



*Supplement of*

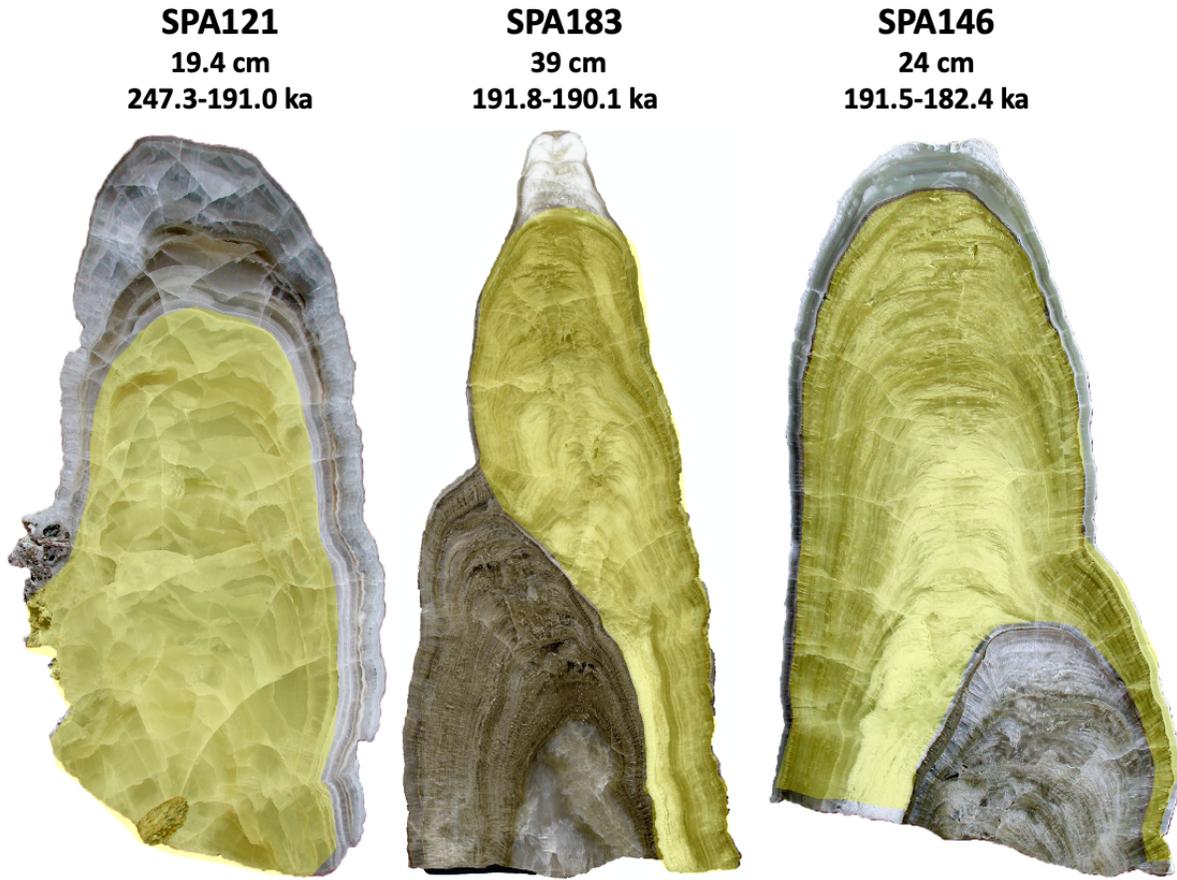
## **Precise timing of MIS 7 substages from the Austrian Alps**

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3 Figure S1: Stalagmites SPA121, 183, and 146. MIS 7 growth sections examined in this study are highlighted in  
4 yellow.

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Supplementary materials for “Precise timing of MIS 7 substages from the Austrian Alps”

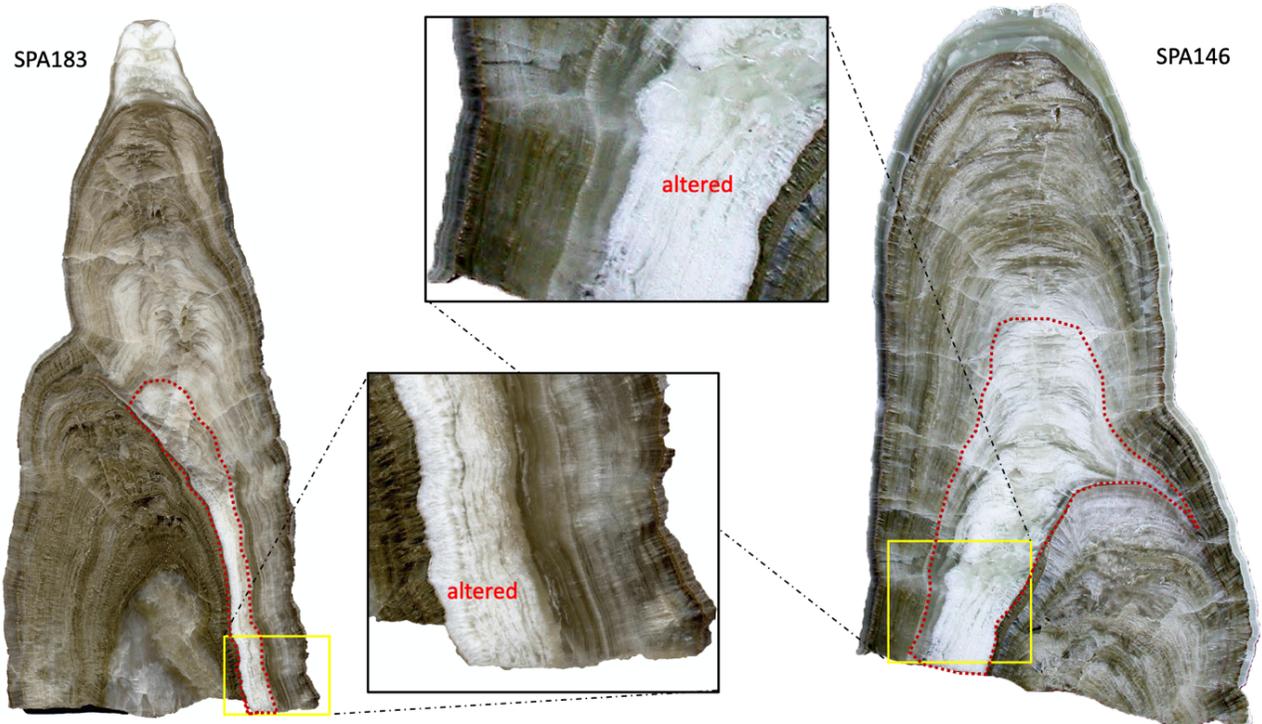


Figure S2: Diagenetically altered portions of SPA183 and 146 highlighted by dashed red lines.

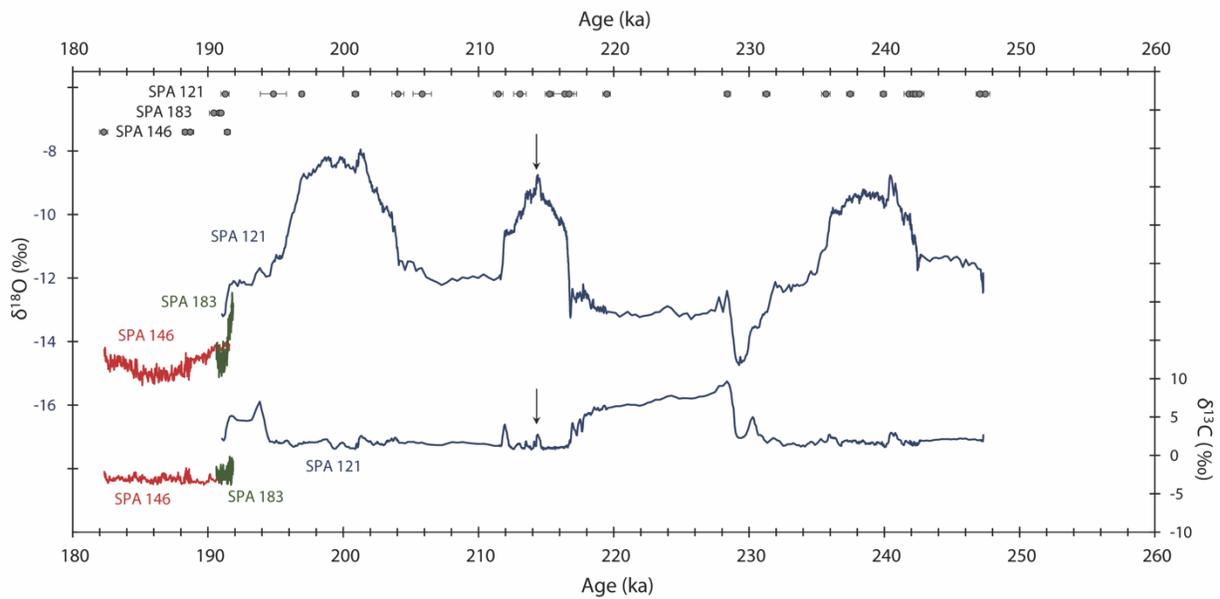
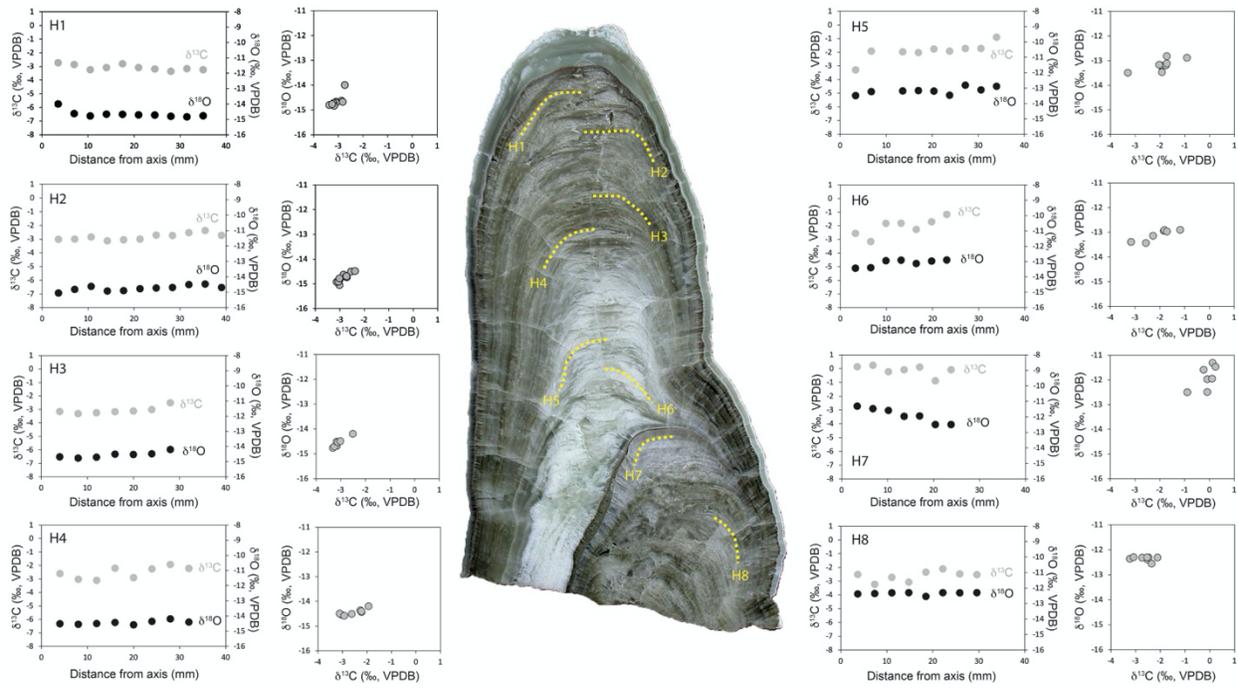


Figure S3:  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  records of stalagmite SPA121 (blue) compared to the shorter growth intervals of stalagmites SPA183 (green) and SPA146 (red). At top, U-Th age results with associated 2 sigma uncertainties. Black arrows indicate location of the dust layer in stalagmite SPA121 (see text).

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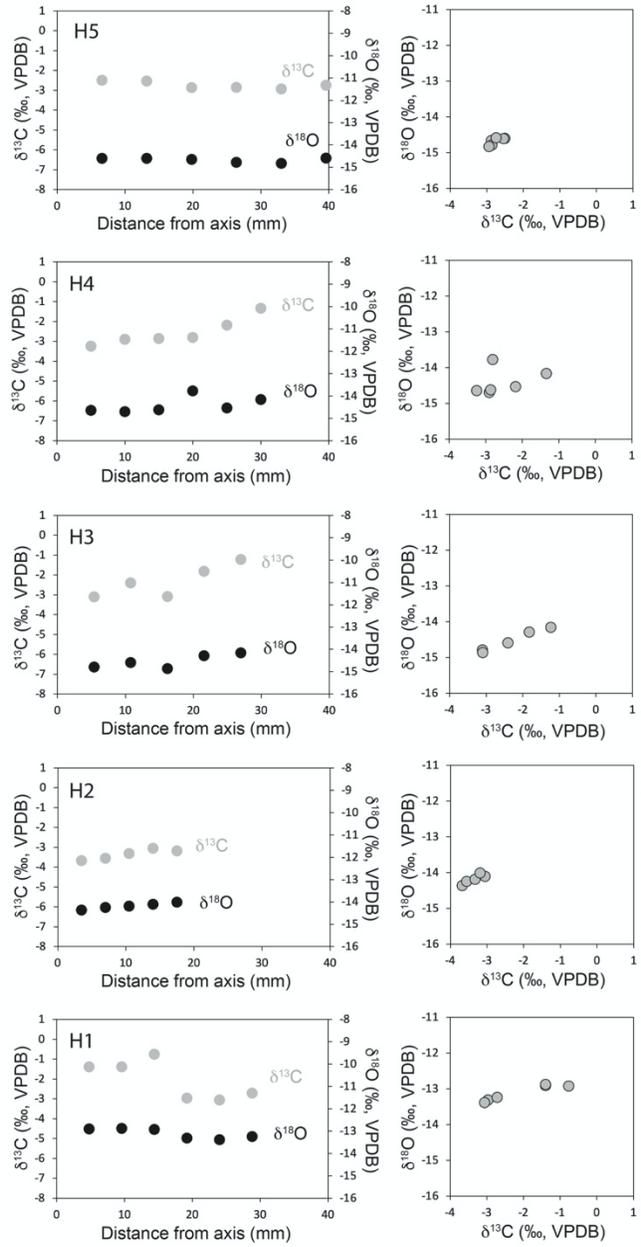
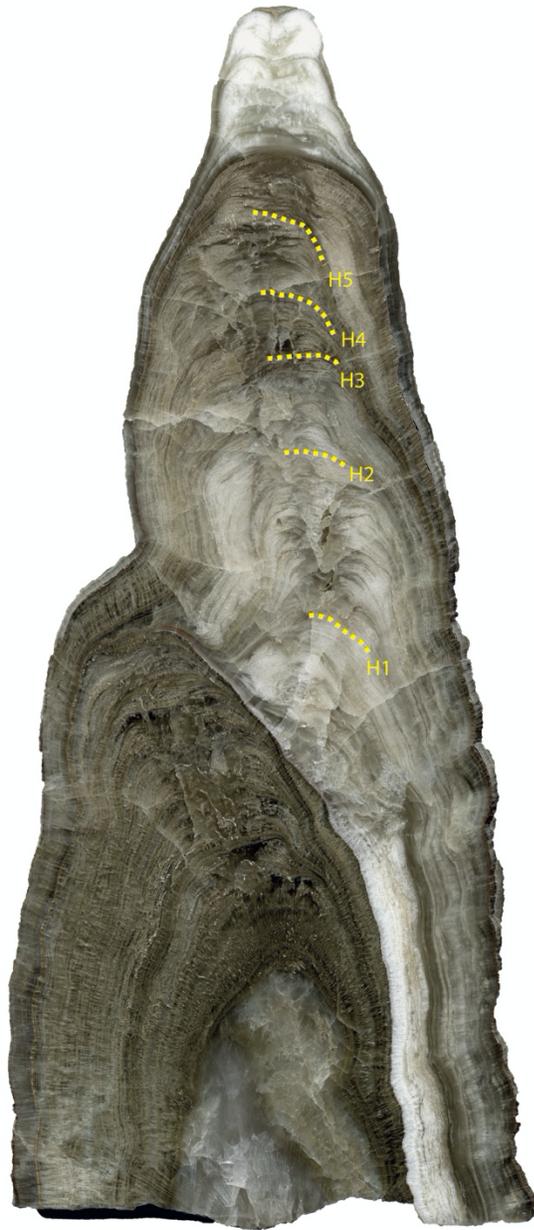
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Figure S4: Hendy test results for stalagmite SPA146. Location of tests (H1-H8) are marked on the slab by yellow dotted lines.

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Figure S5: Supplementary figure 4: Hendy test results for stalagmite SPA183. Location of tests (H1-H5) are marked on the slab by yellow dotted lines.

## Supplementary materials for “Precise timing of MIS 7 substages from the Austrian Alps”

Sample	DFT *	<sup>238</sup> U	<sup>232</sup> Th	$\delta^{234}\text{U}$ **	<sup>230</sup> Th / <sup>232</sup> Th	<sup>230</sup> Th / <sup>238</sup> U	<sup>230</sup> Th Age (yr)	<sup>230</sup> Th Age (yr)	$\delta^{234}\text{U}_{\text{initial}}$ ****	Comments
ID	(mm)	(ppb)	(ppt)	( $\delta$ -units)	(atomic $\cdot 10^{-6}$ )	(activity)	(uncorrected)	(corrected)***	( $\delta$ -units)	
SPA121	48.45	7968 ± 24	1768 ± 5	-7.0 ± 0.4	51,278 ± 20	0.68983 ± 0.00034	129,658 ± 174	129,700 ± 174	-10.1 ± 0.6	
SPA121	51.5	11826 ± 36	77.2 ± 0.3	-114.7 ± 0.2	1,794,848 ± 4171	0.71056 ± 0.00034	191,338 ± 298	191,300 ± 298	-196.8 ± 0.3	
SPA121	55.05	4611 ± 40	458 ± 4	-111.5 ± 1.0	119,160 ± 96	0.71832 ± 0.00059	194,908 ± 963	194,900 ± 963	-193.2 ± 1.8	
SPA121	60.45	5365 ± 22	1857 ± 8	-112.6 ± 0.1	34,284 ± 9	0.71975 ± 0.00020	197,012 ± 192	197,000 ± 192	-196.3 ± 0.2	
SPA121	67.95	544 ± 4	2605 ± 17	-114.2 ± 0.1	2,488 ± 1	0.72294 ± 0.00020	201,144 ± 215	201,000 ± 248	-201.4 ± 0.3	
SPA121	80.25	4704 ± 19	241 ± 1	-117.8 ± 0.2	232,223 ± 280	0.72254 ± 0.00045	204,110 ± 439	204,100 ± 439	-209.6 ± 0.4	
SPA121	81.5	4440 ± 9	90.4 ± 0.2	-116.6 ± 0.7	587,734 ± 180	0.72577 ± 0.00028	205,909 ± 676	205,900 ± 676	-208.5 ± 1.2	
SPA121	83.7	5817 ± 20	398 ± 1	-114.0 ± 0.2	176,846 ± 178	0.73463 ± 0.00030	211,533 ± 340	211,500 ± 340	-207.0 ± 0.4	
SPA121	91.95	6600 ± 18	919 ± 3	-111.2 ± 0.2	87,484 ± 78	0.73921 ± 0.00045	213,138 ± 462	213,100 ± 462	-203.0 ± 0.4	
SPA121	106.95	9049 ± 50	1042 ± 6	-112.0 ± 0.2	106,046 ± 38	0.74064 ± 0.00027	215,316 ± 316	215,300 ± 316	-205.6 ± 0.3	
SPA121	115.2	8471 ± 37	801 ± 3	-107.9 ± 0.1	130,187 ± 335	0.74624 ± 0.00088	216,448 ± 879	216,400 ± 879	-198.7 ± 0.5	
SPA121	119.7	5582 ± 20	721 ± 3	-104.5 ± 0.2	95,699 ± 36	0.75015 ± 0.00030	216,779 ± 341	216,800 ± 341	-192.7 ± 0.3	
SPA121	132.45	12151 ± 33	115.1 ± 0.3	-100.7 ± 0.2	1,317,303 ± 1119	0.75713 ± 0.00022	219,543 ± 278	219,500 ± 278	-187.0 ± 0.3	
SPA121	137	10734 ± 40	62.1 ± 0.2	-108.9 ± 0.1	2,155,246 ± 1062	0.75651 ± 0.00015	228,461 ± 229	228,500 ± 229	-207.5 ± 0.3	
SPA121	142.2	12559 ± 37	434 ± 1	-108.1 ± 0.2	362,477 ± 63	0.75994 ± 0.00016	231,348 ± 273	231,300 ± 273	-207.7 ± 0.3	
SPA121	146.7	19031 ± 95	1909 ± 10	-104.2 ± 0.2	126,242 ± 21	0.76807 ± 0.00018	235,745 ± 315	235,700 ± 315	-202.7 ± 0.4	
SPA121	151.95	8291 ± 21	6023 ± 15	-103.6 ± 0.1	17,484 ± 5	0.77024 ± 0.00016	237,565 ± 270	237,500 ± 271	-202.6 ± 0.3	
SPA121	166.95	7963 ± 17	3632 ± 8	-101.6 ± 0.1	28,003 ± 6	0.77450 ± 0.00014	240,013 ± 233	240,000 ± 233	-200.1 ± 0.3	
SPA121	172.2	11373 ± 34	568 ± 2	-100.6 ± 0.1	256,448 ± 111	0.77719 ± 0.00023	241,878 ± 349	241,900 ± 349	-199.0 ± 0.3	
SPA121	176.7	13101 ± 38	381 ± 1	-103.1 ± 0.1	438,800 ± 84	0.77461 ± 0.00012	242,182 ± 239	242,200 ± 239	-204.1 ± 0.3	
SPA121	179	7146 ± 41	294 ± 2	-104.7 ± 0.2	309,300 ± 100	0.77291 ± 0.00025	242,367 ± 449	242,400 ± 449	-207.5 ± 0.5	
SPA121	184.2	14267 ± 100	1423 ± 10	-101.4 ± 0.1	128,412 ± 39	0.77694 ± 0.00022	242,679 ± 331	242,700 ± 331	-201.0 ± 0.3	
SPA121	187.20	13014 ± 45	1269 ± 4	-101.6 ± 0.1	131,929 ± 27	0.78007 ± 0.00016	247,158 ± 287	247,200 ± 287	-204.2 ± 0.3	
SPA121	190.95	12265 ± 50	2350 ± 10	-102.8 ± 0.1	67,046 ± 16	0.77904 ± 0.00019	247,540 ± 329	247,500 ± 329	-206.7 ± 0.3	
SPA121	193.8	11327 ± 41	10467 ± 38	-101.1 ± 0.1	13,930 ± 10	0.78067 ± 0.00017	247,160 ± 274	247,100 ± 275	-203.1 ± 0.3	
SPA146	15	71975 ± 6	118294 ± 11	20.4 ± 0.3	8,351 ± 14	0.83235 ± 0.00045	182,359 ± 301	182,300 ± 302	34.0 ± 0.5	
SPA146	73	17117 ± 126	71739 ± 530	188.3 ± 0.2	3,982 ± 5	1.01197 ± 0.00034	188,376 ± 193	188,300 ± 204	320.3 ± 0.5	
SPA146	101	17357 ± 154	23985 ± 218	180.3 ± 0.3	11,988 ± 25	1.00474 ± 0.00049	188,759 ± 264	188,700 ± 265	307.1 ± 0.5	
SPA146	115	17722 ± 495	11210 ± 313	200.8 ± 0.3	26,885 ± 8	1.03135 ± 0.00032	191,502 ± 224	191,500 ± 224	344.7 ± 0.6	
SPA146	154	57825 ± 9	3039 ± 1	165.9 ± 0.3	312,313 ± 304	0.99529 ± 0.00036	191,197 ± 236	191,200 ± 236	284.6 ± 0.6	altered
SPA146	162	66265 ± 12	8706 ± 2	161.8 ± 0.3	124,491 ± 136	0.99210 ± 0.00040	191,675 ± 261	191,700 ± 261	277.9 ± 0.6	altered
SPA146	180	42731 ± 3	2421 ± 2	185.4 ± 0.3	295,821 ± 787	1.01608 ± 0.00076	191,702 ± 400	191,700 ± 400	318.4 ± 0.7	altered
SPA183	85	20686 ± 353	138708 ± 2367	163.8 ± 0.3	2,440 ± 1	0.99199 ± 0.00053	190,649 ± 306	190,500 ± 324	280.4 ± 0.6	
SPA183	138.8	18743 ± 406	10928 ± 237	161.0 ± 0.2	27,988 ± 9	0.98970 ± 0.00032	190,908 ± 187	190,900 ± 187	275.9 ± 0.4	
SPA183	140	2135 ± 3	2908 ± 4	169.5 ± 0.2	12,125 ± 19	1.00172 ± 0.00037	192,578 ± 214	192,600 ± 215	291.8 ± 0.4	
SPA183	160	19652 ± 335	5839 ± 100	174.9 ± 0.2	55,716 ± 13	1.00405 ± 0.00025	191,040 ± 150	191,000 ± 151	299.8 ± 0.3	
SPA183	225.2	16905 ± 412	8469 ± 207	193.4 ± 0.2	33,686 ± 22	1.02449 ± 0.00062	191,806 ± 314	191,800 ± 314	332.3 ± 0.5	
SPA183	220	26714 ± 2	12903 ± 2	252.1 ± 0.3	36,934 ± 73	1.08175 ± 0.00069	190,760 ± 336	190,800 ± 336	431.8 ± 0.7	altered
SPA183	240	100414 ± 14	47225 ± 7	134.6 ± 0.3	33,811 ± 34	0.96444 ± 0.00031	191,673 ± 228	191,700 ± 228	231.2 ± 0.6	altered

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32 Table S1: U-Th dating results for Spannagel stalagmites included in this study. Uncertainties are  $2\sigma$ . U decay  
33 constants:  $\lambda_{238} = 1.55125 \times 10^{-10}$  (Jaffey et al., 1971) and  $\lambda_{234} = 2.82206 \times 10^{-6}$  (Cheng et al., 2013). Th decay constant:  
34  $\lambda_{230} = 9.1705 \times 10^{-6}$  (Cheng et al., 2013). Corrected  $^{230}\text{Th}$  ages assume the initial  $^{230}\text{Th}/^{232}\text{Th}$  atomic ratio of  $4.4 \pm 2.2$   
35  $\times 10^{-6}$ . Those are the values for a material at secular equilibrium, with the bulk earth  $^{232}\text{Th}/^{238}\text{U}$  value of 3.8. The errors  
36 are arbitrarily assumed to be 50%. DFT\* = distance from top. \*\*  $\delta^{234}\text{U} = ([^{234}\text{U}/^{238}\text{U}]_{\text{activity}} - 1) \times 1000$ . \*\*\*BP stands  
37 for “Before Present” where the “Present” is defined as the year 1950 A.D. \*\*\*\*  $\delta^{234}\text{U}_{\text{initial}}$  was calculated based on  
38  $^{230}\text{Th}$  age (T), i.e.  $\delta^{234}\text{U}_{\text{initial}} = \delta^{234}\text{U}_{\text{measured}} \times e^{(\lambda_{234})(T)}$ . Italicized ages were sampled within the altered portions of  
39 stalagmites SPA146 and 183 (see text for details), and were not included in final age models.  
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### 44 Supplementary material references

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