Forties Infill drilling 8 years on
Phil Rose, Jeff Pyle, Gregg Barker
Devex May 2011
Forties Field – a mature giant rejuvenated by infill drilling

Aims:
- Illustrate Target generation methodology
- Discuss evolution of drilling campaign
- Forties the future
Forties Field: 
- Four way dip closure cut by many small compactional faults
- Heterogeneous Upper Paleocene turbidite reservoir

Stratigraphic column
Forties Field in 2003 – a giant in decline

- **In place estimate:** 4.2 – 5 billion barrels
- **Produced volume:** 2.5 billion barrels, 50% + recovery factor
- **2003 average rate:** 41,000 bopd
- **Remaining reserve estimate at purchase:** 144mmbo

15 wells produced over 50 mmbo
12 wells injected over 100 mmbw
Forties Field today – continual redevelopment

101 targets tested
81 production completions
4 injection completions

75 mmbo produced to date from Apache drilled wells

Apache wells currently produce 50,000+ bopd

Surface drilling initiated on all platforms to utilise empty slots
Data integration key to finding bypassed pay

Bypassed pay target: Evidence for hydrocarbon, Reservoir, Trap.

- Production history, structure and gross architecture
- Detailed sand distribution and stratigraphy from wells
- Offset gathers
- Seismic inversion data
- 4D seismic
- Angle stacks
- Synthetic modelling
- Lack of sweep offset to T177
- No sweep to FES05 well
- Sweep to FES09 well
- Sweep to FES16 well
Forties Stratigraphy / architecture – requires wells plus seismic

Top Forties / Top Sele only robust log picks – Top Sele excellent seismic pick
Sand body object distribution from integration of well data with lithology seismic
Forties rock physics – prospecting foundation

AVO Crossplot based on average properties from A27

- **Shale 2480mMD Wet sand**
- **Oil sand (in-situ) Wet sand**
- **Shale 2480mMD Shale 2598mMD**
- **Shale 2480mMD Oil sand (in-situ)**
- **Shale 2480mMD Oil sand (FR 30\% Sw)**
- **Shale 2480mMD Oil sand (FR 60\% Sw)**

Increasing hydrocarbon saturation

Lithology projection

Small contrast approximation:
Average rock properties based on A27

- **Sele shale on Forties shale**
- **Sele shale on Forties wet sand**
- **Sele shale on oil Forties oil sand**
Lithology projection results in high confidence prediction of tops of major high net to gross sand bodies.
Base Sele always a hard near stack reflector – BUT lithology projection gives clear differentiation of sand prone vs shale prone response.
CI lithology projection with gamma logs biostrat picks and pressure data

**Step 2** reconcile seismic sandbody distribution with biostrat and pressure data. Then interpret well log correlation markers.
Integration of data has allowed detailed mapping

Flattened cartoon stratigraphic cross section.

Sand shale architecture combined with subtle faulting root cause of trap definition for many bypassed oil accumulations

Critical to flow behaviour of the reservoir
Forties 4D – high value tool

5 out of 7 2011 wells to date located using 2010 4D

2000-2010 4D calibration – red sweep
Target 177 drilled March 2011 – IP 4,000 bopd

Apache
Charlie wing play – thin bed pay not completed

No Charlie wing completions pre 2004

- Play identified by plugging back wells producing from deeper targets
- 7 wells drilled and completed in undrained area, over 10 mmbo produced since 2004
- Using seismic and well data to predict extent of thin bedded sandstones critical for chasing play

Pre-2004 eastern limit of Charlie Sand production

Apache completion

20m

Charlie wing sands

Apache Charlie sand completion

1975-2003 cumulative Charlie sand production
2004-2005 SE Echo campaign – regional DHI with few wells

- 15 wells completed from Echo platform 2004-2005
- Total production to date from those wells
- 23 mmbo
- Still producing over 3,000 bopd
2011 Echo infill campaign driven by 4D

- Seismic resampled into sugar cube geomodel
- Top Sele pick and Lithology Projection seismic used to isolate sand
- 1988-2010 4D volume used to isolate undrained attic
- Remaining cells used to calculate remaining attic thickness map
- Three successful infill wells drilled from Echo in 2011 using this methodology
- Red dots locate current mature target locations

Seismic filtered to sand distribution

Swept volume removed using 1988-2010 4D

2011 completion
2004-2005 completion
Remaining target

Unswept thickness calculated from sugar cube seismic model
Charlie Channel 4D attic play – surprising traps

Forties Charlie Oil Production

- 2009-present 4D campaign
- 2007 DHI campaign

April 2011 average 25mbd

- 2009 10,000 bopd well – 4D target
- 2011 12,000 and 4,000 bopd wells – 4D target from 2010 survey

- 2009 Charlie 4D campaign rejuvenated platform production.
- New opportunities created by 2010 4D data
- Very subtle discontinuities can trap substantial pay columns

Apache Charlie Platform completion

6m pay column at structural crest

20-40m pay columns encountered downdip in channel axis.

2000-2010 4D sweep

2010 4D attic thickness
**First 5 years targets in Undeveloped Areas**

Delta channel 4D targets

NE Flank DHI play

Charlie wing lithology play

Bravo wing lithology play

SE Echo DHI play

Significant early proof of 4D attic mapping in Delta Channel and north of Echo
From 2009 to 2011 4D dominant target type
Current target portfolio – 80 targets identified

Target portfolio May 2011

2km
Portfolio is dynamic and continues to grow as we drill new wells.

Portfolio strength has allowed FASP to be commissioned to be installed in 2012. This will be an 18 slot platform with additional processing facilities bridge linked to Alpha.

Apache is planning for the next 20 years and beyond.