

## ***Interactive comment on “Ice genesis and its long-term dynamics in Scărișoara Ice Cave, Romania” by A. Perșoiu and A. Pazdur***

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### OVERVIEW

The manuscript discusses the genesis, fluctuations, ice flow and age of the cave ice deposit in one of the best documented and investigated ice caves in the world. It provides a well documented and clearly written account of surface accumulation, surface and basal melt, and ice flow, this last topic being a virtually blank area in the available literature on cave ice. Deformation and flow of ice in caves, while not the central topic of this manuscript, is discussed here based on all the available field evidences, including early observations from otherwise difficult to access literature. With its clarity, completeness and focus on processes (to the extent allowed by the current understanding of cave ice science), this manuscript will be a remarkable contribution to the field of

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cave ice research, which is still very much in its infancy.

### GENERAL COMMENTS

The abstract, introduction, descriptions of the site and of the methods are well written and complete. Overall, the discussions on the mechanisms of ice formation and what is called “ice dynamics” are adequately supported by the results and evidences provided, but they rely to a significant extent on a manuscript by Persoiu and others that was still in review. Has that manuscript been accepted in the meantime? A couple of points in section 4 need to be supported by additional data that seem to be available to the authors but are missing from the relevant figures:

1) the stable isotopes fractionation trends observed in present day ice layers are said to be similar to those found for deeper ice layer dated to the LIA and MWP (p. 1916, l. 26-29): please add the data points for these  $\delta\text{O}$  and  $\delta\text{D}$  trends in fig. 3. This is a very nice finding indeed, probably the first time that such a similarity between the isotope signature of observed present-day process and of older ice layers from the same cave ice deposit is published! 2) multi-annual trends in the mass balance of the ice deposit over the last 60 years are said to follow the pattern of wet/dry cold/warm years of the surface climate (p. 1918, l. 15-18): please add the temperature and precipitation time series in Fig. 2.

Before the “conclusions” section, I miss some more detailed discussion about the possible occurrence and significance of stratigraphic gaps, which can be expected to occur in cave ice deposits forming according to the proposed model, about how to detect them, and about how these may affect the estimated long term accumulation rates and age of this ice deposit. Compounded with the chance of radiocarbon-dating reworked organic matter older than the ice hosting it, stratigraphic gaps may prove a major obstacle in extracting useful/readable paleoclimate information from this ice. The manuscript only briefly touches the issue by noting that two thick dark layers rich in organic and mineral content likely represent strong melt events affecting several layers (p. 1919 l. 3-

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8). As it stands now, part of the “conclusions” section is actually a summary, and needs to be improved, especially to the benefit of the wider cryospheric science community. In addition to putting the findings into perspective with regard to the issue of stratigraphic gaps, the age estimate is introduced without adequate discussion, especially considering the described ice deformation and the poorly known bottom morphology of the ice block, and it reads a bit like an afterthought, not even being mentioned in the abstract. Finally, a note on terminology: within the glaciological community “ice dynamics” normally refers to ice flow, but it is used here mostly as meaning “mass balance fluctuations”. Please replace “ice dynamics” with this or a similar suitable expression throughout the text (specifying surface/bottom/. . . where relevant). This is especially important since ice flow in the cave is also addressed in a section of the manuscript.

#### DETAILED COMMENTS

Title: see my remarks about the proper use of the term “dynamics”

p. 1911 l. 4-7: Sentence not very clear, especially for the wider cryosphere audience outside the small cave ice people

l. 20: please also cite the original Romanian names of Biserica, Reservatia Mare, . . . as this will assist the reader in understanding the wealth of older literature only available in Romanian.

p. 1913 l. 12: “ice dynamics” here and everywhere else in the manuscript: fix inappropriate use of “ice dynamics”

l. 16: “T<-15 C”: is -15 correct?

l. 23: is this really due to “geothermal heat” or also/mainly the heat capacity of the rockmass?

p. 1914 l. 1-2: move sentence to the end of the “introduction” section

p. 1915 l. 7: “upper part”: what thickness?

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l. 12: “the preferential. . . isotopes” -> “isotopic fractionation”

l. 19-20: weight compaction is not the only process to go from snow to ice. Melt, percolation and refreezing may also occur.

l. 23: what matters for the percolating water to refreeze or not is the snow temperature, not the air temperature

l. 25: “impenetrable fissures” are only impenetrable in the caver’s perspective. Here they are effectively open, as they do drain the meltwater.

p. 1916, l. 3: “Persoiu 2010” is listed as “in review”. Has it been accepted?

l. 6: “freeze from to bottom” add “surface”

l. 9: “over-cooled”? “colder” is better.

l. 8: “winter, when warmer” -> “winter, when occasional warmer”

l. 22-26: I think these are the same fractionation trend and interpretation first described for cave lake ice in Citterio M., Turri S., Bini A. & Maggi V. (2004) – Observed trends in the chemical composition,  $\delta^{18}\text{O}$  and crystal sizes vs. depth in the first ice core from the “LoLc 1650 Abisso sul Margine dell’Alto Bregai” ice cave (Lecco, Italy). Theoretical and Applied Karstology (Special Issue on Ice Caves) n. 17, 45-50. Consider adding this reference.

l. 26-28: as already commented above, this is very interesting, please overlay the relevant data on Fig. 3.

p. 1917 “Ice dynamics” -> “mass balance”

l. 9: “trends” -> “fluctuation” ?

l. 14-17: Please add climate data to the plot as commented above.

l. 19: Where is Pojarul Politei with respect to the Scarisoara? Also show on the cave survey where the collapsed connection was in Fig. 4.

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l. 21 “overcooling”?

l. 23 “descending cave” has been used as synonymous for “cold trap” by cave topoclimatologists for caves with only one entrance and developing toward lower elevations. Here there is talk of caves with more than one entrance

p. 1918 l. 20: please provide a reference for the regional timing of the LIA

l. 21 fix “bellow”

p. 1919 l. 3: does any melt take place at the lateral ice/rock contact?

p. 1920 l. 5: fix “side of the it”, next line: “bellow” l. 18: take out “hereafter” and improve the “conclusion” section where it sounds mostly as a summary

l. 23- p. 1921 l. 2: this is quite speculative and not fully developed. Either argument it better if there is enough supporting evidence/data or take it out. Also, I can’t see how the basal melt could be stronger at the periphery than at the center of the ice block, thus helping preserving older ice there, if the mechanism producing subfreezing temperature is the air circulation described above and the rock mass is not in permafrost conditions (and from all evidences it is not, or else you would not have basal melting). This couple of sentences read much like an afterthought and they are not fundamental for the manuscript (no mention of this supposed 5000 years age in the abstract).

l. 5: Johnston & al. 2010 is not found in the references list.

Table 1: could you turn this table into a plot? Also, the line wrapping of the two rightmost columns is clearly screwed up.

Fig. 1: add Romanian names and position of collapsed junction to Pjarul Politei Fig. 2: add temperature and precipitation data Fig. 3: add isotopes data for the deeper levels showing the same fractionation trends Fig. 4: explain + and – symbols and the arrows in the caption and possibly the junction toward Pojarul Politei

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Interactive comment on The Cryosphere Discuss., 4, 1909, 2010.

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