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Supplement of

Late Quaternary glacial maxima in southern Patagonia: insights from the Lago Argentino glacier lobe

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Table S1: ^{10}Be ages for boulders sampled from the three moraine complexes in this study. We report the ages according to the different scaling schemes time dependent scaling (Lm: Lal, 1991; Stone, 2000), the non-time-dependent scaling (St: Stone, 2000; Lal, 1991), and the LSDn scaling scheme developed by Lifton et al. (2014) along with 1sigma internal uncertainty. We calculate these ages with three different erosion rates as a part of a sensitivity test with published erosion rates in Patagonia ranging from 0.2–1.4 mm/ka according to Douglass et al. (2006) and Kaplan et al. (2005), respectively. These ages were calculated using a local production rate developed for the late Glacial chronology at Lago Argentino (3.71±0.11 atoms/g/yr: Kaplan et al., 2011).

Sample	Age (ka) - St	Age (ka) - Lm	**Age (ka) - LDSn**	Age (ka) - St	Age (ka) - Lm	**Age (ka) - LDSn**	Age (ka) - St	Age (ka) - Lm	**Age (ka) - LDSn**
	Erosion rate = 0 mm/yr			**Erosion rate = 0.2 mm/yr**			**Erosion rate = 1.4 mm/yr**		
Arroyo Verde II									
AV-001	258.04 ± 12.26	250.07 ± 11.86	**243.05 ± 11.50**	259.18 ± 12.37	251.15 ± 11.96	244.06 ± 11.60	266.34 ± 13.09	257.86 ± 12.63	250.40 ± 12.23
AV-002	139.40 ± 6.59	135.59 ± 6.41	**132.10 ± 6.24**	139.73 ± 6.63	135.90 ± 6.44	132.40 ± 6.27	141.73 ± 6.82	137.79 ± 6.62	134.18 ± 6.44
AV-003	172.62 ± 8.31	167.79 ± 8.06	**163.59 ± 7.85**	173.13 ± 8.35	168.27 ± 8.11	164.04 ± 7.90	176.23 ± 8.67	171.19 ± 8.40	166.83 ± 8.17
AV-004	172.13 ± 8.39	167.21 ± 8.14	**163.15 ± 7.93**	172.63 ± 8.44	167.68 ± 8.19	163.61 ± 7.99	175.72 ± 8.75	170.59 ± 8.48	166.39 ± 8.26
El Tranquilo II									
ET-002	61.44 ± 3.09	60.18 ± 3.03	**59.14 ± 2.97**	61.50 ± 3.10	60.24 ± 3.03	59.20 ± 2.98	61.88 ± 3.14	60.60 ± 3.07	59.54 ± 3.02
ET-004	35.69 ± 2.44	34.99 ± 2.39	**34.39 ± 2.35**	35.67 ± 2.44	35.01 ± 2.40	34.42 ± 2.35	35.83 ± 2.46	35.13 ± 2.41	34.53 ± 2.37
ET-006	32.02 ± 2.20	31.41 ± 2.16	**30.86 ± 2.12**	32.04 ± 2.20	31.43 ± 2.16	30.88 ± 2.12	32.14 ± 2.22	31.523 ± 2.17	30.98 ± 2.14
ET-012	44.64 ± 2.16	43.68 ± 21.1	**42.79 ± 2.07**	44.67 ± 2.16	43.72 ± 2.12	42.82 ± 2.08	44.87 ± 2.19	43.91 ± 2.14	43.00 ± 2.09
ET-013	38.49 ± 6.04	37.72 ± 5.92	**37.10 ± 5.82**	38.51 ± 6.05	37.75 ± 5.93	37.13 ± 5.83	38.66 ± 6.10	37.88 ± 5.97	37.26 ± 5.87
ET-014	47.83 ± 2.88	46.78 ± 2.82	**45.84 ± 2.77**	47.87 ± 2.89	46.82 ± 2.83	45.88 ± 2.77	48.10 ± 2.92	47047 ± 2854	46.09 ± 2.80
ET-017	39.04 ± 2.46	38.27 ± 2.42	**37.60 ± 2.37**	39.06 ± 2.47	38.29 ± 2.42	37.62 ± 2.38	39.21 ± 2.49	38.43 ± 2.44	37.75 ± 2.39
ET-018	28.69 ± 1.59	28.20 ± 1.57	**27.73 ± 1.54**	28.70 ± 1.60	28.21 ± 1.57	27.75 ± 1.54	28.79 ± 1.61	28.29 ± 1.58	27.82 ± 1.55
El Tranquilo I									
ET-007	39.18 ± 1.96	38.39 ± 1.92	**37.76 ± 1.89**	39.20 ± 1.97	38.42 ± 1.93	37.79 ± 1.89	39.35 ± 1.98	38.56 ± 1.94	37.93 ± 1.91
ET-008	38.60 ± 1.96	37.84 ± 1.91	**37.22 ± 1.89**	38.63 ± 1.96	37.86 ± 1.92	37.24 ± 1.89	38.78 ± 1.98	38.01 ± 1.94	37.38 ± 1.90
ET-009	37.04 ± 1.85	36.32 ± 1.82	**35.74 ± 1.78**	37.07 ± 1.86	36.34 ± 1.82	35.76 ± 1.79	37.20 ± 1.87	36.47 ± 1.83	35.89 ± 1.80
ET-010	39.20 ± 1.90	38.41 ± 1.86	**37.78 ± 1.83**	39.22 ± 1.90	38.43 ± 1.87	37.81 ± 1.83	39.38 ± 1.92	38.58 ± 1.88	37.95 ± 1.85
ET-011	36.49 ± 2.26	35.78 ± 2.21	**35.21 ± 2.18**	36.51 ± 2.26	35.80 ± 2.22	35.23 ± 2.18	36.64 ± 2.28	35.93 ± 2.23	35.35 ± 2.20
LA-01	37.13 ± 2.66	36.38 ± 2.61	**35.76 ± 2.56**	37.15 ± 2.67	36.40 ± 2.6	35.78 ± 2.57	37.29 ± 2.69	36.53 ± 2.63	35.90 ± 2.59

Table S2. ^{10}Be Blank Data. All uncertainties are 1σ.					
Blank ID	^{9}Be Added (g)	^{10}Be/^{9}Be[a]	Uncertainty	^{10}Be (10^4 atoms)	Uncertainty (10^4 atoms)
Blank_34-1	0.7697	1.06E-15	3.55E-16	1.377247	0.459392
Blank_34-2	0.7699	1.24E-15	3.59E-16	1.608174	0.464404
Blank_34-3	0.7689	6.17E-16	3.43E-16	0.798183	0.44401
Blank_34-4	0.7673	7.73E-16	5.28E-16	0.997466	0.680543
Blank_34-5	0.7651	6.94E-16	5.45E-16	0.892893	0.70129
Blank_34-6	0.7657	9.46E-16	5.33E-16	1.217989	0.685859
Blank_45-2	0.7652	2.33E-15	8.23E-16	2.992946	1.058384
Blank_45-9	0.7646	6.78E-16	9.77E-16	0.871739	1.256187

[a]Measured relative to standard 07KNSTD with an assumed ^{10}Be/^{9}Be ratio of 2.85×10^{-12} (Nishiizumi et al., 2007).

[b]Carrier used OSUWhite (251.6 ppm ^{9}Be)

Table S3. IRSL samples field information.

Sample Name	Burial Depth (m)	Lat	Lon	Elevation (m)
SCR20-OSL-01	10.6	-50.199602	-71.519789	158
SCR20-OSL-02	2.7	-50.199603	-71.519617	158
SCR20-OSL-03	1.2	-50.177343	-71.566987	182.6
SCR20-OSL-04	1.75	-50.231698	-71.435108	143.9
SCR20-OSL-05	3.45	-50.231727	-71.434802	149.7
SCR20-OSL-06	2.25	-50.231727	-71.434802	149.7

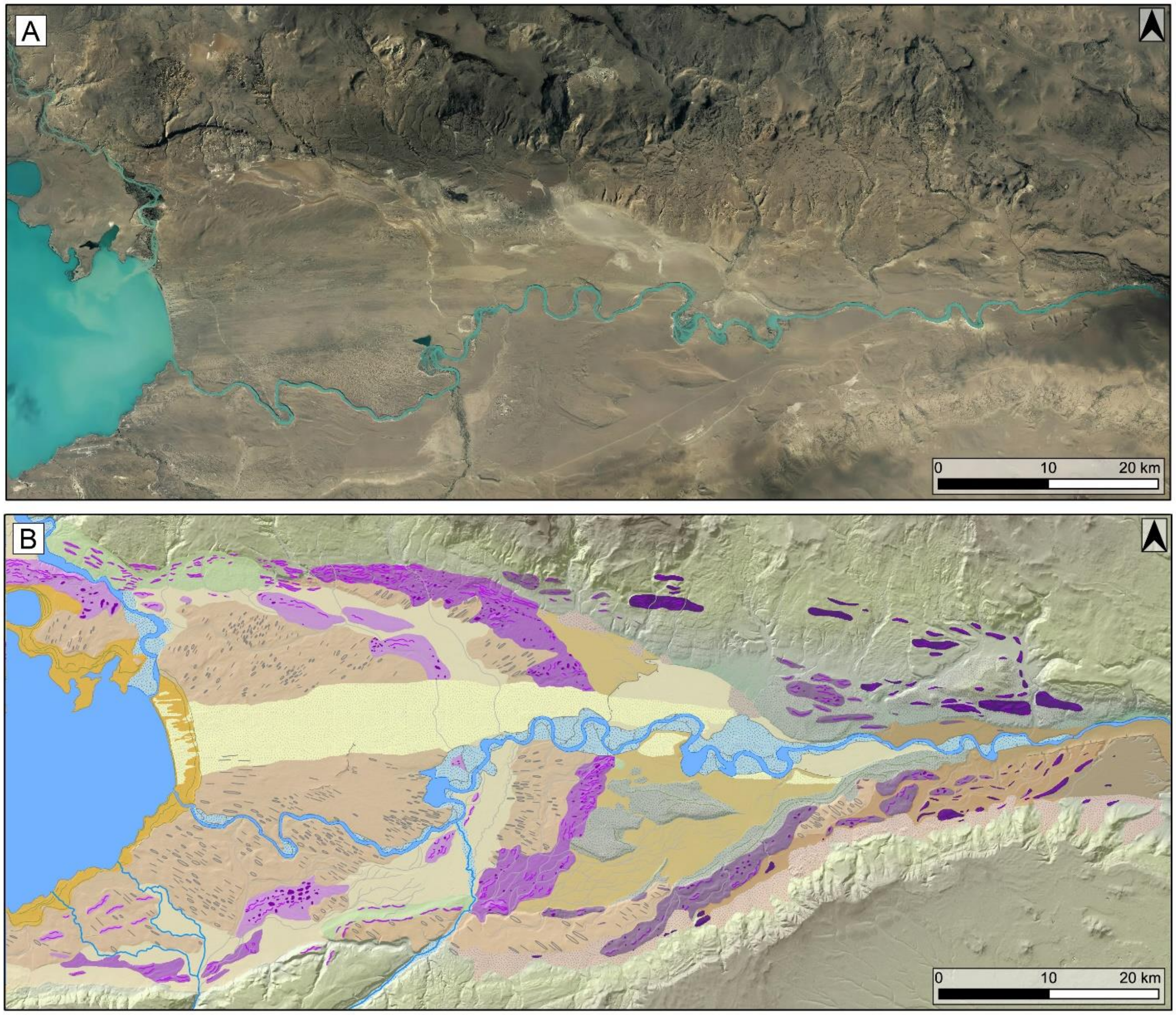

A
0
10
20 km
B
0
10
20 km

Fig. S 1

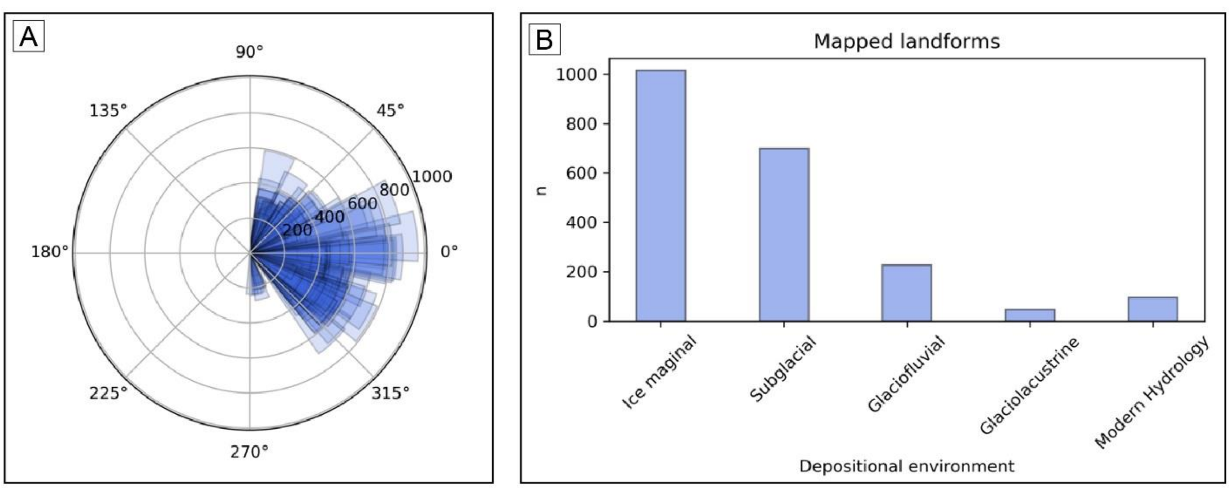

A
90°
135°
45°
180°
0°
225°
315°
270°
200
400
600
800
1000
B
Mapped landforms
n
1000
800
600
400
200
0
Ice maginal
Subglacial
Glaciofluvial
Glaciolacustrine
Modern Hydrology
Depositional environment

Fig. S 2

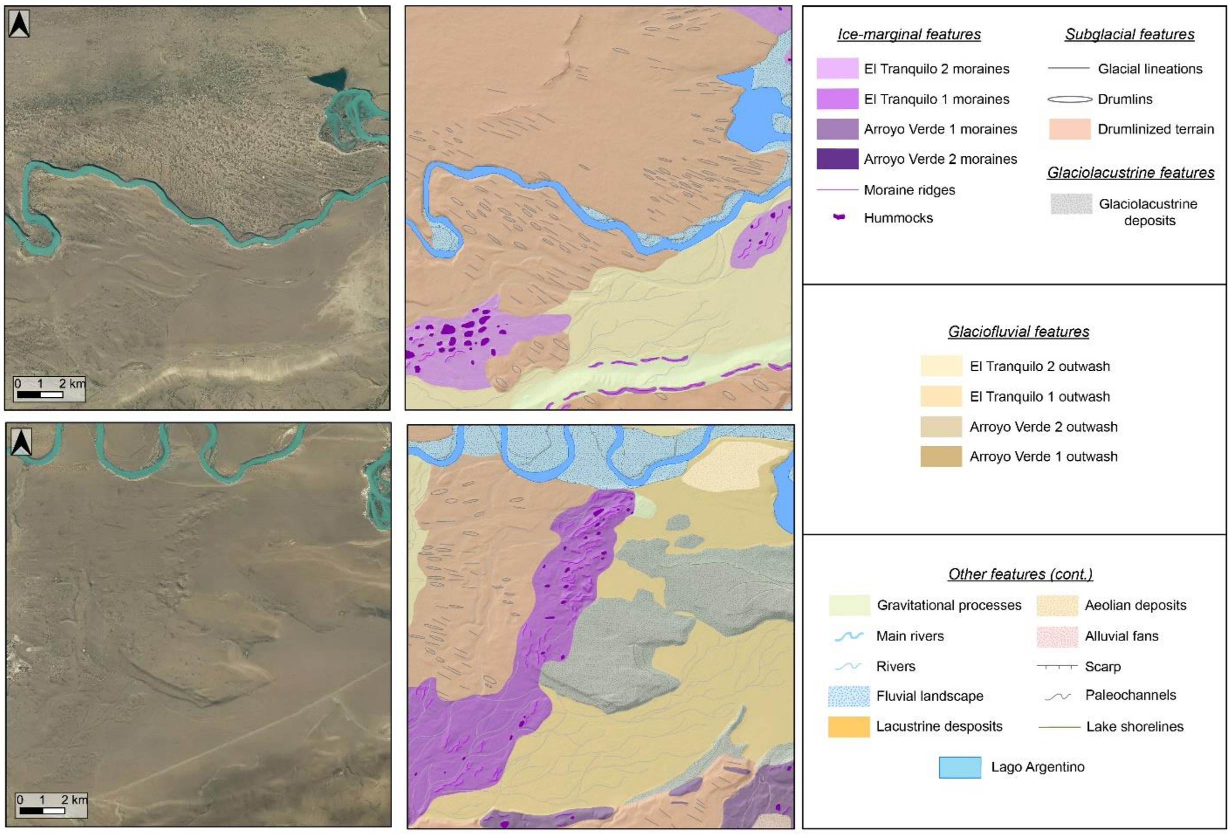

0 1 2 km
0 1 2 km
Ice-marginal features
El Tranquilo 2 moraines
El Tranquilo 1 moraines
Arroyo Verde 1 moraines
Arroyo Verde 2 moraines
Moraine ridges
Hummocks
Subglacial features
Glacial lineations
Drumlins
Drumlinized terrain
Glaciolacustrine features
Glaciolacustrine deposits
Glaciofluvial features
El Tranquilo 2 outwash
El Tranquilo 1 outwash
Arroyo Verde 2 outwash
Arroyo Verde 1 outwash
Other features (cont.)
Gravitational processes
Main rivers
Rivers
Fluvial landscape
Lacustrine desposits
Aeolian deposits
Alluvial fans
Scarp
Paleochannels
Lake shorelines
Lago Argentino

Fig. S 3

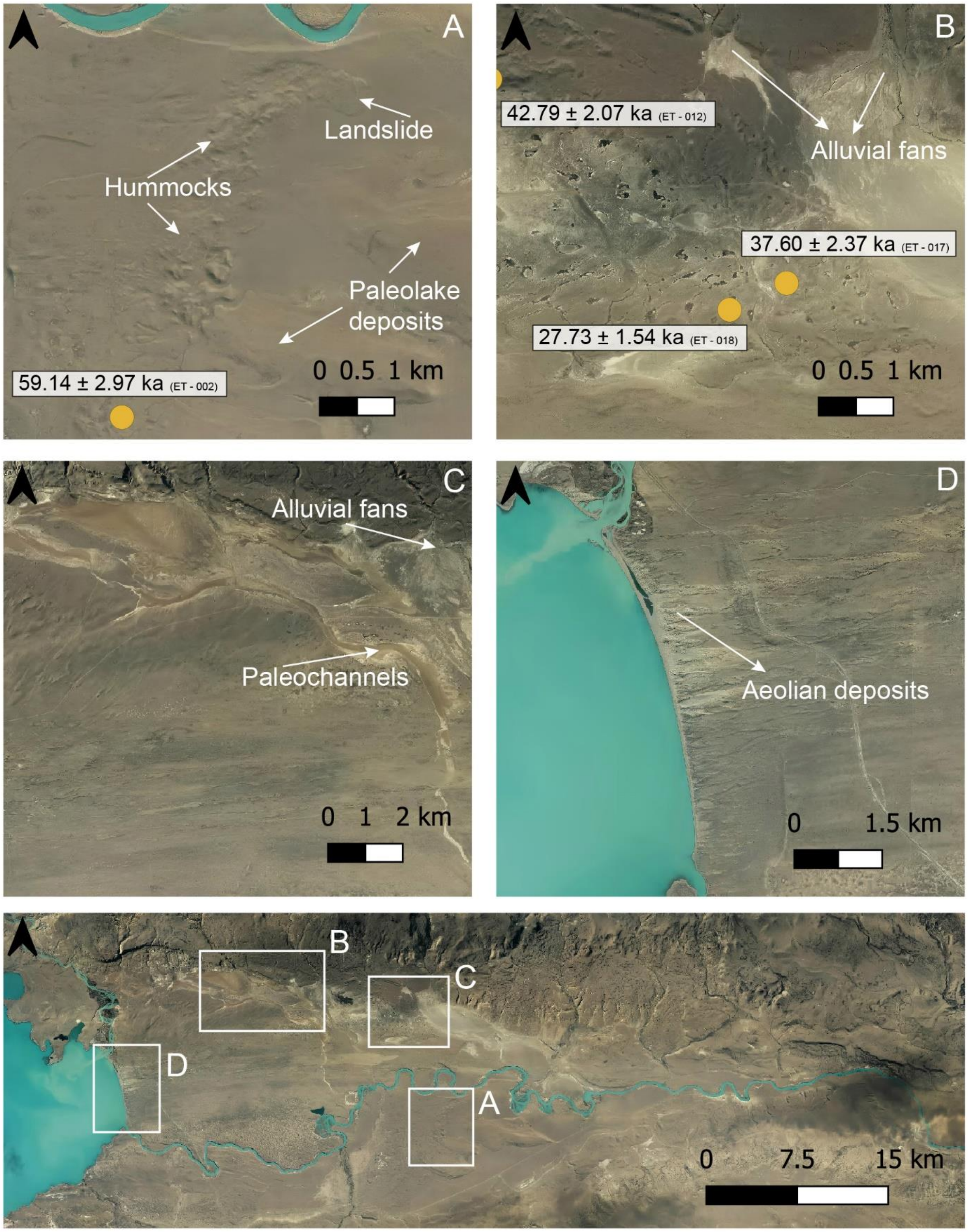
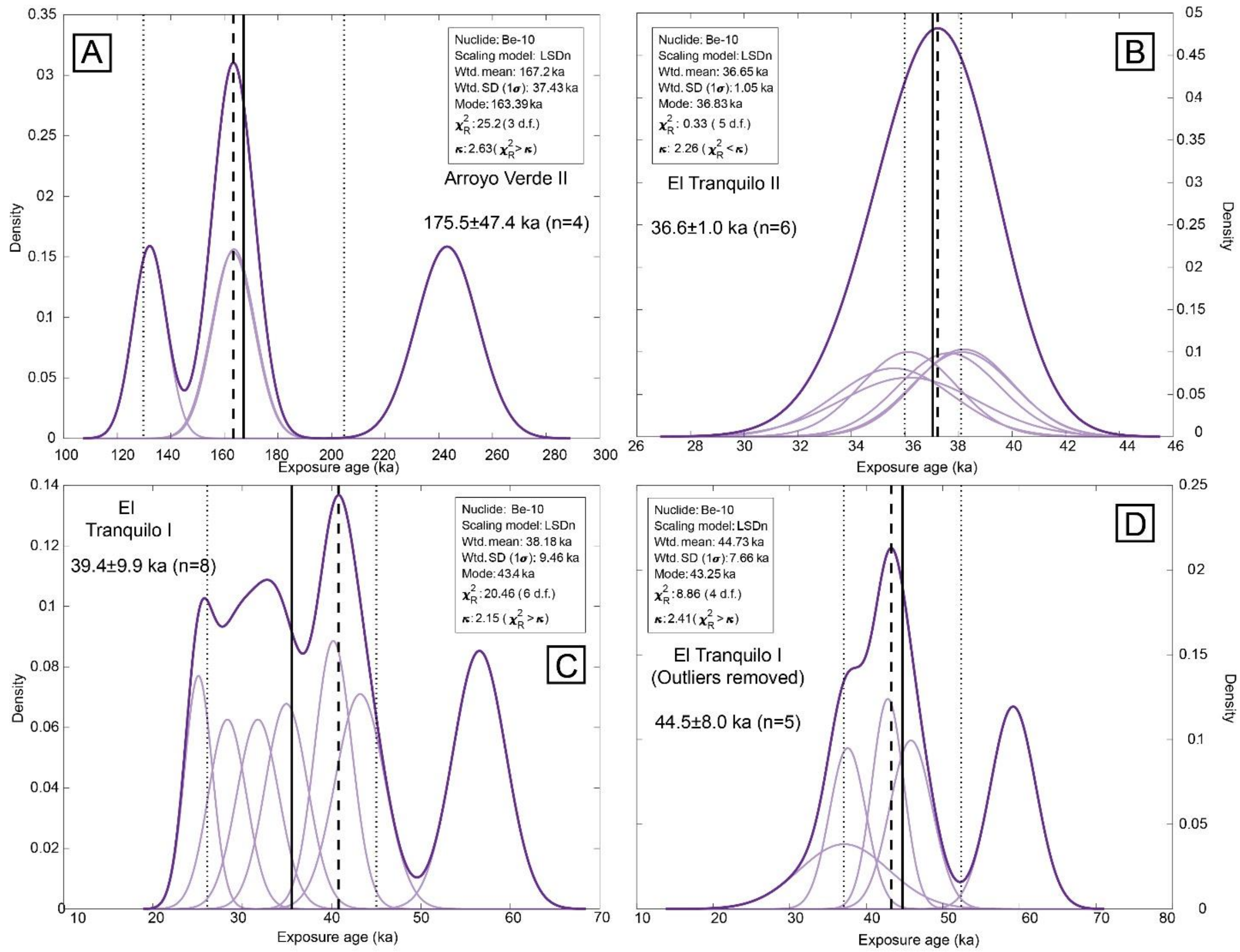

A
Landslide
Hummocks
Paleolake deposits
59.14 ± 2.97 ka (ET - 002)
0 0.5 1 km
B
42.79 ± 2.07 ka (ET - 012)
Alluvial fans
37.60 ± 2.37 ka (ET - 017)
27.73 ± 1.54 ka (ET - 018)
0 0.5 1 km
C
Alluvial fans
Paleochannels
0 1 2 km
D
Aeolian deposits
0 1.5 km
B
C
D
A
0 7.5 15 km

Fig. S 4



A
Nuclide: Be-10
Scaling model: LSDn
Wtd. mean: 167.2 ka
Wtd. SD (1σ): 37.43 ka
Mode: 163.39 ka
χ²R: 25.2 (3 d.f.)
κ: 2.63 (χ²R > κ)
Arroyo Verde II
175.5±47.4 ka (n=4)
Density
Exposure age (ka)
B
Nuclide: Be-10
Scaling model: LSDn
Wtd. mean: 36.65 ka
Wtd. SD (1σ): 1.05 ka
Mode: 36.83 ka
χ²R: 0.33 (5 d.f.)
κ: 2.26 (χ²R < κ)
El Tranquilo II
36.6±1.0 ka (n=6)
Density
Exposure age (ka)
C
El Tranquilo I
39.4±9.9 ka (n=8)
Nuclide: Be-10
Scaling model: LSDn
Wtd. mean: 38.18 ka
Wtd. SD (1σ): 9.46 ka
Mode: 43.4 ka
χ²R: 20.46 (6 d.f.)
κ: 2.15 (χ²R > κ)
Density
Exposure age (ka)
D
Nuclide: Be-10
Scaling model: LSDn
Wtd. mean: 44.73 ka
Wtd. SD (1σ): 7.66 ka
Mode: 43.25 ka
χ²R: 8.86 (4 d.f.)
κ: 2.41 (χ²R > κ)
El Tranquilo I
(Outliers removed)
44.5±8.0 ka (n=5)
Density
Exposure age (ka)

Fig. S 5

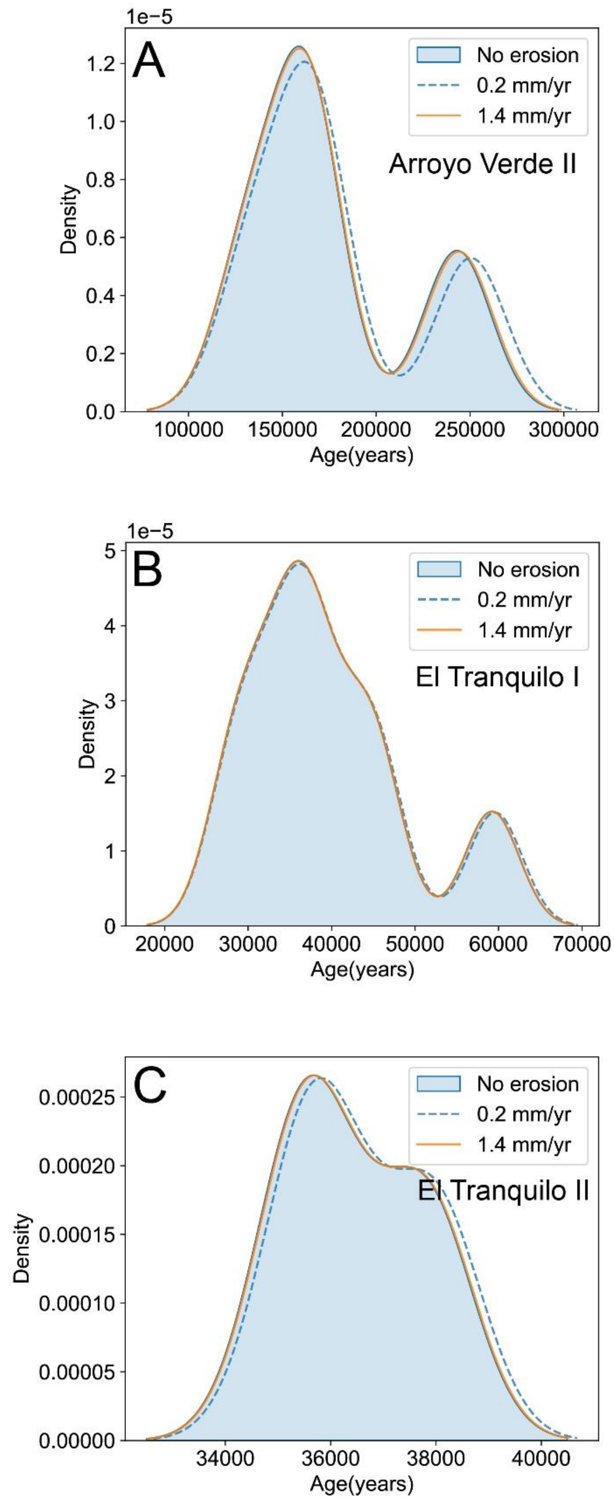

1e−5
A
No erosion
0.2 mm/yr
1.4 mm/yr
Arroyo Verde II
Density
Age(years)
1e−5
B
No erosion
0.2 mm/yr
1.4 mm/yr
El Tranquilo I
Density
Age(years)
C
No erosion
0.2 mm/yr
1.4 mm/yr
El Tranquilo II
Density
Age(years)

Fig. S 6

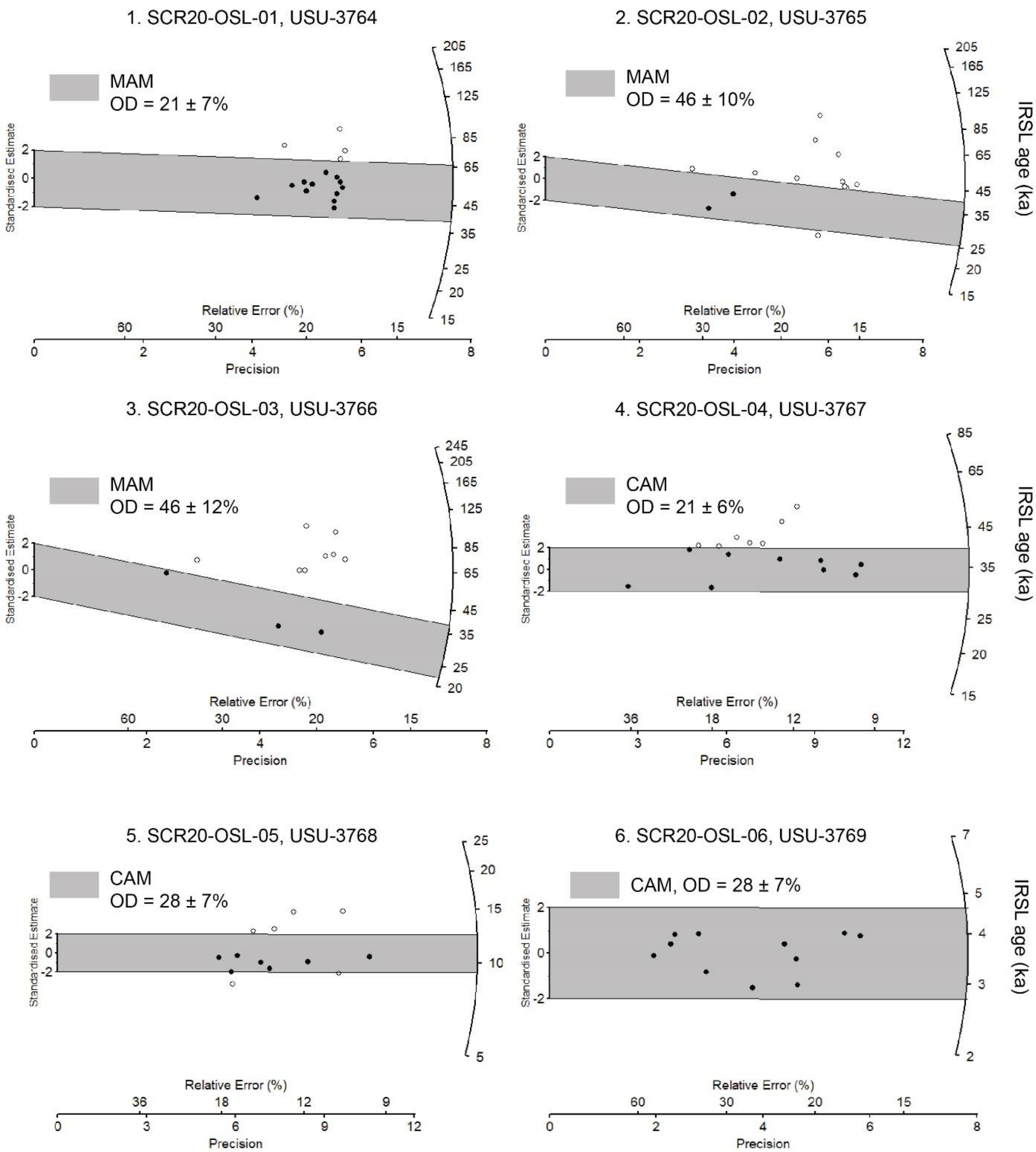

1. SCR20-OSL-01, USU-3764
MAM
OD = 21 ± 7%
2. SCR20-OSL-02, USU-3765
MAM
OD = 46 ± 10%
3. SCR20-OSL-03, USU-3766
MAM
OD = 46 ± 12%
4. SCR20-OSL-04, USU-3767
CAM
OD = 21 ± 6%
5. SCR20-OSL-05, USU-3768
CAM
OD = 28 ± 7%
6. SCR20-OSL-06, USU-3769
CAM, OD = 28 ± 7%
Standardised Estimate
Relative Error (%)
Precision
IRSL age (ka)

Fig. S 7

References

Douglass, D. C., Singer, B. S., Kaplan, M. R., Mickelson, D. M., and Caffee, M. W. Cosmogenic nuclide surface exposure dating of boulders on last-glacial and late-glacial moraines, Lago Buenos Aires, Argentina: Interpretive strategies and paleoclimate implications. Quaternary Geochronology, 1(1):43–58, 2006.

Kaplan, M. R., Douglass, D. C., Singer, B. S., Ackert, R. P., and Caffee, M. W. Cosmogenic nuclide chronology of pre-last glacial maximum moraines at Lago Buenos Aires, 46S, Argentina. Quaternary Research, 63(3):301–315, 2005.

Kaplan, M. R., Strelin, J. A., Schaefer, J. M., Denton, G. H., Finkel, R. C., Schwartz, R., Putnam, A. E., Vandergoes, M. J., Goehring, B. M., and Travis, S. G. In-situ cosmogenic 10Be production rate at Lago Argentino, Patagonia: Implications for late-glacial climate chronology. Earth and Planetary Science Letters, 309(1-2):21–32, 2011.

Lal, D. Cosmic ray labeling of erosion surfaces: in situ nuclide production rates and erosion models. Earth and Planetary Science Letters, 104(2-4):424–439, 1991.

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.

Nishiizumi, K., Imamura, M., Caffee, M. W., Southon, J. R., Finkel, R. C., & McAninch, J. Absolute calibration of 10Be AMS standards. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 258(2), 403-413, 2007.

Stone, J. O. Air pressure and cosmogenic isotope production. Journal of Geophysical Research: Solid Earth, 105(B10):23753–23759, 2000.