

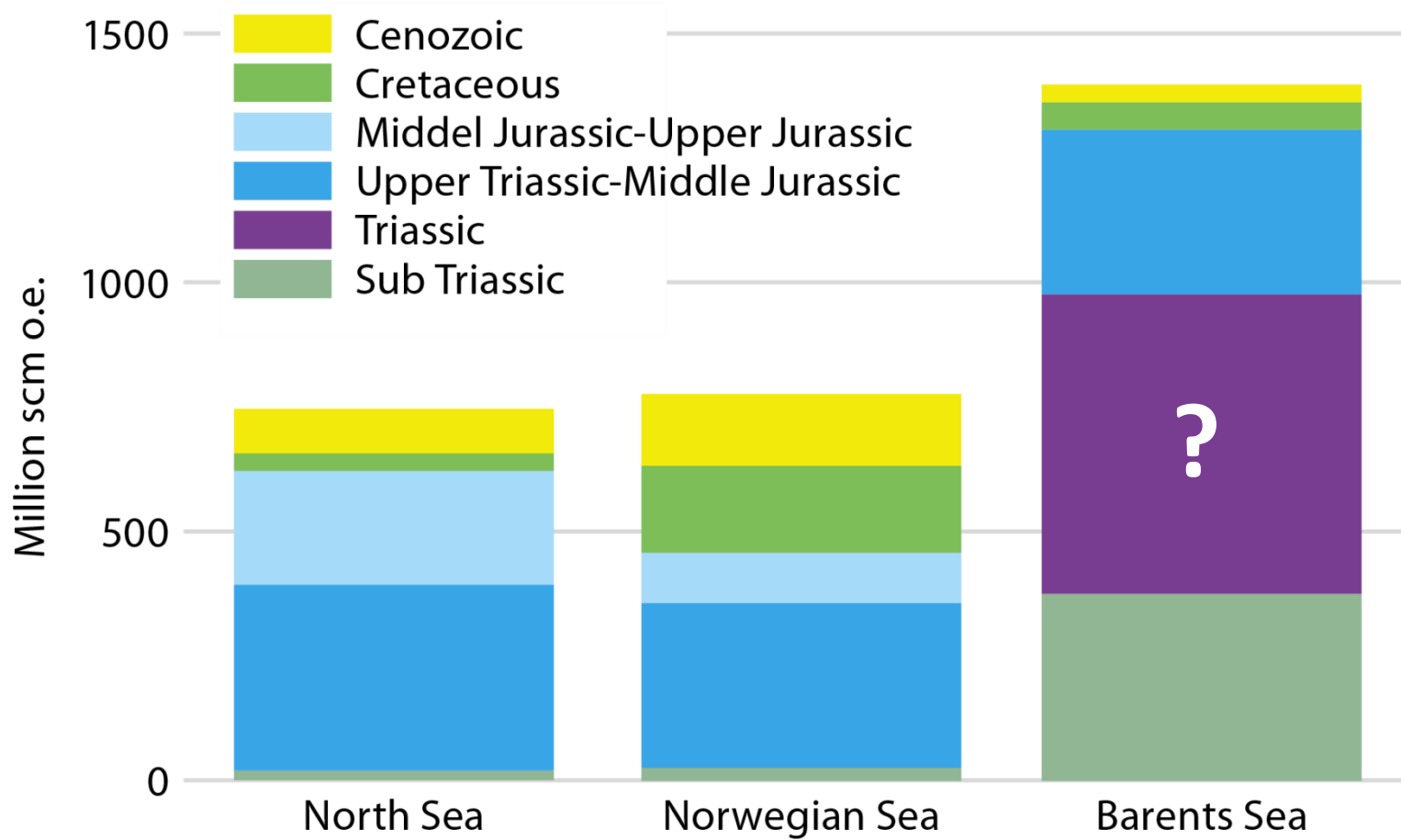
Explaining disappointments and opportunities in the Triassic strata of the Barents Sea

Tore G. Klausen
University of Bergen

W. Helland-Hansen, A. Ryseth, I. Laursen, R. Müller, C.H. Eide, A. Suslova, B.G. Haile, S. Olausson, A. Mørk, G.S. Lord and many more

FORCE - Triassic Park
19.10.2017
Norwegian Petroleum Directorate, Stavanger

TRIASSIC BARENTS SEA – ECONOMIC POTENTIAL?



BARENTS SEA POTENTIAL IS A HOT TOPIC (GEO365)



THE BARENTS SEA DRILLING CAMPAIGN:
LESSONS LEARNED. WAY FORWARD.
24 OCTOBER OSLO | 26 OCTOBER STAVANGER



GEO PUBLISHING

GEONOVA



Oslo October 24th

Location: CGG/Statkraft – Amfi & Expo, Lilleakerveien 4e, U1 Hus 4

[View map](#)

Stavanger October 26th

Location: Clarion Hotel Air – Stavanger Airport Sola

ABOUT THE SEMINAR

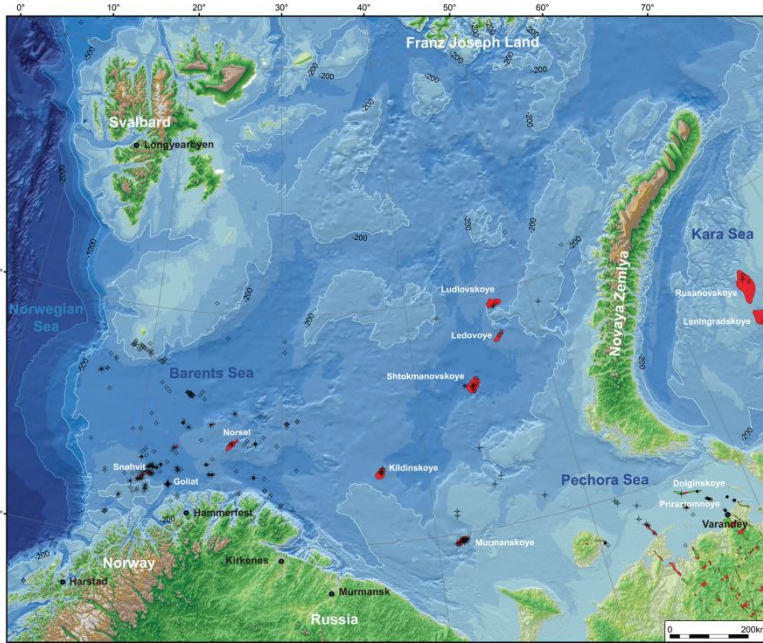
The Barents Sea drilling campaign: «Lessons learned. Way forward.»

The purpose of this seminar is to evaluate the outcome of this year's wildcats based on modern technology. Our speakers will therefore make an attempt to explain how the de-risking could have been done differently – if possible.

We will also ask if the lack of decent discoveries – with one or two exceptions – indicates that the oil companies are too optimistic with respect to oil and gas yet to find in the larger Barents Sea.

Why did they fail? Why did they succeed?

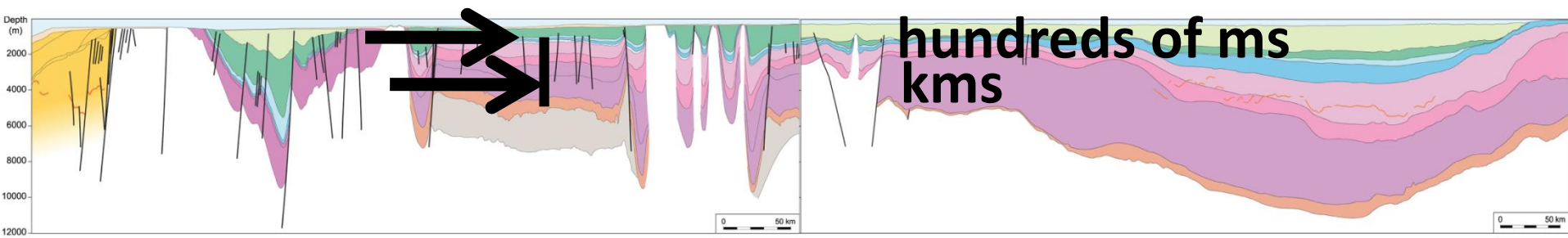
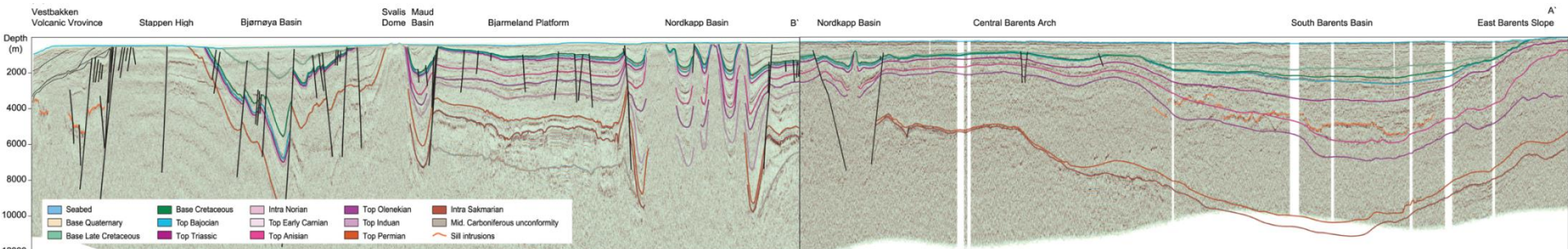
UNDERSTANDING THE BARENTS SEA



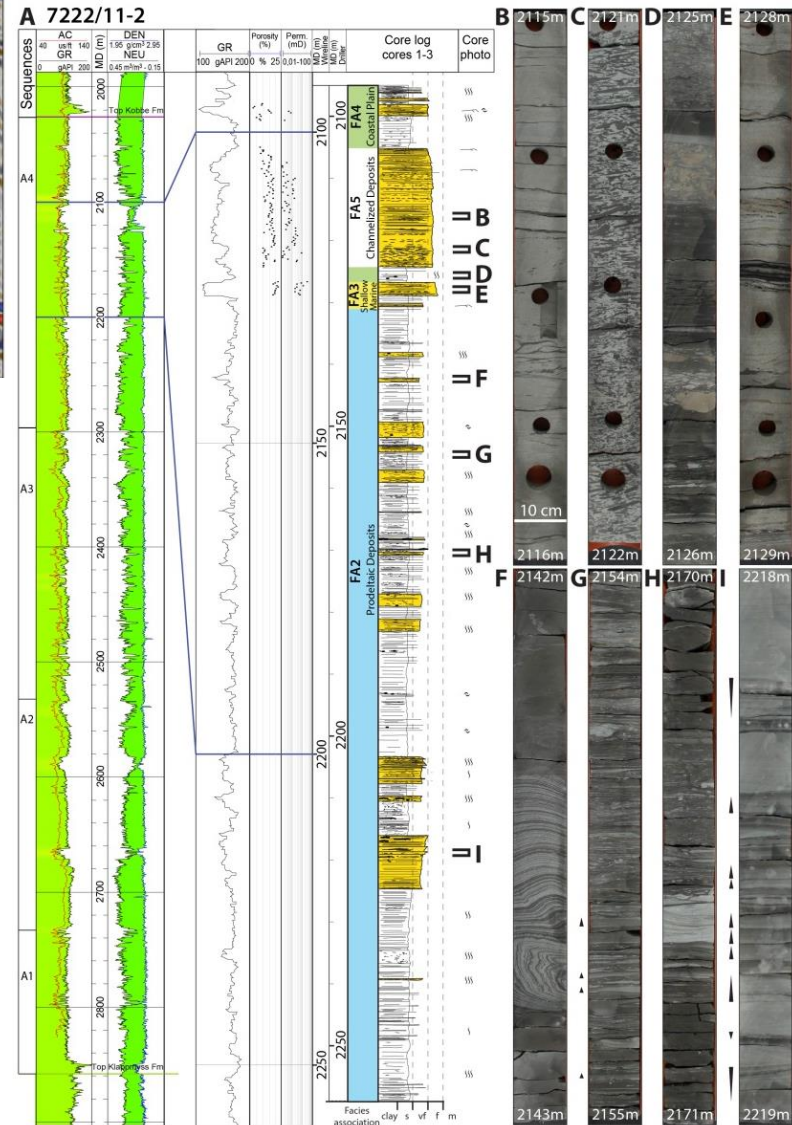
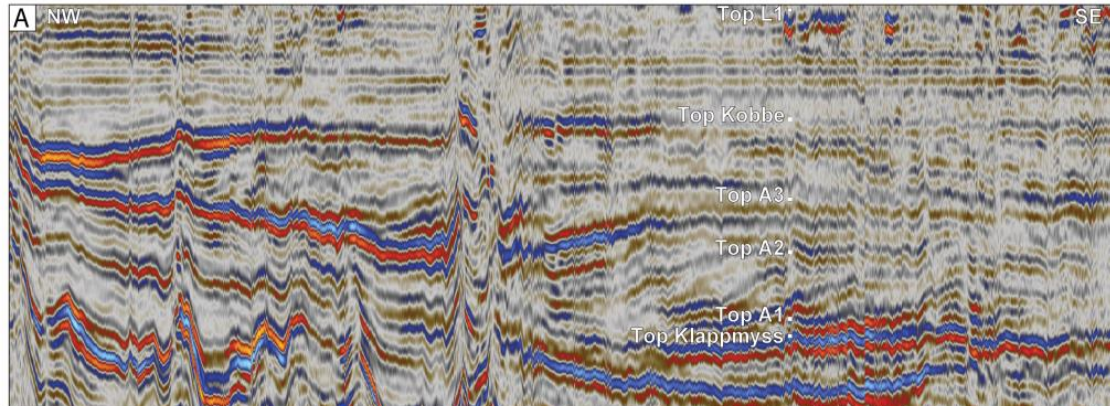
- The Barents Sea is one geological basin divided by several political boundaries
- Triassic sediments are mostly fed from E to W
- Jurassic sedimentary systems are more sand-rich due to less accommodation, but are thus also very condensed and paleogeography is complex
- Hydrocarbon system evolution within the region is complicated by burial, tectonics, magmatism and glaciations

Henriksen et al., 2011

Geological Society of London Spec. Pub.

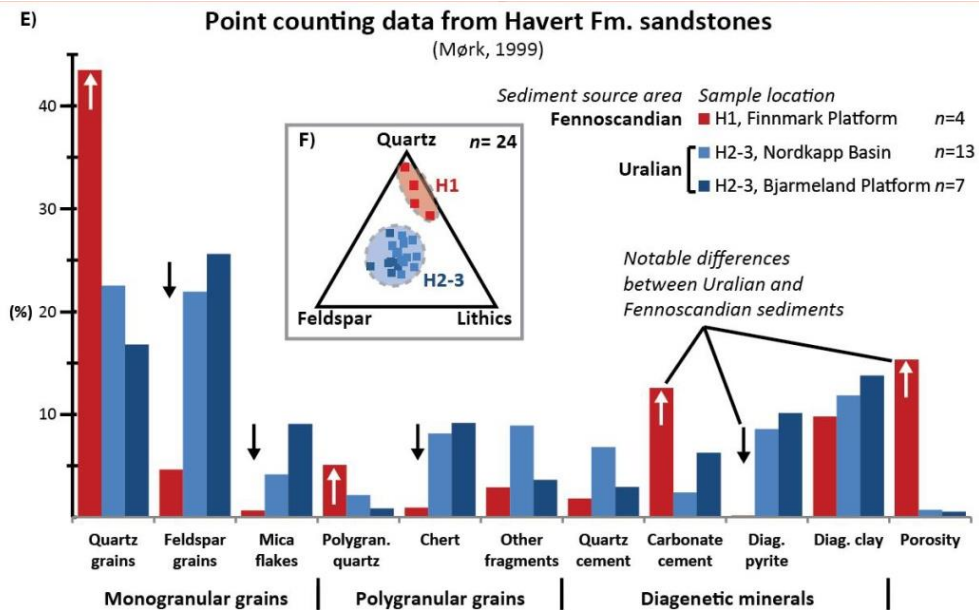
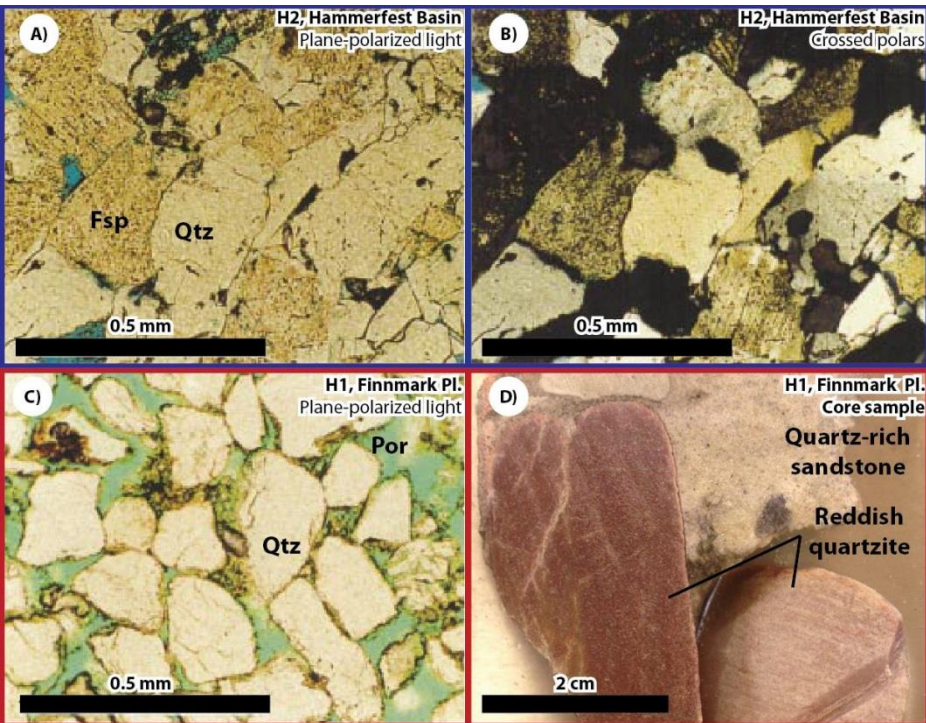


MUD-DOMINATED!



Example: Langlitinden prospect in the Anisian Kobbe Formation
 (Flattened on top Ladinian MFS [Intra Snadd Fm])
 Similar to core sections on display this afternoon

POROSITY AND PERMEABILITY



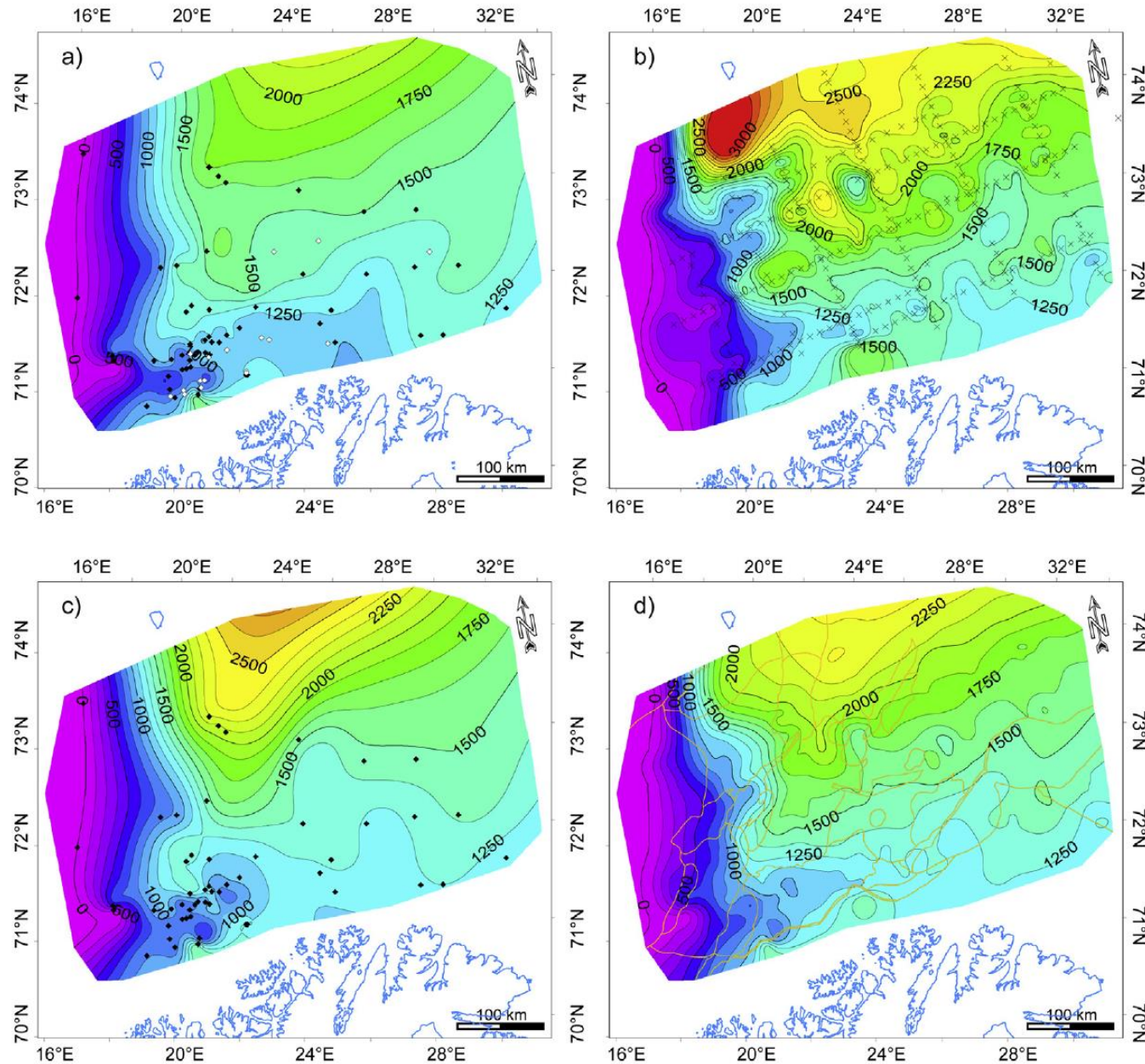
Eide et al., *in press*
GSA Bull.

BURIAL

I. Baig et al. / Marine and Petroleum Geology 73 (2016) 105–130

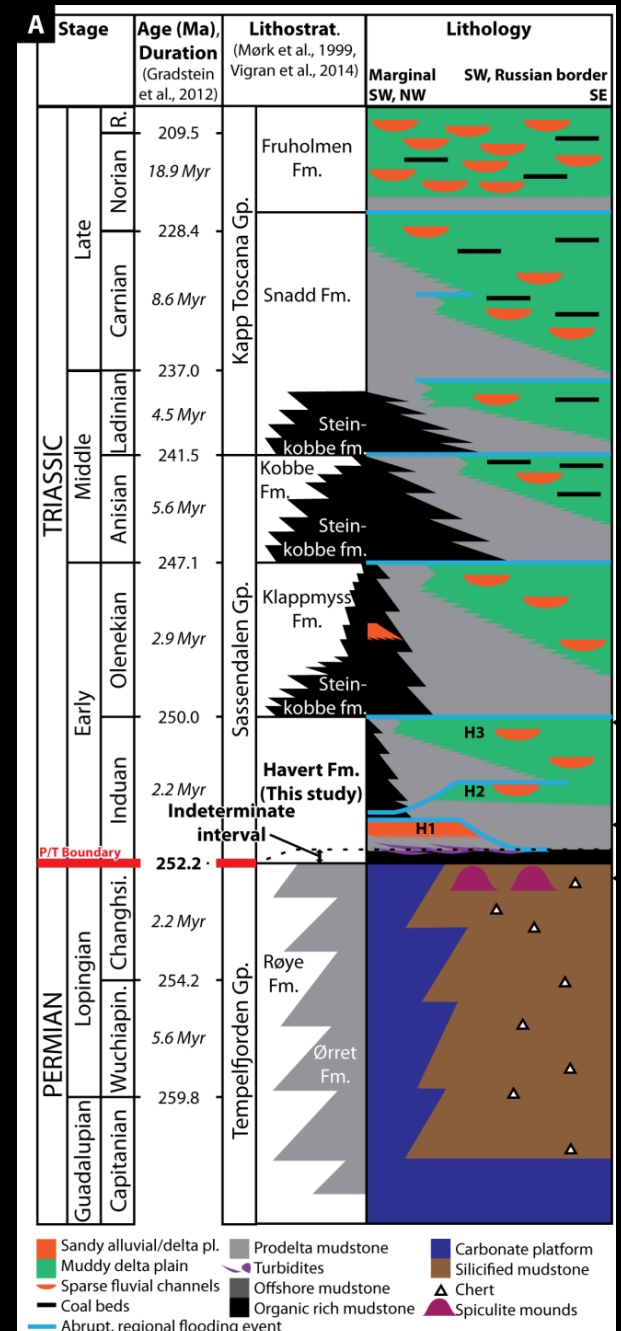
Net exhumation (e.g. Baig et al., 2016) is added to the present depth, which range between 400 to 4000 m

→ The Triassic strata is and has been buried deep, with detrimental effects on reservoir properties

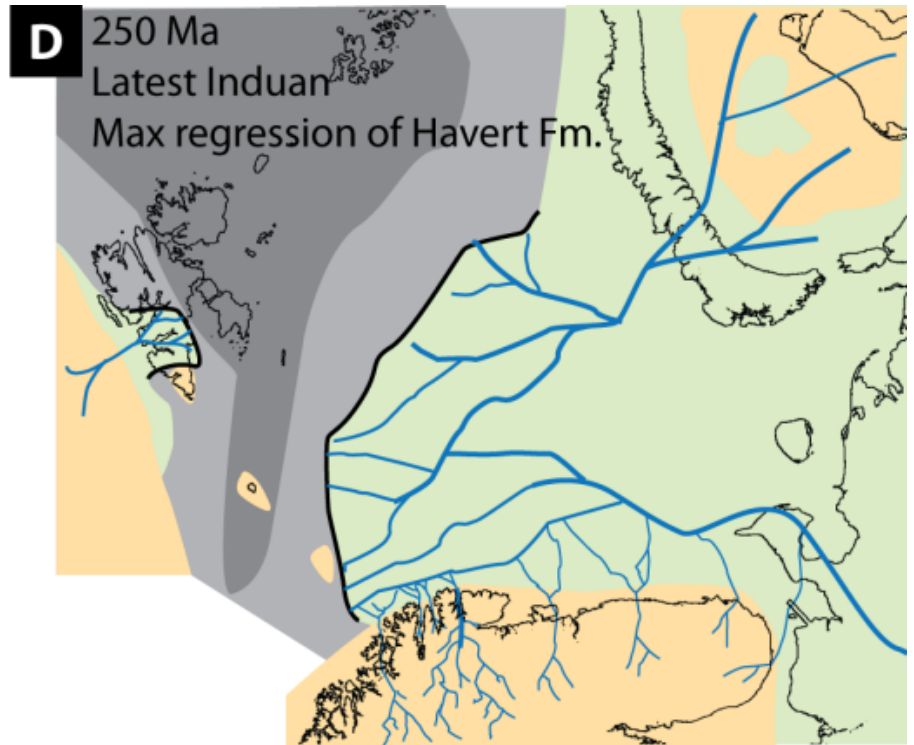
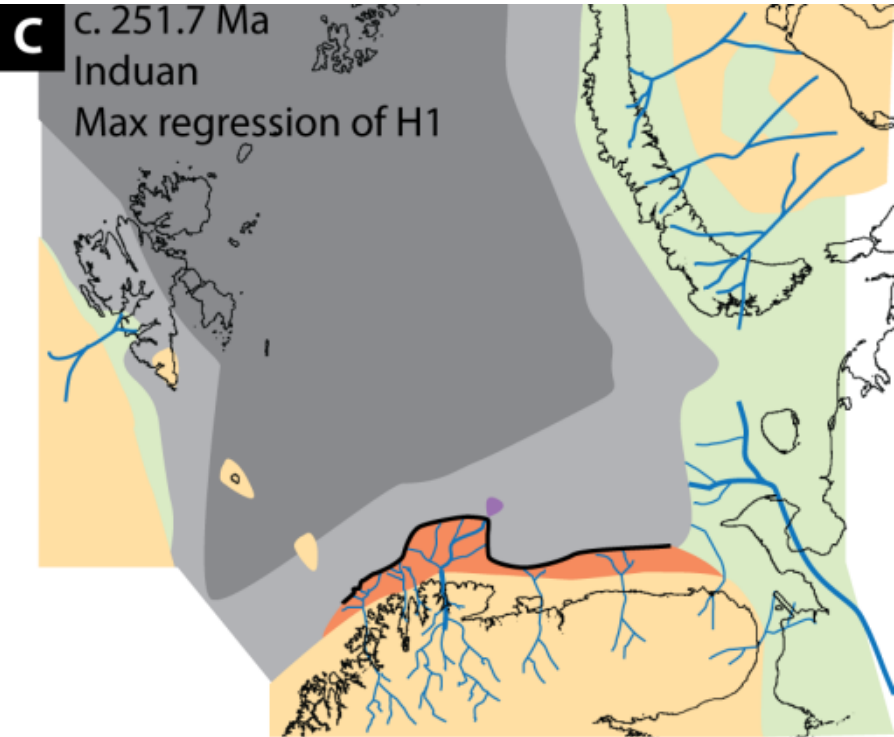


KEY CHALLENGES FOR THE TRIASSIC INTERVAL

- Depositional environment
 - Sandstone presence
 - Potent seal
- Mineralogy/provenance
 - Reservoir quality
- Preservation
 - Post-depositional erosion
- Hydrocarbon charge
 - Burial
 - Presence and quality of source rock
- Realistic opportunities?



HAVERT FORMATION



Eide et al., *in press*
GSA Bull.

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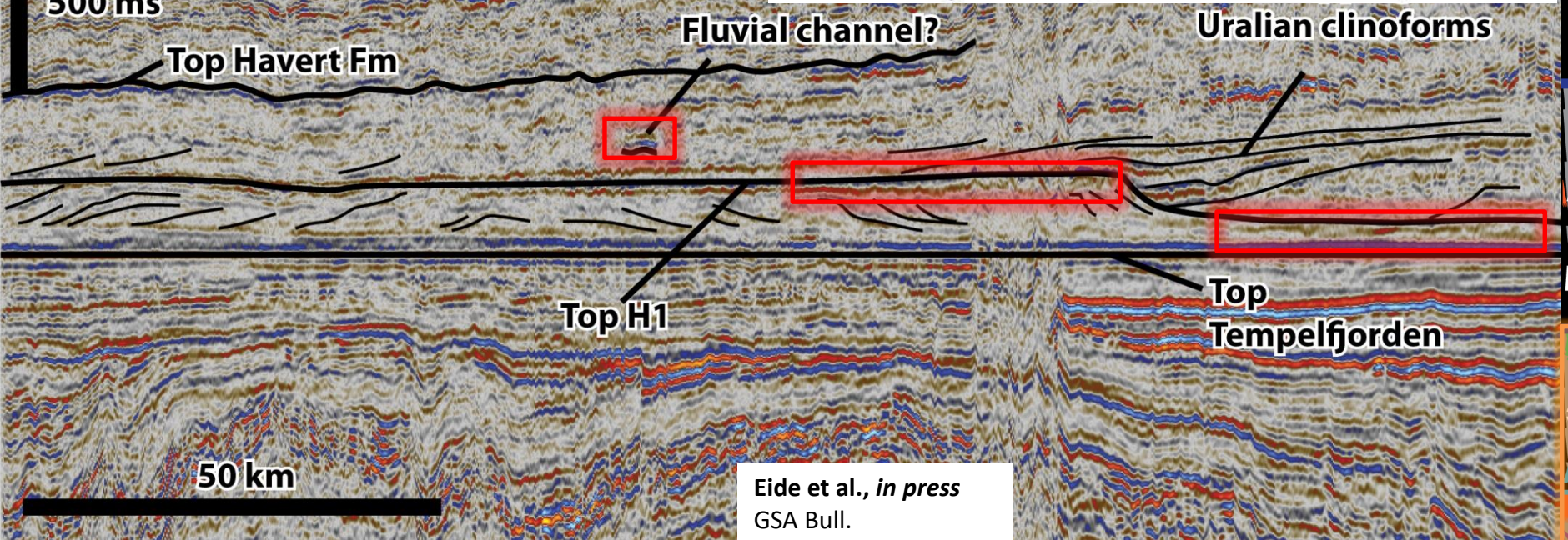
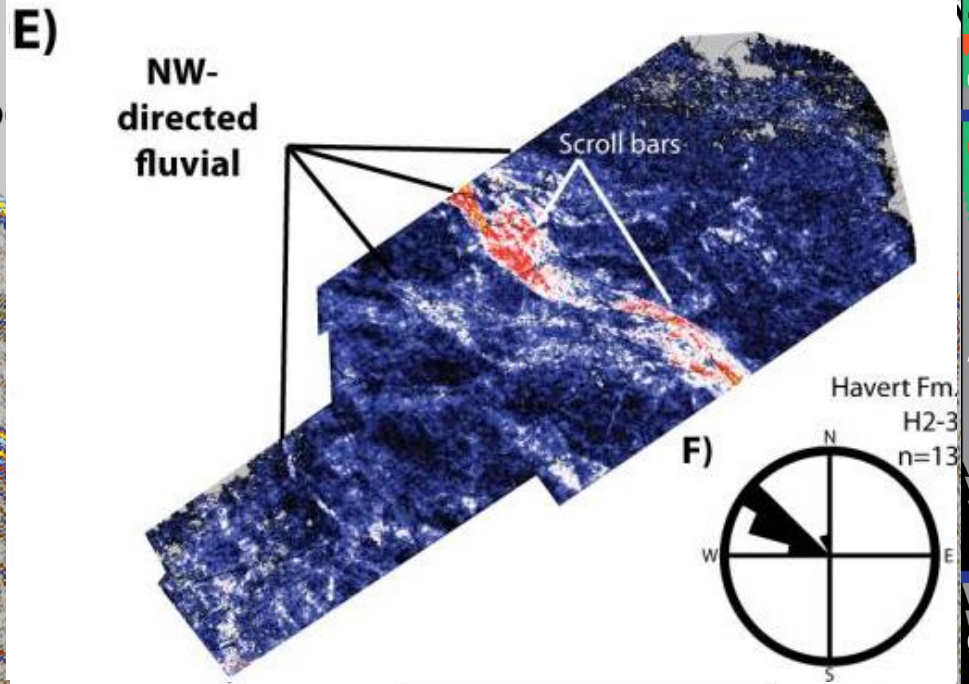
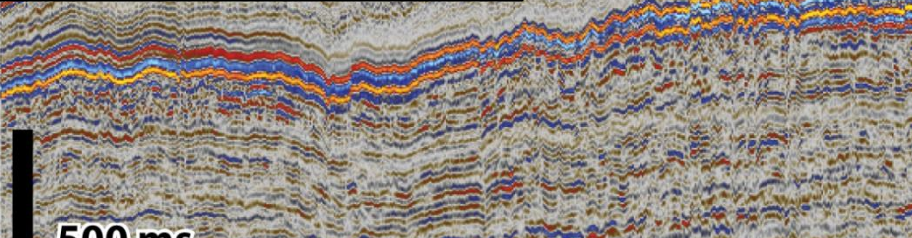
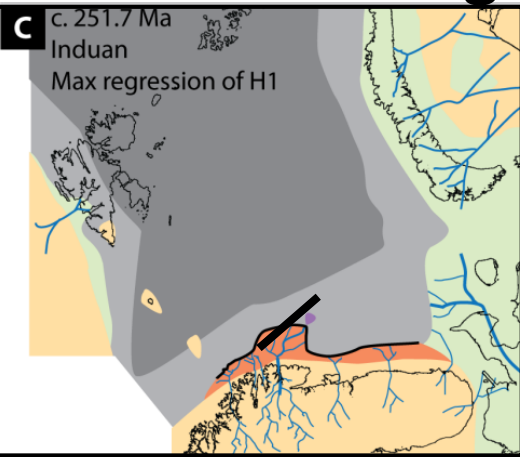
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Progradation of packages in Havert Fm



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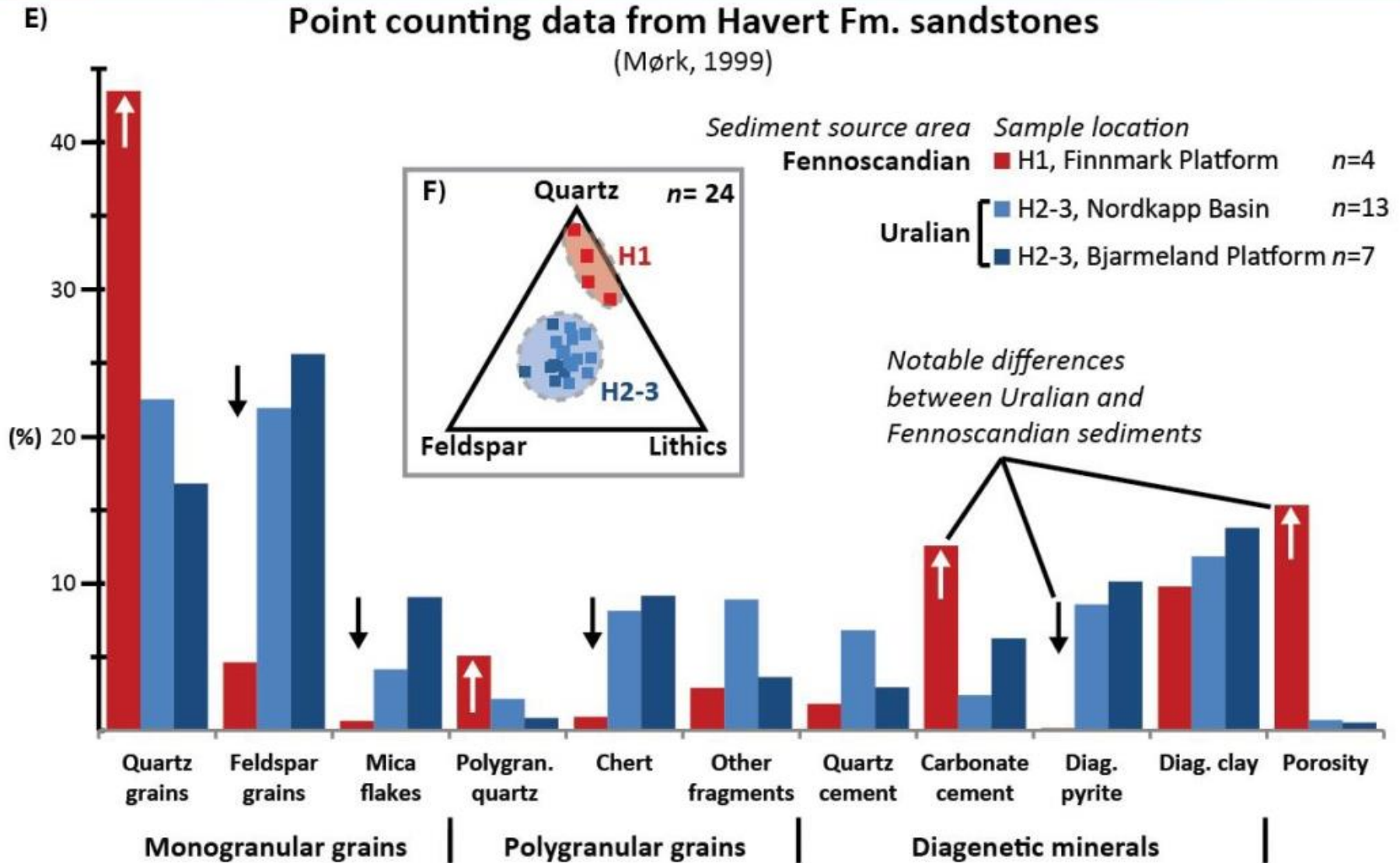
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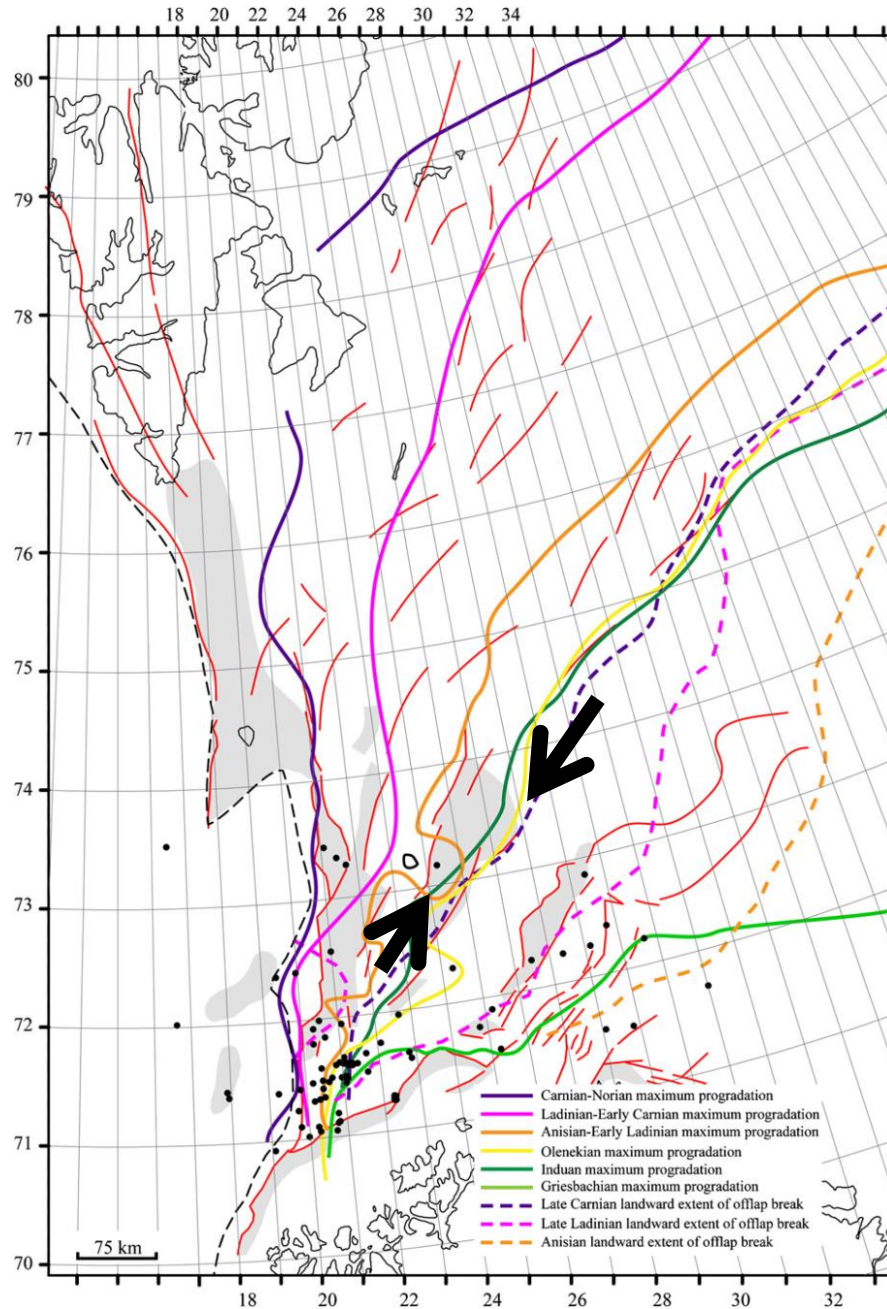
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Provenance control on reservoir properties



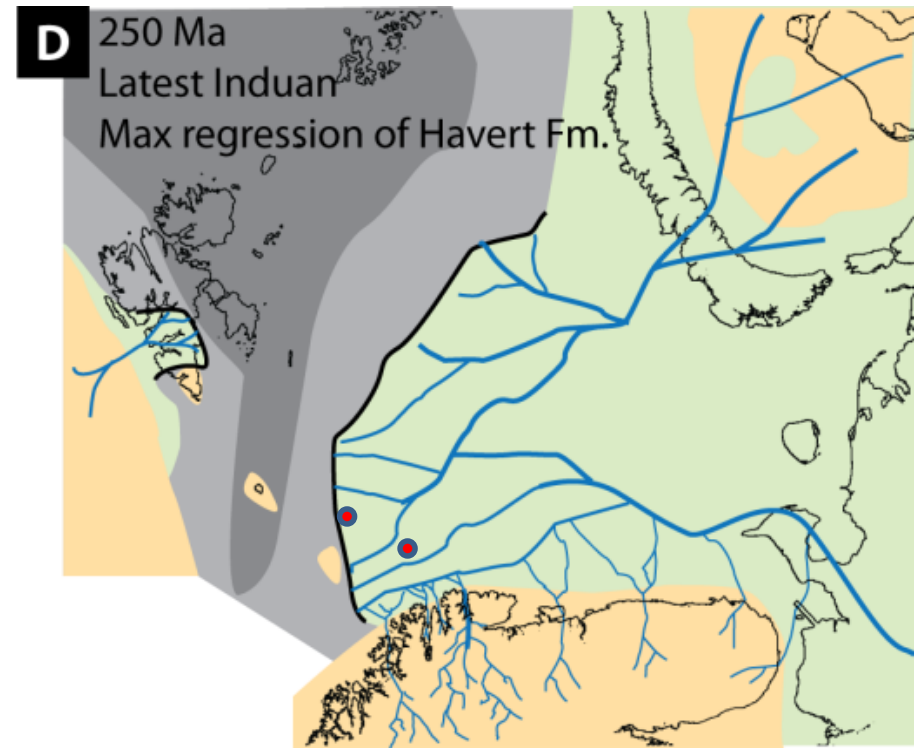
KLAPPMYSS FORMATION

- Olenekian in age
- Condensation and retrogradation
- So far few studies on this formation specifically
- Limited reservoir potential, but important source rock



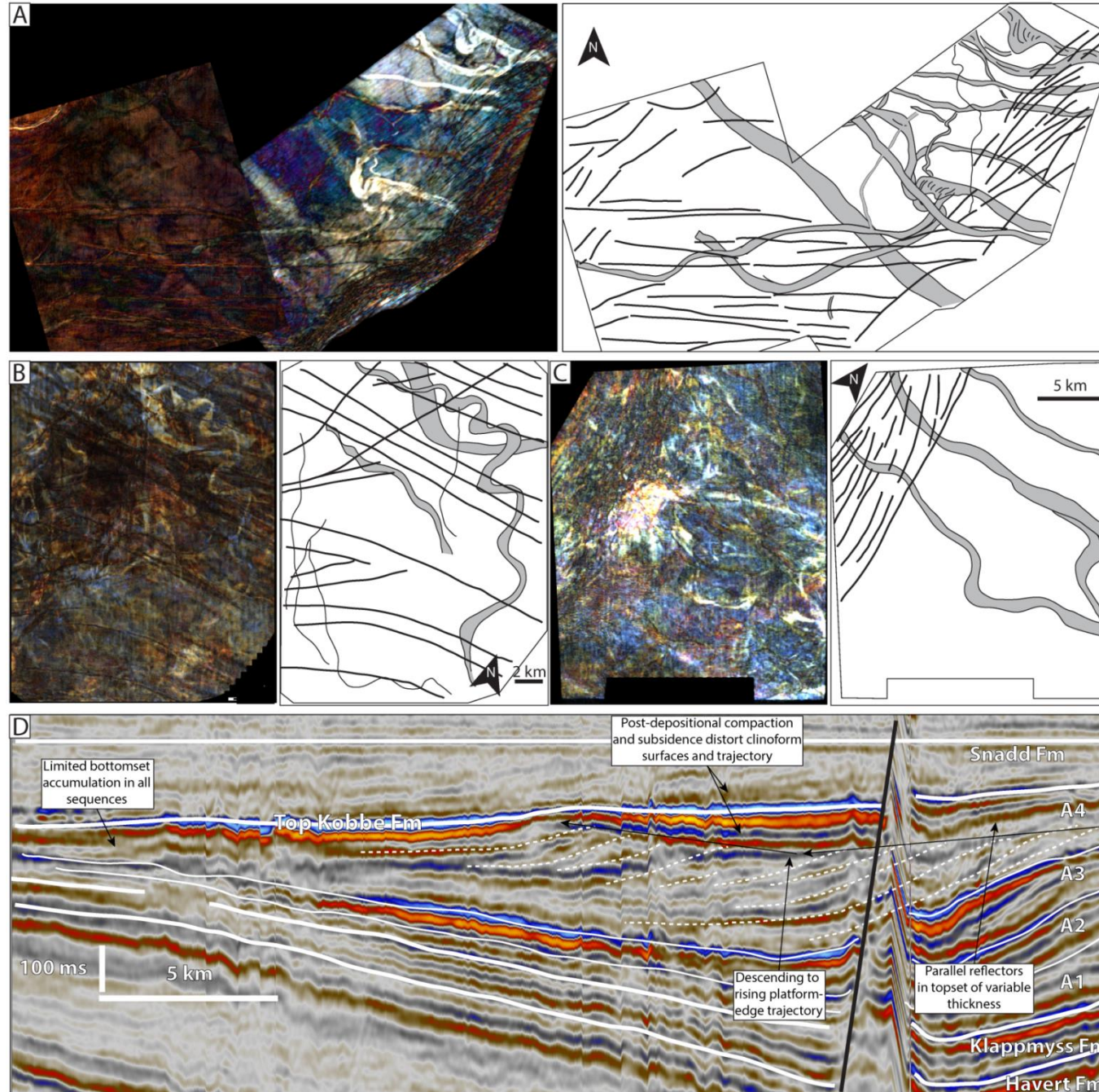
RECENT DISSAPOINTMENTS IN THE HAVERT AND KLAPPMYSS FORMATION

- Atlantis (10 m poor reservoir in Havert, none in Klappmyss)
 - presence and quality of reservoir rocks (distal)
- Kvalross/Kvaltann
 - presence of reservoir (frequency of channel bodies)

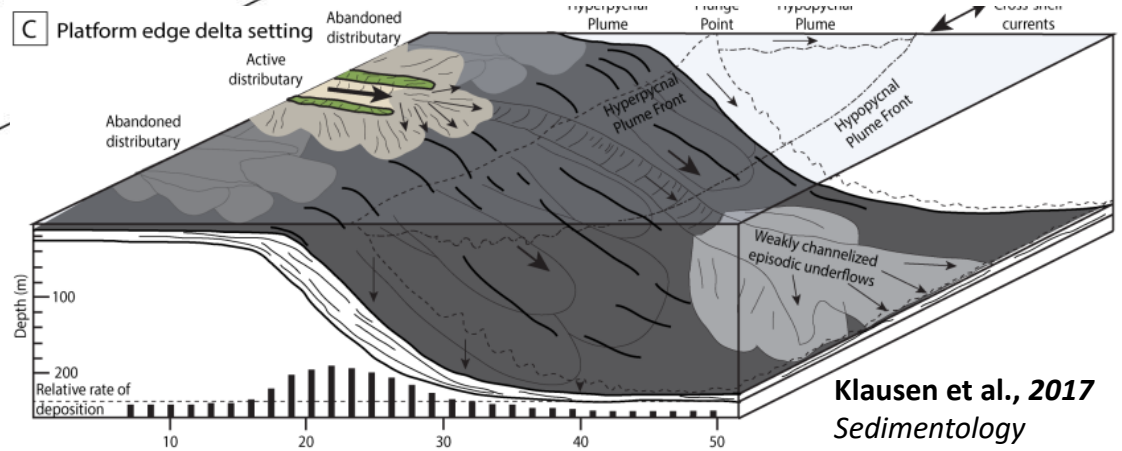
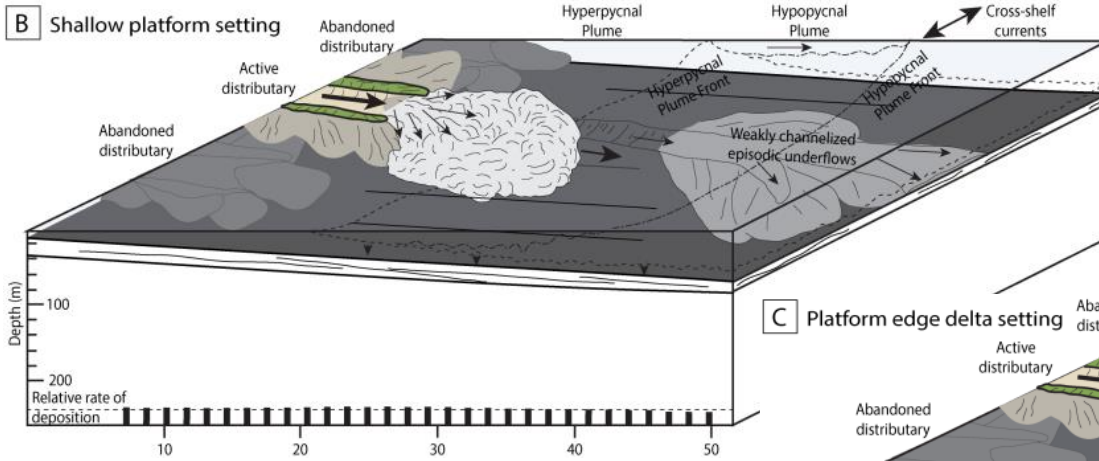
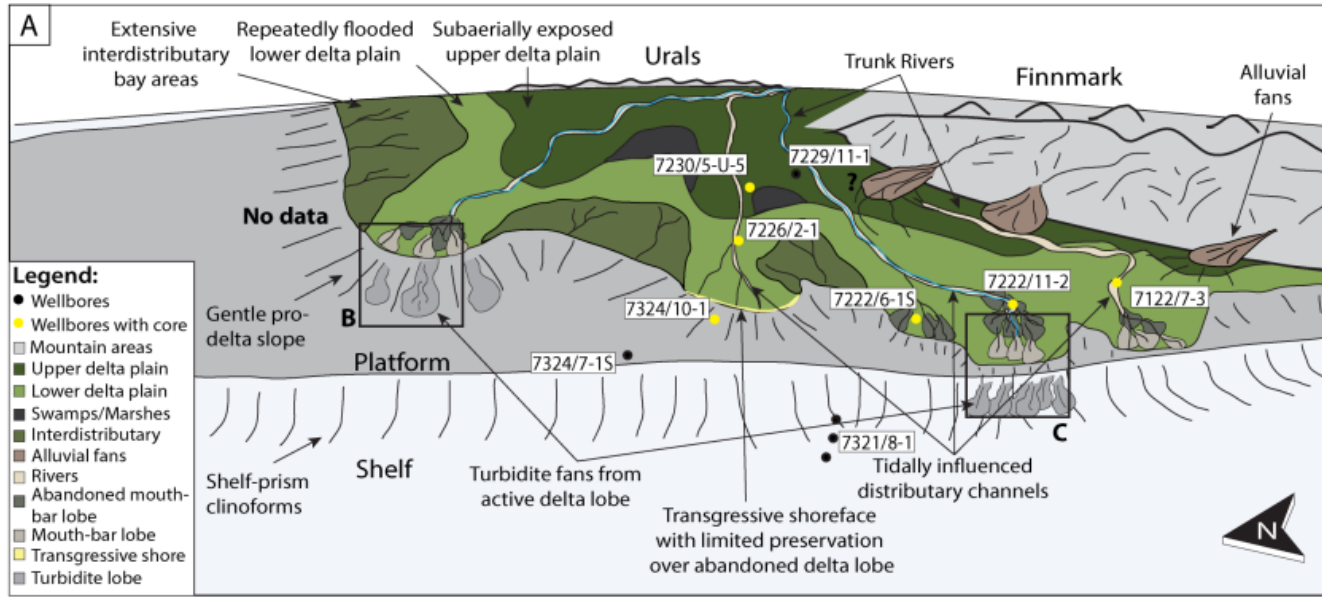


KOBBE FORMATION

- Targets in:
- Channelised deposits (Langlitinden)
 - Clinoform topsets (Aurelia, Atlantis)

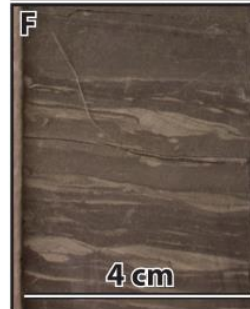
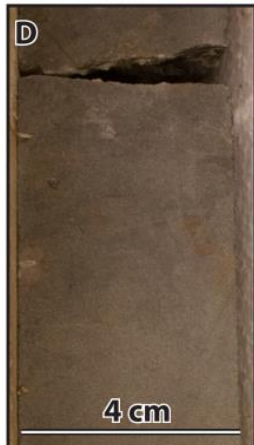
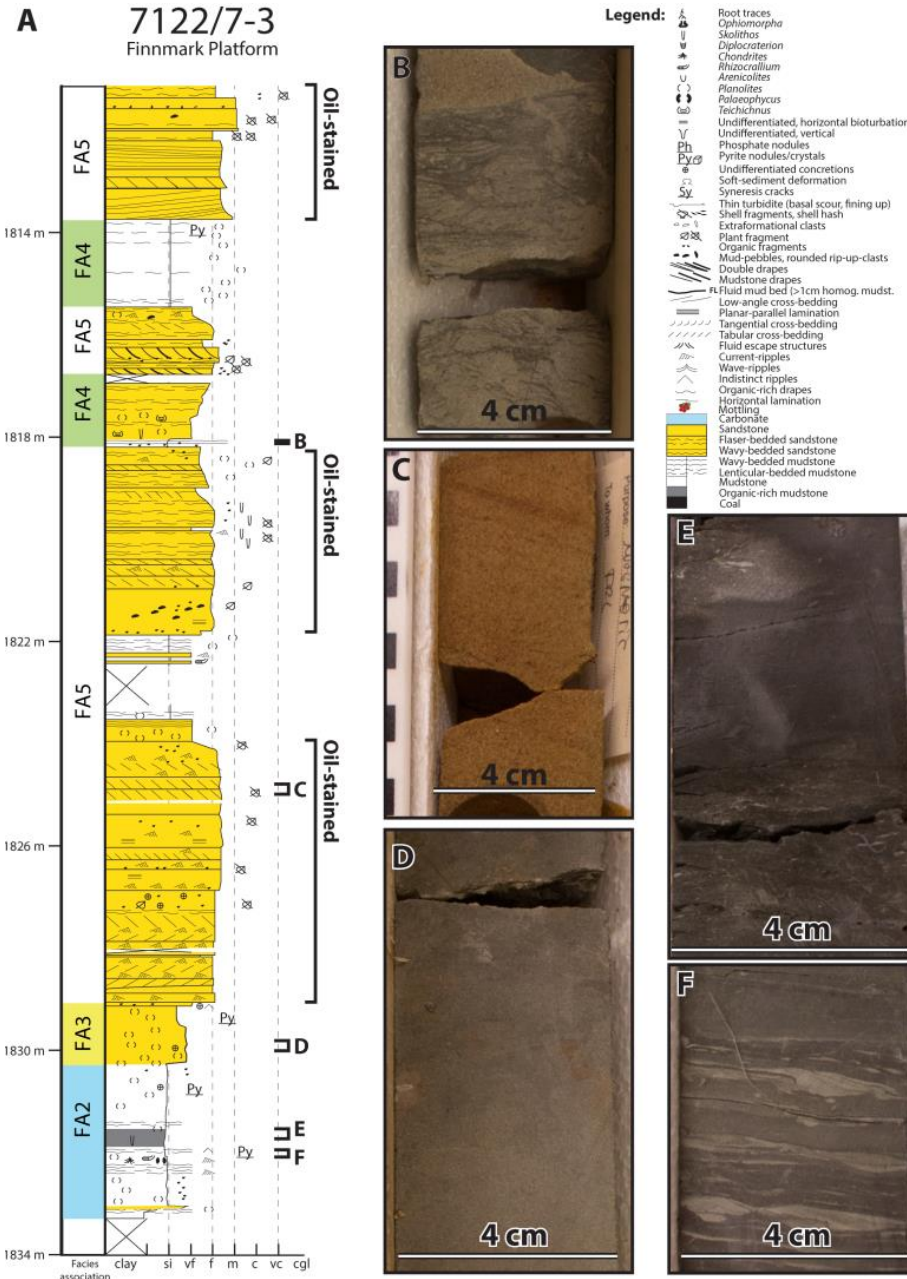


DEPOSITIONAL SYSTEMS IN THE KOBBE FORMATION



Klausen et al., 2017
Sedimentology

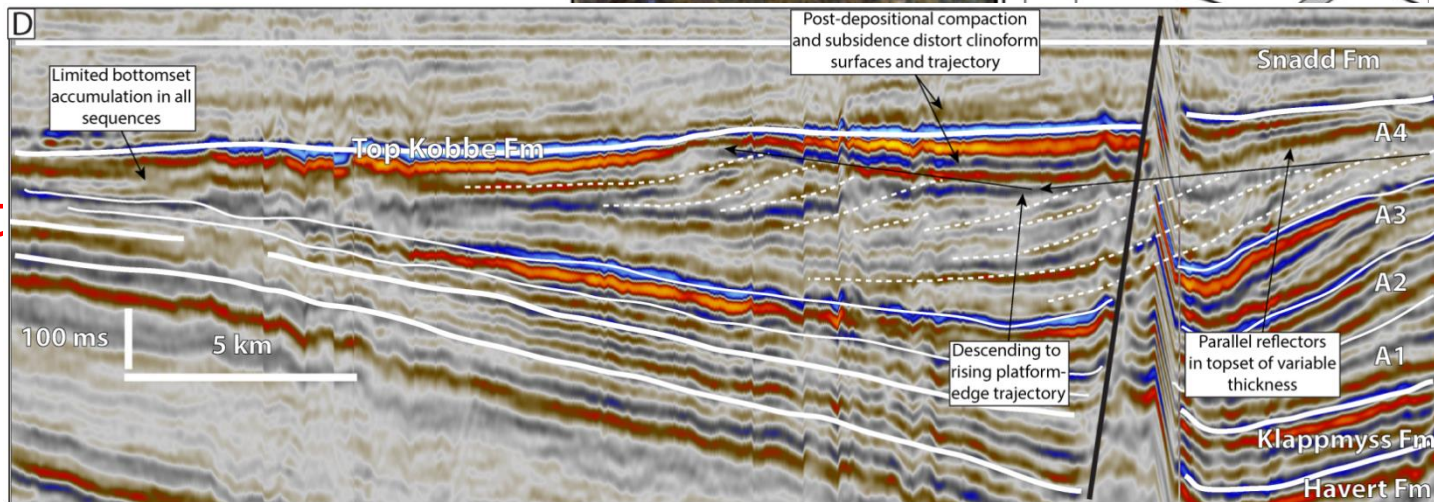
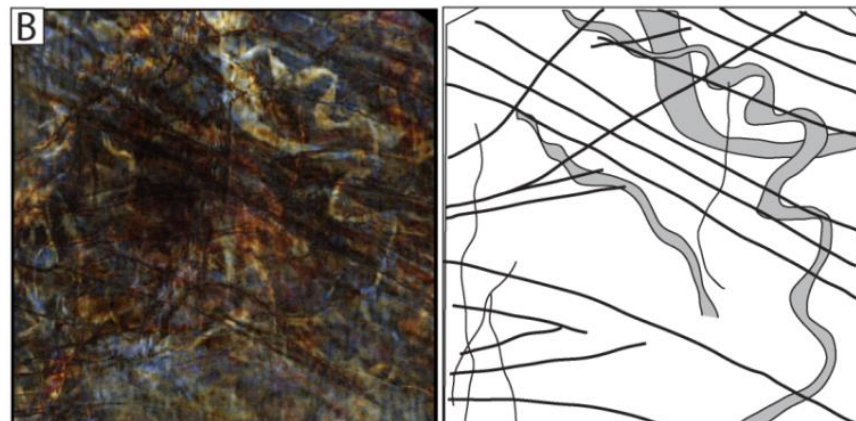
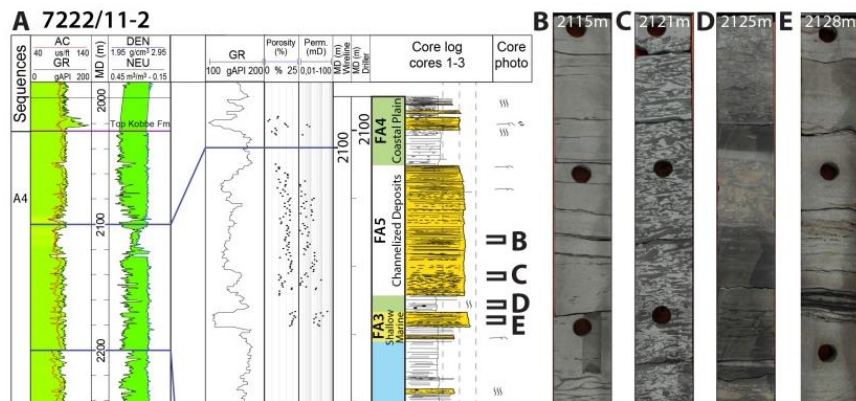
KOBBE FORMATION ALONG THE SOUTHERN MARGIN



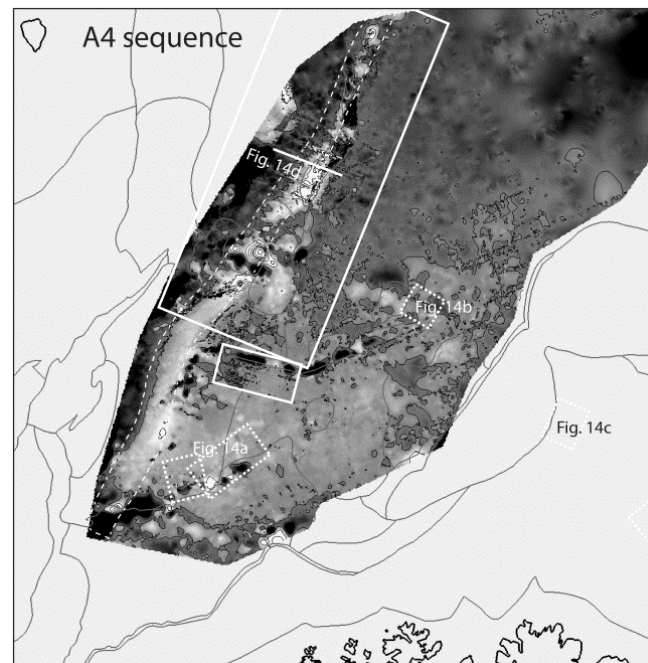
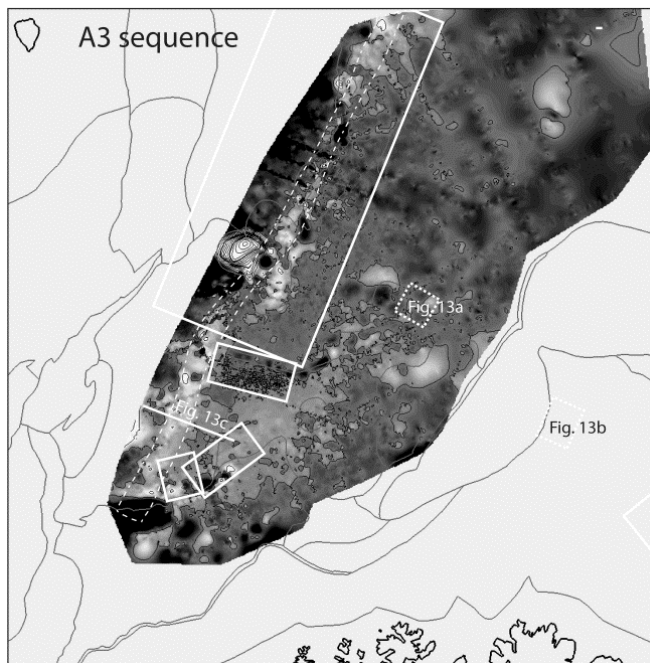
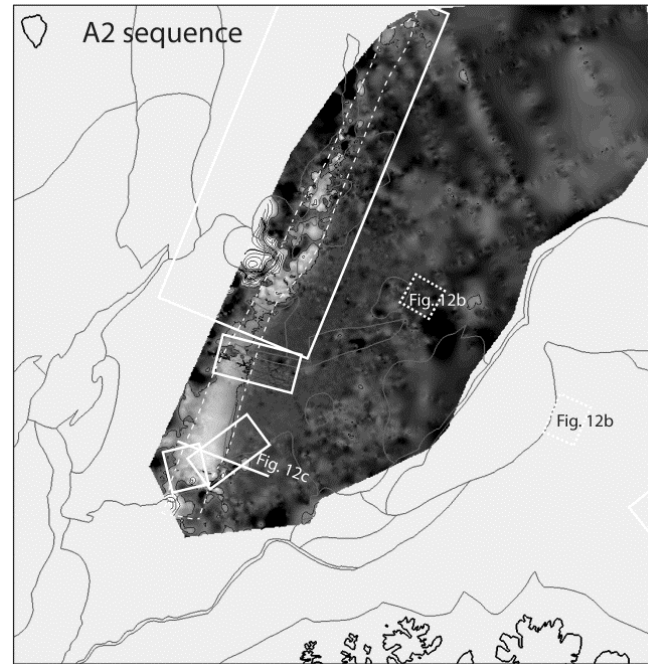
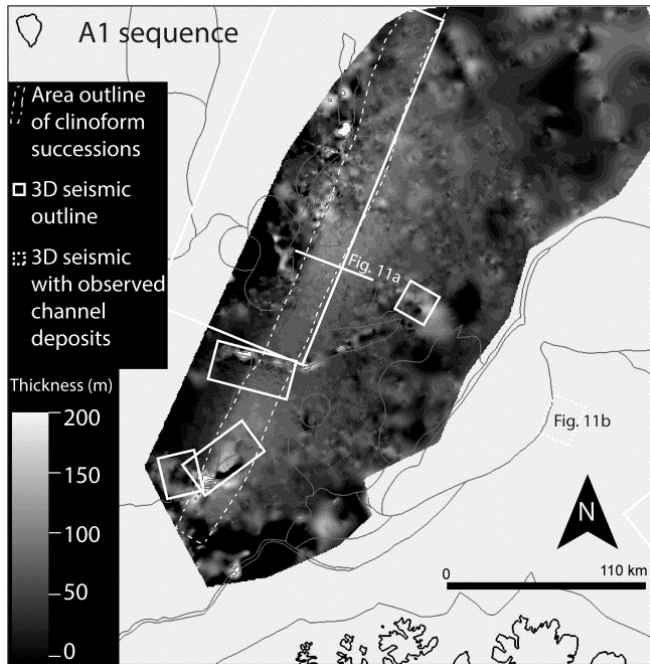
- Positive: Mature sediment from the southern Caledonides
- Negative: Smaller volumes and extent because of the size of the drainage basin

RECENT DISSAPOINTMENTS IN THE KOBBE FORMATION

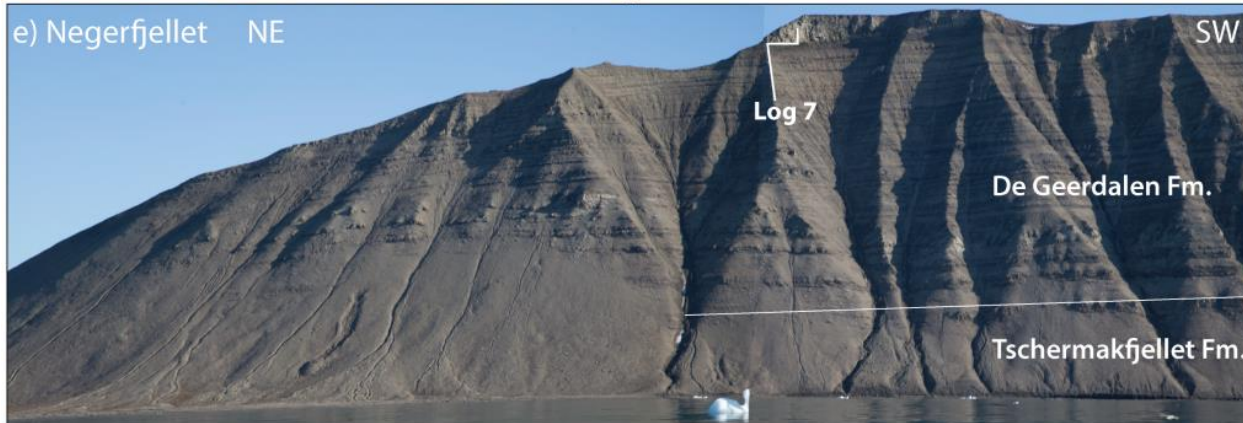
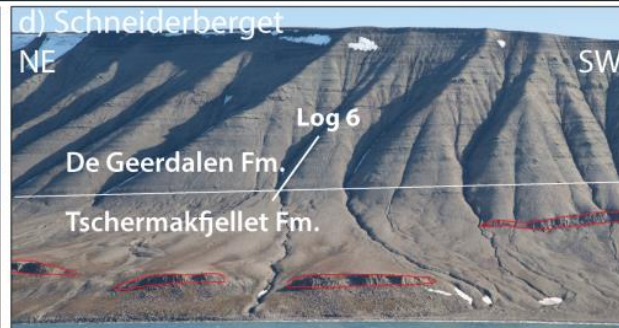
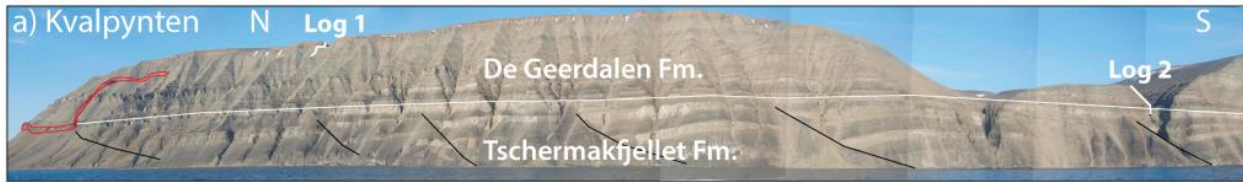
- Langlitinden
 - quality of reservoir rocks
- Goliat Eye
 - presence of reservoir rocks
- Atlantis
 - presence of reservoir rocks
- Aurelia
 - quality of reservoir rocks



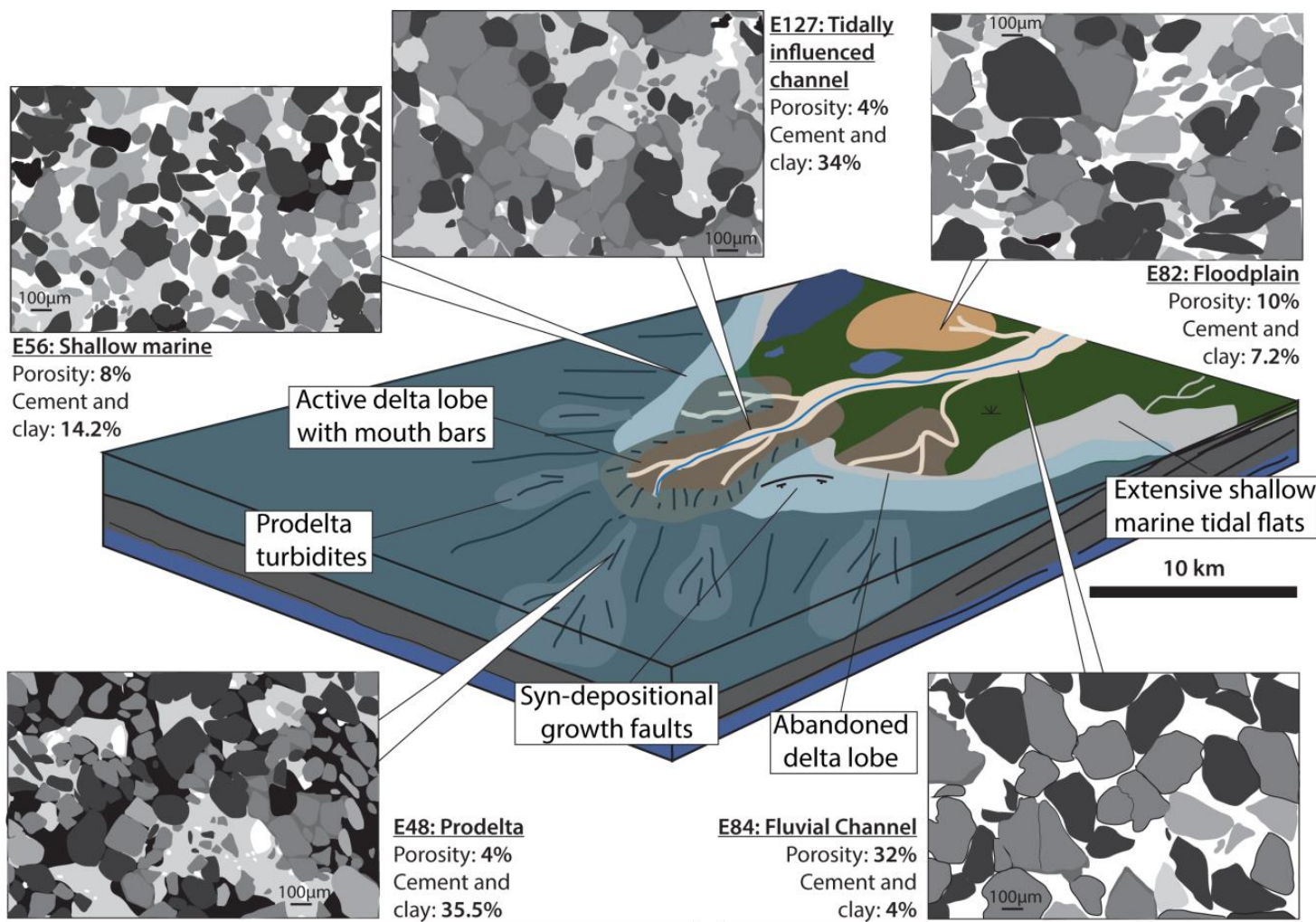
INTRABASINAL HIGHS PROVIDING MATURE SEDIMENTS?



OUTCROP ANALOGUES - PETROGRAPHY AND FACIES



OUTCROP ANALOGUES FOR THE PETROGRAPHIC NATURE OF TRIASSIC DEPOSITIONAL SYSTEMS



Facies legend

Light gray	Tidal	Brown	Shallow marine	Orange	Crevasse splay
Dark gray	Turbidites	Light brown	Channel deposits	Blue	Lacustrine
Dark blue-gray	Prodelta	Green	Floodplain	Dark blue	Interdistributary

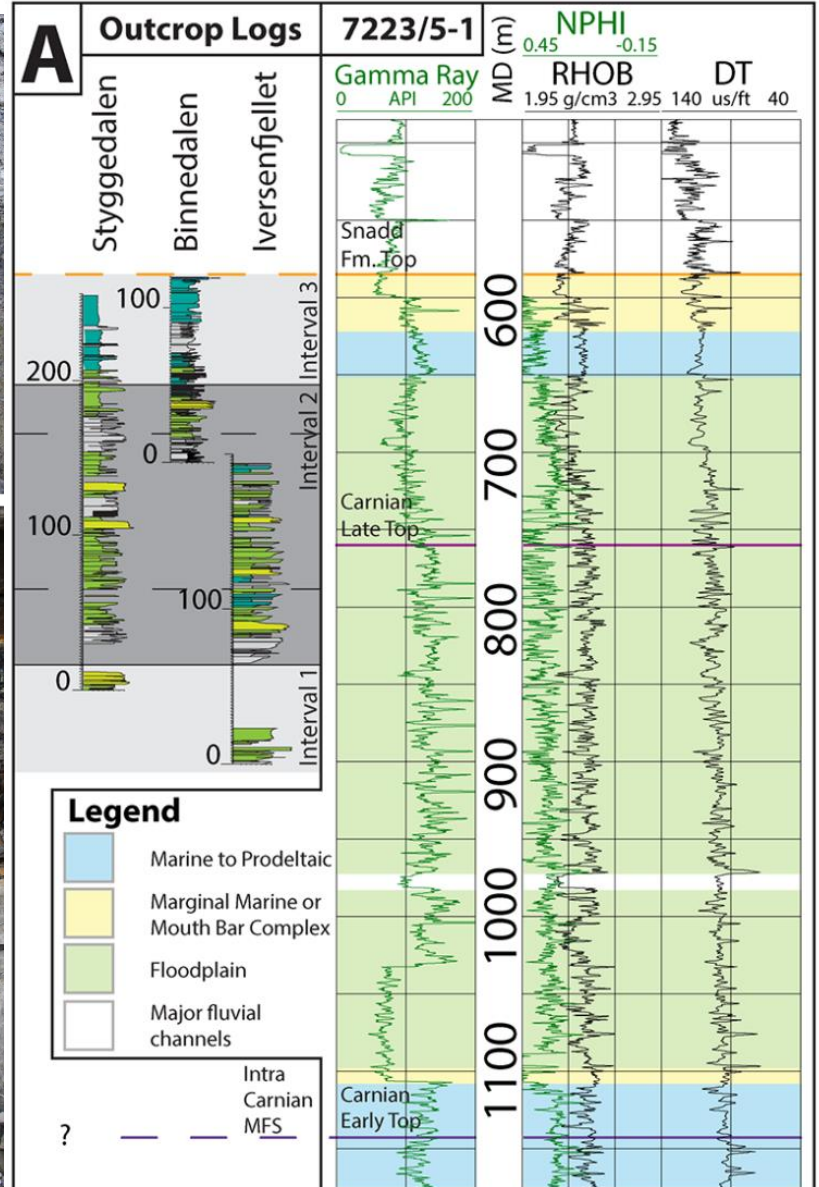
Thin section legend

Light gray	Clay particles	Black	Carbonate cement
Dark gray	Quartz	Dark gray	Quartz cement
Medium gray	Feldspar	Black with diamond	Chlorite coating
Dark gray with black	Rock fragments		

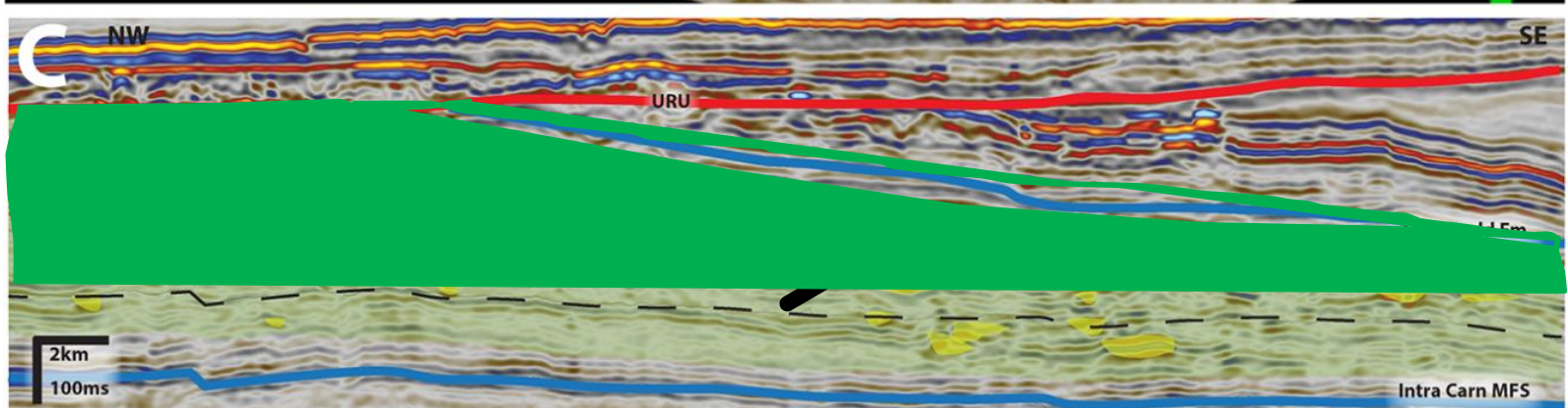
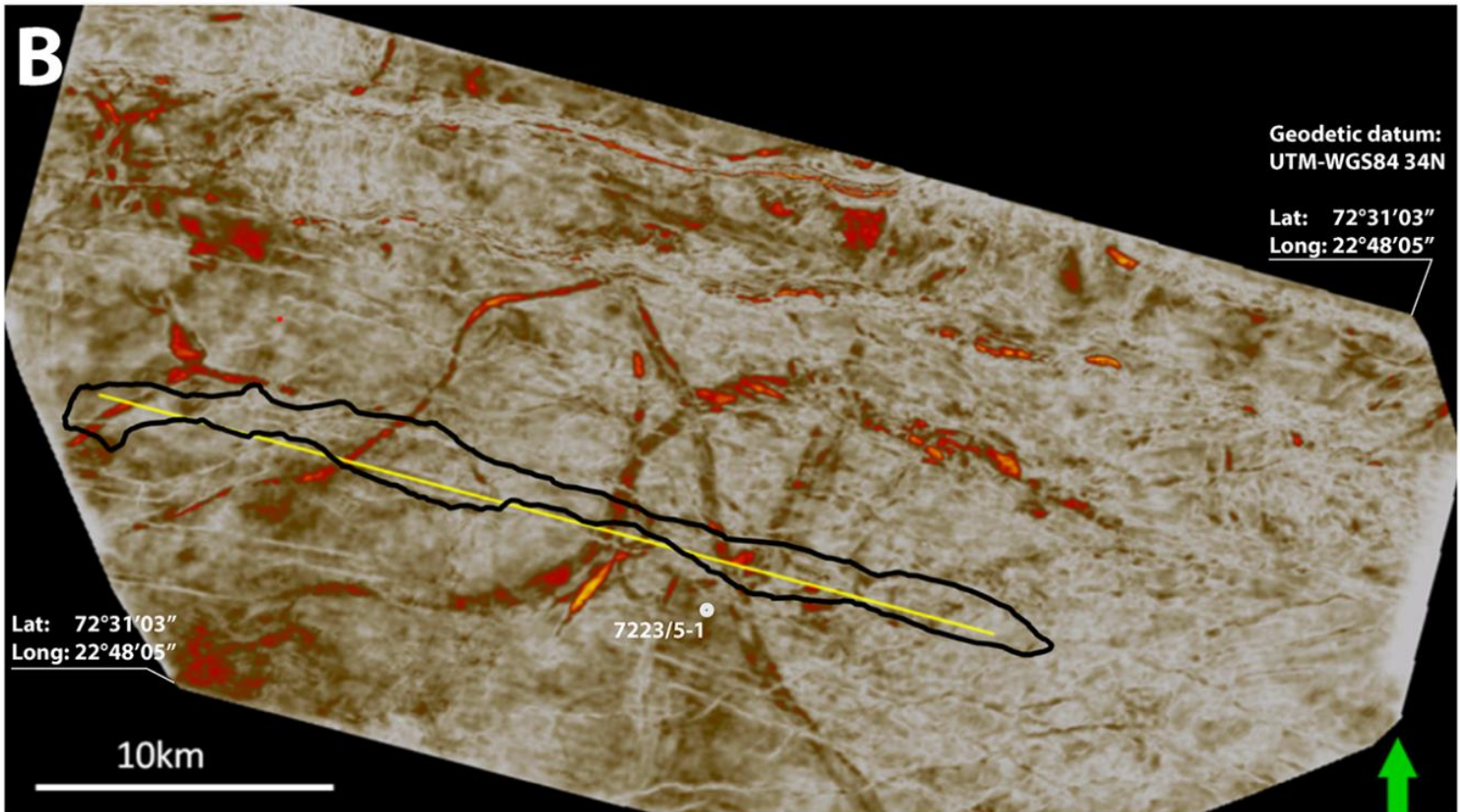
Haile et al., *In review*
Marine and Petroleum Geology

OUTCROP ANALOGUES – SEALING CAPACITY

FRUHO
SNADD
KOBBE
KLAPP
HAVERT



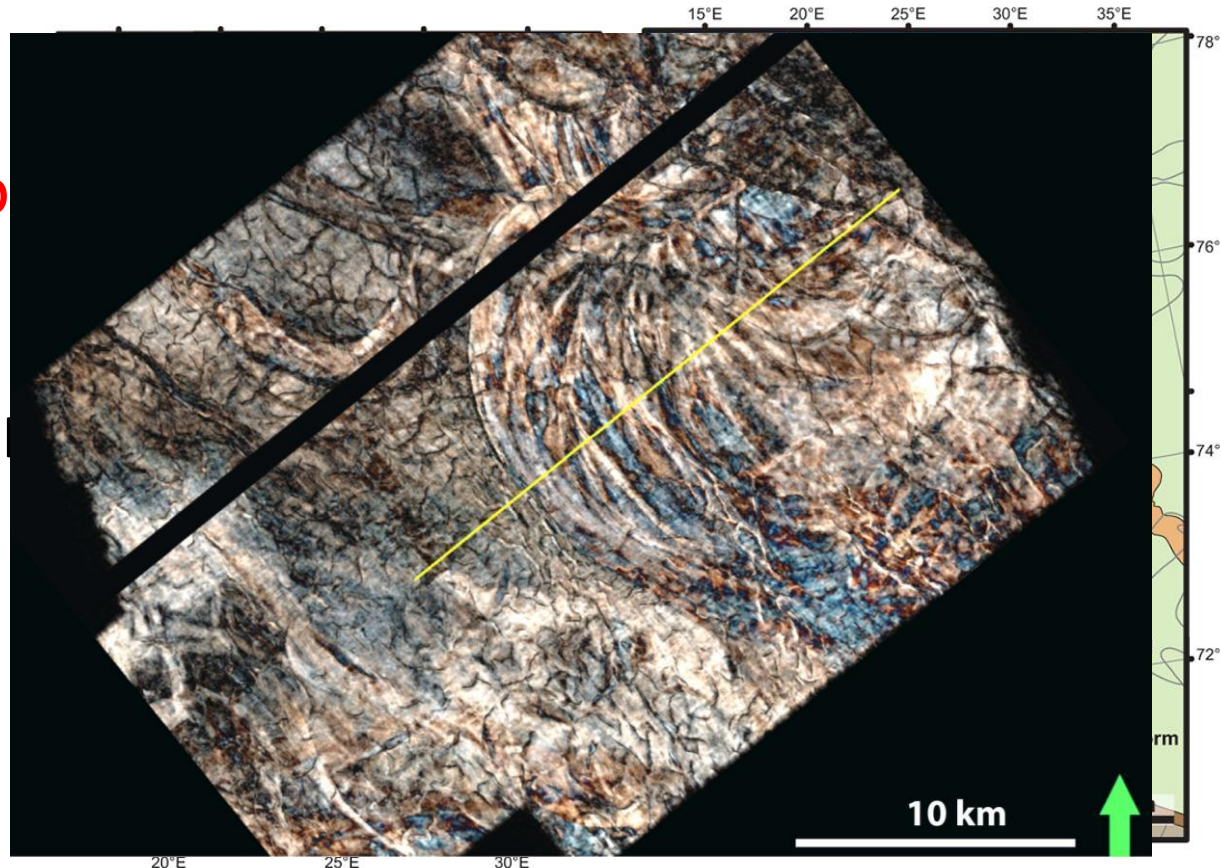
OUTCROP ANALOGUES – SEALING CAPACITY



Klausen and Mørk, 2014
AAPG Bull.

RECENT DISSAPPOINTMENTS IN THE SNADD FORMATION

- Gemini
 - (reservoir properties)
- Korp fjell
 - (seal/hydrocarbon column?)
- Filicudi
 - (reservo
- Hurri?
- Signalhorn



FRUHO

SNADD

KOBBE

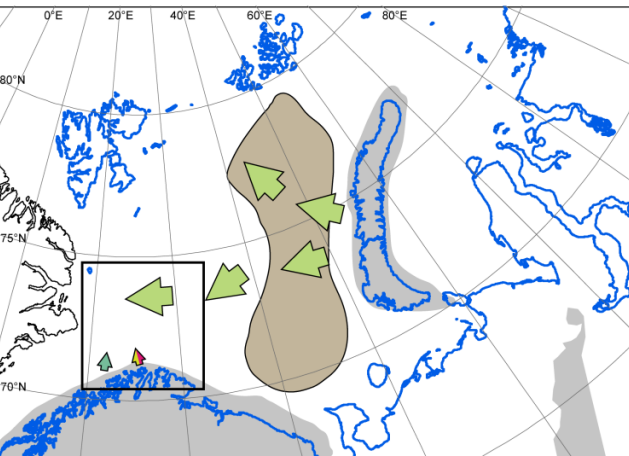
KLAPPM

HAVERT

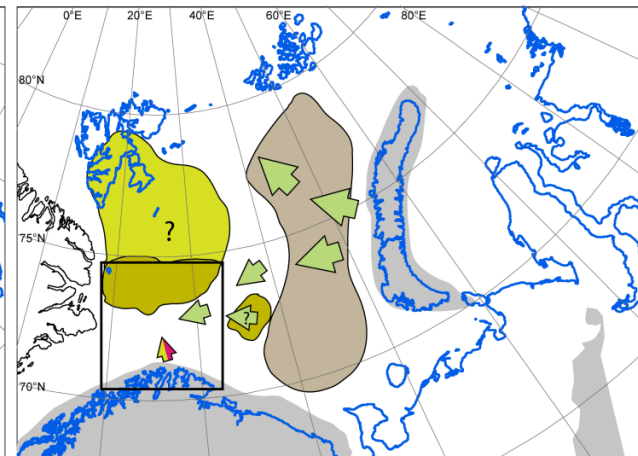
FRUHOLMEN FORMATION – DIFFERENT OR NOT?

FRUHO
SNADD
KOBBE
KLAPPM
HAVERT

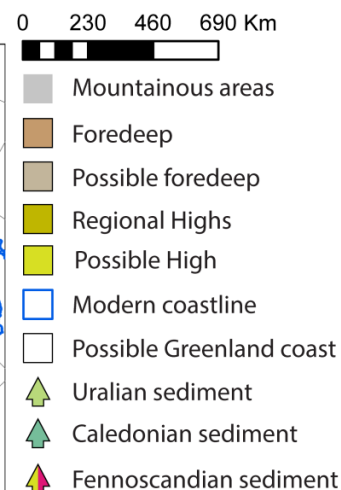
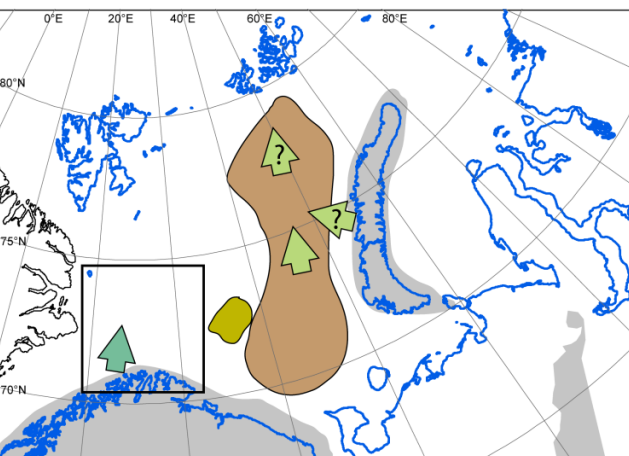
1) Norian-Rhaetian (Fruholmen Fm.)



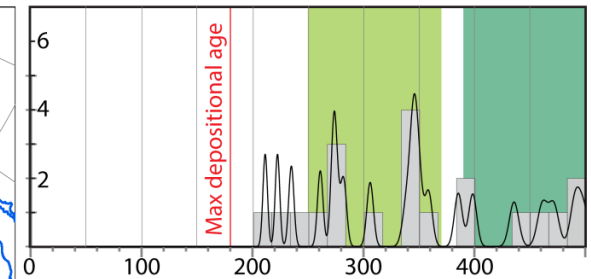
2) Rhaetian-Sinemurian (Tubåen Fm.)



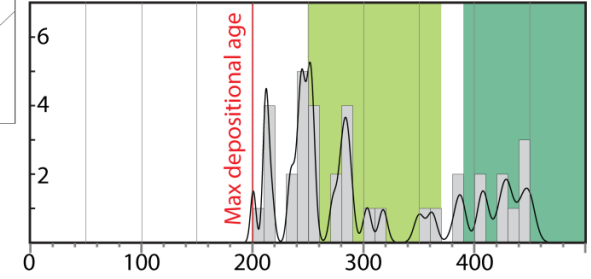
3) Sinemurian-Pliensbachian (Nordmela Fm.)



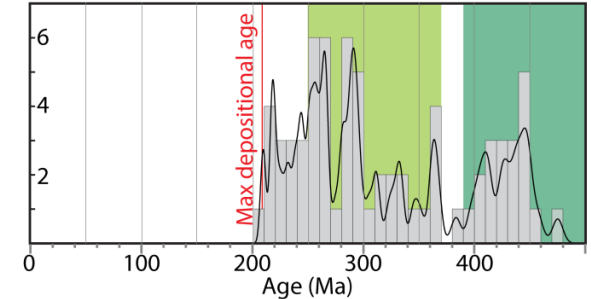
3) Sinemurian-Pliensbachian



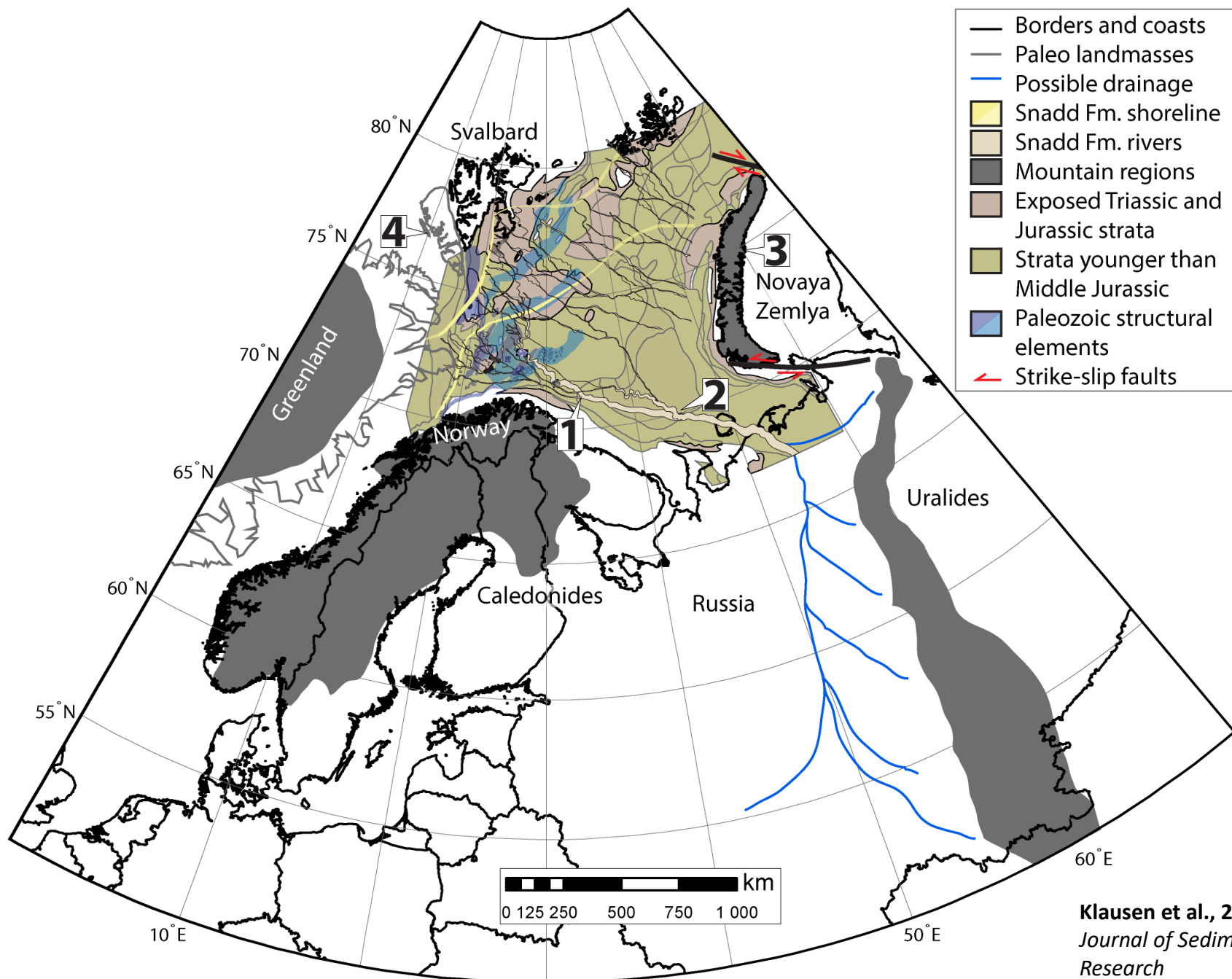
2) Rhaetian-Sinemurian



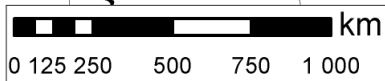
1) Norian-Rhaetian



FRUHOLMEN FORMATION – PROBABLY NOT DIFFERENT



- Borders and coasts
- Paleolandmasses
- Possible drainage
- Snadd Fm. shoreline
- Snadd Fm. rivers
- Mountain regions
- Exposed Triassic and Jurassic strata
- Strata younger than Middle Jurassic
- Paleozoic structural elements
- ↔ Strike-slip faults



Klausen et al., 2014
Journal of Sedimentary Research

FRUHO
 SNADD
 KOBBE
 KLAPPM
 HAVERTE

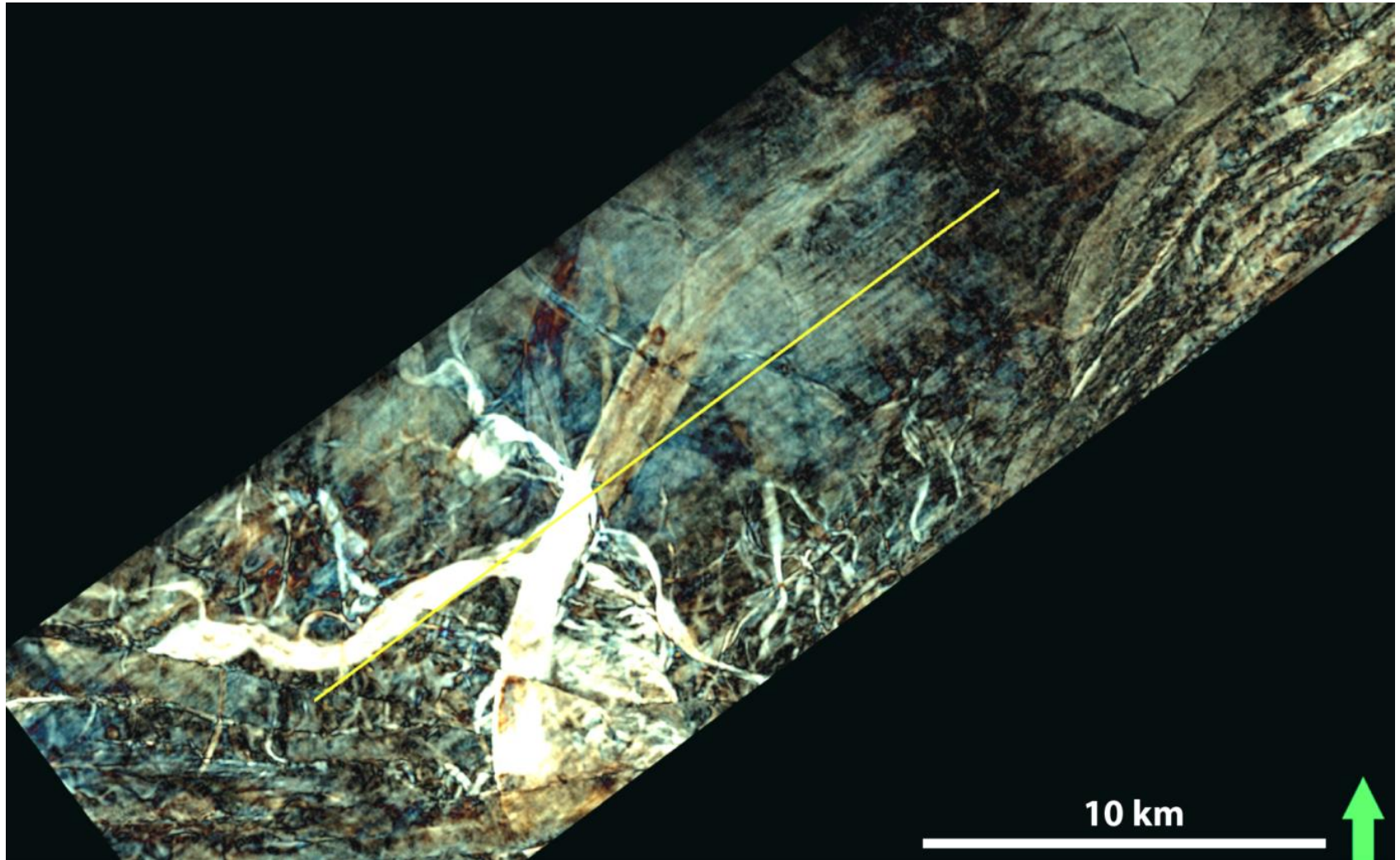
OPPORTUNITIES

- The Triassic Barents Sea is a bucket of mud, what do we do?
 - Respect this fact and restrict drilling to well-studied and proven plays:
 - Southern and proximal systems = best reservoir
 - W and NW = best source rock
- Channel deposits – with important caveats:
 - preserved reservoir
 - hydrocarbon charge
 - efficient seal (high up in the stratigraphy)
- Transgressive shoreline systems
- Systems sourced from mature southern provenance areas

OPPORTUNITIES

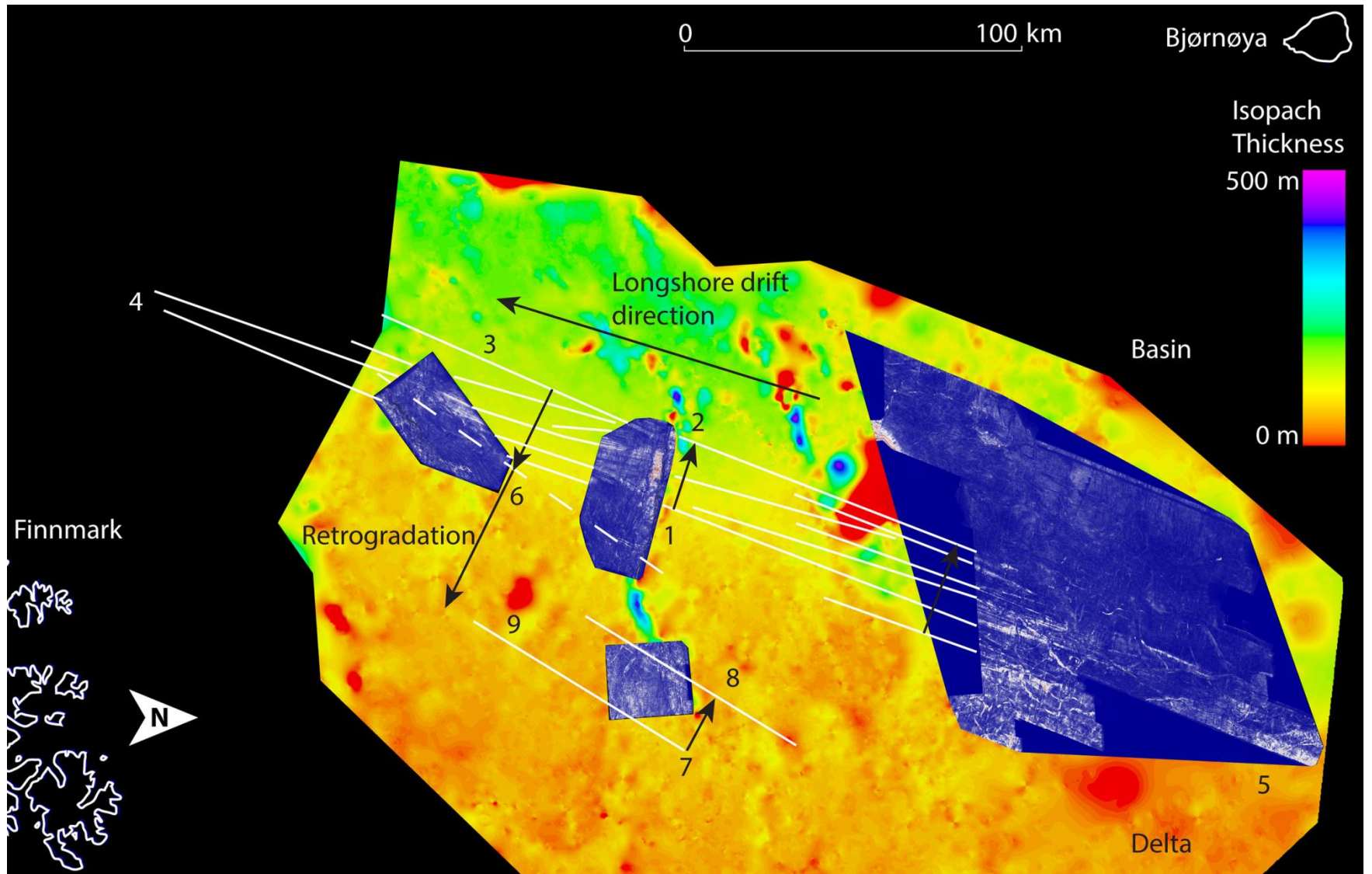
Channel systems in the distal, upper Snadd Formation (HC in e.g. Gemini and Caurus)

- Assuming poor sealing capacity, proximity to potent Fruholmen seal is necessary
- Distal parts are overlying high quality source rocks (Steinkobbe Formation)



WELL-SORTED SHOREFACE SANDSTONES

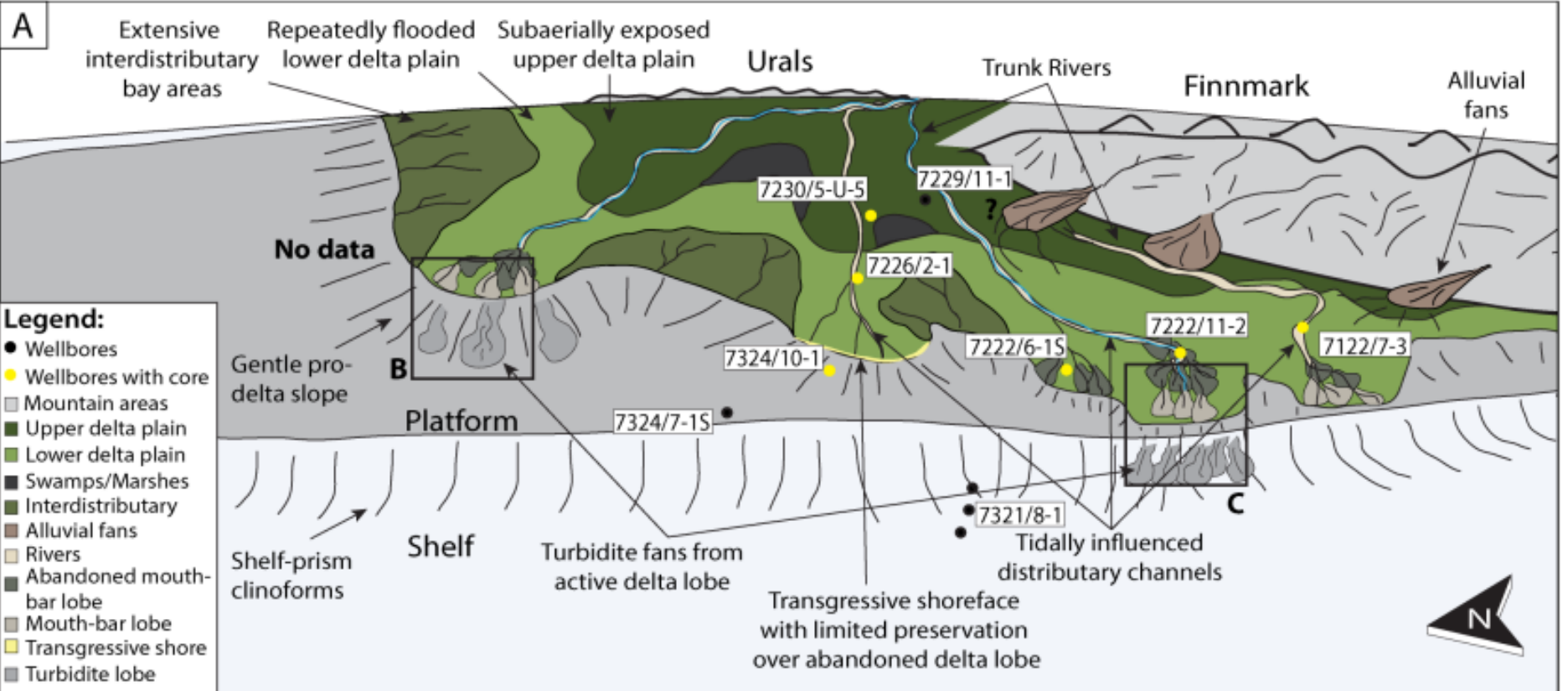
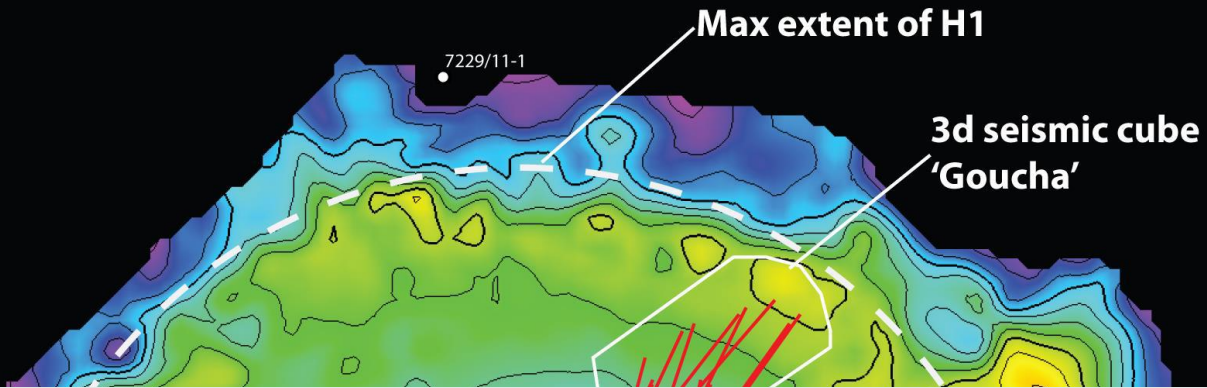
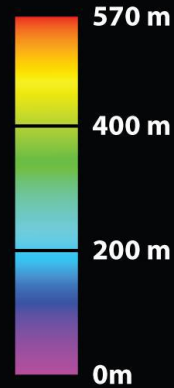
Lower amounts of argillaceous, fine grained material that compromise reservoir properties. Core material available, but largely untested. Also present in upper Snadd.



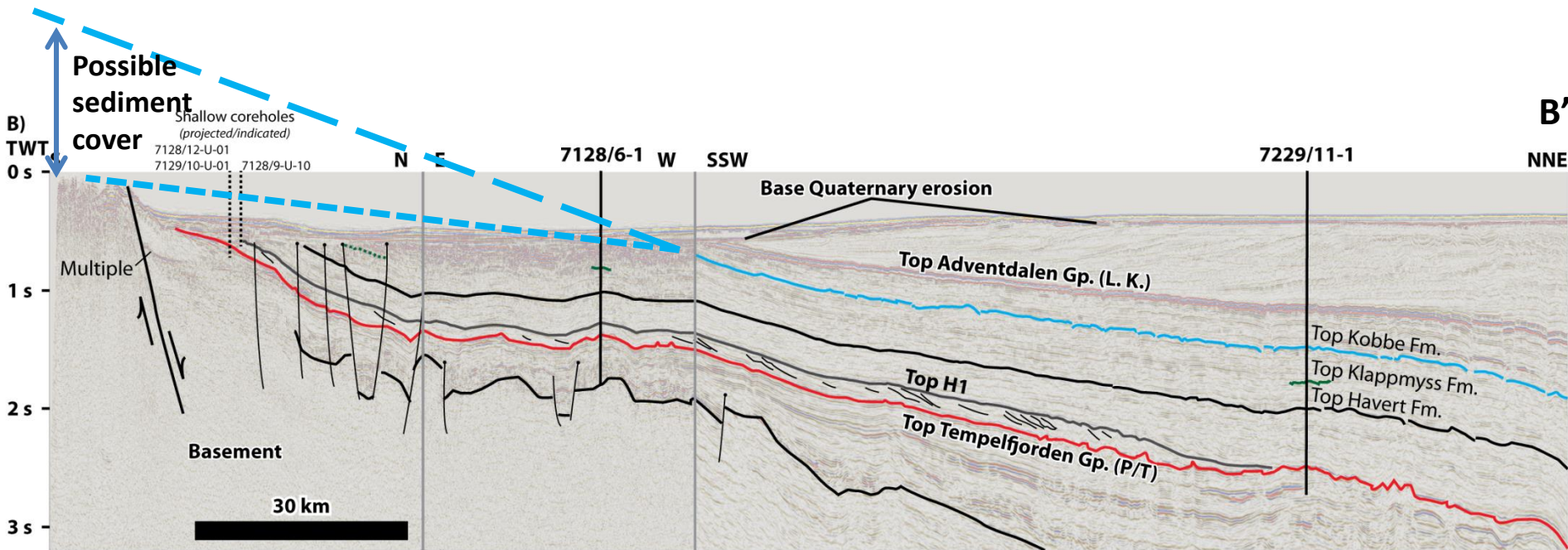
PITFALLS: EXTENT OF SOUTHERN SYSTEMS?

FRUHO
SNADD
KOBBE
KLAPPM
HAVERT

Thickness map of H1 system (depth)

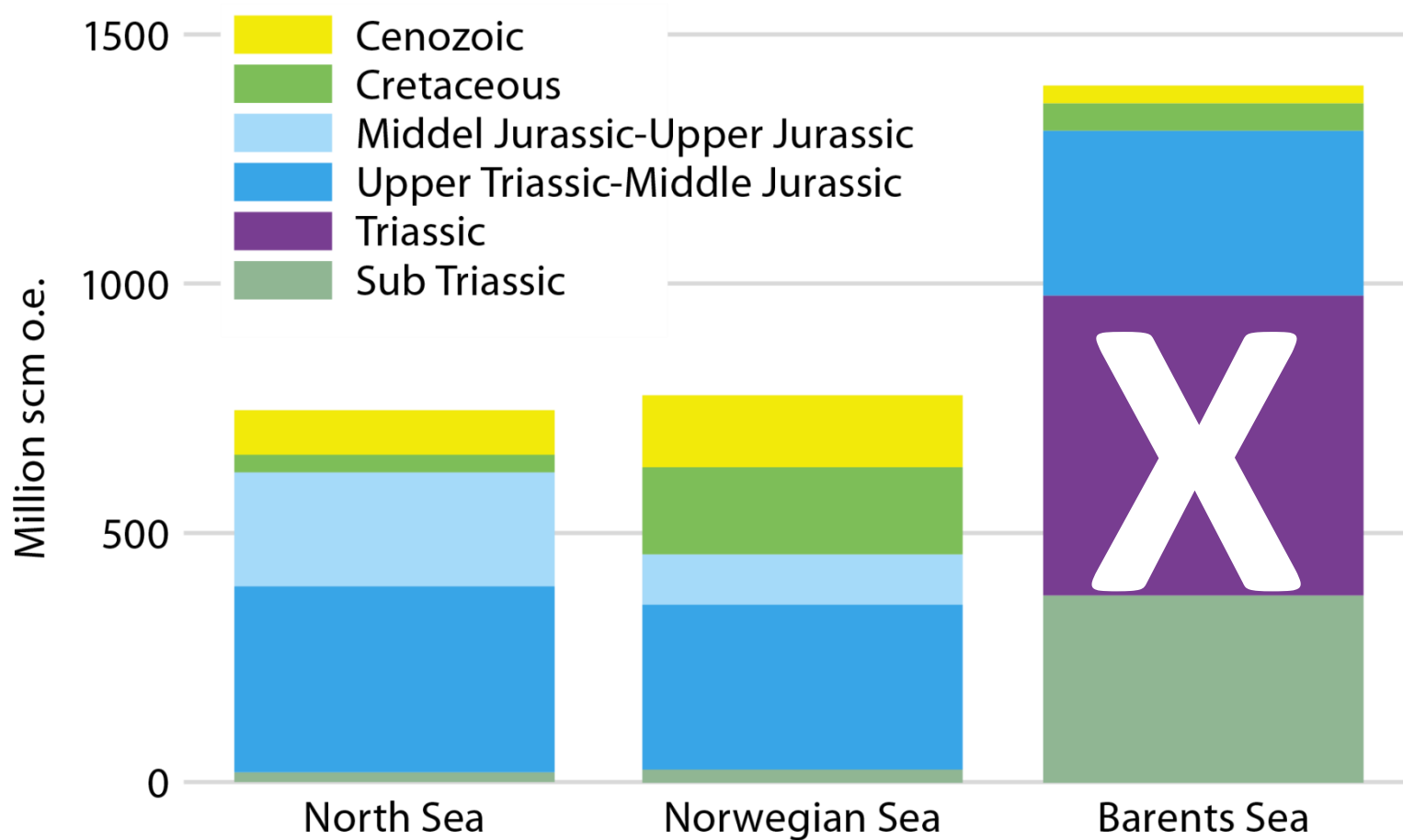


PITFALLS: UPLIFT AND EROSION ALONG SOUTHERN MARGIN



Eide et al., *in press*
GSA Bull.

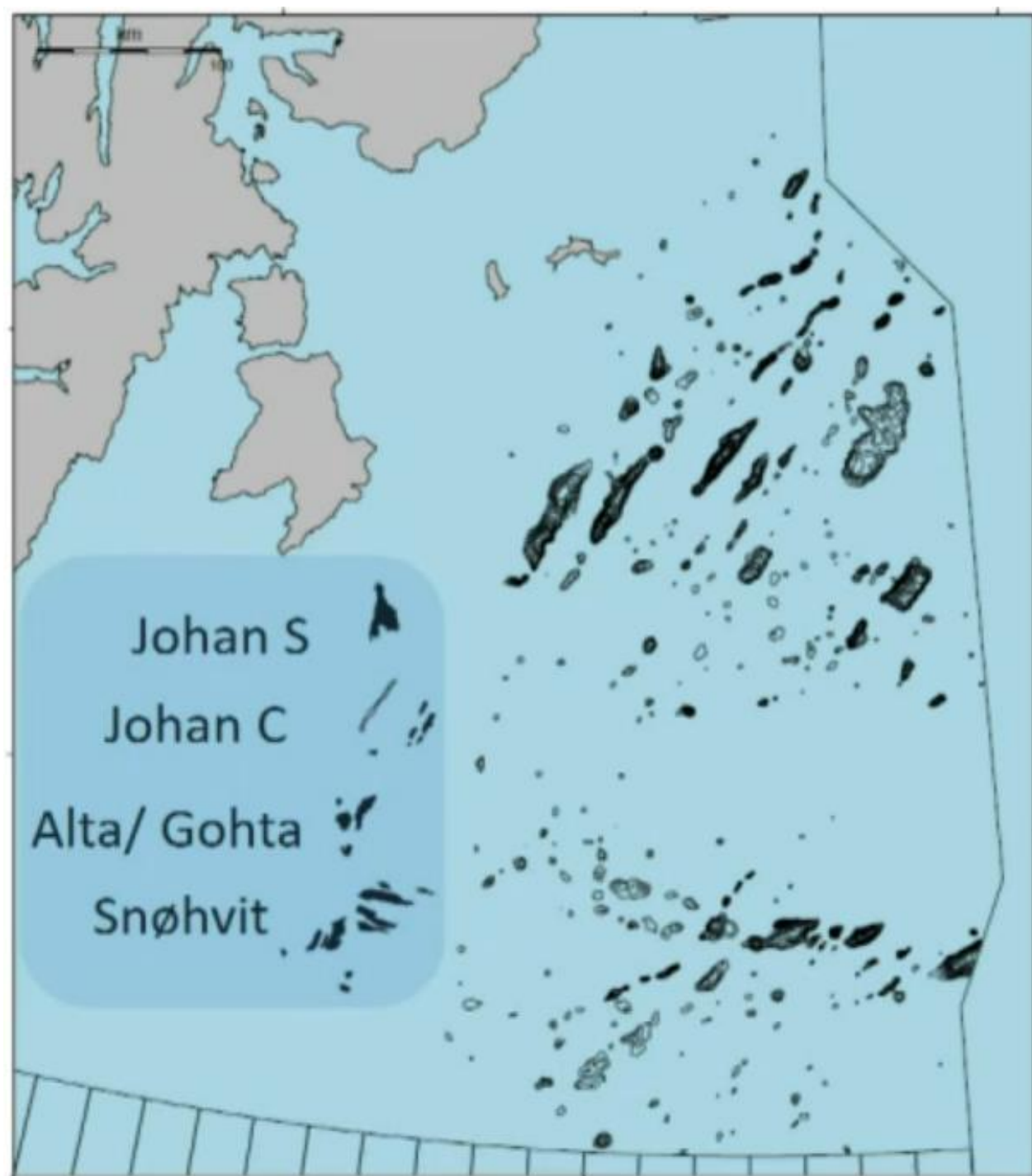
A REVISION OF THE TRIASSIC BARENTS SEA POTENTIAL IS DUE



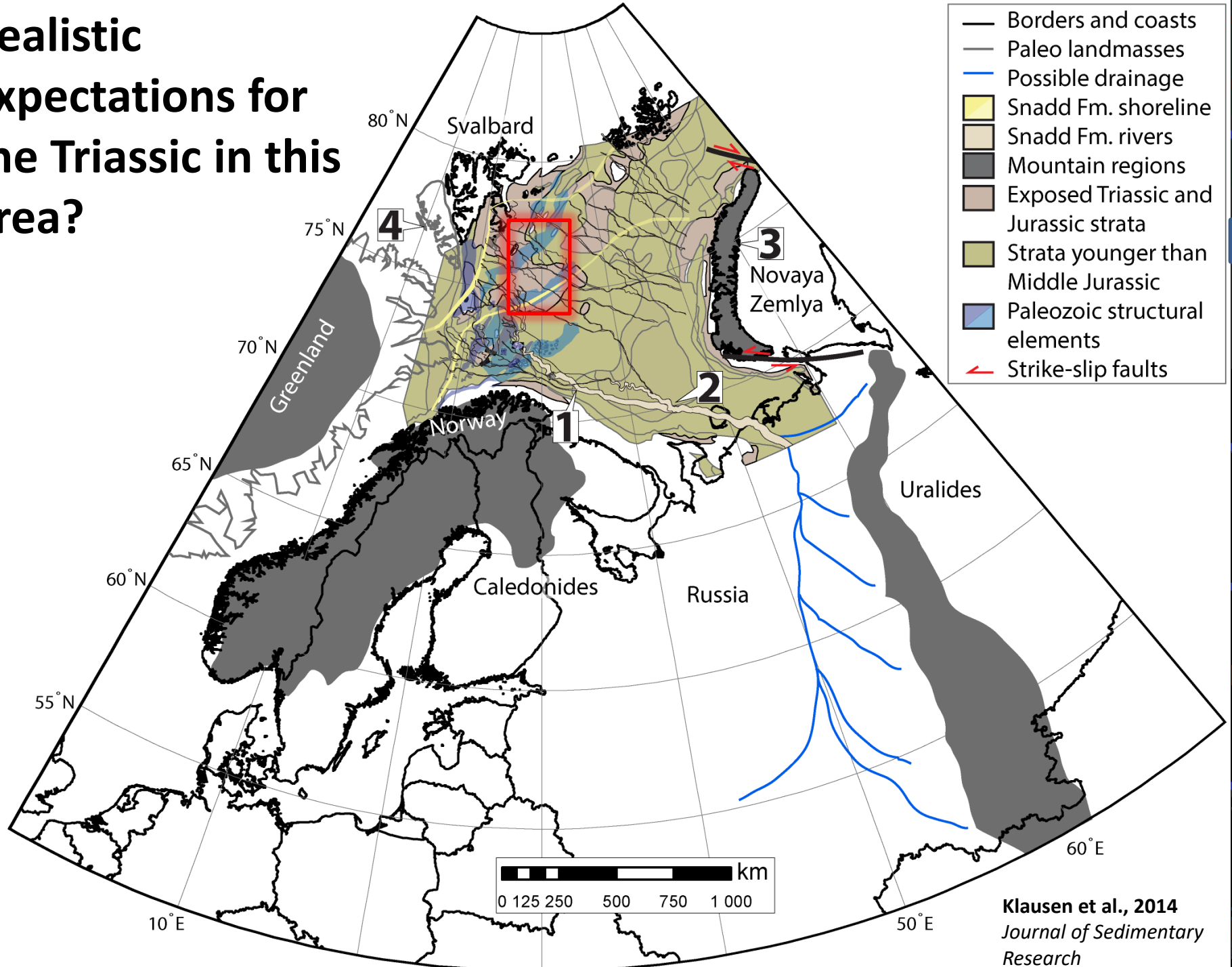
AFFECT RESOURCE ESTIMATES FOR BARENTS SEA NORTH-EAST

NPD's Scenario X:
Triassic reservoirs
increase the
estimates from 9
to 15 billion b.o.e

We will be looking
at shallow core
drillings from the
area this
afternoon

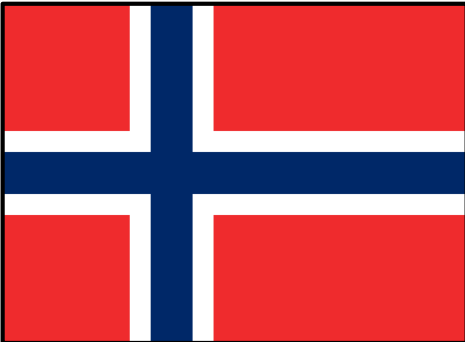
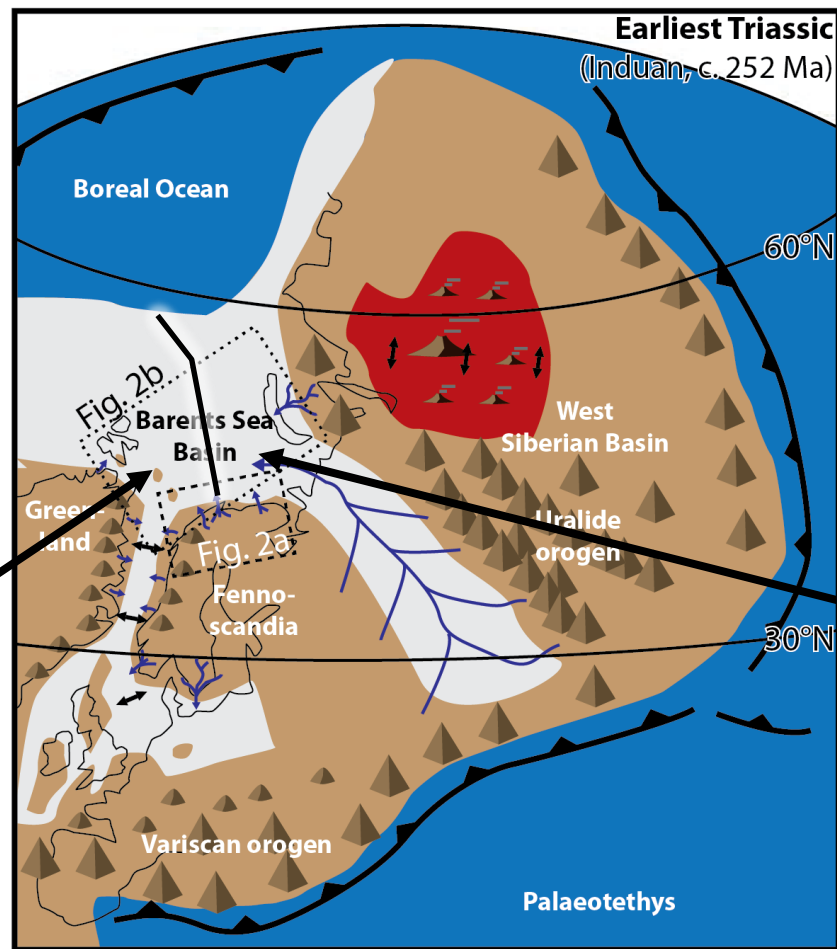


Realistic expectations for the Triassic in this area?



FRUHO
SNADD
KOBBE
KLAPPIM
HAVERTT

ISBAR – Internal and external forcing factors on the Source to sink dynamics of the greater BArents Sea



- Volcanic activity
- Land, high
- Siberian Traps
- Lower mountains
- Basin
- Rivers
- High mountains
- Ocean
- Rifting

Thank you for your attention!

Questions?

Comments?