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 two 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?**


**Unit Interpretations**

- Fresh impact material (>200m craters)
- Highland mantle unit: ice-rich algal deposit?
- Vicissitude flow feature: remnant debris-covered glaciers.
- Glacial-terminal ridges: glacial moraine ridges or pre-glacial crater wall slump deposits (e.g. 4).
- Terminal plateaux: ice-related ground moraine?
- Southern sinuous ridges: esker-like ridges extending from impact basin.
- Transverse Alluvial occuring topographic low-mantled possibly sourced from top.
- Isolated pockmark-like patches of unknown origin; possibly algal deposit?
- Central pflab: deeply seated alluvial bedforms; material sourced from impact?
- Smooth plains and moraines: divot or lacustrine depositional depression into seated mesa within Cr.
- Uplift smooth plains: terraced plains continuous with inverted channel-like sinuous ridges; resistant fluvial deposits?
- Intermediate smooth plains: deposits composed of broad algal valley. Crater floor material or fluvial deposits. Less resistant material?
- Lower smooth plains exposed within valleys dissecting the floor and filling depressions of fluvial or lacustrine origin?
- Crater wall deposits filling topographic lows within impact crater and included by stranded debris; fluvial deposits?
- Meltwater deposits: crater rim, and central pflab-walled regions?

**Structural Interpretations**

- Valley
- Impact crater rim
- Valley floor

**Chukhung Crater hosts two populations of sinuous ridges.**

- **Esker-like ridges (Sr, Fig 3)** emerge from maraine-like deposits (Gtr & Rpu, Fig 3) bounding the terminus of putative debris-covered glaciers (Vff, Fig 3) on the southern crater floor.
- **Inverted channel-like ridges** (within Usp, Fig 3) extend from fluvial valleys on the northern crater wall. They formed prior to glaciation of the crater. Their formation does not require glacial meltwater (Fig 4).

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.


Acknowledgements: We thank Cobalt-Fossait, Edwin Kite and David Mayer for drawing our attention to the study site (C7 and E8), and providing D6Ms (E8 and D8). The Royal Astronomical Society and the British Society for Geomorphology funded FEBO to attend this conference. This work was funded by STFC grants ST/I003421/1 (FEBO) and ST/I000777/1 (MR8/WV9/2L). SJC is supported by the French Space Agency CNES.