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DTM-based morphometric characterization of mounds within Arabia Terra Craters as putative mud volcanoes

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Arabia Terra is a region of Mars where records of surface and subsurface past-water occurrence were detected. In particular, within several craters such as Firsoff, Kotido and an unnamed crater 20 km south-east of Firsoff, putative mud volcanoes were described. These mounds (from 30 m up to 3-400 m for coalescing mounds) present an apical vent-like depression, resembling subaerial Azerbaijan mud volcanoes and gryphons.
HiRISE images (0.25 m/pixel) and derived DTMs (1m) provided useful datasets for interpretation, however, when analyzing the lower resolution images and DTMs (CTX camera 6 m/pixel and ∼20m DTMs) covering the widest part of our area of interest a clear distinction between mounds and erosive remnants such as mesas and yardangs is often ambiguous and not reliable. A numeric approach to parametrize the morphology of mounds on HiRISE images allows to extrapolate the parameters from known areas to other sites where only lower resolution is available and to identify possible new mud volcanic candidates. The correct parametrization to detect the candidate mud volcanoes on moderately high-resolution images is pivotal: mud volcanic features are often associated to methane degassing, which is one of the key investigation objectives of the upcoming ExoMars TGO mission, and in particular for the CaSSIS color stereo camera observation strategy that will provide both images (4.6 m/pixel) and DTMs of the best candidate sites. To achieve this goal, the available 1m resolution HiRISE DTMs in the well-studied south-eastern Firsoff crater were re-interpolated to match the 20m resolution stereo DTM from CTX. In particular the TPI (Topographic Position Index), which relies on the difference of elevation between a raster cell and the average elevation of the neighborhood around that cell, served as the basis for our morphometric classification. TPI along with the cell slope value can be used to classify the cells into slope positions related to different morphologies (hills, narrow valleys, plains, etc.). However, the TPI is scale dependent: for example, the presence of a small hill top within a narrow valley will be hidden if the chosen window size is larger than the valley itself and on the other way round a hill top may not be visible if the window size is smaller than the hill itself. Hence the relation between the window size and dimensions of the analyzed morphological features should be taken in account. For this reason we used a multi-scale approach based on the combination of large and small window sizes in order to combine small positive topographic expressions (such as the mounds) within larger ones, such as the crater inner broad topography (100-1000 m). We were able to automatically map mesas and yardangs and mounds that were discriminated by their peculiar profile curvature on the DTM (degree of concavity/convexity), thus providing a numerical characterization. Hence, by extending this methodology, we were able to automatically map similar objects on CTX DTMs in the whole Firsoff, Kotido and eastern crater.

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