Fishing for answers in deglacial ribbon lakes

advances in Cordilleran paleogeographic, paleoenvironmental and isostatic reconstructions

Timothy Johnsen and Tracy Brennand, Simon Fraser University, British Columbia, Canada

Objectives

- Investigate, survey and correlate paleolake levels
- Reconstruct paleolake geography, evolution and environment
- Reconstruct glacio-isostatic rebound

Why study these lakes?

- Deglacial ribbon lakes have rarely been studied beyond the reconnaissance level
- Abundant sediment exposures and shoreline features are in the study area
- Most glacial lake research has been completed for the low relief setting of the Laurentide Ice Sheet. The study area is moderately high relief

How?

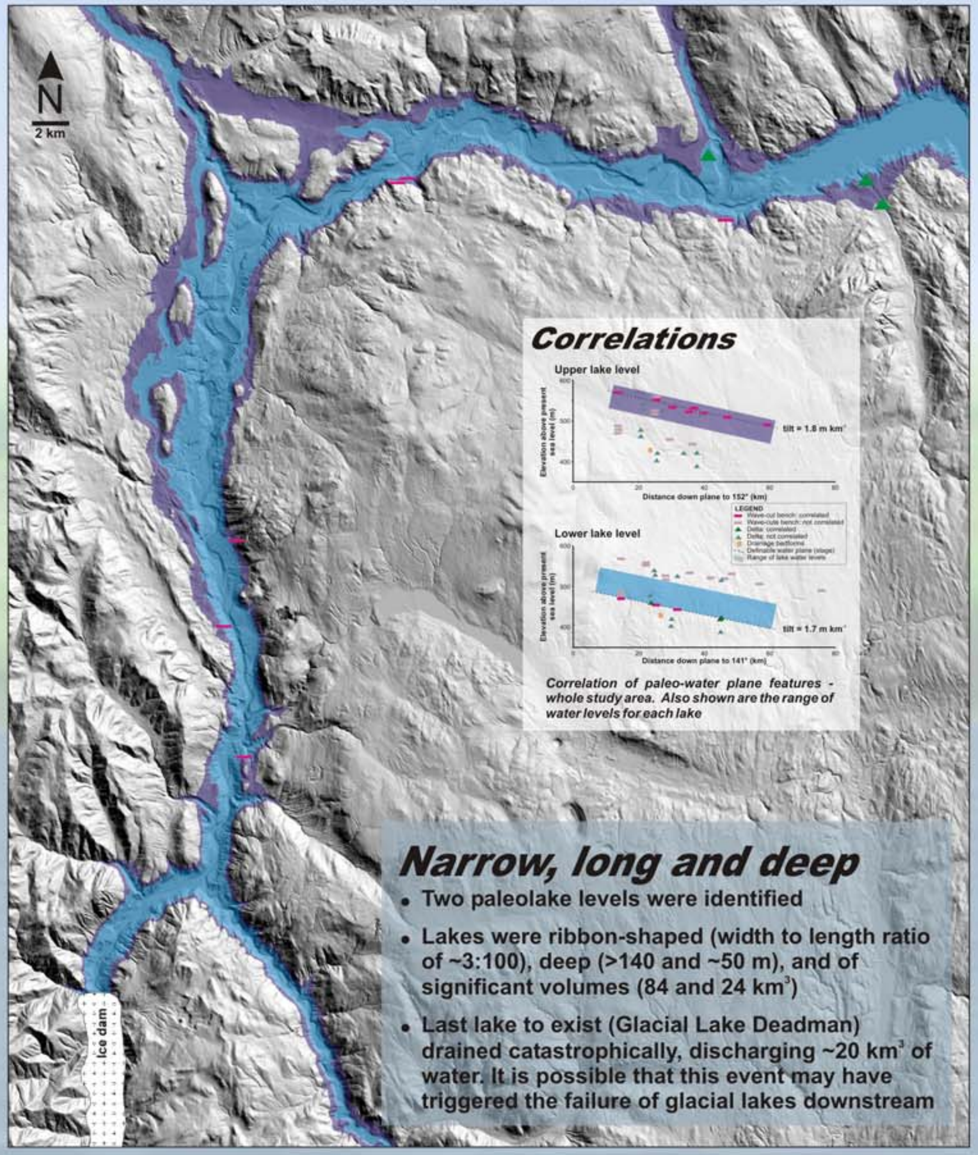
- Integrate a diversity of techniques: geomorphology, sedimentology, aerial photographs, differential GPS, GPR, DEMs and GIS

Delta example. Note multiple delta levels. Paleolake levels projected

Wave-cut bench example (arrows)

Wave-cut benches and delta surfaces were used to reconstruct paleolake levels.

Paleogeography



Correlation of paleo-water plane features - whole study area. Also shown are the range of water levels for each lake

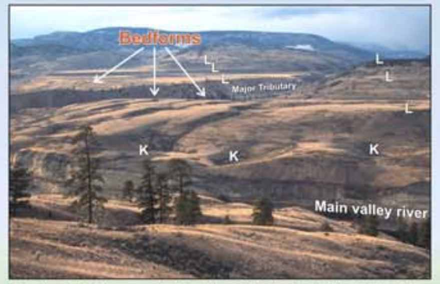
Paleolake levels (blue and purple) projected on DEM for one third of study area (adjusted for glacio-isostatic tilt). Wave-cut benches and deltas shown.

Narrow, long and deep

- Two paleolake levels were identified
- Lakes were ribbon-shaped (width to length ratio of ~3:100), deep (>140 and ~50 m), and of significant volumes (84 and 24 km^3)
- Last lake to exist (Glacial Lake Deadman) drained catastrophically, discharging ~20 km^3 of water. It is possible that this event may have triggered the failure of glacial lakes downstream

Catastrophic drainage

Ice dam failure led to catastrophic lake drainage and development of erosional surfaces and drainage bedforms



Drainage bedforms on delta. "L" = delta levels. "K" = kettle holes.

Eventually the floodwaters reached the marine environment of Georgia Strait, a total distance of ~250 km, where exotic deposits dated at ~10,500 ^{14}C yr BP[1] may have been produced by this jokulhlaup

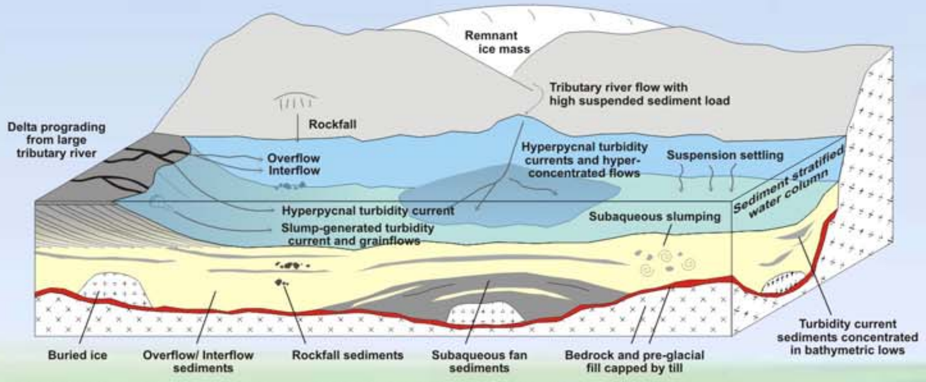
Floodpath

Floodpath of catastrophic lake drainage. Red dots = marine cores that record flood deposits. Dashed box = area of DEM to the left

Glacio-isostasy

- Glacio-isostatic tilts of these lake shorelines are among the highest measured in the world (1.8 - 1.7 m km^{-1})
- Causes: very thin (<35 km thick) and low viscosity lithosphere, paleo-topography of the CIS, rapid deglaciation, and the possible early development of these lakes
- Glacio-isostatic depression in this region was likely hundreds of metres

Paleoenvironment

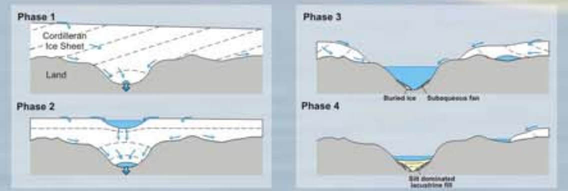


Model of the sedimentary environment: in and around ribbon lakes. Ice dam not shown.

Dynamic and energetic

- Deglacial environment whereby ice dominantly on plateaus, not valleys
- Ice dammed lake with numerous tributaries containing remnant ice masses in their headwaters
- High rates of sedimentation from tributaries that produced deltas, subaqueous fans and high energy lake sediments
- Low energy deposits dominated by laminated silts. Classic varves not produced
- Buried ice producing collapsed sediments and kettle holes

Deglaciation



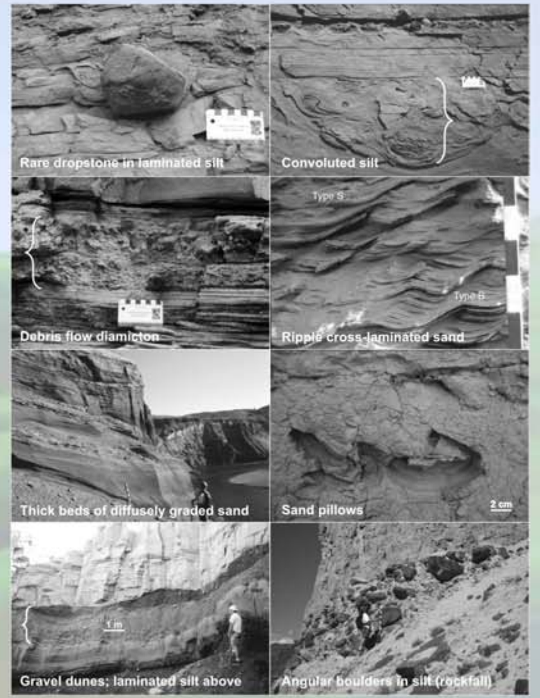
Conceptual model of ice sheet decay around valleys in the moderately high relief of the Thompson Plateau. Meltwater processes, enhanced around valleys, may have lead to valleys deglaciating prior to plateaus. Independent evidence supports the presence of ice on plateau areas during the time of these lakes. *Meltwater drainage routes indicated by blue arrows. Dashed lines are equipotential surfaces.*

Failures

Large underwater failures of sediments produced very large load structures (ball-and-pillow) of sand that occur in convoluted silt and in units tens of metres thick. Within the sand inclusions, convoluted ripple structures and laminations are preserved

Sedimentary facies

Seventeen glaciolacustrine lithofacies were identified (ranging in grain size from clayey-silt to boulder). They record: suspension settling (overflows), turbidity currents, debris flows, grain flows, hyperconcentrated flows (underflows), sediment loading, rockfall and mass failure. *Photocard is 8 cm wide. Stick is 1 m long with 10 cm increments.*



Acknowledgements

NSERC grant to Tracy Brennand; Support from: Colin Wooldridge, Mark Jurca, Chris Kowalchuk, Amanda X, Jerome Lesemann, Thomas James, Edward Johnsen, Tina Cheung

Suggested readings

[1] Blais-Stevens, A., Bornhold, B.D., Kemp, A.E.S., Dean, J.M. and Vaan, A.A. 2001. Overview of the Late Quaternary stratigraphy in Saanich Inlet, British Columbia: results of Ocean Drilling Program Leg 169S. Marine Geology 174: 3-26

Fulton, R.J. 1969. Glacial lake history, southern Interior Plateau, British Columbia. Geological Survey of Canada, Paper 69-37. 14 p.

Fulton, R.J. and Walcott, R.I. 1975. Lithospheric flexure as shown by deformation of glacial lake shorelines in southern British Columbia. Geological Society of America, Memoir 142: 163-173

Fulton, R.J. 1991. A conceptual model for the growth and decay of the Cordilleran Ice Sheet. Géographie Physique et Quaternaire 45: 281-286