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Maximum Reservoir Contact Wells

A new Generation of Wells for Developing Tight Reservoir Facies

by:
Salam P. Salamy-Saudi Aramco

SPE Distinguished Lecturer Series Program
2004 - 2005
Outline

- Evolution of MRC Well Concept
- Implementation: Expanding the Learning Curve
  - MRC Objectives and Designs
  - Results
- Impact on Unit Development Cost
- Summary
- Future Focus Areas- Way Forward!
World Growth of Horizontal Wells

- Annual Well Count
- Cumulative Wells


Annual Well Count vs. Cumulative Wells
Growth Of Horizontal Wells in Saudi Aramco
SHAYBAH FIELD

Shaybah Field Located in Rub’ al-Khali Desert, Saudi Arabia
Developed with Single-Lateral one Km Horizontal Wells in 1996.
Producing Formation the Shu’aiba
Low Permeability (Avg. 13 mD)


Size: 60 Km. X 15 Km.
Shaybah Horizontal Well Flow Profile

Average Production Profile

1Km horizontal well

- Heel: 40%
- Middle: 27%
- Toe: 33%

TD

85% of the Logged Section Showed Flow Contribution
Case Study: GOR Optimization
Horizontal Length Assessment

Cum Oil, MSTB

GOR, SCF/STB

3 Km
2 Km
1 Km

CUM OIL
Horizontal Wells PI as Function of Reservoir Contact – Shaybah Field
Shaybah Field Well Performance

Cum GOR Vs. Cum Oil as Function of Length

Delay Gas Breakthrough
Improve Oil Recovery
Evolution of Horizontal Drilling in Shaybah

- **1999 MP Wells**
- **2000 MP Wells**
- **2001 MP Wells**

- **1 Km Contact**
- **2 Km Contact**
- **3 Km Contact**

Reservoir Contact, Km
Maximum Reservoir Contact (MRC):

A well with an aggregate reservoir contact in excess of 5 kilometers via a single or multi-lateral configuration.
Drivers / Desired Results

- Unit Development Costs
- Unit Operating Costs
- Draw down at a given flow rate
- Water and Gas breakthroughs

Minimize

Maximize

- Long term performance
- Production rate / PI
- Sweep efficiency / Reserves
Challenges

- Safety
- Well Damage
- Cost
- Monitoring
- Reliability
- Complexity
- Control & Re-Entry
The New Architecture: Larger Foot Print

SHYB-753 (Fork)
7.9 Km

SHYB-220 (Hybrid)
12.3 Km

Offshore Carbonate (Fishbone)
7.8 Km

7" liner
### MRC Performance (South Shaybah)

<table>
<thead>
<tr>
<th>Well No.</th>
<th>Reservoir Contact, Km</th>
<th>PI B/D/PSI</th>
<th>Rate MBOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>377</td>
<td>3</td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td>378</td>
<td>5.8</td>
<td>82</td>
<td>8</td>
</tr>
<tr>
<td>379</td>
<td>3</td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td>380</td>
<td>8.5</td>
<td>105</td>
<td>10</td>
</tr>
<tr>
<td>381</td>
<td>3</td>
<td>67</td>
<td>6.5</td>
</tr>
<tr>
<td>Avg. 3-Km</td>
<td>3</td>
<td>39</td>
<td>4.0</td>
</tr>
</tbody>
</table>

**SHYB-380:**

2.5 Fold Increase In PI Compared to Average 3-Km Well
Fork and Fishbone Type Sidetracked in Open Hole

- The total depth: 16,026’
- Contact: 40,384’ (12.3 km)
- 12 MBOD

<table>
<thead>
<tr>
<th>Laterals</th>
<th>Length (ft)</th>
<th>ROP (ft/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MB</td>
<td>9,796</td>
<td>46.6</td>
</tr>
<tr>
<td>L-1</td>
<td>5,350</td>
<td>39.1</td>
</tr>
<tr>
<td>L-2</td>
<td>5,951</td>
<td>39.7</td>
</tr>
<tr>
<td>L-3</td>
<td>3,052</td>
<td>49.6</td>
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<tr>
<td>L-4</td>
<td>2,255</td>
<td>56.4</td>
</tr>
<tr>
<td>L-5</td>
<td>2,964</td>
<td>49.4</td>
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<tr>
<td>L-6</td>
<td>3,597</td>
<td>61.5</td>
</tr>
<tr>
<td>L-7</td>
<td>2,537</td>
<td>59.0</td>
</tr>
<tr>
<td>L-8</td>
<td>4,882</td>
<td>76.9</td>
</tr>
</tbody>
</table>
## MRC Performance (South Shaybah)

<table>
<thead>
<tr>
<th>Well No.</th>
<th>Reservoir Contact, Km</th>
<th>PI B/D/PSI</th>
<th>Rate MBOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>220</td>
<td>12.3</td>
<td>126</td>
<td>12</td>
</tr>
<tr>
<td>219</td>
<td>2</td>
<td>26</td>
<td>3</td>
</tr>
<tr>
<td>207</td>
<td>1</td>
<td>17</td>
<td>2</td>
</tr>
</tbody>
</table>

**SHYB-220:**
- 6 Fold Increase in PI and Rate Compared to 1-Km Well
PI /Rate Vs. Reservoir Contact

- **Reservoir Contact, Km**
  - 1.0
  - 2.0
  - 3.0
  - 5.8
  - 8.5
  - 12.3

- **PI, bbl/day/Psi**
  - 0
  - 20
  - 40
  - 60
  - 80
  - 100
  - 120
  - 140

- **Rate, MBOD**
  - 0
  - 2
  - 4
  - 6
  - 8
  - 10
  - 12
  - 14

Legend:
- **PI, STBD/Psi**
- **Rate, MBOD**
Other Field Examples-MRC Wells

- Onshore Carbonate Reservoir
- Offshore Carbonate Reservoir
Onshore/Carbonate Reservoir

MRC Application
MRC Well Results- PI and Rate Test

Onshore MRC Well Performance

- PI=40 b/d/psi
- PI=85 b/d/psi

Production Rate, MBOD

Offset Horizontal

MRC Well

PI=40 b/d/psi

PI=85 b/d/psi
Offshore/Carbonate Reservoir
- Tested: 14.0 MBOD
- Production Rate:
  - MRC: 10 MBOD
  - Off-set 1 Km: 3 MBOD
Outline

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  - Results
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- Future Focus Areas - Way Forward!
Extra versus Intra Reservoir Drilling Time

1-Km SHYB-257

- Extra Reservoir: 71%
- Intra Reservoir: 29%

MRC 8.5 Km SHYB-380

- Extra Reservoir: 26%
- Intra Reservoir: 74%
Extra versus Intra Reservoir Unit Cost

- Extra Reservoir: 38%
- Intra Reservoir: 62%

1-Km SHYB- 257:
- Extra Reservoir: 32%
- Intra Reservoir: 68%

MRC 8.5 Km SHYB- 380:
- Extra Reservoir: 38%
- Intra Reservoir: 62%
Summary

✓ MRC Wells mark the beginning of a new era.

✓ The experience to date is limited but promising. Over 25 MRC wells have been drilled to-date.

✓ Primary Beneficiaries: Tight-facies.

✓ Opportunities: Medium & High Quality Reservoirs.

✓ MRCs combined with Intelligent Well Technologies will reduce costs.

✓ Drill bit: Tool for modifying Reservoir architecture - Knowledge Management Tool.

✓ Guidelines and Best Practices to Ensure Proper Implementation.
Future Focus Areas- Way Forward

- Formation Damage: Prevention over Remediation
- Reducing Cost Smart/Intelligent Wells
- Appropriate Integration of New Technologies: Solution Oriented vs. Application
THANK YOU