Reply to comment on egusphere-2024-166, Referee #2 Nikita Bondarenko on earthquakes triggered by the subsurface undrained response to reservoir-impoundment at Irapé, EGU-Solid Earth, 2024

The article presents an analytical assessment of the undrained response impact on the state of stress change during reservoir impoundment and associated reservoir triggered seismicity. Authors present laboratory measured permeability and porosity to support the assumption of undrained response. The assessment is based on assumption of oedometer conditions and using analytical expression based on poroelastic relationships. However, a significant deficiency is that Equation 1 has only relation between horizontal stress and pore pressure. Even if the pore pressure is not changing (drained condition) the horizontal stress would change due to the change of vertical stress. This effect is expected to be the same order of magnitude or stronger than the effect of pore pressure change and therefore cannot be neglected. It is recommended that the calculations have to be updated or it should be explicitly shown that the term can be neglected (more details are available in specific comments in the attached file.

Author's response: *We extend our thanks to the reviewer for his careful consideration and positive assessment of the paper. We have addressed the reviewer's comments, which helped clarify some of our assumptions in order to improve the manuscript's quality. In particular, we have updated our calculations.*

Specific comments:

12: Either "Specifically" or "in particular"

Author's response: *We have deleted "in particular".*

22: Is the accuracy of porosimetry sufficient to report it to third decimal places?

Author's response: *According to the specifications of the apparatus, it is sufficient.*

69: The delayed response is dominant in case of the Koyna, however the local maximum of seismic activity is also observed during the maximum water level (http://dx.doi.org/10.1134/S1069351322030077). It might be worthy to mention that both mechanisms are present, but the dominant one is delayed.

Author's response: *We now mention both mechanisms in Table 1.*

122-123: It would be great to mention the depth of earthquakes here.

Author's response: *We now mention the depth of the largest earthquake in the main text and refer to Table S1 for the depth of the other earthquakes.*

127: The number of events cannot be negative, so it would be better to start the vertical axis from 0 and not -1.

Author's response: *We have corrected the vertical axis to start at 0 in Figure 2 in the revised manuscript.*

134: Since only three stations were utilized for the location, it seems to be impossible to determine 4 parameters of earthquake hypocenter (x,y,z,t) without certain assumptions. It would be great to mention if assumptions were made and what is average accuracy of location.

Author's response: *We thank the reviewer for this comment. The authors concur with the reviewer's perspective and have added some additional explanations in the revised manuscript. The positional uncertainty of seismic events is influenced by the quality and spatial distribution of seismometers in the region. At Irapé, the uncertainty is notably high due to operational challenges encountered by the local monitoring stations.*

184-186: It would be great to mention the lower instrumental limit for the permeability and the accuracy of measurements. It also seems to be inconsistent with the information in supplementary material, which says that 0.01 mD is the lower limit. In general, supplementary material contains important information but never referred in the main manuscript which make it difficult to find.

Author's response: *We thank the reviewer for this comment. The authors concur with the reviewer's perspective on the accuracy of the measurements. The lower instrumental limit for the permeability is 0.002 mD, as we now mention in the Supplementary Material (we had a typo in the previous version). We obtained data from most of the measured samples, which present permeability below the precision of the apparatus.*

192 MAJOR: The equation consider only relationship between change in horizontal stress and change in pore pressure. However, the change in vertical stress would also cause change in the horizontal stress, which is neglected. The equation should be:

$$\Delta\sigma_h = \frac{\nu}{1-\nu}\Delta\sigma_v + \alpha\frac{(1-2\nu)}{1-\nu}\Delta p$$

Author's response: *We thank the reviewer for this suggestion. The authors agree with this added term, as the increase of the vertical stress induces an increase in the horizontal stress. We have added this equation in the revised manuscript.*

197: What is the sign agreement here? If the pore pressure is positive and compressive stresses are also positive, it should be no minus sign.

Author's response: *We have corrected this typo.*

198: "mean stress change"

Author's response: *We have added this word.*

201: Equation seems to assume that there is no minus sign in Equation 2. MAJOR: The equation have to be modified due to the change in Equation 1. Or it should be explicitly shown why term proportional to change of vertical stress in neglected.

Author's response: *Yes, we assumed the sign criterion of geomechanics in Equation (2). We have updated Equation (3) to take into account the change in Equation (1).*

224: Is the porosimetry is accurate to report it to three decimal places? It is suggested that "<0.002" is reported instead of "0.002" for permeability.

Author's response: *We have modified Tables 3 and S2.*

226: Since the measurement are close to instrumental limit, it would be great to show this limit on the plot as well as the accuracy of calculated permeability

Author's response: *We have shown in revised manuscript.*

242: It is mentioned further in the text, but it would be great place to say that absence of fractures is assumed.

Author's response: *Thanks for the suggestion, we added this text in the revised manuscript.*

259-261: The permeability measured in the lab is usually 1-2 orders of magnitude lower than the in-situ one even without visible fractures. At least in the laboratory experiments, the presence of open fractures is capable of enhancing the permeability by 5 orders of magnitude (e.g., https://doi.org/10.1038/s41598-022- 19775-4 or https://doi.org/10.22541/essoar.171629597.77744897/v1). It is acceptable to assume that 5 orders of magnitude enhancement is unlikely, but slightly extended discussion would be worthy here.

Author's response: *We thank to reviewer for this insightful suggestions. We have extended this discussion in the revised manuscript.*

334-335: It is not fully clear what is meant by "carefully manipulating reservoir loading". If the change of impoundment rate is meant, it seems unlikely that the impact of undrained response will be different by the end of impoundment. If the limiting the maximum water level is meant, it is not fully clear what is suggested as a limit and rewording might be necessary.

Author's response: *We have re-written the last sentence of the Conclusions. We hope it is clearer now.*