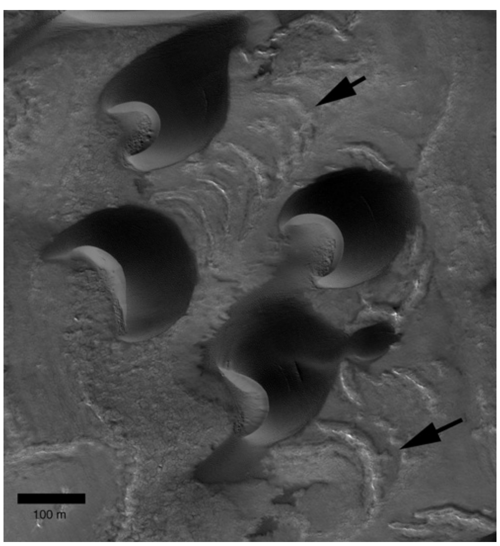
MIGRATION RATES OF NIVEO-AEOLIAN DUNES IN ANTARCTICA: IMPLICATIONS FOR MARTIAN DUNES. M.C. Bourke[1], R. Ewing[2] D. Finnegan[3] and H. A. McGowan[4]. [1]Planetary Science Institute, Tucson, Arizona mbourke@psi.edu [2]Geological Sciences, University of Texas, Austin, TX,. [3]Cold Regions Research & Engineering Laboratory, Hanover NH 03755. [4]School of Geography, Planning and Architecture, University of Queensland, St. Lucia 4072, Australia.

Introduction: Dune migration has not yet been detected on Mars [1, 2]. There are however indications of active and significant sand transport. For example, two dome dunes in the north polar region on Mars disappeared over 3.04 Mars years [3]. HiRise data show arcuate ridges upwind of dunes in Chasma Boreal that mark previous dune positions suggestive of recent migration (Fig. 1) [4]. Dunes that currently display no change could be crusted, indurated, or subject to infrequent episodes of movement. One of the many agents of dune induration may be niveo-aeolian deposits [5]. The effect of niveo-aeolian deposits on dune migration rates remains unknown but is suggested by some to entirely restrict movement [6]. We present the results of a remote sensing study on the influence of niveo-aeolian desposits on dunefield morphodynamics. This data will assist in better understanding the potential transport-limiting effect not only on Earth, but also on Mars and other extraterrestrial surfaces.

Figure 1 Arcuate permafrost ridges upwind of barchan dunes in Chasma Boreale mark the former position of sand dunes. (HiRISE Image 85.0ºN, 339.0ºE, 32.1 cm/px).



The Study Area: The Victoria Valley sand dunes lie in a hyper-arid polar desert with a present day mean annual temperature of -27.4°C [7]. Annual precipitation is <10 mm and summer snowfalls sublime rapidly. The recorded wind speeds exceed the threshold sand entrainment velocity of 5.5 m/sec for 27% of the time during winter and 74% of the time during summer [8]. The dune field consists of a series of transverse and barchan dunes that covers an area of ~1.1 km^2, in a belt which is about 3.1 km long and 0.5 km wide..

Niveo-aeolian Deposits: The aeolian deposits of the McMurdo Dry Valleys in Antarctica are the primary type site for understanding landforms and process rates for perennial niveo-aeolian environments [e.g., the work of 9, 10]. Shallow manual excavations of the dunes show inter-bedded snow and ice layers, likely annual winter or storm deposits [6] (Fig. 2). The snow laminae are discontinuous, and their thickness varies, as does the proportion of snow in the sand layers [11].

Methodology: In our analysis we have used vertical air photographs from 1959, 1961, 1972, 1981 and 1983) combined with high resolution LIDAR data, collected in 2001. The images were all projected to a common pixel dimension and registered to a Lambert Conformal Conic projection using a 1st order polynomial fit and nearest neighbor algorithm. Dune migration was estimated utilizing mapped crestlines (1961-2001) in ARCGIS (Fig. 3). We collected dune morphometric and spacing data (height, length and horn to horn width). We also estimated dunefield defect density (ρ). This is a field-scale measure of the number of the defect pairs per unit length of crestline [12], where defects represent terminations of dune crestlines.

Dune migration rates: Dunes in the Victoria Valley dune field moved on average 62 meters to the west during the 40 year survey period. This translates to an average dune migration rate of 1.5 m per year. Individual dunes displayed considerable variation in movement with values ranging from a total distance 20 m to maximum of 112 m over the 40 yr period. No correlation is observed between dune position in the dune field and migration rate, although terminations that extend toward the valley floor show the greatest degree of change.

Dune morphodynamics: Significant change occurred in the dune field. All crestlines have not only migrated downwind, but also changed position relative to each other. Dune merging, lateral linking and absorption occurred. The decrease in the coefficents of variation, total crest length and defect density and the increase in mean spacing indicate that the dune-field organization increased over time. These data match well with other empirical studies of pattern evolution over time and models of dune-field pattern evolution as self-organizing systems [12-15].

Conclusion: The data show relatively low rates of dune migration for the Victoria Valley. When considered alongside other cold climate studies, these data suggest that dune migration rates are lower in polar deserts than in warm desert environments, which can be between 6 to 20 m/yr. The data from Victoria Valley show that while niveo-aeolian deposits lead to lower rates of dune migration, their presence does not extinguish dune movement on Earth or we would suggest, on Mars.

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Figure 2 (Left)View across eroded windward slope of barchan dune in Victoria Valley. Snow and ice-cemented sand layers are visible.
(Right) Shallow manual excavation of a barchan dune in the Victoria Valley. Section reveals interbedded snow, ice and sand.

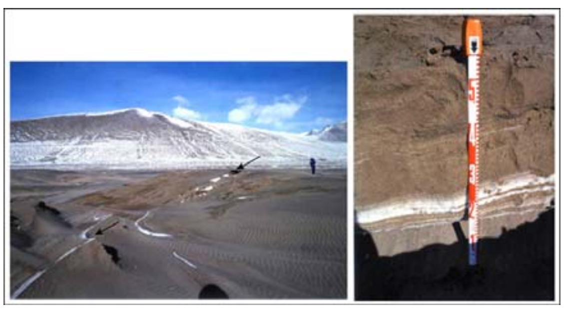
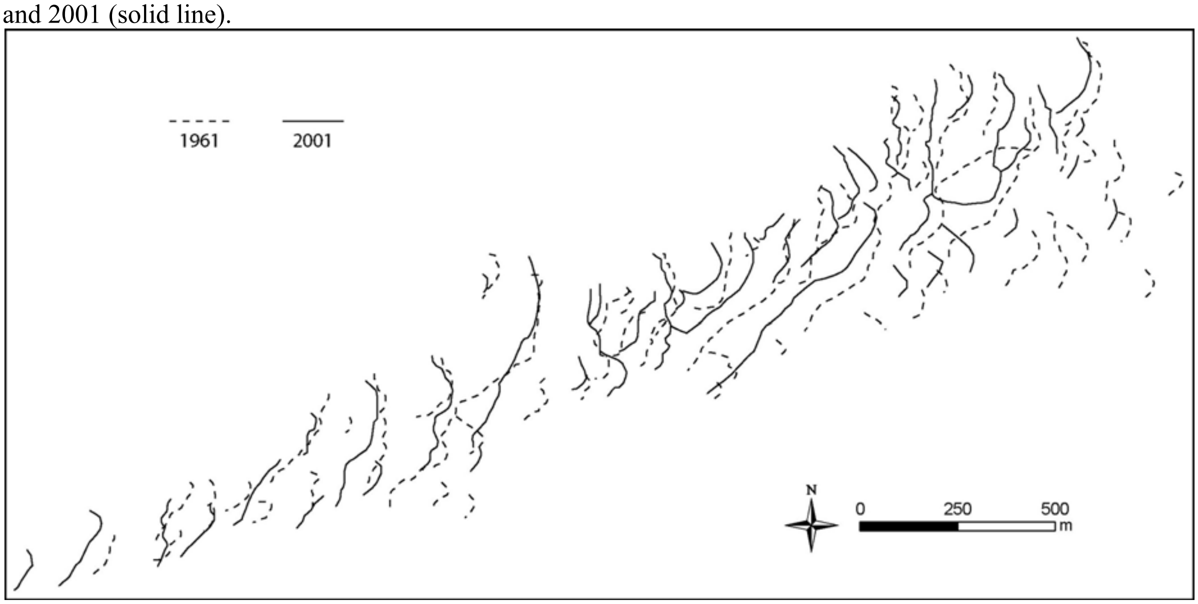


Figure 3: Change in position of sand dunes in Victoria Valley. Digitized dune crest lines 1961 (dashed line) and 2001 (solid line).



References

[1] Zimbelman, J. R., *Geophysical Research Letters* **27**, 1069-1072 (2000). [2] Schatz, V. *et al.*, *Journal of Geophysical Research (Planets)* **111**, 10.1029/2005JE002514 (2006). [3] Bourke, M. C. *et al.*, *Geomorphology* **94**, 247-255 (2008). [4] Bourke, M. C. *et al.*, *Permafrost and Periglacial Processes*, (submitted). [5] Bourke, M. C., *Eos Trans. Fall Meet. Suppl.* **85**, Abstract P21B-01 (2004). [6] Selby, M. J. *et al.*, *New Zealand Journal of Geology and Geophysics* **17**, 543-562 (1974). [7] Doran, P. T. *et al.*, *Journal of Geophysical Research (Atmospheres)* **107**, (2002). [8] Ayling, B. F. *et al.*, *Arctic, Antarctic, and Alpine Research* **38**, 313-324 (2006, 2006). [9] Cailleux, A., *Biuletyn Peryglacjalny* **17**, 57-90 (1967). [10] Calkin, P. E. *et al.*, *Geographical Review* **64**, 189-216 (1974). [11] Miotke, F.-D., *Polarforschung* **55**, 79-125 (1985). [12] Werner, B. T. *et al.*, *Geology* **27**, 727-730 (August 1, 1999, 1999). [13] Ewing, R. C. *et al.*, *Earth Surface Processes and Landforms* **31**, 1176-1191 (2006). [14] Wilkins, D. E. *et al.*, *Geomorphology* **83**, 48-57 (2007/1/15, 2007). [15] Werner, B. T., *Geology* **23**, 1107-1110 (1995).