WIDESPREAD LAYERS IN ARABIA TERRA: IMPLICATIONS FOR MARTIAN GEOLOGIC HISTORY. E. M. Venechuk[1], C. C. Allen[2], and D. Z. Oehler[2], [1]Scripps College, Pomona College Dept. of Geology, Claremont, CA 91711, elizabeth.venechuk@gmail.com, [2]NASA Johnson Space Center, Houston, TX 77058.

Introduction: Layered rocks in Arabia Terra have been the focus of several recent papers [1-3]. Studies have focused on the layers found in crater basins located in the southwest portion of the region. However, Mars Orbiter Camera (MOC) images have identified layered deposits across the region. Terrestrial layered rocks are usually sedimentary, and often deposited in water. Thus extensive layered sequences in Arabia Terra may indicate locations of past, major depositional basins on Mars. Other mechanisms can also create layered rocks, or the appearance of layered rocks, including volcanism (both lava flows and ash falls), wind-blown deposits, and wave-cut terraces at shorelines. By identifying where in the region layers occur, and classifying the layers according to morphology and albedo, past depositional environments may be identified.

Arabia Terra is characterized by heavily cratered Noachian plains, as well as a rise from -4000 m in the northwest to 4000 m in the southeast (Mars Orbital Laser Altimeter [MOLA] datum). This slope may have provided a constraint on sediment deposition and thus layer formation. While most of the region is Noachian in age, a significant percentage of the area is identified as Hesperian. Although the history of the Arabia Terra initially seems to be straightforward – cratered plains with several younger units atop them – analysis of high-resolution imagery may reveal a more complex history.

Methods: 1011 high-resolution (5-12 m/pixel) MOC images from 0 to 40 N and 20 W to 60 E were initially examined for the presence of layers. Three image sets, differentiated by date, were used: AB1-M04, R03-R09, and R10-R15 [4]. These three sets covered several years and all seasons on Mars, so any seasonal variation in visibility was accounted for. A map was generated using ArcGIS, indicating where the layers were located in Arabia.

The image sets R10-R15 and R03-R09 have now been reexamined in order to subdivide the layers according to morphology and albedo. Analysis of the results from this second survey is ongoing, with concentration on the regional distribution of layer types.

Results: 80.2% (811) of the MOC images examined in the first survey show layers, which are present in varying concentrations across the entire region. No trend associated with latitude or longitude was seen; however, trends in layer location do correlate roughly with geologic units and altitude.

In the western half of the study area, certain regions show a noticeable lack of layered outcrops while other regions have numerous examples of layers. When compared with the Viking-era geologic maps, those regions with very few layers generally correlate with Noachian and Hesperian Ridged Units (Nplr and Hr), mapped as volcanic in origin [5,6]. There is also a distinct lack of layers at altitudes between -2500 m and -2000m in the western half of the map. Layers occur regularly above the -2000 m contour line and below the -2500 m line. Both of these altitude changes are relatively steep. In the eastern half of the study area, layered deposits are fairly evenly distributed, with a few exceptions: ridged units tend to have fewer layers, and altitudes above 1000 m tend to have fewer layers. Although there are regions between -2000 m and -2500 m in the eastern half of the map, no corresponding lack of sediments has been identified.

Three distinct types of layers were delineated, based on morphology and albedo. Type One consists of alternating layers of bright and dark rock (Fig. 1). Type Two consists of layers that cannot be visually distinguished from each other, but still erode at regular intervals (Fig. 2). Type Three consists of thin, usually dark layers that do not form even cliff faces, and may shed boulders that can be seen downslope (Fig. 3).

These images are being compared to aerial photos of terrestrial layered rocks of known. On Earth, morphology and albedo of sedimentary layers often correlate with rock type and thus provide evidence of the depositional environment, suggesting that clues to the geologic history of the Arabia Terra may be revealed.

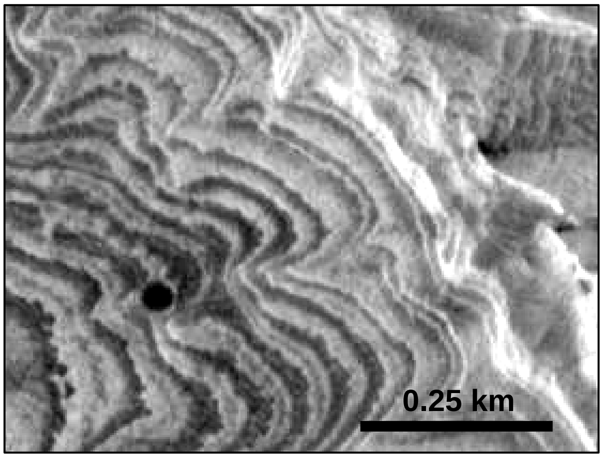

Figure 1. Type One layers: bright-dark. Image M0303117 at 22 N, 8 W [6].

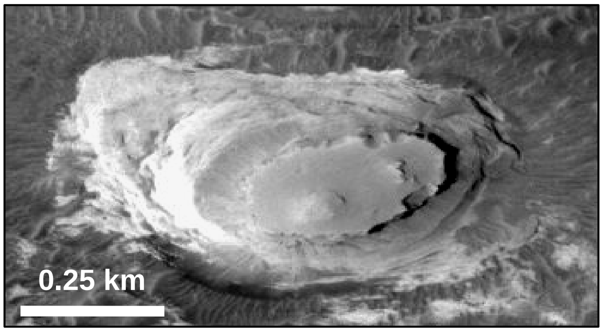

Figure 2. Type Two layers: stair step. At least four layers are visible. Image R1502235, at 1 N, 7 E [6].

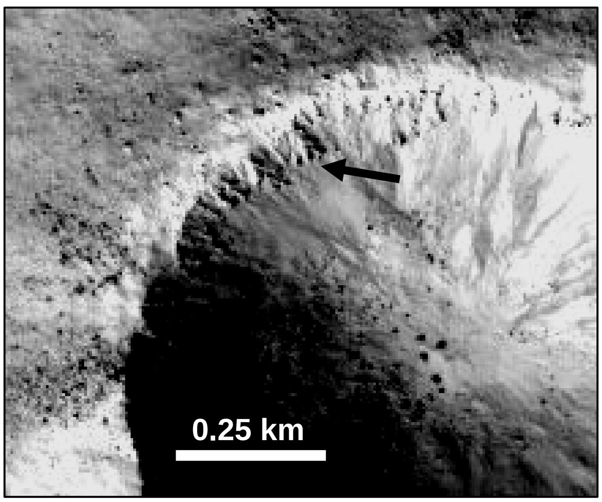

Figure 3. Type Three layers: rubbly. The arrow indicates the rubbly layer seen in the crater wall. Boulders can be seen inside and outside the crater. Image R1100584, at 5 N, 46 E [6].

Discussion: The lack of layers between -2000 m and -2500 m in the western half of Arabia Terra suggests an altitude-dependent erosion or concealment of the layers seen in the surrounding terrain. Both contour lines mark areas of rapid elevation change: a drop of at least 150 m and up to 300 m in topography. The -2500 m contour line roughly marks the planet-wide dichotomy boundary. The few layers between these altitudes are exposed, either in crater walls or within the craters themselves. Several scenarios for the development of this region are possible.

In the first scenario, sediments were deposited only at latitudes above the -2000 m contour. After the dichotomy formed its sharp cliff at what is now -2500 m, sediments were preferentially deposited below this altitude. In the second scenario, sediments were deposited over the entire region regardless of altitude, after which a local depositional event, such as lava flows or a massive dust layer, buried the layers between the altitudes of -2000 m and -2500 m. The formation of the dichotomy boundary cut away at the deposit covering the sediments underneath the region and exposed them below -2500 m. In the third scenario, the entire region was covered with layers, which were then selectively eroded in the areas between -2000 ma and -2500 m, possibly creating the sharp topographic boundaries [7]. In short, the layers were either deposited over the entire region and then locally eroded or buried, or layers were never deposited in the altitude range between -2000 m and -2500 m.

The three types of layers in Arabia Terra may be distinguished by composition. Type One, distinguished by albedo contrasts, may represent episodic deposition such as a terrestrial near-shore environment as sea level rises and falls, depositing alternating mudstones and limestones (Fig. 1). Another possibility involves the sediment supply. Regular volcanic events may provide large amounts of ash that interrupt the usual deposition of sand and dust, creating contrasting layered deposits. Type Two layers, which often forms distinctive 'stair-step' mesas, could represent an environment that is not constant, with unconformities between layers causing the 'stair-step' erosional pattern to emerge (Fig. 2). It is also possible that stair-step morphology only appears to be layering, and instead represents wave-cut terraces, which would also indicate past bodies of water. The third type, thin rubbly layers, could form when lava flows across a sandy region (Fig. 3). The crystalline nature of the lava would make it more resistant to erosion than the particulate material surrounding it, allowing large coherent pieces to fall off and roll downslope.

Future Work: Further analysis of the distribution of layer types will provide additional clues to the early geologic history of Arabia Terra. This work also contributes to an ongoing search for geologic evidence of the source of enhanced methane concentrations detected in the atmosphere of Mars [8].

Acknowledgements: We thank the Lunar and Planetary Institute for funding this research, as well as Robert Gaines, Eric Grosfils, Brian Fessler, Pat McGovern, and Charles Meyer.

References: [1] Edgett K.S. and Malin M.C. (2002) *Geophysical Research Letters, v.29 no. 24, 2179*, 32-1. [2] Edgett K.S. and Malin M.C. (2003) *Science, v. 302, 5652*, 1931-1934. [3] Edgett K.S. (2005) *Mars, v. 1*, 5-58. [4] NASA/JPL/Malin Space Science Systems. [5] Greeley R. and Guest J.E. (1987) *USGS Map I-1602-B.* [6] Scott D.H. and Tanaka K.L. (1986) *USGS Map I-1802-A.* [7] Hynek B.M and Phillips R.J. (2001) *Geology, v. 29, no. 5,* 407-410. [8] Allen C. C. et al. (2006) LPS XXXVII, Abs.