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THE DEVONIAN-MISSISSIPPIAN BESA RIVER GROUP OF LIARD BASIN, BRITISH COLUMBIA: STRATIGRAPHY OF A WORLD-CLASS SHALE GAS RESOURCE

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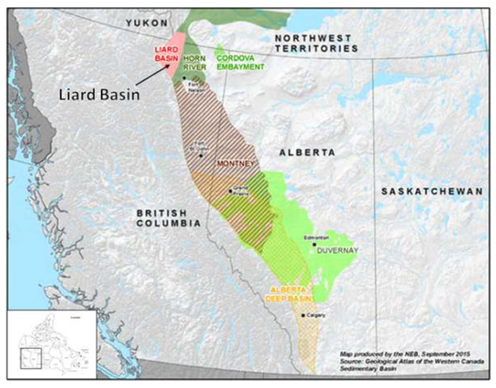
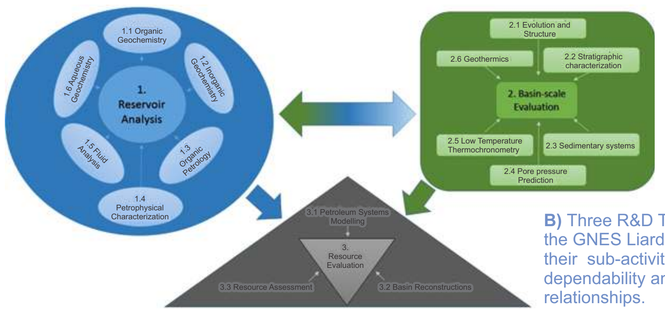


A) Location of sub-basins within the Western Canada Sedimentary Basin. Focus of the research presented in this poster is the Besa River Gp. of the Liard Basin located in Northwestern BC.

Geoscience for New Energy Supply Program (GNES):

- Innovative earth science research to develop new methodologies and generate knowledge of Canada's sub-surface landmass;
- Assist in ensuring that long-term investments in Canada's energy resources meet the social, environmental and economic requirements of Canadians;
- Informs energy industry, regulator and environmental policies and programs;
- Provides informational support to Canada's transition to a lower-carbon energy future. This involves Canada's mission to double clean energy Research & Development (R&D) expenditures by 2020 and geoscience-based solutions to reduce the environmental impact of exploration and development.
- *Canada's unconventional hydrocarbon plays in WCSB and adjoining regions (Fig. 1A):* this enormous resource is still in the early stages of R&D. During the past 5 years, Natural Resources Canada - Geological Survey of Canada has been intensely researching many aspects of unconventional plays through GNES and related programs



B) Three R&D Tasks of the GNES Liard Project, their sub-activities, inter-dependability and relationships.

Liard Basin Natural Gas Project

This GNES project facilitates a science-based, informed shift towards cleaner exploration/development methods and strategies pertaining to natural gas (NG) energy sources locked in the Liard Basin (Fig. 1A). The Liard Project undertakes 3 primary R&D tasks with a number of activities under each task (Fig. 1B).

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Geoscience cross-section, E-W orientation, central Liard Basin

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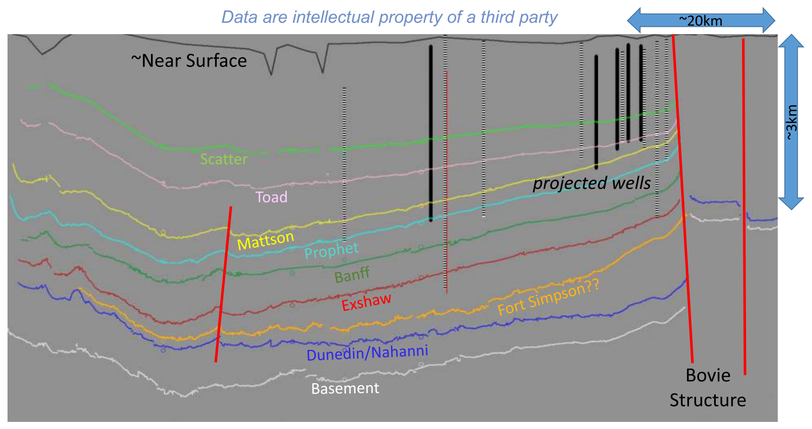

The Middle Devonian to Middle Mississippian Besa River Group in the Liard Basin of northwestern Canada is a distal, shale-dominated succession that is time equivalent to thousands of metres of more proximal carbonates, shales, and sandstones spanning the Fort Simpson to Mattson formations (Fig. 6). Petrophysical logs allow the recognition of specific formations within northeastern subsurface occurrences of the Besa River Group, but this is not obvious in western outcrops and subsurface where the unit remains at formation level .

The Besa River Group contains 6,196 x 109 m^3 of marketable, dry gas within organic-rich mudrocks of the Exshaw-Patry interval[1]. These units define an over 200 m thick, 20 to 30 km wide, north-northeast trending zone in the eastern Liard Basin. These siliceous shales occur at over 5 km depth, producing over-pressured reservoirs and resulting in prolific wells when stimulated through hydraulic fracturing.

The Patry shales are basinal equivalents of upper Kotcho ramp carbonates and calcareous shales, which in turn transition eastward into Wabamun Formation shelf carbonates. The upper Patry interval was deposited during a late Famennian to early Tournaisian second-order transgressive-regressive sequence (Fig. 5). Transgression culminated with deposition of the lower Exshaw black shale and chert, whereas the subsequent regression is recorded by the overlying upper Exshaw and Banff-equivalent strata. Organic-rich Patry shales reflect spread of anoxic bottom waters within deep, basinal environments. These anoxic conditions spread across much of the Western Canada Sedimentary Basin as transgression peaked during deposition of the lower Exshaw.

Convergent plate tectonism and subsequent back-arc extension occurred along the western edge of Laurentia during the latest Devonian and Mississippian. Compression and subsequent extension influenced deposition within Liard Basin and grabens within the Peace River Embayment. Felsic tuff layers within the Exshaw Formation and Patry interval (Fig. 7D-E) were sourced from the westerly located volcanic arc, and their dating is underway to help in further deciphering of global and regional signals imprinted in the Besa River Group.

ACKNOWLEDGEMENTS

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[1]National Energy Board of Canada, 2016. The Unconventional Gas Resources of Mississippian-Devonian Shales in the Liard Basin of British Columbia, the Northwest Territories, and Yukon; Energy Briefing Note, March, 2016, http://publications.gc.ca/site/eng/9.811747/publication.html

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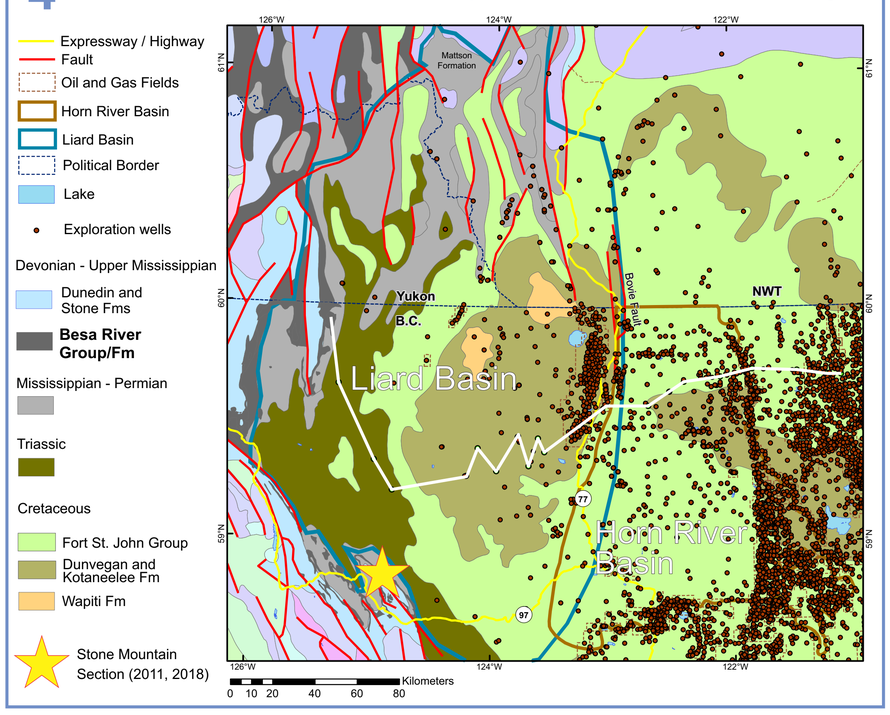
Liard Basin on a simplified bedrock map with trace of cross-section from Fig. 6



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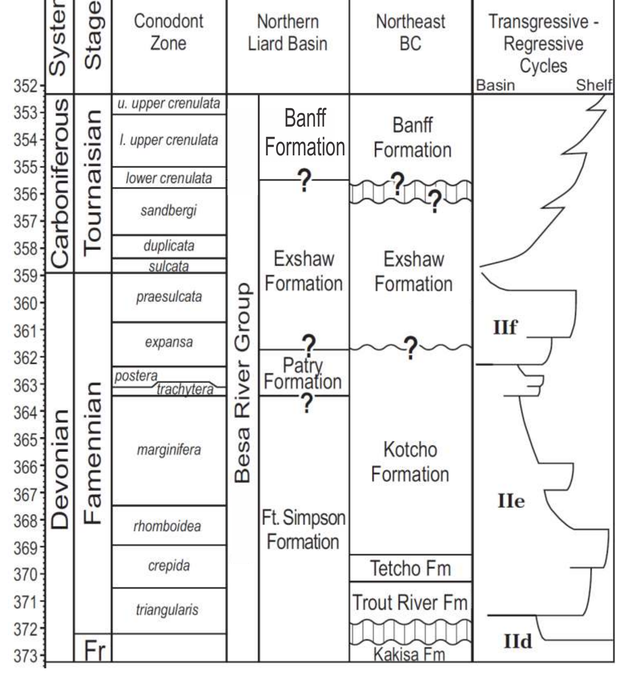

Chronistratigraphic position of middle-upper Besa River Gp.

Conodont zonation for the Famennian is from Kaufmann (2006) and for the Tournaisian from the ICS (2017a). The absolute time scale is from ICS (2017b). This diagram is modified from Richards et al. (2002). Devonian T-R cycles are modified from Morrow and Sandberg (2008). Carboniferous sea-level curve is interpreted from Ross and Ross (1985, 1988).

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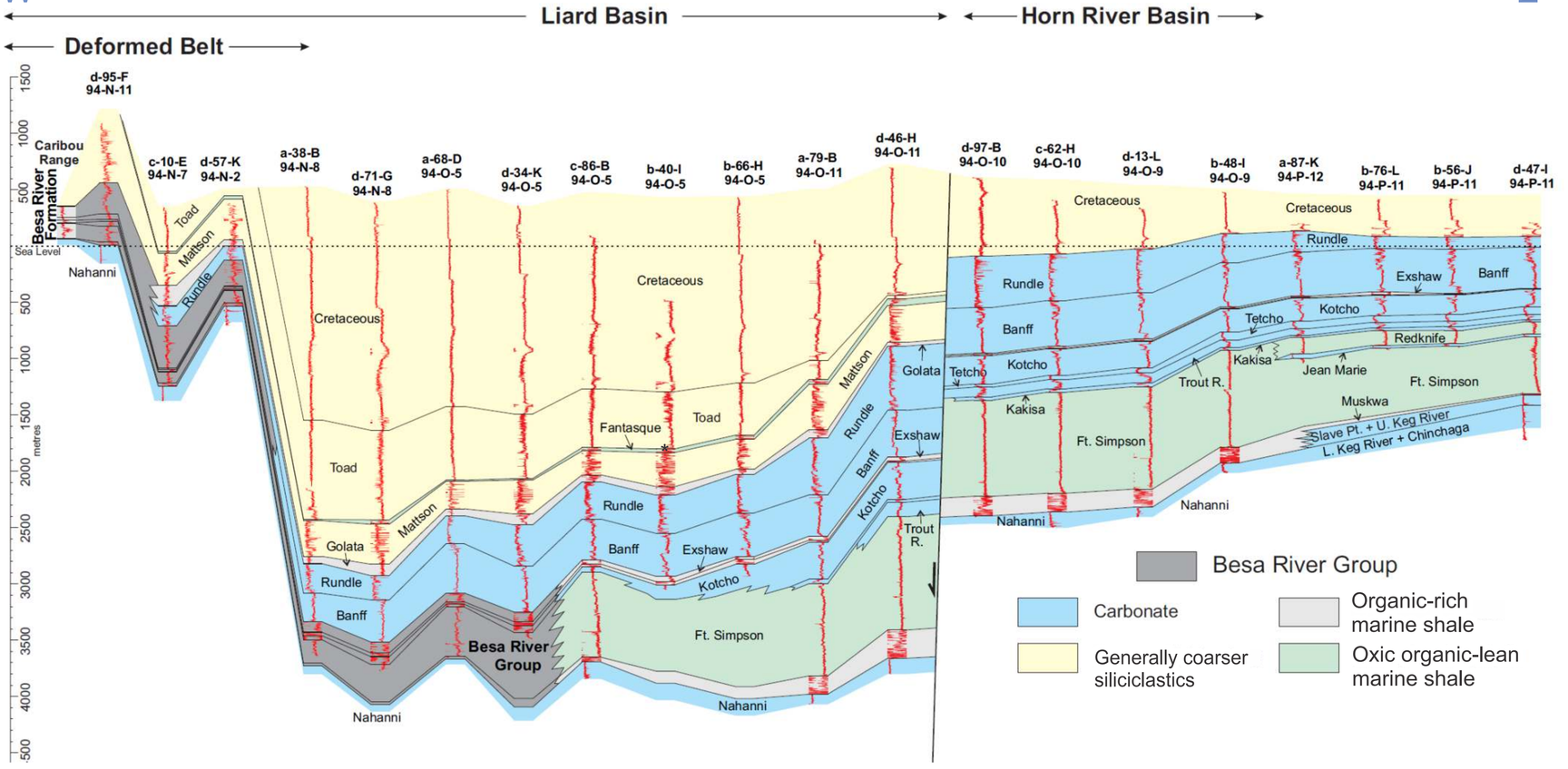

East-west cross-section extending from the western edge of the Cordova Embayment to the Caribou Range in the Mackenzie Mountains. The section displays gamma-ray trace for each well (red log) . *Fantasque is a condensed section of spiculitic chertstone.

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Outcrop and core aspects of Besa River mudrocks

A) Hard bedded cherts (*ch*) intercalated with more fissile shales (*sh*), lower Besa River, Stone Mountain section (Fig 3). Yellow weathering occurs from decomposition of shale pyrites.

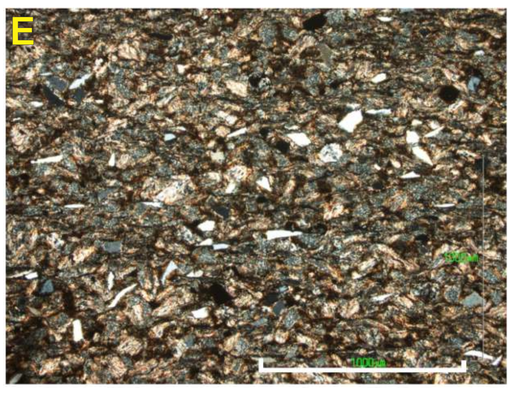
B) Acquiring spectral gamma-ray log from a recessive shale interval, same locality

C) Decameter-scale syndepositional slumping folds in a cherty shale unit tentatively correlated to Muskwa Fm., same locality

All field photos are from 2018 field season.

D) Pyritized bentonitic layer with felsic tuff material, arrowed in top and base; Woodside La Jolie B-3-K well, 4284.75 m depth.

E) Thin-section photomicrograph of a felsic tuff at the base of Exshaw, Woodside Patry b-23-K well, 3710.4 m. Quartz, mica and lithic shards are clearly visible. Cross-polarized light.



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Exshaw-Patry interval in type section for Patry unit*

Depth profiles of total organic carbon content (TOC), porosity, gas saturation, and XRD data plotted against selected borehole logs. Data credit: Apache Canada Ltd., 2012.

**promotion from member to formation status is underway*

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