Author's response to review comments posted for manuscript egusphere-2024-751

Date 22.07.2024

Dear reviewers and dear editor,

we highly appreciate you both having taken time to review our manuscript and sent us valuable comments. We have tried to incorporate all your suggestions into the manuscript. Below we have compiled our point-by-point replies to all your comments in one document.

Comments of anonymous referee #2 (01.07.2024):

Reviewer comment:
My main suggestion for this paper to be published in The Cryosphere would be more context. Although this is a brief communication, as this is not a journal where many readers are going to have knowledge of speleotherms, why this work matters needs to be made much more explicit. This is especially the case given the previous work it builds on had already ruled out ice flow as a mechanism, why did this justify looking at this in more detail, and still getting a result that the process here is likely to lead to fracture? Why is mechanical damage to stalagmites important?

Authors response:
Thank you for suggesting to put this study into a wider context. We have rewritten and expanded the introduction, providing more background and giving more detail as to why our research matters. Also we have added text that argues for this specific study, namely the combined study (fluid-structure-interaction) of stress created by the flow of ice and potential stress damage caused within the stalagmites in one computer simulation. The previous study only modelled wall shear stress at the stalagmite-ice interface and did not account for stress concentration within the stalagmite, which, as shown in this paper, can cause failure in extreme cases.

Reviewer comment:
Line 20: How do these relate to stalagmite sizes in previously glaciated regions? Are these typical sizes, and are the new smaller sizes included here also typical?

Authors response:
The stalagmite dimensions are typical for stalagmites found in caves. So we chose those dimensions to create simulations comparable to real stalagmites.

Reviewer comment:
Line 23: Do you use a sliding law here? If so please specify and cite.

Authors response:
No we do not use any sliding laws as we want to study the two end member cases described in the manuscript (frictionless full sliding vs. no-slip). We have added a sentence to make this clear to the reader.

Reviewer comment:
Line 30: Did you do any sensitivity testing on any of the parameters? E.g. recent studies have shown that the assumption n=3 in Glen's flow law does not always hold (for example see Millstein et al. (2022) https://www.nature.com/articles/s43247-022-00385-x)

Authors response:
No we did not study the sensitivity of Glen's n on our results, however we are are aware of the literature discussion. Thank you for raising that point. The study you mention is carried out on Antarctic ice shelves. Also Cuffey & Paterson (2010) discuss at length the uncertainties of the Glen ice flow parameters. We simulate ice with 1 and 2 m thickness, so we are far away from the shear magnitudes of Antarctica and even thick alpine-style glaciers. Thus we think our assumption of n=3 is okay. Nevertheless we tested for A being either for temperate ice or at -5 deg C. The differences between the results were less than one-tenth of a percent, thus we ignored these variations and assume A for temperate ice in the study. We have stated this in #54.

Reviewer comment:
Line 32: Citation needed for this choice of linear elastic.

Authors response:
We added text and two citations for this choice.

Reviewer comment:
Line 47: Rather than listing simulation numbers which mean little to the reader this paragraph could highlight better the conditions of the simulation that do find failure.

Authors response:
Thank you for this comment. You are right, only listing simulation numbers would not make sense. However in the next sentence in the manuscript we actually discuss the conditions for all those run's. Thus we think the manuscript is good as it is.

Reviewer comment:
Line 66: Is this realistic given in some simulations you're assuming a full-slip condition at the bed, will ice be fully frozen to the stalagmite? You later go on to say full-slip conditions are highly unlikely but if they are worth considering here then why not also for the stalagmite?

Authors response:
You are right, in reality there might be partial slip on the stalagmite wall, especially if there is basal sliding within the cave. However looking at the stalagmites in Fig. 1, you will see that their walls exhibit quite some geometrical features and thus sliding along the stalagmite walls is rather unlikely. In addition, the direct stress coupling between the ice body and the stalagmite wall is also a model assumption.

Reviewer comment:
Line 70: Please add more detail on why these values are an overestimation.

Authors response:
We have added text in the manuscript that describes the situation in detail. As such high stresses would form within the ice downstream of the stalagmite, the ice itself would fail and form cracks. Such cracks would reduce the ability to transfer "pull" of the ice to the stalagmite. As our simulations do not account for crack formation, we transfer the full stress to the stalagmite, resulting in an overestimation of the stress formed within the stalagmite.

Reviewer comment:
Line 94: Could a combination of these processes be occurring?

Authors response:
A combination of both processes is theoretically possible. However the highly-varying cave geometries (roughness and steepness of cave floor, cave geometry around stalagmite) found in reality require a detailed case-by-case study to identify the actual failure mechanisms. In this contribution we merely describe the principle mechanisms possible and what circumstances would favor which process.

We would like to express our gratitude for all the valuable comments.

Kind regards,
Alexander Jarosch on behalf of the authors