USING X-RAY MICRO-COMPUTED TOMOGRAPHY TO EXAMINE VARIATIONS IN SHAPE OF BASALTIC AND QUARTZOFELDSPATHIC AEOLIAN AND FLUVIAL SEDIMENTS. K.G. Mason[1], R.C. Ewing[1], J. Bullard[1], S. Eckley[2], [1]Texas A&M University, [2]Jacobs Technology, NASA Johnson Space Center, Houston, TX. (kgmason@tamu.edu)

Introduction: Sediments and sedimentary rocks contain a rich record of modern and ancient surface processes, climate, and environment [1]. The size and shape of the particles comprising the sediments and rocks are key to determining the provenance, transport history, and specific types of environments [2]. Such interpretations, however, depend on our ability to accurately characterize and disentangle the effects of source material, alteration, and energies in environments on particle size and shape. Here, we explore the use of 3D analysis from x-ray microcomputed tomography (XCT) data to identify differences in particle shape from fluvial vs aeolian environments and basaltic vs. quartzofeldspathic mineralogies.

Many methods and instruments exist to analyze particle shape and size. Particle size analysis is traditionally done through sieving [3]. Laser diffraction technology has improved the speed and numbers of particle size counts as compared to sieving but lacks shape analysis [4]. Dynamic image analysis (DIA) is a state-of-the-art method in which the projected area of a particle is used to calculate 2D size and shape parameters (e.g., circularity) [5]. XCT for 3D particle analysis is a less explored technique in sedimentology and geomorphology applications. Does 3D particle analysis enhance the use of particle size and shape compared to 2D methods? We compare 2D particle analysis using (DIA) with 3D analysis methods using data derived from XCT.

Study area and samples: Aeolian and fluvial basaltic and quartzofeldspathic samples were collected from environments in Iceland and Texas (Fig. 1). Samples from Iceland were collected as part of the

Figure 1: (left) Quartzofeldspathic dune in Padre Island, TX. (middle) Quartz rich lateral bar in Brazos River, TX, (right) basaltic lateral bar and vegetated dune in northern Iceland.

SAND-E project to examine physical and geochemical

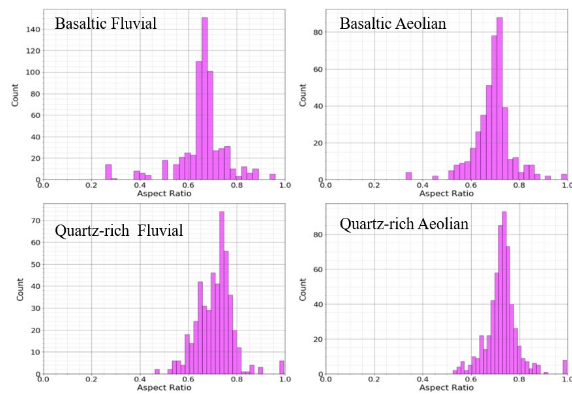

Figure 2: Histogram showing the aspect ratio count of the basaltic and quartzofeldspathic samples from DIA

changes to sediments along basaltic sediment transport pathways with robotic science operations. Samples consist of (i.) quartzofeldspathic sediment from a dune in Padre Island, TX and (ii.) quartzofeldspathic sediment from a lateral bar on Brazos River, TX. (iii.) basaltic sediment from a vegetated dune in Iceland (iv.) basaltic sediment from a lateral bar on a river in Iceland.

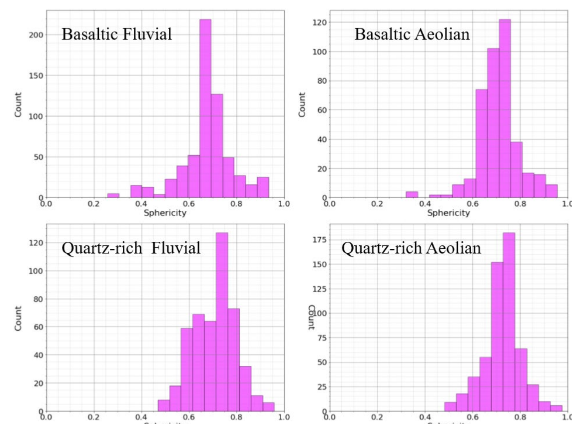

Figure 3: Histogram showing the sphericity count of the basaltic and quartzofeldspathic samples from DIA analysis.

Three shape parameters are described in this abstract. These are aspect ratio which is the width/length ratio of the particle, roundness which is the average curvature radius of all relevant corners divided by the largest inscribed circle radius and sphericity is the box ratio (W/L) adjusted to the Krumbein chart [2]. When these parameters are equal to 1 they represent a perfect circle and/or sphere.

Results: Both 2D data via DIA and 3D data via XCT can produce various shape parameters of sediment. Figures 2-4 visualize aspect ratio, sphericity, and roundness of the four samples described via DIA. The histograms for both figures 2 and 3 are bell shaped. Most of the particles fall within a range of 0.6 to 0.8 for aspect ratio (Fig. 2) and sphericity (Fig. 3). Figure 4 displays the roundness of the particles. The histograms of the basaltic and quartz-rich sample are very different. The basaltic fluvial and aeolian samples show negatively and positively skewed histograms whereas the histograms for the quartzofeldspathic samples are bell shaped. Although skewed, the basaltic samples have multiple modes with similar counts. The basaltic fluvial and basaltic aeolian samples have a roundness below 0.6, which is different from the shape parameters in figures 2 and 3. The quartzofeldspathic samples have definite peaks unlike the multimodal basaltic samples. (Fig. 4). The quartzofeldspathic fluvial and aeolian samples have modes at 0.475 and 0.525, respectively. Overall, figures 2 and 3 show that the samples are circular in shape with high sphericity. Figure 4 shows that the particles are angular and that the basaltic samples are more angular than the quartzofeldspathic samples.

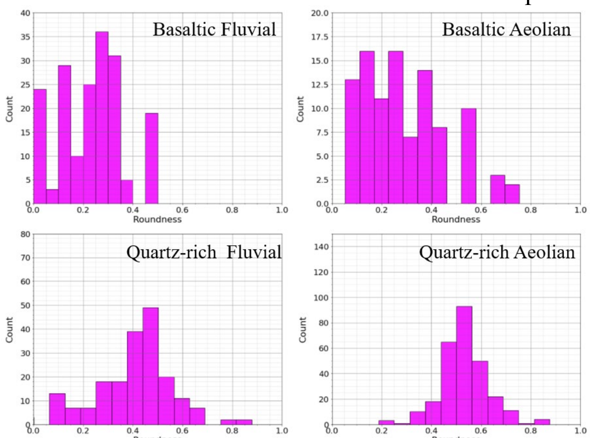

Figure 4: Histogram showing roundness count of basaltic and quartzofeldspathic samples from DIA analysis.

DIA uses projected area as its primary method of particle analysis. XCT provides more options for analysis. Projected area is one method that can be used to calculate shape parameters. Our initial results using Blob3D [6] indicates that this method reproduces similar distributions to those measured by DIA. Spherical harmonics, developed by Garboczi and Bullard [7] is another method to extract shape parameters from 3D particle data. In this method, the 3D shape of star particles can be reconstructed with arbitrarily high fidelity to data via SH analysis and can produce an analytical model of shape from which any number of quantitative shape metrics can be calculated. SH analysis will be compared to DIA and Blob3D results as part of this study.

XCT is unique because it allows for the recreation of virtual particles (Fig. 5). These virtual particles can be viewed and measured in any direction.

Discussion: Based on these shape parameters, the most significant differences in basaltic and quartzofeldspathic sands are the differences in roundness. The basaltic sample have less rounded edges than the quartzofeldspathic samples. This could be explained by how abrasion may affect these two different mineralogies or by the transport distances experienced by the grains. The greatest differences between fluvial and aeolian are also seen in the roundness of the samples. The aeolian samples are more rounded than the fluvial samples. Roundness in aeolian sediment is expected due to the high energy of saltation, which dominates the mode of transport.

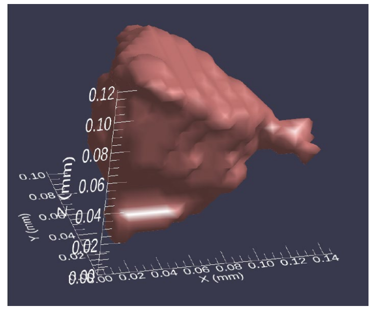

Figure 5: Virtual particle created in Blob3D software using XCT data.

XCT has the capability to produce more rigorous data and may provide more distinct and even different trends than seen through DIA [8]. This is because through XCT, particles can be measured from any direction. XCT ability to recreate virtual particles whose shape and size are copies of actual sediment (e.g., martian and lunar simulant) is especially useful for situation when samples are limited and for analysis of particles when samples appear homogenous through other (2D) methods.

Conclusion: This study allows us to determine the value of 3D analysis for sedimentology and geomorphology of Earth and other planetary bodies, as well as for potential engineering applications. XCT is an emerging in-space technology that could prove important for development of lunar and martian resources for science and engineering applications.

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