Geochronology Discuss., referee comment RC2
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Comment on gchron-2022-10

David Richards (Referee)

Referee comment on "^{230}Th□/□U isochron dating of cryogenic cave carbonates" by Paul Töchterle et al., Geochronology Discuss., https://doi.org/10.5194/gchron-2022-10-RC2, 2022

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^{230}Th/U Isochron Dating of Cryogenic Cave Carbonates. Toechterle and co-authors combine U-Th geochronology and sample characterisation (crystal morphology and δ^{13}C, δ^{18}O analysis) to assess the feasibility of dating cryogenic cave carbonates. Such deposits appear as distinct small patches of crystal aggregates associated with cave ice, and their ages have the potential to provide valuable constraints on the timing of past permafrost conditions.

The authors present a detailed study from a single cave setting in the Peak District, England, UK, to demonstrate that some CCC U-series ages are reliant on significant corrections for initial Th, which can also show wide variability. Accurate ages are possible using isochron tools. This information is relevant for the dating of authigenic carbonates more widely. This has been declared elsewhere in the literature, but is worth revisiting here.

This is a well-targeted study. A simple question is addressed: Can an accurate U-Th age, or age range, be ascribed to a CCC deposit?

High-precision U and Th isotopic analysis has been performed using well-established techniques. A sufficient number of samples and sub-samples have been analysed to explore the issue at hand. The results are thoroughly documented and implications well-expressed.

Principal findings are: 1. A single freezing event (or narrow time window) can be evidenced by tightly-constrained isochrons and non-crystallographic branching forms; 2. Initial Th contamination can be episodic and variable and related to grain size (surface area); 3. As in many geochronological applications (e.g. multiple grain, single aliquots - OSL), future work should consider the distribution of apparent ages within a deposit.

The paper makes useful recommendations and reiterates comments made elsewhere on the need to address initial Th variation in certain settings for accurate U-Th geochronology.

For consideration.

Line 39. "In nature, values for $(^{230}Th/^{232}Th)_0$ vary by orders of magnitude". Please expand on this to report on the sources (and partitioning) of common and radiogenic ^{230}Th, dissolved, detrital and colloidal.

Line 109: BCE is equivalent to BC.. you can't redefine the zero point or datum CE. Use of BP where present is defined aa 1950 CE is preferred.

Line 114: Please address the burgeoning literature associated with probability density functions, kernel density estimates (with detrital zircons, speleothem ages, 10Be moraines etc.). Can you justify your illustration of the statistical distribution? I appreciate that your pdfs are the result of a sensitivity analysis, but they may over-emphasize the relative frequencies.

Line 129: Provide evidence for the composition of the CCC, i.e. calcite.

Line 174: Rephrase this statement.. a concentration cannot be expressed as a ratio. And on this front, please reflect on the use of other indices for detrital components, Al, Zn, Ti etc.. Perhaps future studies could investigate trace elemental variation more fully.

Line 176. "grouped and sorted … on a visual basis". Maybe better to say "visually grouped on the basis of relative surface area and roughness".

Expand. What does roughness mean here? "Relative surface area" – per unit volume? Types A, B and C – list here and refer to Supplementary images.

Fig. 4. Why is the 95%CI not 'symmetrical' w.r.t. the regression line? Or do these shaded areas correspond to the confidence intervals for the global data set for each patch, which is then overlain with regressions for subsets.

Also, your isochron analysis is based on 3-D methods as described in Ludwig and

Titterington (1994). Please guide the reader to the tools you have used - Isoplot/Ex, IsoplotR or alternative? How have you approached error correlations?

Line 184. This is the first mention of $(^{230}Th/^{232}Th)_t$ - this should be defined earlier. Is this at time T= t, i.e. time (age) since precipitation T=0, and also referred by others as measured value (m).

Line 209. The data point with most leverage is not an age, it is a data point in isotope space.

Table 1. Some uncertainties = 0 in the $(^{230}Th/^{232}Th)_t$ column. Please correct.

BCE – please correct. Use age* and define the datum in *footnotes. BCE ≠ years before 1950.

Placement of the isochron age derivation in the final column is ambiguous – is this all data for each patch of subset?

What does isochron-corrected age mean? I presume this is age after correction using derived initial Th for this patch. Please add more detail in footnote. Or remove this column because it is awkward to define these as single ages when they are not independent of the other analyses for the specific patch.

Line 266. The initial Th ratios calculated do not 'theoretically' represent the values of the 'residual water' from which the CCC precipitated. The water will have more than one source of Th (dissolved, particulate, adsorbed, complexed) and the partitioning between the liquid and solid phase will be complex and variable. The initial Th ratios are representative of the components adsorbed or coprecipitated.

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