Topographic evolution of WAIS subglacial bedrock: Insights from low-temperature thermochronology and thermo-kinematic modeling in Marie Byrd Land, West Antarctica

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Bedrock topography is a key boundary condition for ice sheet modeling, and determining changes in subglacial topography through time can provide insight into the timing of ice sheet development, the magnitude of glacial erosion, and the co-development of glaciers and glacial topography.

West Antarctica hosts an unusually high geothermal gradient supported by hot, low-viscosity mantle which likely enhanced the lithospheric response to West Antarctic Ice Sheet (WAIS) cycles of growth and increased the sensitivity of thermochronometers to landscape evolution on million-year timescales. Thus, a valuable record of glacial landscape change might be recovered from apatite fission track [AFT 80-130°C range] and (U-Th)/He [AHe; 50-90°C] dating, provided that landscape evolution can be distinguished from tectonic signals, including the effects of faults. This study utilizes AFT-AHe thermochronology and thermo-kinematic Pecube modeling to investigate interactions between the hot geotherm, glacial erosion, and inferred crustal structures in the Ford Ranges and the DeVicq Glacier trough in western and central Marie Byrd Land (MBL), respectively.

The Ford Ranges host glacial troughs (up to 3km relief) dissecting a low-relief erosional surface. Previous work suggests a majority of bedrock exhumation and cooling occurred at/by 80 Ma. However, new data hint at renewed exhumation linked to glacial incision since WAIS formation at 34 or 20 Ma. Prior (U-Th)/He zircon dates from exposures of crystalline bedrock span 90 – 67 Ma. New AHe bedrock dates are 41 to 26 Ma, while two glacial erratics (presumed to be eroded from walls or floor of glacial troughs) yielded AHe dates of 37 Ma and 16 Ma. Initial modeling results suggest a tectonic boundary between the Ford Ranges and Edward VII Peninsula separating regions with distinct exhumation histories. The boundary may cause differential WAIS incision at 34 or 20 Ma, a possibility being investigated with new models.

The DeVicq Glacier trough (>3.5km relief) coincides with a prominent crustal lineament but lacks temperature-time information compared to other regions. The crustal structure may have accommodated motion between elevated central MBL and the subdued crust of the Ford Ranges. Here, owing to the lack of onshore non-volcanic bedrock exposure, we have employed AHe and AFT dating of glacial sediment marine core samples offshore of the DeVicq Glacier to investigate the timing and rates of exhumation of the bedrock carved by the DeVicq trough, with initial results revealing detrital AHe ages as young as 24 Ma.

Our new Pecube models test a series of thermal, tectonic, and landscape evolution scenarios against a suite of thermochronologic data, allowing us to assess the timing of glacial incision and WAIS initiation in the Ford Ranges, and to seek evidence of an inferred tectonic boundary at DeVicq Trough. Modeling efforts will be aided by new AHe and AFT analyses from ongoing work. These models combine topographic, tectonic, thermal, and key thermochronologic datasets to produce new insight into the unique cryosphere-lithosphere interactions affecting landscape change in West Antarctica.