GRAIN SHAPE ANALYSIS OF SAND- AND SILT-SIZE SEDIMENT AT THE PHOENIX MARS LANDER SITE FROM IMAGES ACQUIRED BY THE PHOENIX OPTICAL MICROSCOPE.

M. A. Velbel[1], E. E. Graham[2], K. R. Foote[2], H. S. Tang[2], A. G. Pecchia[2], J. H. Smith[2], J. K. Letchford[2], B. A. Hampton[1], [1]Department of Geological Sciences, Michigan State University (East Lansing, MI 48824-1115; velbel@msu.edu), [2]Honors College, Michigan State University.

Introduction and Background: The Phoenix Mars Lander landed in Vastitas Borealis, near Mars' northern polar cap, on May 25 2008, and operated until November 2 2008. The landing site is in a valley dominated by periglacial polygonal patterned ground with 3 to 6 meter polygons, with a thin layer of basaltic sand overlying permafrost, and small rocks that are most likely ejecta from the nearby 10 km diameter Heimdall crater. [1] Depth to ice was 2-6 cm. A Robotic Arm (RA) dug trenches and acquired samples of dry soil and sublimation residues from water ice. The RA delivered samples to several instrument packages including the Microscopy, Electrochemistry, and Conductivity Analyzer (MECA), which included an Optical Microscope (OM). The OM was an imager with a fixed-focus, fixed-magnification optical system, two lenses, and LEDs in red, blue, green and ultraviolet for simulating color imaging. Substrates composed of silicon, micro buckets, strong magnets, and weak magnets were distributed on a rotating wheel which could move so the OM could focus and photograph each sample individually [2]. Previous research has distinguished two sand-silt grain types by color (black and brown) [3], quantified grain form by measuring the long and short dimensions of individual grains directly from OM images [4], and measured particle sizes and size distributions [5].

This presentation describes the earliest results of our investigation to use the shapes of the coarsest grains imaged by the Phoenix OM to establish whether grain shapes (form and, especially, roundness) vary between different periglacial landforms, types of surface and near-surface materials, and proximity to ice.

Methods: Preliminary determination of grain roundness has been accomplished by assigning each grain a roundness value. The Krumbein Scale [6] was chosen for the grain analysis after determining that using the Krumbein scale resulted in a narrower range of roundness values than the Powers scale [7], and therefore better discrimination of grain roundness, as expected from previous work [8]. This method allows large numbers of grains to be analyzed quickly [6-8]. For this preliminary study, a total of 60 sand- and coarse silt-size grains were analyzed from six samples. Given the OM's resolution limits and the consequent lack of fine-scale detail in the OM images, only values of intermediate and extreme roundness were distinguishable.

Results: The distribution of grain types (black and brown) among different samples, sample types, and geomorphic positions are shown in Tables 1 and 2 (after References). Ranges of Krumbein roundness are broadly similar for sand- and coarse silt-size grains in all samples examined except Golden Goose, which yielded somewhat lower roundnesses (Fig. 1).

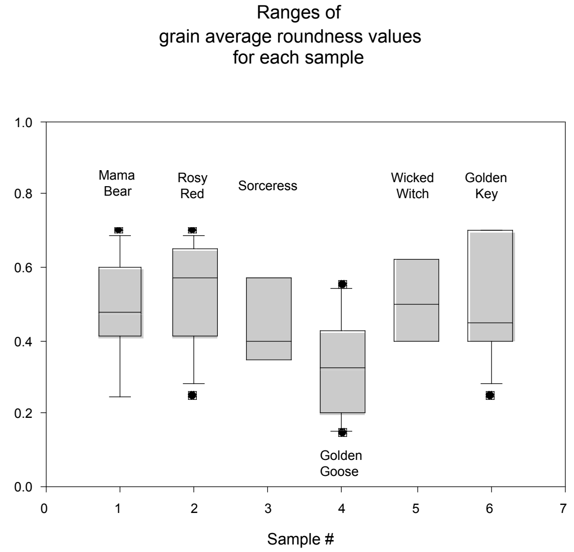

Figure 1. "Box and whisker" diagram showing range of measured of Krumbein grain roundness form sand- and coarse silt-size grains from six Phoenix samples. The lower boundary of the box indicates the 25th percentile, a line within the box marks the median, and the upper boundary of the box indicates the 75th percentile. Where the number of measurements was sufficient to allow, whiskers (error bars) above and below the box indicate the 90th and 10th percentiles, and outlying points are shown.

Discussion: Surface and ice-sublimation residue samples Mama Bear and Golden Key (from the Goldilocks trench), the surface sample Rosy Red Sol25 (from the Burn Alive trench), and the ice-sublimation residue samples Sorceress and Wicked Witch (from the Snow White trench) show that grain shapes do not vary between grains collected at the dry frozen surface and grains that were recovered from ice-bearing materials. Samples Sorceress and Wicked Witch (from the Snow White trench) and Golden Goose (from the Stone Soup trench) show that grain shapes vary between the top and trough of the sampled periglacial polygon at the Phoenix landing site.

Grain shape and grain type. Previous research concluded that brown sand grains are angular to subrounded in shape, whereas black grains have been found to be more rounded [3]. Brown grains constitute 50% of the coarse grains found in the polygon trough, but only 38% of the coarse grains at the edge and the top of the polygon contain only brown grains (Tables 1 and 2). This greater abundance of the less-rounded grain type may help explain why grains from the trough tend to have lower roundness values than grains at the top and edge of the polygon.

Grain shape and periglacial processes: Grains from several different types of samples (surface, and sublimation residues from scrape piles above ice) at several different geomorphic positions (edge and center-top) of the polygon all have medium roundness values with low variations (Fig. 1). This suggests that the grain-shape attributes of sand and coarse silt on and beneath the top and edges of periglacial polygons at the Phoenix landing site may be preserved from a homogenous precursor material, and have not been further modified during the current episode of periglacial processes [9].

Grains in the trough (Golden Goose sample from Stone Soup trench) had a distinctly lower roundness value than grains from samples at the top and edge of the polygon (Fig. 1). Grain roundness in the Golden Goose sample may differ from that of other samples for any of several possible reasons. The trough may have preferenitially accumulated more angular (less rounded) coarse grains than the top and edges of the periglacial polygon. Thermal contraction cracking plays a role in the formation of polygons [10]. The frequent cycles of stress in the trough could cause grains in the trough to be more commonly fractured (and therefore more angular) than grains at the polygon edge or top. Finally, many of the more angular (lower-roundness) sand-sized objects in Golden Goose appear to be sand-sized aggregates (clumps) of smaller grains. These may be incompletely dissagregated rock fragments, although previous work has not identified rock fragments as an abundant grain type at the Phoenix-landing site [3,4]. Alternatively, abundant angular aggregates in Golden Goose may indicate that it was the only sample examined to have been affected by aggregation of fines. Possible reasons differential aggregation in the Golden Goose sample (from the periglacial trough) relative to all the other samples examined in this study (from various depths at the top and edges of the periglacial polygon) remain to be explored.

Conclusions: Similarity in grain roundness among most Phoenix samples indicates uniform modification of grain roundness by processes or factors other than or prior to the current episode of periglacial activity that produced the landforms sampled by the Phoenix RA. Similarity of roundness is consistent with similarity of grain sources, abrasion / transport histories, and depositional processes and environments [11]. Differences in grain roundness in the Golden Goose sample (from the trough adjacent to the periglacial polygon) suggest some difference in grain accumulation, abrasion, fracturing, or aggregation in the trough relative to all other geomorphic settings examined.

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TABLE 1. Comparison of the amount of black and brown grains on the top and edge of the polygon.

	Where on polygon?	Black Grains	Brown Grains
Sorceress	Top, Scrape pile	6	0
Rosy Red	Top, Surface	7	5
Golden Key	Edge, Scrape pile	6	9
Mama Bear	Edge, Surface	8	4
Wicked Witch	Top, Scrape pile	4	1
Total		31	19
Percentage		62%	38%

TABLE 2. Comparison of the amount of black and brown grains elsewhere on the polygon.

	Where on polygon?	Black Grains	Brown Grains
Golden Goose	Trough, Subsurface	5	5
Galloping Hessian	Under Rock	5	5
Total		10	10
Percentage		50%	50%