MELTWATER-INDUCED DEBRIS FLOWS ON COLD-CLIMATE AEOLIAN DUNES AND THE IMPLICATIONS FOR ANALOGOUS PROCESSES ON MARS. Donald M. Hooper, Cynthia L. Dinwiddie, and Ronald N. McGinnis. Geosciences and Engineering Division, Southwest Research Institute®, 6220 Culebra Road, San Antonio, TX 78238-5166 (DHooper@swri.org).

Introduction: We observed small meltwater-induced debris flows on the lee slopes of large dunes at the 67° N latitude Great Kobuk Sand Dunes (GKSD) in Kobuk Valley, Alaska. They bear a striking resemblance to debris flows with fresh-appearing gullies or erosion tracks that occur on the slopes of several mid- to high-latitude dune fields in both Martian hemispheres. Snow partially to fully blankets the GKSD for ~70% of the year, which likely has direct analogy to hydrocryospheric factors that generate debris flows on Mars. The high-latitude, cold-climate GKSD are a valuable terrestrial system within which to conduct an analog study focused on understanding the integrated factors that generate debris-flow gullies on the slopes of Martian aeolian dunes. In this abstract we build upon our related work presented at the 43rd Lunar and Planetary Science Conference [1].

Martian Gullies: Recent analysis of High Resolution Imaging Science Experiment (HiRISE) and Mars Orbiter Camera (MOC) images by several researchers has revealed the possibility of niveo-aeolian deposits, denivation features, and debris-flow gullies on Martian sand dunes [2–11]. Whether contemporary meteorological conditions on Mars are capable of generating liquid water on the surface is a complex matter yet to be resolved to the satisfaction of most researchers [2, 3, 9, 12–15]. Other hypotheses employ liquid CO_2, CO_2 frost, or dry granular flows as the primary agent driving the formation of these gullies [11–12, 14–15].

Kobuk Valley Climate and Meteorology: The climate at the GKSD is subarctic and semiarid (mean annual air temperature: –4°C; mean annual precipitation: 360 mm) with long, cold winters (January mean: –20°C) and brief, warm summers (July mean: 15°C) [16, 17]. Meteorological data from the Kavet Creek remote automated weather station (located 3.6 km from the northern edge of the GKSD) indicate a bimodal wind regime from the east-southeast during November to April and from the west during May to July [17]. Our field work (March 16–31, 2010) coincided with a period of abundant sunshine, but mean daily temperatures did not rise above the melting point of water [18].

Niveo-aeolian deposits composed of interbedded sand, snow, and ice are a common attribute of cold-climate dunes [19–20]. At the GKSD, these wind-transported sand and snow deposits accumulate on the lee slopes of large transverse, longitudinal, and barchanoid dunes. Distinctive morphologic and sedimentologic phenomena called denivation features are produced by the melting of snow and ice present in these deposits. These include spongy and hummocky surfaces, extension cracks, deformed strata, slumping, and compressional structures.

Field Observations at the GKSD: During March 2010, we observed niveo-aeolian deposits, denivation features, and small debris flows at the GKSD (Figs. 1 and 2). Small debris flows originate in shallow alcoves near dune crests, become channelized down lee faces, and terminate with depositional fans. Melting niveo-aeolian deposits provide a source of liquid water for alluvial processes. Slope aspect and insolation are two factors that control the rate of thawing on south- and west-facing slopes.

Figure 1. ***A small meltwater-induced debris flow was observed on the lee slope of a large dune at the GKSD. Note niveo-aeolian (sand and snow) deposits and lobate depositional fan. Scale is 10 cm long.***

Figure 2. A small debris flow with meltwater has created a shallow, incipient gully on the lee slope of a large dune. Denivation has produced spongy and hummocky micro-topography.

Conceptual Model: We propose that these small debris flows are generated when high pore-water pressures develop in thawed, near-surface niveo-aeolian deposits due to impeded infiltration by frozen sand and pore ice. The thawing of niveo-aeolian deposits, perhaps aided by solar insolation, is one possible trigger for generating both terrestrial and Martian debris flows and is a likely mechanism in the formation of the associated gullies [2–3, 9, 21–23] (Fig. 3). Comprehensive surveys are needed at the GKSD to measure debris flow and gully morphologies, volumetric analysis, viscosity, slope angle, porosity, niveo-aeolian stratigraphy, net solar radiative flux, and multipositional and multilevel subsurface temperature and moisture flux profiles.

Conclusions: The GKSD are an important Mars analog site. Small debris flows on dune slopes at the GKSD are activated by seasonal thawing more than a month before the mean daily surface temperature approached 0ºC [18]. The flows consist of a mixture of sand and liquid water cascading down the dune slipface. The debris-flow gullies observed in Martian dune fields may be formed by an analogous process. The presence of Martian gullies with a youthful appearance is a topic of considerable importance because of the possible presence of liquid water. Furthermore, detailed data involving niveo-aeolian transport, deposition, and reworking are sparse and these processes are poorly understood. Our investigation provides insights into the interactions between niveo-aeolian deposition, thawing, insolation, slope aspect, and initiation of alluvial processes.

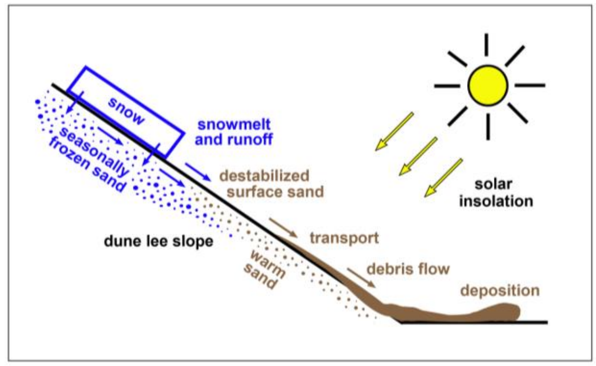

Figure 3. Our conceptual model illustrated as a time series of key slope processes and mechanisms.

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