Deducing Shoreline Trajectories in a Mixed Siliciclastic-Carbonate Depositional Setting, Upper Devonian Imperial Formation, Northwest Territories, Canada*

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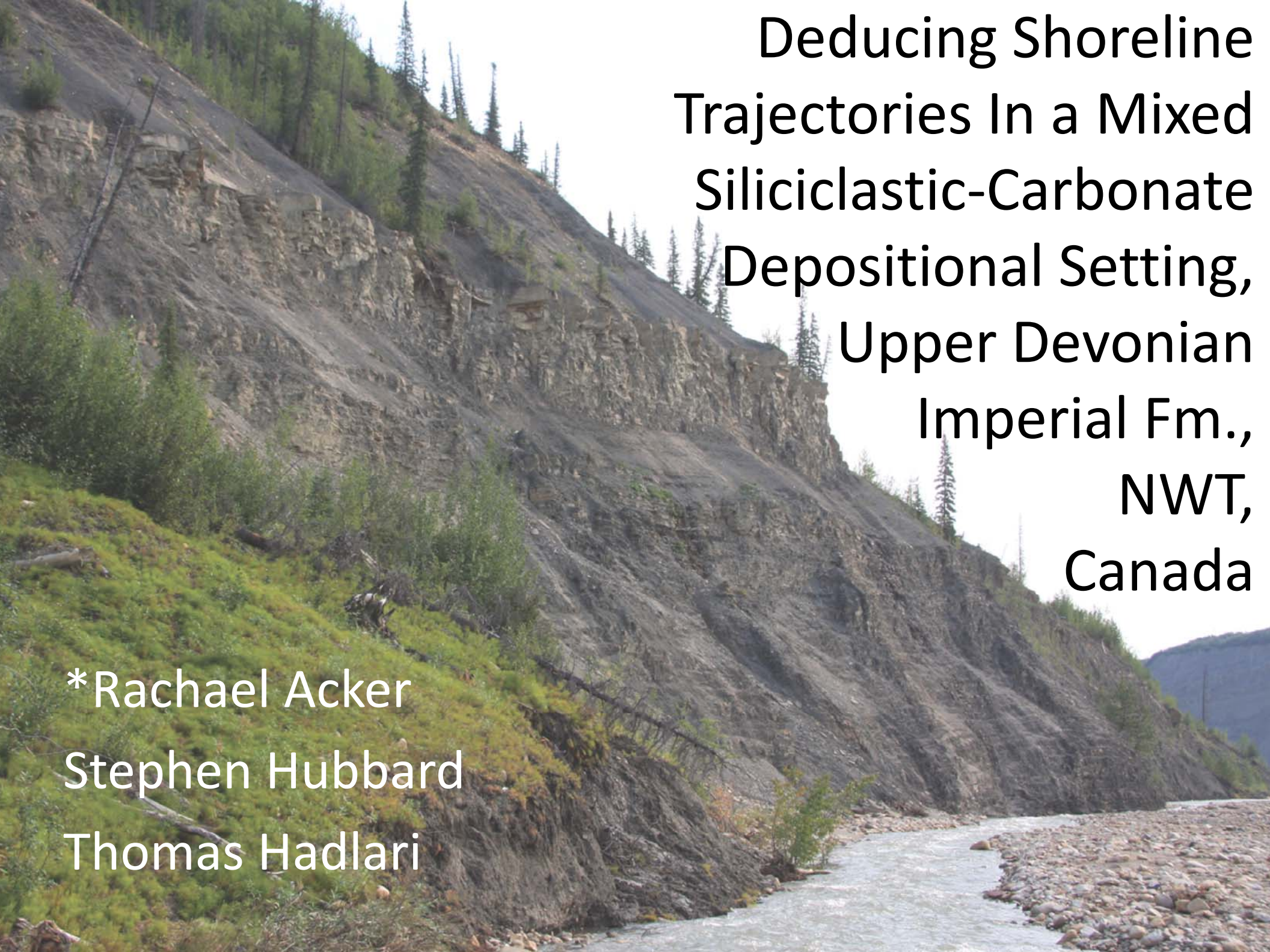
Abstract

Shoreline trajectory analysis provides insight into the depositional evolution of ancient basin margins. A 361 m thick, aerially limited outcrop of the Devonian Imperial Formation in the Mackenzie Corridor, Northwest Territories, Canada, comprises 28 upwards coarsening cycles, 3-15 m thick. The formation is a potential conventional reservoir and unconventional gas target in the subsurface within 10 km of the studied outcrop. The coarsening upwards cycles, or parasequences, are arranged into a series of seven parasequence sets; variations in gross parasequence thickness, sandstone:siltstone ratio, and facies are utilized to deduce shoreline trajectories. The majority of parasequences are capped with hummocky cross-stratified sandstone and the consistency in their character suggests that aggradation was dominant. It is hoped that shoreline trajectory interpretations from the thick, yet aerially limited outcrop exposure can be used to predict stratal packaging in the prospective reservoir region.

Despite the overall aggadational nature of the depositional system, the lower 17-18 parasequences comprise four subtly progradational parasequence sets, inferred to be characterized by rising shoreline trajectories. Each parasequence set is characterized by an upwards increase in gross parasequence thickness, grain-size, and proportion of proximal, sandy facies. The upper 9-10 parasequences form three retrogradational parasequence sets, with each parasequence characterized by an upwards decrease in gross thickness and proportion of sandy lithofacies. These cycles are interpreted to record an overall, slight back-stepping of shorelines through the depositional evolution.

The top of the 18th parasequence is characterized by unique facies attributes, including trough cross-stratification and in-situ fossils (i.e., horn and tabulate corals). In-situ coral growth is interpreted to result from sediment starvation attributed to either: (1) onset of transgression, or (2) autogenically controlled sediment flux (e.g., delta lobe switching). Fossil debris layers characterize the tops of parasequences immediately above and below the in-situ fossil layer. The tops of other parasequences consist of hummocky cross-stratified sandstone beds, suggesting that parasequence 18 preserves the most proximal sandstone beds in the entire stratigraphic package; it marks the transition from progradational to retrogradational shoreline trajectory.



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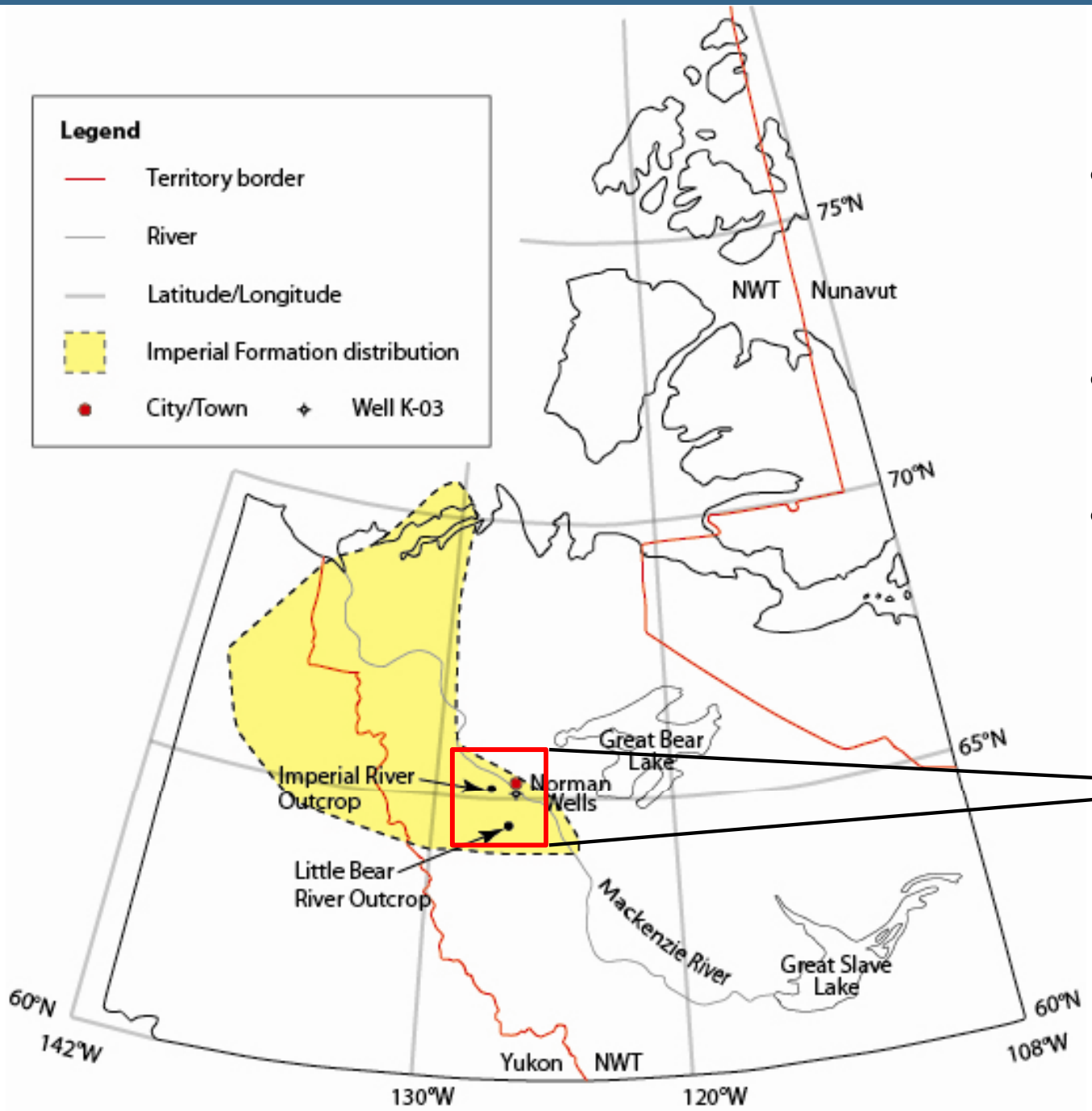
Project Questions and Objectives

- To deduce the depositional history and reservoir potential of the Imperial Formation (NWT)

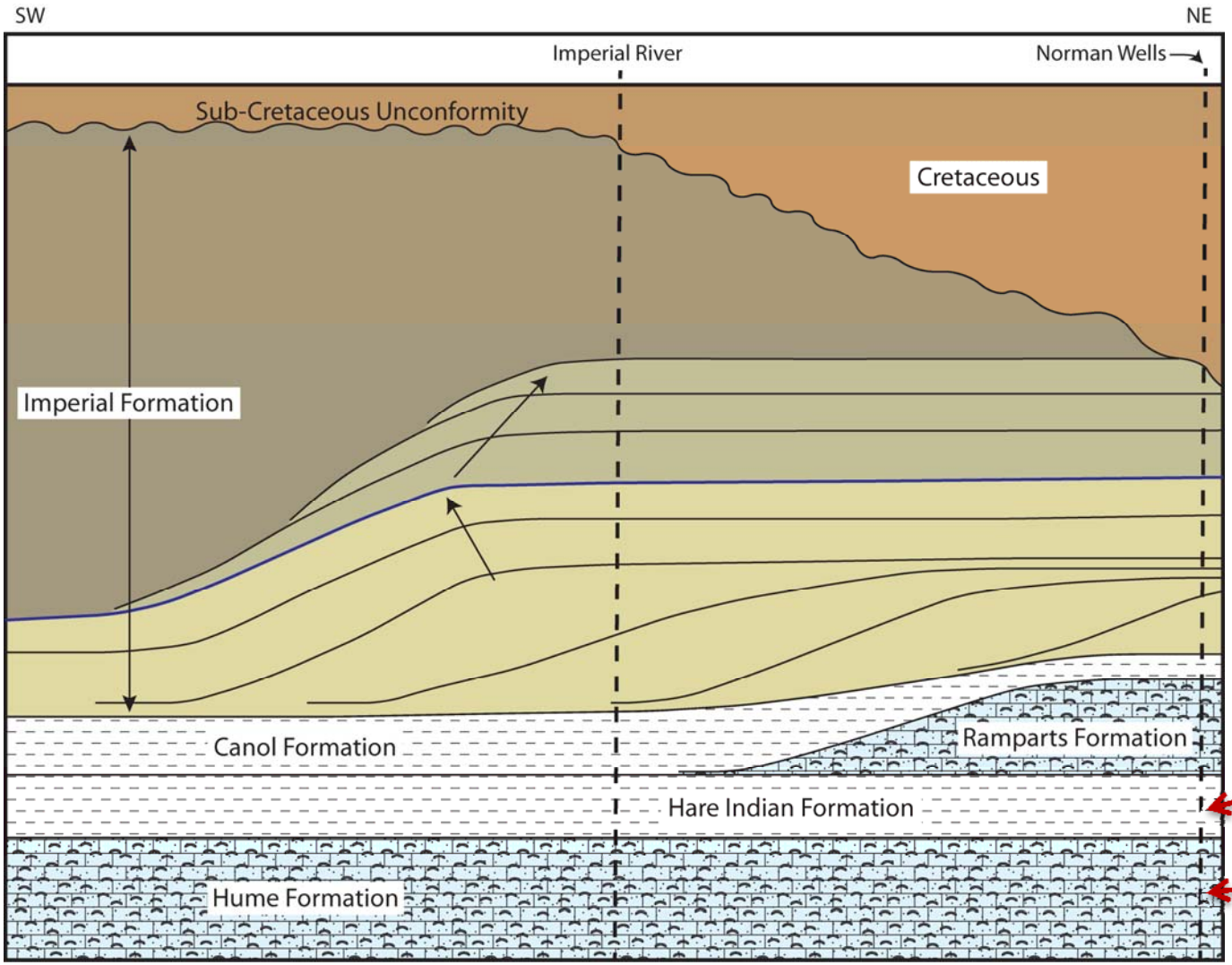
- What can 1-D data (from outcrop or subsurface) tell us about shoreline trajectory and the lateral prediction of sandstone (reservoir)?

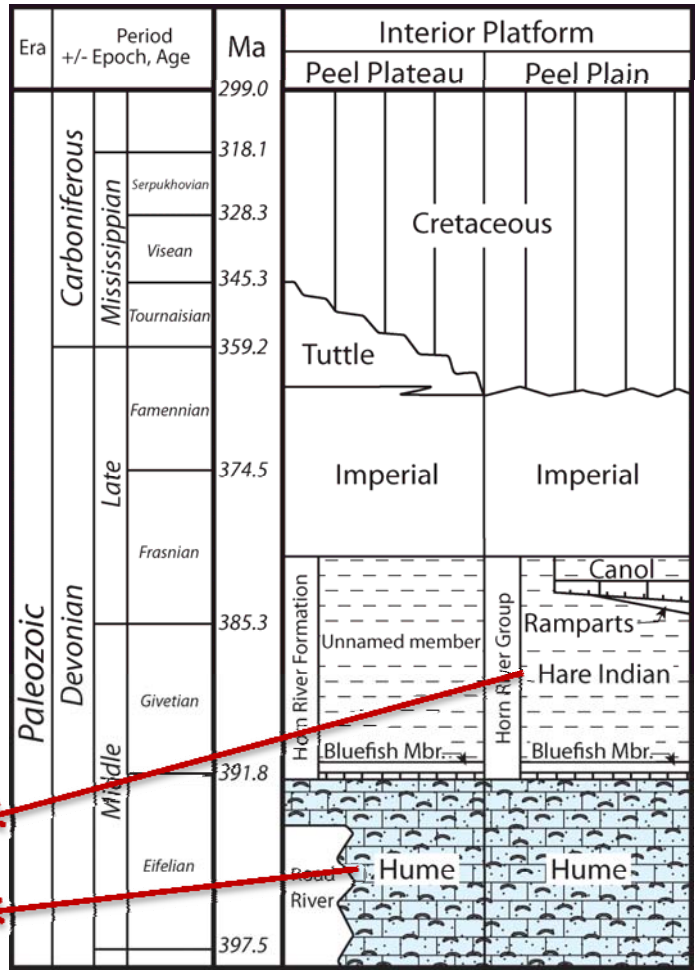
Study Area/Dataset



- Imperial Fm. Distribution
- Imperial River
- Well K-03

Stratigraphic Architecture

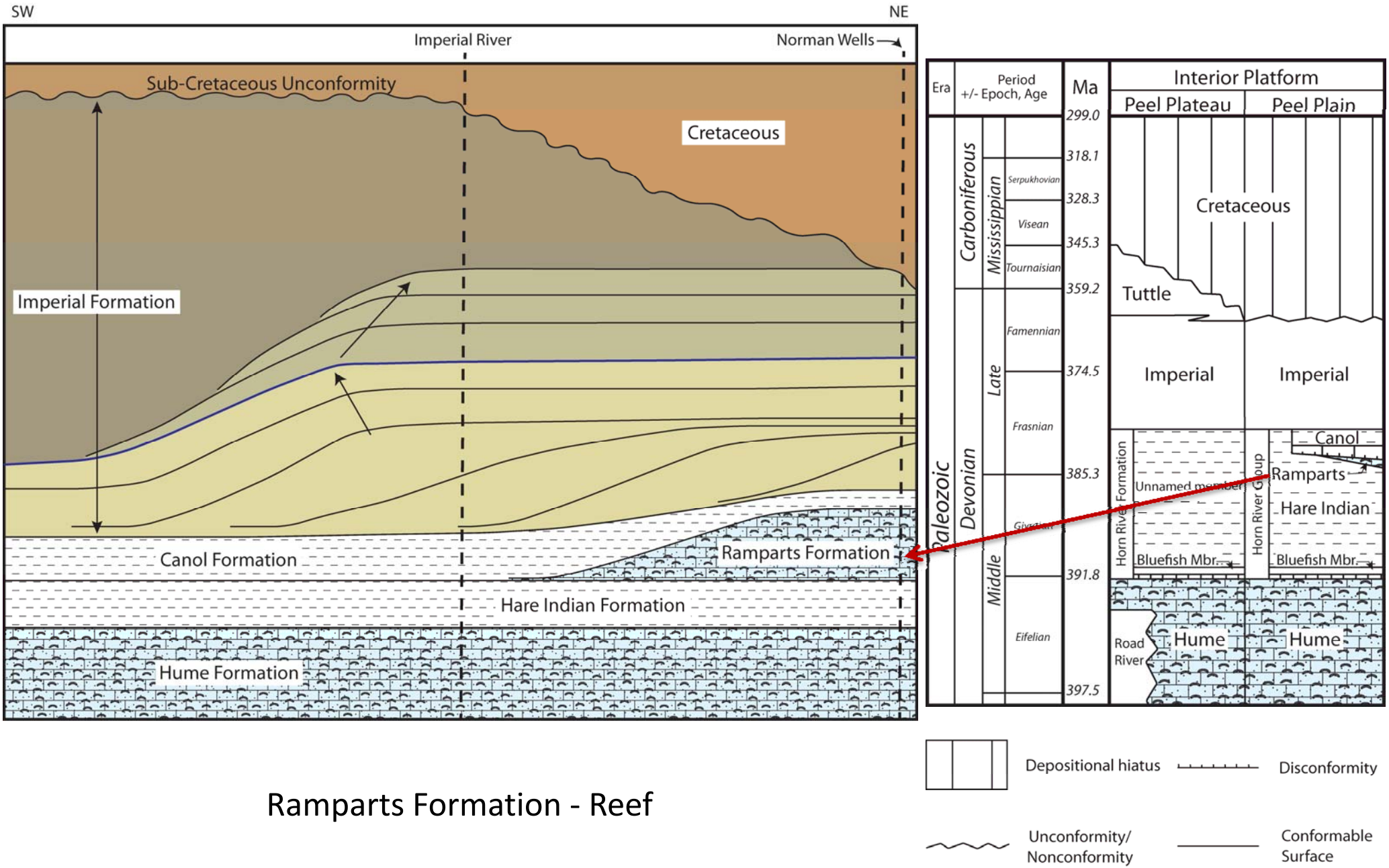




Hare Indian Formation - Siliceous Shales

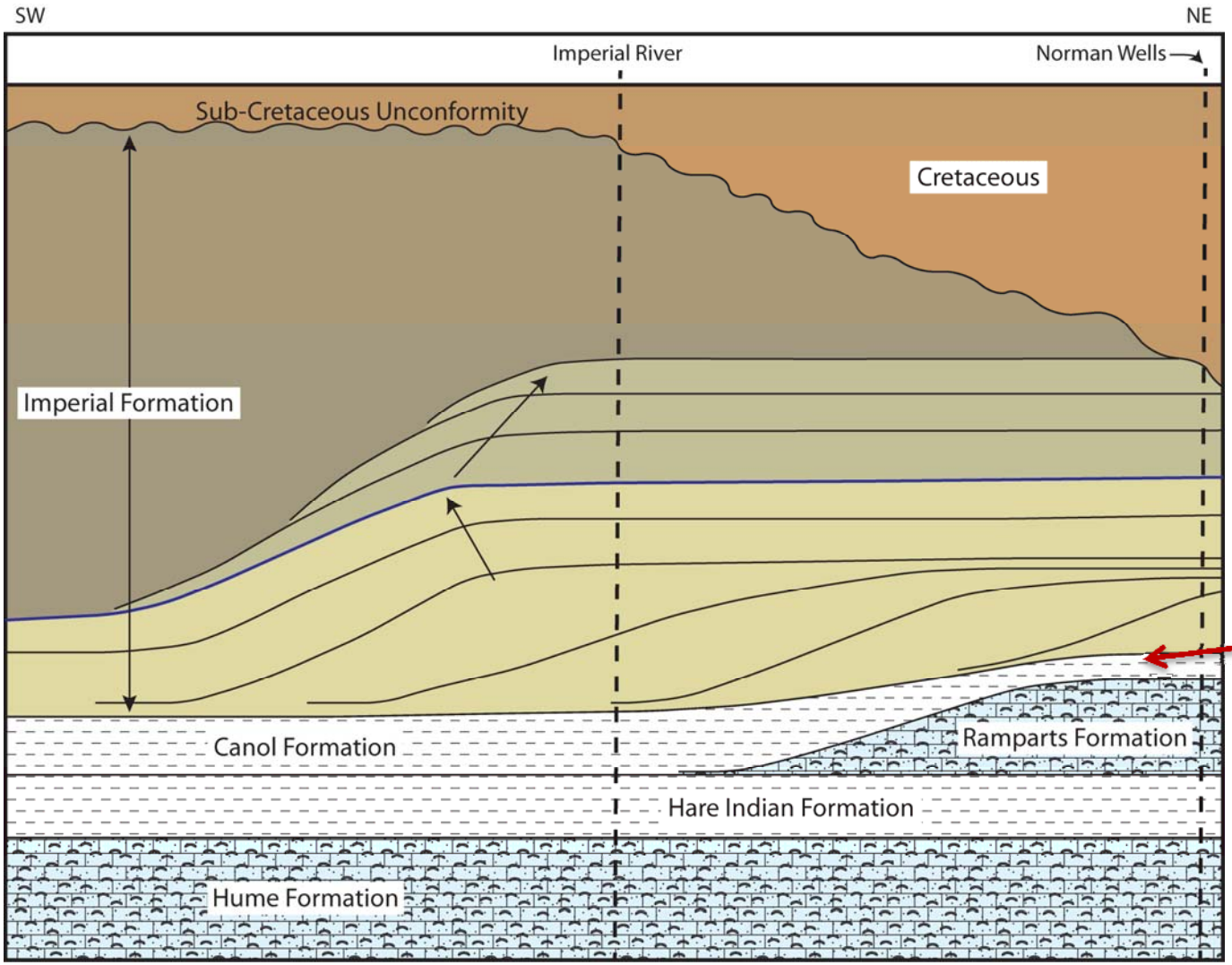
Hume Formation - Carbonate

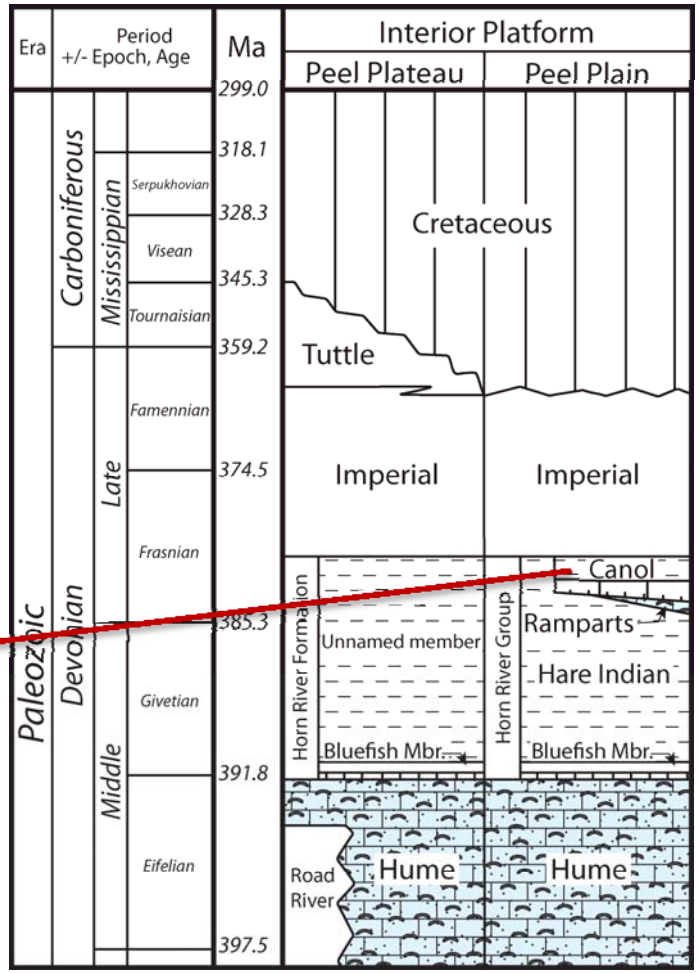
Stratigraphic Architecture



Ramparts Formation - Reef

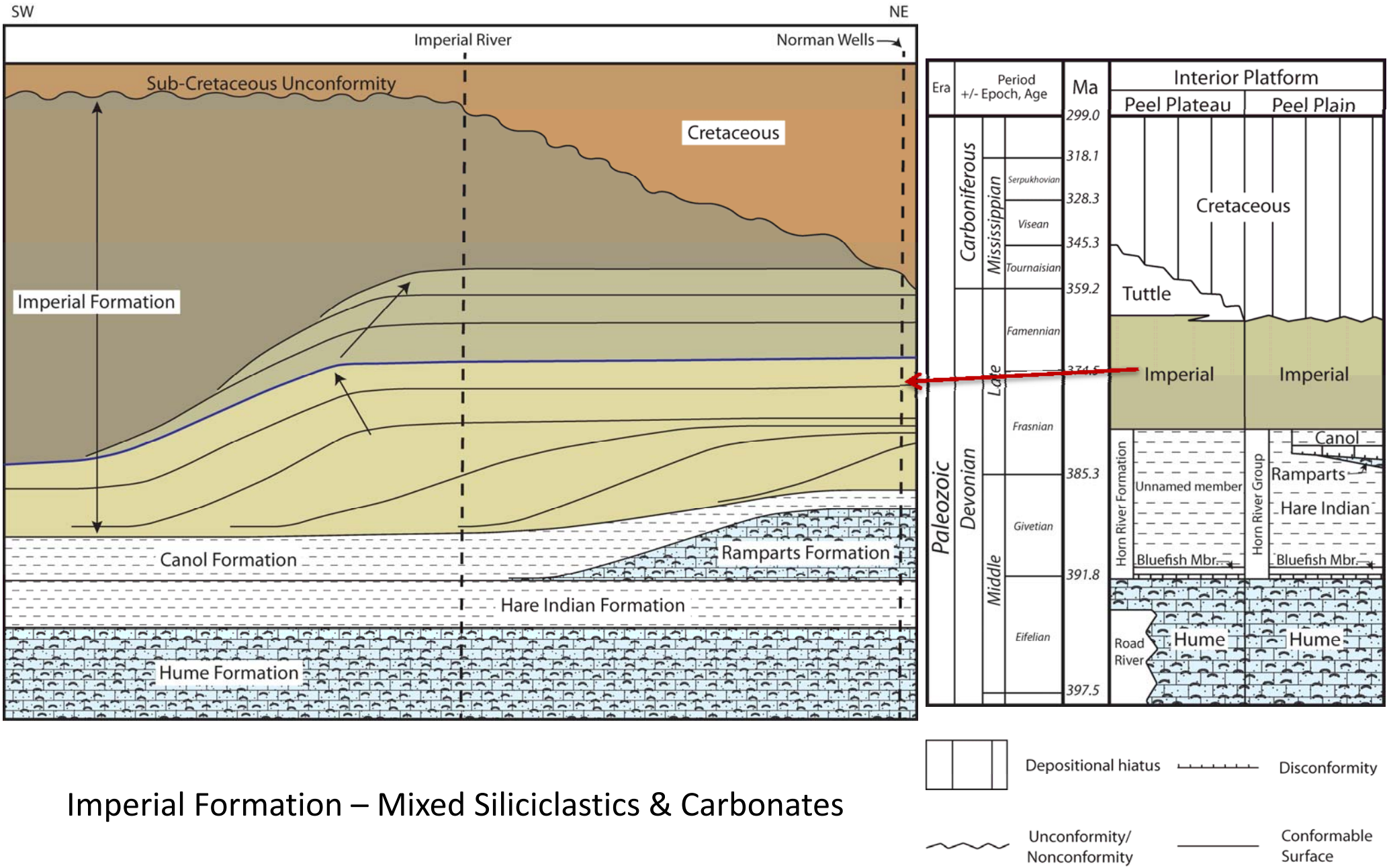
Stratigraphic Architecture





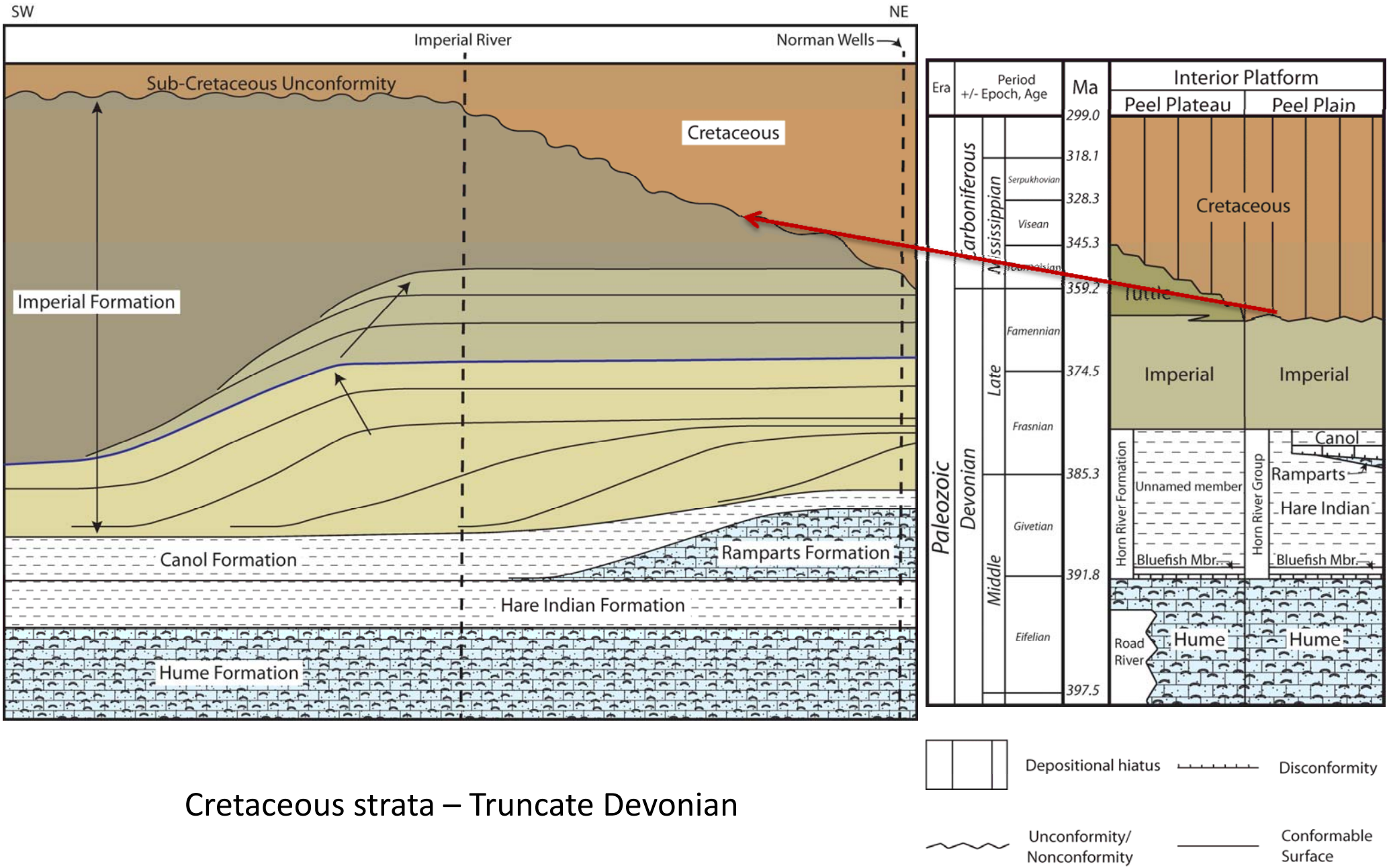
Canol Formation – Carbonaceous Shales

Stratigraphic Architecture



Imperial Formation – Mixed Siliciclastics & Carbonates

Stratigraphic Architecture

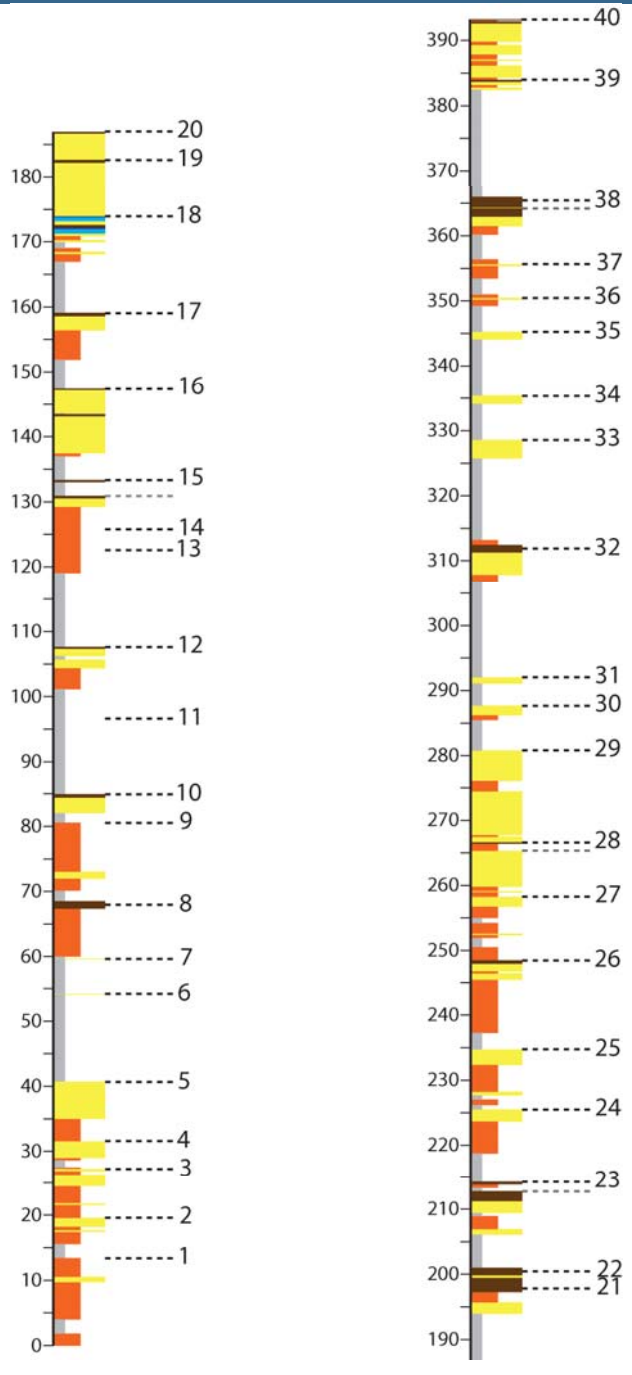


Cretaceous strata – Truncate Devonian

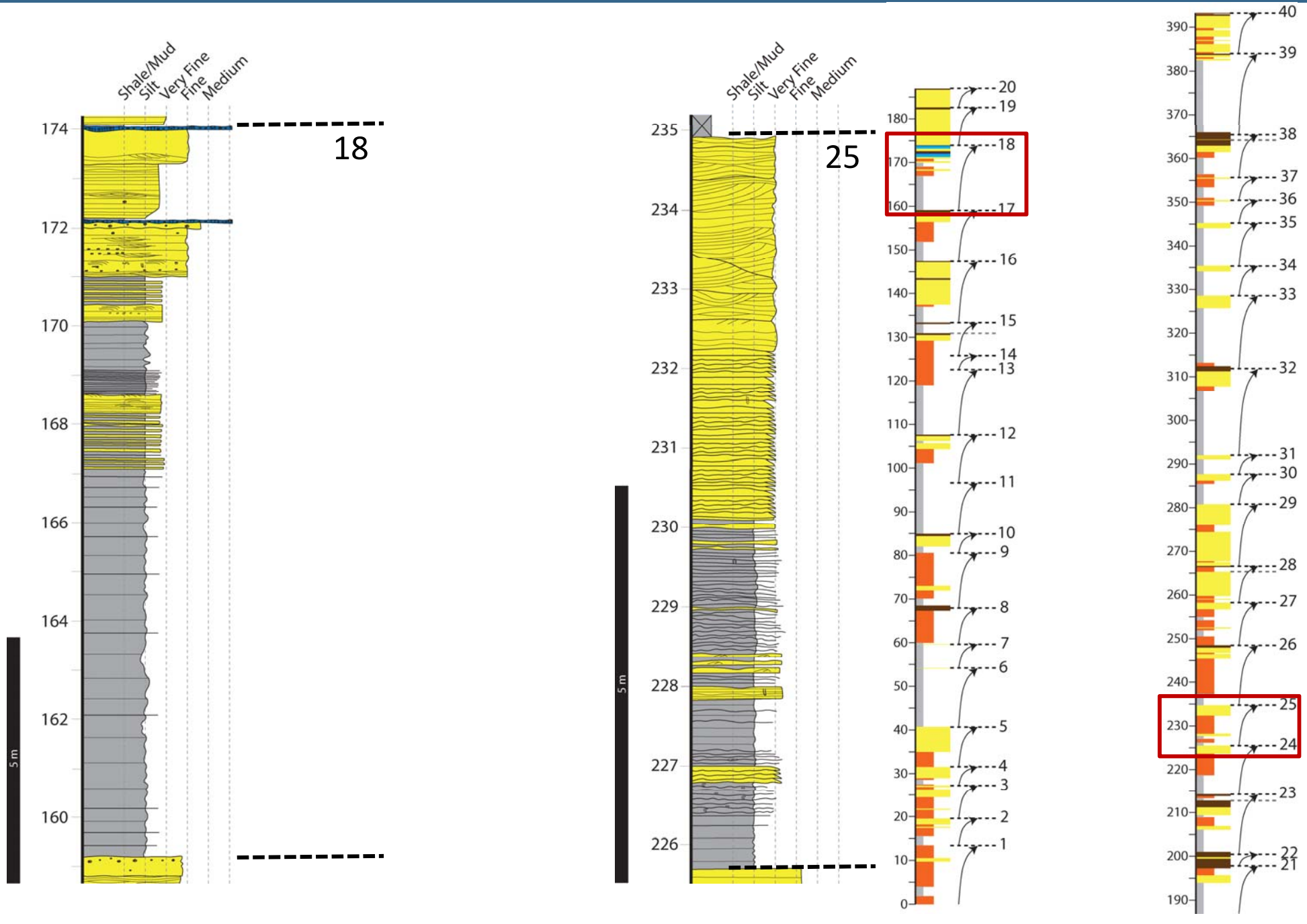
Imperial River Outcrop

Imperial River Outcrop

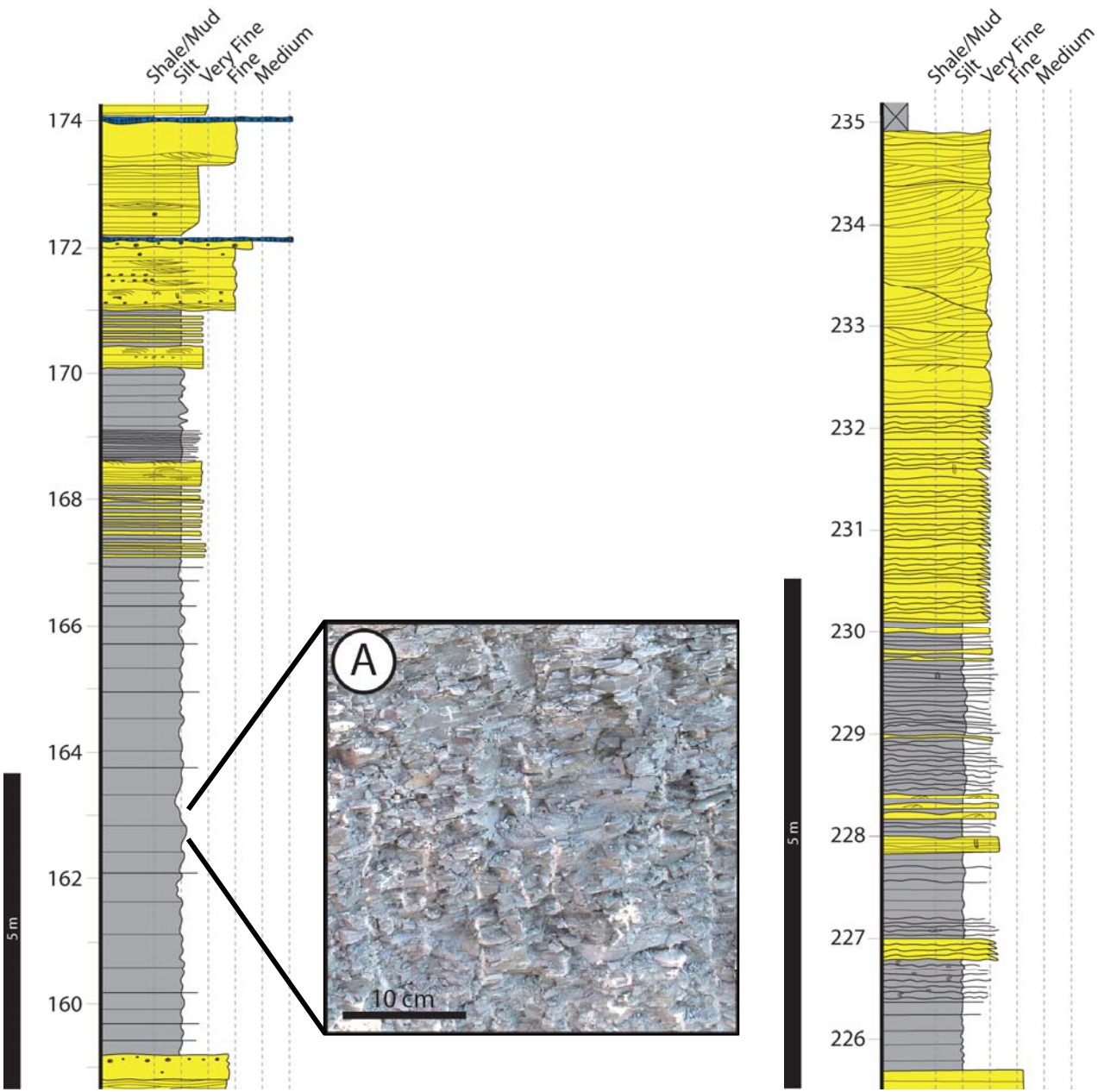
- 40 upwards coarsening cycles
- Grade from mudstone to fine-grained sandstone



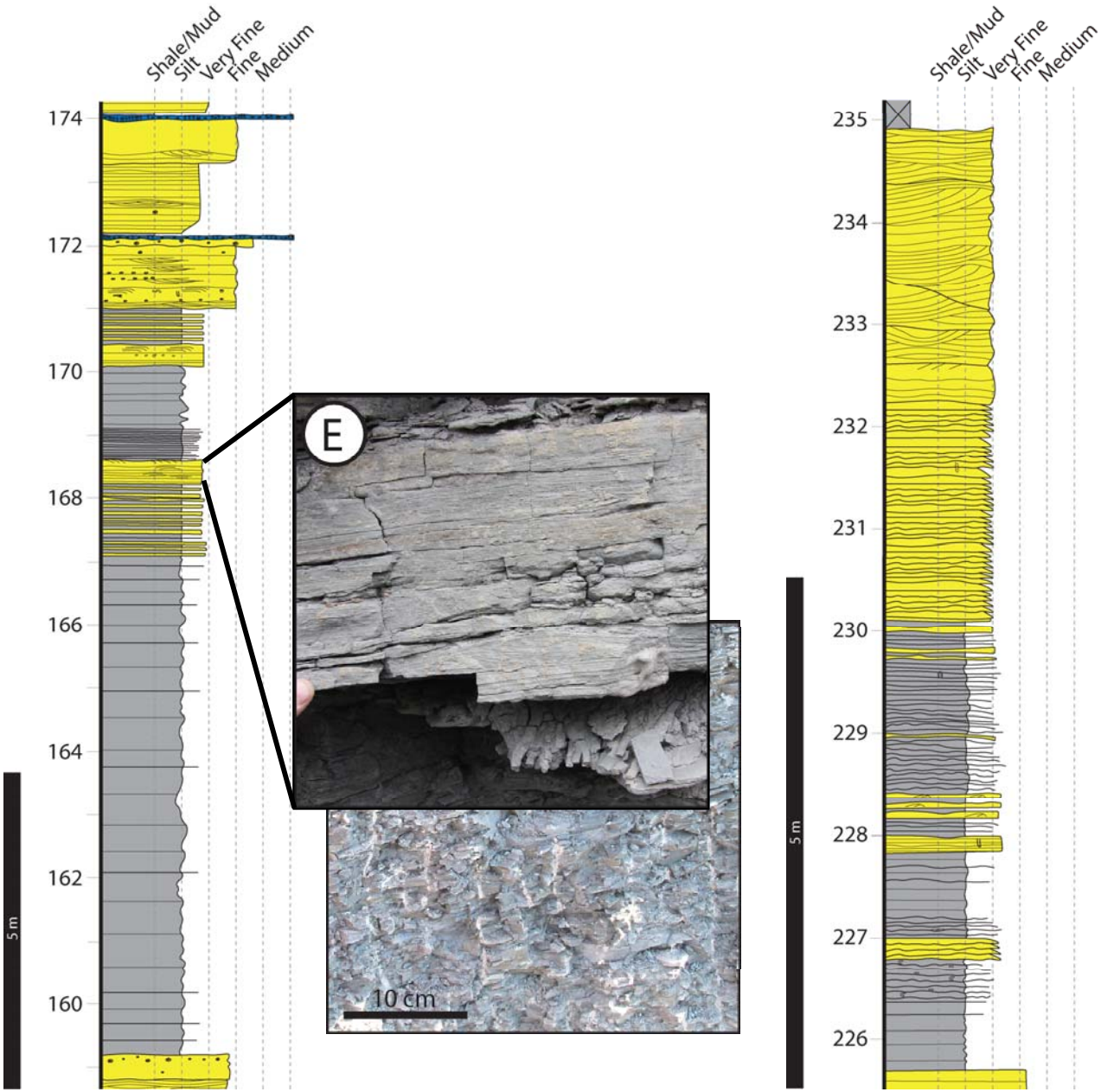
Parasequence



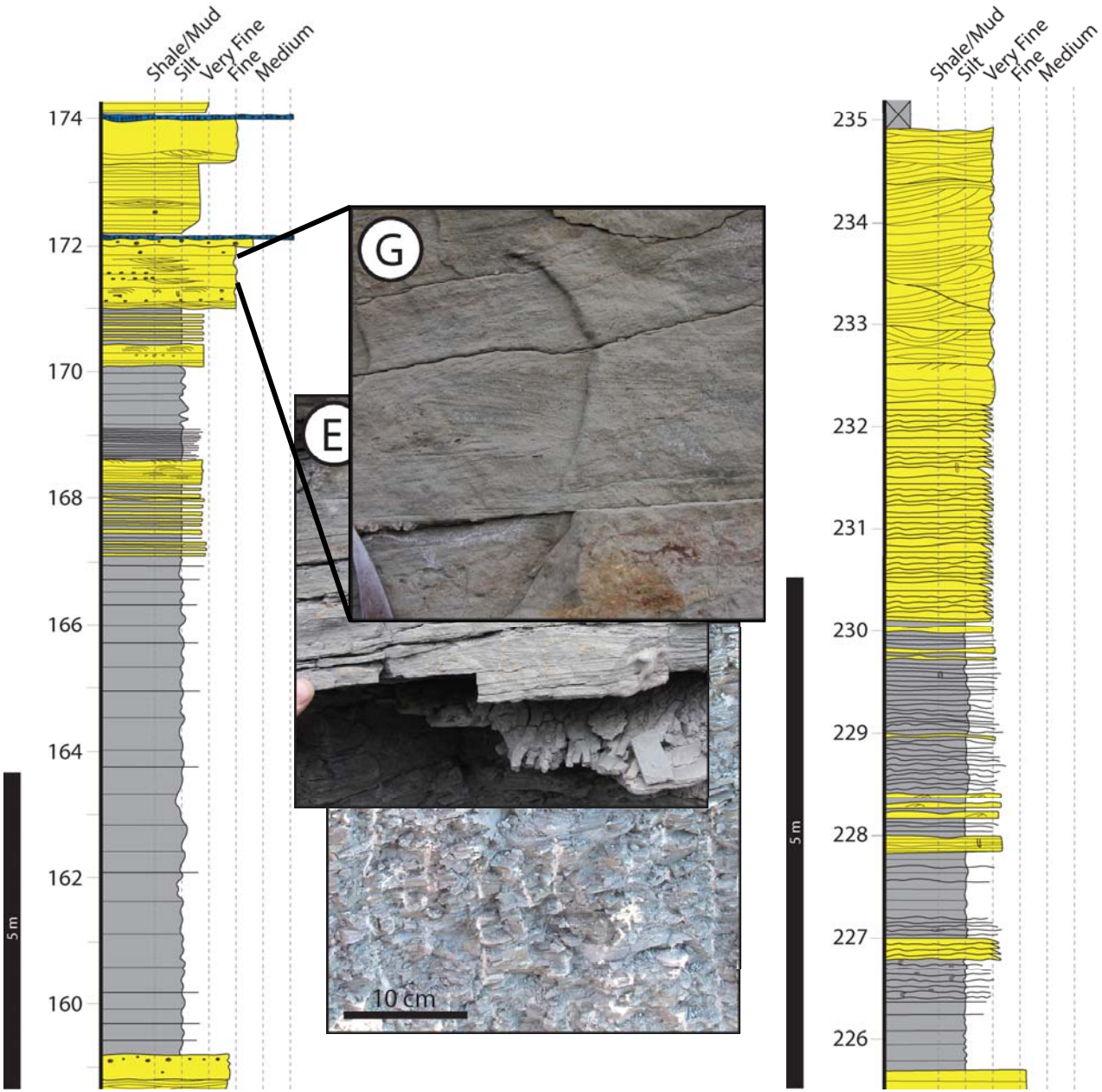
Parasequence Facies



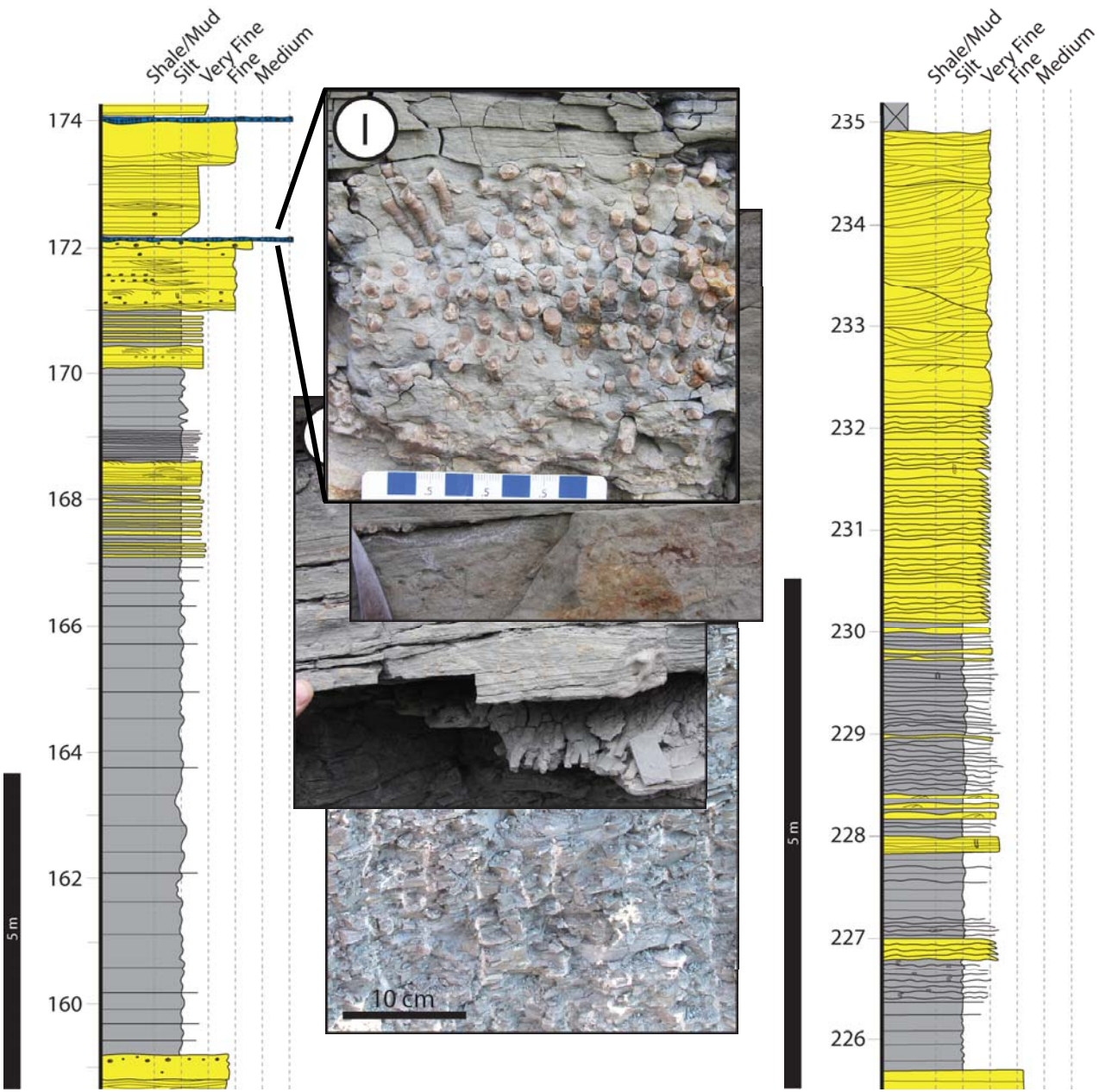
Parasequence Facies



Parasequence Facies



Parasequence Facies



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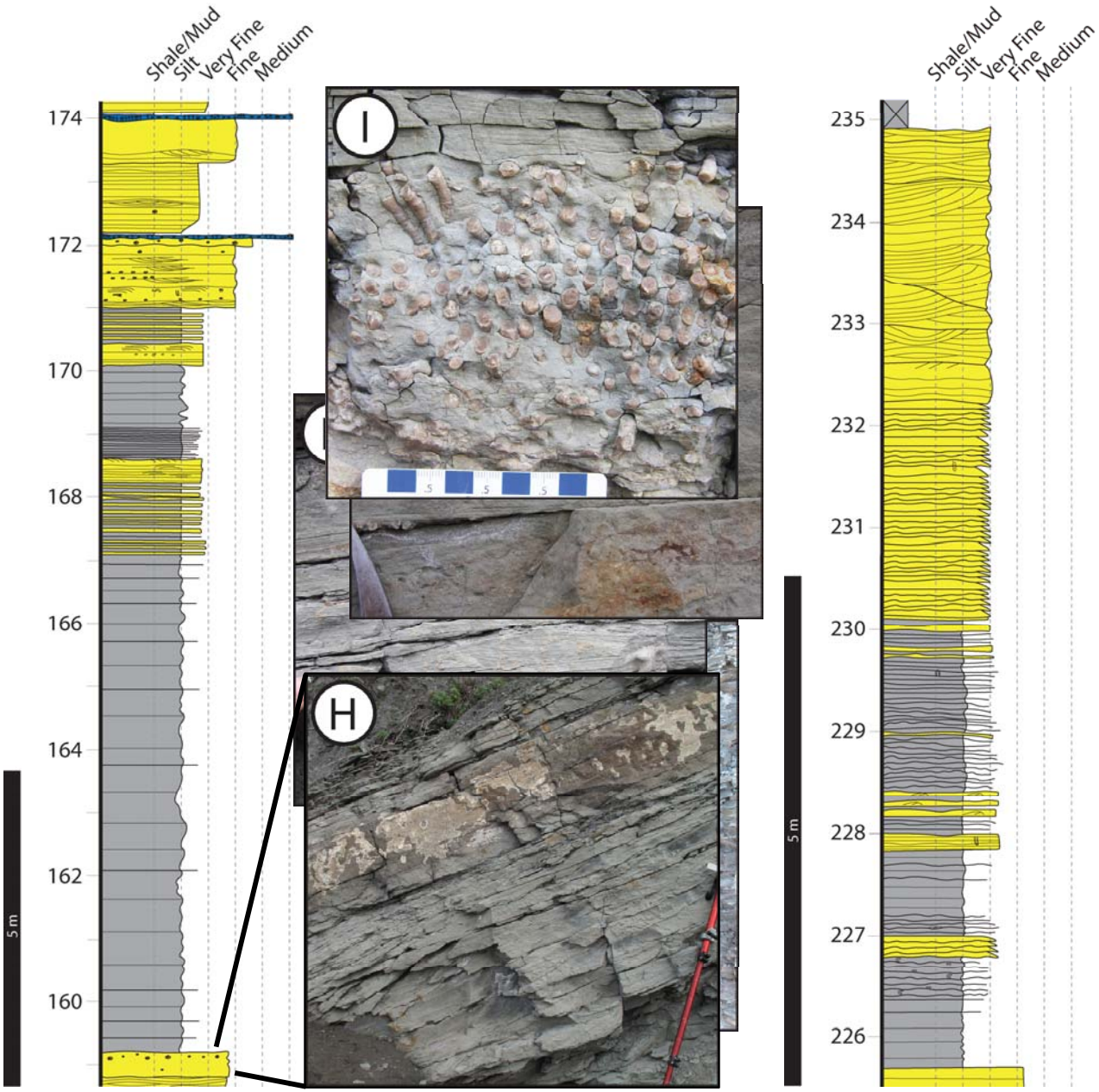
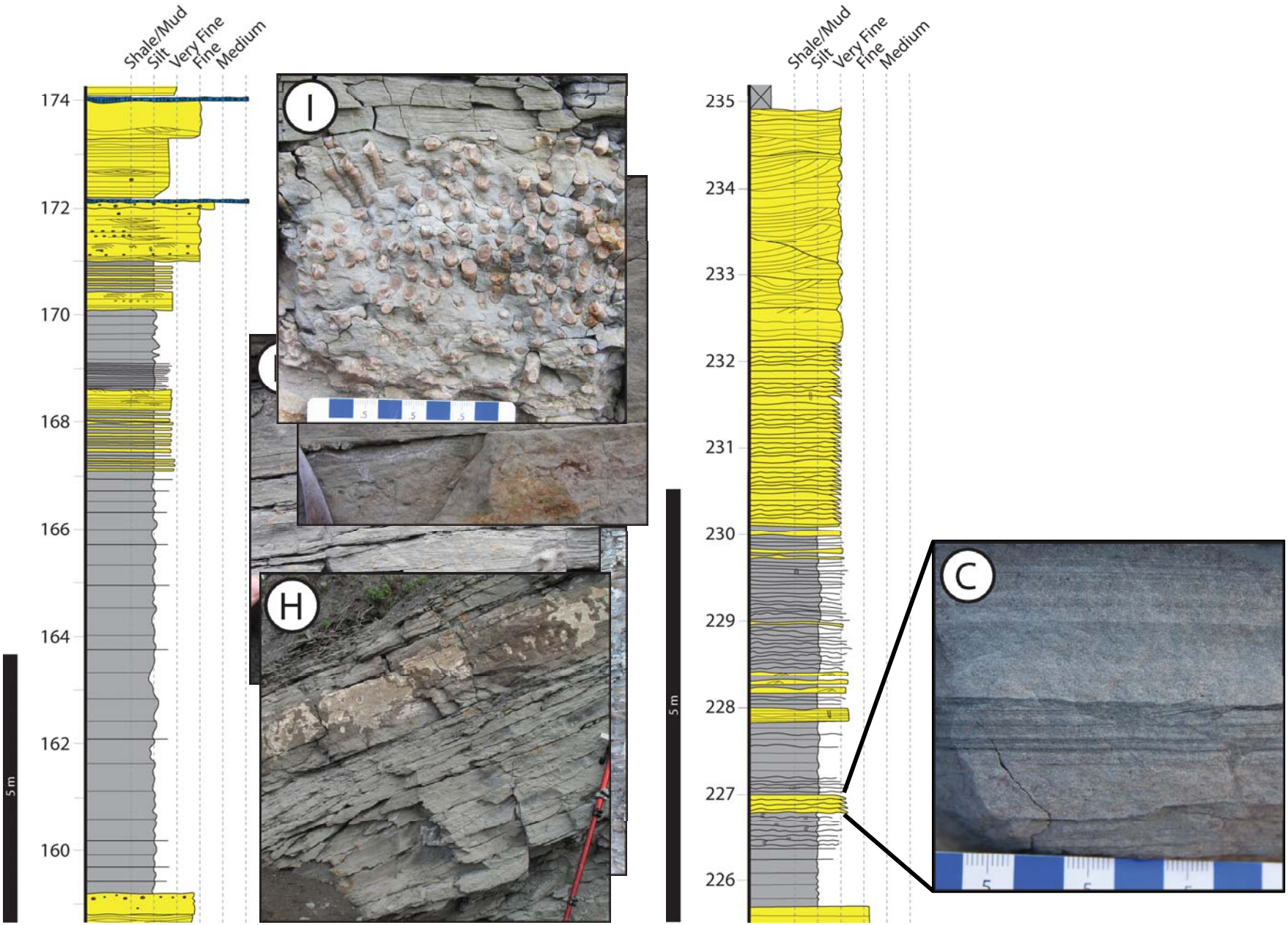
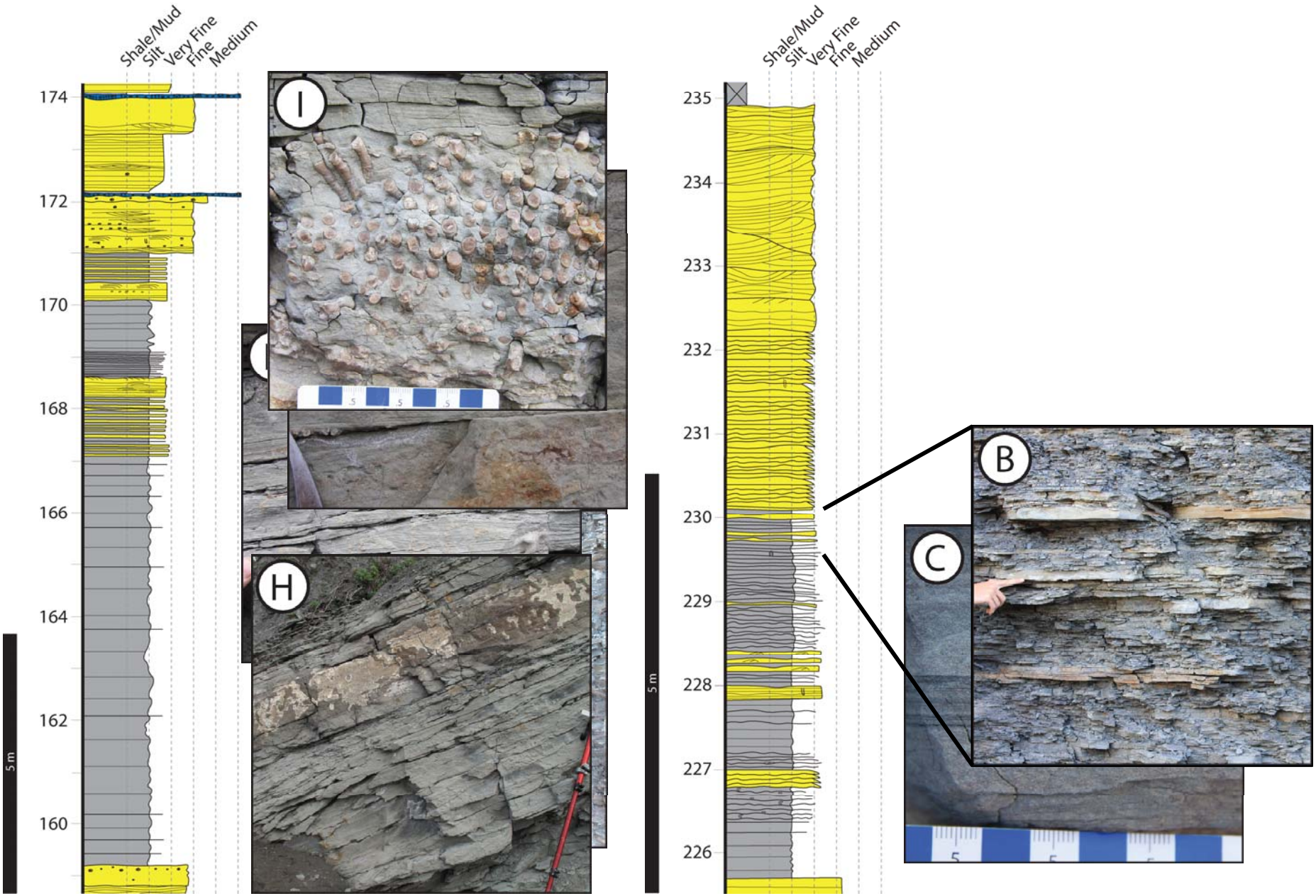


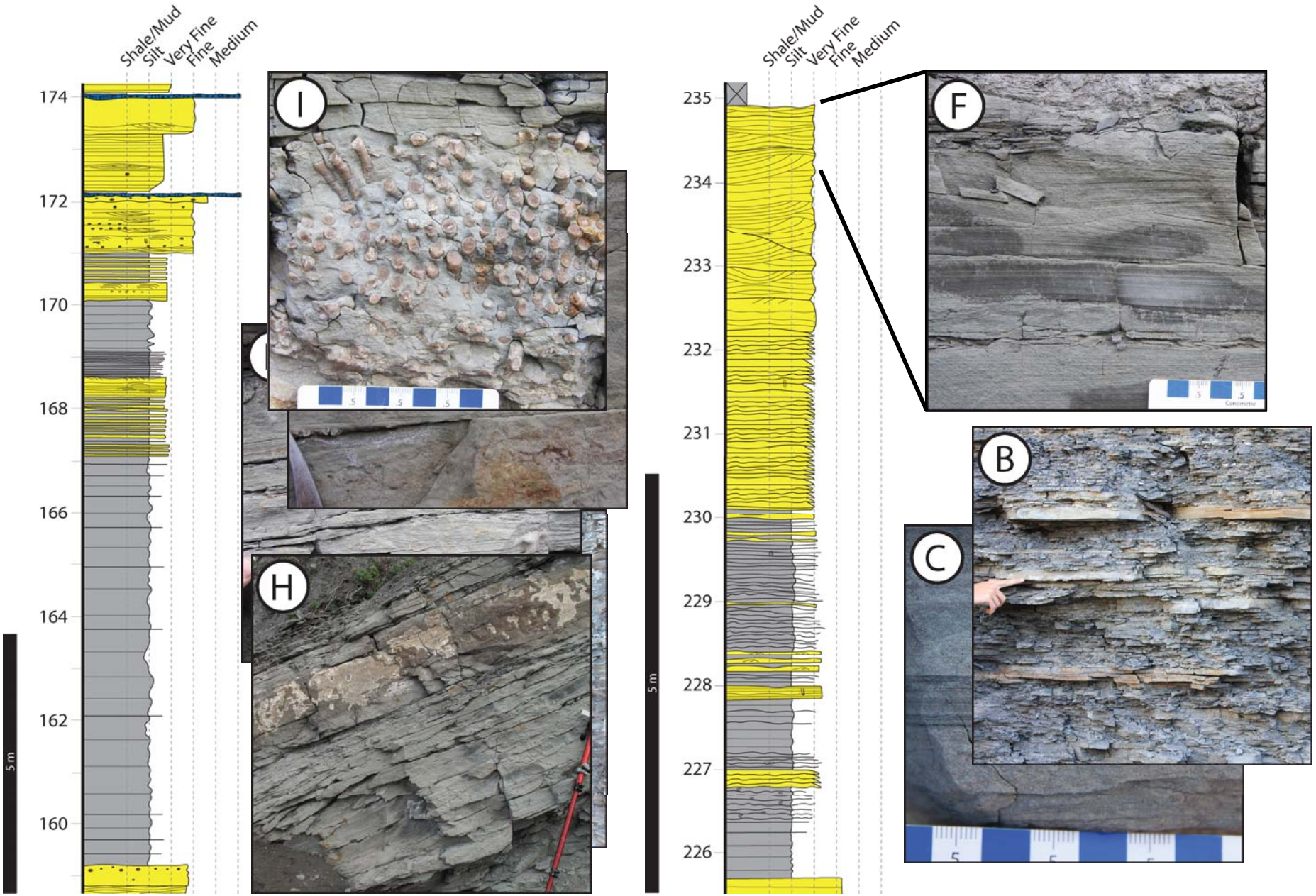
Parasequence Facies



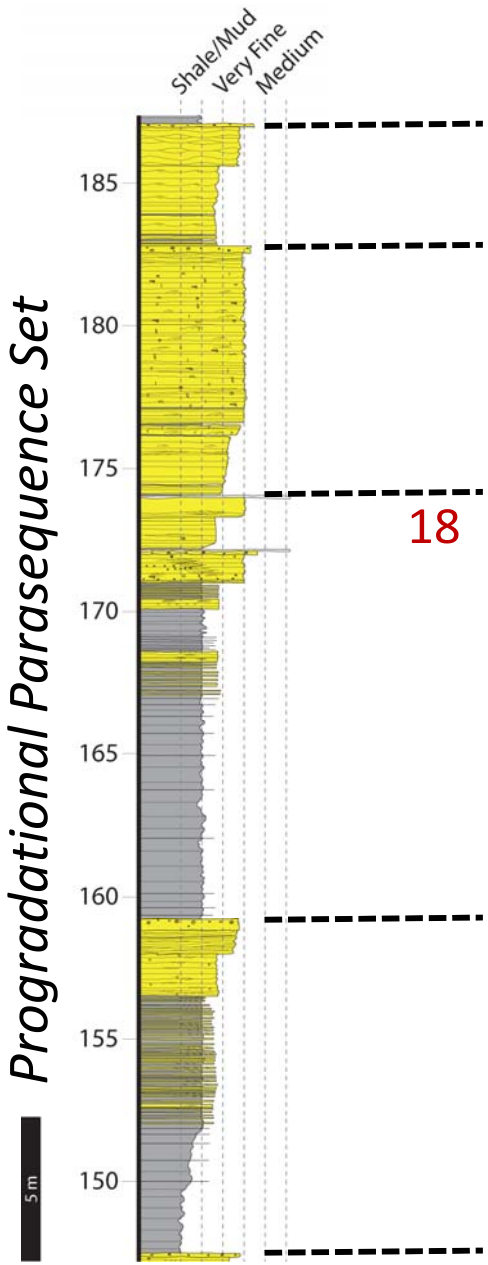
Parasequence Facies

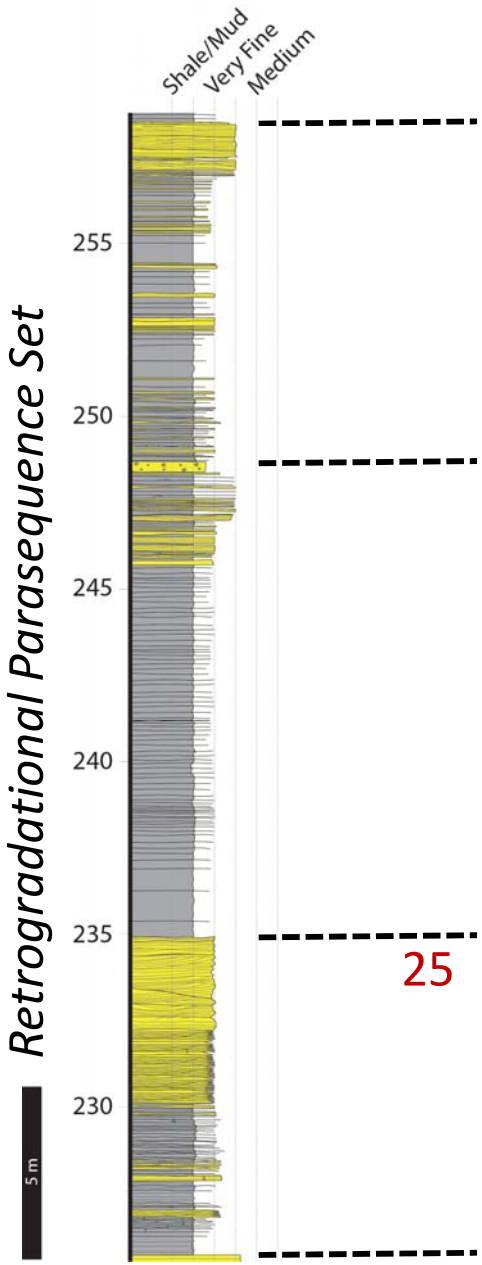


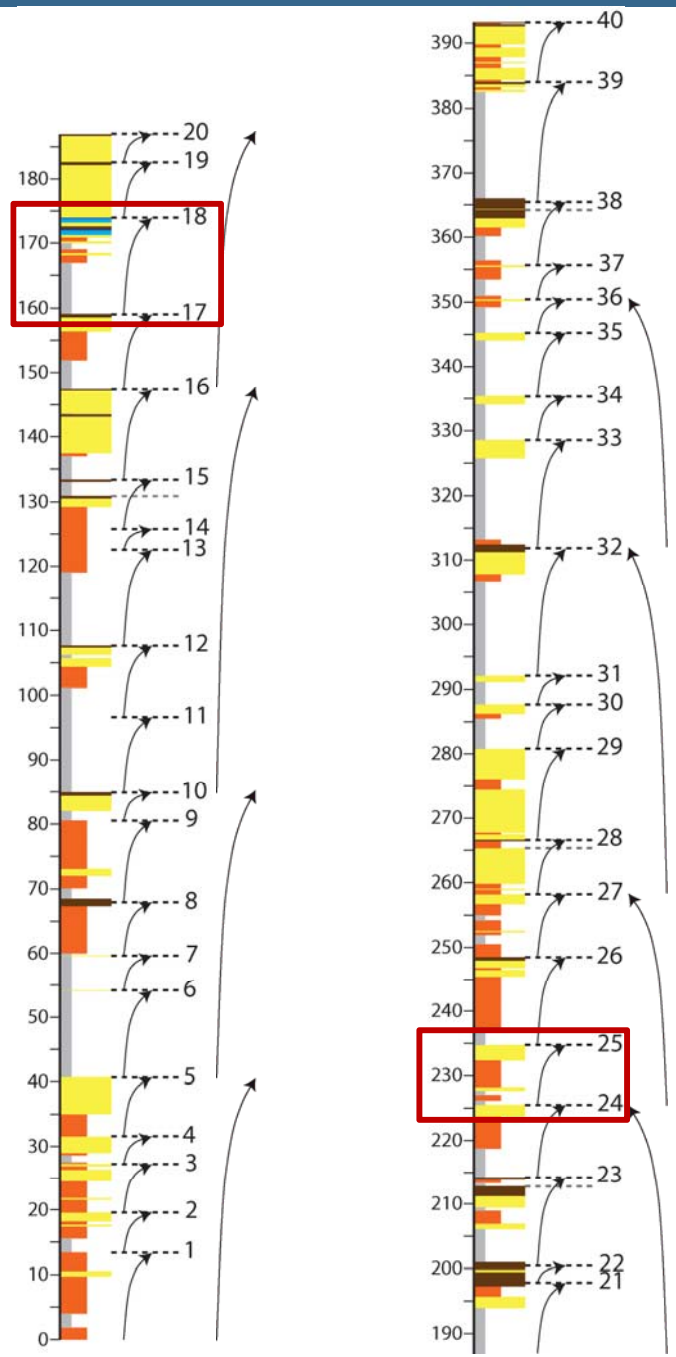
Parasequence Facies



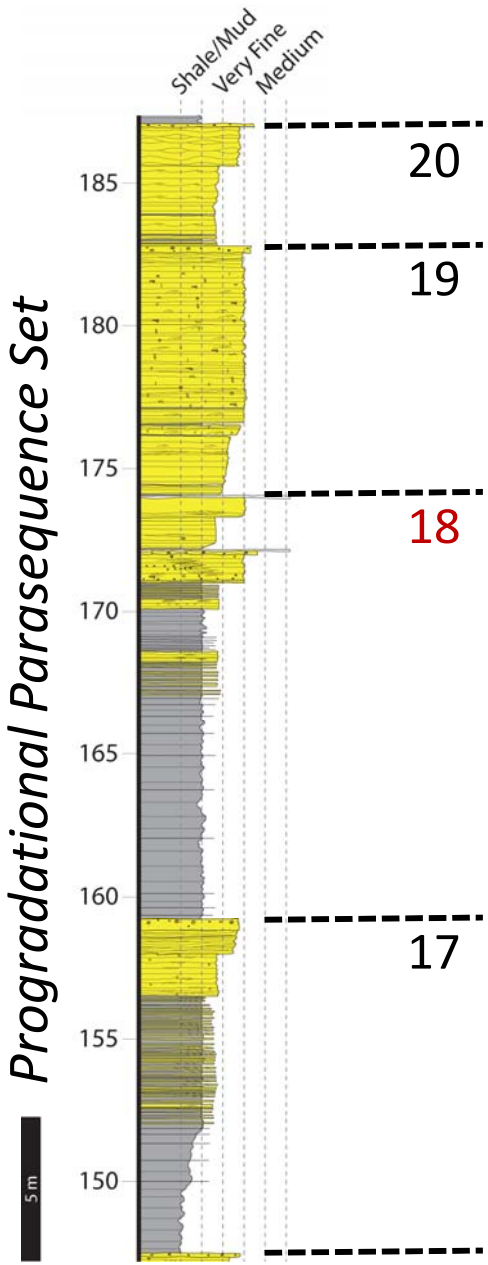
Parasequence Set

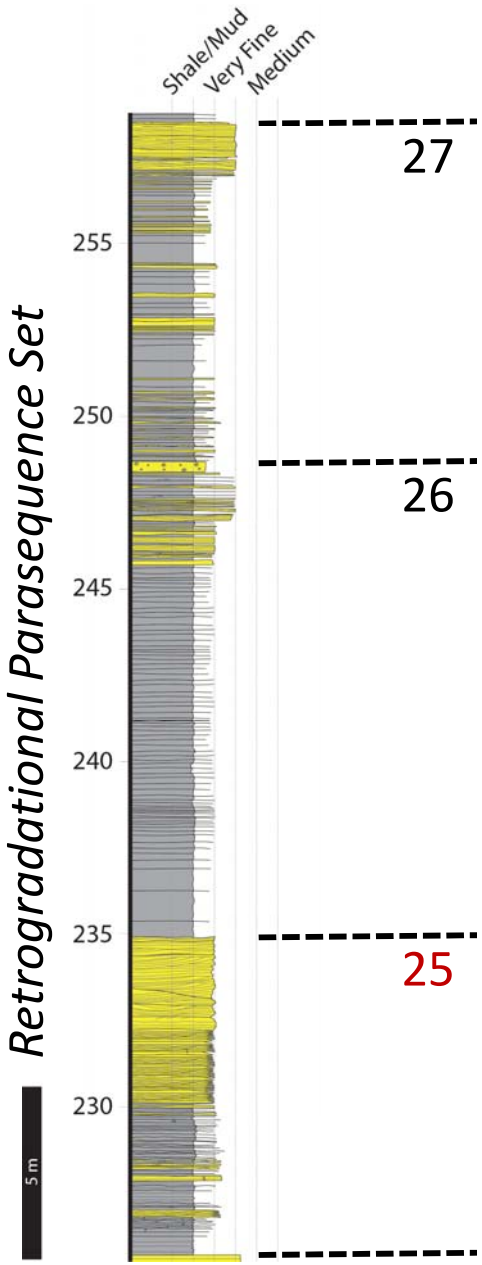


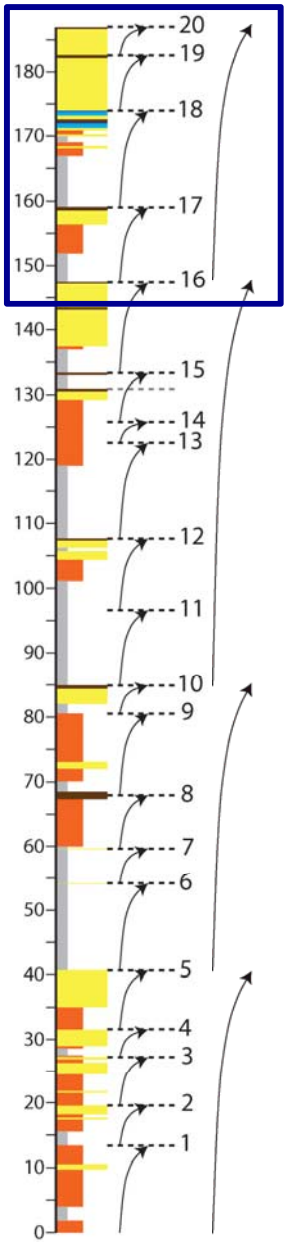


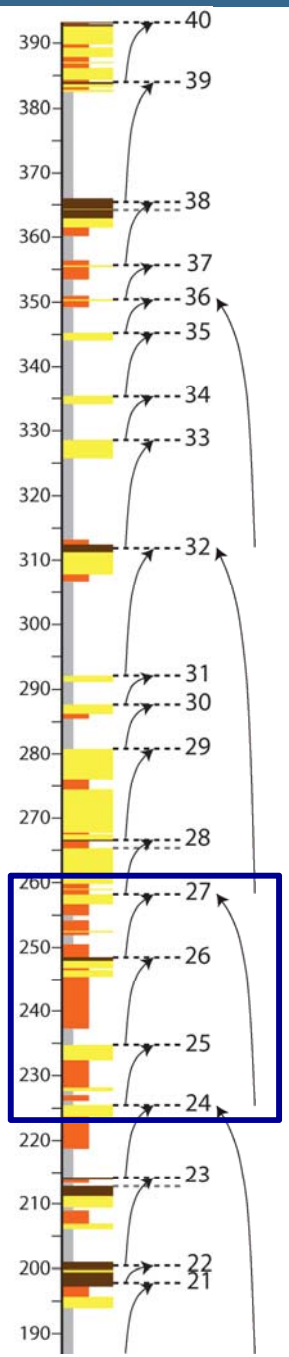


Parasequence Set

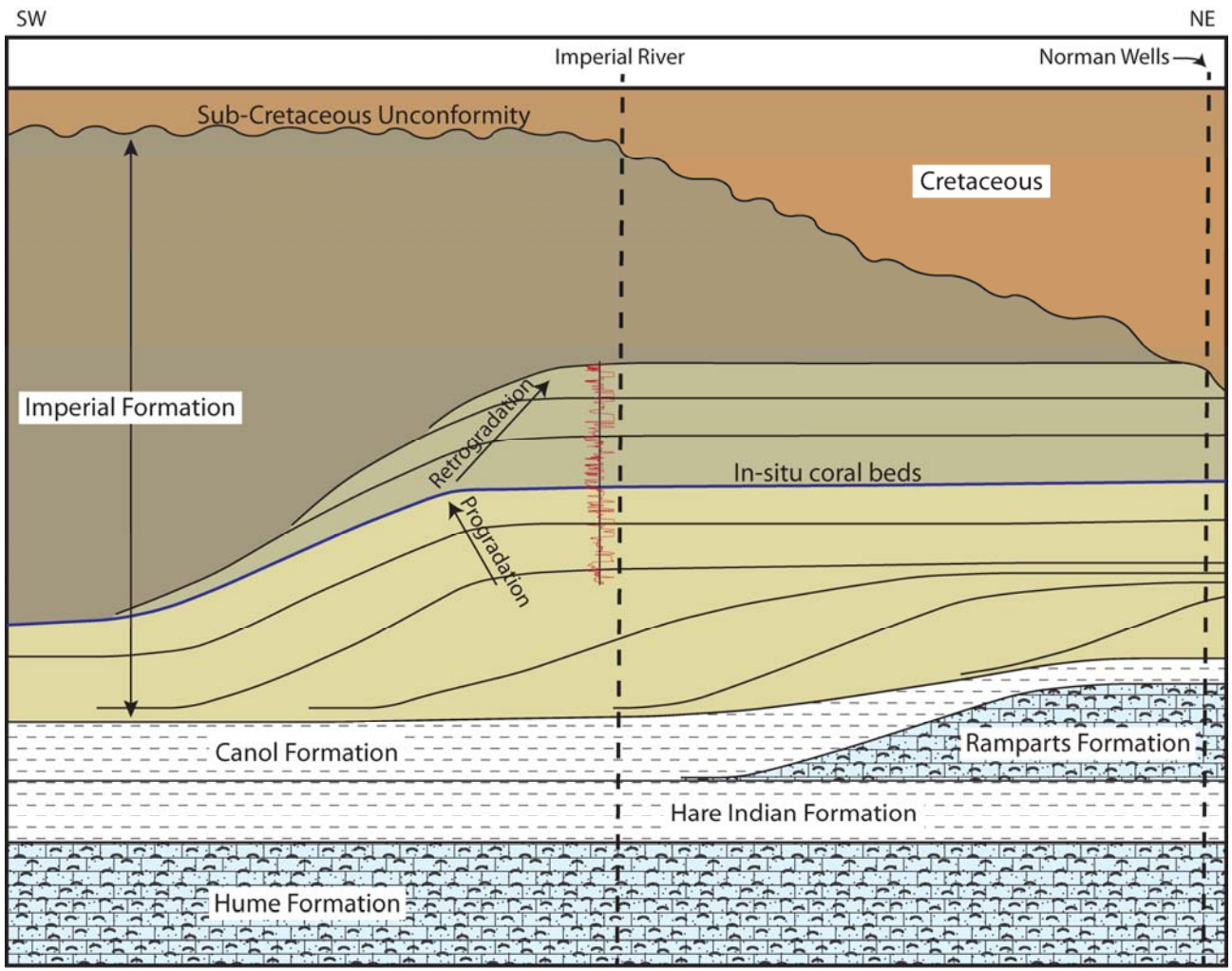


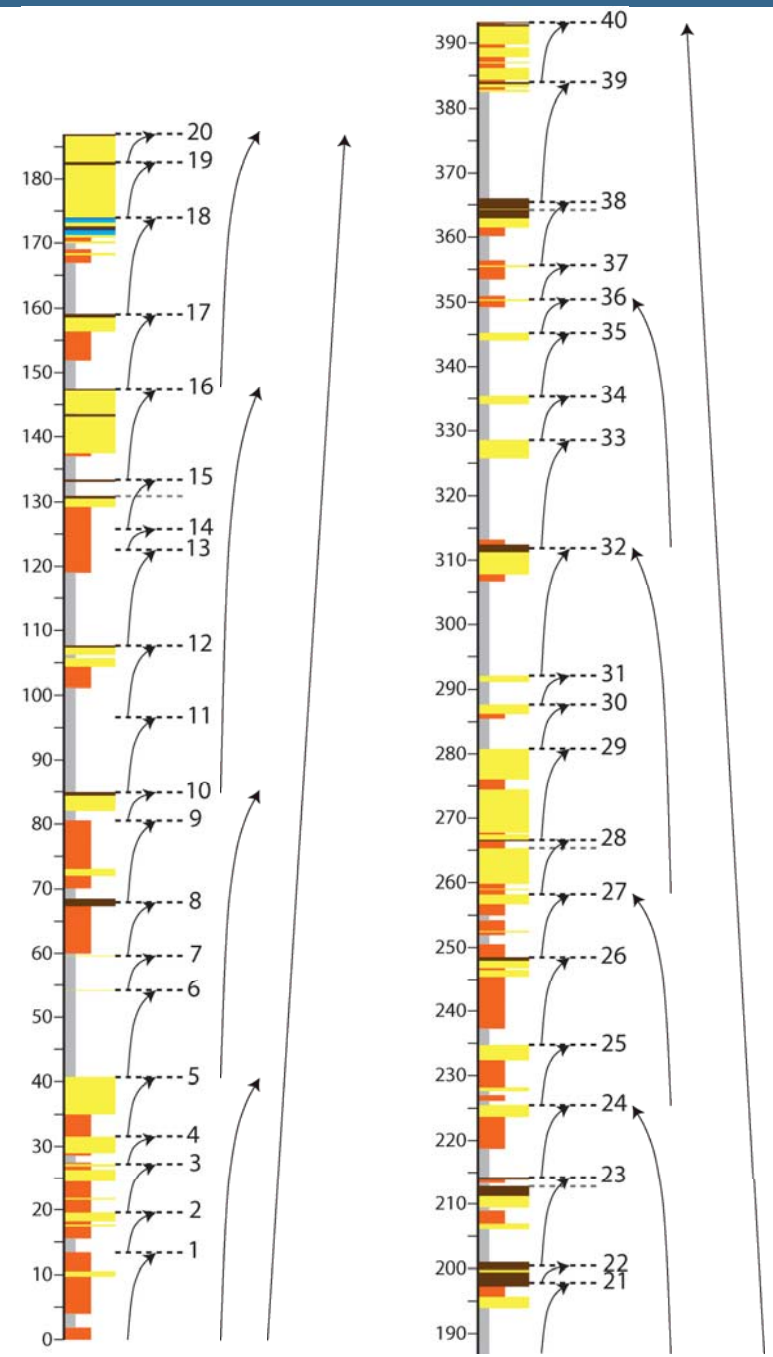






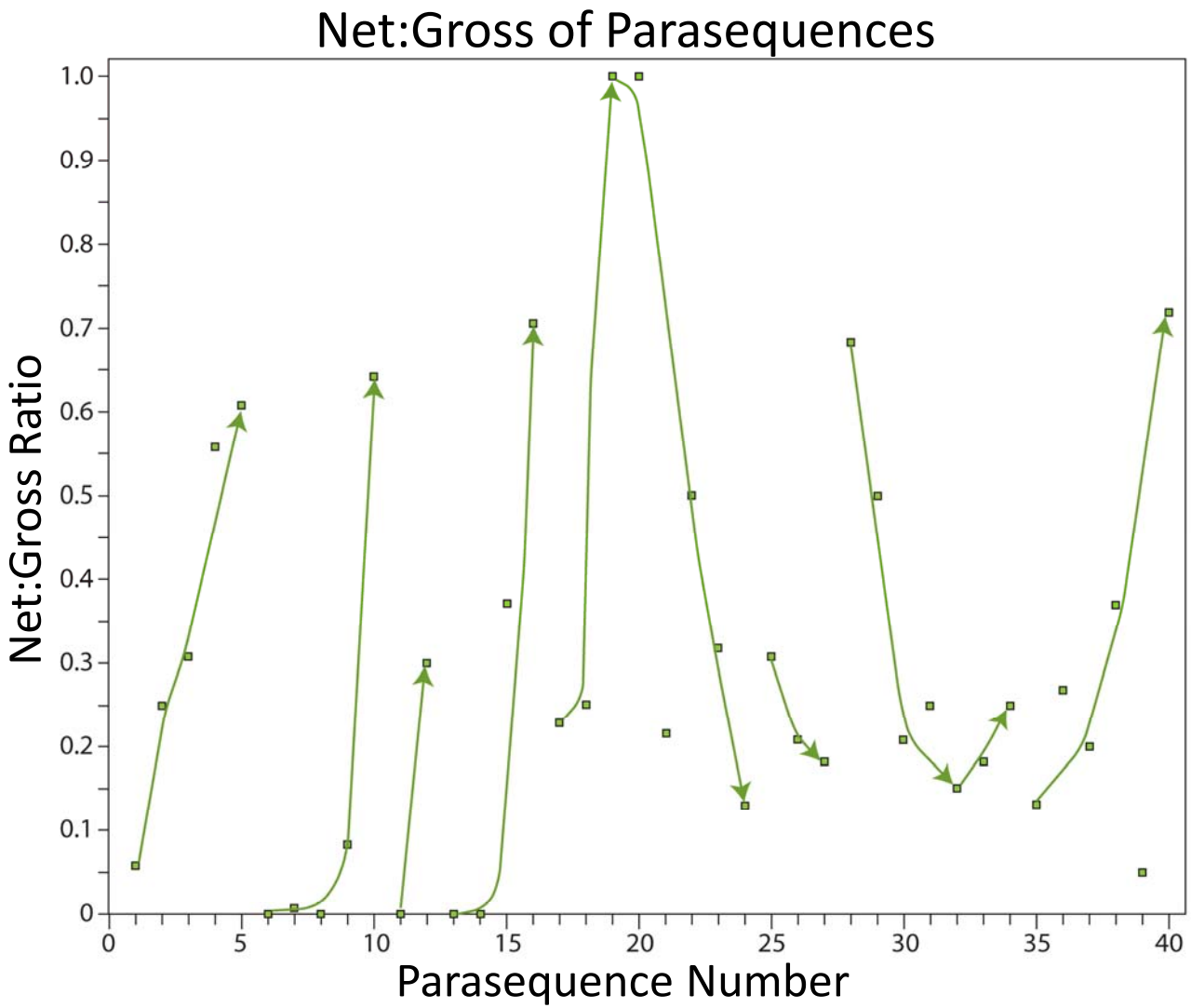
Outcrop Location Context

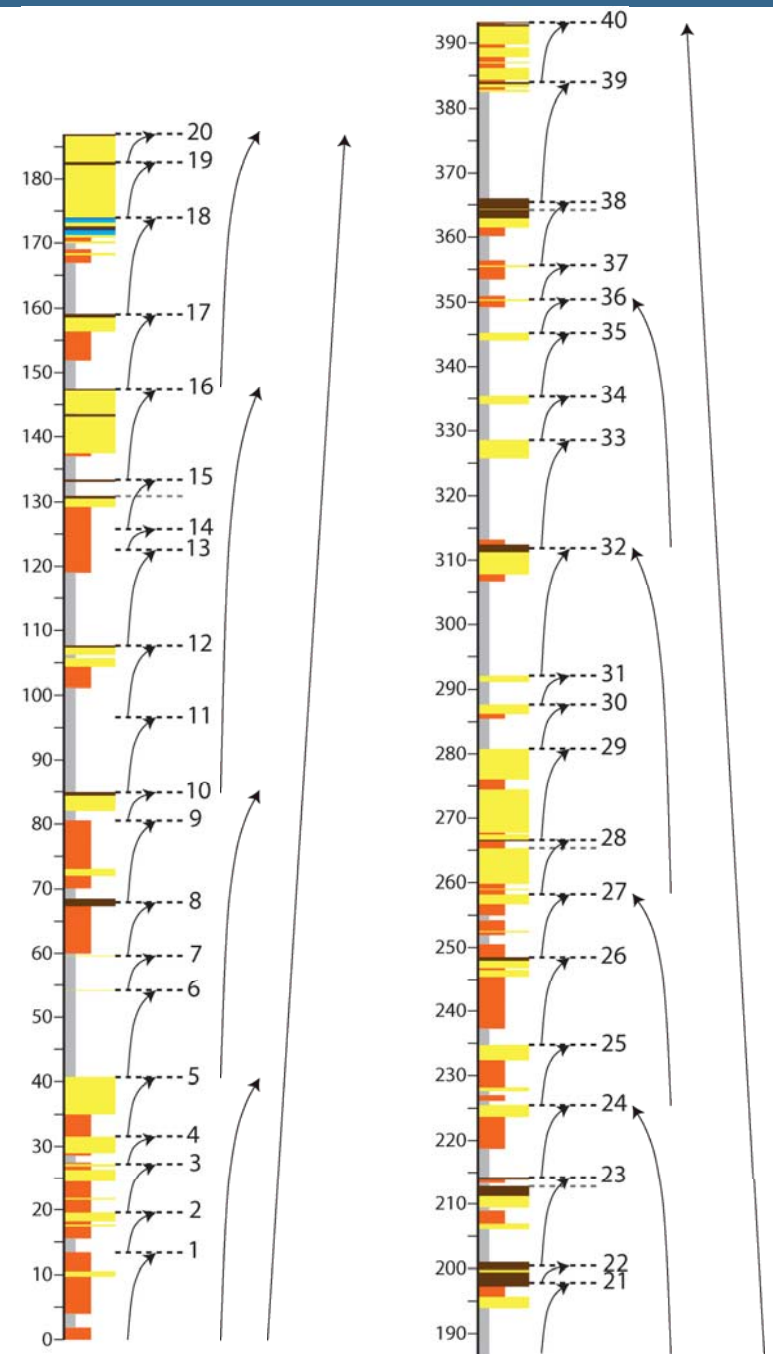




- Overall progradation and retrogradation of parasequence sets

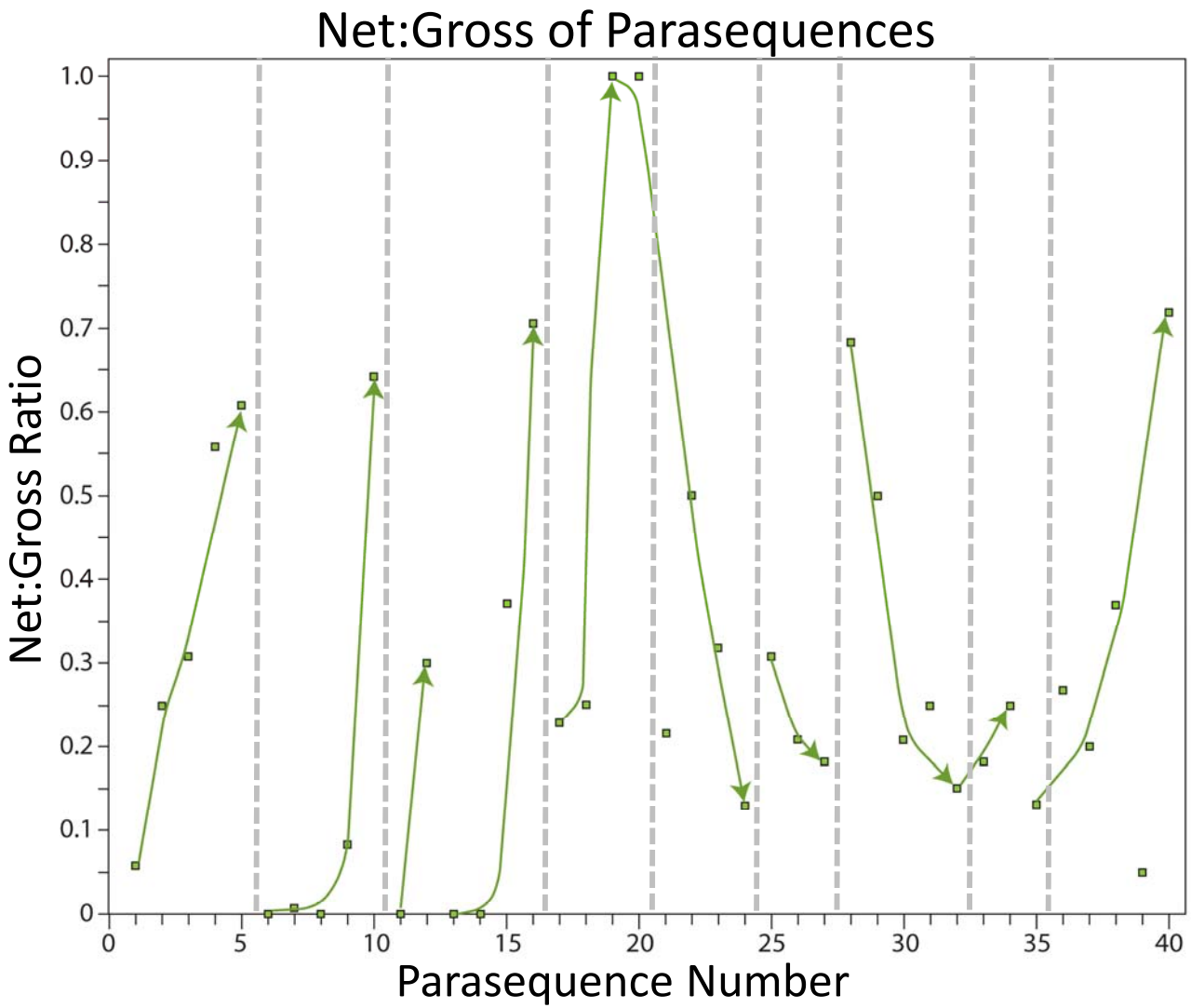
Outcrop Data Comparison

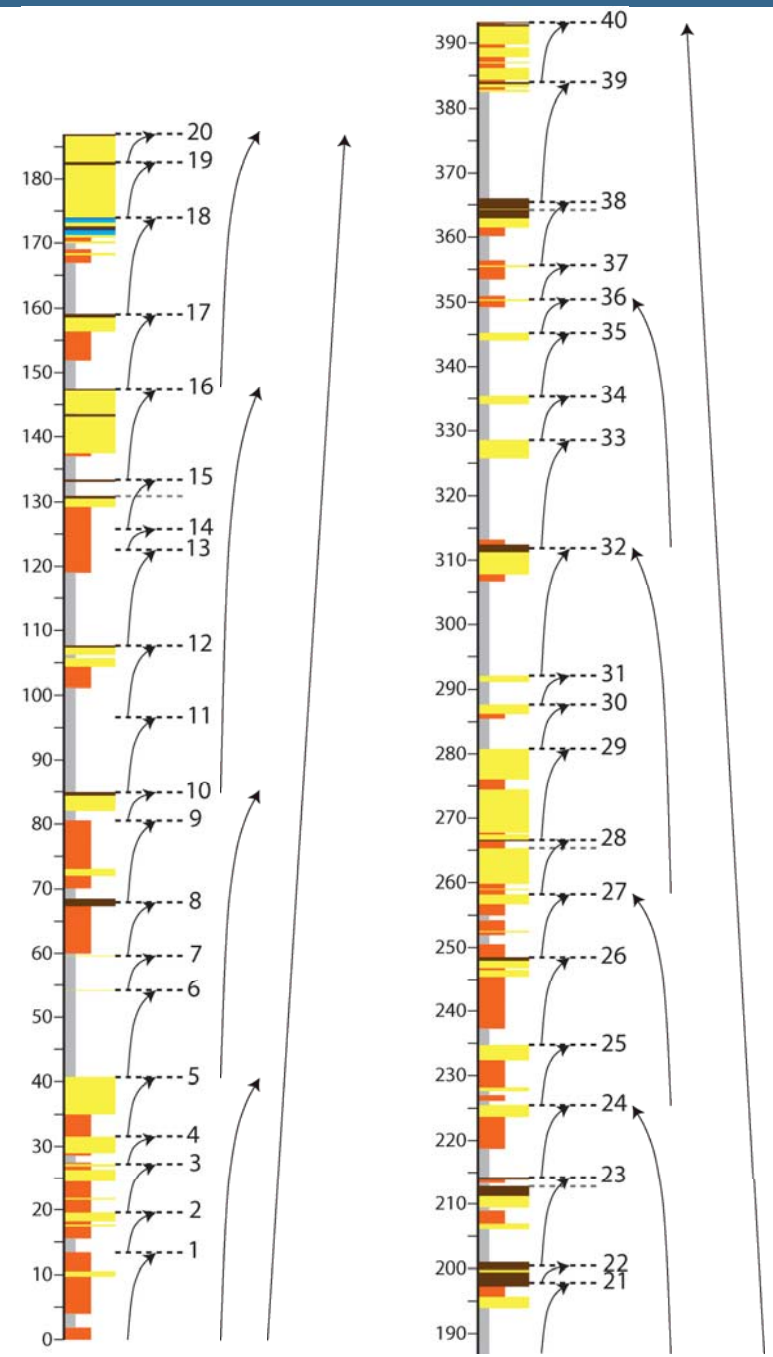




- Parasequence sets based on net:gross

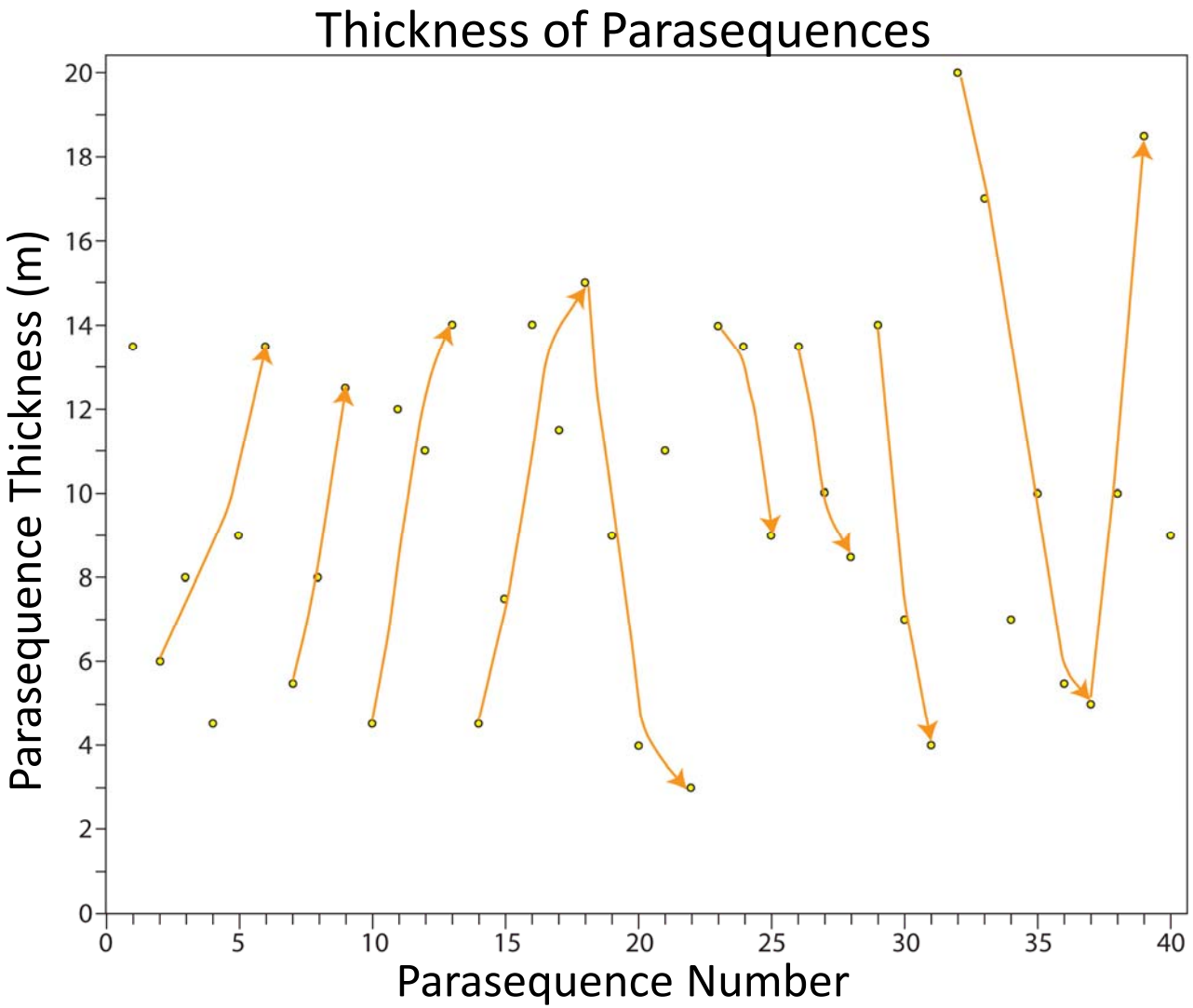
Outcrop Data Comparison

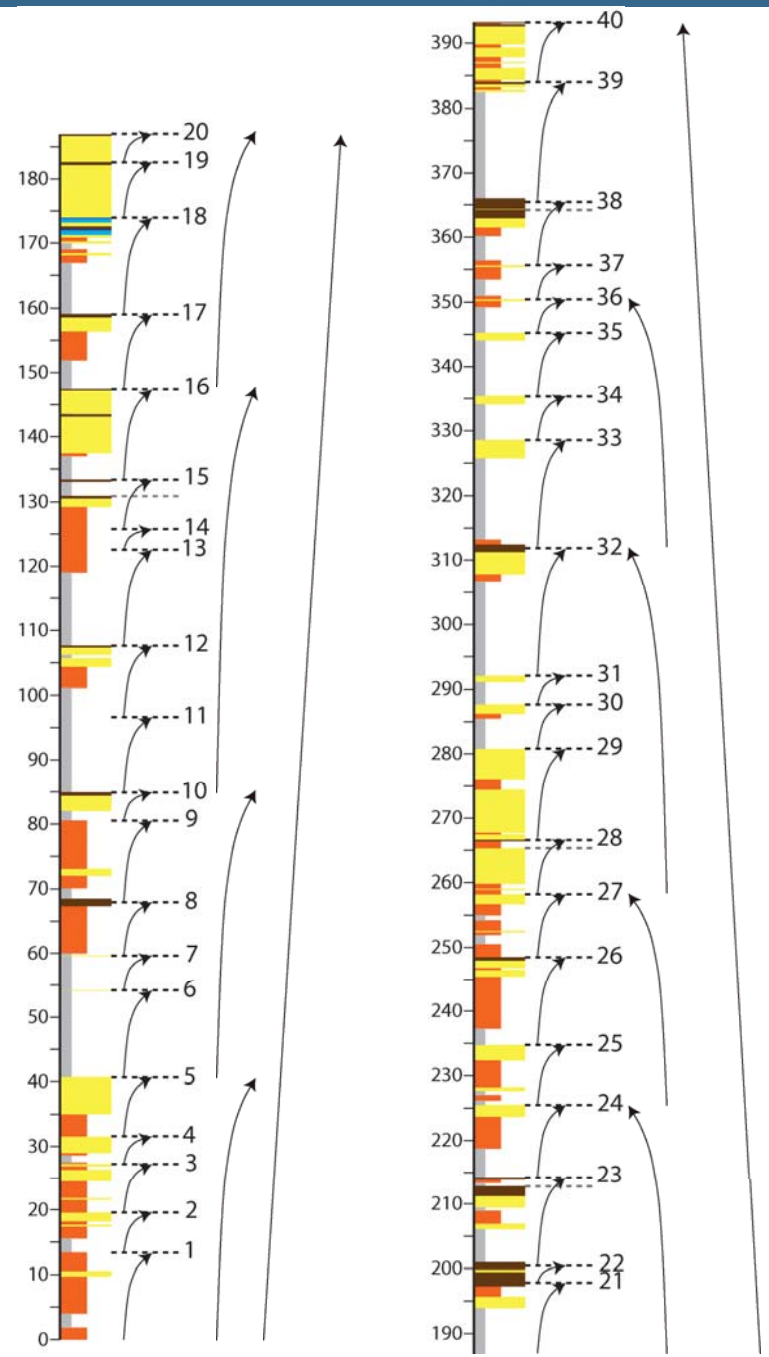




- Parasequence sets based mainly on net:gross

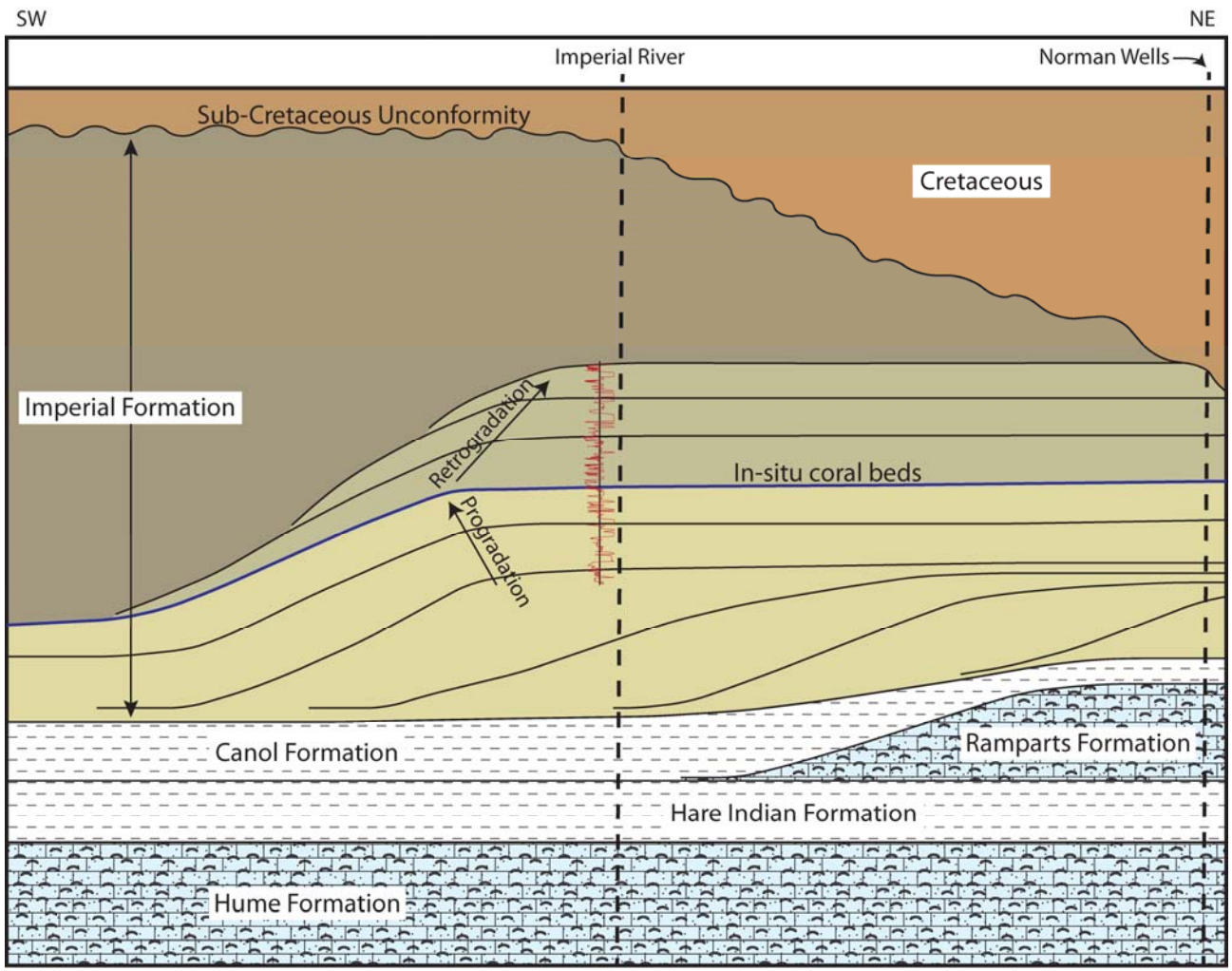
Outcrop Data Comparison

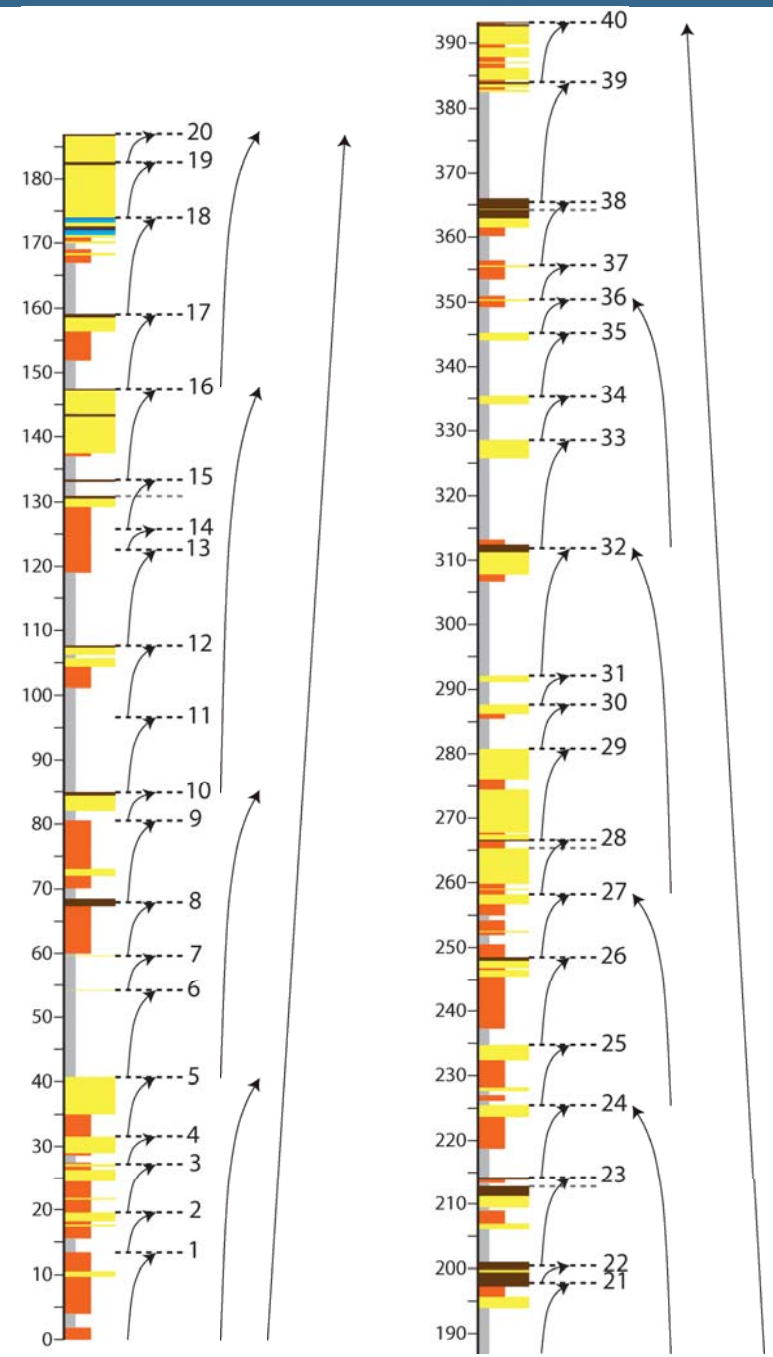




- Other parasequence data plotted

Outcrop Location Context



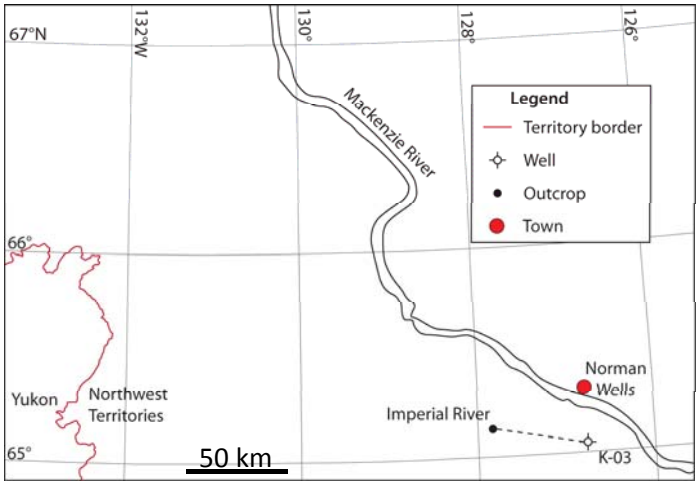


- Overall progradation and retrogradation of parasequence sets

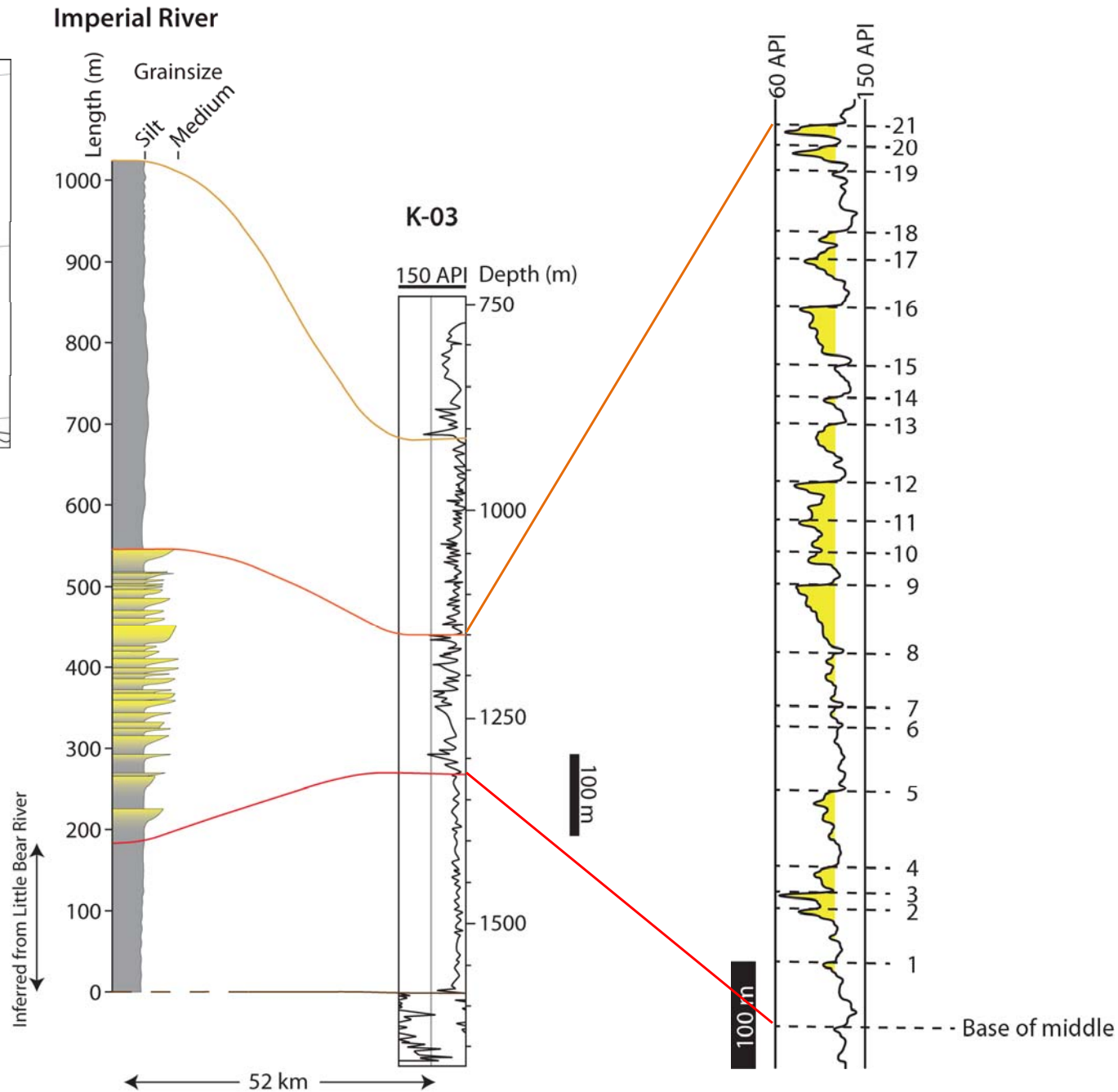
Subsurface Relevance

- Record land sale in Norman Wells region of 2.2 million acres
- At least 7 major producing companies with land holdings
- Several major companies committed over $500 million dollars

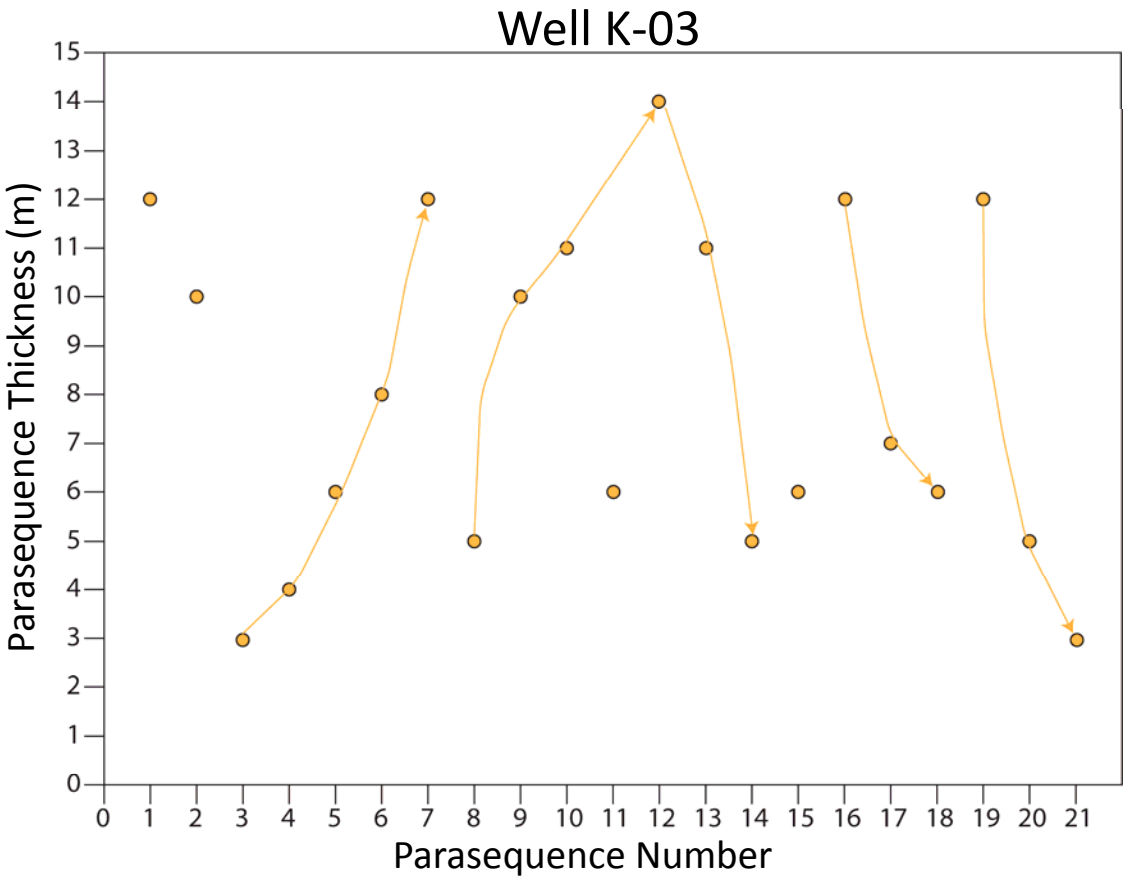
Outcrop to Subsurface Correlation

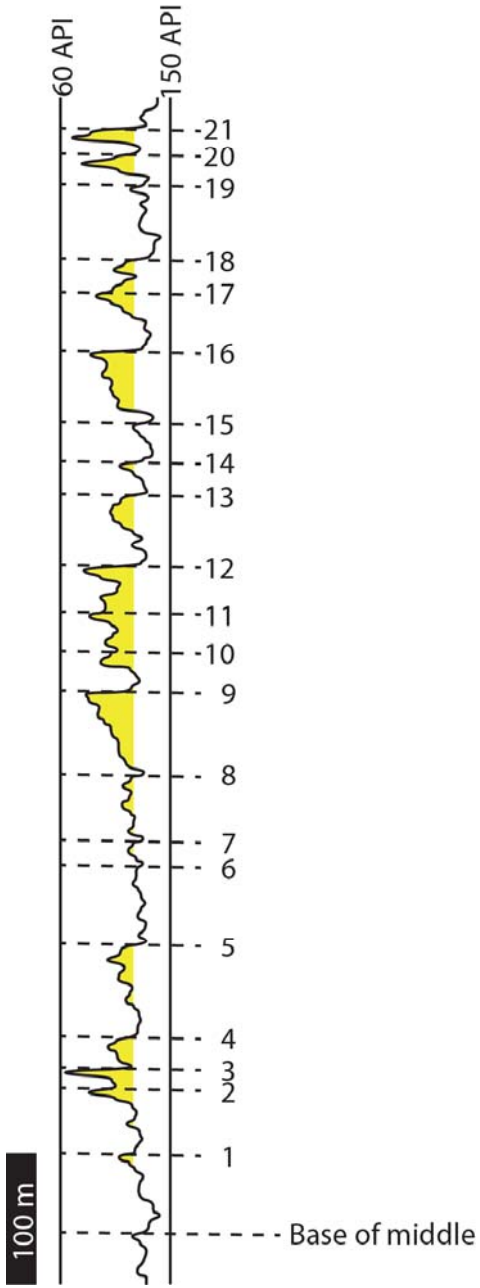


- Sandstone cutoff of 120 API

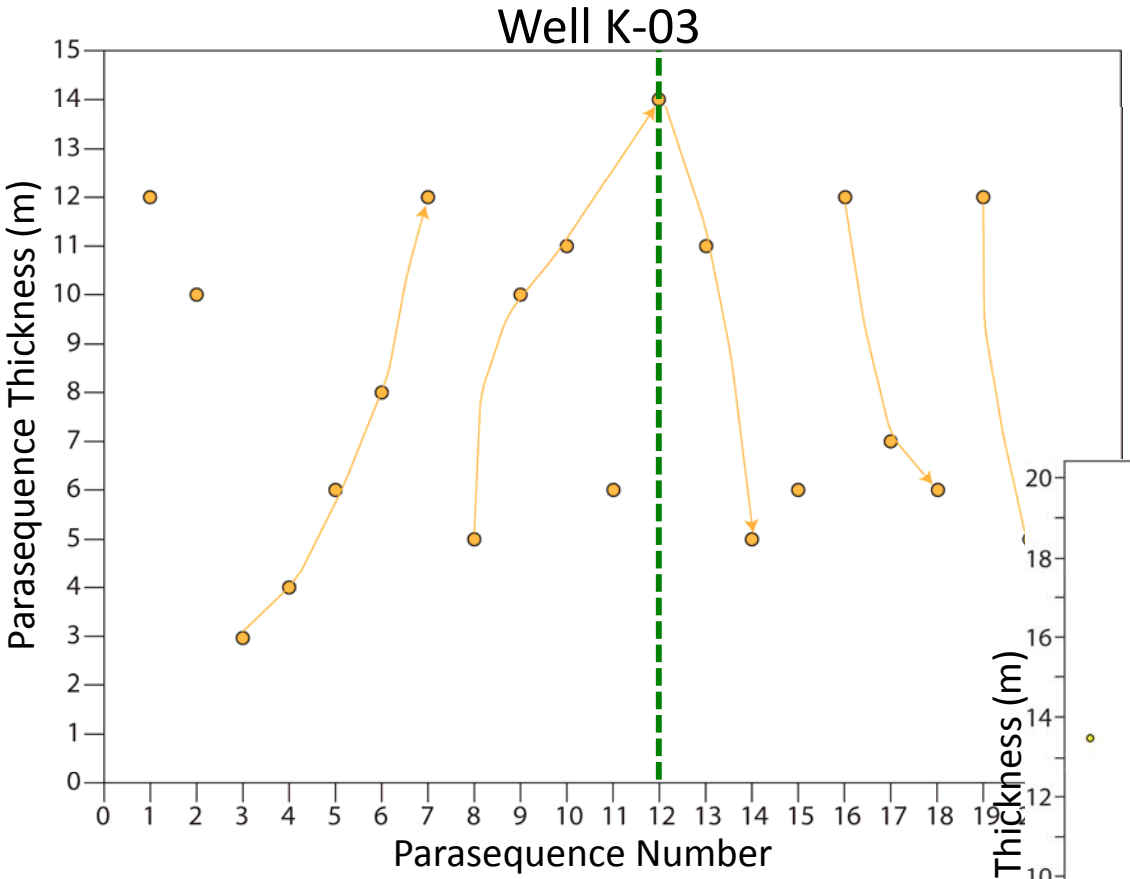


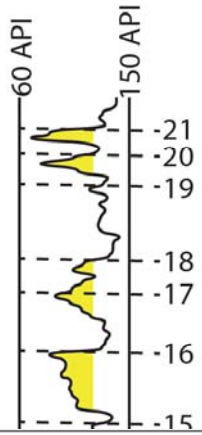
Outcrop to Subsurface Correlation

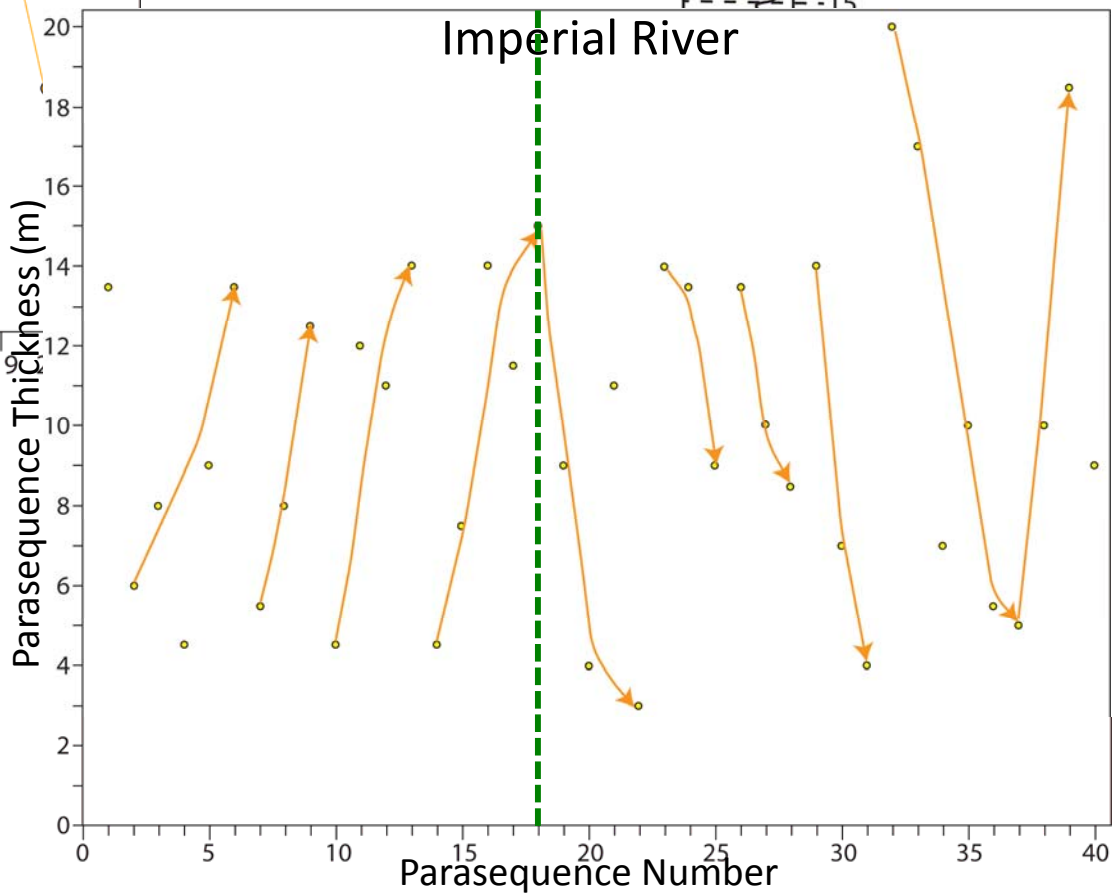




Outcrop to Subsurface Correlation







- Similar thickness trends

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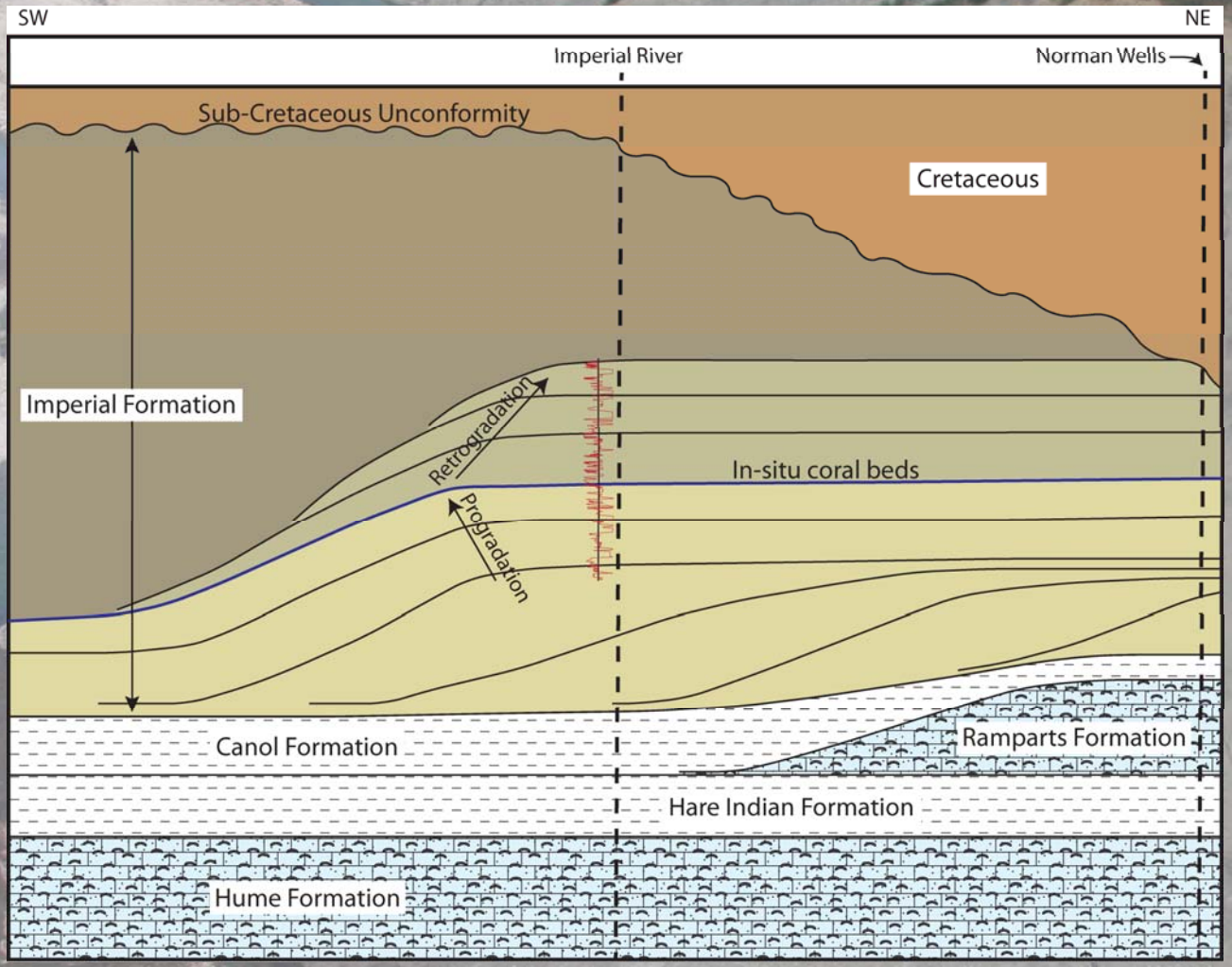

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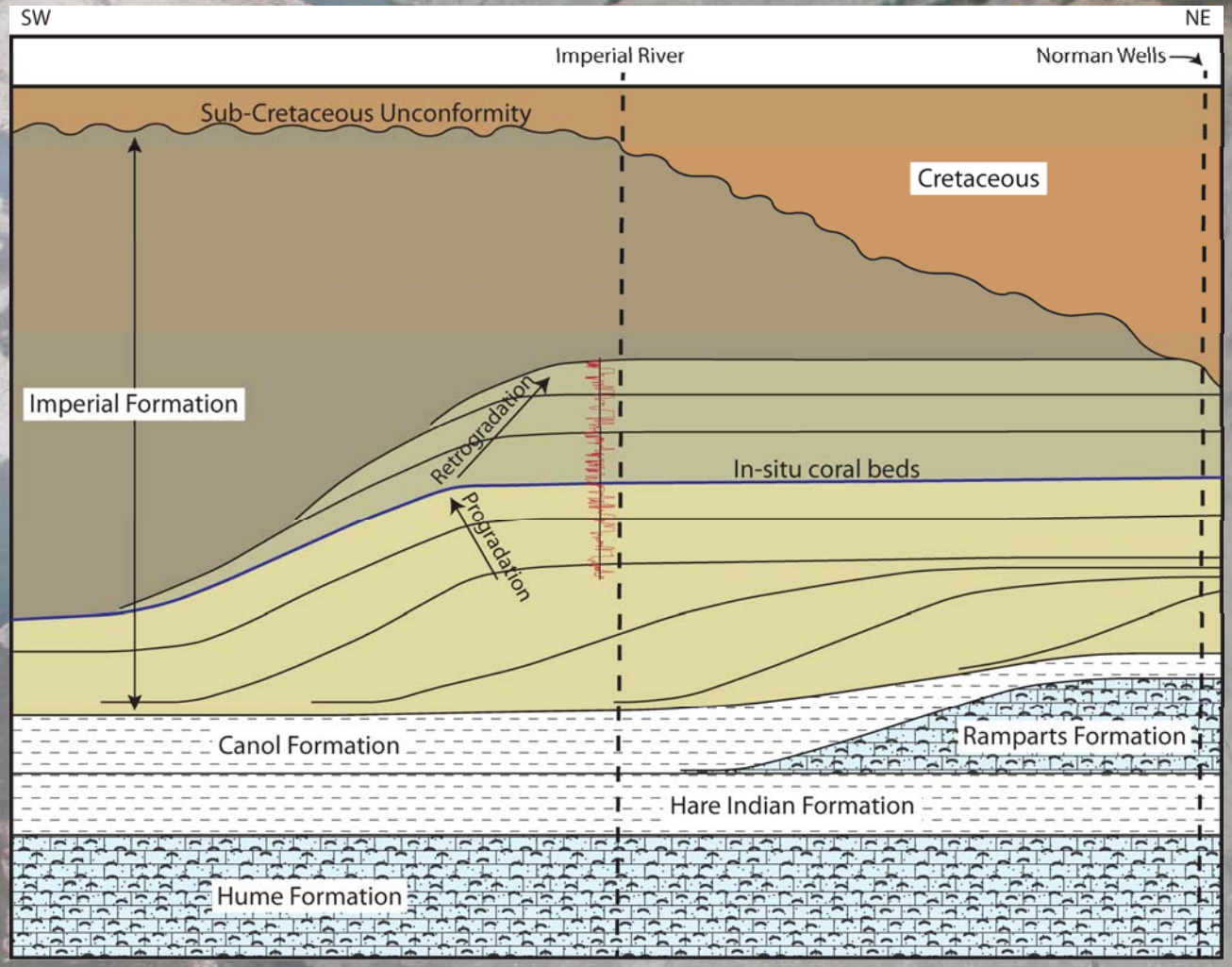

Acknowledgements

- Thanks to the Geological Survey of Canada (GSC) summer students (Katie Montgomery and Tom Proks) for assistance collecting data
- Rob MacNaughton & Karen Fallas (GSC)