Mungo Case Study: Unlocking the late-life field development with HDOBC seismic

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Mungo:
Outline

- Introduction to the Mungo field
  - Location within N.Sea
  - Structure & Stratigraphy
  - Overview Field History

- Mungo Imaging Progression
  - Legacy datasets
  - HDOBC justification

- Early HDOBC insights
  - Effects on Static picture
  - Dynamic influence
  - New Opportunities

- Principal conclusions and Mungo’s immediate future
  - Implications for Phase III
Mungo:
Field Introduction

- Equity: 69% BP, 13.6% Murphy, 12.4% Total, 5% JX NEPUK.
- Located in the East Central Graben of the Central North Sea, 143 miles east of Aberdeen in 88m water depth.
- Development facilities consist of a Normally Unattended Installation (NUI) tied back 22km to ETAP Central Processing Facility.
- 13 producers
- 3 water injectors
- 1 gas injector (offline)
- Current development strategy:
  - maximise oil production by maintaining pressure support from water injection with a future blow-down phase.
Mungo: Structure: ‘Ben’ Mungo

- Salt Diapir structure – draped Palaeocene sandstones overlying Cretaceous Chalk reservoir.
- Extensive oil column, ~965mtvd with a small gas cap.
- Reservoir dips ~40-65° (reaching 85° in SW)
- STOIIP ~420mmstb
- GIIP ~40bscf, solution 480bscf
- 39.3° API
- Structurally & stratigraphically complex
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Mungo: HDOBC Seismic Roadmap

1991 ETAP 3D Mungo Baseline

First Oil

1997 3D PreSTM+PoSDM processing
1992 3D PoSDM processing

2001 4D PreSTM+PoSDM processing

2001 4D

2002/3 3D PreSDM (Isotropic) processing

2005 4D PreSDM (VTI) processing

2005 4D

2006 3D PreSDM (TTI) processing

2006 4D PreSDM (TTI) processing

2007-8-9 spec 3D

2010 HDOBC

2010 3D PreSDM (TTI) processing

2011 HDOBC processing (East)

2010 HDOBC processing (Full-field)

2011 HDOBC HDOBC

2011

Datasets used in pending seismic succession
Mungo: HDOBC
HDOBC Justification

- **Business justification**
  - Multi-well proposal for future Field Infill campaign (Phase III), 1st well scheduled for 2014).
  - Maximise remaining field infill campaign, both Palaeocene reservoir & Chalk development.
  - De-risk current Phase III infill targets and address any future potential.
  - Realise up to ~30mmboe of resources; (10-20mmbbls Palaeocene in East, with circa. 10mmboe combined Palaeocene & Chalk in the West).

- **Technical justification**
  - Improve the static image for optimum well placement.
    - identify, quantify, prioritise and reduce uncertainty around infill drilling targets proposed for Phase III.
    - better internal reservoir definition allowing identification of stratigraphic compartments and sand packages.
    - inform potential options post Phase III.
    - help characterise the chalk reservoir potential?
• **HDOBC justification over Towed Streamer**
  - Acquisition uplift:
    - Improved Signal to Noise ratio - sensors on seabed (quieter environment and stationary).
    - Multi-azimuth illumination of 360deg structures for full wavefield imaging.
    - High fold with diversity of raypaths through subsurface.
    - Allows detection of shear C-waves.
    - Dominance of far offsets.
    - Enhanced Low frequency signal.
    - Ease of acquisition and survey repeatability.
  - Processing improvements:
    - Noise attenuation (denoise P&Z components independently, attenuation of backscatter noise).
    - Demultiple via PZ summation.
    - Improved Velocity modelling via Full Waveform Inversion -> better shallow model.
    - Azimuthal diversity to optimise illumination.
Mungo: HDOBC
Acquisition Design

Mungo West:
Further ~50% coverage with 2 additional patches in the West providing 100% of field covered.

- **25m receiver spacing**
- **400m receiver line spacing**
- **50m x 50m shot spacing.**
- **Acquired by WesternGeco.**

Mungo East acquisition:
~39sqkm HDOBC
~50% field coverage with 2 patches (1x 6x10km patch and 1x 7x8km patch) plus 1x 400m outboard cable

- **50m receiver spacing**
- **400m receiver cable spacing**
- **50m x 50m source, dual source, flip-flop.**
- **3km shot offsets—limited to 7500m radius.**
- **Acquired by RXT**

East acquired in 2010
West acquired in 2011

- 0m 5000m 10000m
  1cm. = 1000 meters

- 50m receiver spacing
- 400m receiver line spacing
- 50m x 50m shot spacing.
- Acquired by WesternGeco.

- Patch of 7 cables spaced 400m
- 8km

- Patch of 6 x 10km cables spaced 400m
- 10km

- 50m receiver spacing
- 400m receiver line spacing
- 50m x 50m shot spacing.
- Acquired by WesternGeco.
Mungo: Data succession
1991 Towed Streamer

1991 TS acquisition, 2006 PreSDM reprocessing

Section view
Mungo: Data succession
2001 Towed Streamer

2001 TS acquisition, 2006 PreSDM reprocessing
Mungo: Data succession
HDOBC (Alpha) dataset

2011 HDOBC acquisition, 2011/12 Alpha processing
Mungo HDOBC vs. Towed Streamer
Raw migration stack (Depth) comparison

1. Higher resolution in overburden due to higher fold, improved S:N.

2. Improved imaging and better continuity of the reflectors, especially on the flank of the diapir structure, data being richer in low frequencies and illuminated better with rich azimuthal content.

3. Inherent demultiple advantages during PZ summation of HDOBC superior to TS which requires post-migration demultiple.

4. Broadband nature of HDOBC datasets will allow enhancement of high frequencies to maximise internal architecture of reservoir interval.
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Mungo: HDOBC Insights
Early structural highlights

Interpretation synopsis:
Current interpretation based upon the West Alpha products

Top Sele Coherency extraction (80ms) generated from Alpha MG data

Additional undrained terrace in Panel 12??

Red lines denote 2010 VIP faults major (solid) minor (dashed)

Existence of internal baffle to support dynamic connection between W175 (Inj) and W171 (prod)
Mungo: HDOBC Insights
Reservoir Management: Assisting the dynamic history

- Reconciling the dynamic performance between Injector W175 and producer W171 situated in Panels 9 & 10.
- Producers W160 and W171 drilled in 2000 into southern areas of field. Injector W175 drilled in 2005 to support both producers.
- Post W175, W171 displayed minimal pressure support whilst W160 demonstrated elevated pressure -> direct connectivity.
- A baffle between W175 and W171 was inferred although no features were evident from previous seismic datasets.
- HDOBC coherency extraction illustrates a clear lineation (radial fault) located between the two wellbores which corroborates the dynamic behaviour.
- Potential future injector to support W171?
Mungo: HDOBC Insights

Infill Targets: Untapped resources in Panel 12?

- W166 producer, a single off-take point is situated in Panel 12.
- Producer W166 drilled in 2009 into undrilled area in north of field. MDT pressures ~600psi indicate partially isolated communication to remainder of field.
- Well displayed rapid early Pressure decline, rate now reduced; mild decline with ~20% wcut -> aquifer influx.
- Mapped STOIIP ~28mmbbls, Material Balance suggests contacted oil volume of 6.66mmstb -> remaining resource.
- Well drilled deep on structure, near to the OWC with potential for up-dip resource and/or adjacent fault block.
- HDOBC coherency extraction illustrates baffle adjacent to W166 which may isolate the area and delineate a potentially undrained fault block.
- Well currently Shut-in due to integrity loss.
- Potential future sidetrack location?
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What has the uplift been?

- Early indications are encouraging, observing some early uplift above the conventional Towed Streamer datasets.

- **Imaging:**
  - Clear uplift in image quality, higher S:N, higher fold and illumination with rich azimuthal content, less multiple -> better continuity of reservoir defining reflectors.

- **Structure:**
  - Much improved image of the diapir, particularly on the steeply-dipping flanks. Reservoir envelope surfaces (Top & Base) are readily mapped (albeit poorer quality in SW).
  - Internal architecture still remains a challenge -> function of thinning wedge, heterogeneity of individual reservoir packages and strong impedance contrasts of the Top & Base events.
  - Salt body better imaged, particularly the canopy which control the up-dip pinch-out of the reservoirs. Extent of the events into the gas cap & thereby connectivity have always been uncertain.

- **Dynamic reconciliation:**
  - Intriguing early observations that help reconcile both field & well performance. Assisting a fully integrated static and dynamic understanding.
• What’s next?
  - Final East & Alpha products evaluated so far.
  - Raw Beta dataset due imminently, (Final Beta datasets due in July 2012).
  - Static description & Phase III target selection will continue on the Alpha products in the interim to improve the integrated understanding.
  - Static & Dynamic workflows has been built with this succession of datasets in mind, i.e. iterative and for quick static model refinement.
  - Rank options and quantify uncertainty prior to final option selection.
  - Detailed well planning (fault placement and final target selection) will utilise the Beta Final datasets upon delivery.
  - Phase III infill drilling campaign potentially commencing 2014.

• Future?
  - Yet to quantify the final uplift of HDOBC over TS on Mungo diapir, although early results look promising.
  - Understanding of such a structurally complex field has certainly been enhanced by the step change in HDOBC technology.
  - HDOBC subsequently acquired over Machar field in 2011.
  - Potentially a future 4D HDOBC?
Mungo Partnership: Murphy Oil, TOTAL & JX NEPUK.

Co-author Steve Campbell & BP Seismic Delivery Team (SDT)

Seismic Processors: CGGV

ETAP Mungo Reservoir Team:
- Mary Ward, Alison Davies, Dave O’Gorman, Richard Pollard also Leendert Padmos and Marie O’Hanlon.