

Evaluation of the role of the Baltic depression during deglaciation of the last Scandinavian Ice Sheet; a landform-driven investigation

Izabela Szuman¹, Jakub Z. Kalita¹, Christiaan R. Diemont², Stephen J. Livingstone², Chris D. Clark², Martin Margold³

¹ Department of Geomorphology, Adam Mickiewicz University, Poznań, 5 62-712, Poland

² Department of Geography, Sheffield University, Sheffield, S10 2NT, United Kingdom of Great Britain - England, Scotland, Wales

³ Department of Physical Geography and Geoecology, Charles University, Prague, 128 43, Czech Republic

General comments:

This study is an ambitious and laborious task mostly based on combination of bathymetric data sets of different resolution supported by data from earlier offshore studies and “onshore literature”. Approaches to utilize increasing amount of high-resolution bathymetric data are crucial to promote scientific discussion on the distribution of submarine glaciogenic features and the influence of sea-bed bedrock/topography on glacial dynamics, especially in the case of streaming ice. The manuscript will add to progress in numerical modelling of the Scandinavian or Fennoscandian ice sheet.

In general, structure and proper length of the manuscript make it easy to crasp. However, the major problem with the manuscript is the quality of the mapping procedure with some likely misinterpretations or lack of alternative explanations in the presented data, as also indicated by *Greenwood et al. in their interactive comments. Moreover, like commented by Greenwood et al., the use of geological maps for coastal periphery-offshore interpretations would have increased the quality of the methodological approach.* Uncertain observations on maps should be better presented/visualized and reasoning/data behind some interpretations, regarding f. ex. moraine landforms, should be better explained. It is important that the results and “dynamic history of the Baltic sector of the SIS” presented in Figure 8 are based on “solid” ground. Nevertheless, it is likely that some mistakes or misinterpretations remain in these kinds of maps based on large data sets with varying resolution. To sum up, the results presented in the manuscript do not convincingly enough support the interpretations made. I think the manuscript should be published after major revision, answering to above-mentioned main concerns (as also interactively commented by Greenwood et al.), and including re-evaluation of some key observations or interpretations pointed out in the specific comments.

Specific comments:

Title: the title is ok but not very “selling” in terms of the glacial dynamics or methodology used.

L_16 (Abstract): ... “that might have resulted in rapid collapse of this ice sheet sector.” <> possible rapid collapse of the ice sheet is not discussed in the main text – it should be removed from the abstract or discussed!

L_37: I would not use the term conduit here, very broad ‘channel’ is simple enough.

L_38: it would be relevant to include information/references on the shifting ice-divide along the Scandes mountains and its probable influence on the ice dynamics!

L_39: you should maybe use more accurate definition here (unconsolidated). There is also different behavior/effect of soft sediments, depending on their composition and grainsize distribution.

L_41-42: “impeding water evacuation from the ice margin” <> not from the ice-margin but from the proglacial basin?

L_53: I think this research question is not really relevant here, the Baltic depression surely had an overall, prominent role for LGM position but related details are more poorly known + in the end you also answer first to the second question which apparently is the main issue.

Table 1: Feldens et al., Dorokhov et al., Schäfer et al., Jensen, All et al. and Jakobsson et al. 2016, 2020 are not mentioned/cited in the text. If these studies are important for the landform interpretations, they should be mentioned!

(Figure 2: “No submarine evidence was available at the time Boulton et al. (2001) drew the figure and it is a purpose of this paper to seek information about the footprint of this ice stream and its likely width.” <> this sentence is simply well put and would be good to replace it into the introduction as well?)

L_125-130: “Our motivation for mapping the coastal periphery of the Baltic is twofold:

1. It eases integration with the much-studied onshore landform record,
2. To provide a high-resolution verification for ice-flow patterns and ice-marginal retreat patterns mapped from the lower quality and resolution bathymetric dataset.

◊ would it be better to place this text into Methods?

L_142: zones of soft sediment (similar consolidation or properties?)

L_144: could these fan-shaped belts be indicated on a map?

L_146: soft sediments has been found ... ◊ does this mean that elsewhere in the basin there are no soft sediments?

L_151: cross-checking ◊ this is a bit unclear way to express this – where there always hydroacoustic or seismic data available for artifact recognition? – somehow related to works presented in Table 1?

L_157: Mapping was carried out ... ◊ in this case the use of geological maps to verify interpretations (where possible) would have been necessary. It is important to include information from geological maps to methods as it likely strengthens the interpretations along the coastline-offshore regions. *Also Greenwood et al. raise this point in their interactive comments!*

Table 2: for the future work, in case there are changes to databases, it would be good to indicate the date when the data was collected (f.ex. 02/2023)

L_168: you mean glaciolacustrine wedges, please explain the term shortly when mentioned for the first time.

L_170: tunnel valleys ◊ do these include possible (braided) subglacial meltwater routes or corridors not strictly classified as tunnel valleys? See possible route in Fig. 3B just below the text: good quality DEM?

L_179-180: “identifying larger features in these regions including moraines, ice marginal channels, and ice marginal deposits was often still possible” ◊ what are these interpretations based on? – any references/supporting earlier data or just interpretation based on ...?

Figure 3: 3C) offshore area west of the Gdansk Bay has been mapped to show marginal meltwater channels (Fig 4) ◊ why not longshore structures (bars & troughs) related to a large spit-platform?

L_200: remove likely

Figure 4: would it be possible to explain in the text why there are so little landforms within the offshore areas located SW and NE from the Landsort Deep?

L_232: Fig. 5B ◊ where are ribbed moraines in this figure? - wrong fig?

Figure 5G: these landforms are not presented on a map!

L_261: (Fig. 7E) ◊ I think that this ice-marginal moraine interpretation is not well justified - any reference from earlier marine investigations or reasoning behind the interpretation?

L_267: (Fig. 7D) ◊ in this figure?

L_268: distinct (?) + inferred (Fig. 7E), with ◊ I can't see this in Fig. 7E

Figure 6B: the leftmost flowset probably has a wrong arrow direction

L_301: geological structures ◊ can you be a bit more precise?

L_308: “Iceberg pits are identified in one locality” ◊ any reference for the interpretation, what is this interpretation based on?

Figure 7D: I'm not convinced that these are glacial lineations! - too non-uniform + winding/overlapping - for me these landforms rather resemble submarine erosional/depositional features by bottom currents!

Figure 7F: why are these interpreted as moraines, any earlier supporting data?

Figure 8: although there likely will remain some erroneous interpretations/details of landforms in this massive data set, this figure (black lines) should stand strong on hard evidence or if black lines are based on uncertain or extrapolated data, they should be marked with f.ex. dashed lines

L_403: 9B <> not shown in the figure

L_405-406: "An example of this is in Pomeranian Bay where a glaciolacustrine fan is overprinted by long cross-cutting MSGs, indicating a subaquatic origin." <> sorry, but I do not understand this sentence (or reasoning), and how does it relate to previous sentence. MSGs refer to ice flow over the wedges BUT I think these MSGs are not glacial features at all but instead submarine current structures!

L_416: prominent moraines <> based on what? - any other supporting data than DEM interpretation?

L_427: (Figs 8F, I; <> wrong figure reference

L_436: outwash fans <> these not mapped in the present study?

L_437: moraine interpretation based on what?

L_450-452: "We confirm this Bothnian ice source from the north, but also identify a Swedish ice source with a ~NW-SE orientation based on our ice marginal and flowset geometries (Figs 6, 8, 9C)." <> just to check this - are you absolutely sure that you are the first ones to report this Swedish ice source in this area?

L_457-458: Bedforms within the Landsort Deep are not presented on map in Fig 4! The Deep is an interesting and outstanding submarine geological feature, so it would be good to discuss its origin (+ references) - could there be any alternative explanation for the features interpreted here as glacial lineations?

Technical corrections:

L_22: MSGL should be opened when used for the first time and abbreviation used later in L_25

L_26: rather than

L_49: , encompassing

Figure 1: index map is of slightly poor resolution and the scale bar is missing from the main Figure 1B.

Figure caption: Svendsen et al. 2004 not in the references list!

Figure 1D: could the two troughs of Gotland Island be indicated on the NW-SE profile?

L_74: 1.1 <> should this rather be 2 Background?

L_77 and 86: northwestward (in my opinion)

L_95: , indicating

L_134: northwestern

L_139: sediment ... the northern part

Figure 3: 3A) Gotland is situated at left so west Gotland basin is wrongly placed, 3B+D) conglomerate? Figure caption says conglomerate.

L_194: Commonly, it is not good to start the sentence with number

L_211: exhibit high

Figure 4: use of colours for the lines is problematic even for slightly red-green blind reader (like me). In addition to colours also different line styles could be used to clarify visualization.

Figure 4: “Light and dark grey indicate onshore and offshore areas respectively” <> I think this should be the other way around

L_248: 75 flowsets

L_260: , including

L_315: lobes as

Figure 8: Again, in addition to colours, different line styles would improve readability! f.ex. uncertain observations could be marked with dashed lines? In southern Sweden there is one black line containing two different retreat directions? + Scale bar is missing!