

Interactive comment on “Alpine permafrost thawing during the Medieval Warm Period identified from cryogenic cave carbonates” by M. Luetscher et al.

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General comments

The paper brings the first detailed study of coarsely crystalline cryogenic cave carbonate (CCCcoarse) formed during the Holocene and interprets the processes of its formation. In fact, it is not the first report on CCCcoarse of Holocene age, since Onac et al. (2011) reported large ikaite aggregates protruding from the melting ice of the Scărișoara Ice Cave (Romania). Nevertheless, the paper of Luetscher et al. is the first detailed study of such type of material of Holocene age. Its publication is justified both by the unique nature of the studied samples, and by its fully appropriate study by a

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wide set of methods. The paper can be published in TC after a minor revision related to specific comments listed below.

Specific comments

I appreciated the introduction of new abbreviations CCCfine and CCCcoarse, which were used in the paper to replace the full description of the CCC subtypes. When written in full, the authors oscillate between coarse crystalline and coarse-crystalline.

In Introduction, page 420, line 23: with respect to the recent distribution and change of the permafrost in the Alps, additional papers can be possibly cited and exploited, e.g. Harris et al. (2003) or Harris et al. (2009).

In the introduction, page 421: It is stated that the microclimate of caves is connected to atmospheric processes but a more detailed discussion of the relationship between surface and cave climate is missing. Heat transfers between the surface and the cave can be related to heat transported by airflow, heat transported with water flow and heat transported by conduction within the rocks. The proportions of these heat transfer mechanisms are different for each cave, with one of these mechanisms being usually dominant. It would be useful to know which heat transfer mechanism the authors consider to be the most important for the studied Leclanché Cave. It would be probably useful to cite some papers which evaluate cave climates based on heat fluxes (e.g., Badino 2005, Domínguez-Villar 2012). For caves which do not have substantial heat fluxes related to airflow or water flow, the conduction of heat within the rocks can be the dominant mechanism controlling their internal climates. Climatic changes in such caves, especially when located deep below the surface (which is not the case here), can be significantly delayed with respect to surface climatic changes. A more detailed discussion of these aspects, that is how is the microclimate of the studied cave related to the surface climate, and how it was changed after excavation of an artificial entrance in the sediment fill, can be useful (probably not here but in the discussion).

Introduction, page 421: Several descriptions of CCCfine come from earlier times than

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the papers cited. As far as the reviewer knows, the first description of CCCfine with an explanation of its origin related to water freezing is contained in Kunsky (1939) based on his study of seasonal ice in cave entrances of the Belanske Tatry, Slovakia. Probably the first description of C and O stable isotope fractionation in CCCfine is contained in Clark and Lauriol (1992), and a detailed subdivision of CCC into fine and coarse crystalline types is contained in the cited Žák et al. (2008, available online in March 2007), published earlier than the cited Spötl (2008).

In the description of the site, page 422: Please specify more precisely what is the structure and structural parameter (200/35) measured on the regional discontinuity (probably dip direction and dip angle of a tectonic structure; nevertheless, the structure guiding the cave in Fig. 1, insert B, seems to be steeper than 35°).

The explanation how the vertical thermal gradient in an adjacent cave is related to the studied cave is too brief. The thermal gradient given for the Grotte des Pingouins is rather steep. Typical Alpine caves thermally controlled by flowing water generally show less steep vertical thermal gradients. The given gradient is even steeper than the normal atmospheric lapse rate. To estimate the average Leclanché Cave temperature from surface climatic data can be possibly more precise.

Introduction, page 423: It is not clear whether a vegetation cover is present on the slightly inclined surface of the Lapi di Bou above the cave. Without any vegetation cover, CO₂ content in the soil and thus the bicarbonate content of the infiltrating water would be low. In the next section Methods on page 424, water samples are mentioned to have been collected from active drips in the cave. Is the chemistry of these waters known?

In Methods: Information on the separation method of sub-samples for stable isotope profiling within the aggregate is missing.

In Discussion, page 427: Opinion of the reviewer is that the formation of CCCcoarse was related to more intensive, short-term water inflows, being able to form cave pools.

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As indicated by the paper of Scholz et al. (2009), the isotopic equilibration between carbonate and water is slow at a low temperature. The fact that the carbonate data follow a decreasing d¹⁸O of the residual, unfrozen water indicates that the freezing was very slow, probably lasting several days, at least. Otherwise, fingerprinting of the changing water d¹⁸O in the formed carbonate would be lost because of carbonate-water disequilibrium. Later in the discussion, a speculation is given about the water volume of the pool, which cannot be checked by the reader if the chemistry of the freezing water is not given. In addition, it is not mentioned which of the carbonate-water equations was used for the calculation of water in isotopic equilibrium with the first carbonate formed. At this place mixed d¹⁸O data are given against VPDB and VSMOW standards. Since both standards are used throughout the paper, please specify which standards were used in each case. Alternatively, you can state that all carbonate data are given relative to VPDB and all water data relative to VSMOW.

In the discussion, page 428, line 28: The discussion that the general range of d¹³C values of CCCcoarse is somehow related to the cavity size and its ventilation regime is contained already in Žák et al. (2004).

Technical corrections

In the description of the study site, page 422: Referring to a particular cave, the word "cave" should be given with capital C, Leclanché Cave.

References used in the paper and missing in the reference list: Jaffey et al. (1971, cited in footnote of Table 1), Killawee et al. (1999), Mangini et al. (2005), Schürch et al. (2003), Zak et al. (2009).

References from the review not contained in the paper:

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