CURVILINEAR RIDGES IN ISIDIS PLANITIA, MARS–THE RESULT OF MUD VOLCANISM?; Philip A. Davis and Kenneth L. Tanaka, U.S. Geological Survey, Flagstaff, AZ 86001

Summary: The south-Texas basin has numerous ridges and isolated volcanoes that resulted from mud volcanism along faults and fractures. The volcanism was initiated in response to excessive overburden pressure resulting from very rapid sedimentation in the basin. The setting and morphologic and morphometric characteristics of these mud volcanoes and ridges are similar to the ridges and domes within Isidis Planitia, Mars. Thus, the domes and ridges within Isidis Planitia may have also been produced by mud volcanism.

Isidis Planitia is an ancient, 800-km-diameter impact basin, which has numerous narrow, curvilinear ridges superposed on its basin-fill material. The ridges are generally concentric around the basin center, but on the perimeter of the basin the ridges are radially oriented to the basin's center. Many of the ridges appear to be chains of cones with summit craters. Numerous isolated domes with summit craters are scattered throughout the basin. According to Grizzaffi and Schultz [1], the cratered hillocks are only a small percentage (less than 0.05%) of the total population. They also found the average and standard deviation of the basal diameters of the hillocks to be less than that observed for terrestrial cinder cones. We obtained 272 photoclinometric profiles across the pitted and unpitted ridge segments and isolated cones and found all of their topographic characteristics to be distinct from terrestrial cinder cones, e.g., the Isidis ridges and cones have smaller basal diameters (0.5-1.1 km, avg. 0.75±0.13 km), lower flank heights (20-100 m, avg. 41±17 m), and lower pit depths (1-10 m, avg. 5±4 m, where present) than terrestrial cinder cones. Although terrestrial cinder cones are commonly aligned and coincident with faults, they rarely occur as continuous chains (Isidis ridges are 10-40 km long [1]) and are not as numerous as those within Isidis Planitia. These morphometric and morphologic inconsistencies between Isidis ridges and terrestrial cinder cones led Grizzaffi and Schultz [1] and Rossbacher and Judson [2] to suggest that the Isidis ridges are the residue from ice-rich deposits and that the pits on the ridges were formed by ablation of ice cores. However, this proposed mechanism of summit-crater formation requires either random occurrence of ice cores along the ridges or very selective ablation of the ice cores.

Frey [3] suggested that these deposits could be pseudocraters, which may be controlled by lava tubes and thus aligned, but Hodges and Moore [4] discount this possibility because of the parallel orientations of the Isidis ridges. They instead favor a volcanic origin in which the ridges are controlled by crustal fracturing. Jöns [5], on the other hand, interpreted the ridges to be depositional, originating from mud sheet floods, and suggested that Isidis Planitia was a large mud lake.

We propose an alternative hypothesis for the origin of the Isidis ridges and domes that can explain their small but consistent size, their preferred orientation, and the low percentage of summit craters on the ridges. We suggest that the ridges and isolated domes were produced by injection and eruption of fluidized sediments (referred to as mud or sedimentary volcanism). Usually mud volcanism produces a few, isolated domes or small fields of scattered domes on Earth. However, there is an example in south Texas [6] where mud volcanism in a mid-Tertiary basin resulted in ridges (with and without summit craters), as well as scattered cones with summit craters. In this case, the ridges and pitted cones occur along deep-seated faults and fractures. The condition thought to have set the stage for this volcanism was rapid basin deposition that exceeded the rate of isostatic adjustment of the underlying basement, which in turn resulted in differential overburden pressures and localized gravity slumping and folding [6]. Fluidized sediments were forced upward along the fold axes and the pre-existing faults and fractures. Mud volcanism that produced the pitted cones resulted from high-pressure gas and mud escape. The basal diameters of the south-Texas mud ridges and volcanoes range from 70-533 m, their heights range from 3-42 m, and their lengths range from 3-30 km [6]. The upper ends of these size ranges are similar to average values for the pitted ridges and cones within Isidis Planitia.

By analogy to the south-Texas basin, we suggest that Isidis Planitia rapidly filled with water-rich sediments, which caused excessive overburden pressures and forced fluidized sediments up along pre-existing fractures produced by the basin impact. The intrusion and extrusion of sediments also might have resulted from basin subsidence, heating of lower water-rich sediments, and possibly seismic induced fluidization [7]. Basal heating of the water-rich sediments may have produced singular cones with summit craters at the intersections of faults and fractures. A similar situation may have occurred in Utopia and Acidalia Planitiae, where arcuate ridges and isolated domes are also common.

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