Resources in the Arctic Ocean

a red herring or a bonanza?

Arctic in the Anthropocene
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The Arctic Ocean

Competition for territory/resources?

- Resources are rare and valuable.
- What are resources?
- How do we find these resources?
- How is ownership established?
- Can these resources cause conflict in the arctic?

What defines resource?

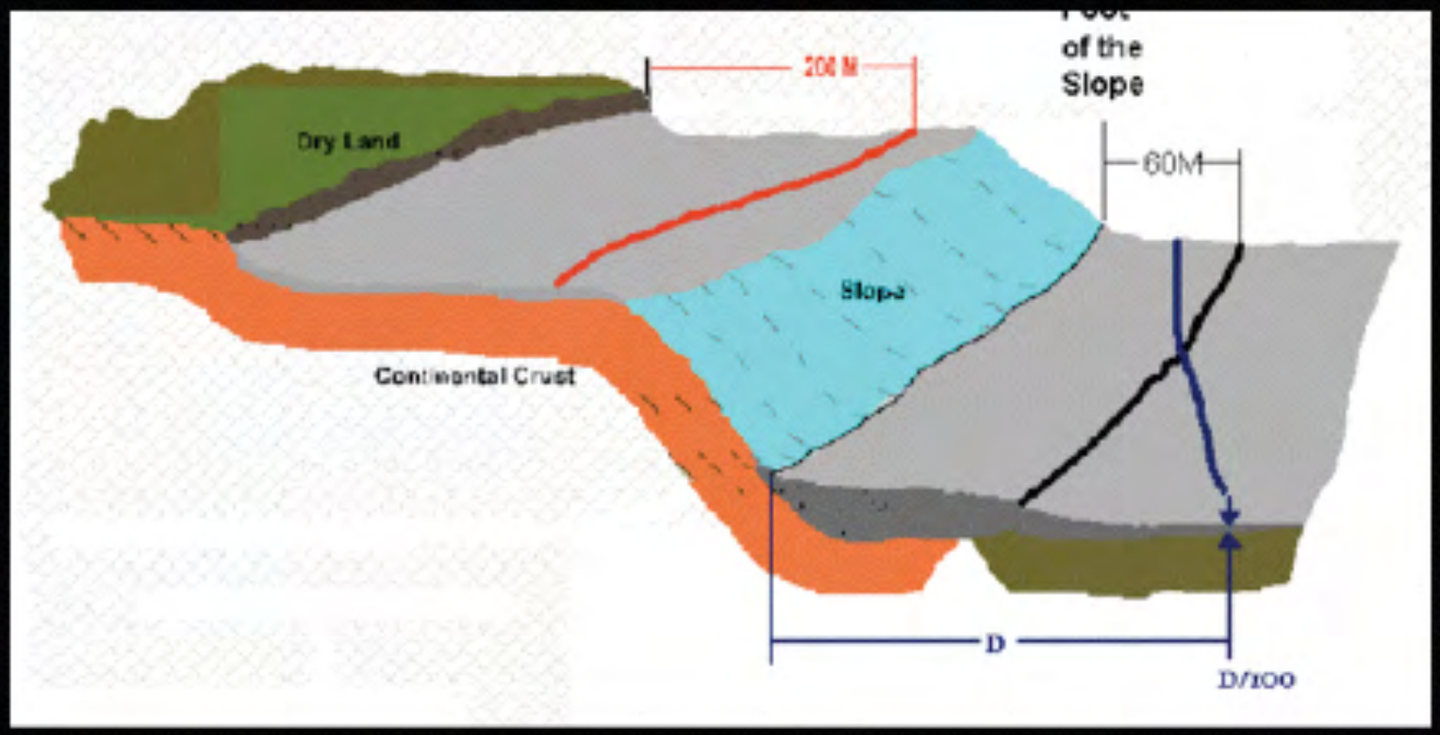
Cost for production and delivery vs market price.

Industry explores for the cheapest reserves first.

These are the largest, closest to market and easiest to produce.

Oil Exploration for complete idiots

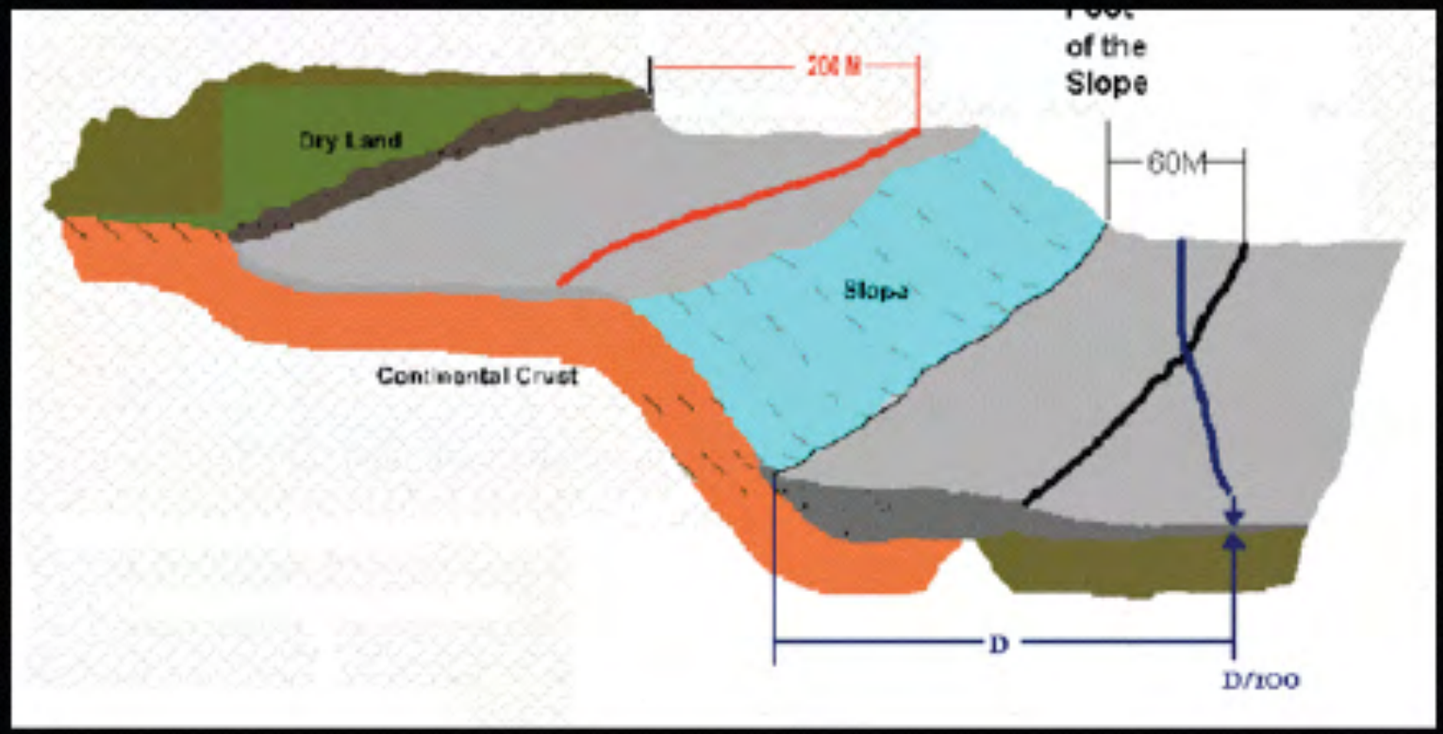
Rule #1 - You find oil (and gas) where you found it.



Oil Exploration for complete idiots

Rule #1 - You find oil (and gas) where you found it.

Rule #2 - There are no other rules.



Oil Exploration for complete idiots

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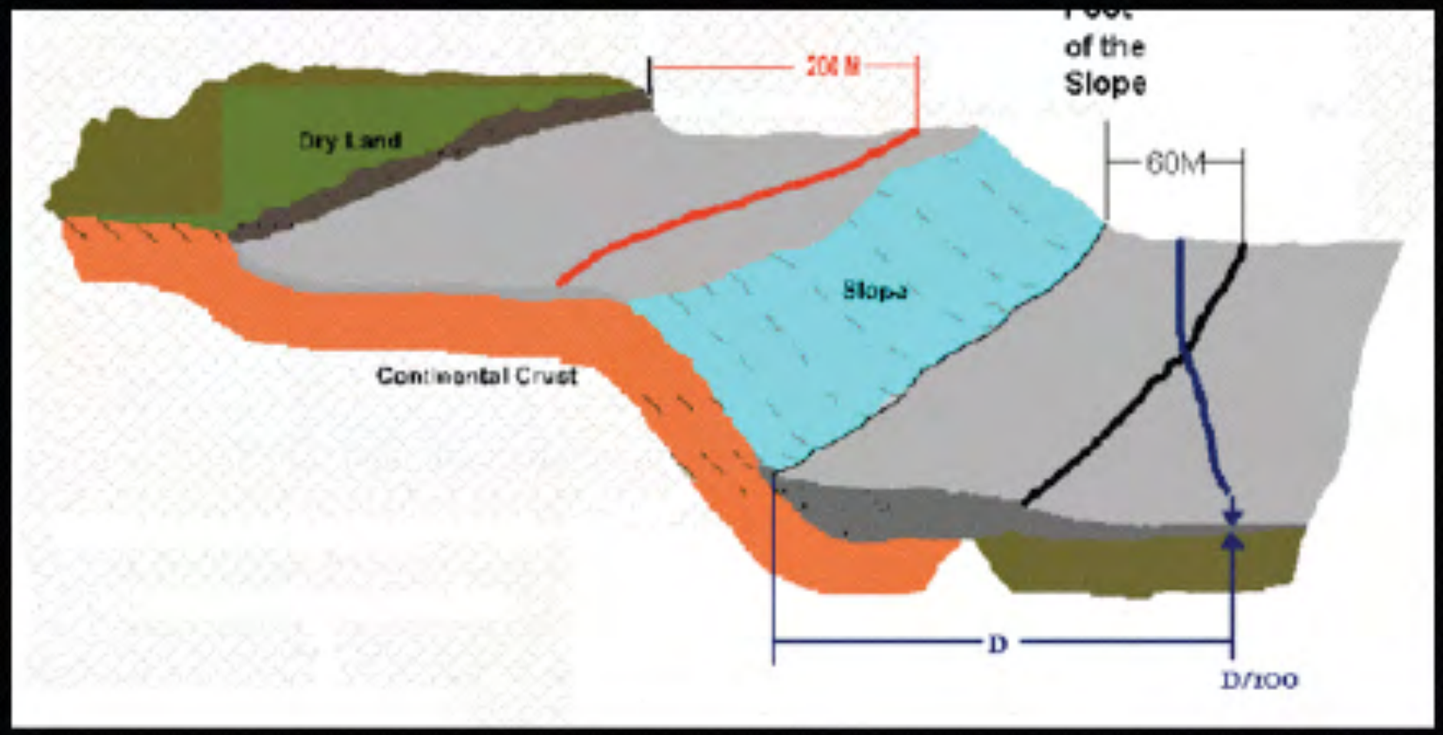
Rule #2 - There are no other rules.

So exploration focuses on known O&G provinces and similar geologic settings.



Requirements for oil and gas formation

prediction on the 100-1000 km scale

- Source Rock
- Heat
- Migration Path
- Reservoir Rock
- a “Trap”

Source Rock

- **Type 1** - formed from algal remains deposited under anoxic conditions in deep lakes
- **Type 2** - formed from marine planktonic and bacterial remains preserved under anoxic conditions in marine environments
- **Type 3** - formed from terrestrial plant material that has been decomposed by bacteria and fungi under oxic or sub-oxic conditions

Preservation of fossil carbon requires an anoxic basin.
4.0% Total Organic Carbon is considered rich source rock.

Source Rock in the Arctic Ocean

High-carbon rocks (source) found on Lomonosov Ridge

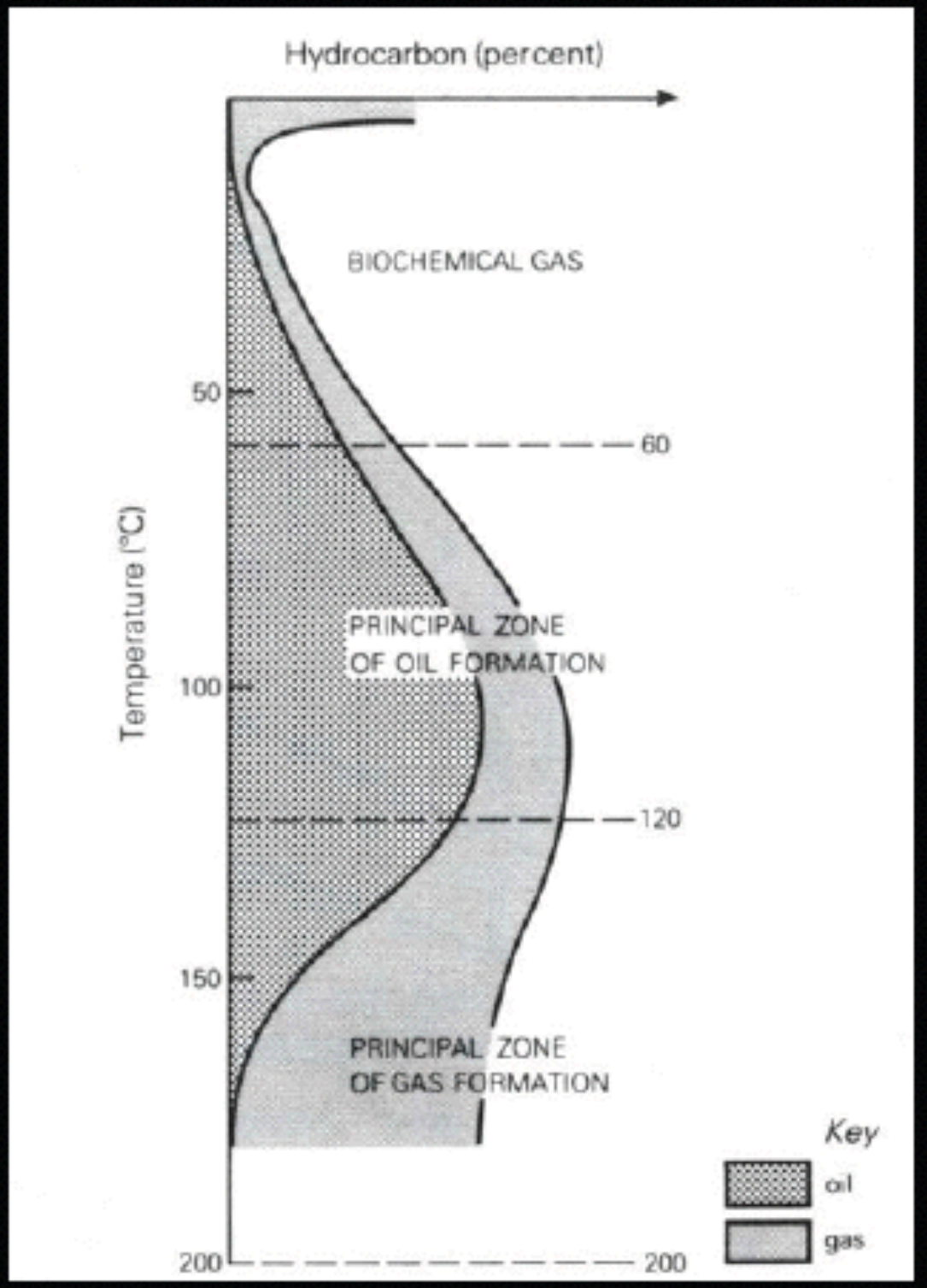
Very rich source rocks have been found on Alpha Ridge

There are good reasons to believe that the Amerasian Basin was very productive and anoxic prior to the opening of Fram Strait.

It is believed that there are extensive source rocks buried to variable depth beneath the Arctic Ocean.

Heat

- Oil and gas are formed through the burial of carbon-rich rock.
- A typical geothermal gradient is ~ 20° C/km
- Burial of sediments slowly increases temperature and pressure leading to oil and gas formation.

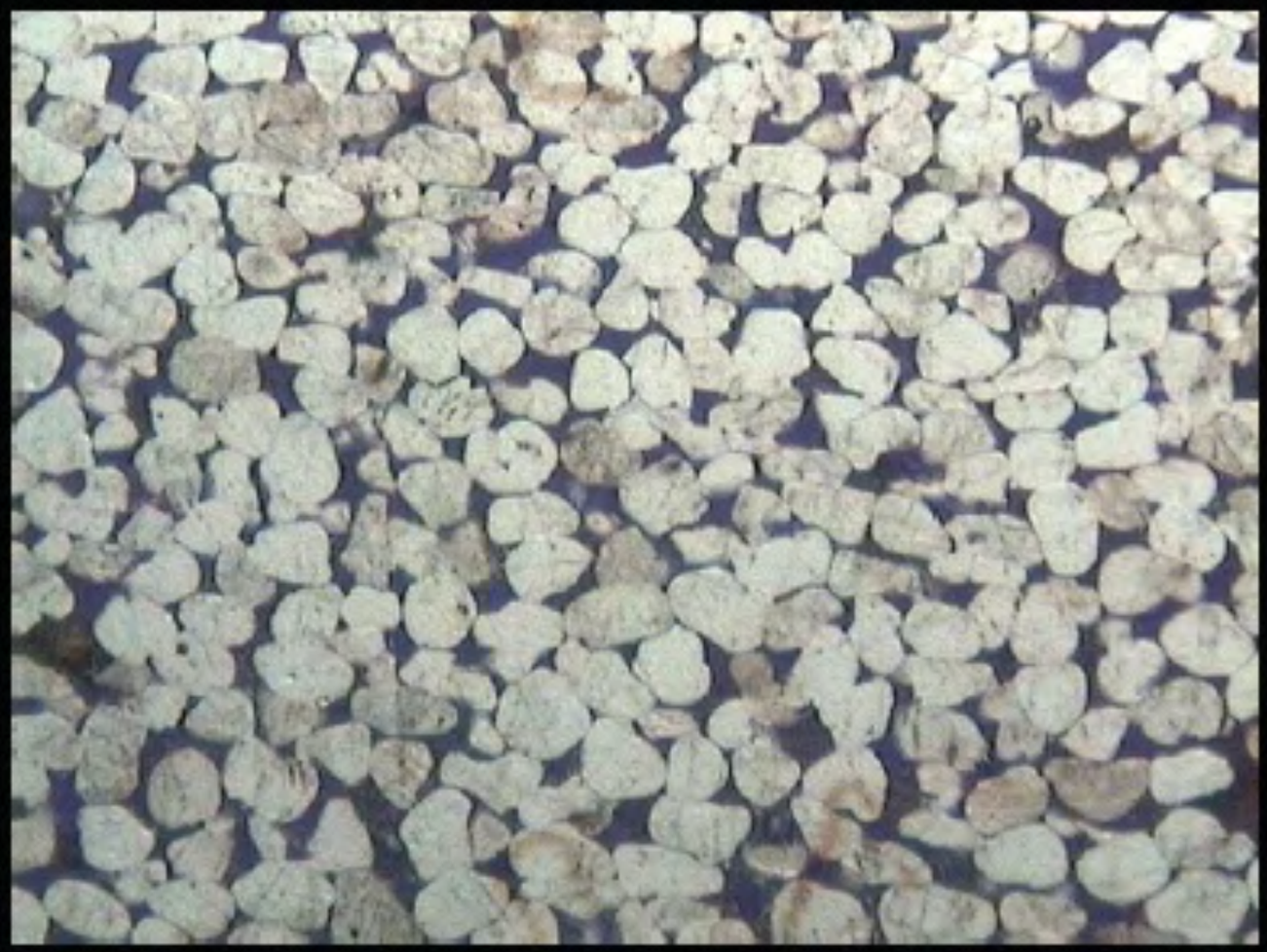


Migration Path

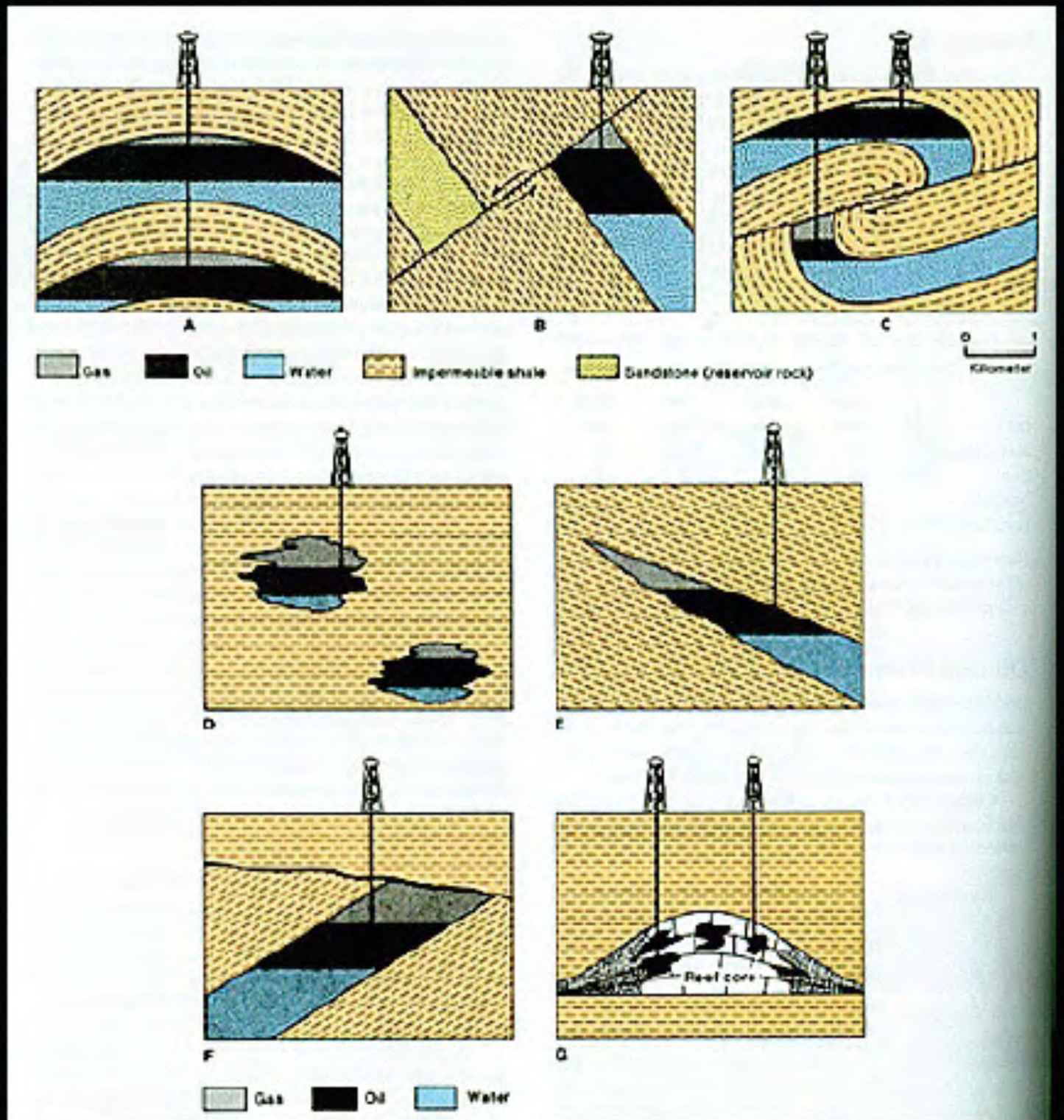
- Compaction drives fluids from rocks
- Once liberated in sufficient quantity, oil and gas, being less dense than formation fluids (brines) will tend to rise faster
- Pathways through porous rock, faults and, perhaps, hydro-fracture

Reservoir Rock

- Good reservoir rocks are both porous and permeable
- There must also be a seal



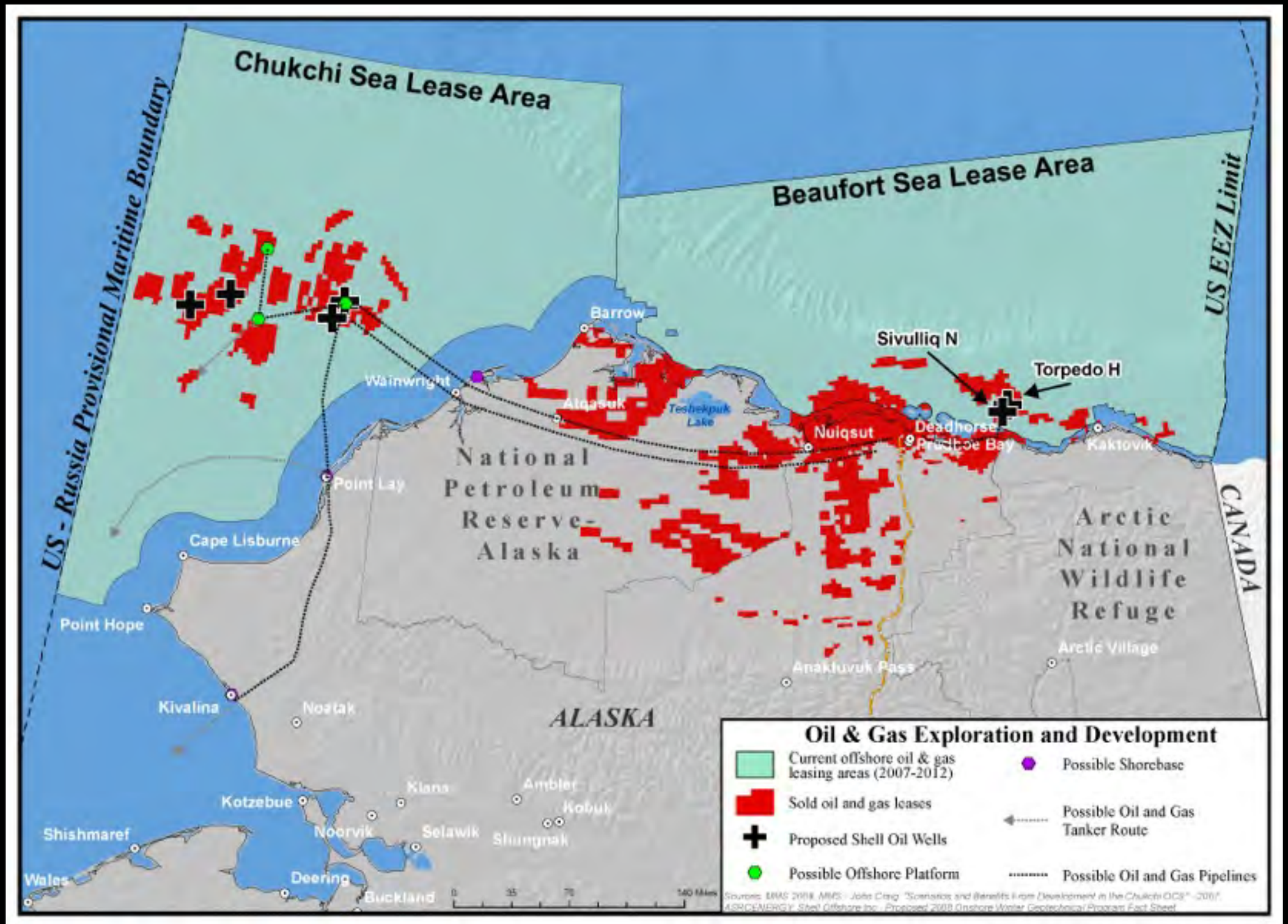
Traps


A
B
C
0
1
Kilometer
Gas
Oil
Water
Impermeable shale
Sandstone (reservoir rock)
D
E
F
G
Reef core
Gas
Oil
Water

Arctic Resources

in production

Alaska Leases




PS 1
PS 2
PS 3
PS 4
PS 5
PS 6
PS 7
PS 8
PS 9
PS 10
PS 11
PS 12
Barrow
Wainwright
Icy Cape
Point Lay
Cape Lisburne
Point Hope
Kivalina
Noatak
Kotzebue
Shishmaret
Selawik
Kobuk
Bettles
Wiseman
Allakaket
Beaver
Fort Yukon
Circle
Livengood
Rampart
Tanana
Huslia
Koyukuk
Jeller
Nome
White Mountain
Koyuk
Nulato
Galena
Kokrines
Ruby
Minto
Fox
Fairbanks
Nenana
Unalakleet
St Michael
Alakanuk
Scammon Bay
Hooper Bay
Pilot Station
Holy Cross
Flat
McGrath
Kalskag
Sleetmute
Kwethluk
Bethel
Tanunak
Kipnuk
Kwigillingok
Nondalton
Dillingham
Ekwok
Curry
Talkeetna
Palmer
Anchorage
Whittier
Cordova
Kenai
Seward
Homer
Seldovia
Tanacross
Dot Lake
Glennallen
Valdez
Colville River
Noatak River
Kobuk River
Koyukuk River
Porcupine River
Yukon River
Tanana River
Susitna River
Copper River
Kuskokwim River
Kuskokwim Bay
Cook Inlet
ARCTIC CIRCLE
SIBERIA
ALASKA
STRAIT
CHUKCHI SEA
NORTON SOUND
BEAUFORT SEA
ARCTIC OCEAN
YUKON
ALASKA

stakeholders

- Oil companies (return on investment)
- Federal government (leasing fees, taxes)
- State government (leasing fees, taxes)

Owners

- Native peoples (PFD, employment)
- Alaska residents (PFD, employment)
- NGOs?
- Others?

Law of the Sea

- Distinguishes the deep sea from Extended Continental Shelves (ECS) based on “natural prolongation”

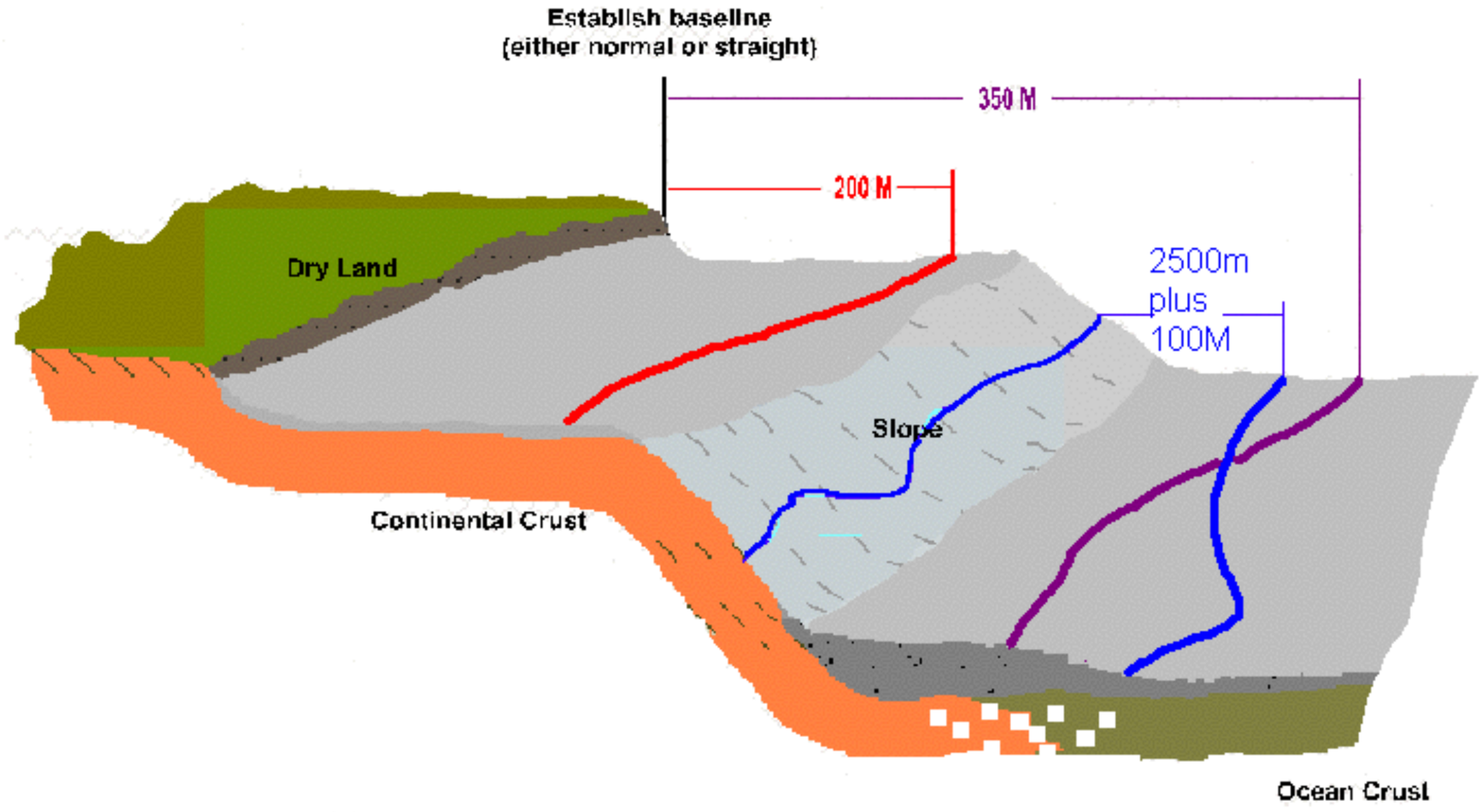
Ownership creates incentives for management
Applies to the seabed and resources below it
The “area” belongs to humanity.

- Claims established by mapping
  Observing these features; 2500 m; FOS, sediment thickness

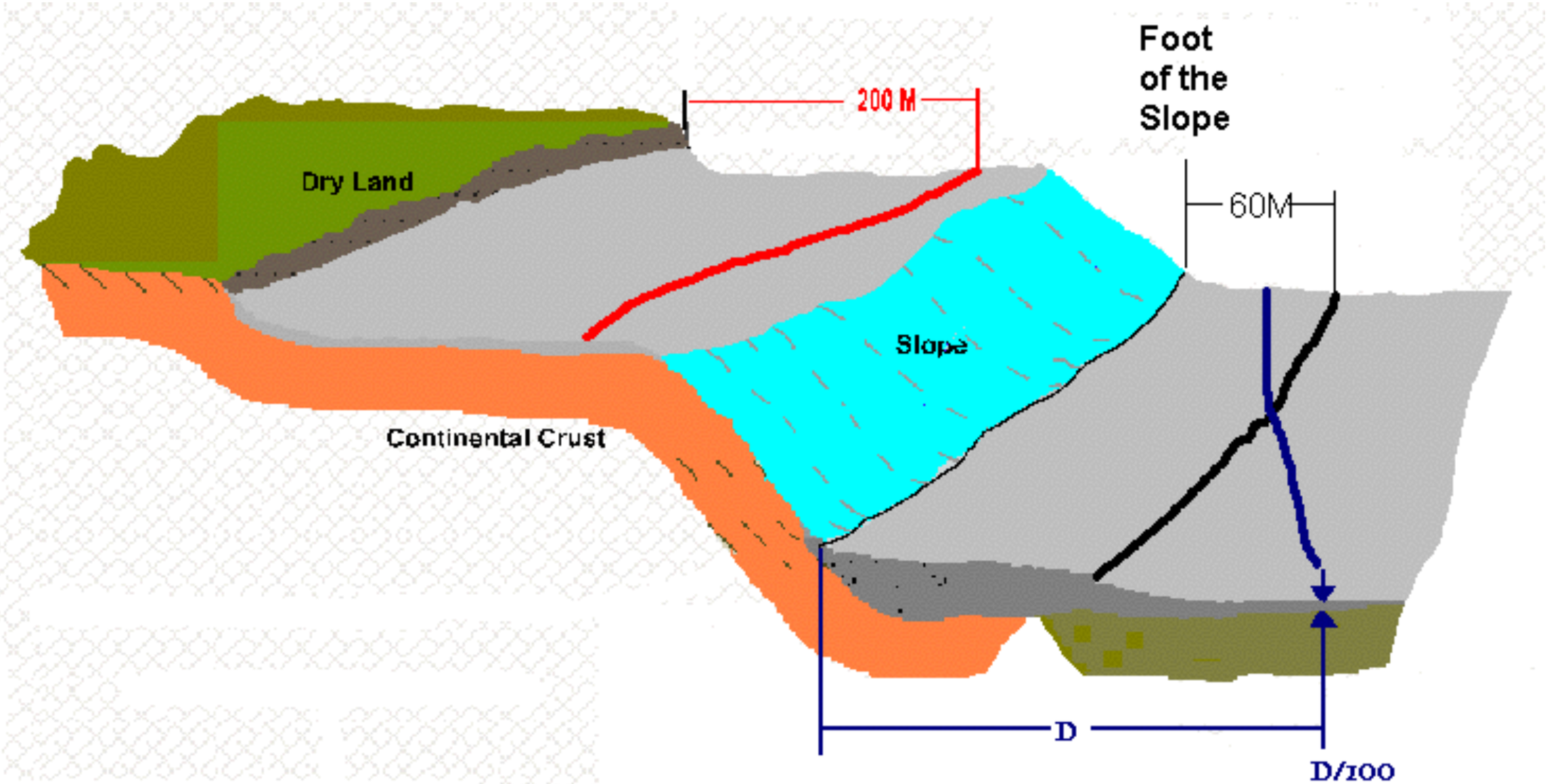
Evaluated and validated by the Technical Commission

- Distinguishes the juridical from the physiographic shelf
- UNCLOS creates an internationally approved process for establishing territorial limits

Continental Shelves are constrained by the most seaward of a line 350M from the Baselines or a line 100M seawards of the 2500m depth contour.



Outer limit drawn from the Foot of the Slope, either a distance of 60M, or to a point where “the thickness of sedimentary rocks ...”



The new limit is maximum extent of the limits formed by the three methods.

Geophysical Data Sets for ECS Determination

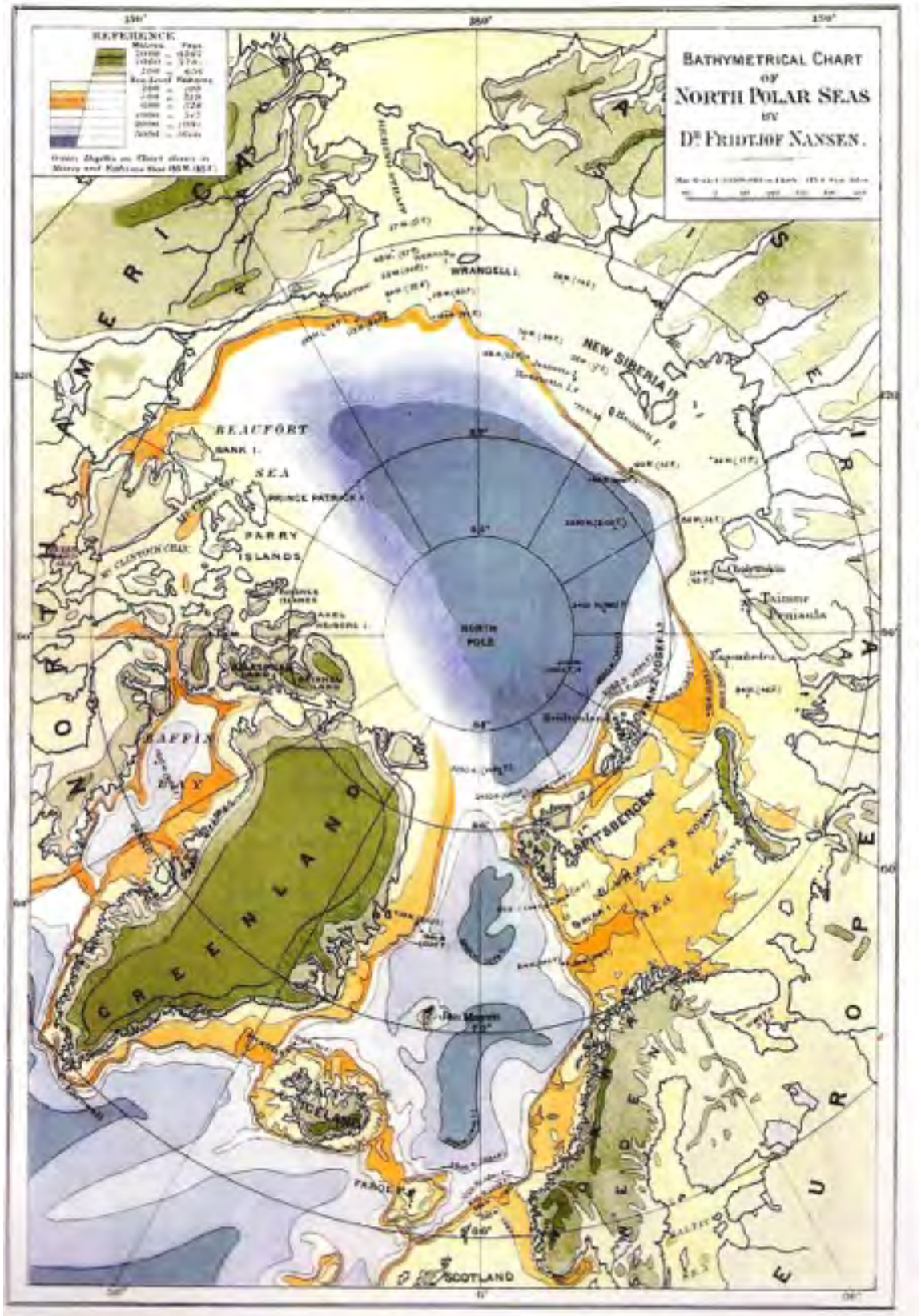
Swath Bathymetry
- 2500 meter isobath
- Foot of Slope

Swath Backscatter
- Seafloor texture/composition

Gravity Anomaly
- Sediment Thickness/Crustal Structure

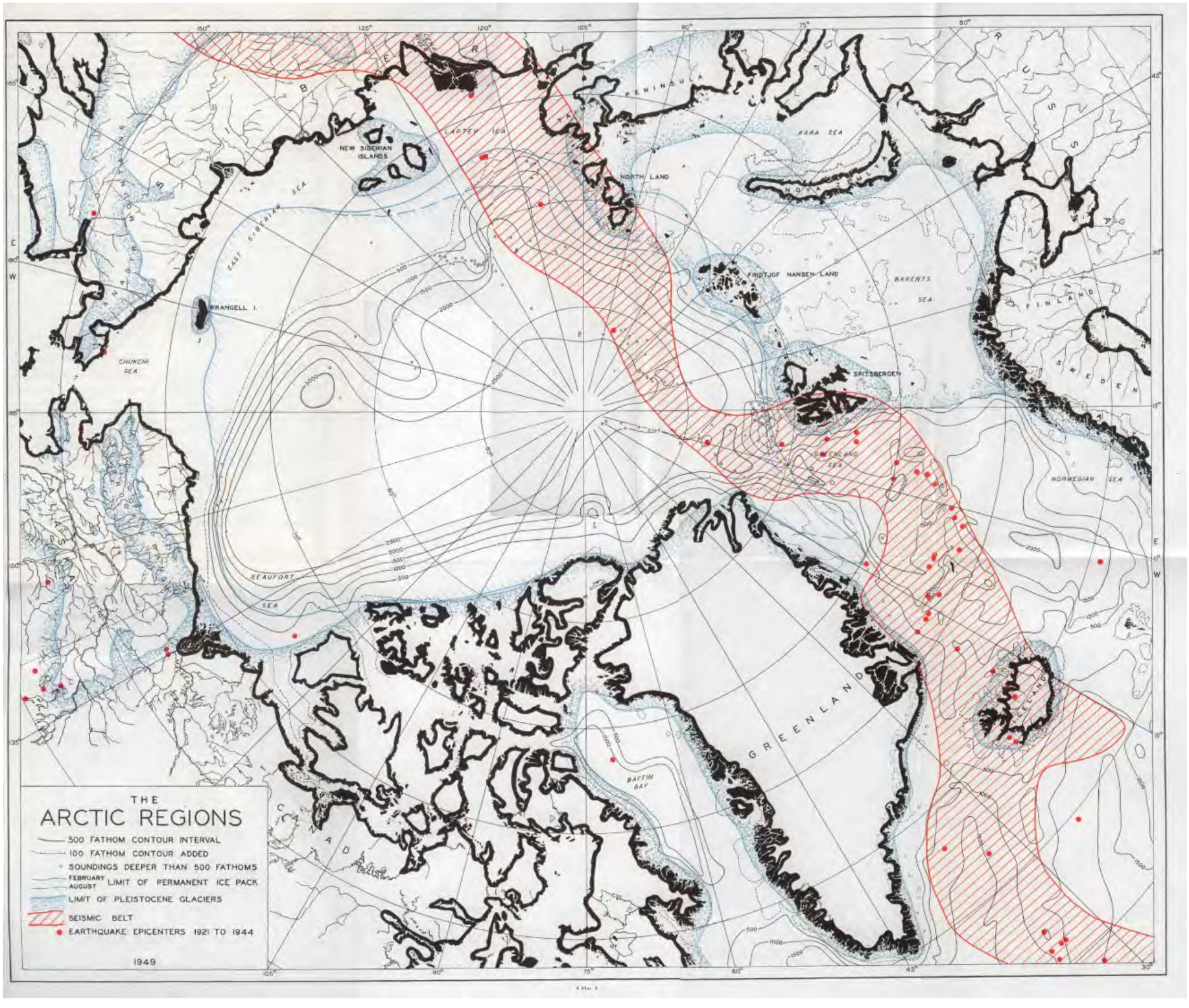
Multi-Channel Seismic Reflection (MCS)
- Sediment Thickness and Crustal Structure
- Scaled in Two-way Time (thickness/sound velocity)

Wide Angle Seismic Refraction
- Sound Velocity as a function of depth
- Needed to re-scale MCS data into depth (for 1% rule)



The 1st Bathymetric Map of the Arctic Ocean
Nansen 1897
“The drift of the Fram”

Emery's 1949 Map

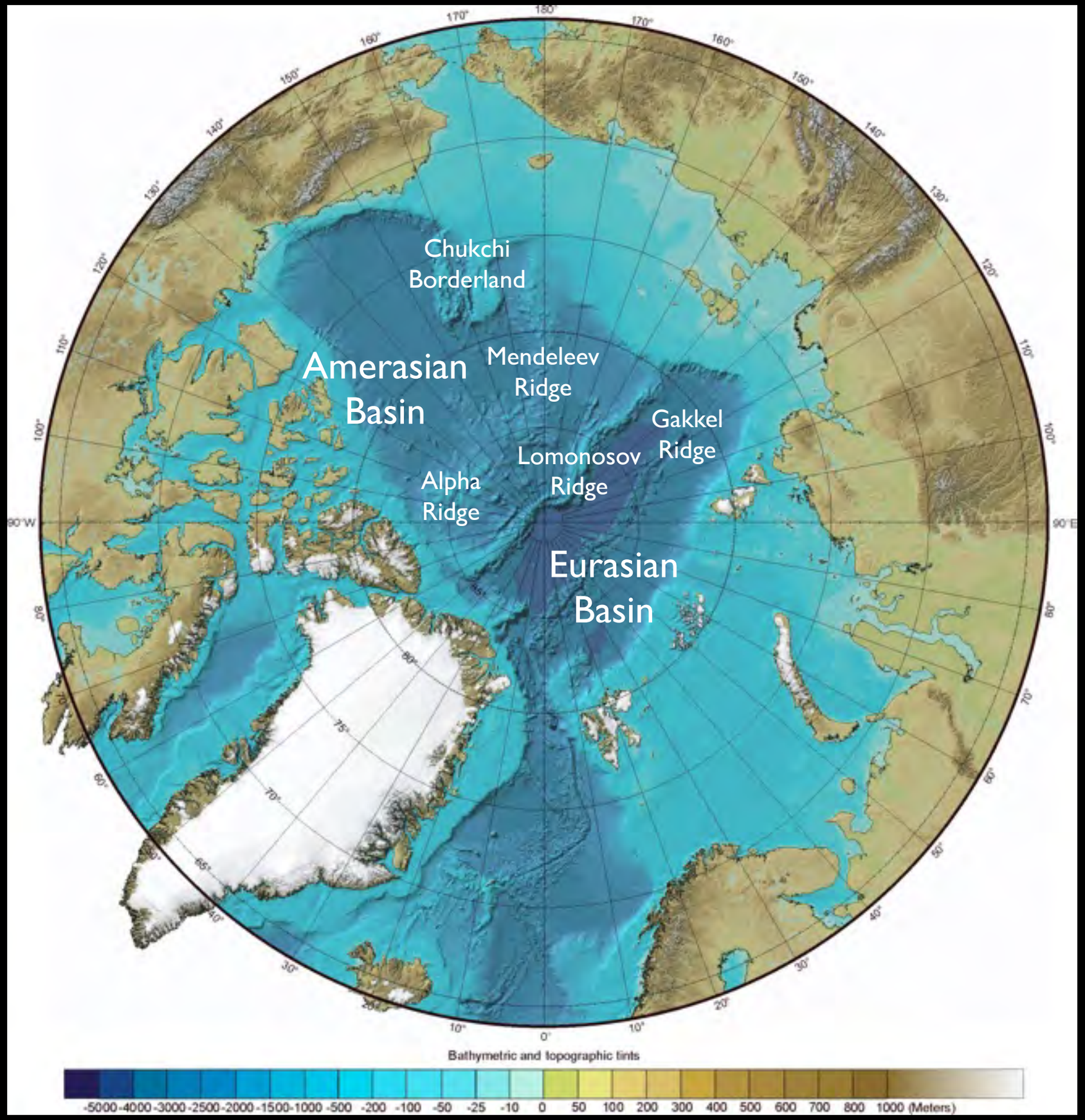


Heezen and Tharp 1971

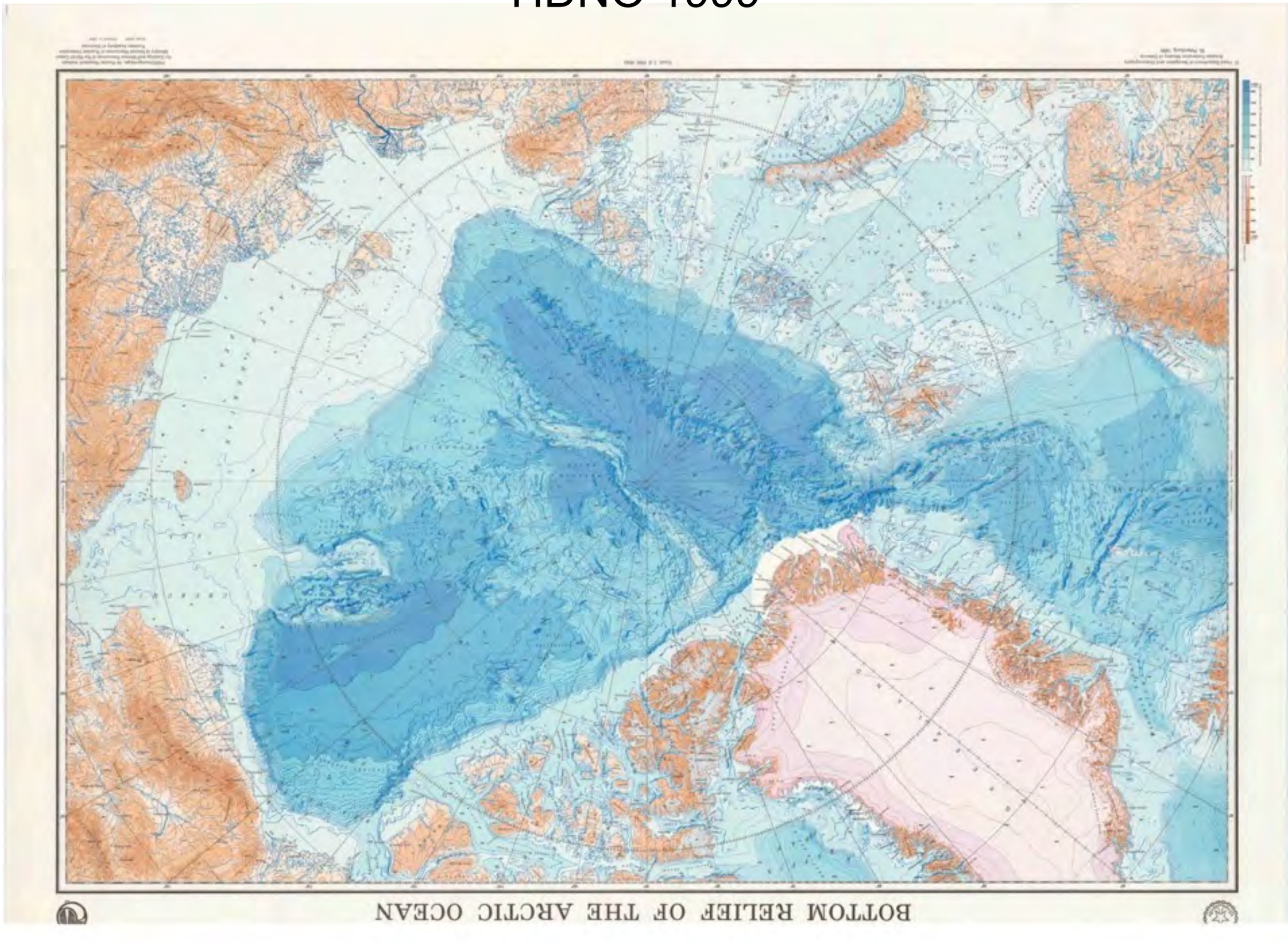
Naval Research Lab - 1986

International Bathymetric Chart of the Arctic Ocean v. 3.0

Two distinct basins of different ages



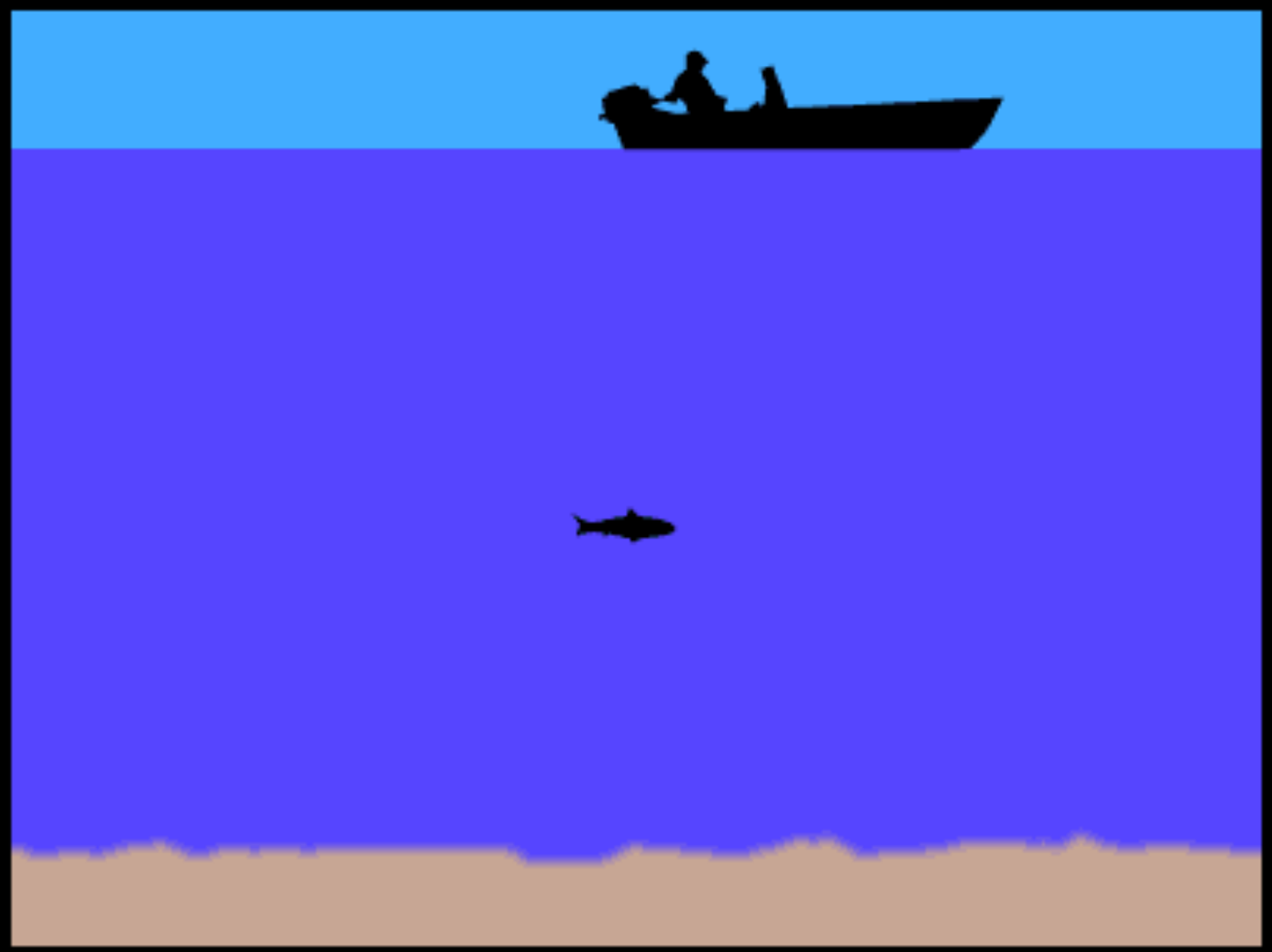
HDNO 1999



Three waves of mapping.

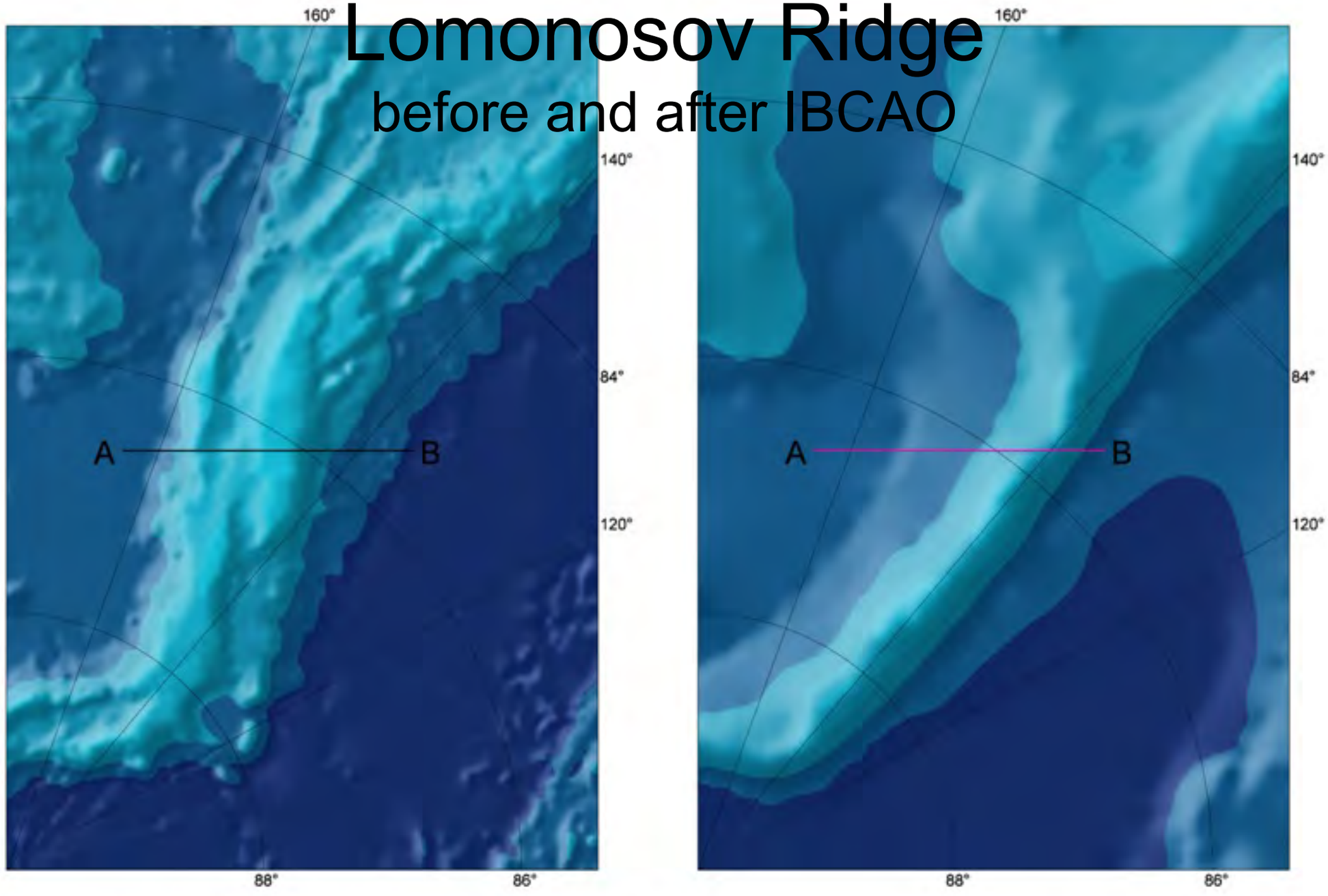
- Security driven mapping; ice islands and classified submarine cruises (60s and 70s).
- Public access mapping; unclassified submarine cruises (SCICEX) and science icebreakers (90s).
- Law of the Sea Mapping (2004-present).
- The ice-free Arctic Ocean

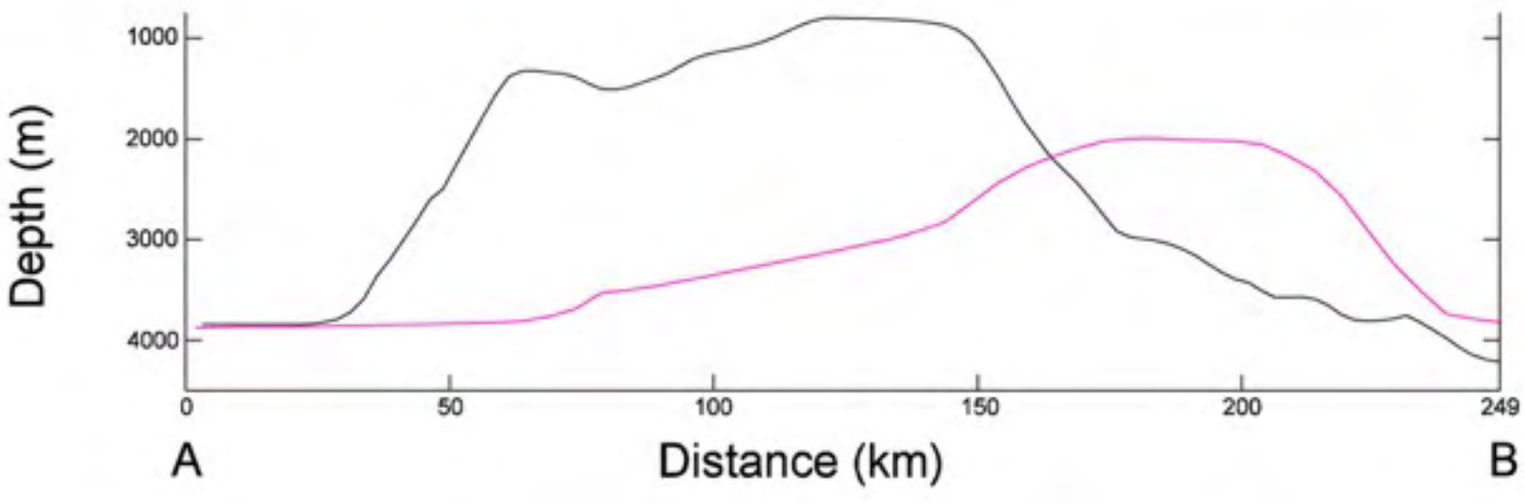
narrow-beam bottom sounding



Lomonosov Ridge

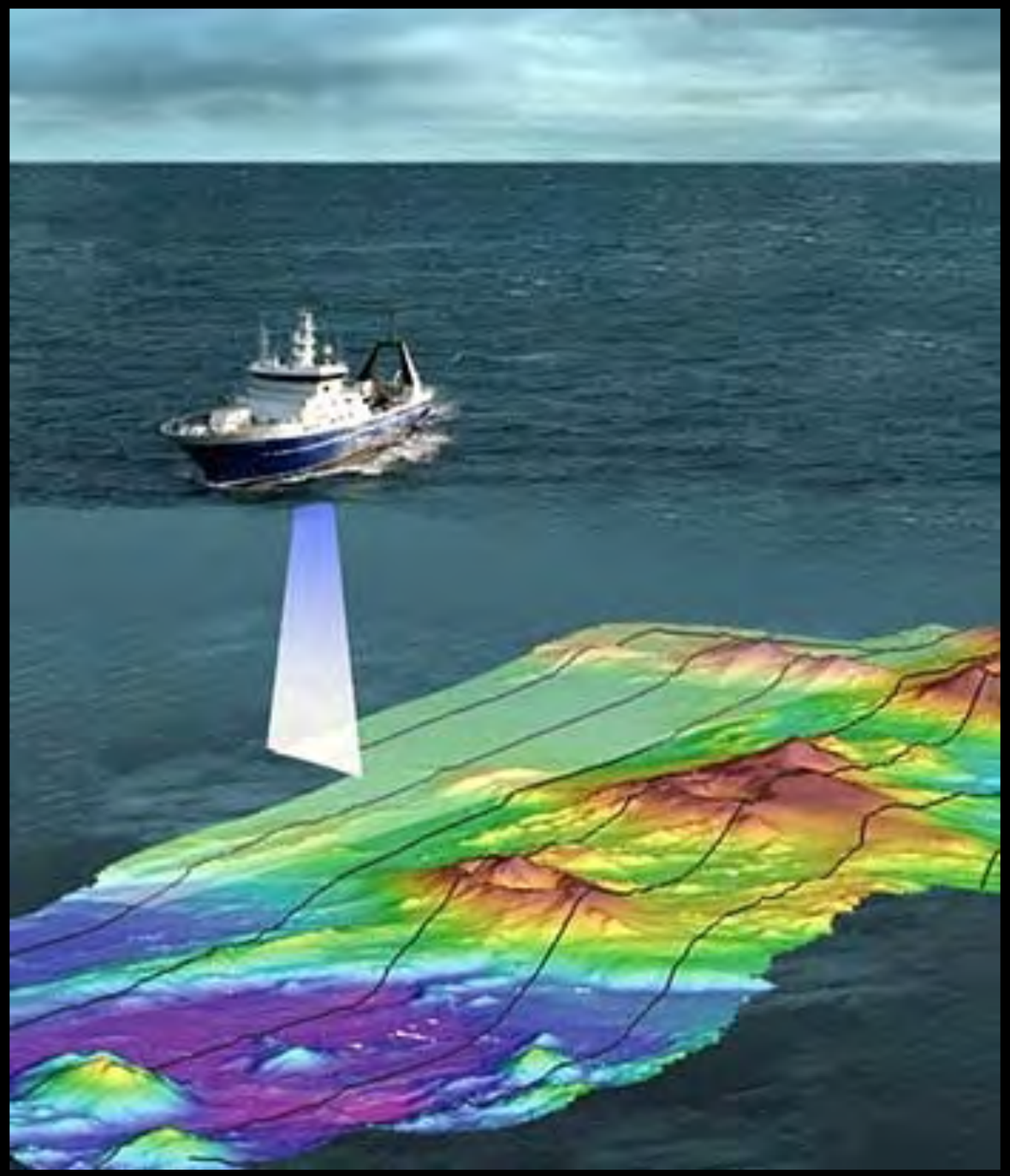
before and after IBCAO



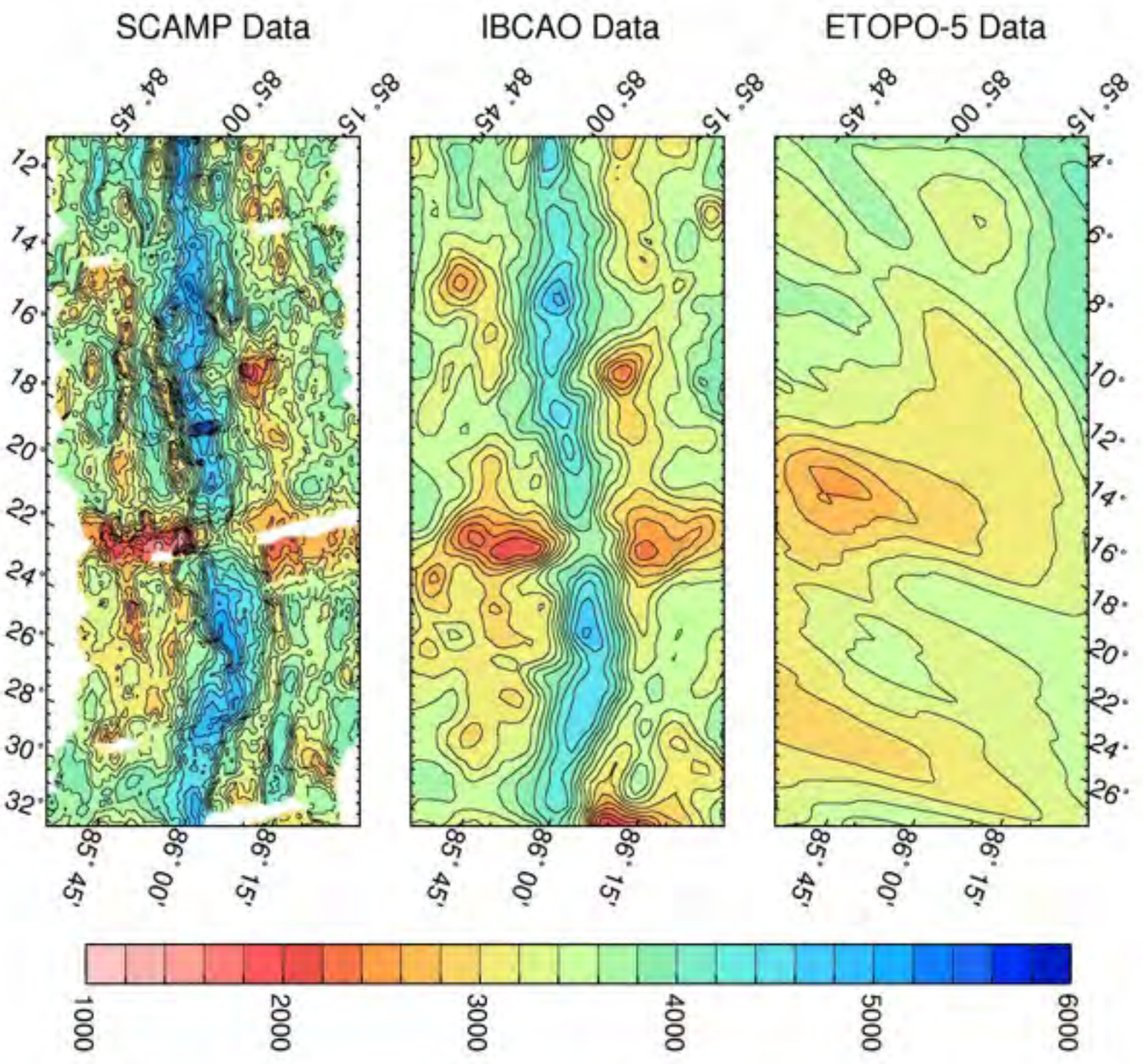


multi-beam mapping

“mowing the lawn”

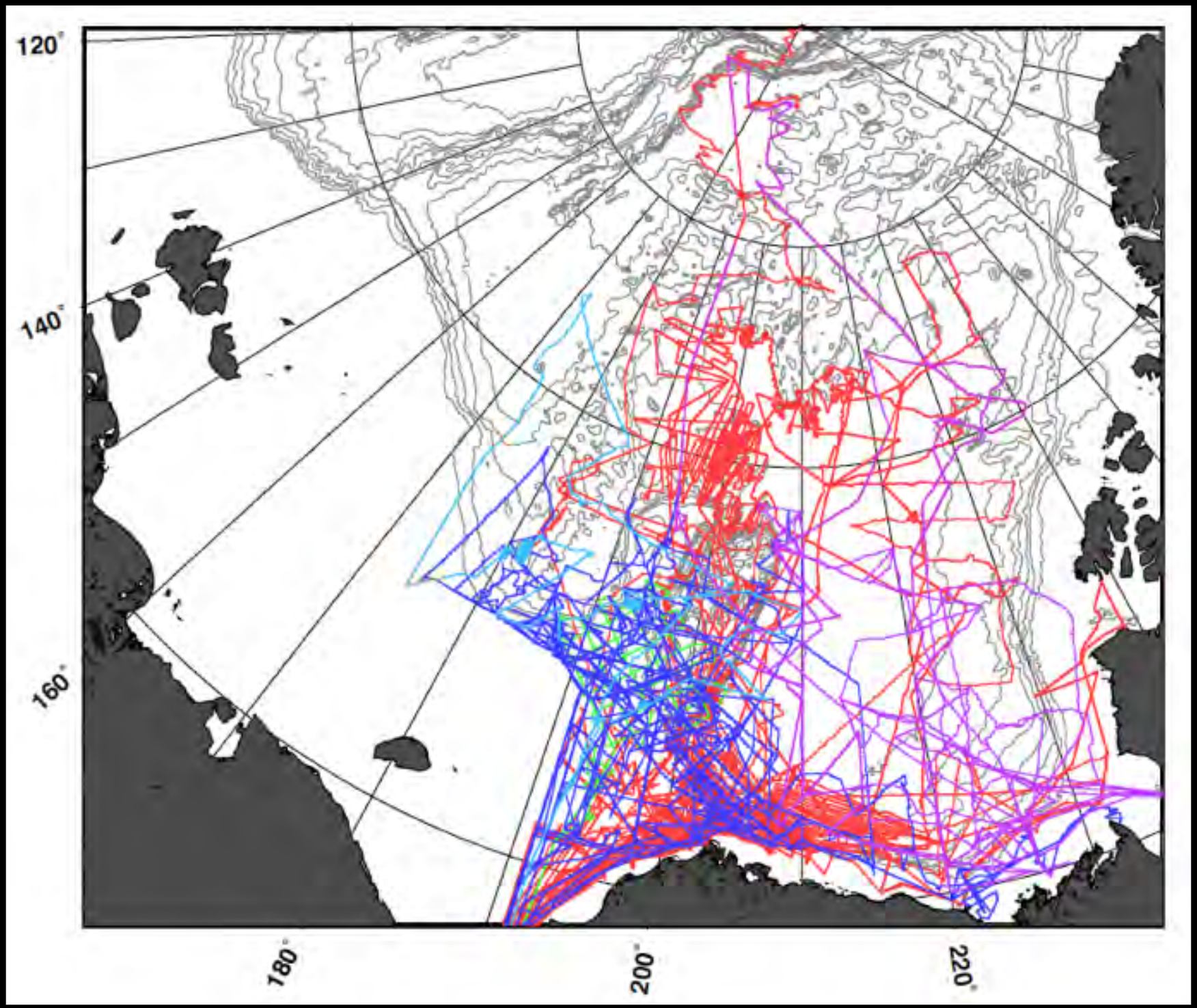


Gakkel Ridge: Comparison Bathymetry

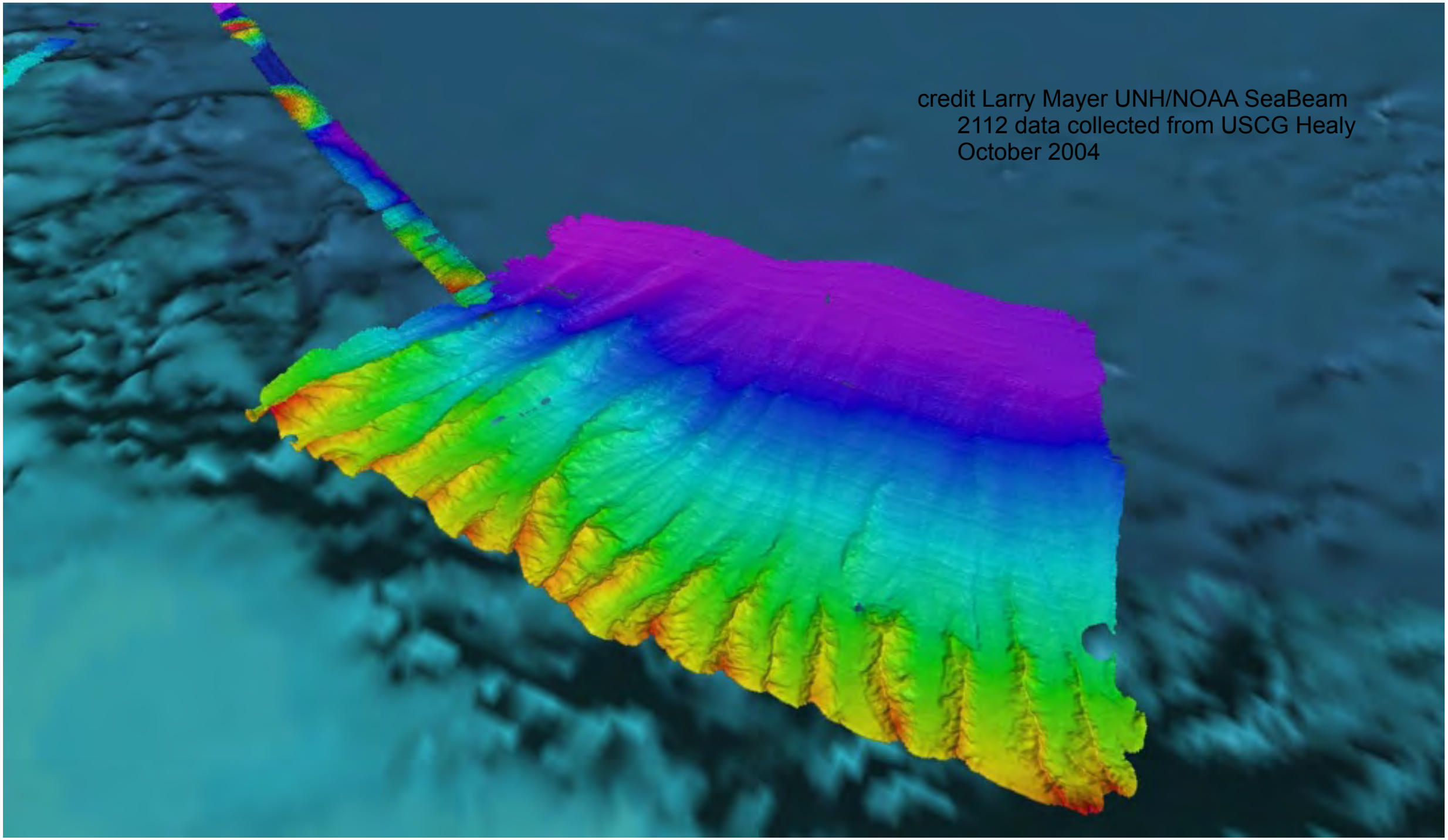


New Arctic Data 2000-2012

Healy, Langseth, Mirai, Araon, St Laurent

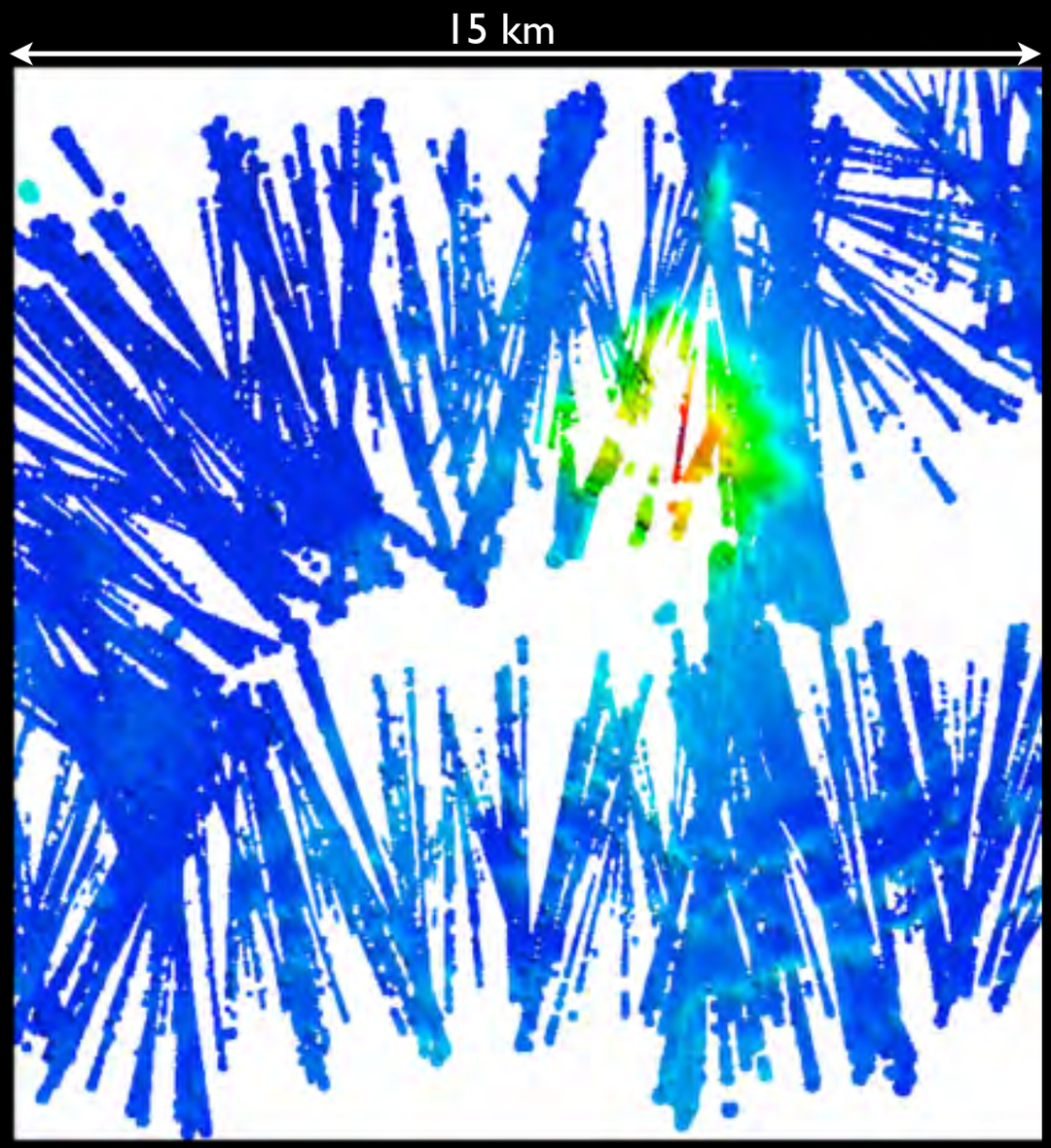


Canyons on the Beaufort Slope



This data used for this image were collected in ice-free waters from USCG Healy.

Backing and Ramming



to establish an ECS

- Documentation of limit lines based on Article 76 of UNCLOS
- Resolution of bi-lateral boundaries
- Evaluated by Technical Commission, which considers the consistency of the submission with UNCLOS
- Announcement of boundaries by each state

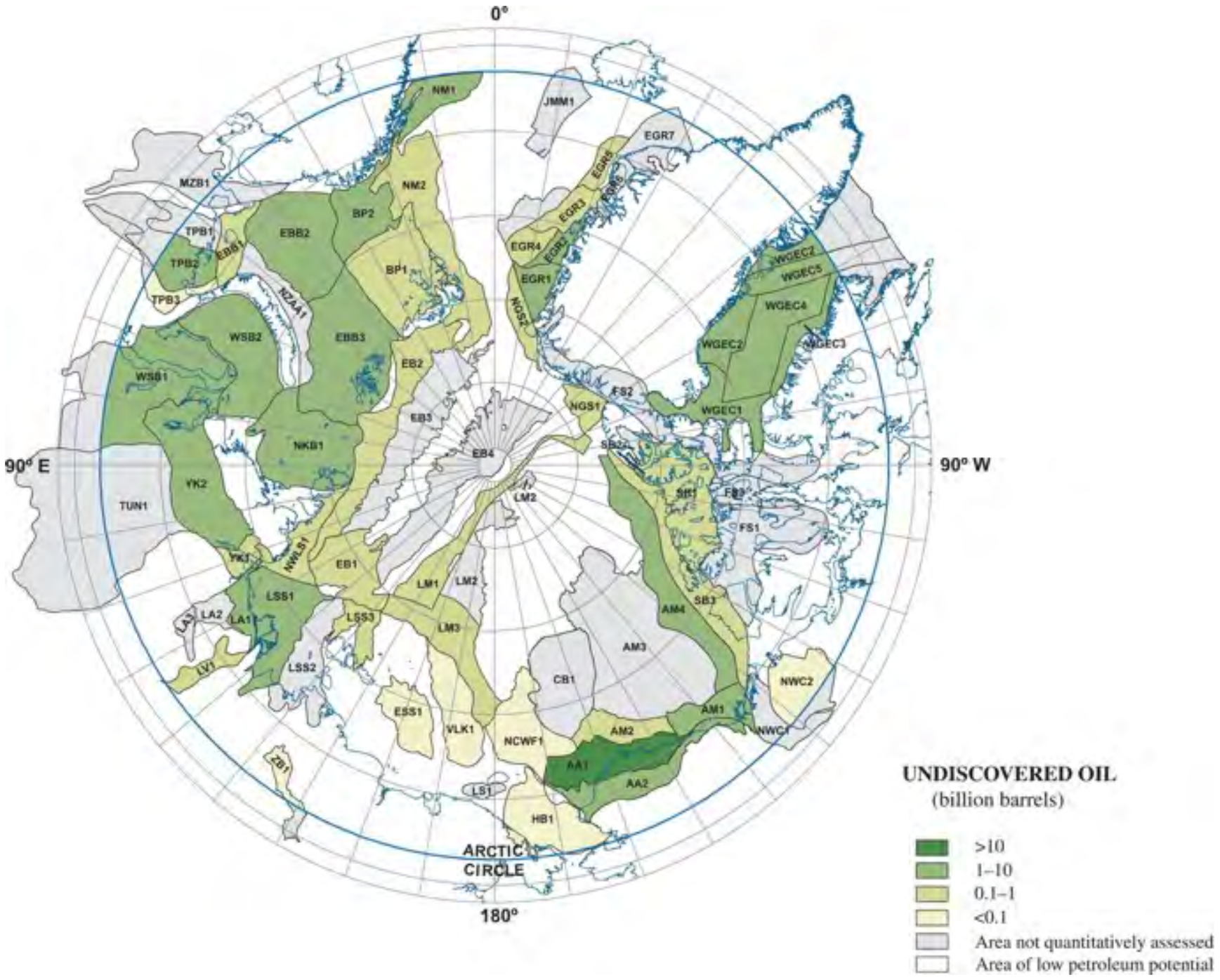
What are the potential resources on the Extended Continental Shelf?

- shellfish (infauna and crabs)
- deep sea mining (manganese crusts and nodules and massive sulfides)
- oil and gas

Where in the Arctic Ocean?

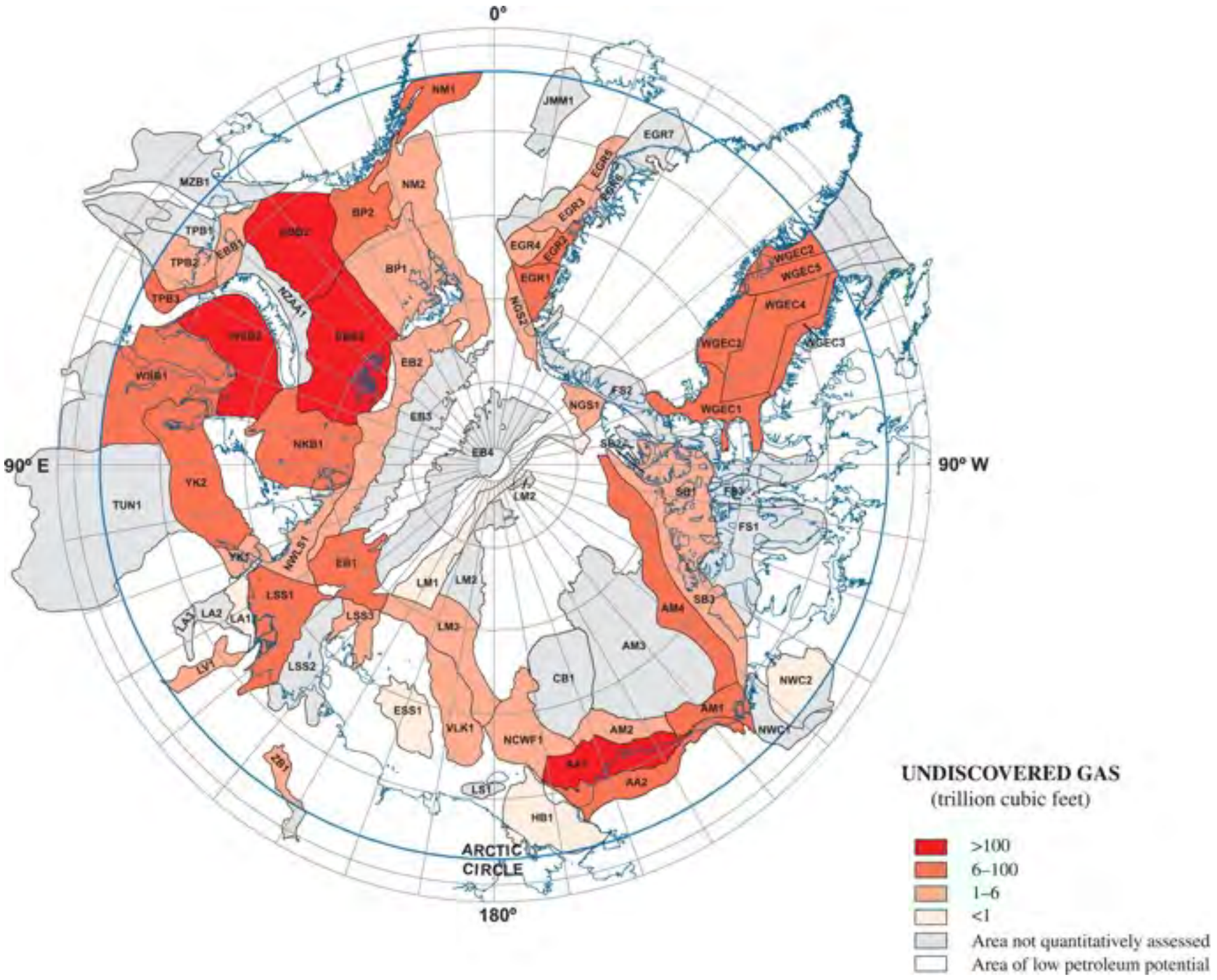
- Lomonosov Ridge?
- Chukchi Borderland?
- Canada Basin?

Map showing the assessment units of the Circum-Arctic Resource Appraisal is color-coded for mean estimated undiscovered oil.



D L Gautier et al. Science 2009;324:1175-1179

Fig. 2 Map showing the AUs of the CARA is color-coded for mean estimated undiscovered gas.



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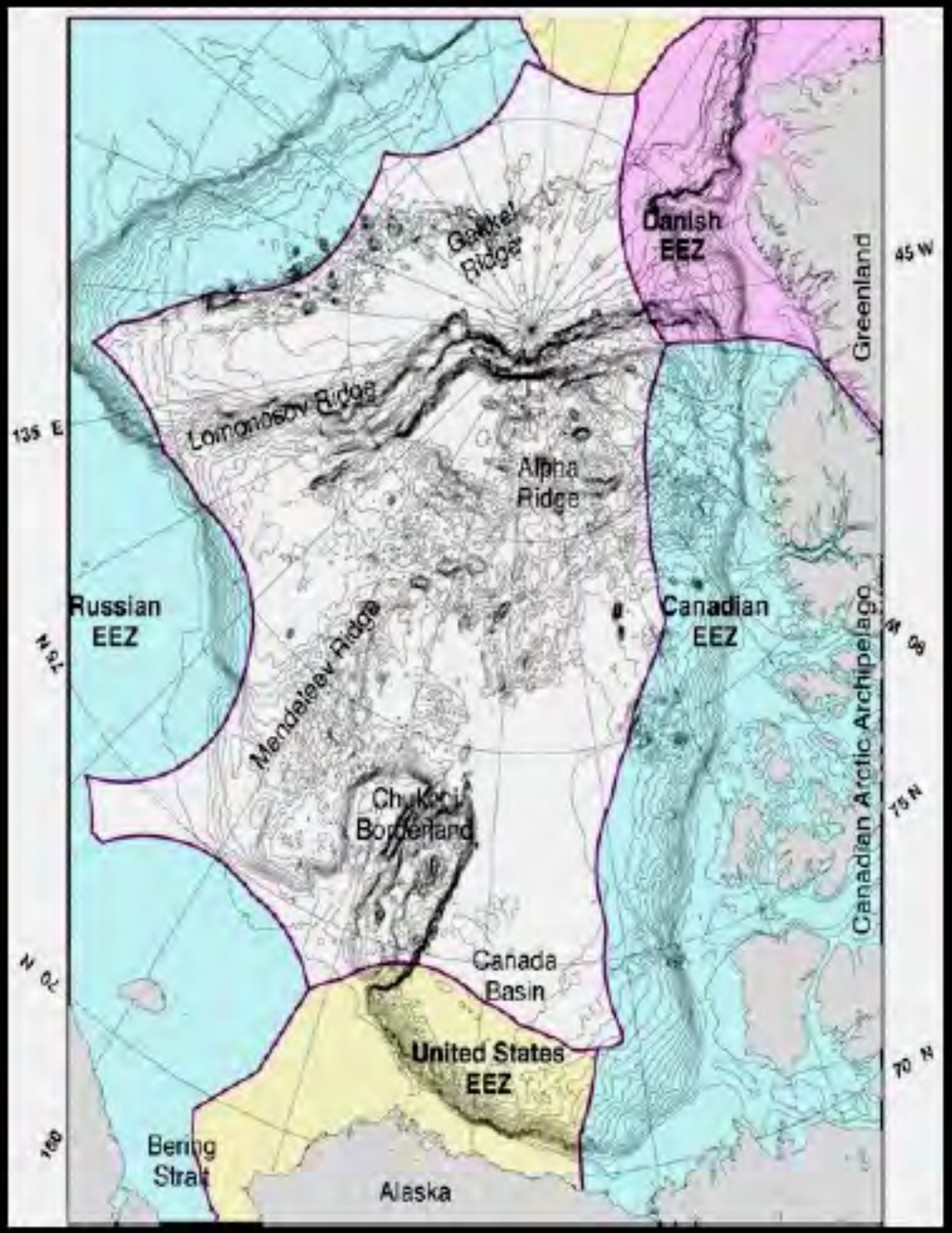
The EEZs of the Arctic Coastal States encompass almost all zones of the seafloor that would be considered prospective for oil and gas.



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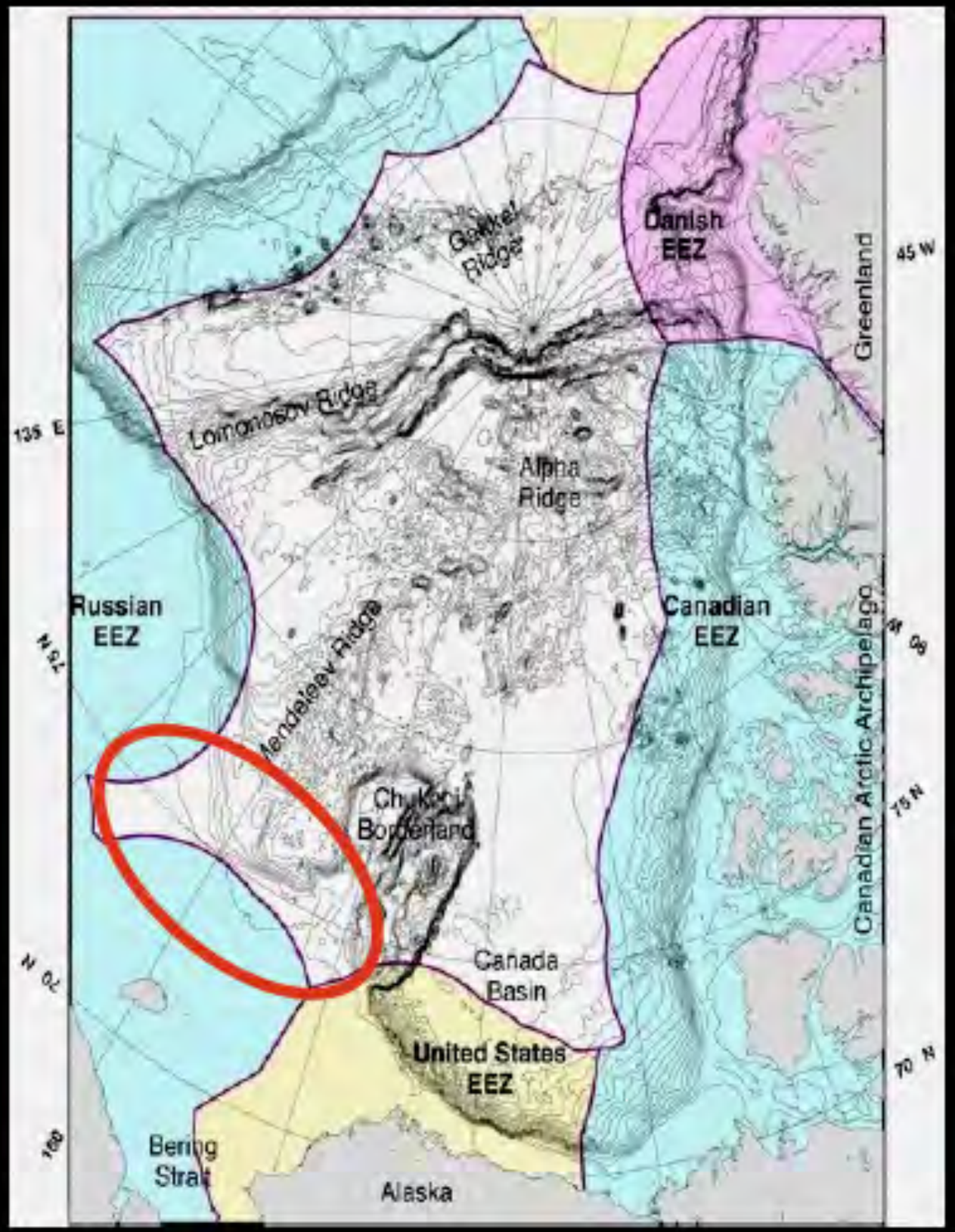

Bottom Line

By current understanding it is unlikely that substantial oil and gas reserves will be found beyond the EEZ in any ECS.

This could change with the evolution of our understanding of how oil and gas form and evolve.

True or False?

evaluate the media narrative

1) A “land” grab is under way in the Arctic Ocean.

FALSE - A process for establishing territorial limits based on data collected in the oceans is being pursued.

2) This is all about resources.

FALSE - Very little of the seafloor that might be claimed is likely to hold much in the way of resources, at least by current understanding.

3) The circum-Arctic states are in conflict due competing claims.

FALSE - These states are cooperating to acquire the data necessary to establish their territorial claims.

4) Planting a Russian flag on the seafloor at the North Pole has consequences for any territorial claims in the Arctic Ocean.

FALSE - We live in the 21st century, not the 16th. The Law of the Sea dictates how territorial limits are described and verified.

The future of the Arctic Ocean

- Ilulissat Declaration
- EU "Arctic Policy"
- Antarctic Treaty for the Arctic
- Militarization
- Industrialization