

BRAND NEW

whitson

Pressure Transient Analysis in whitson⁺

Hamid Behmanesh
Course held Virtually
26 February 2026



Meeting Logistics



80+
PARTICIPANTS

MS Teams
*everyone
muted*



3 hrs
PRESENTATION

We are
recording!



QUESTIONS

Ask questions
in Q&A chat
box

One web-based solution for

Software Platforms

Access cutting-edge, web-based tools designed to empower petroleum engineers – anywhere, anytime.

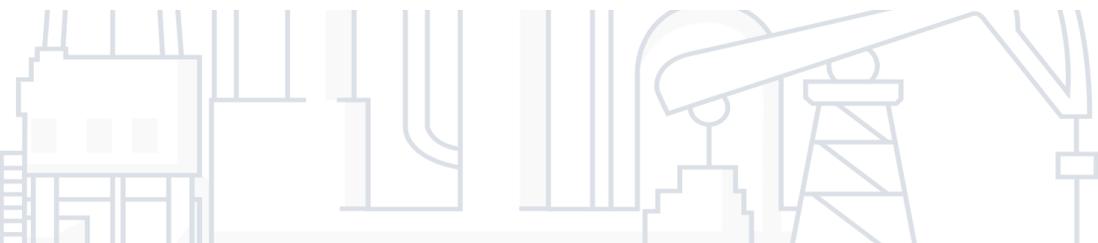
whitson⁺ +

whitson^{PVT} +

whitson^x +

whitson^{lite} +

SNAP +



whitCanada2026

Returning to Calgary this March, expect a focused half-day of real-world case studies from industry expert, networking, and the kind of honest conversations that only happen when the whitson User Community gets together in person.

→ Register

Registration Filling Up: whitCanada

Graciously hosted by our friends at CNRL, this afternoon is a great mix of technical content, presentations from industry experts, and catching up with folks across the community.

 Monday March 16

 12 - 4 pm

 CNRL Conference Centre

 Presentation line up and registration [here](#)



whitCanada2026

Monday March 16, 2026

Graciously hosted by our friends at



Join us for a full afternoon of learning, connection, and insights at whitCanada – here's what's on the agenda:

12-1 PM: Lunch & networking

1-4 PM: Presentations from industry experts

4-6 PM: Happy hour



<https://whitson.com/news/news-whitcanada-2026-in-calgary/>

Professional Development Courses

whitson weekly

Professional Development Courses

Free for our whitson User
Community 😊

Jan 22: Comparison Plots – [Recording](#)

Feb 12: PVT & Phase Behavior – [Recording](#)

Feb 26: Conventional PTA – [sign up](#)

Mar 25: Nodal Analysis – [sign up](#)

Apr 23: Bottomhole Pressure – [sign up](#)

May 7: DCA & Type Wells – [sign up](#)

Jun 24: Analytical & Numerical RTA – [sign up](#)

Aug 19: Flowing Material Balance – [sign up](#)

Sept 24: Numerical Model – [sign up](#)

Oct 15: Nodal Analysis – [sign up](#)

Oct 29: Electric Submersible Pumps – [sign up](#)

Nov 4: Well Tests (CPG, DQI & DFIT) – [sign up](#)

Nov 19: Gas Lift Design – [sign up](#)

Dec 2: DCA & Type Wells – [sign up](#)

Need help: reach out to **Jessica Parsons:** jessica@whitson.com

Need Course Certificate?

whitson

John Doe

has successfully completed

RTA in whitson+

1/2-day Course held Virtually
14 July 2022

Mathias Lia Carlsen

Mathias Lia Carlsen
GM Americas
www.whitson.com

CERTIFICATE OF ATTENDANCE

whitson

Certification

- 1 RTA
- 2 Type Well
- 3 Nodal
- 4 Well Test
- 5 BHP
- 6 Comparison Plot

https://manual.whitson.com/onboarding/certificate_rta/



whitson
Support

Less than 2-minute response time—every ticket, every time!

Software

What we will Cover!

- **whitson⁺** and **PTA** basics
 - Login & Access
 - Workflow (“Clicking the buttons”)
 - General structure and functionality
- **The course has an PTA Focus primarily:**
 - Drawdown Buildup

Open whitson+

courses.whitson.com

Login: Email you registered with

PW: whitsonPTA2026

*Send an e-mail to support@whitson.com if you need help to login.

Introduction

Get the fundamentals down, and the level of everything you do will rise -Michael Jordan



Well Testing

Conventional vs Unconventional

Type of Well Tests

Pressure Transient Analysis (PTA)

Controlled changes in flow rate are imposed on the well

Rate Transient Analysis (RTA)

Uses long-term production rate and pressure data

Modern RTA methods incorporate flowing pressure and transient flow theory

Deliverability Testing

Evaluates the production capacity of a well

Gas wells

Determine IPR/AOF and flow performance relationships (turbulence)

Unconventional Testing

DFIT, pressure interference

Pressure Transient Analysis, PTA

PTA deals with:

- Analyzing pressure vs. time

- Using derivatives

- Identifying flow regimes

- Estimating: k , S , WBS, boundaries ...

It is heavily mathematical:

- Diffusivity equation

- Laplace-space solutions

- Superposition

- Dimensionless variables

In short:

PTA = solving the pressure response of the diffusivity equation.

Well Test Interpretation, WTI

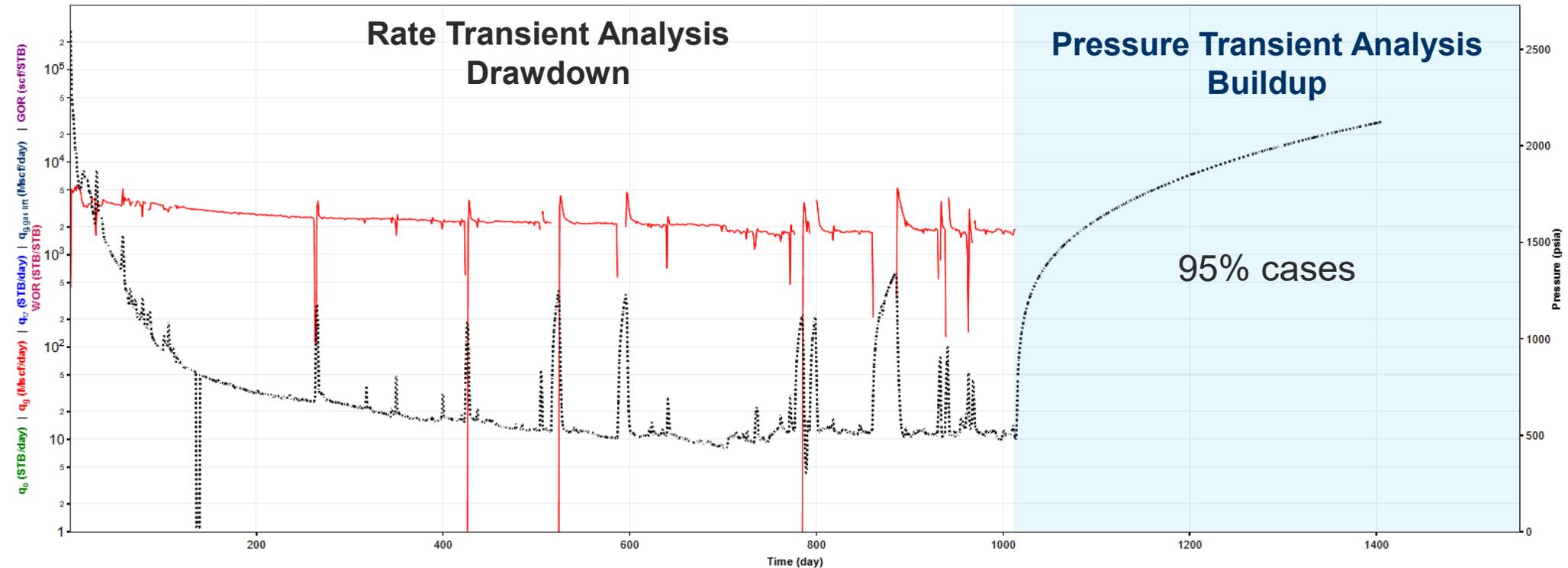
WTI deals with:

- Well Test Interpretation
- Data quality control
- Gauge drift
- Phase redistribution
- Multiphase effects
- Wellbore storage distortion
- Operational context
- Shut-in duration
- Understanding well physics
- Fracture geometry
- Fracture conductivity degradation
- Stress-dependent permeability

In short:

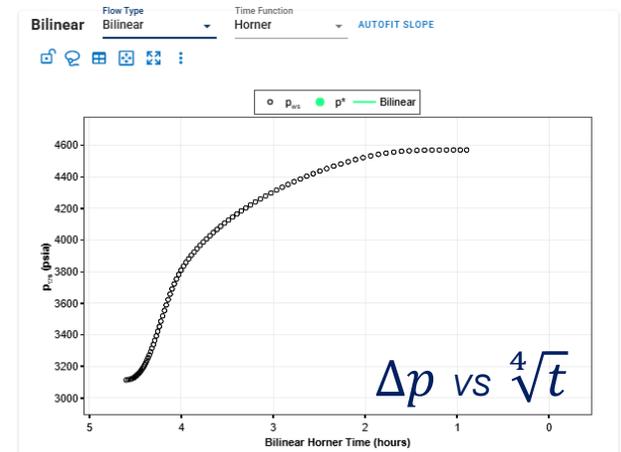
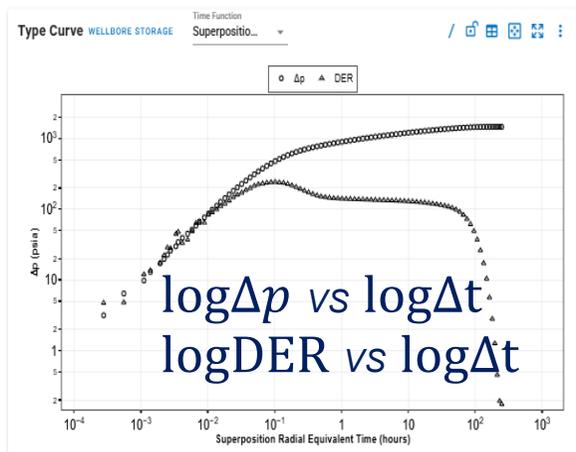
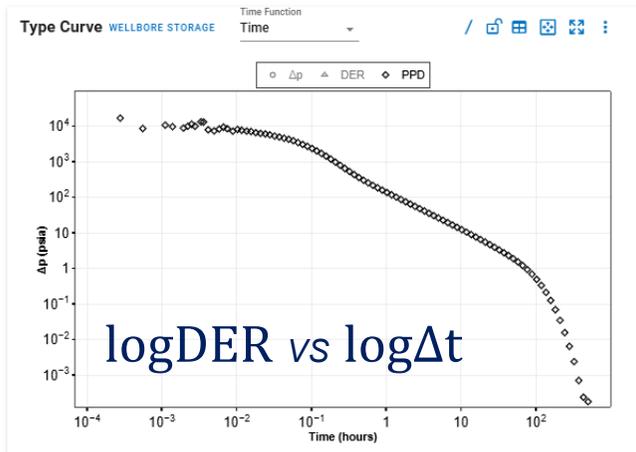
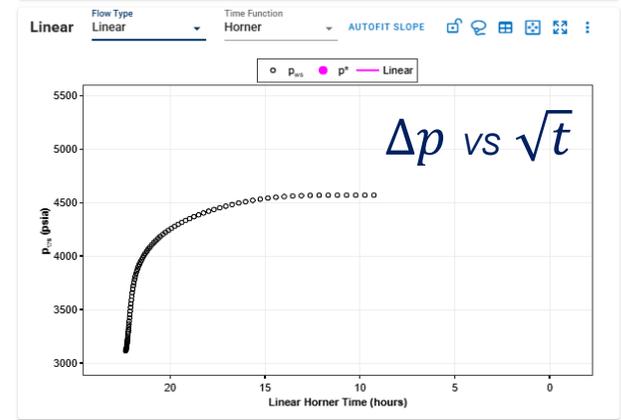
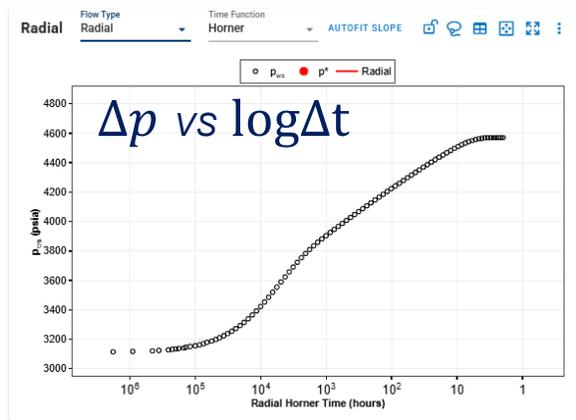
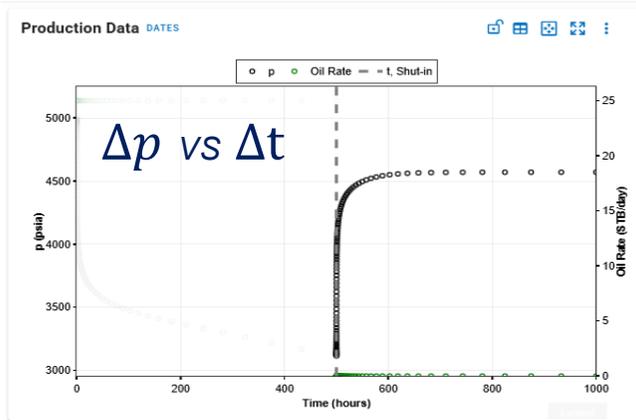
WTI = understanding actual well and reservoir behavior

Type of Well Tests



Much better-quality data
 k , damage/stimulation, boundary, p_i

Type of Well Tests



Type of Well Tests

Nature in charge



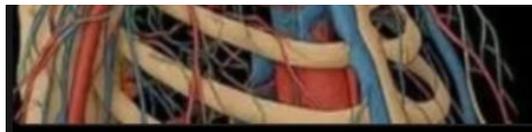
To: ☒ Whitson Issue Tracker; **+1 other**

Cc: ☒ Whitson Support

Hey

The reason the software shows that you need to upload production data is because two days is a very limited period. To perform the PNR DCA calculations, Whitson requires at least three production data points.

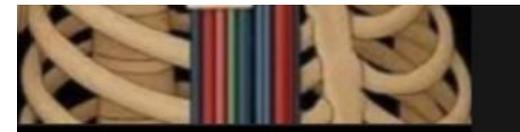
Let me know if you have any questions! 😊



Engineer in charge



Wed 11/5/2025 2:11 PM



Engineers Love Straight Lines

Type of Well Tests (PTA)

Single-Well Pressure Transient Tests

Drawdown, Buildup, Multi-Rate, Step-Rate, Injection, Fall off

Boundary and Reservoir Connectivity Tests

Reservoir Limit, Interference, Pulse

Exploration and Formation Evaluation Tests

Drill Stem Test, Repeat Formation Test

Other Tests

Static/Flowing Gradients, Acoustic Well Sounder

Type of Well Tests (PTA)

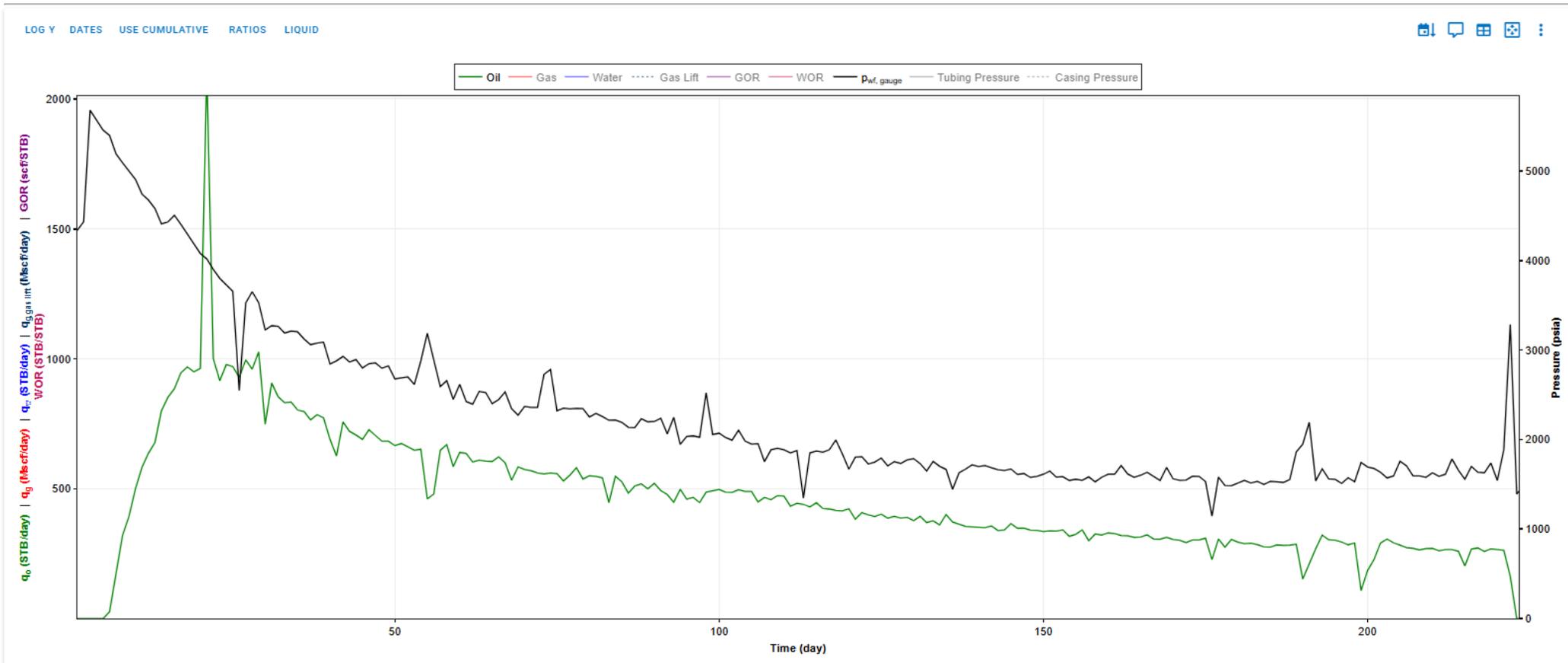
The cost of a good test is visible.
The cost of a poor test is hidden — and much larger.

Pressure transient testing requires shut-in time, operational coordination, and deferred production — all of which have cost.

However, a poorly designed test leads to non-diagnostic data, ambiguous interpretation, and potentially incorrect reservoir decisions — which can cost orders of magnitude more.

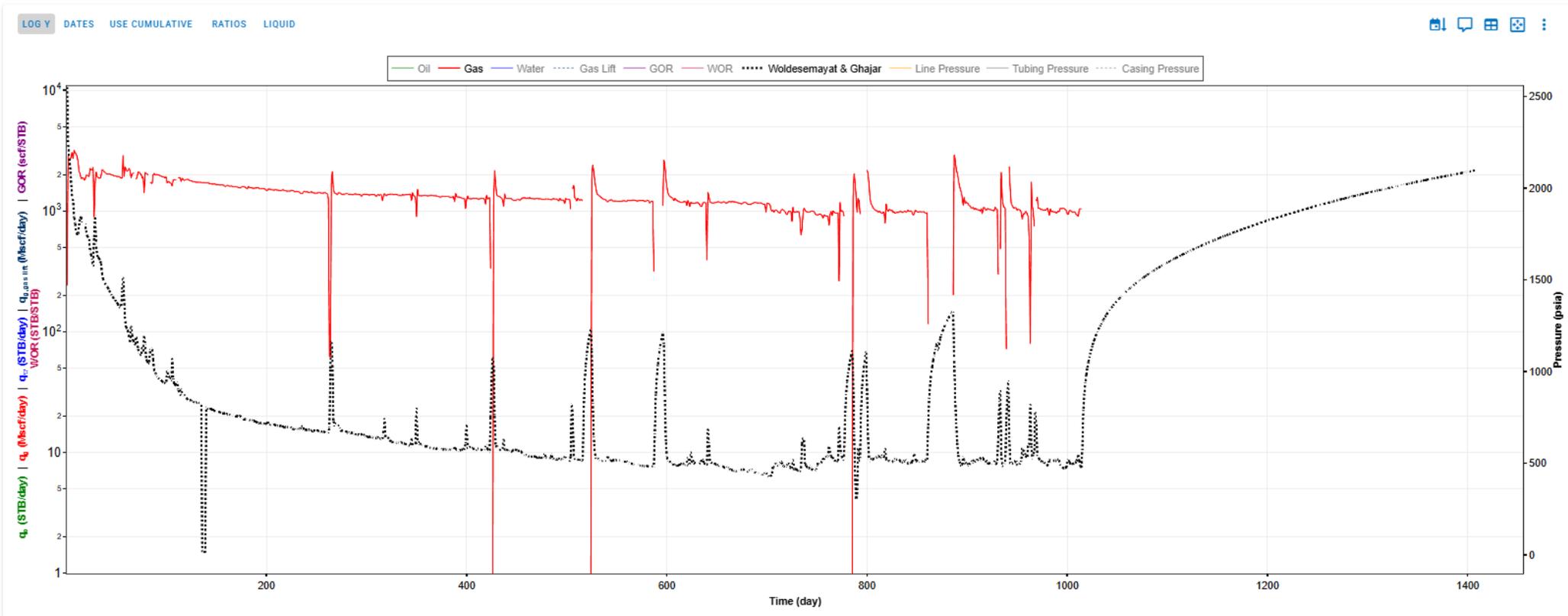
Type of Well Tests (PTA)

Drawdown



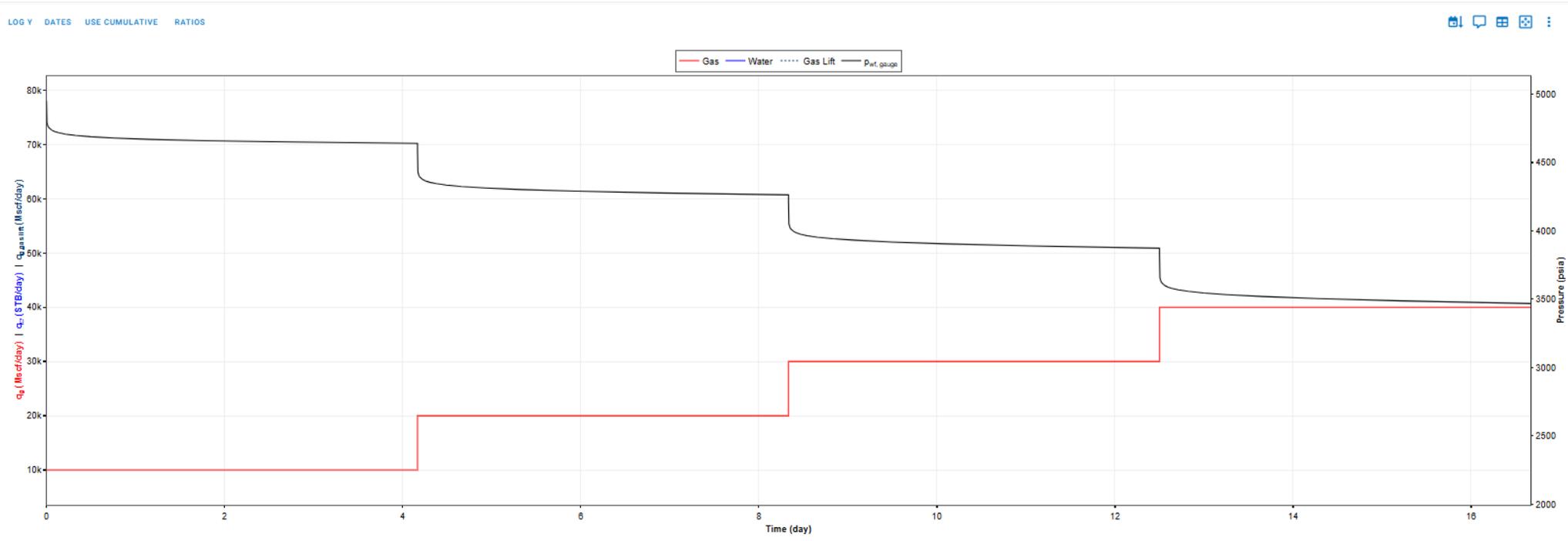
Type of Well Tests (PTA)

Buildup



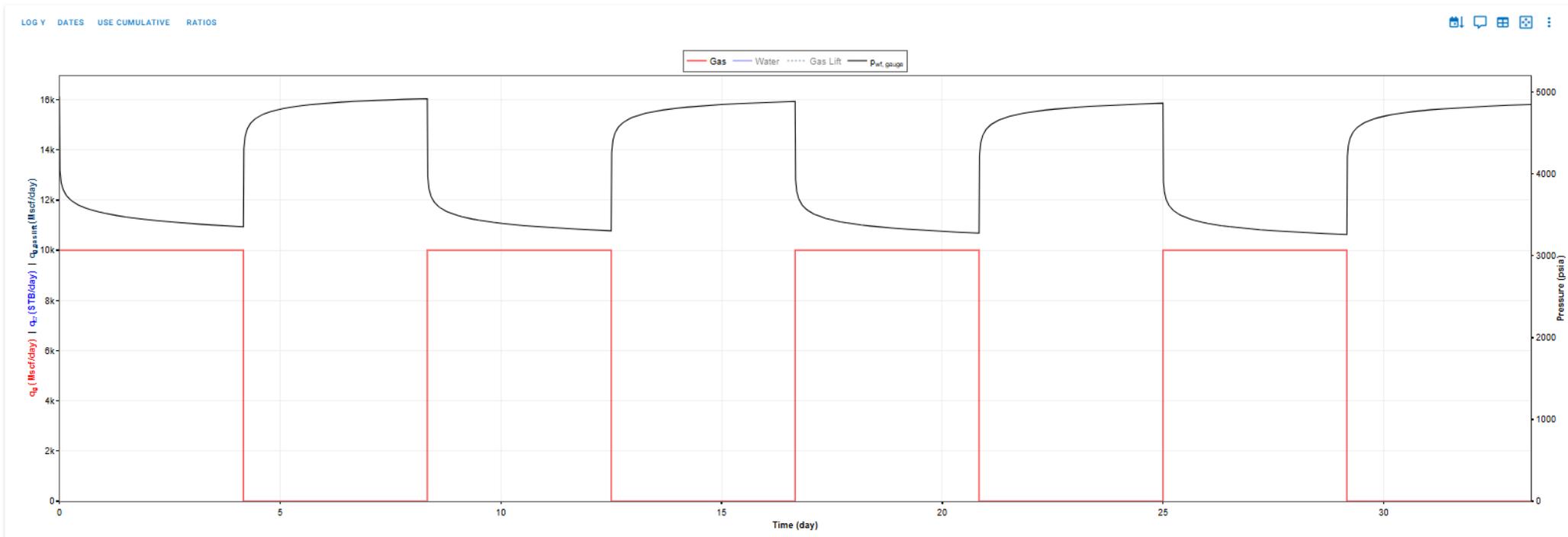
Type of Well Tests (PTA)

Multi-rate Test



Type of Well Tests (PTA)

Pulse Test



Well Testing

Objectives

Objective: Well Productivity

Problem Statement:

Two oil wells, Well A and Well B, are producing at the same rate of 500 STB/D under similar drawdown conditions. Both wells are completed in reservoirs containing identical original oil in place. At first glance, they appear equally valuable. **But are they?**

$$q_o = \frac{kh(p_R - p_w)}{141.2\mu_o B_o \left[\ln\left(\frac{r_e}{r_w}\right) - 0.75 + S \right]}$$

Well Test Application:

With a properly designed injection test (Drawdown/Buildup), we can determine

Reservoir permeability

Skin factor

These parameters define well productivity.

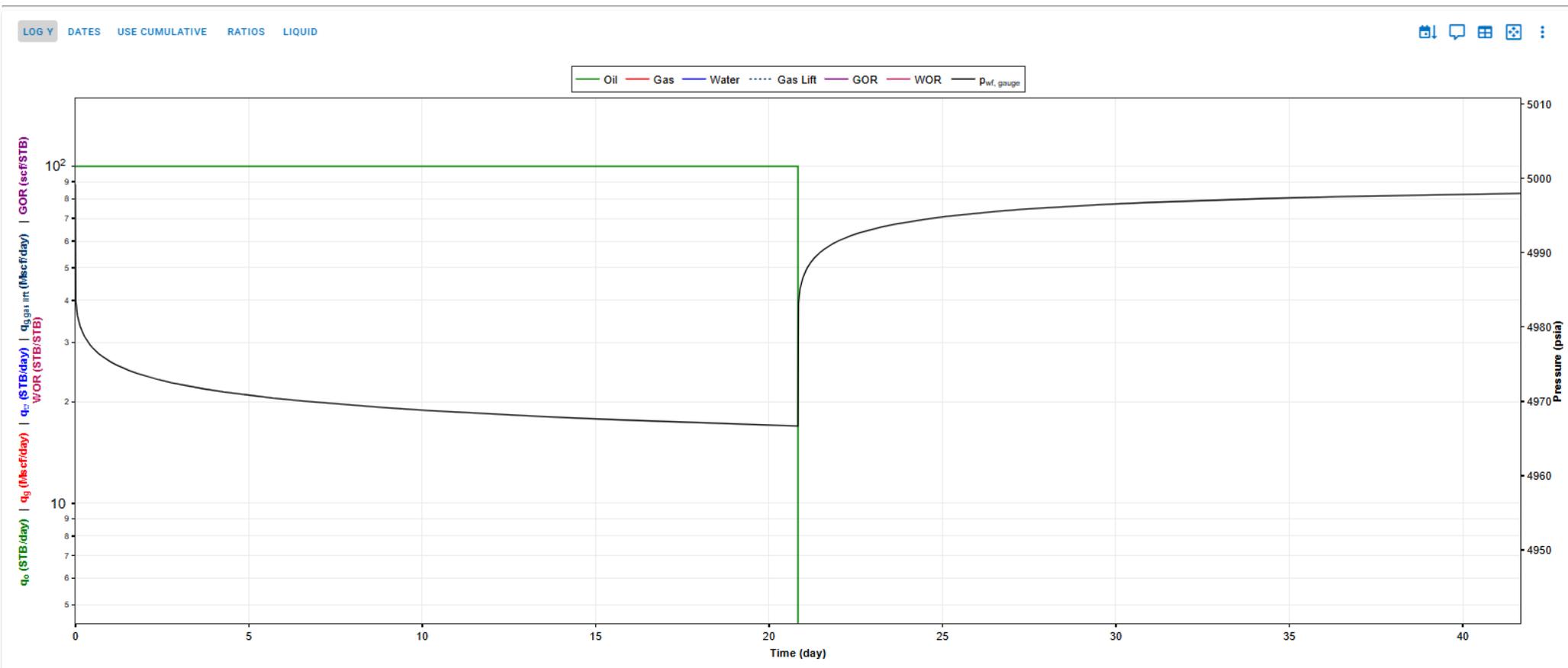
Long-term recovery potential

Economic value of the asset

Objective: Well Productivity

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Two oil wells, Well A and Well B, are producing at the same rate of 500 STB/D under similar drawdown conditions. Both wells are completed in reservoirs containing identical original oil in place. At first glance, they appear equally valuable. **But are they?**



Objective: Well Injectivity

Problem Statement:

An aquifer is being considered for **CO₂ sequestration** (or water disposal). The formation appears thick, laterally extensive, and volumetrically large. A target injection rate of **5,000 bbl/day** (or equivalent CO₂ rate) is required for the project to be viable.

Can the formation sustain this rate?

What surface pressure will be required?

Will injection exceed fracture pressure?

Is the formation suitable for long-term containment?

Well Test Application:

With a properly designed injection test (falloff/ step-rate test) **well test**, we can determine

Reservoir permeability

Skin factor

These parameters define **well productivity**.

Long-term recovery potential

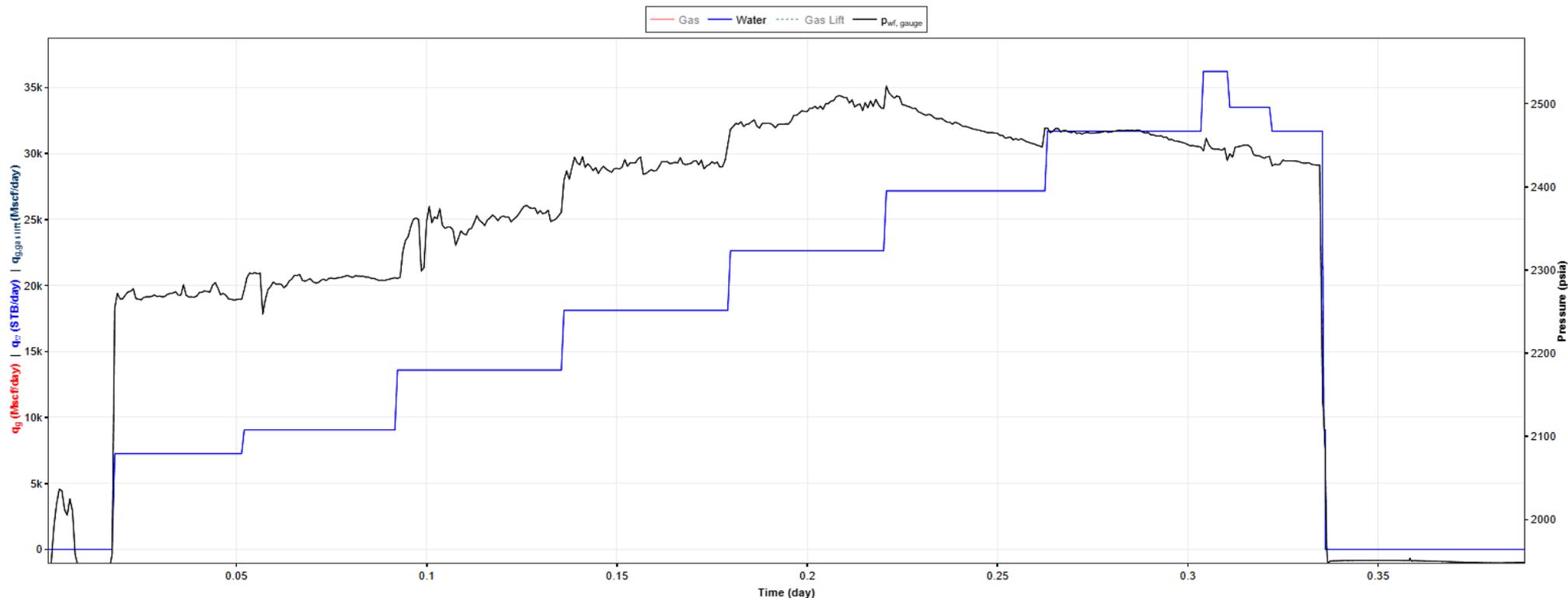
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LOG Y DATES USE CUMULATIVE RATIOS



Objective: Boundary Detection

Problem Statement:

A newly drilled well is completed in a laterally extensive reservoir. Geological maps suggest the formation is continuous and regionally uniform. The well is placed on production at a stable rate. Initial performance appears strong. However, after several days, the pressure response begins to change.

Identify sealing or partially sealing faults
Estimate distance to the boundary

Well Test Application:

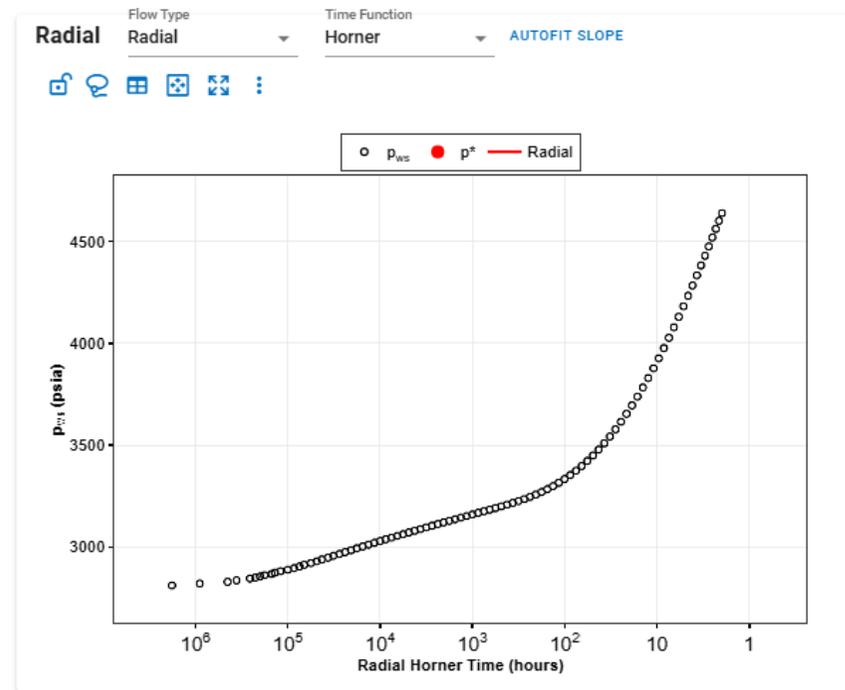
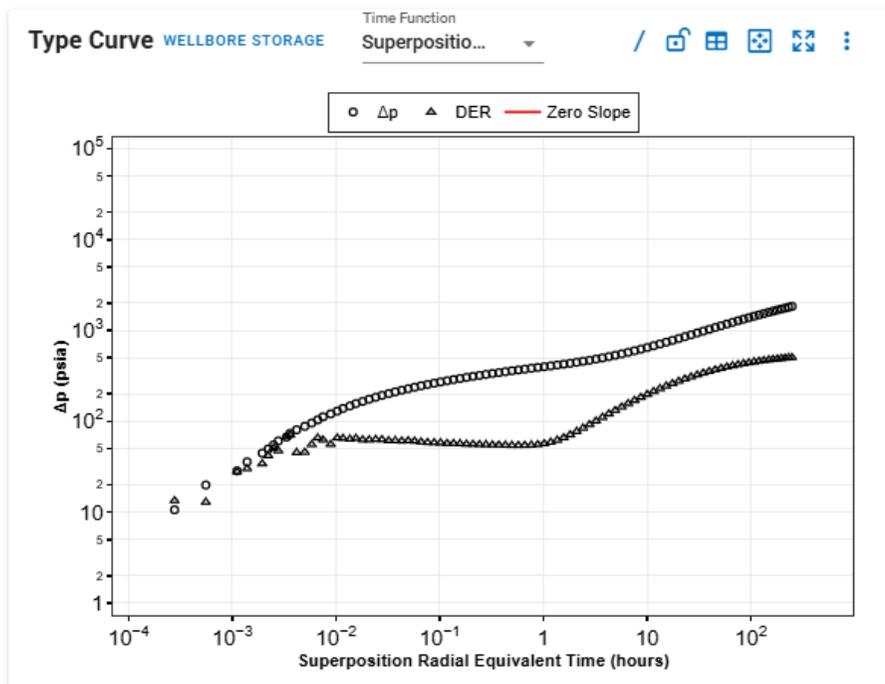
With a properly designed injection test (DD/BU), we can determine the presence of geologically induced reservoir boundaries, such as faults or sealing barriers.

Objective: Boundary Detection

Problem Statement:

A newly drilled well is completed in a laterally extensive reservoir. Geological maps suggest the formation is continuous and regionally uniform. The well is placed on production at a stable rate. Initial performance appears strong. However, after several days, the pressure response begins to change.

Identify sealing or partially sealing faults
Estimate distance to the boundary



Objective: Hydraulic Fracture Characterization

Problem Statement:

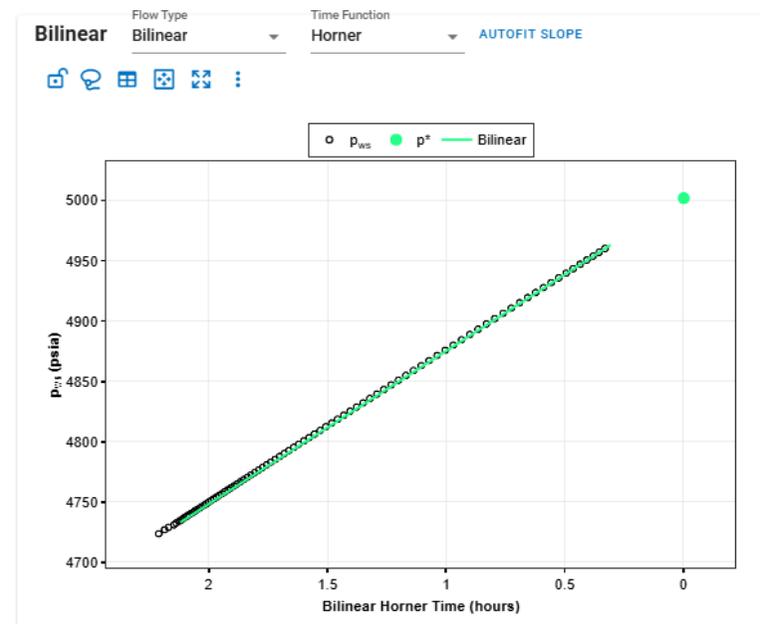
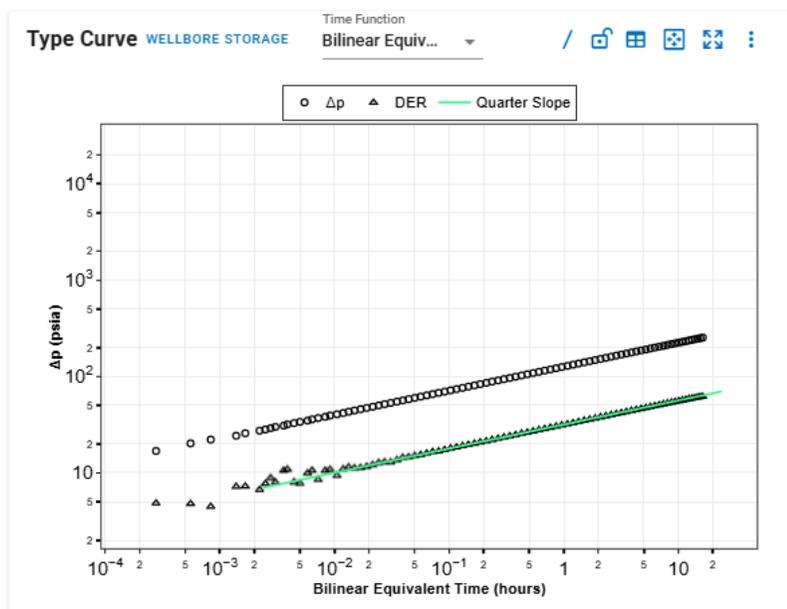
A horizontal well is completed with multiple hydraulic fractures. Stimulation reports indicate significant proppant placement and high expected conductivity. However:

Are the fractures truly high conductivity?

Will fracture performance degrade with time?

Well Test Application:

The pressure derivative signature reveals flow regimes. With a properly designed **drawdown/buildup test**, and **pressure derivative analysis**, we can diagnose fracture behavior.



Objective: Reservoir Depletion

Problem Statement:

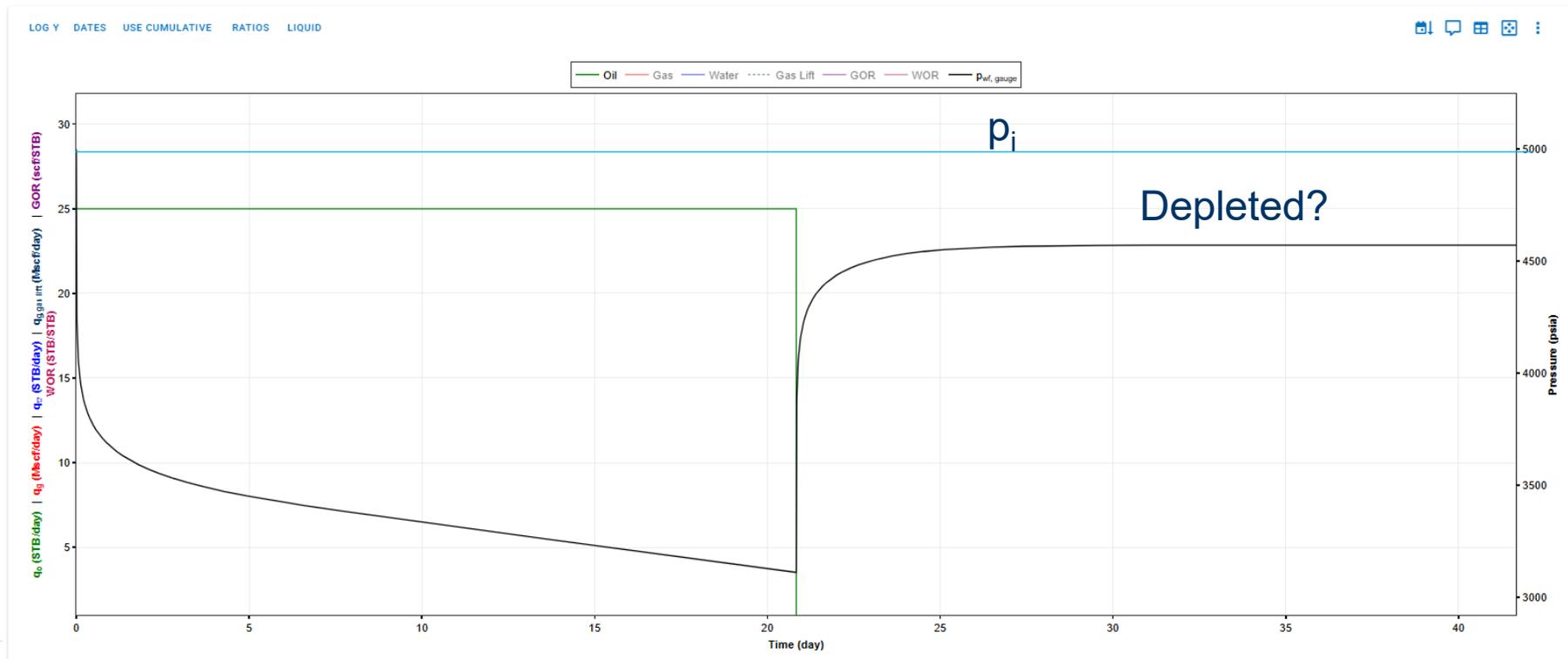
A buildup test is conducted after a short period of flow. Pressure buildup is recorded and the extrapolated pressure appears **lower than the initial reservoir pressure**.

Is this true reservoir depletion?

Gauge/data quality issues?

Well Test Application:

Distinguish wellbore dynamics from true reservoir behavior



Well Test Objectives

Reservoir Characterization

Reservoir pressure

Effective permeability (flow capacity)

Identification of reservoir boundaries/Heterogeneity

Formation Damage or Stimulation

Flow Regime Identification

Fluid sample

Stimulation design

Well productivity and performance over time

Regulatory compliance

Optimum Field Development

Gathering Line/Compressor Size

Well Testing

Drawdown

Well Test Response

PVT



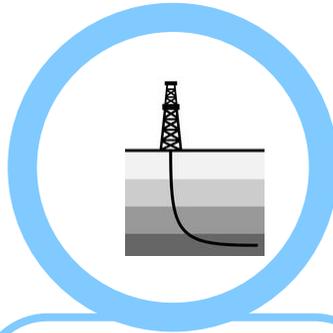
Oil

Water

Gas

Multiphase

Well



Vertical

Horizontal

MFHW

Damage

Stimulation

Storage

Reservoir



Homogeneous

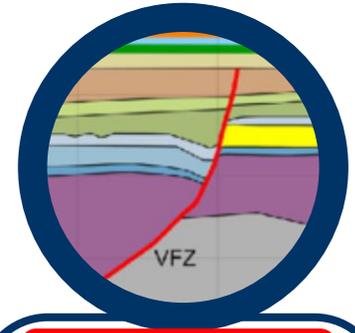
Heterogenous

Multi Layer

Composite

Dual Porosity

Boundary



Infinite Acting

Fault

Composite

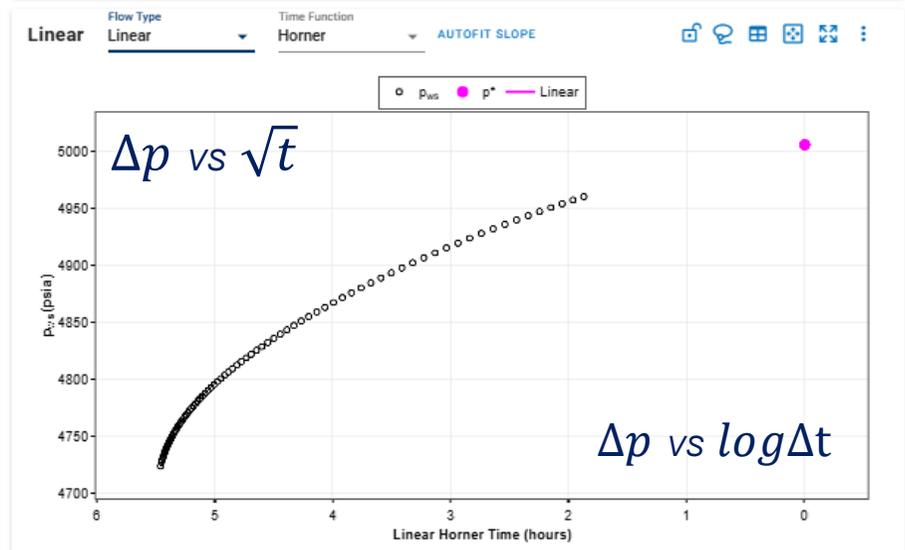
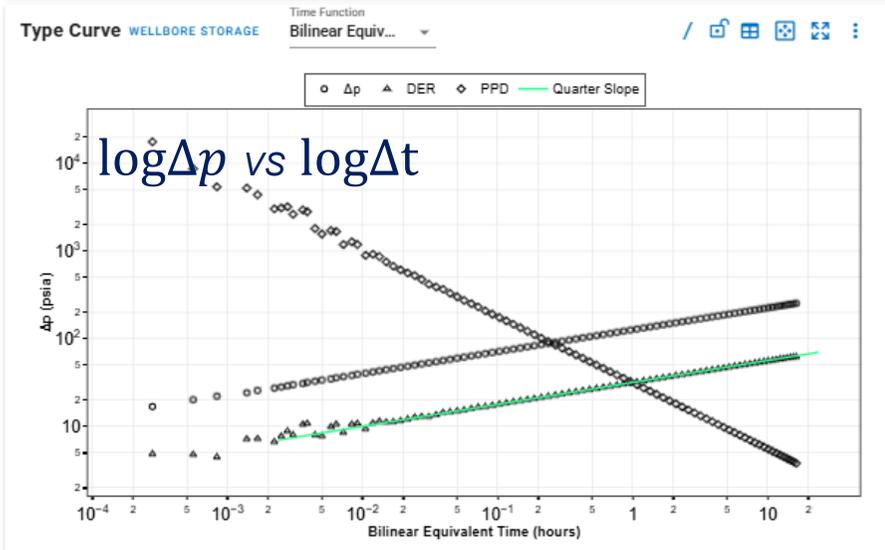
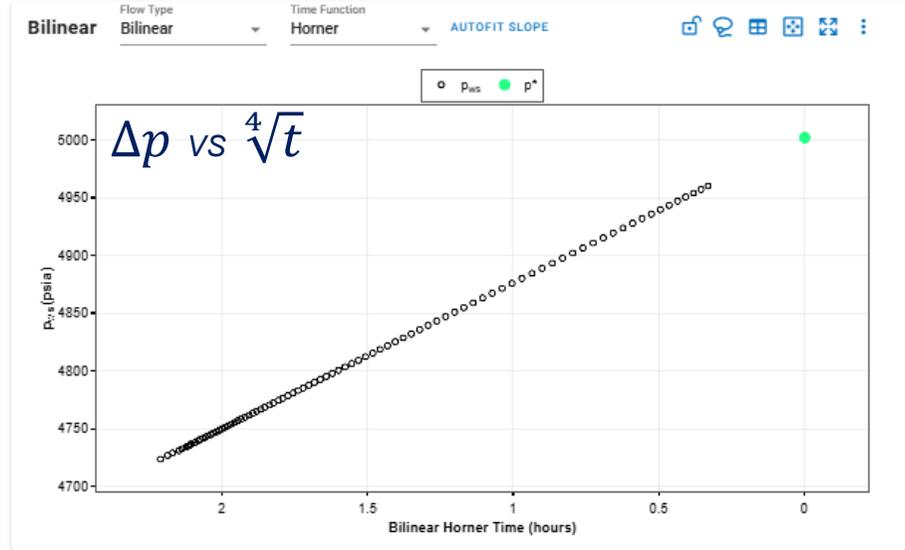
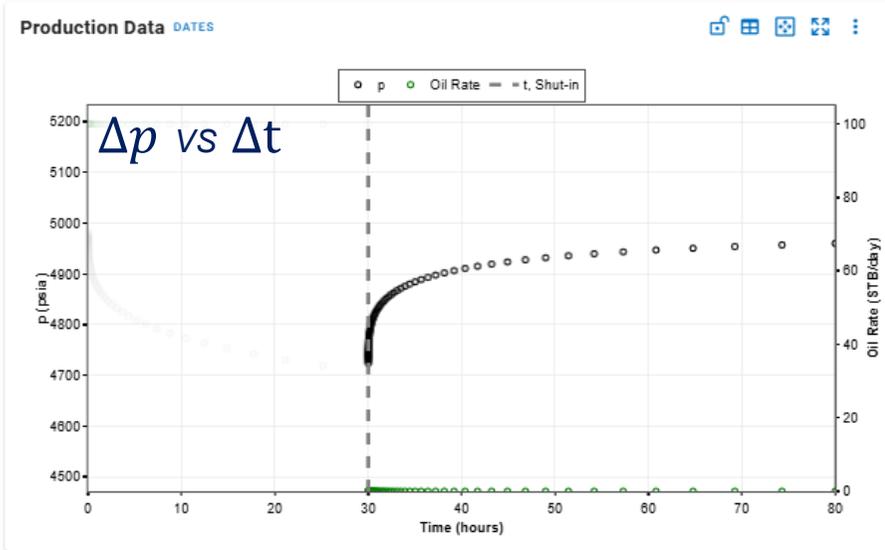
Constant Pressure

No Flow

Channel

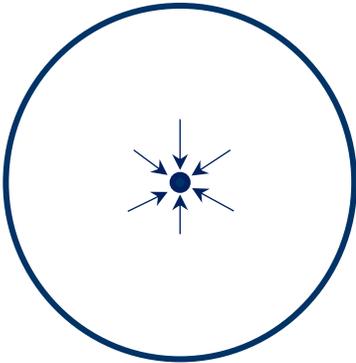
Homogeneous, isotropic, Darcy's law applies, single phase fluid, radial flow, vertical well, constant net pay, constant saturation

Well Test Response

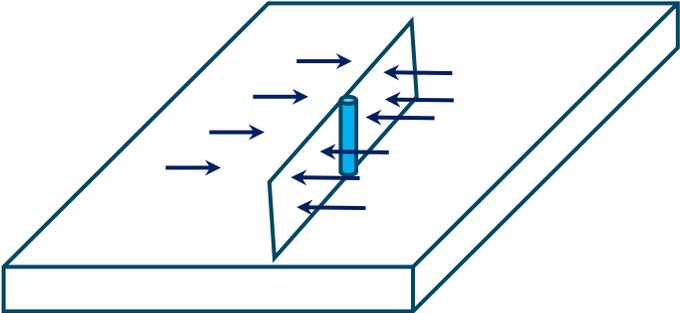


Flow Regime

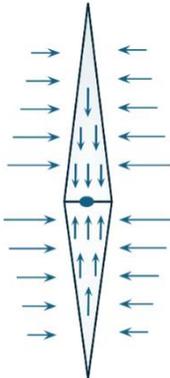
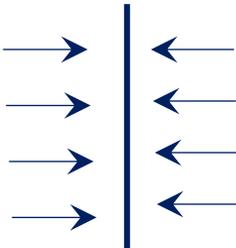
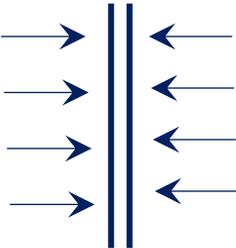
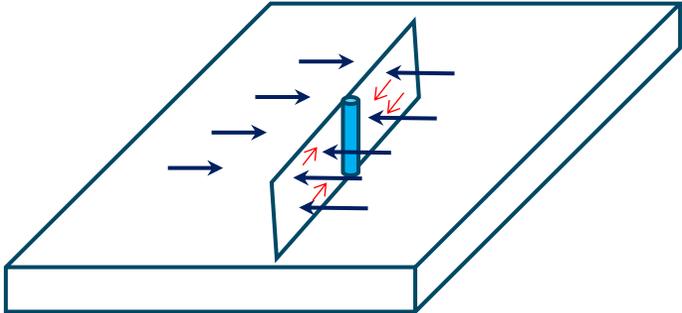
Radial flow



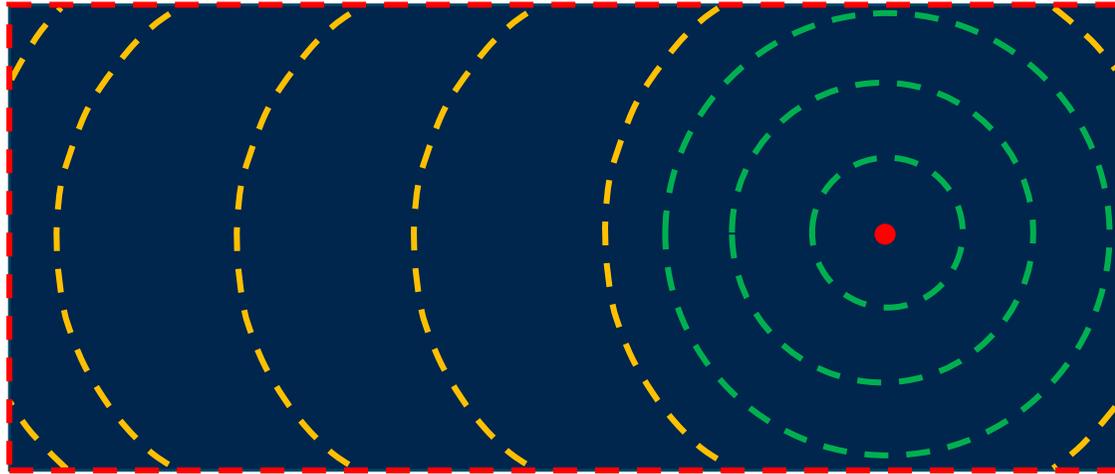
Linear flow



Bilinear flow



Flow Regime



Infinite Acting Flow

Early-time regime where pressure transients expand outward without sensing boundaries.

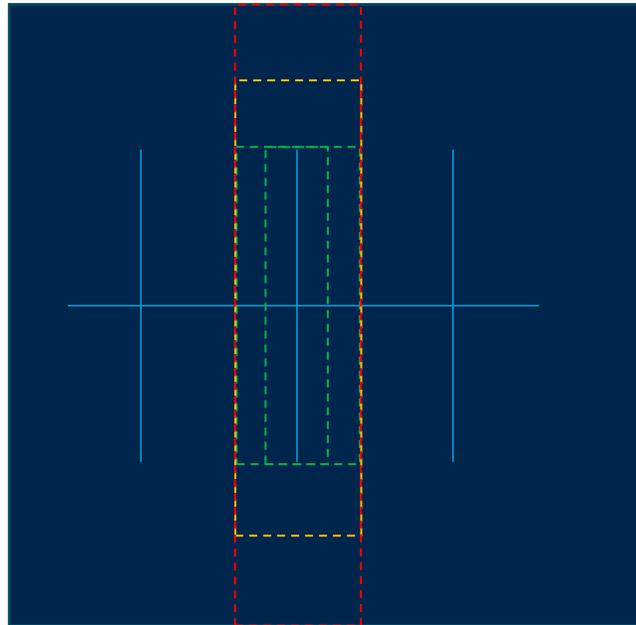
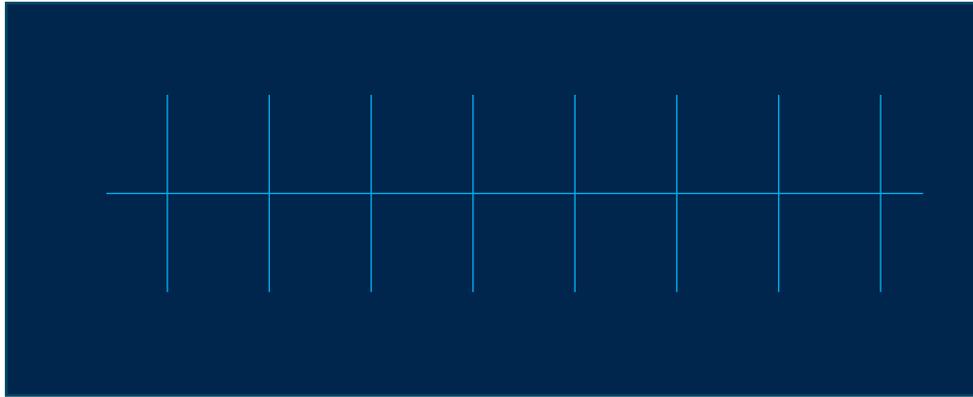
Transitional Flow

Pressure wave begins interacting with reservoir boundaries or heterogeneities.

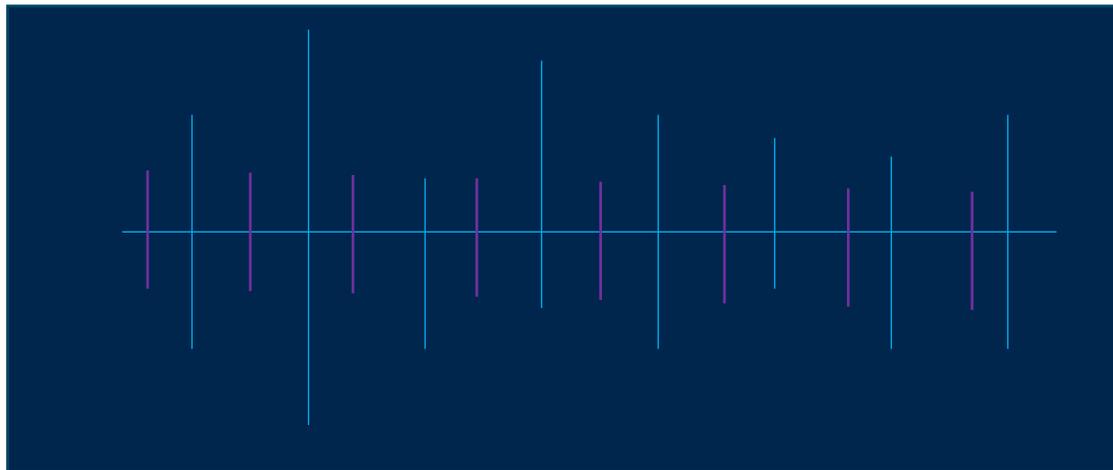
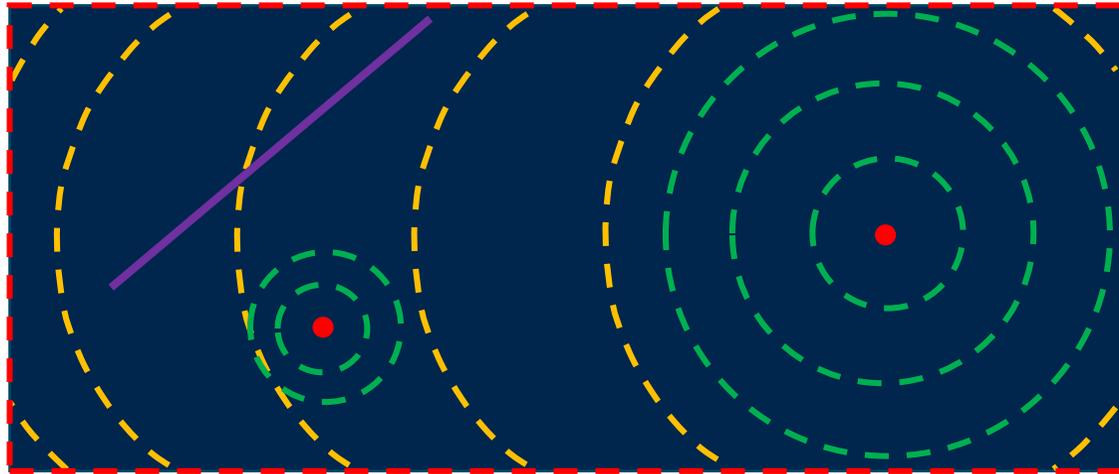
Boundary Dominated Flow

Late-time regime where reservoir limits control well performance, and decline becomes boundary-driven.

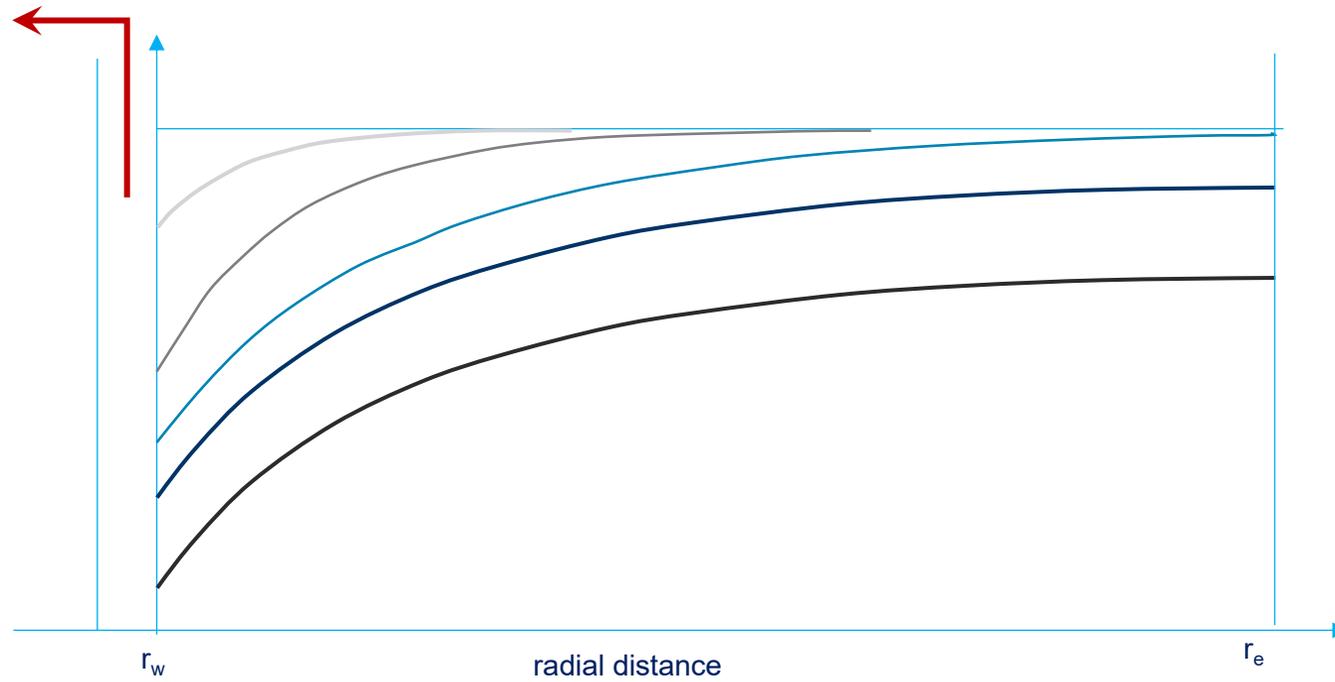
Flow Regime



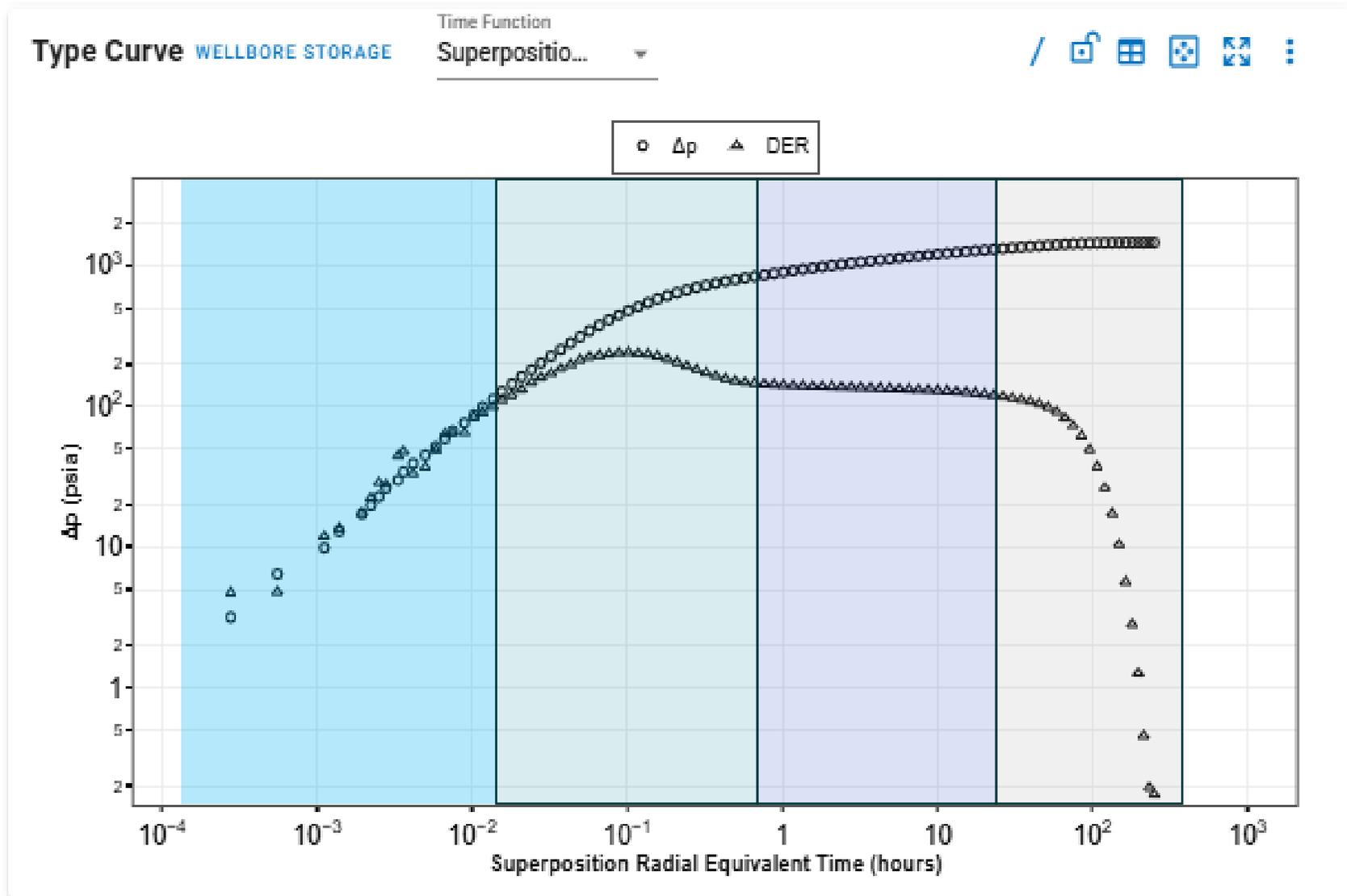
Flow Regime



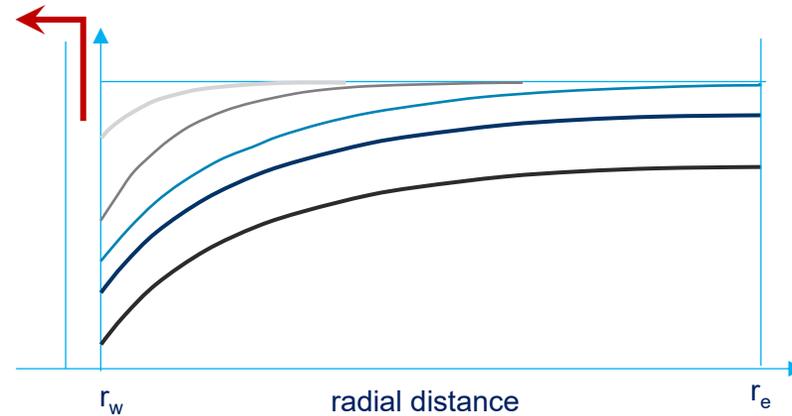
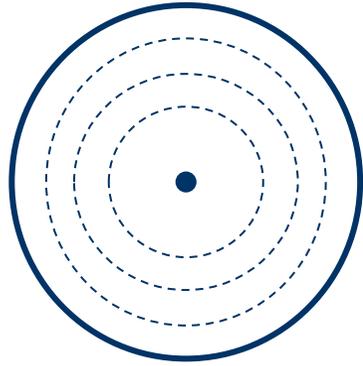
Sequence of Flow Regimes



Sequence of Flow Regimes



Concept-Focused, Not Equation-Heavy



Assumptions:

Homogeneous, isotropic, Darcy's law applies,
single phase fluid, radial flow, vertical well,
constant net pay, constant saturation,
constant temperature,
constant PVT

$$P_D = \frac{2}{r_{De}^2 - 1} \left(\frac{r_D^2}{4} + t_D \right) - \frac{r_{De}^2 \ln r_D}{r_{De}^2 - 1} - \frac{3r_{De}^4 - 4r_{De}^4 \ln r_{De} - 2r_{De}^2 - 1}{4(r_{De}^2 - 1)^2}$$

$$+ \pi \sum_{n=1}^{\infty} e^{-\alpha_n^2 t_D} \frac{J_1^2(\alpha_n r_{De}) [J_1(\alpha_n) Y_0(\alpha_n r_D) - Y_1(\alpha_n) J_0(\alpha_n r_D)]}{\alpha_n [J_1^2(\alpha_n r_{De}) - J_1^2(\alpha_n)]}$$

α_n are roots of:

$$J_1(\alpha_n r_{De}) Y_1(\alpha_n) - J_1(\alpha_n) Y_1(\alpha_n r_{De}) = 0$$

$J_0(x)$: Bessel functions of the first kind of order zero

$J_1(x)$: Bessel functions of the first kind of order one

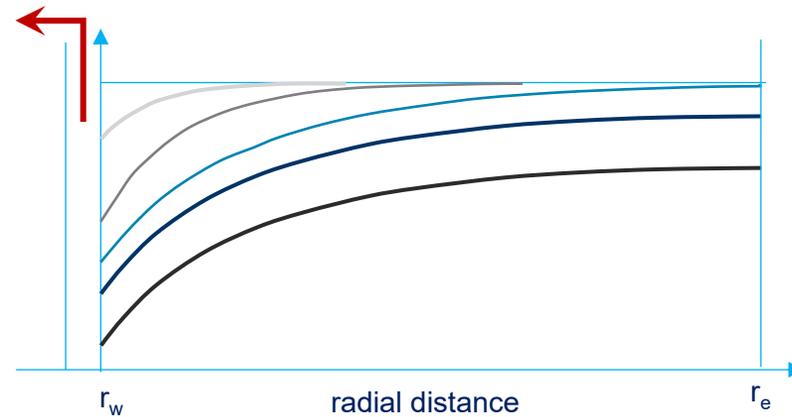
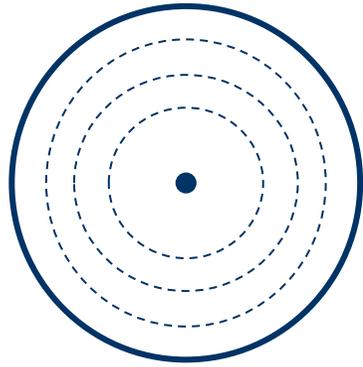
$Y_0(x)$: Bessel functions of the second kind of order zero

$Y_1(x)$: Bessel functions of the second kind of order one

C.S. Matthews, D.G. Russell

Shell Oil Company, 1967

Concept-Focused, Not Equation-Heavy



Assumptions:

Homogeneous, isotropic, Darcy's law applies,
single phase fluid, radial flow, vertical well,
constant net pay, constant saturation,
constant temperature,
constant PVT

Early Time Solution:

$$p_i - p_{wf} = 162.6 \frac{q_o B_o \mu_o}{kh} \left\{ \log(t) + \log\left(\frac{k}{\phi \mu_o c_t r_w^2}\right) - 3.23 \right\}$$

Late Time Solution:

$$p_i - p_{wf} = \frac{q_o t}{c_t N} + \frac{141.2 q_o B_o \mu_o}{kh} \left[\ln\left(\frac{r_e}{r_w}\right) - \frac{3}{4} \right]$$

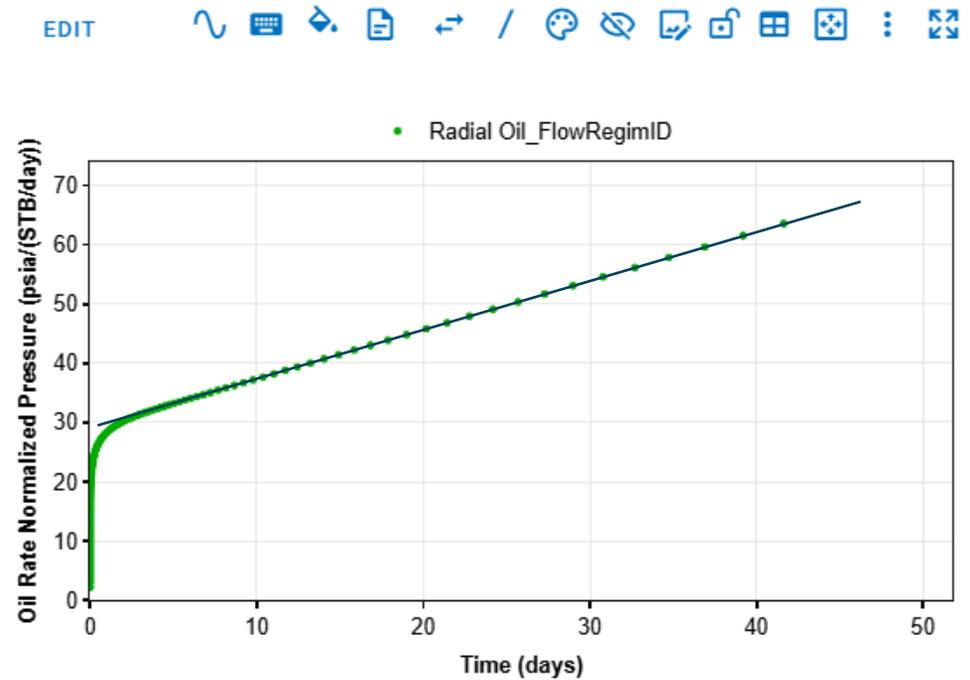
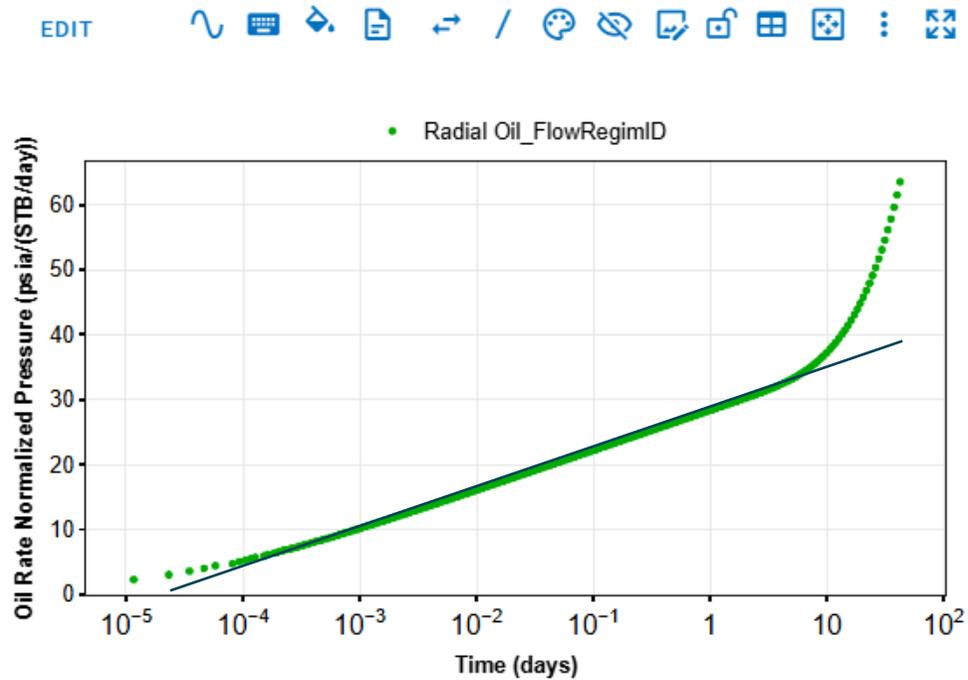
Drawdown Test

Early Time Solution:

$$p_i - p_{wf} = 162.6 \frac{q_o B_o \mu_o}{kh} \left\{ \log(t) + \log\left(\frac{k}{\phi \mu_o c_t r_w^2}\right) - 3.23 \right\}$$

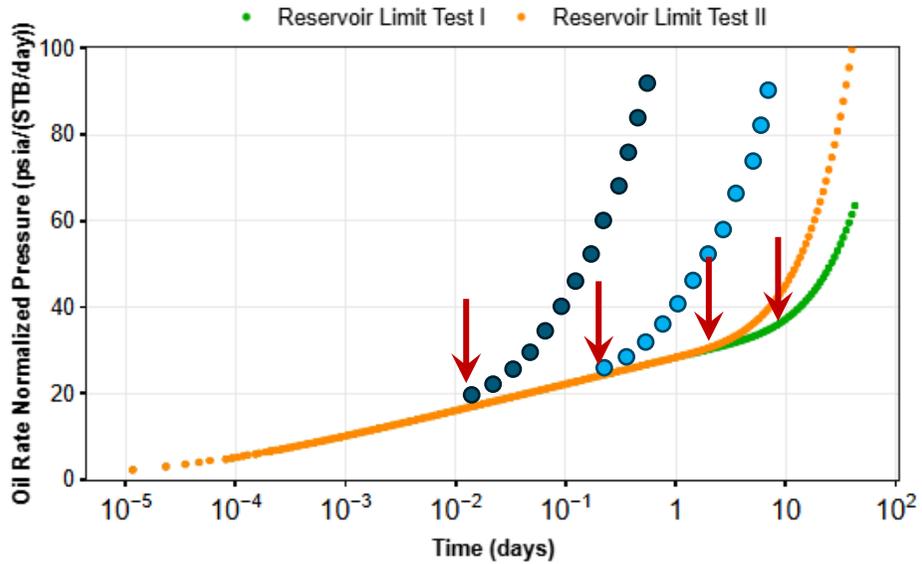
Late Time Solution:

$$p_i - p_{wf} = \frac{q_o t}{c_t N} + \frac{141.2 q_o B_o \mu_o}{kh} \left[\ln\left(\frac{r_e}{r_w}\right) - \frac{3}{4} \right]$$

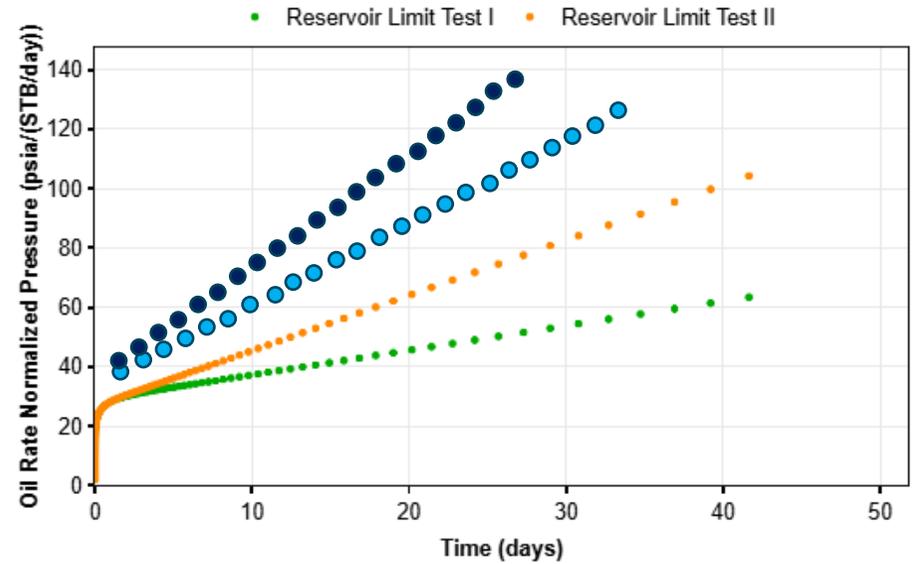


Drawdown Test

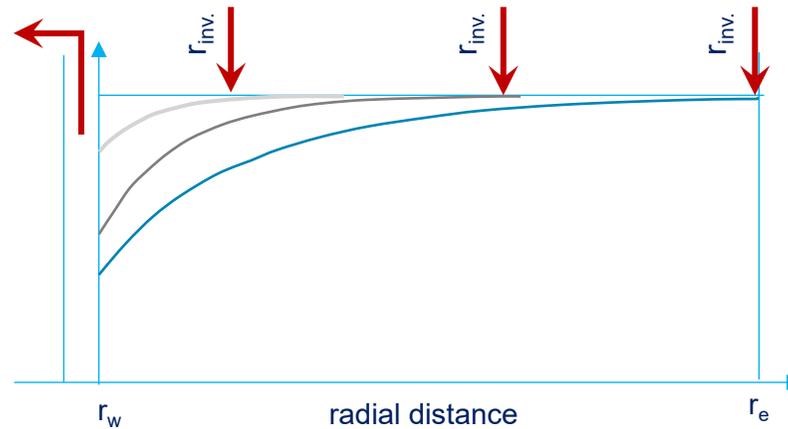
EDIT



EDIT



Radius (distance) of Investigation



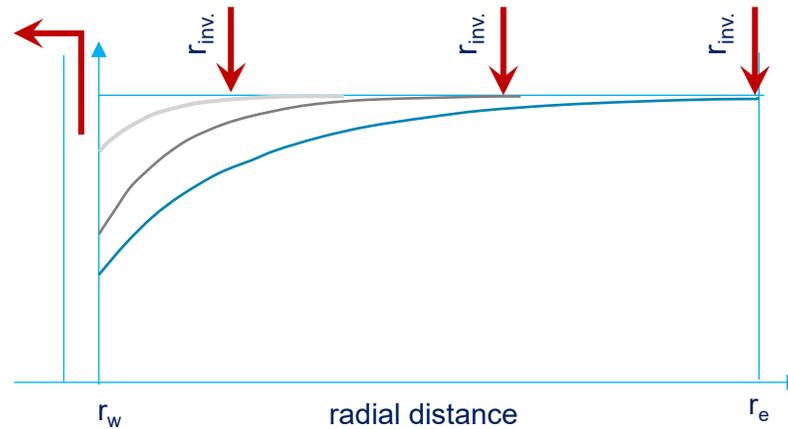
Radius of Investigation

$$r_{inv.}(\text{ft}) = \sqrt{\frac{k(\text{md})t(\text{hr})}{948 \phi\mu(\text{cp})c_t(1/\text{psi})}}$$

$$r_e = \sqrt{\frac{kt_{pss}}{948 \phi\mu c_t}}$$

$$\text{Drainage Area}(t_{pss}) = \pi r_e^2$$

Radius (distance) of Investigation



The radius of investigation is governed solely by **reservoir properties, PVT and elapsed time**.

$$r_{inv.}(ft) = \sqrt{\frac{kt}{948 \phi \mu c_t}}$$

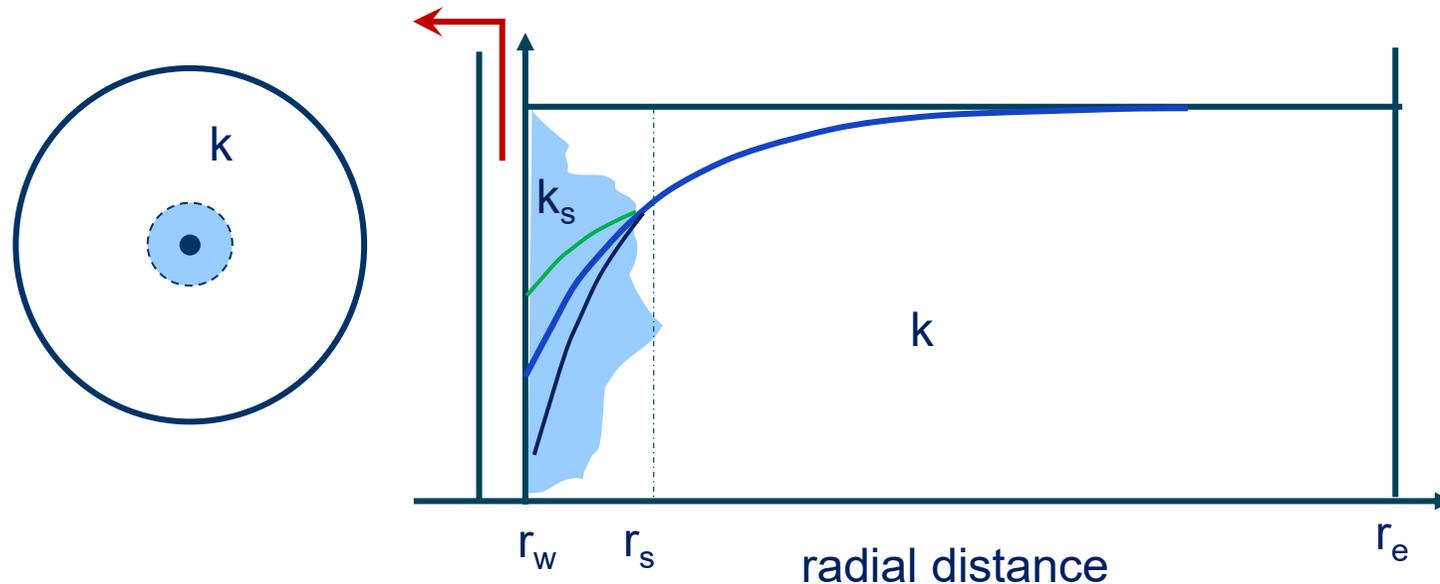
It does **not** depend on the flow rate.

Increasing the production rate will increase the pressure drop. it does not accelerate the radial propagation of the pressure disturbance into the formation.

Skin Effect

Damage
Stimulation

Skin Effect



Skin factor:

A measure of near-wellbore permeability change.

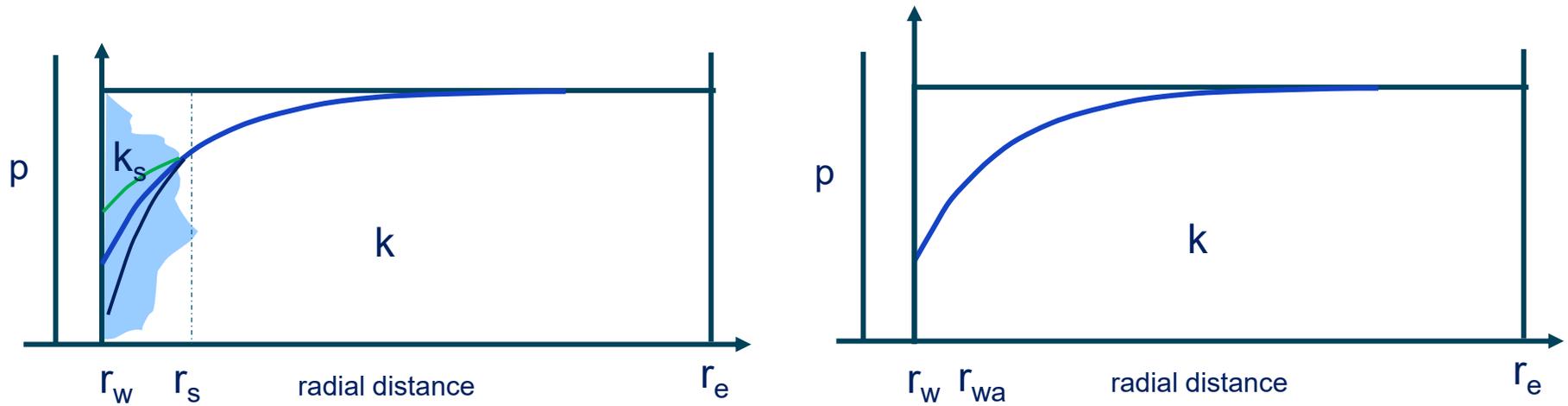
$S > 0$: higher pressure drop (mud invasion, fines migration, swelling clays)

$S < 0$: lower pressure drop (acidizing, frac treatment)

$$\Delta P_s = \frac{141.2 q_o B_o \mu_o}{kh} S$$

$$S = \left(\frac{k}{k_s} - 1 \right) \ln \left(\frac{r_s}{r_w} \right)$$

Skin Effect



Skin factor: Effective Wellbore Radius, r_{wa}

Skin can be interpreted as a change in effective wellbore radius.

Stimulated well ($S < 0$), $r_{wa} > r_w$

Damaged well ($S > 0$), $r_{wa} < r_w$

Skin Effect

$$\Delta P_s = \frac{141.2 q_o B_o \mu_o}{kh} S$$

Early Time Solution:

$$p_i - p_{wf} = 162.6 \frac{q_o B_o \mu_o}{kh} \left\{ \log(t) + \log\left(\frac{k}{\phi \mu_o c_t r_w^2}\right) - 3.23 \right\} + 0.87S$$

Late Time Solution:

$$p_i - p_{wf} = \frac{q_o t}{c_t N} + \frac{141.2 q_o B_o \mu_o}{kh} \left[\ln\left(\frac{r_e}{r_w}\right) - \frac{3}{4} \right] + S$$

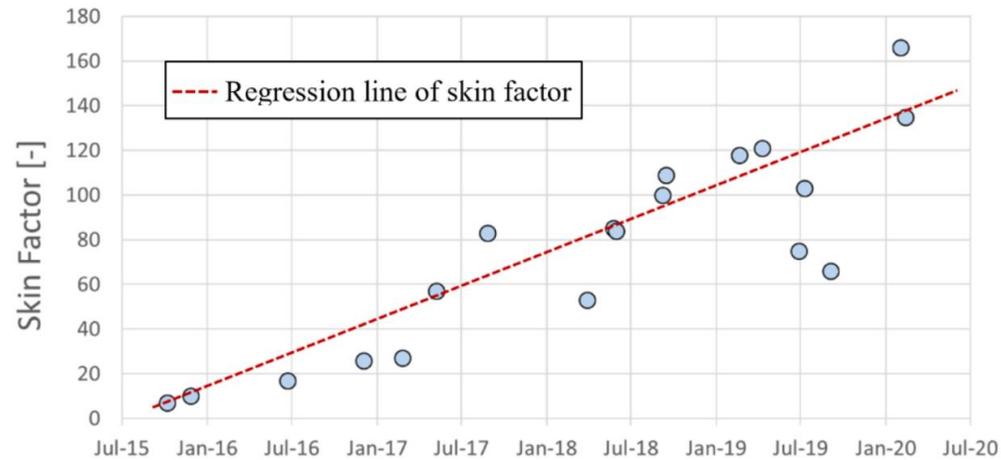
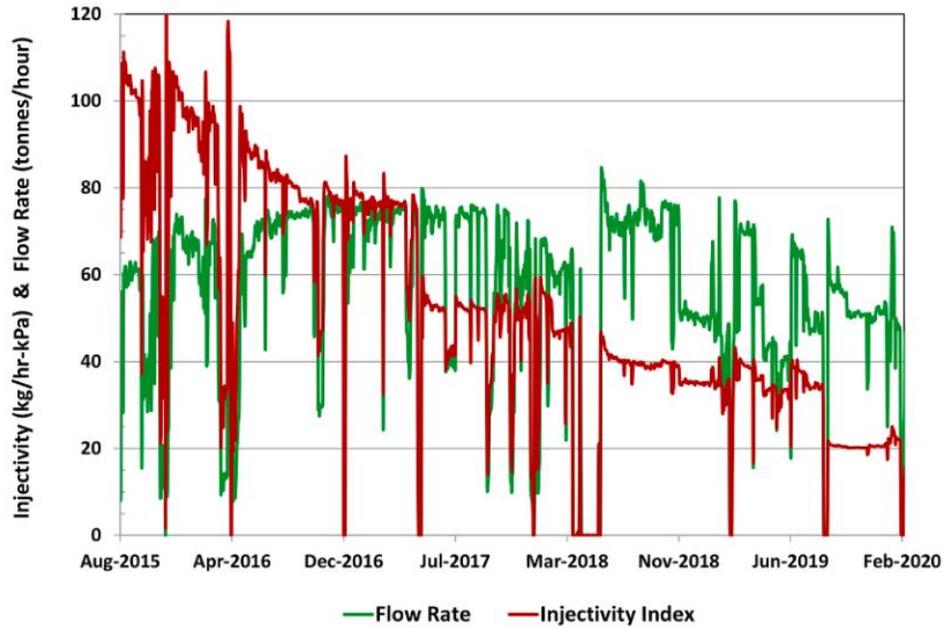
Skin factor:

Skin represents near-wellbore alteration of flow capacity.

$S > 0$: damage, 100 in extreme cases

$S < 0$: stimulation (lowest -6)

Skin Effect



Wellbore Dynamics

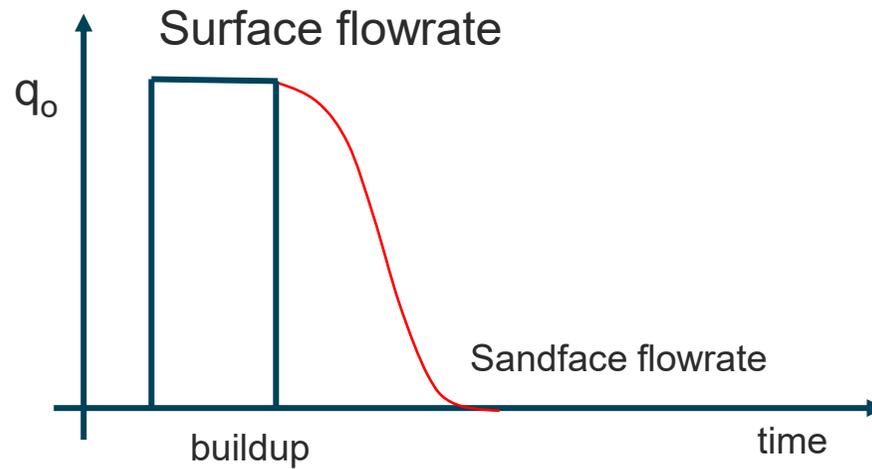
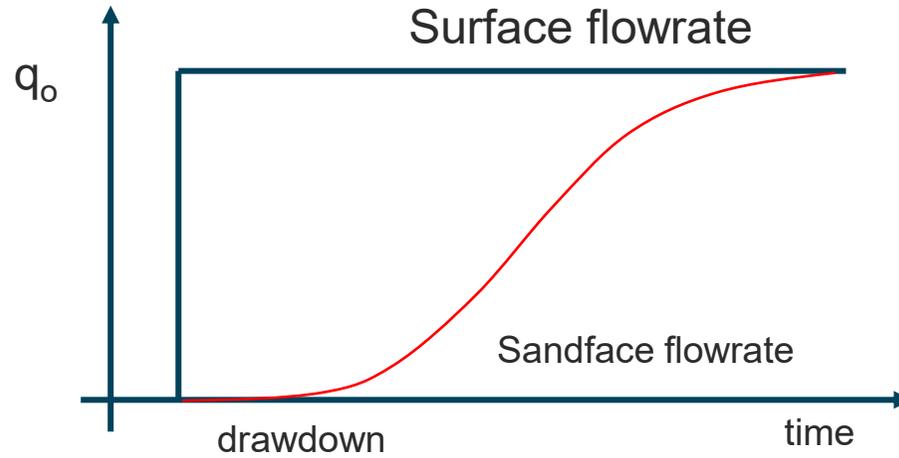
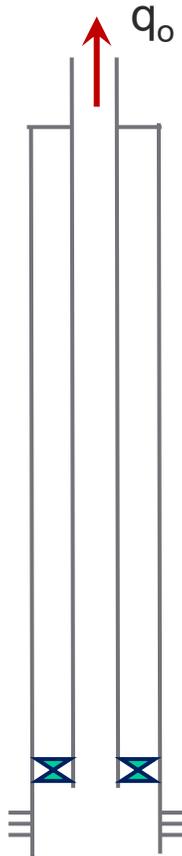
Wellbore Storage

Phase Redistribution

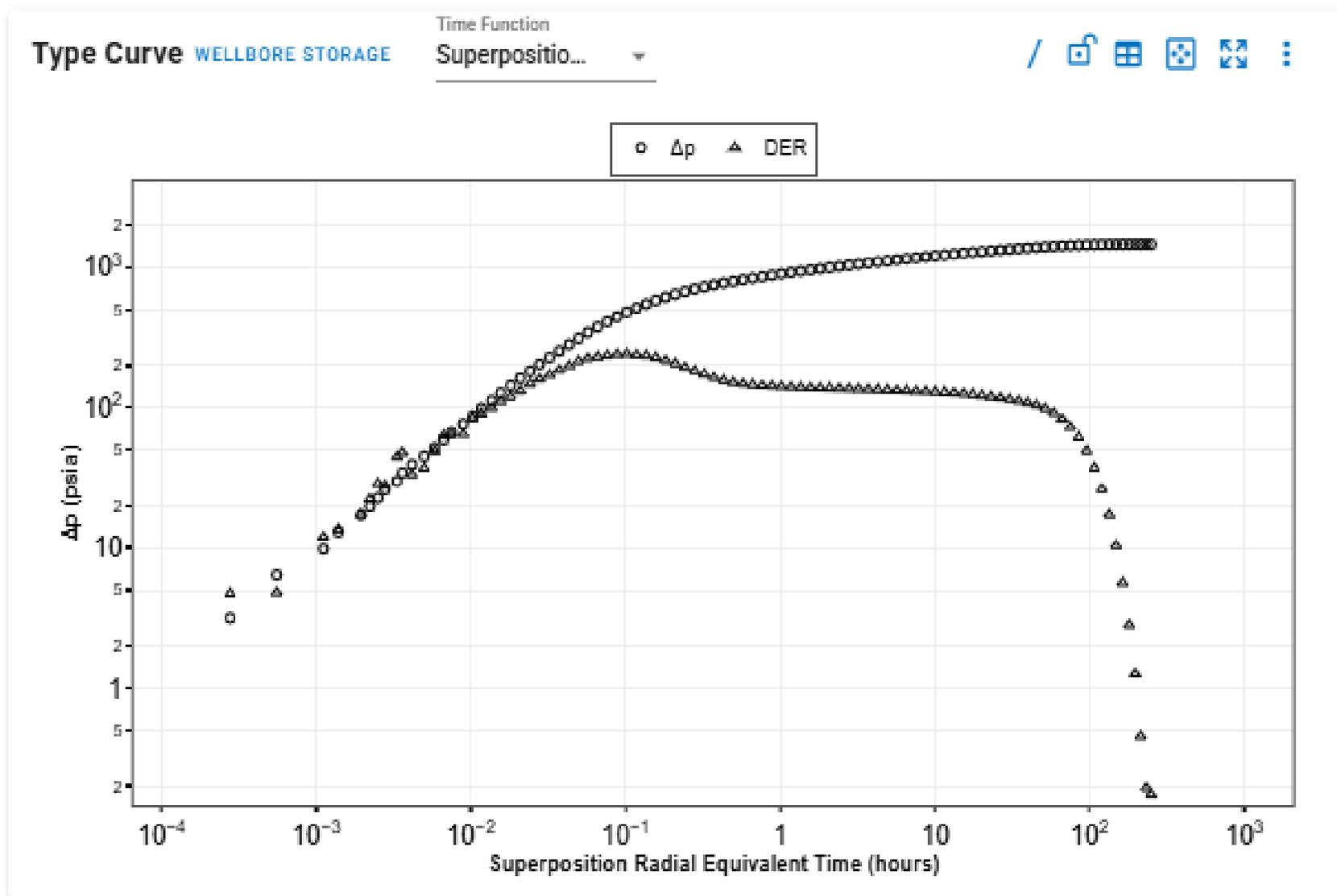
Liquid moving Past Recorder

Recorder Effects

Wellbore Storage



Wellbore Storage



Wellbore Storage

Early-Time Dominance

It dominates before the reservoir response becomes visible

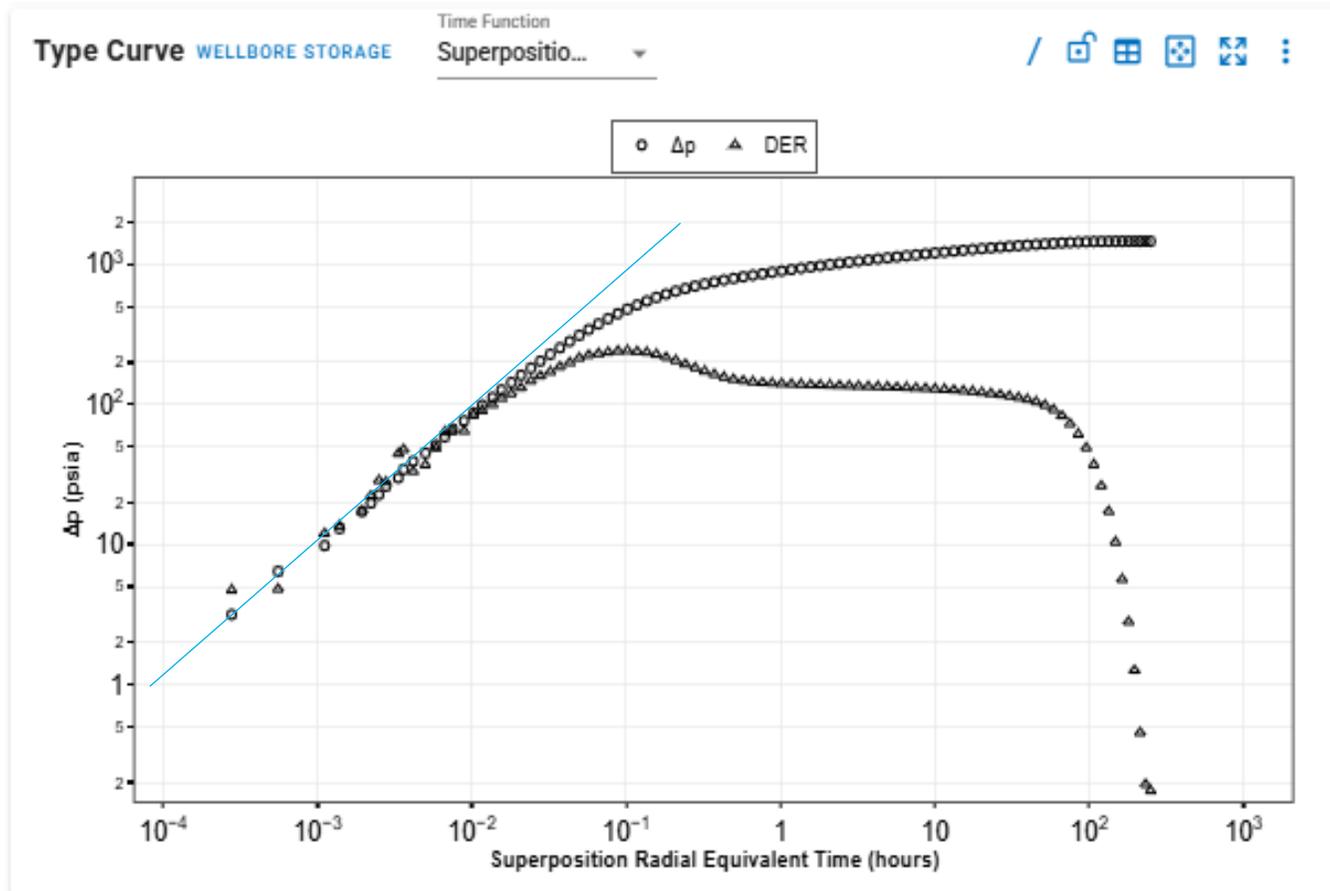
It can completely mask formation properties

- 1 Fluid Expansion (Compressibility Effect)**
Expansion of fluid inside the wellbore
- 2 Changing Liquid Level**
Movement of fluid column
Common in gas wells or partially filled wells

$$\Delta p_{wf}(t) = \frac{q_o B_o t}{24C}$$

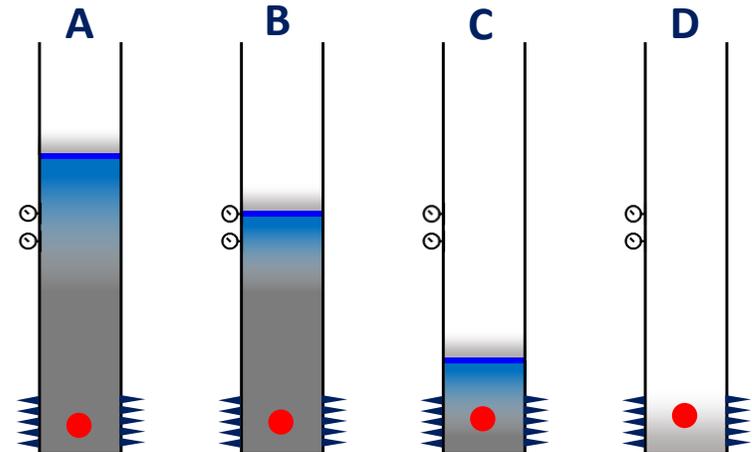
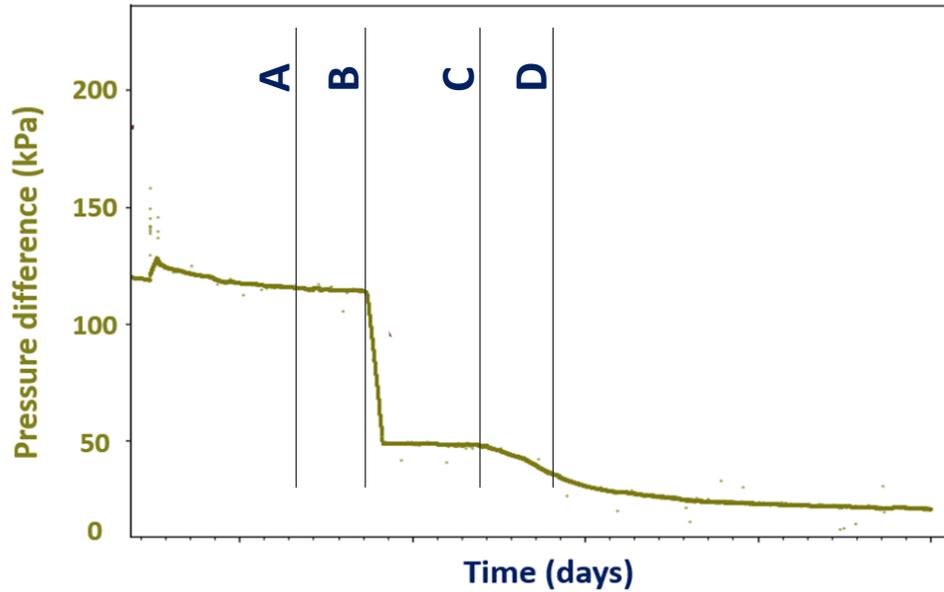
Wellbore Storage

$$\Delta p_{wf}(t) = \frac{q_o B_o t}{24C}$$



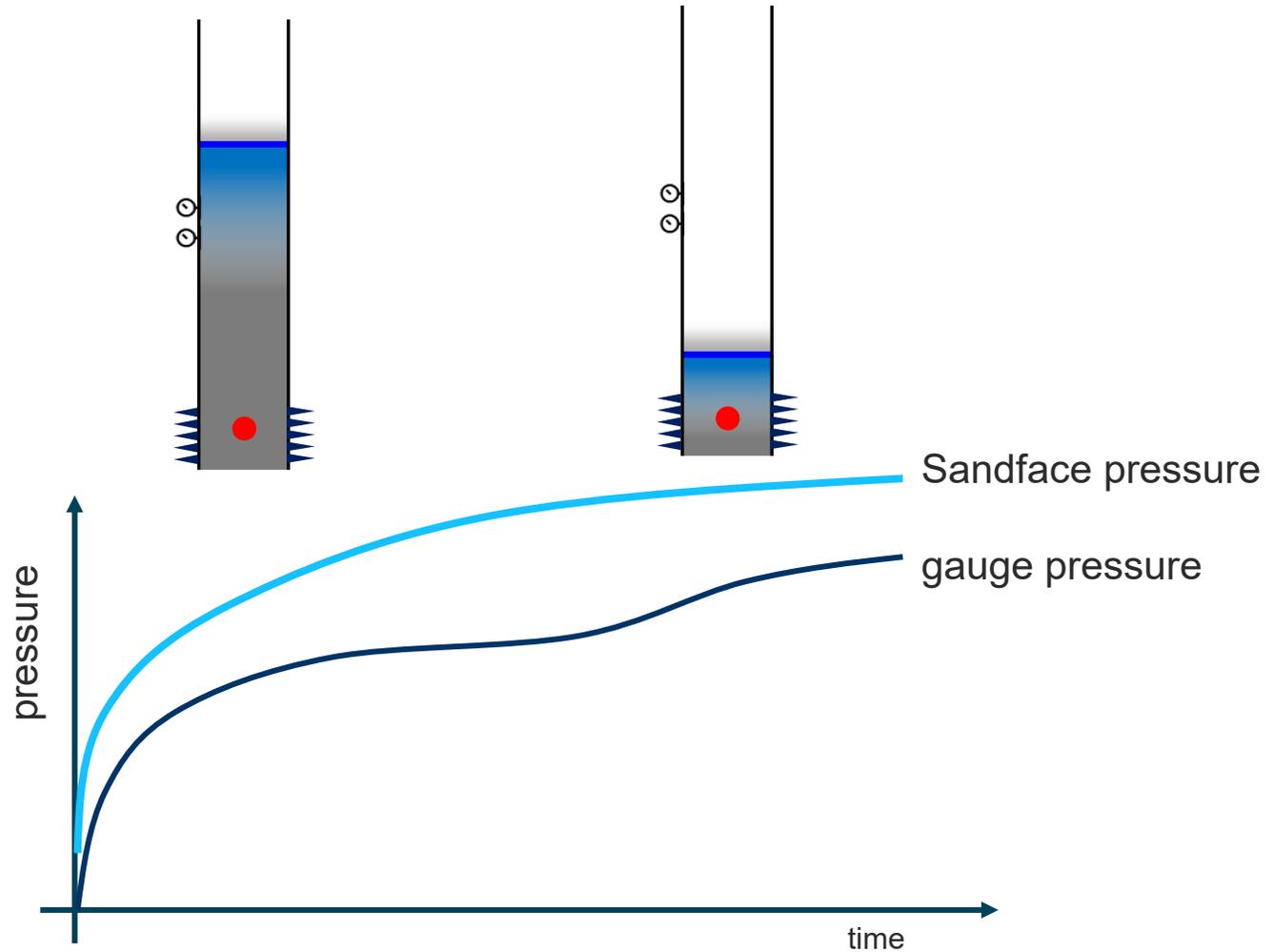
Changing Liquid Levels

During Fall off

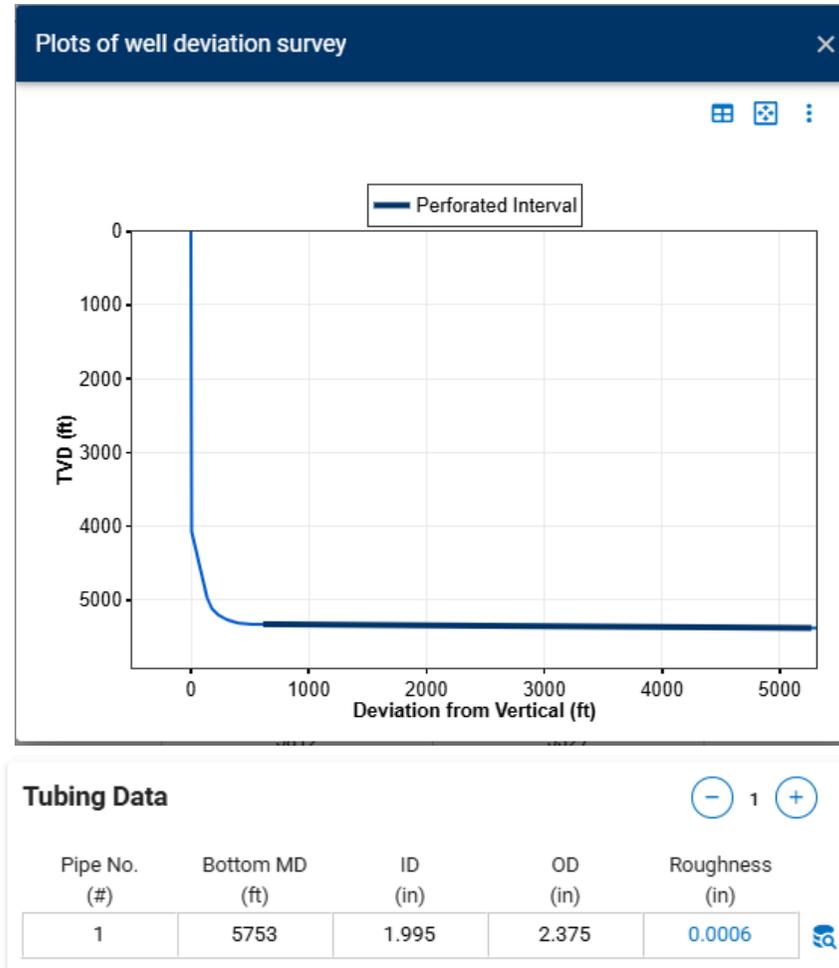


Changing Liquid Levels

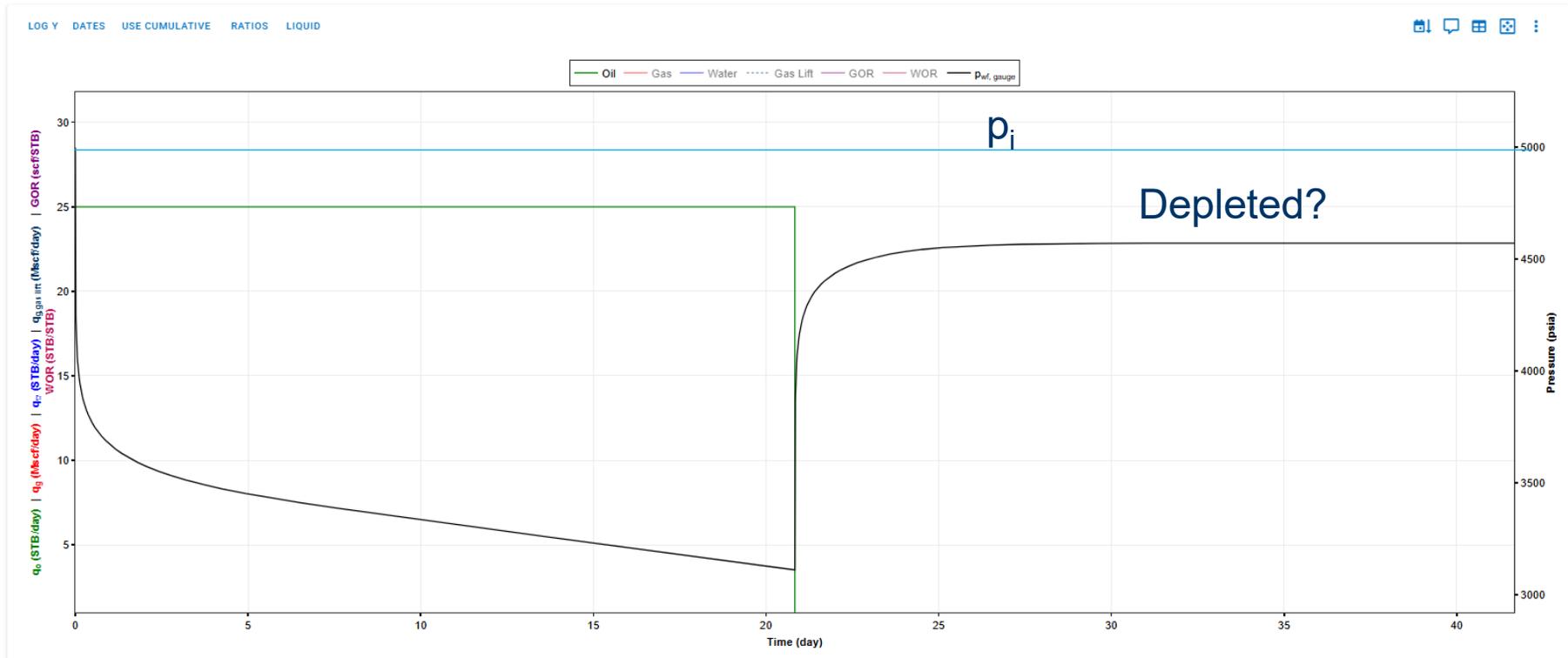
During Buildup



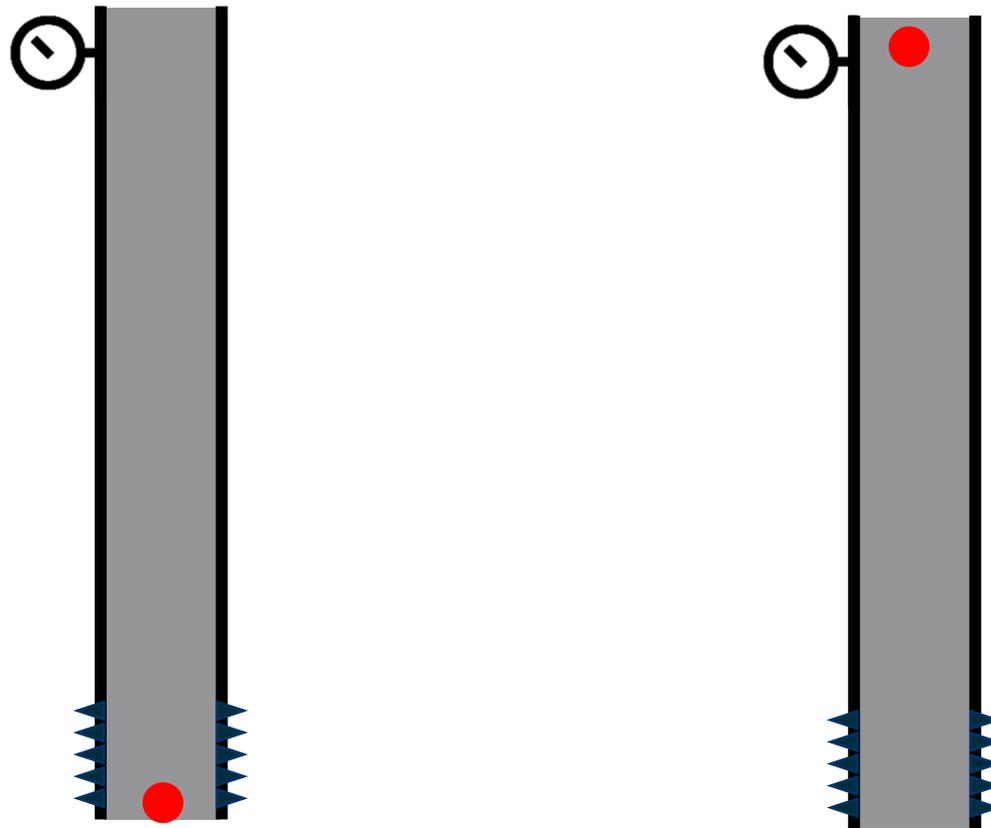
Wellbore Schematics



Changing Liquid Levels



Phase Redistribution



Wellbore Dynamics

Wellbore dynamics describe the pressure behavior controlled by the well itself rather than the reservoir.

Immediately after a rate change or shut-in, the pressure response is governed by:

- Fluid expansion (compressibility effects)

- Liquid level movement

- Multiphase redistribution

Sudden pressure changes are almost always well-related (Primary pressure Derivative)

Early-time interpretation reflects wellbore behavior, not formation properties.

If the response is immediate, steep, or unstable — suspect the well before the reservoir.

What the recorder sees is NOT what the reservoir saw.

Questions....





Questions

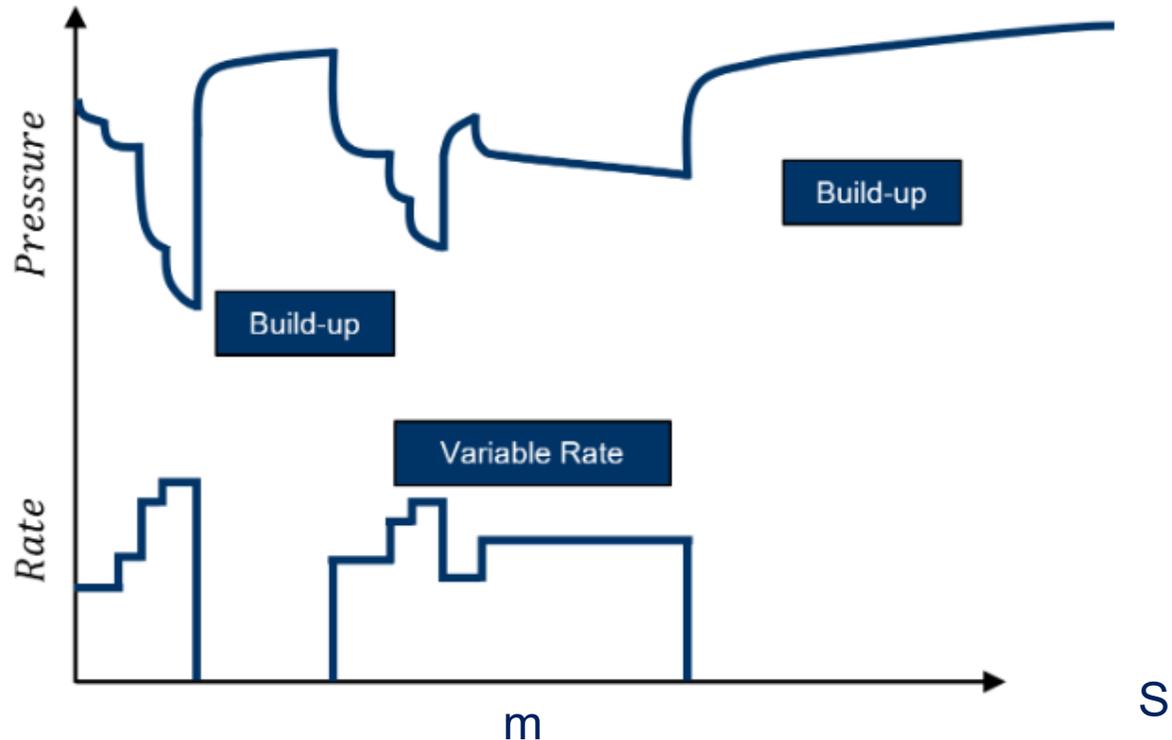
For how long would you recommend shutting in the well before a drawdown analysis to obtain a representative reservoir pressure? In a conventional reservoir

Is there a rule of thumb for how much production before shutting in the well (duration wise) to add when analyzing a build-up

$$\Delta t_e = \frac{t_p \Delta t}{t_p + \Delta t}$$

Superposition

Superposition Principle



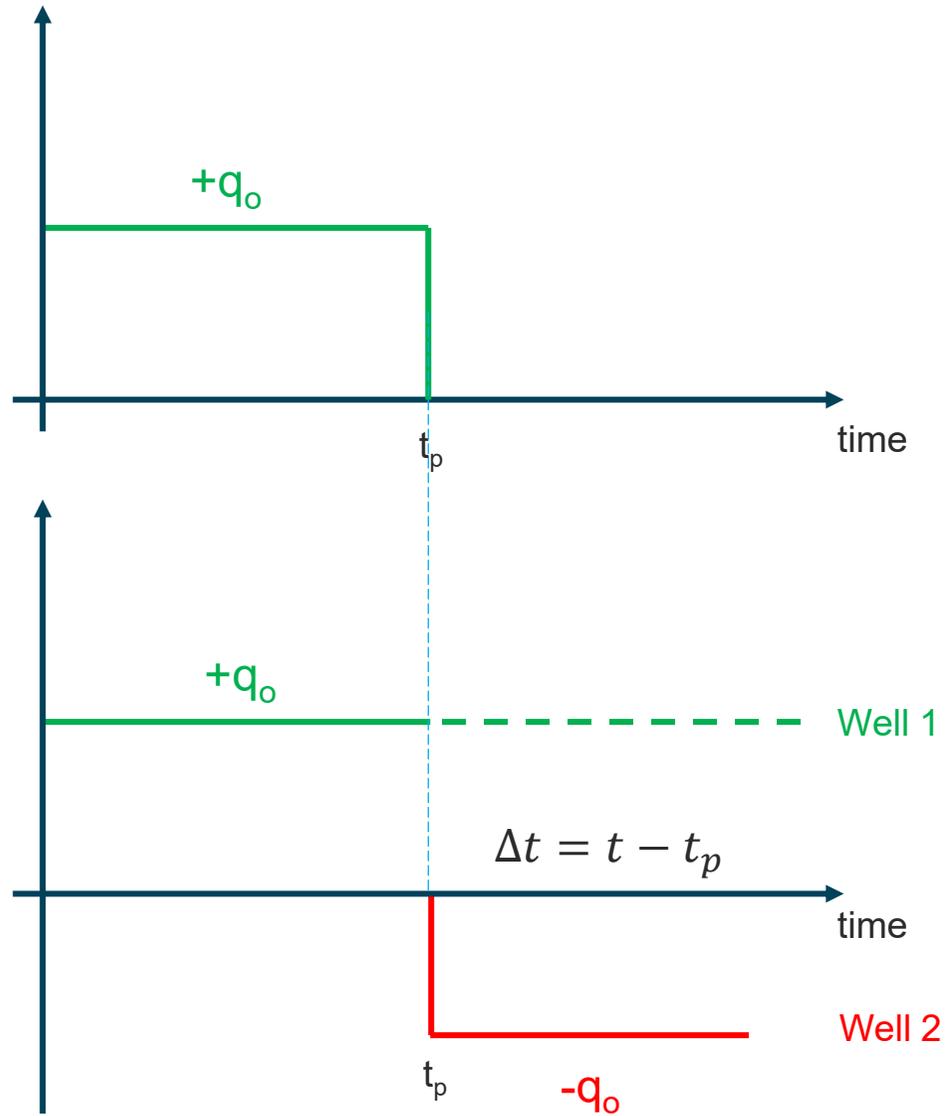
Assumptions:

Homogeneous, isotropic, Darcy's law applies,
 single phase fluid, radial flow, vertical well,
 constant net pay, constant saturation,
 constant temperature,
 constant PVT

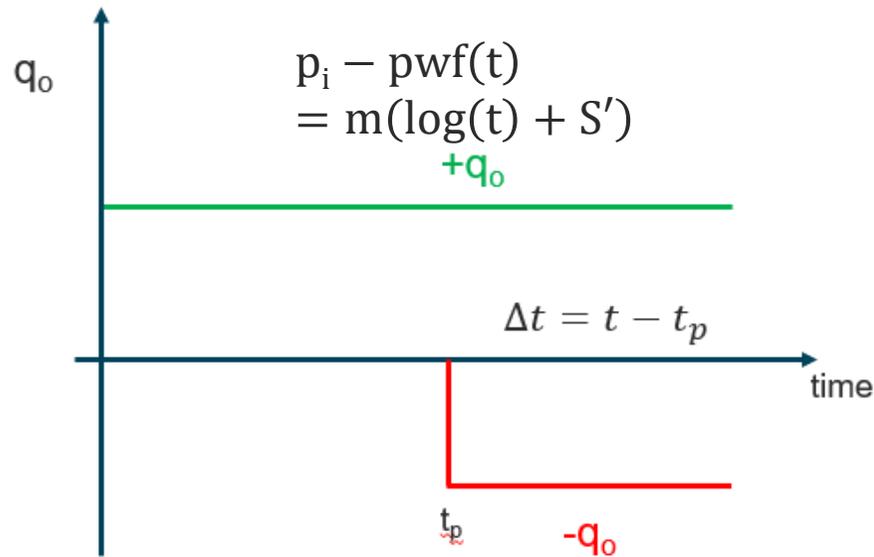
$$p_i - p_{wf}(t) = \overset{m}{162.6 \frac{q_o B_o \mu_o}{kh}} \left\{ \log(t) + \log \left(\frac{k}{\phi \mu_o c_t r_w^2} \right) - 3.23 + 0.87S' \right\}$$

$$p_i - p_{wf}(t) = m(\log(t) + S')$$

Superposition Principle



Superposition Principle



$$\Delta p_{+q} = m(\log(t_p + \Delta t) + S')$$

+

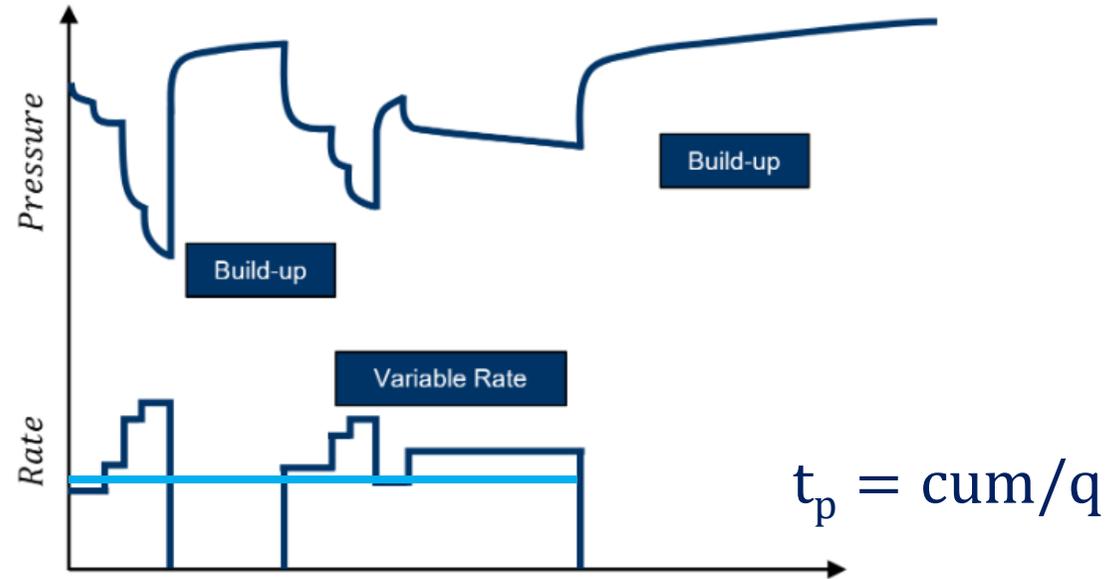
$$\Delta p_{-q} = -m(\log(\Delta t) + S')$$

=

$$p_{ws}(\Delta t) = p_i - m \log \left(\frac{t_p + \Delta t}{\Delta t} \right)$$

Horner time

Superposition Principle



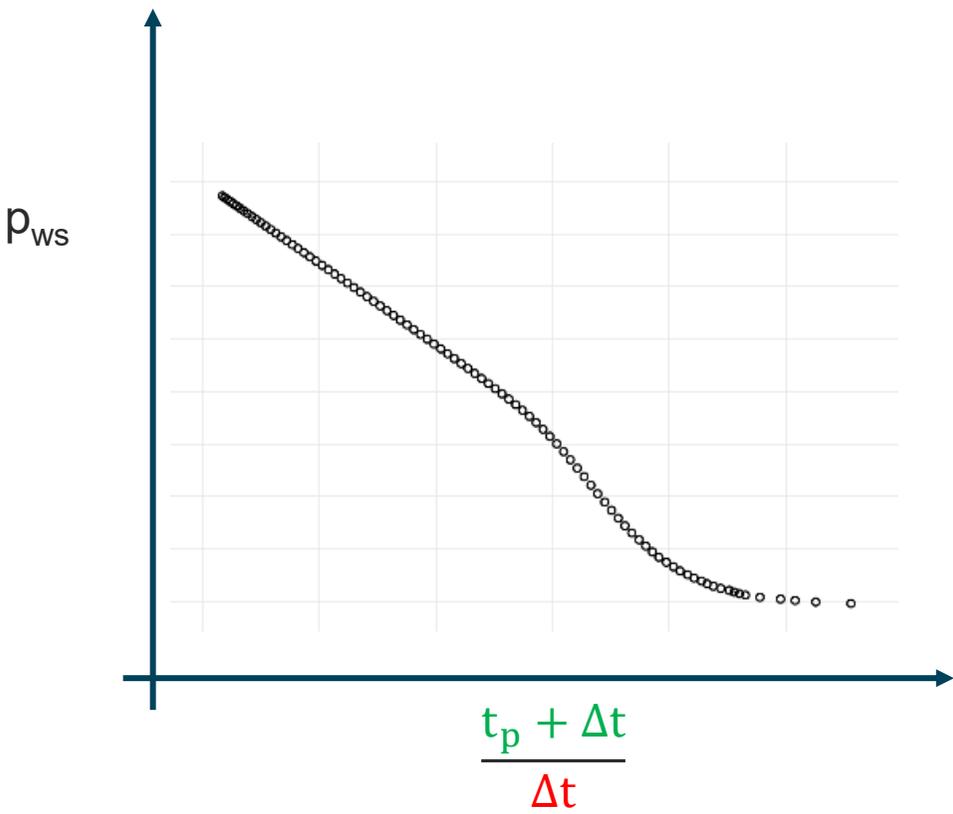
Buildup

Pseudopressure

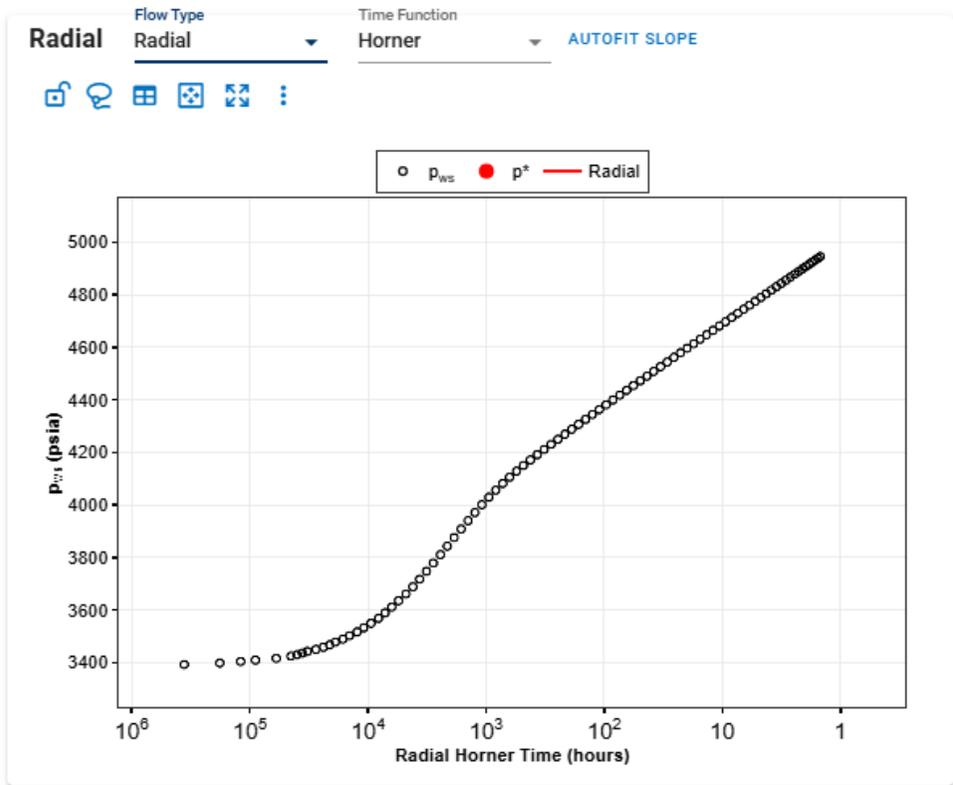
Pseudotime

Buildup Analysis

$$p_{ws}(\Delta t) = p_i - m \log \left(\frac{t_p + \Delta t}{\Delta t} \right)$$



Increasing shut-in time ←



→ Increasing shut-in time

Buildup Analysis

$$p_{ws}(\Delta t) = p_i - m \log\left(\frac{t_p + \Delta t}{\Delta t}\right)$$

$$p_i - p_{wf}(t_p) = m[\log(t_p) + S']$$

$$p_{ws}(\Delta t) - p_{wf}(t_p) = m \left[\log\left(\frac{t_p \Delta t}{t_p + \Delta t}\right) + S' \right]$$

$$\Delta t_e = \frac{t_p \Delta t}{t_p + \Delta t}$$

Gas Wells

Pseudopressure

Pseudotime

Gas Pseudopressure

Homogeneous, isotropic, Darcy's law applies,
single phase fluid, radial flow, vertical well,
constant net pay, constant saturation,
constant temperature,
constant PVT

Gas PVT linearization using pseudopressure:

$$p_p = 2 \int_{p_b}^p \frac{p}{\mu(p)z(p)} dp$$

Type curves and analytical solutions are identical to oil when pressure is replaced by pseudo-pressure.

Gas Pseudotime

Homogeneous, isotropic, Darcy's law applies,
single phase fluid, radial flow, vertical well,
constant net pay, constant saturation,
constant temperature,
constant PVT

Gas PVT linearization using pseudopressure:

$$p_p = 2 \int_{p_b}^p \frac{p}{\mu(p)z(p)} dp$$

Pseudo-pressure incorporates the pressure dependence of the μz term.

The pressure dependence of the μc term must still be accounted for.

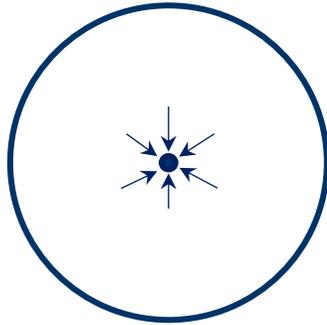
$$t_p = \int_{p_b}^p \frac{dt}{\mu_g c_t}$$

Flow Regime

WBS
Radial
Linear
Bilinear

Flow Regime

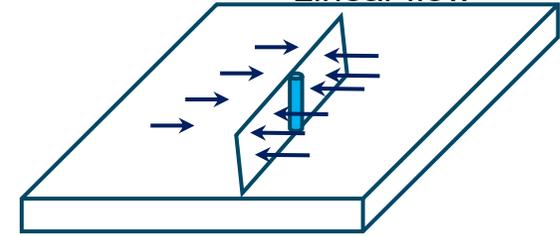
Radial flow



$$p_i - p_{wf}(t) = m(\log(t) + S')$$

$$p_{ws}(\Delta t) - p_{wf}(t_p) = m[\log(\Delta t_e) + S']$$

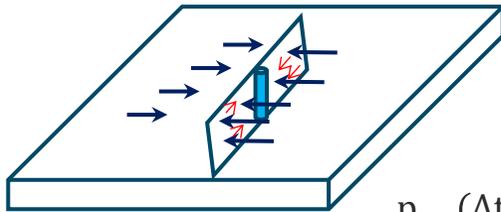
Linear flow



$$p_i - p_{wf}(t) = m_L \sqrt{t}$$

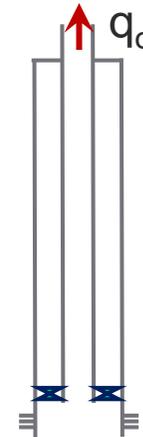
$$p_i - p_{ws}(t_p + \Delta t) = m_L \left[\sqrt{t_p + \Delta t} - \sqrt{\Delta t} \right]$$

Bilinear flow



$$p_i - p_{wf}(t) = m_{BL} t^{1/4}$$

$$p_{ws}(\Delta t) - p_{wf}(t_p) = m_{BL} \left[(t_p + \Delta t)^{1/4} - (\Delta t)^{1/4} \right]$$



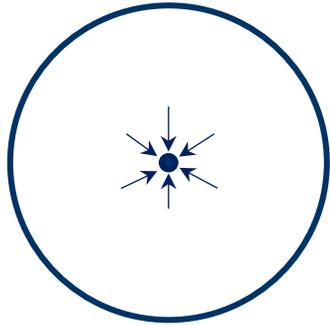
$$p_i - p_{wf}(t) = \frac{q_o B_o t}{24C}$$

Derivative

WBS
Radial
Linear
Bilinear

Derivative Analysis

Radial flow

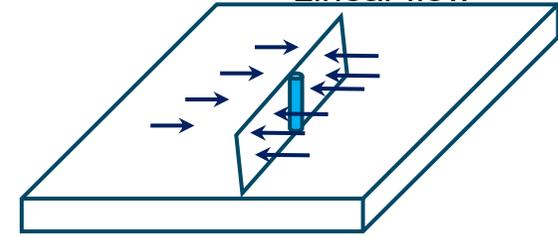


$$p_i - p_{wf} = m(\log(t) + S')$$

$$DER = \frac{m}{2.302}$$

$$DER = \frac{dp}{d \ln t} = t \frac{dp}{dt}$$

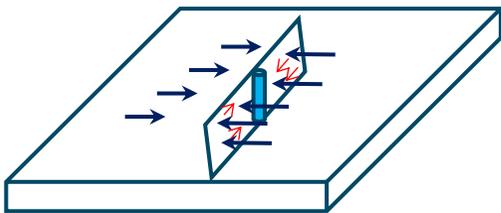
Linear flow



$$p_i - p_{wf}(t) = m_L \sqrt{t}$$

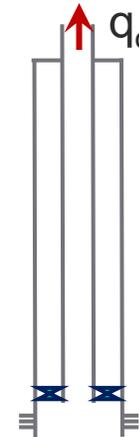
$$DER = \frac{1}{2} \cdot m_L \sqrt{t}$$

Bilinear flow



$$p_i - p_{wf}(t) = m_{BL} t^{1/4}$$

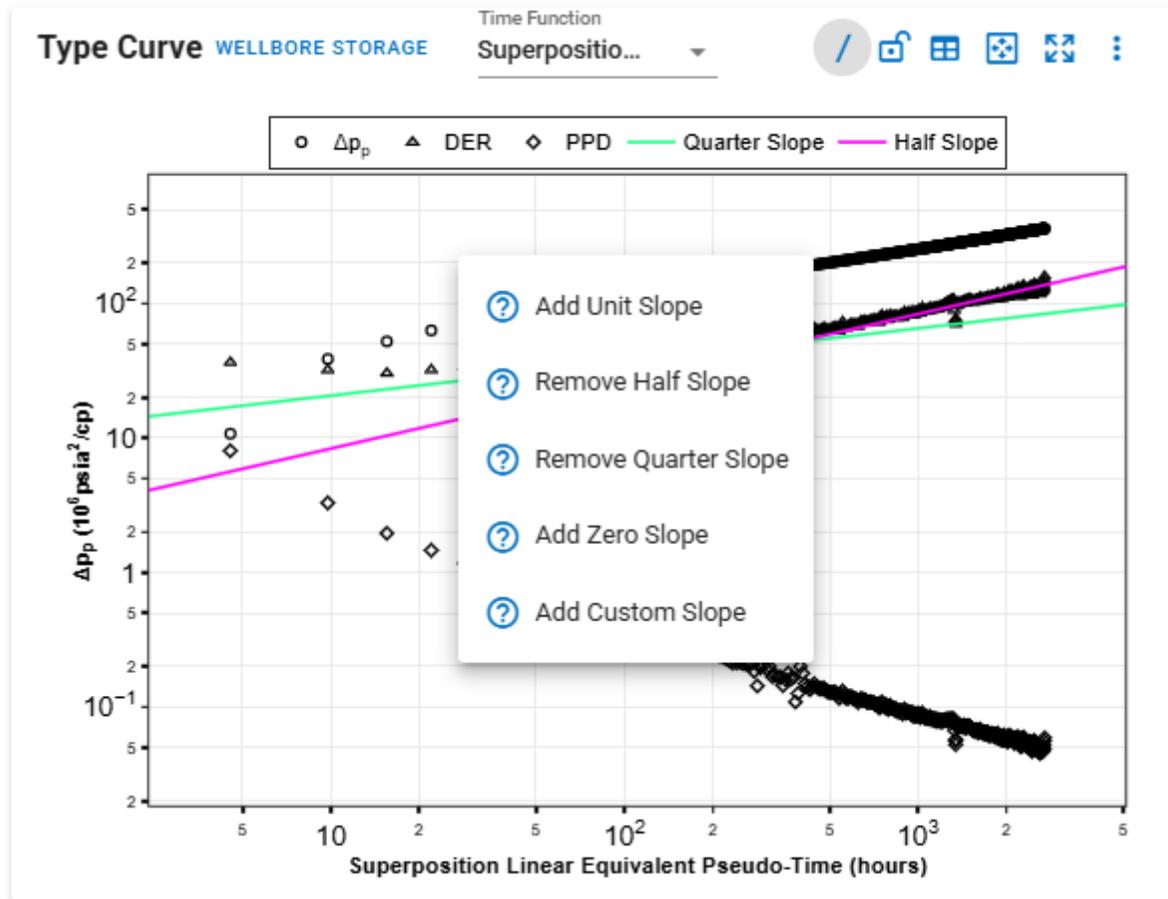
$$DER = \frac{1}{4} \cdot m_{BL} t^{1/4}$$



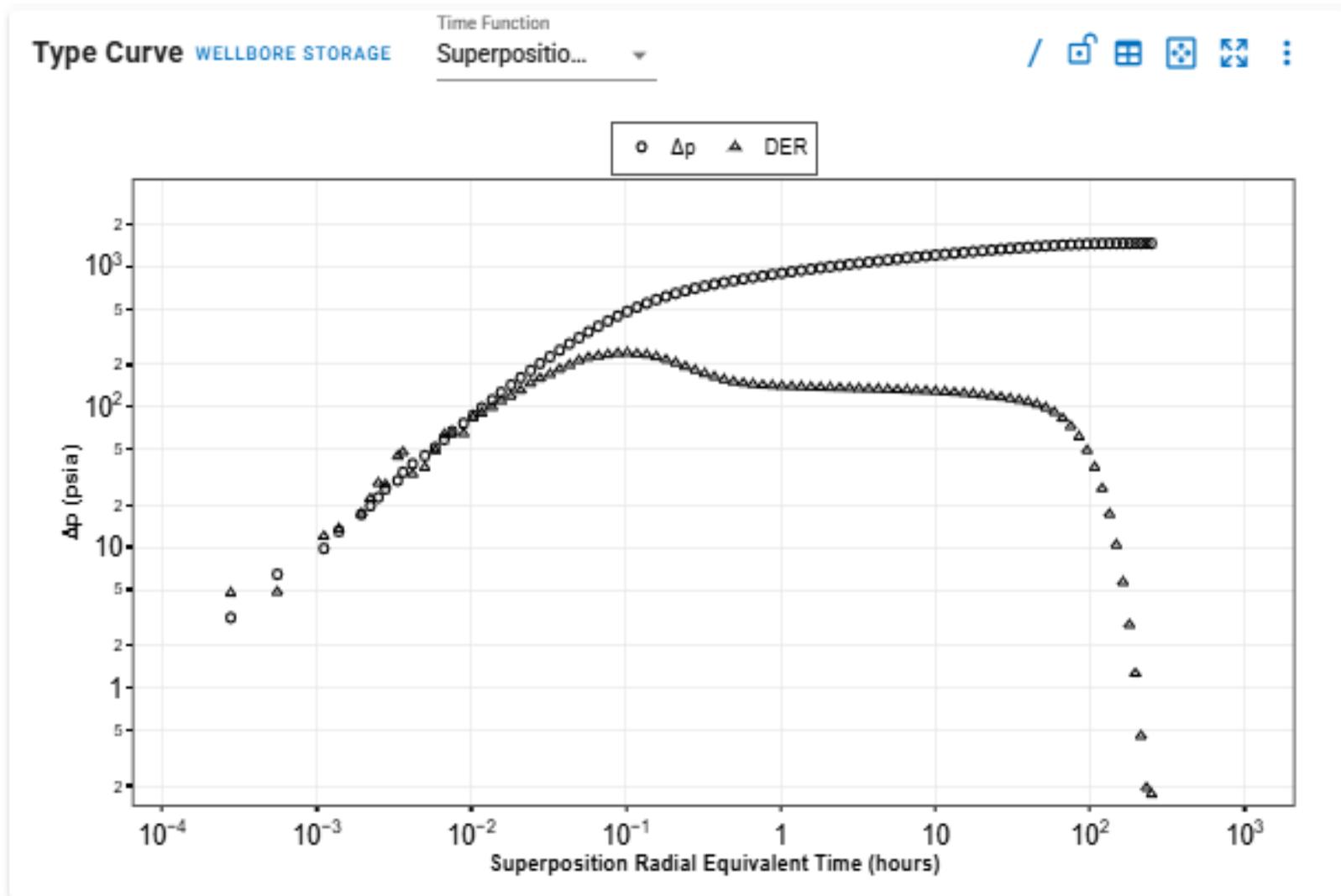
$$p_i - p_{wf}(t) = \frac{q_o B_o t}{24C}$$

$$DER = \frac{q_o B_o t}{24C}$$

Derivative Analysis



Derivative Analysis

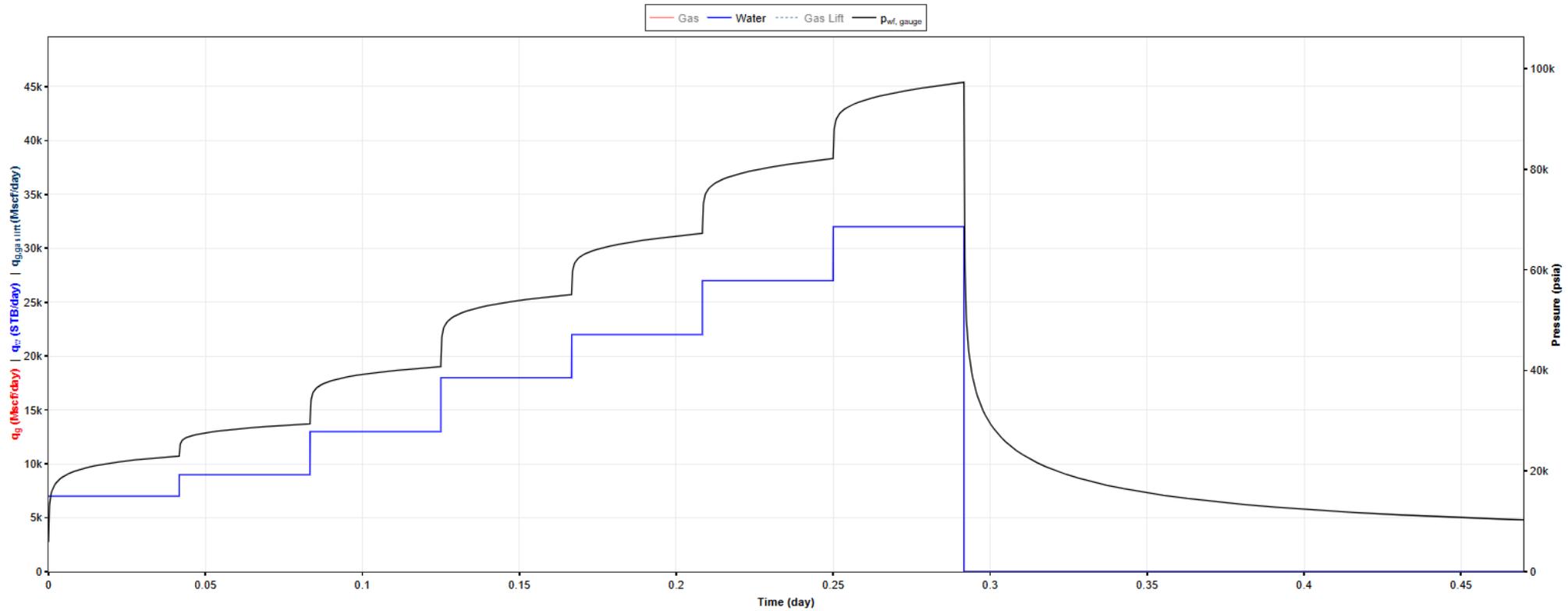


Injection-Fall off

Drawdown-Buildup

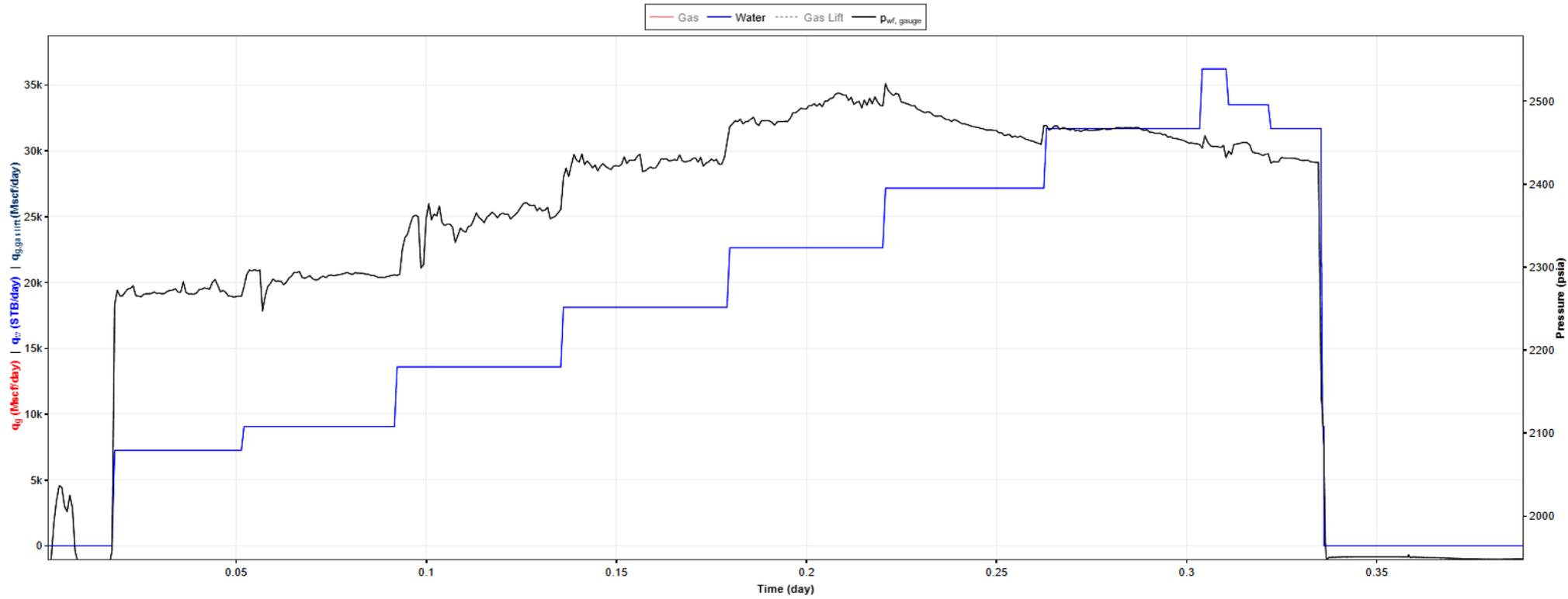
Injection Fall-off

LOG Y DATES USE CUMULATIVE RATIOS



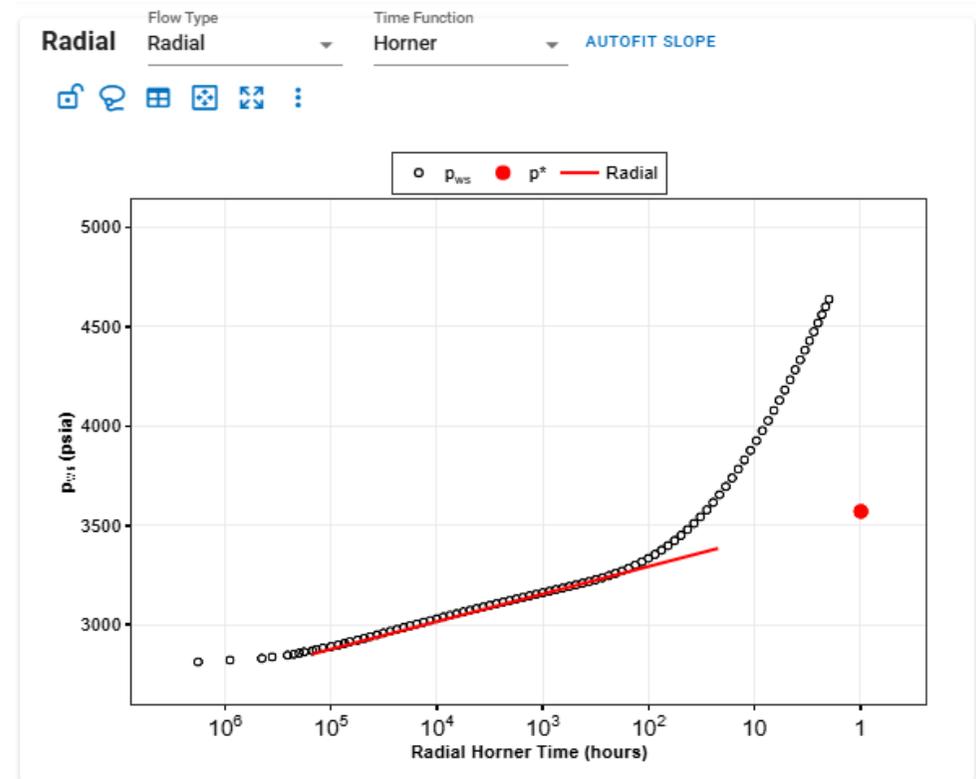
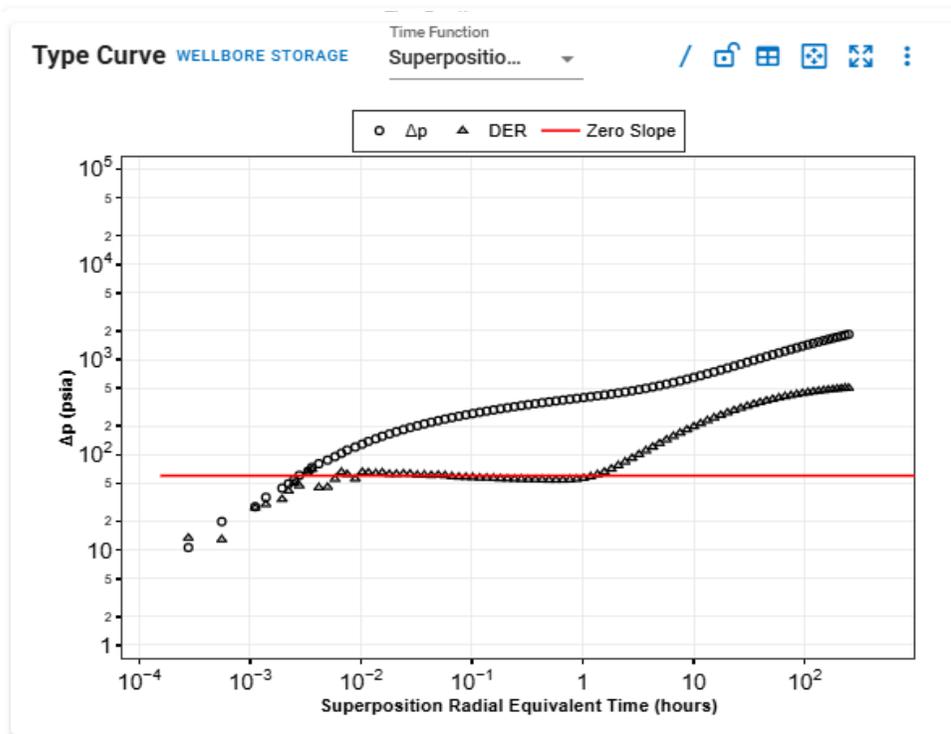
Injection Fall-off

LOG Y DATES USE CUMULATIVE RATIOS

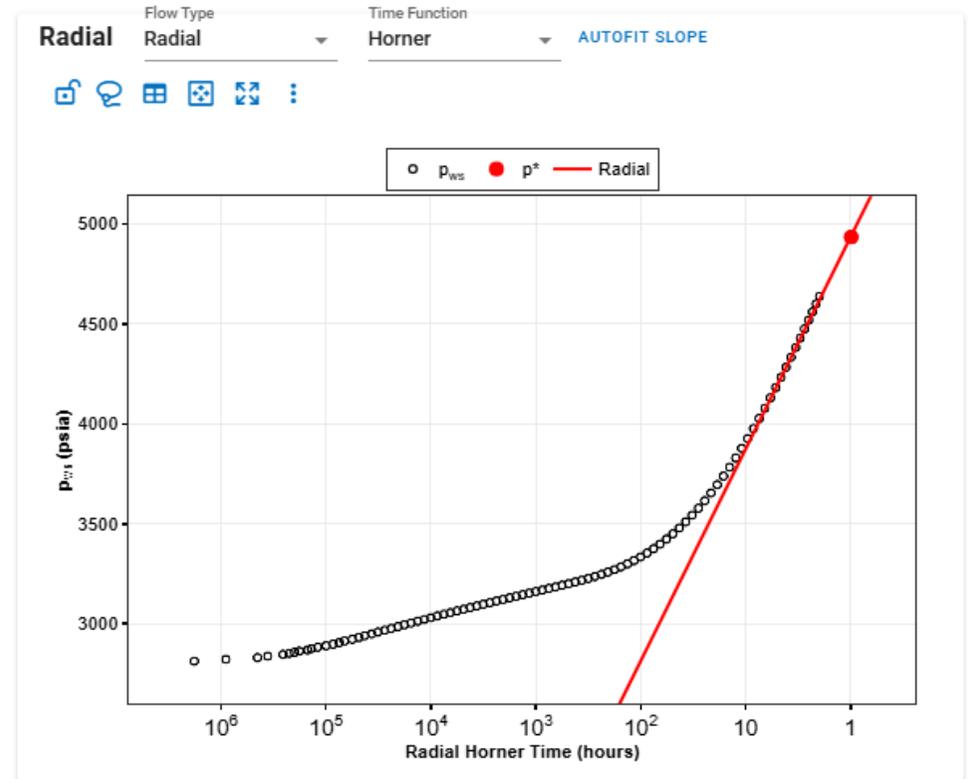
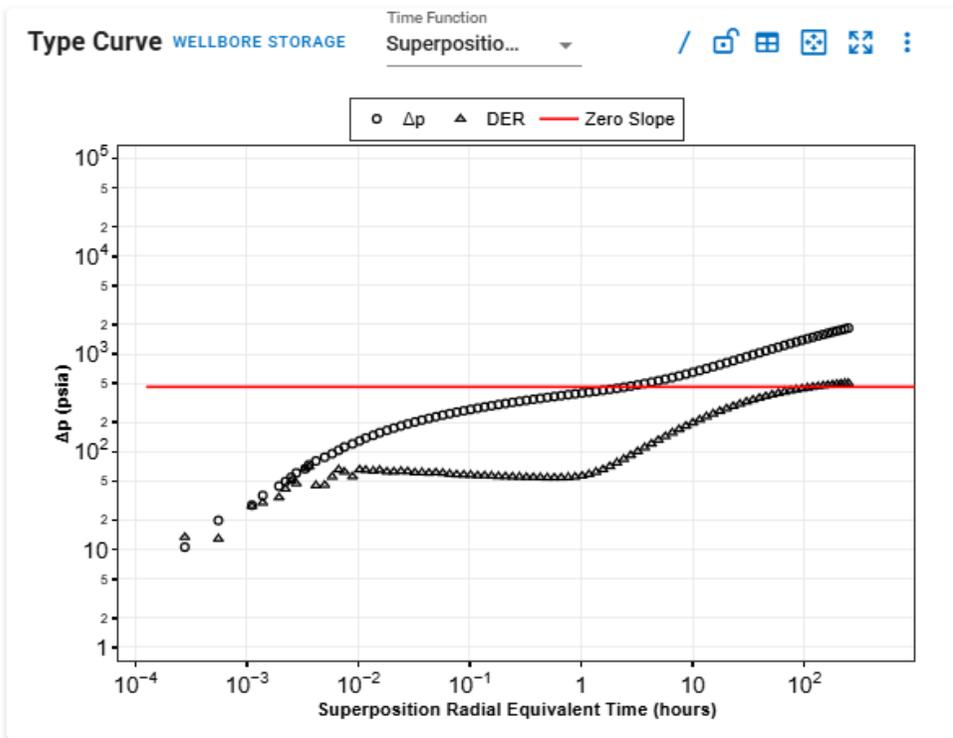


Complex Reservoirs

Composite Reservoir

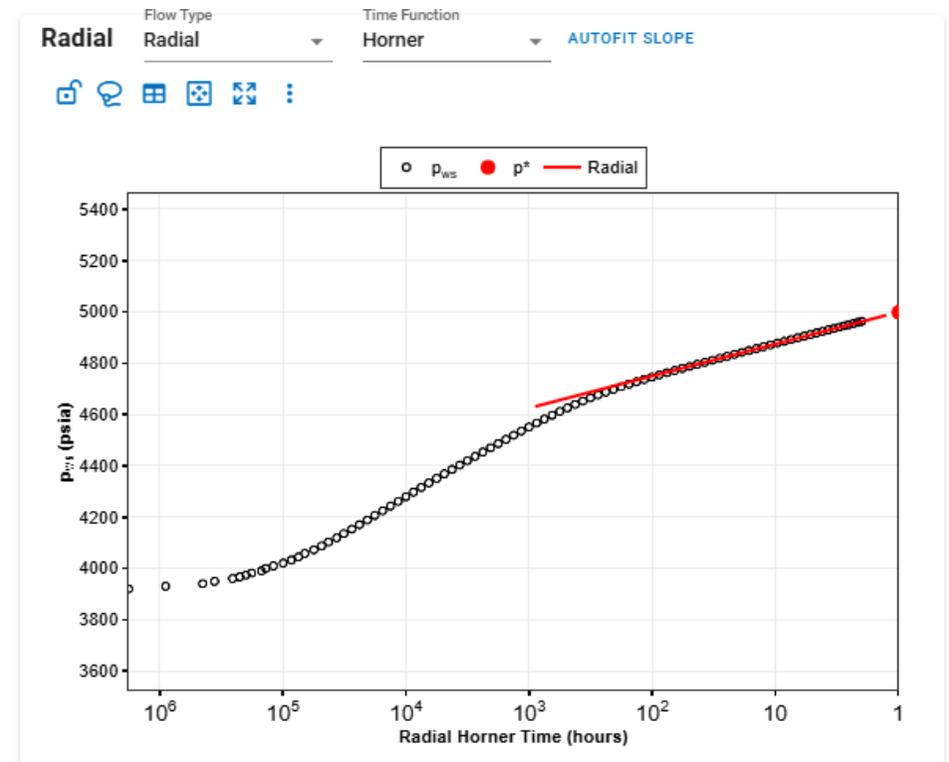
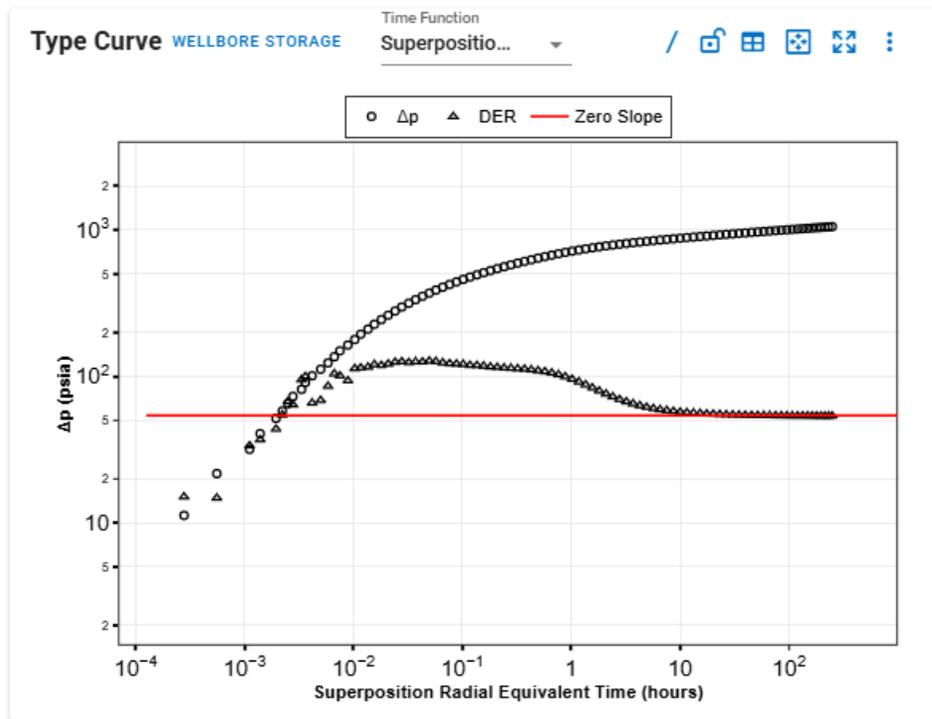


Composite Reservoir



Composite Reservoir

Composite Reservoirs:



Turn This Into Practice!

We'll assume the inputs are correct (PVT, BHP, etc.)

Data validation is a critical first step!

Spot wellbore dynamics — don't confuse them with reservoir effects.

Ensure integration of all related information for a complete analysis.



Questions....





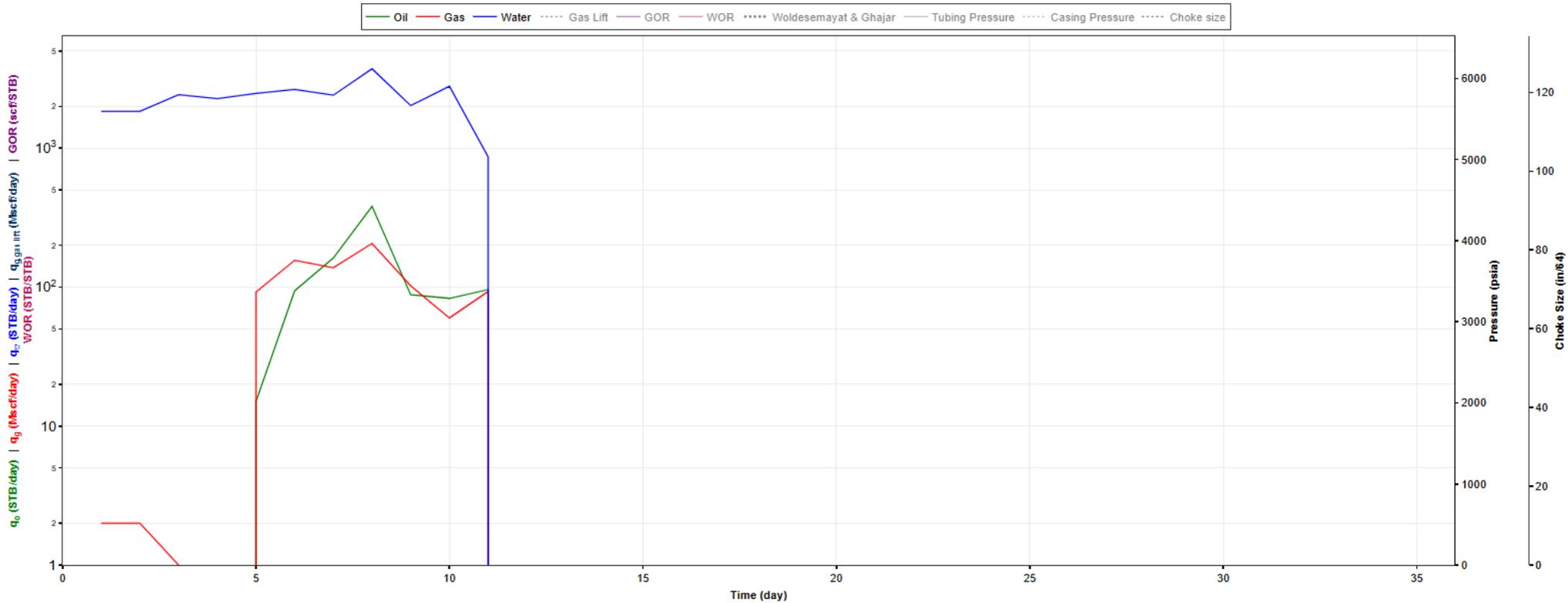
whitson
Support

Less than 2-minute response time—every ticket, every time!

Examples

Example

LOG Y DATES USE CUMULATIVE RATIOS LIQUID



Software Basics

whitson+: Set Zoom to 70-80%

The screenshot displays the whitson+ web application interface. The browser address bar shows the URL: `https://internal.whitson.com/fields/2/projects/49/wells/241/pvt/fluid-definition`. The application header includes navigation menus for Field (Bakken), Project (Stian-PhD-Project), Well (Volatile-Oil), and Analysis (Main). The main content area is titled "FLUID DEFINITION" and contains two panels: "Reservoir Fluid Composition" and "Surface Process".

The "Reservoir Fluid Composition" panel shows the following data:

Method:	API and GOR
T _{reservoir} :	200 F
P _{reservoir, int.} :	8000 psia

The "Surface Process" panel shows the following data:

Process:	Well Specific Process
Stage 1:	300 psia 100 F
Stage 2:	14.7 psia 60 F

The "Phase Envelope" plot shows Pressure (psia) on the y-axis (0 to 8000) and Temperature (F) on the x-axis (0 to 700). The plot includes a legend with the following items:

- Initial Reservoir Conditions (diamond symbol)
- Separator Conditions (square symbol)
- Critical Point (circle symbol)
- Bubblepoint (green line)
- Dewpoint (red line)

The plot shows a bubblepoint curve (green) and a dewpoint curve (red) forming a closed loop. The Initial Reservoir Conditions point is located at approximately 200 F and 8000 psia. The Separator Conditions point is located at approximately 100 F and 500 psia. The Critical Point is located at approximately 380 F and 3800 psia.

A blue callout box with the text "Click here (Alternatively, CTRL + '-' on keyboard)" points to the Zoom menu item in the browser's context menu. The Zoom menu is open, showing the current zoom level at 50% and a zoom in (+) button.

The Windows taskbar at the bottom shows the system tray with the date and time: ENG NO 5:35 PM 3/1/2023.

whitson+: Maximize Screen by "F11"

whitson+ Field: Bakken Project: Stian-PhD-Project Well: Volatile-Oil Analysis: Main

Click F11

Pressure (psia)

Temperature (F)

Initial Reservoir Pressure

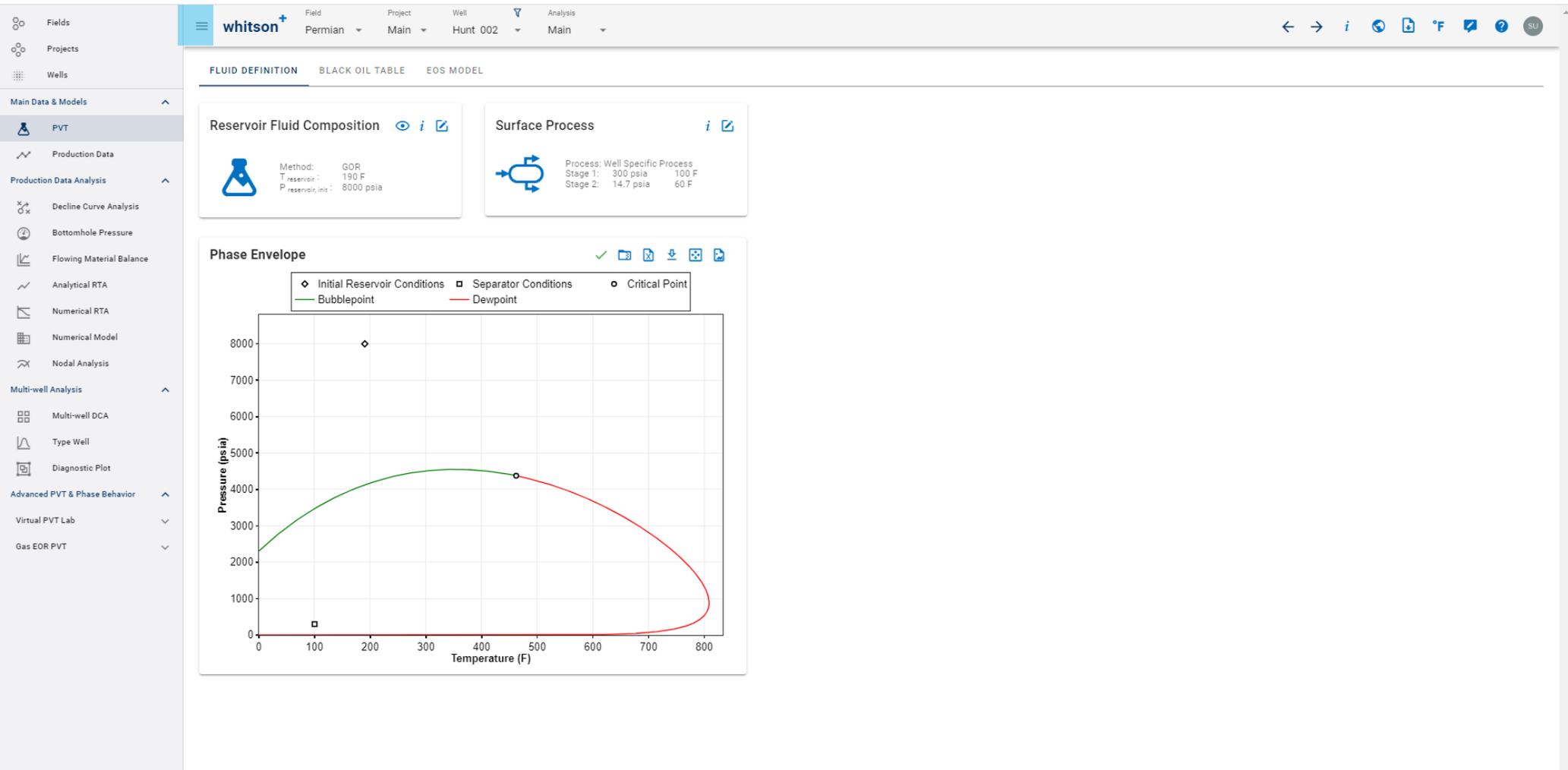
Bubblepoint

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Type here to search

ENG NO 5:37 PM 3/1/2023

whitson⁺: More Screen Real Estate



whitson+: More Screen Real Estate

FLUID DEFINITION BLACK OIL TABLE EOS MODEL

Reservoir Fluid Composition



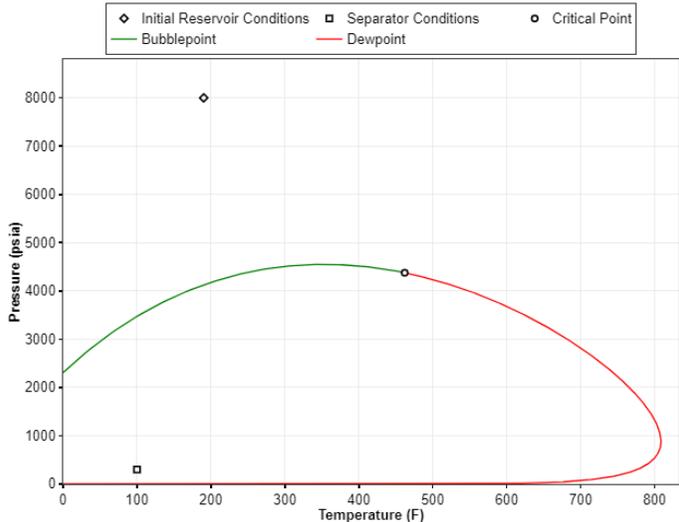
Method: GOR
T_{reservoir}: 190 F
P_{reservoir,init}: 8000 psia

Surface Process



Process: Well Specific Process
Stage 1: 300 psia 100 F
Stage 2: 14.7 psia 60 F

Phase Envelope



whitson+: Navigation Panel

The screenshot displays the whitson+ software interface. On the left is a navigation panel with a tree view of modules. The main area shows a 'Phase Envelope' plot. A blue callout box with the text 'Navigation Panel Overview of all modules' points to the navigation panel.

Navigation Panel Modules:

- Fields
- Projects
- Wells
- Main Data & Models
 - PVT
 - Production Data
 - Production Data Analysis
 - Decline Curve Analysis
 - Bottomhole Pressure
 - Flowing Material Balance
 - Analytical RTA
 - Numerical RTA
 - Numerical Model
 - Nodal Analysis
 - Multi-well Analysis
 - Multi-well DCA
 - Type Well
 - Diagnostic Plot
 - Advanced PVT & Phase Behavior
 - Virtual PVT Lab
 - Gas EOR PVT

Phase Envelope Plot:

The plot shows Pressure (psia) on the y-axis (0 to 8000) and Temperature (F) on the x-axis (0 to 800). The plot includes a green bubblepoint curve and a red dewpoint curve. Key points are marked: Initial Reservoir Conditions (diamond at ~180 F, 8000 psia), Separator Conditions (square at ~100 F, 300 psia), and Critical Point (circle at ~450 F, 4500 psia).

Point	Temperature (F)	Pressure (psia)
Initial Reservoir Conditions	~180	8000
Separator Conditions	~100	300
Critical Point	~450	4500

whitson+: Software Hierarchy

The screenshot displays the whitson+ software interface. The top navigation bar includes 'whitson+' and dropdown menus for 'Field' (Permian), 'Project' (Main), 'Well' (Hunt 002), and 'Analysis' (Main). A toolbar on the right contains navigation icons, with the 'Next / Previous Well' icons circled in red. A blue callout box points to these icons with the text 'Next / Previous Well in a project'. A large blue callout box in the center of the interface reads 'Software Hierarchy Fields → Projects → Wells'. The main content area shows a 'Phase Envelope' plot with 'Pressure (psia)' on the y-axis (0 to 8000) and 'Temperature (F)' on the x-axis (0 to 800). The plot includes a green bubblepoint curve and a red dewpoint curve. A legend indicates 'Initial Reservoir' (diamond) and 'Bubblepoint' (line). A small square icon is also visible on the x-axis at approximately 100 F.

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whitson+: Create Multiple Analyses for a Well

The screenshot displays the whitson+ software interface. The top navigation bar includes 'Field' (Permian), 'Project' (Main), 'Well' (Hunt 002), and 'Analysis' (Main). A dropdown menu under 'Analysis' shows options: 'Add new analysis', 'View all analyses', and 'Main'. A blue callout box points to the 'Add new analysis' option with the text: 'Save an analysis (or interpretation) for a given well'. The main workspace shows two analysis cards: 'Reservoir Fluid Composition' (Method: GOR, T_{reservoir}: 190 F, P_{reservoir, int}: 8000 psia) and 'Surface' (Process: Well Specific Process, Stage 1: 300 psia, 100 F, Stage 2: 14.7 psia, 60 F). Below these is a 'Phase Envelope' plot with Pressure (psia) on the y-axis (0 to 8000) and Temperature (F) on the x-axis (0 to 800). The plot shows a bubblepoint curve (green), a dewpoint curve (red), and a critical point (black circle). Initial Reservoir Conditions (black diamond) are at approximately (190 F, 8000 psia) and Separator Conditions (black square) are at approximately (100 F, 200 psia).

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whitson+: Create Multiple Analyses for a Well

The screenshot shows the whitson+ software interface. On the left is a navigation sidebar with categories like 'Fields', 'Projects', 'Wells', 'Main Data & Models', 'Production Data', 'Production Data Analysis', 'Multi-well Analysis', 'Advanced PVT & Phase Behavior', 'Virtual PVT Lab', and 'Gas EOR PVT'. The main area displays analysis settings for 'Main' under 'Analysis'. A dropdown menu is open, showing 'Add new analysis', 'View all analyses', and 'Main'. Below this are two summary cards: 'Reservoir Fluid Composition' (Method: GOR, T_{reservoir}: 190 F, P_{reservoir, int}: 8000 psia) and 'Surface' (Process: Well Specific Process, Stage 1: 300 psia, 100 F, Stage 2: 14.7 psia, 60 F). A 'Phase Envelope' plot is shown with Pressure (psia) on the y-axis (0 to 8000) and Temperature (F) on the x-axis (0 to 800). The plot includes a green bubblepoint curve, a red dewpoint curve, and a critical point. A legend identifies 'Initial Reservoir Conditions' (diamond), 'Separator Conditions' (square), and 'Critical Point' (circle).

Click here and it will bring you to the well overview page

Well Overview page

The 'Well Overview' page displays a detailed view of the well analysis. It includes sections for 'Well Information', 'Reservoir Properties', 'Completion Metrics', and 'Well Data Audit'. The 'Well Information' section shows well ID '123456789-123', name 'Main', and status 'Active'. The 'Reservoir Properties' section lists reservoir pressure (8000 psia), depth (200 ft), and surface length (100 ft). The 'Completion Metrics' section shows completion type 'Staged Fracture' and completion date '2023-01-15'. The 'Well Data Audit' section shows a list of data points with columns for 'Address Name', 'Asset Type', 'Owner', 'Created', and 'Last Modified'. A table at the bottom shows the following data:

Address Name	Asset Type	Owner	Created	Last Modified
Main	Production Well	Default	23 Feb 2023 15:50	View & Edit Data

whitson+: Change Units

The screenshot displays the whitson+ software interface. At the top, the 'Change Unit System' dropdown menu is open, showing options for 'Field' (selected), 'SI/Metric', and 'SI/Metric'. A blue callout box with the text 'Change Units' is positioned over the dropdown. The main interface shows the 'FLUID DEFINITION' tab with 'Reservoir Fluid Composition' and 'Surface Process' panels. The 'Phase Envelope' plot shows Pressure (psia) vs. Temperature (F) with a bubblepoint curve (green) and a dewpoint curve (red). The plot includes data points for Initial Reservoir Conditions (diamond), Separator Conditions (square), and Critical Point (circle).

Reservoir Fluid Composition

- Method: GOR
- T_{reservoir}: 190 F
- P_{reservoir,init}: 8000 psia

Surface Process

- Process: Well Specific Process
- Stage 1: 300 psia 100 F
- Stage 2: 14.7 psia 60 F

Phase Envelope

- Initial Reservoir Conditions (diamond)
- Separator Conditions (square)
- Critical Point (circle)
- Bubblepoint (green line)
- Dewpoint (red line)

Pressure (psia) vs. Temperature (F)

Point	Temperature (F)	Pressure (psia)
Initial Reservoir Conditions	~190	8000
Separator Conditions	~100	~300
Critical Point	~450	~4500

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whitson+: Input Card

The screenshot displays the whitson+ software interface. The top navigation bar includes 'whitson+', 'Field: Permian', 'Project: Main', 'Well: Hunt 002', and 'Analysis: Main'. Below this, there are tabs for 'FLUID DEFINITION', 'BLACK OIL TABLE', and 'EOS MODEL'. The 'FLUID DEFINITION' tab is active, showing two cards: 'Reservoir Fluid Composition' and 'Surface Process'. The 'Reservoir Fluid Composition' card is highlighted with a blue callout box that says 'Open by clicking here', pointing to an edit icon. A larger blue callout box on the left explains that these cards are 'Input Cards' containing input information for different features. Below the cards is a graph showing 'Temperature (F)' on the x-axis (0 to 800) and pressure on the y-axis (0 to 2000). The graph displays a red curve for 'Dewpoint' and a green curve for 'Separator Conditions'. A small square marker is visible on the x-axis at approximately 100 F.

These “Cards” is what we call an “Input Card” and they contain input information for the different features-

Open by clicking here

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whitson+: Support Ticket

The screenshot displays the whitson+ software interface. The top navigation bar includes 'whitson+', 'Field' (Permian), 'Project' (Main), 'Well' (Hunt 002), and 'Analysis' (Main). The main content area is divided into 'FLUID DEFINITION', 'BLACK OIL TABLE', and 'EOS MODEL'. The 'Reservoir Fluid Composition' panel shows 'Method: GOR', 'T_{reservoir}: 190 F', and 'P_{reservoir, int}: 8000 psia'. The 'Surface Process' panel shows 'Process: Well Specific Process'. The 'Phase Envelope' plot shows Pressure (psia) on the y-axis (0 to 8000) and Temperature (F) on the x-axis (0 to 800). The plot includes a green curve for 'Bubblepoint', a red curve for 'Dewpoint', a black diamond for 'Initial Reservoir Conditions' at approximately (180, 8000), and a black square for 'Separator Conditions' at approximately (100, 200). A 'Feedback / Question' modal window is open, containing the following fields: 'Title', 'Type' (dropdown), 'Module (optional)' (Fluid Definition), 'Field (optional)' (dropdown), 'Project (optional)' (dropdown), 'Well (optional)' (dropdown), 'Calculation ID: cc3a482e-a74d-42ce-8740-93d3ac5f7116', 'Description', and 'Attachment (optional)'. The modal has 'HIDE', 'DISCARD', and 'SAVE' buttons at the bottom.

Feedback / Question

Title

Type Module (optional)
Fluid Definition

Field (optional) Project (optional)

Well (optional)

Calculation ID: cc3a482e-a74d-42ce-8740-93d3ac5f7116

Description

Attachment (optional)

HIDE DISCARD SAVE

**You can also e-mail
support@whitson.com**

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whitson+: Manual

- Fields
- Projects
- Wells
- Main Data & Models
 - PVT
 - Production Data
 - Production Data Analysis
 - Decline Curve Analysis
 - Bottomhole Pressure
 - Flowing Material Balance
 - Analytical RTA
 - Numerical RTA
 - Numerical Model
 - Nodal Analysis
 - Multi-well Analysis
 - Multi-well DCA
 - Type Well
 - Diagnostic Plot
 - Advanced PVT & Phase Behavior
 - Virtual PVT Lab
 - Gas EOR PVT

whitson+ Field: Permian Project: Main Well: Hunt 002 Analysis: Main

User Manual ?

FLUID DEFINITION BLACK OIL TABLE EOS MODEL

Reservoir Fluid Composition

Method: GOR
T_{reservoir}: 190 F
P_{reservoir,init}: 8000 psia

Surface Process

Process: Well Specific Process
Stage 1: 300 psia 100 F
Stage 2: 14.7 psia 60 F

Phase Envelope

Initial Reservoir Conditions Separator Conditions Critical Point
Bubblepoint Dewpoint

Point	Temperature (F)	Pressure (psia)
Initial Reservoir Conditions	~190	8000
Separator Conditions	~100	~300
Critical Point	~470	~4500

User manual

whitson+: Zooming Plots

whitson+ Field Permian Project Main Well Hunt 002 Analysis Main

FLUID DEFINITION BLACK OIL TABLE EOS MODEL

Reservoir Fluid Composition Method: GOR
T_{reservoir}: 190 F
P_{reservoir,init}: 8000 psia

Surface Process Process: Well Specific Process
Stage 1: 300 psia 100 F
Stage 2: 14.7 psia 60 F

Phase Envelope

◆ Initial Reservoir Conditions □ Separator Conditions ○ Critical Point
— Bubblepoint — Dewpoint

Pressure (psia)

Temperature (F)

- ✓ Zoom into certain part of the plots.
- ✓ Reset zoom to default (double click inside of plot area or use icon to upper right).
- ✓ Scale both axes at the same time (y and x), while keeping the origin fixed.
- ✓ Scale one axis (y or x), while keeping the origin fixed.
- ✓ Scale axis by typing a number.
- ✓ Turn on or off legends.

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Important Shortcut: Refresh

- Refresh shortcut: “CTRL + R”
- Use if you experience
 - Bad connection
 - The browser is “stuck”



whitson

We support energy companies, oil services companies, investors and government organizations with expertise and expansive analysis within PVT, gas condensate reservoirs and gas-based EOR. Our coverage ranges from R&D based industry studies to detailed due diligence, transaction or court case projects.

We help our clients find best possible answers to complex questions and assist them in the successful decision-making on technical challenges. We do this through a continuous, transparent dialog with our clients - before, during and after our engagement.

The company was founded by Dr. Curtis Hays Whitson in 1988 and is a Norwegian corporation located in Trondheim, Norway, with local presence in USA, Middle East, India and Indonesia.

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