Accommodation, Sediment Provenance and Paleo-Drainage on the Basal Cretaceous Unconformity across the Canadian Western Interior Basin*

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Search and Discovery Article #30483 (2016)**
Posted December 26, 2016

*Adapted from oral presentation given at AAPG 2016 Annual Convention and Exhibition, Calgary, Alberta, Canada, June 19-22, 2016

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Abstract

Jurassic-Paleogene strata of the Alberta basin are divided into a series of sedimentary wedges that have been linked to major uplift and denudation events in the North American Cordillera. A foreland setting has been interpreted for the entirety of the stratigraphic succession; however, well-established foreland characteristics are not prevalent through all intervals. We hypothesize that the Lower Mannville Group, which mantles the basal Cretaceous unconformity across the basin and contains a majority of western Canada's hydrocarbon resources, is not a foreland basin deposit. During the Aptian, the Western Interior basin of Alberta was dominated by a series of large-scale channel belts that were confined within elongate topographic lows that paralleled the incipient Cordillera to the west. The basin axial drainage networks intersected the Western Interior Seaway, which inundated the basin to the north. Topography on the depositional surface, the sub-Cretaceous unconformity, was controlled by differential erosion of underlying westerly dipping Devonian-Jurassic strata. Foreland basins are defined by numerous characteristics. Their fill is notably asymmetric, thinning away from the orogenic load. Sediment is dominantly derived from the uplifting, or recently uplifted mountain belt. The thickness of Lower Mannville Group strata measured from thousands of well bores across the Western Interior basin, a measure of accommodation, does not show a pronounced asymmetry. Furthermore, detrital zircon analysis from channel-belt deposits across the basin indicates limited Mesozoic grain input from the adjacent Cordillera (in contrast to younger foreland basin units). Recent results have lead to interpretations that the basin captured continental rivers, deriving sediment from as far away as the Appalachian Orogen and the southwestern United States. Although sediment accumulated adjacent to a mountain belt in a foreland position, accommodation was limited and the region was dominated by: (1) net erosion during formation of the sub-Cretaceous unconformity; and (2) subsequent Lower Mannville fluvial sediment transfer across the topographically complex landscape. Our observations challenge a long-accepted paradigm for Mesozoic basin evolution in western Canada, and emphasize variation in foreland basin history with implications for basin-scale sediment distribution and reservoir prediction.

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Accommodation, sediment provenance and paleo-drainage on the basal Cretaceous unconformity across the WCSB

Steve Hubbard, Dale Leckie, Garrett Quinn, Ben Daniels, William Matthews and Bernard Guest

with contributions from Rudi Bhargava, Marie-Pier Boivin, Rebecca Englert, Nicolas Garroni, Danica Heath, Lauren Madronich, Harrison Martin, and Dane Synnott

… and thanks to Thomas Hadlari, Brad Hayes, Peter Putnam, and Per Pedersen

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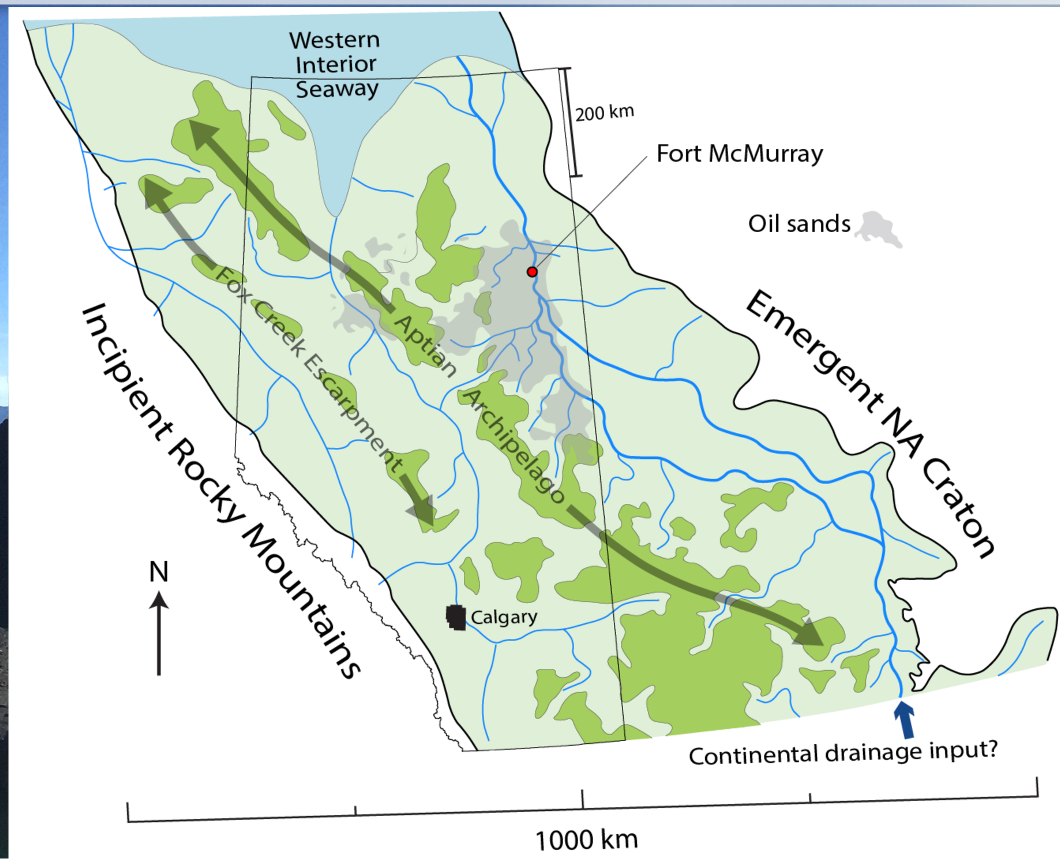
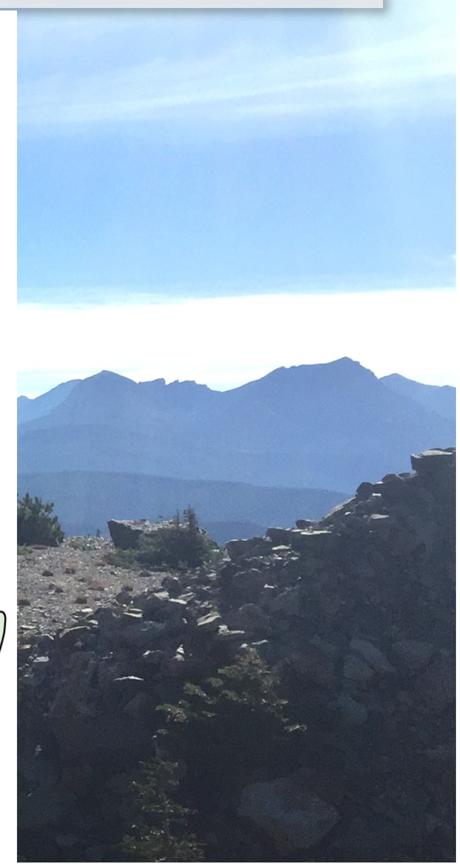
Hypothesis:

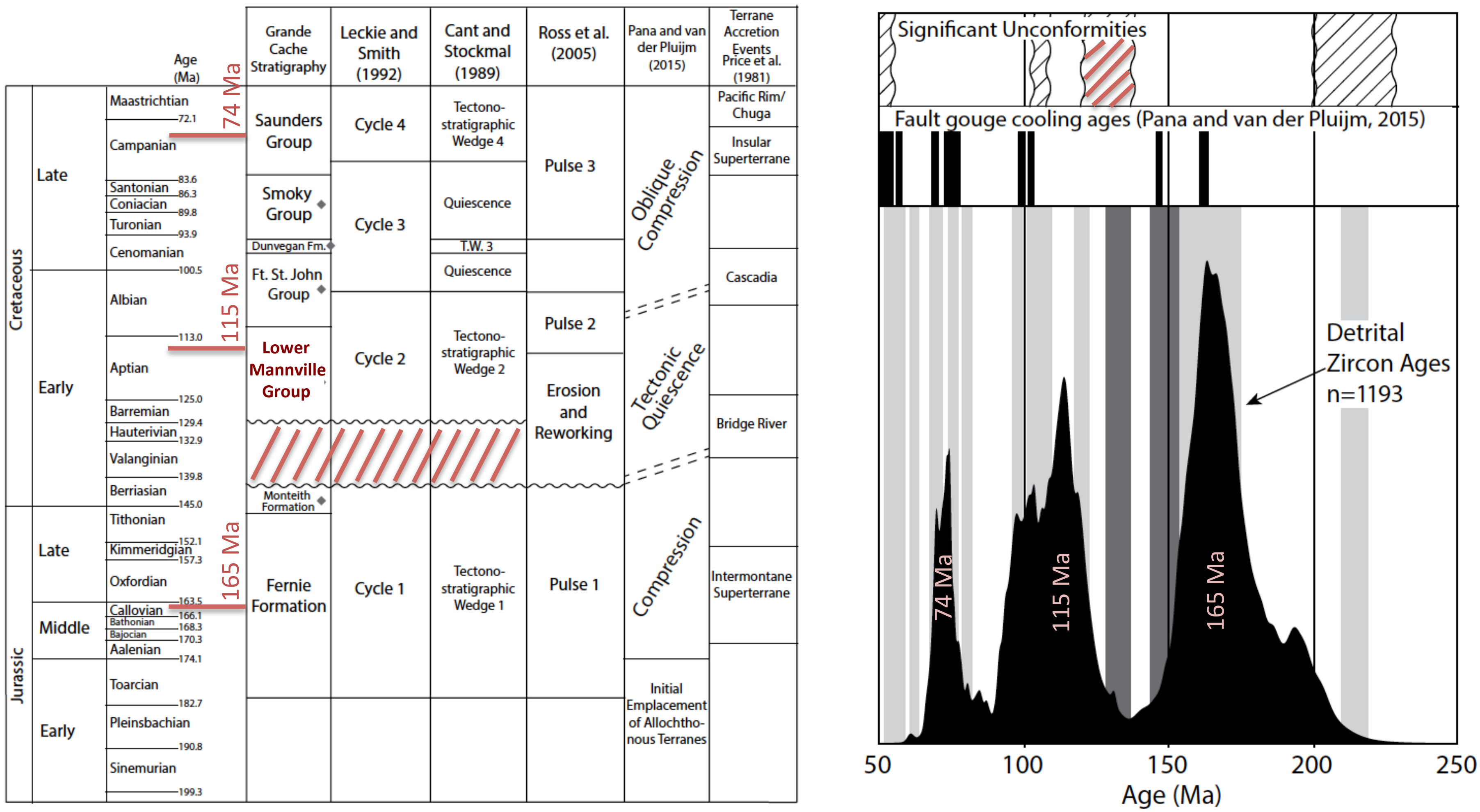
Deposits of the Lower Mannville Group largely accumulated in accommodation generated during a period of basin uplift and erosion rather than foreland basin subsidence





The sub-Cretaceous unconformity and the Lower Mannville Gp.

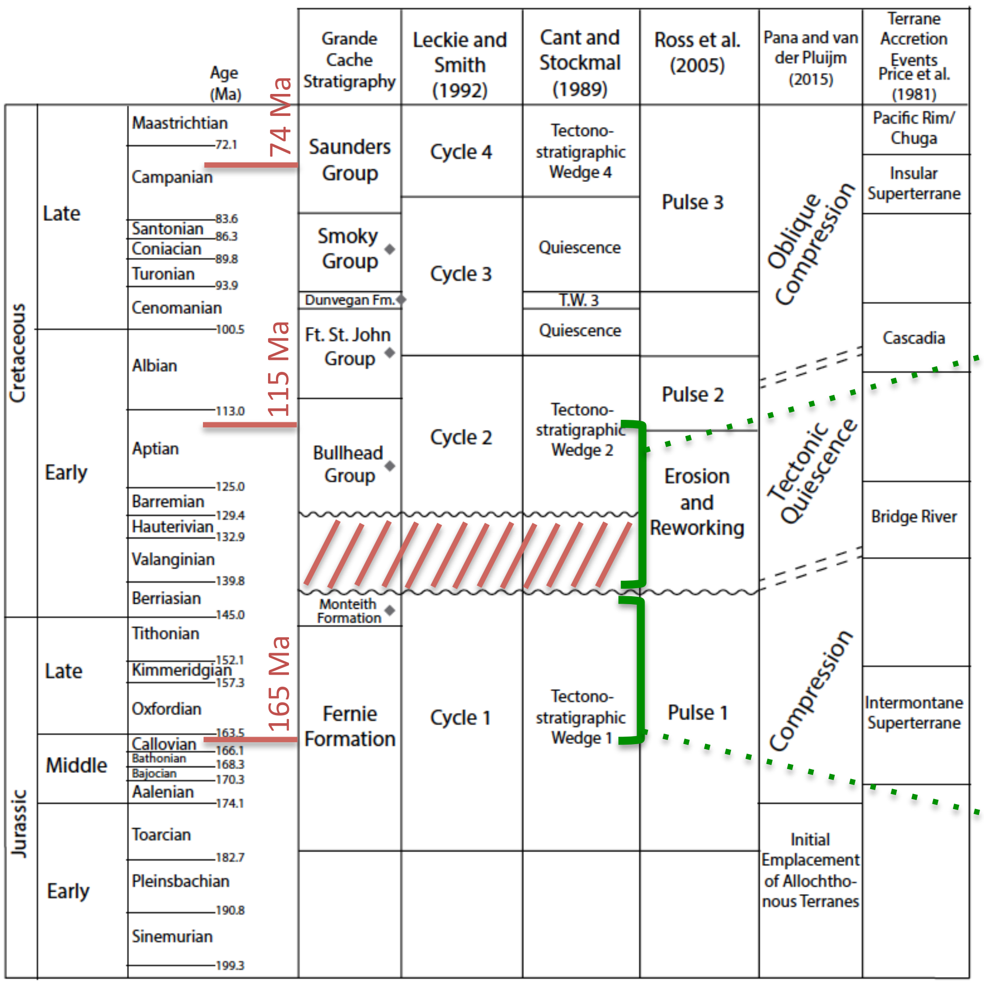
Alberta Basin stratigraphy punctuated by 10-15 Ma hiatus



Quinn et al., 2016, Lithosphere

The sub-Cretaceous unconformity and the Lower Mannville Gp.

Forebulge partitioning or isostatic rebound?



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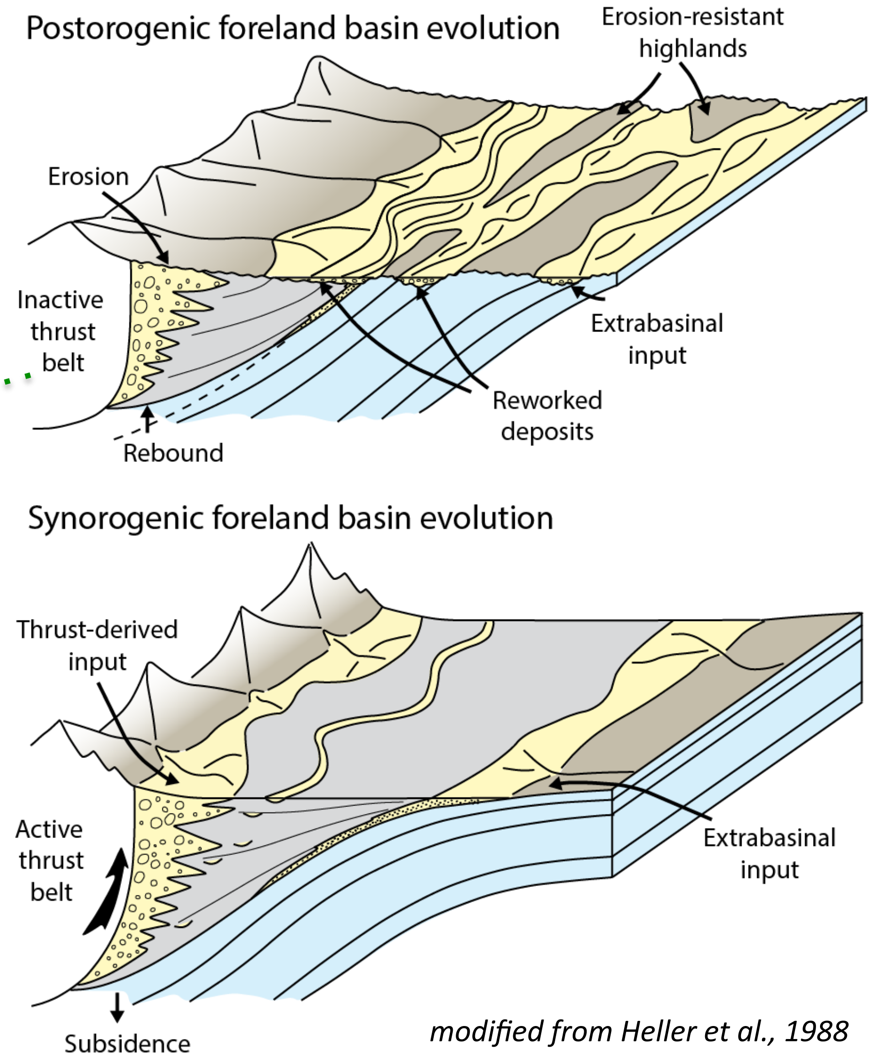

modified from Heller et al., 1988

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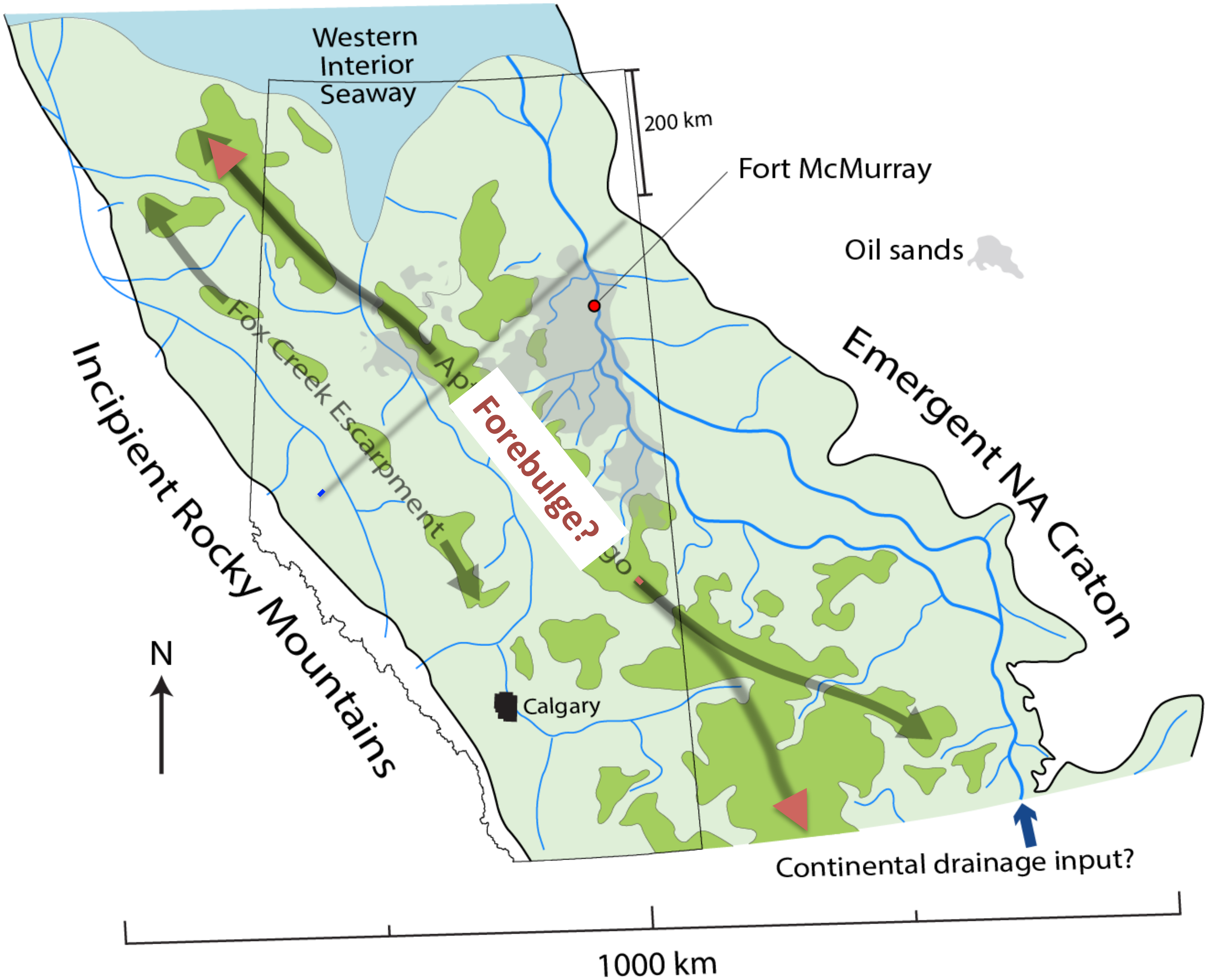
Methodology:

1. *Basin-scale isopach mapping of the Lower Mannville Group*
2. *Detrital zircon geochronology (13 new samples)*

(16 samples from Benyon et al., 2014; Blum et al., 2014; Leier and Gehrels, 2011; Quinn et al., 2016)

Lower Mannville Paleogeography: Axial Drainages and Topographic Divides



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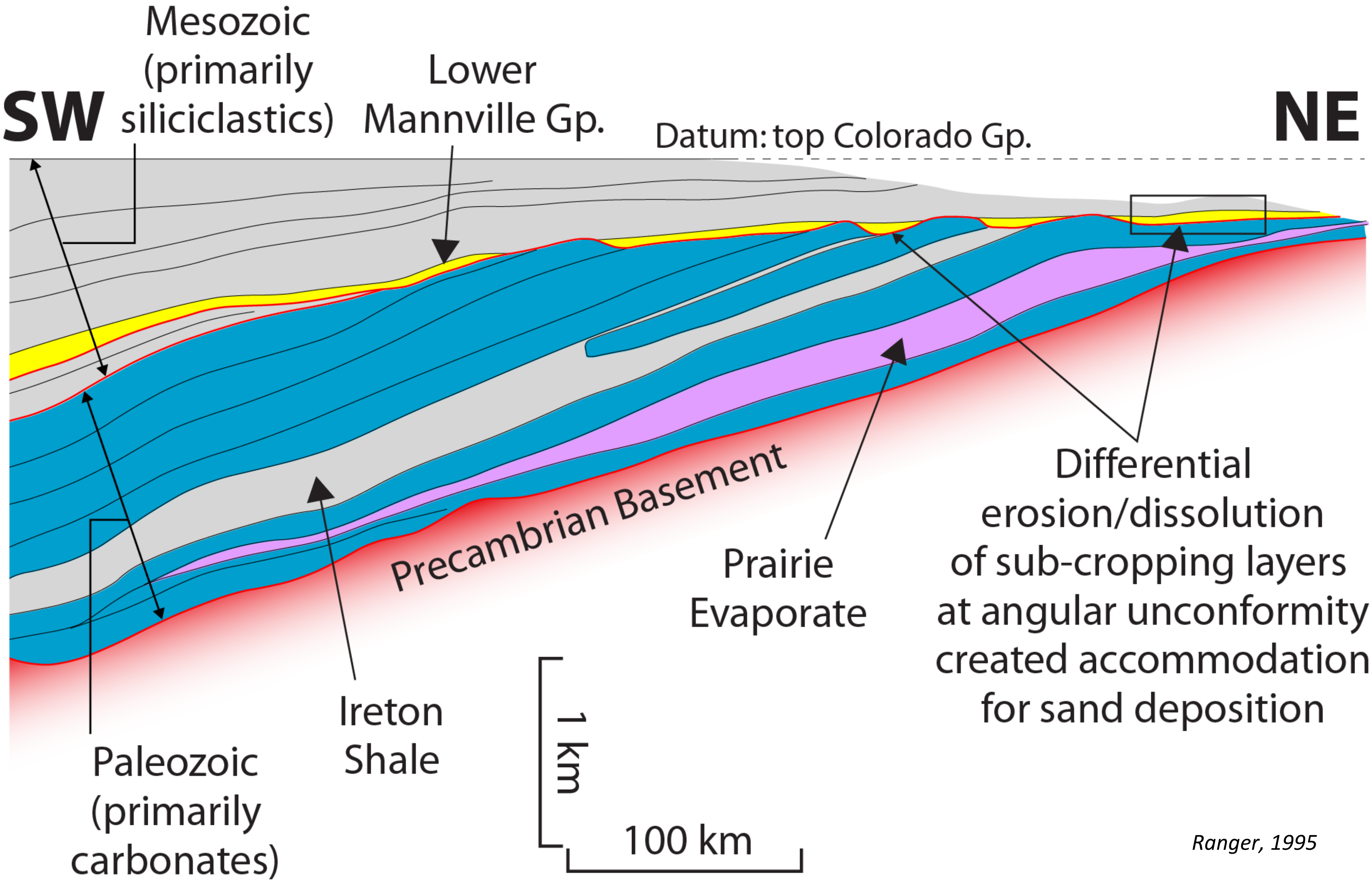

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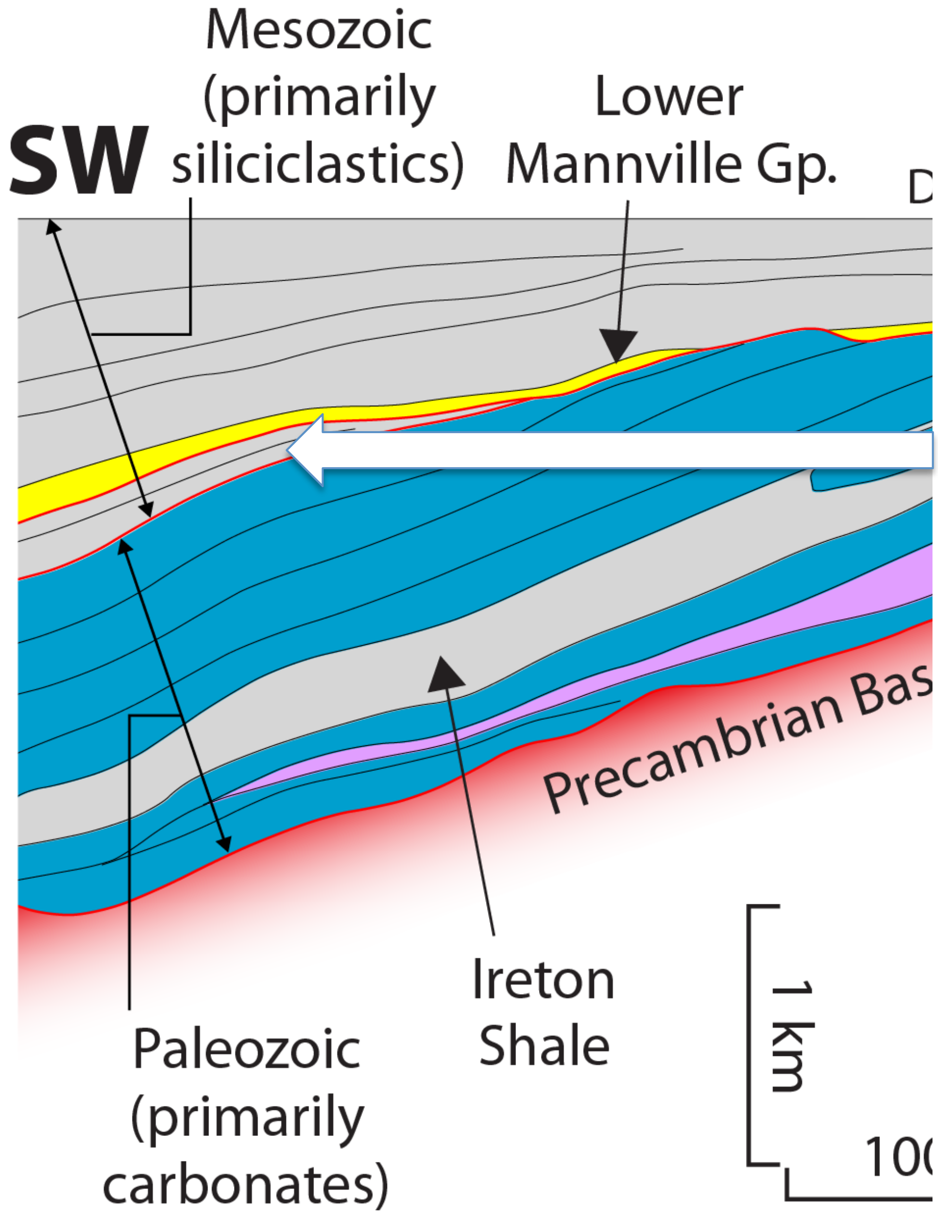
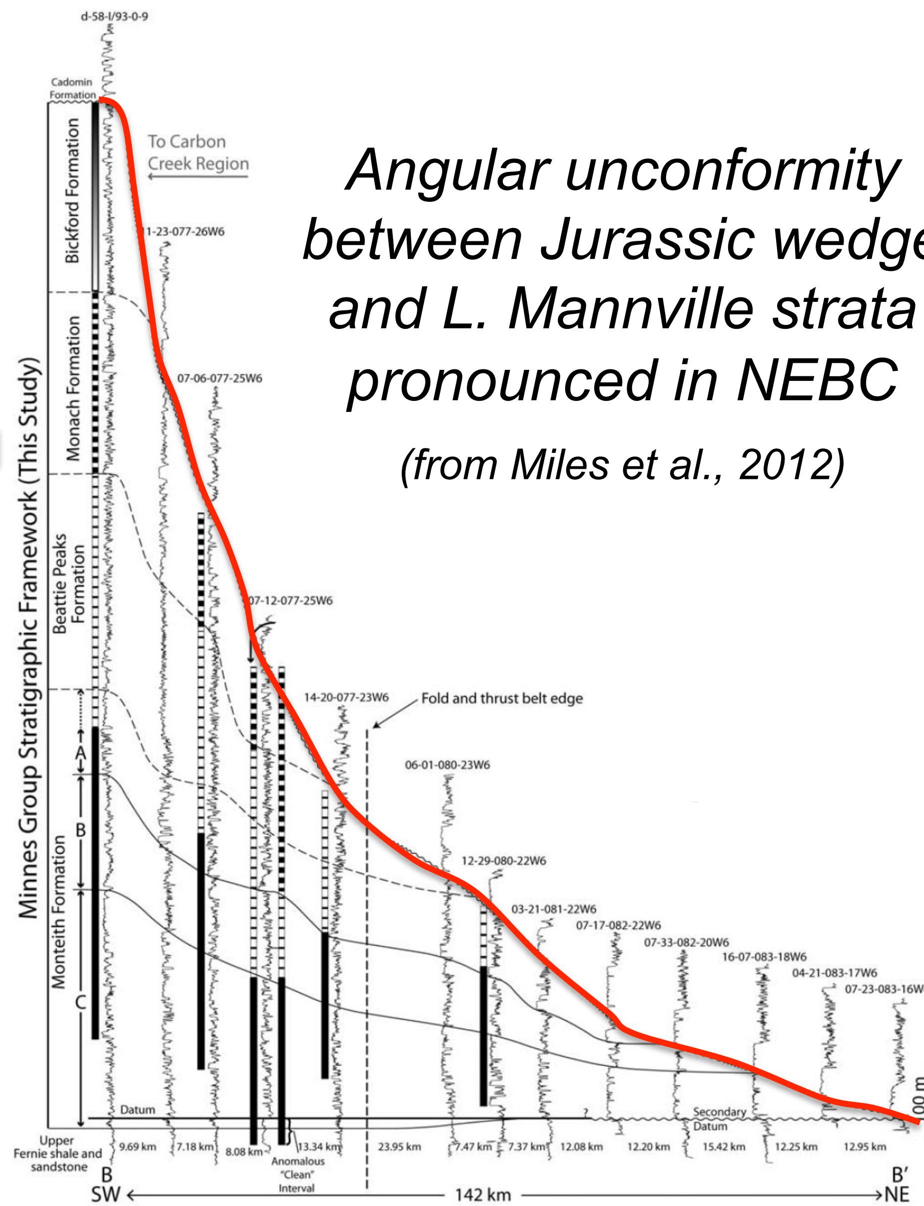
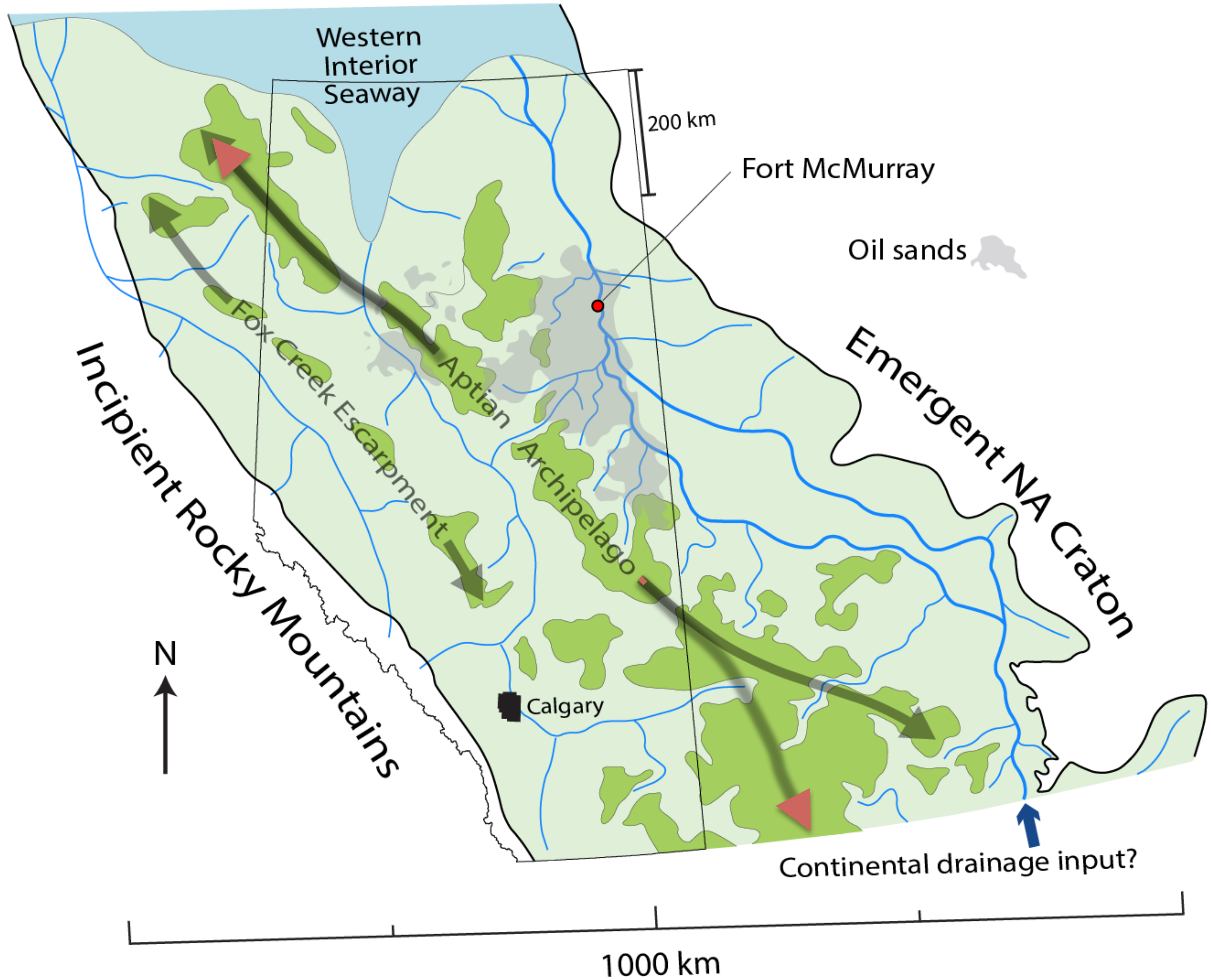




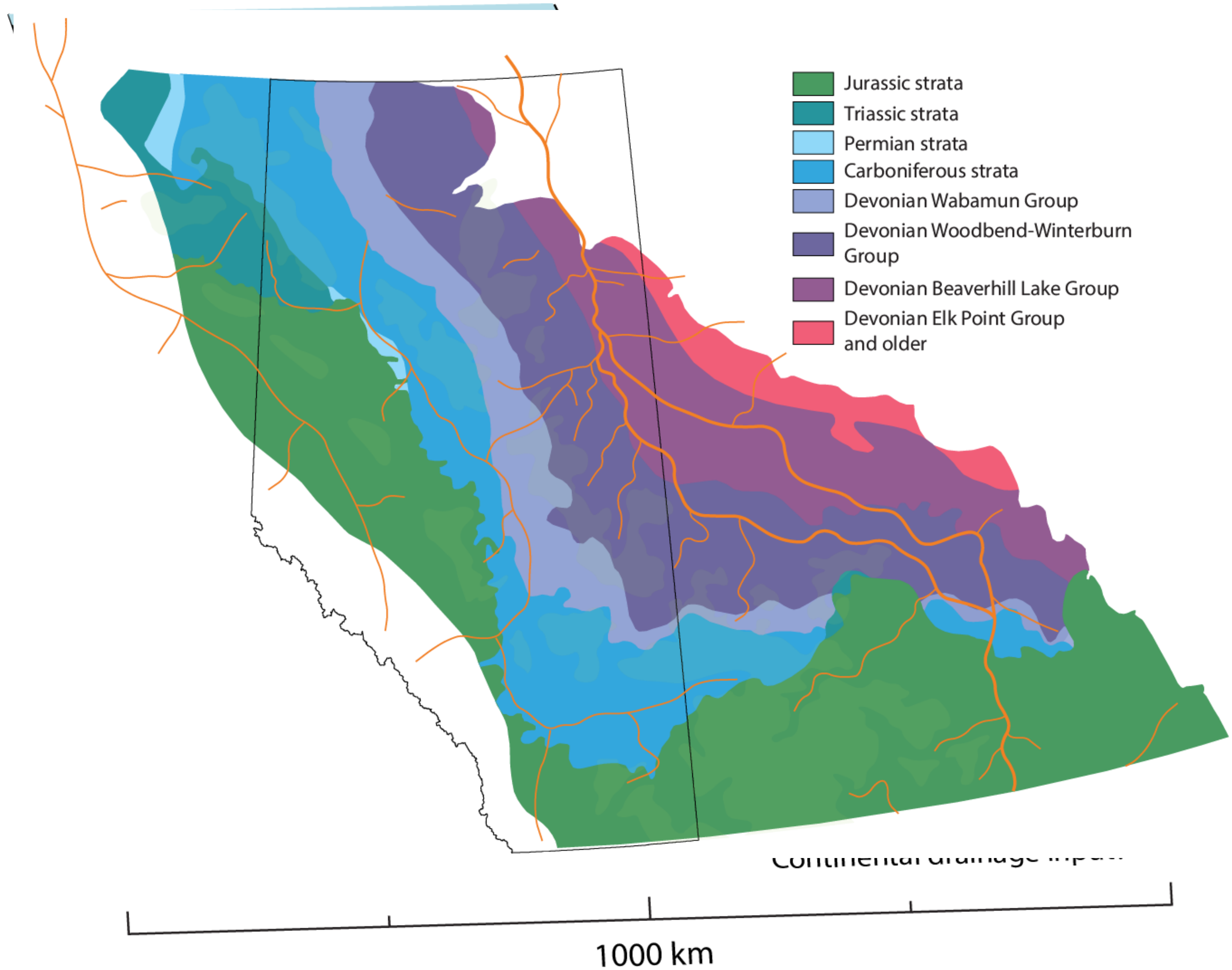
Angular unconformity between Jurassic wedge and L. Mannville strata pronounced in NEBC

(from Miles et al., 2012)

Lower Mannville Isopach Mapping with Implications for Basin-Wide Accommodation Trends



Lower Mannville Isopach Mapping with Implications for Basin-Wide Accommodation Trends



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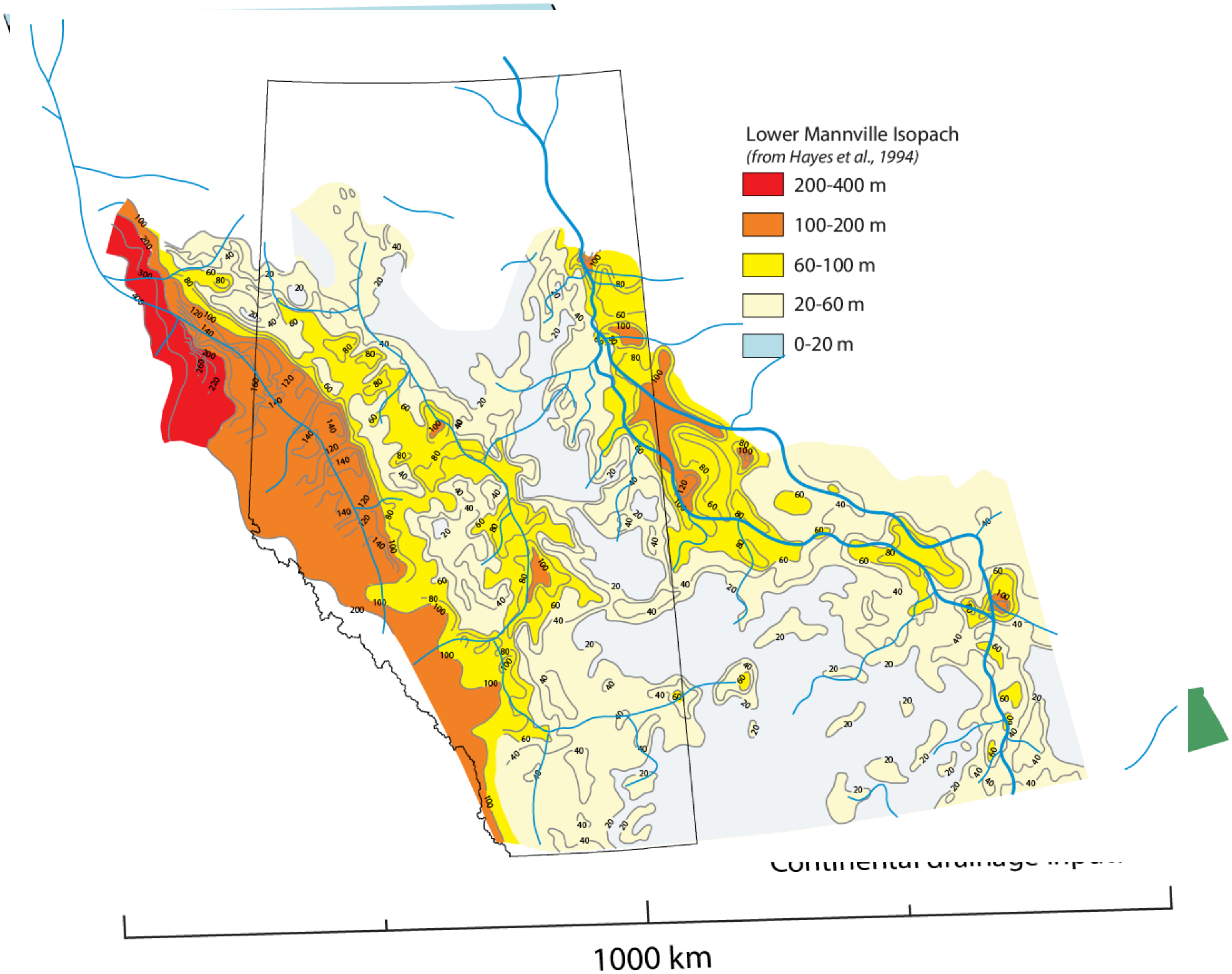

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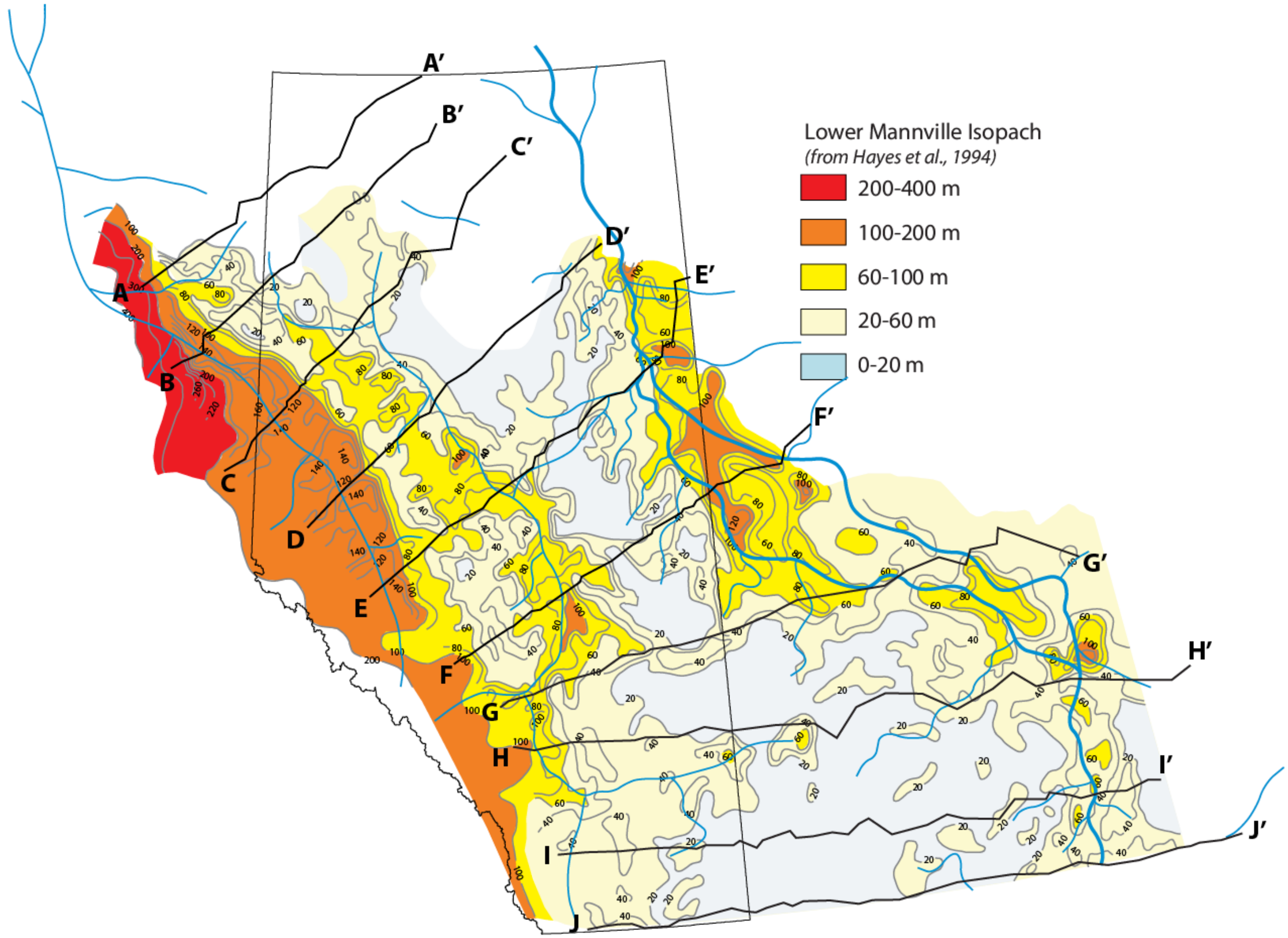

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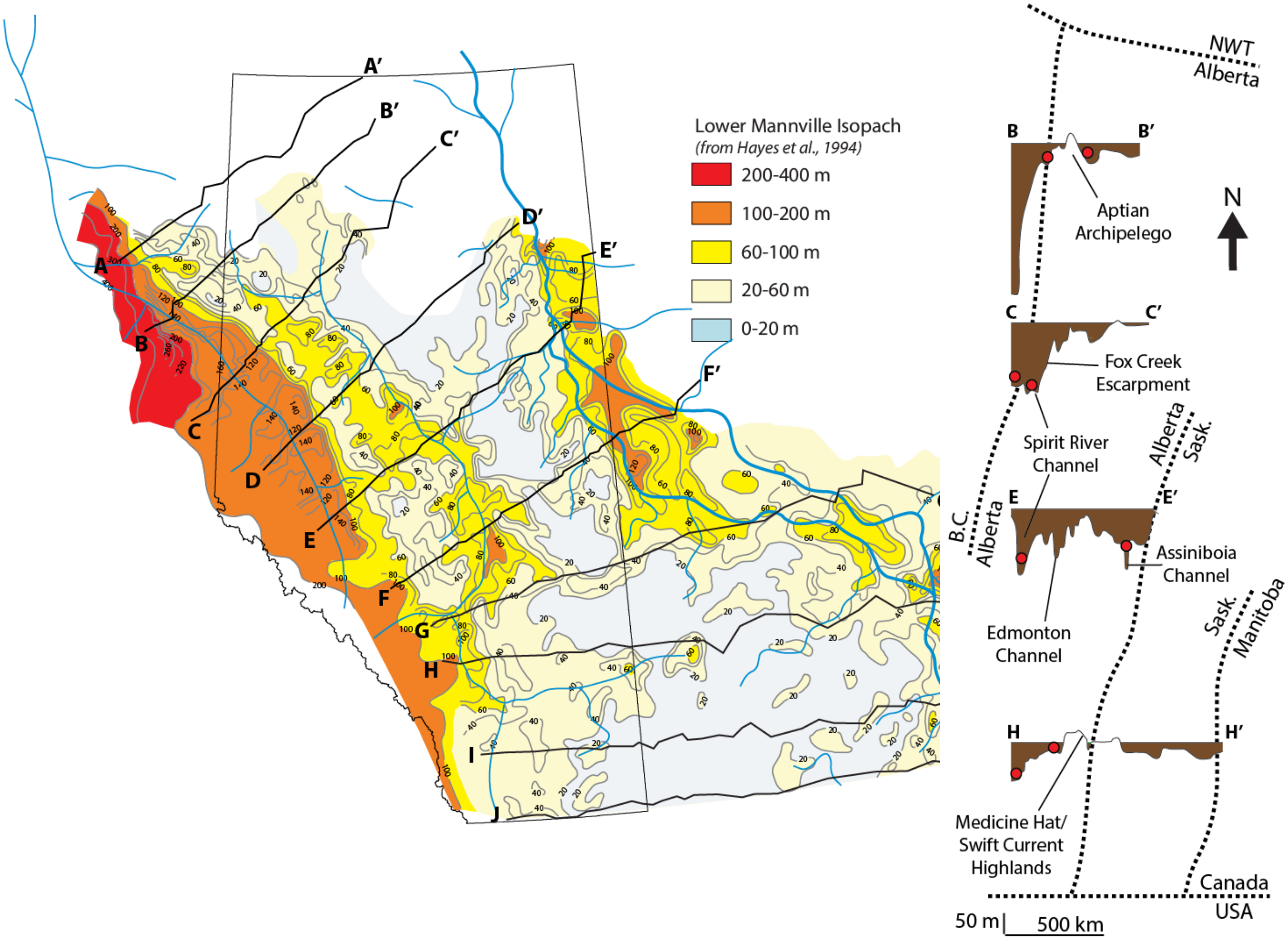

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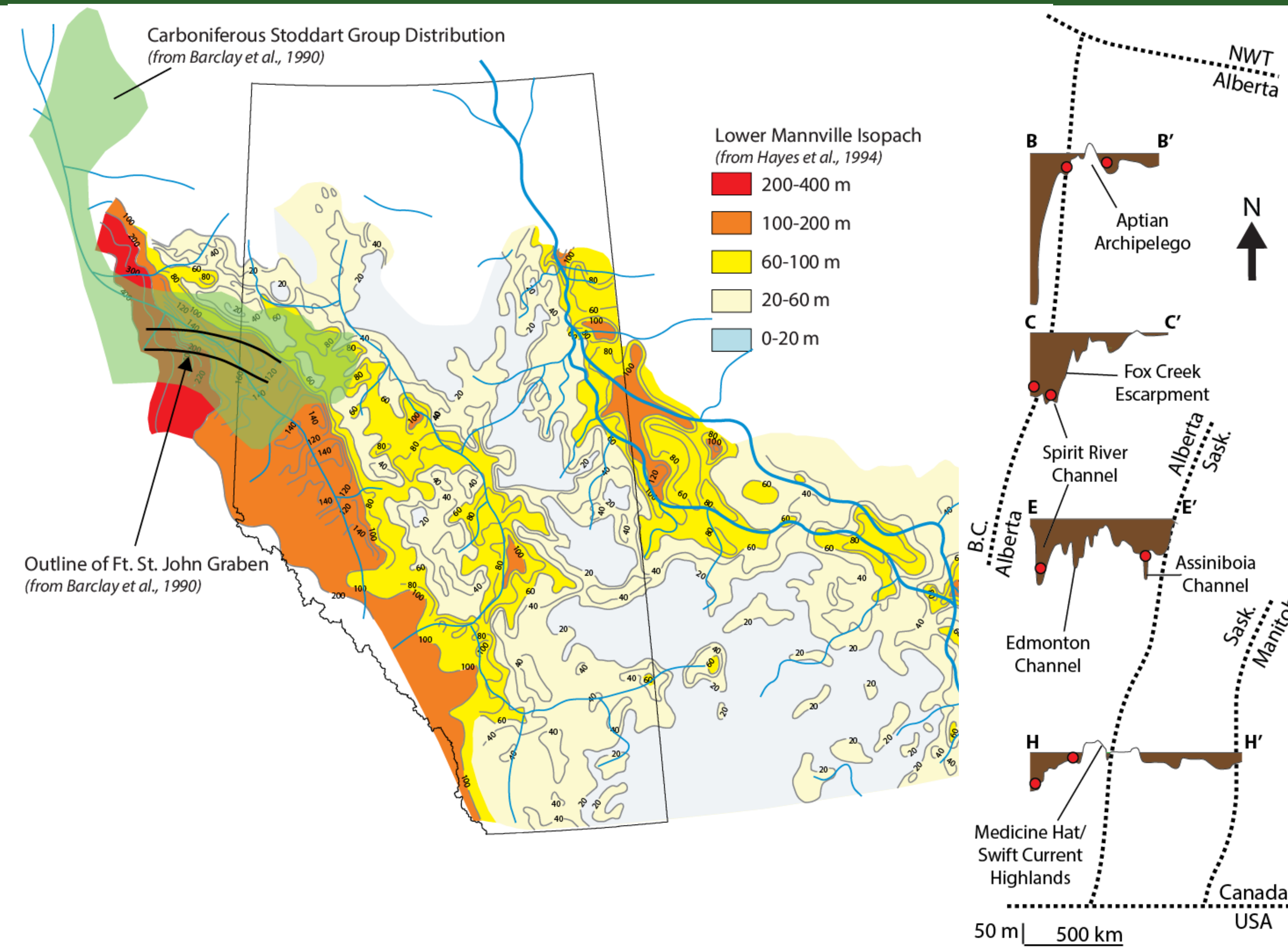

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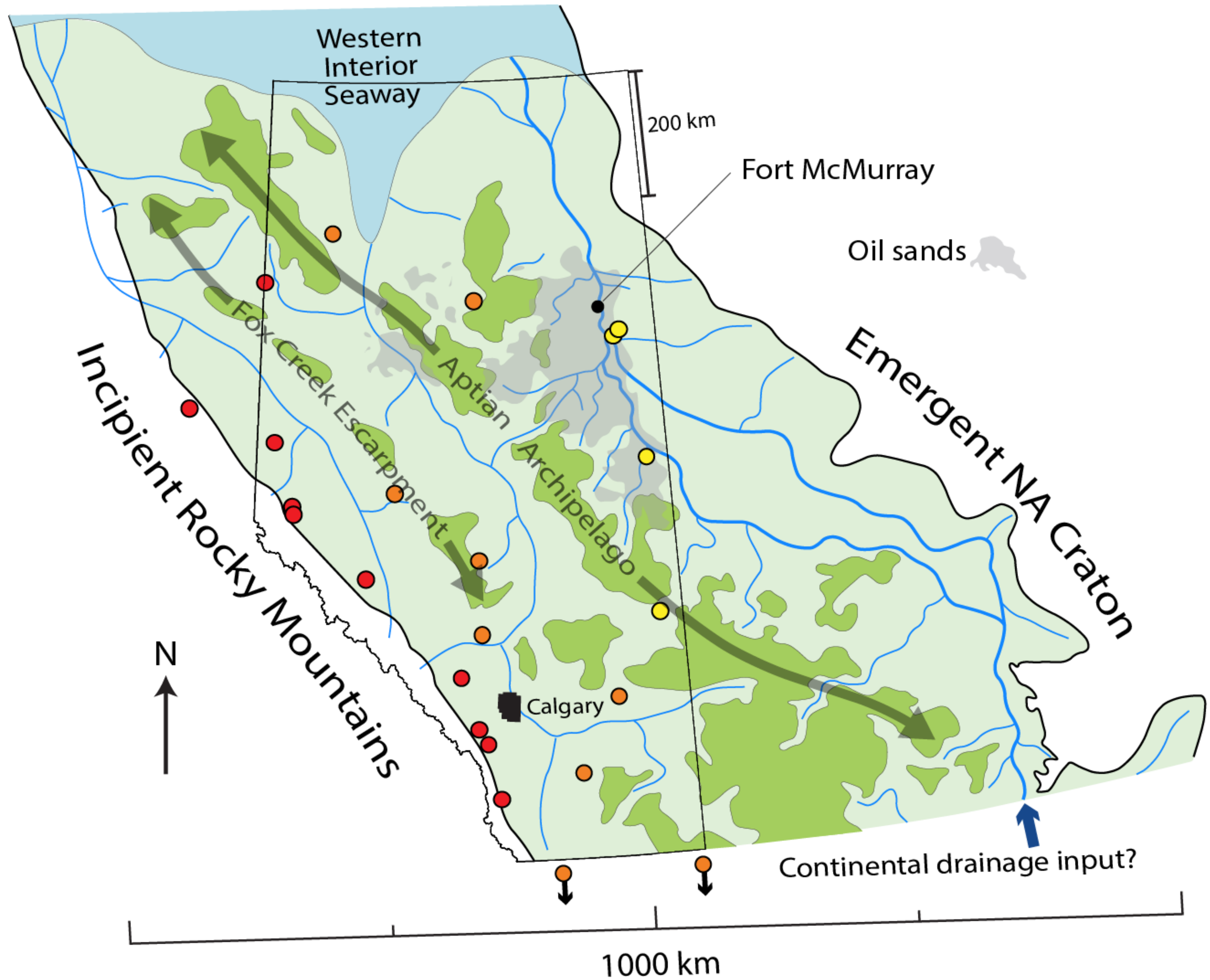
Lower Mannville Sediment Provenance and Sediment Distribution: Detrital Zircon Geochronology



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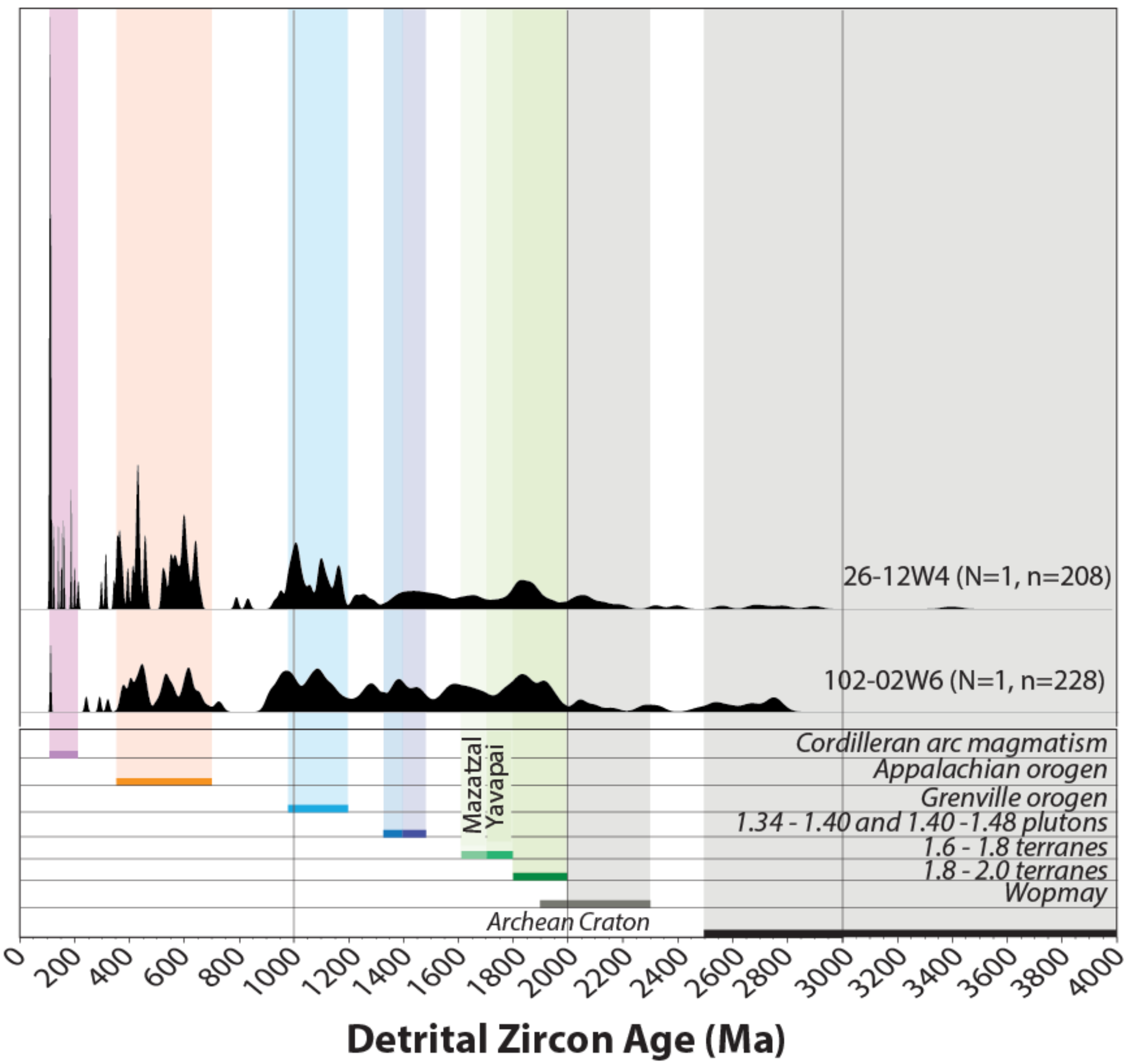

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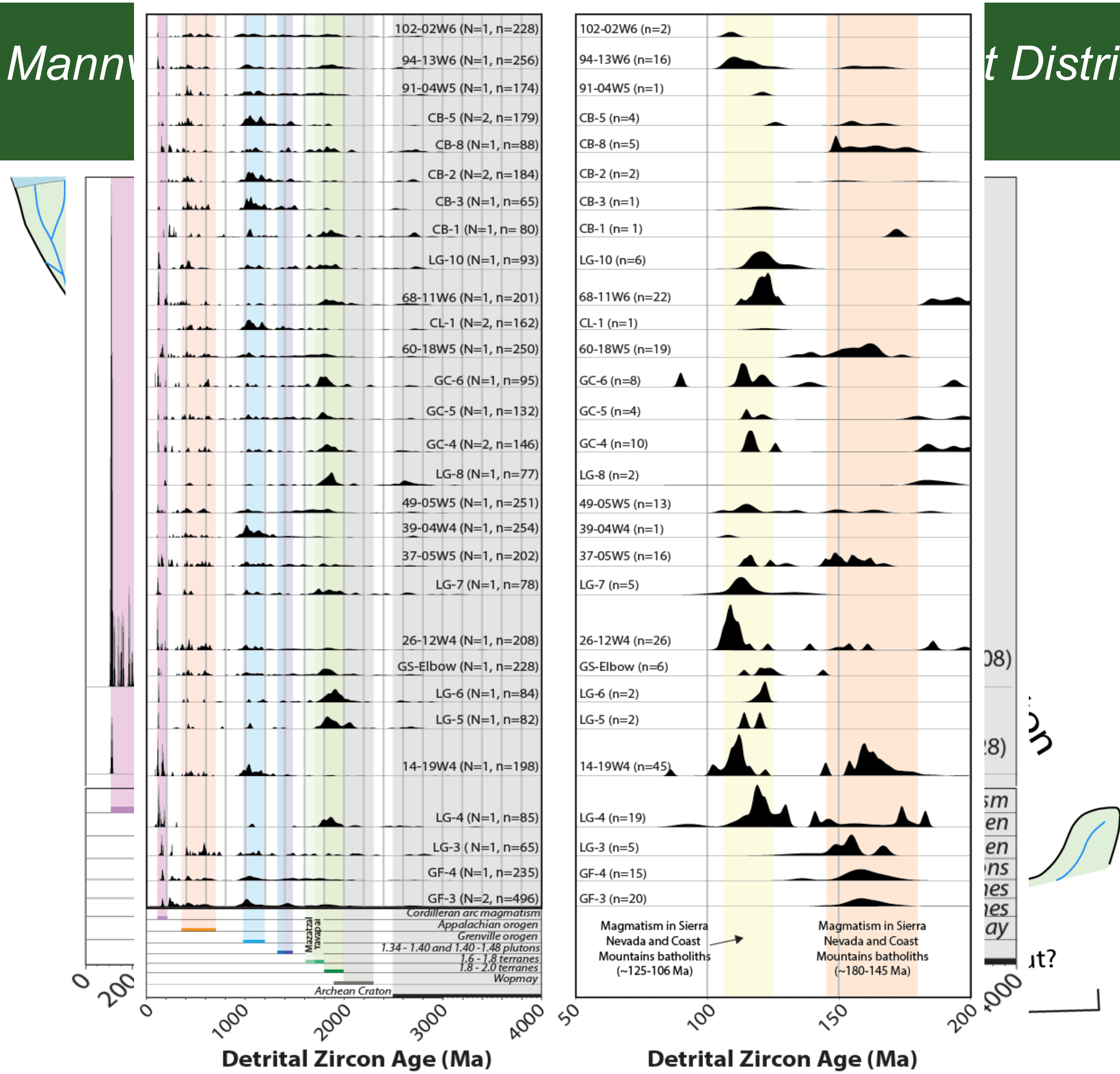

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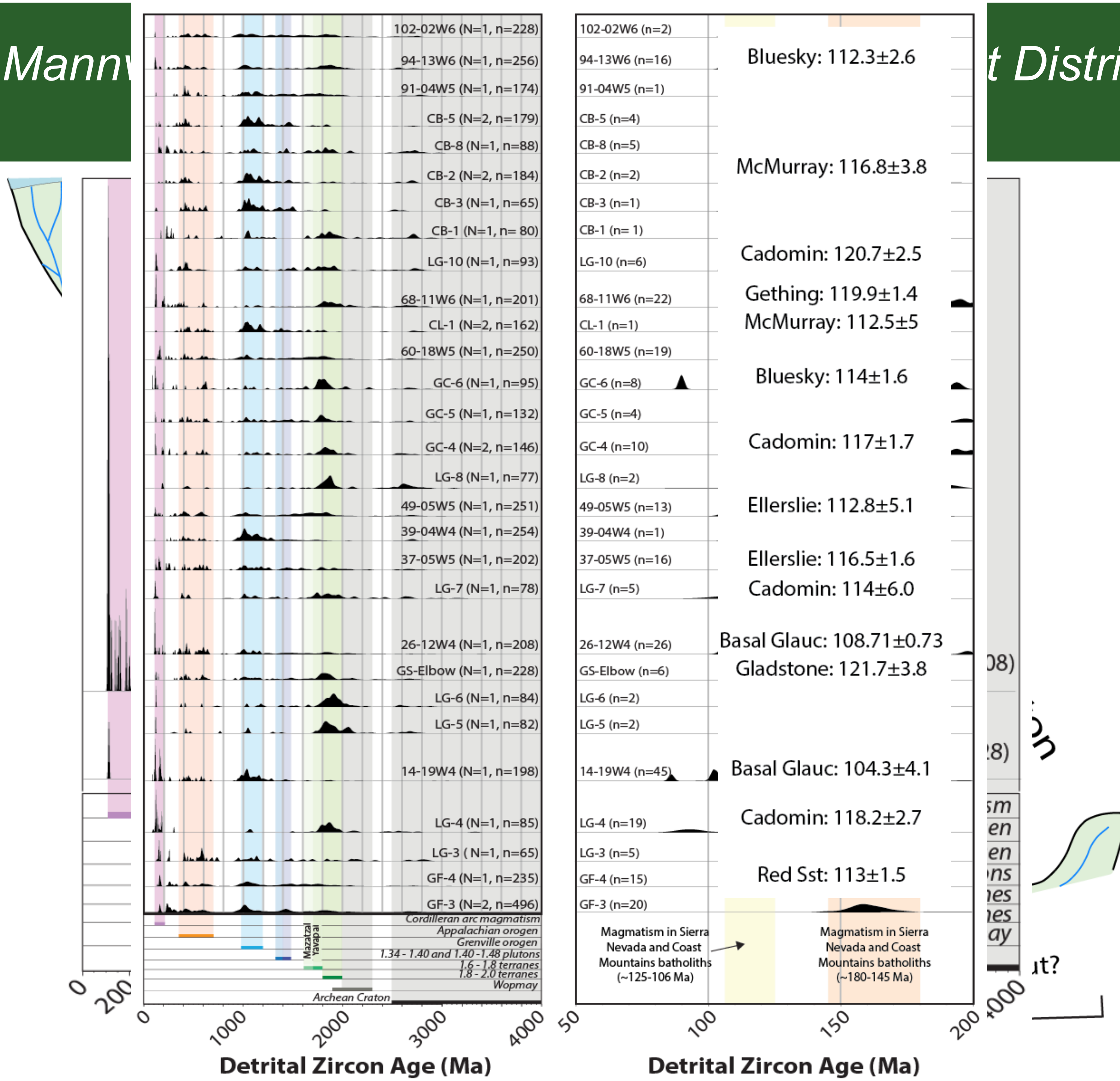
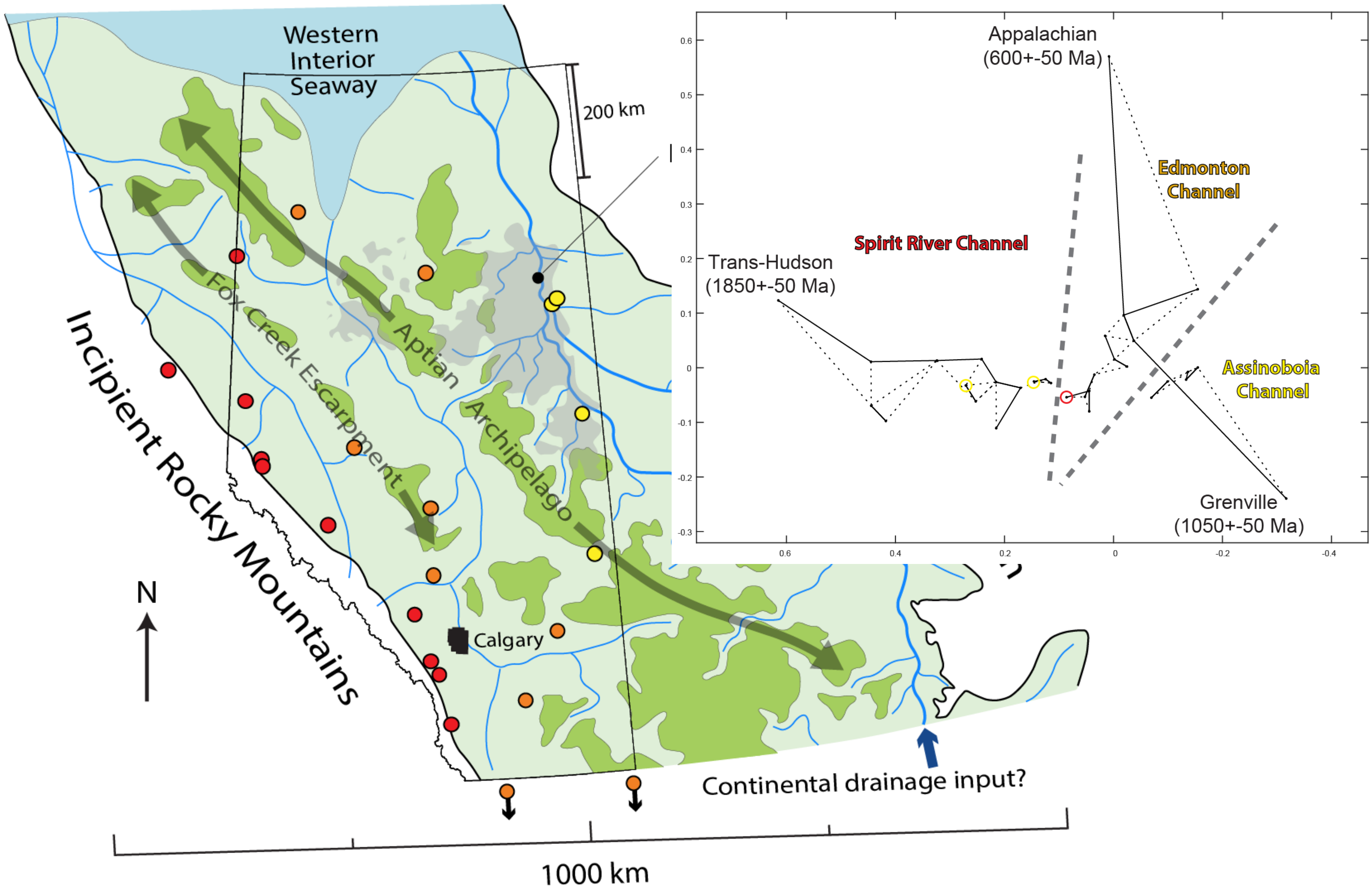


Lower Mannville Sediment Provenance and Sediment Distribution: Multi-Dimensional Scaling



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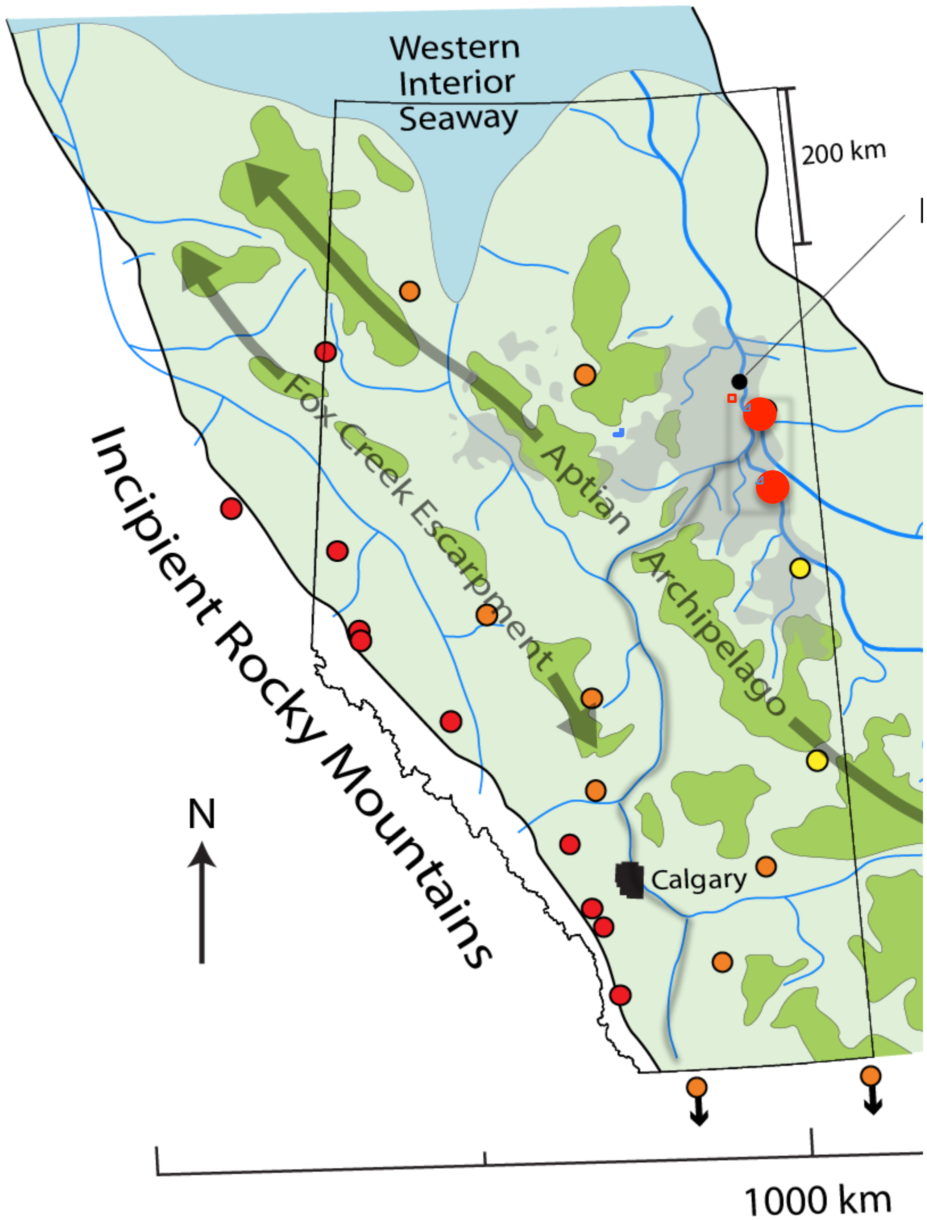

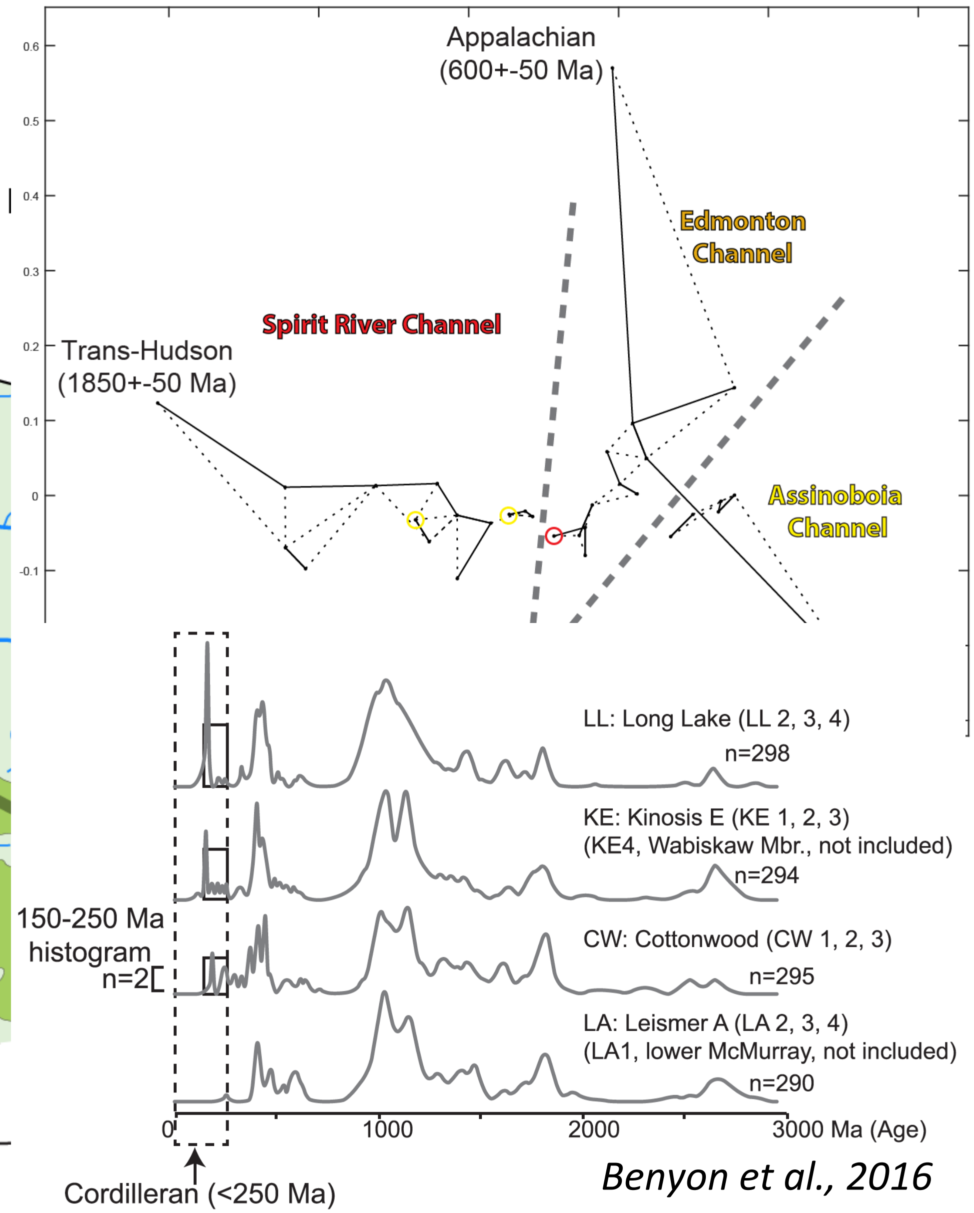

Benyon et al., 2016

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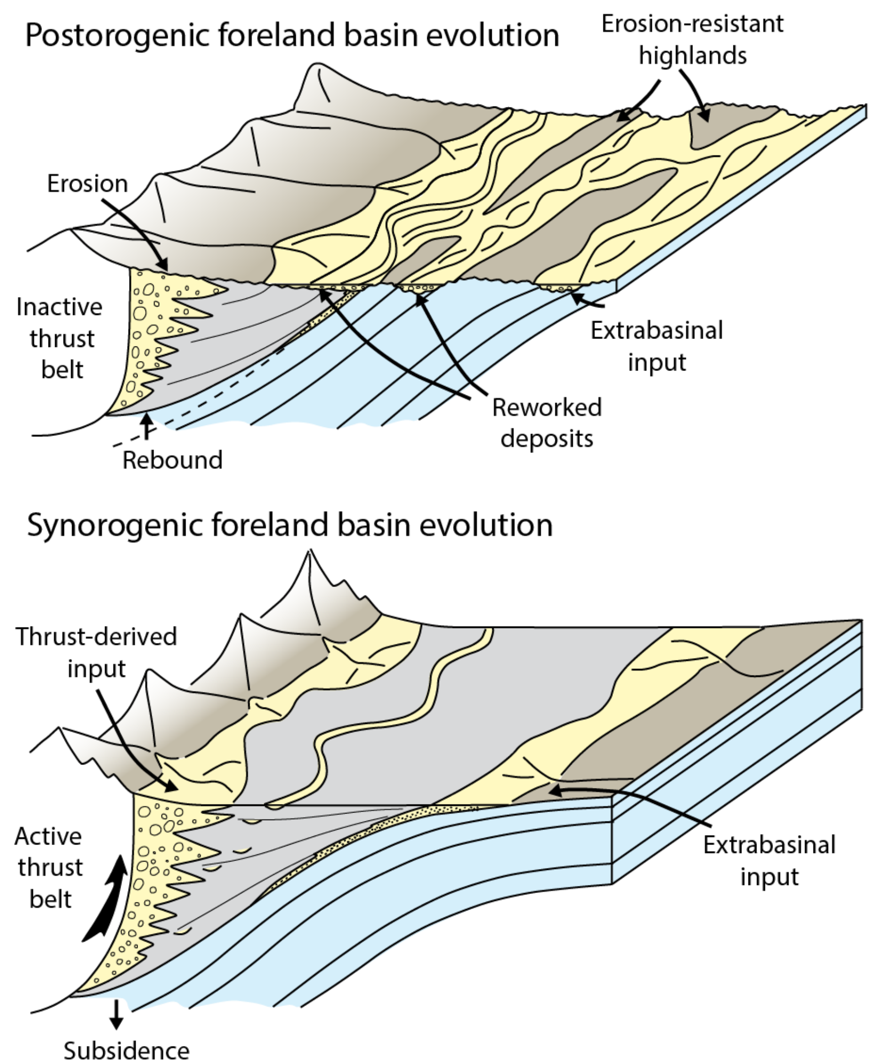
Conclusions

Deposits of the Lower Mannville Group largely accumulated in accommodation generated during a period of basin uplift:

- *Angular sub-Cretaceous u/c*
- *Lack of asymmetric wedge*
- *Segmented basin due to differential erosion of sub-cropping units*
- *Erosion/recycling of proximal units to distal foreland impacted by orogen-parallel topography and capture of continental river*



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NSERC
CRSNG