WEST CANDOR CHASMA, MARS. WHAT IS NEW? B. K. Lucchitta, Astrogeology Science Center, U. S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001. blucchitta@usgs.gov.

Introduction: West Candor Chasma is largely occupied by Interior Layered Deposits (ILD). The ILD crop out in the central highlands of Ceti Mensa and on the floor of surrounding lowlands. The mensa reaches an elevation of 3.6 km above Martian datum and stands 3 to more than 5 km above the surrounding terrain. 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 (from Mars Express DEM). Along the southern margin of the mensa, a ridge extends eastward for about 60 km and terminates in a dome of 3 km elevation. The mensa is conspicuously breached by large curvilinear reentrants on its northwest and southeast sides. The chasma has unique characteristics, among which are (1) its domal shape [1,2], (2) the signature of monohydrated sulfates (kieserite) exposed on steep slopes, and polyhydrated sulfates on gentler slopes [3], (3) haloed veins and knobs, suggesting that fluids percolated through the ILD [4,5], (5) highly distorted beds in southwestern west Candor Chasma [6], (6) a lobe underlain by sheared substrate on the northeast flank of the mensa and other sheared layers [3,7,8]. Characteristics not yet explored in detail are (1) the origin of the curvilinear reentrants, (2) the superposition of ILD on chasma-wall landslides; commonly these landslides are younger than ILD [9], (3) the nature of detached slabs that apparently slid off the mensa in places [8], (4) the origin of massive dark ridges on the west flank of the mensa [10], (5) the make up of dark resistant units within the ILD [1], and (6) the reason for a bench lining the southwestern wall of the chasma [10].

To address some of these topics I am producing a geologic map (MTM -05077 quadrangle, scale 1:500,000) of west Candor Chasma, using a Geographic Information System (GIS) model and all available images. I am mapping the outline of units and structures at the various image scales, down to the scale of HiRISE images. In the following I highlight three topics; (1) a better grasp of the stratigraphy, (2) more findings concerning possible volcanic rocks, and (3) a tentative proposal for the origin of the curvilinear reentrants.

Stratigraphy: The stratigraphy of the ILD in the mensa has been addressed by Mangold [3] and Lucchitta [1], who recognized unconformities near the top, and by Fueten et al. [2], who mapped more conformable finely and massively layered units on the east flank of the mensa. Our recent mapping, however, showed that all layers in Ceti Mensa are more conformable than previously thought. Discontinuities exist and are locally conspicuous, but they may be due to facies changes, pinching out of some layers, possible structural disruption, and selective preservation of layers that are more resistant to erosion than other units.

The overall sequence of major units on the east side and the top of Ceti Mensa are from the bottom up: (1) a lower *massive light-toned unit*, (2) a *layered unit with ledges* [2], (3) a *light-toned unit with conspicuous yardangs*, and (4) a local *light smooth* cap.

The lower *massive light-toned unit* has materials of pink to light ochre hues in HRSC color data [11] and the spectral signature of kieserite [3]. This unit crops out most prominently within the northwest and southeast reentrants breaching the top of the mensa. The unit is locally faceted in the steep slopes of Ceti Mensa, but apparently has a facies with distorted bedding in the more gentle slopes on the east flank of Ceti Mensa, below a prominent scarp.

The *layered unit with ledges* locally rests unconformably on the lower *massive light-toned* unit, but the relations are not clear everywhere. The unit was recognized by Fueten et al. [2] on the east flank of Ceti Mensa, but it also apparently forms the *rim-rock* layers on top of the reentrants. The resistant unit of this *rim rock*, forming an erosional platform near the top of the mensa, can now be traced from the easternmost reaches of the mensa [2] to the top and down on its western flank. Thus the entire top of the mensa is indeed a broad rise locally underlain and supported by these resistant layers.

On top of Ceti Mensa, the resistant *rim rock* has several layers. The topmost one has a *dark bumpy* facies that is of limited extent and appears to fill a swale, which makes the unit look like a surficial flow. In reality, the layer is interbedded with the next higher unit in the sequence, but it appears to be surficial because it is a resistant unit among softer rocks and thus stands in positive relief [12]. The *dark bumpy* facies also drapes over a cone near the north rim of the mensa. A lighter facies of the unit breaks into plaques, blocks, and slabs at the head of the northeast lobe; the slabs then apparently slid down on a sheared substrate [7,8].

The top of the mensa has an isolated patch of the *yardang unit*, which is also light toned and massively bedded, but does not have a kieserite signature. The unit also covers the southern flank of Ceti Mensa and the high ridge extending east on the south side of the mensa. Here, it locally has the signature of polyhydrated sulfates [3].

A major unconformity exists at the base of the topmost *smooth* unit, which rests on the *yardang* unit on its east side and on folded rocks of the *rim-rock* platform on its west side. It is the only unit at the top of Ceti Mensa that does not show a pervasive rib- and dune structure trending NE-SW, with related yardangs trending NW-SE. Instead, it has conspicuous cross bedding in its fabric.

On the west side of the mensa, the *rim-rock* unit and *yardang* unit can be traced into the adjacent lowlands. On the north side, only the *rim-rock* unit slopes into the lowlands; the *yardang* unit is absent. On the south side the *rim-rock* unit is buried by the *yardang* unit; both slope into the lowlands to the south. All units on Ceti Mensa conform with the topography [2] and reflect the domal structure.

Volcanic rocks? The presence of volcanic rocks would support the existence of hydrothermal fluids and alteration of possible sedimentary or trapped eolian lake beds into sulfates. Our mapping revealed several darker, resistant layers of limited extent interbedded in the ILD. One is the *dark bumpy* unit near the top of Ceti Mensa. Another is a dark layer occupying a valley on the eastern flank of the mensa. It is associated with very dark ridges, knobs, and mesas. It also appears to be surficial, but may actually be interbedded and standing in positive relief because of its resistance to

erosion. Neither unit has the bluish hue of basaltic rocks; perhaps they are covered by dust. However, both give rise to dark dune fields that do have the bluish hues of basalt. It is also possibly that brines within the ILD stacks [4] altered the volcanic rocks, but left unaltered grains winnowed out by the wind. Other extensive dark, bluish dune fields on the east side of Ceti Mensa are associated with dark ridges, knobs and possible fissures. However, they also occupy a low area which may have served as a trapping sink. A dike-like structure has been reported on the south flank of Ceti Mensa by Lucchitta [10].

The Ceti Mensa reentrants: The reentrants have largely been attributed to eolian erosion. However, landsliding has been suggested for their origin [13], as has normal faulting for the northwest reentrant [14]. The southeast reentrant has a scarp or ridge at its base that locally reflects a structural discontinuity.

I here propose that the origin of the reentrants may be due to a combination of gravitational slumping and erosion. The following observations support this idea: (1) The northeast lobe containing detached blocks and slabs of *rim rock* occupies the isthmus between the two reentrants on the mensa's northeast side. The slabs ride on a sheared substrate [7,8]. Perhaps similar lobes once occupied the reentrants but slid off completely or remnants were eroded away. (2) More detached slabs are seen at the east base of Ceti Mensa, resting on distorted rocks [8]. (3) The *rim rock* along the reentrants is truncated largely along curvilinear smooth lines that have the shape of landslide break-away scarps. (4) Massive dark ridges trend roughly N-S on the west flank of Ceti Mensa. They approximately mimic the alignment of slightly concave downslope contours in this area. Perhaps they are incipient failure fractures, filled with breccia and cemented by circulating fluids. (4) Massive and faceted beds of the *massive light-toned unit* exposed within the steep slopes of the southeast reentrant give way to a highly distorted facies of the same unit on shallower slopes below. Here we may see a breakaway scar in the steep part of the reentrant and slid off distorted beds in the gentler sloping lower part. An overlying rim-rock slab may also have slid off and is now either incorporated in the distorted beds or eroded. (5) The northern and western lowlands surrounding Ceti Mensa are filled with ILD that overlie chasma-wall landslide deposits. This uncommon situation may come from late-stage fill of the lowlands by detached material that slid off the mensa. (6) Okubo et al.'s [6] study of structures in the lowlands southwest of Ceti Mensa showed possible landsliding to the south within the ILD in this area. This sliding may also have been caused by movement of material off the mensa. (7) The ILD layers within this southwestern part of west Candor Chasma are highly distorted. They, like those on the east side of the mensa, could be beds that slid off the mensa, perhaps formerly overlain by now eroded rim-rock slabs. (8) A conspicuous bench near 1500-1700 m elevation lines the wall rock in this area [10]. Underneath the bench ILD are seen in the wall, whereas above the bench they are not. Thus, the bench marks the uppermost former stand of the ILD in this area. This elevation is far below the elevation of the top of Ceti Mensa. This discrepancy in elevations can be explained if the main edifice only occupied the central part of west Candor Chasma and the surrounding lowlands were later filled with slumped material. (9) Most of the ILD in Ceti Mensa are composed of hydrated sulfates. Thus it is conceivable that the presence of evaporites [3], perhaps including halite or gypsum, resulted in a structurally weakened edifice allowing for the proposed failures.

Conclusion: Detailed mapping in west Candor Chasma, including Ceti Mensa, showed that many structural and stratigraphic discontinuities exist throughout the ILD section, but major unconformities are scarcer than previously thought. Resistant dark layers of limited extent suggest that perhaps volcanic rocks are interbedded in the ILD. Different lines of reasoning converge on the idea that the conspicuous curvilinear reentrants on the flanks of the mensa may be related to gravitational failure combined with erosion.

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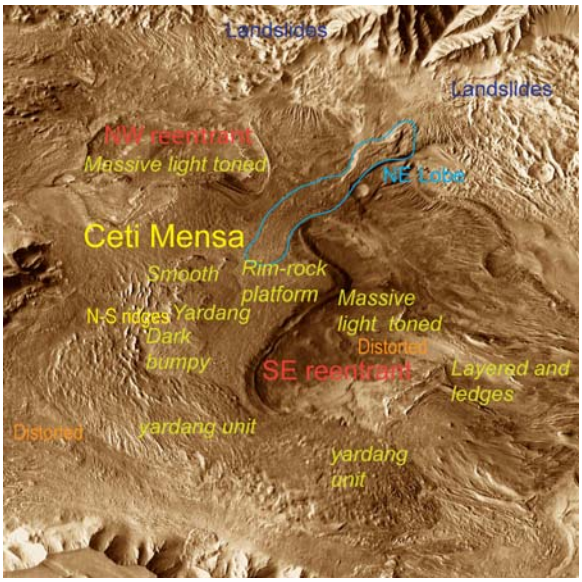

West Candor Chasma and Ceti Mensa. The reentrants are shown in red, the stratigraphic units in italic green. Also shown are the areas with distorted bedding (orange), and the northeast lobe (blue).