**GEOLOGIC MAPPING OF THE MAWRTH VALLIS REGION, MARS: CLUES TO THE ORIGIN OF CLAY MINERAL DEPOSITS.** J. R. Michalski[1], E. Z. Noe Dobrea[2], R. Fergason[3], and M. Golombek, [1]Jet Propulsion Laboratory, California Institute of Technology, (Joseph.R.Michalski@jpl.nasa.gov), [2]Malin Space Science Systems, and [3]Arizona State University.

**Introduction:** The Mawrth Vallis region of Mars contains ancient, layered, clay-bearing rocks of probable sedimentary origin [1-5]. We are currently mapping the geology of the region using a combination of visible, infrared, and topographic data. In this abstract, we describe the geologic units present in the region, structural geology, stratigraphic relationships, thermophysical observations, and early map results.

**Geologic Units:** There are two major types of surface units in the Mawrth Vallis area: light-toned rocks and dark-toned rocks.

*Light-toned unit:* We refer to the light-toned unit as such because it is relatively bright in visible images. I/F derived (at $\lambda$ = 1.1 μm) from Mars Express OMEGA (*Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité*) data averages 0.18 (± 0.05) (at km-scale). The light-toned unit is layered everywhere that it is observed. Layering is evident at the meter- to decameter-scale in two ways: differences in tone between the layers and/or differences in the way layers respond to erosion. Within the "light-toned" unit, there are very light-, light-, and medium-toned layers – possibly related to color differences (Figure 1a). Some of the differences in apparent tone between layers may actually be related to physical differences between the units, which serve to capture dark particles on ledges thereby darkening the layers. Aside from tone, physical response to erosion of the light-toned unit reveals much of the observed layering. Some eroded surfaces form steep cliff faces separated by thin or thick slope-forming surfaces, suggesting, at a minimum, two major lithologies within the light-toned unit. Response to erosion is also evident in surface textures on relatively flat surfaces. In different parts of the Mawrth Vallis area, the light-toned unit produces varied surface textures including: 1) fractured, smooth layers (Figure 1b), 2) butte-forming layers (1c), 3) scaly layers with irregularly shaped, low mesas (1d), and 4) smooth to subdued hummocky surfaces (1e). In some places, the light-toned unit contains impact craters filled by younger light-toned materials as well evidence for circular mesas suggestive of inverted craters that are being exhumed from within the unit (Figure 1d, f).

*Dark-toned unit:* The dark-toned unit has an OMEGA I/F (albedo) of 0.125 (± 0.006). Layering is less obvious in the dark-toned unit, but is observed at the meter-decameter-scale in some places where cross sectional views are observed (Figure 1a-f). The dark unit exhibits apparent intra-unit color differences (Figure 1a), which could be related to subtle compositional variation. Texturally, it has smooth surfaces with abundant small (<1 km) impact craters. An important exception is the presence of low, roughly circular mesas (which we interpret to be the inverted topographic remains of former craters), as well as long, sinuous ridges morphologically similar to inverted channels [2].

*Contact relations:* The dark-toned unit mantles the light-toned unit through a range of elevations and geomorphic settings. At the highest elevations, the dark-toned unit caps mesas and hills as a thin (1-10s meter-thick), smooth, flat layer. In other places, the dark unit fills local lows as basin fill (irregular basins and craters – Fig. 1a). The dark unit occurs against the walls of mesas and ridges where the light-toned unit is high-standing, or as patchy, diffuse contacts on low, flat plains. We interpret this contact between the light-toned and dark-toned unit as disconformable. Based on the presence of buried, filled, and inverted craters within the light-toned unit, we propose that many unconformities exist within the light-toned unit.

**Structure:** Rock units in the Mawrth Vallis area appear flat lying and intact. Interactions between layered bedrock and irregular topography along cliffs and within craters (Figure 1) suggest low dips within the light-toned unit, though local or regional dips of up to a few degrees cannot be ruled out. Minor faults related to impact structures and regional tectonism probably do disrupt the stratigraphy, but these relationships require further analysis with higher resolution image and topographic data. Because the rock units are intact and nearly horizontal, it is reasonable to assume crude stratigraphic correlation throughout the Mawrth Vallis area.

**Stratigraphy:** Gridded MOLA data were used to construct topographic profiles throughout the region. The most important observation is that a significant thickness of light-toned rocks is required to explain the topographic range in outcrop exposure throughout the Mawrth Vallis area regardless of shallow regional dips. In the north Mawrth Vallis area, clay-bearing rocks crop out near -3500 m elevation. The highest part of the section exposed in the south Mawrth Vallis area is near -1700 m elevation. A shallow regional N-S dip of ~1° could affect the interpretation of thickness over this great distance (~300 km). However, similar variations in apparent thickness are also observed in the E-W direction, suggesting that a N-S dip alone will not explain such a large apparent thickness of the light-toned rocks.

**Age:** The age of the light-toned, clay-bearing rock unit is constrained by stratigraphy, crater counts, and structural relationships. All three constraints indicate that the light-toned, clay-bearing rocks are Late Noachian at the youngest [4]. Crater counts suggest two distinct populations of craters in the region. The population (210 craters/$10^6$ $km^2$ area) of large craters (D >16 km) suggests Middle to Early Noachian age [6], while the population (1050 craters/$10^6$ $km^2$ area) of smaller craters (D >2 km) suggests an Early Hesperian age. This relationship can be explained by destruction of smaller craters by resurfacing during the Late Noachian to Early Hesperian.

**Geologic Origin:** Any interpretation of the origin of the clay minerals detected in this region must reconcile their close association with a thick, flat-lying, widespread, layered, undeformed, complex stratigraphic section of rocks that were *deposited over a duration of time* (*i.e.* long enough to deposit, lithify, erode and redeposit multiple intra-unit layers and create intra-unit unconformities). Various interpretations of igneous, hydrothermal, metamorphic, or impact-related origins of the clays appear less consistent with the data than a sedimentary or pyroclastic origin of for the rocks. The clay-bearing sedimentary rocks in the Mawrth Vallis area were deposited early in Mars' history – probably in the first 500-700 My (based on stratigraphy and crater counts), and possibly much earlier (based on age relationships with the dichotomy boundary). Therefore, we interpret the section of clay-bearing rocks exposed near Mawrth Vallis as evidence for an ancient, sustained but dynamic, wet (marine, lacustrine, or fluvial) depositional setting at the Martian surface at this time.

**Geologic Mapping:** We are in the midst of developing a geologic map of the area based on photogeology, topographic data, surface composition, and thermophysical properties. Map relationships allow for interpretation of stratigraphic correlations throughout the Mawrth Vallis area and are providing insights into the temporal and genetic relationships between local geologic units and other major geologic features in the region such as the dichotomy boundary, classical highland plains surfaces, and the Marwth Vallis outflow channel.

References: [1] Poulet et al. (2005) *Nature*, *438,* 623-627. [2] Malin, M. and K. Edgett (2003), *Science*, *290*, 1927-1937. [3] Loizeau, D. et al., (submitted), *JGR*. [4] Michalski, J. and E. Noe Dobrea (submitted) *Geology*. [5] Noe Dobrea, E. and J. Michalski (submitted), *GRL*. [6] Tanaka, K. (1986) *JGR , 91*, E139-E158.

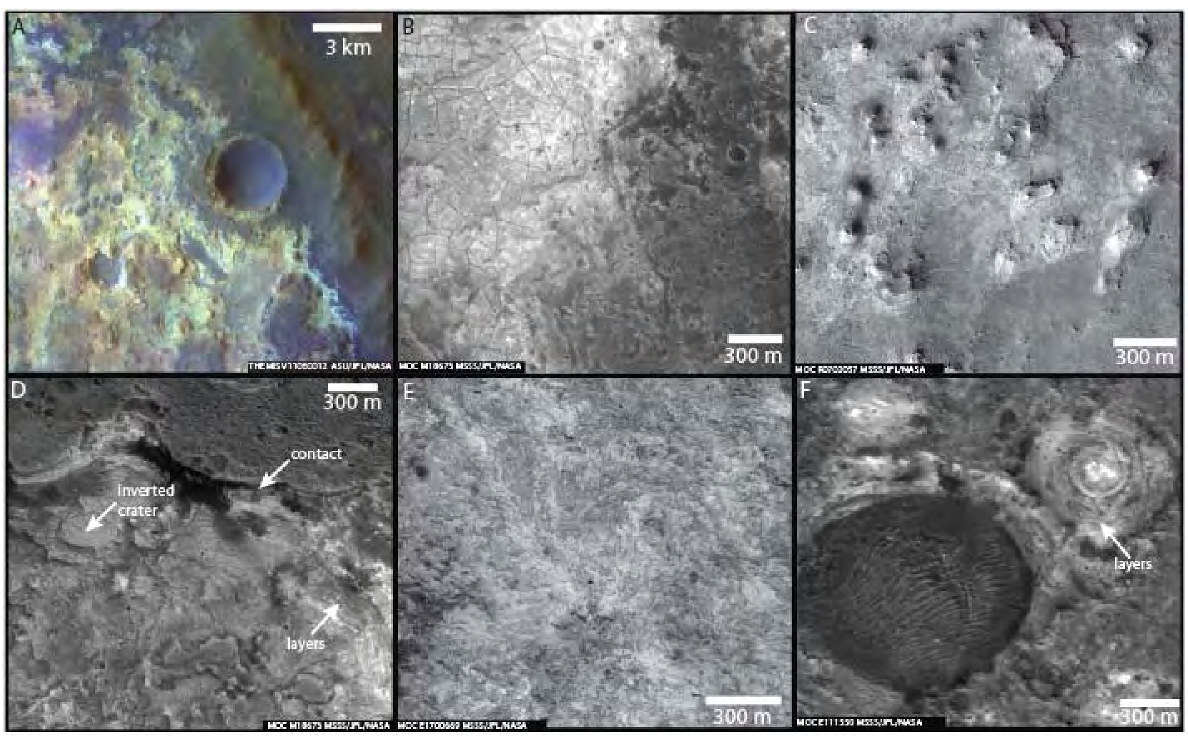


**Figure 1**: A) THEMIS visible data show that light-toned materials exhibit internal changes in color that could correspond to lithologic differences. The overlying dark material has been eroded back to leave a gradual, scaley contact with the light-toned surfaces. Variation in surface textures are shown in MOC narrow angle images, including cracked, smooth surfaces (B), butte-forming layers (C), scaley layers with irregular buttes (note the layers and possible inverted crater) (D), and subdued, hummocky layers (E). In "F," note the earlier crater filled with light-toned materials that were subsequently lithified, impacted, and later filled with dark material.