

FRACTAL ANALYSIS AND POSSIBLE FLUID SOURCE DEPTH IN CRATER MOUNDS, ARABIA TERRA (MARS) R. Pozzobon^{1,2}, F. Mazzarini², M. Massironi³, Pondrelli M.¹, Rossi A. P.⁴, L. Marinangeli¹, ¹IRSPS-DISPUTer, Università G. D'Annunzio, Pescara, Italy, (r.pozzobon@unich.it), ²Istituto Nazionale di Geofisica e Vulcanologia, Pisa, Italy, ³Dipartimento di Geoscienze, Università degli Studi di Padova, Padova, Italy, ⁴Jacobs University Bremen, Bremen, Germany.

Introduction: Arabia Terra is classically dominated by heavily cratered terrain, and some peculiar landforms can be found mostly in craters interior. High resolution images acquired by HiRISE [1](25 cm/px resolution) and CTX [2](Context Camera, 6 m/px resolution) cameras of the Mars Reconnaissance Orbiter mission provided a wide dataset where pitted cones, mounds and knobs can be easily recognized. Those mounds are interpreted to have worked as pathways for subsurface fluid flow and escape [3]. The distribution of cones mounds and orifices could be directly linked to the fracture network connecting their deep fluid source to the surface. In this work we present the fractal analysis of the spatial distribution of mud volcanoes and/or spring deposits source vents in the bottom of Arabia terra craters, aiming to find the depth of their fluid source. In particular the analysis will be focused on Firsoff and Crommelin craters [3].

Arabia Terra Mounds: Several well-exposed examples of mounds can be found within craters bottoms in Arabia Terra.. The most likely mechanism of formation is the ascent of fluid stored in deep reservoirs in overpressure conditions. Fluids find their way to the surface thanks to the local fracture network and their circulation is driven by local tectonism [4-6]. Crommelin and Firsoff craters together with an unnamed crater 1 ~35 km to the south are among the most significant examples of mound affected craters and are the best covered by high resolution images. As it happens on Earth, typically mounds and cones are located within extensive and thick sedimentary sequences, whose lithostatic load can contribute to increase the pore fluid pressure [6-8]. Equatorial layered deposits (ELDs) seem to be the environment where the mounds can be most commonly found. HiRISE images allow to make a distinction between conic-shaped mounds, sometimes presenting a central orifice (Fig. 1) [3], and rock remnants of eroded stratigraphic formations[9]. In some cases mounds tend to align along fault lines leading to hypothesize the existence of a preferential pathway of fluid circulation driven by local structures (Fig. 2).

On Earth facies associated with mud cones are typically breccias and clasts up to boulder size within a finer matrix. Usually the cones present steep slopes on their flanks and may display a central vent or caldera. The

same characteristics can be recognized on several mounds in the analyzed craters. Simple mounds appear as subcircular-based conical features 100–300 m in diameter (or even less in the unnamed crater, up to 50 m in diameter) and 30-50 m height, often characterized by a central small circular depression or orifice [10]. Other shapes include composite coalescing mounds, with height of tens of meters, presenting central orifices. Mud volcanoes are thought to be the surface expression of deep reservoirs of fluid material such as hydrocarbons or sulfates-rich fluid, located at depths up to several kilometers [11].

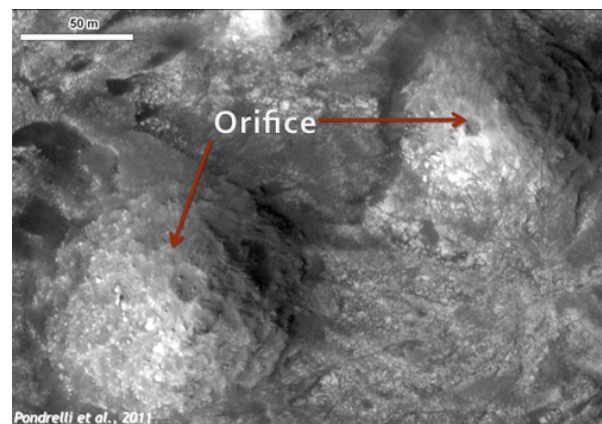


Figure 1: Mounds with central orifice in Firsoff Crater. Breccias and boulders are clearly visible on the mound slopes. HiRISE PSP_003788_1820 (Pondrelli et al., 2011).

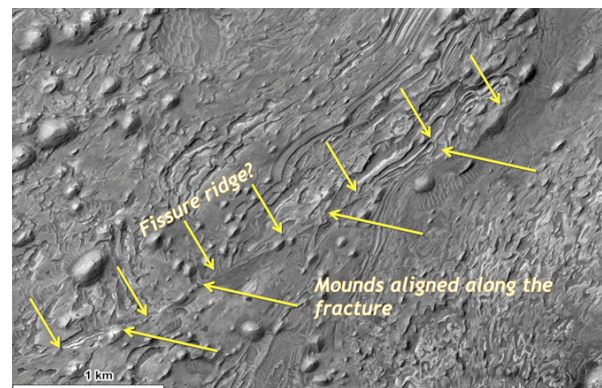


Figure 2: Mounds with central orifice inside the unnamed crater around a fault line. HiRISE ESP_016921_1810.

Fractal analysis of mounds size distribution: The occurrence and spatial distribution of monogenic eruptive structures within volcanic areas on Earth are linked to fracture systems and associated stress fields. Moreover, they testify the presence of deep crustal or subcrustal magma reservoirs directly connected to the surface by a percolating fracture network. The correlation between vent distribution and fracture network properties (the so called backbone) directly linked to the source, can thus be studied in terms of self-similar (fractal) clustering.

Self-similarity in vent distribution is described by a power law distribution with fractal exponent D and defined over a range of lengths comprised between a lower limit (lower cutoff, L_{co}) and an upper limit (upper cutoff, U_{co}). The upper cutoff (U_{co}) for fractal clustering was compared with the respective crustal thickness obtained by existing independent geophysical data in the East African Rift System [12]. The computed U_{cos} for this sector well match the crustal thickness in these volcanic fields. More in detail this computational model verified the strong linear relationship existing between the upper cutoff of the power law distribution and the magma source depth.

This methodology was successfully applied also to the Azerbaijan mud volcano province in Caucasus [13] and here is extended to the case study of mud volcanoes and mounds within Arabia Terra craters.

A detailed cartographic and mapping of mounds, orifices and fault lines in Crommelin Firsoff and unnamed craters were performed on CTX and HiRISE image mosaic, in order to verify the presence of a structural control and obtain the needed statistics to apply the fractal method. The U_{co} values defining the self-similar clustering of mounds (either mud volcanoes or spring layered deposits[14]) can give clues on the depth of their fluid source [12].

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