ALTERNATIVE INTERPRETATION FOR THE EBERSWALDE DELTA, HOLDEN NE CRATER, MARS. C. M. Fedo[1], D. B. Finkelstein[1], and J. E. Moersch[1], [1]Dept. of Earth & Planetary Sciences, University of Tennessee, Knoxville, TN 37996. cfedo@utk.edu, dfinkels@utk.edu, jmoersch@utk.edu

Introduction: Perhaps the most well known example of a deltaic system filling a crater on Mars is the Eberswalde Delta, Holden NE crater. Since its original identification [1], a number of studies [2-4] have detailed the geometry of the fluvio-deltaic distribution system and concluded it is consistent with a long-lived, Noachian-aged crater lake requiring persistent liquid water on the Martian surface. Our examination of black and white images and anaglyphs taken with the High Resolution Imaging Science Experiment (HiRISE) [5] camera reveals that critical components of a delta are not present and that alternative non-deltaic explanations also must be considered as viable.

Delta Components: Based on image interpretation, the main geomorphic feature thought to represent a delta has been divided into six lobes and compared with modern Gulf Coast bird's foot deltas [4]. Using these relationships, it is concluded that meander-bend migration and scroll-bar topography indicate persistent discharge of water across the delta surface [4], much like the original conclusion [1]. Furthermore, stream-channels have been ordered to determine hierarchy and recognized as being straight or meandering, and even evolving from straight to meandering in a downstream direction [2].

Topographic Considerations: One of the more puzzling features is the obvious inverted topography where apparent stream features sit at high topographic levels. Physical weathering since the time of deposition has selectively, and surprisingly, removed material non essential to defining the channels despite billions of years of erosion, coincidentally resulting in a modern landscape with a relief of 10s to 100s of meters that nearly perfectly mimics the Noachian environment.

Examination of the anaglyph image (Fig. 1) showing the distinctive large-scale meander loop reveals that the point bar representing the last loop migration is topographically higher from the previous one, and likewise for each point bar on the loop, requiring uphill lateral migration and water flow in a gravity-based process. The present appearance (Fig. 1) only superficially resembles scroll-bar topography in modern meandering rivers, which is essentially flat. What is much more likely is that the feature represents flat layers that have been excavated by erosion leaving a bowl-shaped depression. A roughly North-South oriented schematic cross section through the feature shows our interpretation of this structure (Fig. 2).

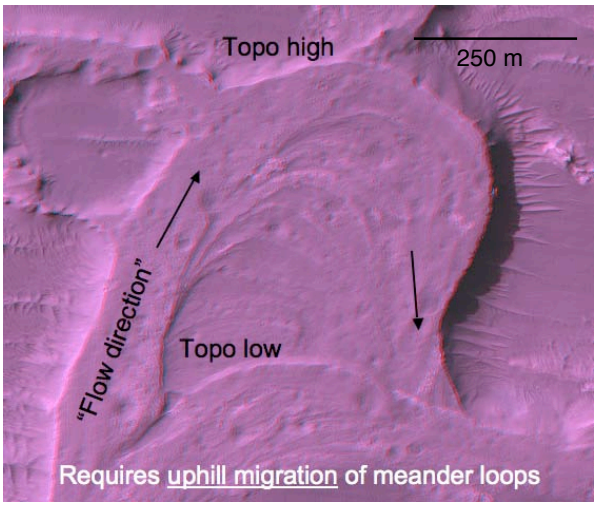

Figure 1. Color anaglyph showing the distinct feature interpreted as a large meander loop system. Note topographic relief showing that the last migration is higher than previous loops. Photo from HiRISE. http://hirise.lpl.arizona.edu/PSP_001534_1560

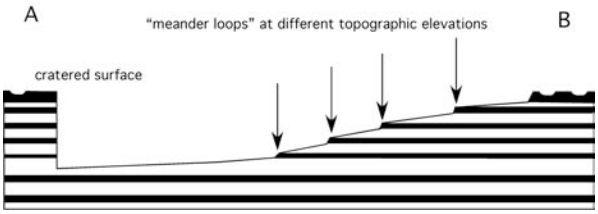

Figure 2. Interpretive sketch cross section oriented approximately N/S across the image in Figure 1 with S on the left and N on the right.

Sedimentological & stratigraphic considerations: Beyond the problems associated with recognizing that the layering represents an essentially flat-lying succession, we can evaluate the layers comprising the delta for their sedimentological characteristics. Delta deposits have a very distinct stratigraphic development related to the progradation of the delta plain over the delta front and pro-delta subenvironments. It is evident from images at the terminus of the "delta" that the layers are essentially flat (Figs. 3, 5), and so we reject the possibility of a Gilbert-type delta with steep basinward dipping foresets.

Detailed imagery of one inferred distributary channel (Fig. 3) shows that there is no channel morphology or cross-sectional geometry associated with a channel. Rather a flat-lying mesa cap is prominent all the way

around this feature and the top is all covered with loose material sculpted into dunes. Nothing at this scale looks like the sedimentology resulting from channel deposition. On Earth, prior to the advent of land-plant stabilization of terrestrial surfaces in the Paleozoic, fluvial systems were dominated by low sinuousity braided streams and braid deltas [e.g., 6], rather than meandering rivers. We also do not see any evidence for discrete shoreline features as might be expected.

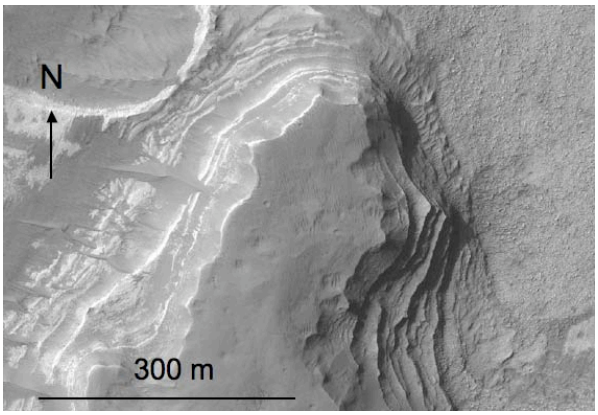

Figure 3. Close-up of a "distributary channel" terminus. Note lack of channel definition on top and side views. Modified from HiRISE image PSP_001534_1560_RED.jp2

The stratigraphic succession is also clearly visible in this image and so can be assessed to interpret depositional environment. Common deltas, like the Eberswalde deposit is inferred to represent [2, 4], have a distinct stratigraphic response to sediment progradation into a standing body of water [7]. Important characteristics of deltas include: a distinct coarsening up from pro-delta muds, to delta-front sands, to delta plain with ribbon-shaped coarse sands resulting from distributary channel deposition. No clear stratigraphic packaging representing these sub-environments can be seen in the cliff walls. A coarse-grained Gilbert-type delta, which is characterized by steeply dipping foreset beds, can be rejected based on the flat stratal orientation, a feature noted by [3]. Recognizing this, [3] proposed the idea of an aggrading delta, although there is no systematics in the stratal packaging that would strongly favor such an interpretation.

A comparison of images from Canyonlands National Park (Fig. 4) and the Holden NE crater (Fig. 5) shown at about the same scale show how erosion-generated topography through flat layers produces a surface morphology resembling a modern channel delivery system, but actually has nothing to do with paleoenvironment of the strata.

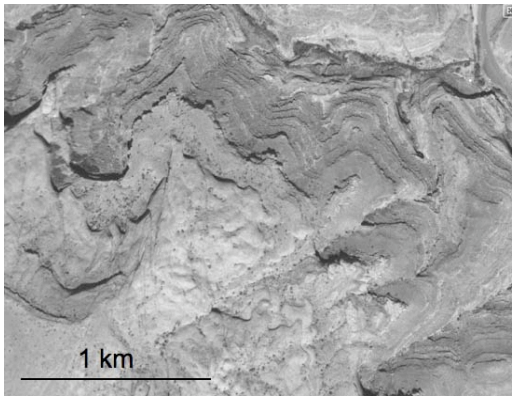

Figure 4. Erosion of horizontal layers from Canyonlands National Park, Utah. Note similarity with Figure 5. Image from Google Earth, location: 37° 57' 22" N, 110° 29' 45" W)

Similarly, strata in the Eberswalde basin possess high lateral continuity (Figs. 3, 5). Close inspection of the geometry of the intersection points shows that supposed channels apparently have confluences in opposite directions. Instead of an exhumed delta, all of the observable geomorphic features can result from accumulated eolian erosion of a deposit of flat-lying strata laid down in environment(s) that cannot be determined from imagery alone.

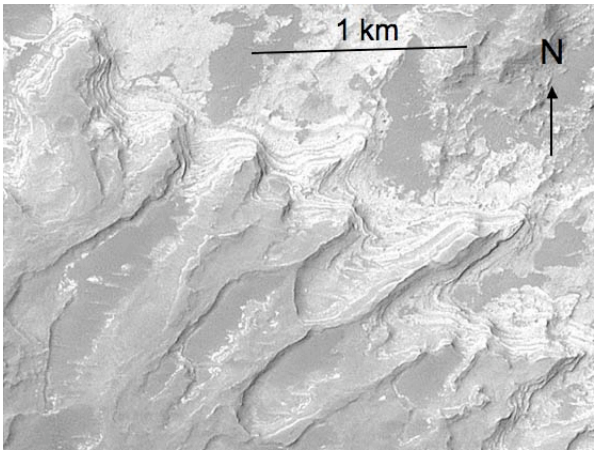

Figure 5. Close-up view of a row of "channels" from the Eberswalde Delta. Modified from HiRISE image PSP_001534_1560_RED.jp2

References: [1] Malin M. C. and Edgett K. S. (2003) *Science, 302,* 1931-1934. [2] Bhattacharya. et al. (2005) *GRL, 32,* L10201. [3] Lewis K. W. and Ahronson O. (2006) *JGR, 111*, E06001. [4] Wood L. J. (2006) *GSA Bull, 118,* 557-566. [5] http://hirise.lpl.arizona.edu/ [6] Fedo C. M. and Cooper J. D. (1990) *J Sed Pet, 60*, 220-234. [7] Reineck and Singh (1980) *Springer-Verlag*, 551p.