MEASUREMENTS OF THE STRIKE AND DIP OF LAYERS IN COPRATES CHASMA, VALLES MARINERIS, MARS. R. A. Beyer, A. S. McEwen, *Department of Planetary Sciences, University of Arizona, Tucson AZ 85721-0092, USA, (rbeyer@lpl.arizona.edu).*

The Mars Orbital Camera (MOC) onboard the Mars Global Surveyor (MGS) spacecraft has observed extensive layering on the martian surface and in the Valles Marineris canyon system [1,2]. Layering seen in the walls of terrestrial canyons is often sedimentary in nature, with new layers being put down by the slow process of deposition from rivers, lakes, or oceans. Alternately, volcanic processes with multiple eruptive episodes can deposit many layers of volcanic rocks. However, unlike any terrestrial canyon the Valles Marineris cuts down over 9 km into the martian crust. Despite this extensive exposure, the origin of the layers is unknown, but there are hypotheses for both sedimentary and volcanic origins. Also relevant to the exposures that we see today is the formation processes of the giant canyon system itself and what geologic changes the region has gone through since that time.

In order to gain more insight into these questions, we seek to gain an accurate, quantitative understanding of the layers seen in the Valles Marineris outcrops by synthesizing data from MOC, the Mars Orbital Laser Altimeter (MOLA) [3], and the Thermal Emission Imaging System (THEMIS) [4]. Layering can be seen in the high-resolution MOC images, and correlated with a particular height from accompanying individual MOLA tracks. In addition to the tracks that accompany many MOC images, there are a great number of MOLA tracks that are independent of any given image that criss-cross an area, and when taken as a whole they can give us a much better understanding of the three-dimensional nature of the martian surface. The infrared multiband images at 100 m/pixel and visible wavelength images at 18 m/pixel from THEMIS will be invaluable for tracing layers, and for constraining their thermo-physical properties (emissivity, determining whether the exposed surface is rock, sand, or dust, etc.). Combining the visible and thermal imaging datasets with a topographic dataset will allow us to quantitatively understand the three-dimensional relationships of the observed ground forms, that any dataset individually would not be able to provide.

These techniques will allow accurate measurements of layer thickness and horizontal extent. Individual layers will be traced across several images to determine how far they extend along the canyon. This will allow us to determine if the layers are flat-lying or if they dip down in a particular direction. Lacustrine deposits should be horizontal unless they are tectonically tilted, in which case the tilted layers should have a systematic relationship to regional tectonics. Air-fall ash or dust will drape over preexisting topography. Sand will pile up against topographic obstacles. Lava flows will be largely but not entirely horizontal. The layers may even be interbedded lavas and sediments. Gaining these kinds of measurements of the layering characteristics of the Valles Marineris exposures may reveal new insights into the formation processes of these features and may have implications for the early geologic history of Mars.

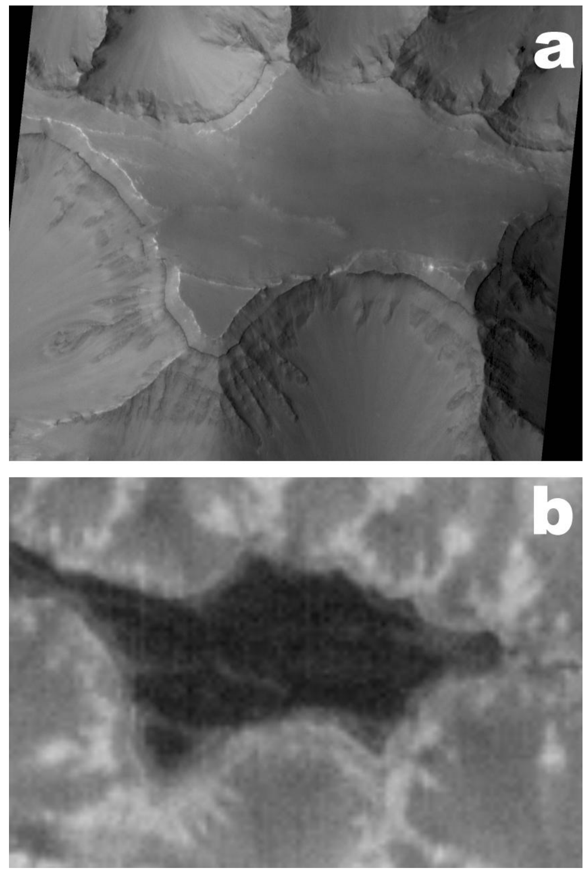

Figure 1: These images show context for the westernmost flat-topped area on the massif in southeast Coprates Chasma. *a.*MOC image AB1/08003, 4.7 m/pixel. *b.*THEMIS nighttime IR brightness temperature image I00820002, 100 m/pixel.

We have begun to make measurements of the observed layers in the MOC images of the large massif in southeastern Coprates Chasma located at roughly 15°S, 55°W. The massif is mapped as undivided material (HNu) [5] , and has a few flat-topped areas along its 225 km length which are mapped as younger fractured material (Hf) [5]. These flat-topped areas along the spine of the massif are most likely the remnants of the plains surface that covered this area prior to the opening of Coprates Chasma. Figure 1 shows MOC and THEMIS context images over the westernmost flat-topped area. These images show the smooth texture of the flat surface and its comparatively low temperature at night indicating that the top surface has a lower thermal inertia than the bedrock exposed along the eroded slopes of the massif. This indicates that there is probably a layer of fine particles collecting in the flat areas

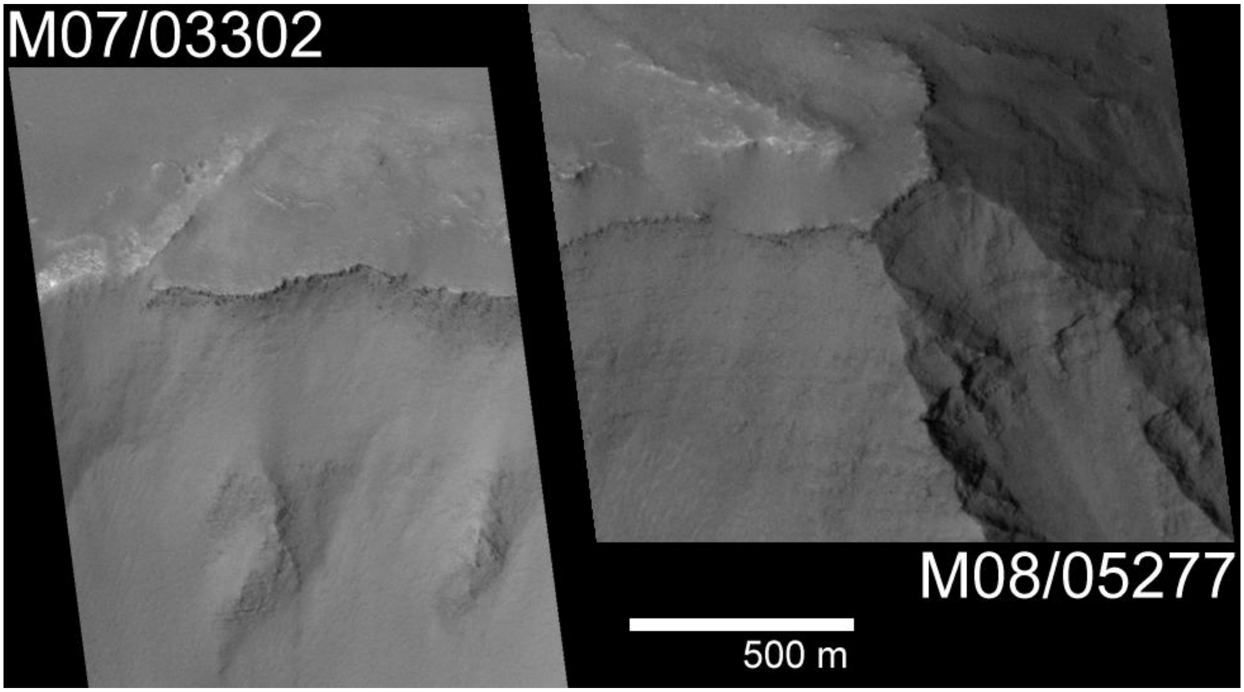

Figure 2: These MOC images show the cliff-forming layer near the top of the flat-topped areas on the massif. Image M08/05277 is about 21 km east of M07/03302.

atop the massif. Figure 2 shows a higher resolution image of the southern edge of that flat area, and displays a resistant cliff-forming unit beneath the dust cover. The MOLA track that was taken simultaneously with M07/03302 indicates that the cliff-forming unit has an elevation of about 1900 m. Twenty-one kilometers to the east is another MOC image/MOLA track pair that the cliff-forming unit can be identified in, and it has an elevation of about 2030 m. This gives a dip of $0.35°$ down to the west for this unit. Additionally, the thickness of this unit appears to be about 10 m at both locations.

If this portion of the Valles Marineris is a large graben system [6,7], then the massif in southeastern Coprates Chasma is a horst block. We have not yet identified the cliff-forming unit in the Coprates Chasma wall rock to the north or south, so the amount of subsidence of the block is not known. If we assume that the cliff-forming layer, whatever it is, was emplaced horizontally, then according to our measurements on the massif itself, it must have tilted down slightly to the west either during canyon formation or in the time since.

We will present our results for the measurements of layers both on the massif in southeastern Coprates Chasma, and on the surrounding wall rocks of Coprates Chasma itself. Ultimately, this technique will be used to make measurements on the very fine layering seen in the interior layered deposits.

[1] Alfred S. McEwen, Michael C. Malin, Michael H. Carr, and William K. Hartmann. Voluminous volcanism on early Mars revealed in Valles Marineris. *Nature*, 397:584–586, February 1999. [2] M. C. Malin and K. S. Edgett. Mars Global Surveyor Mars Orbiter Camera: Interplanetary cruise through primary mission. *J. Geophys. Res.*, 106:23429–23570, October 2001. [3] D. E. Smith, M. T. Zuber, H. V. Frey, J. B. Garvin, J. W. Head, D. O. Muhleman, G. H. Pettengill, R. J. Phillips, S. C. Solomon, H. J. Zwally, W. B. Banerdt, T. C. Duxbury, M. P. Golombek, F. G. Lemoine, G. A. Neumann, and et al. Mars Orbiter Laser Altimeter: Experiment summary after the first year of global mapping of Mars. *J. Geophys. Res.*, 106:23689–23722, October 2001. [4] P. R. Christensen et al. *Science*, submitted, 2003. [5] Nanci E. Witbeck, Kenneth L. Tanaka, and David H. Scott. *Geologic Map of the Valles Marineris Region, Mars*. United States Geologic Survey, 1991. [6] R. A. Schultz. Structural development of Coprates Chasma and western Ophir Planum, Valles Marineris Rift, Mars. *J. Geophys. Res.*, 96:22777–+, December 1991. [7] R. A. Schultz. Multiple-process origin of Valles Marineris basins and troughs, Mars. *Planet. Space. Sci.*, 46:827–834, June 1998.