

Interactive comment on “Cryogenic and non-cryogenic pool calcites reflect alternating permafrost and interglacial periods (Breitscheid-Erdbach Cave, Germany)” by D. K. Richter et al.

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Dear Editor,

The paper is interesting and brings new data on a topic, which is described for the first time (temporal evolution from Weichselian non-cryogenic cave pool rafts to Weichselian cryogenic cave carbonates in one cavity). Since these processes are related to permafrost evolution and destruction, the paper fits well into the Cryosphere journal scope, and its publication is therefore justified. Unfortunately, there are some aspects

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of the manuscript which need improvements. Most of them relate to the terminology and style of presentation.

The topic of cryogenic cave carbonates is relatively new, studied in detail for several years only, and the terminology of individual cryogenic cave carbonate types, and of morphological varieties of crystal aggregates, is not internationally established yet. I would therefore recommend usage of general mineralogical and crystallographic terminology, where possible.

For some identical objects there are used several different names (for instance a name for the studied cave system) - this should be unified throughout the paper. I am not a native English speaker, so I cannot advise the authors any language changes or improvements. Nevertheless, the paper needs by my opinion a language revision. In general, the paper is quite useful, and after a moderate revision related mostly to terminology, it can be accepted for publication without further review. Below are listed individual comments.

1/ Title of the paper. The title of the paper should be possibly modified, since there are mixed some disparate terms. By my opinion, either the formation of studied speleothems should be related to ...alternating permafrost growth and thawing, or to alternating stadial and interstadial (probably not interglacial) periods. The ice fill of the cavity located at shallow depth most probably melted already during the final phases of the last Glacial, not during Holocene. Somewhere in the paper (either in discussion or in description of the studied cave system) it should be explained that the morphology of the studied cave system does not allow cooling of the cavity to freezing temperatures by air circulation (in a contrast to present-day ice caves of temperate zone). The studied part of the cave system is rather remote from the entrance, which was artificially opened by a quarry, and later for tourists from another side of the cave. Therefore, it should be documented/discussed that the cavity was cooled to freezing mostly by permafrost development, not by air circulation within the cave. The term interglacial should not be used as a term for a period within the last Glacial, since as interglacials

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are generally considered longer warm periods between individual glacials (like, e.g., Eemian or Holocene). If I understand the conclusions of the authors well, all studied speleothems were formed within the last Glacial (except of Holocene samples from site 6, sampled for a comparison). It should be also noted/discussed somewhere in the paper that the surface climatic changes propagate into the subsurface environments with significant time delay. This is another reason why I consider the formulation in the title "...alternating permafrost and interglacial periods..." as not suitable.

2/ Title, Abstract, line 2, and further in the paper: name of the studied cave system. The used name of the studied cave system should be unified throughout the paper. In the title of the paper as well as on line 2/p1012 there is used Breitscheid-Erdbach Cave, similarly on the line 19/p1013. On line 9/p1014 there is used "Breitscheid-Erdbach" Cave with parentheses, but on line 14 of the same page we can read "Herbstlabyrinth-Adventhöhlen" cave system. In Fig. 1 there is used Herbstlabyrinth Breitscheider Großhöhle, and in description of the same figure "Breitscheider Großhöhle". I would recommend a term Herbstlabyrinth-Adventhöhle Cave System, since originally independent caves Herbstlabyrinth and Adventhöhle were later connected together. The name Breitscheid-Erdbach is confusing since there is in the area another, mostly unknown cave system (with active water flow) called Erdbachhöhlensystem, with water inflow directly in the Breitscheid village and water discharge near Erdbach. The date of discovery of Herbstlabyrinth part of the system is sometimes given on May 28, 1994, which is not during the winter 1993/1994 as stated.

3/ Abstract line 2 and 3. Throughout the paper, there are many terms describing the observed crystal aggregates, which need revision. I consider the terms crystal sinter or spherulitic crystal sinters as not suitable, since it will be probably internationally not well understood. By my opinion it is better to use in the abstract some generally understandable terms. For instance to speak about accumulation of loose (non-cemented) single crystals and crystal aggregates deposited on the bottom of the cavity. The term spherulitic should be possibly also either better explained, or replaced, since the term

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spherulites is already used in geology for rounded bodies occurring in some vitreous igneous rocks. It should be possibly stated just at the paper beginning that the studied object belong to speleothems, which is a general term for secondary cave mineral precipitates.

4/ Abstract, lines 5 and 6. The formulation should be modified, since the reader can be confused if the given ranges of isotope composition relate to the data obtained at the studied locality, or at all known localities of cryogenic cave carbonates of Central Europe. In fact, the range for all Central European localities is much larger, as seen from Fig 10 of the paper. At the end of line 6 instead of variant it is probably better variable. The information about differences in $\delta^{13}\text{C}$ of these carbonates between different cave localities based on differences in cave ventilation is possibly not well understandable from the abstract alone. Since the abstract occurs in various electronic databases separated from the rest of the paper, it should be well understandable alone, without looking into the whole paper.

5/ Abstract lines 15 to 20. To this part of the abstract relates also the comment 1/. The use of the term interglacial is by my opinion not suitable here, since the last Glacial, and the last permafrost melting, is followed by only one interglacial - the Holocene, which is a common knowledge. For a short warm period within the glacial a term interstadial is correct. The whole abstract should be possibly re-formulated to make it more easily understandable. There are many formulations in the abstracts (e.g., slow genesis on line 5; meaning probably slow precipitation under conditions of isotopic equilibrium between ice and water) which are possibly difficult to understand for people not working on the topic.

6/ Lines 1 to 4 at page 1013. Here it is given in one short paragraph a lot of information. It includes information obtained from present-day iced caves of the temperate zone with high ventilation, where the water freezes in a thin film on the surface of the ice, with kinetically controlled isotope systematic of formed precipitates (high $\delta^{13}\text{C}$ values are here not a result of evaporation effects, but also of a rapid kinetic escape of

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CO₂ from the solution), and also information from more-or-less isolated cavities within the permafrost, with slow water freezing in pools. Possibly the formulation should be expanded and modified to separate these two cases more clearly, and explain in more detail quite different carbonate C and O isotopic patterns of these contrasting environments.

7/ Lines 7-8, page 1013. The list of references related to cryogenic cave carbonates is not complete. For instance there is missing a paper from *International Journal of Speleology*, 38 (2009): 139-152, as well as some most recent papers of Richter et al. from years 2009 and 2010, including accepted papers in press. Missing are also some papers about the Herbstlabyrinth-Adventhöhle Cave System, e.g. Kaiser (1999; *Journal of Cave and Karst Studies*).

8/ Lines 10-15, page 1013. Information contained here looks more as discussion or interpretation, based partly on the observations done in the studied cave. Possibly this interpretation should be moved to Discussion. The processes should be discussed in more detail, since the surface climatic changes are transferred into the subsurface environment with a delay.

9/ Lines 6-7, page 1014. This paper is focused only on cryogenic cave calcites, not on cryogenic calcites (carbonates) in general. They are quite common in subglacial environments of glaciers, soils of permafrost zone, aufeis occurring in high northern latitudes, and other. The word cave should therefore not be missing here.

10/ Lines 9-10, page 1014. Here again the formulation is not precise, since the reader can be confused if the references of Kayser (1907) and Krebs (1966) relate to Devonian rocks of the area in general, or to the cave.

11/ Lines 15 to 17, page 1014. Information contained here should be possibly modified and expanded. The genesis of the cave is in the text first related to a shallow phreatic system, and later in the next sentence it is described as a system of water-level-controlled subhorizontal cave levels. Both can be correct, since cave systems

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like this usually evolve from early phreatic or epiphreatic channels, formed sometimes also by injection of floodwaters, to ideal water-level controlled cave levels, and finally to vadose corridors, which later became drained and inactive, as the active level drops deeper. At least the latest evolution phase of the system, with fluvial removal of part of the clastic sediments, was fluvial. The morphology of the cave system, especially the position (elevation) and size of entrances, their natural or artificial character, and the distance and corridor diameters between the sampling site and the entrance(s) should be described in more detail, since this is the information crucial for understanding of the cave ventilation and cave climate. It would be useful to give some present-day cave temperatures and their seasonal changes, if they were measured.

12/ Line 3, page 1015. If the unconsolidated accumulations of single crystals and crystal aggregates are called "crystal sands", the majority of grains should have sizes between 1/16 and 2 mm. Is it really so? On the photographs there are some crystal aggregates sized above 2 mm.

13/ The section on methods, page 1015. This section is OK, only the name of the mass spectrometer Delta S I would write with a capital letter, and the results are given against the V-PDB, not calibrated. A reference related to CO-1 and CO-8 standards should be added (or at least to add IAEA), or all this information can be removed, it is not necessary. There should be a space between the number and the symbol ‰.

14/ Line 23 and further, the term "small sinter precipitates". I consider this term as not suitable. In the section above the authors speak about "crystal sands" and here about "small sinter precipitates". None of these terms is precisely defined in the paper and it is not sure, if both terms mean the same. The term crystal sands sounds more acceptable than the second term, if both mean the same. Possibly the term sinter should be not used in the paper at all, since the meaning in which the authors use it, is valid only in some European countries. US readers would be confused. I would prefer a terminology based on common geological terms like, e.g., fine-grained (give grain size range) unconsolidated accumulations of crystals and crystal aggregates.

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One possibility is to describe the morphology, grain size, and mode of occurrence of studied speleothems in detail in the site description, introduce some abbreviation and than throughout the paper use only this abbreviation. Also the term crystal sinters should be replaced, possibly by a term crystal sands, if the grain size is in the range of sand, and if the accumulation has some thickness to make a layer. The term "platty crystallites" is also partly confusing, since the crystallite is "a broad term applied to a minute body of unknown mineralogic composition or crystal form that does not polarize light. Crystallites represent the initial stage of crystallization" (Jackson, Glossary of geology, 4th ed.). Similarly the term spherulitic crystal sinters should be modified, this was discussed already above. Since the topic is relatively new, I would recommend either to define any used term precisely, or to use only generally understandable terms of mineralogy and crystallography. If some terms are taken from local literature with difficult access (like "braided sinter" from Erlenmeyer et al. 1992), they should be redefined/explained again.

15/ Lines 9 to 17, page 1017. If I understand the paper well, the sampling site 6 represents a comparison sampling site, where the formation of pool cave rafts continues until present-day, or at least during the Holocene. Other sampling sites are probably inactive today, i.e. without any sinter growth since end of the Glacial. If this is correct, it should be more explicitly directly given here in the text. Also information, if the pool rafts of site 6 were sampled from a pool with crystal growth also on the bottom and/or sides of the pool can be useful. Similarly information about the bed below sampling points 1 to 5, if the base was a bare rock of fallen limestone block, some kind of cave clastic sediments, older generation of cave sinters, etc., can be added. If some crystal growth occurred directly on this base (crystals connected to base at sampling points 1 to 5) should be also said. This can clarify, if the Weichselian non-cryogenic rafts were growing in pools on the cave bottom, or in stagnant pools on the ice surface (without progressive freezing of water).

16/ Line 1 to 4, page 1018. Possibly it would be more precise to use ...oxygen iso-

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tope ratios instead of oxygen ratios, and higher d18O values, instead of 18O-enriched values (18O enriched are the samples, not the values).

17/ Lines 19 to 26, page 1018. If the dating of 28700 ± 1500 years BP is new and presented here for the first time, it should be accompanied by description of analytical method and by data on other usual isotope ratios, enabling estimation of possible proportion of detrital Th. If this datum is already published elsewhere, a reference should be given.

18/ Line 6, page 1021. Here is a new information on existence of "ice attachments" on the cave walls, which represent another indication about former ice fill of the cavity. This information should be contained already earlier, in the description of the locality.

19/ Fig 1. There was another area of mountain glaciation during Weichselian in Western Carpathians, which should be possibly shown in this figure. There is missing an explanation what is the brown colored field in the main map (probably Rheinisches Schiefergebirge).

20/ Fig. 2. It is not sure what shows the arrow entrance, if this is the artificial entrance done for tourist, or some original natural entrance. This should be possibly explained, since the position and presence (or absence) of a natural entrance is important for the cave ventilation. Is the position of the entrance correct?

21 Fig. 4. What do the dashed lines in the cavity show?

Interactive comment on The Cryosphere Discuss., 4, 1011, 2010.

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