The Cryosphere Discussions

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Comment on tc-2021-8

Anonymous Referee #2

Referee comment on "Antecedent control on active ice sheet retreat revealed by seafloor geomorphology, offshore Windmill Islands, Antarctica" by Alexandra L. Post et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-8-RC2, 2021

General comments:

This manuscript presents high-resolution bathymetric data from the Windmill Islands region of East Antarctica. It uses the same data as published in Carson et al. (2017); this new manuscript focuses on the youngest set of glacial landforms preserved on the seafloor and makes some revised interpretations about their formation. These landforms, which include features interpreted as crevasse-squeeze ridges (CSR), are interpreted to have been produced by a tidewater glacier sometime during the mid- to late Holocene. Although the images presented are generally of good quality, and data of this resolution are rare, particularly from the East Antarctic seafloor, I cannot recommend publication of the manuscript in its present form. My main concern relates to the focus of the manuscript, which overlaps with that of Carson et al. (2017) and over-reaches in its discussion of the implications for ice-sheet stability. This work could be revised considerably to become more of a geomorphological study, in which the interesting CSR features are examined in greater detail and form the basis of a high-resolution landform assemblage model for tidewater glaciers in Antarctica.

Main comments:

1. Title and focus.

A revised version of this manuscript should have a greater focus on what is novel about this study, which in my opinion is the description and interpretation of the CSR (and related subdued features including boulder chains).

It is well-known that ice flow and retreat style are controlled by topography and substrate, and the authors themselves state this in their Introduction (Lines 36-37). Section 3.4 of Carson et al. (2017) also includes a discussion of how topography and substrate govern the formation/preservation of these features in the same study area.

Rather than providing "new perspectives for understanding the stability of the East Antarctic margin" (Abstract, Lines 20-21) or "demonstrating the sensitivity of this region to a changing climate" (Discussion, Line 212), the strength of this work is its presentation of a high-resolution tidewater glacial landform assemblage that includes subdued features including CSR. Revising the title and general focus of the manuscript to reflect this would enhance the novelty and impact of this work.

2. Description/ interpretation of glacial landforms.

More detailed descriptions should be provided about the glacial landforms, particularly the CSR, and there should be a clearer separation of description and interpretation. For example, Results section 4.3.1 starts with an interpretation of these features as CSR before describing the landforms that are shown.

In the interpretation, you could state more explicitly that you are interpreting these features as "longitudinal CSR", as opposed to the "rhombohedral" CSR reported by Ottesen and Dowdeswell (2006) and others, or the "transverse" CSR reported from elsewhere in Antarctica.

I'm not entirely convinced about the interpretation of the CSR. Can you rule out the possibility that these features were formed along the lateral margins of a narrow ice lobe (i.e. they are lateral moraines)? For example, in the centre of Fig. 4C, could these arcuate to linear ridges not simply be following the lateral ice margin?

3. Discussion.

The Discussion would benefit from being rewritten to emphasise the novel findings of the manuscript, which essentially relate to the CSR. The start of the Discussion is missing a summary of the landform assemblage that is identified on the seafloor and the relative order in which the features were produced. It would also be useful to produce a new diagram showing the various elements of this Antarctic tidewater glacier landform assemblage, perhaps as a cartoon/schematic.

I also recommend shortening the sections on topographic and substrate controls, and removing some of the over-reaching statements about the implications for ice-sheet stability.

The Discussion should also include further exploration of the mechanism of formation of the CSR, which are typically considered to be formed during the stagnation phase following a glacier surge. How does this fit with your claims that the ice margin was "actively retreating"? And are you confident that these features are not arcuate frontal-lateral moraines?

Detailed comments:

Lines 10-11: Repetition of “suite of features”.

Lines 18-19: This is an example of where interpretation is placed before description. The description is that the bedrock areas lack glacial landforms, and the interpretation is that ice flow was slower here and/or that there was less sediment available for landform construction.

Line 24: “Over glacial and interglacial cycles” – change to “during the last glacial cycle”, because landforms preserved on or close to the seafloor typically date only to this period.

Line 27: Sp. Antarctica.

Line 30. Antarctic Ice Sheet should be capitalised.

Lines 33-34: The wording of this sentence is not clear.

Line 46: Here would be a good place to introduce the concept of cross-shelf troughs, which were eroded and occupied by fast-flowing ice streams, probably over several glacial cycles.

Line 59: Can you be more specific about the nature of this terrestrial research/ how this ice advance was dated to ~4.5 - 4 ka?

Line 70: Refer to Figure 1 at the end of this sentence.

Section 2 is missing a summary of the glacial history of this area, including the likely extent of the ice sheet during the LGM and the suggested 4.5 - 4 ka re-advance. Can you comment on what may have caused the 4 ka re-advance?

Lines 99-100: I think you mean Section 4, but this sentence isn’t needed.

It would be beneficial to have an introductory sentence or two at the start of the Results section, stating that you observe X main types of glacial landforms across the study area.

Line 104: Describe these features as “linear ridges” or similar, and then present their interpretation as “glacial lineations” in the following section.

Line 113: Are “bedrock depressions” sedimentary basins set within a wider region of bedrock, or deeper bedrock regions?

Line 128: At what dimensions do you define a moraine as a “major moraine”? The text in the interpretation section suggests 15 m.

Line 130: This paragraph is interpretation, not description.

Line 164: Describe these features as “linear ridges” or similar, before later interpreting them as CSR.

Line 165: This reference could be confusing, as, whilst their symmetric cross-sectional shape is similar to the CSR reported by Ottesen and Dowdeswell (2006), their elongate plan-view shape is not.

Lines 170-171: This is interpretation, and is not needed here.

Line 178: As these features are mainly found along the sides of the troughs, could they not simply be lateral moraines from a narrow ice lobe?

Discussion. It would be useful to summarise the tidewater glacial landform assemblage at the start of this section.

Section 5.1. This information about the types of glacial landforms that are characteristic of deeper sedimentary troughs vs. shallower or bedrock banks is already well-known and could be summarised in a shorter section. It could also be useful to mention the absence of iceberg ploughmarks from this region, or give their depth-limit, to rule out removal of the glacial record by iceberg scour.

Line 249: The location of these features along the trough sides, and the fact that they "attach" to the end of the moraines, could be taken as evidence to support their formation as lateral moraines instead of CSR.

Line 266: What is the difference between troughs and channels? The two terms are used interchangeably throughout the text, and "sediment-lined depression" is also used in the

following section. It's possible that "channels" could be confused with the meltwater channels in this area.

Line 290: This sentence is very similar to the one on Line 46. When discussing this topic, there should be some mention of cross-shelf troughs and their smaller, inner-shelf subsidiary troughs, given that these features are known to have been formed by and constrained fast-flowing ice streams.

Line 317: "Low sediment delivery due to basal freezing". The ice that formed these landforms presumably wasn't frozen to its bed, because you have shown glacial lineations that indicate relatively fast ice flow.

Line 328-331: I'm a bit confused by this sentence. Are you suggesting that the glacial landforms observed here (CSR, lineations, moraines) are all formed from fine-grained marine sediments rather than till?

Line 332: I'm not sure these data do strengthen the case for the ice re-advance ~4 ka, unless you've identified the likely limit that this advance reached? Landforms such as these could simply record ice-sheet retreat and reorganisation towards the end of the last deglaciation.

Line 334: Indeed, this assemblage of landforms actually shows a relatively slow/steady style of retreat. Stating that "basal melt" can lead to rapid retreat is also confusing/over-simplified. I think you are referring to grounding-line retreat on a retrograde slope.

Line 336: To make any claims about climate variability during the Holocene, you would have to provide new evidence for the ice re-advance at ~4 ka and link this to the climate at that time.

Conclusion: This is missing a description of the features that make up the glacial landform assemblage.