How have glaciers shaped Antarctica's bedrock? Apatite (U-Th)/He evidence for erosion and exhumation along the Shackleton Glacier in the Transantarctic Mountains

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Understanding the interplay between glacial history and tectonics in the massive East Antarctic ice sheet is increasingly important to predicting future glacial responses to tectonic and climatic forcings. The Transantarctic Mountains (TAM) were one of the nucleation sites of the Antarctic ice sheet at ~34 Ma and have some of the highest tip-to-trough relief of any mountain range in the world. The timing and record of bedrock exhumation rates in the central TAM therefore offer insight into both the history of the ice sheet itself and into the unique uplift history of the region. Though a period of TAM Cretaceous uplift along an extensional rift flank and an interval of increased glacial incision and subsequent isostatic peak uplift in the Oligocene have been proposed, the timing and tectonic details of these events as well as that of Antarctic glacial history during the Miocene and Pliocene warm periods are still very much debated. For this study, we collected granite and sandstone samples from Mount Butters and Red Raider Rampart (RRR), which flank the Shackleton Glacier in the central TAM, as part of the East Antarctic Glacial Landscape Evolution (EAGLE) project in 2017. By performing (U-Th)/He thermochronometry on apatite grains from these rocks, we determined the timing at which samples from various elevations cooled to 50-70 ^{o}C, which under typical geothermal gradients represents the last time they passed through ~2 km depth, and thereby constrained age ranges of both increased glacial incision and associated isostatic uplift. Sedimentary samples from Mount Butters showed a major cooling event aligned with Cretaceous TAM uplift and related erosion at ~95 Ma. A sandstone sample from 1707 m on RRR also yielded exceptionally reproducible cooling ages consistent with the Cretaceous cooling observed on Mount Butters. These data reinforce the published inference of initial TAM uplift in the mid-Cretaceous and hint at another smaller exhumation event circa 55 Ma. We did not observe any of the ~34 Ma or younger cooling ages associated with glacial incision in the upper parts of the Shackleton, implying that glacial incision in this area was not extensive enough to excavate younger cooling ages.