Mariner Field: a challenging UK heavy oil development
Ingolf Søreide, Simone Silcock and Ian Thomson, Statoil UK Ltd
Presentation for SPE Aberdeen Section, 25 September 2013
Statoil of Norway has committed $7bn towards developing the largest offshore venture in UK waters for more than a decade.

Confirmation of the investment in the Mariner field comes more than 30 years after its discovery in 1981, and a day after JX Nippon of Japan confirmed it was acquiring a 29 per cent stake in the licence from Statoil’s joint venture partner Eni of Italy.

Statoil’s experience and technology will unlock large reserves

- Approx. 2 billion boe in place
- More than 250 mboe reserves

Production for 30 years

- Average production of ~55,000 bbls/d over the plateau period 2017-2020

Production from the Mariner heavy oil field is expected to begin by 2017 and stretch over 30 years.
Why offshore heavy oil is challenging!

- Inefficient recovery process & low recovery rate
  - Low flow rates
  - Early water break-through
  - High water-cut
- High development costs
  - Many, advanced wells required
  - Efficient well artificial lift system
  - Large liquid & moderate oil capacity
  - Produced water treatment for re-injection
- Special attention to crude handling
  - Meeting crude specifications
  - Storage, transportation and marketing
Mariner Field: a challenging UK heavy oil development: Statoil - SPE Meeting 25 Sep
### Two reservoirs:

<table>
<thead>
<tr>
<th></th>
<th>Maureen</th>
<th>Heimdal</th>
</tr>
</thead>
<tbody>
<tr>
<td>API</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Viscosity, cP</td>
<td>67</td>
<td>508</td>
</tr>
<tr>
<td>NTG, %</td>
<td>85-90</td>
<td>~14*</td>
</tr>
<tr>
<td>Permeability, D</td>
<td>2-5</td>
<td>+10</td>
</tr>
<tr>
<td>Porosity, %</td>
<td>+30</td>
<td>+30</td>
</tr>
<tr>
<td>Pressure, bar</td>
<td>148</td>
<td>126</td>
</tr>
<tr>
<td>Temperature, C</td>
<td>46</td>
<td>38</td>
</tr>
</tbody>
</table>
1977: 2D seismic acquired across 9/12 (P254)

1980: P335 licence awarded to Union Oil (Mariner)
1981: Mariner discovered 9/11-1 well
1982: 2D seismic acquired across 9/11 (P335)

1982: wells 2, 3 & 4 drilled

1991: P726 licence awarded to ConocoPhillips (Mariner East)
1994: Hess becomes operator of P335
1995-1996: 3D seismic acquired

1996: Texaco becomes operator of P335 & P726
1996-1997: wells 5 to 12 drilled, including EWT
2005: Chevron becomes operator of P335
2005: 3D seismic reprocessed

2008: Statoil becomes operator of P335 & P767
2008: HR 3D and core area OBS acquired
2012: Broadband 3D acquired
2017: FIRST OIL

Mariner: project history
• Mariner is currently one of the largest undeveloped resources in the UKCS.

• Discovered in 1981.

• With nearly 2 billion barrels STOIIP

• So why has Mariner remained undeveloped for so many years?
  - Heavy oil 11 – 14 degrees API
  - Highly Viscous / High TAN
  - Offshore North Sea environment
Palaeocene Stratigraphy

(Modified from J. Gjelberg)
Maureen well correlation

Maureen seismic section

9/11a-7 Maureen well logs & image logs
(Ahamedi, et al. 2003, Millennium Atlas)

Maureen Reservoir

Mariner Field: a challenging UK heavy oil development: Statoil - SPE Meeting 25 Sep
Maureen depositional model

- Delta-fed sand-rich turbiditic channels (by-passed) evolving downstream into extensive sheetlike lobes
- Minor collapse scars with Chalk blocks/debris
- Primary reworking of allochtonous chalk blocks (Pre-Maureen Fm. deposition)
- Late stage mixed sand-mud rich turbidites dominated by elongated channelised sheet-like sandlobes (M21.4 res. zone)
- Secondary reworking of the Chalk Group through calcaro-clastic debris flows/slump deposits
- Approximated scale: 0 - 5 km
Maureen stepped OWC's
### Heimdal Reservoir

<table>
<thead>
<tr>
<th>WELL</th>
<th>CORE NO.</th>
<th>CUT</th>
<th>INTERVAL CUT</th>
<th>RECOVERED</th>
<th>RECOVERED</th>
<th>FORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/11-1</td>
<td>Core 1</td>
<td>60</td>
<td>4285’ - 4345’</td>
<td>32</td>
<td>53%</td>
<td>Lista Claystone</td>
</tr>
<tr>
<td></td>
<td>Core 2</td>
<td>40</td>
<td>4345’ - 4385’</td>
<td>2</td>
<td>5%</td>
<td>Heimdal Sst (H30)</td>
</tr>
<tr>
<td>9/11-2</td>
<td>Core 1</td>
<td>31</td>
<td>4170’ - 4201’</td>
<td>0</td>
<td>0%</td>
<td>Heimdal Sst (H30)</td>
</tr>
<tr>
<td></td>
<td>Core 2</td>
<td>14</td>
<td>4201’ - 4215’</td>
<td>0</td>
<td>0%</td>
<td>Heimdal Sst (H30)</td>
</tr>
<tr>
<td>9/11-4</td>
<td>Core 1</td>
<td>12</td>
<td>3912’ - 3924’</td>
<td>1.6</td>
<td>13%</td>
<td>Heimdal Sst (H40)</td>
</tr>
<tr>
<td>9/11a-5</td>
<td>Core 1</td>
<td>21</td>
<td>4362’ - 4383’</td>
<td>19</td>
<td>90%</td>
<td>Lista Claystone</td>
</tr>
</tbody>
</table>

Mariner Field: a challenging UK heavy oil development: Statoil - SPE Meeting 25 Sep
Heimdal channels bypassed direct sediment by-pass down delta front slope during low-stand.

- Maureen Formation
- Lista Formation
- Lower Heimdal
- Middle Heimdal
- Upper Heimdal
- Late stage Lista

Heimdal depositional model

Mariner Field: a challenging UK heavy oil development: Statoil - SPE Meeting 25 Sep
Post depositional remobilisation

Injectite cross-cutting primary reflection

Analogue to upper sands
Post depositional remobilisation
Post depositional remobilisation
Seismic challenges

The sands have nearly the same AI, but show a clear separation from the shale in Vp/Vs domain.

Expected and observed AVO responses:
- Maureen sand – Weak Class 1
- Lista Fm. sand – Weak Class 2 (typically)

Seismic section

Statoil - SPE Meeting 25 Sep
• Heimdal sands prove difficult to image on seismic streamer data and so the current Heimdal reservoir model is stochastic.

• Ocean Bottom Seismic (OBS) survey gives a good image of the sands, but has lower resolution.

• In 2012 Statoil acquired a full field broadband survey (currently being processed).
  – primarily aims to better resolve the Heimdal channels.

• A better handling of the Heimdal will enable a deterministic reservoir model, which can be utilised for Heimdal well placements.
• Drainage Strategy
  • Pressure maintenance / Reservoir Flooding by
    • Produced Water Re-Injection

Maureen Reservoir:
  - 17 Horizontal Producers
  - 5 Slanted Injectors
  - Produced first

Heimdal Reservoir:
  - Inverted Nine-Spot Pattern
  - 39 Dual, Slanted Producers
  - 32 Single, Slanted Injectors
  - Seven wells planned for further appraisal

Inverted-nine-spot pattern, 400 x 400 m
Mariner Field

- Maureen Main
  - 17 Producers
  - 5 Water Injectors
- Heimdal
  - 46/39 Dual MLT’s
  - 32 Water Injectors

Mariner Field: a challenging UK heavy oil development: Statoil - SPE Meeting 25 Sep
Many Challenges....
Mariner Well Types

<table>
<thead>
<tr>
<th>Well Type</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Maureen Producer</td>
<td>46.0</td>
</tr>
<tr>
<td>Single Maureen Water Injector</td>
<td>47.0</td>
</tr>
<tr>
<td>Heimdal MLT Producer</td>
<td>73.0</td>
</tr>
<tr>
<td>Heimdal Water Injector</td>
<td>41.0</td>
</tr>
<tr>
<td>Heimdal MLT sidetrack</td>
<td>70.0</td>
</tr>
<tr>
<td>Heimdal WI sidetrack</td>
<td>37.0</td>
</tr>
</tbody>
</table>
Drilling Operations – Heimdal MLT Wells

Mariner Field: a challenging UK heavy oil development: Statoil - SPE Meeting 25 Sep
Mariner Field: a challenging UK heavy oil development: Statoil - SPE Meeting 25 Sep
Mariner Platform
Mariner Platform
Intervention and Completion Unit (ICU)
Intervention and Completion Unit (ICU)
Intervention and Completion Unit (ICU)
The field development concept
Mariner Field: a challenging UK heavy oil development: Statoil - SPE Meeting 25 Sep
Projected benefits for the UK

- Significant tax revenues
- Operations centre in Aberdeen
- 700 long term jobs
- Knowledge and technology transfer for future UK projects
- Local contractors for support services, maintenance & modifications
Technical advances unlocking Mariner

**Conventional Streamer Seismic**

**Objective:** higher reservoir exposure and reduced cost

**Concept:** branched wells

**Multi-lateral wells**

**Objective:** improved well placement

**Concept:** advanced logging-while-drilling tools

**Advanced geosteering**

**Objective:** improved sweep in the reservoir

**Concept:** optimise number and placement of injectors

**Autonomous inflow control valves**

**Objective:** reduced inflow of water in oil producers

**Concept:** self-adjusting valves

**Isometrix Seismic**

**Infill wells**

**Objective:** higher reservoir exposure

**Concept:** identify new drilling targets

**Optimised water injection strategy**

**Objective:** improved sweep in the reservoir

**Concept:** inject polymer to increase water viscosity

**OBC Seismic**

**Polymer injection**

**Objective:** improved sweep in the reservoir

**Concept:** inject polymer to increase water viscosity

**Multi-lateral wells**

**Objective:** higher reservoir exposure and reduced cost

**Concept:** branched wells

**Advanced geosteering**

**Objective:** improved well placement

**Concept:** advanced logging-while-drilling tools

**Autonomous inflow control valves**

**Objective:** reduced inflow of water in oil producers

**Concept:** self-adjusting valves

**Infill wells**

**Objective:** higher reservoir exposure

**Concept:** identify new drilling targets

**Optimised water injection strategy**

**Objective:** improved sweep in the reservoir

**Concept:** optimise number and placement of injectors

**Polymer injection**

**Objective:** improved sweep in the reservoir

**Concept:** inject polymer to increase water viscosity
First Steel Cut
• Rolled Leg Section
• Diameter 2m
• Thickness 80mm
• Weight approx. 10 tons
Acknowledgements

• Statoil UK Ltd.

• JX Nippon Exploration and Production (U.K.) Limited

• Alba Resources Limited,
  • a wholly owned subsidiary of Cairn Energy PLC
Jacket Installation – 8.30 mins

Topsides Installation – 7.02 mins

Cat J Jackup – 5.58 mins

Cat J working at Mariner – 2.13 mins
Hello

New in town. Here to stay

Thank-you...any questions?