Glacial Geology of the Ohio Range, Antarctica: Constraints on Ice Elevation during the Last Glaciation

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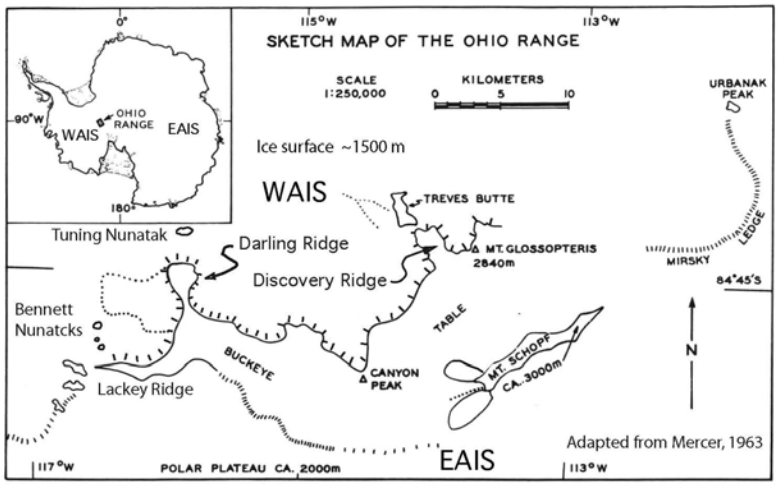
Knowledge of past ice elevations in the Antarctic interior is critical to constrain reconstructions of the West Antarctic Ice Sheet (WAIS) during the last glacial maximum (LGM) and to initialize dynamic ice sheet models of deglaciation following the LGM. Mountains that project through the ice sheet serve as dipsticks that gauge past ice elevations that are recorded by glacial deposits and erosional features preserved on their slopes. The Ohio Range lies at the southern end of the Transantarctic Mountains (85¡S, 114¡W) at the boundary between the East Antarctic Ice Sheet (EAIS) and the WAIS. Near the onset area of the Mercer Ice Stream, the Ohio Range is ideally situated to record past ice elevations in this important sector of the WAIS (Figure 1).

The Ohio Range forms an east-west trending escarpment rising 500 m above the adjacent surface (~1500m) of the WAIS. The escarpment consists of a series of embayments separated by ridges that project into the WAIS and that often are exposed as nunataks beyond the escarpment. Because little ice spills over the escarpment from the Buckeye Table, ice elevations at the base of the escarpment are determined by the adjacent WAIS. Blue ice areas and morainal deposits occur in the lee of the prevailing easterly winds on the west sides of Discovery and Darling Ridge (Figure 1). Mercer (1963) reported the presence of granite erratics 60 m above the adjacent ice surface at Discovery Ridge. During the 2004-2005 field season we visited Discovery Ridge, Darling Ridge. Tuning Nunatak, and the Bennett Nunataks in order to provide constraints on past WAIS elevation at the Ohio Range (Figure 1). The granite cliffs forming the escarpment and nunataks typically exhibit deep cavernous weathering with areas between pits reduced to delicate structures only several centimeters thick (tafoni). The sinuous caverns and pits commonly exceed 50 cm depth and occasionally reach over one meter in size. The granite basement is overlain by sandstone, tillites, coals and shale. At Tuning and Bennett Nunataks (Figure 1), this deeply weathered surface extends to (and presumably beneath) the present ice surface. In many locations, the weathered surface has clearly been overridden by ice. Granite, tillite (particularly molded and striated clasts derived from it) and sandstone clasts occur on and within the cavernously weathered granite on nunataks and in recesses on granite cliff faces where the erratic clasts cannot have fallen from outcrops above. In such locations, the most delicate weathering features have been broken off, resulting in a vandalized appearance. The transition (typically several meters) from such surfaces to those lacking erratics and on which delicate weathering features are preserved is interpreted as a trim line that marks the upper limit of ice during the last high stand of the WAIS while the erratics on the peaks of the nunataks provide minimum constraints.

At Discovery Ridge, granite erratics occur on a terrace at an elevation of 1720 m. The lack of erratics on the sedimentary rocks comprising the slopes above the terrace suggests that the ice level was not significantly higher. A trim line, determined from the lowest elevation of preserved delicate tafoni on the southern end of Treves Butte, immediately adjacent to Discovery Ridge, occurs at ~1750 m, and provides a maximum ice elevation at this location. This result is consistent with the preservation of delicate tafoni in a medium to coarse-grained sandstone layer within the tillite on Discovery Ridge at 1765 m. However, it is not certain this trim line corresponds to the ice that deposited the granite erratics on Discovery ridge or an earlier event. Fresh erratics on rounded and knobby granite bedrock occur to the top of a transect up a flatiron rock formation on the east side of Darling Ridge to 1700 m. Cavernous weathering with delicate tafoni occurs on the cliff about 20m above. A transition from smoothed to deeply weathered rock occurs at a similar elevation on the adjacent ridge line near the northern end of Darling ridge. These features are interpreted as trim lines indicating the WAIS elevation was ~1700 m at Darling Ridge. Based on these observations we conclude that the elevation of the WAIS was approximately 200 m higher during the most recent highstand. These results are the first constraints on maximum ice elevation in this key sector of the ice sheet.

Measurement of cosmogenic nuclides in the erratics and underlying bedrock is underway in order to constrain the timing of ice surface recession in the Ohio Range. Because the summit elevations of the nunataks vary from 1585 m at Tuning Nunatak to 1475 m at the lowest Bennett Nunatak, which is only 13 m above the ice surface, exposure ages of the erratics should document emergence of the nunataks and the rate of down draw of the WAIS in the interior part of the continent. The ubiquitous presence of weathered bedrock surfaces and minimal evidence of glacial erosion, means prior exposure of many erratics is likely. We collected only unweathered angular granite erratics for exposure dating in order to minimize this problem. Although helium is known to diffuse out of quartz, for young samples at Antarctic temperatures, helium appears to be quantitatively retained (Brook et al., 1993). We are in the process of measuring 3He in quartz separates in order to screen the samples for prior exposure before undertaking 10Be and 36Cl analyses. Initial results show that 3He in the quartz is cosmogenic and the 3He concentrations in replicate samples are reproducible. Model exposure ages of three erratics assuming no diffusive loss of 3He range from 4600 yr at Discovery Ridge to 44000 yr at Tuning Nunatak (Figure 1). The younger age provides a minimum estimate for the start of ice recession in the Ohio Range consistent with evidence for propagation of a wave of thinning during deglaciation (Ackert et al., 1999; Conway et al., 1999; Steig et al., 2001; Stone et al., 2003). The older sample may have been deposited during an earlier advance or have prior exposure. Minimum bedrock exposure ages are 130,000 yr at Tuning Nunatak and 1.5 Ma at Bennett Nunataks consistent with the evidence for greater erosion at Tuning Nunatak.


SKETCH MAP OF THE OHIO RANGE
SCALE 1:250,000
KILOMETERS
0 5 10
0°
90°W
180°
OHIO RANGE
WAIS
EAIS
115°W
113°W
Ice surface ~1500 m
WAIS
TREVES BUTTE
MT. GLOSSOPTERIS 2840m
URBANAK PEAK
MIRSKY
LEDGE
84°45'S
Tuning Nunatak
Darling Ridge
Discovery Ridge
Bennett Nunatcks
TABLE
BUCKEYE
CANYON PEAK
MT. SCHOPF CA. 3000m
Lackey Ridge
N
Adapted from Mercer, 1963
117°W
POLAR PLATEAU CA. 2000m
EAIS
113°W