Frozen martian lahars? Evidence from Utopia-Elysium flows

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The Utopia-Elysium flows originate on the northwest of Elysium rise and extend more than a thousand kilometers into the Utopia Basin. They have been interpreted as evidence for mega-lahars triggered by intrusions; either by melting ground ice or by cracking the cryosphere, allowing drainage of confined aquifers.
However, little focus has been placed on the emplacement properties of lahars under martian conditions, though martian temperature and pressure may have had a significant impact on the lahar emplacement and morphology. Based on regional high-resolution data from the CTX camera (6 m/pixel) this study investigates the emplacement mechanisms of the proposed mega-lahars in the Utopia-Elysium region (138-145E; 30-40 N) and how they affected the subsequent geologic development in the area.

The outflow deposits are composed of four units, which display very different morphology in the proximal, medial and distal areas. The central part consists of a channel deposit, CD (1,890 km2), with well-defined tear-drop shaped islands and it incises the surrounding flood plain deposit, FPD (13,730 km2), and the elevated terrace deposit, TD (4,200 km2). All three units are recognizable by their very flat appearance, flow-like textured albedo variations and normal impact craters. On the contrary, the distal deposits called smooth flow, SF (45,400 km2), have diagnostic steep, lobate flow fronts with upward convex snouts, variable thickness (10-100m), enclosed depressions pits and hollows, crenulated rims and internal fractures. Distinct crater morphologies are observed including thermally distinct craters, ring-mold-like craters (RMCs), and ice-cauldron −like features. All four deposits are stratigraphically similar and originate abruptly at approximately -3750 m elevation on the flank of the Elysium rise in association with ridges, fractures and troughs, which we interpret as morphologic evidence of dikes.

We suggest that the diverse morphologies express varying degrees of water drainage and freezing within the outflow deposit. Normal channel and flood plain deposits are found in the central part of the outflow deposit and resemble terrestrial lahar deposits. The overbank deposits create the distal deposits; SF (∼75% of the total outflow deposit in the Galaxias region) show morphologic characteristics similar to ice-rich deposits. This suggests that, unlike terrestrial lahars, the water within these slower moving overbank flows froze due to the cold martian conditions, creating an ice-rich deposit. Furthermore, seventeen mounds resembling moberg ridges (linear, distinct ridge-crests and associated with linear ridges) are found within the ice-rich distal deposits and imply that later volcanic activity was highly affected by the presence of the ice-rich lahar deposits, generating ground-ice-volcano interactions and resulting in a secondary suite of ice-volcano morphologies.