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Origin of proposed Rock–Glacier Landforms in Valles Marineris

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Abstract

The Valles Marineris canyon system exhibits a variety of different landforms associated with landslide mechanisms, ranging from several tens of meters to kilometers in length. They usually cover a surface of 1000 km^2 and have an average volume of up to 5000 km^3 (1; 2). It is assumed that they have been emplaced under either wet or dry conditions from destabilized wall–rock and from surrounding sapping valleys (e.g., 3; 1; 2; 4).

Absolute age determinations performed by crater–size frequency distribution measurements on a variety of image data have furthermore shown that landslides in Valles Marineris span much of Martian history with ages as young as 50 Myr up to 3.5 Gyr (1). Notwithstanding their individual ages and time–span during which they have been emplaced, landslides seem to have formed repetitively producing comparable morphologies and do not show substantial modifications throughout the last 3.5 Gy (1).

We here put our focus on a set of complex tongue-shaped landforms situated in the central parts of Valles Marineris at 283°E, 8°S which were previously identified as a single feature and for which a possible rock–glacier origin has been proposed (5). This assumption implies environmental conditions which are not met today at such latitudes near the equator and which would contradict all observations related to the distribution of periglacial landforms on Mars, such as thermal contraction polygons, thermokarst features, and – especially – lobate debris aprons (e.g., 6; 7; 8; 9; 10; 11) which are considered to be Martian analogues for terrestrial rock glaciers. All such features are located within two latitude belts at Martian mid–latitudes beyond ~35°N/S. Recent observations, however, have shown that relics of such debris aprons are located equatorwards of 40°N and that they might indicate a former extent of such ice-rich units when climatic and environmental boundary conditions were met (12). Age determinations based on crater counts for mid–latitude debris aprons have shown that these features have formed <100 Myr ago (13; 11; 14; 15) whereas the low-latitude landforms are at least as old as >1 Gyr (12).

The feature discussed herein has a length of 14.5 km and a width of 7.2 km at its widest part and 5.6 km near its terminus and can be classified as tongue-shaped landform (e.g., 17; 16). The feature is clearly separated into two large units (figure 1A and B) that are both delineated by a sharp terminal ridge.

While the eastern feature is more or less symmetrical in shape, the western tongue seems to be split along its centre. Between both features dune fields, floor deposits and a set of flat–topped remnants are observed which seem to be partially covered by the western landslide and which probably continue northward. On top of the eastern landform numerous smaller features are observed which partly coalesce but which are also clearly delineated by sharp terminal ridges (figure 1,1-3). While the eastern landform and the smaller superimposed features seem to be related to a sapping valley in the north, the eastern tongue-shaped unit seems to originate at the wall-rock and its talus units. Contrasting to the distribution and alignment of ridges and furrows on rock glaciers (e.g., 17), surface lineations are predominantly aligned in longitudinal direction.

On the basis of our observations we come to the conclusion that the landforms discussed herein form a complex set of landslides derived from wall-rock sliding and/or from surrounding valleys. Consequently, different sources areas are reflected by the complexity of the landslides with several overlapping lobes and individual tongue-shaped features.

Although the tongue-shaped morphology is characteristic of rock–glacier landforms (e.g., 17), the assembly of furrows and ridges strongly suggests an origin caused by several short-termed events rather than slow creep mechanisms. Overlapping lobes and faint compressional ridges as seen at this location are not caused by creep of mountain debris but by multiple events that took place at least as early as 300 Myr ago (with several resurfacing events) as crater counts suggest. Terminal and sharply defined ridges are also unusual for rock-glacier landforms, even if they are highly degraded or inactive (e.g., 18). Furthermore, the H/L$_f$ values and volumes estimated fit quite well

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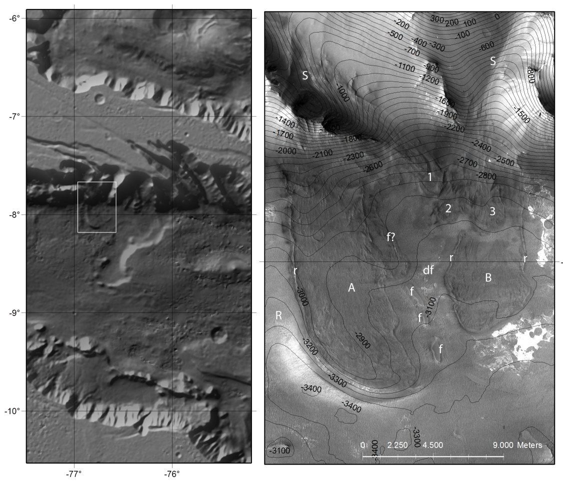

Figure 1: Left: high resolution HRSC terrain model (hillshade representation) at 100 m/px (21), white frame shows location of image scene. Right: MRO CTX scene (P07_003685_1711_XI_08S076W with a scale of 5.9 m/px) depicting the tongue-shaped features described in the text. Two major features (A and B) and numerous smaller landforms (1-3) indicative of landsliding are seen: the large features are separated by a dune field (df) that might mask the former extent of feature A or which might have formed between both features as the terminal ridges (r) of A and B suggest. The unusual asymmetric shape of A might be caused by underlying topographic effects as indicated by the presence of flat–topped remnants f and (masked) f?. A terminal rampart R is visible in the DTM and might be be caused by compressional effects during landslide emplacement.

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to the trends proposed by (19, 20).

Significant degradation and indicators for disintegration, such as numerous elongated depressions and etched surfaces suggest a water content that might have disappeared through diffusion processes and caused such erosional features.

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