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Comparative study of molards on the Mount Meager debris avalanche, Canada, and on Hale crater ejecta, Mars

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Molards are cones of debris that result from the disaggregation of ice-cemented blocks transported by mass movements (e.g., Cruden, Can. J. Earth Sci 1982; Milana, PPP 2016). Recently, the origin of molards has been directly linked to permafrost degradation (Milana, PPP 2016; Morino et al., EPSL 2018). On Earth, permafrost degradation has accelerated in periglacial environments (e.g., Brown and Romanovsky, PPP 2008), but few landforms exist to track this process over time, and molards are a rare example that can serve this purpose. A process similar to permafrost degradation is thought to occur also on Mars, where water ice is known to exist as ground ice polewards of 30-40° in both hemispheres (Byrne et al., Science 2009; Feldman et al., JGR 2004), and where volatiles (H_2O, CO_2, etc.) can easily change phase (Fanale and Cannon, JGR 1974). Volatile loss should play an important role in landscape evolution of Mars, so finding distinctive landforms that testify this under-debate process can aid in understanding the processes that shape the surface of the planet.

Here, we present a comparative study of molards that we have found in the Mount Meager debris-avalanche deposits on Earth with conical landforms that we have identified in the flows emanating from the ejecta deposits of the one billion year old Hale crater on Mars. The Mount Meager debris avalanche (British Columbia, Canada) is the largest landslide in the Canadian history, and permafrost degradation is thought to have contributed to the release of the failure (Roberti et al., Geosphere 2017) and in the development of the molards. We compare morphometric and planimetric measurements of molards on Earth with those for the molard-like features identified in the ejecta of the Hale Crater on Mars, whose ice-rich nature has already been proposed based on other landforms (Jones et al., Icarus 2011).

The visual similarity of the molards of the Mount Meager debris avalanche and of the ejecta flow of Hale crater suggest that they are both formed via the degradation of ice-rich surface material. The finding of candidate molards on Mars adds to the evidence that the impact of Hale Crater was into ice-rich materials, and these landforms have the potential to constrain both the initial ground ice content at the Hale impact site, but also the conditions during ejecta emplacement. Our study shows that permafrost degradation/volatile loss can leave a significant geomorphic fingerprint when combined with rapid mass movements in periglacial terrains on Earth and on Mars.