Tectonostratigraphic Evolution of the Mackenzie Delta - Beaufort Sea Fold Belt*

Timothy Seeley[1] and Deborah A. Spratt[2]

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[1]Chesapeake Energy, Calgary, AB, Canada. (tim.seeley@chk.com)
[2]University of Calgary, Calgary, AB, Canada.

Abstract

Interpretation of 2D seismic data from the western region of the Mackenzie Delta - Beaufort Sea Fold Belt (MDBSFB) shows that Cenozoic deformation produced low-amplitude, long-wavelength faulted anticlines and folds. Filling of backlimb synclines by convergence packages and uplift-related erosion allow dating phases of deformation in the MDBSFB during the Middle-Late Paleocene, Middle Eocene, Early Oligocene, Late Oligocene and Early Miocene.

Interpretation of the seismic data indicates that pre-existing basement normal faults formed buttresses to a basal detachment (occurring at 11 to 12 sec TWT; ~12-13.5 km depth) in the northern part of the study area resulting in contraction and uplift along north- and south-verging thrust sheets above the normal-faulted footwalls. This contraction and uplift formed the previously undocumented Foreland High resulting in the northern limit of the MDBSFB extending 30 to 40 km farther basinward than noted in previous studies. A topographic low, the Central Region, developed between the hinterland of the study area and the Foreland High. This Central Region became the focal point for deposition from the Oligocene through the Late Miocene. The shelf, slope and toe of slope were structurally controlled during this time with syn-depositional deformation occurring in the Early and Late Oligocene and Miocene.

The MDBSFB rock record is compared to a strain class model for Alaska (Seeley and Spratt, 2006). This strain class model uses convergence rates between the proto-Pacific, Pacific and North American plates to empirically classify the style of strain in Alaska and northward (present day orientation) from the Jurassic to Present. The strain class model demonstrates that high convergence rates from the mid-to-Late Cretaceous through Eocene resulted in the deformation that produced uplift of the Brooks and Northeastern Brooks Ranges with development of the MDBSFB as foreland fold belt. Episodic contraction in the Early Oligocene, Late Oligocene and Early Miocene is likely associated with the interactions between the Pacific and North American plates, but at this time, cannot be tied directly to the convergence rates between the plates.

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Tectonostratigraphic Evolution of the Mackenzie Delta-Beaufort Sea Fold Belt

Tim Seeley
Chesapeake Energy

Deborah Spratt
University of Calgary

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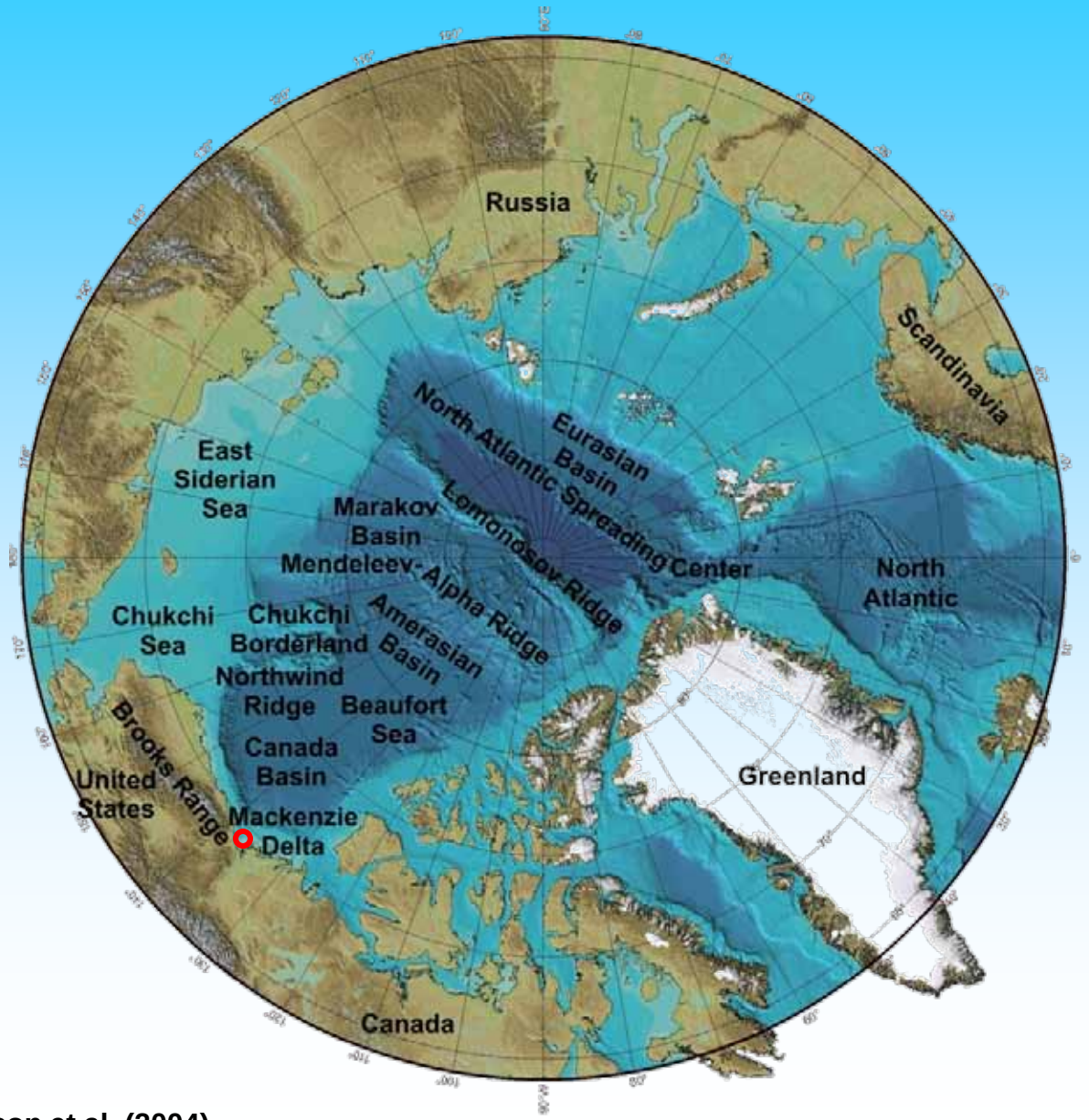


Modified from Jakobsson et al. (2004).

Tectonostratigraphic Evolution of the Mackenzie Delta-Beaufort Sea Fold Belt

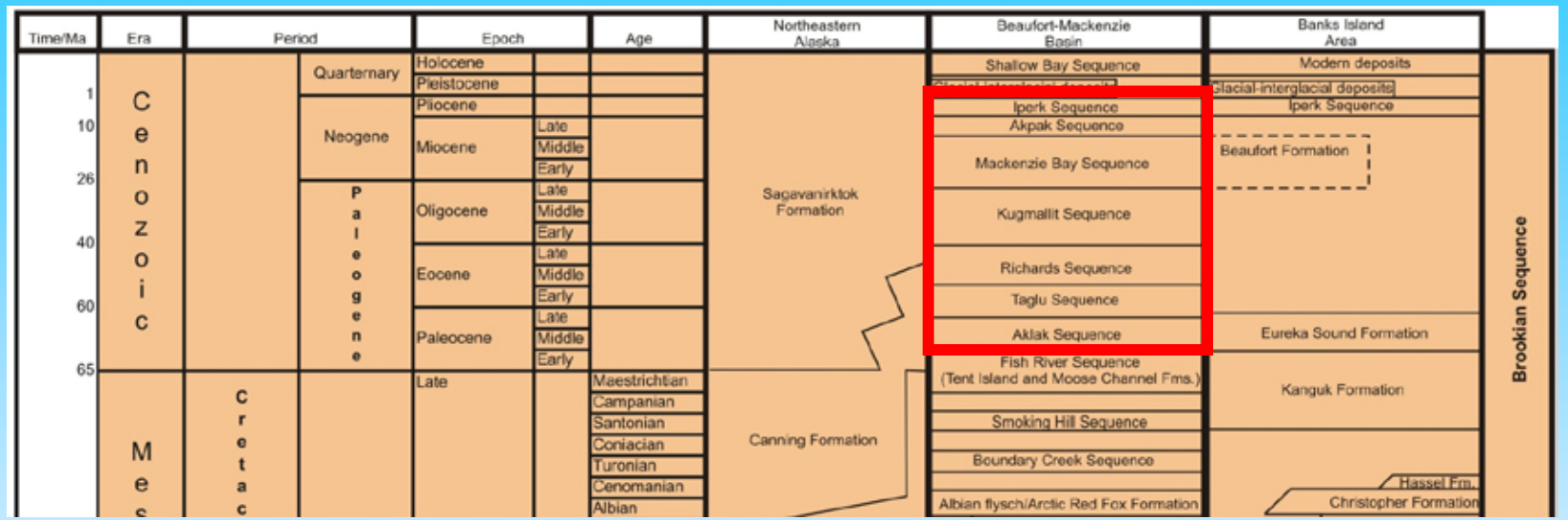
Introduction

1. Multiple phases of contraction from the Paleocene to Middle Miocene resulted in formation of the Mackenzie Delta-Beaufort Sea Fold Belt.

2. Deposition patterns during this time were controlled by the evolution of the Mackenzie Delta-Beaufort Sea Fold Belt.

3. For the most part, the multiple phases of contraction can be tied to interactions between the Proto-Pacific, Pacific and North American plates.

Regional Structural and Stratigraphic Trends
Stratigraphic Column



- **Brookian Sequence represents the change from extensional to contractional deformation which occurred in the Albian.**

Structural Styles and Depositional Patterns in the Study Area of the Mackenzie Delta – Beaufort Sea Fold Belt

Highlights

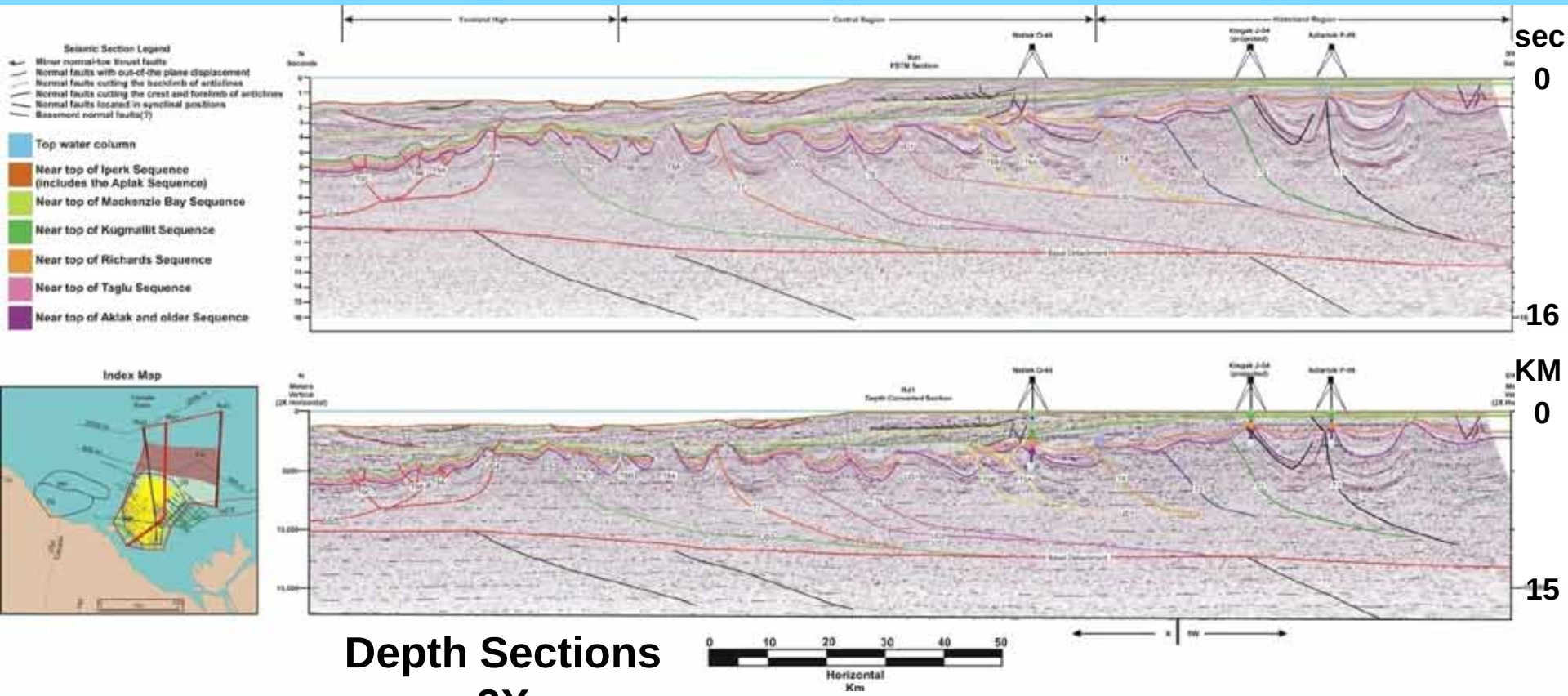
- Structural relief on the Aklak Sequence can exceed 4,000 meters.
- Fill by individual Sequences in backlimb synclines can reach upward of 2,000 meters.
- Shelf to slope transitions for the Oligocene through Pliocene sequences are structurally controlled.
- Episodic uplift and erosion from the Paleocene through the Miocene has resulted removal in excess of 2,800 meters of section.

Structural styles and depositional patterns in the Study Area of the Mackenzie Delta – Beaufort Sea Fold Belt

Rd-1

Regional seismic section

GX ArcticSpan (2006)



Depth Sections

2X

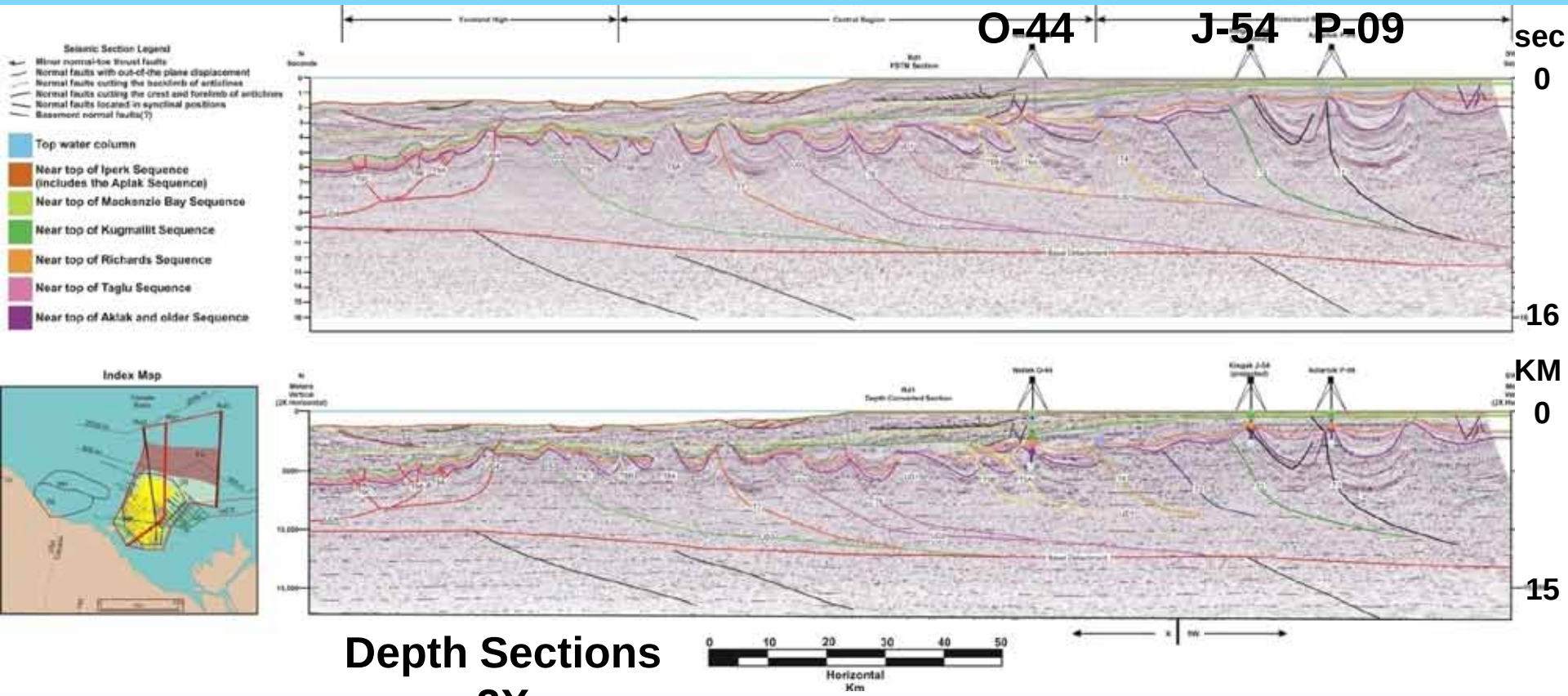
Vertical

Structural styles and depositional patterns in the Study Area of the Mackenzie Delta – Beaufort Sea Fold Belt

Rd-1

Regional seismic section

GX ArcticSpan (2006)



Depth Sections

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Vertical

Structural styles and depositional patterns in the Study Area of the Mackenzie Delta – Beaufort Sea Fold Belt

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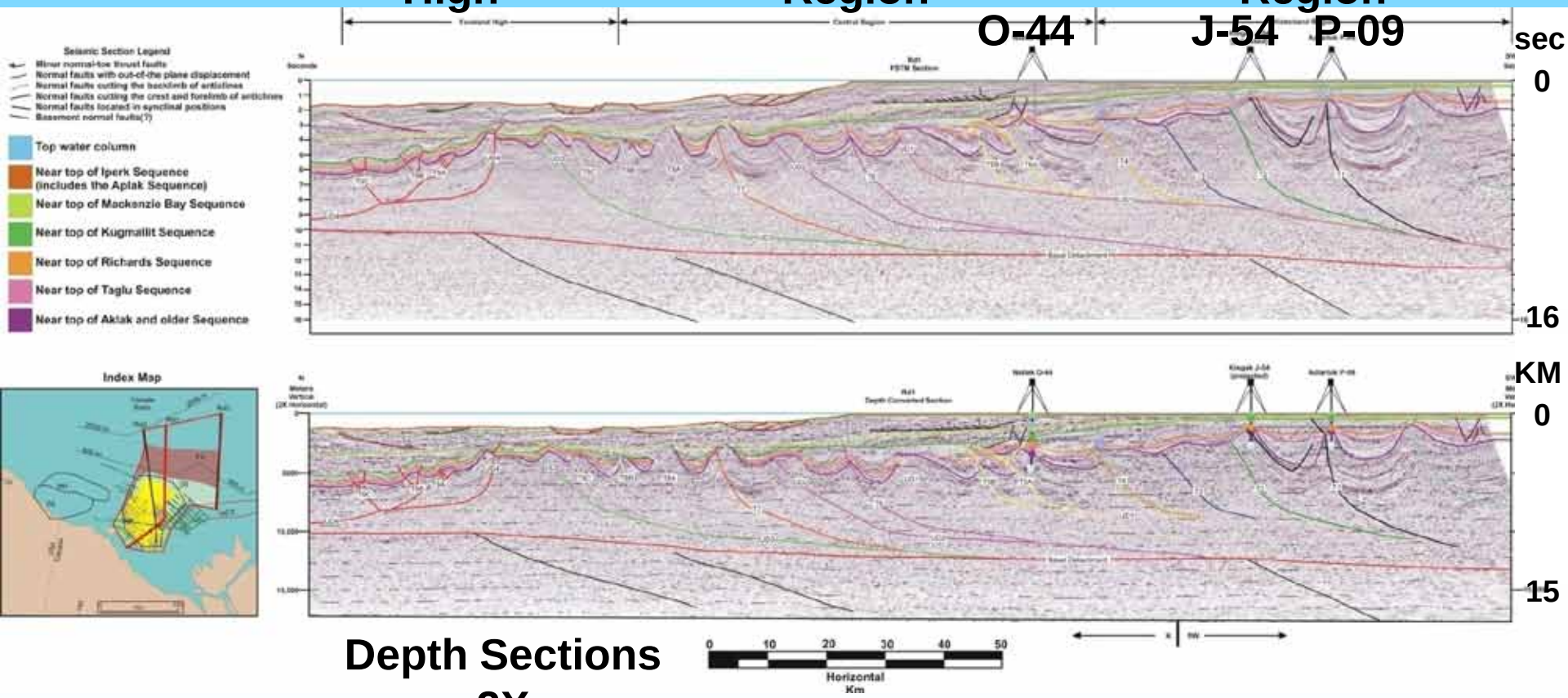
Regional seismic section

GX ArcticSpan (2006)

Foreland High | **Central Region** | **Hinterland Region**



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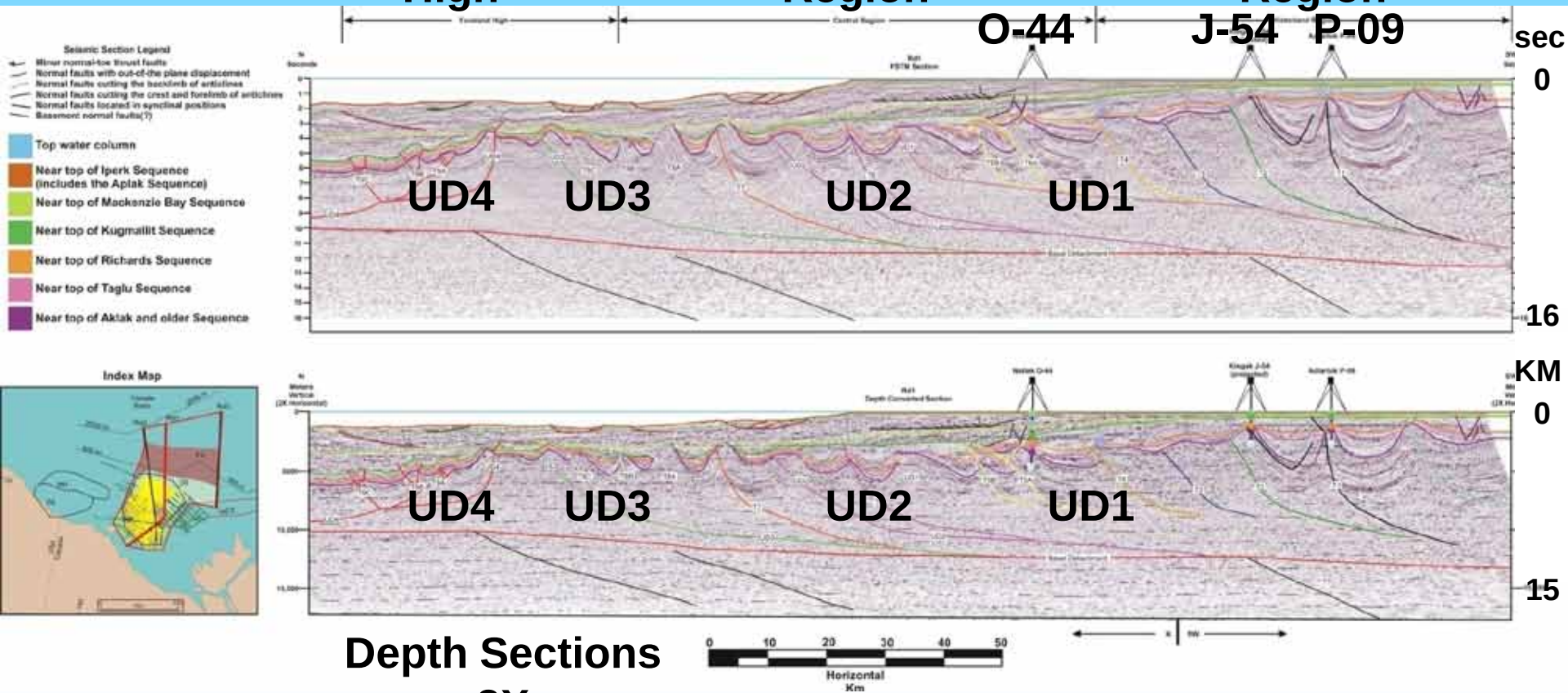

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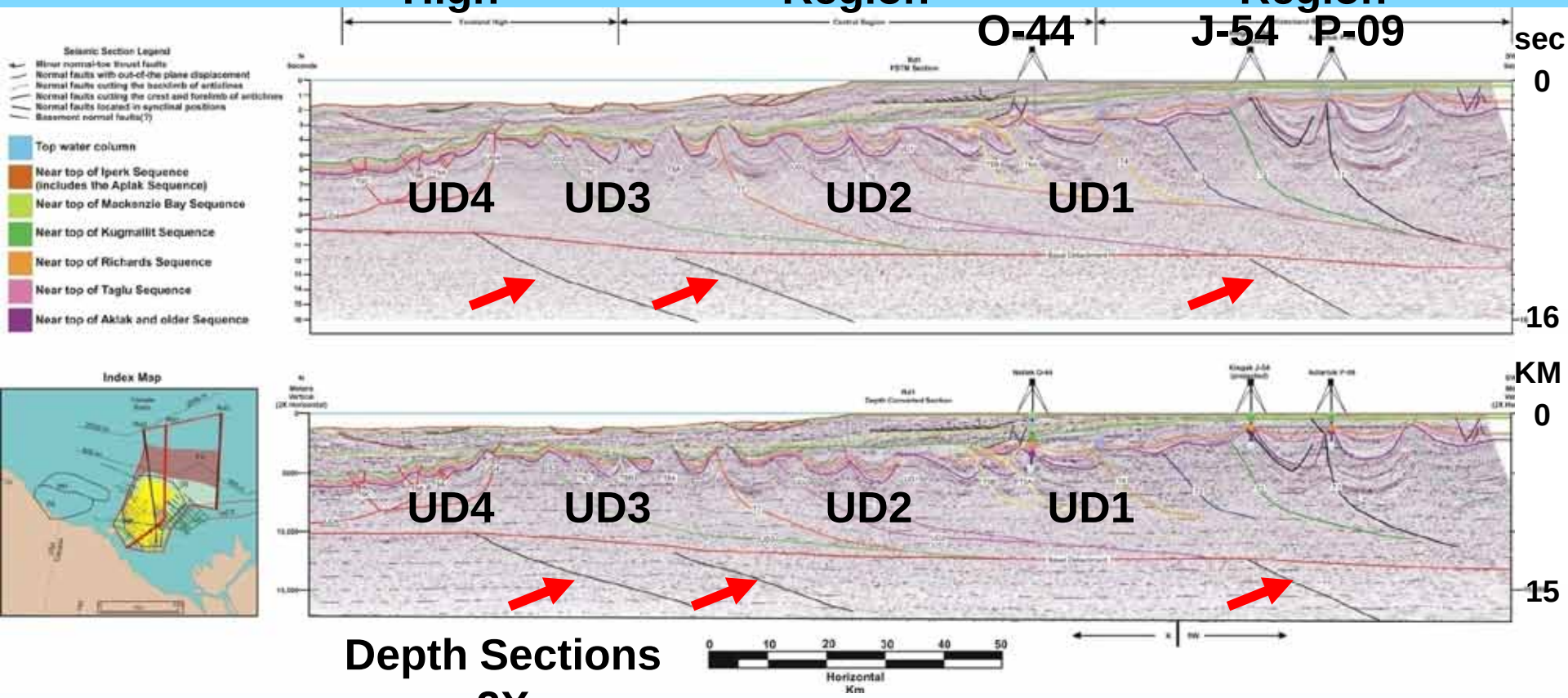

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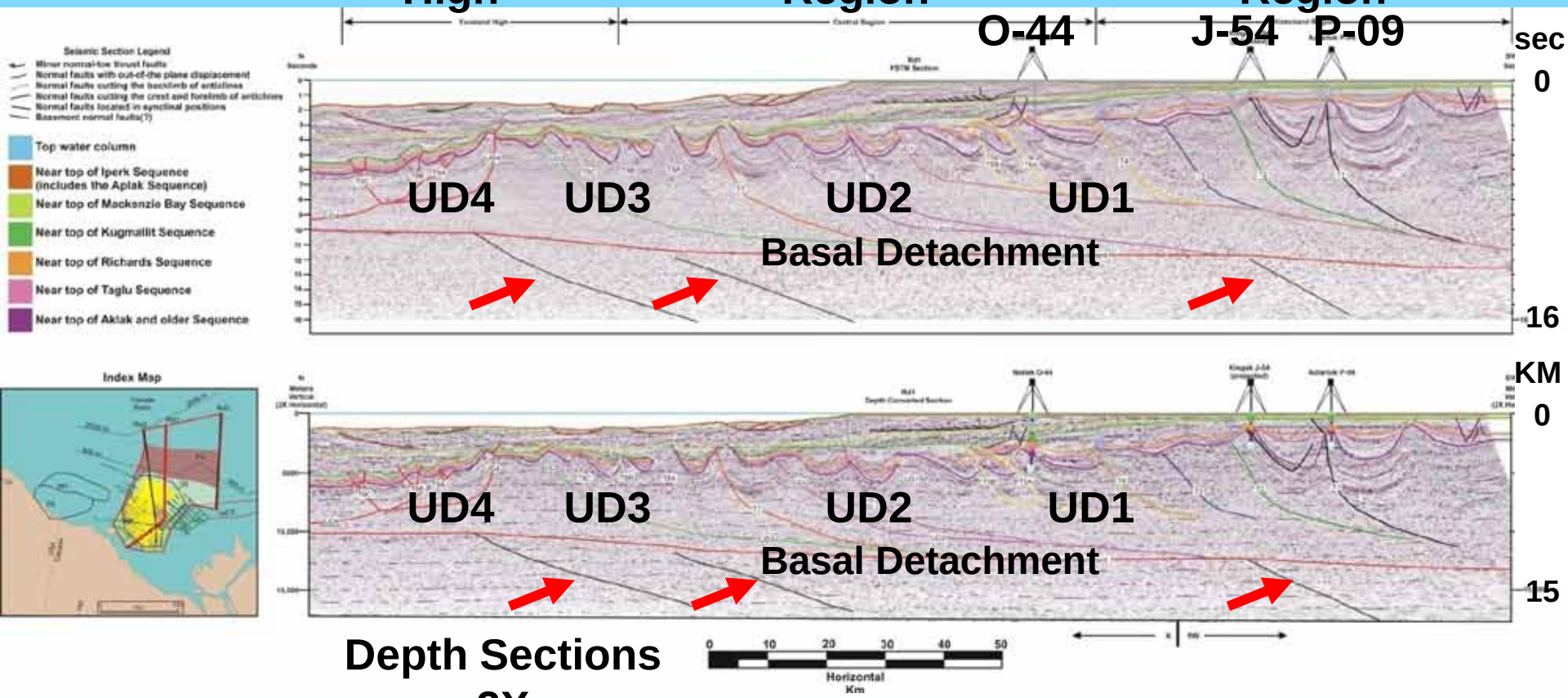

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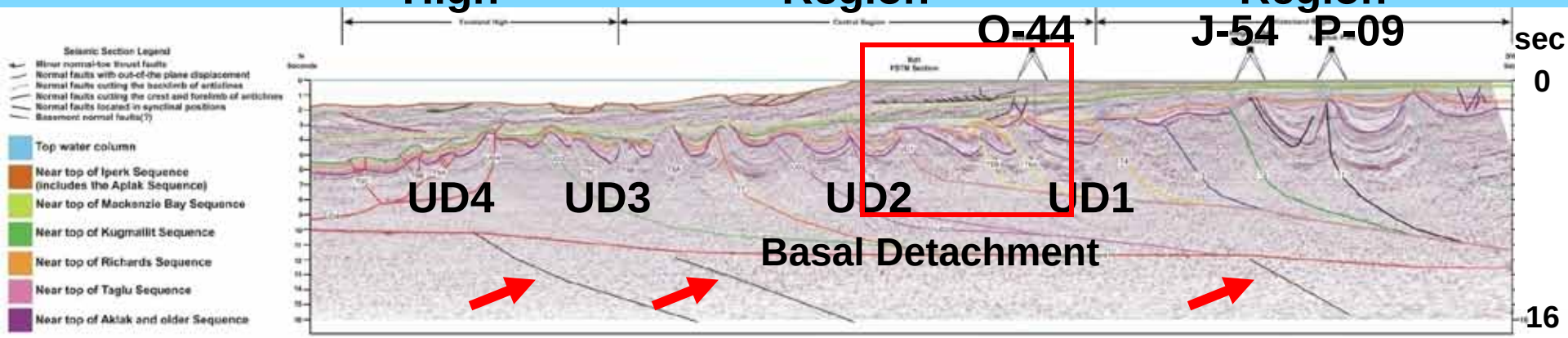
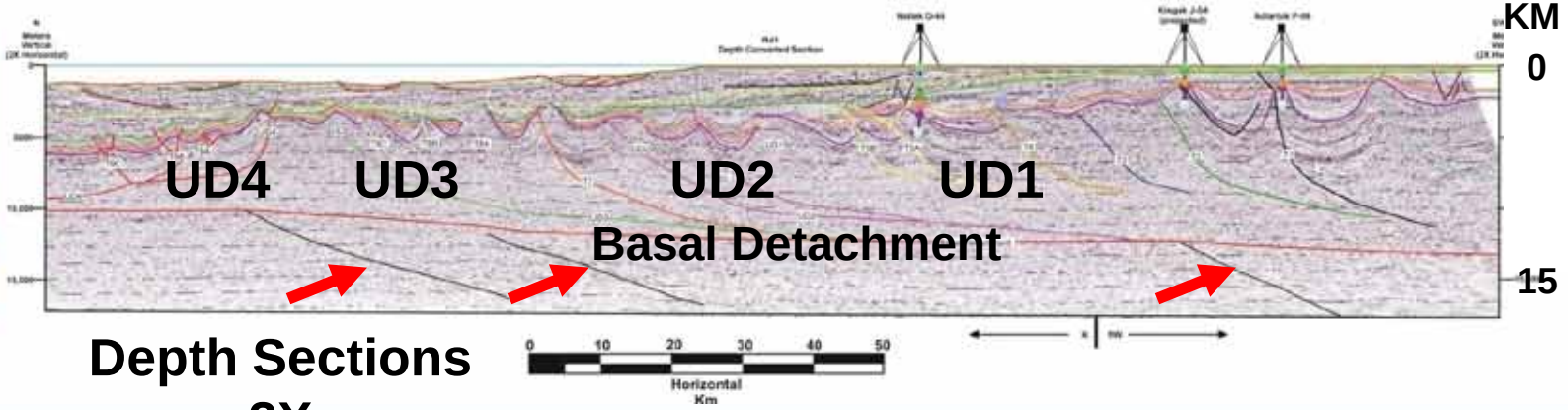
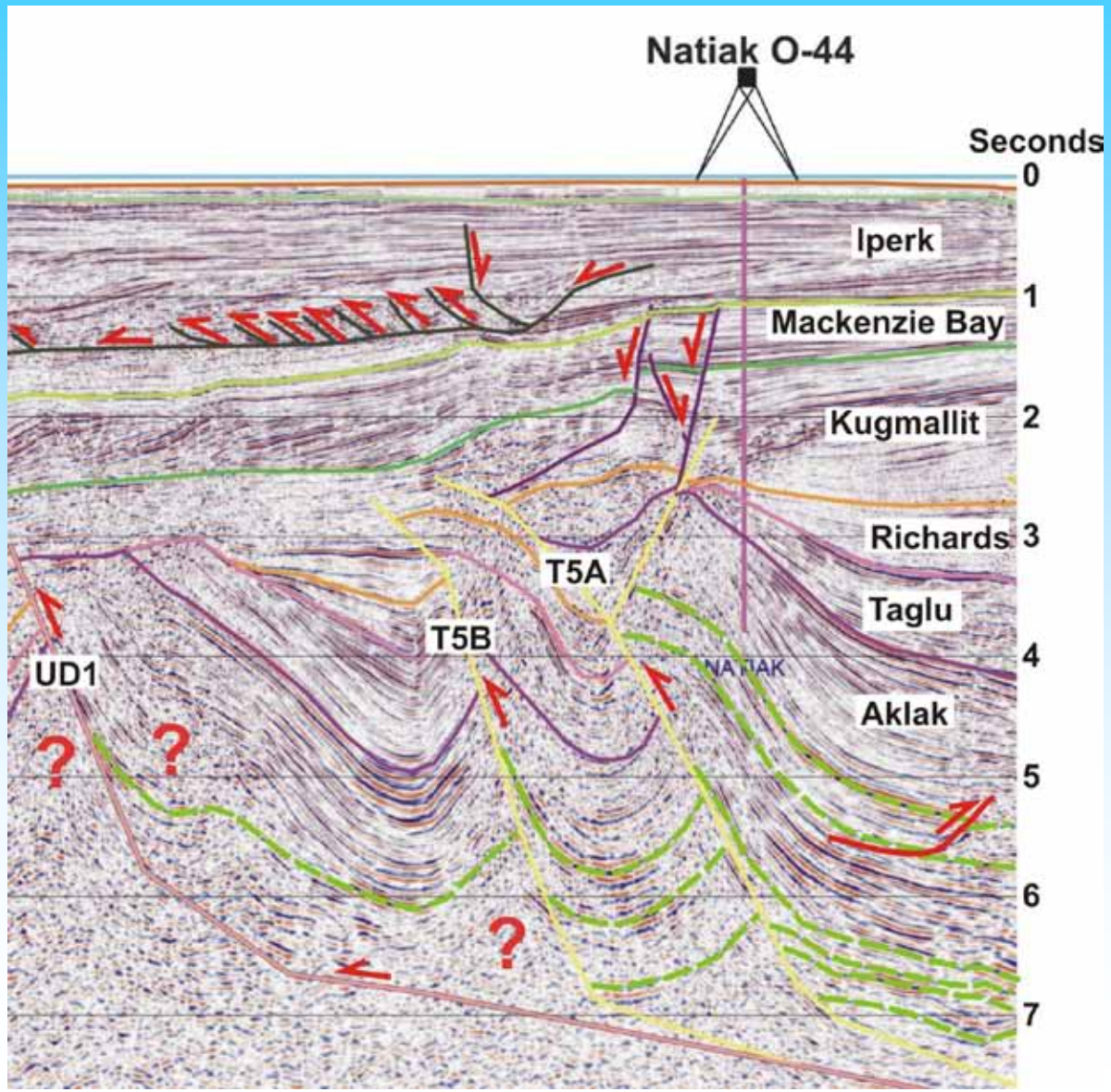




Depth Sections
2X
Vertical

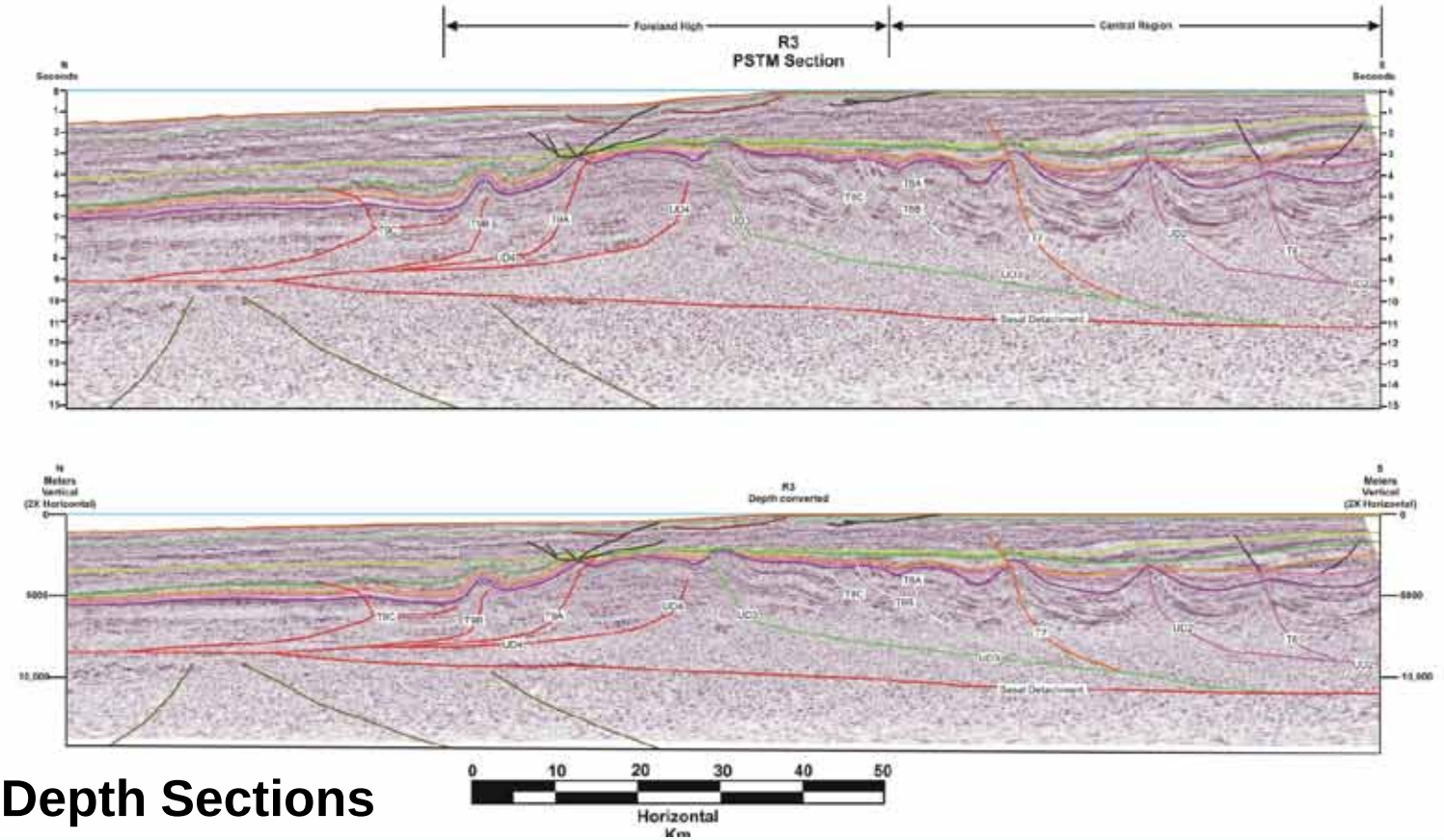
Structural styles and depositional patterns in the Study Area of the Mackenzie Delta – Beaufort Sea Fold Belt

N Rd-1 section S



Structural Styles and Depositional Patterns in the Study Area of the Mackenzie Delta – Beaufort Sea Fold Belt

Rd-3
Regional seismic section
GX ArcticSpan (2006)

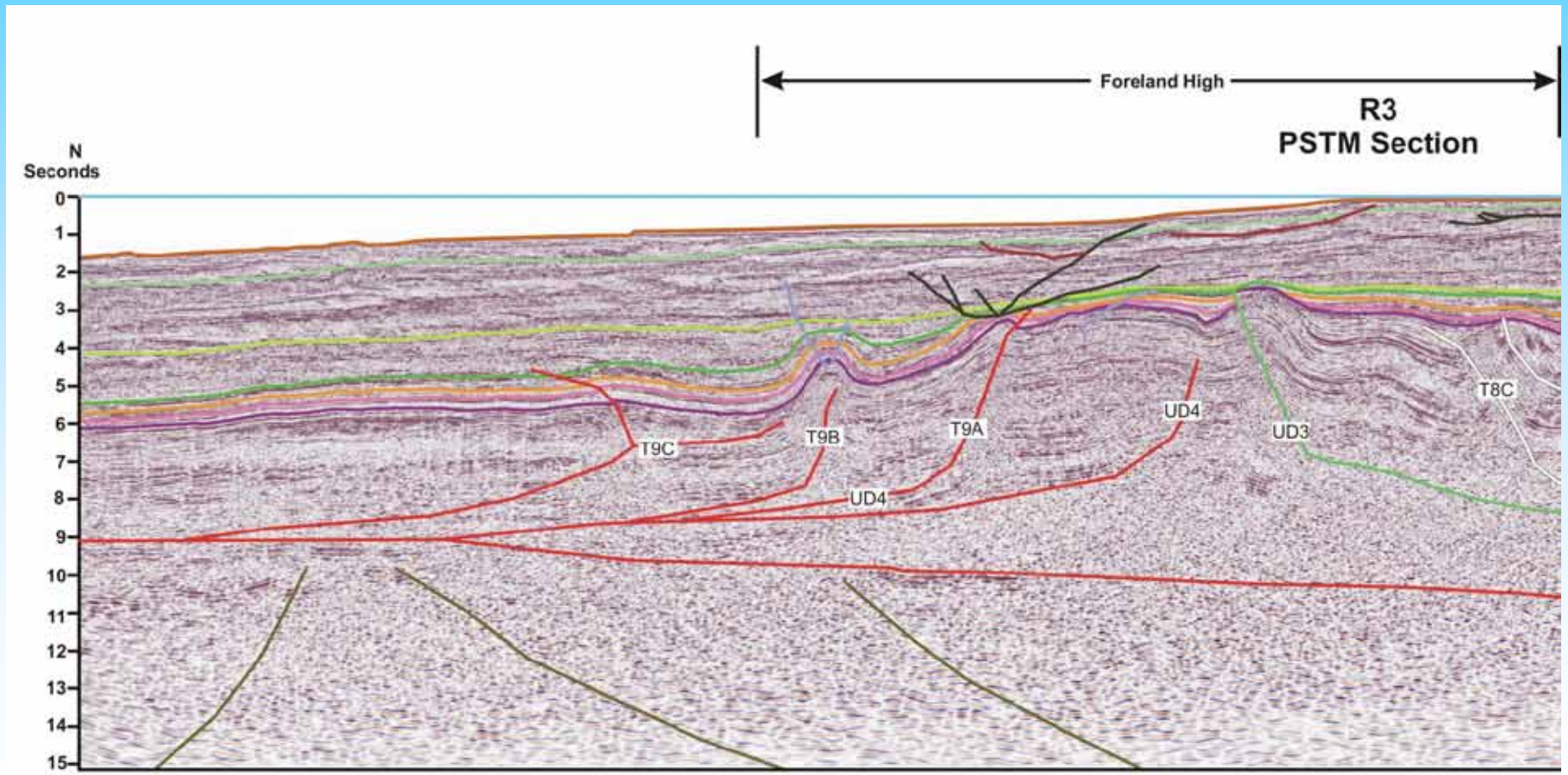


Depth Sections
2X
Vertical

Structural Styles and Depositional Patterns in the Study Area of the Mackenzie Delta – Beaufort Sea Fold Belt

Structural-Depositional Relationships

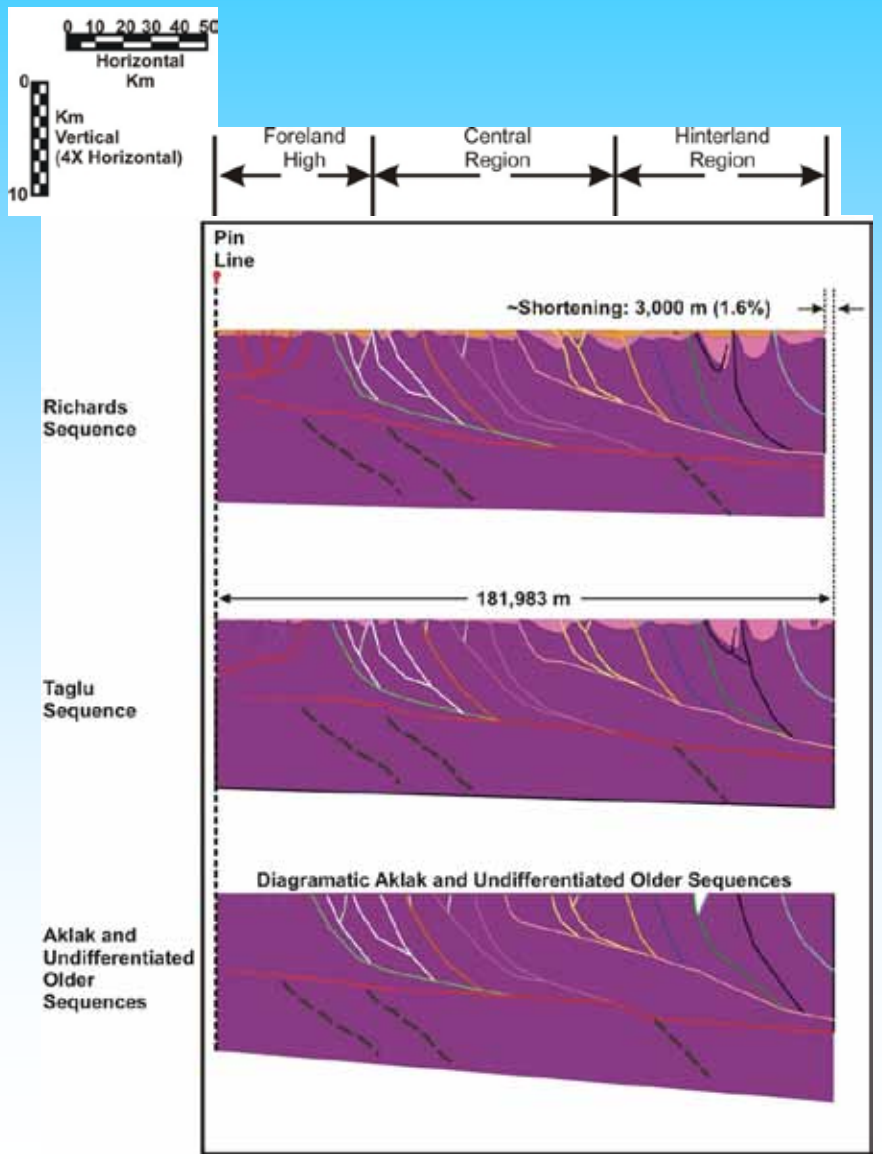
Rd-3 PSTM

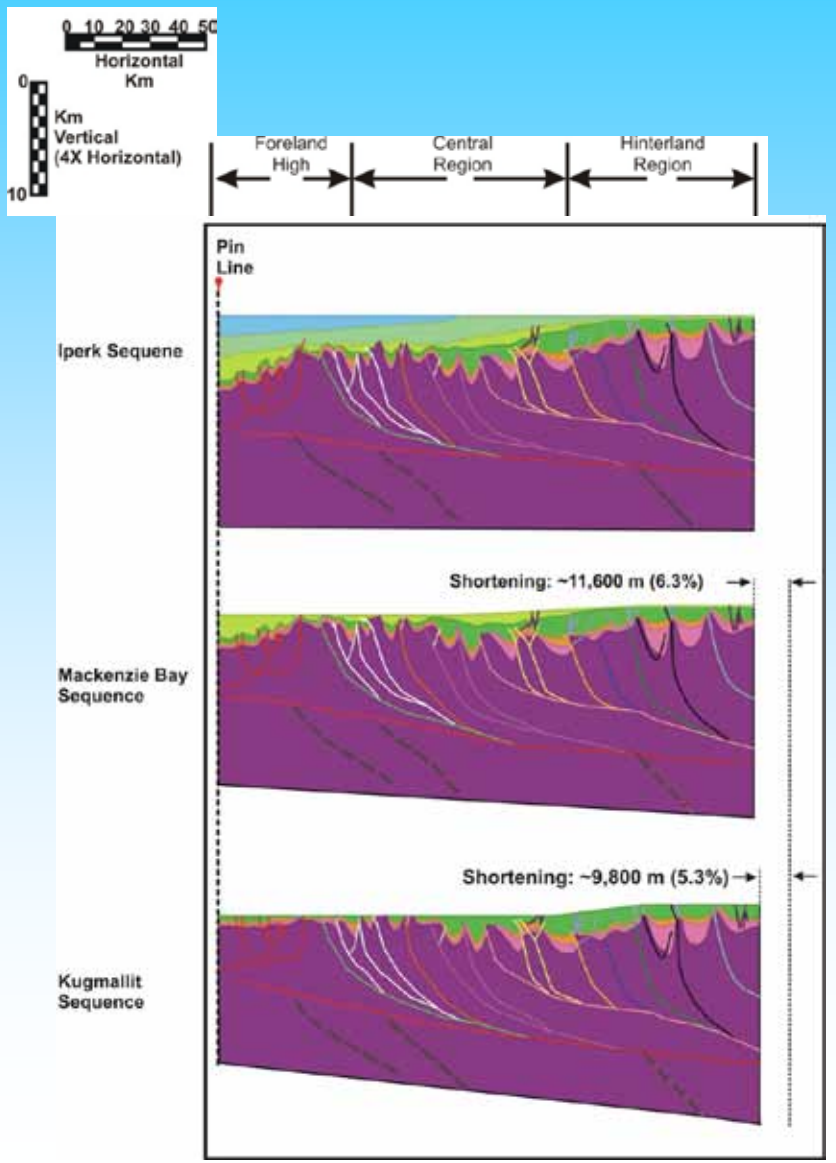


Structural Styles and Depositional Patterns in the Study Area of the Mackenzie Delta – Beaufort Sea Fold Belt

Structural-Depositional Relationships

Rd-1 Section





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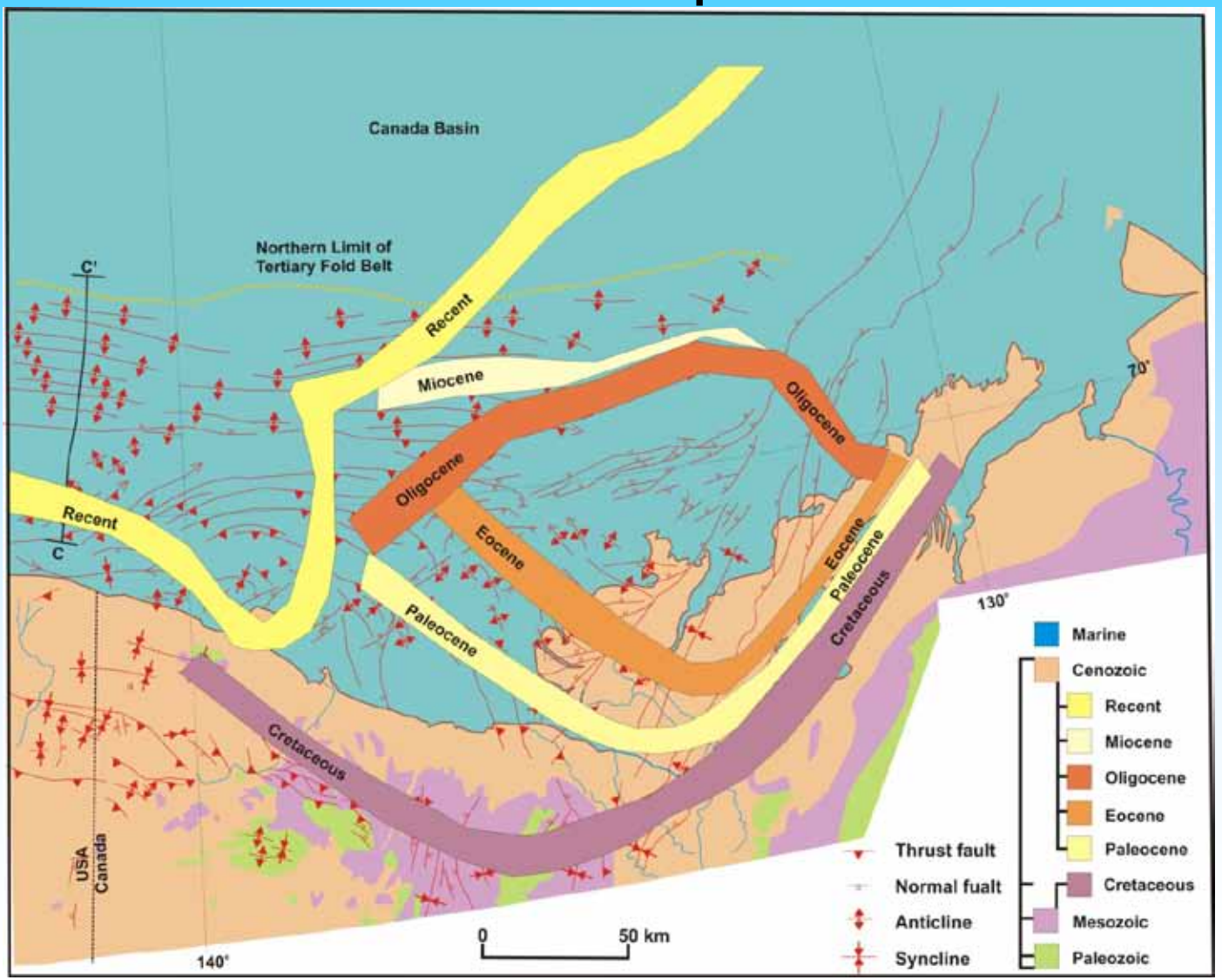
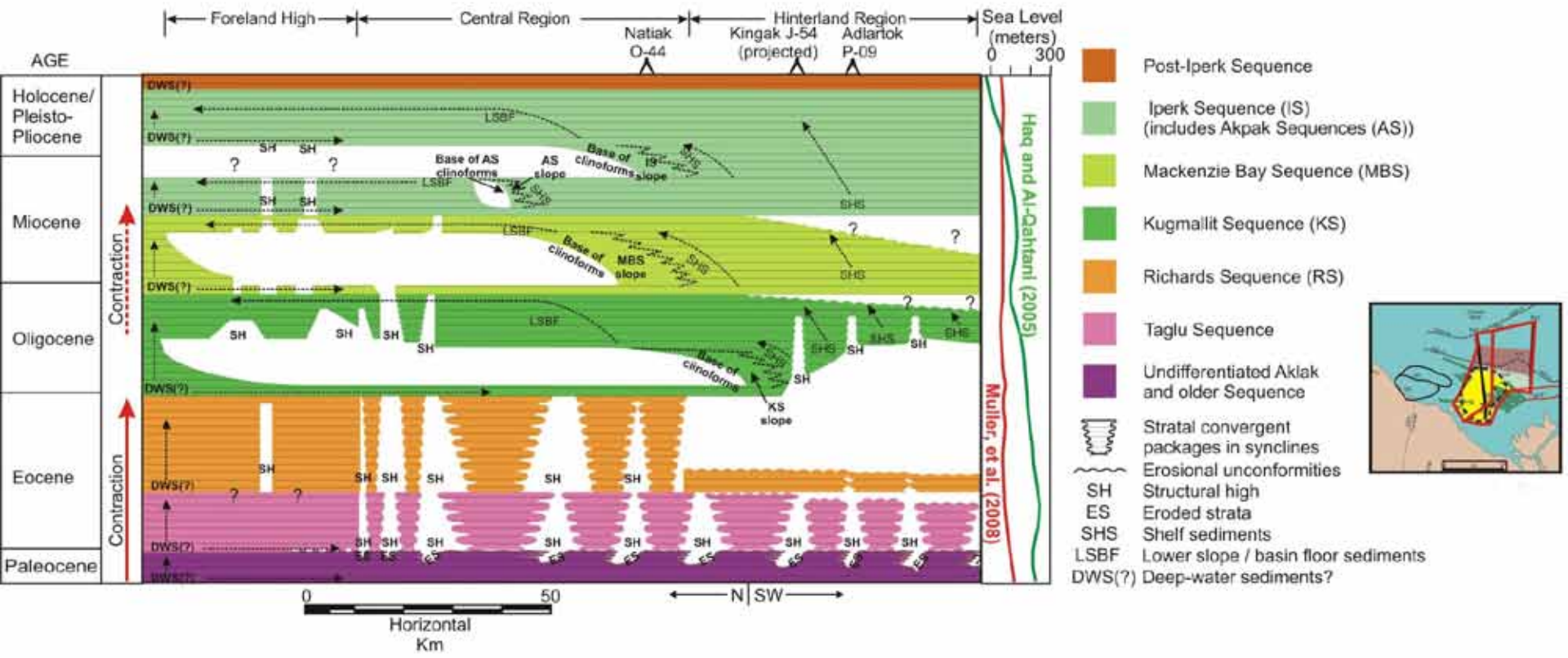


Willumsen and Cote (1982)

Structural Styles and Depositional Patterns in the Study Area of the Mackenzie Delta – Beaufort Sea Fold Belt

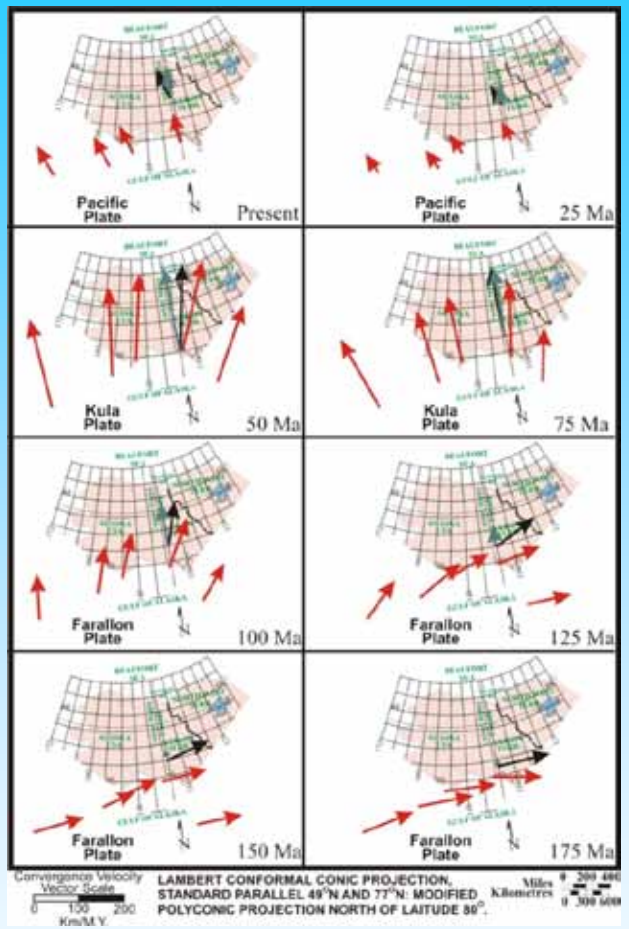
Structural-Depositional Relationships

Rd-1 Section



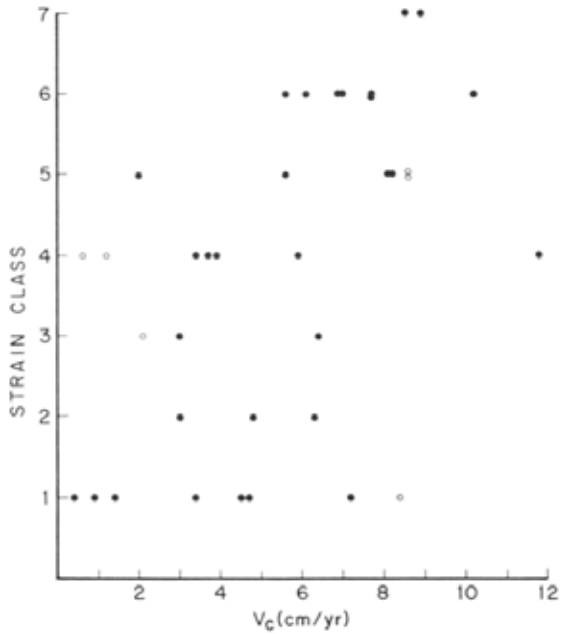
Alaska strain class model

Engebretson et al. (1986)

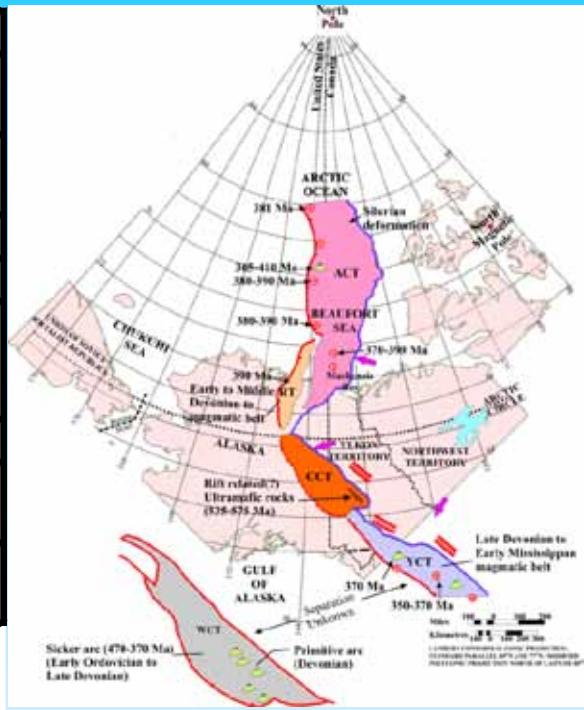


Jarrad (1986)

Strain Class	Description
1	active backarc spreading
2	very slow backarc spreading
3	mildly tensional
4a	neutral
4b	gradient: mildly tensional to mildly compressional
5	mildly compressional
6	moderately compressional
7	very strongly compressional



Modified from Plafker and Berg (1994)

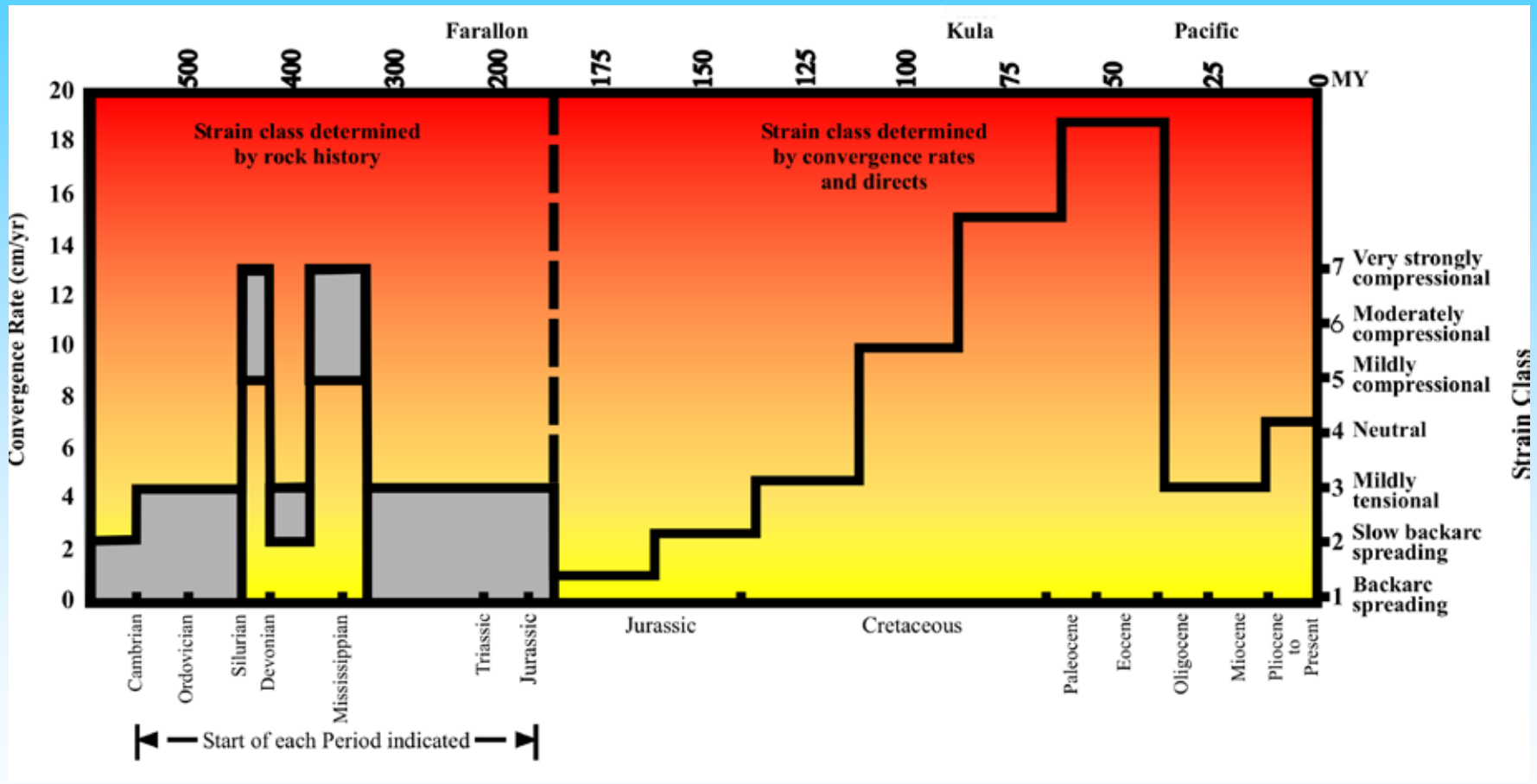


-Cambrian to Ordovician extension.

-Silurian-Devonian uplift (Franklinian orogeny).

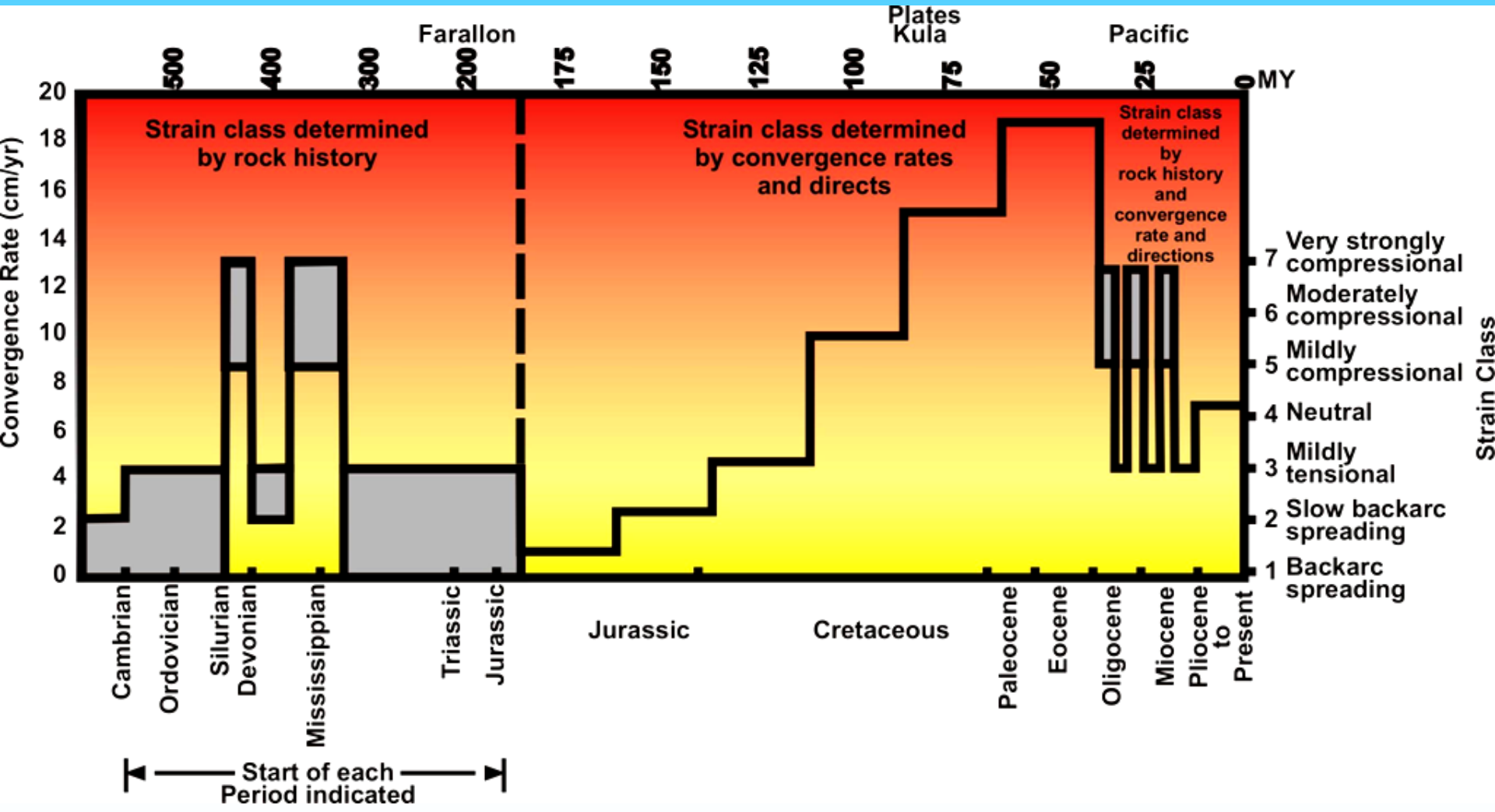
-Late Devonian emplacement of oceanic crust.

Alaska strain class model



Data from Engebretson et al. (1986) and Jarrard (1986)

Alaska strain class model



Tectonostratigraphic Evolution of the Mackenzie Delta-Beaufort Sea Fold Belt

Summary

1. Multiple phases of contraction from the mid-Cretaceous to Middle Miocene resulted in formation of the Mackenzie Delta-Beaufort Sea Fold Belt.
   - Uplift in the Paleocene, Eocene, Oligocene and Miocene resulted in large scale folding and high structural relief (4000 meters for the Aklak Sequence alone) and in excess of 2800 meters of section removed through erosion.
   - Formation of a Hinterland Region where large scale uplift and erosion occurred, a Central Region that became a primary, post-Eocene depocenter and evolution of the Foreland High.

2. Deposition patterns during this time were controlled by the evolution of the Mackenzie Delta-Beaufort Sea Fold Belt.
   - Formation of thick stratal convergence packages in backlimb syncline.
   - Structurally controlled shelf margins and slopes.
   - Foreland High became a depositional barriers as demonstrated by on-lapping sequences.

3. For the most part, the multiple phases of contraction can be tied to interactions between the Proto-Pacific, Pacific and North American plates.

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Support and Acknowledgements

Data

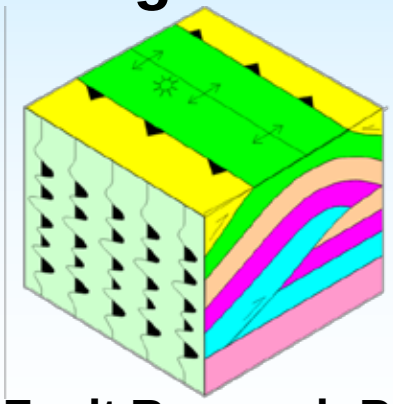
Canadian Forest Oil Ltd./
Forest Oil Corporation

LYNX
Information Systems Ltd.

Software

Geo-Logic
Systems, LLC

Logistics



Fold-Fault Research Project
University of Calgary