METHODS

Uranium-series isotope measurements of HW3 calcite were carried out at the University of Melbourne, Australia, using a Nu-Instruments Nu-Plasma multi-collector ICP-MS. Eighteen subsample blocks (50-200 mg) were prepared following standard methods (Hellstrom, 2003). Calculated ages include a correction for minor amounts of detrital Th using an assumed initial $^{230}Th/^{232}Th$ activity ratio of 1 ± 0.5. U and Th isotopic data, ages and errors (2σ) are shown in Supplementary Table DR1.

Stable isotope ratios ($\delta^{18}O$, $\delta^{13}C$) were obtained by analysis of ~2 mg of powdered speleothem calcite milled from the growth axis. Isotope ratios are expressed in δ notation, the per mil (‰) deviation from the Vienna Pee-Dee Belemnite standard. Simultaneous determination of $\delta^{13}C$ and $\delta^{18}O$ was performed using a Europa Geo 20-20 fitted with a Europa CAPS reaction line at the University of Waikato. Reproducibility of standard materials is 0.06 ‰ for $\delta^{13}C$ and 0.12 ‰ for $\delta^{18}O$.

REFERENCES CITED

Hellstrom, J., 2003, Rapid and accurate U/Th dating using parallel ion-counting multi-collector ICP-MS: Journal of Analytical Atomic Spectrometry, v. 18, p. 1346-1351.

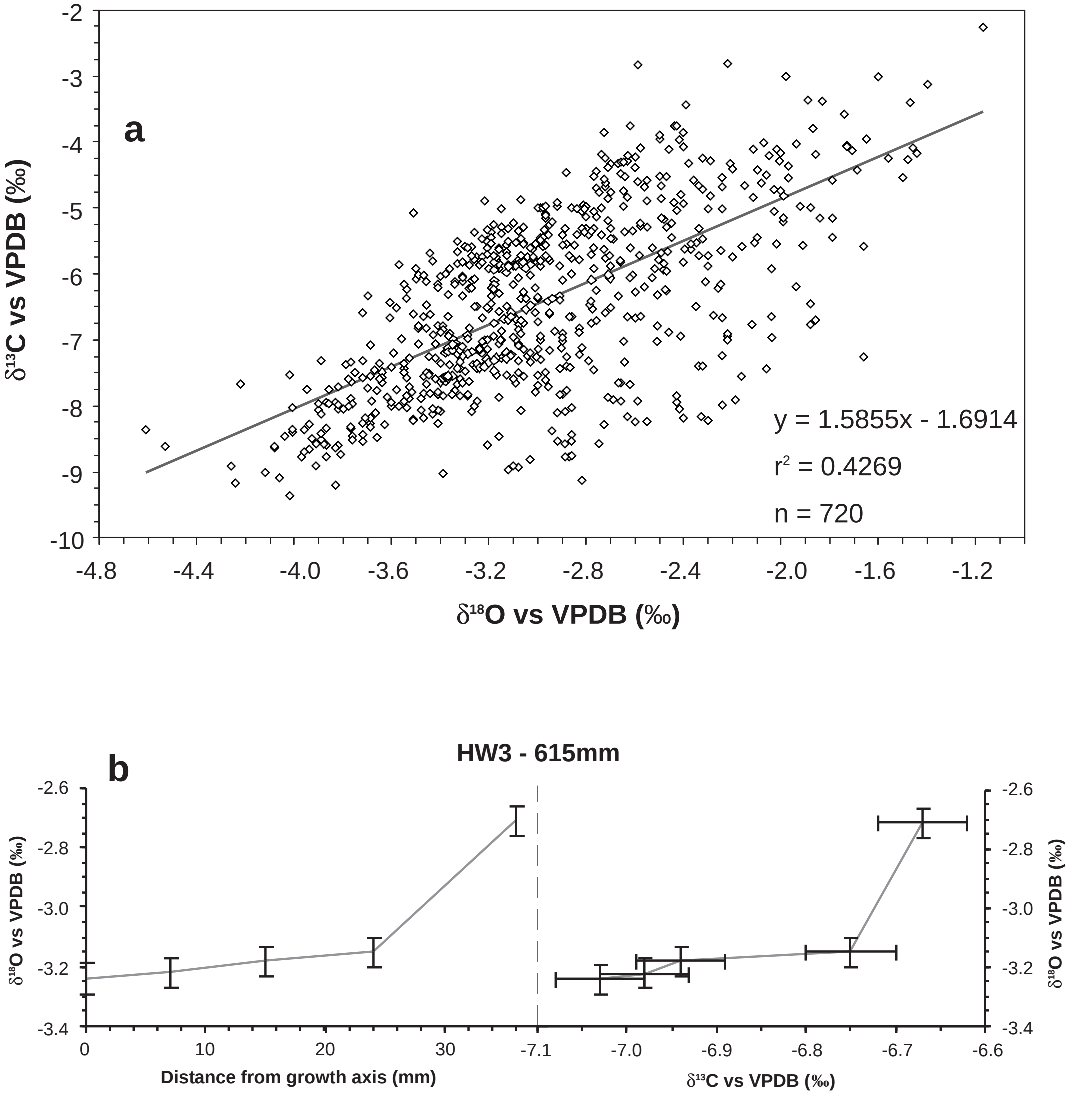
Supplementary Table DR1: Uranium-series data for stalagmite HW3

Depth (mm)	^{238}U (ng/g)	$^{230}Th/^{232}Th$ activity ratio	measured $^{230}Th/^{238}U$ activity ratio	measured $^{234}U/^{238}U$ activity ratio	uncorrected age yrs B.P.	corrected age yrs B.P.	corrected $^{234}U/^{238}U$ activity ratio
9	n.d.	527	0.1805 ± 0.0026	1.7518 ± 0.0051	11744 ± 171	11724 ± 181	1.7772 ± 0.0052
71	n.d.	2082	0.2148 ± 0.0017	1.7444 ± 0.0033	14169 ± 114	14162 ± 122	1.7749 ± 0.0034
130	n.d.	949	0.2390 ± 0.0014	1.7440 ± 0.0035	15872 ± 99	15857 ± 105	1.7782 ± 0.0036
151	102	13941	0.3148 ± 0.0013	1.7103 ± 0.0044	21804 ± 104	21806 ± 118	1.7557 ± 0.0045
183	n.d.	3345	0.3232 ± 0.0013	1.7141 ± 0.0032	22403 ± 102	22398 ± 109	1.7609 ± 0.0033
219	117	4297	0.3677 ± 0.0018	1.6567 ± 0.0035	26835 ± 146	26830 ± 158	1.7086 ± 0.0036
264	113	7431	0.3840 ± 0.0016	1.6578 ± 0.0036	28161 ± 137	28157 ± 150	1.7125 ± 0.0038
295.5	68	560	0.4014 ± 0.0021	1.6431 ± 0.0042	29913 ± 180	29872 ± 199	1.6999 ± 0.0044
319	133	12847	0.4067 ± 0.0016	1.6369 ± 0.0030	30494 ± 141	30499 ± 150	1.6944 ± 0.0031
341	62	253	0.4479 ± 0.0025	1.5894 ± 0.0047	35236 ± 238	35117 ± 266	1.6512 ± 0.0050
361	94	589	0.4893 ± 0.0028	1.5912 ± 0.0034	39033 ± 259	38979 ± 282	1.6602 ± 0.0037
447	54	742	0.5194 ± 0.0030	1.5452 ± 0.0051	43435 ± 315	43387 ± 351	1.6165 ± 0.0055
452	69	1809	0.5720 ± 0.0041	1.5363 ± 0.0040	49163 ± 430	49143 ± 460	1.6165 ± 0.0045
466	75	278	0.6117 ± 0.0020	1.5134 ± 0.0028	54538 ± 237	54386 ± 275	1.5990 ± 0.0030
489	87	296	0.6602 ± 0.0035	1.4913 ± 0.0047	61273 ± 451	61128 ± 504	1.5843 ± 0.0052
529	70	505	0.6751 ± 0.0029	1.4889 ± 0.0034	63269 ± 367	63184 ± 415	1.5848 ± 0.0037
595	77	2052	0.6955 ± 0.0026	1.4647 ± 0.0027	67340 ± 341	67317 ± 378	1.5624 ± 0.0030
627	168	711	0.7186 ± 0.0035	1.4265 ± 0.0037	73080 ± 506	73018 ± 574	1.5246 ± 0.0042

Corrected ages use an initial 230Th/232Th atomic ratio of 1.0 ± 0.5 following equation 1 in Hellstrom (2006), with fully propagated uncertainty. Decay constants used are from Cheng et al. (2000).
Notation: yrs B.P. = years before present, where present is 2007 CE; n.d. = not determined

Cheng, H., Edwards, R.L., Hoff, J., Gallup, C.D., Richards, D.A., and Asmerom, Y., 2000, The half-lives of uranium-234 and thorium-230: Chemical Geology, v. 169, p. 6-25.

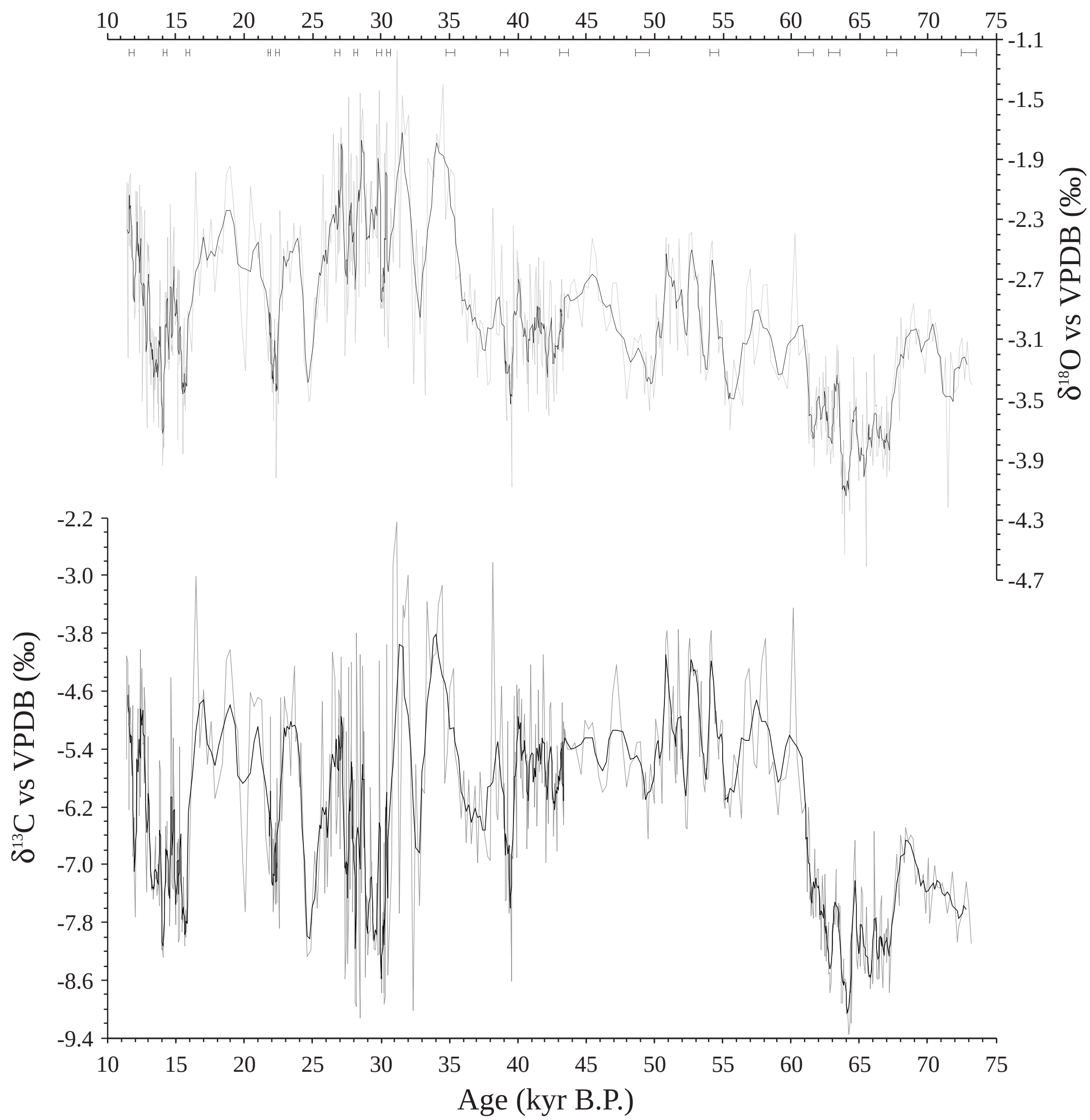
Hellstrom, J., 2006, U-Th dating of speleothems with high initial ^{230}Th using stratigraphical constraint: Quaternary Geochronology, v. 1, p. 289-295.



Supplementary Figure DR1a: $\delta^{13}C$ versus $\delta^{18}O$ along the HW3 growth axis. While the spread of data yields a significant positive correlation (r^2 = 0.427), thelinear trend has a slope of ~1.6. Under non-equilibrium conditions a slope of ~3 would be anticipated (Hendy, 1971). We therefore have greater confidence that theobserved covariance is a function of a common environmental driver and thus the HW3 isotope profiles are reliable palaeoclimate archives.

Supplementary Figure DR1b: Along-layer isotope profile from stalagmite HW3. With increasing distance from the growth axis there is negligible change in isotopic ratio indicating that HW3 calcite was likely deposited in isotopic equilibrium with the drip water.

Hendy, C. H., 1971, The isotopic geochemistry of speleothems – I. The calculation of the effects of different modes of formation on the isotopic composition of speleothems and their applicability as palaeoclimatic indicators: Geochimica et Cosmochimica Acta, v. 35, p. 801-824.



Supplementary Figure DR2: Raw (gray lines)stable isotope data and 5-point running means (black lines) measured in calcite milled from Hollywood Cave speleothem HW3.