02359230

Phone
308-235-2466

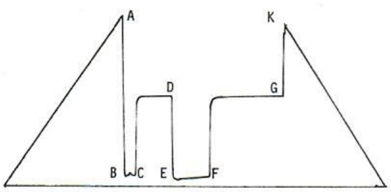
P.O. Box
555

Test-A-Log Co.

Kimball, Nebraska

DRILL STEM TEST SERVICE REPORT

GUIDE TO INTERPRETATION AND IDENTIFICATION OF DST CHARTS



A – Initial Hydrostatic
B – First Initial Flow
C – First Final Flow
D – Initial Shut-in
E – Second Initial Flow
F – Second Final Flow
G – Second Shut-in
H – Third Initial Flow
I – Third Final Flow
J – Third Shut-in
K – Final Hydrostatic

NOMENCLATURE

Symbol	Definition	DST Unit
k	permeability	millidarcys (md)
h	pay thickness	feet (ft.)
u	viscosity	centipoise
T	reservoir temperature	^{o}Rankin (^{o}R)
z	gas compressibility factor at average condition	___
g_{sc}	gas production rate	MCF/d
M	Horner slope for liquid analysis	PSI/Cycle
Mg	Horner slope for (P^2) gas analysis	PSI ^{2}/Cycle
Pi	initial static reservoir pressure	PSI
Pwf	flowing bottom hole pressure	PSI
Ø	porosity	(fraction)
rw	well bore radius	ft.
S	skin factor	___
AOF	absolute open flow	MCF/d
D. R.	damage ratio	___
re	external drainage radius	ft.
ISIP	initial shut-in pressure	PSI
FSIP	final shut-in pressure	PSI
b	approx. radius of investigation	ft.
t	flowing time	hrs.
B	formation volume factor	___
q	liquid production rate	bbls/day
$\bar{c}$	gas compressibility	1/PSI
c	liquid compressibility	1/PSI

Build-Up Analysis Equations

Pressure Analysis

$$kh = \frac{162.6\ Q\mu\beta}{M}$$

$$S = 1.151\left[\frac{P_{1hr} - P_{wf}}{M} - \log\frac{k}{\phi\mu c_t r_w^2} + 3.23\right]$$

$$\Delta P_{Skin} = \frac{141.2\ Q\mu\beta}{kh}\ S$$

$$L = \sqrt{\frac{0.000148\ k\ \Delta t_x}{\phi\mu C_t}}$$

$$\text{Efficiency} = \frac{P - P_{wf} - \Delta P_{Skin}}{P - P_{wf}}$$

Pseudo–Pressure Analysis

$$kh = \frac{1.632 \times 10^3\ Q_g\ T}{M}$$

$$S = 1.151\left[\frac{\Psi_{1hr} - \Psi_{wf}}{M} - \log\left(\frac{k}{\phi\mu c_t r_w^2}\right) + 3.23\right]$$

$$\Delta\Psi_{Skin} = \frac{1422\ Q_g\ T\ S}{kh}$$

$$L = \sqrt{\frac{0.000148\ k\ \Delta t_x}{\phi\mu C_t}}$$

$$\text{Efficiency} = \frac{P - P_{wf} - \Delta P_{Skin}}{P - P_{wf}}$$

Type Curve P Method

$$kh = 141.2\ Q\mu\beta\ \frac{P_{WD}}{\Delta P}$$

$$S = \frac{1}{2}\ \ln\left[\frac{C_D e^{2s}}{\frac{2.637 \times 10^{-4}\ k\ \Delta t}{\phi\mu C_t r_w^2\ \ t_D/C_D}}\right]$$

$$\Delta P_{Skin} = \frac{141.2\ Q\mu\beta}{kh}\ S$$

$$\text{Efficiency} = \frac{P - P_{wf} - \Delta P_{Skin}}{P - P_{wf}}$$

Type Curve P² Method

$$kh = 141.2\ Q\mu\beta\ \frac{P_{WD}}{\Delta t \Delta P}$$

$$S = \frac{1}{2}\ \ln\left[\frac{C_D e^{2s}}{\frac{2.637 \times 10^{-4}\ k\ \Delta t}{\phi\mu C_t r_w^2\ \ t_D/C_D}}\right]$$

$$\Delta P_{Skin} = \frac{141.2\ Q\mu\beta}{kh}\ S$$

$$\text{Efficiency} = \frac{P - P_{wf} - \Delta P_{Skin}}{P - P_{wf}}$$

Fall-Off Analysis Equations

Semi–Log Analysis

Eq. (3.9) $$kh = \frac{162.6\ Q\mu\beta}{M}$$

$$S = 1.151\left[\frac{P_{inj} - P_{1hr}}{M} - \log\left(\frac{k}{\phi\mu c_t r_w^2}\right) + 3.23\right]$$

Eq. (3.10)

Log–Log Analysis

* Eq. (4.4) $$kh = 141.2\ Q\mu\beta\ \frac{P_{WD}}{\Delta P}$$

$$S = \frac{1}{2}\ \ln\left[\frac{C_D e^{2s}}{\frac{2.637 \times 10^{-4}\ k\ \Delta t_m}{\phi\mu C_t r_w^2\ \ t_D/C_D}}\right]$$

Pressure drop due to skin

Eq. (2.9) $$\Delta P_{Skin} = \frac{141.2\ Q\mu\beta}{kh}\ S$$

Flow Efficiency

$$FE = \frac{P - P_{wf} - \Delta P_{Skin}}{P - P_{wf}}$$

Eq. (2.12)

investigation radius

$$= 0.029\sqrt{\frac{k\ \Delta t}{\phi\mu C_t}}$$

Eq. (2.41)

Skin due to Partial Perforations

$$Sp = \left(\frac{h_t}{h_p} - 1\right)\left[\ln\left(\frac{h_t}{h_p}\sqrt{\frac{k_H}{k_V}}\right) - 2\right]$$

* Eq. (2.20)

Advances in Well Test Analysis
Robert C. Earlougher Jr.
Monograph Volume 5 of the Henry L. Doherty Series

* Well Testing
John Lee
SPE Textbook Series Vol 1

Drill-Stem-Test Reporting By:

Michael Hudson

DATA REPORTING SERVICES

P.O. Box 722 Ph. (520) 505-8389

LAKE HAVASU CITY, AZ 86405

Kimball NE
(308) 235-2466

Test-A-Log Co.

Technical Services
(928) 505-8389

Contractor	Excell Drilling
Rig No.	3
Spot	NW/SW/NE
Sec	22
Twp	3 S
Rng	50 W
Field	Stallion
County	Washington
State	Colorado
Elevation	4561' KB - 4550' GL
Formation	J Sand

Surface Choke	1"
Bottom Choke	5/8"
Hole Size	7 7/8"
Core Hole Size	
DP Size & Wt	4 1/2" 16.60
Wt Pipe	
ID of DC	2 1/4"
Length of DC	534'
Total Depth	3936' (driller)
Type of Test	Conventional
Interval	3932'- 3936'

Mud Type	Chemical/Gel			
Weight	9.3			
Viscosity	85			
Water Loss	4.8			
Filter Cake	1/32			
RW	2.0	@	75	Deg F
	2,615			Ppm
B.H.T.	139.8			Deg F
Co. Rep.	Matt Goolsby			
Tester	Roger Seeman			

COMPANY EDWARD MIKE DAVIS
LEASE NAME & NO STATE #32-22
INTERVAL TESTED 3932'- 3936'

Pipe recovery:

1595' Total fluid = 17.68 bbl., consisting of:
3' Oil = 0.04 bbl.
190' Muddy water w/10% oil = 2.70 bbl.
315' Water w/5% oil = 4.47 bbl.
553' Water w/1% oil = 7.85 bbl.
534' Water w/trace of oil = 2.62 bbl.

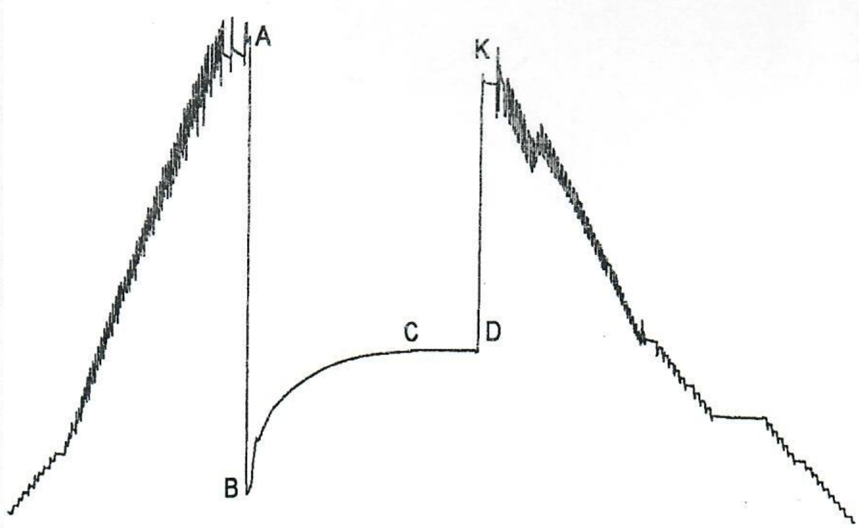
Surface Blow

Began with a 2" blow, increased to a good blow in 7 minutes; began to decrease after 40 minutes to no blow in 75 minutes.

Pressure in Sampler	0	psig
Volume of Sampler	2000	cc
Volume of Sample	2000	cc
Oil:	Trace	cc
Water:	2000	cc
Mud:	0	cc
Gas:	0	cu ft
Other:	0	
Gas/Oil Ratio		
Gravity		API @ 60 Deg F

Gauge Type	Sunada Electronic			
No.	30043	Cap	5000	psi
Depth	3910			ft.
Inside	X		Outside	

COUNTY WASHINGTON
STATE COLORADO
FORMATION J SAND



Initial Hydrostatic	[A]	1950
Final Hydrostatic	[K]	1845
Initial Flow 1	[B]	110
Final Flow 1	[C]	715
Initial Flow 2	[E]	
Final Flow 2	[F]	
Initial Flow 3	[H]	
Final Flow 3	[I]	
Shut-in 1	[D]	723
Shut-in 2	[G]	
Shut-in 3	[J]	

Opened Tool @ 03:35 hrs on 05-08-03

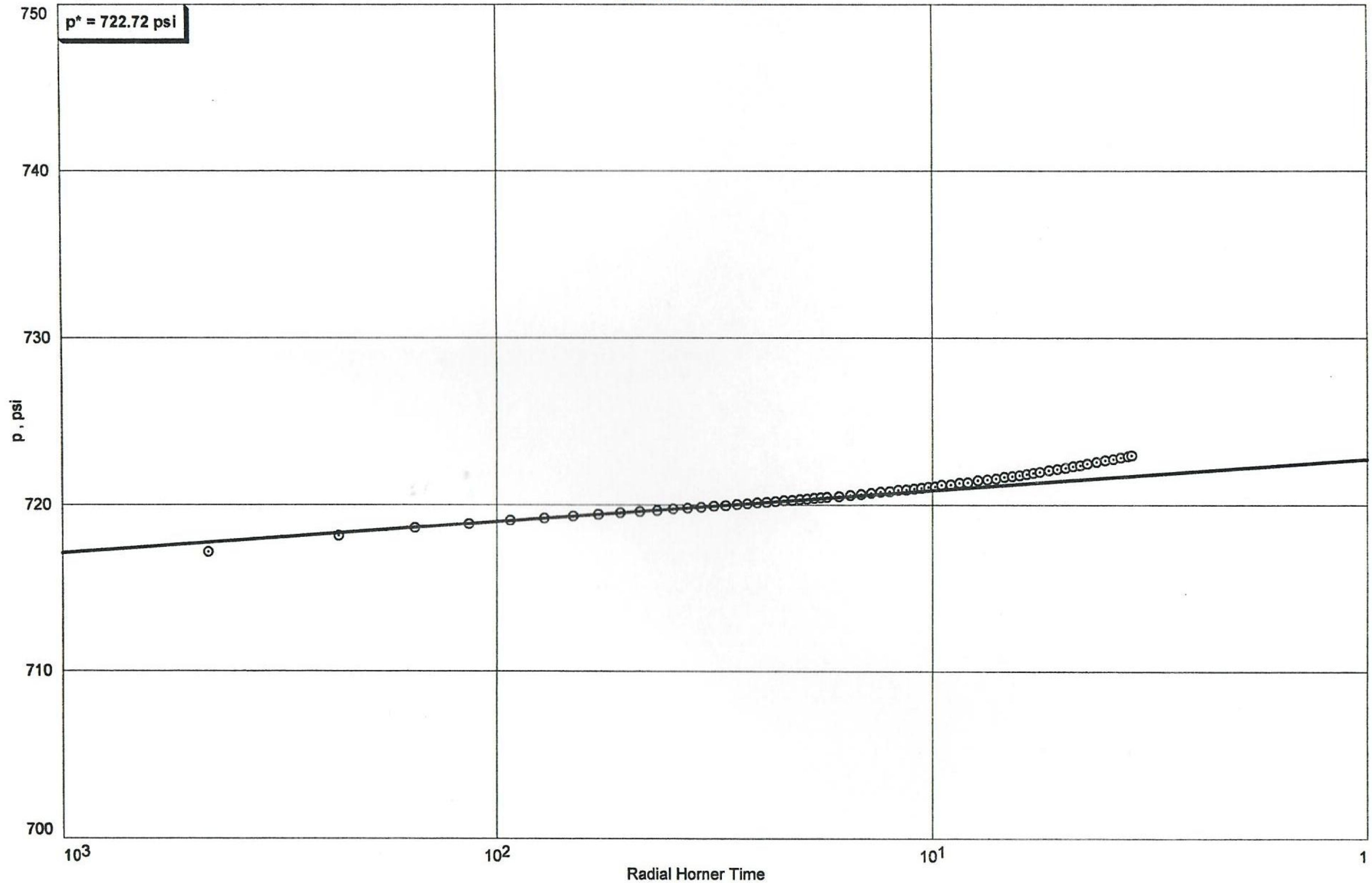
	Reported	Corrected	
Flow 1	75	77	min
Shut-in 1	30	31	min
Flow 2			min
Shut-in 2			min
Flow 3			min
Shut-in 3			min

DATE 05-08-2003
TICKET # 2491
TEST # 4

D.R.S.

Edward Mike Davis
State 32-22, Dst 4
Gauge 30043

RADIAL PLOT



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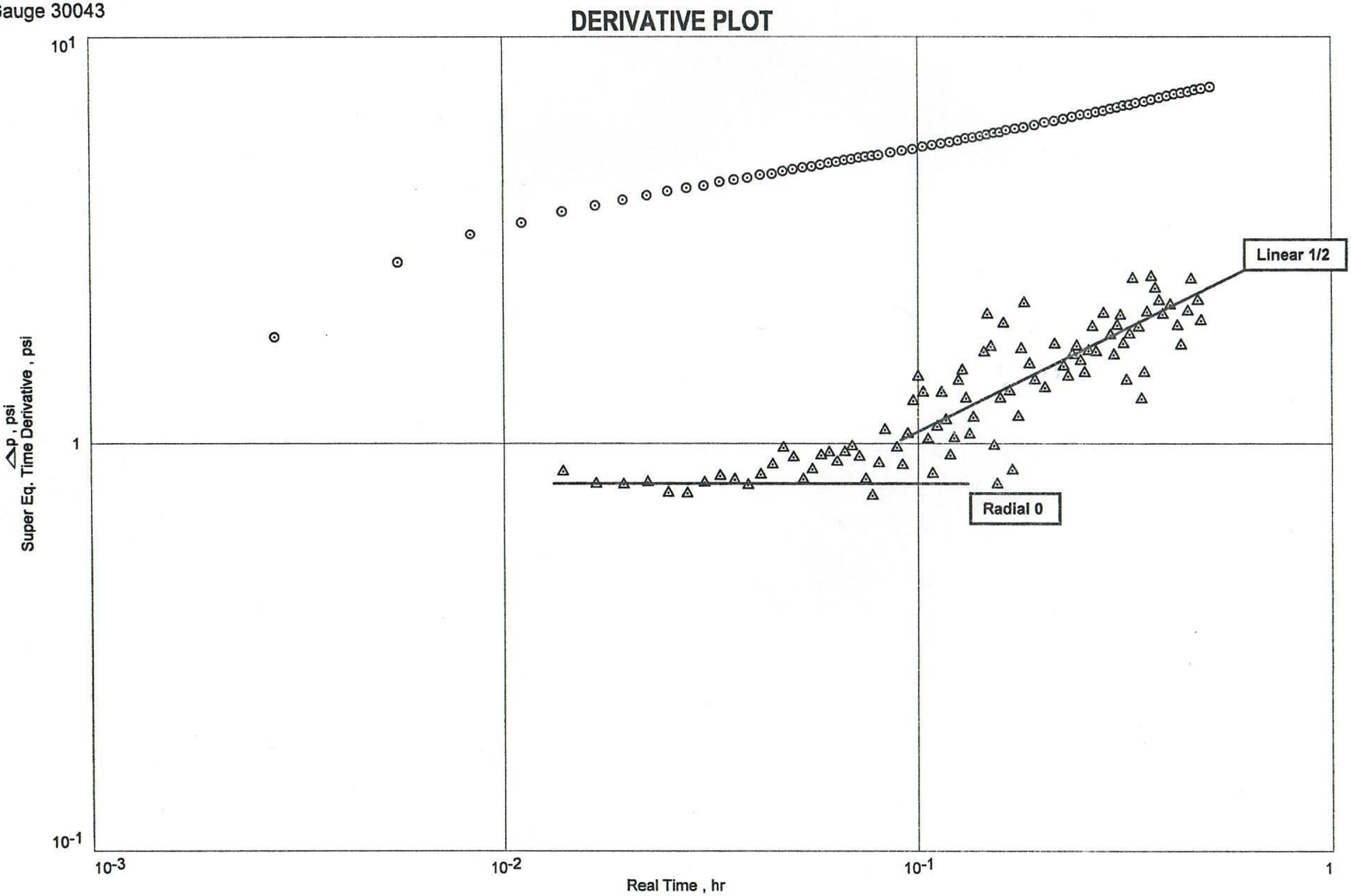
Fast

Edward Mike Davis
State 32-22, Dst 4
Gauge 30043



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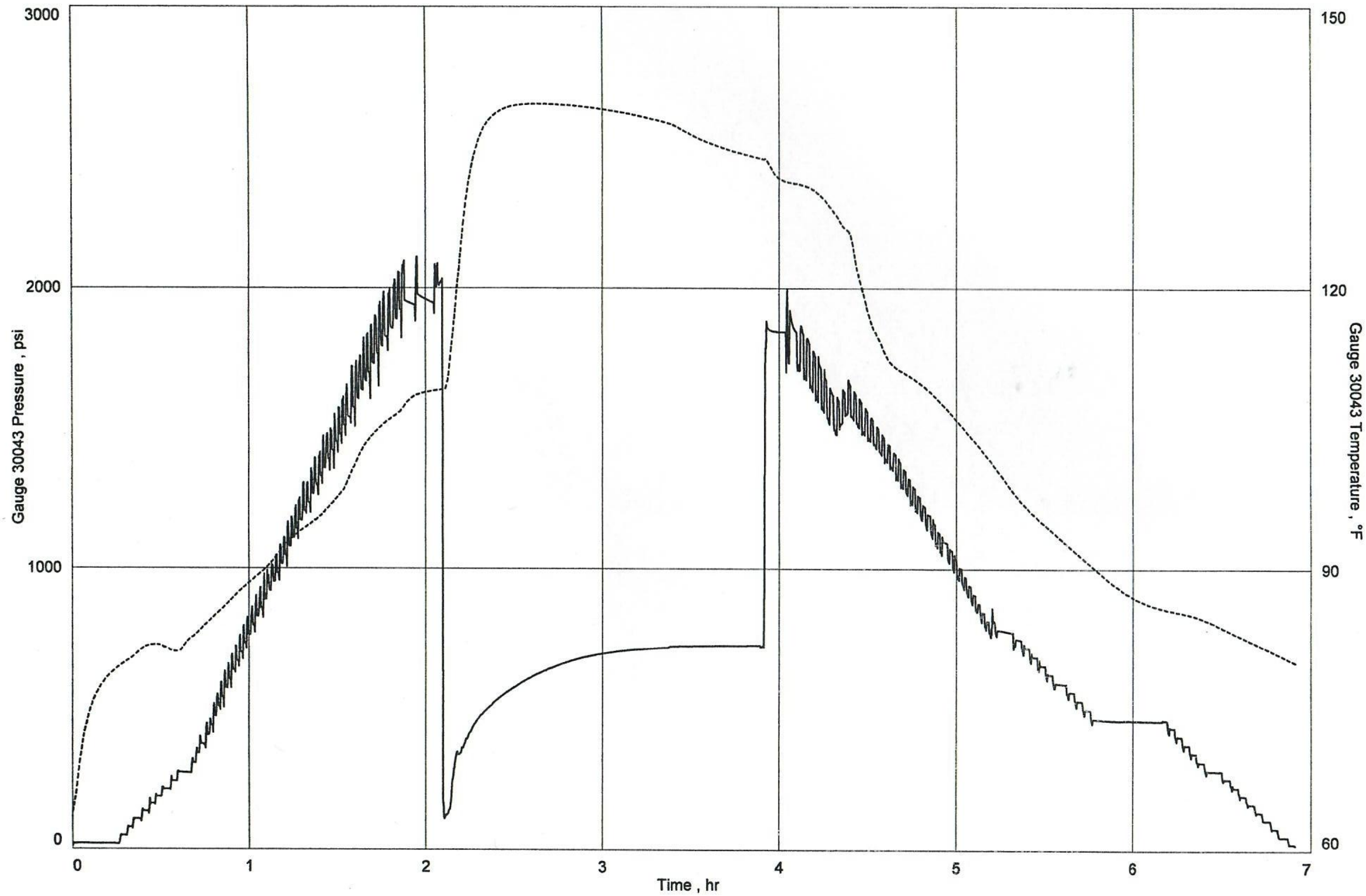

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Fast

Edward Mike Davis
State #32-22

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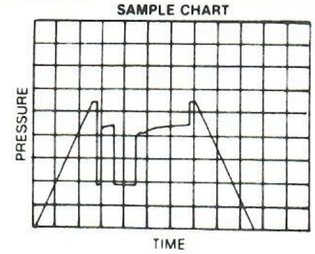
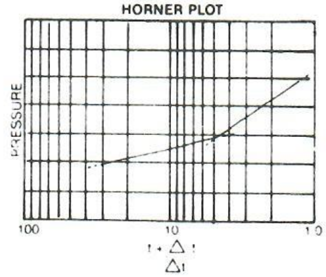
GUIDE TO DETECTION OF GEOLOGICAL ANOMALIES

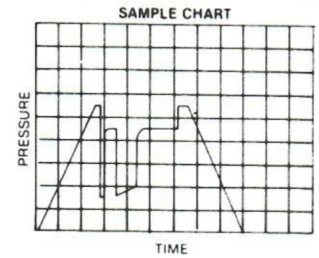


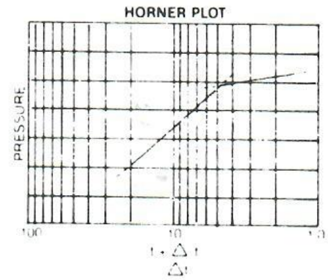


Horner Plot Slope Breaks Upward

Possible Causes

(1) decrease in pay thickness away from the wellbore
(2) decrease in permeability away from the wellbore
(3) increase in viscosity of reservoir fluid (fluid contact)
(4) barrier within the radius of investigation

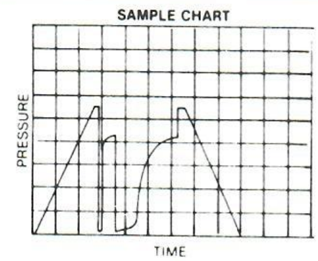


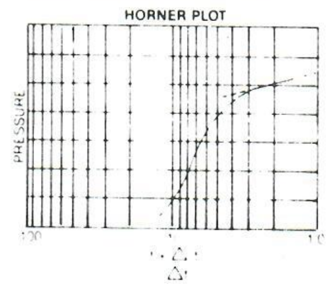


Horner Plot Slope Breaks Downward

Possible Causes

(1) increase in pay thickness away from the wellbore
(2) increase in permeability away from the wellbore
(3) decrease in viscosity away from the wellbore

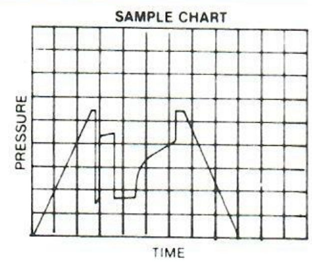


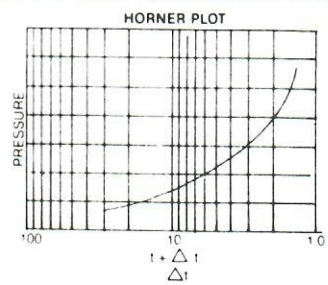


Early Time Deviation of Horner Plot

Possible Causes

(1) wellbore damage due to filtrate invasion, drilling solids, etc.
(2) partial penetration of pay zone
(3) plugging or choking of perforations (casing test only)
(4) wellbore storage effects (low permeability gas wells)

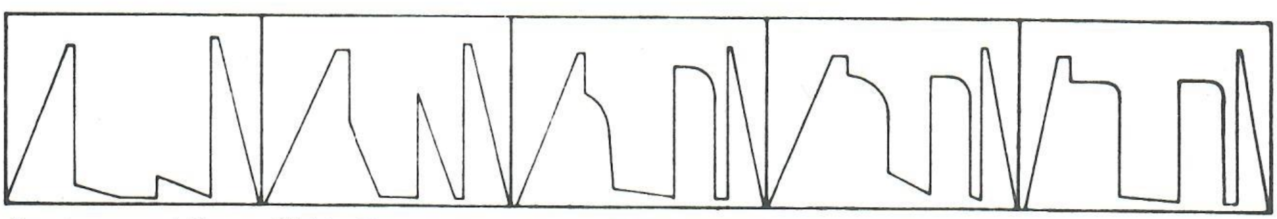




Horner Plot Slope Continually Increasing

Possible Causes

(1) well between two parallel boundaries (channel sand)
(2) induced hydraulic fractures



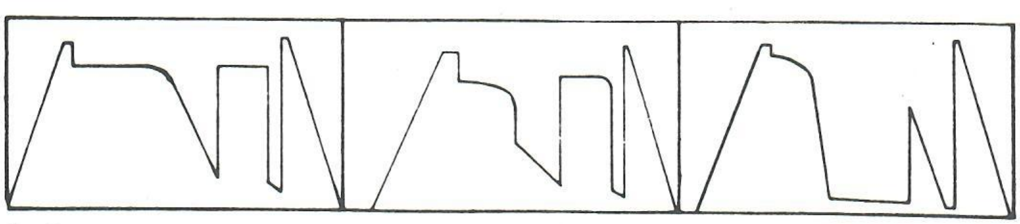
Very low permeability. Usually only mud recovered from interval tested. Virtually no permeability.

Slightly higher permeability. Again usually mud recovered.

Slightly higher permeability. Small recovery, less than 200 ft).

Average permeability. Final and initial shut-ins differ by 50 psi.

Average permeability. Strong damage effect. High shut-in pressure, low flow pressure.



Excelent permeability where final flow final shut-in pressure.

High permeability where ISIP and FSIP are within 10 psi.

Deep well bore invasion or damage. Final shut-in higher than the initial shut-in.