Frozen Dune Dynamics, Accumulation and Preservation of Aeolian Cross-Stratification in the Cavi Unit in the North Polar Region of Mars. G. Kocurek[1] and R. C. Ewing[2], [1]University of Texas at Austin, Department of Geological Sciences, 1 University Station C1100, Austin, TX, 78712, garyk@mail.utexas.edu, [2]Princeton University, Department of Geosciences, Guyot Hall, Princeton, NJ, 08544, rewing@princeton.edu.

Analysis of surfaces within the aeolian cross-stratified Planum Boreum Cavi Unit of the north polar region of Mars demonstrates the nature of niveo-aeolian dune dynamics and the accumulation and preservation of aeolian dune stratification on Mars. An upward gradational transition from the sediment-dominated Cavi Unit into the ice-dominated ice cap layers of Planum Boreum 1 Unit reflects climatic change.

All Cavi surfaces visible on HiRISE images TRA_000863_2640 and PSP_010636_2660 were identified and mapped as (1) stabilization bounding surfaces marked by pronounced polygonal fractures of interpreted permafrost origin that, in some cases, are overlain by ice deposits, (2) stabilization bounding surfaces showing lesser polygonal fracturing, (3) erosional bounding surfaces lacking evidence of permafrost, and (4) internal set cross-strata. The overall unit architecture consists of preserved dune topography in which (1) stacked dune stoss-slope deposits are bounded by erosional surfaces or surfaces showing lesser polygonal fracturing, (2) down-lapping lee-face deposits are bounded by surfaces of pronounced polygonal fractures, and (3) interdune areas show the amalgamation of pronounced polygonally fractured surfaces and ice deposits.

Cavi dune architecture is interpreted as showing cycles of dune reactivation and stabilization by freezing. During reactivation stoss slopes are initially deflated, with subsequent, renewed deposition causing lee faces to prograde as downlapping wedges that taper onto interdune floors. During stabilization the entire dune develops a permafrost surface and wind-blown snow may accumulate in interdune hollows. Only the stoss slopes of dunes are ever deflated to remove the permafrost surface, whereas these surfaces remain intact on the lee slopes and within the interdune areas.

Because dune topography is preserved during stabilization, it serves as the antecedent boundary condition during subsequent reactivation such that renewed deposition conforms to the existing dune topography. Remnant dune topography is carried upward through the Cavi Unit, resulting in exceptionally high angles of bedform climb. The upward persistence of remnant dune topography is most evident in sections parallel to the dune migration direction, whereas in more oblique sections dunes migrate into the section.

Dune migration is eastward, arguing for the existence of circum-polar wind belts during Cavi deposition. The period of cycles of dune stabilization and reactivation are unknown. The Cavi Unit is clearly transitional into the overlying layered ice cap accumulations (Planum Boreum 1 Unit), which show alternating darker, sediment-rich ice layers, and lighter sediment-poor ice layers. The darker sediment-rich layers show the lateral inclusion of preserved dunes with cross-strata of both sediment and ice, and ice that continues as cross-strata lee of dune topography, demonstrating that snow/ice behaved as clastic grains. Lower polar ice caps strata of darker sediment-rich layers and lighter sediment-poor layers are interpreted to mirror Cavi cycles of dune reactivation and stabilization, respectively. Martian climatic change from the Cavi Unit into the layered ice cap, therefore, is one marked primarily by the onset of greatly enhanced snow/ice deposition and decreased sediment availability.

Although the accumulation and preservation of Martian dune strata in the Cavi Unit are most analogous to isolated examples in the Antarctic of Earth, the dynamic processes can be more broadly contrasted with Earth warm-climate deserts as a function of profoundly different source-to-sink boundary conditions. Accumulation of aeolian strata by dune stabilization through freezing is analogous to “stabilizing aeolian systems” on Earth where stabilization most commonly occurs as vegetation. This type of accumulation contrasts sharply with most warm-climate dune systems where accumulation of only basal portions of dunes occurs through spatial and temporal deceleration of winds or a rise in the water table. Freezing on Mars also allows for the preservation of the dune accumulations to yield the Cavi Unit, which rises well above the adjacent plains. This mode of preservation is in contrast to Earth systems where preservation of aeolian accumulations occurs with subsidence and burial, and/or a regional relative rise in the water table that is typically related to sea level.