Solid Earth Discuss.,
https://doi.org/10.5194/se-2020-203-AC2, 2021

Solid Earth Discussions

Interactive comment on "Unprecedented quiescence in resource development area allows detection of long-lived latent seismicity" *by* Rebecca O. Salvage and David W. Eaton

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Received and published: 12 February 2021

All line numbers refer to line numbers in the updated "clean" manuscript i.e. that without the track changes.

1 General Comments

Overall, this well-written paper establishes the presence of "latent" seismicity in an area where resource development had stopped due to restrictions put in

place to prevent the spread of COVID-19. This paper estimates that 70% of the earthquakes measured in the Kiskatinaw area, B.C., between April and August 2020, are due to aseismic slip from leftover fluids becoming trapped in the target formation, after the resource development in the area had been paused. The other 30% of seismicity is either background seismicity, which has been occurring before the resource development in the area, or directly triggered from a teleseismic earthquake.

The authors establish the background of the Kiskatinaw Seismic Monitoring and Mitigation Area (KSMMA), the resource development occurring in the area, and the past and current seismic monitoring taking place. The unique conditions established here involve an expanded seismic network, yet a stoppage of hydraulic fracturing operations due to a global pandemic and not a large seismic event or a depletion of the reservoir as is the case in other areas. The seismic network allows for the detection of small earthquakes, in a region that experiences relatively low natural seismicity.

In this paper it is shown that the most of the detected earthquakes in the area between April and August 2020 are: not the result of direct injection, as there are no spatial or temporal clusters around wells and no active wells during this period; not the result of natural seismicity, as the previously measured seismicity rates are too small to account for the number of events detected; and not triggered by large teleseimic earthquakes. This leads the authors to conclude that previous fluid injections in the area altered the state of stress in a hydraulically linked formation generating aseismic slip loading on unstable zones.

This paper does a good job of testing the possibilities of causes to seismicity

in an area after resource development has paused, where seismicity was uncommon beforehand. After testing the seismicity traits against those that are common from other causes of seismicity, it is determined in this area that the seismicity measured over this period can be labelled as "latent" seismicity. That is, the seismicity is caused by prior resource development in this region, but not directly related to active hydraulic fracturing or salt water disposal.

Thank you for this nice summary and positive comments.

2 Specific Comments

1. **In Section 3.3 the FI index is discussed as way to describe whether fluids play a direct role in seismicity (negative FI) or not (positive FI). I understand that there are no temporal variations of FI, but was a consistently negative FI or consistently positive FI found (Fig 5a)? And would that imply a direct role of fluids or not in the seismicity?**

   We have added a couple of sentences in the discussion where we suggest that the FI is not a commonly used measure in hydraulic fracturing seismicity (it was developed for volcanic environments) and therefore we base the fact that larger amounts of low frequency energy within the waveform is indicative of the role of fluid in its generation upon research in the volcanological community (L 223-230).

2. **Lines 190-193: How is the magnitude of completeness measured? Is it spatially distributed over the KSMMA boundary based on the station density or calculated as the point where the catalogue deviates from the calculated b-value (as shown in Figure 6)? I think there should be a reference to Figure 6 here.**

   You are quite correct that we were missing a reference to Fig. 6 at this point. It has now been added. We have also added a comment about how we compute

the magnitude of completeness (maximum curvature method) and the b-value (least-squares linear regression) for completeness (L 231-237).

3 Technical Comments

- **Line 10 "locate" should be "located"**

  This has been changed.

- **Line 78-79: "In fact, ground displacement remained between 20 and 30 nm at station R25AC for the entirety of 2019." Should this supposed to be the average ground displacement that remained between 20 and 30 nm?**

  This has been changed.

- **Line 99-101: This sentence needs a proper ending ie. "... previous seismicity (available directly from BCOGC), was used to determine the locations in NonLinLoc"**

  Another reviewer also mentioned this, so this sentence and the previous one have been re-written for clarity.

- **Line 111 and Figure 3 caption: "In both years" appears before the mention of 2018 and 2020. It would be helpful to give the specific years before referring to them as both years.**

  Changes in the figure caption and the text mean that this is no longer the case.

- **Line 130: "to present" could this now be replaced by a specific date or month?**

  We have now updated the text and the figures to reflect seismic data for the entirety of 2020.

- **Line 258: CNSN stands for Canadian National Seismograph Network.**

  Thank you for this clarification.

- **Line 268-270: There are 3 "therefore" in 2 sentences.**

  We have used a number of different synonyms now to avoid our use of "therefore".

- **Figure 3: I think it would be easier to compare if the two figures had the same x-axis, and the note mentioning that the 2020 data is complete only until October. Comparing the temporal patterns on different time scales seems difficult.**

  The figure has now been updated to represent data for the entirety of 2020, and so both subplots are now on the same x-axis.

- **Figure 6. Shown but never referenced in the text.**

  This was an oversight on our part and has now been corrected.

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