Aeolian Slipface Processes on Earth and Mars

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Introduction

The surface of Mars is dominated by aeolian features and many locations show ripple and dune migration over the past decade with some sediment fluxes comparable to terrestrial dunes. One of the leading goals in investigating aeolian processes on Mars is to explore the boundary conditions of sediment transport, accumulation, and dune morphology in relation to wind regime as well as to quantify migration rates and sediment flux. The migration of aeolian sand dunes is largely accomplished by a series of grain flows that repeatedly occur on the lee slope (slip face).

Here, we present a comparison of terrestrial and martian grainflow morphologies on a dune slipface and provide approximate sediment flux estimates for the Namib dune slipface in Gale Crater, Mars. We aim to improve estimates of martian dune field migration, sediment flux, and grainflow magnitudes, frequencies, and triggers on slipfaces which will be investigated using 3D computational fluid dynamics (CFD) modelling in the near future.

Methodology

A series of ground-based, high-resolution laser scans were collected in the Maspalomas dune field in Gran Canaria, Spain to investigate grainflow frequency, morphology and slipface advancement. Analysis of these laser scans and simultaneous video recordings have revealed various forms of slipface activity (Fig. 1) and were recorded and categorised based on their morphology and the volume of sediment displaced.

We retrieved images of the Namib dune slipface in the Bagnold dune field on Mars released from NASA/JPL on December 21, 2015 on the 1200th martian sol of the Curiosity rover mission. Grainflow morphologies and other features on the Namib dune slipface were mapped for comparison between Maspalomas and Mars (Fig. 2). We have compared these grainflow morphologies from Maspalomas to those imaged by the Curiosity rover of the Namib slipace on Mars and have identified multiple similarities.

Grain flow thicknesses and volume estimates were approximated using trigonometric calculations based on measurements of shadow length and the sun's elevation at the time the image was taken for both the Maspalomas dune field and the Namib dune on Mars (Table 1). This technique has been verified by the laser scan data collected in Maspalomas, which showed the calculated grainflow thickness estimates to be within the range of thicknesses measured by the ground-based laser scanner.

Main Findings

The morphologies identified in Maspalomas include: *hourglass* (Fig. 1a), *Lobes* (Fig. 1b), and *slabs* (Fig. 1c and d). Identical morphologies were mapped on the Namib slipface on Mars (Fig. 2). Hourglass grainflows (red) and lobes (magenta) are easily distinguished on the Namib slipface while slab flows are less recognisable. It is possible the horizontal cracks (yellow) on the Namib slipface are an early indication of a slab flow in development, similar to Fig. 1c.

The volume of displaced sediment from the most recent wind-triggered event in Fig. 2 is ~16,300 cm^3. The estimated migration rate of the Bagnold dune field is about 0.75m/Mars year (1.8 Earth years), which equates to about 2.97m^3 of transported sediment for this portion of the Namib dune slipface. In order for this area of the slipface to advance 0.75m, the slipface must experience ~182 similar-sized grainflow episodes each Mars year, or 1 grainflow every 4 sols.

Concusions

The morphological similarities between grainflow events on the Namib dune slipface on Mars and those observed in Maspalomas are striking. This work provides new insights into the mechanisms of dune migration and is the beginning of a new avenue of research analysing slipface dynamics in unprecedented detail for both terrestrial and martian aeolian systems.

BSG Travel Grant Value

The BSG travel grant I received made it possible for me to attend EGU for the entire week, allowing me to attend more talks and poster sessions which increased my opportunities for networking and exposed me to similar research projects in my field that informed me of new discoveries and insights in my field of research. The talks I have attended have had a positive impact on how I interpret my research findings and have better prepared me to submit my research for publication.

In addition, I was able to present my own work to a large international audience, which gave me invaluable opportunities to discuss my research with other graduate students and geoscientists for exchanging ideas and chances for future collaboration opportunities.

Table 1. Grainflow statistics including total area of individual flows, thickness of flows, and volume estimates of sediment displacement for each grain flow for earth (Maspalomas, Gran Canaria, Spain) and Mars (Namib dune, Bagnold dune field, Gale Crater).

Maspalomas		**Slipface Slope**	26.6-29.1 deg.
	Grainflow Area (cm^2)	**Avg Flow Thickness (cm)**	**Sediment Volume (cm^3)**
Hourglass	6,205.42	1.86	11,532.01
	20,423.74	1.88	38,313.09
lobes	343.29	1.81	621.36
	741.89	1.11	1,443.75
	2,257.74	1.23	4,876.72
Slab	>118,620.818	2.1	249,557.32
Namib Dune		**Slipface Slope**	26-28 deg.
	Grainflow Area (cm^2)	**Avg Flow Thickness (cm)**	**Sediment Volume (cm^3)**
Hourglass	2,378.01	0.33	784.74
	7,490.50	1.06	7,947.10
lobes	7.314	0.14	1.31
	66.465	0.19	16.15
	83.238	0.16	16.98
	138.827	0.24	43.04
Slab	~16,333.404	0.46	7,507.17

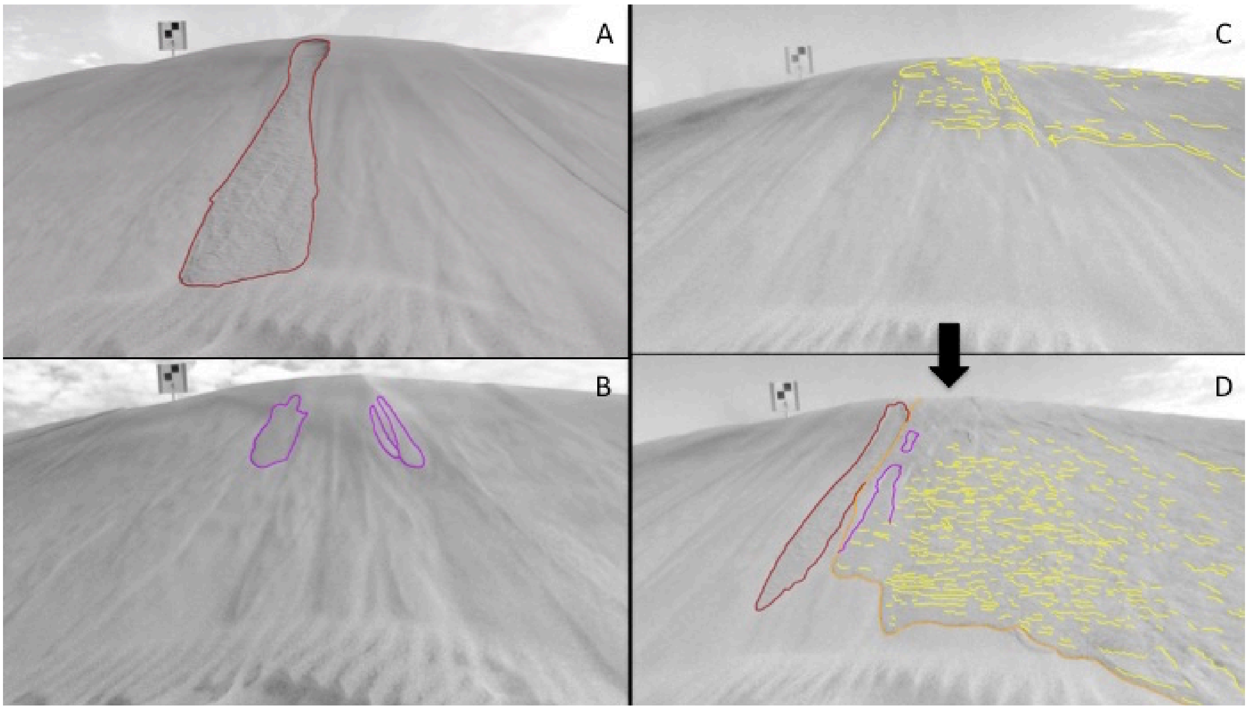

Figure 1. Morphologies of grainflows observed in the Maspalomas dune field study site including hourglass, lobes, and slab. Hourglass grainflows have been mapped in red; lobes in magenta; slabs in orange; and cracks associated with slab formation in yellow. Cells C and D show the development of horizontal cracks that transition into a slab grain flow.

Figure 2. Namib dune slipface in the Bagnold dune field, Mars showing identical grainflow morphologies to the Maspalomas dune slipface. Mapped features include hourglass grainflows (red); lobes (magenta); horizontal cracks possibly associated with slab formation (yellow) and ripples (blue; B).