Assessing the geomorphic development of putative shorelines contiguous to Northern Arabia Terra, Mars.
Valerie E. Webb[1] and George E. McGill[1], [1]Department of Geosciences, University of Massachusetts Amherst, 01003. vwebb@geo.umass.edu.

Introduction: If Mars' Late Hesperian outflow channels were eroded by catastrophic flooding (1,2), it is likely that the water ponded in the northern lowlands (3,4). The surface of the ponded water would correspond to an equipotential surface. To test this hypothesis, Head *et al.* (5) executed a global-scaled topographic study of putative shorelines mapped by Parker *et al*. (6,7) evaluating elevation constancy. More recent results have conflicted with both the Head *et al.* and the Parker *et al.* studies (8,9,10,11). Clearly, the existence of an ancient northern hemispheric ocean exhibiting identifiable shorelines is still a controversial hypothesis and requires further investigation. Detailed, small-scale analysis is needed to supplement and compare to the published global-scale studies. Here, we evaluate a ~400,000 square kilometer study area within and contiguous to northern Arabia Terra (Fig. 1) in order to shed new light on this controversy. We conclude that, within this area, both the Deuteronilus and the Arabia shorelines mapped by Parker *et al.* could be zones of coastal erosion, while the Acidalia shoreline does not adequately depict an equipotential surface nor a coastal geomorphic landscape.

Methods: For this study, Tim Parker has graciously provided us unpublished high resolution (~231 m/pixel) Mars Digital Image Mosaics (MDIMs) with mapped putative shorelines. Using both the primary and extended mission datasets from the Mars Orbiter Laser Altimeter (MOLA), we interpolate an elevation grid at the same resolution as the MDIM's. Creating a shapefile of the coordinates of MOC images available in this area, we then georeference all of these datasets into the same coordinate system and projection using ESRI's ArcMap 8.1 software. The resulting digital elevation model (DEM) allows us to topographically and geodetically evaluate the shorelines at a much higher resolution than previously explored. Furthermore, systematically referencing the Viking data with the Mars Global Surveyor (MGS) data allows us to precisely determine where individual MOLA tracks cross the proposed shoreline trends. Thus, the vertical resolution of the plotted profiles is close to that of the raw satellite data and not merely dependent on the gridding process.

Employing a georeferenced high resolution dataset also allows us to geographically shift the plotted location of individual putative shorelines, testing different location models. A minor shift often results in a significantly altered profile for the tested shoreline. As Parker originally mapped putative shorelines using Viking imagery unaided by MOLA data, we feel these slight shifts are justified. Thus, while still using Parker's mapped shorelines as a model, we are able to adapt his locations and present a near equipotential surface as a new coastal geomorphic model. In order to substantiate these shifts, only the models where MOC and Viking imagery support the newly modified shorelines are applied to insure that the adapted locations are valid within their surrounding geology.

Discussion: Previous studies testing the validity of the shoreline hypothesis have relied on image analysis with too low resolution to provide extensive, meaningful results. With higher resolution imagery and smaller pixel widths, discrepancies in elevation constancy are more accurately quantified. Here, we test post-formation modification models to validate the likelihood of possible local tectonic and isostatic disturbances of regional topography. Our resulting model accounts for the relatively small deviation from topographic constancy along the Deuteronilus and Arabia shorelines as a result of these modification processes. However, our model does not provide sufficient support for the large discrepancies in vertical displacement along the Acidalia profile.

Additional support for the proposed Arabia and Deuteronilus shorelines is provided by their spatial correlations with mapped geologic contacts (12,13). Upon preliminary analysis, McGill (12) discovered that in several cases, putative shorelines within Cydonia Mensae coincide with geologic contacts mapped at a scale of 1:500,000. Further analysis of the Arabia and Deuteronilus contacts within our entire Northern Arabia Terra study area yields that they are clearly younger than the materials they cut. Also, the Deuteronilus shoreline coincides with the Vastitas Borealis Formation (VBF) contact for more than 700 km, a unit purportedly deposited into the northern lowlands via the Late Hesperian outflow channels (9,11). In contrast, the Acidalia shoreline is not significantly correlated with any evident contacts, and the geologic inconsistencies in its location lead to refuting a shoreline interpretation for this trend.

An implication of two distinct shoreline levels within this study area is that two separate highstands are indicated in the geologic record. The mean difference in elevation between the Deuteronilus and Arabia trends is ~500m, a plausible amount of change in sea level decay over time. Another alternative hypothesis is that each stand represents a different episode of flooding (4). We further evaluate both hypotheses and tentatively determine that Deuteronilus appears geologically younger (Middle Amazonian) than the Arabia contact (Late Hesperian to Early Amazonian). It is beyond the scope of this work to distinguish whether the two highstands are representative of a single regressive body of water, or whether

more than one flooding event has occurred.

Conclusions: It is likely that standing water existed within the northern lowlands, even if for only a relatively short time span. Shoreline recognition within high-resolution imagery provides support for its existence. We feel that the identification of putative Arabia and Deuteronilus shorelines within Northern Arabia Terra suggests that the existence of a global-scaled northern ocean cannot be ruled out as a valid resurfacing mechanism for the northern lowlands.

References: 1. M.H. Carr (1979) JGR, 84, 2,995-3,007. 2. V.R. Baker (1982) Univ. of Texas Press, Austin. 3. V.R. Baker, *et al.* (1992) In *Mars*, Univ. of Ariz. Press, 493-522. 4. S.M. Clifford and T.J. Parker (2001) Icarus, 154, 40-79. 5. J.W. Head, *et al.*, (1999) Science, 286, 2,134-2,137. 6. T.J. Parker, *et al.*, (1989) Icarus, 82, 111-145. 7. T.J. Parker, *et al.,* (1993) JGR, 98, 11,061-11,078. 8. M.C. Malin and K.S. Edgett (1999) GRL, 26, 3,049-3,052. 9. K.L. Tanaka, *et al.*, (2002) Planet. Map. Meeting, ASU Abst., CD-ROM PGMM_1724. 10. P. Withers and G.A. Neumann (2001) Nature, 410, 651. 11. M.H. Carr and J.W. Head, (2002) Eos. Trans. AGU, 83, 47. 12. G.E. McGill, (2002) Planet. Map. Meeting, ASU Abst., CD-ROM PGMM_2002. 13. D.H. Scott and K.L. Tanaka (1986), USGS Misc. Inv. Ser. Map 1802-A.

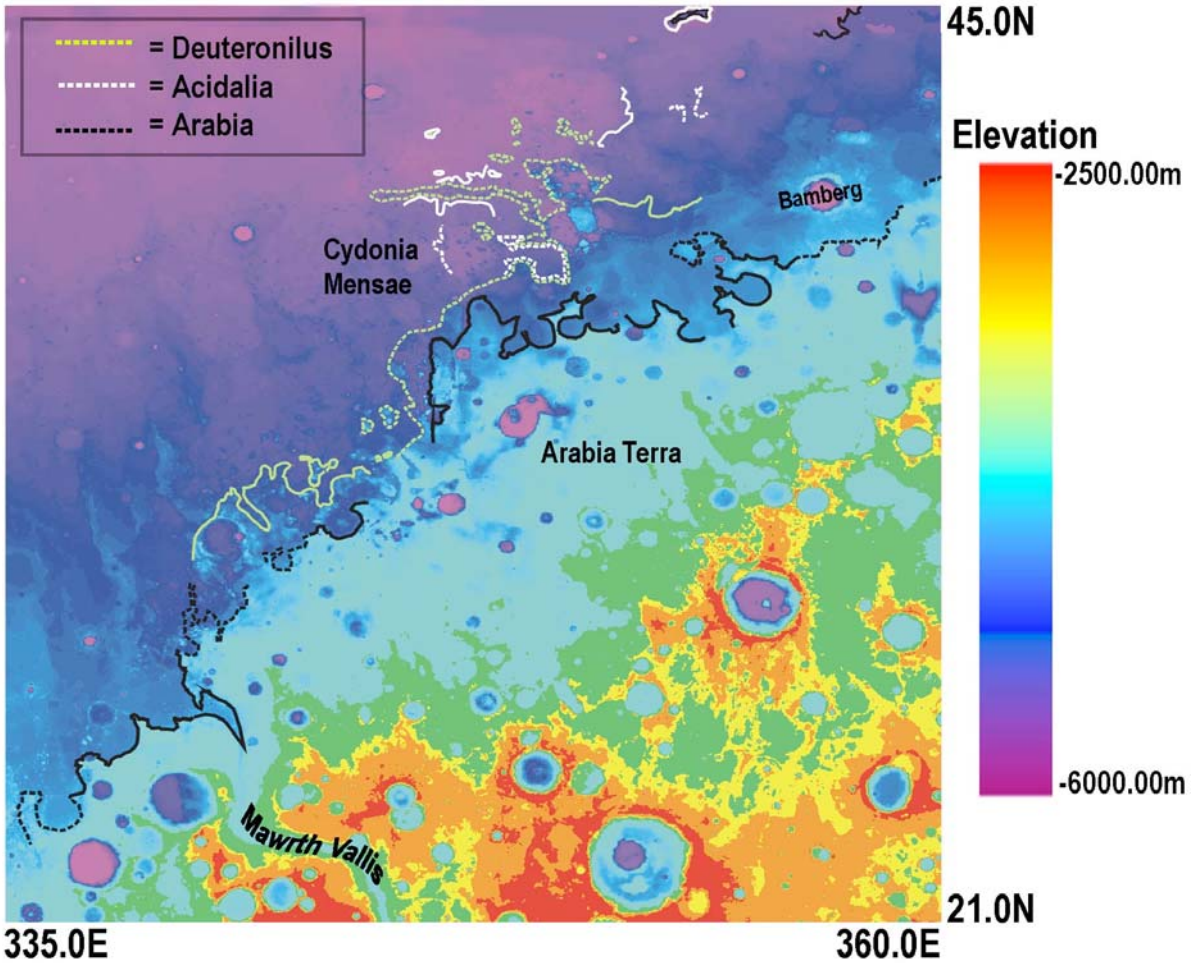

Figure 1: Location of Parker's putative shorelines plotted on 1/128deg per pixel gridded topography. Shorelines are dotted where inferred by Parker. Topography provided by NASA's MOLA Experiment Gridded Data Record (EGDR).