Natural Resources Canada’s Induced Seismicity Research Project: An Update

Honn Kao1, Maurice Lamontagne2, Denis Lavoie3, and John F. Cassidy1


ABSTRACT
The development of unconventional oil and gas in North America has caused a significant increase in seismicity in areas of intensive hydraulic fracturing and wastewater injection operations. These induced earthquakes have attracted considerable attention due to their potential seismic hazards. In 2012, Natural Resources Canada (NRCan) initiated the Induced Seismicity Research (ISR) Activity as part of the Shale Gas Research Project (Environmental Geoscience Program) to investigate the possible relationship between hydraulic fracturing (HF) and shale gas and the changing pattern of local seismicity. In 2015 the activity was expanded to include studies of all injection-related seismic events.

The primary objective of NRCan’s ISR Project is to identify and fit critical knowledge gaps on the seismogenicity of induced earthquakes. Another important goal of ISR is to enhance regulatory performance by providing observation-based science and advice.

NRCan’s ISR Project has three major tasks: 1) Improve real-time earthquake-monitoring capability in major shale gas basins where current seismic coverage is sparse; 2) establish the baseline (pre-development) regional seismicity pattern for monitoring capability in major shale gas basins where current seismic coverage is sparse; and 3) conduct targeted studies on significant induced events to understand the relationship between the seismogenicity and man-made operations.

Working closely with provincial and territorial governments, new real-time broadband seismic stations have been installed in British Columbia (BC), Alberta (AB), New Brunswick (NB), Northwest Territories (NT), Quebec (QC), and Yukon Territory (YT).

The development of unconventional oil and gas in North America has

Unconventional Oil and Gas in Canada

Key Targeted Areas
1. West Canadian Sedimentary Basin, including British Columbia, Alberta, Saskatchewan, Yukon, and Northwest Territories.
3. St. Lawrence Platform, Quebec.

ISR for northeast BC
1. Definition of Regional Seismograph Network

• The Canadian National Seismograph Network (CNSN) had only two stations in NE BC before 2012.
• Network performance analysis was done and published (Mahan et al., 2016).
• Apply the single-station location method to the 3-component broadband seismographs recorded at Fort Nelson station (FBNB) to locate small events missing from the Canadian National Earthquake Database.
• tracing 12-month time windows from 2002 – 2003 4 years before any hydraulic fracturing started in this area.
• 24 events with M<1 between 1.5 and 2.5 were recognized and located.
• Most of smaller than the detection threshold of CNSN for this area (M<2.5).
• There was no event found in the main shale-gas production area (Ellis).
• Since 2013, ISR has established 10 new broadband seismic stations. More stations were setup in the region by provincial agencies and universities.

2. Earthquake occurrences and hydraulic fracturing (HF)

• During HF operations, local seismicity tend to occur in the Elko area. While more scattered pattern is observed for non-HF period.
• No clear change in background seismicity was observed for months with total injection volume less than 200,000 m3 (light green zone).
• When monthly injected volume increased to above 200,000 m3 (light yellow zone), some months began to have more seismic moment (<108 N m). But increases in maximum magnitude was not clear.
• Higher seismic moment and relatively larger earthquakes occurred only during months with total injected volume exceeding 150,000 m3 (light red zone).
• (Farahbod et al., 2015a)

ISR for Moncton sub-basin, NB
1. Working Progress

• Western part of the considered region.
• Complex relationships between the Denawan–Permain succession and the crystalline basement.
• In addition to LMR, 6 new real-time broadband seismic stations were installed since 2013.

2. ISR for the Anticosti Island, QC
• Exploration for unconventional oil and gas is currently underway.
• HF operations for extracting tight oil and shale gas are planned in the near future.
• Installation of 34 broadband seismic stations completed in late 2015.

3. Detailed studies of recent induced earthquakes in BC and AB
2010-07-01, HRB, BC, M=4.6
2011-05-19, HRB, BC, M=2.6
2013-06-28, northern Moncton, BC, M=4.2
2014-04-06, northern Moncton, BC, M=4.4
2015-01-25, Fox Creek, AB, M=4.4
2015-08-16, Fox Creek, AB, M=4.4
2015-08-17, northern Moncton, BC, M=4.4
• * The largest hydraulic fracturing-induced event documented on August 17, 2015 in northern Moncton, BC.

Technical Meetings on Regulatory Performances for Induced Seismicity

Oct. 6, 2015, at the Downtown Campus of the University of Calgary: “Traffic Light Protocol (TLP) for Induced Seismicity”, 64 participants; Meeting conclusion and recommendations are published as a GSC Open-File Report (Kao et al., 2016).
• Jan. 29, 2016, at the GSC-Pacific Sidney office: “New Regulation Proposal for Induced Seismicity and Data Sharing Framework”, 73 participants; Will have a follow-up meeting in Spring 2017.

References
External Collaborators