

Interactive comment on “A re-evaluation of the palaeoclimatic significance of phosphorus variability in speleothems revealed by high-resolution synchrotron micro XRF mapping” by S. Frisia et al.

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The paper attempts to explain the incorporation of phosphorus into tropical speleothems and its significance as a palaeoenvironmental proxy. The authors use a modern analogue from Christmas Island and apply their observations to 4Ma old speleothems from the Nullarbor Plain. The interpretation of trace element concentrations from old speleothems located in systems nowadays hydrologically inactive is properly challenging. Overall, the article represents an interesting contribution to the interpretation of P as a palaeoclimate proxy in a tropical setting and is therefore worth

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to be published. The discussion is well structured but some more emphasis on the results would certainly help the reader to follow the reasoning.

Much of the paper relies on the hypothesis that P originates from the cave host-rock. This assumption is largely based on the fact that P correlates with Ca in modern drips at Smith's cave, on Christmas Island. In my understanding, this is however not sufficient to rule out other potential sources (e.g. soil microbial activity). It would therefore be nice if the authors could elaborate on this, in particular by describing the water-rock interaction more carefully. If, as suggested by the authors, P results from an increased rock/water interaction, why should it anticorrelate with Mg which most likely originates from the dolomitic host-rock? If, on the other hand PCP is invoked to explain high Mg/Ca ratios, why should P correlate with Ca? Some clarification would be appreciated here.

Similarly, the co-precipitation between Ca and P needs to be better explained/demonstrated. Rather than depending on the absolute Ca concentration of the drip water (p.2566 l.18), I would expect the precipitation of calcite being related to the degassing rate (i.e. CO₂ gradient or drip rate). Since “drip rate does not show a good correlation with P concentration” (p.2566 l.5) is there any change observed in the ventilation regime or is there any evidence that cave pCO₂ could be higher during the wet season, when recharge is elevated?

The palaeoclimatic interpretation of the Nullarbor speleothems assumes an analogy between two study sites separated by several thousands of km and located in (present day) different climatic contexts. Since the interpretation largely relies on the rock-water interaction, a better description of the host-rock at Nullarbor would support the discussion. How does the P concentration of the carbonate compare to that at Christmas Island? Is apatite present as well? Moreover, the authors suggest that some P-enrichment could be related to microbial processes. Although it is hinted that microbial mats may be associated to (secondary?) micro-pores, a more detailed petrographic description would be useful here (e.g. description of microbial fabrics/mats in the old

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and/or modern speleothems).

Finally, the authors speculate that the dry periods interpreted from Nullarbor speleothems may reflect a global climate signal associated to the closure of the Central American Seaway. A proper description of the regional climate system is however missing and the link to the “EEP” has to be described first. It is also unclear why a gradual closure of the seaway would lead to “recurrent” dry periods and not simply shift the climate system.

Detailed comments

p. 2560 l.17 Some more information about bacterially related morphologies would be useful here. What are the characteristic features?

p. 2561 l.11 should be “Christmas”

p. 2561 l.21 900-3700 mm: this seems a particularly large annual range, please check the lower value.

p. 2562 l.13 should be “ca. 600-700 yr ago” (delete “at”)

p. 2562 l.13 Hua et al. 2012 is missing from the reference list

p. 2562 l.11 What do you mean by “multiple sources of non-authigenic thorium”? Can you be more explicit?

p. 2562 l.18 How is the age at 30 mm inferred, i.e. linear interpolation between 700a and present? Can you elaborate on the age model? What is the average growth rate, and the sample size?

p.2562 l.15 “P concentration in excess of 10000 ppm relative to the parent water”. Which partitioning coefficient did you use here?

p.2563 l. 1 I don’t know this work, but is it really similar to “seawater”?

p.2563 l.27 should be “were identified”

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p.2565 l.3 can you explain in which sense these are dissimilar to the Great Cayman stalagmites?

p.2566 l.6 should be “voids”

p.2566 l.12 How did you determine the partition coefficient? Have you assumed an average drip discharge?

p.2566 l.16-22 Please rephrase as these two sentences are hard to follow.

p.2566 l.25- p.2567 l.6 The comparison with Ernesto cave brings a lot of confusion and I would prefer not having it mentioned here. Rather, focus the discussion on Smith’s cave and its significance for a tropical system.

p.2567 l.6 should be “hypothesize that”

p.2567 l.12 delete “and is”

p.2567 l.18 should be “although”

p.2567 l.19 shouldn’t it rather be “precipitate silicates”?

p.2568 l.6 Please edit as the text is a bit redundant, i.e. the constant drip rate is mentioned 3 times in 3 lines.

p.2568 l.7 delete “thus”

p.2568 l. 18 What does the “Phase 1” refer to? Can you provide a petrographic description of it here?

p.2568 l.19 should be “onset”

p.2568 l.20 It would be easier to understand if you split this long sentence in two.

p.2569 l.3 What is your “empirical enrichment factor”? The same as for Smith’s cave?

p.2570 l.13 Do you mean constant recharge of the aquifer or constant discharge at the drip?

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p.2570 l.18 EEP what? monsoon, sst change, upwelling, ...?

p.2570 l.23 Please cite a reference for the Pliocene global temperature

p.2570 l.16-20 Can you provide some more information here? At this stage, the reader doesn't know anything about EEP. What was the regional climate before the closure of the Central American Seaway? Do you suggest that the closure initiated "recurrent dry periods"?

p.2571 l.4 Are you sure that the incorporation of P depends on the calcium concentration in the dripwater (and not simply correlates)?

p.2571 l.22 "lasting" rather than "spaced apart" ?

p.2571 l.23 should be "thousands"

Fig. 1 Can you show the P-rich phases on Fig.1a? Do the microcavities shown in 1a correspond to the corroded crystal surfaces in 1b, resp. to the P enriched areas of 1c?

Fig. 2 Since you are measuring drip waters, I would prefer the units in "mg/l" rather than "ppm"

Fig. 3 A few words in the caption explaining how you distinguish Phase 1 from Phase 3 would be helpful here

Fig. 5 "The red arrows visualize the elemental enrichment between the average values of phases 1 and 3 with respect to phase 2". I understand from this sentence that phases 1 and 3 are more enriched than phase 2; the graph however suggests the opposite. Shouldn't you invert the phase numbers in you sentence?

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