Supporting Information

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SI Text

Methods Summary and Supplementary. Samples were collected down the cliff between 220 m and 232 m above sea level (asl), using a diamond saw grinder and a hammer and chisel to extract the samples. Their altitude and position were derived from the light detecting and ranging (LiDAR) digital elevation model, while their thicknesses were precisely measured in the field (Table S2). Because temporal geomagnetic field variations are negligible at these latitudes and over the period considered, the latitudinal and altitudinal scaling were determined at a constant geomagnetic field (1). They range between 1.205 and 1.210 for fast neutron reactions and between 1.073 and 1.077 for muon reactions. The shielding parameters range from 0.46 to 0.50 (Table S2, 2). The parameters describing the specific geometry of each site (strike and dip), together with the full chemical composition of rock and colluvium, are reported in Tables S1 and S2. All the contributions from the various ^{36}Cl production mechanisms using these relevant parameters were then taken into account to determine each sample-specific production rate (3), the used elementary ^{36}Cl production rate from spallation of calcium at sea level and high latitude being 42.0 ± 2.0 atoms of 36 Cl·gram^{-1} of Ca·yr^{-1} as established at a site 150 km away from the Chauvet cave (4). Calibrated at a site whose latitude, elevation, and exposure duration are similar to those of our site, this "local" production rate avoids scaling problems.

The samples were crushed, sieved, and chemically prepared to precipitate AgCl (3). ^{36}Cl and Cl concentrations were determined by isotope dilution accelerator mass spectrometry at Accélérateur pour les Sciences de la Terre, Environnement, Risques–Centre Européen de Recherche et d'Enseignement des Géosciences de l'Environnement (ASTER-CEREGE). The samples contain between 1–9 10^7 atoms of ^{36}Cl and 4–10 ^{36}Cl atoms of Cl. The two blanks have 2×10^5 ^{36}Cl atoms of ^{36}Cl and 9×10^{16} atoms of Cl, which represent less than 1% of the sample concentrations. [Cl] concentrations of the samples were less than 15 ppm. Therefore, the ^{36}Cl production pathways are 84% from Ca spallation, 14% from slow negative muons capture, and less than 2% from thermal and epithermal neutrons capture. The exposure ages were calculated according to Schimmelpfennig et al. (3).

To compare and combine the different ^{36}Cl ages calculated on a scar surface, the method proposed by Ward and Wilson (5) was applied. The method is based on the test statistic, T, given by:

$$T = \sum_{1}^{n} (N_i - N_w)^2 / \sigma_i^2 \qquad \text{[S1]}$$

where N_w is given by:

$$N_w = \left(\sum_{1}^{n} N_i/\sigma_i^2\right)/\left(\sum_{1}^{n} 1/\sigma_i^2\right) \qquad \text{[S2]}$$

N_i and σ_i being the individual calculated ^{36}Cl ages and their associated uncertainties (1σ), respectively. σi were determined propagating the quadratic sum of the analytical errors only.

T has a Chi-square (χ^2) distribution on (n-1) degrees of freedom, n being the number of ^{36}Cl ages on the considered scar. At a 95% confidence interval, equivalent to an uncertainty of $\pm 2\sigma$, the ages are not significantly different if T is lower or equal to $\chi^2_{((n-1),95\%)}$. The inverse-variance weighted mean of the calculated ages is than equal to N_w and the associated uncertainty is determined using:

$$\sigma_w = \sqrt{1/\left(\sum (1/\sigma_i^2)\right)} \qquad \text{[S3]}$$

If T is greater than $\chi^2_{((n-1),95\%)}$, outliers are identified and rejected until the distribution passes the test for the remaining dataset. T, N_w and σ_w are then recalculated as described.

This procedure allows not minimizing the impact of the major source of uncertainties that is the uncertainty on the ^{36}Cl production rate. Both the uncertainty on the age distribution and on the ^{36}Cl production rate are finally propagated through their quadratic sum to yield the uncertainty of the presented weighted mean ages (1σ, Table 1).

1. Stone JO (2000) Air pressure and cosmogenic isotope production. *J Geophy Res* 105:23753–23759.
2. Dunne J, Elmore D, Muzikar P (1999) Scaling factors for the rates of production of cosmogenic nuclides for geometric shielding and attenuation at depth on sloped surfaces. *Geomorphology* 27:3–11.
3. Schimmelpfennig I et al. (2009) Source of in situ ^{36}Cl in basaltics rocks. Implication for calibration of production rates. *Quat Geochronol* 4:441–461.
4. Braucher R, et al. (2011) Production of cosmogenic radionuclides at great depth: A multi element approach. *Earth and Planet Sci. Lett* 309:1–9.
5. Ward GK, Wilson SR (1978) Procedures for comparing and combining radiocarbon age determinations: a critique. *Archaeometry* 20:19–31.

Table S1. Sample locations and descriptions

Sample identity	Dip	Shielding* factor	Latitude	Longitude	Altitude (asl m)	Thickness (cm)	Density† (g·cm^{-3})	Shielded depth (m)
1.01	S 88°	0.50	N 44.23°	E 4.10°	231	2	2.7	5.6
1.02	S 88°	0.50	N 44.23°	E 4.10°	231	3	2.7	6.1
1.03	S 88°	0.50	N 44.23°	E 4.10°	231	2	2.7	4.9
1.05	S 88°	0.50	N 44.23°	E 4.10°	231	2	2.7	5.7
1.06	S 88°	0.50	N 44.23°	E 4.10°	231	4.5	2.7	6.4
2.01	S 89°	0.51	N 44.23°	E 4.10°	227	3.5	2.7	6.6
2.02	S 89°	0.51	N 44.23°	E 4.10°	227	2	2.7	6.2
2.03	S 89°	0.50	N 44.23°	E 4.10°	227	2.5	2.7	5.9
2.04	S 89°	0.49	N 44.23°	E 4.10°	227	2.5	2.7	5.0
2.05	S 89°	0.50	N 44.23°	E 4.10°	227	3.5	2.7	5.0
2.06	S 89°	0.48	N 44.23°	E 4.10°	227	3	2.7	4.9
2.07	S 89°	0.48	N 44.23°	E 4.10°	227	3	2.7	4.7

Sample identity	Dip	Shielding* factor	Latitude	Longitude	Altitude (asl m)	Thickness (cm)	Density† ($g \cdot cm^{-3}$)	Shielded depth (m)
2.08	S 89°	0.46	N 44.23°	E 4.10°	227	5	2.7	4.9
2.09	S 89°	0.46	N 44.23°	E 4.10°	227	2.5	2.7	5.3
3.01	S 86°	0.49	N 44.23°	E 4.10°	224	1.5	2.7	5.3
3.02	S 87°	0.50	N 44.23°	E 4.10°	224	2.5	2.7	5.0
3.03	S 88°	0.50	N 44.23°	E 4.10°	224	3	2.7	4.9
3.04	S 89°	0.48	N 44.23°	E 4.10°	224	3	2.7	4.7
3.06	S 89°	0.48	N 44.23°	E 4.10°	224	3.5	2.7	5.4
4.01	S 89°	0.48	N 44.23°	E 4.10°	222	3	2.7	5.6
6.01	S 90°	0.50	N 44.23°	E 4.10°	227	1.5	2.7	n.a
6.02	S 90°	0.50	N 44.23°	E 4.10°	228	2.5	2.7	n.a.
P1	0	1	N 44.23°	E 4.10°	245	5	2.7	None
P2	0	1	N 44.23°	E 4.10°	245	8	2.7	None
G1	0		N 44.23°	E 4.10°	202	6	2.7	12.4

*Shielding factors were calculated following Dunne J, Elmore D, Muzikar P (1999) Scaling factors for the rates of production of cosmogenic nuclides for geometric shielding and attenuation at depth on sloped surfaces. *Geomorphology* 27:3–11.
†Densities were determined using the Archimedes' principle.

Table S2. Results of the chemical analysis for all samples

Sample identity	Sample weight dissolved (g)	CaO* (%)	$^{36}Cl/^{35}Cl^{\dagger}$ (10^{-14})	$^{35}Cl/^{37}Cl^{\dagger}$	Amount‡ carrier (mg Cl)	[Cl] ppm	^{36}Cl (10^5 atoms/g)	Nucleogenic ^{36}Cl contribution§ (atoms/g)
1.01	37.09	55.48	35.69 ± 1.20	28.02 ± 0.30	0.4960	7.0	3.00 ± 0.11	1.76E+04
1.02	38.02	55.83	35.05 ± 0.97	23.58 ± 0.29	0.4836	8.2	2.87 ± 0.09	1.63E+04
1.03	37.92	55.64	30.17 ± 0.75	20.20 ± 0.24	0.4972	10.1	2.61 ± 0.07	2.03E+04
1.05	36.18	56.04	23.40 ± 0.69	26.40 ± 0.30	0.4960	7.7	2.01 ± 0.06	1.44E+04
1.06	36.82	56.05	26.42 ± 0.93	33.65 ± 0.37	0.4961	5.7	2.18 ± 0.08	1.42E+04
2.01	36.52	56.10	27.77 ± 0.78	23.56 ± 0.33	0.4958	8.7	2.42 ± 0.08	1.51E+04
2.02	36.93	56.32	31.38 ± 0.84	22.16 ± 0.36	0.4948	9.3	2.73 ± 0.09	1.62E+04
2.03	36.26	55.27	29.06 ± 0.75	23.09 ± 0.28	0.4946	9.0	2.55 ± 0.07	1.39E+04
2.04	36.92	55.39	27.45 ± 0.73	19.48 ± 0.26	0.4931	10.8	2.43 ± 0.07	1.55E+04
2.05	34.84	55.95	22.97 ± 0.69	22.49 ± 0.26	0.4953	9.7	2.10 ± 0.07	1.96E+04
2.06	37.60	56.53	25.12 ± 0.78	19.73 ± 0.22	0.4929	10.4	2.17 ± 0.07	1.62E+04
2.07	36.83	56.31	26.34 ± 1.16	24.25 ± 0.39	0.4950	8.3	2.26 ± 0.11	2.50E+04
2.08	36.79	56.51	19.85 ± 0.77	31.00 ± 0.36	0.4894	6.2	1.62 ± 0.07	2.46E+04
2.09	36.83	56.51	25.78 ± 0.68	29.66 ± 0.41	0.4924	6.5	2.14 ± 0.06	1.68E+04
3.01	38.12	56.08	28.15 ± 0.73	30.92 ± 0.20	0.4990	6.1	2.27 ± 0.06	1.76E+04
3.02	37.70	56.30	29.56 ± 1.12	24.08 ± 0.11	0.4992	8.3	2.49 ± 0.09	1.80E+04
3.03	31.46	55.99	27.15 ± 0.74	25.88 ± 0.23	0.4982	9.1	2.71 ± 0.08	2.03E+04
3.04	38.20	56.03	27.53 ± 0.69	22.77 ± 0.14	0.4974	8.7	2.30 ± 0.06	1.96E+04
3.06	37.77	56.24	22.57 ± 0.56	14.89 ± 0.13	0.4966	14.9	2.07 ± 0.05	1.68E+04
4.01	37.98	55.95	26.05 ± 0.64	19.77 ± 0.14	0.4968	10.4	2.24 ± 0.06	1.68E+04
6.01	37.06	55.54	41.10 ± 0.99	18.68 ± 0.13	0.4619	10.6	3.43 ± 0.09	1.24E+04
6.02	37.36	56.55	37.78 ± 0.89	32.18 ± 0.23	0.4956	5.9	3.09 ± 0.08	1.24E+04
P1	37.05	55.65	136.90 ± 1.84	20.03 ± 0.11	0.4998	10.5	12.35 ± 0.18	
P2	39.34	55.19	123.83 ± 1.80	17.27 ± 0.07	0.4994	11.9	10.83 ± 0.16	
G1	36.01	55.61	1.93 ± 0.25	16.66 ± 0.17	0.4960	13.5	0.12 ± 0.02	
			$^{36}Cl/^{35}Cl$ (10^{-14})	**$^{35}Cl/^{37}Cl$**		**Cl (10^{16} atoms)**	**^{36}Cl (10^5 atoms)**	
Blank 1			0.66 ± 0.09	567.30 ± 8.83	0.4898	8.71	1.85	
Blank 2			0.77 ± 0.09	549.47 ± 12.17	0.4958	9.48	2.19	

*Ca concentrations were determined by inductively coupled plasma–optically emission spectrometry (ICP-OES) and uncertainties on CaO% analysis are less than 2% for all samples.
†^{36}Cl and Cl concentrations were determined by AMS and the Ca concentrations by ICP-OES at ASTER-CEREGE.
‡The Cl carrier is enriched in ^{35}Cl (99.90 atoms in %) from Oak Ridge National Laboratory.
§The maximized nucleogenic contribution corresponds to the ^{36}Cl concentration acquired at the shielded depths presented in Table S1.