Preliminary Results of a Passive Seismic Investigation in the Nechako Basin for Mineral and Petroleum Exploration

Melvyn Best*
Bemex Consulting International, Victoria, BC, Canada
best@islandnet.com

James Lakings
Microseismic Inc., Houston, TX, United States

Fil Ferri and Janet Riddell
British Columbia Ministry of Energy, Victoria, BC,Canada

and

John Cassidy
Geological Survey of Canada Pacific, Sidney, BC, Canada

Introduction

The Nechako Basin in Northern British Columbia is part of an area that is recently being revisited for petroleum and mineral exploration. Petroleum exploration in the southern portion of the basin was carried out in the early 1980's by Canadian Hunter. They ran a series of 2D seismic lines, generated a Bouguer gravity map of the entire south portion of the basin and drilled several exploratory wells. Although sediments were encountered along with minor gas kicks and oil staining in the wells the results were not encouraging enough at the time for them to continue. No further petroleum exploration activity has been conducted in the basin since then.

The poor quality of the 2D seismic data due to near surface basalt flows has been a major factor in preventing exploration activity in this area. The problem of poor seismic in basalt covered areas is not new. There are many places with similar problems such as the Columbia Plateau, portions of the Libyan dessert and central western India.

Methodology

Several passive seismic projects are presently being undertaken within the Nechako basin to try and overcome the problems associated with basalt flows.

The first is a project between GSC Pacific, the BC Ministry of Energy, Mines and Petroleum Resources, and the University of Manitoba. Seven broadband seismograph stations have been deployed across the Nechako Basin. These will continue to operate until the summer of 2008, with recordings of distant and regional earthquakes being used to map the sedimentary structure and crustal thickness of the basin.

Specifically, waveforms from distant earthquakes will be used to resolve the shear-wave velocity structure beneath the Nechako Basin and provide information on the thickness and nature of basin-fill sedimentary rocks and also on the thickness of the underlying crust. The advantages of this method are numerous – using natural earthquake sources means that permitting/explosions are unnecessary; the energy is “coming from below” enabling us to see “below the basalts” that blanket the underlying prospective units and have degraded the quality of active source seismic data; and the S-wave information obtained complements the P-wave information obtained from active source seismic studies. The combination of P- and S-wave velocity information provides constraints on Poisson’s ratio, which is indicative of lithologic composition.

To date, an array of seven seismic stations has been deployed (in September, 2006) to sample the entire basin, and during the first two months of operation more than a dozen useful events have been recorded. The results of this study will complement independent active source seismic studies that are planned for the region, by providing images using waves “from below”.

The second project was an 8 week test (October to December, 2006) using an array of five 3-component geophones to determine the microseismic activity in the SE corner of the Nechako basin. The five 3-component geophones (4.5 Hz) were deployed at the corners of a rectangular area approximately 15 km by 25 km with one station near the center of the area. The purpose is to determine if there is enough local seismic activity to carry out a more detailed tomographic velocity inversion of this area using a larger array of 3-component geophones. The area picked for this test was selected because it is associated with a gravity low, there are several old 2D seismic lines in the area, as well as a well for calibration (Figure 1).

The seismic data were recorded in a continuous mode using five Reftek RT130 seismographs. The data were digitized using a sample rate of 2 ms with a +30 dB gain. The Refteks recorded the data using flash memory. Because flash memory was limited to 4 gigabyte per seismograph the data were manually collected three times during the course of the survey and then transferred to a laptop PC. The recording configuration was designed to measure the rate and strength of the local background seismicity in this area and constrain an array design that would be appropriate for mapping structure at scales that are useful for further exploration.

The records from each station were processed using a trigger detection algorithm. A trigger was generated when the 1 second short-term average; (STA) exceeded the 30 second long term average, (LTA) above a given threshold level on two of the three geophone channels for that particular station. The STA/LTA power ratio of 15 dB was used as the threshold level. This ratio was based on other previous, successful microearthquake surveys in environments with similar cultural noise characteristics. A one minute SEG-y event file of all the active stations was output when three or more station triggers could be temporally associated within a five second time window.

Results

Over 1037 trigger files were generated between October 12 and December 17, 2006. A visual inspection of the trigger records was done in order to classify the events as local microearthquakes, regional earthquakes, teleseismic (deep focus) earthquakes or false triggers/air blasts. The majority of the events were false triggers created by air blasts associated with mining or other cultural activities that were coincidental within the area. Local microearthquakes were selected based on the character and arrivals of their phases. High frequency events with arrival time differences between the P-wave and S-wave that are less than five seconds are classified as local microearthquakes. Additionally, these events also have a strong partition of their phase amplitudes on the seismometer components; the P-waves arrive primarily on the vertical component and S-waves arrive dominantly on the horizontal components.

Of the 1037 triggers, only seven were found to be local microearthquakes. Hypocenter locations of four of these events were reliably obtained. The remaining three did not have sufficient S/N to properly locate. The magnitudes of the non-locatable events were 0.5 or less and likely too far from the array center.

The event epicenters show the local earthquakes to be occurring outside of the center of the array. Two events plotted to the west, while the other two plotted to the SE. The events to the SE of the array occurred in close proximity to the location of a magnitude 3.0 event as reported in the NRCAN catalog of earthquakes. This magnitude 3.0 event is the only significant historical earthquake in this area. The background level of seismicity here is consistent with that of a magnitude 3.0 event recurring every 10 years or so over this 4200 square kilometer area.

Summary

Although the number of local microseismic events was not sufficient to carry out tomographic inversion ***economically*** the data will compliment the regional study being carried out using the broadband seismographs and will provide additional information on basin structure. For example by integrating S-velocity information with gravity and MT data, results can be verified and constraints on pore-fill fluids and fracture characteristics can be estimated. This information can be used to develop and constrain models of basin architecture, identify pathways for fluid migration and provide insight into basin composition, all of which are required to further our understanding of the basin's resource potential.

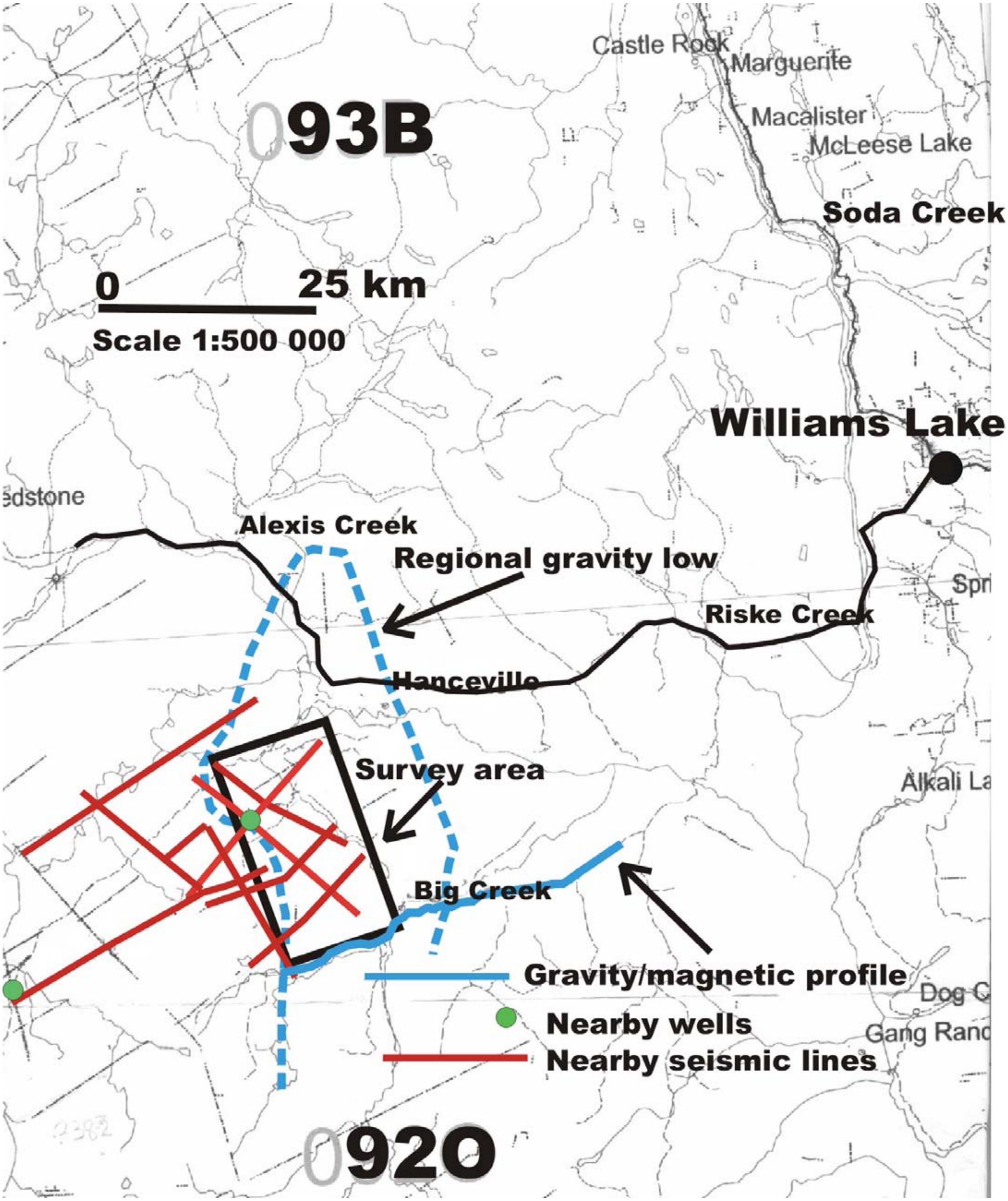

Figure 1. Location map of microseismic investigation area with gravity low, old 2D seismic lines and well locations shown as well. The blue line is a recent gravity magnetic profile collected to confirm the earlier Canadian Hunter gravity data.