

GEOMORPHOLOGICAL STUDY OF SMALL-SCALE MASS MOVEMENT EVENTS AT GALE CRATER, MARS. C. M. Rodriguez Sanchez-Vahamonde^{1,2}, E. G. Rivera-Valentín³; ¹Arecibo Observatory, Universidad Metropolitana, Arecibo, PR 00612; ²Dept. of Geology, University of Puerto Rico at Mayagüez, Mayagüez, PR 00680 (carolina.rodriguez2@upr.edu). ³Arecibo Observatory, Universities Space Research Association, Arecibo, PR 00612 (ed@naic.edu).

Introduction: The possibility for liquid water processes on Mars is reinforced by observations of potentially liquid-triggered mass movement events such as Recurring Slope Lineae (RSL) [1-3], which form on equator-facing walls during spring, fade during the summer, and reoccur every year following the same channel, and the identification of associated hydrated mineralogy [4]. Surface missions with environmental sensors have also demonstrated that measured conditions on the surface of Mars would permit for deliquescence [5,6], the transition from a solid, crystalline salt into an aqueous solution. Indeed, measurements from the Mars Science Laboratory (MSL) Rover Environmental Monitoring Station (REMS) suggest that surface conditions at Gale Crater permit the deliquescence of calcium perchlorate [6], a probable constituent of the regolith at Gale crater [7-9].

Should liquid water form within Gale crater, it may instigate small-scale mass movement events, especially accounting for local topography. Equator-facing slopes within Gale crater would experience higher temperatures, which could permit for more stable areas for liquescence. Indeed, experiments of deliquescence of hygroscopic salts under martian conditions have demonstrated they undergo hysteresis [5,10], lasting much longer, even under replicated diurnal conditions [5]. Here we search for mass movement events at Gale crater by searching for their characteristic morphologies in order to investigate the possibility of active, liquid water processes on present-day Mars.

Methods: We used MastCam, a camera system on board the MSL that supports the driving and sampling operations of the rover, to make a geomorphological catalog of small-scale, mass movements events observed along the rover's traverse from sol 001 through sol 1376. The Martian landscape, soils, and rocks are examined for observable frost and weather phenomena. Images were examined for movements of surface material caused by gravity with a combination of geological agents. We used albedo variations and distinguishing morphologies such as alcoves, aprons, incised, sinuous and/or depositional channels to identify the downslope events. Also, dark or light brown sand channels with bulbous or multi-bulbous ends were taken in consideration. Landscape with bedrocks were given special attention as were areas with cobbles and pebbles for a chance of a visible mass movement event.

Context images of identified mass events were analyzed for evidence of potential triggering by the rover, such as through use of MSL's sampling system.

Results: A total of 71,708 images were studied from which a total of 77 mass movement events were identified. We found that the morphologies could be categorized into five groups.

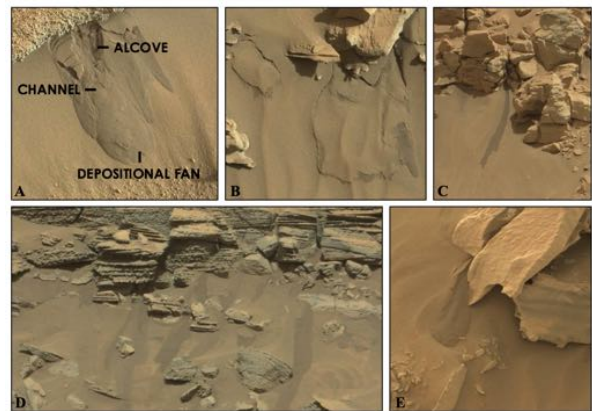


Figure 1. The five archetypes of flows found through MSL's path from sol 001 to 1376 using MastCam images. (A). Events with a defined alcove, channel, and apron, (B). Large mass heap that emanates from underneath lighter sand, (C). Thin, long sinuous channels with no clear incision or depositional sand, (D). Multi-channel events with diverse ends, and (E). Depositional dark sand with bulbous ends. *Image credit: (NASA/JPL-Caltech/MSSS)*

A. Events with a defined alcove, channel, and apron: These features are defined by their alcove, channel, and apron that emanate from a bedrock. They do not include intermixed rocks within the feature, but cobbles and pebbles are visible at the very end apron. This may indicate a high-energy event in order to dislocate the pebbles.

B. Large mass heap that emanates from underneath lighter sand: These features are characterized by two sand colors, light and dark brown, with multi-bulbous ends and it seems that large dark sand mass heaps emanate from underneath lighter sand.

C. Thin, long sinuous channels with no clear incision or depositional sand: This group is associated with thin, long, and sinuous flow-like features that emanate from a bedrock. They do not have a clear incision or depositional sand.

D. Multi-channel events with diverse ends: This group is characterized by many, superimposed, flow-like features with diverse ends emanating from a bedrock. They do not, though, have an alcove, or an apron. Rocks mixing within the flow are not visible. Dark brown sand seems to be emanating from beneath lighter sand.

E. Depositional dark sand with bulbous ends: These features are characterized by dark, depositional sands with bulbous ends that are emanating from a bedrock, but they do not show a well defined source. Cobbles and pebbles are visible in the movement area.

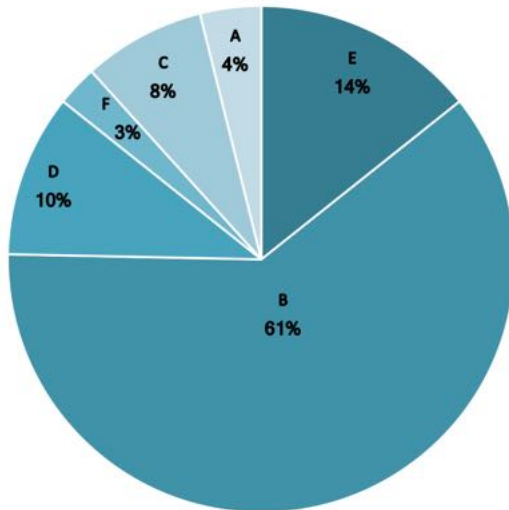


Figure 2. Pie chart demonstrating the occurrence of the identified morphological categories by percent. The letters (A-E) correspond to the morphologies identified in this abstract. Category F corresponds to “Undefined Features”, which are those whose morphologies did not clearly fit within the morphological categories defined in this study.

In Figure 2, we show the percent distribution of the observed categories. We find that 61% of the 77 observed events throughout the traverse of MSL rover correspond to the large mass heaps that emanate from underneath lighter sand, which is the second archetype described above (*i.e.*, type B). The second most abundant archetype corresponds to the depositional dark sand flows with bulbous ends, which accounts for 14% of the total identified mass movement events. 10% of the data correspond to the multi-channel events with diverse ends and the thin, long sinuous channels with no clear incision or depositional sand account for 8% of the data. Events with a defined alcove, channel, and apron only accounted for 4% of the data while another 3% of the data correspond to Undefined Features, which could not be clearly catalogued. No strong seasonal correlation for the observed features was found, but B were only found during winter.

Some features were identified as instigated by the rover during the drilling process. We were thus able to use the observed morphology of the mass movement event as an example of a dry flow. All identified events and morphologies were compared to these, an example of which is shown in Figure 3.

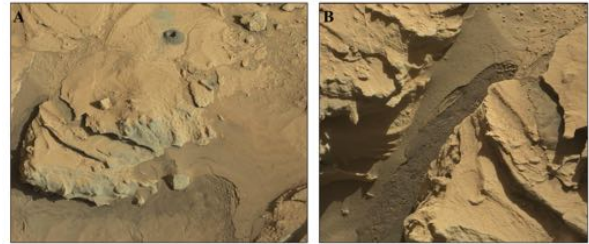


Figure 3. Downslope event instigated by the rover during a drilling process. Here we are showing the context image with the drill site (A), and a zoom in image showing the feature (B).

Conclusions: Our results suggest that small-scale mass movement events within Gale crater are rare as only 77 features were identified during a traverse that covered 1376 sols. Additionally, the identified morphologies seem to indicate that the majority of the observed features correspond with dry events, perhaps instigated by creep. Some observed features, though, do follow morphologies that are associated with liquid-triggered events on Earth. However, the low gravity environment on Mars has been shown to permit mass movement events to enter the flow regime and produce flow-like morphologies without liquids [11, 12]. Further thermodynamic analysis is required to reveal if such features are related to time-periods when liquid water is stable within Gale crater, which could elucidate a link between liquid water availability and the production of small-scale, flow-like features.

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