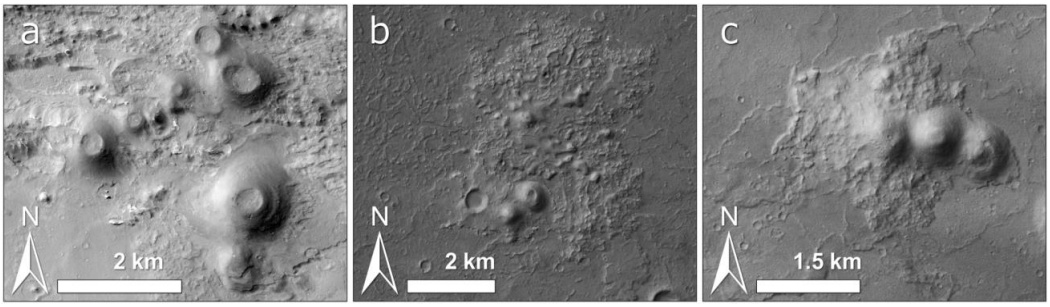

Figure 2: Three clusters of investigated cones and mounds in Coprates Chasma. Note the rough elevated unit on which investigated edifices are superposed (b,c) (a) Based on HiRISE ESP 034131 1670, centered 12.73°S, 62.8°W (b) CTX image G20_026061_1675, 13.28°S, 60.89°W (c) CTX image B22_018268_1659, 12.71°S, 62.38°W.

average 0.34. Fresh terrestrial scoria cones have value of ~0.4 [8] and martian scoria cones ~0.27 [9]. The cones seem to be relatively pristine disrupted only by small impact craters which do not change significantly their shapes.

4. Summary and Conclusions

The studied cones bear many morphological similarities to edifices in Hydraotes Chaos [3] and Ulysses Colles [9] that were previously interpreted as scoria cones. The Coprates cones are smaller (W_{CO} on average 1 km) than the Hydraotes cones (1.5 km) and the Ulysses cones (2.3 km), but with similar W_{CR}/W_{CO} ratios (0.34 for cones in Coprates and 0.27 for cones in Ulysses). This might be caused by a higher atmospheric pressure at the floor of Coprates Chasma (~5 km beneath Mars' global datum) disabling a wider dispersion of ejected particles from the vent [10], by a smaller amount of erupted material or by smaller erosion. The associated elevated rough units around the cones and mounds are also similar to what is observed in Hydraotes Chaos, Ulysses Colles and in some cases around terrestrial scoria cones (e.g. in the Andes) from where is known that these rough units are formed by lava and volcanic deposits. Similar origin of these units might be valid for Mars. Our preliminary results, therefore, support previous suggestions [4, 5] that this field is probable volcanic in origin and consists of scoria cones. If so, this field in Coprates Chasma is probably the largest known field of scoria cones on Mars. Ongoing investigations will help to extend our knowledge about general trends in scoria cone formation and will also help to provide further insight about the evolution of Valles Marineris.

Acknowledgements

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