

The manuscript titled “Influence of reservoir geology on seismic response during decimeter scale hydraulic stimulation in crystalline rock” by Villiger and others is a dense description of a series of injection experiments performed at the Grimsel Test Site, Switzerland. The experiment was well-constructed and the seismic analysis is very complete. While I find the science aspects of this paper intriguing, the organization and in some some cases level of detail distracts from the main topic. The paper seems to be structured like a report more so than a journal article. A lot of detail is included whether it is relevant to the main goal or not. Along those lines, I am not sure that the outlook section describing the researchers next plans is appropriate here. Overall, I find this an important paper with interesting and possibly significant results. However, had I not been reviewing, I probably would have quit reading, because it was hard to keep the track of the goal and relevant information given the organization and distracting information.

The abstract is nice and conveys the main points and conclusions. The section on the Study Site is also nice with a good figure. There is also good information throughout the paper. However, I would suggest looking at the organization to more clearly convey the main points. Below I provide some specific comments for each section.

Introduction

This section is packed full of interesting and useful information of EGS, but at 7 pages seems like a lot to introduce the study at hand, and given the organization while the information is useful and interesting there is not a clear motivation between the introduction and what is to come. The title talks about geology, but this is not introduced until page 3.

Some specific comments:

Organization of paragraph starting Line 124 needs work: line 124 “seismicity rates might be linked to geologic setting”; line 127 “Seismicity may also be dependent on fault orientation”; and then line 131 returns to “seismic response . . . may also be linked to local geological setting”. Seems like should talk about local geologic setting generally and then go into details like fault orientation. As written now is jumpy and distracting.

Figure 1: what is Petrothermal? Should be defined somewhere, not a common term

Methods

This section describes the experimental design for injection and methods used in the catalog construction. Table 1 is a nice concise collection of both the experimental design and results from the seismic analysis. I would suggest a second table that breaks out the seismic information by cycle. You later describe cycles but there is not a clear place to assess this analysis.

The discussion of the AE sensors was really distracting. Strongly suggest moving this discussion to the supplement and just highlight the key points in a subsection “Integration of AE sensors”

Specific comments:

The pick errors seem very specific were they determined empirically? If not how did you decide on these values?

You spend a lot of time discussing pick weights and the velocity model, but when it comes to station corrections there is one sentence referring to another reference. Seems that there could be more here.

The discussion of magnitudes and notation is confusing:

The introduction of the three types of magnitudes paragraph starting line 418 is confusing. I recommend that you start with a direct sentence like “Here we calculate three magnitudes: . . .”

Line 513-514 discusses how you calculate the “adjusted amplitude magnitude” MA (as defined line 426), but in line 514 this is called the “amplitude magnitude”. Please be consistent.

The equation to get the adjusted magnitude is to subtract 4 from the relative magnitude calculation. This seems really large. In the comparison how large was the spread in magnitudes. It would be worth seeing a figure of the Mr Mw comparisons

Results

Specific Comments:

Line 536 says “During HF injections, significantly fewer detections compared to HS injections (Figure 4c,d)”. In Fig 4c, the cumulative number of seismic events is 2000 compared to Fig 4a with 500. Even Fig 4d has 600 which is more than 4a. True HF is less than what is shown in Fig 4b, but your statement is not supported by the figure. When I look at numbers in Table 1, I would still be pushed to use the word “significantly”. There actually seems to be a lot of variability in the total number of detections, which should perhaps be investigated or at least commented on.

Line 537: For HF “a comparably high percentage of detections (33%) were made during shut-in”. This is not evident in Figure 4.

Figure 5a would help to label which were S1 and which S3 injections

Instead of “fitted for” suggest “fit to” throughout text

Line 760, You introduce M0 displacement and M0 hydraulic and then immediately move to a discussion of seismic moment. It would be helpful to have a conceptual description of these parameters when you introduce the terms and how they differ before going into the details.

Line 801: is this really “a best guess”?

The section on Network Performance should come earlier in the discussion and be used to inform the discussion on b-value and the seismic cloud.

Line 868: Why is there a discussion of S-phases. You did not use them. You could simply add a sentence when showing the waveforms in Fig 3 that the S-phases were not of sufficient quality for picking

Discussion, conclusions, and outlook

Given all the information in the Results, I was looking for a concise summary that linked back to main the questions of the paper. This could be an introductory paragraph before diving into the details.

Line 880: you mention “permeability increase, pressure propagation and rock deformation”. These were not directly addressed in the paper

Line 925 what does “the first 100 l of fluid” mean?

Line 175: what does “first 200 l of injected volume” mean