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RYAN SCHULTZ

Seismologist

EDUCATION

- **Ph.D. in Seismology**, *Stanford University* (2019 –)
- **M.Sc. in Geophysics**, *University of Alberta* (2010 – 2012)
- **B.Sc. in Physics with honours**, *University of Alberta* (2007 – 2009)
- **B.Sc. in Chemistry with specialization**, *University of Alberta* (2003 – 2007)

RESEARCH HISTORY [[LINKEDIN](#)]

- **Graduate Research/Teaching Assistant**, *Stanford University* (2019 –)
- **Seismologist**, *Alberta Geological Survey* (2012 –)
- **Geophysical Research Scientist**, *University of Alberta* (2016 – 2019)
- **Student Geophysicist**, *Alberta Geological Survey* (2010 – 2012)
- **Graduate Research/Teaching Assistant**, *University of Alberta* (2010 – 2012)
- **Undergraduate Researcher**, *University of Alberta* (2007 – 2008)

HONOURS AND AWARDS

- **AER Awards of Excellence**, *Alberta Energy Regulator* (2018)
- **AER Awards of Excellence**, *Alberta Energy Regulator* (2015)
- **AER Awards of Excellence**, *Alberta Energy Regulator* (2014)
- **Graduate Student Teaching Award**, *University of Alberta* (2012)
- **Roy Hibbs Memorial Graduate Scholarship**, *University of Alberta* (2011)
- **Alberta Education and Technology Graduate Scholarship**, *Alberta* (2011)
- **Canadian Association of Petroleum Producers Scholarship**, *CAPP* (2011)
- **Canadian Society of Exploration Geophysicists Scholarship**, *CSEG* (2011)
- **Golden Key International Honour Society Member**, *Golden Key* (2011)
- **Queen Elizabeth II Graduate Scholarship**, *University of Alberta* (2011)
- **Jason Lang Scholarship**, *University of Alberta* (2008)
- **Rutherford Scholarship**, *Government of Alberta* (2003)

REGULATIONS DEVELOPED

Schultz, R., Yusifbayov, J., & Shipman, T. (2020). The Scientific Induced Seismicity Monitoring Network (SCISMN). *AER/AGS Open File Report 2019-09*, 16 p.

Alberta Energy Regulator (2019). Subsurface order no. 7: Monitoring and reporting of seismicity in the vicinity of Red Deer, Alberta. *AER Subsurface Order*, AER SSO#7, 4 pp. [URL: <https://www.aer.ca/documents/orders/subsurface-orders/SO7.pdf>].

Alberta Energy Regulator (2019). Recommendations around hydraulic fracturing in the Red Deer area, *AER Bulletin 2019-07*, 2 pp. [URL: <https://www.aer.ca/documents/bulletins/Bulletin-2019-07.pdf>].

Alberta Energy Regulator (2019). Subsurface order no. 6: Monitoring and reporting of seismicity in the vicinity of Brazeau, Alberta. *AER Subsurface Order*, AER SSO#6, 5 pp. [URL: <https://www.aer.ca/documents/orders/subsurface-orders/SO6.pdf>].

Alberta Energy Regulator (2015). Subsurface order no. 2: Monitoring and reporting of seismicity in the vicinity of hydraulic fracturing operations in the Duvernay zone, Fox Creek, Alberta. AER Bulletin 2015-07, 3 pp. [URL: <https://aer.ca/documents/orders/subsurface-orders/SO2.pdf>].

MEDIA INTERVIEWS

- (Apr. 2020). In response to the press release of the paper making recommendations on how to set traffic light thresholds. Links: [Stanford](#), & [SSA](#).
- (Oct. 2019). In response to the regulatory public release of “conversations that matter” explaining the Alberta induced earthquakes. Links: [Resource](#), & [YouTube](#).
- (Dec. 2018). In response to the paper explaining the prior lake-associated icequakes. Links: [Altmetric](#), [CBC](#), [Global News](#), [Resource](#), etc..
- (Jan. 2018). In response to the Science article explaining the operational controls on hydraulic fracturing earthquakes near Fox Creek. Links: [Altmetric](#), [CBC](#), [ScienceNews](#), [Globe and Mail](#), [Global News](#), etc..
- (Jan. 2018). In response to the icequakes felt near Alberta Beach. Links: [CTV](#), [Global News](#), & [Resource](#).
- (Feb. 2017). In response to the paper confirming earthquakes near Fox Creek were induced by hydraulic fracturing. Link: [CBC](#)
- (Feb. 2015). In response to the 22 January 2015, 4.4 ML induced event near Fox Creek, Alberta. Links: [BNN](#) & [CBC](#).
- (Oct. 2014). In response to the 17 October 2014, 2.7 ML felt event near Banff, Alberta. Links: [CTV](#), [CBC](#), [Global News](#), & [660 News](#).

CODING REPOSITORIES [GITHUB]

- Schultz, R.**, & Yusifbayov, J. (2020). Synthetic Magnitude of Completeness (Mc) Estimation. *Matlab*.
- Schultz, R.** (2019). Toolbox for earthquake seismology. *Matlab*.
- Schultz, R.**, & Telesca, L. (2018). Induced Seismicity Association via Cross-Correlation. *Matlab*.
- Schultz, R.** (2014). Shapiro Seismogenic Index (Σ) Function. *Matlab*.
- Schultz, R.** (2014). Gutenberg-Richter *b*-value Computation. *Matlab*.
- Schultz, R.**, & Gu, Y. J. (2013). Radon Transform Codes. *Matlab*.

SERVICE

- Reviewer for:** Nature Geoscience, Nature Scientific Reviews, Geophysical Research Letters, Journal of Geophysical Research, Earth and Planetary Science Letters, Geophysical Journal International, Seismological Research Letters, Bulletin of the Seismological Society of America, Canadian Journal of Earth Sciences, & FACETS.
- Organizer for:** *Assessment and management of hazards from seismicity induced by hydraulic fracturing* session for the 2017 SSA meeting, *Induced seismicity in the United States and Canada* session for the 2017 AGU meeting.

PUBLICATIONS [GOOGLESCHOLAR]

- Schultz, R.**, Skoumal, R., Brudzinski, M., Eaton, D., Baptie, B., Ellsworth, W. (2020) Hydraulic Fracturing Induced Seismicity, *Reviews of Geophysics*, doi: [10.1029/2019RG00695](https://doi.org/10.1029/2019RG00695).
- Schultz, R.**, Beroza, G., Ellsworth, W., & Baker, J. (2020). Risk-informed recommendations for managing hydraulic fracturing induced seismicity via traffic light protocols. *Bull. Seismol. Soc. Am.*, doi: [10.1785/0120200016](https://doi.org/10.1785/0120200016).
- Schultz, R.**, Yusifbayov, J., & Shipman, T. (2020). The Scientific Induced Seismicity Monitoring Network (SCISMN). *AER/AGS Open File Report 2019-09*, 16 p.
- Schultz, R.**, & Wang, R. (2020). A newly emerging case of hydraulic fracturing induced seismicity in the Duvernay East Shale Basin, *Tectonophysics*, doi: [10.1016/j.tecto.2020.228393](https://doi.org/10.1016/j.tecto.2020.228393).
- Schultz, R.** & Nanometrics (2019). Initial seismic hazard assessment for the 2016 induced earthquakes near Fox Creek, Alberta (between January 2013 and January 2016). *AER/AGS Special Report 104*, 115 p.
- Shen, L.W., Schmitt, D.R., & **Schultz, R.** (2019). Frictional Stabilities on Induced Earthquake Fault Planes at Fox Creek, Alberta: A Pore Fluid Pressure Dilemma. *Geophys. Res. Lett.*, *46*, doi: [10.1029/2019GL083566](https://doi.org/10.1029/2019GL083566).
- Schultz, R.**, & Pawley, S. (2019). Induced earthquakes geological susceptibility model for the Duvernay Formation, central Alberta – version 2, *AER/AGS Open File Report 2019-02*, 8 p.
- Schultz, R.**, Atkinson, G., Eaton, D.W., Gu, Y.J., & Kao, H. (2018). Hydraulic fracturing volume is associated with induced earthquake productivity in the Duvernay play. *Science*, *359*(6373), 304-308, doi: [10.1126/science.aao0159](https://doi.org/10.1126/science.aao0159).
- Galloway, E., Hauck, T., Corlett, H., Pană, D., & **Schultz, R.** (2018). Faults and associated karst collapse suggest conduits for fluid flow that influence hydraulic fracturing-induced seismicity. *Proc. Nat. Acad. Sci.*, *115*(43), E10003-E10012, doi: [10.1073/pnas.1807549115](https://doi.org/10.1073/pnas.1807549115).
- Wang, R., Gu, Y.J., **Schultz, R.**, & Chen, Y. (2018). Faults and Non-Double-Couple Components for Induced Earthquakes. *Geophys. Res. Lett.*, *45*(17), 8966-8975, doi: [10.1029/2018GL079027](https://doi.org/10.1029/2018GL079027).
- Eaton, D.W., & **Schultz, R.** (2018). Increased likelihood of induced seismicity in highly overpressured shale formations. *Geophys. J. Int.*, *214*(1), 751-757, doi: [10.1093/gji/ggy167](https://doi.org/10.1093/gji/ggy167).
- Corlett, H., **Schultz, R.**, Branscombe, P., Hauck, T., Haug, K., MacCormack, K., & Shipman, T. (2018). Subsurface faults inferred from reflection seismic, earthquakes, and sedimentological relationships: Implications for induced seismicity in Alberta, Canada. *Mar. Pet. Geo.*, *93*, 135-144, doi: [10.1016/j.marpetgeo.2018.03.008](https://doi.org/10.1016/j.marpetgeo.2018.03.008).
- Pawley, S., **Schultz, R.**, Playter, T., Corlett, H., Shipman, T., Lyster, S., & Hauck, T. (2018). The Geological Susceptibility of Induced Earthquakes in the Duvernay Play. *Geophys. Res. Lett.*, *45*(4), 1786-1793, doi: [10.1002/2017GL076100](https://doi.org/10.1002/2017GL076100).
- Schultz, R.**, Wood, D.E., Jean, G., Yusifbayov, J., & Farrugia, J. (2017). Installation Guide and Developed Learnings for Satellite Telemetered Stations in the Regional Alberta Observatory for Earthquake Studies Network (RAVEN), *AER/AGS Open File Report 2017-06*, 19 p.
- Wang, R., Gu, Y.J., **Schultz, R.**, Zhang, M., & Kim, A. (2017). Source characteristics and geological implications of the January 2016 induced earthquake swarm near Crooked Lake, Alberta. *Geophys. J. Int.*, *210*(2), 979-988, doi: [10.1093/gji/ggx204](https://doi.org/10.1093/gji/ggx204).
- Mahani, A.B., **Schultz, R.**, Kao, H., Walker, D., Johnson, J., & Salas, C. (2017). Fluid injection and seismic activity in the northern Montney play, British Columbia, Canada, with special reference to the 17 August 2015 Mw 4.6 induced earthquake. *Bull. Seismol. Soc. Am.*, *107*(2), 542-552, doi: [10.1785/0120160175](https://doi.org/10.1785/0120160175).
- Schultz, R.**, Wang, R., Gu, Y.J., Haug, K., & Atkinson, G. (2017). A Seismological Overview of the Induced Earthquakes in the Duvernay play near Fox Creek, Alberta. *J. Geophys. Res.: Solid Earth*, doi: [10.1029/2017JB014000](https://doi.org/10.1029/2017JB014000).

[0.1002/2016JB013570](https://doi.org/10.1002/2016JB013570).

- Atkinson, G.M., Eaton, D.W., Ghofrani, H., Walker, D., Cheadle, B., **Schultz, R.**, ... & Liu, Y. (2016). Hydraulic Fracturing and Seismicity in the Western Canada Sedimentary Basin. *Seismol. Res. Lett.*, 87 (3), 631-647, doi: [10.1785/0220150263](https://doi.org/10.1785/0220150263).
- Schultz, R.**, Corlett, H., Haug, K., Kocon, K., MacCormack, K., Stern, V., & Shipman, T. (2016). Linking fossil reefs with earthquakes: Geologic insight to where induced seismicity occurs in Alberta. *Geophys. Res. Lett.*, 43, 2534-2542, doi: [10.1002/2015GL067514](https://doi.org/10.1002/2015GL067514).
- Wang, R., Gu, Y.J., **Schultz, R.**, Kim, A., & Atkinson, G. (2016). Source analysis of a potential hydraulic-fracturing-induced earthquake near Fox Creek, Alberta. *Geophys. Res. Lett.*, 43, 564-573, doi: [10.1002/2015GL066917](https://doi.org/10.1002/2015GL066917).
- Schultz, R.**, Mei, S., Pană, D., Stern, V., Gu, Y.J., Kim, A., & Eaton, D. (2015). The Cardston Earthquake Swarm and Hydraulic Fracturing of the Exshaw Formation (Alberta Bakken Play). *Bull. Seismol. Soc. Am.*, 105(6), 2871-2884, doi: [10.1785/0120150131](https://doi.org/10.1785/0120150131).
- Schultz, R.**, & Stern, V. (2015). The Regional Alberta Observatory for Earthquake Studies Network (RAVEN). *CSEG Recorder*, 40(8), 34-37, URL: <http://csegrecorder.com/articles/view/the-regional-alberta-observatory-for-earthquake-studies-network-raven>.
- Schultz, R.**, Stern, V., Novakovic, M., Atkinson, G., & Gu, Y.J. (2015). Hydraulic fracturing and the Crooked Lake Sequences: Insights gleaned from regional seismic networks, *Geophys. Res. Lett.*, 42(8), 2750-2758, doi: [10.1002/2015GL063455](https://doi.org/10.1002/2015GL063455).
- Schultz, R.**, Stern, V., Gu, Y.J., & Eaton, D. (2015). Detection threshold and location resolution of the Alberta Geological Survey Earthquake Catalogue. *Seismol. Res. Lett.*, 86(2A), 385-397, doi: [10.1785/0220140203](https://doi.org/10.1785/0220140203).
- Schultz, R.**, Stern, V., & Gu, Y.J. (2014). An investigation of seismicity clustered near the Cordell Field, west central Alberta, and its relation to a nearby disposal well. *J. Geophys. Res.: Solid Earth*, 119(4), 3410-3423, doi: [10.1002/2013JB010836](https://doi.org/10.1002/2013JB010836).
- Schultz, R.**, & Gu, Y.J. (2013). Multiresolution imaging of mantle reflectivity structure using SS and P'P' precursors. *Geophys. J. Int.* 195(1), 668-683, doi: [10.1093/gji/ggt266](https://doi.org/10.1093/gji/ggt266).
- 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, Alberta Geological Survey Open File Report, 2013-15, 36 pp, URL: http://ags.aer.ca/publications/OFR_2013_15.html.
- Schultz, R.**, & Gu, Y.J. (2013). Flexible, inversion-based Matlab implementation of the Radon transform. *Comput. Geosci.* 52, 437-442, doi: [10.1016/j.cageo.2012.08.013](https://doi.org/10.1016/j.cageo.2012.08.013).
- Gu, Y.J., Okeler, A., & **Schultz, R.** (2012). Tracking slabs beneath northwestern Pacific subduction zones. *Earth Planet. Sci. Lett.* 331, 269-280, doi: [10.1016/j.epsl.2012.03.023](https://doi.org/10.1016/j.epsl.2012.03.023).
- Gu, Y.J., An, Y., Sacchi, M., **Schultz, R.**, & Ritsema, J. (2009). Mantle reflectivity structure beneath oceanic hotspots. *Geophys. J. Int.* 178(3), 1456-1472, doi: [10.1111/j.1365-246X.2009.04242.x](https://doi.org/10.1111/j.1365-246X.2009.04242.x).

INVITED TALKS

- (Jun. 2019) The geological susceptibility of induced earthquakes in the Duvernay play. *Canadian Society for Exploration Geophysicists Invited Microseismic Users Group Talk, Calgary Canada*.
- (Sep. 2018). Bridging gaps in induced seismicity hazard forecasting in Alberta, Canada. *European Seismological Commission 36th General Assembly, Valetta, Malta*.
- (Oct. 2018). The geological susceptibility of induced earthquakes in the Duvernay play. *Banff 2018 International Induced Seismicity Workshop, Banff, Canada*.
- (Dec. 2017) Hydraulic fracturing completion volume is associated with induced earthquake productivity in the Duvernay play. *Canadian Society for Unconventional Resources Induced Seismicity Workshop*

III, Calgary, Canada.

- (Nov. 2017). An overview of seismology, earthquakes, and induced seismicity in Alberta. *North West Territories Regulatory Meeting, Yellowknife, Canada.*
- (Nov. 2017) Hydraulic fracturing completion volume is associated with induced earthquake productivity in the Duvernay play. *Canadian Society for Exploration Geophysicists Invited Microseismic Users Group Talk, Calgary Canada.*
- (Mar. 2017) A seismological overview of the induced earthquakes in the Duvernay play, near Fox Creek, Alberta. *Pacific Geoscience Centre Seminar, Sidney, BC.*
- (Jun. 2016) Linking fossil reefs with earthquakes: geologic insight to where induced seismicity occurs in Alberta. *Canadian Society for Exploration Geophysicists Invited Microseismic Users Group Talk, Calgary Canada.*
- (Jun. 2016) Linking fossil reefs with earthquakes: geologic insight to where induced seismicity occurs in Alberta. *Canadian Society for Unconventional Resources Invited Talk, Calgary, Canada.*
- (Apr. 2016). Linking fossil reefs with earthquakes: geologic insight to where induced seismicity occurs in Alberta. *Seismological Society of America, Reno, US.*
- (Sep. 2015). Induced earthquakes and seismic monitoring in Alberta. *University of Alberta ATLAS Talk, Edmonton, Canada.*

FIELD WORK EXPERIENCE

- RAVEN** (2013 – 2019): Designed seismological stations and network setup for RAVEN, lead teams to install all stations in the network, continued maintenance of the network after installation, ensured real-time delivery of data to IRIS. *Link: <https://doi.org/10.7914/SN/RV>.*
- NBCXX** (2012): Assisted in the install of five satellite telemetered seismological stations.
- CRANE** (2011 – 2019): Assisted in the install of stations in the CRANE seismological network. Lead the continued maintenance and acquisition of offline data after station installations. *Link: https://www.fdsn.org/networks/detail/Y5_2006/.*
- Turtle Mountain** (2011 – 2019): Assisted in the maintenance and decommissioning of equipment to monitor the landslide susceptibility of Turtle Mountain.