Morphometric Characterisation of Eskers Associated with an Extant Mid-Latitude Glacier on Mars

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Version: Poster

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Evidence for basal melting of modern putative debris-covered glaciers (DCGs) on Mars is extremely rare.

- Modern DCGs are likely frozen to their beds, but has this always been the case?
- Gallagher and Balme [1] identified sinuous ridges in the foreland of a late-Amazonian-aged (~150 Ma) DCG in Phlegra Montes (Figs 1-3).
- They interpreted these ridges as young eskers (Fig 4) – the first of their kind identified in association with a modern DCG on Mars.

**Fig 1:** Global topographic context of Phlegra Montes from Mars Orbiter Laser Altimeter (MOLA)

**Fig 2:** Regional topographic context from MOLA. Black arrows show sections of a regional graben, in which the candidate esker is located. Extent in Fig 1.

**Fig 3:** Context Camera (CTX) image mosaic of candidate esker in proglacial zone of the parent DCG (lined valley N). Extent in Fig 2.

**Fig 4:** Schematic of subglacial esker formation

Eskers are diagnostic of glacial melting.

- Eskers are ridges of sediment deposited by meltwater in ice-walled, typically subglacial drainage conduits, and subsequently exposed by glacier retreat (Fig 4).
- Their morphometry is strongly controlled by the geometry of their parent meltwater conduits which, in turn, is controlled by hydraulic conditions within them [e.g. 2].

We characterise candidate esker morphometry with new high-resolution 3D data

**Fig 5:** New High-Resolution Imaging Science Experiment (HiRISE) anaglyph ESP_044804_2130 of (a) the candidate esker complex, and sections of (b) low-albedo clast-rich zone 1 ridge (c) zone 3 ridges (d) well-preserved, layered, high-albedo, sharp zone 3 ridge crossing a wrinkle ridge.

**Fig 6:** Methods: (a) oblique view of orthophoto overlain on DEM generated from HiRISE images ESP_044316_2130 and ESP_044804_2130; (b) mapped segments and plan-view geometry extraction, (c) cross-sectional profile (location shown in b) and 3D geometry extraction.

**Fig 7:** System lengths for the Phlegra Montes candidate eskers, Dorsa Argentea [4] and Canadian eskers [5]. Boxes - interquartile range; bars - range; dashed lines - median; points - mean.

- Similar length and sinuosity to Canadian eskers (Fig 7, Table 1).
- Similar sinuosity to, but shorter than, ancient (Early Hesperian) putative eskers near Mars’ south pole (Dorsa Argentea) (Table 1).

**Plan-view geometry**

**Table 1:** Segment and system sinuosity statistics for Phlegra Montes candidate eskers (PM), Dorsa Argentea (DA)[4], and Canadian eskers, Earth (CA) [5].

<table>
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<tr>
<th>Segments</th>
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**Cross-sectional morphology**

- Similar heights to Icelandic eskers (~1 – 14 m [6]) (Fig 8a).
- Widths more similar to terrestrial eskers (~10s m – 2 km [2,6]) than Dorsa Argentea [4] (Fig 8b).
- Intermediate side slopes between Icelandic eskers (~11-22° [6]) and Dorsa Argentea, Mars [4] (Fig 8c).
- Lower side slopes than terrestrial eskers could result from fundamental differences in subglacial hydrology between Earth and Mars, which should be explored further.

**Fig 8 (left):** (a) height, (b) width, and (c) mean side slope of the Phlegra Montes candidate eskers (zone 2) and Dorsa Argentea [4], Boxes - interquartile range; bars - range; dashed lines - median; points - mean.

**Ongoing work**

**Phlegra Montes candidate esker morphometry**

- Tests for esker-like response of ridge height to longitudinal bed slope.

**NEW DCG-linked candidate esker in a similar graben setting**

- Abstract #1234, this conference.
- Supports the hypothesis that elevated geothermal heat was a prerequisite for recent basal melting of mid-latitude glaciers on Mars [1].

**Modelling environmental conditions required for basal melting in Phlegra Montes**

- Exploring atmospheric temperature and geothermal heat scenarios using the JPL/University of California Ice Sheet System Model (ISSM) [8].


**Acknowledgements:** FEGB is funded by STFC grant ST/N00421X/1 and is grateful for travel support from the 2017 PSI Pierazzo International Student Travel Award. We are grateful to R.D. Storrar for the Canadian esker data.