Unrecognized Potential for Thick Triassic Reservoirs in Frontier Areas of NE British Columbia*

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Abstract

Accumulation of Middle Triassic strata in northeastern British Columbia has long been attributed to deposition in a passive margin basin with sediment sourced from the east and deposited on the western margin of Pangaea. The 'stable craton' model has been used to explain the thin and relatively even distribution of Middle Triassic marine sediments as a progradational clastic sheet on the passive western edge of ancestral North America. These strata have been a primary focus of hydrocarbon exploration interest in British Columbia for 4 decades. Conventional reservoirs that occur in fine-grained sandstone and coquina intervals in the Halfway Formation are interpreted as barrier island shoreface / inlet successions. Recently, attention has shifted to less conventional play types such as the extensive, gas-prone, low permeability shales and siltstones of the Doig Formation.

Exploration to the west of known pools is mitigated by the prevailing knowledge: i.e. existing depositional models suggest that conventional sand and coquina dominated reservoir units become progressively thinner to the west. Recent work suggests that, rather than a passive margin setting, these strata accumulated during the early stages of foreland basin development. Our observations, based on field work in the Rocky Mountain Front Ranges and Foothills and analysis of limited subsurface data from the sparse wells drilled in this area, support this hypothesis. Detailed correlations, facilitated by conodont and ammonoid biostratigraphy, show that Middle Triassic strata thicken westward into a large trough. Most significantly, the single thin (10-50 m) sandstone sheet that characterizes the Halfway Formation in its eastern reaches is represented by a thick (> 400 m) sandstone-dominated succession. Abrupt changes in unit thicknesses and thick, convolute-bedded intervals implicate the influences of local faulting in deposition. Correlation of the study interval to the western margin of Triassic outcrop preservation reveals abrupt stratal thinning west of the trough, and the presence of a western subaerial high. Furthermore, sandstone / shale ratios suggest sediment sources from the west

rather than solely from the east, as previous basin models demanded. These data indicate that the potential for thick new Triassic reservoirs is high in frontier areas west of the currently developed part of the WCSB (Western Canada Sedimentary Basin).

References

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Websites

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Geological Atlas of Western Canada Sedimentary Basin: Alberta Geological Society, Web accessed 13 July 2010 http://www.ags.gov.ab.ca/publications/wcsb_atlas/atlas.html

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Synopsis

- Conventional wisdom has long attributed accumulation of Middle Triassic strata in the WCSB to deposition in a passive-margin basin setting, with sediment derived from an eastern (cratonic) source.

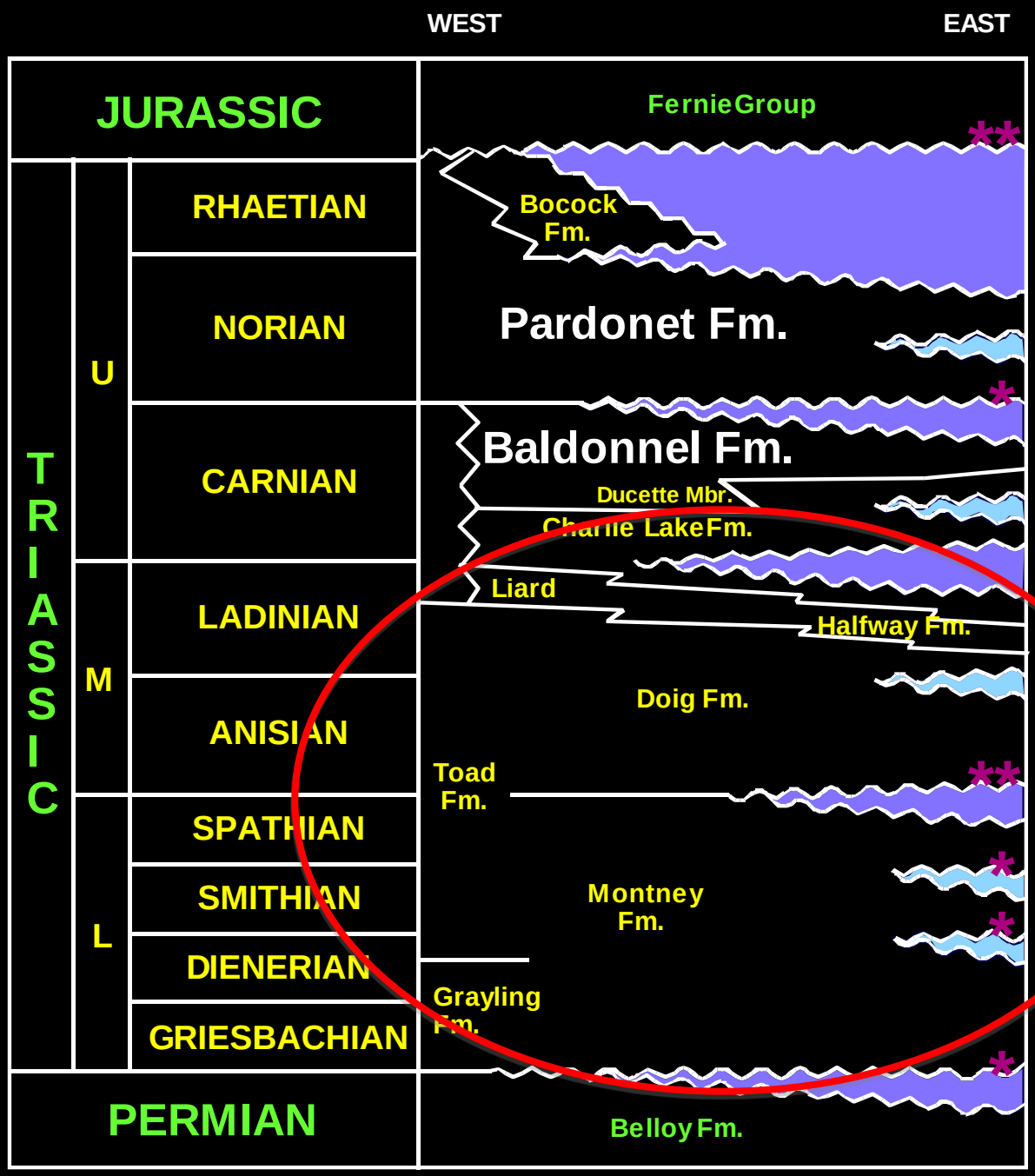
- Consequently existing depositional models dictate that conventional sand and coquina reservoir units should become progressively thinner in a westward direction.

Synopsis

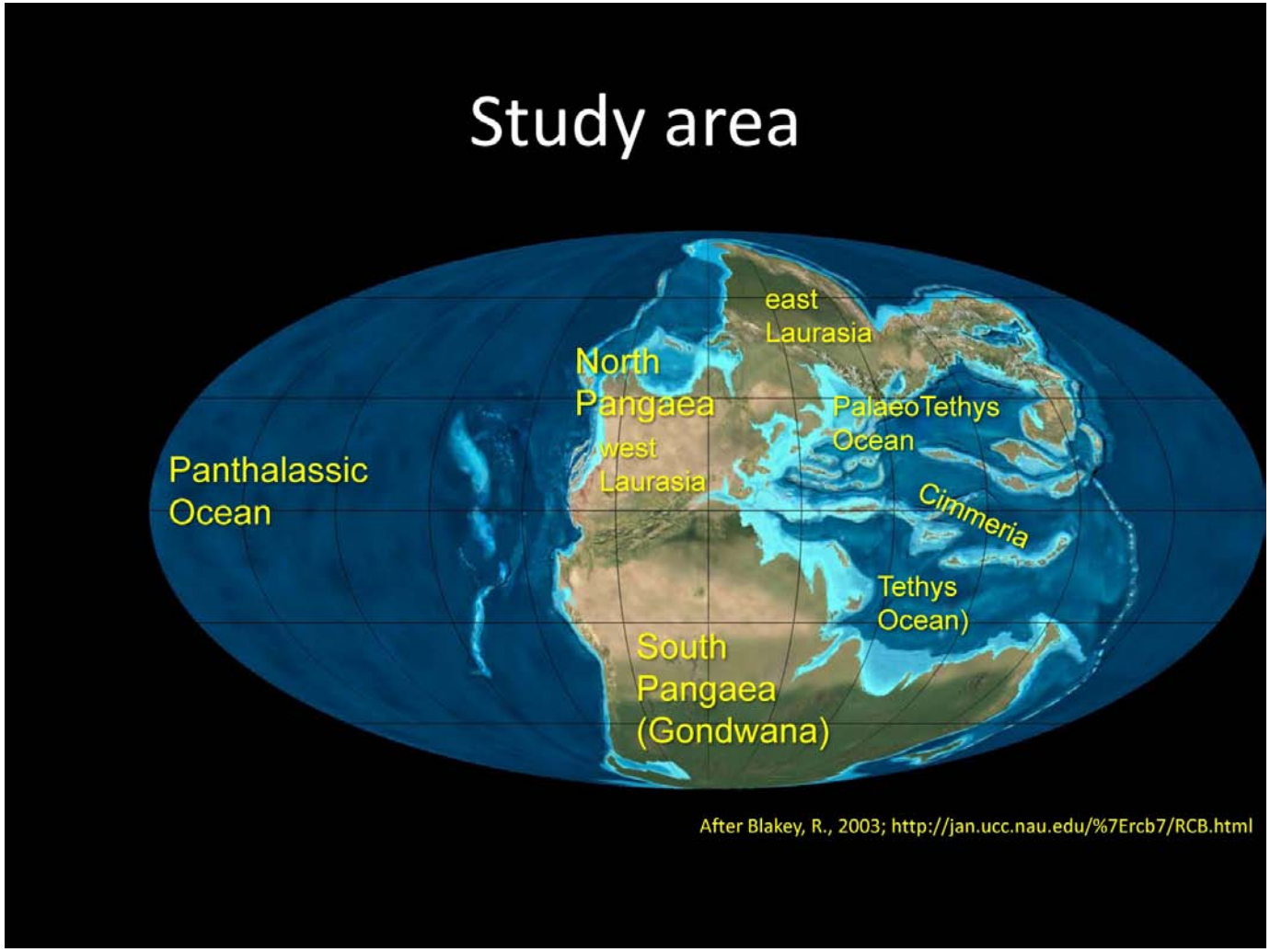
- Observations in frontier (western) subsurface areas as well as in the Rocky Mountain Foothills outcrop belt suggest that, rather than a passive margin setting, these strata accumulated during an interval of regional terrane accretion and consequently were deposited in a tectonically active setting, likely either a back-arc or embryonic foreland basin setting.

- Triassic strata in the WCSB accumulated in a broad fault-bounded trough, with sediment sourced from both the craton to the east as well as uplifts on the west.

Triassic Stratigraphy & Petroleum Systems

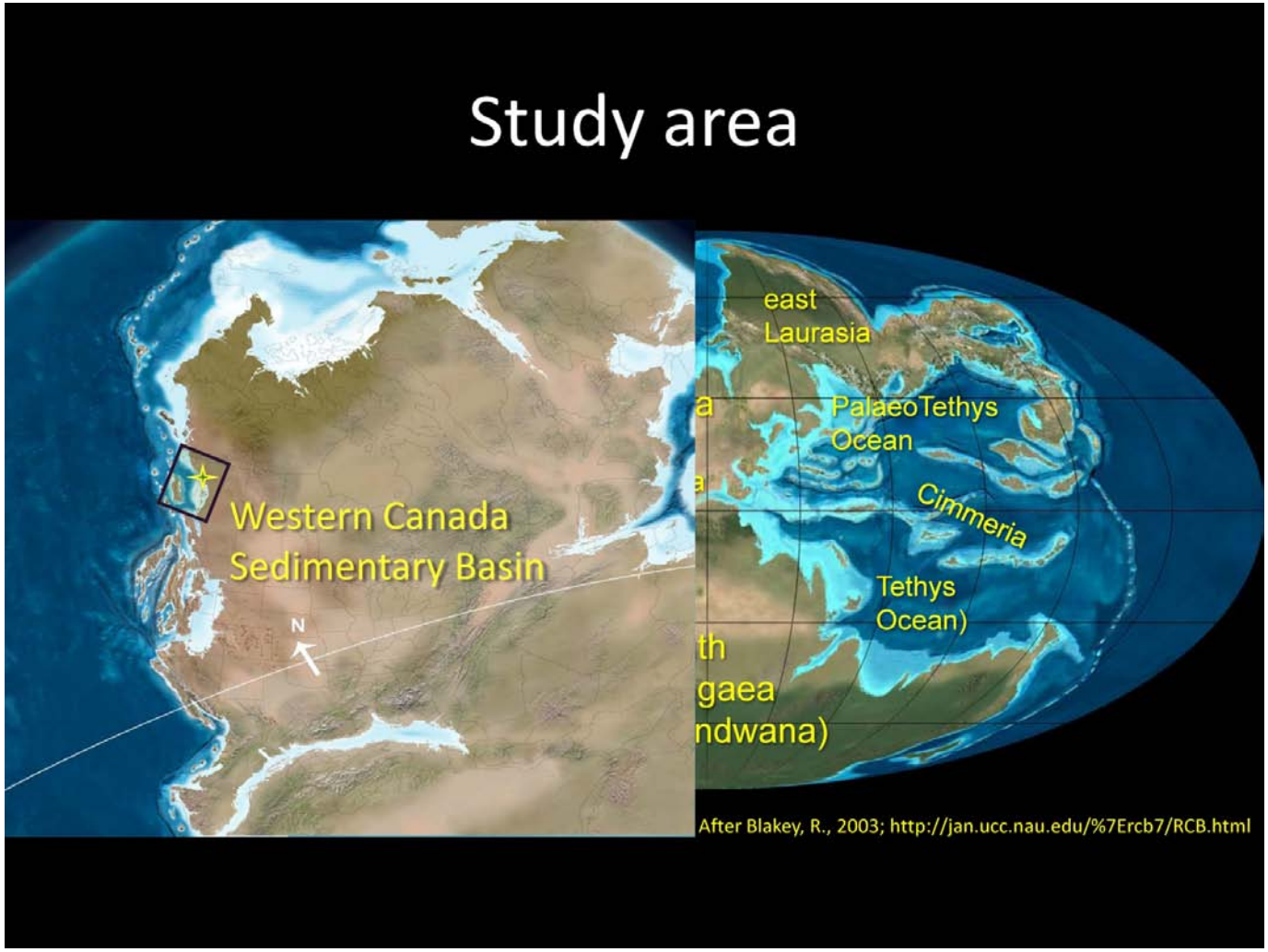


(modified after Embry and Gibson, 1995)



Notes by Presenter:

-One massive globe-spanning continent
-Arid to hyper arid climate in western Canada (evidence includes extensive evaporites, halite, etc….).
-Islands / terranes to west in Panthalassa were previously believed to have been hundreds to thousands of kms away during the Middle Triassic but are now known to have been much closer (work by Fil Ferri, Jim Mortensen and JP Zonneveld).



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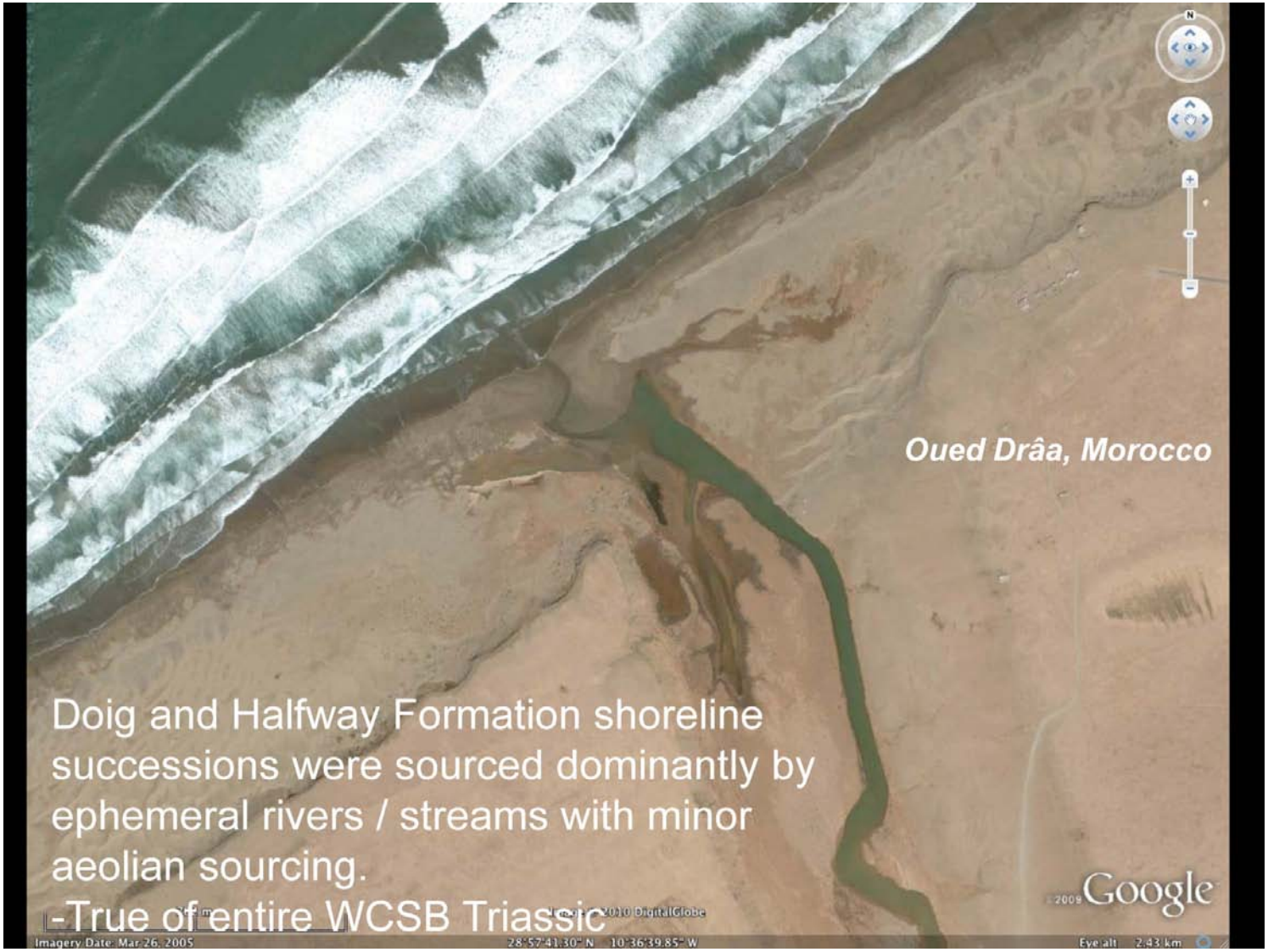
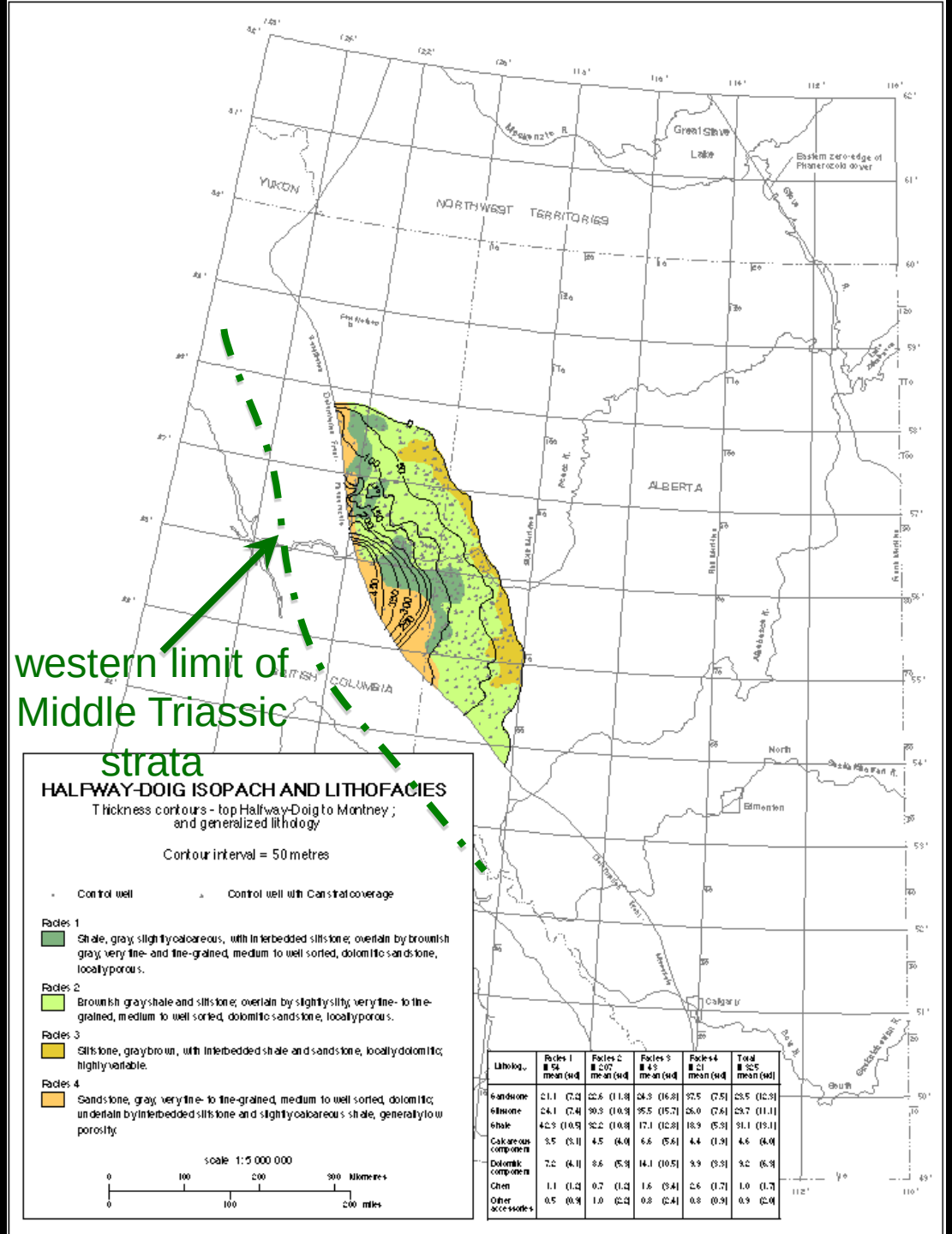


Notes by Presenter: This is a great example of a classic west Saharan ephemeral river. It is 1100 kms long but rarely reaches the ocean.

Doig - Halfway Formation Isopach

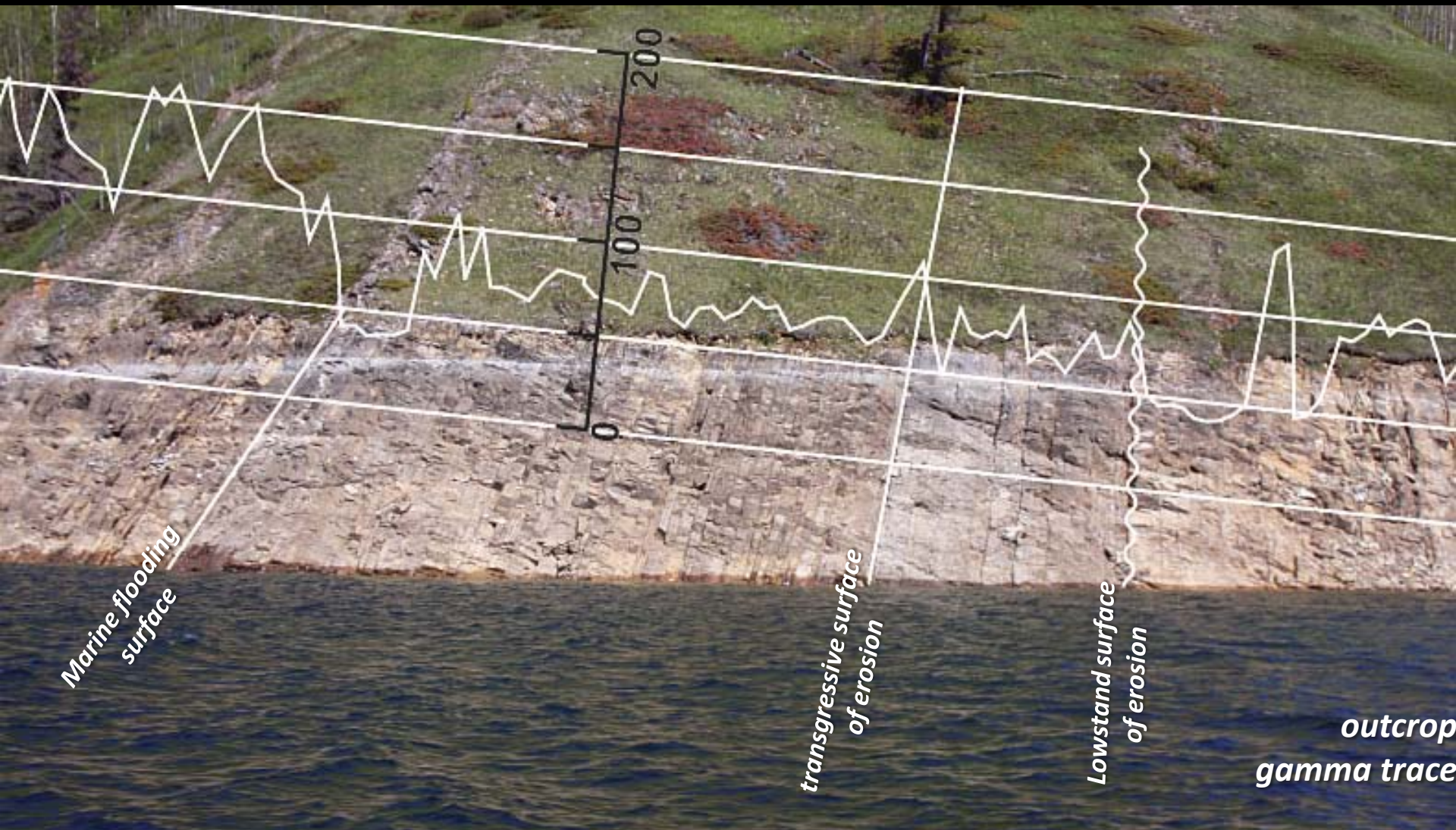


Atlas of the WCSB (CSPG)

Odd trends in the deformed belt.

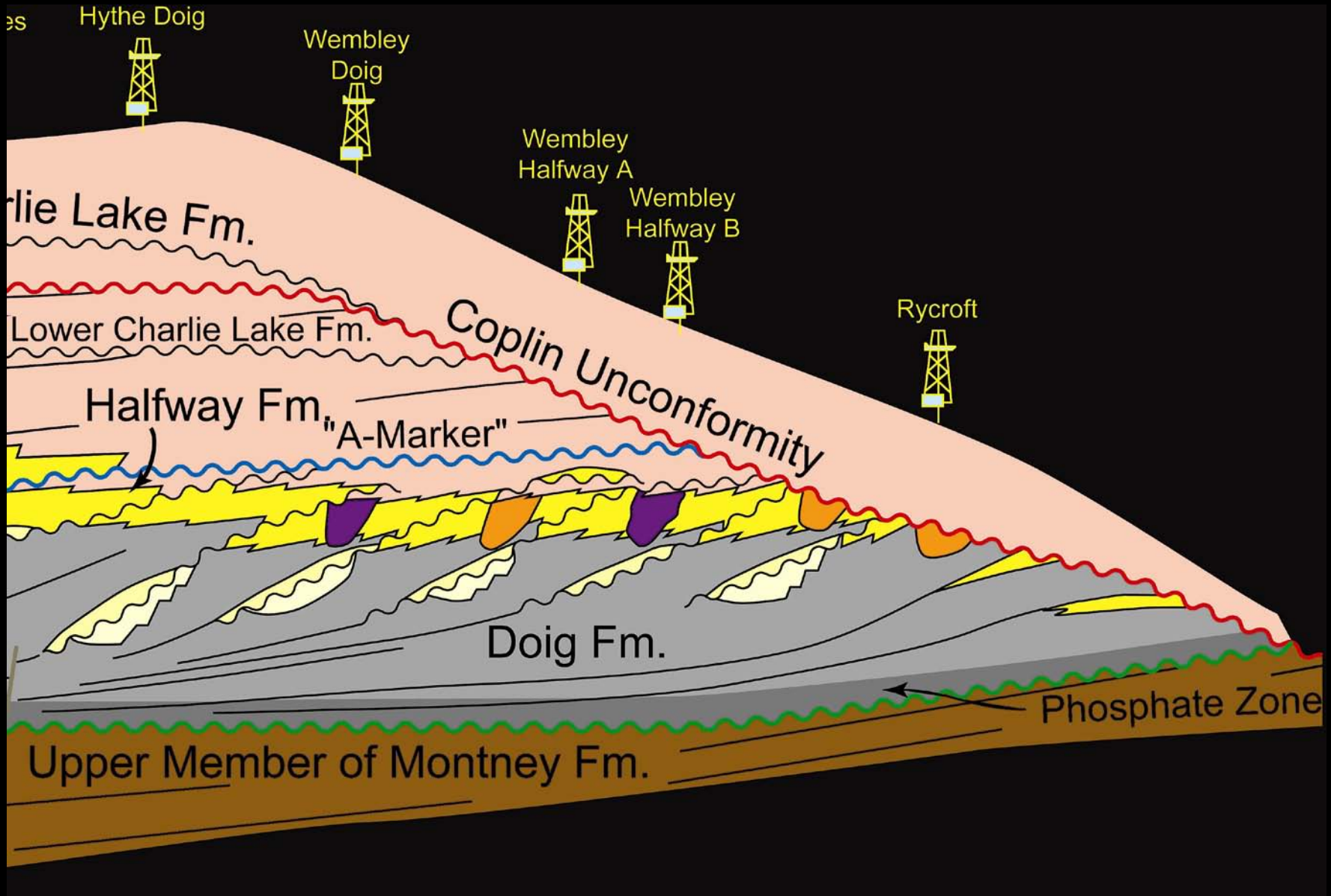
- Stratal geometries inconsistent with passive-margin architectures.
- Regional sandstone/shale ratios.
- Local grain-size increases to the west.
- Craton-derived sediments are strongly quartz-dominated, but also present are feldspathic / micaceous sandstones and local litharenites.
- More “shoreface successions” appear westwards.
- Several carboniferous zircons also been collected from Middle Triassic sandstones.

- The Middle Triassic succession has been interpreted as microtidal to mesotidal barrier island shoreface accumulations and is characterized by thick, laterally extensive accumulations of fine-grained, quartz-dominate sandstone.

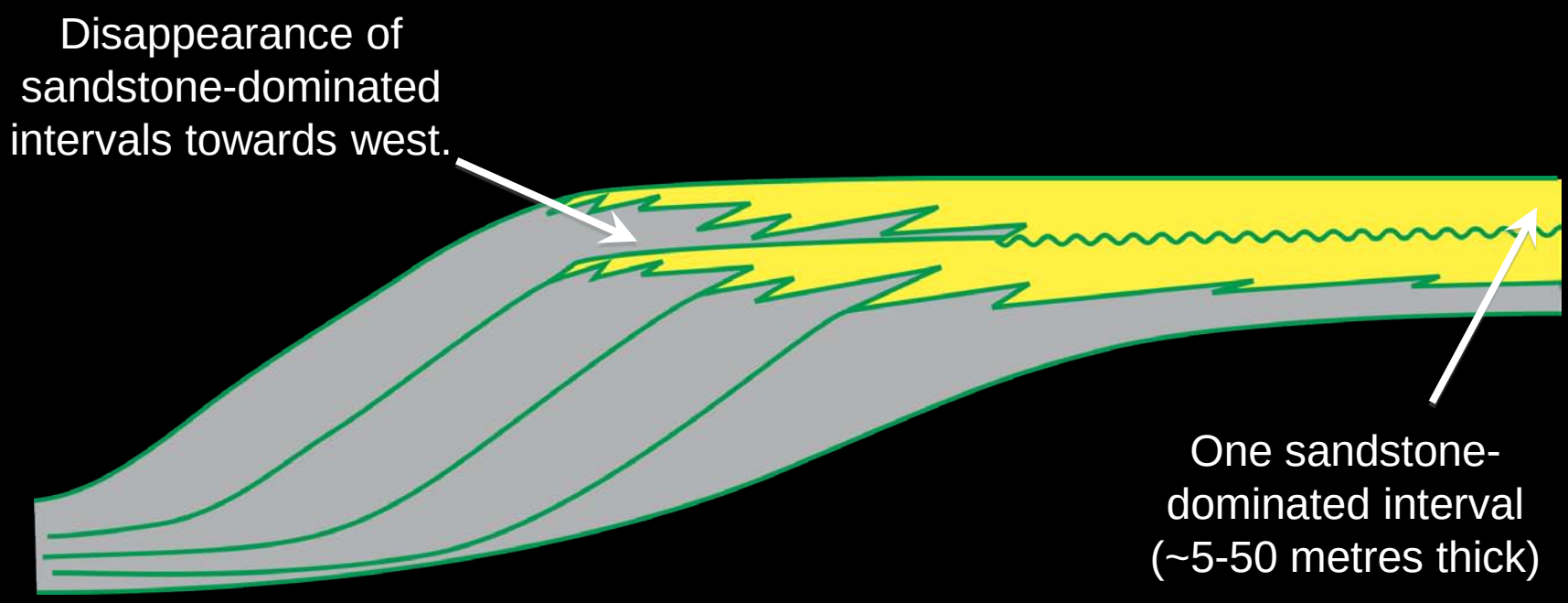


STUDY INTERVAL

-Doig-Halfway succession in subsurface (Toad-Liard in outcrop)



Traditional view of Middle Triassic deposition



But, this model does not account for thickening to the west and multiple stacked shoreface successions observed in the western subsurface & outcrop belt

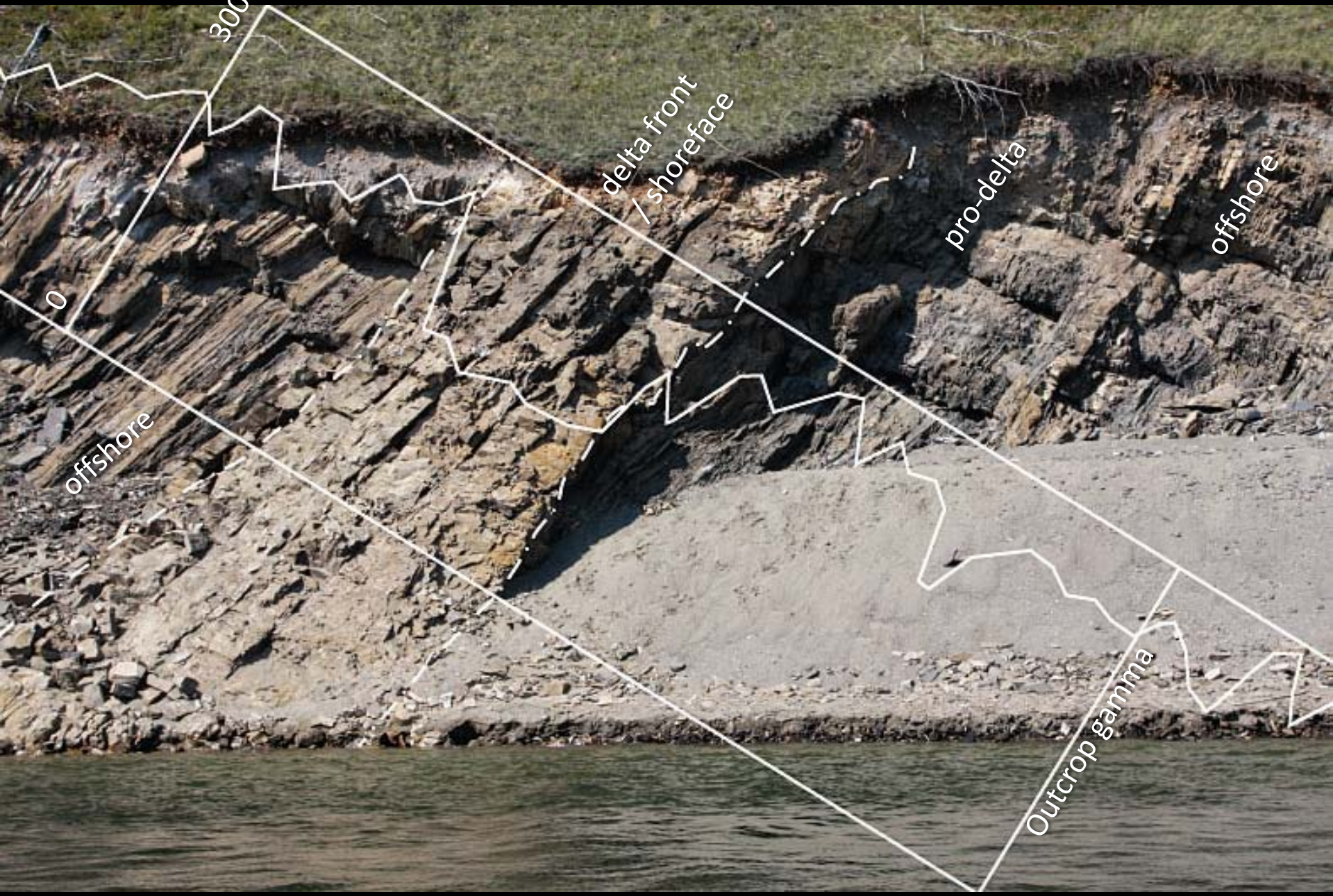
Observed in the deformed belt:

- Sudden changes in thickness of individual stratal packages.
- Large-scale convolute-bedded intervals locally common in shoreface and proximal to distal offshore successions.

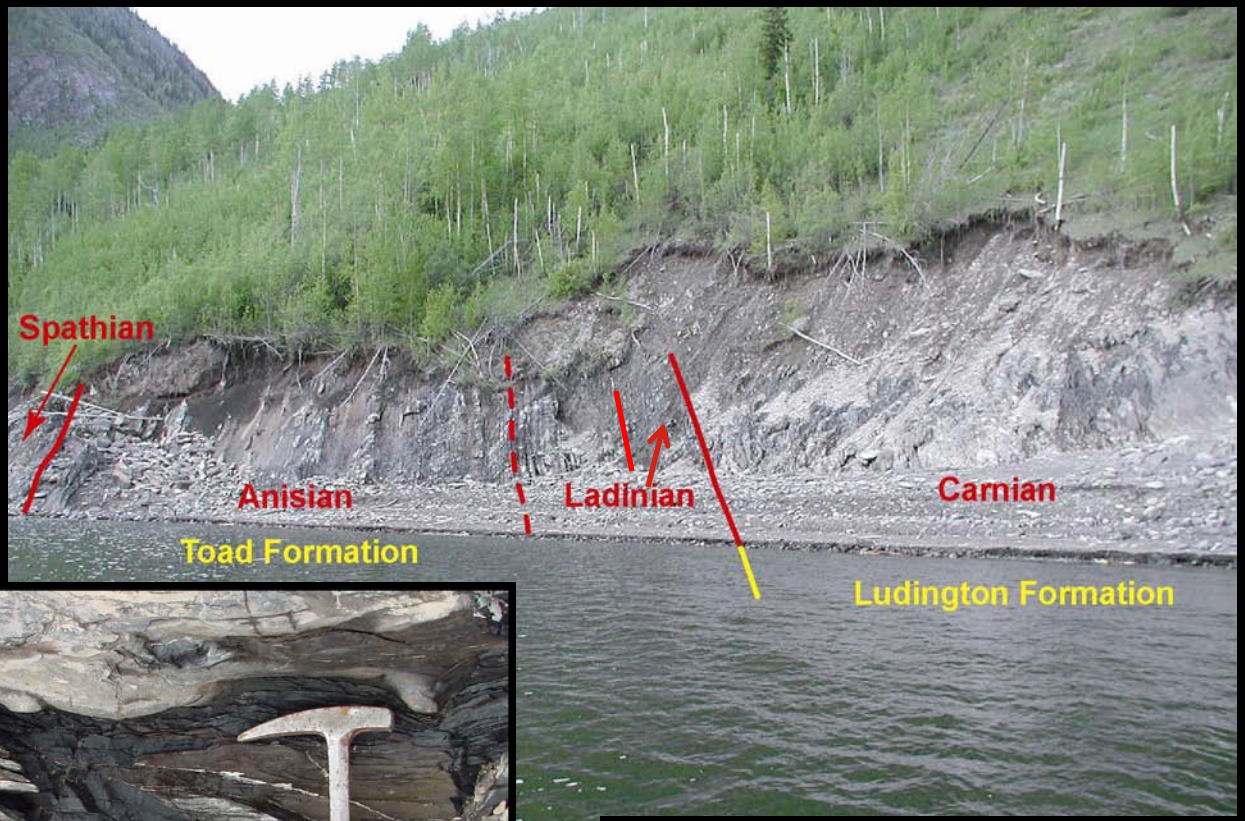

Convolute-bedded interval

Notes by Presenter: Sandstone dike

Notes by Presenter: Sandstone dike


300
0
offshore
delta front
/ shoreface
pro-delta
offshore
Outcrop gamma

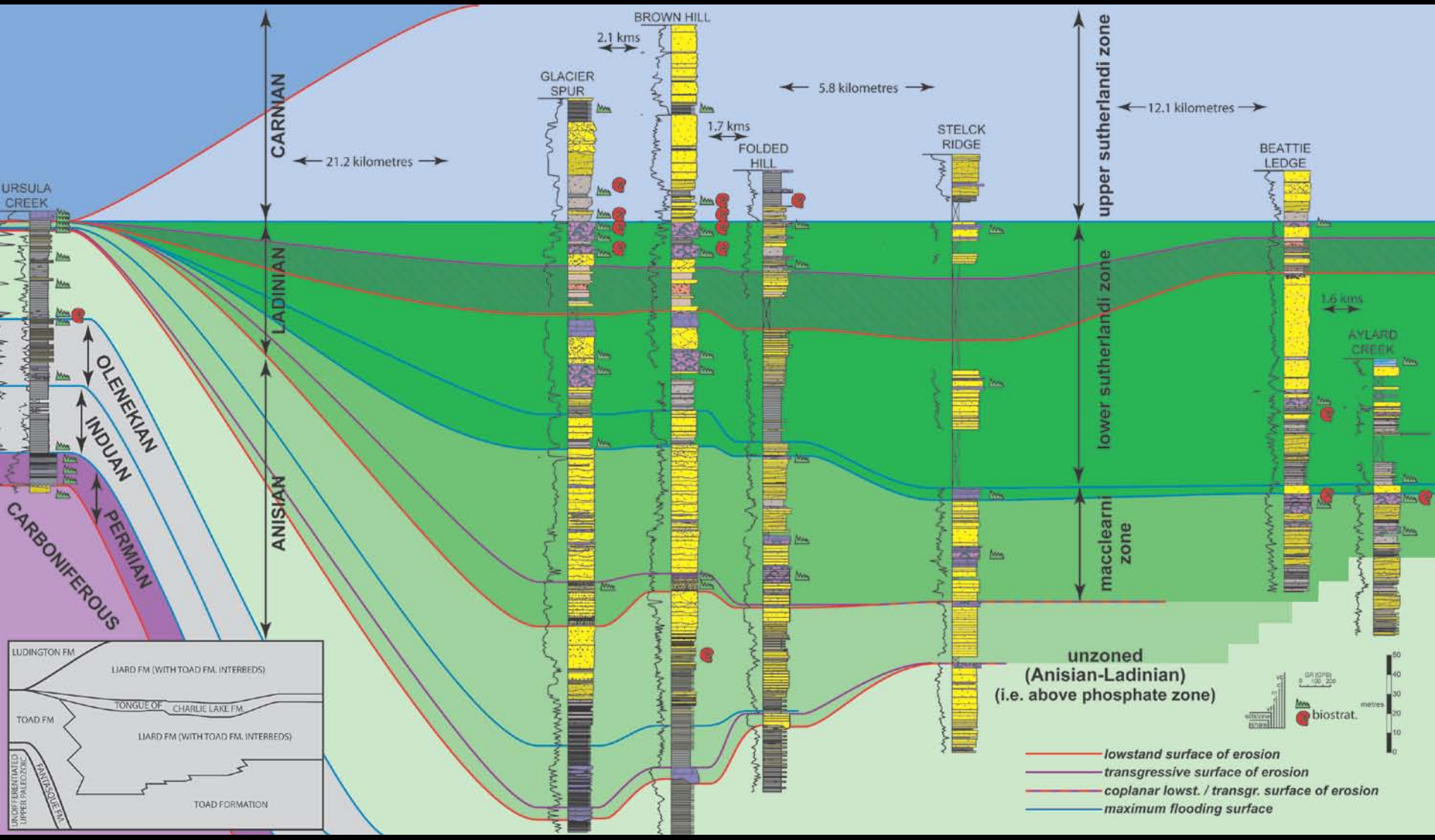
Ursula Creek: western (outboard)



- Ladinian succession is no more than 5.0 meters thick, an order of magnitude thinner than at Brown Hill, ~20 km to the east (~22-24 km palinspastically).

Williston Lake x-section – version 1

Click to View Notes by Presenter

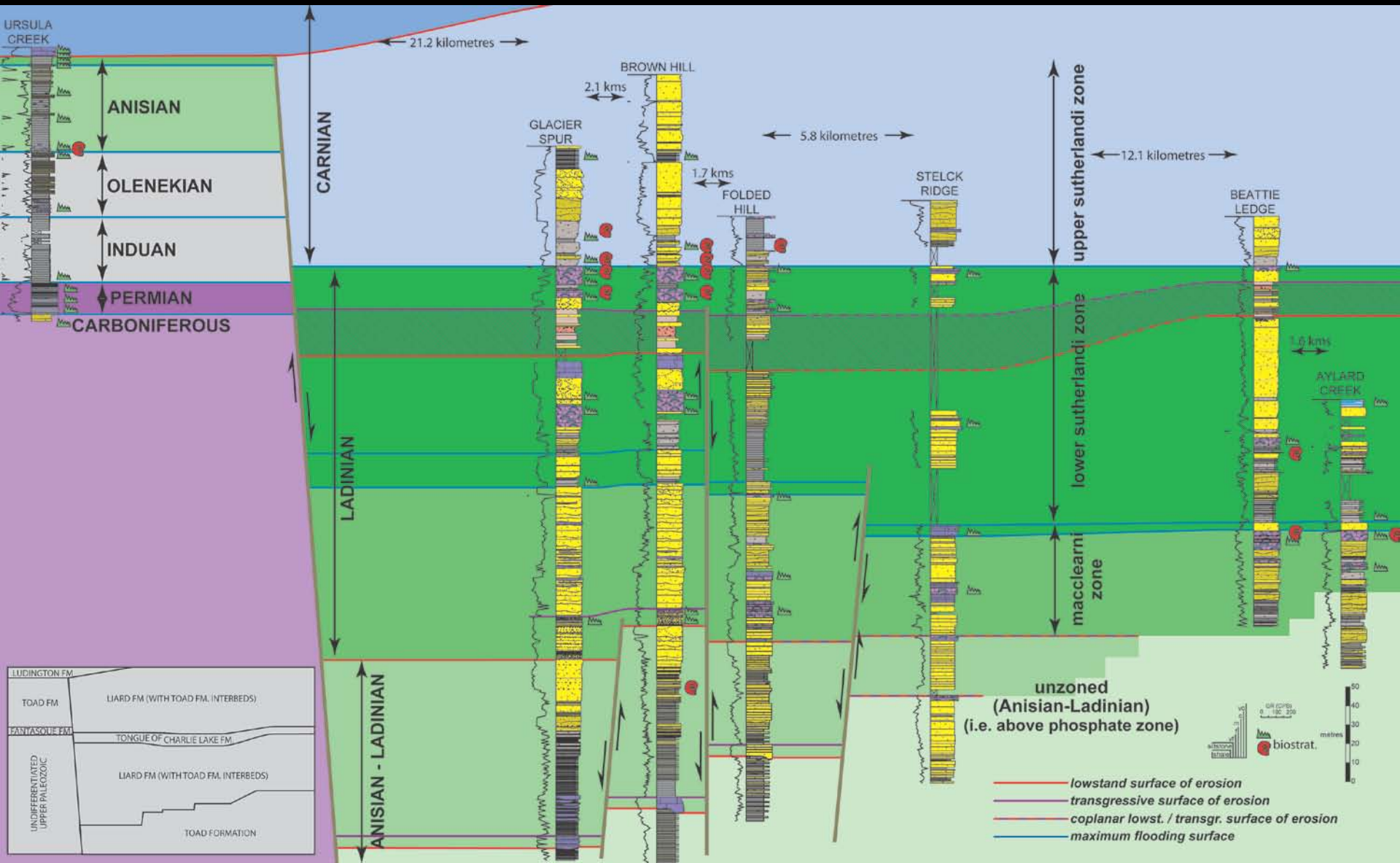


Notes by Presenter: (for previous slide)

This side shows color coded ages in the strata. The inset shows the formations represented. Note that the dark green upper Ladinian and light blue lower Carnian do not occur in the west at Ursula Creek but are the bulk of the eastern sections. Note also that palinspastic reconstructions in the area indicate minimal shortening (~10%) so the sediment thickness changes are unusual for the distance shown. Note also that the middle outcrop (Glacier Spur, Brown Hill and Folded Hill) exhibit anomalous thickness changes as well. Note that the section is hung on the Ladinian-Carnian boundary (on a maximum flooding surface that approximates it). Also, the cross-hatched interval in the dark green is a tongue of Charlie Lake formation that bifurcates the Liard in the study area.

Williston Lake x-section – version 2

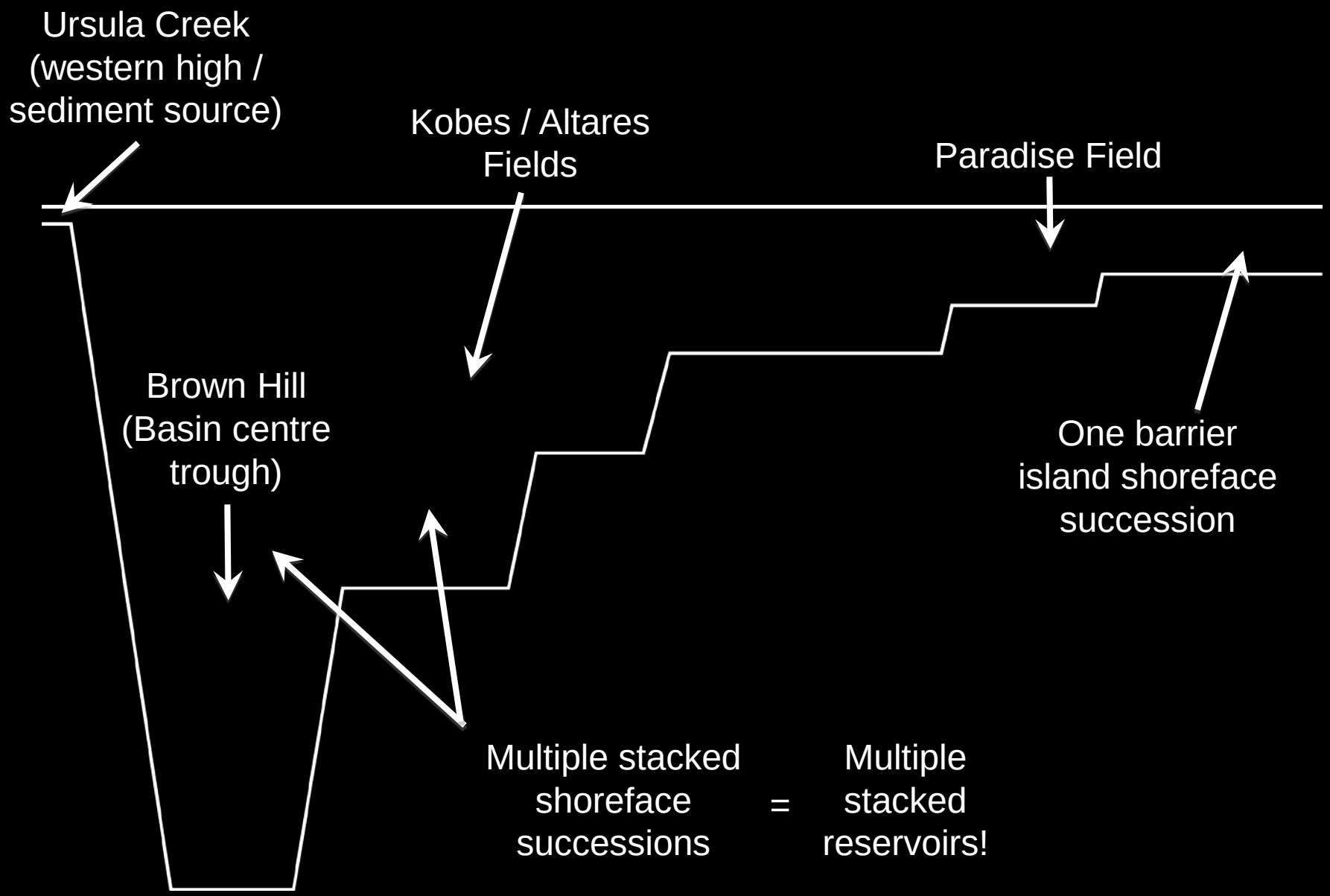
Click to View Notes by Presenter



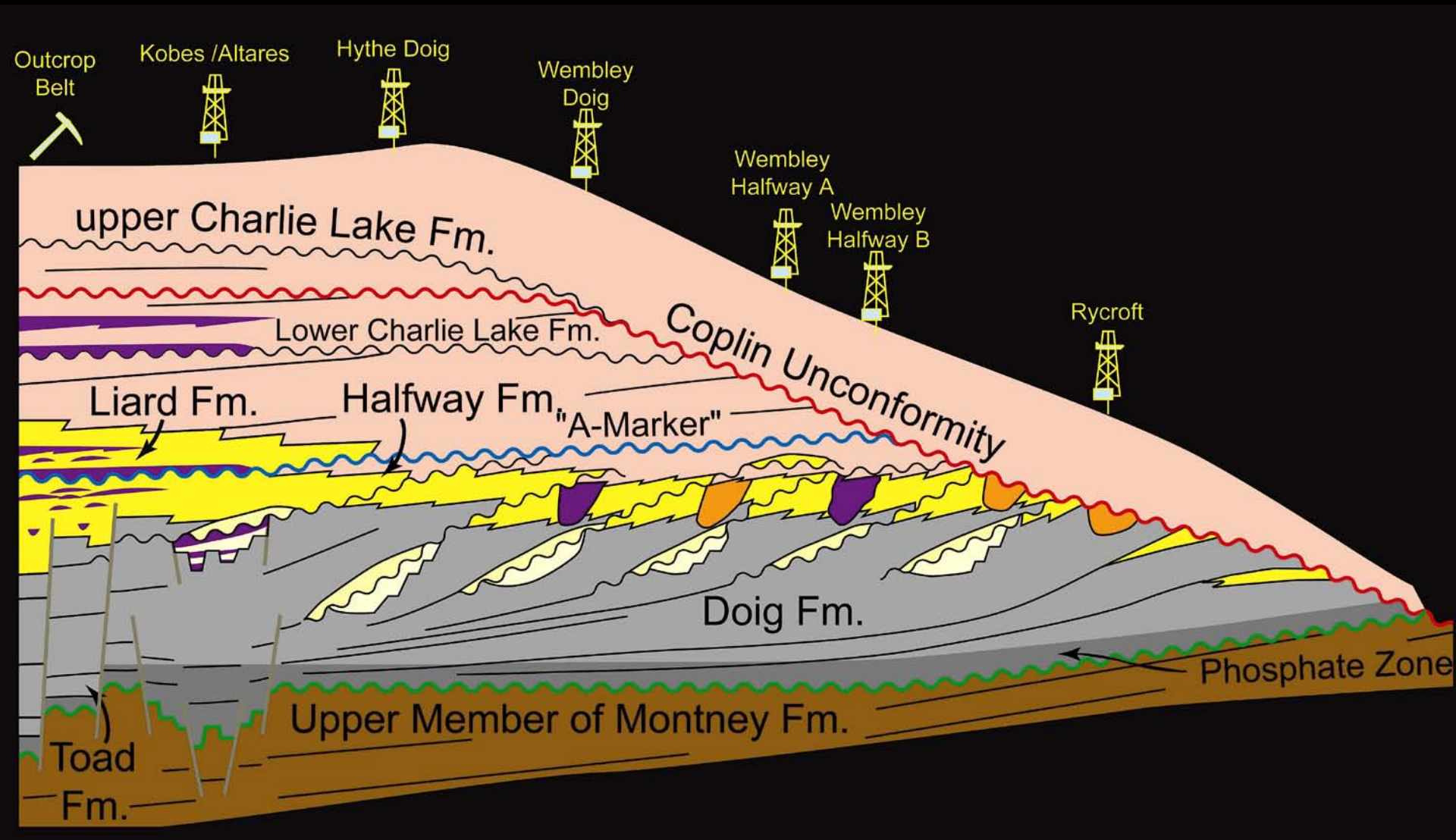
Notes by Presenter (for previous slide):

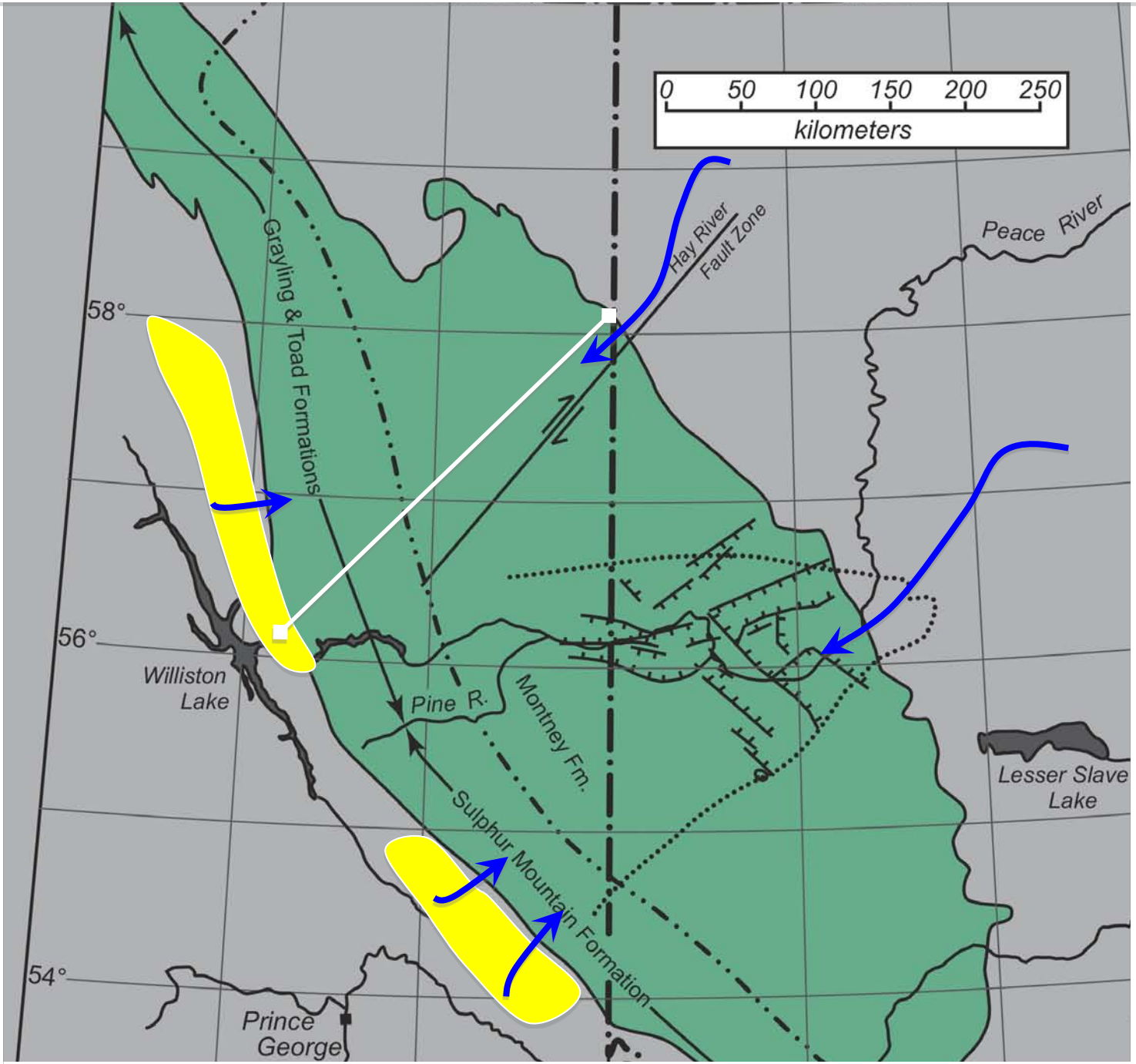
Here is the cross-section. The yellow is the coarser sand, with the Liard (Halfway) being of Ladinian age. The main point that we want to show here is that the sandstone sections disappear westward over some 21 km from Glacier Spur to Ursula Ck. At Ursula Ck, the upper Anisian is condensed and the Ladinia is missing. Clearly this area was a high, probably up into the Carnian. This section also shows that the sequence becomes shallower to the west, as you can see by the decrease in sandy material and its thickness to the east.

Same cross-section as last slide but redrawn to show a more realistic correlation. Several faults must have occurred syndepositionally. The western fault separating Ursula Creek from the eastern sections has hundreds of metres of throw and resulted in non-deposition or erosion of the mid-late Ladinian and lower Carnian section which comprises the bulk of the rest of the sections. Note also that the faults at centre appear to have reversed themselves which is the only logical way to explain thickness changes of several key successions.


Ursula Creek (western high / sediment source)
Kobes / Altares Fields
Paradise Field
Brown Hill (Basin centre trough)
One barrier island shoreface succession
Multiple stacked shoreface successions
=
Multiple stacked reservoirs!

STUDY INTERVAL
-Doig-Halfway succession in subsurface
-Toad-Liard succession in outcrop




0 50 100 150 200 250
kilometers
Hay River
Fault Zone
Peace River
Grayling & Toad Formations
58°
56°
54°
Williston
Lake
Pine R.
Montney Fm.
Sulphur Mountain Formation
Lesser Slave
Lake
Prince
George

Summary

- Existing stratigraphic and sedimentologic models are insufficient to explain observed stratal patterns in the Middle Triassic of western Canada.

- Rather than a passive margin basin, the Middle Triassic WCSB was an evolving back arc basin with a western high and sediment sourcing from both west as well as east.

- Recognition of accurate basin geometry has far-reaching implications for the size and distribution of clastic reservoirs in the Middle Triassic of western Canada

Acknowledgements

- George Pemberton – colleague and guide through the murky underworld of ichnology.
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  Adrian Hickin, Vic Levson, Warren Walsh