Supplementary Material

Materials, Methods and Calculations

Cosmic ray exposure ages are based on ^{10}Be concentrations in quartz, separated from glacially transported erratics. We collected fresh, faceted and abraded clasts likely to have been plucked and transported at the base of the ice sheet, and first exposed to cosmic rays when ice retreated from each sampling site. We collected from open, windswept bedrock pavements to avoid snow cover and disturbance of the clasts by periglacial activity. Sample locations and corrections for sample thickness and exposure geometry are given in Table S1. We extracted beryllium by conventional methods (separations are described in documents available from the UW Cosmogenic Isotope Lab website: www.depts.washington.edu/cosmolab/chem.html). Beryllium isotopic ratios were measured at the Lawrence Livermore Center for Accelerator Mass Spectrometry, and are normalised to LLNL in-house standards. We calculated exposure ages assuming a total ^{10}Be production rate of 5.06 ± 0.30 atom ^{10}Be/g SiO_2/yr at 1013.25 HPa air pressure at latitude > 60° (S1), adjusted to the altitude of each site using correction factors based on Antarctic air pressure (S2). Ages given in Table S2 should be comparable to the calibrated radiocarbon timescale (S3), which is the basis for all ^{14}C ages quoted in this paper. For comparison with ^{14}C ages, the uncertainties in Figs. 1B-F (± 1σ) include ±6% systematic uncertainty in the assumed ^{10}Be production rate; internal errors for sample-to-sample comparison are smaller. Ages of six sets of paired samples - adjacent erratics from the same site - agree to within their ±1σ internal errors. Note that the build-up of ^{10}Be due to cosmic radiation reaching the samples through overlying ice as it thinned, but before it disappeared entirely, is small, even for rocks with such young exposure ages as these. At an ice ablation rate of 5 cm/yr, ^{10}Be that builds up before a rock reaches the ice surface is equivalent to ~35 yr of surface exposure, a ~10% correction to the youngest age measured.

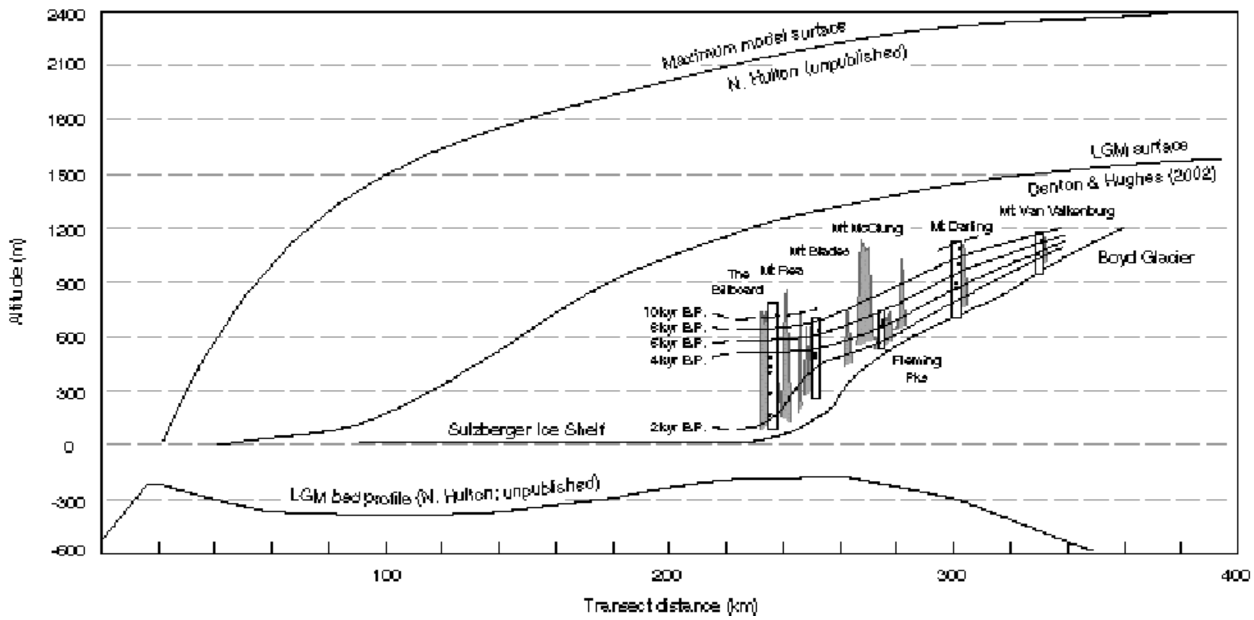

Fig. S1. Former surface profiles for the Boyd Glacier, at the southern edge of the field area, compared to calculated ice sheet profiles for the last glacial maximum. The Boyd Glacier profiles are constrained by exposure ages on mountains flanking the glacier. The calculated ice sheet profiles approximately follow the Boyd Glacier from 142°W, 78°S to its mouth at 146°W, 76°54'S, then extend to the continental shelf edge at 152°W, 75°15'S. The upper profile (S4) can be taken as a maximum limit to LGM ice sheet thickness for two reasons: (i) It is calculated assuming equilibrium with LGM climatic conditions, whereas there may not have been time during the glacial period for the WAIS to build up to equilibrium thickness. (ii) It does not include an ice flow "enhancement factor", commonly used in ice-sheet models to fit observed ice thicknesses. See (S5, S6) for details of the model. The lower profile is drawn from Fig. 2 of ref. (S7).

Table S1: Location and exposure details for glacial erratic samples, Ford Ranges, Marie Byrd Land

Sample	Latitude (° S)	Longitude (° W)	Altitude (m)	Scaling factor* (spallation)	Scaling factor* (muons)	Thickness correction	Horizon correction
Migmatite Ridge† - Eastern Fosdick Mtns							
99-MBL-011-MGM	76.532	144.462	1042	3.381	1.866	0.948	1.000
99-MBL-008-MGM	76.539	144.500	991	3.235	1.822	0.935	1.000
99-MBL-009-MGM	76.539	144.500	991	3.235	1.822	0.956	1.000
99-MBL-019-MGM	76.558	144.446	817	2.774	1.676	0.948	1.000
99-MBL-021-MGM	76.558	144.446	817	2.774	1.676	0.931	1.000
Mt Passel - Denfeld Range							
99-MBL-038-PAS	76.884	144.942	726	2.555	1.604	0.952	1.000
99-MBL-043-PAS	76.868	145.077	569	2.209	1.484	0.952	1.000
99-MBL-044-PAS	76.884	144.958	443	1.958	1.393	0.948	0.991
Mt Van Valkenburg - Clark Mtns							
01-MBL-002-VVB	77.310	142.112	1127	3.636	1.941	0.944	0.996
01-MBL-005-VVB	77.311	142.111	1125	3.630	1.940	0.915	0.997
01-MBL-007-VVB	77.313	142.114	1071	3.467	1.891	0.931	1.000
01-MBL-008-VVB	77.313	142.105	1052	3.411	1.875	0.956	0.998
Mt Darling / Mt Spencer - Allegheny Mtns							
01-MBL-055-DAR	77.261	143.339	1076	3.482	1.896	0.956	0.999
01-MBL-058-DAR	77.262	143.340	1075	3.479	1.895	0.940	1.000
01-MBL-064-DAR	77.265	143.328	988	3.227	1.819	0.948	0.995
01-MBL-070-DAR	77.268	143.323	884	2.945	1.731	0.952	0.996
01-MBL-073-DAR	77.269	143.323	849	2.855	1.702	0.965	0.988
01-MBL-039-SPC	77.290	143.339	751	2.614	1.624	0.931	0.998
01-MBL-041-SPC	77.291	143.349	694	2.481	1.579	0.935	0.999
Fleming Peaks - Eastern Sarnoff Mtns							
01-MBL-083-FLM	77.254	144.435	691	2.474	1.577	0.965	1.000
01-MBL-088-FLM	77.255	144.444	660	2.404	1.553	0.935	1.000
Mt Blades - Western Sarnoff Mtns							
99-MBL-069-BLD	77.161	145.329	632	2.343	1.531	0.948	0.997
99-MBL-073-BLD	77.161	145.318	506	2.080	1.438	0.952	0.990
99-MBL-076-BLD	77.163	145.308	482	2.033	1.421	0.948	0.986
Mt Rea / The Billboard - Western Sarnoff Mtns							
01-MBL-133-BBD	77.074	145.698	779.6	2.682	1.646	0.931	0.999
99-MBL-055-BBD	77.073	145.692	740	2.588	1.615	0.940	0.997
01-MBL-135-BBD	77.073	145.692	740	2.588	1.615	0.944	0.997
01-MBL-140-REA	77.078	145.584	717.2	2.534	1.597	0.899	0.994
99-MBL-056-BBD	77.072	145.688	715	2.529	1.595	0.969	0.997
99-MBL-059-BBD	77.073	145.686	712	2.522	1.593	0.961	0.997
01-MBL-138-BBD	77.073	145.686	702	2.499	1.585	0.931	0.997
01-MBL-143-REA	77.077	145.587	685	2.460	1.572	0.956	0.998
01-MBL-146-REA	77.071	145.595	616	2.308	1.519	0.956	0.997
01-MBL-149-REA	77.071	145.595	610	2.295	1.515	0.948	0.997
99-MBL-061-REA	77.068	145.574	489	2.047	1.426	0.940	0.998
99-MBL-062-REA	77.068	145.574	489	2.047	1.426	0.969	0.998
01-MBL-151-REA	77.068	145.565	433	1.939	1.386	0.948	0.998
01-MBL-153-REA	77.068	145.565	404	1.885	1.366	0.935	0.996
99-MBL-066-REA	77.068	145.548	287	1.679	1.286	0.944	0.990
01-MBL-161A-REA	77.061	145.570	172	1.492	1.211	0.952	0.992
01-MBL-163-REA	77.060	145.569	162	1.477	1.205	0.931	0.993
Mt Rea / Mt Dolber col							
99-MBL-080-GAP	77.084	145.558	352	1.791	1.330	0.952	0.995

99-MBL-081-GAP	77.084	145.558	350	1.788	1.328	0.952	0.994
99-MBL-083/3-GAP	77.082	145.546	245	1.609	1.258	0.961	0.987
99-MBL-084-GAP	77.082	145.545	237	1.596	1.253	0.940	0.987
01-MBL-157/3-GAP	77.081	145.544	226	1.578	1.246	0.944	0.971

* Correction factor relative to 1013.25 mbar and latitude > 60°, based on estimated mean annual air pressure, as described in ref. (S2).
† Informal name.

Table S2: Cosmogenic ^{10}Be exposure ages of glacial erratics, Ford Ranges, Marie Byrd Land

Sample	^{10}Be production rate* (atom/g/yr)	[^{10}Be]† (10^4 atom/g)	Exposure age‡ (yr)
Migmatite Ridge§ - Eastern Fosdick Mtns			
99-MBL-011-MGM	16.1 ± 1	7.58 ± 0.34	4720 ± 350
99-MBL-008-MGM	15.2 ± 0.9	6.27 ± 0.21	4140 ± 280
99-MBL-009-MGM	15.5 ± 0.9	6.42 ± 0.21	4150 ± 280
99-MBL-019-MGM	13.2 ± 0.8	2.9 ± 0.2	2200 ± 200
99-MBL-021-MGM	13.0 ± 0.8	3.16 ± 0.14	2440 ± 180
Mt Passel - Denfeld Range			
99-MBL-038-PAS	12.2 ± 0.7	4.33 ± 0.26	3550 ± 300
99-MBL-043-PAS	10.6 ± 0.6	1.92 ± 0.08	1820 ± 130
99-MBL-044-PAS	9.3 ± 0.5	1.61 ± 0.29	1750 ± 330
Mt Van Valkenburg - Clark Mtns			
01-MBL-002-VVB	17.1 ± 1	10.9 ± 0.25	6370 ± 410
01-MBL-005-VVB	16.6 ± 1	10.21 ± 0.24	6160 ± 390
01-MBL-007-VVB	16.2 ± 1	6.25 ± 0.23	3860 ± 270
01-MBL-008-VVB	16.3 ± 1	5.4 ± 0.17	3310 ± 220
Mt Darling / Mt Spencer - Allegheny Mtns			
01-MBL-055-DAR	16.7 ± 1	15.52 ± 0.42	9320 ± 610
01-MBL-058-DAR	16.4 ± 1	15.11 ± 0.43	9240 ± 610
01-MBL-064-DAR	15.3 ± 0.9	10.56 ± 0.25	6930 ± 440
01-MBL-070-DAR	14.0 ± 0.8	6.41 ± 0.17	4580 ± 300
01-MBL-073-DAR	13.7 ± 0.8	5.24 ± 0.14	3840 ± 250
01-MBL-039-SPC	12.2 ± 0.7	20.3 ± 0.48	16700 ± 1070
01-MBL-041-SPC	11.6 ± 0.7	13.35 ± 0.4	11500 ± 770
Fleming Peaks - Eastern Sarnoff Mtns			
01-MBL-083-FLM	12.0 ± 0.7	5.92 ± 0.15	4940 ± 320
01-MBL-088-FLM	11.3 ± 0.7	4.83 ± 0.17	4270 ± 290
Mt Blades - Western Sarnoff Mtns			
99-MBL-069-BLD	11.1 ± 0.7	7.56 ± 0.23	6810 ± 450
99-MBL-073-BLD	9.9 ± 0.6	3.61 ± 0.15	3660 ± 260
99-MBL-076-BLD	9.6 ± 0.6	2.87 ± 0.32	3010 ± 380
Mt Rea / The Billboard - Western Sarnoff Mtns			
01-MBL-133-BBD	12.5 ± 0.7	49.29 ± 1.12	39700 ± 2540
99-MBL-055-BBD	12.2 ± 0.7	122.71 ± 1.5	103000 ± 6400
01-MBL-135-BBD	12.2 ± 0.7	133.65 ± 3.04	112000 ± 7300
01-MBL-140-REA	11.4 ± 0.7	36.79 ± 0.71	32500 ± 2000
99-MBL-056-BBD	12.3 ± 0.7	12.72 ± 0.34	10400 ± 680
99-MBL-059-BBD	12.1 ± 0.7	35.29 ± 0.82	29300 ± 1900
01-MBL-138-BBD	11.7 ± 0.7	107.75 ± 1.82	94400 ± 6000
01-MBL-143-REA	11.8 ± 0.7	21.88 ± 0.63	18600 ± 1200
01-MBL-146-REA	11.1 ± 0.7	20.71 ± 0.48	18800 ± 1200
01-MBL-149-REA	10.9 ± 0.6	29.06 ± 0.66	26800 ± 1700
99-MBL-061-REA	9.7 ± 0.6	3.01 ± 0.19	3120 ± 270
99-MBL-062-REA	10.0 ± 0.6	3.37 ± 0.11	3390 ± 230
01-MBL-151-REA	9.2 ± 0.5	3.1 ± 0.12	3360 ± 240
01-MBL-153-REA	8.8 ± 0.5	2.43 ± 0.1	2750 ± 200
99-MBL-066-REA	7.9 ± 0.5	2.16 ± 0.07	2740 ± 190
01-MBL-161A-REA	7.1 ± 0.4	1.85 ± 0.12	2600 ± 220
01-MBL-163-REA	6.9 ± 0.4	1.64 ± 0.11	2380 ± 210
Mt Rea / Mt Dolber col			
99-MBL-080-GAP	8.5 ± 0.5	2.02 ± 0.16	2370 ± 230
99-MBL-081-GAP	8.5 ± 0.5	2.11 ± 0.12	2480 ± 200

99-MBL-083/3-GAP	7.7 ± 0.5	1.49 ± 0.08	1940 ± 160
99-MBL-084-GAP	7.5 ± 0.4	0.44 ± 0.05	590 ± 70
01-MBL-157/3-GAP	7.3 ± 0.4	0.22 ± 0.07	300 ± 90

* Assumed ^{10}Be production rates: spallation: 4.95 ± 0.30 atom/g SiO_2/yr, negative muon capture: 0.11 ± 0.02 atom/g SiO_2/yr, at 1013.25 mbar and latitude > 60° (S1,S2).

† Measured relative to LLNL in-house ^{10}Be/^{9}Be standards. Uncertainties propagated at ±1σ level including all known sources of analytical error.

‡ Calculated simple exposure ages. If pre-exposed samples are old erratics that were overrun and buried during previous glaciations, these are lower limits to the cumulative exposure time. Uncertainties are ±1σ (68% confidence) including ^{10}Be measurement uncertainties (see above) and assumed ±6% error in ^{10}Be production rate.

§ Informal name.

Supplementary References and Notes

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