THE DORSA ARGENTEA, MARS: NEW COMPARISONS TO A LARGE SAMPLE OF TERRESTRIAL ESKERS AND QUANTITATIVE TESTS FOR ESKER-LIKE TOPOGRAPHIC RELATIONSHIPS. F. E. G. Butcher[1], S. J. Conway[1,2], N. S. Arnold[3]. [1]Department of Physical Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK (frances.butcher@open.ac.uk), [2] LPG Nantes – UMR CNRS 6112, Université de Nantes, France, [3]Scott Polar Research Institute, University of Cambridge, Lensfield Rd, Cambridge, CB2 1ER, UK.

Introduction: The Dorsa Argentea (DA) are an assemblage of ridges in Mars' southern high latitudes (70°-80°S, 56°W-6°E). Glacial eskers and inverted channels remain as active hypotheses for their formation [1-11]. The esker interpretation is widely used as a basis for reconstructions of meltwater production beneath a putative former ice sheet in the region of the DA during Mars' Hesperian period, despite a lack of rigorous quantitative testing of the esker hypothesis [e.g. 7-8,10-12]. We undertake the first large-scale quantitative analysis of the plan view geometries of the DA [1] in a comparison to >5900 terrestrial esker systems in Canada [13-14]. Statistical tests for esker-like topographic relationships [1-3,15-16] are also completed. Our results support the esker hypothesis and highlight that future studies of the DA and its parent ice sheet should more closely consider the ongoing debate over the spatio-temporal nature of terrestrial esker formation [e.g. 13,17-18], and its implications for reconstructions of ice sheet meltwater production.

Methods: We digitized DA ridge *segments* (individual, unbroken ridges) using ~115 and ~230 m/pixel MOLA DEMs and ~6 m/pixel CTX [19] and ~20 m/pixel HRSC [20] images. We conservatively grouped chains of related ridge segments, separated by gaps, into longer ridge *systems*. Standalone segments <10 km in length were excluded.

Plan view ridge geometry: We calculated system length (L_i) by linearly interpolating across gaps between segments. We calculated continuity as the ratio between the total length of segments comprising a system and L_i, and sinuosity as the ratio between L_i and the shortest linear distance between end points of the system.

Longitudinal change in ridge height and bed slope: We obtained cross sectional (CS) topographic profiles at ~1 km spacing (within the 115 m/pixel DEM) along four major ridges (A-D) and calculated the down-ridge change in ridge height (*dH*). We used base elevations (average elevation of two base points on each CS profile) to calculate longitudinal bed slope (θ_L) between successive CS profiles. Calculations were not performed across ridge gaps or junctions.

Results and analysis: In total, we mapped ~7514 km of ridge systems (Fig. 1, n = 260), for which plan-view geometry data is displayed in Table 1.

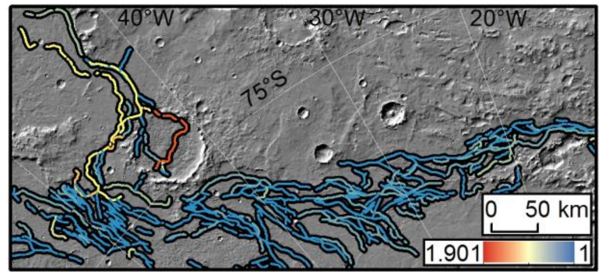

Figure 1. *DA classified by system sinuosity. MOLA hillshade basemap. Adapted from [1].*

	Canada	DA
Sample size, *n*	5932	260
Continuity	0.65	0.90
Mean length (km)	15.6	36.5
Median length (km)	4.1	22.2
Maximum length (km)	760	314
Mean sinuosity	1.08	1.10
Median sinuosity	1.06	1.07
Maximum sinuosity	2.45	1.91

Table 1. *Plan view geometries of Dorsa Argentea and Canadian esker systems [13].*

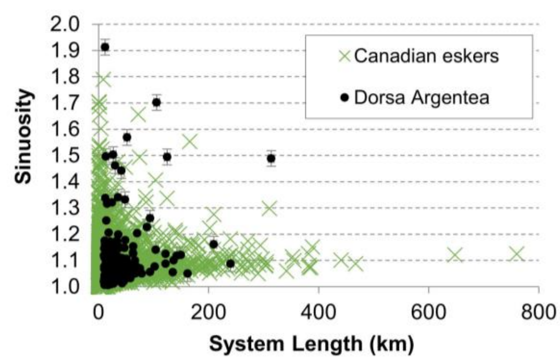

Figure 2. *System sinuosity and length of the DA and Canadian eskers [13]. Adapted from [1].*

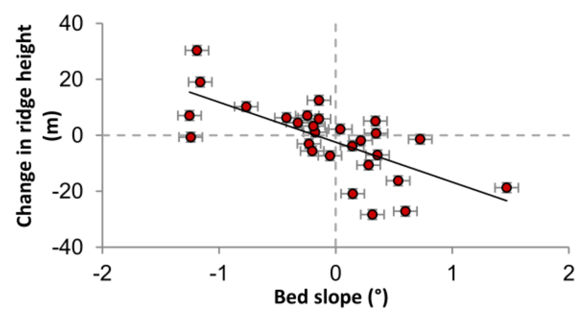

Figure 3. *dH against θ_L for Ridge A. Positive values of θ_L are uphill and negative values downhill. Adapted from [1].*

Gaps between segments account for ~10% of L_i. Some systems are more fragmented, with a minimum continuity of 0.59 ± 0.02. System sinuosity is consistent with values obtained by previous workers [8,10]. Long systems are typically straighter than shorter ones (Fig. 2) and those at the entry to East Argentea Planum have higher sinuosity (~1.48-1.7 ± 0.03) than those within the main valley (~1-1.3 ± 0.03, Fig. 1).

We observe increases in ridge height on downhill slopes and decreases on uphill slopes for ridges A (Fig. 3) B, and C. Ordinary least squares regression analyses indicate that θ_L explains 47.81% (p = 0.000), 59.26% (p = 0.000), 18.27% (p = 0.001) of variance in *dH* on ridges A, B and C, respectively, confirming previously observed topographic relationships [2-3].

Discussion: The lengths and sinuosity of the DA are consistent with >5900 Canadian eskers (Table 1, Fig 2). The great lengths and high continuity of the longest DA ridges, reconstructed ice surface slopes of ~0.06° [11], a putative paleolake in Argentea Planum [7] and fan-forms at ridge termini in this region [11] may be consistent with synchronous formation (Fig. 4b) in long, stable channels extending from the interior of a former, likely stagnant, ice sheet and terminating in a proglacial lake [10,17]. The consistently low sinuosity of ridges in the main basin (Fig.1) could support their formation beneath thick ice, while higher sinuosity of the northernmost ridges (Fig. 1) may result from their formation closer to a stable former ice margin where ice was thinner and subglacial water routing was more strongly controlled by local topography (Fig. 4b). However, Storrar et al. [13] attribute the length-sinuosity relationship for the Canadian eskers (Fig. 2) to time-transgressive formation beneath thin ice at a retreating ice margin (Fig. 4a). A similar relationship for the DA highlights that further work is required to understand the spatio-temporal nature of their formation and its implications for meltwater production in their parent ice sheet [e.g. 13,17-18]. Variations in ridge height along ridges A (Fig. 3), B and C adhere to topographic relationships observed for terrestrial eskers arising from variations in energy available for melting of roofs of subglacial esker-forming conduits [15-16].

Conclusions: (1) Statistical distributions of length and sinuosity of the DA are similar to those of terrestrial eskers in Canada. (2) The DA may have formed synchronously in conduits extending towards the interior of an ice sheet that thinned towards its northern margin, terminating in a proglacial lake. However, the ongoing debate over time-transgressive and synchronous deposition of terrestrial eskers [e.g. 13,17-18] has implications for the nature of ice sheet meltwater production and retreat and should be considered more closely in future studies of the DA. (3) Statistical tests for esker-like relationships between ridge height and topography confirm the strength of these relationships for three of four major DA ridges.

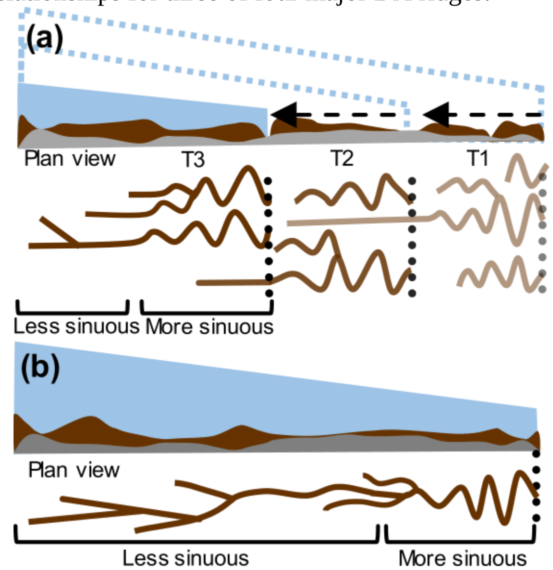

Figure 4. *Schematic of the effect proposed by [13] of **(a)** time-transgressive and **(b)** synchronous esker sedimentation upon esker sinuosity-length relationships.*

Acknowledgements: We are grateful to RD Storrar for the terrestrial esker data in Figure 2. FEGB is funded by STFC grant ST/N50421X/1. SJC was funded by Leverhulme Trust Grant RPG-397.

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