Piper Field, Past, Present & Future

Presentation to Institute of Materials, Minerals & Mining

Julian Slater & Dr Maurice Bamford

BP Aberdeen 11th March 2009

Acknowledgments: Talisman Energy (UK) Limited and ENI UK Limited for giving permission to present
Presentation Structure

- Field Overview
- Location
- Geological Setting
- Reservoir Container
- Properties Within Container
- Alpha Development
- Bravo Development
- Current Operations
- The Future
Location Overview

Piper (Witch Ground Graben)
Discovery date: 1972 (15/17-1A)
Reservoir: Upper Jurassic Piper & Sgiath Sandstones
Oil column: 1,200 ft
OWC: 8,510 ft tvdss
STOIIP: 1362 mmstb

Development
- 1976 – First Oil
- 1976 to 1988 - Steady Production
  - 55 development wells drilled.
  - Peak monthly rate of 302,000 stb/d.
- 6th July 1988 – Piper Alpha disaster.
  - Cumulative Prod - 834 mmstb
- 1988 to 1992 – Redevelopment
  - Piper Bravo installed.
- 1993 – Restart of production.
- 1993 to present – Steady Production
  - 17 Bravo development wells
Piper Field Historic Production

**Piper Alpha**
- Cum Prod – 834 MMstb

**Piper Bravo**
- Cum Prod (end 2008) – 189 MMstb
Structural Setting
3D Projection of Piper Field & Surrounds

W

4 km

E

Piper

Block 2

Block 3

Iona

Saltire

Chanter

TWT Zechstein
Piper Field seismic cross-section

- Two Way Time (msec)
- SW
- Block III
- Block II
- Block I
- NE
- Top Chalk
- BCU
- Top Piper
- Top Zechstein

Slide 11
Piper Field: Top Structure map

1979 2D

2004 3D
Piper Depositional Analogues

Southern Rhode Island
Piper Depositional model

- Shallow marine (to fluvial) sandstones - typically progradational
- Thin transgressive sandstones
- Fine grained dominated, coastal plain, swamp and restricted marine deposition
- Basinal claystone - often organic rich
- Emergent
- Conglomeratic
- Vegetation and coal formation
Piper Depositional model

- Shallow marine (to fluvial) sandstones - typically progradational
- Thin transgressive sandstones
- Fine grained dominated, coastal plain, swamp and restricted marine deposition
- Basinal claystone - often organic rich
- Emergent
- Conglomeratic
- Vegetation and coal formation

Barrier island system

Restricted Marine possibly behind barrier to South

Possibly emergent

Pibroch

Thick transgressive sandstone
Piper Deposition & Reservoir quality

Piper Fm

- Channel (marine or fluvial)
- Middle shoreface
- Lower shoreface
- Offshore and transition
- Transgressive sand

Deposition & Reservoir quality

<table>
<thead>
<tr>
<th>Environment</th>
<th>Porosity</th>
<th>Permeability</th>
<th>Horizontal Continuity</th>
<th>Vertical Continuity</th>
<th>Reservoir Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Plain</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Foreshore</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Upper Shoreface</td>
<td>Very Good</td>
<td>Very Good</td>
<td>Very Good</td>
<td>Very Good</td>
<td>Very Good</td>
</tr>
<tr>
<td>Lower Shoreface</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
</tr>
<tr>
<td>Transition</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Offshore</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Non-Reservoir</td>
</tr>
</tbody>
</table>
Sandstone diagenesis

- Sandstone with high porosity
- Blue area – injected resin to make it easier to see porosity

Coring induced chevron fractures
Secondary Porosity

- Process requires emplacement of significant calcite cement and its subsequent removal.
- Calcite prevents cementation by other minerals.
- Removal of the aggressive calcite cement produces a super-enhanced pore-system.
- Tends to be associated with more proximal arenite facies - lower shoreface, middle shoreface, channel.
Reservoir Summary

- Structure
  - Large NE dipping tilted fault block on margin of Witch Ground Graben
  - Few fault barriers to flow
  - Relatively minor crestal erosion

- Reservoirs
  - Piper Formation (Primary – 86% of STOIIP)
    - Shallow marine shoreface sand system
  - Sgiath Formation (Secondary – 14% of STOIIP)
    - Lower delta plain to inter-distributary bay
    - Secondary porosity enhances reservoir quality

- Aquifer
  - Large & fast acting
Reservoir Quality - Logs

15/17-B08

PIPER FIELD

RESERVOIR PROPERTIES:

PIPER

Thickness (max): 320'
Net/Gross: 0.7-0.9
Porosity: 0.24 (0.18-0.32)
Permeability: 4D (0.5-10)
Water Saturation: 0.1 (0.07-0.15)

SGIATH

Thickness (max): 140'
Net/Gross: 0-0.7
Porosity: 0.24 (0.20-0.28)
Permeability: 1.2D (0.2-4)
Water Saturation: 0.12 (0.08-0.25)
Reservoir Quality - Core

- Piper Formation
  - Primary reservoir
  - Shallow marine shoreface sand system
- Sgiath Formation
  - Lower delta plain to inter-distributary bay mixed clastics and coals

Porosity vs. Permeability

![Porosity vs. Permeability Graph](image)
Oil Properties

- GOR: 450 scf/stb
- API: 37°
- Initial Press: 3,700 psia (8,100 ft TVDSS)
- Bubble Point: 1,600 psia
- Temp: 175 deg F
- CO₂: 0%
- H₂S: 100 - 800 ppm
- Viscosity: 0.79 cP
Oil In Place [STOIIP]

- STOIIP – 1,362 MMstb
  - Recent re-mappings have all given consistent structures and Gross Rock Volumes.
  - Properties constrained by almost 100 well penetrations.
  - Crestal erosion block 1.
  - Block 1 - 1071 MMstb
  - Block 2 - 291 MMstb
• Dec 1972 Discovered 15/17-1B
• Occidental Operated
• Further 5 appraisal wells
• 36 Slot Platform
• 2 Drilling Rigs
• 2D seismic (500m grid)
• 365,000 bbl/d liquids capacity
• 300,000 bbl/d wat inj capacity
• First Production P1 Dec 1976
• Apr 1977 P7 50,000 stb/d
• Aug 1977 P13 drilled into Block 2
• Jan 1978 P16 injection
• Early 1979 20 producers and 4 injectors
• First Production Dec 1976
• Pressure drops rapidly
• 1978 Water injection stabilises pressure
• 1979 up to 300,000 stb/d oil rate
• 1980 rates cut back - res. management
• 1983 3D seismic (75m spacing)
• 1986 Hydrocyclones
• 1985 rapid water cut rise
• July 6th 1988 Piper Alpha disaster
• 43 producers (27 active)
• 12 injectors (8 active)
• 834 million stb produced
• Large Aquifer recharges pressure
- 1990 reprocessed 3D seismic
- 1990 Template installed
- 1991 8 wells pre drilled
- Restart 1993 - Elf Operated
- 24 slot platform 1 rig
- 140,000 bbl/d liquids capacity
- 200,000 bbl/d wat inj capacity
- 1993 3D (12.5m line spacing)
- 1997 12 crestal producers and 5 injectors
- Redrilled Alpha wells
- 2000 Talisman Operated
- 2001 3D seismic (12.5m digital 90 Fold)
Bravo Production

- First Production Jan 1993
- 1993 Estimate of 118 MMSTB cum prod
- 1994 100,000 stb/d oil
- 1995 Injection up to 140,000 bbl/d
- 1998 Estimate of 180 MMSTB cum prod
- 2004 Injection up to 170,000 bbl/d
- 2009 cum prod already 189 MMSTB
- 8000 stb/d at a 93% water cut
- Still another ~50 MMSTB to go
  - Cum prod of 239 MMSTB
Current Operations

- 8000 stb/d @ 93% water cut
  - Washing the Rocks
- Bravo platform acts as an area production Hub
  - Tweedsmuir
  - Tweedsmuir South
  - Chanter
  - Saltire
  - Iona
  - MacCulloch
  - Dumbarton
- Ongoing Wellwork
  - Larger Tubing
  - Deepen Gas Lift
- Facilities Maintenance
  - Safety No1 Priority
  - Maintain high ~90% uptime
  - Gas compression
  - Power generation
  - Water injection
Piper B Platform is area production hub
7 Producing fields hosted by Piper B
- Production re-started in 1993
- 8 leg, 24 slot, fixed steel-jacket
- Sour crude processing
- Multi-train – high operating efficiency
- 475ft of water, 170 beds

Piper field unique in North Sea.
- Exceptional recovery factor
- 2008 production 8000 bopd at 93% water cut.
- Ongoing investment - safety & ops efficiency

Relatively young facilities
- Recent tie-back of TWM field.
- Dumbarton Gas processing and export.
Predicting The Future

- **Decline Analysis**
  - Relatively Simple
  - Fast results
  - Quick to audit
  - Difficult to account for new wells
  - Difficult to account for new projects
  - Can't be used early in field life

- **Reservoir Simulation**
  - Large Effort
  - Years to construct model
  - Match Water cut and Pressure data
    - ~100 wells
    - 30+ years data
  - Predict new well performance

- Both Methods show ~50 MMSTB reserves
Alpha Produced 834 MMSTB, Bravo 189 MMSTB & another ~50 to go

Total Cumulative recovery estimated ~1073 MMSTB

Oil Mapped In Place 1362 MMSTB

79% recovery - highest in North Sea
• **79% Recovery Factor** - highest in the north sea (Fulmar 69%, Brent 58%)
  
• Good Structure, Few sealing faults, High Rock quality, oil properties, large aquifer,

• High number of wells, Water injection, Gas Lift, Developed twice, Continued production at high water cuts
The Future

- **Long Term Producing Hub**
  - Continue to tie in new discoveries
    - Tweedsmuir area
    - Lowlander
    - Discoveries to the North and East

- **Piper Field**
  - Reinterpret field based on new 2008 PreSDM seismic processing
  - Continue to wash rocks with high uptime
  - Lower separator pressure
  - Lower drilling/workover costs
  - Re evaluate Oil In Place
  - Enhanced Oil Recovery
    - Still ~ 300 MMSTB unrecovered