ACTIVE FLOWS AT THE MARS SCIENCE LABORATORY LANDING SITE: RESULTS FROM A SURVEY OF MASTCAM IMAGERY THROUGH SOL 971. J. L. Dickson[1], J. W. Head[1] and M. Kulowski[1], [1]Brown University Department of Earth, Environmental and Planetary Sciences, Providence, RI 02906 USA, jdickson@brown.edu

Introduction: Given the low rates of erosion observed at other landing sites [1-2] and Gale Crater's equatorial latitude where condensation and sublimation of volatiles are not expected [3], sediment transport under contemporary conditions should generally be dominated by saltation of fines. Recent analysis of repeat HiRISE imagery of steep slopes within Aeolis Mons, however, reveals what appear to be new dark downslope flow features in the vicinity of the Mars Science Laboratory (Curiosity) rover [4]. Further, in-situ measurements from the Rover Environmental Monitoring Station (REMS) show that conditions are sufficient during martian night to achieve deliquescence of perchlorate salts [5] known to exist at the MSL site [6]. This introduces the intriguing possibility that the MSL landing site is capable of downslope sediment transport under contemporary conditions.

We conducted a survey of all Mastcam imagery through sol 971 to determine if any slopes show evidence for downslope transport of sediment. To facilitate documentation and avoid redundant observations, 404 mosaics were made (Fig. 1). Among features that were documented: (1) downslope-trending channels, (2) flow fronts, (3) brittle failures that reveal the substrate and (4) low-albedo streaks. Where available, features of interest were evaluated using Navcam stereo products to determine morphological properties. All features consistent with recent or active downslope movement were mapped in HiRISE imagery to assess spatial distribution as a function of the rover's traverse (Fig. 1).

Features observed to form while MSL was in close proximity were discarded from consideration, under the assumption that these were avalanching events caused by the rotary percussive drill or by the motion of the rover itself.

Results: Eighteen mastcam mosaics show evidence for what we interpret to be recent localized downslope movement of fine grained material. Their distribution is controlled by slope availability, with all but two examples occurring in either the Kimberly Formation or Hidden Valley (Fig. 1). These features generally occur in two forms: (1) Brittle detatchment failures and (2) low-albedo flows.

Brittle detatchment failures. The regolith at the Gale Crater site is typically characterized by an armoring layer superposed on a lower albedo unconsolidated fine-grained deposit [7]. We observed 13 separate mosaics that showed this armoring layer detatch in a brit-

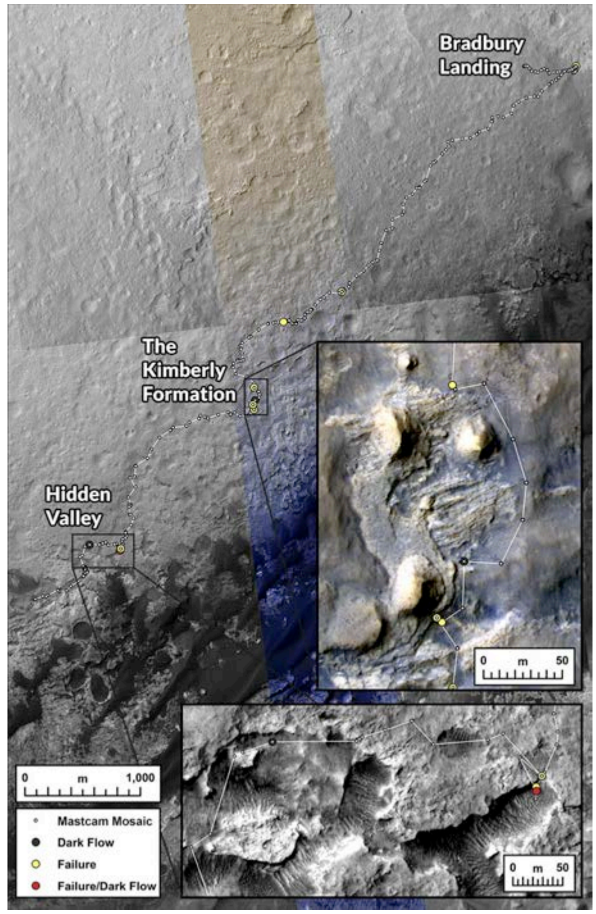

Figure 1. HiRISE mosaic of MSL's traverse through sol 971. Each white marker indicates a Mastcam mosaic constructed and analyzed for this study.

tle manner and slump downslope by ~1 cm (Fig. 2). These failures are directly associated with outcrop overhangs and fractures, with most occurring either directly beneath an overhang or within a few cm. Low-albedo fine-grained material beneath this armoring layer is frequently liberated in small flows associated with the failures (Fig. 2), similar to those described below.

Low-albedo flows. In both the Kimberly Formation and Hidden Valley (Fig. 1), low-albedo material emanates from fractures within outcrops (Fig. 3). Flows are generally around 10 cm in downslope length (Fig. 3b) and vary in morphology. Some exhibit rounded, lobate margins indicative of coherent flow (Fig. 3a) while others are thinner and elongate with increased length to width ratios indicative of fine granular transport.

Figure 2. Mastcam mosaic from sol 631. Brittle failures beneath an outcrop in the Kimberly Formation release low-albedo material. All similar features mapped along MSL's traverse have been in direct association with overhangs and/or fractures. Entire scene is ~20 cm across at the base of the outcrop.

The flow in Fig. 3a was imaged six times in stereo with the Navcam instrument, allowing for repeat measurements of local slope. Slope measurements range from 31.2° to 37.6° with a mean of 34.1°. Slope aspect was estimated using rover and instrument pointing information. These data show that low-albedo flows are only observed on east-facing slopes (Fig. 4), though this could be strongly controlled by slope availability, as the rover has investigated fewer west-facing outcrops.

Discussion: The fresh appearance of these downslope features and their low albedo (i.e. not yet resurfaced by dust) strongly suggest that they are very young and likely represent an ongoing process at Gale Crater. What processes on contemporary Mars could account for this activity? Any explanation would have to account for the apparent 1:1 correlation between low-albedo flows and outcrop fractures and/or prominent overhangs.

The simplest explanation is that fractures and overhangs serve as sediment traps for eolian particles.

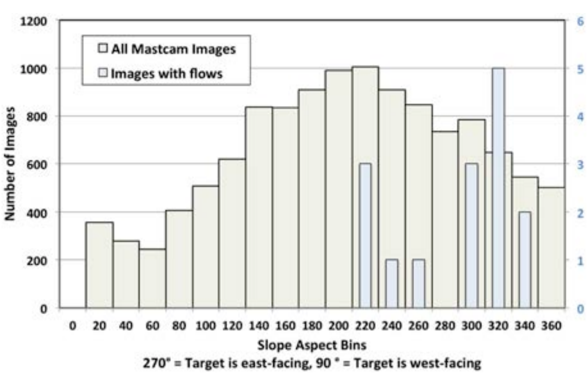

Figure 4. Aspect angle for Mastcam images that contain low-albedo flows. All flows observed through sol 971 have been generally on east-facing slopes.

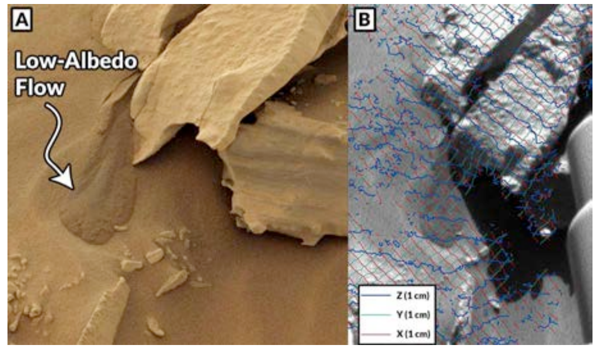

Figure 3. (A) Mastcam mosaic from sol 606 at the base of Mt. Remarkable in the Kimberly Formation. A low-albedo flow emanates from a fractured outcrop. (B) The same feature using the left navigation camera with mesh contours derived from Navcam stereo data overlain.

Gradually, the collected material reaches the angle of repose, inducing granular flow. Since the albedo of the flow is lower than the surrounding regolith, this implies that grains coarser than martian dust are included in the redistributed sediment.

The direct association between flows and fractures/overhangs could also be accounted for by a transient brine model. REMS data show that humidity levels during martian night are sufficient to cause deliquescence of perchlorate salts in the regolith, though this thin brine layer would quickly evaporate [5]. This could account for the destabilization of the armoring surface layer on steep slopes (Fig. 2), which in turn releases underlying dry low-albedo fines. Further, brines that form within fractures would be shielded both during the day and on seasonal timescales and thus more capable of accumulating in small amounts, triggering small, sediment-laden brine flows. This may provide a better explanation for features indicative of more coherent flow (e.g. Fig. 3a). Slope measurements (Fig. 3b), however, show that brines are not required to induce flow at these locations.

Neither of these hypotheses excludes the other, such that both processes could be occurring on present-day Mars. Further detailed analysis of outcrops at the base of Aeolis Mons including detailed slope measurements and small-scale morphology could help to distinguish which features formed by which process.

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