AN ANALYSIS OF AEOLIAN RIPPLES IN WESTERN JEZERO CRATER, MARS. L. M. Berger[1,2], N. R. Williams[2], M. P. Golombek[2]. [1]Occidental College, Los Angeles, CA 90041. [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109.

Introduction: Jezero crater located in the Nili Fossae region of Mars (18.5°N, 77.4°E) is a 45 km diameter impact crater with a preserved fluvio-lacustrine delta [1] that has been selected as the Mars 2020 Rover landing site [2]. Abundant sand ripples partially cover the western floor of Jezero and its deltaic deposits. Wind transports the fine to coarse grained sand [3] by saltation up to topographic barriers, such as the delta front and crater rim, where it accumulates. The distribution and orientations of ripple crests serve as a record of the local wind regime and how wind patterns have changed through time. Wind has been the dominant geologic process in Jezero crater since delta deposition in the Late Noachian and Early Hesperian [1], so understanding past and present wind patterns is key to characterizing both the climatic environment and history of surface modification.

Ripple morphologies provide insight into wind direction as sand ripples form perpendicular to wind. Ripples in Jezero crater comprise six morphologic categories, which were color coded during mapping (Fig. 2i-vi): (i) linear ripples that are straight and distinct from neighboring ripples, (ii) anastomosing linear ripples that are curvilinear and occasionally intersect adjacent ripples, (iii) linear ripples that contain perpendicular cross-ripples, (iv) polygonal ripples that have cellular crests that are completely closed (v) other linear ripples that contain smaller polygonal ripples in between, and (vi) semi-polygonal ripples which contain ripple crests that aren't all parallel and cells are not completely closed. Linear ripples signify one wind direction while more complex ripples are typical of alternating, seasonal, or multiple dominant directions.

Data & Methods: Ripples are clearly resolved in images taken by the High-Resolution Imaging Science Experiment (HiRISE) at 25 cm per pixel [4]. The HiRISE images in Table 1 were co-registered and geo-referenced by applying a spline transformation to manually place over 100 tie-points between small craters seen both in the HiRISE and a coarser-resolution ortho-rectified controlled basemap [5].

We selected 18 representative 300 m by 300 m study areas (Fig. 1): fourteen located inside Jezero crater and four just outside the crater rim to the west. The study areas were selected to have a widely-spaced distribution and sample different ripple morphologies, underlying terrain, albedos, and local topography. We digitally traced ripple crests resolved in HiRISE images using ArcGIS and color-coded them by morphologic classification (Fig. 2).

To examine potential changes over time, pairs of images taken on different dates can be compared. Many ripple migrations may only be resolved over long periods of time (years), but from June to August 2018,

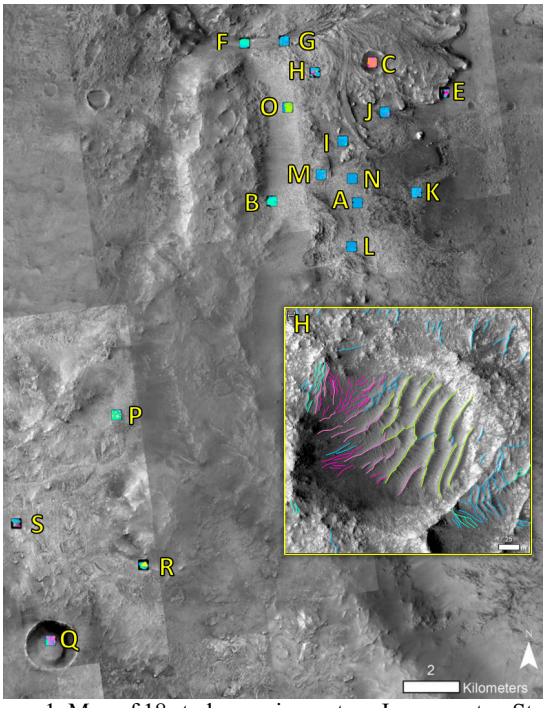

Figure 1. Map of 18 study area in western Jezero crater. Study area H is shown in the bottom left.

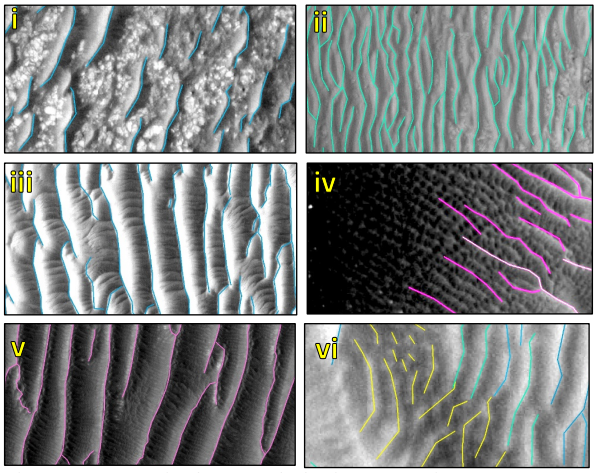

Figure 2. Six ripple morphologies seen in Jezero crater. Examples taken from study boxes. The ripple crests are marked with their representative colors.

a global dust storm occurred on Mars with strong winds that could potentially have driven ripple migration in a much shorter timespan. To look for active ripple migration, we analyzed two HiRISE image pairs – one in the interior of Jezero crater taken across a 4 year timespan, and another pair just external to the west side of Jezero taken shortly before and after the storm.

The circular mean and standard deviation of ripple crest orientation within each study area was calculated

using MatLab to determine the dominant wind direction [6]. Then the digitized crests of the ripples were compared to ripple crests in the corresponding older/younger image to determine if there was any potential sand movement.

Table 1. Images used in analysis with their corresponding name and date taken.

Image Location	Name	Date Taken
Jezero interior: old	ESP_037396_1985	July 19, 2014
Jezero interior	ESP_055290_1985	May 13, 2018
Jezero crater rim	ESP_036618_1985	May 19, 2014
Jezero delta edge	PSP_002387_1985	Jan 29, 2007
West of rim: old	ESP_053022_1985	Nov 18, 2017
West of rim	ESP_057176_1985	Oct 7, 2018

Results: 3734 ripples mapped in all study areas show a strong north-south trend with a mean azimuth of 4° ± 6° (Fig. 3). Variations within each rose diagram are typically ±30°. On the crater floor (Fig. 1) the average ripple azimuth is 8° compared to -2° west of the crater. Average ripple orientation inside 100 m scale craters (C, H, Q, R), is 6°. Immediately inside of the Jezero Crater rim the average ripple orientation is 12.65°. Linear ripples with cross ripples and anastomosing linear ripples are the two most common morphologies seen in the region: they make up 71% of the mapped ripples and are present in 14 of the18 study areas (78%).

The consistency of ripple orientations across the region suggests that regional winds dominate during their formation. The observation that the dominant bedforms are linear ripples indicates that winds are not greatly influenced by local topography. The presence of cross-ripples suggests a secondary wind direction along the long axis of the troughs between large linear ripples. The presence of more polygonal ripples would have indicated more variation in the wind orientation.

On 100 m or larger horizontal scales local topography does not influence the ripple trends. However, on 10 m scales topography does affect ripples with non-linear and intersecting morphologies. For example, study area H is located within a 200 m diameter crater (Fig. 1) which affects wind patterns and the ripple orientation (Fig. 3).

The dominantly northerly trend of the ripples in the Jezero crater region indicates they formed in winds that were orientated east-west. Analysis by Chojnacki et. al. supports wind from the east [3].

The low albedo of ripples in 4 of the 18 study areas sugg suggests that the bright dust has been removed by

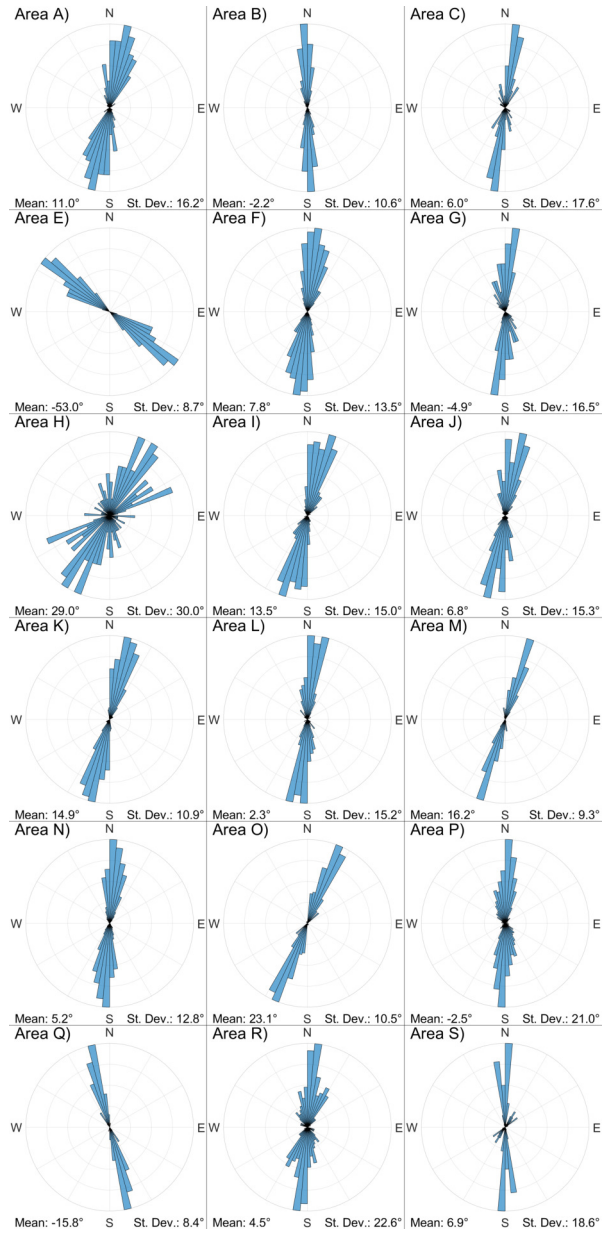

Figure 3. Rose diagrams showing ripple orientation in each study area. The mean and standard deviations are shown.

moving sand exposing the dark underlying basaltic particles. However, no movement of ripples in these areas was detected over the one year or four years time between the before and after images to the east and west of the crater rim, respectively.

References: [1] Goudge et. al. (2015) *JGR* 120(4), 775-808. [2] Goudge et. al. (2016) *Earth and Planetary Science Letters* 458, 357-365. [3] Chojnacki et. al. (2018) *JGR* 123(2), 468-488. [4] McEwen *et al*. (2007) JGR 112, E5. [5] Williams *et al*., 2018, 49th LPSC, #2799. [6] Berens (2009) *Max Planck Institute for Biological Cybernetics*, 184.