

We would like to thank the two referees for providing constructive reviews on our paper on cryogenic cave carbonates.

As requested by the Journal we reply to their comments as follows.

Review by K. Zak

The reviewer requested details about the relationship between cave microclimate and the surface climate. And he adds that „possible systematic differences between cave microclimate and surface climate are usually not discussed in sufficient detail in the speleothem-based paleoclimatic studies“. He provides a lengthy theoretical discussion of how the cave microclimate may be affected and in particular how a climate signal (e.g. a warming) is transmitted into a cave. While we found his description useful (and encourage him to expand this into a nice little paper) we see little possibility to discuss these aspects in our article. The cave is in a remote, high-alpine setting and today's thermal regime is reasonably well characterized by the multi-annual temperature record which is presented in our paper. We have no further observations e.g. on seasonal drip-water to expand this. And we emphasize that additional monitoring would not necessarily improve the understanding of this site, because – as we discuss in detail in the paper – the cave climate likely has changed as a result of the complete deglaciation of this cave. We concur with the reviewer that this change likely was not a unique event in the Quaternary. Whether the formation of CCC was related to a high-precipitation event as hypothesized by the referee can neither be verified nor falsified, nor has such a climate link been advocated by any of the previous studies (in several of which K. Zak was involved). We stand by our interpretation that the timing of CCC formation in MSK Cave does not fit the simple model of CCC formation during a warming (and hence permafrost thawing). In fact, recently published high-precision exposure dates from a well-studied Swiss glacier provide additional evidence of a significant glacier advance right at the time of CCC crystallization in MSK Cave (Schimmelpfennig et al., 2014; this article will be included in the revised version of our paper).

Specific comments:

Page 1494, Abstract, lines 5–7: This sentence was rewritten to:

More precisely, these carbonates record episodes of progressive karst water freezing. Such conditions have been associated with periods of permafrost thawing allowing the infiltration of melt water into formerly dry, frozen caves.

Page 1494, Abstract, lines 13–14: The referee suggested that the pools, which we inferred from the patchy distribution of CCC deposits, were residual water produced during progressive water freezing. We prefer our original interpretation that these pools were produced by drip water carrying latent heat into these cave chambers and causing localized melting, and subsequent slow re-freezing.

Page 1494, Abstract, line 17: The referee re-iterates his suggestion that CCC formation in MSK Cave may reflect high summer rainfall. This is an interesting thought, but difficult to reconcile with the mounting evidence from other alpine archives such as glaciers, which experienced a significant positive mass balance at that time. This argues for frequent snowfalls rather than rain during summer to keep summer ablation low.

Page 1495, lines 20–21: Sentence changed according to the reviewer's suggestion.

Page 1495, lines 26–27: We prefer not to add a supplement with these data, as these samples are from a different cave, were analyzed by a different lab and pertain not to the topic of this article, i.e. CCC.

Page 1496, line 6: We thank the referee for pointing out the new paper co-authored by him on CCC in caves from the central and northern Ural Mountains. In fact we also collaborate with the second author of this paper on CCC from a cave in the southern Ural. However, we decided not to include this article in our paper, because we state that *Previous research on CCC has focused on cave sites located in the periglacial corridor between the former Scandinavian and the Alpine ice sheets* and this statement is still valid. Plus the Ural paper does not add significant new insights which would warrant its citation.

Page 1496, lines 14–17: We agree but this is not the point as we explicitly talk about fine-grained CCC occurrences inside the Alps (and not everywhere).

Page 1496, lines 26–27: The dimensions of the entrance can be easily read off the cave map (Fig. 3).

Page 1497, line 5: Added information about the bedding of the ice:
In 2005, when the cave was first surveyed, up to 5 m thick congelation ice was present in the upper part of the main gallery, whose bedding followed the dip of the gallery and whose surface already showed clear signs of ongoing melting.

Page 1497, lines 25–26: Such high temperatures would indeed be hard to explain. No, the referee mixed up the two curves. As explained in the caption the solid curve – labeled cave air temperature on the right-hand axis – reaches only up to about +1 °C.

Page 1498, lines 5–6: We agree with this comment and have already planned a dedicated cave tour collecting CCC and transporting it under cooled conditions to the lab and analyzing it in a cooled XRD device.

Page 1499, lines 3–5: Yes, correct. No rock fragments released by frost shattering were found on the CCC deposits.

Page 1501, lines 7–9: We do not see the point why the U content of the old flowstone is of relevance for the young CCC formation. The U content is rather high (10 ppm) and similar to samples from Spannagel Cave located not far from MSK site.

Page 1502, line 1: Actually we did not state that „the MSK site shows many similarities with the previously reported CCCcoarse localities“ but rather „MSK site has several aspects in common with previously studied CCCcoarse occurrences“, and we stand by this sentence. This does not exclude some differences in the cave geometry as outlined by the referee. And we emphasize that the seasonal temperature changes recorded in MSK Cave characterize the post-permafrost conditions and should not be regarded as typical of the microclimate during CCC formation (as already detailed in the original version of our paper).

Page 1503, line 8: While we cannot completely rule out the presence of scattered alpine plants above the cave we have noticed only very little vegetation at all in this area. Grass is present but only below the fronts of the rock glaciers.

Page 1505, lines 2–3: We modified the sentence as follows:

²³⁰Th-dating allows to place temporal constraints on when (a) ice was present in today's ice-free chambers of MSK Cave, and (b) when the permafrost above the cave underwent degradation releasing meltwater into the chamber which experienced progressive freezing.

Page 1504, lines 8–13: Not clear to which lines this comments pertains.

All technical corrections are considered in the revised version.