SEDIMENT SORTING AND ROUNDING IN A BASALTIC GLACIO-FLUVIO-AEOLIAN ENVIRONMENT: ÞHÓRISJÖKULL GLACIER, ICELAND. K.G. Mason[1], R.C. Ewing[1], M. Nachon[1], E.B. Rampe[2], B. Horgan[5], M.G.A. Lapotre[4], M.T. Thorpe[2], C.C. Bedford[3,2], P. Sinha[5], E. Champion[1], P. Gray[6], [1]Texas A&M University, [2]NASA Johnson Space Center, [3]Lunar and Planetary Institute, USRA [4]Stanford University, [5]Purdue University, [6] Duke University. (kgmason@tamu.edu)

Introduction: Sediments and sedimentary rocks preserve a rich history of environment and climate. Identifying these signals requires an understanding of the physical and chemical processes that have affected sedimentary deposits [1]. Although these processes have long been studied in quartz-dominated sedimentary systems [2], the relative paucity of studies of basaltic sedimentary systems limits our interpretations of the environment and climate where basaltic source rocks dominate, such as on Mars [3,4].

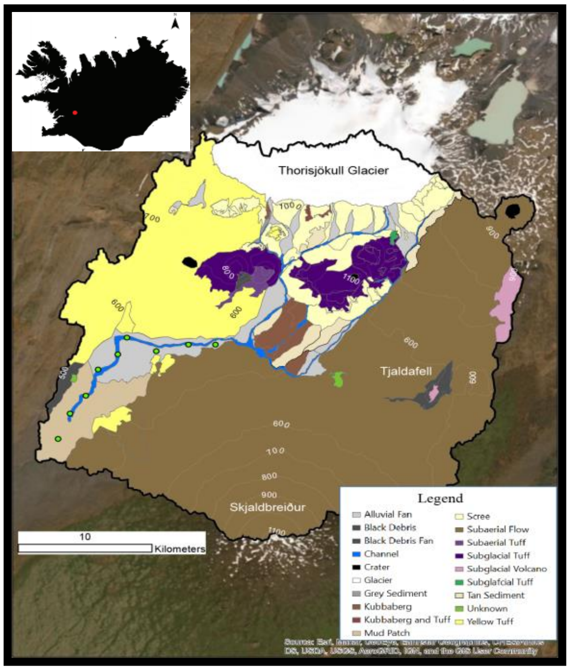

Figure 1: Detailed surface geologic map of field location in SW Iceland. Sample locations represented as green circles. The red box on the inset map of Iceland shows the location of the field site. Images from ESRI and Loftmyndir ehf.

This study is part of the SAND-E: Semi-Autonomous Navigation for Detrital Environments project [5], which uses robotic operations to examine physical and chemical changes to sediments in basaltic glacio-fluvial-aeolian environments in Iceland. This research studies changes in sorting and rounding of fluvial-aeolian sediments along a source and glacier-proximal-to-glacier-distal transect in the outwash plain of the Þórisjökull glacier in SW Iceland (Fig. 1). To this end, we map the source rocks in the catchment, determine particle size and shape for silt-to-cobble grain-size fractions, and evaluate the wind speed required to mobilize available the sediments.

Methodology: The surface geologic map (Fig. 1) was created using satellite images and aerial photographs. Particle size and shape data were collected every 1 km along an ~8 km transect (9 stops), 6.3 km from the base of Þórisjökull glacier (Fig. 1). A cobble count was performed at each stop, which consisted of measurements of the intermediate and long axes of 100 randomly chosen pebble- and cobble-sized grains. Bulk sediment samples that included the finer fractions were collected and their sizes and aspect ratio were determined using a particle analyzer. Grain size was then used to calculate shear velocity to mobilize the grains by wind following equation [6].

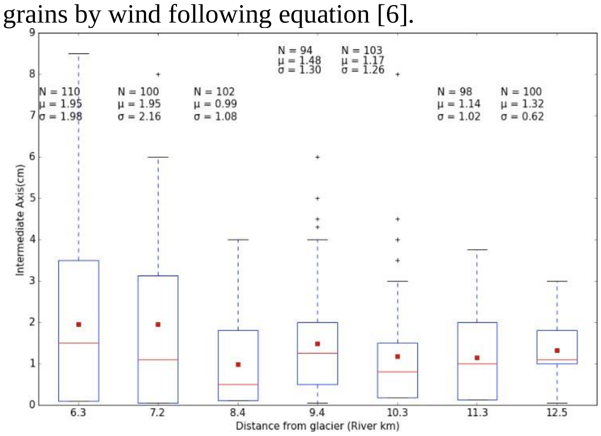

Figure 2: Boxplot of the size of the intermediate axis of sand, pebbles, and cobbles for 7 locations. N is the sample size, μ is mean (red square) and σ is the standard deviation.

Results: A diversity of source rocks exist at the field site that contribute to both aeolian and fluvial sediments. The majority of the sediments can be attributed to lava flows from Skjaldbreidur and tuyas whose volcanic units consist of a subaerial flow cap, hyaloclastite tuff, kubbaberg, and pillow lava.

Minor variations in sediment size exists across the transect. The cobble count data show a decrease in the length of the intermediate axis from proximal to distal (Fig. 2). The decrease is most prominent in the first 2 km of the transect and varies less across the last 6km. Downstream changes in the size of the smaller size fractions are not evident in either the fluvial or aeolian sediments.

Scatter plots comparing aspect ratio and grain size of the bulk sediment show an increase in aspect ratio with grain size. Finer grains (~less than 1 mm) have lower aspect ratios than coarser grains. For all samples, a maximum in aspect ratio (i.e., longest grains) is reached at an intermediate axis of ~2 mm, followed by a decrease or plateau of the aspect ratio for coarser grains (~less than 3mm) (Fig. 3).

Wind detachment thresholds for the fluvial and aeolian particle sizes range from 0.42 to 0.57 m/s. The average measured wind speeds were not sufficient to mobilize the fluvial or aeolian sands at any site. The maximum winds speeds were above the threshold calculated for the average fluvial at the proximal location (Fig. 4)

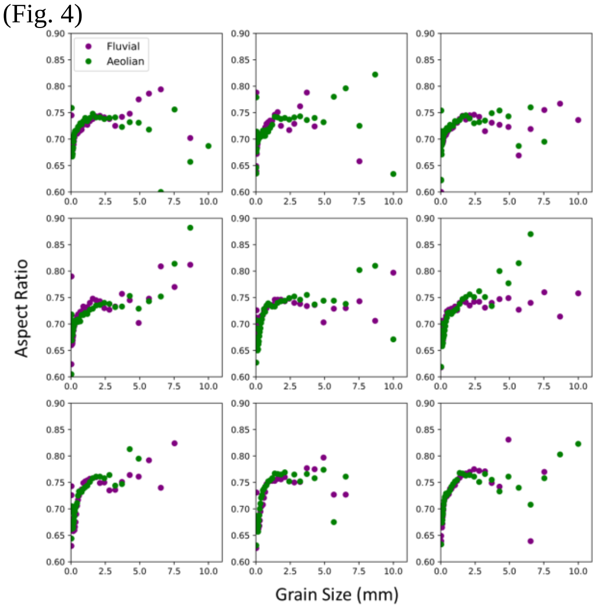

Figure 3: Aspect ratio versus grain diameter of aeolian (green) and fluvial (purple) samples from Stops 1 (upper left) to 9 (lower right) from particle analyzer.

Discussion: The presence of a variety of different source rocks highlight potential differences in sorting and abrasion of particles downstream by both water and wind. The decrease in cobble size from the proximal to distal sites match expectations that the coarser fractions are sorted due to loss of river competence with a downstream decrease in slope [7]. The trends seen in the aspect ratio of different grain sizes are consistent with the tendency of smaller grain sizes to resist rounding through abrasion due to viscously damped impacts, and for coarser grains that experience infrequent transport or travel closer to the bed to also round at a slower pace [8].

Despite the observation of an optimum grain, the low-magnitude rounding emerging from our data may be due to the short overall transport distances from the source and the addition of new particles sourced along the transect. The lack of size variation in the finer fractions may highlight that the transport stage remains high enough to maintain a poorly sorted pebble-to-sand sized sediment population. Wind speeds at or slightly below threshold are consistent with similar particle size and sorting between fluvial and aeolian sands at each location.

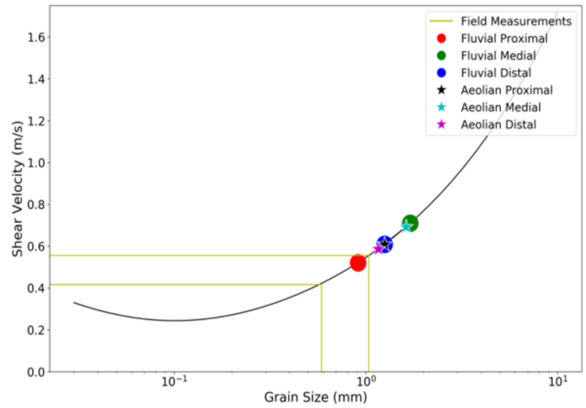

Figure 4: Graph of threshold wind shear velocity versus grain size. Symbols denote aeolian and fluvial sediments, and yellow lines indicate the maximum and average shear velocities of the winds measured in the field.

Conclusion:

- A decrease in grain size occurs from source-proximal to source-distal across all size fractions above 2 mm.
- The trends in aspect ratio versus grain size are consistent with the tendency for smaller and larger grains sizes to be less rounded.
- The lack of significant variation in size and shape of samples may be due to the relatively short length of transect, and fluvial and wind transport capacity.
- Higher wind speeds than were measured are needed to move the medial grain size of the fluvial sediments.

References: [1] Tucker M. E. (2003) *Sedimentary Rocks in the Field.* [2] Nesbitt, H.W. et al. (1996) *Sedimentalogy 43.2:341-358.* [3] Thorpe, M.T. et al. (2019) *Geochimica et Cosmochimica Acta 263 :140-166.* [4] Fedo C. et al. (2015) *Earth and Planetary Science Letters, 423*, 67 -77. [5] Ewing et al. (2019), SAND-E: Semi-Autonomous Navigation for Detrital Environments First Results, *AGU Fall Meeting Abstract EP24A-05.* [6] Shao, Y., & Lu, H. (2000). *Journal of Geophysical Research: Atmospheres*, *105*(D17), 22437-22443.. [7] Miller, K. L., Reitz, M. D., & Jerolmack, D. J. (2014). *Geophysical Research Letters*, *41*(20), 7191-7199. [8] Ziegler, V. (1911) *The Journal of Geology*, 19.7: 645-654.