TEMPORAL WIND VARIABILITY AND EROSION OF THE WESTERN DELTA FAN IN JEZERO CRATER.
T. C. Dorn and M. D. Day, Department of Earth, Planetary, and Space Sciences, University of California Los Angeles, Los Angeles, CA 90095, USA, (planetarytaylor@g.ucla.edu)

Introduction: Jezero crater, the primary landing site for the Mars 2020 rover mission, is ~45 km in diameter and sits on the dichotomy boundary northwest of Isidis basin (Fig. 1a). Understanding the abundant aeolian processes in Jezero using the Mars Environmental Dynamics Analyzer (MEDA)[1], as well as by imaging ventifacts, sand shadows, and abrasion textures, as has been done in Gale crater with data from the Mars Science Laboratory rover, will provide a detailed analysis of local-scale winds in Jezero crater. Pre-landing analysis of the aeolian regime in Jezero crater as a whole is necessary to put these future measurements in their broader geologic framework, provide context for rover operations and investigations, and to address some of the most pressing questions surrounding Jezero crater's development.

Of primary importance within Jezero is the delta fan deposit in the western region of the crater. The delta deposit, currently ~6 km long, once extended another 3 km into the crater [2,3,4]. Previous works have hypothesized that the ~2.7 km^3 of material missing from the delta was removed by wind. This begs the questions: 1) what was the directionality of winds eroding the delta, and 2) where did the missing sediment go once it was eroded?

Yardangs, transverse aeolian ridges (TARs), dunes, and wind streaks have collectively been used to reconstruct winds in modern and ancient systems on Earth and Mars [5,6,7,8,9]. Within Jezero crater, yardangs provide the longest time scale record of ancient winds, whereas TARs, dunes, and wind streaks form on shorter time scales. Using these four aeolian features, we reconstructed the history of winds in Jezero crater. Previous studies have addressed some aeolian features in Jezero crater [10], but there has yet to be an analysis of all wind-formed features occurring within the crater. By using this holistic approach we can better postulate where and how the eroded delta sediments were transported. Ultimately, this wind reconstruction suggested the primary cause of the western delta fan erosion was from southwesterly winds that transported material out of the crater along Isidis contours to the northeast.

Methods: We mapped the orientations and locations of four aeolian features within Jezero: wind streaks, dunes, TARs, and bedrock yardangs. Wind streaks and dunes reflect the modern wind regime and were studied using ~25 cm per pixel HiRISE images. Yardangs and TARs reflect the long-term and topographically-controlled winds, respectively. Yardangs and TARs were mapped using a mosaic of ~6 m per pixel CTX images.

Measurements of each feature were made using GIS software. High and low albedo wind streaks were measured from their interpreted upwind point to their most downwind point where the feature became indistinguishable from the landscape. Lee face orientations were used on dunes to infer formative wind directions. Yardang and TAR orientations reflect wind directions parallel and normal to the elongation direction of the feature, respectively.

The volume of unconsolidated modern aeolian material in Jezero crater was estimated from mapping TARs where coverage was estimated to be >70%. An average wavelength for the TARs was determined from 149 measurements across four transects of the largest TAR coverage areas. Using the average wavelength, their associated height, and a height/width ratio of 0.12 [11], we estimated the volume of unconsolidated material in TARs in Jezero.

Evidence of multiple wind regimes in Jezero crater: The yardangs, TARs, dunes, and wind streaks studied in Jezero crater suggest that the crater interior has been dominantly subject to two wind regimes: modern easterly winds forming TARs, wind streaks, and scattered dunes, and ancient, longer-sustained southwesterly winds forming yardangs and lineations on the delta top surface, indicating these winds are the likely cause of the crater-scale erosion when the delta was first subaerially exposed.

Yardangs. Yardangs occur in the southwestern and northeastern portion of the crater floor (Fig. 1b). Overall, the yardangs exhibit a southwest-northeast elongation, the features being dominantly blunted on the southwest side. This suggests formative winds from the southwest rather than the northeast.

TARs. Regions of dense TARs were mapped (Fig. 1b) and cover ~286 km^2 or ~20% of the 1,400 km^2 crater interior. TARs are primarily oriented north-south; only deviating around topographic obstacles. Using an average wavelength of 32 m, average height of 3.8 m, and a height/width ratio of 0.12 [11], the estimated volume of unconsolidated sediment in TARs is ~0.5 km^3 in Jezero crater.

Dunes. Seven dunes with distinct lee faces were found within Jezero crater; all within the inlet channel valley crossing the crater's northern rim. These ~250 m long bedforms have barchan morphologies elongated parallel to channel walls (Fig. 2). The dune lee faces range from northwest to southwest, indicating migration dominantly to the west.

Wind Streaks. 334 wind streaks (Fig. 1b) in 26 of the 44 studied HiRISE images were identified, spanning 10 Earth years with coverage in each of Mars' seasons. Of the 334 wind streaks in Jezero crater, 331 occur primarily in the unit described as the "volcanic floor unit"[2]. The measurements yield an average orientation of 263° ±8.2° indicating predominantly easterly winds.

Western delta fan erosion: We propose that the missing ~2.7 km^3 of the deltaic sediments were eroded by the longer timescale southwesterly winds that occurred after the delta was first subaerially exposed. Sediment flux rates calculated in Jezero [10] estimate that removing the 3 km of ~50 m thick delta deposit would require, on the highest estimated end, at least a few million years. The interpreted easterly modern winds would place the delta downwind from the aeolian bedforms present in the crater. Therefore, the incorporation of the eroded sediments into these features is unlikely and instead the sediment has been transported out of the crater. Southwesterly winds would have taken the sediments to the northeast along the dichotomy boundary, following a topographic contour. A reorientation in wind regime to modern easterly winds can be seen near the outflow channel crossing the eastern rim. The superposition of N-S trending bedforms over SW-NE bedforms (Fig. 3) suggest a switch in wind regimes could have occurred within the formation timescale of TARs.

Conclusion: Surface geomorphology provides clear and abundant evidence of long-lived active winds in Jezero crater, supporting the widely held interpretation that wind eroded the western delta. While easterly winds continue to cause some erosion and accentuate lithologic heterogeneities in the remaining deltaic units, we attribute most of the delta's erosion to earlier southwesterly wind,

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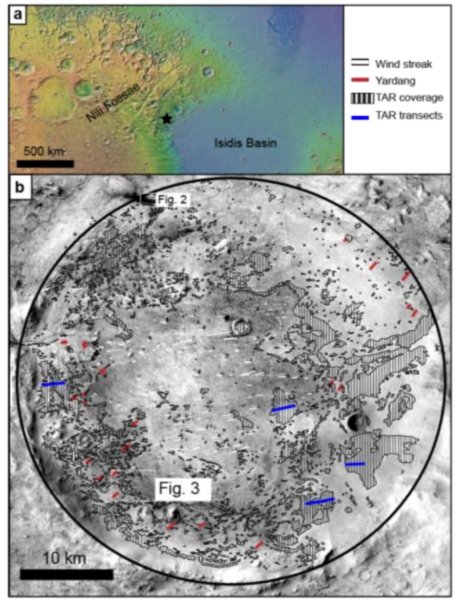

Figure 1. Jezero crater. (a) Mars Orbital Laser Altimeter elevation map of the region surrounding Jezero. (b) CTX mosaic of Jezero crater showing each aeolian feature mapped in this work. (c) North is up in all images. Figure modified from Day and Dorn (2019) [12].

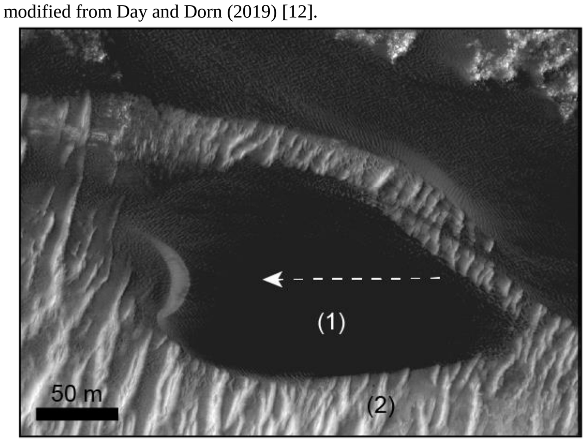

Figure 2. One of seven barchan dunes (1) in the northern channel. Dark sand migrate over the lighter toned, north-south oriented TARs (2). North is up. Figure modified from Day and Dorn (2019) [12].

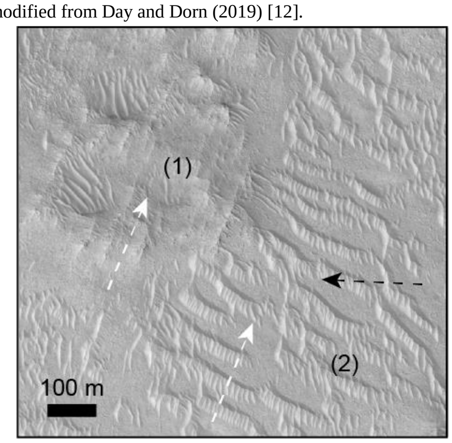

Figure 3. Evidence for wind reorientation in Jezero crater. Surface lineations interpreted as yardangs (1) alongside a modern aeolian bedform field (2). The orientation of the bedforms suggests that they originally formed transverse to the southwesterly winds, but the superimposed pattern of smaller bedforms is consistent with the elsewhere interpreted easterly winds. Figure modified from Day and Dorn (2019) [12].