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URANIUM-SERIES AGES FOR SPELEOTHEM AND TUFA DEPOSITS ASSOCIATED WITH QUATERNARY MAMMALIAN FOSSIL EVIDENCE IN ENGLAND AND WALES

by

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ABSTRACT

We present 52 mass-spectrometric U-series ages for speleothem and travertine samples from important Pleistocene mammalian faunal sites in England and Wales. All samples were analysed as part of the *Ancient Human Occupation of Britain* projects. Ages range from >350 ka (thousand years) to ~5 ka and the majority of calcite material was deposited during interglacial periods.

INTRODUCTION

To provide chronological evidence in support of the *Ancient Human Occupation in Britain* (*AHOB*) project (Stringer, 2006; Currant and Jacobi, 2011), 52 U-Th ages were determined using mass-spectrometric methods for 25 speleothem samples from 8 caves and one surface travertine deposit in England and Wales. The sites include Bacon Hole and Minchin Hole (Gower) and Coygan Cave, South Wales; Bleadon Cavern, Sun Hole and Picken's Hole, Mendip Hills; Tornewton Cave, South Devon; Hindlow Quarry, Derbyshire and Marsworth, Buckinghamshire. A comprehensive survey of stalagmite growth for these samples was beyond the framework for this study. Instead, individual or paired samples were carefully drilled to constrain cessation or initiation of growth and to give some indication of stratigraphic consistency. For a few samples, checks were made of the reproducibility of analyses from the same layer in the sample. U-Th analysis of speleothems samples collected in close proximity to faunal remains and sediments is challenging because of the presence of detrital material and the possibility of remobilisation of uranium from bones after deposition. We found age reversals in a few of the samples. We would normally expect to conduct further analyses to determine whether there was post-depositional alteration of isolated growth layers or to better define the initial Th correction factors. This was not possible in this programme, but we reproduce all analyses to direct future efforts at these important faunal sites.

Analyses were conducted in the Bristol Isotope Group (BIG) facilities, University of Bristol, using standard U and Th separation techniques and mass-spectrometric analysis with a ThermoFinnigan Neptune multi-collector inductively-coupled plasma mass spectrometer (MC-ICPMS) (see Hoffmann, *et al.* 2007 for method details). Analyses were conducted while the ^{229}Th-^{236}U spike used routinely in BIG facilties was being recalibrated and we were also using a secondary electron multiplier with significant non-linearity (see Hoffmann, *et al*. 2005). Data reported here update those that were provided in preliminary form within a report submitted to the AHOB team in 2005, corrected for the spike and non-linearity factors noted above. U-Th ages are listed in Table 1 with and without correction for detrital contamination. We use a mean Bulk Earth ^{230}Th/^{232}Th activity ratio, or (^{230}Th/^{232}Th)$_A$, of 0.8 ± 0.4 for detrital correction (see discussion in Richards and Dorale, 2003). All errors throughout the text are reported at the 2σ level.

Results are summarised below for each site. We recognise there are many controls of speleothem deposition in UK settings: past recharge conditions, flooding, changes in drip path, soil cover, permafrost and more. Here, we make preliminary comparison of the timing of calcite growth periods to the pattern of climate change recorded in marine isotopic record, and by association, global ice volume and temperature. The ages can be used to supplement future compilations of UK speleothem growth frequency (e.g. Atkinson, *et al*. 1978; Gordon, *et al*. 1989).

Further details of the samples, including photographs of the specimens sampled can be found online at http://www.ubss.org.uk/resources/procsupplement/27_1_73-80.pdf.

RESULTS

See Table 1 for U-Th ages and isotopic ratios and concentrations.

Bacon Hole (NGR SS 5604 8682)

The oldest unit dated (BH1982-212) has two growth phases, the first associated with marine isotope stage (MIS) 5e (with ages of 121.3 ± 1.9 ka to 115.5 ± 2.0 ka) and the second, possibly MIS 5c (U-Th age of 103.8 ± 1.2 ka). Two other samples yield ages coincident with MIS 5a, a detritally-contaminated flowstone, BH81-253 (88.4 ± 3.0 and $91 \pm ^{20}_{18}$ ka), and three sub-samples of fragments of cement (BH81-250, ages from 94.1 ± 12 to 84.2 ± 1.9 ka, the youngest age not being affected by detrital contamination). Finally, sample BH-Surface yielded Holocene ages (8.1 ± 0.04 to 5.6 ± 0.1 ka).

Bleadon Cavern (NGR ST 3607 5814)

A sample (BC2-82) of an isolated hanging flowstone, which may have capped the faunal deposits, yielded concordant ages indicating fast growth in MIS 7c ($229.9 \pm ^{6.5}_{6.2}$ ka and $224.1 \pm ^{8.0}_{7.2}$ ka.

Coygan Cave (NGR SN 2848 0913)

A sample from Coygan Cave (Trench 2B Spit 7) that overlies fossiliferous material yielded ages of 71.8 ± 0.9 ka to 67.0 ± 0.8 ka, from early in MIS 4. An early MIS 5e age for the underlying 'DIEP Stalagmiet' was also determined (~ 125 ka based on two analyses).

Hindlow Quarry (NGR SK 086 691)

A bison or horse humerus from this site and encased in ~ 8 mm of calcite was supplied by the late Roger Jacobi for analysis. Samples were carefully drilled to avoid bone contamination, but the resulting analyses ($302 \pm ^{25}_{23}$ ka, $185 \pm ^{11}_{10}$ ka) did not agree and were also subject to detrital contamination with $(^{230}Th/^{230}Th)_A \sim 4$.

Marsworth Quarry (NGR SP 934 145)

Sub-samples from the densest calcite bands of three separate pieces of travertine from Marsworth Quarry were analysed (MAR-96-1-3). All three sub-samples yield concordant ages between 186 ± 4 and 190 ± 4 ka (MIS 7a). These ages are somewhat younger than those reported by Candy and Schreve (2007), who report two clusters of ages from 254 to 234 ka and

220 to 208 ka. Low precision alpha-spectrometric results published for much larger samples by Green *et al*. (1984) were 149 ± $^{32}_{28}$ ka and 171 ± $^{56}_{48}$ ka. Murton *et al*. (2001) present a wide range of ages from 188 ± $^{45}_{32}$ to beyond the limits of U-series dating by alpha-spectrometry of > 400 ka.

Minchin Hole (NGR SS 5553 8688)

Samples from Minchin Hole are archived in the University of Bristol speleothem collection. MH1982-400 is a foundered stalagmite lying in the breccias above the main faunal unit and has ages that are inverted (base, 95.4 $\pm^{1.9}_{1.8}$ ka; top 121.1 $\pm^{2.4}_{2.3}$ ka), and cannot be accepted as reliable. An overlying in situ flowstone (MH1-82; see Proctor, 1994) previously dated by alpha spectrometry at 53 ± 4 to 37 ± 3 ka was not re-dated at this time. MH1-84 is a flowstone from directly beneath the main faunal deposits and over the outer beach. Five analyses yield ages from 81.7 ± 1.0 to 122.6 ± 1.0 ka, but are neither laterally reproducible nor in stratigraphic order. A multi-layered sample, MH82-2, from the inner cave yielded a basal age of 105.3 ± $^{3.6}_{3.5}$ ka, with the top of three overlying units of Holocene age (4.7 ± 0.3 ka). Holocene U-Th ages are also available for the speleothem capping the deposits in the outer cave (MH3-82, Proctor, 1994). It is disappointing that despite availability of pristine calcite in Minchin Hole, there appears to be disturbance of the isotope system at least in the outer part of the cave.

Picken's Hole (NGR ST 3965 5502)

MIS 7 ages were obtained from PH1-82, a sub-sample of flowstone that underlies the main fossiliferous sequence in Picken's Hole (240 ± 13 ka to 200 ± 11 ka). No younger phases of speleothem or cements have been recorded at this site.

Sun Hole (NGR ST 4674 5408)

Speleothem samples were obtained from the UBSS excavations at this site. In this account, the layer numbers (SNH) refer to the notation used by Colluctt *et al.* 1981) SNH 15 is a detrital speleothem from the breccias and has ages towards the limit of U-series techniques at ~ 400 ka. The hanging flowstone unit D (SNH2) yielded ages that are inverted, but agree within error (344 $\pm^{21}_{17}$ ka and 311 $\pm^{13}_{12}$ ka), perhaps equivalent to MIS 9. Three calcite sub-samples were obtained from cemented breccia and yielded concordant MIS 5e ages, one of which was affected by detrital contamination (128.6 ± 2.3 ka, 122.5 ± 2.7 ka and 117.4 ± 1.4 ka). SNH-52B apparently overlies this unit and yielded late MIS 5e/MIS 5d ages (114.5 ± 1.5 ka, 110.1 ± 1.7 ka) and appear to be inverted.

Table 1. (overleaf). *Uranium and Th isotopic concentrations, ratios and ages for sub-samples of spelethem and tufa associated with Quaternary mammal fossils in England and Wales. Analytical uncertainty is quoted at the 2σ level.* $(^{230}Th/^{238}U)_A = 1 - e^{-\lambda 230T} + (^{234}U/^{238}U)_A/1000)[\lambda_{230}/(\lambda_{230} - \lambda_{234})](1 - e^{-(\lambda 230 - \lambda 234)T})$*, where T is the age ka before present (1950). Decay constants are* 9.1577×10^{-6} yr^{-1} *for* ^{230}Th*,* 2.826×10^{-6} yr^{-1} *for* ^{234}U*, and* 1.55125×10^{-10} *yr-1 for* ^{238}U*. The degree of detrital* ^{230}Th *contamination is indicated by the measured* $(^{230}Th/^{232}Th)$ *activity ratio.* $(^{234}U/^{238}U)_{A0}$ *is the initial U isotopic activity ratio. Age corrections were calculated using* $(^{238}U/^{232}Th)_{A0} = 0.8 \pm 0.4$*.*

Lab code	ID		^{238}U	±	^{232}Th	±	$(^{230}Th/^{232}Th)_A$	±	$(^{230}Th/^{238}U)_A$	±	$(^{234}U/^{238}U)_A$	±
BIG-UTh-			**(ng g^{-1})**		**(ng g^{-1})**							
Bacon Hole												
B169	BH1981-212	Top	118.7	*0.3*	3.96	*0.018*	87.1	*0.7*	0.936	*0.006*	1.459	*0.003*
B170	BH1981-212	Middle	55.5	*0.1*	3.19	*0.016*	62.0	*0.5*	1.152	*0.009*	1.615	*0.004*
B171	BH1981-212	Bottom	49.8	*0.1*	4.71	*0.021*	38.1	*0.4*	1.162	*0.009*	1.652	*0.004*
B172	BH-SURFACE	Top	89.8	*0.2*	0.513	*0.002*	39.7	*0.5*	0.073	*0.001*	1.445	*0.003*
B173	BH-SURFACE	Bottom	223.3	*0.5*	0.458	*0.002*	161	*1*	0.106	*0.001*	1.483	*0.003*
B190	BH253	Top	55.6	*0.1*	69.1	*0.5*	1.85	*0.02*	0.740	*0.008*	1.071	*0.003*
B174	BH253	Clean	56.1	*0.2*	15.6	*0.1*	7.73	*0.08*	0.692	*0.006*	1.174	*0.004*
B175	BH253	Dirty	64.2	*0.1*	151	*1*	1.32	*0.01*	1.003	*0.009*	1.055	*0.003*
B177	BH81-250A	A	68.0	*0.1*	9.40	*0.04*	17.3	*0.1*	0.774	*0.003*	1.281	*0.002*
B185	BH81-250B	B	75.2	*0.2*	14.7	*0.1*	11.2	*0.1*	0.706	*0.005*	1.247	*0.003*
B186	BH81-250C	C	64.4	*0.1*	7.08	*0.03*	21.0	*0.2*	0.744	*0.005*	1.284	*0.004*
Bleadon Cavern												
B156	BC2-82	Outer	240.6	*0.6*	25.7	*0.1*	28.7	*0.3*	0.991	*0.010*	1.106	*0.002*
B157	BC2-82	Inner	206.5	*0.5*	27.2	*0.1*	24.6	*0.2*	1.044	*0.008*	1.146	*0.002*
Coygan Cave												
B153	Diep Stalagmiet	Middle	273.5	*0.7*	42.2	*0.2*	21.6	*0.2*	1.077	*0.007*	1.484	*0.003*
B191	Diep Stalagmiet	B	346.4	*0.8*	26.9	*0.1*	41.5	*0.4*	1.040	*0.008*	1.446	*0.003*
B154	IIb	Top	458.2	*0.9*	7.11	*0.04*	109	*1*	0.545	*0.005*	1.169	*0.002*
B155	IIb	Bottom	1061	*2*	8.58	*0.05*	198	*2*	0.518	*0.004*	1.066	*0.002*
Hindlow Quarry												
B178	HQ1-A	A	186.6	*0.4*	113.8	*0.5*	4.38	*0.04*	0.862	*0.007*	1.020	*0.002*
B179	HQ1-B	B	176.4	*0.4*	132.7	*0.7*	4.10	*0.04*	0.996	*0.008*	1.038	*0.003*
Marsworth Quarry												
B192	MAR-96-1	Single	82.3	*0.2*	6.98	*0.03*	41.2	*0.3*	1.127	*0.007*	1.305	*0.003*
B193	MAR-96-2	Single	108.1	*0.2*	9.15	*0.05*	43.9	*0.4*	1.198	*0.009*	1.366	*0.003*
B194	MAR-96-4	Single	109.8	*0.2*	29.8	*0.2*	12.7	*0.1*	1.113	*0.007*	1.283	*0.003*
Minchin Hole												
B146	MH1982-400	Top	57.5	*0.1*	3.08	*0.02*	51.7	*0.6*	0.893	*0.009*	1.282	*0.004*
B147	MH1982-400	Bottom	57.3	*0.1*	1.65	*0.01*	79.3	*1.0*	0.735	*0.009*	1.228	*0.004*
B148	MH82-2	Top	157.4	*0.3*	1.70	*0.01*	12.7	*0.6*	0.044	*0.002*	0.981	*0.002*
B149	MH82-2	Bottom	43.6	*0.1*	10.88	*0.06*	9.4	*0.1*	0.756	*0.010*	1.162	*0.004*
B150	MH1-84	Top	68.1	*0.2*	0.54	*0.003*	297	*3*	0.761	*0.006*	1.143	*0.003*
B165	MH1-84	New Top	61.2	*0.1*	0.60	*0.002*	250	*1*	0.790	*0.003*	1.147	*0.003*
B166	MH1-84	Middle	59.1	*0.1*	8.51	*0.05*	17.8	*0.1*	0.826	*0.005*	1.181	*0.002*
B167	MH1-84	Near Base	60.6	*0.1*	31.6	*0.2*	5.28	*0.04*	0.890	*0.006*	1.256	*0.003*
B151	MH1-84	Bottom	73.0	*0.1*	0.591	*0.003*	255	*2*	0.667	*0.005*	1.237	*0.003*
Pickens Hole												
B158	PH1-82	Top	86.8	*0.2*	0.926	*0.009*	285	*6*	0.979	*0.019*	1.133	*0.003*
B159	PH1-82	Bottom	147.4	*0.3*	0.409	*0.005*	1162	*23*	1.039	*0.017*	1.135	*0.002*
Sun Hole												
B162	SH 15'	Clean	196.1	*0.4*	32.5	*0.1*	20.44	*0.16*	1.093	*0.007*	1.092	*0.002*
B163	SH 15'	Dirty	234.9	*0.4*	168.2	*0.8*	5.04	*0.04*	1.163	*0.008*	1.141	*0.002*
B180	SNH2	Top	234.8	*0.5*	9.98	*0.04*	76.5	*0.7*	1.049	*0.008*	1.071	*0.002*
B181	SNH2	Bottom	384.7	*0.8*	30.1	*0.2*	42.0	*0.4*	1.060	*0.007*	1.094	*0.002*
B182	SNH52	Top	1181	*3*	0.635	*0.003*	4011	*32*	0.695	*0.005*	1.061	*0.002*
B183	SNH52	Bottom	635	*1*	1.71	*0.01*	783	*8*	0.681	*0.006*	1.063	*0.002*
B187	SNH44-A	A	152.7	*0.3*	12.43	*0.04*	28.3	*0.2*	0.744	*0.005*	1.057	*0.002*
B188	SNH44-B	B	154.3	*0.3*	25.9	*0.1*	13.40	*0.11*	0.727	*0.005*	1.050	*0.002*
B189	SNH44-C	C	125.7	*0.2*	6.12	*0.03*	44.7	*0.3*	0.702	*0.004*	1.052	*0.002*
Tornewton Cave												
B137	TNW-29	Outer	43.2	*0.1*	21.6	*0.1*	5.88	*0.06*	0.949	*0.008*	1.112	*0.002*
B138	TNW-29	Inner	36.3	*0.1*	2.21	*0.01*	45.9	*0.5*	0.900	*0.009*	1.048	*0.003*
B145	TNW-30	Top	40.3	*0.1*	3.24	*0.02*	25.3	*0.3*	0.656	*0.007*	1.073	*0.003*
B164	TNW-30	Bottom	42.6	*0.1*	14.31	*0.07*	6.99	*0.06*	0.757	*0.006*	1.108	*0.003*
B139	TNW-32	Top	31.2	*0.1*	6.86	*0.03*	14.2	*0.1*	1.004	*0.009*	1.069	*0.004*
B140	TNW-32	Bottom	32.0	*0.1*	33.5	*0.2*	3.29	*0.03*	1.111	*0.010*	1.143	*0.003*
B141	TNW-34	Middle	31.2	*0.1*	13.79	*0.07*	6.72	*0.07*	0.956	*0.008*	1.083	*0.003*
B142	TN-90-6	Top	134.7	*0.3*	-	-	-	-	0.579	*0.002*	1.130	*0.002*
B143	TN-90-6	Bottom	58.2	*0.1*	0.454	*0.007*	264	*4*	0.664	*0.003*	1.119	*0.003*
B161	TNW-259	Top	43.4	*0.1*	14.48	*0.07*	9.16	*0.07*	0.987	*0.007*	1.079	*0.003*

Lab code	ID		Uncorrected age	+	-	Corrected age	+	-	($^{234}U/^{238}U)_{A0}$	+	-
BIG-UTh-			(ka)			(ka)					
Bacon Hole											
B169	BH1981-212	Top	104.3	*1.1*	*1.2*	103.8	*1.2*	*1.2*	1.621	*0.004*	*0.004*
B170	BH1981-212	Middle	122.1	*1.7*	*1.7*	121.3	*1.9*	*1.8*	1.878	*0.007*	*0.007*
B171	BH1981-212	Bottom	118.9	*1.7*	*1.7*	117.5	*2.0*	*1.9*	1.931	*0.011*	*0.011*
B172	BH-SURFACE	Top	5.7	*0.06*	*0.06*	5.6	*0.1*	*0.1*	1.453	*0.003*	*0.003*
B173	BH-SURFACE	Bottom	8.1	*0.06*	*0.06*	8.1	*0.1*	*0.1*	1.494	*0.003*	*0.003*
B190	BH253	Top	125.4	*2.7*	*2.6*	90.7	*21.1*	*17.5*	1.131	*0.032*	*0.031*
B174	BH253	Clean	94.5	*1.4*	*1.3*	88.4	*3.0*	*3.0*	1.239	*0.010*	*0.010*
B175	BH253	Dirty	298.5	*15.3*	*13.5*	220.8	*133.0*	*50.5*	1.238	*0.126*	*0.135*
B177	BH81-250A	A	96.8	*0.6*	*0.6*	94.1	*1.2*	*1.2*	1.379	*0.007*	*0.007*
B185	BH81-250B	B	88.1	*1.0*	*1.0*	84.2	*1.9*	*1.9*	1.328	*0.009*	*0.009*
B186	BH81-250C	C	90.8	*1.1*	*1.1*	88.7	*1.4*	*1.4*	1.375	*0.007*	*0.006*
Bleadon Cavern											
B156	BC2-82	Outer	226.4	*7.4*	*7.1*	224.1	*8.0*	*7.2*	1.205	*0.006*	*0.006*
B157	BC2-82	Inner	232.6	*6.1*	*5.9*	229.9	*6.5*	*6.2*	1.289	*0.006*	*0.007*
Coygan Cave											
B153	Diep Stalagmiet	Middle	127.5	*1.6*	*1.5*	125.1	*2.3*	*2.3*	1.716	*0.012*	*0.012*
B191	Diep Stalagmiet	B	126.1	*1.7*	*1.7*	124.8	*1.8*	*1.8*	1.647	*0.007*	*0.007*
B154	IIb	Top	67.4	*0.8*	*0.8*	67.0	*0.8*	*0.8*	1.205	*0.003*	*0.003*
B155	IIb	Bottom	72.0	*0.8*	*0.8*	71.8	*0.9*	*0.8*	1.081	*0.002*	*0.002*
Hindlow Quarry											
B178	HQ1-A	A	201.3	*4.9*	*4.7*	184.6	*11.1*	*9.8*	1.039	*0.008*	*0.008*
B179	HQ1-B	B	322.1	*16.8*	*15.0*	302.3	*25.3*	*20.0*	1.109	*0.014*	*0.015*
Marsworth Quarry											
B192	MAR-96-1	Single	187.8	*3.2*	*3.2*	186.3	*3.6*	*3.5*	1.527	*0.007*	*0.007*
B193	MAR-96-2	Single	191.1	*3.9*	*3.6*	189.7	*4.0*	*4.1*	1.639	*0.009*	*0.008*
B194	MAR-96-4	Single	190.7	*3.5*	*3.2*	185.8	*6.2*	*5.8*	1.512	*0.014*	*0.014*
Minchin Hole											
B146	MH1982-400	Top	122.1	*2.4*	*2.4*	121.1	*2.4*	*2.3*	1.402	*0.006*	*0.006*
B147	MH1982-400	Bottom	96.0	*1.8*	*1.8*	95.4	*1.9*	*1.8*	1.300	*0.005*	*0.005*
B148	MH82-2	Top	5.0	*0.3*	*0.3*	4.7	*0.3*	*0.3*	0.981	*0.002*	*0.002*
B149	MH82-2	Bottom	110.9	*2.6*	*2.6*	105.3	*3.6*	*3.5*	1.233	*0.009*	*0.010*
B150	MH1-84	Top	115.8	*1.8*	*1.7*	115.6	*1.7*	*1.7*	1.198	*0.004*	*0.004*
B165	MH1-84	New Top	122.8	*1.1*	*1.0*	122.6	*1.0*	*1.0*	1.209	*0.003*	*0.004*
B166	MH1-84	Middle	125.4	*1.5*	*1.5*	122.4	*1.9*	*1.9*	1.265	*0.006*	*0.006*
B167	MH1-84	Near Base	126.5	*1.7*	*1.7*	115.9	*5.0*	*4.6*	1.407	*0.027*	*0.028*
B151	MH1-84	Bottom	81.9	*1.0*	*1.0*	81.7	*1.0*	*1.0*	1.300	*0.004*	*0.003*
Pickens Hole											
B158	PH1-82	Top	200.2	*11.4*	*10.6*	199.9	*11.3*	*10.7*	1.235	*0.008*	*0.008*
B159	PH1-82	Bottom	237.6	*13.5*	*11.8*	237.6	*13.4*	*12.2*	1.265	*0.011*	*0.009*
Sun Hole											
B162	SH 15'	Clean	390.0	*25.8*	*21.1*	386.5	*29.1*	*23.5*	1.284	*0.021*	*0.016*
B163	SH 15'	Dirty	404.0	*28.1*	*22.5*	390.0	*158.2*	*67.4*	1.512	*0.266*	*0.066*
B180	SNH2	Top	344.7	*21.2*	*17.0*	343.8	*21.2*	*17.2*	1.190	*0.011*	*0.009*
B181	SNH2	Bottom	312.6	*12.1*	*11.4*	310.9	*13.1*	*11.6*	1.230	*0.008*	*0.008*
B182	SNH52	Top	114.5	*1.5*	*1.5*	114.5	*1.5*	*1.5*	1.084	*0.003*	*0.003*
B183	SNH52	Bottom	110.1	*1.6*	*1.6*	110.1	*1.7*	*1.7*	1.086	*0.003*	*0.003*
B187	SNH44-A	A	130.6	*1.9*	*1.9*	128.6	*2.2*	*2.1*	1.083	*0.003*	*0.003*
B188	SNH44-B	B	126.7	*1.7*	*1.7*	122.5	*2.7*	*2.6*	1.074	*0.003*	*0.003*
B189	SNH44-C	C	118.6	*1.3*	*1.2*	117.4	*1.4*	*1.4*	1.074	*0.003*	*0.003*
Tornewton Cave											
B137	TNW-29	Outer	196.4	*4.7*	*4.4*	184.8	*7.3*	*6.6*	1.214	*0.015*	*0.014*
B138	TNW-29	Inner	207.1	*6.4*	*6.0*	205.6	*6.3*	*6.0*	1.087	*0.006*	*0.006*
B145	TNW-30	Top	101.7	*1.9*	*1.8*	102.2	*2.1*	*2.1*	1.100	*0.005*	*0.005*
B164	TNW-30	Bottom	122.2	*1.9*	*1.8*	117.4	*4.3*	*4.1*	1.163	*0.008*	*0.009*
B139	TNW-32	Top	276.6	*13.0*	*11.5*	271.4	*13.2*	*12.2*	1.158	*0.010*	*0.010*
B140	TNW-32	Bottom	298.4	*13.9*	*12.5*	275.2	*66.2*	*40.1*	1.416	*0.050*	*0.043*
B141	TNW-34	Middle	219.8	*6.7*	*6.5*	209.3	*8.9*	*7.5*	1.167	*0.012*	*0.012*
B142	TN-90-6	Top	77.2	*0.5*	*0.5*	-	-	-	-	-	-
B143	TN-90-6	Bottom	96.2	*0.7*	*0.7*	98.2	*0.7*	*0.7*	1.158	*0.003*	*0.003*
B161	TNW-259	Top	247.7	*6.9*	*6.5*	253.6	*9.9*	*8.8*	1.175	*0.009*	*0.009*

Tornewton Cave (NGR SX 8172 6733)

Samples were obtained from British Museum excavations at the site between 1989 and 1992 (see Campbell *et al.*, 1998 for history of excavations). For selected illustrations and sample locations of some of the samples, see illustrations in Proctor (1994) (e.g. Fig. 5.10). TNW-259 was the tip of a large stalagmite that underlay the faunal deposits, and yielded a detritally-contaminated top age of 254 ± ka. Similar early ages were obtained from a small stalagmite broken during excavations, with concordant ages of 271 $\pm^{13}_{12}$ ka and 275 $\pm^{66}_{40}$ ka, the former being less affected by contamination. Sample TNW-30 is a small stalagmite that caps the faunal sequence in Vivians Vault and has ages from at least 117.4 $\pm^{4.3}_{4.1}$ ka to 102.2 ± 2.1 ka (late MIS 5e to early MIS 5c, there is a visible hiatus possibly equivalent to MIS 5d). TN-90-6 is a thin flowstone, the base of which includes fossil material from the Hyena Stratum. Top and bottom ages of (77.2 ± 0.5 ka, 98.2 ± 0.7 ka) in stratigraphic order and indicating deposition in MIS 5c to MIS 5a, These ages agree with data reported using alpha-spectrometric determination by Proctor (1994) of 76 ± 12 ka (TN-90-6A). One further sample comprising a dirty and porous flowstone (TNW-34) of unknown provenance yielded a detritally-contaminated age of 259 $\pm^{10}_{9}$ ka. The stratigraphy at Tornewton Cave has been revisited many times since the first excavations in 1877 (Widger, 1892). These ages supplement the U-Th ages produced by the Open University for a single multi-phased(?) stalagmite that grew from ca. 137 to <23 ka (Gilmour *et al*. 2007).

CONCLUSIONS

We have provided a complete list of U-series isotopic information and age determinations conducted in 2004-5 on behalf of the AHOB projects. We are keen to see these ages in the published domain and consider this to be part of an ongoing effort among speleothem research teams to 'open the archives' and make available all U-Th ages and isotopic information determined. This will guide future researchers to the select suitable samples from relevant speleothem archives, keeping responsible conservation and scientific practice in mind.

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