Supplemental material to “Chemical weathering in a moraine at the ice sheet margin at Kangerlussuaq, western Greenland”

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Location and sampling date of water and till samples

The location of the samples taken in the studied moraine is indicated in the map at the right of Figure 1 in the paper. Several sample types (porewater, meltwater ponds, streams and till) were taken from each of the sampling points, denoted with labels 01 to 16, and Table S1 shows their names, their GPS coordinates and sampling date. The locations of the water samples collected outside the studied moraine are shown in the map in the middle of Figure 1 in the paper and their coordinates and sampling dates are listed in Table S2. The name of each sample consists of some letters to indicate the sample type (PW for porewater; MP for meltwater pond; ST for stream, TS for till sample, and L for lake), followed by an indication about the sampling point: either a two digit number (01 to 16) or some letters: D for “delta”, IT for “ice tunnel”, AW for “artesian flow”. For the two lakes sampled in this study the nomenclature used was the same as that within the GAP project (Henkemans et al. 2018). The sampling year is indicated with an appended two-digit number (either 14, 15 or 16).

Table S1. Coordinates and sampling dates for the waters and till samples from the studied moraine.

Sampling point	Water sample	Date	Coordinates		Till sample	Date	Coordinates	
		yyyy-mm-dd	Lat.(N)	Long.(W)		yyyy-mm-dd	Lat.(N)	Long.(W)
1	PW0114	2014-09-01	67.1531	−50.0498	TS0116	2016-08-24	67.1531	−50.0499
	PW0115	2015-09-27	67.1530	−50.0499				
	PW0116	2016-08-24	67.1531	−50.0499				
	ST0114	2014-09-01	67.1531	−50.0498				
	ST0115	2015-09-25	67.1528	−50.0499				
2	PW0214	2014-09-01	67.1529	−50.0496	TS0216	2016-08-25	67.1529	−50.0494
	MP0214	2014-09-01	67.1529	−50.0496				
	MP0215	2015-09-26	67.1529	−50.0495				
	MP0216	2016-08-29	67.1528	−50.0495				
3	MP0314	2014-09-01	67.1526	−50.0495				
	MP0315	2015-09-26	67.1527	−50.0494				
4	MP0414	2014-09-01	67.1527	−50.0486				
5	PW0516	2016-08-27	67.1515	−50.0467	TS0516	2016-08-27	67.1515	−50.0467
	MP0514	2014-09-03	67.1515	−50.0468				
	MP0516	2016-08-29	67.1515	−50.0467				
6	PW0616	2016-08-27	67.1514	−50.0463	TS0616	2016-08-27	67.1514	−50.0463
7	PW0714	2014-09-03	67.1514	−50.0460				
8	MP0814	2014-09-03	67.1509	−50.0461				
9	PW0916	2016-08-27	67.1512	−50.0453	TS0916	2016-08-27	67.1512	−50.0453
	MP0916	2016-08-27	67.1512	−50.0450				
10	PW1016	2016-08-26	67.1509	−50.0449	TS1016	2016-08-25	67.1509	−50.0450
	MP1016	2016-08-25	67.1509	−50.0448				
11	PW1116	2016-08-26	67.1510	−50.0430	TS1116	2016-08-25	67.1510	−50.0430
	MP1116	2016-08-29	67.1510	−50.0430				
12	MP1216	2016-08-29	67.1560	-50.0497	TS1216	2016-08-29	67.1560	−50.0496
13	MP1316	2016-08-29	67.1470	−50.0439	TS1316	2016-08-29	67.1470	−50.0438
15	MP1516	2016-08-29	67.1442	−50.0429	TS1516	2016-08-29	67.1442	−50.0429

Table S2. Coordinates and sampling dates for the waters collected outside the studied moraine.

Water sample	Date	Coordinates		Comment
	yyyy-mm-dd	Lat.(N)	Long.(W)	
PWD14	2014-09-02	67.1557	−50.0714	Porewater tube in glacial delta.
STAW16	2016-08-24	67.1532	−50.0408	Artesian flow on the ice sheet near the moraine.
STD14	2014-09-02	67.1563	−50.0679	Stream in glacial delta.
STIT16	2016-08-26	67.1572	−50.0655	Terminus outflow from an ice tunnel.
L2515	2015-09-25	67.1495	−50.0797	Lake from which drilling water was extracted for the deep borehole GAP04 (Harper et al. 2016).
L2516	2016-08-25	67.1495	−50.0797	- " -
L3815	2015-09-30	67.1384	−50.0673	Ice dammed lake.

Till data

The grain size distribution and analytical data for the till samples are provided in Tables S3 and S4. Table S3 lists the experimental data for the main components, and Table S4 contains data for some additional chemical elements and the $^{87}Sr/^{86}Sr$ ratios. The sieved till samples were sent on September 2016 to ALS Scandinavia AB in Luleå, Sweden. The oxide percentages in Table S3 were obtained by ICP-AES, while carbon and sulfur where analysed by a LECO Corp. instrument, and the other elements were analysed after lithium borate fusion followed by ICP-MS. The samples analysed for the strontium isotope ratios ($^{87}Sr/^{86}Sr$) were also sent to ALS Scandinavia AB, Luleå, Sweden, on December 2016; the samples were prepared by HNO_3+HF digestion followed by ion-exchange separation and MC-ICP-MS analysis.

The compositions of amphiboles and biotites were estimated with an SEM-EDS instrument (Hitachi S3400N equipped with an energy dispersive system) at the Department for Earth Sciences, Gothenburg University, Sweden. Compositions for the amphiboles and biotites are provided in Tables S5 and S6, respectively. A large number of plagioclases were tested for their Ca/Na ratios and all showed Na-dominated composition being in the oligoclase range An_{20}-An_{30}.

Results of the leaching experiments are reported in Table S7. The samples were centrifuged, acidified and analysed using a triple quadrupole ICP-MS instrument at the Department of Earth Sciences, Gothenburg University (Gothenburg, Sweden). Measurement uncertainties were between 7 and 10 %. Leaching batch experiments with a larger volume (1 L), with the same solid/solution ratio, were run for 7 days, and the samples were sent for isotope analysis (managed by the Äspö Hard Rock Laboratory, Oskarshamn, Sweden) to the Environmental Isotope Laboratory (EIL), University of Waterloo (Waterloo, ON, Canada), and the data are reported in Table S8.

Table S3. Analytical results for the till samples collected in this study. "LOI" stands for loss on ignition at 1000 °C. Note that more precise data for Sr and Ba is given in Table S4.

Sample	Sieve size (mm)	Fraction (%)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	Cr_2O_3	TiO_2	MnO	P_2O_5	SrO	BaO	LOI	Tot.	C	S
			%																
TS0116	<0.04	1.81	62.40	15.40	7.31	5.62	2.83	3.80	1.48	0.02	0.80	0.11	0.22	0.06	0.07	1.75	101.8	0.44	0.02
	0.04-0.125	26.62	64.30	14.70	7.48	5.36	2.58	3.94	1.40	0.01	0.80	0.12	0.21	0.06	0.06	0.80	101.8	0.28	0.02
	0.125-0.25	30.86	67.70	14.10	5.93	4.51	1.99	3.68	1.21	0.01	0.55	0.10	0.11	0.05	0.05	0.46	100.4	0.15	0.01
	0.25-0.5	21.86	70.60	14.00	4.30	3.89	1.46	3.86	1.13	0.01	0.31	0.06	0.03	0.05	0.05	0.24	99.99	0.06	<0.0
	>0.5	18.85	70.90	14.55	4.32	3.66	1.41	4.12	1.71	0.01	0.28	0.06	0.06	0.05	0.07	0.40	101.6	0.09	0.01
TS0516	<0.04	4.55	61.60	14.30	7.35	5.25	2.65	3.40	1.53	0.02	0.81	0.12	0.18	0.04	0.07	1.34	98.66	0.34	0.01
	0.04-0.125	17.44	63.70	13.60	7.58	4.98	2.18	3.30	1.32	0.01	0.91	0.13	0.16	0.04	0.06	0.18	98.15	0.09	0.01
	0.125-0.25	35.31	68.90	13.05	5.23	4.04	1.63	3.42	1.26	0.01	0.47	0.09	0.06	0.04	0.05	0.18	98.43	0.06	<0.0
	0.25-0.5	28.05	72.80	12.75	3.97	3.46	1.25	3.98	1.34	0.01	0.26	0.06	0.03	0.02	0.06	0.13	100.1	0.04	<0.0
	>0.5	14.64	71.30	13.35	4.91	3.44	1.44	3.65	1.72	0.01	0.33	0.07	0.09	0.03	0.06	0.32	100.7	0.06	0.01
TS0616	<0.04	1.89	63.00	14.10	7.11	5.26	2.57	3.60	1.59	0.02	0.85	0.11	0.18	0.05	0.07	2.00	100.5	0.47	0.01
	0.04-0.125	19.37	63.20	13.75	7.18	4.81	2.20	3.35	1.50	0.01	0.75	0.12	0.14	0.04	0.06	0.93	98.04	0.31	0.01
	0.125-0.25	23.36	68.70	13.65	6.76	4.54	1.99	3.42	1.41	0.01	0.68	0.11	0.10	0.04	0.06	0.44	101.9	0.18	0.01
	0.25-0.5	16.91	70.50	13.20	5.01	3.83	1.55	3.66	1.36	0.01	0.33	0.07	0.04	0.04	0.06	0.36	100.0	0.08	<0.0
	>0.5	38.48	69.10	14.00	5.10	3.69	1.47	3.96	1.97	0.01	0.38	0.07	0.08	0.03	0.08	0.25	100.1	0.05	<0.0
TS0916	<0.04	0.94	62.60	14.70	7.17	5.43	2.65	3.78	1.65	0.02	0.85	0.11	0.19	0.05	0.07	1.24	100.5	0.27	0.01
	0.04-0.125	11.90	64.80	14.15	7.15	5.08	2.31	3.45	1.41	0.01	0.86	0.12	0.18	0.03	0.06	0.98	100.5	0.17	0.01
	0.125-0.25	26.27	66.90	13.60	6.69	4.53	2.01	3.38	1.39	0.01	0.65	0.11	0.11	0.04	0.06	0.40	99.88	0.15	0.01
	0.25-0.5	18.97	71.00	13.20	5.64	4.02	1.73	3.91	1.39	0.01	0.39	0.09	0.07	0.02	0.06	0.33	101.8	0.10	<0.0
	>0.5	41.92	69.50	14.30	5.74	3.99	1.81	3.65	1.81	0.01	0.44	0.08	0.07	0.03	0.07	0.32	101.8	0.06	<0.0
TS1016	<0.04	3.62	61.40	14.20	6.79	5.08	2.48	3.42	1.62	0.02	0.75	0.11	0.16	0.04	0.07	1.95	98.09	0.63	0.01
	0.04-0.125	19.33	64.60	13.85	6.73	4.90	2.20	3.62	1.51	0.01	0.77	0.11	0.16	0.05	0.06	0.99	99.56	0.38	0.01
	0.125-0.25	24.77	67.20	13.35	6.23	4.44	1.92	3.35	1.30	0.01	0.69	0.10	0.10	0.02	0.06	0.69	99.46	0.27	0.01
	0.25-0.5	18.01	69.70	12.50	4.69	3.68	1.51	3.75	1.34	0.01	0.35	0.08	0.06	0.02	0.06	0.36	98.11	0.13	<0.0
	>0.5	34.27	69.60	13.70	5.07	3.62	1.66	3.67	1.87	0.01	0.35	0.07	0.08	0.04	0.08	0.40	100.2	0.06	<0.0
TS1116	<0.04	2.98	62.10	14.75	7.54	5.63	2.79	3.86	1.43	0.02	0.91	0.12	0.20	0.05	0.06	0.63	100.0	0.14	0.01
	0.04-0.125	11.79	65.50	14.55	7.75	5.24	2.43	3.61	1.29	0.01	0.89	0.13	0.19	0.05	0.06	0.16	101.8	0.07	0.02
	0.125-0.25	13.24	67.30	13.95	6.83	4.65	2.02	3.62	1.04	0.01	0.75	0.11	0.09	0.04	0.05	0.06	100.5	0.05	0.02
	0.25-0.5	13.94	70.60	13.80	5.23	4.04	1.57	4.05	1.10	0.01	0.40	0.08	0.04	0.06	0.05	-0.01	101.0	0.03	<0.0
	>0.5	58.05	68.90	14.05	5.35	3.91	1.82	3.83	1.67	0.01	0.38	0.07	0.06	0.04	0.07	0.17	100.3	0.03	0.01

(Continued)

Table S3. Continued.

Sample	Sieve size (mm)	Fraction (%)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	Cr_2O_3	TiO_2	MnO	P_2O_5	SrO	BaO	LOI	Tot	C	S
			%																
TS1216	<0.04	0.89	63.00	15.45	7.14	5.55	2.82	3.90	1.44	0.01	0.74	0.11	0.22	0.05	0.07	1.15	101.65	0.28	<0.01
	0.04-0.125	9.91	64.40	14.90	7.27	5.30	2.56	3.89	1.30	0.01	0.75	0.11	0.22	0.06	0.06	0.53	101.36	0.20	0.02
	0.125-0.25	30.54	65.60	14.75	6.79	5.03	2.29	4.18	1.16	0.01	0.66	0.10	0.17	0.07	0.05	0.45	101.31	0.16	0.01
	0.25-0.5	19.58	70.30	14.65	4.93	4.16	1.52	4.32	1.12	0.01	0.37	0.07	0.06	0.06	0.05	0.26	101.88	0.07	<0.01
	>0.5	39.08	69.10	14.30	4.32	3.57	1.47	4.16	1.68	0.01	0.30	0.05	0.06	0.06	0.07	0.23	99.38	0.03	<0.01
TS1316	<0.04	4.61	63.90	14.50	6.88	5.20	2.50	3.51	1.58	0.01	0.75	0.11	0.16	0.04	0.07	1.38	100.59	0.40	0.01
	0.04-0.125	11.68	63.00	14.20	7.56	5.18	2.26	3.54	1.43	0.01	0.83	0.12	0.16	0.04	0.06	0.28	98.67	0.13	0.01
	0.125-0.25	20.99	70.80	13.30	5.96	4.17	1.71	3.40	1.31	0.01	0.56	0.10	0.05	0.04	0.06	0.06	101.53	0.06	0.01
	0.25-0.5	30.09	73.80	13.25	4.18	3.62	1.32	3.64	1.29	0.01	0.29	0.06	0.05	0.02	0.06	0.22	101.81	0.05	<0.01
	>0.5	32.63	72.10	13.25	3.75	2.96	1.04	3.74	1.82	0.01	0.22	0.05	0.05	0.05	0.08	0.25	99.37	0.05	<0.01
TS1516a	<0.04	3.00	62.50	14.50	6.68	5.12	2.47	3.49	1.61	0.01	0.73	0.11	0.15	0.04	0.07	3.36	100.84	1.31	0.04
	0.04-0.125	29.86	64.40	13.90	6.59	4.88	2.20	3.65	1.52	0.01	0.71	0.11	0.16	0.04	0.07	2.05	100.29	0.75	0.03
	0.125-0.25	22.69	66.60	12.90	6.14	4.30	1.84	3.49	1.33	0.01	0.60	0.10	0.09	0.04	0.06	1.00	98.50	0.39	0.02
	0.25-0.5	15.62	71.90	13.25	5.14	3.82	1.49	3.68	1.38	0.01	0.34	0.07	0.05	0.04	0.06	0.50	101.73	0.23	0.02
	>0.5	28.82	70.70	13.50	4.42	3.32	1.44	4.10	2.02	0.01	0.32	0.06	0.06	0.02	0.08	0.50	100.55	0.15	0.01
TS1516b	<0.04	4.94	62.60	14.30	6.96	5.40	2.50	3.70	1.52	0.02	0.83	0.12	0.20	0.04	0.07	1.36	99.62	0.39	0.02
	0.04-0.125	26.37	65.30	13.70	6.24	4.68	1.98	3.44	1.44	0.01	0.63	0.10	0.14	0.04	0.06	0.58	98.34	0.23	0.01
	0.125-0.25	22.27	70.70	13.20	4.98	4.04	1.52	3.50	1.28	0.01	0.48	0.08	0.06	0.03	0.06	0.33	100.27	0.10	0.01
	0.25-0.5	18.49	72.60	12.45	4.19	3.43	1.25	3.88	1.37	0.01	0.27	0.06	0.04	0.02	0.06	0.12	99.75	0.06	<0.01
	>0.5	27.92	68.60	13.30	4.96	3.43	1.43	3.67	1.86	0.01	0.37	0.06	0.06	0.04	0.07	0.33	98.19	0.07	0.02

Table S4. Additional analytical results for the till samples collected in this study. Note that only a few samples were analysed for strontium isotopes.

Sample	Sieve size	Ba	Ce	Er	Eu	Hf	Ho	La	Lu	Nd	Rb	Sm	Sr	Tb	Th	U	V	Y	Yb	Zr	Co	Cu	Sc	Zn	$^{87}Sr/^{86}Sr$
	(mm)	ppm																							‰
TS0116	<0.04	582	94.9	1.94	1.52	14.7	0.68	47.7	0.26	41.7	25.7	6.43	474	0.66	5.25	1.06	146	20.1	2.07	625	19	56	17	85	
	0.04-0.125	542	75.3	1.98	1.36	10.1	0.73	36.2	0.32	32.8	24.3	5.89	477	0.65	4.76	1.10	137	19.6	1.90	448	18	175	15	147	
	0.125-0.25	446	41.9	1.42	1.02	3.8	0.54	21.6	0.22	18.6	21.7	3.58	453	0.49	2.62	0.42	103	13.7	1.34	150	15	73	12	80	
	0.25-0.5	410	23.6	0.94	0.71	2.3	0.31	12.3	0.12	9.9	19.8	1.92	468	0.24	1.74	0.20	71	7.8	0.74	85	11	94	8	83	
	>0.5	564	40.8	0.70	0.75	2.4	0.25	24.5	0.09	15.6	31.1	2.07	445	0.22	3.33	0.37	63	5.8	0.63	102	10	57	8	57	
TS0516	<0.04	559	77.6	2.40	1.51	16.0	0.79	39.5	0.34	34.0	30.5	6.06	383	0.71	5.61	1.12	147	22.9	2.30	685	22	66	17	83	0.71292
	0.04-0.125	486	59.3	2.53	1.49	13.2	0.89	29.4	0.39	27.4	22.7	4.96	357	0.71	4.25	1.22	134	23.6	2.42	541	18	99	16	99	
	0.125-0.25	436	32.9	1.51	0.90	2.6	0.49	16.9	0.20	14.5	20.9	2.64	357	0.44	2.57	0.35	84	12.5	1.33	89	12	53	11	62	
	0.25-0.5	461	22.6	0.72	0.61	1.4	0.25	12.6	0.11	9.7	24.6	1.66	378	0.21	1.71	0.22	63	6.1	0.61	64	9	67	7	61	
	>0.5	602	40.2	0.90	0.80	3.2	0.31	23.3	0.13	15.8	49.9	2.61	389	0.29	5.41	0.42	73	7.5	0.81	120	12	95	8	81	
TS0616	<0.04	624	89.8	2.38	1.62	17.1	0.86	45.1	0.35	39.2	33.0	6.54	391	0.74	6.05	1.22	154	23.1	2.30	709	20	53	17	68	0.71369
	0.04-0.125	543	63.3	2.35	1.35	12.6	0.78	31.3	0.34	29.3	27.6	4.94	368	0.68	4.50	1.05	126	21.4	1.91	505	19	91	15	88	
	0.125-0.25	481	46.2	1.75	1.09	6.2	0.66	22.9	0.26	21.0	24.5	3.80	353	0.54	3.26	0.69	110	17.1	1.94	240	16	85	13	83	
	0.25-0.5	483	29.9	1.02	0.72	1.5	0.35	17.3	0.14	12.8	26.2	2.28	399	0.27	2.15	0.25	88	9.3	0.87	75	11	87	10	77	
	>0.5	635	26.1	0.78	0.69	2.0	0.30	14.4	0.10	11.9	38.7	2.24	365	0.25	2.23	0.31	77	7.2	0.72	91	12	97	9	87	
TS0916	<0.04	611	82.0	2.19	1.46	16.8	0.83	40.1	0.32	37.1	33.2	5.95	389	0.77	6.01	1.27	145	22.3	2.29	689	20	52	15	72	0.71276
	0.04-0.125	561	61.6	2.31	1.43	12.7	0.84	29.9	0.36	27.1	29.2	5.16	392	0.78	4.53	1.03	135	22.5	2.48	504	18	91	15	91	
	0.125-0.25	510	51.0	1.76	1.21	6.4	0.69	26.1	0.24	23.5	27.3	3.96	375	0.55	3.74	0.65	114	17.4	1.77	260	16	82	14	84	
	0.25-0.5	502	38.7	1.12	0.90	2.3	0.38	21.4	0.16	17.1	27.3	2.84	393	0.29	3.29	0.32	90	10.4	1.05	96	12	98	9	84	
	>0.5	605	40.9	0.93	0.90	2.3	0.37	22.2	0.14	17.5	37.8	3.04	347	0.33	4.37	0.69	88	9.5	0.85	106	14	108	11	90	
TS1016	<0.04	574	76.5	2.11	1.41	13.6	0.81	37.3	0.32	33.3	32.6	5.55	368	0.66	5.27	1.14	135	20.5	2.07	563	21	55	16	70	0.71416
	0.04-0.125	556	63.4	2.39	1.44	11.3	0.78	31.8	0.35	28.8	29.0	4.82	369	0.65	5.37	1.14	123	20.6	2.13	452	19	100	15	94	0.71340
	0.125-0.25	533	47.6	2.01	1.07	5.2	0.71	24.0	0.28	22.2	26.7	3.98	374	0.54	3.51	0.72	118	17.4	1.86	215	16	72	13	77	0.71299
	0.25-0.5	450	32.8	0.95	0.75	2.3	0.33	17.8	0.13	14.8	23.7	2.29	345	0.28	2.34	0.32	82	8.6	0.90	99	12	104	9	87	0.71238
	>0.5	633	48.8	0.97	0.68	2.8	0.34	27.5	0.14	19.3	36.9	2.74	392	0.33	2.97	0.36	84	8.4	0.91	112	11	78	10	75	0.71449
TS1116	<0.04	545	87.3	2.40	1.48	17.4	0.80	42.7	0.35	37.1	25.9	6.20	435	0.65	5.17	1.07	155	21.2	2.02	735	22	38	16	72	0.71033
	0.04-0.125	482	68.8	2.45	1.38	13.5	0.84	34.0	0.34	31.0	21.1	5.67	426	0.69	4.83	0.96	134	21.9	2.18	553	18	127	15	118	
	0.125-0.25	432	41.0	1.81	1.06	4.1	0.59	20.9	0.23	19.4	19.5	3.69	468	0.50	2.55	0.43	123	16.3	1.59	162	15	71	13	81	
	0.25-0.5	408	27.8	0.98	0.68	2.4	0.35	14.9	0.14	11.7	18.8	2.07	482	0.27	1.85	0.20	81	9.3	0.99	104	11	75	9	74	
	>0.5	547	28.7	0.82	0.84	3.0	0.29	16.6	0.13	13.2	33.8	2.12	433	0.28	2.59	0.29	86	7.8	0.67	118	12	86	9	80	

(Continued)

Table S4. Continued.

Sample	Sieve size	Ba	Ce	Er	Eu	Hf	Ho	La	Lu	Nd	Rb	Sm	Sr	Tb	Th	U	V	Y	Yb	Zr	Co	Cu	Sc	Zn	$^{87}Sr/^{86}Sr$
	(mm)	ppm																							‰
TS1216	<0.04	577	98.4	1.98	1.52	13.3	0.70	48.8	0.30	40.6	25.2	6.33	518	0.64	4.56	0.89	148	18.6	1.99	550	21	45	16	78	0.70854
	0.04-0.125	502	71.2	1.69	1.46	9.5	0.67	35.4	0.27	32.6	21.1	5.34	524	0.59	3.38	0.67	136	17.3	1.54	410	18	75	15	94	0.70778
	0.125-0.25	444	57.9	1.49	1.16	5.8	0.55	28.6	0.21	26.4	18.2	4.41	532	0.53	3.33	0.45	118	14.9	1.36	231	16	76	12	88	0.70696
	0.25-0.5	415	28.8	0.81	0.83	1.6	0.30	16.3	0.13	13.5	17.6	2.16	575	0.25	1.33	0.18	81	7.5	0.75	74	10	86	8	77	0.70620
	>0.5	564	40.2	0.67	0.86	1.8	0.23	22.1	0.09	17.5	29.5	2.69	516	0.27	2.80	0.21	63	5.7	0.55	87	10	91	7	81	0.70840
TS1316	<0.04	579	72.4	2.14	1.49	11.1	0.77	36.0	0.32	31.8	30.6	5.48	384	0.61	4.35	0.88	142	20.5	1.81	470	20	51	16	69	
	0.04-0.125	520	57.3	2.51	1.51	11.2	0.91	26.9	0.36	25.9	25.1	5.08	379	0.78	3.87	0.87	128	23.5	2.45	450	18	68	15	78	
	0.125-0.25	469	39.2	1.67	0.95	3.5	0.60	19.8	0.26	17.2	21.0	3.06	357	0.50	3.10	0.46	95	16.6	1.64	120	12	72	12	73	
	0.25-0.5	504	26.1	0.89	0.65	1.7	0.31	14.9	0.14	11.8	26.1	1.84	388	0.24	2.00	0.21	76	7.7	0.77	72	8	77	8	67	
	>0.5	640	26.3	0.69	0.63	2.0	0.25	14.3	0.07	11.1	35.4	1.66	387	0.21	2.15	0.30	52	5.5	0.56	80	7	73	6	63	0.71367
TS1516a	<0.04	587	78.2	2.11	1.38	14.2	0.77	40.6	0.33	34.9	31.7	6.02	373	0.67	5.34	1.21	130	20.7	2.22	569	20	48	16	67	0.71367
	0.04-0.125	588	63.1	2.16	1.34	10.4	0.70	31.0	0.32	28.9	29.6	5.15	381	0.59	4.12	0.92	120	19.7	1.91	450	19	90	14	87	0.71352
	0.125-0.25	487	42.0	1.73	1.03	4.5	0.61	20.9	0.25	19.0	24.9	3.41	353	0.49	2.99	0.59	107	16.0	1.50	188	14	70	12	73	0.71305
	0.25-0.5	468	25.9	1.03	0.71	1.7	0.33	15.2	0.12	11.4	24.8	2.09	368	0.25	1.93	0.28	82	8.6	0.94	80	11	64	9	64	0.71248
	>0.5	691	27.1	0.84	0.71	2.4	0.29	15.4	0.11	12.8	43.5	2.25	389	0.22	2.27	0.36	75	7.2	0.79	102	9	70	8	63	0.71408
TS1516b	<0.04	585	79.5	2.28	1.68	16.0	0.85	40.2	0.37	36.5	28.2	6.59	389	0.75	5.03	1.27	144	23.3	2.14	681	20	40	17	68	
	0.04-0.125	539	55.1	2.00	1.32	8.8	0.77	27.2	0.31	24.3	25.1	4.36	381	0.58	3.48	0.77	113	19.4	2.10	368	15	82	14	84	
	0.125-0.25	520	38.5	1.33	1.02	2.8	0.52	19.9	0.22	17.3	25.8	3.42	385	0.42	2.94	0.41	90	13.4	1.36	102	12	79	10	72	
	0.25-0.5	490	28.0	0.68	0.57	1.9	0.30	15.8	0.12	12.0	25.6	2.25	379	0.24	2.27	0.25	70	6.9	0.82	84	10	147	8	110	
	>0.5	624	35.9	0.94	0.76	2.6	0.30	20.0	0.11	15.2	38.7	2.54	379	0.25	3.05	0.39	83	8.5	0.83	109	10	91	8	68	

Table S5. Hornblende composition estimated from SEM-EDS analyses of 6 different unaltered grains located in 4 different samples (TS1316, TS1516b, TS1016 and TS0516). One SEM-EDS analysis per grain was performed on a single spot, and the mean, minimum and maximum element compositions (atomic %) values are directly calculated among the grains.

Element	Atomic %						For the 6 grains		
							Mean	Min.	Max.
O	62.46	63.26	62.48	64.61	63.22	63.2	63.2	62.5	64.6
Mg	2.97	4.33	3.12	3.79	4.8	5.51	4.1	3.0	5.5
Al	5.53	5.18	5.75	5.28	5.12	5.24	5.4	5.1	5.8
Si	14.94	14.86	14.84	14.54	14.74	14.97	14.8	14.5	15.0
K	0.9	0.87	0.91	0.35	0.66	0.7	0.7	0.4	0.9
Ca	4.57	4.53	4.65	4.34	4.41	4.41	4.5	4.3	4.7
Ti	0.44	0.44	0.41	0.41	0.44	0.32	0.4	0.3	0.4
Fe	7.8	6.29	7.7	6.36	5.67	4.89	6.5	4.9	7.8
Mn	0.07	0.15	0.15	<0.1	<0.1	0.11	0.1	0.1	0.2
Cl	0.27	0.12	<0.1	0.09	0.12	<0.1	0.2	0.1	0.3

Table S6. Biotite compositions estimated from SEM-EDS analyses of 4 different, unaltered grains in three different samples (TS1316, TS1516b and TS01516). The mean, minimum and maximum element composition (atomic %) in each grain was first generated (based on 1-5 spots on each grain in the SEM). Afterwards these values were used to calculate a mean, minimum and maximum value for the 12 grains.

Element	Sample TS1316			Sample TS1516b			Sample TS0516			For the 3 samples		
	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
O	61.2	60.7	61.6	61.3	60.9	61.8	61.3	59.2	62.3	61.3	59.2	62.3
Mg	4.9	4.8	5.0	4.5	4.5	4.6	6.7	6.5	6.9	5.4	4.5	6.9
Al	7.4	7.3	7.6	7.3	7.3	7.4	8.2	8.1	8.4	7.6	7.3	8.4
Si	13.8	13.5	14.0	13.5	13.5	13.6	13.3	13.1	13.7	13.5	13.1	14.0
K	4.6	4.2	4.9	4.7	4.6	4.8	4.7	4.4	5.2	4.7	4.2	5.2
Ti	1.1	1.1	1.1	1.0	0.9	1.0	0.9	0.9	1.1	1.0	0.9	1.1
Fe	6.9	6.7	7.1	7.5	7.3	7.7	4.9	4.3	5.9	6.4	4.3	7.7
Mn	0.1	0.1	0.1	0.2	0.1	0.2	<0.1	<0.1	<0.1	0.1	0.1	0.2

Table S7. Results of the leaching experiments: concentration of the major cations, iron and sulfate in the leachates of the four samples over time. The measured pH of the air-saturated de-ionized water was 5.5 at the beginning of the leaching experiments.

Sample	Leaching time (days)	Na meq/L	Mg meq/L	SO_4 meq/L	K meq/L	Ca meq/L	Fe meq/L	∑cations meq/L	pH ±0.1
TS0516	1	0.013	0.016	0.069	0.026	0.059	0.015	0.115	6.02
TS1016	1	0.012	0.037	0.190	0.038	0.146	0.020	0.233	6.33
TS1316	1	0.005	0.015	0.028	0.028	0.067	0.008	0.115	6.64
TS1516b	1	0.005	0.015	0.052	0.028	0.059	0.020	0.107	6.51
TS0516	7	0.068	0.065	0.429	0.065	0.068	0.035	0.266	6.12
TS1016	7	0.070	0.229	1.432	0.135	0.780	0.035	1.214	6.40
TS1316	7	0.030	0.064	0.136	0.063	0.093	0.046	0.249	6.79
TS1516b	7	0.031	0.084	0.431	0.092	0.175	0.067	0.382	6.68
TS0516	305	0.073	0.135	0.673	0.078	0.503	0.030	0.789	5.73
TS1016	305	0.087	0.321	1.414	0.176	1.339	0.044	1.924	6.51
TS1316	305	0.044	0.215	0.389	0.119	0.970	0.051	1.349	6.71
TS1516b	305	0.040	0.163	0.958	0.128	0.765	0.051	1.096	6.59

Table S8. Isotopic results for the leaching experiments. Results for $\delta^{2}H$ and $\delta^{18}O$ are reported based on standard corrections to VSMOW (Vienna Standard Mean Ocean Water) and the results for $\delta^{34}S_{SO4}$ are reported against the Vienna-Canyon Diablo Troilite (VCDT).

Sample	Leaching time	$\delta^{18}O_{SO4}$	Repeat	$\delta^{34}S_{SO4}$	Repeat	EC	SO_4	Cl	$\delta^{2}H$	$\delta^{18}O$
	(days)	VSMOW ± 0.5‰		VCDT ± 0.3‰		mS/cm	meq/L	mmol/L	‰ VSMOW	
TS0516	7	−17.25	−16.90	2.05	2.61	4.545	0.246	0.047		
TS1016	7	−24.60		2.01		12.92	0.989	0.038		
TS1316	7	−16.40		2.16		4.89	0.105	0.008		
TS1516b	7	−27.00	−27.32	0.83	0.92	4.801	0.246	0.064		
Leaching water	-	-	-	-	-	-	<0.004	<0.006	−53.8	−7.19

Water data

Analytical data for the waters sampled in this study are provided in Tables S9 and S10. Sample locations and sampling dates are also described in Tables S1 and S2.

The analysis of the moraine water samples was managed by the accredited Äspö Hard Rock Laboratory (Äspö HRL, located in Oskarshamn, Sweden) belonging to the Swedish Nuclear Fuel and Waste Management Company (SKB, with head office in Solna, Sweden).

Analysis of alkalinity (titration, measurement uncertainty 4 %) and major anions (ion chromatography, ±8 % for chloride and ±12 % for sulfate) were performed at the Äspö HRL. Cation multi-element analyses were performed at ALS Scandinavia AB (Luleå, Sweden) by a combination of Inductively Coupled Plasma Sector Field Mass Spectrometry (ICP-SFMS) and Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES), with uncertainties around 7 % for the main components (Na, K, Ca, Mg, Si, Fe, Mn), ±10 % for Sr, and around ±20 % for the remaining chemical elements. Most samples collected in 2016 were also sent to DEEP for dissolved inorganic carbon (DIC), dissolved organic carbon (DOC) and total organic carbon (TOC) with an Analytikjena multi N/C 3100 instrument. For the DIC analysis the sample is acidified with phosphoric acid and the amount of released carbon dioxide is determined by a non-dispersive infrared sensor. The analysis of non-purgeable organic carbon (DOC and TOC) is performed according to the Swedish standard SS-EN-1484: after acidification with hydrochloric acid and purging, the sample is oxidised at 800°C and the CO_2 thus formed is determined by a non-dispersive infrared sensor. The Analytikjena instrument analyses non-purgeable organic carbon with an uncertainty of 0.25 mg/L.

Deuterium and ^{18}O were determined using mass spectrometry at the Institute for Energy Technology (Kjeller, Norway) and the results for $\delta^{18}O$ and $\delta^{2}H$ are based on VSMOW (Vienna Standard Mean Ocean Water) with uncertainties of ±0.2 ‰ and ±0.8 ‰, respectively. Tritium was analysed by liquid scintillation counting at the Environmental Isotope Laboratory, University of Waterloo (Waterloo, ON, Canada) with a detection limit of 0.8 tritium units (TU) and an uncertainty of ±0.8 TU. Carbon-13 and Carbon-14 were analysed at the Tandem laboratory, Ångström laboratory, Uppsala University (Uppsala, Sweden) using Accelerator Mass Spectrometry (AMS) instruments. $\delta^{13}C$ is reported against the PeeDee Belemnite (PDB) standard, and the uncertainties are ±0.1 ‰. The uncertainties in pMC (percent modern carbon) are given in the data tables. Sulfate isotopes ($\delta^{34}S_{SO4}$ and $\delta^{18}O_{SO4}$) were determined at the Environmental Isotope Laboratory (EIL), University of Waterloo (Waterloo, ON, Canada) using isotope ratio mass spectrometers (IRMS) after $BaCl_2$ precipitation, as described by Henkemans et al. (2018). Results for $\delta^{18}O_{SO4}$ are reported based on standard corrections to VSMOW (Vienna Standard Mean Ocean Water) and the results for $\delta^{34}S_{SO4}$ are reported against the Vienna-Canyon Diablo Troilite (VCDT). The uncertainties for $\delta^{34}S_{SO4}$ and $\delta^{18}O_{SO4}$ are ±0.3‰ and ±0.4‰, respectively. $^{87}Sr/^{86}Sr$ isotopic ratios were also determined at EIL using thermal ionization mass spectrometry (TIMS), and the reported uncertainty is less than ±0.00002.

Table S9. Geochemical and isotopic composition of the water samples including the moraine porewaters and ponds (PW and MP samples), the streams (ST) and lakes (LA). Charge balance, equilibrium partial pressure of CO_2 and saturation indices of calcite and gypsum have been calculated using PHREEQC (Parkhurst and Appelo 2013), taking into account the DIC values when available.

Sample	T	pH	Conduct.	Alk	Na	K	Mg	Ca	Sr	Fe	Al	Si	Cl	SO_4	δ^2H_{VSMOW}	$\delta^{18}O_{VSMOW}$	PHREEQC results			
	(°C)		(µS/cm)	µeq/L	µmol/L										‰	‰	Charge balance	log P_{CO2}	Saturation indices calcite	Saturation indices gypsum
PW0114	6.5	6.44	265.0	241	251	143	309	831	1.69	0.57		313	93.9	888	−176.03	−23.10	13	−2.37	−2.57	−1.84
PW0115	1.0	6.34	119.3	733	121	103	179	459	1.16	4.83	13	263	69.7	316	−200.47	−25.64	6	−1.82	−2.50	−2.44
PW0116	7.6	6.81	338.1	2806	544	251	576	1380	2.49	38.50	20	363	281	770	−208.93	−27.58	4	−2.09	−0.57	−1.76
PW0214	4.6	6.03	103.7	390	87.0	83	109	327	0.76	2.13		256	61.5	262	−216.97	−28.79	4	−1.75	−3.14	−2.65
PW0516	7.3	6.69	286.2	490	154	153	213	1093	1.05	0.50	1.5	192	40.9	1158	−194.03	−24.65	2	−2.32	−1.91	−1.64
PW0616	6.9	7.09	165.3	1155	264	112	141	609	0.76	23.82	41	279	53.9	302	−207.90	−24.91	7	−2.28	−1.51	−2.38
PW0714	9.9	6.89	333.0	564	154	167	140	651	0.81	3.19		203	101	548	−192.05	−24.52	5	−2.43	−1.78	−2.12
PW0916	3.9	7.18	199.5	895	409	96	165	736	0.93	35.28	74	329	60.6	612	−230.72	−29.22	10	−2.72	−1.50	−2.02
PW1016	6.3	6.75	87.8	511	258	109	70.8	247	0.40	22.20	51	265	90.8	212	−251.57	−32.14	9	−2.51	−2.55	−2.85
PW1116	7.2	6.61	56.1	318	121	87	30.6	130	0.24	5.34	11	58.7	90.8	106	−251.92	−32.90	-4	−2.45	−3.02	−3.39
PWD14	6.7	7.47	29.3	179	29.7	26.6	21.3	85.3	0.19	3.08		44.9	51.3	41.3	−219.34	−29.45	-6	−3.51	−2.53	−3.94
MP0214	8.1	7.20	132.4	229	63.5	66	143	404	0.86	3.38		208	13.3	446	−190.78	−23.28	4	−3.14	−2.07	−2.36
MP0215	2.2	6.91	152.2	431	73.1	81	182	482	1.08	1.69	2.2	237	13.8	423	−209.85	−26.59	3	−2.61	−2.12	−2.31
MP0216	8.8	6.96	130.9	449	100	69	146	434	0.83	2.49	5.9	237	10.2	365	−214.96	−26.37	7	−3.05	−1.58	−2.42
MP0314	8.3	7.35	194.5	249	66.1	81	189	644	1.02	2.02		184	18.9	692	−188.47	−24.22	5	−3.26	−1.71	−2.02
MP0315	2.2	6.85	218.0	454	85.3	104	239	771	1.29	2.04	0.3	202	23.1	793	−192.33	−24.51	2	−2.53	−1.98	−1.89
MP0414	5.0	7.17	37.9	105	24.3	31.7	32.0	123	0.19	2.99		61.2	9.3	109	−216.94	−28.37	6	−3.45	−2.95	−3.38
MP0514	8.0	7.14	132.1	469	43.2	94	107	482	0.56	17.91		170	15.2	430	−205.50	−26.35	0	−2.77	−1.75	−2.31
MP0516	9.9	7.41	125.0	682	43.9	91	95	472	0.50	3.19	3.6	153	9.0	280	−216.45	−26.24	1	−3.27	−0.91	−2.50
MP0814	9.4	7.02	200.2	323	50.5	100	157	736	0.69	0.54		144	24.5	743	−223.21	−29.54	3	−2.81	−1.86	−1.95
MP0916	7.0	7.55	138.4	729	124	86	118	541	0.62	15.11	42	220	13.8	324	−209.86	−24.91	11	−2.60	−1.72	−2.38
MP1016	9.0	7.33	134.9	683	94.4	79	104	494	0.55	12.71	30	271	<6	303	−234.43	−29.08	8	−2.71	−1.60	−2.45
MP1116	6.4	6.38	10.5	45.9	52.6	<10	10.2	40.4	0.10	2.02	3.7	25.9	<6	36.4	−240.92	−30.68	19	−6.53	−1.96	−4.30
MP1216	6.4	7.28	88.7	398	103	68	73.6	329	0.71	8.99	26	236	9.3	223	−205.76	−24.94	13	−2.78	−2.27	−2.71
MP1316	8.6	6.96	64.4	357	24.6	58	54.7	225	0.28	3.90	8.9	129	7.1	126	−233.73	−29.58	5	−2.92	−2.19	−3.10
MP1516	8.2	7.09	111.9	115	51.8	45	104	422	0.57	3.83	7.8	108	7.62	426	−229.93	−29.26	11	−3.41	−2.63	−2.36
ST0114	8.7	7.24	66.5	295	31.6	51	69.1	219	0.29	10.06		81.5	16.6	159	−205.38	−26.76	4	−3.06	−2.14	−3.01
ST0115	0.9	7.06	66.9	302	30.7	52	66.7	228	0.29	2.08	1.5	66.2	15.8	147	−200.25	−25.41	5	−2.91	−2.43	−3.01
STD14	0.9	6.17	11.5	78.7	23.7	21	38.8	57.4	0.19	34.56		90.1	<6	14.4	−220.22	−29.58	48	−2.59	−4.45	−4.55
STIT16	0.4	6.13	4.9	34.4	43.5	<10	9.8	20.3	0.07	7.88	16.1	36.0	<6	5.00	−213.47	−28.04	76	−3.69	−5.66	−5.43
STAW16	1.4	5.49	3.2	<33	18.9	<10	<4	2.69	0.02	0.07	0.25	<1	5.92	2.39	−237.22	−30.89	46			−6.60
L2515	2.3	8.17	182.4	1500	334	156	448	382	0.55	2.67	0.88	15.0	262	58.1	−119.21	−12.60	7	−4.31	0.46	−3.29
L2516	10.2	9.09	176.4	1475	342	136	406	362	0.47	1.79	0.15	20.3	281	46.6	−116.85	−11.42	4	−4.88	0.90	−3.46
L3815	1.3	7.11	11.2	68.8	10.7	11.6	15.1	34.4	0.08	2.45	3.9	23.6	5.9	15.3	−217.92‡	−28.67‡	13	−3.44	−4.08	−4.72

(Continued)

Table S9. Continued.

Sample	TOC	DOC	DIC	PO4_P†	P†	NH_4	NO_2	NO_3+NO_2	$\delta^{18}O_{SO4}$	$\delta^{34}S_{SO4}$	$^{87}Sr/^{86}Sr$	$\delta^{13}C_{VPDB}$ inorg.	$\delta^{13}C_{VPDB}$ org.	^{14}C inorg.	^{14}C org.	^{3}H
			μmol/L				mg/L		‰			‰		pMC %		T.U.
PW0114																
PW0115				0.0452	0.302	0.570	0.0022	0.1550								
PW0116	2023	866	3197		23.4				−11.92	10.67	0.72900					3.2
PW0214																
PW0516					0.315						0.74662					
PW0616		241	1324		1.49						0.74550					
PW0714																
PW0916					1.80						0.74376					
PW1016					1.51											
PW1116					9.59						0.74435					
PWD14																
MP0214																
MP0215				<0.016	0.225	0.0389	0.0050	1.8600	−21.70	0.92						2.0
MP0216	450	316	475		0.378				−16.06	0.75	0.72894					<0.8
MP0314																
MP0315				<0.016	0.161	0.0543	0.0049	0.8450	−17.64	1.53						3.2
MP0414																
MP0514																
MP0516	208	167	691		0.142				−15.54	1.97	0.74627					2.0
MP0814																
MP0916	200	150	724		0.623				−20.37	1.56	0.74487	−5.2	−25.8	89.4 ± 0.4	82.4 ± 0.4	1.9
MP1016	191	117	674		0.423				−23.82	1.96	0.74396					<0.8
MP1116	58.3	16.7	16.7		0.352						0.74163					0.9
MP1216	300	208	408		0.520				−22.53	1.05	0.72781					2.6
MP1316	150	125	391		0.182				−23.64	1.43	0.74905					1.2
MP1516	408	316	108		0.339				−24.75	−0.30	0.74384	−14.0	−23.2	83.0 ± 0.3	78.3 ± 0.4	1.4
ST0114																
ST0115				<0.016	0.149	0.0142	0.0005	0.1090								
STD14																
STIT16	175	16.7	25.0		0.391						0.72420		−28.0	91.2 ± 0.4	70.5 ± 0.4	<0.8
STAW16					0.077											<0.8
L2515				0.0226	0.277	0.0160	<0.0002	0.0016			0.74373	−3.7	−25.4	154.0 ± 0.5	123.1 ± 0.4	6.7
L2516	1407	1374	1232		0.121				1.42	12.36	0.74480	−5.2	−26.1	148.9 ± 0.3	123.7 ± 0.4	8.6
L3815				<0.016	0.163	0.0007	0.0012	0.0458			0.72978	−10.7	−27.8	93.7 ± 0.8	70.3 ± 0.3	<0.8

†: Analyses of phosphate-phosphorus were performed spectrophotometrically; analyses of total elemental phosphorus were performed with ICP-SFMS.
‡: $\delta^{2}H_{VSMOW}$ and $\delta^{18}O_{VSMOW}$ for sample L3215 were determined at the Environmental Isotope Laboratory, University of Waterloo (Waterloo, ON, Canada).

Table S10. Additional analytical results for the water samples collected in this study.

Sample	Ba	Cd	Co	Cr	Cu	Li	Mn	Mo	Ni	Pb	Rb	Sc	Sr	V	Y	Zn	Zr	U	Th
	µg/L																		
PW0114							<3						148						
PW0115	58.8	0.027	4.44	1.13	21.4	0.74	710	3.02	11.7	0.09	6.78	0.05	102	1.03	0.109	19.9	0.084	0.030	0.076
PW0116	213	0.089	20.30	1.45	54.6	0.72	2780	1.72	59.4	0.19	13.9	0.17	218	1.60	0.453	220	0.305	0.553	0.223
PW0214							181						66.4						
PW0516	165	0.019	2.30	0.23	26.0	0.56	83	2.65	11.8	0.02	5.52	0.05	91.8	0.40	0.028	26.7	<0.03	0.055	<0.02
PW0616	287	0.019	1.28	1.88	48.3	1.07	37	6.88	9.27	0.47	4.41	0.20	66.9	2.69	0.332	45.2	0.146	0.213	0.196
PW0714							183						71.1						
PW0916	303	0.019	2.06	3.42	54.2	2.01	63	4.11	12.2	0.53	3.62	0.36	81.4	4.89	0.424	51.5	0.214	0.167	0.323
PW1016	255	0.014	2.56	2.22	84.0	0.96	52	1.75	24.9	0.48	3.28	0.17	35.0	2.86	0.451	73.3	0.216	0.111	0.261
PW1116	17.6	0.010	1.15	0.65	54.0	0.85	38	1.32	16.5	0.12	4.35	<0.05	21.2	0.89	0.073	18.4	0.042	0.016	0.059
PWD14							19						16.3						
MP0214							31						75.7						
MP0215	31.2	0.015	1.06	0.35	13.3	0.85	66	0.12	26.4	0.02	4.20	<0.05	94.7	0.22	0.077	4.67	<0.03	0.038	0.042
MP0216	92.7	0.015	0.98	0.44	14.0	0.74	49	0.27	16.7	0.05	3.93	<0.05	72.4	0.52	0.121	22.5	0.043	0.082	0.058
MP0314							85						89.1						
MP0315	24.4	0.017	0.96	0.22	8.38	0.97	73	0.08	33.7	<0.01	5.15	<0.05	113	0.12	0.047	12.0	<0.03	0.025	<0.02
MP0414							4						16.5						
MP0514							67						49.1						
MP0516	20.1	0.005	1.04	0.26	7.52	0.61	35	1.29	5.40	0.03	4.48	<0.05	43.6	0.49	0.056	3.41	<0.03	0.115	0.022
MP0814							10						60.2						
MP0916	148	0.008	0.526	1.48	11.5	0.90	16	1.86	3.34	0.17	3.36	0.11	54.1	2.08	0.236	38.0	0.103	0.178	0.123
MP1016	109	0.005	0.642	1.17	9.6	1.23	36	1.05	4.47	0.16	3.12	0.10	47.9	1.82	0.180	37.8	0.077	0.070	0.111
MP1116	46.3	<0.002	0.237	0.22	1.51	0.47	8	0.07	1.48	0.04	0.37	<0.05	8.64	0.48	0.026	8.18	<0.03	0.006	0.028
MP1216	81.0	0.006	0.512	0.82	12.3	0.98	19	0.30	3.82	0.13	2.03	0.10	62.1	1.58	0.161	18.5	0.183	0.054	0.107
MP1316	22.3	0.005	0.560	0.79	7.48	0.44	20	0.87	5.14	0.05	3.19	<0.05	24.4	0.78	0.135	7.16	0.042	0.040	0.050
MP1516	84.4	0.048	2.42	0.75	9.28	1.30	163	0.59	9.79	0.11	2.51	<0.05	49.6	1.01	0.114	11.00	0.058	0.048	0.065
ST0114							14						25.7						
ST0115	11.2	0.005	0.155	0.20	4.21	0.24	9	0.36	3.73	1.55	2.75	<0.05	25.6	0.15	0.043	6.83	<0.03	0.021	0.027
STD14							32						16.3						
STIT16	88.5	0.002	0.345	0.72	3.06	0.47	10	<0.05	1.27	0.10	0.60	0.08	6.43	1.32	0.130	4.32	<0.03	0.017	0.056
STAW16	26.8	<0.002	0.014	<0.01	<0.1	0.04	0	<0.05	<0.05	<0.01	<0.03	<0.05	1.36	0.29	<0.005	1.24	<0.03	0.002	<0.02
L2515	9.79	0.007	0.084	0.56	1.33	1.30	4	<0.05	1.88	0.12	6.63	<0.05	48.4	0.13	0.017	4.57	<0.03	0.011	<0.02
L2516	69.0	<0.002	0.079	0.11	0.86	1.61	3	<0.05	1.47	<0.01	5.38	<0.05	41.4	0.28	0.015	3.27	<0.03	0.012	<0.02
L3815	3.80	0.003	0.212	0.24	1.60	0.23	17	<0.05	1.11	0.05	0.70	<0.05	7.22	0.37	0.027	2.01	<0.03	0.006	<0.02

(continued)

Table S10. Continued.

Sample	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
	µg/L													
PW0114														
PW0115	0.803	1.450	0.156	0.538	0.067	0.010	0.038	<0.005	0.022	<0.005	0.010	<0.004	0.008	<0.005
PW0116	3.810	6.830	0.668	2.500	0.309	0.055	0.164	0.017	0.081	0.015	0.038	0.005	0.030	0.005
PW0214														
PW0516	0.205	0.310	0.033	0.128	0.016	0.008	0.010	<0.005	<0.005	<0.005	<0.005	<0.004	<0.005	<0.005
PW0616	2.410	4.540	0.475	1.640	0.240	0.046	0.130	0.014	0.073	0.012	0.029	<0.004	0.023	<0.005
PW0714														
PW0916	2.890	5.510	0.559	1.910	0.305	0.060	0.167	0.019	0.094	0.017	0.041	0.005	0.032	<0.005
PW1016	3.150	6.340	0.625	2.230	0.316	0.060	0.181	0.020	0.105	0.017	0.043	0.005	0.032	0.005
PW1116	0.476	0.909	0.095	0.324	0.041	0.008	0.029	<0.005	0.015	<0.005	0.007	<0.004	0.006	<0.005
PWD14														
MP0214														
MP0215	0.542	0.905	0.107	0.386	0.050	0.008	0.028	<0.005	0.015	<0.005	0.007	<0.004	0.006	<0.005
MP0216	0.827	1.420	0.164	0.573	0.071	0.015	0.042	<0.005	0.022	<0.005	0.010	<0.004	0.007	<0.005
MP0314														
MP0315	0.350	0.490	0.058	0.206	0.026	<0.005	0.015	<0.005	0.008	<0.005	<0.005	<0.004	<0.005	<0.005
MP0414														
MP0514														
MP0516	0.346	0.550	0.067	0.229	0.031	0.007	0.019	<0.005	0.009	<0.005	<0.005	<0.004	<0.005	<0.005
MP0814														
MP0916	1.370	2.410	0.261	0.875	0.139	0.033	0.074	0.008	0.043	0.007	0.019	<0.004	0.013	<0.005
MP1016	1.090	2.000	0.210	0.733	0.114	0.025	0.067	0.007	0.037	0.007	0.016	<0.004	0.010	<0.005
MP1116	0.211	0.423	0.044	0.141	0.018	0.005	0.010	<0.005	0.005	<0.005	<0.005	<0.004	<0.005	<0.005
MP1216	1.160	1.980	0.225	0.774	0.096	0.021	0.061	0.006	0.033	0.005	0.013	<0.004	0.010	<0.005
MP1316	0.825	1.340	0.161	0.588	0.075	0.015	0.049	<0.005	0.023	<0.005	0.011	<0.004	0.009	<0.005
MP1516	0.622	1.180	0.124	0.442	0.058	0.015	0.040	<0.005	0.023	<0.005	0.011	<0.004	0.008	<0.005
ST0114														
ST0115	0.357	0.516	0.069	0.245	0.031	<0.005	0.019	<0.005	0.009	<0.005	<0.005	<0.004	<0.005	<0.005
STD14														
STIT16	1.060	2.030	0.198	0.673	0.088	0.022	0.048	0.005	0.025	<0.005	0.010	<0.004	0.007	<0.005
STAW16	0.007	0.015	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.004	<0.005	<0.005
L2515	0.069	0.122	0.016	0.055	0.008	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.004	<0.005	<0.005
L2516	0.034	0.054	0.008	0.028	0.014	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.004	<0.005	<0.005
L3815	0.213	0.410	0.044	0.147	0.018	<0.005	0.010	<0.005	0.006	<0.005	<0.005	<0.004	<0.005	<0.005

Stability diagrams

Figure S1 shows the location of the studied moraine porewaters and ponds in diagrams that consider the stability fields of some key aluminosilicate minerals.

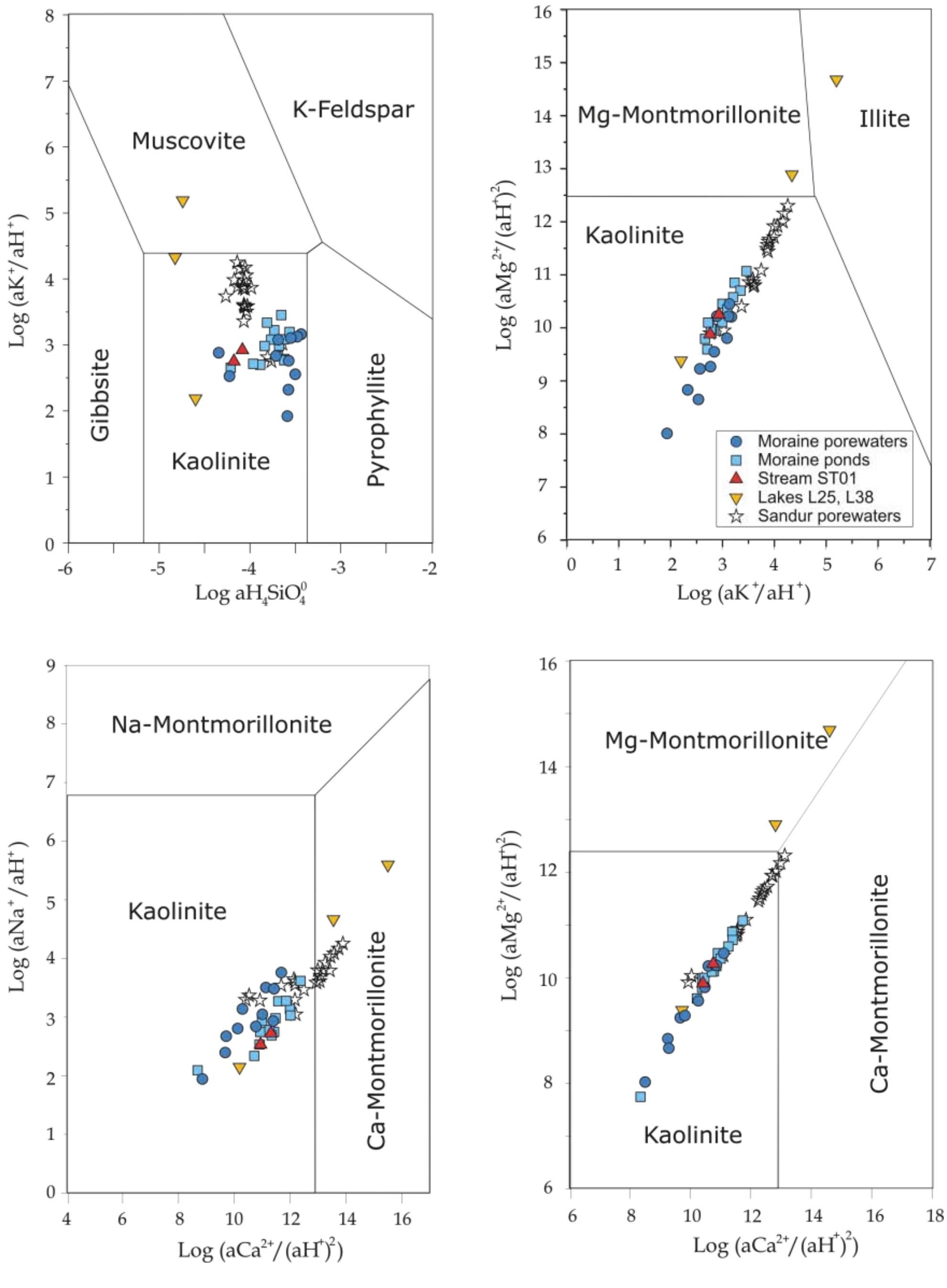


Figure S1: Mineral stability diagrams calculated for 7 ºC showing the composition the studied waters. Sandur porewaters from (Deuerling et al. 2018) are also plotted for comparison. The field boundaries are calculated using the data in (Helgeson 1969; Robie, Hemingway, and Fisher 1979; Hemingway, Haas, Jr., and Robinson, Jr. 1982). Upper right and bottom diagrams have been constructed considering a value of −3.7 for the logarithm of silica activity.

Additional diagrams

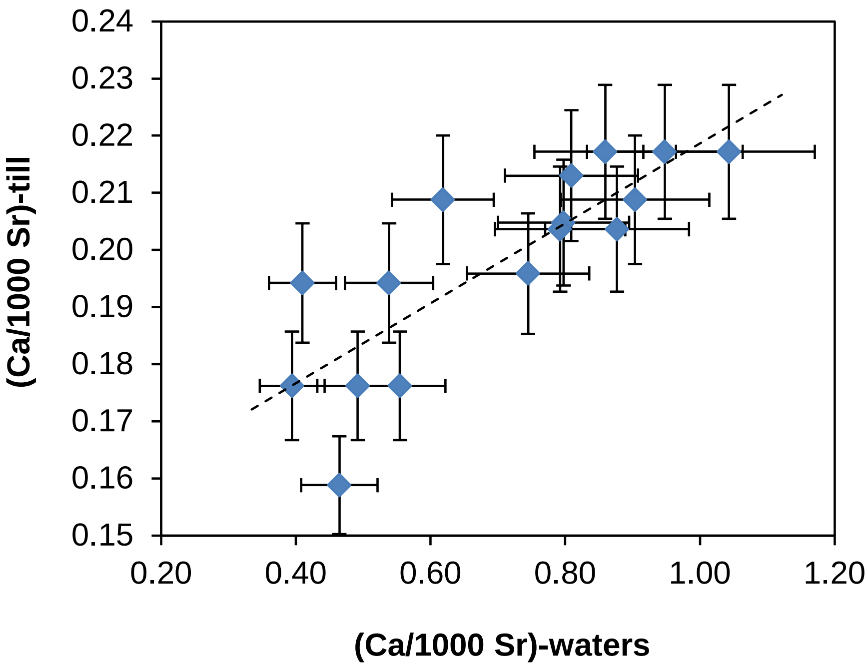
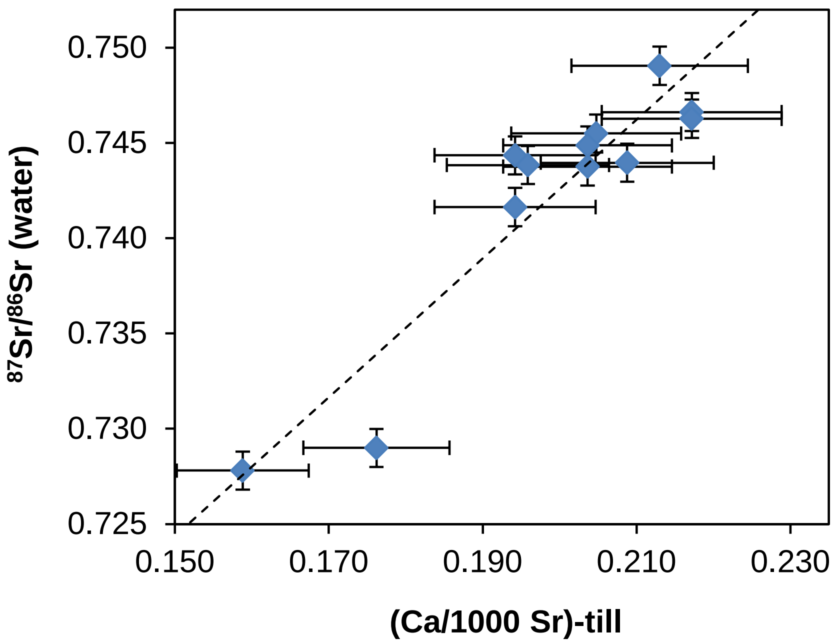


Figure S2: Molar ratios (Ca/(1000 Sr) for the two finest till fractions (data from Tables S3 and S4), plotted against the corresponding values for the waters sampled at the same location (data from Table S9). The regression line has R = 0.82, and the error bars correspond to the maximum uncertainty of the analyses.



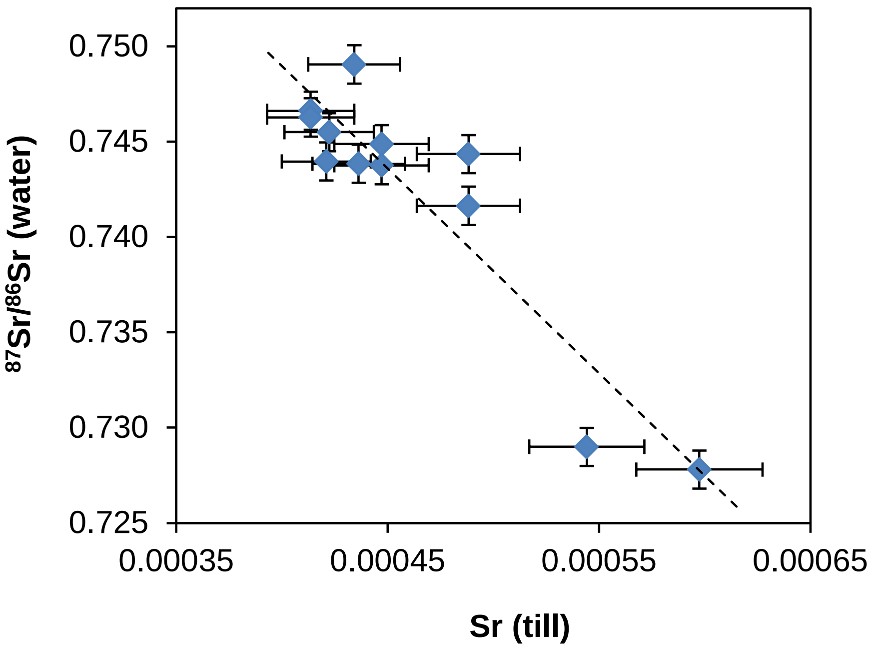


Figure S3: Top: $^{87}Sr/^{86}Sr$ ratios for the waters (data from Table S9) plotted against the molar ratios (Ca/(1000 Sr) for the two finest till fractions sampled at the same location (data from Tables S3 and S4); the regression line has R = 0.93. Bottom: $^{87}Sr/^{86}Sr$ ratios for the waters (data from Table S9) plotted against the strontium contents of the two finest till fractions (mol/100 g, data from Table S4) sampled at the same location; the regression line has R = 0.92. For both diagrams the error bars represent the maximum uncertainties reported for the analytical procedures.

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Photographs of some sampling points

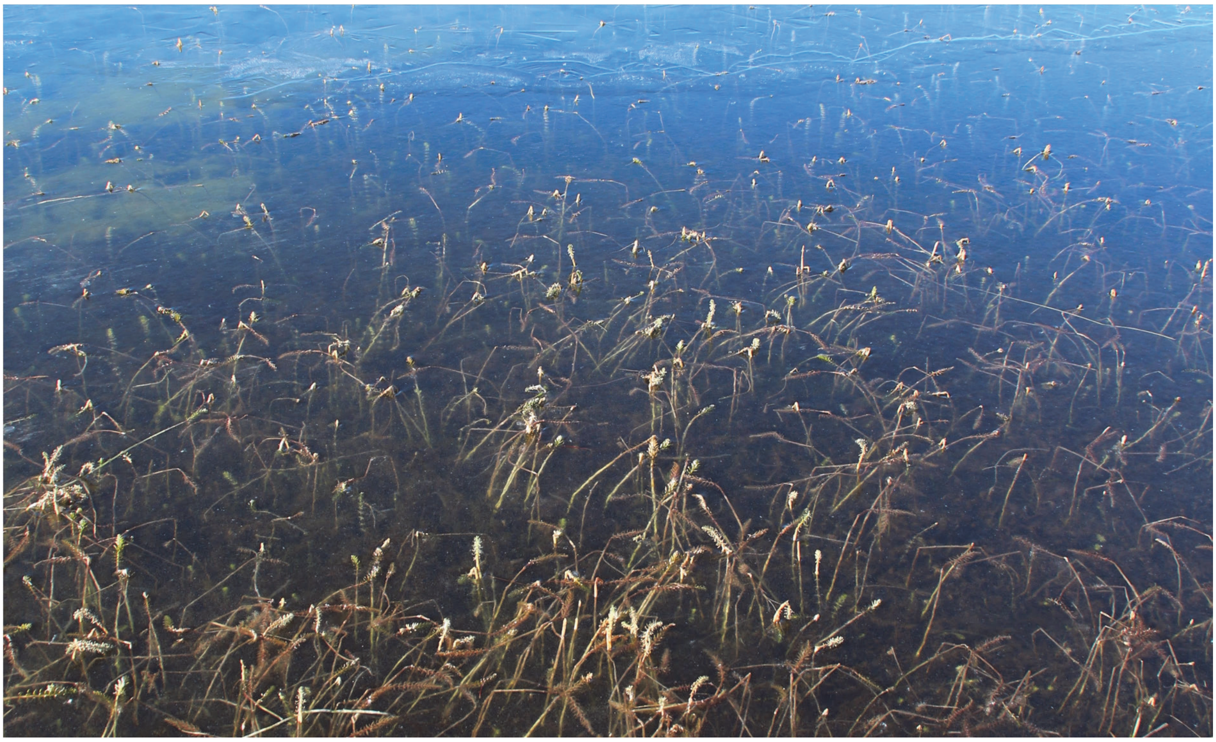
View of the “delta” facing East. The subglacial discharge sampling point (the “ice tunnel”) is at the bottom of the dark glacier tongue in the left side of the photograph. The “ice tunnel” is the source of meltwater passing through the delta. The northern part of the study moraine may be seen behind the dark glacier tongue with the ice sheet in the back. Immediately to the right of the glacier tongue there is a border of bare bedrock, followed by a hill partly covered by till, vegetation and erratics. On the top of the hill, to the right of the photograph (almost too small to be seen) there is a container enclosing the top of the GAP-04 deep borehole and its instrumentation. Photograph taken on 2014-08-30 at 16:56 local time. © I Puigdomenech.

View of MP09 (moraine pond 09) facing the North-East, in the mid part of the moraine, with the ice sheet on the background. The PW09 (porewater tube 09) may be seen at the left of the picture. Dried-up and withered small bushes and grass (reddish-brown) may be seen on the shores. Photograph taken 2016-08-27 at 13:20 local time. © I Puigdomenech.

View of MP15 (moraine pond 15) facing South, in the southern part of the studied moraine. The moraine was in this location fully water saturated; the darker patches are newly exposed volumes, probably due to glacier movements. Photograph taken on 2016-08-29 at 16:13 local time. © E-L Tullborg.

View of the L25 (“drilling water pond”) facing the North-West, with the ice sheet (Isunnguata Sermia) on the background with a terminal moraine (not investigated in this study). The surface of the lake is covered by a few cm thick layer of ice. Photograph taken 2015-09-25 at 14:40 local time.
© I Puigdomenech.

Macrophytes growing in L25 (“drilling water pond”). The surface of the lake is covered by a few cm thick layer of ice; the top of some of the aquatic plants protruding slightly through the ice layer. Photograph taken 2015-09-25 at 14:47 local time. © I Puigdomenech.



View of the north shore of L38 (“ice dammed lake”) facing East, with Russell glacier in the background. Photograph taken on 2015-09-23 at 14:57 local time. © E-L Tullborg.