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Hints at diapirism in Arabia Terra bulged craters (Mars)

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Abstract

Impact craters within Arabia Terra region, on Mars, display a large central bulge, sometimes showing a well-preserved stratification (light albedo layered deposits). In craters like Crommelin or an unnamed crater (that is numbered 12000088**)** located a few hundreds kilometers on the East some unusual landforms and structures among the layered deposits were observed. In particular, on Crommelin's bulge and its surroundings we found fold systems with axis parallel to the bulge perimeter. The fold sets are typical compressional structure often associated to diapiric rise on Earth [1]. In addition on top of 12000088 crater's bulge the evidence of sulfate signatures was detected as well as the presence of small bowl-shaped depressions. Several fluid-carved channels that depart radially from the bulge are cut by a ring of normal faults, thus suggesting a collapse of the bulge summit. Thus, on the basis of the previous observations it is possible to hypothesize that diapiric rise could have been responsible for central bulging both on Crommelin and 12000088 craters and likely on other bulged craters on Arabia Terra.

1. Methods

A high-resolution image dataset as well as DTMs were required to perform structural analyses on both craters to verify strata dips and dip directions within the Crommelin crater floor and evaluate the presence of faulting in the 12000088 Crater central bulge. In order to have an overall detailed view as well as good coverage of the study areas overlapping CTX images (6 m/px) were selected as pairs to produce stereo DTMs. In addition, where available, HiRISE stereo images (0.25 m/px) were used. The DTMs were produced with Ames Stereo Pipeline and validated with the alignment on HRSC DTM (from DLR 100 m/px) and calibrating the heights according to MOLA topography (460 m/px) [2]. Moreover, the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) onboard Mars Reconnaissance Orbiter (MRO) was used to study the spectral signatures on the crater 12000088 bulge's summit.

2. Crommelin Crater's Folds

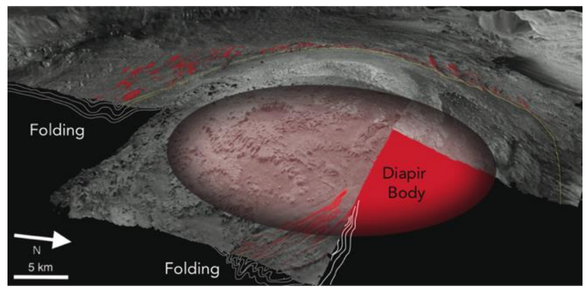

Figure 1: Perspective view and conceptual sketch of the diapiric body emplacement that likely caused bulging and folding. The diapir stays under the sedimentary layering coverage

Several areas around Crommelin Craters bulge display clear stratification identified as ELD (Equatorial Layered Deposits, [3]) suitable for analysis of strata dips and dip directions on DTMs. Four different areas with folded stratigraphy were identified all around the central bulge displaying concentric axial planes. On the western sector of the bulge a sequence of symmetric folds was identified, bearing two anticlines and a syncline inbetween. The approximate wavelength is ~2.5-3 km and the amplitude is ~4-6 km. On the NW sector of Crommelin Crater a sequence of 3 synclines and anticlines was measured and identified as asymmetric folds. The average amplitude is ~2.5-3 km and the wavelength ~2 km. A similar case can be found in the NE sector of the crater on the bulge slope where we identified another set of kilometric scale strongly asymmetric synclines and anticlines. In all these cases the axial planes are concentric to the central bulge and the folds vergence is radial pointing outwards. In the southern sector several basin-like structures are present displaying a clear inward-dipping stratification with the dip angle progressively increasing towards the center of the basin. The major folding phase presents the axial plane concentric to the bulge and a second one more gentle orthogonal

3. Crater 12000088 structures and terrains composition

Crater 12000088 is located ~650 km eastern to Crommelin and is slightly smaller in size being ~50 km in diameter. This crater is actually composed of two intersecting craters, with the younger crater (~20 km in diameter) superimposed to the larger one. The inner bulge's height is less pronounced and follows an inner average slope that is in accordance with the regional slope. The bulge is surrounded by a change in slope in correspondence to several radial channels that appear to be water-carved (fig. 2). On the eastern part some furrows and channels seem to flow preferentially in direction of the deeper smaller crater. A ring of normal faults all around the central bulge were identified on images and verified with DTM topographic profiles. Most of the channels are cut by the ring of faults as well as the ejecta blanket of a ~7 km crater (fig. 2) supporting the hypothesis of tectonic summit collapse of the bulge (clearly visible also in fig. 2). Spectra analyzed from CRISM show clearly overtone absorption bands compatible with hydrated mineralogy. In particular the presence of absorption around 1.2, 1.5, 2.0, and 2.4um are indicative of hydrated sulfate (e.g., Mg-sulfates).

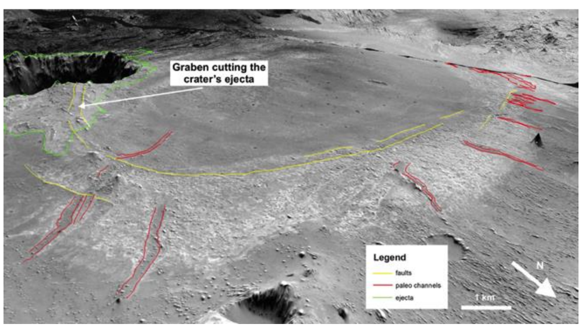

Figure 2: Perspective view of 12000088 crater interior. The crosscutting relationship between radial channels, faults system and inner crater's ejecta is clearly recognizable. To emphasize the morphologies a 5x vertical exaggeration was applied on the CTX stereo DTM

3.1 Karst Morphologies

On the top of 12000088 crater's bulge from HiRISE images and stereo DTMs we recognized some peculiar circular features that cannot be associated to impact craters, since they completely lack rims and ejecta, although being in some cases ~100 m in diameter. Doline-like depressions on the bulge were analysed with photoclinometric method based on sun incidence to infer the topography and slopes. The measurements showed several similarities with collapse dolines commonly found in gypsum terrains on Earth presenting a high circularity index, steep walls and debris at their bottom. Similar features developed in gypsum, with minor axes ranging from 10 to 150 meters comparable to those on 12000088 cratere can be found in New Mexico [4] and Turkey [5] confirming the karst sinkholes genesis hypothesis.

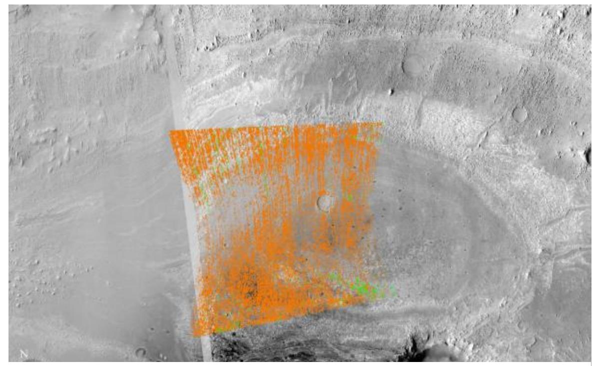

Figure 3: CRISM image with in orange the BD2400 band depth that emphasizes the presence of sulphates. In green the BD1900FRT that highlights the presence of a small amount of hydrated minerals.

4. Implications

All these evidences suggest that crater bulges may be hint for diapiric phenomenon at different stages of evolution, either being a subsurface or an exhumed diapir body. This led to deformation of the surrounding rocks giving origin to fold sets (Crommelin Crater) and to normal faulting and bulge's dissolution caused by the encounter with a subsurface fluid table (Crater 12000088). The trigger for the phenomenon could have been the impact cratering itself, having removed a rock mass volume that generated a differential lithostatic load favoring low density buried salt bodies to uprise.

References

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