Esker formation and meltwater routing on and beneath the margins of the last Cordilleran Ice Sheet: implications for modelling ice sheet hydrology

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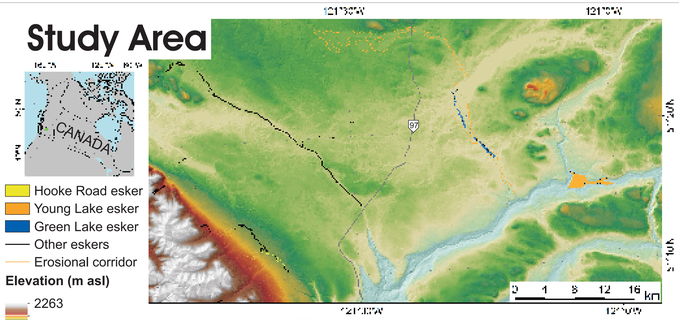
Rationale

It has been suggested that esker spacing under ice sheets flowing over low relief, sediment covered substrates is constrained by self-organizing perennial subglacial streams whose location is controlled by groundwater transmissivity and basal heat flux (Boulton et al., 2007a,b, 2009). Modelling implications suggest esker spacing should be regular and may be used to reconstruct basal melt rates (if groundwater transmissivity is known). We test these theoretical assertions on British Columbia's relatively low relief southern Fraser Plateau, where eskers formed under the margins of the retreating Cordilleran Ice Sheet and are now exposed on the land surface.

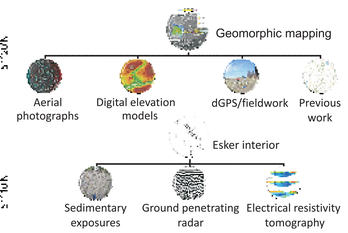
Objectives

1. Examine esker morphology, sedimentary architecture and composition associated with the decaying Cordilleran Ice Sheet in south-central BC
2. Infer related variations in conduit type and glacial hydrology

Study Area



Methods

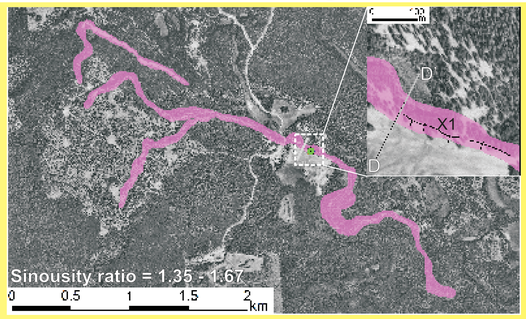


Morphology

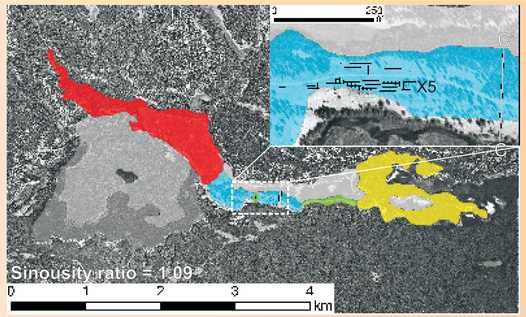
- Round-crested
- Multi-crested
- Flat-crested
- Sharp-crested
- Widening
- Depression
- Hummocky
- Slump
- Bedrock
- Erosional corridor
- Esker cross profile
- Radar grid location

Esker Morphology

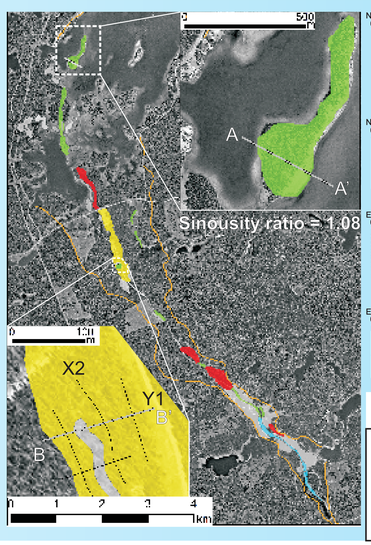
Hooke Road Esker

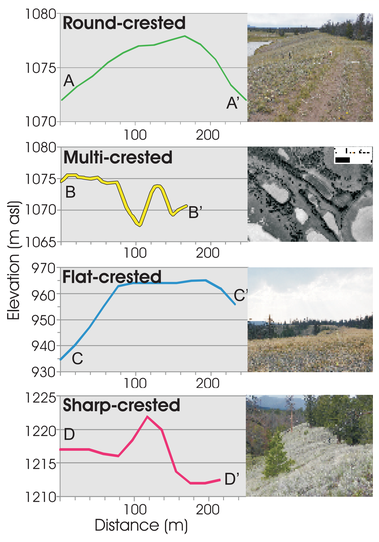


Young Lake Esker



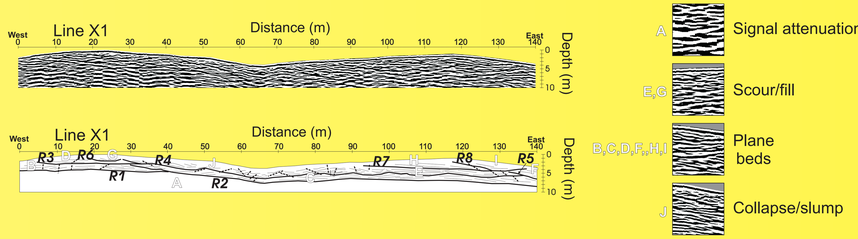
Green Lake Esker

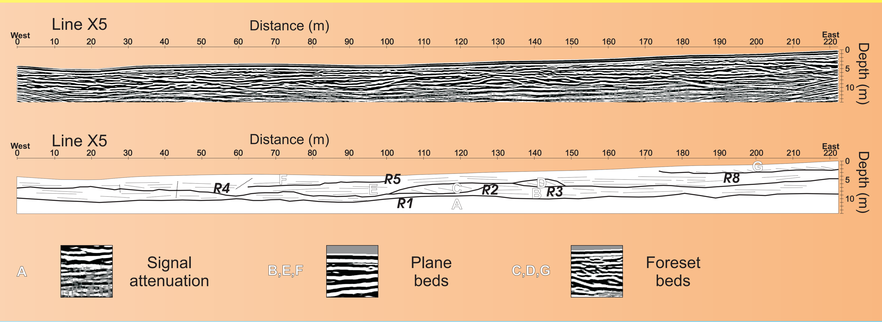


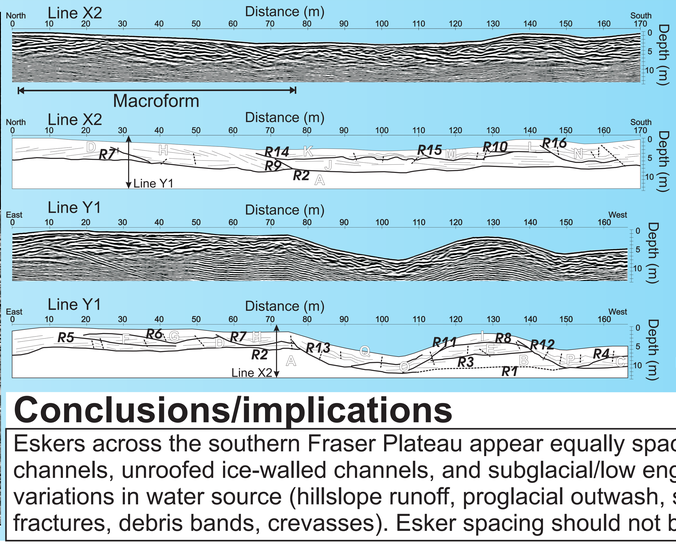


Esker Architecture

R10 Radar bounding surface ..... Offset reflections (faults) A Radar elements



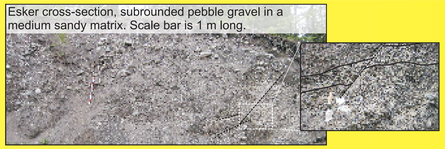


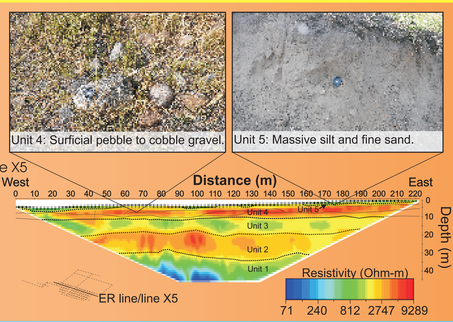


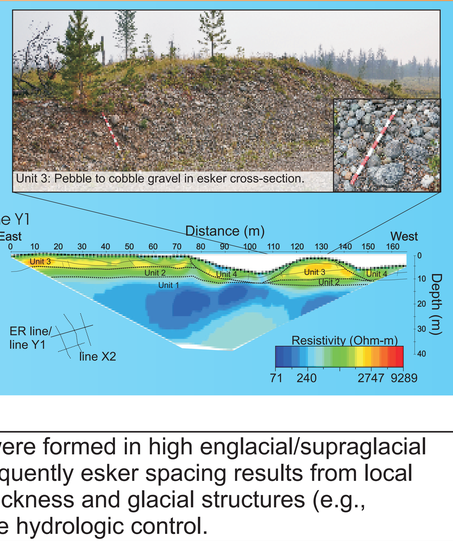
Esker Composition

High resistivity (sand and gravel) — Moderate resistivity (silt and diamict) — Low resistivity (water saturated)

Resistivity units boundaries — GPR unit boundaries — Faults/offset GPR reflections







Summary

- Esker occurs in association with ice marginal channels
- High overall sinuosity ratio (1.35-1.65, cf. Gulley et al. 2009) that includes some straight segments
- Sharp undulatory crest, frequent faulting
- Planar bedded, clast-supported gravel with some shallow scour and fill

Consistent with deposition from seasonal flow in a high englacial/supraglacial channel

- Low sinuosity ratio (1.09) suggests a channel topographically constrained by land and ice, its location facilitated by pre-existing glaciological structure (e.g., crevasse)
- Flat crest, surrounded by depressions, and few faults
- Tabular bedded gravel with broad scour and fill structures and slipface deposits

Consistent with braided river deposition in an unroofed ice-walled channel

- Esker occurs within an erosional corridor connected to a subglacial lake basin
- Very low sinuosity ratio (1.08) reflects deposition largely constrained within pre-existing erosional corridor and/or along glaciological structure (e.g., crevasse)
- Multi-crested, with enclosed depressions
- Faulted and slumped segments end-to-end with segments containing undisturbed bedding
- Upflow and downflow accreting ridge-scale composite macroform suggests high energy flow in a single event

Consistent with deposition in a subglacial/ low englacial conduit with high energy flow

Conclusions/implications

Eskers across the southern Fraser Plateau appear equally spaced (~15-20 km), yet were formed in high englacial/supraglacial channels, unroofed ice-walled channels, and subglacial/low englacial conduits, consequently esker spacing results from local variations in water source (hillslope runoff, proglacial outwash, subglacial lake), ice thickness and glacial structures (e.g., fractures, debris bands, crevasses). Esker spacing should not be used to infer a single hydrologic control.

References

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