FORCE Regional Conference: Underexplored Plays

Preservation of reservoir quality at great depths Case: The Beta Statfjord Discovery

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core energy

Stavanger, Norway, April 8th, 2015

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Outline

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Sedimentology

Mineralogy & Diagenesis

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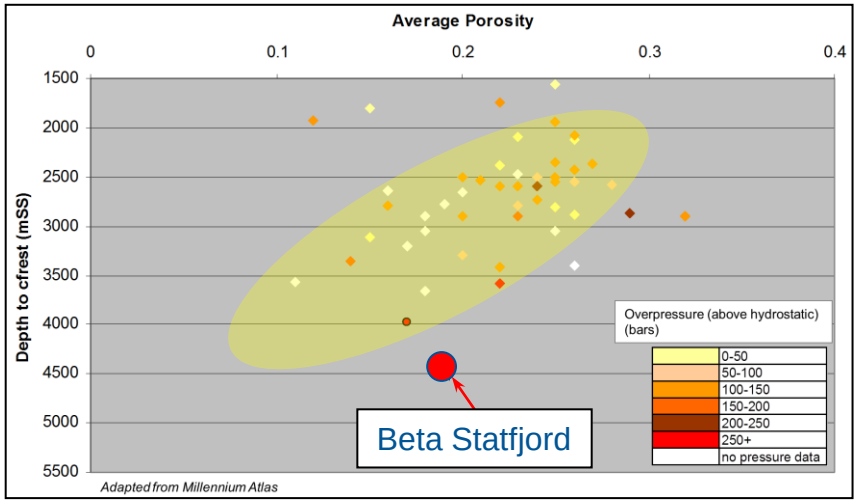
Overview

Facts and observations of the Beta Statfjord discovery:

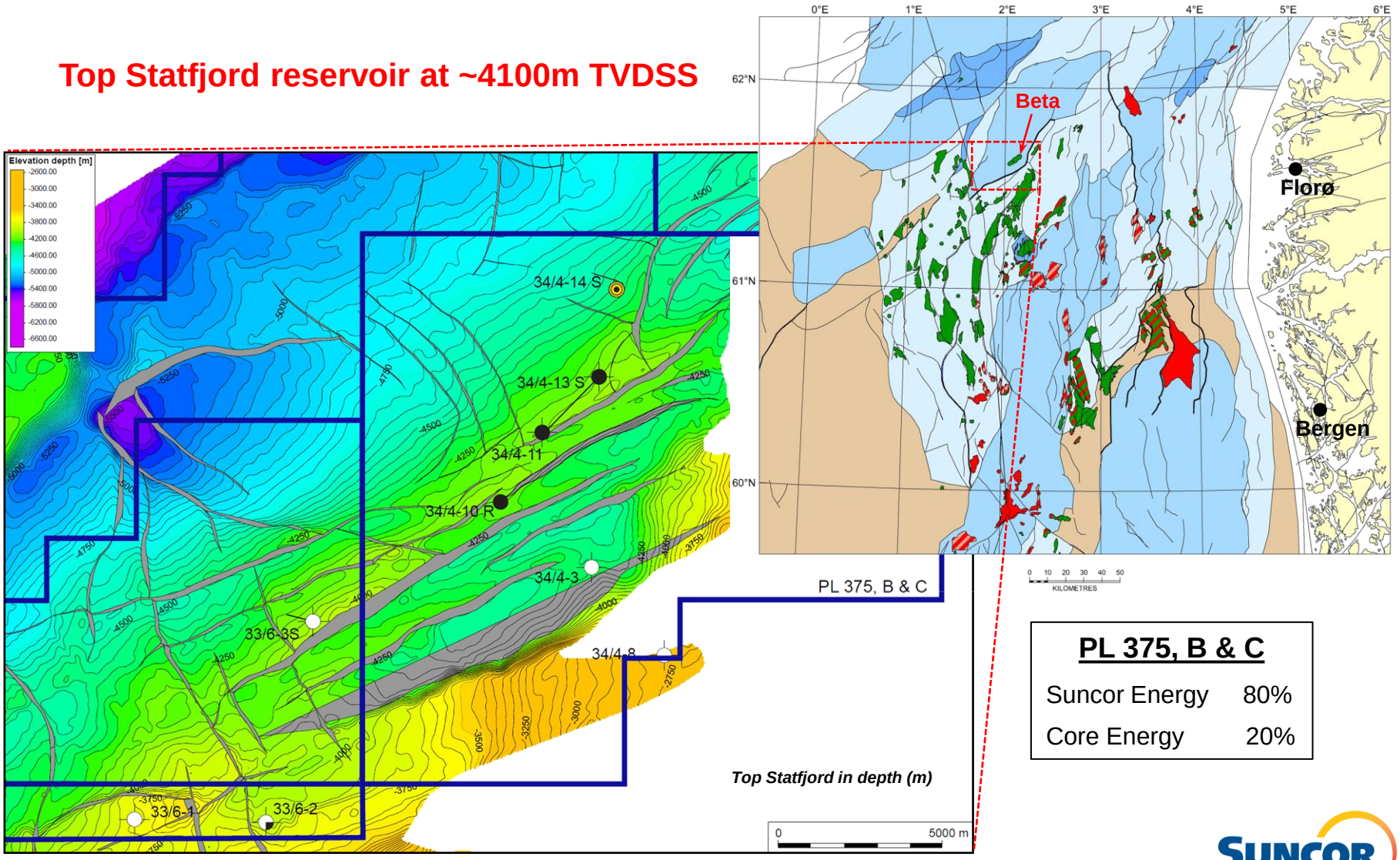
- Excellent reservoir properties @ ~4100m TVDSS.
  - Avg. Porosity range: ~19%
  - Avg. Permeability: >1 Darcy.

- Key controls on reservoir quality:
  - Grain size
  - Clay coatings
  - Lack of potassium in the system
  - Early oil emplacement
  - Overpressure



The Beta Statfjord Discovery

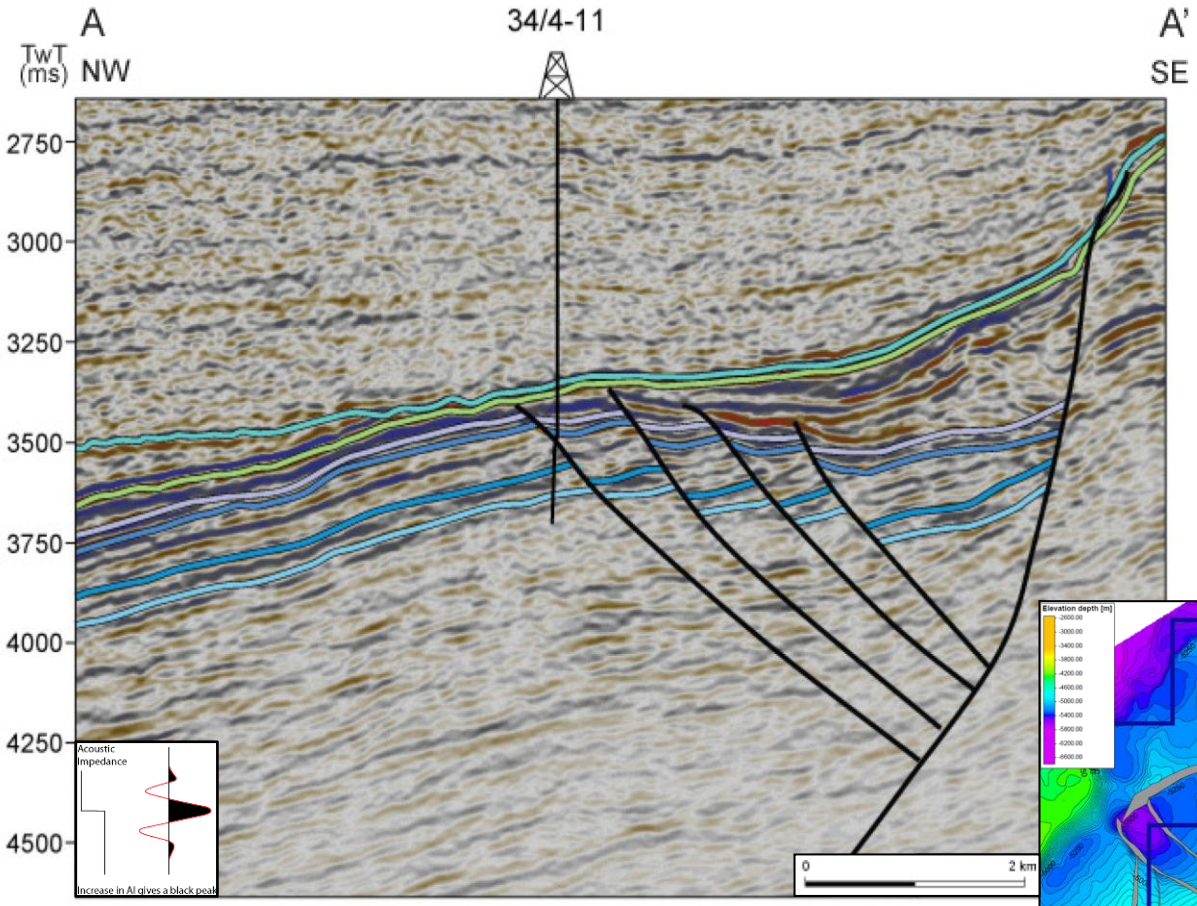
Top Statfjord reservoir at ~4100m TVDSS

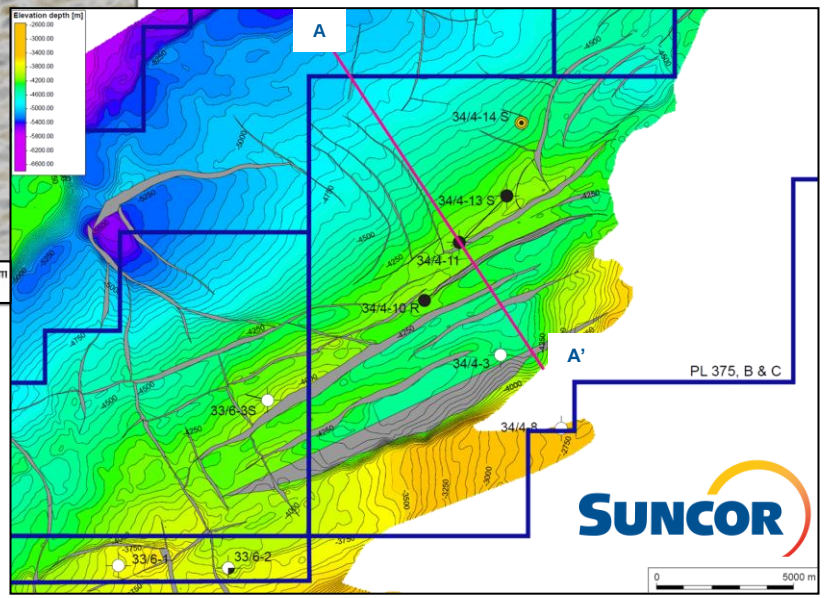


PL 375, B & C

Suncor Energy	80%
Core Energy	20%

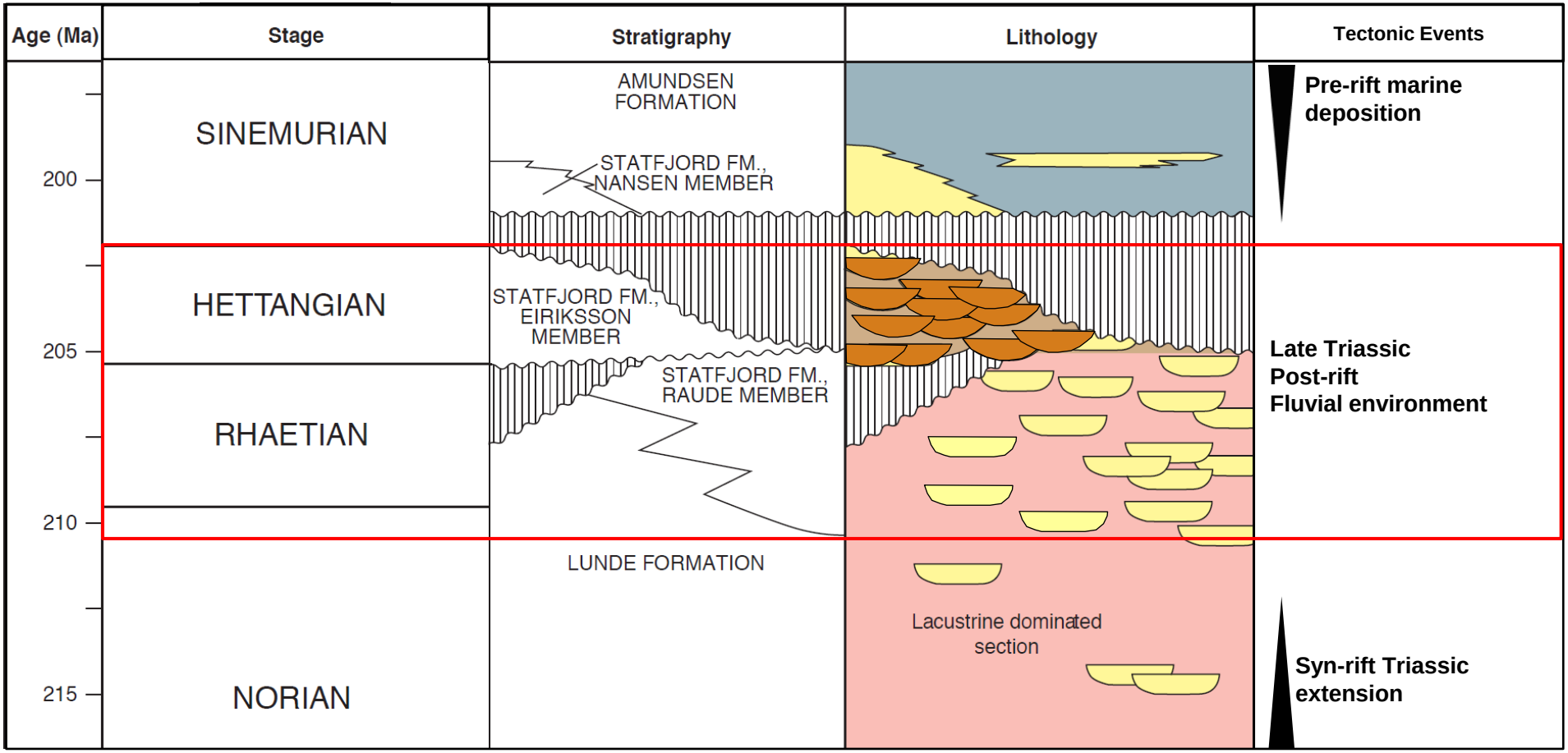
Structural Setting of the Beta Statfjord Discovery





The Beta Statfjord discovery is ~1300m down-dip of the Snorre High

Stratigraphic Setting of the Statfjord Gp



Modified from NPD, Suncor, 2013

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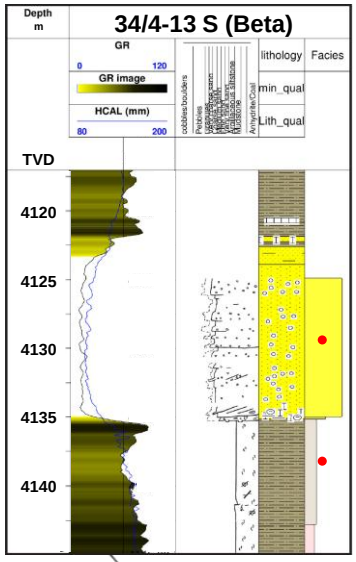
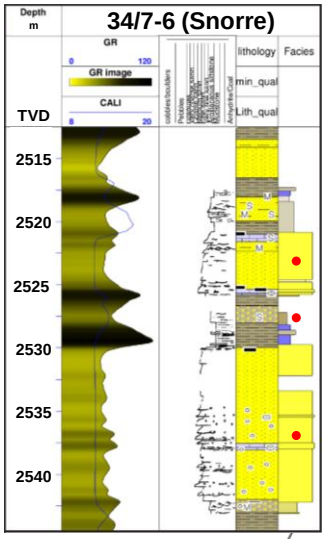
Sedimentological Setting of the Statfjord Gp



High energy
Coarse grain
Ephemeral channel ??
Thalweg ??

Dry climate soils

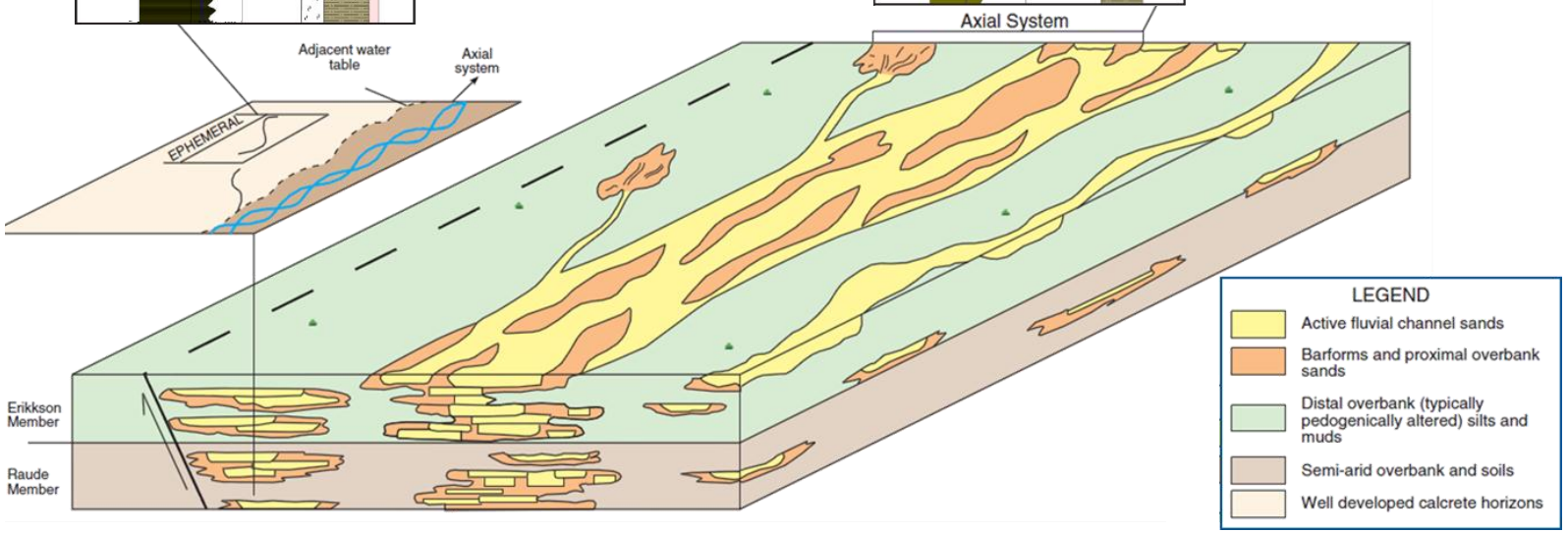


Minor carbonaceous material (indication of wet climate)

Singular channel

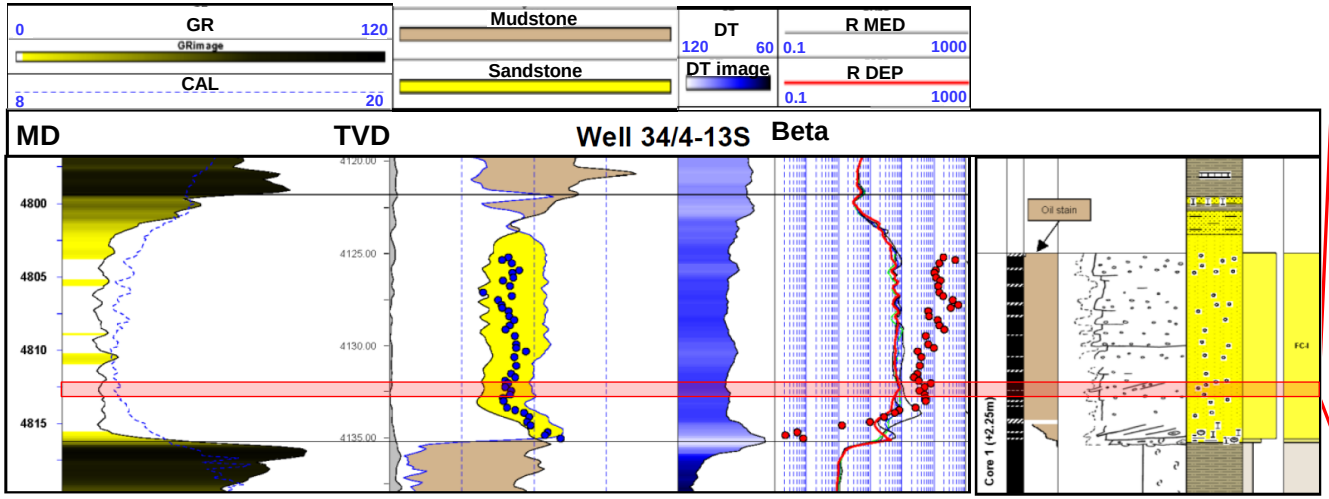
Overbank sands and silts pedogenetically altered.

Multi-storey stacked channels system
Vertically aggraded
Low sinuosity (Braided system)



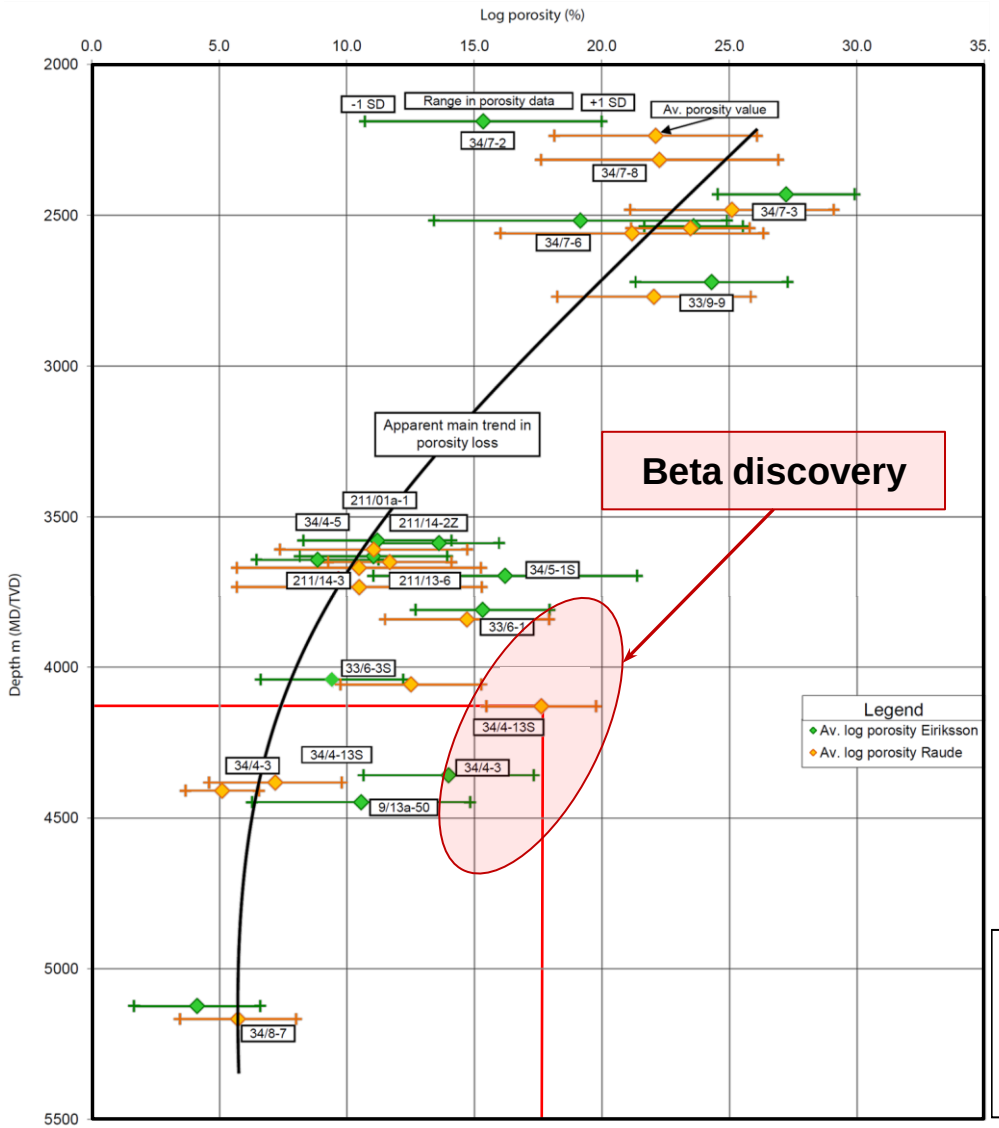
Fluvial Channel Sands

- Very coarse grained sandstone
- Planar laminated structure
- High energy
- Oil stains



Note: *Core section drilled with ~37º angle inclination*

Quality of the Fluvial Channel Sandstones



Initial reservoir quality at deposition:

- Coarse (lower) grained - >10 Darcy permeability
- Moderately well sorted - >30% porosity

Facies		Av. porosity (%)	Av. permeability (mD)
Best reservoir quality:	FC-l	23.3	1218.7
Best reservoir quality:	FC-u	19.7	195.5
Worst reservoir quality:	OB-s	14.4	41.0
Worst reservoir quality:	OB-s(p)	13.3	13.1

Note: Calculated from a larger dataset

Legend

FC-l – Lower fluvial channel sst
FC-u – Upper fluvial channel sst
OB-s – Overbank sst
OB-s(p) – Pedogenically altered overbank sst

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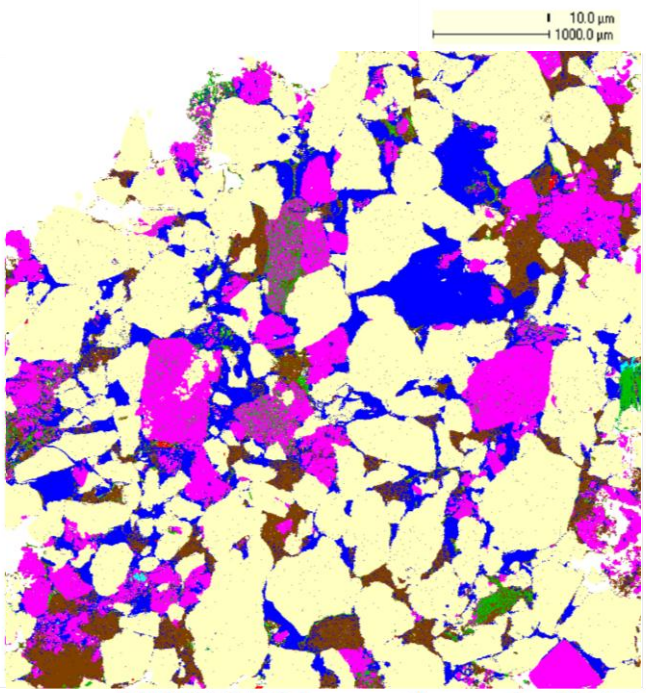
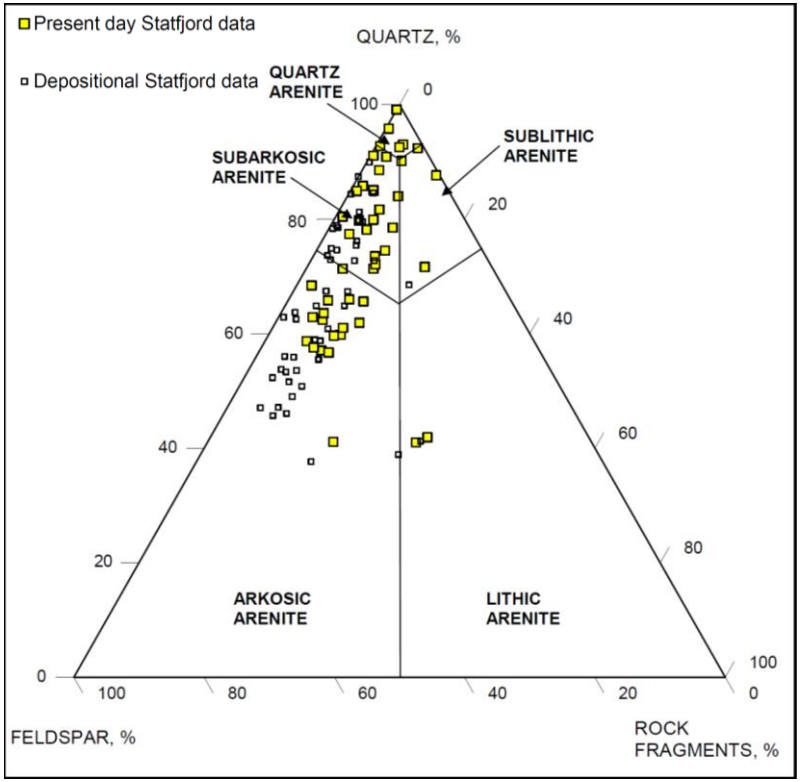
Mineral Composition



QEMSCAN image of sample 4811.6m, well 34/4-13S



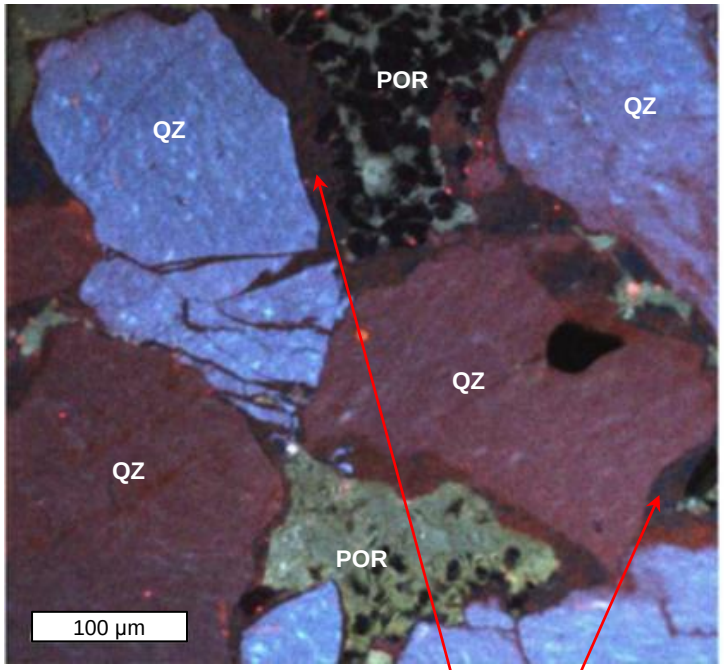
- Quartz – 50-90%
- Plagioclase feldspars – 10-40% (up to 78% of original plagioclases are preserved at depth of ~3900m TVDSS)
- Rock fragments 5-10%
- Mica
- Heavy minerals in traces:
  Garnet, staurolite, zircon, rutile, sphene and opaques

Sub-arkosic arenites from granitic or very high grade metamorphic hinterland

Mineralogy – Cements

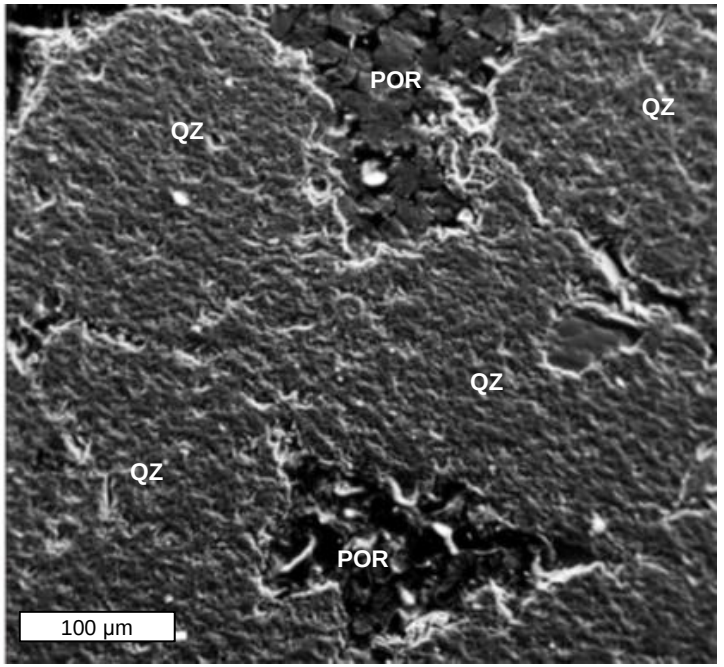
Well 34/4-5

CL



Depth: 3549.00m TVDSS
Overbank facies

Electron image



Porosity: 18.9%
Permeability: 13.0 mD

Quartz overgrowths in a water bearing interval (~2%)

Other cements include traces of calcite with lesser dolomite and siderite

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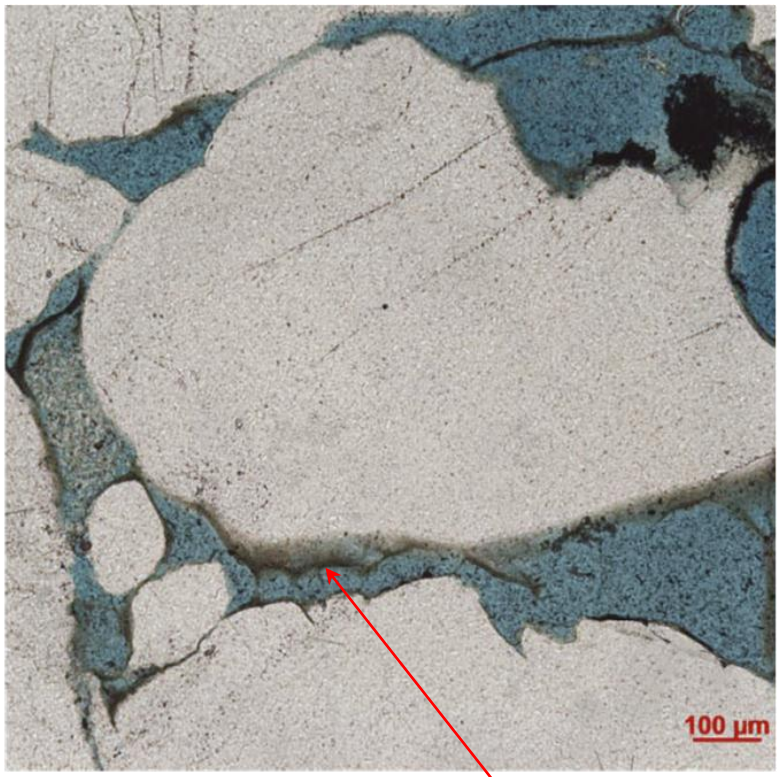
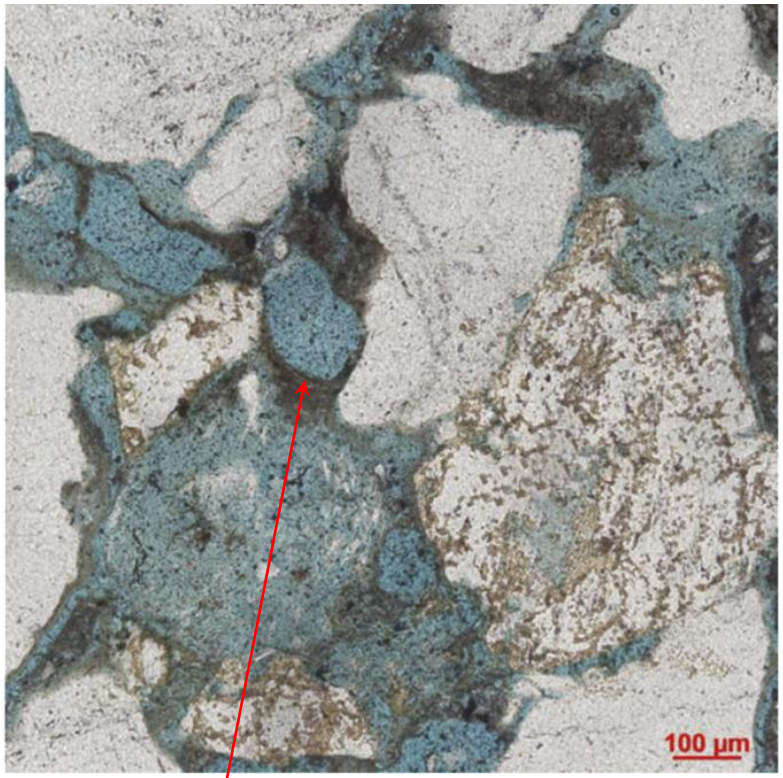
Mineralogy – Clay Minerals

Well 34/4-13 S
Depth: 4108.10m TVDSS
Fluvial Channel facies

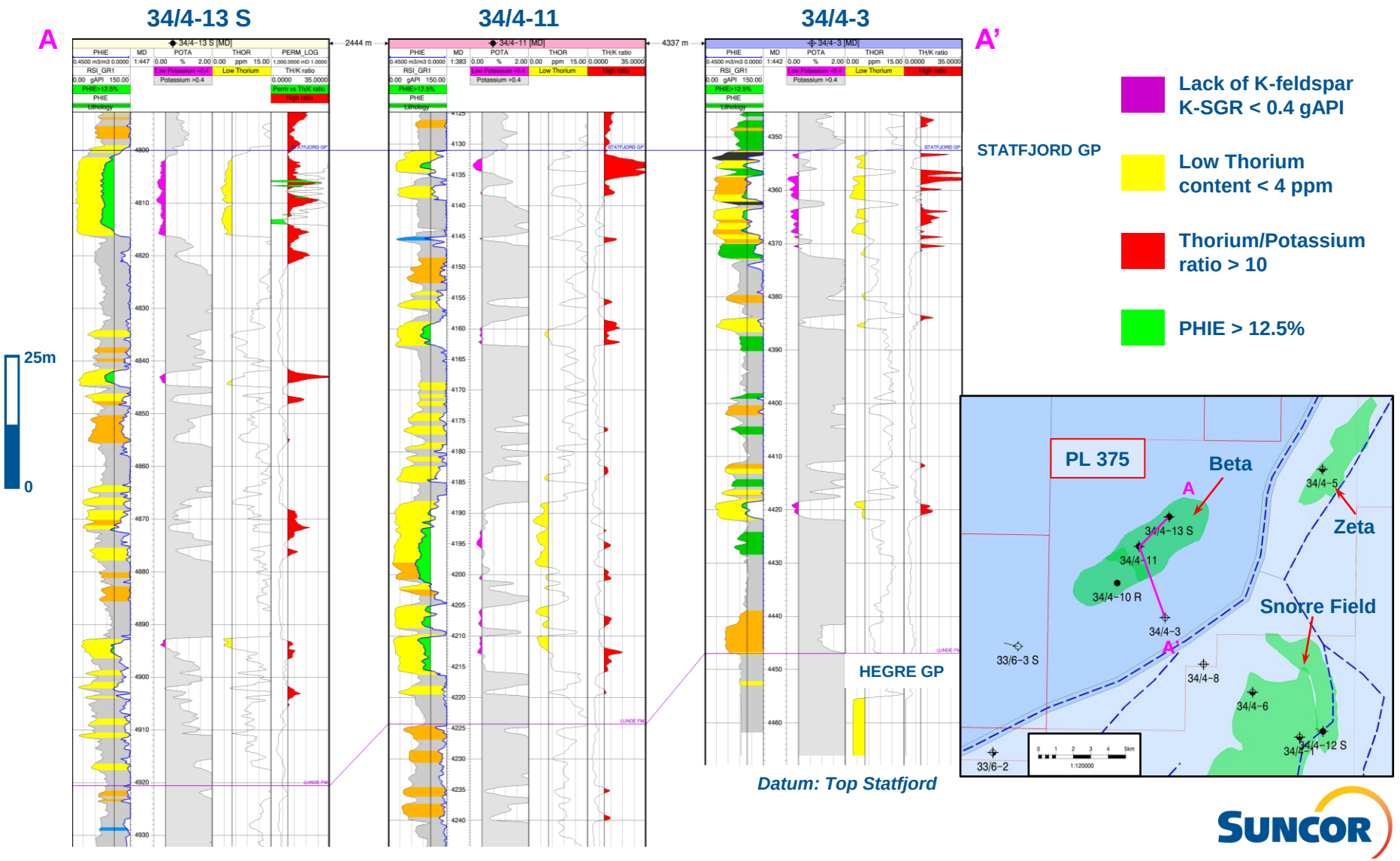


Well 33/9-9
Depth: 2717m TVDSS
Fluvial Channel facies

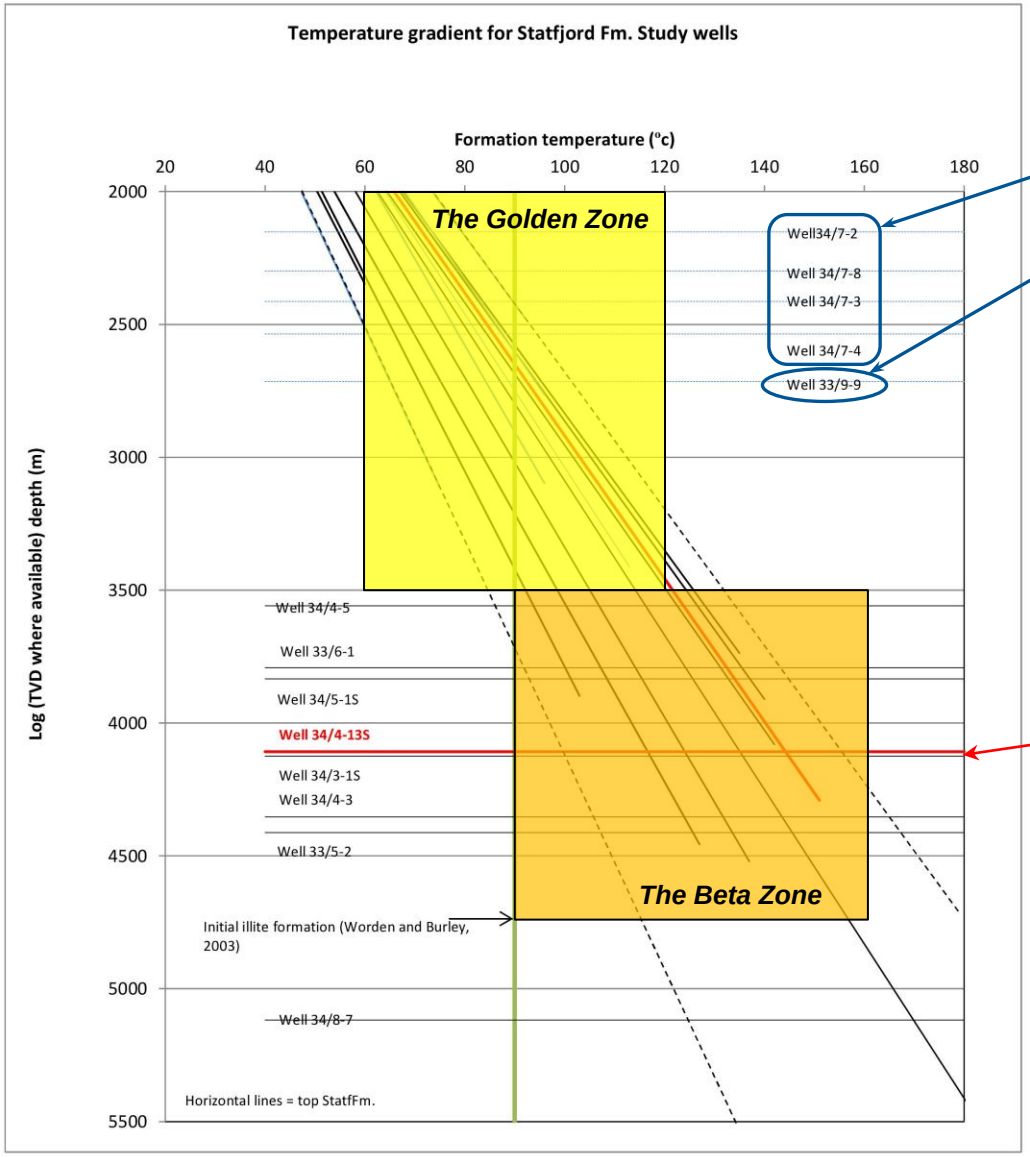


Clay coatings

Lack of K-feldspar – Particular to Marulk Basin in Statfjord Gp sst?

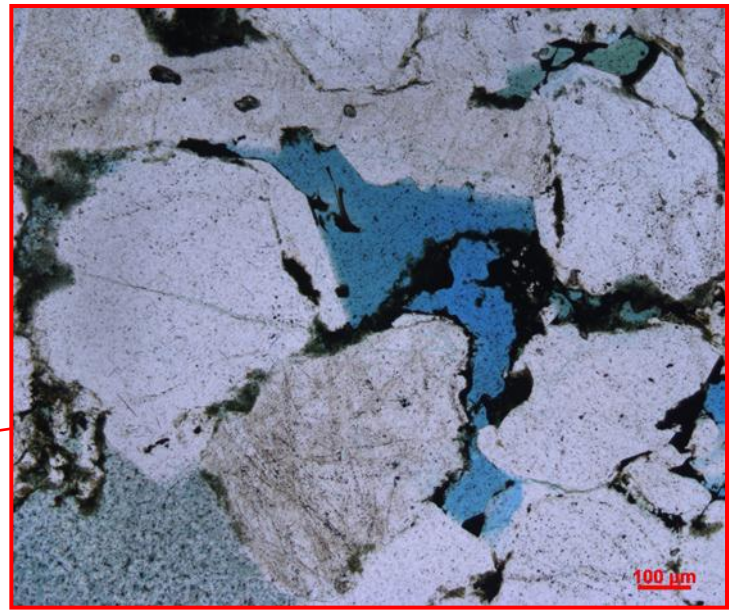


Diagenesis – Formation Temperature



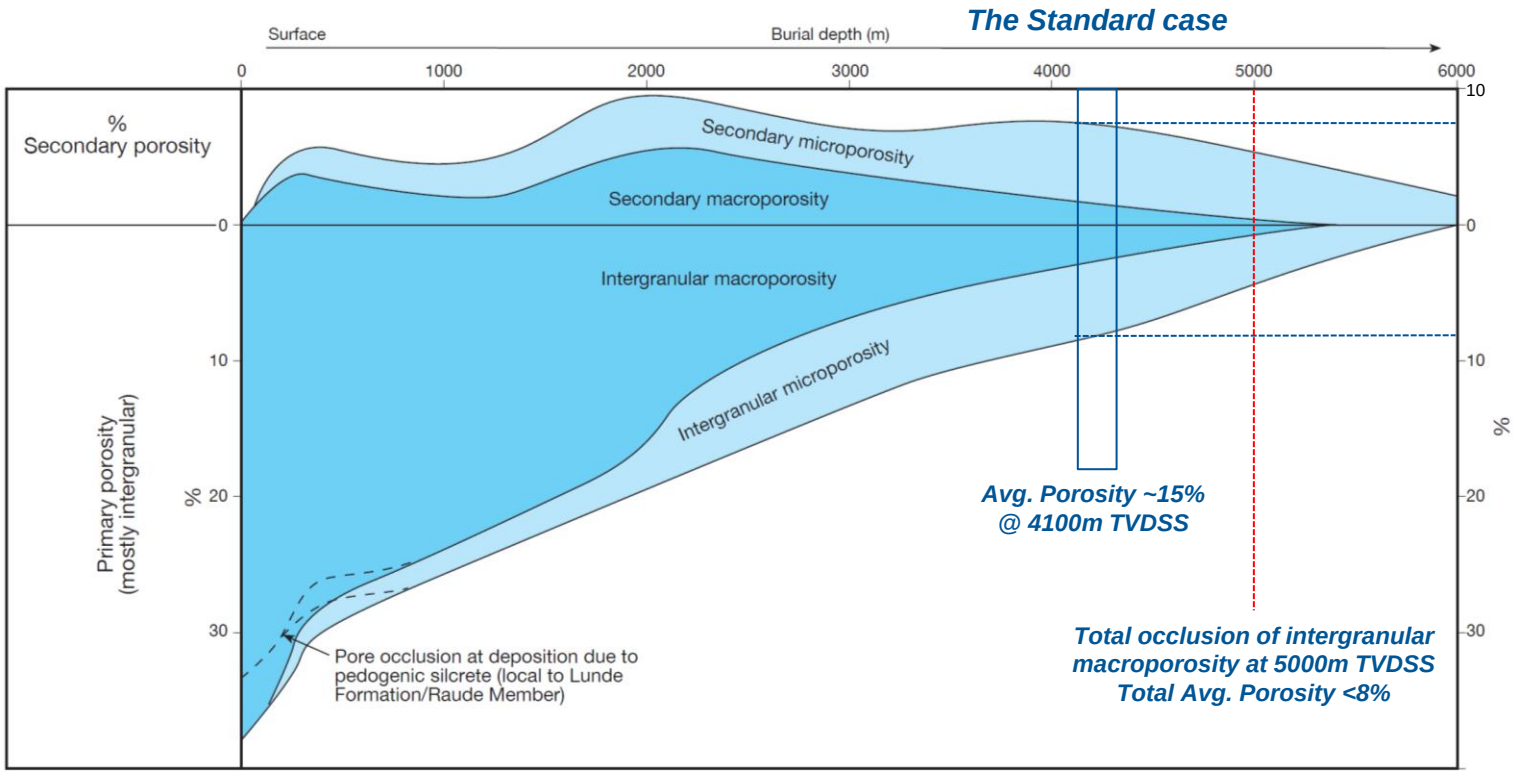
The Snorre oil field

The Statfjord oil field



Quartz overgrowth encased hydrocarbon (early emplacement)

Diagenesis – Models of Porosity Variation with Depth

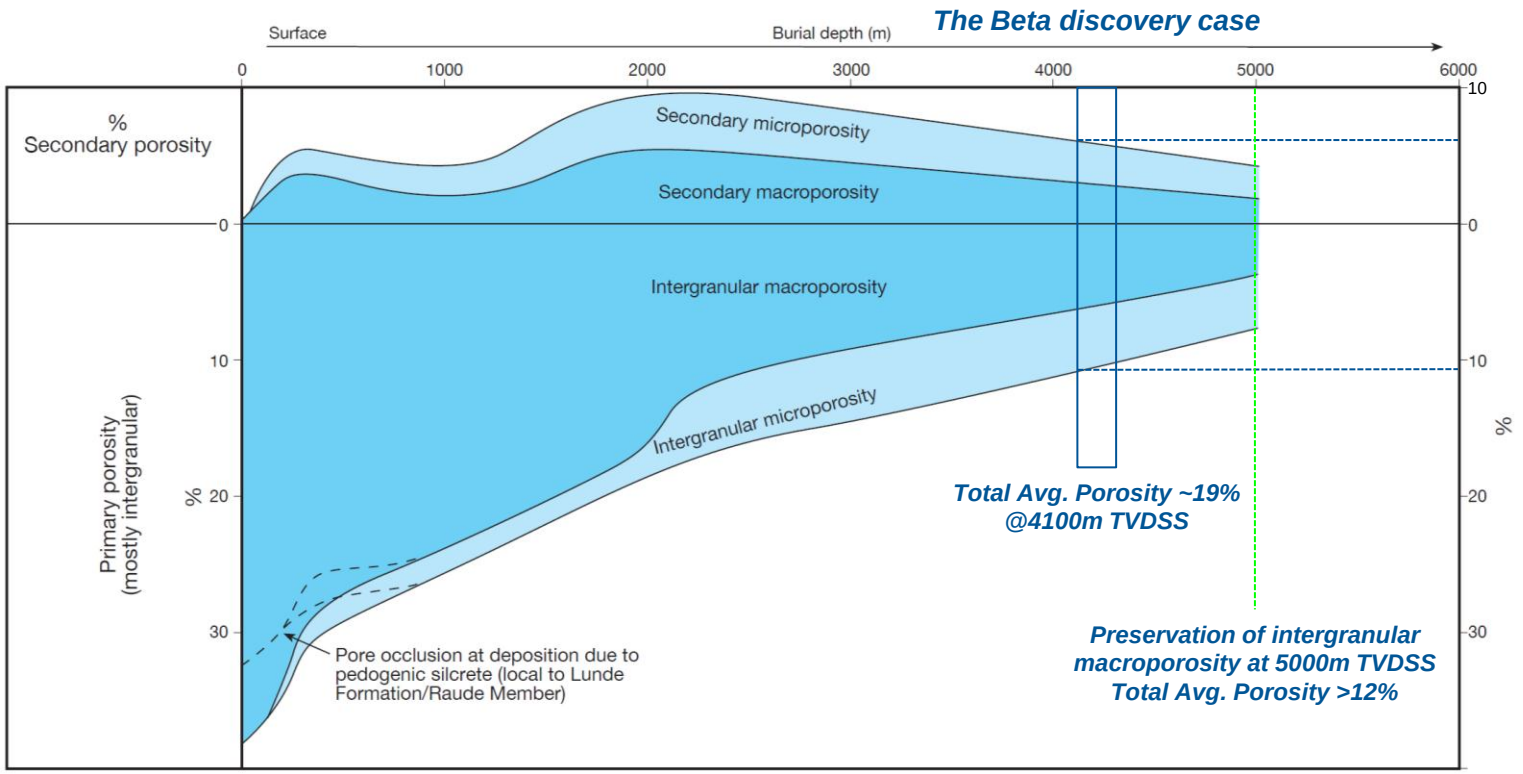


The Standard case:

The water bearing intervals allows prolonged diagenesis causing:

- Quartz cementation and pore occlusion
- Extensive feldspar dissolution (up to 80%)
- Extensive intergranular and grain dissolution authigenic clays. Illitisation below 3200m

Diagenesis – Models of Porosity Variation with Depth



The Beta discovery case:

The early oil emplacement restricts prolonged diagenesis causing:

- Limited quartz cementation
- Limited feldspar dissolution
- Limited intergranular and grain dissolution authigenic clays

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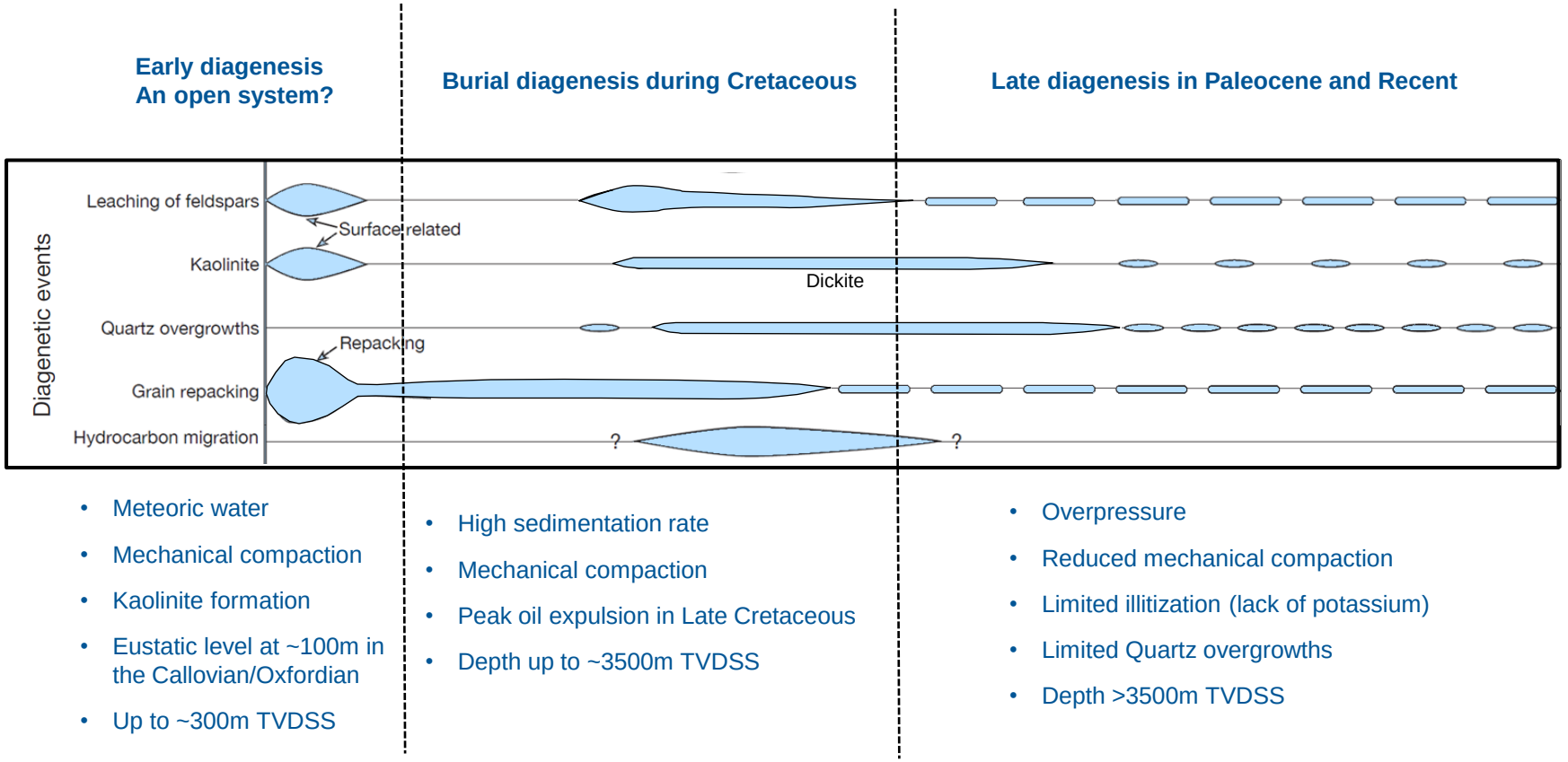

- Meteoric water
- Mechanical compaction
- Kaolinite formation
- Eustatic level at ~100m in the Callovian/Oxfordian
- Up to ~300m TVDSS

- High sedimentation rate
- Mechanical compaction
- Peak oil expulsion in Late Cretaceous
- Depth up to ~3500m TVDSS

- Overpressure
- Reduced mechanical compaction
- Limited illitization (lack of potassium)
- Limited Quartz overgrowths
- Depth >3500m TVDSS

- Preservation of the initially open system?
- Reduced chemical and mechanical compaction

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Thank you for your attention. Questions?

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Stavanger, Norway, April 8th, 2015

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