Dear Reviewer, we are very grateful for the careful revision of our manuscript and for making our study more complete. We benefited greatly from your feedback and, after careful revision and implementation of your comments and critiques, we are coming back with the manuscript revision and detailed replies to your comments. Please let us know in case of any questions or concerns regarding the new version of the manuscript or the replies below. Our replies are in red and your comments are in black.

I would like to emphasize that the boundary conditions and physical properties of the numerical models need to be more thoroughly explained, and the consequences for the results presented more thoroughly discussed.

We now discuss the boundary conditions in greater detail (Section 5.4) as well as show them directly on the model in Figure 8. We have changed the structure of the manuscript, where numerical modelling is now only rather small part of the discussion. We shift the main focus of the study to the probabilistic analysis of fault reactivation as well as to the analysis of the mapped faults in the greater Ruhr region within the slip tendency vs. dilation tendency parameter space.

'Ln 1 : The initial sentence should be tempered. The success of deep geothermal systems significantly relies on the integration of various geological and physical processes, which could be defined in numerical modelling by a complete THMC coupling (Chester and Logan 1986; Byerlee, 1994; Barton et al., 1995; Scholz, 2002; Violay et al., 2017, ...). Furthermore, many other parameters such as cost drilling and feed in tariffs supporting the development of geothermal energy must be taken into account to evaluate the feasibility and viability of the project.'

We agree with the reviewer. We delete this sentence from the manuscript altogether and make appropriate changes to the manuscript (see Introduction).

'Ln 2 : The terms "fault" and "fault zone" are used successively between the first and second sentences. It might be clearer for the reader to use a single term, which could be defined in the introduction.'

We accept the suggestion and use 'fault' throughout the manuscript. We now explain what we consider a 'fault' in the introduction part of the manuscript (L20-21).

'Ln 18 : I would suggest adding references here. It might also be interesting for the reader to see, at this point, the definition of "fault" that as used throughout the remainder of the study.'

We accept the comment. Reference is added and the definition of a 'fault' applicable for the manuscript is included (L20-21).

'Ln 21 : Might use a less global term than "Anthropogenic", perhaps geothermal activities? This would require a revision of the sentence structure.'

We amend the sentence as suggested by the reviewer (L23)

'Ln 24 : I suggest revising the sentence structure, perhaps changing "On the other hand" to "Moreover"?'

We amend the sentence as suggested by the reviewer (L25)

'Ln 26 : May I suggest some recent studies on this topic : Guillou-Frottier et al., 2013, Moeck, 2014, Duwiquet et al., 2019.'

References are added (L27-28).

'Ln 55 & 60 : Though comprehensive and clear thus far, your introduction might benefit from incorporating a review of the current state of the art concerning the application of these two geomechanical criteria (Ts, Td) in analogous contexts. Consider referencing studies like Moeck et al. (2009), among potentially others. The same consideration applies to THM numerical modeling. Providing a logical justification for their utilization, accompanied by a review of prior studies on this subject, would enhance the overall contextual understanding. I have in mind Armandine Les Landes et al., 2019, and/or Duwiquet et al., 2021, but undoubtedly, there are other relevant studies as well.'

We agree with the reviewer and add missing references both to the Ts, Td analysis and for the numerical modelling part (L56-71).

'Subsection 3.2: Here, you are directed towards the use of commercial software. At this stage, it might be prudent to conduct calibration tests for the employed THM coupling in comparison to the open-source codes that have been used and published.

We believe that the comparison of our numerical model developed using commercial software such as COMSOL software with other open source codes goes beyond the scope of this paper. The use of COMSOL software is a common practice in science seen already in many peer-reviewed publications e.g., *Taillefer et al., 2018* or *Kruszewski et al., 2023*. The main scope of our paper is not to investigate different finite element implementations in commercial software and open source codes. This should be done in the course of a benchmark study that uses a defined model set up for which maybe even an analytical solution exists. Our focus is to investigate the reactivation potential of faults based on probabilistic approaches using an example of the greater Ruhr region. We, anyway, publish numerical model, including all necessary information about input parameters, boundary conditions, discretization etc., with the manuscript to allow reproducibility of the results presented in our study. These can be checked by the readers of our study (as well as reviewers) in terms of their comparability with any other open source codes.

It would be advisable to directly specify the boundary conditions of the employed numerical models on Figure 3. The clarity of the figure would be enhanced by clearly displaying the dimensions of the considered system. (…)

The dimensions of the model geometry and fault geometry as well as boundary conditions are now presented in Figure 8. The details on the boundary conditions are also described in detail in section 5.4 of the manuscript (L299-307). Dimensions of the model are mentioned in the caption of Figure 8 and can be also directly deducted based on the axes in Figure 8.

(…) In the figure description, you provide information about the number of cells used, but the cell sizes vary between the fault and other lithologies. What are the minimum and maximum sizes, and how were these sizes chosen? (…)

We have now refined our numerical resolution in the presented model. The mesh size, therefore, changed from the initial model published with this manuscript. The updated model has now 1,276,857 (tetrahedral) mesh elements and 214,326 mesh vertices with average element quality of 0.66. The updated model will be made available with the revised version of the manuscript. Following minimum and maximum cell size were, therefore, selected for discretization in the updated model:

Underburden: minimum element size of 42 m and maximum of 2360 m;

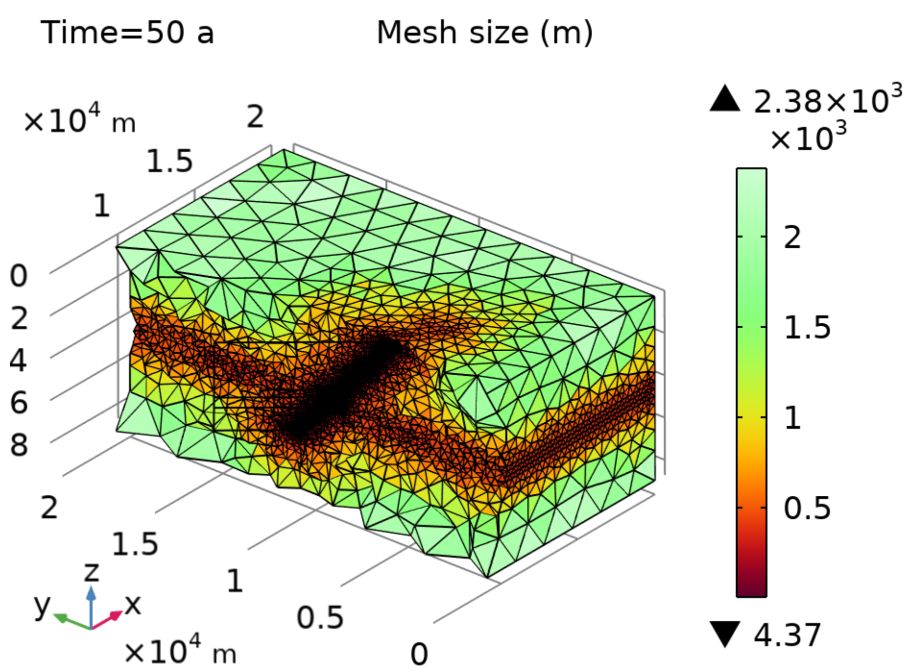
Overburden: minimum element size of 37 m and maximum of 2380 m;

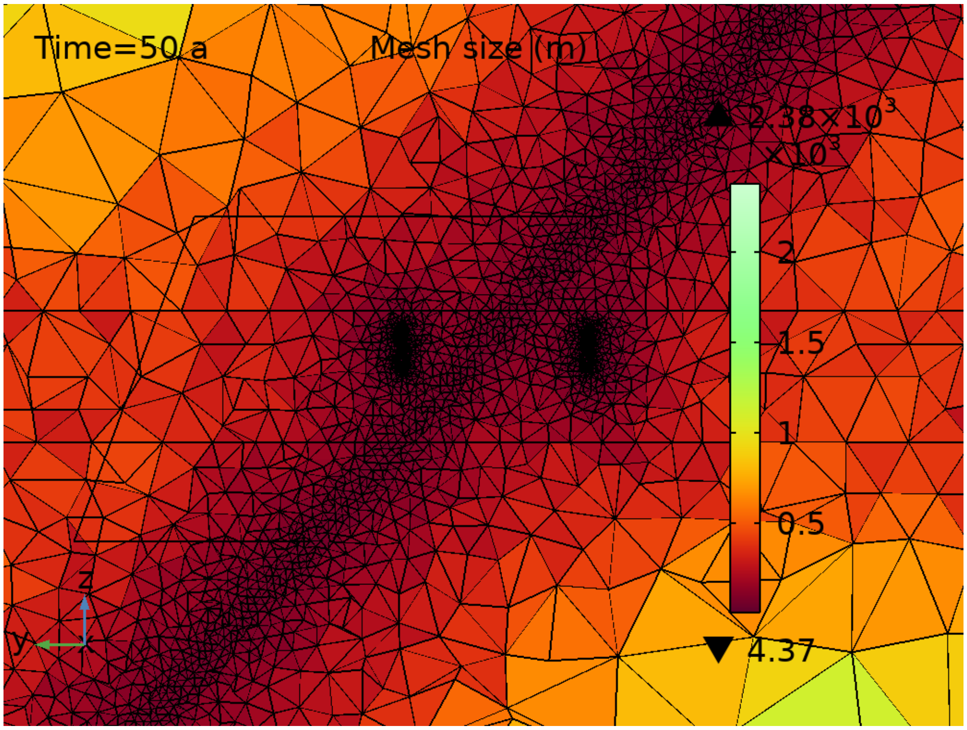
Reservoir: minimum element size of 4.4 m and maximum of 555 m;

Fault: minimum element size of 33 m and maximum of 66 m (we use finer mesh on the fault that is represented in the model as a plane);

Boreholes: maximum element size was limited to 5 m (we use finer mesh around the boreholes that are represented in the model as line/edge elements).

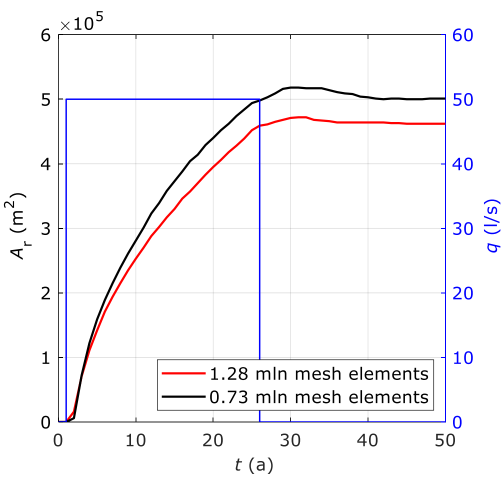
Below we include two snapshots showing the mesh size for the whole model (only volumes visible) with the maximum and minimum element sizes as well as a close-up of the mesh size around the two boreholes and the fault. The selection of mesh size was based i) on the type of physics (i.e., solid mechanics, fluid flow and heat transfer in porous media) used in the numerical model as well as ii) to achieve computational efficiency (i.e., having the same results but with shortest computational time).

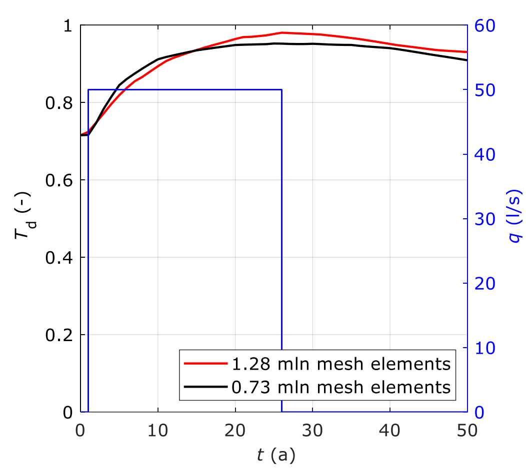




(…) Have convergence tests been conducted to ensure that the numerical results are no longer dependent on the cell size? (…)

Yes, we have carried out convergence tests on models three different mesh sizes. Below a snapshot comparing results of the cumulative reactivated fault area (Ar; on the left) as well as the maximum dilation tendency on the fault plane (on the right) computed with the model discretized into 0.73 $\cdot 10^6$ elements and one discretized in 1.28 $\cdot 10^6$elements. We skip the model with 0.3 $\cdot 10^6$ elements, where model results were deemed to be dependent on mesh size. The results we deemed to be satisfactory and we use the model discretized in 1.28 $\cdot 10^6$ elements for our discussion in the manuscript.





(…) Additionally, how are the meshes considered in the modeled wells? Is it a radial mesh? What impact does this have on the final result ?'

There is an ever-present difficulty in modelling small scale elements like boreholes with a diameter of tens of centimeters embedded in reservoir models spanning tens of kilometers. For computation efficiency, we decided to use 1D line/edge elements to model the two boreholes. We limit the maximum element size to 5 m; i.e., we make the mesh size in the reservoir and around boreholes finer.

'Ln 181 : It may be necessary to reconsider the dimensions of the fault (a width of 9 km?) and provide information on the fault thickness.'

The fault (along-dip) length and (along-strike) width were both based on geological information from the region, being it seismic lines (DEKORP 1990) and fault trace maps (GD 2014 and GD 2019). The mentioned fault width is actually the along-strike-width of the fault. Faults of such widths are common in the region, what can be seen in Figure 1 in the manuscript. Fault (hydraulic) thickness is mentioned and referenced in Table 2.

'Table 2 : The permeability of the fault (10^{-11} m²) is not referenced. Such a high permeability value could lead to fluid flow velocities that exceed the limits of the applicability of Darcy's law. It is essential to verify this by examining whether fluid flow velocities are consistent. For example, in comparison, other numerical models (but same software) impose fault permeability values close to 10^{-14} m² and find corresponding field data for this value (Roche et al., 2018; Taillefer et al., 2017). It seems important here to provide further explanation of your approach. Additionally, the imposed permeability value for the reservoir also lacks a reference.'

We agree with the reviewer and carry out numerical simulations for fault permeability of 10-14 m² in and use this permeability as our fault permeability in the updated numerical model. We have tested our approaches with both permeability values and have seen rather negligible change for slip tendency or dilation tendency. This have been also discussed in more detailed in *Kruszewski et al. (2023).* We also add reference to fault permeability of 10-14 m² in Table 2. We add a reference for reservoir permeability to Table 2 that is based on the lower limit for successful exploitation of hydrothermal reservoirs in Bavaria (*Fritzer et al. 2012*) and indication of reservoir permeability from the Californie geothermal field in the western Netherlands in the Lower Rhine Graben (based on the technical reports of the *SCAN* project; *https://www.nlog.nl/en/scan*).

'Ln 200 : You fixed a temperature at the bottom of the model. In order to limit boundary conditions at the model's base, wouldn't it be preferable to use a heat flux instead? These aspects could be either modified or discussed in the relevant section.'

We set the following values of temperature at the top and bottom sides of the model to merely recreate a temperature gradient across the numerical model based on the geothermal gradient of the region of 35 °C/km (reference included in the manuscript). The initial temperature field in the model represents, therefore, the geothermal gradient of the region. We find this assumption to be the most suitable solution for sedimentary regions like the Ruhr region where no thermal anomalies are expected. Our model does not intent to model groundwater movement, and connected temperature changes due to faulting, in and around the reservoir. As a result, we do not see the necessity for using the heat flux as boundary conditions and are convinced that the approach we used is sufficient for investigating the normal and shear stresses and resultant slip and dilation tendencies on faults. We amend the manuscript text to include abovementioned points (L305-306).