General comments

The manuscript deals with the impact of petrophysical properties, background hydraulic gradient, fractures and fault zones on the performance/lifetime of a deep geothermal reservoir. Thereby, a systematic numerical modelling approach has been applied. The manuscript is well written. The English writing does not need any improvement, except for some very rare typos. Figures are of excellent quality. The topic is also of interest to both the deep geothermal and wider geoscientific community (e.g. basin hydraulics) and publication is recommended. However, the manuscript would benefit from some minor revisions related to the structure and in particular some technical points:

- Manuscript structure: For any generic numerical study, appropriate input parameters and real-world analogs are important. I would therefore recommend to merge the first part of the "Discussion" (lines 312-327) with the "Introduction" and to move or even repeat some parts in the "Methods" section, in particular the "Scenarios" section. The reader of the manuscript would greatly benefit from a direct real world example for the chosen permeabilities, porosities and in particular background hydraulic gradients (BHG) right in the "Methods" section. Especially, the various BHGs require some geological scenarios (what can cause a directed BHG? Topography, overpressure, ...?). Also, the authors might consider merging the entire discussion with the results section for better readability.
- Convection: Convection is not considered in the numerical modelling to save computational cost. As the authors state correctly, convection is likely to be neglected in sediment layers. However, in fault zone-controlled reservoirs, convection is known to have a big impact on the initial temperature field (e.g. Soultz-sous-Forets). Please at least discuss the possible impact of convection on this study's results related to fault zones or consider running a few models that account for convective flow to highlight the impact.
- Bottomhole pressure (BHP) and flow rate: The authors work with a fixed flow rate, which for the low and medium permeability scenarios results in impossible bottomhole pressures well above the lithostatic stress. Nevertheless, this is only mentioned briefly at the end of the manuscript. Here the authors also state that in these cases "*the BHG is outperformed by the artificial flow field caused by the very high bottomhole pressure*". This has to be mentioned directly in the "Methods" section. The actual value of the low and medium permeability models has to be questioned. The BHG appears to be one of the main drivers, but it is completely overruled by the impossible BHPs in the low and possibly also medium perm-scenarios. In that way, only the low and medium perm model without BHG (0 mm/m) might have some value since the shape of the HDI should not be impacted in that scenario (or is it?). In addition, wouldn't the induced BHPs also impact the flow velocity in the reservoir and therefore also thermal breakthrough (I am not certain here, but at least mention and discuss)? As a consequence, I would recommend to exclude all other low and medium perm scenarios with a BHG > 0 mm/m. Otherwise please discuss accordingly and inform the reader in the "Methods" section about a) the unrealistic BHPs, b) their impact and c) why the models might still have some value. Alternatively, the models could be rerun for different flow rates (e.g. with a fixed draw-down pressure, which is a much better technical parameter to be controlled and more or less independent of the geology/petrophysics).

Please see detailed line-by-line comments below:

Abstract

Well written, please consider to avoid usage of acronyms (BHG and HDI)

Introduction

Line 33: Maybe better say hydrothermal than deep geothermal (petrothermal/HDR is also deep geothermal, but only produces from fractures)

Methods

Very minor, but almost all sentences start with “We…”

Numerical model:

This section is very well written and nicely explains the governing equations!

Geometry of the model:

The horizontal extent of the model seems to be rather small (only 4 km), while the vertical extent is very high (2.3 km). It is not clear if this extent only represents the reservoir or also overburden and footwall sediments. Please specify.

Line 91: The rescaling of the well diameter and “length” is confusing. Please explain in more detail, how and why the rescaling has been done and what is meant by “length” and “active part” (perforated production zone?).

Temperature:

Line 97: The gradient’s unit is wrong (should be 0.047 degC/m not per km). Also, please briefly explain why the respective gradient and surface temperature have been chosen. Especially, since the gradient is very high and the surface temperature is very low.

Line 105: This explanation of the model size should be move to the geometry section (2.2). The explanation itself is not really convincing: the model probably could have been extended to 10x10 km without significantly more cells, since no high resolution is required at the boundaries and far away from the wells. Please at least mention/discuss possible effects here and in the discussion section.

Fluid flow:

Please explain the setups of the various background hydraulic gradients here or later (see next comment). Also please explain how the variation is implemented. Figure 1b is not doing a good job explaining the variation. Is the BHG varying from the center towards a certain direction? Or from one “edge” of the model domain to the opposite one? Is the BHG a differential gradient in the reservoir or the entire cube? Since this seems to be such an important parameter, please try to be as precise as possible. Also, please provide some geological scenarios that justify the chosen variations in hydraulic gradient.

Scenarios:

Line 127: At 2-3 km burial depth, a matrix permeability of 10-11 m2 (10 Darcy) seems a bit high and probably impossible, when combined with 3% or 14% porosity. Please discuss or at least think about removing the high-perm-low-poro scenarios (or give an adequate geological scenario). In general, please consider giving some real world analogs/examples for the chosen poro-perm scenarios. The sandstone reservoir literature should be full of good examples.

Line 145-146: It would be nice to have some real-world justification for the chosen fault permeabilities. There is a lot of literature available.

Lines 149/150: Please provide some geological scenarios that justify the chosen variations in hydraulic gradient.

Results

Line 165/166: According to figures 2e & 2f, this is only true if the BHG is applied in the direction of the injection well (fig. 2f).

Line 180: This makes sense, but how realistic is it to have a rock/sediment with a permeability of 10^{-11} m² and a porosity of only 5% or 14%?

Line 236: Why is the stabilization at 100°C?

Line 237: Wouldn't you expect a significant effect of convective flow in a vertical fracture?

Line 253-254: Please rephrase or put more detail. What do you mean by: "a closed geothermal loop may not be feasible"?

Line 258: Not sure what we can really learn from this part, since many real-world projects have shown the significant impact of convection on the temperature field of fault-controlled reservoirs (e.g. Soultz-sous-Forets).

Line 258f: What is the permeability of the matrix (host rock)?

Line 291: "…BHG, ~~does~~ the temperature stays…"

Discussion

Line 313-328: Maybe this part would be much better placed in the introduction and in some parts in the "Scenarios"-part (see previous comments on mentioning analogs etc).

Line 335: How does the bottomhole pressure impact the influence of the BHG? In particular in the low-permeability case? Please mention earlier (e.g. in the Methods or Scenarios section(s)).

Line 335f: Here is the answer of the last comment: "the BHG is outperformed by the artificial flow field caused by the very high bottomhole pressure". Actually, the bottomhole pressures in the medium and low permeability cases are impossible in nature. The question is then, what is the meaning of the modelling results? An elegant way to avoid this problem would be to work with a constant draw-down instead.

Line 361: Please consider providing some geological scenarios for variations in BHG.

Line 379f: "Notably, in the low and intermediate permeable models, where permeability contrasts are higher than 1 order of magnitude, none of the tested BHG configurations could compensate for the small volume". Or is this again related to the unnaturally high BHPs in the low and medium permeability scenarios? Please discuss.

Line 387: instead of "borecore": core from boreholes