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The Cryosphere
Discussions

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 uses cosmogenic isotope analysis in an imaginative and thorough way to establish that moraines in the central Transantarctic Mountains have been accumulating for at least 15 Ma. This is an important finding. The implication is that the East Antarctic Ice sheet has been present in approximately its present form for the same period. This means it has survived warmer than present climate interludes such as those of the Miocene and Pliocene. The glaciological significance of the finding is twofold. First the moraines tell of the behaviour of the ice sheet close

to its centre, namely the head of Shackleton Glacier, a major outlet glacier traversing the Transantarctic Mountains. Second, the results confirm earlier indications of East Antarctic ice-sheet persistence for 15 Ma based in volcanic ash dating in the different location of the McMurdo Dry Valleys. Two locations using two different forms of dating adds traction to the idea of a persistent East Antarctic ice sheet since the Miocene. The paper is also significant in the way cosmogenic isotope analysis can be used investigate extremely old exposure histories and rates of change. The researchers analysed 180 samples from 24 deposits, using four isotopes. The moraines form an orderly topographic sequence with the highest moraines furthest away from the ice margin being the oldest ($\sim$ 15 Ma) and the lower ones closer to the ice margin with ages of 3.0 - 0.4 Ma. Although no specialist in the intricacies of cosmogenic isotope analysis, I was impressed by the care in sampling and the targeted use of different isotopes to establish confidence limits, to identify and explain outliers, and to yield reliable exposure ages. The results yield the lowest erosion rates on earth at 0.5 – 3.0 cm per million years. Moreover the long time scale was used to test such ideas as the rate of mountain uplift. The record of relative elevation change represented by the decline of ages towards the glacier margin is argued to reflect isostatic uplift of the mountains as a result of erosion of bedrock by glaciers. Differential tectonic uplift is ruled out because the oldest moraines drape over fault scarps. 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. 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 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. Ditto Uplift. Reference a fundamental paper on flexural uplift eg Stern & Tenbrink, JGR,1989, 94, p.10315? Technical corrections 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? Fig 8 and caption. Explain what 8c shows? Southwest Col drift not explicitly shown on the figure.

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