MARTIAN "GULLIES": A MORPHOLOGICAL AND MORPHOMETRICAL (RE-)CLASSIFICATION OF PROCESSES ON CRATER WALLS IN EASTERN UTOPIA PLANITIA, MARS. Radu Dan Capitan[1], Gordon R. Osinski[1,2] and M. Van De Wiel[3], [1]Centre for Planetary Science and Exploration University of Western Ontario, London, ON, Canada N6A 5B7 (rcapita@uwo.ca), [2] Dept. of Earth Sciences/Physics and Astronomy, University of Western Ontario, London, ON, Canada N6A 5B7 [3]Dept. of Geography, University of Western Ontario, London, ON, Canada N6A 5C2.

Introduction: The mechanisms of formation and the environmental conditions required for the development of different types of temporary short channels on Mars – typically collectively referred to as "gullies" in the literature – have been debated since their discovery by Malin and Edgett (2000a). Most models invoke, and are intrinsically linked to, the availability of liquid H_2O on Mars during recent times (e.g., Malin and Edgett, 2000a; Head et al., 2008; Lanza et al., 2010; Levy et al., 2010; Kneissl et al., 2010). Generally, the generic term describing the erosional and depositional processes affecting crater walls associated with brief water runoff is "gullying" (Carr, 1996; Malin and Edgett, 2000a; Dickson and Head, 2009); although the most recent comparisons with terrestrial counterparts also refer to debris flows (Dickson et al., 2007; Lanza et al., 2010). Here, we show that both mechanisms of formation and terminology to describe such processes can be revisited and better constrained using the morphological indicators and morphometrical characteristics of landforms developed on impact crater walls.

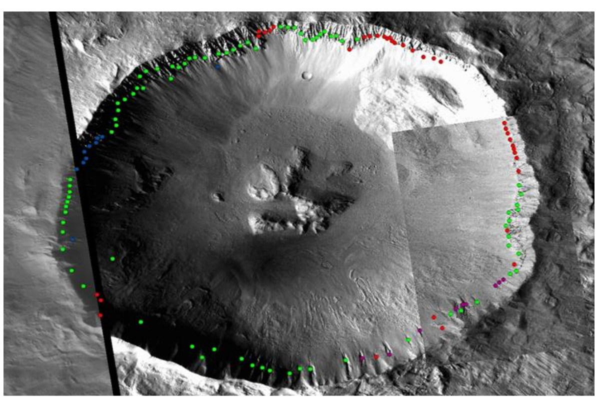

Fig. 1. A Martian impact crater in eastern Utopia presents different types of morphologies that shape its walls. Image credit: CTX and HiRISE imagery NASA/MRO.

Study region: The study sites are located north and west of Hrad Vallis in eastern Utopia Planitia in the northern plains of Mars. The geologic deposits that cover this area comprise volcanic products on the flank of Elysium Mons and impact crater deposits. We have focused on three arbitrary craters of diverse diameters to evaluate the characteristics of "gullying" processes. Mapping of inner crater deposits of the three craters shows that surface deposits comprise brecciated deposits of crater rims and coluvial deposits on the flanks of the crater walls.

Results: This study indentifies a variety of processes associated with erosional and depositional structures within impact craters in eastern Utopia Planitia, Mars (Fig. 1). Differentiation of the morphological characteristics of erosional and depositional structures within three impact structures suggests that four types of landforms develop on craters walls (Figs. 1, 2): (a) debris flows, (b) linear or dendritic channels resembling gullies, (c) head-cut channels, and (d) dry flows; besides these structures most of craters walls are covered with talus deposits (e) (Figure 2). More than 260 individual examples of these four landforms were identified, mapped and classified.

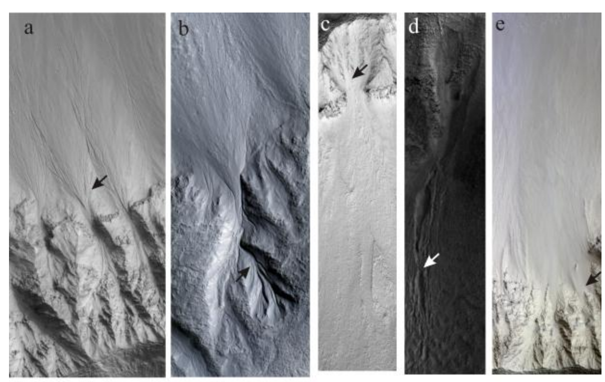

Fig. 2. Five types of channeling and mass movements can be identified in the study region and can be assimilated in to the current description of Martian gullying. (a) Debris flows; (b) Gullies; (c) Dry flows; (d) Head-cut-channels; (e) Talus. Arrows point to the specific landforms. Scale bars are 100 m. Image credit: HiRISE imagery NASA/MRO.

The morphometrical characteristics of flows on craters walls show that there is a relationship between the accumulation area and slope of processes, which indicate a morphometric threshold between the wet and dry phases of erosion; with gully channels developing on low angle colluvial slopes while the debris flows are forming on more abrupt slopes (Fig. 3).

Discussion: Careful consideration of the morphological characteristics of the erosional and depositional structures suggests that four types of landforms developed on these craters walls (Fig. 2): debris flows, linear or dendritic channels resembling gullies, head-cut channels, and dry flows. Thus, previous conclusions based on the regional or global occurrence of so-called “gullies” may need to be revisited because, as we have shown, not all of these landforms are, in fact, gullies by definition.

Previous studies [1,2,3] have mostly focused on the orientation characteristics of gully-type landforms and the environmental conditions that contributed to their formation. Most of these studies favored the term gully for all wet processes affecting crater walls, although debris flows have also recently been described [4,5]. The full development of these structures shows that the wet-member structures (e.g., temporary channels resembling gullies) and mixed types (e.g., debris flows) evolved under different environmental conditions than that of present-day Mars. It is suggested that the most important controlling factors for flow initiation and development on the crater walls are related to the morphometry of craters walls, water availability and exposure of bedrock within crater walls (Fig. 3).

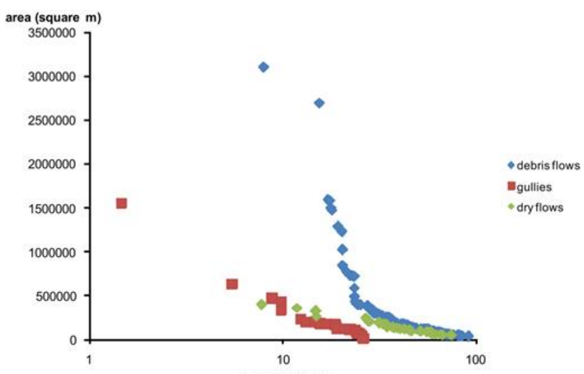

Fig. 3 Relationship between crater wall slope and length of channel for Martian processes.

An important outcome of the present study is that the morphological analyses proved that most landforms are fully developed under different climatic conditions that operate nowadays on Mars. Because the distribution of processes around the crater walls is controlled by different factors, and the processes span from the wet member structures to dry ones, we concluded that as the climatic conditions changed and the availability of water reduced, the processes tend to evolve from gullying in the initial most developed phase, to debris flows and finally to dry flows, a final component that can be related to the actual atmospheric Martian conditions.

Also, it is shown that different morphologies are primarly controlled by the inherited morphometry of the crater walls that complete the influence of the environmental control. As such, the mixture of forms that develop on the same side of the craters (Fig. 1) can be mostly explained by the control on initiation of differnet types of processes done by morphometry of either the alcove, channel or apron components.

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