

The Cryosphere Discuss., referee comment RC2
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Comment on tc-2021-294

Anonymous Referee #2

Referee comment on "Chronostratigraphy of the Larsen blue-ice area in northern Victoria Land, East Antarctica, and its implications for paleoclimate" by Giyoon Lee et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-294-RC2>, 2021

General comments

The authors present a thorough analysis of ice samples collected in a blue ice area in Northern Victoria Land, East Antarctica. With complementary methods, both in the field, and in the laboratory, the chronostratigraphy of the ice is analyzed. By comparing the results to existing ice core records, a convincing proof of the estimated age of the ice and the gas entrapped in the ice is provided. Together with radar observations, the analyses from a three-dimensional image of age isochrones, which also allows an estimation of the age of ice near the bedrock. Given the importance of Antarctic blue ice areas in the recent developments in the search for the oldest ice, where 2.7-million-year-old ice has been recovered from a blue ice area in the Transantarctic mountains, the manuscript is very relevant for future paleoclimatic studies, and it can help in defining field work practices of sample collection and motivating site selection for shallow ice cores from blue ice areas.

The authors place their manuscript into context through a short literature review, after which the methods are described with clear subheadings. The results and discussion do justify the conclusions that are drawn, after which the paper is shortly wrapped up in a conclusion.

I do think the implications of the analyses are underexposed and need to be further elaborated without reducing the technical details. These technical details are generally clearly described and seem to ensure reproducible research, although the editor must know that I do not have the required laboratory experience/background to criticize this well. I have noted my suggestions below.

Specific comments per section

Abstract: clear and concise

Line 1: I do think the first line provides a circular argument

Line 26: BIAs

1 Introduction: In general, the introduction gives all necessary background for reading the paper. However, I think the structure is a bit confusing, with paragraphs that do not follow each other in a logical order. Moreover, the last paragraph that introduces the study is too concise and does not clearly bring forward the goal of the research. Proposed solution: I would suggest to merge the paragraph starting on line 77 to the other paragraph on blue ice areas, starting on line 47. Moreover, the approaches in the study (now outlined in the last paragraph), could be merged into the paragraphs starting from line 56 and from line 65 and/or the last paragraph can be more elaborate.

Line 42: I think it is important to mention that the flow is redirected. Normally, the ice flows under gravitational forces towards the margins of the continent. Moreover, it is not the bedrock itself that causes the ice to flow upwards, but it is the bedrock geometry (which in some sense is equal to the mentioned basal topographic obstacles). Also, in many cases these obstacles are exposed above the ice (nunataks).

Line 52: instead of blue ice, specify that you mean samples taken from blue ice areas. This remark also applies to the rest of the paper.

Figure 1: Specify that orange dots represent "a selection" or "examples", as not all BIA where the chronology has been studied seem to be included (e.g., Zekollari et al. 2019)

- Zekollari, S. Goderis, V. Debaille, M. van Ginneken, J. Gattacceca, A. J. Timothy Jull, J. T. M. Lenaerts, A. Yamaguchi, P. Huybrechts, P. Claeys, Unravelling the high-altitude Nansen blue ice field meteorite trap (East Antarctica) and implications for regional palaeo-conditions. *Geochim. Cosmochim. Acta.* **248**, 289–310 (2019).

2 Study area and methods: In general, well-structured and clearly described.

Line 97: (Fig. 2a)

Line 97-99: A low mean annual temperature does not guaranty the absence of melt in a blue ice area. We need to know either the standard deviation of this annual temperature, or a maximum/high percentile of the observations.

Line 104: Using Quantarctica needs to be acknowledged by also citing the entire dataset and the corresponding paper

- Matsuoka, K., Skoglund, A., & Roth, G. (2018). Quantarctica [Data set]. Norwegian Polar Institute. <https://doi.org/10.21334/npolar.2018.8516e961>
- Matsuoka, A. Skoglund, G. Roth, J. De Pomereu, H. Griffiths, R. Headland, B. Herried, K. Katsumata, A. Le, K. Licht, F. Morgan, P. D. Neff, C. Ritz, M. Scheinert, T. Tamura, A. Van De Putte, M. Van Den Broeke, A. Von Deschwanden, Quantarctica, an integrated mapping environment for Antarctica, the Southern Ocean, and sub-Antarctic islands. *Environ. Model. Softw.* 140, 105015 (2021).

Line 104-105: it is remarkable that the stratigraphy is disturbed upstream. Why does this not have implications on the stratigraphy downstream? What is the cause of the disturbances? Is there a temporal component to this? These questions should be addressed in the results and discussion section.

Line 110-113: can be more concise and clearer, something like: reprojected perpendicular to a line parallel to the ice flow direction.

Figure 2: mention that dust bands are observed in the field and how they are measured (GPS tracks?)

Line 135: change "interval" to "spacing"?

Line 136: specify that these are vertical intervals (also in line 146).

Line 154: an average offset should be one number, not a range.

Line 182: in this section I miss the description of the $\delta\text{Ar}/\text{N}_2$ analyses that are mentioned in the abstract and published in the supplementary materials.

Line 228: please briefly specify here why you use the TALDICE ice core in your research.

3 Results and discussion: In general, the emphasis of this section seems to be more on the results than on the discussion. To make the manuscript more accessible for a wide readership and to do justice to the analyses performed by the authors, most paragraphs would need some additional sentences that discuss (the implications) of the data.

Line 243: This line should be at the end of the subsection 3.1, as now first the authors explain the stratigraphic profile, then discuss the basal topography and then return to discussing the stratigraphic profile. Also, in Figure 3b, the ice thickness varies between 200 and 320 meter (not 400). Lastly, it would be nice to have a qualitative statement that the ice thickness decreases along the flow and how this relates to the exposure of glacial ice (as mentioned in the introduction).

Line 245: are these crevasses, cavities, or cracks observed during the measurement campaign?

Figure 3: From Figure S1, it does not appear that the GPR has been performed as a grid of flight lines, are the results presented in panel a obtained by interpolation? Moreover, in the text there is no reference/analysis of the data shown in panel a, so I would suggest to either move the panel to supplementary materials or discuss it in the main text.

Line 277: Reconsider combining section 3.3 and 3.4 and renaming it: "analysis of gas entrapped in the ice".

Line 252-271: clear and nice balance between results and discussion of results.

Line 259: Please mention the references to the other published ice core records.

Line 265: why do you conduct a linear interpolation? To have measurements at equal horizontal/vertical spacing?

Line 279: What do you mean by altered? In Figure A1 only large fluctuations can be observed. Proof for altering comes only when discussing the comparison of the results from NIPR to SNU. This textual discussion would be greatly supported by plotting them in a (separate?) figure.

Line 295: Refer to Figure 4.

Line 303: Reconsider combining section 3.5 and 3.6 and adding a little introduction that explains your approach of first identifying the glacial termination, then matching the measured isotope and gas concentration profiles with existing (dated) ice cores, and then confirming your findings with the ^{81}Kr dating.

Line 319: ... > 1.95 m (Fig. A2); the offset....

Line 319: It is not clear why the offset may also come from age difference.

Line 321: The statement about that it is altered naturally and/or contaminated is rather speculative. It is also in disagreement with section 3.3. In my opinion, this observation is very interesting and deserves further research (could be mentioned as limitation/recommendation).

Figure 7: Consider omitting T3, T5 and T6, and check the color scheme for color blinds.

Line 342: (Fig 8d)

Line 345-355: Did you consider an automated method such as dynamic time wrapping? Also, it would be nice to discuss already in this paragraph the relation between the corrections made to match the horizontal distance to the age and the observed dip angles (as in line 380-384).

Line 371: I do not understand how biases in the $\delta^{18}\text{O}_{\text{ice}}$ record are avoided by interpolating the original record.

Line 374: This statement is not clear and can be elaborated.

Figure 9: Panel d does not show much more detail and could be omitted.

Line: 398-403: This paragraph sounds more like a part of the conclusion.

Line 398: The first sentence undersells the results. It can be a valuable (but obvious) recommendation but needs an explanation of why we would need more precise ages. Moreover, it is not in line with the statement on Line 412.

Line 401: please specify which atmospheric greenhouse gas can be measured at what depth (very relevant for other field work missions).

Line 401-403: nice and clear statement.

4 Conclusion: The conclusion section can be more elaborate. I suggest including the last paragraph of the previous section (line 398-403). Moreover, an estimation of the horizontal relationship between distance and age (i.e., xxx year/horizontal m), would be informative for other studies at blue ice areas.

Line 409-410: would be nice to guide the reader along the blue ice area and explain why the observations reveal a very typical glacial termination (as for instance Line 304-305, and the mention of the Antarctic Cold Reversal). Moreover, the Δage along the flowline (Figure A6) can be included in this explanation.

Line 414: not only on blue ice areas in the Northern Victoria Land. The comprehensiveness makes it a valuable study for BIAs across the Antarctic continent.

Appendices: clear and concise.

Figure A3, A4: Consider omitting T3, T5 and T6.