SUPPLEMENTARY INFORMATION

First chronostratigraphic framework of the fluvial valleys in the eastern Cantabrian margin of the Iberian peninsula (Bay of Biscay, Spain).

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MATERIAL AND METHODS

1. Sampling

The sampling was performed by hammering a light-tight PVC tube into the section, after previous cleaning of the outcrop to remove the surface sediment directly exposed to sunlight and avoid the possible contamination of soil and landslide materials. *In situ* dosimetry measurements were carried out with a portable NaI probe at the exact sampling spot for all samples except CANT15128 and CANT15140. Additional sediment samples were collected from each sample position for water content evaluation and further laboratory analyses.

2. Methods

2.1. Sample preparation

Sample preparation was carried out under strict red light conditions to avoid OSL signal depletion before measurements and following the standard procedure at Sheffield University. Samples were wet sieved to extract the grain size fraction 90-250 μm and then, chemically treated to isolate the quartz fraction. Samples were treated with 1M HCl to dissolve carbonates, and with 30% H_2O_2 to remove organic matter. Heavy minerals and feldspars were removed by heavy liquid separation process with a sodium polytungstate solution at specific density steps of 2.70 and 2.58. HF (40%) etching was performed for 1 hour to dissolve the remaining feldspars and to remove the external layer of the quartz grains. Feldspar contamination was tested for using IR stimulation prior to OSL measurements. The samples were re-sieved after chemical treatment to select the grain size between 90 and 250 μm . Due to differences between samples, different grain sizes within that range were selected depending on quartz availability (see [Table S1](#)).

2.2. OSL dating procedure

Samples were dated at Sheffield University (UK) using a multi-grain Single Aliquot Regenerative-dose (SAR) protocol ([Murray and Wintle, 2000, 2003](#)), Table S1 in Supplementary Information. Every sample was mounted on stainless steel discs using a silicone spray. The measurements were performed on small multi-grain aliquots containing ~30 grains per aliquot, as this aliquots size has shown to provide similar resolution to single grains even in cases of incomplete bleaching ([Medialdea et al., 2014](#)). 18 to 48 aliquots of each samples were measured.

Quartz OSL measurements were made using automated Risø TL/ OSL DA-20 luminescence readers ([Bøtter-Jensen et al., 2010](#)). Luminescence was detected using a bialkali EMI 9235QB photomultiplier tube through a 7.5 mm Hoya U-340 filter. Stimulation used a blue ($470 \pm 30 \text{ nm}$) light emitting diode array providing a stimulation power of $\sim 80 \text{ mW/cm}^2$ at the sample position.

Preliminary tests including a dose recovery preheat plateau test to determine the most suitable preheat temperature and an IR depletion measurement ([Duller, 2003](#)) to detect the potential contamination of feldspar in the quartz extracts, were carried out. Rejection criteria for the D_e values derived from the measured aliquots was applied: recycling ratio or IR depletion ratio $< 20\%$, recuperation $< 5\%$ or natural

normalized signal (L_x/T_x) above saturation of the dose response curve.

Equivalent doses (D_e) were estimated using Analyst 4.31.7 (Duller, 2015), by interpolation of the natural test-dose signal onto the dose response curve fitted using a single saturating exponential function. To calculate a single D_e , three different approaches were carried out: (i) The Central Age Model (CAM) (ii) The Minimum Age Model (MAM) and the (iii) Finite Mixture Model (FMM), all three by Galbraith et al. 1999), CAM was applied on the dose distributions derived from the accepted aliquots and after discarding outliers (i.e. beyond 2 standard deviations of mean). MAM was applied on the dose distribution including outliers. A σ_b of 0.2 was used.

2.3. ESR dating procedure

ESR dating of the quartz samples was carried out at CENIEH (Spain) using a multi-grains multi-aliquots additive dose method and following the Multiple Centre (MC) approach as in Duval et al. (2017).

Each sample was divided into 12 aliquots. Ten aliquots were irradiated using a ^{137}Cs Gammacell-1000 gamma irradiator to the following doses: 100, 200, 394.6, 796.1, 1598.9, 3197.9, 6001.1, 10003.1, 15002.8 and 25018.1 Gy. The non-bleachable residual ESR signals of the Aluminium centre were measured after exposing an aliquot of each natural sample in a SOL 500 (Dr Hönle) solar light simulator for 1338 h.

ESR measurements were carried out with an EMXmicro 6/1 Bruker X-band ESR spectrometer coupled to a standard rectangular ER 4102ST cavity. To ensure constant experimental conditions over time, the temperature of the water circulating in the magnet is controlled and stabilized at 18 °C by a water-cooled Thermo Scientific NESLAB thermoflex 3500 chiller, and the temperature of the room was kept constant at 20 °C by an air conditioning unit. ESR measurements were performed at low temperature (90.0 ± 0.1 K) using a ER4141VT Digital Temperature control system based on liquid nitrogen cooling. Further details about the setup and about its stability over time can be found in Duval and Guilarte Moreno (2012).

The ESR signal associated to Al centre was measured as follows: 10.02 mW microwave power, 1024 points resolution, 20 mT sweep width, 100 kHz modulation frequency, 0.1 mT modulation amplitude, 40 ms conversion time, 10.24 ms time constant and 1 scan. Each aliquot was measured 3 times after $\sim 120^\circ$ rotation in the cavity in order to consider angular dependence of the signal due to sample heterogeneity. Then, ESR measurements were repeated 3 times over distinct days to evaluate the variability of the D_e values. A mean ESR intensity was extracted for D_e calculation. The ESR intensity of the Al signal was evaluated from peak-to-peak amplitude measurements between the top of the first peak and the bottom of the last one, as indicated in Fig. S6.

Figure S6

The ESR signal associated to Ti centres was measured as follows: 5.02 mW microwave power, 1024 points resolution, 20 mT sweep width, 100 kHz modulation frequency, 0.1 mT modulation amplitude, 60 ms conversion time, 20.48 ms time constant and from 2 to 15 scans to ensure a good S/N ratio. Each sample was measured 4 times and a mean ESR intensity was extracted for D_e calculation. The ESR intensity of the Ti signal was evaluated in various ways (options A to E; Fig. S6), as described in Duval and Guilarte (2015).

ESR intensities of Al and Ti centres were corrected by the corresponding receiver gain value, number of scans, aliquot mass and a temperature correction factor (Duval and Guilarte Moreno, 2012). The fitting procedures were carried out with the Microcal Origin Pro 6.0 software using a Levenberg-Marquardt algorithm by chi-square minimisation and data were weighted by the inverse of the squared ESR intensity ($1/I^2$). For the Al centre, an exponential+linear (EXP+LIN) function was fitted through the experimental points, as it has been demonstrated that this function better describes the analytical data set compared to the classical single saturating exponential function (SSE) (Duval, 2012; Duval et al., 2016). D_e values were obtained by extrapolating the EXP+LIN function to the residual ESR intensity. For the Ti-centres, the single saturating exponential function (SSE) was used and results were compared to those derived from the Ti-2 function (fitting equations are provided in supplementary information, Table S3).

2.4. Dose rate evaluation and age calculation

The total dose rate value was derived from a combination of *in situ* and laboratory measurements. The external gamma dose rate was measured *in situ* with a portable gamma spectrometer (Canberra Inspector 1000 coupled with a 1.5*1.5 inch NaI (TI) probe) and calculated using the Threshold approach (Duval and Arnold 2013). Radioelement contents (U, Th, and K) were measured by ICP-MS and used to derive external beta dose rates for all samples. The grain thickness removed after HF etching was assumed to be between 10-30 μm and external alpha contribution was therefore considered negligible. For the two samples missing *in situ* measurements (CANT15128 and CANT15140), the gamma dose rate was derived from the ICP-MS measurements. Internal dose was assumed to be 0.05 ± 0.03 Gy/ka as in Duval et al. (2017). Dose rate calculation was performed with the present-day water content measured for each sample and an associated error of $\pm 5\%$ error was considered (Table S1). Total dose rate and ages were calculated using DRAC v1.2 (Dose Rate and Age Calculator, Durcan et al., 2015).

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1 TABLES

Sample	Terrace level	Geographic location		Altitude a.s.l.	Depth below ground surface	Measured water content ($\pm 5\%$)	Selected grain size	Type of deposit (see Fig. S1, S2 and S3)
		Latitude	longitude	(m)	(m)	(%)	μm	
CANT15127	TD7 +10m	43°8'55.987"N	2°24'41.535"W	127	2.0	13	125-250	Well preserved sand unit over a well-defined channel facies
CANT15128	TD6 +20m	43°9'20.134"N	2°24'23.475"W	129	0.5	11	90-180	Pebble level with silty matrix
CANT15129	TD7 +10m	43°5'46.152"N	2°25'52.053"W	165	1.0	10	125-212	Silty alluvial plain facies
CANT15130	TD6 +20m	43°13'33.728"N	2°24'24.841"W	45	3.0	19	125-180	Well preserved sand level
CANT15131	TD4 +50m	43°13'43.989"N	2°24'26.017"W	75	2.0	13	125-250	Well preserved sand level with sporadic pebbles
CANT15132	TD3 +64	43°13'28.994"N	2°24'10.863"W	90	0.8	5	125-180	Doubtful leached sandy/silt unit
CANT15133	TN6 +20m	43°9'49.474"N	2°55'29.818"W	105	2.0	11	125-180	Well preserved sand unit over a well-defined channel facies
CANT15134	TN6 +20m	43°10'32.334"N	2°54'53.893"W	95	2.0	9	90-180	Well preserved sand unit (80 cm thick) over a well-defined channel facies
CANT15135	TO10 +5m	43°17'32.088"N	1°50'54.305"W	39	0.8	22	125-212	Doubtful silty floodplain deposit, undistinguishable from the soil
CANT15136	TO9 +10m	43°17'19.312"N	1°50'6.129"W	62	1.5	15	125-212	Doubtful silty floodplain deposit, undistinguishable from the soil
CANT15137	TO8 +15m	43°17'32.291"N	1°51'31.127"W	41	1.0	13	125-212	Doubtful silty floodplain deposit, undistinguishable from the soil
CANT15138	TO8 +15m	43°17'38.633"N	1°52'7.836"W	34	1.5	24	180-250	Doubtful silty floodplain deposit, undistinguishable from the soil
CANT15139	TO6 +25m	43°17'30.335"N	1°51'34.801"W	49	2.0	14	125-180	Well preserved sand unit over a well-defined channel facies
CANT15140	TO5 +36m	43°17'27.721"N	1°51'39.169"W	60	1.0	27	90-180	Doubtful silty floodplain deposit, undistinguishable from the soil

2 *Table S1: Sample information.*

	Treatment	Observe
1	Give Dose, D_i	—
2	Preheat (160-300°C for 10 s)	—
3	Optically stimulate for 60 s at 125°C	L_i
4	Give test dose, D_t	—
5	Het to 160°C	—
6	Optically stimulate for 60 s at 125°C	T_t
7	Return to 1	—

Table S2: Single-aliquot regenerative-dose protocol used in the present study (Murray and Wintle, 2003).

Function	Equation	Fitted parameters
Ti-2	$I(D) = a * (e^{-(D+D_e)/D_1} - e^{-(D+D_e)/D_2})$	a, D_1, D_2, D_e
SSE	$I(D) = I_{max} * (1 - e^{-D+D_e/D_0})$	I_{max}, D_e, D_0
EXP+LIN	$I(D) = I_{max} * (1 - e^{-D+D_e/D_0}) + m * (D + D_e)$	I_{max}, m, D_e, D_0

Table S3: Equations of the fitting functions. The 2 variables are D , the applied dose (Gy), and I , the ESR intensity (arbitrary units) corresponding to D . Further information may be found in Duval and Guilarte (2015), Duval et al (2009) and Duval (2012) for the Ti-2, SSE and EXP+LIN functions, respectively.

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CANT15127 (TD7 +10m)			
Al centre			
Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation
0	0.311	0.007	2.1%
100	0.315	0.028	9.0%
200	0.380	0.022	5.8%
394.6	0.433	0.015	3.4%
796.1	0.536	0.033	6.2%
1598.9	0.640	0.064	10.0%
3197.9	0.811	0.033	4.1%
6001.1	0.966	0.041	4.2%
10003.1	1.205	0.021	1.7%
15002.8	1.387	0.016	1.1%
25018.1	1.608	0.071	4.4%

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CANT15130 (TD6 +20m)			
Al centre			
Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation
0	0.337	0.003	1.0%
100	0.374	0.007	1.8%
200	0.393	0.003	0.9%
394.6	0.433	0.015	3.5%
796.1	0.505	0.013	2.5%
1598.9	0.629	0.005	0.8%
3197.9	0.789	0.012	1.6%
6001.1	0.960	0.027	2.8%
10003.1	1.111	0.024	2.1%
15002.8	1.274	0.017	1.3%
25018.1	1.590	0.016	1.0%

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Al centre			
Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation
0	0.276	0.008	3.0%
100	0.352	0.012	3.4%
200	0.343	0.015	4.3%
394.6	0.421	0.011	2.6%
796.1	0.508	0.001	0.2%
1598.9	0.609	0.015	2.5%
3197.9	0.774	0.013	1.7%
6001.1	0.963	0.022	2.3%
10003.1	1.252	0.013	1.0%
15002.8	1.369	0.038	2.8%
25018.1	1.643	0.022	1.3%

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CANT15139 (TO6 +25m)			
Al centre			
Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation
	0.361	0.003	0.8%
100	0.399	0.003	0.7%
200	0.410	0.006	1.5%
394.6	0.431	0.003	0.6%
796.1	0.460	0.010	2.1%
1598.9	0.582	0.007	1.2%
3197.9	0.735	0.007	0.9%
6001.1	0.934	0.039	4.2%
10003.1	1.146	0.007	0.6%
15002.8	1.292	0.023	1.8%
25018.1	1.716	0.004	0.2%

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Table S4: ESR data collected from the measurement of the Al centre.

CANT15134 (TN6 +20m)			
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CANT15127 (TD7 +10m)															
Ti-Li (option A)				Ti-Li (option D)				Ti-Li (option E)				Ti-H (option C)			
Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation
0	16.376	1.189	7.3%	0	11.128	0.748	6.7%	0	4.748	0.657	13.8%	0	7.230	0.720	10.0%
100	17.604	0.663	3.8%	100	12.132	0.291	2.4%	100	5.472	0.612	11.2%	100	8.312	0.489	5.9%
200	20.185	0.640	3.2%	200	13.888	0.619	4.5%	200	6.297	0.443	7.0%	200	9.935	0.500	5.0%
394.6	22.954	0.377	1.6%	394.6	17.139	0.536	3.1%	394.6	5.815	0.600	10.3%	394.6	12.427	0.350	2.8%
796.1	27.633	0.434	1.6%	796.1	20.439	0.329	1.6%	796.1	7.194	0.169	2.3%	796.1	14.760	0.610	4.1%
1598.9	29.856	0.658	2.2%	1598.9	22.722	0.963	4.2%	1598.9	7.134	0.460	6.4%	1598.9	17.261	0.424	2.5%
3197.9	36.836	0.596	1.6%	3197.9	26.820	0.291	1.1%	3197.9	10.016	0.378	3.8%	3197.9	19.005	0.250	1.3%
6001.1	38.283	0.891	2.3%	6001.1	27.056	0.603	2.2%	6001.1	11.227	1.351	12.0%	6001.1	18.069	0.867	4.8%
10003.1	40.536	2.014	5.0%	10003.1	28.153	0.586	2.1%	10003.1	12.383	1.883	15.2%	10003.1	16.984	0.853	5.0%
15002.8	38.552	0.931	2.4%	15002.8	26.511	1.185	4.5%	15002.8	12.041	1.724	14.3%	15002.8	16.843	0.926	5.5%
25018.1	34.879	1.211	3.5%	25018.1	23.383	1.181	5.1%	25018.1	11.496	1.241	10.8%	25018.1	12.973	1.041	8.0%

18 *Table S5: ESR data collected from the measurement of the Ti centres in sample CANT15127.*

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CANT15130 (TD6 +20m)															
Ti-Li (option A)				Ti-Li (option D)				Ti-Li (option E)				Ti-H (option C)			
Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation
0	13.732	0.256	1.9%	0	9.310	0.165	1.8%	0	4.422	0.261	5.9%	0	6.283	0.117	1.9%
100	15.587	0.658	4.2%	100	10.269	0.312	3.0%	100	5.318	0.347	6.5%	100	6.644	0.347	5.2%
200	15.984	0.900	5.6%	200	11.028	0.644	5.8%	200	4.956	0.296	6.0%	200	7.935	0.560	7.1%
394.6	17.799	0.690	3.9%	394.6	12.858	0.655	5.1%	394.6	4.941	0.125	2.5%	394.6	9.009	0.119	1.3%
796.1	20.806	0.417	2.0%	796.1	15.387	0.499	3.2%	796.1	5.419	0.367	6.8%	796.1	11.079	0.248	2.2%
1598.9	24.500	0.585	2.4%	1598.9	18.351	0.369	2.0%	1598.9	6.149	0.353	5.7%	1598.9	13.000	0.753	5.8%
3197.9	27.505	0.684	2.5%	3197.9	19.977	0.430	2.2%	3197.9	7.528	0.255	3.4%	3197.9	13.999	0.125	0.9%
6001.1	30.415	0.864	2.8%	6001.1	21.033	0.628	3.0%	6001.1	9.382	0.291	3.1%	6001.1	12.933	0.167	1.3%
10003.1	29.522	0.811	2.7%	10003.1	20.130	0.722	3.6%	10003.1	9.392	0.102	1.1%	10003.1	12.201	0.864	7.1%
15002.8	29.302	0.298	1.0%	15002.8	19.242	0.326	1.7%	15002.8	10.060	0.548	5.5%	15002.8	10.175	0.169	1.7%
25018.1	24.863	0.807	3.2%	25018.1	16.692	0.478	2.9%	25018.1	8.171	0.329	4.0%	25018.1	8.532	0.173	2.0%

23 *Table S6: ESR data collected from the measurement of the Ti centres in sample CANT15130.*

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CANT15133 (TN6 +20m)															
Ti-Li (option A)				Ti-Li (option D)				Ti-Li (option E)				Ti-H (option C)			
Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation
0	10.504	0.455	4.3%	0	7.047	0.230	3.3%	0	3.457	0.284	8.2%	0	4.641	0.239	5.1%
100	10.647	0.539	5.1%	100	7.324	0.423	5.8%	100	3.323	0.270	8.1%	100	5.210	0.446	8.6%
200	11.741	0.423	3.6%	200	7.925	0.374	4.7%	200	3.816	0.057	1.5%	200	5.480	0.231	4.2%
394.6	12.363	0.193	1.6%	394.6	8.711	0.244	2.8%	394.6	3.652	0.102	2.8%	394.6	6.315	0.171	2.7%
796.1	14.430	0.920	6.4%	796.1	10.671	0.462	4.3%	796.1	3.758	0.463	12.3%	796.1	7.439	0.282	3.8%
1598.9	17.202	0.724	4.2%	1598.9	12.844	0.360	2.8%	1598.9	4.359	0.396	9.1%	1598.9	9.174	0.209	2.3%
3197.9	20.638	0.698	3.4%	3197.9	15.027	0.482	3.2%	3197.9	5.611	0.514	9.2%	3197.9	9.182	0.447	4.9%
6001.1	23.717	0.800	3.4%	6001.1	16.776	1.046	6.2%	6001.1	6.941	0.443	6.4%	6001.1	9.137	0.943	10.3%
10003.1	24.772	1.323	5.3%	10003.1	17.065	0.624	3.7%	10003.1	7.707	0.708	9.2%	10003.1	7.928	0.680	8.6%
15002.8	25.516	0.729	2.9%	15002.8	18.267	0.615	3.4%	15002.8	7.248	0.208	2.9%	15002.8	8.863	0.396	4.5%
25018.1	20.180	0.771	3.8%	25018.1	14.280	1.490	10.4%	25018.1	5.900	0.978	16.6%	25018.1	6.346	0.785	12.4%

27 *Table S7: ESR data collected from the measurement of the Ti centres in sample CANT15133.*

CANT15134 (TN6 +20m)															
Ti-Li (option A)				Ti-Li (option D)				Ti-Li (option E)				Ti-H (option C)			
Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation
0	5.667	0.371	6.6%	0	4.072	0.081	2.0%	0	1.595	0.291	18.2%	0	2.951	0.225	7.6%
100	6.828	0.195	2.9%	100	5.191	0.162	3.1%	100	1.637	0.357	21.8%	100	3.716	0.113	3.0%
200	6.518	0.437	6.7%	200	4.898	0.378	7.7%	200	1.621	0.059	3.6%	200	3.843	0.263	6.8%
394.6	7.897	0.259	3.3%	394.6	5.747	0.164	2.8%	394.6	2.150	0.095	4.4%	394.6	4.682	0.101	2.2%
796.1	8.702	0.275	3.2%	796.1	6.708	0.003	0.0%	796.1	1.994	0.272	13.6%	796.1	5.339	0.178	3.3%
1598.9	9.564	0.933	9.8%	1598.9	7.575	0.512	6.8%	1598.9	1.989	0.421	21.2%	1598.9	5.887	0.139	2.4%
3197.9	11.283	0.606	5.4%	3197.9	8.900	0.471	5.3%	3197.9	2.383	0.135	5.7%	3197.9	6.183	0.522	8.4%
6001.1	12.781	0.726	5.7%	6001.1	9.363	0.479	5.1%	6001.1	3.418	0.247	7.2%	6001.1	6.130	0.171	2.8%
10003.1	12.559	1.029	8.2%	10003.1	9.836	0.703	7.2%	10003.1	2.723	0.326	12.0%	10003.1	5.756	0.908	15.8%
15002.8	13.163	0.873	6.6%	15002.8	10.391	0.719	6.9%	15002.8	2.773	0.155	5.6%	15002.8	5.121	0.051	1.0%
25018.1	9.897	0.293	3.0%	25018.1	8.256	0.191	2.3%	25018.1	1.641	0.102	6.2%	25018.1	4.426	0.162	3.7%

Table S8: ESR data collected from the measurement of the Ti centres in sample CANT15134.

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CANT15139 (TO6 +25m)															
Ti-Li (option A)				Ti-Li (option D)				Ti-Li (option E)				Ti-H (option C)			
Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation	Dose (Gy)	ESR intensity (a.u.)	s.d.	Coef. of variation
0	33.101	2.626	7.9%	0	20.747	1.622	7.8%	0	12.354	1.005	8.1%	0	6.935	0.925	13.3%
100	36.065	1.008	2.8%	100	22.500	0.526	2.3%	100	13.565	0.510	3.8%	100	7.058	0.256	3.6%
200	37.253	0.698	1.9%	200	23.358	0.381	1.6%	200	13.896	0.320	2.3%	200	8.384	0.506	6.0%
394.6	38.627	0.801	2.1%	394.6	24.382	0.454	1.9%	394.6	14.245	0.560	3.9%	394.6	8.580	0.738	8.6%
796.1	43.156	0.817	1.9%	796.1	26.833	1.813	6.8%	796.1	16.324	1.197	7.3%	796.1	9.708	0.553	5.7%
1598.9	53.267	2.568	4.8%	1598.9	33.824	1.312	3.9%	1598.9	19.444	1.484	7.6%	1598.9	13.223	1.340	10.1%
3197.9	66.604	3.553	5.3%	3197.9	42.542	1.879	4.4%	3197.9	24.063	1.803	7.5%	3197.9	14.640	0.354	2.4%
6001.1	87.132	1.948	2.2%	6001.1	55.771	1.160	2.1%	6001.1	31.361	1.382	4.4%	6001.1	15.479	1.270	8.2%
10003.1	95.201	3.397	3.6%	10003.1	60.754	2.390	3.9%	10003.1	34.447	1.185	3.4%	10003.1	18.149	0.975	5.4%
15002.8	89.736	1.430	1.6%	15002.8	57.090	1.213	2.1%	15002.8	32.646	0.276	0.8%	15002.8	15.713	0.647	4.1%
25018.1	70.126	1.982	2.8%	25018.1	47.704	1.205	2.5%	25018.1	22.423	0.785	3.5%	25018.1	10.814	1.971	18.2%

34 *Table S9: ESR data collected from the measurement of the Ti centres in sample CANT15139.*
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Al centre							
Sample	Terrace level	Number of measurements	Bleaching Coeff. (%)	ESR intensities repeatability (%)	De repeatability (%)	Adj. r^2	D _e (Gy)
CANT15127	TD7 +10m	4	58.7 ± 3.3	0.6	13.1	0.993	771 ± 132
CANT15130	TD6 +20m	3	58.8 ± 2.7	0.9	11.1	0.999	1130 ± 50
CANT15133	TN6 +20m	3	56.7 ± 3.3	3.9	7.5	0.993	1144 ± 192
CANT15134	TN6 +20m	2*	55.0 ± 2.8	0.9	3.4	0.989	836 ± 177
CANT15139	TO6 +25m	3	61.0 ± 3.3	0.4	2.5	0.997	2013 ± 271

Table S10: ESR fitting results derived from the measurement of the Al centre. (*) sample CANT15134 was lost after the second measurement. The bleaching coefficient corresponds to the relative difference between the ESR intensities of the natural and bleached aliquots. The repeatability of the ESR intensities was assessed through the variability of the mean ESR intensity obtained after each day of measurements. Similarly, the repeatability of the De values corresponds to the variability of the De values calculated for each day of measurement.

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Ti-Li Centre										
Sample	Terrace level	number of meas.	Option D				Option A		Option E	
			ESR intensity repeatability (%)	De repeatability (%)	Adj. r^2	D _e (Gy)	Adj. r^2	D _e (Gy)	Adj. r^2	D _e (Gy)
CANT15127	TD7 +10m	4	2.0	15.1	0.993	466 ± 64	0.980	804 ± 168	0.921	2007 ± 780
CANT15130	TD6 +20m	3	1.9	5.4	0.998	694 ± 42	0.994	1041 ± 111	0.990	2487 ± 505
CANT15133	TN6 +20m	3	2.2	1.5	0.991	1090 ± 138	0.995	1863 ± 182	0.969	3547 ± 1292
CANT15134	TN6 +20m	2	3.9	34.0	0.984	745 ± 91	0.957	1378 ± 333	0.807	2818 ± 1267
CANT15139	TO6 +25m	3	1.8	9.3	0.997	1824 ± 164	0.997	2015 ± 181	0.999	1957 ± 174

Table S11: ESR fitting results derived from the measurement of the Ti-Li centre. The repeatability of the ESR intensities was assessed through the variability of the mean ESR intensity obtained after each day of measurements. Similarly, the repeatability of the De values corresponds to the variability of the De values calculated for each day of measurement.

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Ti-H centre						
Sample	Terrace level	Number of meas.	ESR intensity repeatability (%)	De repeatability (%)	Adj. r^2	D _e (Gy)
CANT15127	TD7 +10m	4	1.4	15.8	0.992	367 ± 38
CANT15130	TD6 +20m	3	1.8	1.6	0.994	515 ± 51
CANT15133	TN6 +20m	3	3.8	28.7	0.983	539 ± 74
CANT15134	TN6 +20m	2	3.7	23.8	0.984	464 ± 70
CANT15139	TO6 +25m	3	1.7	20.2	0.986	1511 ± 222

Table S12: ESR data and fitting results for the Ti-H centre.

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Sample	Terrace level	K (%)	Th (ppm)	U (ppm)
CANT15127	TD7 +10m	1.4±0.1	12±1.2	2.71±0.3
CANT15128	TD6 +20m	1.5±0.1	11.5±1.2	2.74±0.3
CANT15129	TD7 +10m	1.8±0.1	15.4±1.5	3.75±0.4
CANT15130	TD6 +20m	1.5±0.1	13.5±1.4	3.47±0.3
CANT15131	TD4 +50m	1.7±0.1	13.8±1.4	3.67±0.4
CANT15132	TD3 +64m	1.7±0.1	12.1±1.2	3.36±0.3
CANT15133	TN6 +20m	0.9±0.0	7.8±0.8	1.71±0.2
CANT15134	TN6 +20m	0.9±0.0	12.5±1.3	3.16±0.3
CANT15135	TO10 +5m	2.1±0.1	15.5±1.6	3.32±0.3
CANT15136	TO9 +10m	2.3±0.1	15.4±1.5	3.76±0.4
CANT15137	TO8 +15m	1.7±0.1	15.7±1.6	3.42±0.3
CANT15138	TO8 +15m	1.8±0.1	16.7±1.7	4.22±0.4
CANT15139	TO6 +25m	2.5±0.1	25.5±2.6	4.21±0.4
CANT15140	TO5 +36m	0.9±0.0	7.6±0.8	2.13±0.2

Table S13: Radioelement concentrations obtained by ICP-MS analyses.

Gamma dose rate (Gy/ka)				
Sample	Terrace level	<i>in situ</i>	Laboratory	Ratio laboratory/ <i>in situ</i>
CANT15127	TD7 +10m	1.035	1.066	1.03
CANT15128	TD6 +20m	n.m.	1.084	-
CANT15129	TD7 +10m	1.215	1.438	1.18
CANT15130	TD6 +20m	1.024	1.148	1.12
CANT15131	TD4 +50m	1.115	1.293	1.16
CANT15132	TD3 +64m	1.136	1.292	1.14
CANT15133	TN6 +20m	0.606	0.697	1.15
CANT15134	TN6 +20m	0.929	1.066	1.15
CANT15135	TO10 +5m	1.515	1.294	0.85
CANT15136	TO9 +10m	1.323	1.472	1.11
CANT15137	TO8 +15m	1.255	1.350	1.08
CANT15138	TO8 +15m	1.300	1.348	1.04
CANT15139	TO6 +25m	1.903	1.989	1.05
CANT15140	TO5 +36m	n.m.	0.631	-

Table S14: Comparison of the gamma dose rates derived from *in situ* and laboratory (ICP-MS) analyses. No *in situ* measurements performed for samples CANT15128 and CANT15140 (n.m.). *In situ* gamma dose rate were obtained from a NaI gamma probe and using the Threshold approach (Duyal and Arnold, 2013). Laboratory gamma dose rates were obtained from the radioelement concentration measured by ICP-MS and using the measured water content.

Figure S1: Pictures of the sediment samples collected in the Nerbioi valley.

Figure S2: Pictures of the sediment samples collected in the Deba valley.

Figure S3: Pictures of the sediment samples collected in the Oiartzun valley.

Figure S4: OSL Dose response curves (DRCs) and corresponding radial plots

Figure S5: OSL dose distribution. A) CANT15127, B) CANT15128, C) CANT15129, D) CANT15130, E) CANT15131, F) CANT15133, G) CANT15134, H) CANT15136, I) CANT15137, J) CANT15138, K) CANT15139.

Figure S6: Examples of ESR spectra obtained in the present study. Left: ESR signal of the Aluminum centre; Right: ESR signal of the Titanium centre.

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Figure S7: ESR DRCs derived from the Al centre.

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Figure S8: ESR DRCs derived from the Ti-Li option A.

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Figure S9: ESR DRCs derived from the Ti-Li option D.

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85 Figure S10: ESR DRCs derived from the Ti-Li option E.

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Figure S11: ESR DRCs derived from the Ti-H centre.

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