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Seismic Imaging Beneath the Volcanic Rocks of the Nechako Basin, British Columbia

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Summary

To date there has been only minor exploration for hydrocarbons in the Nechako basin, which underlies much of the Cariboo-Chilcotin plateau of central British Columbia. A major impediment to exploration of the basin is the extensive surface cover of Tertiary to Recent volcanic rocks, which can reach thicknesses as great as 600 m. The most recent exploration effort, which ended in 1986, was undertaken by Canadian Hunter, and provided highly variable seismic imaging of the stratigraphy and basin architecture, in part due to the effects of the surface volcanics. In summer 2008, Geoscience BC acquired 330 km of seismic data in the central part of the basin to constrain the distribution of Cretaceous sedimentary rocks. We present the initial results of this survey, and assess the effectiveness of modern seismic acquisition in this volcanic-covered environment.

Introduction

The Nechako Basin, which is located in the interior plateau of British Columbia between the Coast Mountains and the Rocky Mountains, has seen very little exploration for hydrocarbons, in marked contrast to the western Canadian sedimentary basin. Investigation of reports of surface oil and gas in the Kersley area, south of Quesnel, led to the drilling of the first well in 1931, with some further wells drilled in the same area in the 1950s, but no oil and gas shows were identified (Hayes, 2002). In 1960, Honolulu Oil acquired 44 line-km of seismic data near Nazko, west of Quesnel, and drilled one well, a-4-L (Figure 1), which was dry with a few live oil shows (Ferri and Riddell, 2006). In an attempt to define better the basin stratigraphy, Hudson's Bay Oil and Gas drilled well c-75-A in the southern part of the basin near Redstone, also in 1960. In 1972, another well was drilled near Punchaw, southwest of Prince George, and although some oil stains were noted at fault contacts, the well intersected 250 m of unconsolidated material above volcanic rocks identified as being from the Cache Creek terrane (Ferri and Riddell, 2006). The only extensive exploration of the Nechako basin was carried out by Canadian Hunter Exploration between 1979 and 1986. The company acquired approximately 3000 line-km of gravity data and 1300 line-km of seismic data, and drilled two wells in 1980, another two in 1981, and a final well in 1985, before abandoning its exploration of the area. Ten gas shows were reported in three wells, and 26 live oil and 49 dead oil shows were detected during drilling (Hannigan et al., 1994)

The structure and hydrocarbon potential of the basin was most recently reviewed by Hannigan et al. (1994), but remains poorly understood. Some key results of Hannigan et al.'s study are summarised here. Exploration wells have penetrated Early Eocene to Pliocene sediments, but no hydrocarbon shows were detected. Typically these sediments are interbedded with volcanic sequences, whose thicknesses can exceed 1000 m. Porosity in sands average approximately 8%. Late Cretaceous oil and gas plays involve open and transitional marine to terrestrial sediments, which filled the Nechako Basin from the east. Structural traps would likely involve compressional folds and drag folds over thrust faults, together with normal fault blocks that formed in the Middle to Late Eocene. Primary porosity in these rocks appears to be very low, but secondary fracture porosity does exist. Carbonaceous and bituminous shales and sandstones plus some coal suggest a potential for the generation of gas. The most significant oil and gas plays in the Nechako Basin are in Taylor Creek (Riddell et al., 2007) and Skeena (Hannigan et al., 1994) sedimentary rocks, which can be as thick as 400 m to 3000 m, derived mostly from the east by uplift of the Omineca belt in the Early Cretaceous. Potential reservoir sands have been suggested within both marine and non-marine sandstone and shale sequences. Five wells have penetrated these Cretaceous strata, where all the oil and gas shows in the Canadian Hunter wells were identified. Jurassic rocks in the Nechako Basin are generally metamorphosed, and likely to be overmature with regard to hydrocarbon preservation.

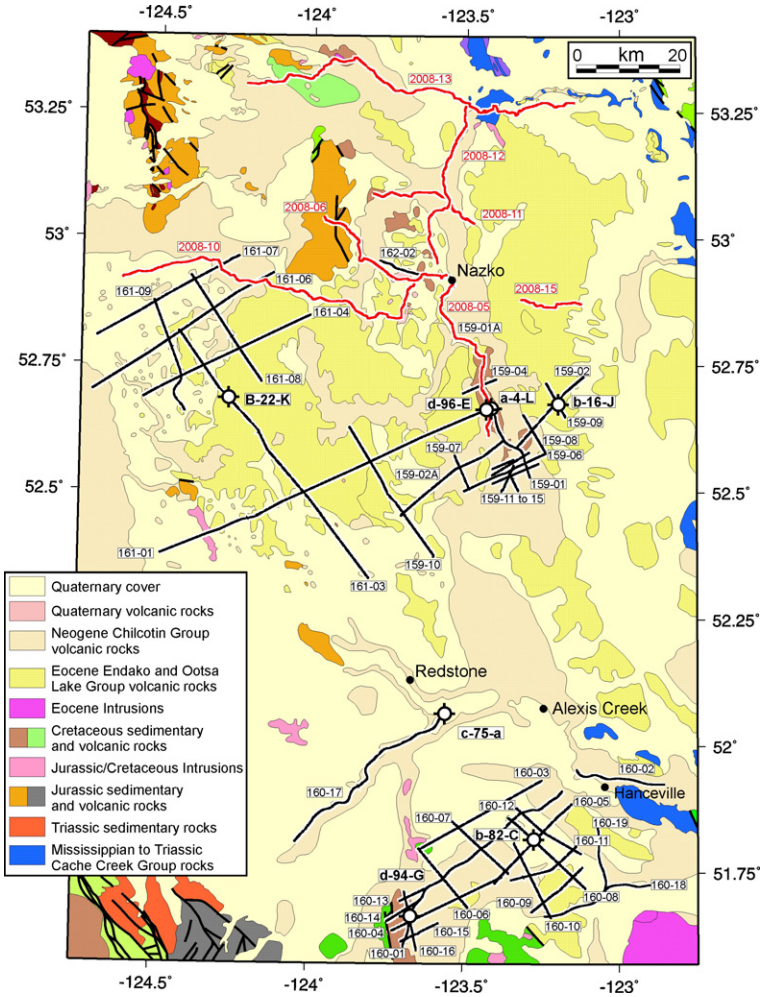

Figure 1. Nechako basin showing the 1020 line-km of the Canadian Hunter seismic lines (black) that were reprocessed by Geoscience BC, and the 300 line-km acquired by Geoscience BC in summer 2008 (red).

The evolution of Nechako basin is poorly known, because much of the basin is covered by Tertiary and more recent volcanic rocks and glacial deposits. Jura-Cretaceous rocks found along the southern and northern margins of the basin probably continue under the volcanic/glacial cover, but their subsurface extent has not been well defined. Cretaceous rocks are exposed along the Nazko river valley, and define a NNW-striking trend at the surface in the central part of the basin (rocks shown as brown in Figure 1). Rocks of this age are also found further south in a few limited surface outcrops, and the three southern exploration wells. With the extensive volcanic cover and limited geophysical data, it is not clear if the Early Cretaceous sedimentary rocks were deposited within separate sub-basins or if they are the remnants of a much larger basin. This fundamental question on the nature of Nechako basin was not resolved by the seismic data acquired by Canadian Hunter, because the quality of the images was often poor, likely due to the combined effects of the volcanic cover and the seismic acquisition technology available at the time (Hayward and Calvert, 2008). There is therefore a strong argument for acquiring extensive regional geophysical data across the basin. In summer 2008, Geoscience BC acquired 330 km of seismic data near Nazko along and across the NNW-oriented surface trend of Early Cretaceous rocks in the central Nechako basin. The primary objectives of the survey were:

1) To evaluate the effectiveness of modern seismic acquisition technology in this volcanic-covered basin;
2) To map the extension into the subsurface of the outcropping Cretaceous rocks, and to identify the primary structural controls on their distribution in the central part of the basin.

Seismic Acquisition Parameters

The quality of the Canadian Hunter vibroseis seismic data, is quite variable, likely due to the effects of the near-surface volcanic rocks, which can reach a thickness of 600 m. In some volcanic areas, very few first arrivals can be observed, suggesting that source coupling can be a significant problem. In other areas where volcanic rocks lie at the surface, first arrivals were well recorded to the maximum offset, but no laterally continuous underlying reflections are present on the stack section. In areas with no volcanic surface rocks, the data quality is usually reasonable given the technology of the time. Therefore much of the new survey design was directed towards maximising the signal to noise ratio, and the main characteristics of the survey were:

1) Large array of vibrators and long sweeps to maximise source effort;
2) High stack fold through the use of a short source interval and large number of recording channels;
3) Restriction of the sweep to lower frequencies to improve transmission through near-surface volcanic rocks;
4) Long offsets to record deeper, sub-volcanic reflections and first arrivals that can constrain the thickness of the volcanic layer, and perhaps the depth to the igneous basement;
5) Extended correlation of long sweeps to record mid-lower crustal reflections that will constrain the evolution of any sub-basins and provide data QC in areas where shallower reflections may not be present.

	GBC 2008	CH 1981
Source interval (m)	40	100
Receiver interval (m)	20	50
No. channels	960	96
Max. Offset (m)	14390	2550

Nominal fold	240	24
Fold at 0.5 s (est.)	50	20
No. vibrators x weight (kg)	4 x 24,000	5 x 7467
No. sweeps per VP	4	16
Peak force (%)	80	60-75
Sweep duration (s)	28	15
Sweep bandwidth (Hz)	8-64	10-70

Table 1. Comparison of key parameters between the 1981 Canadian Hunter seismic survey and those used in the 2008 Geoscience BC survey.

In this paper, we present an initial interpretation of these new seismic data, and review the effectiveness of this survey at imaging the basin structures under the volcanic cover.

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