

GLO/100

19 Pages

Original

ADDENDUM TO
TECHNICAL REPORT ON
DE BRAGA #2
CHURCHILL COUNTY, NEVADA

FLOW TEST AND FLUID SAMPLE DATA

INITIAL GRADIENT SURVEYS

The rig was released from De Braga #2 on May 8, 1979. Static pressure and temperature surveys were run on May 19 and May 21, respectively. These are graphed on Figures 1 and 2. Reservoir pressure is above saturation throughout the completion interval indicating that the reservoir is filled 100% with hot water.

PIT TEST

The pit test, which was done on May 22, is shown on Table 1. Wellhead pressure and temperature were stable at 20 psig and 252°F respectively throughout the test. Differential pressure across the orifice varied from 80 inches of water at the start of the test to 87 inches, but all of this change was apparently due to a build-up of gas on the high pressure side of the meter. The differential pin was re-zero'd at 1235 hours.

Pit rate was computed using pit dimensions of 60 feet by 80 feet, assuming a square and flat bottom. Average pit rate was 150,000 lb/hr. Deviation from perfect pit geometry probably accounts for the high pit rates estimated at the beginning of the test. Pit leakage was apparent after the test. This leakage probably became significant near the end of the test when water level reached fresh dirt near the rim of the pit. This may explain the low pit rates calculated near the end of the test.

Mass flow was also computed from orifice data using the two-phase Murdock equation as follows:

$$W_m = \frac{1900 K_g Y_g F_a d^2 \sqrt{\gamma_g} \sqrt{\Delta P}}{(1-y) + 1.26y \frac{K_g Y_g}{K_L} \sqrt{\gamma_g / \gamma_L}} = 152,000 \text{ lb/hr.}$$

Where:

$$d = 5.25 \text{ in.}$$

$$K_g = .684$$

$$K_L = .704$$

$$F_a = 1.0045$$

$$\gamma_L = 58.8 \text{ lb/cf}$$

$$\gamma_g = .073 \text{ lb/cf}$$

$$y = .935 \text{ (if } T = 310^\circ\text{F and } P_i = 35 \text{ psia)}$$

$$Y_g = 1 - \frac{(.41 + .35 B^4)}{1.339 - 6.8 \times 10^{-5} T} \cdot \frac{\Delta P}{P_i} = .9692$$

Where:

$$\Delta P = 80 \text{ inches} \times .433 \frac{\text{psi}}{\text{ft}} \times \frac{\text{ft}}{12 \text{ in.}} = 2.89 \text{ psi}$$

$$P_i = 20 + 14.7 = 34.7 \text{ psia}$$

$$T = 252^\circ\text{F}$$

$$B = d/D = 5.25 \text{ in.} / 7.625 \text{ in.} = .6885$$

PRESSURE BUILD-UP TEST

Pressure build-up, recorded with gauges hung at 2600 feet, is shown on Table 2 and Figure 3. Comparison of Figures 1 and 3 shows that pressure recovered completely indicating no measurable depletion of the reservoir during the test. Figure 4, a log-log graph of pressure rise vs. shut-in time was used to identify the nature and duration of wellbore storage effects.

Figure 4 shows that wellbore storage dies out at .33 hours shut-in time. The data beyond that graphs as the semi-log straight line on Figure 3. Build-up prior to .33 hours on Figure 4 shows the shift of the storage constant from C_2 to C_1 as a rising liquid column compresses and dissipates vapor trapped in the wellbore.

Reservoir permeability-thickness and skin factor were calculated from Figure 3 as follows:

$$kh = \frac{695 w \mu}{\rho m} = 10,000 \text{ md.ft.}$$

Where: $w = 150,000 \text{ lb/hr.}$
 $\mu = .18 \text{ cp}$
 $\rho = 58.8 \text{ lb/cf.}$
 $m = 32 \text{ psi/cycle}$

$$S = 1.151 \left[\frac{P_{1hr} - P_{wf}}{m} - \text{Log} \left(\frac{kh}{\phi h \mu C_t r_w^2} \right) + 3.23 \right]$$

Where: $P_{1hr} = 1110 \text{ psig}$
 $P_{wf} = 925 \text{ psig}$
 $m = 32 \text{ psi/n}$
 $kh = 10,000 \text{ md.ft.}$
 $\phi = .20 \text{ (estimated)}$
 $h = 600 \text{ feet}$
 $\mu = .18 \text{ cp}$
 $C_t = 4.5 \times 10^{-6} \text{ psi}^{-1}$
 $r_w = .36 \text{ ft.}$

$$S = +.1$$

PRODUCTIVITY INDEX

Productivity index was computed two ways: first from the actual measured drop in sandface pressure after 3.67 hours of production and second a theoretical stabilized productivity index using kh and assumptions that pseudo-steady state has been reached:

$$P.I. = \frac{W}{P_i - P_{wf}} = \frac{1.657 kh \rho}{\mu \ln(re/rw)}$$

$$P.I. (\text{actual}) = \frac{150,000 \text{ lb/hr}}{1116 - 925} = 785 \text{ lb/hr/psi}$$

$$P.I. (\text{theoretical}) = \frac{1.657 kh \rho}{\mu \ln(re/rw)} = 628 \text{ lb/hr/psi}$$

Where: $kh = 10 \text{ darcies}$
 $\mu = .18 \text{ cp}$
 $re = 2000 \text{ feet}$
 $r_w = .36 \text{ feet}$
 $\rho = 58.8 \text{ lb/cf}$

Actual Productivity Index after 3.67 hours of flow was slightly higher than the theoretical pseudo-steady state productivity index, indicating that pseudo-steady state had not been reached during this short test.

The lower value of 628 lb/hr/psi represents what the well will do when the area of influence has reached the limits of the reservoir. Two thousand feet was chosen to represent minimum distance to the reservoir boundary because De Braga No. 1, approximately 2000 feet away, appears to be in the same reservoir with De Braga No. 2.

GRADIENT SURVEYS AFTER TESTING

Temperature and pressure surveys run one day after the production test on May 23 are graphed on Figures 5 and 6 respectively. A comparison of temperature profiles, Figures 2 and 5 combined, is made on Figure 7. There is little difference in temperature between these two surveys, but the post test temperature gradient shows slight heating above 3500 feet and slight cooling below 3500 feet.

Static temperature gradients run prior to and after the test both show a prominent hot zone from 1200' to 1800' with a maximum temperature of 310°F at 1400'. Both surveys show a temperature reversal below this zone, but temperature increases from 3500' down, with maximum recorded temperature (336°F) at total depth (6920 ft.).

Temperature gradient is 5.5°F/100 ft. in the bottom 200 feet of the hole indicating that another hot zone may have been partially penetrated. The survey run 23 hours after pit testing shows cooling below 3250' and heating above 3250'. The data does not conclusively show what interval contributed most of the production.

CHEMICAL SAMPLING

Fluid samples were taken at 30-minute intervals throughout the test for measurement of pH and chlorides. Chlorides were stabilizing at 145 ppm_w and pH was 7.1 at the end of the test. This data is shown on Table 3.

Prior to shut-in, water samples were taken for analysis of H₂S, NH₃, CO₂ and total non-condensibles. This data is presented on Table 3.

Fluid samples were also sent to Brea for analysis of silica, general properties and metals (As, B, Ba, Ca, Cs, k, Li, Mb, Na, Rb, Sr, Cl, F, Ag, Cr, Cu, Fe, Mn, Ni, Pb, Zn). Results of this analysis are presented in Table 4.

Table 1
DE BRAGA #2
5-22-79

Time	WELLHEAD		ORIFICE DATA			Depth of Water in Pit (24,960#/in)	PRODUCTION RATE	
	Ptf, psig	Ttf, °F	Ps, psig	in H ₂ O	psig		Orifice Rate Lb/Hr	Pit Rate Lb/Hr
0830	Arrived on location							
0858	70	80						
0905	Opened master valve, immediate flow of water to pit							
0908	Opened 3" valve							
0914	Opened 6" valve							
0916	Water to base of pit gauge pole							
0930	20	252	20	80	2.887	1.5 in.	152,000	160,457
0945	20	252	20	80	2.887	4.0 in.	152,000	149,760
1000	20	252	20	82	2.887	5.5 in.	152,000	149,760
1030	20	252	20	83	2.887	8.5 in.	152,000	149,760
1100	20	252	20	84	2.887	11.5 in.	152,000	149,760
1130	20	252	20	85	2.887	14.5 in.	152,000	149,760
	Clocks started at 1125							
1151	Instruments hung at 2600 ft.							
1200	20	252	20	87	2.887	17.5 in.	152,000	149,760
1230	20	253	20	87	2.887	20.0 in.	152,000	124,800
1235	Re-zero'd differential pen							
1240	Mercury thermometer temp. 254°F							
1245	Shut well in							
1246	30	262				21.0 in.	152,000	99,840
1247	27	264						
1254	20	255						
1300	60	252						
1315	68	238						
1330	72	227						
1345						20.25		
1415	72	201				20.00		
1436	72							
1445						19.50		
								Pit Leakage (18,720)

Table 2

DE BRAGA #2
PRESSURE BUILD-UP
5/22/79

Swab Gate: 3892 MSL
Datum: 2,600 feet
t = 3.62 hours
w = 150,000 lb/hr.

<u>Shut-In Time</u> <u>Hours</u>	<u>Pressure</u> <u>psig</u>	<u>t + Δt</u> <u>Δt</u>
0	925	
.017	956	214
.033	979	111
.05	1000	73
.067	1012	55
.083	1018	45
.100	1031	37
.117	1037	32
.133	1041	28
.150	1050	25
.167	1076	23
.183	1085	21
.200	1087	19
.217	1089	18
.233	1091	17
.250	1093	15
.333	1097	12
.50	1099	8.2
.583	1101	7.2
.667	1103	6.4
.833	1103	5.3

Table 2
- Continued -

<u>Shut-In Time</u> <u>Hours</u>	<u>Pressure</u> <u>psig</u>	<u>t + Δt</u> <u>Δt</u>
1.00	1105	4.6
1.50	1110	3.4
2.0	1112	2.8
2.5	1114	2.5
3.0	1114	2.2
5.5	1116	1.7
6.5	1116	1.6
7.5	1116	1.5
8.8	1116	1.4

Table 3

CHEMICAL SAMPLING
DE BRAGA NO. 2

5/22/79

Sampling During Test

<u>Sample No.</u>	<u>Time</u>	<u>pH</u>	<u>Chloride ppm(mg/l)</u>
1	09:20	8.42	143.9
2	09:52	8.78	127.6
3	10:24	8.86	126.2
4	10:54	8.83	132.59
5	11:	8.83	143.9
6	12:00	8.81	145.3
7	12:30	7.13	144.65

Sampling Just Prior to End of Test

<u>Sample No.</u>	<u>H₂S ppm</u>	<u>NH₃ ppm</u>	<u>CO₂ ppm</u>	<u>Non-Cond. % by Vol.</u>
1 downstream	10.5	63	0	0.007
2 downstream	10.77	61.5	0	0.0057
3 downstream	12.00	64.15	-	
4 upstream	12.30	59.63	0	

TABLE 4

De Braga Well #2
5/22/79

General Properties

pH 8.6
 Specific Gravity @60°F 1.006
 Metals Present as Determined by Emission Spectroscopy of Residue
 from Total Dissolved Solids:

>10%	Na
0.1 - 1%	K, Ca, Si
<0.1%	Mg, Sr

Metals and Silicon

		mg/l
Aluminum	4.7	
Arsenic	0.19	"
Barium	0.3	"
Boron	16	"
Cadmium	<0.01	"
Calcium	69	"
Cesium	0.2	"
Chromium	0.03	"
Cobalt	<.03	"
Copper	<.02	"
Iron	7.2	"
Lead	0.1	"
Lithium	1.8	"
Magnesium	0.08	"
Manganese	0.2	"
Mercury	nd<.0005	"
Nickel	0.07	"
Potassium	88	"
Rubidium	0.6	"
Silicon	120	"
Silver	nd<.02	"
Sodium	1240	"
Strontium	1.9	"
Zinc	0.1	"

Anions and Other Constituents

Ammonia	4
Bromide	3
Chloride	1830
Sulfate	278
Sulfide	0.5
Thiosulfate	9
CO ₂ (incl. HCO ₃)	0

TABLE 4

Anions Sought but not Detected (ND) at the
Concentrations Indicated

Thiocyanate	ND (<1 mg/l)
Iodide	ND (<1 mg/l)
Phosphate	ND (<1 mg/l)
Nitrate	ND (<4 mg/l)
Acetate	ND (<10 mg/l)
Fluoride	ND (<3 mg/l)

TABLE 4

De Braga Well #2 Non-Condensable Gases
5/22/79

CH ₄	27-31 mol%
H ₂	1.5 - 2 "
N ₂	57 - 59 "
H ₂ S	7 - 8.5 "
Ethane	3.0
Propane	2.2
i-Butane	0.2
n-Butane	0.7
i-Pentane	0.1
n-Pentane	0.2
2,2 Dimethyl Pentane	0.005
Cyclopentane	0.04
2,3 Dimethyl Pentane	0.006
2-Methyl Pentane	0.03
3-Methyl Pentane	0.04
n-Hexane	0.1
Methyl Cyclopentane	0.05
Benzene :	0.006
Cyclohexane	0.05
2,3 Dimethylpentane	0.003
3-Methylhexane	0.007
2-Methylhexane	0.005
2,3 Dimethylpentane	<.001
1c3 Dimethylcyclopentane	<.001
1t3 Dimethylcyclopentane	<.001
1t2 Dimethylcyclopentane	0.002
n-Heptane	0.005
1c2 Dimethylcyclopentane	<.001
Methylcyclohexane	0.02
Toluene	<.001
2-Methyl Heptane	<.001
n-Octane	<.001
Ethylcyclohexane	<.001
Ethyl Benzene :	<.001
Mean molecular wt.	25-26

Above values calculated exclusive of air
and are based on 29.5% CH₄ content.

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SUBSURFACE PRESSURE SURVEY

FIGURE 1

OWNER Union Oil Co. of Calif. FIELD Stillwater WELL NAME De Braga #2
 CASING 9-5/8" to 968' ELEV 3885' DATE 5-19-79
 LINER DESCRIPTION: 7" from 968' to 6946' ZERO POINT Swab Gate (+7')
 DEPTH 6946'

HOLE DESCRIPTION:

INSTRUMENT
 SERIAL NO 12833

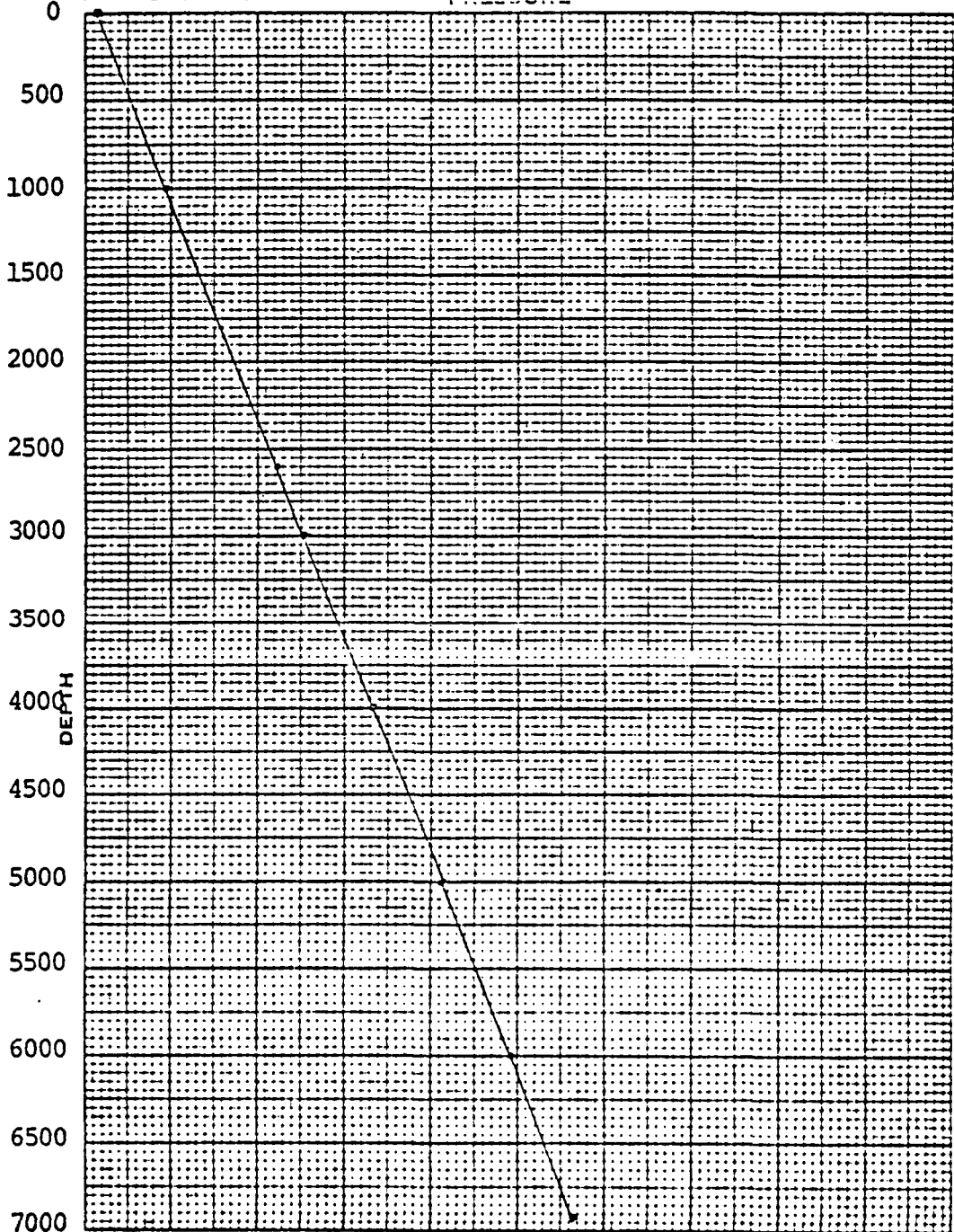
PURPOSE Pressure Gradient

MAX TEMP _____ °F @ _____

REMARKS: Fluid to surface - last flow for 30 min. on 5-16-79.

0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000

ABLIZATION PERIOD



PRESSURES	GAUGE	BOHB
CASING PSI		

DEPTH	PRESSURE	GRADIENT
0	67	
1000	462	
2600	1101	
3000	1262	
4000	1663	
5000	2062	
6000	2461	
6920	2823	

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SUBSURFACE TEMPERATURE SURVEY

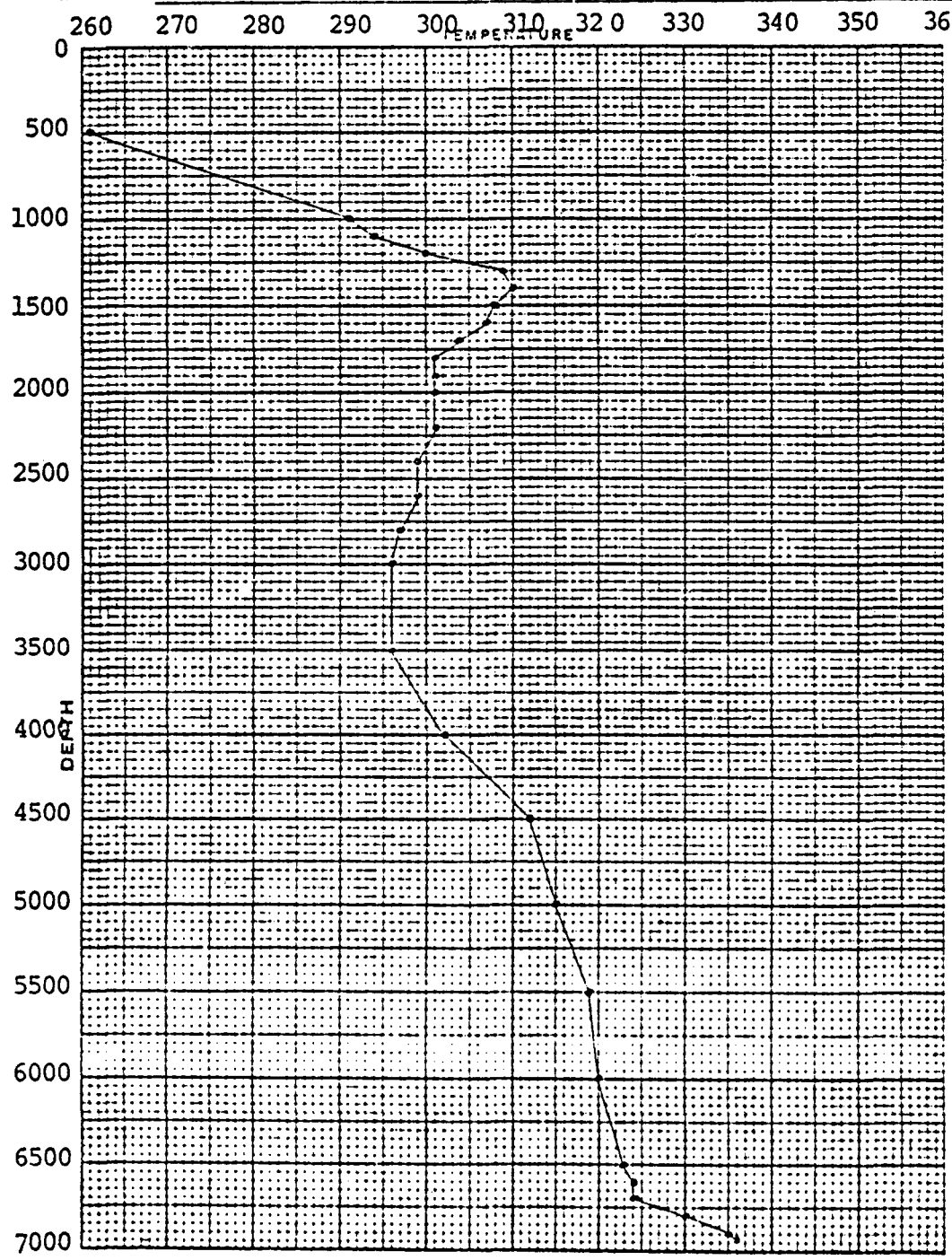
FIGURE 2

OWNER Union Oil Co. of Calif. FIELD Stillwater WELL NAME De Braga #2
 CASING 9-5/8" to 968' ELEV 1885 DATE 5-21-79
 LINER DESCRIPTION 7" from 968' to 6946' ZERO POINT Swab Gate (GL+7')
 DEPTH 6946'

HOLE DESCRIPTION:

INSTRUMENT _____
 SERIAL NO 12833

PURPOSE Temp. traverse survey MAX TEMP _____ °F @ _____
 REMARKS Fluid to surface - last flow for 30 min. on 5-16-79



STABILIZATION PERIOD			
PRESSURES	GAUGE	BOMB	
CASING PSI			
DEPTH	TEMP.	DEPTH	TEMP.
500	261		
1000	291		
1100	294		
1200	300		
1300	309		
1400	310		
1500	308		
1600	307		
1700	304		
1800	301		
1900	301		
2000	301		
2200	301		
2400	299		
2600	299		
2800	297		
3000	296		
3500	296		
4000	302		
4500	312		
5000	315		
5500	319		
6000	320		
6500	323		
6600	324		
6700	324		
6800	330		
6900	335		
6920	336		

BY:

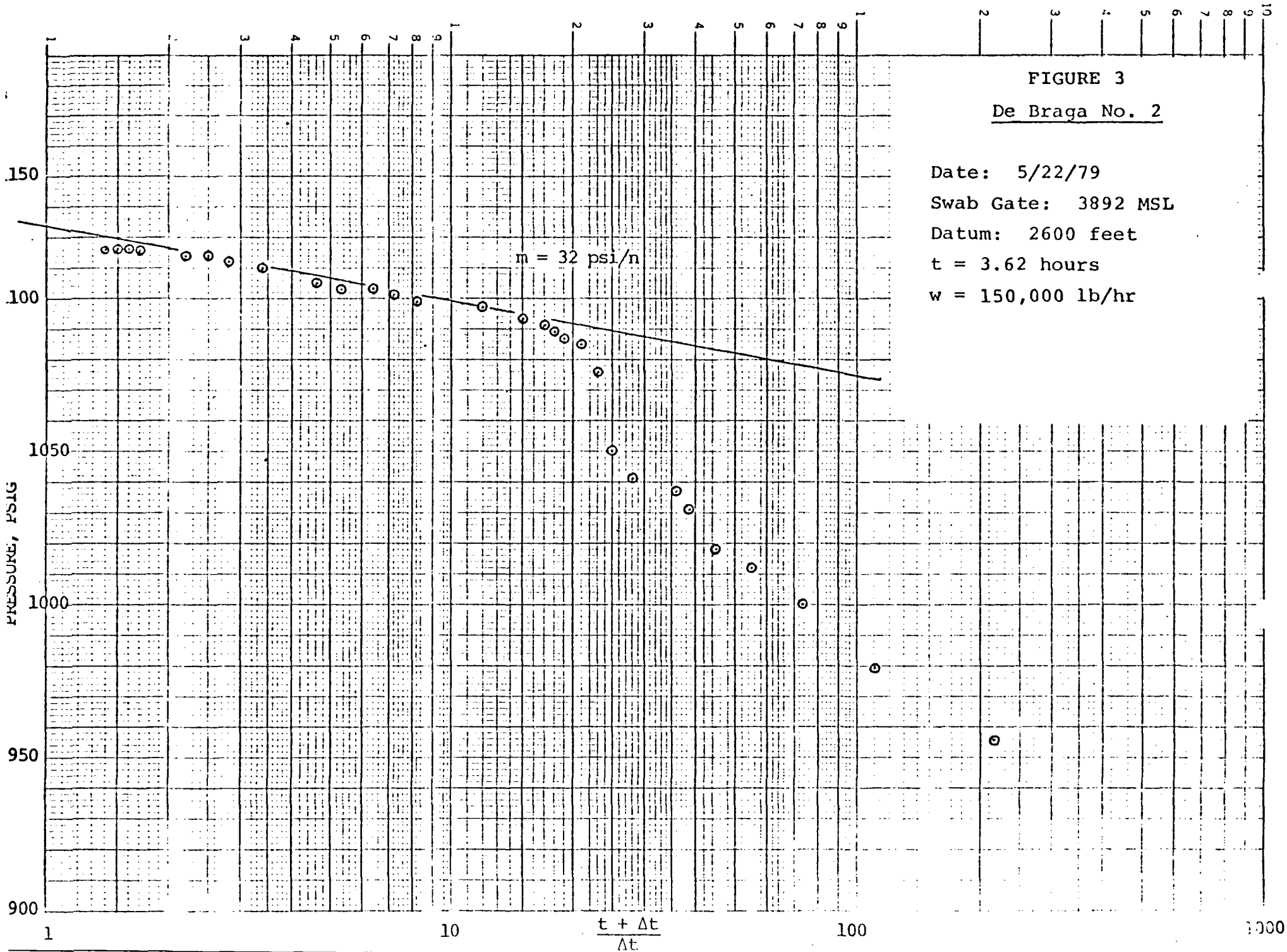
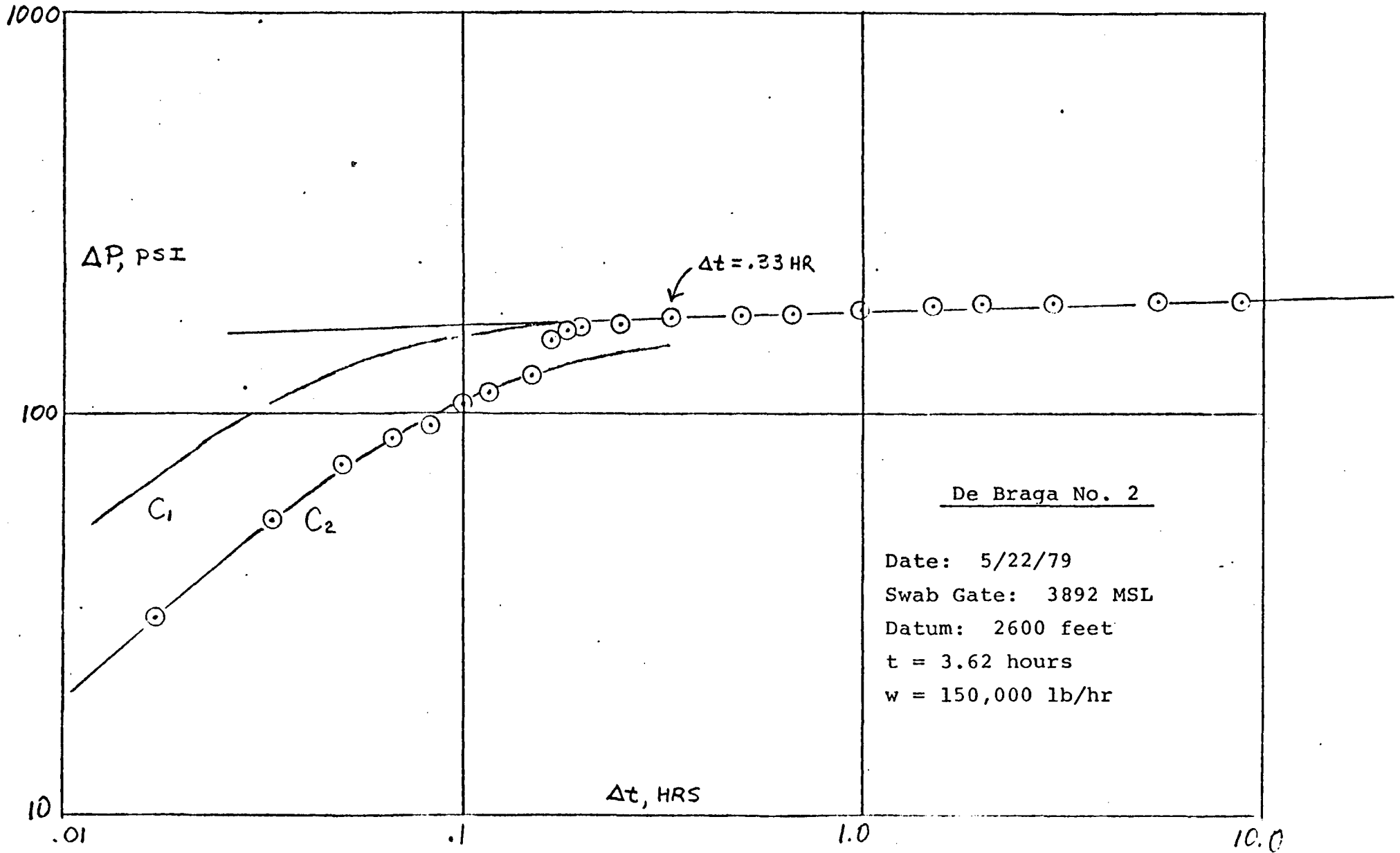


FIGURE 4



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SUBSURFACE TEMPERATURE SURVEY

FIGURE 5

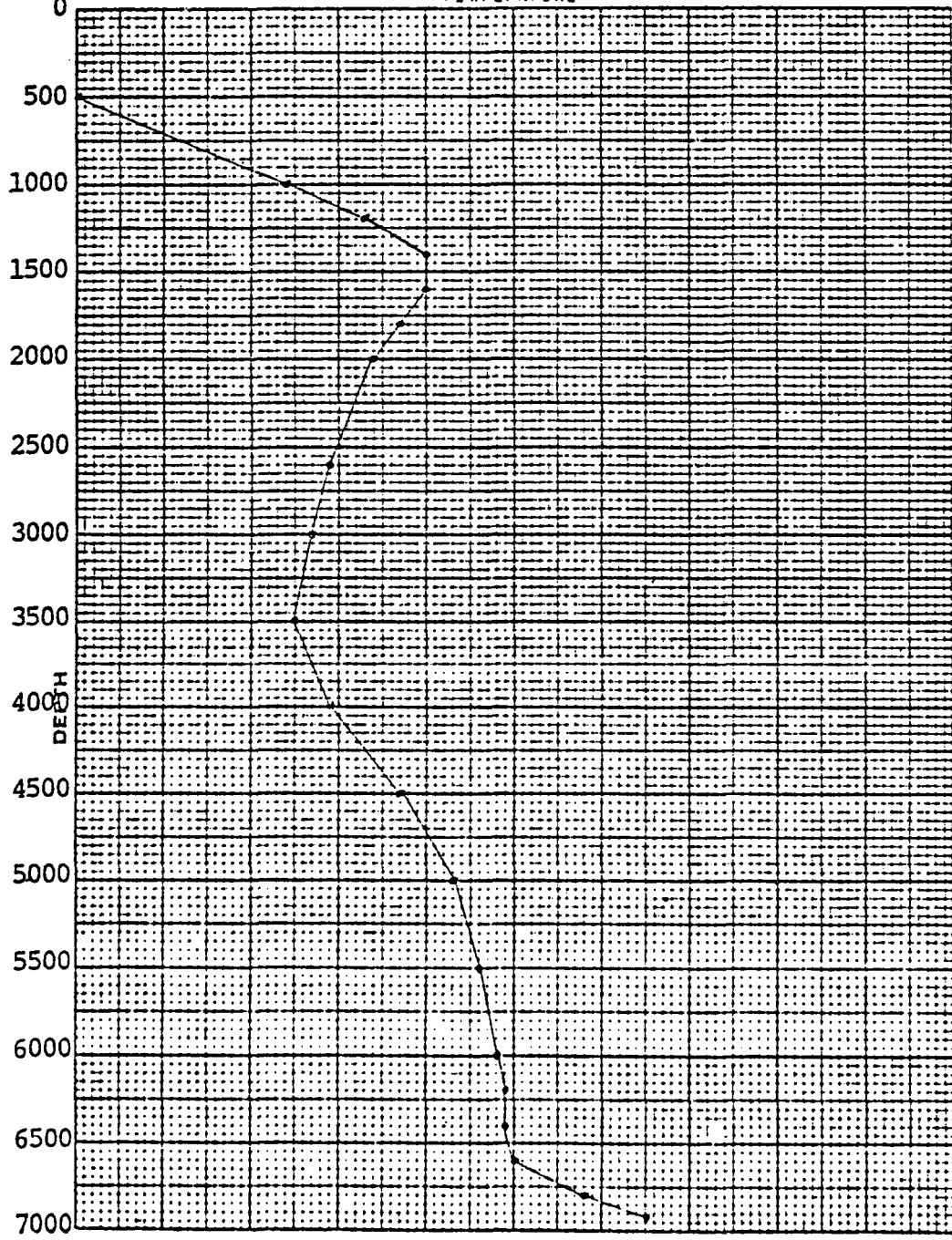
OWNER Union Oil Co. of Calif. FIELD Stillwater WELL NAME De Braga #2
 CASING 9-5/8" to 968' ELEV 3885 DATE 5-23-79
 LINER DESCRIPTION 7" to 6946' ZERO POINT _____
 DEPTH _____

HOLE DESCRIPTION: _____ INSTRUMENT _____ FA _____
 SERIAL NO 10172

PURPOSE Gradient Survey MAX TEMP _____ °F @ _____
 REMARKS First Survey after flow test of 5-22-79

270 280 290 300 310 320 330 340 350 360 370 TEMPERATURE

STABILIZATION PERIOD



PRESSURES		GAUGE		BOMB	
CASING PSI					
DEPTH	TEMP.	DEPTH	TEMP.	DEPTH	TEMP.
500	270				
1000	294				
1200	303				
1400	310				
1600	310				
1800	307				
2000	304				
2600	299				
3000	297				
3500	295				
4000	299				
4500	307				
5000	313				
5500	316				
6000	318				
6200	319				
6400	319				
6600	320				
6800	328				
6920	335				

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SUBSURFACE PRESSURE SURVEY

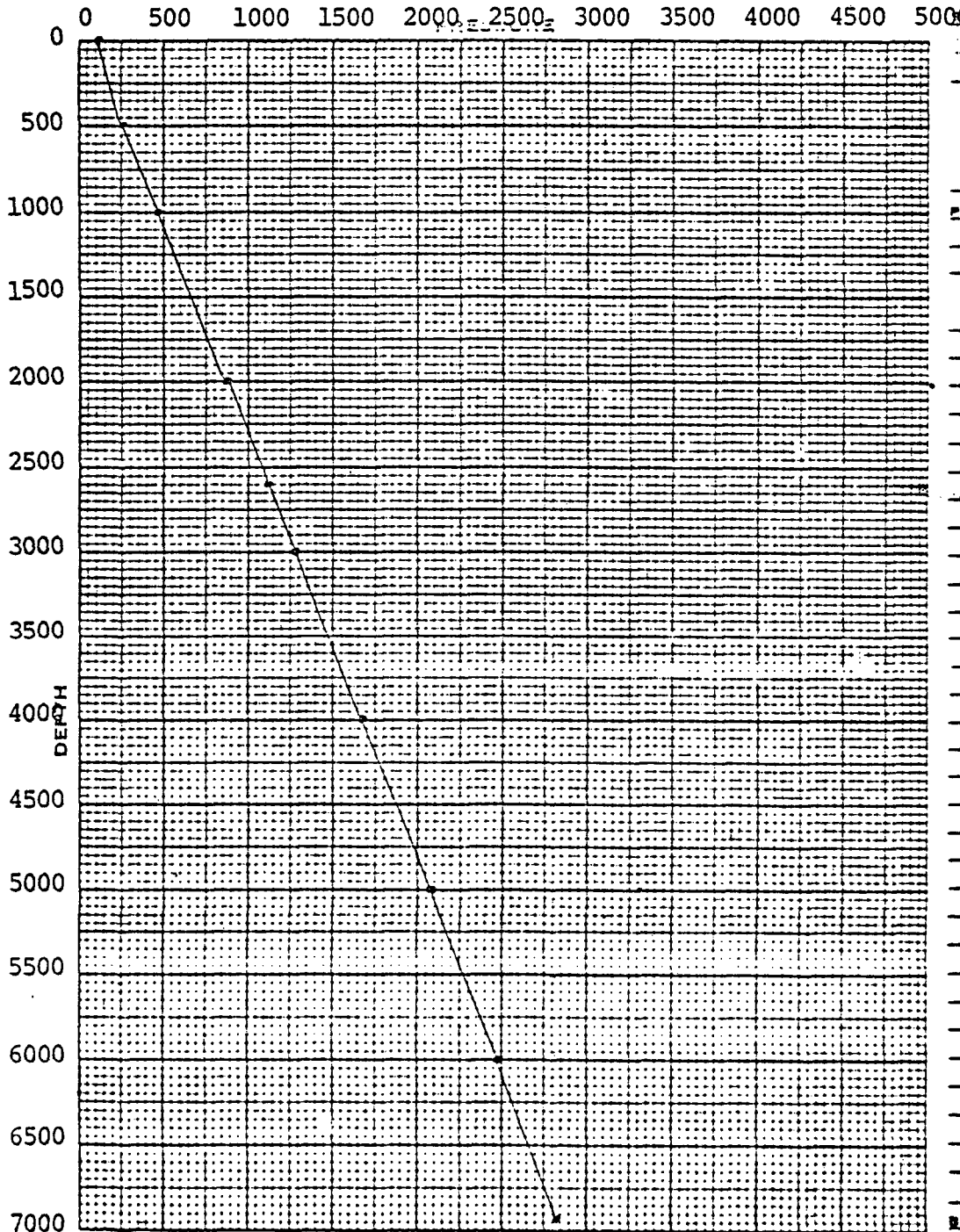
FIGURE 6

OWNER Union Oil Co. of Calif. FIELD Stillwater WELL NAME De Braga #2
 CASING 9-5/8" to 968' ELEV 3885 DATE 5-23-79
 LINER DESCRIPTION: _____ ZERO POINT _____
 _____ DEPTH _____

HOLE DESCRIPTION: _____ INSTRUMENT _____
 _____ SERIAL NO 12833

PURPOSE Gradient Survey MAX TEMP _____ °F @ _____

REMARKS: First survey after flow test of 5-22-79



PRESSURE	GAUGE	BOND
CASING PSI		

DEPTH	PRESSURE	GRADIENT
0	76	
500	251	
1000	469	
2000	870	
2600	1114	
3000	1273	
4000	1680	
5000	2072	
6000	2471	
6920	2835	

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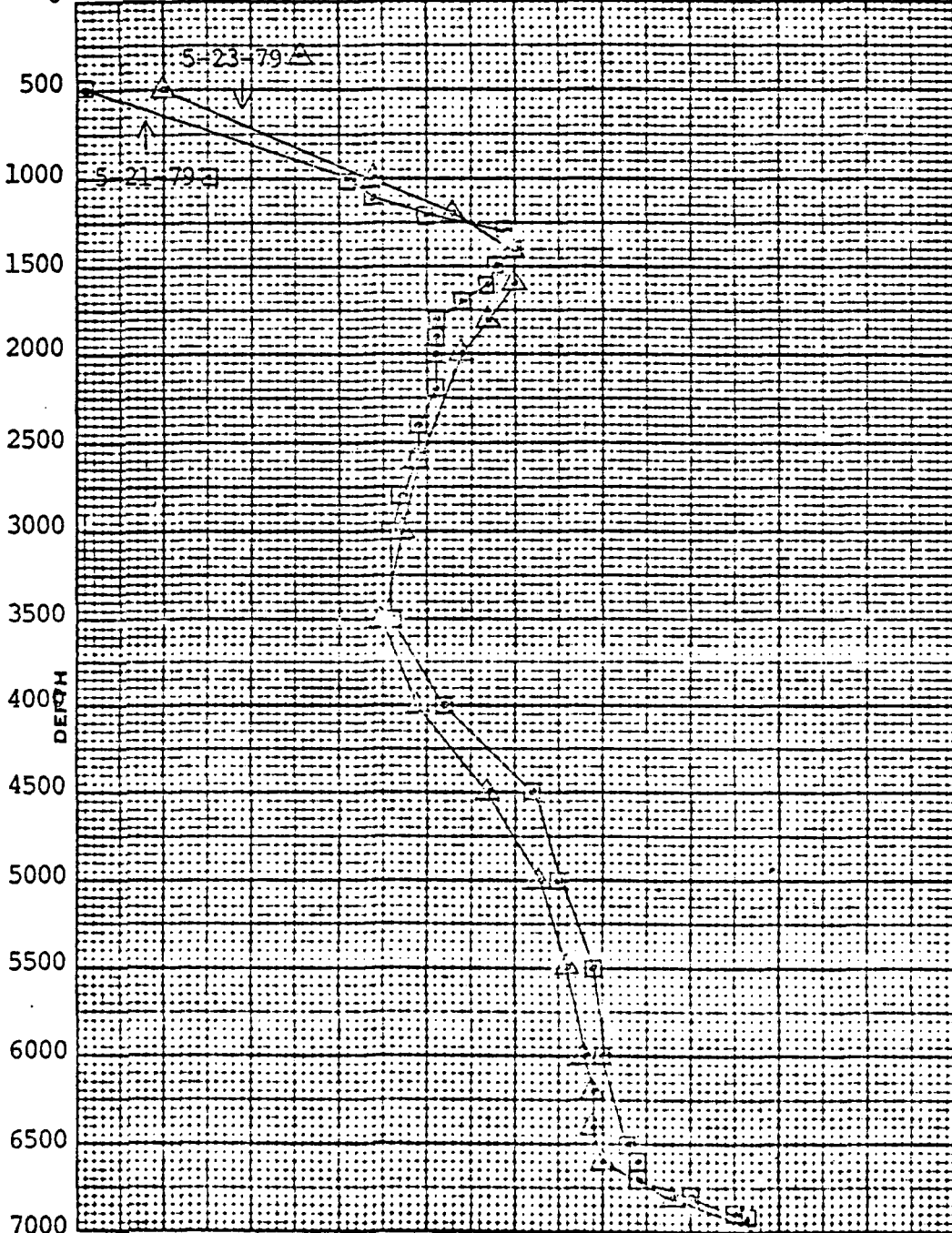
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SUBSURFACE TEMPERATURE SURVEY

FIGURE 7

OWNER Union Oil Co. of Calif. FIELD Stillwater WELL NAME De Braga #2
 CASING _____ ELEV _____ DATE _____
 LINER DESCRIPTION _____ ZERO POINT _____
 _____ DEPTH _____
 HOLE DESCRIPTION: _____ INSTRUMENT _____
 _____ SERIAL NO _____

PURPOSE Temp. 5-21-79 & Temp. 5-23-79 vs. Depth MAX TEMP _____

REMARKS _____ TEMPERATURE _____ STABILIZATION PERIOD _____
 0 260 270 280 290 300 310 320 330 340 350 360



PRESSURES		GAUGE		BOB	
CASING PSI					
DEPTH	TEMP.	DEPTH	TEMP.		
5-21-79 □		5-23-79 △			
500	261	500	270		
1000	291	1000	294		
1100	294	1200	303		
1200	300	1400	310		
1300	309	1600	310		
1400	310	1800	307		
1500	308	2000	304		
1600	307	2600	299		
1700	304	3000	297		
1800	301	3500	295		
1900	301	4000	299		
2000	301	4500	307		
2200	301	5000	312		
2400	299	5500	316		
2600	299	6000	319		
2800	297	6200	319		
3000	296	6400	319		
3500	296	6600	320		
4000	302	6800	323		
4500	312	6920	325		
5000	315				
5500	319				
6000	320				
6500	323				
6600	324				
6700	324				
6800	330				
6900	335				
6920	336				

BY: _____