REINTERPRETATION OF THE MARTIAN EBERSWALDE DELTA IN THE LIGHT OF NEW HIRISE IMAGES.

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Introduction: The MER rovers have allowed us unparalleled insights into past Martian surface processes and documented past aqueous surface environments [1]. Yet, that water was flowing across the surface was most vividly demonstrated in earlier MOC images. The Eberswalde Delta (Fig. 1), the "smoking gun" of Malin and Edgett [2], is *prima facie* evidence that water not only existed at the surface of Mars, but also that fluvial activity shaped the Martian surface for extended time periods [2, 3]. This fan-shaped deposit, consisting of overlapping distributary lobes that were fed by meandering channels, has attracted the curiosity of researchers with varied backgrounds. Estimates of the time span that this sediment body may represent have ranged from decades to millennia [4, 5]. A new HIRISE image (PSP_001336_1560) allows a reassessment of (1) the grain size of the material transported through the channels; (2) suggests a highly episodic and energetic nature of discharge; and (3) has implications for the erosional expression of the delta.

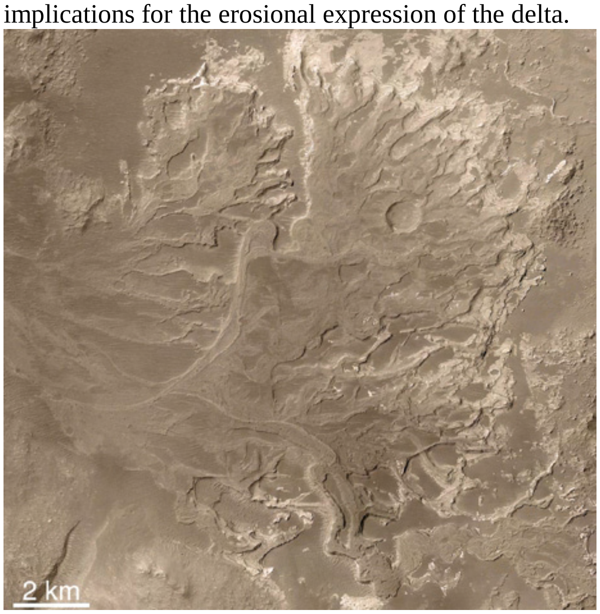

Fig. 1: MOC image of Eberswalde fossil delta (image NASA/JPL/MSSS).

Observations: One of the variables that previously had to remain unconstrained, yet significantly affects estimates of discharge and time of formation estimates, is the grain size of the deposited sediment. In a new HIRSE image (PSP_001336_1560) there is clear indication that intermittently meter size boulders were transported through the channels of the Eberswalde delta (Fig. 2).

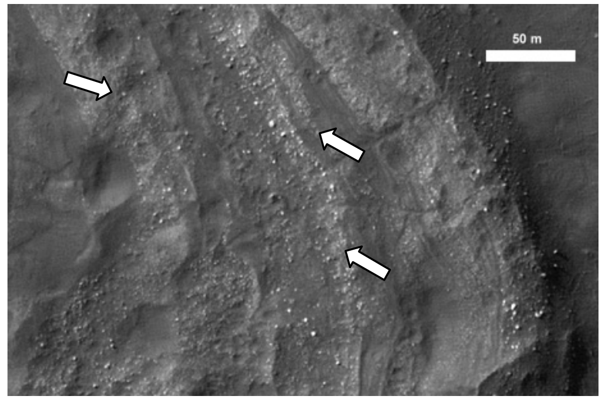

Fig. 2: Close-up of boulder beds in a point bar deposit at Eberswalde (arrows). The lighter, grainy looking layers probably are boulder deposits. (NASA/JPL/UA)

While some of the larger features sitting on the exposure surface are quite possibly fragments of finer grained rocks, the stratiform nature and scoured base of layers that consist of coarse appearing (~ meter size or larger) particles are probably bona fide boulder beds (Fig. 3). Having these interspersed with finer appearing material in the point bar deposits, suggests that the latter unresolved material is more likely of gravel (cm to dm size), than of sand size.

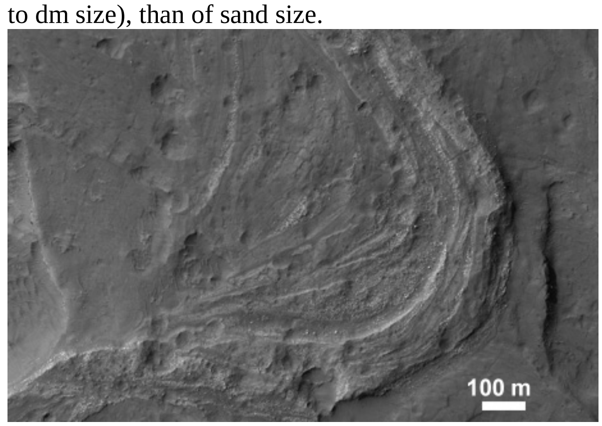

Fig. 3: Stratiform nature of lighter colored and grainy looking boulder beds in Eberswalde point bars. (NASA/JPL/UA)

The implication of this observation and its attendant reinterpretation of the grain sizes present in Eberswalde fluvial channels is that significantly higher current velocities are needed to move sediment through these channels than previously estimated [4, 5].

Fluvial transport of meter size and larger boulders on Earth would require flow velocities of 10m/sec or more [6]. Although reduced Martian gravity lowers the critical erosion velocity for a given grain size, the velocities are still quite large. Simple evaluation of the Froude criterion for a bankfull channel depth of 5-10 meters indicates that of even for the onset of upper flow regime conditions flow velocities of 4.3-6 m/s are required at Martian gravity. Since for meter size boulders we are substantially above the upper flow regime threshold, flow velocities as high as 10 m/s may have been required to deposit the materials observed in the coarsest gravel beds at Eberswalde. On Earth, flow velocities in that range are only observed associated with catastrophic rainfall events (e.g. associated with hurricanes [7]) and ice dam failure in glacial settings (e.g. the Spokane Flood [8]).

At the upper end of the envisioned flow velocity range (10 m/s) the estimated 24 km^3 [2] of the Eberwalde basin would be filled (128 m channel width, 5 m average depth) within 43 days, and at 5 m/s it would still only require 86 days. Of course, it is highly unlikely that flow velocities in that range can be sustained for more than a few days at any given time. Yet, given the most likely gravelly nature of the channel fill we may reasonably speculate that a small number of spasmodic events, rather than continued flow may have filled the basin in a short time span.

The implication that the channels fills and point bars are largely composed of gravel and boulder size material also has a bearing on the exhumation of the delta system in positive relief (Fig. 1). On Earth this would typically imply that better cemented channel sands resisted erosion, whereas overbank fines (clay and silt dominated), deposited between channels, were easily eroded. However, given the extreme energies indicated by the Eberswalde channel deposits, it is highly likely that the overbank deposits were actually of sand size and not necessarily rich in clays. If such a composite sediment body (channel gravels, overbank sands) is subjected to eolian erosion, only the sandy interchannel deposits are likely to be removed and transported, whereas the gravel filled channels will remain where they are because even in a much denser (Earth-like) atmosphere the winds would not be able to move them.

Another interesting feature that shows up in the HIRISE image are polygonal patterns on many of the layers within the Eberswalde Crater (Fig. 4). These are much too large (size 1-6 m) to be likely desiccation cracks of mudstones. Having said already that the channels probably injected sand-laden flows into the basin, it is more likely that the polygonal layers are sandstones. On Earth, sandtones can develop polygonal patterns at this scale as a consequence of thermal contraction on evaporite encrusted surfaces in a manner similar to ice wedges [9].

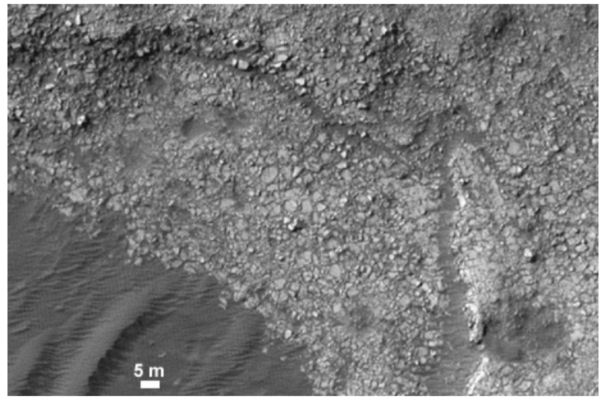

Fig. 4: Polygonal pattern in presumed sandstone layers. They measure in size from 1 to 6 m across, comparable polygonal cracks in sandstones on Earth. (NASA/JPL/UA)

Conclusion: HIRISE imaging provides critical new information about the origin of the Eberswalde delta. Rather than indicating sustained flow over long time periods, it seems to have originated via brief pulses of highly energetic discharge that was able to move meter size boulders. The sinuosity of the distributary channels, while traditionally taken as an indication of continued flow, may instead simply be an expression of excess energy, a contributing factor to meandering on Earth [10]. The polygonal patterned surfaces associated with the delta may indicate basinal sand deposition followed by evaporation of the basin fill prior to the next depositional episode. These new observations suggest an alternative scenario of formation for the Eberswalde delta that would allow for a much longer time period to be recorded by the deltaic deposits than previously presumed. While deltas on Mars may show superficial morphologic similarlity with terrestrial deltas, Martian deltas may preserve a much more punctuated sedimentary record. With regard to Eberswalde being a highly ranked potential landing site for Mars Science Lab, the likely lack of extensive mudstone deposits makes it a much less attractive target for finding preserved organic matter.

References: [1] Grotzinger J. et al. (2005) *EPSL, 240*, 11-72. [2] Malin M. and Edgett K. (2003) *Science*, *302*, 1931-1934. [3] Moore et al. (2003) *Geoph. Res. Let.*, *30*. [4] Jerolmack et al. (2004) *Geoph. Res. Let.*, *31* [5] Lewis K.W. and Aharonson O. (2006) *Geoph. Res. Let.*, *111*. [6] Sundborg A. (1956) *Geogr. Ann*, *38*, 125-316. [7] Smith M.E. et al. (2002) USGS, WRIR 01-4266. [8] Bretz J.H. (1925) *Journal of Geology*, *33*, 97-115. [9] Kocurek G. and Hunter R.E. (1986) *Journal of Sedimentary Petrology*, *56*, 895-904. [10] Loepold L.B. and Wolman M.G. (1960) *UGSA Bull.*, *71*, 769-794.