The Glaciolacustrine Sediment Record of Cariboo Lake, BC: Implications for Holocene Fluvial and Glacial Watershed Dynamics

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0.1 Introduction

Records of the magnitude and rate of change of the environment that extend beyond currently observable record are crucial to understanding the processes and environmental and societal impacts of current climate change [@Turney2019; @Huber2012; @Nelson2016]. Environmental reconstructions at the sub-annual (e.g. ice cores, tree rings, and corals), to multi-decadal (e.g. sediments, pollen, boreholes) have proven useful in describing past environmental conditions across the globe [@Masson2013]. Sedimentary sequences collected from glaciated watersheds have been important in contributing to regional understanding of climate and hydrologic variability over the late Holocene. Research by @Neukom2019 have utilized sedimentary sequences as part of larger paleolimnological collections to provide a reconstruction of temperature variability over the last 2000 years. Despite their importance, relatively few records have been collected across the globe. In Canada, recovered sedimentary sequences have been collected from geographically limited regions including: Squamish Valley, East of the Rocky Mountains. Few continuos sedimentary sequences have been collected from the Cariboo Mountain region. This study presents a new record of hydroclimatic variability over the past 10 k years by sub-bottom acousitc (coarse resolution), and 2 k years through sediment cores (~50-100 yr variability).

0.2 Study Area

Cariboo Lake is located in the northern foothills of the Columbia Mountains, 85 km northeast of Williams Lake, British Columbia 1. The lake receives runoff from an area of 3242 km^2, and the watershed relief ranges from 2600 m asl in the headwaters to 600 m asl at the Cariboo Lake outlet. The Cariboo Lake watershed has 80 km ^{2} (as of 2017) of permanent ice cover which covers 2.4% of the total watershed. The most extensive glaciated terrain is proximal to Mt. Lunn roughly 60 km upstream of Cariboo Lake.

The Cariboo River, located on the east end of the lake provides the main source of sediment into the lake. The bathymetry of Cariboo Lake shows evidence of past glacial scouring, indicated by deep scour channels 2. The lake is separated into two main basins, by the Keithley Creek fan delta. The upstream basin is called the main Cariboo Lake basin, and the downstream basin is called the Keithley Creek basin. The bathymetry of the lake reaches a maximum depth of over 50 m in two scour channels within the central part of the main Cariboo Lake basin.

Sediment connectivity to headwater glaciers along the Cariboo River is limited due to lake filtering by Lanezi and Sandy lake. Lanezi Lake is a deep fjord lake with a bathymetry reaching a maximum depth of 170 m. Sandy Lake is much shallower reaching a maximum depth of 6 m. The Matthews River, which meets the Cariboo River just below Lanezi Lake provides less filtered connection to meltwater from several alpine glaciers including the largest chunk of ice in the Cariboo Lake watershed, the Roberts Peak Galcier.

0.3 Methods

Field Methods

A field campaign was conducted during the summer of 2017 to collect sub-bottom acoustic soundings, dredge samples, and sediment cores. Thirty-four km of sub-bottom acoustic soundings were collected across Cariboo Lake using a 10 kHz StrataBox 3510 HD. An Ekman dredge was used to collect 20 ~10 cm^3 samples of sediment from the lake bottom. The dredge samples were subsampled in the field using an 80 mm diameter PVC cylinder pushed into the block of sediment. The remaining sediment was kept as a bulk sediment sample. Four sediment cores (V1-V4) were collected using a Rossfelder submersible vibracorer with a 6 m long 70 mm diameter aluminum pipe. The Ekman subsample cores and the vibracores were split longitudinally with one half preserved as an archive and the other as a workging half. The working half samples were prepared for imaging by scraping the core parallel to the sediment laminae to create a flat surface which showed the sediment stratigraphy. The stratigraphy of cores V1 and V2 were best preserved and were selected for detailed analysis.

Laboratory Methods

Cores V1 and V2 were subsampled with 2 cm^3 of sediment extracted at a 5 cm interval, with additional samples taken within stratigraphic breaks. The Ekman bulk samples and vibracores were analyzed for laminae thickness, organic content, and particle size. Laminae couplets were digitally counted and measured for thickness using the ImageJ @imageJcite software. Organic content was determined by loss-on-ignition analysis (550 °C) following methods in @Smith2003. Samples were first weighed to provide an initial wet weight, then dried at 60 °C and weighed again after oven drying. The samples were then placed in a furnace at 550 °C for 2.5 hours and weighed a third time. Grain size analysis was conducted using a Mastersizer Particle Size Analyzer 3000. Samples were prepared following methods by @Gray2010 to remove the fine fraction of particles from organic material. This involved a removal of organic material using three sequential alloquots of 20% H202 until the sample stopped reacting. To prevent flocculation of sediment grains the samples were dispersed in 0.05% solution of Calgon for 24 hours. The chronology of both cores was provided by AMS ^{14}C dating of wood fragments at the André E. Lalonde AMS Laboratory at the University of Ottawa and varve chronology from laninae counting.

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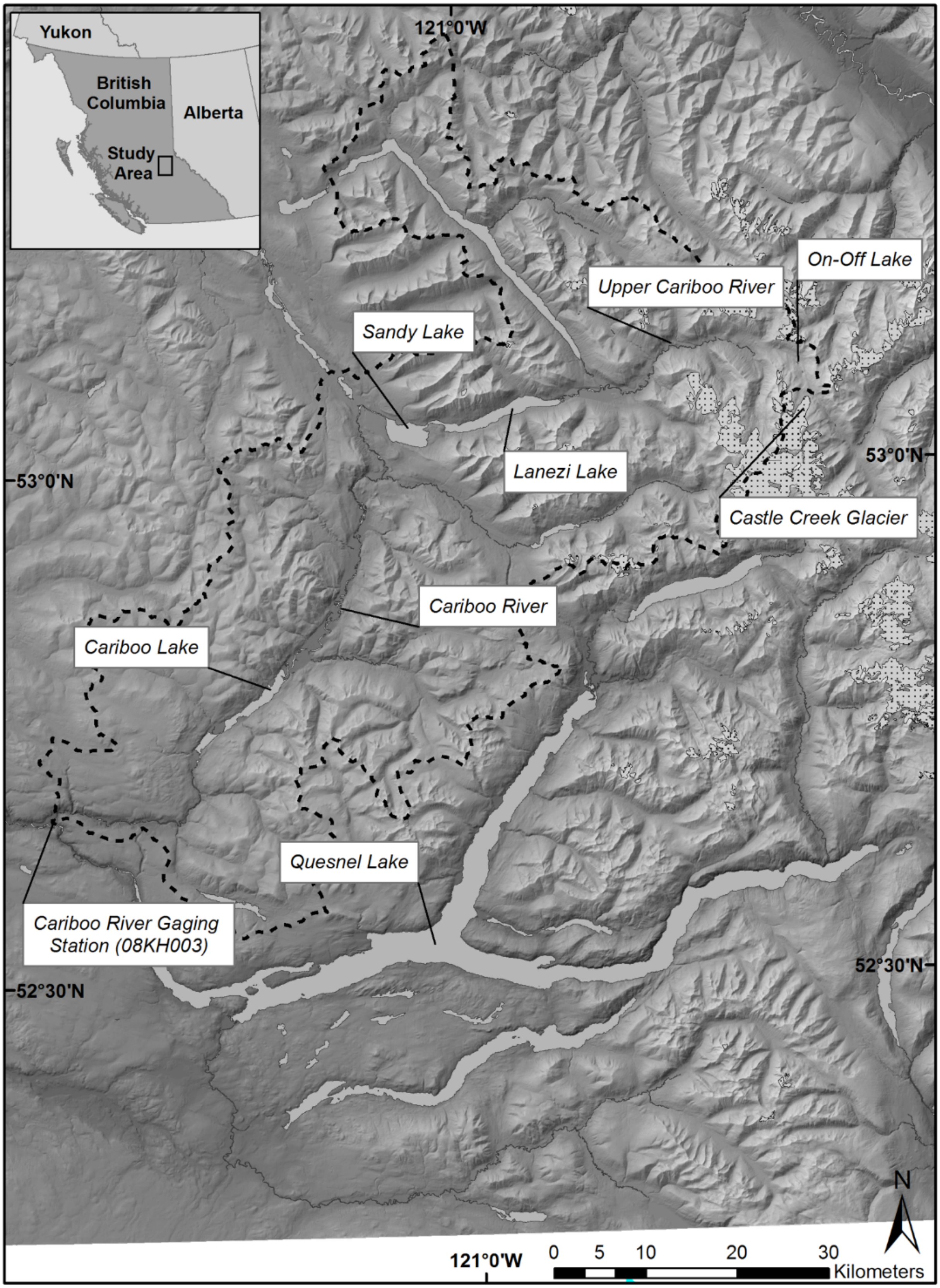

Figure 1: Map showing the Cariboo Lake basin.

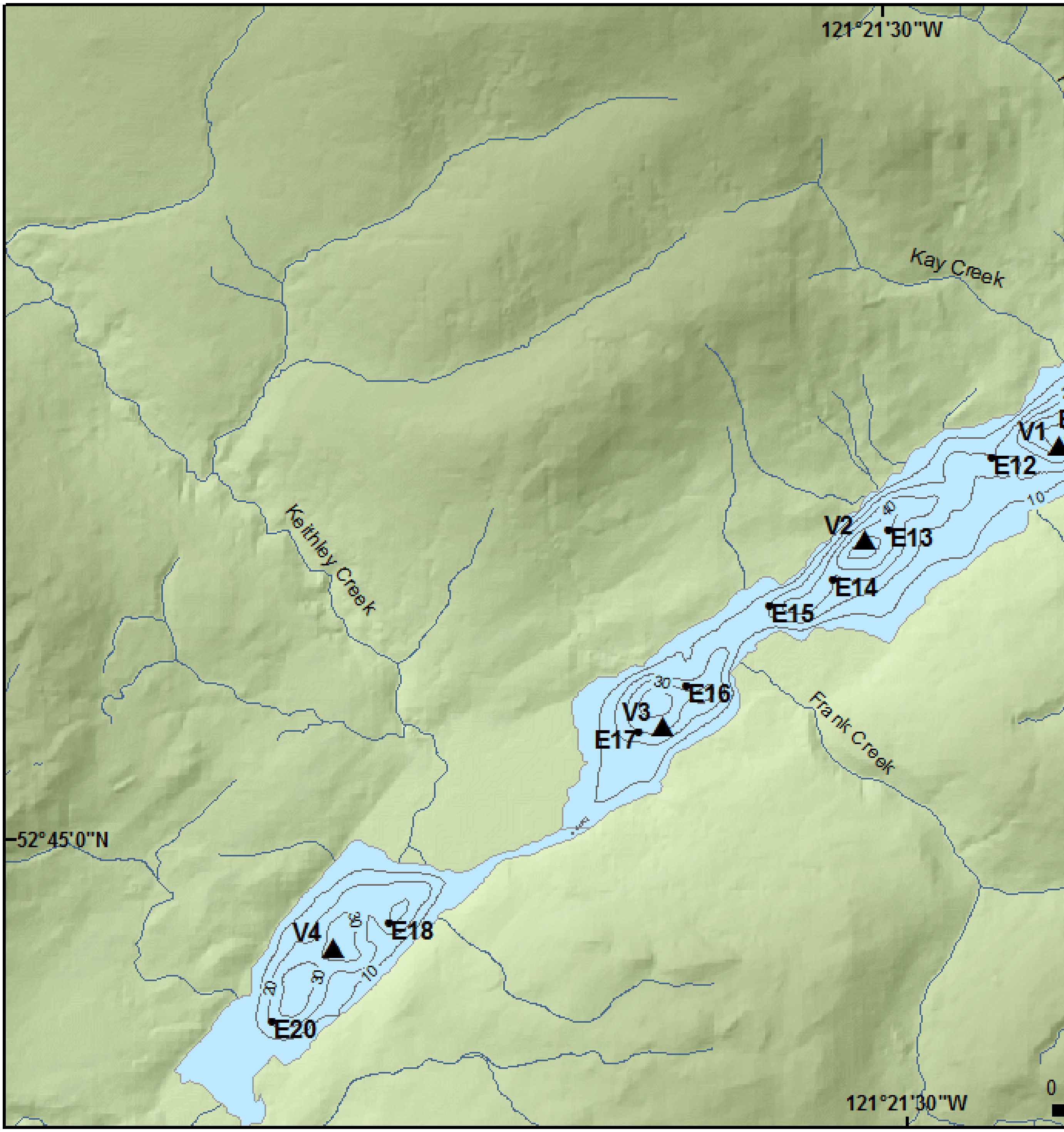

Figure 2: Map showing the Cariboo Lake bathymetry and coring locations.