

SIGNIFICANT BOULDER MOVEMENT ON CRATER SLOPES IN TERRA SIRENUM, MARS. P.M. Grindrod¹, J.M. Davis¹, S.J. Conway², and T. de Haas³, ¹ Natural History Museum, London, UK (p.grindrod@nhm.ac.uk), ² Université de Nantes, France, ³ Universiteit Utrecht, The Netherlands.

Introduction: The last decade has seen significant improvements in the identification and monitoring of active surface processes on Mars. Repeat observations have allowed the study of a wide range of features and processes. Many of these studies have concentrated on changes observed on the slopes of crater walls, particularly on gully [e.g. 1] and recurring slope lineae (RSL) features [e.g. 2]. To date, none of these active features have been driven by endogenic processes, with environmental conditions instead more likely. However, given the successful landing of InSight, and possible imminent detections of Marsquakes, we are interested in identifying features that are not easily explained by environmentally-driven processes. To this end, we recently developed a technique for identifying surface deformation related to Marsquakes, but found no such evidence in a small area of Cerberus Fossae [3].

Here we use repeat images to study significant boulder movement in an unnamed crater in Terra Sirenum. Dark flows on the crater walls are made mostly of meter-scale boulders, and through a rigorous co-registration procedure, have identified several areas of active boulder falls within this crater and discuss possible causes for the activity.

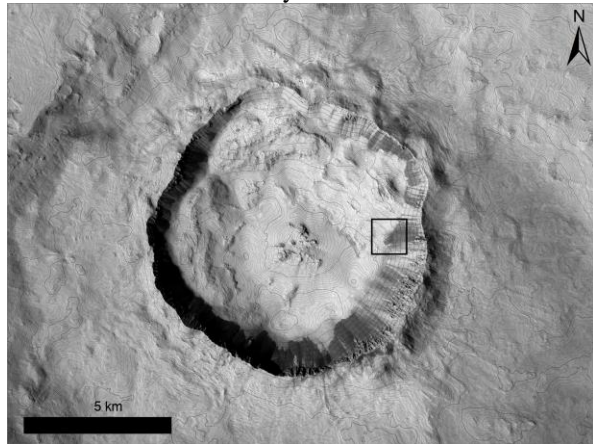


Figure 1. CTX orthoimage and contours (intervals: thick = 100 m, thin = 10 m) from stereo DTM, of the study crater. Black box shows the location of Figure 2.

Data and Methods: We utilized repeat CTX and HiRISE images of the study region, which cover over 10 Earth years. We followed standard stereo Digital Terrain Model (DTM) and image co-registration procedures [e.g. 4], using ISIS and SocetSet. All images were orthorectified to the DTM and underwent post-processing in ISIS before exporting to a GIS package for analysis.

CTX. As of December 2018, there are 6 repeat CTX images covering the target crater, including all wall slopes. We created a stereo DTM to which all CTX images were co-registered and orthorectified.

HiRISE. As of December 2018, there are 9 repeat HiRISE images covering the target crater, with 5 of the western wall and 4 of the eastern wall. We created a stereo DTM of both walls, and co-registered and orthorectified the relevant images. We concentrate this study on the eastern wall, due to better illumination conditions across images.

Study Area – Crater in Terra Sirenum: The study area is a ~9 km diameter unnamed crater (-15.7°, 203.6°), that sits within a larger ~25 km diameter crater in Terra Sirenum, approximately 275 km NNW of Mangala Fossae. Dark deposits on the slopes of the crater can be observed in CTX images (Figure 1), which in HiRISE images can be resolved of being mostly composed of meter-scale boulders (Figure 2). These deposits appear relatively young, with no apparent effect from aeolian modification or impact craters – in short, these deposits appear to be the most recent geomorphological features in this crater.

Observations: Here we summarize the active changes that we have observed in this crater, and complementary observations in the surrounding region.

CTX. Changes in CTX images appear mostly as localized darkening of features measuring a few pixels across. Due to the illumination effects, most of these changes are identified on the eastern wall. It is not clear at this image resolution whether the changes reflect common slope streaks [e.g. 5] or some other feature type.

HiRISE. Changes in HiRISE images reveal that the larger-scale (~10 m) darkening of the surface is due to the movement and impact of meter-scale boulders bouncing and rolling down the crater walls. Dark streaks are left on the steeper parts of the slopes, whereas ‘herringbone pattern’ dark patches are present on the shallower slopes, where boulders have impacted. Numerous smaller scale (~1 m) slope streaks are seen to form on smaller slopes inside the crater. We also observe areas similar features that have become more subdued in appearance over time, as a result of dust deposition. Overall, we observe noticeably more boulder movement between 7 June 2007 and 28 March 2012 than between 28 March 2012 and 17 October 2018. Most of the change in the latter time period is dust obscuration of previous changes.

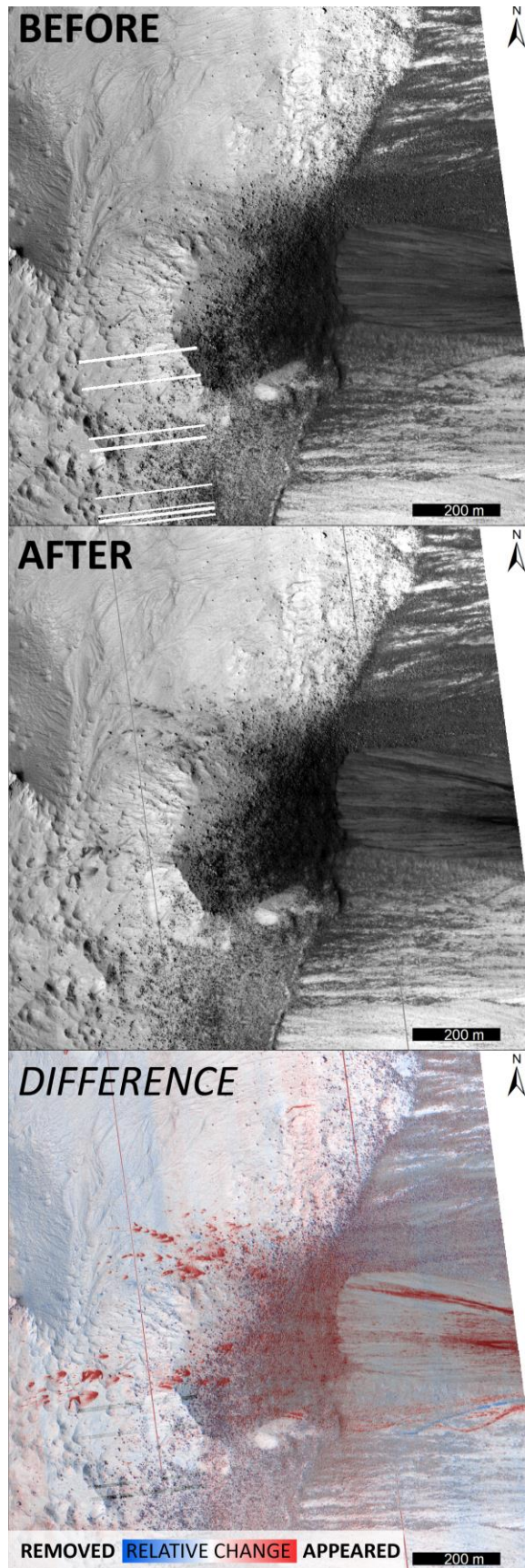


Figure 2 (Opposite). Typical boulder movement. HiRISE images of before (top) and after (middle) nearly 6 (Earth) years. Bottom image highlights the changes, with red showing features that have appeared, and blue features that have been removed/faded.

Discussion: There are several plausible mechanisms for the changes that we have observed. It is noticeable that no other impact crater or steep slope in the surrounding region have similar boulder-rich deposits, suggesting that it is possible that there is a local boulder layer that is being exposed, exhumed and undergoing collapse in our study crater. However, this reasoning does not fully explain the apparent stochastic nature of the changes, which could be due to localized processes such as Marsquakes, enhanced aeolian erosion, or recent impacts. We investigated the latter by checking all (218 as of December 2018) HiRISE images for slope streaks and possible new impacts, within a 500 km radius of the study area (Figure 3). We find no correlation between the distribution of slope streaks, new impacts and boulder movement, leaving open the question of the process responsible for these changes.

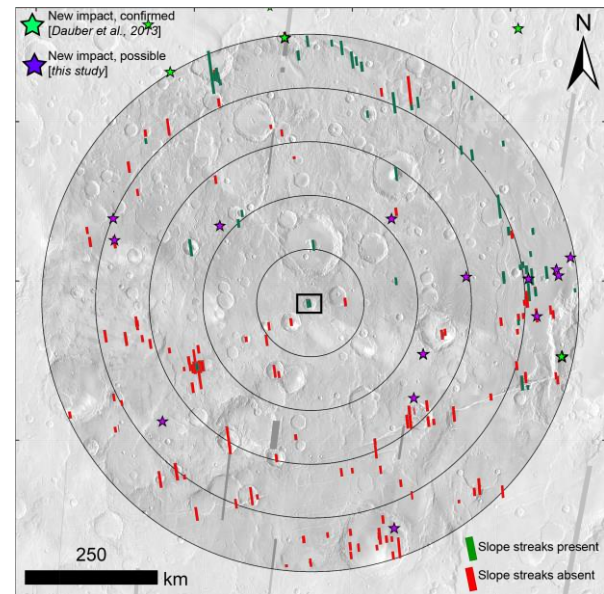


Figure 3. Regional distribution of HiRISE images with (green) and without (red) slope streaks, with circles of 100-500 km radius centered on the study area. Also shown are confirmed [6] and possible [this study] new impact sites.

References: [1] Dundas, C.M. et al. (2015) *Icarus*, 251, 244-263. [2] McEwen, A.S. et al. (2013) *Nature Geosci.*, 7, 53-58. [3] Grindrod, P.M. et al. (2018) *JGR*, 123, 1881-1900. [4] Fergason, R.L. et al. (2017) *Space Sci. Revs.*, 211, 109-133. [5] Schorgofer, N. et al. (2007) *Icarus*, 191, 132-140. [6] Dauber, I.J. et al. (2013) *Icarus*, 225, 506-516.