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EGUSPHERE-2024-2486
Final response RC2

We thank Benjamin Boyes for his thorough review of our work and, in responding to raised issues, we will be able to present an updated version of the manuscript that contains important improvements in its writing, arguments, and figures. Below we will address the reviewer comments in the order they were presented. The reviewer's comments are given in default font, with our original text, on which the comments were made, repeated in italics for reference. Our response is given in blue-, and suggested changes to the manuscript in red-type fonts.

RC2 – Benjamin Boyes

General remarks

This article presents a new framework for understanding late glacial landscape evolution in northern Sweden. The study uses original geomorphological data and previously published chronometric data to reconstruct Fennoscandian Ice Sheet retreat patterns, ice dammed lake development, and the evolution of post-glacial faults. This publication is suitable for publication in *The Cryosphere* after minor revisions, and I look forward to seeing it published.

We thank the reviewer for his encouraging feedback and for considering our work a valuable contribution to the understanding of late glacial landscape evolution in northern Sweden. We are pleased that the reviewer finds our study fit for publication.

Academic rigour and accuracy
The study's methodology is comprehensive, and the results are clearly laid out. However, it would be useful if the following points are clarified:

- The mapping methods could be more clearly laid out. The manuscript suggests you mapped a wide array of features, but details (e.g. how polylines are drawn to map landforms) are only provided for ice dammed lakes (and associated features).

The mapping approach for the other landforms will be described in an extra column in Table 1, while the more comprehensive description for the ice-dammed lake traces is kept in the text as it was. We will add a sentence referring to Table 1 for the details on the mapping approach.

"The mapping approach, that is, how the landforms are delimited in GIS software, is briefly described for all landforms in Table 1. Given the focus on ice-dammed lake traces, the mapping approach of raised shorelines and perched deltas, and the methodology to identify ice-dammed lake stages, are described in more detail below."

- The fault lines and rock slope failure deposits are not presented in the results. These data are from previous work (as suggested by Figure 1b) and the source of these data need to be more obviously discussed in the text. If you checked these against the LiDAR data, this needs to be discussed.

Thank you for this suggestion. We will add a paragraph in the Methods/Datasets section to discuss the data sources in more detail.

"Vector datasets of previously published studies were used for different purposes. The international database of Munier et al. (2020) contains glacially-induced faults in northern Fennoscandia (Fig. 1b), of which many were previously proposed and recently confirmed based on the recent LiDAR data. The faults in the database were cross-referenced with the LiDAR-based DEM, but no effort was made to identify new faults. The dataset was used to identify cross-cutting relationships between glacial landforms and fault scarps. The deglaciation isochrons reconstructed by Stroeven et al. (2016) were used to evaluate the implications of the direction of mapped landforms and to constrain the chronology (Fig. 1b). Cosmogenic nuclide ^{10}Be exposure ages of two rock slope failure (RSF) deposits were taken from Stroeven et al. (2002, 2016). The RSF extents were cross-referenced against the LiDAR-based DEM."

- The mapping is good and has added considerable detail to the region, and I like how clear the supplementary map is. However, from personal experience mapping landforms in this region from similar LiDAR data and in the field, I think some features have not been mapped. This is entirely subjective, but it would be good to know why you chose to map certain features and if you chose to omit any?

We are not sure whether this comment is referring to entire feature classes or to individual features: in our answer we presume that latter. Although there is of course the aim to identify all features, there were certainly features where the actual landform type remained ambiguous. In this respect the map is conservative: we only mapped features of which the genetic interpretation could be confidently determined. Given that dataset, we were able to draw robust conclusions, which are insensitive to the total number of mapped features.

- The relative timing (e.g. last glacial vs previous glacial) of some of the features needs clarification. Why have you decided which landforms are pre-last glacial, and maybe show these features on a map of their own? You mention that this is a thing, but don't provide any evidence of pre-last glacial landforms.

We appreciate the reviewer's comment regarding the relative timing of our mapped features. We understand the importance of distinguishing between last glacial and pre-last glacial landforms. However, we do not believe that we explicitly stated it as a significant issue ("a thing") in our manuscript. Our intention was to provide a general context, as we did in the following sections:

- **Study area section (lines 95-103)**: We describe that the area is known for its palimpsest landforms.
- **Discussion/Ice-marginal positions section (lines 411-413)**: We reiterate that it is known that landforms are not exclusively from the last deglaciation.
- **Discussion/Glacially-induced faulting section (lines 470-475)**: We mention that traces of older glaciations can complicate reconstructions, such as those of relative timing between fault rupture and glacial landforms. We mention that glacial landforms cut by the Pärvie Fault within the study area align with reconstructed deglaciation directions.

We are uncertain about the improvements the reviewer is suggesting. After careful consideration, we believe that the current presentation aligns best with the overall objectives of our manuscript. Therefore, we will retain the original content on this topic. We thank the reviewer for making us re-think this topic.

- As I understand it, mkm^{-1} is a unit referring to slope? A short sentence clarifying what this means would be helpful.

Thank you for pointing this out: it is indeed a unit referring to the gradient of the shorelines. A sentence will be added to the Methods chapter to explain the unit.

“The tilting of the shorelines is described as a gradient in m km^{-1} where the elevation difference (in meters) is given over the distance (in kilometers) in direction of the reference plane.”

- Some discussion on how your geomorphological mapping compares with existing geomorphological maps could be interesting. You do this comprehensively for the lakes, but not the other landforms.

This is a good idea. It requires two steps. First, we need to explain what data sources we have for comparison and how they were digitized, and then we will suggest a section discussing how our mapping compares to the previously published maps.

A statement on the inclusion of printed maps for cross-referencing will be included in the Methods chapter.

“Several printed maps were digitized to cross-reference the mapping. The geomorphological maps by Melander (1977a, 1977b) were georectified by the Agency for Digital Government (DIGG; https://www.digg.se/en), which were then georeferenced in GIS software using locations on the map with known coordinates. Additionally, a scanned and georeferenced map by Hättestrand (1998) was imported into the GIS environment.”

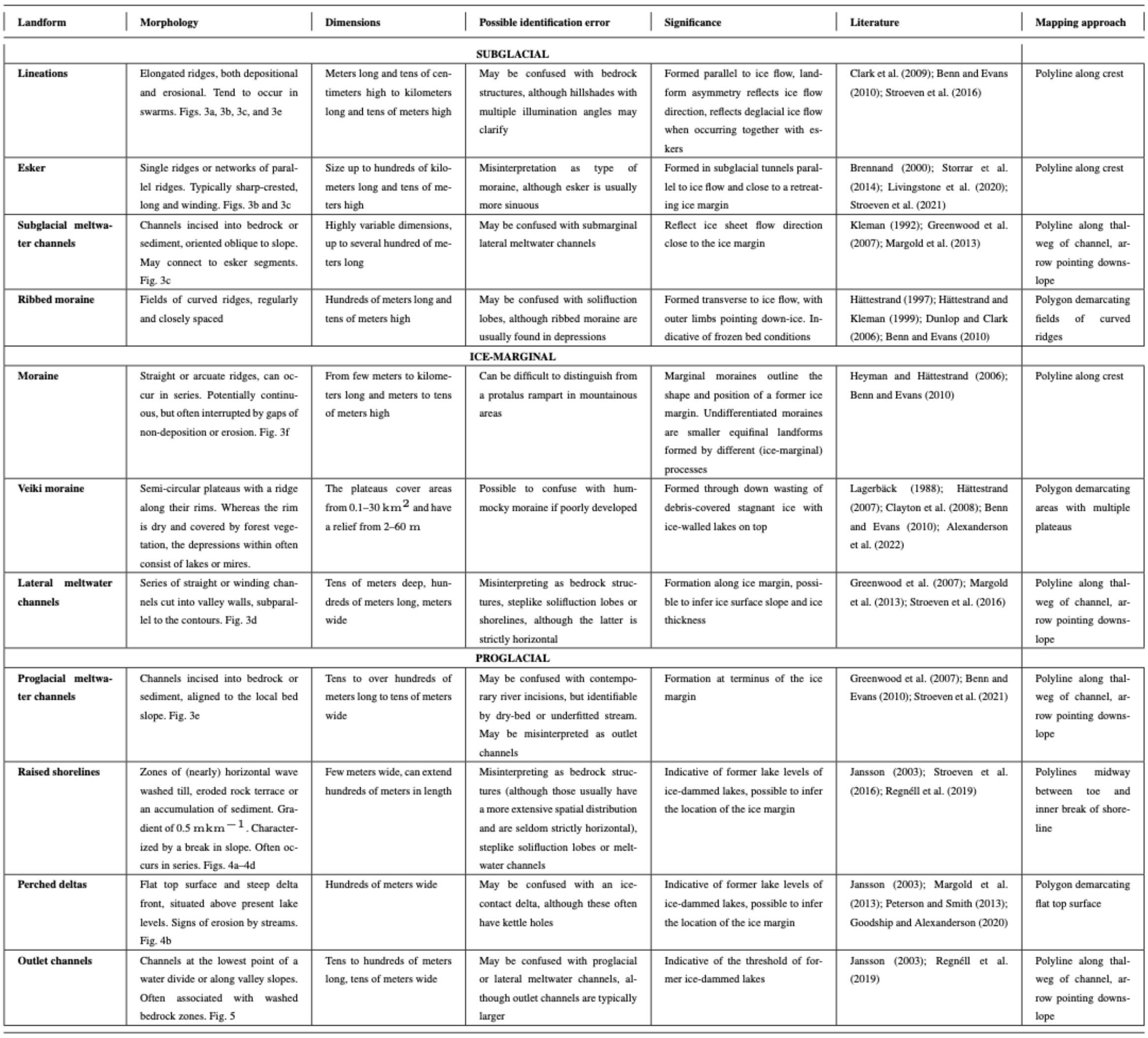
We will add another paragraph to our Discussion where we will present a global comparison between our mapping and previous maps.

“The most detailed geomorphological maps of the Torneträsk region were produced by Melander (1977a, 1977b). His landform interpretation is based on aerial photographs and extensive field verification, and resulted in a comprehensive geomorphological map presented at 1:250,000. Our mapping (Fig. S1) is consistent with his mapping but adds considerable detail in terms of the number of raised shorelines (resulting in more ice-dammed lake stages), and the number of channels in flights of lateral meltwater channels. Additionally, whereas we map different types of meltwater channels, Melander (1977a, 1977b) only categorizes glaciofluvial channels by size. For example, some large glaciofluvial channels correspond to outlet channels of ice-dammed lakes in this study. A critical difference between our maps is the number of lineations; our mapping includes significantly more lineations in both the premontane and the montane regions. The last glacial geomorphological map covering the Torneträsk region was produced from aerial photographs by Hättestrand (1998) at 1:1,250,000. Unlike Melander (1977a, b), this map includes large and small scale lineations, ribbed moraine, DeGeer moraines, and Veiki moraine. Our landform distributions of those features are consistent with the Hättestrand(1998) map but provide more detail, as individual lineations are outlined rather than a representative for a larger area. Thus, our mapping based on high-resolution LiDAR data, as expected, adds more detail in terms of landform count but is consistent with previously-mapped landform distributions. The critical implication of added detail in our mapping resides in a more detailed reconstruction of the ice-dammed lakes, but does not alter general inferences on ice retreat from ice flow directional indicators.”

- Table 1: This is a nice comprehensive table – I particularly like the "possible identification error" column. It would be helpful to have in this table a column that explains the mapping approach, as an example figure in e.g. Boyes et al., 2021 (https://doi.org/10.1080/17445647.2021.1970036) and/or as text.

This suggestion will improve the description of our mapping approach. We will add the mapping approach as the last text column in Table 1.

Table 1. Landform classification table describing the morphology, dimensions, possible identification errors, paleoglaciological significance, and the mapping approach of the landforms mapped in this study.

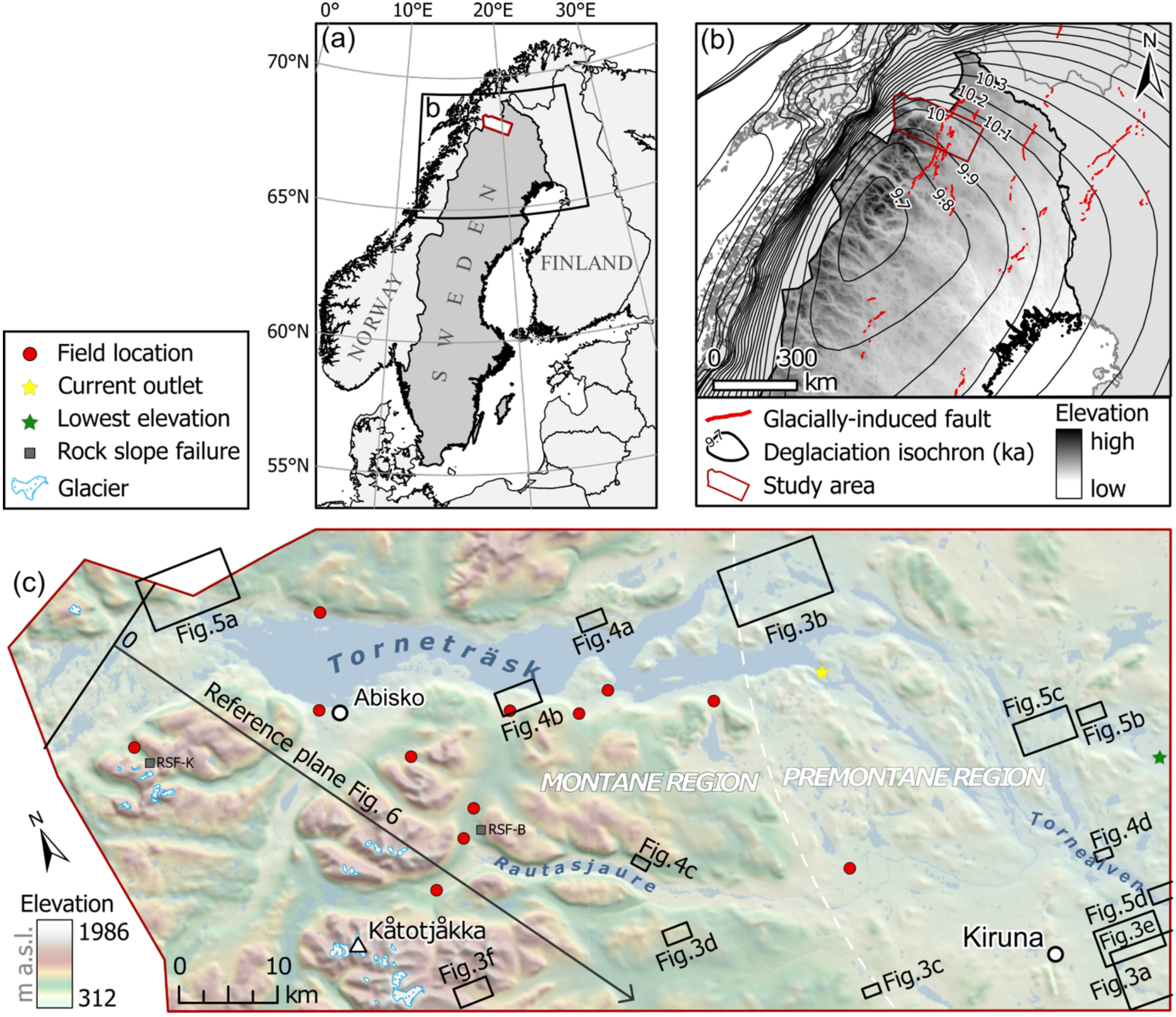


Landform	Morphology	Dimensions	Possible identification error	Significance	Literature	Mapping approach
SUBGLACIAL						
Lineations	Elongated ridges, both depositional and erosional. Tend to occur in swarms. Figs. 3a, 3b, 3c, and 3e	Meters long and tens of centimeters high to kilometers long and tens of meters high	May be confused with bedrock structures, although hillshades with multiple illumination angles may clarify	Formed parallel to ice flow, landform asymmetry reflects ice flow direction, reflects deglacial ice flow when occurring together with eskers	Clark et al. (2009); Benn and Evans (2010); Stroeven et al. (2016)	Polyline along crest
Esker	Single ridges or networks of parallel ridges. Typically sharp-crested, long and winding. Figs. 3b and 3c	Size up to hundreds of kilometers long and tens of meters high	Misinterpretation as type of moraine, although esker is usually more sinuous	Formed in subglacial tunnels parallel to ice flow and close to a retreating ice margin	Brennand (2000); Storrar et al. (2014); Livingstone et al. (2020); Stroeven et al. (2021)	Polyline along crest
Subglacial meltwater channels	Channels incised into bedrock or sediment, oriented oblique to slope. May connect to esker segments. Fig. 3c	Highly variable dimensions, up to several hundred of meters long	May be confused with submarginal lateral meltwater channels	Reflect ice sheet flow direction close to the ice margin	Kleman (1992); Greenwood et al. (2007); Margold et al. (2013)	Polyline along thalweg of channel, arrow pointing downslope
Ribbed moraine	Fields of curved ridges, regularly and closely spaced	Hundreds of meters long and tens of meters high	May be confused with solifluction lobes, although ribbed moraine are usually found in depressions	Formed transverse to ice flow, with outer limbs pointing down-ice. Indicative of frozen bed conditions	Hättestrand (1997); Hättestrand and Kleman (1999); Dunlop and Clark (2006); Benn and Evans (2010)	Polygon demarcating fields of curved ridges
ICE-MARGINAL						
Moraine	Straight or arcuate ridges, can occur in series. Potentially continuous, but often interrupted by gaps of non-deposition or erosion. Fig. 3f	From few meters to kilometers long and meters to tens of meters high	Can be difficult to distinguish from a protalus rampart in mountainous areas	Marginal moraines outline the shape and position of a former ice margin. Undifferentiated moraines are smaller equifinal landforms formed by different (ice-marginal) processes	Heyman and Hättestrand (2006); Benn and Evans (2010)	Polyline along crest
Veiki moraine	Semi-circular plateaus with a ridge along their rims. Whereas the rim is dry and covered by forest vegetation, the depressions within often consist of lakes or mires.	The plateaus cover areas from 0.1–30 km^2 and have a relief from 2–60 m	Possible to confuse with hummocky moraine if poorly developed	Formed through down wasting of debris-covered stagnant ice with ice-walled lakes on top	Lagerbäck (1988); Hättestrand (2007); Clayton et al. (2008); Benn and Evans (2010); Alexanderson et al. (2022)	Polygon demarcating areas with multiple plateaus
Lateral meltwater channels	Series of straight or winding channels cut into valley walls, subparallel to the contours. Fig. 3d	Tens of meters deep, hundreds of meters long, meters wide	Misinterpreting as bedrock structures, steplike solifluction lobes or shorelines, although the latter is strictly horizontal	Formation along ice margin, possible to infer ice surface slope and ice thickness	Greenwood et al. (2007); Margold et al. (2013); Stroeven et al. (2016)	Polyline along thalweg of channel, arrow pointing downslope
PROGLACIAL						
Proglacial meltwater channels	Channels incised into bedrock or sediment, aligned to the local bed slope. Fig. 3e	Tens to over hundreds of meters long to tens of meters wide	May be confused with contemporary river incisions, but identifiable by dry-bed or underfitted stream. May be misinterpreted as outlet channels	Formation at terminus of the ice margin	Greenwood et al. (2007); Benn and Evans (2010); Stroeven et al. (2021)	Polyline along thalweg of channel, arrow pointing downslope
Raised shorelines	Zones of (nearly) horizontal wave washed till, eroded rock terrace or an accumulation of sediment. Gradient of 0.5 $\mathrm{m\,km^{-1}}$. Characterized by a break in slope. Often occurs in series. Figs. 4a–4d	Few meters wide, can extend hundreds of meters in length	Misinterpreting as bedrock structures (although those usually have a more extensive spatial distribution and are seldom strictly horizontal), steplike solifluction lobes or meltwater channels	Indicative of former lake levels of ice-dammed lakes, possible to infer the location of the ice margin	Jansson (2003); Stroeven et al. (2016); Regnéll et al. (2019)	Polylines midway between toe and inner break of shoreline
Perched deltas	Flat top surface and steep delta front, situated above present lake levels. Signs of erosion by streams. Fig. 4b	Hundreds of meters wide	May be confused with an ice-contact delta, although these often have kettle holes	Indicative of former lake levels of ice-dammed lakes, possible to infer the location of the ice margin	Jansson (2003); Margold et al. (2013); Peterson and Smith (2013); Goodship and Alexanderson (2020)	Polygon demarcating flat top surface
Outlet channels	Channels at the lowest point of a water divide or along valley slopes. Often associated with washed bedrock zones. Fig. 5	Tens to hundreds of meters long, tens of meters wide	May be confused with proglacial or lateral meltwater channels, although outlet channels are typically larger	Indicative of the threshold of former ice-dammed lakes	Jansson (2003); Regnéll et al. (2019)	Polyline along thalweg of channel, arrow pointing downslope

- Figure 1: In panel b, consider thinning out the isochrons or making the panel bigger. At present, it's a little difficult to see all of the components in the figure.

We enlarged panels a and b and thinned out the isochrons and country borders in panel b, which made it easier to appreciate all components in the figure.

Old Figure 1:


0°
10°E
20°E
30°E
70°N
65°N
60°N
55°N
(a)
b
NORWAY
SWEDEN
FINLAND
(b)
10.3
10.2
10
10.1
9.9
9.8
9.7
N
0
300
km
Glacially-induced fault
Deglaciation isochron (ka)
Study area
Elevation
high
low
Field location
Current outlet
Lowest elevation
Rock slope failure
Glacier
(c)
Fig.5a
0
Torneträsk
Fig.4a
Fig.3b
Abisko
Fig.4b
Reference plane Fig. 6
RSF-K
RSF-B
MONTANE REGION
PREMONTANE REGION
Fig.5c
Fig.5b
Torneälven
Fig.4d
Rautasjaure
Fig.4c
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Elevation
m a.s.l.
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312
Kåtotjåkka
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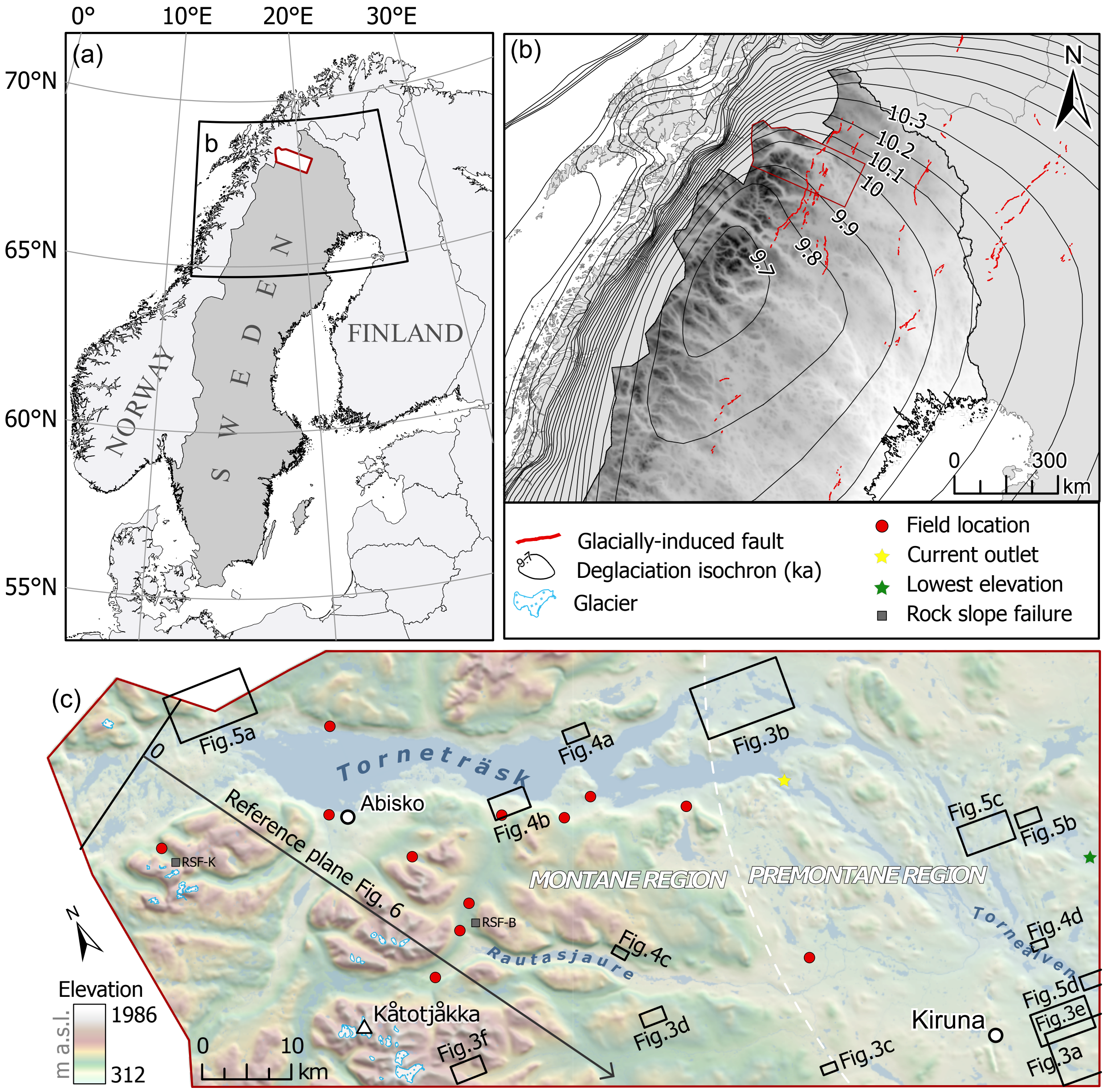
Kiruna
Fig.5d
Fig.3e
Fig.3a

New Figure 1:



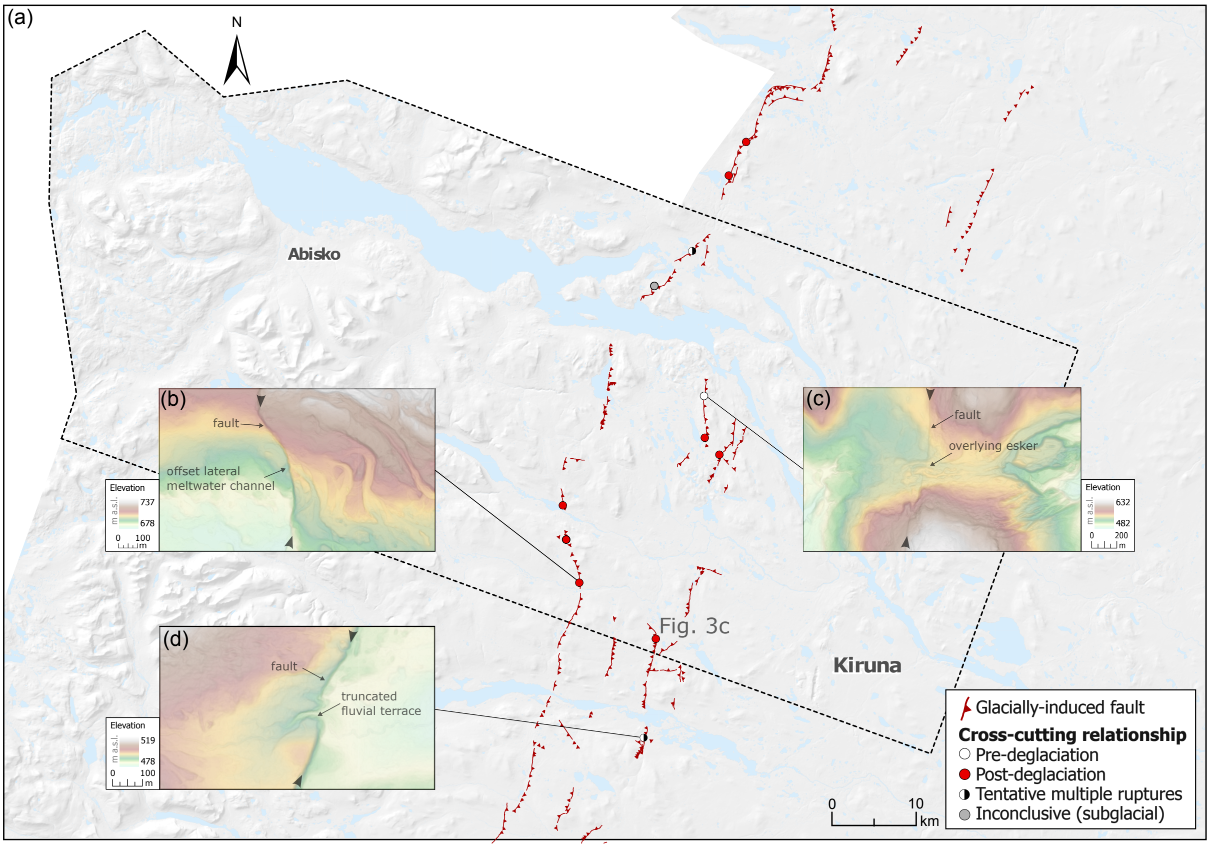
- Figure 9: If you are unsure whether the ice sheet also retreated into the Kebnekaise/Sarek Mountains, consider leaving a ? symbol over these locations in your retreat pattern to acknowledge this.

We will add another question mark in panel g over the mountains of Kebnekaise, which better visualises that the retreat at this location remains unconstrained. The Sarek Mountains are well outside the mapping boundaries.

- Figure 10: The cross-cutting is really difficult to see. Make the panels bigger with nice and clear LiDAR hillshade images.

We thank the reviewer for his comment, which has also been raised by reviewer 1. We present an improved Figure 10 below.

Old Figure 10:



New Figure 10:

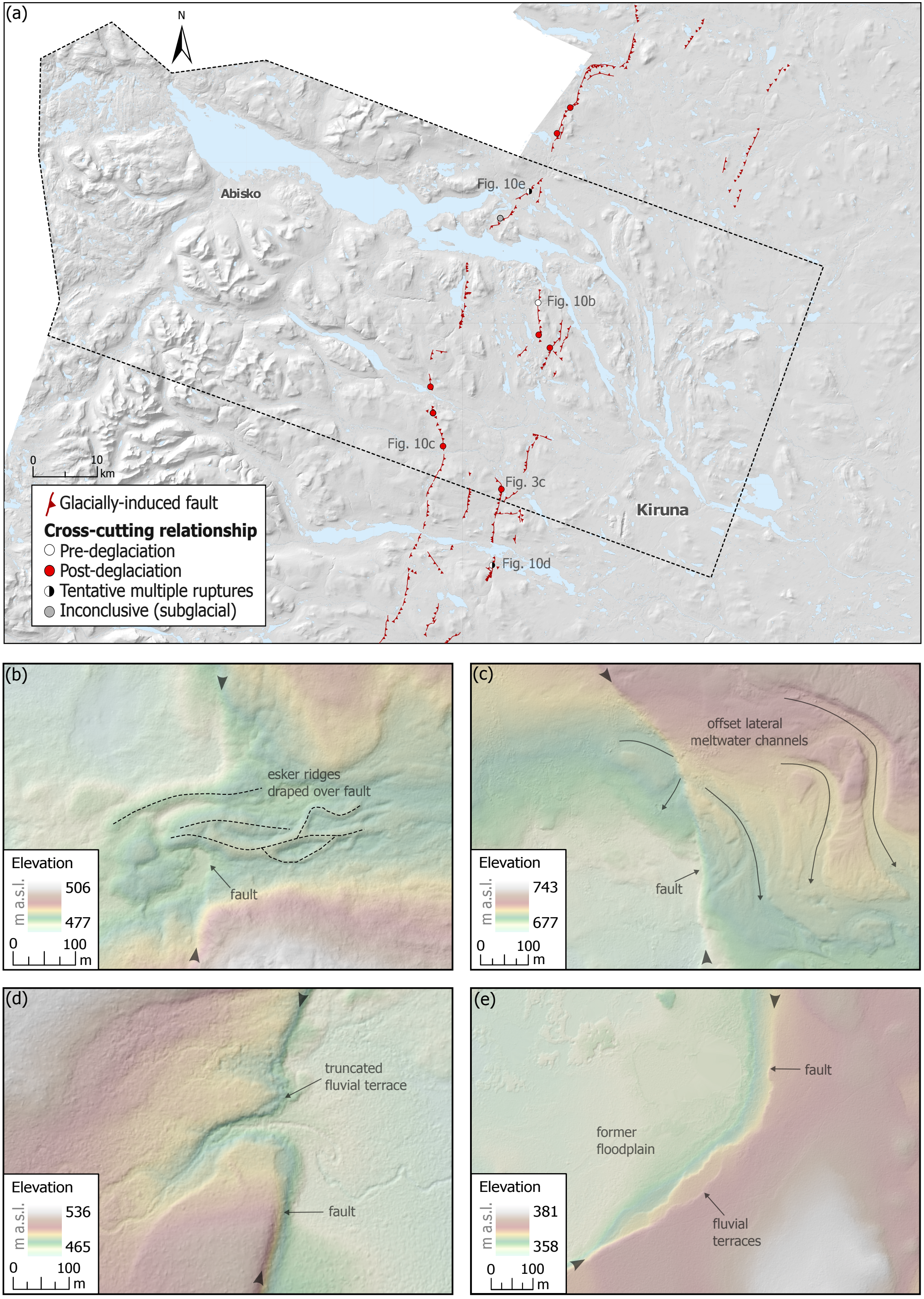


Figure 10. (a) Observed cross-cutting relationships between the glacial geomorphology and the fault scarp traces of the Pärvie Fault. Examples include cross-cutting (b) pre-dating deglaciation, where an esker drapes a fault scarp, (c) post-dating deglaciation, where glaciofluvial landforms are cut by a fault scarp, and (d-e) occurring, tentatively, multiple times, where fluvial terraces are offset by multiple ruptures (panel (d) is the same location as in Smith et al. 2021, Fig 12.4). The background is a shaded relief based on the DEM provided by ©Lantmäteriet.

- *Line 119: … "as these are considered the optimal values for the visualization of hillshade relief models for the purpose of glacial geomorphological mapping (Chandler et al., 2018)."*

Chandler et al., 2018 don't suggest these values for hillshade images, other authors do (specifically Chandler cite Smith and Clark, 2005 and Hughes et al., 2010). Change (or add) the citation to other sources.

Thank you for spotting that, the older citations will be adopted.

"The DEM was processed in ArcGIS Pro 2.9.3. to create a hillshade relief model using an illumination angle with an altitude of 30° and azimuths of 45° and 315°, as these are considered the optimal values for the visualization of hillshade relief models for the purpose of glacial geomorphological mapping (Smith and Clark, 2005; Hughes et al., 2010)."

- *Lines 119-121: "Additional azimuths of 90°, ° and 180°, perpendicular and parallel to the dominant lineation orientation, respectively, were applied to reduce the 'azimuth bias' (Smith and Clark, 2005; Chandler et al., 2018)."*

Either remove the statement or define which azimuths were used.

The degree symbol has been removed, there was no other azimuth used than the two already mentioned. Reviewer 1 had the same comment, thank you for spotting this.

"Additional azimuths of 90° and 180°"

- *Lines 164-167: "The glacial geomorphology of the Torneträsk Basin is presented in Fig. S1. The total comes to 6633 mapped features, of which there are 2796 lineations, 678 eskers, 39 ribbed moraine, 1262 meltwater channels, 155 marginal moraines, 510 undifferentiated moraines, 894 raised shorelines, 206 perched deltas, 25 outlet channels, and 38 veiki moraines. Note that the count includes all segments of a landform, so it represents a feature count instead of a landform count."*

Here you provide numbers of how many features you have mapped. However, because you have not detailed the mapping approach for each landform type, it is not clear whether the quoted 6,633 mapped features are individual features or groups of features. For example, you say you have mapped 38 veiki moraines – is that 38 areas of veiki moraine, or 38 individual veiki moraine plateau?

The mapping approach is now described in Table 1, which clarifies that ribbed moraine and veiki moraine are mapped as areas, rather than individual ridges or plateaus. The text will also be changed to emphasize that the feature count refers to the number of ribbed moraine and veiki moraine areas.

"The total comes to 6633 mapped features, of which there are 2796 lineations, 678 eskers, 39 areas of ribbed moraine, 1262 meltwater channels, 155 marginal moraines, 510 undifferentiated moraines, 894 raised shorelines, 206 perched deltas, 25 outlet channels, and 38 areas of veiki moraine."

Later on in the results section, you go on to say landforms are found "relatively often" in x locations. It would be better to put a number (i.e. %) on this.

We will specify the percentage of landforms where they were mentioned in relation to the montane and the premontane regions, in their respective Results sections.

Line 170:
"Lineations occur across the area but are most common in the premontane region (60%, Fig. 3a)."

Line 179:
"Eskers occur across the area, but are most frequent in the montane region (63%)."

Lines 187-188:
"Subglacial meltwater channels are prevalent in the entire study area, although most of them occur in the premontane region (72%)."

Lines 193-194:
"Ribbed moraine occurs predominantly in the premontane region (56%) and in the montane region on uplands north of Torneträsk and in between Rautasjaure and Torneträsk (Fig. S1)."

Line 204:
"Whereas subglacial channels are abundant in the premontane region (72%), lateral meltwater channels are relatively rare (21%)."

Line 223:
"Moraines are virtually lacking in the premontane region (4%, Fig. S1)" ...

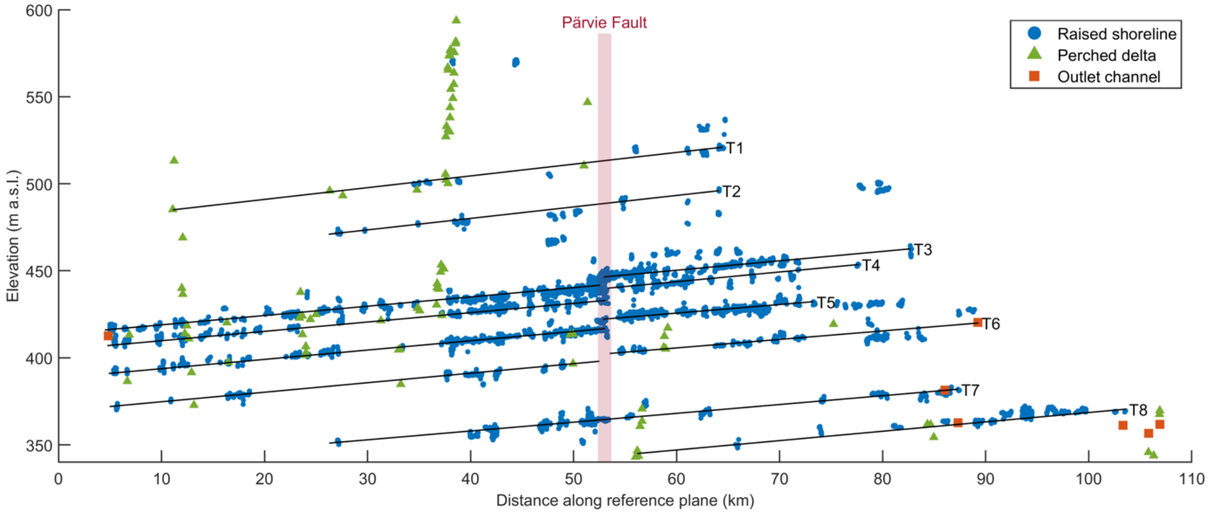
- *Lines 257-259: "However, whereas there is abundant information on fault displacement of glacial geomorphology, indicating that the Pärvie Fault ruptured after landform formation (Figs. 3b and 3c), there are no other geomorphological cross-cutting relationships that show the exact offset as well as the raised shorelines."*

Please point to this cross-cutting relationship on the figure.

Thank you for asking clarification on this, reviewer 1 commented on the same lines. The crosscutting relationship between the fault and shorelines is only evident from regional analyses using the graph that plots the shoreline elevations along a reference plane, not from the LiDAR imagery itself due to the lack of continuity of the shorelines at the location of the fault scarp. This study is basically outlining a new technique to identify fault ruptures. Additionally, a new potential Figure 6 is presented to show the raised shorelines at the location where the fault crosscuts the basin.

"there are no geomorphological cross-cutting relationships visible in the LiDAR imagery that show the offset of raised shorelines at the exact location of the fault scarp."

Old Figure 6:



New Figure 6:

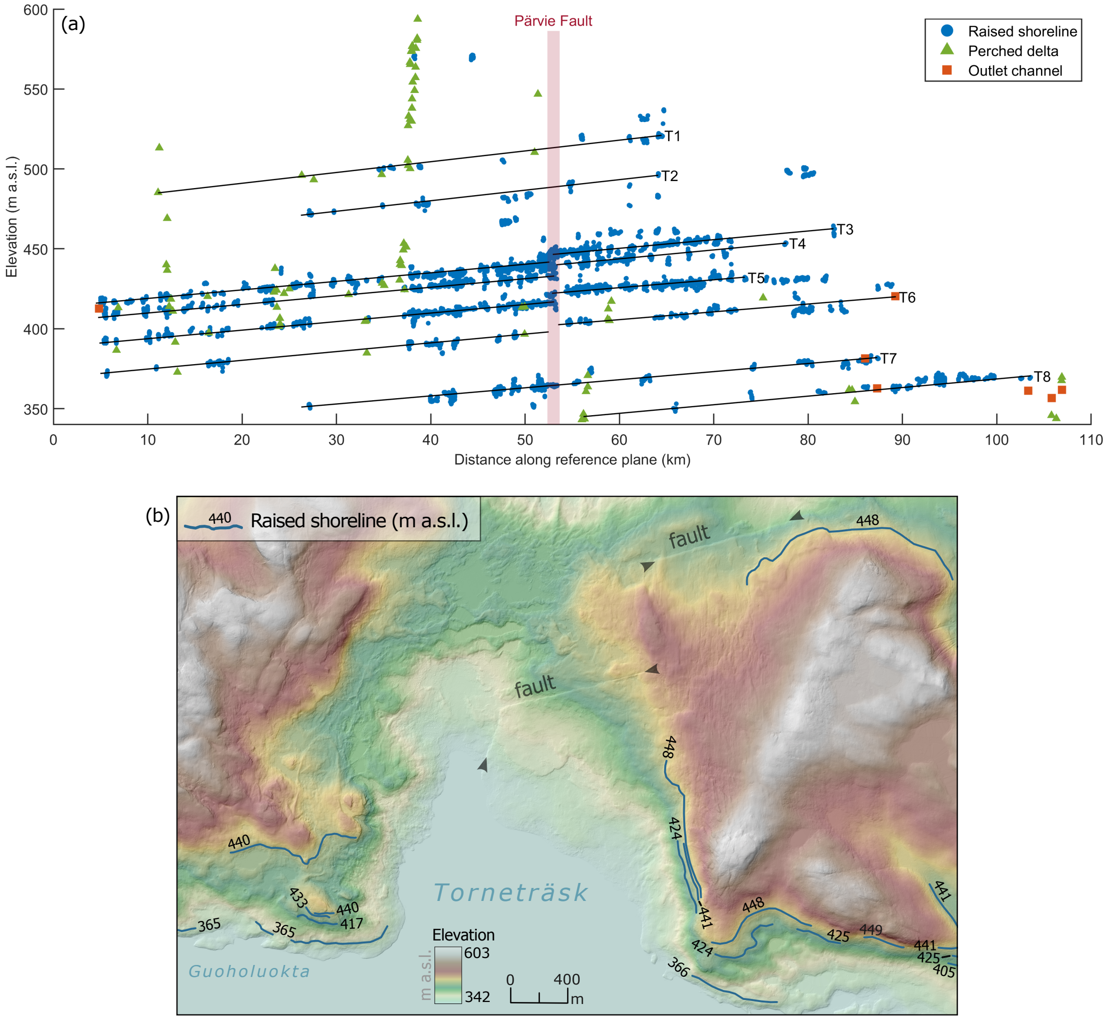


Figure 6. (a) Lake stages identified from the elevations of raised shorelines, perched deltas, and outlet channels of ice-dammed lake Torneträsk. At the Abscissa value of zero, the ordinate value is 342 m a.s.l., the current elevation of the surface of Torneträsk. The approximate location

where the Pärvie Fault crosscuts the Torneträsk Basin is indicated by the red bar. The distance is calculated along an axis perpendicular to the isobases of postglacial rebound of the shorelines (see Fig. 1c). The corresponding elevation ranges are summarised in Table 2. (b) Elevations of raised shorelines of ice-dammed lake Torneträsk on either side of the Pärvie Fault where it crosscuts the northern shore of Torneträsk (see red bar in (a)), illustrating elevation jumps of around 8 m for the higher raised shorelines (T3-T6), while the lowest raised shoreline (T7) crosses the fault at 365–366 m a.s.l. The background is a shaded relief based on the DEM provided by ©Lantmäteriet.

- *Lines 419-423: "Hence, a strong control of topography on ice retreat patterns and rates is evident, as other studies have demonstrated for the FIS (Stroeven et al., 2016; Szuman et al., 2024), the British-Irish Ice Sheet (Greenwood et al., 2007; Hughes et al., 2014), and the Cordilleran Ice Sheet (Kleman et al., 2010; Dulfer et al., 2022)."*

Topographic controls on ice sheet geometry during retreat of a thinning ice sheet have also been highlighted in northwest Russia (https://doi.org/10.1002/jqs.1130; https://doi.org/10.1016/j.quascirev.2022.107872; https://doi.org/10.1111/bor.12653).

Thank you for these suggestions. We will add another citation to represent the deglaciation of the northwestern sector of the Fennoscandian Ice Sheet.

"Hence, a strong control of topography on ice retreat patterns and rates is evident, as other studies have demonstrated for the FIS (Stroeven et al., 2016; Boyes et al., 2023; Szuman et al., 2024)" …

- *Lines 436-439: "In the reconstruction of Stroeven et al. (2016), the retreating ice margin swept across the study area in a time span of 500yr (Fig. 1b). The ice-marginal positions that dammed the successive ice-dammed lake stages of Torneträsk fall approximately in-between their 10.1 and >9.9 cal ka BP isochrons (Fig. 1b), which would suggest the ice-dammed lake system of Torneträsk existed for a total duration of <200 yr."*

You briefly mention timing of lakes here and have more detail on faulting chronology in Section 5.4. Could you have a single chronology section that deals with the chronologies of each component (ice sheet retreat, ice dammed lake formation/drainage, and faulting) as they are interlinked.

We agree that the chronologies of each component in this reconstruction are interlinked and that it is worth exploring whether a single chronology section improves the structure of the paper. We will aim to consolidate the chronologies of each component into a single section.

It would be better to use the point chronometric data presented by Stroeven et al., 2016 and in the DATED-1 database rather than comparing to the isochrons as this may provide more relevant information for your reconstruction.

The point chronometric data of Stroeven et al. (2016) and the DATED-1 database present challenges for comparison with our mapping due to limited constraints over a large area. Stroeven et al. (2016) lack landform types, making it difficult to draw any conclusions about ages without going into the geomorphological context of every sample individually. Many samples are from bedrock, representing cumulative exposure from previous ice-free periods.

The DATED-1 database includes only seven individual ages within our study area, of which four are deglacial. Three of these deglacial ages are radiocarbon dates from the same moraine-dammed lake, of which the location is stored incorrect in the database.

Given the scarcity of data in our region, we believe that a comparison with point chronometric data would not significantly enhance our reconstruction. We will therefore refrain from implementing the suggested changes.

- *Line 515: "There are two large rock slope failure (RSF) deposits in the study area that were potentially triggered by ruptures along the Pärvie Fault."*

You've suggested that the rock slope failure deposits are a result of post-glacial earthquakes. Such landslides can also be triggered by glacial de-buttressing during glacier retreat. You should include some discussion on this point, and if you still consider these landslides to be earthquake induced, then you need to clearly provide evidence for this.

We agree that this statement needs to be discussed, and we will add a paragraph in our Discussion, arguing that we cannot conclude whether the rock slope failure deposits are earthquake-induced or the product from other processes. The comment also inspired to look for more geomorphological evidence regarding subglacial fault rupture.

"The formation of landslides in northern Fennoscandia has been associated to earthquakes caused by post-glacial faulting (Sutinen, 2005; Lagerbäck and Sundh, 2008). There are two large landslides in the study area, but the absence of a larger group of landslides in the vicinity of the Pärvie Fault challenges the potential earthquake-induced origin. It is predominantly the scattering of a group of landslides across a discrete area, in close proximity to a fault, and their synchronous age rendering it likely that they were triggered by an earthquake (e.g., Jibson, 1996; Ojala et al., 2019). The spatial distribution of the two RSF deposits and the corresponding ages are therefore not enough evidence to conclude whether they were triggered by an earthquake or by other triggers, such as glacier debuttressing after deglaciation.

The absence of a group of landslides could hint towards the nature of the Pärvie Fault rupture. It is in stark contrast to the large groups of earthquake-induced landslides nearby glacially-induced faults in northern Finland (e.g., Ojala et al., 2019). The presence of fault scarps but absence of landslides could support the occurrence of earthquakes underneath the retreating ice sheet. The crosscut shorelines of Torneträsk indicate that the fault scarps locally ruptured at a close distance to the retreating ice margin. Although there is mounting evidence that the Pärvie Fault was not the result of a single rupture, it cannot be ruled out that there was a partial subglacial rupture. Sutinen et al. (2019) suggests morphological signs of subglacial rupture could be anastomosing networks of eskers (Fig. 10b) and subglacial crevasse fillings, which are both present in the Torneträsk area (Ploeg, 2022)."

References

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