Authors' Responses to Reviews

The separate responds to comments of both reviewers were uploaded to the Interactive discussion.

https://hess.copernicus.org/preprints/hess-2020-473/hess-2020-473-AC1-supplement.pdf

https://hess.copernicus.org/preprints/hess-2020-473/hess-2020-473-AC2-supplement.pdf

Here, we combine the responses, and point to corresponding changes in the manuscript. We have also considered the editor's remarks.

We have uploaded a version with tracked changes and a clean version of the manuscript. The new references are marked red in the version with tracked changes.

General comments:

The main objective of both reviewers is that we generalize our special case of Carbonic Acid Speleogenesis. We must stress that we are aware of the other modelling efforts on the hypogene speleogenesis. Given the two quoted conceptual frameworks (hydrological and geochemical), speleogenetic settings are extremely diverse. All aspects are therefore beyond the scope of our work; however we agree that a better description of how our settings fit within the framework of the conceptual models, is needed. The changes in the Introduction and Discussion were made to consider these comments.

Terminology issue:

We have also changed the term hypogene to hypogenic in the entire the manuscript. This was suggested by a native speaker that we discussed with (A.N. Palmer) who suggest to use *"hypogenic" or "hypogenetic", because "gene" is a physical object, while "--genic" or "genetic" refers to origin.*

Changes in the manuscript:

Title

In the title, we have deleted the word *first,* so that it reads "Early hypogenic Carbonic Acid Speleogenesis in unconfined limestone aquifers by upwelling deep-seated waters with high CO_2 concentration: A modelling approach"

Abstract

We have considered the comments (1&2) by Steffen Birk (SB) regarding the abstract. We have replaced the first sentence of the abstract "*Hypogene caves originate from upwelling deep-seated waters loaded with CO_2 that mix with meteoric waters in a limestone aquifer.*" by "Here *we present first results on digital modelling of a specific setting of hypogenic Carbonic Acid Speleogenesis (CAS).*" We have also changed the last sentence to "*These findings give important insight into mechanisms of carbonic acid* speleogenesis *(CAS) in a special setting of unconfined aquifers. They also have implications to the understanding of corresponding sulphuric acid speleogenesis (SAS)."*

This clarifies that our paper considers a specific type of hypogenic setting and speleogenesis. However, the mechanisms discovered by our model may be applied to other hypogenic settings. These changes also consider general comments given by Alexander Klimchouk (AK).

Introduction

We have considered the comments 3-5 by SB and comments 1&2 by AK as pointed out in our replies to the reviews. To this extend the Introduction has been largely rewritten. We have placed our scenario within general framework of hypogenic speleogenesis and models of s as proposed by Palmer and Klimchouk, and alsoporosity evolution in mixing zones. The introduction to the geochemical concept has been extended. We furthermore mention and discuss other models of hypogene settings and stress the setting that our model applies to. We refer to earlier modelling efforts that explore this concept in terms of "thermal hypgene speleogenesis" and cross-formational upwelling flow. We have clarified that our work presents a specific hypothetic setting of an unconfined aquifer for both SAS and CAS. We have also pointed out natural settings that our model applies to. An example of Black Hills is also referred in description of the modelling domain. We mention that evolution of porosity in mixing zones has attracted a wider interest in different contexts.

The model

We have changed few details in Figure 3 for better clarity.

Discussion

To consider the further comments of both reviewers, we have made a deep revision of discussion, which is in mostly rewritten. We again stress the relevant natural settings and discuss the relation to SAS settings. We also point out the limitations of the model and the reasons to keep the settings simple. We compare and discuss this settings to the one presented in 2010 paper (Gabrovšek & Dreybrodt, 2010). To this extend we present and discuss a case when upwelling flow mixes with regional flow under confined settings, which is a response to Comment 6 by Steffen Birk and Comments 3a and 3b by Alexander Klimchouk.

To add some complexity (Comments 3a and 3b by AK) we have added the scenario with embedded prominent fractures.

Final remarks

We again thank both reviewers and the editor dr. Neuweiler for all their work and valuable suggestions. We are aware that the model somehow applies for specific settings. However, the outlined mechanisms are surely present in much broader spectrum of realistic settings. We are also aware of the other modelling efforts that demonstrate other mechanisms in hypogenic settings and in mixing zones.

We believe that this manuscript to some extend fills the gap between detailed theoretical studies of processes in the mixing zones and intuitive understanding of speleogenesis.

Although we are aware that some concerns of the reviewers may remain, we hope that the changes and our reasoning fulfill their expectations.

Yours Sincerely,
Franci Gabrovšek & Wolfgang Dreybrodt