

**Author response to referee comments on “A 14.5 million-year record of East Antarctic Ice Sheet fluctuations from the central Transantarctic Mountains, constrained with cosmogenic  $^3\text{He}$ ,  $^{10}\text{Be}$ ,  $^{21}\text{Ne}$ , and  $^{26}\text{Al}$ ”**

We thank David Sugden for his review of the manuscript and his insightful comments.

Below, we address referee comments and describe additional, unsolicited changes that we've made to improve the manuscript. Referee comments are supplied in bold, with our responses in regular text.

**Specific comments:**

**1. Is it possible that some of the moraines near the ice margin are ice-cored? Are any of these moraines stranded blue-ice moraines? If so, could subsequent ablation help explain some outliers? Bearing in mind the blue ice moraines at high altitudes in the TAM, it would be good to hear your view on this.**

Although we recognize that the blue-ice moraine model is important at high elevation sites throughout the TAM, our field observations suggest that moraines at Roberts Massif are not stranded blue-ice moraines. In general, we characterize the moraines at Roberts Massif as boulder belt moraines, associated with thin drifts of angular boulders and directly overlying bedrock in several locations. Furthermore, the present ice fronts facing the moraine complexes are convex, have minimal debris within the ice, and do not have accumulating debris fields. These observations, coupled with the absence of modern blue-ice moraines at Roberts Massif, suggest that sediment supply to the glacier is low, which is inconsistent with blue-ice moraines forming at other TAM locations today. While we do not interpret the Roberts Massif moraines as stranded blue-ice moraines, we acknowledge that (at least some) young outliers in our cosmogenic-nuclide dataset may result from ablation of a small ice core from moraines, and have added a sentence on this topic on lines 466-467 and a parenthetical reference on line 472.

**2. The start of the discussion is the place where you reference studies implying the presence of grounded ice in the Ross and its effect in blocking the flow of Transantarctic outlet glaciers. Later you make this an argument for the stability of the West Antarctic ice sheet for 15 Ma. Could you describe the evidence that the upper parts of Shackleton Glacier are affected by conditions near its convergence with Ross Sea ice? Once established for the reader, then the argument is strong. I was of the belief that there was little change higher up the transverse glaciers**

We agree that this argument needed clarification. Previous studies have shown that buttressing by Ross Sea ice affects ice thickness at the heads of TAM outlet glaciers, albeit significantly less thickening than at the mouths of these glaciers. To further our argument, we've updated the paragraph on lines 534-544 to include references that evidence the effect of buttressing ice in the Ross Sea on the uppermost reaches of TAM glaciers. Because the moraines at Roberts Massif mark times when the ice configuration was similar to today, we speculate that there was at least a buttressing ice shelf in the Ross Sea, or even a grounded ice sheet. Either of these scenarios would require inflow of ice to the Ross Sea from West Antarctica. However, we recognize that we cannot distinguish between a Ross Ice Shelf (ice configuration in the Ross Sea similar to today) and a Ross Ice Sheet (ice configuration similar to the Last Glacial Maximum) with our data. Therefore, we've also updated the paragraph on lines 534-544 and the final sentence of the paper on lines 690-693 to allow for either of these possibilities.

**3. Lines 546-553. Origin of debris from the base. Reference here the direct evidence of basal freezing near Mt Archernar? Eg. Bader et al, 2016, Q.S.R. and Graly et al. 2018, J.Glac. This seems more significant than reference to a general continental scale model.**

References to Bader et al. (2016) and Graly et al. (2018) added.

**4. Ditto Uplift. Reference a fundamental paper on flexural uplift eg Stern & Tenbrink, JGR,1989, 94, p.10315?**

Reference to Stern and ten Brink (1989) added.

**Technical corrections:**

**1. Fig 3 and caption. I found the labels on the Figure and the caption confusing. For example, where is B? And (b) seems to describe the highlighted area in A'. What does (c) show?**

We've clarified the inset labels in both the figure and the caption.

**2. Fig 8 and caption. Explain what 8c shows? Southwest Col drift not explicitly shown on the figure.**

We've added the word "drift" to the Southwest Col label in Figure 8a and 8b, and bolded it for clarity. We also added a description of inset c, which does not show the Southwest Col drift, to the figure caption.

**Additional changes to the manuscript:**

1. We correct a miscount in total sample numbers found in the original submission, which included samples from the Supplementary Information that are not critical to the interpretations discussed in the text. Thus, we revise the total number of samples discussed in the text from 180 to 168 on lines 13 and 70, as well as the breakdown of cosmogenic-nuclide measurements on lines 392-393.
2. Removed a stray '---' from line 489.
3. Changed erroneous section reference to Section 4.1 on line 529 to the correct Section 3.1.