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Climate of the Past Discussions



# *Interactive comment on* "Holocene climate change, permafrost, and cryogenic carbonate formation: insights from a recently deglaciated, high-elevation cave in the Austrian Alps" *by* C. Spötl and H. Cheng

**Anonymous Referee #2**

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General comments

The paper "Holocene climate change, permafrost, and cryogenic carbonate formation: insights from a recently deglaciated, high-elevation cave in the Austrian Alps" discusses the occurrence and formation of coarsely crystalline cryogenic cave carbonate (CCC-coarse) in the Mitterschneidkar Eishöhle (MSK cave), which is located in the Austrian Alps (Tuxer Hauptkamm) at a height of c. 2558 m a.s.l., and its relationship to Holocene climate induced changes in the Alpine permafrost. For this, the paper presents new data of CCCcoarse formed in MSK cave including petrography data, $\delta$13C and $\delta$18O



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values as well as 230Th ages. In particular, this article is only the third publication mentioning CCCcoarse in the Alpine region so far. The authors discuss the conditions of the permafrost and the MSK cave environment that are necessary for the formations of CCCcoarse, thereby stressing, that a detailed knowledge on these parameter is essential for the interpretation of the occurrence of CCCcoarse and their temporal distribution. Furthermore, the paper compares the age distribution of CCCcoarse from MSK cave with other palaeoclimate archives from the Alpine region to draw conclusions on the evolution of the permafrost above and the formation of CCCcoarse in MSK cave. The article makes a great contribution to the already published studies on cryogenic cave carbonates and highlights the possibility of CCCcoarse for reconstructions of the Alpine permafrost. The paper is worth for publication after some minor corrections, which are listed in the specific comments.

Specific comments:

1) Formation of CCCcoarse in MSK cave:

The 230Th dating of the sampled CCCcoarse suggest, that they grew at c. 2600 years BP and that, therefore, the cave (or at least Eiskammer and Kleine Kammer) was (partly) filled with ice and that stable thermal conditions (close to 0 °C) exist within the cave (Page 1507, line 11-13). To explain the formation of CCCcoarse in MSK cave and link to changes of the permafrost zone – MSK cave was "until very recently" within the mountain permafrost zone of the Tuxer Hauptkamm (Page 1506, line 7-10 and line 21-24) – the authors are arguing with the model of Richter et al. (2010), that was proposed to explain cryogenic pool calcites in the Herbstlabyrith-Advent cave system. However, the model of Richter et al. (2010) is only partly applicable for the formation of CCCcoarse in MSK cave, because first the propagation of the 0 °C isotherm is unknown and second the mechanism of CaCO3 dissolution in the hostrock in unknown – the latter is at least not caused by the accumulation of CO2 in the soil zone above the cave, because there is no soil and no (documented) vegetation above MSK cave (Page 1503, line 7-10). In contrast to the Herbstlabyrith-Advent cave system, where



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the 0 °C isotherm is propagating from top to bottom during warming periods, at MSK cave the 0 °C isotherm is propagating in the different direction during warming periods.

The quality of the paper can be improved, if the authors could discuss these points in the manuscript (origin of CaCO3, propagation of the 0 °C isotherm) and point out the differences between MSK cave and the Herbstlabyrith-Advent cave system and make conclusions for an advanced model of CCCcoarse formation in Alpin regions based on the model of Richter et al. (2010).

Q: Is it possible that calcite precipitation was also partly caused by microbial communities, noted to be the origin of organic compounds in CCCcoarse from MSK cave (Page 1503, line 7-10)?

2) Interpreation of $\delta$13C and $\delta$18O values and 230Th dating:

The $\delta$13C and $\delta$18O values together with the 230Th dating of the CCCcoarse from MSK cave give clear insights into the formation environment via the isotope signature and evolution lines of the analysed CCCcoarse. The authors state that the white and brown crystals represent two different formation episodes (Page 1503, line 15-27) and that the brown crystals have formed after the white ones (Page 1504, line 27-28). Furthermore, no samples were found between the analysed isotope values of the white and brown crystals (Page 1503, line 15-27).

Q) How much CCCcoarse samples from MSK cave were measured for their isotope signature and what fraction (approximately) was is compared to the overall amount of CCCcoarse samples of each heap? – the authors not, that they have taken two samples from Kleine Kammer and 5 from Eiskammer, 7 samples in total; there are much more isotope values pictures in Figure 10. Are the isotope values are all from the 7 sampled CCCcoarse, but CCCcoarse was sampled several times? Is it possible that the isotope offset between the white and brown crystals is caused by a sampling hiatus? It would be good for the reader if the authors could give this additional information in the paper and discuss it briefly.



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The 230Th dating of sample MSK6B suggests that this sample grew at c. 1739±39 years BP (Table 1). However, the isotope evolution of this sample suggests that it grew during the same time as the samples of heap number 4, 5, 6, because of the uniform isotope composition (Page 1504, line 16-17; Fig. 10) – also heap number 4 became isolated from heap number 5 and 6 (Page 1504, line 20-21) – that cluster between 2600 years BP and 3000 years BP.

Q) This contradiction between these two statements is not discussed in the paper but be worth to do, because it raises several questions regarding the quality of the 230Th dating (diagenesis) and stable isotope sampling (sampling hiatus; see also above). Is it possible that the former pool (area) in which sample MSK6B grew underwent several melting and freezing periods and that sample MSK6B record, therefore, different periods of time?

Technical corrections:

1) Fig. 10 must be enlarged in the final manuscript, because it is hardly possible to read it. Furthermore, Fig. 10 b and c can be combined. 2) Table 1: There are to many ... after the W. 3) Page 1503, line 15: It is not Fig. 9 but Fig. 10 that illustrates C and O isotope values. 4) Page 1504, line 4: Insert a link to Fig. 11 here, picturing the 230Th datings. 5) Page 1504, line 26: It is not Fig. 9 but Fig. 10 that illustrates C and O isotope values. 6) Page 1509, line 8-10: [..] ice cave a linked these [..] Do the authors mean “has” instead of “a”?

RICHTER, D. K., MEISSNER, P., IMMENHAUSER, A., SCHULTE, U. & DORSTEN, I. 2010. Cryogenic and non-cryogenic pool calcites indicating permafrost and non-permafrost periods: a case study from the Herbstlabyrinth-Advent Cave system (Germany). The Cryosphere, 4, 501-509.

Interactive comment on Clim. Past Discuss., 10, 1493, 2014.