OF-WTWI-1984-42

HYDROLOGIC TEST DATA, J. FRIEMEL #1 WELL, DEAF SMITH COUNTY, PALO DURO BASIN, TEXAS PANHANDLE

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1984

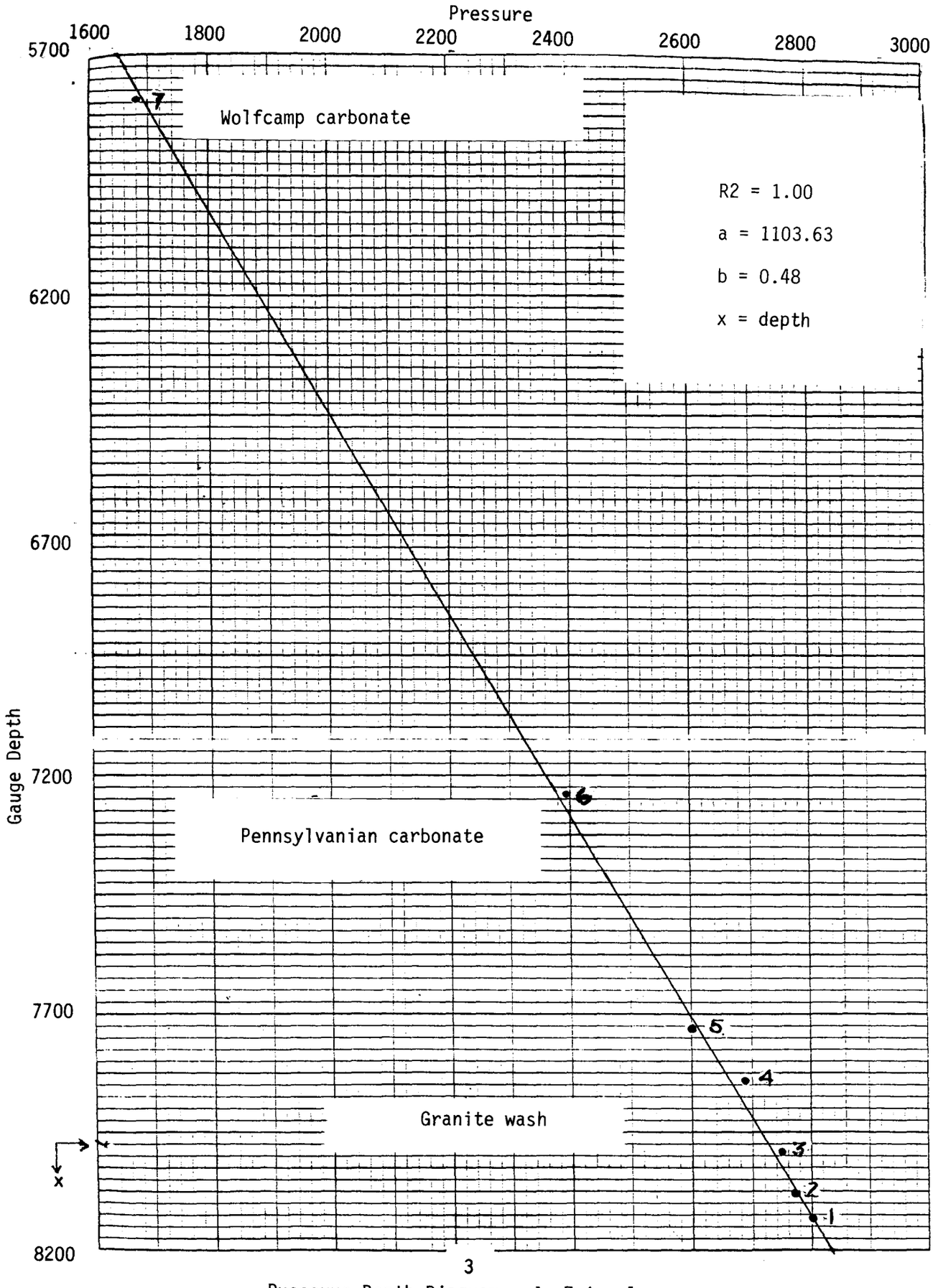
Hydrologic Test Data, J. Friemel #1 Well,
Deaf Smith County, Palo Duro Basin, Texas Panhandle

The following report gives the hydraulic conductivity and head values of eight zones in the DOE-SWEC J. Friemel #1 well, as determined from pump test and drill-stem test data. The results are given in tabulated form first, followed by the calculations performed to obtain the results.

J.FRIEMEL NO.1 HEAD DATA

KELLY BUSHING ELEVATION 4025 FEET

TEST INTERVAL	GAUGE DEPTH	SHUT IN PRESSURE	EQUIVALENT FRESH WATER HEAD	0.48 PSI/FOOT BRINE HEAD
GRANITE WASH 1	8130	2800	2331	1728
GRANITE WASH 2	8082	2770	2311	1714
GRANITE WASH 3	7994	2747	2346	1754
GRANITE WASH 4	7842	2683	2351	1773
GRANITE WASH 5	7670	2600	2332	1772
PENN CARBONATE 6	7242	2395	2289	1773
WOLFCAMP CARB 7	5798	1680	2089	1727



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Pressure Depth Diagram: J. Friemel

J.FRIEMEL HYDROLOGIC WELL TEST DATA

TEST ZONE	DEPTH(FT)	FORMATION	TEST ID #	K (MD)	MULTIPLE TEST STATISTICS		
					ARITHMETIC MEAN		STANDARD DEVIATION
1	8168 - 8204	GRANITE WASH	RECOVERY 1	43.6			
			RECOVERY 2	39.0			
			RECOVERY 3	42.7	ZONE 1	44.7	4.4
			RECOVERY 4	49.7			
			RECOVERY 5	48.4			
2	8122 - 8132	GRANITE WASH	RECOVERY 1	122.3			
3	8040 - 8050	GRANITE WASH	RECOVERY 1	148.7			
4	7896 - 7904	GRANITE WASH	RECOVERY 1	41.9			
			RECOVERY 1A	37.4	ZONE 4	40.2	2.4
			RECOVERY 2	41.3			
5	7707 - 7711 7729 - 7734	GRANITE WASH	RECOVERY 1	254.3			
6	7300 - 7326	PENNSYLVANIAN L.S.	RECOVERY 1	97.1			
			RECOVERY 6	81.7	ZONE 6	89.1	7.7
			RECOVERY 7	88.4			
7	5825 - 5926	WOLFCAMP L.S.	RECOVERY 1	0.91			
			RECOVERY 2	0.93			
			RECOVERY 3	0.85	ZONE 7	0.89	0.04
			RECOVERY 4	0.85			

J FRIEMEL DRILL STEM TEST PERMEABILITY DATA

TEST NUMBER	DEPTH	FORMATION	CALCULATED PERMEABILITY
6	5630 - 5909	WOLFCAMP L.S.	1.1 MILLIDARCY

J. FRIEMEL # 1, ZONE-1

10/20/83

RECOVERY TEST ANALYSIS

Perforated Interval : 8168' – 8204'

$\phi_{sonic} = 0.168$
$\phi_{D(SD)} = 0.184$
$\phi_{N(LS)} = 0.203$
; $h = 36'$
$\phi_{avg} = 0.185$

TEST # 1 (6/20 – 6/22/83) : $t_p = 26.663$ hrs , $P_{wf} = 1540.43$ psi

$\Delta t_{tot.} = 50.135$ hrs , $P_{ws\,final} = 2789.56$ psi

$Q = 470$ STB/D. ; $r_w = 5\frac{1}{2}'' \div 2 = 0.2292'$

$C_t = 7 * 10^{-6}$ psi^{-1}

From Ramey Plot : $K = 13.8$ md $\quad S \simeq +2$

From Horner Plot : $K = 43.6$ md $\quad S = -4.4$

Note : The Ramey Type curve match was not satisfactory. Horner Plot $K = 43.6$ md & $S \simeq 0$ seems a better result.

TEST # 2 : (6/23 – 6/24/83) : $t_p = 21.052$ hrs , $P_{wf} = 1983.96$ psi

$\Delta t_{sl.\,total} = 23.401$ hrs , $P_{ws.\,final} = 2781.92$ psi

$Q_p = 240$ STB/D

From Horner Plot : $K = 38.96$ md

RECOVERY TEST # 3 (6/24 – 6/27/83)

t_p = 2.221 hrs , P_{wf} = 1541.28

$\Delta t_{S.I}$ = 63.775 hrs , $P_{ws.final}$ = 2792.89 psi

Q_p = 518 STB/D (est. from daily morning reports. = GPM * 0.9)

From Horner Plot : K = 42.7 md.

RECOVERY TEST # 4 (7/1 – 7/4/83)

t_p = 99.758 hrs , P_{wf} = 1994.29 psi

Δt_{SI} = 67.957 hrs , $P_{ws.f.}$ = 2768.36 psi

Q_p = 478 STB/D

From Horner Plot : K = 49.66 md

RECOVERY TEST # 5 (7/5 – 7/7/83)

t_p = 30.702 hrs , P_{wf} = 1596.02 psi

Δt_{SI} = 39.675 hrs , $P_{ws.final}$ = 2768.21 psi

Q_p = 466 STB/D

From Horner Plot : K = 48.4 md

J. Friemel #1, Zone 1: Recovery Test #1 (6/20-6/22/83)

RAMEY LOG-LOG PLOT

$$C = \frac{qB}{24} \cdot \frac{\Delta t}{\Delta P}$$

$$= \frac{470 * 1 * 0.005}{24 * 600} = 0.000163 \ \text{RB/psi}$$

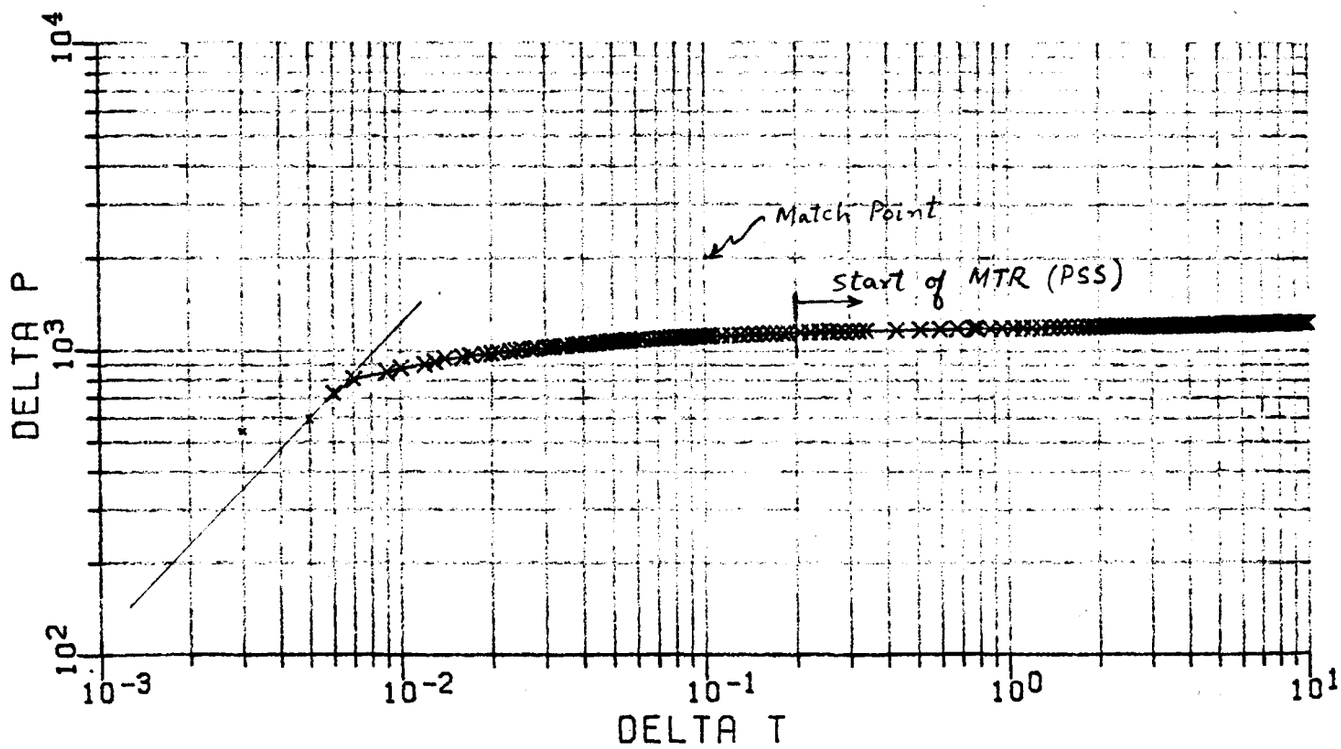
$$= 1.63 * 10^{-4}$$

$$C_D = \frac{5.615\,C}{2\pi\phi c_t h r_w^2} = \frac{5.615 * 1.63 * 10^{-4}}{2\pi (0.185) * (7 * 10^{-6}) 36 (0.2292)^2} = \underline{5.95 * 10^{1}}$$

Match Point:

$$\Delta t_M = 10^{-1}\ \text{hr} \Rightarrow (t_D)_M = 2 * 10^{3}$$
$$\Delta P_M = 2 * 10^{3}\ \text{psi} \Rightarrow (P_D)_M = 13$$
$$\Big\} \ \underline{s \simeq 2}$$

$$K = \frac{141.2\,qB\mu}{h} * \frac{(P_D)_M}{\Delta P_M} = \frac{141.2 * 470 * 1 * 1.15}{36} * \frac{13}{2 * 10^{3}} = \underline{13.8}\ \text{md}$$



J. Friemel #1, Zone 1: Recovery Test #1 (6/20-6/22/83)

HORNER BUILDUP PLOT

$$K = \frac{162.6\, qB\mu}{mh} = \frac{162.6 * 470 * 1 * 1.15}{56 * 36}$$

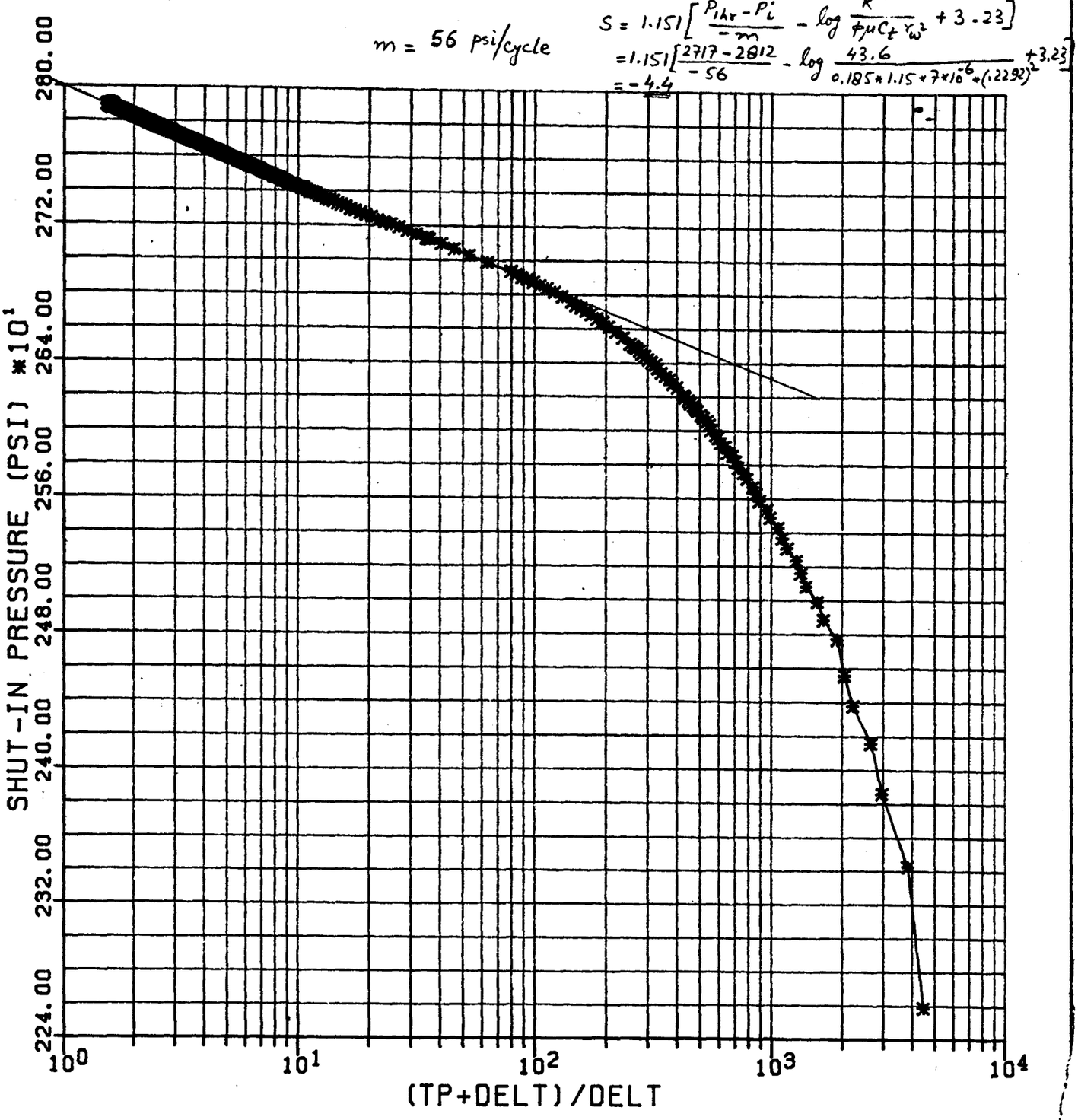
$$= 43.6 \text{ md}$$

$m = 56$ psi/cycle

$$S = 1.151\left[\frac{P_{1hr} - P_i}{-m} - \log\frac{K}{\phi\mu C_t r_w^2} + 3.23\right]$$

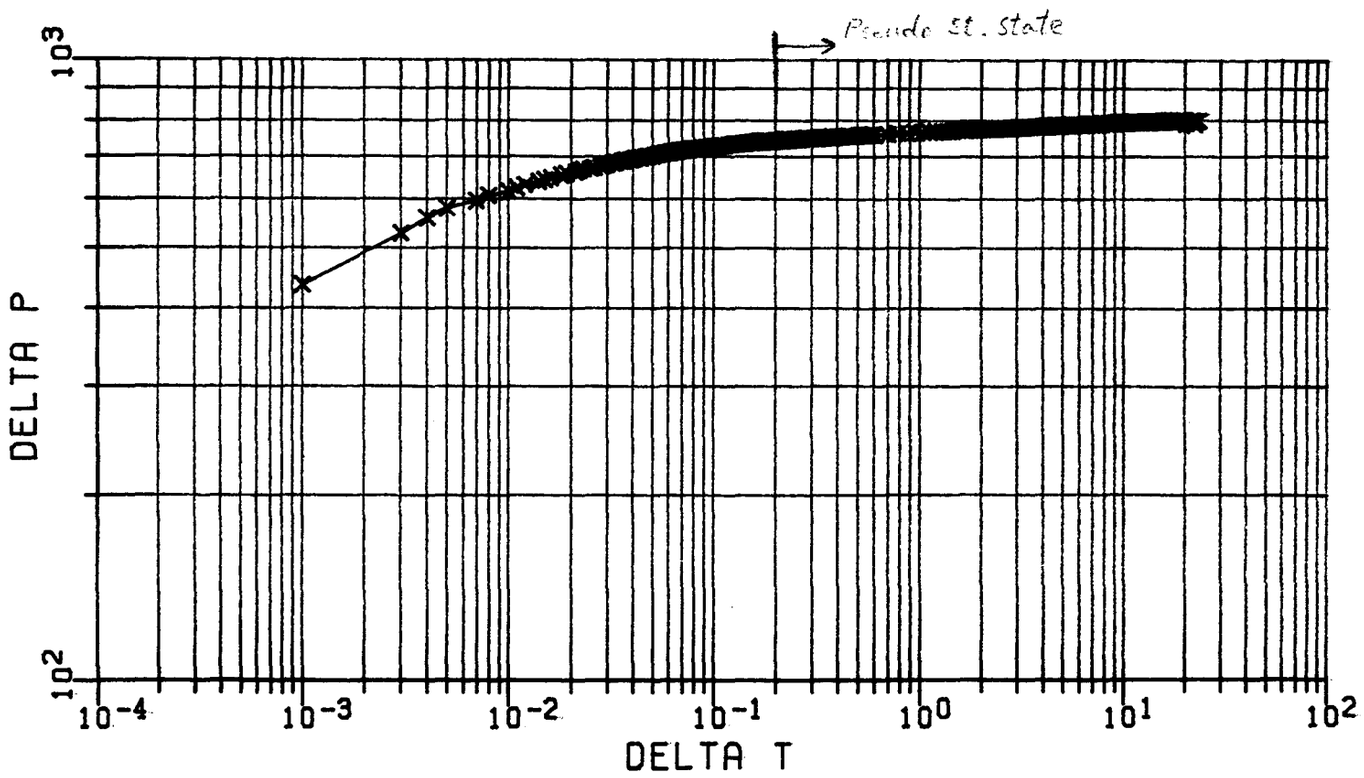
$$= 1.151\left[\frac{2717 - 2812}{-56} - \log\frac{43.6}{0.185 * 1.15 * 7 * 10^{-6} * (.2292)^2} + 3.23\right]$$

$$= -4.4$$



J. Friemel #1, Zone 1: Recovery Test #2 (6/23-6/24/83)

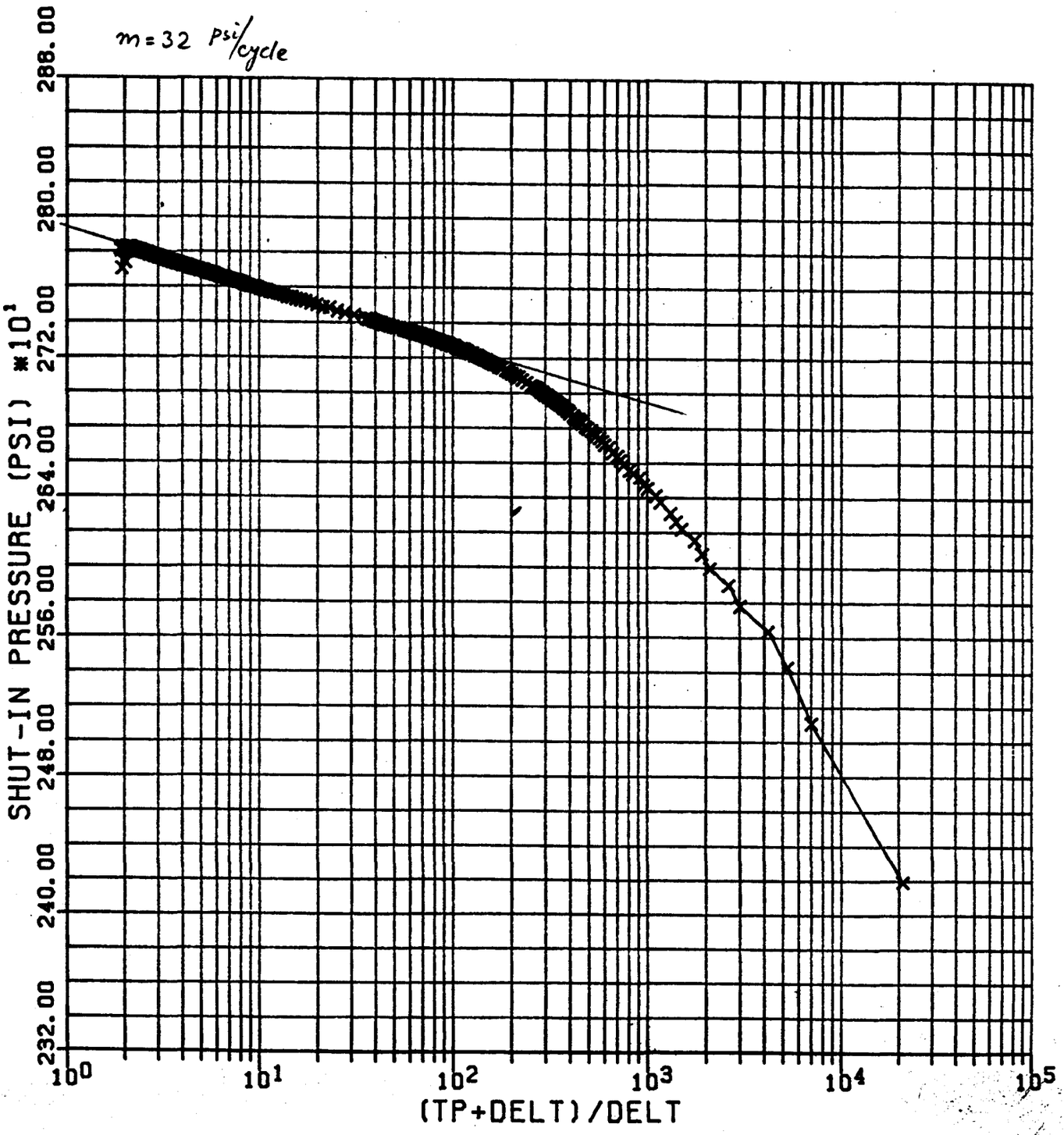
RAMEY LØG-LØG PLØT



J. Friemel #1, Zone 1: Recovery Test #2 (6/23-6/24/83)

HORNER BUILDUP PLOT

$$K = \frac{162.6 * 240 * 1 * 1.15}{36 * 32} = 38.96 \text{ md}$$



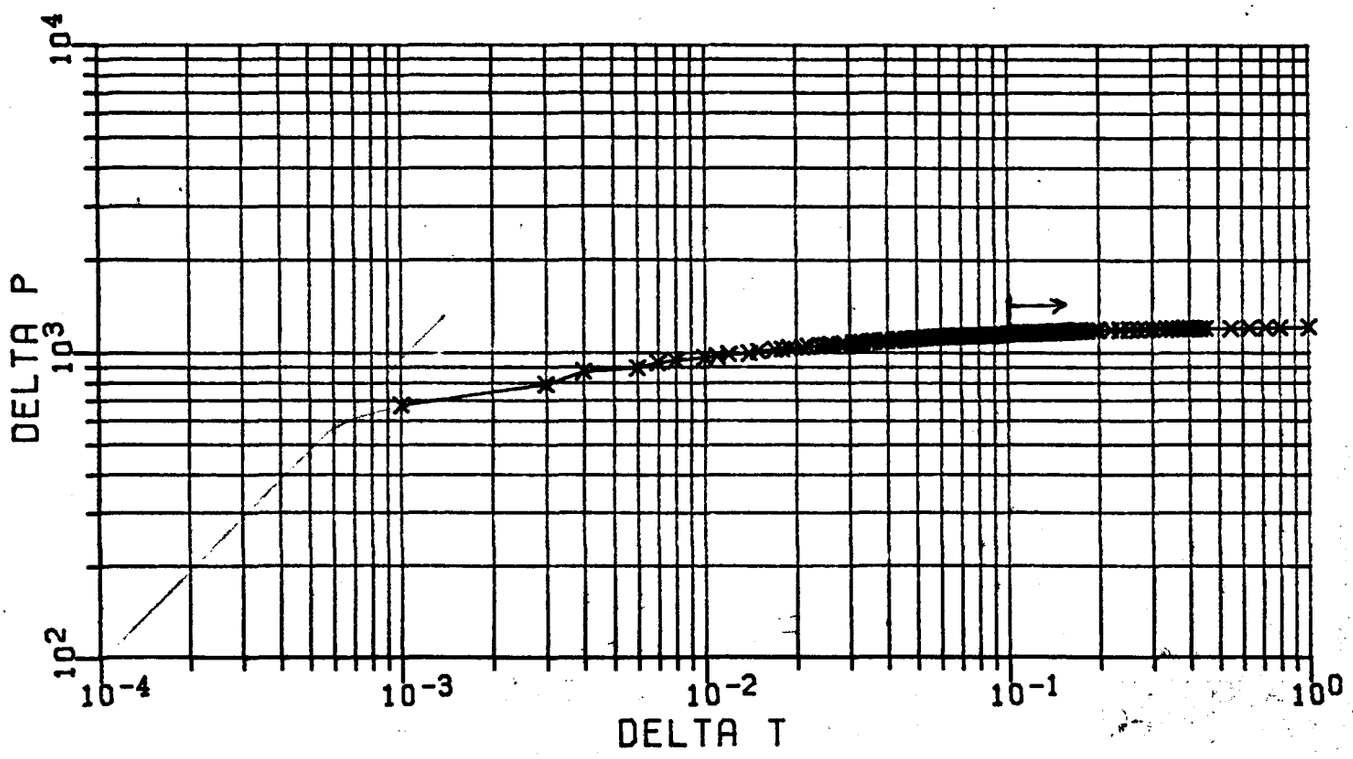
J. Friemel #1, Zone 1: Recovery Test #3 (6/24-6/27/83)

RAMEY LOG-LOG PLOT

$$C = \frac{qB}{24} \cdot \frac{\Delta t}{\Delta p}$$

$$= \frac{518 * 1 * 0.0003}{24 * 290} = 2.2 * 10^{-5} \text{ RB/psi}$$

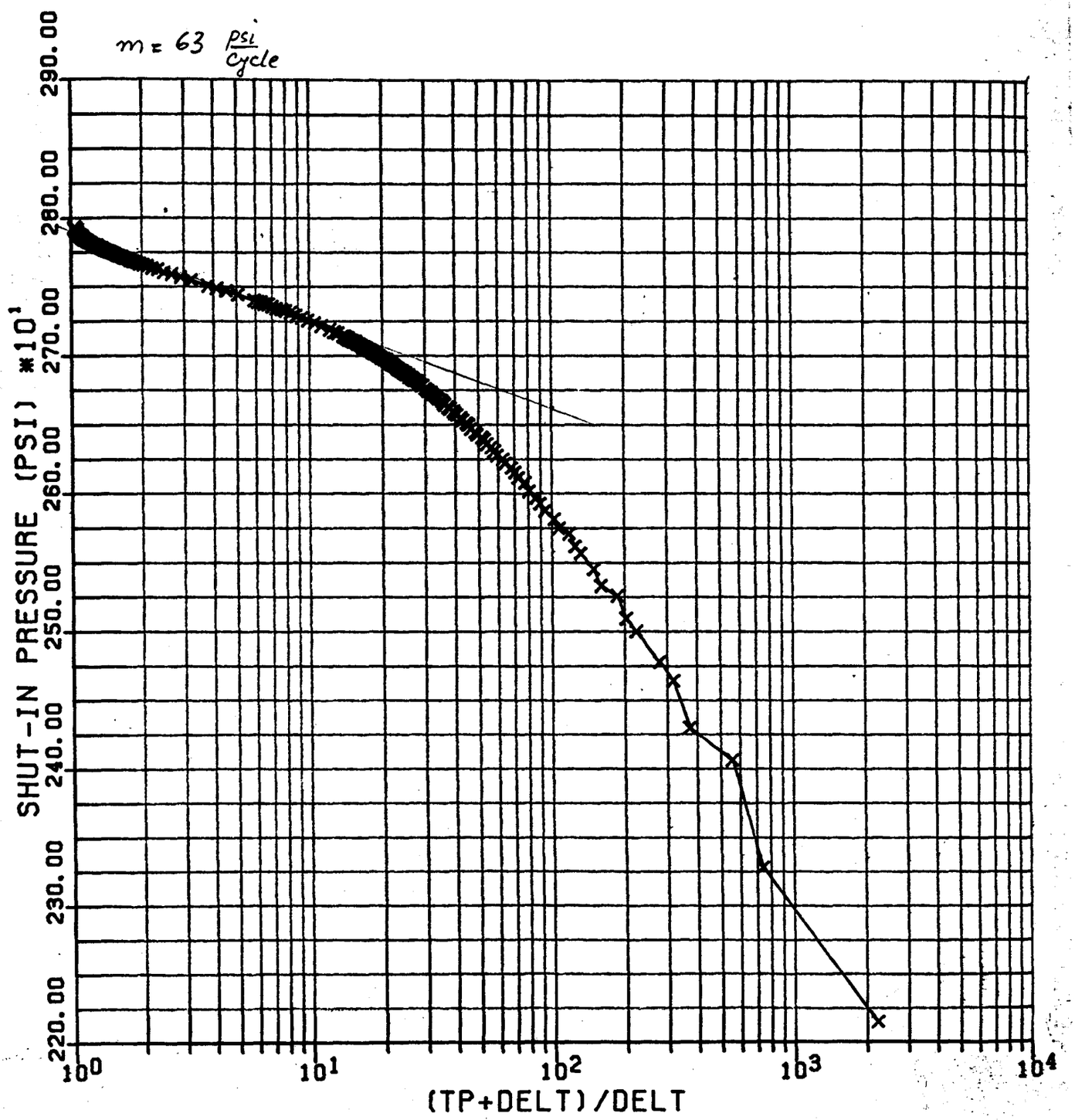
$$C_D = \frac{5.615 * C}{2\pi\phi C_t h r_w^2} = 0.8 * 10^{1}$$



J. Friemel #1, Zone 1: Recovery Test #3 (6/24-6/27/83)

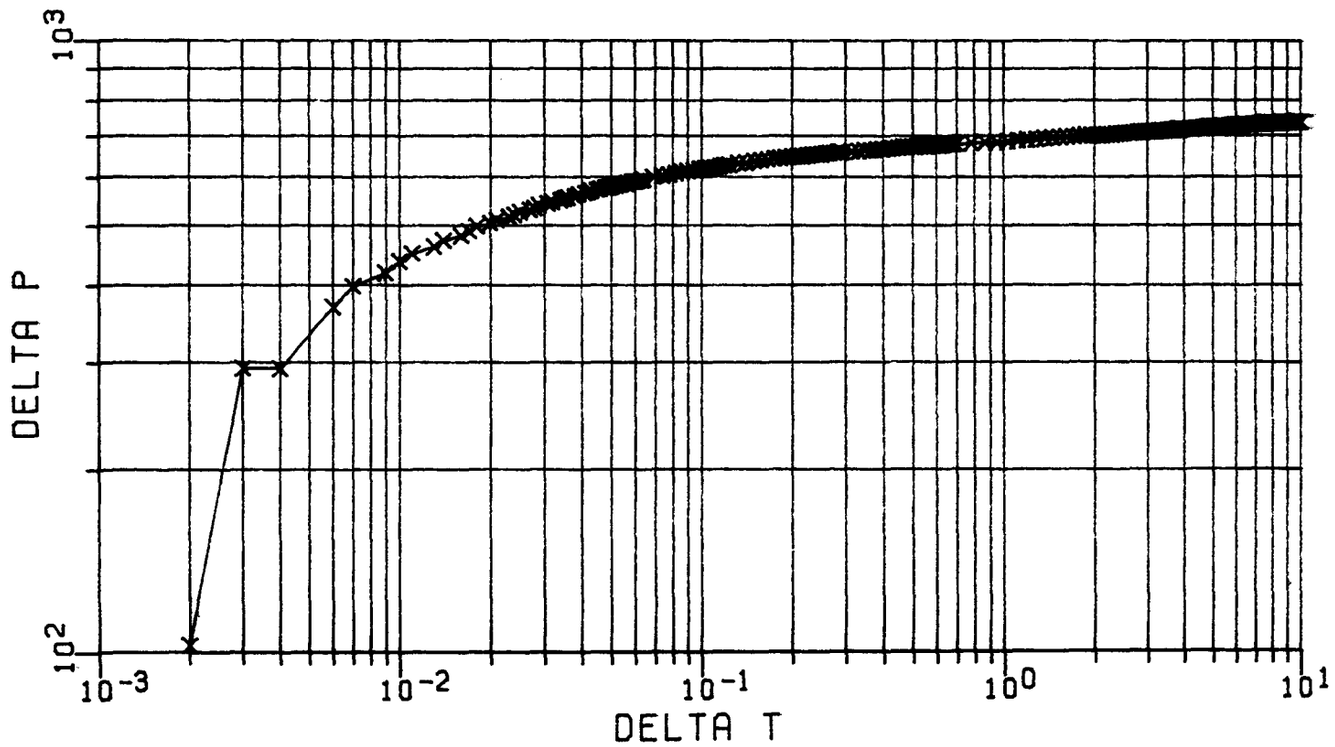
HORNER BUILDUP PLOT

$$K = \frac{162.6\ q\beta\mu}{mh} = \frac{162.6 * 518 * 1 * 1.15}{63 * 36} = \underline{42.7}\ md$$



J. Friemel #1, Zone 1: Recovery Test #4 (7/1-7/4/83)

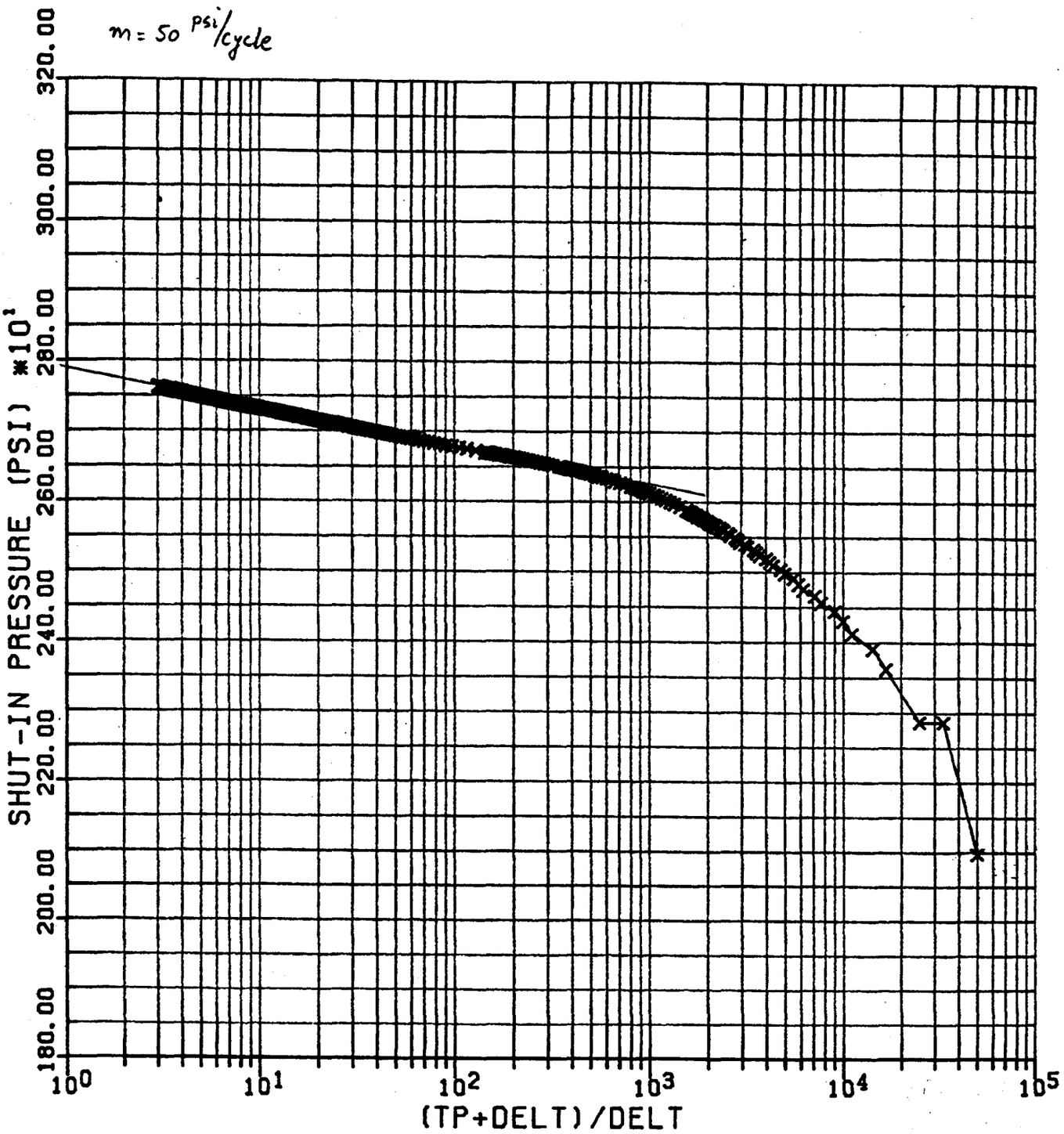
RAMEY LOG-LOG PLOT



J. Friemel #1, Zone 1: Recovery Test #4 (7/1-7/4/83)

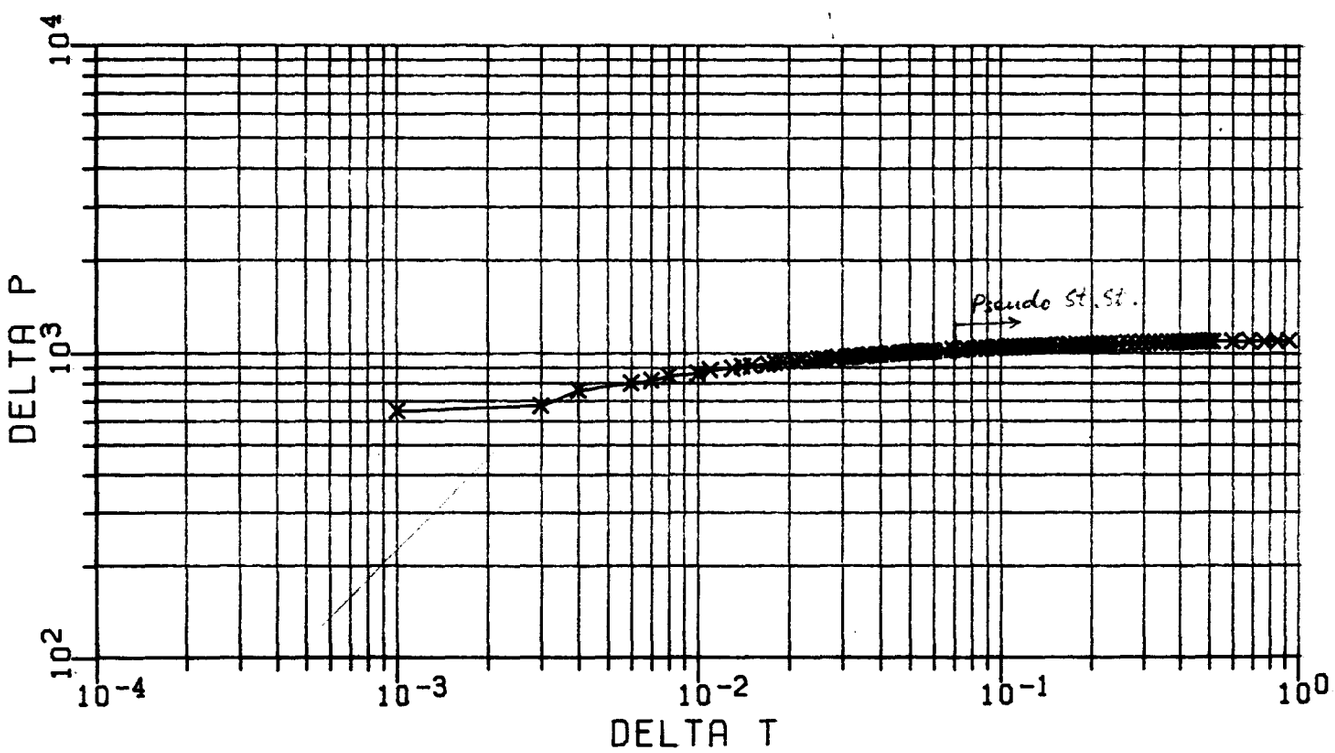
HORNER BUILDUP PLOT

$$k = \frac{162.6 * 478 * 1 * 1.15}{50 * 36} = \underline{\underline{49.66}} \text{ md}$$



J. Friemel #1, Zone 1: Recovery Test #5 (7/5-7/7/83)

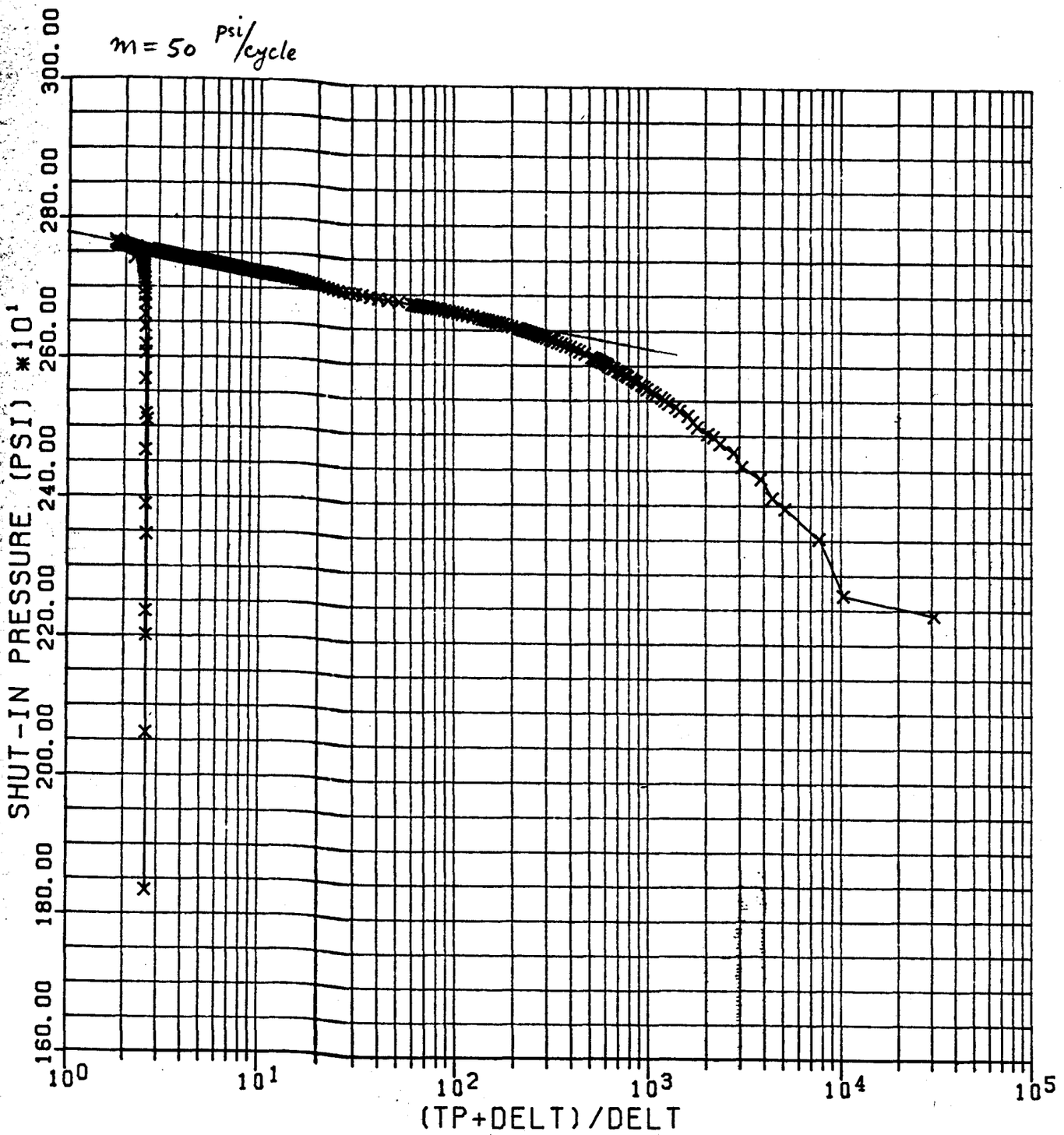
RAMEY LØG-LØG PLØT



J. Friemel #1, Zone 1: Recovery Test #5 (7/5-7/7/83)

HORNER BUILDUP PLOT

$$k = \frac{162.6 * 466 * 1 * 1.15}{50 * 36} = 48.4 \text{ md}$$



J. FRIEMEL #1 10/26/83

RECOVERY TEST ANALYSIS

ZONE-2 : (8122 - 8132') ; 7/20 - 7/21/83

$h = 10'$, $t_p = 45.26$ psi, $P_{wf} = 1773.85$ psi

$Q_p = 523.2$ STB/D, $P_{ws.final} = 2727$ psi, $\Delta t = 25.821$ hrs

$\phi_{est.} = 0.245$

From Horner Plot : $K = 122.3$ md

$$S = 1.151\left[\frac{P_{1hr} - P_i}{m} - \log\frac{Kt}{\phi\mu C_t r_w^2} + 3.23\right]$$

$$= 1.151\left[\frac{2630 - 2707}{-80} - \log\frac{122.3 * 1}{0.245 * 1.15 * 7 * 10^{-6} * 0.2292^2} + 3.23\right]$$

$$= 1.151\left[1.9625 - 9.072 + 3.23\right] = -4.47$$

ZONE-3 (8040' - 8050') ; 7/29 - 8/1/83

$h = 10'$, $t_p = 46$ hrs, $P_{wf.} = 2534.40$ psi

$Q_p = 636$ STB/D ; $P_{ws.final} = 2729.3$ psi, $\Delta t = 72.72$ hrs

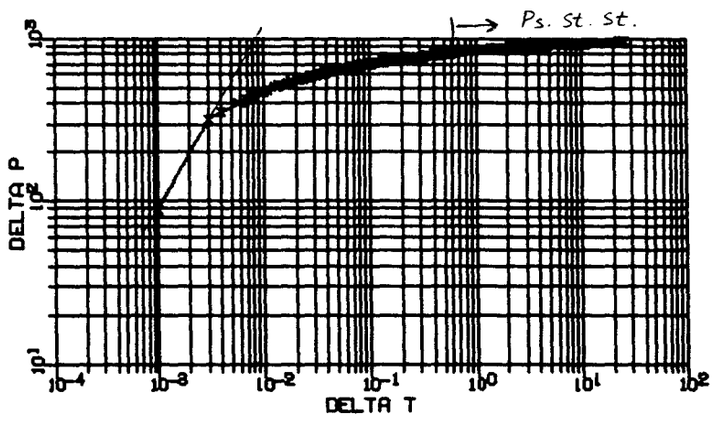
Ramey log-log Plot : The pressure buildup is not uniform. No $\frac{1}{2}$ slope line is distinguishable; hence no fracture calculations can be done. A larger wellbore storage seems to cause the concave shape of the curve, also repeated on the Horner plot.

From Horner Plot : $K = 148.7$ md.

J. Friemel #1, Zone 2; Recovery Test (7/20-7/21/83)

Δt=0.991 hrs.

RAMEY PLOT



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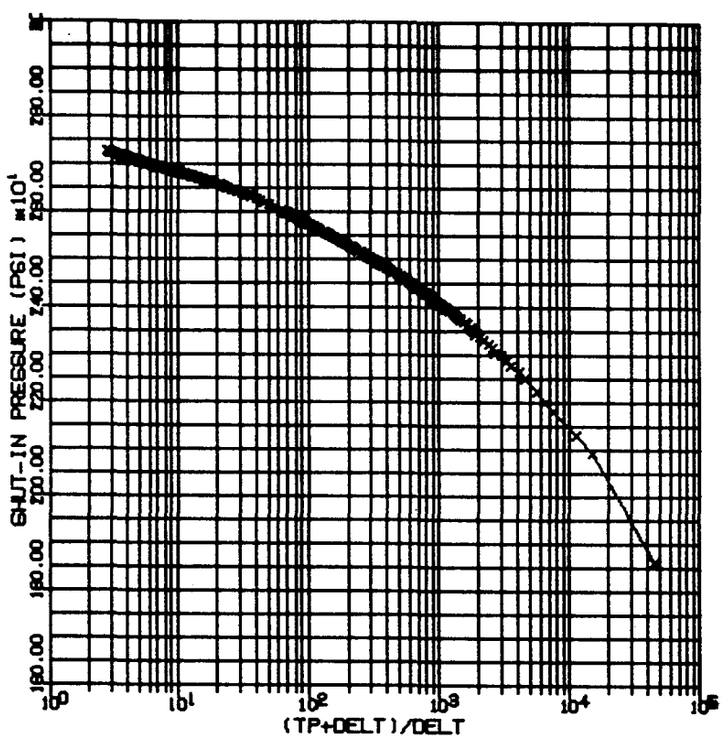
J. Friemel #1, Zone 2; Recovery Test

Horner Plot



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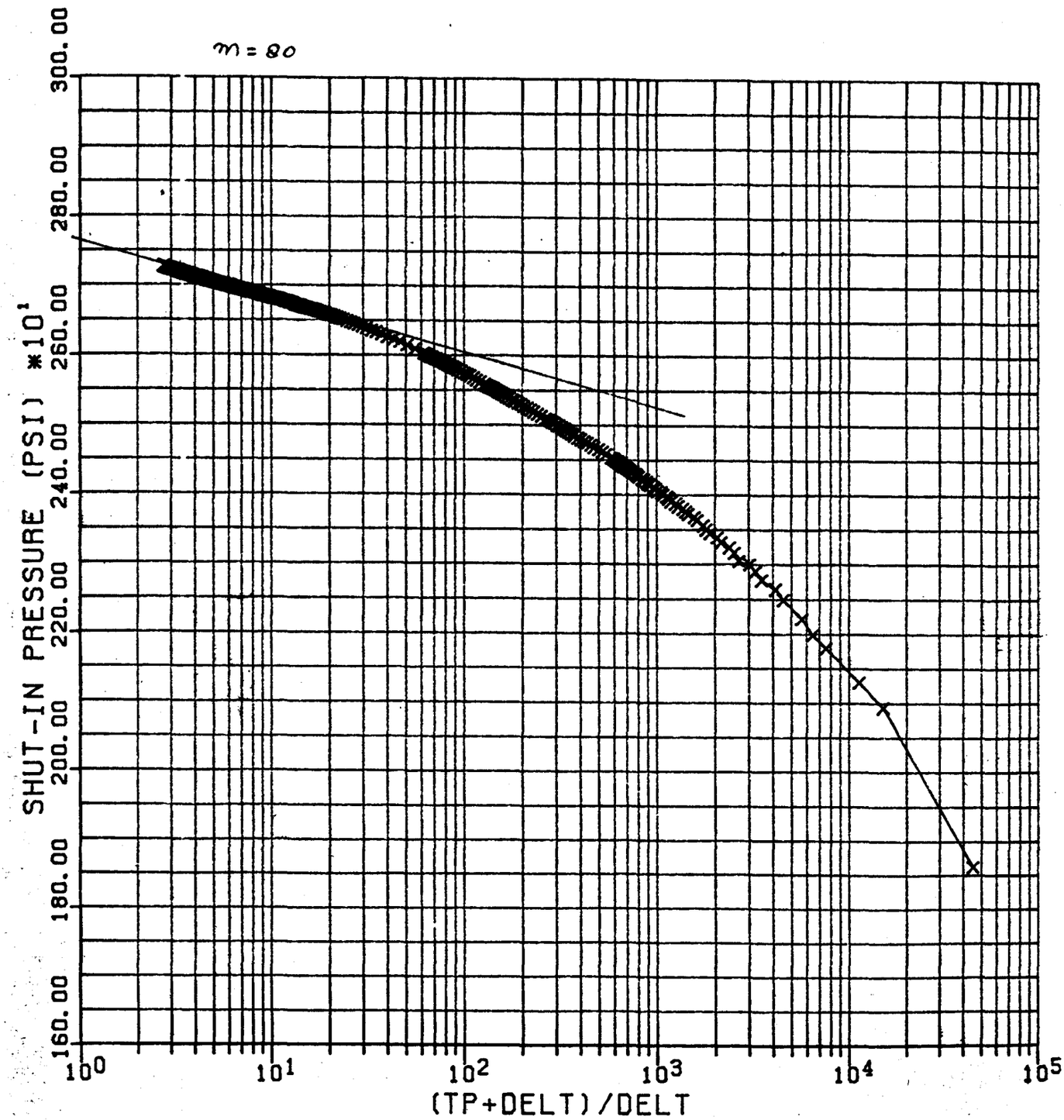
J. Friemel #1, Zone 2; Recovery Test (7/20-7/21/83)

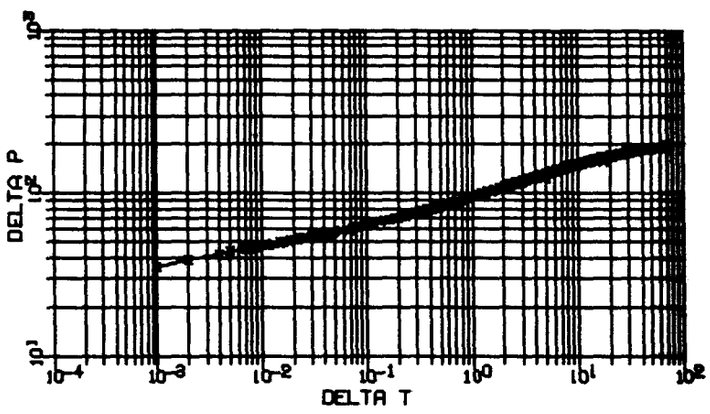
HORNER BUILDUP PLOT

$$K = \frac{162.6 * 523.2 * 1 * 1.15}{80 * 10} = \underline{122.3} \text{ md}$$



J. Friemel #1, Zone 3; Recovery Test

Δt=0.970 hrs.



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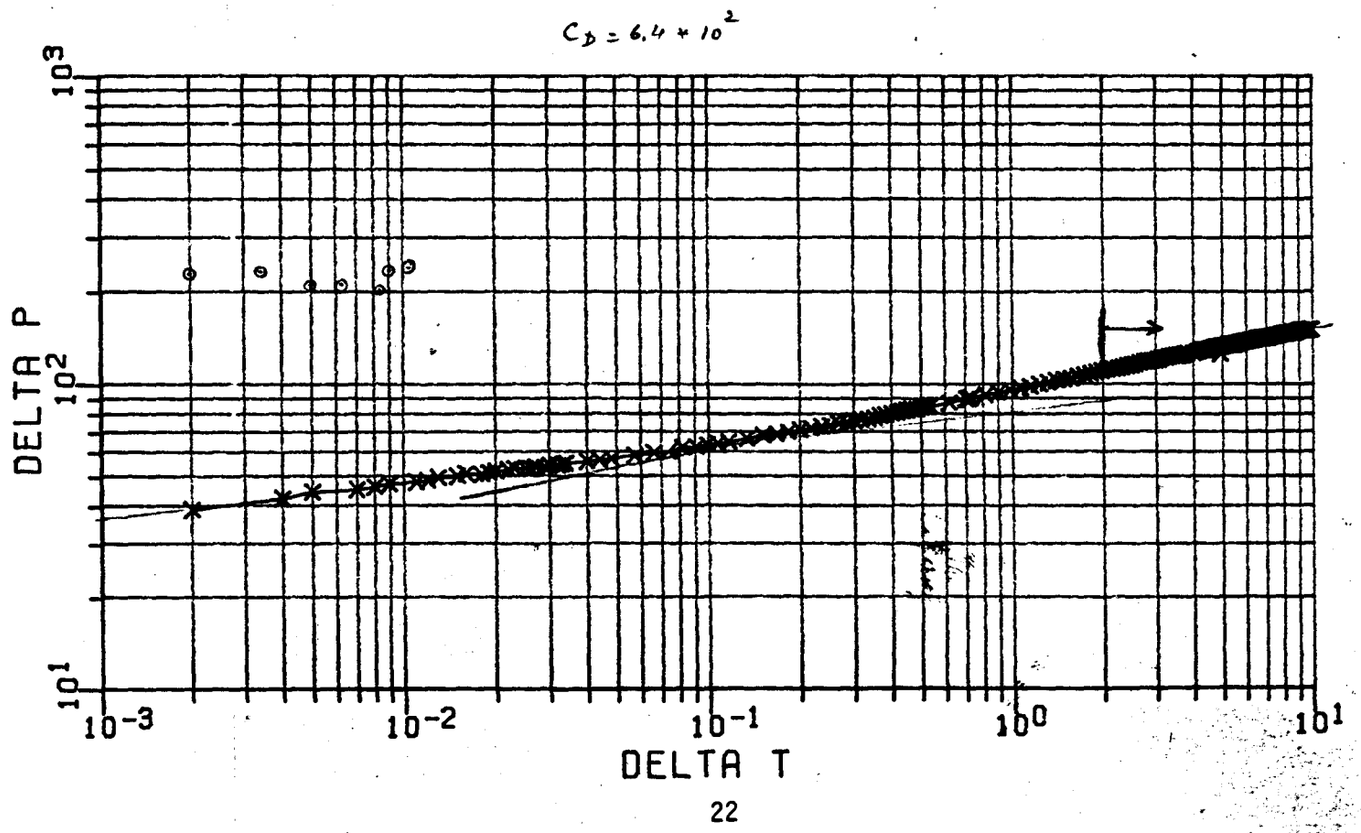
J. Friemel #1, Zone 3; Recovery Test (7/29-8/1/83)

RAMEY LOG-LOG PLOT



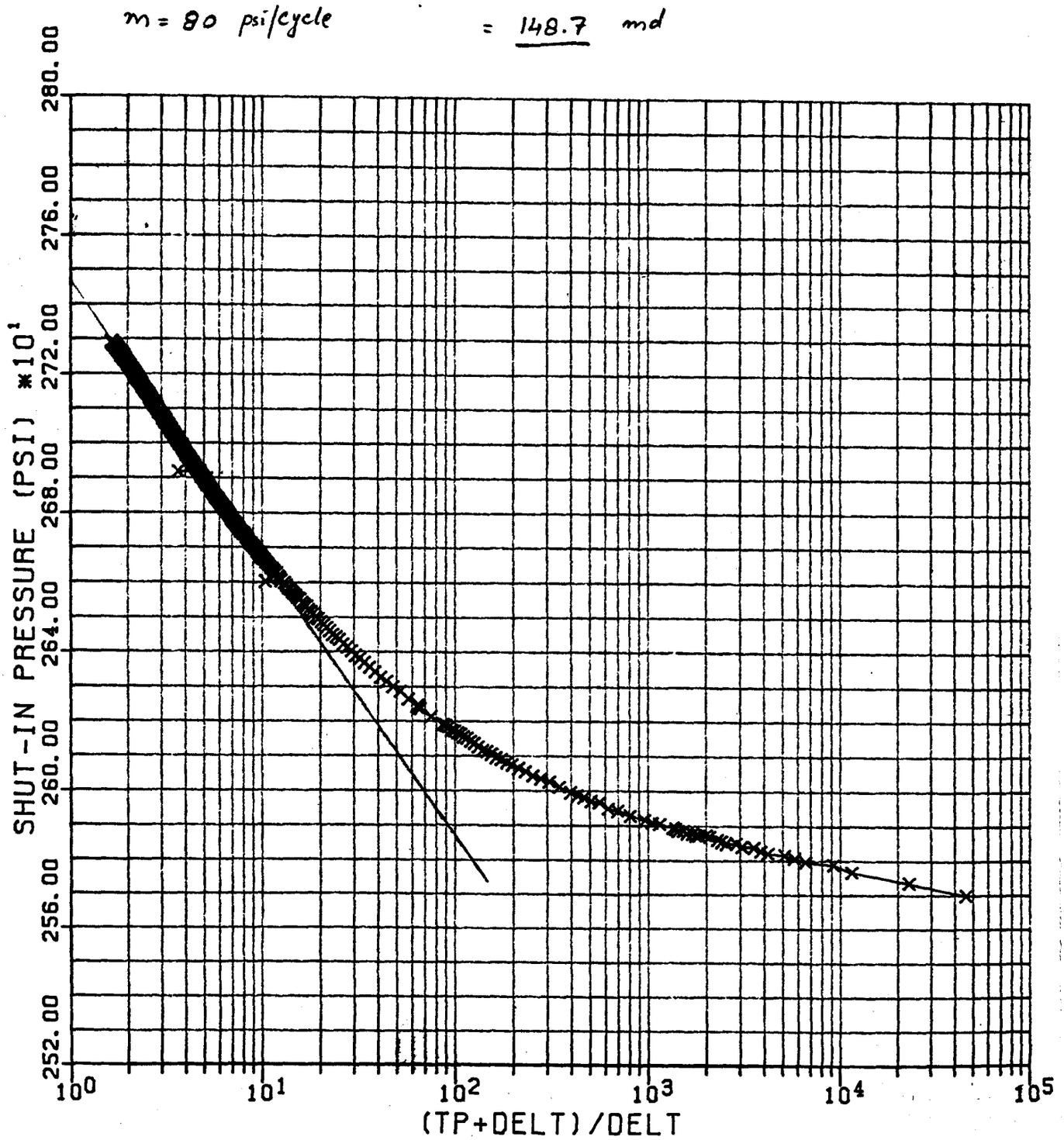
J. Friemel #1, Zone 3; Recovery Test (7/29-8/1/83)

HORNER BUILDUP PLOT

$$K = \frac{162.6 * 636 * 1.15}{80 * 10}$$

$m = 80$ psi/cycle

$= 148.7$ md



ZONE 4: (7896' - 7904')

TEST #1 (8/21 - 8/23/83)

$h = 8'$, $t_p = 27.86$ hrs, $P_{wf} = 1459.92$ psi, $\phi = 0.206$

$Q_p = 148.8$ STB/D, $P_{ws.final} = 2575.08$ psi, $\Delta t = 40.668$ hrs

From Horner Plot: $K = \underline{41.90}$ md

Note: The upswing in the curve on Horner Plot after about 1 hr of shut-in is attributed to reservoir heterogeneity. With a longer shut-in period the pressure buildup would probably again flatten out with a slope of the curve equal to the earlier section.

TEST #1A (8/26 - 8/29/83)

$h = 8'$, $t_p = 85.42$ hrs, $P_{wf} = 554.19$ psi, $\phi = 0.206$

$Q_p = 200$ STB/D, $P_{ws.final} = 2420.48$ psi, $\Delta t_{s.i.} = 60.461$ hrs

From Horner Plot: $K_1 = \underline{37.40}$ md

$K_2 = 10.05$ md (far-wellbore reservoir K)

Note: The shape of the Horner buildup curve is very similar to the Test #1 curve, again indicating reservoir heterogeneity.

TEST #2 (9/2 - 9/5/83)

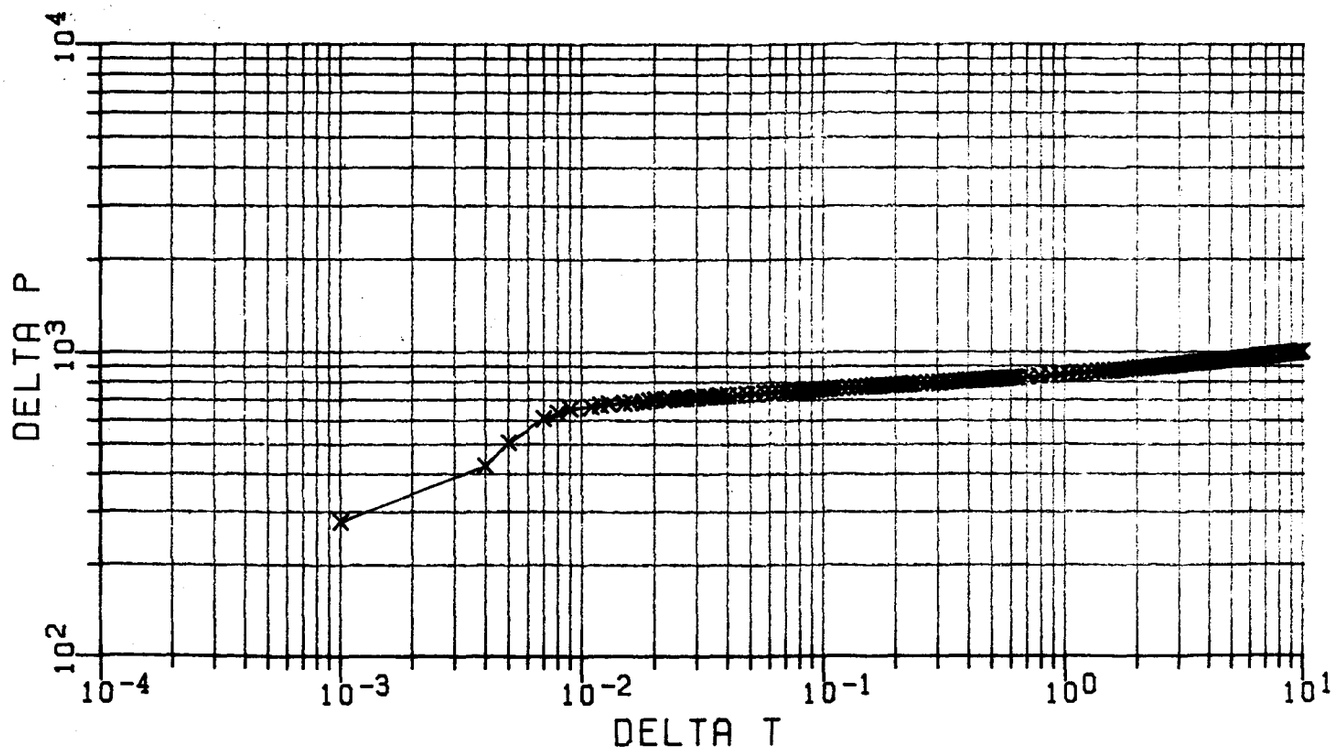
$h = 8'$, $t_p = 100.757$ hrs, $P_{wf} = 417.88$ psi,

$Q_p = 88.27$ B/D, $P_{ws.final} = 2440.07$ psi, $\Delta t_{s.i.} = 65.072$ hrs

From Horner Plot: $K = \underline{41.26}$ md

J. Friemel #1, Zone 4; Recovery Test #1 (8/21-8/23/83)

RAMEY LOG-LOG PLOT

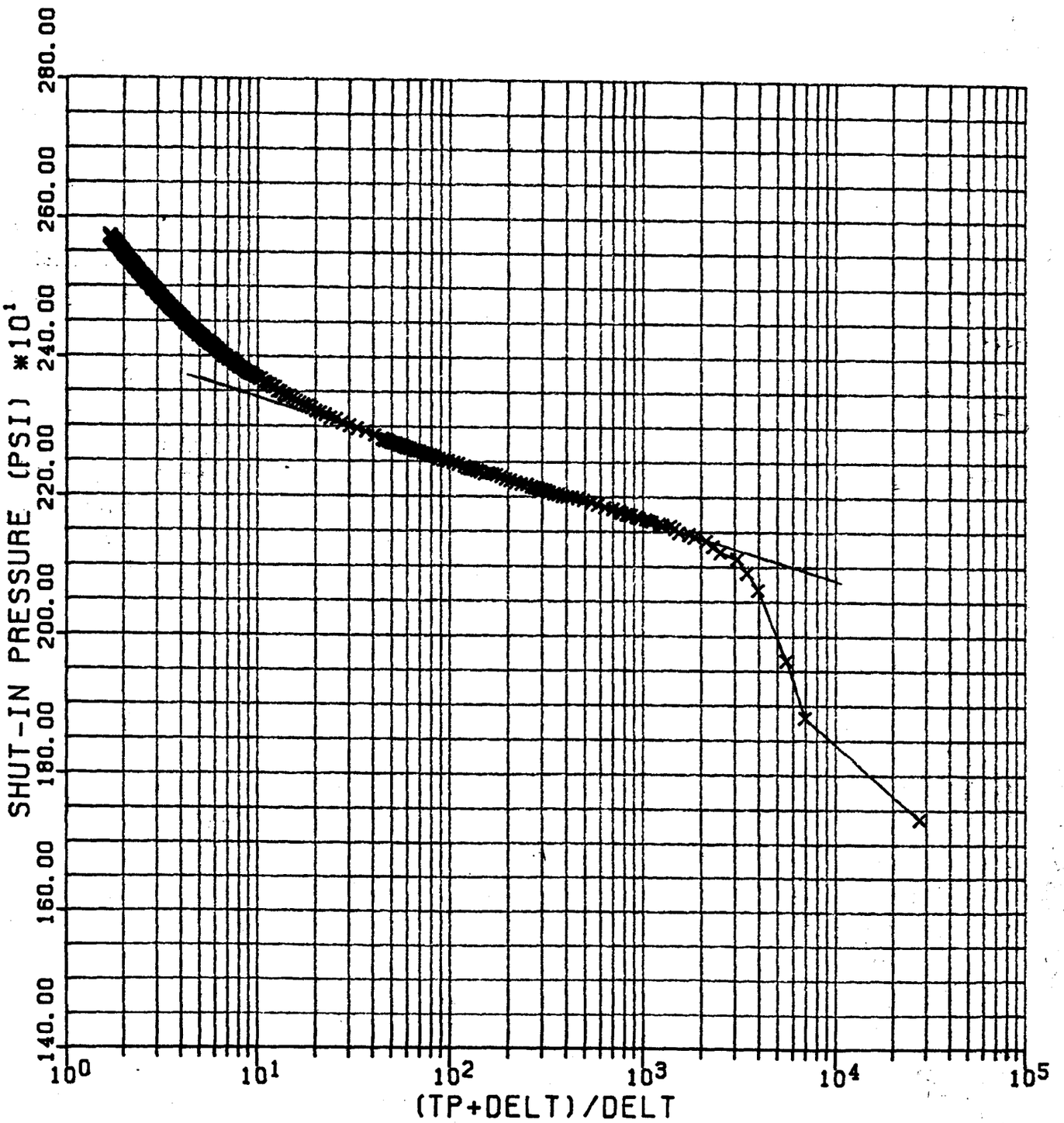


J. Friemel #1, Zone 4; Recovery Test #1 (8/21-8/22/83)

HORNER BUILDJP PLOT

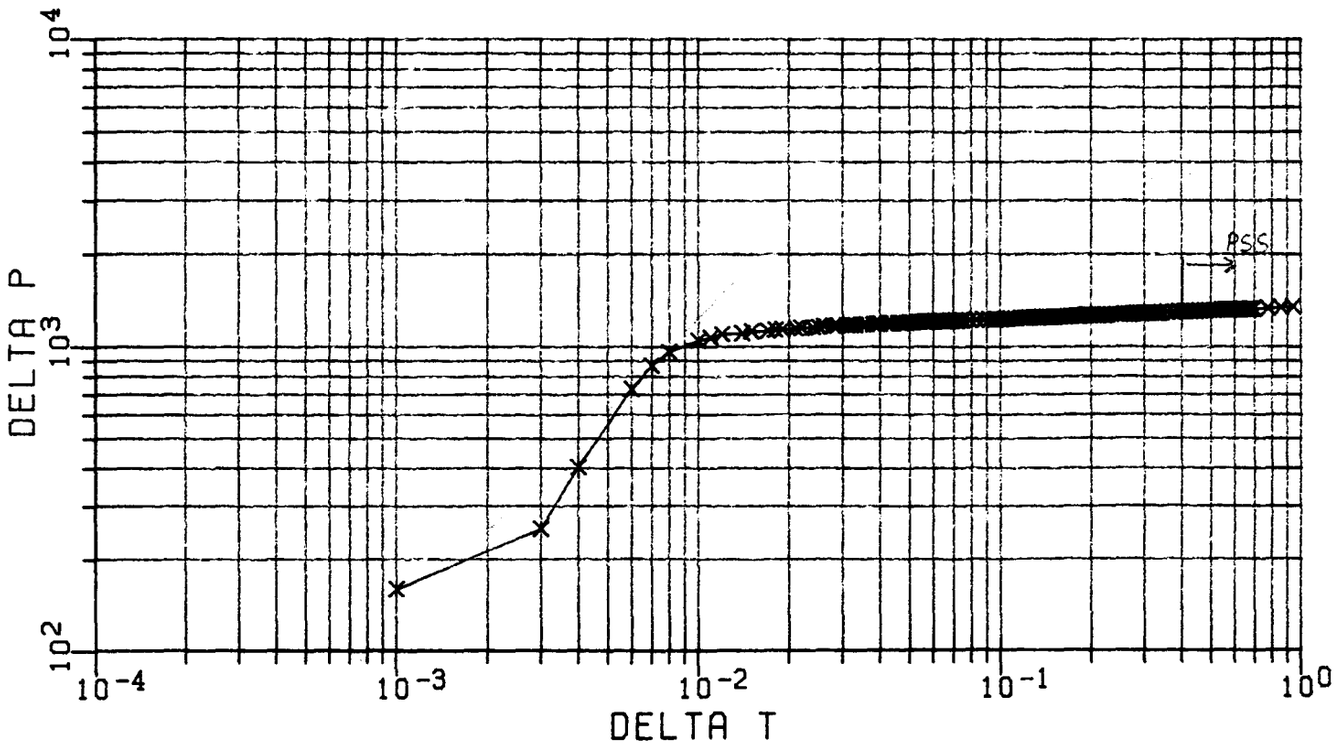
$m = 83$ psi/cycle

$$K = \frac{162.6 * 148.8 * 1.15}{83 * 8} = 41.90 \text{ md}$$



J. Friemel #1, Zone 4; Recovery Test #1A (8/26-8/29/83)

RAMEY LOG-LOG PLOT

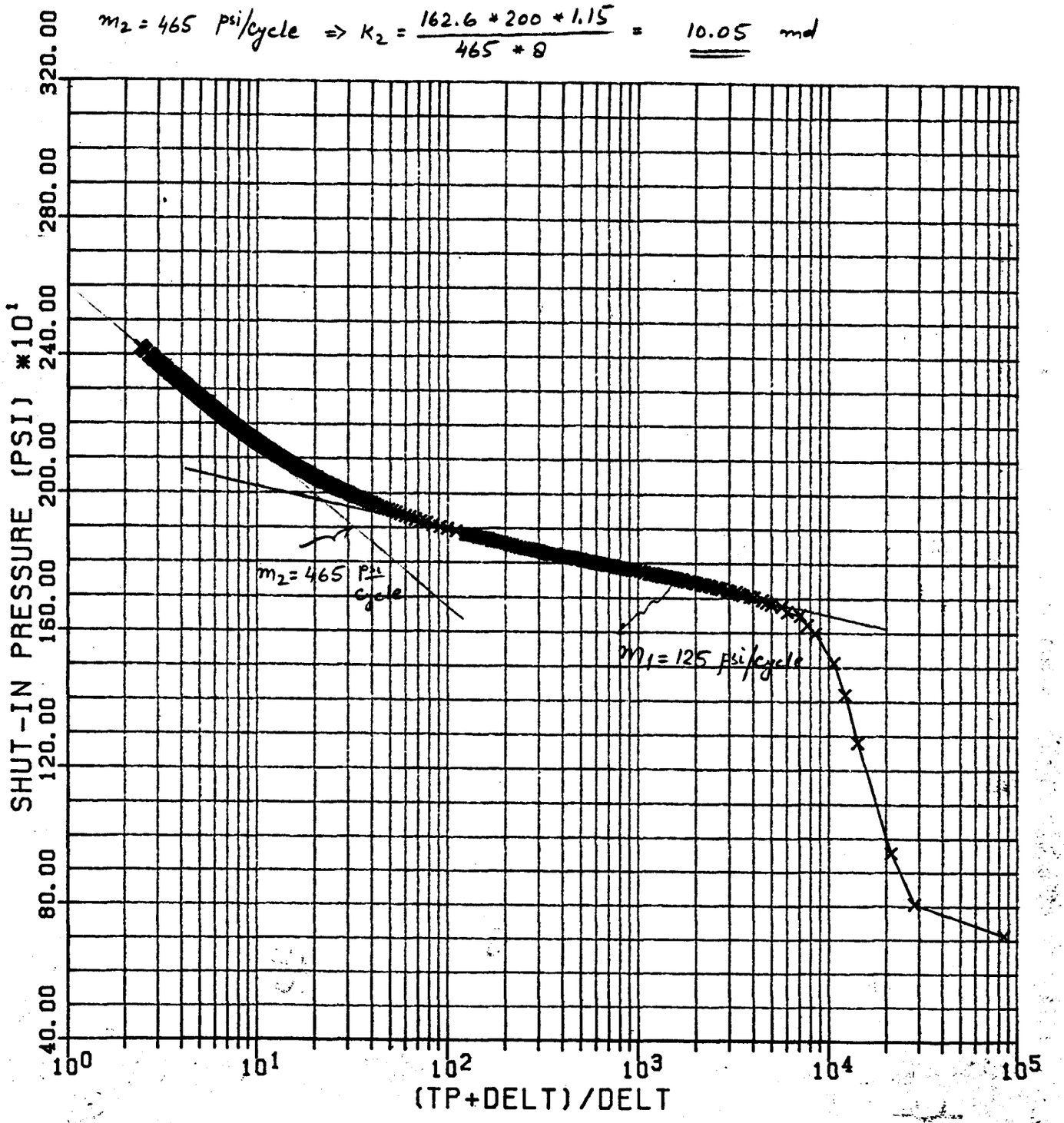


J. Friemel #1, Zone 4; Recovery Test #1A (8/26-8/29/83)

HORNER BUILDUP PLOT

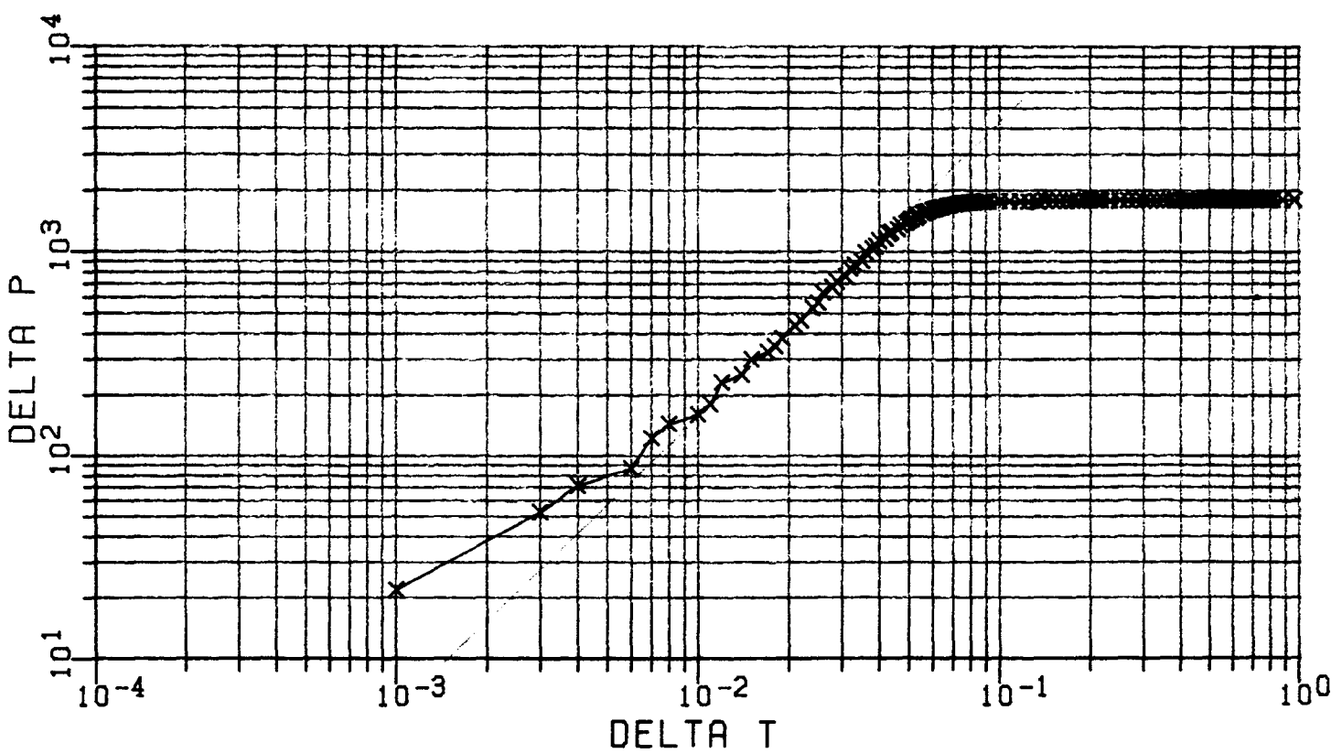
$m_1 = 125$ psi/cycle $\Rightarrow$ $K_1 = \dfrac{162.6 * 200 * 1.15}{125 * 8} = \underline{37.40}$ md

$m_2 = 465$ psi/cycle $\Rightarrow$ $K_2 = \dfrac{162.6 * 200 * 1.15}{465 * 8} = \underline{10.05}$ md



J. Friemel #1, Zone 4; Recovery Test #2 (9/2-9/5/83)

RAMEY LOG-LOG PLOT

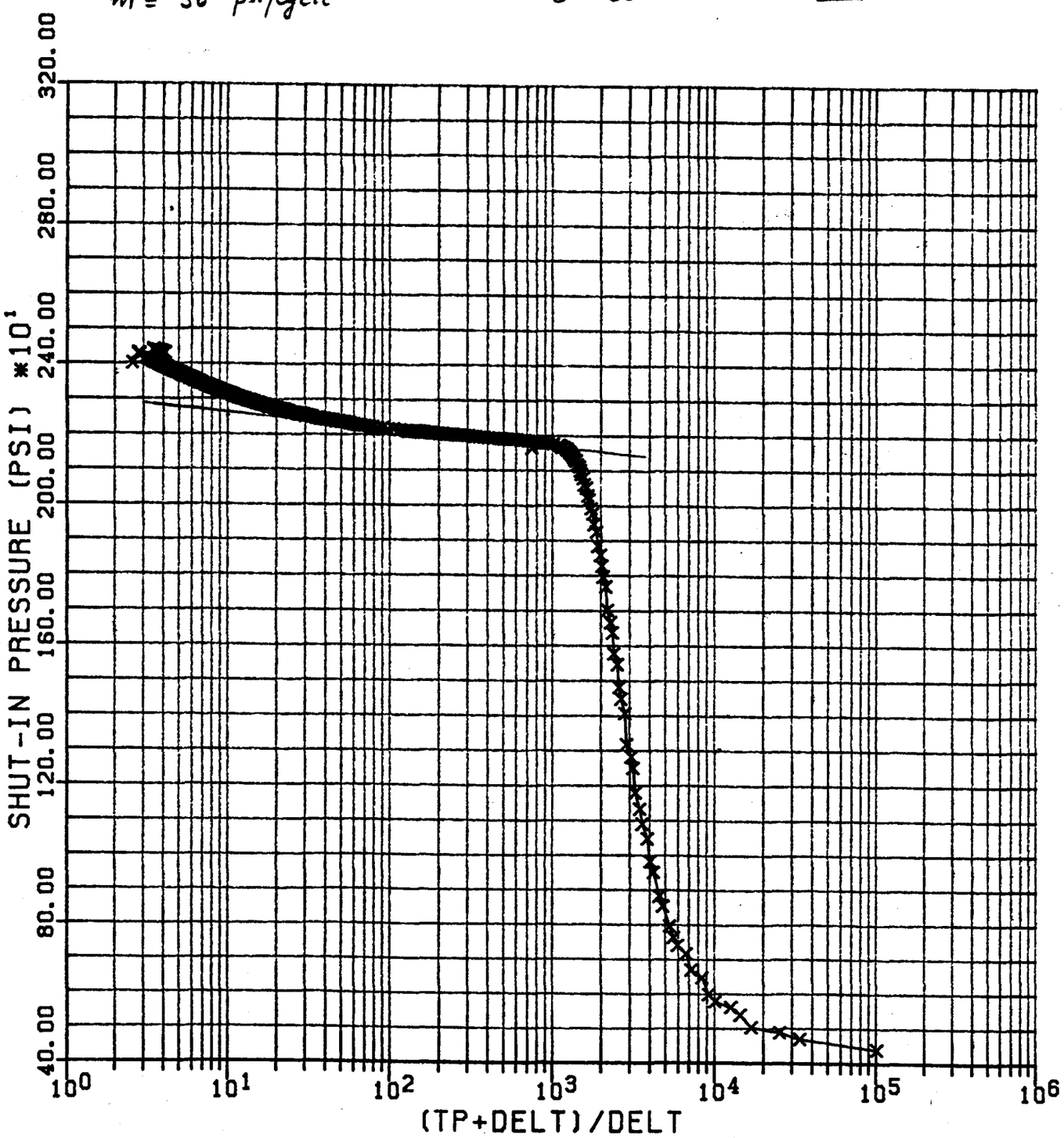


J. Friemel #1, Zone 4; Recovery Test #2 (9/2-9/5/83)

HORNER BUILDUP PLOT

$m = 50$ psi/cycle

$$K = \frac{162.6 * 88.27 * 1.15}{8 * 50} = 41.26 \text{ md}$$



ZONE - 5 : Perfs @ 7707 - 7711 ft & 7729 - 7734 ft.

$h = 22.5'$, $\phi_{avg} = 0.182$

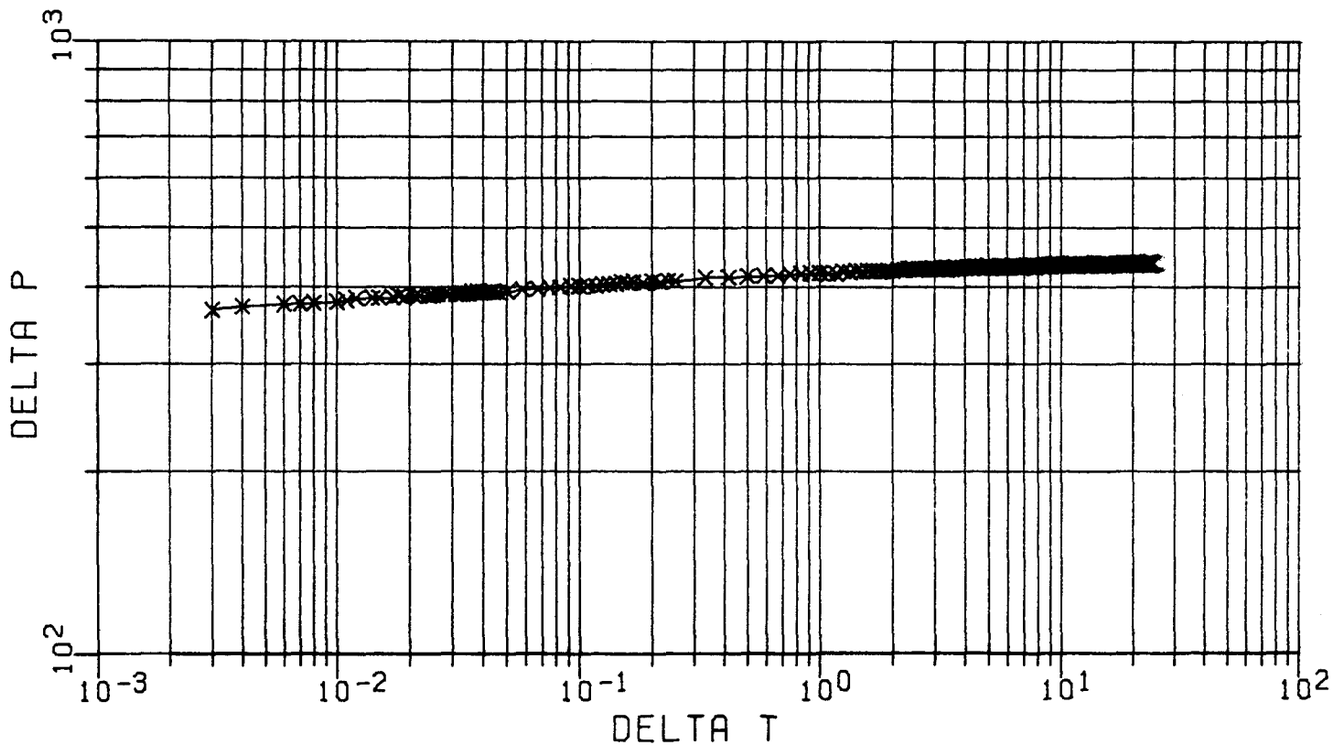
$t_p = 48.005$ hrs, $Q_p = 705$ STB/D, $P_{wf} = 2148.48$ psi

$P_{ws.final} = 2584.0$ psi, $\Delta t = 23.76$ hrs

From Horner Plot : $k = \dfrac{162.6 * 612 * 1.15}{22.5 * 20} = \underline{254.3}$ md

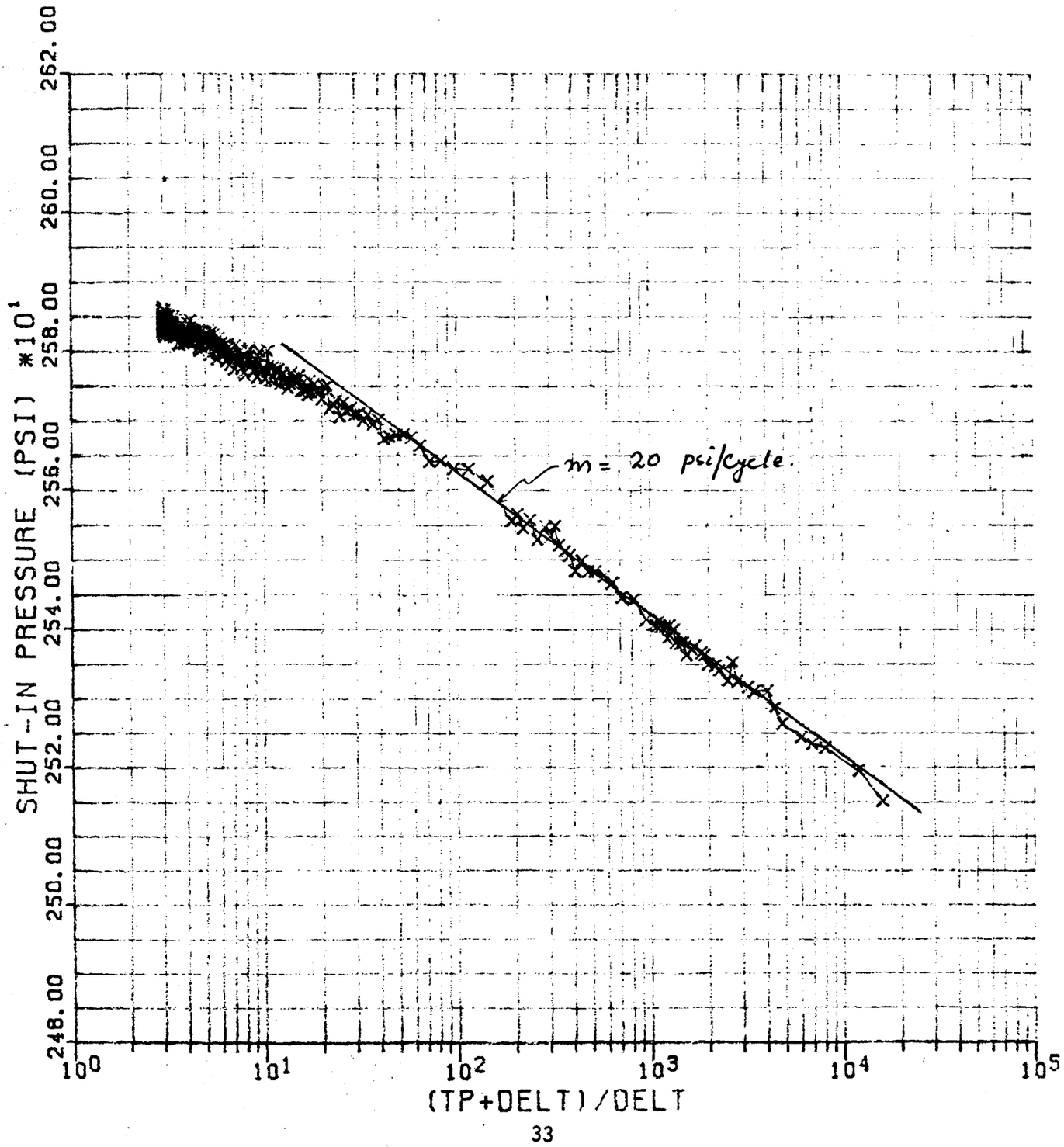
J. Friemel #1, Zone 5; Recovery Test #1 (9/22-9/23/83)

RAMEY LØG-LØG PLØT



J. Friemel #1, Zone 5; Recovery Test #1 (9/22-9/23/83)

HORNER BUILDUP PLOT



3/01/84

J. FRIEMEL-1, ZONE-6; Recovery Test Analyses

Zone-6 net thickness $h = 26'$ (7300 - 7326 ft)

Recovery Test # 1 : (10/2 thru 10/4/83)

Horner Analysis - slope $m = 40$ psi/cycle ; $Q_p = 540$ STB/D

$P_{wf} = 1272.06$ psi ; $t_p = 48.077$ hrs

$$k = \frac{162.6(540)(1.15)(1)}{40\ (26)} = \underline{97.1}\ \text{md}$$

Recovery Test # 6 : (11/1 thru 11/3/83)

Horner Analysis - slope $m = 55$ psi/cycle ; $Q_p = 625$ STB/D

$P_{wf} = 1202.93$ psi ; $t_p = 101.792$ hrs

$$k = \frac{162.6\ (625)(1.15)(1)}{55\ (26)} = \underline{81.73}\ \text{md}$$

Recovery Test # 7 (11/5 thru 11/6/83)

Horner Analysis - slope $m = 36$ psi/cycle ; $Q_p = 442.64$ STB/D

$P_{wf} = 1587.78$ psi ; $t_p = 47.967$ hrs

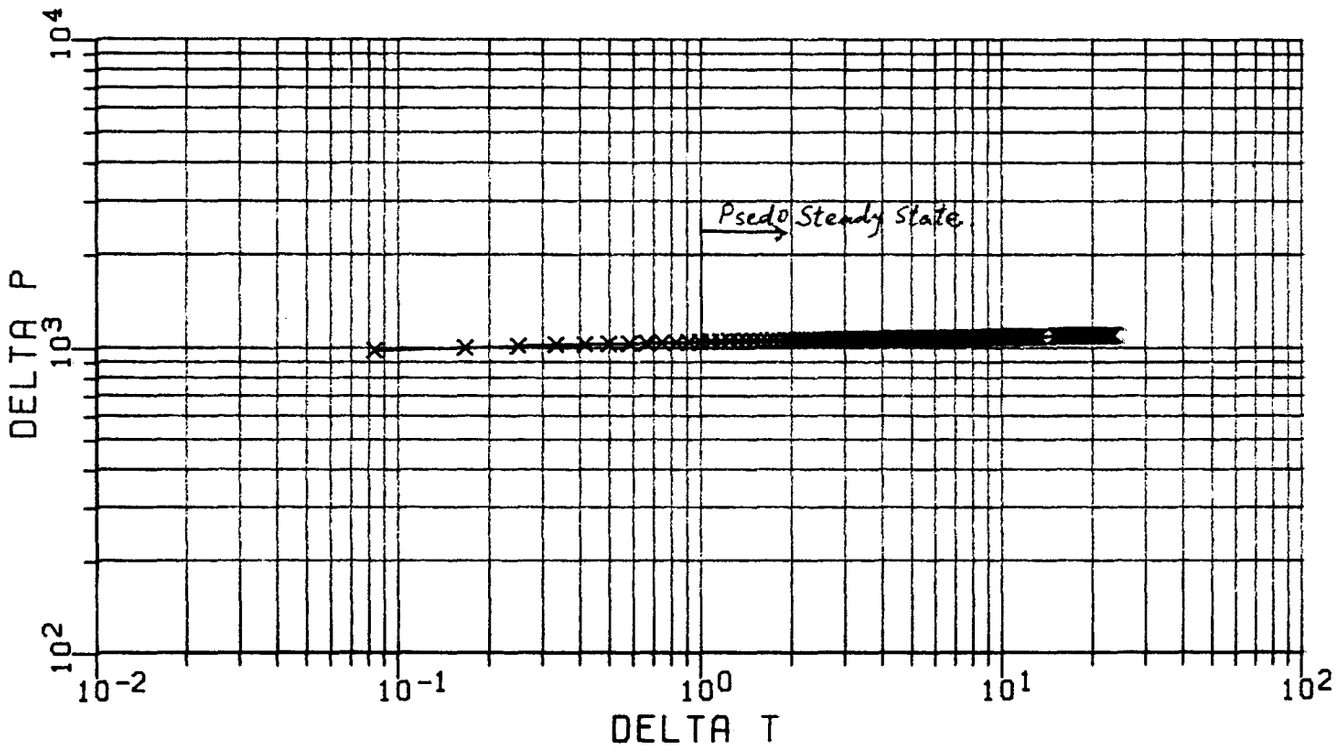
$$k = \frac{162.6(442.64)(1.15)(1)}{36\ (26)} = \underline{88.43}\ \text{md}$$

J. FRIEMAL # 1 — 2/21/84

ZONE-6

Date	Time		Operations
9/30/83	11:20:00		Started Pumping (Q_p = 540 STB/D) ($P_{i\,test.}$ = 2395 psi
10/2/83	11:24:41		End DD #1. Start Rec. 1. (P_{wf} = 1272.06 psi, Q_p = 540 STB/D, t_p = 48.077 hrs
	Unscheduled End		due to Pump Problem.
10/3	24 hrs	Rec. 1	Continue Rec. 1
10/4	11:53:40		End Rec. #1 $P_{ws.f}$ = 2379.97 ; Δt = 48.483 hr
10/4	11:54:0		Begin DD # 2
	19: ? ? ?		Interrupt DD #2 (Major Pump Problem)
10/25	S.D. Due to Pump Prob. No data Collected for Rec. Test # 2.		
10/26	16:24:35		Begin DD # 4
10/27	5:19:55		Ca.. Malfunction? Data aquisition ceased.
10/27	14:36:30		(Continue Pumping after 1 hr interruption) End DD # 4 Begin Short Term Recovery #5 (P_{wf} = 1600.94 psi, t_p ≅ 23 hrs. Q_p = NA)
10/28	10:26:20		End Recov. Test # 5
10/28	10:26:20		Begin Long Term DD #6. (Q_p = 576 STB/D)
10/29 - 10/31	24 hrs	DD #6	Continue DD #6 Q_p = 625 STB/D.
11/1 — 11/10	Reports Missing		
11/1/83	16:12:20		End DD #6 P_{wf} = 1202.93 Q_p = 625 STB/D t_p = 101.792 hrs.
11/1/83	16:12:20	Rec. #6	Begin Rec. #6. $P_{ws.f}$ = 2361.18 psi Δt = 47.067 h
11/3/83	15:16:20		End Rec. #6
11/3	15:16:20	DD 7	Begin DD # 7 P_{wf} = 1587.78, t_p = 47.967
11/5	15:14:20		End DD # 7 Q_p = 442.64 B/D
11/5	15:14:20	Rec. 7	Begin Rec # 7 P_{ws} = 2360.40, 24 hrs data missing
11/6	16:13:00		End Rec. #7 Δt = 24.808 hrs
11/6	16:13:00	DD #8	Begin DD # 8 P_{wf} = 2090.19, t_p = 39.964 hrs
11/8	8:10:50		End DD # 8 Q_p = 146.16 STB/D
11/8	8:10:50		Start Swabbing & DH Sampling.
11/12			
11/12			Start to Pull tubing for recompleting in Zone-7.

RAMEY LOG-LOG PLOT

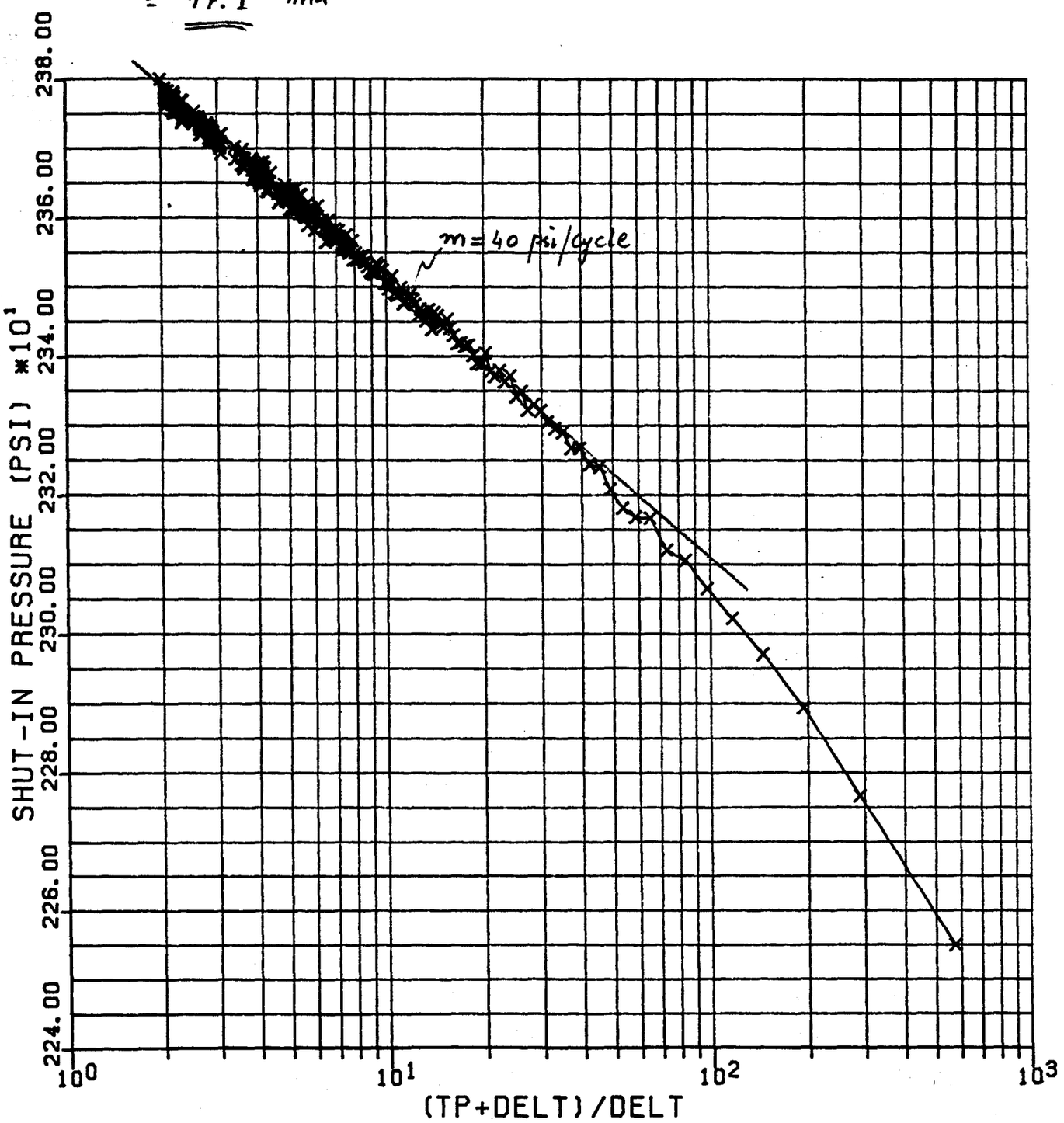


J. Friemel #1, Zone 6; Recovery Test #1 (10/2-10/4/83)

HORNER BUILDUP PLOT

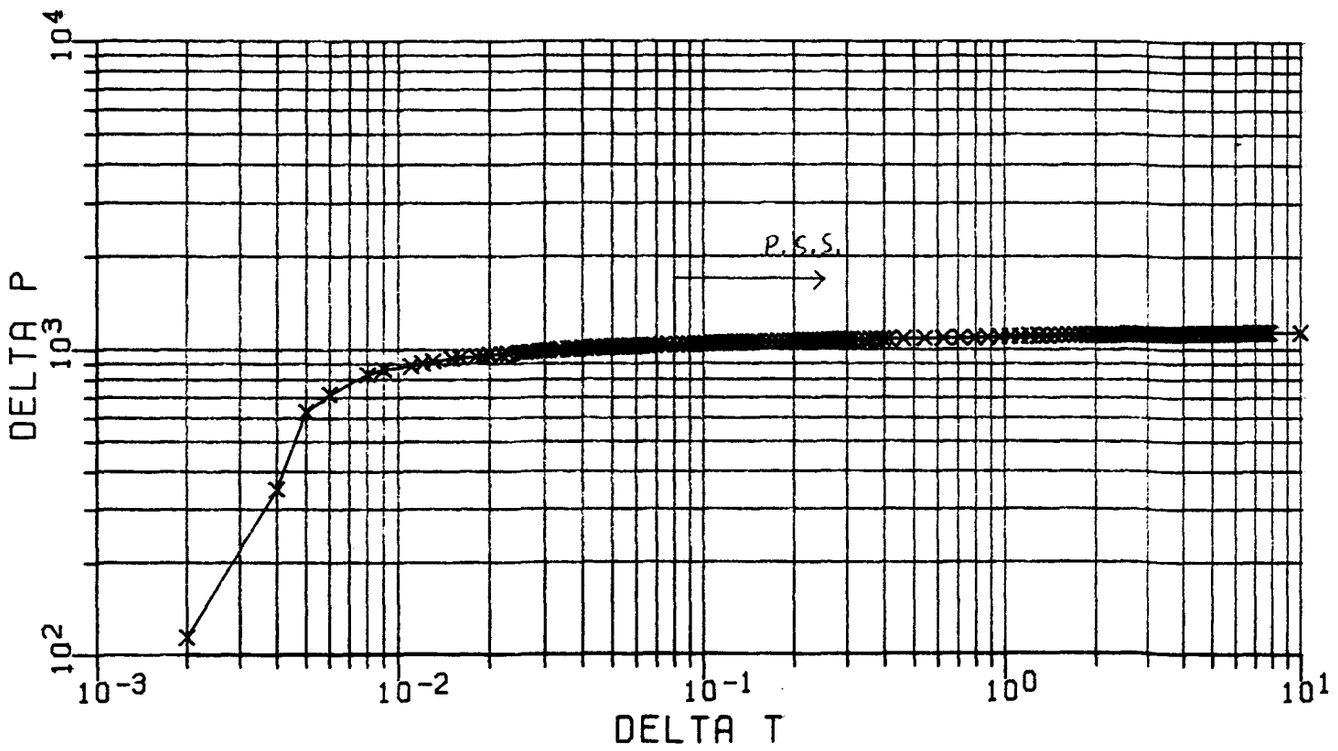
$$K = \frac{162.6\ Q\ B\ \mu}{m\ h} = \frac{162.6\,(540)\,(1.15)\,(1)}{40\,(26)}$$

$$= 97.1 \text{ md}$$



J. Friemel #1, Zone 6; Recovery Test #6 (11/1-11/3/83)

RAMEY LOG-LOG PLOT

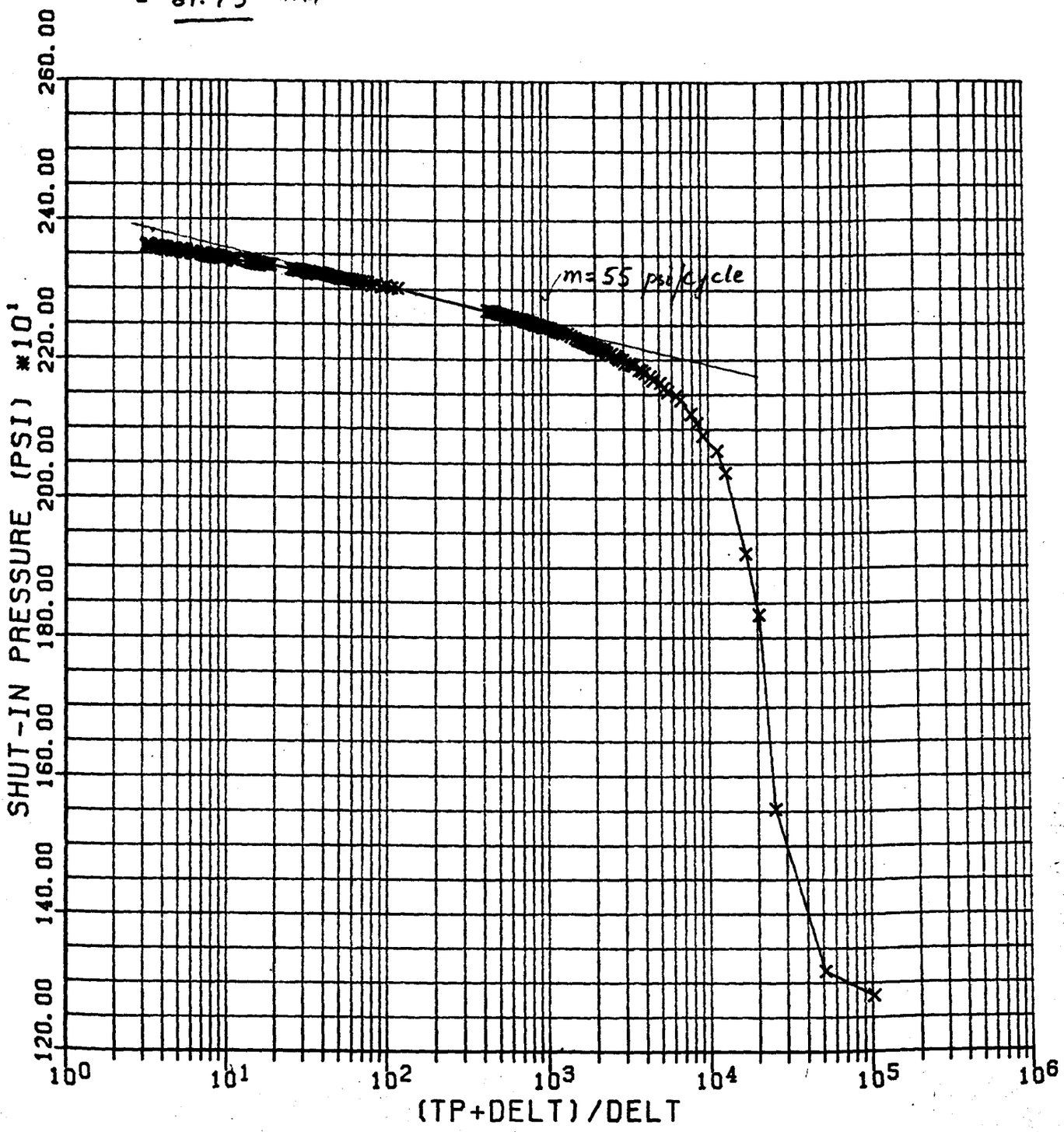


J. Friemel #1, Zone 6; Recovery Test #6 (11/1-11/3/83)

HORNER BUILDUP PLOT

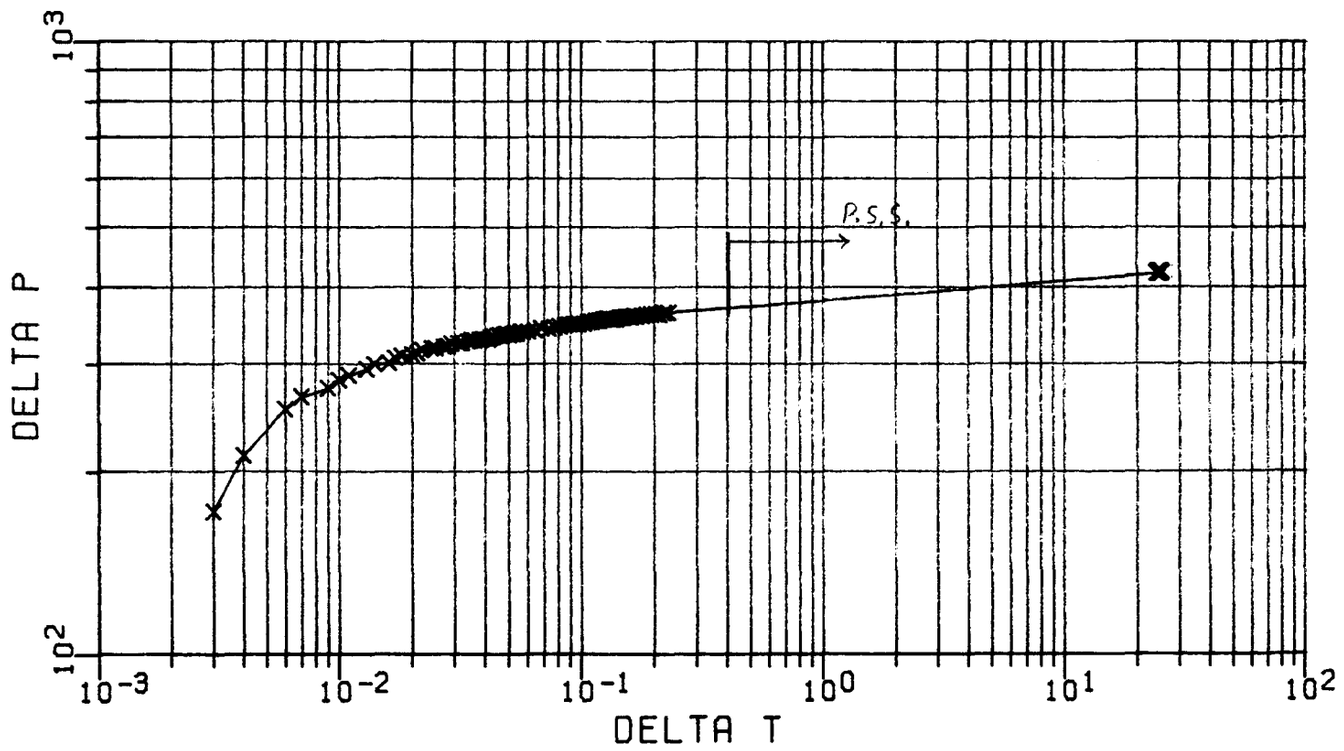
$$K = \frac{162.6\,Q\mu B}{mh} = \frac{162.6\,(625)(1.15)(1)}{55\,(26)}$$

$$= 81.73 \text{ md}$$



J. Friemel #1, Zone 6; Recovery Test #7 (11/5-11/6/83)

RAMEY LØG-LØG PLØT

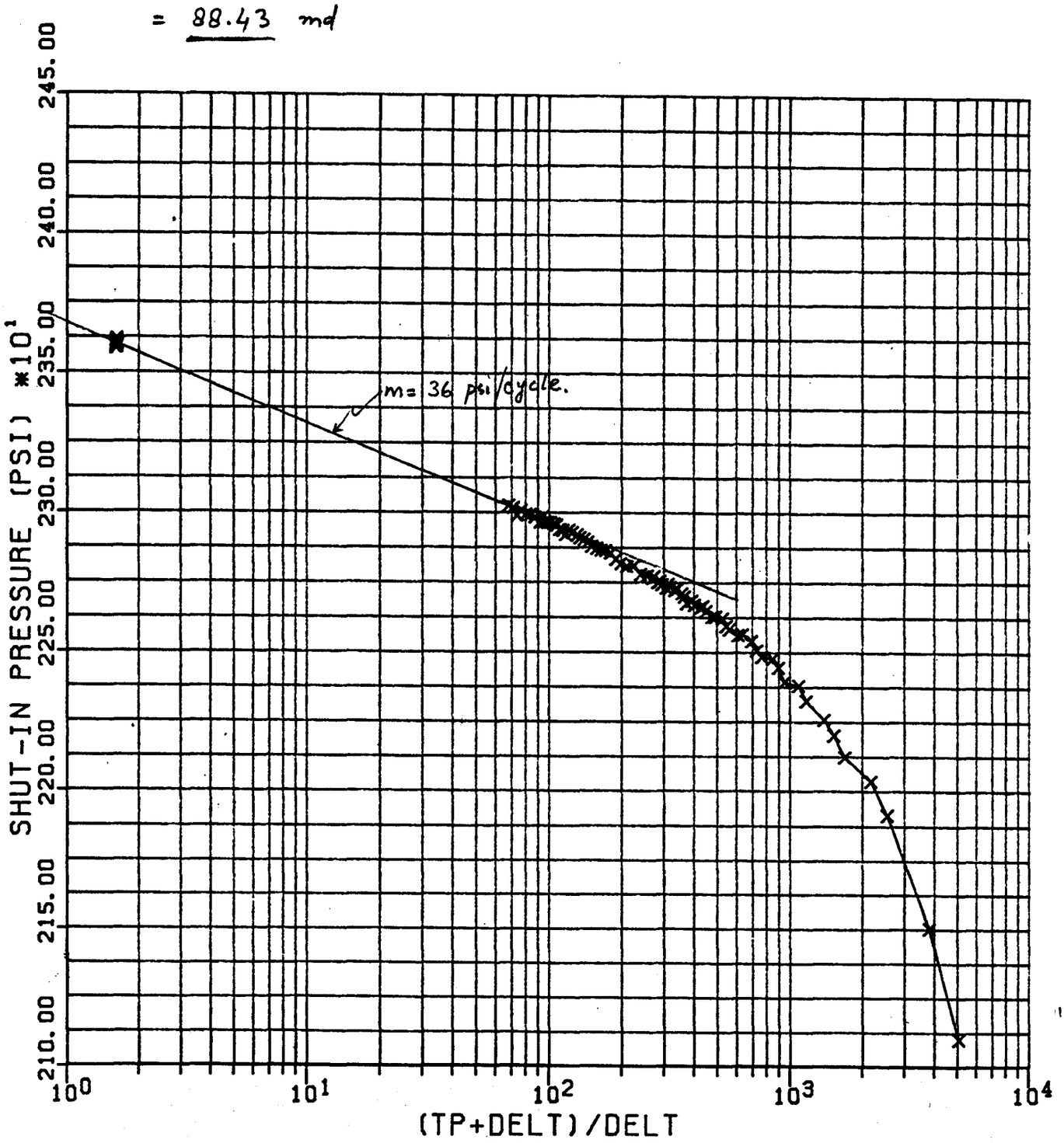


J. Friemel #1, Zone 6, Recovery Test #7 (11/5-11/6/83)

HORNER BUILDUP PLOT

$$K = \frac{162.6\,Q\mu B}{mh} = \frac{162.6(442.64)(1.15)(1)}{36\,(26)}$$

$$= \underline{88.43}\ md$$



3/8/84

J. FRIEMEL #1 : ZONE-7 RECOVERY TESTS

Recovery Test #1 : (12/6 Thru 12/9/84)

$Q_p = 30.86$ STB/D , $t_p = 243.89$ hrs , $P_{wf} = 735.79$ psi

$h = 101$ ft.

From HORNER PLOT : $m = 60$ psi/cycle

$$k = \frac{162.6\, Q B \mu}{mh} = \frac{162.6(30.86)(1)(1.1)}{60(101)} = \underline{0.91} \text{ md}$$

Recovery Test #2 : (12/22 Thru 12/28/84)

$Q_p = 34.29$ STB/D , $t_p = 287.561$ hrs , $P_{wf} = 605.89$ psi

From HORNER PLOT : $m = 65$ psi/cycle

$$k = \frac{162.6(34.29)(1)(1.1)}{65(101)} = \underline{0.93} \text{ md}$$

Recovery Test #3 : (12/30/83 - 1/9/84)

$Q_p = 31.2$ STB/D , $t_p = 52.601$ hrs , $P_{wf} = 738.20$ psi

From HORNER PLOT : $m = 65$ psi/cycle

$$k = \frac{162.6\, Q B \mu}{mh} = \frac{162.6(31.2)(1)(1.1)}{65(101)} = \underline{0.85} \text{ md}$$

Recovery Test #4 : (1/20 - 1/22/84)

$Q_p = 38.204$ STB/D , $t_p = 266.53$ hrs , $P_{wf} = 550.93$ psi

From HORNER PLOT : $m = 80$ psi/cycle

$$k = \frac{162.6\, Q B \mu}{mh} = \frac{162.6(38.204)(1)(1.1)}{80(101)} = \underline{0.85} \text{ md}$$

J. FRIEMAL #1 : ZONE-7

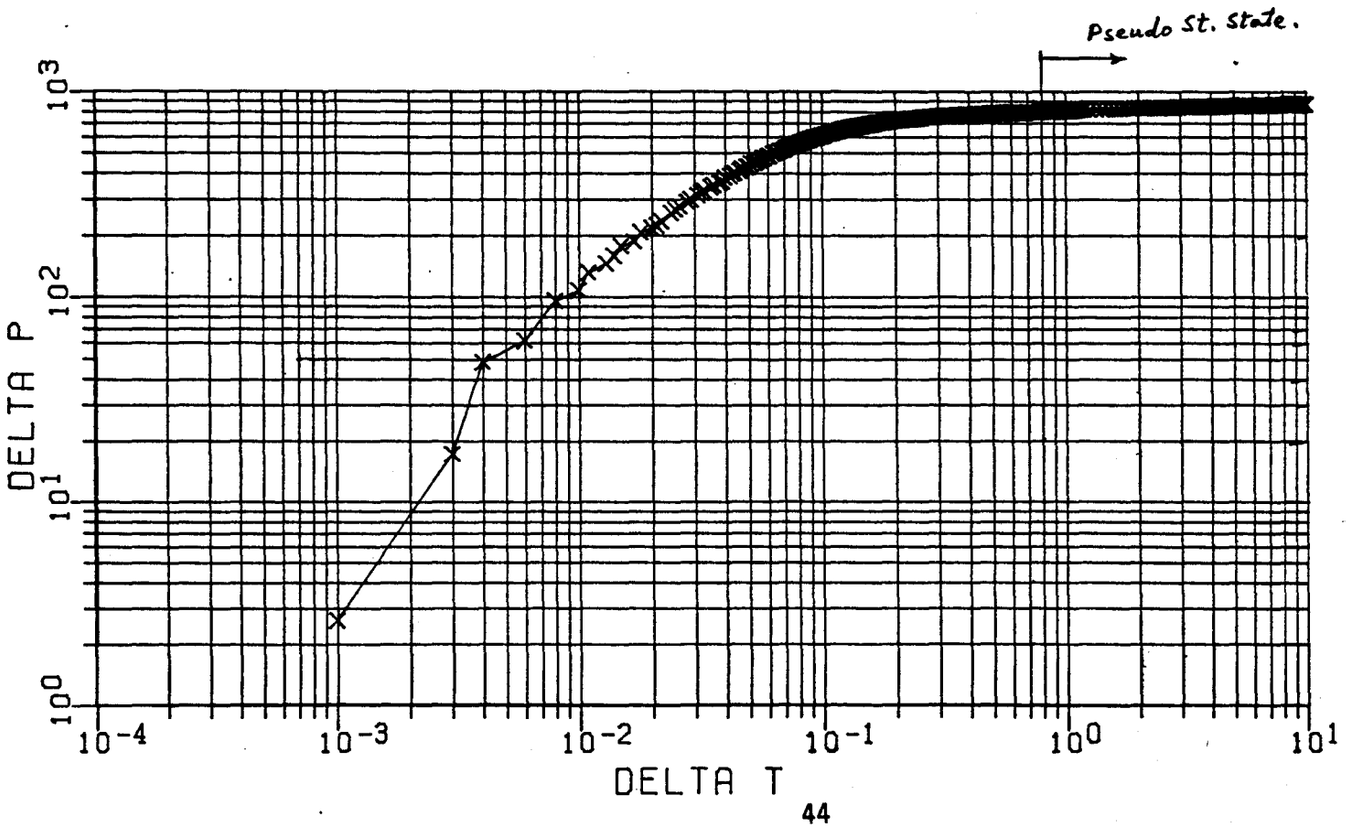
Buc

Date	Time	Operations
11/21 - 11/22	1200 - 1221:50	Swab, collect BH samples; run in w/pump
11/22	11221:50 - 1440:40	Pumping
	14:40:40 - 24:00:00	S.I. for initial Recovery. (P_{wf} = 763.04 psi)
11/23	00:00:00 - 24:00:00	Continue initial recovery
11/24	00:00 - 24:00	" "
11/25	00:00 - 24:00	" "
11/26	00:00 - 1115:50	Complete initial Rec. for P_i (P_{ws} = 1676.72)
	11:15:50 - 24:00:00	Start pumping (Drawdown #1)
11/27	00:00 - 24:00:00	Continue DD #1
11/28	00:00 - 24:00:00	" "
11/29 - 12/5	00:00 - 24:00	" " q_p = 0.9 gpm = 30.86 B/D; t_p = 243.89 hrs; P_{wf} = 735.79 psia
12/6	15:10:05	End DD #1. Begin Rec. #1 (Rec-1)
12/7 - 12/8	00:00 - 24:00	Continue Recovery #1
12/9	09:17:15	Complete Rec #1. ($P_{ws,f}$ = 1652.11 psi)
	09:17:15	Start DD #2 Δt = 66.119 hrs
12/9 - 12/21	00:00 - 24:00	Continue DD #2 287.561 ~~51.792~~ hrs
12/22	04:34:54	End DD #2. Start Rec #2. P_{wf} = 605.89; q_p = 34.29 B/D psi
12/23 - 12/27	00:00 - 24:00	Continue Rec. #2 (Rec #2)
12/28	11:01:15	End Rec. #2. Begin DD #3 P_{ws} = 1654.23 psi; Δt = 150.439 hrs
12/29	00:00 - 24:00	Continue DD #3 q_p = 0.91 GPM = 31.2 B/D; P_{wf} = 738.20; t_p = 52.601 hrs
12/30 -	15:34:50	End DD #3. Begin Rec. #3
12/31 - 1/8/84	00:00 - 24:00	Continue Rec #3 (Rec #3)
1/9/84	15:13:55	End Rec #3. Begin DD #4 P_{ws} = 1661.32 psi; Δt = 239.651 hrs
1/9/84	15:13:55	Begin DD #4 q_p = 1.114 GPM = 38.204 B/D
1/20/84	17:46:15	End DD #4 t_p = 266.53 hrs; P_{wf} = 550.93
1/20/84	17:46:15	Begin Rec. #4 $P_{ws,f}$ = 1630.11 psi
1/~~23~~22/84	~~01:29:37~~ 23:54:38	End Rec #4 (Rec #4) Δt = ~~55.723~~ hrs.
1/23 - 1/26	Swab - DH Sample	
1/26 →	Prepare for Vert. Perm. Test.	

Need Daily Reports ↓

J. Friemel #1, Zone 7; Recovery Test #1 (12/6-12/9/83)

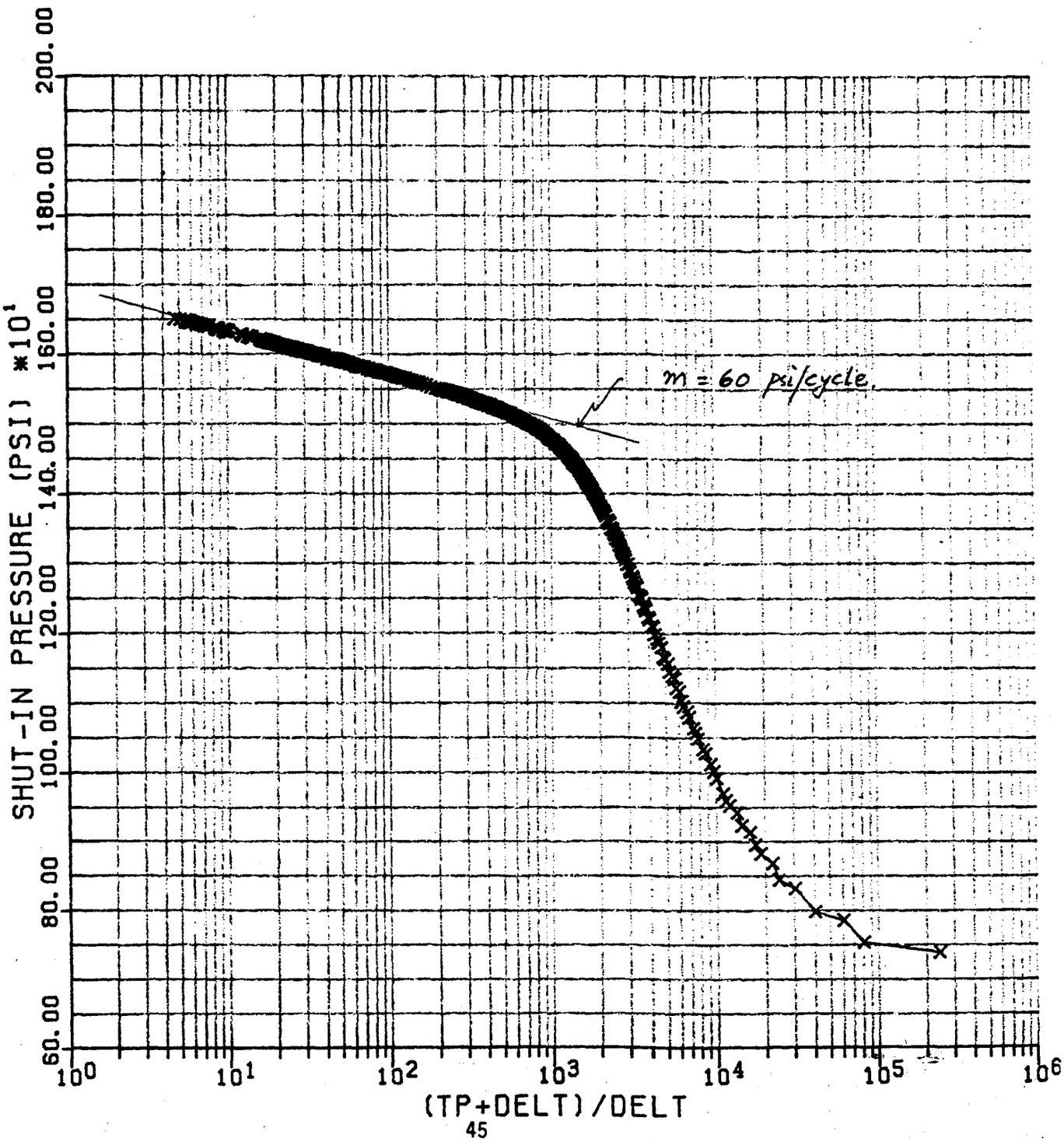
RAMEY LOG-LOG PLOT



J. Friemel #1, Zone 7; Recovery Test #1 (12/6-12/9/83)

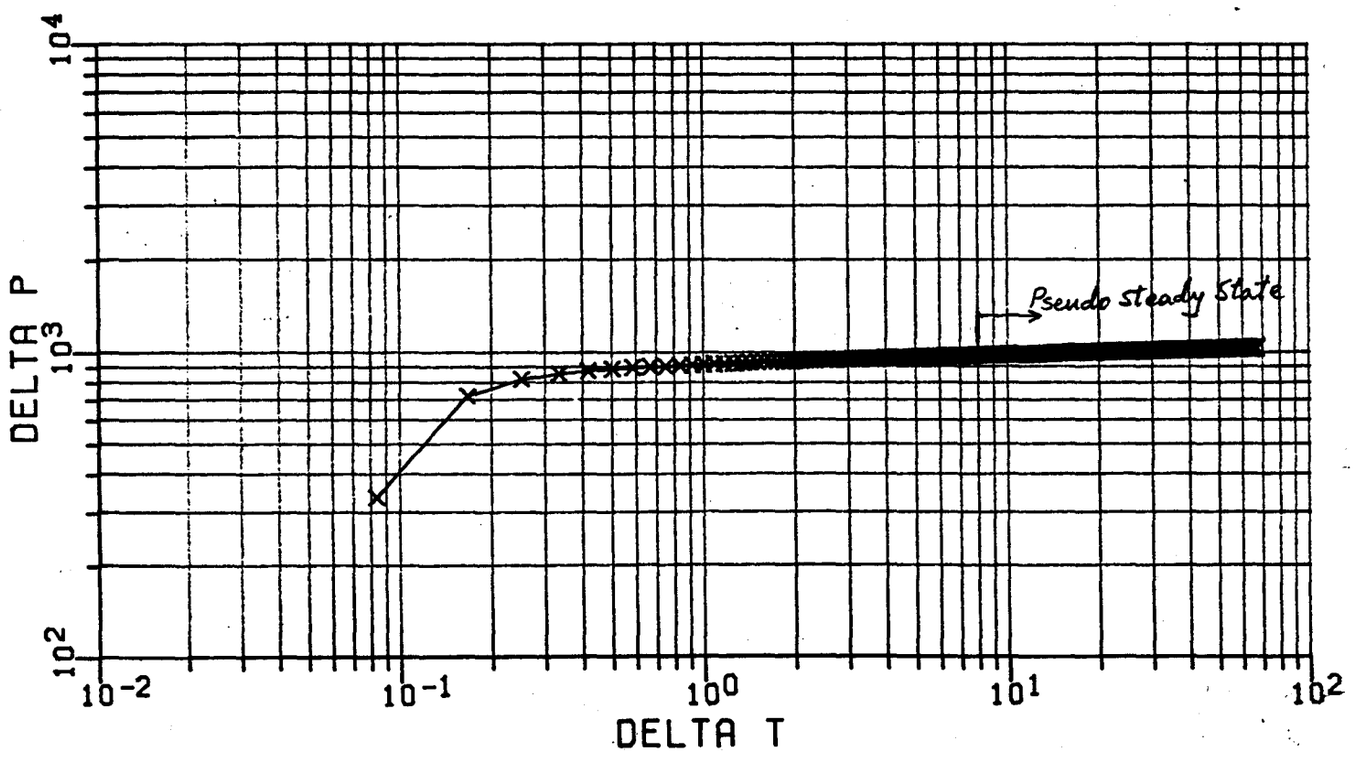
HORNER BUILDUP PLOT

$$k = \frac{162.6\ qB\mu}{mh} = \frac{162.6\,(30.86)(1.1)}{60\,(101)} = \underline{\underline{0.91}}\ md$$



J. Friemel #1, Zone 7; Recovery Test #2

RAMEY LOG-LOG PLOT

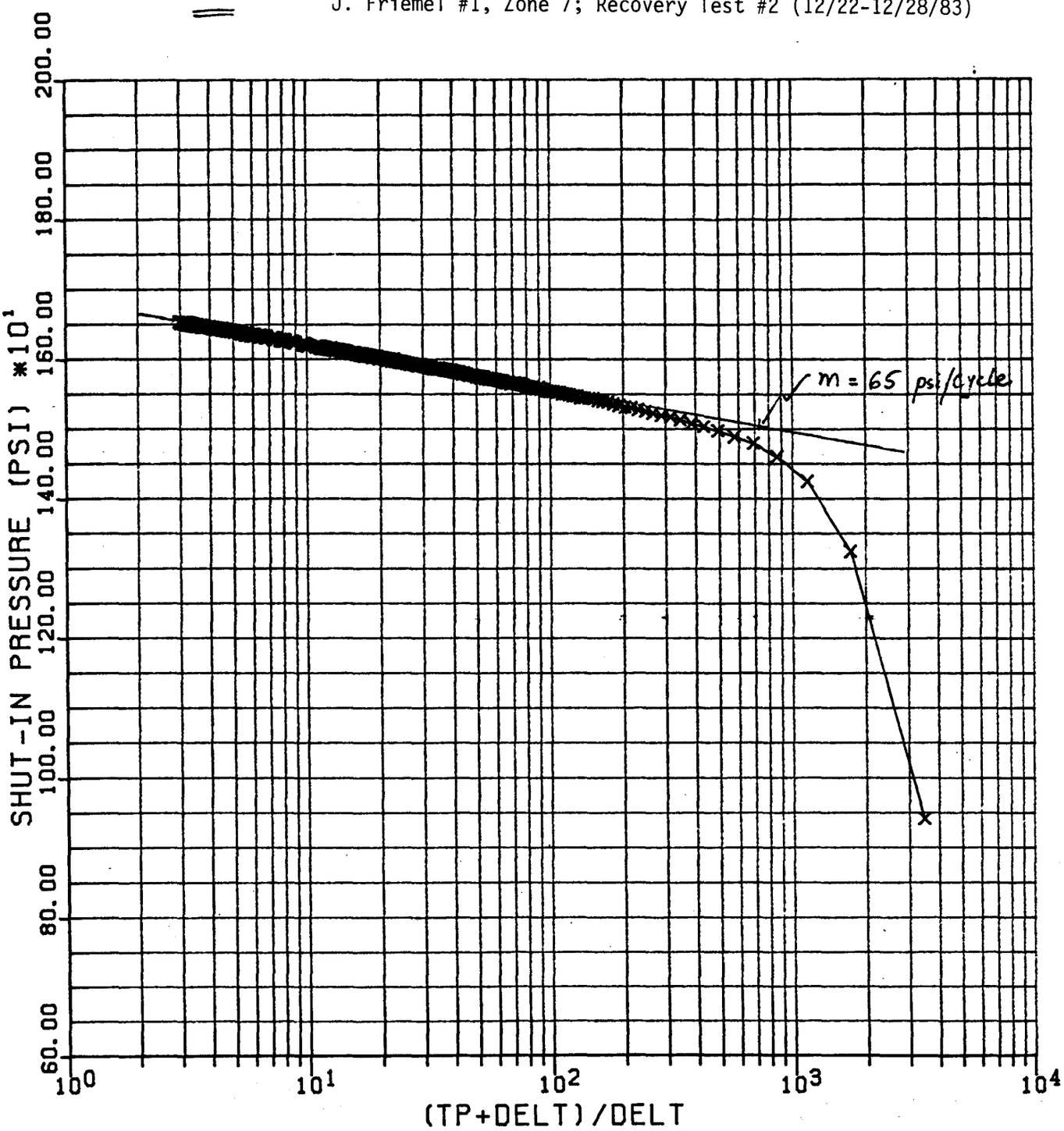


HORNER BUILDUP PLOT

$$k = \frac{162.6 * Q B/\mu}{m h} = \frac{162.6(34.29)(1)(1.1)}{65(101)}$$

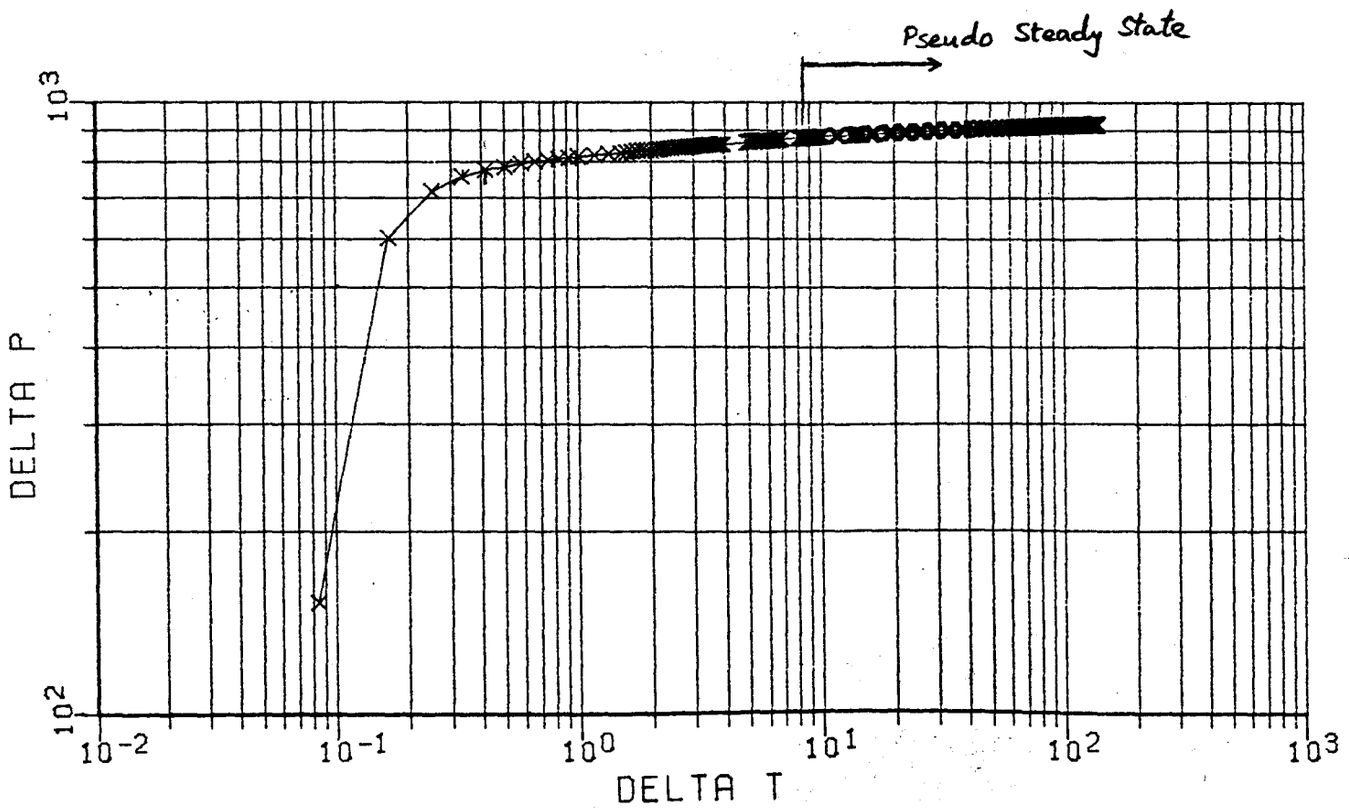
$$= 0.93 \text{ md}$$

J. Friemel #1, Zone 7; Recovery Test #2 (12/22-12/28/83)



J. Friemel #1, Zone 7; Recovery Test #3 (12/30/83-1/9/84)

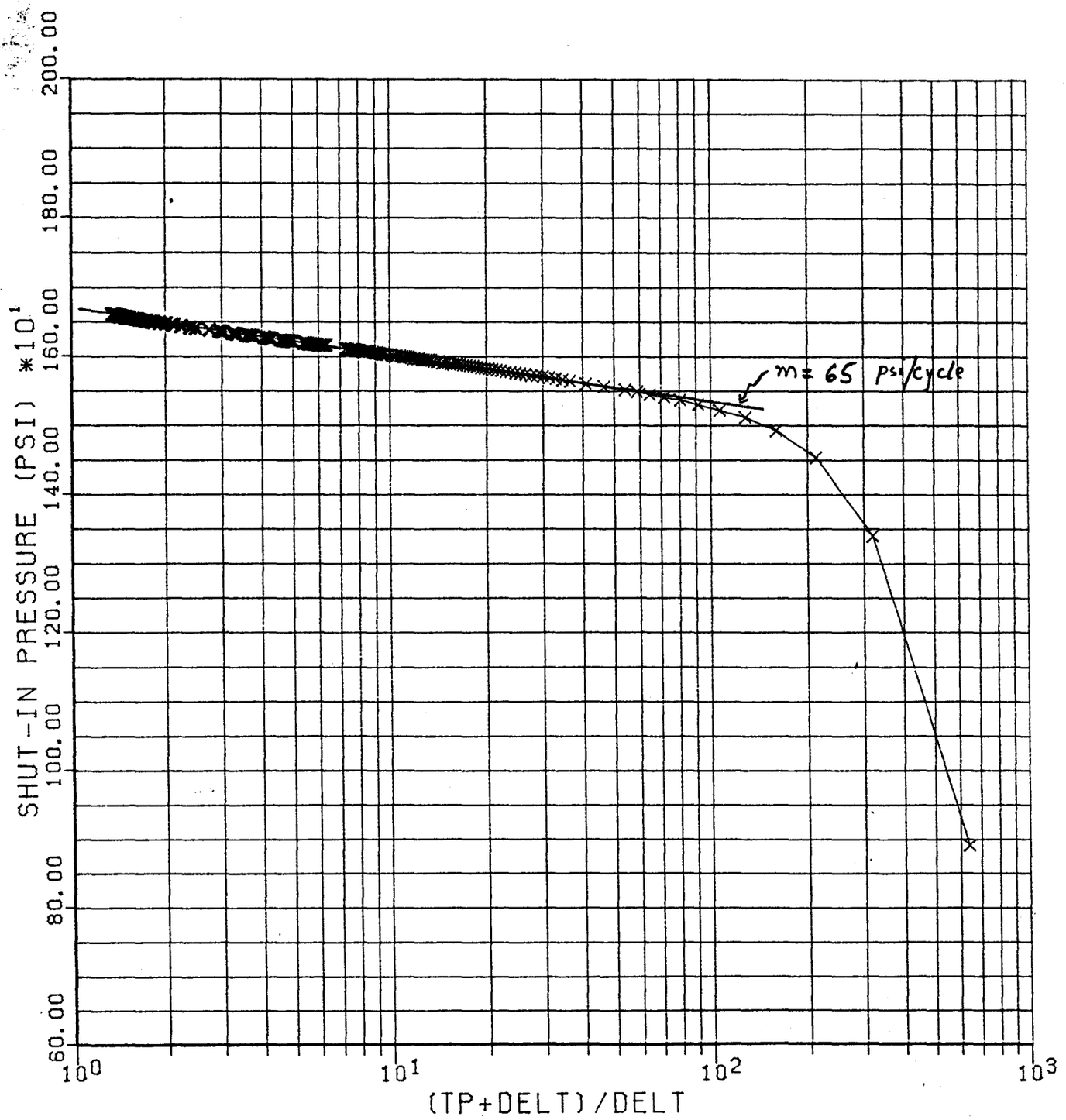
RAMEY LOG-LOG PLOT



J. Friemel #1, Zone 7, Recovery Test #3 (12/30/83-1/9/84)

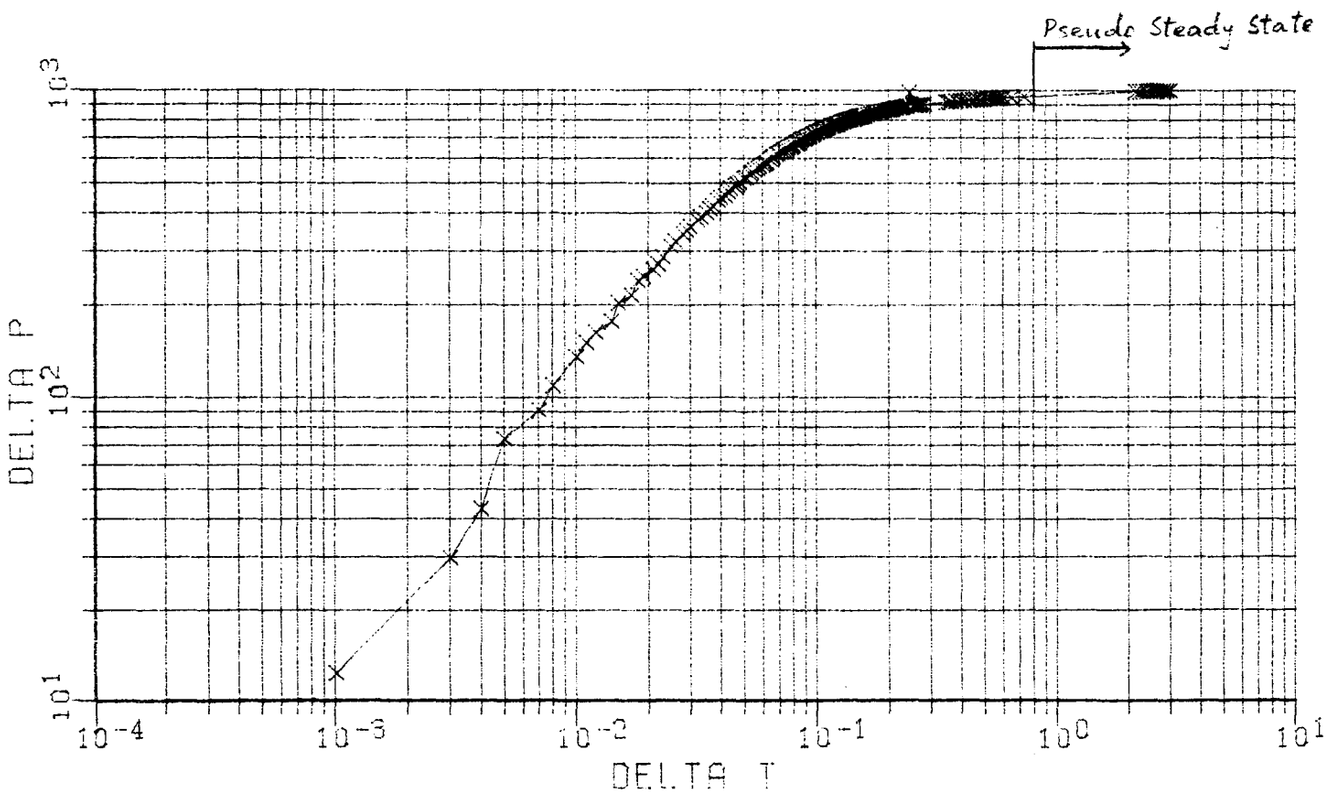
HORNER BUILDUP PLOT

$$k = \frac{162.6(31.2)(1.1)}{65\,(101)} = 0.85 \text{ md}$$



J. Friemel #1, Zone 7; Recovery Test #4 (1/20-1/22/84)

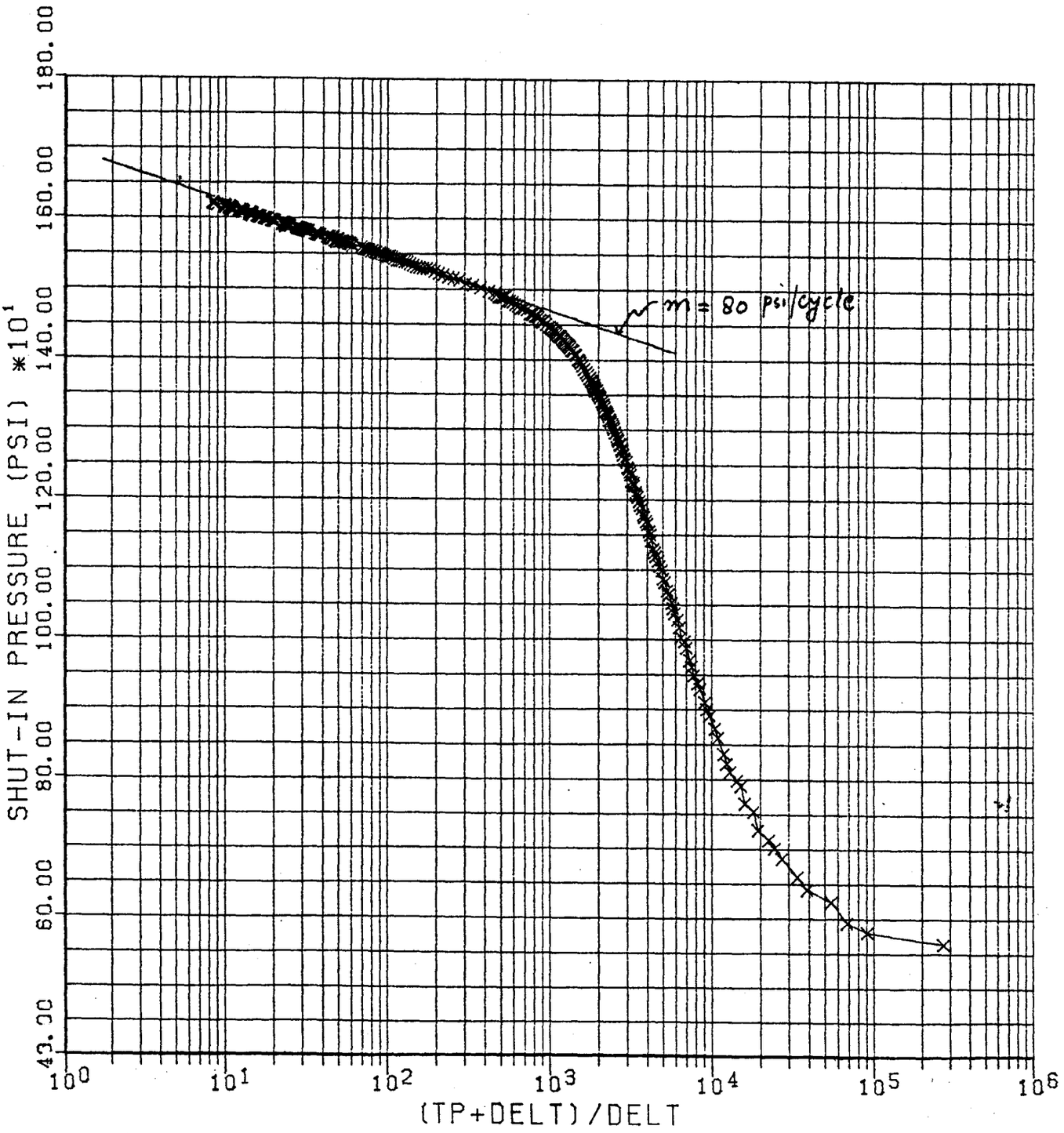
RAMEY LOG-LOG PLOT



J. Friemel #1, Zone 7; Recovery Test #4 (1/20-1/22/84)

HORNER BUILDUP PLOT

$$K = \frac{162.6(qB/\mu)}{mh} = \frac{162.6(38.204)(1)(1.1)}{80(101)} = \underline{0.85}\ md$$



DST Worksheet

☐ confidential ☐ Want TBEG corehole info. ☐ CORE data

COUNTY		ELEVATION (ft)	API NO.
DEAF SMITH		4016 (GR) KB	
FORMATION (DST)	FORMATION (PI)	DEPTH	DATE TESTED
Wolfcamp		5630 to 5909 ft	1/20/83
COMPANY SNEC/DOE		ELEVATION -1614 to -1893 ft msl	DATE ANALYZED 2/4/83
LEASE AND WELL J. FRIEMEL #1			
ACTUAL THICKNESS (ft)	EST. EFFECTIVE THICKNESS (ft)		ANALYST
279			SUSAN

RECOVERY DESCRIPTION
10 Ft mud, slightly water cut
372 Ft Mud, " "
548 Ft Water " mud cut
765 Ft Water, very slight trace of mud

TOTAL RECOVERY = 1695 ft.

First Flow Rate

a.	Total Recovery (ft)	1695	A
b.	1st Final Flowing Pressure (FFP1)	403.5	B
c.	2nd Final Flowing Pressure (FFP2)	959.8	C
d.	Fraction of Total Flow in 1st period, b/c	0.42	D
e.	Footage of 1st Period recovery (ft) a x d	712.6	E
f.	Collar length (ft)	206	F
g.	Footage of Collar Filled in 1st period (ft) smaller of e or f	206	G
h.	Footage of Pipe Filled in 1st period e-f if e > f	506.6	H
i.	Collar I.D. (in)	2.25	I
j.	Collar Capacity (BBL/ft) $\pi(i/24)^2/5.61$	0.00492	J
k.	Collar volume filled in 1st flow period (BBL) j x g	1.014	K
l.	Pipe I.D. or API type	3.8	L
m.	Pipe capacity (BBL/ft) $\pi(l/24)^2/5.61$	0.01404	M
n.	Pipe volume filled in 1st flow period (BBL) m x h	7.11	N
o.	Total Recovery in first Period (BBL) k + n	8.127	O
p.	Flowing time (min)	11	P
q.	Flowing time (days) p/1440	0.00764	Q
r.	Flow rate in 1st period (BBL/day) o/q	1063.7	R

Second Flow Rate

Was collar completely filled in 1st period? (Is e > f? Y or N). . . . . Y

Y - go to cc

N - Was collar completely full after 2nd period (Is a > f? Y or N) . . . . .

u. Y - Footage of collar filled in 2nd period (ft) f - g. . . . . u

go to z

v. N - Footage of collar filled in 2nd period (ft) a - g. v

w. Footage of pipe filled in 2nd period (ft). . . . . w

z. Collar Volume filled in 2nd period (bbl) j x u or v. . . . . z

aa. Footage of pipe filled in 2nd period (ft) (a - f(> 0), or w) . . . . . aa

bb. Volume of pipe filled in 2nd period (BBL) aa x m . . . . . bb

go to ee

cc. Footage of pipe filled in 2nd period (ft) a - e. . . . . 982.4 cc

dd. Volume of pipe filled in 2nd period (BBL) cc x m. . . . . 13.793 dd

ee. Total Recovery in 2nd Period (BBL) z + bb; or dd . . . . . 13.793 ee

yy. Flowing time (min) . . . . . 59 yy

zz. Flowing time (day) yy/1440 . . . . . 0.04097 zz

zzz. Flow rate in 2nd period (bbl/day) ee/zz 336.7

Gauge Check

		Number of gauge 1) J-1902	2)	
ff.	Depth of gauge (ft).	5903		ff
gg.	Initial hydrostatic pressure of gauge in ff (psi).	2844.4		gg
hh.	Final hydrostatic pressure of gauge in ff (psi).	2776.3		hh
ii.	Greater of gg or hh (psi).	2844.4		ii
jj.	Hydrostatic gradient (ii / ff) (psi/ft)	0.482		jj
kk.	Apparent mud sp. gravity (jj/0.433).	1.113		
mm.	Apparent mud weight (kk x 8.34) (lbs/gal).	9.28		
nn.	Reported mud weight (lbs/gal).		9.0	

Annular Volume

Hole Diameter (ft) . . . . .

Tool Diameter (ft) O.D. . . . . .

Annular Capacity (bbl/ft). . . . . .

Annular Volume (bbl) . . . . . .

Specific gravity of recovery

oo. Recovery hydrostatic gradient (c/a) psi/ft). 0.251

pp. Recovery specific gravity (oo/0.433) 0.581

Summary of test

	Number of gauge 1)	2)
First flow period (t_1; min).		11
Initial flowing pressure (psi)		216.2
Final flowing pressure (psi)		403.5
Second flow period (t_2; min)		59
Initial flowing pressure (psi)		426.2
Final flowing pressure (psi)		959.8
Initial SIP (psi).		1692.1
Final SIP (psi).		1669.9
Slope of initial build-up curve (psi/cycle).		-650
Slope of final build-up curve (psi/cycle).		-576

Summary of test con't.

qq.	Initial extrapolated pressure (psi)	1745
rr.	Final extrapolated pressure (psi)	1808
ss.	Ground elevation (or kelly bushing)	4016
tt.	Elevation of gauge used in plots (ss - ff) (ft)	-1887
uu.	Initial pressure head (qq/0.433) (ft)	4030
vv.	Final pressure head (rr/0.433) (ft)	4176
	Initial fresh-water head (tt + uu) (ft)	2143
	Final fresh-water head (tt + vv) (ft)	2289
	Indicated average permeability (md)	
	Estimated actual permeability (md)	
	Indicated average permeability (md) (second period)	
	Estimated actual permeability (md) (second period)	
	No straight line on Horner plot.	☐
	Test Killed.	☐

Permeability Calculation

Indicated average permeability (md) (use average h)
Estimated actual permeability (md) (use effective h)

$$k = \frac{162.6\, q\mu}{mh}$$

where

h = test interval (ft)
m = slope of straight-line portion of Horner buildup plot (psi/log cycle) (1st straight line if slope break)
q = production rate (bbl/day) for flow period immediately preceding this shut-in period (line r or zzz)
μ = viscosity (assume = 1.0)

COMMENTS

1) Are initial and final buildup lines curved or have break in slope?

no

2) Do initial and final buildup lines extrapolate to same pi? (<5% diff)

Yes (1745, 1808 psi)

3) Do K_1 and K_2 agree? (<50% diff)

no

4) Reason for curved line/slope break:

5) Head elev (DST):
Head elev (PI):
Reason PI was different:

From FIG ① ↓ FIG ② ↓

$$K_1 = \frac{-162.6 \times q\mu}{mh} = \frac{-162.6 \times 1063.7 \times 1}{-576 \times 279} = 1.08 \text{ md} \quad (0.99 \text{ md})$$

$$K_2 = \frac{-162.6 \times 336.7}{-650 \times 279} = 0.30 \text{ md} \quad (0.27 \text{ md})$$

DST J. FRIEMEL #1

SHUT-IN #1

Time mins	Time Hrs	Pressure Psi	$\frac{t+\Delta t}{\Delta t}$	$\log \frac{t+\Delta t}{\Delta t}$	
0	0	403.50	—	—	
8.39	0.1398	1540.97	2.311	0.3638	t_{shut} = 47 mins
16.79	0.2798	1615.10	1655	0.2188	t_{flow} = 11 mins
25.18	0.4197	1659.50	1.437	0.1575	
33.57	0.5595	1677.2	1.328	0.1232	
41.96	0.6993	1686.2	1.262	0.1011	
47.00	0.7833	1692.1	1.234	0.0913	

Shut in #2

t_{shut} = 112 mins
t_{Flow} = 70 mins

Time mins	Time Hrs	Pressure psi	$\frac{t+\Delta t}{\Delta t}$	$\log \frac{t+\Delta t}{t}$
0	0	959.8	—	—
21.54	0.3590	1358.6	4.2501	0.0284
43.08	0.718	1528.4	2.6250	0.4191
64.62	1.077	1584.9	2.2437	0.3509
86.15	1.436	1641.6	1.8120	0.2583
112.00	1.867	1669.9	1.6249	0.2108

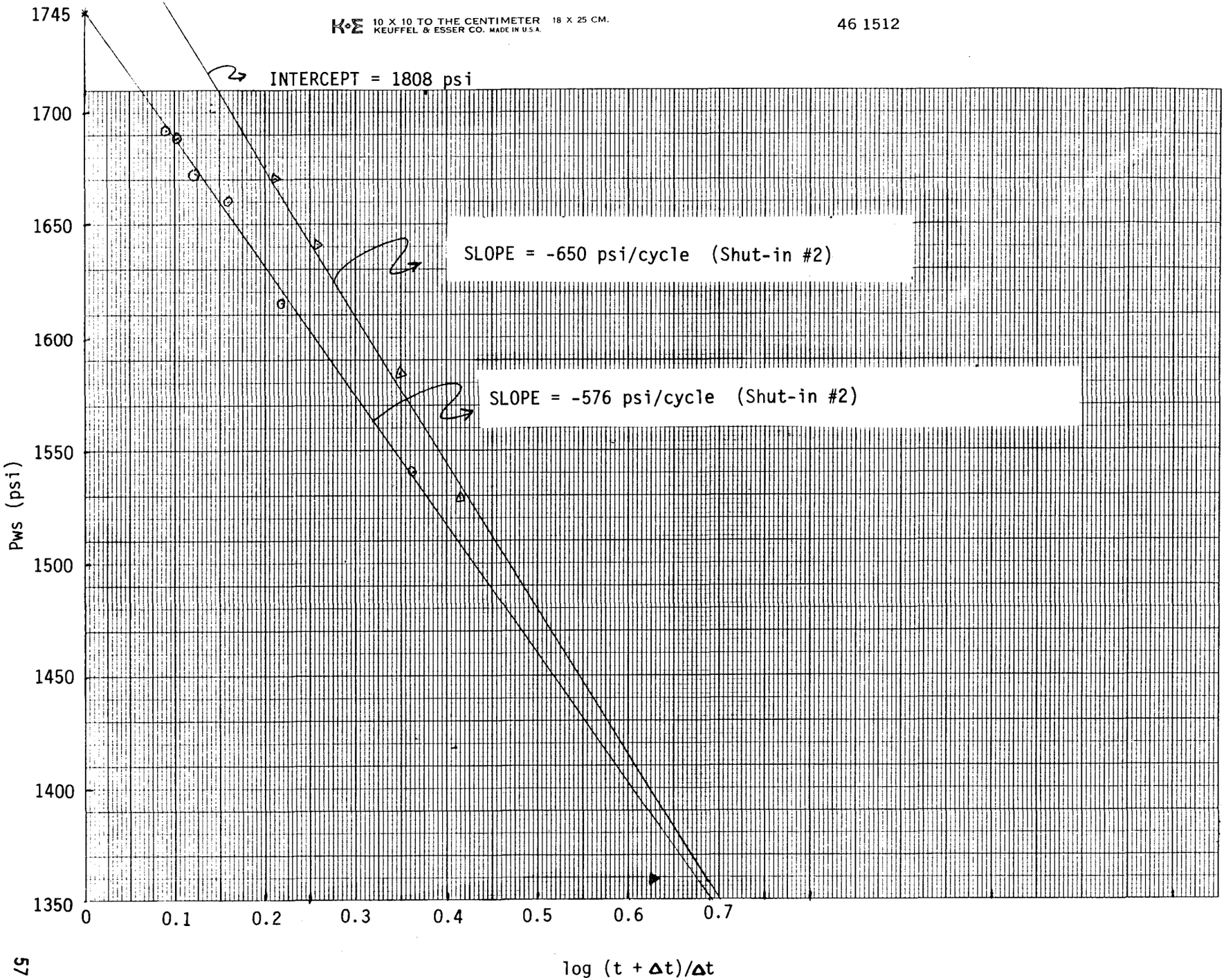


Figure 1. Horner plot of J. Friemel #1 Wolfcamp drill-stem test.