Solid Earth Discussions

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Comment on se-2021-84

Anonymous Referee #2

Referee comment on "Seismic monitoring of the STIMTEC hydraulic stimulation experiment in anisotropic metamorphic gneiss" by Carolin Morag Boese et al., Solid Earth Discuss., https://doi.org/10.5194/se-2021-84-RC2, 2021

This manuscript details the framework for a dm-scale hydraulic fracturing experiment instrumented with ultrasonic monitoring, acoustic emission (AE) sensors, accelerometers and broadband sensors. The authors detail the role of heterogeneity on the active/passive seismic data, and specifically quantify the p-wave anisotropy in their system. They also demonstrate highly variable AE response to hydraulic stimulation, and attribute this to structural and stress heterogeneities in the rock mass.

Overall, the manuscript is well-written and clearly articulated. I do share some of the same concerns as reviewer #1, specifically that the manuscript could be refocused to tighten the discussions surrounding the relationship between the ultrasonic transmission (UT), AE locations and hydraulic stimulation. Beyond this, I make some minor scientific and technical suggestions below, mostly surrounding clarifications to the figures:

Scientific revisions/clarifications:

- Line 308-310: Is there a pre-amplification or band-pass stage to your AE data acquisition?
- Line 395-397: '…and more emergent, low-signal to noise ratio onsets,….' Does this refer to the s-waves here? Are the s-arrivals being weighted 50% less for relocations? Or do you mean there are two classes of p-waves, sharp and diffuse/emergent?
- Line 505-507: What do you mean by the 'best velocity model is tuned to the injection borehole'? This sounds like a sampling bias, because there are more samples here? If so, could you clarify this further?
- Lines 631-633: This statement confuses me a little, because in my experience, even aseismic slip has AEs associated with it during lab-scale AE monitoring, arising from grain-grain sliding/fracturing. This goes back to my comment 1 above whether the AEs you're monitoring are predominantly related to the co-seismic stage (likely no pre-amp, so requires more AE intensity and consequently picks fewer events).
- Line 718-719: It would be nice to see this correlation associated with pre-existing structures reflected in Figure 8 somehow, potentially by integrating the FMI scans into the figure?
- Lines 720-722: Perhaps I missed this, but how do you estimate velocity and amplitude

changes in the UT data? I assume it is some sort of cross-correlation technique, and if so, it would be useful to see the template, i.e., p, s-arrivals, and the amplitudes (peak-to-peak, rms, 0-to-peak or something else). What is the error in these measurements?

- All figures of the drftways (eg. 1, 3, 4a etc.) – Are these the same isometric projections? I see the cardinal directions annotated in a couple of them but not all, so it's not quite clear what the orientations of the various drftways, boreholes are. Also, the 5 m scale is not very clear.
- Figure 3 – I wonder if there's a better way to illustrate the ray-paths because it is not too useful for the lower (deeper?) boreholes since all you see is grey lines.
- Figure 4b – The injection and validation borehole annotations, as well as the pre/post stimulation annotations are unclear relative to the figure and I'm not sure what they refer to.
- Figure 5 could be more readable with a cross-sectional view in addition to the isometric view. Additionally, I also suggest exploring the possibility of scaling the AE dots by size and/or location uncertainty (depending on which one's more variable).
- Figure 7: I didn't catch the annotations in the figures until my final reading. I would suggest increasing the font size significantly and changing the star color on these.
- Figure 8: Similar to the vp drop, it seems like there's a recovery at ~45 m. Does this, then, correspond to a less heterogeneous, more competent formation?