1    **Supplementary materials for "Precise timing of MIS 7 sub-stages from the Austrian Alps"**
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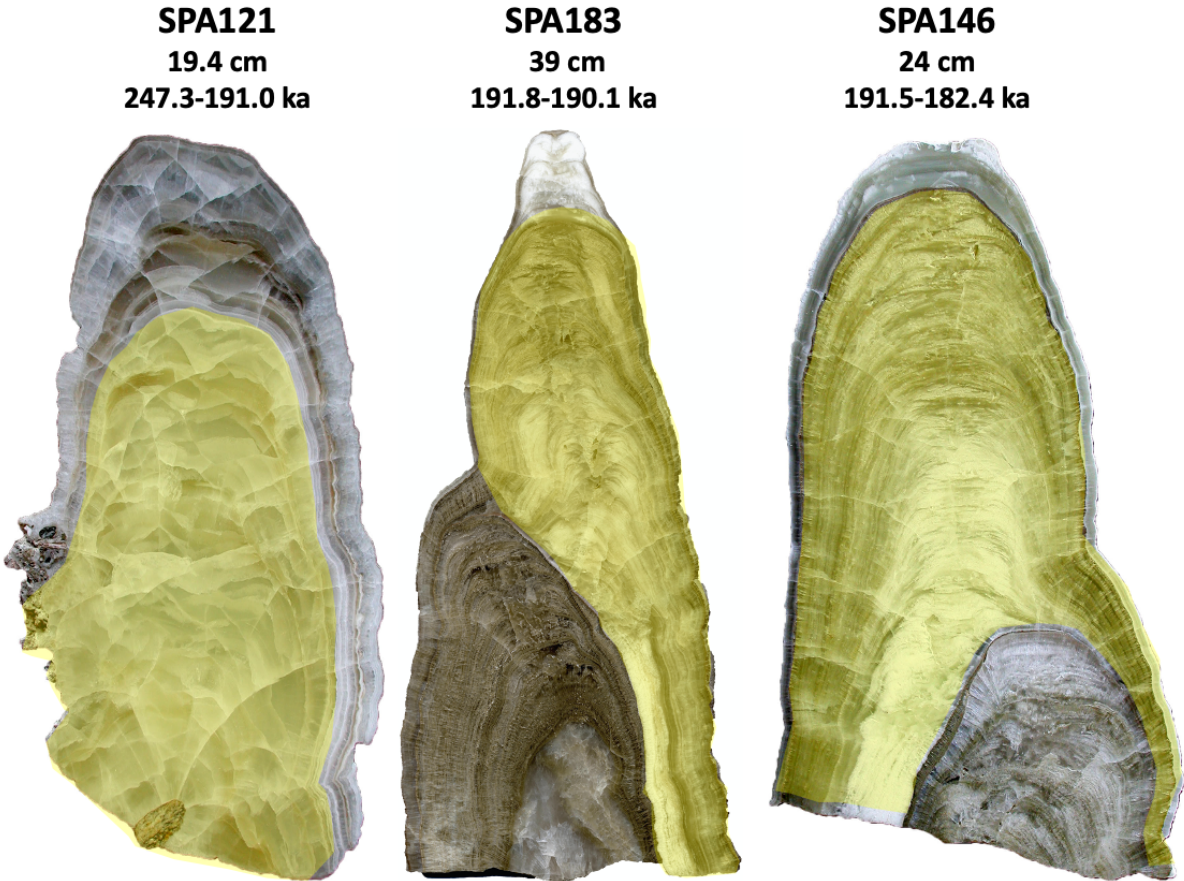
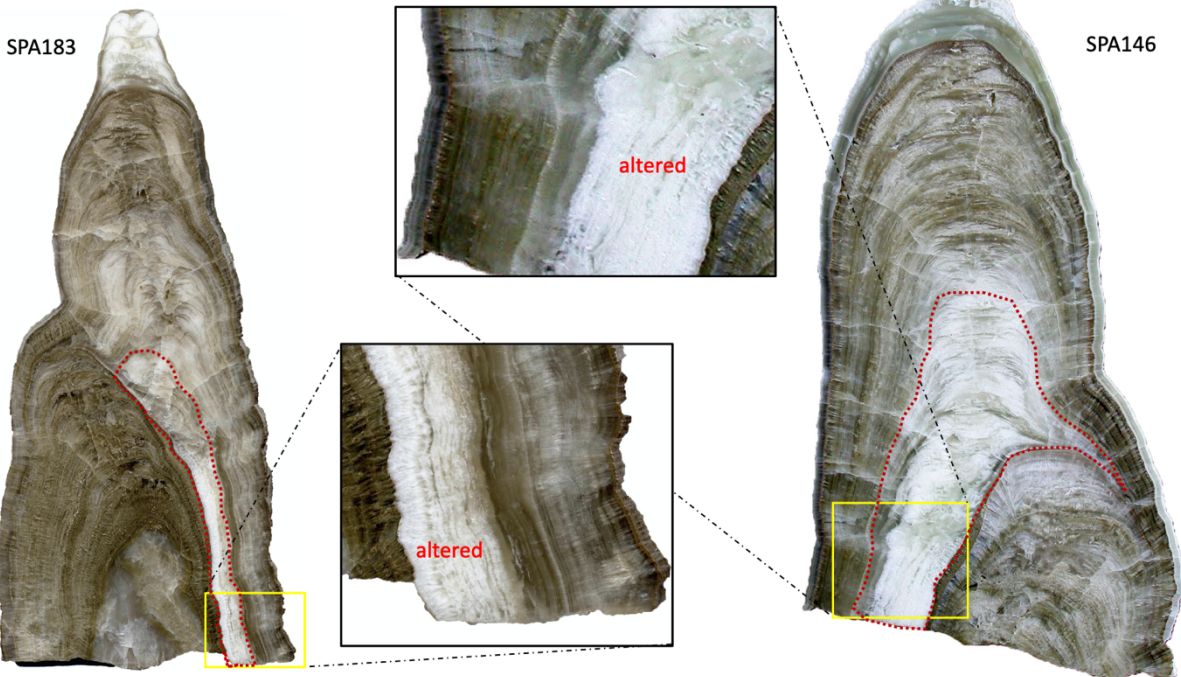

7
8    **Supplementary figure 1: Stalagmites SPA121, 183, and 146. MIS 7 growth sections highlighted in yellow**
9

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11   **Supplementary figure 2: Diagenetically altered portions of SPA183 and 146 highlighted by dashed red lines.**
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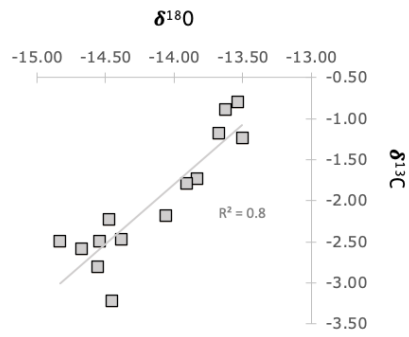
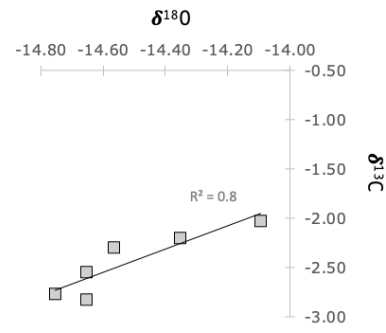
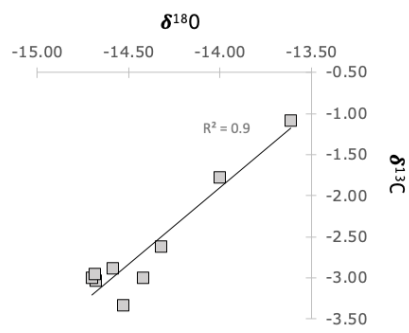
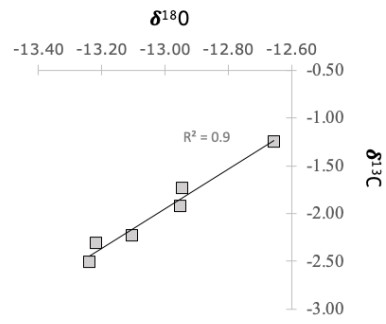
13

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15  **Supplementary figure 3: Hendy tests of SPA146 and SPA183 with respective r² values.**
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| Sample ID | DFT * (mm) | $^{238}$U (ppb) | | $^{232}$Th (ppt) | | $\delta^{234}$U ** (δ-units) | | $^{230}$Th / $^{232}$Th (atomic · 10$^{-6}$) | | $^{230}$Th / $^{238}$U (activity) | | $^{230}$Th Age (yr) (uncorrected) | | $^{230}$Th Age (yr) (corrected)*** | | $\delta^{234}$U$_{Initial}$ **** (δ-units) | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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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20 **Supplementary table 1: U-Th dating results for Spannagel stalagmites included in this study. Uncertainties are**
21 **$2\sigma$. U decay constants: $\lambda_{238}$ = 1.55125x10$^{-10}$ (Jaffey et al. 1971) and $\lambda_{234}$ = 2.82206x10$^{-6}$ (Cheng et al. 2013). Th**
22 **decay constant: $\lambda_{230}$ = 9.1705x10$^{-6}$ (Cheng et al. 2013). Corrected $^{230}$Th ages assume the initial $^{230}$Th/$^{232}$Th atomic**
23 **ratio of 4.4 ±2.2 x10$^{-6}$. Those are the values for a material at secular equilibrium, with the bulk earth $^{232}$Th/$^{238}$U**
24 **value of 3.8. The errors are arbitrarily assumed to be 50%. DFT\* = distance from top. \*\* $\delta^{234}$U =**
25 **([$^{234}$U/$^{238}$U]$_{activity}$ − 1)x1000. \*\*\*BP stands for "Before Present" where the "Present" is defined as the year 1950**
26 **A.D. \*\*\*\* $\delta^{234}$U$_{initial}$ was calculated based on $^{230}$Th age (T), i.e. $\delta^{234}$U$_{initial}$ = $\delta^{234}$U$_{measured}$ x e$^{(\lambda.234)(T)}$. Italicized ages**
27 **were sampled within the altered portions of stalagmites SPA146 and 183 (see text for details), and were not**
28 **included in final age models.**

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