FIELD OBSERVATIONS OF YARDANGS IN THE ARGENTINE PUNA: WHAT DEDOS AND CAP SLOPES REVEAL. J. M. Sevy[1], J. Radebaugh[1], D. McDougall[1], L. Kerber[2], J. Rabinovitch[2], [1]Department of Geological Sciences, Brigham Young University, Provo, UT 84602, USA (JonathonSevy@byu.edu); [2]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr. Pasadena, CA 91109, USA.

Introduction: Yardangs are wind-carved linear ridges that are found selectively on Earth and extensively on Mars and other planets [1-4]. The history of the morphologic development of yardangs is not well known, but is thought to depend on the action of wind on the surface and the material properties of the substrate being acted upon [5-8]. In the Puna high plateau of Argentina there are ignimbrite deposits, many of which have been eroded into yardang fields commonly called fleets. Yardangs fleets are composed of roughly tear-drop shaped, evenly-spaced ridges with noses that to face into the dominate wind, that together resemble a fleet of boats sailing. A prominent fleet, known as Campo de la Piedra Pomez (CCP), was studied during the December 2018 and 2019 field seasons to more fully understand their morphology and formation (figure 1.) [6-10].

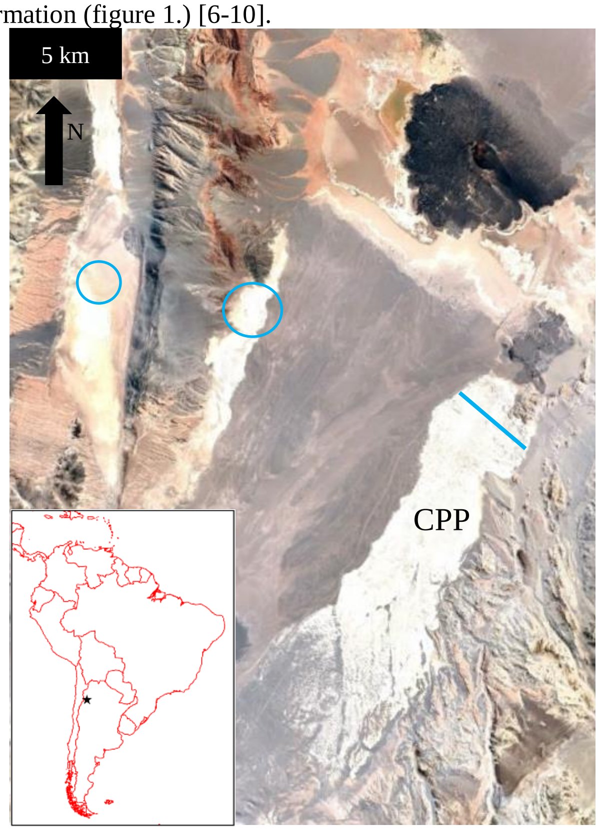

Figure 1. Map of field location. Transect walked through the CPP is marked by the blue line. Locations visited withing the two other yardang fleets visited are circled in blue.

Methods: A 5.3 km transect of the Main CPP was chosen to walk through in the northern end of the fleet that was determined to contain representative yardang placement and morphology, and to best represent the windward, middle and leeward sections of the field. Using dedo length as a proxy for wind direction and erosive power, dedos on 26 yardangs were measured for average length of forward and reverse dedos – forward dedos pointing into the known wind direction, and reverse dedos pointing >90° from the normal wind direction.

Three yardangs along this same transect and one yardang farther south were measured more closely and plotted as a rose diagram of dedos direction (figure 2), measuring ~80-90 dedos on each yardang. This was done in order to determine in which direction the erosive power of the wind is most effective. These three yardangs were selected at the front, middle and back of the fleet to help characterize the variations in the winds across the transect more accurately.

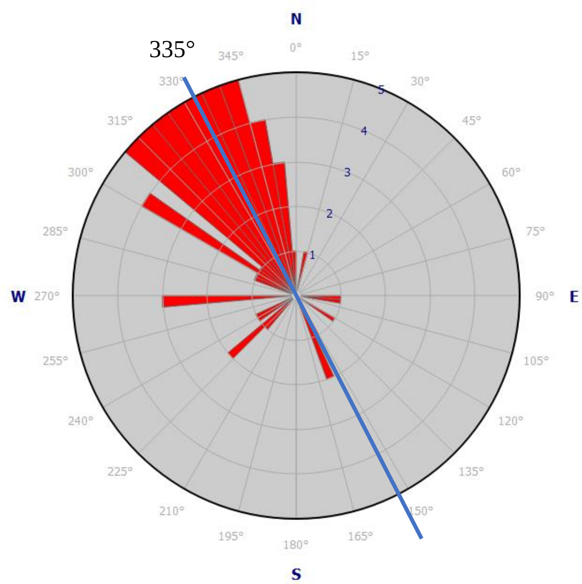

Figure 2. Rose diagram of dedos on yardang in the front of the CPP. Reverse dedos show a tendency to favor southwest, over the east.

The dedos on the 26 yardangs were interpolated in ArcGIS to show the relative forward and reverse wind erosive power though the transect. The dedos on the four select yardangs were also measured for trend and plunge on each facet of the yardang, and we recorded in which direction the dedos on each facet were pointing to give three dimensional direction to the dedos on each facet as well their relationship to the facet itself.

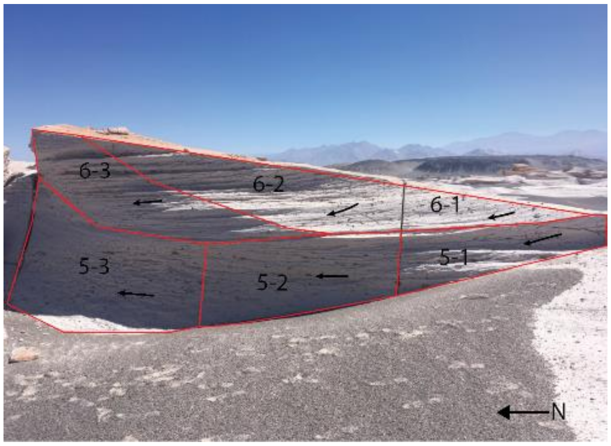

Figure 3. Annotated image of yardang at the front of the CPP fleet. Facets outlined in red, dedo direction shown by arrows (pointing toward the wind).

It was noted while measuring dedos on yardangs through the transect that the top of yardangs seemed to have a consistent strike and dip. The strike and dip of the tops of 29 yardangs were then measured throughout the CPP, and on 40 yardangs in two nearby fleets. 2-4 strike and dip measurements were taken at each yardang depending on size. The average slope of the ground around the yardangs was also measured and the data was normalized to the dip off the ground.

Results: Dedos were dominantly aligned with two main wind directions, one directly down the yardang field (Northwest wind) and the other at x degrees from the dominant wind. Forward dedos increased in length toward the front of the field, and reverse dedos increased in length toward the back of the field. This further confirms that many reverse dedos are from a reverse wind, rather than from flow separation and recirculation [1]. The forward dedos through the fleet average 4.0 cm, and the reverse dedos average 3.3 cm. Assuming that the length of the dedos is dominantly controlled by physical weathering and erosion parallel to the direction the dedo is pointing, this shows that the dominant wind is in fact from the northwest, with a strong, but less erosive south-southwesterly wind.

The dip of the yardang prow through the CPP and two other nearby yardang fleets was measured to be consistently ~9-13° leeward. The measured tops of yardangs ranged from 5° to 33°, with the average in the three fleets being 18°, 10° and 8° respectively. In order to better compare the tops with the angle of incoming wind these were normalized to the slope of the ground around the yardang. In the main CPP, the yardang tops had a normalized average dip of 10° (see figure 4). The other two fleets were normalized to average dips of 9° and 13°. This consistency of leeward dip from the ground though the fleets suggests that this is the equilibrium morphology of the tops of the yardangs.

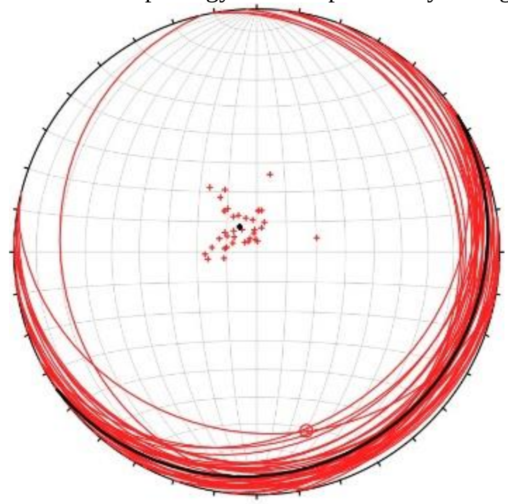

Figure 4. Stereograph of strike and dip of the top of yardangs in the CPP. The average dip (shown in black) is 10°, with an average strike of 146°.

Conclusions: We found that the yardangs had increasing forward dedos toward the front of the fleet, and increasing reverse dedos toward the back of the fleet. This indicates a second wind direction from an opposing direction, rather than wind separation and recirculation. Rose diagrams of dedos show that this opposing wind is coming from a west/southwest direction, rather than a complete 180° southeast.

Future Work: Although the normalized dip of ~10° of the top of yardangs suggests an equilibrium morphology, it is not conclusive what factors could be playing a role in shaping the tops of these yardangs. Future work will focus on determining what factors play a role in forming this steady state equilibrium angle. Determining how much the reverse wind of the field erects this angle.

References: [1] Greeley and Iverson (1985). [2] Kerber et al. (2011) *Icarus* 216, 212-220. [3] Paillou et al. (2016) *Icarus* 270 211-221. [4] Northrup (2018) BYU MS Thesis. [5] de Silva S. et al. (2010) *PSS* 58, 459-471. [6] Kerber et al., (2020) *LPSC* Submitted Abstract; [7] Rabinovitch et al. (2020) this meeting. [8] McDougall et al. (2020) this meeting. [9] Rabinovitch et al., (2019) *LPSC* Abstract #2250; [10] McDougall et al., (2019) *LPSC* Abstract #3202.