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Supplement of

Evidence for fire in the Pliocene Arctic in response to amplified temperature

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Supplementary Information

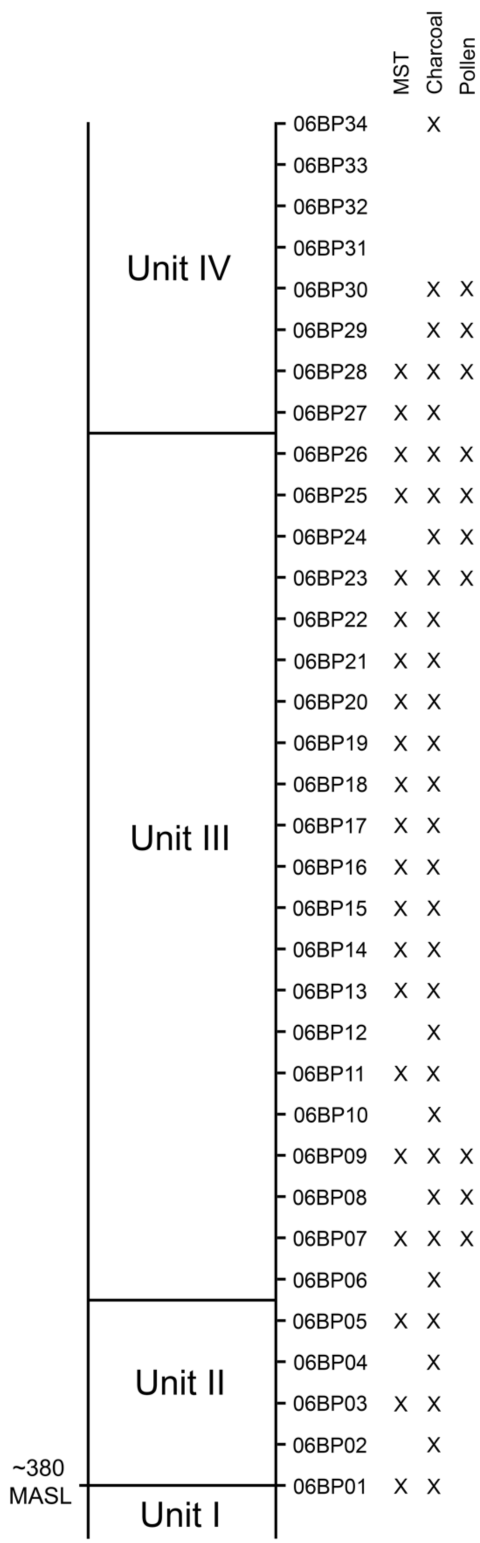


Figure S1. Approximate position of the 2006 samples to the Units as per stratigraphic interpretation of Mitchell et al. 2016. Columns on the right indicate available results for each sample taken.

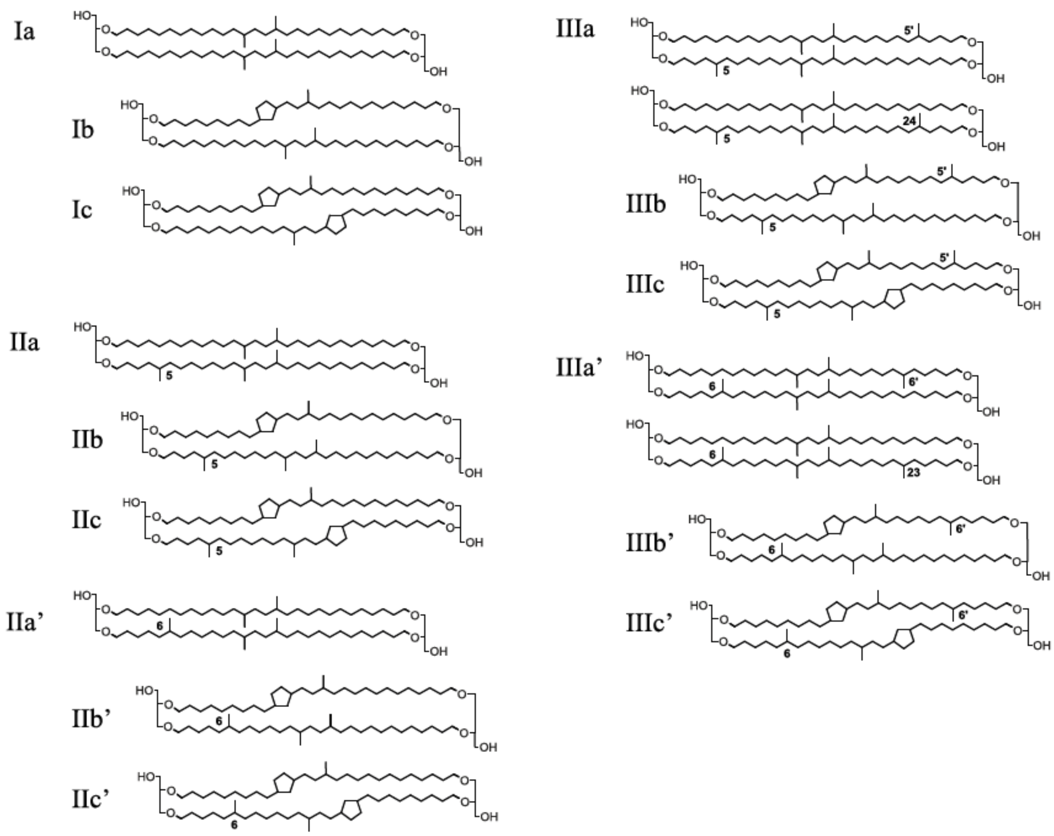
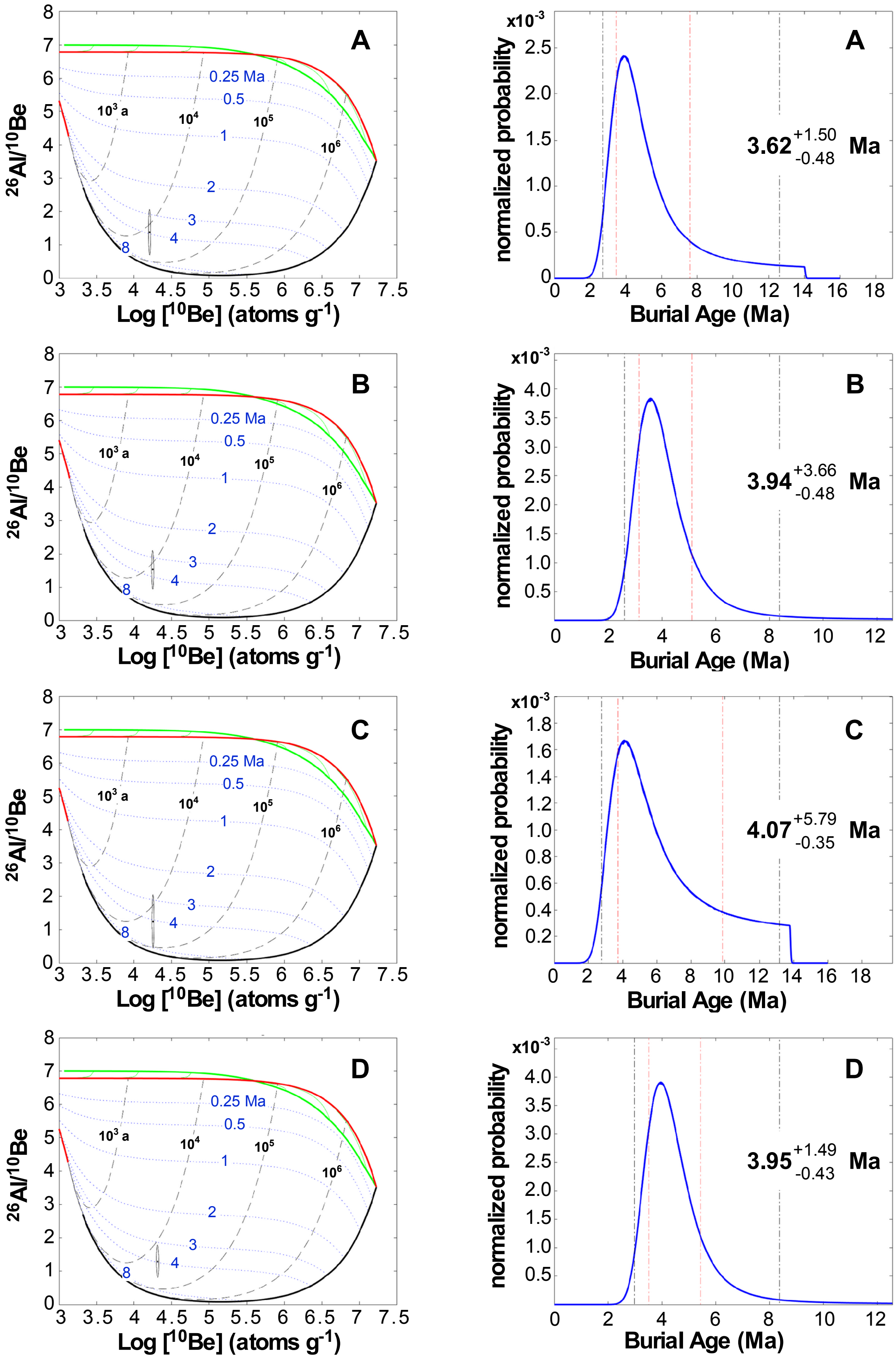


Figure S2. Molecular structures of all 15 brGDGTs (I-III). The molecules designated with a prime symbol are referred to as the 6-methyl brGDGTs.



A
B
C
D
^{26}Al/^{10}Be
Log [^{10}Be] (atoms g^{-1})
0.25 Ma
0.5
1
2
3
4
8
10^3 a
10^4
10^5
10^6
normalized probability
x10^{-3}
Burial Age (Ma)
3.62 $^{+1.50}_{-0.48}$ Ma
3.94 $^{+3.66}_{-0.48}$ Ma
4.07 $^{+5.79}_{-0.35}$ Ma
3.95 $^{+1.49}_{-0.43}$ Ma

Figure S3. Burial age results. depthID: average initial sample depth, pdfmaxage: the most probable age as determined from the probability density function, sigma1plus and sigma1minus: the +/-1sigma errors in pdfmaxage, sigma2plus and sigma2minus: the +/-2sigma errors in pdfmaxage, exposure_meanvalue: mean value of pre-buildup exposure age taken from FMINLBFGS optimization algorithm, burial_meanvalue: mean value of burial age taken from FMINLBFGS optimization algorithm. The 26Al/10Be vs. log10 10Be plots are unique for each mass depth. The generally horizontal dotted curves are burial isochrons, from top to bottom 0.25, 0.50, 1.0, 2.0, 3.0, 4.0. and 8.0 Ma, and the near-vertical dashed lines are pre-burial minimum exposure duration isochrons, from left to right 103, 104, 105, and 106 years. The PDF plots are probability distributions of 2000 solutions of the data.

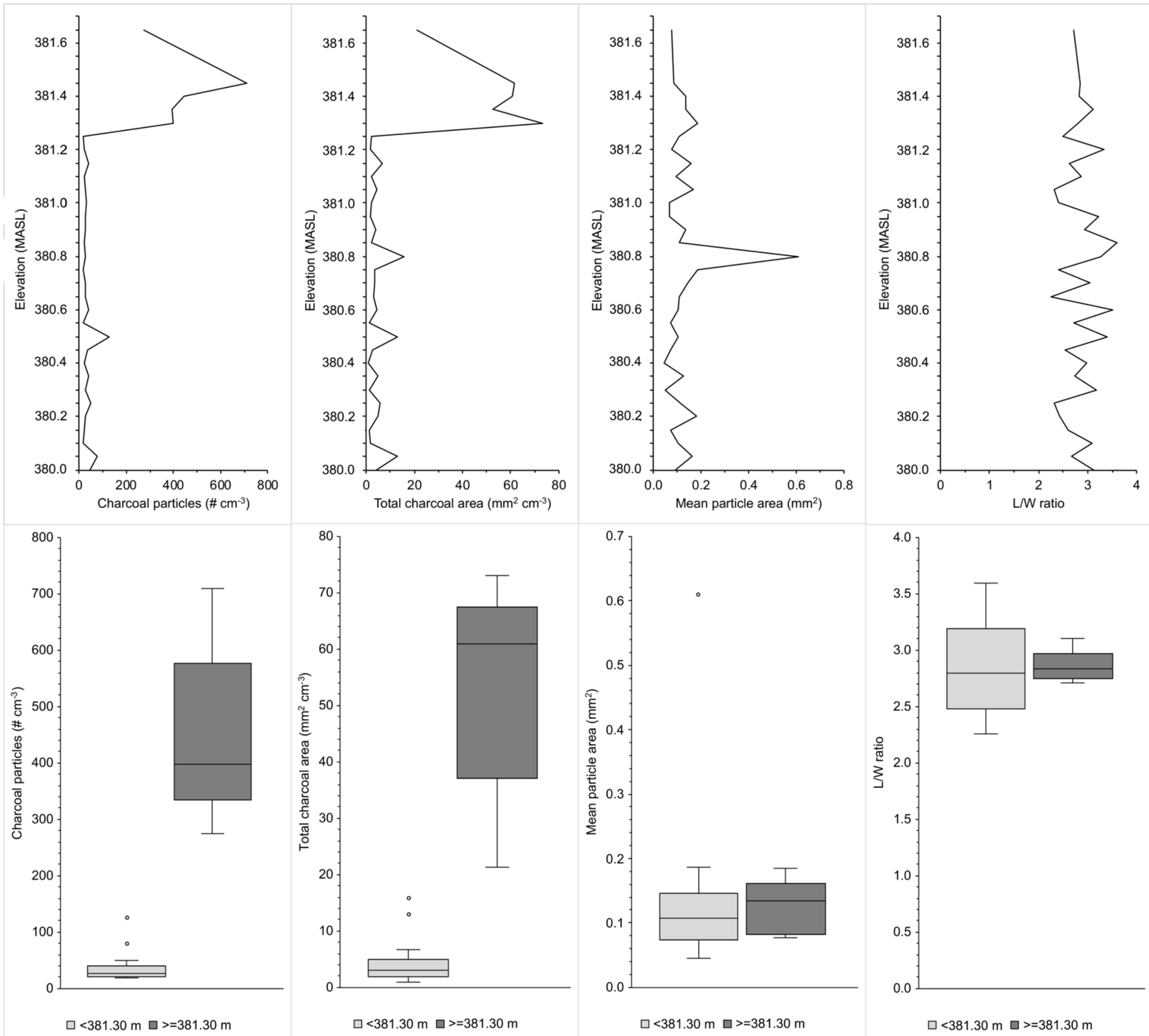


Figure S4. A comparison of the count, area and shape (length to width) of the uppermost samples (381.30–381.65 MASL) that have a higher mean charcoal concentration, to the lowermost samples (380–381.25 MASL)

Table S1. Data used to generate CO_2 reconstructions in Figure 1.

Method	Ref	Age	CO2	CO2 low	CO2 high
Paleosols	Cerling, 1992	4	300	0	1000
Paleosols	Da et al., 2015	1.0	244	153	403
Paleosols	Da et al., 2015	1.1	214	134	353
Paleosols	Da et al., 2015	1.2	335	210	552
Paleosols	Da et al., 2015	1.2	217	136	357
Paleosols	Da et al., 2015	1.2	193	121	319
Paleosols	Da et al., 2015	1.3	141	88	233
Paleosols	Da et al., 2015	1.3	157	98	258
Paleosols	Da et al., 2015	1.3	196	123	324
Paleosols	Da et al., 2015	1.4	194	122	321
Paleosols	Da et al., 2015	1.4	192	120	317
Paleosols	Da et al., 2015	1.4	192	120	316
Paleosols	Da et al., 2015	1.4	194	121	320
Paleosols	Da et al., 2015	1.5	239	150	394
Paleosols	Da et al., 2015	1.5	210	132	347
Paleosols	Da et al., 2015	1.5	303	190	500
Paleosols	Da et al., 2015	1.6	282	177	465
Paleosols	Da et al., 2015	1.6	230	144	380
Paleosols	Da et al., 2015	1.6	247	154	407
Paleosols	Da et al., 2015	1.6	207	130	342
Paleosols	Da et al., 2015	1.7	239	150	394
Paleosols	Da et al., 2015	1.8	230	144	379
Paleosols	Da et al., 2015	1.9	307	192	507
Paleosols	Da et al., 2015	1.9	252	158	415
Paleosols	Da et al., 2015	2.1	299	187	494
Paleosols	Da et al., 2015	2.1	300	188	495
Paleosols	Da et al., 2015	2.1	278	174	458

Paleosols	Da et al., 2015	2.2	338	212	557
Paleosols	Da et al., 2015	2.3	387	243	639
Paleosols	Da et al., 2015	2.3	342	214	564
Paleosols	Da et al., 2015	2.3	405	254	669
Paleosols	Da et al., 2015	2.6	400	251	660
Paleosols	Da et al., 2015	2.6	385	241	636
Paleosols	Ekart et al., 1999	5.0	324	162	648
Alkenones	Seki et al., 2010	0.9	243	221	264
Alkenones	Zhang et al., 2013	0.93	291	255	374
Alkenones	Seki et al., 2010	1.0	252	230	275
Alkenones	Zhang et al., 2013	1.05	301	261	393
Alkenones	Zhang et al., 2013	1.19	322	281	416
Alkenones	Seki et al., 2010	1.2	266	243	290
Alkenones	Zhang et al., 2013	1.21	311	263	414
Alkenones	Zhang et al., 2013	1.22	317	278	409
Alkenones	Zhang et al., 2013	1.23	322	278	422
Alkenones	Zhang et al., 2013	1.25	291	257	372
Alkenones	Zhang et al., 2013	1.27	309	257	416
Alkenones	Zhang et al., 2013	1.28	298	263	382
Alkenones	Seki et al., 2010	1.3	271	246	295
Alkenones	Zhang et al., 2013	1.35	326	276	434
Alkenones	Seki et al., 2010	1.5	277	252	302
Alkenones	Zhang et al., 2013	1.64	298	255	392
Alkenones	Zhang et al., 2013	1.73	312	271	405
Alkenones	Seki et al., 2010	1.8	270	246	295
Alkenones	Zhang et al., 2013	1.97	309	263	408
Alkenones	Zhang et al., 2013	2.09	329	275	442
Alkenones	Seki et al., 2010	2.1	254	231	277
Alkenones	Zhang et al., 2013	2.19	331	279	441

Alkenones	Zhang et al., 2013	2.30	337	285	450
Alkenones	Seki et al., 2010	2.3	273	249	298
Alkenones	Zhang et al., 2013	2.40	344	288	461
Alkenones	Zhang et al., 2013	2.59	333	280	446
Alkenones	Seki et al., 2010	2.6	267	243	291
Alkenones	Zhang et al., 2013	2.60	305	255	410
Alkenones	Zhang et al., 2013	2.72	317	266	424
Alkenones	Seki et al., 2010	2.8	299	272	326
Alkenones	Badger et al., 2013b	2.81	282	261	304
Alkenones	Seki et al., 2010	2.8	303	276	331
Alkenones	Badger et al., 2013b	2.85	294	269	320
Alkenones	Badger et al., 2013b	2.86	288	269	307
Alkenones	Seki et al., 2010	2.9	323	294	352
Alkenones	Badger et al., 2013b	2.90	270	252	288
Alkenones	Badger et al., 2013b	2.92	278	260	297
Alkenones	Badger et al., 2013b	2.93	270	252	288
Alkenones	Seki et al., 2010	2.9	333	303	363
Alkenones	Zhang et al., 2013	2.94	307	261	407
Alkenones	Badger et al., 2013b	2.94	307	285	330
Alkenones	Badger et al., 2013b	2.98	258	242	275
Alkenones	Seki et al., 2010	3.0	372	338	405
Alkenones	Badger et al., 2013b	3.00	255	239	272
Alkenones	Badger et al., 2013b	3.02	265	247	283
Alkenones	Badger et al., 2013b	3.03	262	240	285
Alkenones	Seki et al., 2010	3.1	353	321	385
Alkenones	Badger et al., 2013b	3.07	284	253	318
Alkenones	Zhang et al., 2013	3.08	338	290	444
Alkenones	Badger et al., 2013b	3.09	254	237	271
Alkenones	Badger et al., 2013b	3.10	275	255	296

Alkenones	Badger et al., 2013b	3.11	271	253	290
Alkenones	Seki et al., 2010	3.1	344	313	375
Alkenones	Badger et al., 2013b	3.13	272	254	290
Alkenones	Zhang et al., 2013	3.13	318	265	428
Alkenones	Badger et al., 2013b	3.16	278	258	298
Alkenones	Seki et al., 2010	3.2	335	305	365
Alkenones	Badger et al., 2013b	3.18	259	239	280
Alkenones	Badger et al., 2013b	3.19	274	255	294
Alkenones	Badger et al., 2013b	3.20	272	254	290
Alkenones	Badger et al., 2013b	3.21	267	245	290
Alkenones	Badger et al., 2013b	3.22	265	246	285
Alkenones	Seki et al., 2010	3.2	341	310	372
Alkenones	Badger et al., 2013b	3.24	273	253	293
Alkenones	Badger et al., 2013b	3.26	270	251	290
Alkenones	Badger et al., 2013b	3.27	262	244	280
Alkenones	Badger et al., 2013b	3.28	258	241	275
Alkenones	Badger et al., 2013b	3.29	276	257	295
Alkenones	Zhang et al., 2013	3.32	336	291	437
Alkenones	Zhang et al., 2013	3.36	321	278	417
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Alkenones	Zhang et al., 2013	3.67	346	309	437
Alkenones	Seki et al., 2010	3.8	357	325	389
Alkenones	Zhang et al., 2013	3.85	327	291	414
Alkenones	Seki et al., 2010	3.9	338	307	368
Alkenones	Zhang et al., 2013	3.99	334	295	427
Alkenones	Seki et al., 2010	4.0	329	300	359

Alkenones	Zhang et al., 2013	4.11	348	307	445
Alkenones	Seki et al., 2010	4.1	354	322	385
Alkenones	Seki et al., 2010	4.3	381	348	414
Alkenones	Seki et al., 2010	4.4	351	320	382
Alkenones	Zhang et al., 2013	4.45	379	345	471
Alkenones	Seki et al., 2010	4.6	370	337	402
Alkenones	Zhang et al., 2013	4.78	361	332	443
Alkenones	Seki et al., 2010	4.8	351	320	382
Alkenones	Seki et al., 2010	4.9	383	350	417
Alkenones	Seki et al., 2010	4.9	422	385	459
Alkenones	Seki et al., 2010	5.0	448	409	488
Alkenones	Seki et al., 2010	5.2	457	417	497
Stomata	Wang et al, 2015	0.95	278	195	459
Stomata	Wang et al, 2015	1.85	280	196	462
Stomata	van der Burgh et al., 1993 (updated by Kürschner et al., 1996)	2.1	358	250	590
Stomata	Wang et al, 2015	2.6	285	200	470
Stomata	Wang et al, 2015	2.65	279	195	460
Stomata	Kürschner et al., 1996	2.775	276	193	455
Stomata	Wang et al, 2015	2.9	280	196	462
Stomata	Stults et al., 2011	3.095	357	333	376
Stomata	Kürschner et al., 1996	3.4	330	315	349
Stomata	Retallack, 2009a	3.89	355	249	586
Stomata	Kürschner et al., 1996	4	363	254	598
Stomata	Kürschner et al., 1996	4.6	270	189	446
Stomata	van der Burgh et al., 1993 (updated by Kürschner et al., 1996)	5.1	358	250	590
Marine Boron	Seki et al., 2010	0.90	278	265	290

Marine Boron	Stap et al., 2016	0.94	183	112	254
Marine Boron	Seki et al., 2010	1.50	279	266	291
Marine Boron	Stap et al., 2016	1.82	250	178	322
Marine Boron	Bartoli et al., 2011	1.98	219	196	245
Marine Boron	Bartoli et al., 2011	2.03	262	236	291
Marine Boron	Bartoli et al., 2011	2.08	246	221	274
Marine Boron	Seki et al., 2010	2.11	274	262	287
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Marine Boron	Martinez-Boti et al., 2015	2.47	340	302	379
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Marine Boron	Martinez-Boti et al., 2015	2.50	357	316	398
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Marine Boron	Martinez-Boti et al., 2015	2.55	335	297	374
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Marine Boron	Martinez-Boti et al., 2015	2.96	346	307	385
Marine Boron	Martinez-Boti et al., 2015	2.98	328	291	366
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Marine Boron	Bartoli et al., 2011	3.00	354	321	392
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Marine Boron	Bartoli et al., 2011	3.07	265	239	294
Marine Boron	Bartoli et al., 2011	3.08	411	374	454
Marine Boron	Martinez-Boti et al., 2015	3.09	334	296	374
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Marine Boron	Martinez-Boti et al., 2015	3.18	381	337	424
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Marine Boron	Martinez-Boti et al., 2015	3.24	354	314	396
Marine Boron	Martinez-Boti et al., 2015	3.24	441	385	499
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Marine Boron	Martinez-Boti et al., 2015	3.26	348	307	390
Marine Boron	Martinez-Boti et al., 2015	3.27	365	319	412
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Marine Boron	Stap et al., 2016	4.10	380	305	456
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Marine Boron	Bartoli et al., 2011	4.58	425	387	469
Marine Boron	Stap et al., 2016	5.19	433	347	523

References

Badger, M. P. S., Schmidt, D. N., Mackensen, A., and Pancost, R. D., 2013b, High-resolution alkenone palaeobarometry indicates relatively stable pCO2 during the Pliocene (3.3–2.8 Ma): Philosophical Transactions of the Royal Society A, v. 371, 20130094.

Bartoli, G., Hönisch, B., and Zeebe, R.E., 2011, Atmospheric CO2 decline during the Pliocene intensification of Northern Hemisphere glaciations: Paleoceanography, v. 26, PA4213, doi:10.1029/2010PA002055.

Cerling, T.E., 1992, Use of carbon isotopes in paleosols as an indicator of the P(CO2) of the paleoatmosphere: Global Biogeochemical Cycles, v. 6, p. 307-314.

Da, J., Zhang, Y. G., Wang, H., Balsam, W., and Ji, J., 2015, An Early Pleistocene atmospheric CO2 record based on pedogenic carbonate from the Chinese loess deposits: Earth and Planetary Science Letters, v. 426, p. 69-75.

Ekart, D.D., Cerling, T.E., Montañez, I.P., and Tabor, N.J., 1999, A 400 million year carbon isotope record of pedogenic carbonate: implications for paleoatmospheric carbon dioxide: American Journal of Science, v. 299, p. 805-827.

Kürschner, W.M., 1996, Leaf stomata as biosensors of paleoatmospheric CO2 levels: LPP Contributions Series, v. 5, p. 1-153.

Martínez-Botí, M. A., Foster, G. L., Chalk, T. B., Rohling, E. J., Sexton, P. F., Lunt, D. J., Pancost, R. D., Badger, M. P. S., and Schmidt, D. N., 2015, Plio-Pleistocene climate sensitivity evaluated using high-resolution CO2 records: Nature, v. 518, p. 49-54.

Retallack, G.J., 2009a, Greenhouse crises of the past 300 million years: GSA Bulletin, v. 121, p. 1441-1455.

Seki, O., Foster, G.L., Schmidt, D.N., Mackensen, A., Kawamura, K., and Pancost, R.D., 2010, Alkenone and boron-based Pliocene pCO2 records: Earth and Planetary Science Letters, v. 292, p. 201-211.

Stap, L. B., de Boer, B., Ziegler, M., Bintanja, R., Lourens, L. J., and van de Wal, R. S. W., 2016, CO2 over the past 5 million years: continuous simulation and new δ11B-based proxy data: Earth and Planetary Science Letters, v. 439, p. 1-10.

Stults, D.Z., Wagner-Cremer, F., and Axsmith, B.J., 2011, Atmospheric paleo-CO2 estimates based on Taxodium distichum (Cupressaceae) fossils from the Miocene and Pliocene of eastern North America: Palaeogeography Palaeoclimatology Palaeoecology, v. 309, p. 327-332.

van der Burgh, J., Visscher, H., Dilcher, D.L., and Kürschner, W.M., 1993, Paleoatmospheric signatures in Neogene fossil leaves: Science, v. 260, p. 1788-1790.

Wang, Y., Momohara, A., Wang, L., Lebreton-Anberrée, J., and Zhou, Z., 2015, Evolutionary history of atmospheric CO2 during the late Cenozoic from fossilized Metasequoia needles: PLoS ONE, v. 10 (7), e0130941.

Zhang, Y. G., Pagani, M., Liu, Z., Bohaty, S. M., and DeConto, R., 2013, A 40-million-year history of atmospheric CO2: Philosophical Transactions of the Royal Society A, v. 371, 20130096.

Table S2. $^{26}Al/^{10}Be$ burial ages

PDF max age (yr)	1s error +ve (yr)	1s error -ve (yr)	meanvalue (yr)
3.62E+06	1.50E+06	4.78E+05	3.58E+06
3.94E+06	3.66E+06	4.77E+05	NA
4.07E+06	5.79E+06	3.51E+05	NA
3.95E+06	1.49E+06	4.31E+05	3.95E+06

Table S3. Data used to generate Figure 4.

Sample	Elevation	MST	MSTmin	MSTmax	CharCount	Charmin	Charmax	1 std	Pollen
06BP01	380.00	15.10	13.50	16.70	44.00	33.31	54.69	10.69	
06BP02	380.05				79.00	62.44	95.56	16.56	
06BP03	380.10	15.38	13.78	16.98	18.00	14.39	21.61	3.61	
06BP04	380.15				20.00	13.65	26.35	6.35	
06BP05	380.20	15.63	14.03	17.23	27.00	23.39	30.61	3.61	
06BP06	380.25				50.00	29.79	70.21	20.21	
06BP07	380.30	15.35	13.75	16.95	26.00	16.93	35.07	9.07	1
06BP08	380.35				39.00	29.36	48.64	9.64	1
06BP09	380.40	14.55	12.95	16.15	21.00	12.81	29.19	8.19	1
06BP10	380.45				34.00	22.85	45.15	11.15	
06BP11	380.50	14.94	13.34	16.54	126.00	88.73	163.27	37.27	
06BP12	380.55				19.00	14.07	23.93	4.93	
06BP13	380.60	15.07	13.47	16.67	40.00	23.80	56.20	16.20	
06BP14	380.65	15.12	13.52	16.72	26.00	20.49	31.51	5.51	
06BP15	380.70	14.75	13.15	16.35	25.00	13.98	36.02	11.02	
06BP16	380.75	14.95	13.35	16.55	18.00	15.00	21.00	3.00	
06BP17	380.80	15.22	13.62	16.82	26.00	21.27	30.73	4.73	
06BP18	380.85	14.99	13.39	16.59	20.00	13.57	26.43	6.43	
06BP19	380.90	15.41	13.81	17.01	29.00	20.67	37.33	8.33	
06BP20	380.95	14.70	13.10	16.30	28.00	17.88	38.12	10.12	
06BP21	3810	14.14	12.54	15.74	33.00	23.83	42.17	9.17	
06BP22	3815	14.90	13.30	16.50	25.00	21.94	28.06	3.06	
06BP23	381.10	14.81	13.21	16.41	24.00	16.19	31.81	7.81	1
06BP24	381.15	14.99	13.39	16.59	42.00	39.35	44.65	2.65	1
06BP25	381.20	14.82	13.22	16.42	21.00	14.44	27.56	6.56	1
06BP26	381.25	14.60	13.00	16.20	19.00	15.49	22.51	3.51	1
06BP27	381.30	14.43	12.83	16.03	397.00	307.28	486.72	89.72	

06BP28	381.35	15.03	13.43	16.63	393.00	304.74	481.26	88.26	1
06BP29	381.40				445.00	320.14	569.86	124.86	1
06BP30	381.45				710.00	385.49	1034.51	324.51	1
06BP34	381.65				275.00	195.00	355.00	80.00	
BP-A-20*	~381.35	15.11	13.51	16.71					

*2010 field season sample

Table S4. Fractional abundances of the brGDGTs found in the Beaver Pond sediments.

Sample Name	Ia	Ib	Ic	IIa	IIb	IIc	IIIa	IIIb	IIIc	IIa′	IIb′	IIc′	IIIa′	IIIb′	IIIc′
BP-A-02	0.08	0.05	0.01	0.15	0.05	0.00	0.27	0.01	0.00	0.12	0.05	0.00	0.21	0.01	0.00
BP-A-03	0.07	0.03	0.00	0.11	0.03	0.00	0.26	0.00	0.00	0.15	0.05	0.00	0.30	0.01	0.00
BP-A-04	0.12	0.04	0.00	0.13	0.03	0.00	0.23	0.00	0.00	0.15	0.04	0.00	0.25	0.01	0.00
06BP01	0.10	0.04	0.01	0.13	0.03	0.00	0.31	0.00	0.00	0.12	0.03	0.00	0.22	0.00	0.00
06BP16	0.11	0.04	0.00	0.15	0.03	0.00	0.30	0.00	0.00	0.13	0.03	0.00	0.20	0.00	0.00
06BP18*	0.11	0.03	0.00	0.15	0.02	0.00	0.29	0.00	0.00	0.14	0.03	0.00	0.21	0.00	0.00
06BP18*	0.11	0.03	0.00	0.15	0.02	0.00	0.29	0.00	0.00	0.13	0.03	0.00	0.21	0.00	0.00
BP-F-73*	0.10	0.04	0.00	0.19	0.03	0.00	0.26	0.00	0.00	0.14	0.03	0.00	0.19	0.01	0.00
BP-F-73*	0.11	0.05	0.00	0.22	0.04	0.00	0.21	0.00	0.00	0.16	0.04	0.00	0.15	0.01	0.00
BP-A-06	0.11	0.04	0.01	0.15	0.03	0.00	0.24	0.00	0.00	0.15	0.04	0.00	0.22	0.01	0.00
BP-A-07	0.13	0.04	0.01	0.16	0.03	0.00	0.23	0.00	0.00	0.15	0.04	0.00	0.20	0.01	0.00
06BP03	0.11	0.04	0.00	0.15	0.03	0.00	0.28	0.00	0.00	0.13	0.03	0.00	0.22	0.01	0.00
06BP05*	0.10	0.04	0.00	0.15	0.03	0.00	0.29	0.00	0.00	0.12	0.03	0.00	0.23	0.01	0.00
06BP05*	0.11	0.04	0.01	0.16	0.03	0.00	0.28	0.00	0.00	0.13	0.03	0.00	0.19	0.00	0.00
06BP07	0.13	0.04	0.00	0.19	0.03	0.00	0.28	0.00	0.00	0.13	0.03	0.00	0.16	0.00	0.00
06BP09	0.09	0.03	0.00	0.14	0.03	0.00	0.30	0.00	0.00	0.13	0.03	0.00	0.23	0.01	0.00
06BP11*	0.11	0.04	0.01	0.16	0.03	0.00	0.31	0.00	0.00	0.12	0.03	0.00	0.19	0.00	0.00
06BP11*	0.10	0.04	0.00	0.15	0.03	0.00	0.29	0.00	0.00	0.14	0.03	0.00	0.21	0.00	0.00
06BP13	0.11	0.04	0.00	0.15	0.03	0.00	0.30	0.00	0.00	0.13	0.03	0.00	0.20	0.00	0.00
06BP14*	0.10	0.04	0.00	0.15	0.03	0.00	0.29	0.00	0.00	0.13	0.03	0.00	0.21	0.00	0.00
06BP14*	0.10	0.04	0.00	0.14	0.03	0.00	0.30	0.00	0.00	0.14	0.03	0.00	0.21	0.01	0.00
06BP15*	0.10	0.03	0.00	0.12	0.03	0.00	0.31	0.00	0.00	0.12	0.03	0.00	0.23	0.00	0.00
06BP15*	0.09	0.04	0.01	0.15	0.03	0.00	0.35	0.00	0.00	0.11	0.02	0.00	0.20	0.00	0.00

06BP17*	0.09	0.03	0.00	0.14	0.03	0.00	0.31	0.00	0.00	0.15	0.04	0.00	0.20	0.00	0.00
06BP17*	0.10	0.04	0.01	0.15	0.03	0.00	0.29	0.00	0.00	0.12	0.03	0.00	0.21	0.00	0.00
06BP19	0.11	0.04	0.00	0.14	0.03	0.00	0.28	0.00	0.00	0.13	0.03	0.00	0.22	0.00	0.00
06BP20	0.11	0.03	0.00	0.16	0.03	0.00	0.30	0.00	0.00	0.12	0.03	0.00	0.20	0.00	0.00
06BP21	0.08	0.04	0.01	0.14	0.03	0.00	0.38	0.00	0.00	0.09	0.02	0.00	0.19	0.00	0.00
06BP22*	0.12	0.04	0.00	0.17	0.03	0.00	0.29	0.00	0.00	0.12	0.03	0.00	0.19	0.00	0.00
06BP22*	0.11	0.04	0.00	0.16	0.03	0.00	0.31	0.00	0.00	0.12	0.03	0.00	0.19	0.00	0.00
06BP23*	0.15	0.04	0.01	0.21	0.03	0.00	0.37	0.00	0.00	0.14	0.03	0.00	0.00	0.00	0.00
06BP23*	0.12	0.04	0.00	0.17	0.03	0.00	0.30	0.00	0.00	0.12	0.03	0.00	0.18	0.00	0.00
BP-F-78*	0.09	0.04	0.00	0.13	0.03	0.00	0.26	0.00	0.00	0.14	0.04	0.00	0.24	0.01	0.00
BP-F-78*	0.10	0.05	0.00	0.15	0.04	0.00	0.22	0.00	0.00	0.17	0.04	0.00	0.20	0.01	0.00
06BP24*	0.12	0.04	0.00	0.17	0.03	0.00	0.30	0.00	0.00	0.12	0.03	0.00	0.18	0.00	0.00
06BP24*	0.13	0.03	0.00	0.16	0.02	0.00	0.28	0.00	0.00	0.13	0.03	0.00	0.20	0.00	0.00
BP-A-16	0.13	0.05	0.01	0.14	0.03	0.00	0.23	0.00	0.00	0.15	0.04	0.00	0.20	0.01	0.00
06BP25*	0.12	0.03	0.00	0.16	0.02	0.00	0.28	0.00	0.00	0.13	0.03	0.00	0.21	0.00	0.00
06BP25*	0.12	0.03	0.00	0.16	0.02	0.00	0.29	0.00	0.00	0.13	0.03	0.00	0.20	0.00	0.00
BP-A-17	0.14	0.04	0.01	0.16	0.03	0.00	0.26	0.00	0.00	0.14	0.03	0.00	0.18	0.00	0.00
06BP26*	0.10	0.03	0.00	0.15	0.03	0.00	0.34	0.00	0.00	0.11	0.02	0.00	0.20	0.00	0.00
06BP26*	0.12	0.03	0.00	0.16	0.02	0.00	0.30	0.00	0.00	0.12	0.03	0.00	0.20	0.00	0.00
06BP27*	0.08	0.03	0.00	0.12	0.02	0.00	0.33	0.00	0.00	0.11	0.03	0.00	0.25	0.00	0.00
06BP27*	0.08	0.03	0.00	0.12	0.02	0.00	0.33	0.00	0.00	0.12	0.03	0.00	0.26	0.00	0.00
BP-A-18 1	0.15	0.04	0.00	0.18	0.03	0.00	0.24	0.00	0.00	0.14	0.03	0.00	0.17	0.00	0.00
06BP28*	0.06	0.02	0.00	0.08	0.02	0.01	0.33	0.00	0.00	0.10	0.03	0.01	0.32	0.01	0.00
06BP28*	0.08	0.03	0.00	0.09	0.02	0.00	0.29	0.01	0.00	0.13	0.04	0.00	0.31	0.00	0.00
06BP28*	0.08	0.03	0.00	0.10	0.03	0.00	0.30	0.01	0.00	0.13	0.04	0.00	0.28	0.00	0.00
BP-A-20*	0.07	0.03	0.00	0.10	0.03	0.00	0.31	0.01	0.00	0.11	0.05	0.00	0.28	0.01	0.00
BP-A-20*	0.08	0.03	0.00	0.11	0.03	0.00	0.29	0.01	0.00	0.12	0.05	0.00	0.26	0.01	0.00

BP-A-69*	0.08	0.04	0.00	0.13	0.03	0.00	0.35	0.00	0.00	0.10	0.02	0.00	0.23	0.00	0.00
BP-A-69*	0.09	0.04	0.00	0.14	0.03	0.00	0.32	0.01	0.00	0.11	0.02	0.00	0.23	0.00	0.00

*indicates polar fraction was re-analyzed

Table S5. Input for burial modelling

Depth	Bulk Density	Latitude	Longitude	Surface elevation	^{10}Be conc	^{10}Be conc err	^{26}Al conc	^{26}Al conc err	Eros Rate
cm	g cm^{-3}	deg	deg	m	atoms g^{-1}	atoms g^{-1}	atoms g^{-1}	atoms g^{-1}	cm ka^{-1}
18050	2.2	78.550	-82.373	333	17665	402	26986	7335	2.25
18097	2.2	78.550	-82.373	333	16163	376	22263	7889	2.25
18155	2.2	78.550	-82.373	333	17853	387	22322	10215	2.25
18222	2.2	78.550	-82.373	333	20505	598	26508	7147	2.25

Notes:

1. We attempted a depth-profile type isochron burial date (Balco and Rovey, 2010), however the differences in the measured concentrations were too small and uncertainties in ^{26}Al were too large to define an isochron curve. Therefore we used the more common method of simple burial dating using the relationship of ^{26}Al/^{10}Be vs. log^{10}Be, which requires the assumption that the pre-burial ratio of the sand samples was the production ratio of ^{26}Al/^{10}Be (6.75).

2. We computed the ^{26}Al/^{10}Be burial ages that best fits the measured concentrations, assuming a simple surface buildup and burial history. The depositional environment in the Pliocene was an alluvial fan and pebble-braided-stream system along a mountainous piedmont. Therefore it is reasonable to assume that there was little opportunity for long-term (Ma) deep burial (>20 m) of stored sediment during transport from the nearby mountains. Thus we assume, like most other applications of the simple burial method, that the initial ratio in the sand grains was 6.75 and that only one significant burial event affected the grains in the past 8 Ma (by that time, both isotopes have effectively reached saturation). We use the Lifton et al. (2014) constraints and approach for scaling the production rates in the catchment (buildup) and in the sampled section (post-depositional). The calculations include post-depositional muon production (cosmic ray influx according to Lifton et al., 2014) and erosion of the surface.

3. While the current depth of the samples is approximately 10 m below gravel and till, muons can still penetrate to produce cosmogenic ^{26}Al and ^{10}Be. In other words, the samples are not completely shielded. However, we estimate that there was more sediment and ice above the samples during the Pliocene and Pleistocene as follows: The surface of the Beaufort Formation is more than 40 m higher in elevation across Strathcona Fiord than at BP. Furthermore the region has been

significantly eroded since the Pliocene sediment was deposited, as stream paleoflow indicators reveal that the fiord was filled at the time of BP deposition. The amount of erosion in the fiord is much greater than 400 m. We conservatively estimate that 50 m of post-Pliocene erosion occurred above the fiord on the opposite side, or 90 m of sediment loss on the BP side. This would equate to an erosion rate over 4 Ma of 2.25 cm ka^{-1}. Besides sediment with a bulk density of 2.2 g cm^{-3} for coarse sand and sandy gravel, BP would have been covered by ice for the majority of the Quaternary, given its close proximity to the second largest ice field in Canada, Prince of Wales Ice Field. Plateau ice thicknesses are currently >200 m (Kinnard et al., 2008) (i.e. equivalent to approximately 81.8 m of sandy gravel), whereas the ice field is much thicker in valleys and would have been even thicker during much of the Pleistocene. While the mass depth that shielded the samples at any time remains uncertain, our most reasonable estimate is 90.0 +81.8 or 171.8 m of average gravel cover (mass depth = 37.8 x 103 g cm^2). We added 171.8 m to each of the modern sample depths (8.70, 9.17, 9.74, and 10.42 m). While the uncertainty in the actual mass depth is large, a greater shielding thickness does not change the age significantly once depths are greater than 50 m (much deeper burial would yield a slightly younger mean age of 3.6 Ma, while a shallower depth estimate will significantly increase the age beyond the ca. 8 Ma saturation limit. Therefore, we prefer the revised calculated mean burial age over the minimum ages reported in Rybczynski et al. (2013) which were derived using unreasonably great depths and zero erosion (needed for no muogenic production) and a superseded production rate systematics.

4. The mean age of the four samples is 3.9 +1.5/-0.5 Ma. The final most probable ages are therefore our best estimate of burial duration of the Beaver Pond layer. The burial age and error (1σ and 2σ shown in Figure S3) is determined using a systematic parameter search and chi-squared statistic to create a continuous probability density function. We also calculate a burial mean-value age using the FMINLBFGS optimization algorithm (from Matlab file exchange) for comparison with the probability distribution function most probable burial age approach. Those burial mean-value ages were not available for two of the samples because the tails of their pdfs reach beyond the saturation value.

Supplemental References

Balco, G. and Rovey, C. W.: Absolute chronology for major Pleistocene advances of the Laurentide Ice Sheet, Geology, 38, 795–798, 2010.

Kinnard, C., Koerner, R. M., Zdanowicz, C. M., Fisher, D. A., Zheng, J., Sharp, M. J., Nicholson, L., and Lauriol, B.: Stratigraphic analysis of an ice core from the Prince of Wales Icefield, Ellesmere Island, Arctic Canada, using digital image analysis: High-resolution density, past summer warmth reconstruction, and melt effect on ice core solid conductivity, Journal of Geophysical Research: Atmospheres, 113, 2008.

Lifton, N., Sato, T., and Dunai, T. J.: Scaling in situ cosmogenic nuclide production rates using analytical approximations to atmospheric cosmic-ray fluxes, Earth and Planetary Science Letters, 386, 149–160, 2014.

Rybczynski, N., Gosse, J. C., Richard Harington, C., Wogelius, R. A., Hidy, A. J., and Buckley, M.: Mid-Pliocene warm-period deposits in the High Arctic yield insight into camel evolution, Nature Communications, 4, 1–9, 2013.