DIGITAL GLOBAL MAP OF POTENTIAL OCEAN PALEOSHORELINES ON MARS. T. J. Parker and F. J. Calef, Jet Proplusion Laboratory, California Institute of Technology, (timothy.j.parker@jpl.nasa.gov).

Introduction: Significant improvements over Viking data have been realized from the orbiter missions since the late 1990s, and the acquisition of new data continues. The image datasets provide high-resolution views that, when mosaicked and georeferenced to the MOLA gridded topography, enable the compilation of accurate maps of proposed ocean shorelines.

The primary objective of this study is to provide an accurate map of these features, in the form of GIS shapefiles. This map can then be used to investigate deviations of the proposed paleoshorelines from horizontality that might indicate neotectonic changes such as mass accumulations and crustal deformations at Tharsis and other large volcanic constructs over geologic time. Detrending the surfaces defined by the proposed shorelines should enable estimations of fluid volumes that may have been contained within them, and allow verification of whether the features are parallel to one another in elevation.

"Levels" in the West Deuteronilus Mensae/East Acidalia Region

Parker et al. [1] identified 7 Levels (proposed "shorlines") in the Mamers Valles region. Based on the appearance of these features at Viking image scales, and their inferred topographic and age relationships, they were interpreted to be most comparable to wave-eroded shorelines in terrestrial paleolakes (lacking terrestrial-scale oceanic tides). With the availability of MOLA global and HRSC regional topography, the levels have been found to approximate level surfaces, or planar surfaces that appear to have been gently tilted (in general, toward Tharsis).

But the higher-resolution image data, beginning with MOC, shows boundary morphology that does not appear to support a shoreline interpretation involving wave erosion and longshore sediment transport, an argument first made by Malin and Edgett [2]. At very large images scales in west Deuteronilus Mensae, many of the better preserved of these features exhibit lobate flow-front morphology suggestive of very low-viscosity lava or debris flows advancing up the sloping highland margin from the northern plains, though the measurable thickness of this material is often negligible at the scale of the MOLA topography data in this region. This morphology suggests the material encroaching onto the sloping margin is still present, but most of the fluid that brought it to these elevations is not. The Arabia Level and many of the levels identified south of Elysium Planitia (below) do exhibit morphologies that are reminiscent of terrestrial paleolake strandlines or shore platform development, however, though unusual accumulations of relatively thick crust-like material is also be present in some places.

All of the levels described and any material deposits associated with them remain elevated with respect to the northern plains interior, even just a few kilometers from the contact defining a particular level, and thus still appear to require withdrawal of vast amounts of some fluid from the northern basin after their emplacement.

South Elysium Levels

Clifford and Parker [3] attempted to correlate the Arabia level with additional boundary features identified along the sloping highland margin south of Elysium Planitia ([3], Fig. 6 and Table III). The Arabia and Deuteronilus levels are both readily identifiable along southern Isidis, but the Arabia Level was difficult to trace east of Isidis in Viking data. This resulted in a misidentification of the Arabial Level along the dichotomy boundary between Isidis and Arcadia Planitiae (it should have been traced north of the Elysium volcanic rise). Preliminary results in preparing this submission show that the Arabia Level is lower in elevation than all the levels mapped in the south Elysium region by Clifford and Parker [3]. The level previously identified as the Arabia Level at the base of Apollinaris Patera ([3] Fig. 6) is approximately 2 kilometers higher in elevation than the Arabia Level measured at Mamers Valles. In our current mapping, we've renamed this the Ma'adim Level, corresponding to the elevation of the upper surface of the Ma'adim Vallis "delta" remnant mesas in southern Gusev Crater (-1550m).

Preliminary Conclusions/Testable Hypotheses:

Based on the highest-resolution image data available during the 1980s and 1990s, [1,4] hypothesized that the best explanation for the geomorphic features and contacts seen along the highland margin was erosion and deposition of material onto pre-existing terrain at a series of shorelines around the planet's northern lowland plains. These shorelines were inferred to indicate paleoclimate conditions that allowed liquid water to remain stable at the surface long enough for wind-driven waves to produce the features through wave refraction and longshore sediment transport. While the Arabia Level in the west Deuteronilus region does exhibit terracing in HiRISE images that is reminiscent of strandlines in terrestrial paleolakes, most of the other mapped levels in this region do not. Instead, boundary morphology at the prominent, Deuteronilus Level exhibits lobate flow fronts and textures that resemble low-viscosity lava or debris flows. Still, the MOLA-based topography does verify the earlier impression that the contacts are elevated by hundreds of meters to kilometers with respect to the northern plains interior, implying that millions of cubic kilometers of material receded after the levels were emplaced along the plains margins.

Parker et al. [1] inferred marine conditions in a cooling climate based on the following observations: Starting at the Arabia Level and working plainward, plains textures transition from "smooth plains" between the Arabia and Ismenius Levels; to small-scale polygonally-patterned ground between the Ismenius and Deuteronilus Levels; to Thumbprint terrain (with bright conical hills interpreted as pingos) between the Deuteronilus and Acidalia Levels; to Mottled plains below the Acidalia Level. The reasoning was that: Smooth plains could indicate cold climate conditions hadn't ensued until the shoreline had receded and plains had been desiccated; small-scale polygons were ice-wedge polygons formed by thermal cycling in a cold climate with water or ice present in the near surface; "one-off" pingos formed in a permanently cold climate after shoreline recession as near-surface groundwater froze. This scenario may have been plausible based on the limited resolution data from Viking, but other morphologies described herein need also be considered in formulating a testable hypothesis based on the newer, very-high resolution image data. These newly-identified landforms and textures might also be consistent with a cooling marine environment, but may suggest that the initial conditions were never more clement than terrestrial arctic environments.

In other words, if Mars had oceans, the observed morphologies may suggest that they were covered with thick ice covers, and the flow front morphology seen along the Deuteronilus Level may indicate ice-shoving due to a short-lived transgressive event caused by channel activity elsewhere into the northern plains. For the morphology to be preserved at the surface at these latitudes today, the ice cover would either need to be dirty or itself be mantled with other material, such as eolian debris, impact ejecta, or lava flow.

Indeed, four of the newly-identified landforms at the Deuteronilus and Ismenius Levels might be best understood as related to brief disruptions of a thick debris and ice covered ocean; the fluvial rills above the Ismenius Level, and the lobate mounds, dark streaks, and platy flow-textured plains between the two levels.

For the sake of argument, lets assume that an ice and debris-covered ocean is present at about the elevation of the Ismenius Level, but that it's gradually receding due to loss via sublimation and redistribution elsewhere on Mars. The ice cover is frozen to the substrate at the edges, but floating as the topography drops off toward the northern plains interior. The fluvial rills could have formed due to a catastrophic disruption of this ice cover – perhaps due to an impact or landslide into the ocean. The dark streaks might also have formed at this time, their orientations with respect to the small knobs and "kinks" in the streaks themselves indicating the direction of motion of the ice cover over underlying topography. In this scenario, the dark streaks represent gores in the ice cover as the ice was pushed past the immovable knobs. Subsequent refreezing and sublimation of the water from the debris/ice cover at the Ismenius Level has permanently preserved the gores as pseudomorphs of the earlier environmental setting. When the ocean had receded to about the Deuteronilus Level, floods into the northern plains triggered a minor transgression to produce the lobate flow fronts and mounds at the Deuteronilus Level. The mounds resemble mud volcanoes on Earth, and may have formed as water and sediment under pressure broke through the debris/ice cover that had once again frozen to the substrate at the margins. Following cessation of the floods, the disrupted cover refroze, this time producing pingos (and thumbprint terrain) as the debris/ice cover froze.

References: [1] Parker T.J. et al. (1989) Icarus, 82, 111-145. [2] Malin M.C. and Edgett K.S. (1999) GRL, 26, 3049-3052. [3] Clifford S.M. and Parker T.J. (2001) Icarus, 154, 40-79. [4] Parker T.J. et al. (1993) JGR, 98, 11061-11078.