

Depositional Model for Shale Gas Deposits of the Besa River Formation in Liard Basin, British Columbia*

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Abstract

The Middle Devonian to Middle Mississippian Besa River Formation is a predominantly shale succession that was deposited in the Liard Basin and now outcrops along the eastern slopes of the Rocky Mountains in northeast British Columbia. It contains the deep-water basinal equivalents to carbonate and shale developed to the east in the subsurface of the Western Canada Sedimentary Basin. In the outcrop belt of westernmost Liard Basin, the Besa River Formation is about 300 m thick whereas the correlative carbonate and shale are over 2000 m thick near the Bovie structure. In central Liard Basin, the upper Besa River Formation contains a gas-saturated, silica- and organic-rich section equivalent to the Exshaw Formation and an underlying unit informally referred to as the Patry Member. The Exshaw and Patry succession has recently been the focus of shale-gas exploration, with the initial development well producing over 6.5 BCF ($184 \times 10^6 \text{ m}^3$) of natural gas since 2011. Re-Os systematics of shale in upper part of the organic-rich zone, together with U-Pb dating of an associated thin tuff define an age at the Devonian-Mississippian boundary and corroborates correlation with the Exshaw Formation. The underlying organic-rich Patry sequence is developed in central and western Liard Basin and is considerably thicker along its eastern limit at the Kotcho shelf edge, where it defines a north to north-easterly trending section that is over 200 m thick. The proposed depositional model for this succession incorporates a regional transgression near the end of Late Devonian Kotcho deposition that is accompanied by anoxic bottom waters. Maximum flooding occurred during deposition of the lower Exshaw. It is postulated that a west-side-down normal fault, similar in orientation to the Bovie structure, created the accommodation space for accumulation of a thicker section of organic-rich rocks. This model would suggest that the extensional tectonics related to the Bovie structure were initiated during the Late Devonian. The Exshaw Formation thickens along the northwestern margin of the Peace River Embayment (PRE), an extensional feature coeval with the Carboniferous Liard Basin. Although a thicker section of the Exshaw Formation was tested along the northwest margin of the PRE, this unit has not been penetrated within the westernmost part of the PRE, particularly in the Fort St. John Graben system. Application of the model from Liard Basin would suggest the potential for a much thicker Exshaw section may exist in that area.

Reference Cited

Mossop, G.D., K.E. Wallace-Dudley, G.G. Smith, and J.C. Harrison, 2004, Sedimentary Basins of Canada: Geological Survey of Canada, Open File Map 4673, scale 1:5 000 000.



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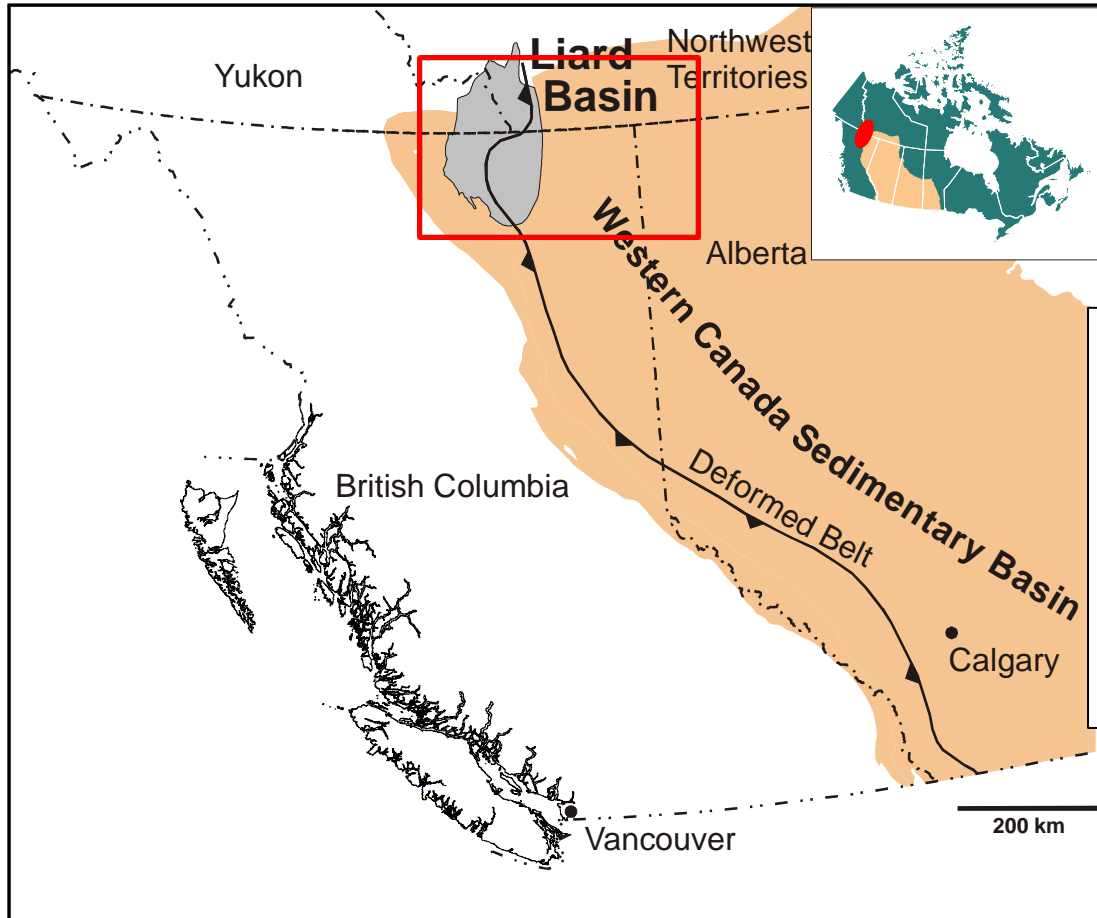


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Summary

- **Introduction**
- **Regional / Local Geology**
- **Reservoir**
- **Correlations**
- **Depositional Model**
- **Extrapolation of the Model**
- **Conclusions**

Location

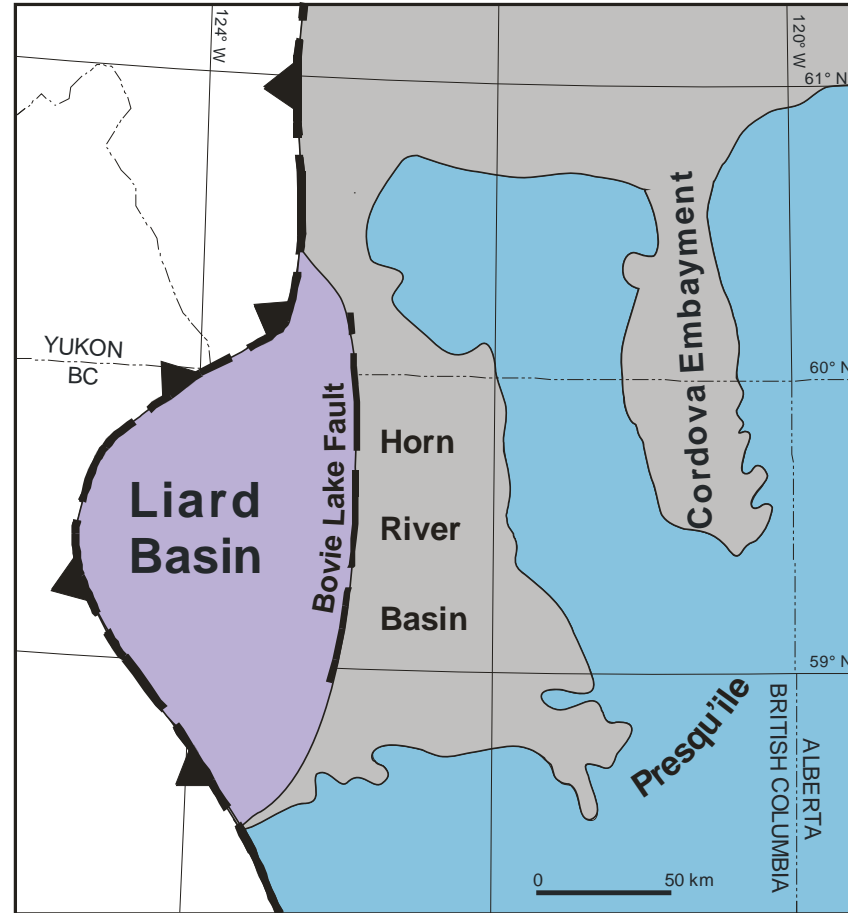


Resource Assessment:
Total Gas-in-Place: 1,213 Tcf
Total Marketable: 219 Tcf
BC Gas-in-Place: 848 Tcf
BC Marketable: 167 Tcf



Ministry of
Natural Gas
Development

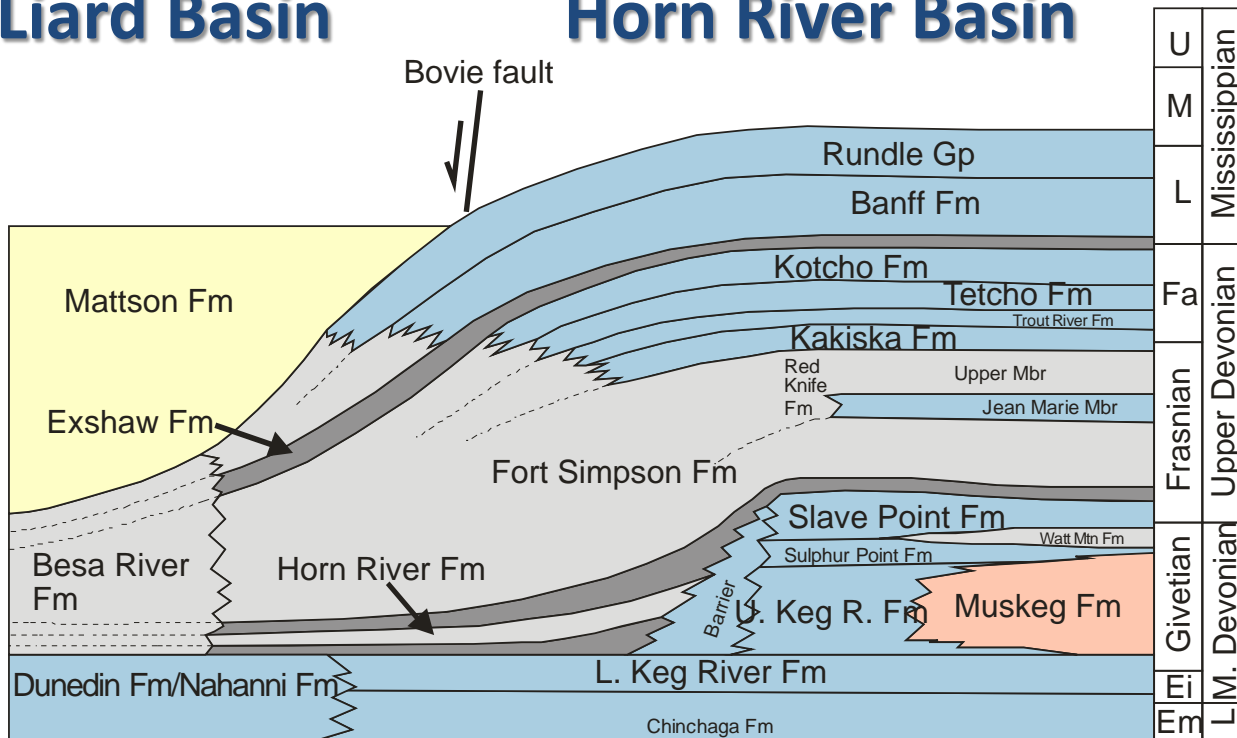
Middle to Late Devonian



Stratigraphy

Liard Basin

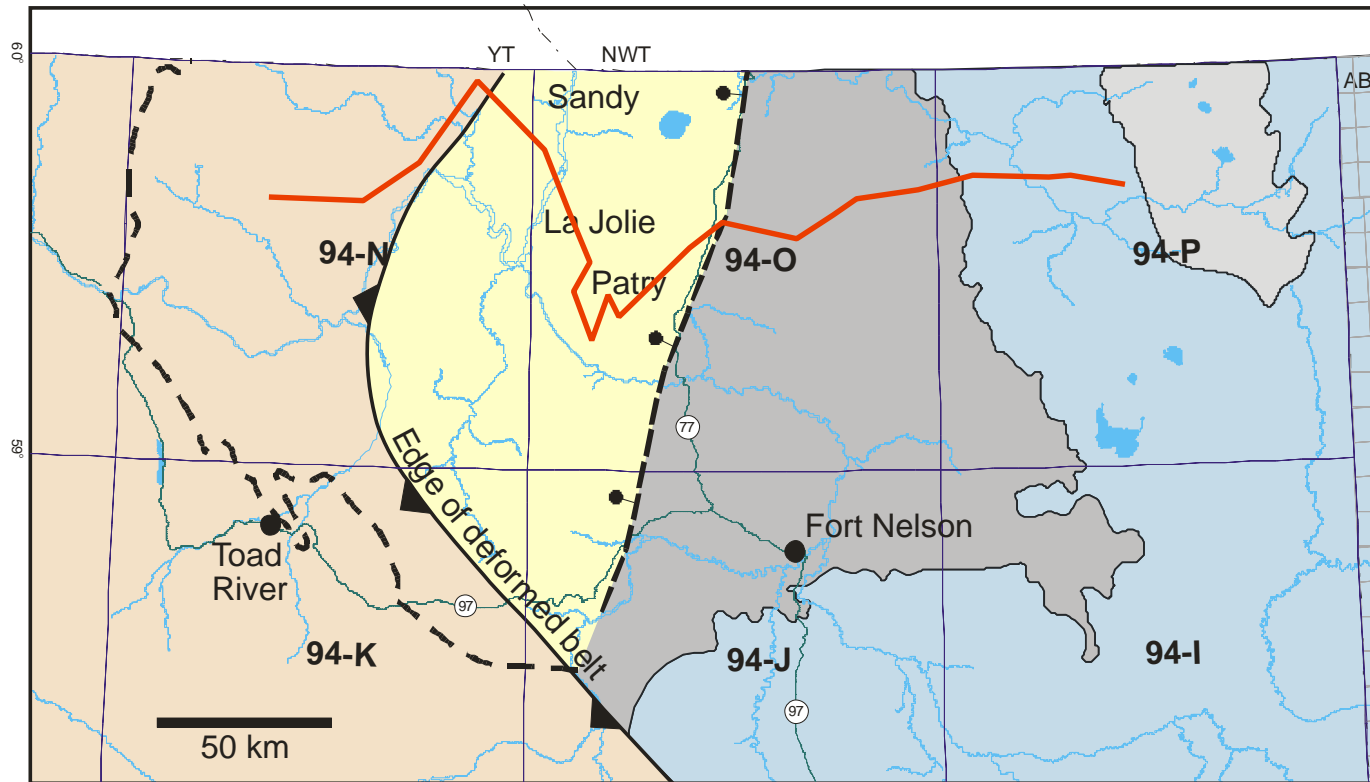
Horn River Basin



Sandstone
 Shale
 Carbonate
 Evaporite
 Black shale containing maximum flooding surface

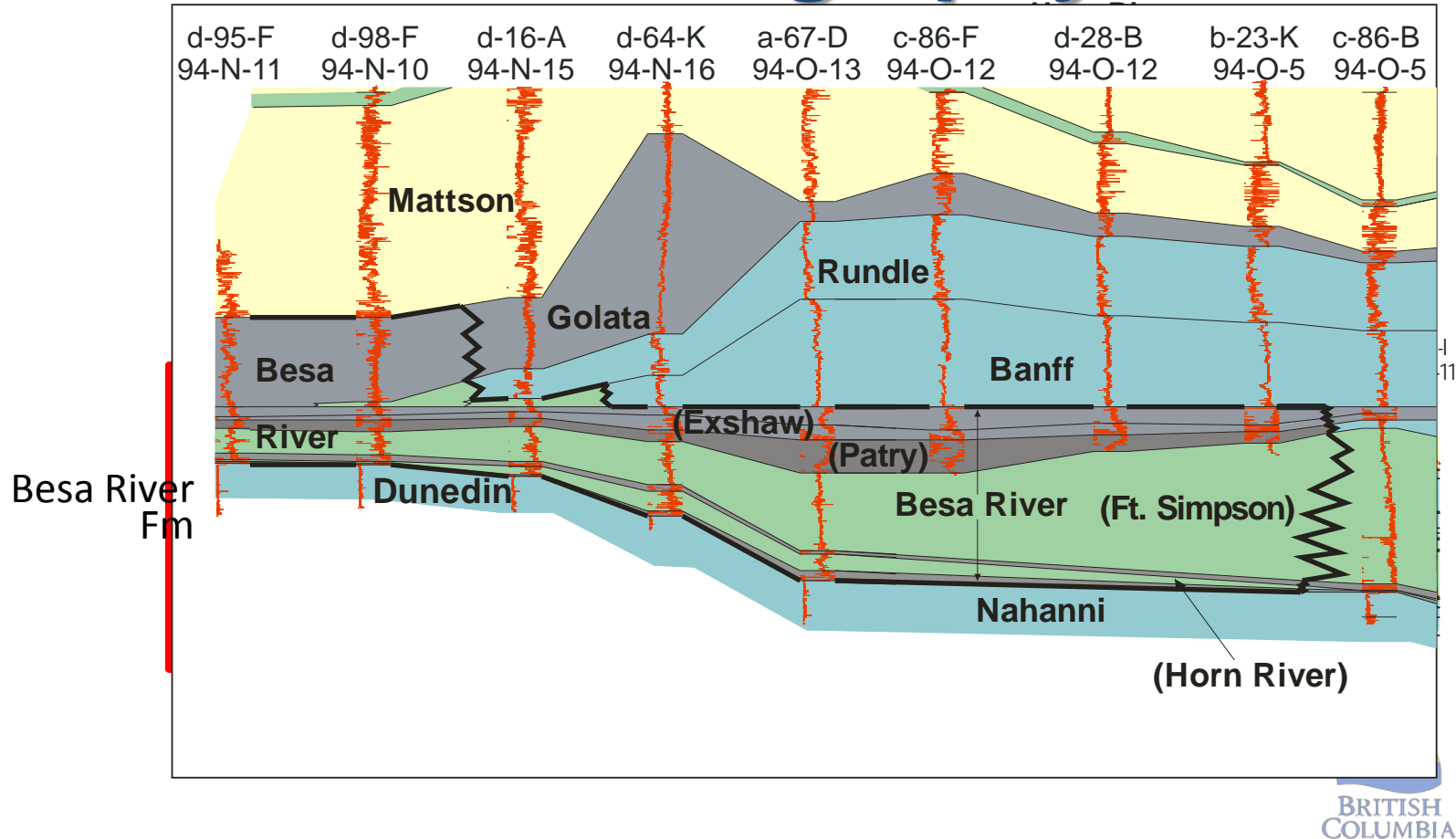


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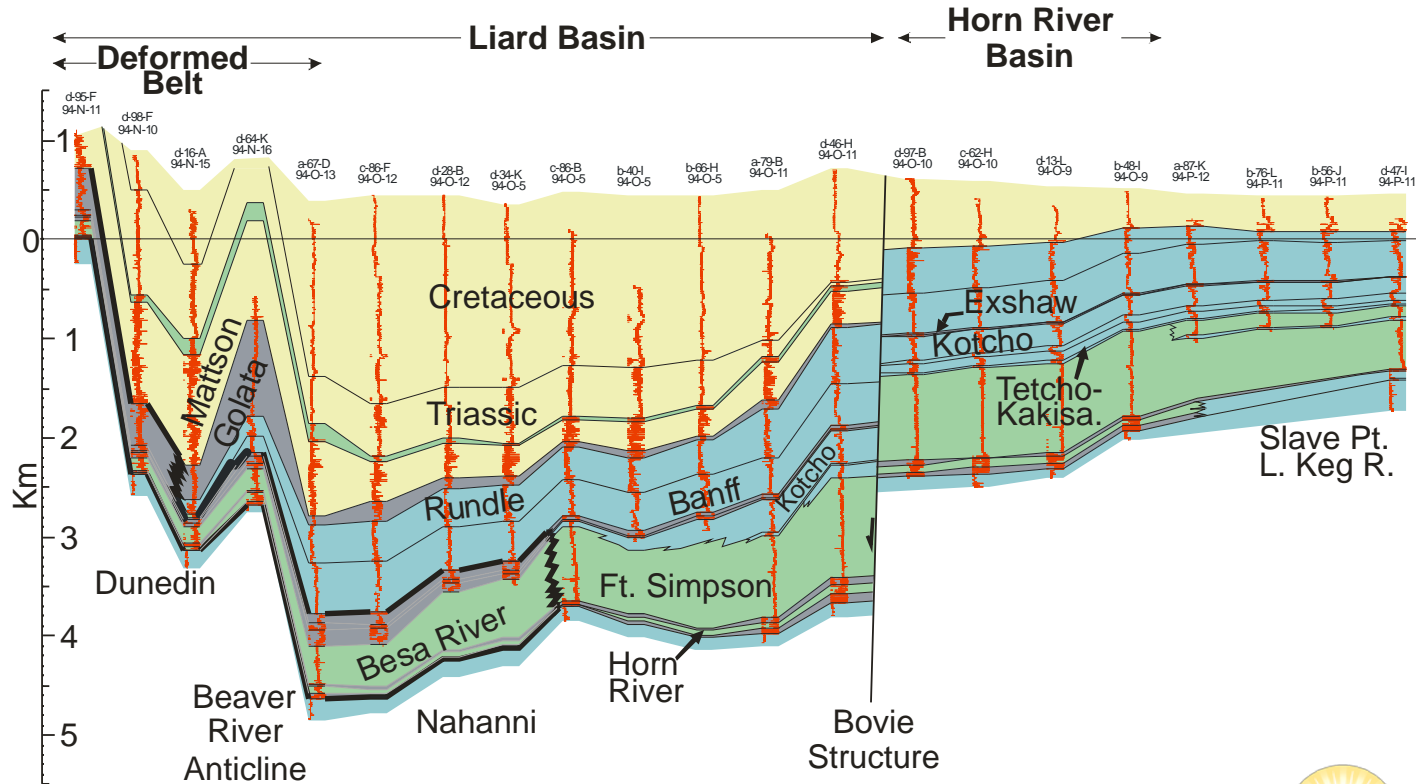


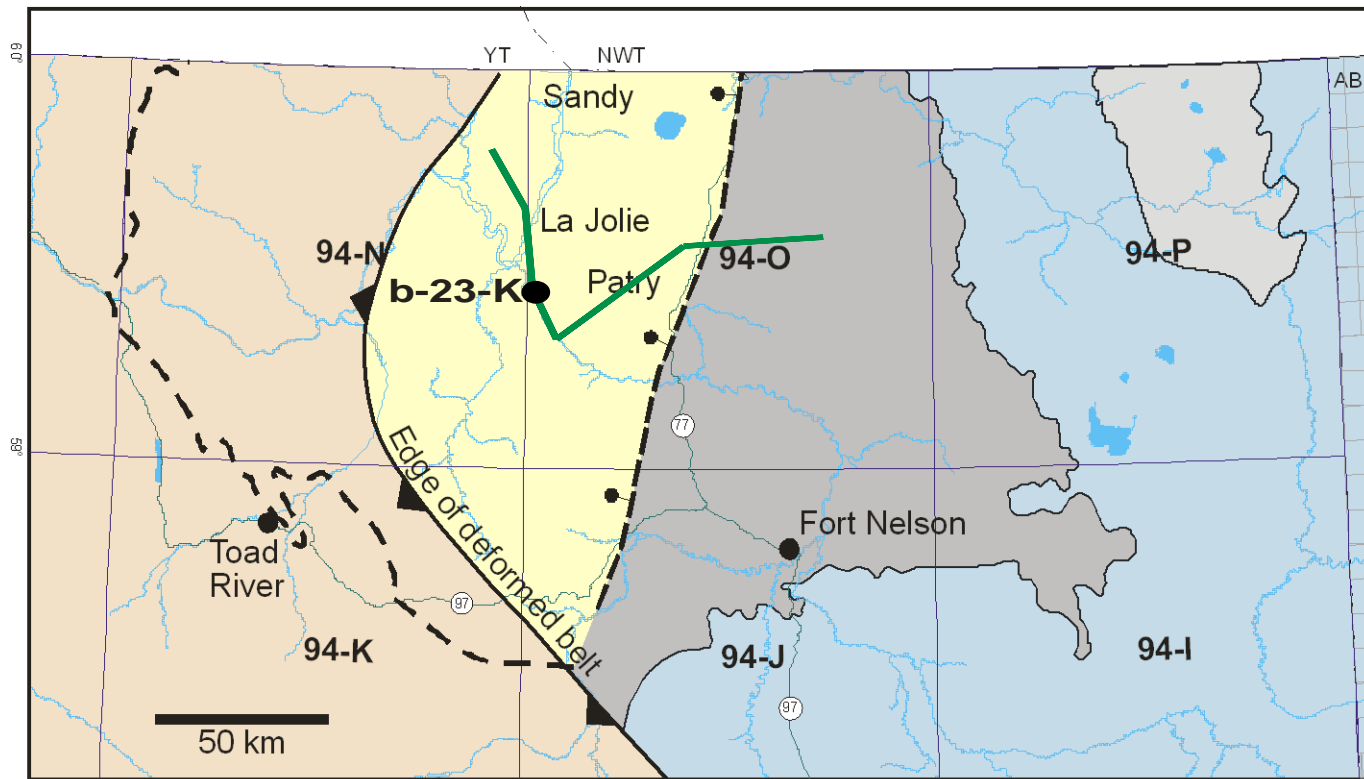
- Liard Basin
- Horn River Basin
- Cordova Embayment
- Slave Point
- Deformed Belt
- Bovie Structure
- Edge of Liard Basin in deformed belt (after Mossop et al., 2004)

Stratigraphy



Structure

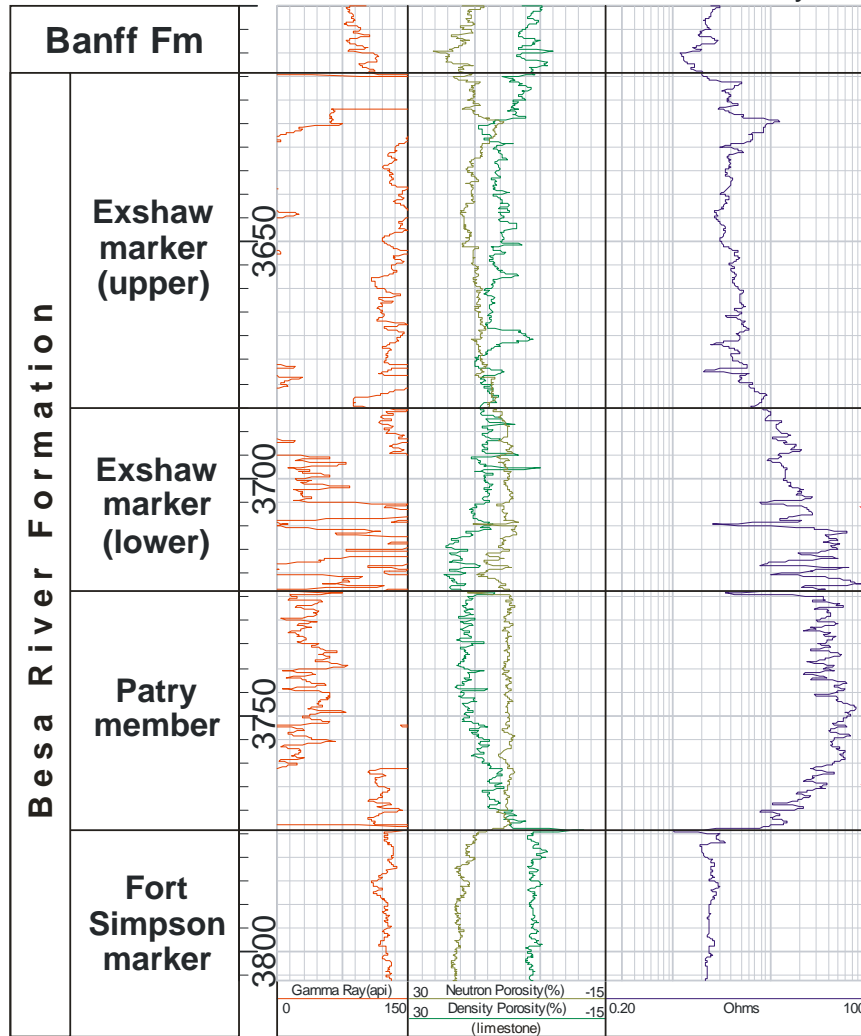




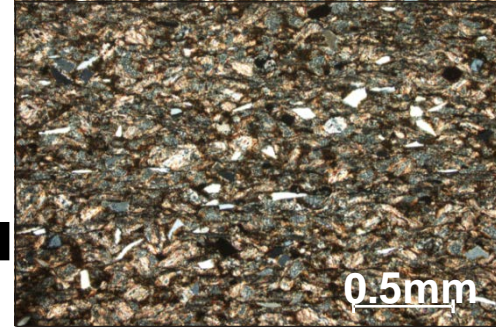
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CHEVRON - WOODSIDE

PATRY b-23-K / 94-O-5



U/Pb Age:
358.9 ± 5.9 Ma
Tuff; 3710.4m



Re/Os Ages:

353.4 ± 5.9 Ma
n=6; 3709m

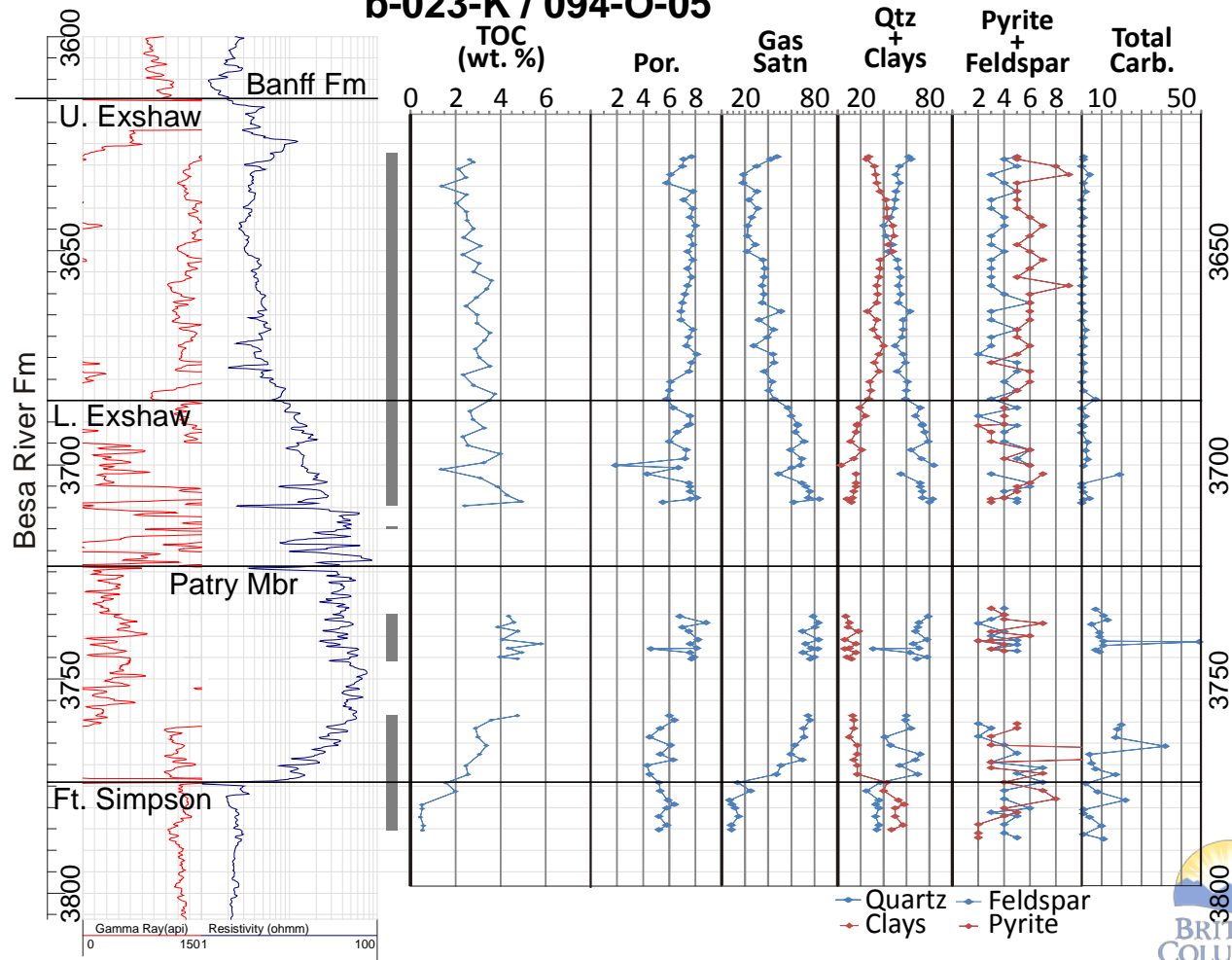


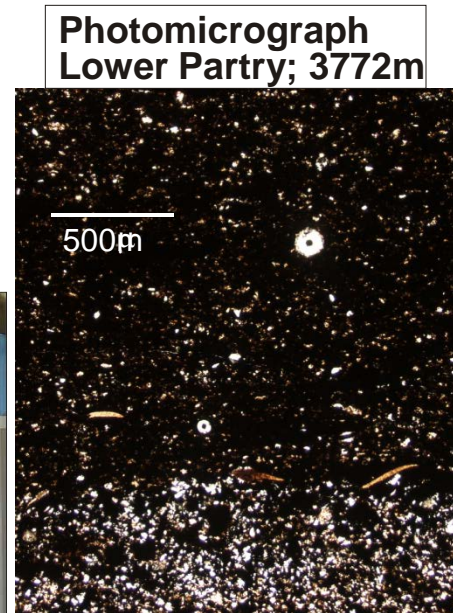
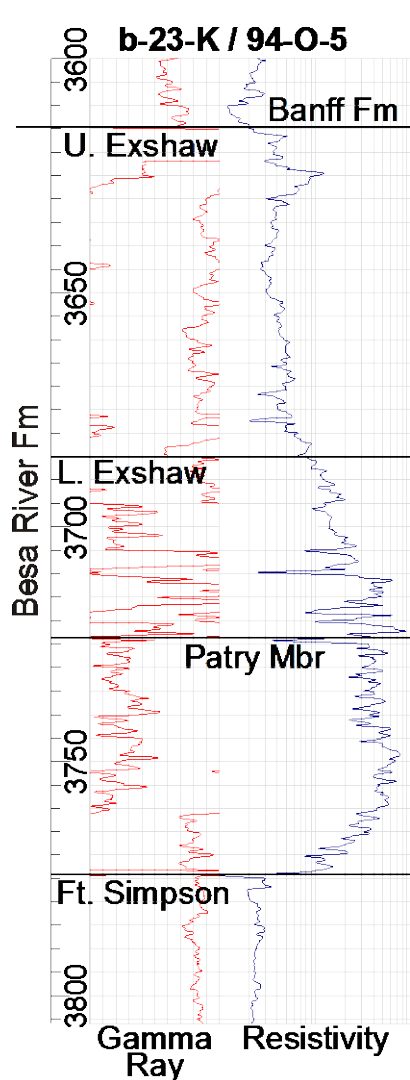
365 ± 14 Ma
n=9; 3762m

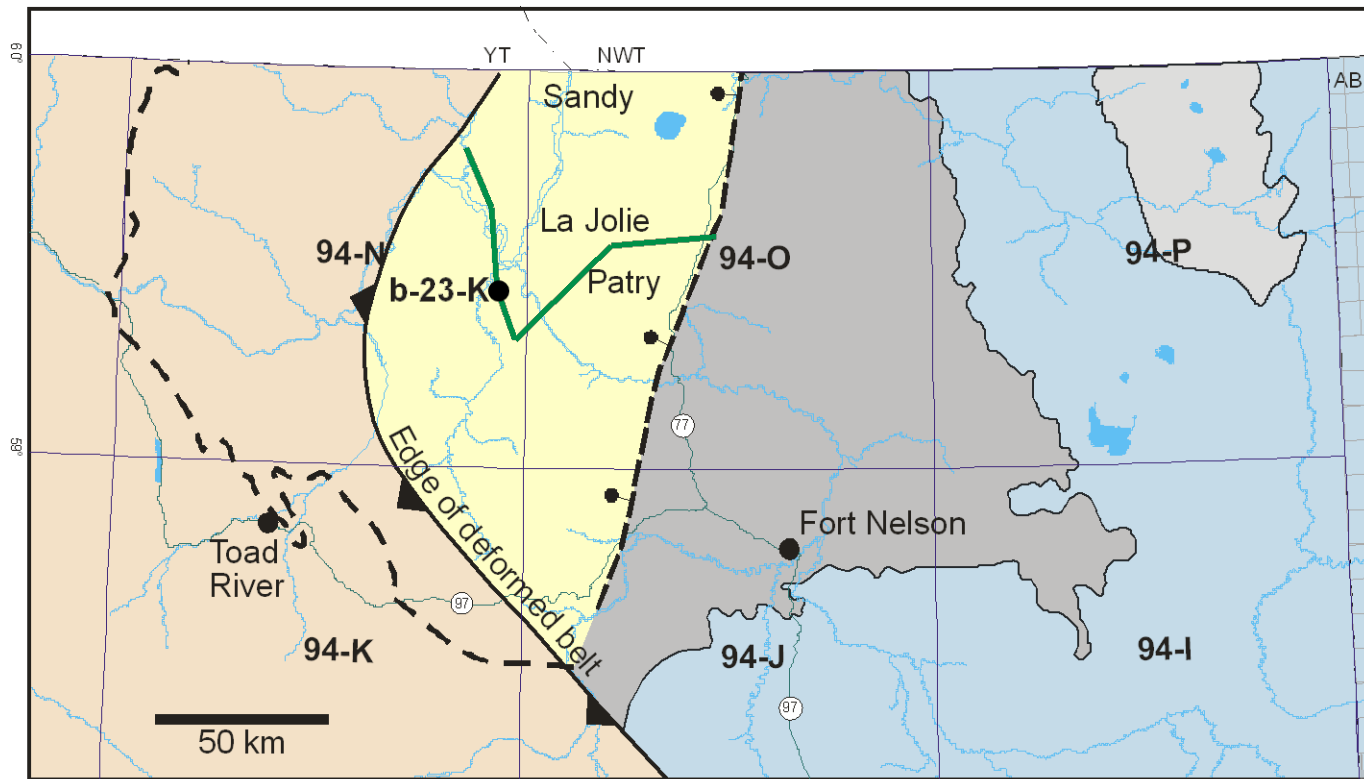


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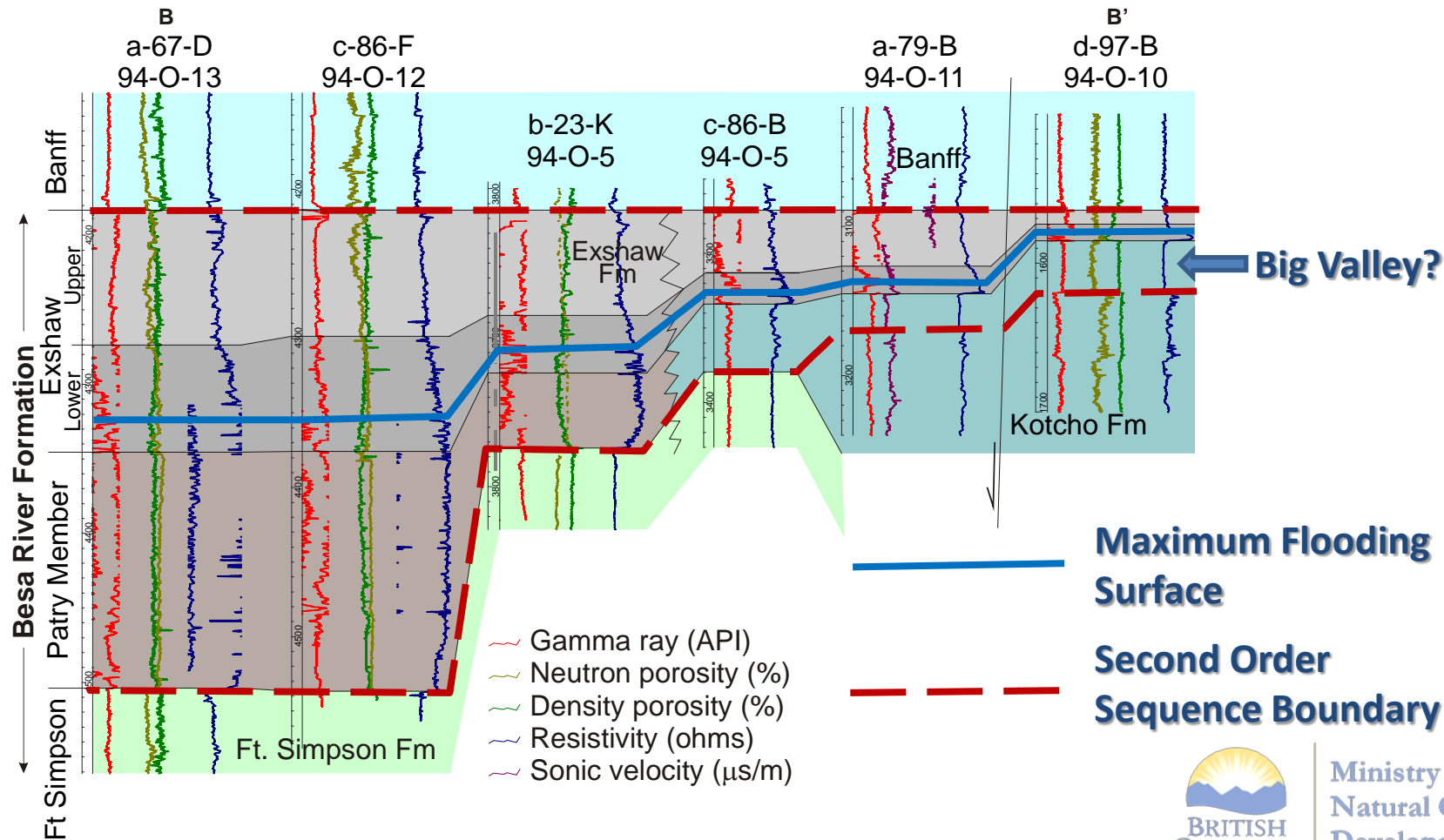
b-023-K / 094-O-05





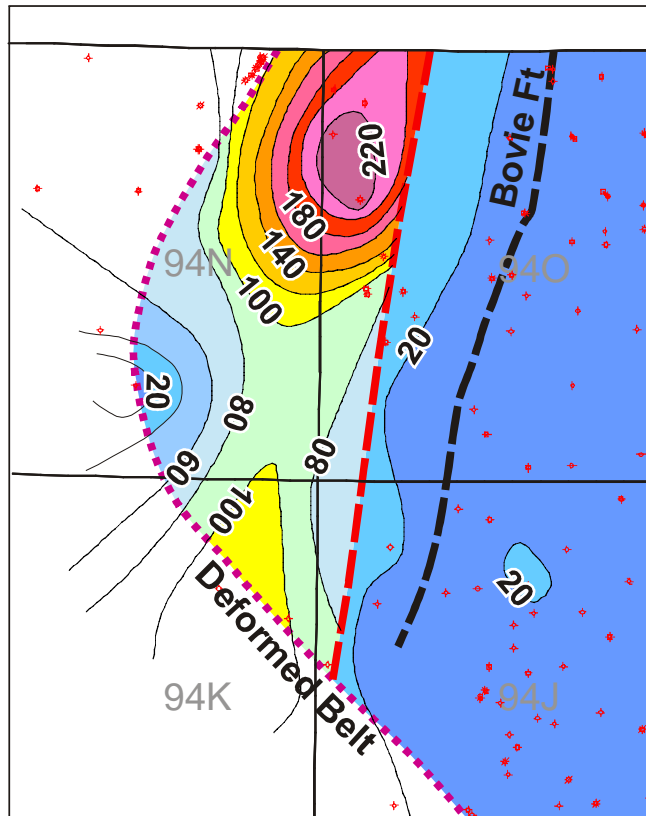


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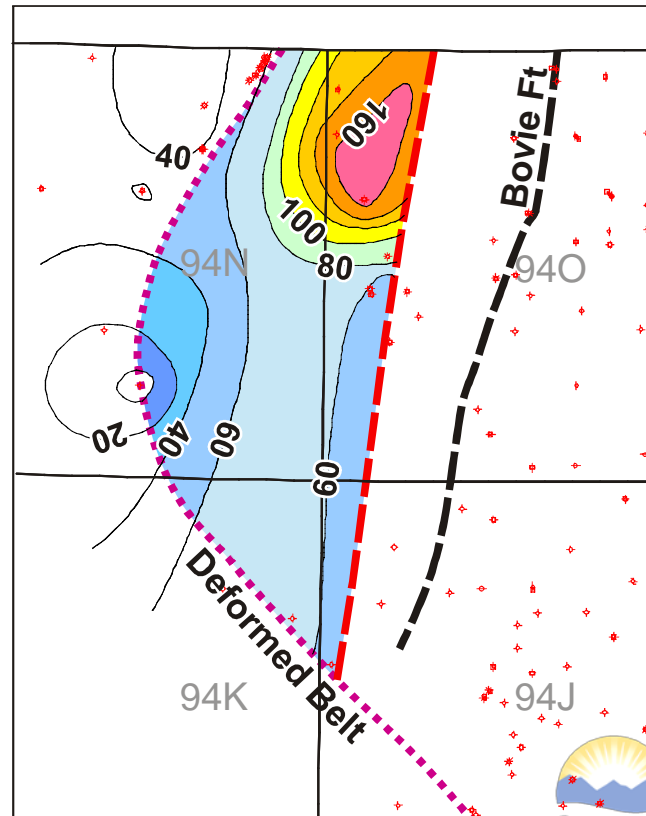


Isopachs

Patry + Lower Exshaw

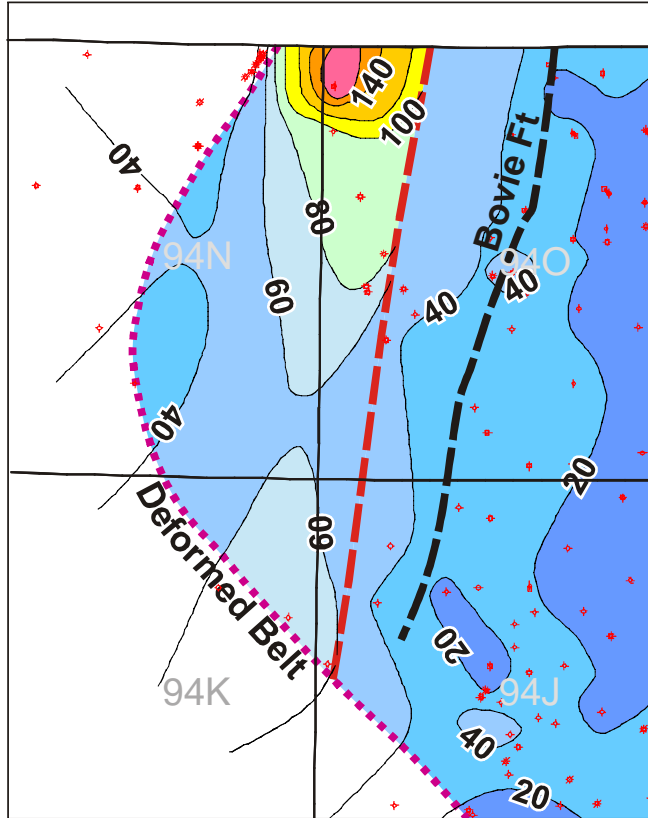


Patry

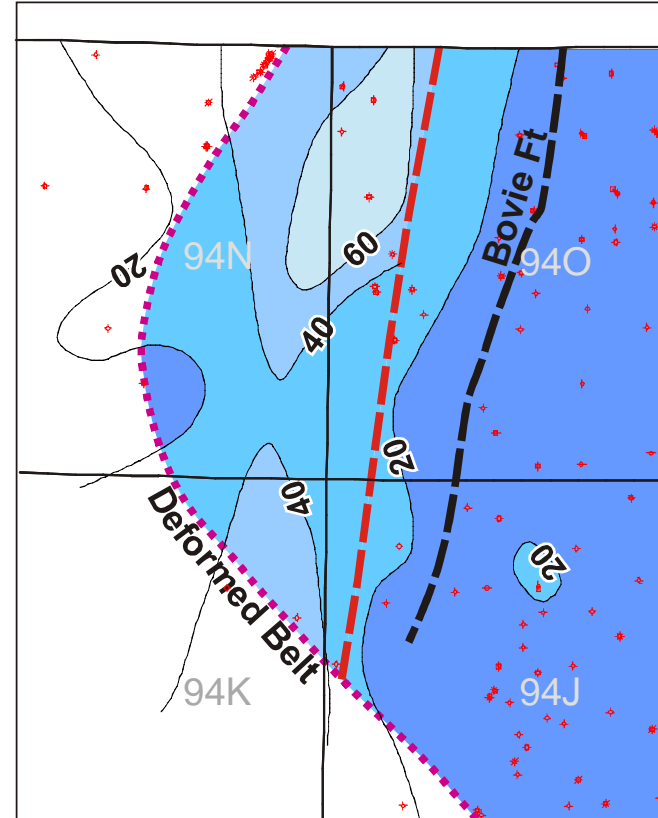


Isopachs

Upper Exshaw

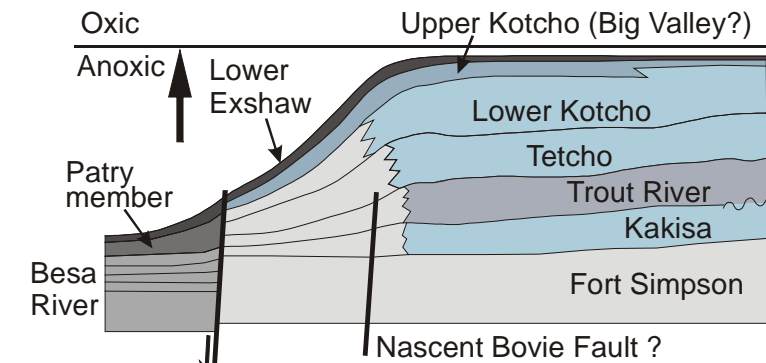


Lower Exshaw



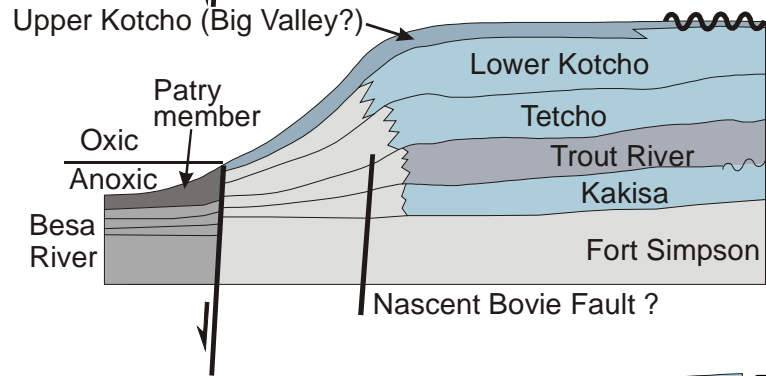
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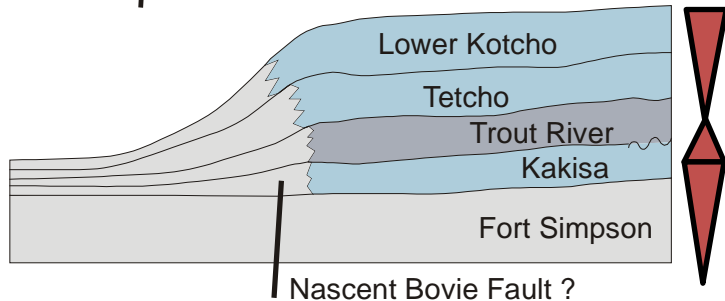
U. Famennian to L. Tournaisian

Deposition of lower Exshaw represents maximum flooding surface. Continued fault motion in the west leads to thicker Exshaw sections.



M. to U. Famennian (U. Dev)

Shales in upper Kotcho reflect beginning of transgressive system tract. Organic-rich shales of the Patry Mbr are coeval. A Bovie-parallel fault is inferred to have provided accommodation space.

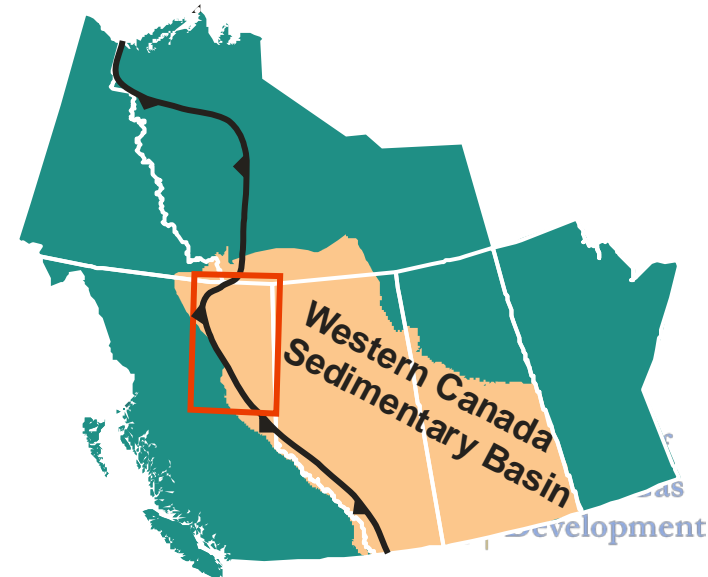
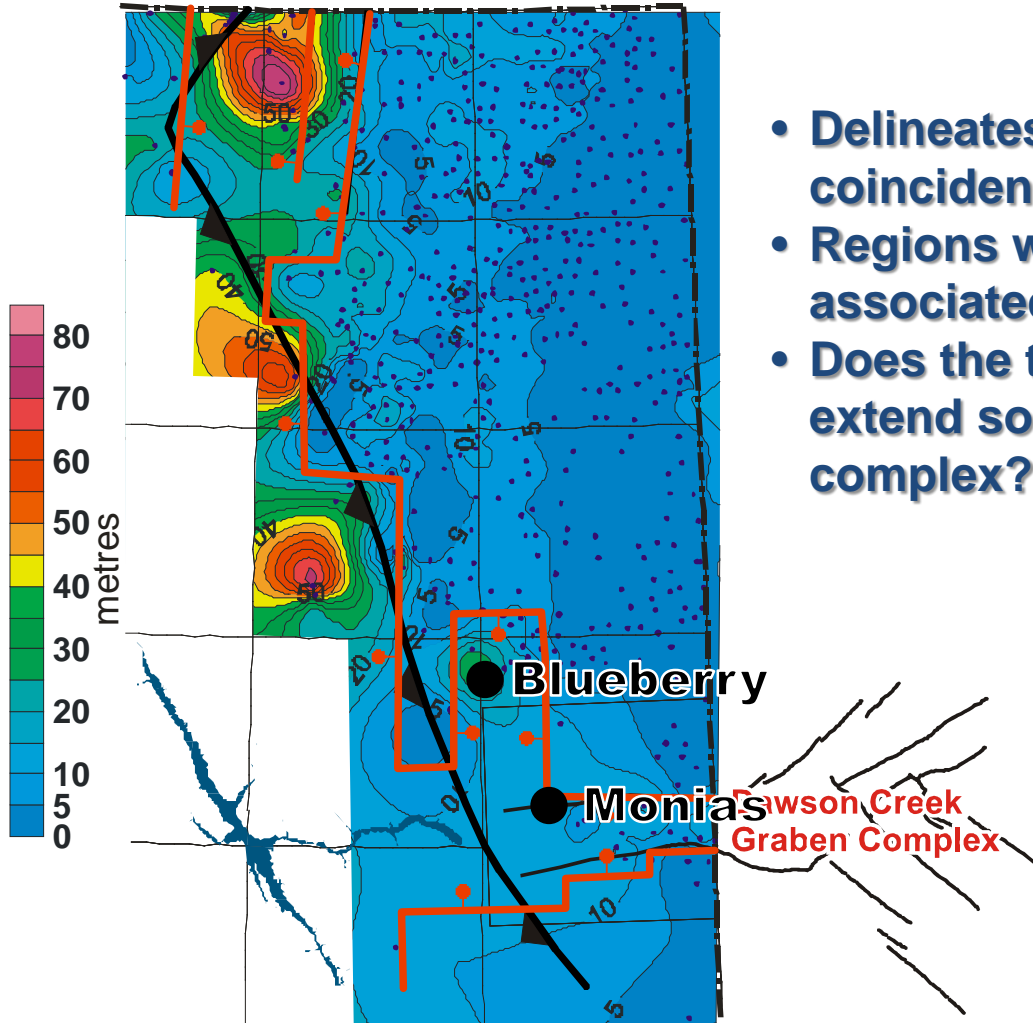


Frasnian to M. Famennian (U. Dev)

Wabamun and Winterburn strata transition westward into normal marine shales similar to Fort Simpson Fm. Top of lower Kotcho represents 2nd order boundary (HST)

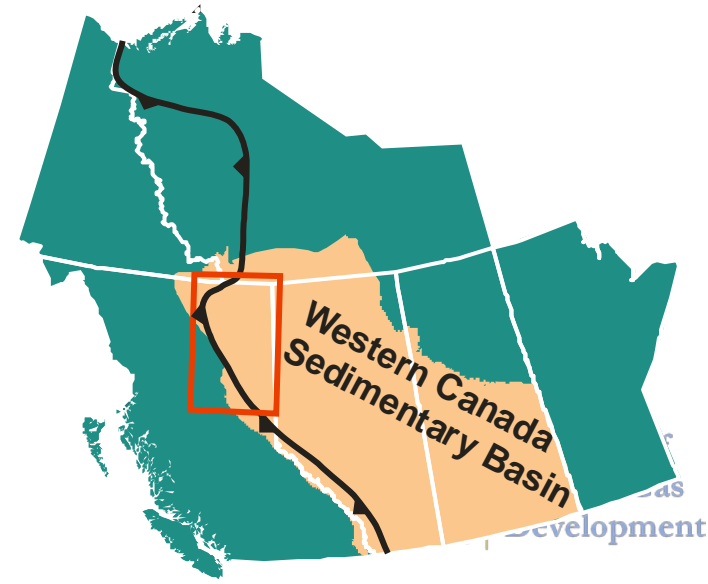
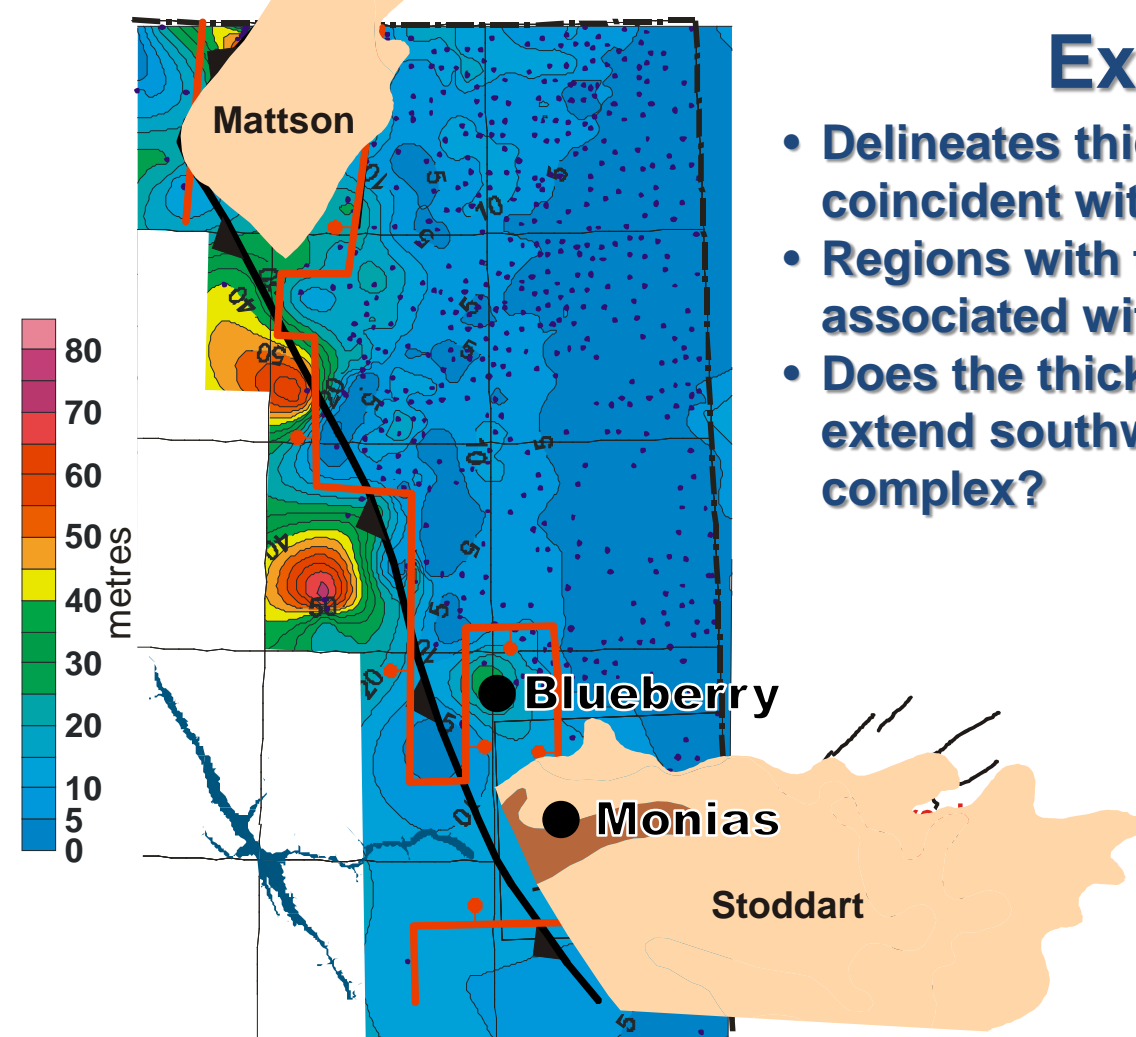
Exshaw Isopach

- Delineates thickening in Peace R. area coincident with Dawson Ck. Graben Complex
- Regions with thickest Exshaw are also associated with Patry lithologies
- Does the thick Exshaw in Blueberry area extend southward into the axis of the graben complex?



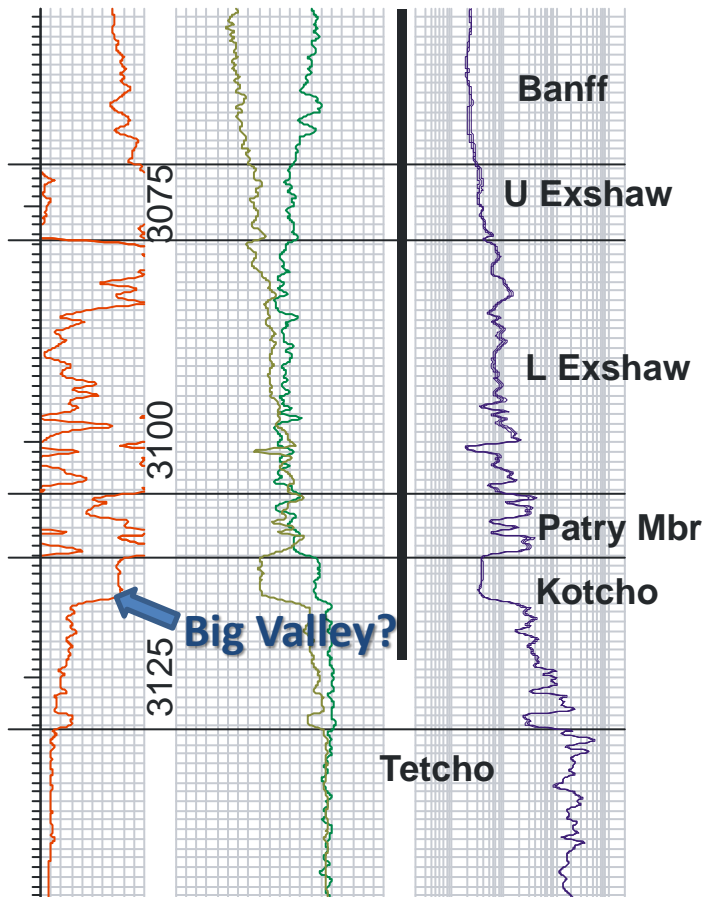
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Suncor Blueberry d-68-D 94-A-13

GR Den - Neut Resistivity

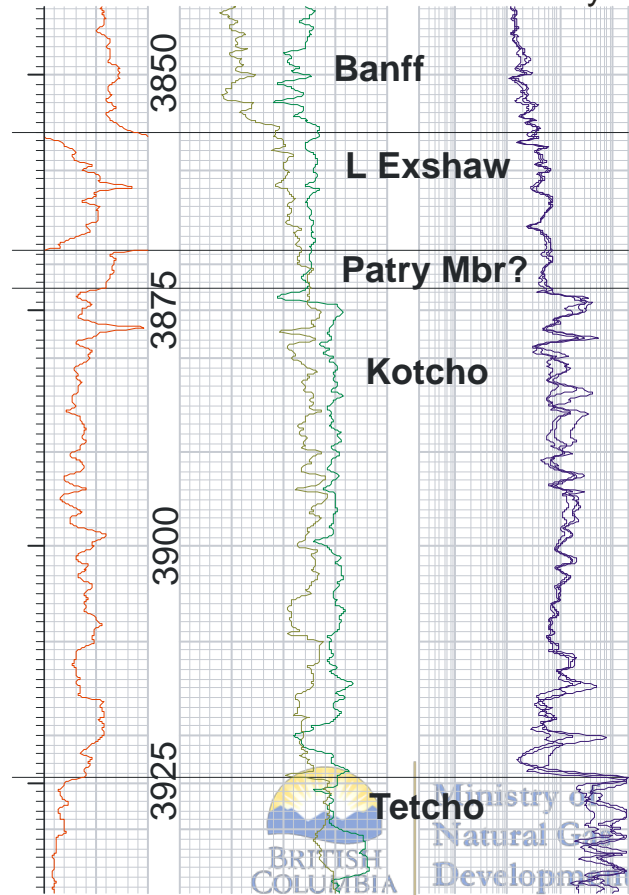


Patry Mbr. ~3106.5m TVD



Encana Monias 6-09-083-22W6

GR Den - Neut Resistivity



Conclusions

- Shale gas development in Liard Basin includes strata equivalent to the Lower Exshaw Fm and an underlying unit called the “Patry Member”
- Combined thicknesses can be in excess of 200 m
- Deposition of the thickest section is inferred to be fault controlled and related to the Bovie structure.
- Extrapolating this model regionally suggests the western edge of the Dawson Ck graben may host a thick section of Exshaw and Patry lithologies.