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A survey of landforms indicating slope processes in the mid-latitudes of Mercury

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Introduction: The way that material is transported downslope via mass wasting can be indicative of the environmental conditions of that planetary body. For example, on Mars the discovery of gullies (alcove-channel-fan systems) was initially linked to flowing liquid water (e.g., Malin and Edgett, 2000), but now is linked to the seasonal sublimation of carbon dioxide ice (e.g., Dundas et al., 2019) and hence the existence of gullies tells us about the climate on Mars. The existence of long runout landslides on Ceres has been linked to the existence of ground ice on that body (Duarte et al., 2019). Before the arrival of MESSENGER at Mercury, processes driven by crustal volatiles were not considered likely, yet the existence of faculae indicating explosive volcanism (e.g., Jozwiak et al., 2018) and hollows indicating volatile loss in the top ten to hundreds of metres (e.g., Blewett et al., 2011), have refuted this assumption. Inspired by these discoveries and the serendipitous identification of what appear to be downslope mass wasting features (Malliband et al., 2019), we have performed a systematic survey for landforms that may indicate slope processes. In a second step we will then assess if these features are linked to surface volatile-driven processes. The results of our survey will be useful for selecting targets for acquisition by BepiColombo's instruments.

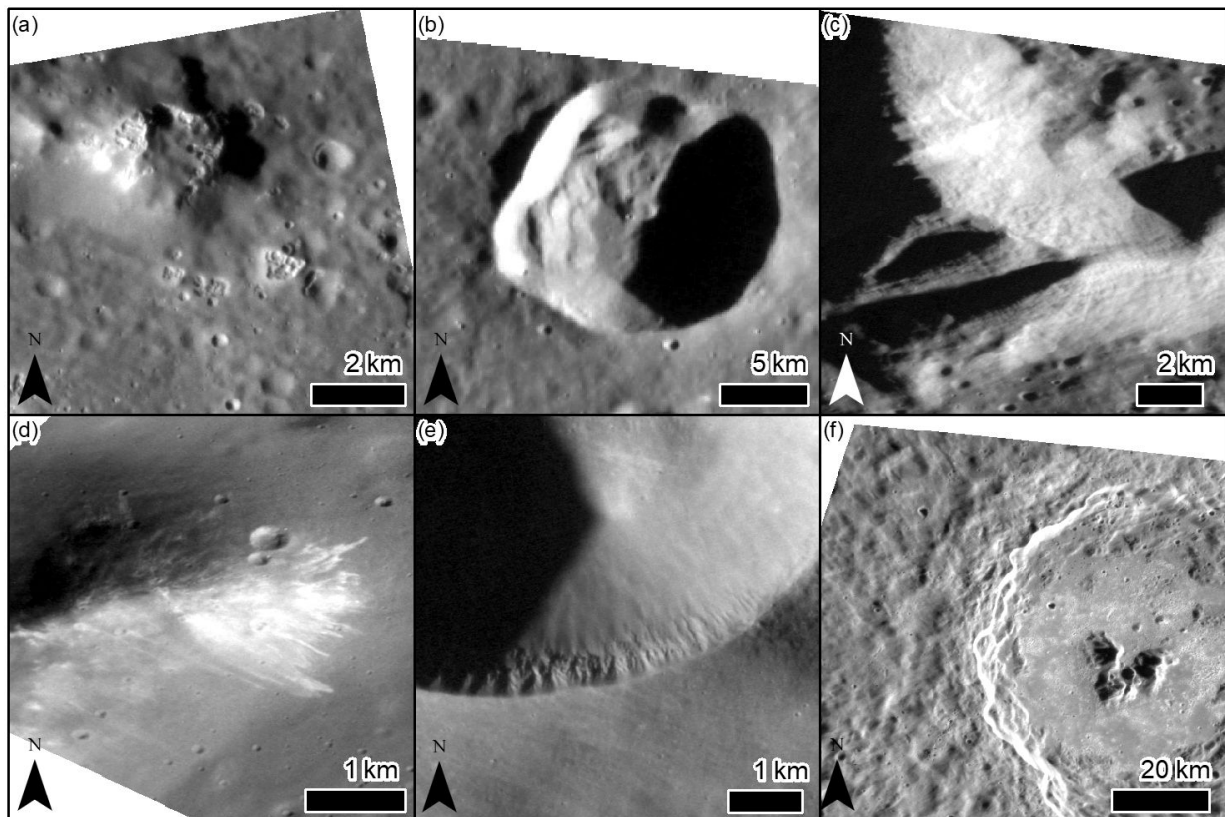


Figure 1: Examples of features identified in this study: (a) hollows in image EN0221196012M, (b) landslides on a crater wall in image EN0227768640M, (c) Cross-hatch texture in image EN0223744554M, (d) lineae in image EN1044173928M, (e) spur and gully morphology in EN1034263486M and (f) lobate ejecta in image EN0220761474M.

Data and Methods: We used all images from MESSENGER's Mercury Dual Imaging System (MDIS) Narrow Angle Camera (NAC) at better than 100 m/pixel mean resolution between latitudes of 20°N and 65°N to survey for landforms that might indicate slope processes. Here, we report on the intermediate results where we have found 1387 images out of the 8936 so far analysed which have evidence for potential slope processes.

Preliminary results: We have so far identified the following distinct classes of landform (in descending order of frequency), shown in Figure 1:

- Hollows – these are the most common landform we identified and can be found superposed on sloping terrain. As reported in previous research (e.g. Blewett et al., 2011; Thomas et al., 2014) they are identifiable by their high albedo and are expressed as steep-sided shallow flat-floored depressions. They can be up to tens of kilometres in diameter. Hollows are identifiable even in the highest resolution images so we cannot give an estimate of their minimal diameter.
- Lineae – first identified by Malliband et al. (2019) these are downslope trending linear features that are expressed as albedo in high-sun images and as relief in low-sun images.
- “Cross-hatch” also called “Elephant hide” texture (Zharkova et al., 2020) which is also found on the Moon, is a regular surface texture.
- Landslides – identifiable by the head-scarp and associated deposits as reported in Brunetti et al. (2015).
- Spur and gully morphology - characterised by protruding regularly spaced spurs of bedrock at the top of the slope with talus aprons downslope. They commonly found on Mars (Conway et al., 2018) and rarely on the Moon (Senthil Kumar et al., 2013) and Vesta (Krohn et al., 2014).

- Ejecta lobes – these are coherent sheets of ejecta deposits with a somewhat lobate, raised lateral margins as described in (Xiao and Komatsu, 2013) and have been related to topographic steps.
- Rimless pits, interpreted as volcanic vents (e.g., Jozwiak et al., 2018; Pegg et al., 2021) – these were mapped to provide context to the other observations, as they indicate volatile-driven processes and their steep walls can host mass wasting features.

Conclusions and future work: Nearly all the features described above are associated with slopes on crater walls or peak elements, with relatively few occurring on the walls of pits interpreted as volcanic vents. We aim to analyse the geographic distribution of these features taking into account their visibility with viewing geometry/illumination conditions. Further, we will examine their context and inter-relationships. Our preliminary observations indicate that, spur and gully morphology, lineae and ejecta lobes only occur only in relatively fresh craters, whereas “Cross-hatch” morphology is only found in relatively degraded craters.

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