Oil Prospectivity of the Triassic-Jurassic Succession of Sverdrup Basin, Canadian Arctic Archipelago*

Ashton Embry[1]

Search and Discovery Article #30127 (2010)
Posted August 9, 2010

*Adapted from oral presentation at AAPG Convention, New Orleans, Louisiana, April 11-14, 2010; Please see closely related article "Lower Triassic Stratigraphy and Petroleum Potential, Sverdrup Basin, Arctic Canada", S&D Article #30105 (2009).

[1]Geological Survey of Canada, Calgary, AB, Canada (aembry@nrcan.gc.ca)

Abstract

The Sverdrup Basin of the Canadian Arctic Archipelago is an established petroliferous basin with 17 discovered oil and gas fields. Almost all the hydrocarbons occur in Triassic-Jurassic shallow marine sandstones and were sourced from Middle to Upper Triassic bituminous shales. The discovered fields occur on the culminations of Paleogene structures, many of which are cored by Carboniferous salt which contributed to the growth of the structures through the basin development.

Three prospective areas for future discoveries in the Triassic-Jurassic succession have been outlined and these include western Sverdrup, southeastern Sverdrup, and the Fosheim Peninsula area which is located on the east-central flank of the basin. These areas are delineated on the basis of the occurrence of mature Triassic source rocks and the subsurface occurrence of potential reservoir strata in the Triassic-Jurassic succession.

Most of the large structures in these prospective areas were mapped and tested in the initial round of hydrocarbon exploration. However, a number of smaller culminations remain to be tested and more detailed seismic surveys may well reveal the presence of other ones. Overall, the structural play involving Triassic-Jurassic strata still has considerable potential left.

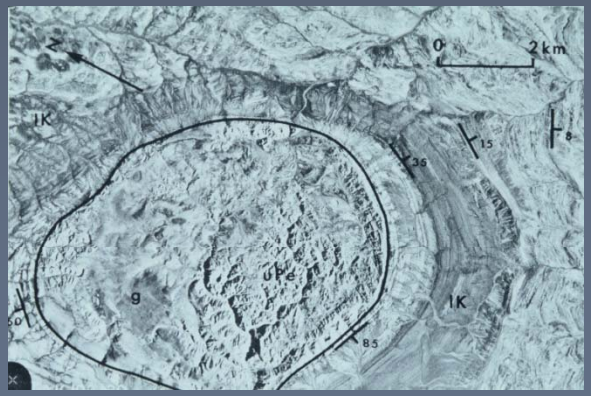
The largest potential plays which have not been tested are those involving a stratigraphic component as part of the hydrocarbon trapping mechanism. Potential reservoir units are developed on the 3rd order sequence scale and 22 such sequences have been delineated in the Triassic-Jurassic succession. Most of them contain a progradational, shallow marine sandstone unit which is in part porous within the prospective areas. These units are often truncated by unconformities on the basin margins and change facies to non-porous strata basinward. The pinchouts of these porous units in proper structural orientations provide good petroleum prospects because they were

already present during the maturation and migration of the Triassic-sourced hydrocarbons and are less likely to be associated with fractures which allow hydrocarbons to escape.

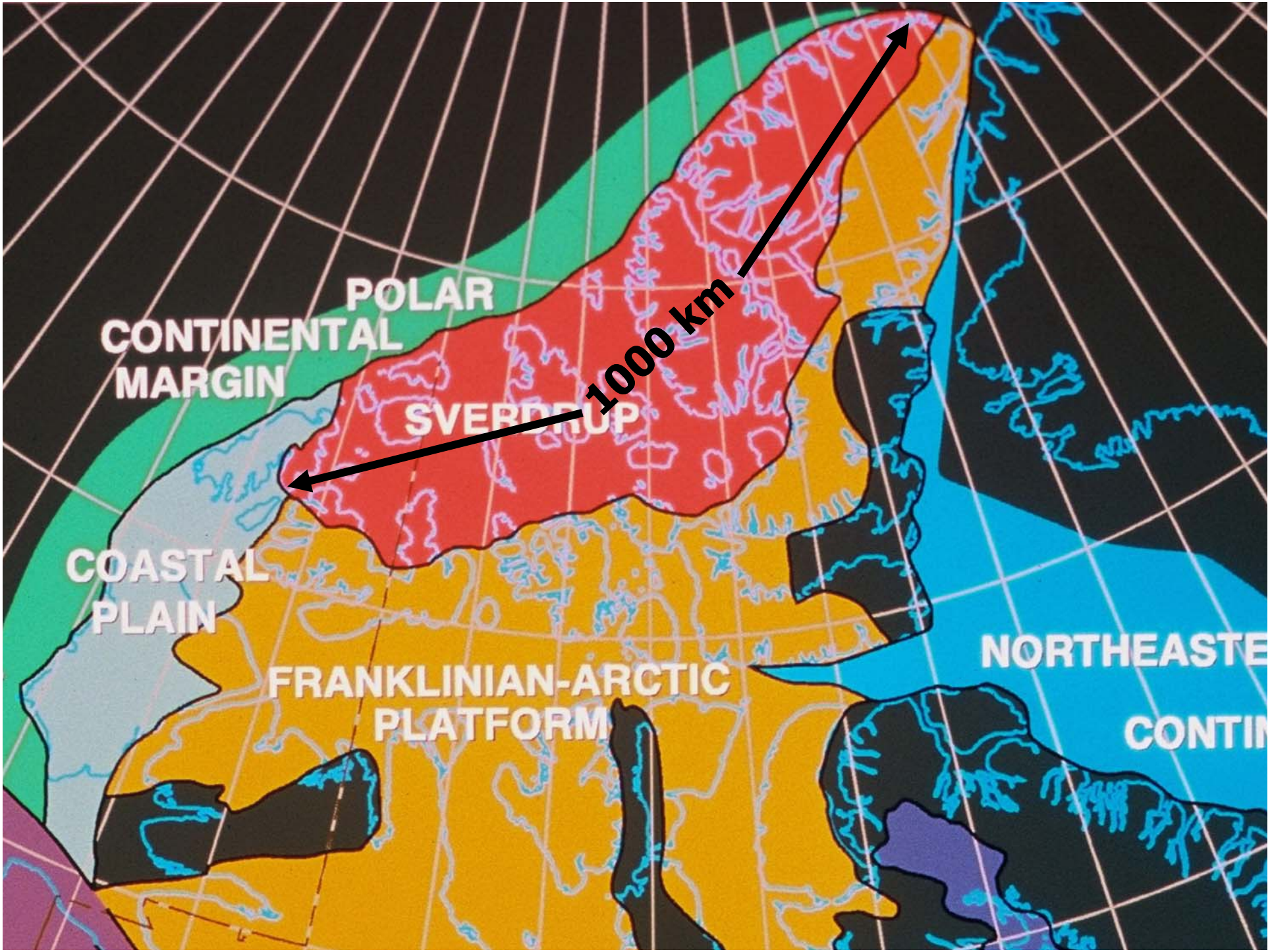
Oil Prospectivity of the Triassic-Jurassic Succession of Sverdrup Basin, Canadian Arctic Archipelago

Ashton Embry

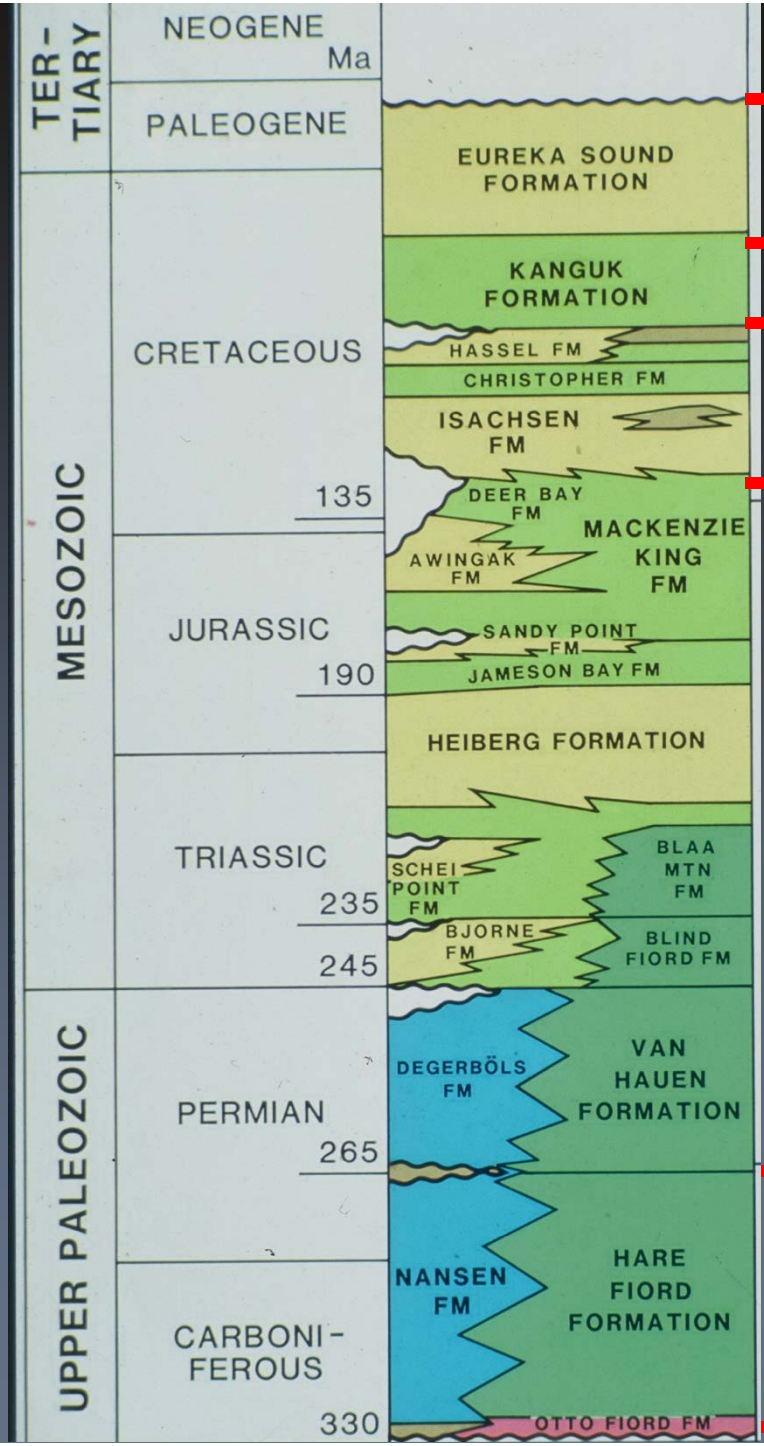
Geological Survey of Canada




BATHYMETRY OF THE ARCTIC OCEAN
NAVAL RESEARCH LABORATORY – ACOUSTICS DIVISION
ACOUSTIC MEDIA CHARACTERIZATION BRANCH
Sverdrup
Basin


POLAR
CONTINENTAL
MARGIN
1000 km
SVERDRUP
COASTAL
PLAIN
FRANKLINIAN-ARCTIC
PLATFORM
NORTHEASTE
CONTI

Tectonic History Sverdrup Basin



Deformation

Foreland

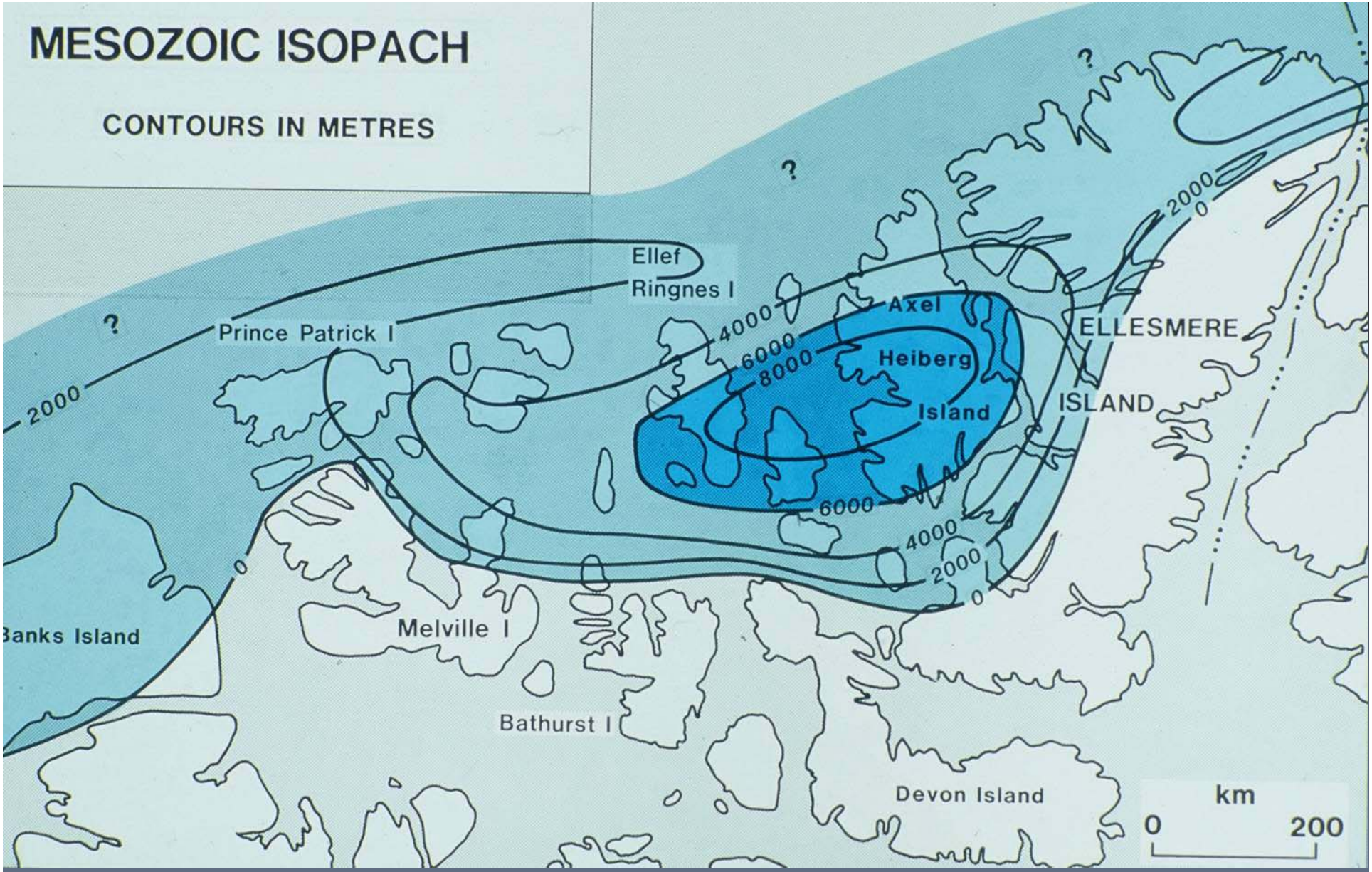
Thermal Subsidence

Rifting, Volcanism

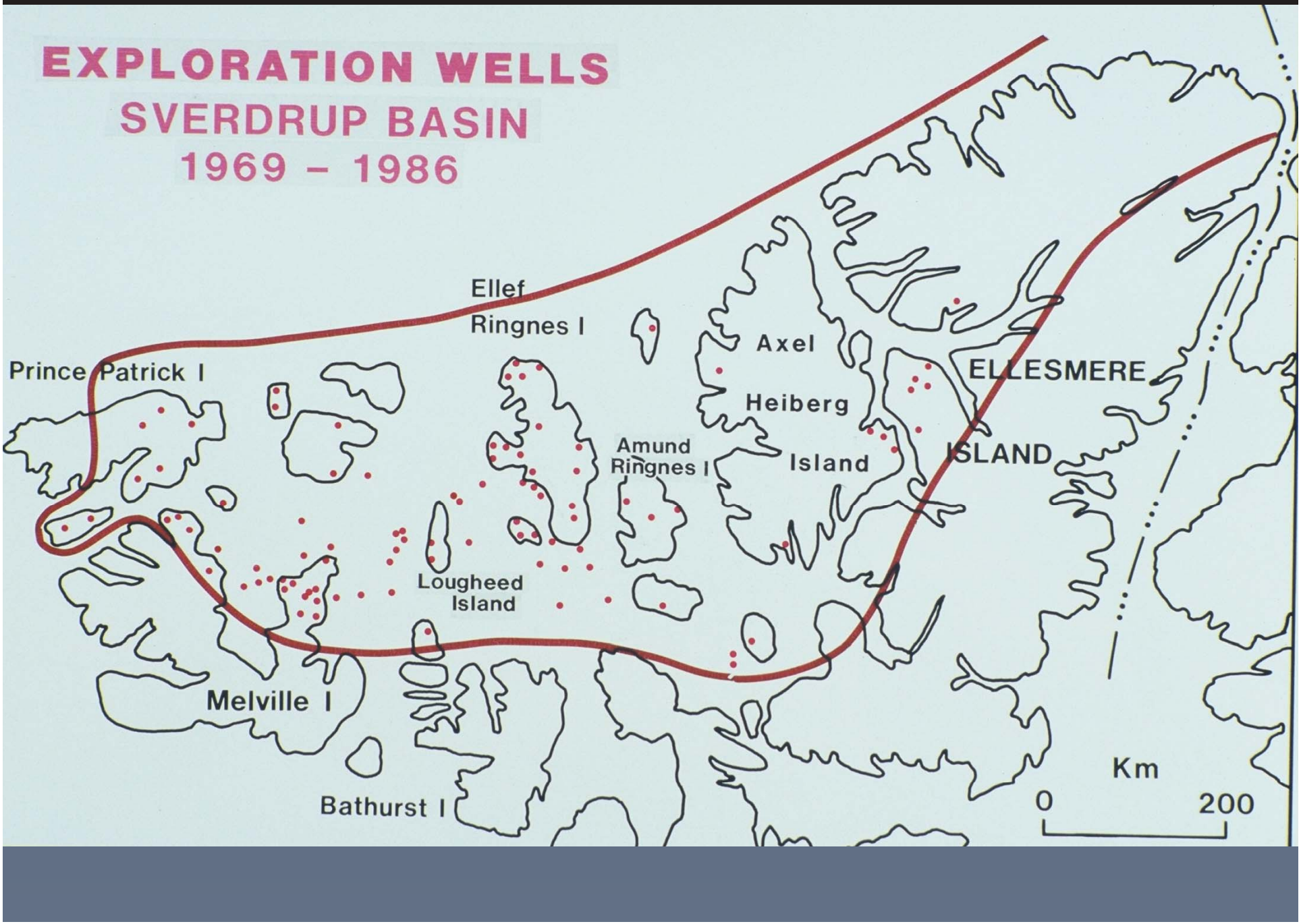
Thermal Subsidence

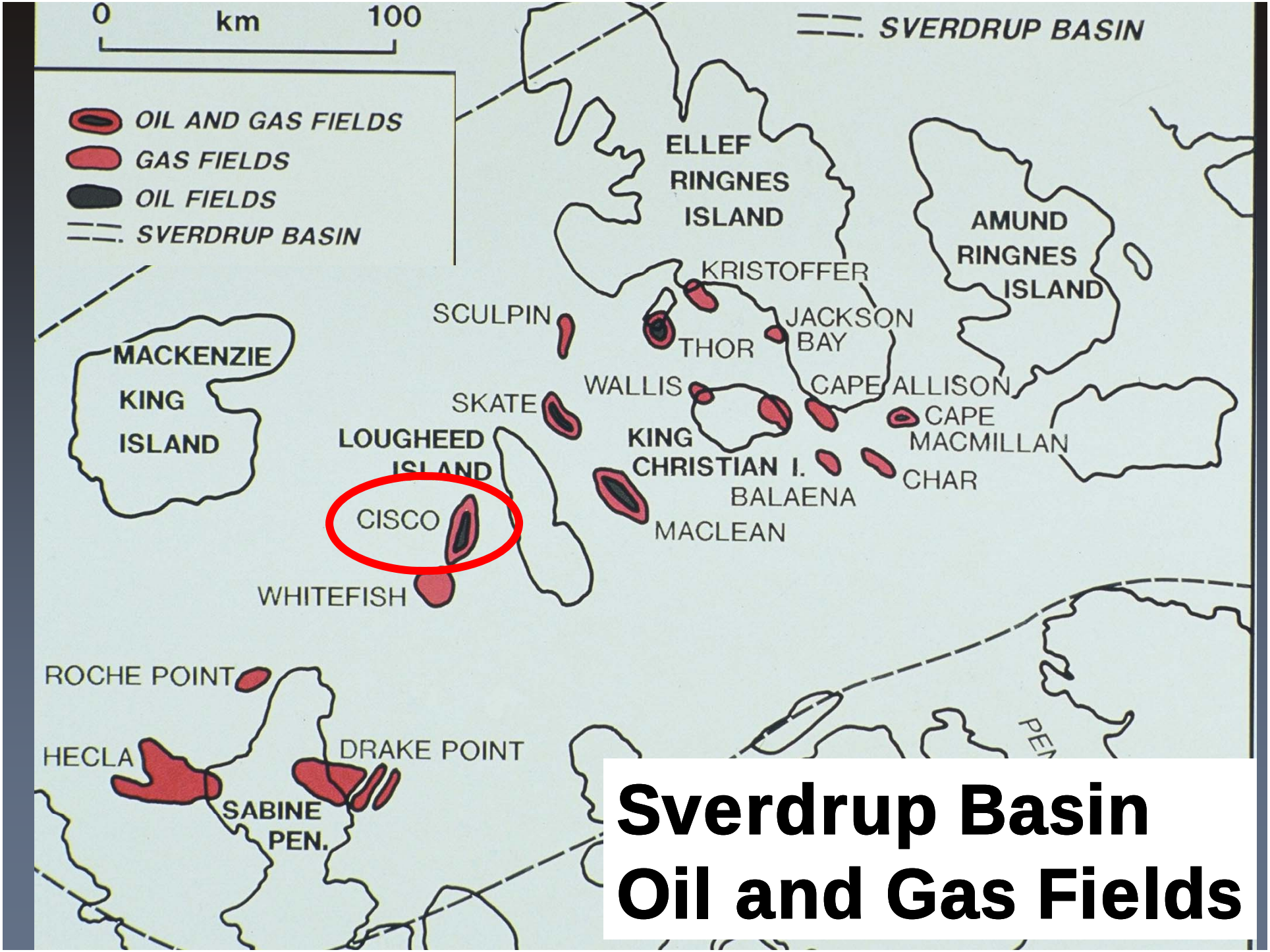
Rifting

Early Mesozoic



Mesozoic Isopach
Canadian Arctic Islands


EXPLORATION WELLS
SVERDRUP BASIN
1969 – 1986
Ellef
Ringnes I
Prince Patrick I
Axel
Heiberg
Island
ELLESMERE
ISLAND
Amund
Ringnes I
Lougheed
Island
Melville I
Bathurst I
Km
0
200

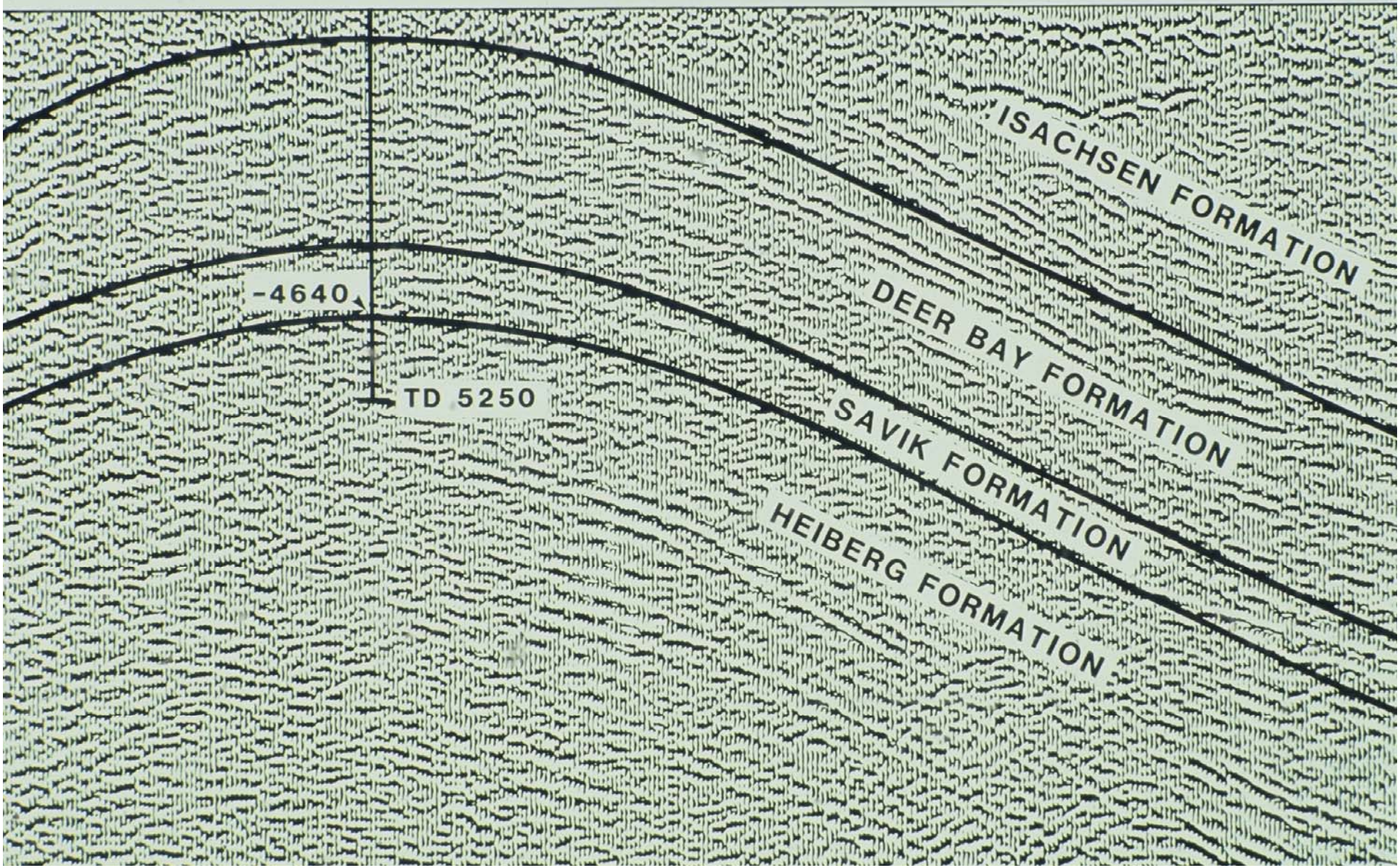


Sverdrup Basin Oil and Gas Fields

PAN et al JACKSON A G-16A

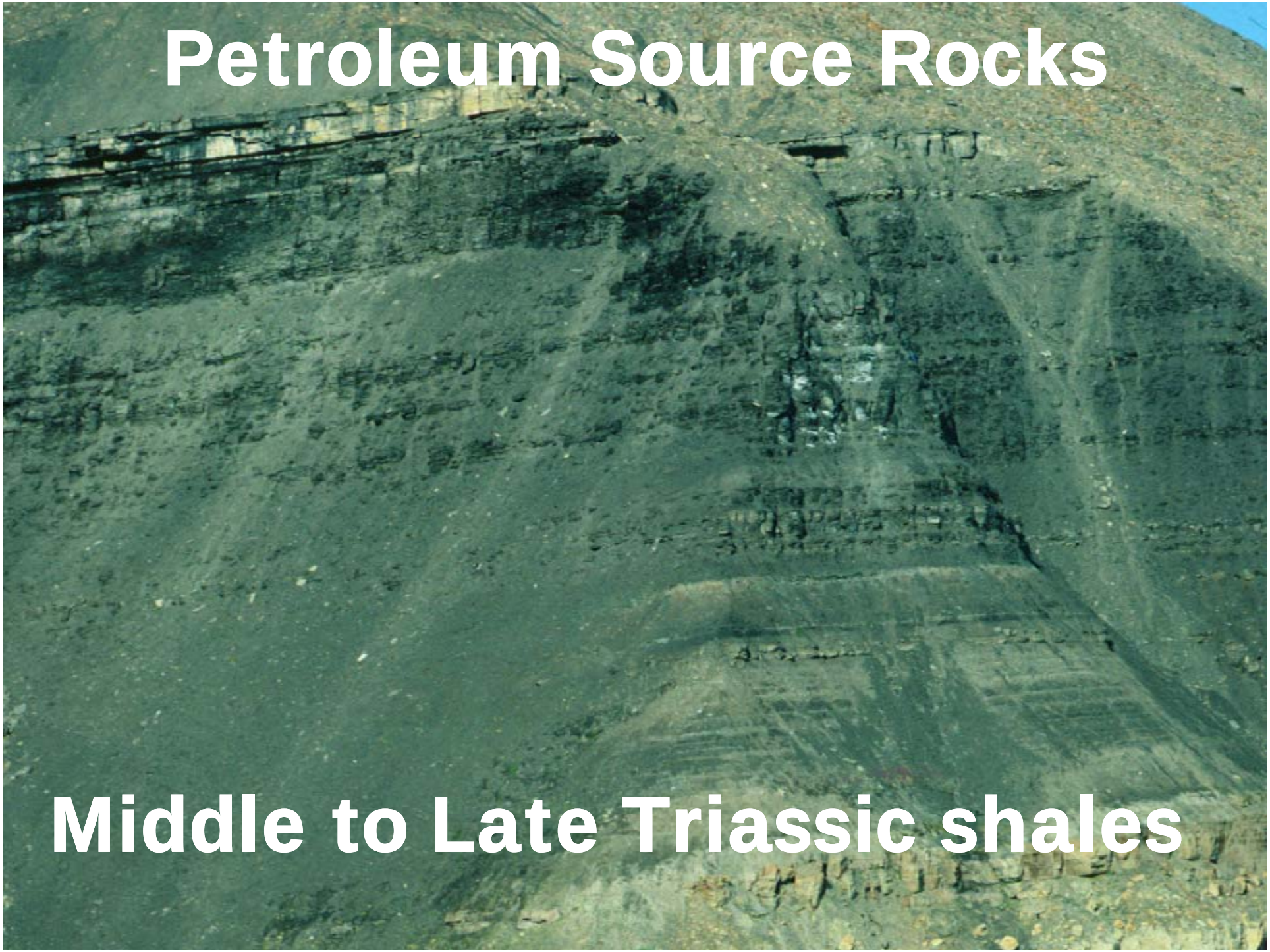
SW

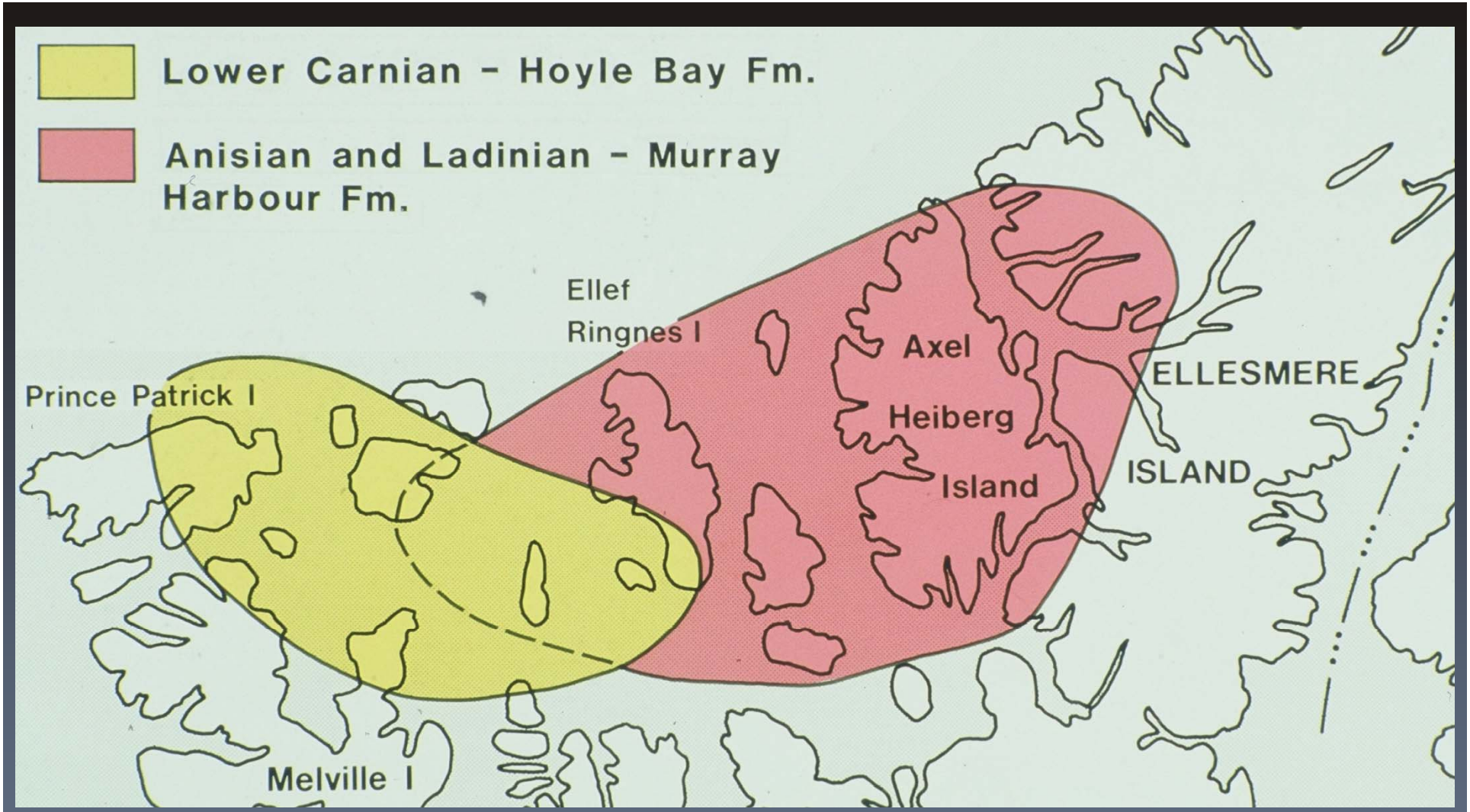
WATER DEPTH 220'



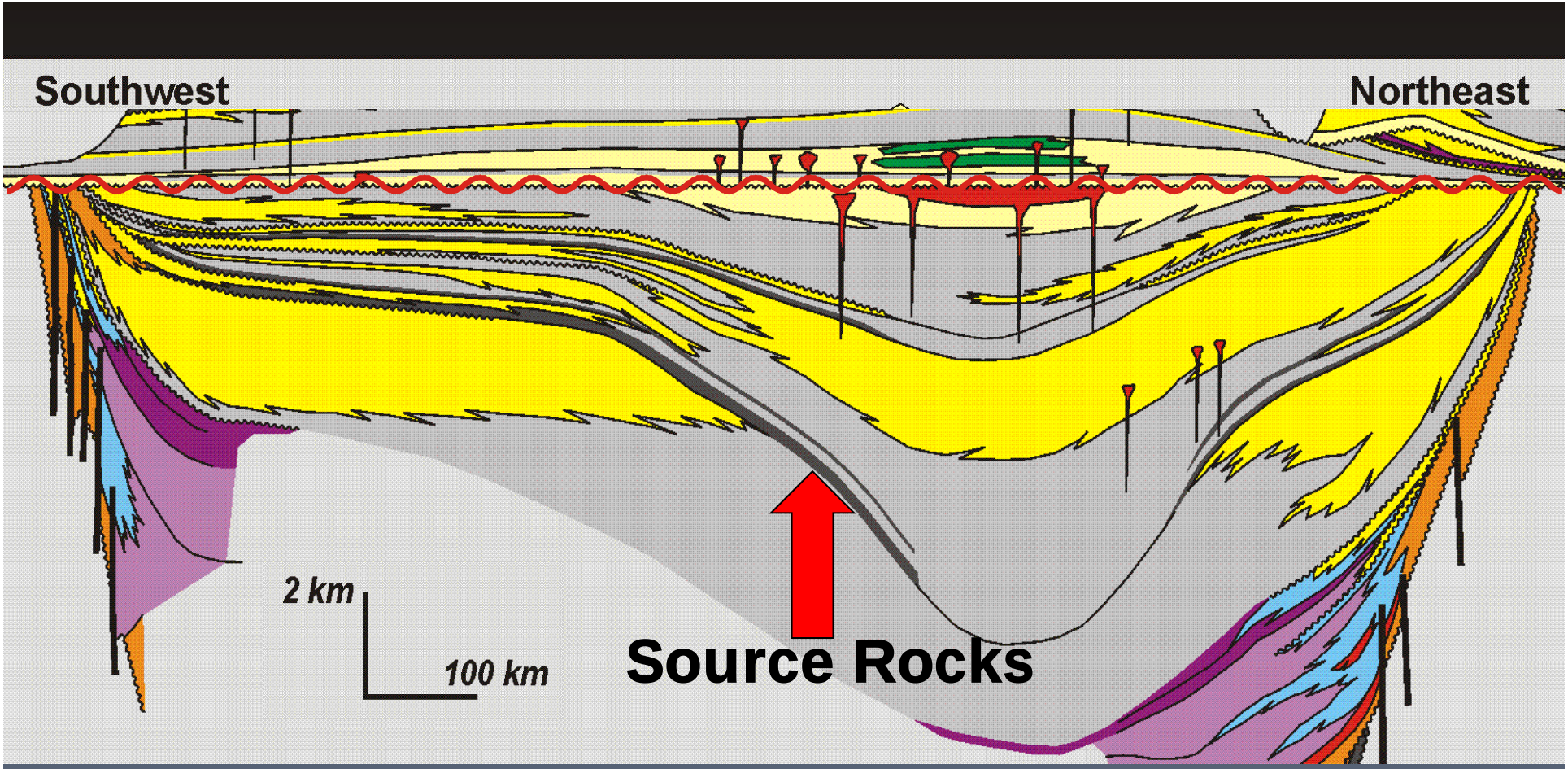
GAS FIELDS

- DRAKE 5.3 Tcf
- HECLA 3.6 Tcf
- WHITEFISH 2.4 Tcf
- JACKSON BAY 1.1 Tcf
- THOR 0.7 Tcf
- KRISTOFFER 0.7 Tcf
- CAPE ALLISON 0.6 Tcf
- MACLEAN 0.6 Tcf
- KING CHRISTIAN 0.6 Tcf
- ROCHE POINT 0.4 Tcf
- CHAR 0.4 Tcf
- SKATE 0.2 Tcf
- CISCO 0.2 Tcf
- WALLIS 0.1 Tcf
- MACMILLAN 0.1 Tcf
- SCULPIN 0.05 Tcf

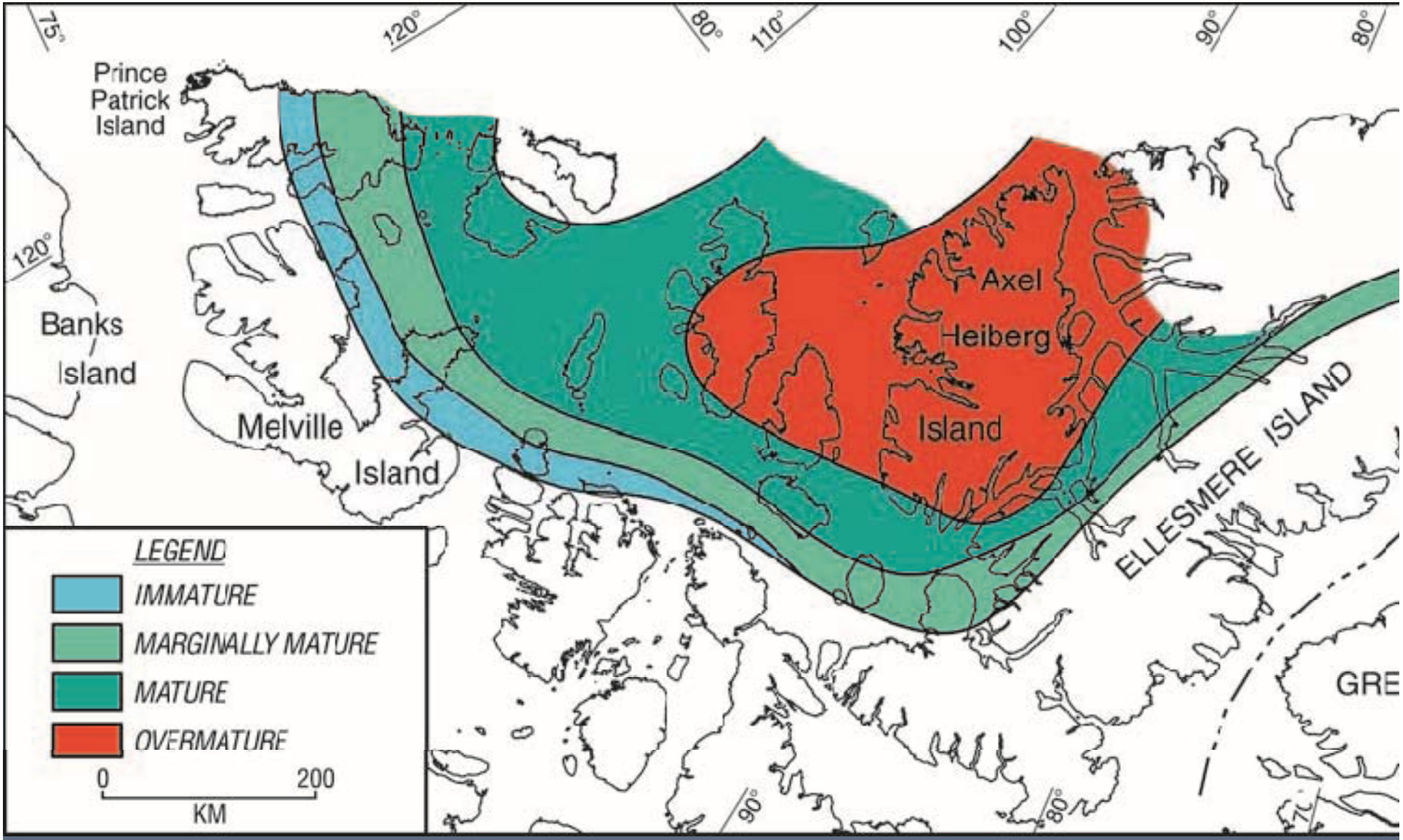

Petroleum Source Rocks
Middle to Late Triassic shales



Triassic Source Rock Distribution



Mesozoic Stratigraphic Cross Section, Sverdrup Basin



Thermal Maturity
Middle Triassic Source Rocks

Petroleum Migration and Trapping History

Oil was generated from the rich Triassic source rocks beginning in Late Jurassic and was trapped in updip salt structures and stratigraphic traps.

Petroleum Migration and Trapping History

Major generation of gas began in the basin centre in Late Early Cretaceous with greatly increased sedimentation and widespread igneous intrusion.

The large volumes of gas likely flushed oil from the main structural traps during Late Cretaceous and Tertiary.

The Question of the Day

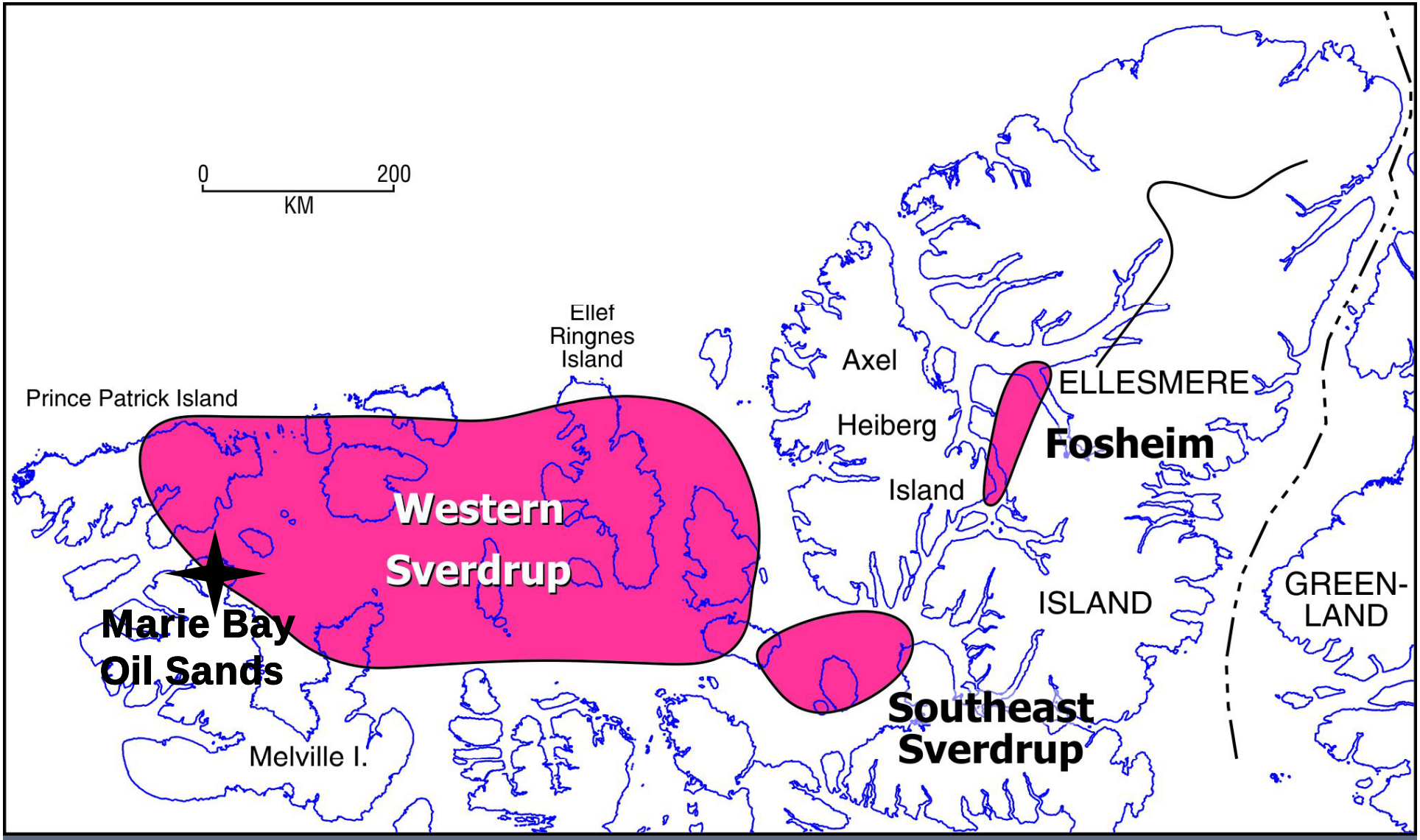
Oil Prospects

The best prospects for oil are stratigraphic traps in the Triassic-Jurassic succession that were present during the generation of oil in the Jurassic/Cretaceous and escaped subsequent gas flushing.

The main fairways for stratigraphically-trapped oil in Triassic-Jurassic strata have been delineated on the basis of two main constraints

- **Potential reservoir strata of the Triassic-Jurassic succession are in the subsurface**

- **Triassic source strata are in the oil window over much of the area**



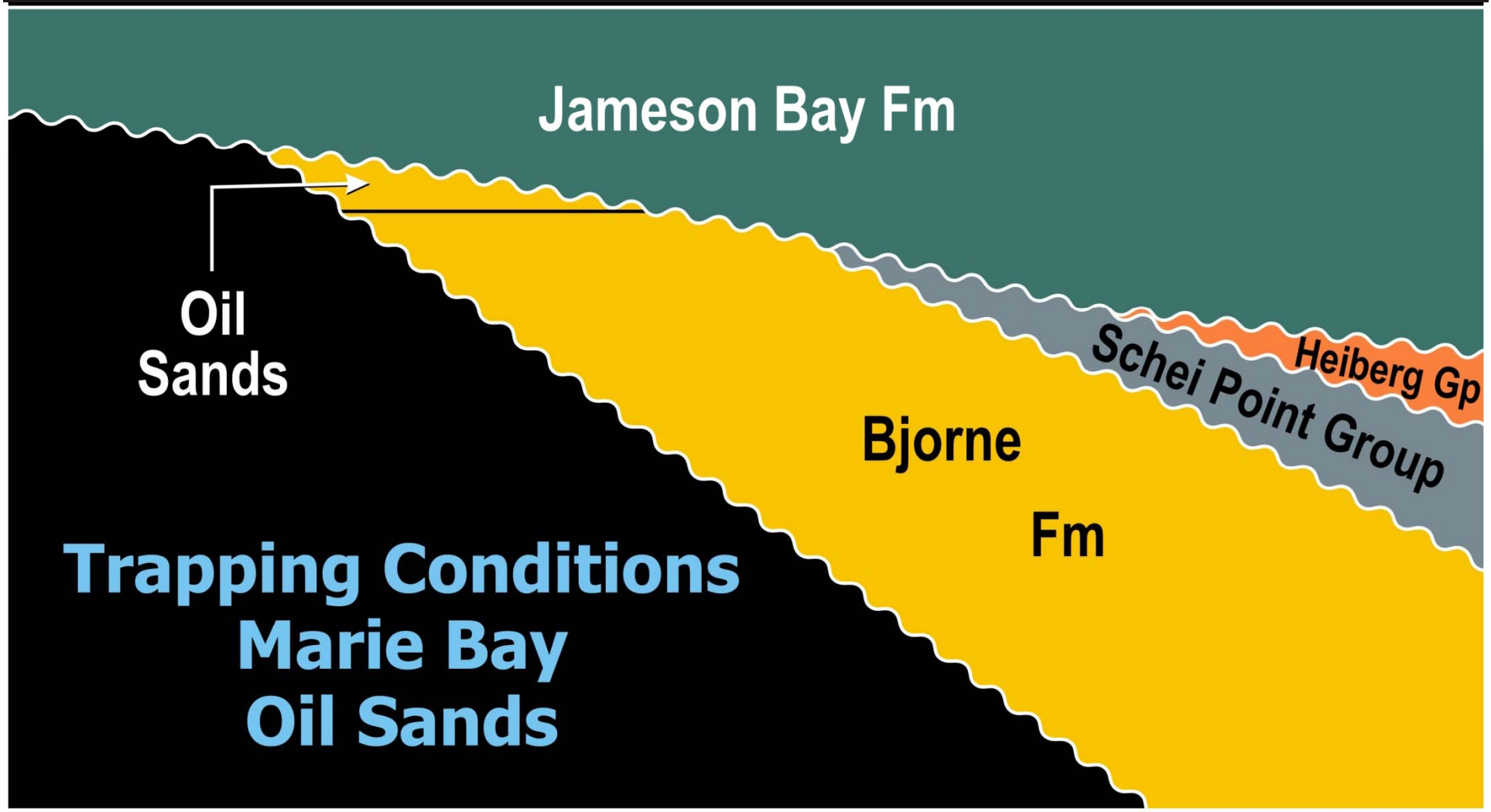
Prospective Areas For Oil Fields

Potential Traps

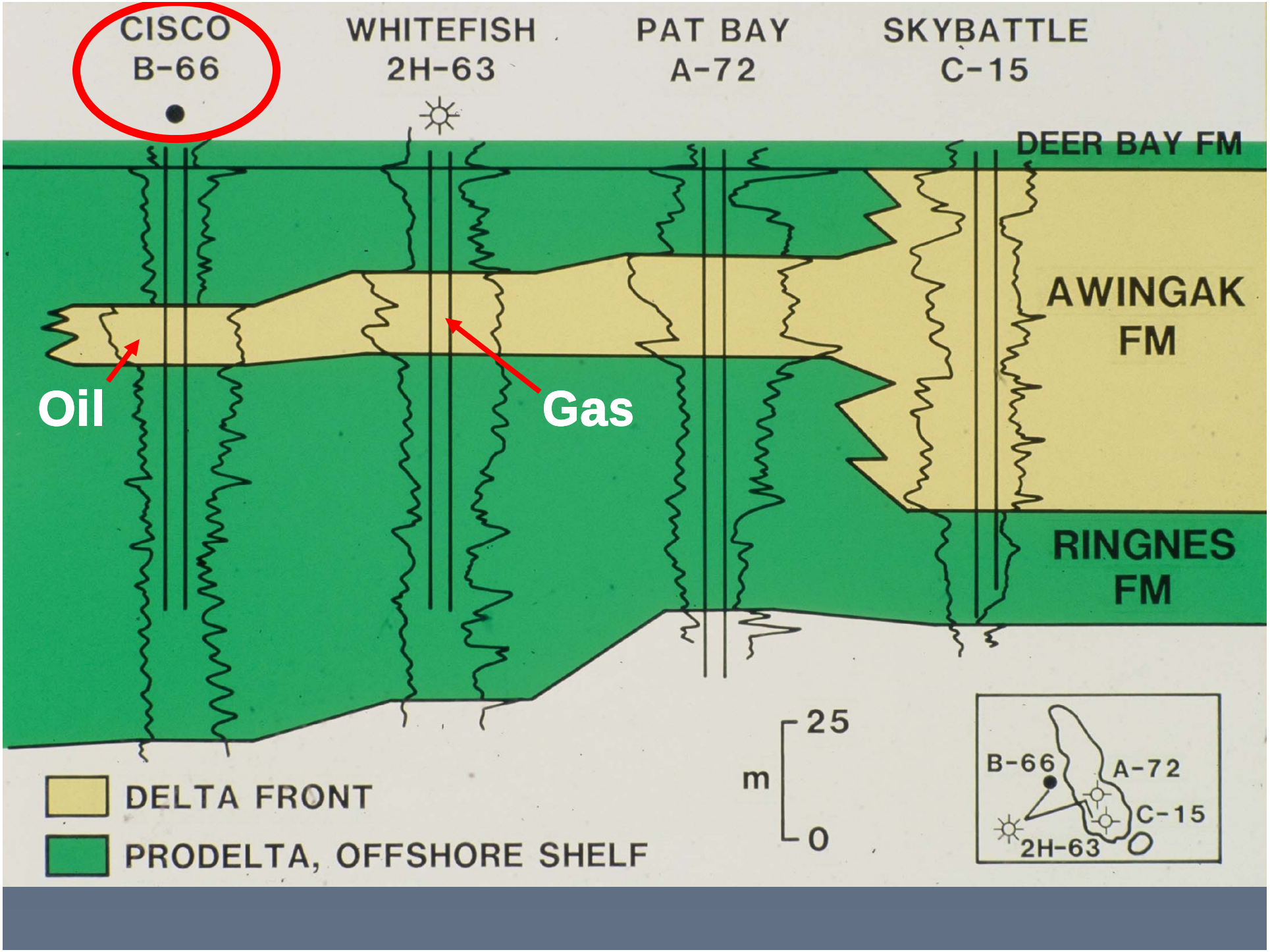
The Triassic-Jurassic Succession consists almost exclusively of shallow marine to non-marine siliciclastic deposits.

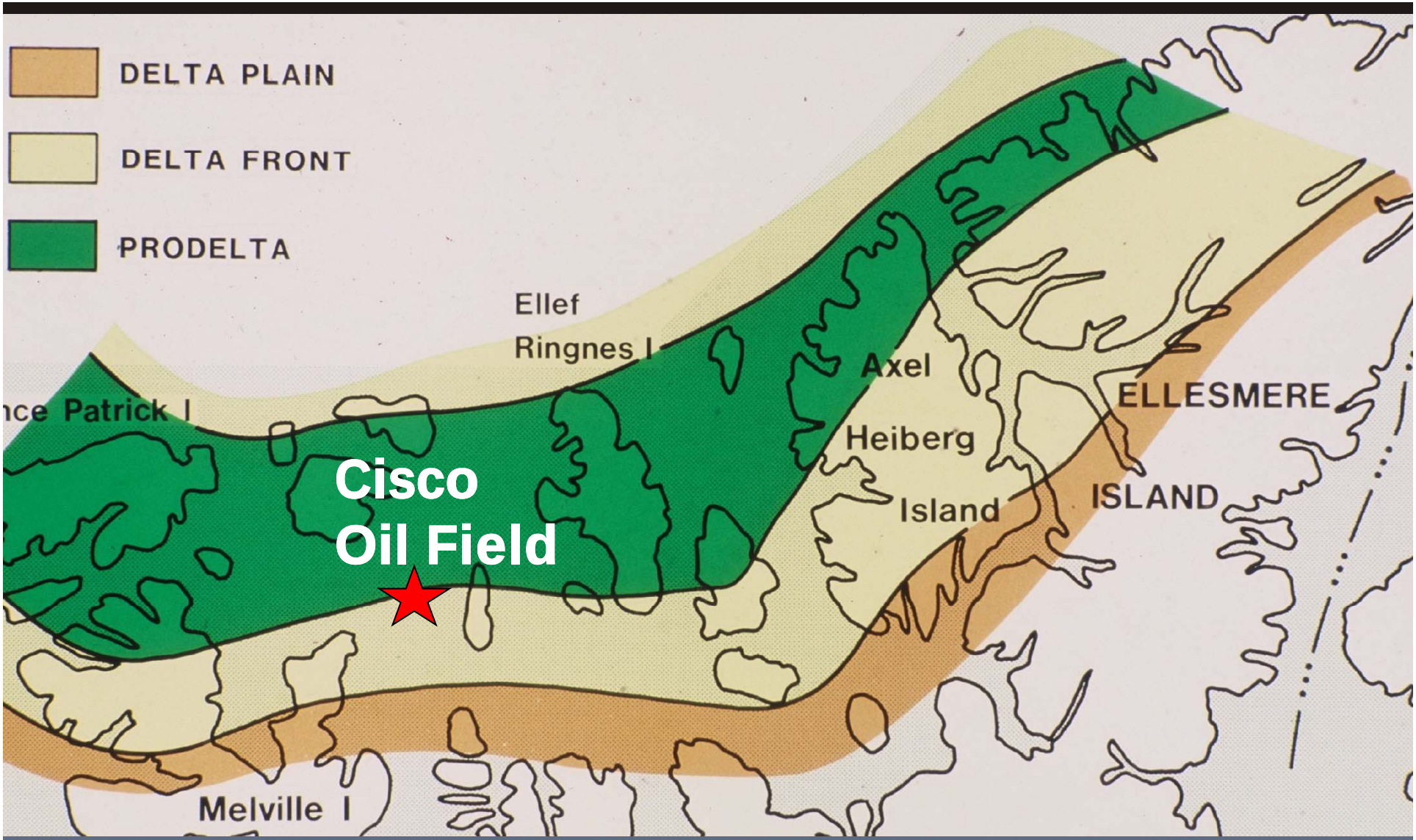
Potential stratigraphic traps include erosional edges of sandstone units and basinward pinchouts of sandstone units.

Bitumen in Bjorne Sandstone, Marie Bay Oil Sands

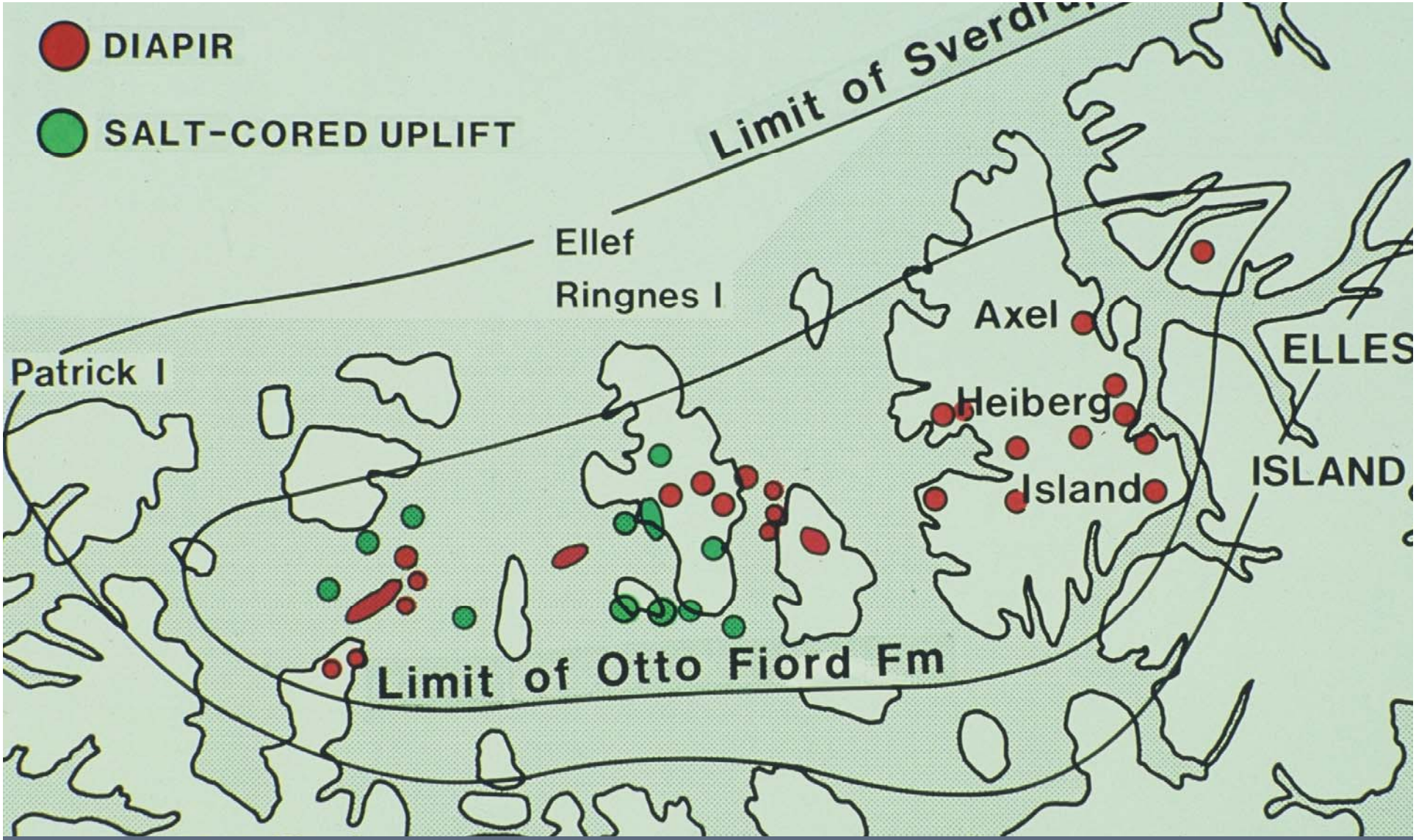


Stratigraphic Trap Related to Truncation of Early Triassic, Nonmarine Sandstones (Bjorne Formation)

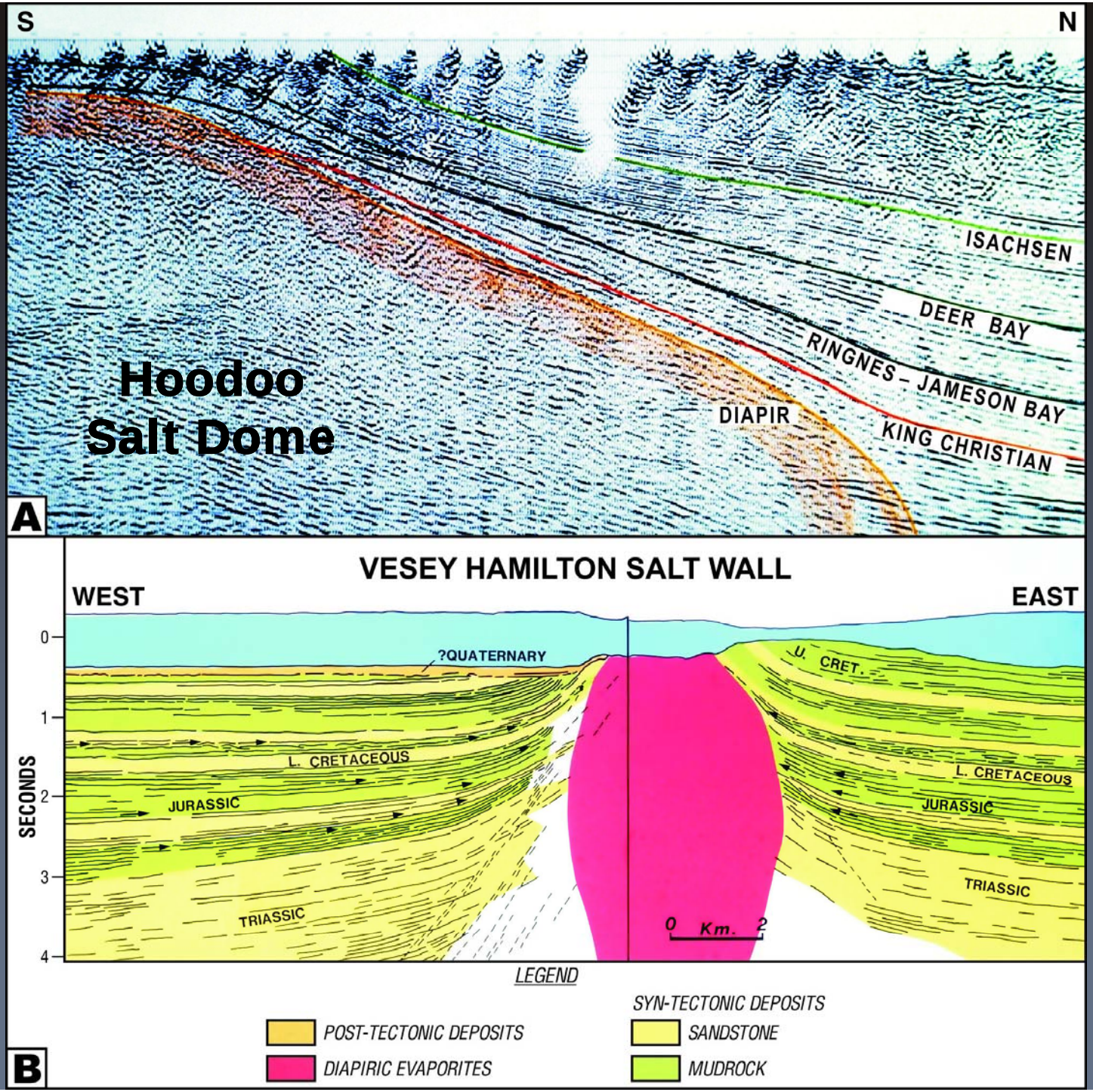

CISCO
B-66
WHITEFISH
2H-63
PAT BAY
A-72
SKYBATTLE
C-15
DEER BAY FM
AWINGAK
FM
RINGNES
FM
Oil
Gas
25
m
0
DELTA FRONT
PRODELTA, OFFSHORE SHELF
B-66
A-72
C-15
2H-63

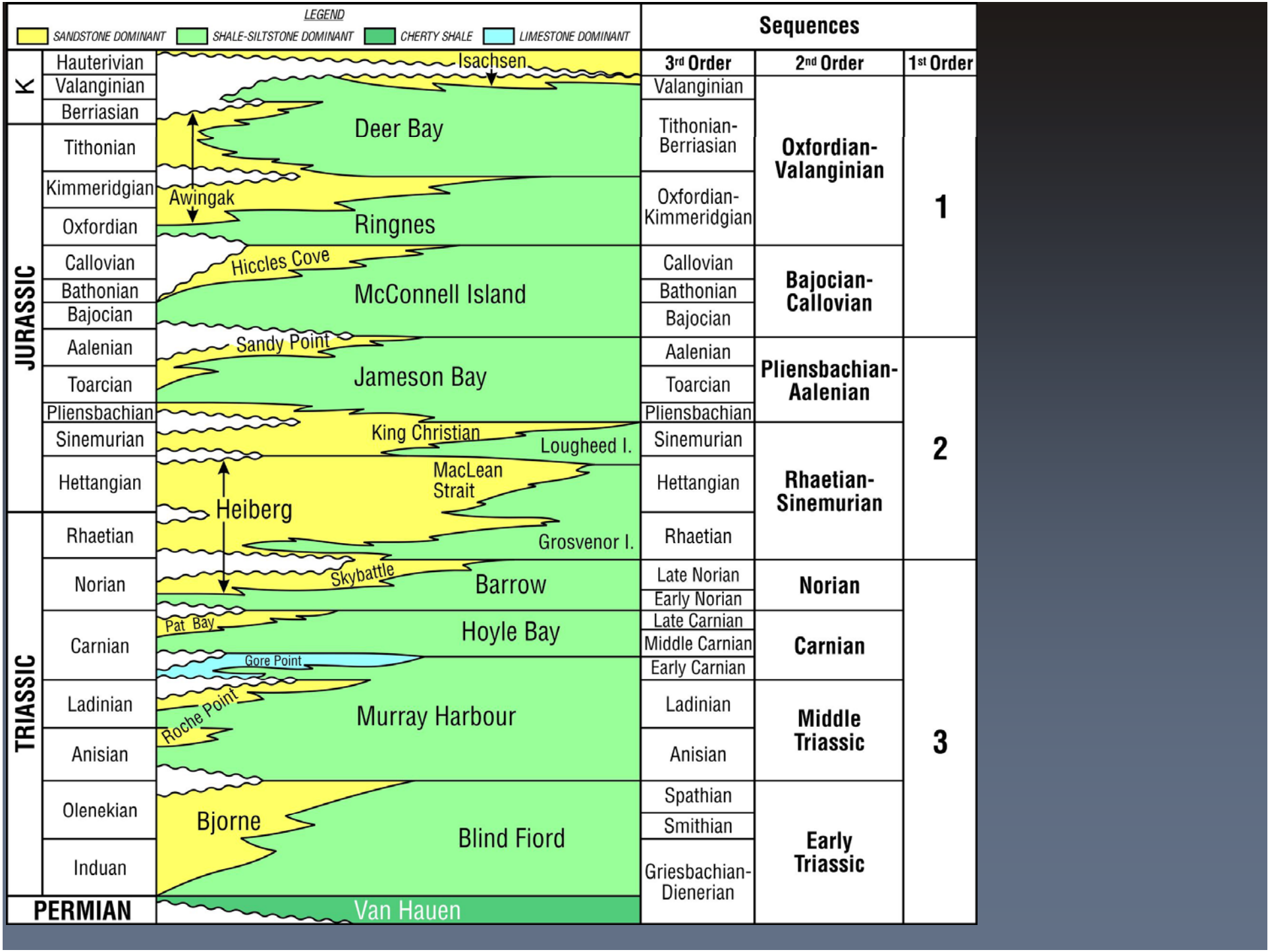


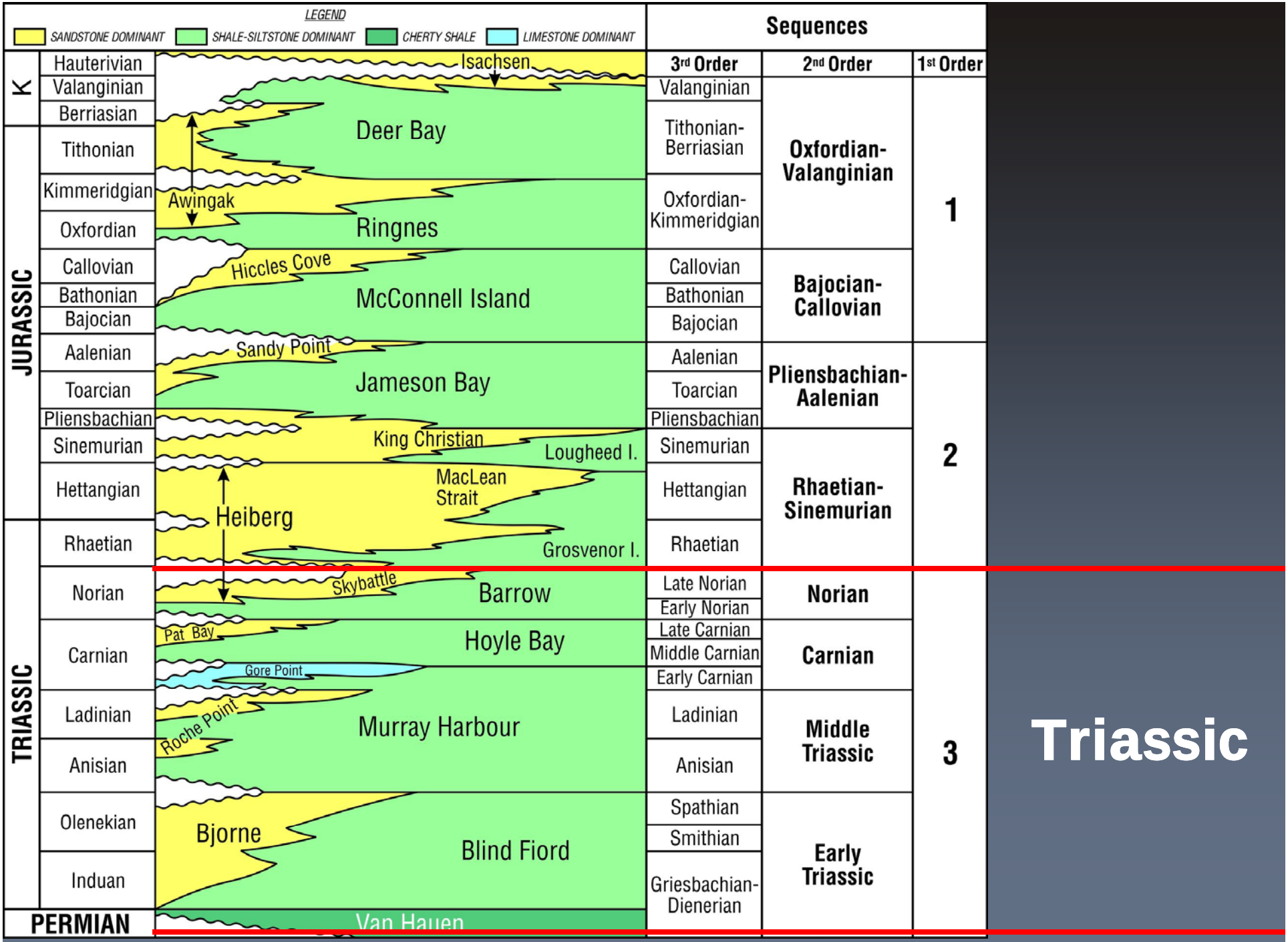
Kimmeridgian Paleogeography



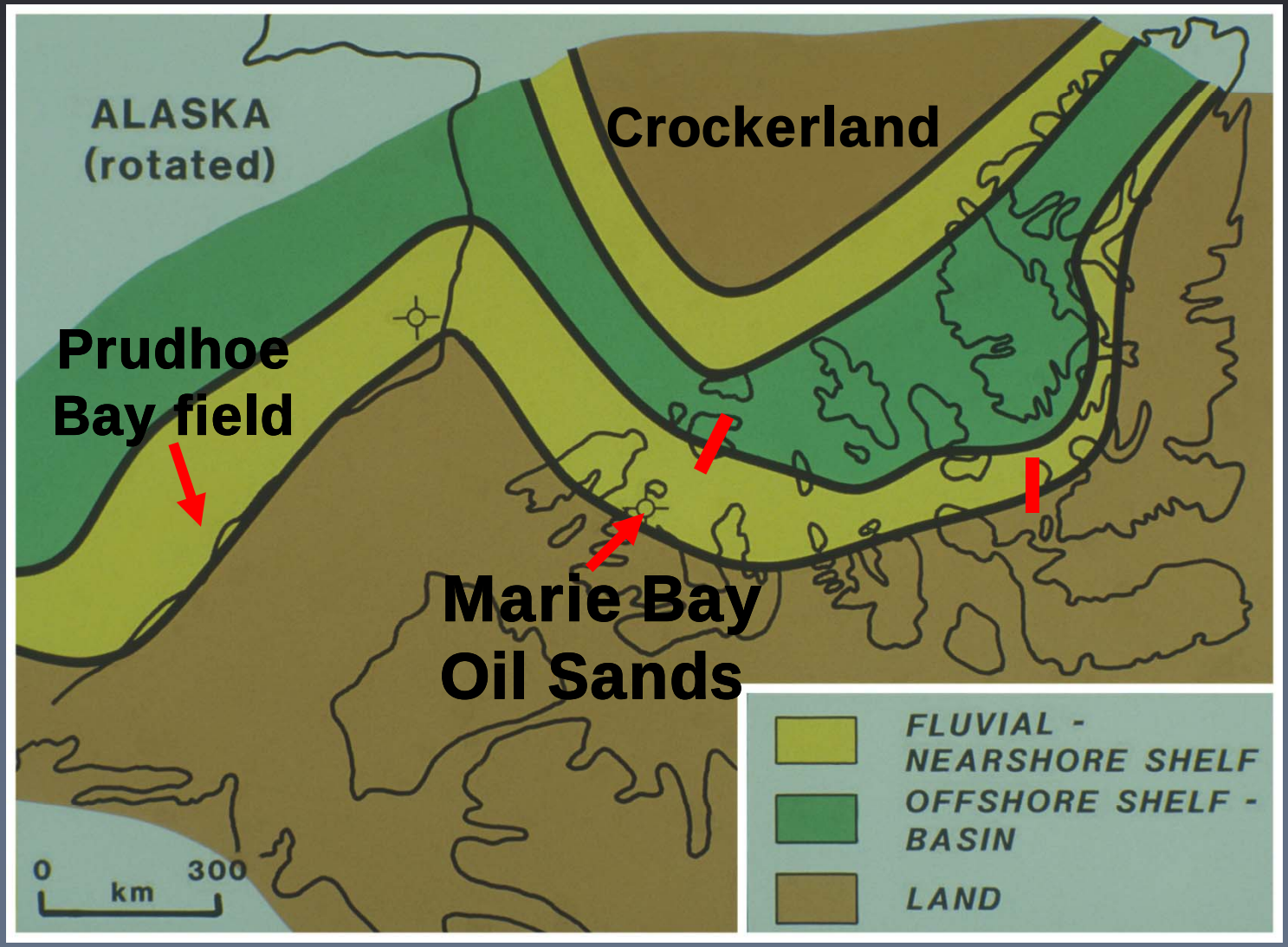
Salt Structures

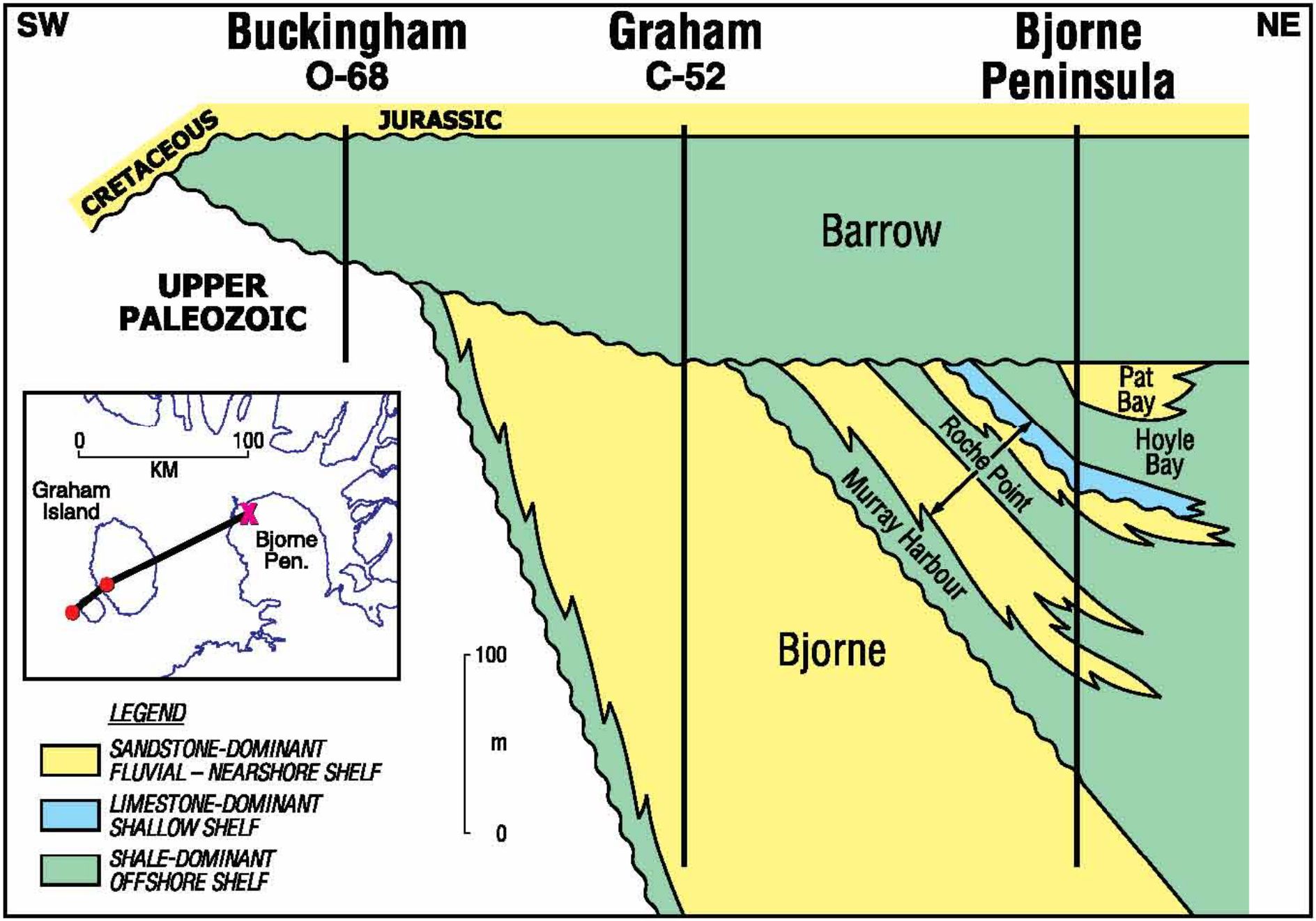

S
N
ISACHSEN
DEER BAY
RINGNES – JAMESON BAY
KING CHRISTIAN
DIAPIR
Hoodoo
Salt Dome
A
VESEY HAMILTON SALT WALL
WEST
EAST
SECONDS
0
1
2
3
4
?QUATERNARY
U. CRET.
L. CRETACEOUS
JURASSIC
TRIASSIC
0 Km. 2
LEGEND
POST-TECTONIC DEPOSITS
DIAPIRIC EVAPORITES
SYN-TECTONIC DEPOSITS
SANDSTONE
MUDROCK
B


LEGEND
SANDSTONE DOMINANT
SHALE-SILTSTONE DOMINANT
CHERTY SHALE
LIMESTONE DOMINANT
Sequences
3rd Order
2nd Order
1st Order
K
JURASSIC
TRIASSIC
PERMIAN
Hauterivian
Valanginian
Berriasian
Tithonian
Kimmeridgian
Oxfordian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Rhaetian
Norian
Carnian
Ladinian
Anisian
Olenekian
Induan
Isachsen
Deer Bay
Awingak
Ringnes
Hiccles Cove
McConnell Island
Sandy Point
Jameson Bay
King Christian
Lougheed I.
MacLean Strait
Heiberg
Grosvenor I.
Skybattle
Barrow
Pat Bay
Hoyle Bay
Gore Point
Roche Point
Murray Harbour
Bjorne
Blind Fiord
Van Hauen
Valanginian
Tithonian-Berriasian
Oxfordian-Kimmeridgian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Rhaetian
Late Norian
Early Norian
Late Carnian
Middle Carnian
Early Carnian
Ladinian
Anisian
Spathian
Smithian
Griesbachian-Dienerian
Oxfordian-Valanginian
Bajocian-Callovian
Pliensbachian-Aalenian
Rhaetian-Sinemurian
Norian
Carnian
Middle Triassic
Early Triassic
1
2
3

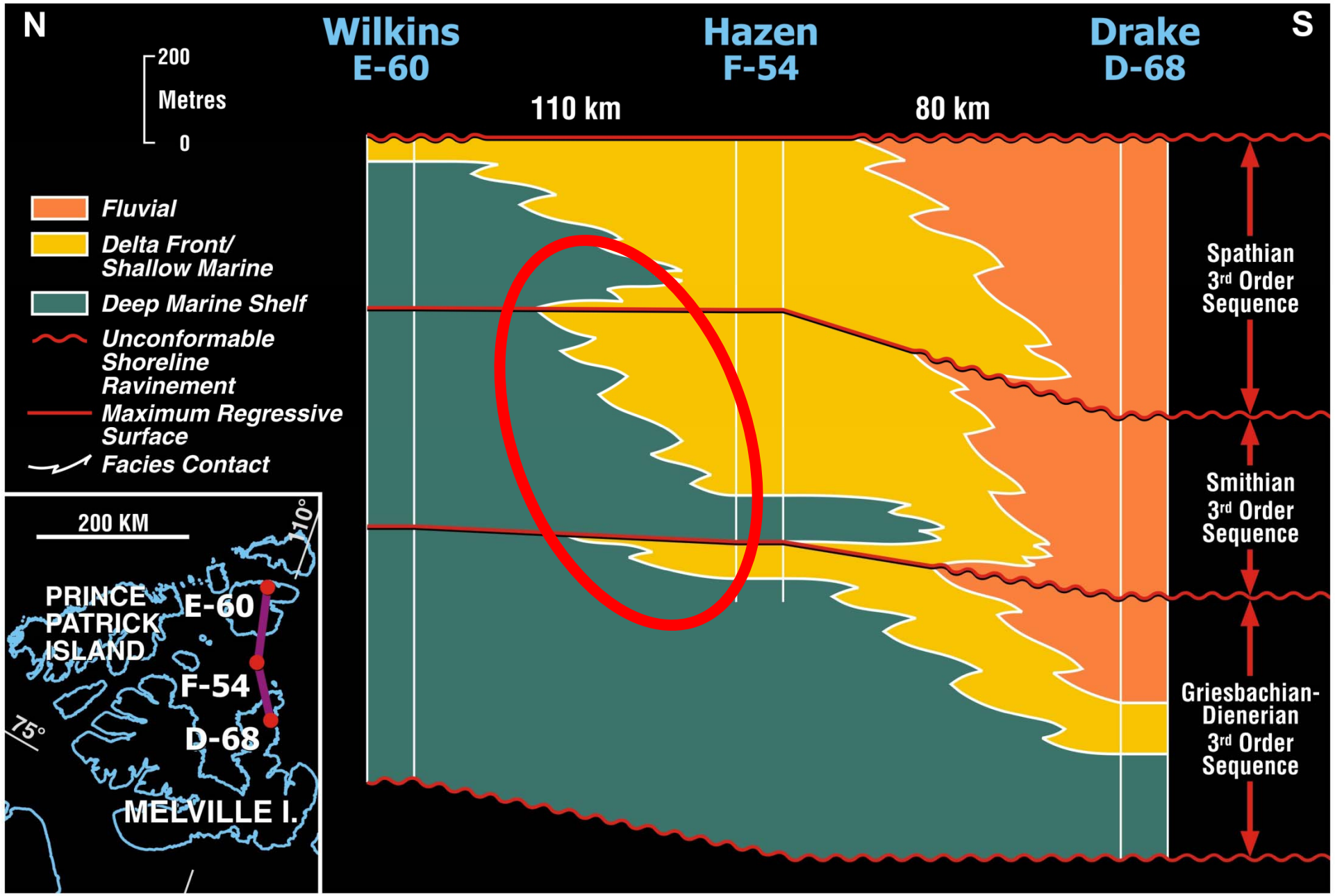

LEGEND
SANDSTONE DOMINANT
SHALE-SILTSTONE DOMINANT
CHERTY SHALE
LIMESTONE DOMINANT
Sequences
3rd Order
2nd Order
1st Order
K
JURASSIC
TRIASSIC
PERMIAN
Hauterivian
Valanginian
Berriasian
Tithonian
Kimmeridgian
Oxfordian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Rhaetian
Norian
Carnian
Ladinian
Anisian
Olenekian
Induan
Isachsen
Deer Bay
Awingak
Ringnes
Hiccles Cove
McConnell Island
Sandy Point
Jameson Bay
King Christian
Lougheed I.
MacLean Strait
Heiberg
Grosvenor I.
Skybattle
Barrow
Pat Bay
Hoyle Bay
Gore Point
Roche Point
Murray Harbour
Bjorne
Blind Fiord
Van Hauen
Valanginian
Tithonian-Berriasian
Oxfordian-Kimmeridgian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Rhaetian
Late Norian
Early Norian
Late Carnian
Middle Carnian
Early Carnian
Ladinian
Anisian
Spathian
Smithian
Griesbachian-Dienerian
Oxfordian-Valanginian
Bajocian-Callovian
Pliensbachian-Aalenian
Rhaetian-Sinemurian
Norian
Carnian
Middle Triassic
Early Triassic
1
2
3
Triassic

Early Triassic Paleogeography
Pre-drift Restoration

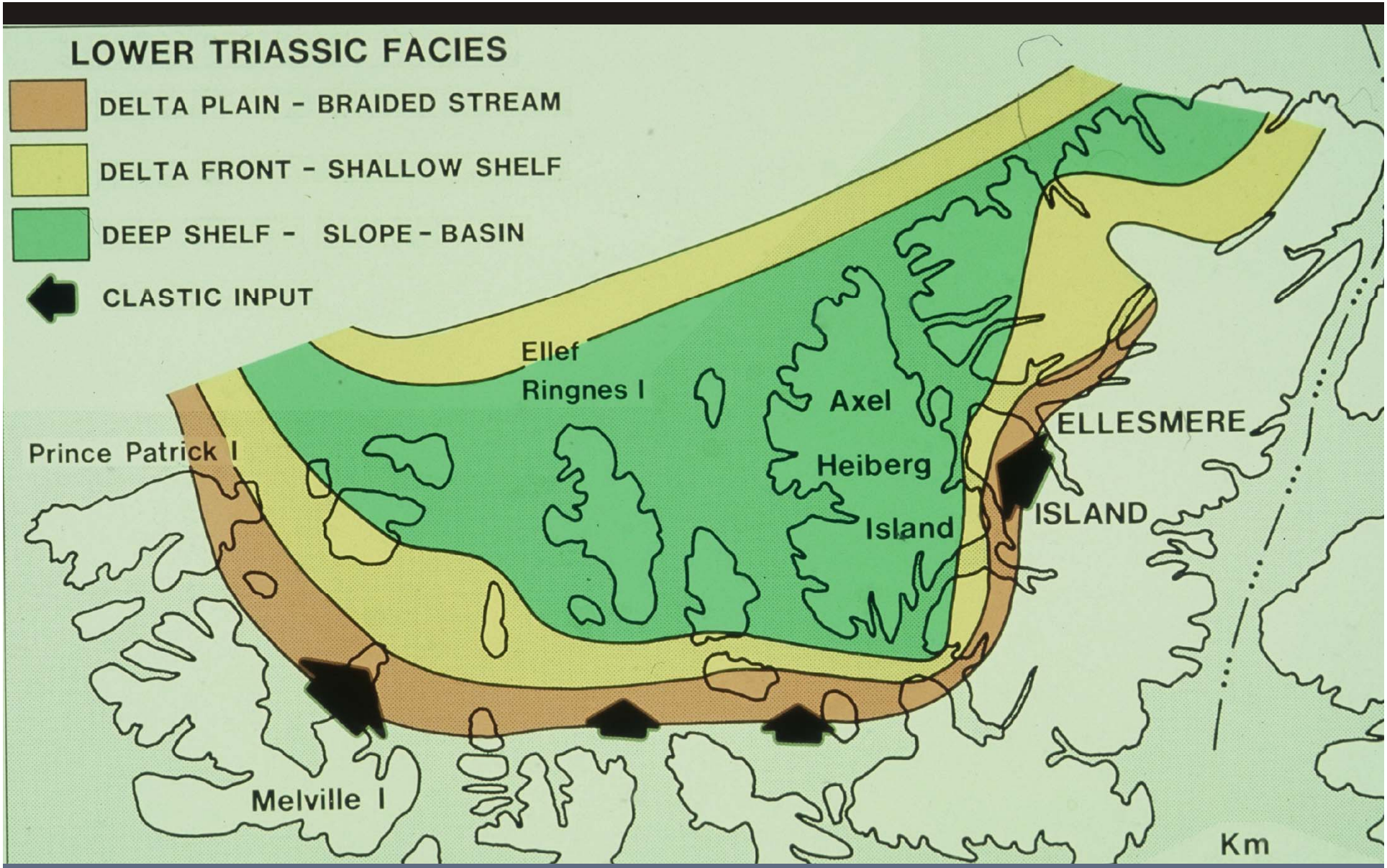




Truncation and Overstep of Bjorne Fm By Norian Strata



Early Triassic Sequence, Western Sverdrup Basin



Lower Triassic Paleogeography

II

Blaa Mountain

Sawtooth

Cape With

Esayoo

Yelve

Gore Point Fm

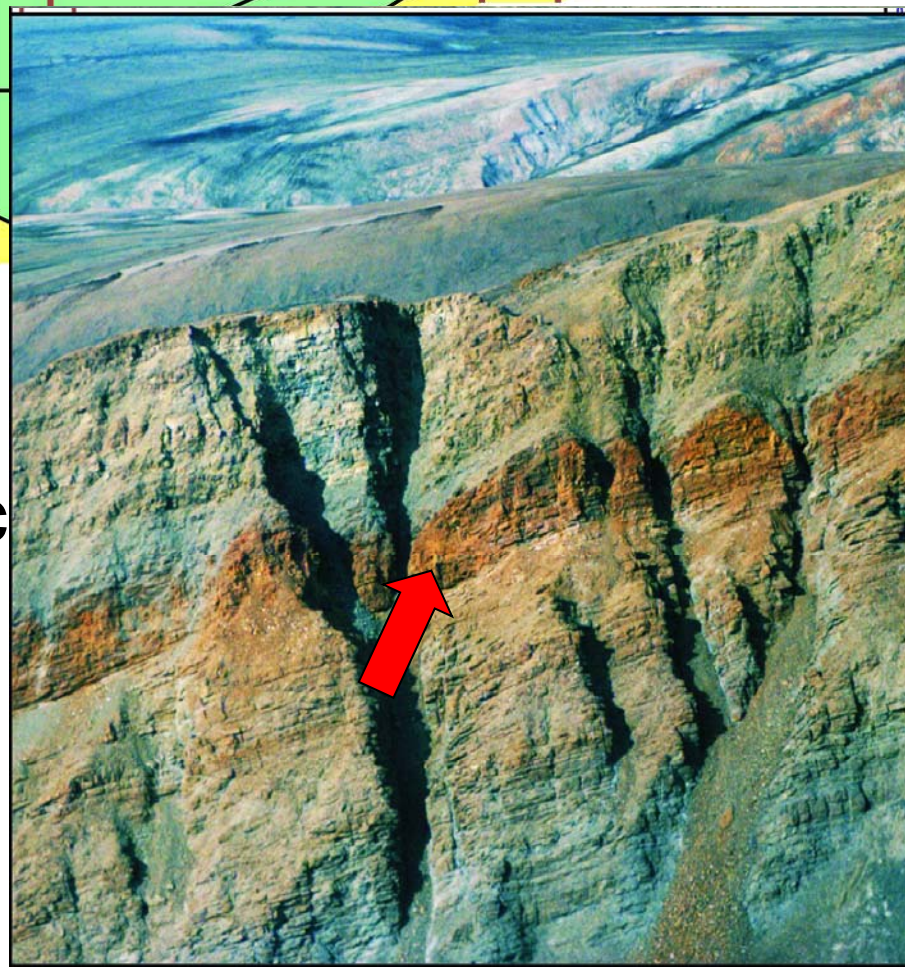
Roche Point Fm

Murray

Harbour

Fm

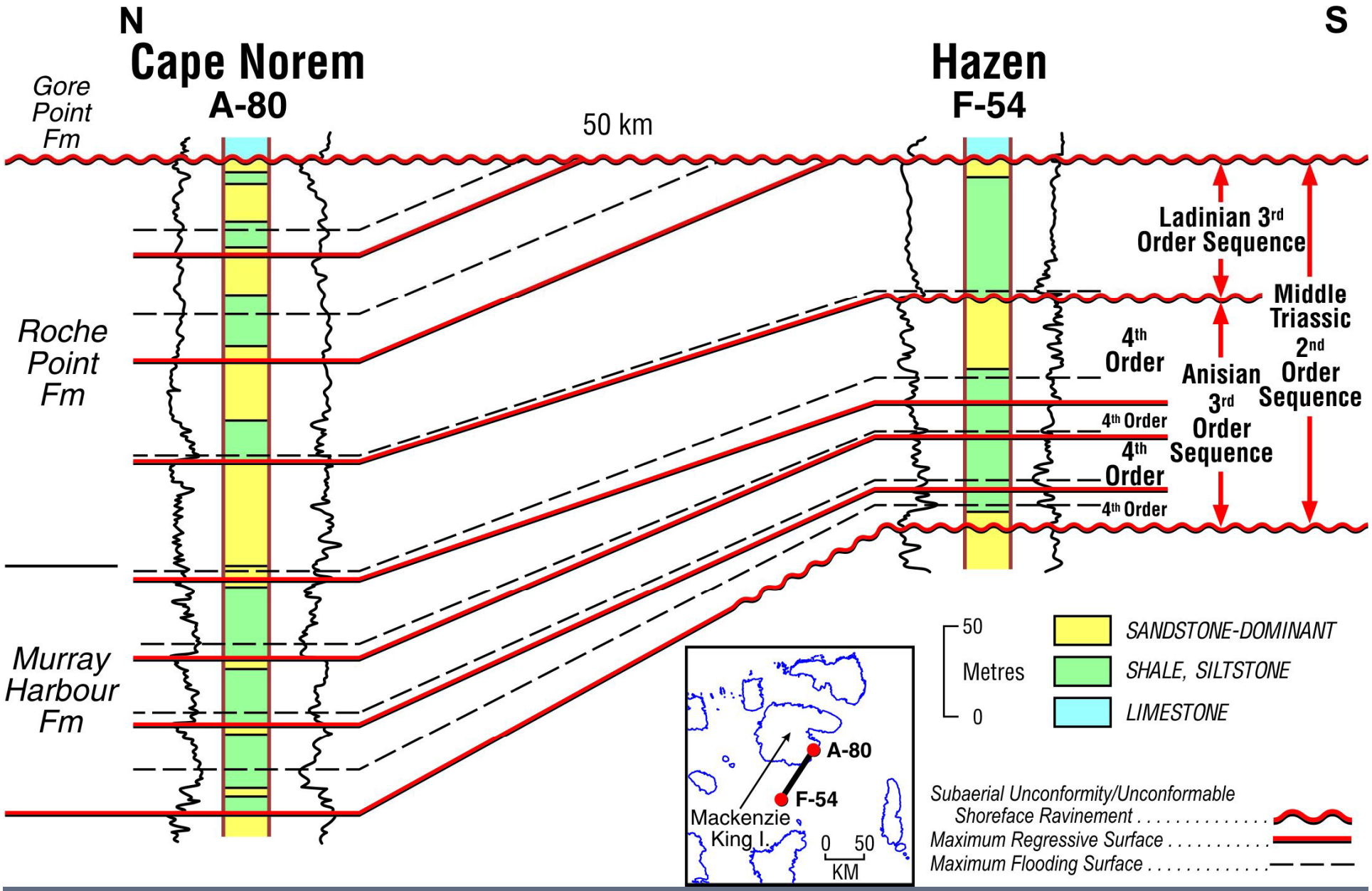
Bjorne Fm



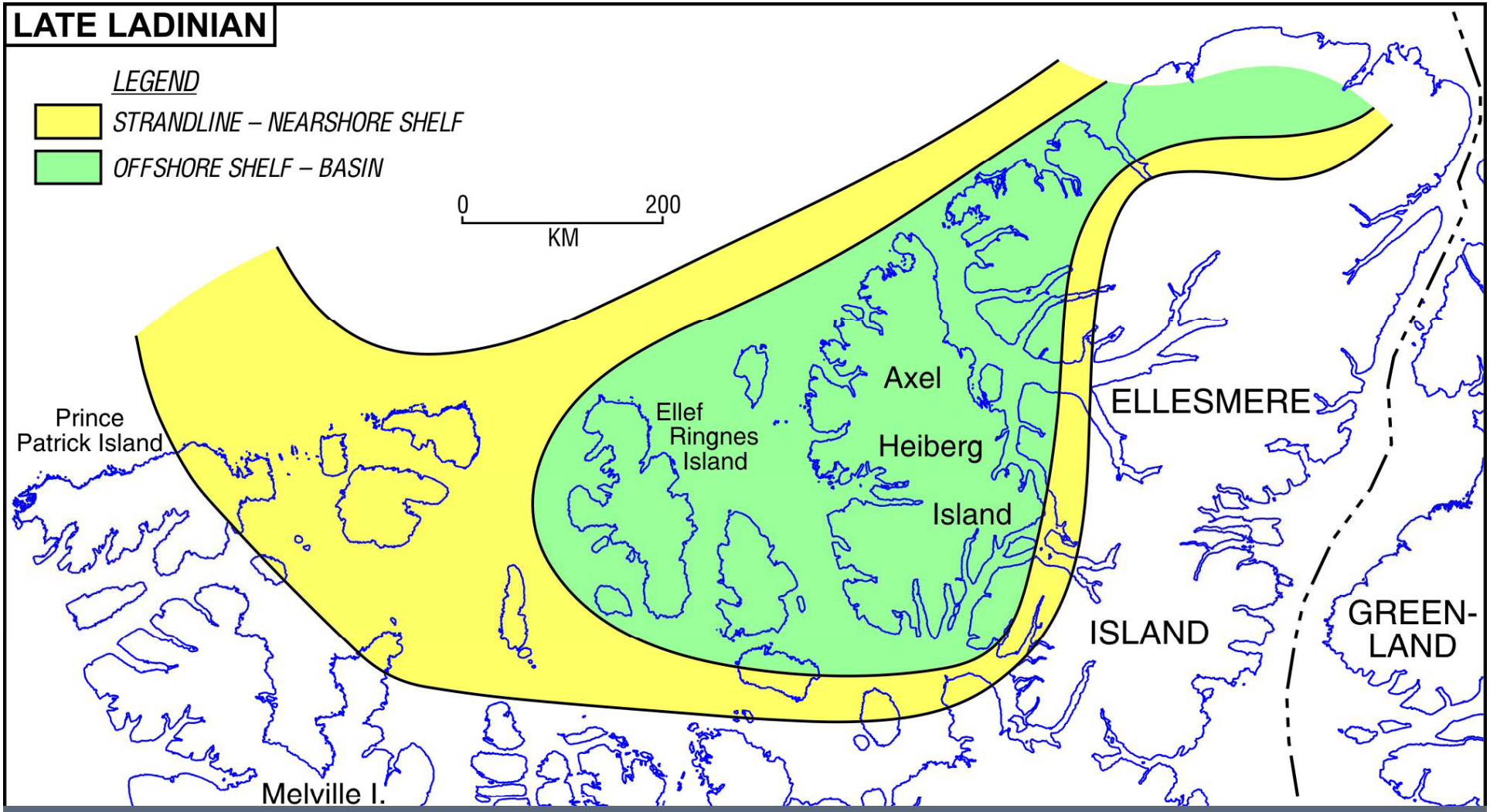
Middle Triassic

LEGEND

- *SANDSTONE SHALLOW MARINE*
- *SHALE AND SILTSTONE OFFSHORE MARINE*
- *LIMESTONE OFFSHORE MARINE*

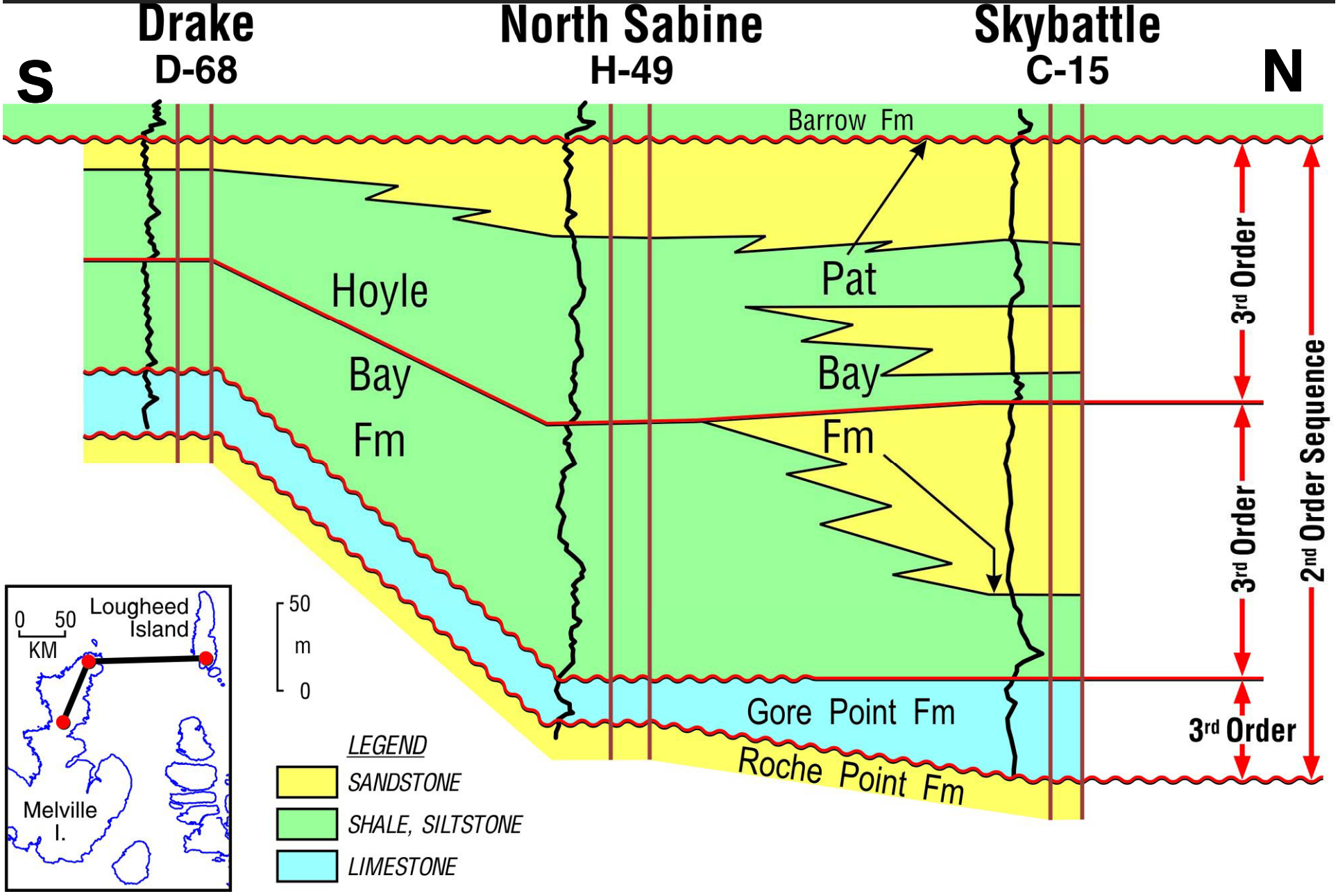


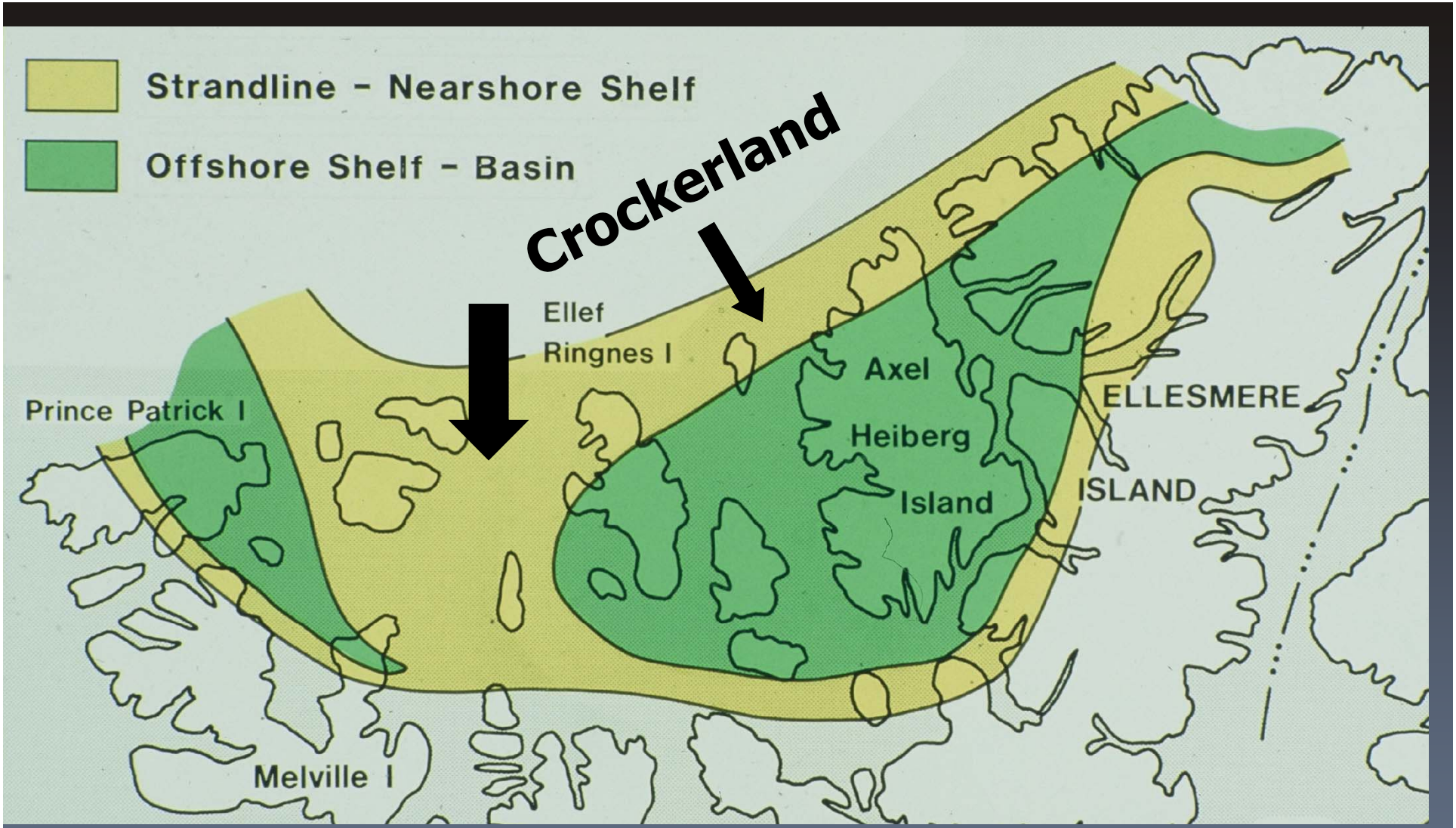
Truncation Ladinian Sandstones on Flank of Salt Structure



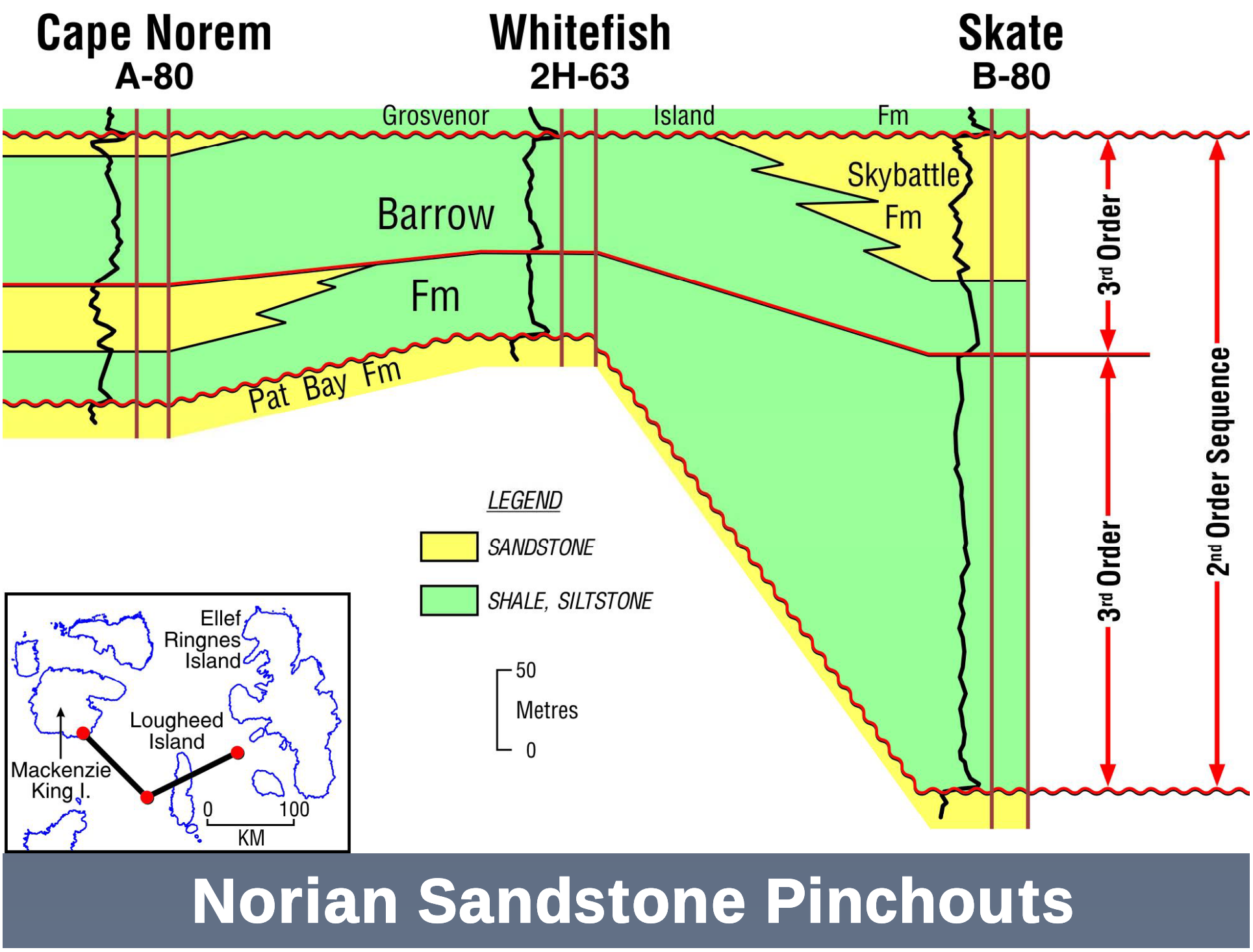
Late Ladinian Paleogeography

Carnian Stratigraphy Western Sverdrup

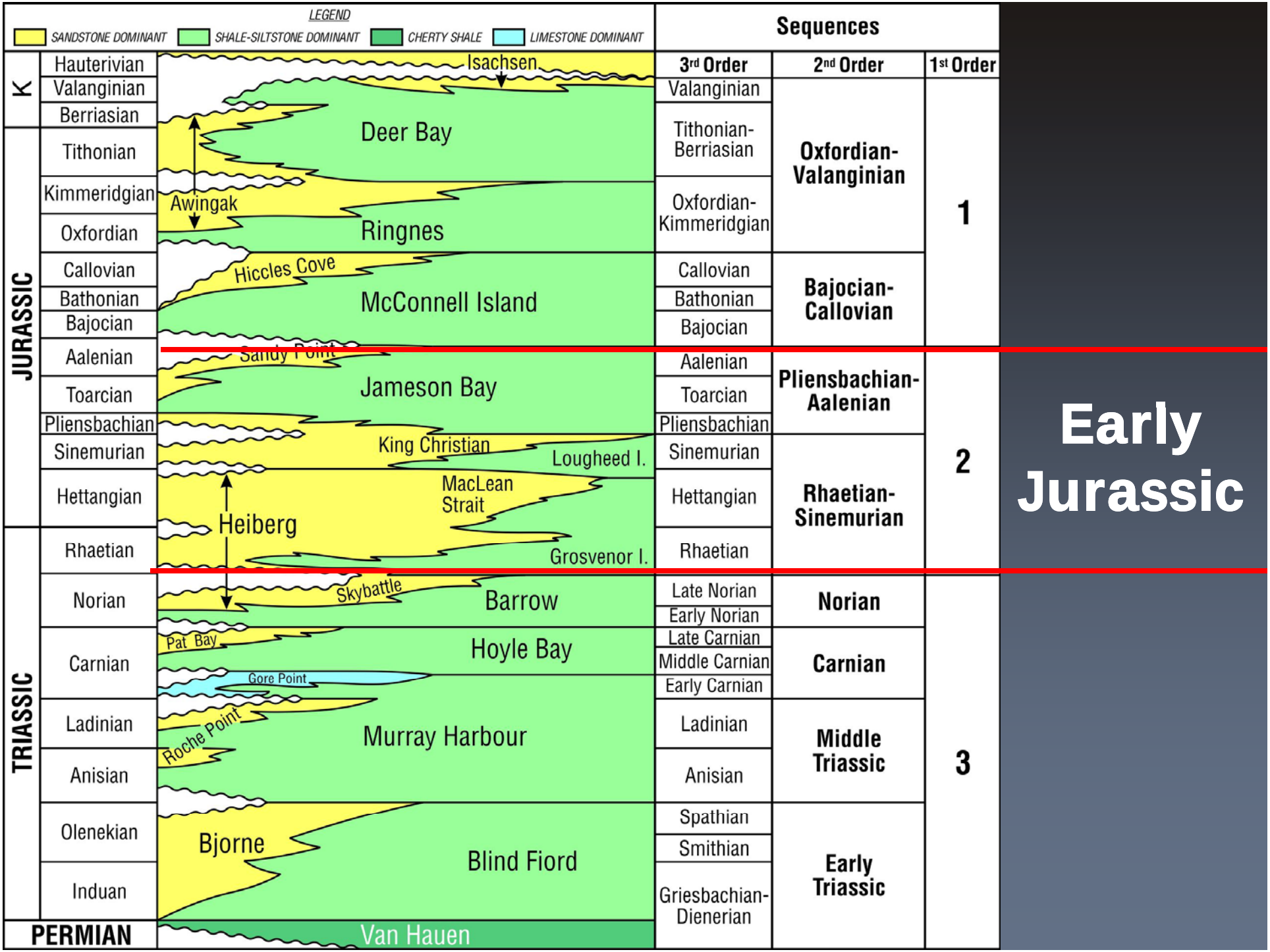


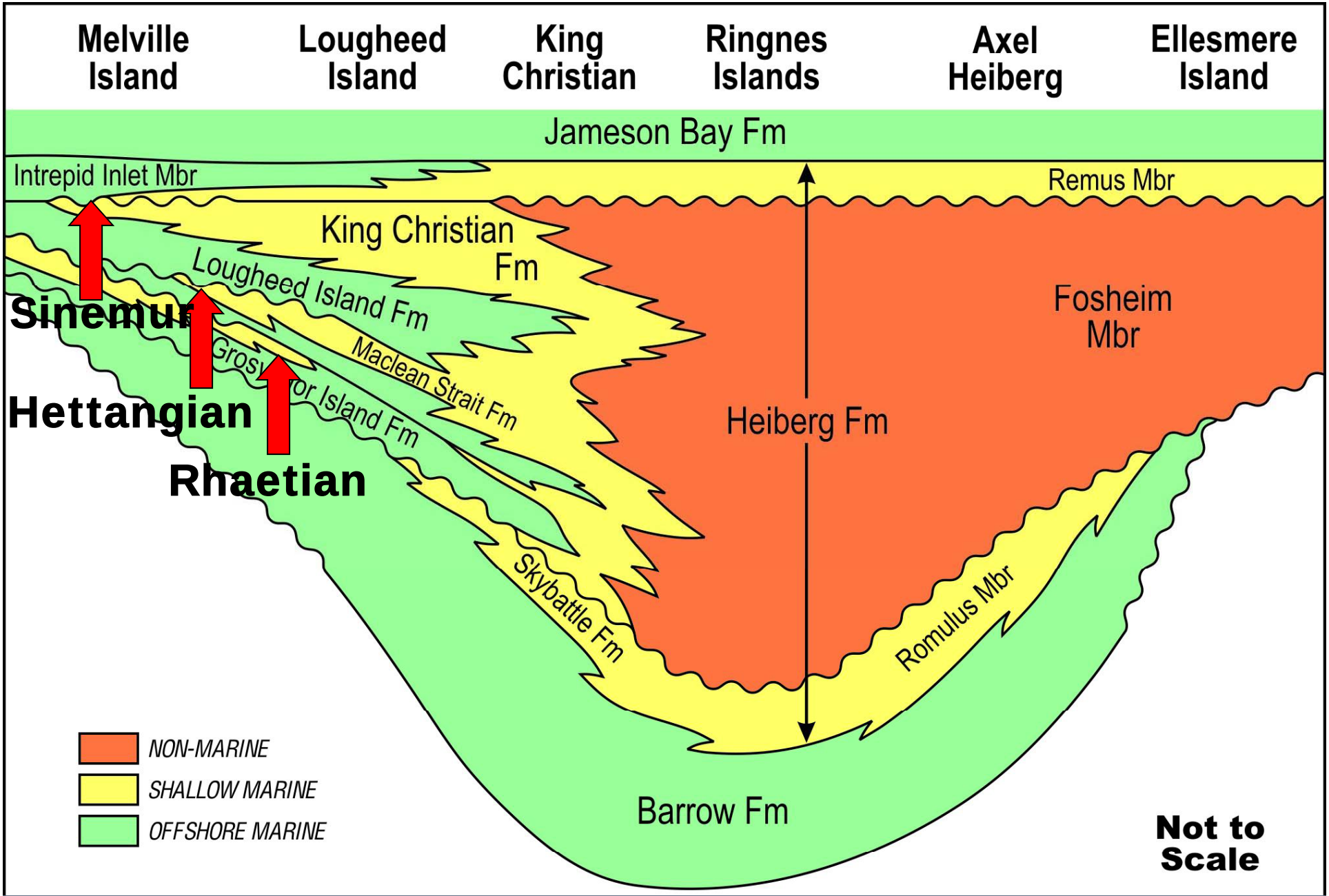


Late Carnian Paleogeography

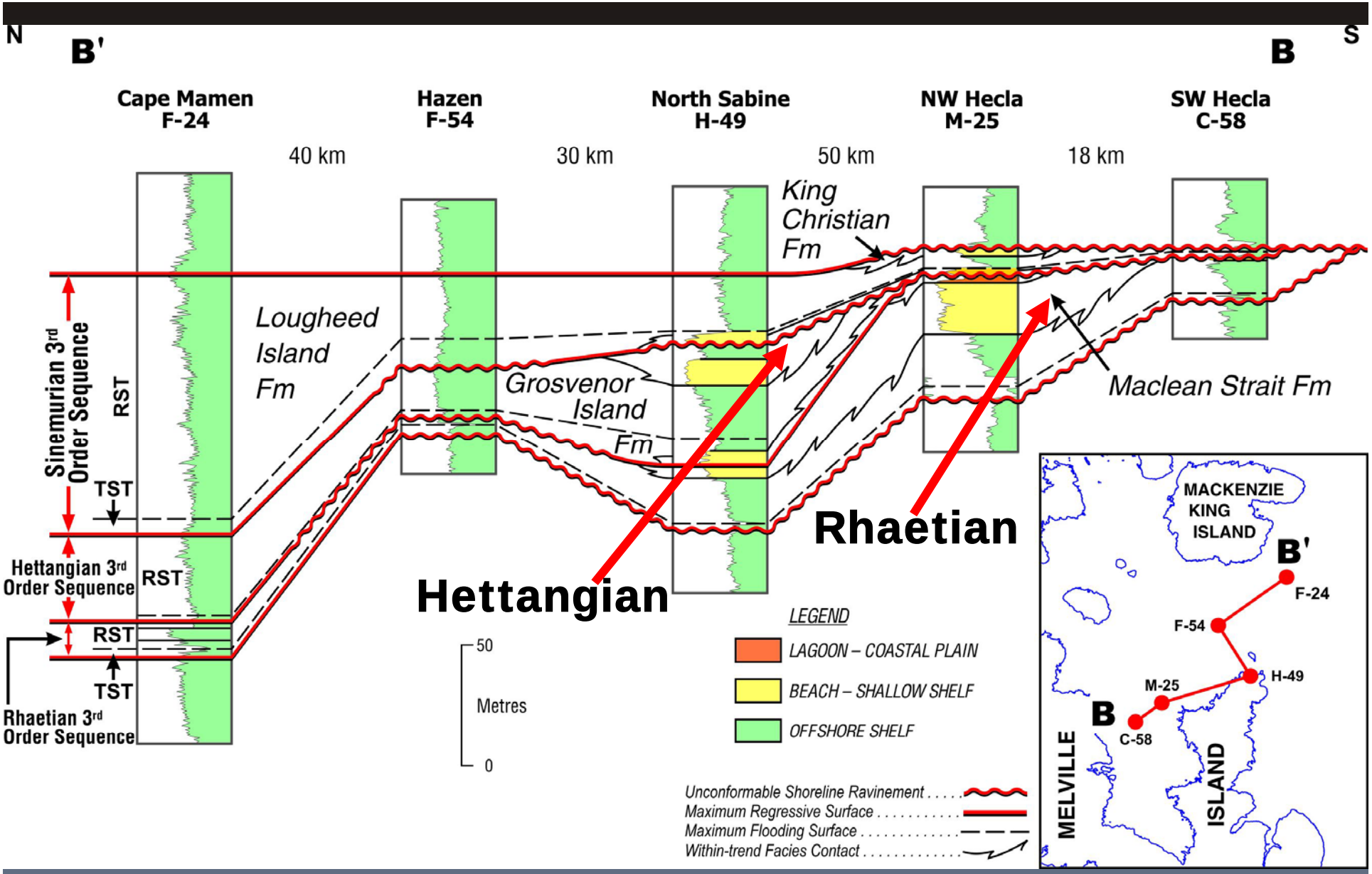


Norian Sandstone Pinchouts

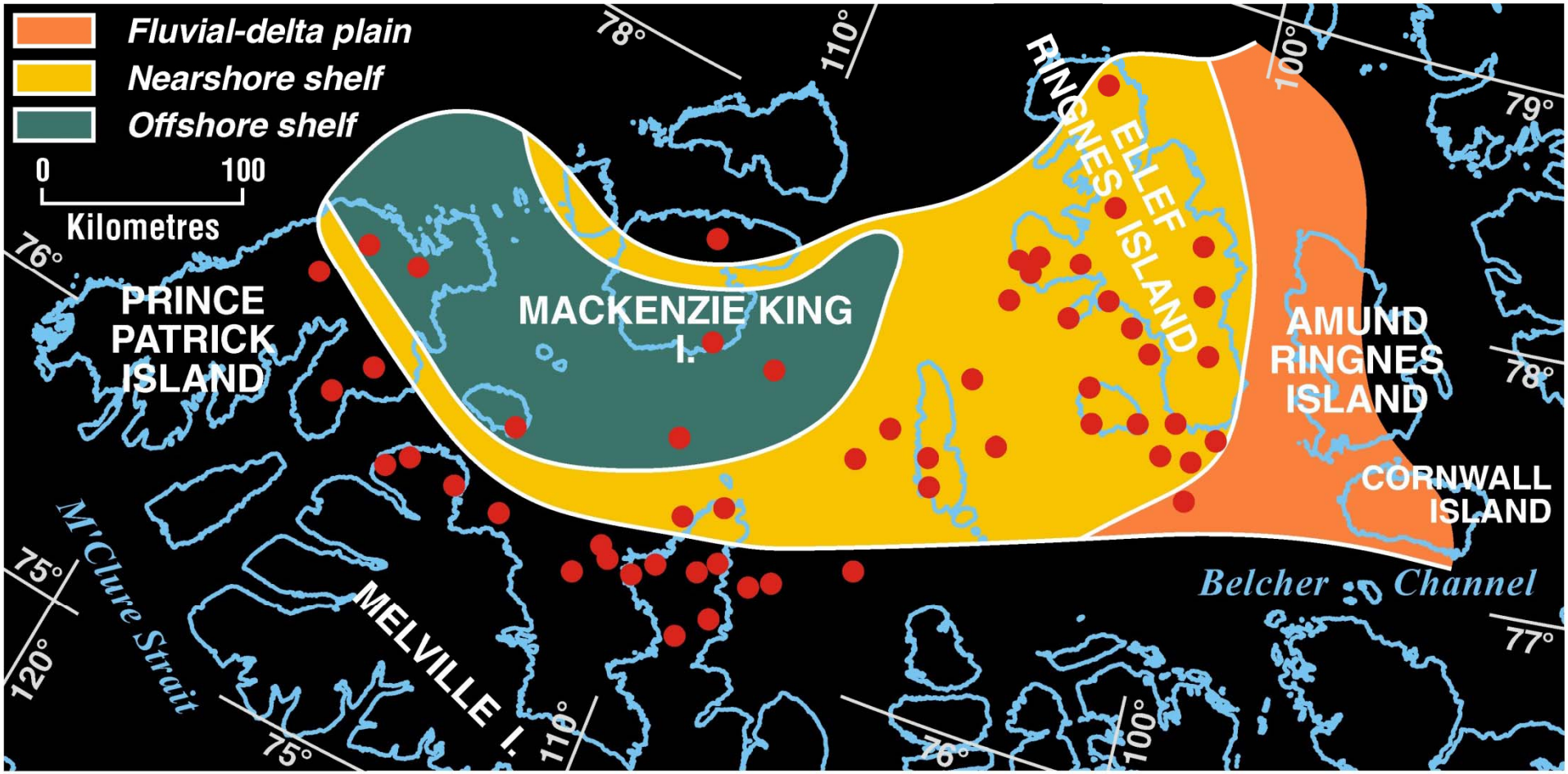

LEGEND
SANDSTONE DOMINANT
SHALE-SILTSTONE DOMINANT
CHERTY SHALE
LIMESTONE DOMINANT
Sequences
3rd Order
2nd Order
1st Order
K
JURASSIC
TRIASSIC
PERMIAN
Hauterivian
Valanginian
Berriasian
Tithonian
Kimmeridgian
Oxfordian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Rhaetian
Norian
Carnian
Ladinian
Anisian
Olenekian
Induan
Isachsen
Deer Bay
Awingak
Ringnes
Hiccles Cove
McConnell Island
Sandy Point
Jameson Bay
King Christian
Lougheed I.
MacLean Strait
Heiberg
Grosvenor I.
Skybattle
Barrow
Pat Bay
Hoyle Bay
Gore Point
Roche Point
Murray Harbour
Bjorne
Blind Fiord
Van Hauen
Valanginian
Tithonian-Berriasian
Oxfordian-Kimmeridgian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Rhaetian
Late Norian
Early Norian
Late Carnian
Middle Carnian
Early Carnian
Ladinian
Anisian
Spathian
Smithian
Griesbachian-Dienerian
Oxfordian-Valanginian
Bajocian-Callovian
Pliensbachian-Aalenian
Rhaetian-Sinemurian
Norian
Carnian
Middle Triassic
Early Triassic
1
2
3
Early Jurassic



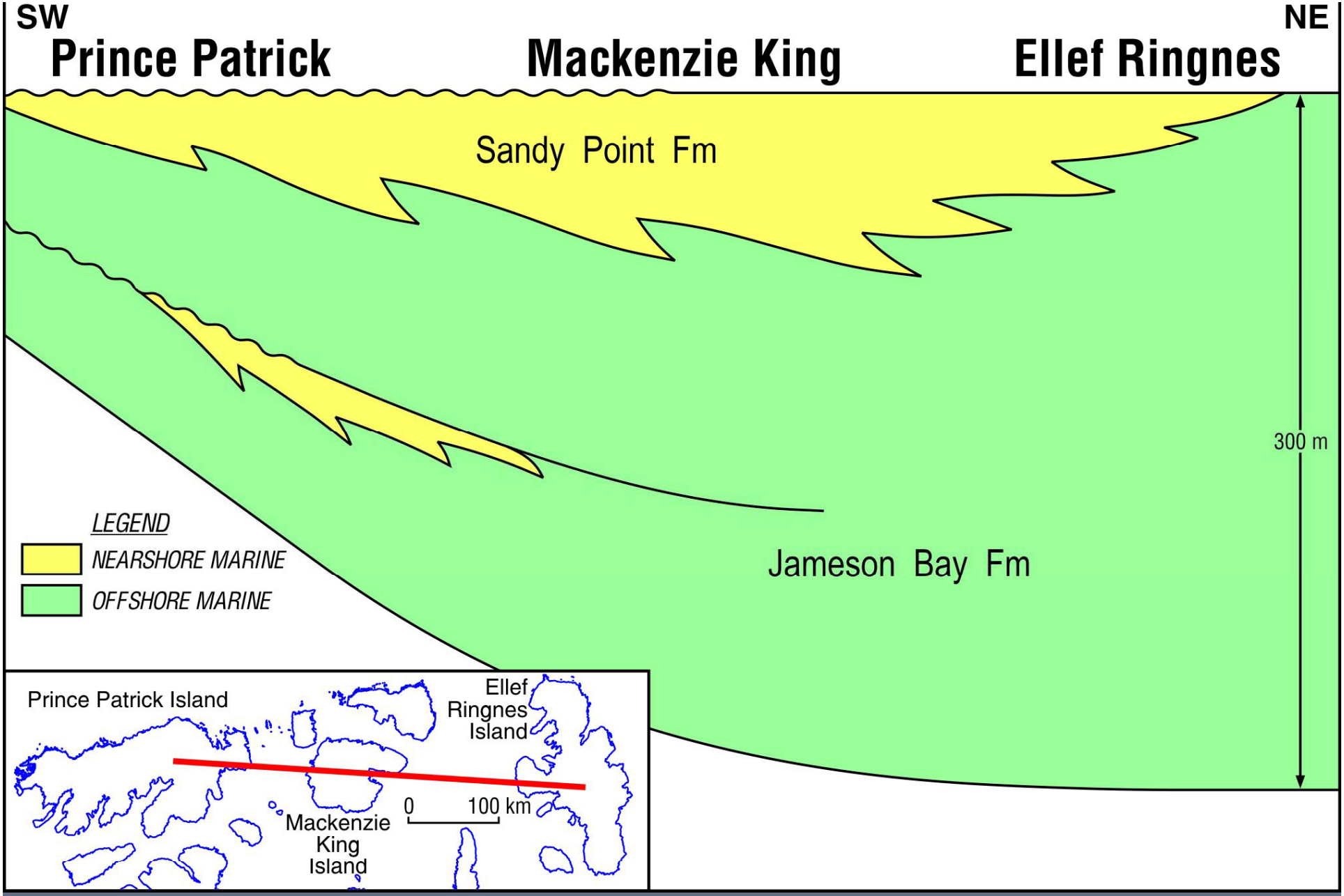
Latest Triassic – Early Jurassic Stratigraphy



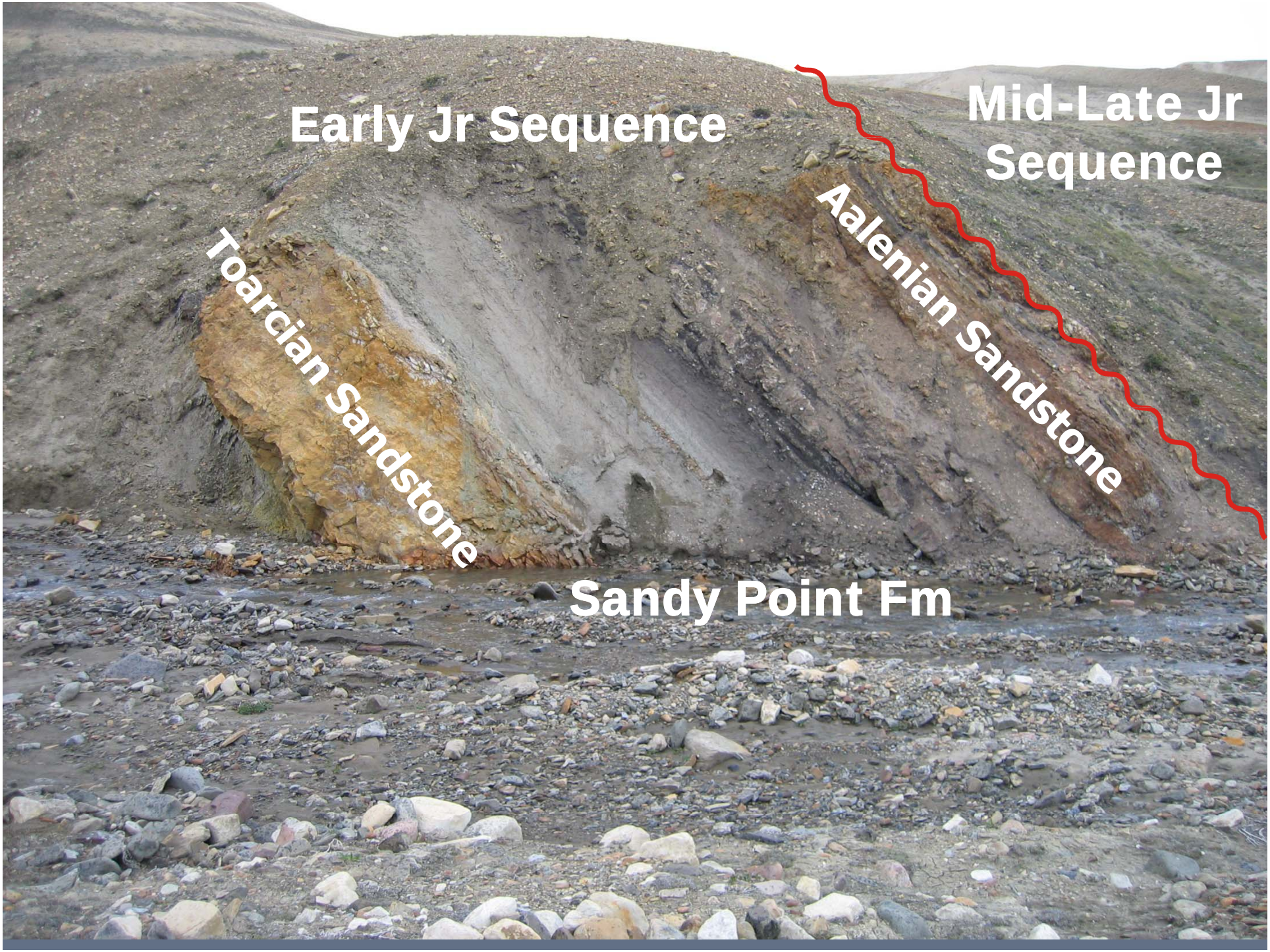
Truncation and Pinchouts of the Rhaetian and Hettangian Sandstone Units

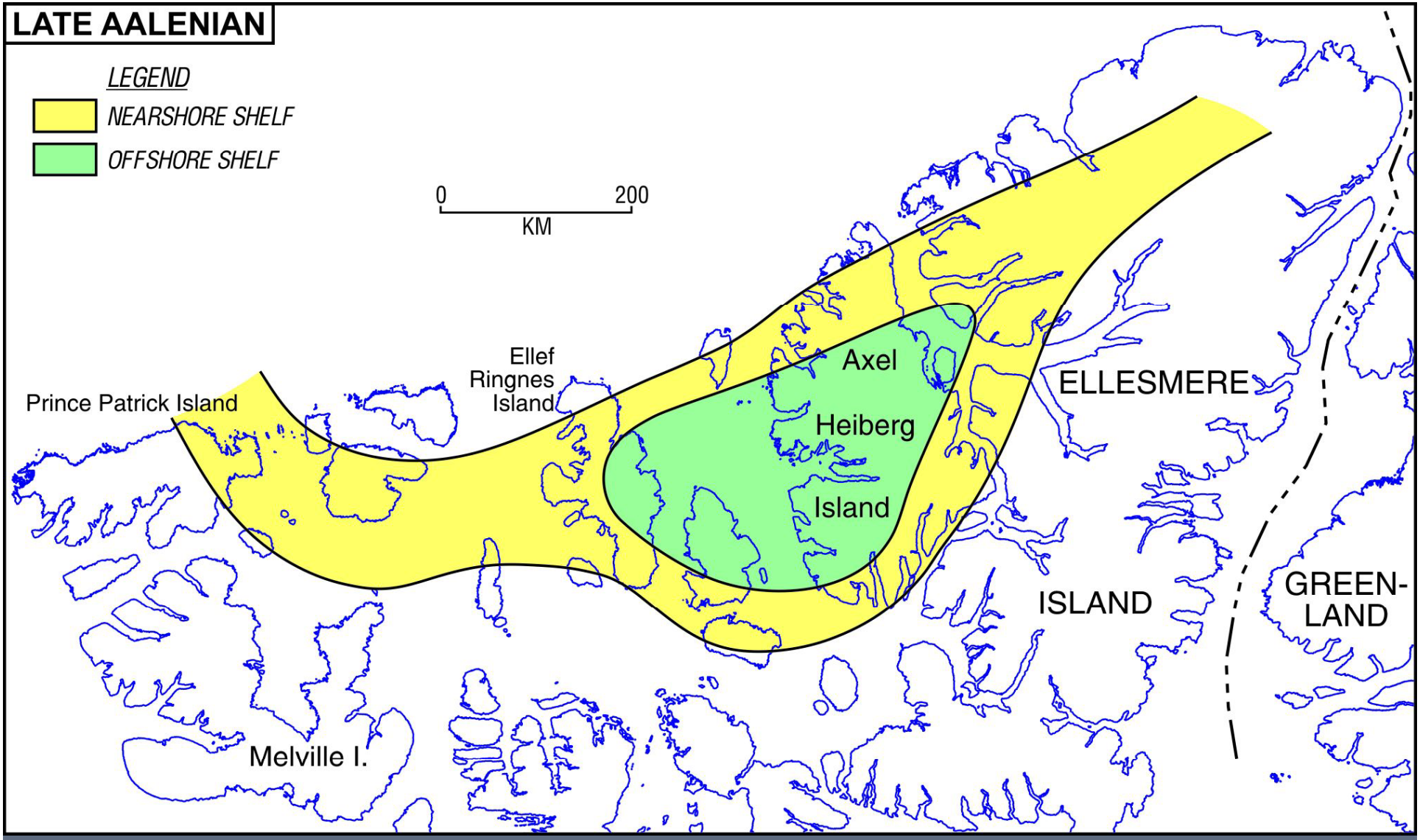


Hettangian Facies

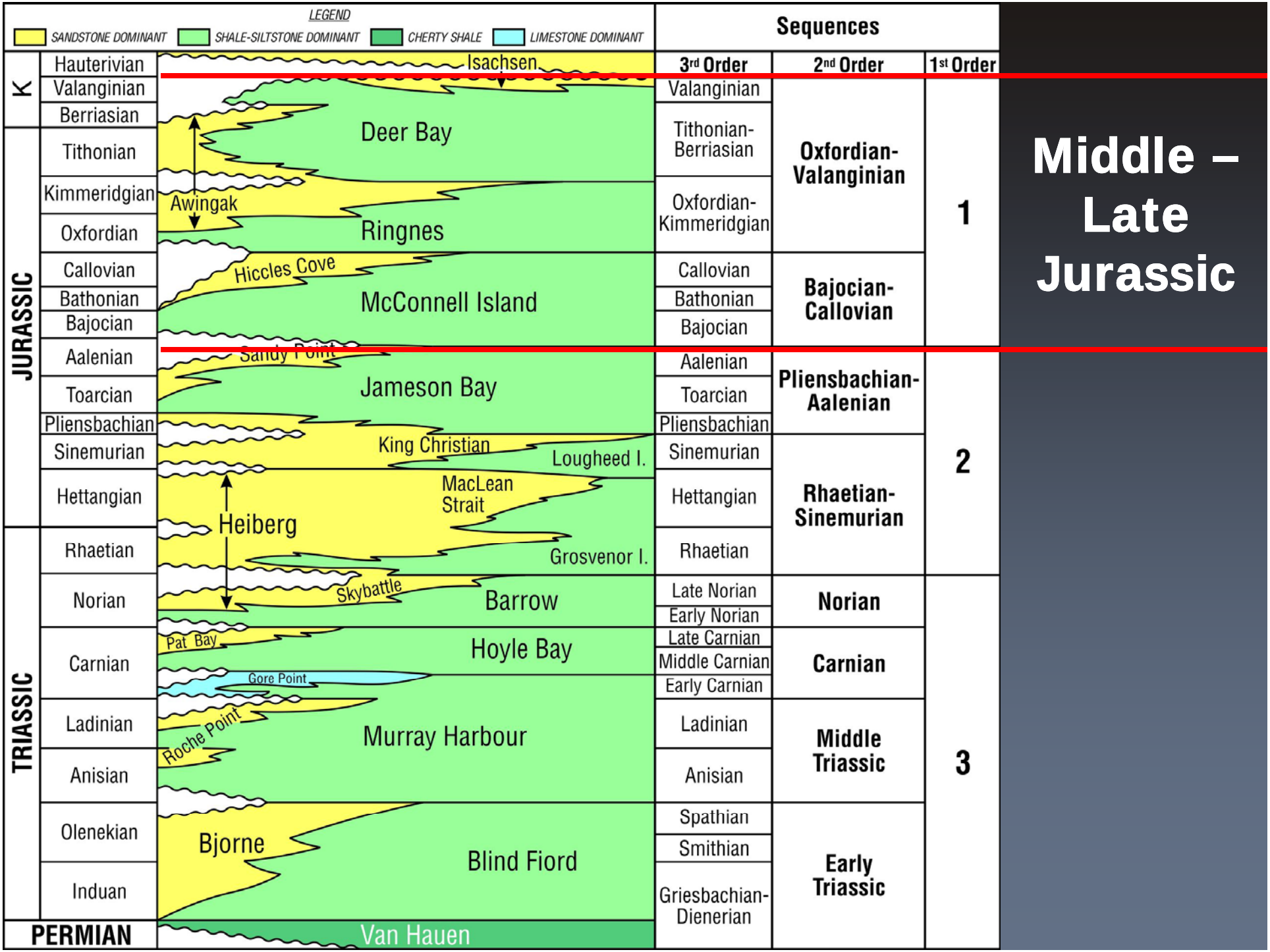


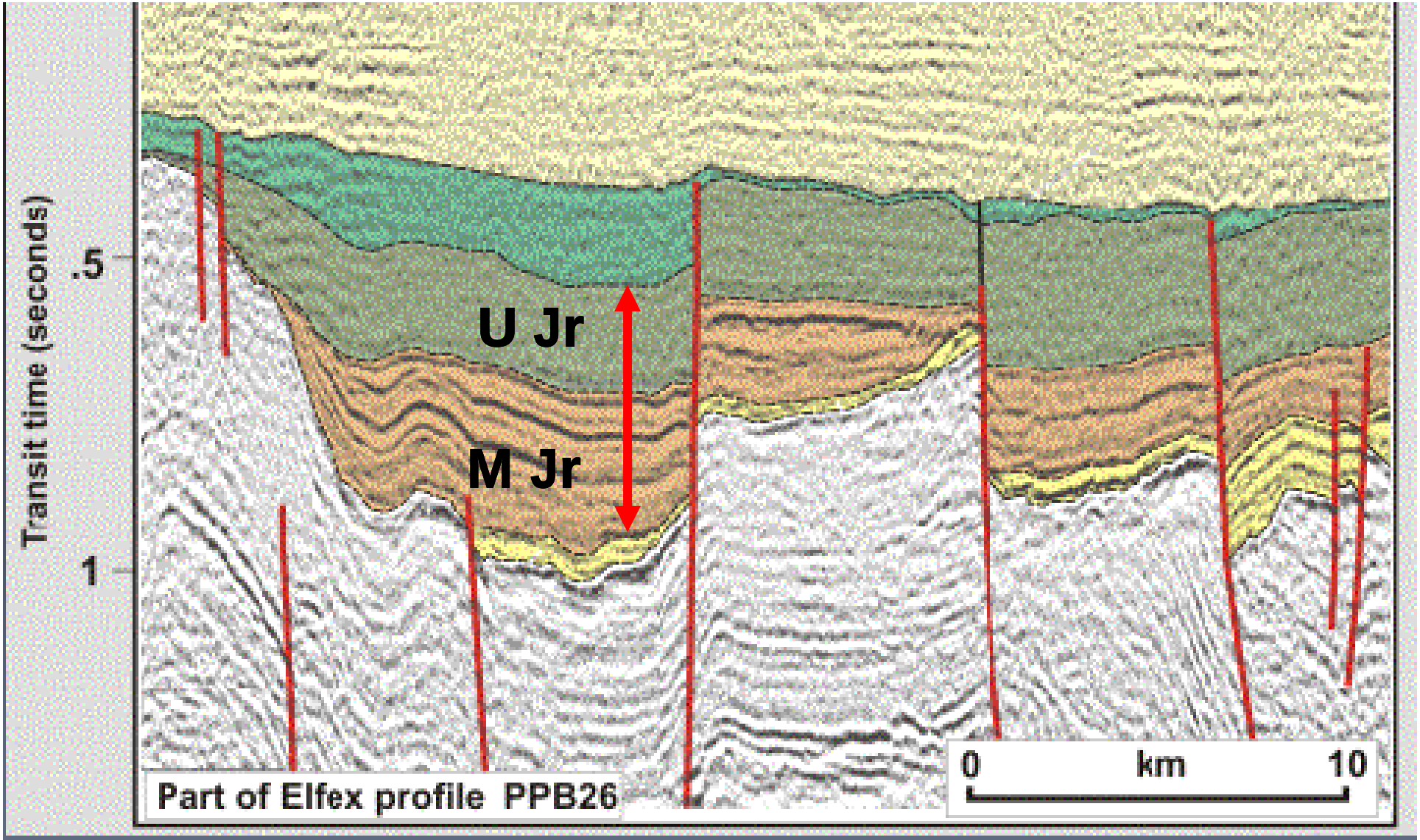
Early- Middle Jurassic Sandstone Pinchouts


Early Jr Sequence
Mid-Late Jr Sequence
Toarcian Sandstone
Aalenian Sandstone
Sandy Point Fm

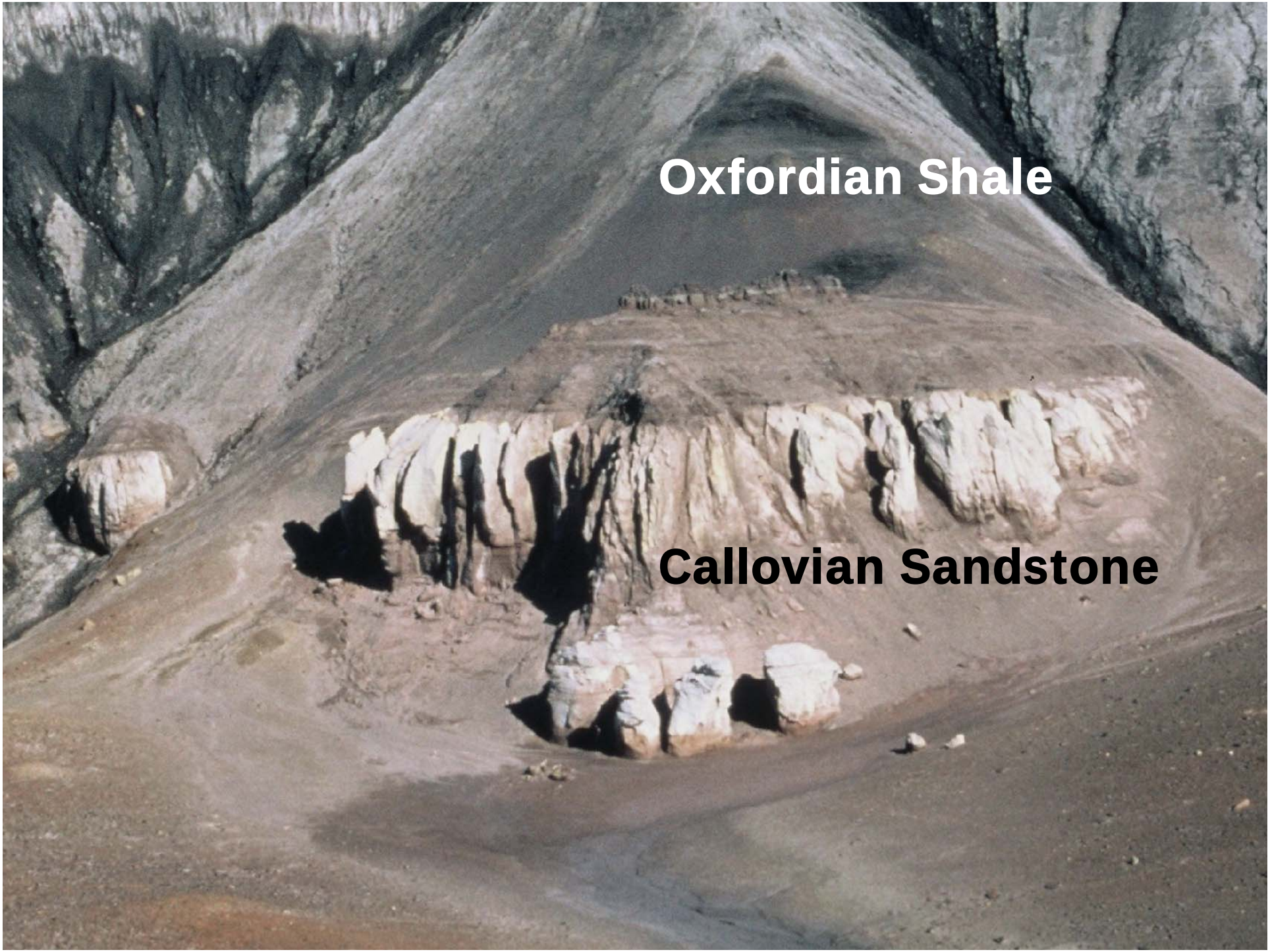


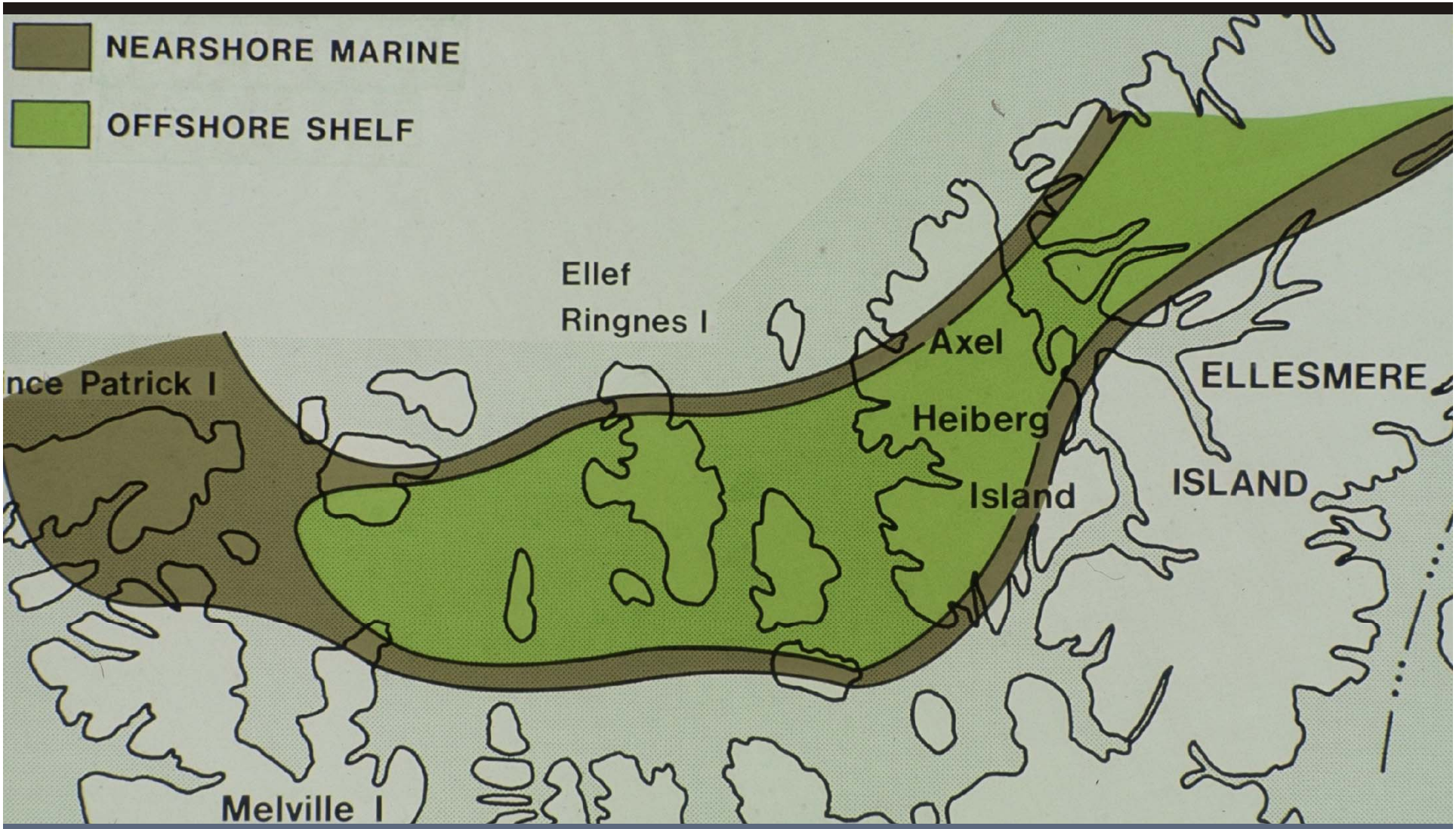
Early Middle Jurassic Sandstone Distribution


LEGEND
SANDSTONE DOMINANT
SHALE-SILTSTONE DOMINANT
CHERTY SHALE
LIMESTONE DOMINANT
Sequences
3rd Order
2nd Order
1st Order
K
JURASSIC
TRIASSIC
PERMIAN
Hauterivian
Valanginian
Berriasian
Tithonian
Kimmeridgian
Oxfordian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Rhaetian
Norian
Carnian
Ladinian
Anisian
Olenekian
Induan
Isachsen
Deer Bay
Awingak
Ringnes
Hiccles Cove
McConnell Island
Sandy Point
Jameson Bay
King Christian
Lougheed I.
MacLean Strait
Heiberg
Grosvenor I.
Skybattle
Barrow
Pat Bay
Hoyle Bay
Gore Point
Roche Point
Murray Harbour
Bjorne
Blind Fiord
Van Hauen
Valanginian
Tithonian-Berriasian
Oxfordian-Kimmeridgian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Rhaetian
Late Norian
Early Norian
Late Carnian
Middle Carnian
Early Carnian
Ladinian
Anisian
Spathian
Smithian
Griesbachian-Dienerian
Oxfordian-Valanginian
Bajocian-Callovian
Pliensbachian-Aalenian
Rhaetian-Sinemurian
Norian
Carnian
Middle Triassic
Early Triassic
1
2
3
Middle – Late Jurassic

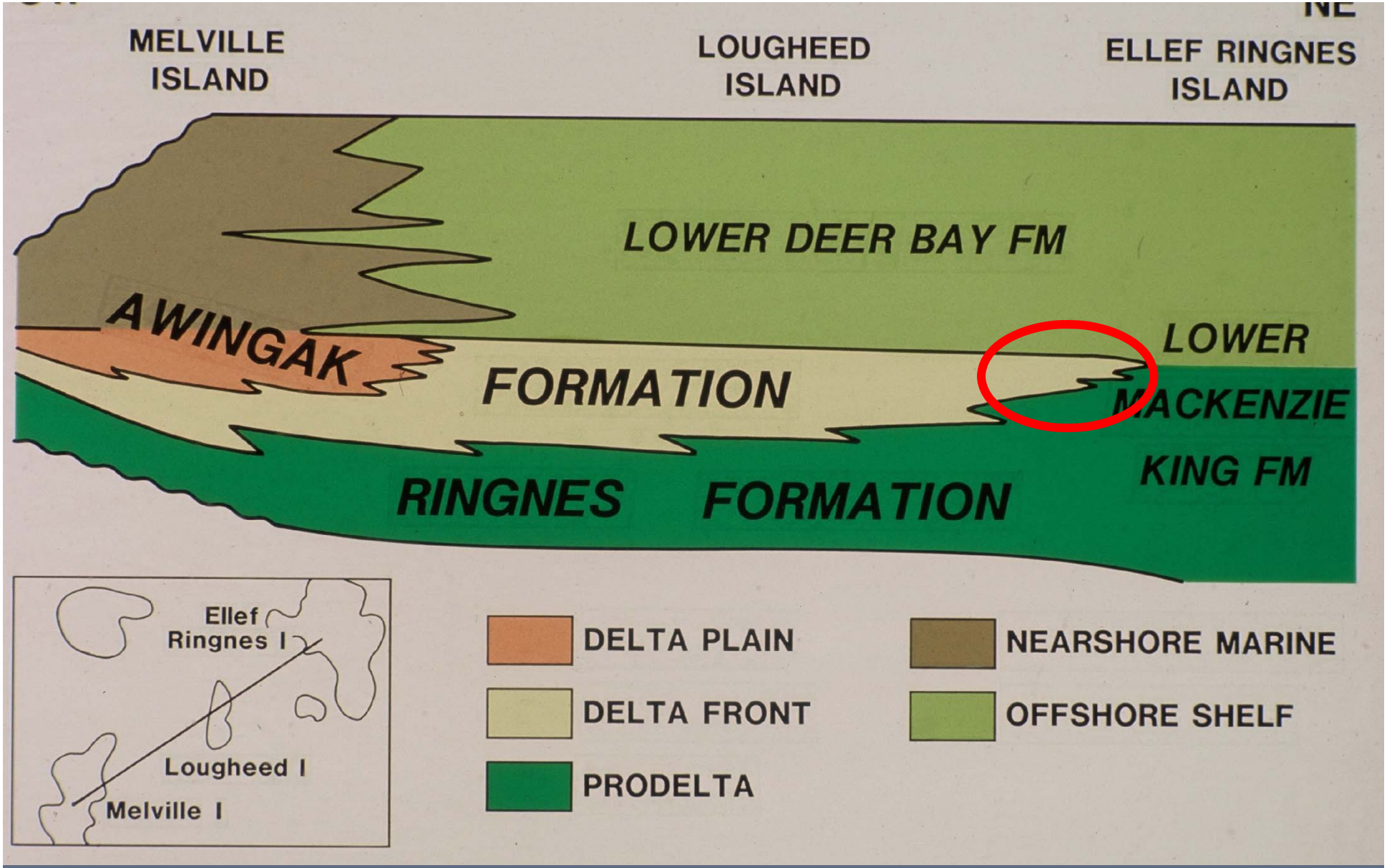


Initiation of Amerasia Basin Rifting at Base Bajocian

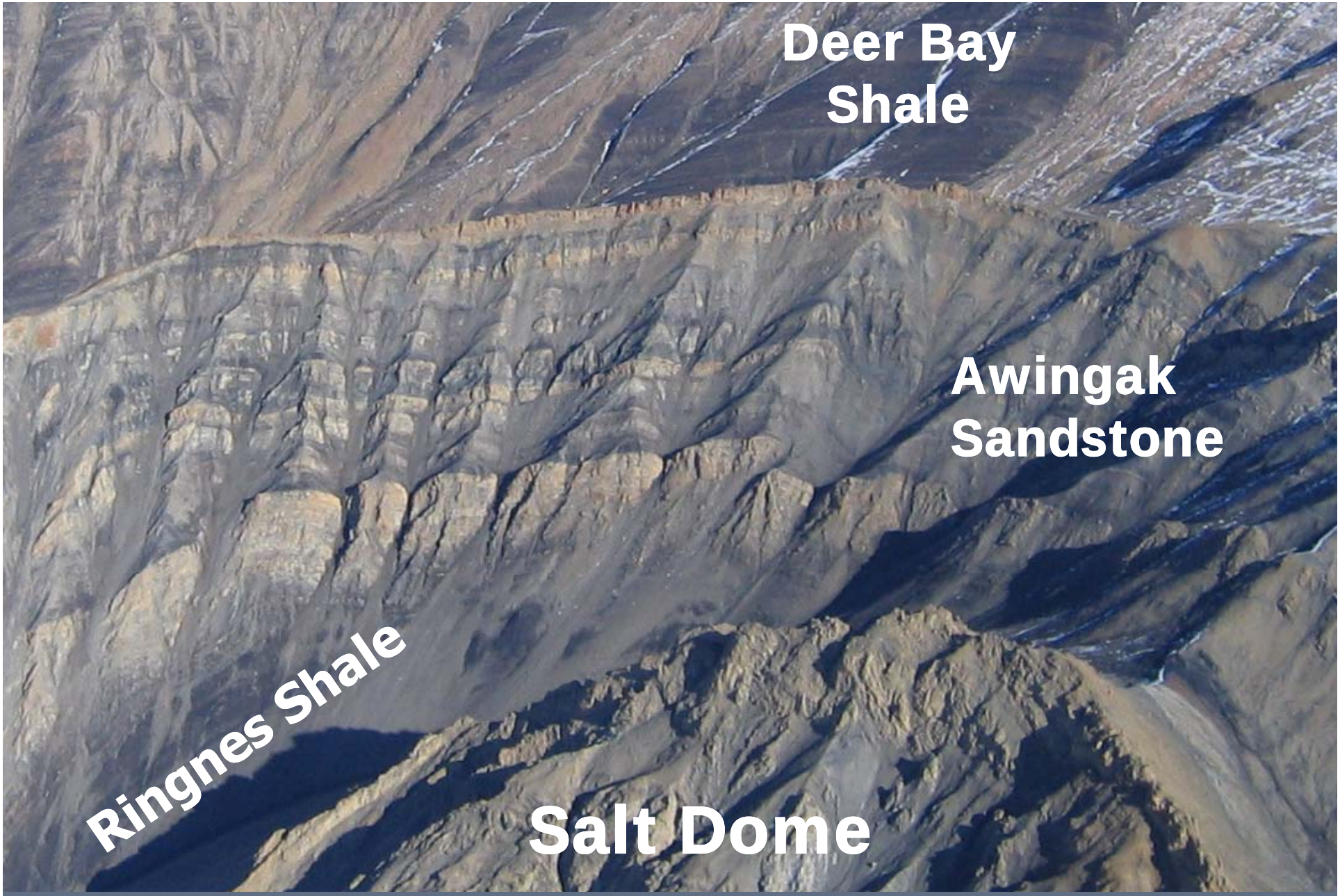

Oxfordian Shale
Callovian Sandstone



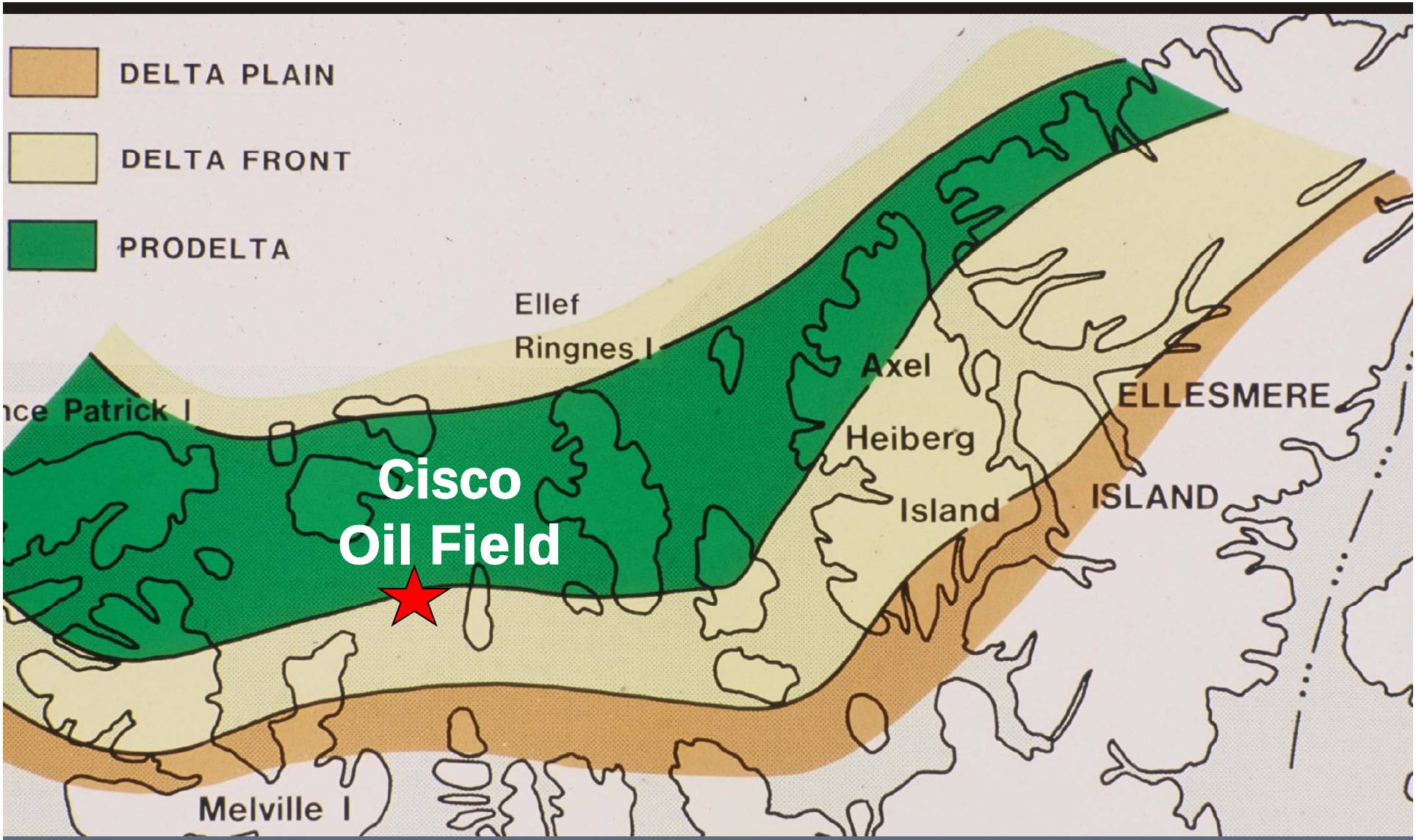
Late Callovian Paleogeography



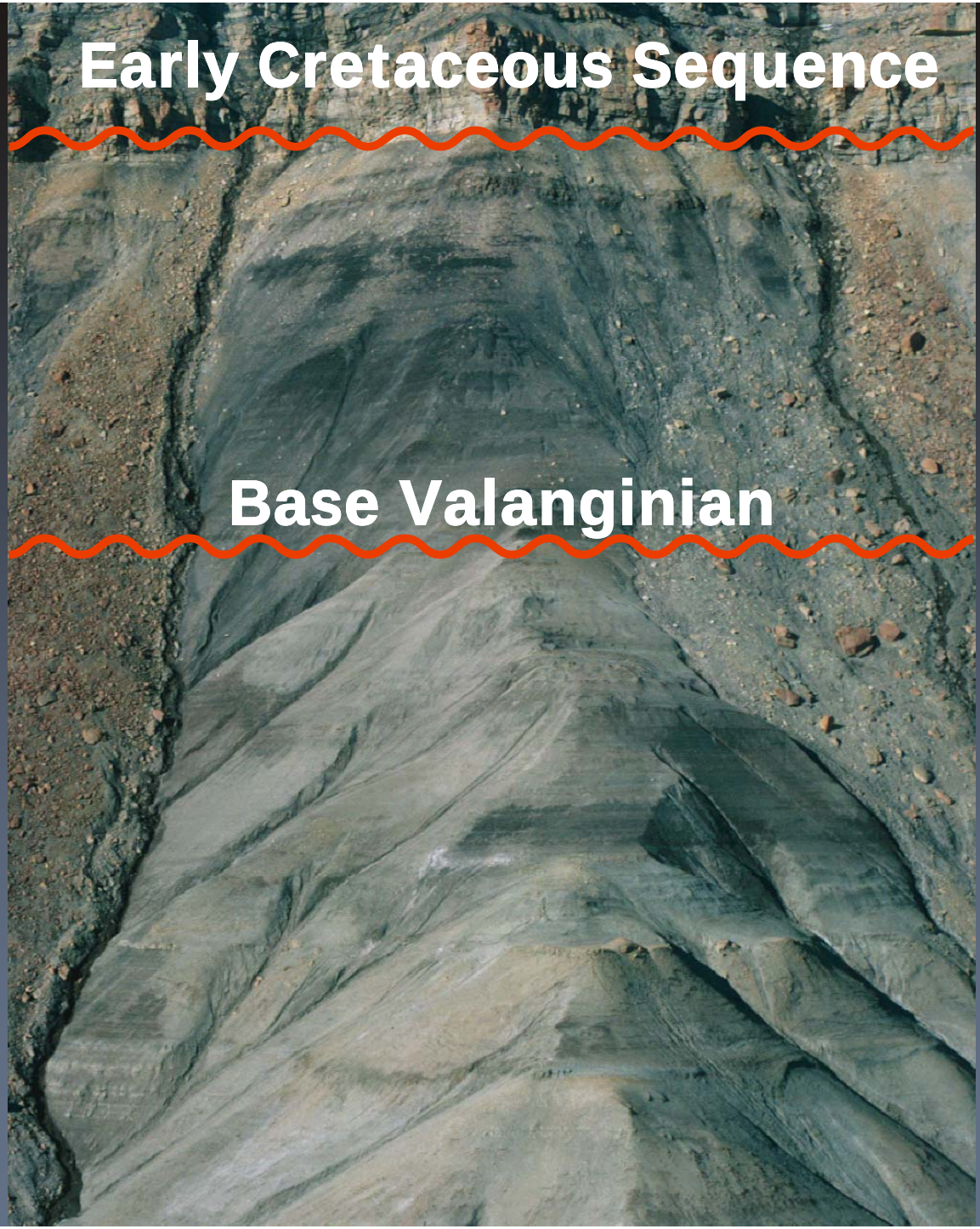
Late Jurassic Stratigraphy



Late Jurassic Strata



Kimmeridgian Paleogeography


Early Cretaceous Sequence
Base Valanginian

Isolated, Coarse-Grained Sandstone Units Occur at the Base of the Valanginian Sequence

Isolated Sandstone Unit at the Base of the Valanginian Sequence

Conclusions

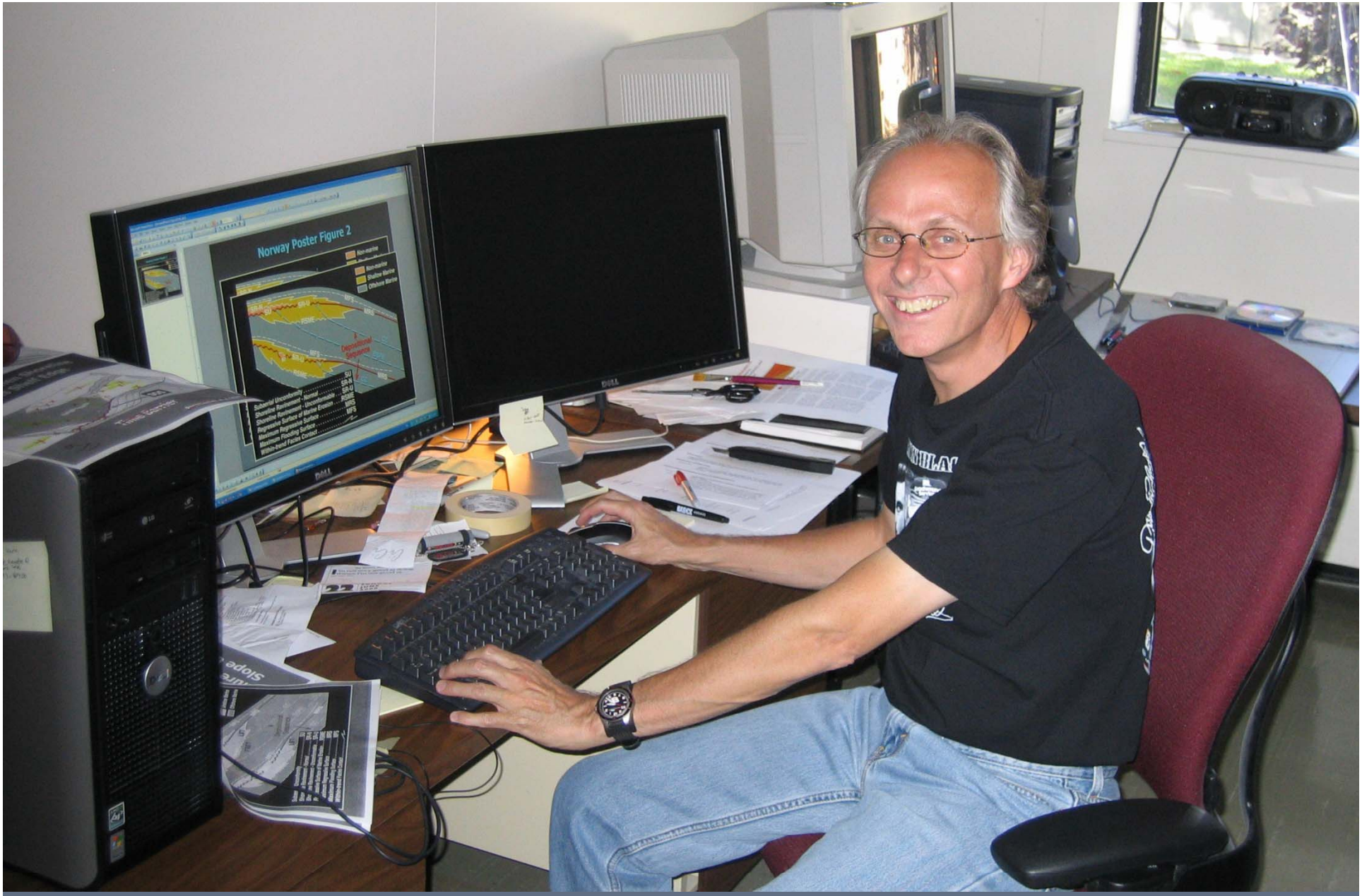
- **Rich Oil-prone source rocks of Middle-Late Triassic age extend throughout the Sverdrup Basin and copious quantities of oil were generated in the Cretaceous.**
- **Numerous stratigraphic traps which are associated with sandstone truncation and pinchouts occur in the Triassic to Jurassic succession and many likely escaped later gas flushing.**

Conclusions

- **The Triassic to Jurassic succession is highly prospective for oil in the western portion of the basin and over smaller areas on the eastern and southeastern flanks of the basin.**

Thank You To:

Geological Survey of Canada for Continued Support



Dave Sargent for Art Work