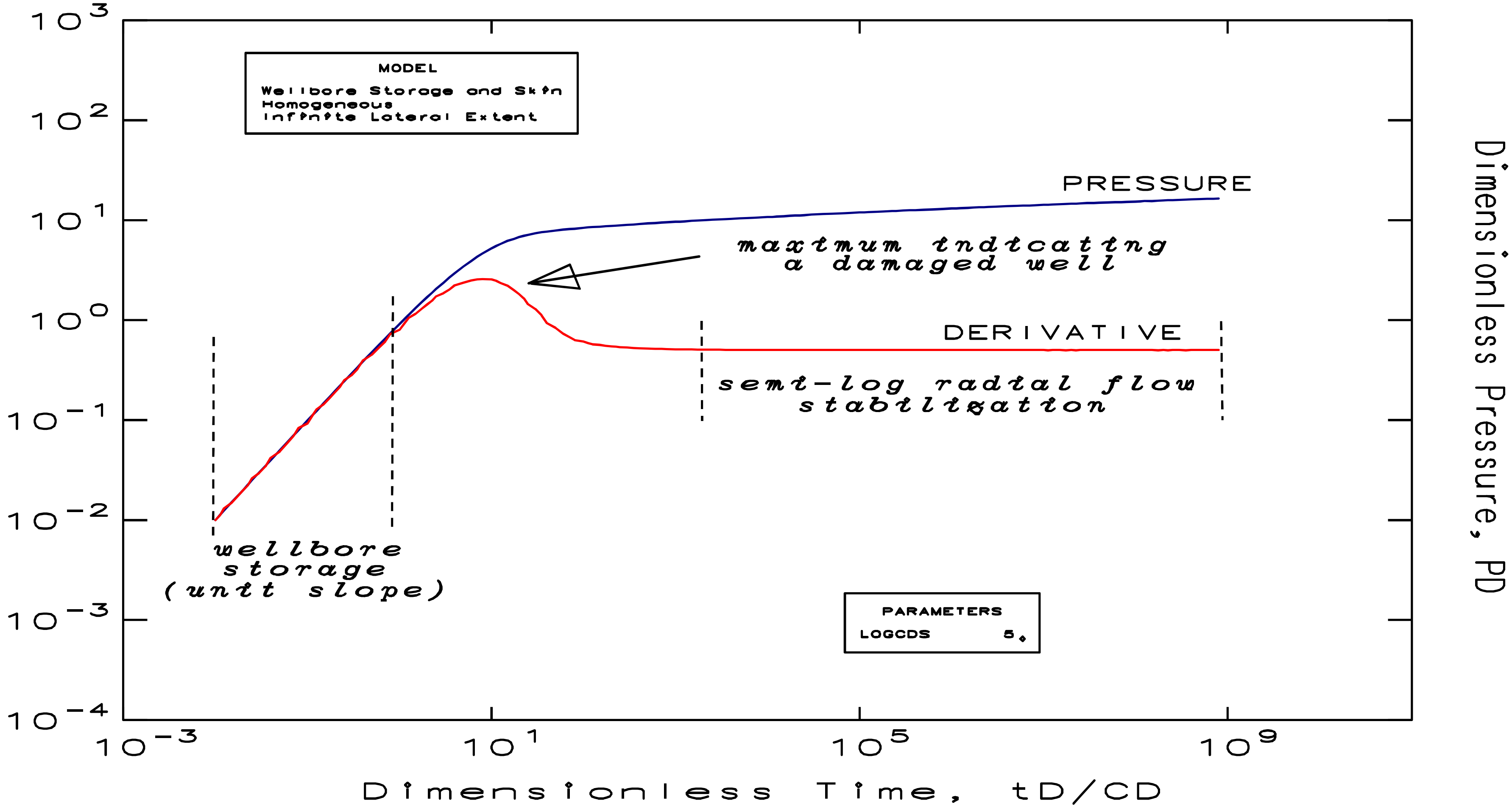
WELL TEST INTERPRETATION MODELS

NEAR WELLBORE EFFECTS	RESERVOIR BEHAVIOUR	BOUNDARY EFFECTS
Wellbore Storage Skin Fractures Partial Penetration Horizontal Well	Homogeneous Heterogeneous -2-Porosity -2-Permeability -Composite	Infinite extent Specified Rate Specified Pressure Leaky Boundary
EARLY TIMES	MIDDLE TIMES	LATE TIMES

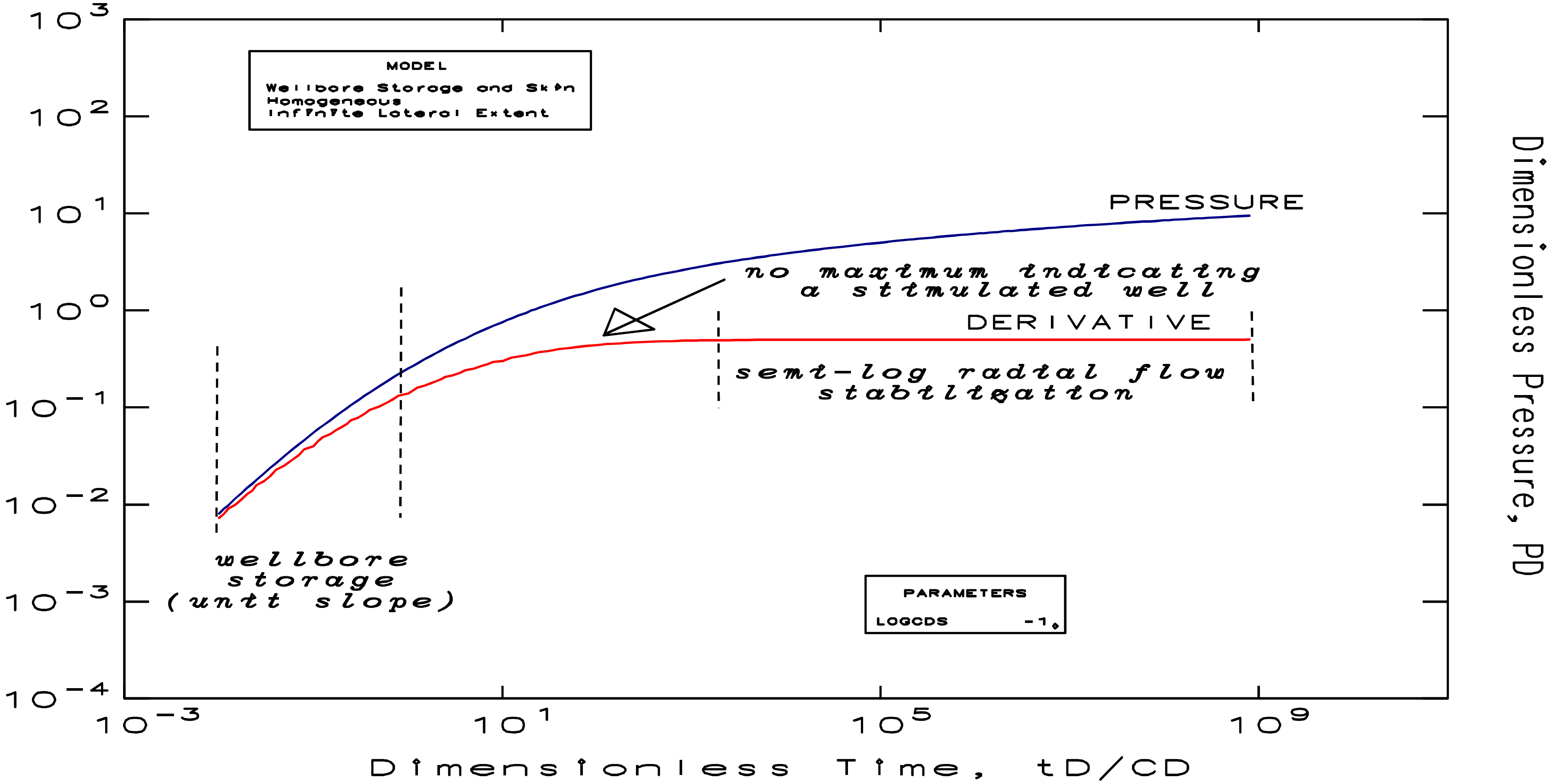
WELL TEST INTERPRETATION MODELS

NEAR WELLBORE EFFECTS	RESERVOIR BEHAVIOUR	BOUNDARY EFFECTS
Wellbore Storage Skin Fracture	Homogeneous	Infinite extent
Partial Penetration	Heterogeneous	Specified Rate
Horizontal Well	-2-Porosity	Specified Pressure
	-2-Permeability	Leaky Boundary
	-Composite	
EARLY TIMES	MIDDLE TIMES	LATE TIMES

Wellbore Storage and Skin, Homogeneous Behaviour, Infinite Acting



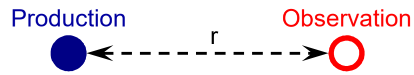
Wellbore Storage and Skin, Homogeneous Behaviour, Infinite Acting



WELL TEST INTERPRETATION MODELS

NEAR WELLBORE EFFECTS	RESERVOIR BEHAVIOUR	BOUNDARY EFFECTS
Wellbore Storage	Homogeneous	Infinite extent
Skin	Heterogeneous	Specified Rate
Fracture	-2-Porosity	Specified Pressure
Partial Penetration	-2-Permeability	Leaky Boundary
	-Composite	
Horizontal Well		
EARLY TIMES	MIDDLE TIMES	LATE TIMES

INTERFERENCE TEST IN AN INFINITE RESERVOIR WITH HOMOGENEOUS BEHAVIOUR:

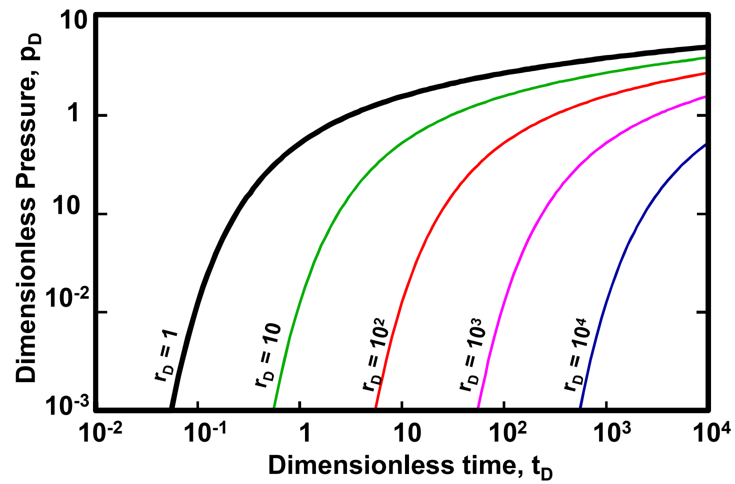


Dimensionless parameters, non-unique match

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

$$t_D = \frac{0.000264\,k}{\phi\mu\, c_t r_w^2}\Delta t$$

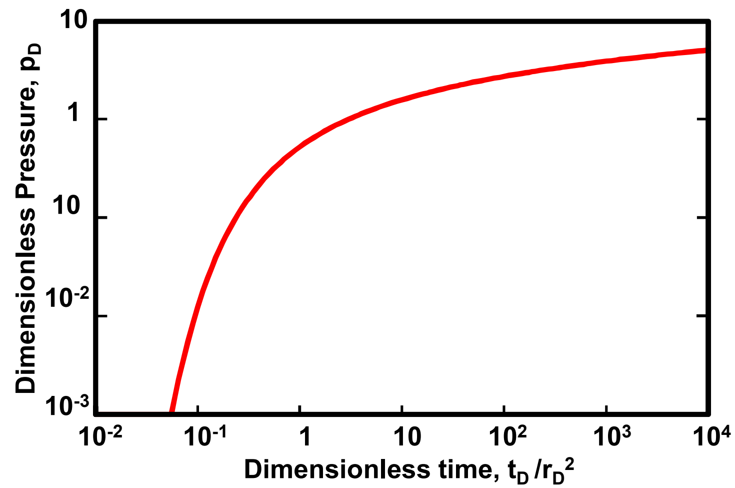
$$r_D = \frac{r}{r_w}$$



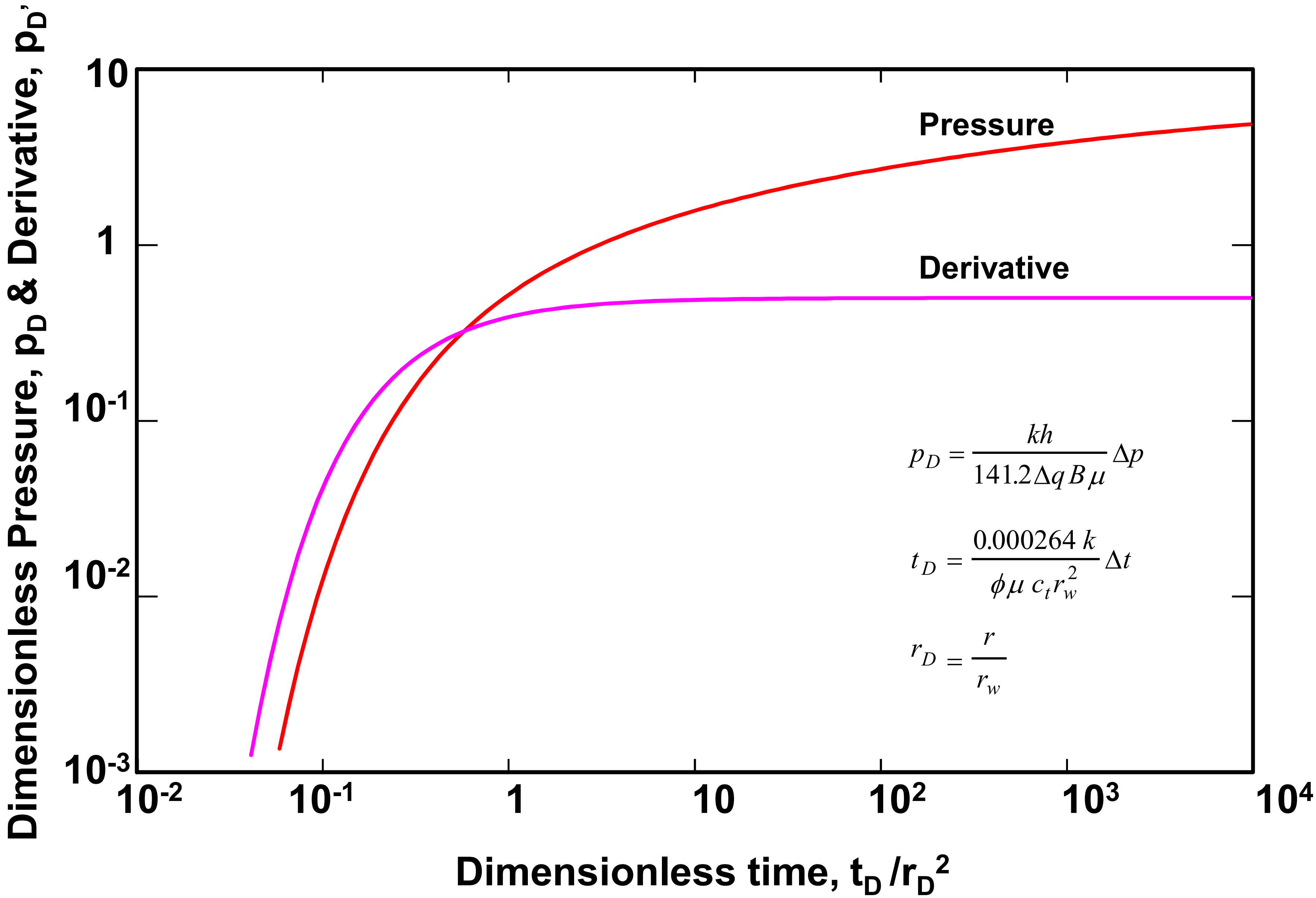
Independent variables, unique match

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

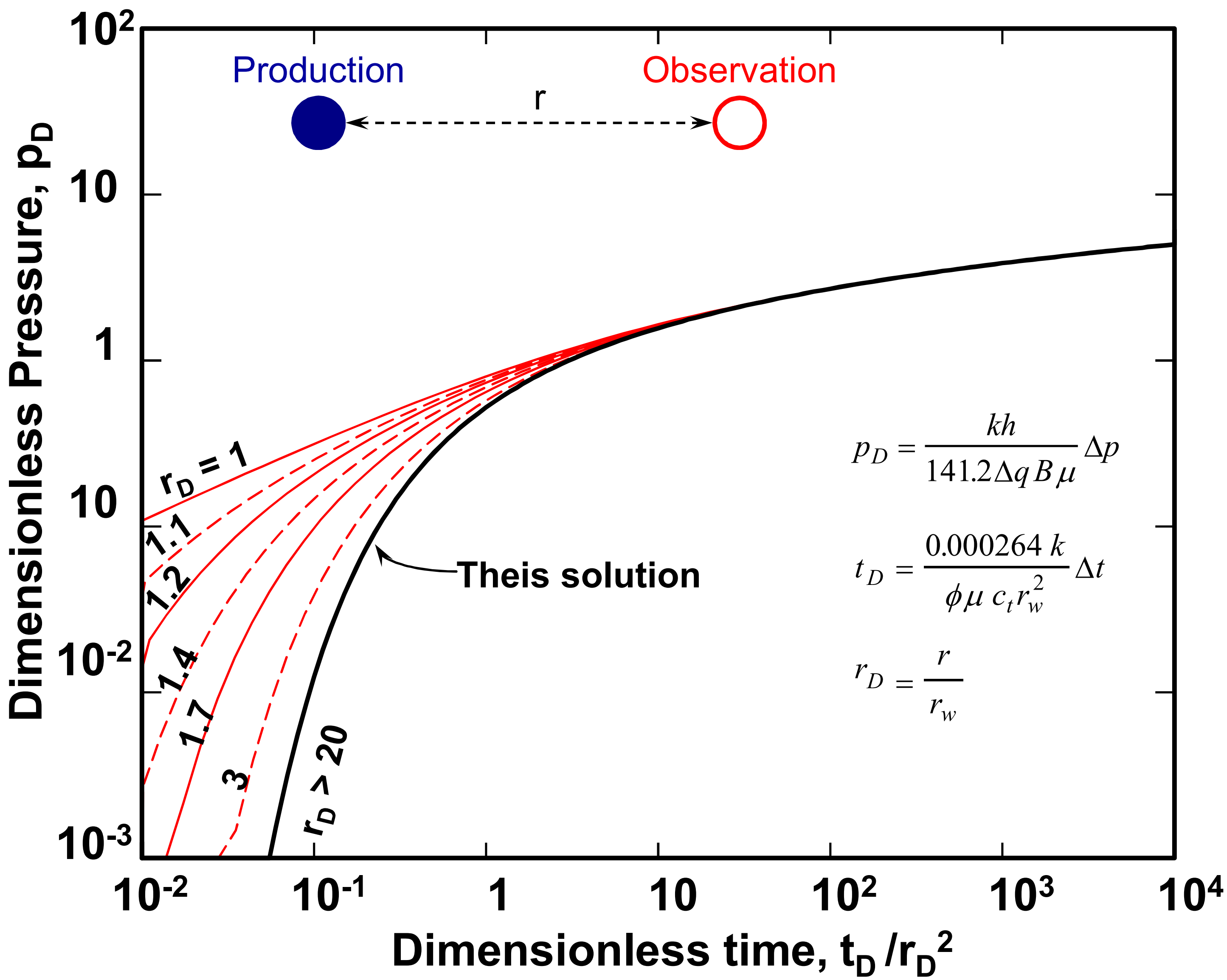
$$t_D \big/ r_D^2 = \frac{0.000264\,k}{\phi\mu\, c_t r^2}\Delta t$$



Drawdown Type Curve for a Line Source well



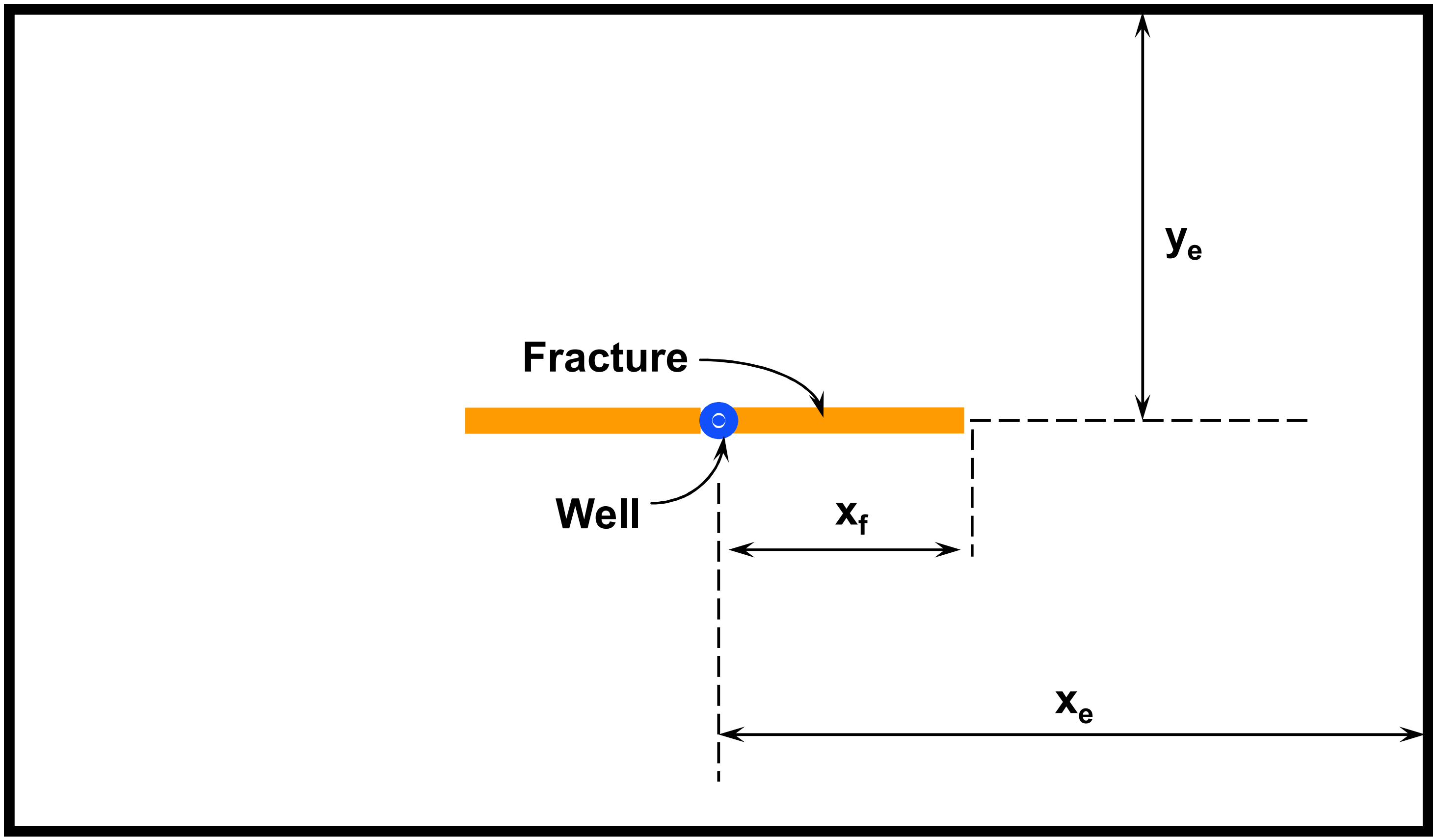
Drawdown Type Curve for a Line Source well



WELL TEST INTERPRETATION MODELS

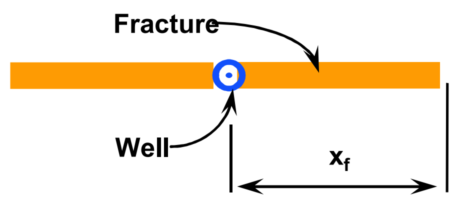
NEAR WELLBORE EFFECTS	RESERVOIR BEHAVIOUR	BOUNDARY EFFECTS
Wellbore Storage	**Homogeneous**	**Infinite extent**
Skin	Heterogeneous	Specified Rate
Fracture	-2-Porosity	Specified Pressure
Partial Penetration	-2-Permeability	Leaky Boundary
	-Composite	
Horizontal Well		
EARLY TIMES	MIDDLE TIMES	LATE TIMES

SCHEMATIC OF A VERTICALLY FRACTURED WELL AT THE CENTRE OF A RECTANGULAR RESERVOIR

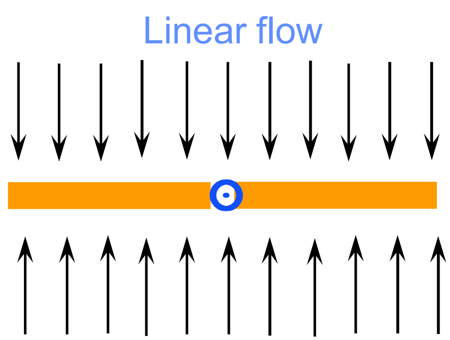


INFINITE CONDUCTIVITY VERTICAL FRACTURE

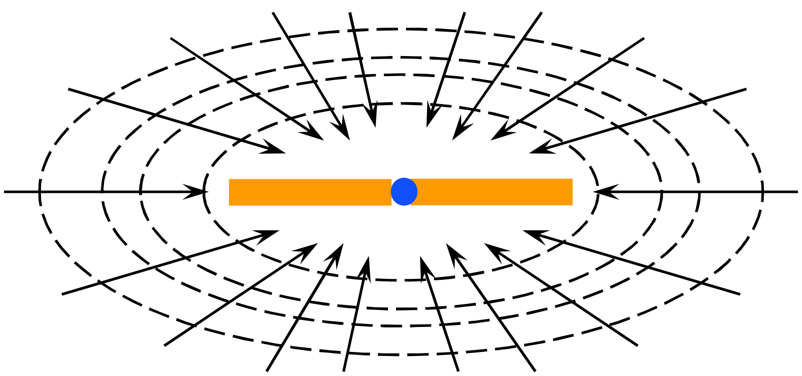
Flow Regimes



Linear Flow

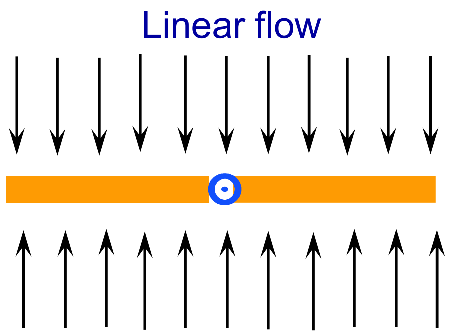


Pseudo-Radial Flow



DERIVATIVE FOR HIGH CONDUCTIVITY FRACTURE (Early Times)

High conductivity fracture



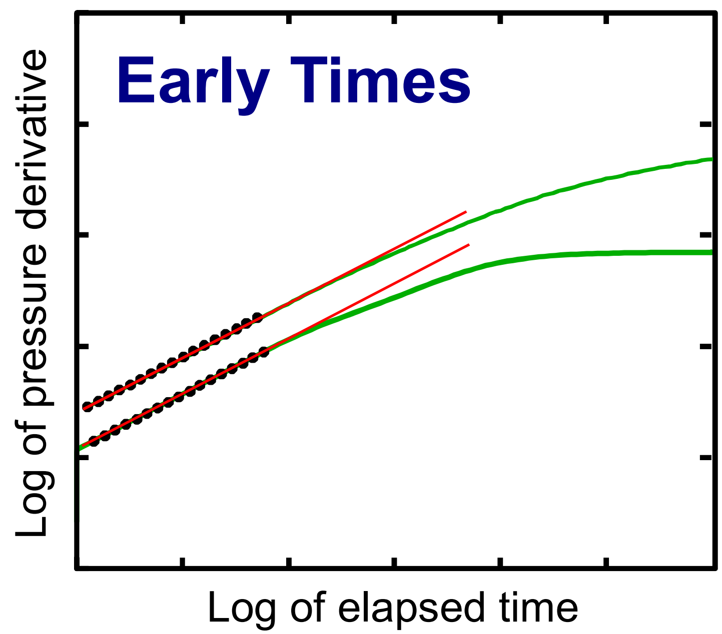
$$p_D = \left(\pi \, t_{Df}\right)^{1/2}$$

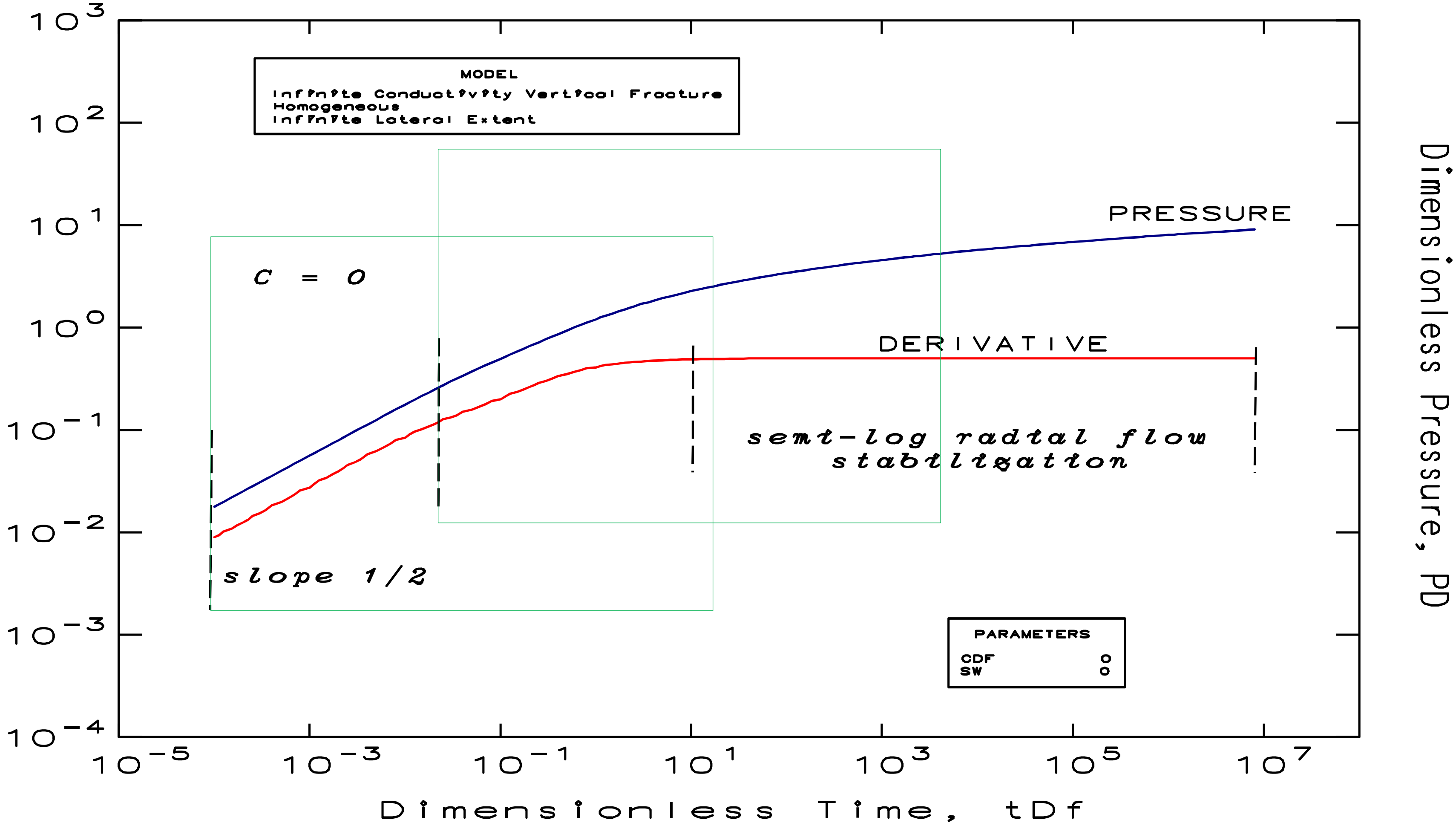
$$p_D = \frac{kh}{141.2 \Delta q \, B \, \mu} \Delta p$$

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

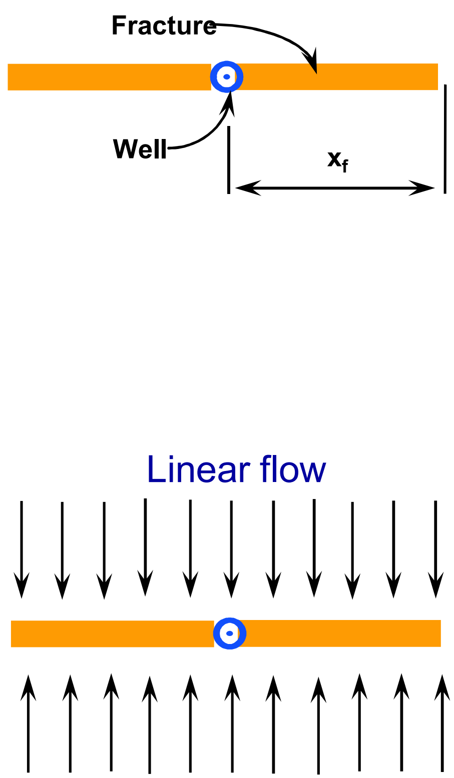
$$\frac{dp_D}{d \ln\left(t_{Df}\right)} = 0.5\left(\pi \, t_{Df}\right)^{1/2} = (0.5) p_D$$

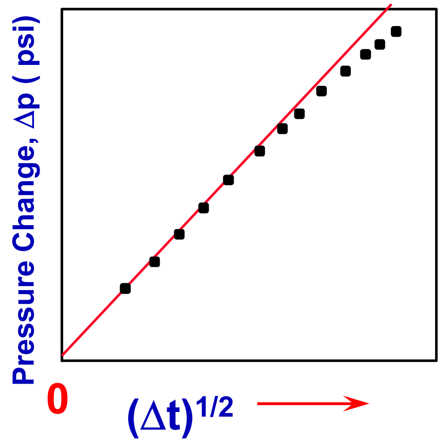
- ❑ **Half-unit slope log-log straight line**
- ❑ **Derivative is one half the pressure**



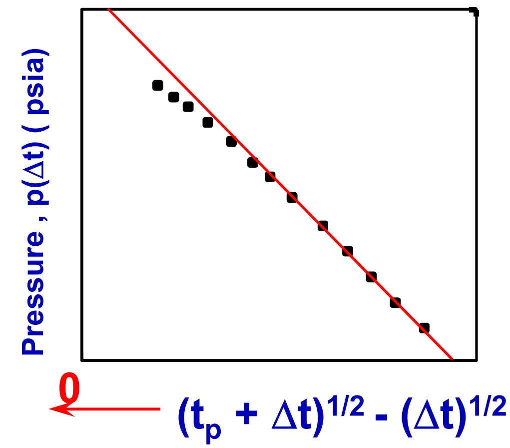

MODEL
Infinite Conductivity Vertical Fracture
Homogeneous
Infinite Lateral Extent
PRESSURE
DERIVATIVE
C = 0
semi-log radial flow
stabilization
slope 1/2
PARAMETERS
CDF 0
SW 0
Dimensionless Time, tDf
Dimensionless Pressure, PD

STRAIGHT LINE METHODS FOR A HIGH CONDUCTIVITY FRACTURE
(Early Times)





Specialised Plot



Horner Plot

$$\Delta p = 4.06 \frac{\Delta qB}{hx_f}\sqrt{\frac{\mu}{\phi c_t k}}\sqrt{\Delta t}$$

$$p(\Delta t) = \bar{p}_i - 4.06 \frac{\Delta qB}{hx_f}\sqrt{\frac{\mu}{\phi c_t k}}\left[\left(t_p + \Delta t\right)^{1/2} - (\Delta t)^{1/2}\right]$$

$$m_{\mathrm{HKF}} = 4.06 \frac{\Delta qB}{hx_f}\sqrt{\frac{\mu}{\phi c_t k}}$$ psi/(hr)$^{1/2}$

$$k\, x_f^2 = 16.52 \frac{\mu}{\phi c_t}\left(\frac{\Delta q B}{h\, m_{\mathrm{HKF}}}\right)^2$$ mD.sqft

FRACTURED WELL

DIRECT METHOD

INFINITE CONDUCTIVITY FRACTURE

- **Wellbore Storage and Skin type curves**
- **Infinite Conductivity Fracture**

FINITE CONDUCTIVITY FRACTURE

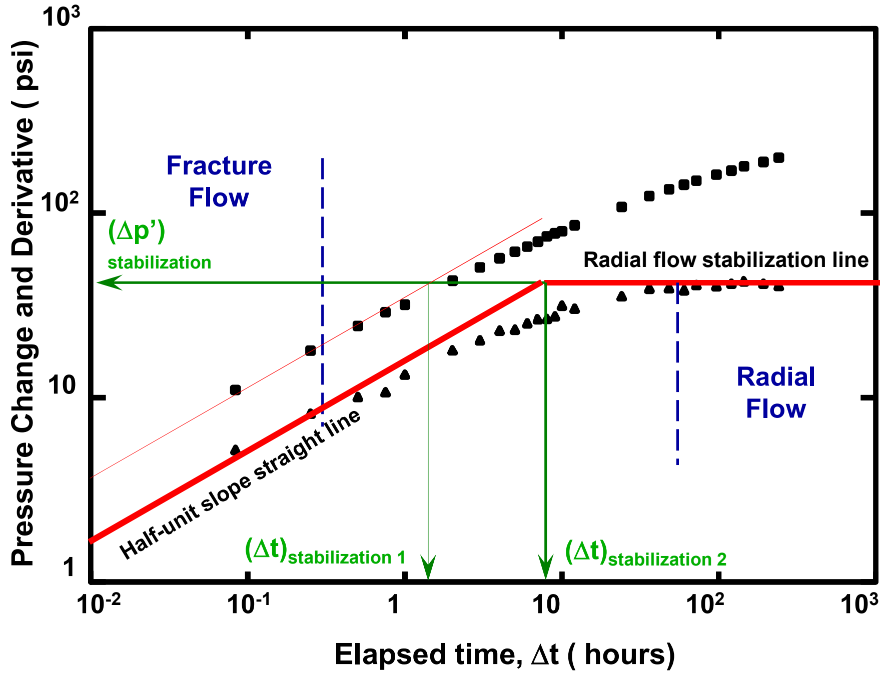
DIRECT METHOD FOR HIGH CONDUCTIVITY VERTICAL FRACTURE

PM $\qquad$ **TM**

$$p_D = \frac{kh}{141.2\,\Delta q\,B\,\mu}\Delta p \qquad t_{Df} = \frac{0.000264\,k}{\phi\mu\,c_t x_f^2}\Delta t$$

Fracture Flow : $p_D = \sqrt{\pi t_{Df}}$

$$\frac{dp_D}{d\ln(t_{Df})} = t_{Df}\frac{dp_D}{dt_{Df}} = t_{Df}\frac{1}{2}\sqrt{\frac{\pi}{t_{Df}}} = \frac{1}{2}\sqrt{\pi\,t_{Df}} = (0.5)p_D$$



$$\text{PM} = (p_D/\Delta p)_{\text{match}} = (p'_D)_{\text{stabilization}} / (\Delta p')_{\text{stabilization}} = \frac{kh}{141.2\Delta q B\mu} \qquad \text{PM} = 0.5/(\Delta p')_{\text{stabilization}} \Rightarrow kh$$

$$\text{TM} = \left(\frac{t_{Df}}{\Delta t}\right)_{\text{match}} = (t_{Df})_{\text{stabilization}} / (\Delta t)_{\text{stabilization}} = \frac{0.000264k}{\phi\mu c_t x_f^2}$$

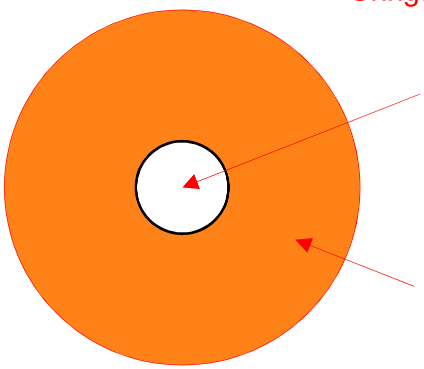
$$(p'_D)_{\text{stabilization 1}} = 0.5 = \sqrt{\pi (t_{Df})_{\text{stabilization 1}}} \longrightarrow (t_{Df})_{\text{stabilization 1}} = \frac{0.25}{\pi} \qquad \text{TM} = 0.25/\pi(\Delta t)_{\text{stabilization 1}} \Rightarrow x_f$$

$$(p'_D)_{\text{stabilization 2}} = 0.5 = 0.5\sqrt{\pi (t_{Df})_{\text{stabilization 2}}} \longrightarrow (t_{Df})_{\text{stabilization 2}} = \frac{1}{\pi} \qquad \text{TM} = 1/\pi(\Delta t)_{\text{stabilization 2}} \Rightarrow x_f$$

Well with Wellbore Storage & Skin, in a Reservoir of Infinite Extent with Homogeneous Behaviour

Minimum value of C_De^{2S} for an acidized well

Gringarten, Bourdet, Landel and Kniazeff SPE8205 54th ATCE Las Vegas 1979



$$k = \infty \quad \varphi = \varphi_m$$

$$C_{w+S} = C_w + \pi\left(r_{we}^2 - r_w^2\right)h\,\varphi\,c_t$$

$$C_{w+S} = C_w + \pi\, r_w^2\left(e^{-2S} - 1\right)h\,\varphi\,c_t$$

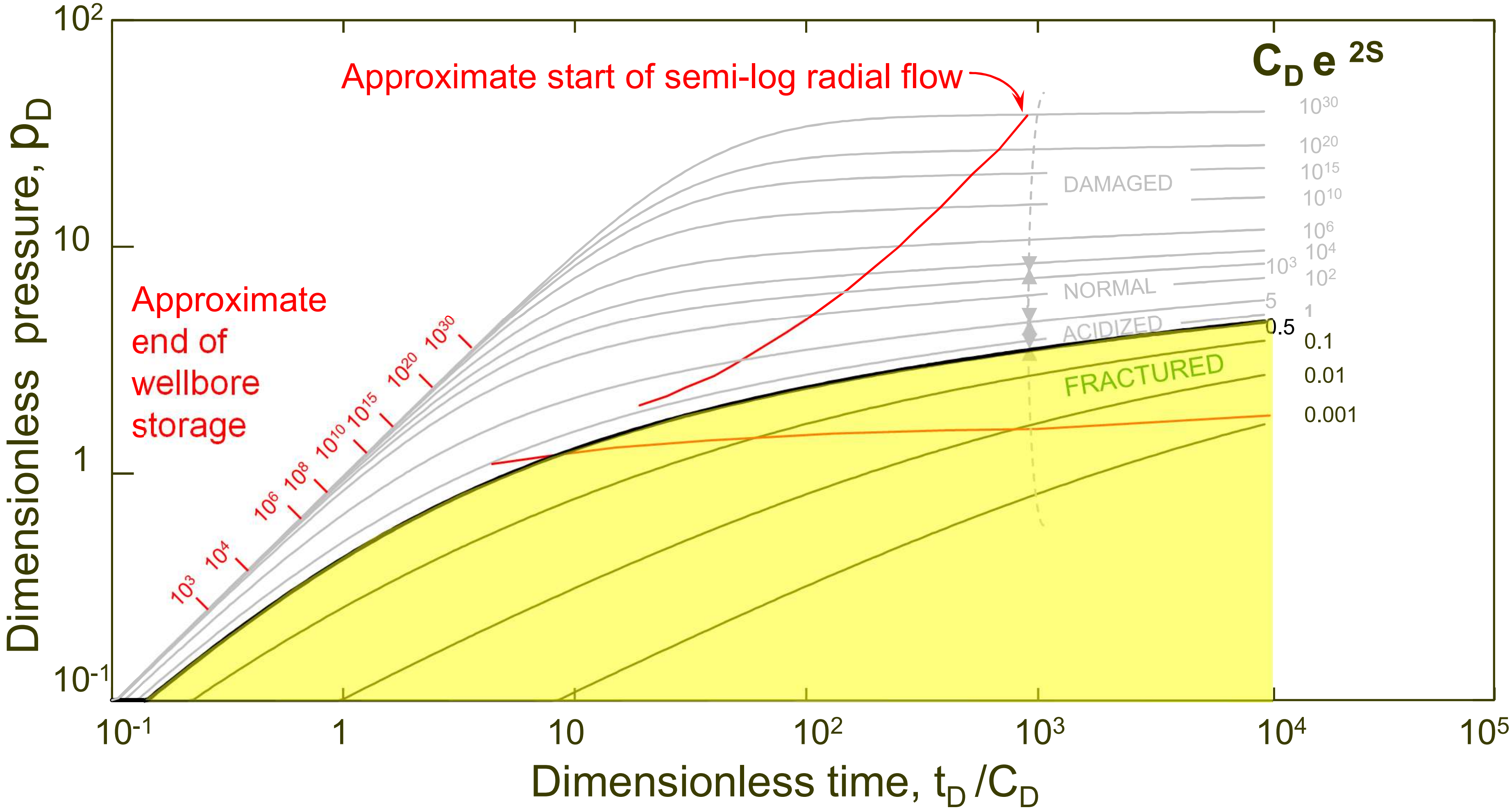
$$\left(Ce^{2S}\right)_{w+S} = \left(Ce^{2S}\right)_w + \pi\, r_w^2\left(1 - e^{-2S}\right)h\,\varphi\,c_t$$

$$\left(C_De^{2S}\right)_{w+S} = \left(C_De^{2S}\right)_w + \frac{\pi\, r_w^2\left(1 - e^{-2S}\right)h\,\varphi\,c_t}{2\pi\, h\,\varphi\,c_t\, r_w^2} = \left(C_De^{2S}\right)_w + \frac{1 - e^{-2S}}{2}$$

Minimum value of $(C_De^{2S})_{w+S} = 0.5$

Lower values of $(C_De^{2S})_{w+S}$ must correspond to fractured wells with wellbore storage

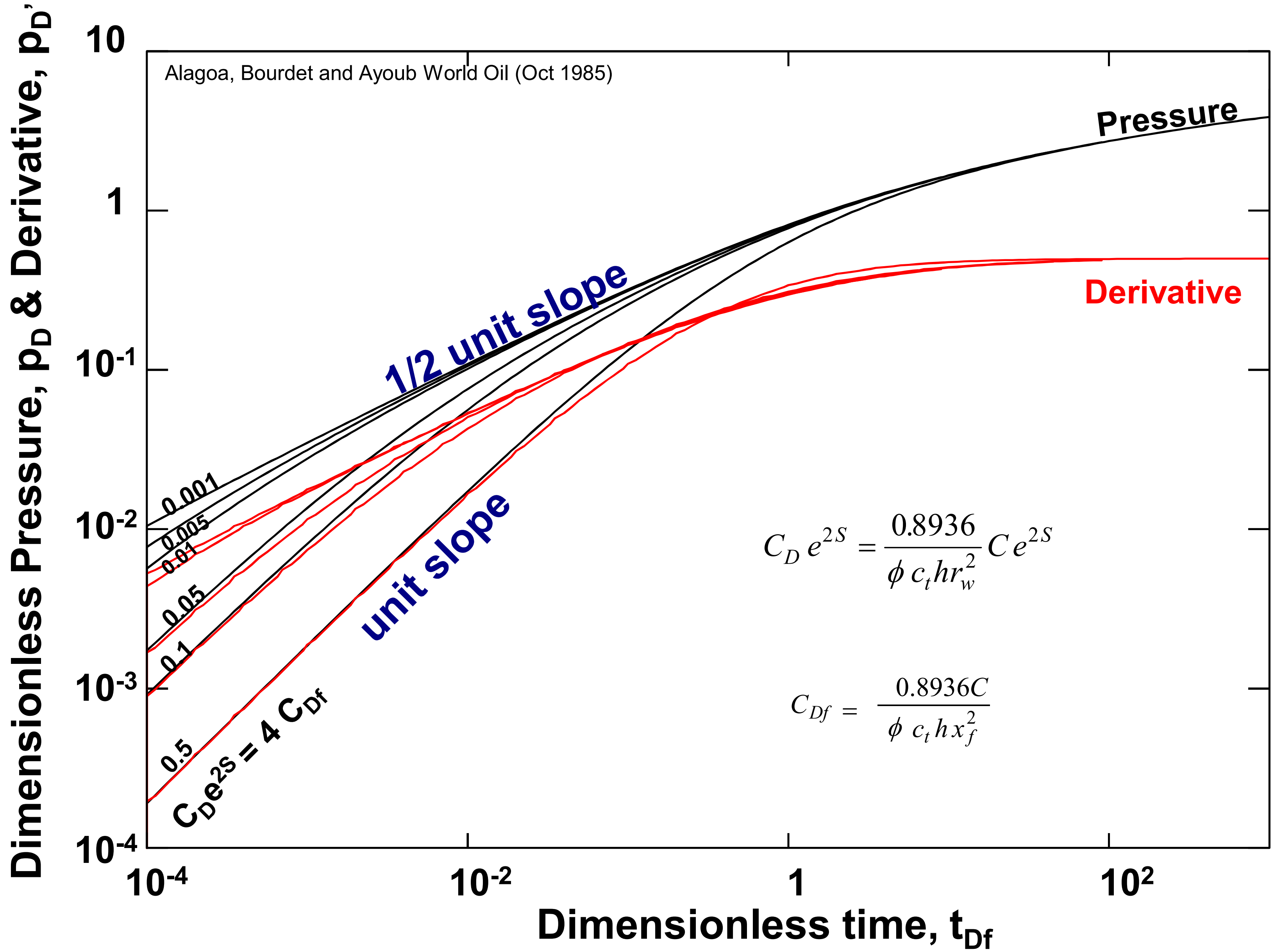
Drawdown Type Curve for a Well with Wellbore Storage & Skin, in a Reservoir of Infinite Extent with Homogeneous Behaviour



$C_D e^{2S} < 0.5$ Yields kh, C, S

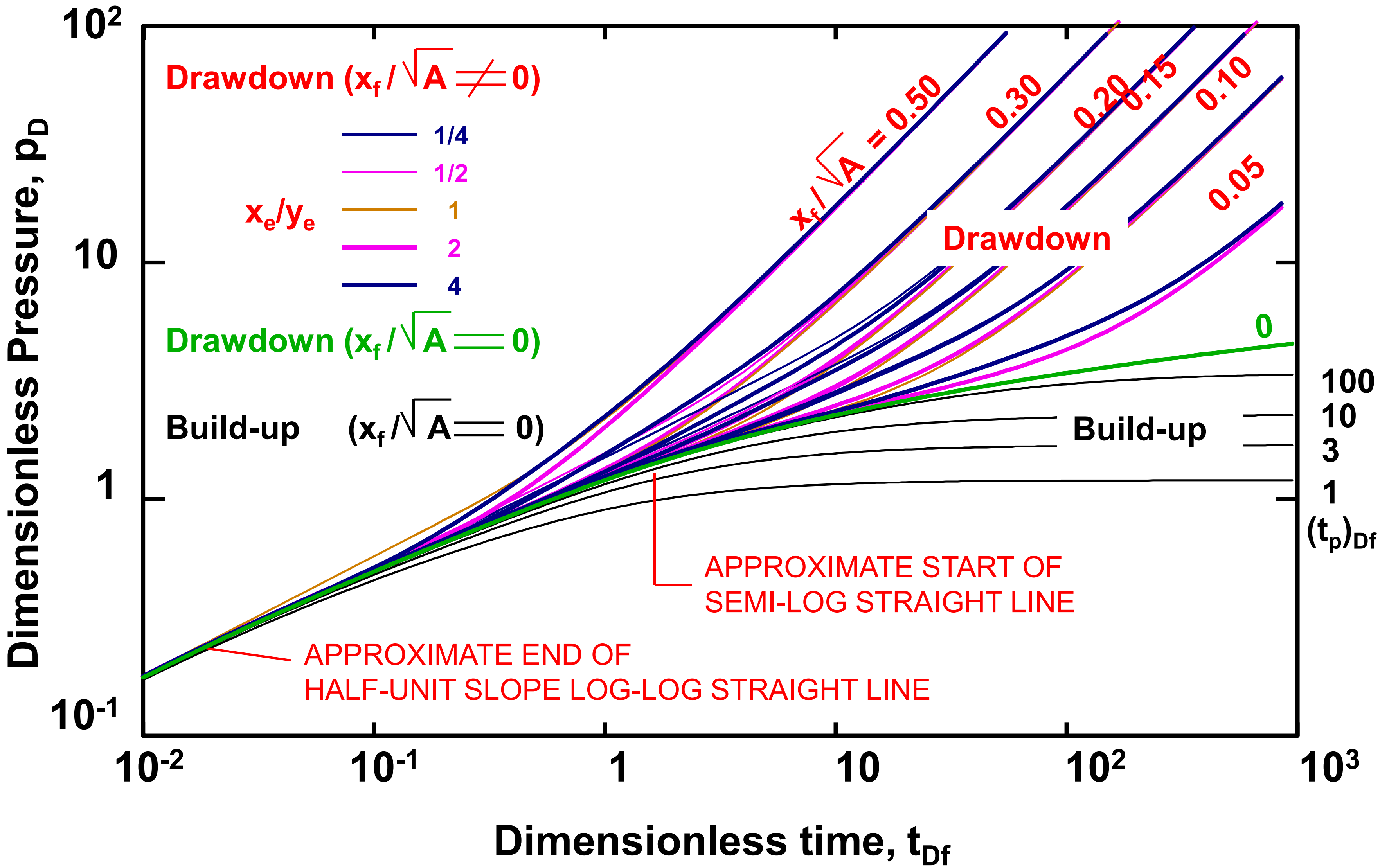
$r_{we} = r_w e^{-S} = x_f/2$ Yields $x_f = 2 r_w e^{-S}$

Fractured Well with Wellbore Storage & Skin

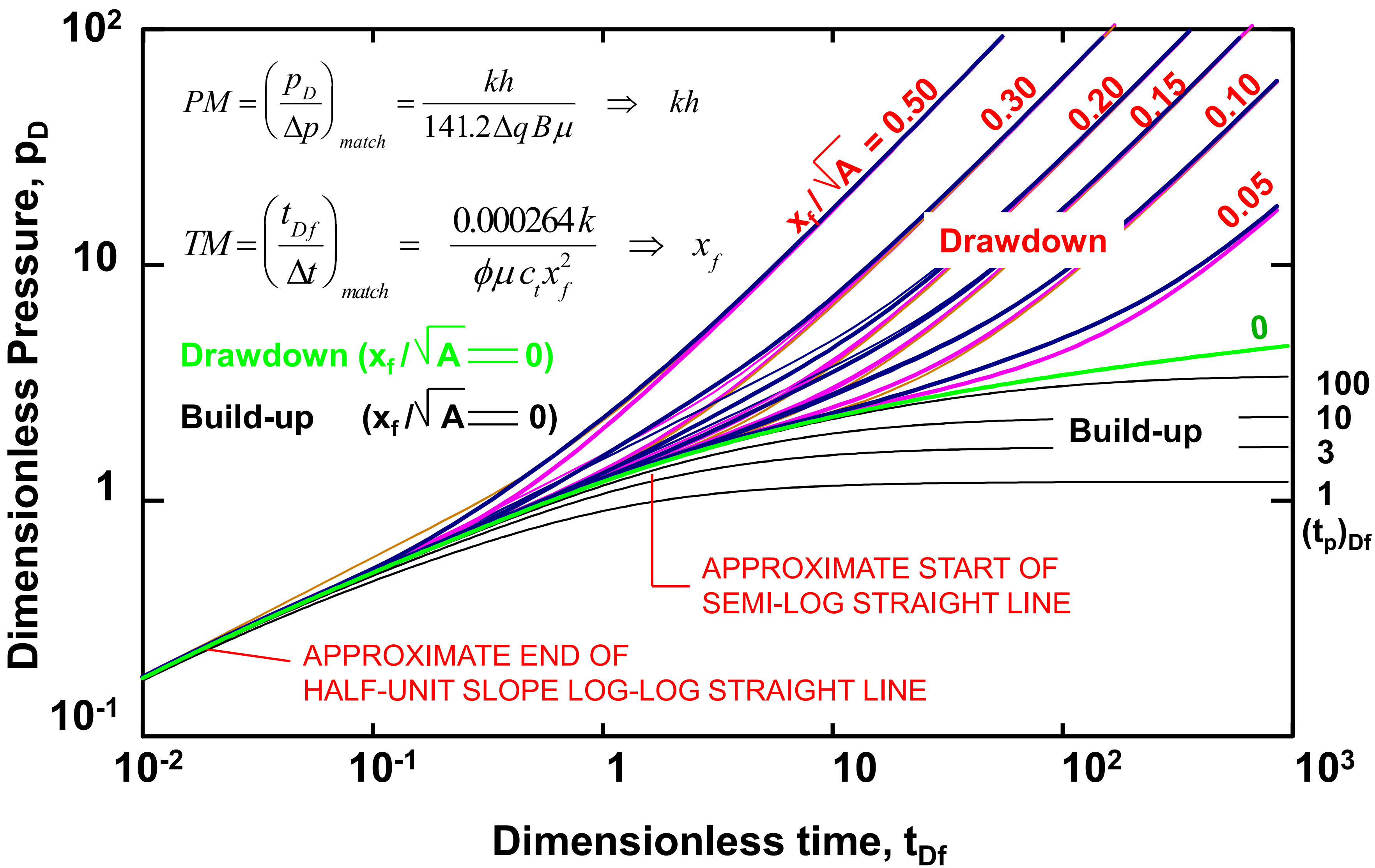


INFINITE CONDUCTIVITY VERTICAL FRACTURE AT THE CENTRE OF A CLOSED RECTANGLE

Gringarten SPE 7452 1978

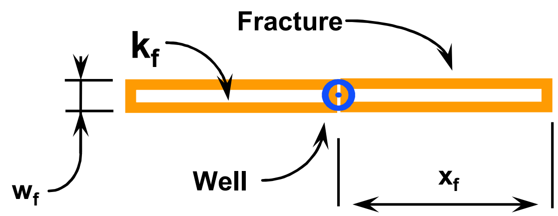


INFINITE CONDUCTIVITY VERTICAL FRACTURE AT THE CENTRE OF A CLOSED RECTANGLE



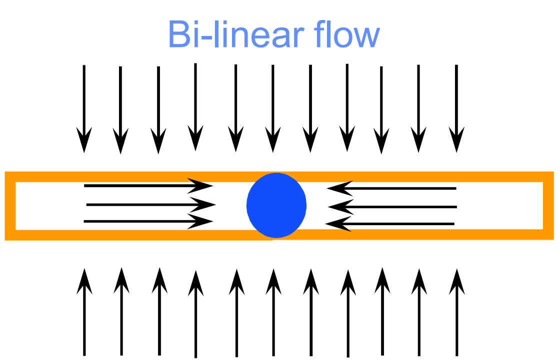
FINITE CONDUCTIVITY VERTICAL FRACTURE

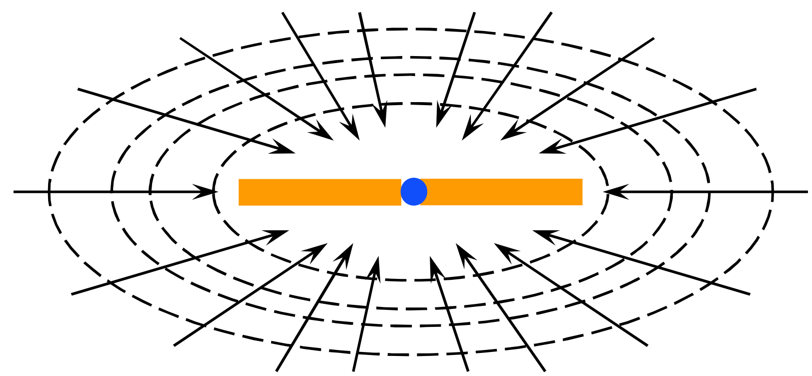
Flow Regimes



Bi-Linear & Linear Flow

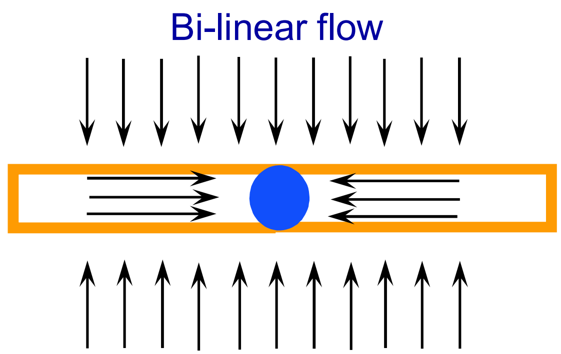
Pseudo-Radial Flow





DERIVATIVE FOR LOW CONDUCTIVITY FRACTURE (Early Times)

Low conductivity fracture



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

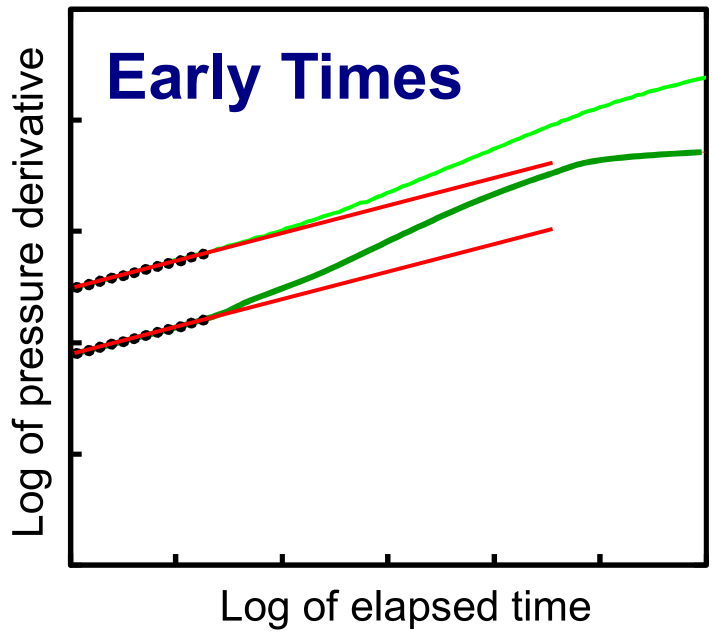
$$p_D = \frac{kh}{141.2\Delta q B\mu}\Delta p$$

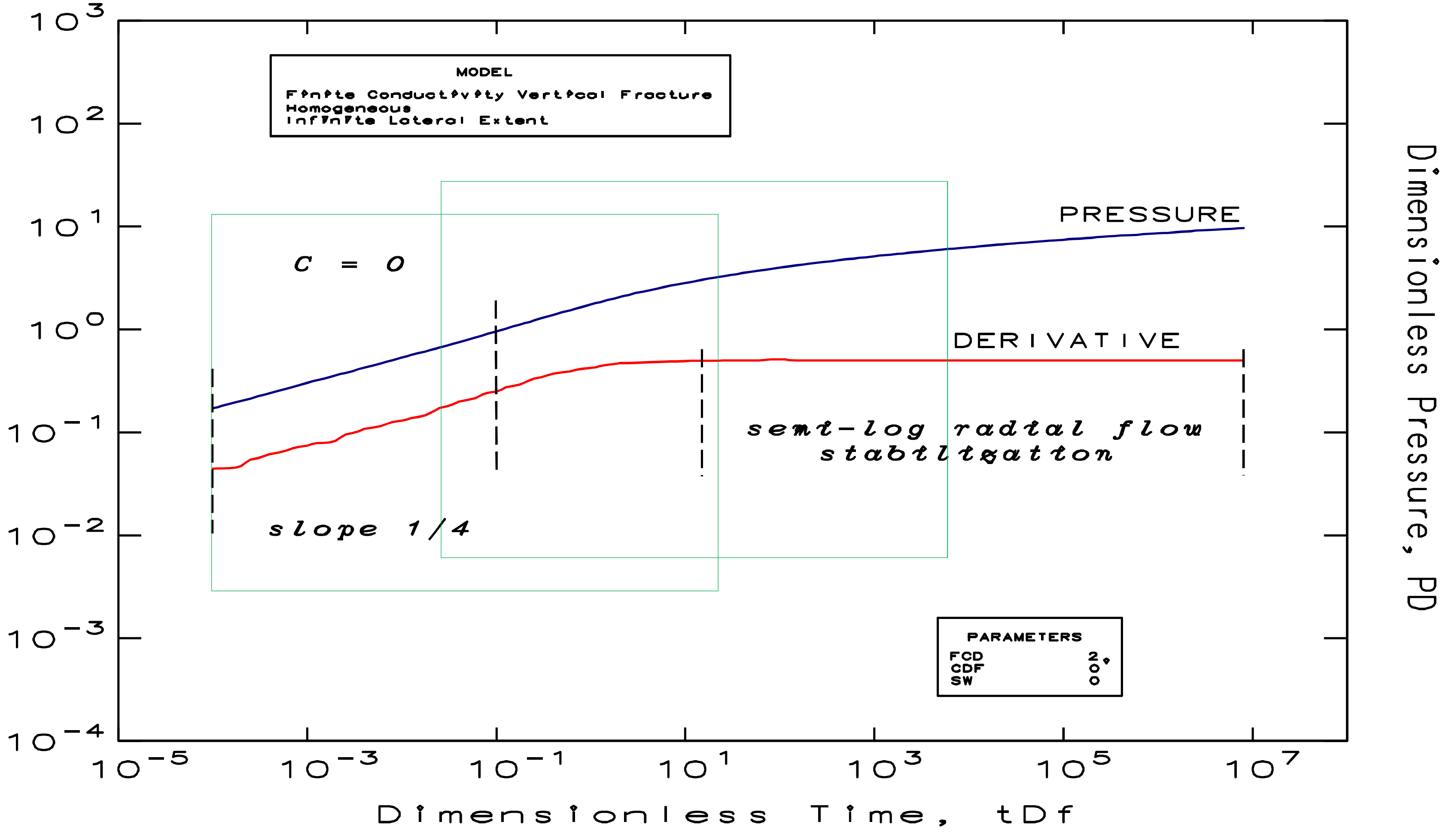
$$t_{Df} = \frac{0.000264\, k}{\phi\mu\, c_t x_f^2}\Delta t$$

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

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

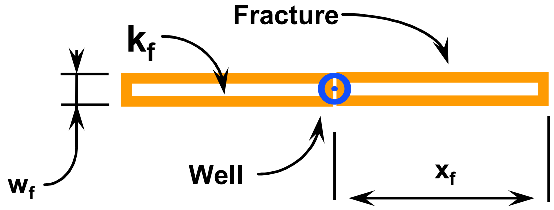
- ❑ **Quarter-unit slope log-log straight line**
- ❑ **Derivative is one fourth the pressure**

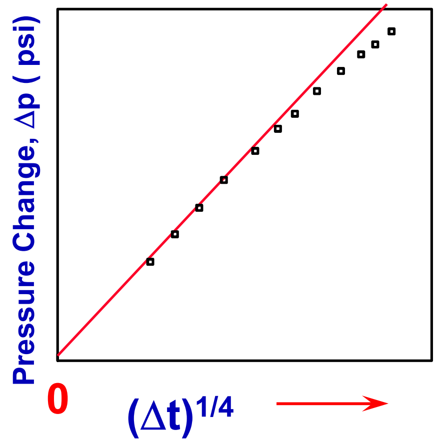


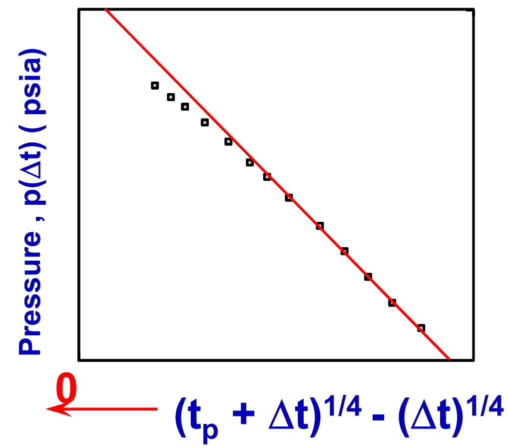

MODEL
Finite Conductivity Vertical Fracture
Homogeneous
Infinite Lateral Extent
PRESSURE
DERIVATIVE
C = 0
slope 1/4
semi-log radial flow
stabilization
PARAMETERS
FCD 2.
CDF 0
SW 0
Dimensionless Time, tDf
Dimensionless Pressure, PD

STRAIGHT LINE METHOD FOR A LOW CONDUCTIVITY FRACTURE

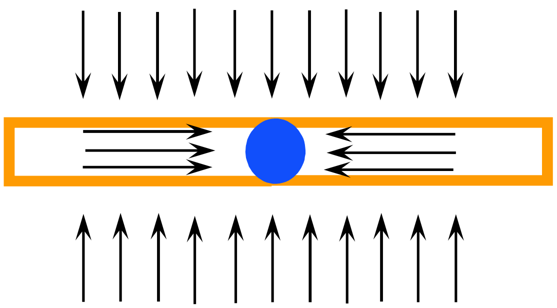
(Early Times)







Bi-linear flow



Specialised Plot

$$\Delta p = 44.1 \frac{\Delta q B \mu}{h \sqrt{k_f w_f} \sqrt[4]{\phi \mu c_t k}} \sqrt[4]{\Delta t}$$

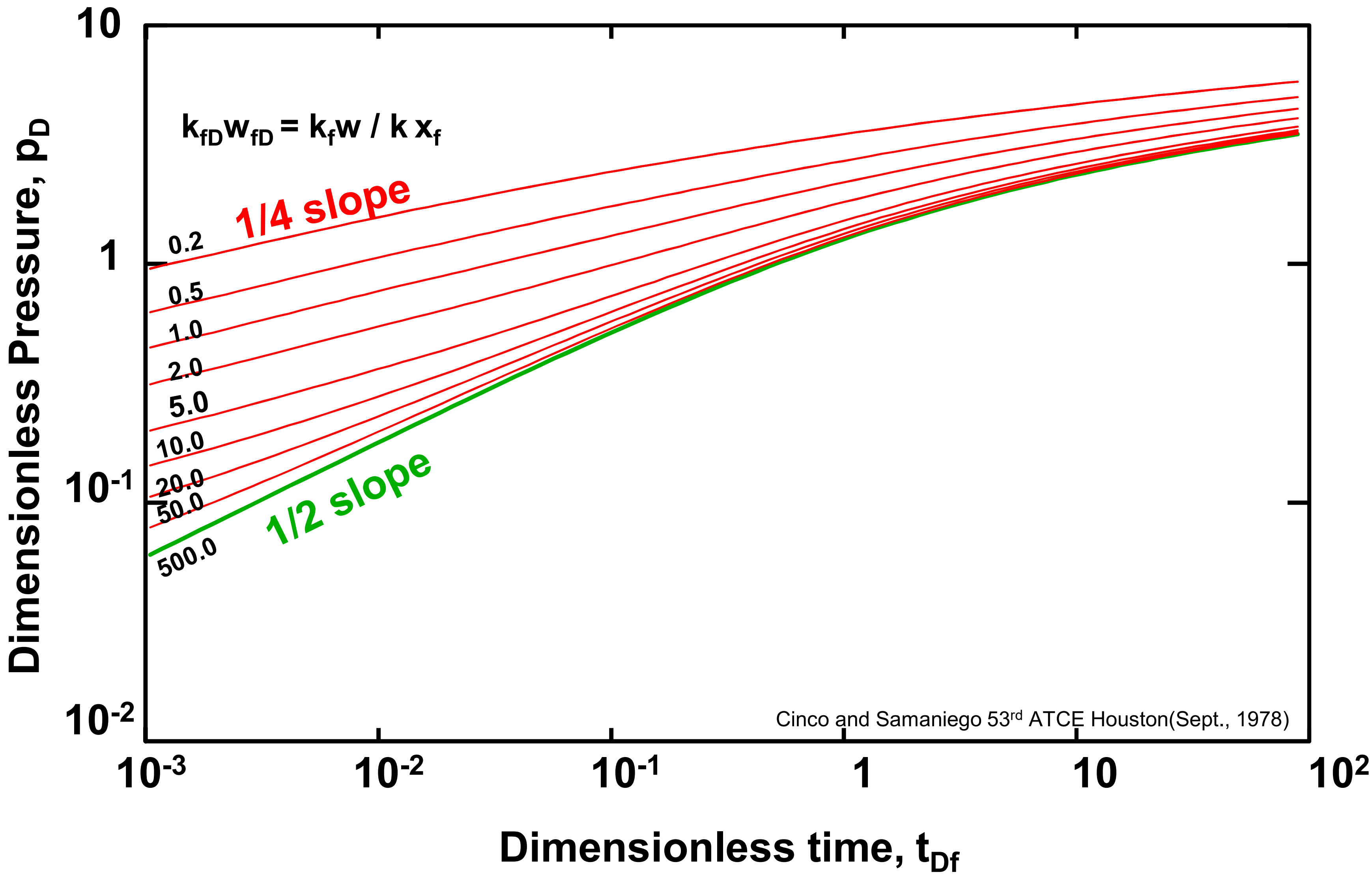
Horner Plot

$$p(\Delta t) = \overline{p}_i - 44.1 \frac{\Delta q B \mu}{h \sqrt{k_f w_f} \sqrt[4]{\phi \mu c_t k}} \left[\left(t_p + \Delta t\right)^{1/4} - \left(\Delta t\right)^{1/4} \right]$$

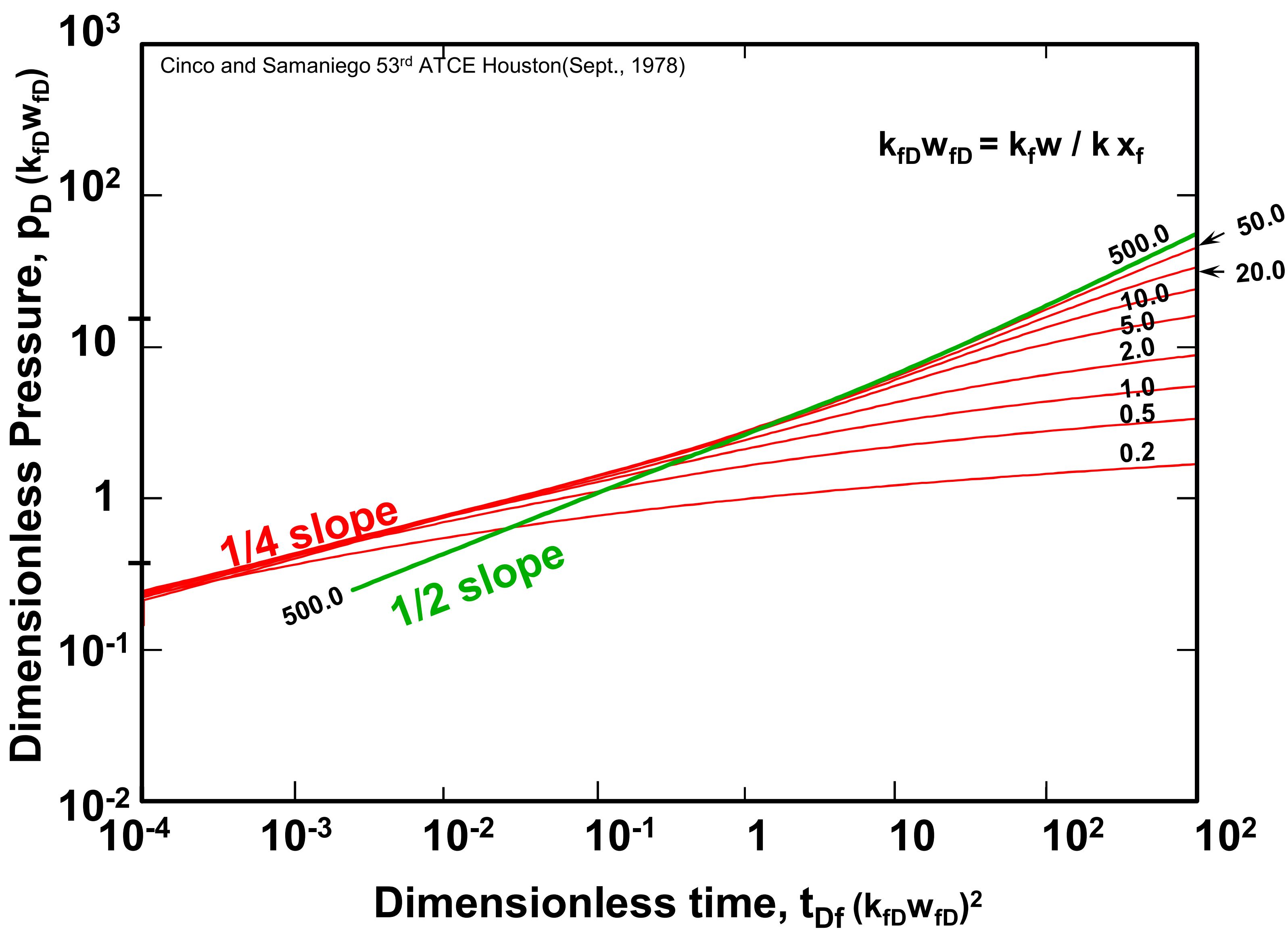
$$m_{\mathrm{LKF}} = 44.1 \frac{\Delta q B \mu}{h \sqrt{k_f w_f} \sqrt[4]{\phi \mu c_t k}} \quad \text{psi/(hr)}^{1/4}$$

$$k_f w_f = 1944.8 \left(\frac{\Delta q B \mu}{h\, m_{\mathrm{LKF}}} \right)^2 \frac{1}{\sqrt{\phi \mu c_t k}} \quad \text{mD.ft}$$

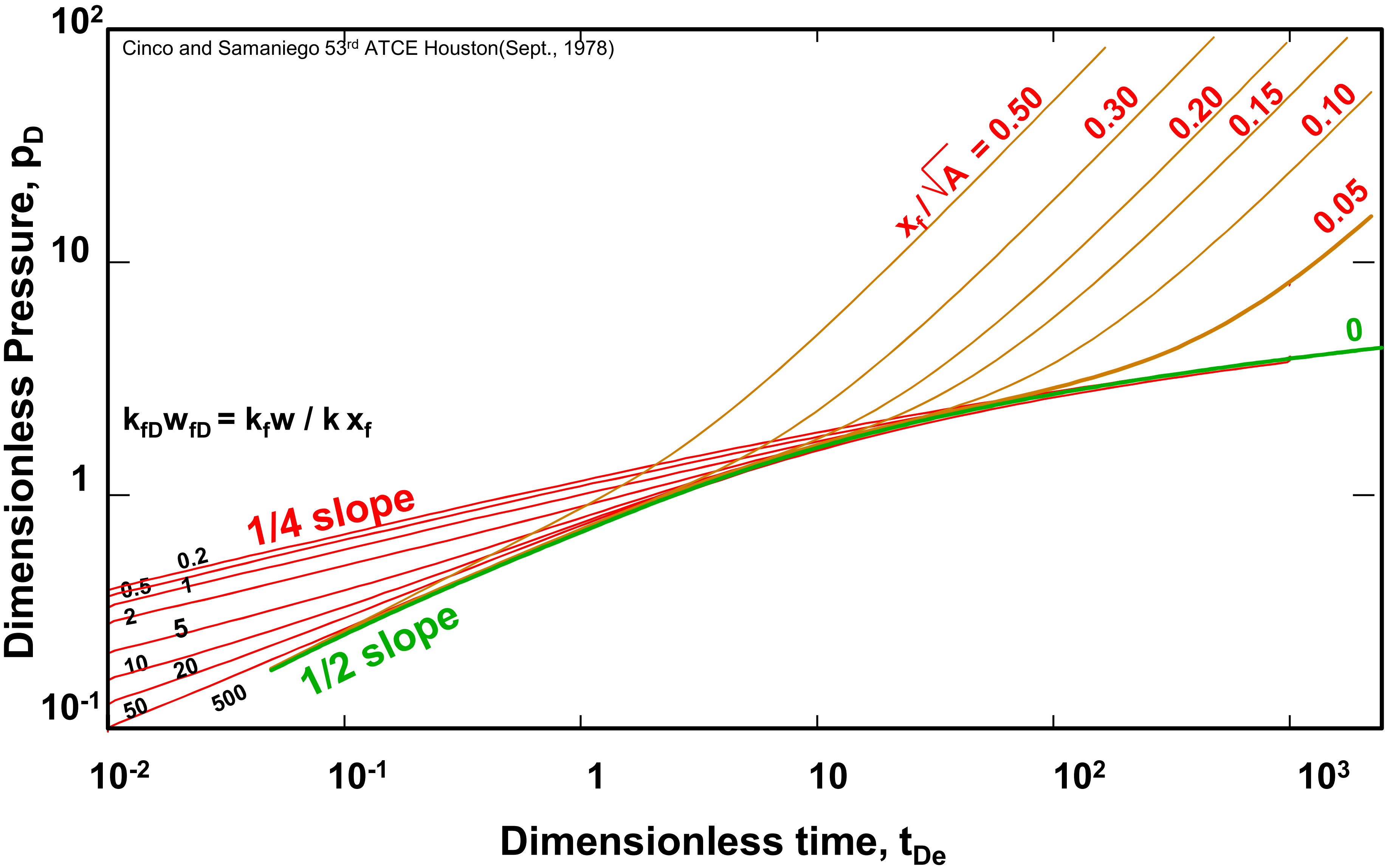
FINITE CONDUCTIVITY VERTICAL FRACTURE



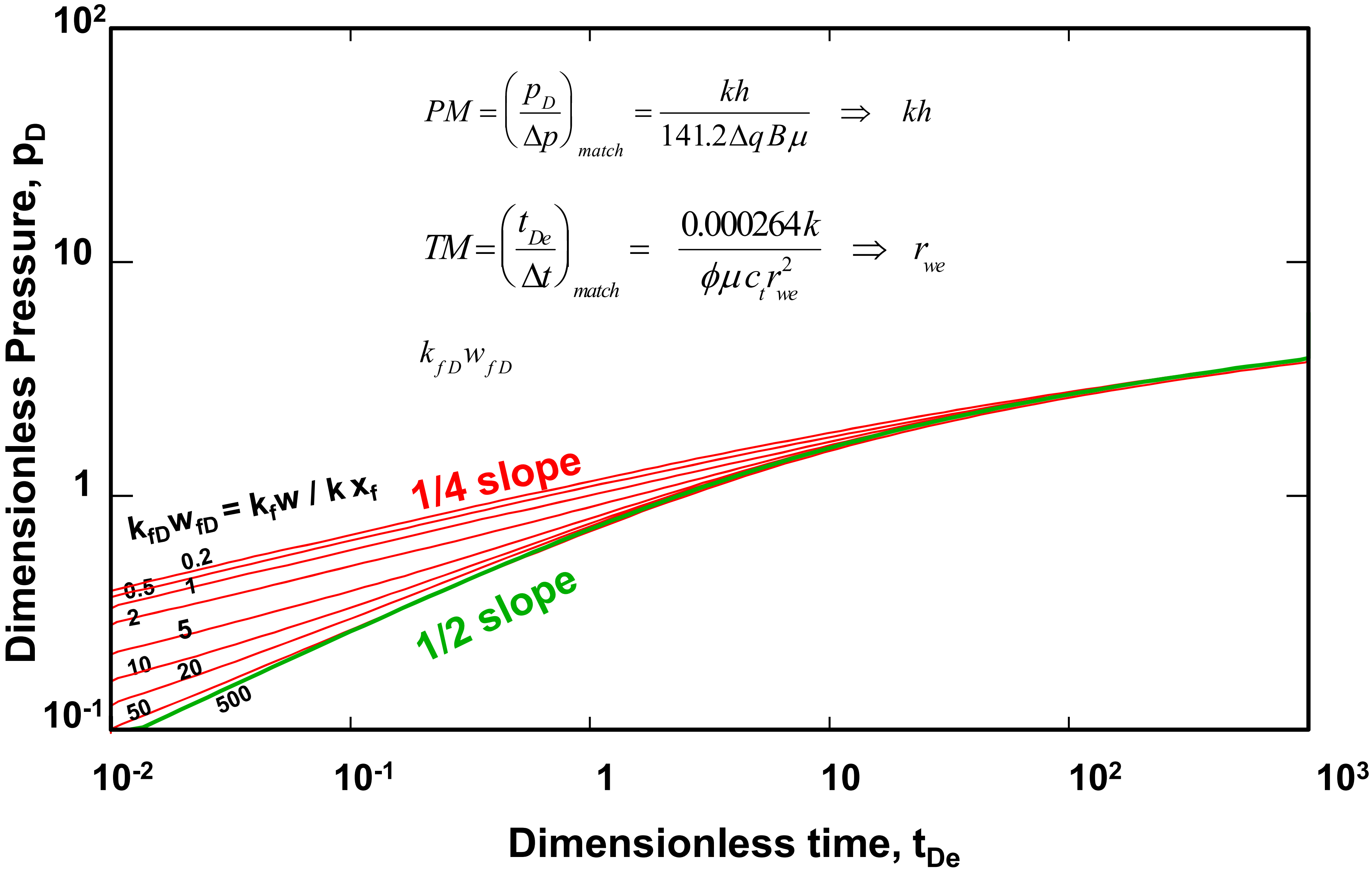
FINITE CONDUCTIVITY VERTICAL FRACTURE

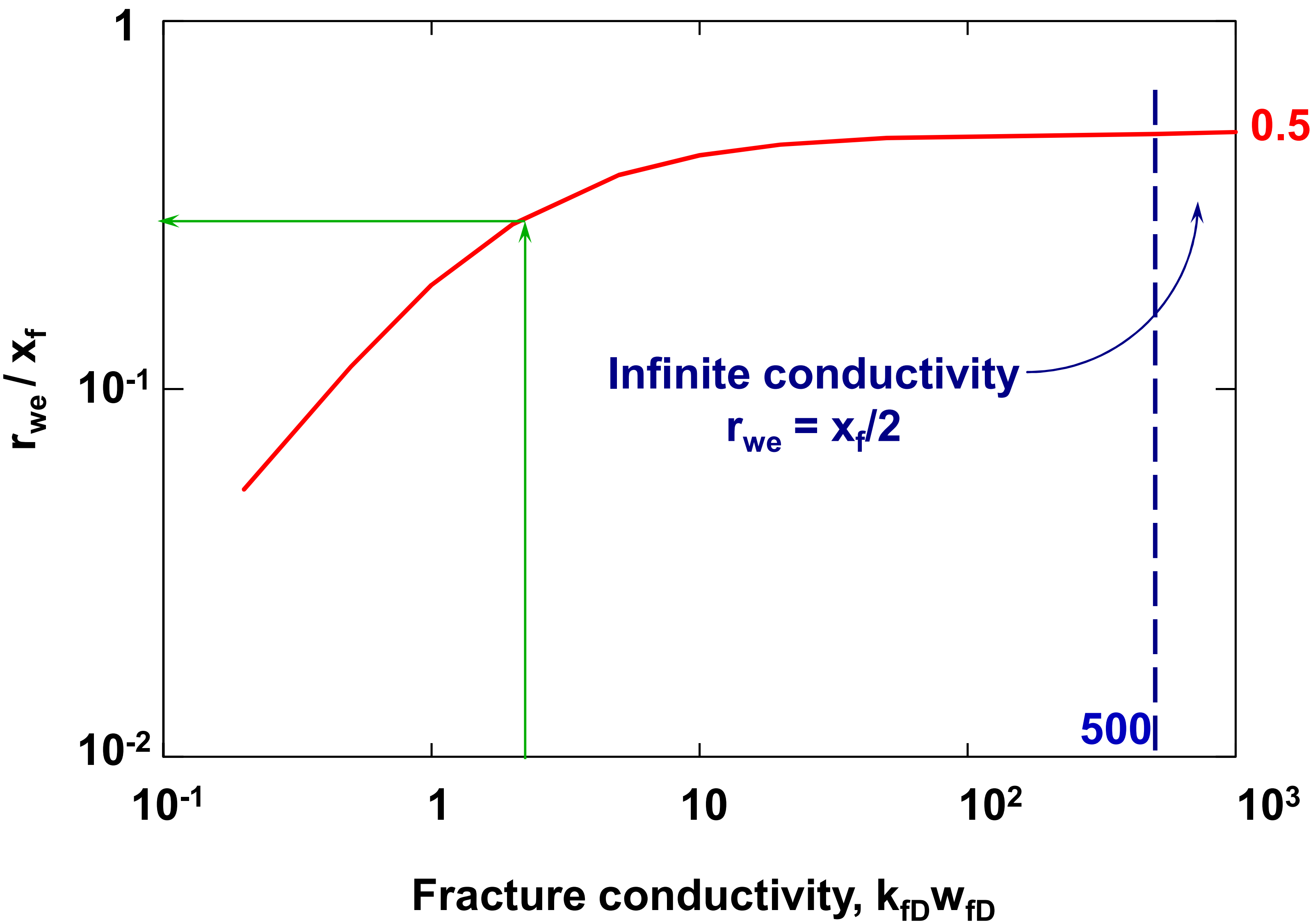


FINITE CONDUCTIVITY VERTICAL FRACTURE AT THE CENTRE OF A CLOSED SQUARE

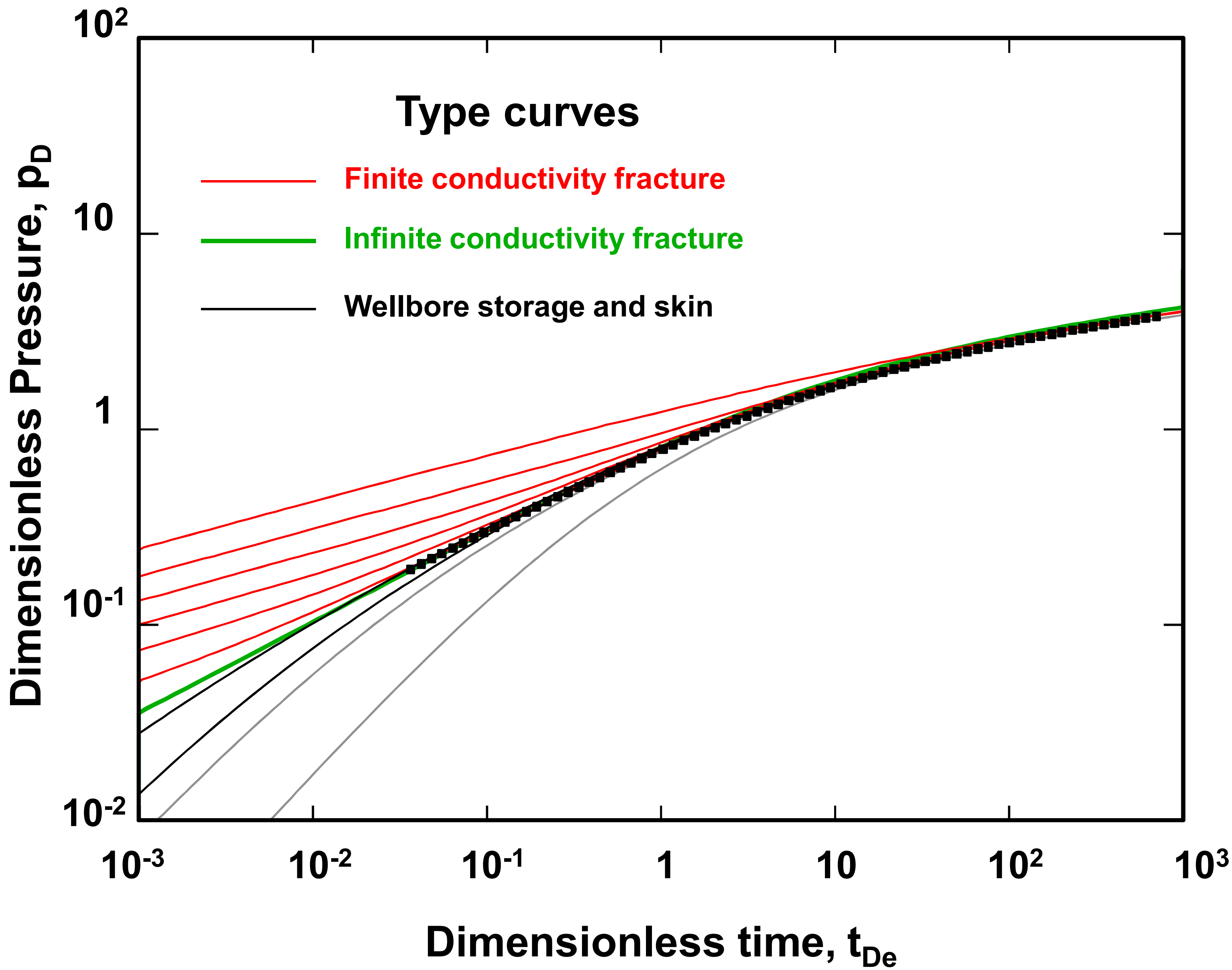


FINITE CONDUCTIVITY VERTICAL FRACTURE





1
10^{-1}
10^{-2}
r_{we} / x_f
0.5
Infinite conductivity
$r_{we} = x_f/2$
500
10^{-1}
1
10
10^2
10^3
Fracture conductivity, $k_{fD}w_{fD}$

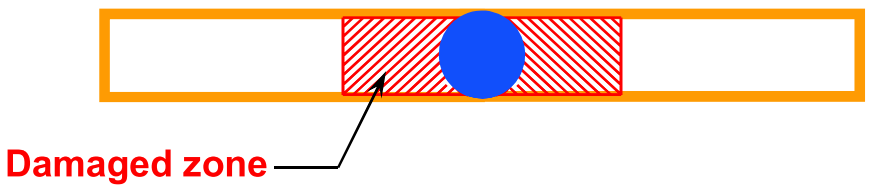

Type curves
Finite conductivity fracture
Infinite conductivity fracture
Wellbore storage and skin
Dimensionless Pressure, p_D
Dimensionless time, t_{De}
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3

	PM	TM
Wellbore storage and skin	$p_D = \frac{kh}{141.2 \Delta q B \mu} \Delta p$	$\frac{t_D}{C_D} = 0.000295 \frac{kh}{\mu C} \Delta t$
Infinite conductivity fracture	$p_D = \frac{kh}{141.2 \Delta q B \mu} \Delta p$	$t_{Df} = \frac{0.000264 k}{\phi \mu c_t x_f^2} \Delta t$
Finite conductivity fracture	$p_D = \frac{kh}{141.2 \Delta q B \mu} \Delta p$	$t_{De} = \frac{0.000264 k}{\phi \mu c_t r_{we}^2} \Delta t$

DAMAGED FRACTURE

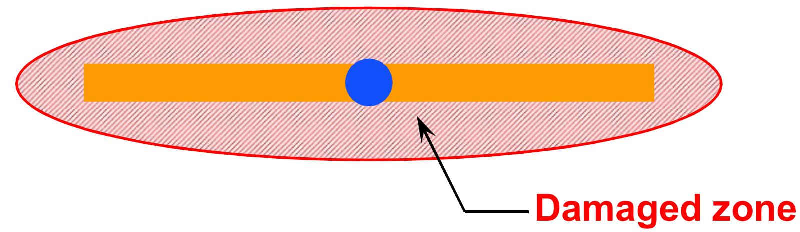
Choked vertical fracture

Chavez, Alejandro and Cinco-Ley, SPE 104004(Sept., 2006)



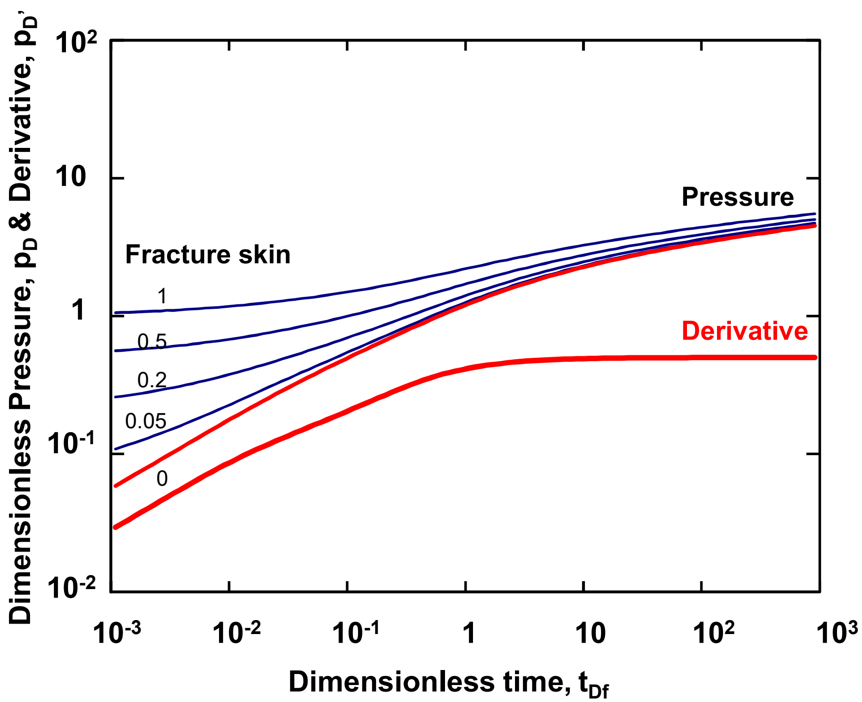
Vertical fracture with fluid loss damage

Cinco-Ley and Samaniego SPE 6752 52nd ATCE(Sept 1977)

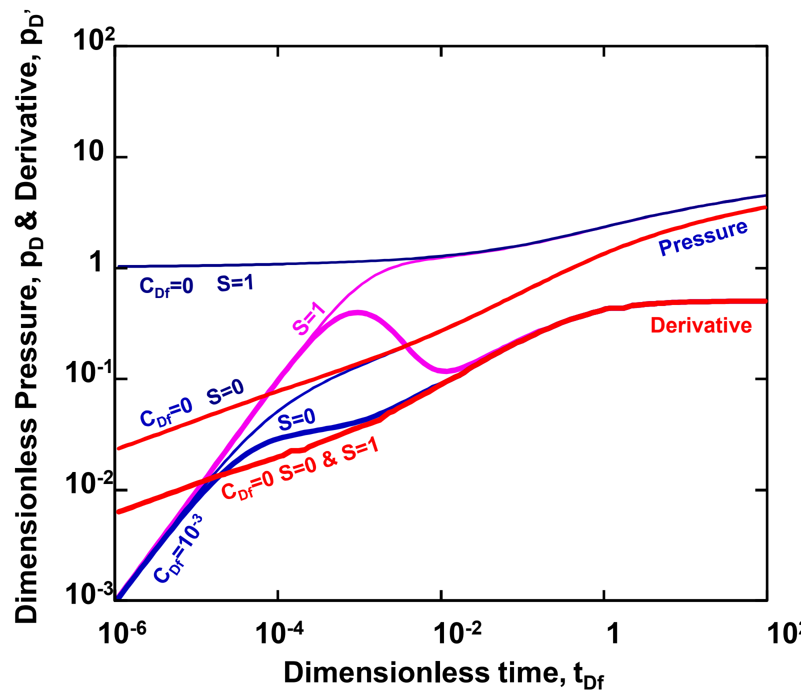


- **SKIN ADDITIVE TO DIMENSIONLESS PRESSURE**
- **NO EFFECT ON DERIVATIVE UNLESS THERE IS WELLBORE STORAGE**

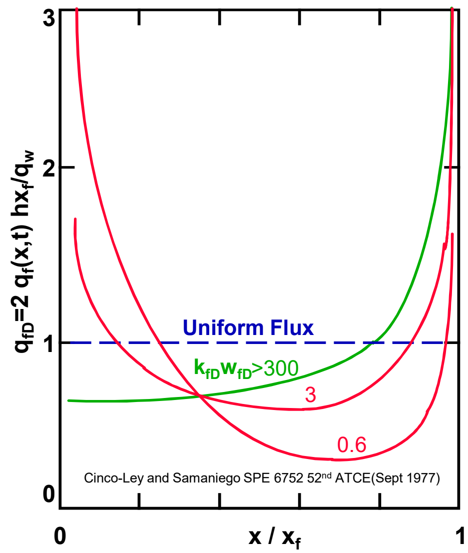
INFINITE CONDUCTIVITY

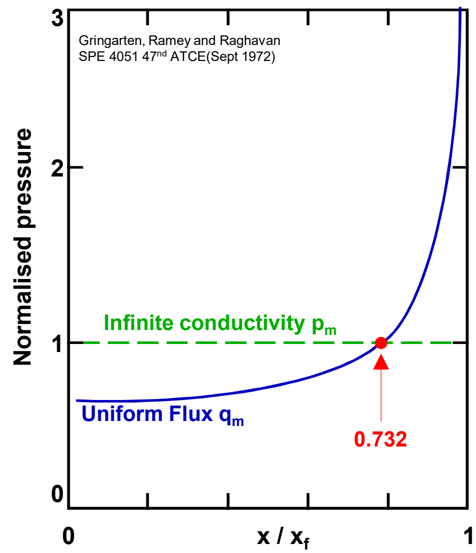


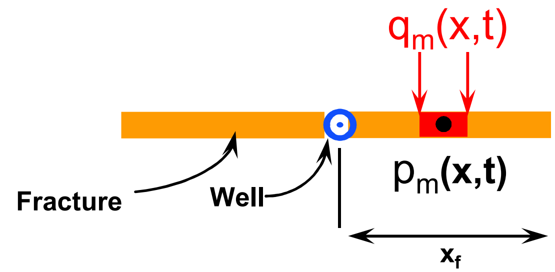
FINITE CONDUCTIVITY



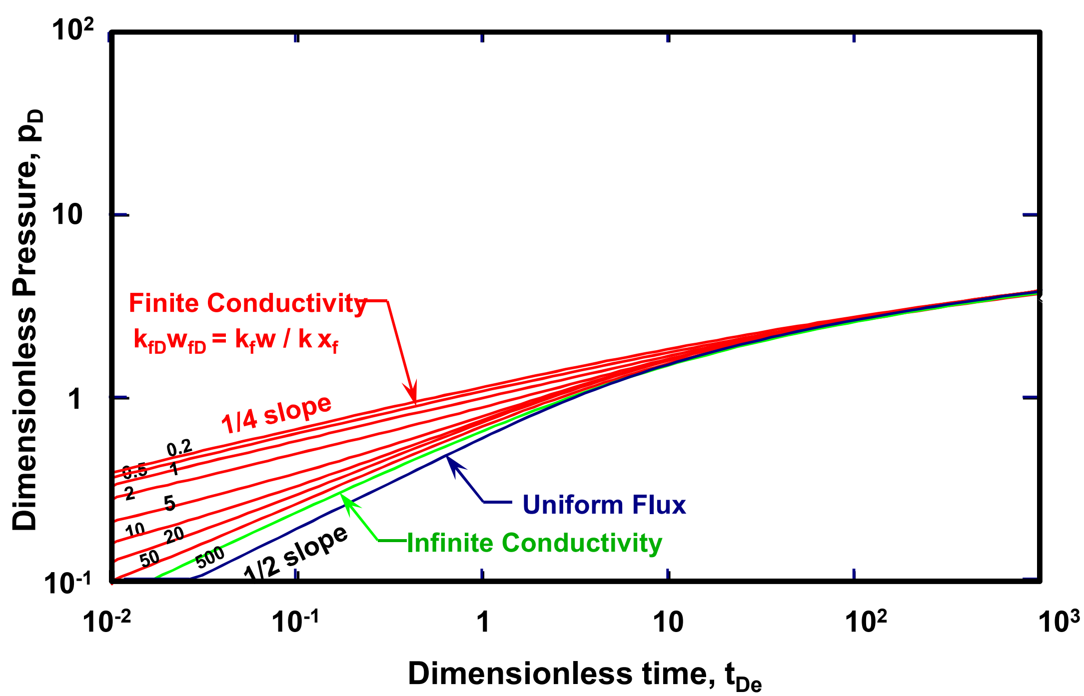
UNIFORM FLUX VERTICAL FRACTURE







$q_m(x,t)$ influx / unit area / unit time

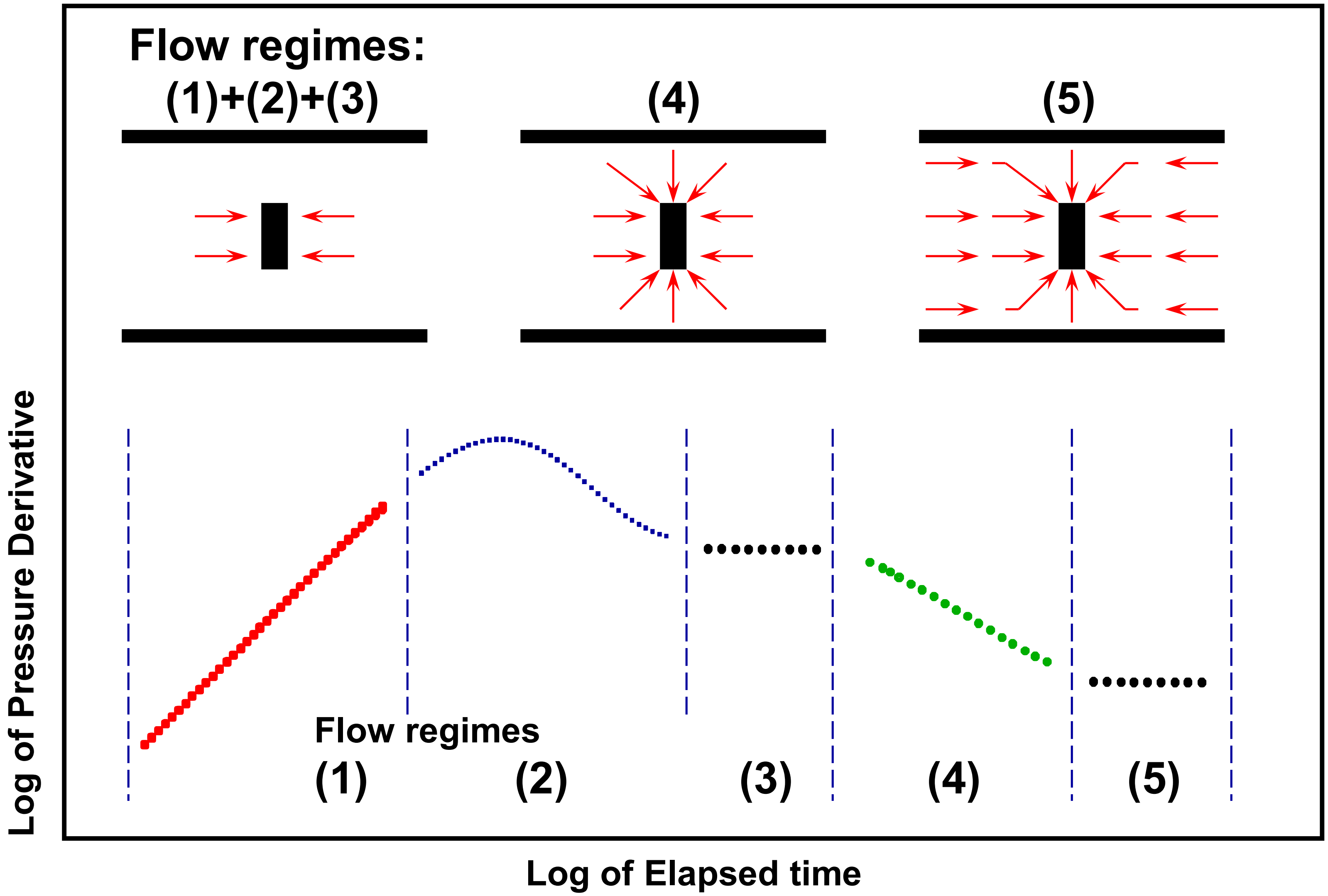


- $q_m(x,t)$ uniform (constant) over the fracture length:
  UNIFORM FLUX FRACTURE
- $p_m(x,t)$ uniform (constant) over the fracture length:
  INFINITE CONDUCTIVITY FRACTURE
- Infinite fracture is a limiting case of
  FINITE CONDUCTIVITY FRACTURE

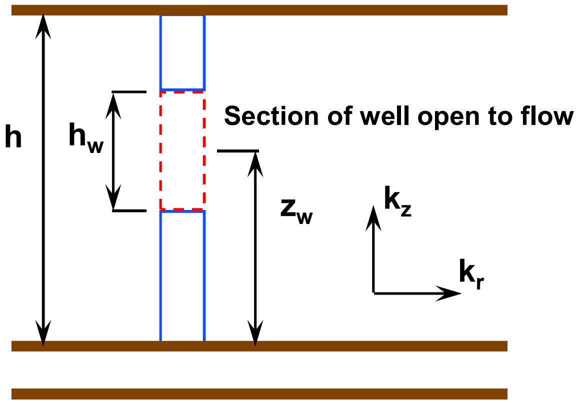
WELL TEST INTERPRETATION MODELS

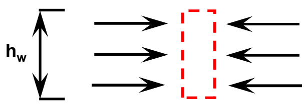
NEAR WELLBORE EFFECTS	RESERVOIR BEHAVIOUR	BOUNDARY EFFECTS
Wellbore Storage	**Homogeneous**	**Infinite extent**
Skin	Heterogeneous	Specified Rate
Fracture	-2-Porosity	Specified Pressure
Partial Penetration	-2-Permeability	Leaky Boundary
	-Composite	
Horizontal Well		
EARLY TIMES	MIDDLE TIMES	LATE TIMES

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

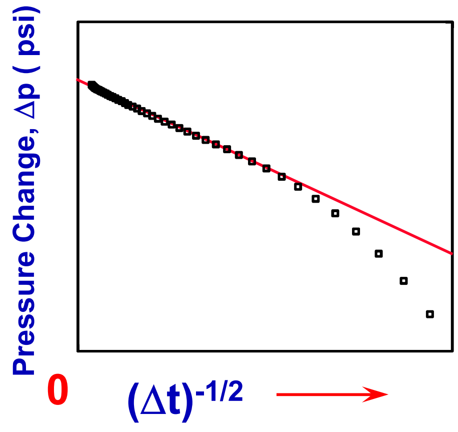


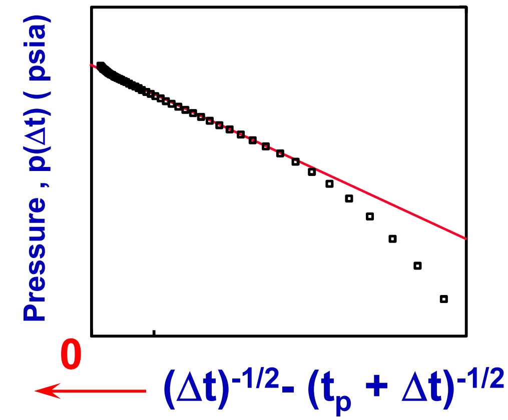
STRAIGHT LINE METHOD FOR SPHERICAL FLOW (Middle Times)





Radial flow over open interval



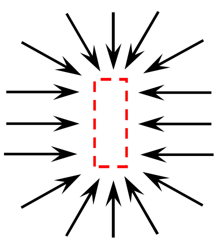


Specialised Plot

$$\Delta p = 70.6\frac{\Delta qB\mu}{k_{\mathrm{SPH}} r_{\mathrm{SPH}}} - 2452.9\frac{\Delta qB\mu\sqrt{\phi\mu c_t}}{k_{\mathrm{SPH}}^{3/2}\sqrt{\Delta t}}$$

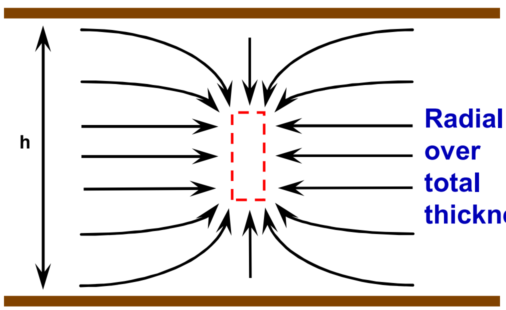
Horner Plot

$$p(\Delta t) = \bar{p}_i - 70.6\frac{\Delta qB\mu}{k_{\mathrm{SPH}} r_{\mathrm{SPH}}} - 2452.9\frac{\Delta qB\mu\left(\phi\mu c_t\right)^{1/2}}{\left(k_{\mathrm{SPH}}\right)^{3/2}}\left[\left(\Delta t\right)^{-1/2} - \left(t_p + \Delta t\right)^{-1/2}\right]$$



Spherical flow

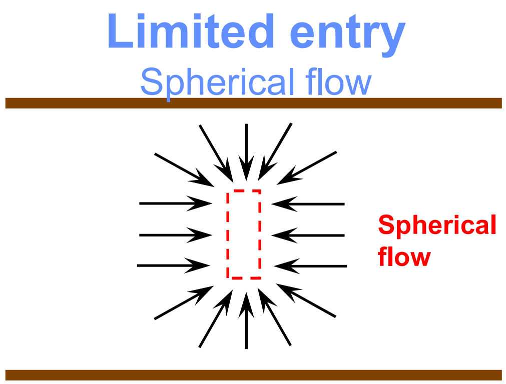
$$k_{\mathrm{SPH}} = \sqrt[3]{k_r^2 k_z}$$



Radial flow over total thickness

$$m_{\mathrm{SPH}} = 2452.9\frac{\Delta qB\mu\left(\phi\mu c_t\right)^{1/2}}{\left(k_{\mathrm{SPH}}\right)^{3/2}} \qquad k_{\mathrm{SPH}} = \left[2452.9\frac{\Delta qB\mu\left(\phi\mu c_t\right)^{1/2}}{m_{\mathrm{SPH}}}\right]^{2/3} \text{ mD}$$

DERIVATIVE FOR SPHERICAL FLOW (Middle Times)



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

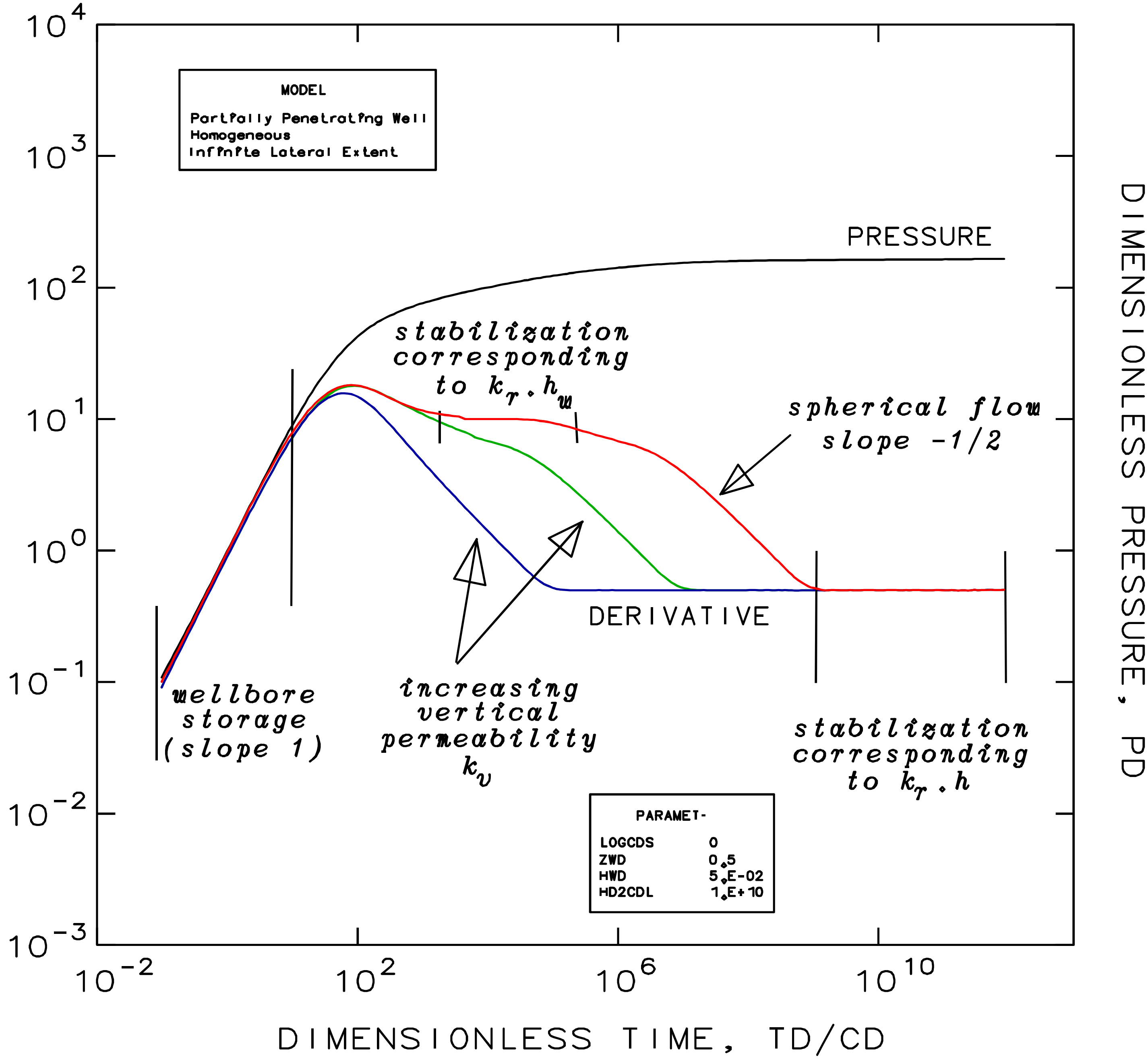
$$p_{\mathrm{SPH}\,D} = \frac{k_{\mathrm{SPH}}\, r_{\mathrm{SPH}}}{141.2\ \Delta q B \mu}\Delta p$$

$$t_{\mathrm{SPH}\,D} = \frac{0.00264\, k_{\mathrm{SPH}}}{\phi\, \mu\, c_t\, r_{\mathrm{SPH}}^2}\Delta t$$

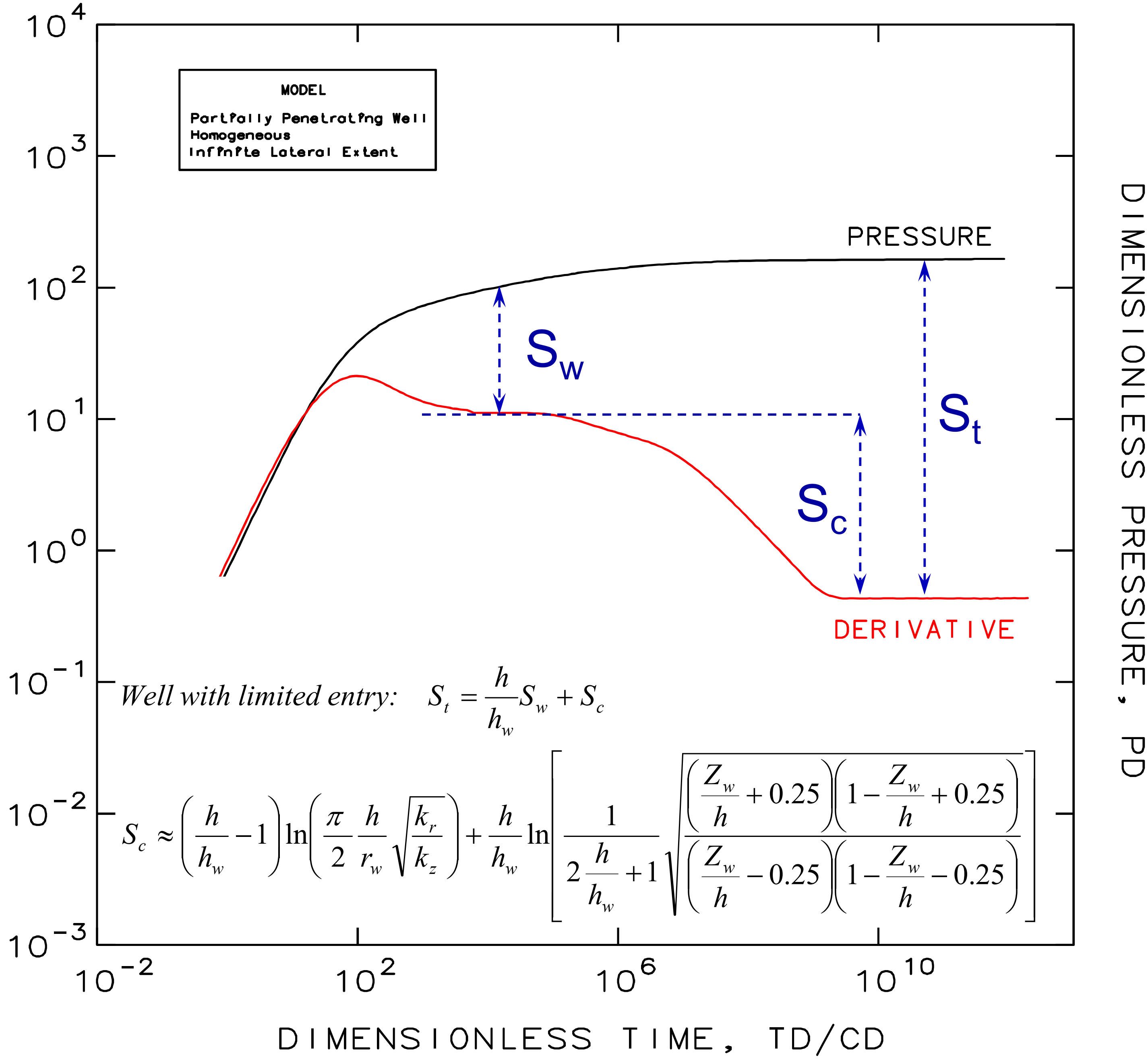
$$\frac{dp_D}{d\ln\left(t_{\mathrm{SPH}\,D}\right)} = \frac{1}{2}\left[\frac{1}{2}\left(\pi\, t_{\mathrm{SPH}\,D}\right)^{-1/2}\right]$$

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

WELL WITH LIMITED ENTRY



WELL WITH LIMITED ENTRY

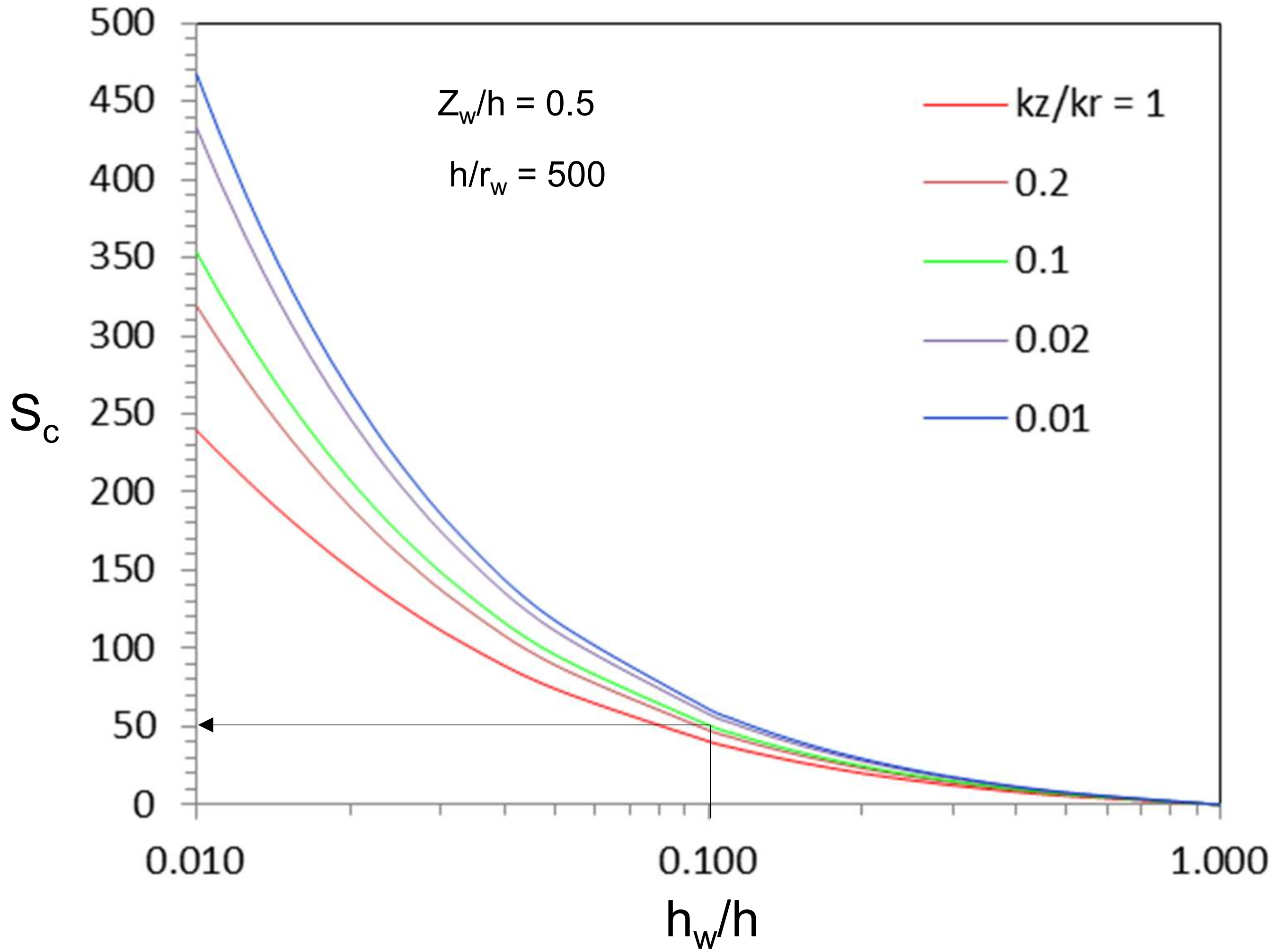


Well with limited entry: $S_t = \frac{h}{h_w} S_w + S_c$

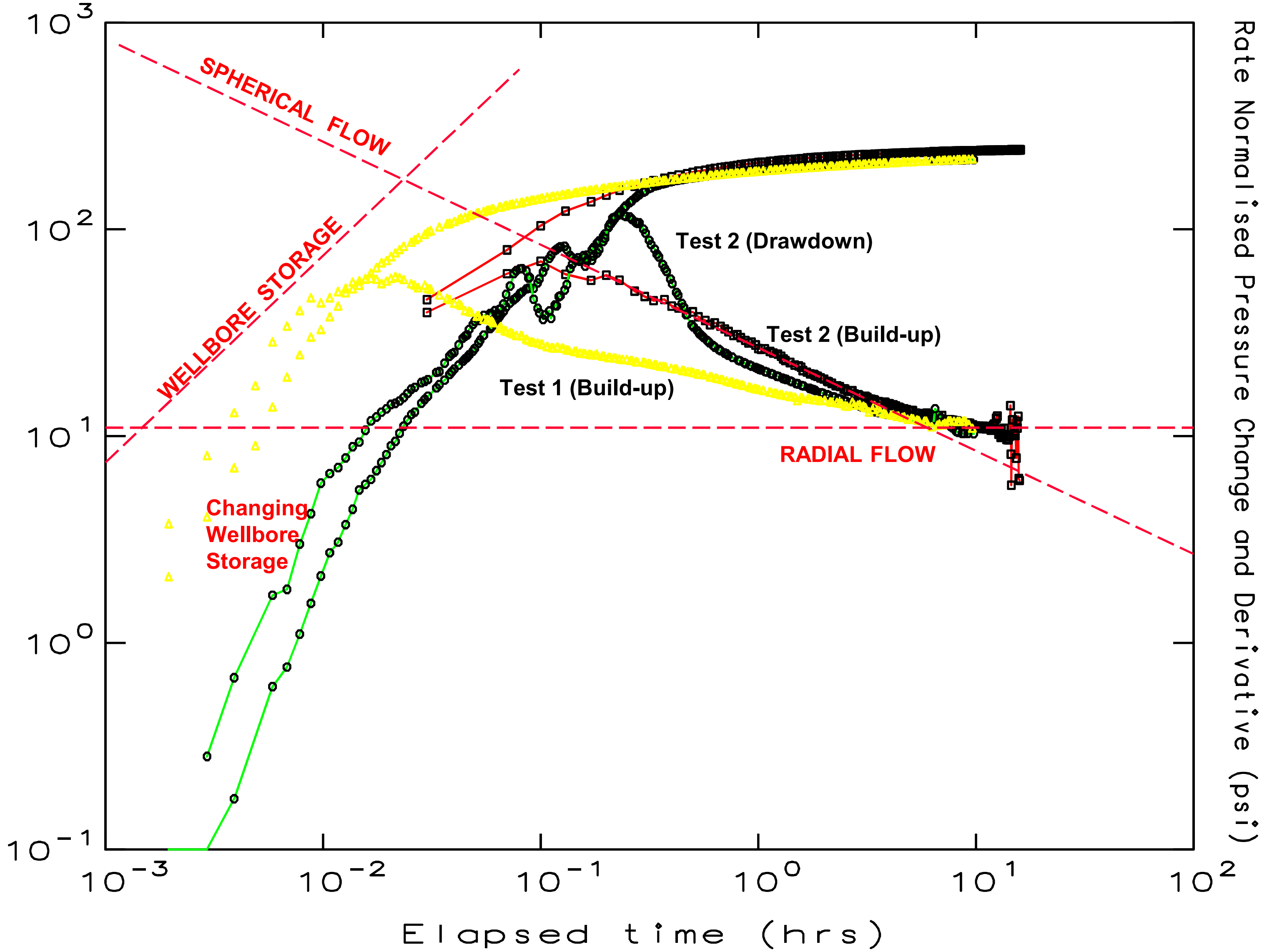
$$S_c \approx \left(\frac{h}{h_w}-1\right)\ln\left(\frac{\pi}{2}\frac{h}{r_w}\sqrt{\frac{k_r}{k_z}}\right) + \frac{h}{h_w}\ln\left[\frac{1}{2\frac{h}{h_w}+1}\sqrt{\frac{\left(\frac{Z_w}{h}+0.25\right)\left(1-\frac{Z_w}{h}+0.25\right)}{\left(\frac{Z_w}{h}-0.25\right)\left(1-\frac{Z_w}{h}-0.25\right)}}\right]$$

WELL WITH LIMITED ENTRY

$$S_c \approx \left(\frac{h}{h_w}-1\right)\ln\left(\frac{\pi}{2}\frac{h}{r_w}\sqrt{\frac{k_r}{k_z}}\right)+\frac{h}{h_w}\ln\left[\frac{1}{2\frac{h}{h_w}+1}\sqrt{\frac{\left(\frac{Z_w}{h}+0.25\right)\left(1-\frac{Z_w}{h}+0.25\right)}{\left(\frac{Z_w}{h}-0.25\right)\left(1-\frac{Z_w}{h}-0.25\right)}}\right]$$

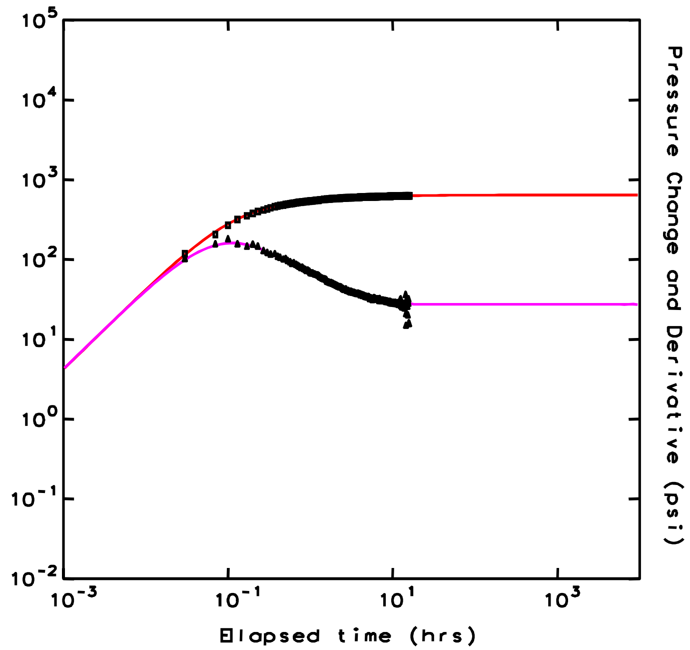


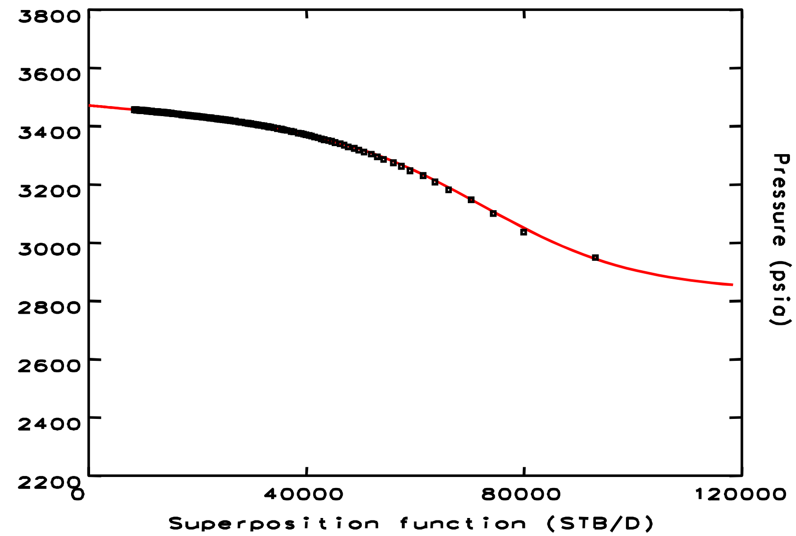
Maureen A2

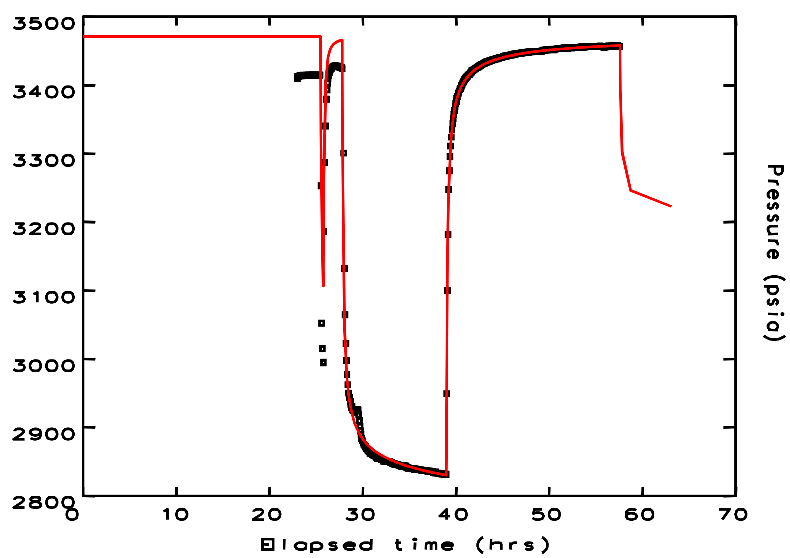


SPHERICAL FLOW
WELLBORE STORAGE
Test 2 (Drawdown)
Test 2 (Build-up)
Test 1 (Build-up)
RADIAL FLOW
Changing
Wellbore
Storage
10³
10²
10¹
10⁰
10⁻¹
10⁻³
10⁻²
10⁻¹
10⁰
10¹
10²
Elapsed time (hrs)
Rate Normalised Pressure Change and Derivative (psi)

Maureen A2 Test 1 (Exploration)



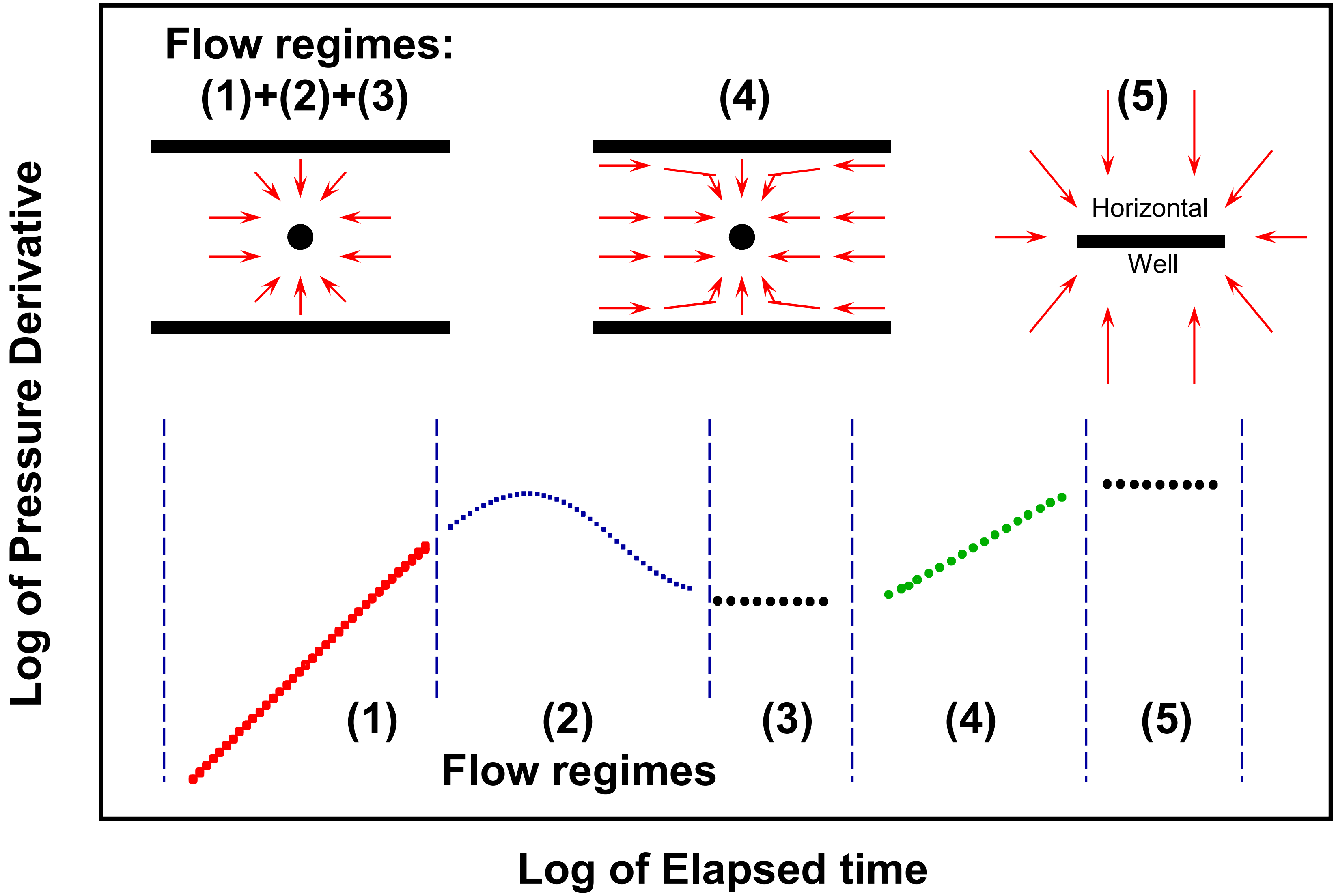




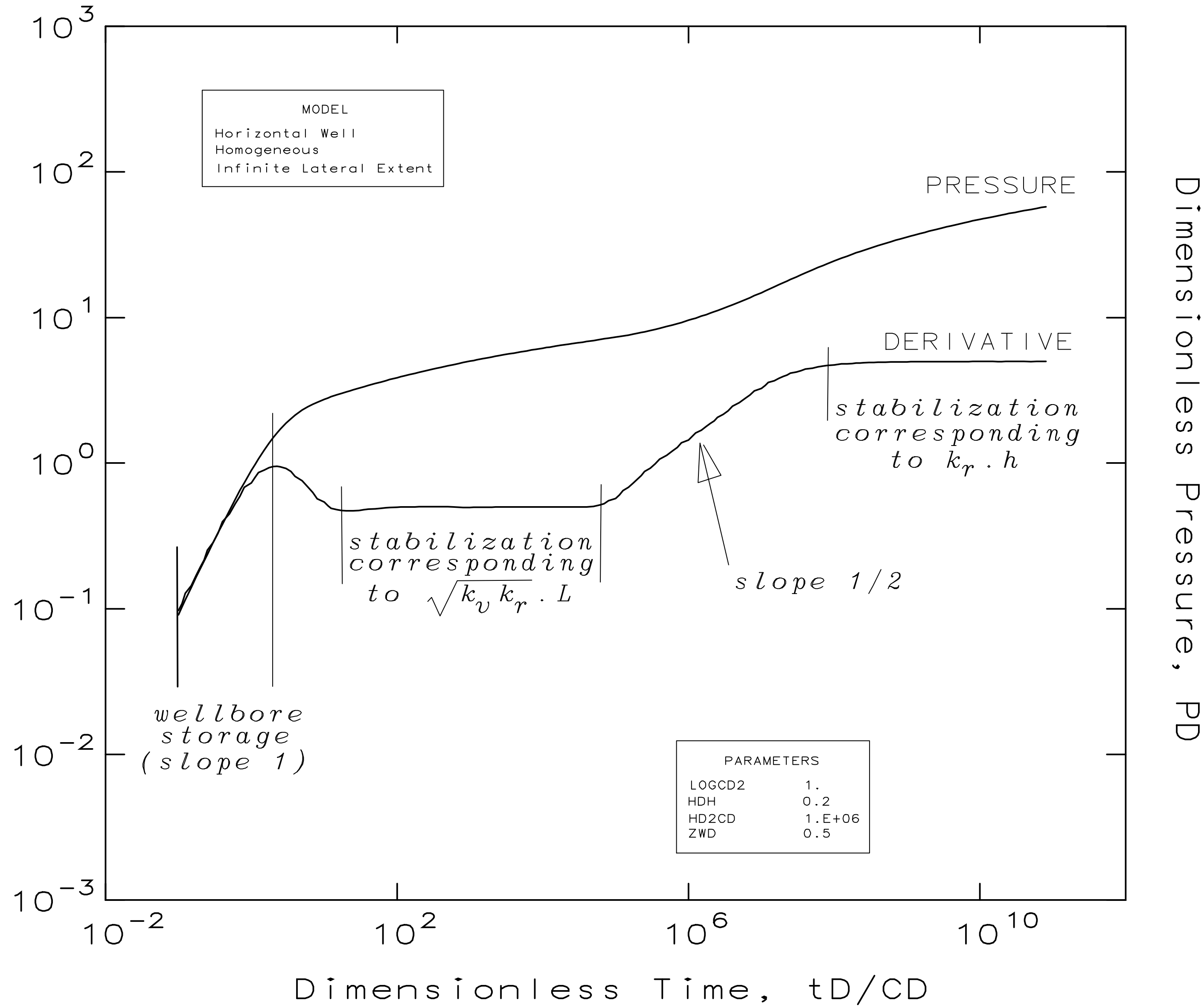
WELL TEST INTERPRETATION MODELS

NEAR WELLBORE EFFECTS	RESERVOIR BEHAVIOUR	BOUNDARY EFFECTS
Wellbore Storage	Homogeneous	Infinite extent
Skin	Heterogeneous	Specified Rate
Fracture	-2-Porosity	Specified Pressure
Partial Penetration	-2-Permeability	Leaky Boundary
Horizontal Well	-Composite	
EARLY TIMES	MIDDLE TIMES	LATE TIMES

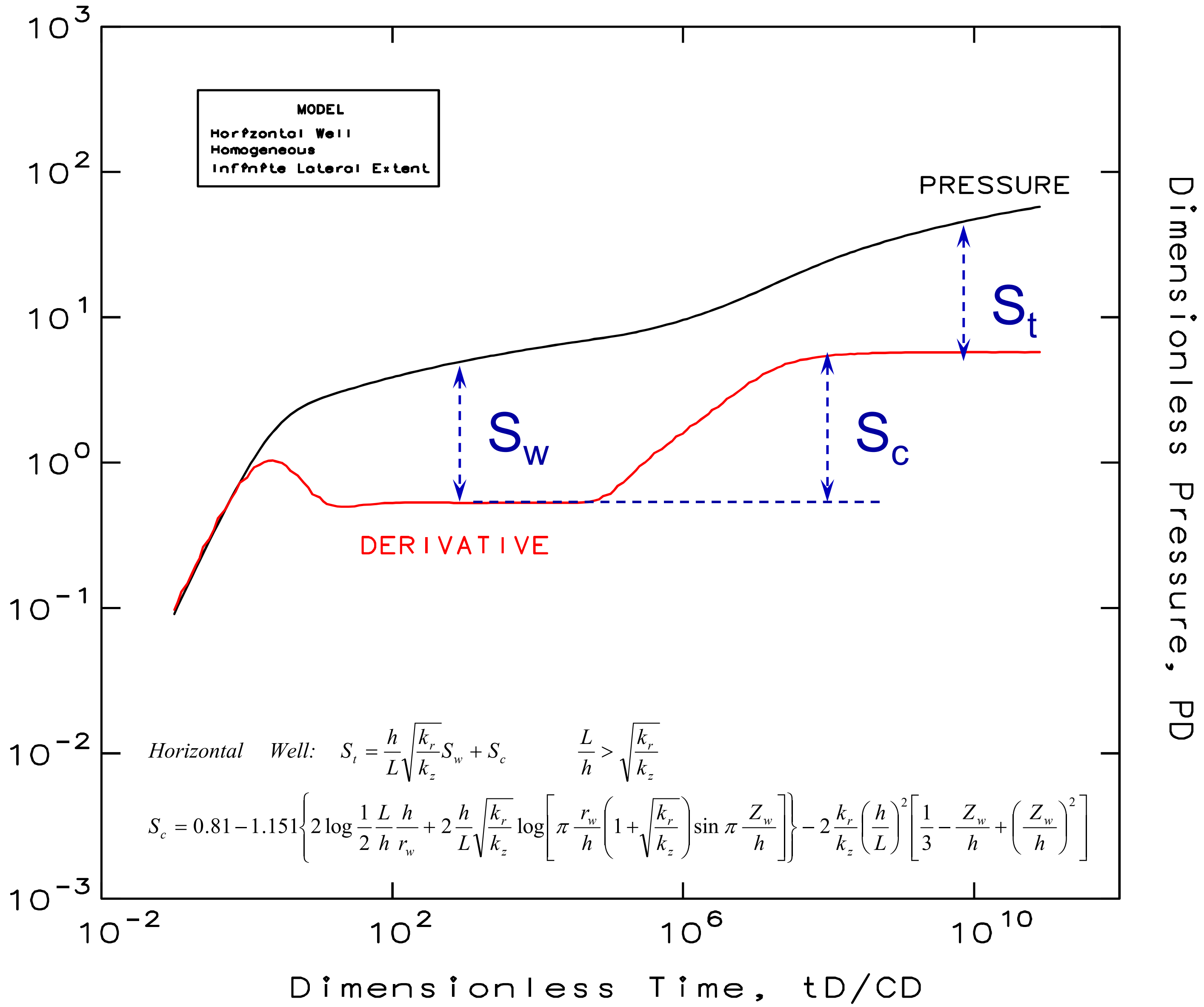
Horizontal well with wellbore storage and skin in an infinite reservoir with homogeneous behaviour



HORIZONTAL WELL



HORIZONTAL WELL

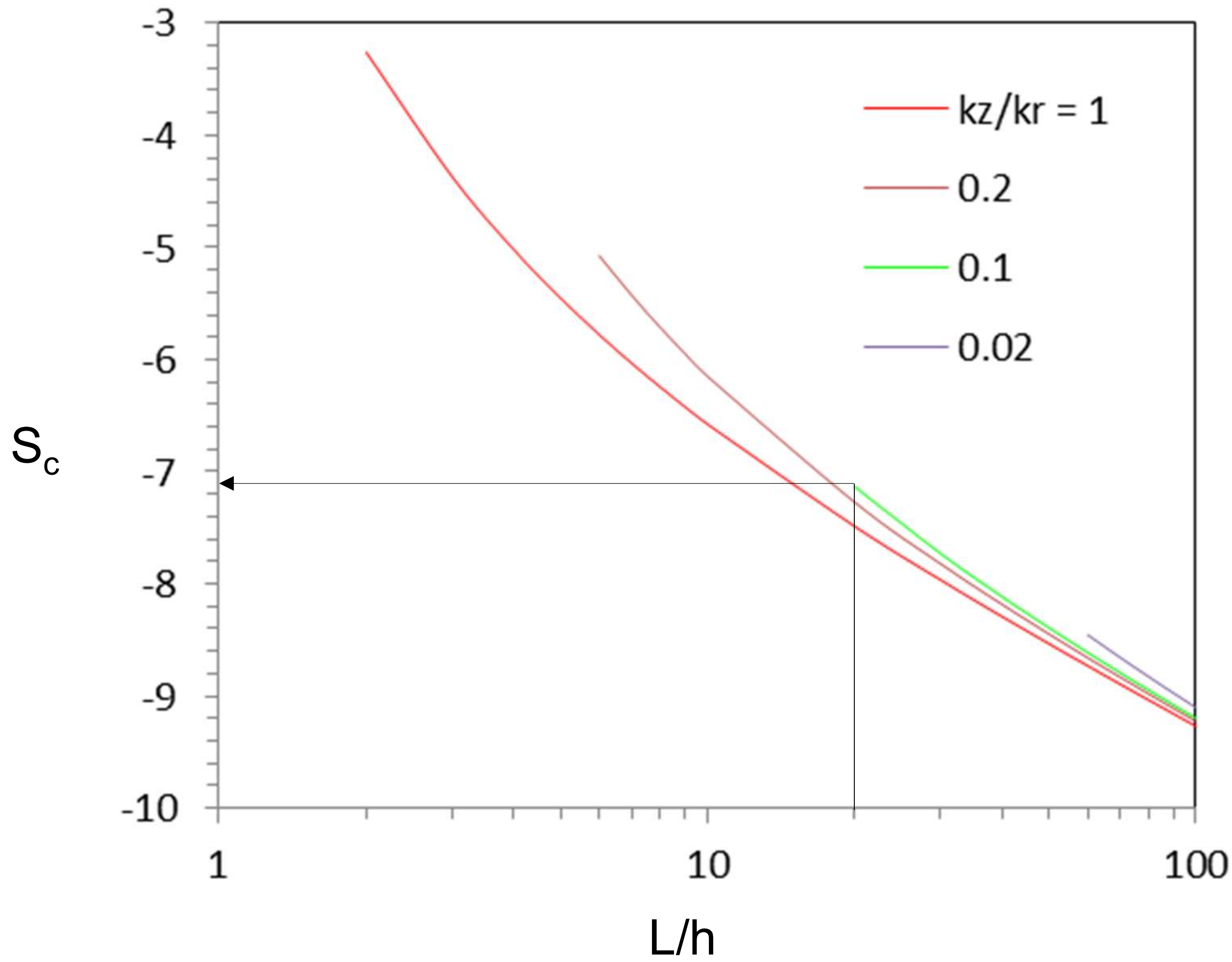


Horizontal Well: $S_t = \frac{h}{L}\sqrt{\frac{k_r}{k_z}}S_w + S_c \qquad \frac{L}{h} > \sqrt{\frac{k_r}{k_z}}$

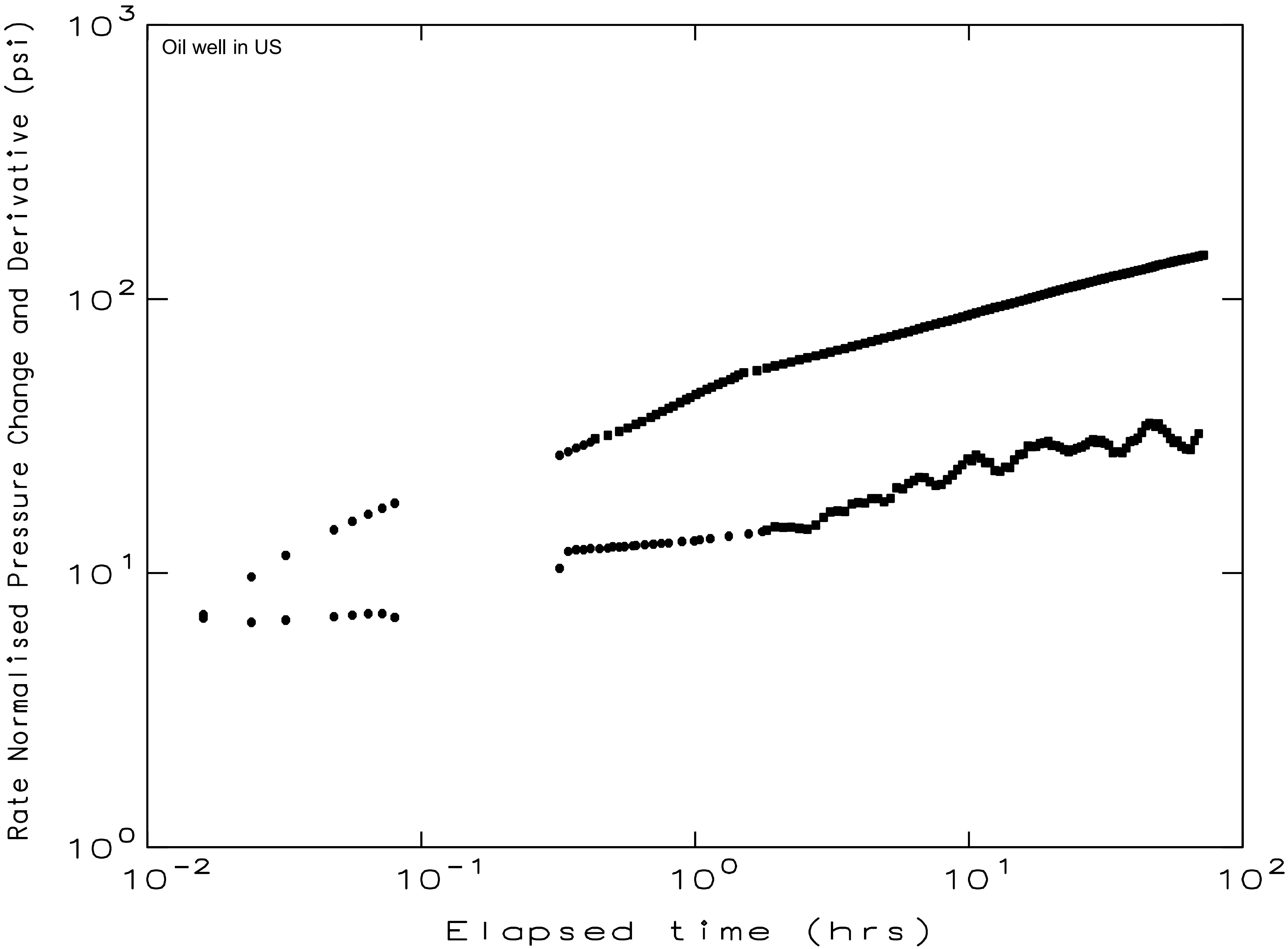
$$S_c = 0.81 - 1.151\left\{2\log\frac{1}{2}\frac{L}{h}\frac{h}{r_w} + 2\frac{h}{L}\sqrt{\frac{k_r}{k_z}}\log\left[\pi\frac{r_w}{h}\left(1+\sqrt{\frac{k_r}{k_z}}\right)\sin\pi\frac{Z_w}{h}\right]\right\} - 2\frac{k_r}{k_z}\left(\frac{h}{L}\right)^2\left[\frac{1}{3} - \frac{Z_w}{h} + \left(\frac{Z_w}{h}\right)^2\right]$$

HORIZONTAL WELL

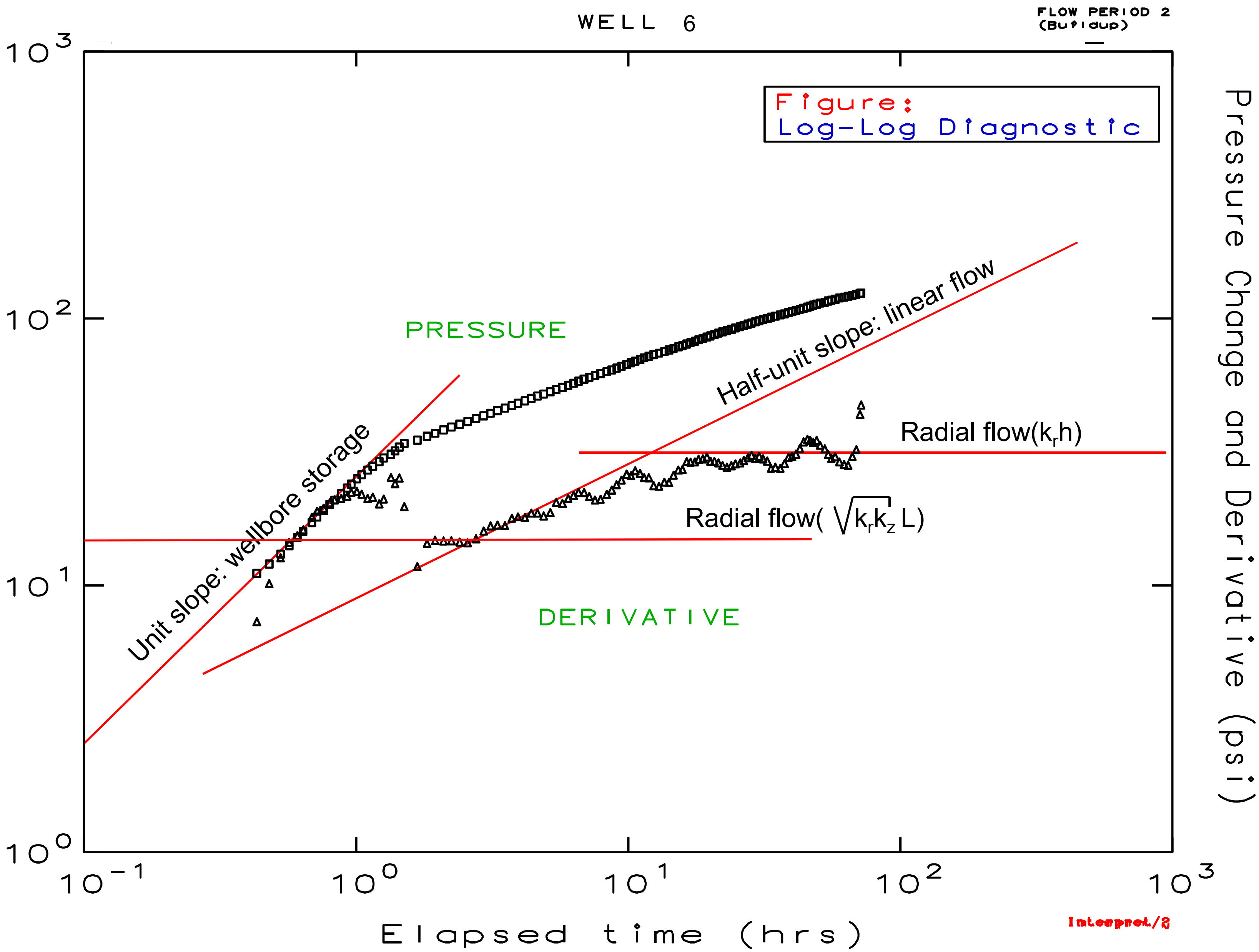
$$S_c = 0.81 - 1.151\left\{2\log\frac{1}{2}\frac{L}{h}\frac{h}{r_w} + 2\frac{h}{L}\sqrt{\frac{k_r}{k_z}}\log\left[\pi\frac{r_w}{h}\left(1+\sqrt{\frac{k_r}{k_z}}\right)\sin\pi\frac{Z_w}{h}\right]\right\} - 2\frac{k_r}{k_z}\left(\frac{h}{L}\right)^2\left[\frac{1}{3} - \frac{Z_w}{h} + \left(\frac{Z_w}{h}\right)^2\right]$$



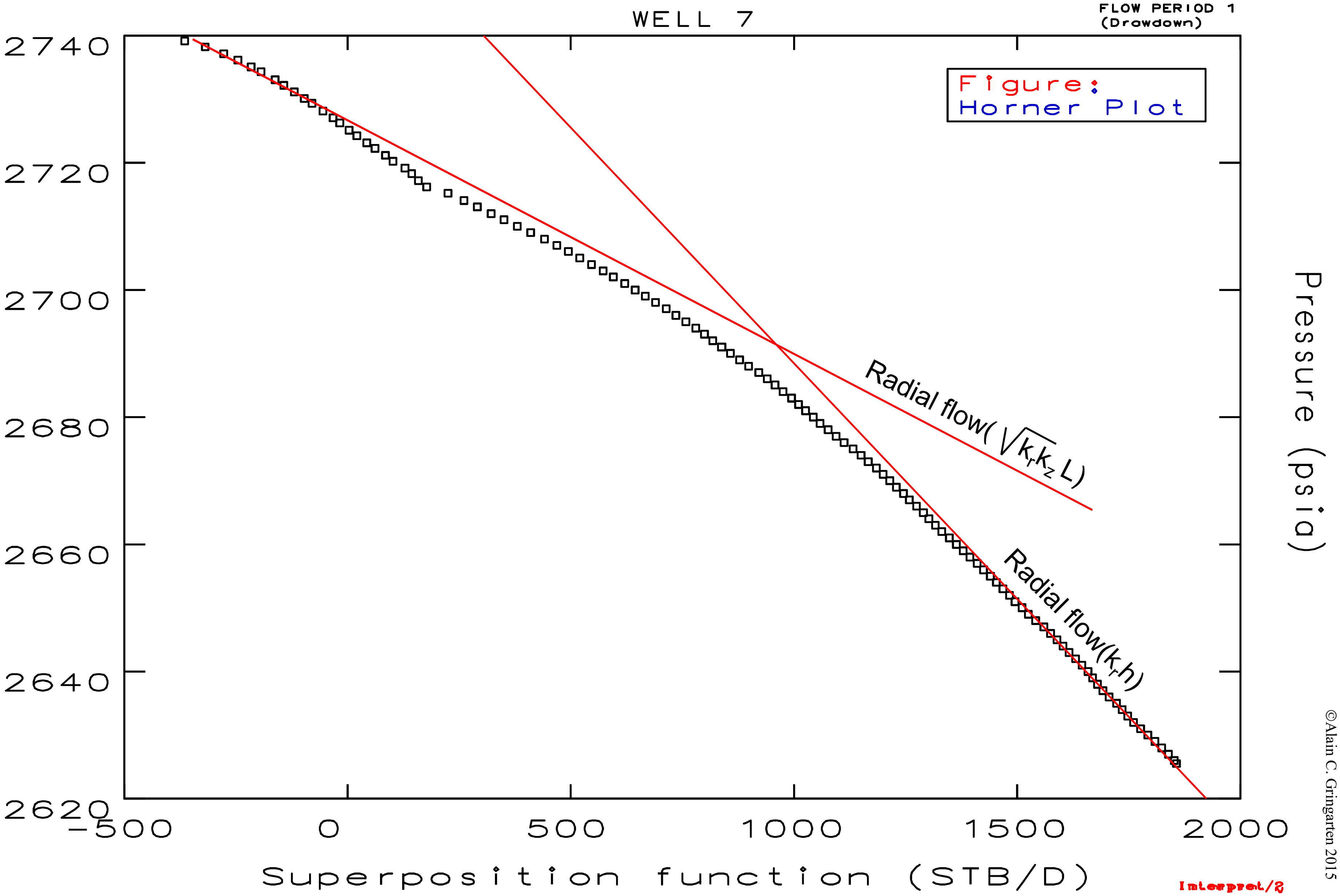
HORIZONTAL WELL



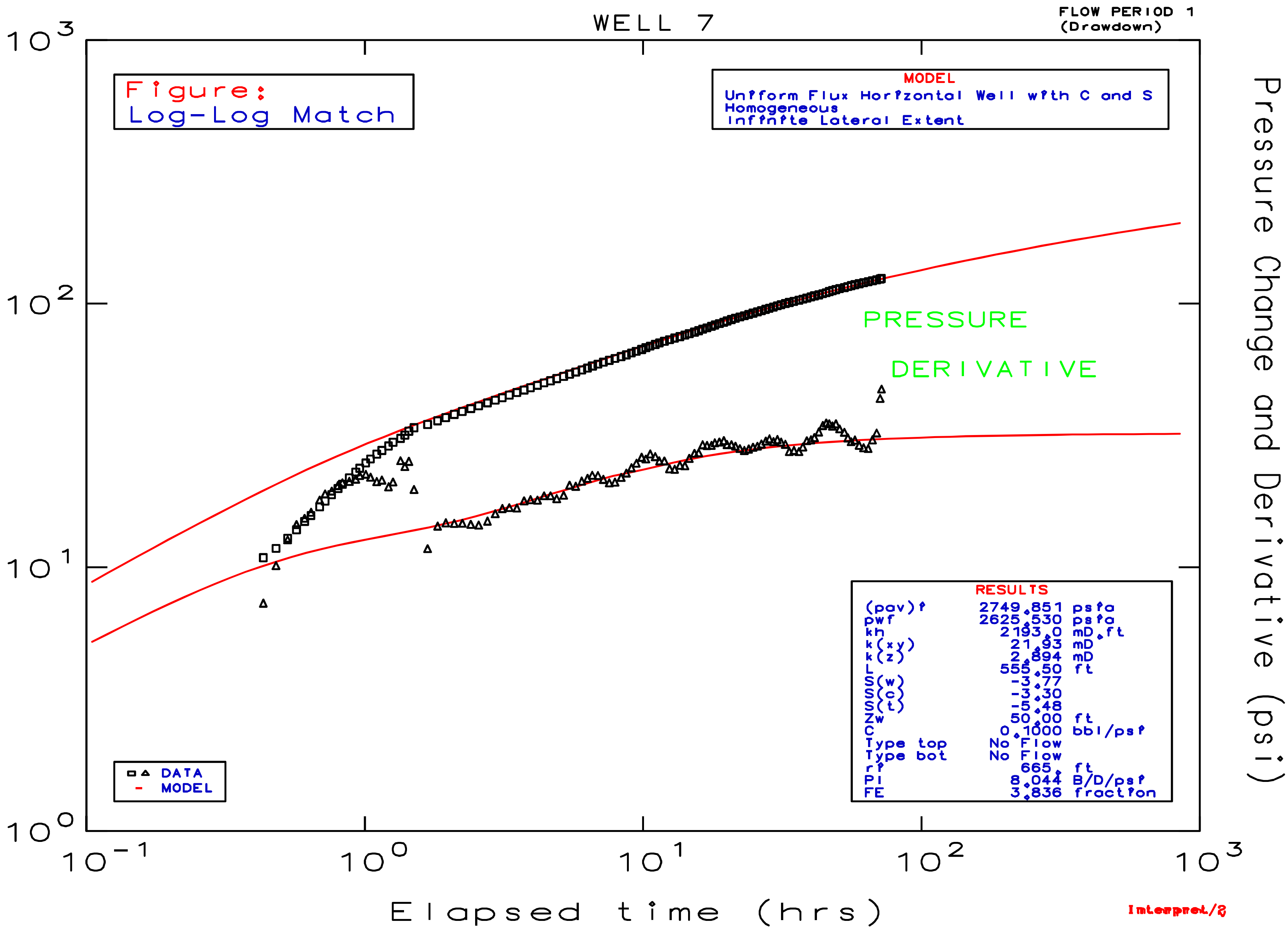
HORIZONTAL WELL



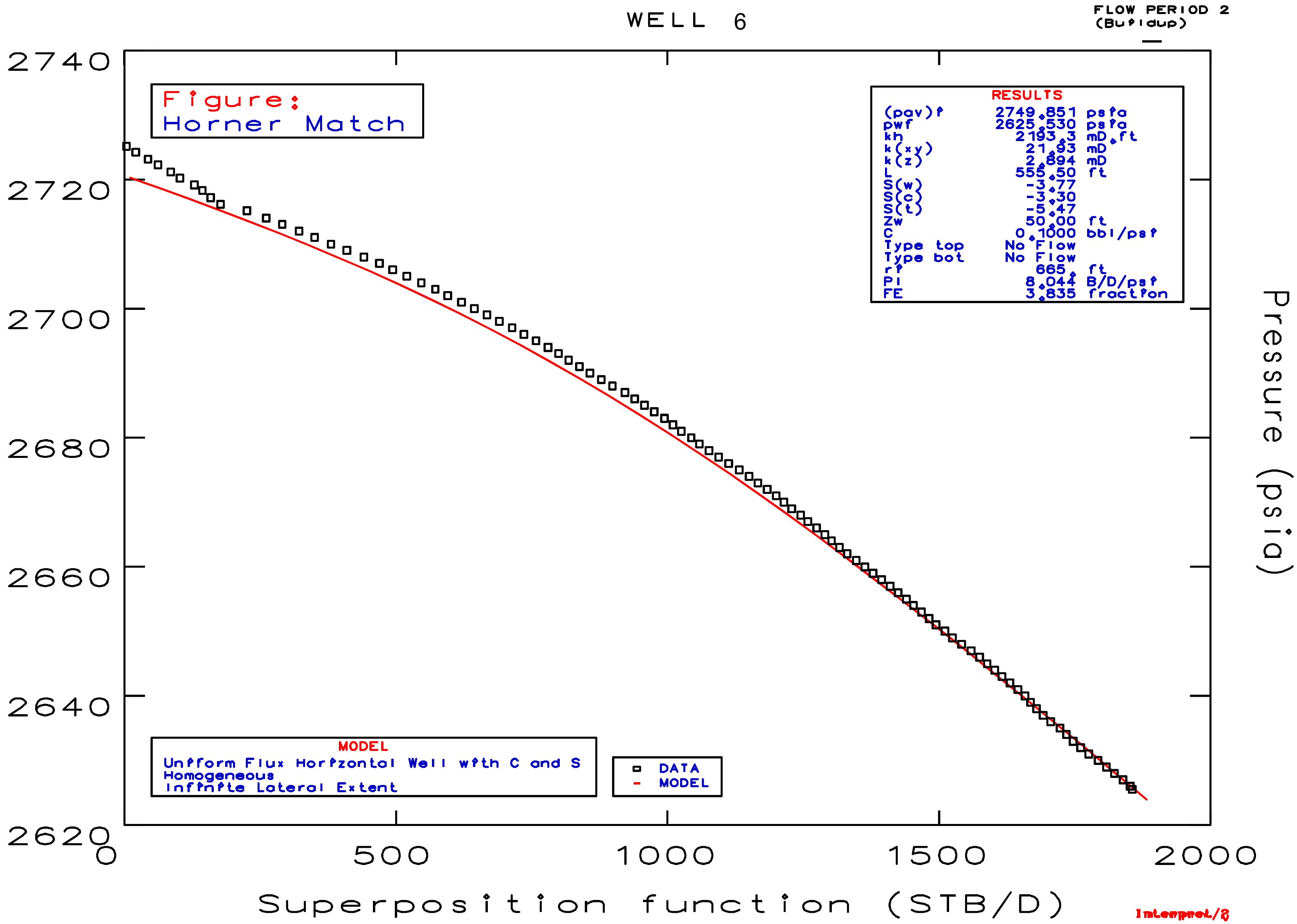
HORIZONTAL WELL



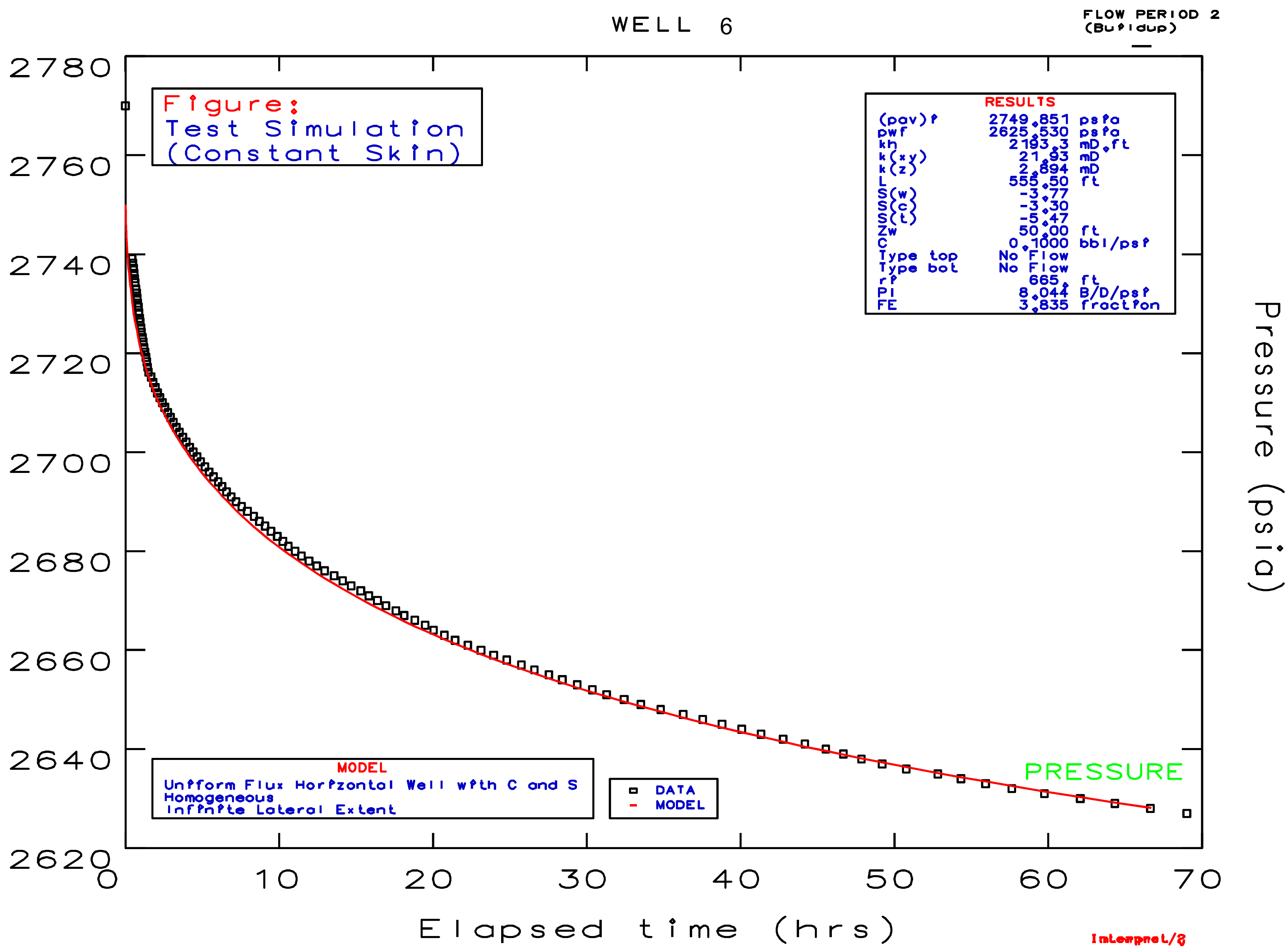
HORIZONTAL WELL



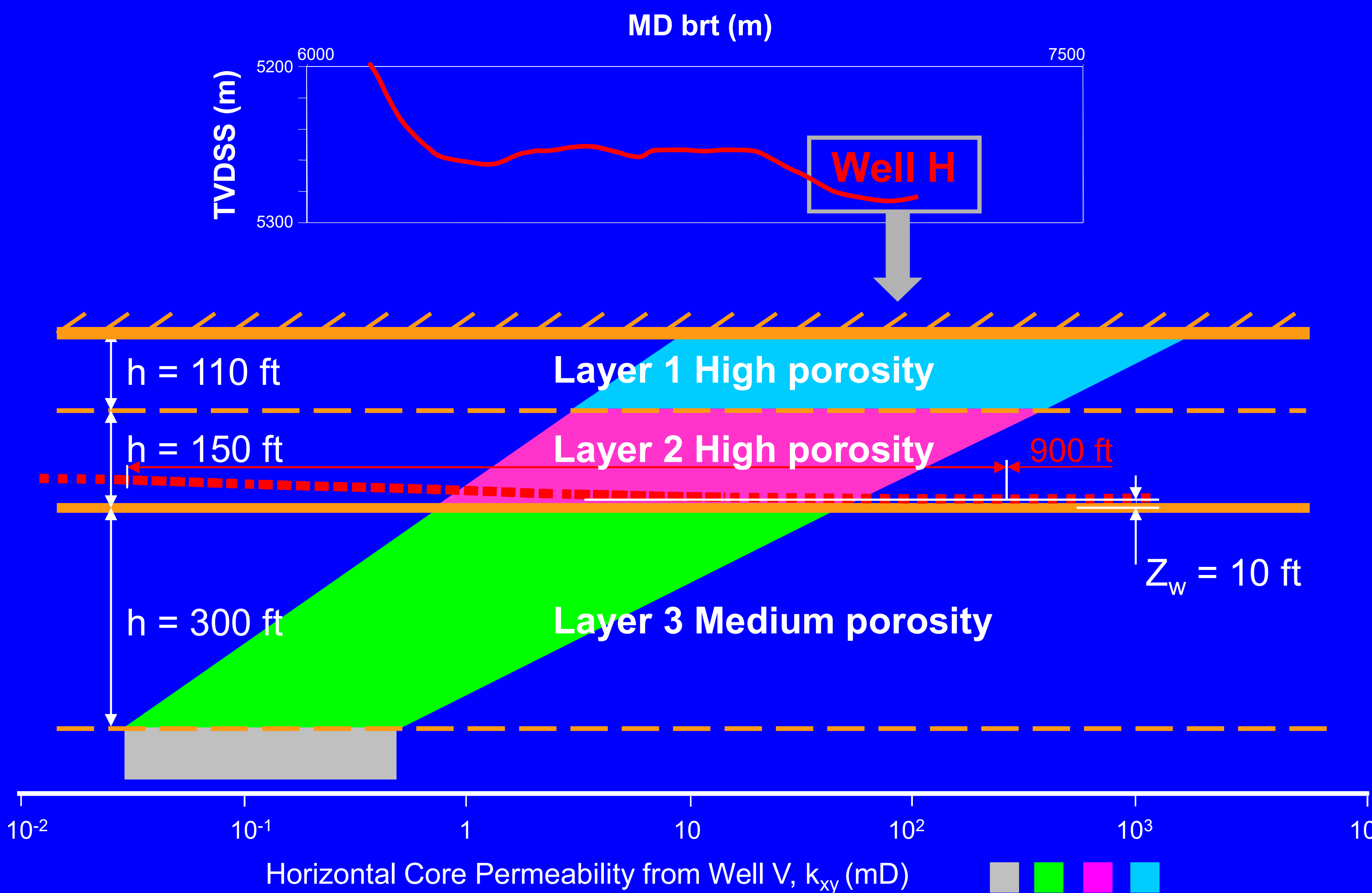
HORIZONTAL WELL



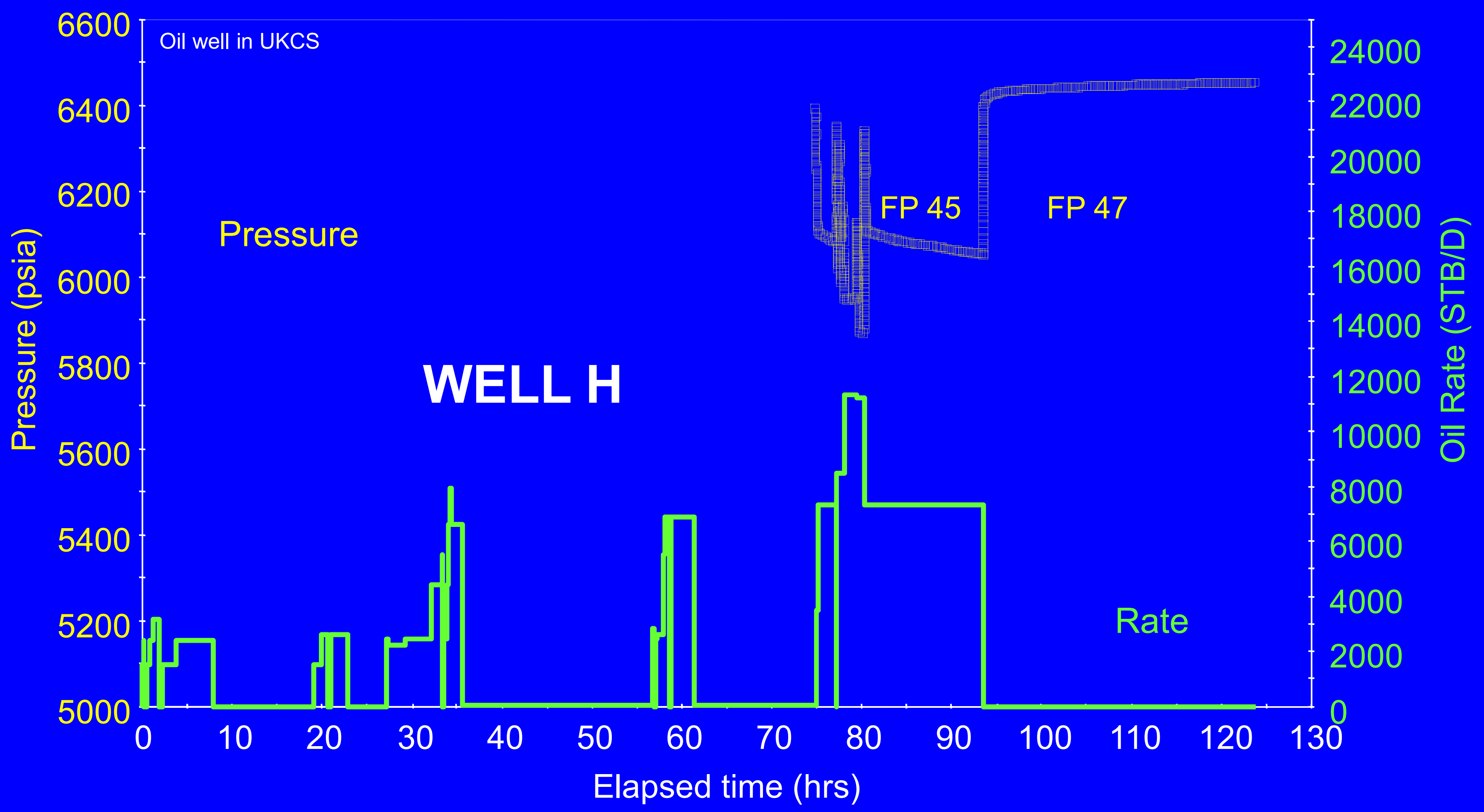
HORIZONTAL WELL

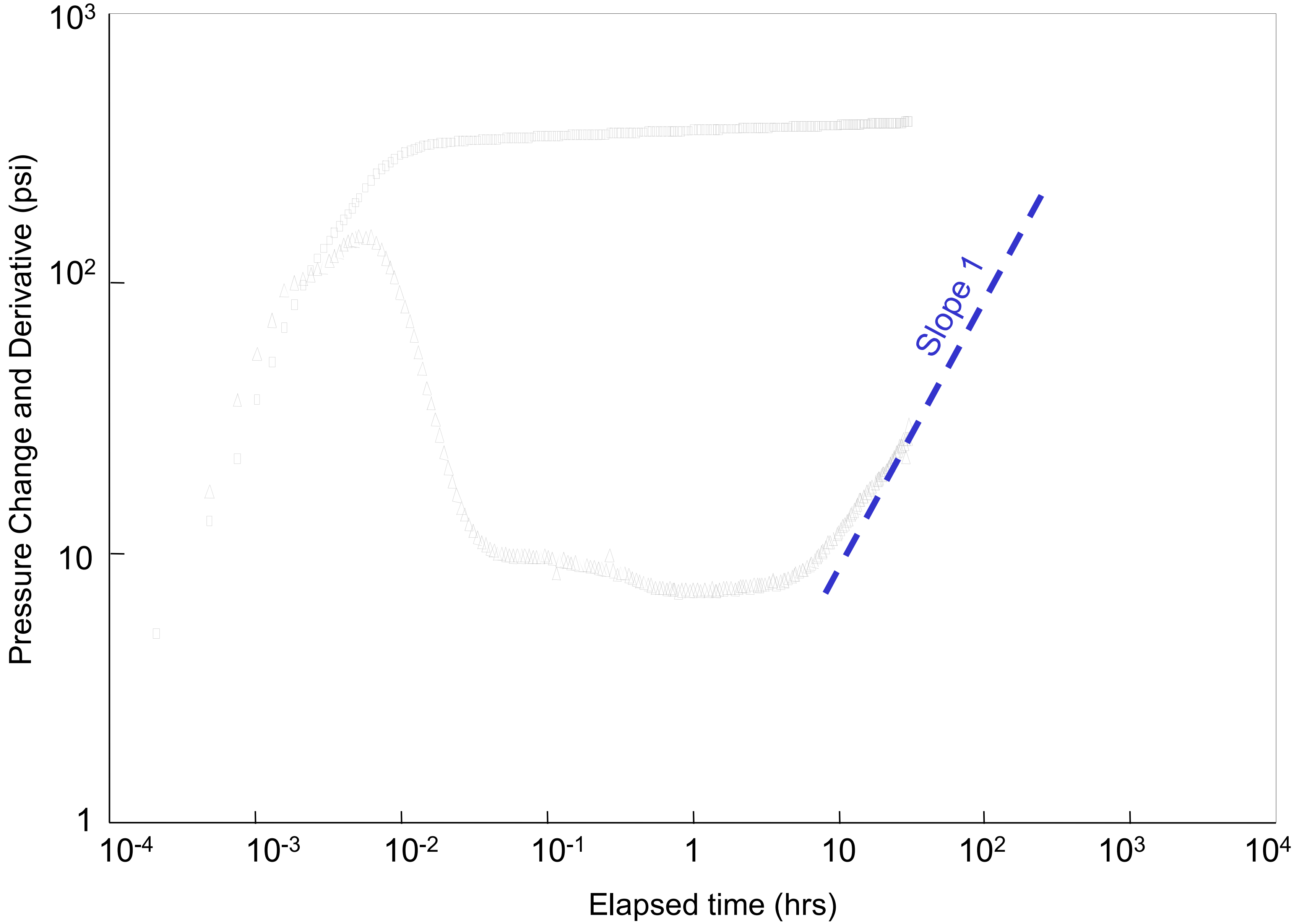


Cross section Well H

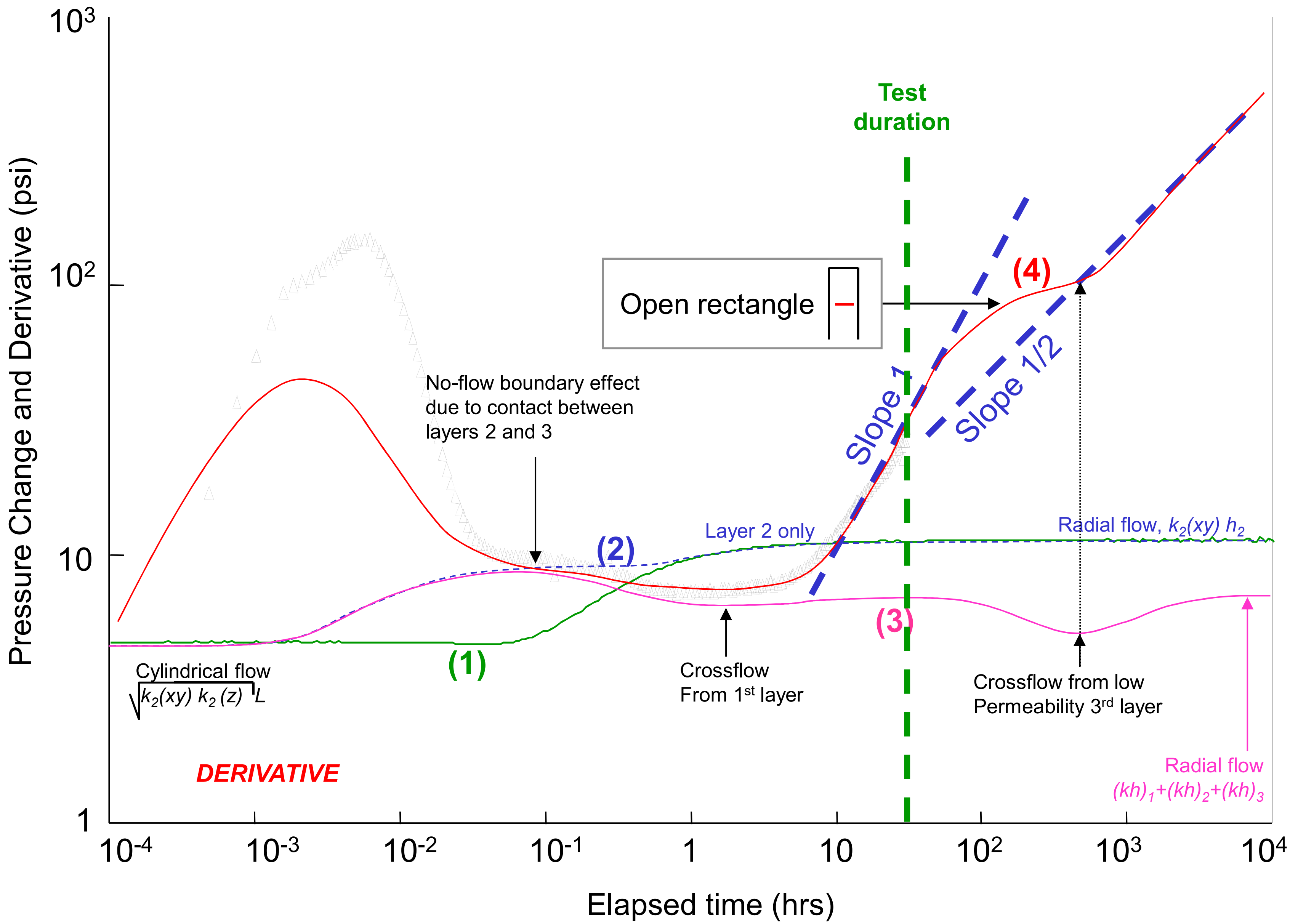


Test on Well H



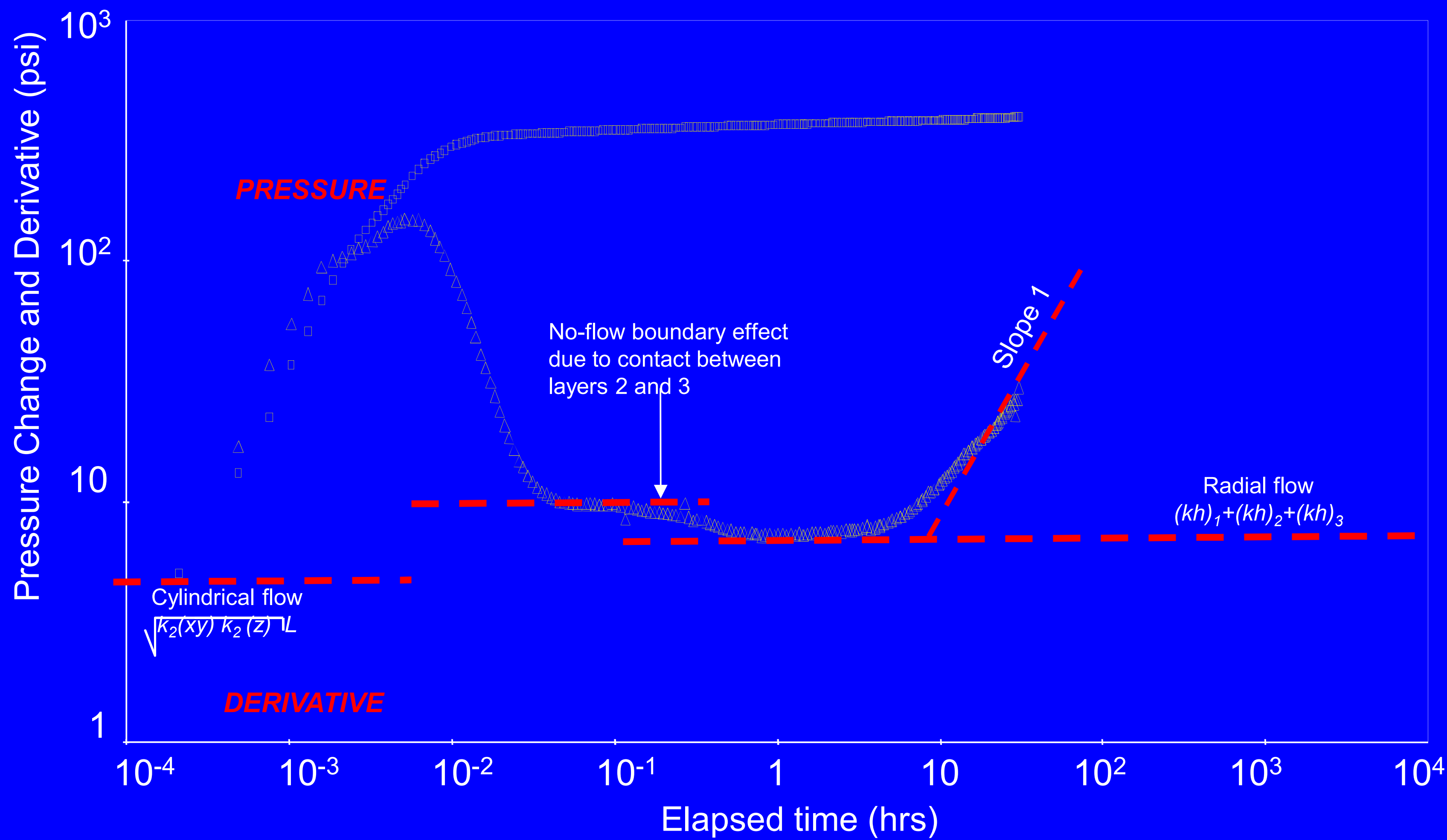


Pressure Change and Derivative (psi)
10^3
10^2
10
1
10^-4
10^-3
10^-2
10^-1
1
10
10^2
10^3
10^4
Elapsed time (hrs)
Slope 1

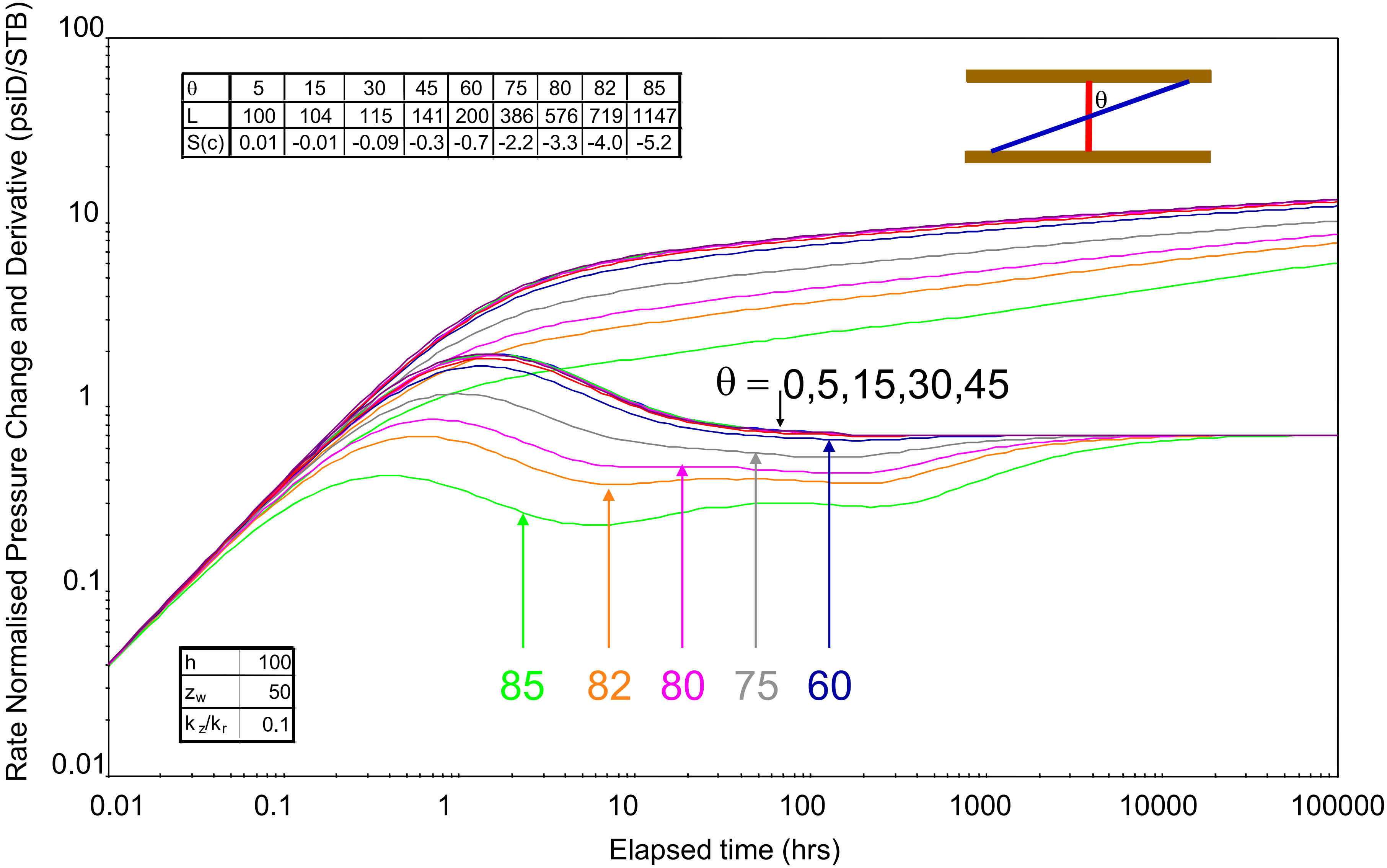


Pressure Change and Derivative (psi)
10^3
10^2
10
1
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4
Elapsed time (hrs)
Test duration
Open rectangle
(4)
Slope 1
Slope 1/2
No-flow boundary effect due to contact between layers 2 and 3
(2)
Layer 2 only
Radial flow, $k_2(xy)\ h_2$
(3)
(1)
Cylindrical flow
$\sqrt{k_2(xy)\ k_2(z)}\ L$
Crossflow From 1st layer
Crossflow from low Permeability 3rd layer
DERIVATIVE
Radial flow
$(kh)_1+(kh)_2+(kh)_3$

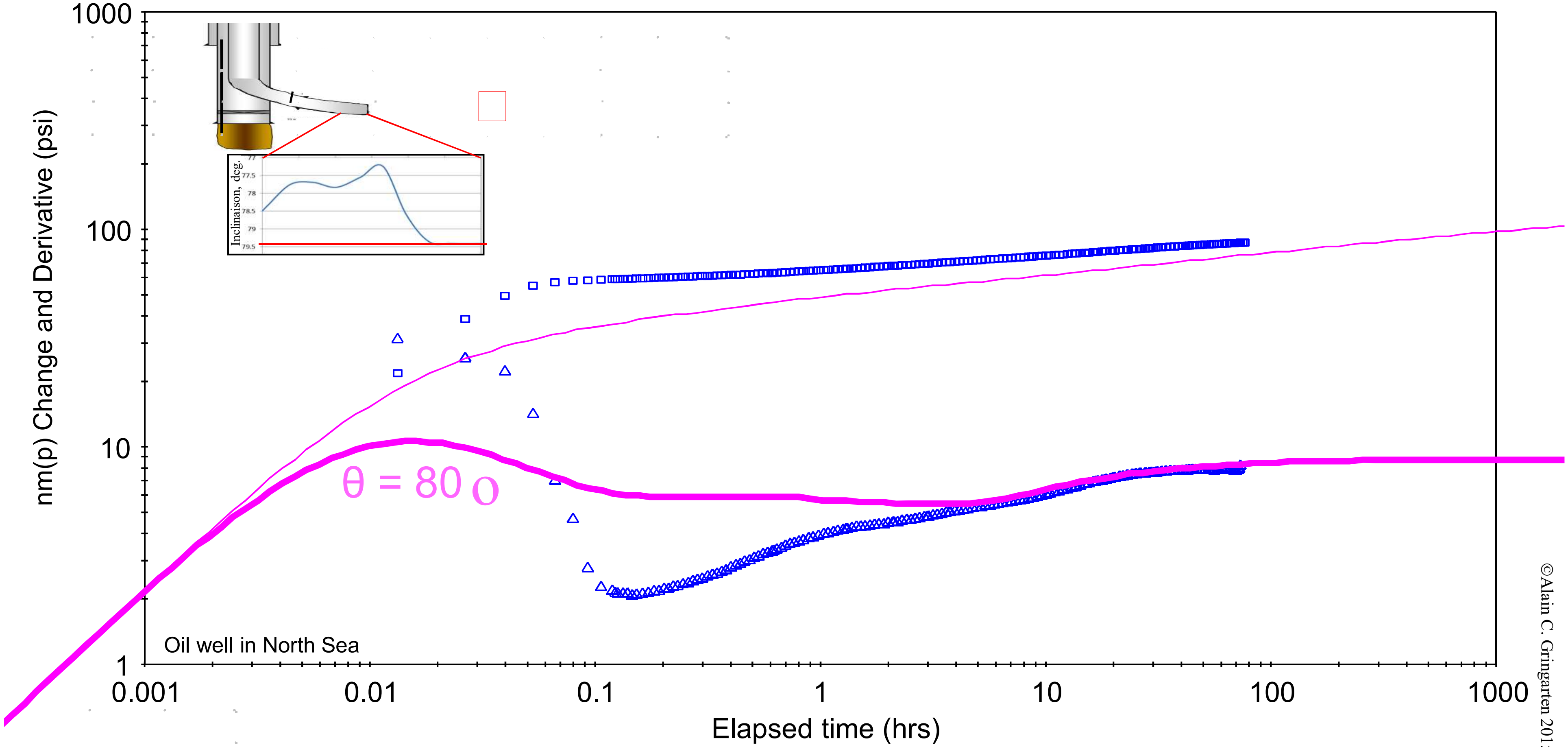
Analysis of test on Well H



INCLINED WELL



80^0 well

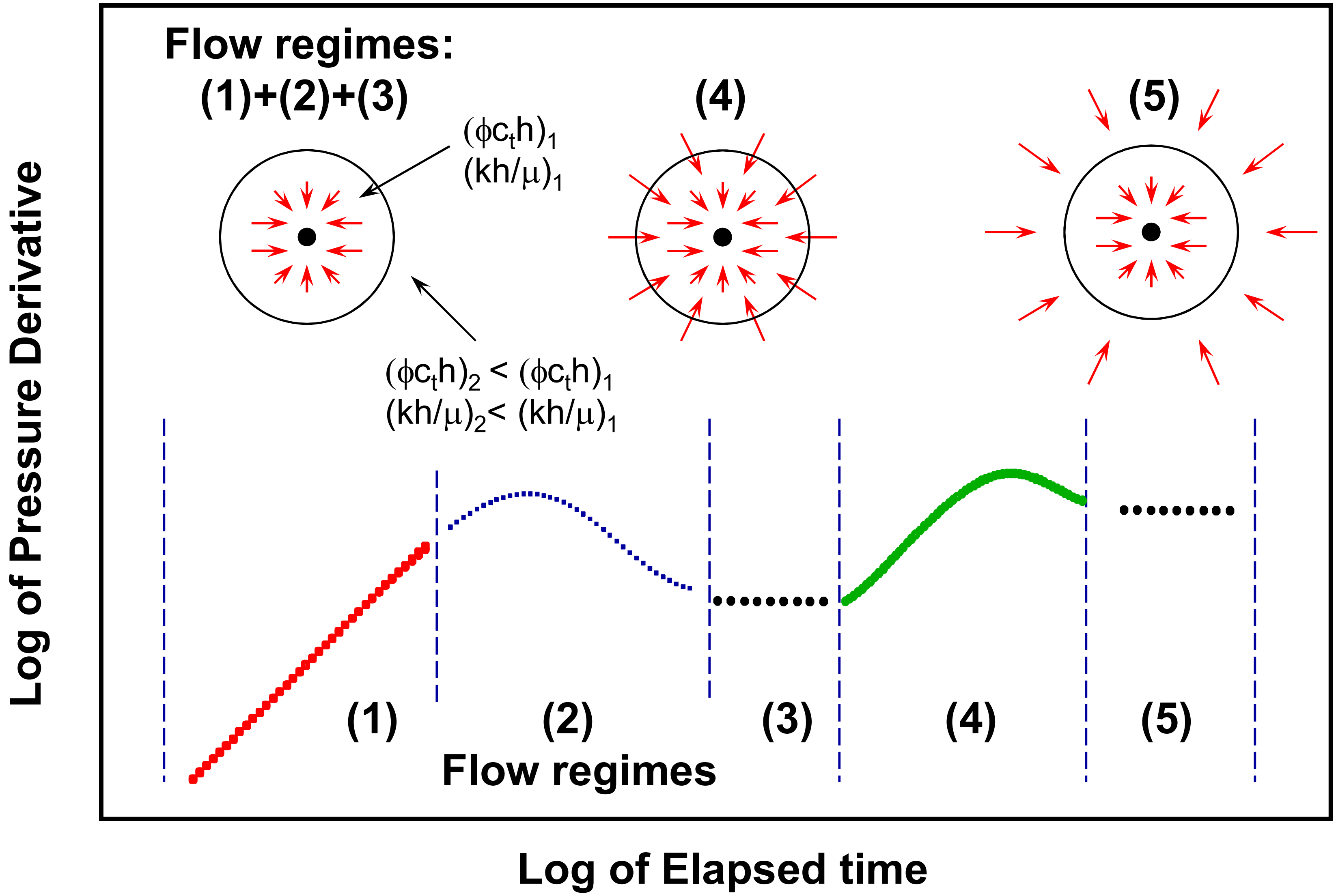


1000
100
10
1
nm(p) Change and Derivative (psi)
0.001
0.01
0.1
1
10
100
1000
Elapsed time (hrs)
θ = 80 o
Oil well in North Sea
Inclinaison, deg.

WELL TEST INTERPRETATION MODELS

NEAR WELLBORE EFFECTS	RESERVOIR BEHAVIOUR	BOUNDARY EFFECTS
Wellbore Storage	Homogeneous	Infinite extent
Skin	Heterogeneous	Specified Rate
Fracture	- 2-Porosity	Specified Pressure
Partial Penetration	- 2-Permeability	Leaky Boundary
	- Composite	
Horizontal Well		
EARLY TIMES	MIDDLE TIMES	LATE TIMES

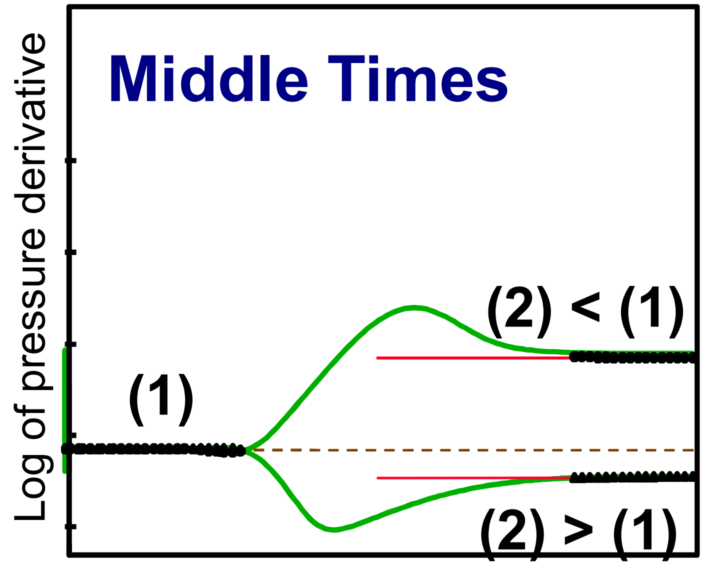
Well with wellbore storage and skin in an infinite reservoir with composite behaviour



DERIVATIVE FOR HETEROGENEOUS BEHAVIOUR (Middle Times)

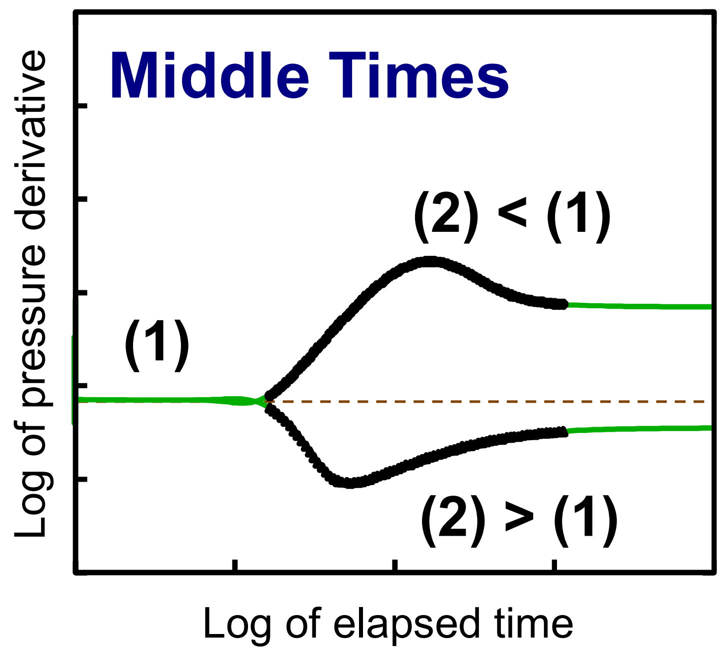
Mobility change

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

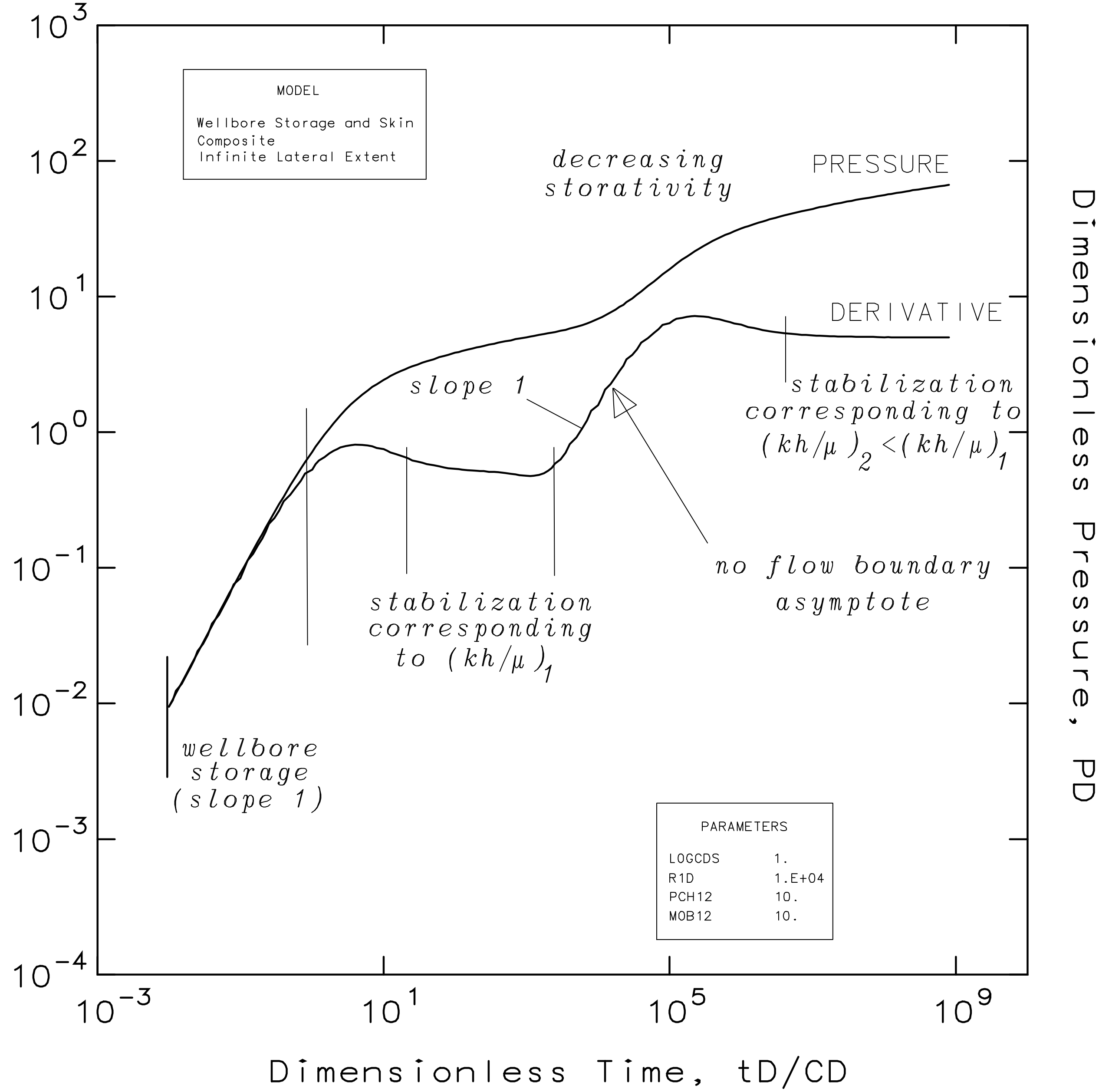


Storativity change

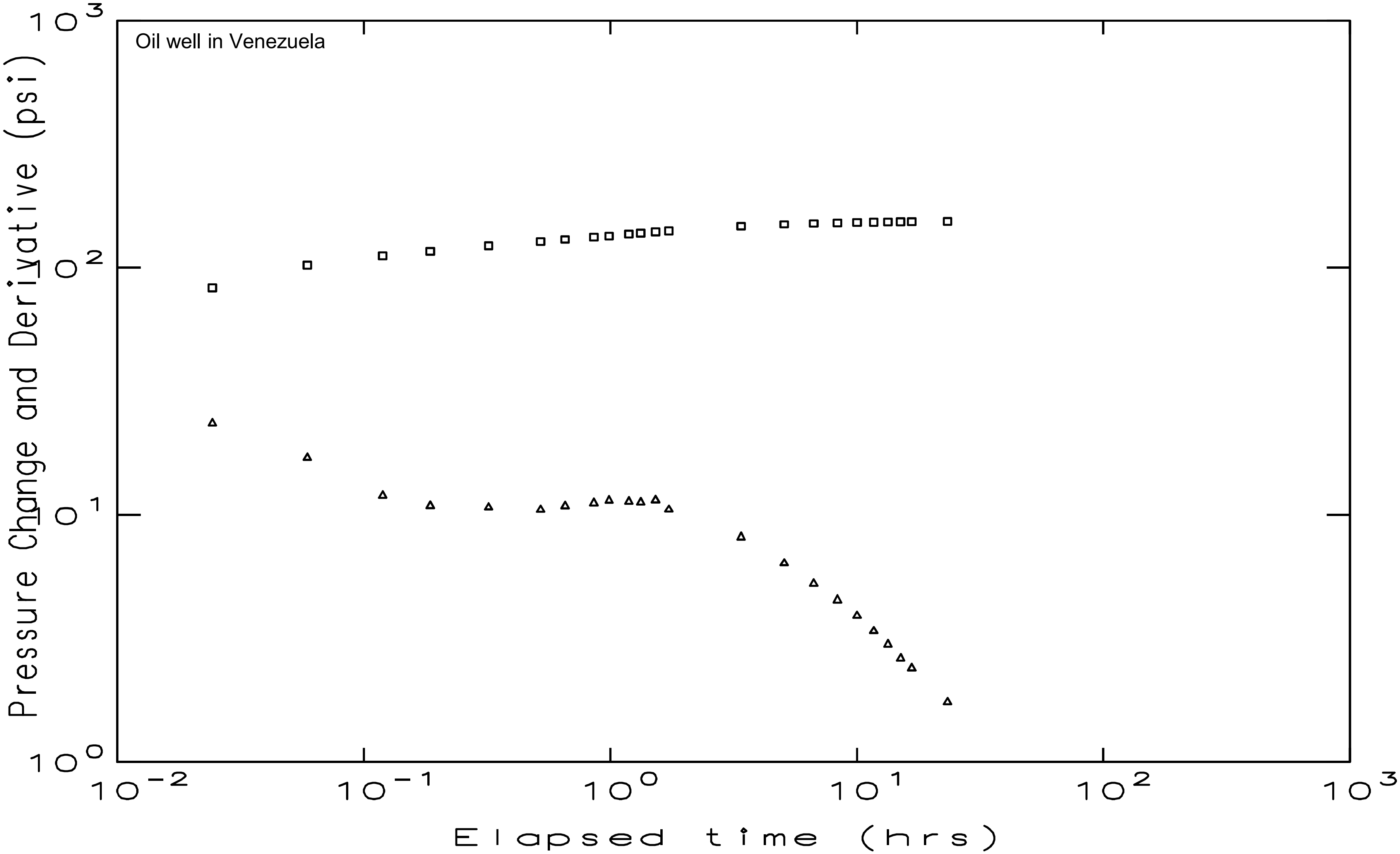
$$\left(\phi c_t h\right)_1 \rightarrow \left(\phi c_t h\right)_2$$



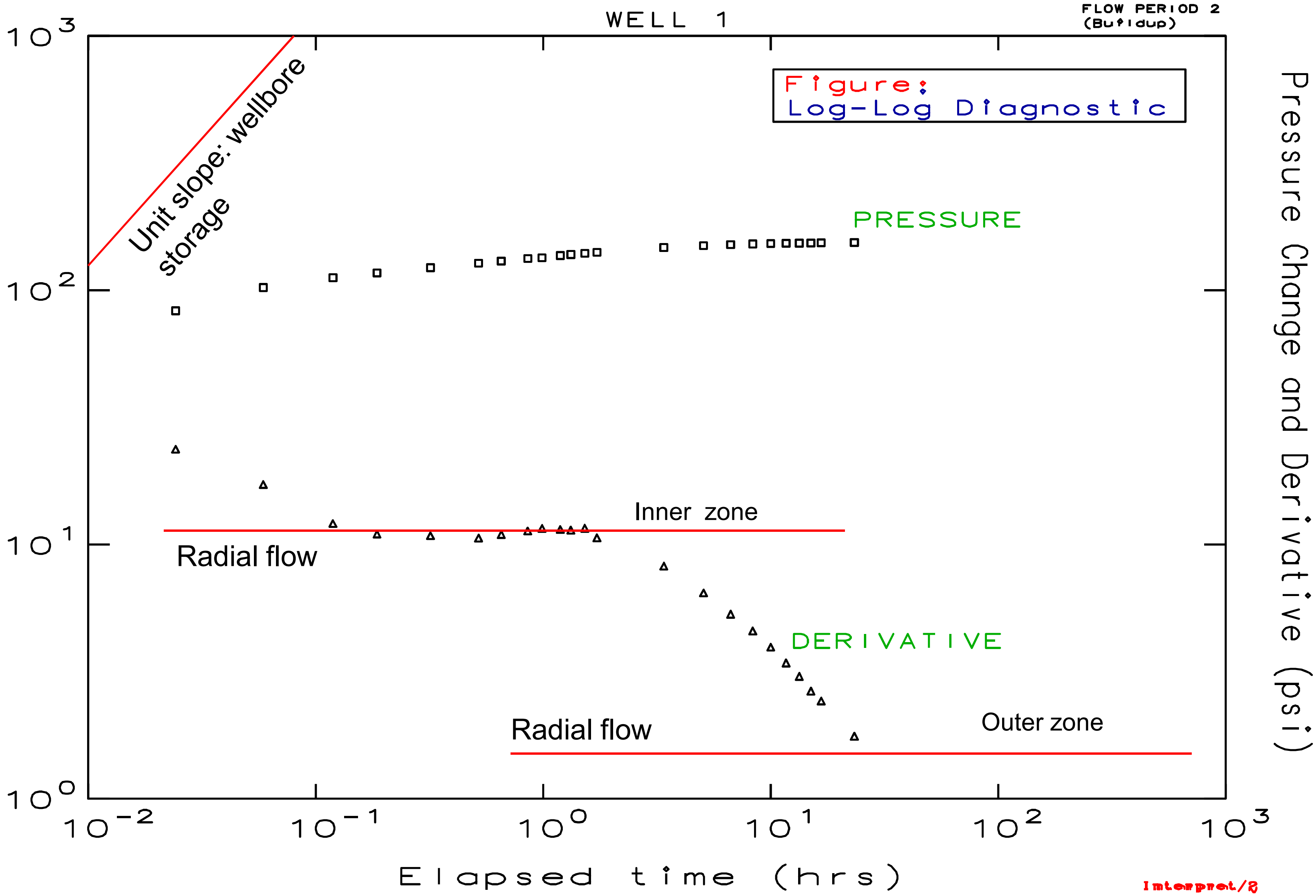
COMPOSITE BEHAVIOUR



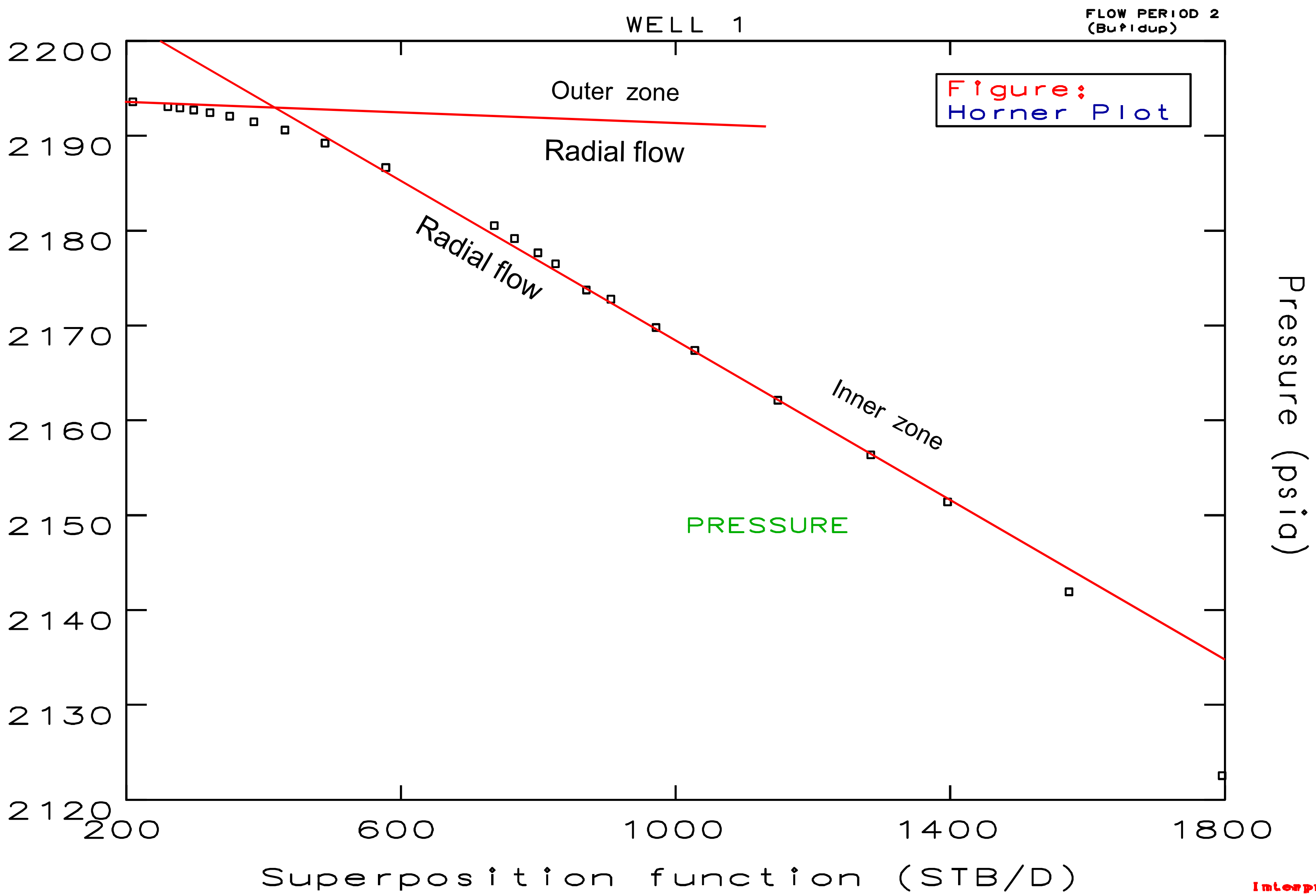
COMPOSITE BEHAVIOUR



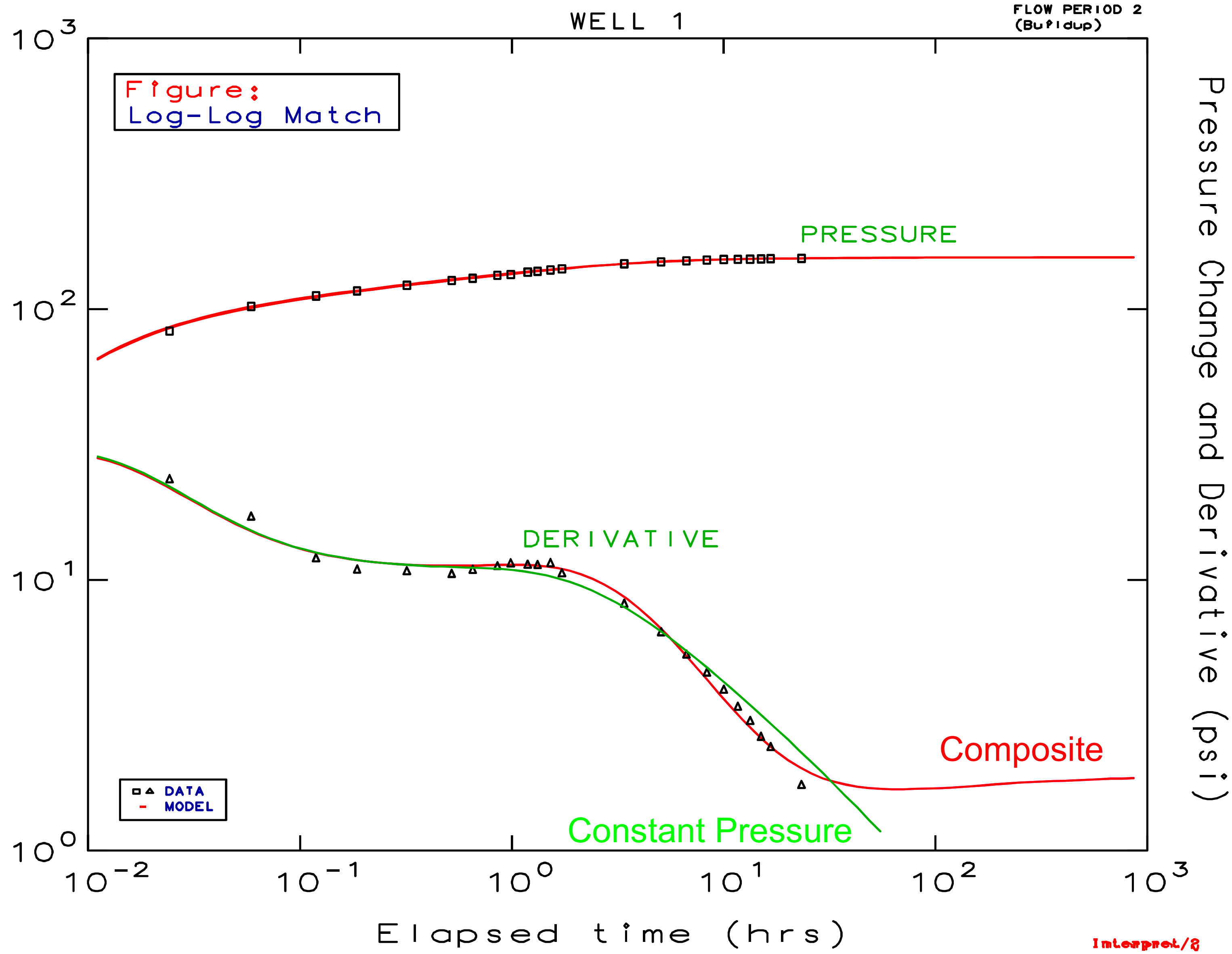
COMPOSITE BEHAVIOUR



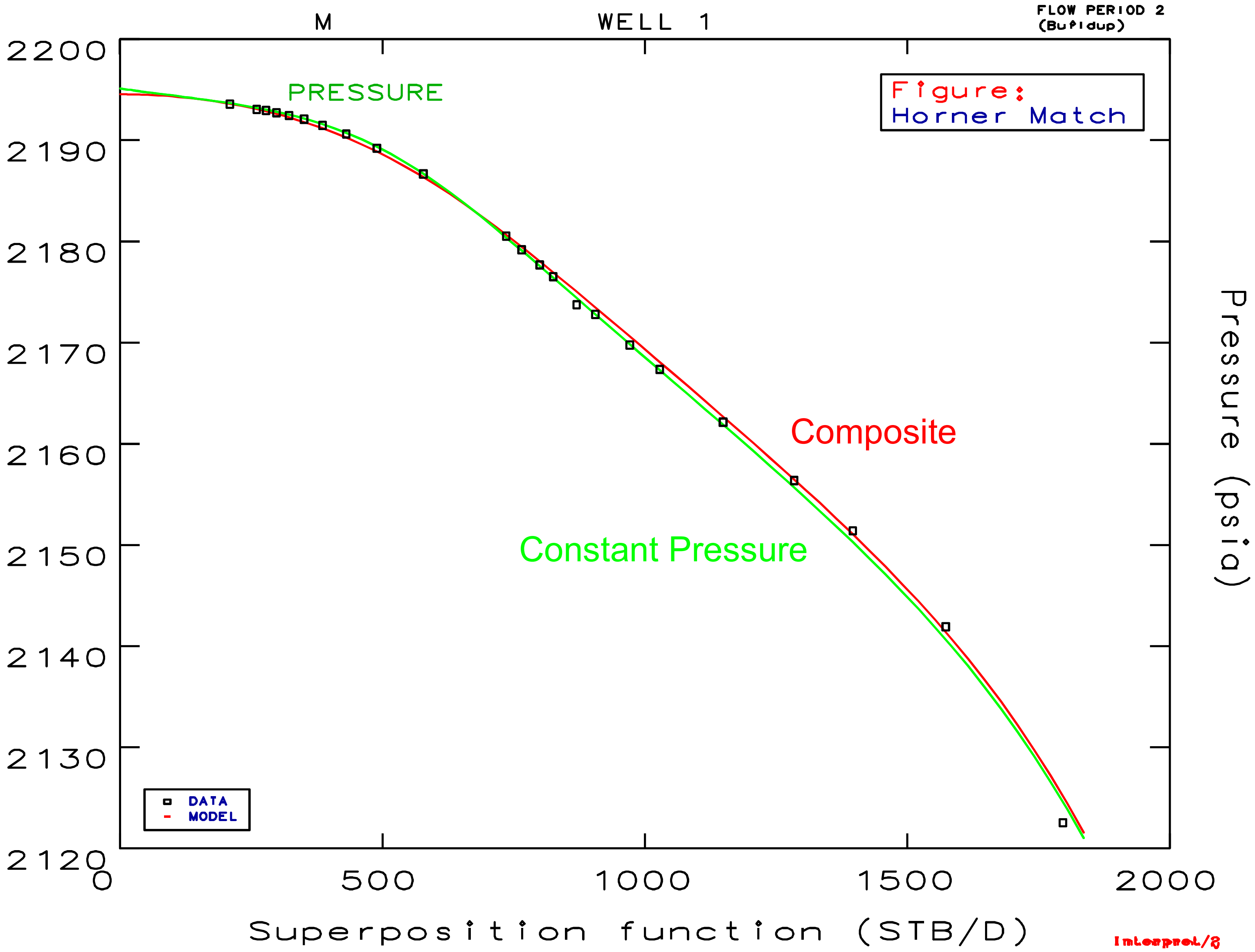
COMPOSITE BEHAVIOUR



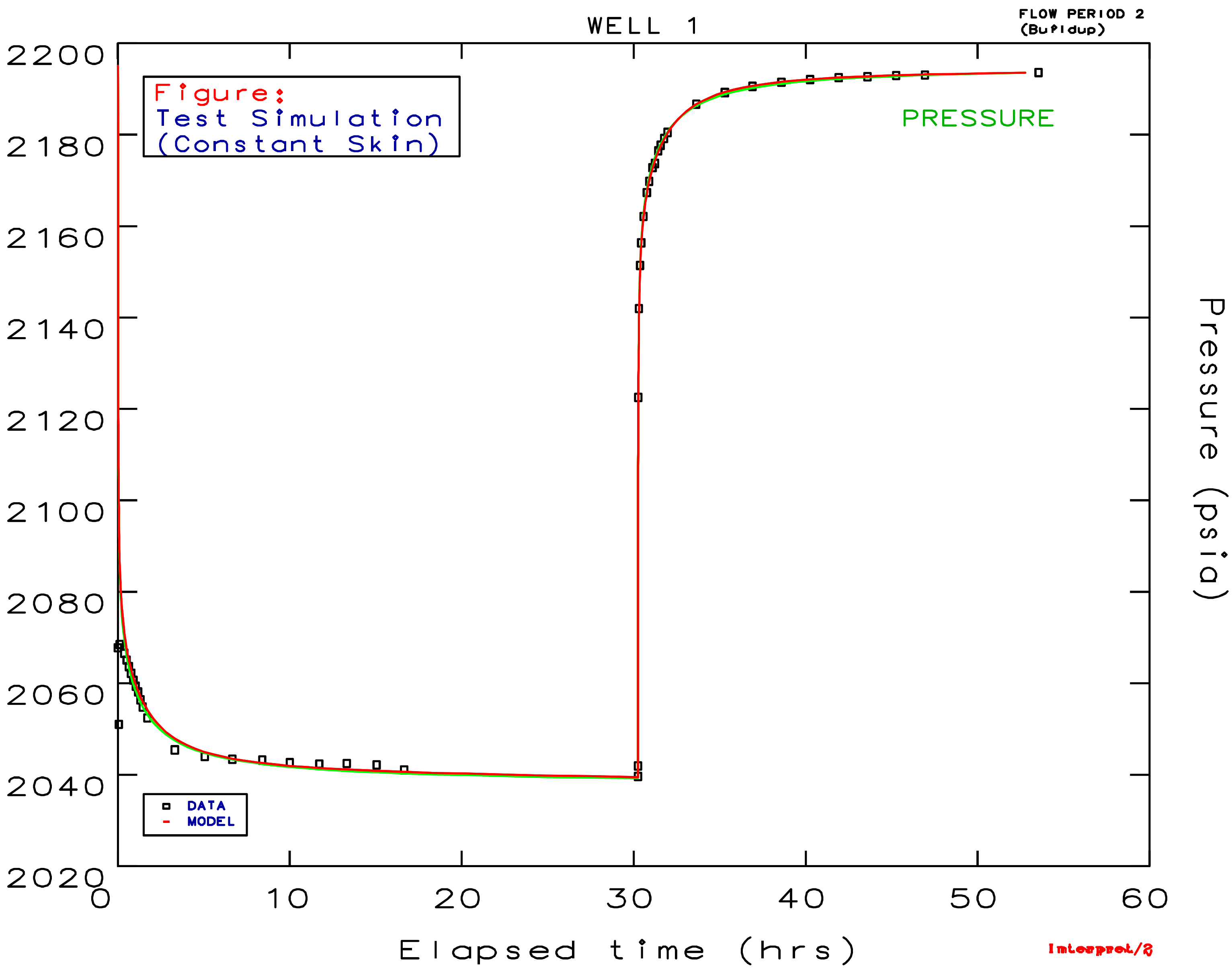
COMPOSITE BEHAVIOUR



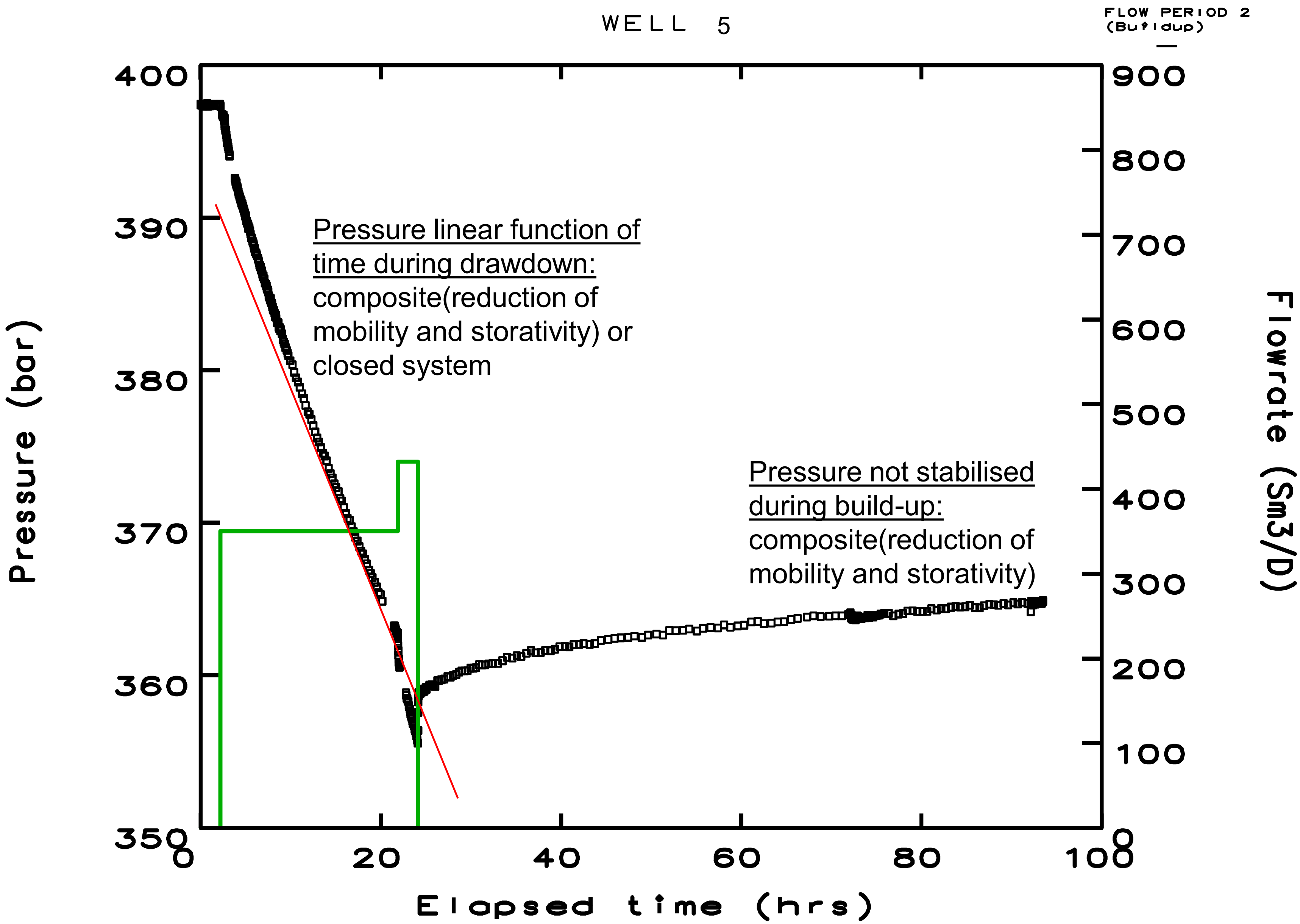
COMPOSITE BEHAVIOUR



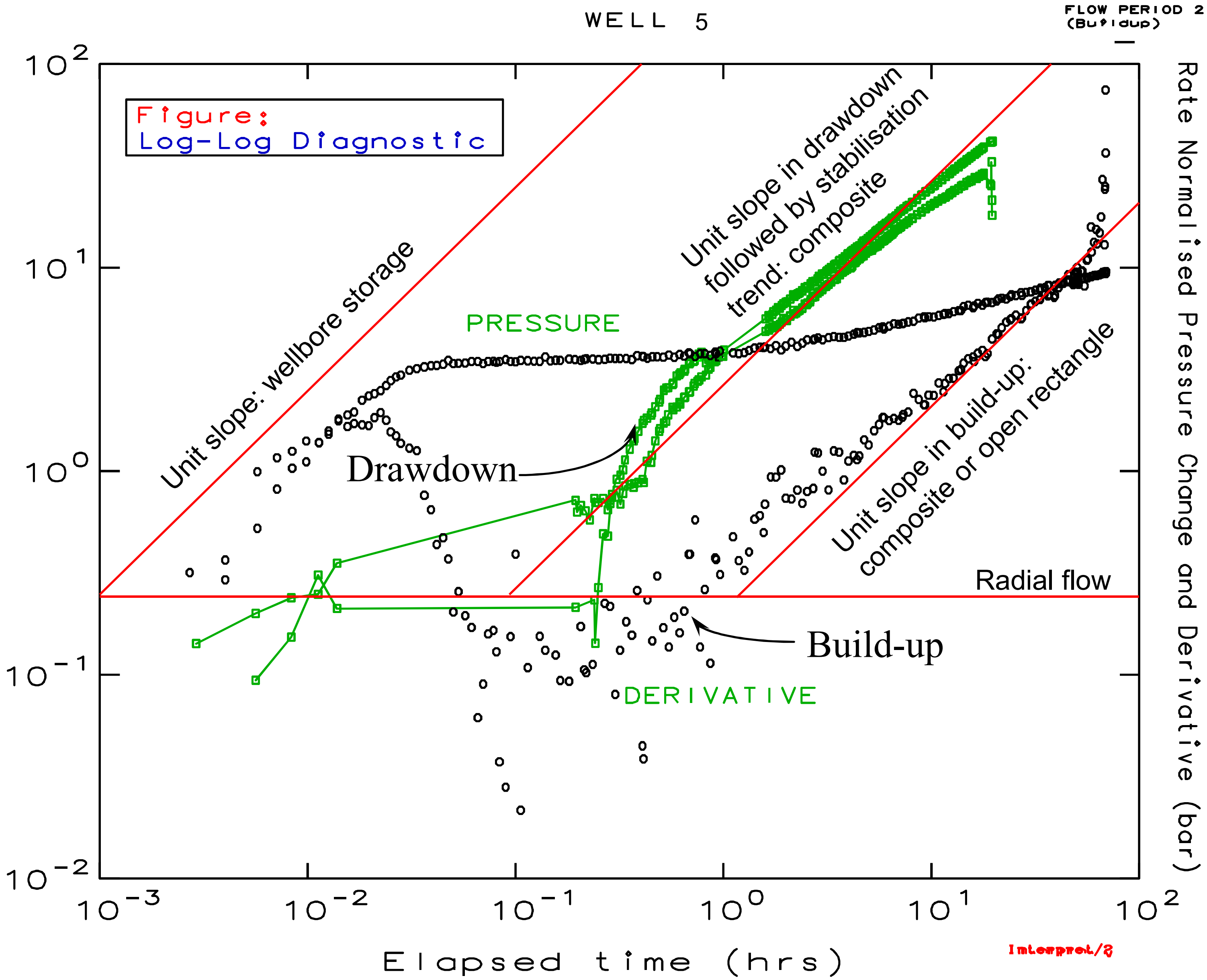
COMPOSITE BEHAVIOUR



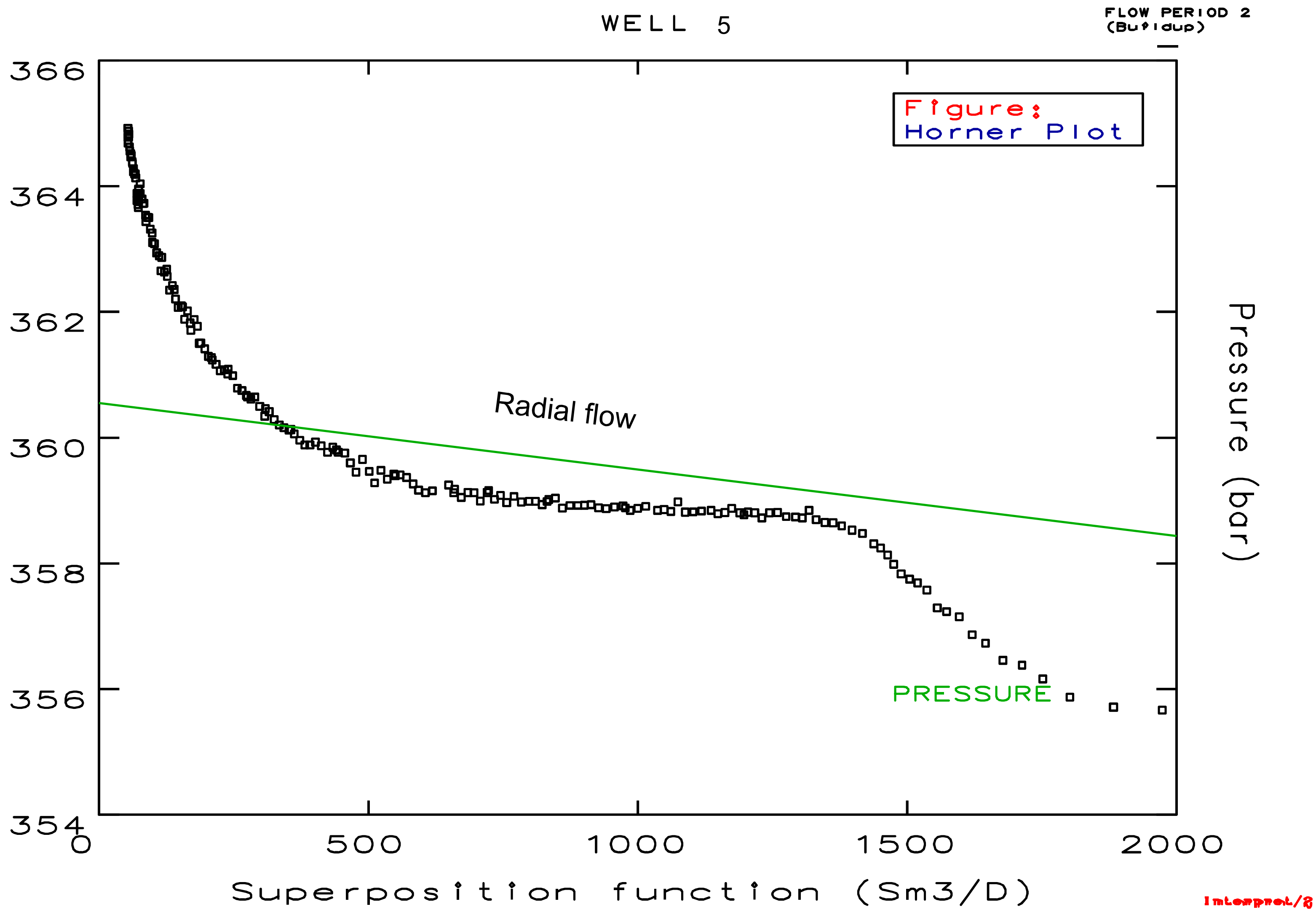
COMPOSITE BEHAVIOUR
Water well in Croatia



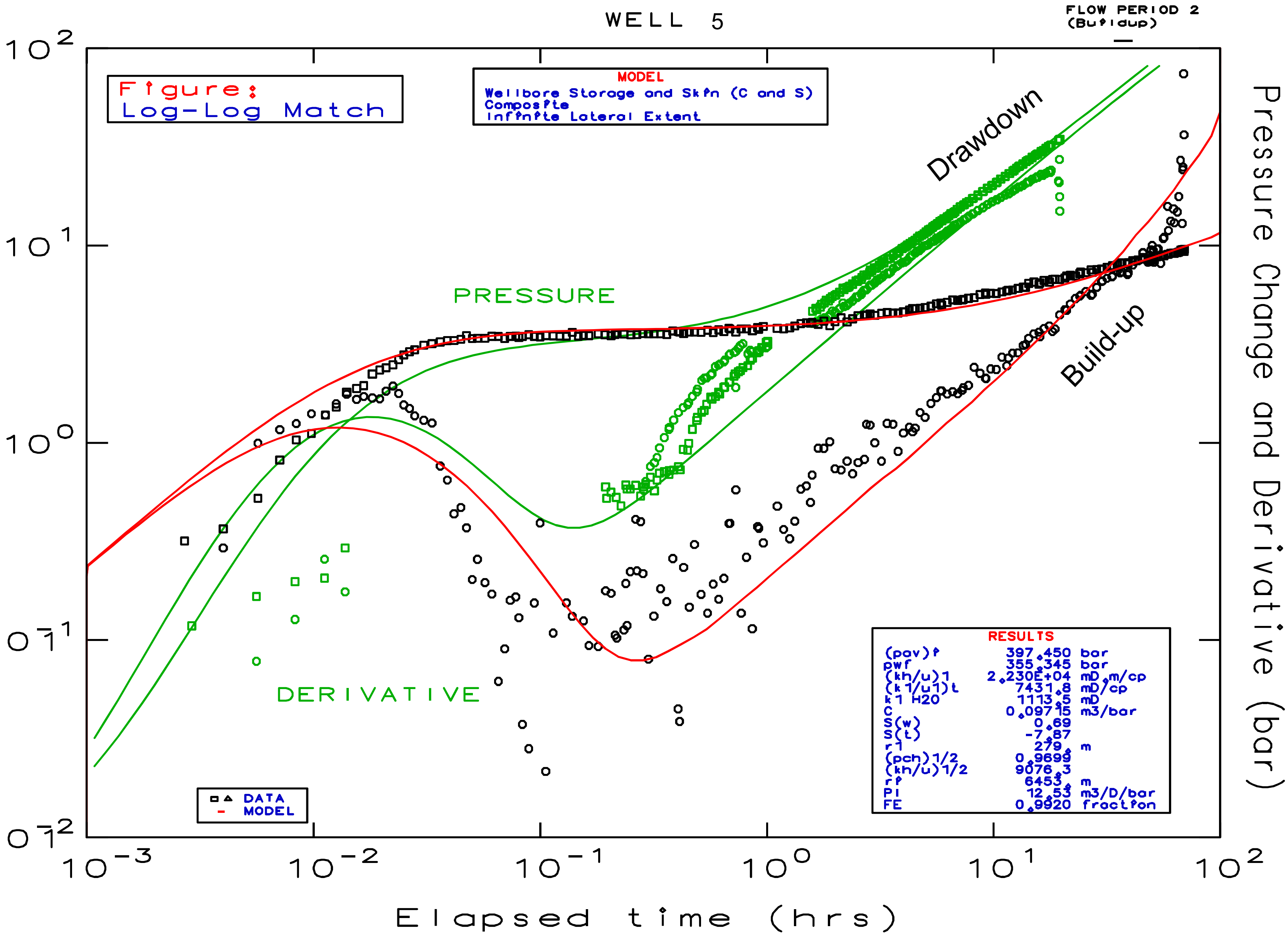
COMPOSITE BEHAVIOUR
Water well in Croatia



COMPOSITE BEHAVIOUR
Water well in Croatia

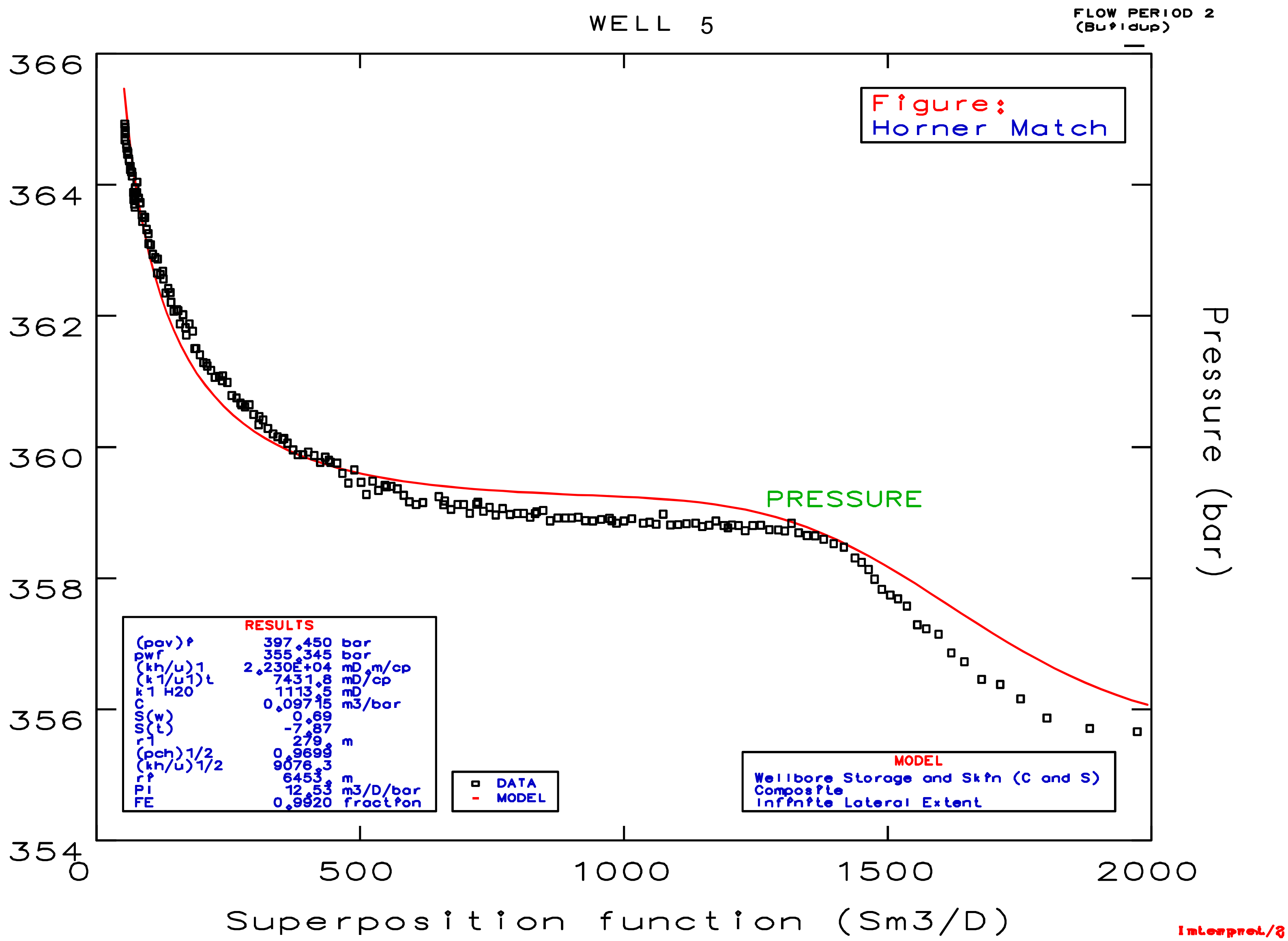


COMPOSITE BEHAVIOUR
Water well in Croatia

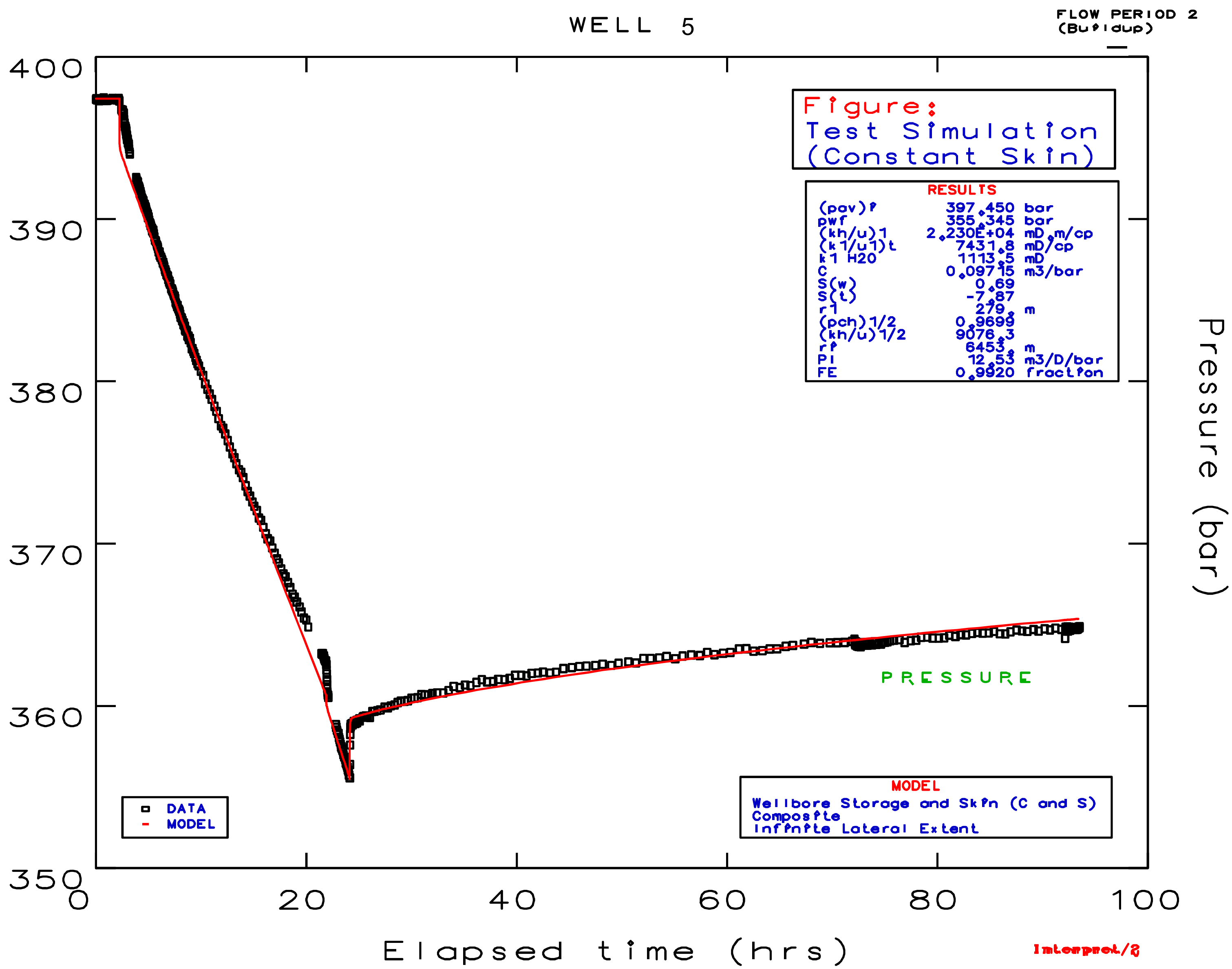


COMPOSITE BEHAVIOUR

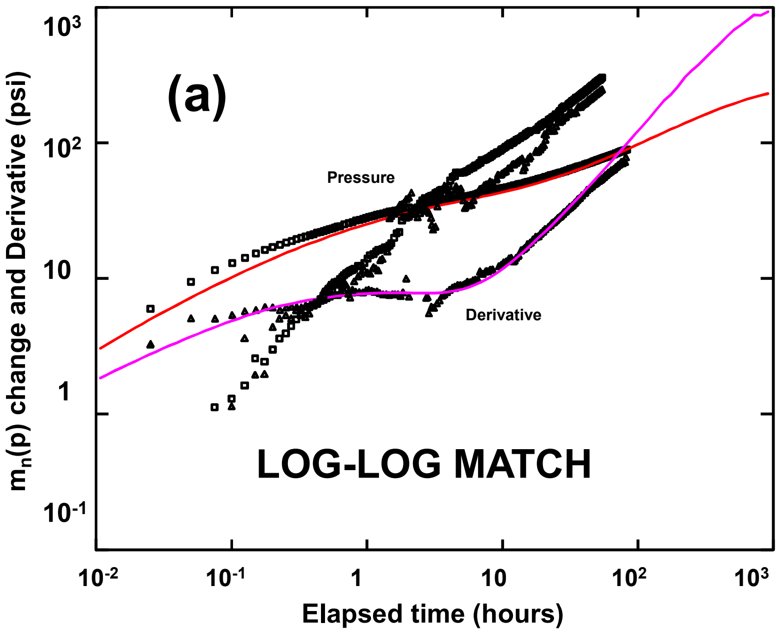
Water well in Croatia

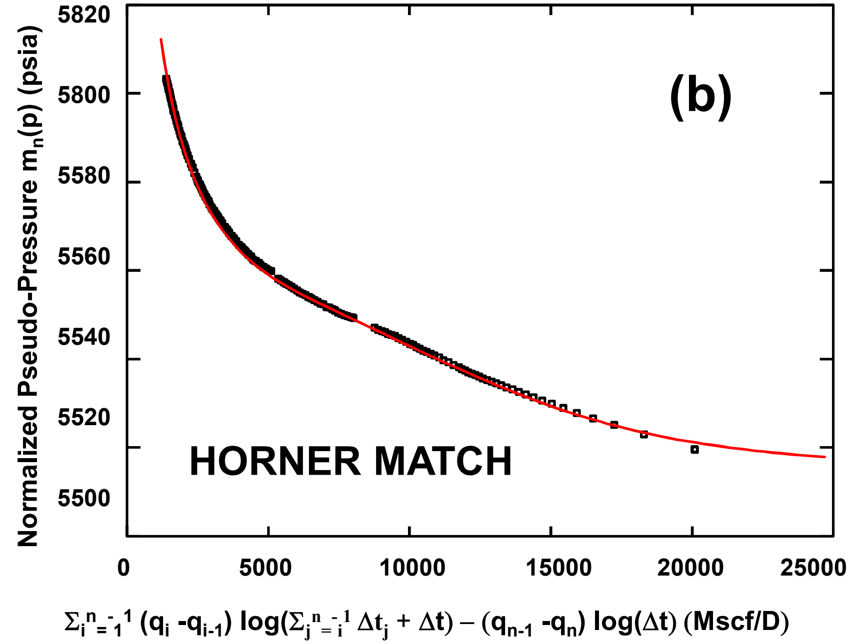


COMPOSITE BEHAVIOUR
Water well in Croatia



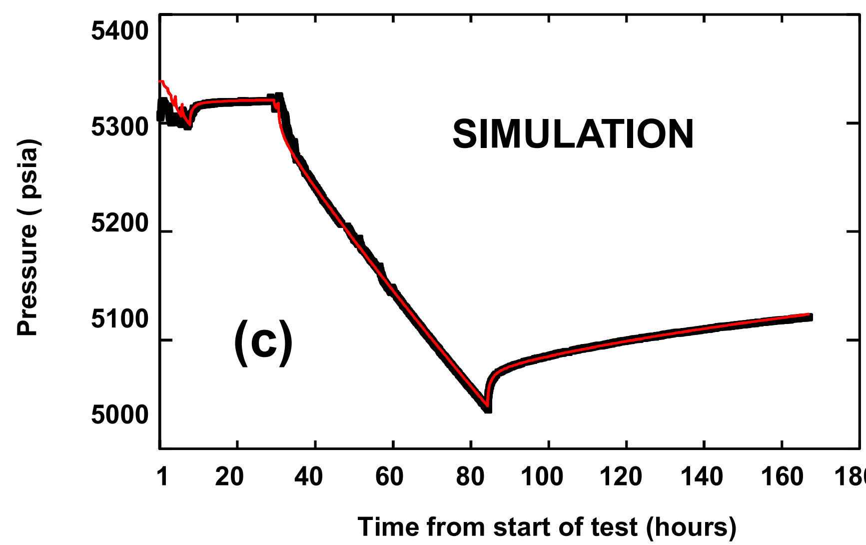
COMPOSITE BEHAVIOUR
Gas well off-shore Louisiana



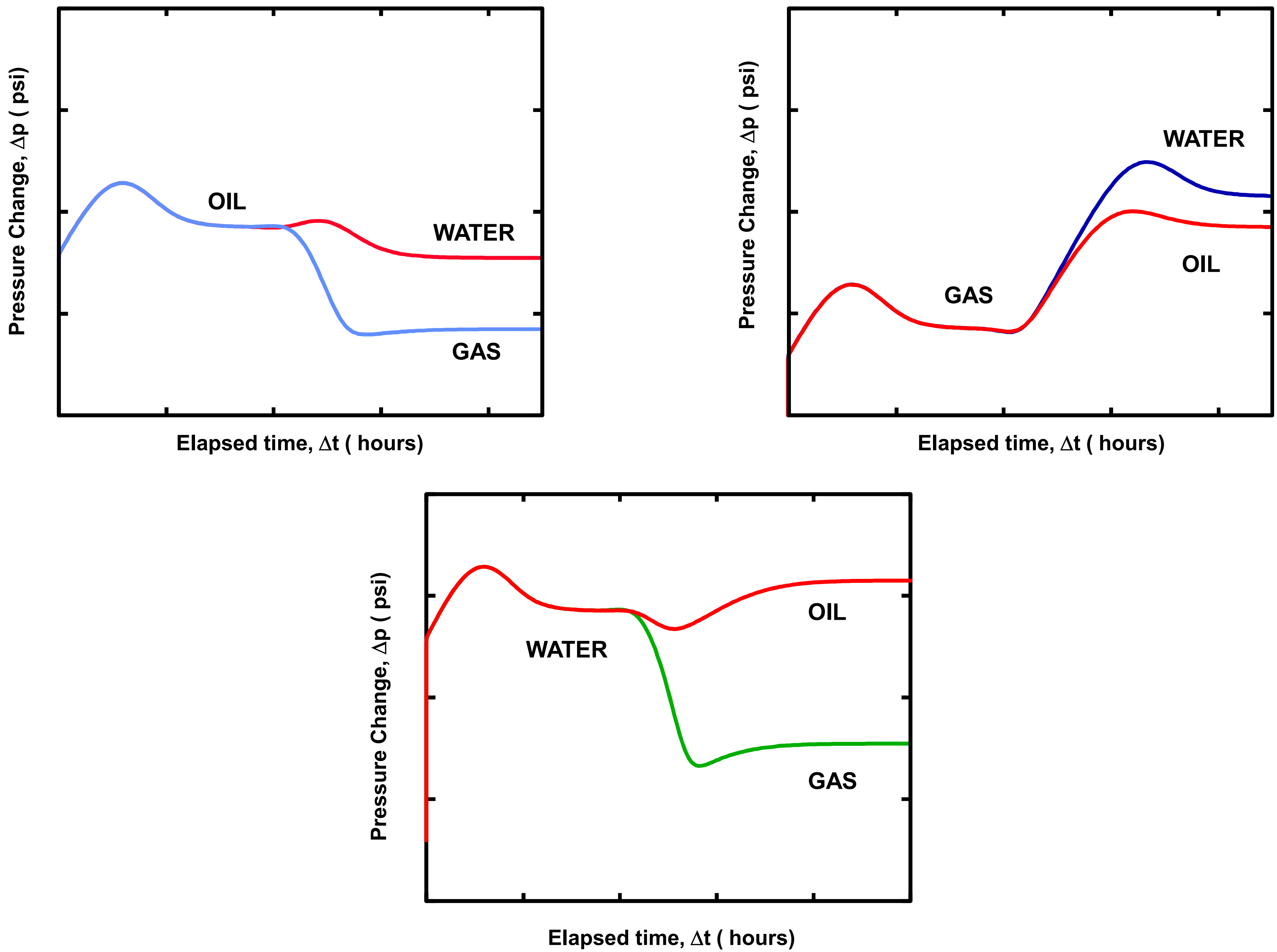


Type Curve

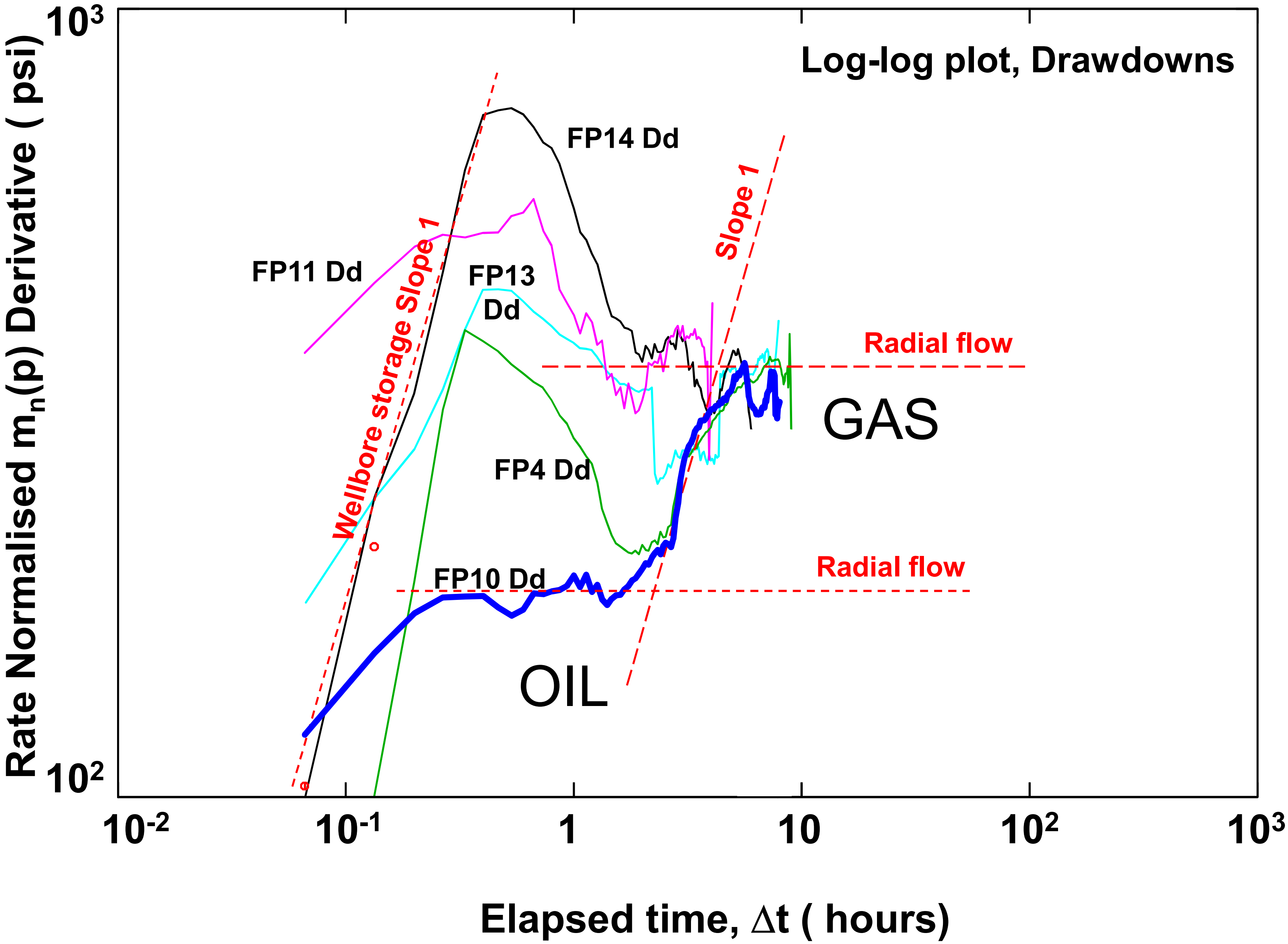
Data



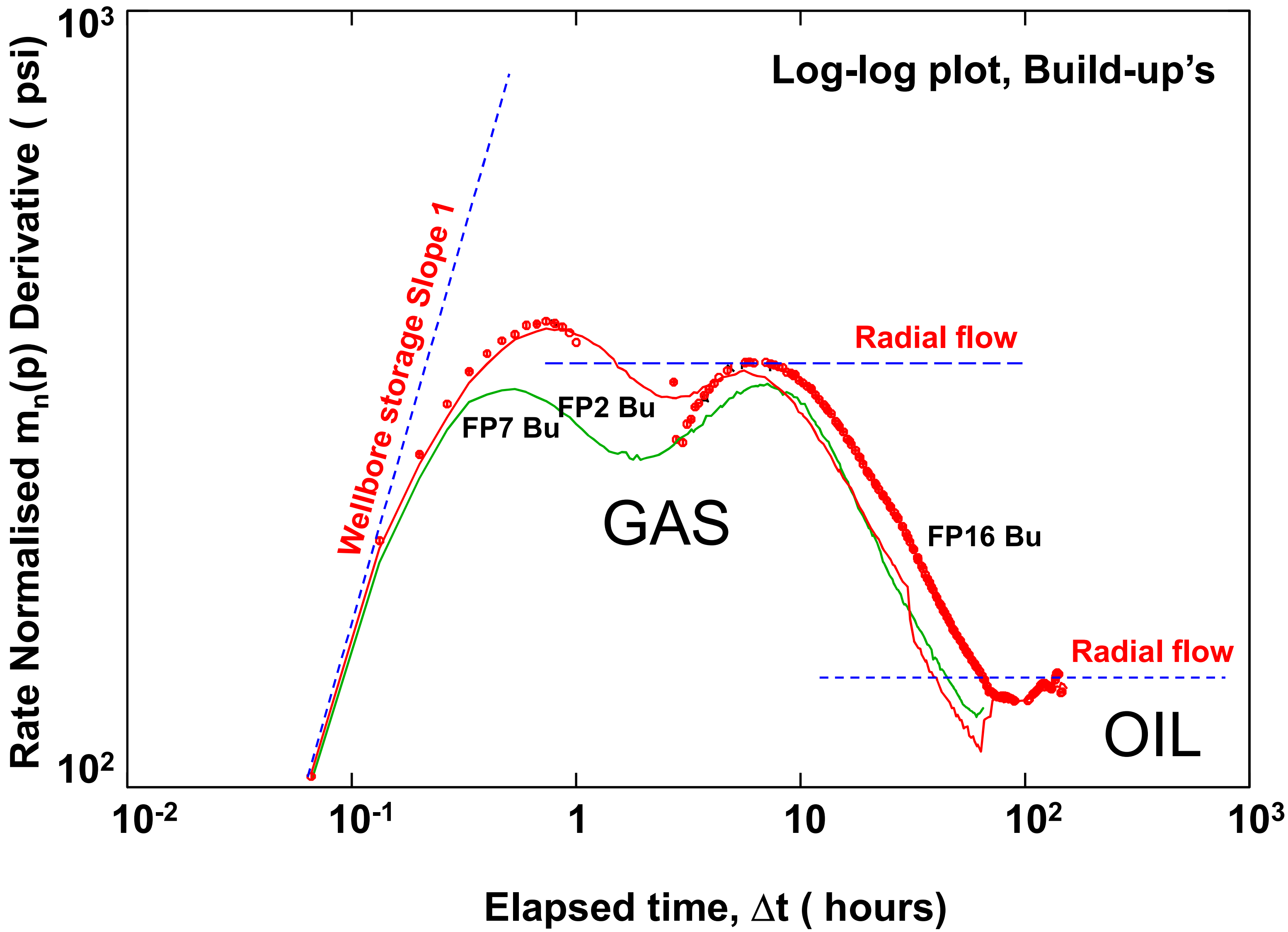
COMPOSITE BEHAVIOUR DUE TO FLUIDS



VOLATILE OIL WELL IN RUSSIA



VOLATILE OIL WELL



VOLATILE OIL WELL