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Comment on gchron-2021-21

Ross Whitmore (Referee)

Referee comment on "Cosmogenic nuclide exposure age scatter records glacial history and processes in McMurdo Sound, Antarctica" by Andrew J. Christ et al., Geochronology Discuss., https://doi.org/10.5194/gchron-2021-21-RC2, 2021

General Comments:

This paper suggests something very interesting, a moraine from MIS8 in the Ross Sea Region would be a substantial find. However, as the manuscript stands I don't think that the data set presented is robust enough to make this claim. The authors could talk about the possibility of a MIS8 landform, but simply put they need more data from this landform. By toning down the rhetoric and qualifying their statements they could give their work the amount of discussion and speculation as supported by their small, albeit important dataset (n=3). I think this would strengthen the paper and make it clear that this needs to be a target of further research.

Additionally, the authors do not discuss correction for nucleogenic ^{3}He production via geologic processes. This could be a reason for the systematically older ^{3}He ages. If this is the case then their data set might settle on specific age ranges for their respective landforms, regardless of rock type. Furthermore, the overarching statements about all of one rock type consistently having a previous exposure history seems to be a bit of a stretch. The distribution of bedrock is hard to know under the ice sheet however, some seemingly omnipresent rock units in the area must have bedrock cropping out under the ice sheet (e.g. Beacon Sandstone and Ferrar Dolorite). I feel it is important to think about the volumes of sediment flux here. The total amount of exposed bedrock next to an outlet glacier like Byrd Glacier is very small compared to the whole catchment (~1,000,000 km^{2}). Simply put, are the relatively small nunataks areas shedding enough material to totally flood the depositional landforms with sediment that has a complex exposure history? The outlet glacier systems mentioned in the manuscript which impinge on the Southern Dry Valleys at the LGM (Byrd, Mullock, and Skelton) are connected to the EAIS, I think it is reasonable to assume that most of the sediment will be derived from subglacial processes happening in different portions of the polythermal outlet glaciers in both current and extended ice sheet configurations. A good dataset to juxtapose the sediment recycling idea against is Tucker Glacier in Northern Victoria Land. Tucker is not connected to the EAIS and has a restricted sediment supply with presumably large amounts of clast recycling or supraglacial input from the Admiralty Mountains to the north and the Victory Mountains to the south (Balco et al., 2019 and Goehring et al., 2019). It

could be worthwhile to run the samples from this area for a second nuclide to comprehensively evaluate if they have a complex exposure history before you make the claim that they do. I recognize that further analysis presents more work but, it could answer some of the questions around complex exposure histories.

I am extremely interested to see how this manuscript changes. I think there is some valuable observations here, but they need to be given proper context.

Many thanks,

Dr. Ross Whitmore

Specific Comments:

- You are not working in McMurdo Sound you are working on the exposed bedrock around the sound. You could say the McMurdo Sound Region or the Southern McMurdo Dry Valleys.
- Please consider the role of nucleogenic ^{3}He in the rocks when recalculating your results.
- Please tone down the rhetoric and qualify your statements for the potential MIS8 landform. This is a good target for robust work to demonstrate that the landform is of a consistent age from east to west and across its apparent age range.
- Some discussion about how sampling proceded and what type of material was collected would be useful. E.g. when working on a glacial dip stick samples are selected based on morphology and position in the landscape. While clast morphology is not a panacea to filter anomalously young or old erratics it is a good general principal to guide in sample selection.
- Carefully format all of you tables so they are legible. If this means turning the table sideways then go for it.
- Make sure that you have presented all of the data necessary for your work to be recalculated in the future. (e.i. denudation rate, pressure flag, g of sample, carrier concentration, etc.).
- Incorporate your blank scheme into the wider data calculation tables to remove ambiguity about what samples used what blank.
- Make sure that you are consistent about what you call the online calculator you used to produce your results.
- Please think about statistically significant results. Three samples from one landform isn't that robust for the claims you are making (MIS8 moraine).
- I know you have provided your data to a repository that you started, but since you got so much from ICE-D it would be good to use that community resource too. Besides having your data present in a number of places is a good thing for your own exposure.

Technical Comments:

- Line 22: the Ferrar Dolorite crops out not outcrops.
- Line 33: "**dating landforms and surfaces (Christ et al., 2021a; Wells et al., 1995), reconstructing changes in climate over millions of years (Bierman et al., 2016; Schaefer et al., 2016; Shakun et al., 2018), among many other applications**." Should be changed to "*dating landforms/exposed bedrock surfaces (Christ et al., 2021a; Wells et al., 1995), and reconstructing changes in climate over millions of years (Bierman et al., 2016; Schaefer et al., 2016; Shakun et al., 2018); among many other applications.*
- Line 80: "**During past glacial periods when southerly EAIS outletglaciers expanded into the Ross Sea, grounded ice circumvented volcanic features and overflowed into McMurdo Sound from the east (Christ and Bierman, 2020; Denton and Marchant, 2000; Greenwood et al., 2018; Hall et al., 2015; Stuiver et al., 1981) (Fig. 1).**" to something like "Grounded EAIS ice overroad some or all of the volcanic features in teh McMurdo Sound region, impounding the flow of Koettlitz Glacier and other portions of the McMurdo Dry Valleys (use your citation)*"*
- Lines 87-89: Not all of the outlet glacier reconstructions in the region have had issues. See Jones et al 2015, Jones et al., 2021, Stutz et al., (in review The Cryosphere). If you want to keep this text the way it is you could say "*yet, previous effort at Koettlitz Glacier have yielded a pattern of complex exposure histories (use your citations).*"
- Lines 125-128: is a run-on sentence. You could break it into component parts and explain what you mean.
- Figure 2: white text on some parts of the map is really hard to see. I didn't realize that Mount Discovery and Black Island had text on them until I went to comment about the lack of text. I always struggle with it when making maps of Antarctica. You could try bolding the outline of the words more, make a shaded box to highlight the text, or move the name below the feature like you did for Minna Bluff.
- Line 176: Some discussion around why you choose the LSDn scaling scheme would be nice. What are the benefits of using it to this work? (e.g. *We recalculate the legacy data and apply the LSDn scaling scheme to all samples for ease of comparison between samples collected in the 1990's and 2010's...orwhatever your reason was for selecting it)*
- Line 180: You should really cite the original sources for purification procedures (Brown et al., 1991 and Kohl and Nishiizumi, 1992).
- Lines 180-181: It would be useful to give the specifications of the AMS used for the work.
- Line 200: You say the maximum elevation is 775 m previously in the text and 770 m here.
- Figure 4: It would be useful to have more distinct colors representing your Quaternary units. The yellow's, while the standard geologic mapping color for Q units, are hard to differentiate.
- Figure 5: It would be quite useful to see a different symbol or different colour representing different lithologies.
- Lines 290-291: Can you really quantify the magnitude of and processes responsible for the exposure age scatter with such a small data set that has not taken into consideration all of the necessary variables to calculate an exposure ages? This would be better softened and qualified. Additionally, multiple nuclides on the same samples will tell you if there is a complex exposure history.
- Line 313: Close the parentheses here.
- Line 320: To be fair, from what I have seen you cannot tie all of one rock type back to a single outcrop in the Dry Valleys or the wider Transantarctic Mountains region (with one rare exception). The units where your material has been derived are almost

omnipresent and exist both above and below current and paleo-ice sheet configurations. I think you might be over extending your argument.

- Sections 5.3.1-5.3.2: This is a bit too simplistic. While yes there are specific rock types exposed adjacent to the glaciers other extensive units must also be present at some point along the glacier as well and there is no telling where the erratic was plucked from under the glacier.
- Line 344-346: This is why you need to get the nucleogenic concentration right.
- Line 350-351: Rephrase this, rock fall is a form of mass wasting that is subject to physical weathering processes.
- Lines 371-375: This is a run-on sentence, break it down a bit.
- Line 373 remove “of”.
- Lines 385-387: what are the odds that this is simply a coincidence? This is potentially a recycled clast from somewhere other than Mount Discovery.
- Lines 387-390: What erosion rate are you assuming to make this calculation? You could fiddle with the ER until the age is what in the ball park of what you would expect and then see if the erosion rate is realistic for what we know of the area. If it is several meters of erosion than the clast may have been uncovered later or rolled through periglacial processes. Also, why didn't any of the other samples need to be adjusted for ER?