INVESTIGATING MARTIAN DELTAS FOR EVIDENCE OF PALEOSHORELINES. Vincent A. Soldano[1], Scott W. McCoy[1], Wendy M. Calvin[1] and Kenneth D. Adams[2], [1]Department of Geological Science and Engineering, University of Nevada – Reno, vsoldano@nevada.unr.edu. [2]Desert Research Institute.

Introduction: On Earth, waves powered by wind erode, transport, and deposit sediments to cut and build shorelines features like terraces and beaches (Fig. 1). In desiccating lakes, this wave action leaves behind a flight of paleoshorlines that mark elevations where lake level paused long enough to develop a shoreline feature (Fig. 2). A diagnostic feature of shorelines is that they themselves are flat-lying or horizontal like the water's edge they mark. There is evidence that Mars once retained water in craters, and it has been suggested that an ocean occupied the northern lowland terrain [8]. It is expected that wave erosion on Mars would be analogous to that on Earth [1]. In this study we investigate deltas for paleoshorlines that could provide evidence for the persistence of bodies of water on Mars.

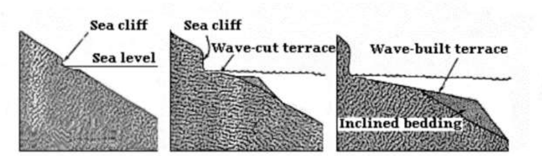

Figure 1: An illustration of how wave-cut benches form at water-level.

Deltas provide a unique opportunity to search for evidence of paleoshorelines on Mars [2-7]. Previous work has shown that most deltas on Mars lack incisions providing evidence of a hydrologic cycle that is different from Earth [2]. This suggests that most Martian deltas form via outburst floods during catastrophic events that fill a depression [typically a crater] with water [4]. Then, as paleolakes dry up, they may leave evidence of water-level changes as shorelines.

On Earth, paleoshorelines are evident in many places related to dropping water levels. Fig. 2 shows an example from Walker Lake, NV.

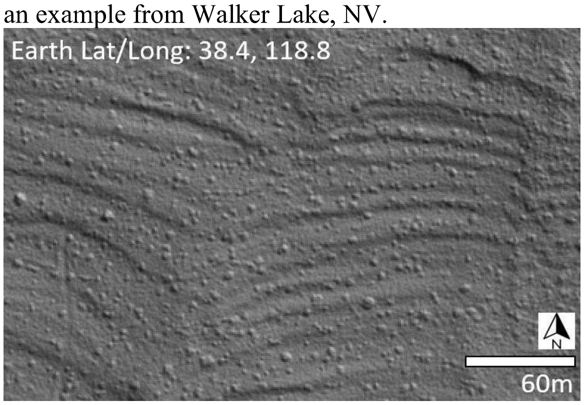

Figure 2: Paleoshorlines that mark former water-levels.

Methods: We utilized stereo image pairs from both Context Imager (CTX) and the High-Resolution Imaging Science Experiment (HiRISE). We contoured digital elevation models (DEMs) made from both cameras to explore whether features that appear as albedo changes on the imagery were in fact horizontal, suggesting potential shorelines. CTX DEMs that had promising horizontal features were then examined using HiRISE data at 30cm per pixel (Fig. 3). We employed the Mars Système d'Information (MarsSI) to create high-resolution digital elevation models [9]. The MarsSI web-based interface allowed us to find Martian deltas with HiRISE stereo coverage, create DEMs, and download them to conduct further analysis in ArcGISPro. Contours and shaded relief imagery were viewed and then exported to JMARS to explore context and distribution of the analyzed deltas [10].

As a test of the reliability of the DEM, we note that large depositional lobes of deltas with prominent topset-foreset transitions are horizontal, whether or not there are benches on or near the delta.

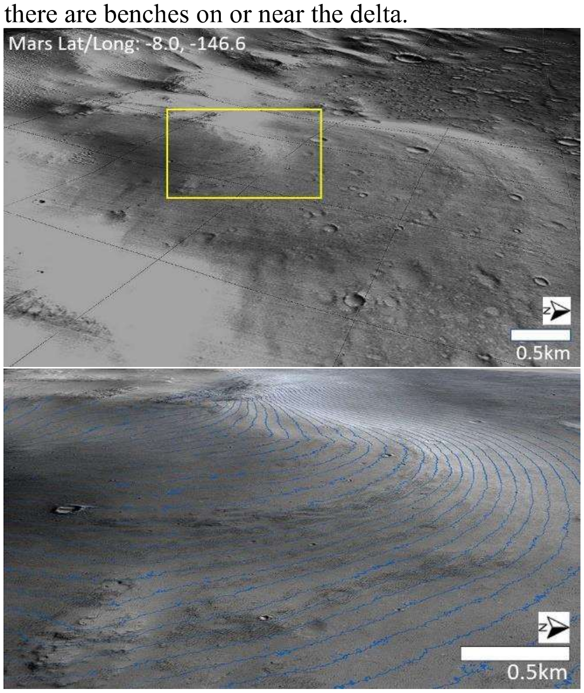

Figure 3: Perspective view and HiRISE DEM with contours that show horizontal features reminiscent of wave-cut benches. Yellow box highlights the location of contours on delta (contour interval 5m).

While some deltas have horizontal features, many do not (Fig. 4). In addition to horizontal topography, we also gathered data on fan azimuth, elevation, channel length, level of incision, and geologic age. These were considered to find any correlation between deltas that exhibit possible paleoshorelines, and those that do not.

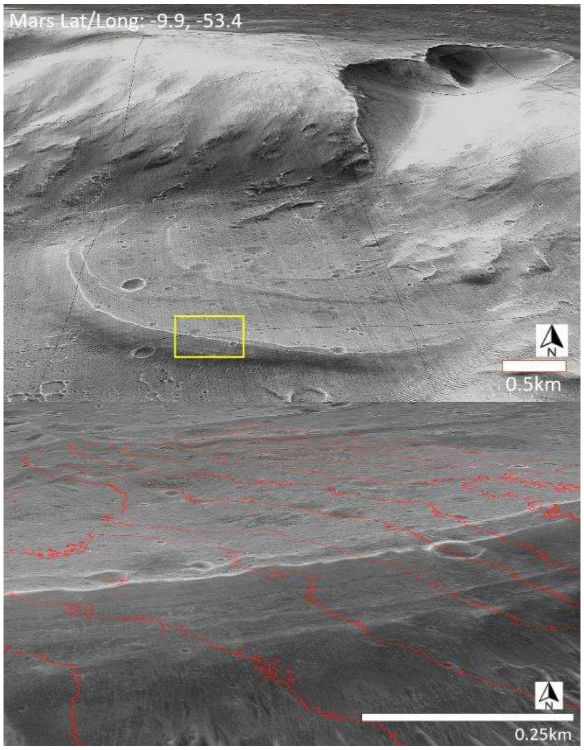

Figure 4: Perspective view and HiRISE DEM. In this example contour lines cross the slope breaks of the delta scarp so they are not horizontal. Yellow box highlights the location of contours on delta (contour interval 5m).

Results: To date we have been able to examine nine stereo pairs with usable DEMs. Three of the nine deltas showed evidence of horizontal benches (Fig. 3), whereas the rest exhibited topography that cut across contours and so are not horizontal (Fig 4). All the deltas examined are located between 30S and 30N, and fan azimuth was not correlated to the presence or absence of horizontal benches. Similarly horizontal benches occur at a range of elevations. Nearly all the deltas were unincised, and their corresponding channels varied widely in length. The geologic age units in which the deltas are found range from the Early Noachian to the Amazonian. However, the three deltas exhibiting horizontal bench features are in the Middle Noachian and the Amazonian-Hesperian. They are also located on the major topographic dichotomy that separates the southern highlands from the flatter northern plains (Fig 5).

Discussion: In our limited sample, one in three deltas show evidence of horizontal benches. The horizontal nature of the delta topset-foreset transition (or scarp) supports previous interpretations that these are, indeed, deltas. Among those locations that exhibit horizontal benches, one simple interpretation is that they were wave-cut. Prior work has shown that typical wind and wave height should be able to create such features on Mars [1]. However, preservation of such features may be uncommon because long-term wind erosion, mass wasting, and creep will contribute to the destruction of this morphology. Interestingly, the deltas that have retained potential evidence of past shorelines date to a time when Mars is considered to be the most hydrologically active, supporting the formation of these features through wave action. Their preservation in selected locations may provide clues to the duration and intensity of wave action or the level of induration of delta deposits.

Acknowledgements: This work was funded by NASA Solar System Workings # 80NSSC19K0165.

References: [1] Adams and McCoy (2017) *GSA,* https://gsa.confex.com/gsa/2017AM/webprogram/Paper303500.html. [2] Soldano, V. A., et al. (2022) 53rd LPSC, #1714. [3] Di Achille, & Hynek, (2010) *Nature Geoscience*, *3*(7), 459–463. [4] Goudge, et al. (2021) *Nature*, *597*(7878), 645–649. [5] Rivera-Hernández, & Palucis (2019). *GRL*, *46*(15), 8689–8699. [6] Wilson, et al. (2021) *GRL*, *48*(4). [7] De Toffoli, et al. *GRL*, *48*(17). [8] Parker, T. J., et al. (1993) *JGR*, *98* (E6), 11061, https://doi.org/10.1029/93je00618. [9] Data have been processed with the MarsSI (emars.univ-lyon1.fr) application, funded by the European Union's Seventh Framework Programme (FP7/2007-2013) (ERC Grant Agreement No. 280168). Quantin-Nataf et al. (2018) *PSS, 150*, 157, https://doi.org/10.1016/j.pss.2017.09.014 [10] Christensen, P.R. et al. *JMARS – A Planetary GIS.* [11] Tanaka, K. L. (2014). *Geologic Map of Mars* (USGS Scientific Investigations Map).

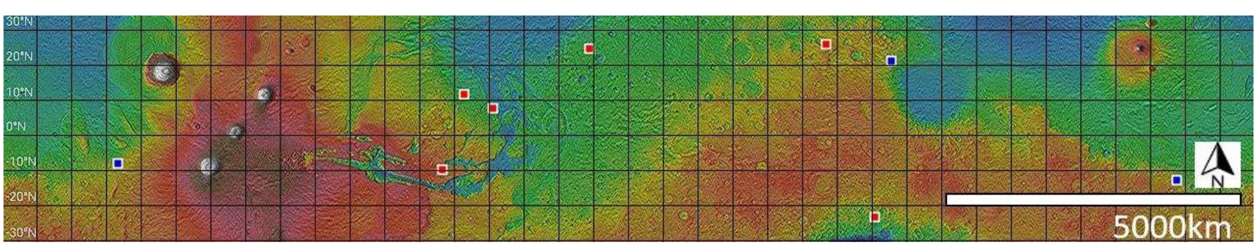

Figure 5: A map of the Martian surface showing the geographic placement of the Martian deltas in this study. The blue color indicates deltas that exhibit horizontal benches, the red color indicates those that do not.