DUNES CREATING AN ABRUPT INCREASE IN GYPSUM GRAIN CONCENTRATION ALONG A TRANSPORT PATHWAY AT WHITE SANDS NATIONAL MONUMENT, NM, USA. L. K. Fenton[1], J. L. Bishop[1], S. King[2], B. Lafuente[3], [1]SETI Institute (189 Bernardo Ave., Ste. 100, Mountain View, CA, 94043, USA, lfenton@seti.org), [2]California State University, Sacramento, CA, USA, [3]University of Arizona, Tucson, AZ, USA.

Introduction: In 2005, a large quantity of the mineral gypsum was unexpectedly identified on Mars in the high latitude dune sands of Olympia Undae (Langevin et al., 2005). Because gypsum is formed in the presence of liquid water, the discovery of this extensive deposit has important implications for the climatic and sedimentary history of the currently cold and dry north polar regions of Mars. CRISM data indicate that gypsum sand grains appear to concentrate at dune crests [1-3], but the significance of this pattern is not clear.

The intent of our work is to investigate how aeolian processes distribute soft and hard sand grains (e.g., gypsum and other minerals, respectively) across active dunes. We performed a field investigation at White Sands National Monument (WSNM) in New Mexico, USA, selecting sites for their likely contamination by non-gypsum grains. Field samples from these dunes have been separated by grain size and apparent color, and mineralogical analysis has been done with the combined use of X-ray diffraction (XRD), visible and near-infrared (VNIR) spectroscopy, Raman spectroscopy, and Fourier Transform infrared (FTIR) spectroscopy. This presentation focuses on the compositional variation of coarse grains found at the study site.

Study Area: The White Sands Dune Field is located in the Tularosa Basin in New Mexico, USA. The southern portion of the dune field is contained in the WSNM (see Fig. 1a). The dune sand is derived from sediment eroded from lake beds located immediately upwind (on Alkali Flat, to the west) [4-7].

The study area is a barchanoid dune located at the western edge of the dune field, along the northern border of WSNM (see Fig. 1b). The area was chosen for a transport pathway of dolomite grains that are present, among the more plentiful gypsum grains, upwind on Alkali Flat. Samples from this area were collected along one main streamwise traverse (locations 1 through 9), the upper slip face (SF), and two coarse-grained ripples (Ripples 1 and 2).

Ripple 1 is located 224 m WSW and upwind of the study dune brink. Its component grains reflect the transport pathway that has carried dolomite, gypsum, and other minerals from Alkali Flat to the main dune field. The crest of Ripple 1 was covered in 1-4 mm grains, and the sample scoop disturbed the surface layer, producing rafts of cohesive clods.

Ripple 2 is located in a local low between two barchanoid dunes south of the study dune. These grains have traveled up a portion of the stoss face; their components may reflect transport on the dunes in addition to that along the transport pathway. The crest of Ripple 2 was covered by 1-2 mm grains, and lacked both the larger grains and the cohesion found at Ripple 1.

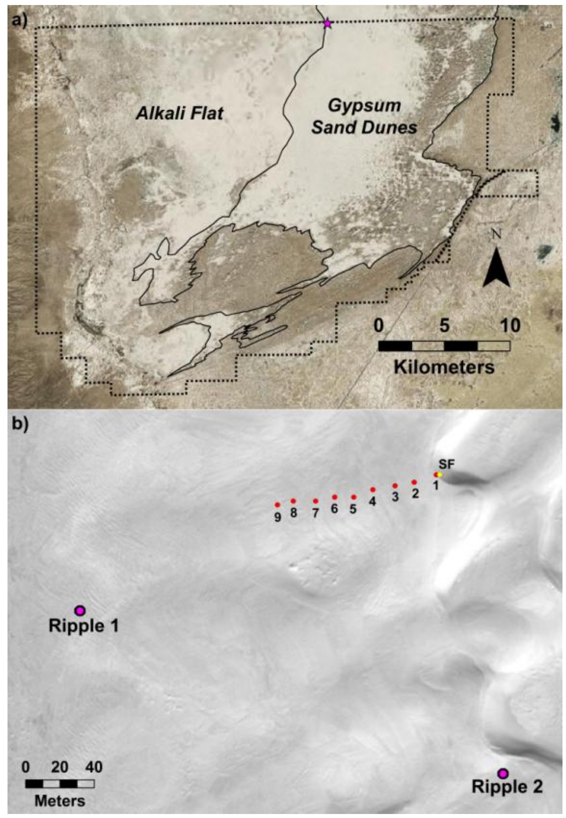

Figure 1. The study area, including a) its location inside WSNM (magenta star) and b) sampling locations. Note that Ripple 1 is upwind of the main dune field and Ripple 2 is near the crest of a dune.

VNIR, XRD, and Raman Spectroscopy: Gypsum dominated all samples at all grain sizes smaller than 1mm. However, this was not the case for coarse grains (>1 mm). Coarse grains from the crests of Ripples 1 and 2 were isolated and manually sorted by apparent color. Ripple 1 coarse grains were separated into white, beige, brown, translucent, pink, green, and dark grains. Ripple 2 coarse grains were separated into white and dark grains.

Ripple 1. Figure 2 shows VNIR spectra of seven different grain color groups found in the Ripple 1 crest. White and beige grains contained gypsum and dolomite; translucent grains contained quartz; pink grains contained hematite, calcite, and microcline; green grains contained the clays beidellite and prehnite; and the dark grains contained a yet undetermined mafic component.

Ripple 2. In contrast, the coarse grains of Ripple 2 contained mainly white and dark fractions, which appear similar to the white and dark components of Ripple 1 (i.e., they are dominted by gypsum).

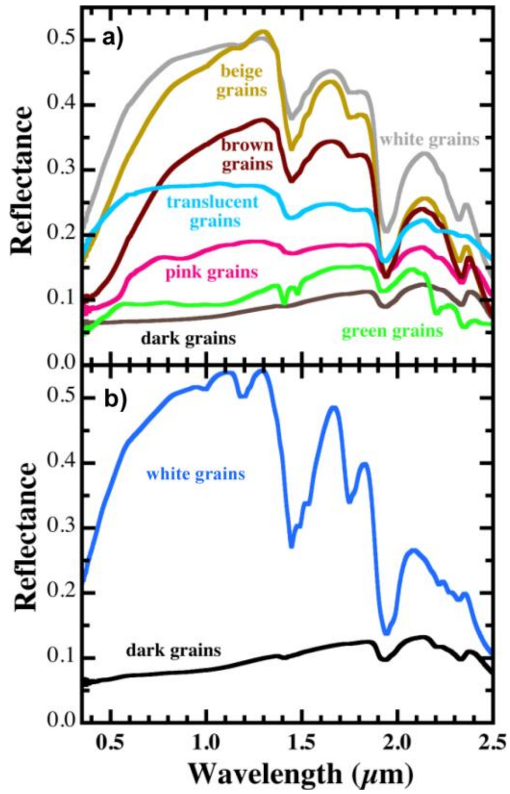

Figure 2. VNIR spectra of >1mm grains from a) Ripple 1 and b) Ripple 2. Note the great variety of mineralogies in Ripple 1 relative to Ripple 2.

Discussion: In the distance from Ripple 1 to Ripple 2, the coarse grain population changed considerably. Larger grains (>2 mm) were lost, as was the wide variety of multicolored grains. This shift was likely caused by differences in grain transport.

Creep. Coarse grains commonly travel in creep, pushed along the ground by saltating grains. A creep flux model [8,9] predicts that the creep flux q_c is inversely proportional to the grain density ρ_g. In this case, the mass flux of creeping grains relative to that of gypsum q_{c_gypsum} is simply ρ_{gypsum}/ρ_g. Figure 3 shows that the relative creep fluxes of minerals found at WSNM have a slight dependence on grain density, but it is not significant enough to explain the sharp dropoff of heavy minerals on the dune stoss slope.

Saltation. The wind can blow strongly enough to saltate 1 mm grains at WSNM [10]. Using threshold friction velocities u_{*t} estimated from [11] and the WSNM formative friction velocity u_* of 0.39 m/s of [12] accelerated 1.4x by flow acceleration up a dune stoss side [13], the steady state saltation mass flux can be estimated from [14]. Figure 3 shows the mass flux q relative to that of gypsum grains q_{gypsum} for both 400 μm (the median size at WSNM [11]) and 1 mm grains (Fig. 3). At 400 μm, saltation has little dependence on grain density. However, 1 mm gypsum grains would outmass 1 mm dolomite grains by 5x.

Conclusions: Saltation of coarse grains (>1 mm) explains an observed increase in grain sorting and decrease in mineralogical variation in the coarse grain population along the upwind edge of the WSNM dune field. This work demonstrates that sorting by transport is another process that should be considered when investigating the mineralogical maturity of a dune field, although this process may be unique to dune fields rich in evaporitic sediments.

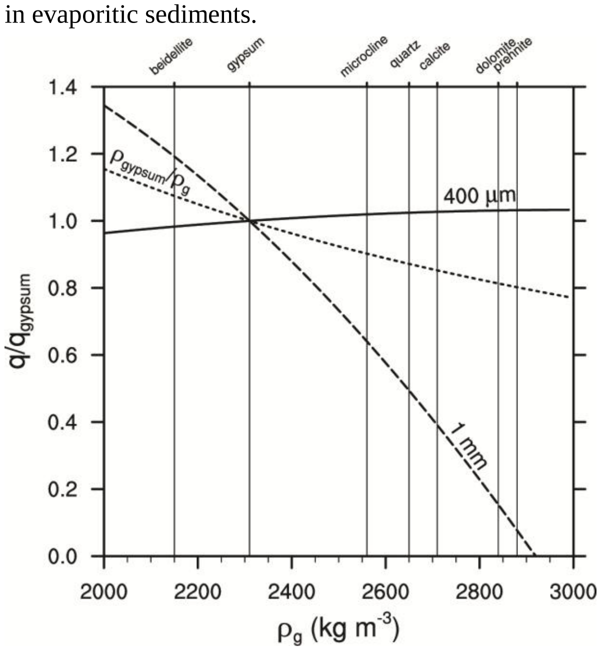

Figure 3. The saltation mass flux of 400 μm (solid line) and 1 mm (dashed line) grains relative to gypsum grains of the same size. The dotted line shows the creep mass flux relative to gypsum grains. Grains in saltation segregate by density much more strongly than those in creep.

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