# Updates on Faults and Structural Framework of the Peace River Arch Region, Northwest Alberta, Obtained using a New Approach*

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Search and Discovery Article #30399 (2015)
Posted February 23, 2015

*Adapted from extended abstract prepared in conjunction with a presentation given at CSPG/CSEG 2007 GeoConvention, Calgary, AB, Canada, May 14-17, 2007,


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## Abstract

Peace River Arch is one of the most extensively studied tectonic features in Western Canada Sedimentary Basin (WCSB). Descriptions of faults in the sedimentary cover of this region have been carried out for 50 years. In general, the conventional approach for structure study uses potential field data including aeromagnetic and gravity data for detecting the basement structures, and geophysical well log data (combined with seismic data when available) for interpreting the sedimentary cover structures. With respect to well log data, the main approach is to interpret faults from isopach and structure top contour maps. For the Peace River Arch region, descriptions of faults, as presented by Sikabonyi and Rodgers (1959), Jones (1980), Cant (1988), Barclay et al. (1990), Dix (1990), O'Connell et al. (1990) and O'Connell (1994), are all based on use of well log and sedimentological data to identify fault locations and trends, as well as magnitudes and types of offset.

## Introduction

The conventional well log and seismic interpretation techniques have achieved varying success in detecting regional structure and major faults (dozens of meters offset). However, the structure top contour maps are usually characterized by a regional trend (see Mossop and Shetsen, 1994), and this trend can mask local structure and faults that cause only minor offset (e.g., a few metres). Variations at such a metre-scale dimension on the structure top contour map usually show as subtle irregularities in contour lines or subtle variations in the spacing of contour lines and, thus, are difficult to interpret. As a result, it is difficult to interpret faults with small offsets by using the conventional structure top contour approach. These faults are also beyond the detection resolution of conventional seismic data.

## Current Study

The present study uses a new approach to detecting faults with small, meter-scale offsets (5 to 10 metre) (Mei, 2006). This new approach applies trend surface analysis on formation-top picks, but it is fundamentally different from the conventional trend surface analysis in that it models a geological trend, other than a mathematic trend. The conventional trend surface analysis uses the global polynomial method and the power of the polynomial (e.g., first, second or third) is the only parameter for input. It generates only a mathematical polynomial trend that is inadequate for extracting meter-scale formation-top offset information. The geological trend is modeled using local polynomial or Kriging techniques, which allow input of geological knowledge into the trend modeling.

## Discussion and Conclusions

The new approach has a higher resolution in detecting formation-top offsets and higher accuracy in digitizing fault locations compared the conventional contour map, seismic-section and aeromagnetic-data interpretation techniques in structure mapping for the sedimentary cover. As a result, it leads to a significant update to the structure framework of the Peace River Arch region. A close comparison of the maps created using the new approach with those published by Sikabonyi and Rodgers (1959), Barclay et al. (1990), Richards et al. (1994) and Henderson et al. (1994) results in the following findings:

1) The Fort St. John Graben and the Belloy Graben were originally named by Sikabonyi and Rodgers (1959) for two structures recognized from a pre-Middle Devonian contour map (see Sikabonyi and Rodgers, 1959, Figures 3 and 4); the Fort St. John Graben extends northeast from the town of Fort St. John. Barclay et al. (1990), however, used the name Fort St. John Graben (FSJG) for the graben interpreted from the isopach and structure contour maps of the Stoddart Group and the Belloy Formation (Barclay et al., 1990, Figures 6 and 7), which extends southeast from the town of Fort St. John. Barclay et al. (1990) redefined the Fort St. John Graben to include both the Fort St. John Graben and the Belloy Graben sensu Sikabonyi and Rodgers (1959). The present study found that the structures of the Fort St. John Graben and the Belloy Graben interpreted by Sikabonyi and Rodgers (1959) are different from the structures of the Fort St. John Graben as redefined by Barclay et al. (1990), and they do not overlap in space on the Alberta side (see below for more details).

2) Sikabonyi and Rodgers (1959) recognized an unnamed, southeast-trending graben structure at about 56°N, 120°W (Sikabonyi and Rodgers, 1959, Figures 14, 15 and 20). This graben structure overlaps in space with the one interpreted from the isopach and structure maps of the Stoddart Group and the Belloy Formation and named as the Fort St. John Graben by Barclay et al. (1990, Figures 6 and 7). The same graben structure has also been clearly identified by the present study (see Figures 42, 44, 45, 47, 50, 54 and 56). Comparison of Figures 4, 14, 15 and 20 in Sikabonyi and Rodgers (1959) clearly shows that the unnamed, southeast-trending graben structure at 56°N, 120°W on Figures 14, 15 and 20 is not the same feature as the Fort St. John Graben displayed on Figure 4 of Sikabonyi and Rodgers (1959). For purposes of clarification and communication, this southeast-trending graben structure at 56°N, 120°W is renamed as the Fort St. John – Blueberry Graben.

3) Comparison of Figures 4, 14 and 15 in Sikabonyi and Rodgers (1959) also clearly shows that the Belloy Graben is not connected to the Fort St. John Graben sensu Sikabonyi and Rodgers (1959), or to the graben interpreted from the isopach and structure contour maps of the Stoddart Group and the Belloy Formation by Barclay et al. (1990, Figures 6 and 7). The Belloy Graben has been clearly identified, from the residual maps of Devonian to Cretaceous formations in the present study, as lying north of the Dunvegan Fault of Richards et al. (1994). It is not the southeastern extension of the Fort St. John Graben as redefined by Barclay et al. (1990).

4) The positions of the north flank of the FSJG shown on Figures 6 and 7 of Barclay et al. (1990) are not consistent, partly due to limitations in data spacing and contouring technology used at that time. Specifically, the positions shift around the location of the Rycroft Fault, as displayed

on Figure 14.5 of Richards et al. (1994). This position has been consistently identified by the present study (e.g., Figures 42, 44, 45, 47, 50, 54 and 56), clearly indicating that the north flank of the southeastern extension of the Fort St. John Graben sensu Barclay et al. (1990) is located around the Rycroft Fault. The results of both Barclay et al. (1990) and the present study demonstrate that the southeastern extension of the Fort St. John Graben sensu Barclay et al. (1990) is located mainly to the southwest of the Rycroft Fault. Its south flank is located where Sikabonyi and Rodgers (1959, Figure 20) identified the Saddle Hill Fault. This means that Richards et al. (1994, Figure 14.5) misinterpreted and mislabeled the southeastern extension of the Fort St. John Graben sensu Barclay et al. (1990).

5) The present study (Figure 1) demonstrates that the downthrown side on the Rycroft Fault is to the south, which agrees with the interpretation of Barclay et al. (1990). The present study also demonstrates that a horst lies between the Rycroft and Dunvegan faults, not a half graben as interpreted by Richards et al. (1994, Figure 14.5). This can also be confirmed from the seismic sections presented by Hope et al. (1999, Figure 8) and Eaton et al. (1999, Figure 4), regardless of the fact that the Rycroft Fault was interpreted as a faulted zone in both papers.

6) The Hines Creek graben of Barclay et al. (1990) and Richards et al. (1994) overlaps with the North Peace River Graben of Sikabonyi and Rodgers (1959, Figure 4); the Dunvegan Fault of Richards et al. (1994) was originally named the Belloy Fault by Sikabonyi and Rodgers (1959, Figures 15 and 16).

7) Most of the DCGC related faults (e.g., Josephine Creek, Farmington, Gordondale, Belloy (Dunvegan), Fairview, Bluesky, Berwyn, Normandville (Tangent), Whitemud, Hines Creek and Beaton Creek faults) were also identified from the formation tops of the Upper Cretaceous (Figure 2), although with less amount of offset (5 to 10 meters), using the new approach. This provides direct evidence of reactivation of the DCGC in the Late Cretaceous.

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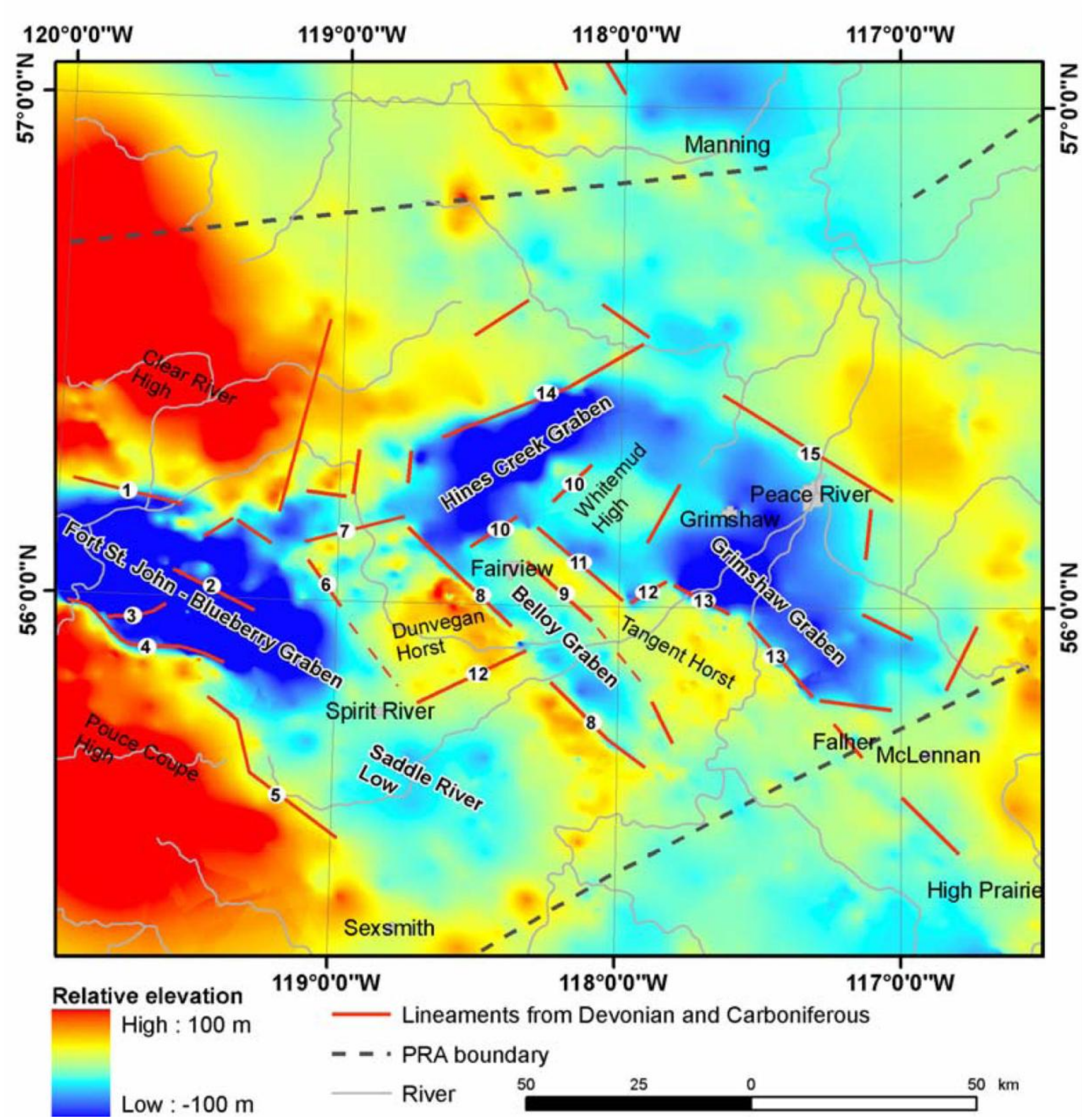


Figure 1. Refined interpretation of the Dawson Creek graben complex (DCGC), superimposed on the residual map for the top of the Debolt Formation. Major faults: 1, Bear Canyon; 2, Josephine Creek; 3, Farmington; 4, Gordondale; 5, Saddle Hills; 6, Rycroft; 7, George; 8, Belloy (Dunvegan); 9, Fairview; 10, Whitemud; 11, Bluesky; 12, Berwyn; 13, Normandville (Tangent); 14, Hines Creek; 15, Peace River.

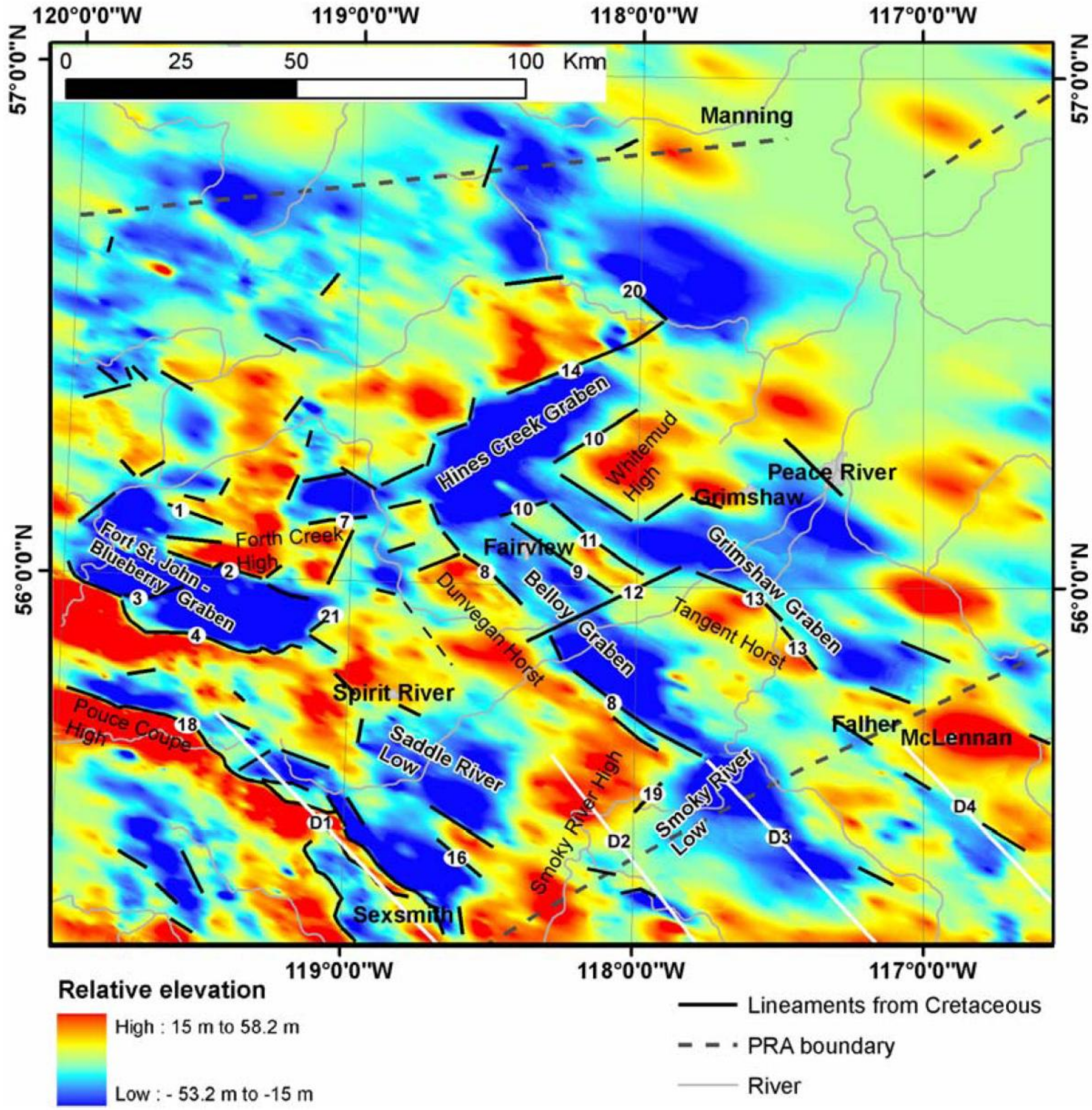


Figure 2. Formation-top offset pattern and interpreted faults of Cretaceous formations, superimposed on the residual map for the Basal Fish Scale Zone (BFSZ). Major faults: 1, Bear Canyon; 2, Josephine Creek; 3, Farmington; 4, Gordondale; 7, George; 8, Belloy (Dunvegan); 9, Fairview; 10, Whitemud; 11, Bluesky; 12, Berwyn; 13, Normandville (Tangent); 14, Hines Creek; 16, Teepee; 18, Pouce Coupe; 19, Smoky River; 20, Beaton Creek; 21, Blueberry. D1–D4, the four faults interpreted by Donaldson et al. (1998).