EPSC Abstracts
Vol. 11, EPSC2017-584, 2017
European Planetary Science Congress 2017

Morphometric comparison and genetic implications of terrestrial, lunar and martian lava tubes

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Abstract

In this abstract we present a morphometric comparison between Terrestrial, Lunar and Martian lava tube collapses, based on high-resolution DTMs. The morphometric study allows identifying the depth of emplacement of the pyroducts in the different planetary bodies and sheds light on their formation processes, different sizes and ceiling stability due to the different planetary parameters and volcanism regimes.

1. Introduction

In the last twenty years pit craters, skylights, rills, and outflow channels on Lunar and Martian volcanic fields have been commonly interpreted as collapsed sections of lava tubes [1], although a clear understanding of their dimension, depth and formation processes in comparison to the Earth analogues remains elusive. As demonstrated by previous authors [2], not all pit crater chains can be directly related to lava tubes, but also other volcanic and tectonic processes are surely driving the formation of several of these pits. In order to identify the most promising lava tube candidates on Mars and the Moon we have adopted some main criteria that allows to distinguish lava tube pit chains on Earth not only from other volcanic pit features, but also between the two main different terrestrial morphotypes described (overcrusted and inflated) [3]. Following this necessary distinction, we present a morphometric comparison between lava tubes on Earth with some of the most prominent lava tube candidates identified on Mars and the Moon.

2. Lava tubes on Earth, Moon and Mars

Pit chains related to lava tubes on Earth present peculiar characters: 1) collapses are elongated ellipses with the minor axis representing the width of the tube; 2) their alignment is sinuous and can be braided; 3) the depth/width of the collapses represent the asymmetry ratio (ellipticity of the conduit), which is varying between inflated and overcrusted tubes. Taking these characters into account, we have performed morphometric analysis of terrestrial collapses and tubes dimension, focusing on Hawaii systems and in the Corona system of Lanzarote, which represents one of the most voluminous terrestrial tubes. On Mars, potential lava tube candidates have been proposed and measured on Hadriaca Patera, Arsia and Olympus Mons. On the Moon, we performed morphometric analysis in the area of Marius Hills, and specifically along the sinuous rills related to the Marius Hill skylight and along a pit chain in a parallel rill.

3. Methods

For all the morphometric analyses we relied on high-resolution DTMs. The lunar lava tube candidates have been measured on the Selene-Kaguya/LRO LOLA merged DTMs at ~59.22 meters/pixel gobal DTM, which is the result of merging and coregistration of stereo images from JAXA Selene-Kaguya mission with Lunar Reconnaissance Orbiter Laser Altimeter [4]. Martian DTMs were obtained by the stereo matching overlapping CTX (Context Camera, Mars Reconnaissane Orbiter) images at ~6 metrs/pixel with Ames Stereo Pipeline software [5]. The resulting DTMs at ~18 meters post spacing, were successively co-registered on validated HRSC DTMs provided by Mars Express mission and adjusted to the MOLA areoid. The collapses of the Corona Volcano lava tube, were measured on a 5 meters resolution DTM obtained from the interpolation of LIDAR shots provided by SGS.

4. Results and discussion

The data obtained are in agreement with recent modeling of lava tube stability on Mars and the Moon.

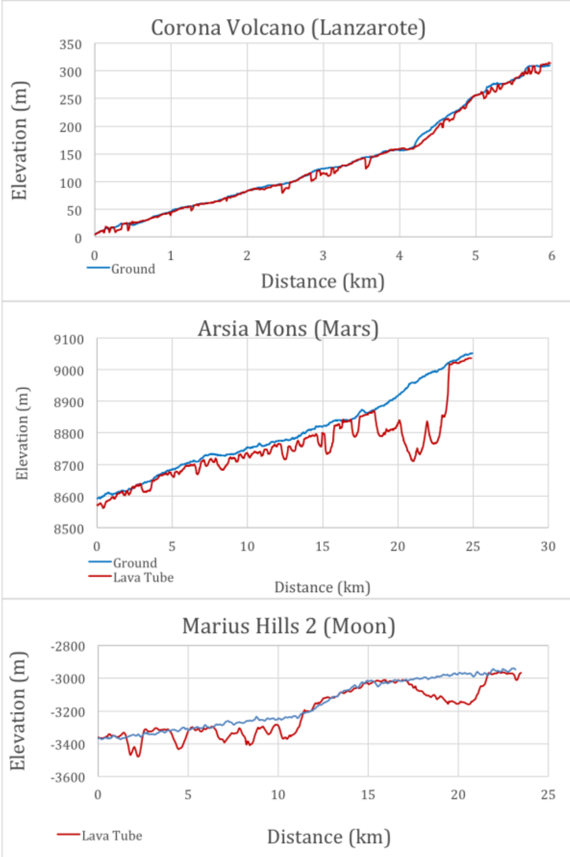

Figure 1: Examples of topographic profiles extracted along the tubes highlighting the collapses alignments and depths. In a) Marius Hills tubes b) Arsia Mons and c) Corona volcano

bodies [6] and sheds light on their formation processes and depth of emplacement. The depths of the collapses in each chain show a trend of maximum depth which correspond to the level of emplacement of the collapsed tube. While on Earth this is between 10 to a maximum of 30 meters, on the Moon the depth of the pit chain of Marius Hill is more than 100 m. On Mars this value is between 20 to 50 in Hardiaca Patera and between 30 to 80 in Arsia Mons. The minor axis analysis of the pit (which represent the witdth of the collapsed tube) shows a relevant increasing trend from Earth (20-30 m), to Mars (250 m), and to the Moon (0,8-1 km), suggesting that an increasing dimension of the conduits depending on gravity and effusion rates. However on the Moon pit chains are not so common suggesting that the most of the tubes have not been collapsed due to the higher stability of the ceilings, and are probably lying below deflated sinuous rills like where the Marius Skylight has opened to the surface. The asymmetry ratio (depth versus minor axis) is increasing from Earth to Mars and reach its maximum on the moon chains. This trend suggest that inflation processes are much more common and crucial in these planetary bodies compared to Earth.

References

[1] Cushing, G. E. (2012). Candidate cave entrances on Mars. Journal of Cave and Karst Studies, 74(1), 33-47.

[2] Wyrick, D., Ferrill, D. A., Morris, A. P., Colton, S. L., & Sims, D. W. (2004). Distribution, morphology, and origins of Martian pit crater chains. Journal of Geophysical Research: Planets, 109(E6).

[3] Kempe, S., Bauer, I., Bosted, P., Coons, D., & Elhard, R. (2010). Inflationary versus crusted-over roofs of pyroducts (lava tunnels). In Proceedings 14th International Symposium on Vulcanospeleology (p. 93).

[4] Barker, M.K., E. Mazarico, G.A. Neumann, M.T. Zuberc, J. Haruyama, D.E. Smith, (2016), A new lunar digital elevation model from the Lunar Orbiter Laser Altimeter and SELENE Terrain Camera, Icarus, Volume 273, Pages 346–355 doi:10.1016/j.icarus.2015.07.039.

[5] Shean, D. E., O. Alexandrov, Z. Moratto, B. E. Smith, I. R. Joughin, C. C. Porter, Morin, P. J. 2016. An automated, open-source pipeline for mass production of digital elevation models (DEMs) from very high-resolution commercial stereo satellite imagery. ISPRS Journal of Photogrammetry and Remote Sensing. **116**.

[6] Blair, D. M., Chappaz, L., Sood, R., Milbury, C., Bobet, A., Melosh, H. J., ... & Freed, A. M. (2017). The structural stability of lunar lava tubes. Icarus, 282, 47-55.