

## ELLESMERE ISLAND AS AN ANALOG OF KASEI VALLES, MARS: LANDSCAPES RESULTING FROM LARGE-SCALE SELECTIVE LINEAR EROSION OF SUB-POLAR ICE SHEETS.

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**Introduction:** Terrestrial anastomosing glacial troughs and streamlined landforms matching the ideally formed channel systems of Mars are lacking. The disparate geology and topography of Earth and Mars may well have variably influenced the erosion of such landforms, which are probably more ideally formed on Mars due to the spatial uniformity and erodibility of the wide expanses of crater scarred, pristine regolith plains. Likewise, the circular ramparts that craters present against the onslaught of erosion, compared to the random forms typical on Earth, would be reflected in the geometries of eroded forms. An important question to be addressed is: how would ice sheet-generated landscapes on Earth appear if not influenced by pre-existing channeling, topography, and structure of bedrock? Considering the morphology of Kasei Valles, might regolith have supported the generation of its ideally-shaped streamlined landforms akin to the well-formed islands of glacial spillways, yet through the processes of large-scale glacial erosion evidenced by its extant areal scour indicative of wet-based erosion?

**Discussion:** There are examples of terrestrial ice sheet-generated landforms for which landscape considerations might explain the above mentioned disparity. Fig. 1a shows Kasei Valles, an erosional landform network comprised of interconnected or anastomosing channels or troughs, supposedly breached and non-breached streamlined landforms, and valley-wide areal scour. Thought to be a flood or glacial spillway channel system, Kasei Valles is here interpreted as a set of glacial troughs and streamlined landforms, likely eroded by sub-polar ice sheets [1]. A terrestrial analog can be seen in Fig. 1b. It shows a portion of eastern Ellesmere Island recently exposed by the retreating ice sheet where several streamlined landforms are visible among a network of interconnected glacial troughs. Though the landforms at Kasei Valles are more curvilinear, whereas more angular at Ellesmere, this could be explained by the uniform and easily eroded regolith, compared to the structured and resistant bedrock.

Also, the widespread areal scour at Kasei Valles (Fig. 2), which extends over most streamlined forms, is more consistent with the uniform areal scour typical of ice sheets than the more spatially variable and localized erosion typical of the generally more focused erosion caused by floods. This is because the pressure melting point within ice sheets (see explanation below) promotes sheet-like erosion, except where geologic and topographic factors promote channelization.

The erosion of the exposed landscape at Ellesmere Island occurred at the base of the nearby ice sheet before it retreated. Although related to intermediate-scale asymmetric and symmetric erosional landforms such as roches moutonnees, whalebacks, rock drumlins, and crag and tails, the scale of the landforms are more consistent with “large-scale selective linear erosion” associated with sub-polar ice sheets, which are cold-based where thinner and warm-based where thick enough [1]. Ice streams within the ice sheet slid across the bedrock with varying velocities, both spatially and temporally, to erode the anastomosing network of troughs. Although inundated by the ice sheet, the streamlined landforms were marked by relatively less basal sliding and erosion than the troughs, having been overlain by thinner, slower moving or stagnant cold-based ice. Similarly, “non-breached” streamlined landforms at Kasei Valles may have been inundated by cold-based ice, but were spared the erosion evidenced by the areal scour of adjacent lower topography.

The causes of these spatial variations of erosion are better understood if one imagines the pressure melting point, where sliding may occur, as a dynamic, 3-dimensional layer at depth, controlled by ice thickness and basal and flow variations [1, 2]. Erosion principally occurs beneath thicker ice where the pressure melting point is met, where warmed by geothermal heat flux, frictional heating, and through heat transfer by water. As erosion continues, enhanced by positive feedback through increasing frictional heating and ice thickness, subglacial troughs lengthen, widen, deepen, and even connect, influenced by parameters such as topography, pre-existing channelling, and faults. Also, as ice flows from a given area, the ice thins and the pressure melting point may drop below the ground surface, causing sliding to cease and flow velocities to decrease in that area. These positive and negative feedback mechanisms cause an ice sheet to maintain a sheet like flow, yet erode troughs where velocities are highest. Anastomosing of troughs result from long-term fluctuations in ice drainage patterns within an ice sheet, represented by linked-flow networks or evolving or switching time-transgressive flow patterns.

In line with these considerations and other morphological interpretations, including those previously presented elsewhere [3, 4, 5], I argue for a sub-polar ice sheet-based interpretation of Kasei Valles, in which variable and widespread erosion induced areal scour and stripped regolith to leave behind its streamlined

landform and trough system. This possible glacial origin of Kasei Valles is related globally to other valley systems on Mars in an previous abstract and an associated poster paper, which outlines ongoing research [6].

**References:** [1] Benn B.I. and Evans J.A. (1998) *Glaciers & Glaciation*. Arnold Pub., p. 323-365. [2] Arfstrom, J.D. (2004) LPSC Abstract, 35, 1105. [3] Arfstrom, J.D. (2013) LPSC Abstract, 44, 1001. [4]

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**Figure 1a:** (top): Eastern Kasei Valles, MOLA. **1b:** (bottom): Eastern Ellesmere Island. Arrows indicate former flow direction within channels or troughs and S's indicate location of streamlined forms.

