EPSC Abstracts
Vol. 11, EPSC2017-107-1, 2017
European Planetary Science Congress 2017


# Kilometer-sized cones on Mars: igneous or mud volcanoes?

**P. Brož** (1), P. Fawdon (2,3), and O. Čadek (4)
(1) Institute of Geophysics of the Czech Academy of Science (**Petr.broz@ig.cas.cz**), (2) Birkbeck, University of London, Malet St, London WC1E 7HX, (3) Open University, Milton Keynes MK7 6AA, United Kingdom (4) Faculty of Mathematics and Physics, Department of Geophysics, Charles University in Prague, Czech Republic.

## Abstract

Here we present our project about the investigation of kilometer-sized cones on Mars in the attempt to reveal if such cones had been formed by igneous or mud volcanoes based on detailed investigation of their morphometries, morphologies, and spatial distributions.

## 1. Introduction

There is an ongoing debate within scientific community about the formation process of kilometer-sized cones reported from several regions on Mars (e.g., [1-8]). Two of the main mechanisms considered as possible explanations, are (1) small scale igneous volcanism (e.g., [1,4-7]) and (2) mud volcanism (e.g., [2,8,10]). It is important to differentiate between these two processes because of the very different implications these processes have for the Martian crust and near surface environment. Both processes involve key factors of environmental habitability meaning that understanding the origin of these features is important in our understanding of recent habitability of Mars.

On Earth small volcanoes and mud volcanism form of morphologically similar landforms (Fig. 1). Both processes form cones with relatively steep flanks and central craters on their tops; often additionally associated with flow-like units spreading around those cones. Consequently, because of this convergence of form, is not readily apparent how to distinguish between these two processes using satellite images. As a consequence, on Mars (Fig. 2) both processes (e.g, [2] vs. [7], [8] vs. [9]) have been invoked to explain the observed cones and this introduces an element of ambiguity where the geological context dose not substantially favours only one process over the other. However, examples exist with a clear geological setting indicating a parsimonious explanation. Two examples of this are the cones on the flanks of Pavonis Mons [1] and at Ulysses Colles which is situated on heavily fractured crust inside the Tharsis. In these contexts, the cones are interpreted to be parasitic igneous volcanoes and a field of volcanic scoria cones [6, 9] respectively. Here these interpretations are possible because of the dominantly volcano-tectonic setting and lack of large centre of sedimentary deposition, necessary for mud volcanism.

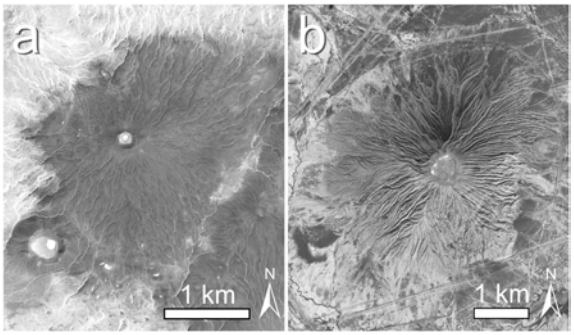


Figure 1: An example of terrestrial igneous (a) and mud (b) volcano showing striking similarities in their morphologies. (a) Volcano in Libya (centered 17.30°E , 26.142°N, © CNES/SPOT) (b) Mud volcano in Azerbaijan (centereted 49.29°E, 40.163°N, © ImageGlobe). Images obtained from GoogleEarth™.

## 2. Project aim

The aim of this study is compare the morphologies and morphometries of Martian putative scoria cones and mud volcanoes to explore differences and/or similarities in their shapes and hence to investigate if we can distinguee between causal mechanisms. This work builds on the work done by [7] by investigating an additional cone field in Chryse Planitia where the putative mud volcanoes have previously been described [9]. To do this we use topographic data derived from HiRISE (~30 cm/pixel, [12]) and CTX (5–6 m/pixel; [13]) stereo images. New high-resolution DEM were computed for 8 HiRISE stereo pairs (Fig. 2) using the methods described in [14]. From these several basic morphometrical parameters are measured for each cone, including the average,

the maximum slope of the cone's flanks and delineation of the volcano shape. This is done in plan view by numerical tracing where the slope exceeds 1°, following the method used in [9]. To analyse the spatial distribution of these edifices, we applied the Poisson Nearest Neighbor (PNN) analysis in similar way as applied in [15].

## 3. Preliminary results

We previously showed [9] that cones within three regions of different geological context (Ulysses Colles, Hydraotes Colles and the Coprates cones) show striking similarities in their morphologies. However the minor differences that are seen in their morphometries can be explained by variations in atmospheric pressure and gravity between the two fields. The shape of the cones can be reconstructed numerically by tracking the ballistic trajectories of ejected particles and recording the cumulative deposition of repeatedly ejected particles using this method concluded [9] that these cones represent small-scale igneous volcanoes, i.e. scoria cones.

When we compared cones from Chryse Planitia with those previously investigated cones, we found that although the edifices show some similarities in shapes, investigation of their morphologies and morphometries together show a number of important variations. While cones attributed as putative Martian scoria cones are often clustered, have multiple central craters, are superposed on elevated flow-like units and variations in their shapes can be explained by simple numerical model, the putative mud volcanoes are characteristic by freestanding edifices with one central crater (if even present) which may be breached. If so the breached section covered a substantial portion of the craters circumference. Putative mud volcanoes also show a wide variety in shapes (three different types) within the field suggesting a more complex scenario for their formation more susceptible to environmental conditions.

Therefore, our preliminary results suggest previous notion by [10] that cones in Chryse Planitia may represent Martian mud volcanoes as these cones actually show much wider variations in their general shapes, distributions and appearance than those investigated by [9] which have been interpreted as Martian putative scoria cones.

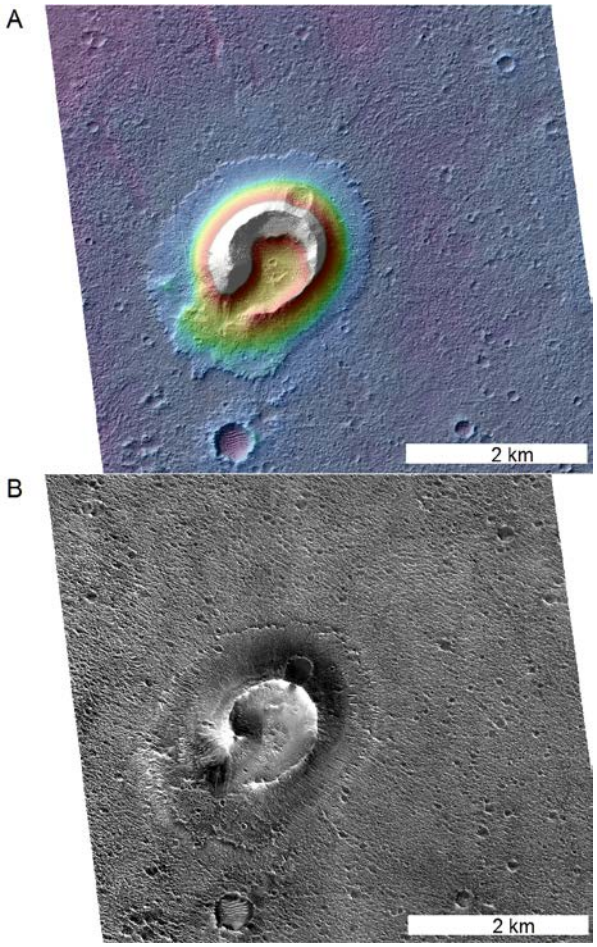


Figure 2: A comparison between (A) a HiRISE DTM overlain on a hillshade model and (B) the HiRSE image of the same cone in Chryse Planitia. This shows the detail available for the morphometric analysis.

## References

[1] Bleacher et al., 2007, JGR 112 [2] Skinner and Tanaka, 2007, Icarus 186 [3] Harrison and Chapman, 2008, Icarus 198 [4] Meresse et al., 2008, Icarus 194 [5] Lanz et al., 2010, JGR 115, E12019 [6] Brož and Hauber, 2012, Icarus 218 [7] Brož and Hauber, 2013, JGR 118 [8] Okubo, 2016, Icarus 269 [9] Brož et al., 2015, JGR 120 [10] Komatsu et al., 2016, Icarus 268 [11] Brož et al., EPSL, under review (2017) [12] McEwen et al., 2007, JGR 112, E05S02 [13] Malin et al., 2007, JGR 112, E05S04 [14] Moratto et al. (2010), LPSC, XLI, Abstract #2364 [15] Corvec et al., 2013, Earth-Science Reviews, 124.