PRESSURE DERIVATIVE ANALYSIS

NEAR WELLBORE EFFECTS

- Wellbore Storage
- High Conductivity Fracture
- Low Conductivity Fracture
- Limited Entry
- Horizontal Well

RESERVOIR BEHAVIOUR

- Homogeneous Behaviour
- Double porosity Behaviour
- Double permeability Behaviour
- Composite Behaviour
- Layered reservoirs (w/wo crossflow)

BOUNDARY EFFECTS

- Single Fault
- Leaky Fault
- Channel
- Wedge
- Open or Closed Rectangle
- Constant Pressure

THE USE OF PRESSURE DERIVATIVES IN WELL TEST ANALYSIS

dp/dt:

Tiab, D. and Kumar, A.:"Application of the p'_D Function to Interference Analysis," *J. Pet. Tech.* (Aug., 1980), 1465-1470.

Tiab, D. and Kumar, A.:"Detection and Location of Two Parallel Sealing Faults around a Well," *J. Pet. Tech.* (Oct., 1980), 1701-1708.

Tiab, D. and Crichlow, H.B..:"Pressure Analysis of Multiple-Sealing-Fault Systems and Bounded Reservoirs by Type Curve Matching," *SPEJ* (Dec., 1979) 378-392.

dp/dln(t):

Kuiper (Tjeerd) Shell, several years before Bourdet (Cor van Kruijsdijk, personal communication): internal Shell report showed a log-log plot of the Horner derivative versus time but without the pressure change data superimposed. Kuiper was a production technologist specialized in hydraulic fracturing.

Bourdet, D. P., Whittle, T. M., Douglas, A. A. and Pirard, Y. M.: "A New Set of Type Curves Simplifies Well Test Analysis," *World Oil* (May, 1983) 95-106.

Bourdet, D. P., Ayoub, J. A., Whittle, T. M., Pirard, Y. M. and Kniazeff, V.: "Interpreting Data in Fractured Reservoirs," *World Oil* (Oct., 1983) 77-87.

Clark, D. G. and Van Golf-Racht, T. D.: "Pressure Derivative Approach to Transient Test Analysis: A High-Permeability North Sea Reservoir Example," *SPE12969* Oct 1984; *J. Pet. Tech.* (Nov., 1985) 2023-2039.

Wong, D.W., Harrington, A.G. and Cinco-Ley, H.:"Application of the Pressure-Derivative Function in the Pressure-Transient Testing of Fractured Wells,“ *SPE 13058* ATCE Houston (Sept 1984); *SPEFE.*(Oct., 1985) 470-480.

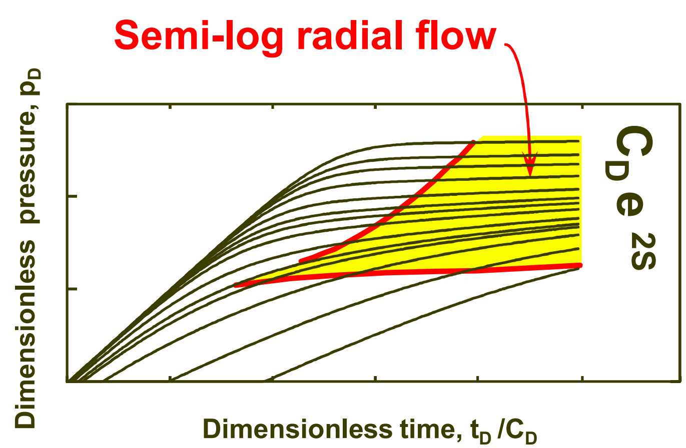
Alagoa, A., Bourdet, D. and Ayoub, J.A.:"How to Simplify The Analysis of Fractured Well Tests," *World Oil* (Oct. 1985)

DERIVATIVE FOR RADIAL FLOW (Middle Times)

Radial flow following wellbore storage (dimensionless)

$$p_D = \frac{1}{2}\left(\ln\frac{t_D}{C_D} + 0.80907 + \ln C_D e^{2S}\right) \qquad p_D = \frac{kh}{141.2\,\Delta q\,B\,\mu}\Delta p$$

- Function of time
- Function of $C_D\,e^{2S}$



Derivative with respect to ln(time)

$$p_D' = \frac{dp_D}{d\ln\left(\frac{t_D}{C_D}\right)} = \quad 0.5$$

- Independent of time
- Independent of ***S***
- Independent of near-wellbore effects

$$p_D = \frac{1}{2}\left(\ln t_{De} + 0.80907\right)$$

$$t_{De} = \frac{0.000264\,k}{\phi\mu c_t r_{we}^2}\Delta t \qquad r_{we} = r_w e^{-S}$$

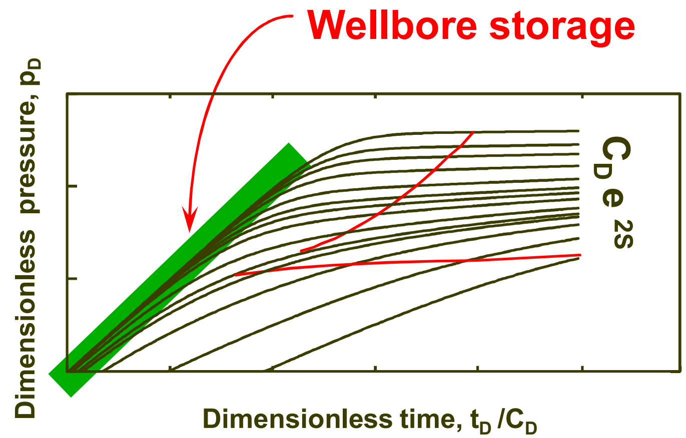
$$p_D' = \frac{dp_D}{d\ln(t_{De})} = 0.5$$

DERIVATIVE FOR WELLBORE STORAGE (Early Times)

Wellbore storage (dimensionless)

$$p_D = \frac{t_D}{C_D}$$

$$p_D = \frac{kh}{141.2\,\Delta q\, B\,\mu}\Delta p$$



Derivative with respect to ln(time)

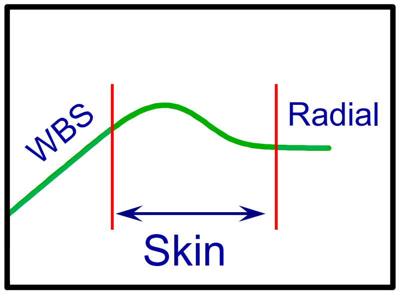
$$p_D' = \frac{dp_D}{d\ln\left(\frac{t_D}{C_D}\right)} = \frac{t_D}{C_D}\frac{dp_D}{d\frac{t_D}{C_D}}$$

$$p_D' = \frac{t_D}{C_D} = p_D$$

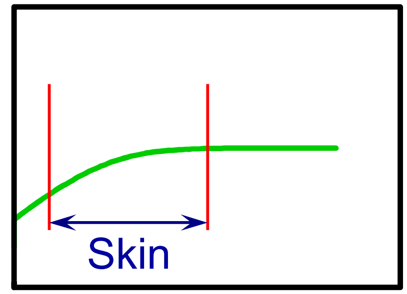
- ❑ Unit slope log-log straight line
- ❑ Same as pressure

DERIVATIVE FOR SKIN (Early Times)

Derivative

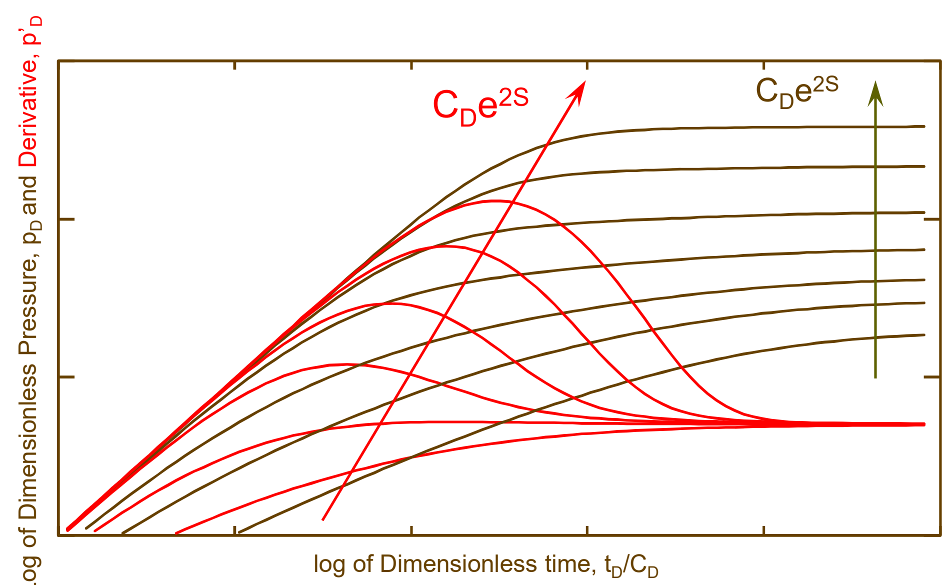


Damaged well
Maximum



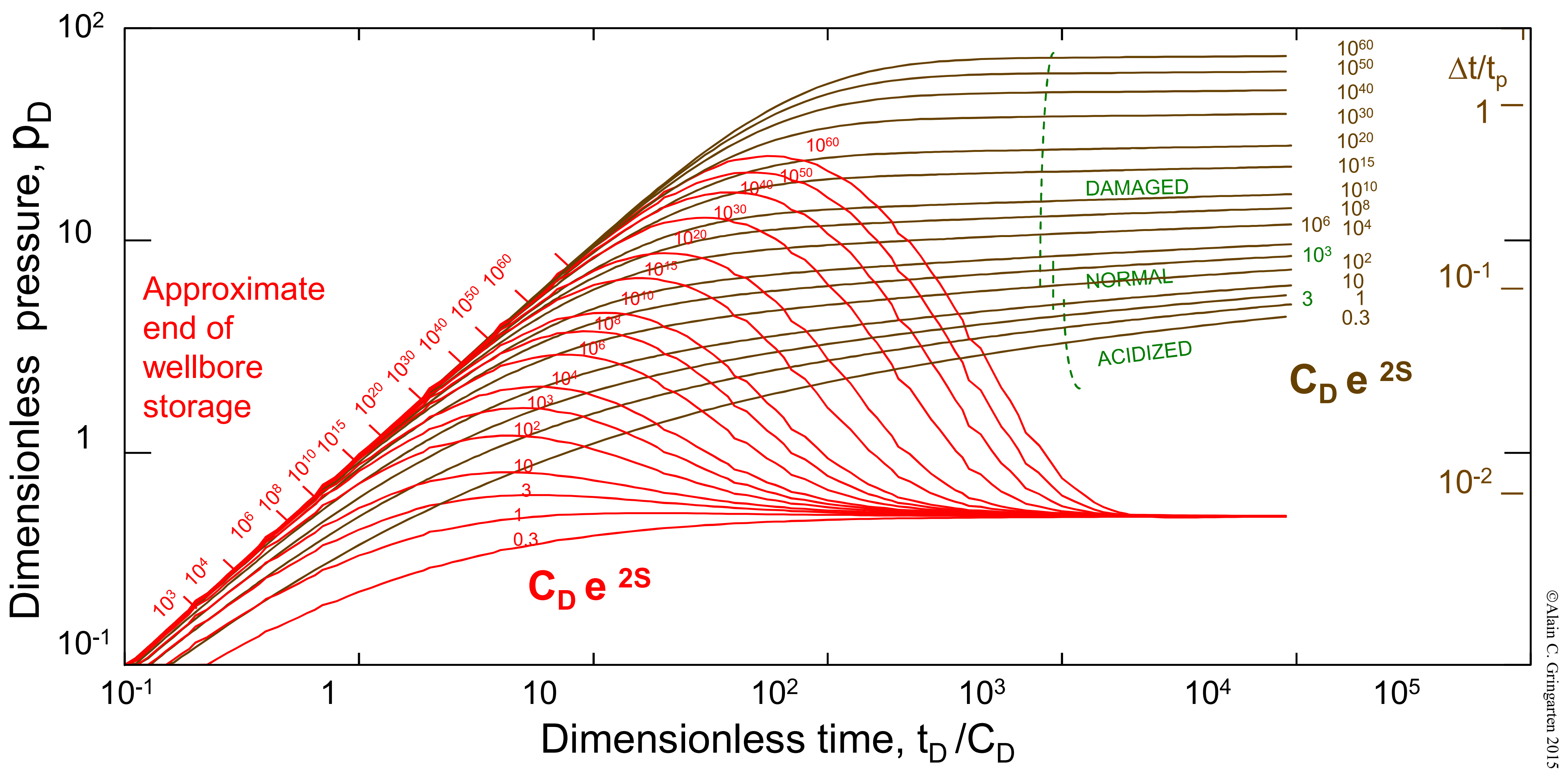
Stimulated well
No maximum

Wellbore storage and skin, homogeneous behaviour, infinite extent

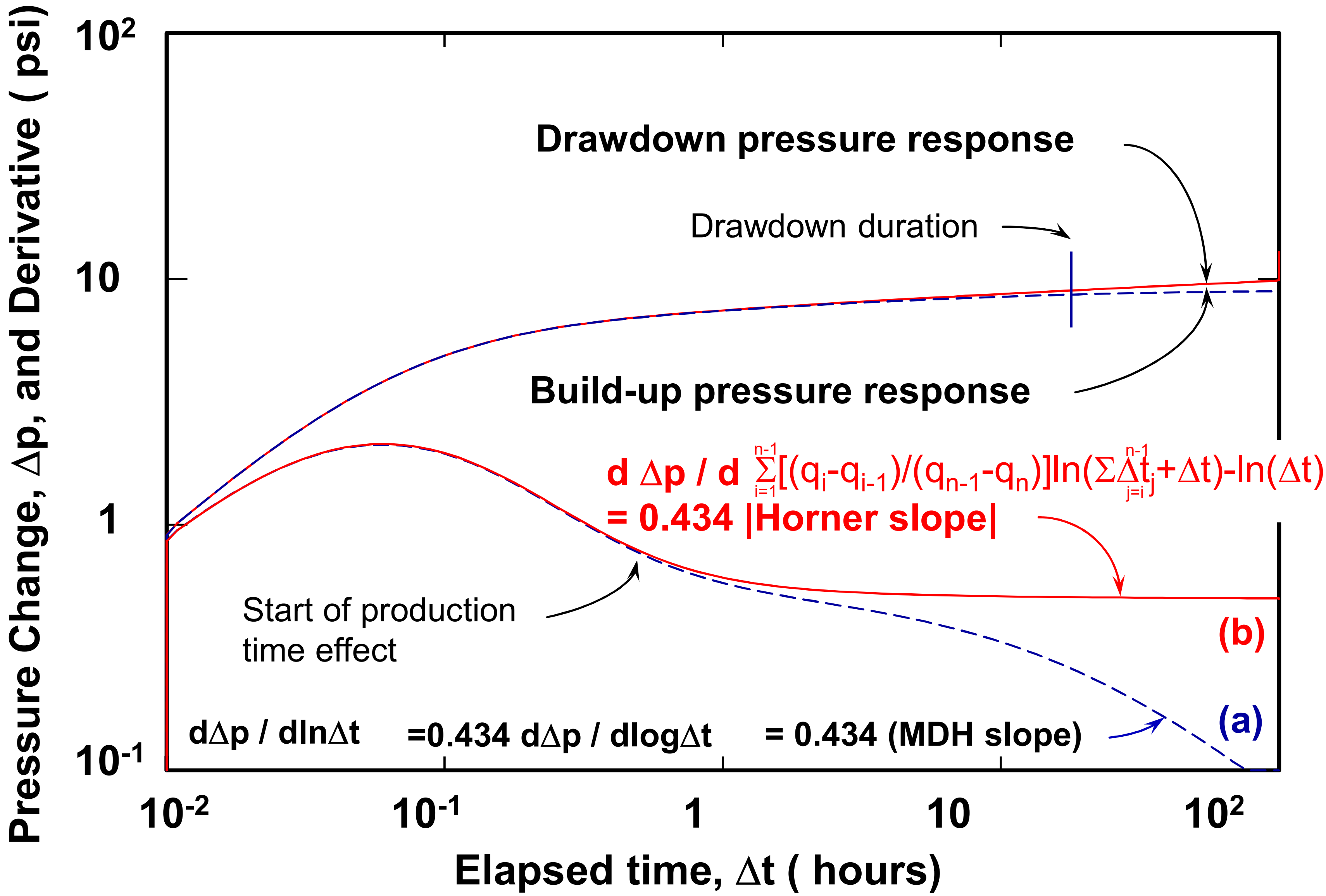


Bourdet (and Whittle, Douglas and Pirard) Type Curve

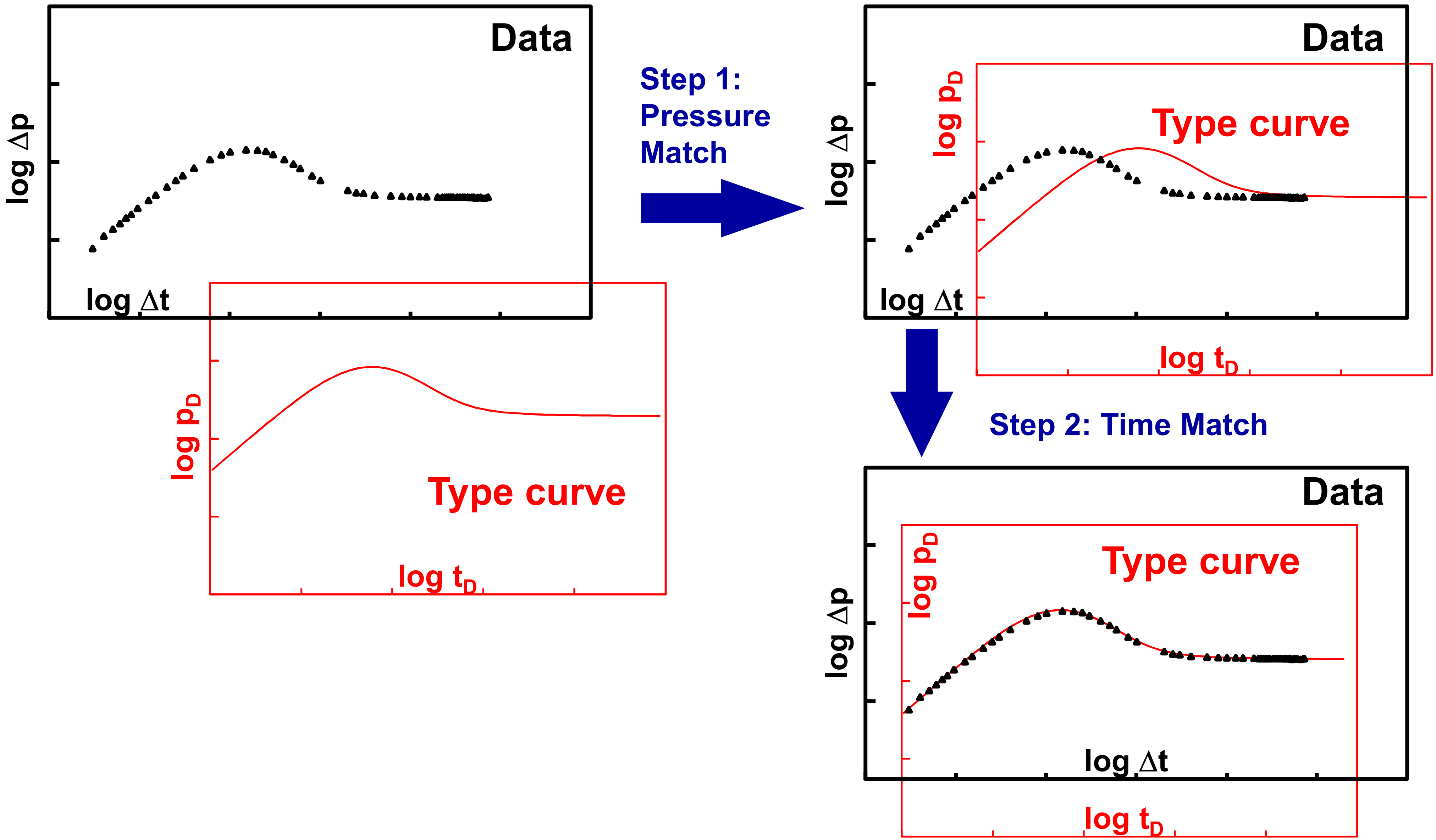
World Oil 196 (6) May 1983



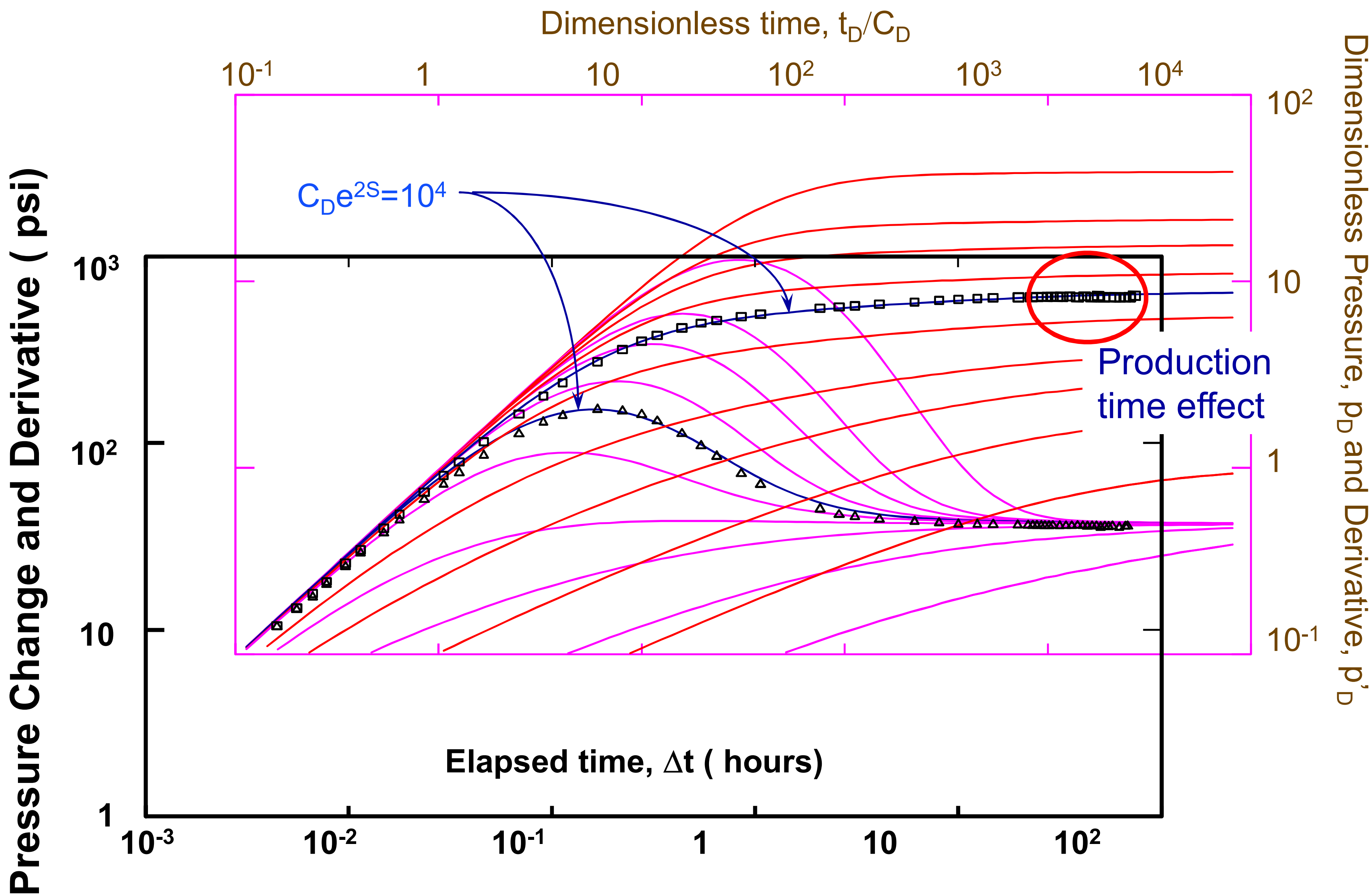
Build-up derivatives calculated with respect to elapsed time and with respect to Horner time

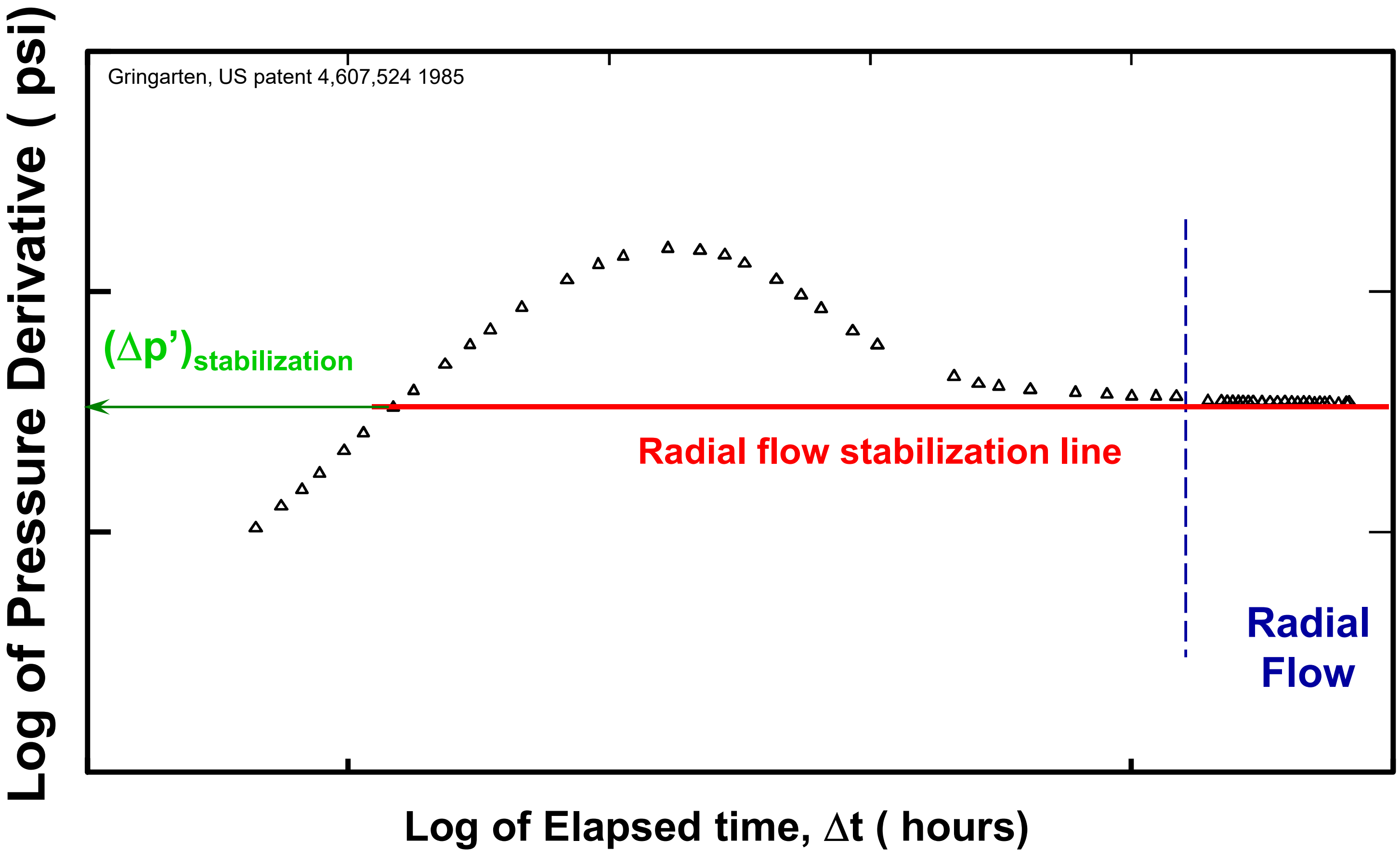


Practice of derivative type curve matching



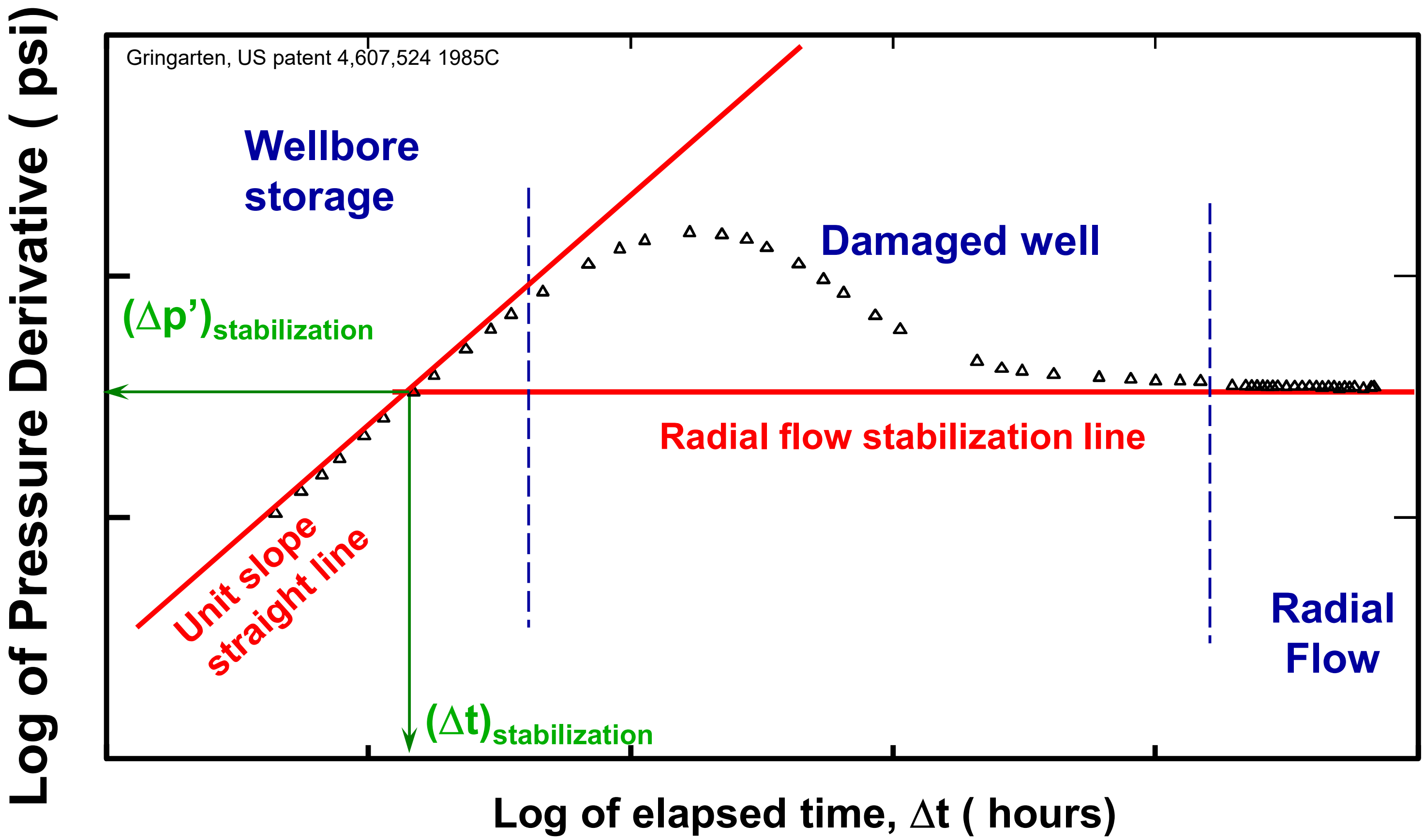
Final log-log plot for Example 1





$$PM = \left(p_D / \Delta p\right)_{match} = \left(p'_D\right)_{stabilisation} / (\Delta p')_{stabilisation}$$

$$PM = 0.5 / (\Delta p')_{stabilisation} = \frac{kh}{141.2\, \Delta q\, B\, \mu} \Rightarrow kh$$



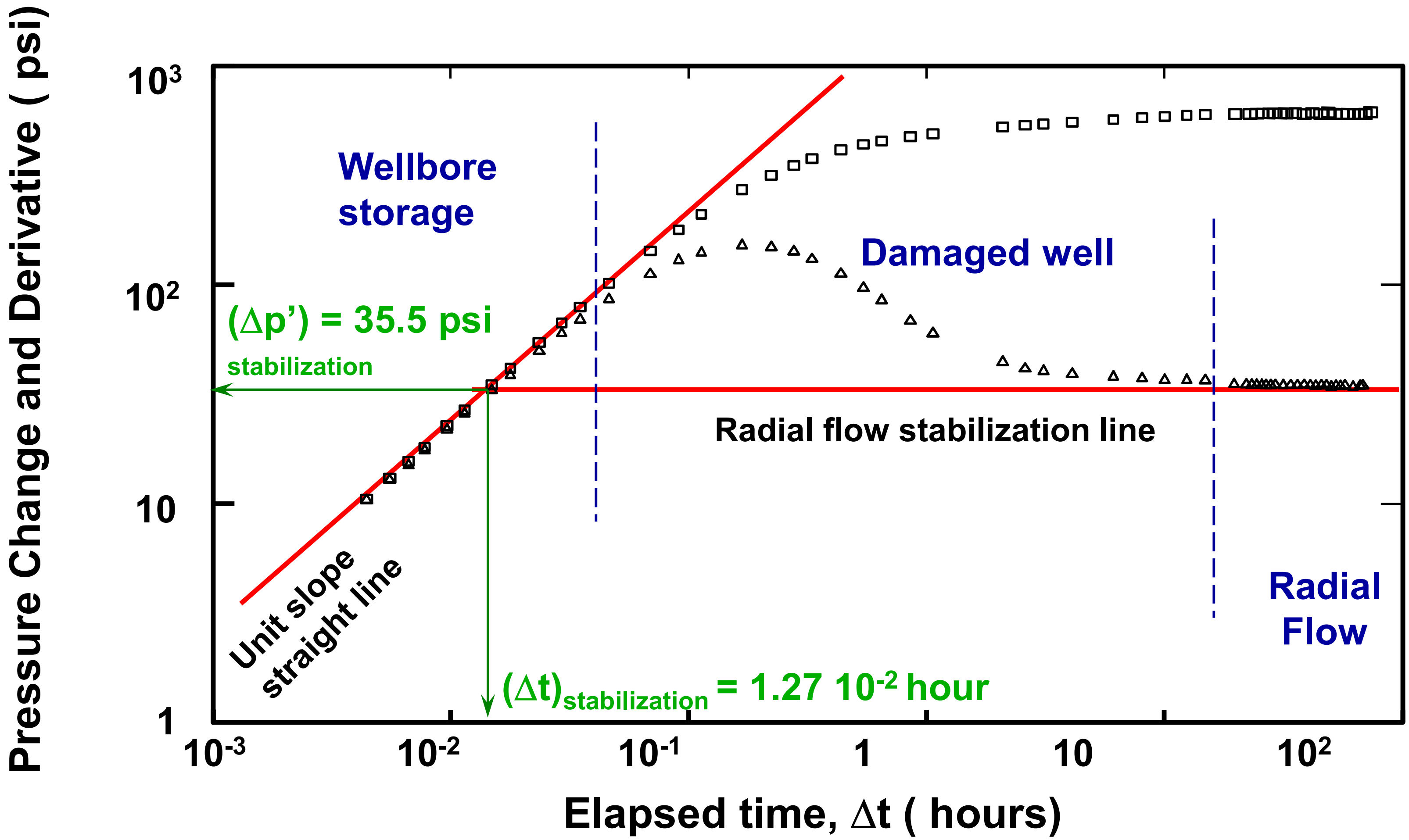
Wellbore storage (dimensionless):

$$p'_D = \frac{t_D}{C_D}$$

$$(p'_D)_{\text{stabilisation}} = 0.5 \quad \Rightarrow \quad (t_D/C_D)_{\text{stabilisation}} = 0.5$$

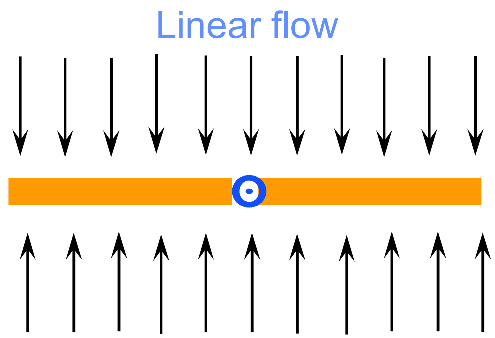
$$\text{TM} = \left(\frac{t_D/C_D}{\Delta t}\right)_{\text{match}} = (t_D/C_D)_{\text{stabilisation}} \Big/ (\Delta t)_{\text{stabilisation}} = 0.5 \Big/ (\Delta t)_{\text{stabilisation}} = 0.000295 \frac{k\,h}{\mu}\frac{1}{C} \quad \Rightarrow C$$

Log-log diagnostic plot for Example 1
(Flow period #2, build-up)



DERIVATIVE FOR HIGH CONDUCTIVITY FRACTURE (Early Times)

High conductivity fracture



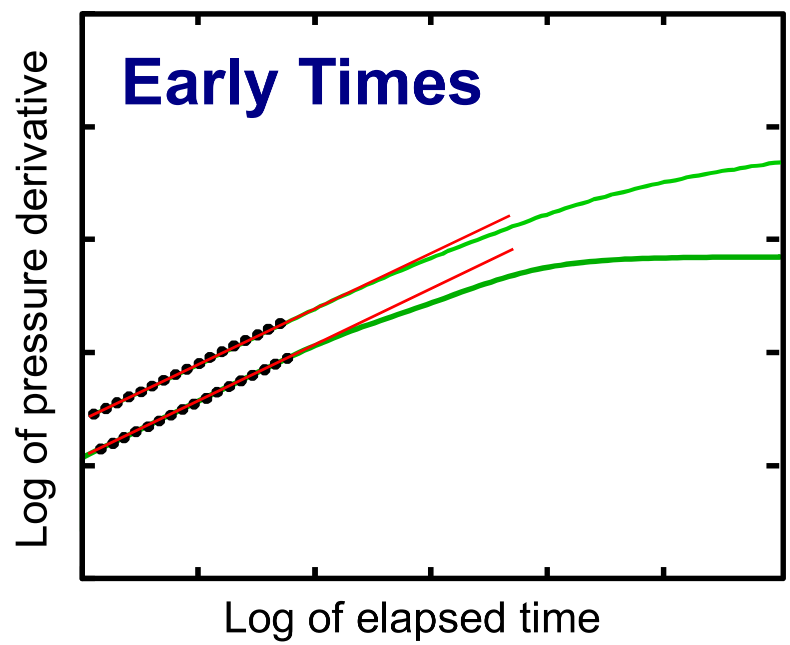
$$p_D = \left(\pi\, t_{Df}\right)^{1/2}$$

$$p_D = \frac{kh}{141.2\,\Delta q\, B\,\mu}\Delta p$$

$$t_{Df} = \frac{0.000264\,k}{\phi\mu\, c_t x_f^2}\Delta t$$

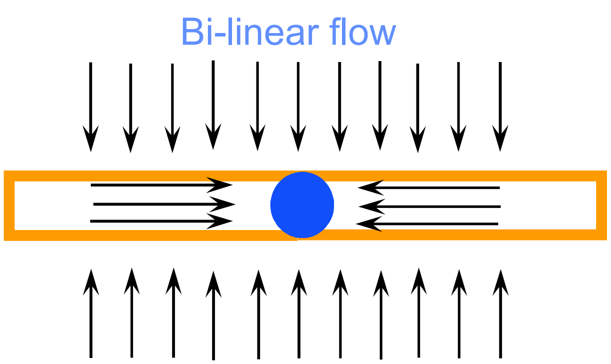
$$\frac{dp_D}{d\ln\left(t_{Df}\right)} = 0.5\left(\pi\, t_{Df}\right)^{1/2} = (0.5)\,p_D$$

- ❑ **Half-unit slope log-log straight line**
- ❑ **Derivative is one half the pressure**



DERIVATIVE FOR LOW CONDUCTIVITY FRACTURE (Early Times)

Low conductivity fracture



$$p_D = 2.45\left(k_{fD}\, w_D\right)^{-1/2}\left(t_{Df}\right)^{1/4}$$

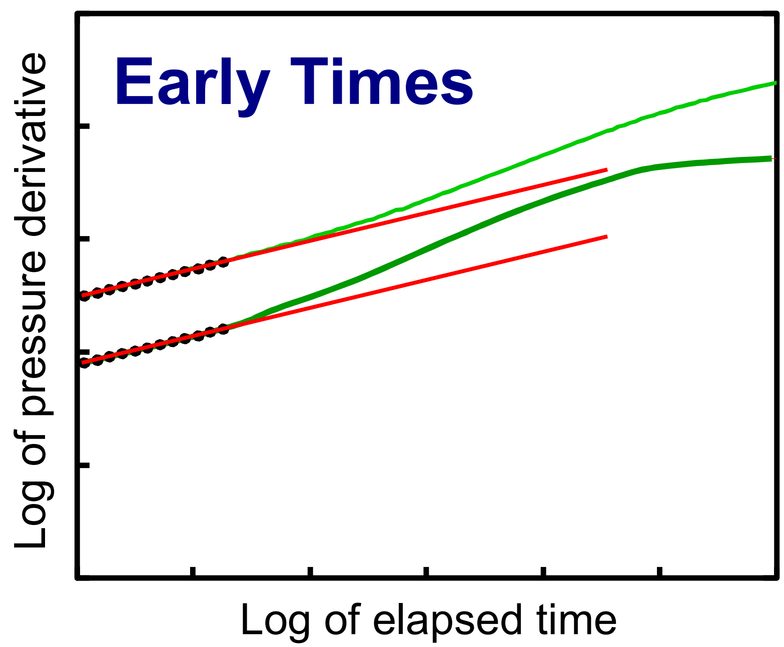
$$p_D = \frac{kh}{141.2\,\Delta q\, B\,\mu}\Delta p$$

$$t_{Df} = \frac{0.000264\, k}{\phi\mu\, c_t x_f^2}\Delta t$$

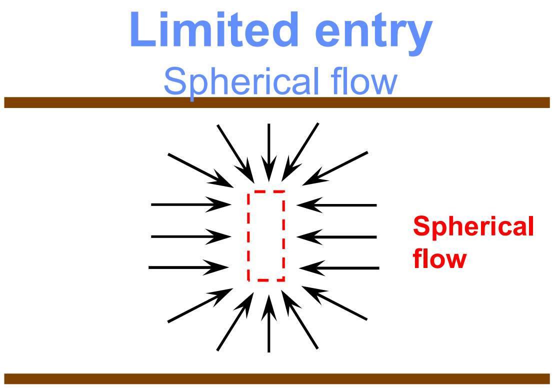
$$k_{fD} w_D = \frac{k_f w_f}{k\, x_f}$$

$$\frac{dp_D}{d\ln\left(t_{Df}\right)} = (0.25)\,2.45\left(k_{fD}\, w_D\right)^{-1/2}\left(t_{Df}\right)^{1/4} = (0.25)\,p_D$$

- ❑ **Quarter-unit slope log-log straight line**
- ❑ **Derivative is one fourth the pressure**



DERIVATIVE FOR SPHERICAL FLOW (Middle Times)



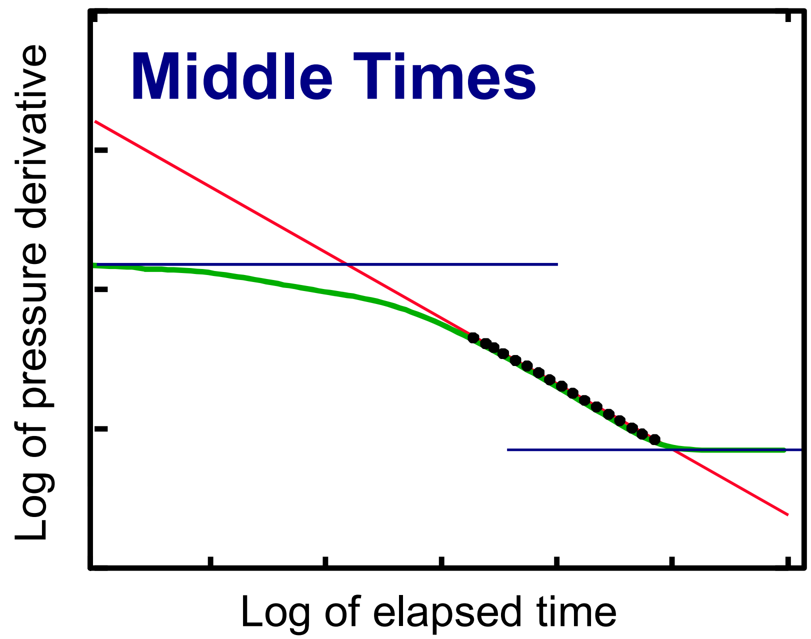
$$p_{\mathrm{SPH}\ D} = \frac{1}{2}\left[1 - \left(\pi\ t_{\mathrm{SPH}\ D}\right)^{-1/2}\right]$$

$$p_{\mathrm{SPH}\ D} = \frac{k_{\mathrm{SPH}}\ r_{\mathrm{SPH}}}{141.2\ \Delta q B \mu}\Delta p$$

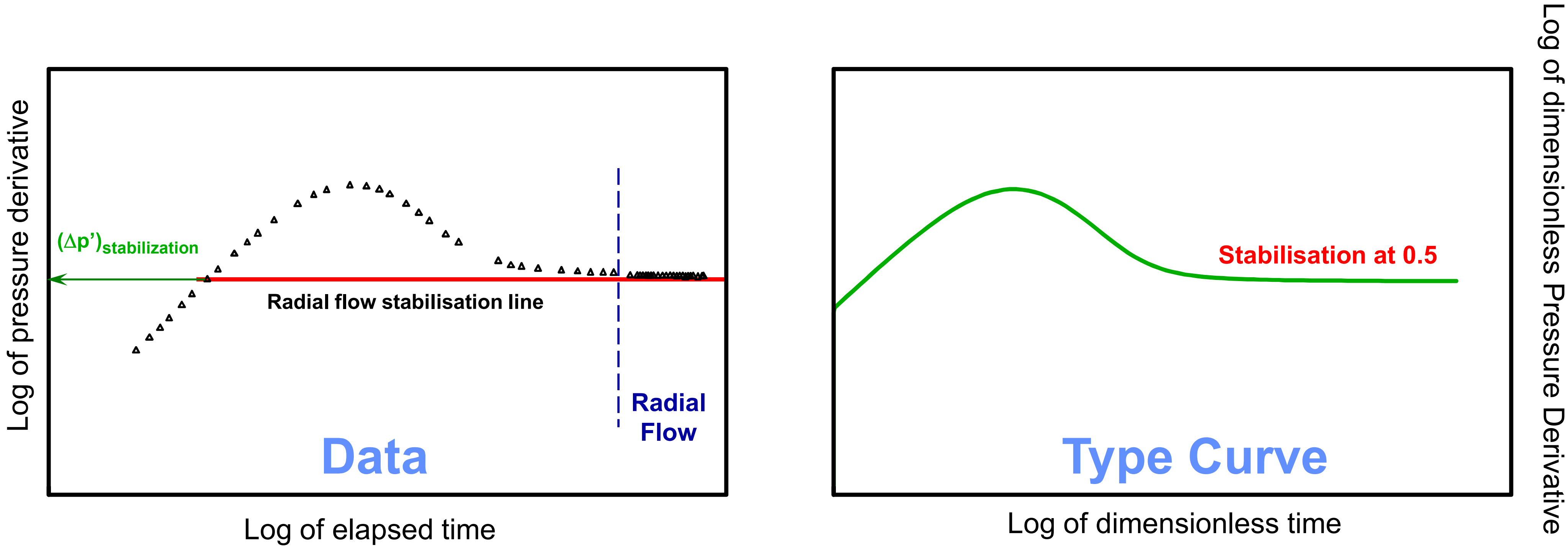
$$t_{\mathrm{SPH}\ D} = \frac{0.000264\ k_{\mathrm{SPH}}}{\phi \mu c_t r_{\mathrm{SPH}}^2}\Delta t$$

$$\frac{dp_D}{d\ln\left(t_{\mathrm{SPH}\ D}\right)} = \frac{1}{2}\left[\frac{1}{2}\left(\pi\ t_{\mathrm{SPH}\ D}\right)^{-1/2}\right]$$

- ❑ **Negative Half-unit slope log-log straight line**



DERIVATIVE FOR HOMOGENEOUS BEHAVIOUR (Radial flow at Middle Times)



$$PM = 0.5 / (\Delta p')_{\text{stabilization}} = \frac{1}{141.2\ \Delta q\ B}\left(\frac{kh}{\mu}\right)$$

$$(\Delta p')_{\text{stabilization}} \quad \textit{corresponds} \quad \textit{to} \quad \left(\frac{kh}{\mu}\right)$$

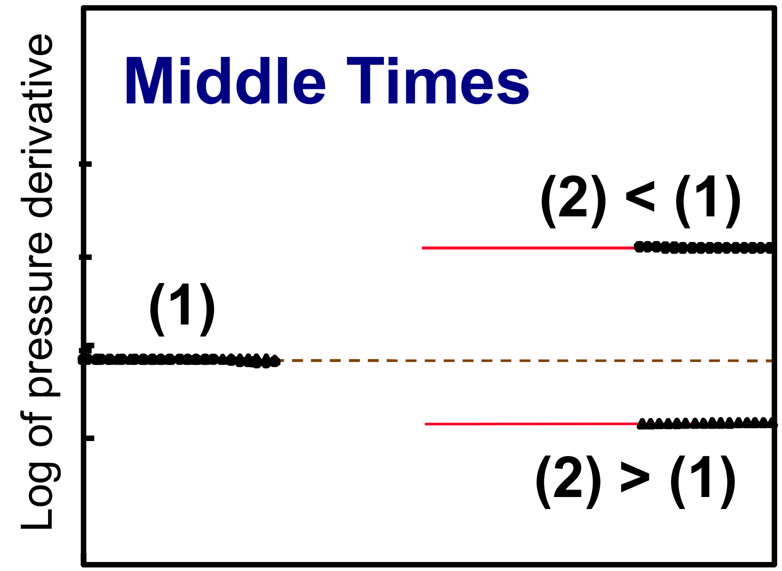
$$(\Delta p')_{\text{stabilization}} \quad \textit{increases}, \quad \left(\frac{kh}{\mu}\right) \quad \textit{decreases}$$

$$(\Delta p')_{\text{stabilization}} \quad \textit{decreases}, \quad \left(\frac{kh}{\mu}\right) \quad \textit{increases}$$

DERIVATIVE FOR HETEROGENEOUS BEHAVIOUR (Middle Times)

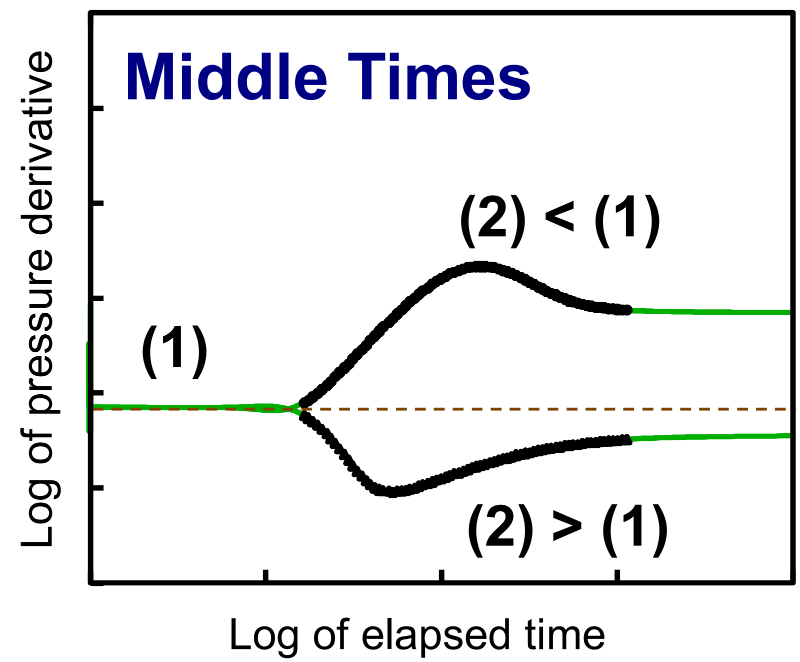
Mobility change

$$\left(\frac{kh}{\mu}\right)_1 \rightarrow \left(\frac{kh}{\mu}\right)_2$$



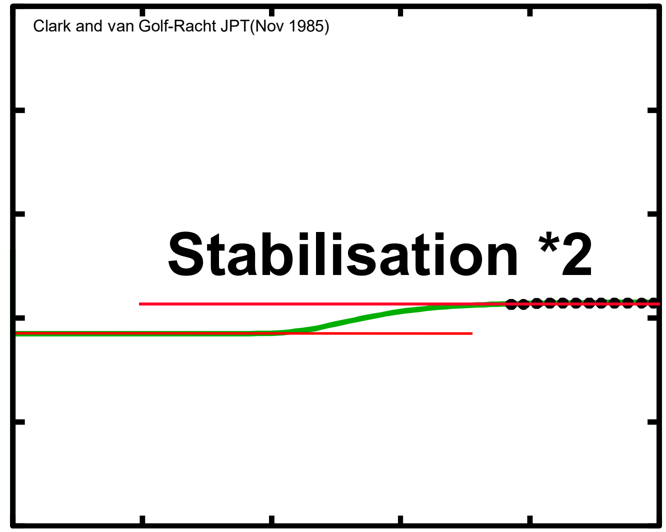
Storativity change

$$(\phi c_t h)_1 \rightarrow (\phi c_t h)_2$$

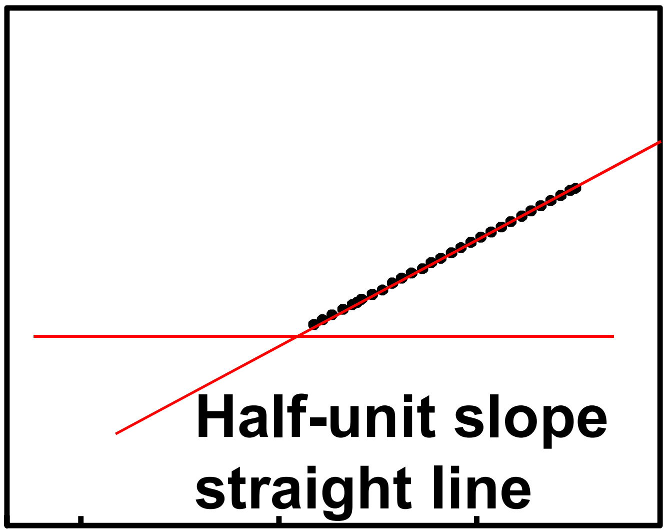


DERIVATIVE FOR BOUNDARY EFFECTS (Late Times)

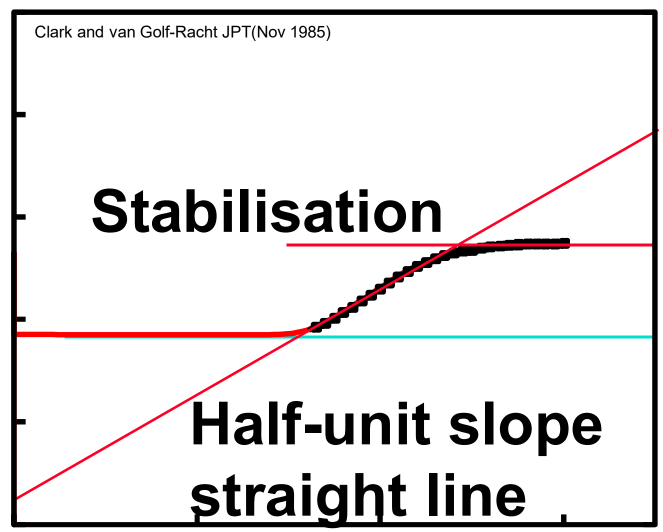
One Sealing Fault



Channel Boundaries

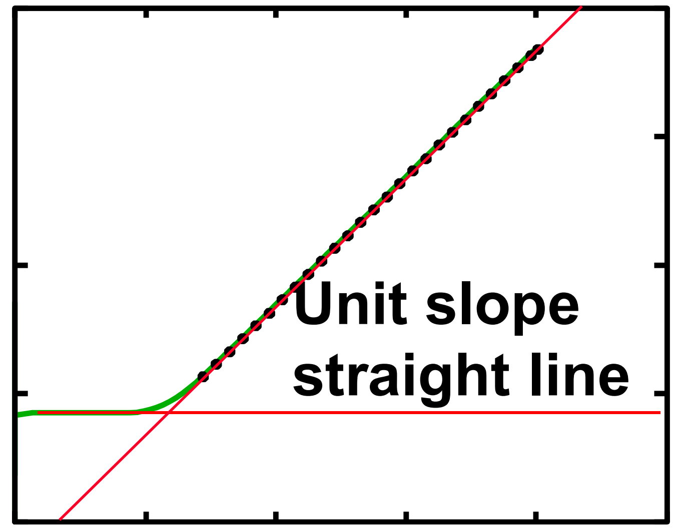


Intersecting Faults

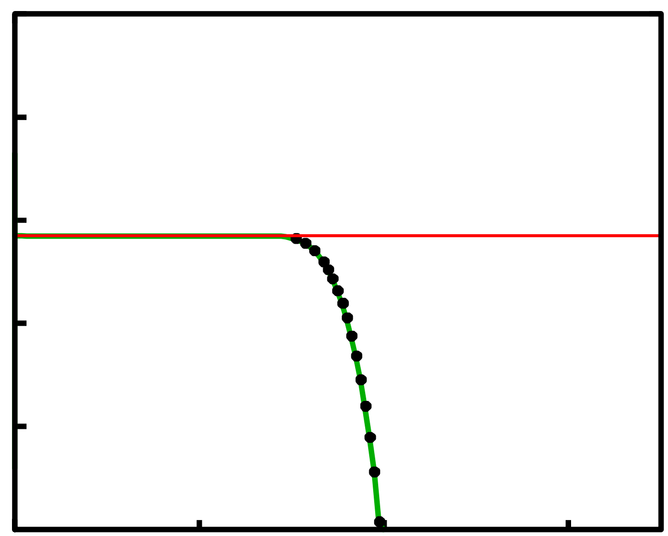


DERIVATIVE FOR BOUNDARY EFFECTS (Late Times)

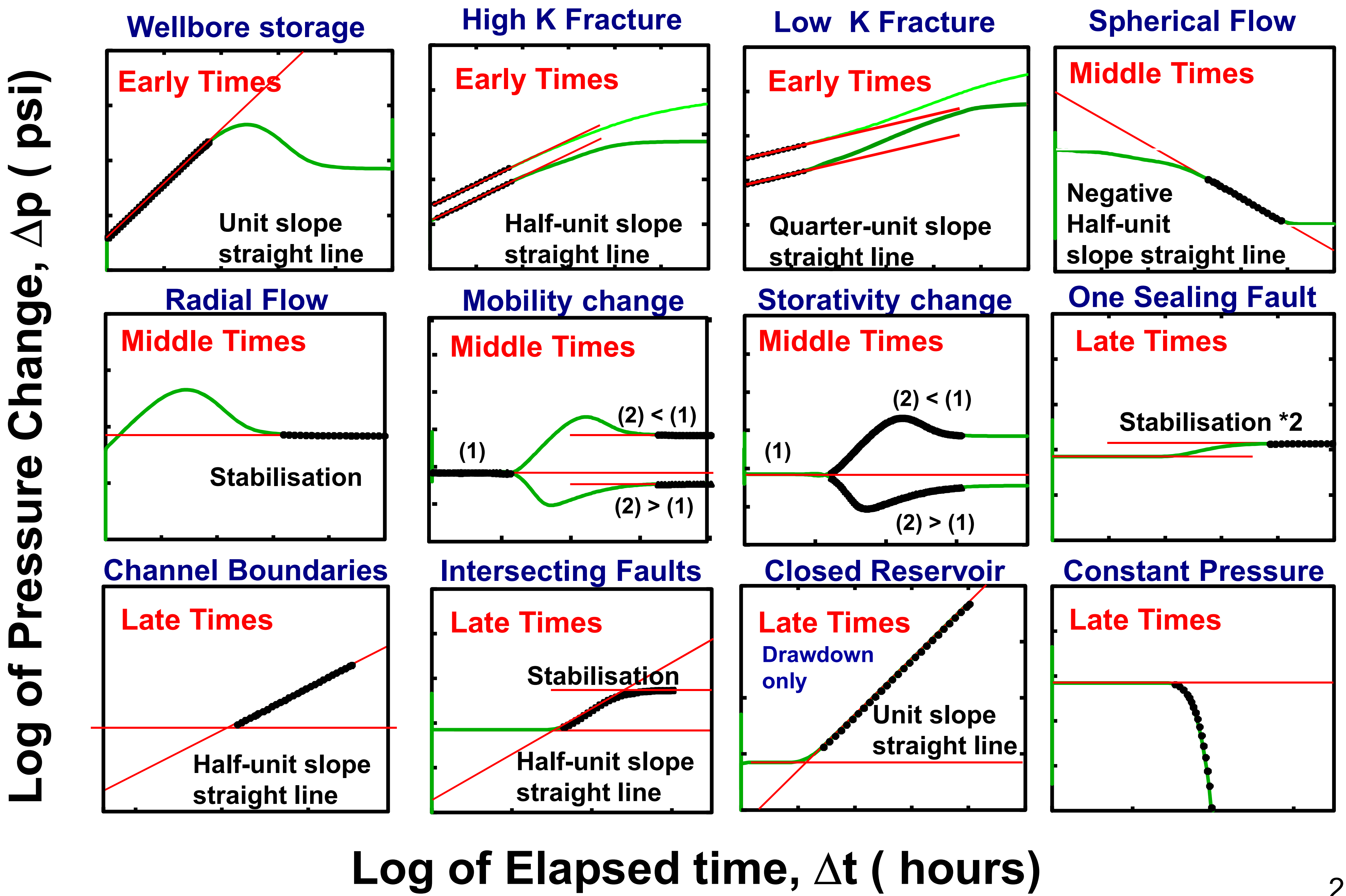
Closed Reservoir (Drawdown)



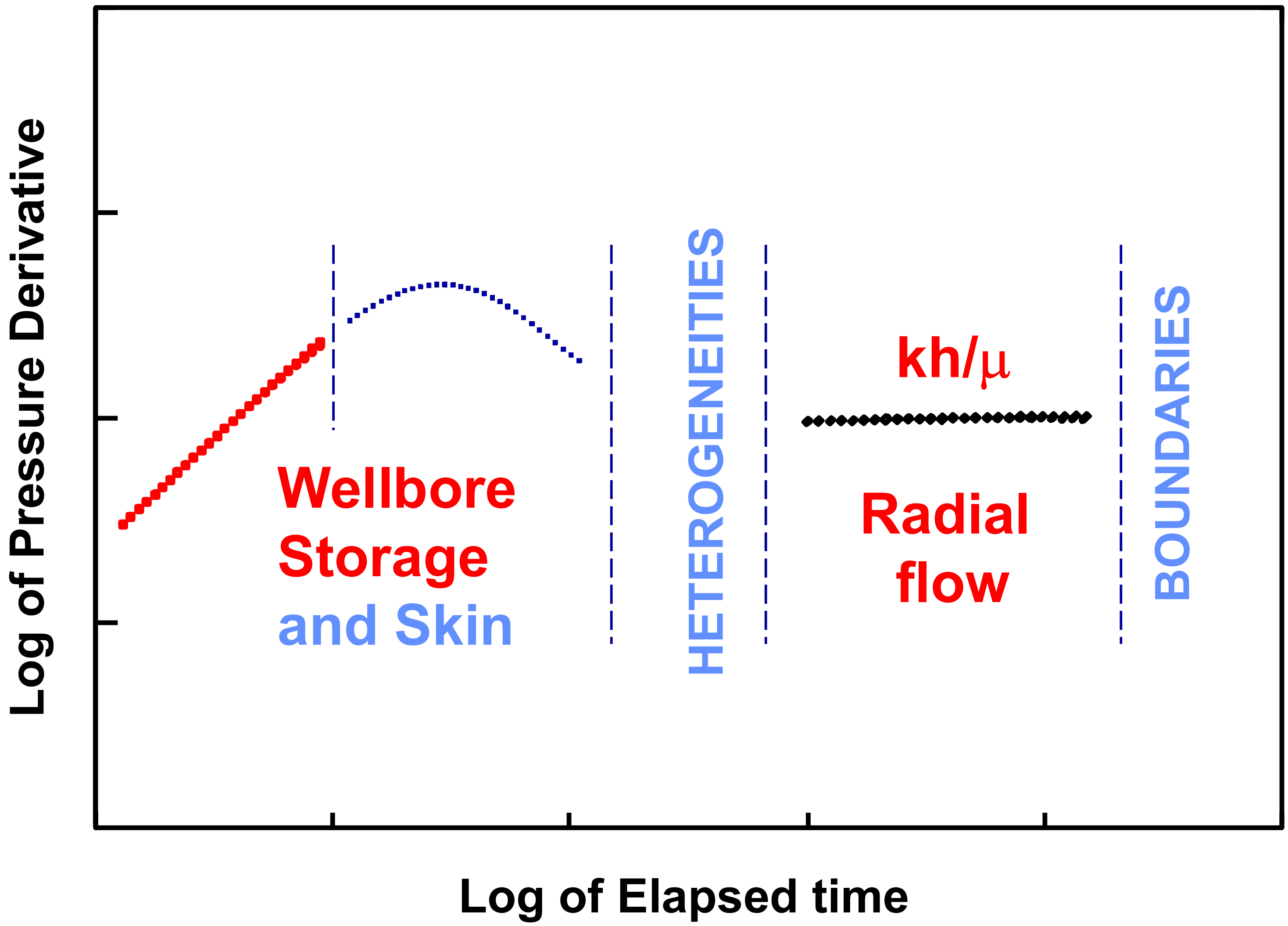
Constant Pressure
or
Closed Reservoir (Build-up)



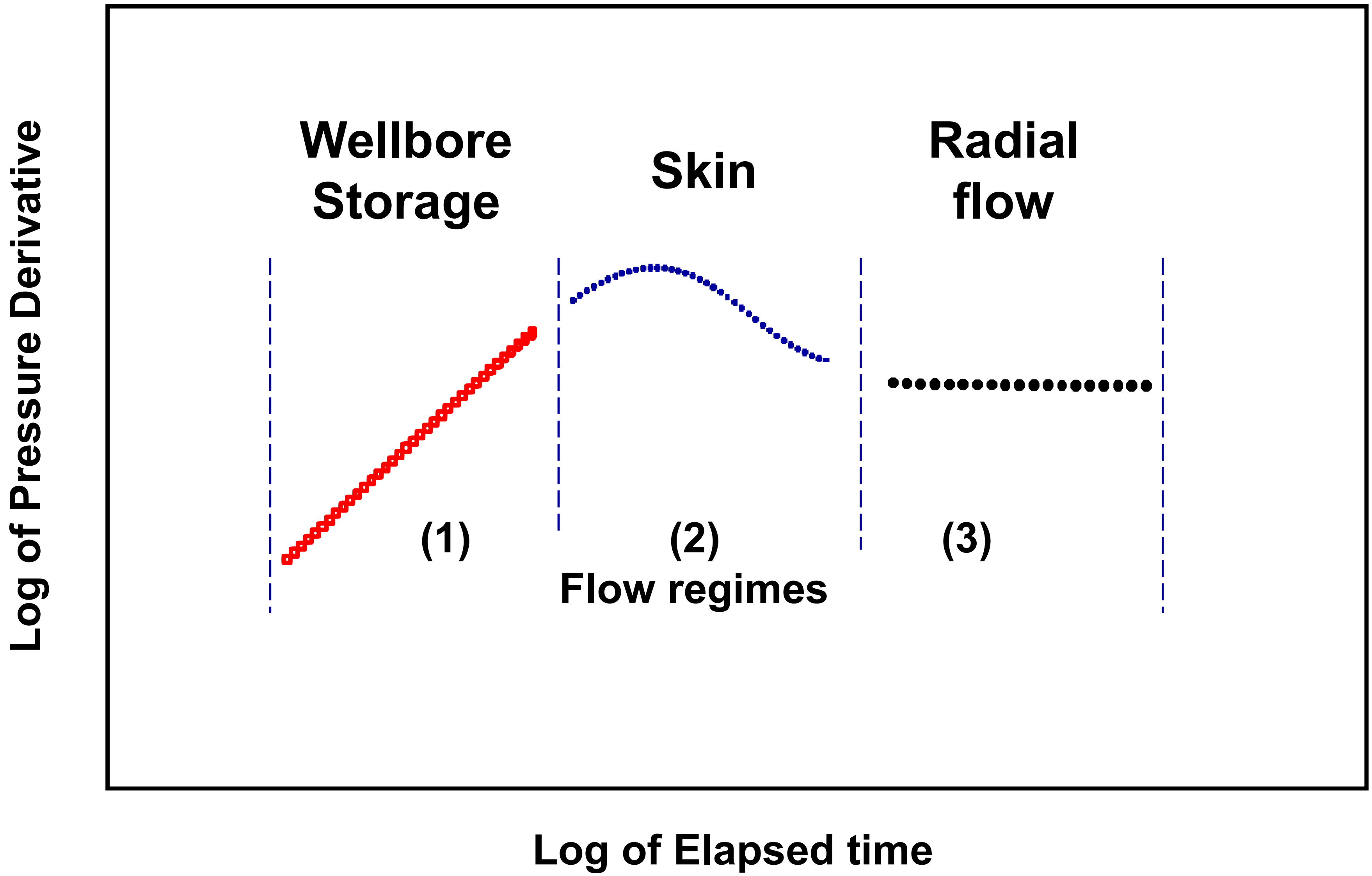
Summary: LOG-LOG DERIVATIVE ANALYSIS



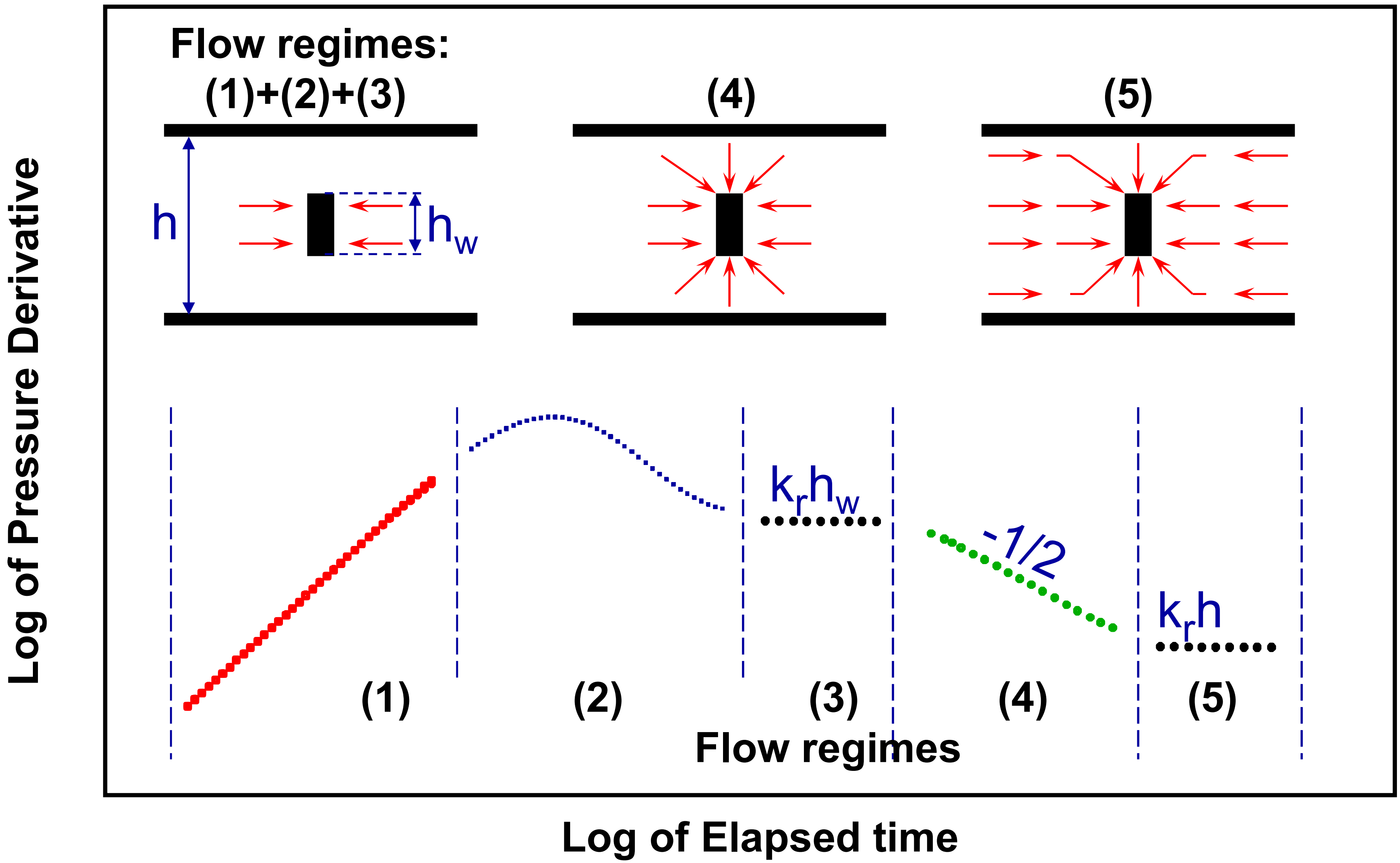
Identification process with pressure derivatives



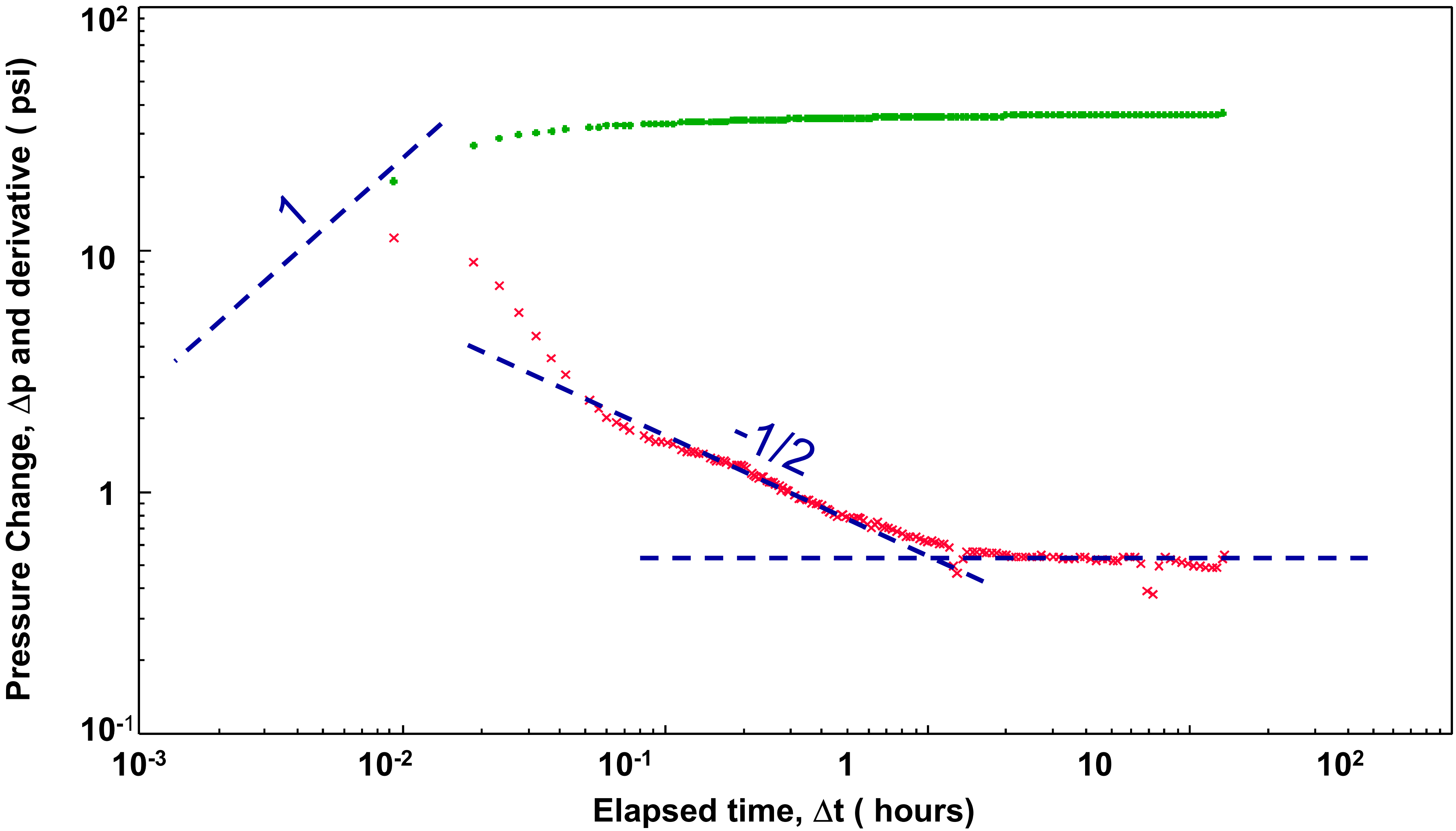
Pressure derivative for a well with wellbore storage and skin in an infinite reservoir with homogeneous behaviour



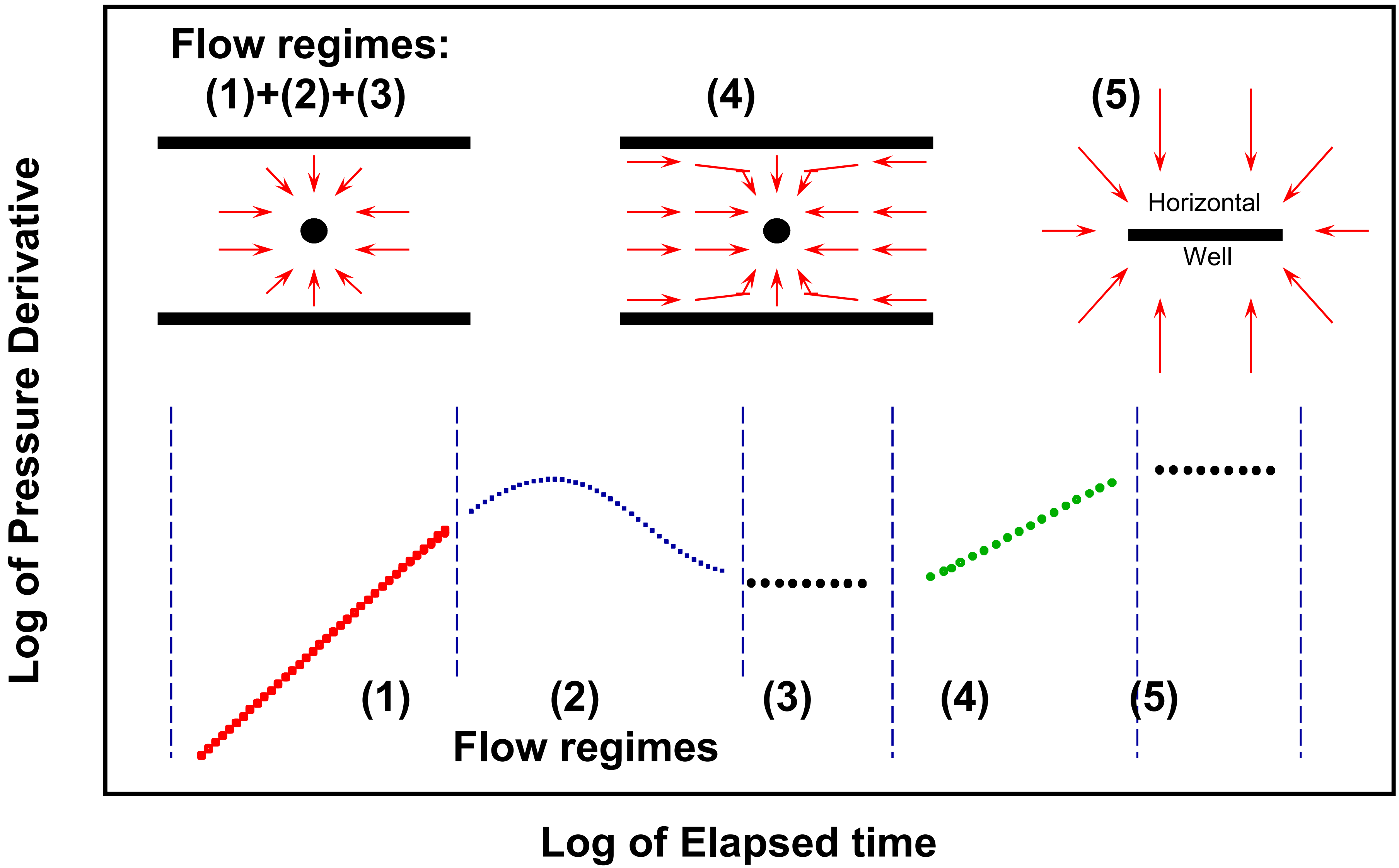
Well with wellbore storage and skin and limited entry in an infinite reservoir with homogeneous behaviour



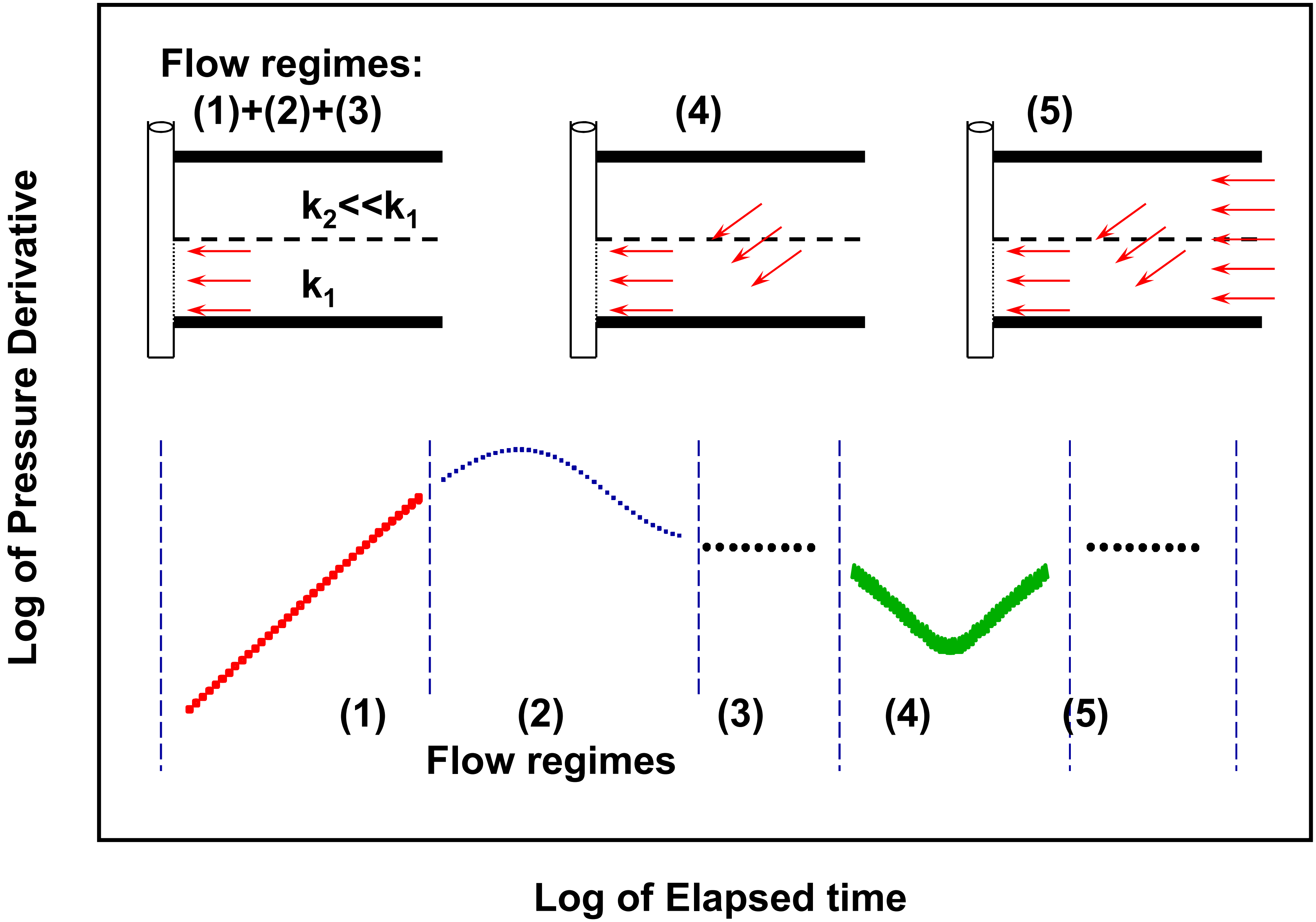
LIMITED ENTRY



Horizontal well with wellbore storage and skin in an infinite reservoir with homogeneous behaviour



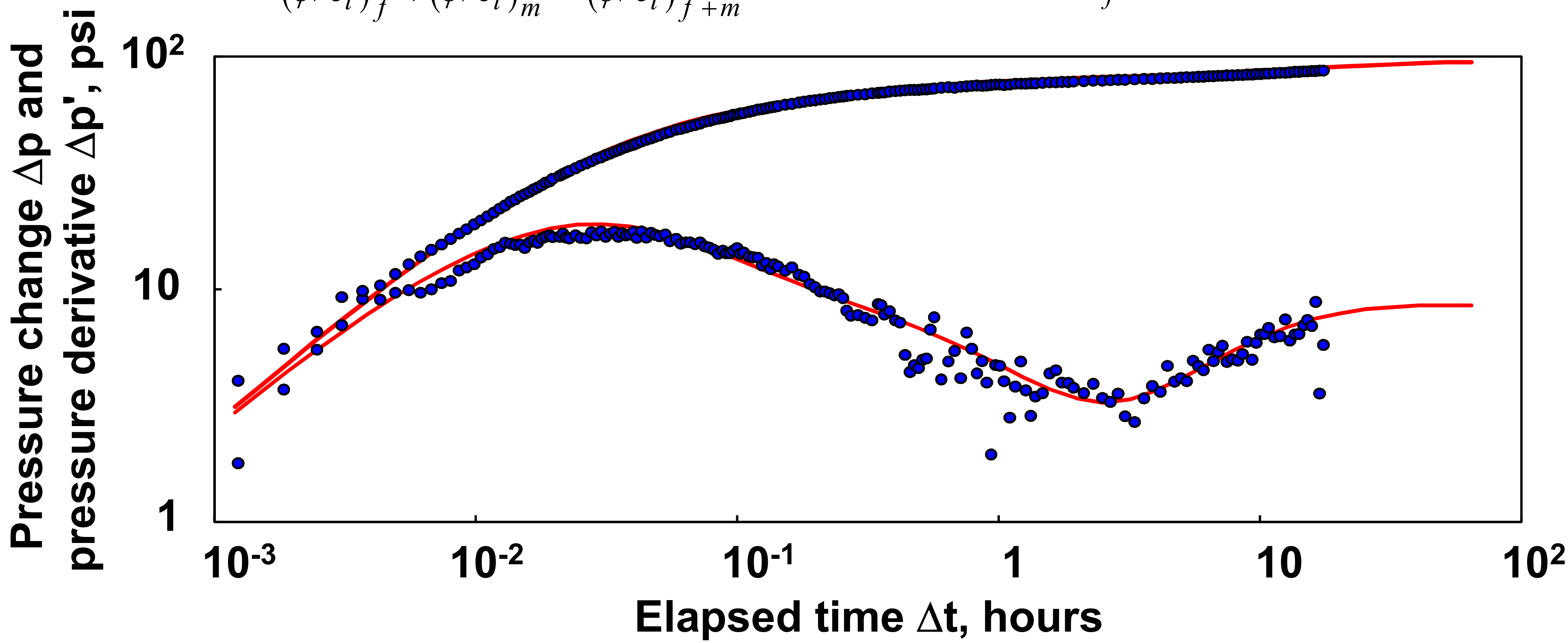
Well with wellbore storage and skin in an infinite reservoir with double-porosity behaviour



DOUBLE POROSITY

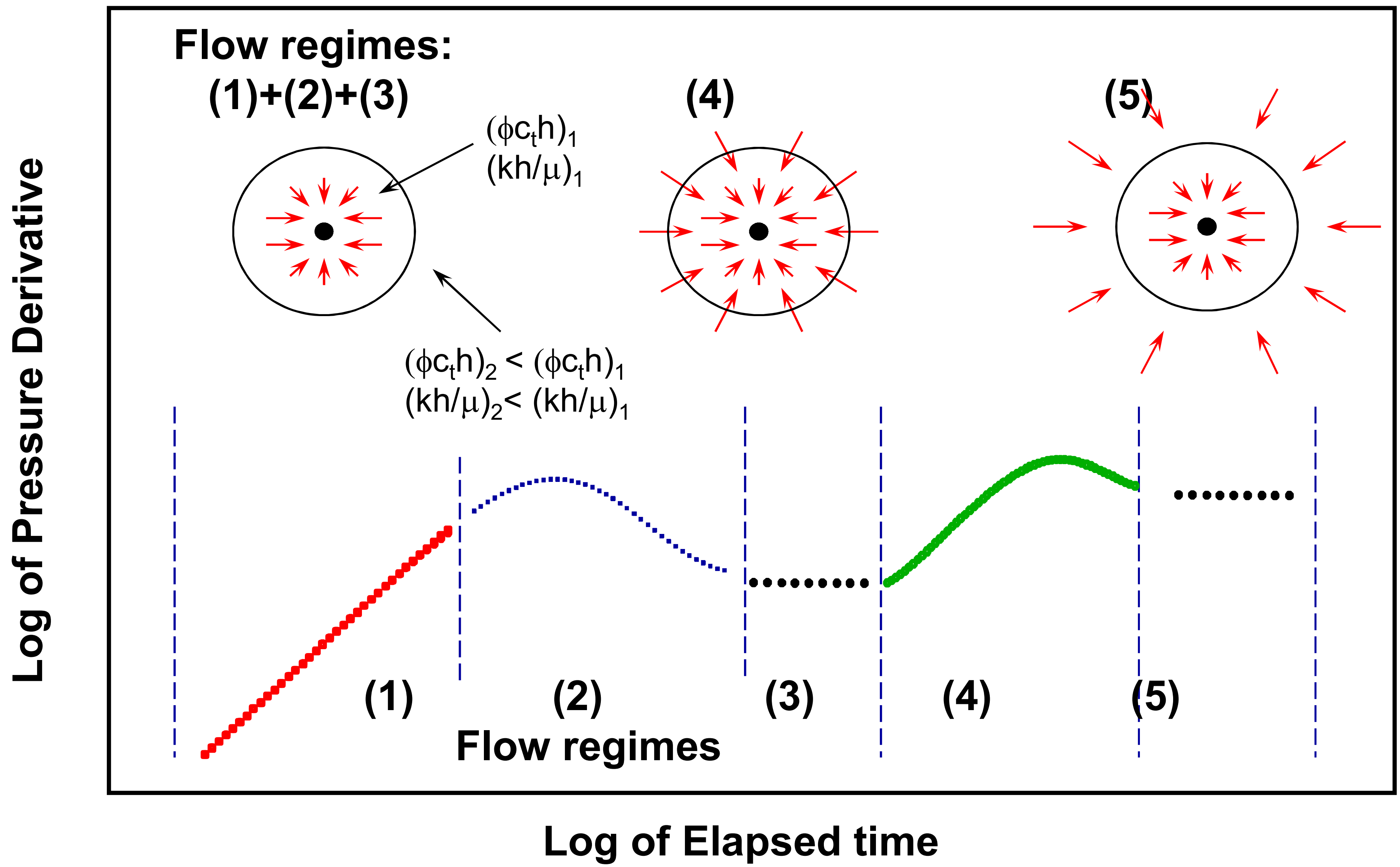
$$\omega = \frac{(\phi V c_t)_f}{(\phi V c_t)_f + (\phi V c_t)_m} = \frac{(\phi V c_t)_f}{(\phi V c_t)_{f+m}}$$

$$\lambda = \alpha r_w^2 \frac{k_m}{k_f} \qquad \alpha = \frac{4n(n+2)}{l^2}$$

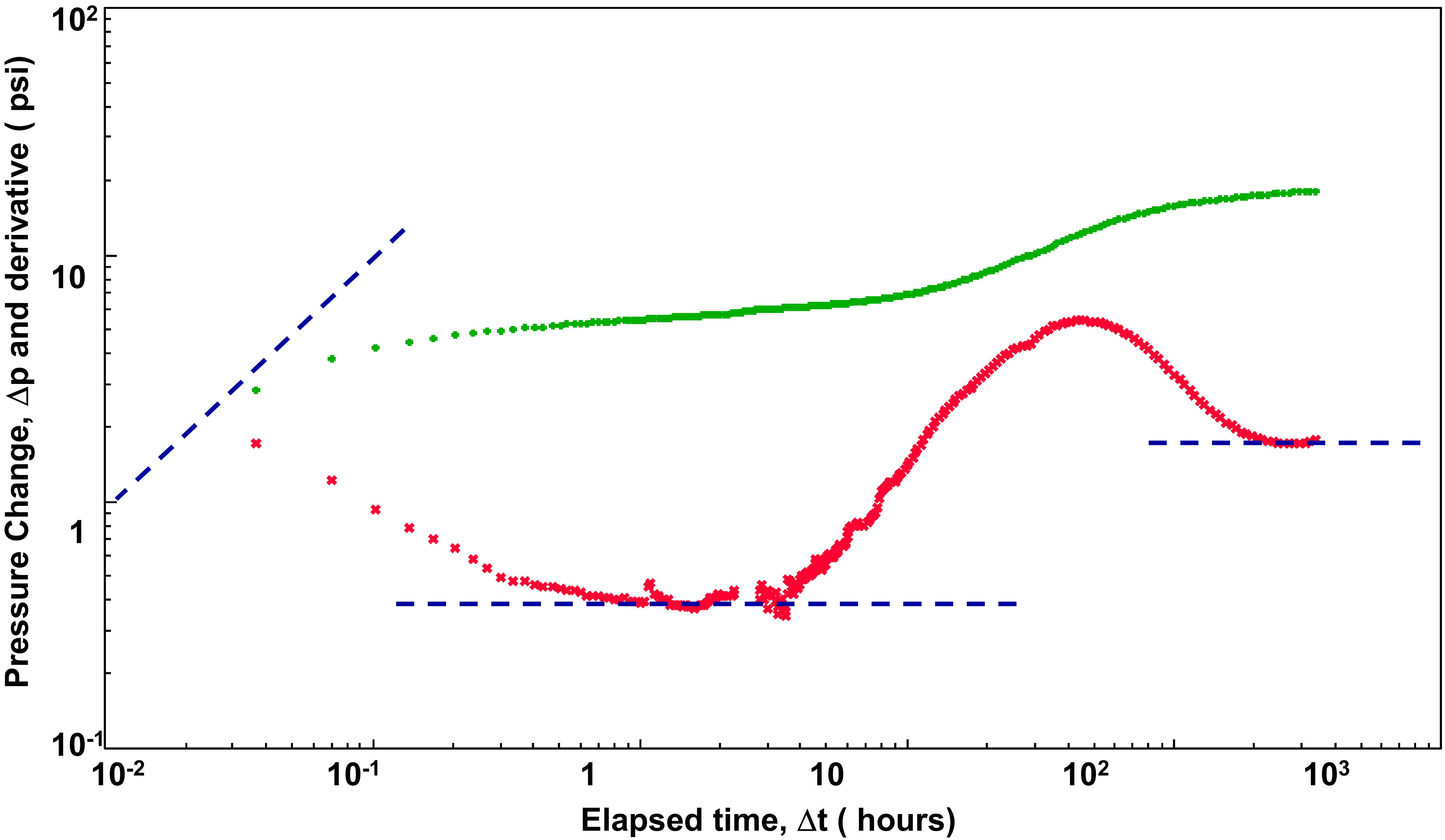


$$S_m = \frac{k_m}{r_m}\frac{h_s}{k_s} \qquad \lambda = \frac{12}{h_s^2} r_w^2 \frac{k_s}{k_f}$$

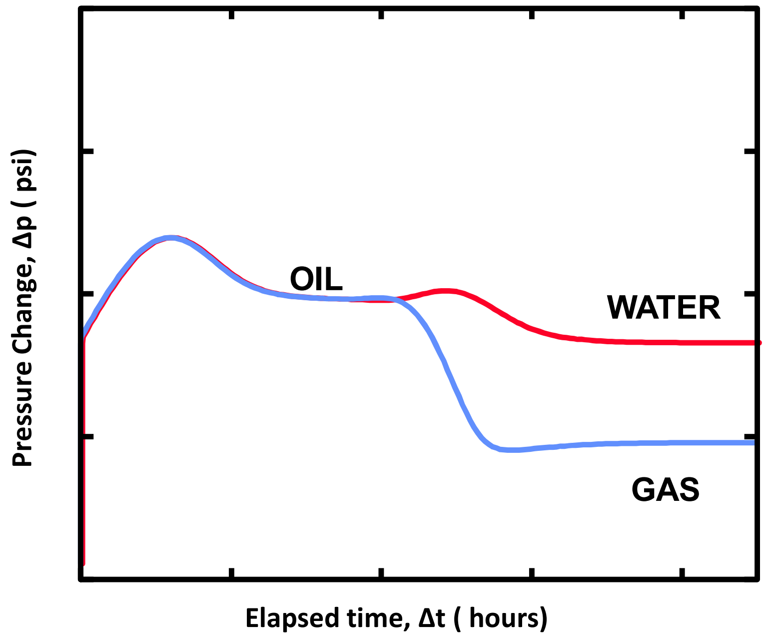
Well with wellbore storage and skin in an infinite reservoir with composite behaviour

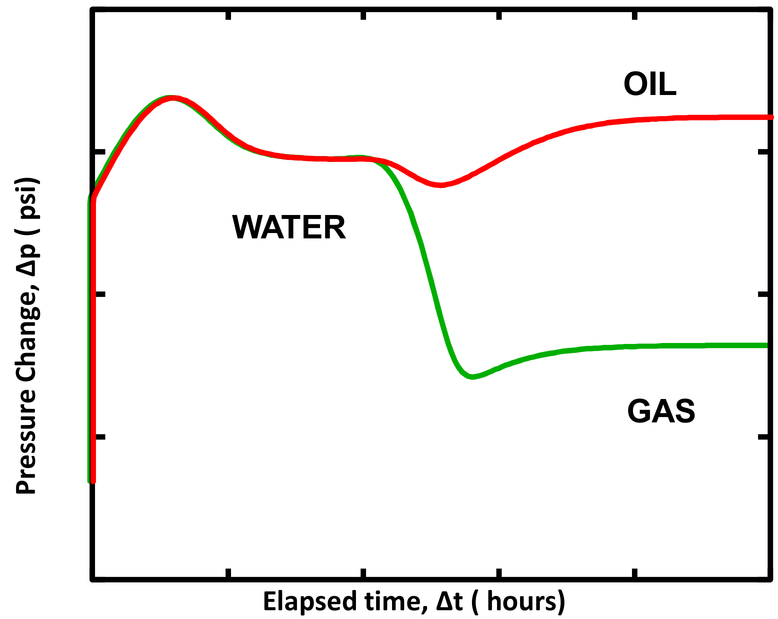


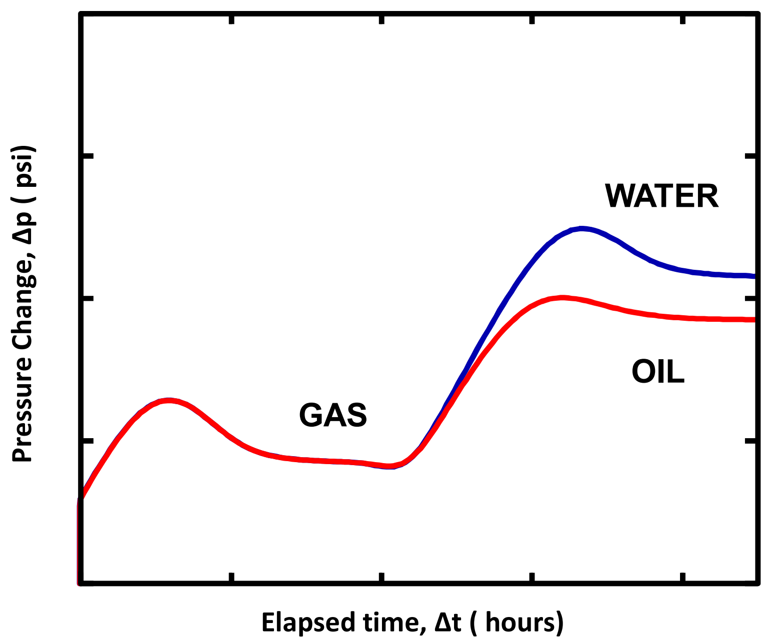
COMPOSITE BEHAVIOUR



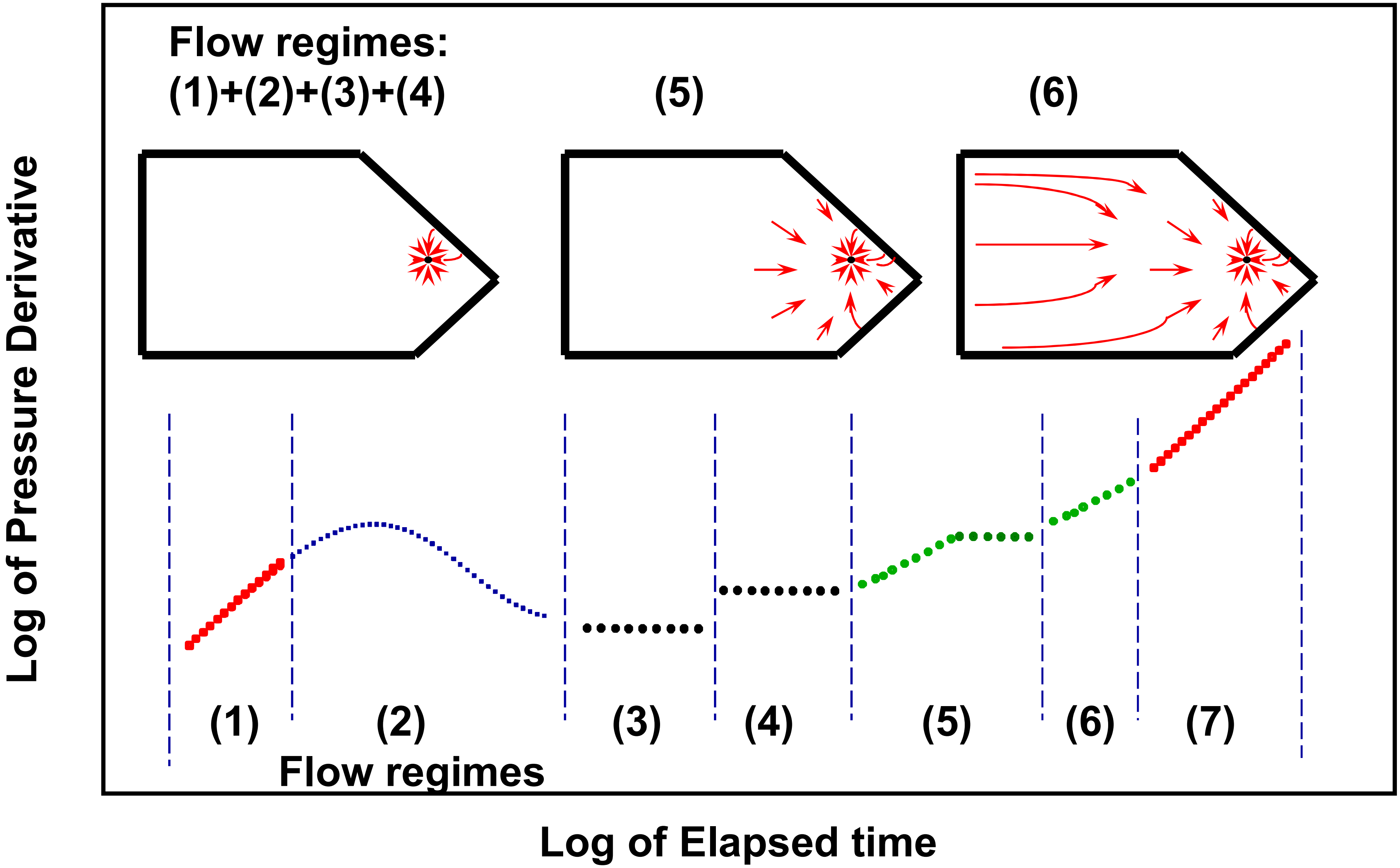
COMPOSITE BEHAVIOUR DUE TO FLUIDS



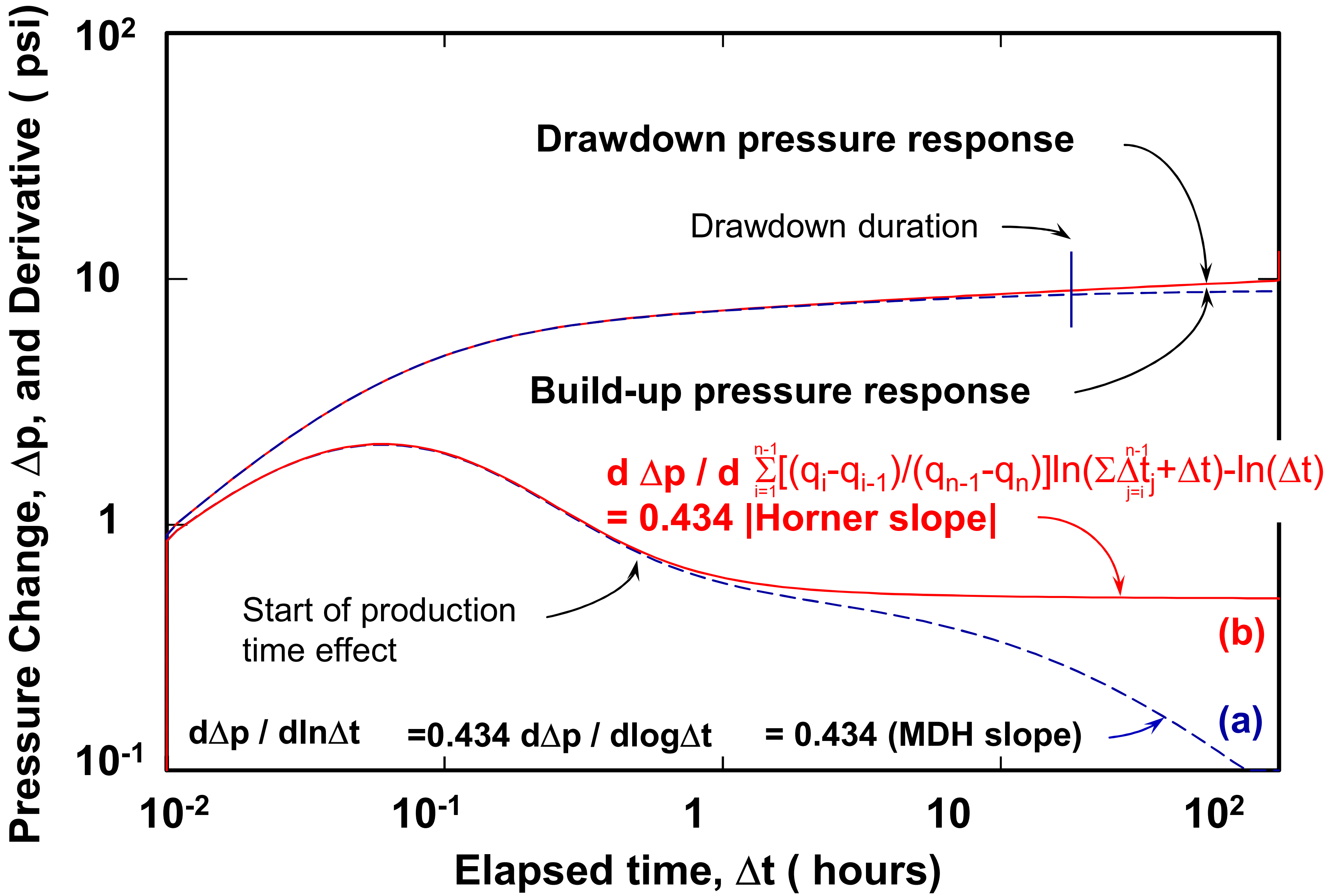




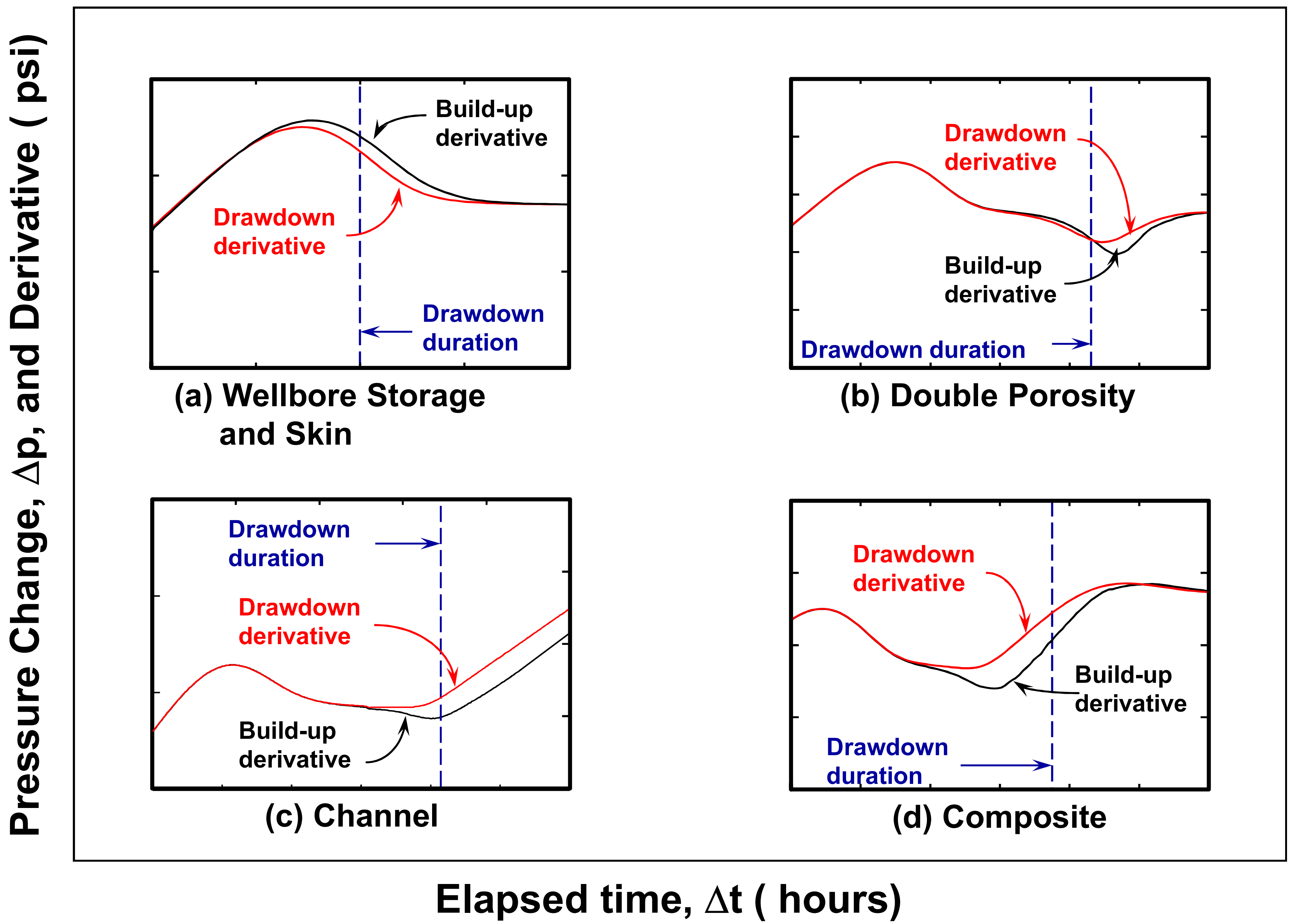
Well with wellbore storage and skin in an closed reservoir of irregular shape with homogeneous behaviour



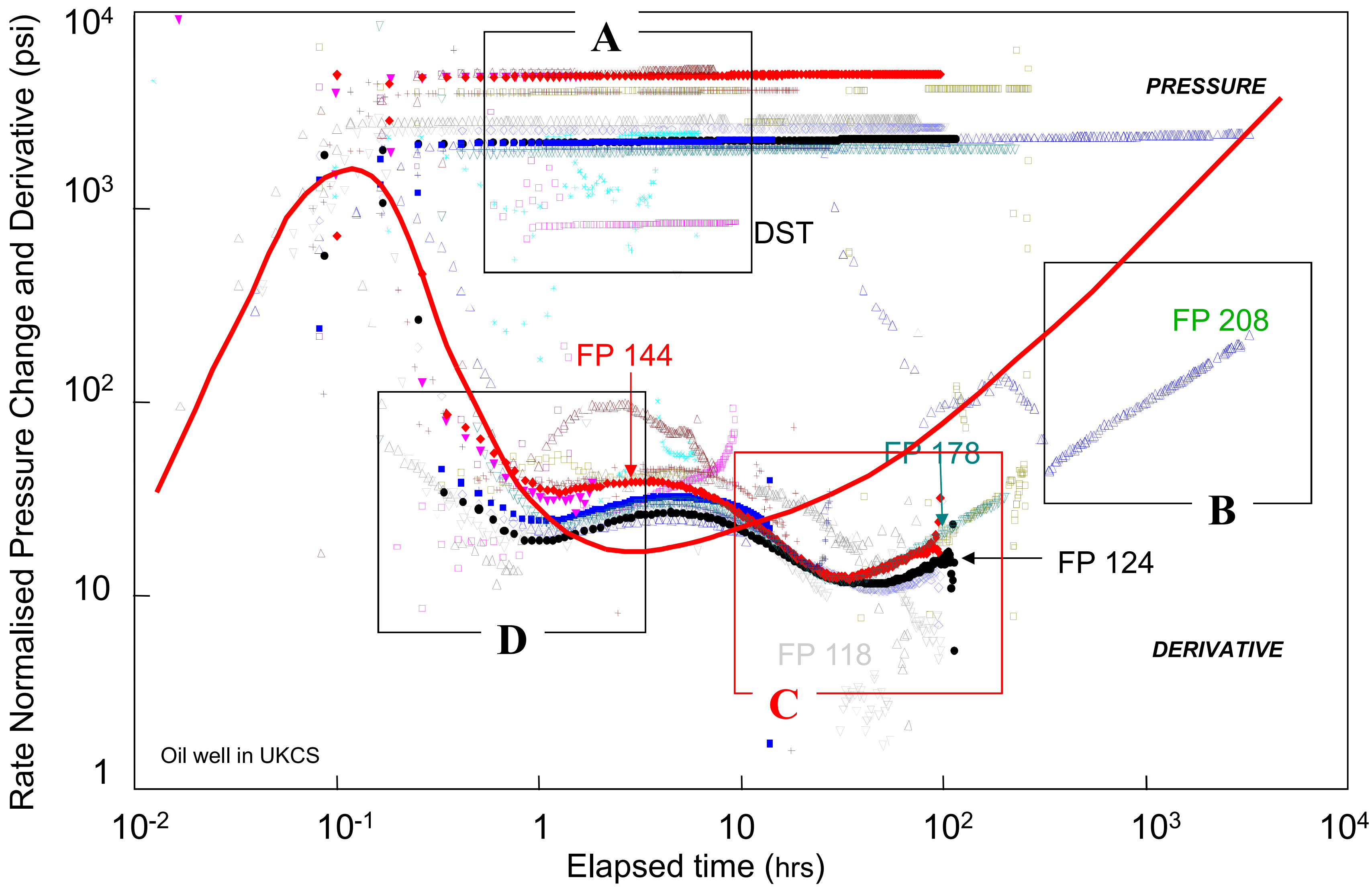
Build-up derivatives calculated with respect to elapsed time and with respect to Horner time



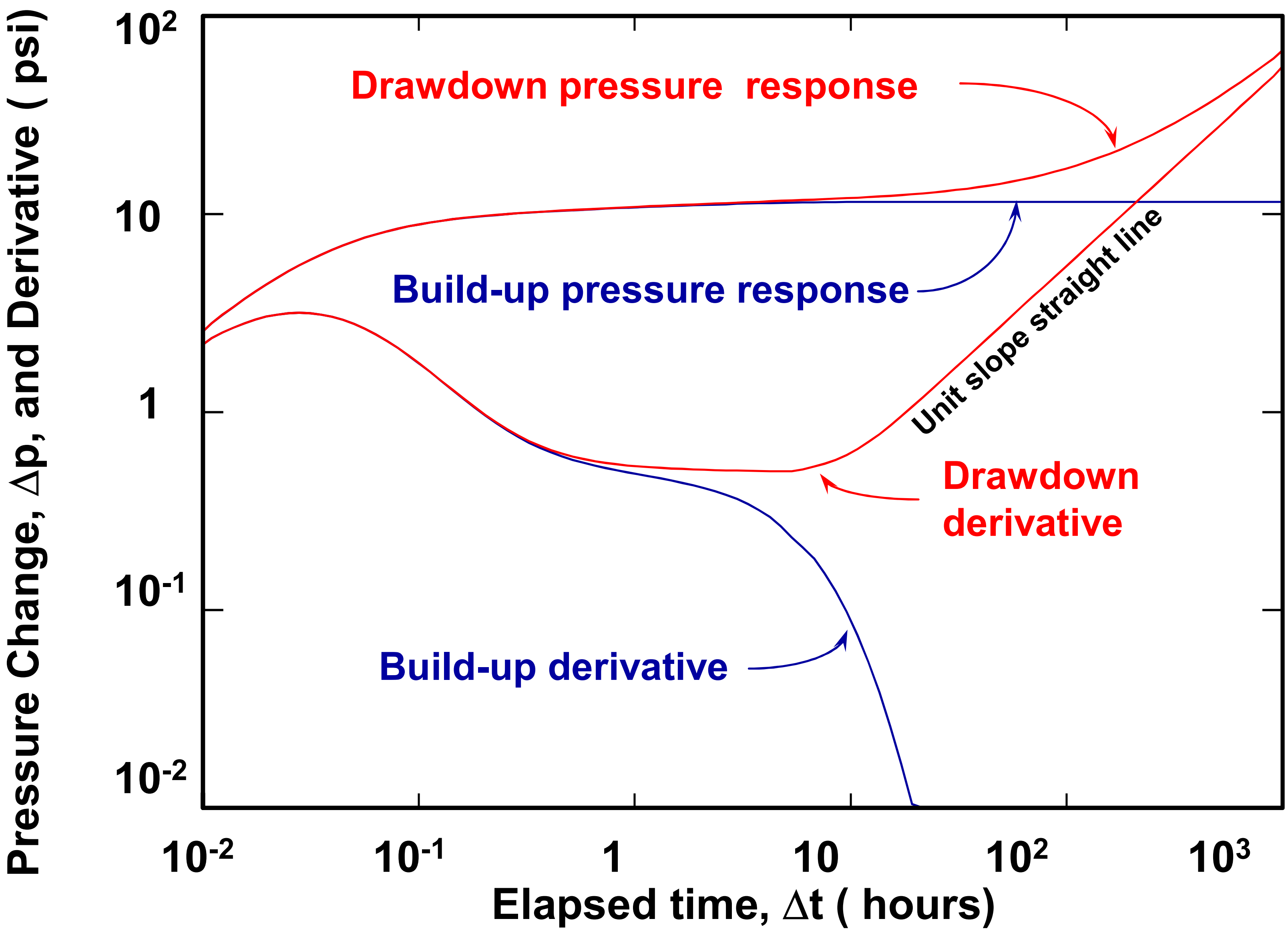
Comparison between drawdown and build-up derivatives



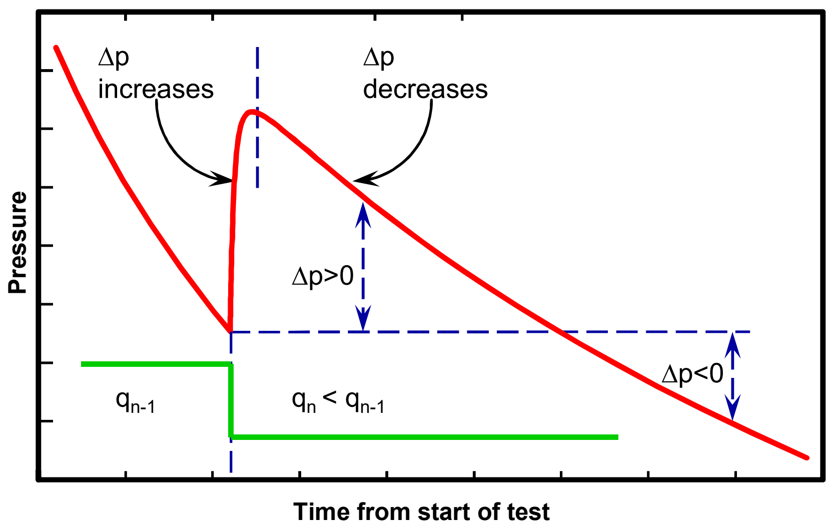
Analysis of extended test on Well V

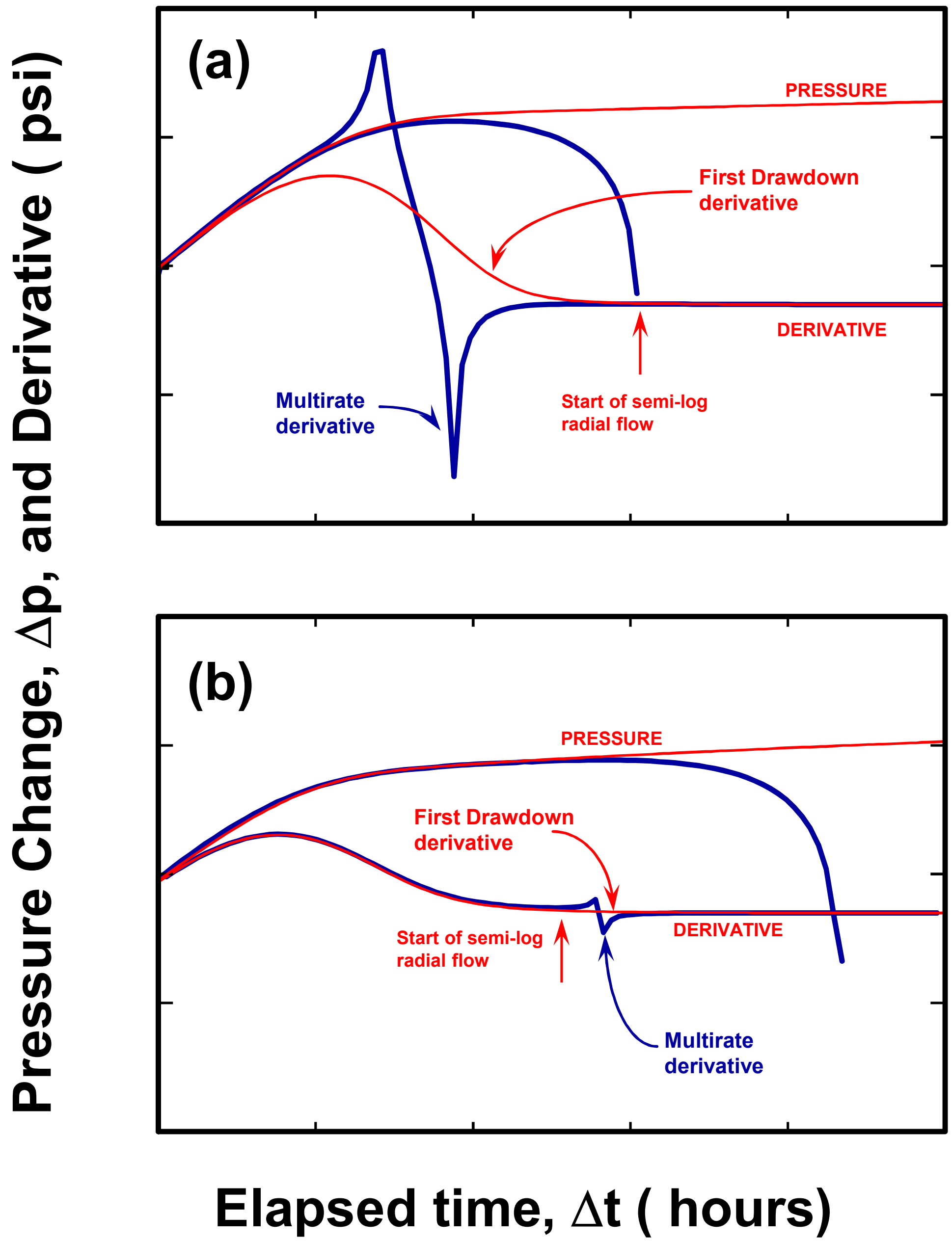


Build-up derivative showing depletion when pseudo-steady flow has been reached during drawdown

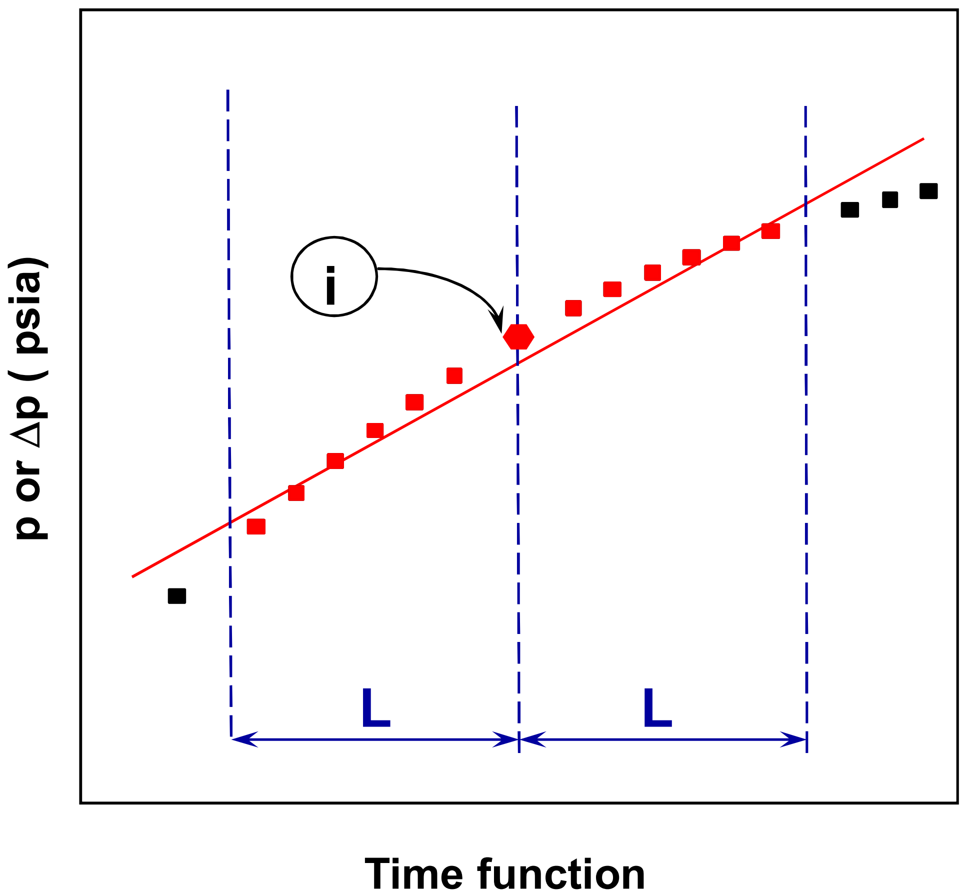


Comparison between drawdown and multirate derivatives

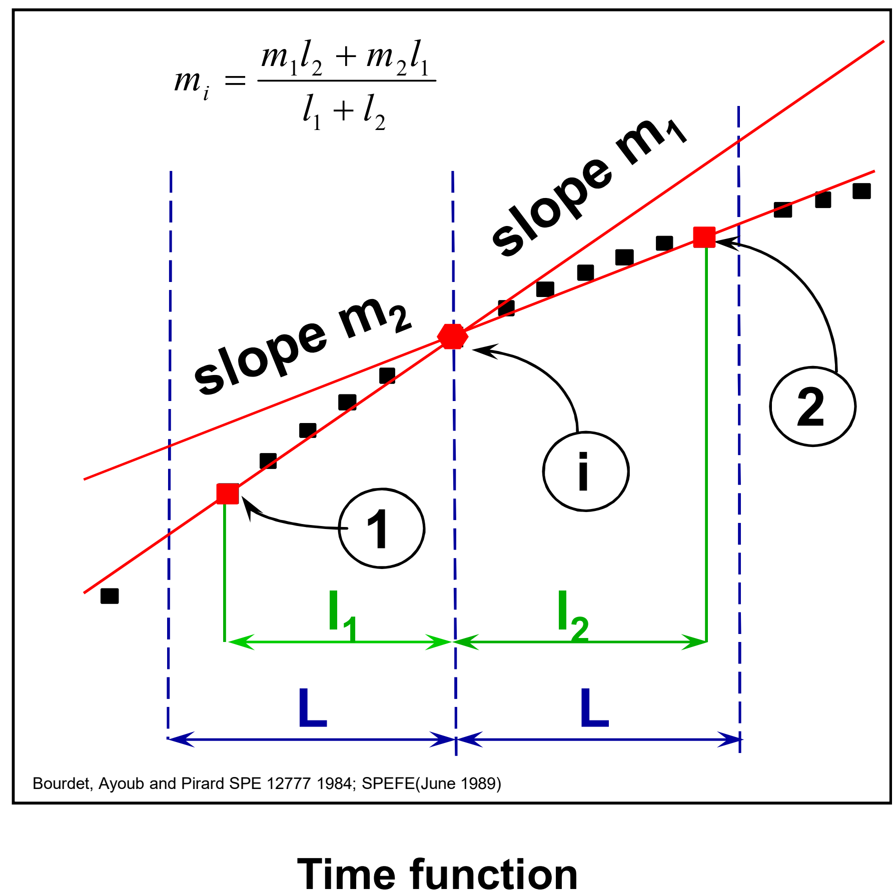




MOST COMMON ALGORITHMS FOR CALCULATING PRESSURE DERIVATIVES



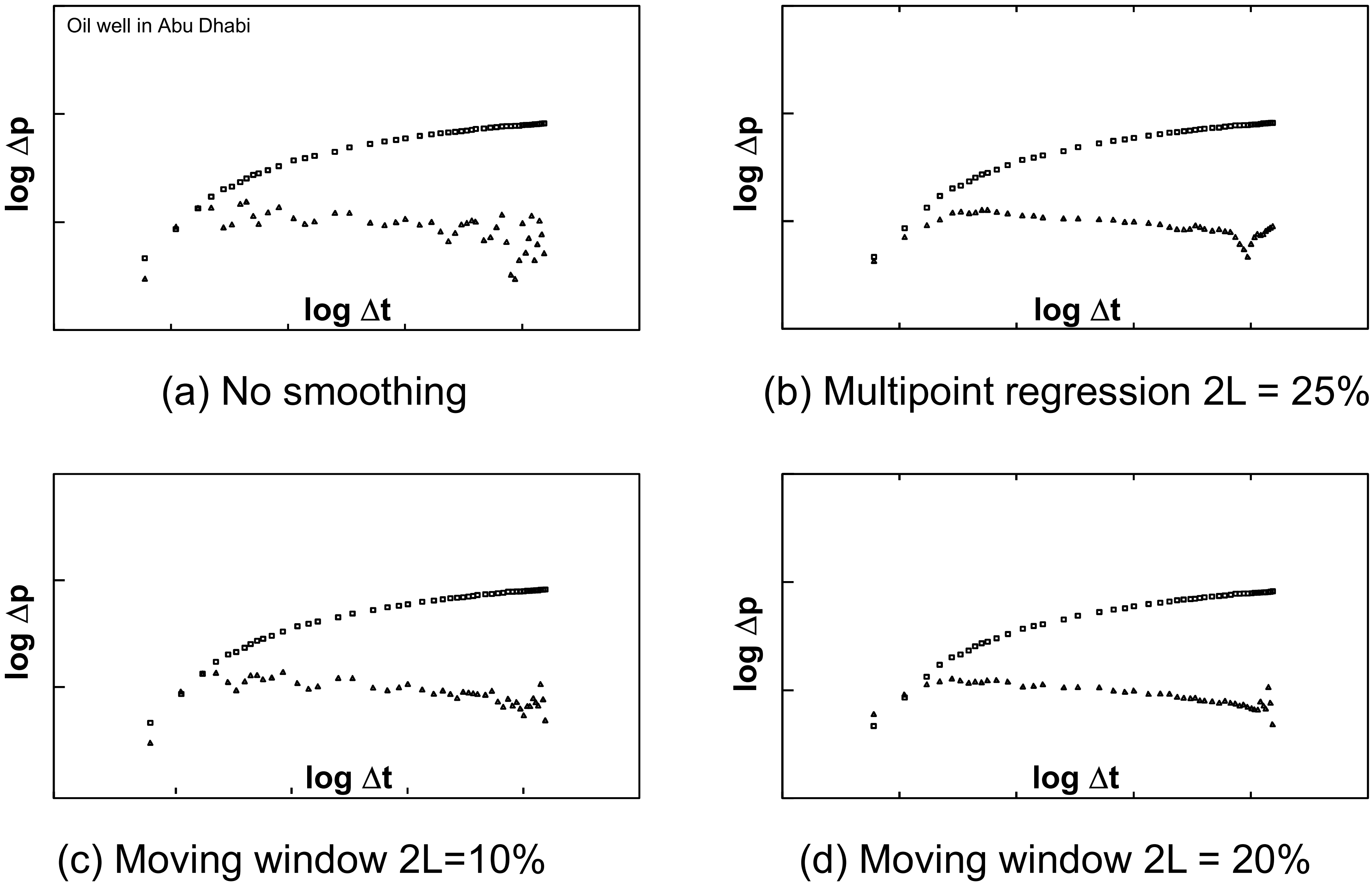
(a) Multipoint regression



(b) Moving window

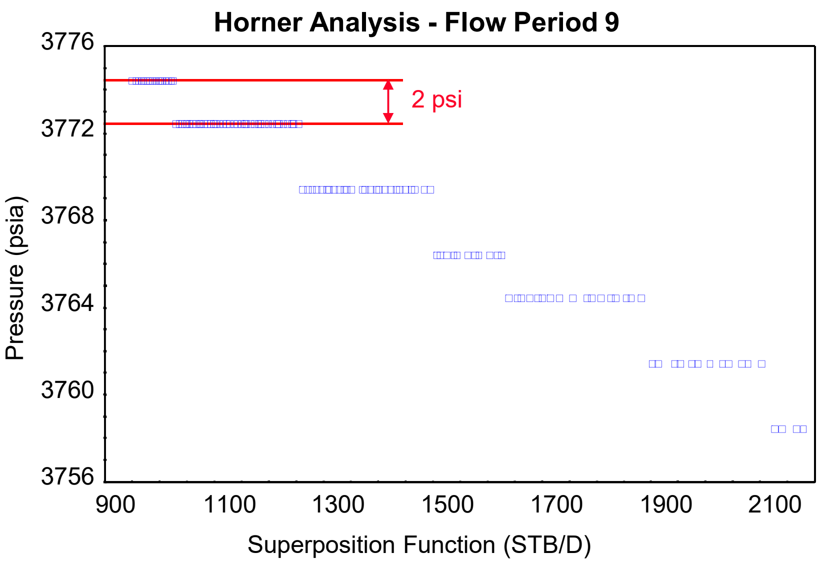
EXAMPLE OF DERIVATIVE SMOOTHING FOR MECHANICAL GAUGE DATA

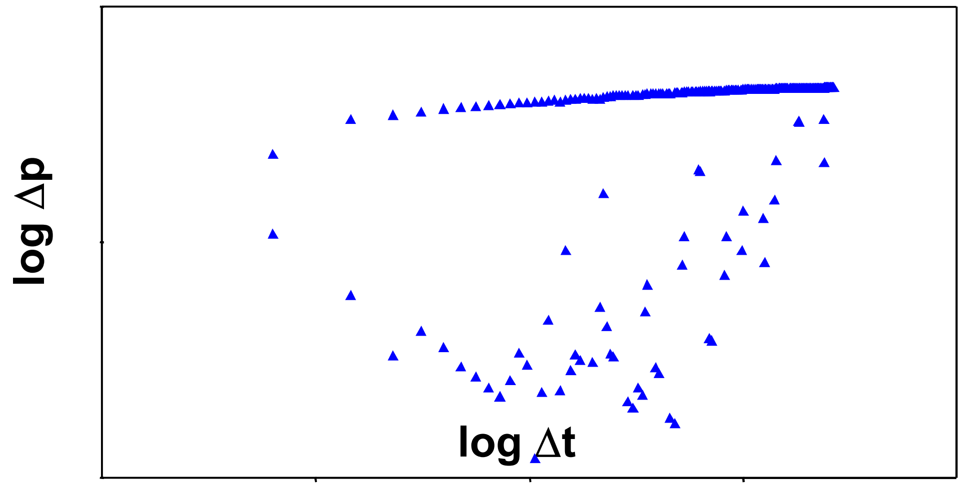
(RE06EX2)



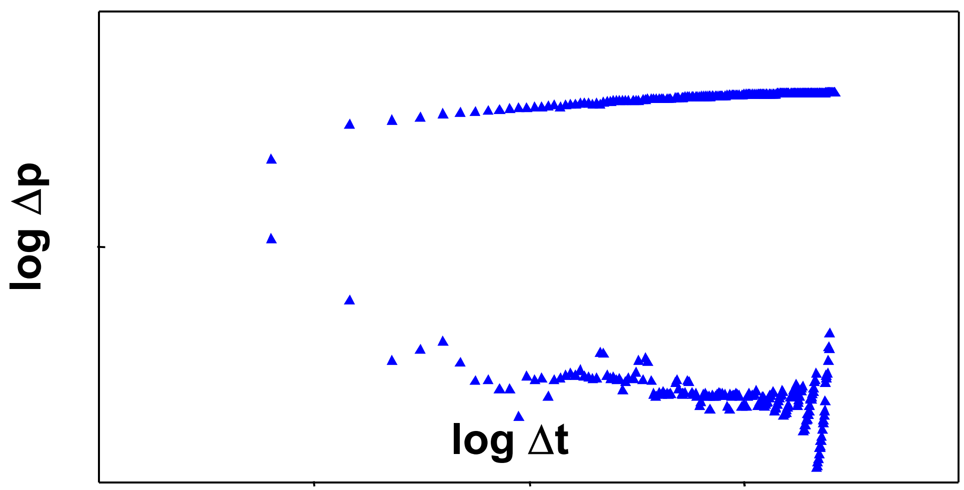
EXAMPLE OF DERIVATIVE SMOOTHING FOR MECHANICAL GAUGE DATA

(Maureen Well X5 DST 4)

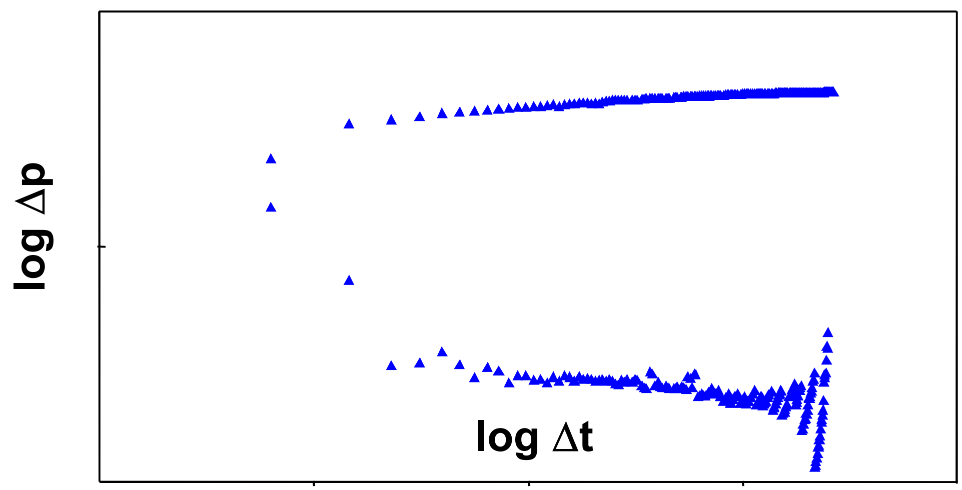




(a) No smoothing

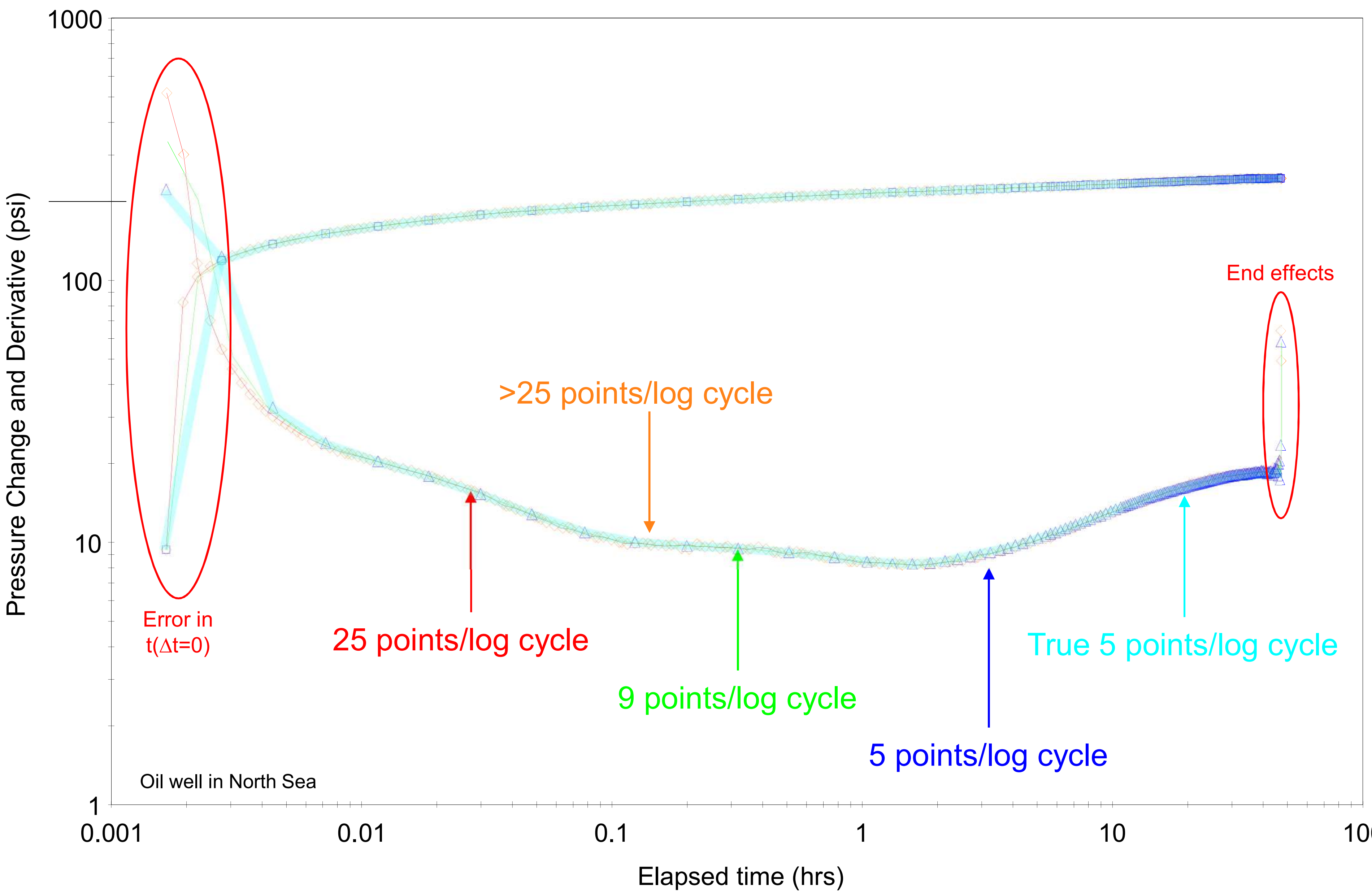


(c) Moving window 2L=17% (default)

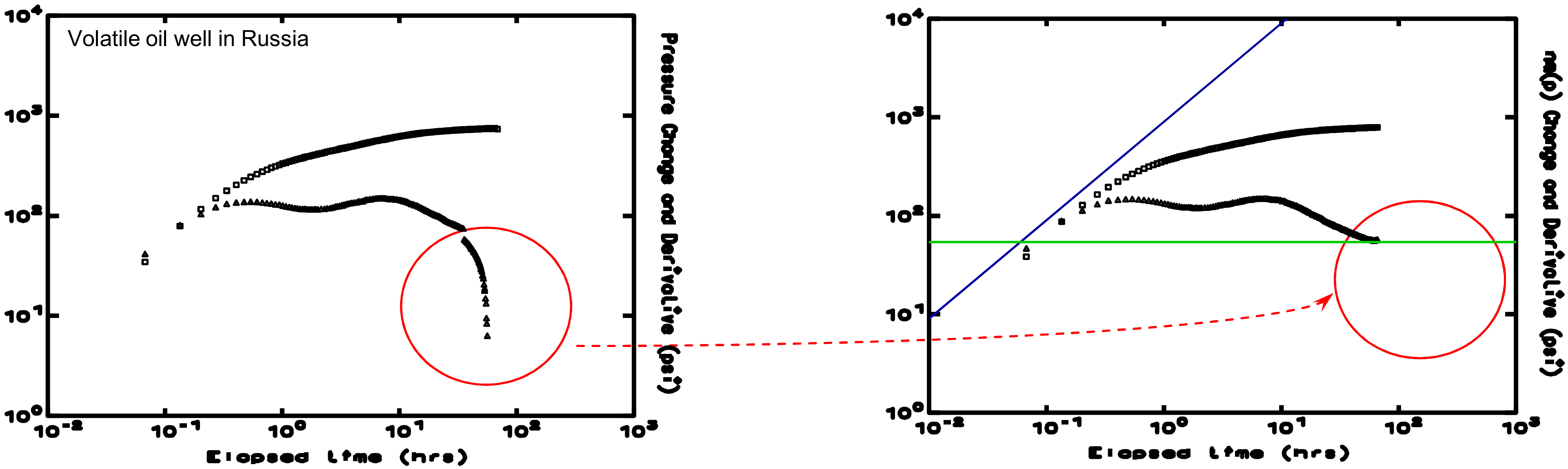


(c) Moving window 2L=35%

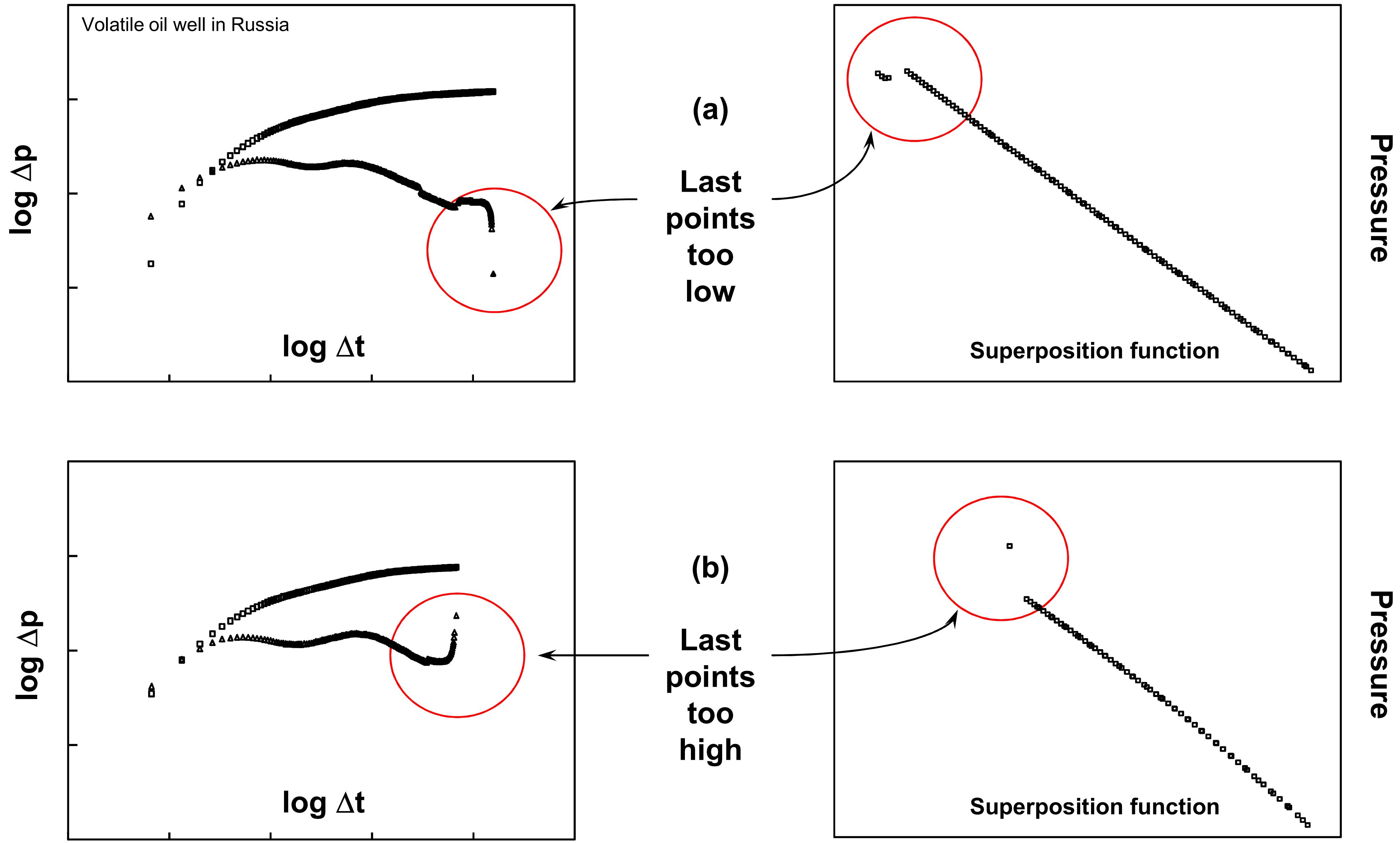
IMPACT OF POINT DENSITY



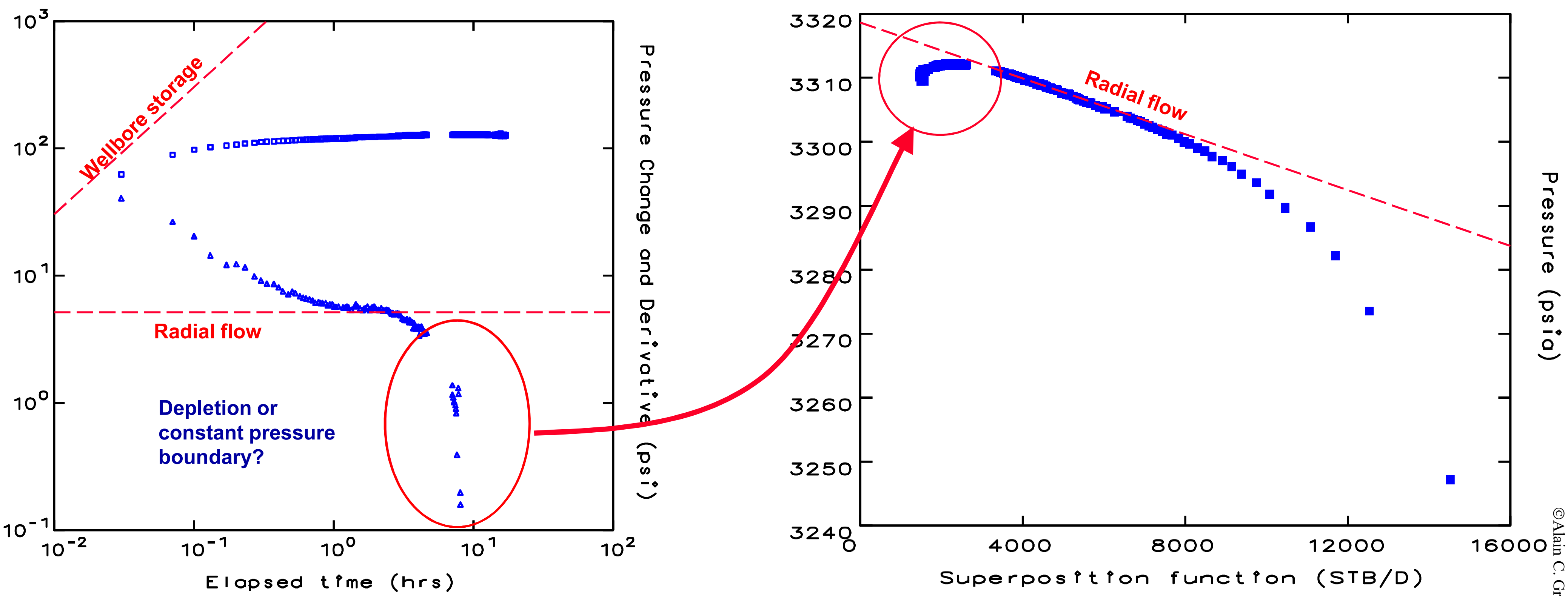
EXAMPLE OF DERIVATIVE END EFFECTS



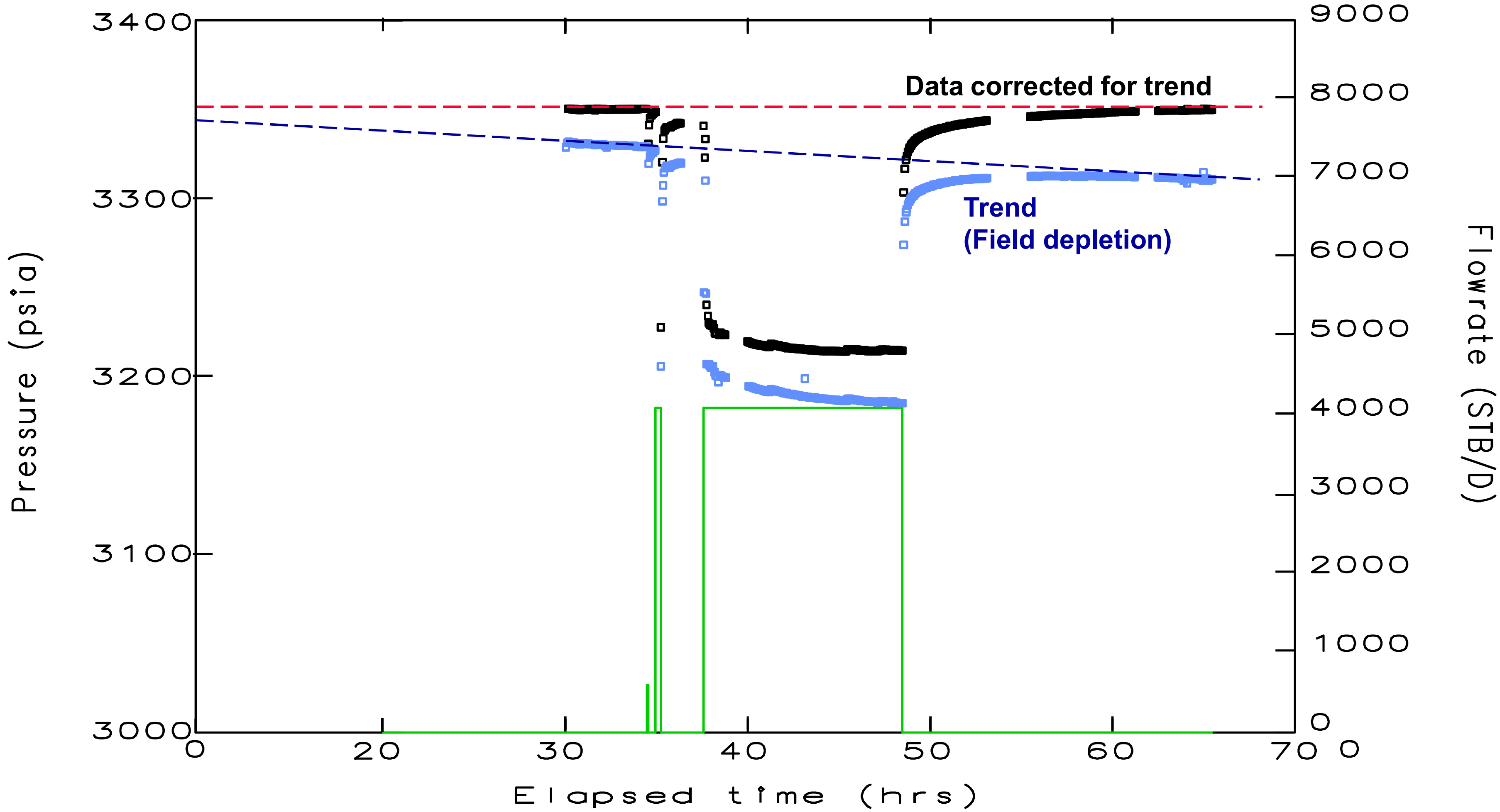
EXAMPLE OF DERIVATIVE END EFFECTS



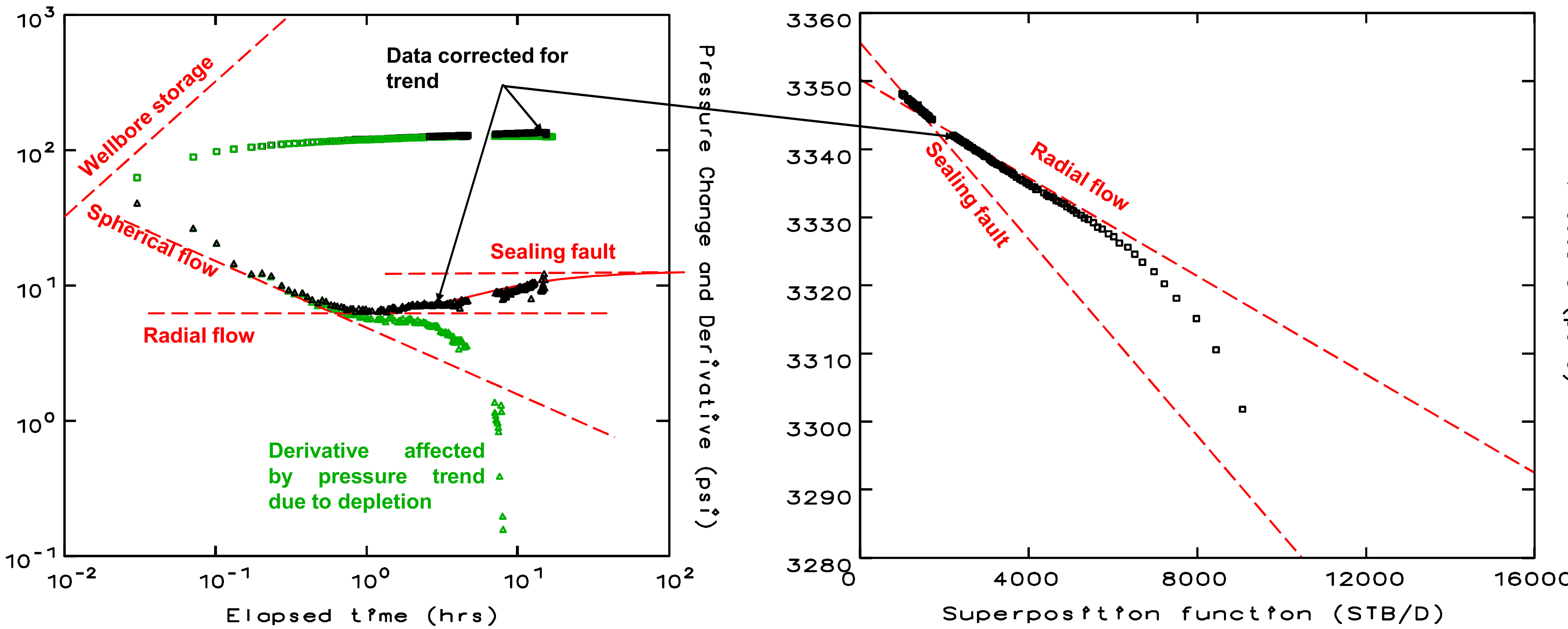
EXAMPLE OF PRESSURE TREND EFFECTS



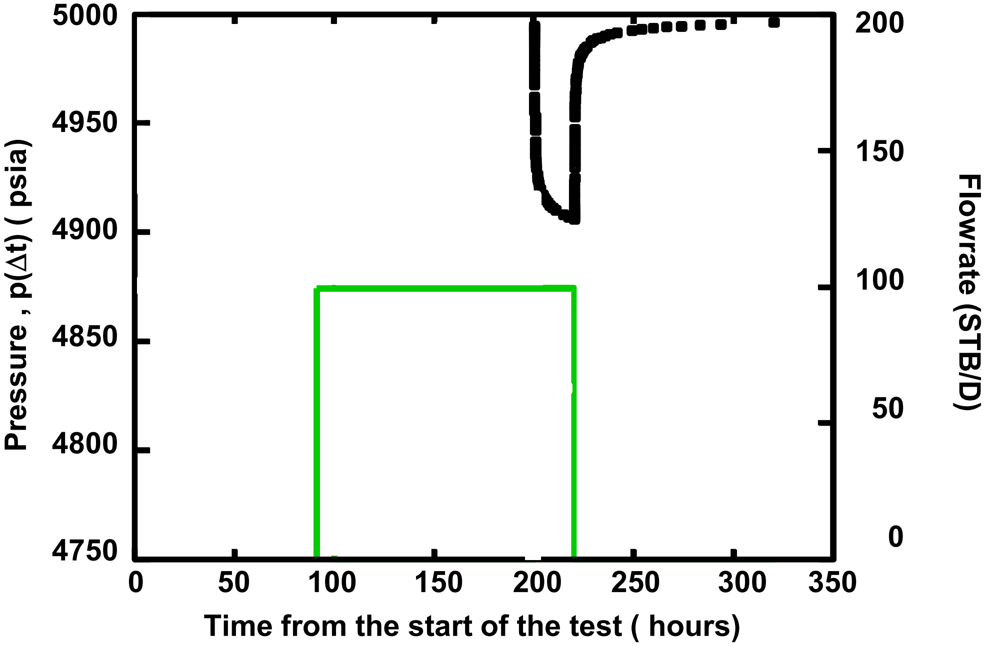
EXAMPLE OF PRESSURE TREND EFFECTS

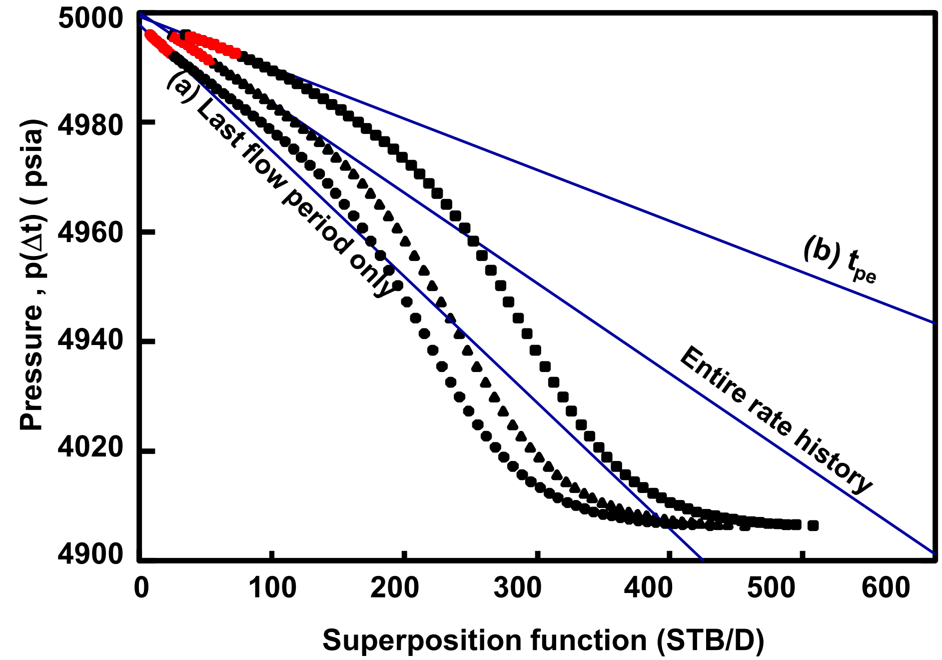


EXAMPLE OF PRESSURE TREND EFFECTS



INFLUENCE OF RATE HISTORY SIMPLIFICATION
ON HORNER AND SUPERPOSITION PLOT SHAPE





$$t_{pe} = 24\frac{V_p}{q} = 24(100+20)(100/24)/100 = 120 hrs$$

Vp = cumulative production since the last pressure equalisation

Constant Production Rate before Closing in

$$p_w = p_o - \frac{q\mu}{4\pi kh}\ln\frac{t_o+\vartheta}{\vartheta} \ldots\ldots (V)$$

Variable Production Rate before Closing in

$$p_w = p_o - \frac{\mu}{4\pi kh}\left\{q_o \ln\frac{t_o+\vartheta}{t_o+\vartheta-t_1} + q_1 \ln\frac{t_o+\vartheta-t_1}{t_o+\vartheta-t_2} + q_2 \ln\frac{t_o+\vartheta-t_2}{t_o+\vartheta-t_3} + q_3 \ln\frac{t_o+\vartheta-t_3}{\vartheta}\right\} \ldots\ldots (VI)$$

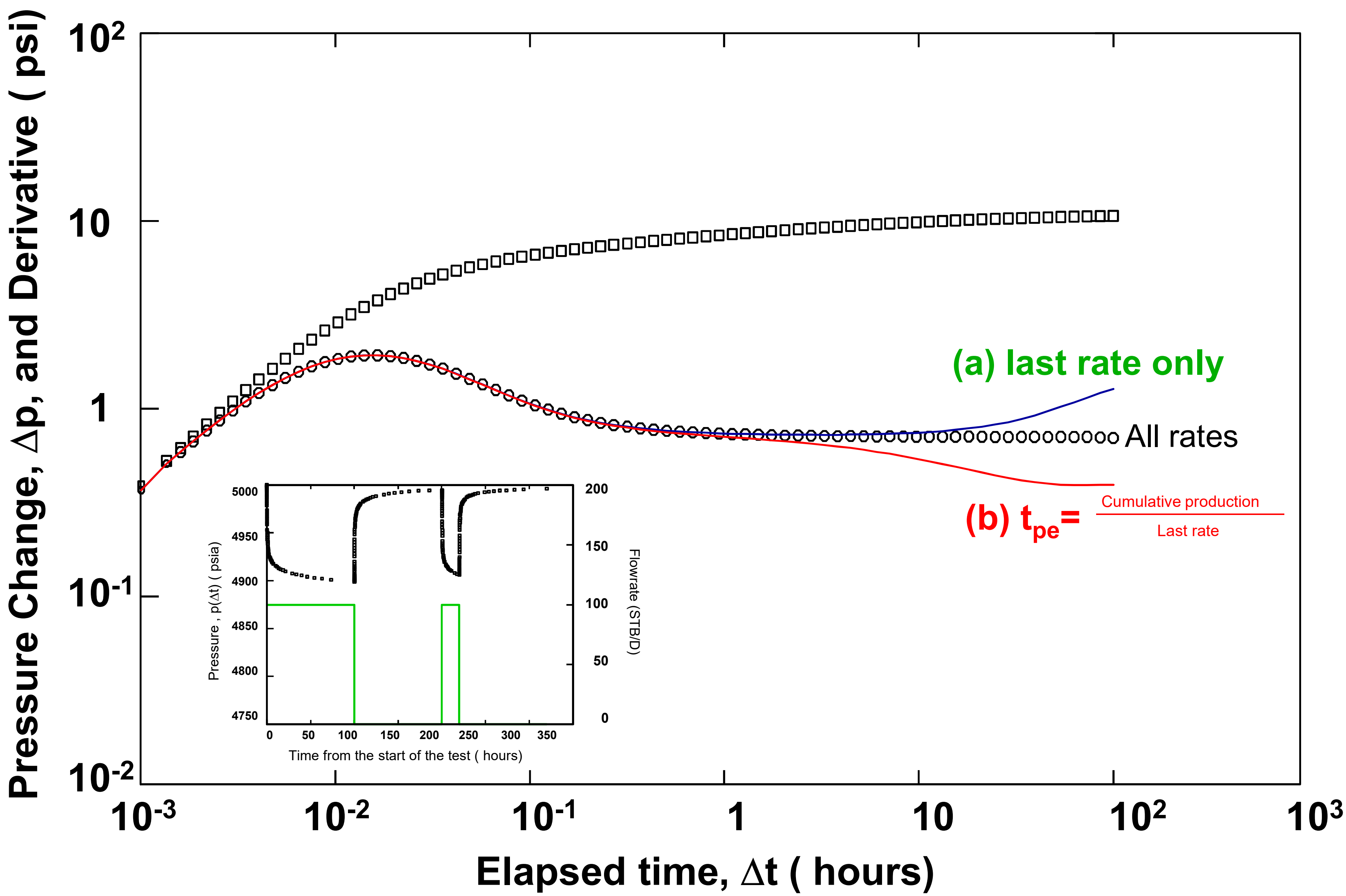
Horner 3rd World Pet. Congress (1951)

Superposition will normally be more precise than is warranted by the other inaccuracies which are unavoidably present—in fact only rarely has it ever proved of value to apply this elaborate method. Instead, the equation V is usually modified by simply introducing a so-called corrected time t_c, and writing

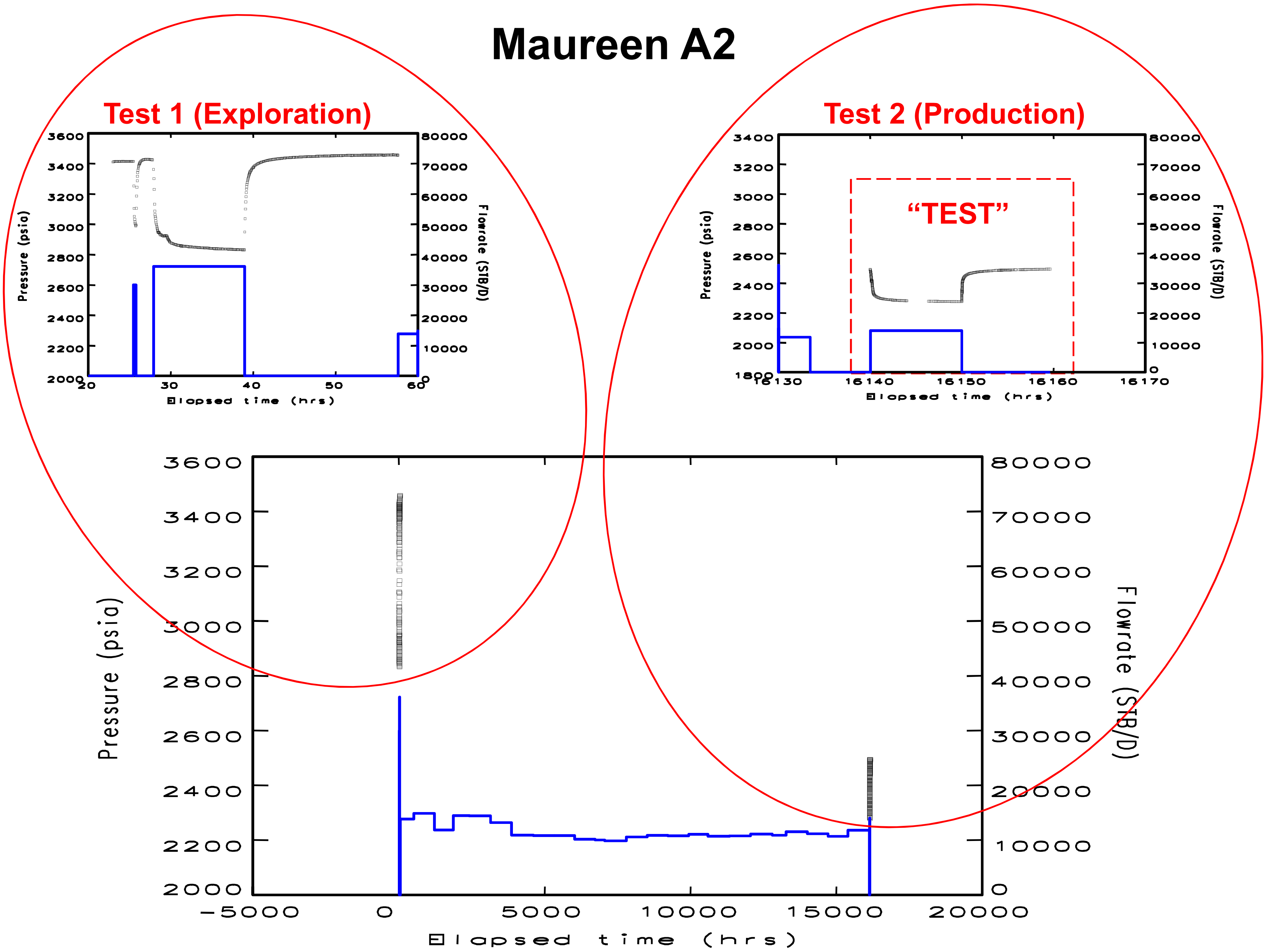
$$p_w = p_o - \frac{q\mu}{4\pi kh}\ln\frac{t_c+\vartheta}{\vartheta} \ldots\ldots (VII)$$

where q is calculated from the last established production rate before closing in the well; t_c is obtained by dividing the total cumulative production of the well by the last established production rate.

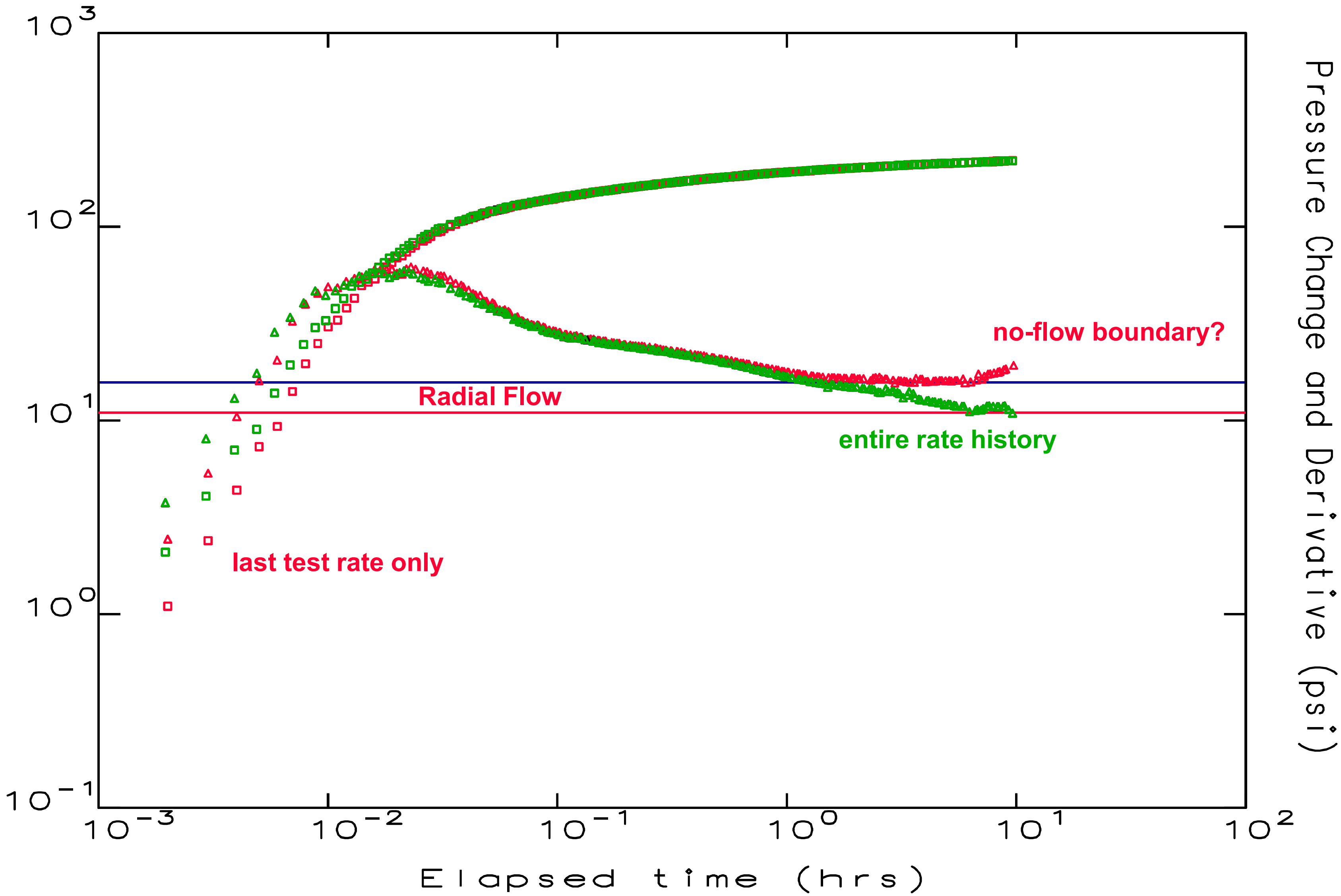
INFLUENCE OF RATE HISTORY SIMPLIFICATION ON PRESSURE DERIVATIVE PLOT SHAPE



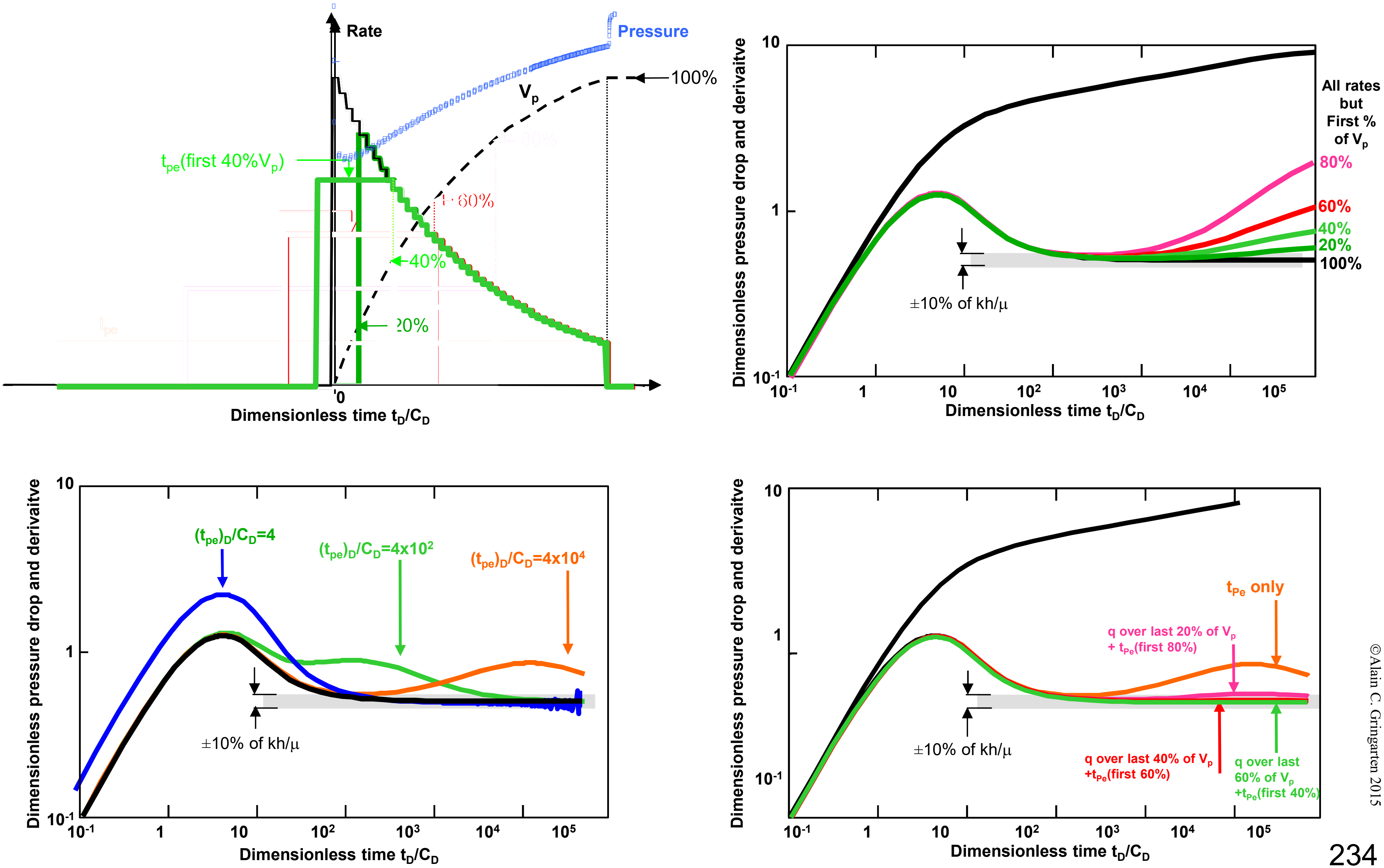
Maureen A2


Test 1 (Exploration)
Test 2 (Production)
"TEST"
Pressure (psia)
Flowrate (STB/D)
Elapsed time (hrs)

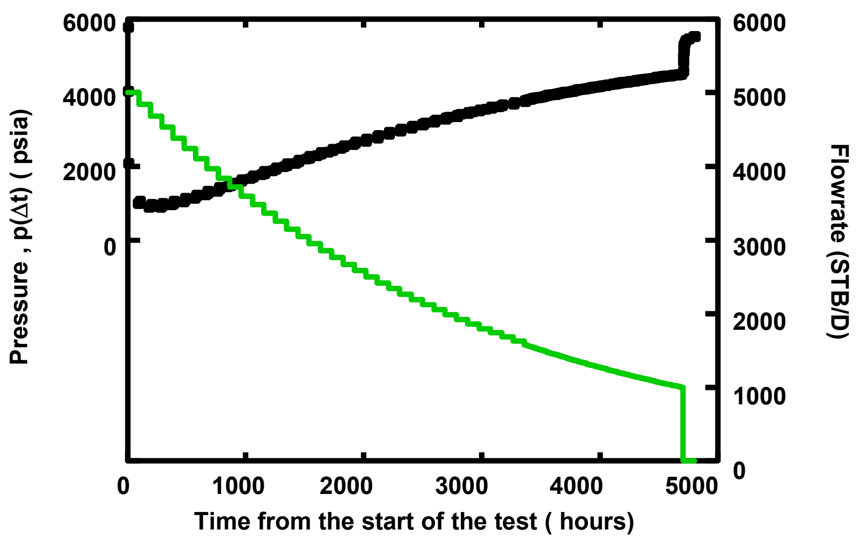
Maureen A2 Test 2 (Production)

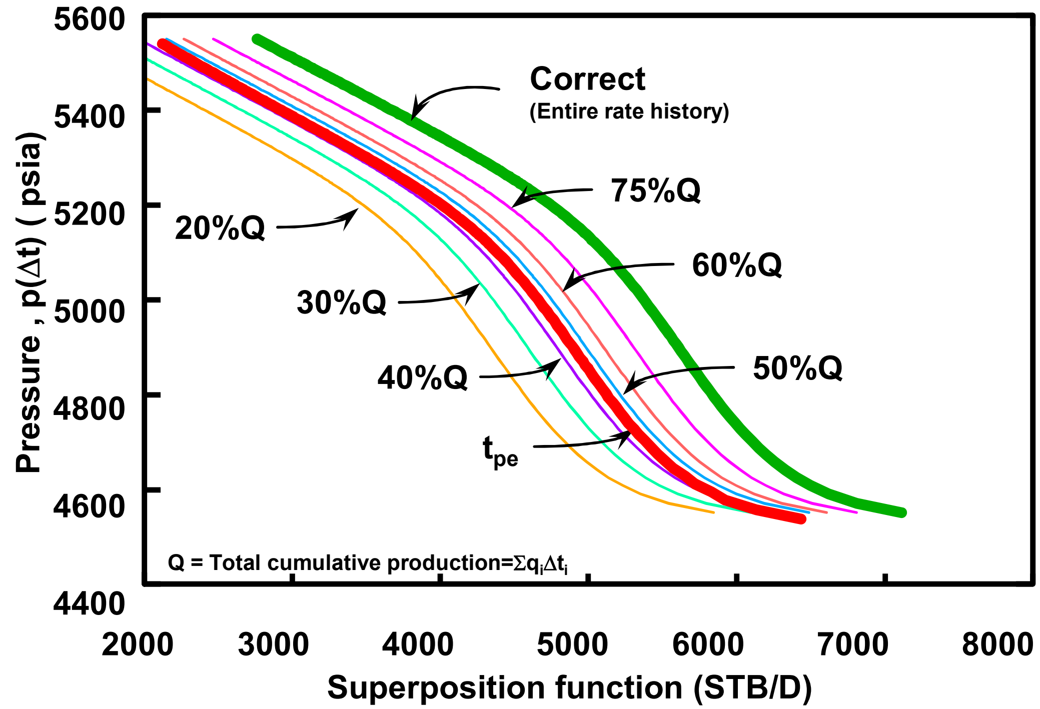


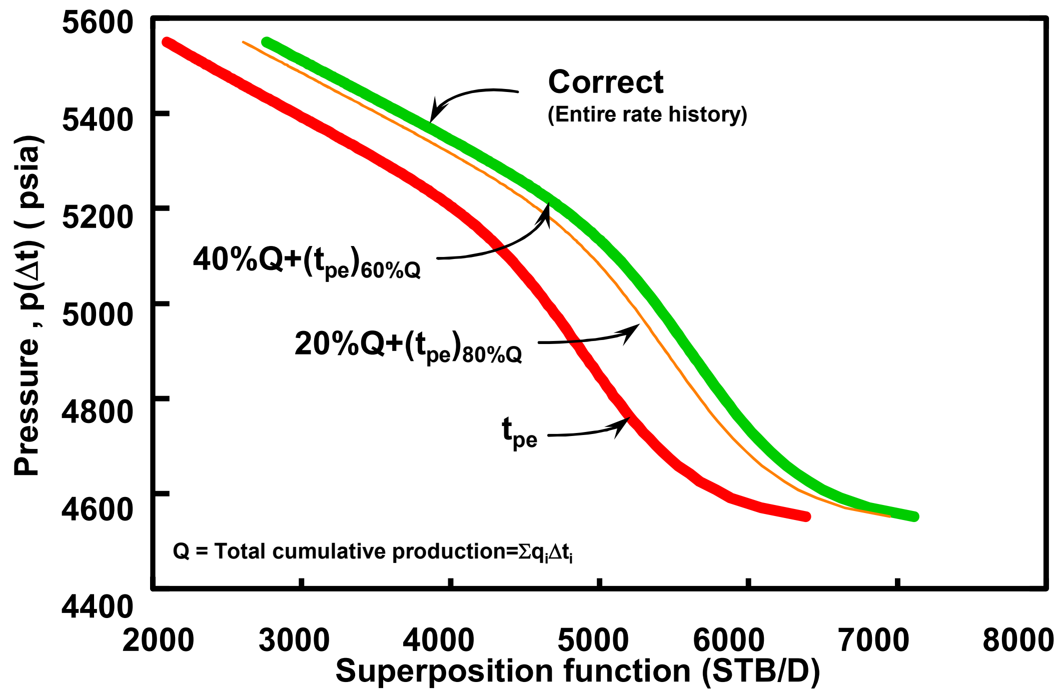
INFLUENCE OF RATE HISTORY SIMPLIFICATION ON PRESSURE DERIVATIVE PLOT SHAPE



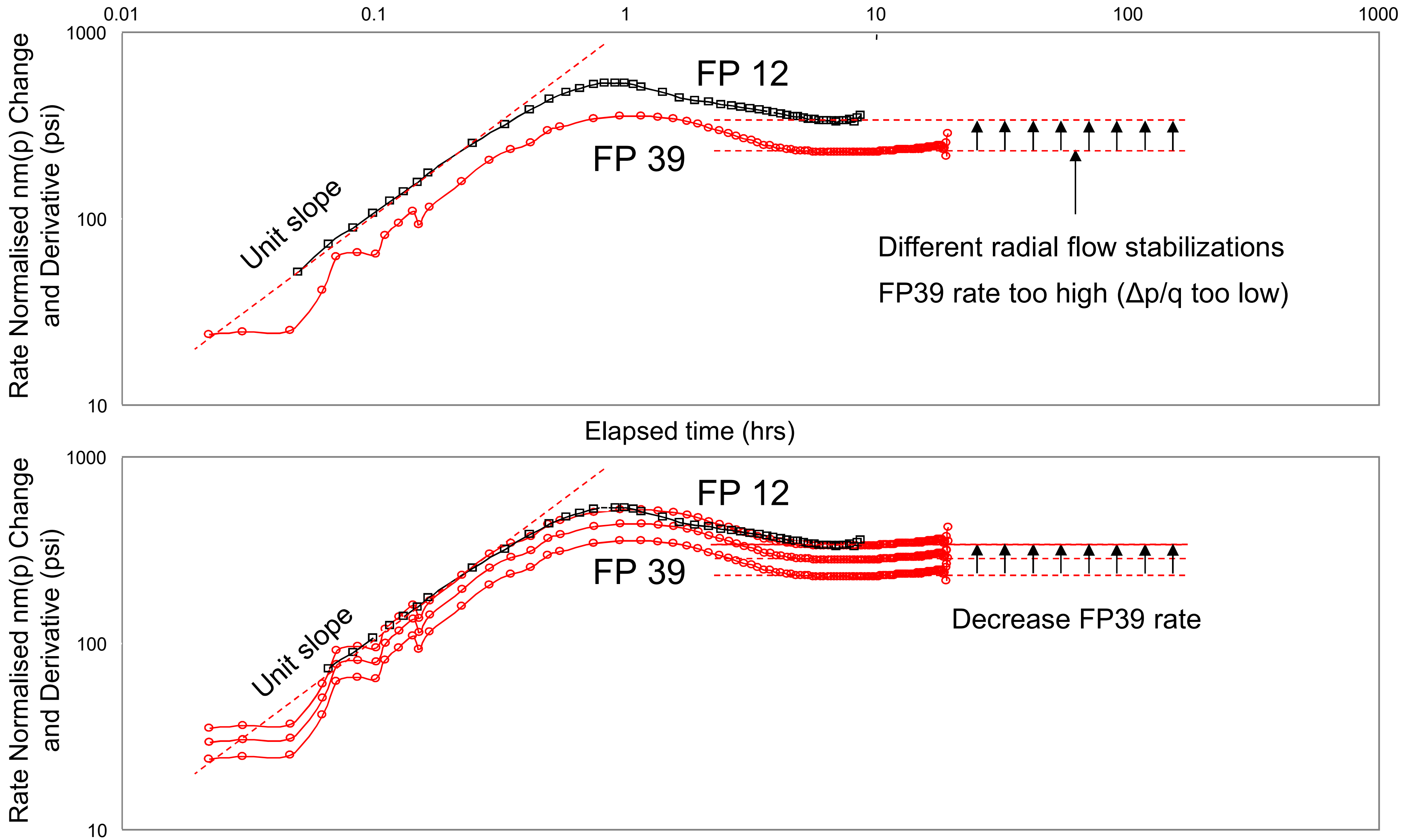
INFLUENCE OF RATE HISTORY SIMPLIFICATION
ON HORNER AND SUPERPOSITION PLOT SHAPE



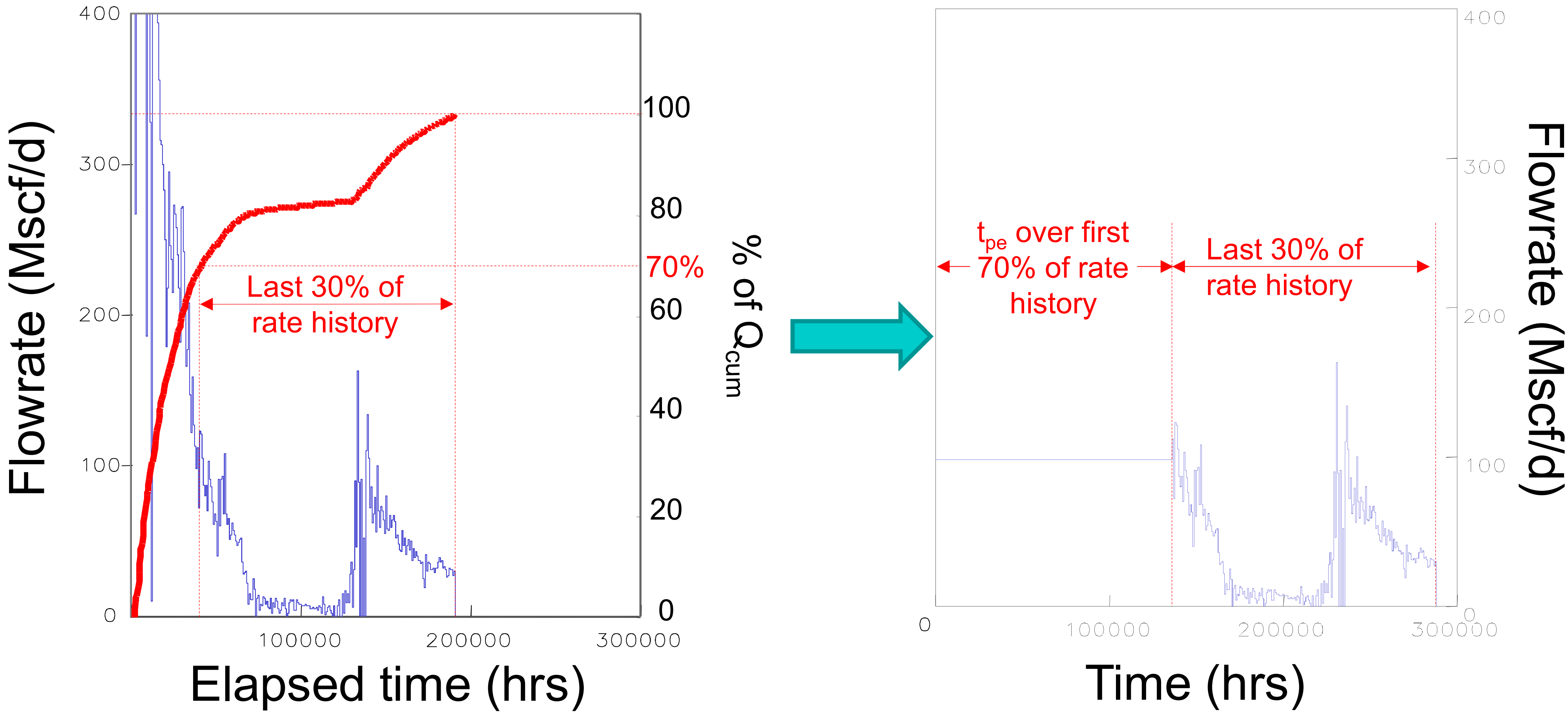




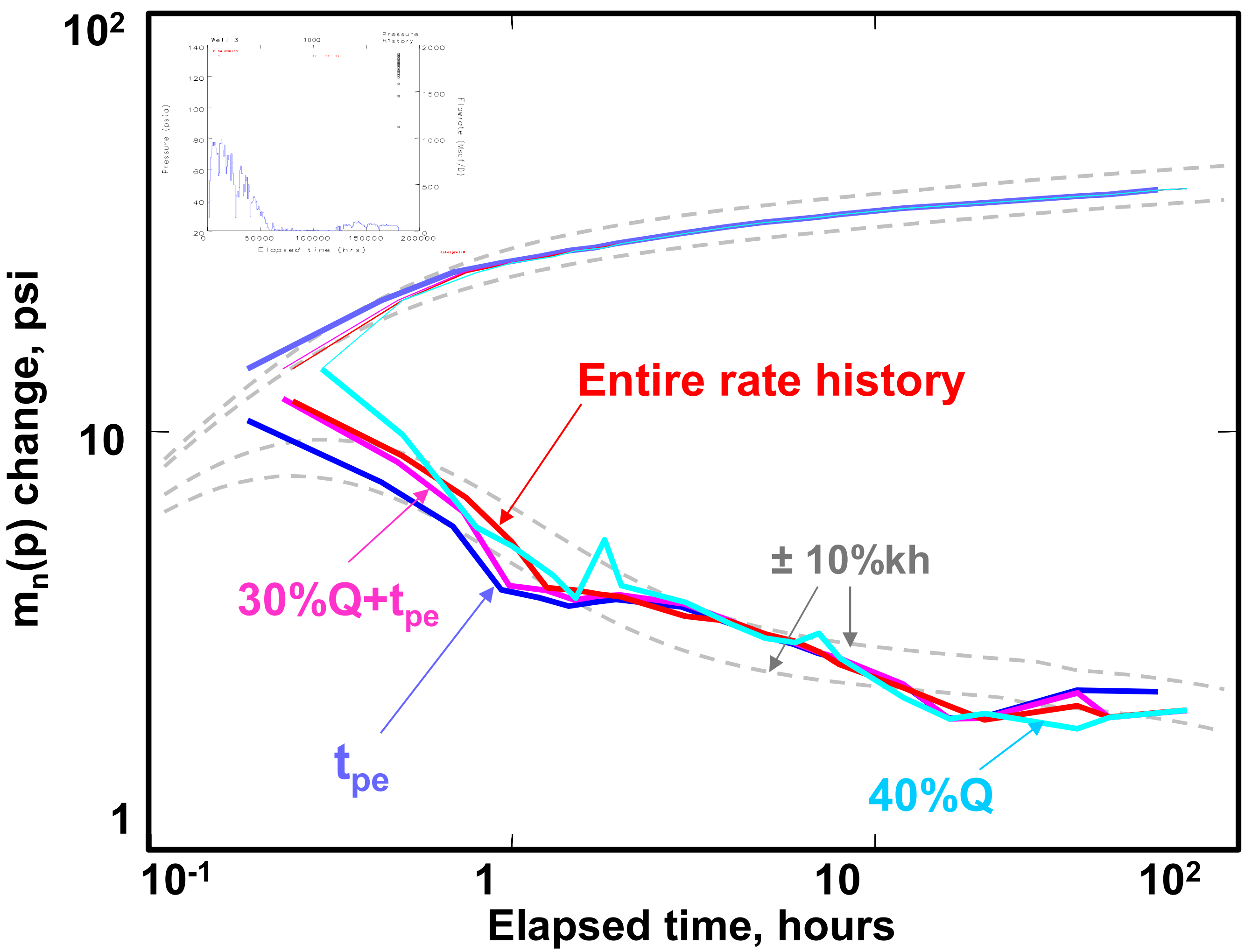
RATE CORRECTION



Field example:
New rate history approximation

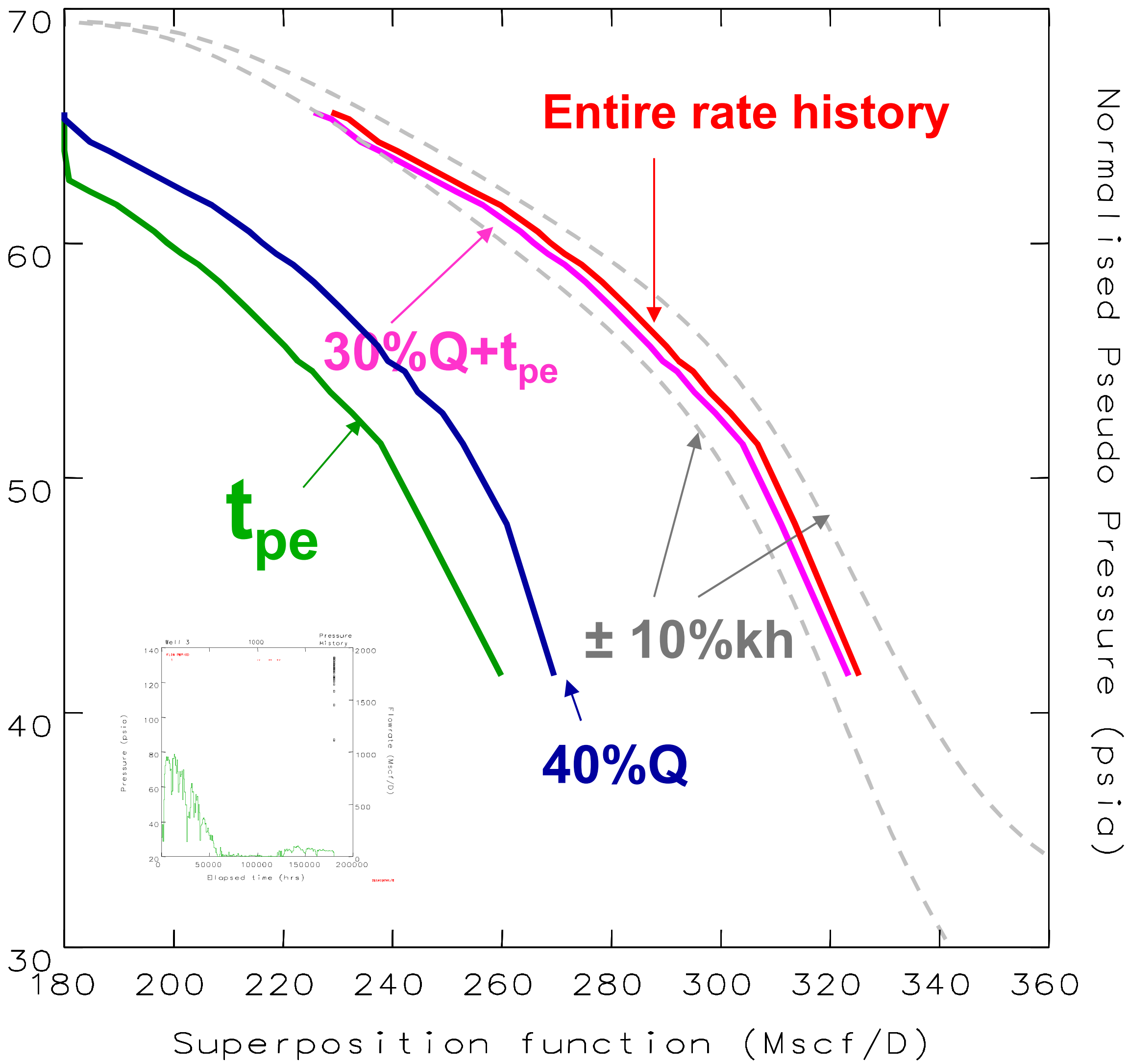


Field example: Log-Log Plot



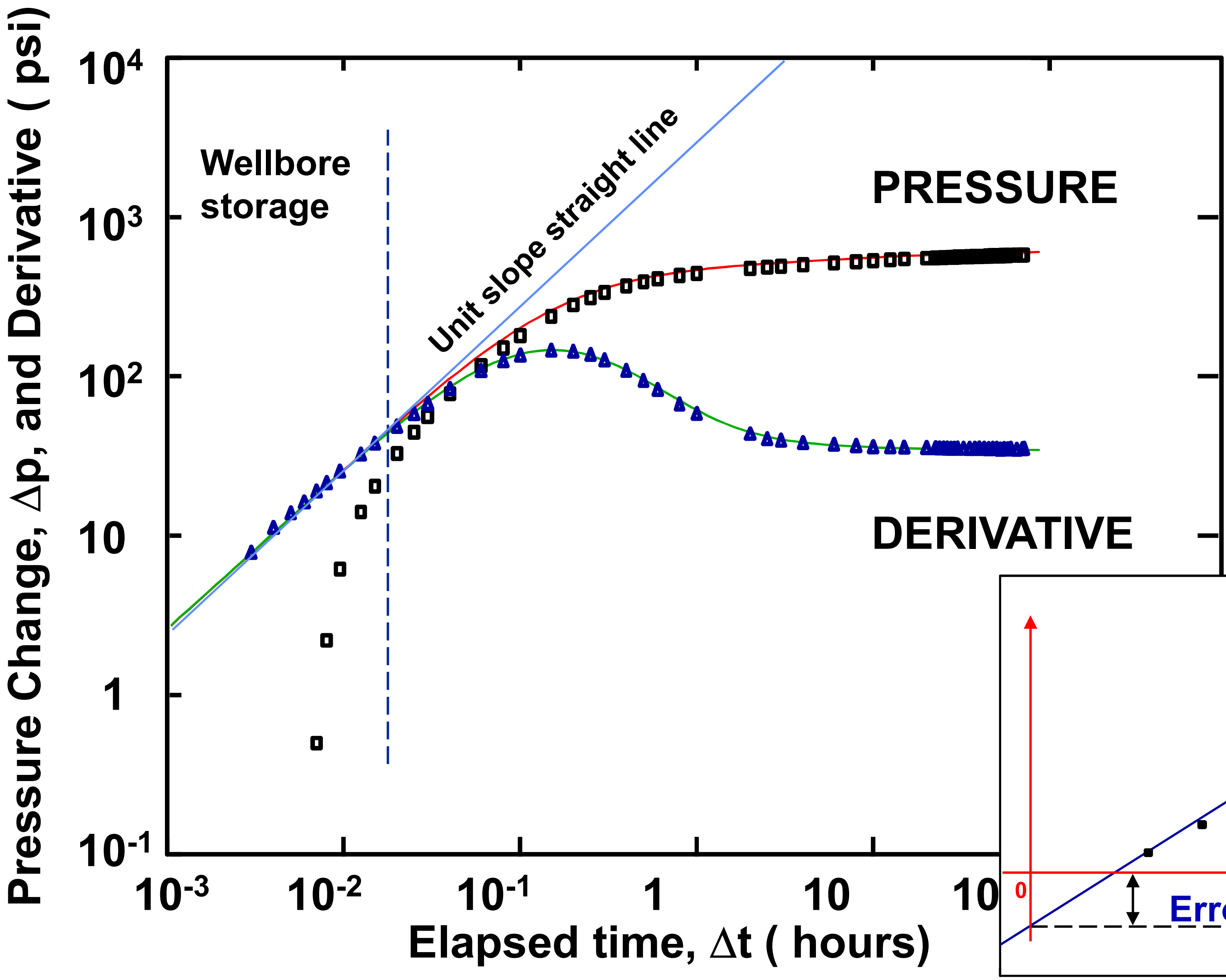
SPE63077 FAQs in well test analysis

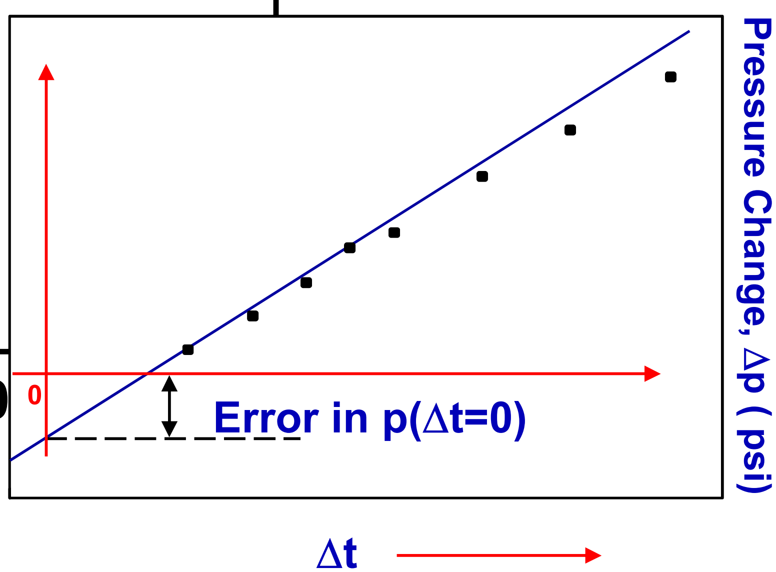
Field example: Horner Plot



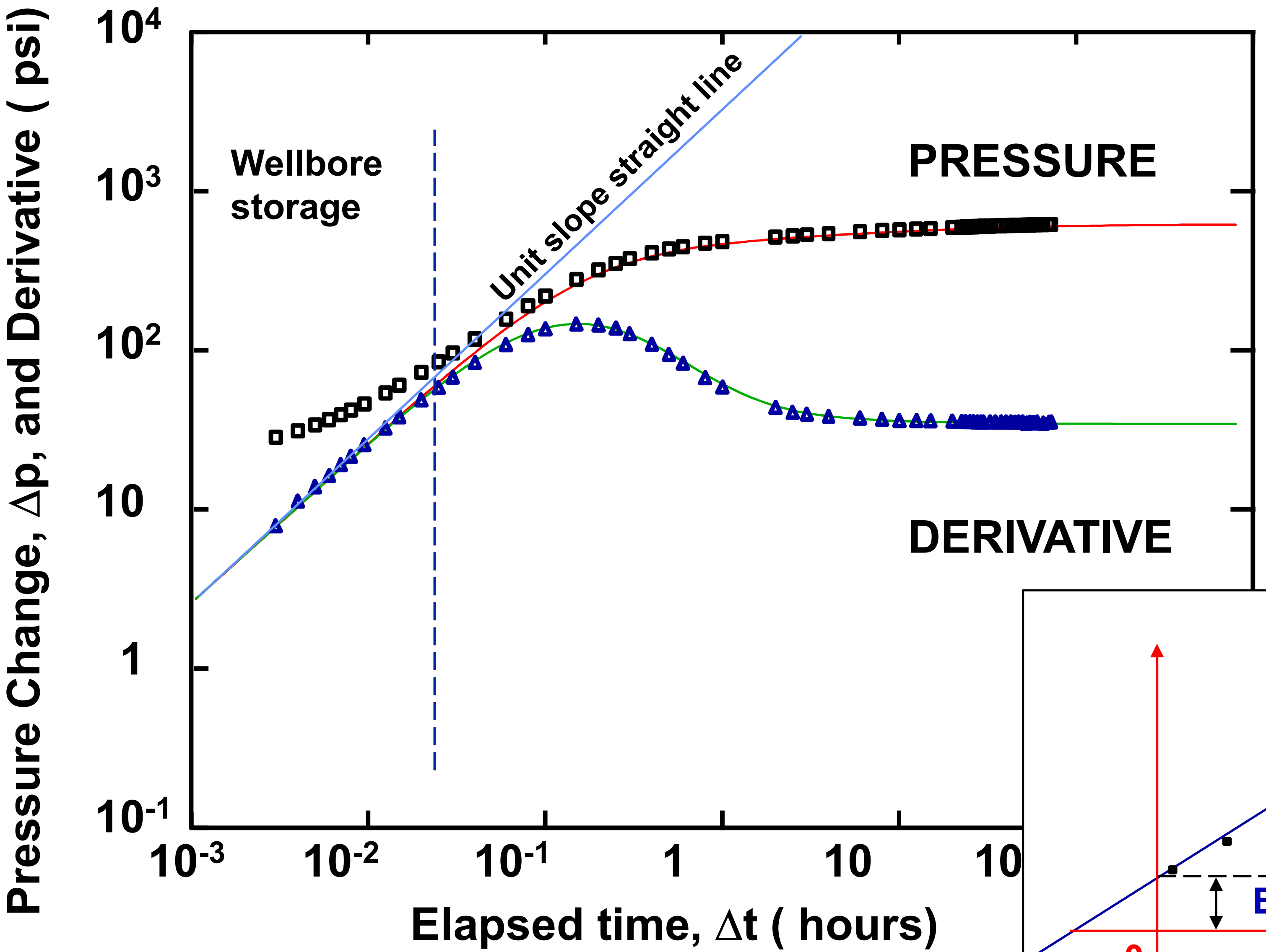
SPE63077 FAQs in well test analysis

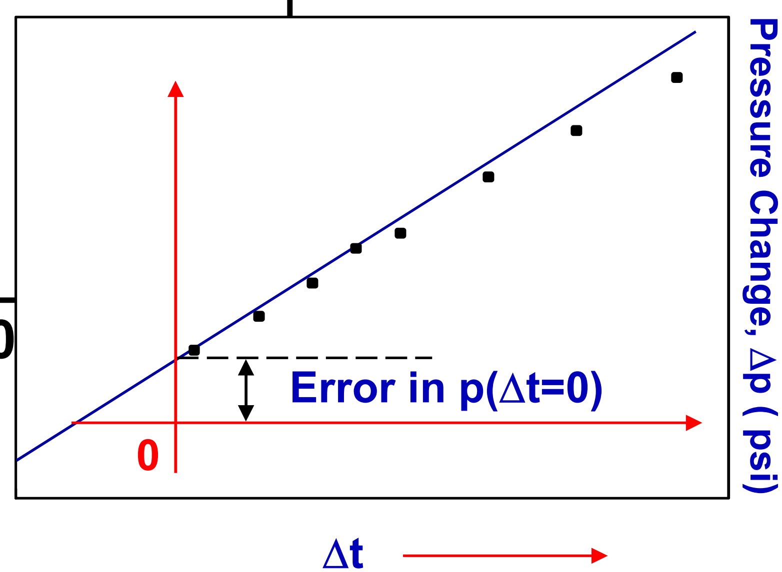
WELLBORE STORAGE WITH ERROR ON PRESSURE AT START OF FLOW PERIOD: P(Δt =0) TOO HIGH



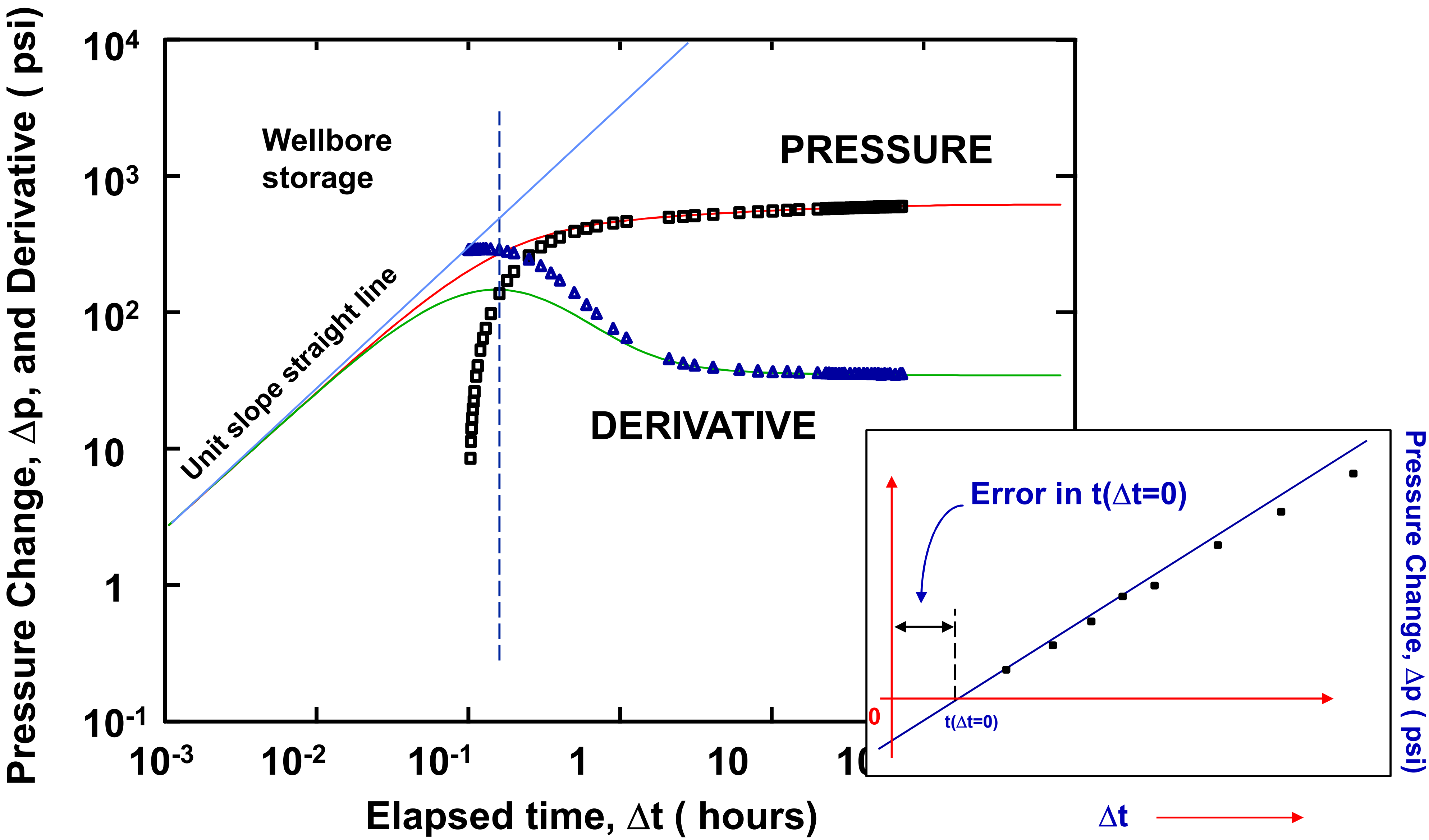


WELLBORE STORAGE WITH ERROR ON PRESSURE AT START OF FLOW PERIOD: p(Δt =0) TOO LOW

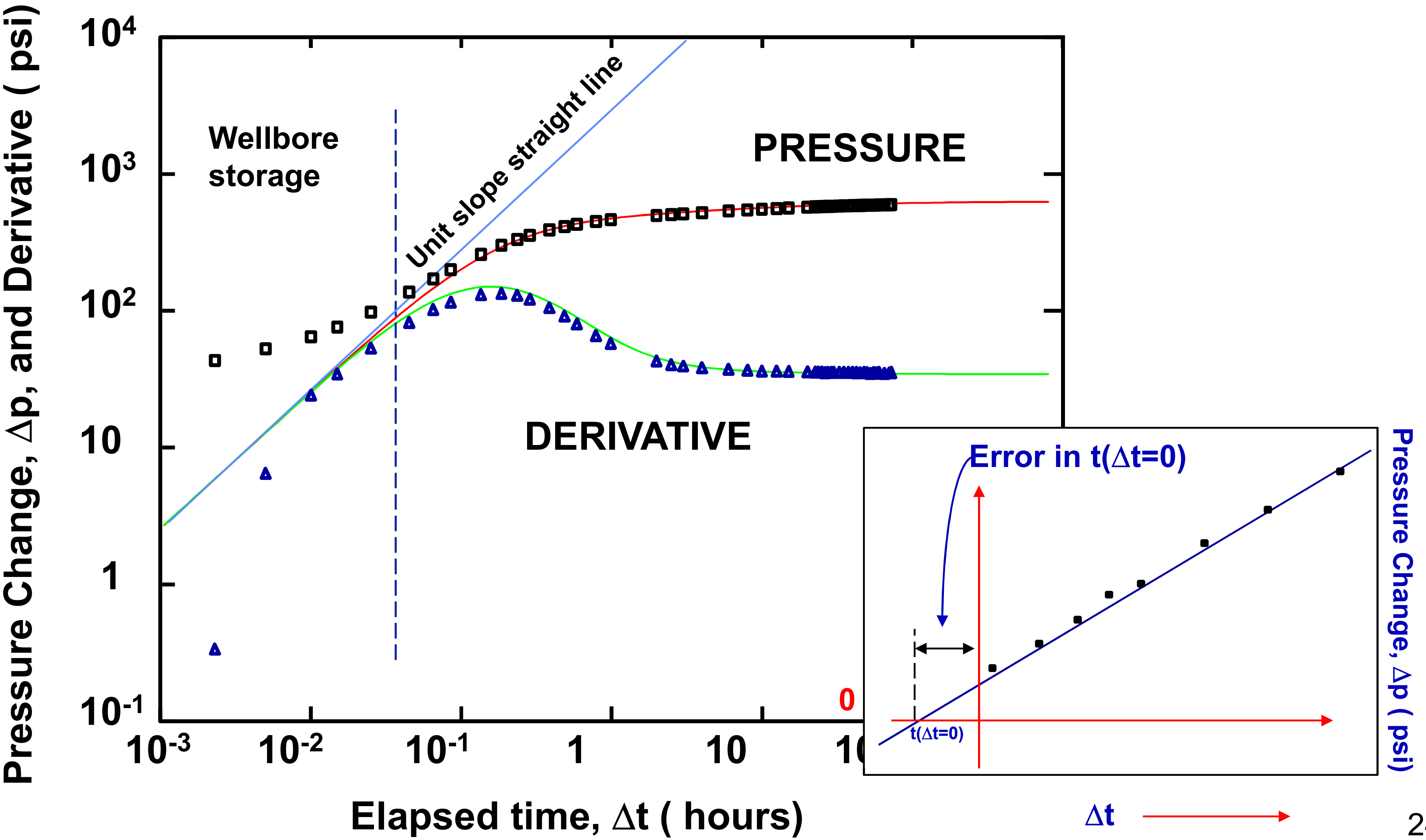




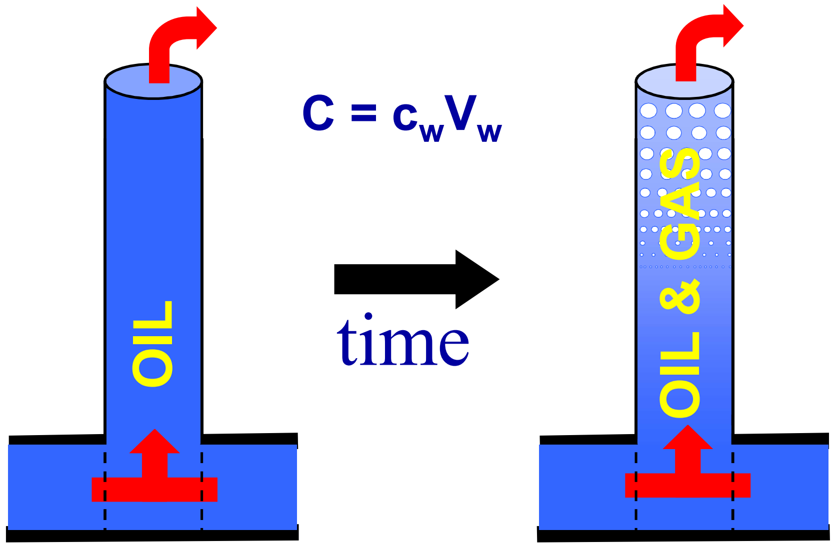
WELLBORE STORAGE WITH ERROR ON TIME AT START OF FLOW PERIOD: t(Δt =0) TOO EARLY

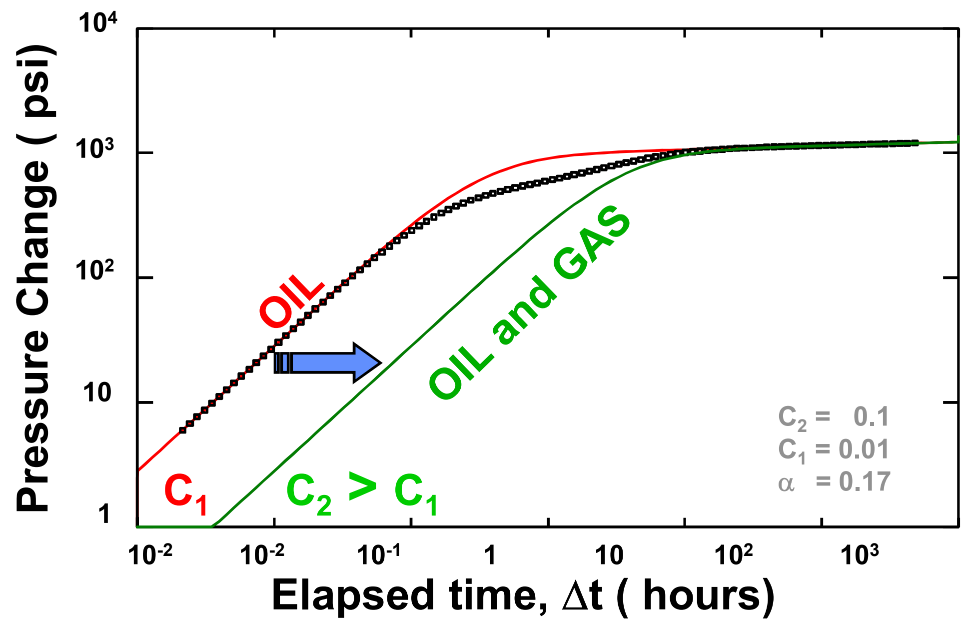


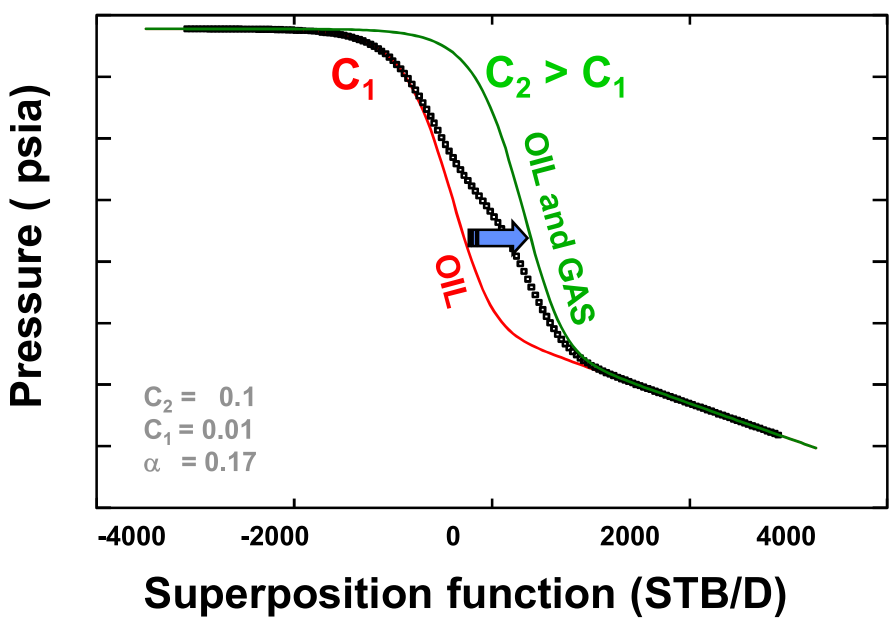
WELLBORE STORAGE WITH ERROR ON TIME AT START OF FLOW PERIOD: $t(\Delta t = 0)$ TOO LATE

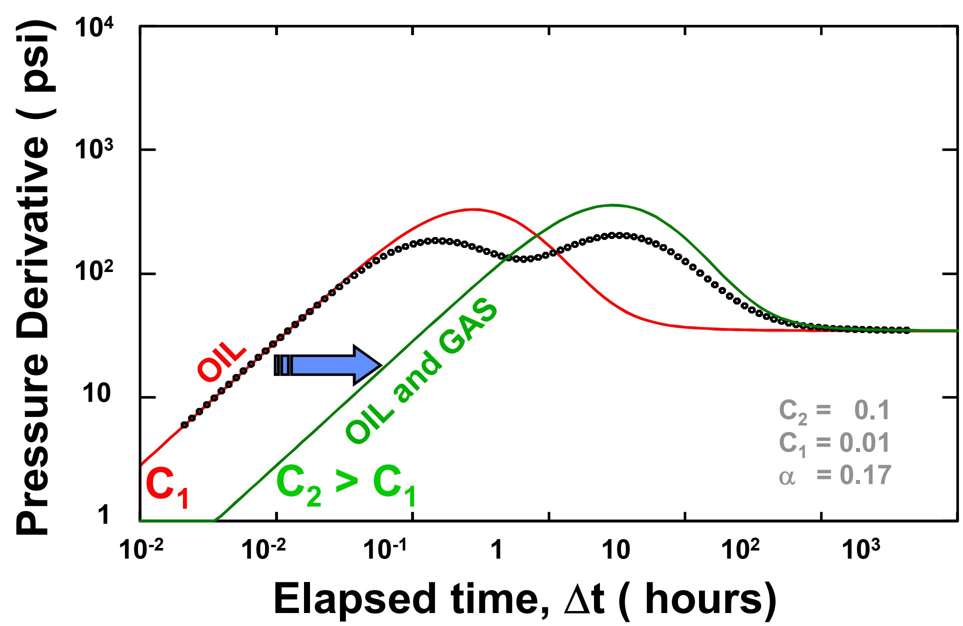


DRAWDOWN: Wellbore storage *increases* due to change from single phase flow to multiphase flow in the wellbore

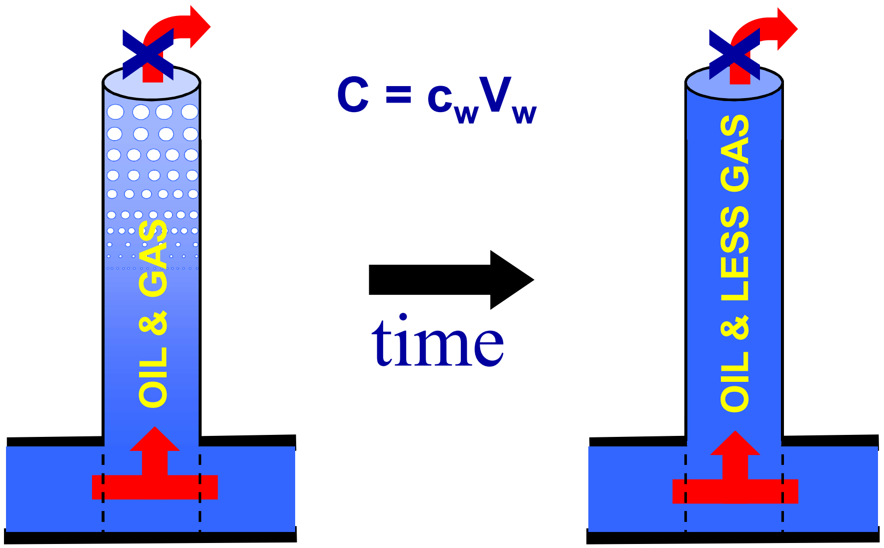


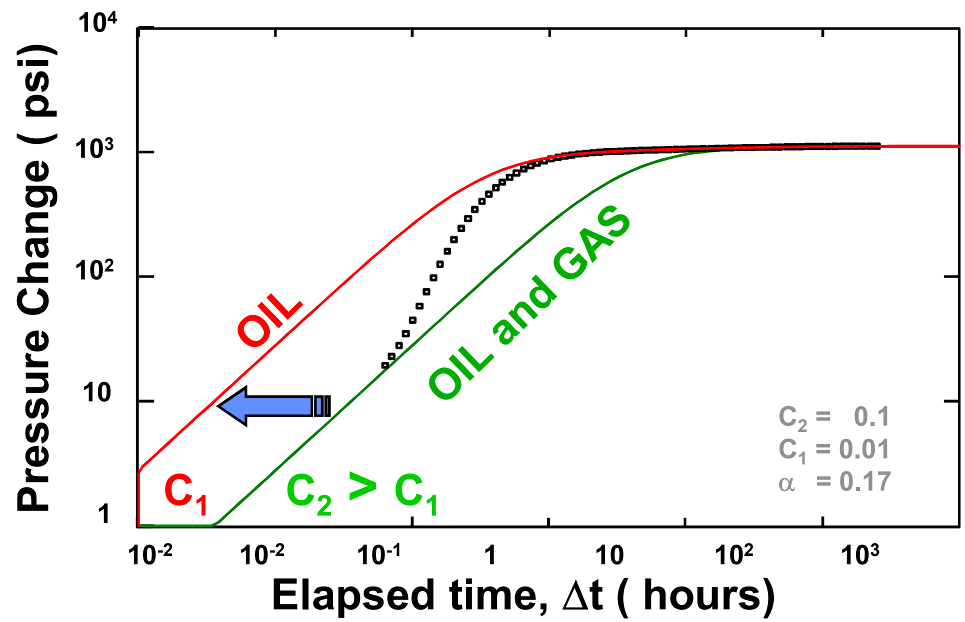


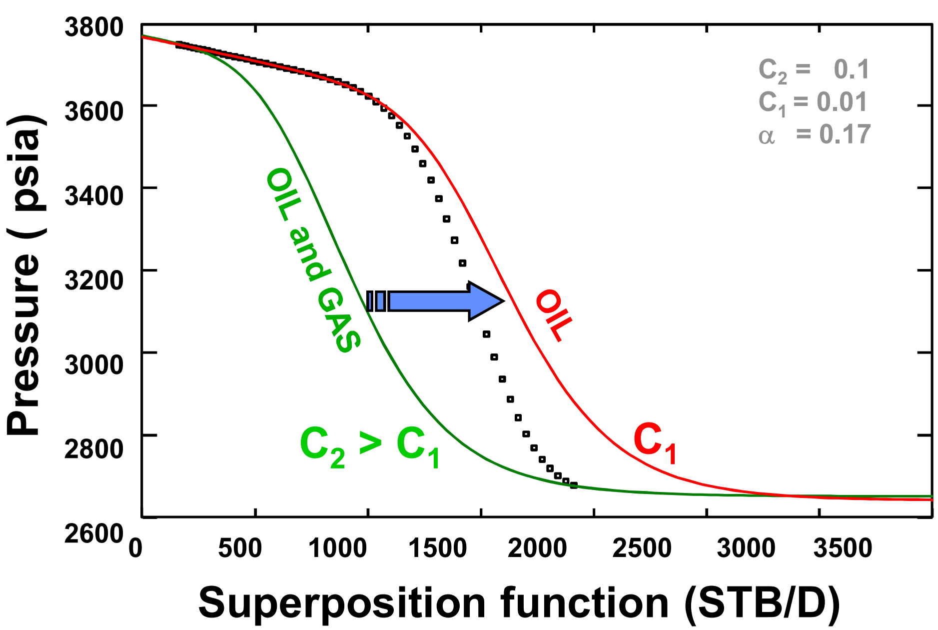


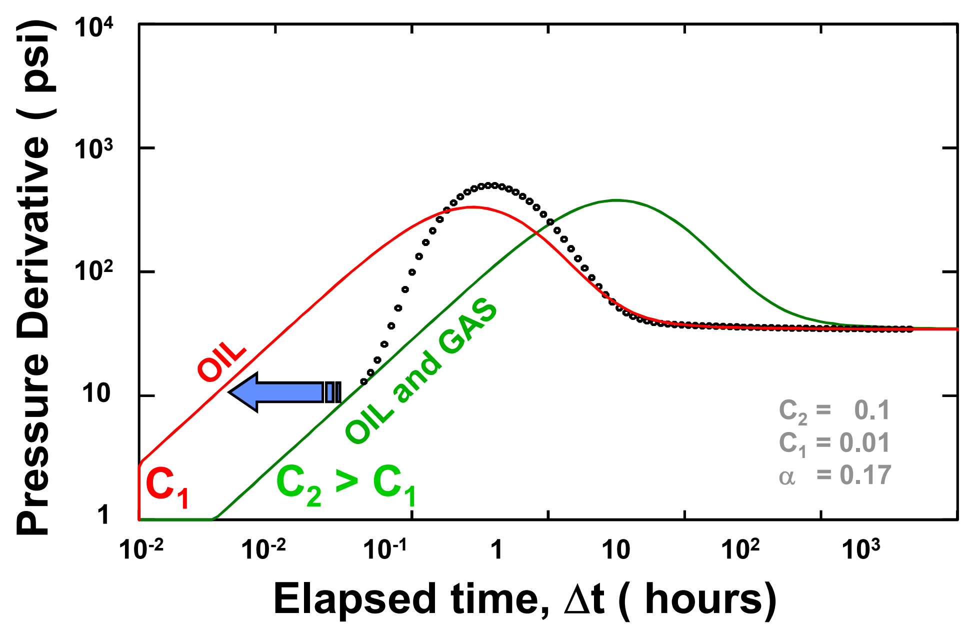


BUILD-UP: Wellbore storage *decreases* due to change from multiphase flow in the wellbore to single phase flow

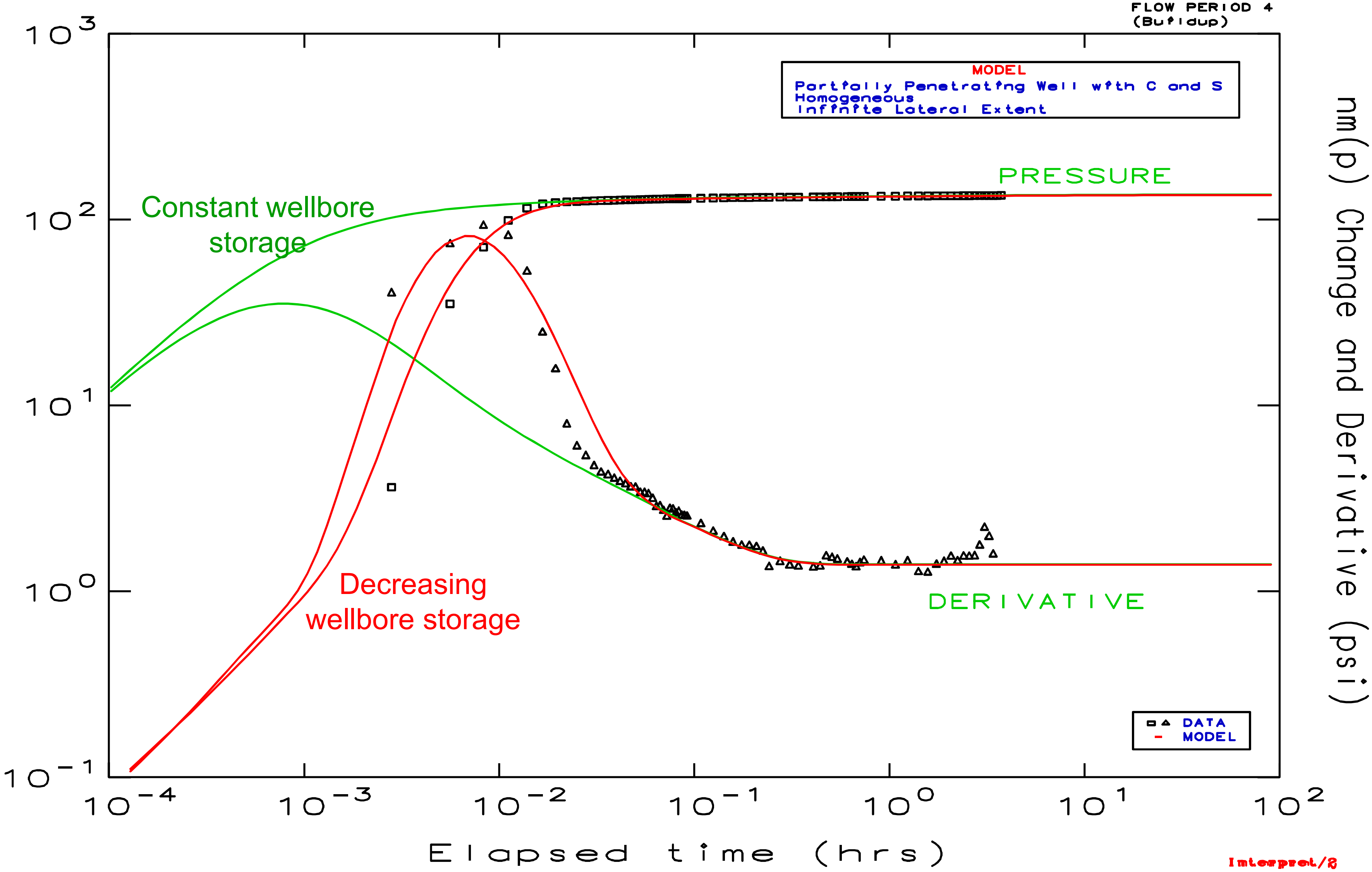




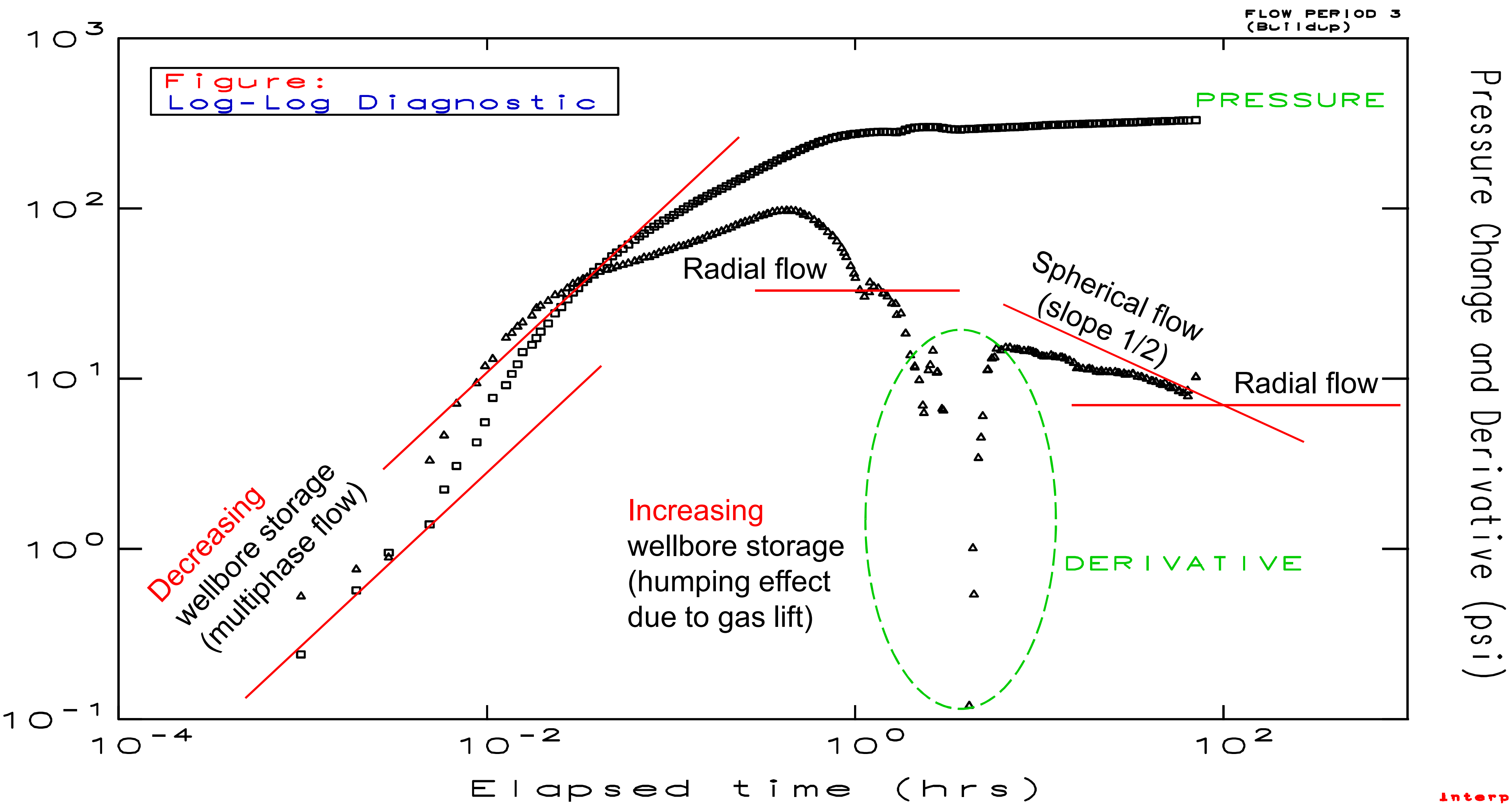




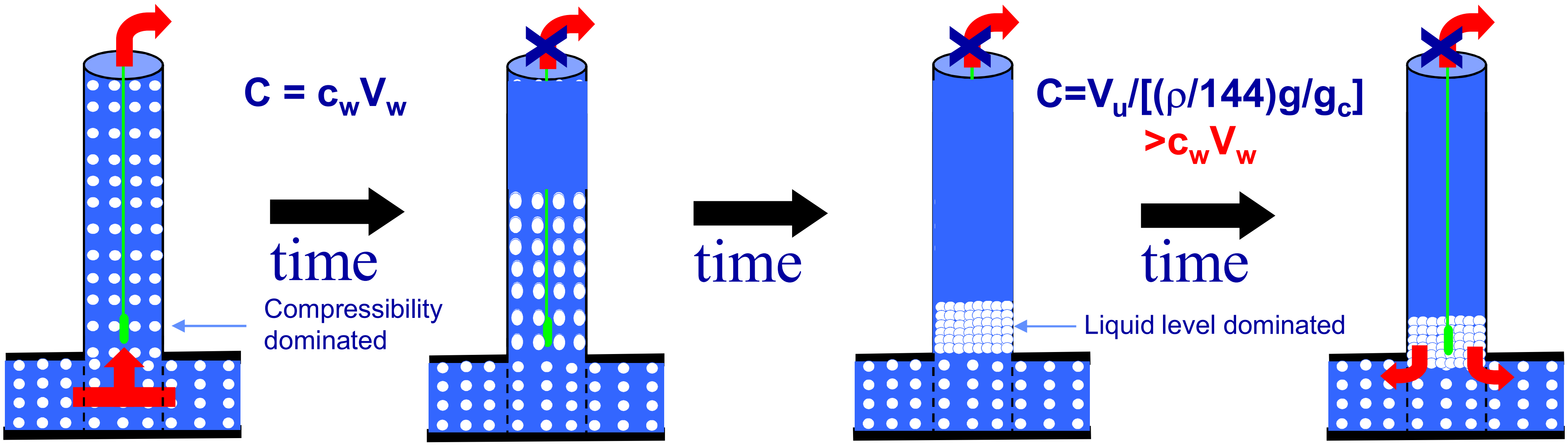
BUILD-UP: **Wellbore storage** ***decreases*** **due to** ***a decrease in fluid compressibility in the wellbore***



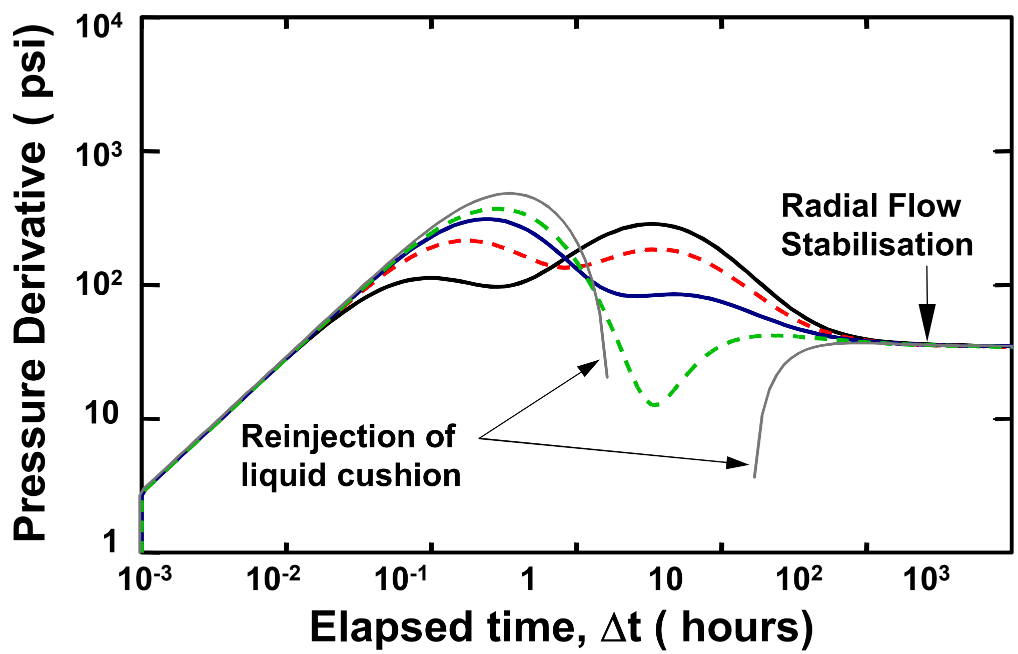
Multiphase flow vs. phase redistribution in the wellbore



DRAWDOWN or BUILD-UP: **Wellbore storage *increases* due to phase redistribution in the wellbore**



- **gas lifted oil well**
- **gas condensate well with liquid drop out**
- **oil or gas well producing water**

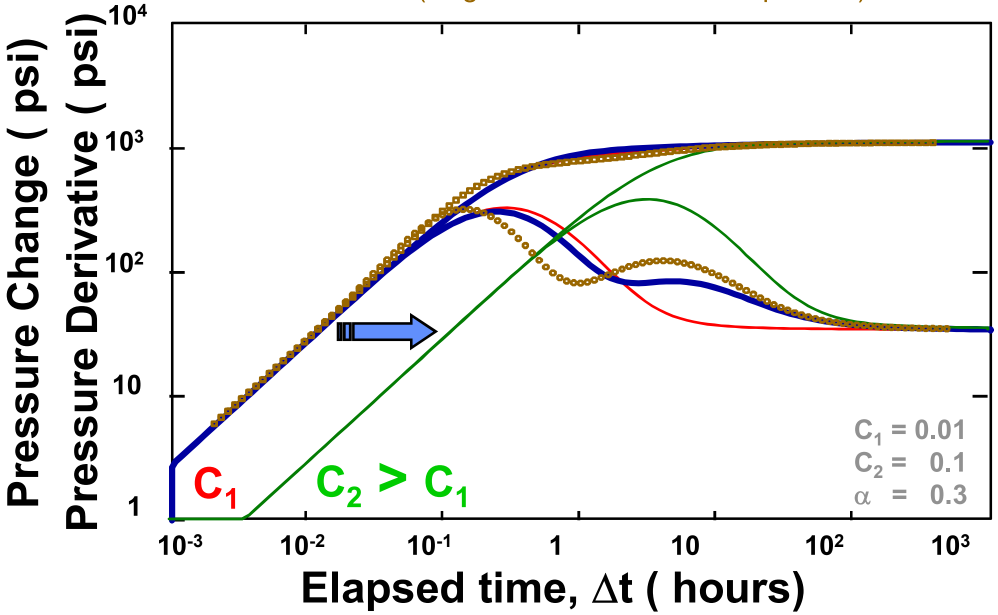


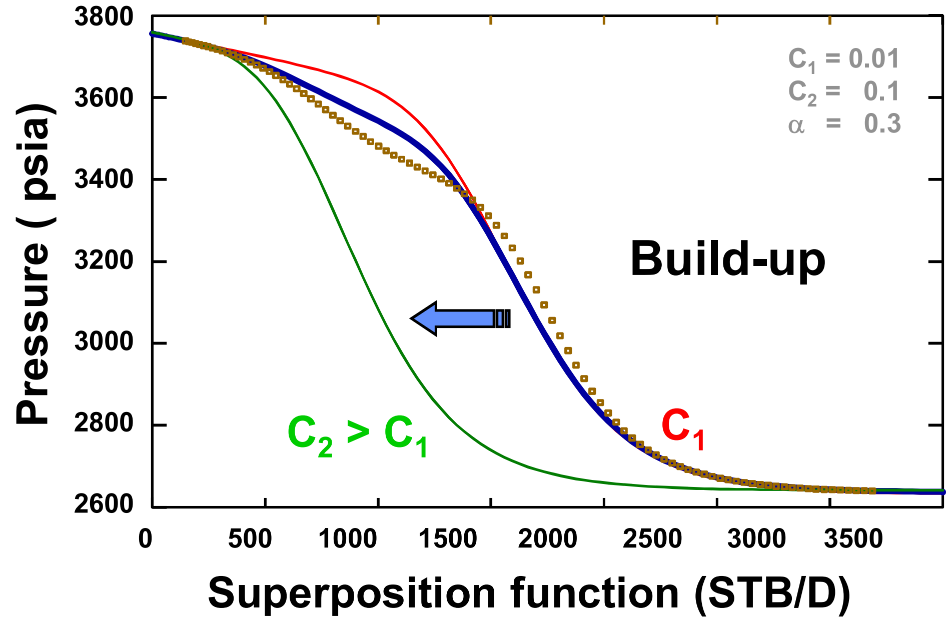
DRAWDOWN or BUILD-UP:

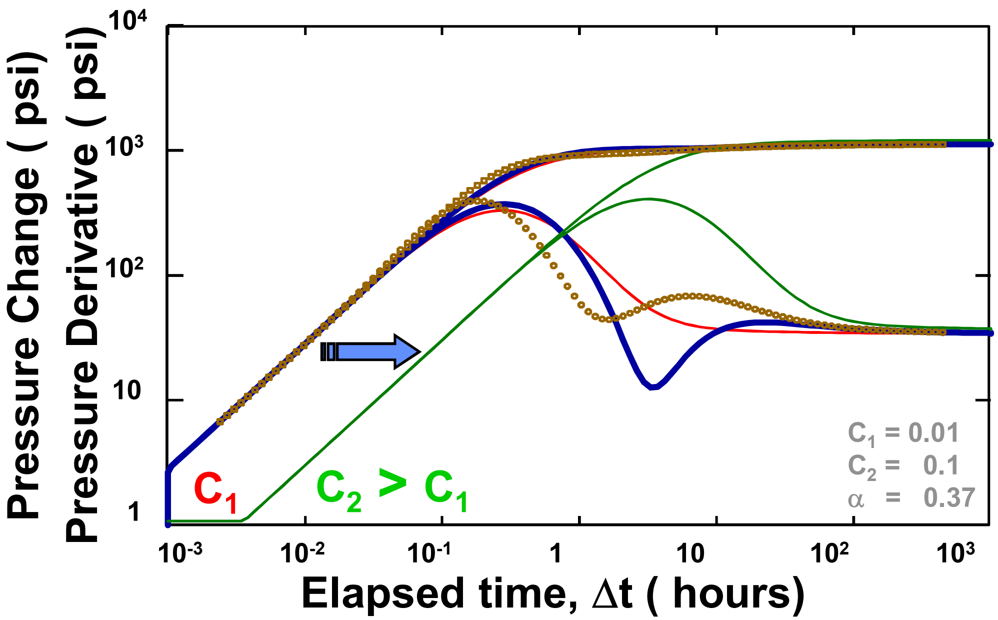
Wellbore storage *increases* due to phase redistribution in the wellbore

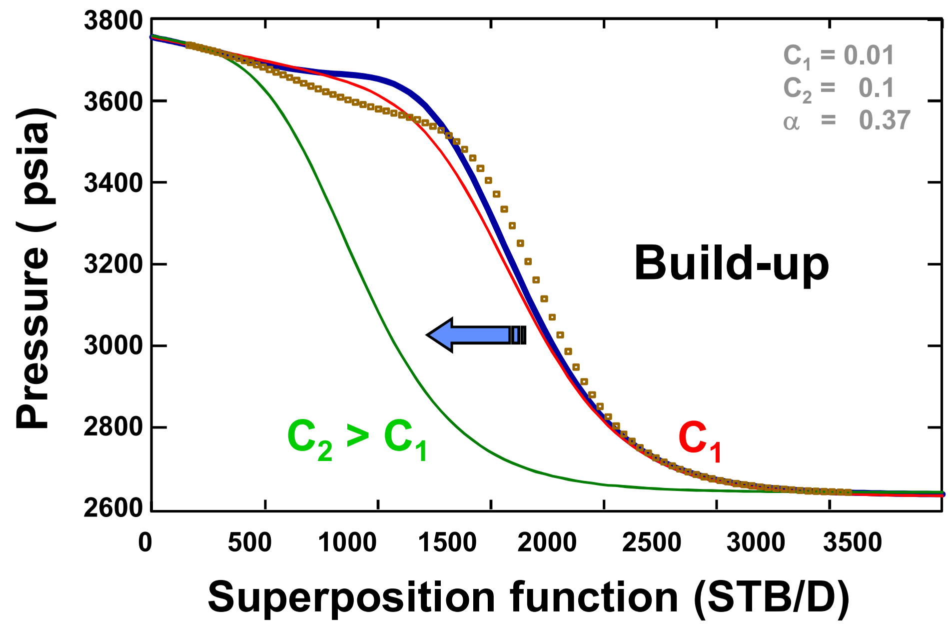
Exponential (Fair SPEJ Apr 1981)

Error function (Hegeman *et al.* SPEFE Sept 1993)



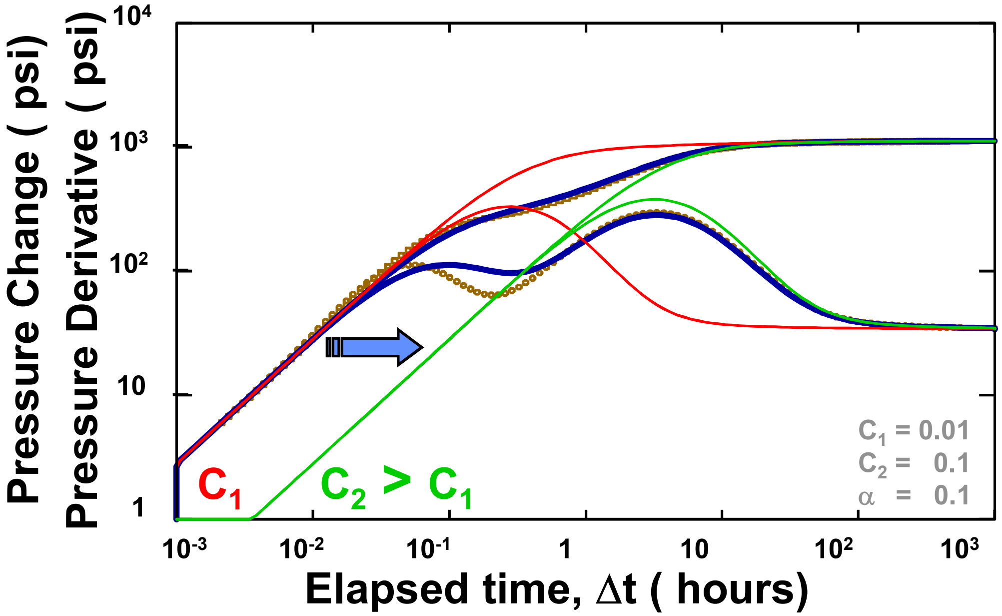


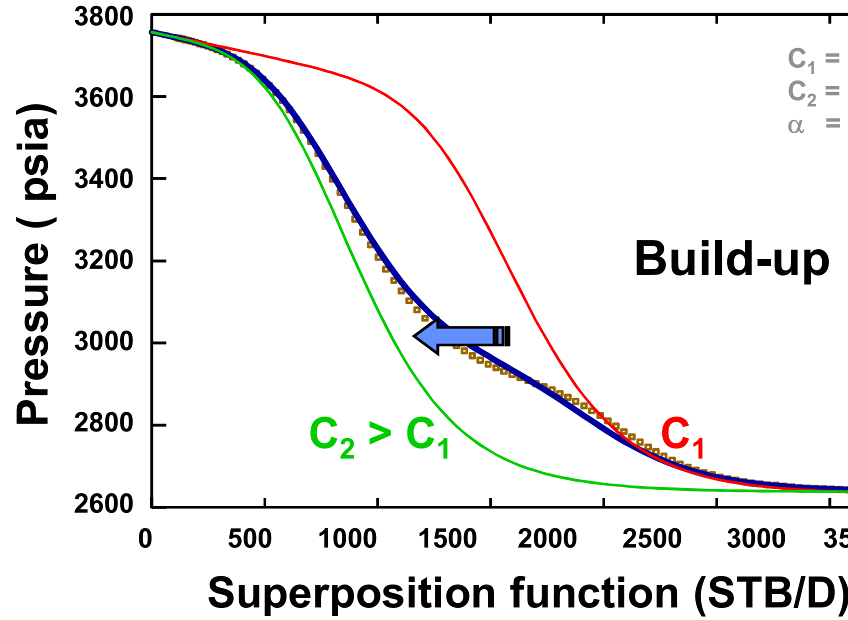


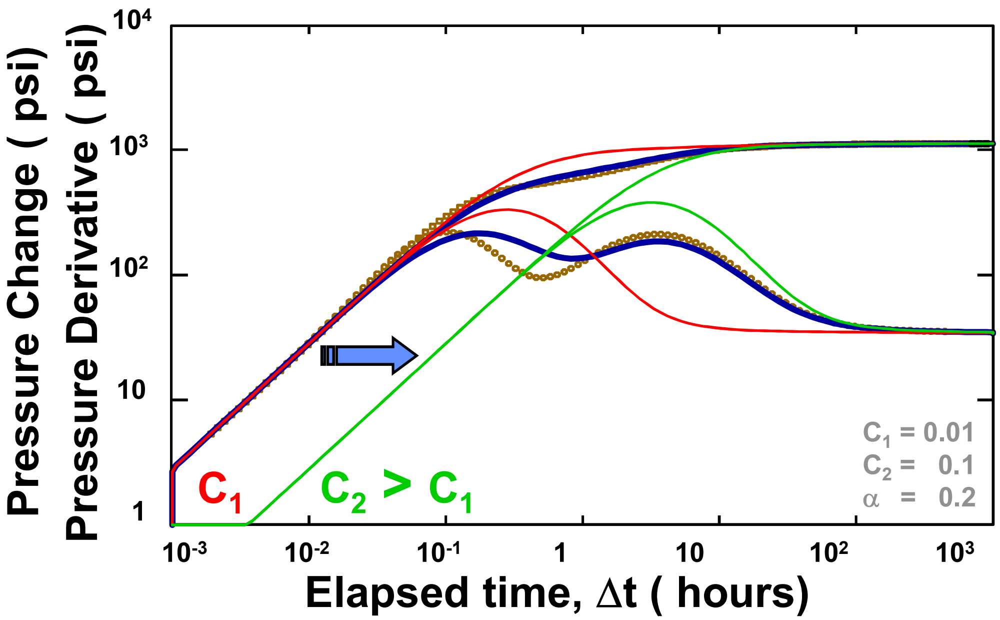


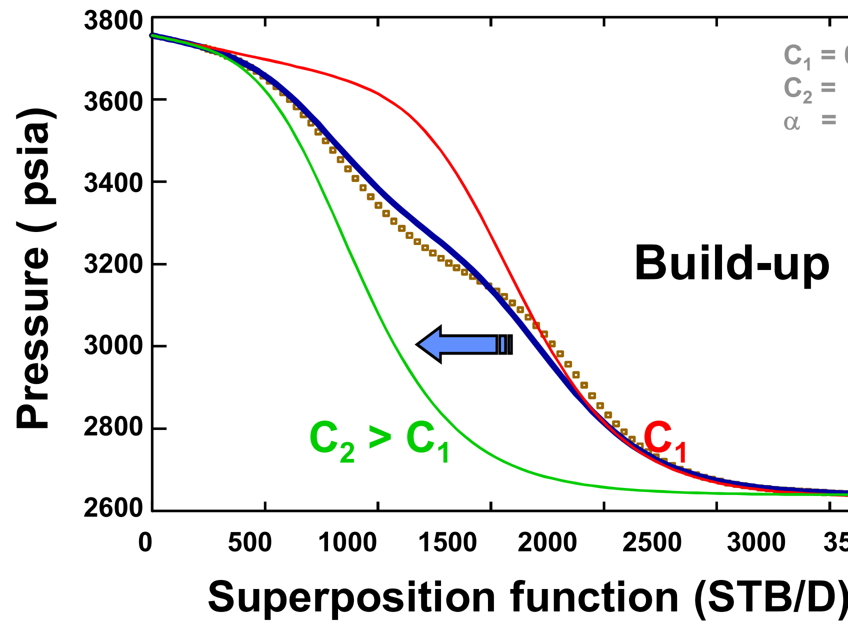
DRAWDOWN or BUILD-UP:

Wellbore storage *increases* due to phase redistribution in the wellbore



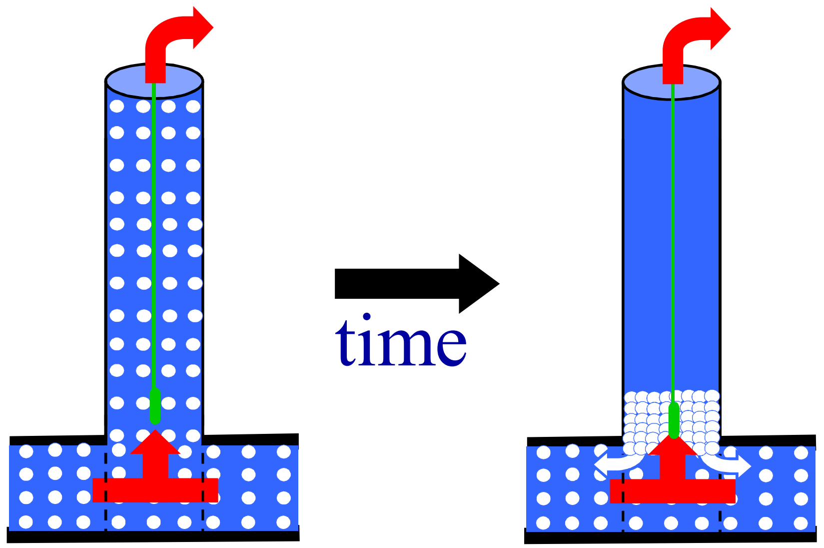




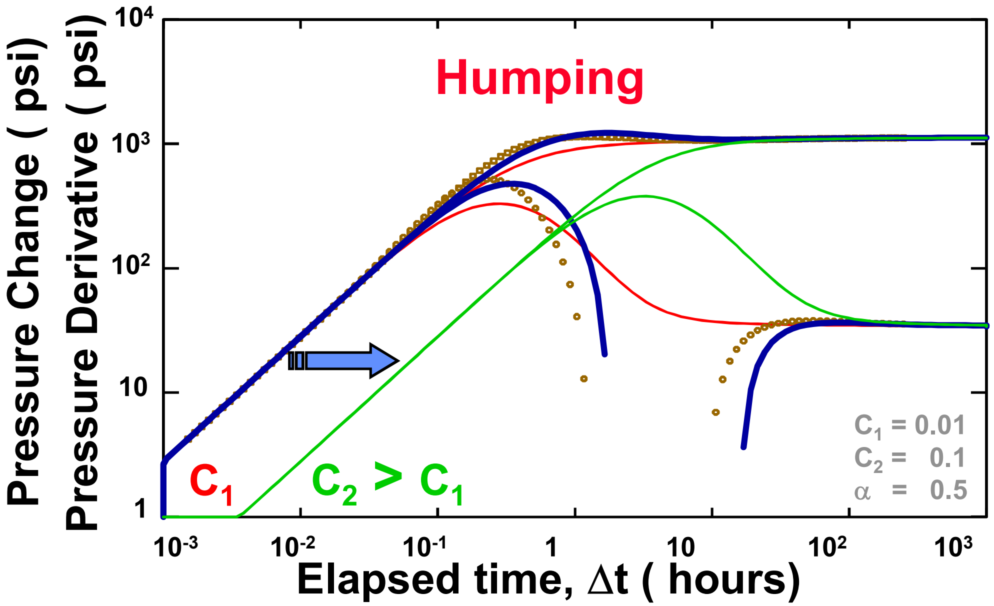


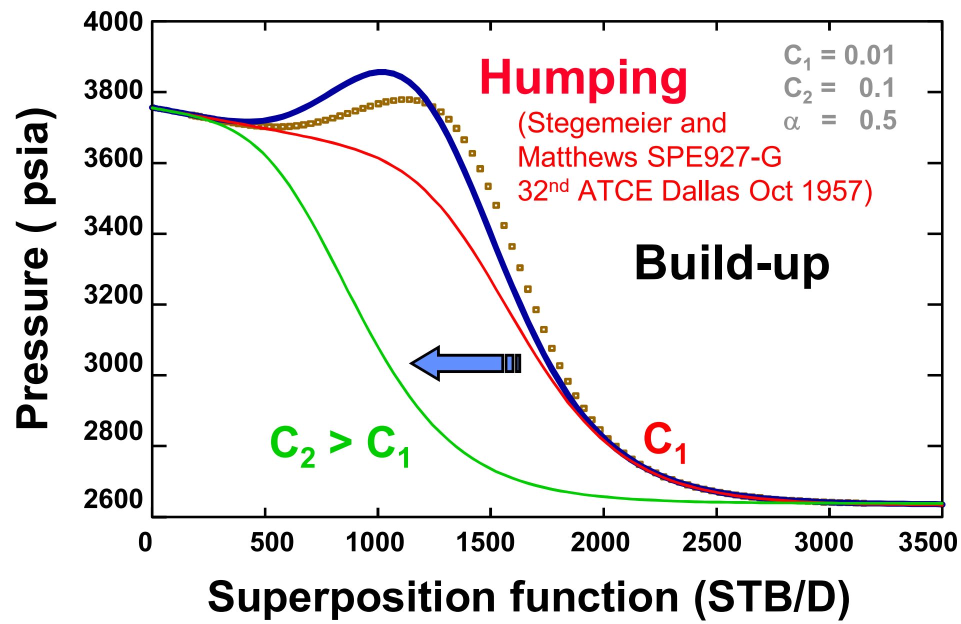
DRAWDOWN or BUILD-UP:

Wellbore storage *increases* due to phase redistribution in the wellbore



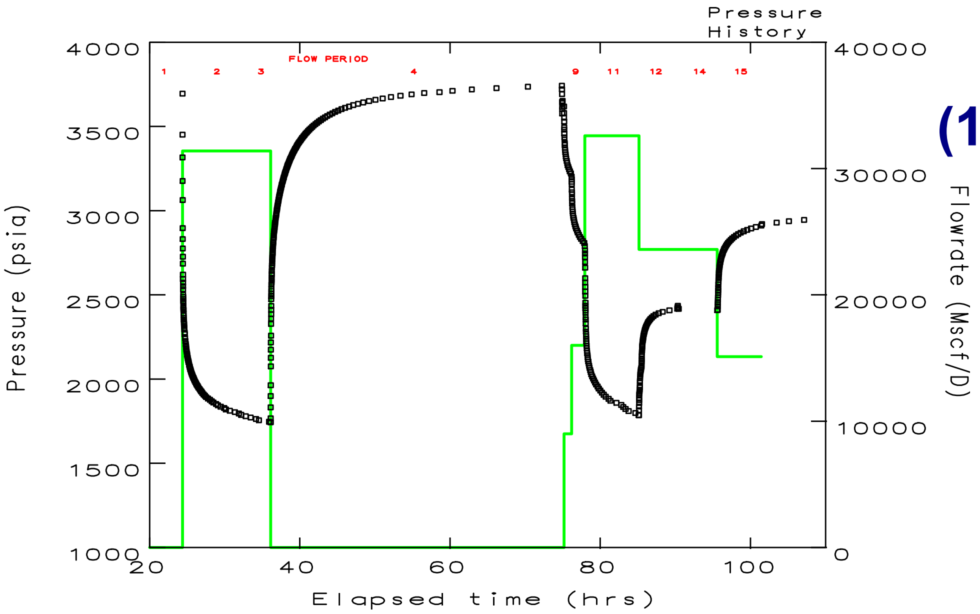
Reinjection of liquid cushion

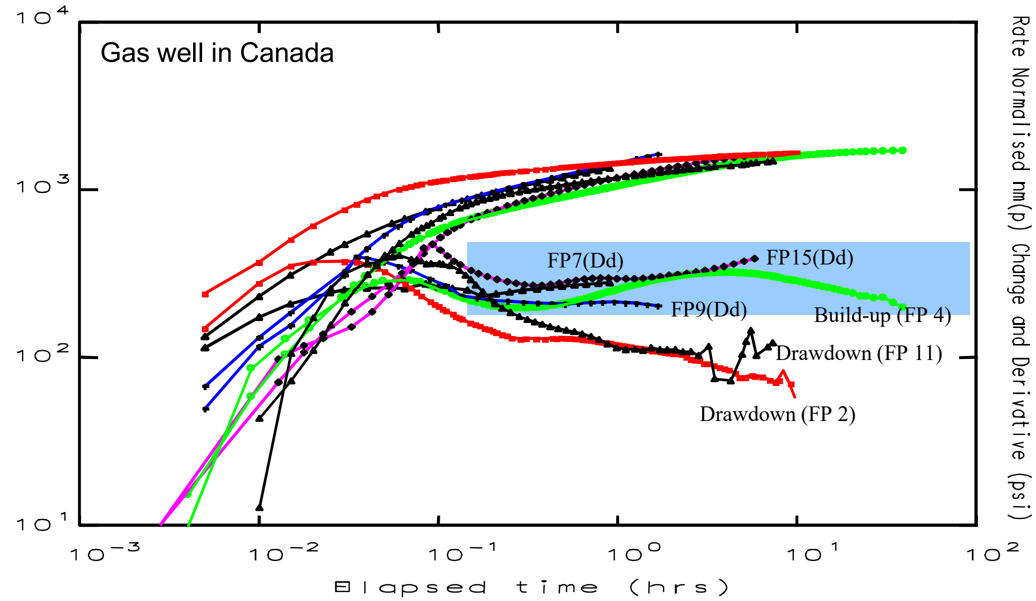




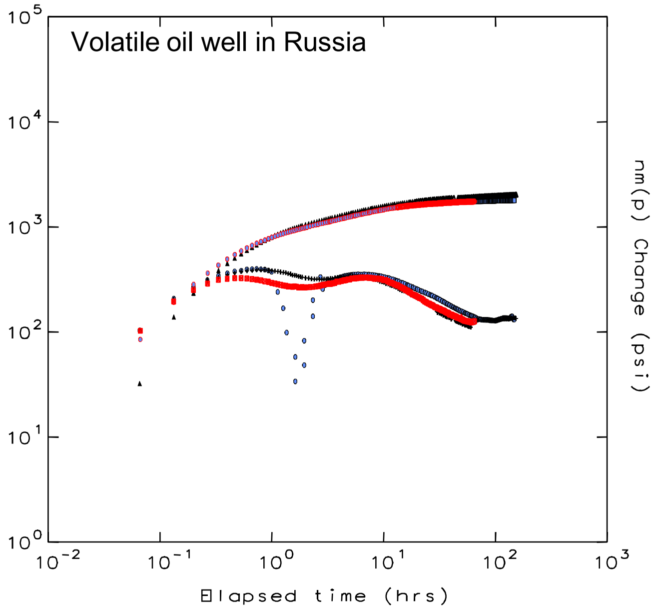
Wellbore storage increases due to phase redistribution in the wellbore (1) gas well with water; (2) volatile oil))

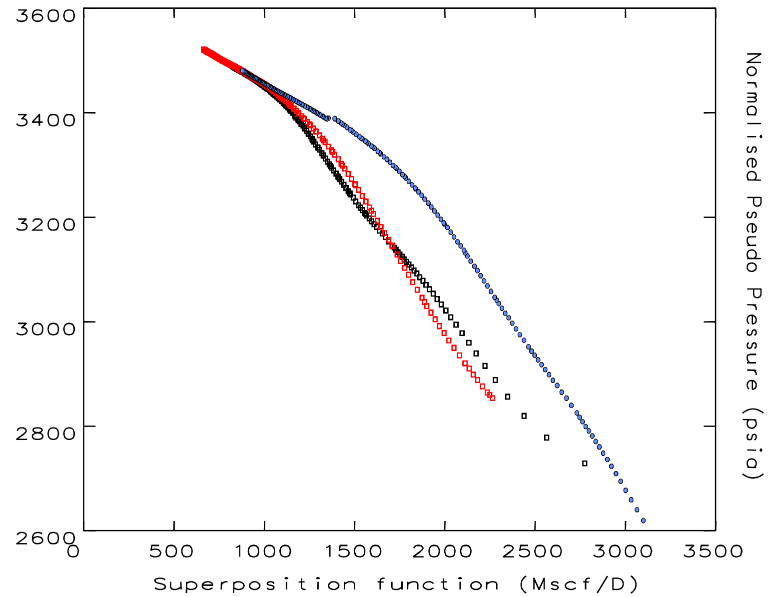
(1)



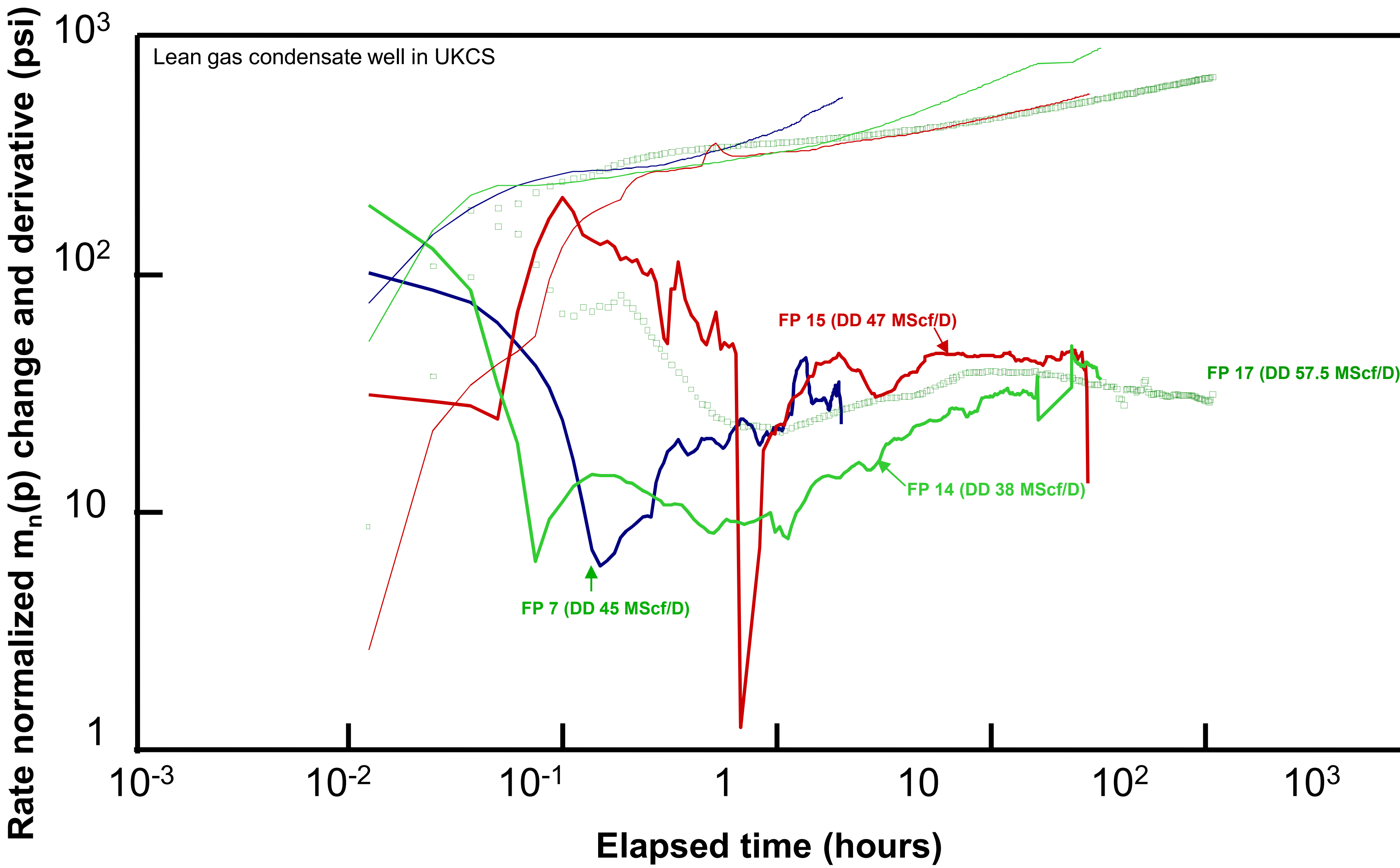


(2)

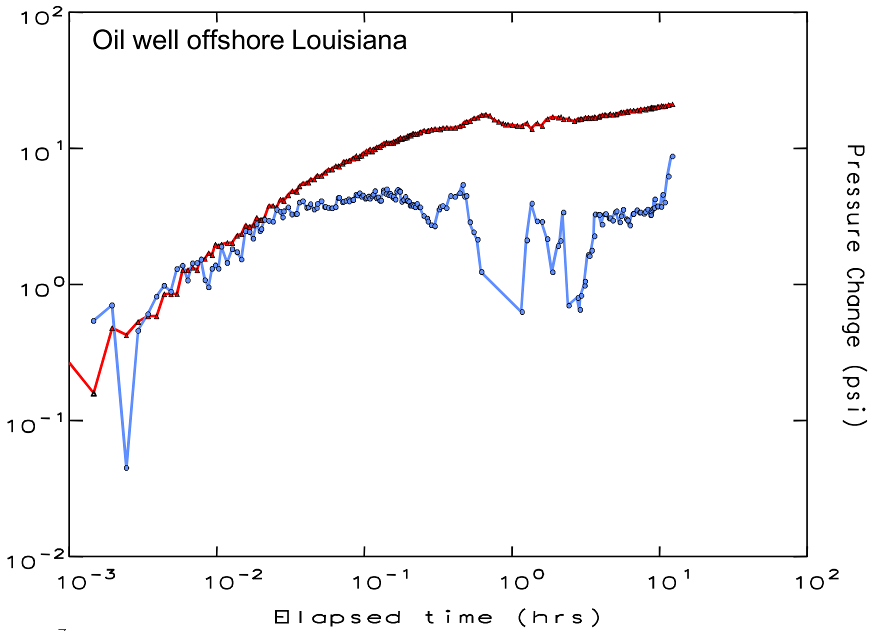


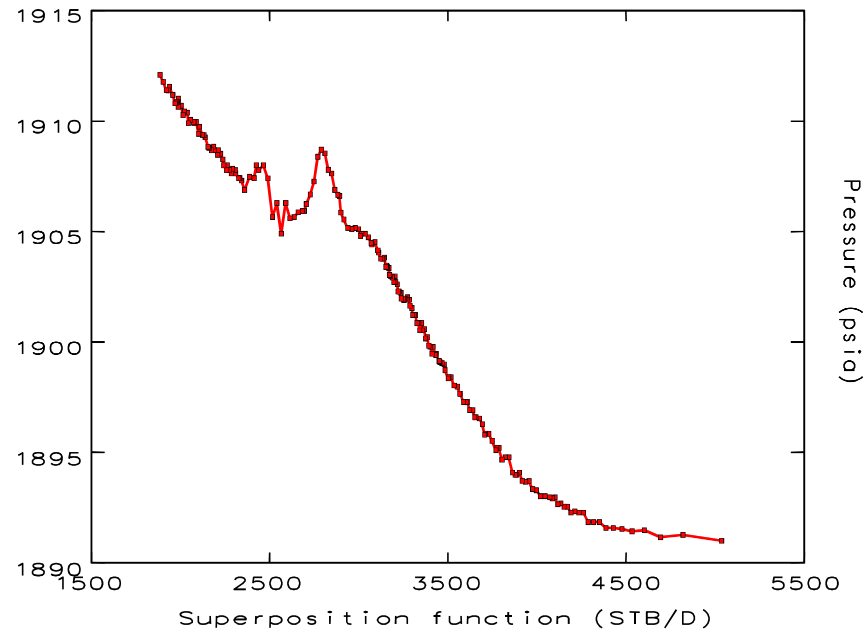


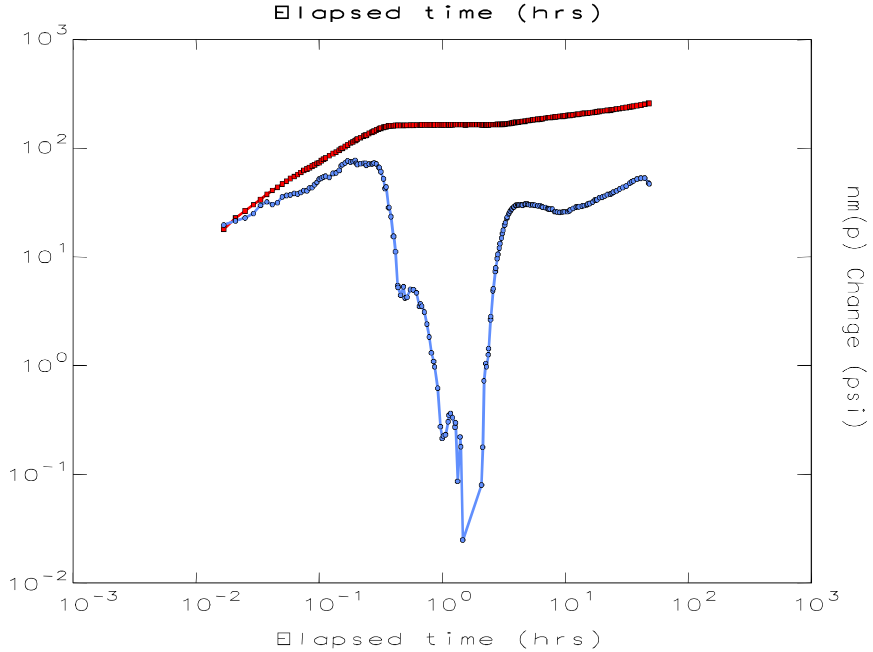
Wellbore storage increases due to phase redistribution in the wellbore: gas condensate well

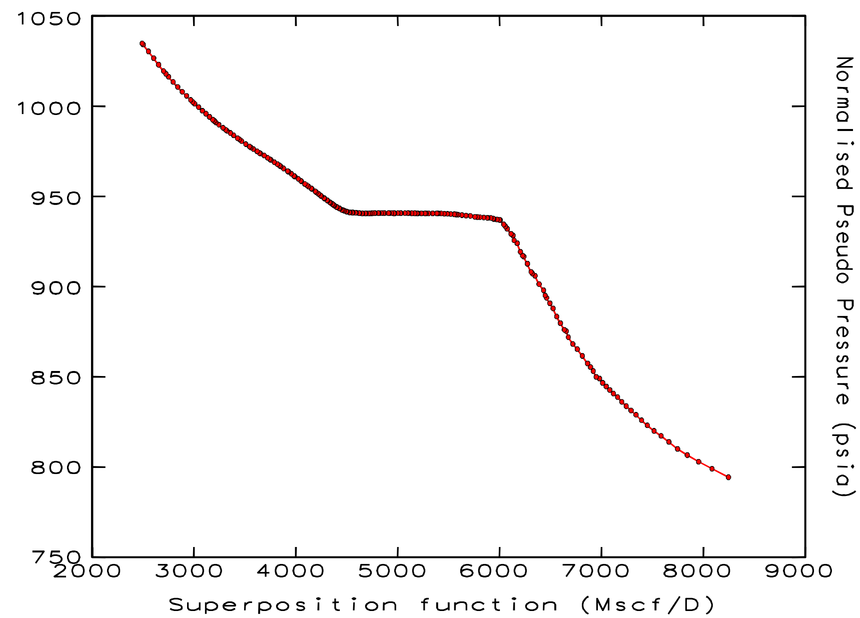


Wellbore storage increases due to phase redistribution in the wellbore (Build-up's in gas-lifted wells)









AGARWAL EFFECTIVE TIME

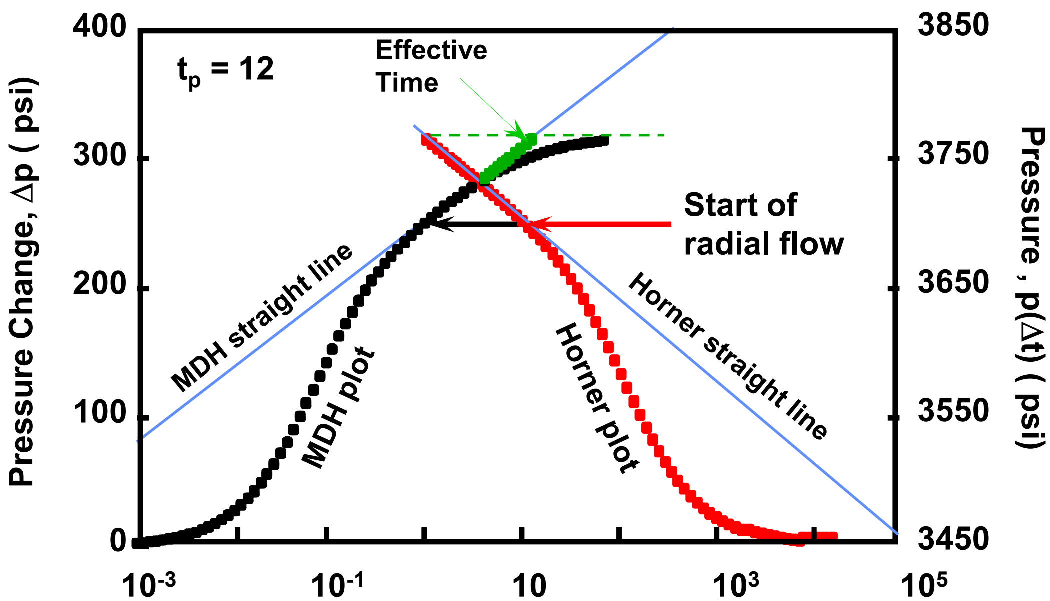
SPE 9289, 1980

$$\text{PM}\ \Delta p(\Delta t) = \text{PM}\left[p(\Delta t) - p(\Delta t = 0)\right] \equiv p_D(\text{TM}\Delta t) + p_D(\text{TM}t_p) - p_D\left[\text{TM}(t_p + \Delta t)\right]$$

If $p_D(\text{TM}\Delta t)$ AND $p_D(\text{TM}t_p)$ can be approximated by a log (Radial flow):

$$\Delta p = 162.6\frac{\Delta q B\mu}{kh}\left[\log\frac{t_p\Delta t}{t_p + \Delta t} + \log\frac{k}{\phi\mu c_t r_{wa}^2} - 3.23\right]$$

$$\Delta t_{\text{eff R}} = \frac{t_p\Delta t}{t_p + \Delta t}$$ **= effective time**



$$\Delta t, \quad \frac{t_p + \Delta t}{\Delta t} \quad and \quad \frac{t_p\Delta t}{t_p + \Delta t}$$

Objective: convert build-up data into equivalent drawdown data

$$\Delta t_{\text{eff L}} = (t_p)^{1/2} + (\Delta t)^{1/2} - (t_p + \Delta t)^{1/2}$$

$$\Delta t_{\text{eff SPH}} = (t_p)^{-1/2} + (\Delta t)^{-1/2} - (t_p + \Delta t)^{-1/2}$$

AGARWAL EFFECTIVE TIME

Objective: convert build-up data into equivalent drawdown data that can be analysed with drawdown type curves

John Lee, Well Testing,
SPE Textbook Series Vol. 1, 1982, page 63

4.2 Fundamentals of Type Curves

Many type curves commonly are used to determine formation permeability and to characterize damage and stimulation of the tested well. Further, some are used to determine the beginning of the MTR for a Horner analysis. Most of these curves were generated by simulating constant-rate pressure drawdown (or injection) tests; however, most also can be applied to buildup (or falloff) tests if an equivalent shut-in time[8] is used as the time variable on the graph.

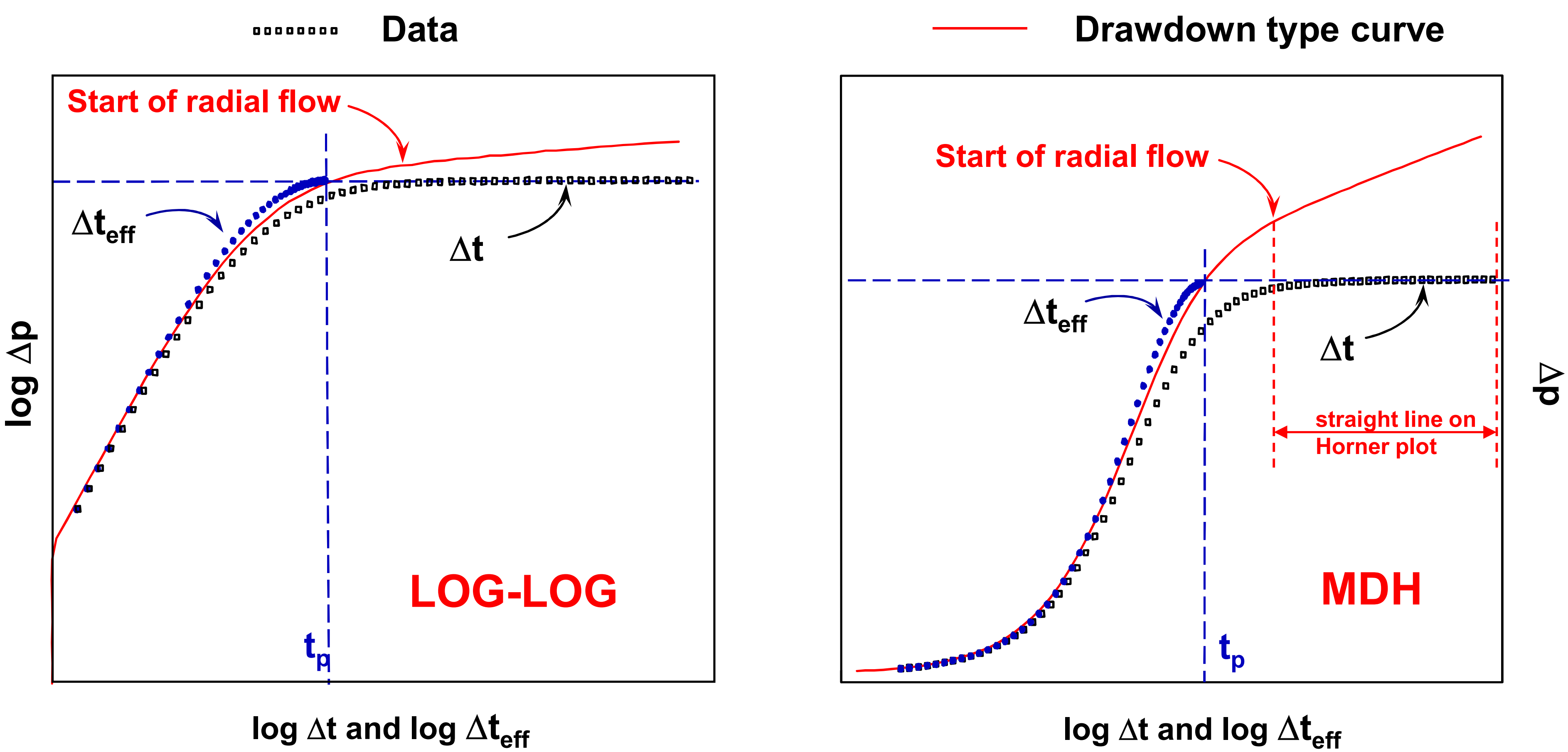
PANSYSTEM defaults to equivalent time.

PROBLEM:

- **Over-corrects if t_p is small compared to Build-up duration**
- **Reduces a long build-up into a short equivalent drawdown**
- **Modifies the shape of boundaries**

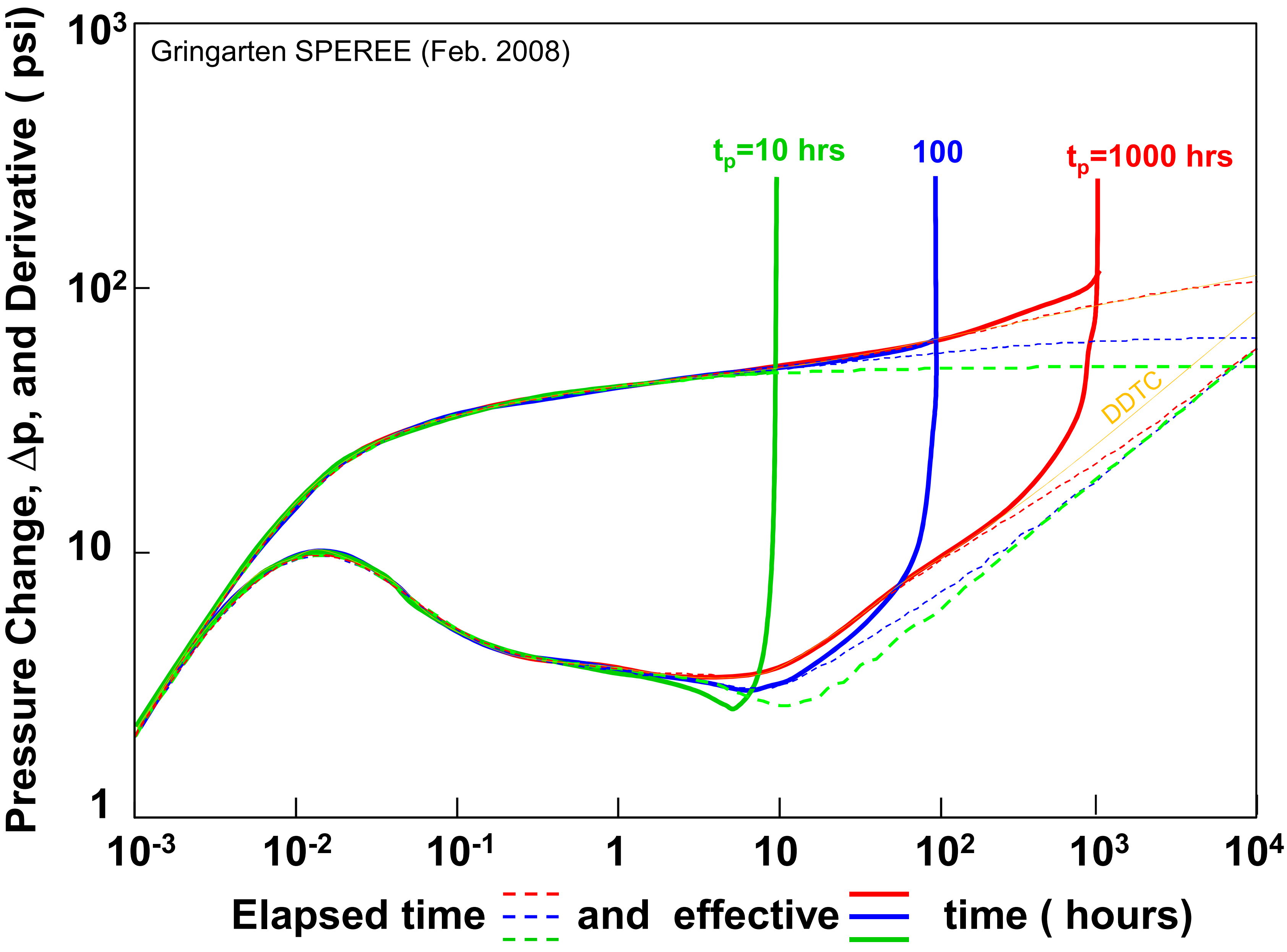
AGARWAL EFFECTIVE TIME

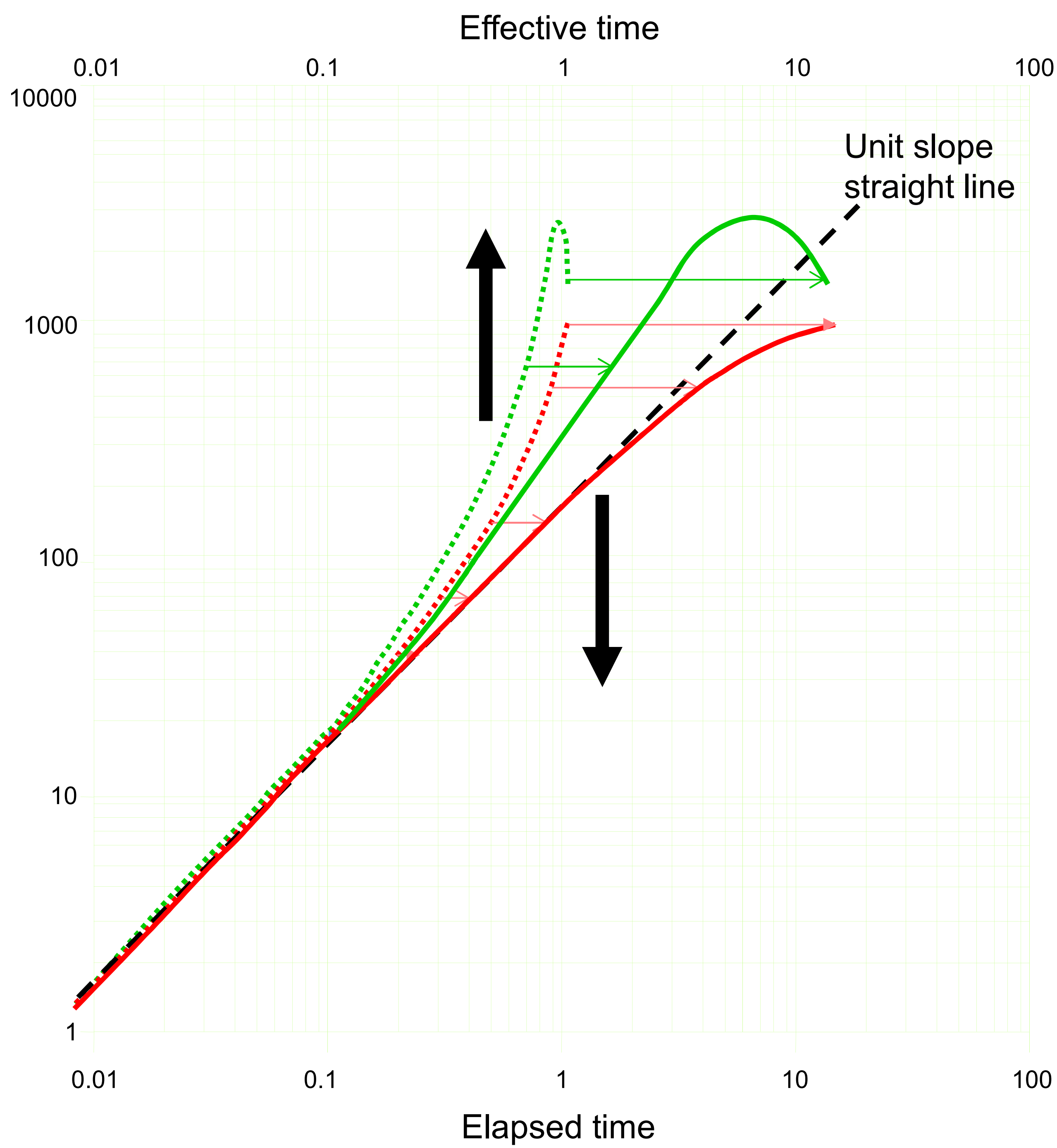
- ❑Over-corrects if t_p is small compared to Build-up duration
- ❑Reduces a long build-up into a short equivalent drawdown



INFLUENCE OF AGARWAL EFFECTIVE TIME ON DERIVATIVE SHAPES

❑Modifies the shape of boundaries





$$\Delta t_{effective} = \frac{t_p \ \Delta t}{t_p + \Delta t}$$

$$\Delta t = \frac{t_p \ \Delta t_{effective}}{t_p - \Delta t_{effective}}$$

Effective time	Elapsed time
1.0E-02	1.0E-02
2.0E-02	2.0E-02
3.0E-02	3.1E-02
5.0E-02	5.2E-02
8.0E-02	8.6E-02
1.0E-01	1.1E-01
2.0E-01	2.4E-01
3.0E-01	4.0E-01
5.0E-01	8.7E-01
7.0E-01	1.714913
8.0E-01	2.5E+00
9.0E-01	3.8E+00
1.0E+00	6.47046
1.1E+00	15.71353

AGARWAL EFFECTIVE TIME

Objective: convert build-up data into equivalent drawdown data that can be analysed with drawdown type curves

John Lee, Well Testing,
SPE Textbook Series Vol. 1, 1982, page 63

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George Stewart, Well Test Design & Analysis,
PennWell Corporation, 2011, page 183

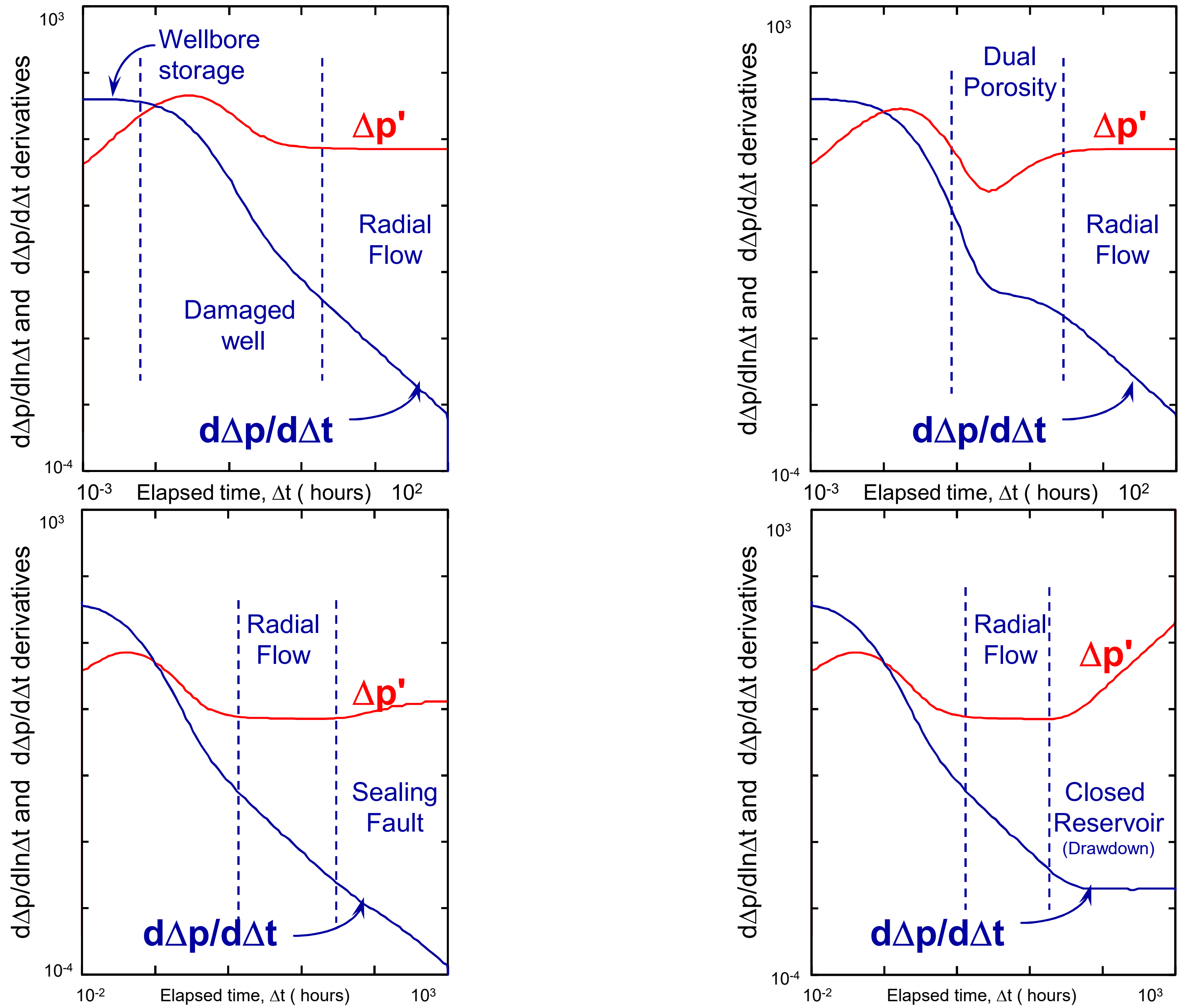
PANSYSTEM defaults to equivalent time, and the author now concurs with Gringarten that default to elapsed time would be preferable.

In summary:

- ❑When you need it (t_p is small), it does not work
- ❑When it works, you don't need it

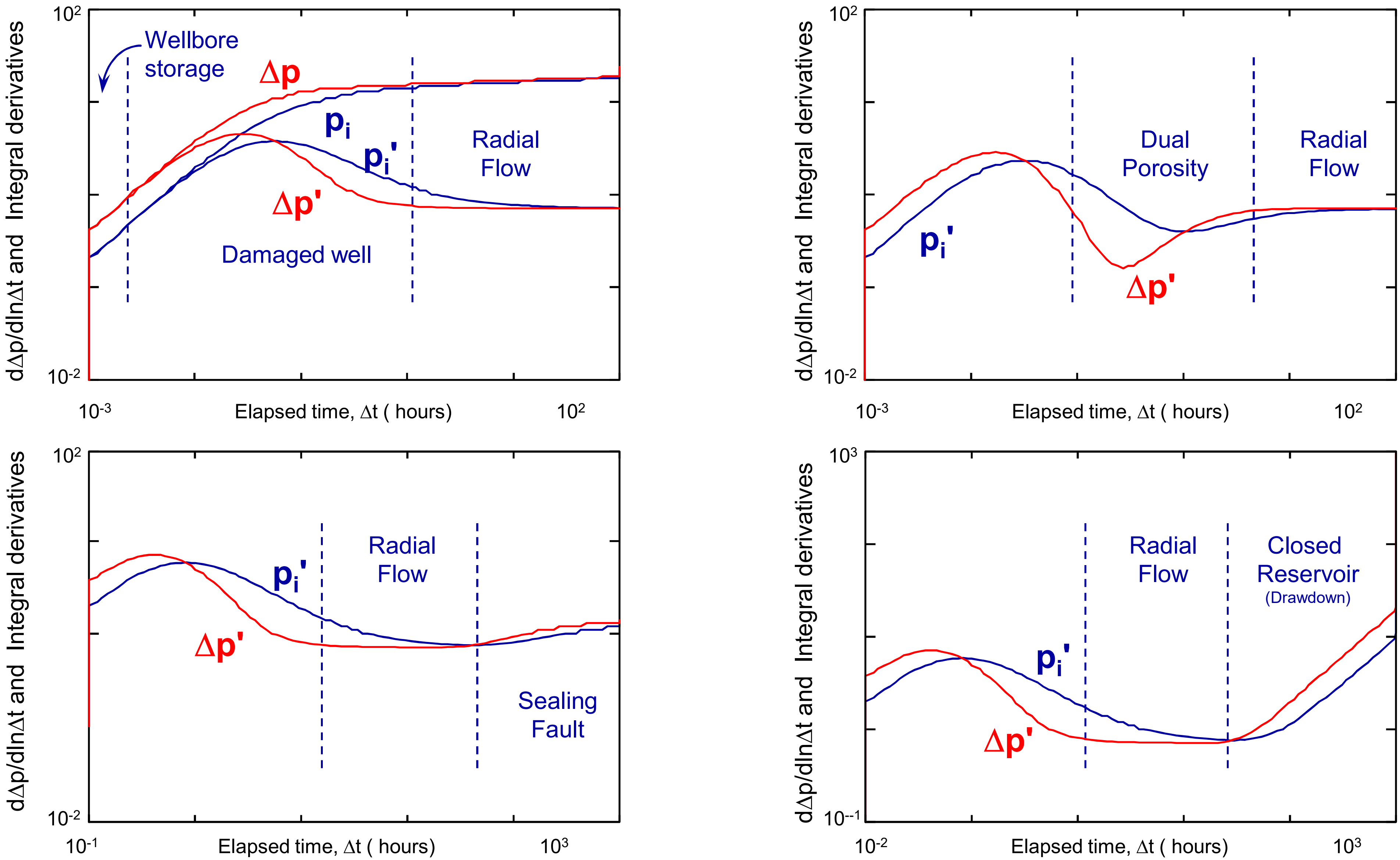
Comparison between Δp'=dΔp/dlnΔt and dΔp/dΔt derivatives

Mattar and Zaoral JCPT Apr 1992, vol. 31, No. 4



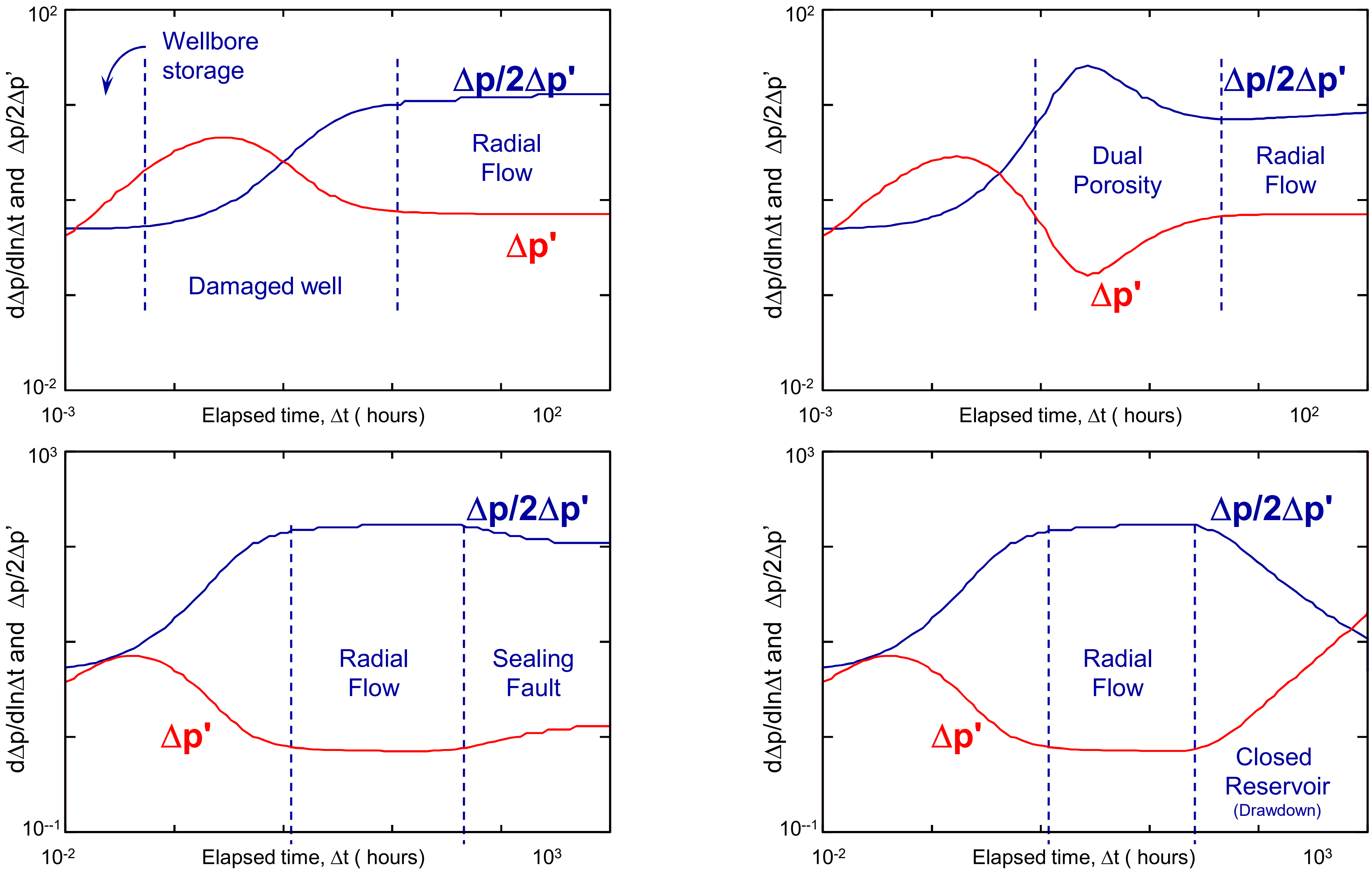
Comparison between Δp'=dΔp/dlnΔt and the Derivative of the Pressure Integral

Blasingame, Johnston and Lee SPE 18799 1989

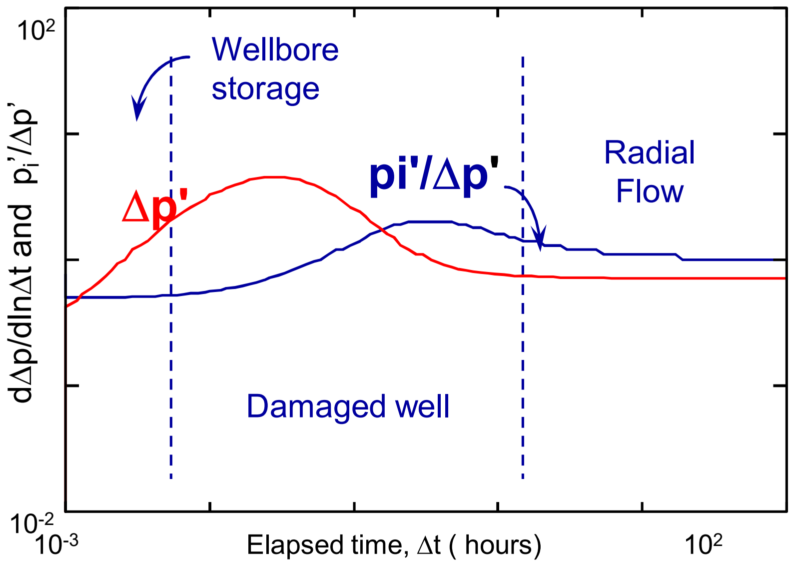


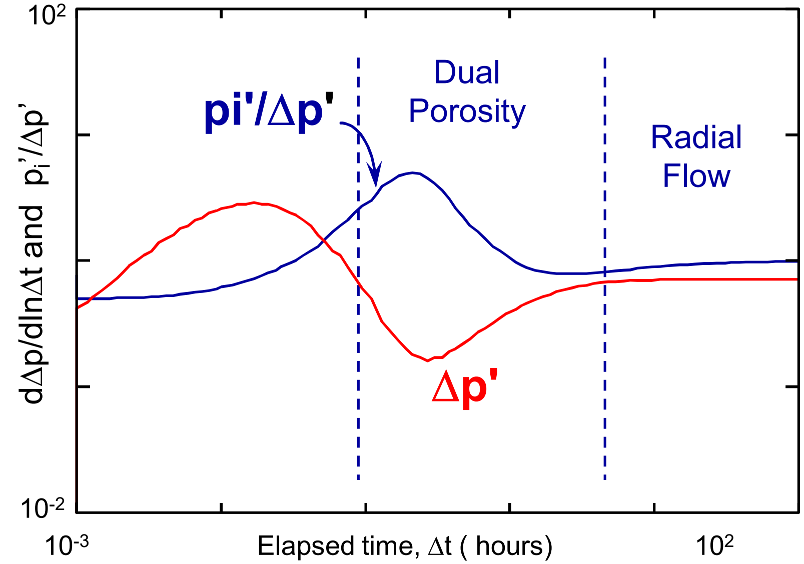
Comparison between Δp’=dΔp/dlnΔt and Δp/2Δp’

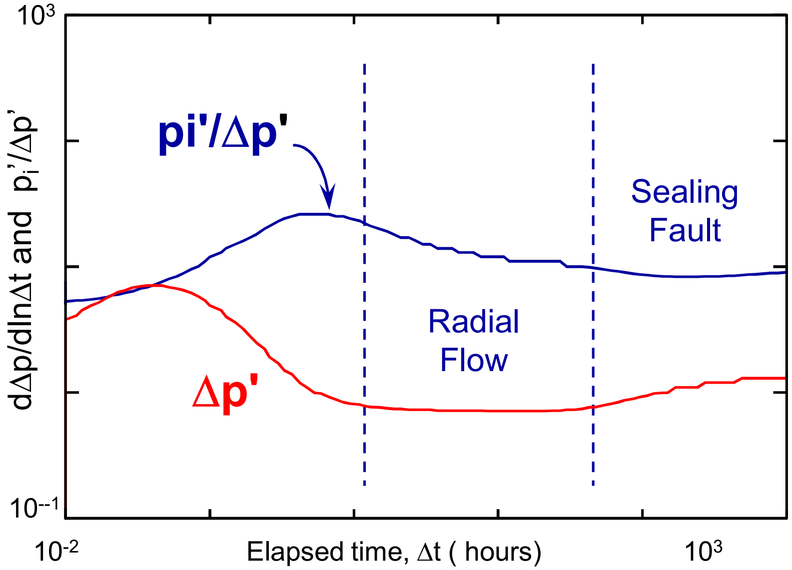
Onur and Reynolds SPE 16473 1988

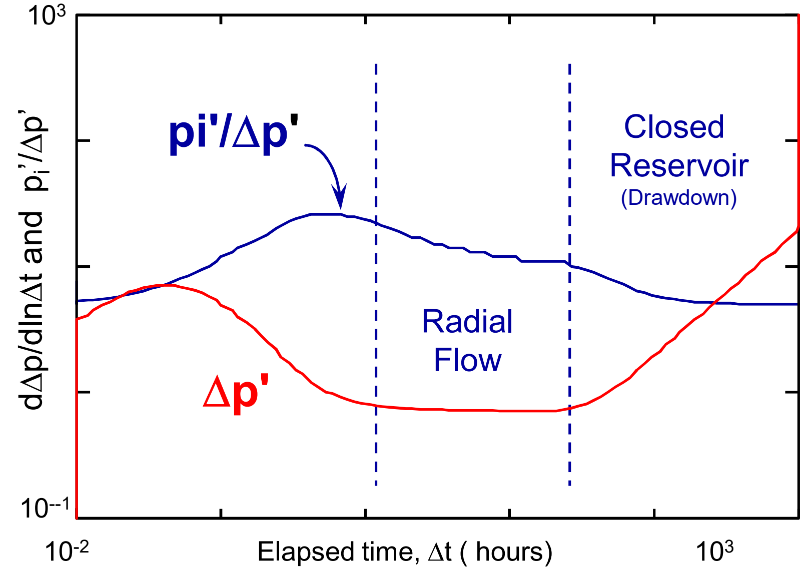


Comparison between Δp'=dΔp/dlnΔt and pi'/Δp'

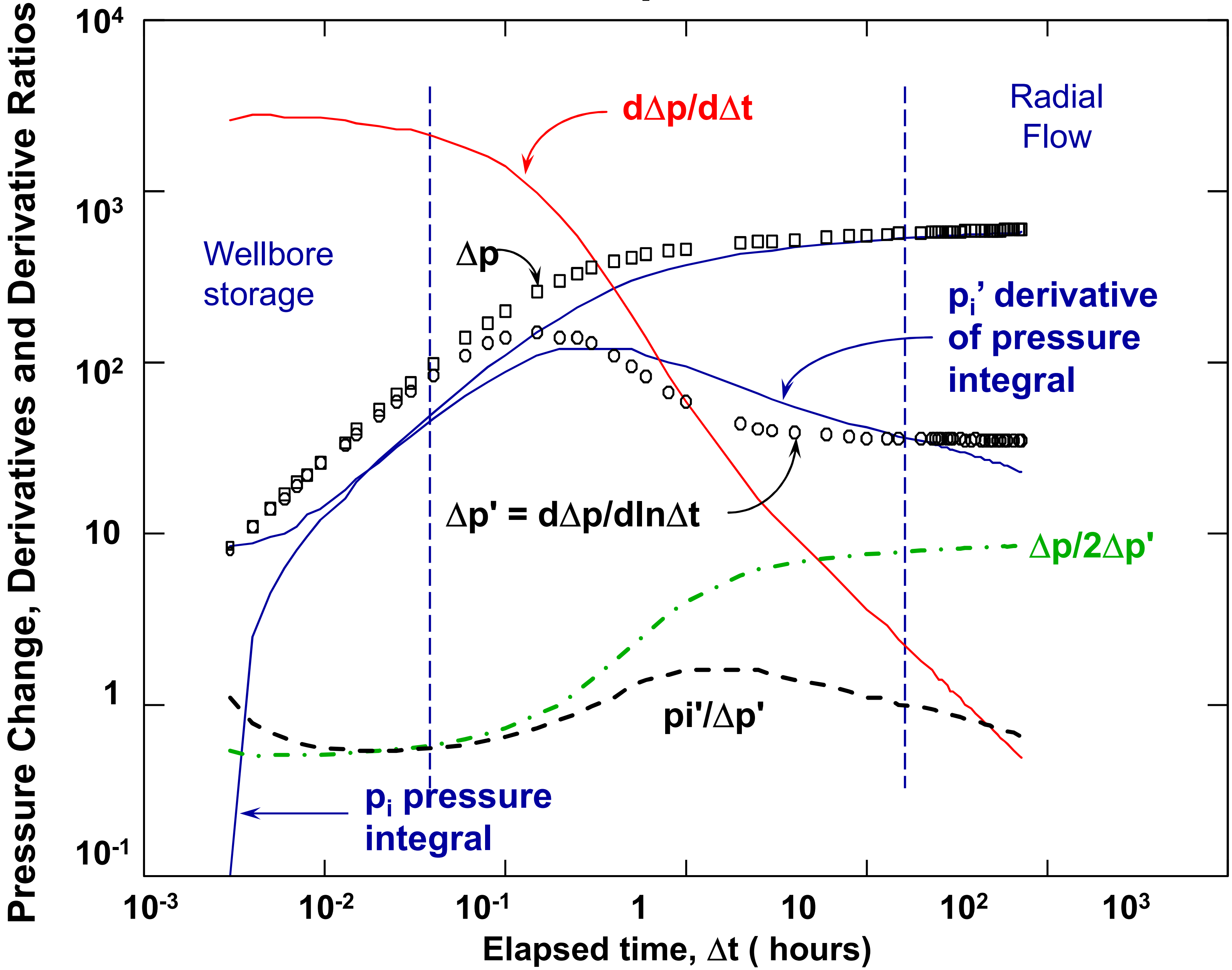








Comparison between various derivatives and derivative ratios for Example 1



Summary: PRESSURE DERIVATIVE ANALYSIS

ADVANTAGES:

- Powerful identification

LIMITATIONS:

- It is calculated (except when obtained by deconvolution)

- **Affected by data quality and derivation algorithm**
- **Affected by production history**