Crater Influence on Global and Local Distribution of Dune Fields: Application of MGD^3

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Introduction: Windblown sand is often trapped by craters, but what role do craters play in the final form and location of dune fields? Can localized crater effects be separated from global influences? In order to use dunes to address global and local-scale climatic and sedimentary questions, we need to be able to distinguish between global and local influences. As a first step we use the GIS-based Mars Global Digital Dune Database (MGD^3) to study the spatial distribution of dune fields that reside in craters.

Background: Why study dunes on Mars? Sand dunes are among the most widespread aeolian features present on Mars, occurring over a wide range of elevations and terrain types. In general, aeolian dunes form when a source of sand-sized grains exists, winds of saltation strength carry the grains, and the winds subsequently weaken below the threshold for sand transport [1]. Thus dunes serve as a unique record of the interaction between the planet's atmosphere and surface and contribute to our understanding of both climatic and sedimentary processes.

Background: Overview of MGD^3. Version 1.0 of the database provides a comprehensive view of the geographic distribution of medium to large-size dune fields (>1 km^2) between 65º N and 65º S latitude. It encompasses ~550 dune fields, covering ~70,000 km^2. The database was created using Thermal Emission Imaging System (THEMIS) infrared (IR) images to locate potential dune features. Higher resolution THEMIS visible (VIS) [2] and Mars Orbiter Camera Narrow Angle (MOC NA) [3] images were used to assign earth-based dune classifications [4] and, where possible, slipface measurements. When a dune field was located within a crater, the associated crater rim was digitized so that the crater's spatial relationship to the dune field could be quantified. Output from a NASA/Ames General Circulation Model (GCM) is also included in the database. MGD^3 is available as USGS Open File Report 2007-1158, and can be downloaded from http://pubs.usgs.gov/of/2007/1158/.

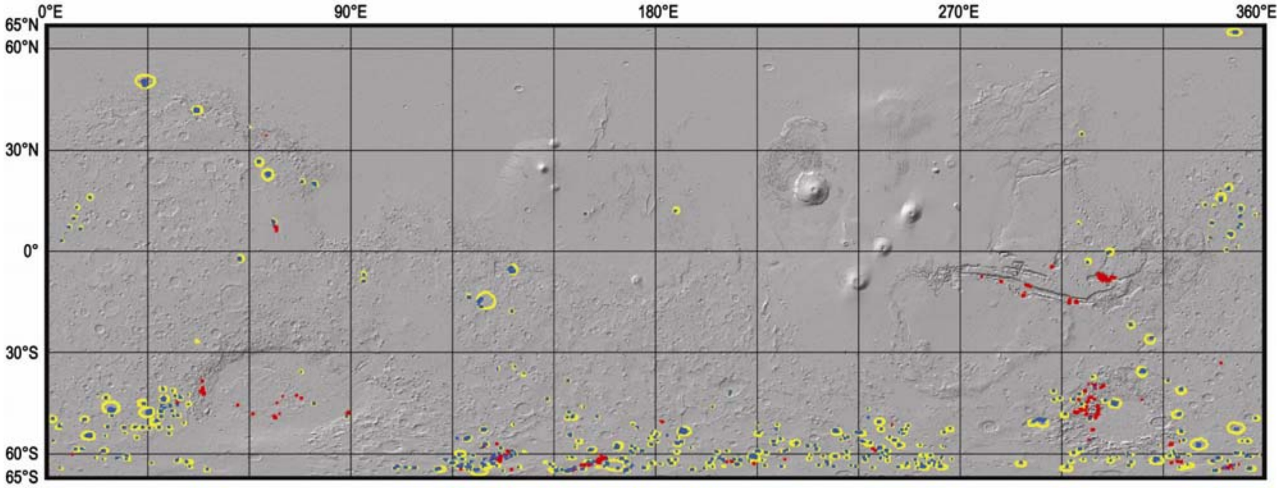
Discussion: *Global: Geographic Distribution of Dune Fields in Craters.* Nearly 80% of the dune fields in the database reside in craters. Of the ~425 dune fields that formed within craters, ~385 (90%) are located between 0º and 65º S latitude, with only ~40 located between 0º and 65º N latitude. Figure 1 plots their locations and Figure 2 summarizes, in chart form, their latitudinal distribution. Is this uneven distribution attributable to global atmospheric conditions or to crater distribution and characteristics? Because so many dune fields reside in craters, it is important to understand the influence that craters exert over the eventual morphology and distribution of dune fields.

Local: Dune Centroid Azimuth compared to GCM. One clue to crater influence is the position of the individual dune field within its associated crater. We quantify this by calculating the azimuth of the line connecting the centroid of the crater to the centroid of the dune field and refer to it as dune centroid azimuth. We find that dune centroid azimuth often agrees with the GCM modeled wind direction when a single, regularly shaped dune field occupies a smooth-floored crater. Under these conditions, the dune field was probably able to move unimpeded across the crater floor, reflecting regional wind patterns. Figure 3 shows an example of two predominantly smooth-floored craters where dune centroid azimuth and GCM modeled wind direction agree. Agreement rate falls when crater floors are topographically complex. Rough floors may simply impede dune field movement. Alternatively, the topographic barriers created by complex floor and rim morphology may create local wind patterns that influence the distribution of dune fields more than regional winds. Hence, under some conditions dune centroid azimuth may be a good proxy for global/regional wind direction, but under other conditions it may represent local conditions. Clearly, crater morphology should be considered when assigning climatic and sedimentary significance to dune field distribution. Other crater characteristics that might modify global processes, and thus dune morphology and distribution, need to be identified and considered.

Summary: Dune-field morphology and location are important clues to the climatic and sedimentary processes that shaped the surface of Mars. Because such a large percentage of dune fields are located within craters, it is important to understand how crater characteristics, including floor and rim morphology, may have modified the dunes within.

References: [1] Bagnold, R.A. (1941) The physics of blown sand and desert dunes. London: Methuen, 265 pp. [2] Christensen, P.R., et. al., THEMIS Public Data Releases, PDS node, ASU, http://themis-data.asu.edu. [3] Malin, M.C., et. al., Malin Space Science Systems Mars Orbiter Camera Image Gallery http://www.msss.com. [4] McKee, E.D. (1979). In: E.D. McKee (Editor), USGS Professional Paper 1052. [5] Fenton, L.K., et al., (2003) JGR, 108 (E12).

Figure 1. Geographic distribution of dune fields on MOLA shaded relief background. Dune fields located outside craters are red. Dune fields located inside craters are blue. Rims of craters containing dune fields are yellow.



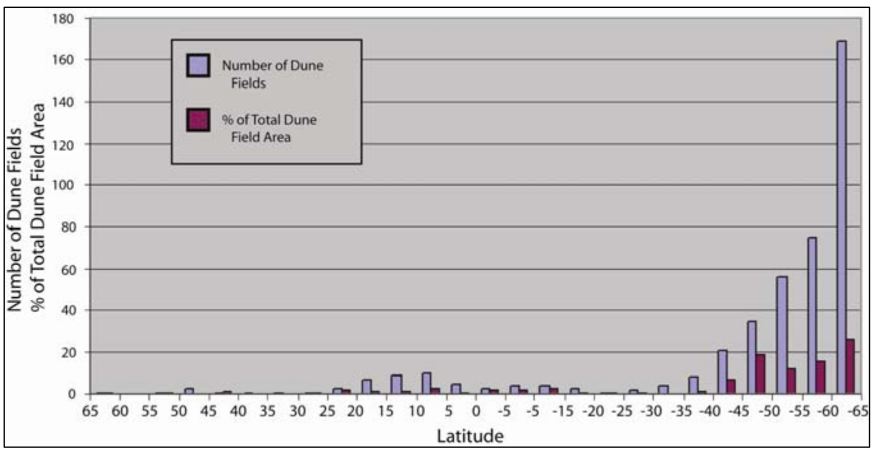


Figure 2. Distribution by latitude of dune fields in craters. Blue represents the number of dune fields and red represents the area covered, given as percent of total area.

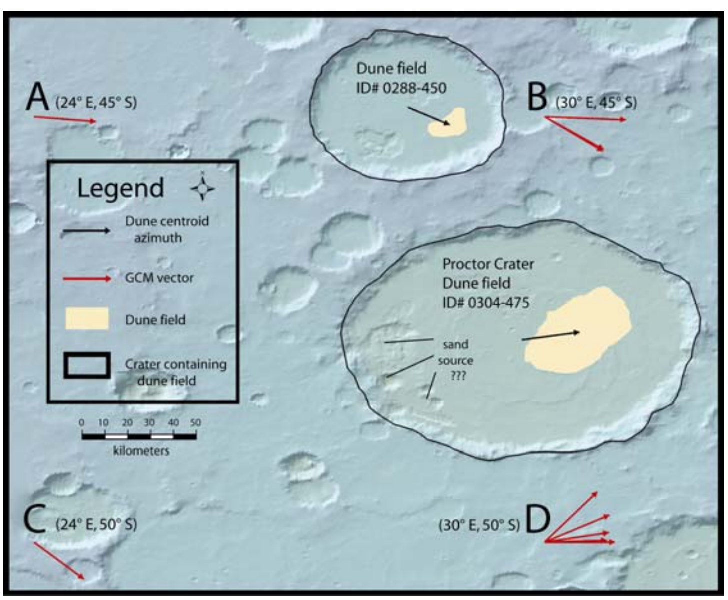


Figure 3. Examples of dune centroid azimuths that agree with GCM modeled wind direction. In both craters the pits may have been the source of material for the dunes [5]. In Proctor crater the alignment of the possible sand source, dune centroid azimuth, and dune field support that theory. Background is MOLA shaded relief with color to indicate elevation. Elevation in this figure ranges from ~0 to ~2500m.