AEOLIAN EROSION OF FILLED MARTIAN CRATERS. M. D. Day[1], G. A. Kocurek[1], W. E. Anderson[2], A. Hamed[3], K. T. Christensen[3], [1]University of Texas at Austin (mdday@utexas.edu), [2]Baylor University, [3]University of Illinois at Urbana Champaign.

Introduction: Craters are the dominant sedimentary basins on Mars. These topographic depressions provide immediate accommodation space for sediment influx and often house layered strata [1]. Understanding the dynamics of sediment transport into craters, the formation of layered strata within craters, and the potential for sediment transport out of craters are key elements of the overall sedimentary budget on Mars.

Many of the layered deposits identified within craters are interpreted to be horizontally bedded units that do not always extend across the entire basin floor [2]. Instead, orbital observations have shown a range of craters from fully filled, to those with central mounds, to those with small layered buttes [1]. Based on these observations, *Malin and Edgett, 2000* hypothesized that intracrater layered deposits erode predictably from flat, to pitted, to mounded, and eventually to small isolated buttes. To account for these different stages, we propose long-term aeolian erosion as the dominant process in forming these interior morphologies and transporting sediment out of craters.

Aeolian processes have been recognized as important to the erosion of the surface of Mars for decades [3]. Although saltation is difficult to initiate on Mars, once initiated, transport can be sustained even with winds an order of magnitude slower than the fluid threshold velocity [4]. With liquid water unstable on the Martian surface, wind becomes the main driver of sediment transport [5]. Dunes, ventifacts, regs, and yardangs litter the surface of Mars and provide direct evidence of aeolian erosion [6]. These features can be used to infer wind directions over time. More broadly, landscape evolution on Mars, including the formation of inverted topography and removal of strata, can be attributed to aeolian processes in the absence of water.

Gale Crater, the landing site of the Mars Science Laboratory rover Curiosity, contains an approximately 5 km high layered mound (Figure 1) [7]. Gale Crater is an example of a partially filled crater, in which the interior layered mound is interpreted to represent the intermediate stage of aeolian erosion from completely filled. This interpretation is an alternative to the hypothesis that the layered strata formed initially as a mound [8].

This study aims to address the hypothesis that long-term aeolian deflation could give rise to the spectrum of crater fill described by *Malin and Edgett, 2000*. We test the feasibility of this hypothesis with both physical and numerical models using a unidirectional wind. The development of more complex meteorological conditions once the crater is partly or completely evacuated of sediment [9] is not addressed here.

Modeling Filled Crater Erosion: Modeling approaches used here include: (1) large eddy

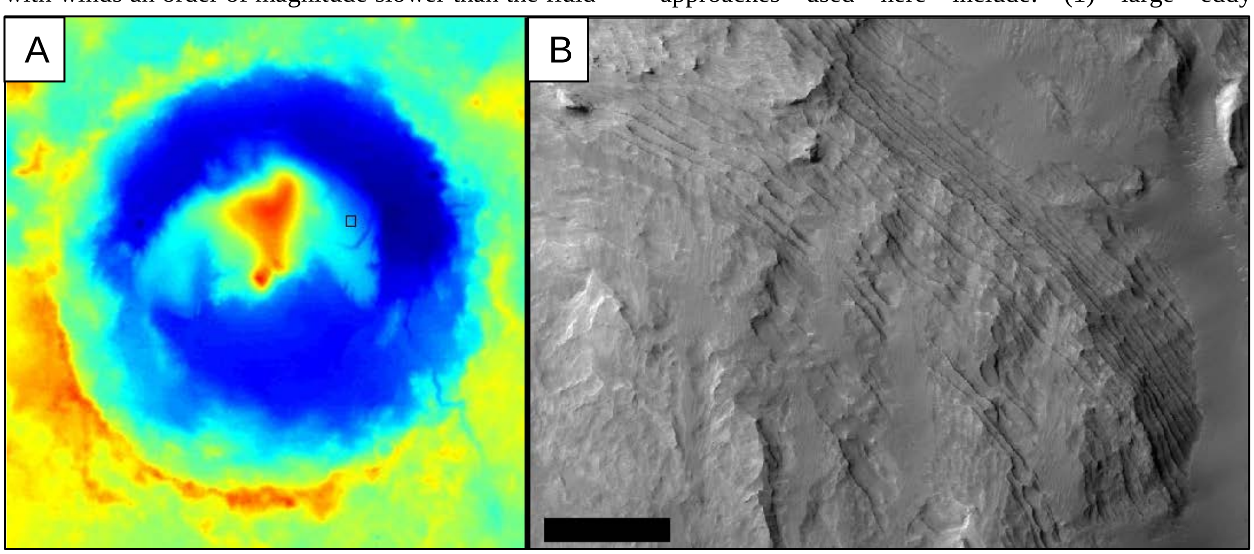

Figure 1: Example of a partially filled crater with interior layered deposit. Both panels are of Gale Crater and north is up. A) DEM of Gale Crater and its interior ~ 5 km high central layered mound. The black box indicates the approximate position of B). Gale Crater is ~155 km across. Background hillslope has been removed to facilitate volumetric analysis. B) HiRISE image of layered strata in Gale's central mound. Scale bar is 500 m. ESP_026291_1750.

simulation (LES), (2) physical modeling in a wind tunnel, and (3) refractive index matching (RIM). Each technique was conducted independently. Simulations begin their configuration with a filled crater.

Large Eddy Simulation: We conducted a series of LESs on a variety of modeled ideal crater topographies. Generated via superimposed Gaussian curves, the model crater topography was restricted to have a 1:10 depth-to-diameter ratio, as typical of fresh craters, or a 1:30 depth-to-diameter ratio, as consistent with more ancient examples. Crater models were all symmetrical, thus the chosen wind direction was arbitrary.

Wind Tunnel Modeling: A series of physical models were constructed to capture the topography of an idealized crater. Filled with fine sand, these crater models were subjected to a constant unidirectional wind, and their loss of fill monitored until empty. Like the LES models, the physical models were restricted to 1:10 or 1:30 depth-to-diameter ratios. Water was added to the sand at a ratio of approximately 1:7 in order to increase the cohesion of the modeled crater fill. Digital elevation models of the modeled crater and its interior were taken at time intervals during the experiment to quantitatively analyze the amount, location, and rate of material lost.

Refractive Index Matching: Flow around and over a model of Gale Crater is under study using the RIM technique in concert with particle-image velocimetry (PIV) measurements. The fluid and crater model have the same refractive index, allowing for high-resolution measurement of instantaneous fluid velocity fields using PIV. The crater model under study is a three-times vertically exaggerated topographic model of Gale Crater to analyze flow around the representative modern system. Based on the morphology of the mound, and previous analyses of aeolian features within the crater [10], we used a NNW wind direction for the study. Preparation and analysis of the data using this technique is presently underway.

Preliminary Results: Initial results from this study indicate that aeolian erosion can result in the formation of mounds from intracrater layered deposits. LES results indicate spatial differences in shear stresses over the interior of a partially filled crater. Observed stresses were higher near the rim and lower at the center. Associated with the formation of helical vortices just inside the crater rim, these elevated stresses indicate regions where erosion would be relatively increased (Figure 2). Wind tunnel experiments support these findings. When exposed to a unidirectional wind, the interior fill became pitted and was removed preferentially from the inner edge of the crater. This erosion generated an outer moat and then a central mound before eventually removing all material. We interpret the difference in stresses seen in the LES as the cause of preferential scouring near the crater rim observed in wind-tunnel experiments.

Our findings are consistent with orbital observations of intracrater layered deposits and the erosion hypothesis presented by *Malin and Edgett, 2000*. Though analysis is still ongoing, preliminary results of the study show that central mounds could form under certain conditions of aeolian flow. The simplicity of our approach thus far, however, limits the general application of the results to Mars, and raises important questions. Do the wind-tunnel and LES results apply to a range of crater sizes? At what point in sediment evacuation from craters do more complicated meteorological conditions develop? What grain size can be removed from craters and at what atmospheric density and wind speed? Coupled with our current findings, these questions will guide the scope of continued work.

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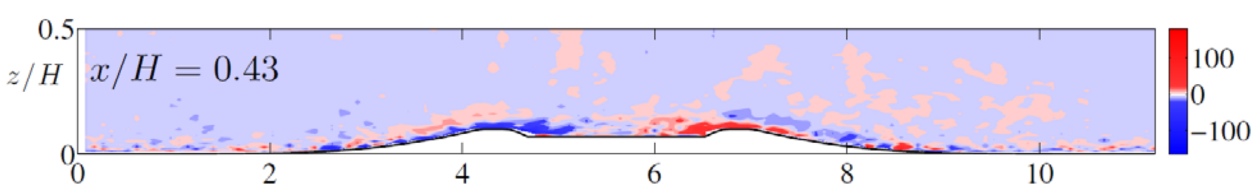

Figure 2: Contours of streamwise vorticity from large eddy simulation of flow over an idealized partially filled crater. The cross section is taken perpendicular to the flow direction and just inside the upwind rim of the crater. Blue and red indicate clockwise and counterclockwise vorticity respectively.