SMALL MOUNDS IN CHRYSE PLANITIA, MARS: TESTING A MUD VOLCANO HYPOTHESIS.

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Introduction: Mound features interpreted to be mud volcanoes occur at various locations on Mars, including Isidis Planitia [1, 2], southern Utopia Planitia [3], the Utopia/Isidis overlap [4], Acidalia Planitia [5, 6], and Arabia Terra [7]. Mud volcanism on Mars, if proven, would be very important in understanding the processes of sedimentation, water saturation, and fluid and gas movement in the crust. Accumulations of deep subsurface materials transported upward to the surface could become prime sites for future astrobiological investigations. The presence of mud volcanoes has also been suggested in parts of Chryse Planitia [8, 9]. Here, we describe new observations of a small field of landforms near 19°N, 37°W in Chryse Planitia. Their morphological characteristics were originally reported by Komatsu et al. [10] to closely match those of terrestrial mud volcanoes. We present the latest results of HiRISE and CRISM data analysis that generally support the proposed mud volcano interpretation with some noteworthy morphological characteristics different from those of typical terrestrial mud volcanoes.

Geomorphology:

Cones. Conical edifices with summit craters (Fig. 1) are up to over 1 km wide and are widely distributed. Flow features emanating outward from the breached summit crater are typically characterized by a ragged surface texture. But the summit crater floors and the cone exterior surfaces appear to be smooth. Layering is observed in the summit crater walls.

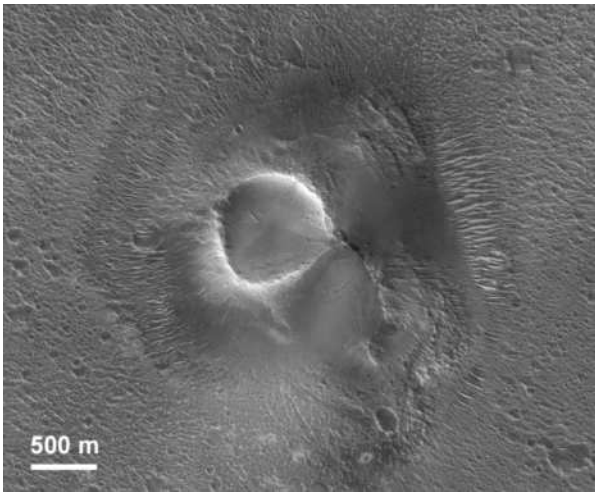

Fig. 1. Chryse Cone. HiRISE image.

Shield-like features. Shield-like features up to over 1 km in diameter are also widely distributed. Based on HiRISE stereo data (Fig. 2), they have lower height-to-diameter ratios than the cones. Single or multiple central craters or pitted cones are observed, and flow features typically emanate from these structures. High-resolution images of shield-like features reveal a boulder-rich, rough surface texture (Fig. 2, inset).

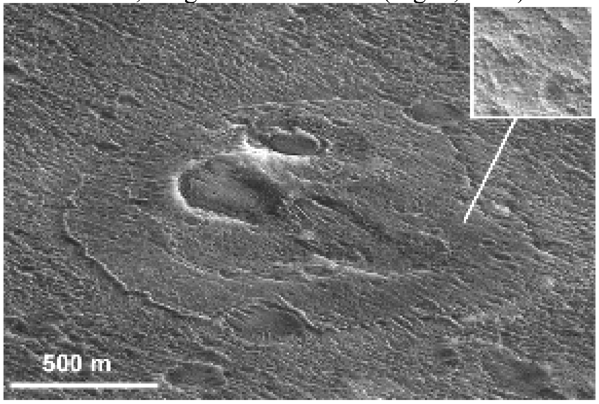

Fig. 2. Shield-like feature with a crater and a pitted cone. HiRISE 3-D image (from a stereo pair).

Round mounds. Round mounds are up to several hundred meters wide, and occur both isolated or grouped. The surface textures of the round mounds and the surroundings resemble each other, confirming the earlier observation that their margins transition gradually into the surrounding materials [10]. The HiRISE data with DTM visualization reveal several round mounds with central knob-like features (Fig. 3).

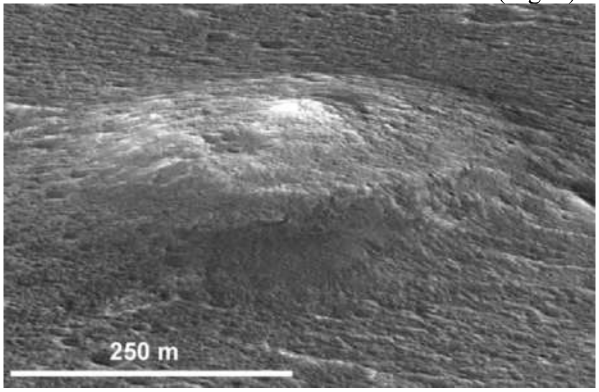

Fig. 3. Round mound with a knob-like feature. HiRISE 3-D image (from a stereo pair).

Spectral analysis: We have acquired visible CRISM data and conducted preliminary analysis, resulting in three main findings: 1) Summit crater rings of cones and shield-like features appear to be enriched in nanophase ferric minerals. Nanophase ferric minerals are also detected on round mounds. 2) Mafic minerals occur on at least one cone (Fig. 1) and some round mounds (Fig. 3), and on the walls and floors of impact craters in the surrounding plains. 3) Some shield-like features seem to be slightly more enriched in nanophase ferric minerals over their surfaces in comparison to the surrounding plains.

The enrichment of nanophase ferric minerals is similar to that reported for Acidalia putative mud volcanoes [6]. We cannot ascertain whether the enrichment is in the bulk of the summit craters and round mound materials or if it occurs just at their surfaces (e.g., if the surface textures more efficiently trap surficial Fe^{3+}-rich dust). The mafic mineral locations coincide with slightly dark-toned materials in the HiRISE image of Figs. 1 and 3, and they may be loose materials such as sands or may represent the bulk composition of the cone or the round mounds. The mafic minerals infilling impact craters are accumulated as aeolian sediment, forming small dune fields.

Discussion: The suite of the landforms observed in the Chryse field poses characteristics common to mud volcanism. Cone- and shield-like edifices with summit craters are observed in mud volcano fields on Earth. However, cracks commonly formed on dried mud surfaces are not identified at least in our observations. The type of features similar to erosional gullies developed on terrestrial mud volcanoes are not observed. Round mounds are suggested to be pingos, or a combined gas-hydrate and pingo manifestation, or to represent a type of venting structures of mud and gas [10]. Round mounds with extruded vent structures occur in some terrestrial mud volcano fields.

The flow features with a rugged surface texture resembles mud breccia (Fig. 4), but the Martian features are dotted with small depressions that are possibly degassing features. The smooth-looking summit crater infill materials observed in the Chryse features are very similar to mud-infilling craters associated with terrestrial mud volcanoes (Fig. 5).

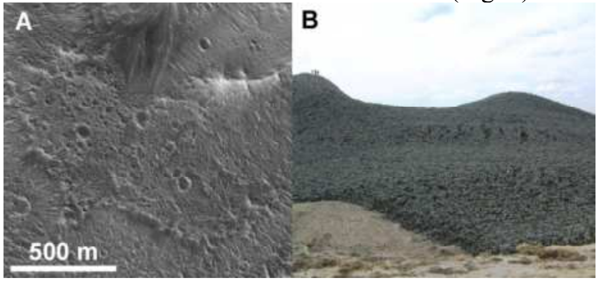

Fig. 4. The ragged surface texture of flow features. A) Chryse Planitia, Mars. HiRISE image. B) Mud breccia, Azerbaijan. Standing people at upper left for scale.

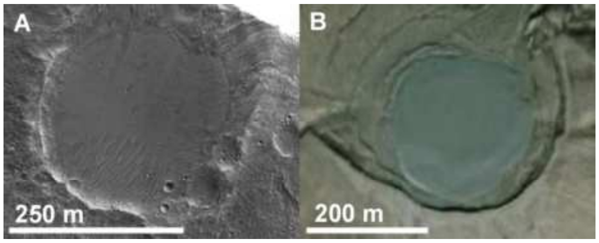

Fig. 5. The smooth-looking summit crater infill materials. A) Chryse Planitia, Mars. HiRISE image. B) Mud volcano, Azerbaijan. Google Earth image.

The lack of CRISM IR data inhibits our investigation of whether clay minerals exist within the Chryse features, but the detected nanophase ferric minerals may indicate involvement of water. The mafic minerals could be trapped aeolian sediment or other materials brought up to the surfaces from within the crust. THEMIS nighttime IR data indicate that the surfaces of the Chryse features are characterized by lower thermal inertia values with respect to their surroundings [10]. These properties of the materials are not consistent with those expected for solidified lava. However, pyroclastic materials could have properties consistent with such observations. We examined two SHARAD data tracks to gain insights on the subsurface structures of the Chryse basin in the area of the mound features. The radargrams show no clear reflective interfaces in the penetrable subsurface (1500 m for ice, 100s m in rocks). This does not exclude the presence of a stratigraphic sequence in the basin. If it exists, the layer boundaries do not have strong reflective properties with respect to the SHARAD specification, or the layering is too fine to be resolved by SHARAD (vertical resolution: 15 m). Alternatively, subsurface materials have chaotic facies, producing no clear layer boundaries.

Conclusions: The current state of our study of the Chryse features supports mud volcanism, or other mechanisms producing morphological characteristics similar to mud volcanism. The differences noted between the Chryse features and typical terrestrial mud volcanoes (i.e., lack of mudcracks and erosional gullies, presence of small depressions on flow features) may be partially attributed to the differences in the atmospheric conditions (low P and T, no rain on Mars).

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