nature

https://doi.org/10.1038/s41586-020-2165-4

Supplementary information

Dating the skull from Broken Hill, Zambia, and its position in human evolution

In the format provided by the authors and unedited

Rainer Grün✉, Alistair Pike, Frank McDermott, Stephen Eggins, Graham Mortimer, Maxime Aubert, Lesley Kinsley, Renaud Joannes-Boyau, Michael Rumsey, Christiane Denys, James Brink, Tara Clark & Chris Stringer✉

Supplementary Information Table 1: Faunal list of Broken Hill small mammals

Species	Within the skull	Bulk sediment
Saccostomus campestris	1	2
Steatomys pratensis	2	x
Gerbilliscus validus	6	x
Gerbilliscus leucogaster	x	1
Aethomys kaiseri	19	
Aethomys chrysophilus	x	x
Arvicanthis sp.	3	20
Lemniscomys rosalia	x	x
Mastomys sp.	44	x
Mus minutoides	3	X
Mus triton	14	X
Pelomys fallax	34	X
Grammomys dolichurus	7	
Thallomys paedulcus	10	X
Otomys angoniensis	53	3
Cryptomys hottentotus	1	
Elephantulus brachyrhynchus	?	X
Crocidura fuscomurina	?	x
Crocidura hirta	?	X
Crocidura luna	?	X
Crocidura mariquensis	?	X
Crocidura turba	?	X
Suncus varilla	?	x

Supplementary Information Table 2: Elemental analyses on skull E686 and rodent material found inside the skull

Semi-quantitative analyses, Oakley (1947)				Laser ablation (ppm)			
	Pb	Zn	V		Pb	Zn	V
BH Skull	4	15	trace	BH-A	44.8	15.2	28
				BH-B	30.9	14.1	16
Rodent	20	5	0.3	Rodent-1A	49.9	19.0	103
				Rodent-1B	47.2	17.9	96
				Rodent-2A	44.6	18.4	49
				Rodent-2B	48.8	15.9	54
				Rodent-3A	64.3	17.2	1448
				Rodent-3B	59.0	19.4	489

Supplementary Information Table 3: Solution U-series results (Errors: 2 s.d.))

Sample	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	$^{230}Th/^{232}Th$	Age (ka)	Age error (ka)	Initial $^{234}U/^{238}U$	$^{234}U/^{238}Ui$ error
[1]Skull (E686)									
Dentine	4.6234	0.0334	4.4914	0.0170	>10000	215.8	4.0	7.4188	0.0644
[2]Femur Midshaft (EM793)									
A	2.4563	0.0266	2.9648	0.0181	>10000	146.4	3.3	3.9697	0.0270
B	2.5134	0.0267	2.9311	0.0174	>10000	155.9	3.5	3.9984	0.0283
C	2.5195	0.0266	2.8763	0.0199	>10000	162.6	4.0	3.9685	0.0300
D	2.5063	0.0266	2.9341	0.0181	>10000	154.8	3.5	3.9936	0.0282
E	2.4106	0.0260	2.9133	0.0210	2709	146.3	3.4	3.8913	0.0276
Average	2.4812	0.0495	2.9239	0.0346		153.0	6.5	3.9629	0.0523
[1]Femur Head (E907)									
	2.5423	0.0060	2.9418	0.0028	>10000	158.1	0.8	4.0337	0.0062
[1]Pelvis (E719)									
	1.8997	0.0049	2.6322	0.0025	575	117.6	0.5	3.2743	0.0038
[3]Rodent									
2016o-K	2.1198	0.0047	3.1930	0.0026	445	102.2	0.4	3.9258	0.0037
[4]Calcitic Layer (hide)									
1	3.0222	0.0168	3.7394	0.0084	>10000	137.6	1.4	5.0394	0.0159
2	3.2067	0.0014	3.4834	0.0016	>10000	175.1	0.2	5.0711	0.0019

[1] solution TIMS, Australian National University
[2] solution TIMS, Open University (AP)
[3] solution ICP-MCMS, University of Queensland
[4] solution TIMS, Open University (FMcD)

Supplementary Information Table 4: 2016 laser ablation $^{230}Th/^{238}U$ runs on basicranial fragment. For hole positions, see Extended Data Figures 5B, C. nd: not detemined, Th concentration below background. Errors are 2 s.d.

	Inside Hole #1					**Inside Hole #2**				
Bin #	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error
1	14.0	12.3	1141	5.210	0.111	14.9	4.4	3360	4.578	0.066
2	12.9	1.6	8150	4.669	0.117	13.0	8.3	1559	4.766	0.072
3	11.9	4.1	2911	4.064	0.067	13.6	8.7	1571	4.990	0.065
4	11.2	8.0	1395	4.147	0.090	11.0	4.5	2440	4.740	0.114
5	10.2	5.7	1771	4.188	0.102	10.0	12.6	798	4.114	0.084
6	10.7	4.7	2296	4.143	0.053	10.3	3.6	2891	4.038	0.070
7	10.6	3.0	3493	4.294	0.052	9.8	6.4	1527	3.996	0.070
8	10.6	2.8	3771	4.538	0.066	10.2	3.8	2684	4.201	0.069
9	9.2	4.4	2074	4.256	0.066	8.2	1.2	6861	4.067	0.071
10	9.2	3.4	2684	4.373	0.057	8.2	1.4	5937	4.174	0.089
11	7.7	5.3	1467	4.426	0.097	7.1	11.9	594	4.133	0.081
12	7.3	1.6	4654	4.441	0.070	6.1	6.6	930	4.019	0.061
13	6.4	2.6	2416	4.446	0.061	5.7	1.3	4432	4.219	0.087
14	5.4	6.4	845	4.356	0.072	5.0	1.2	4183	4.097	0.081
15	5.1	1.2	4259	4.484	0.082	4.3	1.1	4017	4.158	0.092
16	4.8	0.5	9066	4.567	0.088	3.8	0.3	11325	4.279	0.092
17	3.6	4.0	913	4.311	0.099	3.1	1.3	2379	4.233	0.086
18	3.3	1.8	1820	4.421	0.121	1.7	2.1	843	4.214	0.104
19	2.9	5.6	517	4.417	0.091	1.5	1.8	818	4.018	0.152
20	2.6	10.1	255	4.448	0.073	1.3	1.3	1027	4.272	0.169
21	2.2	6.8	322	4.650	0.087	1.1	2.1	530	4.318	0.117
22	1.8	3.2	552	4.533	0.112	0.8	3.9	193	4.052	0.184
23	1.5	3.2	471	4.225	0.134	0.6	1.5	391	3.986	0.227
24	1.3	2.3	580	4.023	0.169	0.5	0.7	687	3.815	0.267
25	1.4	2.1	665	4.506	0.145	0.4	0.7	516	4.049	0.211
26	1.4	1.1	1327	4.663	0.114	0.3	0.2	1715	4.025	0.282
27	1.2	1.4	881	4.402	0.154	0.4	nd	nd	4.504	0.298
28	0.9	1.4	685	4.130	0.151	0.5	0.5	858	4.080	0.212
29	0.9	1.2	697	4.771	0.217	0.5	0.6	860	4.314	0.280
30	0.9	1.2	744	4.205	0.169	0.5	0.3	1819	4.136	0.226

Supplementary Information Table 4, continued

	Inside Hole #3					Inside Hole #4				
Bin #	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error
1	14.5	14.1	1033	4.928	0.086	14.7	2.4	6110	5.006	0.141
2	10.4	9.7	1078	4.220	0.103	12.7	7.7	1637	4.528	0.064
3	10.3	2.4	4226	3.981	0.068	11.9	7.8	1512	4.295	0.078
4	10.6	1.7	6331	3.980	0.091	11.8	3.8	3132	4.616	0.068
5	10.8	1.4	7791	4.153	0.100	11.0	0.5	21379	4.647	0.065
6	9.7	4.7	2069	3.997	0.070	10.7	11.6	921	4.538	0.062
7	9.8	2.3	4259	4.393	0.078	9.7	1.0	9534	4.299	0.058
8	6.8	17.4	389	4.363	0.081	9.1	7.1	1287	4.065	0.091
9	5.7	6.4	897	4.304	0.067	7.8	1.4	5385	4.091	0.068
10	4.9	4.9	990	4.067	0.079	8.7	0.9	9310	4.502	0.086
11	4.7	3.5	1332	4.157	0.092	7.7	1.9	3970	4.430	0.118
12	4.0	3.4	1161	4.246	0.107	7.2	3.5	2054	4.489	0.096
13	3.3	1.3	2516	4.340	0.130	6.4	5.2	1237	4.517	0.096
14	2.4	4.5	545	4.227	0.111	4.8	5.3	913	4.180	0.099
15	1.4	2.5	578	3.832	0.156	4.3	5.9	723	4.095	0.091
16	0.7	1.2	569	3.897	0.245	2.8	6.8	414	3.838	0.131
17	0.5	1.4	342	3.857	0.168	0.6	3.1	182	3.463	0.135
18	0.4	0.5	799	3.888	0.229	0.4	1.1	386	3.495	0.233
19	0.3	0.5	600	3.709	0.306	0.4	1.7	215	3.580	0.263
20	0.3	0.6	439	3.646	0.327	0.4	0.8	459	3.688	0.293
21	0.2	0.1	1828	3.727	0.478	0.3	0.5	668	3.240	0.264
22	0.2	0.0	3591	3.833	0.392	0.4	0.6	625	3.704	0.244
23	0.1	0.0	11082	3.601	0.427	0.4	0.6	798	3.780	0.258
24	0.1	0.2	901	3.616	0.563	0.4	0.4	1128	3.685	0.218
25	0.2	0.1	3853	4.118	0.368	0.4	0.6	642	3.899	0.352
26	0.3	0.9	314	3.681	0.276	0.3	0.4	687	3.350	0.379
27	0.3	0.2	1306	3.667	0.279	0.2	0.4	522	3.447	0.403
28	0.2	0.6	336	4.051	0.439	0.2	0.0	4109	3.162	0.423
29	0.2	0.0	nd	3.171	0.369	0.1	0.6	240	2.851	0.356
30	0.1	nd	nd	3.383	0.488	0.1	0.6	228	3.045	0.422

Supplementary Information Table 4, continued

	Inside Hole #5					Inside Hole #6				
Bin #	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error
1	14.2	6.8	2094	5.102	0.092	13.4	12.1	1110	5.257	0.085
2	12.3	3.3	3696	4.591	0.115	12.2	7.1	1716	4.834	0.084
3	10.5	2.6	4087	4.012	0.098	11.0	4.0	2791	4.274	0.068
4	11.0	2.0	5450	3.981	0.059	10.1	2.9	3547	4.080	0.051
5	10.4	0.8	13657	4.023	0.087	9.4	9.0	1047	3.822	0.085
6	10.0	1.2	8494	3.828	0.074	9.1	1.3	7243	3.958	0.070
7	8.9	6.7	1319	3.849	0.078	8.8	11.2	779	4.218	0.085
8	8.0	5.1	1580	3.979	0.076	7.1	22.9	310	4.056	0.082
9	8.1	4.4	1847	3.992	0.062	6.9	4.4	1565	4.016	0.116
10	7.2	5.1	1422	3.925	0.084	5.8	2.0	2876	4.072	0.090
11	6.0	10.3	587	4.039	0.079	6.2	1.6	3893	4.376	0.088
12	5.2	3.9	1324	4.358	0.089	5.7	3.0	1897	4.196	0.100
13	4.2	3.0	1422	4.425	0.106	4.7	2.0	2374	3.952	0.109
14	3.4	5.3	647	4.172	0.083	4.4	1.8	2478	3.977	0.089
15	2.8	4.5	630	4.221	0.088	3.9	2.3	1658	4.138	0.122
16	1.1	3.3	330	3.839	0.202	3.7	2.0	1894	4.447	0.116
17	0.6	0.4	1459	3.610	0.203	2.9	5.2	553	4.418	0.086
18	0.9	0.9	1063	3.941	0.189	2.2	2.0	1071	4.364	0.100
19	0.9	0.8	1106	3.910	0.133	1.8	1.3	1405	4.171	0.123
20	0.7	0.8	946	3.956	0.177	1.5	2.2	701	4.102	0.129
21	0.7	0.8	845	4.012	0.201	1.5	2.3	630	4.385	0.146
22	0.6	0.4	1461	3.950	0.222	1.5	0.8	1901	4.363	0.204
23	0.5	0.5	876	3.806	0.207	1.4	0.7	2103	4.220	0.145
24	0.4	0.6	616	3.597	0.197	1.0	1.8	586	4.040	0.151
25	0.4	0.5	665	3.747	0.224	0.9	1.9	470	4.040	0.168
26	0.3	0.6	520	3.857	0.221	0.9	0.9	963	3.988	0.137
27	0.3	0.7	422	3.354	0.266	0.9	0.7	1221	4.209	0.153
28	0.3	0.7	452	3.619	0.309	0.8	0.9	930	3.979	0.189
29	0.2	0.3	698	3.346	0.313	0.7	0.2	3141	3.757	0.161
30	0.2	nd	nd	3.492	0.420	0.6	0.3	2040	3.801	0.195

Supplementary Information Table 4, continued

	Inside Hole #7					Inside Hole #8				
Bin #	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error
1	12.5	5.7	2170	4.579	0.086	15.1	8.2	1839	4.088	0.050
2	12.0	2.3	5123	4.635	0.069	12.1	7.7	1578	3.991	0.055
3	10.9	9.8	1108	4.319	0.075	12.1	2.4	4986	4.128	0.066
4	10.1	16.7	609	4.324	0.062	11.7	2.2	5339	4.266	0.067
5	9.3	4.6	2025	4.285	0.069	10.4	1.7	5982	4.302	0.056
6	9.6	5.9	1618	4.136	0.082	10.5	1.8	5704	4.355	0.065
7	9.1	1.5	5990	4.208	0.073	9.2	19.0	483	4.346	0.076
8	9.3	2.0	4732	4.443	0.074	9.1	2.7	3348	4.349	0.074
9	8.4	1.0	8621	4.340	0.090	9.0	2.0	4400	4.268	0.069
10	8.1	0.9	8609	4.446	0.070	7.6	3.1	2419	4.196	0.078
11	8.2	0.7	12567	4.652	0.097	7.3	0.5	14085	4.305	0.099
12	7.1	0.8	9178	4.052	0.094	7.8	3.8	2026	4.569	0.103
13	6.6	1.1	5998	4.234	0.084	6.8	11.2	609	4.488	0.085
14	5.5	2.5	2165	4.130	0.066	5.9	7.3	813	4.384	0.101
15	5.3	1.0	5367	4.184	0.105	4.8	2.7	1772	4.215	0.135
16	4.3	5.9	729	4.377	0.121	4.5	3.4	1326	4.236	0.079
17	3.9	1.9	2122	4.345	0.105	3.6	0.7	5490	4.044	0.084
18	4.0	1.8	2228	4.455	0.119	3.8	8.9	427	4.307	0.067
19	3.2	2.9	1102	4.113	0.118	3.6	5.6	646	4.250	0.119
20	2.9	8.4	342	4.340	0.110	3.3	3.3	1000	4.799	0.128
21	2.8	4.0	693	4.522	0.096	3.3	3.0	1097	4.804	0.081
22	2.6	0.9	2823	4.498	0.112	2.9	0.3	9530	4.761	0.126
23	2.3	1.3	1821	4.453	0.114	2.7	0.5	4983	4.750	0.099
24	1.9	0.8	2323	4.138	0.119	2.2	0.3	7644	4.462	0.127
25	1.8	0.2	9733	4.215	0.147	2.2	2.2	987	4.601	0.116
26	1.8	0.5	3274	4.232	0.153	2.1	1.2	1802	4.453	0.189
27	1.7	0.9	1936	4.446	0.194	1.6	38.1	41	3.585	0.132
28	1.4	0.3	4408	4.103	0.127	0.5	20.9	26	4.031	0.168
29	1.3	0.1	21804	4.164	0.112	0.6	29.6	19	4.078	0.162
30	1.2	3.5	342	4.259	0.178	0.5	17.1	30	4.131	0.308

Supplementary Information Table 4, continued

	Outside Hole #1					Outside Hole #2				
Bin #	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error
1	4.6	2.4	1931	4.290	0.085	16.9	2.2	7699	3.859	0.111
2	3.7	3.3	1148	4.291	0.068	16.8	2.9	5835	4.427	0.057
3	3.2	3.0	1057	4.347	0.088	15.2	1.9	8001	4.774	0.057
4	2.7	1.9	1424	4.269	0.111	15.1	0.4	38447	4.916	0.080
5	2.2	1.5	1411	4.320	0.083	13.5	20.8	651	4.959	0.071
6	1.9	1.0	1928	4.178	0.135	11.0	8.7	1258	4.640	0.065
7	1.6	0.5	3131	4.301	0.117	10.2	4.6	2184	4.354	0.058
8	1.2	1.1	1097	4.295	0.136	9.5	1.9	4994	4.145	0.064
9	1.1	0.8	1296	4.200	0.168	8.7	0.5	16767	4.026	0.066
10	1.0	0.3	2903	4.160	0.114	8.4	2.4	3432	4.088	0.057
11	1.0	0.5	2026	4.065	0.129	8.1	4.5	1811	4.250	0.058
12	0.8	0.9	971	3.883	0.152	6.7	2.5	2716	3.927	0.071
13	0.7	0.7	1086	3.974	0.228	6.1	0.5	12198	3.818	0.081
14	0.6	0.3	1830	3.738	0.183	5.1	0.6	8351	3.834	0.097
15	0.6	0.5	1055	3.548	0.153	4.8	1.7	2768	3.953	0.087
16	0.5	0.6	883	3.493	0.233	5.3	0.7	7762	4.528	0.123
17	0.5	0.1	3957	3.533	0.155	5.0	0.7	6801	4.561	0.079
18	0.5	0.4	1251	3.654	0.207	4.6	0.9	5081	4.484	0.075
19	0.5	0.1	3635	3.691	0.215	4.4	0.9	4797	4.482	0.080
20	0.5	0.1	5655	3.614	0.203	4.0	0.7	5786	4.332	0.062
21	0.6	5.2	111	3.389	0.186	4.3	0.8	5161	4.557	0.069
22	1.1	170.1	7	3.045	0.204	3.7	3.0	1257	4.670	0.093
23	0.7	71.1	9	3.171	0.262	3.5	2.5	1426	4.606	0.101
24	0.5	6.0	77	3.401	0.235	3.2	6.7	472	4.559	0.104
25	0.4	6.3	65	3.339	0.169	2.8	1.3	2166	4.532	0.113
26	0.4	4.6	94	3.391	0.199	2.7	1.3	2126	4.601	0.129
27	0.4	3.3	120	3.342	0.194	2.3	1.0	2345	4.415	0.100
28	0.4	2.5	162	3.238	0.208	2.0	0.7	2741	4.170	0.105
29	0.4	1.7	244	3.553	0.187	1.8	1.1	1685	4.244	0.103
30	4.6	2.4	1931	4.290	0.085	1.5	0.8	1960	4.088	0.128

Supplementary Information Table 4, continued

	Outside Hole #3					Outside Hole #4				
Bin #	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error
1	15.5	4.5	3461	3.615	0.102	14.3	2.9	5016	4.117	0.103
2	12.6	2.5	5154	4.023	0.086	13.4	2.5	5414	4.310	0.070
3	15.0	3.3	4525	4.420	0.089	13.2	2.5	5360	4.501	0.049
4	14.4	3.0	4872	4.726	0.131	11.3	0.8	14299	4.370	0.054
5	13.4	1.5	8975	4.577	0.137	11.6	nd	nd	4.432	0.067
6	13.5	0.9	15358	4.656	0.075	12.5	0.6	20268	4.621	0.070
7	12.9	3.2	4019	4.900	0.071	13.0	12.0	1087	5.000	0.061
8	12.7	7.3	1739	5.119	0.097	12.2	4.5	2707	4.945	0.075
9	10.7	3.3	3219	4.821	0.087	9.7	2.1	4703	4.774	0.046
10	9.5	3.3	2834	4.626	0.132	8.6	1.0	8586	4.763	0.043
11	9.5	12.0	797	4.724	0.082	8.0	0.7	11395	4.606	0.082
12	8.4	2.9	2943	4.431	0.158	7.5	5.9	1257	4.262	0.080
13	8.5	9.3	917	4.658	0.090	7.0	4.5	1543	4.254	0.066
14	7.9	5.6	1406	4.543	0.066	6.0	1.1	5381	4.299	0.080
15	6.9	4.2	1641	4.419	0.138	5.3	0.3	20252	4.215	0.074
16	6.3	2.5	2548	4.354	0.086	4.2	nd	nd	4.083	0.074
17	5.8	1.6	3567	4.361	0.093	3.8	nd	nd	4.121	0.078
18	5.9	0.4	14010	4.298	0.101	3.6	0.1	30030	4.241	0.095
19	5.7	0.3	19984	4.253	0.128	3.2	1.1	2926	4.360	0.083
20	5.4	2.6	2053	4.363	0.077	2.6	0.8	3382	4.231	0.072
21	5.2	9.6	535	4.408	0.071	2.7	0.4	6394	4.387	0.103
22	4.8	1.5	3225	4.352	0.099	2.8	0.0	-87918	4.527	0.102
23	4.5	2.5	1784	4.463	0.103	2.4	0.3	7234	4.518	0.102
24	4.3	2.9	1506	4.443	0.179	2.0	1.0	2061	4.458	0.111
25	4.1	1.2	3471	4.733	0.114	1.7	0.6	2797	4.364	0.122
26	3.9	1.7	2319	4.705	0.105	1.7	0.1	16168	4.294	0.122
27	3.9	1.5	2576	4.388	0.102	1.6	0.1	12496	4.155	0.093
28	3.7	0.6	6110	4.558	0.086	1.4	nd	nd	4.370	0.125
29	2.4	13.8	177	4.121	0.174	1.3	0.1	8661	4.421	0.126
30	3.0	40.8	74	2.958	0.236	1.2	nd	nd	4.426	0.147

Supplementary Information Table 5: 2014 laser ablation $^{234}U/^{238}U$ runs on basicranial fragment. For hole positions, see Extended Data Figures 5B, C. nd: not detemined, Th concentration below background. Errors are 2 s.d.

	Inside Hole #1					**Inside Hole #2**				
Bin #	U (ppm)	Th (ppb)	U/Th	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	U (ppm)	Th (ppb)	U/Th	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error
1	11.6	3.5	3293	3.730	0.038	11.0	3.1	3509	3.844	0.031
2	10.1	5.9	1717	3.643	0.045	9.9	3.4	2962	3.729	0.029
3	8.9	6.9	1288	3.621	0.022	9.4	4.1	2275	3.829	0.028
4	7.1	6.0	1189	3.766	0.043	7.5	2.3	3206	3.738	0.026
5	6.8	2.6	2619	3.834	0.029	6.4	11.3	563	3.634	0.034
6	5.2	2.8	1817	3.750	0.034	5.8	5.8	1009	3.561	0.041
7	3.5	1.2	2797	3.563	0.050	5.4	4.9	1092	3.611	0.044
8	2.8	1.9	1448	3.554	0.041	4.2	2.3	1804	3.750	0.055
9	2.1	1.1	1970	3.660	0.055	2.5	4.8	517	3.381	0.048
10	1.7	1.2	1447	3.635	0.042	2.1	0.4	4606	3.591	0.048
11	1.5	1.5	1014	3.618	0.043	1.7	0.6	2853	3.515	0.064
12	1.3	1.3	996	3.702	0.055	1.3	1.4	947	3.426	0.057
13	1.0	0.4	2349	3.615	0.056	1.2	0.3	3665	3.436	0.068
14	0.7	0.6	1202	3.652	0.087	1.1	0.4	2825	3.378	0.065
15	0.4	0.6	723	3.659	0.079	0.9	0.5	1573	3.377	0.085
16	0.4	0.7	580	3.595	0.082	0.3	0.7	501	3.603	0.100
17	0.4	0.1	3074	3.642	0.101	0.2	0.0	4794	3.583	0.124
18	0.3	0.5	470	3.733	0.119	0.2	0.3	522	3.577	0.152
19	0.3	0.4	777	3.779	0.108	0.1	0.0	2550	3.673	0.141
20	0.3	0.1	2315	3.683	0.104	0.1	nd	nd	3.624	0.173
21	0.2	0.3	535	3.697	0.137	0.1	nd	nd	3.786	0.161
22	0.2	0.3	493	3.751	0.162	0.2	0.4	542	3.581	0.114
23	0.2	nd	nd	3.661	0.129	0.2	nd	nd	3.554	0.099
24	0.1	0.3	473	3.502	0.119	0.2	0.2	1047	3.540	0.119
25	0.2	0.1	1352	3.635	0.132	0.1	0.1	2603	3.563	0.154
26	0.2	0.5	321	3.685	0.140	0.1	0.2	667	3.479	0.139
27	0.2	0.2	632	3.672	0.121	0.1	0.4	145	3.798	0.312
28	0.1	nd	nd	3.558	0.125	0.0	0.1	449	3.927	0.236
29	0.1	nd	nd	3.579	0.142	0.0	nd	nd	3.777	0.308
30	0.1	nd	nd	3.586	0.158	0.0	0.1	268	3.758	0.316

Supplementary Information Table 5, continued

	Inside Hole #3				
Bin #	U (ppm)	Th (ppb)	U/Th	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error
1	11.5	5.4	2107	3.868	0.036
2	10.1	6.1	1640	3.621	0.024
3	9.5	8.4	1132	3.602	0.036
4	8.4	4.2	2015	3.676	0.022
5	8.3	3.1	2653	3.678	0.050
6	8.1	0.9	8686	3.745	0.048
7	7.0	3.9	1814	3.706	0.042
8	5.8	3.7	1581	3.593	0.049
9	4.2	5.0	830	3.479	0.034
10	3.5	4.1	850	3.449	0.034
11	3.2	1.0	3066	3.636	0.033
12	2.7	1.1	2384	3.608	0.043
13	2.0	2.4	838	3.764	0.051
14	0.8	1.5	494	3.620	0.094
15	0.6	0.7	914	3.680	0.086
16	0.6	0.2	3303	3.799	0.071
17	0.5	1.0	536	3.731	0.083
18	0.5	0.4	1300	3.631	0.066
19	0.4	0.2	1635	3.753	0.090
20	0.3	0.6	483	3.747	0.101
21	0.2	0.7	345	3.815	0.125
22	0.2	0.4	480	3.540	0.106
23	0.2	0.2	751	3.615	0.122
24	0.2	0.5	344	3.785	0.125
25	0.2	0.2	931	3.885	0.164
26	0.1	nd	nd	3.557	0.153
27	0.2	0.6	290	3.564	0.122
28	0.2	0.1	1819	3.726	0.137
29	0.2	0.0	3486	3.716	0.145
30	0.2	0.2	1099	3.810	0.141

Supplementary Information Table 5, continued

	Outside Hole #1					Outside Hole #2				
Bin #	U (ppm)	Th (ppb)	U/Th	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	U (ppm)	Th (ppb)	U/Th	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error
1	16.2	36.6	442	3.847	0.029	17.1	1.4	12532	4.204	0.026
2	13.8	2.7	5086	3.953	0.026	14.8	2.4	6249	4.213	0.024
3	14.1	5.3	2655	4.071	0.025	13.0	7.0	1849	4.262	0.040
4	13.6	5.0	2720	4.151	0.030	10.2	1.7	5880	3.968	0.036
5	12.8	2.2	5843	4.180	0.024	9.0	3.4	2677	4.083	0.043
6	11.9	0.2	52122	4.233	0.052	8.0	1.3	6064	4.051	0.054
7	11.2	5.8	1952	4.261	0.050	7.7	1.3	6102	3.995	0.067
8	9.5	3.0	3169	4.174	0.033	7.2	2.2	3201	3.790	0.042
9	7.1	3.8	1878	3.842	0.055	7.1	0.8	9155	3.762	0.028
10	5.9	9.1	651	3.846	0.045	6.3	2.3	2713	3.671	0.049
11	5.1	1.2	4268	3.800	0.072	6.2	12.1	510	3.819	0.060
12	5.1	1.2	4231	3.851	0.078	5.6	2.9	1926	3.896	0.048
13	4.6	1.0	4781	3.886	0.059	4.6	0.8	6081	3.793	0.055
14	3.9	0.0	120847	3.882	0.040	4.4	1.2	3798	3.867	0.038
15	3.4	0.7	4670	3.888	0.034	4.3	1.5	2924	3.982	0.053
16	3.0	0.8	3878	3.792	0.041	3.7	0.7	5359	3.888	0.040
17	2.9	0.5	5961	3.884	0.058	3.5	0.5	7285	4.043	0.075
18	3.0	0.8	3628	4.061	0.050	2.9	0.8	3534	3.991	0.062
19	2.3	nd	nd	3.923	0.052	2.2	0.1	18043	3.891	0.066
20	2.0	nd	nd	3.858	0.058	1.9	0.2	7619	3.826	0.052
21	1.6	5.4	298	3.917	0.051	1.6	0.7	2265	3.793	0.073
22	1.5	1.0	1450	3.966	0.062	1.2	0.7	1652	3.554	0.045
23	1.4	nd	nd	3.912	0.053	0.9	0.7	1332	3.723	0.059
24	1.3	0.7	1977	3.884	0.056	0.9	0.4	1994	3.891	0.059
25	1.3	0.5	2698	3.961	0.061	0.8	0.0	29135	3.881	0.089
26	1.1	0.5	2277	3.996	0.060	0.8	nd	nd	3.874	0.073
27	1.0	nd	nd	4.104	0.065	0.7	nd	nd	3.873	0.087
28	0.9	0.0	1327573	4.077	0.057	0.7	0.1	12793	3.878	0.070
29	0.8	0.1	8549	4.069	0.082	0.6	0.0	12791	3.926	0.079
30	0.7	nd	nd	4.128	0.074	0.6	0.1	7682	3.832	0.067

Supplementary Information Table 5, continued

	Outside Hole #3					Outside Hole #4				
Bin #	U (ppm)	Th (ppb)	U/Th	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	U (ppm)	Th (ppb)	U/Th	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error
1	20.1	5.6	3587	4.312	0.025	22.1	8.8	2512	4.285	0.022
2	16.8	8.8	1894	4.363	0.027	19.6	6.0	3267	4.314	0.018
3	13.0	5.1	2541	4.176	0.046	17.1	2.8	6040	4.330	0.021
4	10.6	3.3	3245	3.928	0.029	14.6	2.2	6492	4.247	0.024
5	9.7	6.8	1425	3.830	0.040	12.3	3.9	3143	4.140	0.032
6	9.0	4.5	2013	3.710	0.022	11.2	4.7	2356	4.114	0.036
7	8.7	9.0	973	3.771	0.031	9.9	0.9	10720	3.988	0.062
8	8.3	6.1	1350	3.828	0.025	8.6	0.8	11218	3.872	0.026
9	7.6	2.1	3646	3.761	0.042	7.7	14.0	547	3.867	0.033
10	6.9	3.5	1942	3.743	0.029	6.7	7.8	863	3.716	0.034
11	5.9	2.4	2492	3.622	0.027	6.6	1.1	6056	3.798	0.045
12	4.7	1.3	3654	3.488	0.034	5.8	1.4	4138	3.679	0.022
13	4.3	1.4	3083	3.573	0.046	5.2	1.2	4436	3.695	0.028
14	4.3	3.1	1380	3.701	0.052	4.6	1.5	3126	3.529	0.039
15	3.8	5.6	688	3.763	0.042	4.1	0.5	7596	3.668	0.043
16	3.2	3.4	950	3.662	0.044	3.6	0.5	7552	3.742	0.035
17	2.9	1.6	1877	3.628	0.060	3.6	0.5	6600	3.964	0.067
18	2.5	0.9	2870	3.606	0.049	3.5	0.4	9380	3.923	0.028
19	2.3	1.0	2311	3.781	0.080	3.1	0.4	8560	3.986	0.074
20	2.0	0.7	2867	3.867	0.048	2.7	0.5	4894	3.788	0.059
21	1.6	0.5	3198	3.916	0.062	2.2	0.5	4110	3.634	0.044
22	1.4	0.9	1495	3.800	0.072	1.8	0.7	2554	3.746	0.040
23	1.2	0.2	6565	3.806	0.063	2.0	0.6	3539	3.739	0.041
24	1.1	0.5	2312	4.022	0.062	1.9	1.1	1662	3.829	0.059
25	1.0	0.9	1084	3.884	0.051	1.7	0.2	8870	3.936	0.071
26	0.8	nd	nd	3.801	0.073	1.6	0.4	3899	3.830	0.067
27	0.7	0.1	4908	3.843	0.107	1.3	nd	nd	3.754	0.052
28	0.6	0.2	4016	3.836	0.070	1.2	0.0	139708	3.707	0.071
29	0.7	0.3	1997	3.900	0.073	1.3	0.4	2996	3.728	0.064
30	0.4	nd	nd	3.804	12.542	1.3	nd	nd	3.808	0.053

Supplementary Information Table 6: Averaged $^{230}Th/^{238}U$ and $^{234}U/^{238}U$ depth profiles (from Supplementary Information Tables 4 and 5) and age calculations, see Extended Data Figures 5B, C. Errors on individual measurements are 2 s.d. (excluding error of the standard, which is a correlated error for all individual measurements). Errors on averages are combined 2-s.d. of the error of the mean and error of the standard.

Inside Holes	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	Age (ka)	Age error (ka)	Initial $^{234}U/^{238}U$	$^{234}U/^{238}Ui$ error
1	4.843	0.141	3.814	0.043	468	106	11.549	3.089
2	4.529	0.101	3.665	0.033	404	52	9.343	1.197
3	4.258	0.114	3.684	0.073	305	35	7.353	0.547
4	4.267	0.100	3.727	0.026	295	24	7.269	0.404
5	4.192	0.085	3.715	0.061	282	23	7.015	0.320
6	4.124	0.081	3.686	0.062	275	22	6.842	0.286
7	4.200	0.066	3.627	0.042	309	21	7.275	0.325
8	4.249	0.072	3.632	0.060	320	28	7.486	0.426
9	4.167	0.049	3.507	0.082	343	38	7.594	0.530
10	4.219	0.072	3.558	0.056	338	32	7.648	0.512
11	4.315	0.070	3.590	0.038	357	30	8.090	0.557
12	4.296	0.071	3.579	0.081	355	45	8.029	0.718
13	4.327	0.066	3.605	0.095	354	48	8.079	0.751
14	4.190	0.047	3.550	0.087	333	37	7.519	0.478
15	4.166	0.063	3.572	0.098	318	38	7.301	0.472
16	4.185	0.102	3.665	0.067	293	30	7.102	0.432
17	4.035	0.127	3.652	0.043	266	26	6.615	0.383
18	4.136	0.118	3.647	0.046	287	29	6.958	0.446
19	4.021	0.099	3.735	0.032	247	17	6.485	0.248
20	4.156	0.138	3.685	0.035	282	30	6.953	0.489
21	4.207	0.184	3.766	0.035	273	36	6.975	0.596
22	4.212	0.134	3.624	0.065	312	41	7.336	0.662
23	4.103	0.135	3.610	0.031	290	32	6.919	0.515
24	3.922	0.106	3.609	0.089	254	26	6.348	0.298
25	4.147	0.102	3.694	0.098	278	31	6.902	0.387
26	4.031	0.149	3.574	0.060	284	36	6.736	0.541
27	3.952	0.171	3.678	0.068	246	31	6.361	0.428
28	3.894	0.119	3.737	0.107	227	24	6.196	0.251
29	3.807	0.228	3.691	0.058	222	33	6.034	0.449
30	3.806	0.160	3.718	0.068	218	23	6.027	0.303
Averages								
3-26	4.172	0.101	3.637	0.074	298	34	7.122	0.475

Supplementary Information Table 6, continued

Outside Holes	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	Age (ka)	Age error (ka)	Initial $^{234}U/^{238}U$	$^{234}U/^{238}Ui$ error
1	3.864	0.145	4.162	0.215	175	22	6.182	0.205
2	4.254	0.120	4.176	0.104	212	18	6.783	0.221
3	4.565	0.107	4.170	0.048	253	18	7.481	0.297
4	4.671	0.160	4.016	0.059	306	39	8.148	0.738
5	4.656	0.157	4.031	0.090	299	40	8.041	0.702
6	4.639	0.010	3.998	0.133	304	36	8.063	0.405
7	4.752	0.201	4.009	0.123	327	65	8.571	1.220
8	4.737	0.300	3.931	0.106	351	101	8.886	2.142
9	4.540	0.257	3.789	0.023	347	81	8.416	1.680
10	4.492	0.206	3.753	0.044	346	67	8.304	1.352
11	4.527	0.142	3.747	0.054	360	55	8.581	1.112
12	4.207	0.148	3.745	0.112	278	40	7.011	0.539
13	4.244	0.243	3.750	0.080	284	54	7.128	0.883
14	4.225	0.208	3.817	0.050	265	39	6.953	0.627
15	4.196	0.135	3.878	0.055	248	23	6.801	0.349
16	4.322	0.129	3.781	0.057	293	32	7.350	0.522
17	4.348	0.127	3.852	0.105	280	35	7.288	0.487
18	4.341	0.074	3.886	0.122	271	30	7.205	0.308
19	4.365	0.066	3.865	0.037	280	16	7.323	0.241
20	4.309	0.040	3.850	0.011	273	8	7.161	0.130
21	4.451	0.054	3.875	0.036	295	15	7.619	0.234
22	4.516	0.092	3.773	0.104	345	50	8.346	0.826
23	4.529	0.042	3.814	0.047	334	21	8.215	0.330
24	4.487	0.036	3.932	0.039	288	12	7.619	0.164
25	4.543	0.106	3.909	0.023	307	25	7.916	0.483
26	4.533	0.123	3.890	0.049	310	32	7.932	0.593
27	4.319	0.082	3.940	0.072	257	19	7.066	0.244
28	4.366	0.112	3.930	0.064	266	24	7.215	0.354
29	4.262	0.087	3.965	0.045	243	15	6.892	0.217
30	3.824	0.444	3.922	0.090	194	49	6.057	0.679
Averages								
4-26	4.462	0.108	3.865	0.079	301	37	7.696	0.557

Supplementary Information Table 7: U-series results on the Broken Hill Femur midshaft (EM793). nd: not detemined, Th concentration below background. Errors on individual measurements are 2 s.d. (excluding error of the standard, which is a correlated error for all individual measurements). Errors on averages are combined 2-s.d. of the error of the mean and error of the standard.

	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	Age (ka)	Age error (ka)
1	41.2	15.3	2693	2.270	0.049	2.840	0.035	138	6
2	43.2	7.3	5918	2.260	0.049	2.870	0.035	135	6
3	41.8	5.0	8360	2.150	0.047	2.920	0.035	120	5
4	40.0	2.4	16667	2.250	0.049	2.960	0.036	127	5
5	37.8	nd	nd	2.260	0.050	2.970	0.036	127	5
6	39.3	nd	nd	2.710	0.057	2.950	0.036	178	9
7	38.3	7.7	4974	2.610	0.056	2.900	0.036	171	8
8	35.4	nd	nd	2.570	0.056	2.950	0.036	160	8
9	34.2	1.6	21375	2.600	0.057	2.940	0.036	165	8
10	33.1	35.2	940	2.560	0.056	2.960	0.037	158	7
11	32.2	6.7	4806	2.590	0.057	2.920	0.036	166	8
12	32.4	nd	nd	2.600	0.057	2.950	0.037	164	8
13	31.6	8.2	3854	2.590	0.057	2.940	0.037	164	8
14	30.6	38.2	801	2.470	0.055	2.950	0.037	149	7
15	33.0	41.1	803	2.600	0.057	2.760	0.035	189	10
16	27.8	6.1	4557	2.340	0.054	2.970	0.037	134	6
17	26.8	10.6	2528	2.500	0.057	2.920	0.038	156	8
18	27.7	9.9	2798	2.250	0.052	2.890	0.037	132	6
19	25.8	2.6	9923	2.350	0.055	2.790	0.036	152	7
20	26.9	7.8	3449	2.540	0.058	2.930	0.037	159	8
21	25.3	4.1	6171	2.620	0.060	2.840	0.037	180	10
22	24.6	15.2	1618	2.750	0.063	2.970	0.038	181	10
23	24.3	19.0	1279	2.690	0.062	2.950	0.038	175	9
24	22.6	22.7	996	2.700	0.063	2.850	0.037	190	11
25	21.9	nd	nd	2.670	0.063	2.960	0.039	171	9
26	21.8	35.6	612	2.730	0.064	2.860	0.037	193	11
27	23.2	4.5	5156	2.800	0.064	2.980	0.039	186	10
28	23.6	8.8	2682	2.720	0.063	2.990	0.039	174	9
29	23.5	19.9	1181	2.710	0.063	2.920	0.038	182	10
30	25.4	7.1	3577	2.630	0.060	2.940	0.038	169	9
31	27.1	4.5	6022	2.660	0.060	2.930	0.038	174	9
32	28.2	13.3	2120	2.810	0.062	2.920	0.037	196	11
33	29.1	10.0	2910	2.740	0.061	2.950	0.037	182	10
AVERAGE VALUES									
	initial $^{234}U/^{238}U$	$^{234}U/^{238}U$i error		$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	Age (ka)	Age error (ka)
1-33	4.032	0.071		2.555	0.066	2.919	0.038	162	9
6-33*	4.092	0.072		2.611	0.062	2.921	0.038	169	9

Younger ages for 1-5 may be due to secondary overprint

Supplementary Information Table 8: Gamma spectrometric results (in italics: average TIMS results from Supplementary InformationTable 3). Errors are 2 s.d..

$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	Th/U Age (ka)	Age error (ka)	$^{231}Pa/^{235}U$	$^{231}Pa/^{235}U$ error	Pa/U Age (ka)	Age error (ka)
Femur Midshaft (EM793)									
2.722	0.061	*2.924*	*0.035*	183	10	1.042	0.023	∞	
Femur Head (E907)									
2.610	0.064	*2.942*	*0.003*	166	8	1.045	0.028	∞	
Pelvis (E719)									
2.316	0.062	*2.632*	*0.002*	166	9	0.953	0.030	145	+48/-23

Supplementary Information Table 9: U-series results on the Broken Hill Tibia (E691). Errors on individual measurements are 2 s.d. (excluding error of the standard, which is a correlated error for all individual measurements). Errors on averages are combined 2-s.d. of the error of the mean and error of the standard.

Tibia Cross Section 1	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	Age (ka)	Age error (ka)
1	11.07	3.3	3320	4.143	0.063	4.129	0.027	206	8
2	10.15	3.4	2940	3.997	0.125	4.174	0.025	186	12
3	9.17	8.7	1050	3.641	0.110	4.082	0.030	163	9
4	6.66	15.1	440	3.889	0.109	3.966	0.042	197	13
5	7.56	5.7	1330	3.505	0.124	3.922	0.031	164	11
6	7.14	7.4	950	3.290	0.075	3.740	0.030	160	7
7	8.25	5.1	1600	3.987	0.073	3.998	0.024	204	9
8	8.59	3.4	2560	3.740	0.117	3.940	0.021	184	12
9	8.12	2.8	2930	3.698	0.089	4.068	0.026	168	8
10	8.59	1.9	4430	3.944	0.064	3.971	0.027	202	8
11	8.33	5.3	1570	3.699	0.075	4.085	0.025	167	7
12	8.85	8.2	1070	3.298	0.062	4.036	0.025	139	5
13	9.57	7.3	1300	3.670	0.063	3.801	0.029	191	8
14	8.80	2.7	3220	3.708	0.084	3.832	0.026	192	9
15	8.53	4.6	1830	3.650	0.065	3.779	0.034	191	8
16	9.79	8.3	1170	3.848	0.064	3.923	0.027	197	8
17	8.81	15.4	570	3.928	0.056	4.003	0.028	197	7
18	9.75	3.0	3220	3.725	0.079	3.883	0.037	188	9
AVERAGE VALUES									
	initial $^{234}U/^{238}U$	$^{234}U/^{238}U$i error		$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	Age (ka)	Age error (ka)
1-18	5.880	0.120		3.752	0.093	3.963	0.028	183	9

Tibia Cross Section 2	U (ppm)	Th (ppb)	U/Th	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	Age (ka)	Age error (ka)
1	9.03	3.8	2360	3.062	0.066	4.089	0.023	121	4
2	9.18	4.8	1920	3.464	0.156	4.130	0.019	146	11
3	9.01	13.3	670	3.694	0.073	3.668	0.038	210	11
4	8.04	2.6	3090	3.523	0.070	4.025	0.025	157	6
5	8.13	2.5	3240	3.727	0.106	3.965	0.024	180	10
6	8.23	6.7	1230	3.537	0.057	3.984	0.026	162	5
7	6.27	3.0	2090	3.660	0.093	4.075	0.031	165	8
8	6.73	2.4	2770	3.667	0.063	4.077	0.033	165	6
9	7.95	1.3	5900	3.805	0.082	4.095	0.029	176	8
10	7.03	5.5	1280	3.551	0.082	4.157	0.031	150	6
11	6.35	3.9	1610	3.732	0.058	3.977	0.029	179	6
12	7.24	3.7	1970	3.691	0.088	3.987	0.036	175	9
13	7.26	3.4	2140	3.554	0.072	4.010	0.029	161	6
14	8.65	5.4	1580	3.921	0.071	3.726	0.035	233	12
15	8.32	5.0	1650	3.803	0.063	4.102	0.025	175	6
16	8.50	3.3	2550	3.774	0.074	4.080	0.028	174	7
17	7.93	4.3	1840	3.816	0.059	3.944	0.033	191	7
18	7.95	1.5	5260	3.729	0.086	3.947	0.040	182	9
AVERAGE VALUES									
	initial $^{234}U/^{238}U$	$^{234}U/^{238}U$i error		$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	Age (ka)	Age error (ka)
3-18*	5.914	0.117		3.703	0.091	4.002	0.030	175	9

*Holes 1-2 show signs of secondary overprint

Supplementary Information Table 10: Summary of laser ablation results on small mammals extracted from the sediment inside the skull and its surroundings. Errors on individual measurements are 2 s.d. (excluding error of the standard, which is a correlated error for all individual measurements). Errors on averages are combined 2-s.d. of the error of the mean and error of the standard.

	$^{230}Th/^{238}U$	$^{230}Th/^{238}U$ error	$^{234}U/^{238}U$	$^{234}U/^{238}U$ error	Age (ka)	Age error (ka)	initial $^{234}U/^{238}U$	$^{234}U/^{238}Ui$ error
small mammals inside skull								
2010i-A	2.579	0.117	3.272	0.078	133	12	4.309	0.113
2010i-B	2.858	0.132	3.223	0.077	164	16	4.534	0.150
2010i-C	2.695	0.122	3.201	0.063	150	13	4.356	0.122
2010i-D	2.497	0.114	3.061	0.074	142	13	4.077	0.113
2016i-A1*	2.383	0.059	2.913	0.048	143	8	3.868	0.062
2016i-A2	2.324	0.059	2.913	0.048	137	7	3.819	0.061
2016i-B2*	5.603	0.142	4.749	0.052	311	29	10.005	0.705
2016i-C1	2.290	0.057	2.998	0.039	128	6	3.863	0.053
2016i-C2	2.234	0.055	2.998	0.039	122	6	3.822	0.051
2016i-D1	1.985	0.055	2.975	0.015	103	4	3.643	0.034
2016i-D2*	2.092	0.053	3.029	0.035	109	5	3.757	0.046
small mammals outside skull								
2016o-A1	2.371	0.059	2.966	0.065	138	8	3.899	0.070
2016o-A2	2.329	0.058	2.966	0.065	133	8	3.865	0.070
2016o-B1	2.524	0.064	3.118	0.042	140	7	4.144	0.063
2016o-B2	2.434	0.060	3.118	0.042	132	6	4.071	0.058
2016o-C1	2.214	0.055	3.146	0.052	112	5	3.940	0.059
2016o-C2	2.289	0.056	3.146	0.052	118	6	3.990	0.060
2016o-D1	2.181	0.054	2.902	0.032	124	6	3.703	0.047
2016o-D2	2.180	0.055	2.902	0.032	124	6	3.701	0.047
2016o-E1	2.120	0.055	3.146	0.037	111	5	3.931	0.048
2016o-E2	2.187	0.054	3.156	0.037	111	5	3.923	0.048
2016o-F1	2.272	0.056	3.242	0.038	111	5	4.063	0.049
2016o-F2	2.281	0.056	3.242	0.050	111	5	4.069	0.050
2016o-G1	2.230	0.056	3.214	0.056	110	5	4.012	0.062
2016o-G2	2.248	0.056	3.214	0.056	110	5	4.023	0.061
2016o-H1	2.254	0.056	3.157	0.030	114	5	3.976	0.045
2016o-H2	2.079	0.054	3.147	0.030	101	4	3.868	0.042
2016o-I1	2.227	0.057	3.358	0.032	102	4	4.142	0.045
2016o-I2	2.403	0.060	3.358	0.032	114	5	4.253	0.049
2016o-J1	2.203	0.055	2.839	0.036	131	6	3.665	0.051
2016o-J2	2.278	0.057	2.839	0.036	139	7	3.723	0.054
Average Cluster 1[#]	2.400	0.068	3.014	0.037	136	7	3.958	0.062
Average Cluster 2[#]	2.198	0.052	3.187	0.070	108	5	3.967	0.071

Supplementary Information Table 11: Sediment analysis (detection limits: K: 20 ppm; Th: 0.01 ppm; U:0.01 ppm)

Sample	Description	U(ppm)	Th(ppm)	K(ppm)	β-DR* (μGy/a)	γ-DR* (μGy/a)	Effective β DR$ (μGy/a)	Effective γ-DR# (μGy/a)	Effective external DR (μGy/a)
E686S1	in skull, fine	2.26	1.06	270	380	310	41	223	264
E686S2	in skull coarse	4.32	1.78	332	705	576	77	414	491
E686	**sediment inside skull**			**Average**	**543**	**443**	**59**	**319**	**378**
1	laminar deposit (hide)	12.99	0.24	116	1909	1464	209	1052	1262
2	grey sediment	17.79	9.12	1470	2962	2459	322	1770	2092
3	brown lose sediment	6.82	9.55	1177	1352	1248	145	900	1045
4	dark solidified sediment	6.75	8.17	1258	1310	1176	141	848	989
5	rust coloured sediment	14.84	1.17	174	2208	1717	242	1234	1476
6	brown sediment	3.59	9.43	2286	967	909	102	657	759
7	Breccia E556B	4.3	13.32	3302	1259	1200	133	867	1000
8	Breccia w. artefact	7.66	8.6	434	1389	1278	150	921	1071
9	Breccia w. tooth	2.17	4.73	1928	601	517	63	373	437
10	grey breccia	2.89	2.14	496	520	437	56	315	371
11	grey breccia	7.42	7.16	1557	1404	1210	151	872	1023
12	brown breccia	19.64	11.2	670	3225	2745	351	1976	2327
13	brown breccia	4.2	5.58	1122	856	764	92	551	643
14	brown breccia	3.66	2.28	525	638	531	69	382	451
15	brown rock	99.21	16.86	536	14965	11893	2148	11060	13208
16	red rust rock	26.38	0.24	200	3866	2960	556	2753	3309
17	dark brown rock	55.86	10.89	491	8480	6768	1217	6294	7511
18	brown rock	5.99	9.32	1768	1272	1159	178	1078	1256
19	rock	1.76	3.01	301	364	348	51	324	375
20	red rock	9.87	5.66	945	1670	1396	238	1298	1536

* infinite matrix dose rate

$ beta dose rate corrected for 2π geometry, attenuation for a 1000μm enamel layer and 20% water

gamma dose rate corrected for 7% self irradiation by the skull; and 20% water content (except rocks)

Supplementary Information Table 12: US-ESR analysis (1-σ errors)

Skull: Weight: 1112 g; volume: 636 cm^3;average U: 12.86±0.54 ppm $^{230}Th/^{238}U$: 4.307±0.056, $^{234}U/^{238}U$: 3.752±0.038, 20±10% water
Closed system gamma dose: 92±18.5 Gy (with 20±10% water)
gamma shielding[#]: 0.0764 (U), 0.069 (Th); 0.063 (K)
X-ray and CT scanning: 60±20 Gy**

Enamel: 774±13 Gy[@]; 1.02±0.10 ppm U; 0.13±0.02 alpha efficiency[*]; 1000±100 µm thickness[$]
Dentine: 10.1±1.0 ppm U, 10±5% water
$^{234}U/^{238}U$: 4.491±0.009
$^{230}Th/^{238}U$: 4.623±0.017
Sediment: 3.29±1.03 ppm U; 1.42±0.36 ppm Th, 0.03±0.01 % K
Water: 20±10%

[#] Calculated after Nathan and Grün (2003)
[@] See Joannes-Boyau and Grün (2011)
[*] Grün and Katzenberger-Apel (1994)
[$] Beta attenuation calculated after Marsh (1999)
** Duval and Martin-Frances (2017)

ESR DATA (Grün 2009) Results (1-sigma):

Closed system skull gamma dose	93±9 Gy
De minus selfirradiation and CT:	621±26 Gy
Gamma dose rate, sediment	318±71 µGy a^{-1}
Beta dose rate, sediment	58±19 µGy a^{-1}
Internal dose rate:	1525±307 µGy a^{-1}
Beta dose rate, dentine:	462±83 µGy a^{-1}
Total dose rate:	2363±326 µGy a^{-1}
p-values enamel/dentine	-0.93±0.05
Age:	262+33/-26 ka

References:

Duval, M., Martín-Frances, L., 2017. Quantifying the impact of µCT-scanning of human fossil teeth on ESR age results. American Journal of Physical Anthropology 163, 205-212.

Grün, R., 2009. The DATA program for the calculation of ESR age estimates on tooth enamel. Quaternary Geochronology 4: 231-232.

Grün, R., Katzenberger-Apel, O., 1994. An alpha irradiator for ESR dating. Ancient TL 12: 35-38.

Joannes-Boyau, R., Grün, R., 2011. A comprehensive model for CO_2^- radicals in fossil tooth enamel: implications for ESR dating. Quaternary Geochronology 6, 82-97.

Marsh, R.E. 1999. Beta-gradient isochrons using electron paramagnetic resonance: towards a new dating method in archaeology. MSc Thesis, McMaster University.

Nathan, R., Grün, R., 2003. Gamma dosing and shielding of a human tooth by a mandible and skull cap. Ancient TL 21: 79-84.

Supplementary Information Table 13: ESR modeling

External dose modelling (2-sigma)

Closed system skull gamma dose	93±9 Gy
Closed system alpha and beta dose	442±57
X-ray and CT scanning	60±40 (Duval and Martín-Francés, 2017)
External dose component	179±77
Dose rate Model 1	1708 (minus 870) μGy a^{-1}
Dose rate Model 2	1284 (minus 523) μGy a^{-1}
Dose rate Model 3	1953 (minus 1085) μGy a^{-1}
Dose rate Model 4	875 (minus 415) μGy a^{-1}
Possible age range (Model 1)	<175 ka
Possible age range (Model 2)	<221 ka
Possible age range (Model 3)	<156 ka
Possible age range (Model 4)	<335 ka

Reference:

Duval, M., Martín-Francés, L., 2017. Quantifying the impact of μCT-scanning of human fossil teeth on ESR age results. American Journal of Physical Anthropology 163, 205-212.