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“Intelligent Wells”
A Realistic Vision for the Next 10 Years!

Younes Jalali
Schlumberger

Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl
Topics

• i-wells, brief description

• 2 Scenarios for 2010-2020
i-wells -- Key Idea

Flow control that is both selective and non-invasive is key to an i-well; monitoring is also important.

Selective Control
(Downhole @ Reservoir Level)

Non-Invasive Control
(Intervention w/o Borehole-Entry)
Control – Activation Type

Production Packer & Control Line

Flow Control

GAS

OIL
Control – Activation Type

Flow Control

OIL

Flow Control

OIL
Control – Non-Activation Type

Liner Completion (no control)  ICD* Completion (selective control)

*ICD – inflow control device.
i-well Configurations...

Ellipses represent distinct flow units or formations.
An Emblematic Field
2010-2020

A. “Low-Hanging” Scenario

B. “High-Hanging” Scenario
Scenario A

- Within reach
- Already underway
- Focus on offshore & producers
  - **Horizontals**: exciting developments
  - **Non-Horizontals**: business as usual
Horizontal Drilling & Measurements

Boundary & Mobility Logs*

*DTBB – distance to bed boundary, based on directional deep resistivity measurements
*FTWD – formation testing while drilling, spot measurements of pore pressure & mobility
Pay Thickness Estimation

![Graph showing relative frequency of pay thickness values](image-url)
Permeability Estimation

Petrophysics & Mobility Log

- Porosity Log
- Water Saturation Log
- Mobility & PP Points

Inferred Permeability Log

- Calculated permeability from model (\(\mu_i=0.5\))
- Calculated \(k\) from model 1
-Mobility from mobility

Permeability Distribution
Productivity Estimation

*Zhang et al (EAGE 9020) – Well Productivity Estimation during Drilling
Drilling Decisions

- Cumulative Probability: 75%
- Reservoir Footage: 10\(^3\) ft
- PI Target
- Bit Point
- Min Footage Requirement
- Footage for 100% Cumulative Probability
Completion Risks (1/3)

pore pressure profile*

Depletion, Risk of Crossflow

*Frank et al (SPE 87091)
Completion Risks (2/3)

High Mobility, Risk of Water Entry

Mobility (mD/μp)

Measured Depth, 1000 ft

Pore Pressure (psia)

Water Sat.

Porosity

Measured Depth, 1000 ft
Completion Risks (3/3)

*bed boundary profile*

Pinchout, Risk of Untapped Oil @ Toe

TVD, ft

Measured Depth, ft

Top

Base

“pinchout”
De-Risk the Completion

Drilling Measurements

No Risk Factor
Completion w/o i-Control

Risk Factor
Completion w/ i-Control

completion decisions during drilling, imperative!
De-Risk Platform

- Interactive Analysis Tools
- Domain Experts
- Connectivity Real-Time
- Drilling Measurements

“Time-Critical Analysis”
De-Risk Drilling & Completion // Speed & Accuracy Key
Scenario B

- Harder to reach
- Need a good “tailwind”
- Tailwind inevitable, timing uncertain
The Tailwind

- **2010** ~ 85 million bpd (current global oil demand)*
- **2020** ~ 95 million bpd (projected demand, OPEC Ref. Case)**
- **Gap** ~ 10 million bpd (old fields, new fields, heavy oil, condensates)
- **i-well focus shifting to Giants & Injection**

*US DOE / EIA (JPT, Aug. 2010, p.6)

**OPEC, World Oil Outlook, 2009, p. 159.
Early Indications

World Liquid Fuels Consumption

- Total consumption
- Annual growth
- Forecast

Source: Short-Term Energy Outlook, August 2010
Importance of Top-100

Maturity of Top100

Top100 Field from 1940s

Top 100 Field from 1970s

Ref: http://en.wikipedia.org/wiki/Ekofisk_oil_field
Criticality of Injection

• Hard to control, hard to monitor
• Achilles’ heel of Res. Management
• Sweep efficiency – key metric
• Intelligent injection, a necessity
Injection – Single Layer

Water Injector with Distributed Temperature Sensors (DTS)
But no Flow Control

Bui et al (SPE 89924)
Injection – 2 Layers

Gajraj et al. (SPE 74392)
Injection – 3 Layers

Without Flow Control: Two 3½” Tubing Strings

With Flow Control: One 4½” Tubing String

Gajraj et al (SPE 74392)
Injection – WAG

WATER Cycle (60 days)

GAS Cycle (40 days)

Identical Layers

Gajraj et al (SPE 74392)
Final Remark

At this juncture, with 10 yrs of i-well accomplishments & history, competitive advantage with i-wells can be derived only through 2 avenues (under-explored):

– Intelligent Drilling

– Intelligent Injection
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