Update on Regional Seismograph Network in Northeastern British Columbia (NTS 094C, G, I, O, P)

C.J. Salas, Geoscience BC, Vancouver, BC, salas@geosciencebc.com

D. Walker, BC Oil and Gas Commission, Victoria, BC

Salas, C.J. and Walker, D. (2014): Update on regional seismograph network in northeastern British Columbia (NTS 094C, G, I, O, P); *in* Geoscience BC Summary of Activities 2013, Geoscience BC, Report 2014-1, p. 123–126.

Introduction

Recently, BC Oil and Gas Commission (BCOGC) released a report titled *Investigation of Observed Seismicity in the Horn River Basin* (BC Oil and Gas Commission, 2012). The report noted that during the study period from April 2009 to December 2011, along with the routine microseismicity created by hydraulic fracturing (fraccing), 250 low magnitude seismic events were triggered by fluid injection while fraccing. It was additionally noted that over 8000 high-volume hydraulic fracturing completions were conducted since 2007 with no associated seismicity. None of these events caused any injury, property damage or was found to pose any risk to public safety or the environment.

As a result of the study, BCOGC recommended augmenting the existing Canadian National Seismograph Network's (CNSN) coverage in northeastern British Columbia to better track the effects of completions/fluid injection and induced seismicity. Enhancements to the seismograph network would increase the understanding of induced seismicity and its relationship to oil and gas operations, such as fraccing and injection of disposal fluids. Natural gas policy makers and regulators, the natural gas industry, communities and First Nations have a common interest in learning more about this issue to support the responsible development of BC's natural gas resources. The improvement to this seismograph array network would increase the understanding of the relationship between multistage fraccing and induced seismicity.

In mid-2012, a consortium headed by Geoscience BC, along with the Canadian Association of Petroleum Producers (CAPP), BCOGC and Natural Resources Canada (NRCan), initiated a project to add six seismograph stations to complement the two pre-existing CNSN stations in northeastern BC. The state-of-the-art stations were installed by late March 2013 and fully integrated into the CNSN by August 2013.

Keywords: *seismicity, unconventional gas, seismograph, fraccing*

This publication is also available, free of charge, as colour digital files in Adobe Acrobat® PDF format from the Geoscience BC website: http://www.geosciencebc.com/s/DataReleases.asp.

Background

The BCOGC report was commissioned in response to public and regulatory concerns with respect to induced seismicity associated with hydrofracturing operations in the Horn River Basin. The study looked at seismic events occurring in the Horn River Basin between April 2009 and December 2011, during which time 38 low-level seismic events were recorded by the CNSN's two stations near Hudson's Hope and Fort Nelson (Figure 1). These events ranged in magnitude between 2.2 and 3.8 on the Richter scale. The largest event was recorded on May 19, 2011, and was felt on the surface, although no damage or injuries were reported. The last seven events occurred during the period between December 8 and December 13, 2011. Prior to April 2009, the seismograph network had not detected any seismicity in the Horn River Basin. The seismograph stations can only detect events as low as approximately 2.4 Richter; hence it was not possible to demonstrate whether smaller level events occurred during this time period. Seismic events in the range of 0.5–2.0 Richter are very common and are termed micro-earthquakes whereas those between 2.0–3.9 Richter are called minor earthquakes. Those events within the lower end of the range (i.e., 2.0 Richter) are rarely felt whereas those within the upper range (i.e., 3.9 Richter) are often felt, but rarely cause damage.

The CNSN had several technical limitations when used for the study of induced seismicity (BC Oil and Gas Commission, 2012). The first shortcoming was due to the limited station coverage, which resulted in a 5–10 km uncertainty of the epicentre's location while carrying an even larger uncertainty of the focal depth. Secondly, although the instrument's minimum magnitude detection is approximately 2.4 Richter, calibration with an oil and gas industry–operated seismic array found that it had failed to detect 15 events of >2.4 Richter during a two-month period. Therefore, it is likely that events in the 2.0–3.0 Richter range have been historically under-reported.

Using CNSN's data, along with help from industry, NRCan, the University of BC and the Alberta Geological Survey (AGS), BCOGC noted the low-level seismic events

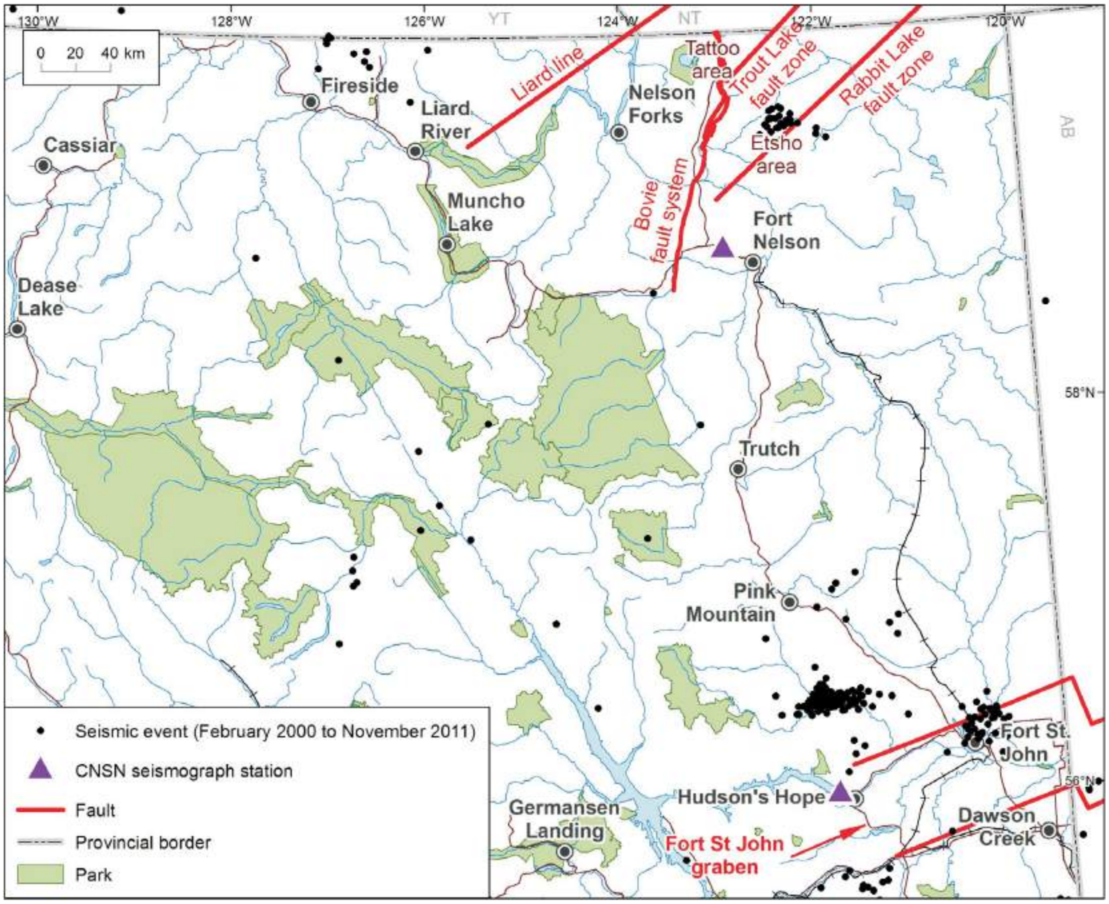

Figure 1. Location of Canadian National Seismic Network (CNSN) seismograph stations and anomalous induced seismic events recorded between February 2000 and November 2011, northeastern British Columbia.

were centred on the Etsho and Tattoo areas of northeastern BC (Figure 1). Additional dense array data provided by operators conducting completion operations captured an additional 212 anomalous seismic events (>2.0 Richter) in the greater Etsho area. The BCOGC's study concluded that these events were synchronous with fraccing operations and occurred at approximately the same depths as the frac stages. Furthermore, it was surmised that the anomalous induced seismicity recorded over the period between April 2009 and December 2011 was the result of fault movement due to fluid injection during hydraulic fracturing.

In addition, BCOGC stated that during the study period, the low level seismic events did not incur any property damage or injuries, nor did these events pose any risk to public safety or the environment.

Based on the study, BCOGC made seven recommendations in their report, namely

- improve accuracy of CNSN with respect to induced seismicity in northeastern BC;
- perform geotechnical assessments to identify pre-existing faulting;
- establish procedures and requirements for identification of induced seismicity;
- place ground motion sensors in selected northeastern BC communities;
- BCOGC to study use of mobile dense arrays;
- require submission of microseismic reports; and
- study the relationship between fraccing and seismicity.

In response to BCOGC's first recommendation, a research consortium was created between Geoscience BC, CAPP, BCOGC and NRCan to help improve the accuracy of the CNSN. A memorandum of understanding (MOU) was signed between the partners in July 2012 with a mandate to collect, interpret and make public, the data collected from the installation of six new seismograph stations to complement the pre-existing CNSN network. The project has \$1 million in funding from 50/50 equity partners Geoscience BC and CAPP (through Science Community Environmental Knowledge Funding) with in-kind support from BCOGC and NRCan. The project has a mandate to monitor induced seismic activity for a total of five years (until June 2017) with an interim review scheduled for June 2014 to assess the project's performance.

The project is managed by joint steering and technical committees largely comprising representatives from each of the partners. There are four members from each of the partners in the steering committee, and its role is to oversee general project direction and execution with respect to the MOU and to provide financial guidance to the technical committee. A communication plan has been drafted by the steering committee to aid in regular stakeholder communication along with missives that may be necessary in response to an anomalous induced seismic event. At present, all events registered by the network are published on the Earthquakes Canada (NRCan) website (http://www.earthquakescanada.nrcan.gc.ca/index-eng.php).

The technical committee's mandate is to oversee operation and maintenance of the seismographs and review and advise on all technical aspects relating to the project. The technical committee comprises seven individuals: three from industry, one academia and three from government agencies (NRCan, BCOGC and AGS). During the initial installation and testing stages, both committees are meeting on a quarterly basis.

Summary of Activities

In early January 2013, the final locations of the stations were approved by the technical committee. Their placement allows for strategic coverage of the Liard, Horn River and Cordova basins along with the Montney gas play.

The lead technical partner, NRCan, recommended the use of the Nanometrics-made Trillium 120PH broadband seismometer, as it is a state-of-the-art unit. The recommendation was based on technical criteria such as

- continuous data transmittal with minimal power consumption (6 W or less, a necessary requisite given they are solar powered);
- ability for placement in any kind of terrain, such as in soil and/or gravel or directly on bedrock;
- high tilt tolerance (i.e., tolerant of the angle the hole is drilled at);
- tolerance of very cold temperatures;
- excellent reliability, with a solid worldwide reputation; and
- compatibility with CNSN.

Given the outlined points, a decision was made by the partners to sole source the instruments and their installation to Nanometrics Inc.

Installation of the seismometers began in February 2013 and was completed by mid-March 2013. At four of the six locations, the seismographs were mounted on screw-piled, 5 by 5 m pads, set to a depth of approximately 10 m. These sites typically used pre-existing well pads. The other two seismographs were mounted directly on bedrock. All stations went 'live' by the end of March (Figure 2) and were fully incorporated into the CNSN by mid-August 2013.

Figure 2. Installed seismograph near Fort Nelson, northeastern British Columbia.

Data collected by the stations are sent via satellite (a central site VSAT System) to NRCan's Pacific Geoscience Centre in Sidney, BC, where the data are processed by an Apollo server (a seismic-specific software package), which converts it to CNSN-compatible format. The data stream is then redirected to both the AGS and the Geological Survey of Canada where it is processed with data from the CNSN. Routine analysis of seismic events is not done in real time, unless the seismic event is >4.0 Richter. In this case, analyses would be reported in real time. There is typically a one- to two-day delay between when the data arrives and when the interpretation of the seismic event is posted. The interpreted seismic events are posted on the Earthquakes Canada webpage.

Since the stations came online in late March, events have been recorded in three general areas: Altares and Graham, Fort St. John and Septimus, and Beg (Figure 3).

Between March 31 and November 8, 2013, the area around Altares and Graham experienced 23 low magnitude events (<2.5 Richter) whereas the area around Fort St. John and Septimus recorded six events; one event measured on May 27 was interpreted as a 4.2 Richter event, and was felt on surface in Fort St. John (11 km north of the epicentre). No damage or injuries were reported. There were two subsequent aftershocks of 2.8 and 2.5 Richter on May 28 and June 2, respectively. Subsequent work by NRCan has put the focal depth of the original event at approximately 3 km below surface. The Beg area has noted 10 events, all within a 5 km radius suggesting good epicentre resolution.

Additional Work

The network is continuously being reviewed by the technical partners to ensure that the best accuracy and precision is achieved. The initial five months of operation have demonstrated epicentre accuracy that appears to be in the 2–15 km range. Epicentre resolution, although inconsistent, has

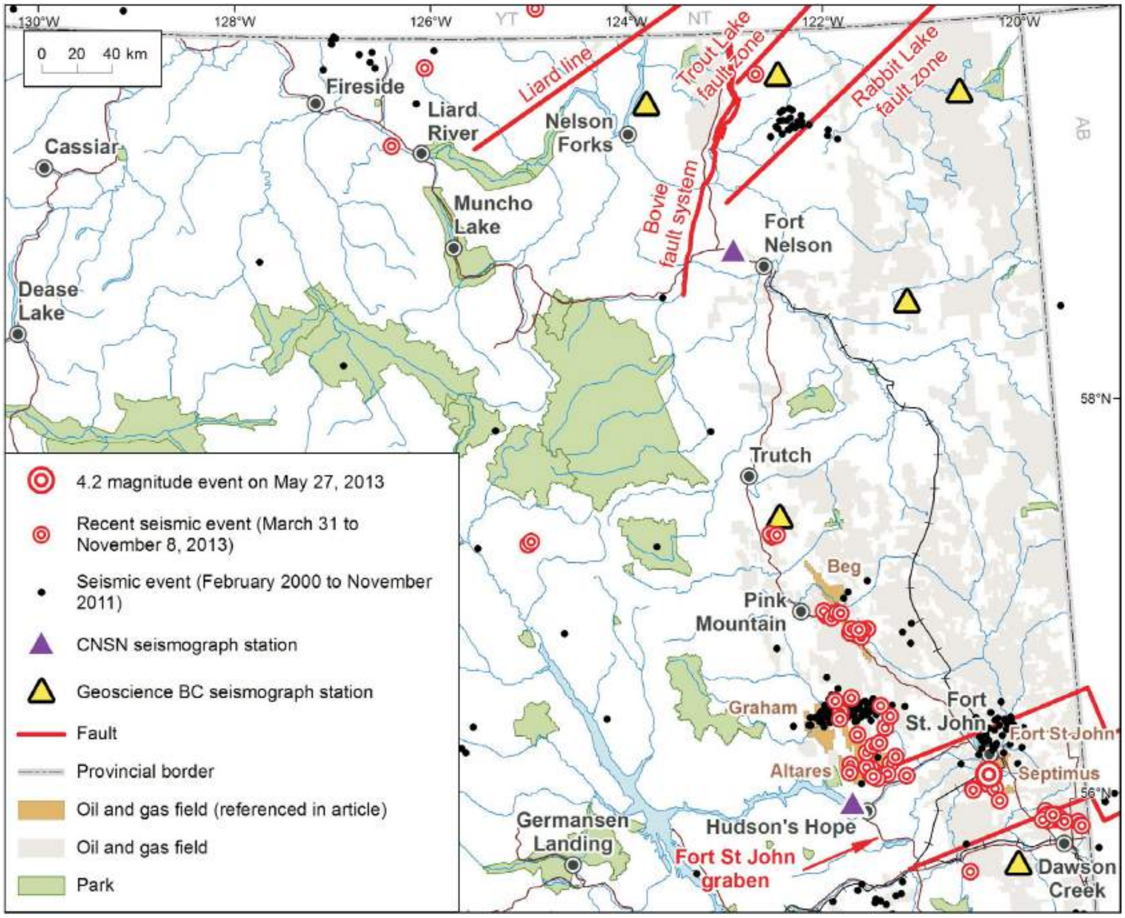

Figure 3. Location of anomalous seismic events captured by the CNSN network from February 2000 to November 2011 and by the enhanced network from March 31 to November 8, 2013, northeastern British Columbia.

been steadily improving with additional calibration to industry, high density, microseismic arrays, and is now generally estimated to be within 5 km. Epicentre resolution also seems to vary spatially across the region. Minimum magnitude resolution has been estimated to be 1.5–2.0 M_L (local magnitude). Further technical work is necessary to optimize and calibrate the system for it to reach its expected potential. A technical plan is currently being devised to further improve magnitude and epicentre resolution.

The data collected by the network is currently being used by BCOGC, not only for monitoring induced seismicity, but also for the development of protocols necessary for responsible hydrofracturing operations.

It is expected that NRCan and BCOGC in conjunction with the University of BC, among others, will publish studies based on data collected from the consortium's seismic network.

At the end of the five-year project, several outcomes could ensue:

- termination of the project,
- additional funding for more monitoring,
- transferal of the stations to the CNSN or
- decommissioning of the network.

Conclusion

The consortium's regional seismograph network was installed mid-March and has been fully integrated into the CNSN as of August 2013. Epicentre and magnitude resolution have been improved greatly since installation of the network. The technical committee will continue to look for ways to optimize the network.

The network has noted low magnitude events concentrated in the Beg, Altares and Graham, and Fort St. John and Septimus areas. The data collected by the network is being used by BCOGC to develop the needed protocols for responsible fraccing and fluid disposal operations. It is expected the collected data will initiate future academic studies into fraccing and fluid disposal induced seismicity.

Reference

BC Oil and Gas Commission (2012): Investigation of observed seismicity in the Horn River Basin; BC Oil and Gas Commission, Technical Report, 29 p, URL <http://www.bcogc.ca/document.aspx?documentID=1270> [August 2012].