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Martian Crater Degradation by Eolian Processes: Analogy with the Rio Cuarto Crater Field, Argentina; J.A. Grant and P.H. Schultz, Brown University, Providence, RI 02912.

Introduction: Numerous degraded and rimless craters occur across broad areas of the martian surface that are mantled by thick, unconformable deposits (Fig.1). These regions include Arabia, Mesogaea, Electris, Tempe, the interior and surface to the northwest of Isidis Basin, southern Ismenius Lacus, and the polar layered terrains (1-7). Occurrence of the deposits (1-7) and low regional thermal inertias (8-9) indicate that at least some accumulated fine-grained sediment (effective particle diameters of 0.1-0.5 mm or coarse silt to medium sand) to a thickness of 100's to 1000's of meters. Most unconformable deposits experienced some eolian modification (1-2, 4) that may be recent in some locales (1). Despite the presence of these deposits, simple eolian deposition appears incapable of creating the numerous degraded and rimless craters occurring within their limits (10-11). Nevertheless, terrestrial analyses of the Rio Cuarto craters formed into loessoid deposits (12-14) demonstrates that eolian redistribution of fine-grained sediment in and around craters produces degraded morphologies that are analogous to some found in mantled regions on Mars.

The Rio Cuarto Craters: The Rio Cuarto Crater Field is located at 64°15'W, 32°45'S in Argentina (12-13). Formation occurred during a low angle impact (12-13) into the Pampas plains that created ten elongate depressions extending from north to south over 30 km. Individual craters are up to 4.5 km long, 10 m deep, and all possess a 4:1 length-to-width ratio. Present expression of the craters is confined to the loessoid Pampean Formation comprised of coarse silt, very fine sand, and lesser fine sand (~0.03-0.25 mm; 14). Rim relief around the craters (Fig. 2) varies from low on upwind or north ends to more hummocky along the sides to high at downwind or south ends (12, 14). Side rims are typically mantled by eolian dunes that grade outward to the surrounding plains (Fig. 2) and side walls are alternately exposed and buried by downwind-migrating transverse dunes. Variably active longitudinal and transverse dune fields bury topography at the downwind ends of the craters (11, 14), some extending 1 km beyond the rim. Crater floors are partially stripped to expose a calcrete-like surface, especially towards downwind ends. Time of the Rio Cuarto impact remains uncertain, but was likely within the past few thousand years (11-12). Hence, degradation at Rio Cuarto is influenced by substrate and climate, thereby indicating the survival time of oblique craters in fine-grained substrates is short compared to deep craters formed by higher angle impacts (7).

Eolian Degradation at Rio Cuarto: Rapid, mostly eolian degradation predominates at Rio Cuarto based on analyses of regional sedimentology and preserved geomorphic features. Additional contributions to overall denudation are made by mass wasting and lesser fluvial processes. These conclusions are supported by: A) the large number and diversity of dunes in and around the craters that indicates a sustained, abundant sediment supply; B) the uniform, fine-grained character of the Pampean loessoid material that makes it susceptible to deflation; C) a paucity of large, lithic ejecta fragments capable of producing surface armoring lag deposits during erosion (15); D) formation of yardangs in some craters (14); E) low drainage densities in and around the craters (~0.4-2.5 km/km^2 and 0.3-0.5 km/km^2, respectively); F) rare examples of rim and wall incisement; and G) the degraded character of most mass wasting features inside the craters.

Eolian degradation is accomplished by strong prevailing winds that erode upwind rims of the Rio Cuarto craters, produce a net downwind transport of sediment, and cause backwasting of crater walls (Fig. 2). Some wind funneled into the craters escapes over side rims, decelerates, and forms deposits subsequently redistributed into dunes (Fig. 2). Eolian scouring of crater sides results in oversteepening, collapse, and significant crater enlargement via backwasting: resultant deposits are redistributed into downwind migrating transverse dunes as evidenced by the modified appearance of mass wasting debris. Most sediment stripped from crater floors is transported downwind through gaps in the impact topography (11,12) and forms longitudinal and more distal transverse dune fields. Fluvial degradation is limited by moderate hydraulic conductivity in the sandy loess (0.3-3.0 m/day) that combined with low regional gradients causes infiltration and subsurface drainage of most precipitation.

Comparisons to Mars: Analogy with Rio Cuarto indicates that eolian redistribution of sediment in areas of thick fine-grained accumulations on Mars can significantly degrade or even destroy craters. In these areas, craters may be largely confined to the fine-grained deposits, thereby creating a setting much like that at Rio Cuarto. On Mars, such craters may experience wholesale rim destruction by strong, shifting winds. Conversely, transport out of some craters could lead to near-rim deposition and formation of "false" rims. Deflation along crater walls, resultant oversteepening and mass wasting would destroy rims through backwasting and crater enlargement. Efficient eolian removal of sediment deflated from inside the Rio Cuarto craters implies that similarly derived grains could be removed from both shallow and perhaps deep martian craters by eolian activity. Therefore, eolian degradation of craters on Mars may not be self-limiting or produce obvious deposits, but may best be identified by the presence of near-rim or intra-crater dunes and a paucity of degradation signatures associated with other processes. Eolian modification of craters formed in the martian unconformable deposits may have accelerated during past epochs of more equable climate (4, 6-7). Similarities between the substrate and degradational character at Rio Cuarto and that inferred for craters in the fine-grained martian deposits implies comparative studies using high resolution Mars Observer imagery will further resolve the history of climate-controlled degradation on Mars.

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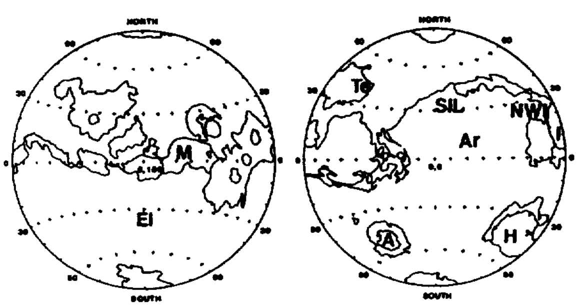

Figure 1. Regions of significant fine-grained, unconformable deposition on Mars. Letters correspond to the following locations: Mesogaea, M; Electris, El; Tempe, Te; southern Ismenius Lacus, SIL; Arabia, Ar; northwest of Isidis, NWI; Isidis basin, I; Argyre basin, A; and Hellas basin, H.

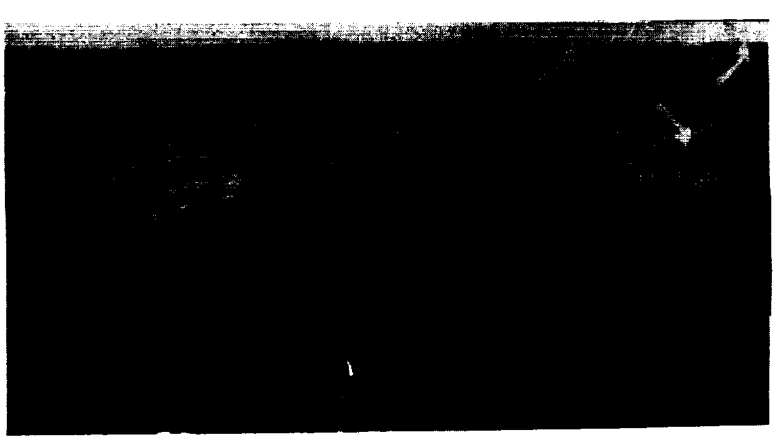

Figure 2. Prevailing wind flow (white arrows) into and through one of the smallest craters in the Rio Cuarto Field (~1 km long). These winds erode upwind sections of the rim and transport sediment eroded from along the walls out of the craters where it is deposited and redistributed into near-rim dunes. These bounding dunes grade to the level of the surrounding plains over several ~100's of m around the larger craters. Eolian degradation produces a net downwind transport of sediment.