Evidence for Recent Wet-Based Crater Glaciation in Tempe Terra, Mars.

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Evidence for recent wet-based crater glaciation in Tempe Terra, Mars?

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Evidence for basal melting of putative debris-covered glaciers in Mars’ mid-latitudes is extremely rare.

- The glaciers are currently frozen to their beds, but has this always been the case?
- Eskers (Fig 1) emerging from mid-latitude glaciers [1-2] indicate at least two localized melting events beneath existing glaciers ~110-150 Myr ago (Fig 2).

Eskers indicate past glacial melting.

1 Ice at glacier bed melts.
2 Meltwater carves a tunnel through the ice.
3 Meltwater deposits sediment in the tunnel.
4 A ridge of sediment (an esker) is left when the ice retreats.

Are glacier-linked sinuous ridges in Chukhung Crater eskers?


The two sinuous ridge populations are morphologically distinct, supporting different origins.

- The esker-like ridges are younger, more sinuous, and have sharper crests than the inverted channel-like ridges (Fig 5).
- However, the ridges have similar dimensions, so differences in crest morphology could be due to differences in degradation state rather than formation mechanism.

The esker-like ridges ascend valley walls.

- Esker-forming meltwater can ascend bed slopes under hydraulic pressure in subglacial tunnels [8]. Ascent of valley walls (Fig 6b) is inconsistent with deposition under gravity-driven flow in subaerial fluvial channels.
- However, ascent of slopes could be inherited from differential erosion under the alternative inverted channel hypothesis, rather than a primary feature.

There are challenges for the esker hypothesis.

- The esker-like ridges could be a second population of inverted channels.
- Glacial deposits (Vff, Gtr, Rpu) covering the southern crater floor hinder scrutiny of the relationship of the esker-like ridges to pre-glacial fluvial deposits.
- Eskers are ice-contact deposits but there is no additional evidence for past glaciation northward of the moraine-like deposits (Gtr & Rpu).
- There is one esker-like ridge system on the northern floor, where there is no evidence for glaciation.

Lessons from Chukhung Crater.

- Even where sinuous ridges emerge from existing glaciers, and where they have esker-like non-slope-conforming topographic signatures, conclusive identification as eskers is complicated by similarities in form between inverted channels and eskers [e.g. 8].
- Regional mapping and quantitative 3D morphometric analyses [e.g. 2, 9] should always be performed before an esker origin can be concluded. Such analyses are ongoing for Chukhung Crater.


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**Fig 1:** Schematic of esker formation.

**Fig 2:** Esker (pink, 14 km long) emerging from a debris covered glacier (blue) in Tempe Terra [2]. Oblique shaded-relief map of HiRISE digital elevation model.

**Fig 3:** Geomorphic map of Chukhung Crater on CTX image basemap. Inset: MOLA elevation map of Mars’ northern hemisphere showing the locations of Chukhung Crater & the two known glacier-linked eskers.

**Fig 4:** Schematic of inverted channel formation [e.g. 5].

**Fig 5:** (a) Esker-like ridge (Ssr) superposing inverted channel-like ridge (Usp) [extent in Fig 3. CTX image P04_002577_2186_XN_38N072W], and (b) topographic profiles AA’ and BB’ from (a) extracted from digital elevation model generated from HiRISE images ESP_017477_2190 and ESP_018545_2190 [6].

**Fig 6:** (a) Esker-like sinuous ridges (white arrows) emerging from moraine-like deposits (Gtr & Rpu) at glacier (Vff) termini, CTX image P04_002577_2186_XN_38N072W. (b) Esker-like ridge ascending a valley wall, HiRISE image ESP_023303_2183.

**Fig 7:** Evidence for recent wet-based crater glaciation in Tempe Terra, Mars?