P13B-1369

Great Kobuk Sand Dunes, Alaska: A Terrestrial Analog Site for Polar, Topographically Confined Martian Dune Fields

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Martian dune systems belong to two broad categories: (i) the sprawling north polar erg, rich in and immobilized by seasonal and perennial volatiles; and (ii) isolated low- to high-latitude dune fields confined by topography. While modern dune migration on Mars is nearly imperceptibly slow, recent studies are producing robust evidence for aeolian activity, including bedform modification. Cold-climate terrestrial dunes containing volatile reservoirs provide an important analog to Martian polar dunes because permafrost and seasonal cycles of CO_2 and H_2O frost mantling are thought to partially decouple Martian polar dunes from atmospheric forcing.

The 67°N latitude, 62 km^2 Great Kobuk Sand Dunes (GKSD) are a terrestrial analog for polar, intercrater dune fields on Mars. Formative winds affected by complex topography and the presence of volatiles and intercalated snow within the GKSD have direct analogy to factors that impede migration of Martian polar dunes. This system offers the opportunity to study cold-climate, noncoastal, topographically constrained, climbing and reversing barchanoid, transverse, longitudinal, and star dunes.

The Kobuk Valley climate is subarctic and semiarid with long, cold winters and brief, warm summers. Niveoaeolian sedimentation occurs within west-facing lee slope catchments. In March 2010, we found the seasonally frozen layer to range in thickness from 1.5 to 4.0 m, and no evidence for shallow permafrost. Instead, using GPR and boreholes, we found a system-wide groundwater aquifer that nearly parallels topography and cuts across steeply dipping bedforms. GPR cannot uniquely detect ice and water; however, a similar analysis of rover-based GPR might be used to detect volatiles in Martian dunes. The perennial volatile reservoir is liquid because of mean annual air temperature, intense solar heating before, during, and after 38 days of continuous summer daylight, high dry sand thermal conductivity, higher wet sand thermal conductivity, infiltration of relatively warm summer precipitation, and the insulative properties of longlived snowcover. We hypothesize that the seasonally frozen layer and niveoaeolian deposits combined with a shallow aqueous reservoir are responsible for the low migration rate of the GKSD (i.e., ~1.3 m/yr over a recent 5-year period).

Just as migration of the GKSD is affected by partial to full snowcover for 70% of the year, Martian polar dunes are affected by partial to full frost mantling for 70% of the year, significantly limiting the duration of aeolian transport. Thin water films surrounding sand grains at the GKSD make moist sand cohesive and structurally stable, like a solid. The partially saturated sand above the capillary fringe of an unconfined aquifer in the GKSD will limit sand available for aeolian transport, potentially similar to effects of permafrost within a Martian dune. We will present our geophysical, geomorphologic, and meteorologic field data and modeling analyses.

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