ENIGMATIC FEATURES OF A CRATER IN ARABIA TERRA, MARS. H. Lahtela[1,2], J. Korteniemi[1], G. G. Ori[2], M. Pondrelli[2], S. Di Lorenzo[2], G. Neukum[3] and the HRSC Co-Investigator Team. [1]Division of Astronomy, Dept. of Physical Sciences, P.O.Box 3000, 90014 University of Oulu, Finland (hlahtela@student.oulu.fi), [2]IRSPS, Universita d'Annunzio, Pescara, Italy, [3]Institute of Geosciences, Freie Universität Berlin, Germany.

Introduction: This study discusses the characteristics of an enigmatic ~25 km crater (Fig. 1a), located at 36,0Nº/351,8Eº, in Arabia Terra; highland side of the dichotomy boundary. It has roughly circular shape and exhibits almost no raised rim. From HRSC, THEMIS, MOC and MOLA data, four distinct terrain units are identified: 1) smooth floor, 2) unit cracked by severe fissuring, 3) low albedo depression and 4) prominent central bulges (Fig. 1b). All units tell of intense crater floor deformation. This structure differs drastically from a standard impact crater. It is an interesting study subject, providing detailed info with which similar features in the region can be re-evaluated.

Structure description: The crater is mapped to be of Noachian age [1]. It is ~700 m deep, and has no apparent rim or traceable ejecta field. The crater is located on a shallow 0.3° regional NE trending slope.

The crater walls exhibit layering. However, only one layer is observed to be continuous around the crater (except in E), at a level depth of -3.6 - -3.7 km MPR. It is darker than the under- and overlying layers, and is the source of numerous gullies (Fig. 1d). Layering is observed in several but not all craters in the region. Two channels (mouth width <1 km) cut trough the wall, but there is no sign of delta formation or clear terraces within the crater.

Flat material occupies the W and S crater floor, resembling 'normal looking' crater fill, i.e. sedimentary materials accumulated and partly eroded after crater formation. On the floor at the foot of crater walls there are indications of mass wasting deposits.

Fractured terrain is observed when closer to crater center. The western part of this unit has chaotic appearance. Fracture walls exhibit horizontal layers (Fig. 1c). The unit slopes down to an 11 km diameter and 50 m deep smooth-floored depression at the crater center.

Bulges. The central depression has two separate prominent bulges. The western one is clearly more massive (height H=300 m, volume V=6 km^3; Fig 1 "1") than the eastern one (H=70 m, V=0.04 km^3; Fig 1 "2"). Even though the bulges lie in the depression, they clearly reach higher than the main crater floor. They are significantly offset from the crater center (large 4.2 km, small 7.5 km). Both bulges have similar shapes: narrow E-W ridge traverses along their S edge, creating a N-S asymmetry (N flank 6°, S flank 15°). Cliffs and terraces are found on the lower slopes.

Albedo. The crater floor exhibits intense color variations. Lowest albedo is seen on the large bulge SE flank. From there it diffuses into brighter tones until the edge of the chaotic terrain in the W and end of the depression in the E are reached. No shadows contribute to the albedo variations; Sun is located high up in SW, creating short shadows on the NE lees.

Discussion of the implications: The crater is either of volcanic or impact origin. This is discussed below, based on the terrain morphology.

Shape. A fresh 25 km Martian impact crater [2] is 1.7 km deep. The studied structure is ~1 km shallower, indicating that if it is of impact origin, it has been filled with thick sediment layers. The absence of features typical for fresh impacts, a raised rim and an ejecta blanket, also point towards either a very old eroded impact crater or alternatively a volcanic caldera. For the latter, the shallowness would cause no discrepancy.

The large amount of sediments could originate from a vast distributary system bringing deposits into the crater. This would fill the basin with horizontal sediment sheets, and form an erosion-resistant delta at the channel mouth. Even in the extremely modified Holden crater the delta is still visible [3]. However, no distributary system and/or delta are found here. Clastic lake sediments or subaerial dust could also fill a basin, but they would drape and smooth its appearance. Since e.g. the bulges and rim have still notably steep slopes, this alternative is also excluded.

The bulges tower high above the rest of the crater floor. If they are remnants of sedimentary layers, their excavation method has been very efficient. There is no evidence of such an extensive erosional process, which could have removed all the material except these two bulges down to the current crater floor level.

Detected layering can not be used as a constraint determining the origin of the crater filling. Both lacustrine sediments and a sequence of pyroclastic and volcanic flooding can create this kind of layered structure.

Fractured terrain and the depression: Volcanic heating removing volatiles from the ground could result in the creation of both 1) a depression and 2) surrounding chaotic terrain at the contact between volatile-depleted and volatile-rich crater floor [4]. Also numerous studies on the dissected crater-like features near the dichotomy boundary [e.g. 5, 6 and 7] associate them with volcanic and hydrothermal activity.

Bulges: Several bulge types are observed in impact craters. The most probable is a central peak. An average fresh 25 km Martian crater has a ~200 m high central peak [2]. In the studied crater, the larger bulge rises to 300 m. Assuming the bulges are remnants of the original central peak, and taking into account the calculated fresh crater depth, the total peak height is still 1300 m. The secondary small bulge is also not typical of standard impact craters. In addition, the bulge system is located far (~6 km, i.e. ~50% of the crater radius) from crater center. This is very rare for even oblique impacts. From this, we can interpret that the bulges are not remnants of a typical central peak.

Terraces on the bulge refer to sedimentary layering. The cliffs may be caused by 1) very clear contacts between the floor and the bulge material units, 2) cliffs caused by erosion of the bulge or 3) remnants of previously surrounding and now-eroded material remaining on the sides of the bulges. The available images do not allow confirming/disproving any of these possibilities.

Salt diapirs occur when less dense salt deposits are buried under a layer (>1km) of compacting clastic sediments becoming denser than evaporate [8]. Perturbation of this unstable geological structure could result in rising diapirs, even salt domes. The bulges here are too large to have been caused by this process type.

The surface materials of the bulges and the depression differ from the surrounding terrain. It must be noted that this observation is based only to the appearance, and must thus be taken only as guide line. The dark deposits on Mars are often thought to be mafic/ultramafic dust/sand, probably originating from volcanic sources [e.g. 9, 10, 11]. The geological map [1] recognizes the dark material units inside several craters in the region, including this one. It was interpreted to be of aeolian origin. The same conclusion was made from MOC data [12]. However, in this particular case dark material covers only the large bulges and their immediate surroundings with ease, indicating that it is closely linked to bulge characteristics.

Based on this exclusion, two separate volcanic domes (or a single dome divided into two due to its own mass) are the most reasonable explanations for the bulges. They have been formed on the floor of an ancient crater due to dike propagation in the fractured floor, or into an ancient volcanic caldera.

Conclusions and further studies: With the current data, the origin of the crater can not be explained totally unambiguously. However, when impact and volcanic formations are compared, the latter is more plausible. The crater must still be put to a regional context before sufficient conclusions can be drawn.

References: [1] Witbeck & Underwood (1984) USGS Misc.Inv. Geol. Map I-1614. [2] Garvin et al. (2003) 6th Mars Conf., #3277. [3] Pondrelli et al. (2005) JGR, 110, E04016. [4] Wichman, & Schultz (1995) JGR, 100, 3233-3244. [5] Schultz & Orphal (1978) Meteoritics, 13, 622-625. [6] Newsom (2001) LPSC 32 #1402. [7] Korteniemi et al. (2005) JGR, 110, E12S18. [8] Ismail-Zadeh et al. (2002) Geoph. J. Int., 148, 288-302. [9] Zimbelman (1988) NASA MEVTV: Volc. On Mars, 19-21. [10] Edgett & Christensen (1994) JGR, 99, E1, 1997-2018. [11] Ruff & Christensen (2002) JGR, 107 E12, 5127. [12] Edgett (2002) JGR, 107, E6, 5038.

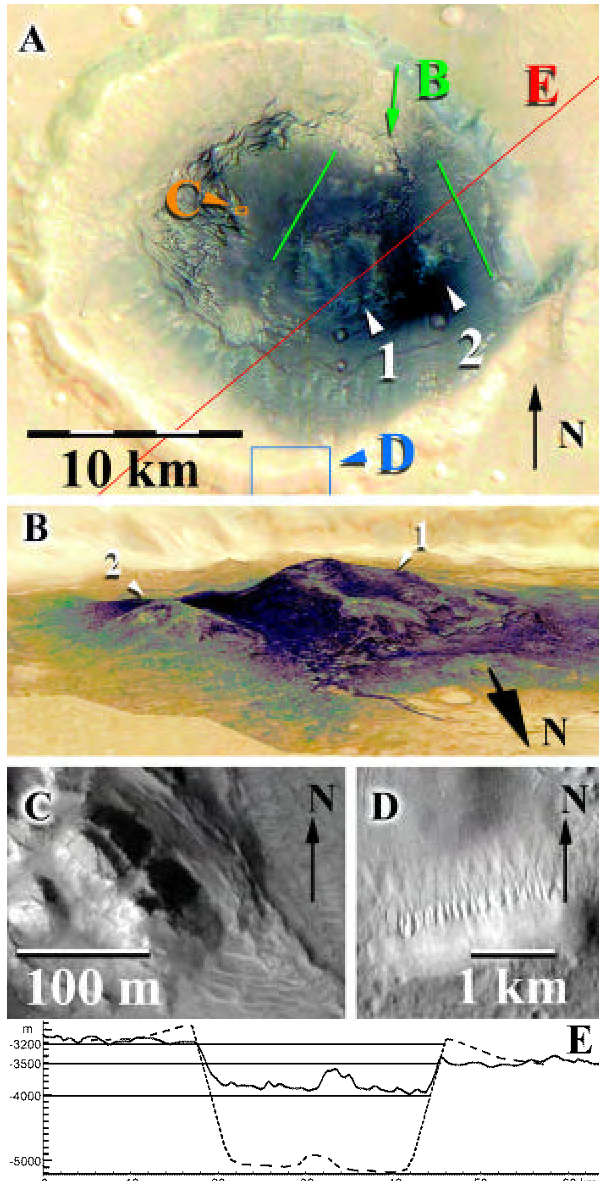

Fig. 1. A: Studied crater has a depression with low albedo (HRSC color), which is surrounded by a fractured zone. B: Two bulges rise above the rest of the crater floor from the depression. (HRSC DTM). C: The fractured mesas exhibit layering (MOC). D: The crater wall has one continuous layer. It is the source of numerous gullies (THEMIS). E: Topographical profiles (studied crater vs. a fresh 25 km impact crater [dashed line; from 2]) show that the crater is notably shallow.