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A Twenty-Five Year Perspective on Use of Pressure Transient Analysis

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What’s in the Title?

• Twenty-five Years
1983
Tektronix 4014
Pressure Analysis
Workstation
PAWS
Cost 72,000 USD
Log-Log Diagnostic Plot
Bourdet 1983

What’s in the Title?

• Twenty-five Years

• Use of Pressure Transient Analysis (PTA)
  – This lecture illustrates how we have used PTA in the last 25 years. By understanding that, you can use this technology better in the future.
The Three Big Questions

• Why do we do it?
• How can we do it better?
• What’s the big picture?
Why Do We do Well Tests?

- Fluids - (gas or oil, PVT, surface processing issues, pipeline design)
- Rate - Reservoir (permeability)
- Rate - Completion (skin, length, conductivity)
- Continuity - (compartments, drainage area, nearby boundaries)
Continuity Well Testing
Thin-Beds Tahoe

127 hrs. of infinite-acting radial flow
Skin Analyses on Gulf of Mexico Wells
Skin Analyses on Gulf of Mexico Wells
Another observation probe possible at 4.5 or 7m

Observation while Producing

Producing Interval
Distribution of Perm, 53-ft Thickness, $K_{avg} = 106$ md

Distance from well(ft)

Red – Producing Zone
Gray – Observation Probes

- **17280 ft:** $K^H = 370$ md-ft, $K = 25$ md
- **17290 ft:**
- **17300 ft:** $K^H = 1050$ md-ft, $K = 66$ md
- **17310 ft:** $K^H = 2200$ md-ft, $K = 275$ md
- **17320 ft:**
- **17330 ft:** $K^H = 1970$ md-ft, $K = 141$ md
Practical Deconvolution

Fig. 1. Test Example 1. Pressure (markers) and rate data

Fig. 2. Test Example 1. Comparison of deconvolved responses derived from PBU 1 (red) and PBU 2 (blue) pressure data using the initial reservoir pressure of 6314.3 psi.

Fig. 4. Test Example 1. Comparison of deconvolved responses derived from PBU 1 and PBU 2 pressure data using the initial reservoir pressure of 6319 psi.

SPE 90680 by M. Levitan, et al.
How does Perm-Thickness Change?

K*H reduction more severe than lab data. Probably loss of H.
What is a horizontal well?
Varying Numbers of Beds in 88-degree Slant Well

Early Radial Flow

Pseudo-Radial Flow

Linear Flow

SPE 104480 by P.S. Fair
What is a horizontal well?
Varying Numbers of Beds in 88-degree Slant Well

SPE 104480 by P.S. Fair
Summary and Conclusions

• Why do we do it?
  – Pie chart – 21-test 1993-lookback
  – Continuity test - thin beds
  – Skin distributions

• How can we do it better?
  – Permanent downhole gauges for well and reservoir management
  – Wireline Formation Tester – cheaper, safer, and greener but more information
Summary and Conclusions

• What’s the big picture?
  – PTA results versus petrophysical lab perm data
  – Geological layering for accurate interpretation of horizontal wells

• Most examples are from Gulf of Mexico but principles are universal.
Backup & Extras
Estimation of PTA Perm from Petrophysical Data
Rationales for Exploratory and Appraisal Well Tests

- Rate Reservoir: 6
- Continuity: 4
- Fluids: 8
- Rate Completion: 3

1993 Shell Case Studies
Optimal Value Testing
What is it?

• Fit for purpose with lowest cost and HSE impact
• Any test where hydrocarbons are not produced directly to surface
  • New in toolbox
    ★ Wireline formation test
      – Closed system test
      – Injection test
Comparison of Permeability Estimates

Percentage <= X-value

Ratio of PTA Perm to Petrophysical Perm

Sequential BU’s Showing Loss of H Acids Jobs

- Perm-Thickness (md-ft)
- Years since Start of Well
- K*H
- Skin

Acid Jobs
Pseudo-Skin Factors for Slant Wells

SPE 104480 by P.S. Fair
Holistic Well Testing

- All of the input data
- All of the gauges
- All of the build-up
- All of the build-ups
- All of the production history
- All of the non-well test data
  - Operational
  - Petrophysical
  - Geological