Tectono-Stratigraphic Habitat and Estimated Volume of Undiscovered Petroleum Resources North of the Arctic Circle*

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Abstract

A study of published and unpublished geologic mapping and potential field, seismic reflection, seismic refraction, and bathymetric data has identified 139 tectono-stratigraphic sedimentary accumulations underlying the Arctic Region between 64° and the North Pole. Petroleum exploration and geologic evaluation of these accumulations suggest that 31 percent of them contain petroleum deposits and that 44 percent are likely to contain and 25 percent possibly contain technically recoverable accumulations of oil, natural gas, and (or) natural gas liquids. Approximately 76 percent of the accumulations occur on continents, 14 percent in the rifted or strike-slip margins of continents, 3 percent in major prodeltas deposited on oceanic crust, and 7 percent in ocean basins seaward of their marginal progradational sedimentary prisms.

Mean estimates from the U.S. Geological Survey's Circum-Arctic Resource Appraisal suggest that 401 BBOE of undiscovered resources occur in continents north of the Arctic Circle. Of these estimated resources, enumerated as the sum of billions of barrels of oil, natural gas liquids, and oil-equivalent natural gas (BBOE), about 365.3 BBOE (91 percent) occurs in basins created by rift and thermo-isostatic (sag) events, about 18 BBOE (4.5 percent) in foreland basins and another 18 BBOE in transtensional basins, platforms and extensional basins lying adjacent to ocean basins formed by seafloor spreading.

Continental margins, which consist of progradational sedimentary prisms that are commonly underlain by rift deposits or strike-slip faults, contain an estimated 73 BBOE (14 percent) of the undiscovered petroleum resource estimated to lie north of the Arctic Circle. About 67 BBOE (92 percent) of this estimated resource occurs in rifted and 6 BBOE (8 percent) in strike-slip Arctic margins, such as Northern Greenland and the Amerasia Basin margin of Lomonosov Ridge. Another 13.8 BBOE (3 percent) of the estimated resource is assigned to the prodeltas of the major Lena and Mackenzie River systems of Eurasia and North America, which were deposited largely on oceanic crust. Basinward of their marginal progradational sedimentary prisms the ocean basins lying north of the Arctic Circle are estimated to contain only about 37 BBOE (7 percent) of the undiscovered petroleum resource of the Arctic.

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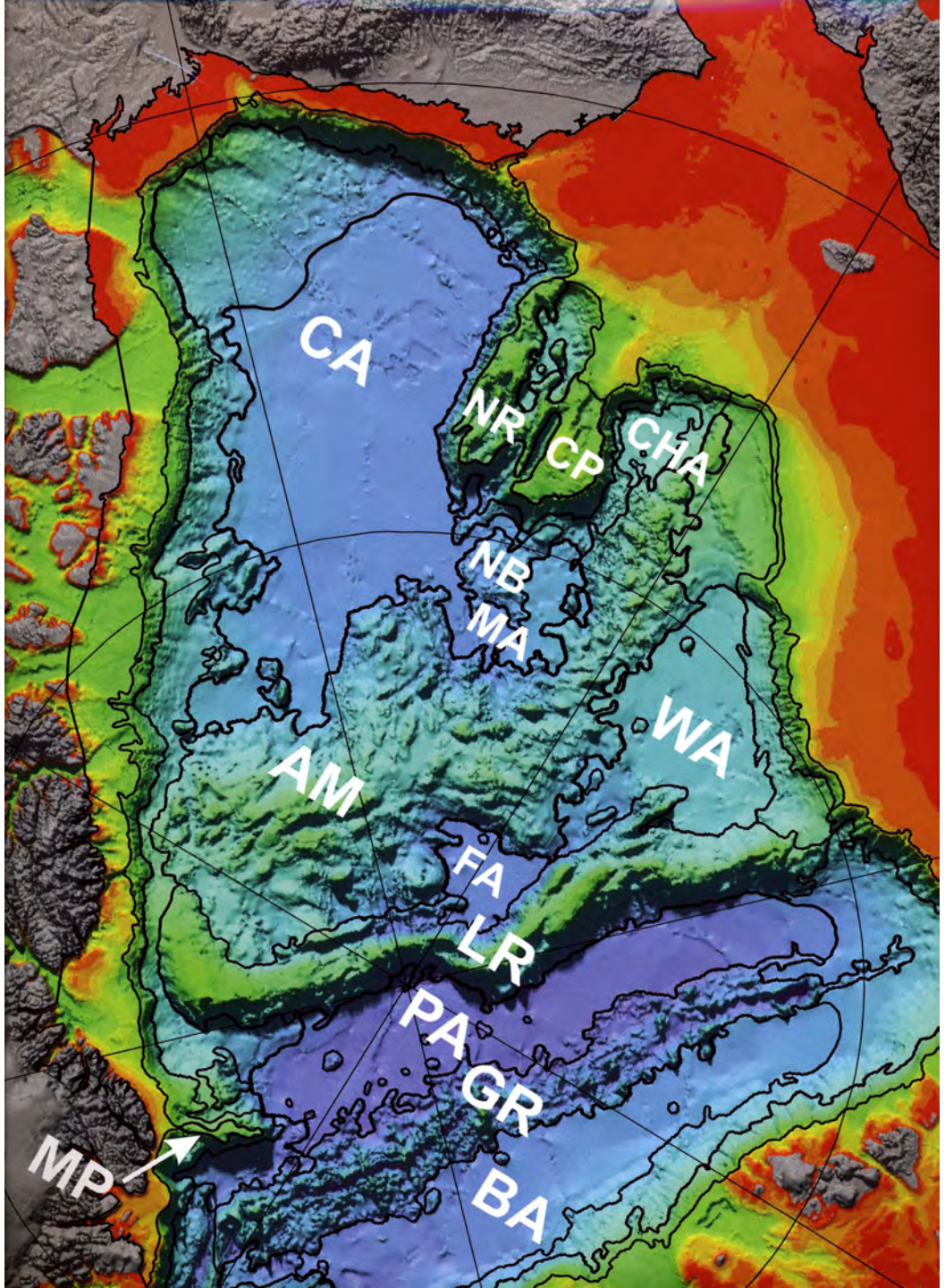
TECTONO-STRATIGRAPHIC HABITAT & EST. VOL., UNDISCOVERED PETROLEUM NORTH OF ARCTIC CIRCLE

by

A. Grantz, D.L. Gautier, R.A.Scott, S.S. Drachev and T.E. Moore

CARA SYMPOSIUM

June 10, 2009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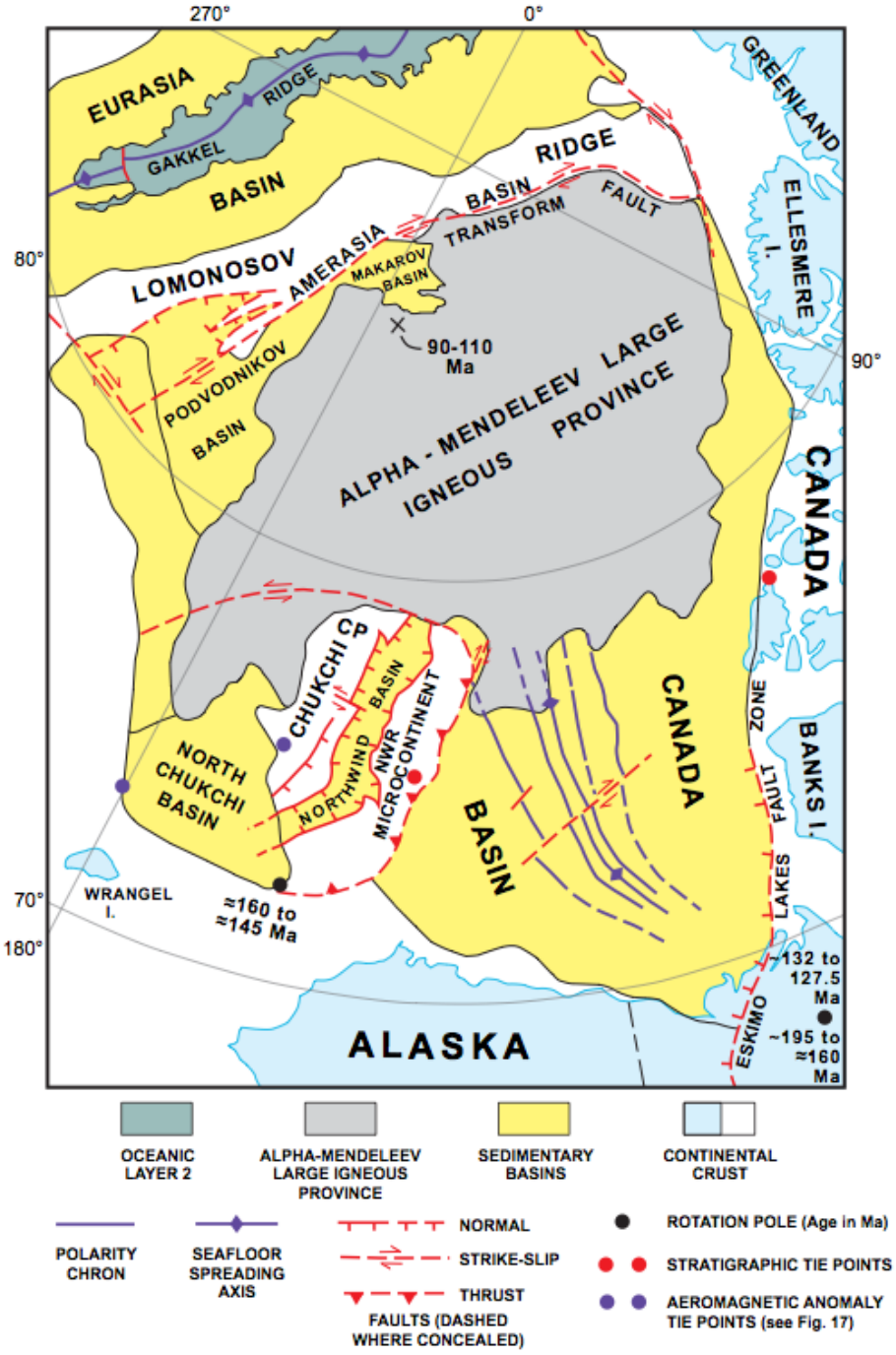
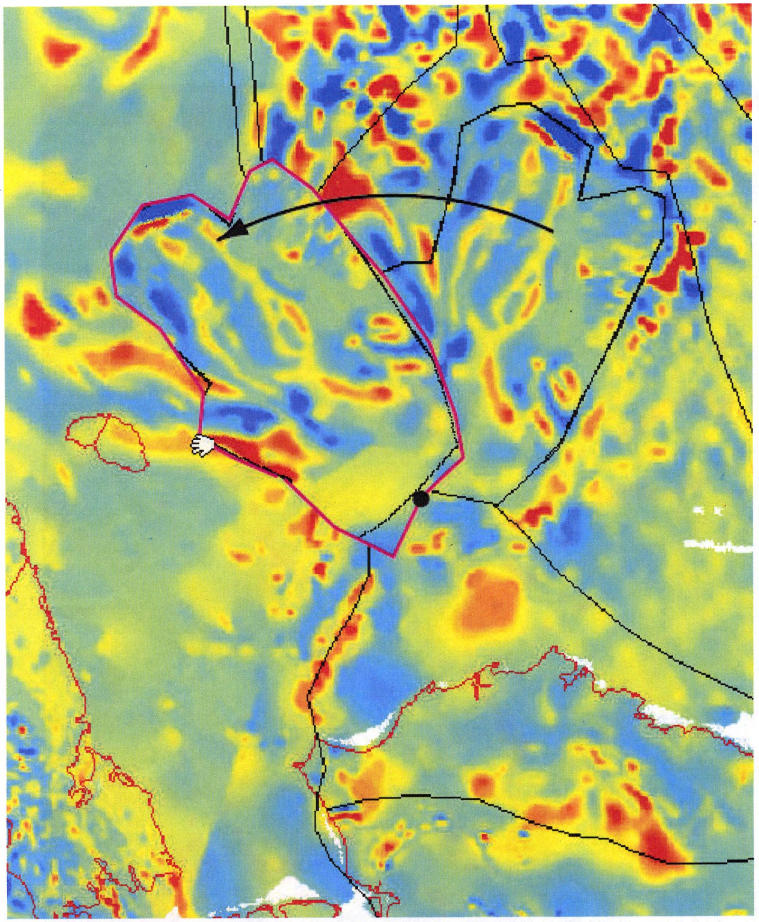
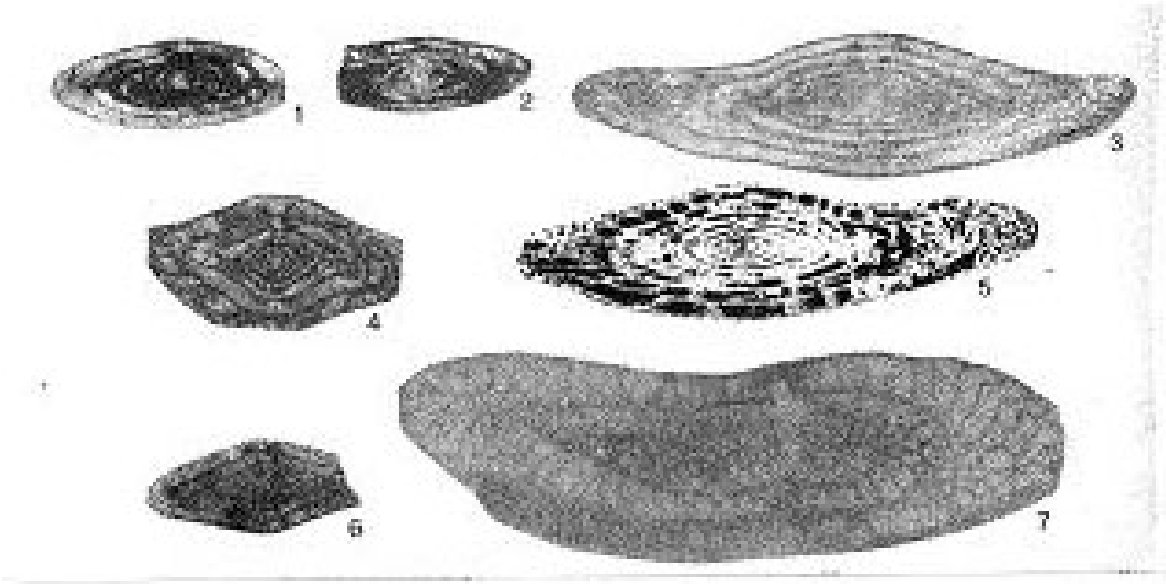

270°
0°
80°
90°
70°
180°
EURASIA
RIDGE
GAKKEL
BASIN
RIDGE
BASIN
TRANSFORM
FAULT
GREENLAND
ELLESMERE I.
LOMONOSOV
AMERASIA
MAKAROV BASIN
90-110 Ma
PODVODNIKOV
BASIN
ALPHA - MENDELEEV LARGE IGNEOUS PROVINCE
CANADA
CHUKCHI CP
BASIN
NORTHWIND
NWR
MICROCONTINENT
NORTH CHUKCHI BASIN
CANADA
BASIN
ZONE
FAULT
BANKS I.
LAKES
WRANGEL I.
≈160 to ≈145 Ma
~132 to 127.5 Ma
~195 to ≈160 Ma
ESKIMO
ALASKA
OCEANIC LAYER 2
ALPHA-MENDELEEV LARGE IGNEOUS PROVINCE
SEDIMENTARY BASINS
CONTINENTAL CRUST
POLARITY CHRON
SEAFLOOR SPREADING AXIS
NORMAL
STRIKE-SLIP
THRUST
FAULTS (DASHED WHERE CONCEALED)
ROTATION POLE (Age in Ma)
STRATIGRAPHIC TIE POINTS
AEROMAGNETIC ANOMALY TIE POINTS (see Fig. 17)

Fig. 2



AEROMAGNETIC EVIDENCE
ORIGINAL POSITION OF CHUKCH MICROPLATE
IN SIBERIA MARGIN

[Map and interpretation by Erik Lundin, STATOIL]



(Stevens and Ross, 1997)

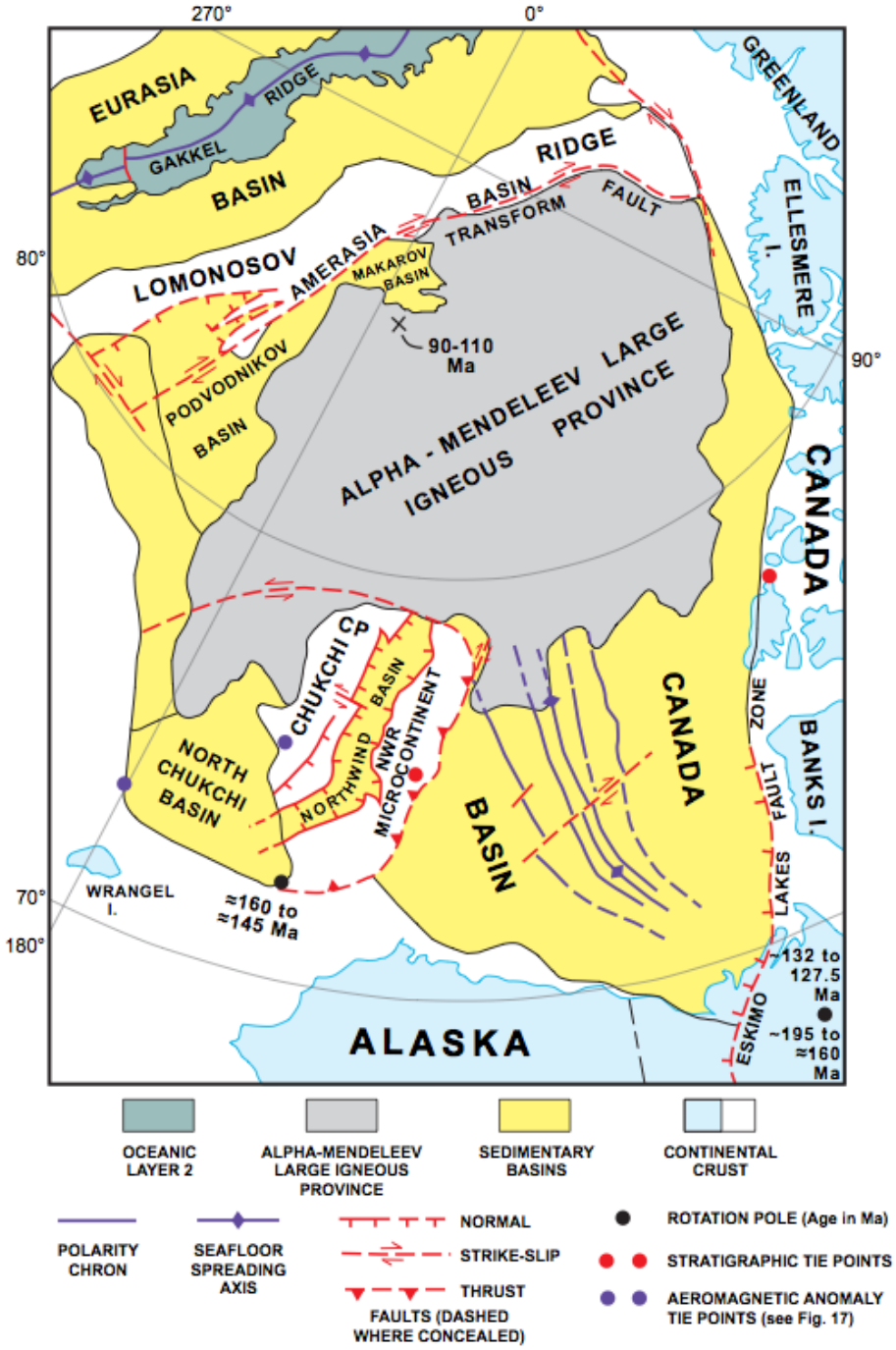
MID-CARBONIFEROUS TO EARLY PERMIAN

FUSULINIDS---NORTHWIND RIDGE

Arctic Fusulinid Province

Canadian Arctic Islands to Western Urals

Absent from Siberia


270°
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EURASIA
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90-110 Ma
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ROTATION POLE (Age in Ma)
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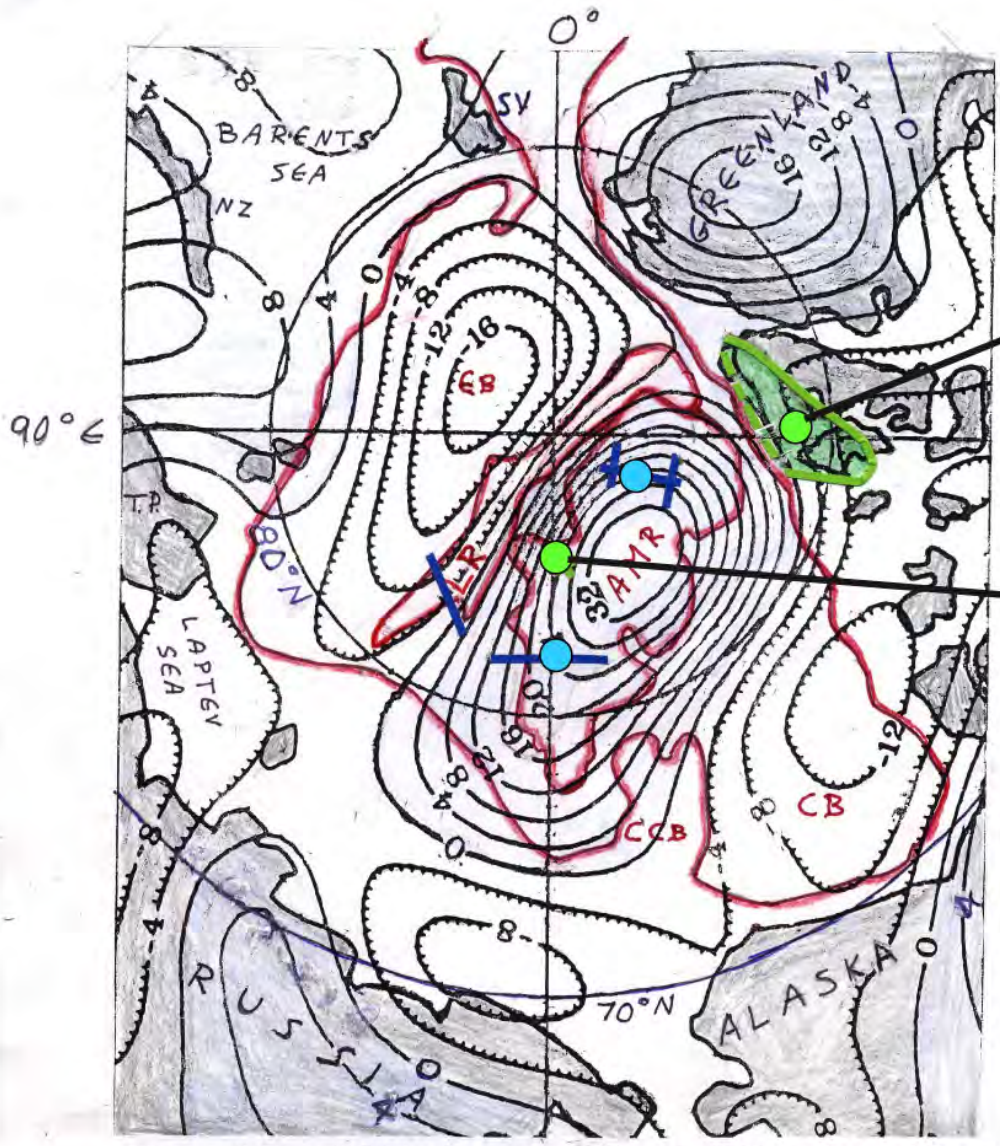
AEROMAGNETIC ANOMALY TIE POINTS (see Fig. 17)

Fig. 2



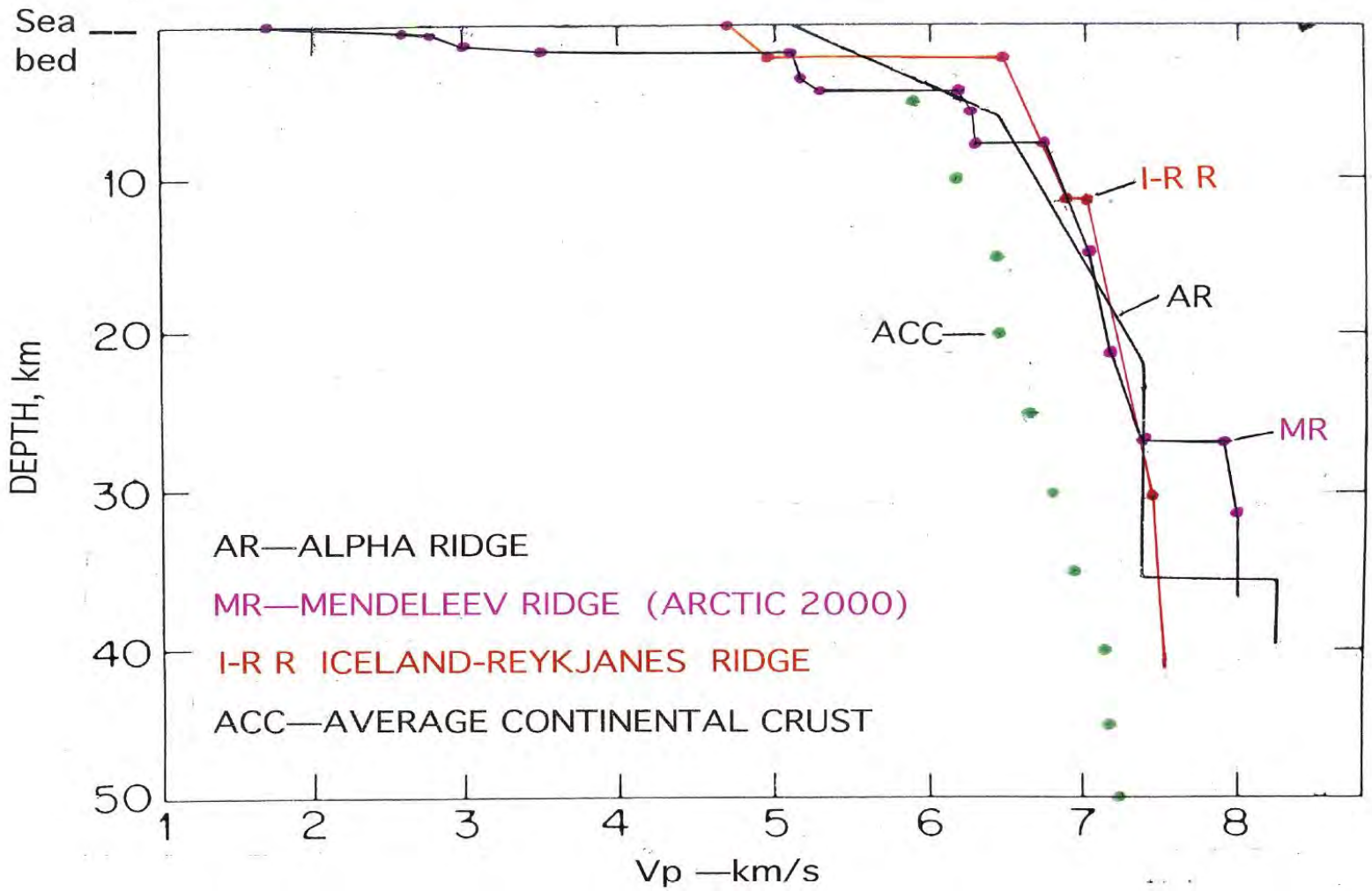
Mostly 136-98 Ma

110-90 Ma

(Mean altitude 331 km) (Haines, 1985; Embry and Osadetz, 1988; Jokat et al., 1999)

MAGSAT VERTICAL FIELD ANOMALY, nT

Shelf break, ridge outline. AMR-Alpha-Mendeleev, LR-Lomonosov Ridge



COMPARISON OF Vp-DEPTH FUNCTIONS

ALPHA AND MENDELEEV RIDGES

Data from:

Asudeh et al., 1988, Zamansky et al., 1999, Christensen and Mooney, 1995, Lebedeva-Ivanova et al., 2006,

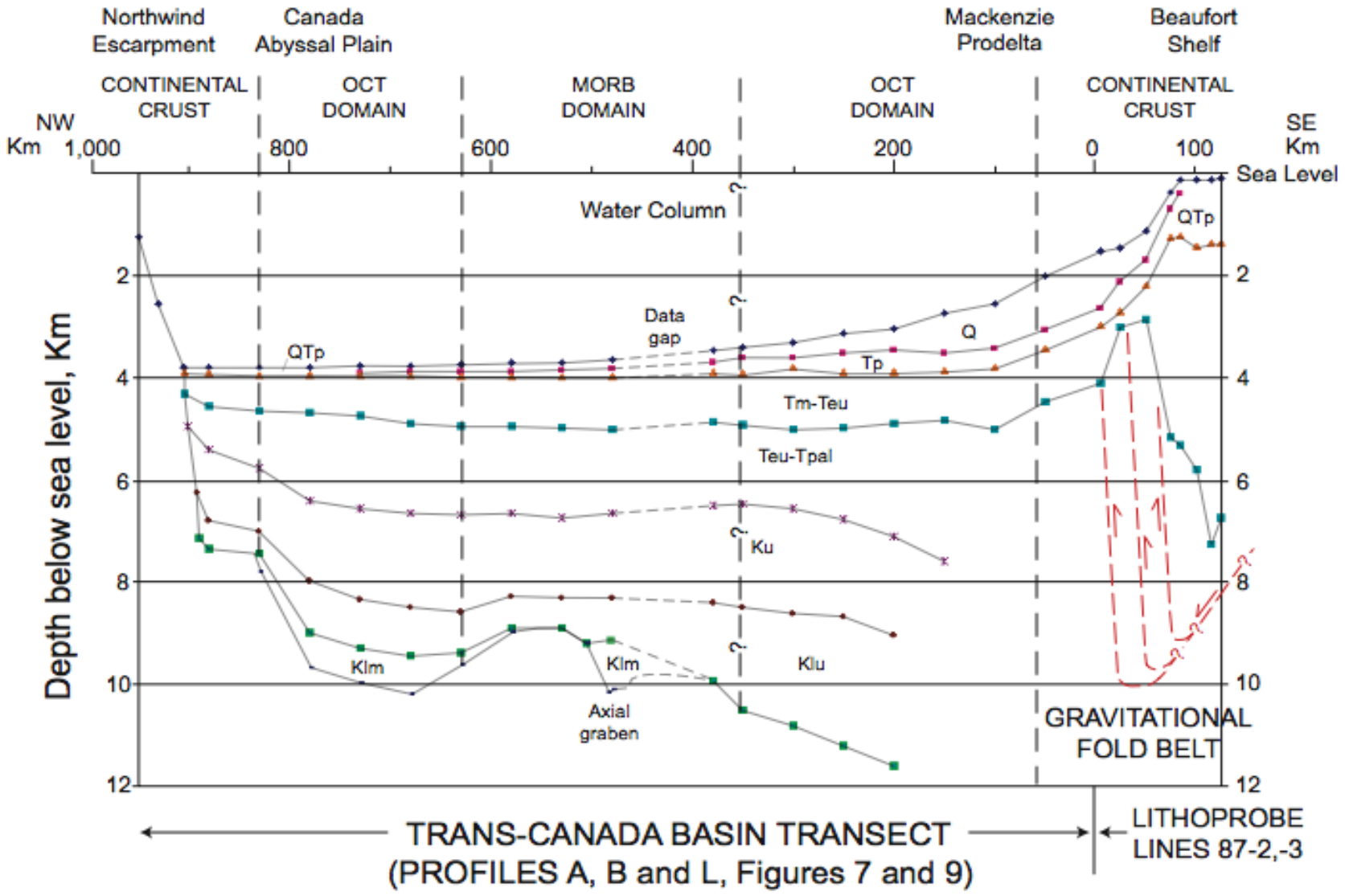
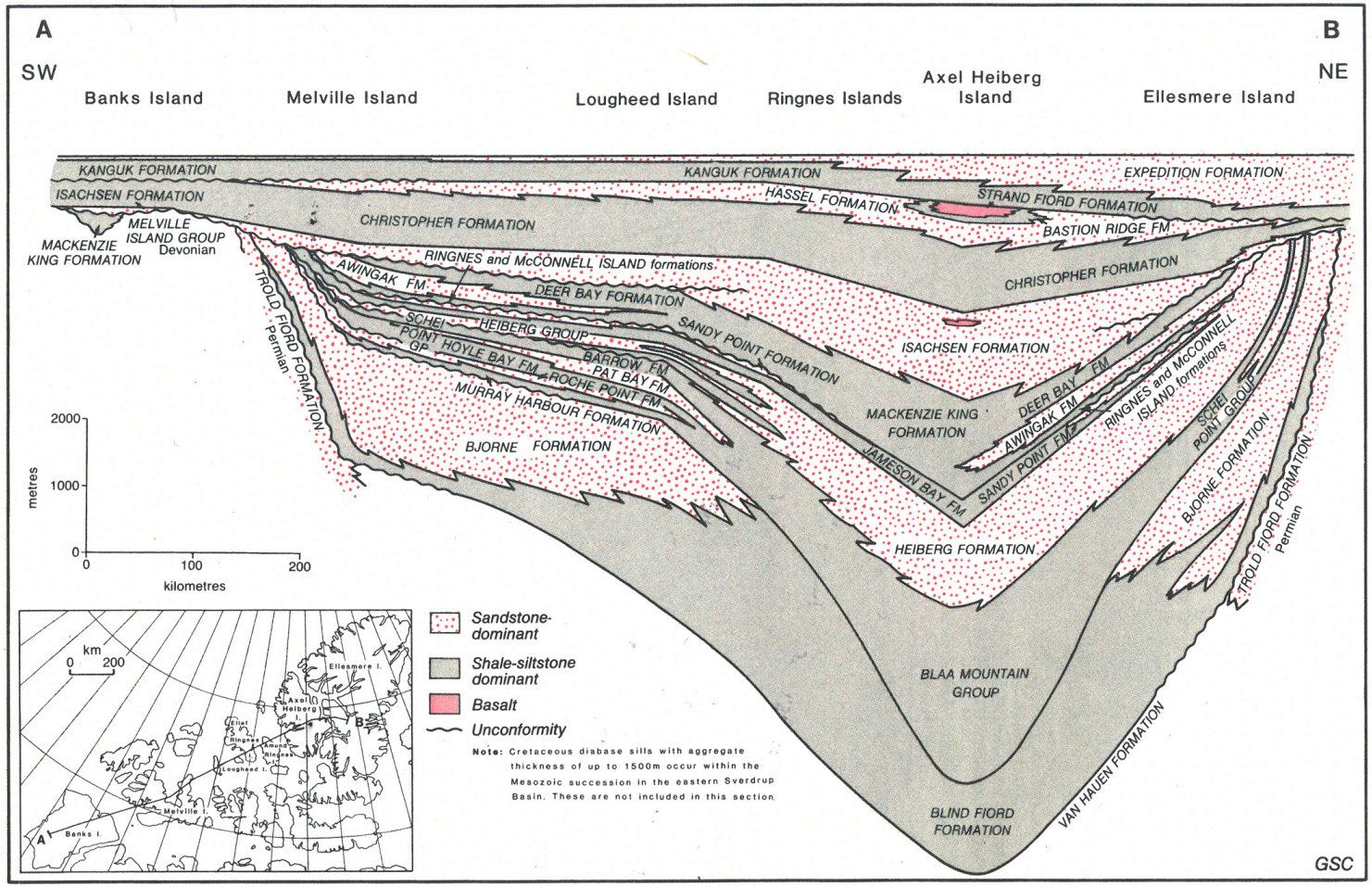
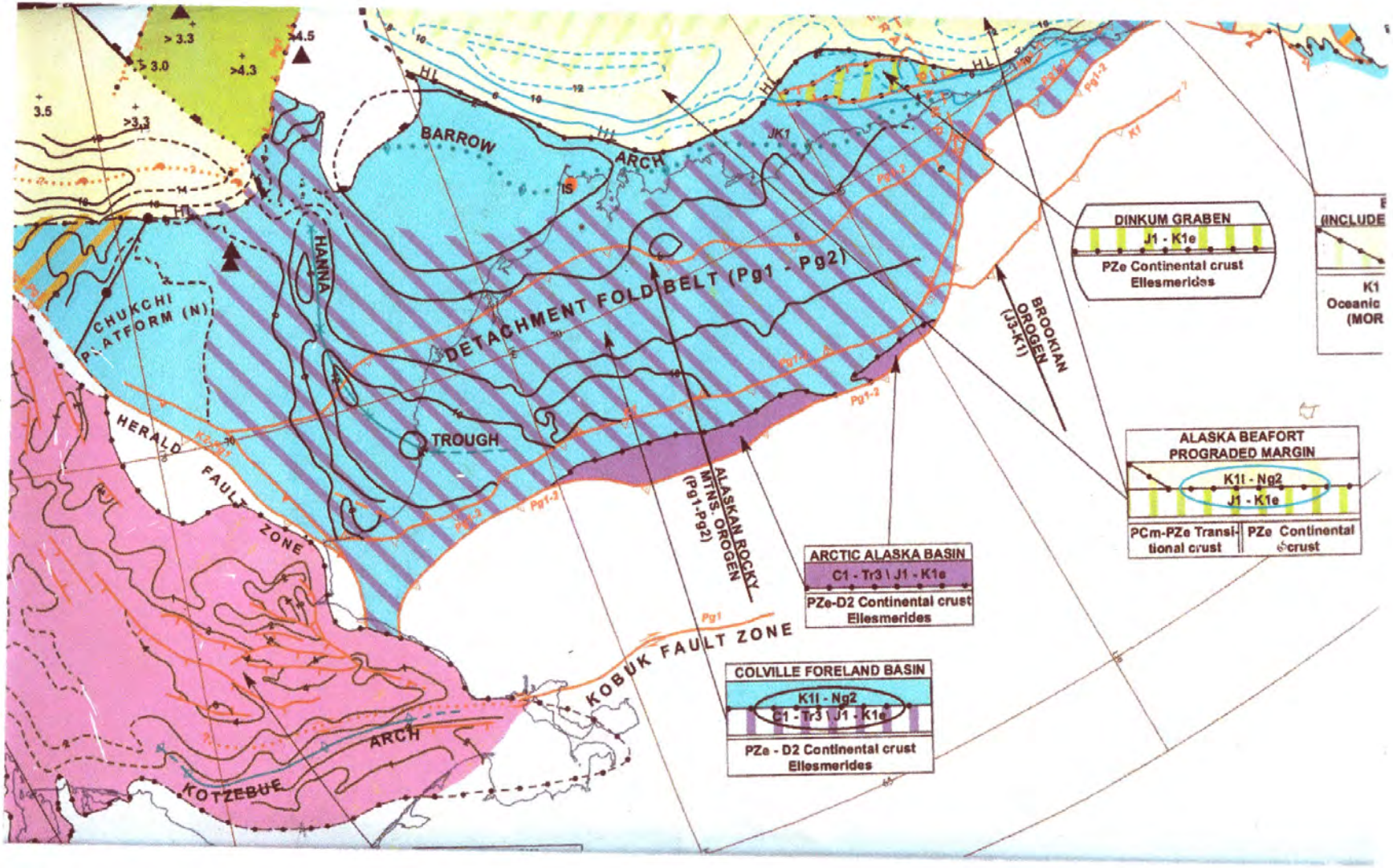

Northwind Escarpment
Canada Abyssal Plain
Mackenzie Prodelta
Beaufort Shelf
CONTINENTAL CRUST
OCT DOMAIN
MORB DOMAIN
OCT DOMAIN
CONTINENTAL CRUST
NW
Km
1,000
800
600
400
200
0
100
SE
Km
Sea Level
Water Column
QTp
Data gap
Q
Tp
Tm-Teu
Teu-Tpal
Ku
Klm
Klm
Klu
Axial graben
GRAVITATIONAL FOLD BELT
Depth below sea level, Km
2
4
6
8
10
12
TRANS-CANADA BASIN TRANSECT
(PROFILES A, B and L, Figures 7 and 9)
LITHOPROBE LINES 87-2,-3

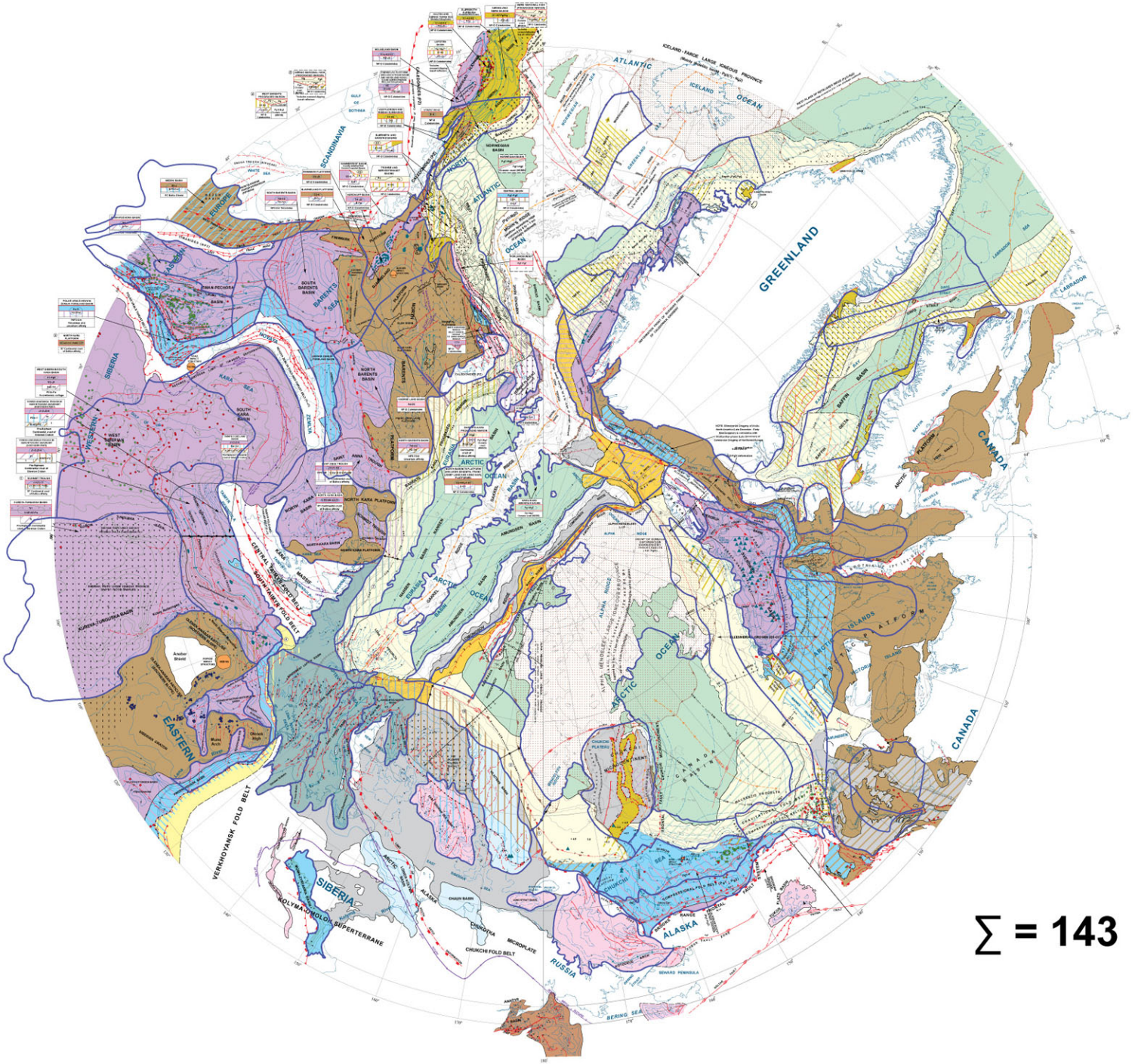
Fig. 17

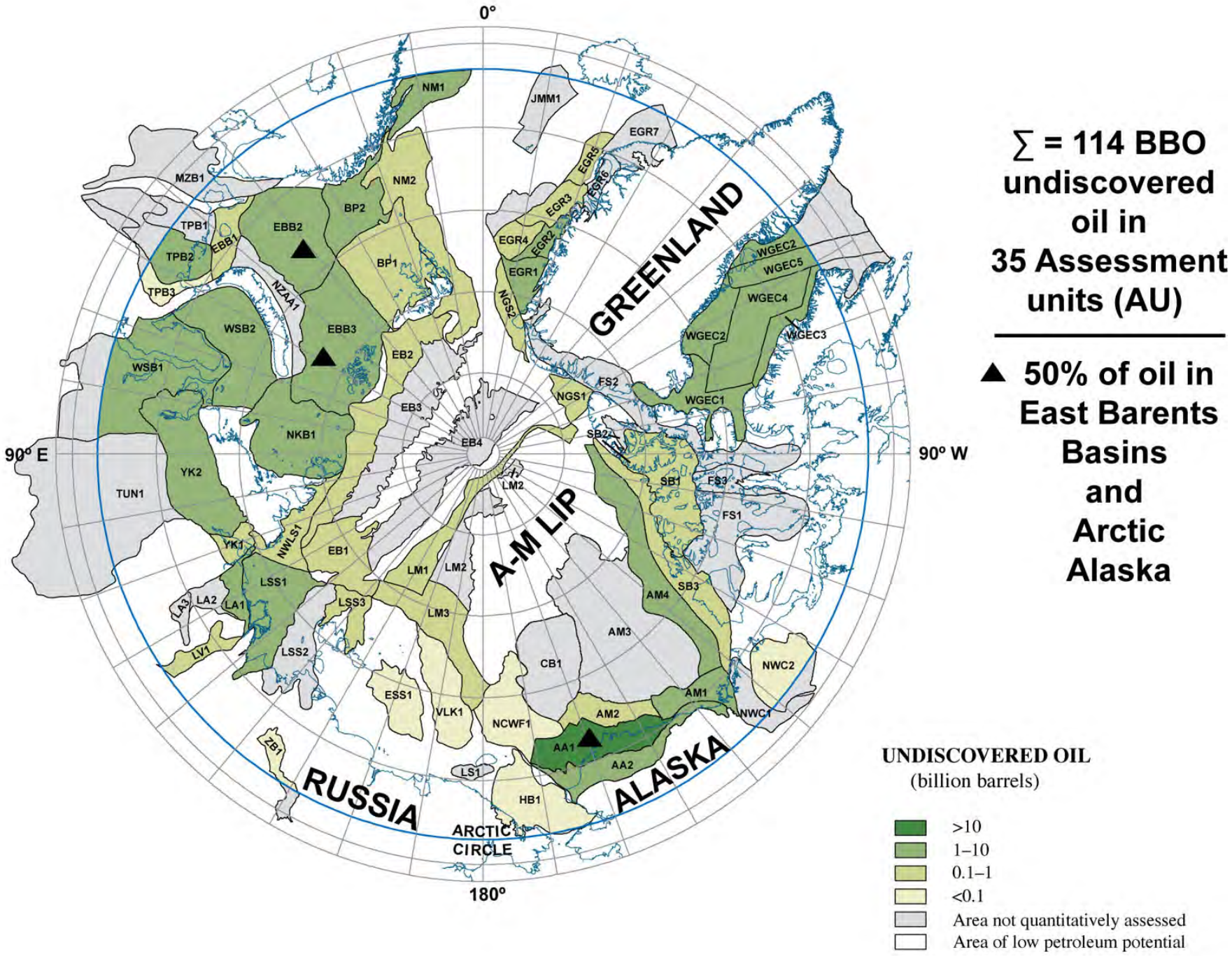


Sverdrup Basin, Canada Arctic Islands

(Embry, 1991)


BARROW ARCH
HANNA TROUGH
CHUKCHI PLATFORM (N)
DETACHMENT FOLD BELT (Pg1 - Pg2)
HERALD FAULT ZONE
KOTZEBUE ARCH
KOBUK FAULT ZONE
ALASKAN ROCKY MTNS. OROGEN (Pg1-Pg2)
BROOKIAN OROGEN (J3-K1)
DINKUM GRABEN
J1 - K1e
PZe Continental crust
Ellesmerides
ALASKA BEAFORT PROGRADED MARGIN
K1l - Ng2
J1 - K1e
PCm-PZe Transi-tional crust
PZe Continental crust
ARCTIC ALASKA BASIN
C1 - Tr3 \ J1 - K1e
PZe-D2 Continental crust
Ellesmerides
COLVILLE FORELAND BASIN
K1l - Ng2
C1 - Tr3 \ J1 - K1e
PZe - D2 Continental crust
Ellesmerides


ATLANTIC
OCEAN
ICELAND
GREENLAND
SCANDINAVIA
EUROPE
NORTH ATLANTIC OCEAN
NORWEGIAN BASIN
BARENTS SEA
SOUTH BARENTS BASIN
NORTH BARENTS BASIN
SIBERIA
KARA SEA
SOUTH KARA BASIN
NORTH KARA PLATFORM
NORTH KARA BASIN
ARCTIC OCEAN
LOMONOSOV RIDGE
ALPHA RIDGE
CANADA
CANADA BASIN
ARCTIC ISLANDS
BAFFIN BASIN
LABRADOR SEA
EASTERN
VERKHOYANSK FOLD BELT
SIBERIA
RUSSIA
ALASKA
CHUKCHI SEA
CHUKCHI FOLD BELT
BERING SEA
ANADYR BASIN
∑ = 143

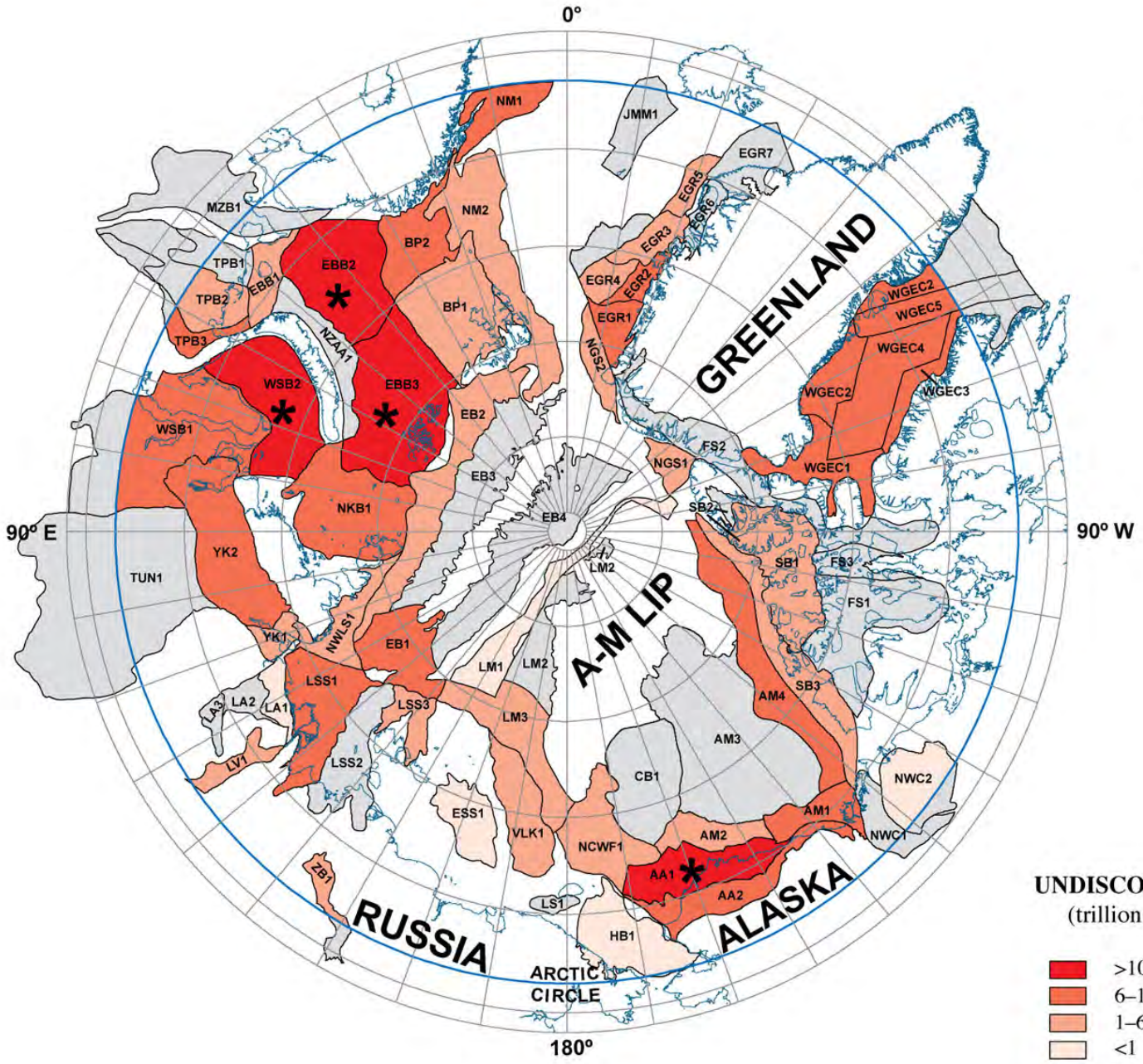


∑ = 114 BBO undiscovered oil in 35 Assessment units (AU)

▲ 50% of oil in East Barents Basins and Arctic Alaska

UNDISCOVERED OIL
(billion barrels)

- >10
- 1–10
- 0.1–1
- <0.1
- Area not quantitatively assessed
- Area of low petroleum potential



∑ = 1,973 TCF of undiscovered natural gas in 35 Assessment units (AU)

*** 75% of natural gas in West Siberia and East Barents Basins and Arctic Alaska**

UNDISCOVERED GAS
(trillion cubic feet)

- >100
- 6–100
- 1–6
- <1
- Area not quantitatively assessed
- Area of low petroleum potential

SEDIMENTARY SUCCESSIONS ON CONTINENTAL CRUST

M Stable shelf and platform

S Coastal plain and marine shelf

L Shelves with rift and thermo-isostatic (sag) basins

S Transtensional rift basin

M Extensional basin on continental crust along margin of adjacent ocean basin

M Extensional basin on continental crust along strike of adjacent ocean basin

Extensional basin of undetermined origin

M Foreland basin

S Fore-arc basin

$\sum = 12$

SEDIMENTARY SUCCESSIONS ACROSS CONTINENTAL MARGINS

M Progradational sedimentary succession across predominantly rifted passive margin of existing ocean basin

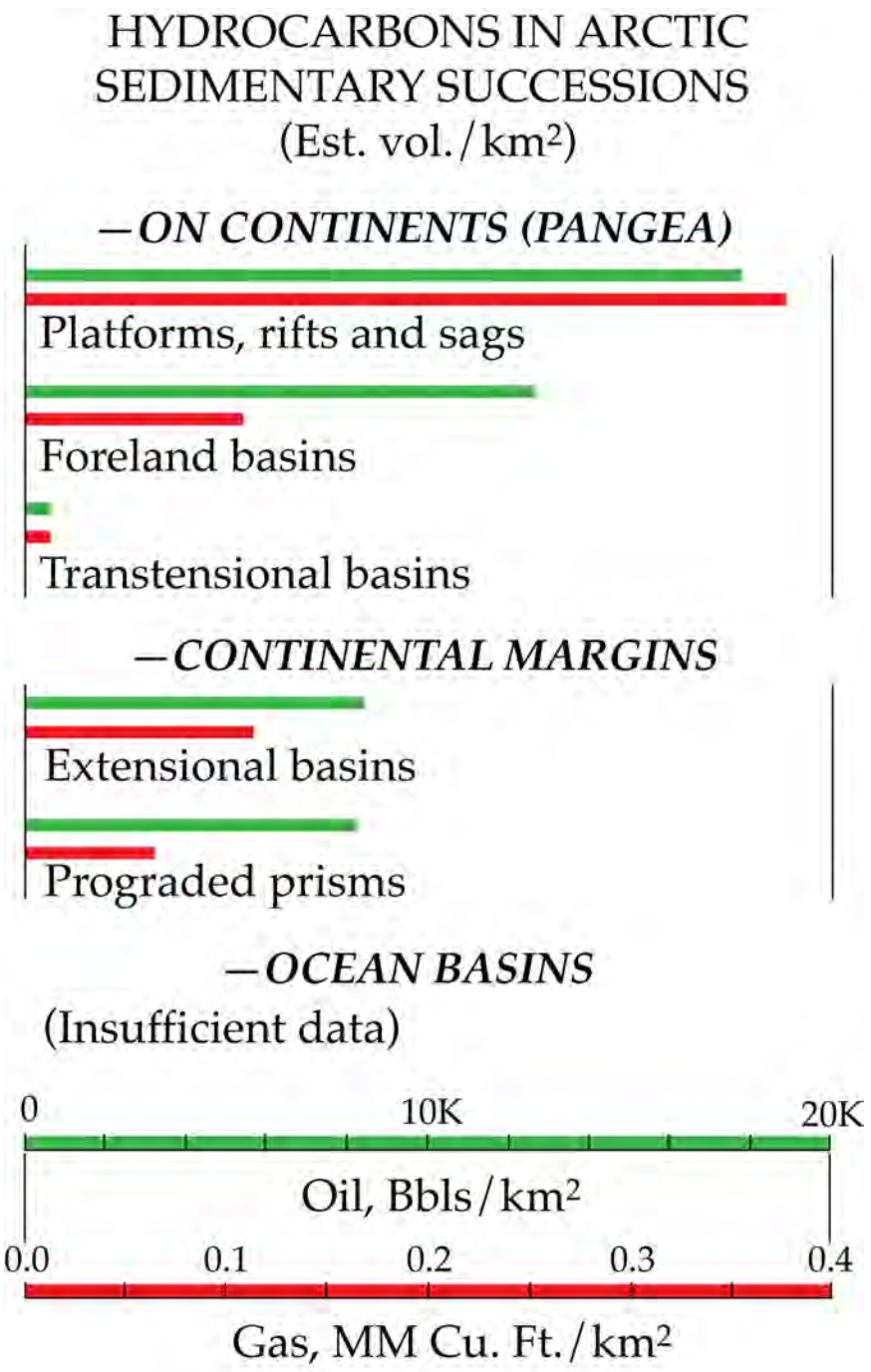
S Progradational sedimentary succession across shear margin of existing ocean basin

S Progradational sedimentary succession across passive margin of extinct ocean basin

SEDIMENTARY SUCCESSIONS ON OCEANIC CRUST

? Ocean basin (MORB and OCT crust)

L = Large M = Medium S = Small


HYDROCARBONS IN ARCTIC SEDIMENTARY SUCCESSIONS
(Est. vol./km²)
—ON CONTINENTS (PANGEA)
Platforms, rifts and sags
Foreland basins
Transtensional basins
—CONTINENTAL MARGINS
Extensional basins
Prograded prisms
—OCEAN BASINS
(Insufficient data)
0
10K
20K
Oil, Bbls/km²
0.0
0.1
0.2
0.3
0.4
Gas, MM Cu. Ft./km²