Long-term glacial history of the central Transantarctic Mountains

Perry Spector[1] and John Stone[1]
1: Department of Earth and Space Science, University of Washington

Model simulations of past configurations of the Antarctic Ice Sheet are poorly constrained by geologic observations. Although extensive research has been devoted to unraveling the post-Last Glacial Maximum (LGM) deglacial chronology, constraints on prior episodes of the ice sheet's history are extremely rare. The history of ice thickness changes can be constrained by measurements of cosmogenic nuclides in bedrock surfaces. In 2010-11, we sampled an elevation transect of bedrock from Mt Hope, located in the central Transantarctic Mountains at the mouth of Beardmore Glacier and abutting the Ross Sea. Over glacial cycles, ice levels at Mt Hope would have been sensitive to thickness and grounding line changes of the West Antarctic Ice Sheet as well as ice elevation changes in East Antarctica that were communicated through the Transantarctic Mountains by Beardmore Glacier. Here we present a record of Quaternary exposure and ice cover from Mt Hope, derived from measurements of cosmic ray-produced ^{26}Al and ^{10}Be in bedrock surfaces.

Bedrock exposed during interglacial periods accumulates cosmogenic nuclides such as ^{10}Be and ^{26}Al. During glacial periods, thick ice cover shields bedrock from cosmic radiation, and differential nuclide decay rates (^{10}Be $t_{1/2}$ = ~1.4 Myr; ^{26}Al $t_{1/2}$ = ~0.7 Myr) leads to isotopic disequilibrium. In cases where bedrock has been protected by non-erosive, cold-based ice during glacial periods, the concentrations of these nuclides provide million-year records of exposure and ice cover. Although these measurements cannot date specific glaciations, for each sample we can determine: 1) lower limits on the cumulative exposure time and time ice covered and 2) upper limits on the proportion of time each sample has been ice-free.

Paired ^{26}Al-^{10}Be measurements from Mt Hope bedrock show that the proportion of time samples have been exposed increases with elevation, as expected. Results from the weathered bedrock that characterizes the upper slopes of Mt Hope show that, although the summit (827 m elevation) was overrun by ~250 m of LGM ice, these surfaces have been nearly continuous exposed for over 0.5 Myr and up to 2 Myr. This implies that highstands similar to the LGM have not been long-lived in this part of Antarctica. On the lower flanks of Mt Hope, striated and glacially-carved bedrock are evidence for subglacial erosion by warm-based ice. Surprisingly, isotopic data from this bedrock display substantial disequilibrium in ^{26}Al/^{10}Be, indicating that, despite being repeatedly overrun by ice discharged from Beardmore Glacier, there was insufficient subglacial erosion to completely erase the record of prior exposure.

During the most recent deglaciation, a knoll on Mt Hope's north slope became ice free ~1-2 kyr prior to higher elevations on the mountain's prominent southeast ridge, based on ^{10}Be measurements of glacial erratics. The paired ^{26}Al-^{10}Be record from Mt Hope bedrock show that this is not a phenomenon unique to the last deglaciation, for bedrock on the knoll has been exposed and ice covered (for at least ~300 kyr and ~250 kyr, respectively) longer than bedrock at higher elevations on the southeast ridge. This necessitates that bedrock below ~250 m elevation has been ice covered for much of the last half of the Pleistocene.