

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2022-18

Anonymous Referee #1

Referee comment on "Cosmogenic nuclide dating of two stacked ice masses: Ong Valley, Antarctica" by Marie Bergelin et al., The Cryosphere Discuss.,
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General comments

This paper presents an interesting and novel data set from a mixed media (ice-sediment) core collected from an ice-free valley in the Transantarctic Mountains. The main aim of the study is to constrain the age of emplacement of the ice body/bodies found underneath a debris layer, an important topic as ancient glacial ice has high potential as a paleo-environmental archive. This study applies a brand new (to my knowledge) multi-nuclide approach to cosmogenically dating the ice body, or more specifically, the minerogenic debris on top and within it. The cosmogenic data-set is of high quality and importance and is without doubt worthy of publication.

The added novelty of this study comes from the application of forward model that predicts the evolution of nuclide concentrations with depth in a sublimating debris-rich ice mass given certain assumptions. This is a strong contribution to the cosmogenic toolbox and will undoubtedly be of interest to other researchers. The authors include well commented code that i was able to (mostly) follow and run myself. They should be commended for this.

My overall feeling is that this has potential to be a very influential paper, the finding that the ice is many millions of years old is exciting and will be of wide interest. I want to be supportive of this paper however i'm afraid to say i think the paper would benefit from a fairly significant re-write/re-structuring. The overall structure and clarity could be improved significantly and i think the different but complimentary approaches to constraining the age of the ice masses more clearly and logically articulated. Currently the descriptions of the overarching principles and their applications are scattered throughout the paper and i found it very difficult to follow.

Specific comments

I think there are several specific aspects of the paper and its structure that could be developed to improve the clarity. Firstly, I think the overall contextual information given regarding the core is not sufficient. The core clearly displays a varied stratigraphy, evident in both the visual appearance and measured debris content of the ice. This stratigraphy seems critical to the interpretation of the subsequent cosmogenic nuclide data but it is only very briefly described in the results section. The sub-division of the core into individual units should be based on the stratigraphy (i.e. descriptive) and not on the interpretation of the cosmo data (i.e. interpretative). It would also provide an opportunity to introduce some of the potential complexity within the core (e.g. potentially more than one ice mass/ice deposition event) given the observed stratigraphy. This would then seem to give a foundation for describing what units were sampled and why/what they might inform upon. I also think the core description should come much earlier in the paper, perhaps after the study site section, as is often done in ocean core studies.

The results section is very short and doesn't describe that data in enough detail for the reader to subsequently follow the paper. The cosmogenic data from the core is the central data-set but is described in less than five lines. The down core variation should be specifically described and quantified. The variations have implications for the subsequent application of the model.

Another comment regards the structure, both the overall structure and structure of individual sections. I appreciate that this may have been quite a tricky paper to write as it involves a number of approaches (surface exposure dating, burial dating, depth-profile dating) and modelling. I always find in similar cases structure can be hard to decide upon but one way I find helpful is to start with the simple(!) parts and add complexity. Currently it feels the paper sometimes tries to address all the complexity at once. For example in Section 4.3 the overarching principles of nuclide production at depth are described after the complexities of evolving mass shielding and depth. This seems like the wrong way round. Additionally, sentences describing key concepts are scattered throughout the paper; for example in section 6.2 (522-523, 526-536). The reader needs to be as up-to-speed as possible before the model results are introduced. I wonder whether the bulk of the model description should be moved to supplementary and only the key concepts described in the paper (perhaps in the discussion section).

Is burial dating part of the model? Line 526 suggests not but line 611 suggests it is? I am really confused. I think the model results and burial dating results need to be more clearly defined as to what is what. Section 6.2 has forward modelling in the title but seems to refer entirely to burial dating units that the forward model wasn't applied to? The burial ages are only given at the very end of section 6 even though they are used as constraints for the model?

I am clearly not following what was done from the text. I think a much clearer structure that separates the measured results from the modelled results is needed. The authors need to be explicit about what is what throughout the paper. The paper needs to set up a logical structure and follow it throughout, to me it currently jumps about from one approach to another making it really hard for me to follow and subsequently review. The authors will of course be very familiar with the steps involved in deriving the results but for someone seeing this for the first time it is not obvious.

I would also ask that the authors think about some of the terminology used. The title describes dating of ice masses but the text commonly refers to ice mass (singular). Similarly i dont think the term "middle" ice is helpful when talking about a vertical core with potentially multiple ice masses within it. To me the term paleo-surface implies it is in situ which i dont think the authors are implying; i think this links back to the point about sub-dividing the core on descriptive grounds not interpretative.