COMPARATIVE STUDY OF SUBGLACIAL CHANNELS ON DEVON ISLAND, NUNAVUT, CANADA, AND CHANNELS IN VEDRA VALLES, MARS.

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Introduction: Devon Island, located around 75ºN and 87ºW in the Canadian Arctic Archipelago, has a landscape uniquely suited to study cold and polythermal based glaciation and associated landform assemblages [1, 2]. Minimal precipitation and vegetation on Devon Island have prevented the significant degradation of this landscape since ice exposure (~8000 radiocarbon years BP [1]), allowing the landforms to be studied from the km- to cm-scale [3]. Although covered by the thin (<1000 m), cold-to-polythermal based Innuitian Ice Sheet at the Last Glacial Maximum, there is a conspicuous lack of typical glacial landforms on Devon Island, such as eskers, moraines, and striations [1]. Instead, the main evidence of glaciation are subglacial channels and fjords. Devon Island's characteristics make it a prime analogue site for investigations of glacial and subglacial processes on Mars [7, 8].

Subglacial meltwater channels can be identified by their flat-bottomed cross-sections and undulating longitudinal profiles [4, 5]. They range in scale from mm to km wide [6]. In planform the Devon Island subglacial channels are typically short and straight, regularly spaced, with anabranching headwaters, and drain into a main stem (Figure 1A). Subglacial channels may cross topographic divides as flow is driven by pressure from the overlying ice [5].

Part of the interest for characterizing possible subglacial drainage landscapes on Mars derives from the debate surrounding early Mars climate. Previously, the formation of valley networks was attributed largely to erosion by surface runoff [9] and sapping erosion [10], implying the need for warmer and wetter climate conditions. However, the protracted presence of liquid surface water is hard to reconcile with recent climate models that predict a much colder and drier early Mars [11]. Instead, erosion of a fraction of valley networks was likely the result of localized basal meltwater flow under a polythermal-based highlands ice sheet, which would be consistent with both Mars climate modelling and valley network geomorphology. Devon Island is therefore a key analogue to consider [12, 8].

Hypothesis: Following the hypothesis that a fraction of valleys on Mars could have originated subglacially, here we consider a subglacial channel network on Devon Island (Figure 1A) and establish a detailed morphological comparison with Vedra Valles, a valley network on Mars (Figure 1B), identified as possibly subglacial in origin [8].

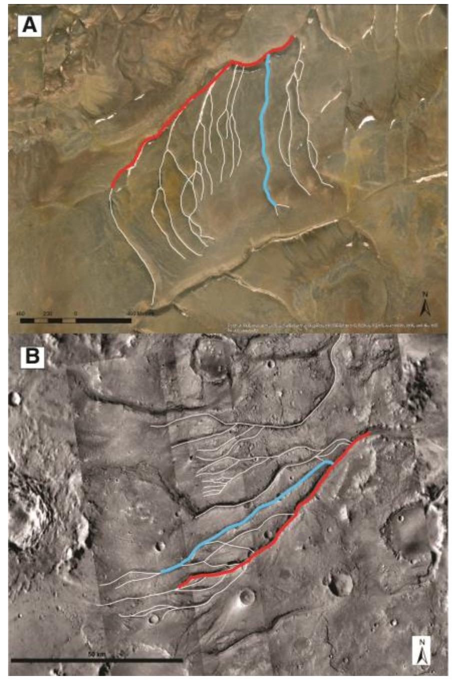

Figure 1. A) Satellite image of a subglacial channel network, Devon Island, Canada. B) CTX mosaic of channel network in Vedra Valles, Mars. White lines delineate network; blue lines indicate tributary channels; red lines indicate main stems.

Methods: Following past work, we identified a series of subglacial channel networks in central Devon Island. Our team visited the island in July 2022, to collect LiDAR data via drone, in addition to detailed field notes and photos. LiDAR data was then processed and to produce cm-scale resolution DEMs. Here, we focus on Subglacial Channel Network 1 (SG1, Figure 1A). Width and depth measurements of SG1 and Vedra Valles were obtained using ArcGIS and JMARS software, respectively.

Subglacial Channels on Devon Island: SG1 is ~ 2 km in width and > 1.35 km long from the headwaters to the outlet. The width and depth of individual channels is 20 – 134 m and 4 – 24 m, respectively. Main stem cross-sections are flat-bottomed, with an area that increases with depth downstream from ~6.5 m to 36 m (Figure 2A). Notably, width measurements display a bimodal distribution; channel width ranges between either ~120 – 134 m or ~42 – 69 m, increasing downstream. Width measurements from a single tributary channel display alternating downstream widening and narrowing (Figure 2C).

Proposed subglacial channels in Vedra Valles: In planform, this channel network resembles SG1 on Devon Island wherein channels are relatively short, straight, and drain into a main stem that is deeper than the tributaries (Figure 1B). Vedra Valles is approximately 47 km wide and individual channels within are 2 – 7 km wide and < 400 m deep. In cross-section, the main stem is consistently flat-bottomed along its length, with depth gently increasing downstream. Width measurements are bimodal, similar to the main stem at SG1, wherein channel width increases downstream from ~0.95 – 1.4 km to ~2.9 – 3.8 km (Figure 2B). The longitudinal profile of the main stem displays significant undulations, consistent with terrestrial subglacial channel profiles [3, 4]. Generally, depth increases downstream.

Analysis of a single tributary channel within the network reveals a downstream widening and narrowing pattern similar to SG1 (Figure 2D). Cross-sectional profiles are flat-bottomed; however, the cross-section of the channel varies significantly with depth.

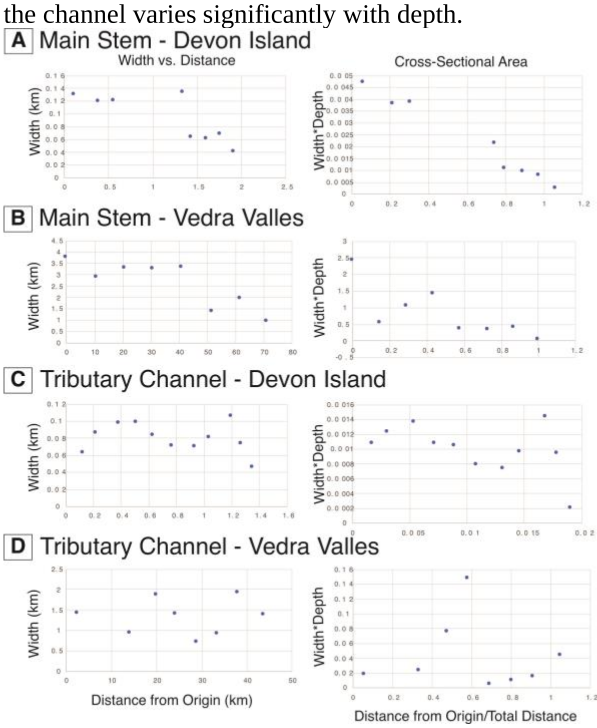

*Figure 2. Right column: Width (km) versus distance (km). Left column: Cross-sectional area of channels (width*depth versus distance from origin/total distance). Downstream is to the right.*

Results and Discussion: The Vedra Valles system on Mars bears significant resemblance to subglacial channels on Devon Island. When compared to subglacial channels on Devon, initial morphological observations suggest the features in Vedra Valles are consistent with a network of subglacial meltwater channels.

Both terrestrial and Martian main stems appear to abruptly widen downstream (Figure 2A-B left), contrasting with fluvial channel morphology that steadily widens downstream. Tributary channels at both study sites display periodic widening and narrowing trends (Figure 2C-D left), consistent with observations of linked cavities in other previously glaciated terrains due to turbulent flow occurring in closed (subglacial) bedrock channels [13-15]. Cross-sectional area of all channels appears to follow variability in depth (Figure 2 right), indicating the presence of longitudinal undulations.

Conclusion: Our work shows that Devon Island is a unique analogue to polythermal glacial environments on Mars. We explore the morphological and morphometrical similarity of Vedra Valles and SG1, showing cross-sectional and longitudinal profile patterns inconsistent with overland flow. This suggests that Vedra Valles could have formed in a similar manner to subglacial channels on Devon Island, as the result of subglacial meltwater drainage under a cold- to polythermal-based ice sheet.

Further comparison between these two channel networks will elucidate possible patterns of subglacial meltwater activity and drainage on Mars, and establish metrics to help identify further subglacial erosion among the martian valley networks.

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