Utilizing Ground Motion in the Traffic Light System for the Management of Induced Seismicity in Alberta

Fleming, N.A.[A], Green, R.S.[A], Li, M.[C]. Zhou, Y [B] and Grasselli, G._.[C]

The increased use of hydraulic fracturing in recent decades has resulted in public concern over induced seismicity. Regulatory agencies have identified that these man-made earthquakes can be caused by either wastewater disposal or hydraulic fracturing, with the latter being an increasingly common source in Western Canada[2]. Induced seismicity is regulated in Western Canada through programs including the 'Traffic Light System' which informs operational responses to induced seismic events depending on the local magnitude[1].

While the structure of these regulations focuses on the seismic magnitude, it is becoming increasingly evident that determination of ground motion is more important for estimating potential psychological or physical damages[3, 4]. We completed seismic wave propagation simulations within the Western Canada Sedimentary Basin, which confirmed previous finding in scientific literature demonstrating the importance of considering ground motion as opposed to magnitude in the regulation of induced seismic events [3]. The propagation of historic induced seismic events was simulated utilizing the modelling software SPECFEM 3D Cartesian, in consideration of varying sediment types and thicknesses, to generate shaking maps and waveforms at receivers, demonstrating the variations in potential damages. This technique theoretically demonstrates that induced seismic activity causes different levels of ground motion, and therefore damages, depending on the impedance and thickness of sediments, with potential application to improve the existing induced seismicity regulation in Western Canada.

We present recommendations to utilize ground motion as a parameter for determining thresholds for the Traffic Light System instead of earthquake magnitude. Thresholds that account for the exposure and vulnerability of individuals to the ground shaking will provide more protection to personal well-being compared to the current system. Our recommendations would provide greater protection in more vulnerable areas, and higher tolerances for shaking in remote areas. This flexibility provides benefits to both private industry and the public.

FOOTNOTES:

[A]*University of Calgary /* [B]*University of Alberta/* [C]*University of Toronto*

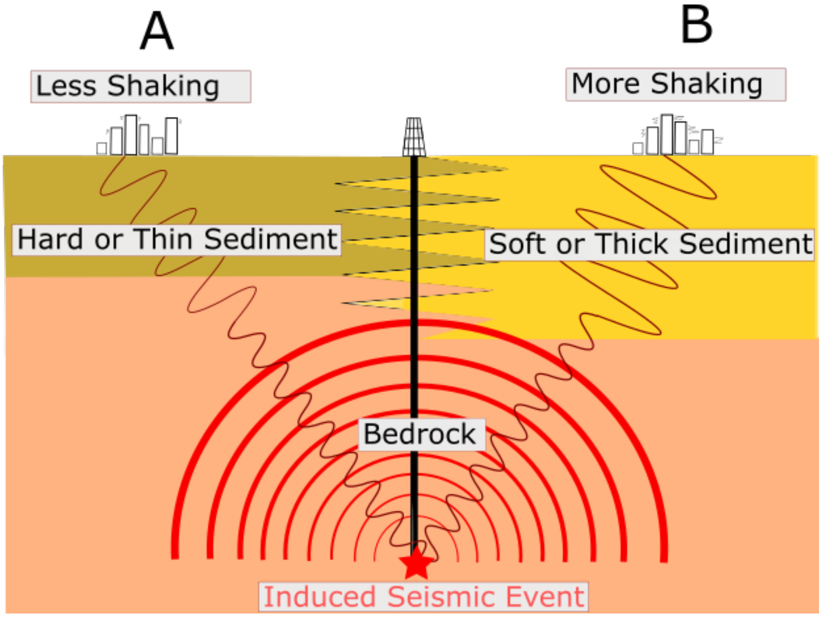

Figure 1. Cross-section view of conceptual model of induced seismicity, demonstrating potential variability in 'felt' shaking on the surface (ground motion) due to local variations in surficial sedimeint thickness and impedence.

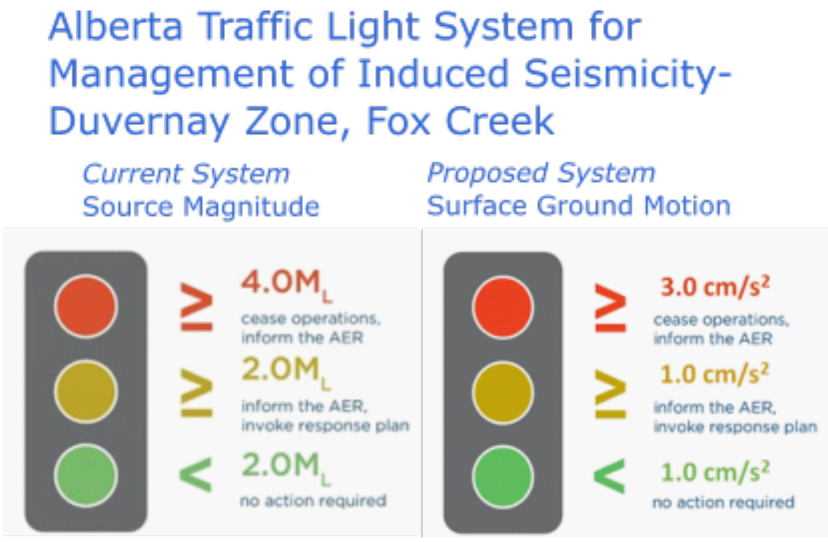

Figure 2. Conceptual overview of the current Traffic Light System for manageent of induced seismicity, with basis in measuring local source magnitude, and the proposed revised system which would manage surface ground motion (peak ground accelleratiuon) at the nearest affected residence. (After Alberta Energy Regulator[1])

ACKNOWLEDGEMENTS:

Computational Infrastructure for Geodynamics (http://geodynamics.org)
Crust Model Crust 1.0 (https://igppweb.ucsd.edu/~gabi/crust1.html)
Incorporated Research Institution for Seismology (IRIS)

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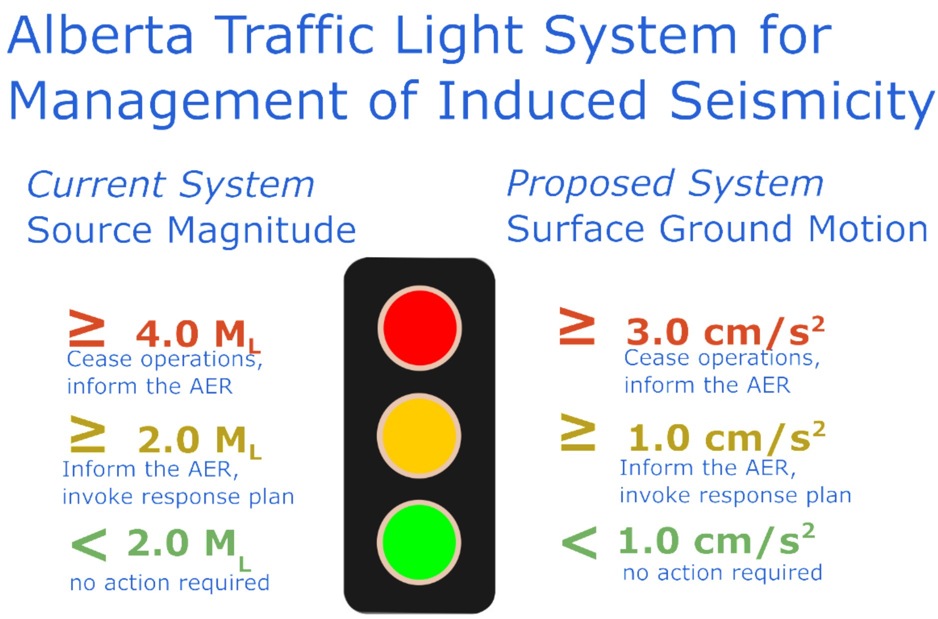
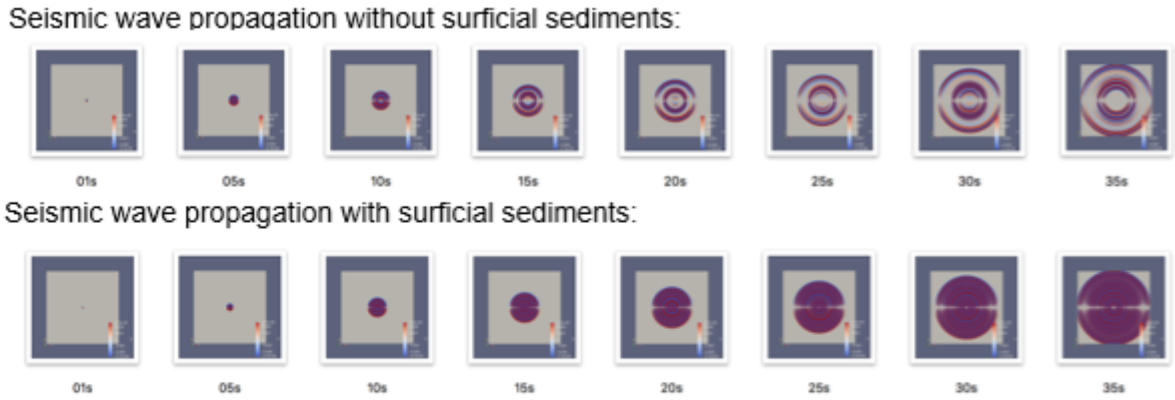
Potential Figures:

We could even add to this with suggested changes in the cut-offs when using PGA… (This could be the 'policy side…??' (RG:I think It might be nice to add the one I created with the PGA limits)

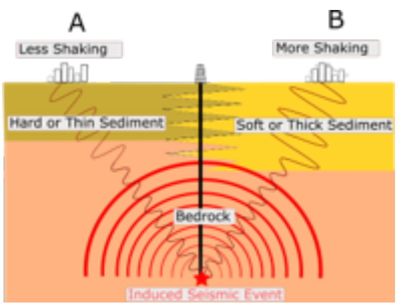


(NF: oops! Apparently this is what happens when I start doing stuff before checking what else has been put up... Haha, looks like we were both thinking the same thing though!)

--> (might also try and put something like this in the video instead of what we had with the confusing slide listing all the measurement types...)



We could adapt the poster figure with simulation resurts?



Or include the simple conceptual model as a starting point…?

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The increased use of hydraulic fracturing in recent decades has resulted in public concern over induced seismicity. Regulatory agencies have identified that these man-made earthquakes can be caused by either wastewater disposal or hydraulic fracturing, with the latter being an increasingly common source in Western Canada (BCOG 2017, Atkinson et al. 2015). Induced seismicity is regulated in Western Canada through programs including the 'Traffic Light System' which informs operational responses to induced seismic events depending on the local magnitude (Alberta Energy Regulator, 2018).

While the structure of these regulations focuses on seismic magnitude, it is becoming increasing evident that determination of ground motion is more important for estimating potential damages (Yenier et al. 2016). We completed seismic wave propagation modelling, which confirmed finding in scientific literature demonstrating the potential and importance of consideration of ground motion as opposed to magnitude in the regulation of induced seismic events. Data obtained from the Incorporated Research Institutions for Seismology (IRIS) was simulated utilizing the modelling software SPECFEM 3D Cartesian. Modelling of the propagation of historic induced seismic events, in consideration of varying sediment types and thicknesses, is used to generate shaking maps demonstrating the variations in potential damages. This technique theoretically demonstrates that induced seismic activity causes different levels of ground motion, and therefore damages, depending on the softness and thickness of sediments, with potential application to improve the existing induced seismicity regulation in Western Canada.

We present recommendations to utilize ground motion as a parameter for determining thresholds for the Traffic Light System instead of earthquake magnitude. Thresholds that account for the exposure and vulnerability of individuals to the ground shaking will provide significantly more protection to personal well-being compared to the current system. Our recommendations would provide greater protection in more vulnerable areas, and higher tolerances for shaking in remote areas. This flexibility provides benefits to both private industry and the public.

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Final IUGG Abstract Submission:

Title: **Utilizing Ground Motion in the Traffic Light System to Better Mitigate Potential Damages Caused by Induced Seismic Events**

Yiru Zhou, Mei Li, Neil Fleming, Ryan Green

The increased use of hydraulic fracturing in recent decades has resulted in public concern over induced seismicity. Regulatory agencies have identified that these man-made earthquakes can be caused by either wastewater disposal or hydraulic fracturing, with the latter being an increasingly common source in Western Canada (BCOG 2017, Atkinson et al. 2015). Induced seismicity is regulated in Western Canada through programs including the 'Traffic Light System' which informs operational responses to induced seismic events depending on the local magnitude (Alberta Energy Regulator, 2018). While the structure of these regulations focuses on seismic magnitude, it is becoming increasing evident that determination of ground acceleration is more important for estimating potential damages (Yenier et al. 2016). This poster will present the findings of seismic wave propagation modelling in order to demonstrate the potential and importance of consideration of ground motion as opposed to magnitude in the regulation of induced seismic events. Data obtained from the Incorporated Research Institutions for Seismology (IRIS) is simulated utilizing the modelling software SPECFEM 3D Cartesian. Modelling of the propagation of historic induced seismic events, in consideration of varying sediment types and thicknesses, is used to generate shaking maps demonstrating the variations in potential damages. This technique theoretically demonstrates that induced seismic activity causes different levels of ground motion, and therefore damages, depending

on the softness and thickness of sediments, with potential application to improve the existing induced seismicity regulation in Western Canada.

-- 235 words--

Policy Paper Abstract

Title: The Traffic Light System and the Management of Induced Seismicity in Alberta

Concern over public safety has risen over the past decade due to the increase of induced seismic events near the town of Fox Creek, Alberta. These induced seismic events are highly correlated with the increase in hydraulic fracturing activities in the region starting in 2013. The Traffic Light System is a mitigation method implemented by the Alberta Energy Regulator in an attempt to reduce the risks to infrastructure damage and human well-being caused by induced seismic events. Currently, the Traffic Light System in Alberta only considers earthquake magnitude when determining thresholds. We have completed Alberta-specific earthquake modeling that confirms findings in scientific literature suggesting that ground motion is a better parameter to determine induced seismicity risks. This is because ground motion describes what is felt on the surface while the local magnitude only describes the total energy exerted by seismic event at the source. We present recommendations to utilize ground motion as a parameter for determining thresholds for the Traffic Light System instead of earthquake magnitude. Thresholds that account for the exposure and vulnerability of individuals to the ground shaking will provide significantly more protection to personal well-being compared to the current system. Our recommendations would provide greater protection in more vulnerable areas, and higher tolerances for shaking in remote areas. This flexibility provides benefits to both private industry and the public.