Reservoir Engineering Aspects of Unconventional Resources

Pressure Transient Analysis (PTA):
Identifying Practical Aspects of Time-Pressure Analysis Including Flow Regime Diagnostics

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Reservoir Pressure — Value Proposition

Discussion:
- Characterize reservoir performance without wellbore pressure effects.
- Diagnose offset behavior. *(i.e., "well-to-well fracture interaction" ("frac-hits"))*
- Diagnose production interference. *(... induced or natural fractures, faults, etc.)*

Rate and pressure functions vs. time, multi-well interference. *(Source: SPE 187180)*

Rate and pressure functions vs. time, Examples of "Frac-Hits." *(Source: URTeC 2670079)*
Reservoir Pressure — Influence of Uncertainties

Discussion:
- Wellbore phase segregation → bias in surface pressures (shut-ins).
- Surface pressure issues. (... temperature compensation, operations, etc.)
- Location of pressure sensor. (... the wellhead, "before the curve," etc.)
- Mechanical issues. (... e.g., downhole gauges not properly set, leaks, etc.)

\[(p_{t1})_{\text{meas}}, (p_{w1})_{\text{meas}}, \text{ and } (T_{t1})_{\text{meas}} \text{ vs. time,}
\]

(Source: IJGGC 2013 (Liebscher))

\[(p_{t1})_{\text{meas}} \text{ and } (T_{t1})_{\text{meas}} \text{ vs. time.}
\]

(Source: PETSOC-97-35)
**Reservoir Pressure — Implications of Errors and Inconsistencies**

Discussion:
- **(inconsistencies)** $p_{tf}$ influenced/biased by operational practices.
- **(inconsistencies)** Downhole measurements less affected by operations.
- **(errors)** Gauge failure (rare) or gauge losing calibration (uncommon).

Rate and pressure functions vs. time.
(Source: URTeC 1934785)
**Reservoir Pressure — Need to Continuously Monitor Reservoir Pressures**

**Discussion:**
- Surface pressures \( (p_{sf}) \) necessary for operations and choke management.
- \( p_{sf} \rightarrow p_{wf} \) conversion has uncertainty that may bias analysis/interpretation.
- The clarity and resolution of \( p_{wf} \) data make these data **essential**.
- \( p_{wf} \) data represent the "ground truth" for the in-situ reservoir pressure.

Comparison: \( (p_{wf})_{meas} \) and \( (p_{wf})_{calc} \) vs. time. (Source: SPE 178608)
Discussion: Marcellus PA Cases (normalized to similar derivative shape)

- Very strong grouping for all three wells — unique character.
- Grouping = \( f(\text{permeability, well completion, fracture conductivity}) \).
- 3 (three) wells shown in this collection.
Discussion: Montney PTA Cases (normalized to similar derivative shape)
- These trends are grouped according to derivative character.
- Grouping = $f$(permeability, well conditions, fracture conductivity).
- Note that each shape has at least 2 wells that make up that group.
Time-Rate-Pressure Analysis — PTA (SPE 145463 (Mayerhofer))


a. Gas production rates and flowing tubing pressures show communication between the two wells.

b. First post-frac buildup (final interpretation with dual-porosity slab interpretation and DFIT matrix permeability).

c. Second post-frac buildup after 5 months of production affected by Well 1H offset production (dual-porosity slab interpretation with DFIT matrix permeability).
PTA Cases in Bakken (Oil Shale) [SPE 162473 (Kurtoglu)]
Reservoir Pressure — Quantifying Pressure Interference (SPE 191407)

Pressure response due to Well 3H being "put-on-production" (or POP'd).

Chow Pressure Group (pressure derivative function)
For all for 4 wells due to Well 3H being "POP'd."

Pressure interference response in Well 4H.
(due to Well 3H POP)

Pressure interference response in Well 6H.
(due to Well 3H POP)

Pressure interference response in Well 5H.
(due to Well 3H POP)