Paleo-Ballantyne Strait of the Sverdrup Basin - Late Paleozoic and Early Mesozoic Gateway to Alaska*

Ashton Embry[1] and Tom Brent[1]

Search and Discovery Article #50369 (2010)
Posted December 31, 2010

*Adapted from oral presentation at AAPG Conference and Exhibition, Calgary, Alberta, Canada, September 12-15, 2010

[1]GSC, Calgary, AB, Canada. (aembry@nrcan.gc.ca)

Abstract

The Sverdrup Basin of Arctic Canada formed in Early Carboniferous and was an active area of subsidence and deposition until Late Eocene. Throughout the basin history, the main sediment source areas lay to the south and east and consisted primarily of Devonian clastic strata. From Carboniferous to Middle Jurassic, that is, before the opening of the oceanic Amerasia Basin, the Sverdrup Basin was flanked to the northwest by a land mass known as Crockerland. Facies relationships in the far northeastern portion of the basin, demonstrate that the Late Paleozoic -Mesozoic seaway continued northeastward between the two landmasses and linked up to the seaways in the Barents Sea region.

Before any well or seismic data were available, there was uncertainty regarding the continuation of the Late Paleozoic-Mesozoic seaway to the west past the present day Canadian Arctic Islands. The well and seismic data in the southwestern corner of the basin show that, from Carboniferous through early Middle Jurassic, the seaway did indeed continue to the west and that the basin axis in this area was oriented west-northwest. This axis now hits the current Arctic Ocean (Amerasia Basin) margin at right angles. Because this axis occurs within present day Ballantyne Strait, we have called the narrow seaway between the Paleozoic Fold Belt to the south and Crockerland to the north, Paleo-Ballantyne Strait.

The occurrence of this narrow seaway, which hits the Amerasia Basin at right angles, provides an important constraint on any proposed model for the opening of the Amerasia Basin. In any proposed reconstruction, a continuation of the seaway must be present on the crustal block that is placed adjacent to this portion of the Canadian Arctic margin. Notably, a very similar, narrow Late

Paleozoic to Mesozoic seaway called the Central Chukchi Basin is present west of northern Alaska. The axis of the Central Chukchi Basin also hits the Amerasia Basin at right angles. Restoration of northern Alaska and adjacent northeast Russia against the Canadian margin by clockwise rotation results in a perfect match of these two basin axes. It seems reasonable to conclude that the Amerasia Basin opened by counterclockwise rotation and that Paleo-Ballantyne Strait was the Gateway to Alaska. Given this, the geology of the southwestern Sverdrup Basin has much to offer those who are contemplating exploration in the Chukchi Basin.

References

Carey, S.W., 1958, The tectonic approach to continental drift, *in* S.W. Carey, (ed.) Continental Drift, A Symposium: Geology Department, University of Tasmania, Hobart, p. 177-356.

Balkwill, H.R., 1978, Evolution of Sverdrup Basin, Arctic Canada: AAPG Bulletin, v. 62/6, p. 1004-0128.

Brosge, W.P. and I.L. Tailleur, 1969, Isopach maps of upper Paleozoic and Mesozoic rocks, northern Alaska: USGS Open File Report 69-26, 10 p.

Grantz, A., M. Holmes, and B.A. Kososki, 1975, Geologic framework of the Alaskan continental terrace in the Chukchi and Beaufort seas: Canadian Society of Petroleum Geologists Memoir, v. 4, p. 669-700.

Grantz, A., L. Johnson, J.F. Sweeney, O. Edholm, R.K.H. Falconer, D.M. Hopkins, Y. Kristoffersen, H.C. Larsen, and J. Thiede, 1982, The Arctic region, *in* Decade of North American Geology (DNAG), GSA Special Publication, p. 105-115.

Grantz, A., S.D. May, and P.E. Hart, 1990, Geology of the Arctic continental margin of Alaska *in* A. Grantz, G.L. Johnson, and J.F. Sweeney, eds., The Arctic Ocean region: North American Geology, v. L, p. 257-288.

Harland, R., 1984, Recent and late Quaternary dinoflagellate cysts from the area of the Greenland-Iceland-Faeroe-Scotland Ridge: Journal of Micropalaeontology, v. 3/2, p. 95-108.

Lane, L.S., 2007, Devonian-Carboniferous paleogeography and orogenesis, northern Yukon and adjacent Arctic Alaska: Canadian Journal of Earth Sciences, v. 44/5, p. 679-694.

Sherwood, K.W., J.D. Craig, J. Scherr, P.P. Johnson, and L.W. Cooke, 2002, Undiscovered oil and gas resources of U.S. arctic Alaska outer continental shelves: AAPG Bulletin, v. 86/6, p. 1159-1160.

Toro, J., F.C. Toro, K.J. Bird, and C. Harrison, 2004, The Arctic Alaska-Canada connection revisited: GSA Abstracts with Programs, v. 36/5, p. 22.

Website

National Oceanic and Atmospheric Administration (NOAA): Web accessed 14 December 2010, http://www.noaa.gov/wx.html

Paleo-Ballantyne Strait of the Sverdrup Basin – Late Paleozoic and Early Mesozoic Gateway to Alaska

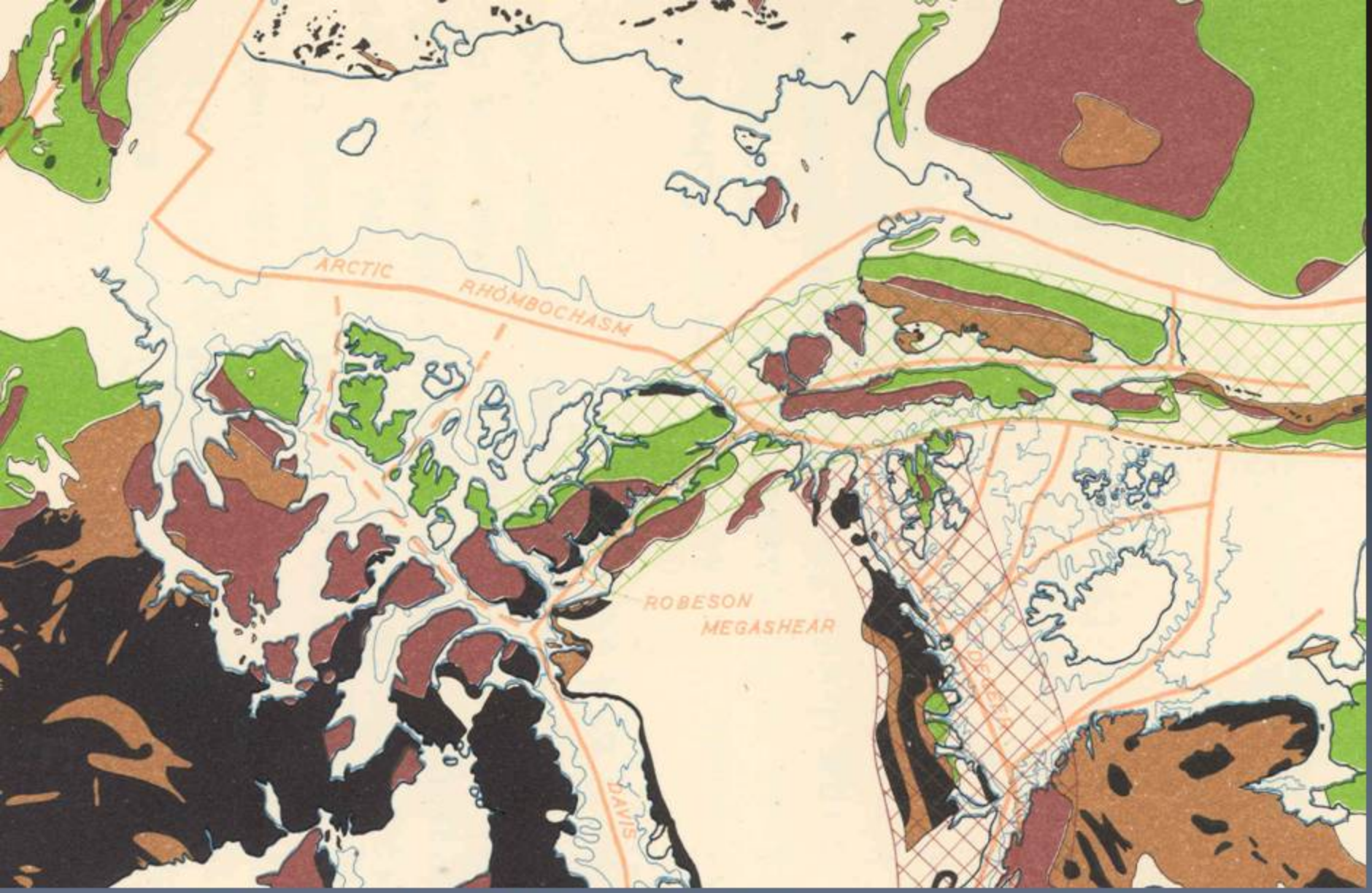
Ashton Embry and Tom Brent

Geological Survey of Canada

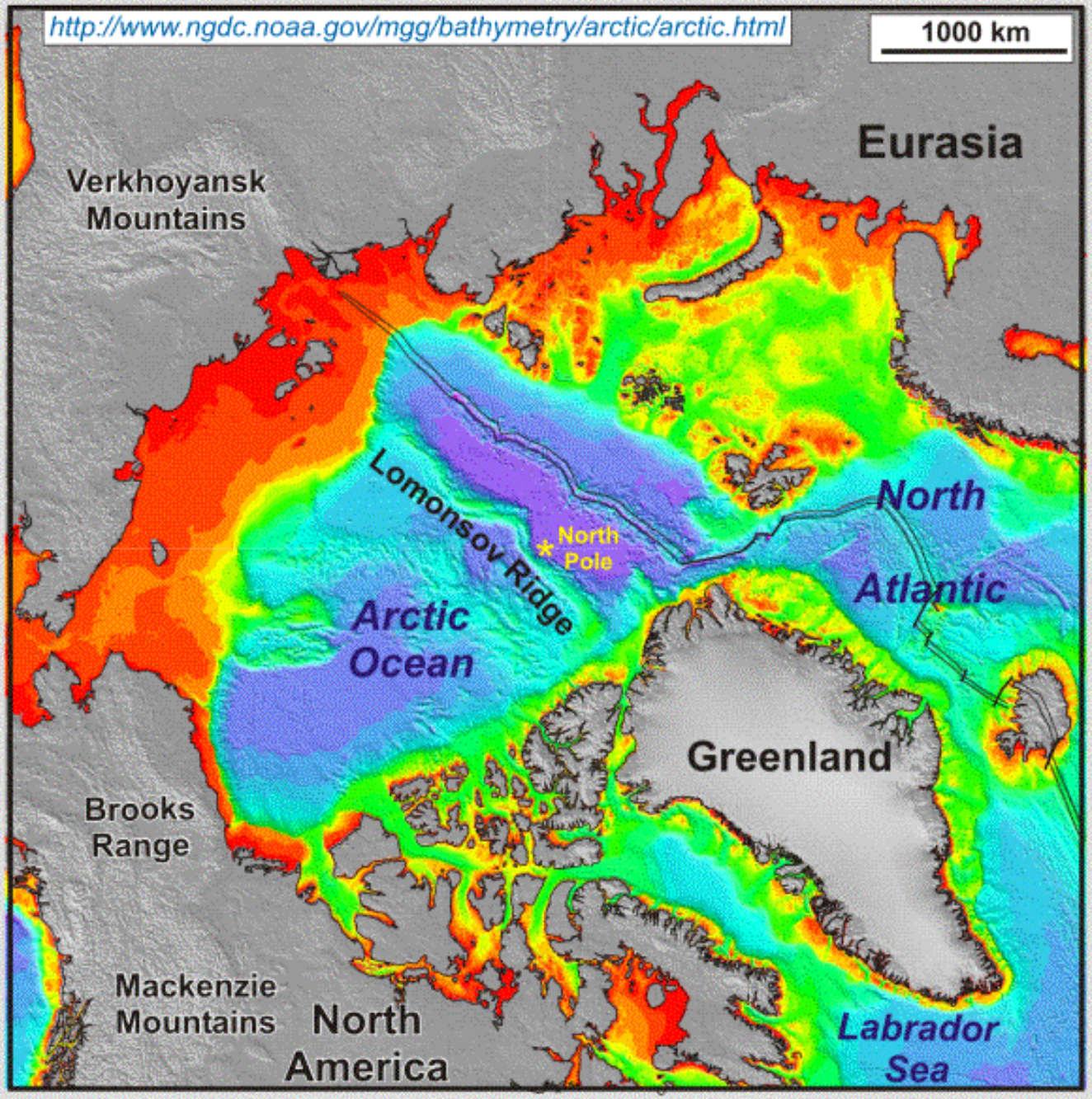

Paleo-Ballantyne Strait

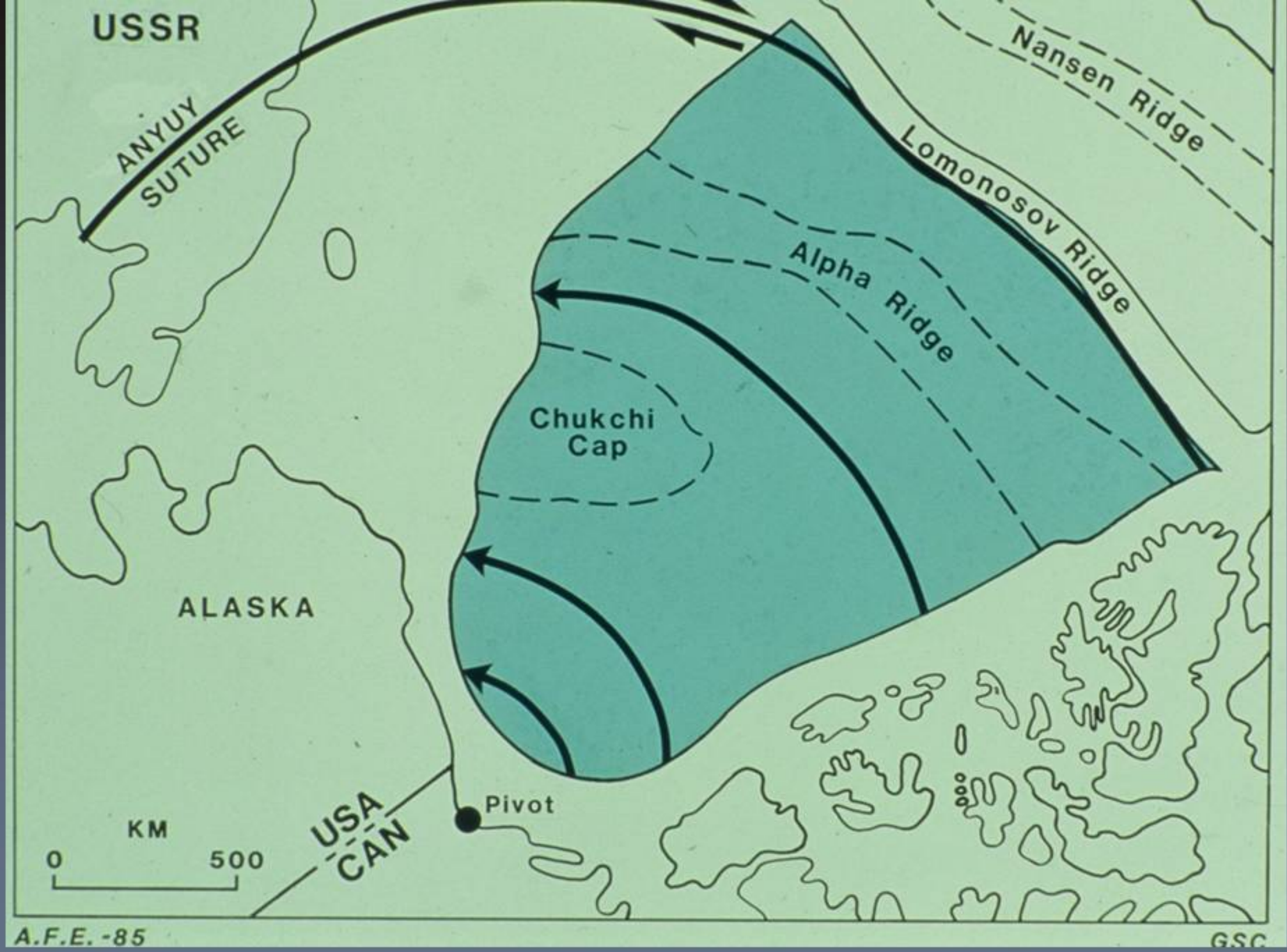
Three Models for Opening Amerasia Basin

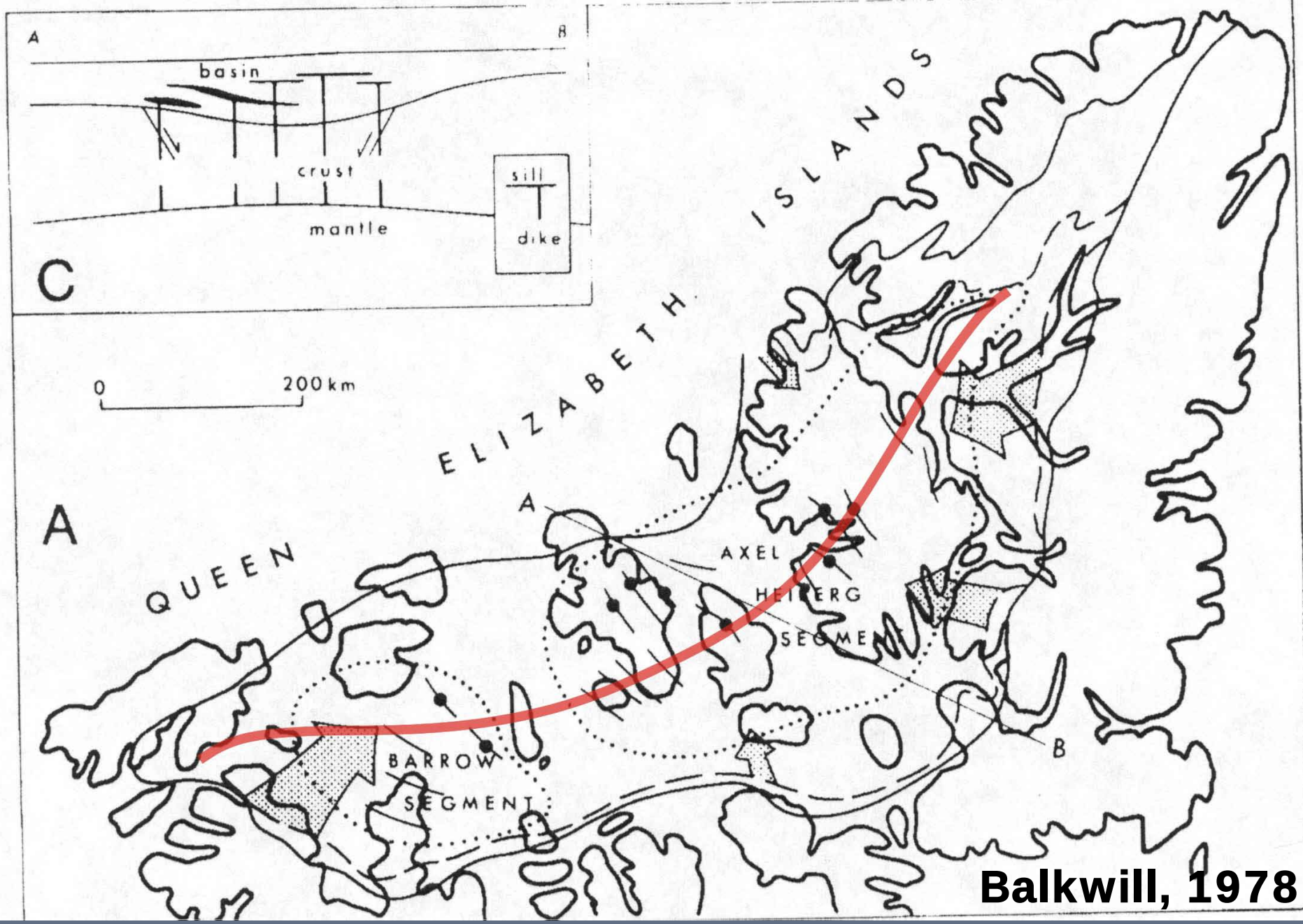
Carey's 1958 Rotation Hypothesis for Arctic Ocean



Carey's (1958) Closure of the Arctic Ocean


http://www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html
1000 km
Eurasia
Verkhoyansk Mountains
Lomonsov Ridge
North Pole
North Atlantic
Arctic Ocean
Greenland
Brooks Range
Mackenzie Mountains
North America
Labrador Sea
Relief and water depth
Shallow
Deep
Spreading ridge

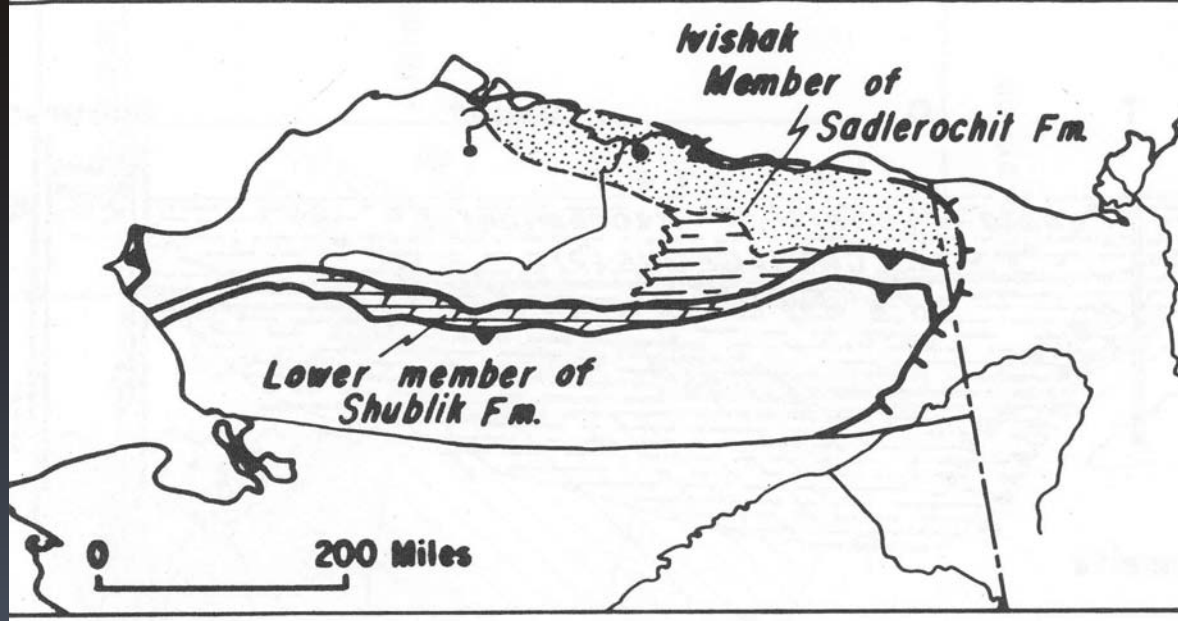

USSR
ANYUY SUTURE
Nansen Ridge
Lomonosov Ridge
Alpha Ridge
Chukchi Cap
ALASKA
Pivot
USA
CAN
KM
0
500
A.F.E. -85
GSC



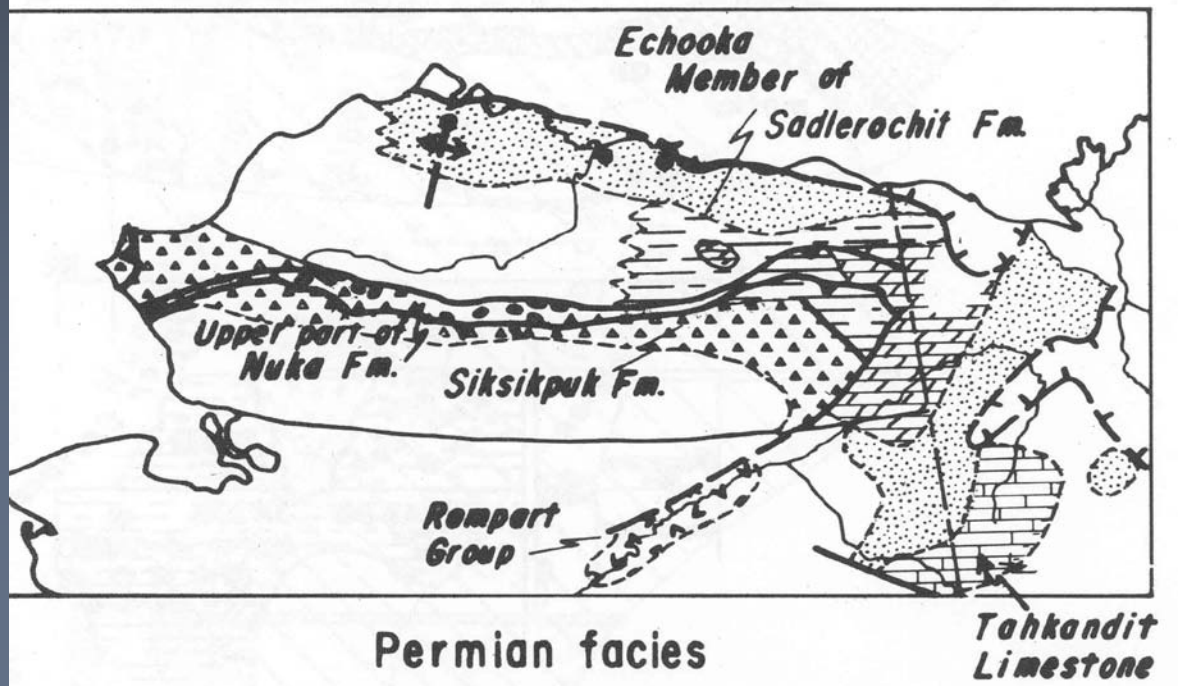
Pre-1980 Interpretation of SW Sverdrup Basin

Pre-1980 Interpretation of Mesozoic paleogeography, northern Alaska.

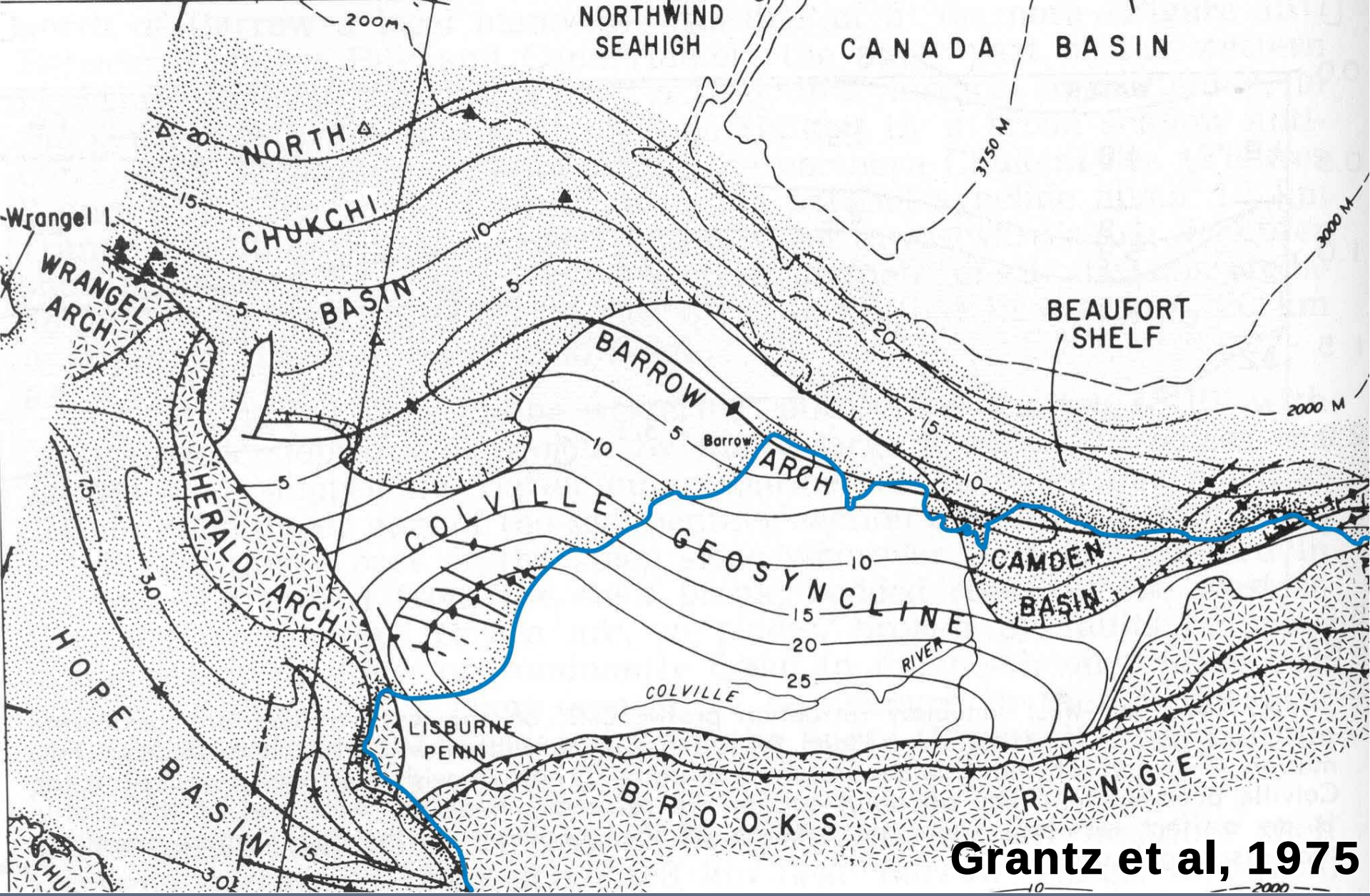
Brosge and Tailleur, 1969



Lower Triassic facies



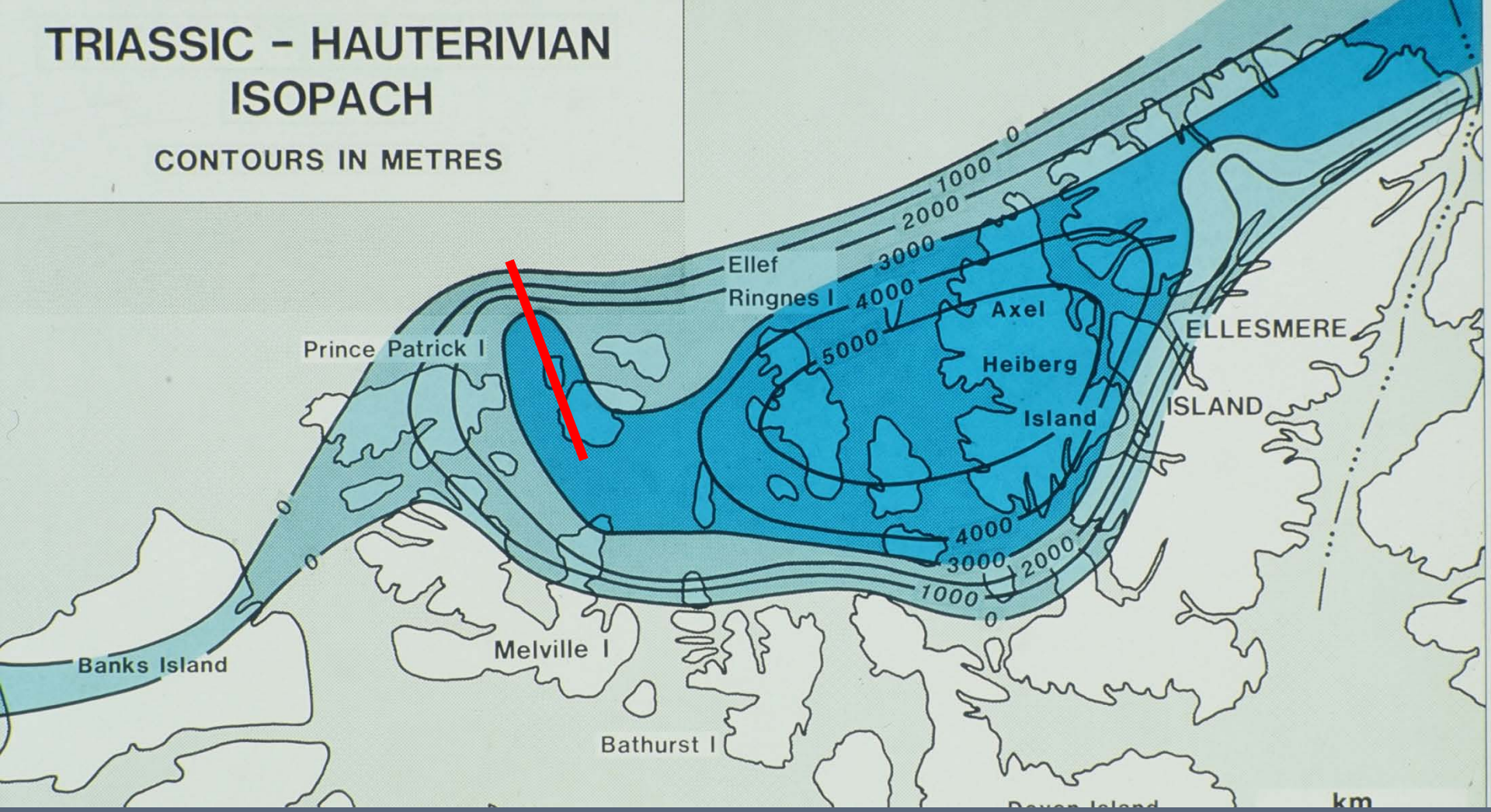
Permian facies



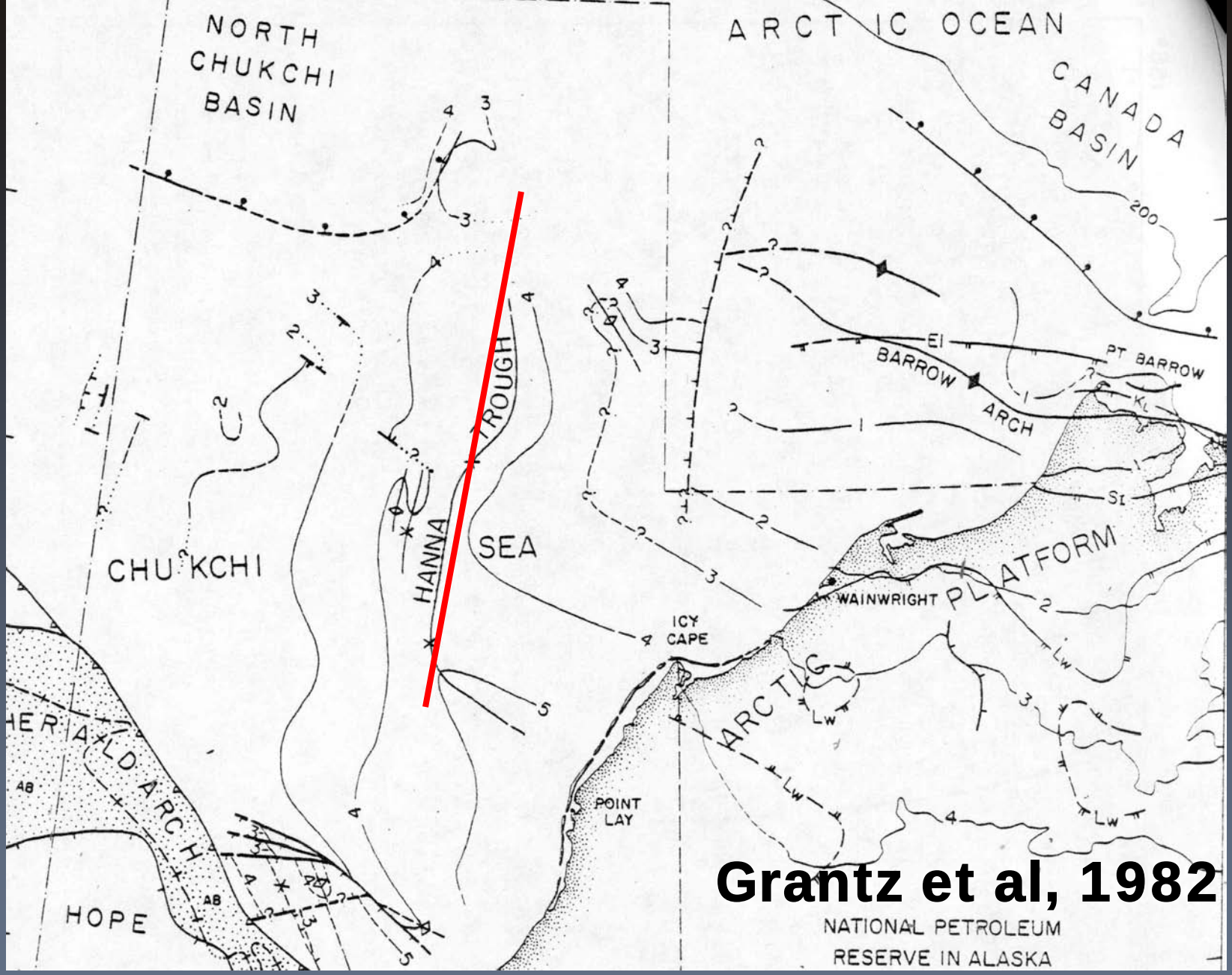
Grantz et al, 1975

Pre-1980 Interpretation of post –Devonian Basins, northern Alaska

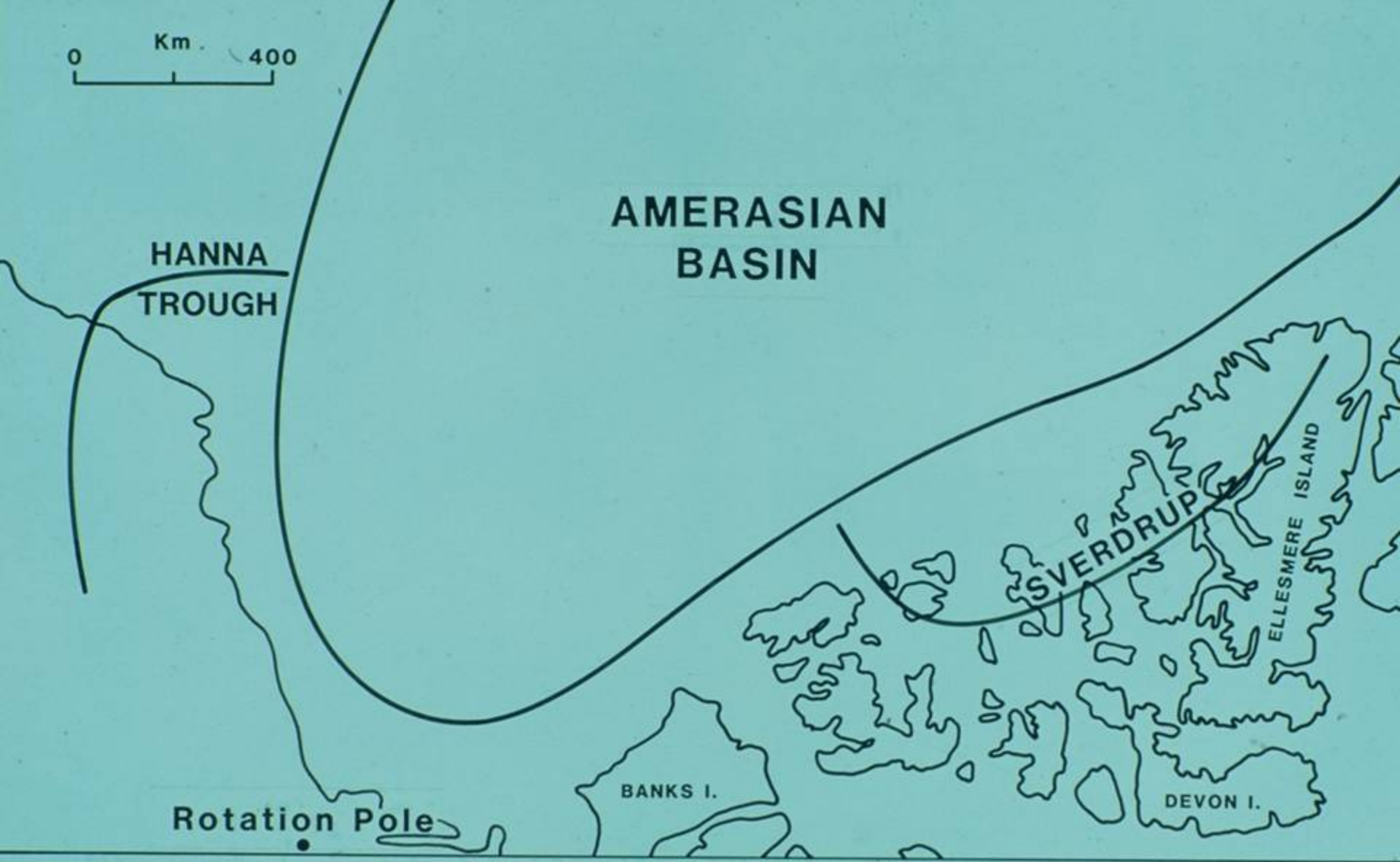
Tailleur and Brosge's 1969 attempt to use facies relationships to support the rotation of Alaska



1980 Birth of the Paleo-Ballantyne Strait Concept



Discovering the Hanna Trough

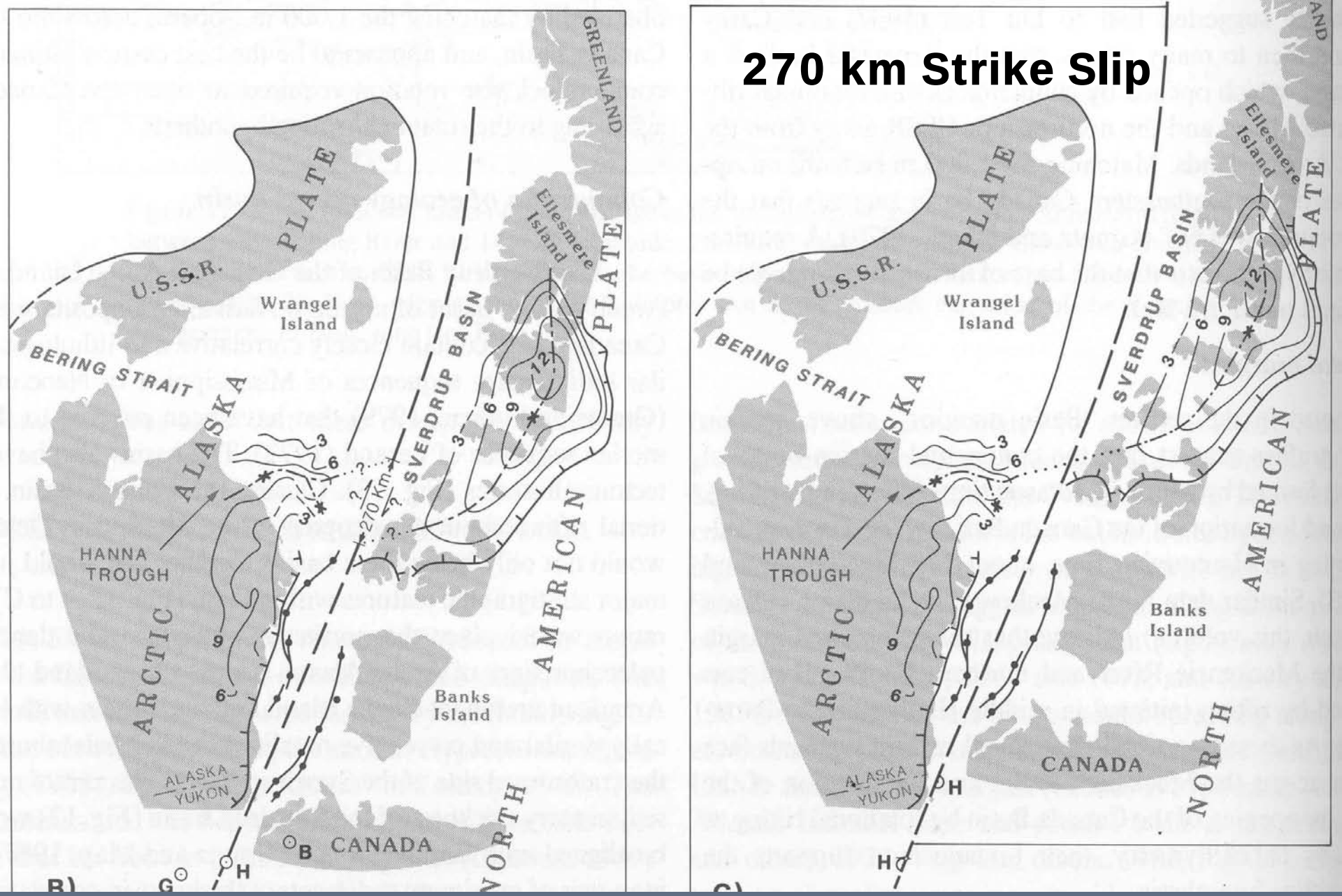


TRIASSIC - BASAL CRETACEOUS BASIN AXES

AFE-85

RESTORATION OF BASIN AXIS BY ROTATION

AFE-85



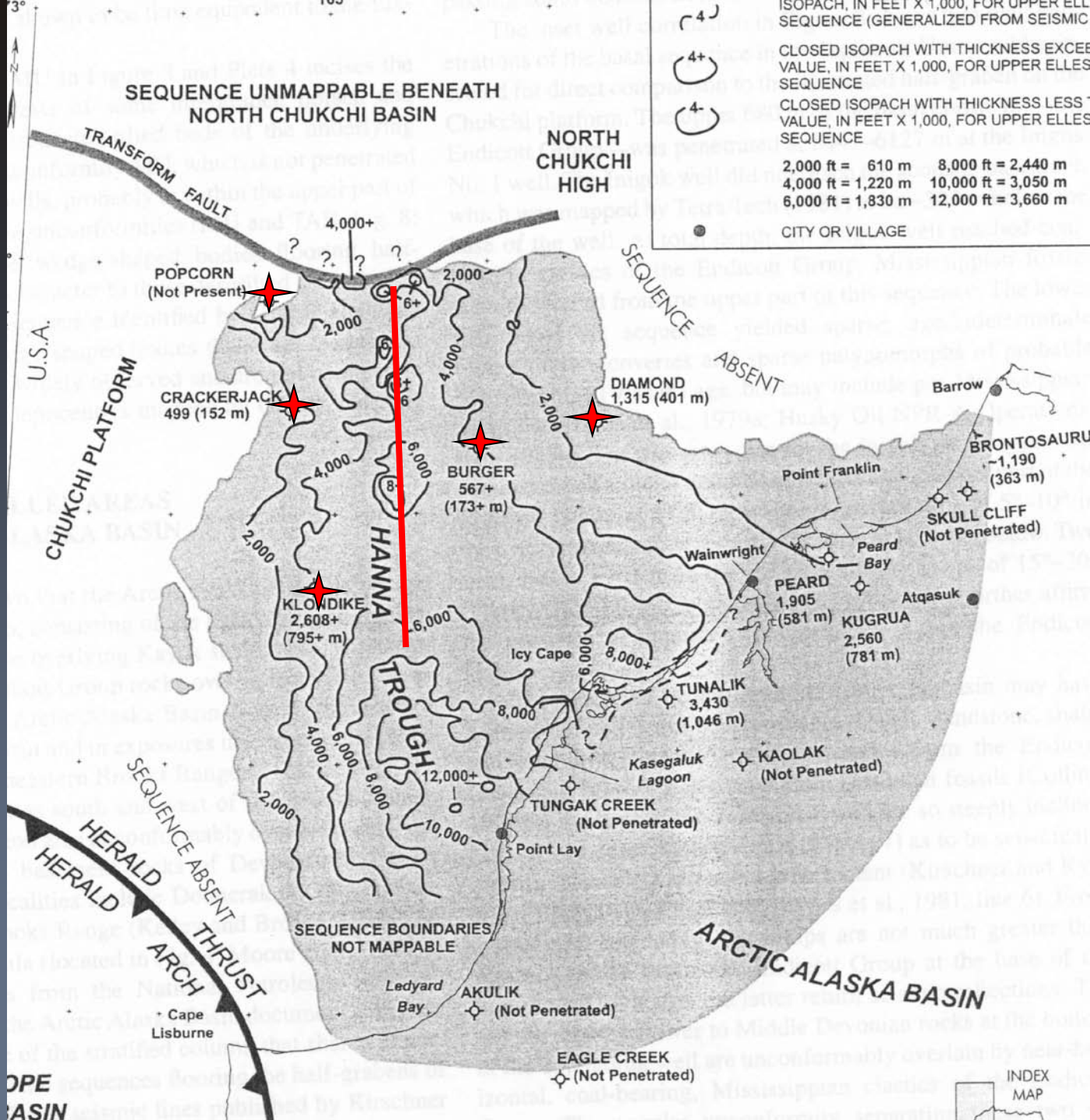
Matching Basin Axes, Grantz and May, 1990

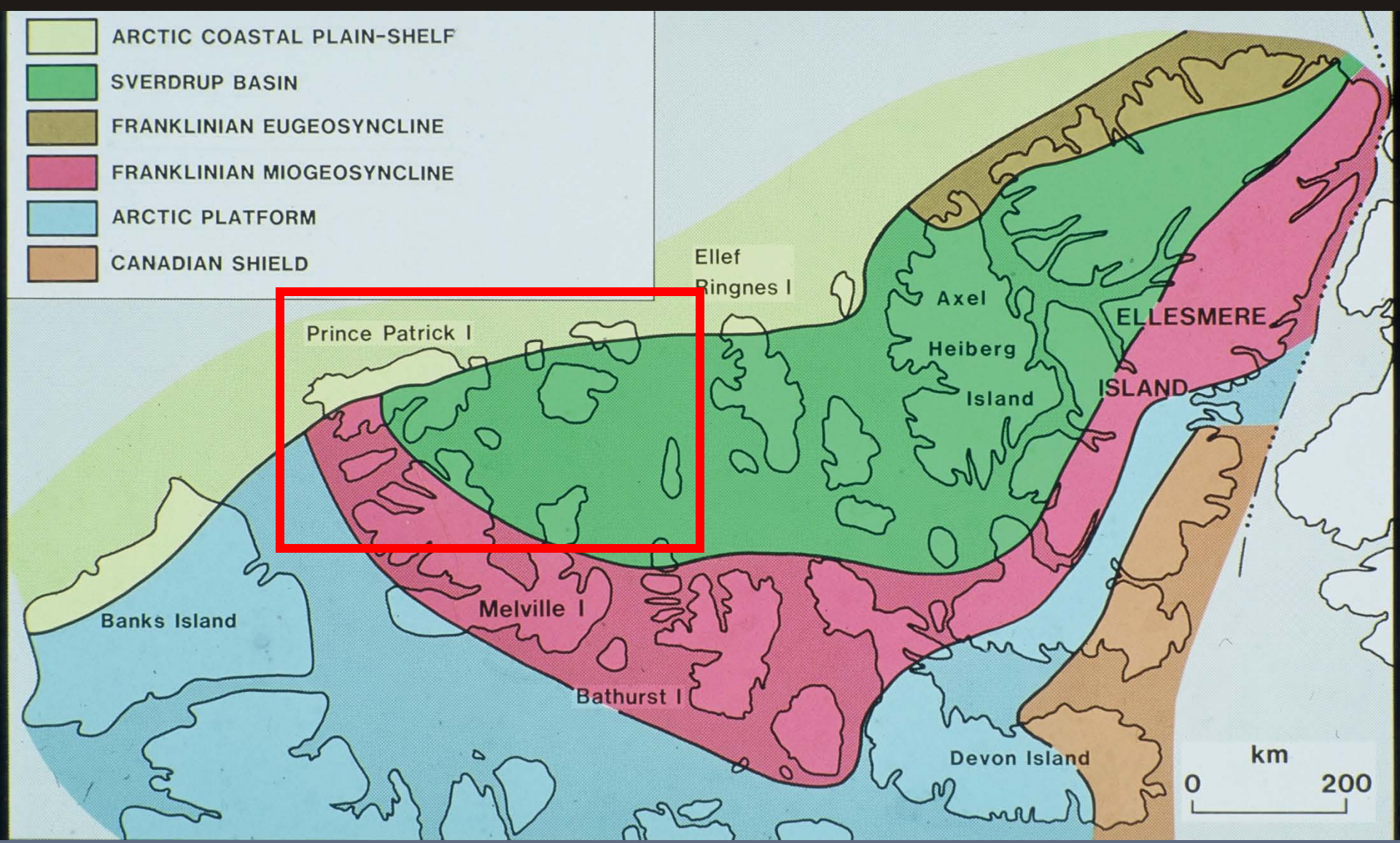
Beware of model-driven interpretations. Careful review of data sources is necessary to ensure interpretations follow from data.

Larry Lane, 2007

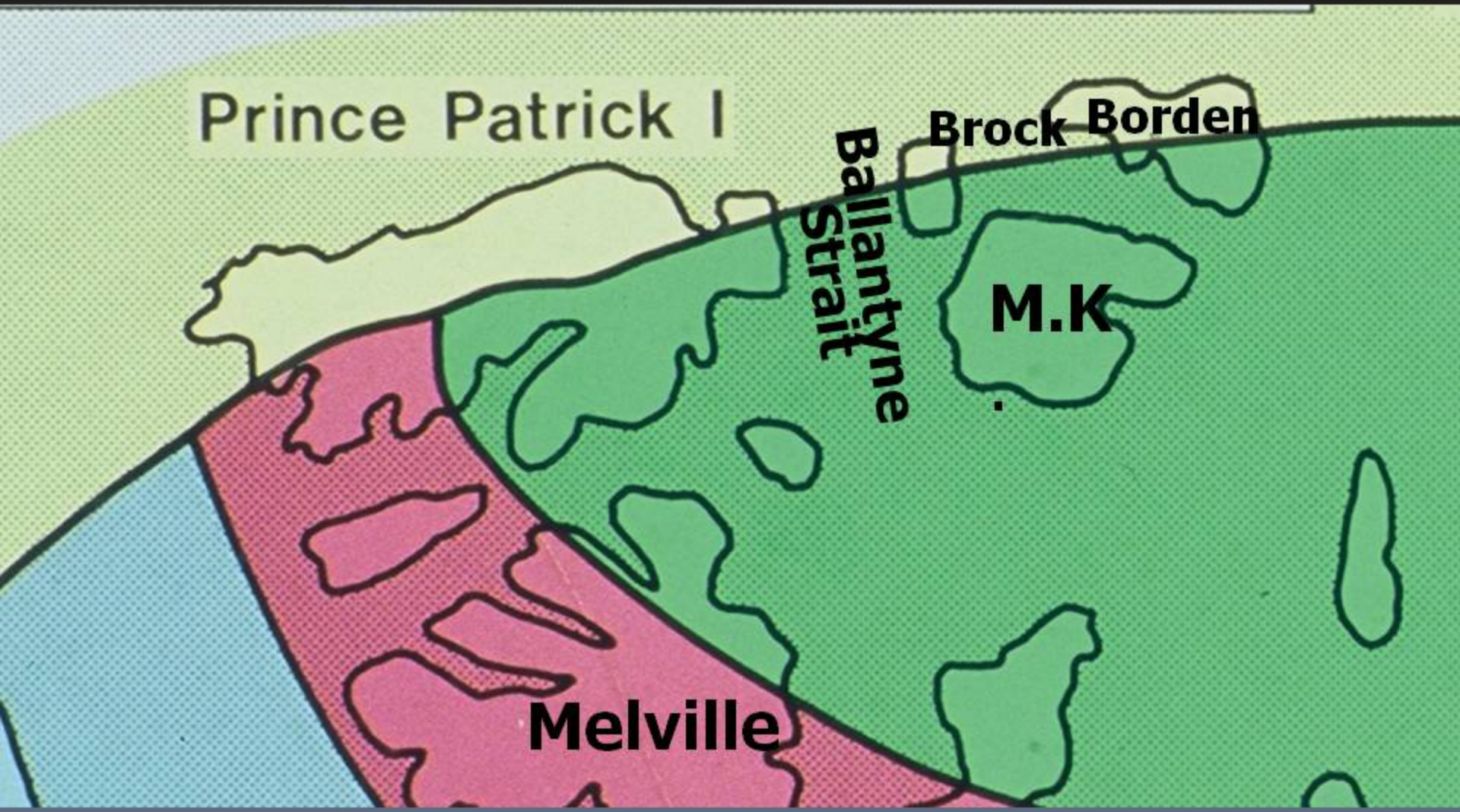
Late Permian to Middle Jurassic Isopach

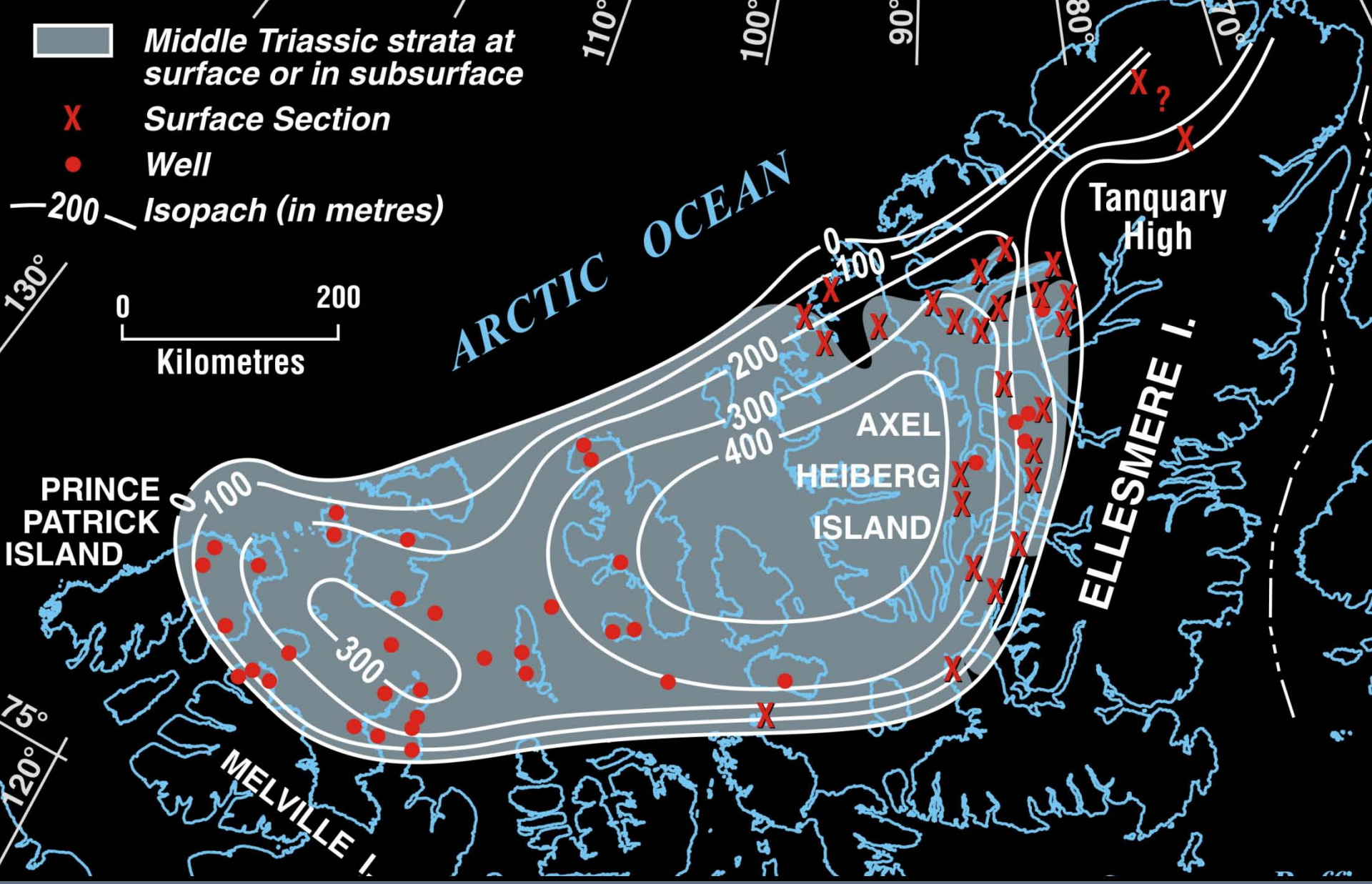
Sherwood et al, 2002



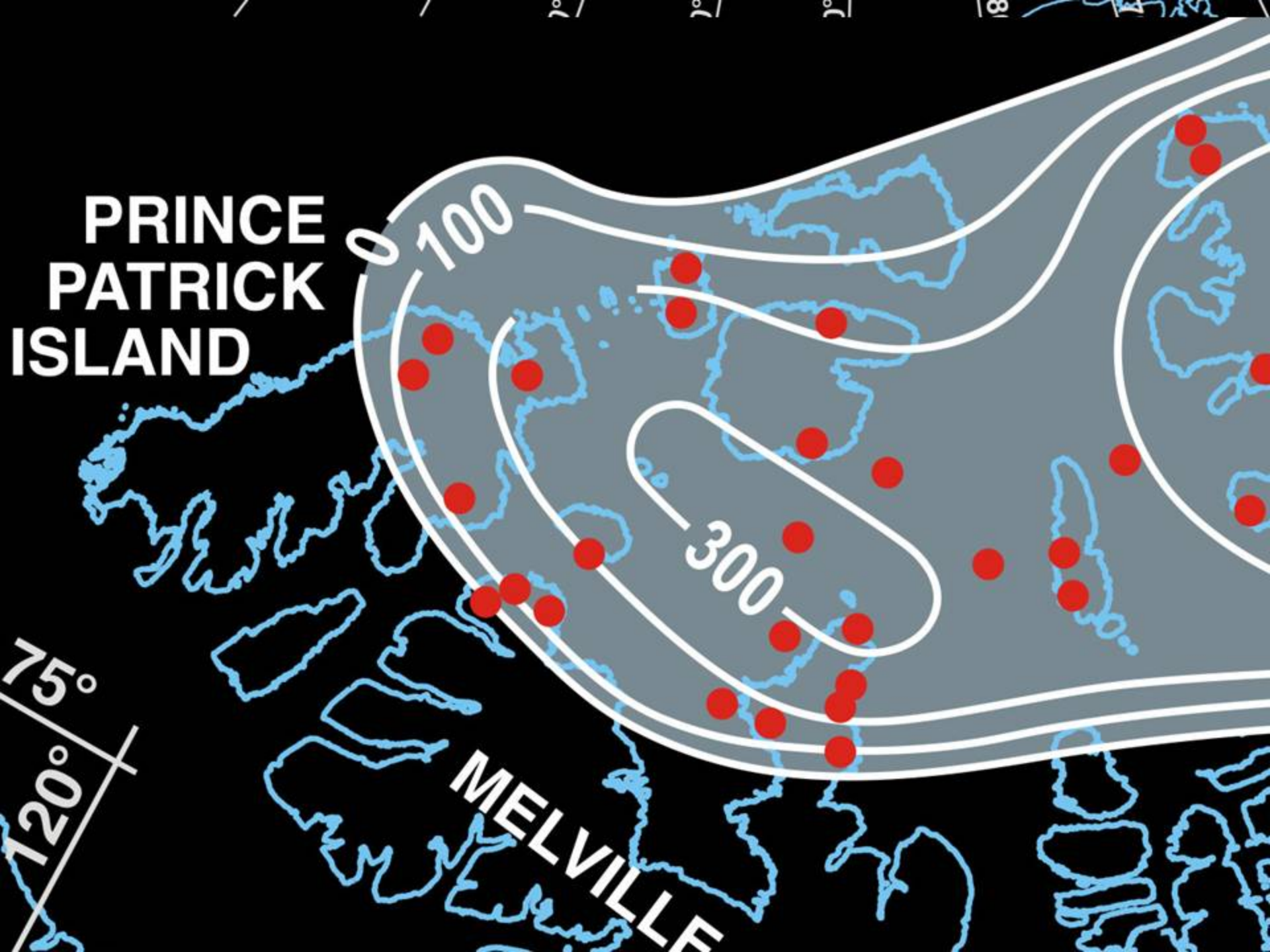


Geological Provinces
Canadian Arctic Islands

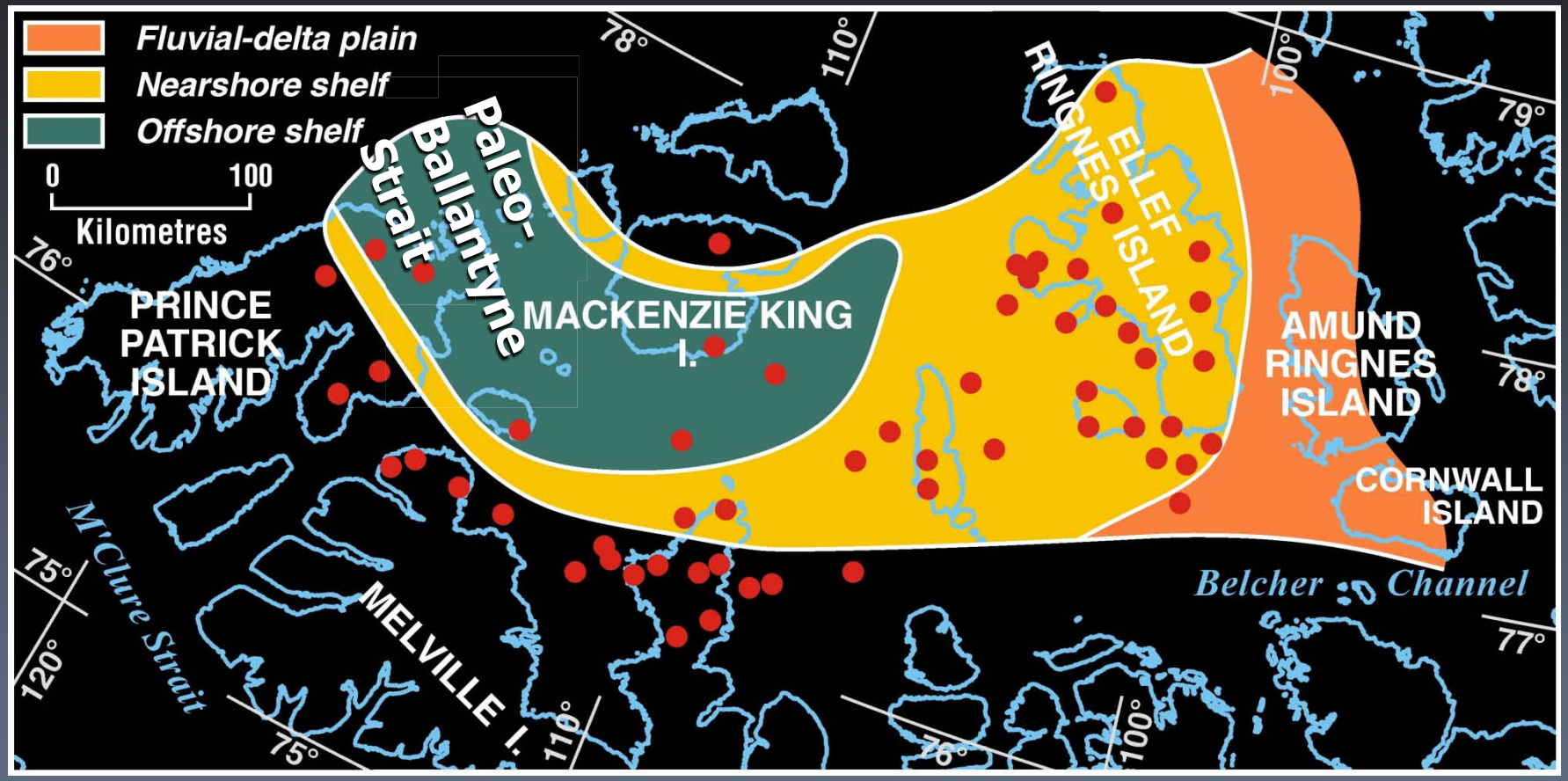

Prince Patrick I
Brock
Borden
Ballantyne Strait
M.K
Melville



Middle Triassic Control Points and Isopach


PRINCE
PATRICK
ISLAND
0
100
300
75°
120°
MELVILLE

Hettangian Facies

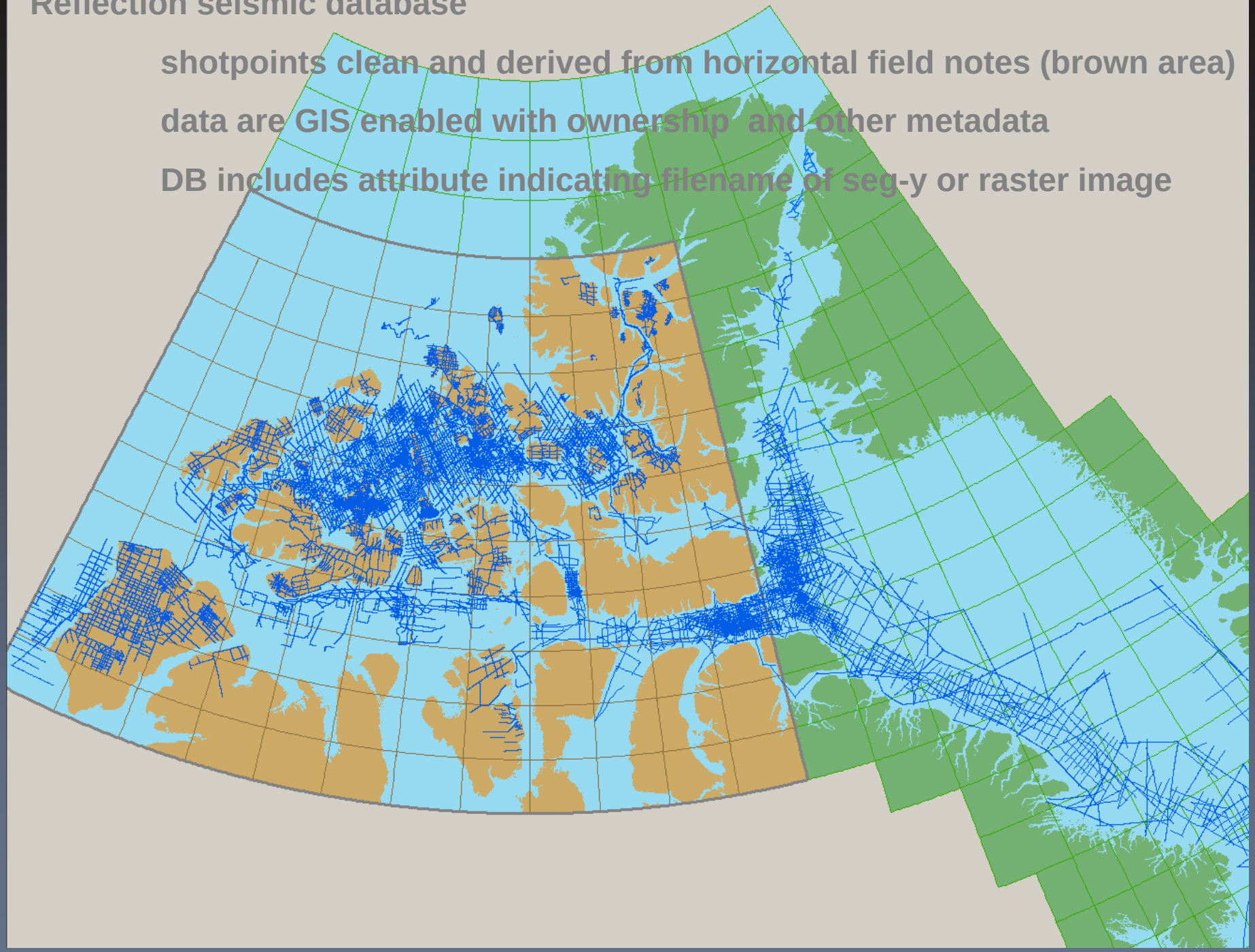


Reflection seismic database

shotpoints clean and derived from horizontal field notes (brown area)

data are GIS enabled with ownership and other metadata

DB includes attribute indicating filename of seg-y or raster image

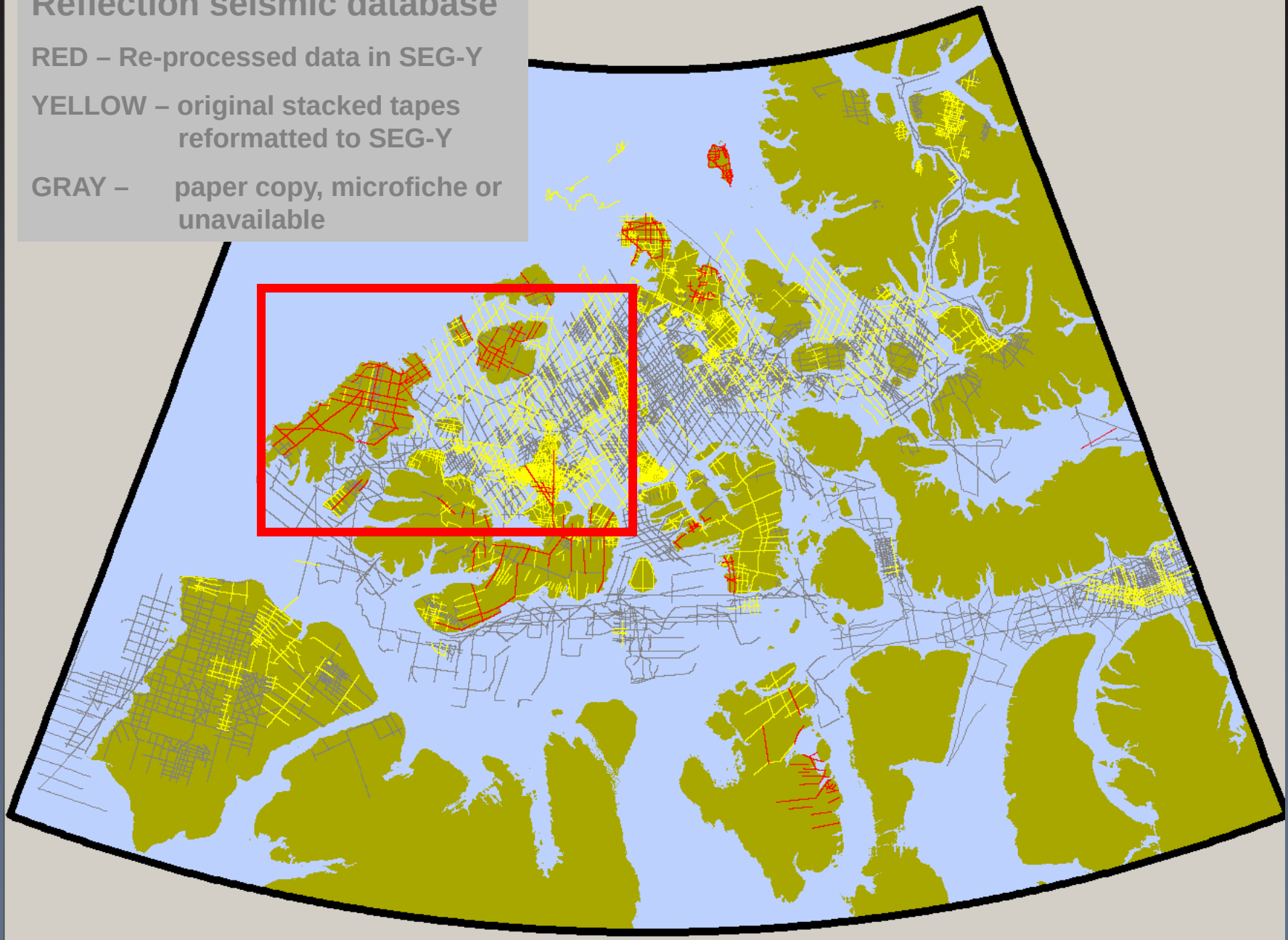


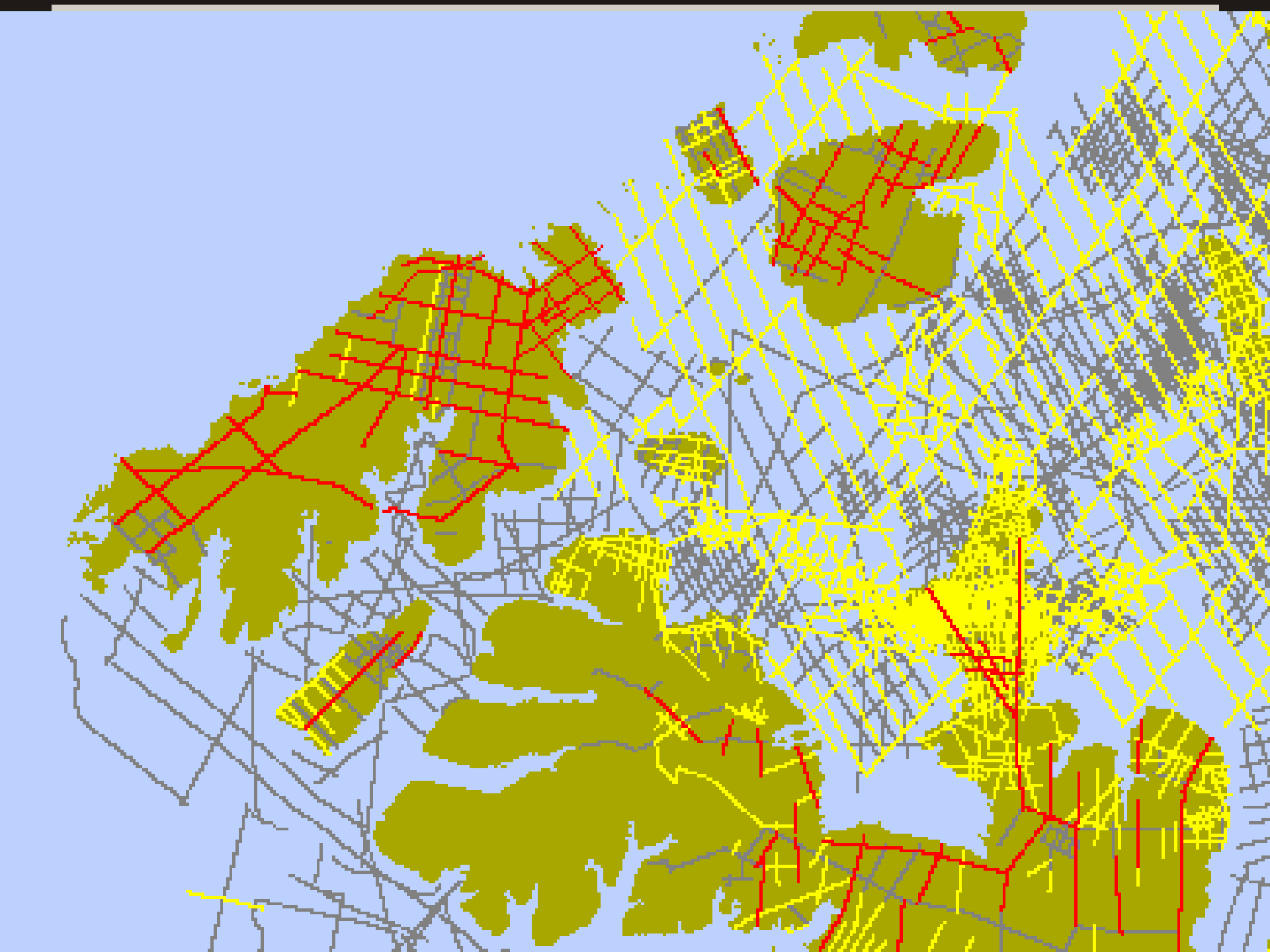
Reflection seismic database

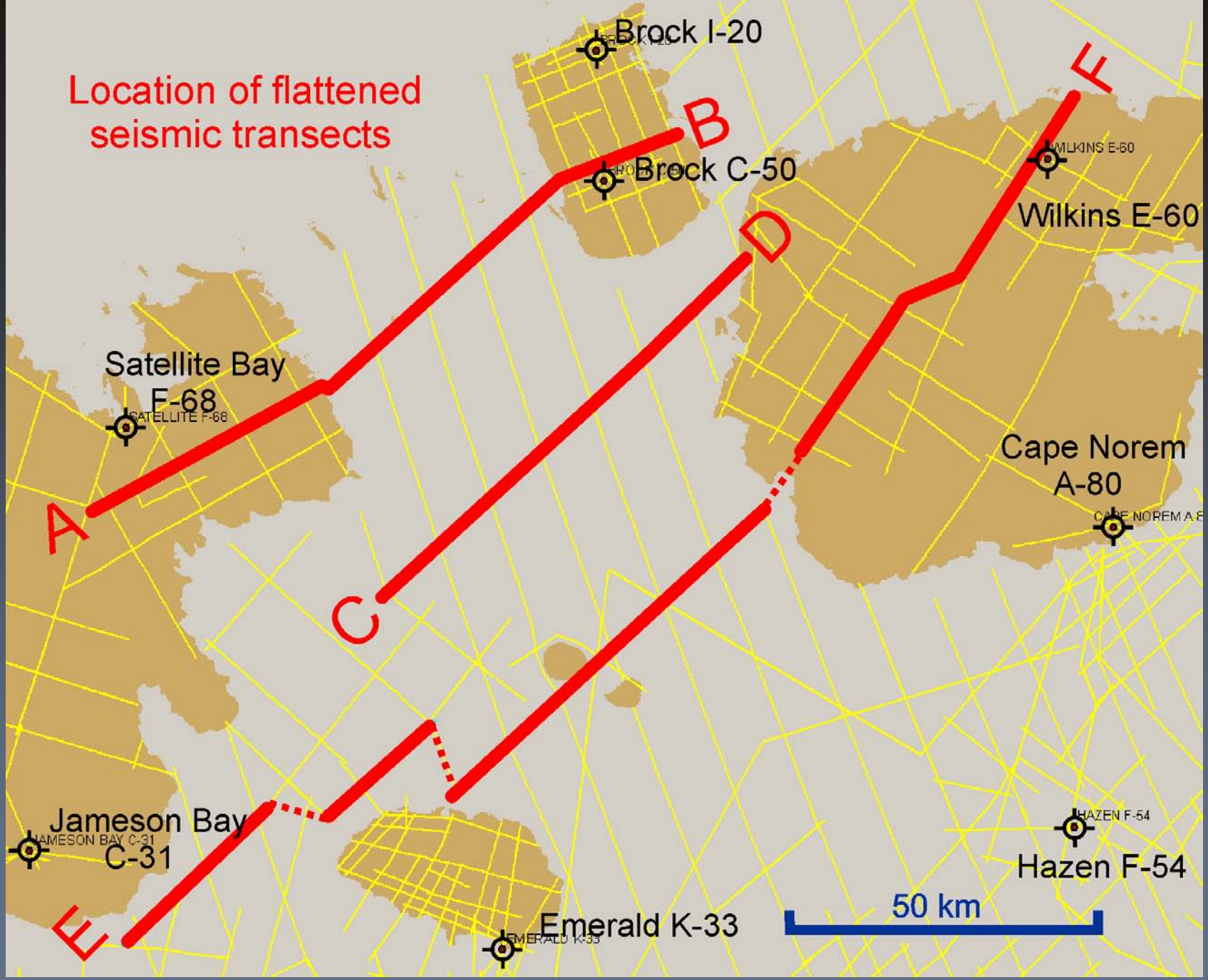
RED – Re-processed data in SEG-Y

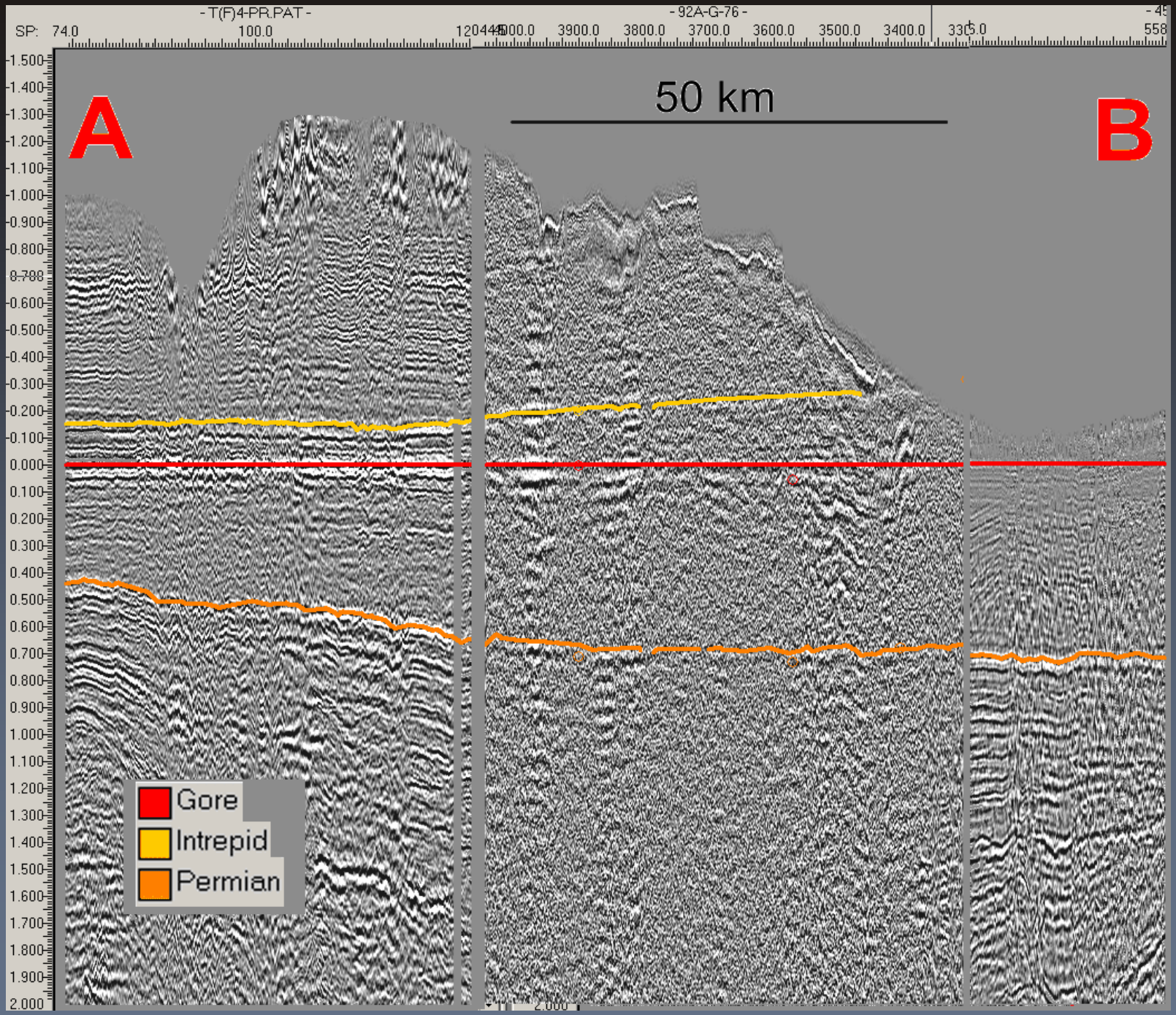
YELLOW – original stacked tapes reformatted to SEG-Y

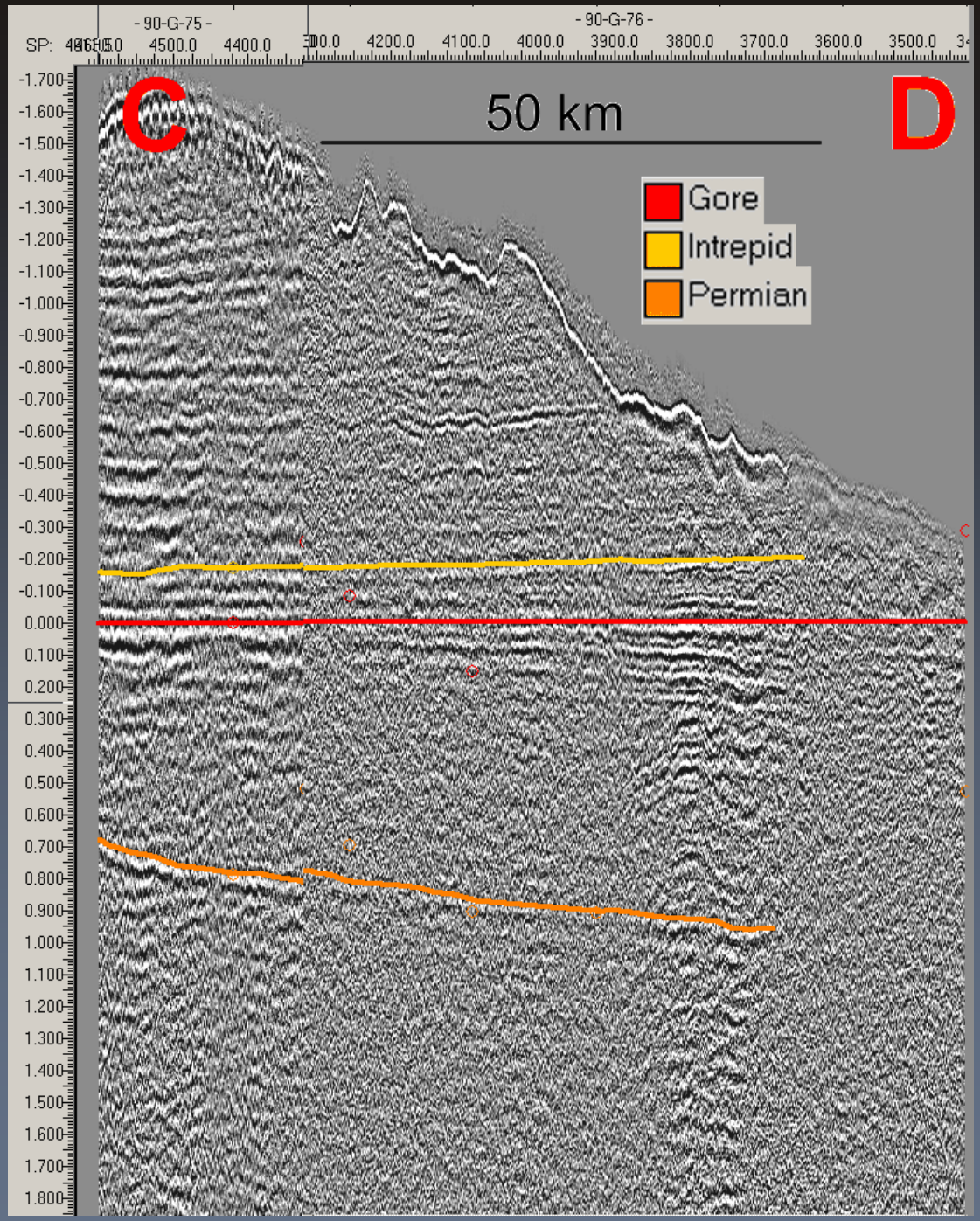
GRAY – paper copy, microfiche or unavailable

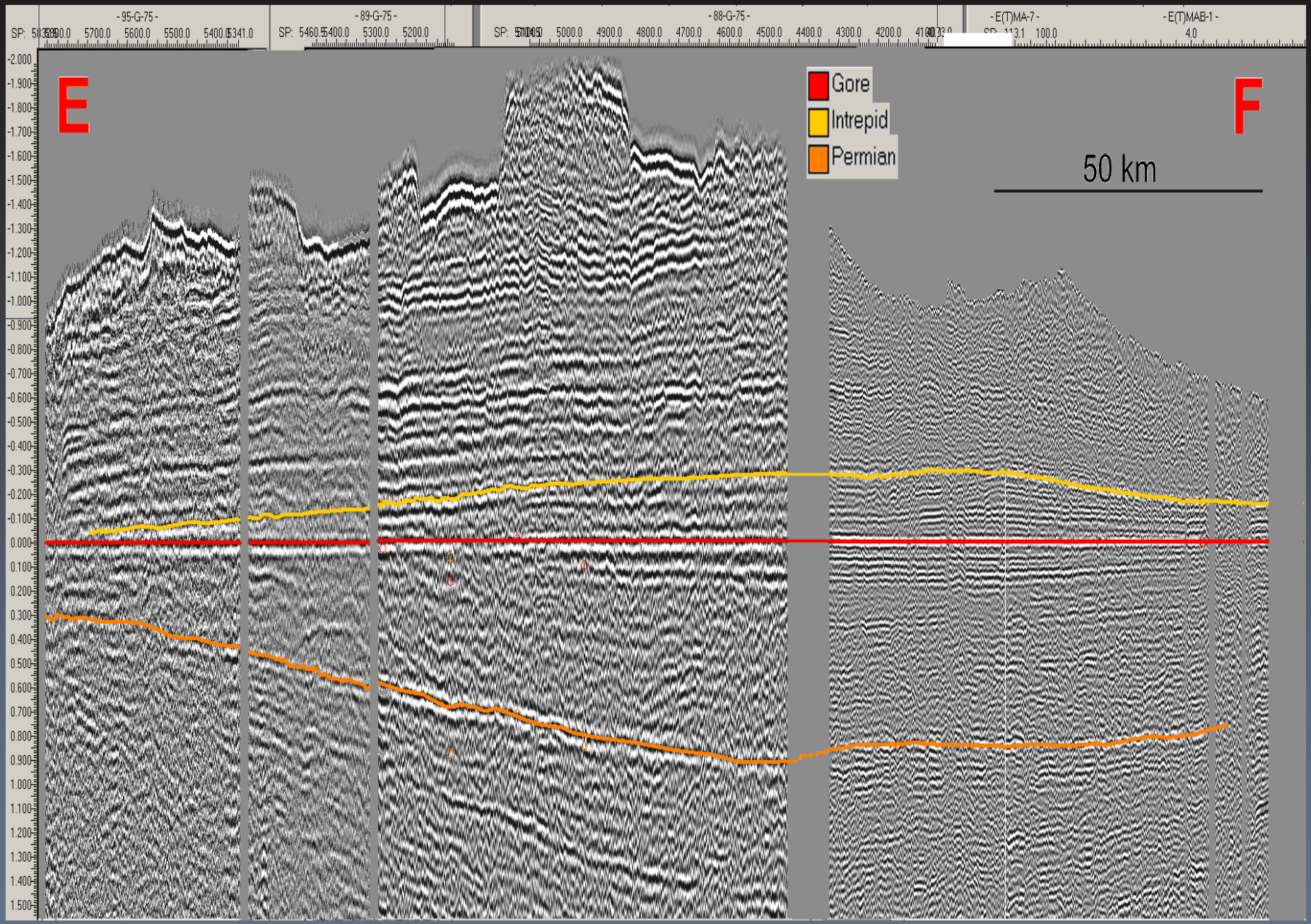


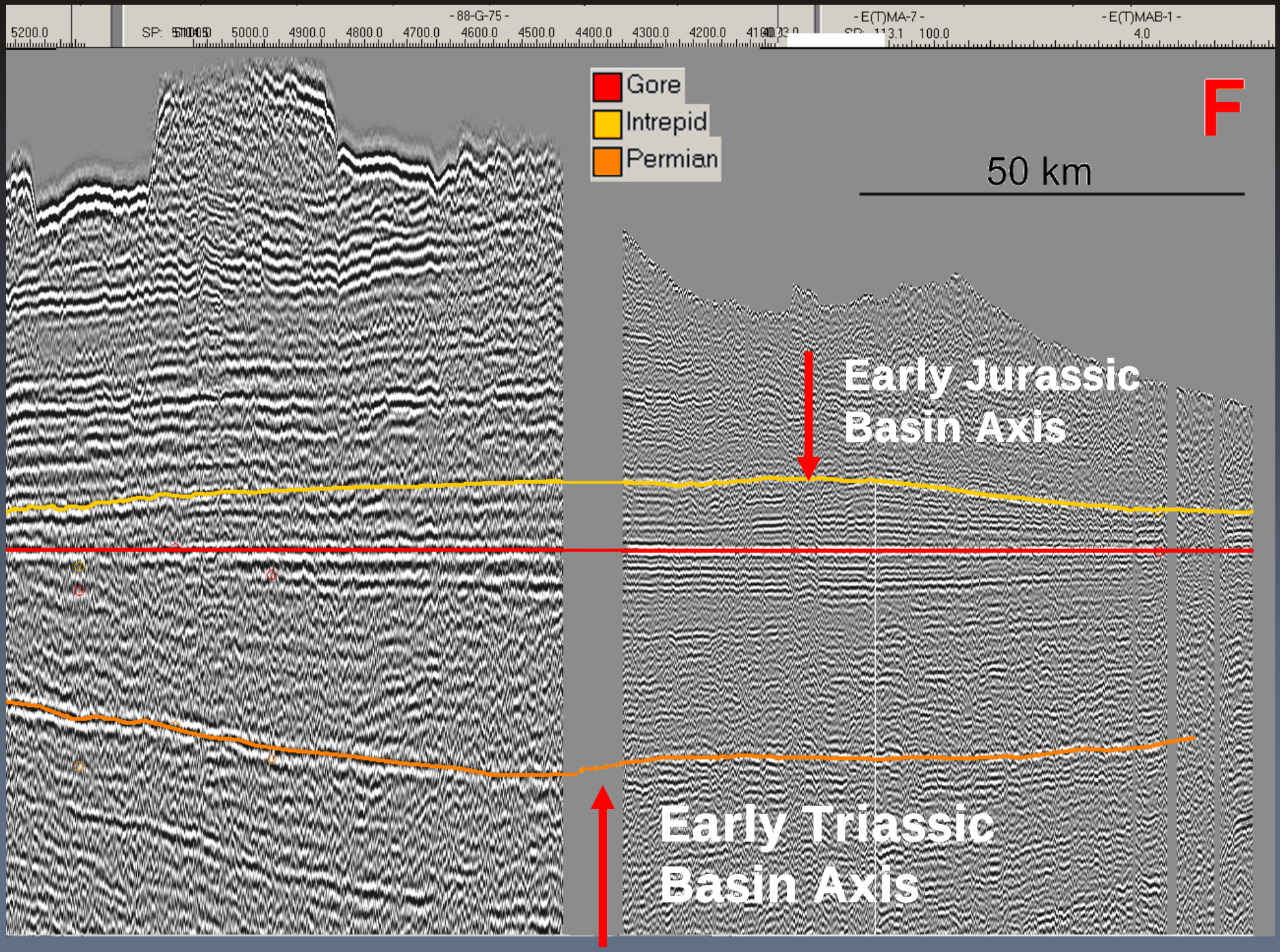


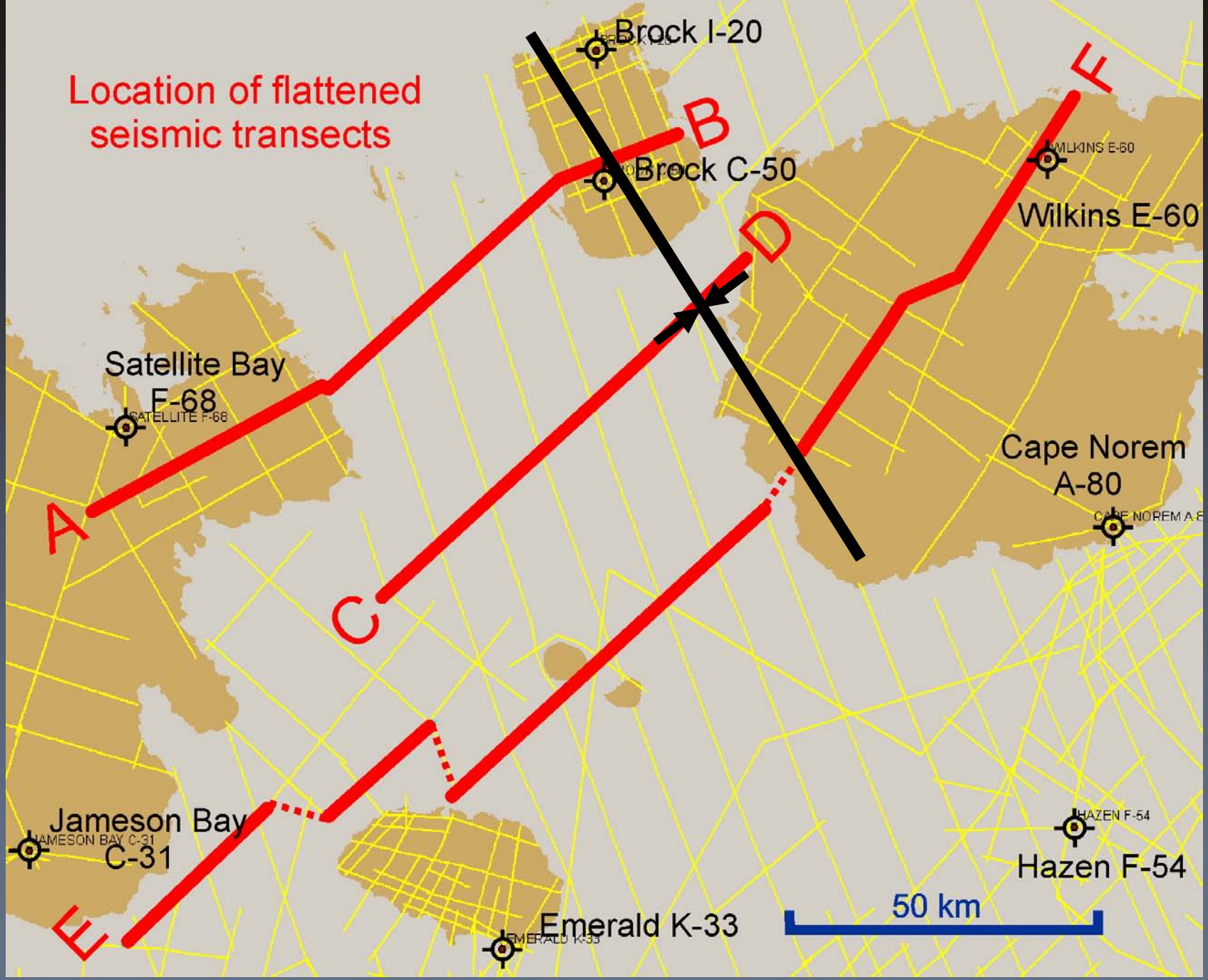

Location of flattened seismic transects
Brock I-20
Brock C-50
Wilkins E-60
Satellite Bay F-68
Cape Norem A-80
Jameson Bay C-31
Hazen F-54
Emerald K-33
50 km
A
B
C
D
E
F

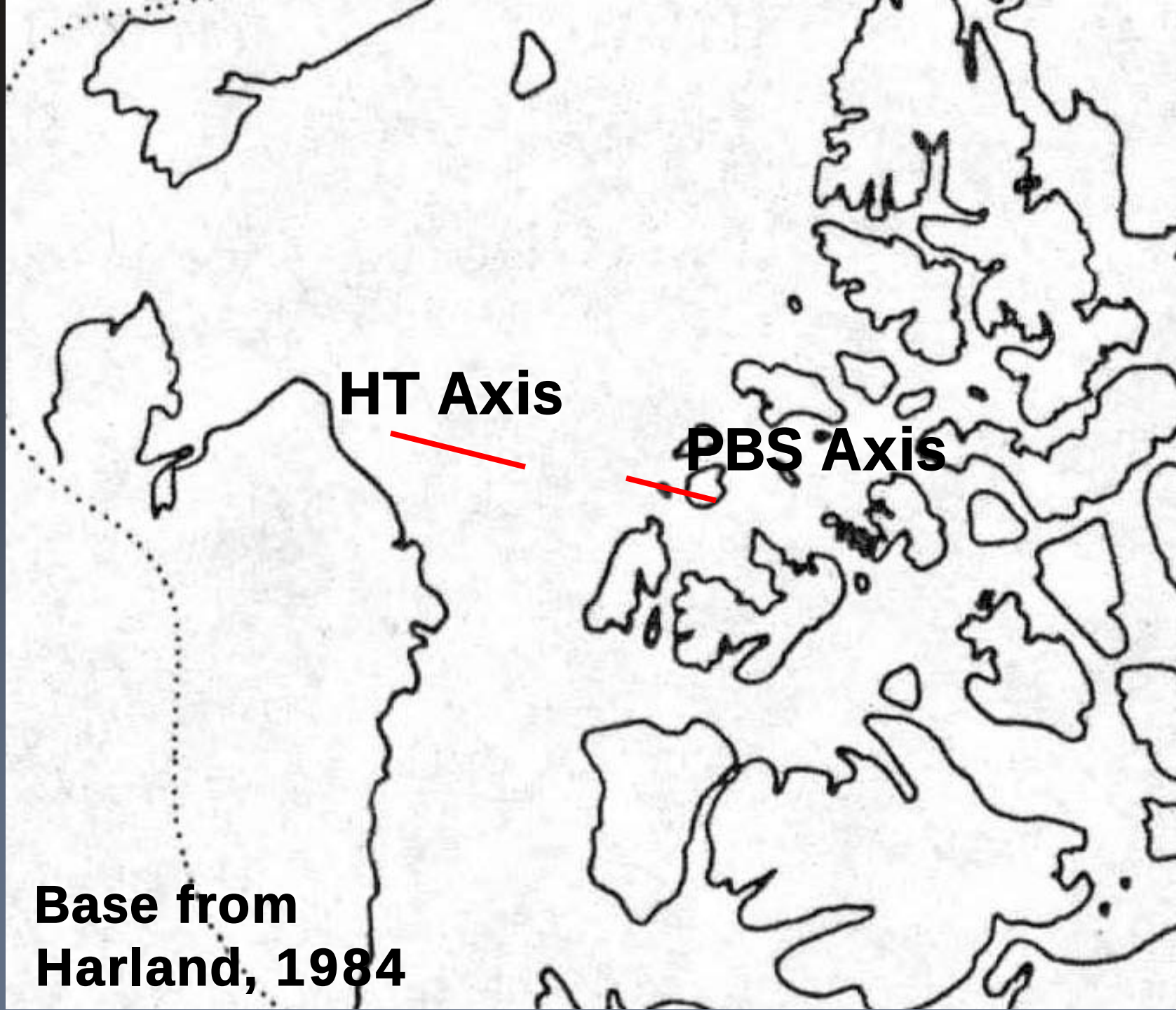

- T(F)4-PR.PAT -
- 92A-G-76 -
SP: 74.0
100.0
4000.0
3900.0
3800.0
3700.0
3600.0
3500.0
3400.0
3300.0
1.500
1.400
1.300
1.200
1.100
1.000
0.900
0.800
0.788
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800
0.900
1.000
1.100
1.200
1.300
1.400
1.500
1.600
1.700
1.800
1.900
2.000
A
50 km
B
Gore
Intrepid
Permian

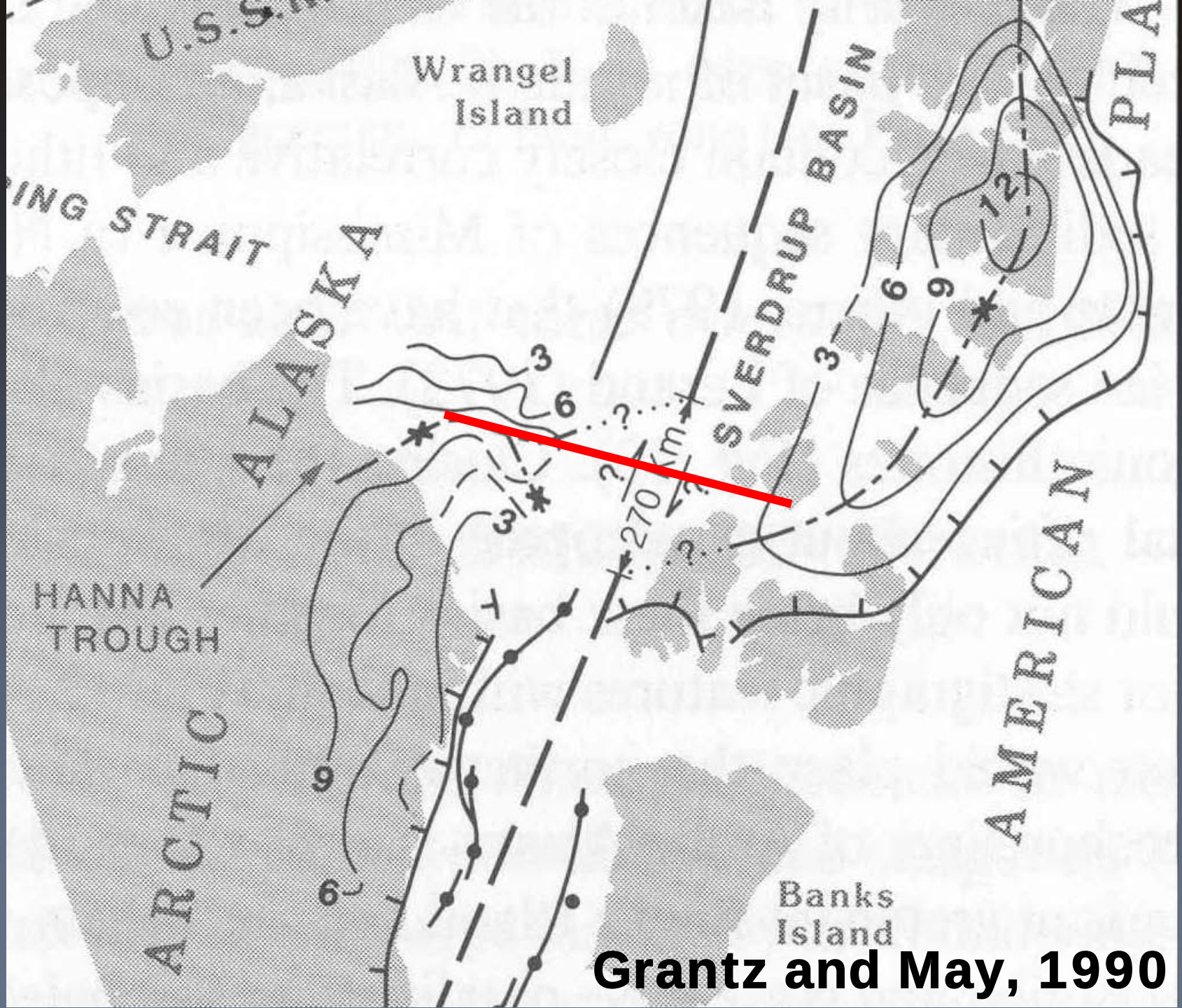

- 90-G-75 -
- 90-G-76 -
SP:
4500.0
4400.0
4200.0
4100.0
4000.0
3900.0
3800.0
3700.0
3600.0
3500.0
C
D
50 km
Gore
Intrepid
Permian
-1.700
-1.600
-1.500
-1.400
-1.300
-1.200
-1.100
-1.000
-0.900
-0.800
-0.700
-0.600
-0.500
-0.400
-0.300
-0.200
-0.100
0.000
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800
0.900
1.000
1.100
1.200
1.300
1.400
1.500
1.600
1.700
1.800


E
F
Gore
Intrepid
Permian
50 km

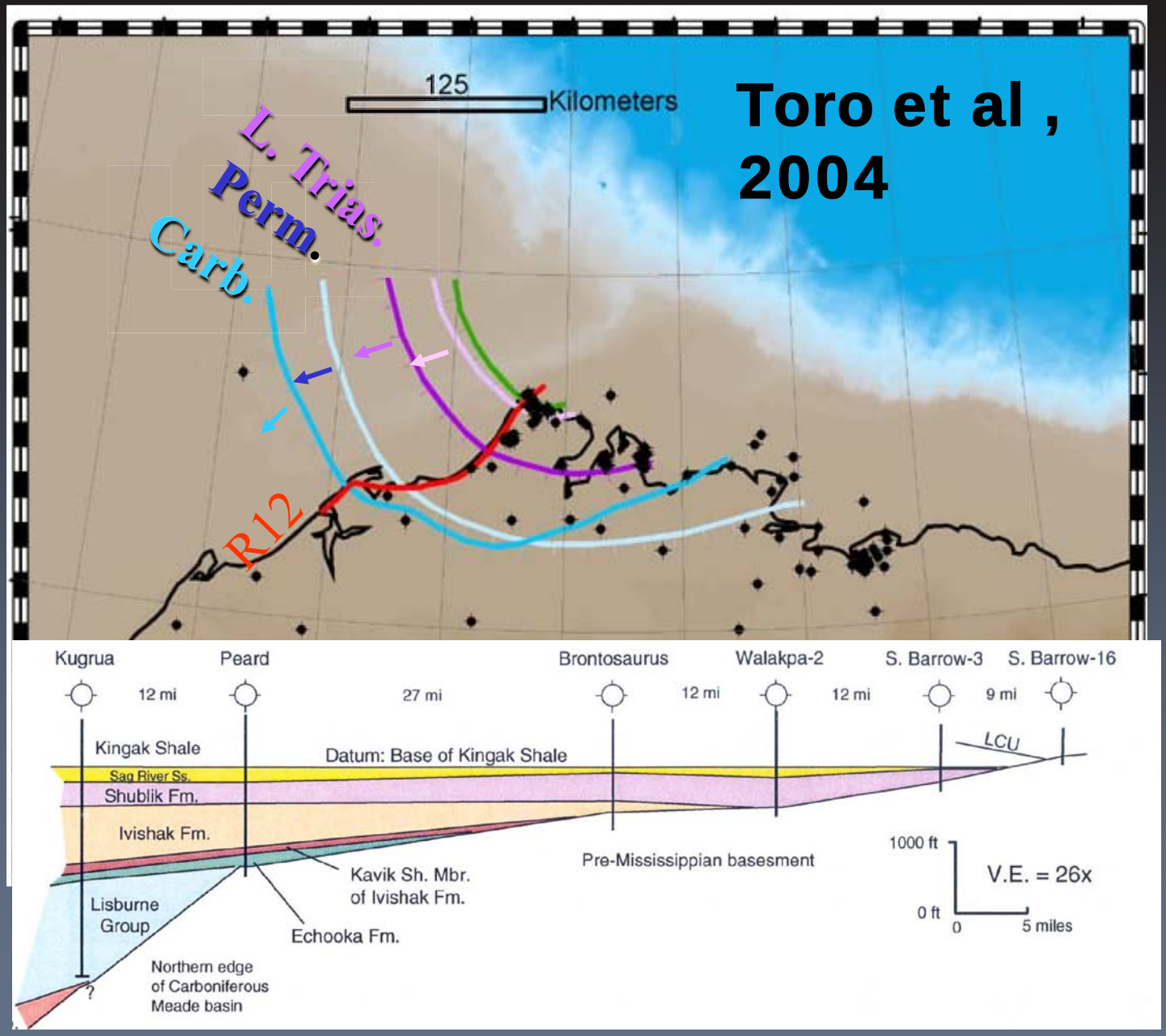

- 88-G-75 -
- E(T)MA-7 -
- E(T)MAB-1 -
Gore
Intrepid
Permian
F
50 km
Early Jurassic
Basin Axis
Early Triassic
Basin Axis


Location of flattened seismic transects
Brock I-20
Brock C-50
Wilkins E-60
Satellite Bay F-68
Cape Norem A-80
Jameson Bay C-31
Hazen F-54
Emerald K-33
50 km
A
B
C
D
E
F

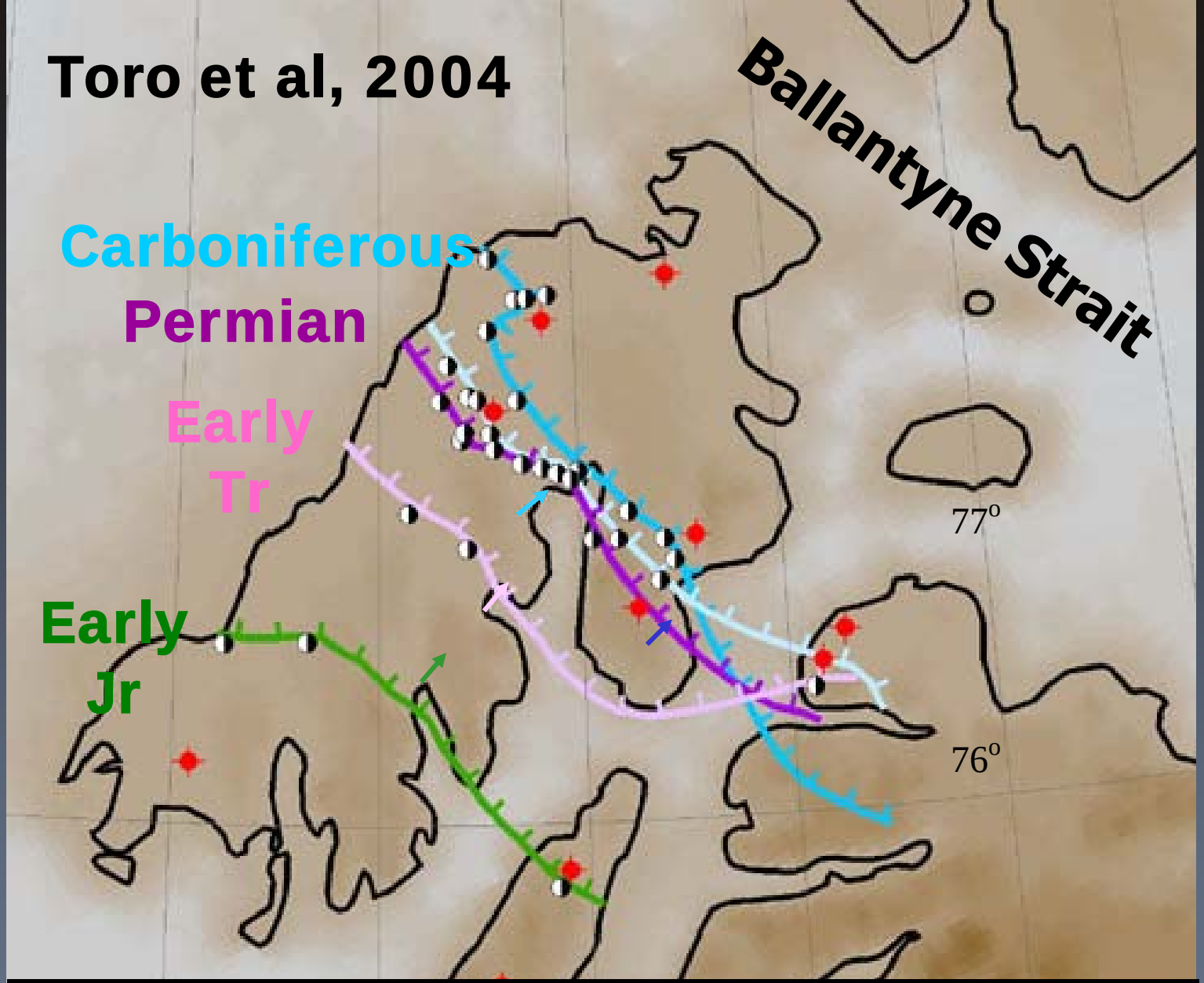

HT Axis
PBS Axis
Base from
Harland, 1984



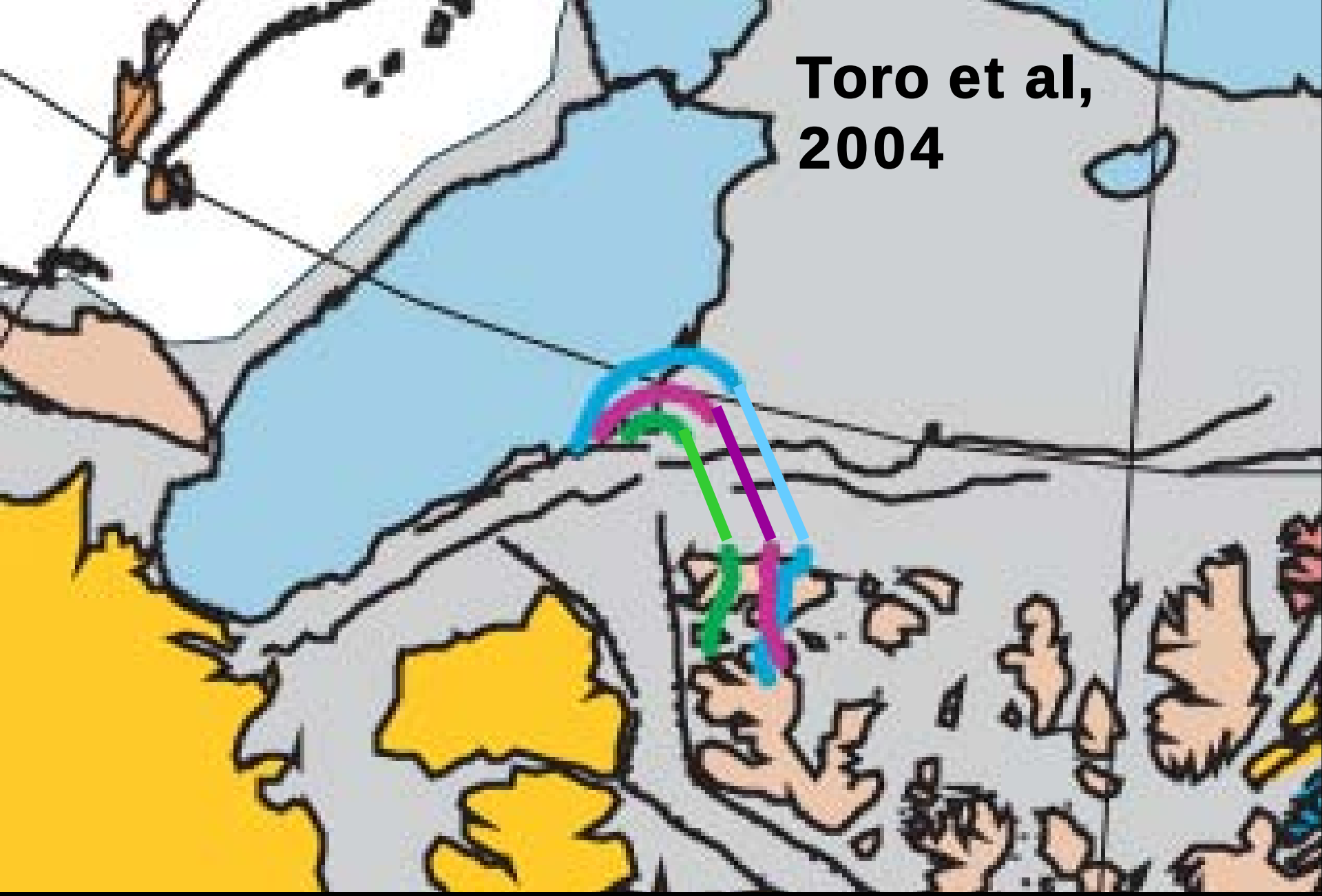
Grantz and May, 1990



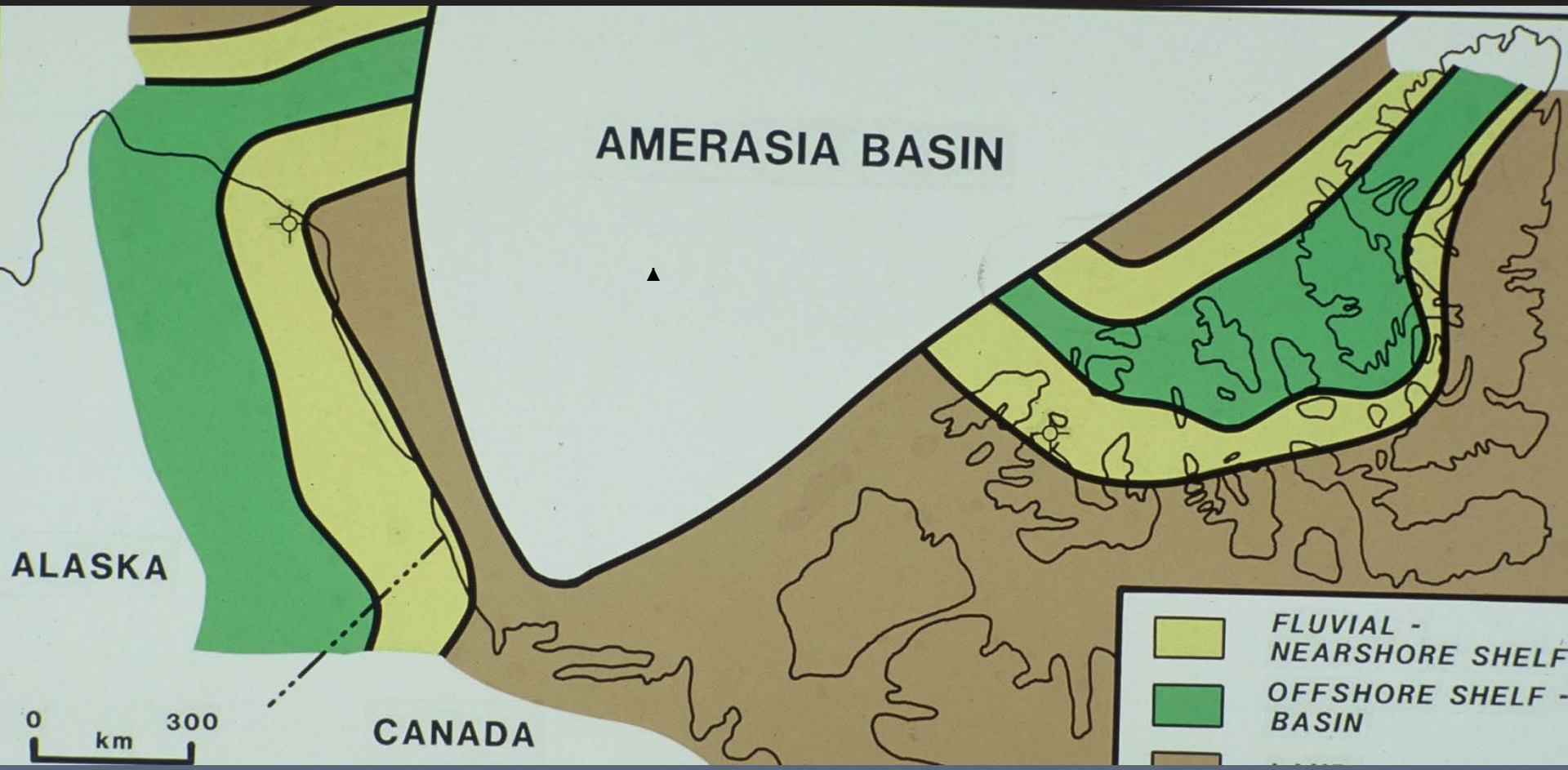
Erosional Edges on NE Flank of Hanna Trough



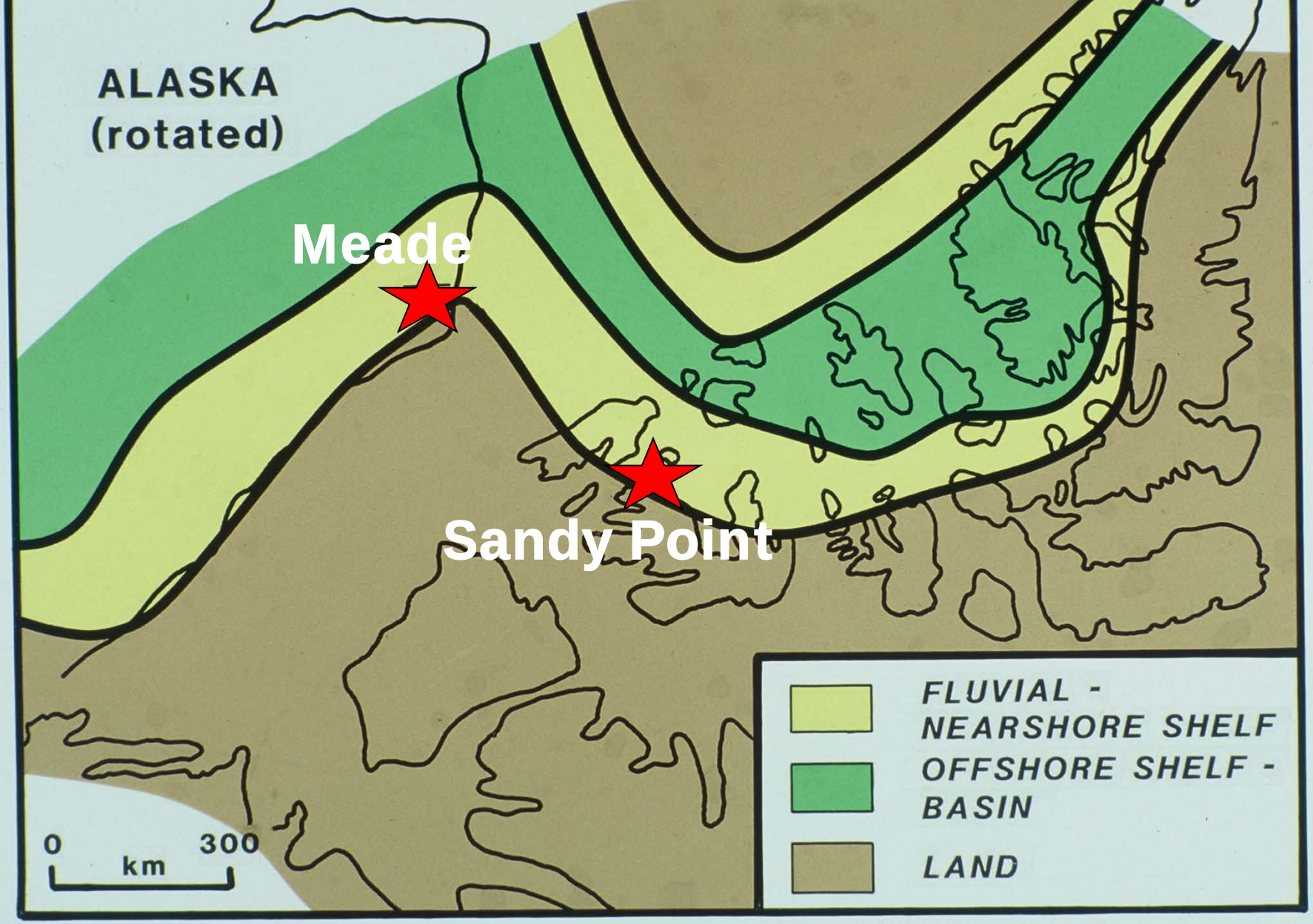
Erosional Edges southern flank Paleo-Ballantyne Strait



Alignment of Erosional Edges

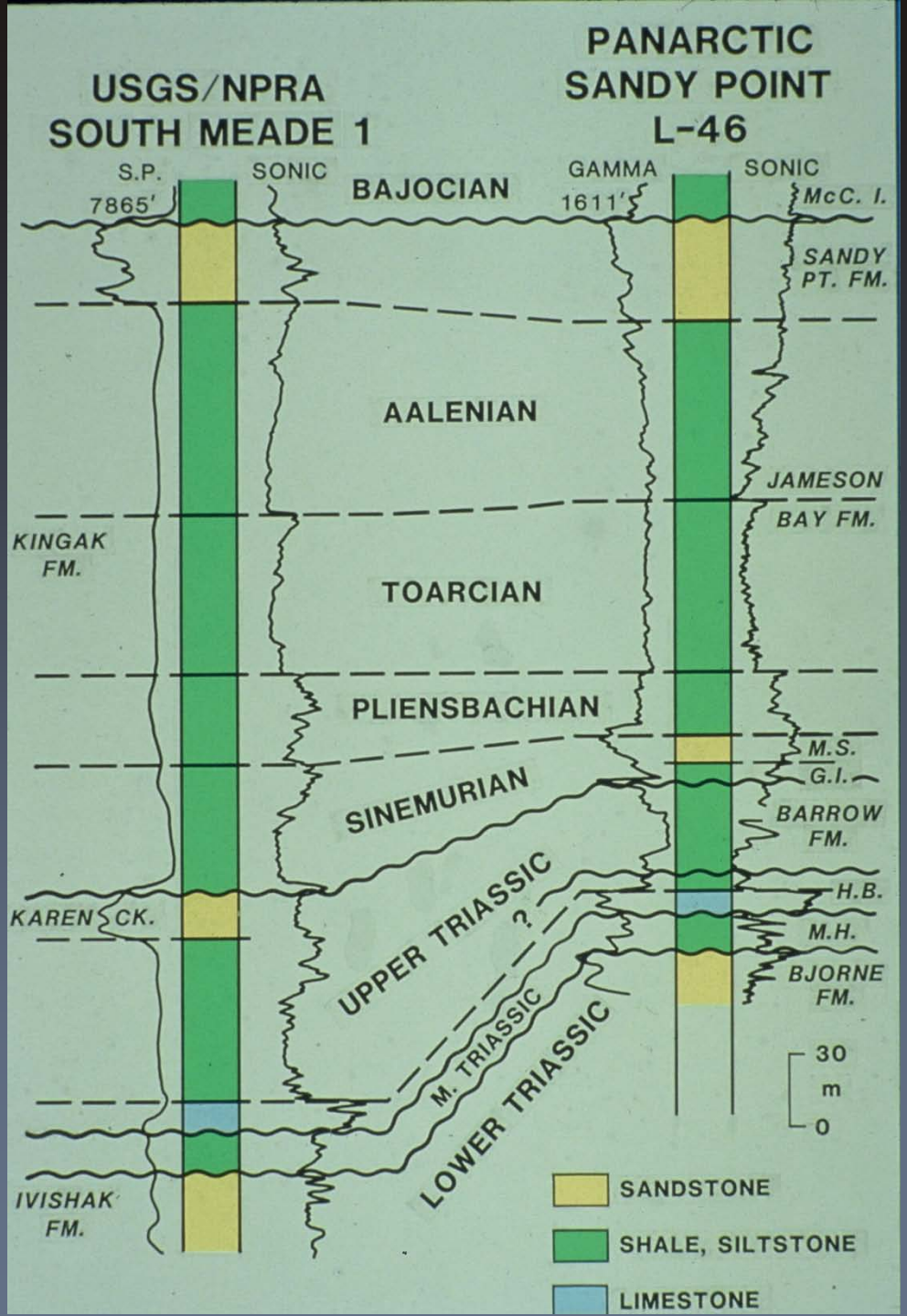


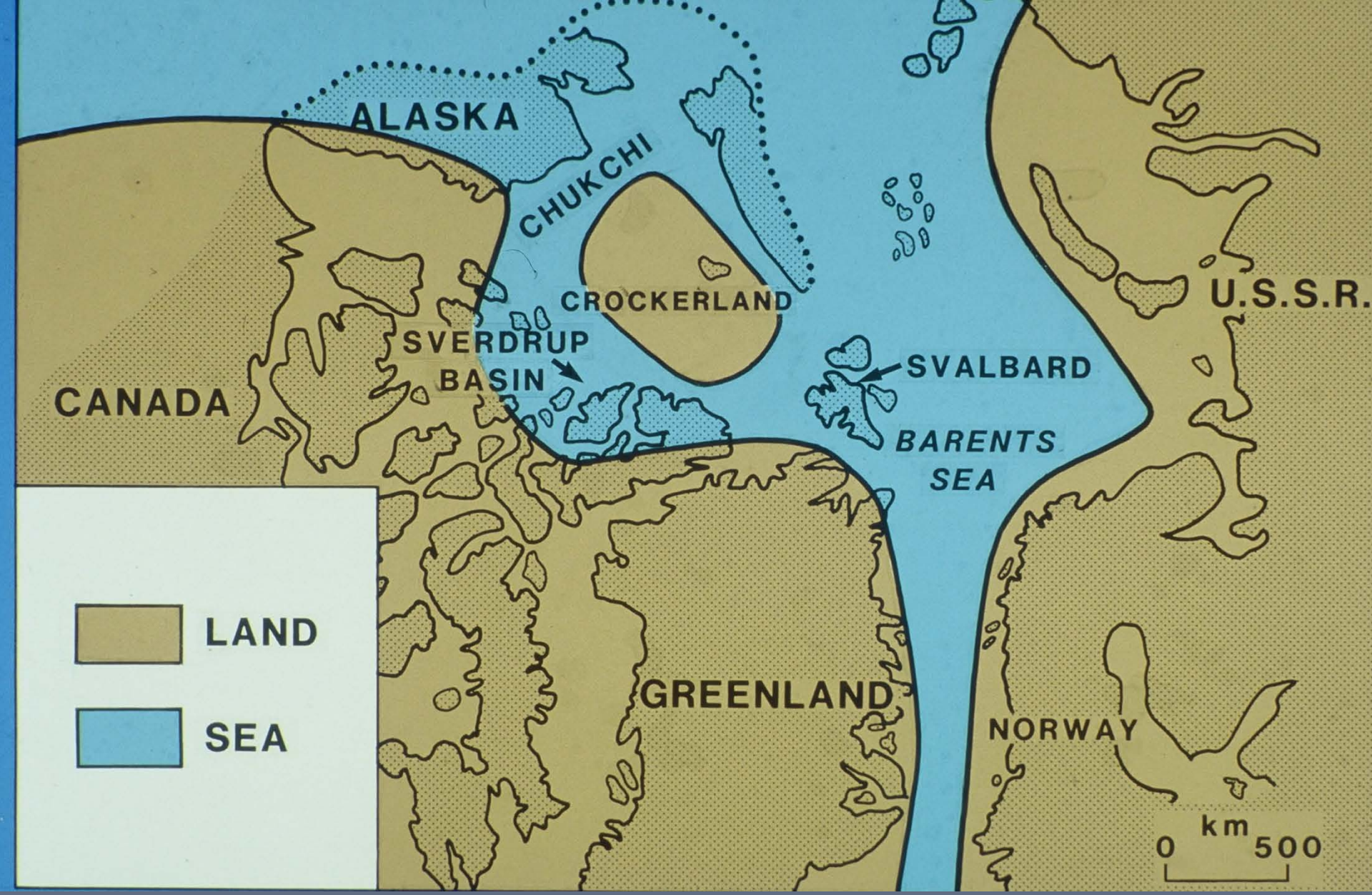
Early Triassic Facies



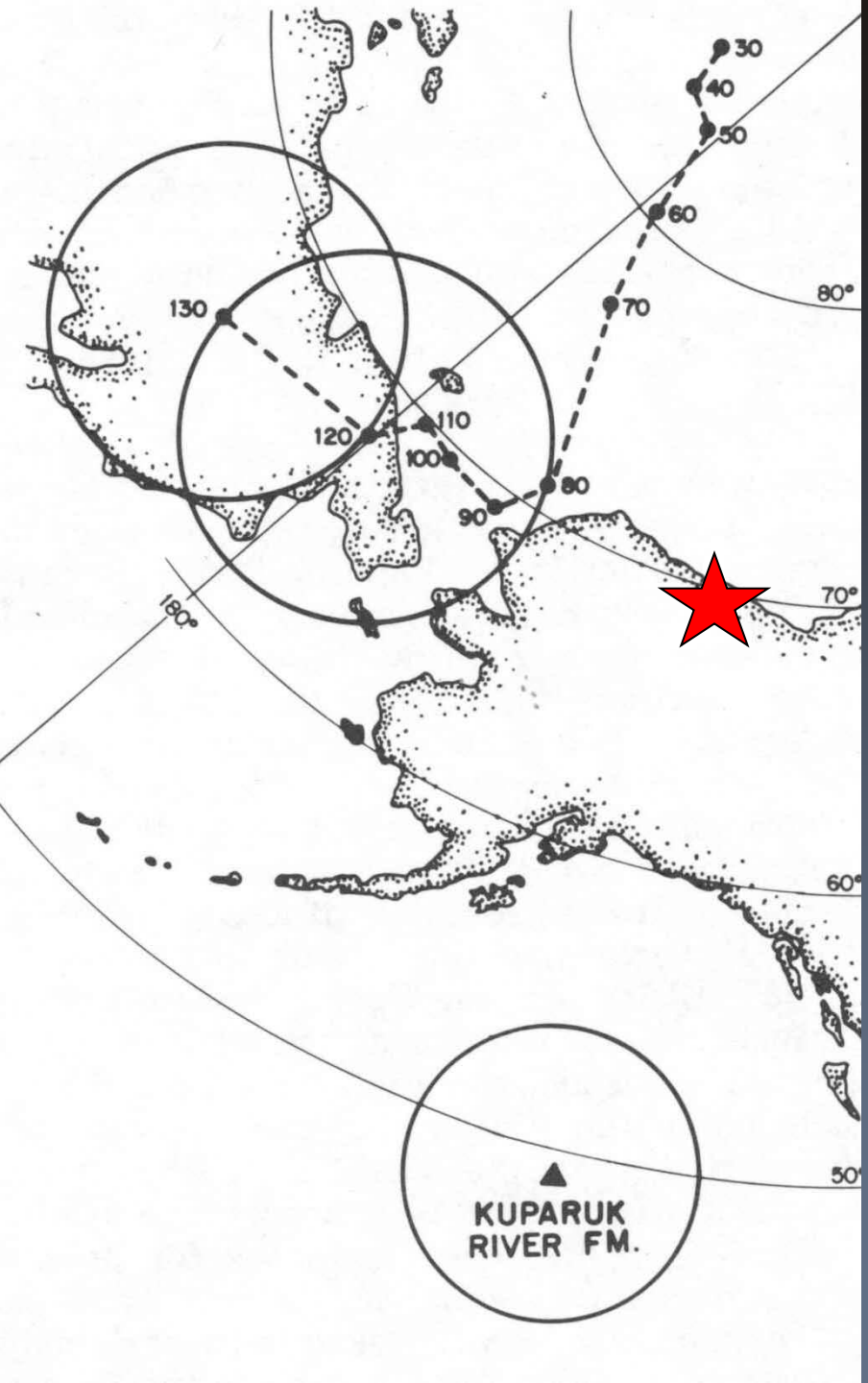
Triassic Paleogeography

Correlation of a well on eastern flank of Hanna Trough with a well on the southern flank of Paleo-Ballantyne Strait.

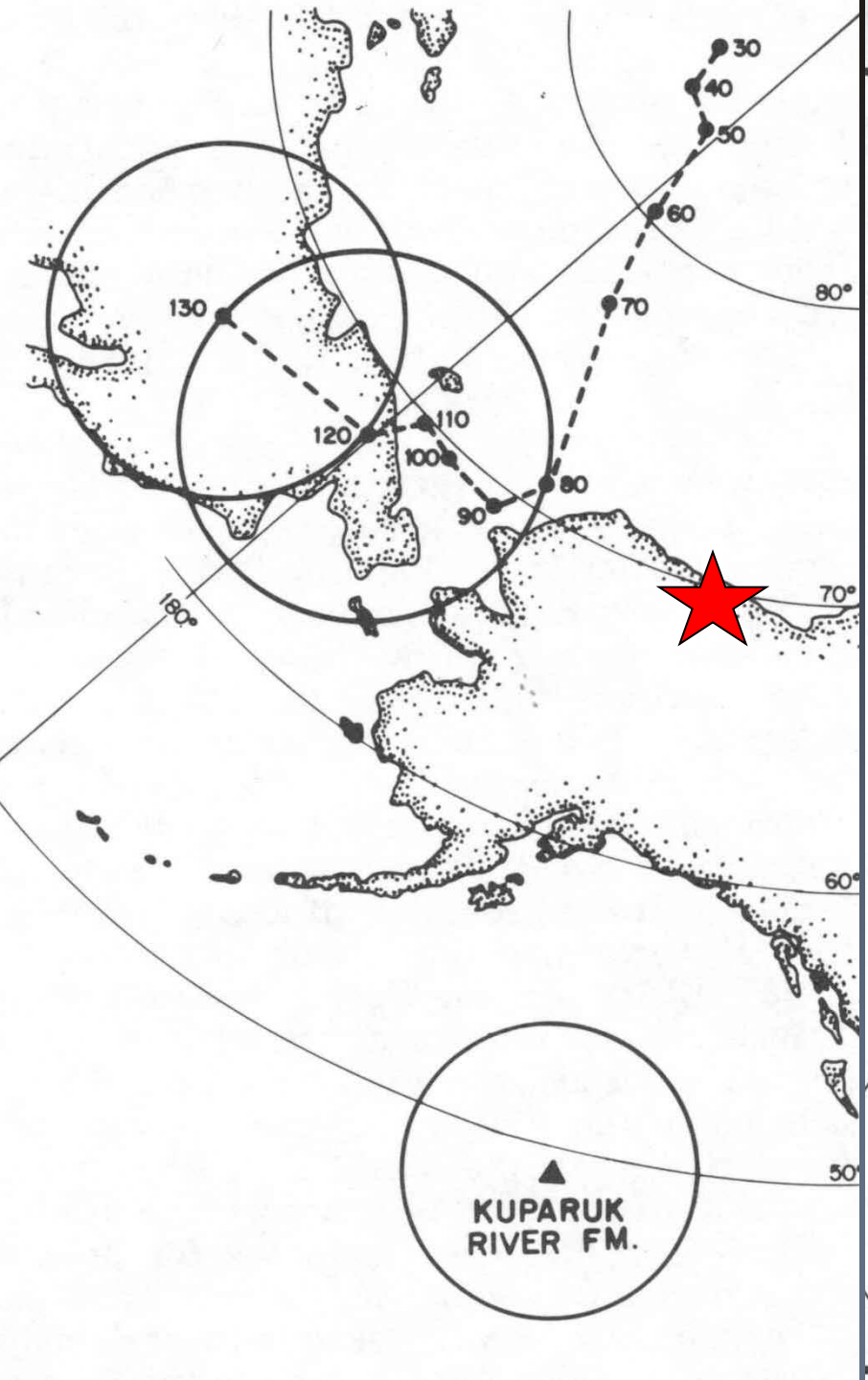


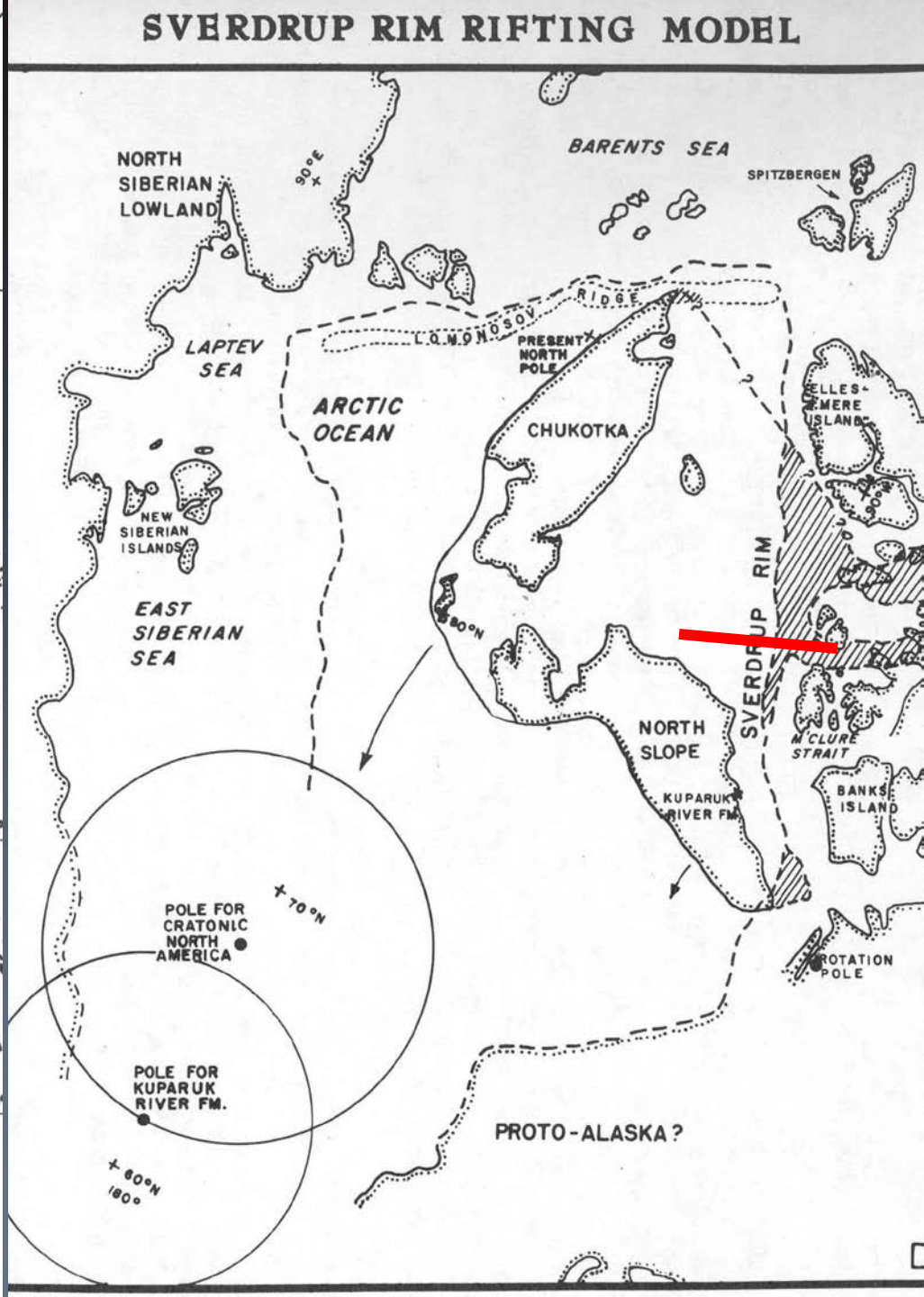


Regional View



Paleomagnetic results from oriented cores in Valanginian Sandstones demonstrating that Northern Alaska has moved relative to NA


30
40
50
60
70
80°
130
120
110
100
90
80
70°
180°
60°
50°
KUPARUK
RIVER FM.


SVERDRUP RIM RIFTING MODEL
NORTH
SIBERIAN
LOWLAND
90°E
BARENTS SEA
SPITZBERGEN
LOMONOSOV RIDGE
PRESENT
NORTH
POLE
LAPTEV
SEA
ARCTIC
OCEAN
CHUKOTKA
ELLES-
MERE
ISLAND
NEW
SIBERIAN
ISLANDS
EAST
SIBERIAN
SEA
80°N
SVERDRUP RIM
NORTH
SLOPE
M'CLURE
STRAIT
KUPARUK
RIVER FM
BANKS
ISLAND
POLE FOR
CRATONIC
NORTH
AMERICA
70°N
ROTATION
POLE
POLE FOR
KUPARUK
RIVER FM.
60°N
180°
PROTO-ALASKA?

“Smoking Gun” Evidence for Counterclockwise Rotation of Northern Alaska

1. Match of Sverdrup Basin (Paleo-Ballantyne Strait) and Hanna Trough Axes
2. Match of erosion edges of Carboniferous, Permian, Early Triassic and Early Jurassic
3. Match of Early Mesozoic facies belts
4. Match of Kuparuk paleomagnetic pole with NA pole

“Smoking Gun” Evidence for Counterclockwise Rotation of Northern Alaska

When two or more pieces of “smoking gun” evidence point to the same interpretation, go with it.

Conclusions

1. Seismic data and well data have allowed a placement of the axis of the SW Sverdrup Basin within Paleo-Ballantyne Strait.
2. The location of the axis of the Hanna Trough is also well established.
3. The two basin axes closely align when the Amerasian basin is closed by clockwise rotation of the Arctic Alaska plate.

Suggestions

I suggest we accept the counterclockwise rotation of Alaska interpretation and examine weaker, seemingly contradictory, evidence in light of this well established phenomenon.

I also that suggest the geology of the western Sverdrup Basin may be very instructive for those looking at exploring in the Chukchi Sea.


Thank You for
Your Attention
CF-GOD
Modellers
Close Encounters with the
Amerasia Basin