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The 125-km-diameter Hale impact crater is located in the southern hemisphere of Mars and has been dated to 1 Ga (Early to Middle Amazonian; Jones et al., 2011). It is thought to have penetrated the martian cryosphere, because it hosts landforms indicating volatile mobilisation post-impact: its ejecta are lobate and bear channels, and the interior is pervasively pitted and hosts alluvial fans (Collins-May et al. 2020; El-Maarry et al., 2013; Jones et al., 2011; Tornabene et al., 2012). Here, we test the hypothesis that conical mounds found within the ejecta are “molards” by comparing them to terrestrial analogues. Molards are conical mounds of debris resulting from the degradation of blocks of ice-rich material which have been mobilised by a landslide and are found in periglacial environments (Morino et al., 2019).

Our study area (240x180 km) is in the South-East part of the Hale impact crater ejecta (36°–39°S, 36°–31°W). We analyse the spatial and topographic distribution of the conical mounds using orbital images from 25 cm/pixel to 15 m/pixel and measure their height, width and slope using 1 m/pixel elevation data. We then compare them to conical mounds on the deposits of the 2010 Mount Meager debris avalanche, Canada (Roberti et al. 2017) and of the 2000 Paatuut landslide in western Greenland (Dahl-Jensen et al. 2004).

The conical mounds of the Hale impact crater are located at the distal boundary of the thickest part of the ejecta blanket, which reflects the spatial distribution of mounds along the distal parts of the terminal lobe of the Mount Meager debris avalanche. Furthermore, mounds in the Hale impact crater have comparable shapes and flank slopes to molards in the Mount Meager and Paatuut case studies, but are one order of magnitude bigger. This size difference is consistent with the flow-depth that transported the blocks also being one order of magnitude bigger than on Earth.

We infer that conical mounds near the Hale impact crater are a result of fragmented blocks of ice-

cemented regolith produced by the impact and transported by the ejecta flows, and finally degraded into cones of debris (molards) by the loss of interstitial ice. Our interpretation supports the prevailing hypothesis that the Hale impact event penetrated the martian cryosphere and further provides important constraints on the rheology of martian ejecta deposits that can be tested by future studies and in other locations on Mars.

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