**RECONSTRUCTING THE ORIGINAL VOLUME AND EXTENT OF THE SEDIMENTARY DEPOSITS OF MERIDIANI PLANUM AND ARABIA TERRA.** K. J. Zabrusky[1] and J. C. Andews-Hanna[2], [1]Department of Geology, Colorado School of Mines, Golden, CO, e-mail: kzabrusky@mymail.mines.edu, [2]Department of Geophysics and Center for Space Resources, Colorado School of Mines, Golden, CO, e-mail: jcahanna@mines.edu.

**Introduction:** The Meridiani deposits on Mars have been of particular interest due to their unique mineralogy and the evidence they present for liquid water. While the current deposits are extensive, with an area of ~$3\times10^5$ km$^2$ [1,2], they appear to be the eroded remains of an even larger deposit [2,3]. In this study, we examine the evidence for remnants of a once larger sedimentary deposit covering much of Arabia Terra. We then reconstruct the area and volume of the pre-erosional deposit and discuss how this volume was reduced to the current size by erosion of the deposits and the ultimate fate of the eroded material.

**Extent of Meridiani Deposits:** Beyond Meridiani Planum, a number of sedimentary deposits are preserved as intra-crater deposits, pedestal craters, and mantling units throughout Arabia Terra [3,4]. Despite widespread dust cover, hydrated mineral and hydrated sulfate signatures have been detected in several intra-crater deposits, suggesting a similar composition to Meridiani Planum [3,5]. The intra-crater deposits within Becquerel and other craters have a characteristic periodic layering seen in HIRISE images, resulting from climatic control of the deposition [6]. A similar periodicity has been noted in the Meridiani deposits, as well as other deposits throughout Arabia Terra [3], suggesting that they shared a similar depositional process and are therefore related (Figure 1).

The existing deposits have constant dip angles over 100's of km, following the regional dip of Arabia Terra [7]. These uniform dip angles are consistent with the hypothesized origin of the Meridiani deposits as a groundwater-fed playa. Hydrological models predict a smoothly varying water table, producing sub-planar deposit surfaces with consistent dip directions and angles both within Meridiani and throughout Arabia Terra [6]. The diffusive and sub-planar nature of the cementation mechanism justifies the fitting of a single surface to the data points as a first-order approximation of the pre-erosional deposit. In several locations, multiple pedestal craters with similar elevations confirm the interpretation of a once more extensive deposit surface. These factors were considered when selecting data points to represent the topography of the original deposit surface, which were then interpolated to reconstruct the pre-erosional deposit.

**Modeling:** The fitted surfaces were calculated by first building a set of data points representative of the pre-erosional surface. Since it is unlikely that remnant deposits at these points escaped erosion while the surrounding areas were stripped away, these points represent lower bounds on the pre-erosional topography and thickness of the deposit. The first points selected were on Meridiani Planum itself; since these sediments are still intact, there will be zero deposit predicted here. Points were then chosen at the edge of the known deposit, where a distinct break with adjoining units occurs. An inverted crater (topographically higher than the surrounding plains but made of the same sediments) was also chosen as it too preserves an older deposit surface. From Meridiani, data points were chosen successively further away on features interpreted to be remnants of the sedimentary deposit. Most of the points lie on intra-crater deposits or pedestal crater benches. Intracrater deposits were distinguished from central peaks by their smooth, mound-like morphology, the fact that they may rise above the rim, and by HIRISE images of layering where available. Pedestal craters were identified as those that stood above the surrounding topography and were surrounded by a flat-topped bench composed of sediments preserved by the ejecta blanket. For pedestals further from the known Meridiani deposits, HIRISE images were also used, where available, to see if the preserved sediments shared the characteristic fine-scaled layering.

These points were then interpolated to a continuous surface in ArcGIS using both Kriging and a least squares, best-fit plane. Working with each surface model separately, the MOLA topography data were subtracted on a pixel basis, giving the height of the deposit per pixel. Areas in which the predicted pre-

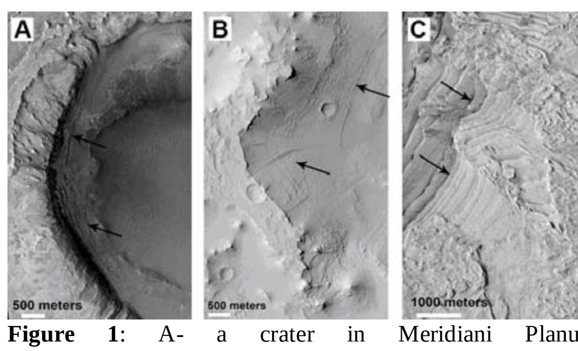


**Figure 1**: A- a crater in Meridiani Planum (ESP_011910_1825); B- the inner wall of a pedestal crater at 17.4N, 19.5E (PSP_009351_1975); C- the intra-crater deposit within Becquerel crater (PSP_001546_2015). Note the similar rhythmic layering (resistant beds indicated by arrows). See http://hirise.lpl.arizona.edu/ for full images. Images: NASA/JPL/University of Arizona

erosional deposit surface was below the present-day ancient cratered surface of Arabia Terra represent regions originally lacking deposits, possibly resulting from a paleo-water table that remained at depth below the surface. No correction was made for craters that are younger than the deposits, resulting in an over-estimation of deposit thickness in places. However, careful selection of the data points ensures that the surfaces are a good first approximation of the eroded deposits. The interpolated deposit surface was limited to the smallest rectilinear region in latitude-longitude space containing data points. This conservative approach may underestimate the true extent of the deposits, which may extend beyond the limits of the observed exposures.

**Discussion:** Both models give a good first order approximation of the volume of Meridiani-like deposits removed from Arabia Terra. The Kriging model produced a volume of $2.21\times10^6$ km$^3$, while the best-fit plane gave a volume of $2.25\times10^6$ km$^3$. The largest volumes were held in the basins of eastern Arabia Terra (Figure 2), but each model produced a unique deposit distribution as they interacted with the topography differently. The presence of thick deposits in these depressions is confirmed by km-high pedestal craters with periodic fine-scale layering exposed in the pedestal margins. There was also a significant deposit predicted in Iani Chaos, though this depression may be a result of erosion and collapse during chaos formation in the Hesperian. The best-fit plane model gives a dip angle of 0.04°, oriented N43°W. The curved Krige surface cannot be characterized by a single dip angle, but dips approximately 0.08° at a direction of N56°W in the vicinity of Meridiani Planum. These dip directions agree well with the measured value of 15-60° west of north, though the magnitude of the dip is at the low end of the observed range of 0.05-1.0° [7]. The calculated dip direction and magnitude agree well with those predicted from hydrological modeling of N46°W and 0.035° at Meridiani [3].

Another consideration for these deposits is how long this estimated volume would take to erode. The average height of eroded material from the best-fit plane model, for example, is 309 m, with a maximum of 2984 m. Using the Hesperian-Amazonian erosion rate estimates for Meridiani Planum of 0.1 to 10 nm/yr [8], 309 m would take >30 Ga to erode. This indicates that either the post-depositional erosion rate was much higher than in the present epoch, or the models are over-estimating the thickness. While the deposit thickness away from the measured remnants is highly uncertain, erosion of a km or more is required adjacent to the large pedestal craters, thereby ruling out the latter possibility. A lower bound on the erosion rate can be determined by assuming that the 1 km of material adjacent to the pedestal craters was eroded subsequent to the ~3.7 Ga age of the deposits, leading to a rate of ~2.6 μm/yr. This rate is comparable to erosion rates earlier in the Noachian [8]. Interestingly, large-scale erosion could only occur after hydrological activity had ceased its role in the deposition process. Thus, these high erosion rates reveal a period of transition on early Mars, after the cessation of the active hydrological cycle required to produce the Meridiani-type deposits but before the cold and hyper-arid Mars of today. During this time, Mars was able to sustain high erosion rates despite its apparent aridity, likely requiring a much thicker atmosphere than today.

The fate of these deposits must also be considered; $2.2\times10^6$ km$^3$ gives a global equivalent layer of 15 m if distributed uniformly over the surface. The sediments were possibly concentrated into new deposits, or may have contributed to the fill in the northern lowlands and Utopia impact basin. While some fraction of the eroded material may have been reworked into the top several meters of martian soil [9], it does not appear possible to dispose of the entire eroded volume in this manner. Possible repositories for these large volumes of eroded sediments are the subject of ongoing study.

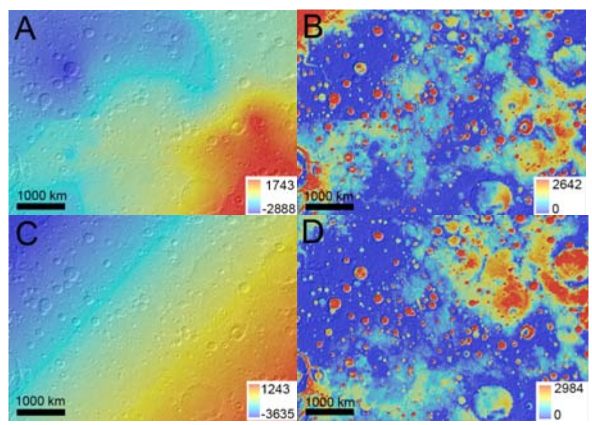


**Figure 2**: A- Krige surface; B- thickness derived from subtracting MOLA topography from Krige surface (positive values only); C– planar surface; D– deposit thickness derived from subtracting MOLA topography from the best-fit plane. All surfaces on MOLA hillshade. All values in meters.

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