

Supplementary data Table 1a) *Position of samples, physical properties, chemical composition, and characteristics of sampled boulder in the Horcones and lower Las Cuevas valley*

	DT02	H 13	H 21	H 32	H 36	AT 01	AT 05	PE 01	PE 02	PE 03
Rock type	Volcanic Breccia	Volcanic Breccia	Sandstone – Tordillo Formation	Sediment Breccia	Sediment Breccia	Andesitic Breccia	Andesitic Breccia	Granite	Dacitic breccia	Dacite
Density [g/cm ³]	2.5363	2.6430	2.4885	2.5094	2.6188	2.6996	2.6382	2.5914	2.6803	2.5784
Porosity [%]	0.0078	0.0078	0.01	0.01	0.01	0.0078	0.0078	0.01	0.01	0.01
Elevation [m]	3573	3458	3431	3050	2928	3927	3594	2535	2516	2525
Lat	32.7640	32.7615	32.7626	32.7988	32.8154	32.7767	32.7651	32.8572	32.8574	32.8578
Long	69.9839	69.9697	69.9688	69.9436	69.9432	69.9988	69.9826	69.5476	69.5476	69.5476
CO ₂ [%]	0.8	1.8	7.25	6.7	2.05	1.15	2.1	0.9	6.15	1
Na ₂ O [%]	4.44	3.67	6.07	3.94	3.73	5.26	5.11	2.93	3.37	5.23
MgO [%]	2.25	2.32	0.38	1.71	1.54	1.84	0.93	0.53	2.36	2.9
Al ₂ O ₃ [%]	17.1	16.4	13.2	13.9	16.6	18.9	15.2	13.1	15	16.1
SiO ₂ [%]	59.8	58	57.7	56.3	58.8	56	63.2	72.5	48.5	61.7
P ₂ O ₅ [%]	0.27	0.24	0.14	0.23	0.28	0.38	0.22	0.23	0.46	0.24
K ₂ O [%]	2.01	1.7	1.56	1.86	3.07	1.81	2.18	4.7	1.43	2.81
CaO [%]	5.79	7.96	9.06	8.43	5.37	6.32	4.36	0.76	12.3	3.93
TiO ₂ [%]	0.67	0.8	0.57	0.79	0.54	0.83	0.62	0.3	1.16	0.6
MnO [%]	0.1	0.12	0.16	0.13	0.11	0.11	0.09	0.05	0.13	0.09
Fe ₂ O ₃ [%]	5.71	5.94	3.39	5.87	6.83	6.29	5.09	2.45	8.27	4.7
Cl [ppm]										
B [ppm]	8	9	24	27	23	19	23	17	17	22
Sm [ppm]	2	3	5	3	2	4	<2 (1.5)	4	2	3
Gd [ppm]	2	3	5	3	2	4	<2 (1.5)	4	2	3
U [ppm]	1.6	1	1.9	1.4	0.5	0.8	0.6	5.3	1.7	2.4
Th [ppm]	5.6	4.1	6	5	3.6	2.9	3	9.1	5.4	5.1
Snow cover *	54	55	55	45	55	1.2	0.33	0.53	0.53	0.53
Boulder dimension**	12×10×5	2.5×2×1.5	2×2×1.5	4×4×2.5	2×2×1.5	30×15×7	25×15×4	1×1×1	4×2×2	1×1×0.8
Dip direction [°]	N/A	N/A	17	N/A	N/A	28	22	N/A	N/A	N/A
Shielding	0.98	0.99	0.99	0.97	0.99	0.99	0.88	0.97	0.98	0.98

* Average annual snow cover in cm

** Length, width, height above surrounding ground in m

Supplementary data Table 1b) Position of samples, physical properties, chemical composition, and characteristics of sampled boulder in the upper Las Cuevas valley

	CU0101	CU0102	CU0201	CU0202	CUA01	CUA02	CU3	CU401	CU402
Rock type	Andesitic conglomerate	Andesitic conglomerate	Andesitic conglomerate	Andesitic conglomerate	Andesitic conglomerate	Andesitic conglomerate	Andesitic conglomerate	Andesitic conglomerate	Andesitic conglomerate
Density [g/cm ³]	2.7250	2.7250	2.7250	2.7250	2.7250	2.7250	2.7250	2.7250	2.7250
Porosity [%]	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072
Elevation [m]	3171	3171	3123	3123	3300	3575	3621	3606	3483
Lat	32.8125	32.8125	32.8144	32.8144	32.8005	32.8022	32.8239	32.7995	32.8015
Long	70.0463	70.0464	70.0358	70.0358	70.0384	70.0391	70.0411	70.5467	70.5467
CO ₂ [%]	1.1	1.15	1.85	1.95	1.9	1.35	1.2	1.6	0.9
Na ₂ O [%]	4.16	4.91	3.86	4.79	4.13	4.39	4.93	4.46	5.65
MgO [%]	2.02	1.65	2.87	2.86	3.23	2.21	1.4	2.49	0.83
Al ₂ O ₃ [%]	18.7	19.7	18	18.6	17.8	17.8	18.2	17.8	16.7
SiO ₂ [%]	53.3	55.3	54.2	56.3	54.7	56.7	54.4	53.7	67.5
P ₂ O ₅ [%]	0.29	0.37	0.35	0.34	0.31	0.35	0.29	0.3	0.16
K ₂ O [%]	1.83	1.51	1.33	0.81	1.63	2.04	2.2	1.23	2.37
CaO [%]	7.72	6.68	6.45	5.99	6.5	6.03	7.2	7.32	2.85
TiO ₂ [%]	1.01	0.73	1.09	0.71	0.96	0.86	1.03	1.08	0.39
MnO [%]	0.15	0.1	0.14	0.14	0.12	0.1	0.1	0.12	0.03
Fe ₂ O ₃ [%]	8.69	6.93	8.95	6.78	8.43	7.29	7.84	9.34	2.24
Cl [ppm]									
B [ppm]	28	15	19	17	34	23	35	24	10
Sm [ppm]	4	3	2	2	3	3	3	3	<2 (1.5)
Gd [ppm]	4	3	2	2	3	3	3	3	<2 (1.5)
U [ppm]	1.3	0.8	1	0.3	1	1.1	0.9	1.1	1.7
Th [ppm]	4.7	3.2	3.6	1.1	4.1	4.6	3.2	3.8	4.4
Snow cover *	33	43	33	80	0	0	0.63	0.96	0.96
Boulder dimension**	10×5×5	5×3×1.5	5×4×2	2×2×1	Sliding surface	Sliding surface	10×5×5	1.5×1.5×1	2.5×2×0.5
Dip direction [°]	N/A	N/A	N/A	10	40	45	N/A	N/A	N/A
Shielding	0.92	0.92	1	0.9	0.67	0.62	0.95	0.97	0.95

* Average annual snow cover in cm

** Length, width, height above surrounding ground in m