An integrated description of the stratigraphy and depositional environment of the “Main Pay” member of the Zubair Formation, Rumaila, Iraq

M Wells¹, D Kitching¹, D Finucane², B Kostic³

¹ BP, Rumaila Support Team, Sunbury, UK
² BP, Subsurface Technology Group, Houston, USA
³ Badley Ashton & Associates, UK

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Outline

Introduction
• Rumaila location and Redevelopment Plan objectives
• Early Cretaceous stratigraphic, palaeogeographic and palaeoclimatic context

Database and workflow
• Core and image log coverage and interpretation workflow
• Hierarchical integrated sedimentological and palynological description: depositional processes, genetic elements and delta advance-retreat cycles
• Use of image logs in interpreting away from cored wells and developing the depositional model

Business implications and conclusions
• A depositional model for the “Main Pay” of Rumaila
• Identifying bypassed oil through integrated subsurface description
Rumaila Field Redevelopment Plan

Three key business objectives:

- Increase production to an Initial Production Target
- Ramp up production to a Plateau Production Target
- Sustain plateau production
Early Cretaceous Stratigraphy and Palaeogeography

- Carbonate-dominated passive margin with periods of major clastic influx
- Zubair Fm. records one clastic influx
  - Uplift of Arabian shield to west
  - Rivers fed deltas to the east & pushed carbonates to the shelf-edge
- Overall retrogradational (back-stepping) marginal-marine sediments
- Final abandonment marked by return to carbonate deposition (Shu’aiba)

Davies et al., 2002

Aptian, 121.8Ma

Scotese, 2012
Early Cretaceous Climate, Waves and Tides

A) Climate zones based on lithology indicators

B) Present-day worldwide tropical cyclones: 1985-2005

C) Twice-daily tidal range based on paleotidal modelling

- Warm, wet, tropical climate
  - rapid hinterland weathering & erosion
  - high discharge rivers
  - abundant vegetation
- Generally low wind speeds and no storms expected given location on equatorial doldrums
- Amplification of twice-daily tides predicted across Arabian shelf
Core and Image Log Data Coverage

Core coverage by stratigraphy

Shu’aiba
Upper Shale
Main Pay
4th Pay

Zubair Fm.

N
S

Core

Image log (processed)

Image log (to be processed)
Core Processing, Description and Interpretation

Before – whole core, sometimes jumbled pieces

After – slabbed & resinated museum slices, better curation
Depositional Processes

- 1 km core systematically described on cm-scale
- Key observations:
  a) Common trough cross-stratified sandstones and syneresis cracked heterolithics – *fluvial processes often dominant*
  b) Double mud drapes and rhythmic laminae sets – *moderate tidal influence*
  c) Very rare wave structures (no HCS observed) – *limited wave influence*
  d) Small burrows, rare open marine ichnofauna; often brackish palynological signature – *stressed conditions (salinity, sediment influx)*
  e) Muds poorly preserved – palynology crucial to understanding setting
Image Log-derived Facies

Cm-scale features such as *lamination, cross-stratification, heterolithics, bioturbation, roots, coals and cemented horizons* can be picked out.

- **Laminated, rippled or structureless sandstone**
- **Cross-stratified sandstone**
- **Bioturbated sandstone**
- **Laminated, irregular or deformed heterolithics**
- **Cross-stratified heterolithics**
- **Bioturbated heterolithics**
- **Laminated mudstone**
- **Bioturbated mudstone**
- **Rooted mudstone, sandstone or heterolithics**
- **Coal**
- **Carbonate or carbonate cemented horizon**
Genetic Elements from Core & Wireline

All available data (*core lithotypes, image log facies, dips, wireline, palynology & stratigraphic position*) are integrated for genetic element identification.

<table>
<thead>
<tr>
<th>Gross Depositional Environment</th>
<th>Genetic Element</th>
<th>Description</th>
<th>Palynology</th>
<th>Wireline</th>
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<tbody>
<tr>
<td>Deltaic coastline</td>
<td>AB</td>
<td>Channel abandonment</td>
<td>Terrestrial</td>
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<td>FL</td>
<td>Floodplain</td>
<td>Brackish</td>
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<td>Delta Plain</td>
<td>CM</td>
<td>Coastal / deltaic marsh</td>
<td>Open marine</td>
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<td>MF</td>
<td>Tidal mudflat</td>
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<td>Delta Front</td>
<td>CH</td>
<td>Fluvial / distributary channel-fill</td>
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<td>SS / SF</td>
<td>Intra- / interchannel and coastal sandsheet and tidal sandflat</td>
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<td>MB</td>
<td>Mouthbar</td>
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<td>ID / L</td>
<td>Interdistributary bay; lagoon</td>
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<td>PD</td>
<td>Prodelta</td>
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<td>Non-deltaic coastline</td>
<td>USF</td>
<td>Upper shoreface</td>
<td>Palynology</td>
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<td>LSF</td>
<td>Lower shoreface</td>
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<td>Marine shelf</td>
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<td>Offshore transition zone</td>
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<td>OS</td>
<td>Offshore / Marine shelf</td>
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<td>Clastic-starved carbonate shelf (undiff.)</td>
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Palaeocurrents from Image Logs

Schematic distributary channel networks
Delta Advance-Retreat Cycles

- 30-50m scale delta advance-retreat cycles
- Identifiable in core, image logs and wireline
- Impact pressure stratigraphy and fluid zones
Correlation of Delta Advance-Retreat Cycles

- Two advance-retreat cycles identified in Main Pay
- Decrease in Net:Gross towards north consistent with northeastward depositional dip
Depositional model: Fluvial-dominated, tide-influenced delta

- Abandoned delta lobe undergoing tidal reworking
- Tropical vegetation on delta plain, especially around lagoons, marsh areas & tidal flats
- Fluvial-dominated mouthbars with sandflats inbetween
- Lateral amalgamation of distributary channel sands due to low accommodation space
- Very low-angle prodelta to offshore slope (<<1°); prodelta <5-10m water depth
- Tidal influence in distributary channels maintaining mostly straight channels
Summary and Forward Plan

- Early Cretaceous Zubair Fm. records the episodic advance-retreat of a fluvial-dominated, tide-influenced delta

- Close integration of detailed sedimentological core description, palynological analysis and wireline logs is critical for understanding reservoir layering at cm- to m-scale

- Image logs provide a highly valuable insight into the sedimentology of uncored wells; from facies analysis to palaecurrent directions

- Integration of the depositional model with formation pressure tests and fluid saturation data informs targeting of bypassed oil

Future work will include:
- Palynological analysis on cuttings samples
- Heavy mineral analysis and provenance study using historical cores
- Collection and analysis of more core
- Continued collection, analysis and integration of image logs
- Detailed field-wide mapping of genetic elements and shale barriers/baffles