SEASONAL DARK DUNE SPOTS AND DARK DUNE SPOT FLOWS IN THE SOUTHERN LATITUDES OF MARS.

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Introduction: Seasonally ephemeral, defrosting-related Dark Dune Spots (DDS) and their downslope flows on Martian sand dunes (**Fig. 1**) are enigmatic, 10-to-100-m-scale features unique to frost-covered sand dunes that form at subfreezing temperatures. Their origin has puzzled the planetary æolian and cryospheric science communities for nearly two decades [1–15]. Hypotheses for these features have ranged from dry, basaltic sand avalanches to brine-and-sand debris flows.

We have begun a study of these seasonal processes on mid-to-high-latitude dune fields in the southern hemisphere of Mars to resolve environmental controls on formation of DDS and their downslope flows at select locations where rich data sets of repeat imagery, thermal and hyperspectral data, and HiRISE digital terrain models (DTMs) are currently available for comprehensive analyses.

Three unique DTMs in Kaiser crater (19.471°E, 46.981°S), a DTM in Russell crater (12.933°E, 54.303°S), and a DTM in an unnamed crater (17.513°E, 54.592°S; located 159 km east of the Russell crater DTM) delineate the current study areas. With sufficient time and resources, we will extend this study to the high-latitude footprint of a DTM covering the edge of a dune field within an unnamed crater (178.212°E, 70.331°S; provisionally referred to here as Keystone crater), which is located 59 km north of Richardson crater.

Overarching Science Goal: Determine if DDS and DDS flows represent seasonal phenomena involving a cold-trapped H_2O frost/snow layer above or below seasonally deposited CO_2 frost/ice, or if other processes, such as topographic heterogeneity and destabilized dry sand flows, are at work.

Science Merit: Seasonally recurring, transient melt of surface water ice, snow, or frost deposits, and thaw of pore ice and ice lenses are potential triggers for generating downslope flows on polar sand dunes on Mars [e.g., 4, 10, 16] and on Earth [e.g., 17, 18]. Mass wasting flows form on mid-to-high-latitude sand dunes under defrosting conditions in mid-winter to early spring in both Martian hemispheres. In the presence of low-eutectic salt(s), localized melt of seasonal frost deposits and pore ice may yield annual, briny debris flows under the current Martian climate. Multitemporal image and remote sensing data analyses are expected to reveal interactions between seasonal insolation, sand and dust, and condensed volatiles (H_2O and CO_2) that produce phase transitions and trigger mass wasting on sand dune slopes.

Objective: Resolve latitudinal effects and environmental controls on seasonal formation of DDS and DDS flows in the southern hemisphere of Mars to determine if these features represent areas where brine may be episodically metastable on/near the surface (i.e., so long as the liquid is subjected to only small disturbances in temperature/pressure), or if other processes, such as destabilized dry sand flows, are at work.

Methodology: We constrain the origins of DDS flows by analyzing mission data for spectral evolution, geomorphic signatures, and thermal attributes, and modeling near-surface ground temperatures. This pilot study demonstrates that the proposed methods and tasks can lead to conclusions about the dry vs. wet hypotheses.

Task 1. Site Environmental Context: We are compiling and analyzing time series of Mars optical, thermal infrared emission, and hyperspectral infrared data collocated with HiRISE DTMs of dune fields across a mid-to-high-latitude gradient to resolve prevailing environmental conditions and their multiyear variability (over a period for up to 10 Mars years) and repeatability during seasonal DDS and DDS flow formation and evolution, and the relationships of solar longitude, insolation, and slope characteristics to these seasonal processes.

Task 2. Analyses & Hypothesis Testing: We are analyzing the geomorphologic, thermal infrared emission, and hyperspectral context of DDS and DDS flows, including mass-wasting signatures, spatio-temporal distribution and evolution of local albedo and solid-state volatiles (H_2O and or CO_2) present in winter, salts present in summer, and depth of H_2O ice in the sediment column, and interpreting the project-derived data in relationship to each dune field's topographic context to test "wet vs. dry" hypotheses for the composition of materials mobilized during DDS flow processes at each site along the latitudinal gradient. We are evaluating two general hypotheses for the origins of DDS flows: dry sand avalanche vs. briny sand flows. We are analyzing the topographic, geomorphologic, thermal infrared emission and hyperspectral context of DDS and DDS flows and conducting thermal modeling to estimate where H_2O

ice is located within the sediment column and whether it lies inert on the surface or is available at depth to actively form brine. We are examining multiple lines of evidence to test the general alternative hypotheses (i.e., dry vs. wet) for DDS flows, and to arrive at a set of constrained, but more highly detailed hypotheses that remain consistent with mission data.

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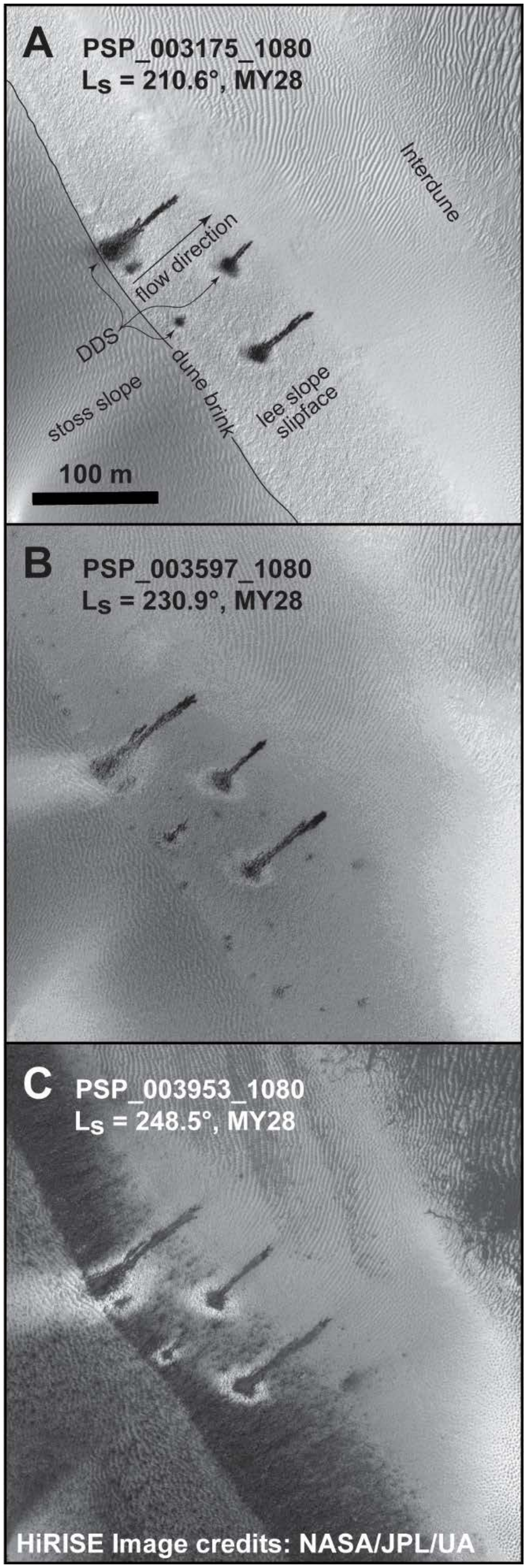

Fig. 1. Transverse dune in Richardson crater (179.7°E, 72.3°S) defrosts over a ~60 sol period in mid-to-late southern spring. ***We examine multiyear spatio-temporal evolution (e.g., parts A–C) of flows emanating from Dark Dune Spots on mid-to-high-latitude southern sand dunes.*** *Note: 32 sols elapsed between part A and B; 27 sols elapsed between part B and C.*