MARS AEOLIAN ANALOG: MULTI-LAYER SALTATION SENSOR. R. K. Hayward[1], T. N. Titus[1], and R. Bogle. [1]U.S.G.S., Astrogeology Science Center, 2255 N. Gemini Dr., Flagstaff, AZ 86001, rhayward@usgs.gov.

Introduction: If you could send a single instrument to Mars to study aeolian features, what would it be? This question has guided the field work at our Mars analog site, the Grand Falls dune field. The site is an active dune field of barchan and dome dunes, composed of quartz and basalt sand [1] (Figure 1). We have monitored sediment flux there since 2013 [2, 3], using a Sensit solid-state saltation sensor (S4) and a set of three Big Spring Number Eight (BSNE) passive sediment samplers, at 20, 50, and 100 cm above ground level (AGL). The samplers are "weighing BSNEs" that automatically weigh and log accumulated sediment weight. Wind data is collected from a set of three anemometers installed at the same heights as the weighing BSNEs. We have been testing a "Mars BSNE" that records data as time-lapse photos of the sand as it accumulates in the collection chamber. Our research has been extended another three years and expanded to include an experimental multi-layered solid-state saltation sensor (MLS4, Figure 2). We will evaluate its suitability to be part of an instrument payload on a Mars rover or lander.

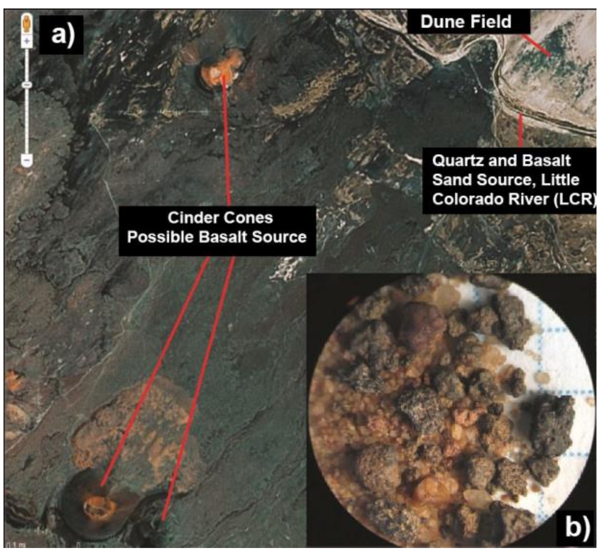

Figure 1. a) Context map for GF dune field showing relationship to cinder cones (possible source of the basalt sand) and to the LCR (source of the quartz and basalt sand). Map is from Google Earth. b) Microphotograph (1.3 mm grid) of sample from a basalt ripple crest, courtesy Jim Zimbelman.

Previous Research: In our previous work at Grand Falls, we sought to 1) test whether the "Mars BSNE" could be used to estimate flux rates, 2) estimate the sediment flux rate at Grand Falls using conventional methods, and 3) field test whether hysteresis, the continuation of sand transport by lower velocity winds once saltation has been initiated, could be responsible for the higher than expected flux rates observed by Bridges et al. [4] in sand dunes on Mars.

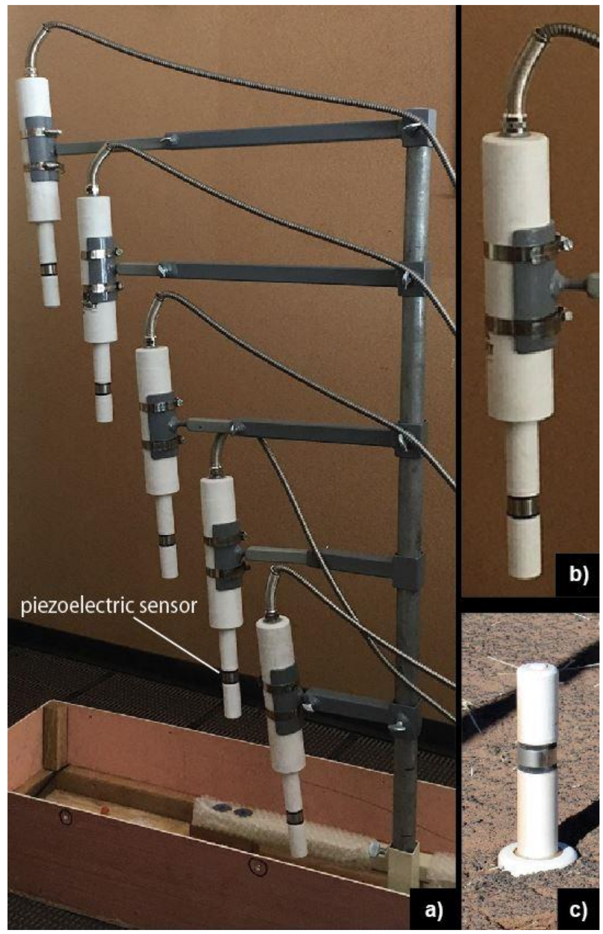

Figure 2. a) MLS4, before being deployed to field. In field, sensors will be 20, 40, 60, 80, and 100 cm AGL. b) close-up of one Sensit on MLS4, c) close-up of a Sensit in usual in-ground position (in place since 2013).

As we collected and analyzed data, several observations shaped the focus of our new study. 1) We estimated flux rates using conventional methods (the mass of sediment collected in the weighing BSNEs). These estimates suggested that, under some conditions, a bimodal distribution of grain size/density of the source sand could significantly increase flux rates. 2) The "Mars BSNE" showed potential. However, increased photo resolution, a sediment collection chamber that shows more detail, and night imaging, would be needed to make the instrument viable for accurate flux rate estimates or hysteresis studies. 3) Hysteresis analysis could also not be conducted using the weighing BSNEs. While they recorded sediment weight each minute, the uncertainty within those measurements due to wind vibrations, was larger than any increase in sediment mass over a period of a few minutes. The weighing BSNEs were also sensitive to an apparent diurnal effect, likely the result of condensation of water at night and evaporation of water during the day (Figure 3). 4) The S4 is not sensitive to either wind vibration or diurnal moisture effects, more reliably indicates the start and stop of saltation events, and thus is better for hysteresis studies. 5) S4 measurements can be calibrated using the sediment mass collected in the BSNEs and used to estimate flux rates.

We concluded that 1) the S4 may be a more valuable single instrument than a BSNE to send to Mars, and 2) before we can evaluate role of hysteresis, we must characterize the effect of bimodal grain size/density population on flux rate. Based on these conclusions, we decided to build a new instrument to test at Grand Falls and to refocus our research.

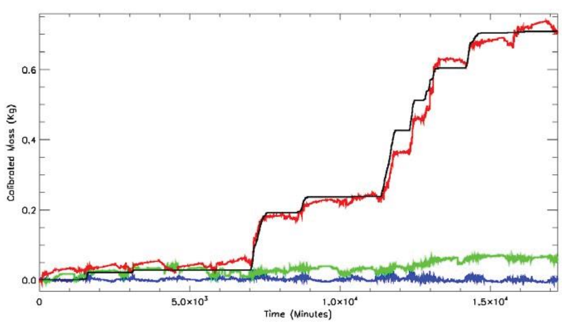

Figure 3. Comparison of the BSNE cumulative weights to calibrated S4. Red, green, and blue lines refer to BSNEs at 20, 50, and 100 cm heights respectively. Black line is estimate of mass calculated from S4 voltage, using the calibration coefficient.

New Research: The objective of our new research is to characterize saltation and sand transport when two distinct sediment populations are involved, and arrive at sediment estimates appropriate for bimodal sand populations on Earth and Mars. In the process, we will determine whether MLS4 can be used to estimate sediment flux at an established Mars analog site, and thus evaluate the utility of MLS4 as part of an instrument payload on a rover or lander.

Bimodal grain size/density background. The Grand Falls dunes consist primarily of quartz and basalt sand. The basalt sand tends to be coarser and less rounded than the quartz sand. There are at least two known dune fields on Mars with bimodal mineral compositions: Olympia Undae [e.g. 5, 6] and Ogygis Undae [7]. It is a reasonable assumption that the two distinct mineral compositions are also different in size and/or density, thus resulting in differing threshold velocities and different scale heights for the sediment flux.

Science questions. (1) What is the effect of bimodal sediment populations on sediment flux estimates? (2) What is the wind shear needed to only mobilize a single population? (3) What is the wind shear needed to mobilize both populations? (4) How much can this effect increase the estimated Mars flux for dune fields with bimodal populations?

The instrument. Each S4 in the MLS4 has a piezoelectric sensor that records impacts from all directions. MLS4 must be sensitive enough to not only detect impacts from saltating particles, but also from particles being carried in suspension. We have found only one case where this concept has been tested. In May 1991, at Owens Lake, CA, a 4-level saltation sensor was tested and acquired particle flux as high as 50 cm AGL [8]. This example suggests that the MLS4 concept has merit and its viability should be explored.

Summary: Based on three years of study at the Mars analog site, we have refocused out research. We will characterize saltation and sand transport when two distinct sediment populations are involved, arrive at sediment estimates appropriate for bimodal sand populations on Earth and Mars, and field test MLS4.

References: [1] Bogle et al. (2015) *Geopmorphology 228*. [2] Hayward et al. (2015) Fourth International Planetary Dunes Workshop, Abstract #8007. [3] Titus et al. (2016) LPS XXXXV, Abstract #1201. [4] Bridges et al. (2012) Nature, 485, 339-342, doi:10.1038/ nature 11022. [5] Fishbaugh et al. (2007) JGR 112, E07002. doi:10.1029/2006JE00 2862 [6] Masse et al. (2012) EPSL 317-318: 44-55. [7] Charles et al. (2016) EPSL 458. [8] Gillette et al. (1997) JGR 102, No. D22. 97D00961.

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