Underbalanced Drilling

14 May 2015
Agenda

• Drilling overview
• Underbalanced Drilling
  – What is it?
  – Why to drill UBD?
  – Evaluation Criteria
  – Equipment
  – Well Control
• Case Study
Conventional Drilling
What is Underbalanced Drilling?

\[ P_{\text{reservoir}} > P_{\text{bore hole}} \]

- Low weight Drilling Fluid
  - Naturally
  - Induced
Comparison

\[ P_{\text{reservoir}} < P_{\text{bore hole}} \]

\[ P_{\text{reservoir}} > P_{\text{bore hole}} \]
What is Underbalanced Drilling?

\[ P_{\text{reservoir}} > P_{\text{bore hole}} \]

- Low weight Drilling Fluid
  - Naturally
  - Induced

- Control
Why to Drill Underbalanced?

- To maximize hydrocarbon recovery
  - Reduce formation damage
  - Produce earlier
  - Increase reservoir knowledge
  - Enhanced oil recovery
Why to Drill Underbalanced?

- To minimize P related drilling problems
  - Differential sticking
  - Minimal fluid losses
  - Improve penetration rate
Why to Drill Underbalanced?

• To minimize P related drilling problems

“Chip hold down effect”
Underbalanced Drilling

**COST**

- OBD
- **UBD** +30%

**PRODUCTION**

- OBD
- **UBD** 300%

UBD is another tool in the box, not a Panacea
Limitations

• Technical
  – Wellbore stability
  – Water inflow
  – Directional drilling
  – Unsuitable reservoir

• Economic
  – Equipment
  – Personnel

• Expertise
Evaluation Criteria

• Determine BHP requirements
  \[ P_{\text{reservoir}} - P_{\text{drilling fluid}} > 200 \text{ psi} \]
Evaluation Criteria

• Identify the drilling fluid system
  – Gas-air
  – Gasified Fluid
  – Stable Foam
  – Drilling Fluid
Evaluation Criteria

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Evaluation Criteria

• Determine BHP requirements
• Identify the drilling fluid options
• Well design and modelling
  – Fluid (Compressibility)
  – Cuttings removal
  – Formation inflow
  – Rock integrity
Evaluation Criteria

• Determine BHP requirements
• Identify the drilling fluid system
• Well design and modelling
• Select the surface equipment
  – Productivity -> Capacity at surface
Case Study

- On-shore, New Mexico, 20 June 2006
- Spud date 17 May 2006
- Overbalanced drilling until @ 9,471 ft
- Expected formation pressure is 5,000 psi
- Drilling underbalanced 300 psi
- Hydrostatic pressure used was 4,700 psi
- Mud weight: 9.5 ppg, diesel based
Case Study

- Highly permeable formation with large fluid losses expected
- Objective was to avoid economical losses due to the loss of drilling fluids and excess rig time
- Objective to prevent differential sticking of drill pipe
Case Study

- Drilling system: jointed pipe
- No gas generation equipment because the chose liquid system: diesel
- Rotating head
- Basic mud gas separation
- Gas production sent to flair
Well site
Surface Equipment

- Drilling System
- Well control equipment
- Gas-generation equipment
- Surface separation equipment
Drilling System

– Jointed Pipe drilling
– Coiled Tubing
Snubbing Unit
Rotating Head
Downhole Equipment

- Pressure-While-Drilling (PWD) sensors
- eMWD tools
- Non return valves
- Deployment valves
Downhole Equipment

- Deployment valves
Well Control Mechanisms

Barrier
Primary
Secondary

OBD
Hydrostatic P
BOP

UBD
Flow + P*
BOP

PRESSURE CONTROL
FLOW CONTROL
Well Control Mechanisms

FLOW CONTROL
Well Control Mechanisms

OBD
- Hydrostatic (Dynamic)
- Friction (Dynamic)
- BOP

UBD
- Hydrostatic (Passive)
- Flow and pressure control Friction (Dynamic)
- Choke Pressure

PRESSURE CONTROL

FLOW CONTROL

Gas Injection Rate

Pressure
Due Diligence

• Underbalanced
  – “… that method of drilling whereby the terrastatic pressure exceeds the pressure exerted by the drilling fluid column in the bore of a well.”

• Producing While Drilling
  – “… those methods of drilling whereby the formation fluids are deliberately allowed in the bore of a Drilling Well and thence removed to the surface while … Drilling activities are continued …”
Conditions

I. “… a blowout preventer configuration including one rotating head …”

II. “… any sources of ignition are removed … from any area … which operations are being conducted …”

III. “all oil/gas separators … will be placed at a safe distance from the drilling rig …”
Case Study

- On 20 June 2006 at 10,427 feet
- Well flowing in uncontrolled manner. Expected Pressure: 300 psi
  Actual Pressure: 800 psi
- Casing annular shut and killing operation began with 10.7 ppg mud.
- Gas bubble came in annular and Pressure increased to 2400 psi POP
- Casing burst, Gas leaked at surface
Case Study

- Failure on the rotating head caused a gas build up in the annular.
- Well control: increased drilling fluid to 11.2 ppg
- 25 June 2006 finally killed the well
Case Study

- Remedial measures
  - Located the burst section and squeezed
- Remedial Casing 7 in and then continued with plan UBD section
- Claim: 3.5 MM
- Deductible: 250 k
Increased Risk?