MORPHOLOGY AND MORPHOMETRY OF CETI MENSA, WEST CANDOR CHASMA, MARS. L.R. Gaddis[1], J. Skinner[1], T. Hare[1], R. Kirk[1], T. Titus[1], L. Weller[1], Gerhard Neukum[2] and the HRSC Co-Investigator Team, [1]U.S. Geological Survey, Astrogeology Program, 2255 N. Gemini Drive, Flagstaff, AZ (lgaddis@usgs.gov); [2]Institute of Geological Sciences, Freie Universitat Berlin, Germany.

Introduction: We use high-resolution topographic data to examine the morphology and morphometry of Ceti Mensa (CM), a feature comprised of layered units on the floor of West Candor Chasma in the Valles Marineris (VM), Mars (**Figure 1**). Our goal is to characterize slopes, thicknesses, and elevations of these layers in their local and regional contexts to constrain their origin. Portions of the VM have relatively high hydrogen abundance, and water may have played a significant role in the formation of such layers [1].

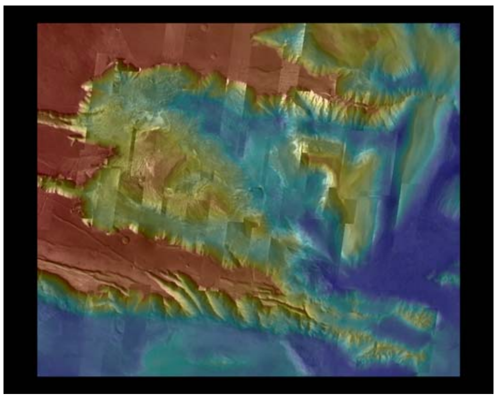

Figure 1. *THEMIS VIS mosaic of West Candor Chasma with MOLA elevation data adding color (red=high, blue=low).*

Geologic Setting: Ceti Mensa (-3.5 to -4.7°N, 250.8 to 253.9°E) covers >9000 km^2 of West Candor Chasma and rises >3000 m from the chasma floor. The highest point of the mesa reaches 3300 m, ~900 m below the surrounding cratered plateau of southern Lunae Planum. The mesa is heavily dissected in two places, resulting in curvilinear scarps, one facing northwest and the other southeast. These scarps, locally >1500 m high, expose massive layered sequences that apparently constitute the internal bulk of the mesa. A 100-m deep moat forms the base of CM on the south, and the northern margin is disrupted by hummocky materials associated with slumped wall-rock and irregular depressions with highly variable texture and albedo. The slopes of the flanks of CM range from 1° to 8°, with the steepest areas to the south. Ceti Mensa has been called "Red Mesa" because of the red-colored, smooth-surfaced depressions that show ferric oxide mineralization [2]. HRSC color data [3] confirm the presence of this reddish deposit near the Ceti scarps (**Figure 2**).

A variety of origins have been proposed for layered deposits within the VM. Lucchitta [4] proposed that some layered materials in the floor of West Candor are products of mass-wasting of older interior layered deposits that may have been saturated with ice, possibly from former lakes. Weitz et al. [5] suggested that fluvial processes may have played a role in eroding some of the interior layered deposits within the VM. Chapman et al. [6] suggest that very young ice-formed features occur on the floor of central Candor. Komatsu et al. [7] also indicate that subice volcanism may have played a role in forming some VM layered deposits. Whatever their origin, the presence of hydrated sulfate minerals (such as kieserite and gypsum) observed in light-toned layered deposits of West Candor using Mars Express (MEX) OMEGA data [8] suggests that repeated episodes of wetting and drying have not occurred where these deposits are observed. Origin of these deposits by evaporation from standing bodies of water (such as might occur in a shallow, briny lake) and by circulating acidic fluids in hydrothermal environments have been proposed [8].

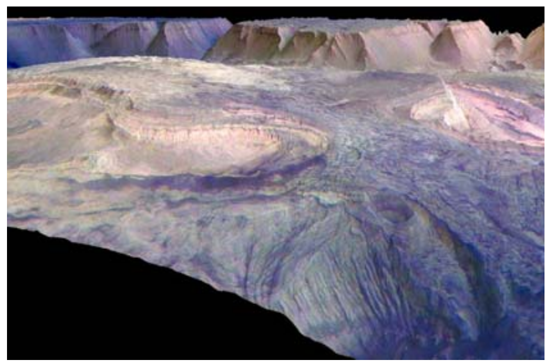

Figure 2. *3-D view of HRSC image (orbit h1235) of Ceti Mensa.*

Data: Topographic data for this analysis include digital elevation models (DEMs) derived from a 'thermoclinometry' method (applied to Mars Odyssey (MO) THEMIS data and Mars Global Surveyor (MGS) MOLA data [9-11]) and from Mars Express High Resolution Stereo Camera (HRSC) images [3, 12]. 'Thermoclinometry' uses THEMIS VIS and day and night IR data to cancel the effects of albedo in an image and enhance the topography. The result is a detailed topographic model of a site on Mars, with low-frequency topography derived from MOLA data and high-resolution topography from THEMIS data at ~80 m resolution. The HRSC color view was constructed using red, green, and blue channels with a separate stretch for each band, and it has been pan-sharpened with the nadir image [12]. These data are complemented by numerous images from MGS MOC NA and MO THEMIS VIS and IR instruments.

Observations: The interior of West Candor Chasma has five major units, listed below from oldest to youngest.

Massively-Layered Units. Ceti Mensa appears to be largely comprised of massive layers that are mostly traceable throughout and below the two eroded scarps.

These units have a moderate albedo and are ~150 m in average thickness; the layers apparently thin upsection. The massively-layered units have a pink to light ochre hue in HRSC color data, and they are the sites of kieserite mineralization [8].

Moderately-Layered Units. The massively-layered units of Ceti Mensa appear to grade upsection into moderately-layered units that comprise the surface of CM. These units extend from the uppermost portions of the mesa to the outer margins and locally have medium- to low-albedo surface hummocks. Yardangs have developed in several places within this unit. The outer margins of Ceti Mensa do not show well-developed layers, suggesting that these surfaces represent dip slopes or that the layers have been eroded away. The moderately-layered units are light-toned in HRSC color data and they extend to the base of the wall-rock in the western region of the chasma but elsewhere they are buried by thinly layered deposits.

Thinly-Layered Units. The moderately-layered units of Ceti Mensa are progressively buried along its margins by alternating high- and low-albedo materials with hummocky and pock-marked surfaces. These bright-dark layered units are commonly <10 m thick and appear to be nearly horizontal. The thinly-layered units are most common at <500 m elevation in the southern, eastern, and northern regions of the chasma, but they are not seen at these elevations in the western region. In places, horizontal, eroded outcrops of the thinly-layered units extend up the chasma walls to ~1900 m elevation. These units have an extremely low albedo and dark blue-black hues in HRSC color data. Similar units occur locally on the plateau surface.

Dark-Mantle deposits. Low-albedo mantles, many with dune forms, occur in the southern, eastern, and northern regions of the chasma. These materials fill local depressions and onlap and thinly bury adjacent terrains. These materials most likely represent excavated and re-distributed sand and (or) silt-sized particles sourced from the thinly-layered units described above. Basaltic compositions have been suggested for many of these deposits [13]. Dune forms suggest a dominant wind direct toward the SSE. Many of these deposits occur in the lee of topographic promontories.

Talus materials. The youngest materials appear to be gravity-fed talus deposits that cover the base of the chasma walls. This material has a moderate albedo and very smooth surface texture. In some areas, the talus lies both over and under thinly-layered units, indicating that the mass-wasting of chasma walls is generally time-transgressive and likely still occurring.

Morphometry: The ~high (~75-m) resolution of the derived DEMs allows us to derive the strike and dip of surface and exhumed internal layers of Ceti Mensa. Using a three-point problem solver in ArcGIS, we resolve shallowly sloping layers (<8°) that form a dip slope on most of the preserved outer surfaces. The internal layers steepen slightly down-section, to a maximum of >11°. These measurements are consistent with those of others [14, 15], they support emplacement of CM as non-flat units, and suggest that CM is comprised of two overlapping, domical edifices. The western dome is centered at -5.31°N, 283.61°E and rises to 2965 m elevation, and the eastern dome is centered at -5.74°N, 283.89°E and rises to 3045 m elevation. The gently sloping summits of these features are separated by a shallow central valley and a distance of 30 km.

Implications: These morphologic and morphometric observations of Ceti Mensa suggest that it may be unusual among interior layered deposits of the VM, but its origin remains enigmatic. The presence of kieserite and/or gypsum in low-lying, more massively-layered units of CM may be consistent with an early water-rich environment in the floor of West Candor. Indeed the exposed scarps and general absence of associated debris along the margins of CM suggest that much of the removed material has exited West Candor Chasma, and the presence of flow-like units and irregular depressions along the margins suggest that some form of fluidized flow has had a role in redistribution of local materials. However, the two domical features of CM consist mainly of sloping, light-toned, friable materials, and they are not capped by horizontal layers (as might be expected in the case of a sub-ice volcanic origin [e.g., 7]). These observations are less consistent with an origin of the CM plateau units by lacustrine deposition or sub-ice volcanism, and more suggestive of an origin by explosive, subaerial hyaloclastic eruptions, possibly in shallow water.

Future Work: At present (in advance of drilling or penetrator efforts), layered deposits in canyon, channel, and crater walls may provide the best exposures of subsurface geologic units on Mars and thus the best means of characterizing geologic processes that have operated in Mars' past. The continuing focus of this work is to constrain the origin and distribution of layered deposits in West Candor Chasma and throughout the VM. We will continue to utilize the thermoclinometric method as new THEMIS data become available, and to use the HRSC data for more detailed morphometric analyses. Further, we will incorporate analyses of TES and THEMIS multispectral data to characterize the compositions and thermophysical properties of the layered deposits as well as the aeolian and dark mantling materials.

References: [1] Feldman et al., 2004, JGR-P 109. [2] Geissler et al., 1993, Icarus 106, 380-391. [3] Neukum et al., 2004, ESA SP-1240, 17-35. [4] Lucchitta, 1996, LPSC XXVII, #2059; [5] Weitz et al., 2001, LPSC XXXII, #1629. [6] Chapman et al., 2005, LPSC 36, #1850; [7] Komatsu et al., 2004, Plan. Space Sci. 52, 167-187. [8] Gendrin et al., 2005, Science 307, 1587-1591. [9] Soderblom et al., 2002, LPSC XXXIII, #1254. [10] Soderblom and Kirk, 2003, LPSC XXXXIV, #1730. [11] Kirk et al., 2005, PERS 71, 1167-1178. [12] Kirk et al., this volume. [13] Gaddis et al., 2003, LPSC XXXIV, #1956. [14] Zegers et al., this volume. [15] Stesky et al., this volume.