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1. Detailed Site Descriptions
2. Detailed Analytic Methodology
3. Table of Blanks for Batches in which Wisconsin samples were run

1. Detailed Site Descriptions (see Figure D-1 for site maps)

Rock Springs Quartzite Quarry Site- Two shielded samples (WS-BG-1 and WS-BG-2) were taken from the wall of an abandoned rock quarry located near Rock Springs, Wisconsin about 12 km west of the terminal moraine in the Driftless zone, an area never glaciated (Fig. 2 site 1, Table 2, Fig. 3, Fig. 4, Fig. D-1). The samples were taken from under about 25 to 30 meters of material in the quarry wall (Fig. 4A).

Baraboo Hills Site - A few striated bedrock exposures are present behind the late glacial maximum position in the Baraboo Hills (Fig. 2, site 2, Table 2, Fig. 4, Fig. D-1) an extensive area of quartzite outcrop. In a few places behind the glacial margin the quartzite was striated and plucked by the Green Bay Lobe while at its maximum position. We sampled one site near the eastern end of the Baraboo Hills about 10 km behind the late Wisconsin ice margin position. The site is in the ice marginal zone and is dominated by hummocky end moraines and outwash fans. The sampled outcrop is about 75 m long and 50 m wide on the west side of a bedrock ridge that trends north to south (Fig. 4). Three samples (WS-14, WS-15, WS-16) were taken on the west facing bedrock slope (Fig. D-1).

Waterloo Site - Numerous small quartzite outcrops are present just east of Waterloo, Wisconsin (Fig. 2, site 3, Table 2, Fig. 4, Fig. D-1). The Precambrian Waterloo Quartzite has been streamlined and possibly exhumed by glacial erosion. This rock is similar in age and composition to the Baraboo Quartzite. This site lies in the middle of

the largest drumlin field in Wisconsin (Colgan and Mickelson, 1997, Colgan 1999), about 55 km behind the late Wisconsin ice margin position (Fig. 2). All of the outcrops in the area are small rounded knobs (less than 50 m in diameter), and some have striated and grooved surfaces (Fig. 4). Four samples (WS-1, WS-2, WS-3, WS-4) were taken from four outcrops on a hill (Fig. D-1). Another sample (WS-5), was taken from an outcrop about a mile east of the other four samples.

Bush and Katsma Rocks Sites - These sites are located about 30 km behind the late Wisconsin ice margin position (Fig. 2, site 4, Table 2, Fig. 4, Fig. D-1). The two large rhyolite outcrops are striated and have large chattermarks. The rhyolite is dark purple and contains small phenocryts of quartz and feldspar. The outcrops were chosen because they are the only resistant quartz-bearing outcrops in the area. The outcrops also are surrounded by drumlins and other features of streamlined glacial terrain (Fig. D-1). Both outcrops have little soil cover, but are densely surrounded by cedar and juniper trees (Fig. 4). Samples WS-17 and WS-18 were take from Bush Rock and samples WS-19 and WS-20 were taken from Katsma Rock.

Observatory Hill Site - This large outcrop of Precambrian meta-rhyolite rises about 100 m above the surrounding area and is located about 30 km behind the late Wisconsin ice margin position (Fig. 2, site 5, Table 2, Fig. 4, Fig. D-1). The hilltop consists of numerous rounded knobs of meta-rhyolite containing small quartz phenocryts. Most knobs have striations, glacial polish, chattermarks, and grooves and some surfaces are ventifacted (Fig. 4). The ventifact features probably formed during deglaciation when the area was surrounded by outwash plains and proglacial lakes; ventifaction only slightly modified pre-existing striated surfaces eroding probaly less than a cm of rock. The west side of the hill is steeper than the east side suggesting glacial plucking (Fig. D-1). Two

samples (WS-6 and WS-7) were taken from a large area of outcrop on the west side of the hill at about 338 m above sea level. Two other samples were taken from smaller outcrops near the summit of the hill at a slightly higher elevation (WS-8 and WS-9).

Cactus Rock Site - This outcrop of Precambrian granite is located about 5 km south of New London, Wisconsin (Fig. 2 site 6, Table 2, Fig. 4, Fig. D-1) within an area of streamline glacial terrain. The outcrop is about 70 to 75 km behind the late Wisconsin ice margin as measured along a flow line (Fig. 2). The outcrop is a rounded knob that rises above the surrounding area 20 to 30 m (Fig. 4). The southwest side of the outcrop is steep; glacial plucking has likely occurred. The northeast side of the outcrop is more gently sloped. The outcrop is striated and has chatter marks and grooves near its highest point (Fig. 4). Three directions of ice flow are indicated. An early set of large chattermarks, grooves, and striae indicate two ice flow directions due west and slightly northwest (270 and 290^{o}). These flow direction is probably related to ice flow when the Green Bay Lobe was at its maximum position and as retreat commenced. A less well developed set of chattermarks, grooves, and striae indicate flow to the southwest (220-225^{o}). This flow direction could be related to a retreating ice margin and deposition of the Horicon Formation (oldest till in area) or the later Chilton advance of the lobe during deposition of the Kewaunee Formation (the surface till in the area). This site may have been exposed during the initial deglaciation of the Green Bay Lobe and then covered again during the Chilton advance at about 13,000 ^{14}C yr B.P., and then deglaciated shortly thereafter (perhaps less than 1000 years of ice cover, Fig. 3). Two samples (WS-10 and WS-11) were taken near the highest point of the outcrop within meters of each other. Two other samples (WS-12 and WS-13) were taken 35 and 70 meters to the southwest and at lower elevations than the first two samples (Fig. D-1).

2. Detailed Analytical Procedure

Samples were returned to the University of Vermont where they were crushed, ground, and sieved. For all but WS-1, the 250 to 800 μm grain size was processed. For WS-1, three different grain sizes were processed after sieving: WS-1A (125 to 250 μm), WS-1B (250 to 500 μm), and WS-1C (500 to 1000 μm). Samples were HCl etched (6N) in ultrasonic baths for 12 hours and then sonicated repeatedly (for 48 to 72 hours) in mixtures of 1% HF and 1% HNO_3. Density separation was then used on some samples to remove impurities and samples were again etched in 1% HF and 1% HNO_3. For the granites, this treatment resulted in quartz mineral separates with 75 to 110 ppm Al. For quartzite and rhyolite, stable Al content was usually higher, in some cases much higher and could not be reduced by additional acid leaching.

In one sample, WS-5, excessive ^{27}Al (>5000 ppm) prevented us from making meaningful isotopic measurements. Two samples of meta-rhyolite from the Bush Rock site (WS-17 and WS-18) and one sample of meta-rhyolite from Observatory Hill (WS-8) yielded insufficient quartz and could not be analyzed. Other samples of Precambrian meta-rhyolite from Katsma Rock and Observatory Hill yielded only small amounts of quartz, and it was necessary to process a large mass of these rocks (~ 5 kg).

After a final HF etching, the remaining quartz was dissolved in HF along with ~250 μg Be carrier (SPEX ICP standard). Samples were processed in batches of eight, six samples and two blanks. After dissolution, two aliquots were removed from each HF solution for determination of stable Al content by inductively coupled argon plasma spectrometry -- optical emission (ICP-AE). Each aliquot was analyzed twice and the results normalized to internal standards run as unknowns. Be recovery, as measured by

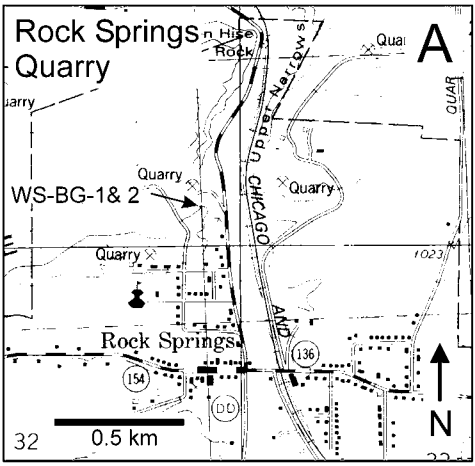
ICP-AE, averaged 99.0 ± 2.6%. Al recovery, for blanks as measured by ICP, averaged 99.6 ± 2.9%.

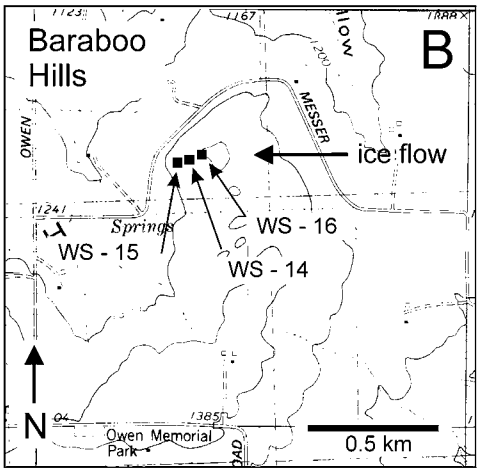
We purified the solutions by anion exchange to remove Fe and used pH-specific precipitation to remove Ti. We separated Be and Al using cation exchange and precipitated them as hydroxides. After conversion to oxide form, we loaded samples into targets at the University of Vermont and took them to Lawrence Livermore National Laboratory for analysis by AMS. Results were normalized to standards prepared by K. Nishiizumi. Blank corrections were made by subtracting the weighted average ratio of the two blanks measured along with each batch fully propagating the uncertainty.

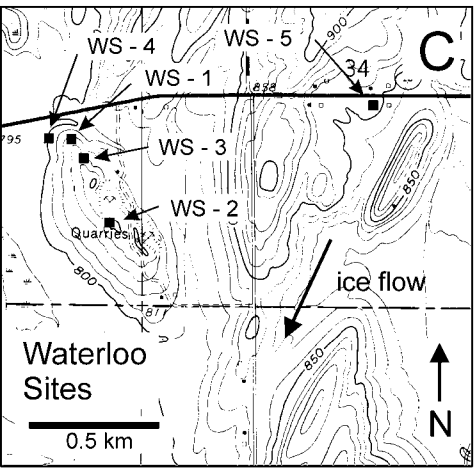
Table R-1. Process Blanks for Wisconsin Samples

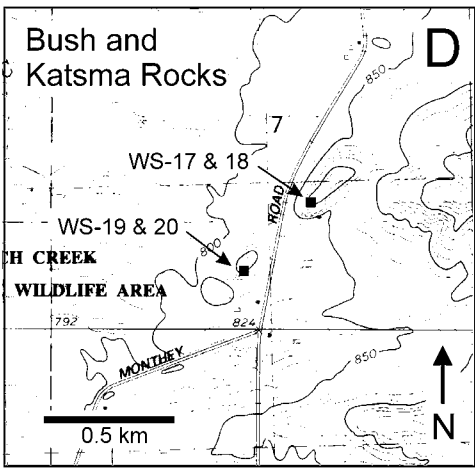
Batch Number	$^{26}Al/Al$ ($\times 10^{-15}$)	$^{10}Be/Be$ ($\times 10^{-15}$)
89	4.8 ± 2.5	17.0 ± 3.2
	0.9 ± 0.6	16.2 ± 3.2
93	1.8 ± 1.1	44.2 ± 9.8
	1.4 ± 1.1	34.3 ± 5.5
95	2.0 ± 1.0	16.0 ± 7.6
	1.3 ± 0.9	19.7 ± 4.4
109	3.1 ± 3.1	24.1 ± 3.9
	2.4 ± 1.4	28.1 ± 5.4
114	1.1 ± 0.8	18.8 ± 4.4
	6.8 ± 1.7	22.6 ± 2.5

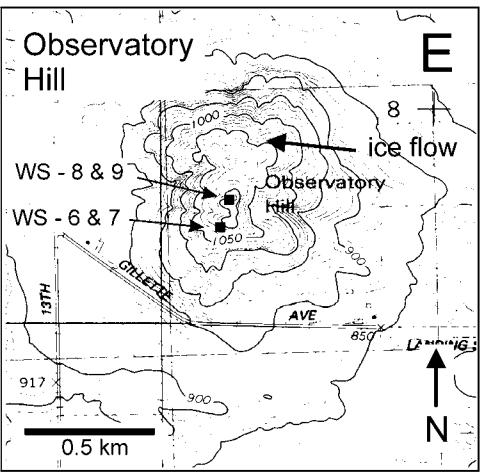
Figure D-1. Topographic maps of sample sites. A – Rock Springs site (U.S.G.S. Rock Springs, WI, 1:24,000 quadrangle); B - Detail of Baraboo Hills site (U.S.G.S. Durwards Glen, WI, 1:24,000 quadrangle); C - Detail of Waterloo site (U.S.G.S. Waterloo, WI, 1:24,000 quadrangle); D. Bush and Katsma Rock sites (U.S.G.S. Pardeville, WI, 1:24,000 quadrangle); E - Observatory Hill site (U.S.G.S. Observatory Hill, WI, 1:24,000 quadrangle); F- Cactus Rock site (U.S.G.S. Readfield, WI, 1:24,000 quadrangle).

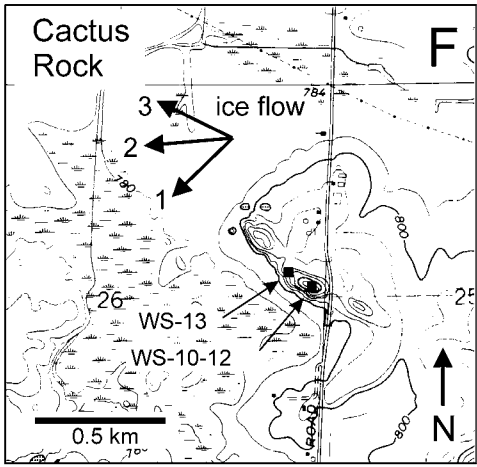

Rock Springs Quarry
A
WS-BG-1& 2
Quarry
Quarry
Quarry
Rock Springs
CHICAGO
AND
0.5 km
N


Baraboo Hills
B
ice flow
WS - 16
WS - 15
WS - 14
Springs
Owen Memorial Park
0.5 km
N


C
WS - 4
WS - 1
WS - 5
34
WS - 3
WS - 2
Quarries
ice flow
Waterloo Sites
0.5 km
N


Bush and Katsma Rocks
D
7
WS-17 & 18
WS-19 & 20
ROAD
WILDLIFE AREA
MONTHEY
0.5 km
N


Observatory Hill
E
8
ice flow
WS - 8 & 9
WS - 6 & 7
Observatory Hill
GILLETTE
13TH
AVE
0.5 km
N


Cactus Rock
F
3
2
1
ice flow
26
WS-13
WS-10-12
0.5 km
N