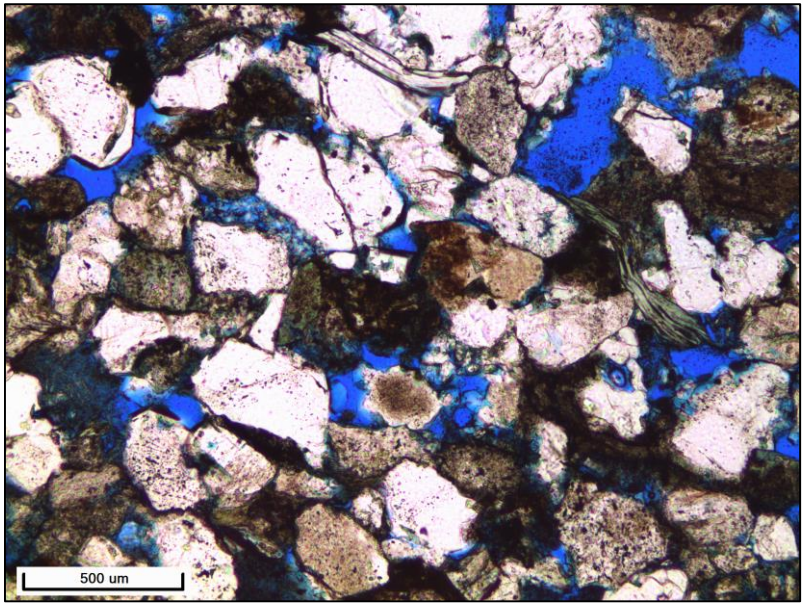
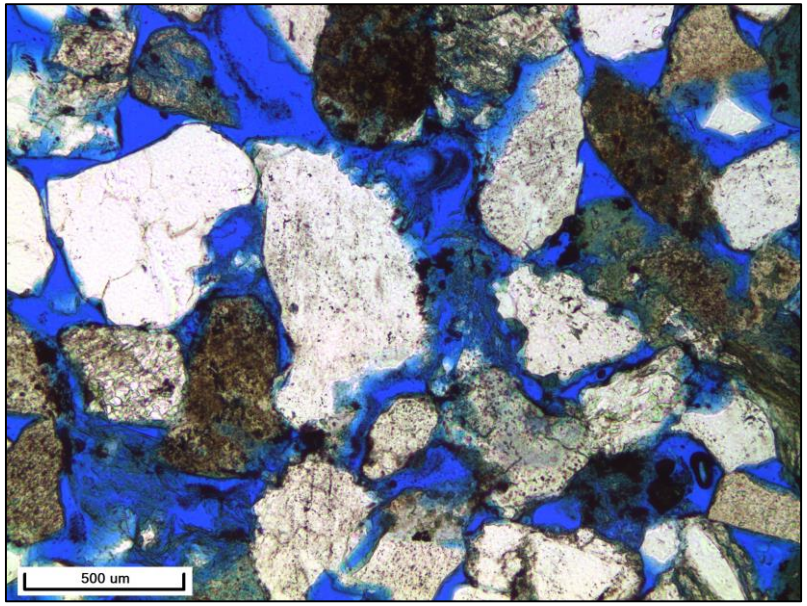
Diagenesis and Reservoir Quality of Anisian and Carnian channels in the southwestern Barents Sea





How are sedimentary and diagenetic processes linked to reservoir quality?

Lina Hedvig Line (VISTA/UiO), Jens Jahren (UiO) & Helge Hellevang (UiO)

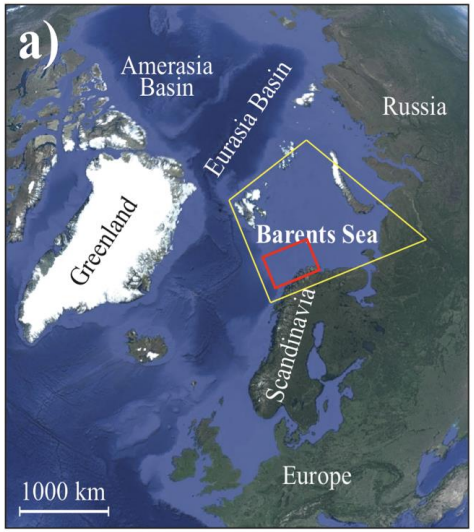
VISTA

UiO

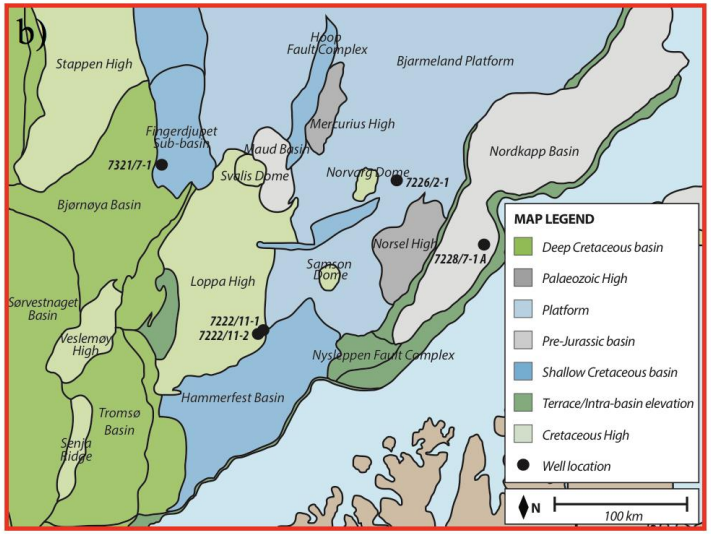
Agenda

- Introduction
- Dataset
- Results
  - Mineral composition
  - Petrography of framework grains
  - Intergranular volume
  - Chlorite coating characteristics
  - Reservoir quality
- Discussion
  - Early diagenesis
  - Mechanical compaction
  - Burial diagenesis
- Conclusion

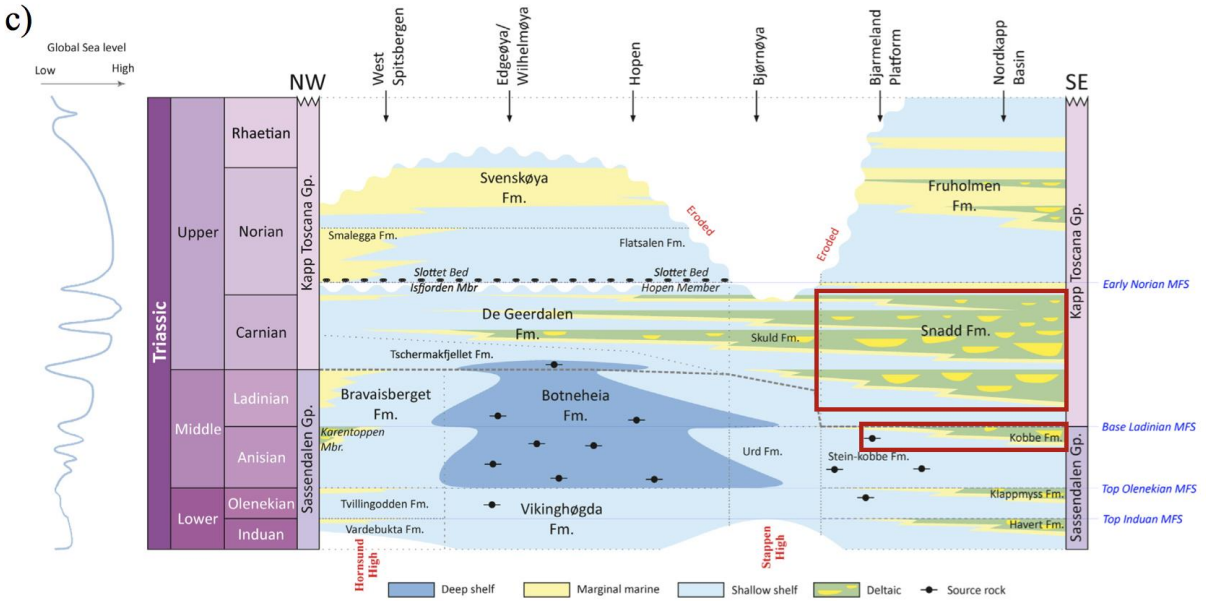
Introduction



Map of the greater Barents Sea after Google Earth (2016).



Map of the southwestern Barents Sea after NPD Factmaps (2017).



Triassic chronostratigraphy and facies summary after Fleming et al. (2016).

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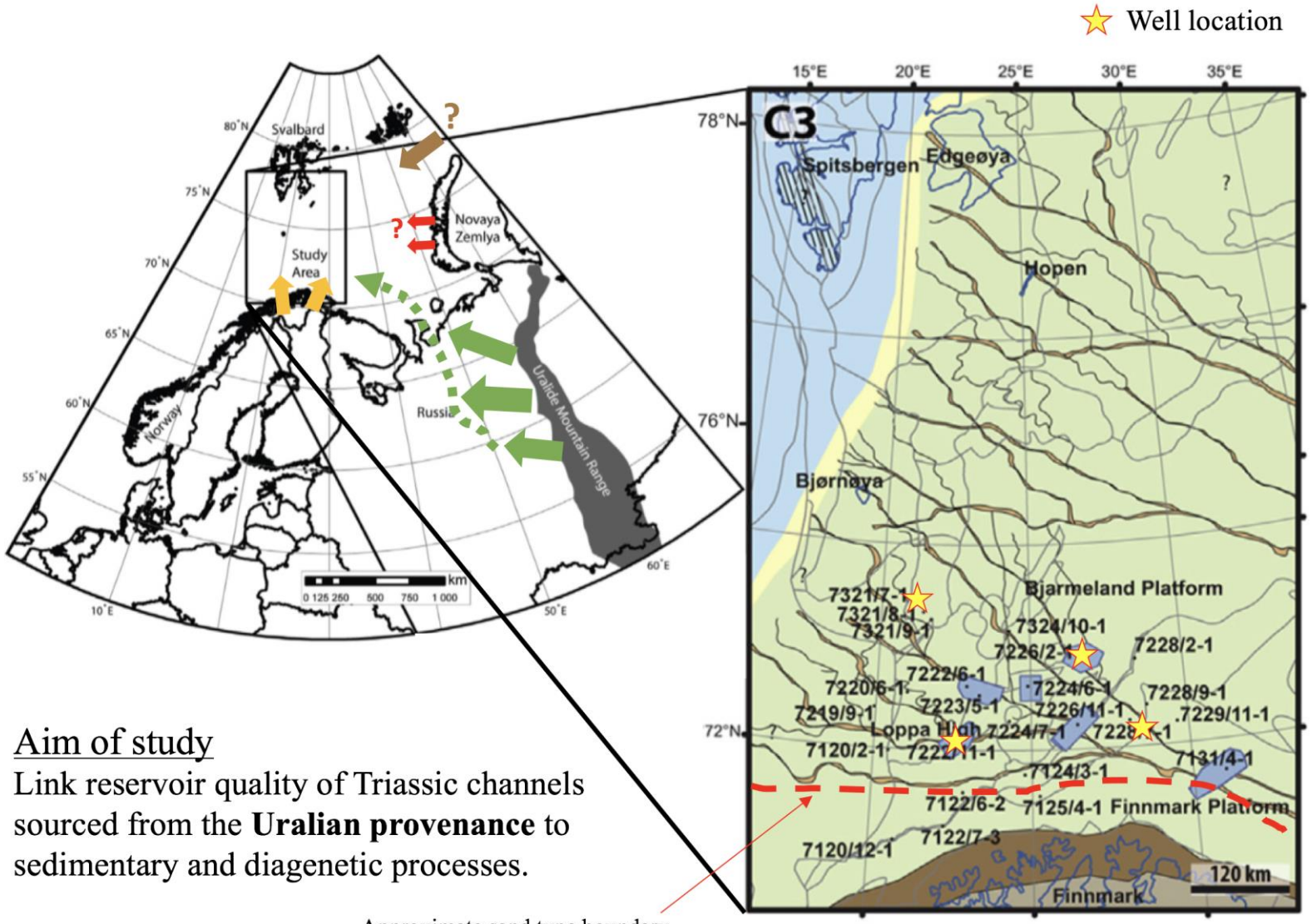
Triassic hydrocarbon play in the southwestern Barents Sea



Aim of study

Link reservoir quality of Triassic channels sourced from the **Uralian provenance** to sedimentary and diagenetic processes.

Approximate sand type boundary after Fleming et al. (2016)

Paleogeographic reconstruction of the Carnian time interval after Klausen et al. (2015).

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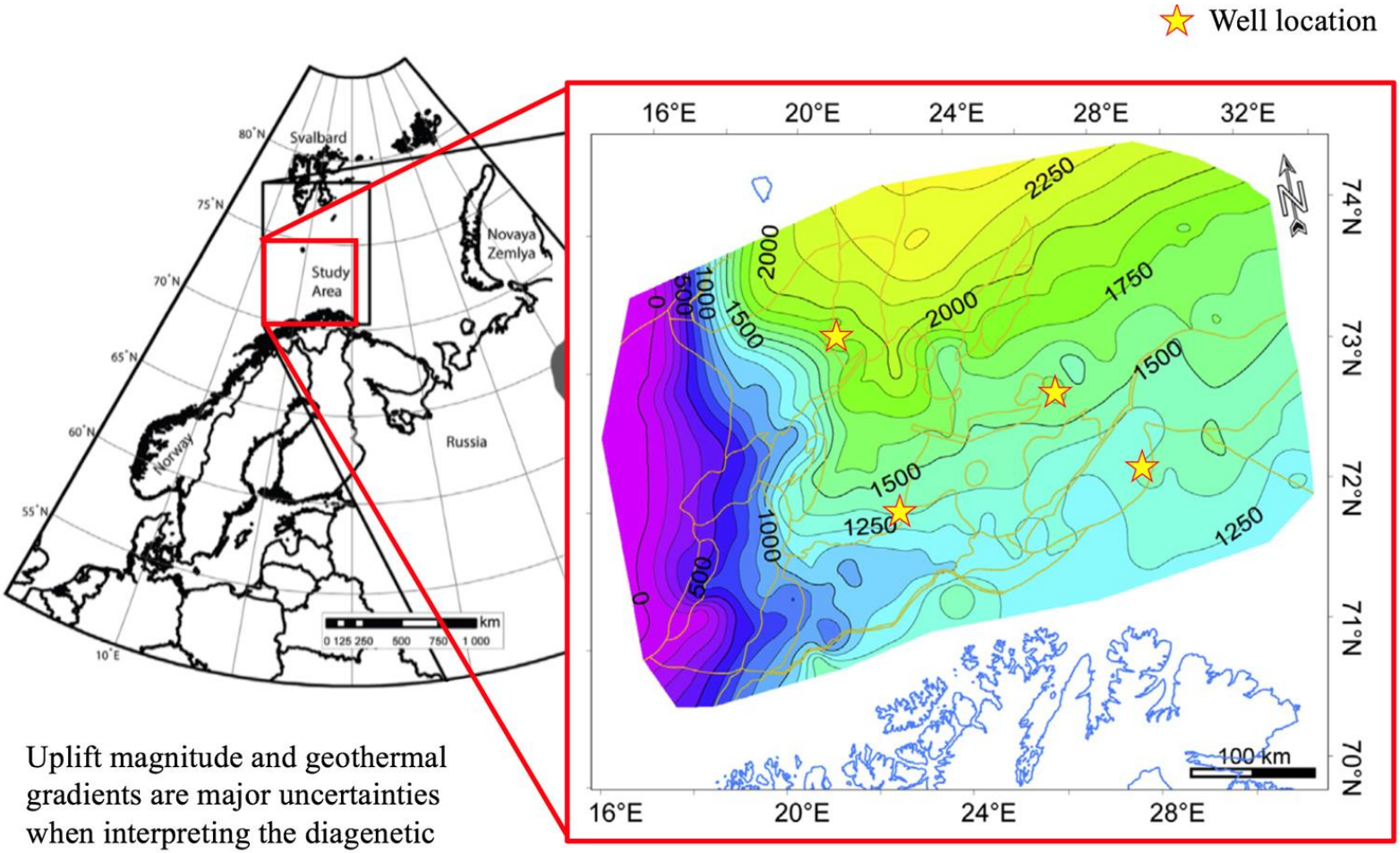
Uplift and erosion



Uplift magnitude and geothermal gradients are major uncertainties when interpreting the diagenetic evolution of sediments in the Barents Sea.

Arithmetic average net exhumation map of the southwestern Barents Shelf based on shot gathers, Sonic logs and vitrinite reflectance data, after Baig et al. (2016).

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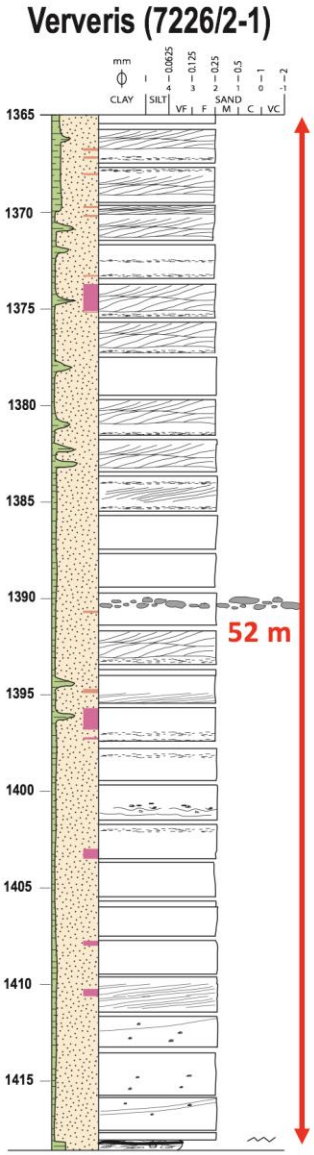
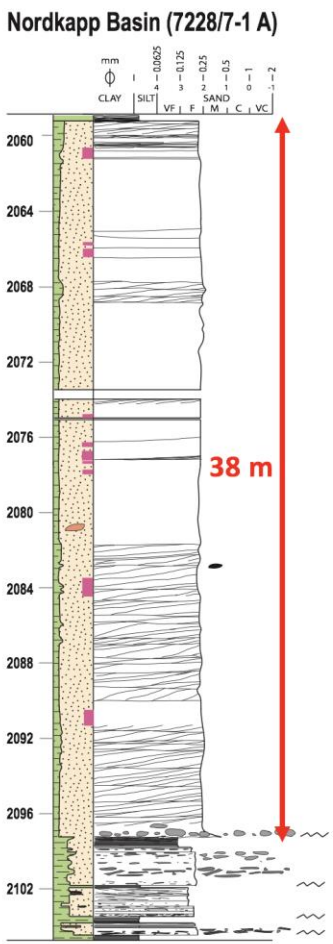
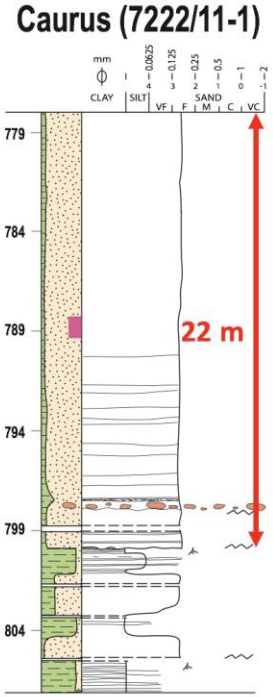
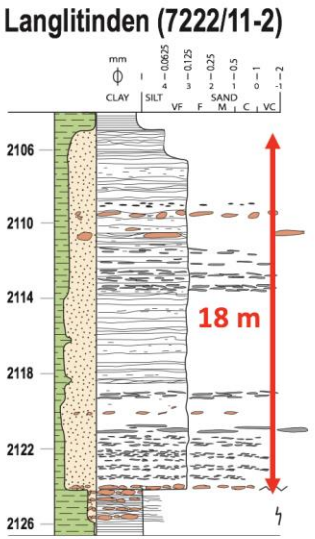
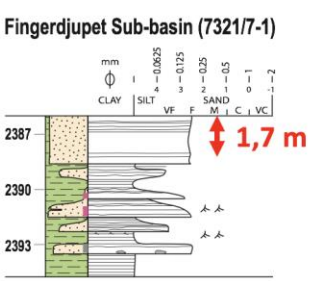
Database: Triassic channels SW Barents Sea



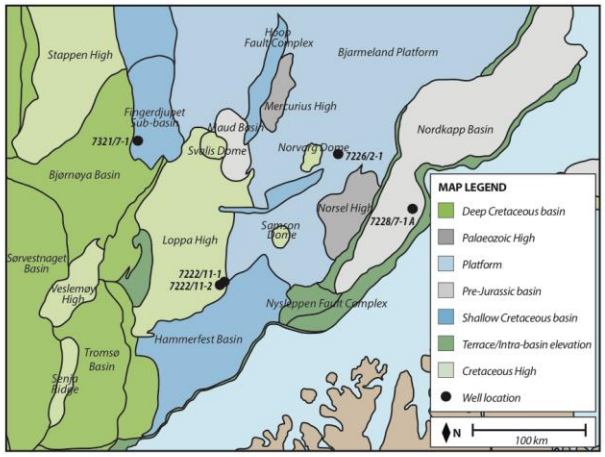








57 samples
- Bulk XRD analysis
- Modal analysis
- SEM analysis
- Core plug data



LOG LEGEND

Clasts and fragments
- Shell fragments
- Coal fragments
- Rounded clasts
- Mudrock clasts
- Siderite concretions/clasts
- Plant fragment

Sedimentary structures
- Crossbedding
- Stringers of coal fragments
- Mud drapes
- Bioturbation
- Erosional surface

Cements
- Calcite cement
- Quartz cement
- Siderite cement

Lithology
- Shale/mudstone
- Sandstone

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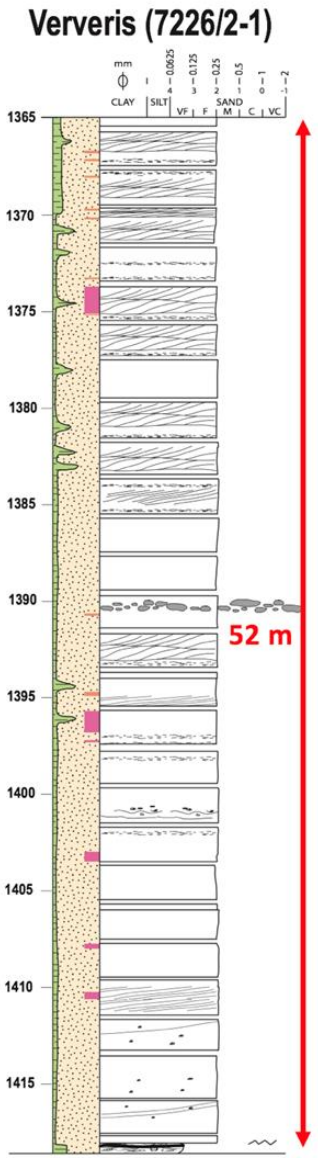
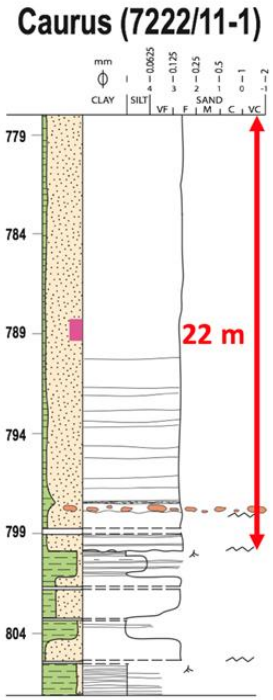
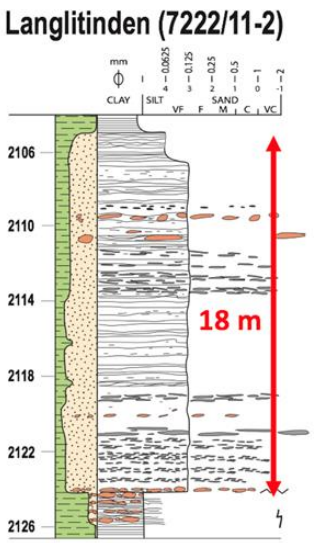
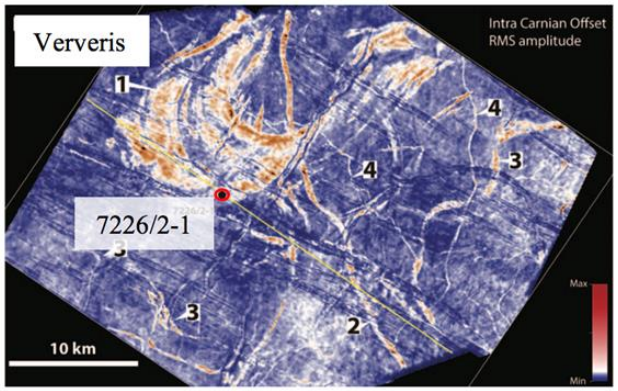
Database: Triassic channels SW Barents Sea

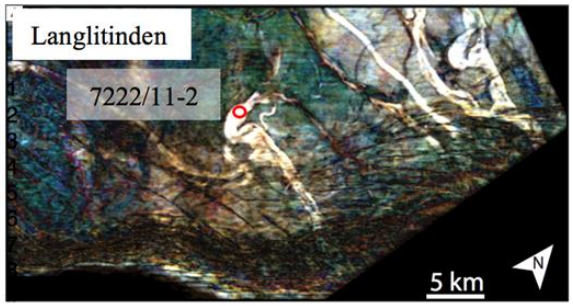




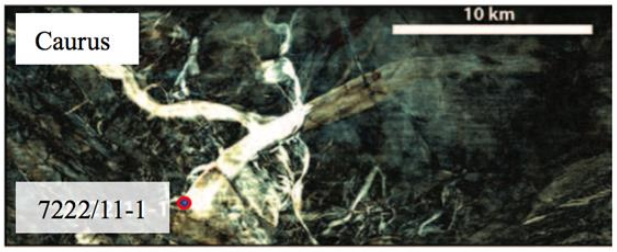




RMS attribute map from below the intra Carnian flooding surface, Ververis survey (after Klausen et al., 2014).



Seismic attribute map of the Anisian channel belt cored in the Langlitinden well (after Klausen et al., 2016)



RGB-blended spectral-decomposition volume of the Caurus survey (after Klausen et al., 2014).

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Petrographic results

Mineralogical composition

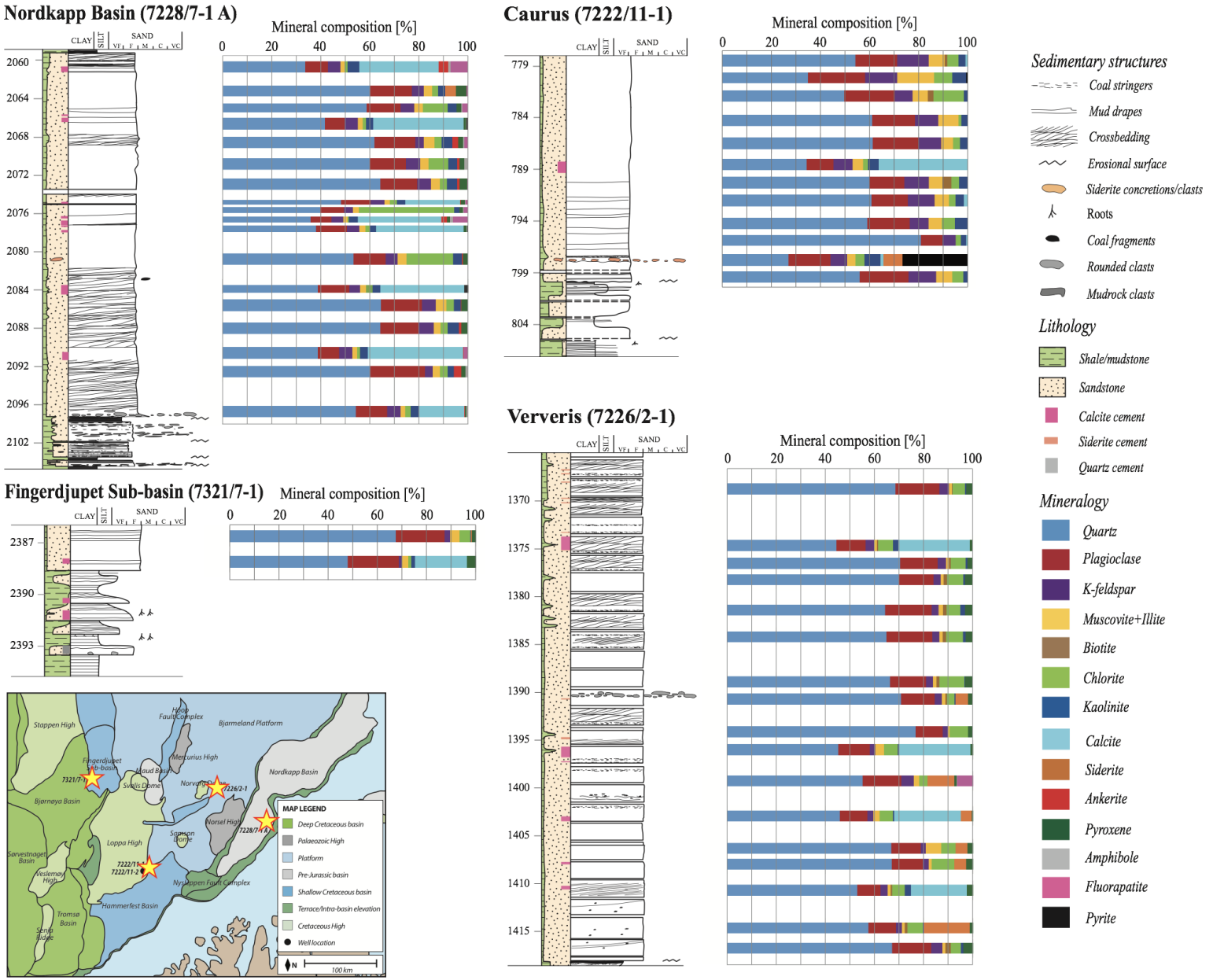
Petrography and texture of framework grains

Intergranular volume

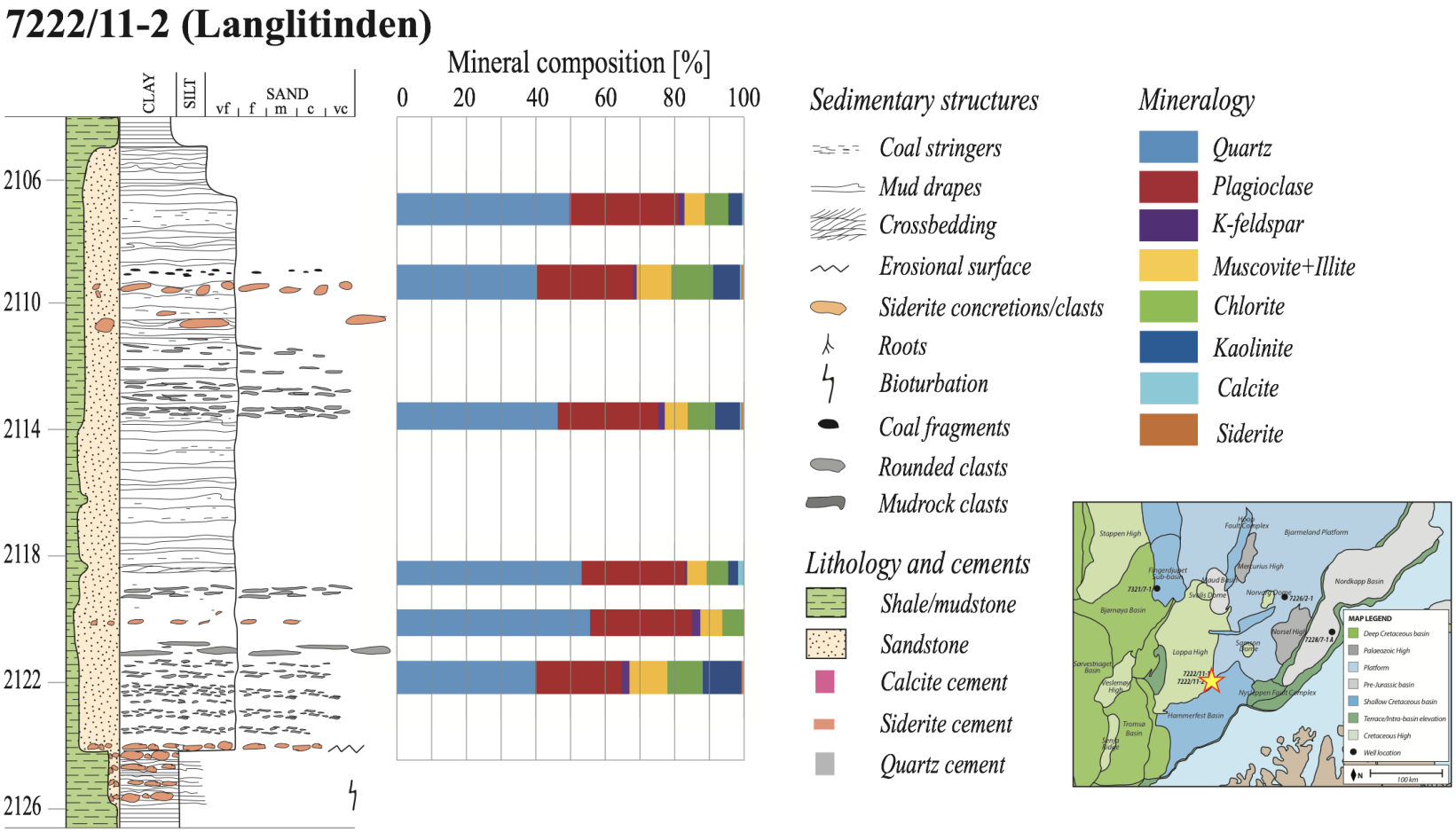
Chlorite coating characteristics

Reservoir quality

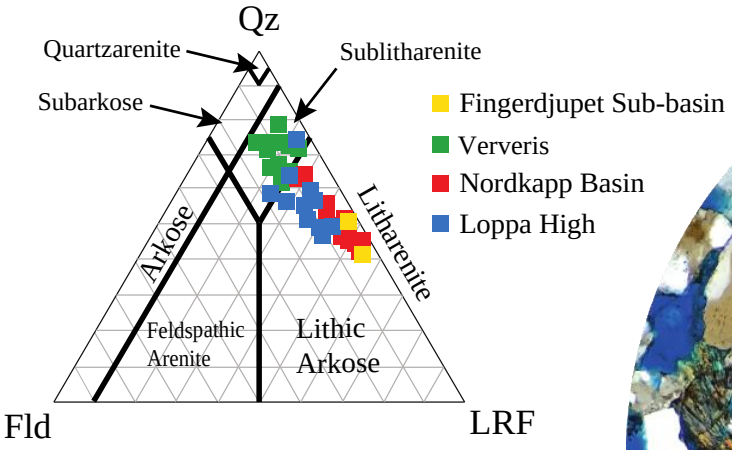
Mineralogical composition – Snadd Formation

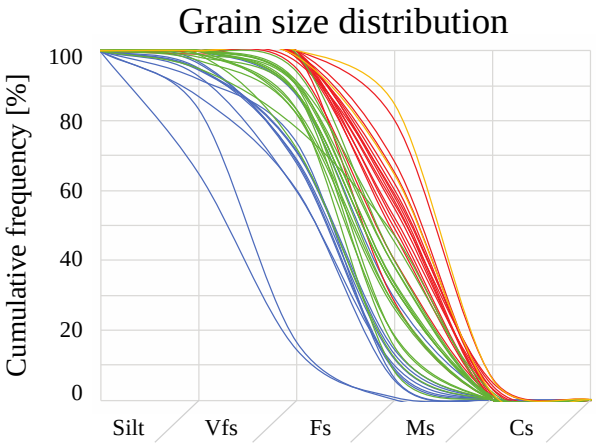


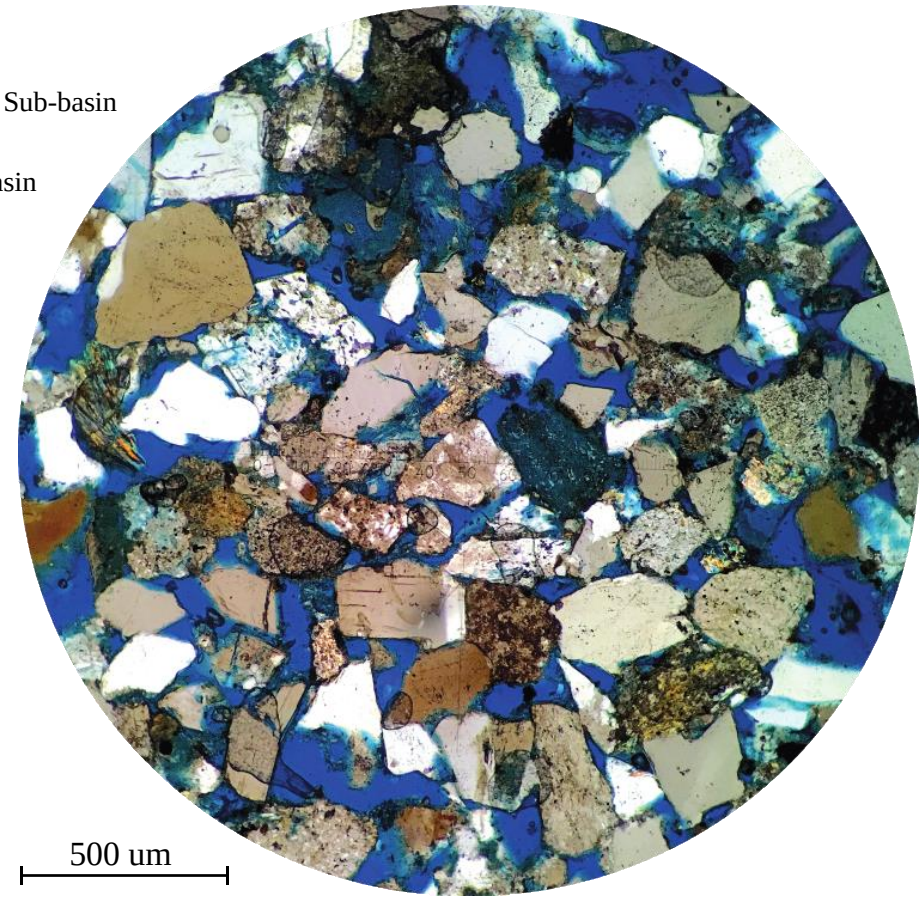
Mineralogical composition – Kobbe Formation



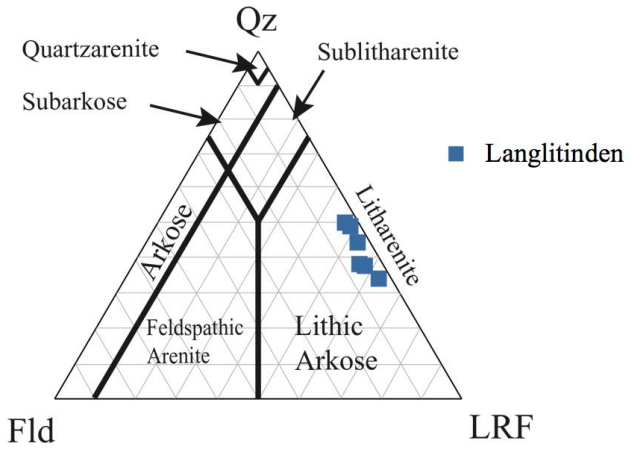
Petrography of framework grains

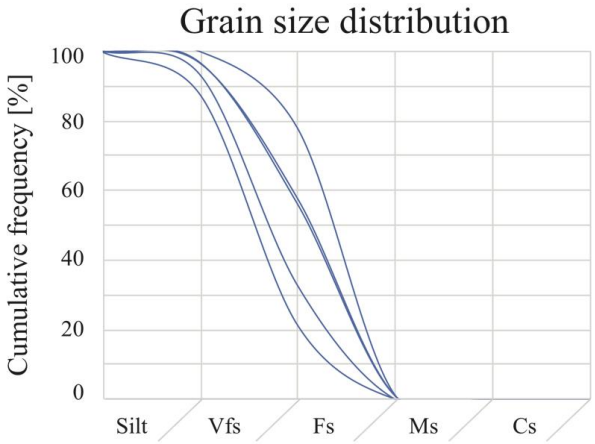


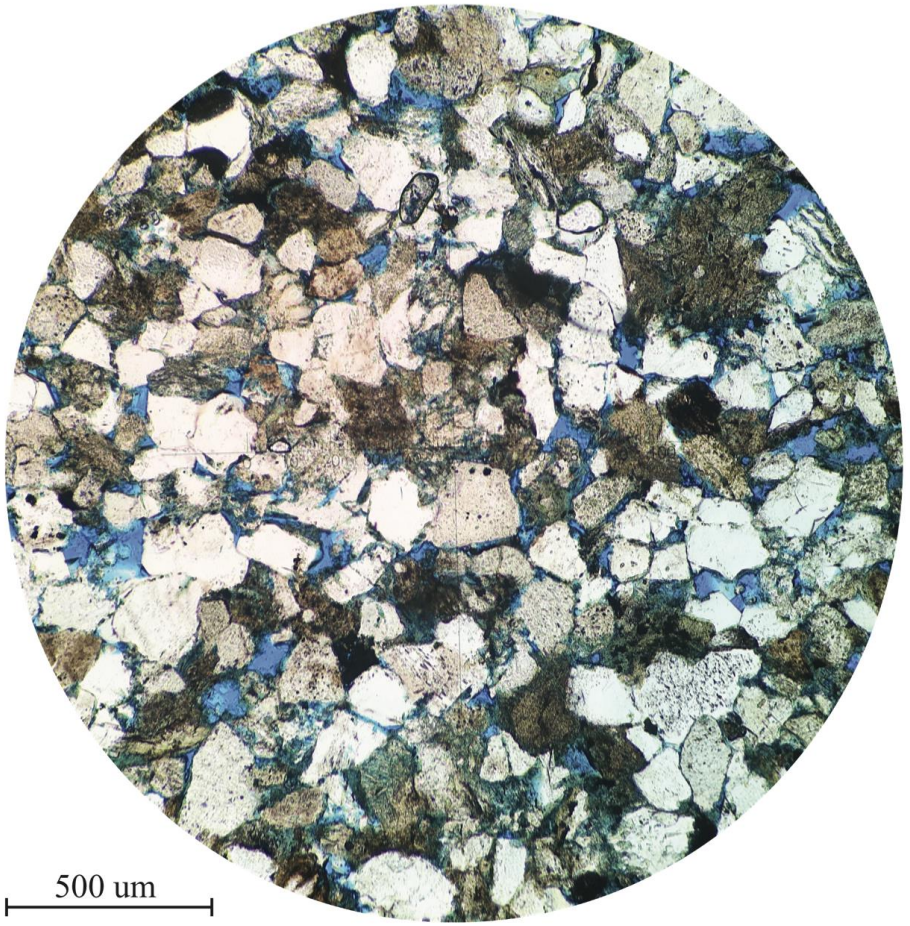




Petrography of framework grains







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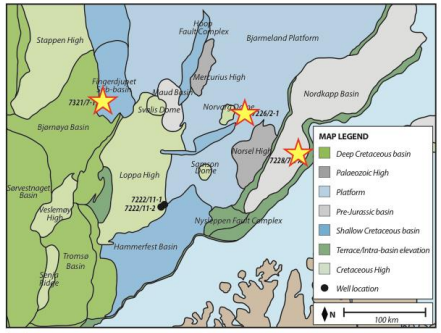
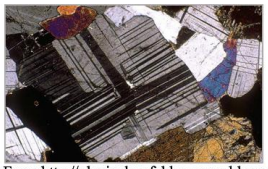
Preservation of detrital feldspar grains – Snadd Formation

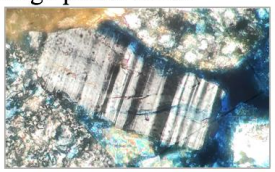


Unweathered

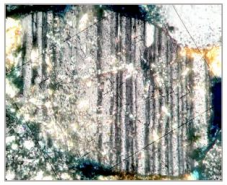


From http://plagioclasefeldspar.weebly.com/

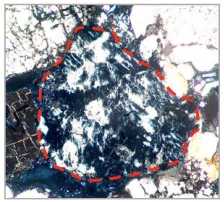
High preservation



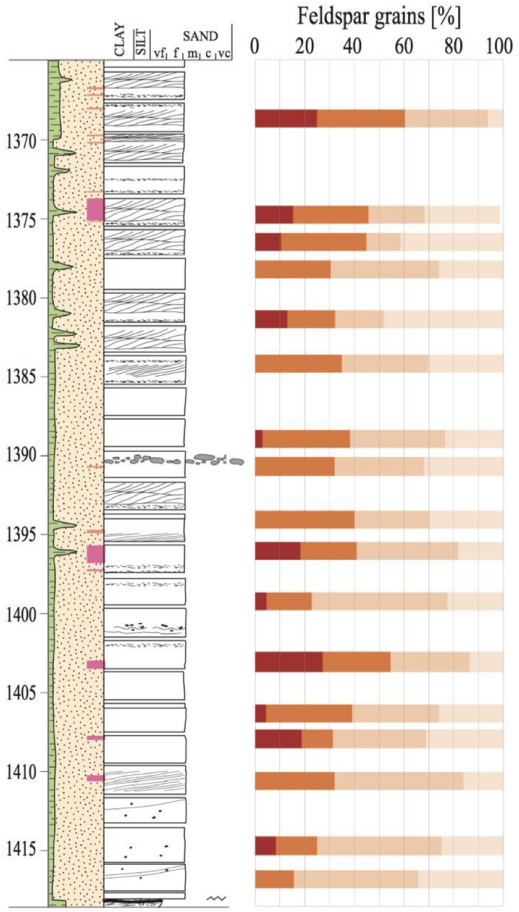
Intermed. preservation



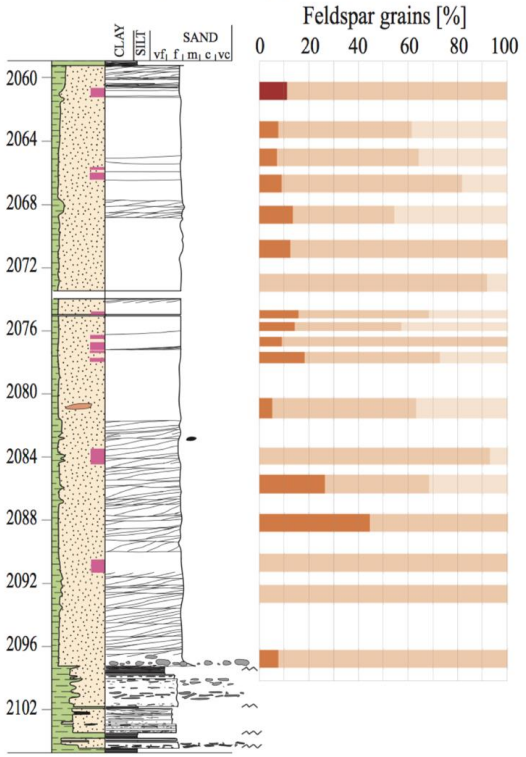
Poor/dissolved



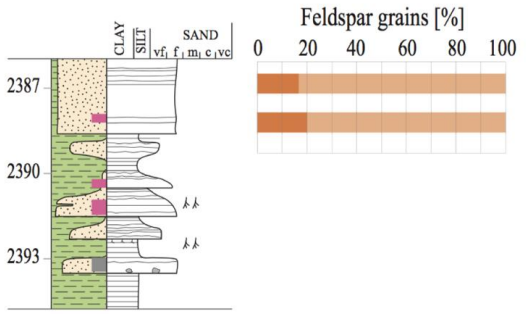
7226/2-1 (Ververis)



7228/7-1 A (Nordkapp Basin)



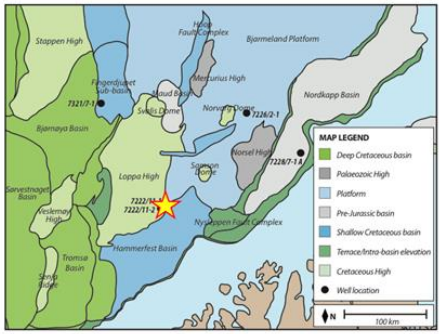
7321/7-1 (Fingerdjupet Sub-Basin)



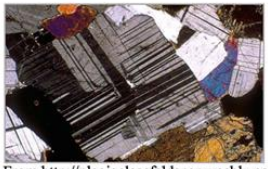
Feldspar dissolution degree

- *Unweathered (fresh grain)*
- *High preservation*
- *Intermediate preservation*
- *Poor preservation/dissolved*

Preservation of detrital feldspar grains – Kobbe Formation

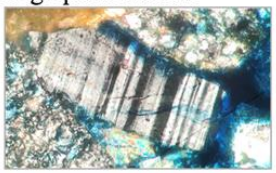


Unweathered

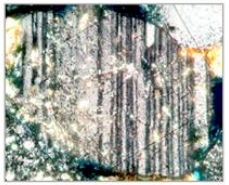


From http://plagioclasefeldspar.weebly.com/

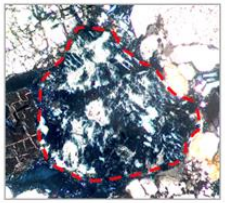
High preservation



Intermed. preservation



Poor/dissolved



Feldspar dissolution degree

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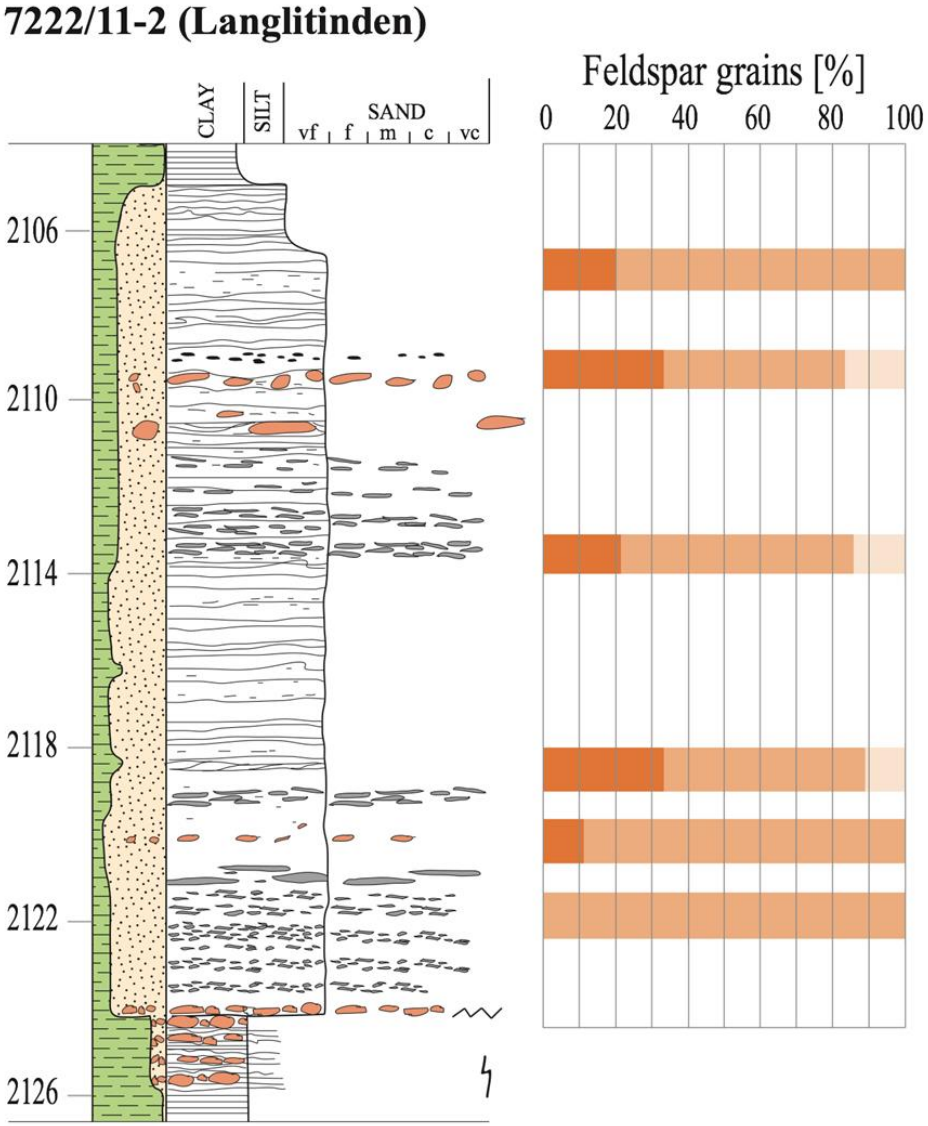

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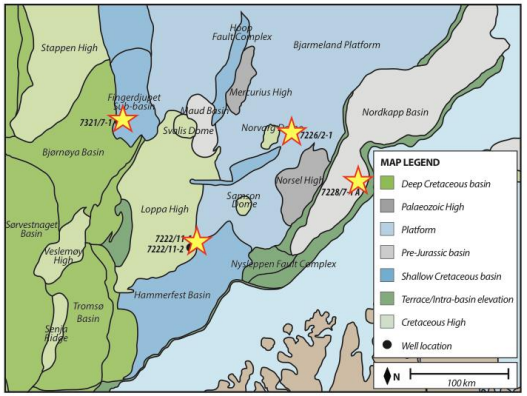
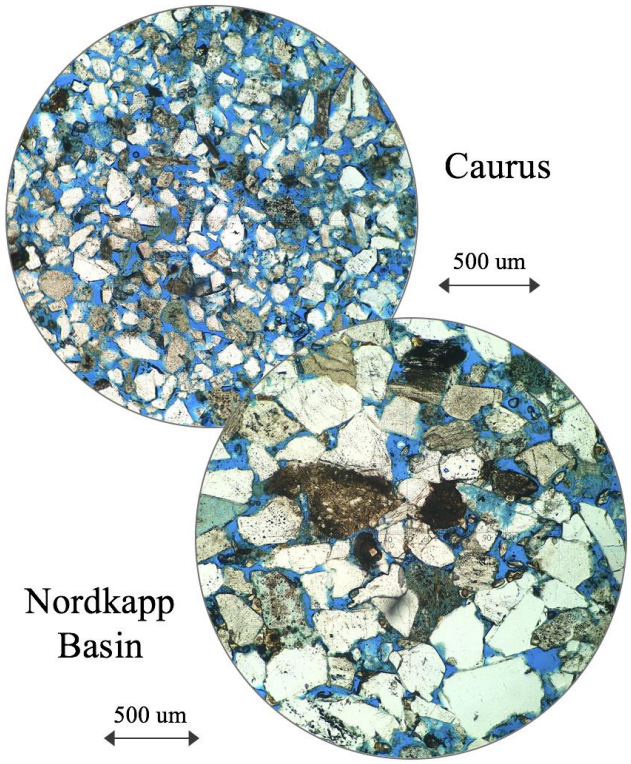
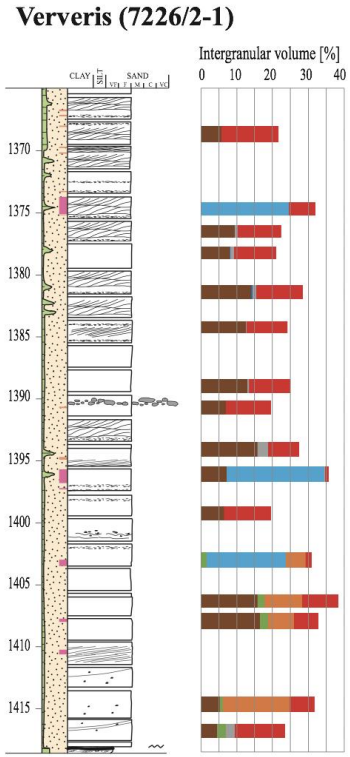
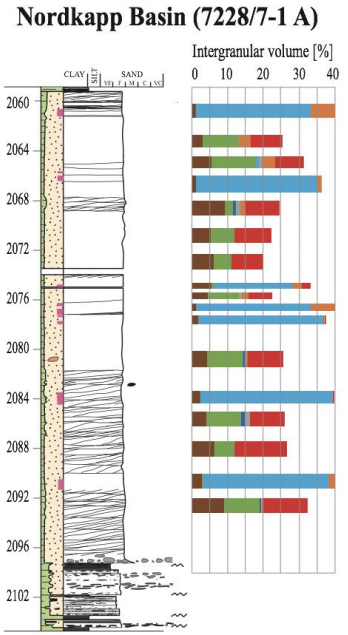
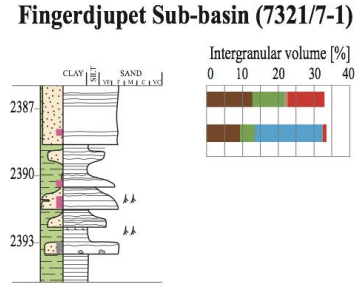
Intergranular volume – Snadd Formation

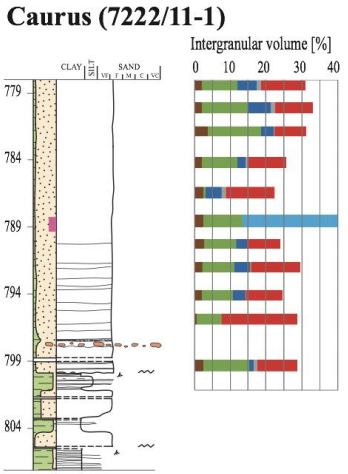


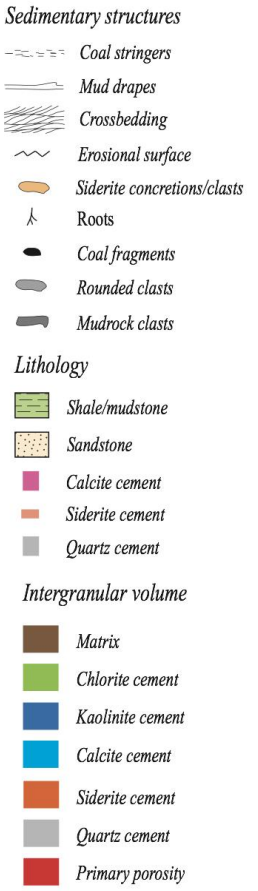




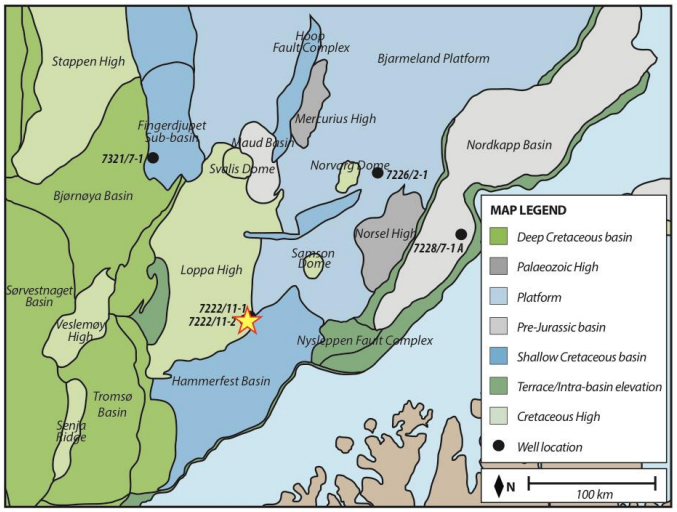


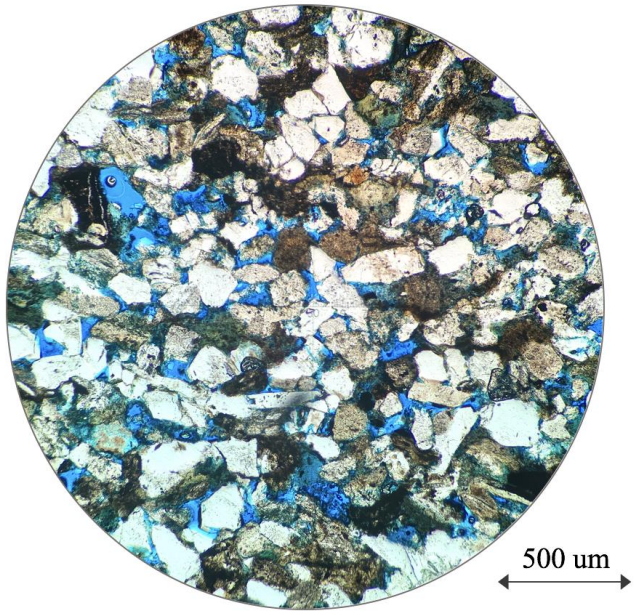


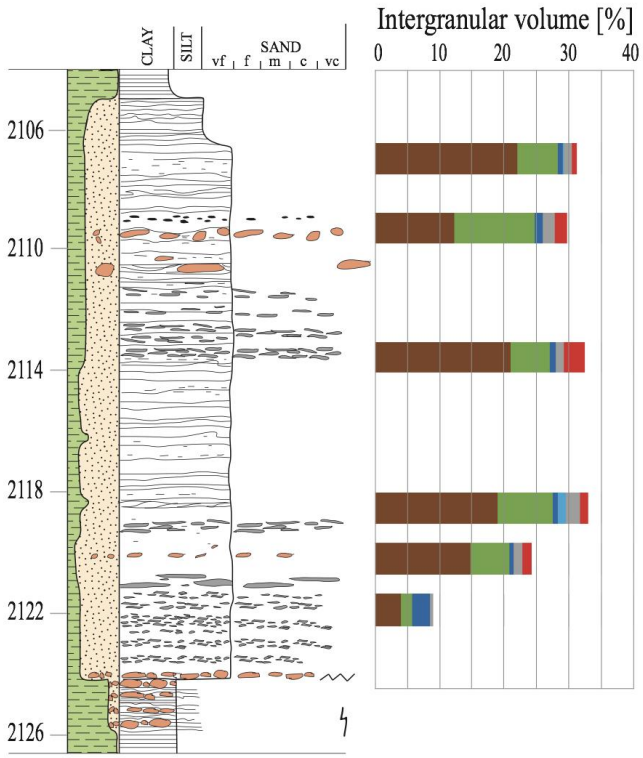




Intergranular volume – Kobbe Formation







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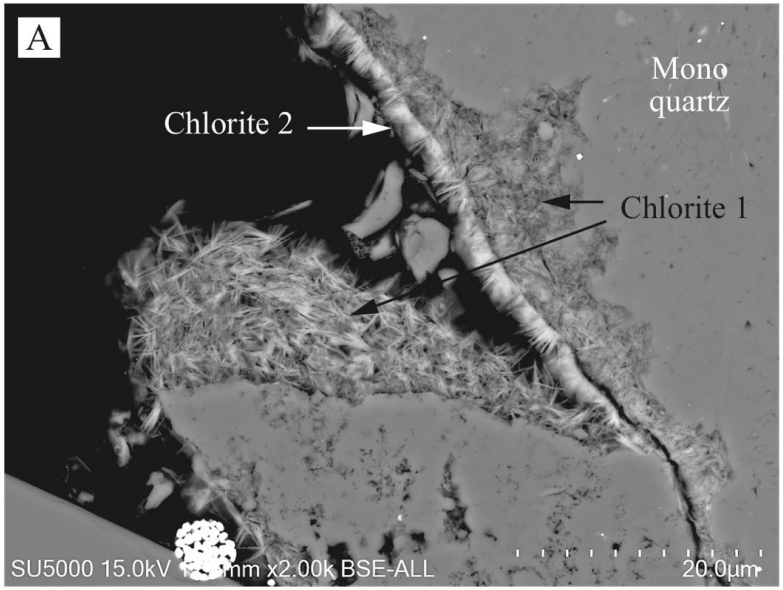
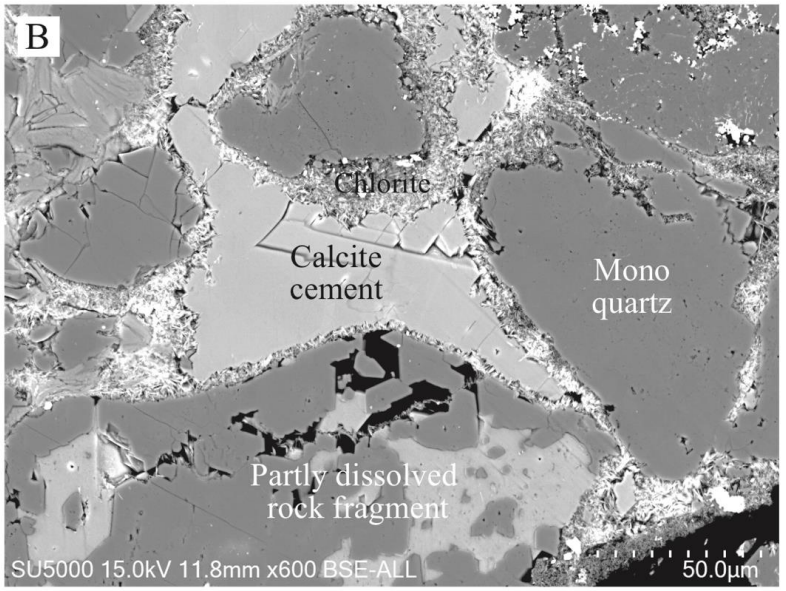
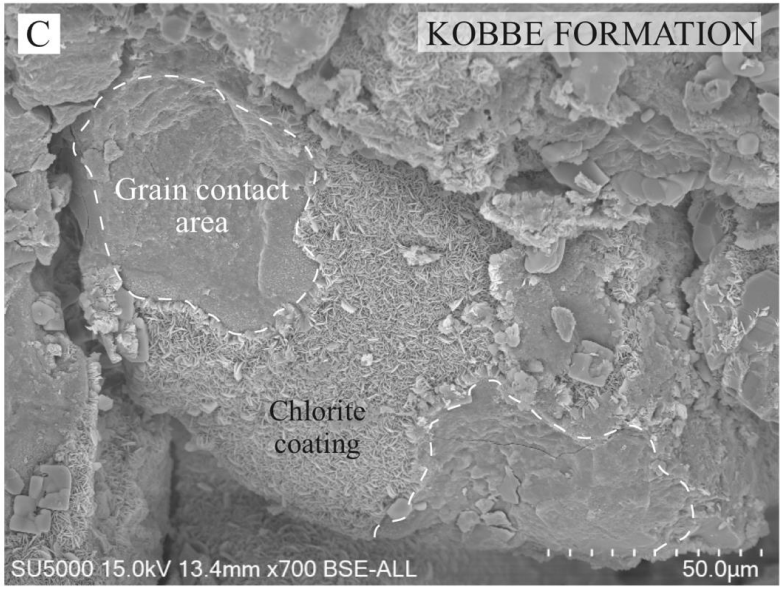
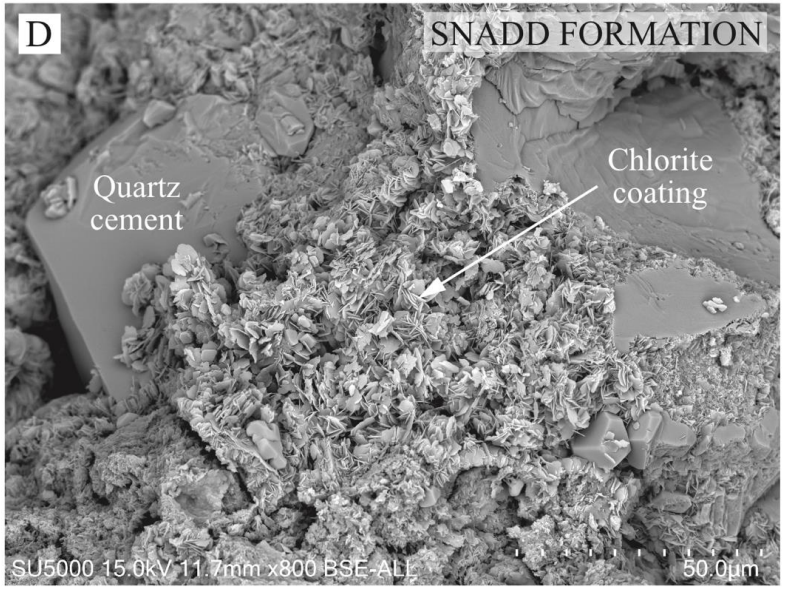
Chlorite coating characteristics









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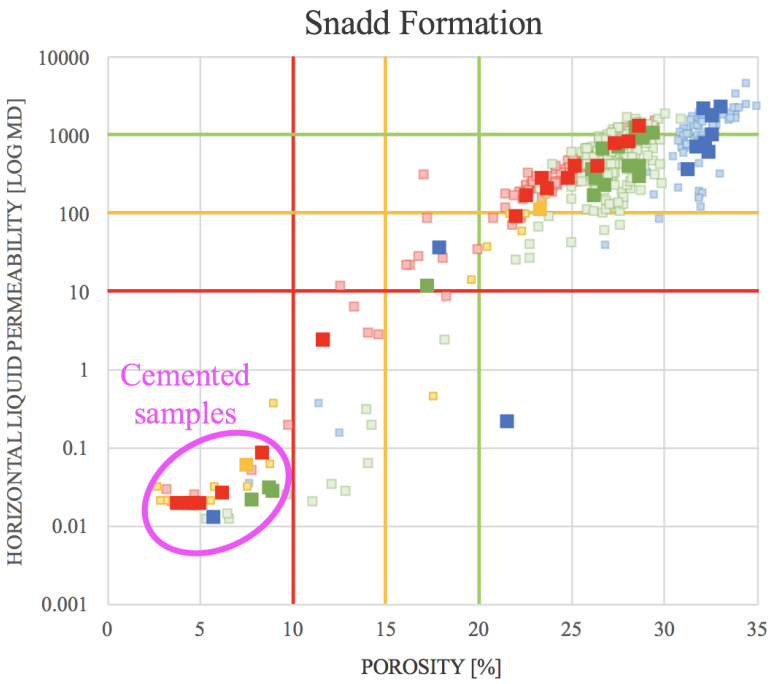
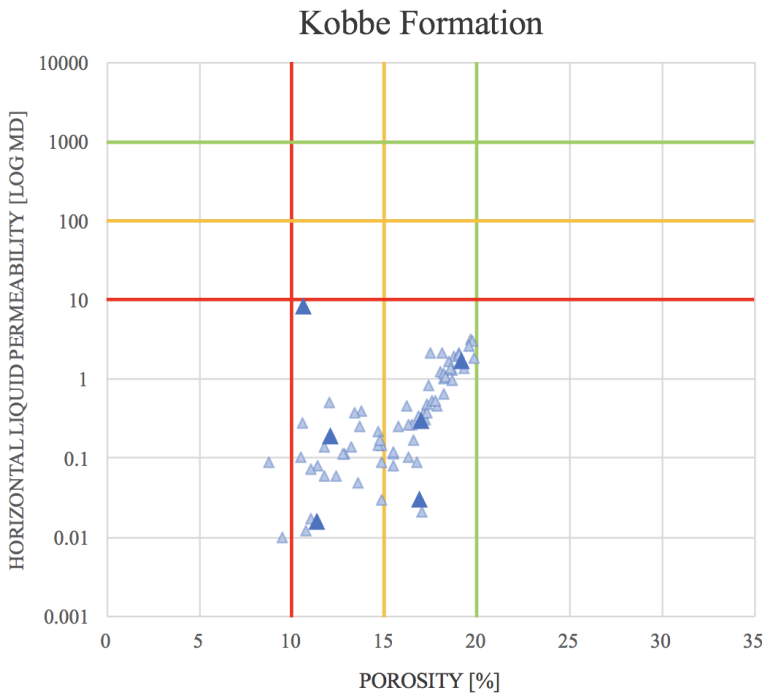
Reservoir quality – Core plug data

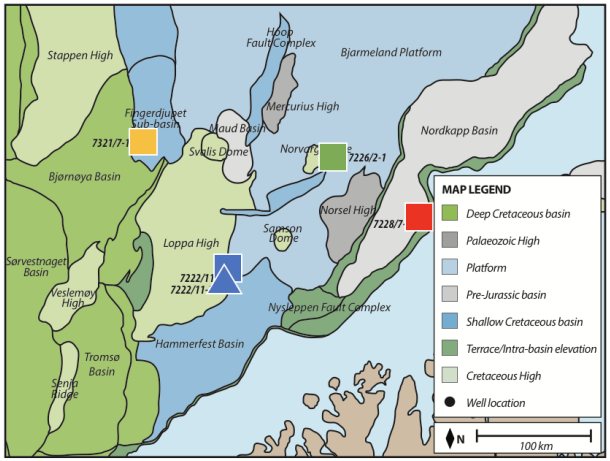




Cut-off fair RQ
Cut-off good RQ
Cut-off very good RQ

Caurus
Ververis
Nordkapp Basin
Fingerdjupet Sub-basin
Langlitinden

Data points comparable to petrographic results



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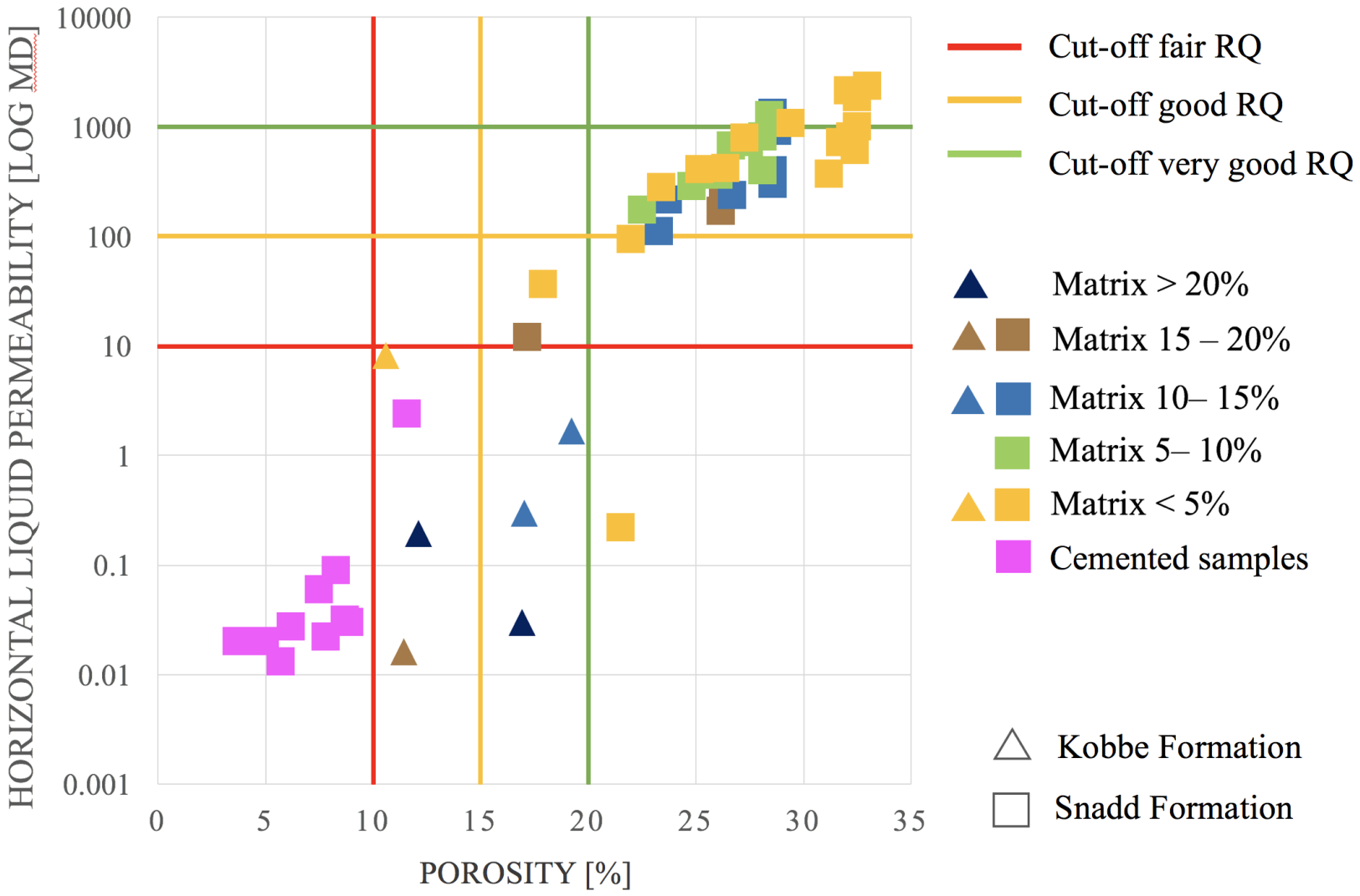
Reservoir quality versus matrix content



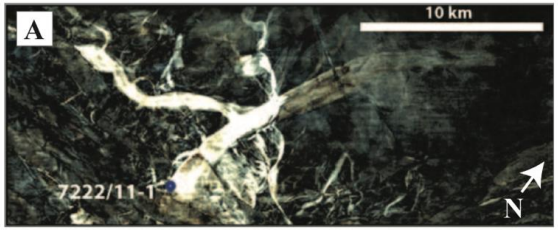
Discussion

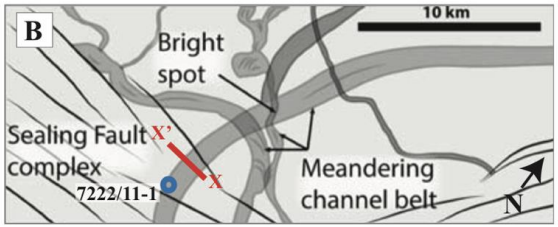
0 – 100 m: Early diagenetic processes

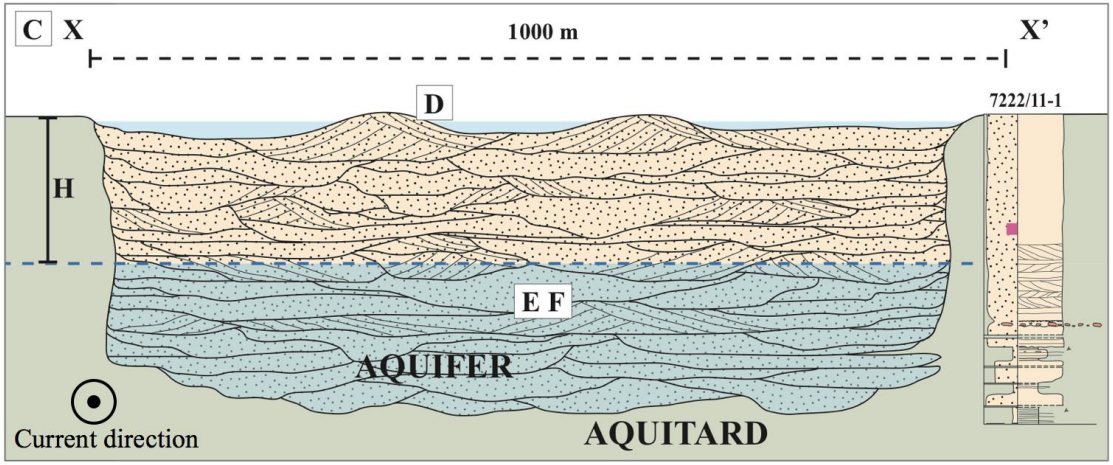
0 – 2000 m: Mechanical compaction

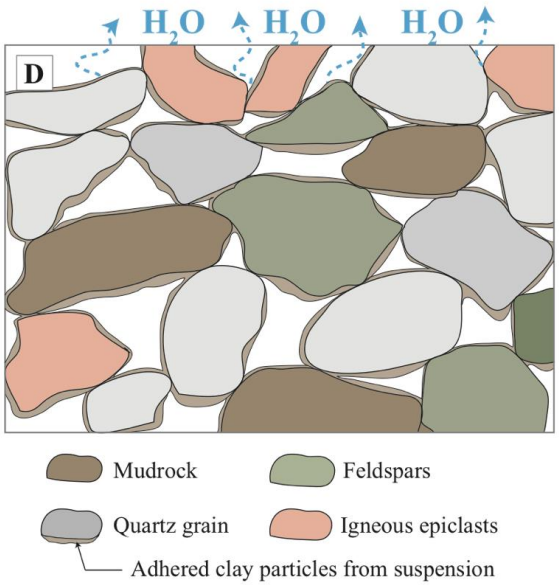
> 2000 m: Burial diagenesis

Early diagenetic processes

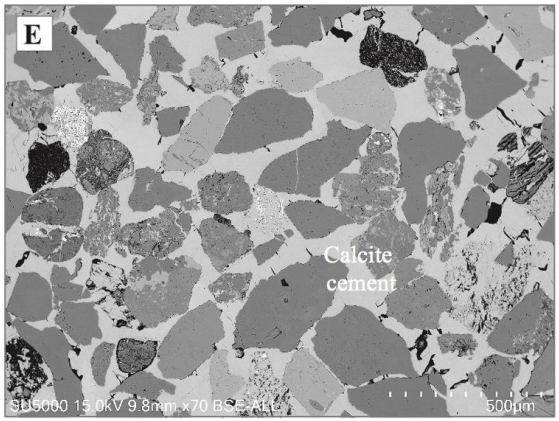


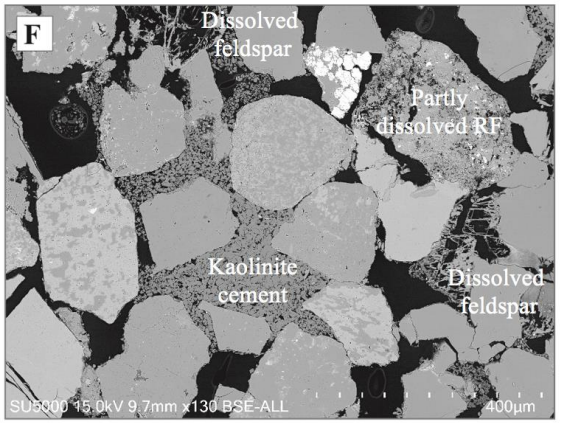






Mudflat shales (aquitard)
Meteoric water table
H Depth to meteoric water table (vadose zone)
Channelized sandstone
Channelized sandstone submerged in meteoric water (aquifer)





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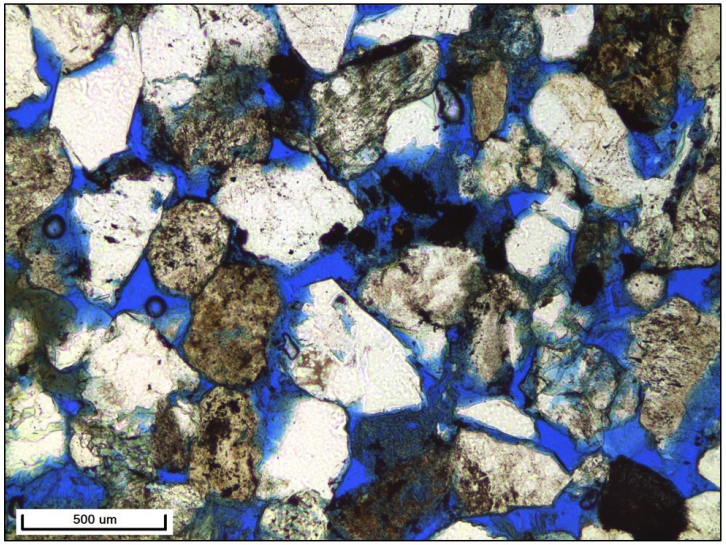
Mechanical compaction



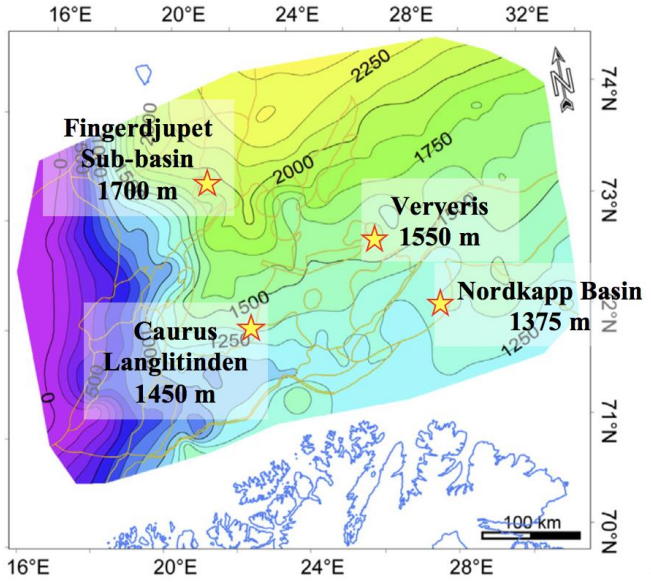
Long grain contacts are most common due to high concentrations of lithic rock fragments (LRF).

Average*	IGV	Qz cement	LRF	Matrix
Nordkapp Basin	25.8%	0.48%	42.1%	6.3%
Ververis	30.9%	0.70%	18.0%	10%
Caurus	28%	0.57%	32.5%	2.4%
Langlitinden	26.6%	0.00%	53.5%	15.5%
Fingerdjupet Sub-basin	33%	0.50%	45.9%	12.8%

* Calcite cemented samples excluded from average

Well	Maximal burial depth of core interval [m TVD]	Calculated temperature at maximal burial [°C]**
Nordkapp Basin	3434 - 3479	115
Ververis	2915 - 2967	100
Caurus	2228 - 2250	72
Langlitinden	3556 - 3574	117
Fingerdjupet Sub-basin	4086 - 4088	157

** Calculated based on present-day bottom hole temperature



Arithmetic average net exhumation map after Baig et al. (2016).

0 – 2000 METER BURIAL

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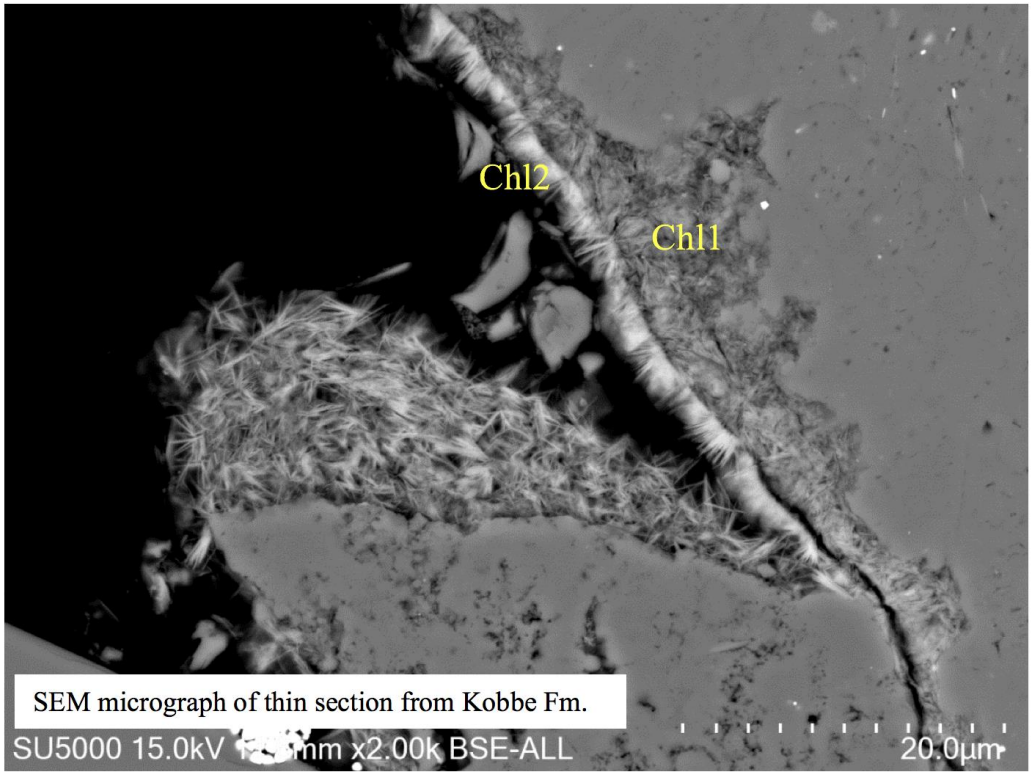
Burial diagenesis



INTERMEDIATE BURIAL (2 – 3.5 KM)
50 - 120°C

Recrystallization of precursor clay coating (Chl1) < 70°C.

Formation of totally recrystallized authigenic chlorite coating (Chl2) between 80 - 100°C.

DEEP BURIAL (<3.5 KM)
>120°C

Illitization of kaolinite and K-feldspar at temperatures >130°C.

> 2000 METER BURIAL

Requirements for quartz cementation
1. Threshold temperature (70 - 80°C).
2. Pore water supersaturated in silica.
3. Available surface area.

No grain fracturing and little nucleation surface available for quartz overgrowth due to chlorite coating

→ Mechanical compaction is the main porosity-reducing process in the Triassic channels sourced from the Urals.

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Conclusion

What controls reservoir quality in Triassic channel belts sourced from the Uralides?

- The reservoir quality in the Kobbe Formation channel belt is poor due to high concentrations of clay matrix that significantly reduce permeability. Strong tidal influence in a mud-rich delta facilitated high matrix concentrations in the channel. Kobbe Formation channels north of the Hammerfest Basin are considered high risk targets for future exploration.
- The reservoir quality in the Snadd Formation channel belts in this study is good to very good. Internal differences is likely related to early diagenetic alterations, controlled by the capacity of meteoric water. Large-scale (1– 10 km) Snadd Formation channel belts are considered good reservoir targets for future exploration.
- Porosity-preserving chlorite coatings are expected to occur in most large-scale channel belts sourced from the Uralides.
  - Compaction in deeply buried (>2 km) channels is likely stress-dependent.
  - Porosity preservation is controlled by mineralogical and textural properties.
- Updated petrographic database for Triassic channels in the southwestern Barents Sea. Results might be used as input in geologic models.

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