Aeolian Erosion of Filled Martian Craters

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Background

Craters are the dominant sedimentary basins on Mars. These topographic depressions provide immediate accommodation space for sediment influx and often house layered strata [1]. Many of these layered deposits are interpreted to be horizontally bedded units that do not extend across the entire basin floor [2]. Among these, Gale Crater contains an approximately 5 km high layered mound. Based on orbital observations, Malin and Edgett, 2000 hypothesized that intracrater layered deposits erode predictably from flat, to pitted, to mounded, and eventually to small isolated buttes. This study proposes that long-term aeolian deflation could give rise to the spectrum of crater fill described by above.

Aeolian processes have been recognized as important to the erosion of the surface of Mars for decades [3]. With liquid water unstable on the Martian surface, wind becomes the main driver of sediment transport [5]. Dunes, ventifacts, regs, and yardangs litter Mars for decades [3]. With liquid water unstable on the Martian surface, wind becomes the main driver of sediment transport [5]. Dunes, ventifacts, regs, and yardangs litter Mars for decades [3].

Large Eddy Simulation

We conducted a series of LESs on a variety of modeled ideal crater topographies. Generated via superimposed Gaussian curves, the crater topography was restricted to have a 1:10 depth-to-diameter ratio, as typical of fresh simple craters. Two stages of crater fill were tested: 100% fill and 90% fill (10% deflation). Crater models were all symmetrical, thus the chosen wind direction was arbitrary. Results indicate that helical vortices develop along the interior rim of the crater. We interpret these vortices and increased stresses to be the cause of high erosion rates observed in wind tunnel experiments.

Future Work

Future work will focus on answering the following questions:

• How do these results vary for complex craters?
• How does the flow field vary in an actively evolving crater?

Refractive Index Matching:
The flow over an acrylic model of the Gale Crater is currently under study using particle-image velocimetry (PIV) along with the refractive index matching (RIM) technique. Using the RIM technique grants full optical access to the model allowing for high-resolution measurements of the flow field over the crater. Spatial filtering was performed with the original DEM to mitigate the small scale roughness in the terrain of the crater.

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 a 1:10 depth-to-diameter ratio.

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 every two minutes during the experiment to quantify erosion rate.

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