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

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Stavanger, Norway, April 8th, 2015
Outline

Introduction

Sedimentology

Mineralogy & Diagenesis

Summary
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Summary
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

Top Statfjord in depth (m)

PL 375, B & C
Suncor Energy  80%
Core Energy     20%
The Beta Statfjord discovery is ~1300m down-dip of the Snorre High
Stratigraphic Setting of the Statfjord Gp

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<th>Age (Ma)</th>
<th>Stage</th>
<th>Stratigraphy</th>
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<td>Lacustrine dominated section</td>
<td>Syn-rift Triassic extension</td>
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<td>Pre-rift marine deposition</td>
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Modified from NPD, Suncor, 2013

Braided, amalgamated channels
Meandering channels
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 ~37° angle inclination
Quality of the Fluvial Channel Sandstones

Initial reservoir quality at deposition:
- Coarse (lower) grained - >10 Darcy permeability
- Moderately well sorted - >30% porosity

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

Note: Calculated from a larger dataset
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Mineral Composition

- 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

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

Other cements include traces of calcite with lesser dolomite and siderite

Depth: 3549.00m TVDSS
Overbank facies

Porosity: 18.9%
Permeability: 13.0 mD
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?

34/4-13 S

34/4-11

34/4-3

A

A'

Lack of K-feldspar
K-SGR < 0.4 gAPI

Low Thorium content < 4 ppm

Thorium/Potassium ratio > 10

PHIE > 12.5%

Datum: Top Statfjord

STATFJORD GP

HEGRE GP

PL 375

Beta

Zeta

Snorre Field
Diagenesis – Formation Temperature

The Golden Zone

The Beta Zone

The Snorre oil field

The Statfjord oil field

Quartz overgrowth encased hydrocarbon (early emplacement)
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

Total Avg. Porosity ~19% @4100m TVDSS
Preservation of intergranular macroporosity at 5000m TVDSS
Total Avg. Porosity >12%
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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
Thank you for your attention. Questions?

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