The Cryosphere Discuss., 4, C767–C781, 2010
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The Cryosphere Discussions



# *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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referee: "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."



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We will change the title to: “Cryogenic and non-cryogenic calcites indicating permafrost and non-permafrost periods: A case study from the “Herbstlabyrinth-Advent” Cave system (Germany)” to avoid confusion.

referee: “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.”

We will add information concerning cave morphology, cave air circulation, temperatures, cave history (artificial changes) and more detailed information about the localities in the next version of the manuscript in Chapter 2 which is the “Geographical and geological setting”.

referee: “The term interglacial should not be used as a term for a period within the last Glacial, since as interglacials are generally considered longer warm periods between individual glacials (like, e.g., Eemian or Holocene).”

We will change the relevant passages to “between glacial/stadial to interglacial/interstadial”.

referee: “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).”

The relevant passage in the former conclusion chaper was misleading (page 1022, line 6-8). We will modify it to: “If successful, the combination of paleoenvironmental information from cave climate archives, precipitated during interglacials and probably



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interstadial with evidence from periods with cryogenic cave calcites allows for a much ..."

referee "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."

We will add further information to the Chapter 1 – Introduction - as follows: Page 1013, line 12 "... during these transitional periods, mean annual temperatures outside of the cave gradually decrease and then fall below freezing point. Because of the low heat conductivity of rocks this decrease in temperature is reaches the subsurface with some delay (as described by Pielsticker, 2000) so that low frequent temperature changes are not displayed in cryogenic cave calcite records, depending on the overburden of the cave."

Furthermore we add information to the discussion as follows: (Page 1021, line 1-2) "Beginning of cave ice formation when the 0°C isotherm reaches the roof of the cave with some delay, because of low heat conductivity of rock (Pielsticker, 2000), during the beginning of Weichselian interstadial."

referee: "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 Herbstlabyrint-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





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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."

We will use a single term for in the next manuscript version which is as follows: "Herbstlabyrinth-Advent" Cave system because your suggestion ("Herbstlabyrinth-Adventhöhle Cave system") would imply a duplication of the term "cave" because "Höhle" means cave in German.

referee: "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."

The date of the discovery differs according to the references used. We consider the discovery in winter 1993/1994 as more likely one.

referee: "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 spherulites is already used in geology for rounded bodies occurring in some vitreous igneous rocks."

We will do several changes in the used terminology according to your suggestions: "speleothem particles" instead of "small sinter precipitates" "aggregates and individuals of crystals with rhombohedral faces" instead of "rhombohedral crystal sinters" We keep the term "spherulitic", because the "spherulitic crystal speleothems" are crystallographically quite similar to the 'igneous' spherultites, because they both have a radiate fibrous structure. We suppose to add "(crystals with radiate fibrous structure)" when we introduce the term "spherulitic crystal speleothems" first, to emphasize what is meant.

referee “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.”

We will add to the Introduction (page 1012, line 24): “In contrast to the genesis of most other carbonate speleothems (e.g. stalagmites) from saturated cave waters above 0°C (e.g. Hill  Forti 1997) cryogenic cave calcites (CCC sensu Zak et al., 2004) form during freezing of cave waters.”

referee: “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.”

We will modify lines 5 and 6 in the abstract to “The carbon and oxygen isotopic composition of these precipitates (ïĄď13C=+0.6 and $-7.3$ ‰ $18O$ =-6.9$to$-18.0 corresponds to those of known slowly precipitated cryogenic calcites in Central European caves.”

referee: “At the end of line 6 instead of variant it is probably better variable.”

We agree.

referee: “The information about differences in d13C 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.”

We will modify the relevant passage to: “Particularly, the C/O isotopic composition of the Breitscheid cryogenic cave calcites reflect mean levels of cave ventilation in comparison with the carbon and oxygen isotopic composition of cryogenic cave calcites from other caves of Central Europe.”





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referee: “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.”

We will remove “The last stage then grades into the present day, warm period” and will modify the following sentence to as follows: “Judging from the data compiled here, the last permafrost stage in the Rätselhalle is followed by a warmer period (interstadial and/or Holocene). During this warmer period the cave ice melted and cryogenic and non-cryogenic Weichselian calcite precipitates were deposited on the cave ground or on fallen blocks, respectively.”

referee: “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 d13C values are here not a result of evaporation effects, but also of a rapid kinetic escape of 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.”

We will advance the relevant passage as follows: “In present day ice caves of the temperate zone with high ventilation, water freezes in a thin film on the surface of ice. Due to rapid kinetic escape of CO2 from the solution, rapid freezing of cave waters leads to





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high d13C values of precipitated calcites (Lacelle 2007, Spötl 2008). In contrast, slowly freezing waters and related preferential 18O incorporation into the ice in more or less isolated cavities within permafrost, leads to low d18O values of calcite precipitates from this fluid (Žák et al. 2004)."

referee: "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)."

We will add: (page 1013, Lines 7-8) "Žák, K., Hercman, H., Orvosova, M., and Jackova, I.: Cryogenic cave carbonates from the Cold Wind Cave, Nizke Tatry Mountains, Slovakia; extending the age range of cryogenic cave carbonate formation to the Saalian, International Journal of Speleology, 38, 139-152, 2009."

"Richter, D. K., Mangini, A., and Voigt, S.: Erste Th/U-datierte Kryocalcite der mittleren Weichseleiszeit aus einer Höhle des Rheinischen Schiefergebirges (Heilenbecker Höhle, Bergisches Land), Mitt. Verb. dt. Höhlen- u. Karstforsch., 55, 125-127, 2009c."

"Richter, D. K., Schulte, U., Mangini, A., Erlemeyer, A., and Erlemeyer, M.: Mittel- und oberpleistozäne Calcitpartikel kryogener Entstehung aus der Apostelhöhle südöstlich Brilon (Sauerland, NRW), Geol. Paläont. Westf., (in press)."

and

(page 1014, line 18) "Kaiser, T. M.: New pleistocene vertebrate assemblages in the Breitscheid-Erdbach Cave system (Iberg Limestone, Dill Basin, Germany), Journal of Caves and Karst Studies, 61, 145-149, 1999." to the references.

referee: "8/ Lines 10-15, page 1013. Information contained here looks more as dis-





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cussion 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."

The information contained in this paragraph is well known from several other well studied localities. Therefore we use these concepts more or less as a fact and we confine ourselves to improve and expand the general ideas concerning the precipitation of cryogenic cave calcites known so far with our study.

referee: "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."

We agree.

referee: "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."

We will change this passage as follows: "The "Herbstlabyrinth-Advent" Cave system formed in the Upper Devonian Iberg Limestone of Breitscheid on the NE margin of the Tertiary Westerwald vulcanite (Fig. 1). The reefal deposits of the Iberg Limestone (Kayser, 1907; Krebs, 1966), located on a volcano basement in the Rhenoherzynic trough of the Rhenish Slate Mountains (Krebs, 1971), is well known for its abundant karst phenomena of Late Cenozoic age (Stengel-Rutkowski, 1968)."

referee: "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 waterlevel-controlled subhorizontal cave levels. Both can be correct, since cave systems 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."

We will modify the relevant passage as follows: "Kaiser et al. (1998, 1999) identified four karst levels, which today are situated in the vadose zone with a temporal active fluvial system in the lowest part of the cave, and three subsequent stages of speleothem formation have been identified but not yet dated." Furthermore we will add information concerning the cave system as already explained above.

referee: "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."

Indeed, the majority of the grains is sand-sized. It will be explained/defined as you can see in our reply to comment 14/.

referee: "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 ‰'



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We change it as follows: “Carbon and oxygen isotopic composition of calcite were determined with a Delta S mass spectrometer (Finnigan MAT) and expressed against the V-PDB standard. “(Standards: CO 1 and CO 8)” will be removed. The space between number and the symbol ‰ will also be added.

referee: “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. 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 "platy 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.”

We will do some changes as follows: “Accumulations of “crystal sand” (loose individual



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crystals and aggregates – mostly sand sized, sometimes more than 2 mm in size) consisting of speleothem particles covering the cave floor . . .” to replace “small sinter precipitates” by using “speleothem particles” and to introduce the latter term as well as “crystal sand”. As described in the reply to the first referee comment we will use “speleothem” instead of “sinter” throughout the manuscript. The term “crystallites” will be replaced by the term “aggregates”. The term “spherulitic” won’t be replaced, but some additional information added, as described above – further information see cited papers of Richter and Niggemann 2005 and Richter and Riechelmann 2008. A short explanation what is meant with the term "braided sinter“ is still given in the manuscript (page 1017, line 4).

referee: “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).”

We will modify the title “Small sinter precipitates from sinter basins” to “speleothem particles from an active sinter basin” and modify some of the text to make this clearer. Information about the bed below the sampling points is given in Fig. 4. None of the described “speleothem particles” is attached to the cave floor. But this is explained by the added definition “crystal sand” as “loose individual crystals and aggregates . . .”. In



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our opinion the sampling site of the recent rafts is already explained in the text (page 1017, line 12): “At the edge of this sinter basin, above the present water level, ancient raft deposits are attached to flowstones.”

referee: “16/ Line 1 to 4, page 1018. Possibly it would be more precise to use ...oxygen isotope ratios instead of oxygen ratios, and higher d18O values, instead of 18O-enriched values (18O enriched are the samples, not the values).”

We agree.

referee: “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.”

We will add on page 1018, line 21: “. . . and R. Eichstädter). Results of dating of Lab. No. 5056: $\delta$U (corrected) = 431,5 ‰ (absolute error 8,2), 238U = 0,9889 ng/g (absolute error 0,0035), 232Th = 22,45 ng/g (absolute error 0,29), 230Th = 5,48 pg/g (absolute error 0,24), corrected age = 28,7 ka (error 1,5 ka).”

referee: “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.”

We will add to chapter 2 – Geographical and geological setting (page 1014, below line 25 in a new paragraph: “Ice attachments display a former presence of ice in the cave’s history”.

referee: “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)."

The area will be added into the figure and the explanation will be given in the caption.

referee: "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?"

As already said above, we will add information concerning the cave system (containing some facts about the artificial entrance) in the next manuscript version. The position of the entrance in Fig. 2 is correct.

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

The dashed lines are the lower and upper boundary of a huge inclined flowstone, whose inclination is symbolized by the slight transition from grey to white. The dashed lines will be removed, because they are not necessary for the description of the localities.

All in all following references will be added: Žák, K., Hercman, H., Orvosova, M., and Jackova, I.: Cryogenic cave carbonates from the Cold Wind Cave, Nizke Tatry Mountains, Slovakia; extending the age range of cryogenic cave carbonate formation to the Saalian, International Journal of Speleology, 38, 139-152, 2009.

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Kaiser, T. M.: New pleistocene vertebrate assemblages in the Breitscheid-Erdbach Cave system (Iberg Limestone, Dill Basin, Germany), Journal of Caves and Karst Studies, 61, 145-149, 1999.

Hill, C. A., and Forti, P.: Cave minerals of the world, National Speleological Society, Huntsville, AL, 463 pp., 1997.

Pielsticker, K.-H.: Höhlen und Permafrost - Thermophysikalische Prozesse von Höhlenvereisungen während des Quartärs, Bochumer geol. u. geotechn. Arb. , 55, 187-196, 2000.

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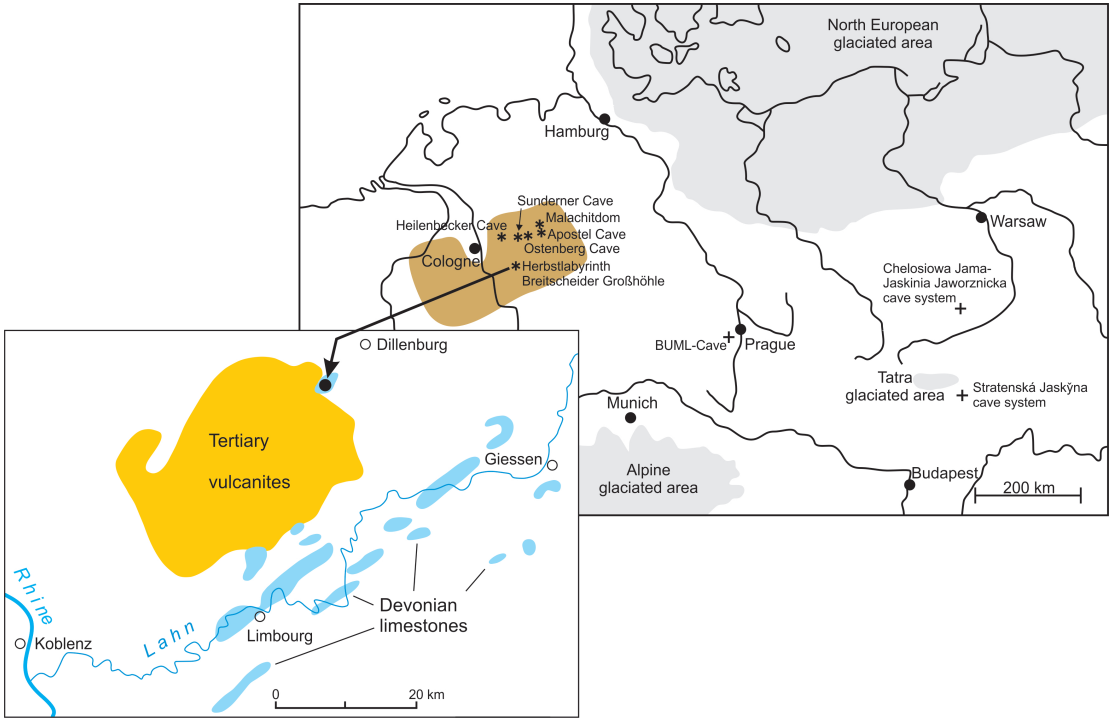


**Fig. 1.** Map showing the position of the "Herbstlabyrinth-Advent" Cave system as well as the other caves of Central Europe from which cryocalcites have been described (light brown – Rhenish Slate Mountains, li



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