

Barth et al. (2022)  
Geochronology Review  
Anonymous Referee #2

This manuscript presents an intriguing set of exposure ages from late Pleistocene to Holocene glacial deposits in the Beartooth Mountains of the western United States. The late Pleistocene ages of the oldest dated moraine position and potential associations with the Younger Dryas will attract a lot of interest. But in my view, the most newsworthy aspect of the study is that it provides rare age control for the late Holocene record of glaciation in this region, which remains sparsely documented. The exposure ages are rather scattered on the youngest landforms, but despite this scatter, the data provide a clear signature of glacial activity during the Neoglacial and LIA.

*Thank you for the helpful assessment and review of our paper. We agree that the late-Holocene ages are noteworthy and provide valuable insight into Neoglacial and LIA glaciation in this region.*

Regarding the youngest landforms, there's some acknowledgement of the complexities involved in interpreting these ages as either climate-driven glacial events or periglacial processes leading to rock glacier formation. I would like to see more discussion about that complex issue and the caution in interpreting such ages.

*Agreed. We will expand upon possible interpretations of the late-Holocene data – particularly related to the possible influence of rockfall and rock glaciation. The additional explanation should acknowledge limitations of the data while supporting the conclusions presented in this paper.*

Overall, however, the ages reported in this manuscript are valuable and should be published because they advance our knowledge of late Pleistocene glacial events and late Holocene stabilizations/readvances of mountain glaciers in the western US.

I have a list of more detailed suggestions below, and recommend publication after moderate revisions.

Line 60: correct spelling is Absaroka

*Corrected.*

Line 63: Replace Course with Coarse

*Corrected.*

Figure 1: A more specific locator inset map with the Beartooth Mountains labeled would be more helpful than highlighting the entire states of Montana and Wyoming. Main map needs lat-lon ticks.

*Agreed. We are adding a symbol to indicate the study area location along the border of Montana and Wyoming. Latitude and longitude ticks are to be added as well.*

Figure 2: This figure would be more informative if additional information was added, such as other glacial deposits or features, former ice flow directions, etc. There's also a lot of area included on eastern side of the map that doesn't include any plotted moraine or age information and therefore doesn't need to be shown.

*Figure 2 is to be cropped, thus eliminating the excess eastern portion of the map and focusing more on the glacial deposits discussed in this paper. We will add generalized ice-flow directions and map the rock glacier located to the west of Triangle Lake. Latitude and longitude ticks are to be added on this map as well.*

Figure 2 again: With this degree of scatter among the exposure ages, it may not be meaningful to report an average age. Instead, reporting the range of ages could be more useful for interpretations. The scatter also makes me wonder if these features are rock glaciers or proglacial ramparts, rather than moraines? This is acknowledged later in the discussion, but a satellite image base map would help visualize the landforms at these field sites.

*Figure 2 will now include satellite imagery as a base map to assist with visualization of the landforms and provide support for our interpretation as moraines – based on morphology and geometry. We plan to remove the mean ages listed beneath each distribution and will discuss the range of ages in the text.*

Line 118: What exactly is meant by "deflated" moraine? Does this refer to ice-stagnation features or melting of an ice-cored moraine? Or wind deflation of fine-grained material from the surface?

*We plan to expand upon this point by discussing the effects of wind deflation of fine-grained material and settling of sediments within the moraine. We will reference recent work by Sortor (2022) where cosmogenic nuclide measurements were used to estimate the rate of moraine deflation within the Front Range of Colorado, USA, which is analogous to the moraines of our study area.*

Line 175: I'm not sure why it's useful to mention how many samples were collected if they weren't all measured.

*Agreed. The line is removed and now reads: "Eighteen samples were collected and processed for <sup>10</sup>Be extraction that best represent our selection criteria..."*

Results section: Ages reported in this section do not match the ages plotted on Figure 2. This needs to be corrected.

*Thank you for identifying this error. All ages in the figures and manuscript are now reported using the Promontory Point production rate and LSDn scaling scheme.*

Line 226: It does not seem warranted to report these exposure ages to the nearest year. I suggest rounding to the nearest decade or century, or whatever is justified by the actual precision of the results. Same comment for other quoted ages throughout the manuscript.

*Agreed. Late-Holocene ages and uncertainties are rounded to the nearest decade based on the average decadal uncertainty for those ages, while Pleistocene ages and uncertainties are rounded to the nearest century for the same reason.*

Lines 231-234: I'm not following the logic here. If rockfall is suspected, then the youngest ages may be reflecting the timing of that rockfall rather than a period of glaciation.

*Ages for the youngest moraines will now be presented as ranges instead of a mean age or the youngest age. We will interpret the ages as a limiting range of deglaciation from the moraine and suggestive of glacial conditions prior to abandonment.*

Lines 238-239: Again, considering the youngest ages to be the minimum-limiting ages of glaciation is risky if rockfall delivery is suspected.

*Same as above.*

Lines 244-245: What about choice of scaling? How much does that change the ages? I don't see Table 2 in the main text.

*Discussion of other production rates have been removed to reduce confusion described by Reviewer #1. As such, we are not inclined to discuss the effect of various scaling schemes on our reported ages at this time and Table 2 is also no longer necessary.*

Lines 338-341: The apparent variability in the timing of moraine abandonment in the YD stadial seems to fall within age uncertainties, so it's difficult to make a strong case for this.

*Agreed. We added the following sentence at the end of the paragraph to emphasize this point: "However, multi-centennial scale uncertainties within each age prevent conclusive attribution of moraines to early or later periods of the YD."*