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Possible Subsurface Sediment Mobilization and Release of Volatiles in Southern Chryse Planitia, Mars

Ilse Van de Burgt (1,2), Ernst Hauber (1), Petr Broẑ (3), and Ondřej Čadek (4)

(1) DLR, Institute of Planetary Research, Berlin, Germany (ernst.hauber@dlr.de), (2) University of Utrecht, The Netherlands (vdburgt.i@gmail.com), (3) Institute of Geophysics, Czech Academy of Science (petr.broz@ig.cas.cz), (4) Charles University, Prague, Czech Republic (oc@karel.troja.mff.cuni.cz)

Ever since the presence of methane in the Martian atmosphere was first reported, mud volcanism was hypothesized to be a possible release mechanism, and various mud volcano fields have been tentatively identified. It is difficult, however, to define diagnostic morphological properties of mud volcanism in remote sensing data, and some of the reported mud volcanoes have alternatively been interpreted as igneous volcanoes. In this study, we test the hypothesis by Komatsu and colleagues (Icarus 268, p. 56–75, 2016) that small cone- or pie-shaped landforms in Chryse Planitia are mud volcanoes. As the use of the term "mud volcanism" has far-reaching implications, we prefer to follow a conservative approach and use the more generic term "subsurface sediment mobilization".

Our study area (8°N to 31°N/315°E to 330°E) is located near the southern boundary of Chryse Planitia at the terminations of large outflow channels. Ancient highlands are eroded into streamlined "islands", and the former floor of the channels has been resurfaced and forms a flat plain that slopes gently towards the north. Three types of landforms possibly indicative of extrusive processes in the study area were previously described: type 1 (steep-sided cones, type 2 (pie-like, structures), and type 3 (dome-shaped features). We include a fourth type, which is characterized by a sheet-like appearance with irregular plan shape and lobate margins. Objects of this type are nearly flat and typically larger than 1 km in diameter. In several areas these features can be observed in association with the other types suggesting a genetic link.

The spatial distribution of the features appears to be anticorrelated to the highlands. Nearest neighbour analysis of the total population (N=1280) shows a less than 1% likelihood that the spatial distribution could be random. Within individual clusters the distribution appears to be ordered in two cases and random in one case. The different types appear in weakly expressed ENE-WSW oriented bands and the long axis of elongated features exhibit a preferred E-W orientation, ranging from 65° to 115°, with a mean orientation of 88°.

Fractures appear in patterns that are oriented parallel to the flow direction in the outflow chan-nels, and their distribution is anticorrelated to the highlands. The most densely populated fracture areas are observed in the northern parts of the study area, without a clear correlation to the location of the conical features. Further upstream, the fractures display more transverse orientations.

The exclusive location of the mapped features in the sedimentary plains be-tween the erosional remnants of the ancient highlands suggests a formation mechanism that is linked to a relatively shallow source beneath these sediments. Igneous volcanoes are fed from deep sources, and their spatial distribution would not be expected to be controlled by the relatively small variations in surface topography observed in the study area. Therefore, we favour a sedimentary volcanic origin. In the following steps we will (a) constrain the subsurface stratigraphy, and (b) develop a numerical model with which we test the hypothesis whether subsurface sediment mobilization is a plausible formation mechanism.