# QUALITATIVE INTERPRETATION OF POTENTIAL FIELD PROFILES: SOUTHERN NECHAKO BASIN

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## INTRODUCTION

The Nechako basin (Fig. 1) is one of several interior basins within British Columbia. Although the potential for economic quantities of hydrocarbons exists within the basin (Hannigan et. al., 1994) only limited exploration has been carried out. Quaternary surficial sediments and Tertiary volcanic outcrop cover large areas of the basin, limiting surface geological mapping and potentially creating seismic acquisition problems. In addition volcanic rocks within the sedimentary section can cause seismic acquisition and processing problems. The presence of these volcanic rocks also complicates the interpretation of seismic and magnetic data.

Several companies explored for oil and gas within the Nechako basin prior to 1980 but no commercial quantities were found. In the early 1980's Canadian Hunter carried out an exploration program consisting of a regional gravity survey, a limited number of 2D seismic lines and the drilling of several wells (Petrel Robertson, 2002). As no economic accumulations of hydrocarbons were encountered during drilling they abandoned the play. No additional exploration activity has been conducted since that time.

As part of the BC government's initiative for economic development within British Columbia, Bemex Consulting International was awarded a contract to carry out ground gravity and magnetic surveys in the southern Nechako basin. The purpose of the survey is to promote the basin's potential and to illustrate how integrated potential field data can provide constraints on basin structure, sediment thickness and volcanic structures within the sedimentary section. An approximate east-west profile was selected for this survey based on the regional gravity data collected by Canadian Hunter. Data collected along this profile included gravity, total field magnetic and the vertical gradient of the total field. Elevations and UTM coordinates were acquired along the profile as well.

This report describes the data acquisition and processing steps for the ground geophysical survey as well as a preliminary qualitative interpretation of these profiles.

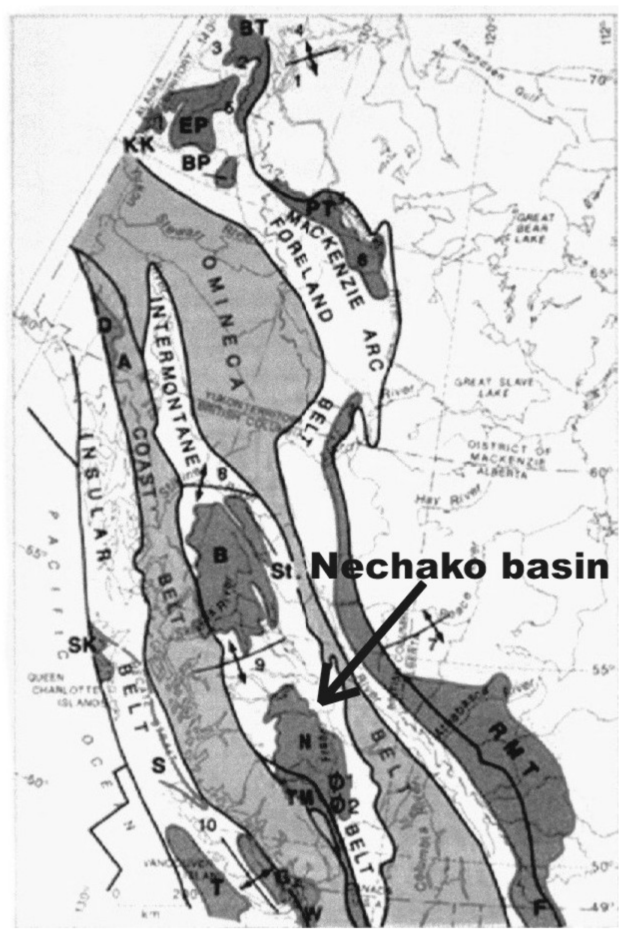


Figure 1. Morphological Belts of the Canadian Cordillera showing the position of the Nechako Basin and related tectonic elements (from Yorath, 1991). Note: B = Bowser basin, N = Nechako basin.

## ACQUISITION AND PROCESSING

Ground gravity and magnetic data were collected along a 33 km profile at approximately 330 and 165 m spacing respectively. The data were collected along the road that connects Riske Creek and Big Creek (Fig. 2).

The location of the profile was chosen to cross a significant gravity low centered near Big Creek that was observed on the Canadian Hunter regional gravity survey.

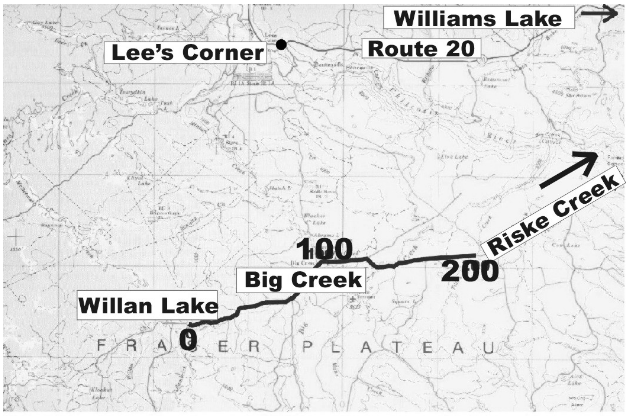


Figure 2. Location of profile along Big Creek – Risk Creek Road (from NTS 92O). The profile goes from station 0 in the west near Willan Lake to station 200 in the east.

A Lacoste-Romberg gravity meter was used to measure the relative change in gravity between each station. Measurements at several stations were repeated approximately 4 hours apart to correct for instrument and tidal drift. Relative elevations were measured at each gravity station using a laser level. These relative elevations were then tied to a known elevation above sea level near station 122. UTM coordinates (NAD 83) were obtained from BC TRIM maps at a scale of 1:50 000.

A GEM rover gradiometer was used to measure the magnetic field and the vertical gradient of the magnetic field at each gravity station and approximately mid-way between each gravity station. A second GEM magnetometer was used as a base station. Several base stations were located along the profile, depending on where the roving survey was being conducted that day.

Processing of the gravity data consisted of drift corrections, latitude corrections, free air elevation corrections and Bouguer elevation corrections (a Bouguer density of 2350 $kg/m^3$ (2.35 g/cc) was determined from tests carried out over areas with significant topographic relief. The density is consistent with the density used for the Canadian Hunter survey). Terrain corrections up to and including ring D (Hammer, 1939) were also computed. The overall accuracy of the gravity data is estimated to be ± 0.60 mGal, or better.

The total magnetic field data were corrected for diurnal variations using the base station readings. No other corrections were applied to the total magnetic field data and the vertical gradient of the total magnetic field data.

Plots of the corrected gravity data, elevation above sea level and corrected magnetic field data are given in Fig. 3. More details on data acquisition and processing can be found in Best (2004).

## REGIONAL SETTING

The Nechako Basin is a Mesozoic forearc basin (Yorath, 1991), located in the Intermontane belt of the southern Canadian Cordillera (Fig. 1). Spatially, the Nechako Basin is bounded by the Skeena Arch to the north, the Fraser River Fault System to the east, and the Coast Mountain plutons to the west (Fig. 1).

The tectonic history of the Nechako Basin is complex. Its structural geology is poorly understood, due largely to extensive Quaternary sediments covering the surface and large areas of Tertiary volcanic outcrop. Outcrops of deformed Mesozoic sediments are present, but isolated within the basin proper. More continuous outcrop occurs along the western flank (Petrel Robertson, 2002).

The Nechako Basin sediments were derived from bordering uplifts related to contraction during terrane accretion (Gabrielse et al.., 1991). The Takla and Hazelton Groups, comprising volcanic and sedimentary strata, were deposited during Triassic and Early-Middle Jurassic time. The formation of the Skeena Arch (Yorath, 1991) during middle Jurassic (?) segregated the Nechako Basin from the Bowser Basin to the north.

In Middle Jurassic to Early Cretaceous time, the Intermontane and Insular super-terranes were accreted to each other, and to North America. (Gabrielse and Yorath, 1991). Sedimentation from the resulting uplifts was shed both west into the Nechako Basin and other intermontane basins and east into the Rocky Mountain Fold belt. Transpressional tectonics dominated until the Eocene, at which time there was a change to a regime of dextral transtension (Price, 1994), and an episode of associated magmatism.

Deformation styles in the Nechako Basin were affected by both lithological contrasts and tectonics. Deformation of Stikine and Cache Creek rocks can be related to early Mesozoic accretionary prisms and subduction zones. Structures related to the early Mesozoic include folds and (northwest trending) thrust faults, which verge either east or west, depending on position in the Intermontane Belt (Grabrielse, 1991, Price, 1994). Major transcurrent faults, related to Eocene extension, cut and bound the basin.

## PRELIMINARY INTERPRETATION OF GRAVITY AND MAGNETIC PROFILES

The final processed gravity and magnetic data are shown in Fig. 3. The gravity profile confirms the presence of a low near Big Creek with a magnitude comparable to that of the low on the regional CanadianHunter gravity map (Petrel Robertson, 2002). This feature has an approximate width of 20 to 25 km.

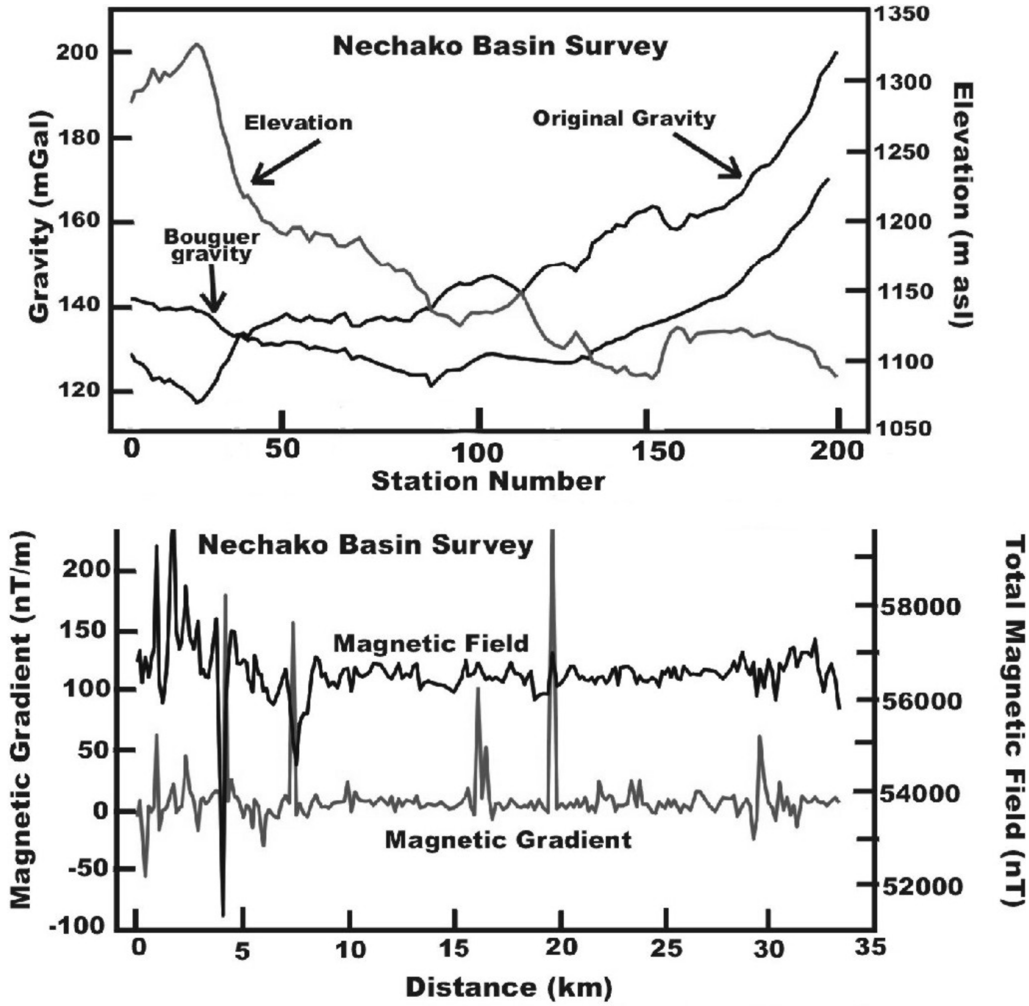


Figure 3. Elevation above sea level, corrected gravity and corrected magnetic data versus distance (km) from station zero. Station number is shown on the upper diagram with station zero at the western end of the Big Creek–Riske Creek profile.

A plot of a linear regional gravity trend passing through stations 0 and 200 of the final gravity data is provided in Figure 4(a). Although a linear regional trend may not be the best choice it is as good a choice as any for this single profile. Figure 4(b) is the residual gravity data after the linear regional trend has been subtracted from the gravity data.

There are several features worth noting along the gravity profile in Fig. 4(b). A gravity low centered near 14.5 km has a width of approximately 800 m and a magnitude of 3 to 4 mGal. This feature may be related to a paleochannel associated with Big Creek since the profile is closest to the creek at this location. A broader low with a magnitude of 3 to 4 mGal centered around 21 km has a width of approximately 3 to 4 km. Neither of these local lows appear to be associated with elevation changes (Fig. 3).

The gravity low that crosses the entire profile has a magnitude of approximately 35 mGal. Negative gravity anomalies are caused by material of higher density surrounding lower density rocks centered over the negative anomaly. There are an infinite number of models that can fit the gravity data.

One tempting model is to assume a fault-related grabben filled with low density sedimentary rocks. Figure 5 is an example of such a density model that fits the general shape of the residual gravity anomaly. In this case it is a 3 to 4 km thick, low density body (0.3 g/cc lower than the surrounding rock) centered over the gravity low. The top of the body is this case is only a few hundred metres below the surface.

Unfortunately a change in volcanic rock type (density) could also cause such a gravity low. Without additional information we cannot be sure of the model.

The total magnetic field data and vertical gradient are also shown in Fig. 3. The average value of the total magnetic field is approximately 57,500 nT between stations 0 and 36 (0 and 6 km). There are large variations within the magnetic field (from 52,000 to 60,000 nT) along this same segment of the profile. These large magnetic field values are associated with higher elevation and are likely related to shallow basalt flows. This may explain, at least in part, the tendency towards higher gravity values in that region.

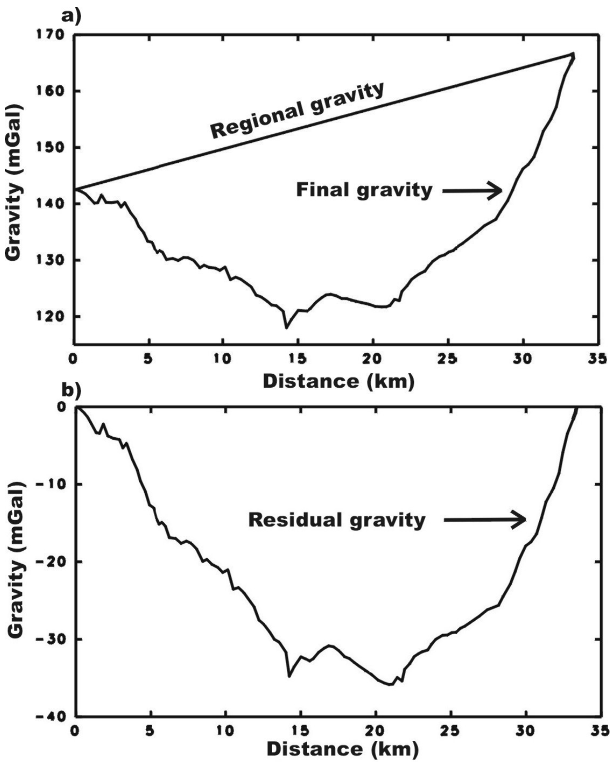


Figure 4. Regional-residual gravity separation. a) Bouguer gravity and linear regional gravity. b) Residual gravity (regional minus Bouguer).

The rest of the profile has an average total field value closer to 56,500 nT, with less variation in the magnetic field magnitude. The magnetic features from station 36 to the end of the line at station 200 are therefore likely deeper than the magnetic features between station 0 and station 36. The deeper magnetic features are coincident with the gravity low which perhaps indicates that sediments may exist above the magnetic basement in this area.

## RECOMMENDATIONS FOR FURTHER INTERPRETATION

The qualitative description of the gravity and magnetic profiles presented above is quite limited. However if the gravity and magnetic profiles are studied in conjunction with regional potential field data a more detailed interpretation can be provided.

Consequently we recommend integrating the above profiles with regional potential field data (GSC regional aeromagnetic data and the Canadian Hunter regional gravity data) to carry out a preliminary interpretation of the southern portion of the Neshkoro basin, particularly in the vicinity of the regional gravity low.

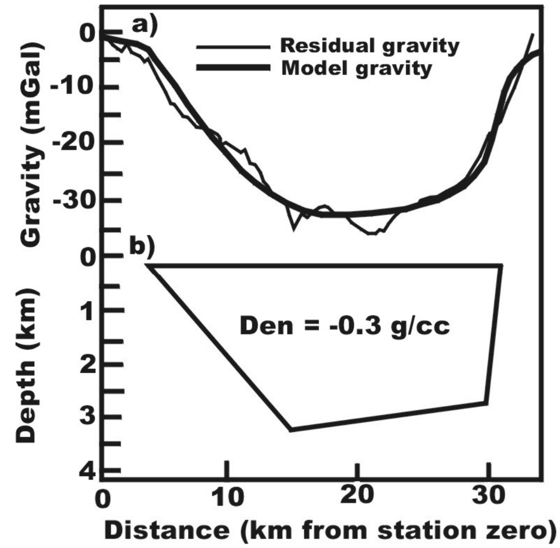


Figure 5. Example of two-dimensional gravity modelling a) Model versus residual gravity data b) Depth model assuming a density contrast between the host rock and gravity anomaly of -0.3 g/cc.

In addition to the regional potential field data the interpretation should incorporate geological information as well as all available well and seismic data. One or more of the Canadian Hunter seismic lines that cross or are close to the regional gravity low should be incorporated into the interpretation (they should be reprocessed first, if the digital data is available). The seismic and well data can be used to provide depth constraints for the quantitative interpretation of the gravity and magnetic data.

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