

Clim. Past Discuss., community comment CC2
<https://doi.org/10.5194/cp-2021-132-CC2>, 2021
© Author(s) 2021. This work is distributed under
the Creative Commons Attribution 4.0 License.



Comment on cp-2021-132

Martin Roy

Community comment on "Was there a glacial outburst flood in the Torngat Mountains during Marine Isotope Stage 3?" by Tamara Pico et al., *Clim. Past Discuss.*, <https://doi.org/10.5194/cp-2021-132-CC2>, 2021

The manuscript of Pico et al. presents evidence for a glacial lake that developed before the LGM in the Koroc River valley and adjoining basins, to the west of the Torngat Mountains (NE Quebec-Labrador). It is then hypothesized that the drainage of this lake into the Labrador Sea may have contributed to climate perturbations (Heinrich events) during Marine Isotope Stage 3 – an interval of the last glacial cycle for which the authors claim to be characterized by a significantly reduced ice cover in the region formerly covered by the Laurentide ice sheet (LIS).

As glacial geologists working since several years on the deglaciation of the greater Ungava Bay region, we were extremely enthusiastic about this new piece of information. Indeed, the Labrador-Ungava region is a key area for the study of the evolution of the LIS during the last glacial cycle. Previous work in this region has showed the occurrence of several ice-dammed lakes that developed during the last deglaciation and their location near a critical sector of the North Atlantic makes freshwater forcings from this region highly relevant to paleoclimate studies. It is also a remote area difficult to access and as such, many aspects of its geological record remain to be studied.

The conclusions drawn in this study are mainly based on the assumption that a glacial lake existed and that it drained during MIS 3. The geological evidence presented in support to this MIS 3 ice-dammed lake and flood are:

- 1) a wave-cut bench (c.f., shoreline) at an elevation of 890 m used to reconstruct a high-elevation ice-dammed lake in the Koroc River valley;
- 2) an inlet channel filled with cobbles recording the abrupt drainage of the lake;
- 3) two cosmogenic ages from bedrock surfaces exposed by lakeshore erosion indicating an age of ~ 36 ka (MIS 3).

It appears that these landforms and ^{10}Be ages come from a single site (as suggested by the geographic coordinates in the Table). Also, no geological evidence is presented for the damming mechanism of the lake, which is based on the presumed occurrence of the LIS margin in the lower reach of the Koroc River and valley glaciers in its upper reach.

Careful examination of the manuscript and data therein, and consideration of available geological maps (see below), leads us to conclude that, at this stage, the geomorphological evidence and geochronological data reported are unfortunately too fragmentary to support the existence of this glacial lake and outburst flood during MIS 3. More importantly, we believe that the interpretation of the geomorphological features reported may be incorrect, while the proposed ice margin configuration for the LIS and valley glaciers appears inconsistent with the reduced ice cover scenario presented for MIS 3 in the study.

We further expand these points in the paragraphs below, in addition to comment on geochronological approach used.

Geomorphological evidence for a pre-LGM glacial Lake Koroc and outburst flood

The evidence supporting the existence of this glacial lake is essentially enclosed in the two photographs presented in Figure 4. In Fig. 4A, it is not clear to what geomorphological feature(s) the authors refer to when "interpolating" a former lake level running up high across the valley. Despite the low resolution of the photo, an apparent trim line can be seen and from this distance, it seems to separate permafrost terrains (frost-shattered bedrock and felsenmeer) present on the high mountain top from the lower freshly glacially-eroded valley walls. In the foreground of this photo, it is also difficult to identify the geomorphological feature supposed to represent a former shoreline, but the action of freeze-thaw processes on the bedrock and deposits is clearly present with slopes partly covered by solifluction lobes dissected by meltwater channels.

The photo in 4B is supposed to show a wave-cut bench and bedrock surfaces exposed by lakeshore erosion. However, the entire feature lacks the continuity that would normally characterize a shoreline. Based on this photo, this setting could be interpreted as a frost-shattered erosional bedrock surface (felsenmeer), while the presence of the smoother rock surfaces on the gently sloping terrain may reflect erosion (block removal) by meltwater. Erosion of Archean gneissic rocks by lakeshore wave-action would require a lot of time, which is generally not the case with the short-lived ice-dammed lakes of Ungava-Labrador.

Given the importance of this glacial lake in the study, and considering the associated implications for paleogeographic reconstructions, the manuscript should better document the characteristics of the shorelines reported. An unanswered question concerns the number of sites with shorelines that have been documented? The manuscript reports currently one, although it is mentioned that "this glacial lake was identified based on geomorphological mapping of shorelines, spillways, and drainage channels" (Lines 199-200). Indeed, these features form key indicators for identifying a glacial lake and the results from this mapping should be clearly presented to constrain the areal extent of the lake and build a proper case for its existence. A glacial lake of this importance should have left several geomorphological evidence of its presence in the study area, even in the context of preservation by a non-erosive cold-based ice.

Similarly, the claim of the "first direct evidence on land for an MIS 3 jokulhaup" (Lines 363 and 407) can be questioned. This outburst flood was identified on the basis of "a small inlet channel at this elevation with rounded, imbricated cobbles" (c.f. Fig. 4). Again, the geological support for this outburst flood should be better documented and the feature reported here should be better detailed, especially regarding its spatial relationship with respect to the lake configuration (location in the study area?).

As mentioned in the manuscript, the drainage of glacial lakes through outburst floods

occurred during the last deglaciation in the Ungava-Labrador region. The nearby Lake Naskaupi indeed drained through outburst flooding events that left behind a wealth of large-scale geomorphological deposits and landforms, such as km-size ripples and other features like multi-tens of meters thick alluvial bars (Dubé-Loubert and Roy, 2017; Dubé-Loubert et al., 2018). Even if we assume that part of these features was eroded by the ice advance of the last glaciation (MIS 2), evidence for the outburst drainage of a lake the size of the hypothetical pre-LGM Lake Koroc should still be present in the geomorphological and sedimentary records of this region.

We note that insights on whether a pre-LGM glacial lake existed in the Koroc River valley may be gained in part from two detailed Quaternary geology maps produced by the Geological Survey of Canada that cover the whole Koroc River drainage basin (Paradis and Parent, 2002a, 2002b). These maps do show evidence for glacial lake(s) at lower elevations in the Koroc River valley, but these glacial lake deposits and landforms (deltas and shorelines) are part of a morpho-sedimentary assemblage typical of the early Holocene deglaciation. Small and scarce occurrences of glacial lake deposits are found in places at higher elevations, but they likely relate to ephemeral lakes that were dammed by small retreating glacier tongues during the last deglaciation, as indicated by belts of minor moraine crests in these minor valleys. The maps also show that the high-elevation terrains of the study area consist essentially of bedrock exposures that are commonly blanketed and flanked by block fields (felsenmeer) produced by frost action, with abundant solifluction lobes – a setting reminiscent of the features presented in the photos of Figure 4. Given the ease of access to these maps (references below), this critical information should have been taken into consideration when attempting to reconstruct such a lake.

Configuration of the ice masses damming the lake

Accepting the premise that a pre-LGM glacial lake occupied the Koroc River valley also raises other important questions regarding the configuration and origin of the ice masses that dammed the lake at that time. Given the lack of geological data constraining ice-margin positions during MIS 3 in Labrador-Ungava, the authors use a series of assumptions about the ice dam locations.

Some of these are coherent with paleogeographic reconstructions of the last deglaciation, when the lower reach of the rivers flowing into southeastern Ungava Bay was dammed by the margin of the retreating Labrador Ice Dome – a damming mechanism that resulted in the accumulation of large amount of meltwater in river valleys such as the Koroc River. Although this scenario is consistent with the last deglaciation, it nonetheless involves a substantial ice mass located in north-central Quebec in order to have an ice margin extending down into the Ungava Bay lowlands. This ice margin would also have to be very thick and voluminous to hold the large meltwater body (high hydrostatic pressure) associated with a pre-LGM Lake Koroc with a surface-elevation at ~900 m. These considerations appear counterintuitive in the context of a drastically reduced ice cover for MIS 3 that is presented in the manuscript.

Damming a high-elevation glacial lake (~900 m) in this region also requires the presence of ice masses in the upper reaches of the Koroc River drainage watershed, without which, the lake would drain via different low-elevation outlets. To circumvent this problem, it is stipulated that several valley glaciers occupied low-lying topographic depressions to prevent excess meltwater to flow eastward across the continental divide separating the Ungava Bay and Labrador Sea watersheds. Unfortunately, no geological evidence is presented to support the existence of these valley glaciers. The manuscript refers to the work of Ives to support the existence of these valley glaciers in the Torngats, although it

does not relate to old valley glaciations. Accordingly, the manuscript should build a better case for this aspect of the reconstruction.

Again, drawing comparisons based on the geological maps reported above, the deglacial (Holocene) geomorphology of the numerous secondary valleys of this region shows a record of small-scale moraines and ice-contact deposits that tend to suggest that these valley glaciers were perhaps not large enough to hold such a large lake. For these valley glaciers to be efficient for the damming of the pre-LGM Lake Koroc would imply larger valley glaciers and ice caps, which in turn calls for a large amount of ice above the Torngats at that time – a scenario inconsistent with the hypothesis of a significantly reduced ice cover presented for this time interval.

Geochronological constraints

An important limitation regarding the conclusions reached by the study relates to the fact the MIS 3 age assigned to the old glacial Lake Koroc is based on only two cosmogenic ages. This represents an extremely low number of geochronological constraints considering the method employed here and given the complexity and variety of terrains present in formerly glaciated environments.

For instance, several studies have documented complex arrangements of subglacial thermal conditions in the Labrador-Ungava region, which show evidence that high-elevation regions were likely characterized by at least a partial cold-based ice cover (Marquette et al., 2004; Staiger et al., 2005; Rice et al., JQS 2019; Dubé-Loubert et al., Geomorph. 2021). Although this provides a setting for a non-erosive ice cover and thus the preservation of old geomorphological features, it does warrant caution in the interpretation of cosmogenic ages, which may be affected by inheritance signal from previous exposures and result with age overestimates.

However, the manuscript presents a different interpretation for the two pre-deglaciation ^{10}Be ages obtained. The favored age of $\sim 56 \pm 3$ ka derives from a correction applied to the two samples to take into account a period of burial by ice; a plausible choice of calculation and consistent with the hypothesis presented in the study. Still, considering the inheritance problem inherent to high elevation terrains of this region, it would have been essential to carry out paired isotope (Al/Be) measurements to characterize the history of ice cover of this site – an approach that would greatly facilitate the interpretation of the results. In addition, as for the geomorphological evidence for the lake, it would have been important to present ^{10}Be ages from more than one site in order to support the deductions made on the basis of the two geochronological constraints.

Summary

We believe the manuscript presents an interesting hypothesis regarding the possibility of a pre-LGM glacial lake to the east of the Torngat Mountains and the potential contribution of its drainage to the forcing mechanisms responsible for the climate variability (Heinrich events) of MIS 3. Unfortunately, the geomorphological evidence and geochronological data supporting the existence of a glacial Lake Koroc during MIS 3 are too fragmentary and unconvincing at the moment, while the proposed configuration of the damming LIS margins and valley glaciers appears inconsistent with the scenario of significantly reduced ice cover presented. As stated at numerous places in the manuscript, we concur with the authors that further fieldwork is required to convincingly show that old (relict) geomorphological features are present on high-elevation terrains of Labrador-Ungava. At

this point we would simply urge caution in using such a small amount of geological evidence to claim the existence of a glacial lake and outburst flood, especially when using the reconstruction to constrain the ice margin of the Laurentide ice sheet during MIS 3 in one of its core sectors.

Martin Roy – Department of Earth and atmospheric sciences / Geotop Research Center, University of Quebec at Montreal, Montréal (QC), Canada.

Hugo Dubé-Loubert – Quebec Ministry of Energy and Natural Resources, Val d'Or (QC), Canada.

References for the maps by the Geological Survey of Canada.

Quaternary geology of the Koroc River in Quebec-Newfoundland and Labrador (eastern and western map sheets 2013A and 2013A, scale 1:125,000).

Paradis, SJ and Parent, M, 2002. Géologie des formations en surface, Rivière Koroc (moitié est), Québec-Terre-Neuve-et-Labrador, Commission Géologique du Canada, Carte 2013A, échelle 1 :125,000. (available on <https://geoscan.nrcan.gc.ca>)

Paradis, SJ and Parent, M, 2002. Géologie des formations en surface, Rivière Koroc (moitié ouest), Québec-Terre-Neuve-et-Labrador, Commission Géologique du Canada, Carte 2014A, échelle 1 :125,000). (available on <https://geoscan.nrcan.gc.ca>)