Creating a Regional Seismograph Network in Northeastern British Columbia to Study the Effect of Induced Seismicity from Unconventional Gas Completions (NTS 094C, G, I, O, P)

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Introduction

Recently, geoscientists have applied their knowledge of rock mechanics and geophysics to develop shale gas reserves through multistage, high volume, hydraulic fracturing completions of horizontal wells and monitoring these completions with microseismic geophone arrays. Along with the routine microseismicity created by hydraulic fracturing, 250 low magnitude seismic events were triggered by fluid injection while hydraulic fracturing (fraccing) in the Horn River Basin of northeastern British Columbia from April 2009 to December 2011. The BC Oil and Gas Commission (BCOGC) released a report on these events in August 2012, which noted that over 8000 high volume hydraulic fracturing completions have been performed in all of northeastern BC with no associated seismicity (BC Oil and Gas Commission, 2012). None of these events caused any injury, property damage or was found to pose any risk to public safety or the environment.

The BCOGC has recommended augmenting the Canadian National Seismograph Network (CNSN) to better track the effects of completions and induced seismicity. Enhancements to the seismograph network will increase the understanding of induced seismicity and its relationship to oil and gas operations, such as fraccing and injection. 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, and improving this seismograph array network is one step in increasing the understanding of this relationship.

A consortium headed by Geoscience BC, along with the Canadian Association of Petroleum Producers (CAPP), BCOGC and Natural Resources Canada (NRCan), has initiated a project to add six seismograph stations to complement the two pre-existing CNSN stations. The state-of-the-art stations will provide the necessary data needed to further understand the relationship between multistage fraccing and induced low magnitude events and ultimately aid in the responsible development of unconventional gas resources.

Keywords: *seismicity, unconventional gas, seismograph, fraccing, Horn River Basin*

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Background

During the period between April 2009 and December 2011, 38 low level seismic events were recorded by the CNSN's two stations near Hudson's Hope and Fort Nelson (Figure 1). The events ranged in magnitude between 2.2 and 3.8 on the Richter scale. The largest event (May 19, 2011) 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. The seismograph stations can detect events down to 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 (United States Geological Survey, 2012). Those on the lower end of the range (i.e., 2.0 Richter) are rarely felt while those on the upper range (i.e., 3.9 Richter) are often felt but rarely cause damage.

The current CNSN has several technical limitations when used for the study of induced seismicity (BC Oil and Gas Commission, 2012). The first shortcoming is due to the limited station coverage, which results in a 5–10 km uncertainty on the epicentre's location while carrying an even larger uncertainty on the focal depth. Secondly, although the instruments 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 >2.4 Richter during a two-month period. Hence, it is

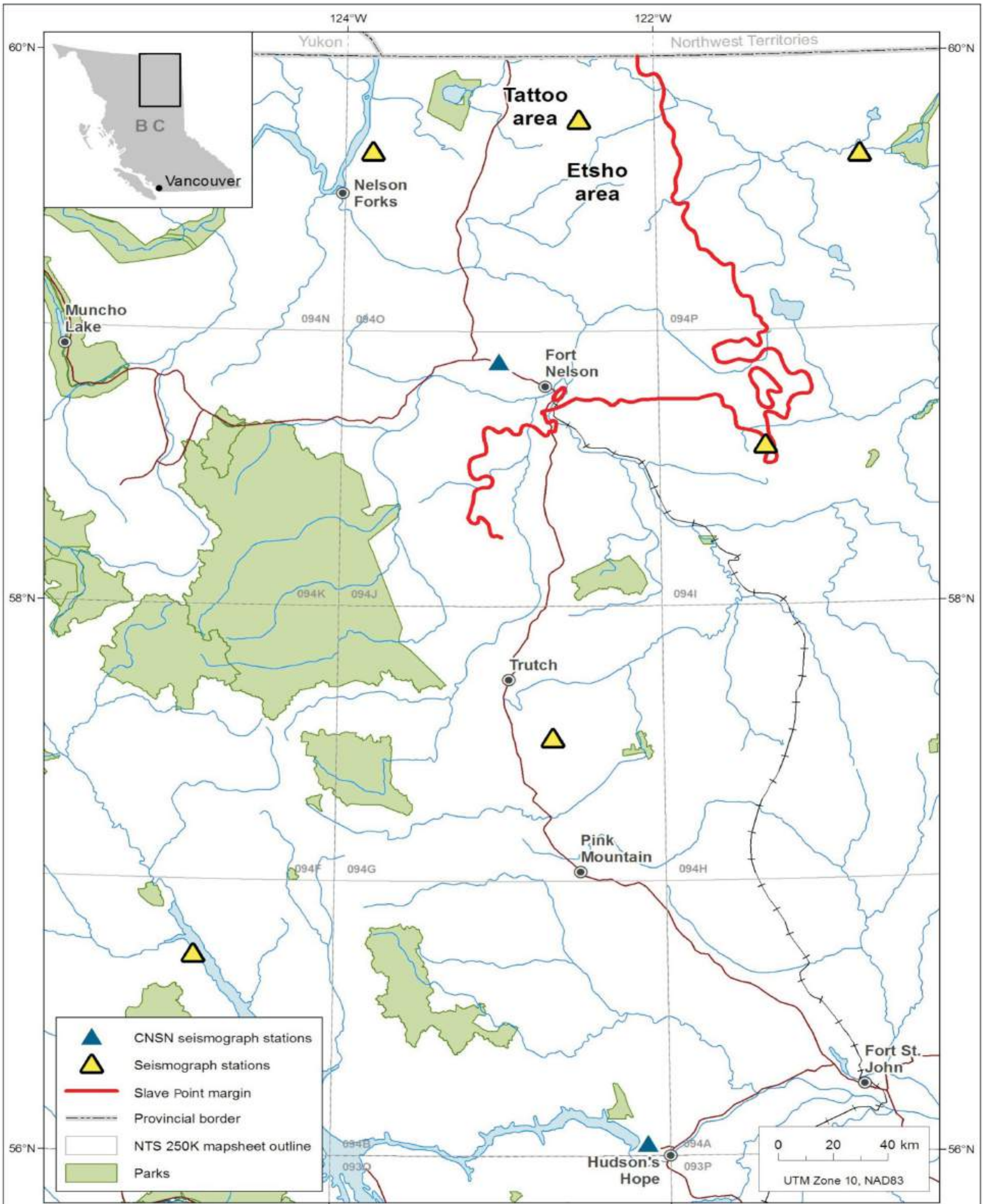

Figure 1. Map of northeastern British Columbia showing the locations of the two current Canadian National Seismograph Network (CNSN) seismograph stations and the site locations for the six Geoscience BC-led consortium seismograph stations.

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), the BCOGC noted the low level seismic events were centred around 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 completion operations and occurred at approximately the same depths as the fracturing stages. Furthermore, it was surmised that the anomalous induced seismicity seen over the period between April 2009 and December 2011 was the result of fault movement due to hydraulic fracturing.

The BCOGC report concluded with seven recommendations:

1) improve the accuracy of the CNSN in northeastern BC,
2) perform geological and seismic assessments to identify pre-existing faults,
3) establish procedures and requirements for induced seismicity monitoring reporting,
4) station ground motion sensors near selected northeastern BC communities to quantify the risk from ground motion,
5) the Commission will study the deployment of a portable dense seismograph array to selected locations where induced seismicity is anticipated or has occurred,
6) require the submission of microseismic reports to monitor hydraulic fracturing for containment of microfracturing and to identify existing faults, and
7) study the relationship between hydraulic fracturing parameters and seismicity.

Creation of a Consortium to Study Induced Seismicity in Northeastern BC

In response to the BCOGC's recommendations, a consortium was created between Geoscience BC, CAPP, BCOGC and NRCan to expand the CNSN in northeastern BC. The data collected will be analyzed, interpreted and published on Geoscience BC's website (www.geosciencebc.com). The project is managed by Geoscience BC and jointly funded by Geoscience BC and CAPP, with in-kind technical support provided by BCOGC and NRCan. A technical committee will be appointed by the partners to oversee the technical work. The budget for the research program is $1.0 million over five years.

Technical Specifications and Interpretive Workflow

Six new seismographs will be installed throughout northeastern BC to augment the coverage of the CNSN (Figure 1). At four of the locations, the seismographs are mounted on screw-piled pads, set to a depth of approximately 10 m, at the site of 5 by 5 m pads, usually using pre-existing well pads. The other two seismographs are mounted directly on bedrock. The chosen seismographs are state-of-the-art Trillium 120PH broadband seismographs. They are solar powered and have very low power consumption. The seismographs will be installed, maintained and operated by Nanometrics Inc.

Once data has been received at the station, it is 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 is not in real time, unless the seismic event is >4.0 Richter, at which time it would be reported in real time. It is expected that there will be a 1–2 day delay between when the data arrives and the posted interpretation of the seismic event. The seismic events will be posted on the Earthquakes Canada (NRCan) website (http://www.earthquakescanada.nrcan.gc.ca/recent/maps-cartes/index-eng.php).

The stations are currently being permitted and installation is expected to begin by year-end. It is anticipated that the network will be operational in early 2013.

Acknowledgments

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