Exposure history of West Antarctic nunataks

Perry Spector, John Stone, Howard Conway, Dale Winebrenner
Department of Earth and Space Science
University of Washington

Cameron Lewis, John Paden, Prasad Gogineni
Center for Remote Sensing of Ice Sheets
University of Kansas

There is strong evidence that the West Antarctic Ice Sheet has been thinner during the Pleistocene, however the timing, duration, and magnitude of past deglaciations are poorly known. Ice-sheet elevation changes over glacial and interglacial periods can be revealed by cosmogenic-nuclide measurements of bedrock surfaces. Whether ice was thinner during past warm climates can be tested by measuring cosmogenic nuclides in currently subglacial bedrock surfaces, provided that cold-based ice has protected the surfaces from erosion. During 2012-13, we visited three groups of small nunataks in West Antarctica with the intention of locating favorable drilling sites for the recovery of subglacial bedrock to look for evidence of thinner ice in the past. We traveled to the Whitmore Mountains, located near the ice-sheet divide, and the Pirrit and Nash Hills, nunatak groups located in the Weddell sector of West Antarctica at ~1300 and ~1500 m, respectively.

At the Pirrit Hills, fresh glacial erratics are evidence of thicker ice during the last ice age and indicate that ice levels were at least ~350 m, but less than ~510 m, above the present level. Despite thicker ice, bedrock at all three sites, extending down to the present ice level, is weathered and exhibits delicate cavernous forms, evidence of prolonged subaerial weathering prior to the last ice age. The preservation of these features, along with the lack of evidence for wet-based glacial erosion, indicates that former ice cover was cold-based and protected the underlying bedrock.

Cosmogenic ^{10}Be measurements of bedrock surfaces show that the majority of the Pirrit Hills have been exposed for over ~0.5 Myr and up to ~4.3 Myr. Even within a few meters of the present ice surface, two bedrock samples yield minimum exposure ages of ~230 and ~490 kyr. Paired ^{26}Al and ^{10}Be measurements from Pirrit Hills bedrock indicate that past episodes of ice cover thicker than the present were not long-lived and that the bedrock surfaces experienced very low erosion rates for at least the past ~0.5 Myr. Bedrock measurements from the Whitmore Mountains show even longer exposure and no evidence of prior ice cover.

Ice-penetrating radar surveys, conducted around minor nunataks of the Pirrit Hills, revealed detailed bedrock topography to depths of ~400 m (see accompanying abstract by Lewis et al.). Of particular interest is a gently-dipping ridge radiating from the small granitic outcrop of Harter Nunatak. Between 100 to 300 m below the ice surface, internal reflectors within the ice truncate against this ridge. Although this could result from basal melting, no evidence exists for wet-based ice, and basal melting is unlikely to occur at this shallow depth. The truncating reflectors appear to result from onlapping snow layers, implying exposure of the ridge during a time of thinner ice.

At the Pirrit Hills, evidence for past ice-free conditions and cover by cold-based, protective ice suggest that the cosmogenic-nuclide signal of prolonged exposure extends below the modern ice surface. This favors the Pirrit Hills as a potential site for future subglacial drilling to depths of a few hundred meters.