CHARACTERISTICS OF BASALTIC SAND: SIZE, SHAPE, AND COMPOSITION AS A FUNCTION OF TRANSPORT PROCESS AND DISTANCE. R. A. Craddock[1], Z. A. Needell[1], and T. R. Rose[2], [1]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, DC 20560 (craddockb@si.edu) [2]Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560.

Overview: The chemical and physical characteristics of sedimentary material can provide valuable clues about transport processes, distance traveled, and provenance, all of which are aspects of Martian geography that we would like to better understand. For a typical sedimentary deposit on Earth, for example, it has been shown that the ratio of feldspar to quartz can be used to assess the maturity (or transport distance) of a terrestrial deposit, because feldspar is more vulnerable to weathering than quartz [1, 2]. Further, chemical analysis can also be used to determine potential sediment sources [3, 4], and grain-size sorting can be used to distinguish aeolian sediments (typically well-sorted) from fluvial sediments (poorly sorted in high energy environments). It is also common to use the shapes of individual quartz particles to determine transport process and distance, all of which can help us better understand the history of a sample of sedimentary material and the geological processes that created and emplaced it.

These traditional sedimentological concepts are now being applied to our interpretation of Martian surface materials. Sullivan *et al.* [5], for example, used grain-size and shape to assess eolian processes and to qualify transport distances of deposits found at the Spirit landing site in Gusev Crater. Stockstill-Cahill *et al.* [6] used variations in mineral abundances observed in multispectral data to determine the provenance of dark dunes found in Amazonis Planitia craters. While applying our understanding of terrestrial sedimentary materials to Martian surface materials is intuitively sound and logical, the problem is that most of our current understanding is based on sediments derived from felsic materials (e.g., granite) primarily because that is the composition of most of the landmass on the Earth. However, the Martian surface is composed primarily of mafic material, or basalt, which generates much different sedimentary particles as it weathers. Instead of quartz, feldspar, and heavy minerals commonly found in most terrestrial sedimentary deposits, basaltic sediments are composed of varying amounts of olivine, pyroxene, plagioclase, and vitric and lithic fragments.

One of the few locations on Earth containing such material is the Ka'u Desert of Hawaii. This area is unique in that both eolian and fluvial sediment pathways occur in the same area, thus allowing a direct comparison of particles transported by different processes over identical distances (~20 km). We are currently documenting the physical and chemical changes that take place in basaltic sediments as they are transported by wind and water over increasing distances. This will result in an improvement in our understanding of traditional sedimentological concepts when applying them to Martian surface materials.

Process: The Ka'u Desert is ~350 km^2 and contains the largest basaltic dune fields on Earth. We have identified several different dune types located in various parts of the desert, including climbing and falling dunes, sand sheets, parabolic dunes (that were initially barchans), and crescentic dunes. Fluvial sediments occur as floodout deposits where ephemeral streams go from confined to unconfined flow outside the continuous Keanakako'i Formation [7]. There are also a number of sand bottom streams and playas that occur along a series of channels that extend from the Keanakako'i Formation ~20 km to the sea. We have collected samples from dunes and fluvial deposits at various locations in the Ka'u Desert, at varying distances from sources and subject to different environmental processes.

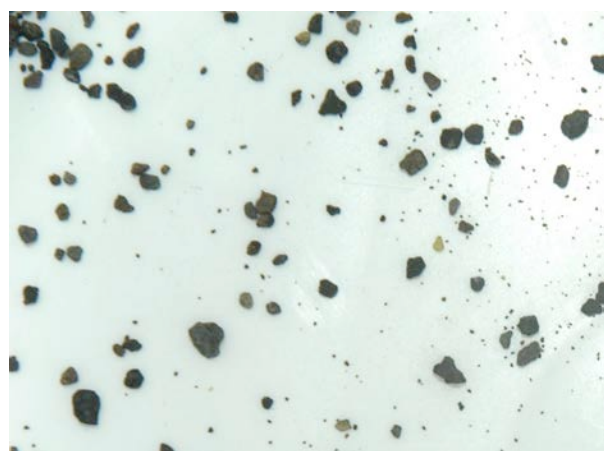

Figure 1. Test photograph of material obtained from the lower part of a climbing dune. Such images have been used to conduct analyses of the grain-size distribution and are being compared to results from dry and wet sieving.

In the lab, we have begun to use optical and scanning electron microscopic images to assess how grain size, shape, and angularity of individual particles change with increasing transport distances. We are also conducting point counts of particles contained within each sample to better understand how olivine, pyroxene, feldspar, and lithic and vitric fragments weather with increasing transport distances. Selected samples are being analyzed for changes in chemistry. The results from this study will help us to understand how basaltic sediments may weather physically and chemically on Mars, and it may provide additional insights into the formation of Martian soils and dust. In addition, we are conducting statistical analyses of our samples using photographs from an optical microscope; analyses that could be easily performed in situ by a rover. By spreading the loose material on a blank background and photographing from above (Fig. 1), we are obtaining 2-D projections of grain sizes and shapes. Using simple morphological operations to separate touching grains, we are obtaining grain size distribution weighted by number fraction, area fraction, or estimated volume fraction (see Fig. 2 where the coarse sand from the top of a climbing dune is compared to the finer sand within the dune)—giving much better grain size resolution and requiring much less labor than sieving. Further, we are using the resulting 2-D images to perform Fourier grain shape analyses, similar to those proposed by Ehrlich and Weinberg [8], where the perimeter of each grain is broken down into its fourier components and the weights of each harmonic are averaged over a large number of grains. This averaged spectrum gives a quantitative measure of the roughness and angularity of the grain shape and has been used to determine the sources of mixed populations of quartz particles [e.g. 9]. The results from our study will provide information needed to determine provenance and transport distances of sedimentary material imaged by MER, MSL and the 2018 lander.

Observations: To date, our results have been mostly qualitative. From exposed cross sections and test augers, we know that the stratigraphy within the dunes is complicated, and generally reflects the stratigraphy of the Keanakako'i Formation itself [e.g., more vitric-rich sands are generally in the lower part of the sections as described in 10]. It is not immediately clear if layers within the dunes are the result of local reworking of the tephra, or if the material was transported several to tens of kilometers. There is also the basic question of when and how the dunes actually formed. This requires a better understanding of both the lithology and timing of events, which will come with further analysis. Our preliminary grain size studies have also shown expected results. We found stratification of the sand in a climbing dune, with the material composing the lower part of the dune being bimodal, made up of a fine dust and coarse, dark lithic grains, while the material from the upper part of the dune is better sorted, consisting of relatively fine grained dark sand.

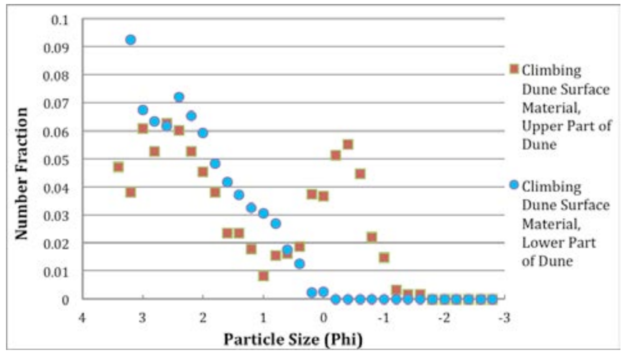

Figure 2. Grain size distribution for sand from lower (fine) and upper (coarse and bimodal) sections of a climbing dune. The fine grained material is pictured in Figure 1.

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