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Interactive comment on "A 14.5 million-year record of East Antarctic Ice Sheet fluctuations from the central Transantarctic Mountains, constrained with cosmogenic ^{3}He, ^{10}Be, ^{21}Ne, and ^{26}Al" *by* Allie Balter et al.

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Significance and novelty:

This paper focuses on the application of cosmogenic nuclide dating to ancient glacial deposits in Antarctica and shows how such information can be used to get a better understanding of paleo-ice sheet dynamics. The authors find that the East Antarctic Ice Sheet existed in similar to present extent since Miocene times (~15 Ma) near Shackleton Glacier. A pattern so far mostly seen in marine records off-shore East Antarctica,

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Discussion paper

and at the same time a topic of elevated interest for the community as the mid-Miocene period is considered to reflect climate conditions well within future predictions. Sampling and field work are outstanding in detail, quantity, and strategy. The analytical work has been conducted rigorously and with high scientific standards. Nuclide measurements are assessed thoroughly, and discussion of outliers/problems is suitable. Overall, data handling and presentation is transparent and comprehensible, and this paper offers 163 new exposure ages from over 20 moraines in a remote region in the central TAM. The combination of sample distribution, amount, and the measurement of up to four different cosmogenic nuclides (including two stable and two radiogenic) provides great detail regarding the samples (glacial) history and reduces the uncertainties that are part of dating of glacial deposits (e.g. nuclide inheritance, post-depositional disturbance). The authors present data from a large suite of moraines at Roberts Massif, central TAM, which shows increasing exposure ages with increasing distance and elevation away from the modern ice edge, a pattern one would expect from glacial thinning and/or rock uplift. In an area where terrestrial record is sparse this new data provides valuable evidence for an East Antarctic Ice Sheet configuration relatively stable since mid-Miocene with very low surface erosion (« 5 cm/Myr) and cold-based conditions for the East Antarctic Ice Sheet at least since 14.5 Ma. Isostatic rebound as consequence of glacial incision is found to be driving observed uplift of almost 200 m. The presented data does not exclude a reduced ice sheet during the mid-Pliocene warm period, as related evidence would be hidden beneath the current ice sheet. This is an important paper and it was a pleasure to read.

Specific comments:

1) Based on the detailed description of field work and sampling, the authors put a great deal of effort into sample selection and documentation, especially to minimize effects of common complications in surface exposure dating, e.g. nuclide inheritance or non-cosmogenic nuclides. So mainly out of curiosity, could some boulders of sufficient size have provided shielded samples to get direct measurements of inherited / non-

cosmogenic nuclides in combination with the surface samples?

2) No potential shielding from snow cover is discussed, and I assume it is considered negligible in respect to locality and the known average low snow accumulation. However, the age of the samples allows for some degree of uncertainty on seasonal or prolonged snow cover, and I would be interested to hear the authors thoughts on this.

3) Line 269-271: *"First described by Mercer (1972), the Sirius Group occurs throughout the upper (> ~2000 m elevation) TAM as erosional remnants of clay-rich diamicton that are correlated with at least one period of past temperate glaciation."* I read this as Sirius deposits are exclusively found above 2000 m, which could be misleading because there are Sirius Group outcrops are at lower elevations, e.g. Hambrey et al., 2003, and Mayewski 1975. I suggest changing the statement to > ~1500 m.

4) Line 571: *"≤~200m"*, this is a little odd, I would just write <~200 m

5) Section 4.1, Uplift at Roberts Massif: I understand the notion to compare potential uplift rates with existing data (here McMurdo Dry Valleys). However, I question the reliability of evaluating uplift rates or isostatic rebound over the extend of almost 1000 km, and thereby neglecting the influence of regional morphology and geologic structures. For me, the argumentation implies the whole TAM behaved as one block, undisturbed from north to south, while trough incision driven by glacial erosion (as discussed to be the main driver of uplift at Roberts Massif) can also (re-)activate underlying faults and induce block uplift (e.g. Studinger et al. 2006, or as shown for the Shackleton Range: Paxman et al., 2017). This would reflect in localized uplift rates which could be very different from the McMurdo Dry Valleys. I think this section would benefit from additional details on uplift along the TAM (e.g. Paxman et al., 2019).

Technical corrections:

Fig 1 and 3: missing scale bar and Lat/Lon labels (Fig 1), also, if possible, highlight/mark study area in figure 1

Fig 4, caption: no mention of (d) in the caption and missing reference to (d) under a); see : *"... with numbers corresponding to moraine names in (c) and letters A and A' corresponding to positions in (c)."*

Fig 5 (b), caption: It would be interesting to know the length of the pole for better scale or just give an approximate thickness.

Fig 11: text and axis labels are quite small, and rather hard to read

Fig 12: Please check numbering for BBY, BGE and WAL, it's different in figure 4. Also in the map (Fig 4) it is not quite clear which one is BGE.

Fig 14, caption: (c) is missing, and as a consequence subsequent description is off by one letter. *"Colors on the timescale at the bottom correspond to moraine colors in Figures 4, 7, and 8."* They don't, at least not for the reader, e.g. 'Pliocene' is more yellow then the orange of the moraines in the overview figures. Also, the color scheme used for the age data (d) implies a relation to the timescale used, which I find a little confusing. Maybe a different set of colors or symbols could make this figure clearer.

For the figures in general: The marker and information overlaying satellite maps are of mediocre quality/readability, which might be the result of compressing the images for this pre-print version, if not it would be worth looking into to ensure good quality images in the final version.

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