SLIPPERY SLOPES ON CETI MENSA, WEST CANDOR CHASMA, MARS: ANALYSIS OF A LOBATE DEPOSIT.
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Introduction: Ceti Mensa occupies the central part of west Candor Chasma (Fig. 1). It is a broad dome formed by a thick stack of interior layered deposits (ILD) and reaches an elevation of 3600 m above Martian datum. The mensa stands 3000 to more than 5000 m above the surrounding terrain, and resistant layers near the top slope about 5° to the north, as much as 10° to the south, and about 3° to the west and east. Along the southern margin of the mensa a ridge extends eastward for about 60 km and terminates in a dome of 3000 m elevation. Two conspicuous curvilinear reentrants breach the mesa on its northwest and southeast sides, exposing a basal, light-toned massive unit overlain by a clifly layered unit. The massive unit has materials of pink to light ochre hues in HRSC color data [1], and carries the spectral signature of kieserite [2,3,4]. The top of Ceti Mensa contains more light-toned material that is deeply eroded and capped by a surficial unit that unconformably overlies all other units near the top. Several lobes extend off Ceti Mensa into the surrounding lowlands and into a depression below the southeast reentrant. One of these lobes (Fig. 2), located on the north side of Ceti Mensa, is the subject of this report. The study is based on a GIS model of west Candor Chasma and includes all image data from recent and former missions and elevation data from Mars Odyssey and Mars Express.

Description: The lobe extends from the northern flank of the edifice toward the valley floor to the northeast. It starts near the 2800 m contour and extends down to the -1900 m contour, a drop of 4700 m, over a distance of about 50 km (gradient 0.094, slope 5.4 °). The lobe is well defined, is bordered by smooth scarps, and stands in relief above the surrounding terrain. Less well developed remnants of possible former lobes occur near the main one, but do not stand in similar relief. The material of the lobe is composed of the surficial unit that unconformably straddles the upper units of Ceti Mensa. A dark, bulbous member of this surficial unit caps a hill near the mensa top and overlaps the light lower member of the unit. Both the dark and light members of the surficial unit have a signature of polyhydrated sulfates [3,4], whereas the bulk of Ceti Mensa, exposed in steep slopes in the reentrants, mostly has the signature of monohydrated sulfates [3,4].

The head of the lobe, on its west side, originates within the surficial unit near the contact between the dark and light members. The unit becomes jointed, and cracks locally follow the outlines of round hills in the dark unit. Down slope, the joints separate and the unit breaks into angular to rounded blocks. The eastern head of the lobe is marked by an arc-shaped concave-downward scarp; the surficial unit is missing below the scarp and reappears farther down slope as irregular blocks that eventually merge with the western side of the lobe. The material missing below the scarp may be eroded off. However, the arc shape of the scarp is reminiscent of landslide scars and suggests that the missing material may have been removed by sliding.

The main part of the lobe is composed of angular to sub-rounded blocks with upturned margins. The blocks are on the order of 500 m wide, but become elongated to as much as 3 km in steeper parts. In the upper middle part of the lobe, the elongation is so pronounced that the blocks become long stringers with upturned edges. Where the lobe skirts an exhumed impact crater, the long axis of the blocks becomes perpendicular to the slope, as if the down-slope movement were impeded, perhaps by the buried and overridden ejecta blanket of the crater. At its toe, the lobe extends out over the adjacent valley floor for about 2 km. A subsidiary, mostly eroded lobe extends beyond the toe for another 4 km. Blocky valley floor material, similar to but less rounded than that of the lobe, overlaps landslide material coming off the trough walls. This situation is unusual as landslides are generally younger than ILD mounds.

The material in the blocks is light colored and generally massive. The upturned rims appear to be more resistant to erosion than the centers, which are hollowed out. Bedding is seen only in a few places in high-resolution images and is mostly sub-horizontal. However, finely layered, smeared, disordered, and locally brecciated material, surrounded by dark trapped sand, shows through in the cracks and gaps between the blocks. In places, multiple densely spaced apparent shear horizons suggest that the material between the blocks was squeezed. The substrate of the blocks, where exposed in the scarps bordering the lobe, is finely layered and nearly parallel to the base of the lobe. However, high resolution images show that the bedding is disrupted, brecciated, and contorted on a small scale. In several places the substrate is strung out as if it were sheared.

The blocky material in this lobe resembles rounded blocky material with upturned rims on the southwestern floor of Melas Chasma. Weitz et al. [5] and Skilling et al. [6] proposed that this unit formed as a debris flow whose jostling formed the rounding and upturned edges [5,6]. Komatsu and DiCicenzo [7] suggested that the rounded shapes were depositional and came from salt pans. This interpretation is consistent with the finding that the layered deposits within Valles Marineris contain abundant sulfates [2]. Quantin et al. [8] noted that this blocky deposit occurs where channels break though a wall-rock ridge, suggesting that the blocks might be deltaic. Inspection of high-resolution images shows that light-toned deposits in channels are indeed associated with these light-toned, rounded blocks, supporting Quantin et al.’s [8] contention. On the other hand, the rounded blocks also appear to have impinged on each other, perhaps indicating some minor slumping in the area.

Discussion: Could the lobe material be merely the erosional remnant of a surface layer that was once more extensive? Evidence for this notion is that similar material occurs in the vicinity of the lobe. However, the main lobe is different; it is very well defined, does not have ragged edges, as one would expect from erosion, and its toe extends out over the valley floor. Also, movement on the lobe is suggested by the elongation of blocks down slope and the reversal of elongation where the lobe overrides a buried crater. The upturned rims may be from jostling of the blocks and imping-
ing on each other, combined with deflation. The evidence for apparent shear surfaces associated with breccia layers between blocks and near the base of the lobe, where exposed in the bounding scarps, suggests movement by creep on a malleable substrate. All of these observations converge on the proposition that the lobe was formed by sliding, even though it may have been just a few kilometers.

As images show, the material in the lobe is derived from the surface layer that unconformably covers units at the top of Ceti Mensa. How did this layer form? As the blocky material in this layer resembles that on the floor of Melas Chasma, a similar origin is suggested. The Melas material apparently came from deposits associated with fluvial activity [8] and may be salt deposits [7]. The signature of polyhydrated sulfates [3,4] supports such an origin for the surface unit on top of Ceti Mensa as well. However, in Melas Chasma the blocky deposit occurs on the floor near the mouth of valleys and channels, whereas on Ceti Mensa it is on an isolated mesa standing high above the surrounding valley floor. One would have to surmise that the top of Ceti Mensa once was near a low point in west Candor Chasma, after the chasma was filled with ILD from wall to wall. Then, the material between the current mensa and the chasma walls were eroded. Indeed, both the dark and light surficial material on top of Ceti Mensa are cut by the reentrant scarps and therefore deposition of this material preceded the erosion or slumping that formed these scarps.

The above considerations support that the ILD were emplaced as flat-lying lakebeds. Why then are Ceti Mensa and other ILD domal structures? On Ceti Mensa, the discussed lobe provides evidence of surface sliding. However, sliding or creep-type movement within deeper layers occurred as well. On the south side of Ceti Mensa, inclined beds are highly deformed internally, showing many unconformities, discontinuities, and structural disturbances within beds (point 2 in Fig. 1). On the southeastern end of Ceti Mensa shear surfaces are conspicuous as is a landslide lobe nearby [2] (point 3 in Fig. 1). Another lobe heads into the depression below the southeast reentrant of the mensa (point 4 in Fig. 1). This lobe has brecciated material at its base and overlies a corrugated substrate perhaps deformed by boudinage. All of these observations suggest that the sides of the mensa are prone to slippage and detachment faulting. Thus it is conceivable that the presence of evaporates [2,3,4], perhaps including halite or gypsum, induced gravity gliding on the free slopes that developed after deep erosion of the main ILD stacks, thus giving rise to the prevalent domal structures. Diapiric uplift [9] of the central, thickest evaporite beds of the ILD stacks may have contributed to the domal shape as well.