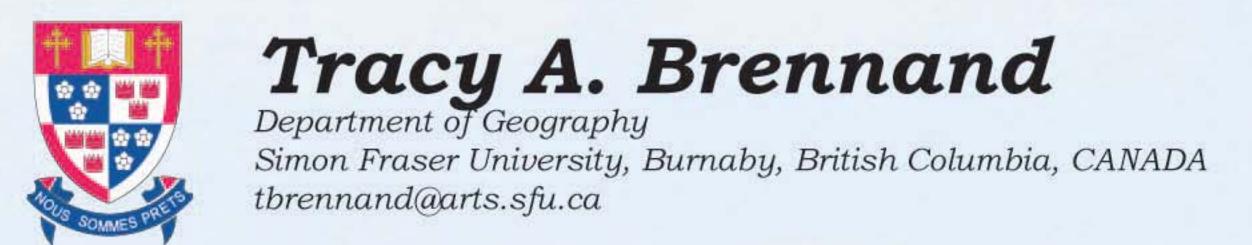
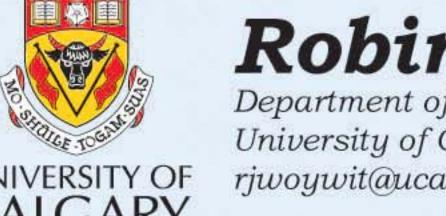
Late-glacial ice-sheet paleohydrology of southern Alberta



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ABSTRACT

Glacial lake sediments, eskers and meltwater channels are important indicators of past ice sheet hydrology. Although surficial geological mapping in southern Alberta has revealed the distribution of glacial landforms and sediments, little is known about their stratigraphic and geomorphic relationships. Eskers may or may not terminate in fans. Regionally, they exhibit a deranged pattern. Eskers are often found adjacent to, or within, meltwater channels interpreted to be subglacial (tunnel channels) and/or proglacial in origin. Lacustrine sediments, associated with eskers and meltwater channels, have also been interpreted as proglacial or subglacial in origin. These conflicting interpretations invoke different hydrological conditions and, therefore, radically different reconstructions of the late-glacial paleohydrology in the southwestern sector of the Laurentide Ice Sheet.

This study integrates empirical field (geomorphology and sedimentology) and digital (surficial and bedrock geology, DEMs) data to address the following questions. First, did the distribution of glacial lakes have an effect on esker distribution and pattern? Second, was esker distribution and pattern controlled by the presence of meltwater channels? Third, what was the relative timing of eskers, channels and lakes? Preliminary research indicates that: (i) long eskers occur in association with lake basins, short eskers occur on uplands, (ii) long eskers are located in broad, linear depressions and meltwater channels, (iii) short eskers contain highly-deformed sediment, long eskers do not, and (iv) extensive fan complexes, located where meltwater channels enter lake basins, are overlain and truncated by eskers. These initial results indicate that at least some meltwater channels and long eskers provided long-lived hydraulic connection between subglacial reservoirs and/or proglacial lakes, dammed by stagnant ice. In contrast, short upland eskers record short-lived R-channel drainage without

OBJECTIVES

This poster presents preliminary research focused on understanding the late glacial environments in southern Alberta. This area was in the southwestern sector of the Laurentide Ice Sheet (LIS) (Fig. 1). The ultimate goal is to understand the style of deglaciation and how this style controlled meltwater storage and routing. To address this goal we have identified three initial objectives:

- 1. To establish what effect glacial lakes had on the location and operation of prairie eskers.
- 2. To establish the relationship between glacial meltwater channels and the location of eskers.
- 3. To establish the relative timing of operation of these hydrologic



Fig. 1: The location of the study area is located in the southwestern sector of the Laurentide ice sheet.

RESEARCH DESIGN

This project integrates empirical field data and existing digital data. Field data includes detailed sedimentologic investigations with geomorphic mapping. Existing digital data includes the surficial geology [1, 2], bedrock geology, and digital elevation models (DEMs). The surficial geology [1,2] data are compilation of earlier mapping efforts and were presented at 1:500,000. The DEMs were captured at 1:20,000 and presented with 100m postings. We used these data sources as a basis for initial hypotheses testing and focusing of our field research efforts. For this part of the project we used the data for the following

- 1. To investigate the spatial connectivity of glacial lake basins and the extent of eskers using existing digital (i.e. GIS) coverages. This has required that we verify all eskers in the databases due to numerous inconsistencies.
- 2. Integrating the surficial geology and DEM we have been able to establish the importance of regional concavities and meltwater channels to the location of eskers.
- 3. By conducting multiple queries on the GIS data we have been able to establish a rudimentary relationship between eskers and the substrate.

REGIONAL DISTRIBUTION OF ESKERS

The initial analysis of eskers has shown the following regional characteristics and patterns:

- 1. Eskers are dispersed throughout the region. The maps of [1,2] indicate that a greater number of features occur in areas of high relief hummocky terrain than occur in areas dominated by bedrock or thin Quaternary sediments (Fig. 2). These numbers are misleading to some degree - ongoing airphoto/field verification of eskers in these thick Quaternary sediment regions is revealing that many of these features are not eskers but small, glaciotectonic ridges or linked hummocks.
- 2. Eskers are distributed throughout the elevation range displayed in the study area, but with a tendency to concentrate at certain elevations (Fig. 3). In particular, there is a concentration in a arcuate (concave west) ring from the Rosalind area. This again is somewhat misleading in that many of the eskers in this ring are either linked hummocks or glaciotectonic ridges. This area is dominated by hummocky terrain of traditionally referred to as the Viking and Suffield moraines.
- 3. Probably the most striking regional tendency is for the largest, longest, and highest density of eskers to be located in areas where there is limited surficial sediments, where bedrock is within 3 m of the surface.
- 4. The largest eskers are found in close association with mapped glacial lake basins and extensive undifferentiated glaciofluvial/glaciolacustrine deposits.

ESKER MORPHOLOGY

Generally, there is a difference in eskers located in local topographic lows as compared to those in upland locations.

- 1. Most eskers have a undulating crestline (Figs. 4, 5, and 6). Although this has only been verified sedimentologically and from geophysical (GPR) surveys at a few locations, these undulations likely relate to internal elements that have been interpreted as large bedforms or macroforms [3].
- 2. Fans located at the terminus of eskers are present at some locations, but are most common in large esker systems that terminate in
- lakes. Multiple fan/esker segments like those described by [4] are not present in the area. 3. Eskers located topographic lows and channels are longer than those on the uplands.
- 4. Eskers generally have sharp crestlines. However, lateral widenings (commonly at the outside of bends) have been identified in many locations. In some instances, these widenings occur at locations where the crestline is not as undulating.
- 5. Eskers on uplands tend to have a deranged pattern whereas lowland eskers demonstrate more integration.

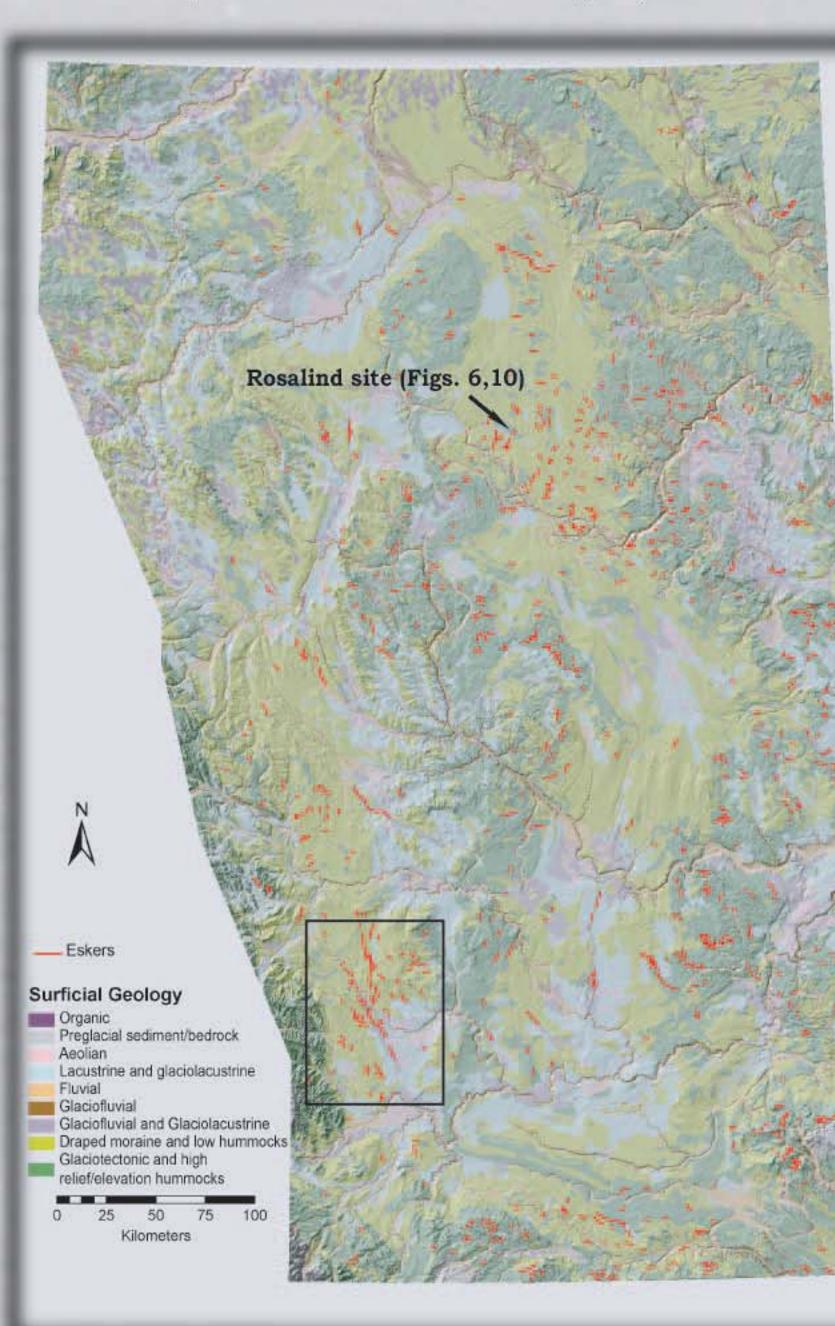


Fig. 2: Generalized surficial geology with a hillshade modulation showing the association of eskers and surficial materials. Sources: [1,2] and 1:20,000 DEMs.

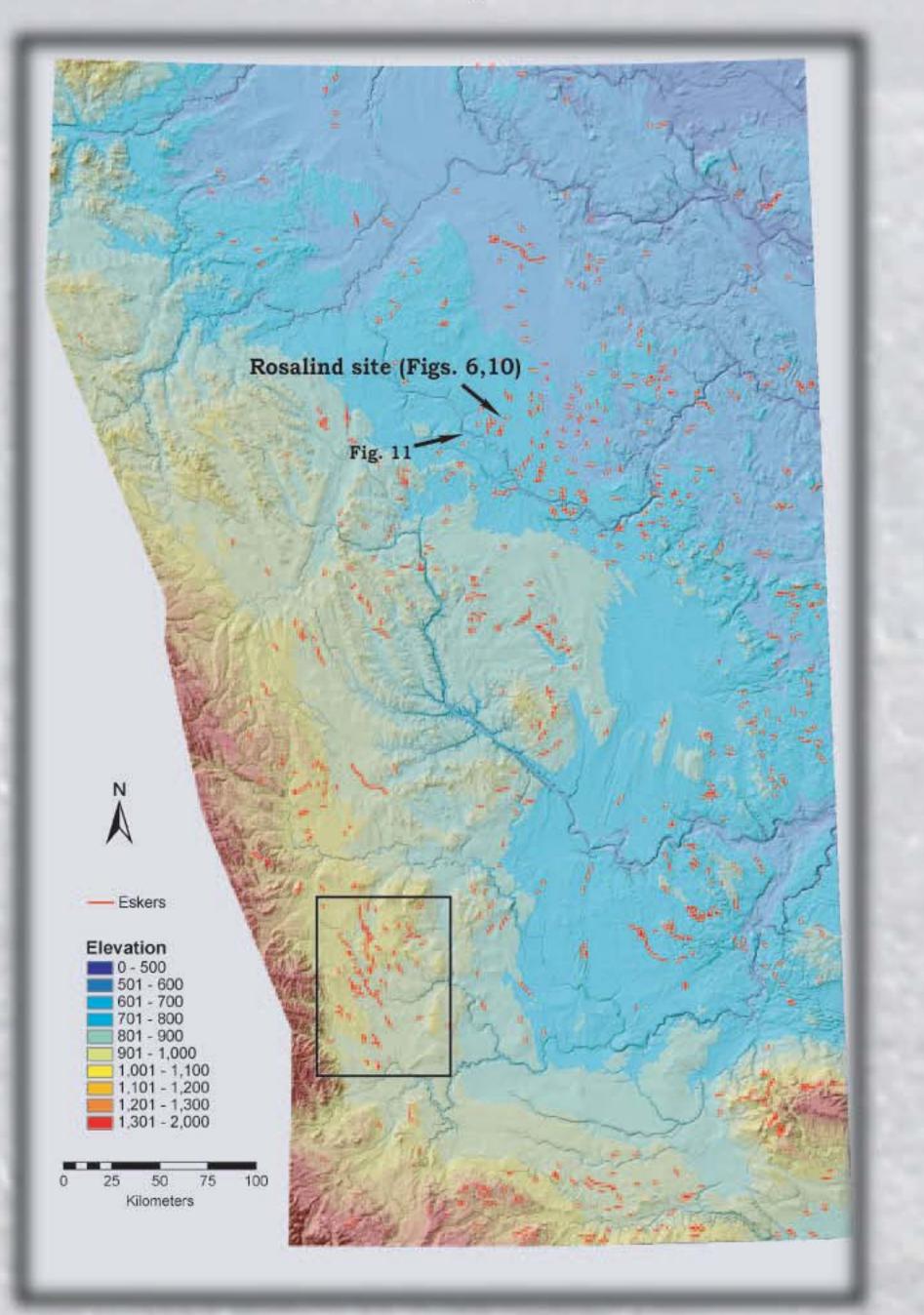


Fig. 3: Binned elevation with a hillshade modulation showing the topographic context of eskers in southern Alberta. Sources: [1,2] and 1:20,000 DEMs.



sediments. Note the rhythmicity of the bumps with relief of approx. 2-3 metres.



broad and discontinuous. Note the bedrock exposed in dugout in foreground



Fig. 7: Esker truncates large deposits of horizontally stratified sand and gravel which mostly fill the large channel.



Fig. 6: Undulating crestline on this esker is partly due to major post-depositional slumping and faulting associated with removal of lateral ice support.

SEDIMENT / LANDFORM ASSOCIATIONS

The association of eskers with other landforms and sediments is also related to their topographic position.

- 1. Eskers located in channels invariably truncate large deposits of sand and gravel (Fig. 7). These sand and gravel deposits nearly fill the channels in some places and grade out into glacial lake basins (Figs. 8 and 9). These are generally the largest, longest and most continuous eskers.
- 2. Eskers in lowland positions, including channels, possess limited post-depostional disturbance of the sediments, whereas upland eskers have evidence of significant disturbance (Fig. 10). Till-filled eskers [4] are only present where till is thicker, indicating significant post-esker-operation deformation into the conduit.
- 3. The largest eskers invariably rest on thin Quaternary sediments, many directly on bedrock (Figs. 5 and 11).
- 4. Fans located at the terminus of eskers are present at some locations, but are most common in large esker systems that terminate in lakes. Multiple fan/esker segments like those described by [5] are not present in upland areas. Where eskers occupy channels and exit into glacial lake basins may have multiple, broad fans (Figs. 5 and 8).
- 5. Eskers may have a till cap (Fig. 12). This till has a coarser matrix than most tills in the area and is relatively stone poor. This till has not been observed on eskers within the bounds of glacial lake basins, although it is common above these elevations.

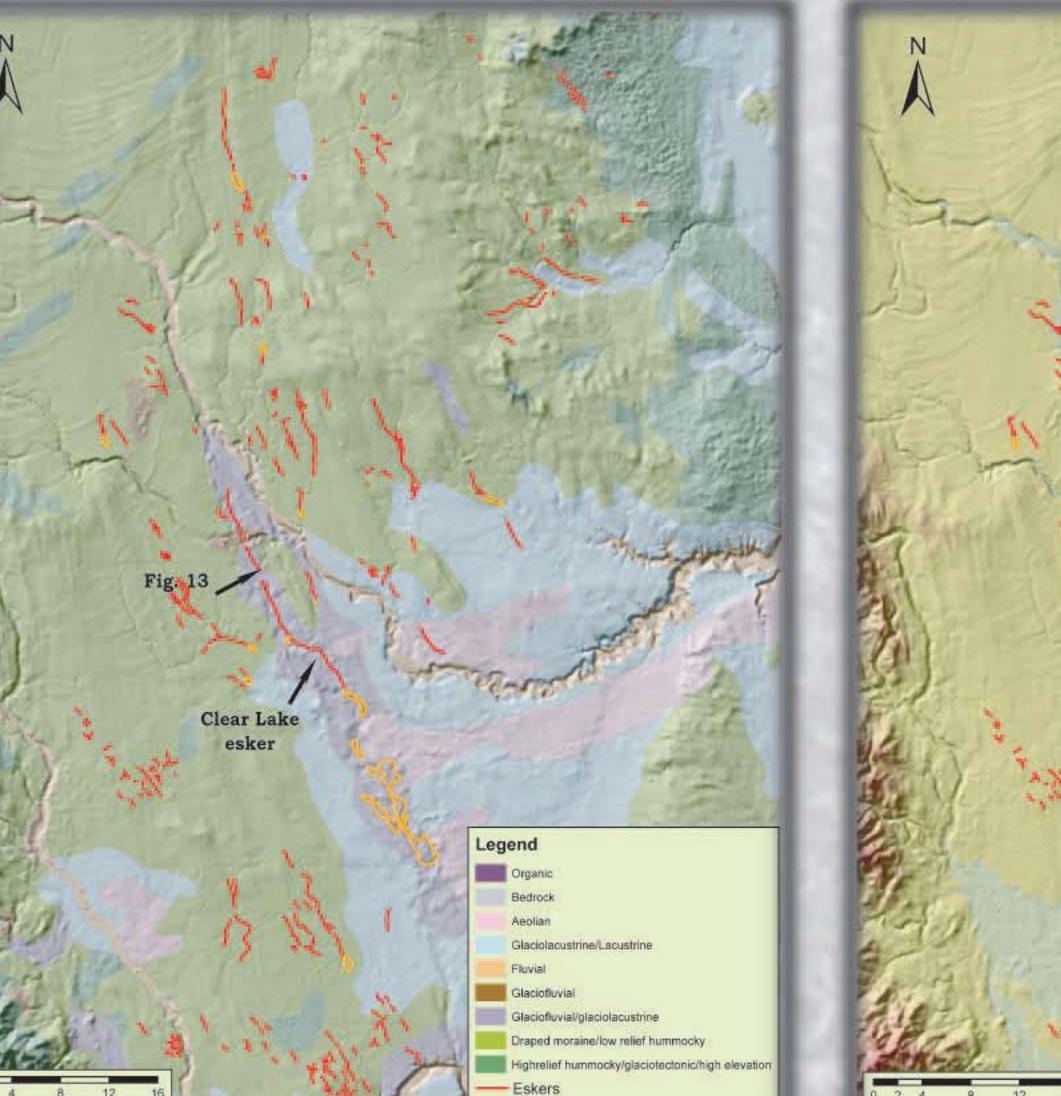
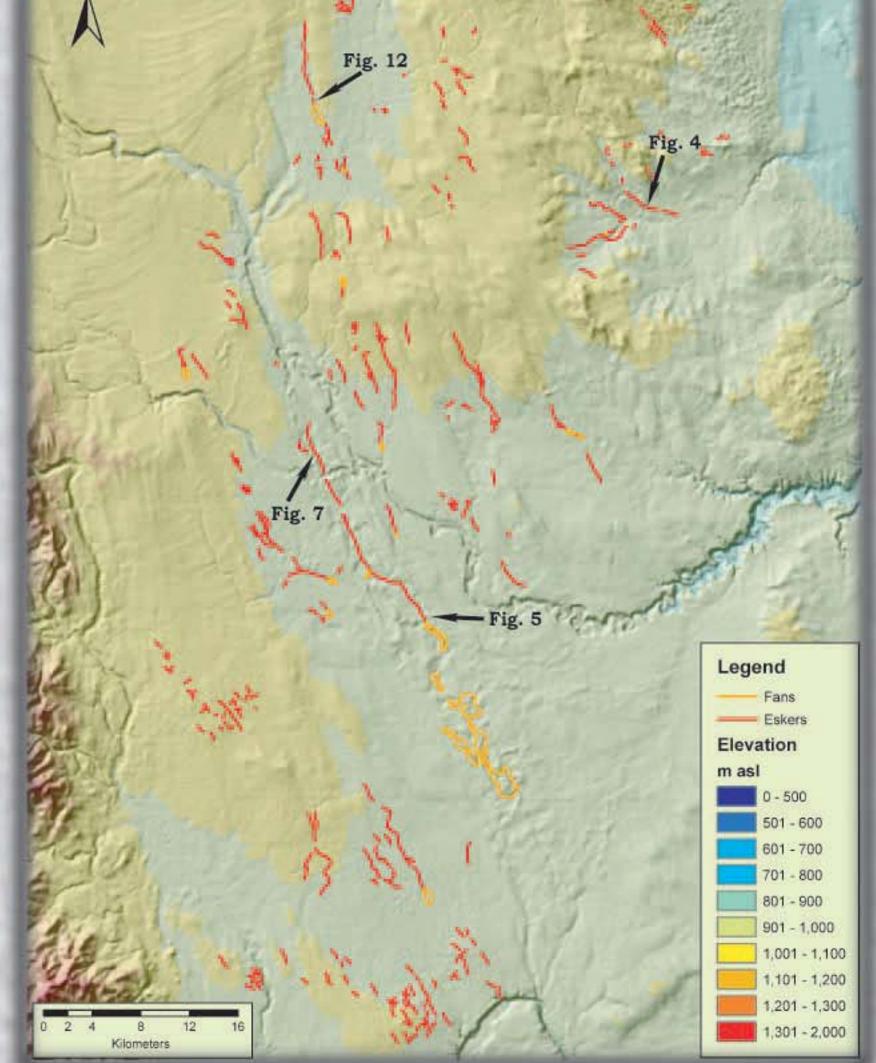


Fig. 8: Results of detailed airphoto interpretation of eskers and fans draped on Fig. 9: Esker truncates large deposits of horizontally stratified sand and grave the surfical geology. Clear Water esker dissects extensive glaciofluvial / which mostly fill the large channel. glaciolacustrine sediments (purple). Shorter eskers are on bedrock controlled uplands.



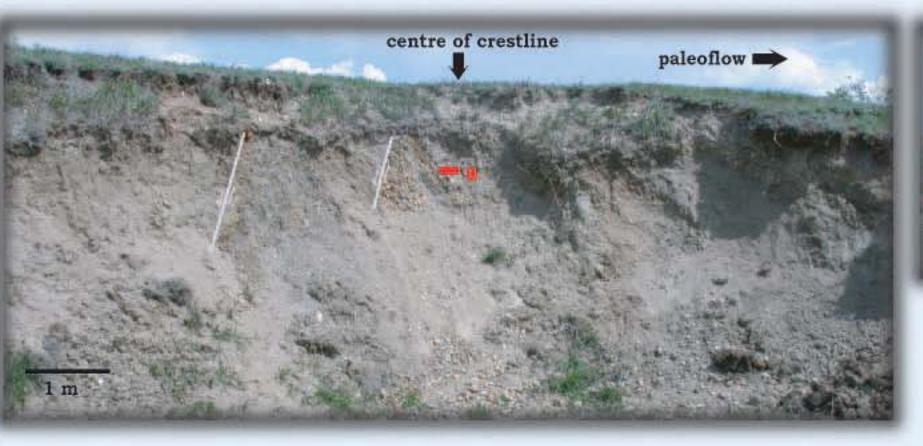




Fig. 12: Upland eskers often have a cap of loosely

INTERPRETATION/CONCLUSIONS

meltwater flow prior to the tunnel channel incision.

Fig. 13: Fluted escarpment that flanks the Clear Lake esker. This upland is bedrock cored

with a thin cover of till. The sculpting of the ridge was likely done by a broad, subglacial

Based on the observations to date, we can conclude the following factors are important for esker formation:

- 1. Lakes were important for establishing large esker systems. All significant esker systems in Alberta terminate in glacial lake basins. This linkage has been identified as being a critical control of esker location [6]. The difference in size and lack of significant post-depositional disturbance indicates that the upland eskers were short-lived and did not experience the hydraulic damming of the larger, lake-terminating systems. The till cap indicates minimal removal of debris from the glacier ice and, possibly, limited operation.
- 2. Large eskers are typically located in channels and truncate gravel/sand fills. This suggests that after erosion of the channels, they were mostly filled, presumably providing sediment for later esker formation. The channels may be tunnel channels in other cases or be preglacial fluvial tributaries. The channel fills are late Pleistocene in age due to the presence of shield rocks and only a single glaciation in the region [7].
- 3. These relationships indicate a long-lived hydraulic connection in these larger systems between channels, lakes and eskers.

These landform / sediment associations lead to the following sequence of events for the Clear Lake esker environment:

- 1. The fluted escarpment (Fig. 13) indicates that meltwater erosion preceded formation of the tunnel channel and esker system. Due to the upland's composition and morphology we interpret the formation by vortices in a subglacial meltwater flow, similar to that advocated by [8].
- 2. Following this broad flow phase, the meltwater progressively channelized [9,10], bifurcating around this escarpment. Following the erosion of this channel, discharge dropped, depositing the massive gravel/sand deposit as the channelized flow expanded into the lake basin.
- 3. The last stage involved formation of the esker for extended periods, kept open by hydraulic damming provide by the lake basin. The R-channel reworked the preexising sediment of the large fan.

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