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For Those About To Rock - Revisiting the Rocky Mountain House Seismogenic Zone

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Background

The Western Canada Sedimentary Basin is relatively tectonically quiescent, with some notable exceptions. One such cluster is the Rocky Mountain House Seismogenic Zone (RMHSZ), a long-lived (1970-present) cluster of earthquakes located approximately 35 kilometers southwest of the town of Rocky Mountain House in west-central Alberta. Numerous authors have attributed this seismicity to production and secondary recovery from the Strachan D3-A Leduc reef gas pool (Baranova et al. 1999; Wetmiller 1986; Stern et al. 2013; Schultz & Wang, 2020).

The RMHSZ accounts for 5 of the 10 largest earthquakes in Alberta's recorded history (NRCan, 2021). These events range in magnitude from M_L 3.8 to 4.27, with the most recent occurring on 24 May 2020 (3.8 M_L; NRCan, 2021). Although Stern et al. (2013) observed that seismicity in the RMHSZ had declined with reduced gas production, activity has persisted into the present day: 100 earthquakes were reported by the Alberta Energy Regulator in this region between January 2019 and March 2021 (Figure 1).

Events in the RMHSZ can be induced or, more rarely, natural in origin. The extraction of gas from this reservoir over time altered stress on an underlying thrust fault that extended deep into the crystalline basement (Wetmiller, 1986; Schultz & Wang, 2020). Schultz & Wang (2020) noted the largest event in their RMHSZ catalogue (4.27 M_L on 10 March 2019) as an outlier: this event was likely natural as it lacked any spatiotemporal association with industry activity. The depth of this event (~15 km) in comparison to that of known induced events (2.5 to 4 km) further supported a natural origin as increased depth is now recognized as a potential discriminator for induced versus natural events (Zhang et al., 2016).

Methods

We report initial results from the first 15 months of monitoring using a temporary broadband seismograph array installed above a prototype geothermal pilot in Clearwater County, Alberta. This array can detect regional seismic events as well as microearthquakes and fills in a gap in the public seismograph network previously serviced by BRGNA (Bergen, Alberta). Our array is located 40 km east of the RMHSZ and is therefore well-situated to pick up smaller earthquakes that may not be recorded by the provincial network. Analysis is ongoing using open-source software programs like ObsPy (Beyreuther et al., 2010) and REDPy (Hotovec-Ellis & Jeffries, 2016).

Results

Recording began at two of the stations in July 2020, and the array became fully operational in September 2020. Between July 2020 and March 2021, 5 earthquakes were reported by the Alberta Energy Regulator (AER) in the RMHSZ. Combined with public data from the IRIS network, this work will analyze the existing catalogue of earthquakes and aims to identify new events that

were not detected previously. This approach should elucidate smaller, natural earthquakes associated with the 10 March 2019 event, and serves to update the work performed by Schultz & Wang (2020) on the RMHSZ to the present day.

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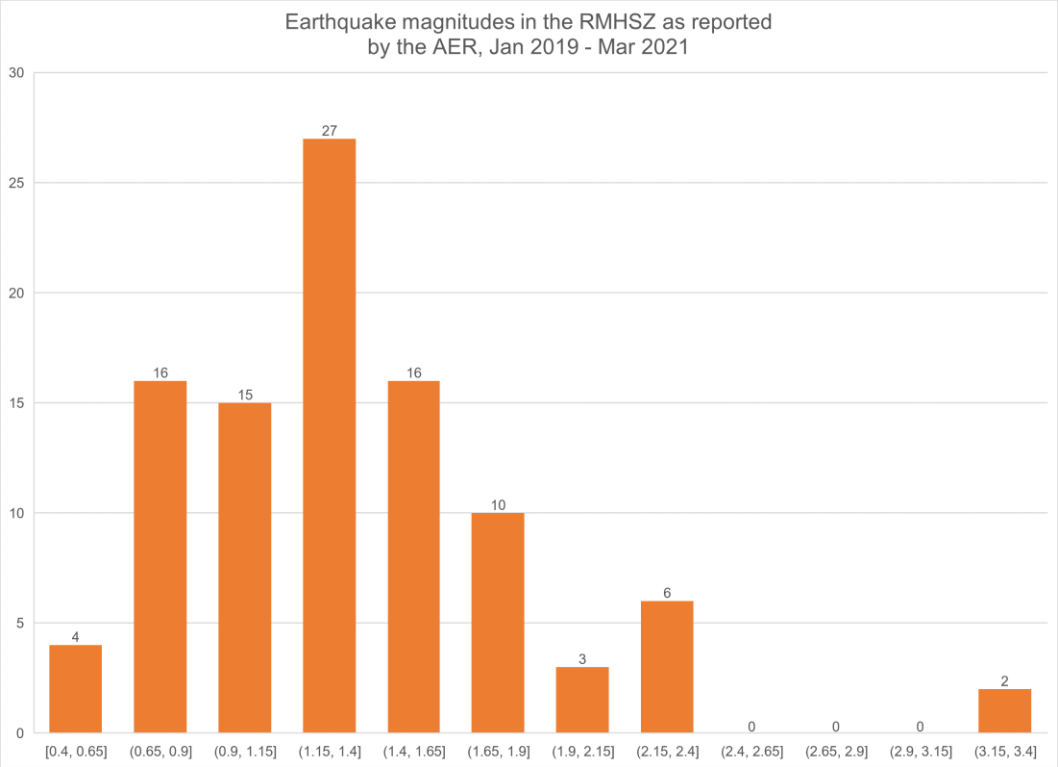
Figure 1: Histogram of earthquake magnitudes in the RMHSZ as reported by the AER (2021), Jan 2019-March 2021.



References

AER Earthquake Dashboard. Last accessed March 23, 2021 from https://ags-aer.shinyapps.io/Seismicity_waveform_app/.

Baranova, V., Mustaqeem, A., & Bell, S. (1999). A model for induced seismicity caused by hydrocarbon production in the Western Canada Sedimentary Basin. *Canadian Journal of Earth Sciences, 36(1)*, 47-64. https://doi.org/10.1139/e98-080.

Beyreuther, M., Barsch, R., Krischer, L., Megies, T., Behr, Y., and Wassermann, J. (2010). ObsPy: A Python toolbox for seismology. *Seismological Research Letters 81(3),* 530-533.

Hotovec-Ellis, A.J., & Jeffries, C. (2016). Near Real-time Detection, Clustering, and Analysis of Repeating Earthquakes: Application to Mount St. Helens and Redoubt Volcanoes – Invited. Presented at Seismological Society of America Annual Meeting, Reno, Nevada, 20 Apr.

Natural Resources Canada. (2021). Earthquake details (2021-02-13) – regional seismicity. Accessed March 23, 2021 from https://earthquakescanada.nrcan.gc.ca/recent/2021/20210214.0133/seismicity-en.php#hist5.

Schultz, R., & Wang, R. (2020). Newly emerging cases of hydraulic fracturing induced seismicity in the Duvernay East Shale Basin. *Tectonophysics*, *779*, https://doi.org/ 10.1016/j.tecto.2020.228393.

Stern, V. H., Schultz, R. J., Shen, L., Gu, Y. J., & Eaton, D. W. (2013). Alberta earthquake catalogue, version 1.0: September 2006 through December 2010 – AER/AGS open file report 2013-2015.

Wetmiller, R. J. (1986). Earthquakes near Rocky Mountain House, Alberta, and their relationship to gas production facilities. *Canadian Journal of Earth Sciences, 23(2)*, 172-181. https://doi.org/10.1139/e86-020.

Zhang, H., Eaton, D.W., Li, G., Liu, Y., Harrington, R.M. (2016). Discriminating induced seismicity from induced earthquakes using moment tensors and source spectra. *Journal of Geophysical Research: Solid Earth, 121,* 972-993. https://doi.org/10.1002/2015JB012603.