PRELIMINARY INTERPRETATION OF THE SOUTHERN NECHAKO BASIN FROM POTENTIAL FIELD DATA

Melvyn E. Best[1]

Best, Melvyn E., (2008), Preliminary Interpretation of the Southern Nechako Basin from Potential Field Data in Geoscience Reports 2008, *BC Ministry of Energy, Mines and Petroleum Resources*, pages 1-7.

[1]Bemex Consulting International , 3701 Wild Berry Bend, Victoria, B.C V9C 4M7; 250-657-4225; Best@islandnet.com

INTRODUCTION

The Nechako Basin is one of the interior basins within British Columbia (Figure 1). Most of the basin is covered with glacial overburden of variable thickness, and in the southern Nechako Basin basalt flows cover a significant portion of the surface (Riddell 2006). The report focuses on the southern portion of the basin for two reasons: firstly, sediments are known to exist in the southern portion of the basin, implying at least the possibility of oil and gas accumulations, and secondly, a regional gravity survey was carried out by Canadian Hunter Exploration Limited in the southern Nechako Basin.

In the early 1980s Canadian Hunter carried out an exploration program consisting of 2D seismic reflection and gravity surveys (Best 2004). The quality of the original seismic data was generally poor due to the basalt cover, thus making subsurface mapping difficult. The gravity survey located a number of Bouguer gravity lows within the survey area that could be sediment-filled basins. Several wells were drilled based on the combined survey results, but no commercial accumulations of hydrocarbons were found. However, sediments were encountered in a couple of wells, as well as oil staining and gas kicks. Since that time, no exploration activity has taken place within the basin.

This report discusses the steps involved in processing the Canadian Hunter gravity data and the Geological Survey of Canada (GSC) aeromagnetic data for the southern Nechako Basin (Figure 1). A discussion is presented of how the gravity data set was manipulated to produce a digital grid. The aeromagnetic data were provided by the GSC as a 200 m by 200 m digital grid. This report explains how subsidiary maps, such as derivative and shaded relief maps, were obtained from the digital grids.

One of the objectives of this report is to provide access to the maps and images generated during this project. The maps and images available are listed in Appendices A and B of this report; they can be downloaded from the Interior Basins website of the BC Ministry of Energy, Mines and Petroleum Resources at the following web address; http://www.em.gov.bc.ca/subwebs/oilandgas/petroleum_geology/cog/interior.htm. In addition, a preliminary interpretation of the data based on magnetic lineaments is provided. This interpretation is not detailed but has been provided to give the reader an initial overview of the main features observed within the data sets.

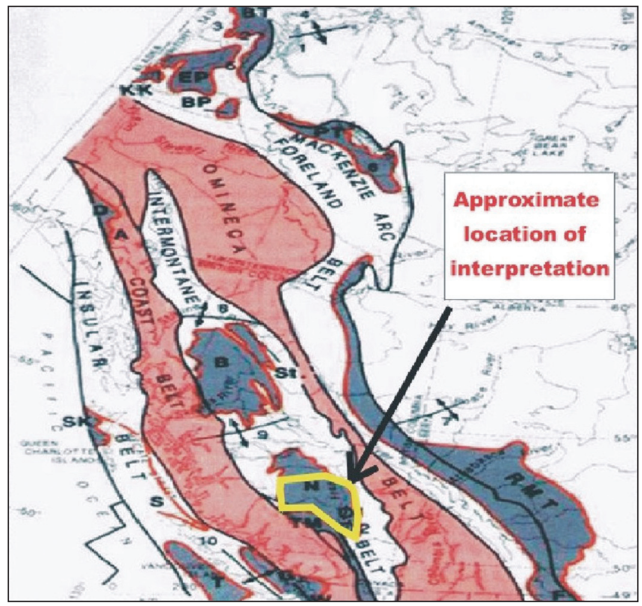

Figure 1: The grey shaded area with the letter N is the outline of the Nechako Basin. The yellow outline represents the approximate location of the gravity data in the southern Nechako Basin.

POTENTIAL FIELD DATA

The gravity data collected by Canadian Hunter were available as a hand-contoured Bouguer gravity map. The original field data do exist but are confidential. To allow further processing of the gravity data, the contour map was digitized along each contour to provide a digital database. The digitizing was carried out by Focus Corporation of Victoria. These data were then entered into Geosoft Oasis Montaj (Version 6.4.1, 2007), and a 200 m by 200m grid of the Bouguer gravity data was generated using the minimum curvature gridding option. The location of the gravity survey lines are shown on Petroleum Geology Map 2006-1 (map 1 of 3 in Riddell 2006). The average spacing between lines is 10 km, so a 200 m grid is a smoothed version of the data. Fortunately the gravity data are quite smooth so that changes in the magnitude of the Bouguer gravity with position are generally small. The colour image in Figure 2 of this gridded data was compared with the original Bouguer gravity contour map and found to represent the original data accurately. Very few gravity survey lines are located near the edges of the Bouguer gravity map (Riddell 2006). Care should therefore be exercised when interpreting features near the edges of the Bouguer gravity map and the images derived from it.

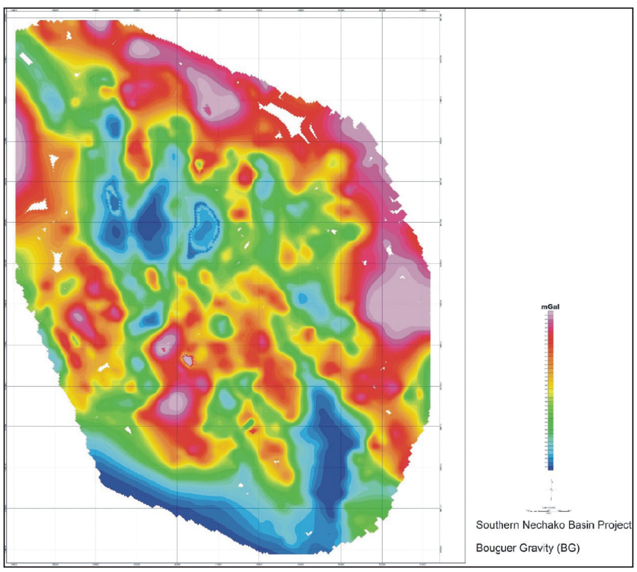

Figure 2: Bouguer gravity map generated from the digitized contour data.

The aeromagnetic data were obtained from the GSC as 200 m by 200 m total magnetic field intensity (TMI) gridded data. All data corrections, including levelling, were carried out before the grid was created. The gridded data were entered into Geosoft Oasis Montaj to generate the colour image in Figure 3. The magnetic survey covers a larger area than the gravity survey, which is outlined by the black polygon on the figure.

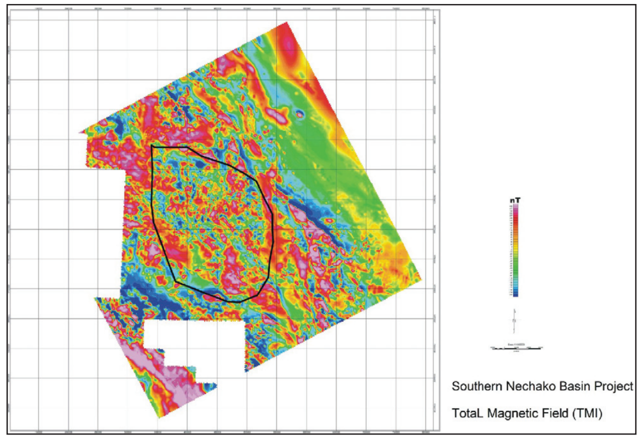

Figure 3: Total magnetic field intensity (TMI) map.

DERIVED GRIDDED MAPS

The gravity and magnetic grids were subsequently used to generate a number of derivative and shaded relief grids and maps with the Geosoft software. A list of the Geosoft maps and grids and the images generated from them is provided in Appendix A; these are available at the Interior Basins website of the BC Ministry of Energy, Mines and Petroleum Resources (the web address is provided in Appendix A)

Geosoft maps have a title, a scale, and UTM and/or latitude and longitude coordinates. Geosoft grids do not have these features. Geosoft map and grid files can only be read using Geosoft software; however, there is free software available from the Geosoft website (http://www.geosoft/com) to display these files. In addition, .jpg images of most of the Geosoft maps were generated within Geosoft for those who prefer bitmap images.

Gravity products

Only first derivative grids and maps (first horizontal derivative in the x and y directions, [i.e., N-S and E-W], the first vertical derivative, and the analytic derivative) were computed because the gravity data is smooth and the spacing between survey lines large. Shaded relief maps with the sun in the northeast were also computed for several of these maps.

Magnetic products

First derivative grids and maps (first vertical derivative, analytic derivative, x and y, [i.e., N-S and E-W], and horizontal derivatives) were computed. In addition, the second vertical derivative was computed since the TMI has significant spatial variation. Shaded relief maps with the sun in the northeast (and a few with the sun in the northwest) were computed for some of the derivative maps

Derivative maps

The vertical and horizontal derivatives, which are basically the rate of change of the magnetic or gravity field, can be computed from the gridded data. The x and y horizontal derivatives can be computed numerically from the gridded data by taking the difference between successive grid values and dividing by the grid spacing. The vertical derivative can be computed by applying a frequency domain operator derived from potential field theory to the frequency domain magnetic field data and then using the inverse Fourier transform to compute the corresponding spatial domain vertical derivative.

Computing the derivative of the magnetic or gravity field is equivalent to applying a filter operation to the magnetic or gravity data. Derivative operators are somewhat similar to high pass filters since they emphasize shorter wavelength (shallower) magnetic or gravity sources.

Horizontal derivative maps The horizontal derivative has a peak value over the edge of the magnetic or gravity source body. It has a peak at the steepest slope, which is basically the maximum rate of change of the magnetic or gravity field. Horizontal derivatives can be computed in the x and y directions as well as any arbitrary direction.

Vertical derivative maps The first vertical derivative usually locates the edge of a magnetic or gravity source body. Sometimes the second vertical derivative is computed, although there is usually more noise and any effects of improper levelling of aeromagnetic data will stand out strongly.

Analytic signal maps The analytic signal, or total gradient, is the square root of the sum of the squares of the x and y horizontal gradients and the z (vertical) gradient. The maxima (ridges and peaks) of the computed analytic signal locate the edges and corners of magnetic and gravity source bodies (for example, basement fault block boundaries, basement lithology contacts, fault/shear zones, igneous and salt diapirs, etc.). Analytic signal maxima for magnetic data have the property that they occur directly over faults and contacts, regardless of structural dip and independent of the direction of induced and/or remanent magnetism.

Shaded relief maps

Artificial shading of coloured maps and images can be used to enhance linear features. This technique was originally designed to enhance satellite images but is now applied routinely to geophysical data. An artificial (mathematical) illumination source is beamed at the image from a specific location (for example, from the northwest at an angle of 45° from the horizontal) and the projected shadow is calculated for each pixel. If there are strong northeast-trending features in the image, they will be emphasized by their shadow. Different illumination angles and azimuths will cause the eye to focus on different linear features.

PRELIMINARY INTERPRETATION

The lineament interpretation is based on the magnetic data, particularly the second vertical derivative map (Figure 4). Figure 5 shows the lineament interpretation overlying the second vertical derivative map. The location of the gravity survey is also outlined on Figure 5. The main lineament trends are approximately NNW-SSE, NW-SE, and NE-SW, although other lineament directions can be seen on the map. The NNW-SSE trend is roughly parallel to the Fraser fault, and the NW-SE trend is roughly parallel to the Yalakom fault.

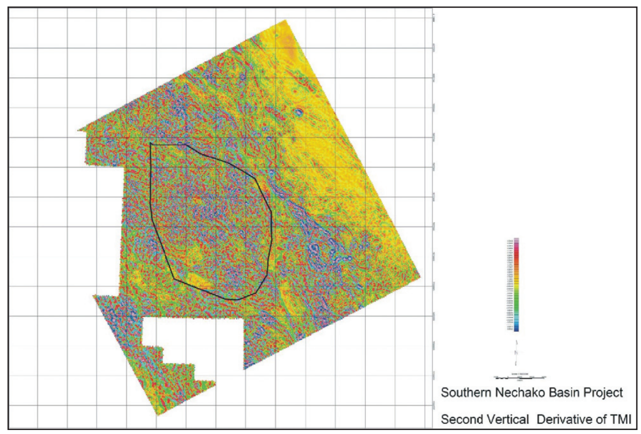

Figure 4: Second vertical derivative of the TMI map. The location of the gravity survey is outlined on the map for reference.

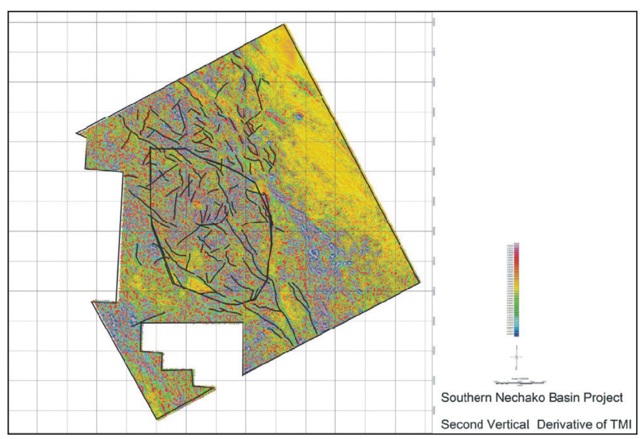

Figure 5: Second vertical derivative of the TMI map with lineament interpretation overlain on it.

Figure 6 shows the locations of the lineaments and the outline of the gravity survey. There are interesting features associated with several of these lineaments. For example, lineament B follows the mapped contact between Hazelton Group rocks and granites of Late Cretaceous age. Lineament A also follows a mapped contact. Lineament C appears to follow a contact, although there is significant Quaternary cover in the area, making it difficult to compare to known geology. Lineament D is coincident with a mapped fault (the mapped fault is the section of the lineament next to the letter D in figure 6). Lineament D is part of the Fraser fault system, and lineament G and its extensions to the northwest are associated with the Yalakom fault system.

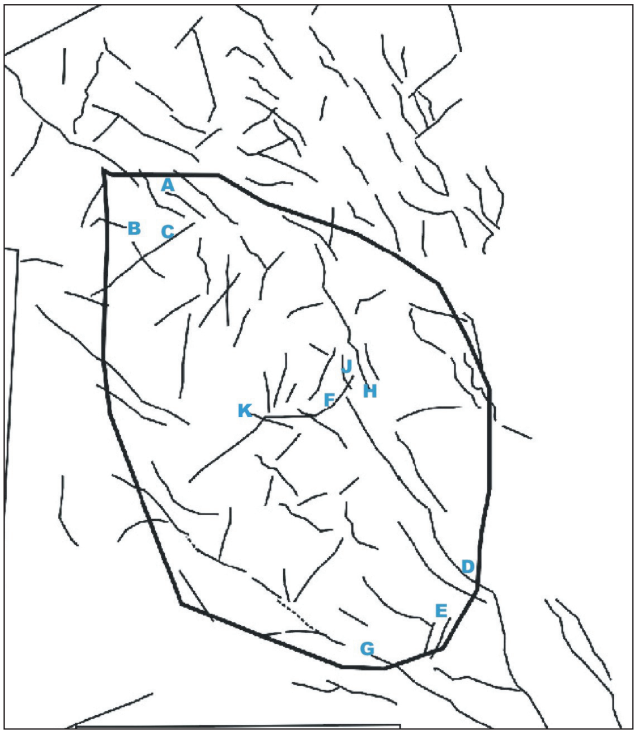

Figure 6: Lineament interpretation with interesting features labelled.

Lineaments F and K separate a gravity low to the north from a gravity high to the south. In addition, there appears to be a change in geology, although Quaternary cover makes it difficult to be certain (Riddell 2006). The southern section of lineament H and lineament J bracket Taylor Creek sediments exposed along the Nazko River valley. The two NNE-SSW lineaments associated with lineament E are coincident with mapped faults. These two lineaments are also associated with known seismic activity (Best and Lakings 2008).

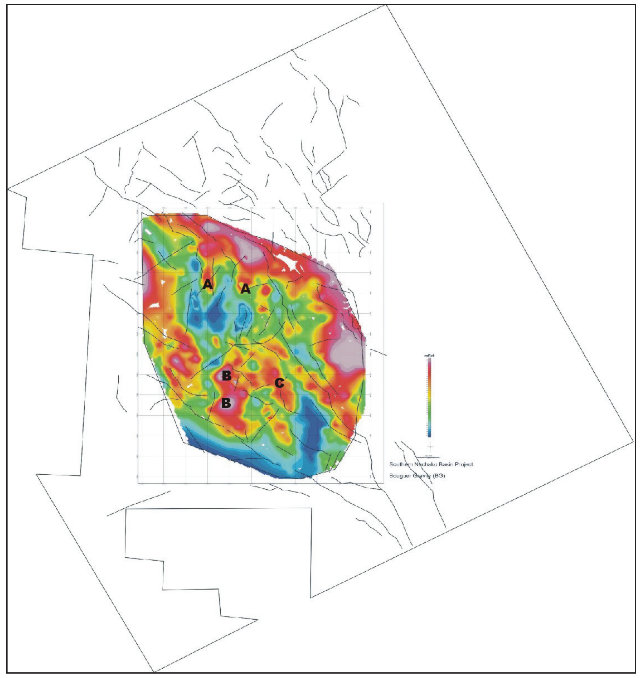

Figure 7: Bouguer gravity map with lineaments overlain on it.

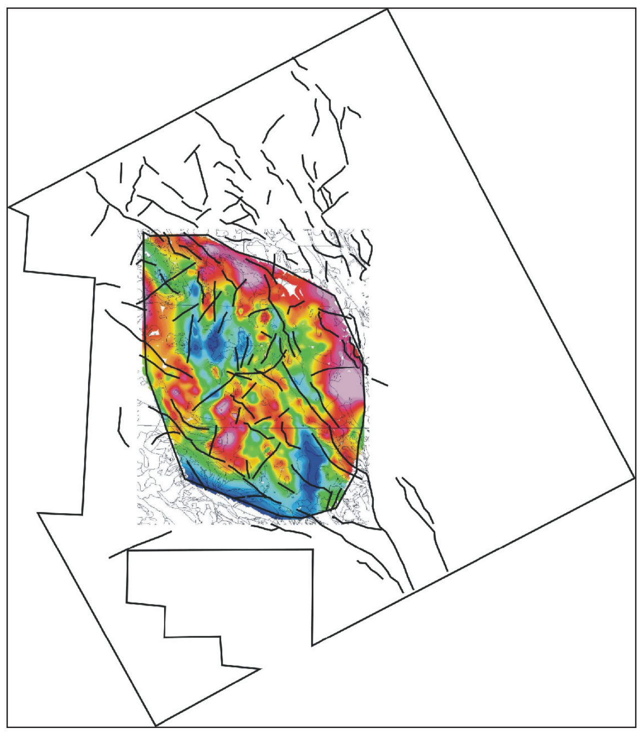

Figure 8: Bouguer gravity map with geology polygons and lineaments.

Figure 7 is the Bouguer gravity map with the lineaments overlain on it. Figure 8 is the Bouguer gravity map with polygons of the geology as well as the lineaments. The Hazelton Group rocks in the north (Riddell 2006) are associated with high gravity values. Indeed the two fingers of high gravity (labelled A on Figure 7) are associated with mapped outcrops of Hazelton Group rocks. Similarly the large gravity high in the south (labelled B on Figure 7) appears to be associated with Triassic diorites and tonalites. The rocks associated with the gravity high labelled C are not identifiable because of Quaternary and basalt cover. The gravity lows appear to be associated with Paleogene

Endako Group rocks and Early Cretaceous granodiorites (Riddell 2006).

Figure 9 is the total magnetic intensity map with polygons of geology as well as lineaments. The outline of the gravity survey is also shown on this figure. The Hazelton Group rocks in the northern part of the gravity survey (labelled A in the figure) are associated with lower values of the magnetic field. The large magnetic feature in the south-central area of the gravity survey (labelled B in the Figure) is associated with Spences Bridge Group rocks. There are many more subtle features, sometimes associated with lineaments and sometimes not, which should be followed up in future studies.

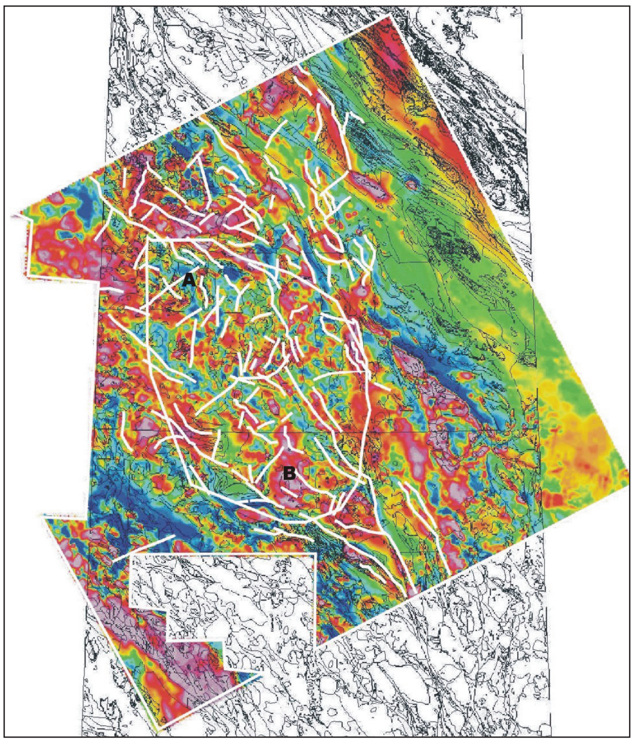

Figure 9: TMI map with geology polygons and lineaments.

CONCLUSIONS

The derivative and shaded relief maps generated from the gravity and magnetic data in the southern Nechako Basin have provided a preliminary interpretation of the potential field data. Many lineaments derived from the second vertical derivative of the TMI were found to correlate with known geology and helped define boundaries within the survey area. A qualitative relationship can be observed between known geology and the gravity and magnetic data, even though no detailed modelling was carried out. Further modelling of the combined data set would be a useful exercise to help quantify the geology in areas of Quaternary and basalt cover.

Appendix B lists some additional CorelDraw (.cdr) files of the lineament map overlaying the second vertical derivative map and other derivative gravity and magnetic maps, as well as the TMI and Bouguer gravity maps. These are also available at the Interior Basins website of the BC Ministry of Energy, Mines and Petroleum Resources.

REFERENCES

Best, M.E. (2004): Qualitative interpretation of potential field profiles, southern Nechako Basin; Summary of Activities 2004, *BC Ministry of Energy and Mines*, pages 73 to 78.

Best, M.E., and Lakings, J. (2008): Results from a reconnaissance microearthquake survey in the Nechako Basin of British Columbia, October 12 – December 17, 2006; Petroleum Geology Open File 2007-12, *BC Ministry of Energy, Mines and Petroleum Resources.*

Riddell, J.M. (compiler) (2006): Geology of the southern Nechako Basin NTS 92N, 92O, 93B, 93C, 93F, 93G: *BC Ministry of Energy, Mines and Petroleum Resources*, Petroleum Geology Map 2006-1, 1:400 000 scale, 3 sheets.

APPENDIX A

List Of Maps, Grids, And Images

These are available at the Interior Basins website of the BC Ministry of Energy, Mines and Petroleum Resources http://www.em.gov.bc.ca/subwebs/oilandgas/petroleum_geology/cog/interior.htm

Gravity Geosoft Grids

grid type	**file name**
Analytic derivative	grav_analytic.grd
Hor gradient (N-S direction)	grav_hor_grad_0.grd
Hor gradient (E-W direction)	grad_hor_grad_90.grd
First vertical derivative	grav_vd1.grd
Bouguer gravity	grav_grid.grd

Gravity Geosoft Maps

map type	**file name**
Analytic derivative	grav_analytic.map
Hor gradient (E-W direction)	grav_hor_grad_90.grd.map
First vertical derivative	grav_vd1.grd.map
Bouguer gravity	grav_grid.grd.map
Bouguer gravity (shad NW)	grav_grid.grd_shad315.map
Bouguer gravity (shad NE)	grav_grid.grd_shad45.map

Gravity images

image type	**file name**
Bouguer gravity	grav.grd.jpg
First vertical derivative	grav_vd1.jpg
First vert der (shad NE)	grav_vd1_shad45.jpg
Analytic derivative	grav_analytic.jpg
Hor gradient (N-S)	grav_hor_der_0.jpg
Hor gradient (E-W)	grav_hor_der_90.jpg
Bouguer gravity (shad NW)	grav_shad315.jpg
Bouguer gravity (shad NE)	grav_shad45.jpg

Magnetic Geosoft Grids

grid type	**file name**
Analytic derivative	mag_analytic.grd
Hor gradient (N-S direction)	mag_hor_grad_0.grd
Hor gradient (E-W direction)	mag_hor_grad_90.grd
TMI (shad NE)	mag_shad_45.grd
First vertical derivative	mag_vd1.grd
Second vertical derivative	mag_vd2.grd
Total magnetic intensity (TMI)	magnetics_200m.grd

Magnetic Geosoft Maps

map type	**file name**
analytic derivative	mag_analytic.grd.map
analytic derivative (shad NW)	mag_analytic_shad315.map
analytic derivative (shad NE)	mag_analytic_shad45.map
analytic derivative (shad NE and masked to gravity map)	mag_analytic.shad45_mask.map
magnetic hor gradient (N-S)	mag_hor_grad_0.grd.map
magnetic hor gradient (N-S and masked to gravity map)	mag_hor_grad_0_mask.grd.map
magnetic hor gradient (E-W)	mag_hor_grad_90.grd.map
magnetic hor gradient (E-W and masked to gravity map)	mag_hor_grad_90_mask.grd.map
First vertical der (shad NW)	mag_vd1_shad315.map
First vertical der (shad NE)	mag_vd1_shad45.map
First vertical der (shad NE and masked to gravity map)	mag_vd1_shad45_mask.map
Second vertical der	mag_vd2.grd.map
Second vertical der (masked to gravity map)	mag_vd2_mask.map
Second vertical der (shad NW)	mag_vd2_shad315.map
Second vertical der (shad NE)	mag_vd2_shad45.map
Second vertical der (shad NE and masked to gravity map	mag_vd2_shad45_mask.map
TMI and masked to gravity map	magnetics_200m.grd_mask.map
TMI with mask outline of gravity map	magnetics_200m.grd_mask_outline.map
TMI (shad NE)	magnetics_200m.grd_shad45.map
Total magnetic intensity (200 m grid) (TMI)	magnetics_200m.grd.map

Magnetic images

image type	**file name**
TMI (200 m grid)	mag_200m_grd.jpg
TM I (200 m grid and outline of gravity mask)	mag_200m_grd_mask_outline.jpg
Analytic derivative	mag_analytic.jpg
Analytic der (shad NW)	mag_analytic_shad315.jpg
Analytic der (shad NE)	mag_analytic_shad45.jpg
Analytic der (with mask of gravity map)	mag_analytic_shad45_mask.jpg
Hor der (N-S)	mag_hor_der_0.jpg
Hor der (E-W)	mag_hor_der_90.jpg
First vertical derivative	mag_vd1.jpg
First vertical der (shad NW)	mag_vd1_shad315.jpg
First vertical der (shad NE)	mag_vd1_shad45.jpg
Second vertical derivative	mag_vd2.jpg
Second vert der (shad NE)	mag_vd2_shad45.jpg
TMI with mask of gravity map	magnetics_200m.grd_mask.jpg

APPENDIX B

List Of Coreldraw (CDR) Files Of Lineaments Overlaying Maps

These are available at the Interior basins website of the BC Ministry of Energy, Mines and Petroleum Resources http://www.em.gov.bc.ca/subwebs/oilandgas/petroleum_geology/cog/interior.htm

Gravity files

map type	file name
First vertical derivative map	grav_1vd_lineaments.cdr
Analytic derivative map	grav_analytic_lineaments.cdr
Bouguer gravity map	grav_grid_lineaments.cdr
Bouguer gravity map with geology polygons	grav_geology_lineaments.cdr

Magnetic files

map type	file name
Second vertical derivative map	mag_v2d_lineaments.cdr
First vertical derivative map	mag_1vd_lineaments.cdr
Analytic derivative map	mag_analytic_lineaments.cdr
Horizontal derivative (N-S) map	mag_hor_der_0_lineaments.cdr
Horizontal derivative (E-W) map	mag_hor_der_90_lineaments.cdr
TMI map	mag_200m_grid_lineamants.cdr
TMI map with geology polygons	mag_geology