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A PETROPHYSICAL STUDY OF THE STAIRWAY AND PACOOTA
SANDSTONES IN FOUR WELLS FROM THE MEREENIE FIELD
AMADEUS BASIN, NORTHERN TERRITORY.

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by

B.A. McKay and R.M. Bresnehan

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INTRODUCTION

The Mereenie field is a large oil and gas productive sandstone reservoir which lies within Licences L3 and L4 of the Amadeus Basin, Northern Territory. Seven wells have been drilled in the field, six of which are potentially gas productive; two wells also proved the existence of an oil column. One well, North-West Mereenie No. 1, is a dry hole.

The Petroleum Technology Laboratory previously carried out on East Mereenie No. 1 and No. 4 petrophysical studies, which included capillary-pressure, electrical-resistivity, water-flooding and relative-permeability tests (McKay, 1966, 1967, 1971). This report presents additional petrophysical data measured on cores from those two wells and also on recently acquired core from East Mereenie No. 2 and West Mereenie No. 1. These data include capillary-pressure measurements, gas-displacement by water in the gas-productive zones, water-flooding tests in samples from wells having an oil column, and electrical-resistivity tests.

The study was carried out to help the Reservoir Engineering Subgroup of the Petroleum Technology Section assess the hydrocarbon reserves and potential productivity of the petroleum reservoirs in the Mereenie field (Kurylowicz & Ozimic, in prep.). Specifically, the tests determined the recovery efficiency of gas and oil in the Pacoota sandstone should the drive mechanism in the reservoir prove to be water encroachment.

Petrophysical tests

The following core samples were prepared for testing:

Thirty-nine $\frac{3}{4}$ -inch diameter plugs for capillary pressure tests - 3 from East Mereenie No. 1, 26 from East Mereenie No. 2, 3 from East Mereenie No. 4, and 7 from West Mereenie No. 1.

Thirty-five $1\frac{1}{8}$ -inch diameter samples for gas and oil waterflood displacement and electrical resistivity tests - 12 from East Mereenie No. 1, 17 from East Mereenie No. 2, and 3 each from East Mereenie No. 4 and West Mereenie No. 1.

The thirty-nine $\frac{3}{4}$ -inch diameter plugs were diamond-drilled parallel to bedding planes from whole core pieces from the wells concerned. The plugs were trimmed to approximately $1\frac{1}{4}$ inches in length, cleaned in a centrifugal extractor, and oven dried for 36 hours at 105° C. The permeability of each plug was then measured with respect to dry nitrogen in a Hassler cell. On the basis of these values, a selection of $1\frac{1}{8}$ -inch diameter plugs was made from each well; plugs with a permeability of less than 0.4 millidarcy were discarded. These plugs were drilled, trimmed, cleaned and dried as described previously. Upon cooling, porosity and permeability with respect to dry nitrogen were measured on each sample.

(1) Capillary-pressure tests.

These were performed by the mercury injection method in a Ruska type mercury pump following the method of Purcell (1949). Non-wetting fluid (mercury) is injected in the pore system of the sample at increasing pressure steps and the saturated mercury volume recorded at each step. When a maximum pressure of 1400 psia is reached, the process is reversed by lowering the pressure in steps to absolute zero to obtain the mercury withdrawal characteristics (hystereses) of the samples. The capillary injection and withdrawal curves for each plug were

constructed from the saturation and pressure values at each step.

(2) Gas-displacement tests.

These tests were conducted by saturating 22 core plugs from the gas zones in the three wells, East Mereenie No. 1, 2 and 4, with distilled water then flushing each sample pore volume to a residual water saturation value using humidified nitrogen. The residual water saturation in each case was pre-determined from the capillary-pressure tests of an adjacent plug and by the location of the free water table in the reservoir.

Gas-recovery tests were determined in a Hassler cell by flushing the samples with fresh water. The effluent from each sample was monitored with a soap-bubble pipette and water flushing was continued until gas production essentially ceased. Gas-recovery tests by water imbibition were also attempted; however, this technique was unsatisfactory because of the generally low permeability and the extended time required for water-saturation stabilization in each of the plugs.

(3) Electrical Resistivity.

For these tests, thirty five 1 1/8-inch diameter samples from the four wells were dried and then saturated with 3 percent NaCl brine having a salinity similar to that of the formation water in the Pacoota reservoir (30 000 ppm). The samples were left undisturbed in this brine for a period of 48 hours to reach ionic equilibrium.

Electrical-resistivity tests were then carried out by measuring the voltage drop across each of the samples when a 5 milliamperere current was passed through them. A formation factor was calculated for each sample from the ratio of the sample resistivity to the brine resistivity. An average correlation curve of formation factor and sample porosity was derived for the four wells.

(4) Oil-displacement tests by water flooding.

Ten samples from the oil-productive horizons in three wells (East Mereenie No. 1 and 2, and West Mereenie No. 1) were used for waterflood tests. The samples were saturated with 3 percent brine and flushed in a Hassler cell to residual water saturation using a viscous mineral oil. Subsequently, the viscous oil was replaced with a light refined oil (Soltrol-C), and permeability with respect to that phase was measured in each of the samples.

Waterflood tests were conducted using a 3 percent brine as the displacing phase at an oil water viscosity ratio of about 1.48 : 1. Flooding was continued to a water "cut" greater than 99%, at which point permeability to the flooding water was measured. The incremental oil and water volumes which were taken throughout the flood tests were used to plot a curve of water injected in pore volumes versus the oil recovery in percent pore volume. A water "cut" curve showing percent of water flowing in the effluent was also plotted against the oil recovery.

Discussion

(1) Capillary pressures.

The results of these tests are presented in Figures 1 to 80; Figures 1 to 41 represent data from a previous report. (McKay, 1966, 1967).

The wide range of sample types and permeabilities selected for these tests is reflected in the capillary pressure results. Samples with a permeability greater than 1 millidarcy generally show fair to good reservoir characteristics with moderate to low threshold pressures and generally low irreducible water saturations (15 to 30 percent of pore volume). However, below 1 millidarcy, the samples tested showed poor reservoir properties with low porosities, medium to extremely high threshold pressures and high irreducible water saturations.

The shape of the capillary-pressure curves, particularly where the samples are permeable, is generally characterised by a uniform saturation increase to the non-wetting phase; that is, a very low curve slope up to irreducible saturation. This is most commonly shown in East Mereenie No. 1 and No. 4, and is an indication of an even, well sorted pore distribution.

(2) Gas-displacement tests.

Water-displacement tests were carried out on samples from the gas and oil columns in the Mereenie field, assuming that water from the aquifer underlying the hydrocarbons in the Pacoota and Stairway Sandstone formations would effectively sweep the reservoir under the influence of pressure drawdown during production. The results for displacement of gas by water from the gas horizons in three wells are shown in Table 1 and 1A.

Gas recoveries by dynamic water displacement for samples from the three wells tested were only fair, recoveries ranging from 24.6 percent to 35.4 percent of pore volume, an average of 49.3 percent of the gas in place. East Mereenie No. 4 well showed the best results with an average recovery of 59.3 percent of gas in place, although the three available samples from this well showed poor porosity and permeability, and high residual water saturations.

As stated earlier the values for the residual water saturations in the gas zone were derived from adjacent plugs for mercury-injection capillary-pressure tests, the maximum injection pressure of which was 1400 psia. When this pressure is converted to height above a free water table, a value of about 234 feet is obtained (Pirson, 1958). The thickness of the Stairway/Pacoota Sandstones gas reservoir generally exceeds 500 feet (in addition to the oil column below it in some wells); it can therefore be concluded that the irreducible water saturations in Table 1 and 1A are probably conservative, and the actual water saturations in the gas zone of the reservoirs concerned are likely to be somewhat lower.

(3) Electrical resistivity

The results of resistivity tests for the four wells are presented in Table No. 2 and, as a plot of formation factor versus porosity, in Figure 99; Figure 100 also shows a formation factor/porosity plot for samples examined in East Mereenie No. 4 (McKay, 1967).

The formation factor/porosity plot in Figure 99, which is a plot of the results listed in Table 2, reveals a rather severe scattering of points for the four wells tested, even though a broad range of sample porosities was employed. The resultant cementation factor (1.71) is low for well consolidated materials such as the Stairway and Pacoota Sandstones, and is not consistent with Pirson's 1958 classification. However, the results for East Mereenie No. 4 (Figure 100) show a much better porosity/formation factor correlation and a cementation factor which more closely agrees with Pirson.

(4) Oil-displacement tests.

These tests, like similar studies on the gas horizons, were carried out assuming flooding by water from the underlying aquifer during production. The results are presented in Table 3 (porosity, permeability and residual water saturation of the samples before the flood tests) and Table 4 (recovery in terms of pore volumes, hydrocarbon volumes and water "cut"). The results of Table 4 are also presented graphically in Figures 81 to 98; Figures 81 to 88 are taken from McKay (1971).

The waterflood results shown in the attached data sheets and curves reveal quite favourable oil recovery by water displacement. The average oil recovery at water breakthrough ranged from 44 to 64 percent of oil in place for the four wells tested. Additional oil recovery subsequent to water breakthrough was noted in all the samples; this averaged 55 percent of oil in place at 1 pore volume water throughput (97 percent water cut) to a recovery of 62 percent of oil in place at 5 pore volumes throughout (99 percent water cut). However, considering the rather poor flow capacity of the Pacoota Sandstone, it is doubtful if a water cut greater than 97 percent could be tolerated in the production stream; therefore, the recovery factor of 55 percent of oil in place is probably the maximum production figure which could be expected for the Pacoota Sandstone.

During the preparation for these tests, it was noted that irreducible water saturations obtained by dynamic displacement with viscous oil were often lower than those obtained in the adjacent mercury injection capillary pressure plug. This is particularly apparent in some samples (4753' to 4769') from the oil column of East Mercenie No. 2 where irreducible water saturations of 8 to 11 percent of pore volume were obtained by flushing the brine saturated samples to irreducible water with oil. The corresponding capillary-pressure plug for these intervals showed irreducible saturations of 18 to 25 percent of pore volume. Since the two plugs were cut immediately adjacent to each other in generally uniform material, the reason for the discrepancies is not clear and additional testing to resolve this problem may be warranted.

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Table 1

Gas Recovery by Water Displacement - Mereenie Field, Northern Territory

Well	Sample depth (feet)	Porosity (% bulk volume)	Permeability to nitrogen (Md.)	Residual water saturation by mercury injection (% P.V.)	Gas recovery by water displacement					Lithology
					% P.V.			% H.C.V.		
					Residual water	Residual gas	Gas recovery	Residual gas	Gas recovery	
East Mereenie No. 1	2653	12.6	2.1	25	26.0	29.5	44.5	40.0	60.2	Sst; f.gr.
	3824	13.1	47	20	22.6	37.1	40.3	48.0	52.0	Sst; m.gr. sl. slty
	3830	11.4	235	15	17.5	39.5	43.0	47.9	52.1	As above
	3849	5.0	1.2	30	24.4	43.4	32.2	57.4	42.6	Sst; m.gr. to c.gr. Sl. pyritic
	3853	7.9	18	20	24.6	38.8	36.6	51.5	48.5	Sst; m.gr.
	4126	8.5	8.1	20	17.4	55.0	27.5	66.5	33.3	Sst; m.gr.
	4136	12.1	15	15	15.3	49.4	35.3	58.4	41.7	Sst; f.gr to m.gr.
	4138	8.8	2.5	20	22.4	31.4	46.2	40.5	59.5	Sst; f.gr. sl. pyr.
	4275	9.2	13	20	22.6	51.6	25.8	66.7	33.3	Sst; m.gr. sl. pyr.
	4494	9.9	6.2	25	37.8	34.0	28.2	54.6	45.4	Sst; f.gr. sl. pyr.
	4525	8.2	3.1	40	41.9	28.7	29.4	49.4	50.6	Sst; v.f. gr. to m.gr.
Averages		9.7	32	22.7	24.7	39.8	35.4	52.8	47.2	

P.V. - Pore Volume

H.C.V. - Hydrocarbon volume

Table 1 (continued)

Well	Sample depth (feet)	Porosity (% bulk volume)	Permeability to nitrogen (Md.)	Residual water saturation by mercury injection (% P.V.)	Gas recovery by water displacement					Lithology
					% P.V.			% H.C.V.		
					Residual water	Residual gas	Gas recovery	Residual gas	Gas recovery	
East Mercenie No. 2	4159	5.9	2.4	32	28.8	51.9	19.3	72.9	27.1	Sst; f.gr. to m.gr.
	4180	8.0	44	27	19.5	47.5	33.0	59.0	41.0	Sst; m.gr sl. slty
	4189	7.8	15	23	24.2	63.7	12.1	84.0	16.0	Sst; f.gr to m.gr.
	4270	7.0	0.6	60	65.5	11.7	22.8	34.0	66.0	Sst; f.gr. slty shly incl.
	4328	7.3	8.8	30	29.2	48.5	22.3	68.3	31.7	Sst; f.gr. to m.gr. shly lam, pyr.
	4340	9.2	1.6	12	15.8	52.7	31.5	62.5	37.4	Sst; f.gr. to m.gr.
	4369	9.4	22	30	31.4	40.9	27.7	59.5	40.5	Sst; m.gr. sl. pyr.
	4388	4.9	0.13	57	57.7	14.0	28.3	33.1	66.9	Slst; aren, shly pyr.
	Averages	7.4	11.8	33.8	34.0	41.4	24.6	59.2	40.8	
East Mercenie No. 4	4197	6.4	0.21	60	71.0	9.3	19.7	32.0	68.0	Slst; aren, slty, lam
	4198	8.8	15	25	14.6	67.4	18.0	78.9	21.1	Sst; m.gr. sl. slty
	4203	4.5	0.95	60	56.0	5.3	38.7	11.3	88.7	Slst; aren, shly. lam
	Averages	6.6	5.4	48.3	47.2	27.3	25.5	40.7	59.3	

Table 2

Formation Factors - Mereenie Field

Well Number	Sample Number	Depth (feet)	Porosity (% bulk volume)	Permeability to nitrogen (Md.)	Formation factor	Fluid production
E. Mereenie No. 1	2	2653	12.6	2.1	41.6	Gas
	5	3824	13.1	47	31.6	"
	6	3830	11.4	235	26.8	"
	7	3849	5.0	1.2	170.9	"
	8	3853	7.9	18	93.6	"
	9	4126	8.5	8.1	75.1	"
	10	4136	12.1	15	60.3	"
	11	4138	8.8	2.5	36.3	"
	12	4275	9.2	13	60.6	"
	14	4494	9.9	6.2	53.8	"
	15	4525	8.2	3.1	67.8	"
	18	4690	9.7	1.4	48.6	Oil
E. Mereenie No. 2	1	4159	5.9	2.4	151	Gas
	2	4168	2.5		59	"
	3	4180	8.0	44	70	"
	4	4189	7.8	15	109	"
	7	4270	7.0	0.6	53	"
	11	4328	7.3	8.9	92	"
	13	4340	9.2	1.6	110	"
	16	4369	9.4	22	67	"
	18	4388	4.9	0.13	118	"
	21	4446	6.9	0.30	80	Oil
	24	4474	2.7	0.69	151	"
	28	4494	5.0	0.14	149	"
	33	4653	5.4	2.1	132	"
	36	4753	11.1	82	37	"
	37	4755	11.2	43	41	"
	38	4759	11.0	75	46	"
	39	4769	9.9	71	43	"
W. Mereenie No. 1	2	4575	8.5	0.31	94	Oil
	4	4596	3.8	0.37	156	"
	5	4644	8.0	1.4	68	"
E. Mereenie No. 4	1	4197	6.4	0.21	70	Gas
	2	4198	8.8	15	76	"
	3	4203	4.5	0.95	52	"

9.
TABLE 3.

Well - East Merceenie No. 1

Sample number	Depth (feet)	Porosity (% bulk volume)	Permeability (millidarcys)			Residual water saturation before waterflood (% pore volume)	Lithology
			to dry nitrogen	to oil at residual water sat'n (before flood)	to water at residual oil saturation after flood)		
18	4690	9.7	1.4	0.45	0.1	33.0	Sst; m.gr. to c.gr.

Well - East Merceenie No. 2

21	4446	6.9	0.3	0.11	<0.1	35.0	Sst; f.gr. slty.
33	4653	5.4	2.1	1.0	0.25	35.0	Sst; m.gr.
36	4753	11.1	82	80	8.6	11.0	Sst; f.gr. to m.gr.
37	4755	11.2	43	42	2.1	11.2	Sst; f.gr.
38	4759	11.0	75	74	6.0	11.3	As above
39	4769	9.9	71	57	4.5	8.5	Sst; f.gr. to m.gr.

Well - West Merceenie No. 1

2	4575	8.1	0.31	0.14	<0.1	26.2	Sst; f.gr.
4	4596	3.8	0.37	0.15	<0.1	37.0	Sst; m.gr. to c.gr.
5	4644	8.0	1.4	0.62	<0.1	37.5	Sst; m. gr. to v. c.gr. slty.

Well - East Merceenie No. 4

Results from EWR Record No. 1971/131	4631	8.4	31	30	11.6	16.0	
	4633	8.5	13	9.5	1.2	15.2	
	4710	10.4	34	31	7.1	9.5	
	4711	10.0	26	21	3.8	11.5	
	4712	10.1	16	16	5.6	13.2	
	4713	11.3	55	53	13.6	13.8	
	4752	9.7	6.3	4.0	0.42	20.0	

TABLE 4.

Water salinity - 30 000 ppm NaCl
Producing oil/water viscosity ratio = 1.48:1

Well - East Moreene No. 1

Sample Number	Depth (feet)	Oil Recovery										Water Cut			
		% gas volume					% hydrocarbon volume					% total production			
		B.T.	1 P.V.	5 P.V.	10 P.V.	20 P.V.	B.T.	1 P.V.	5 P.V.	10 P.V.	20 P.V.	1 P.V.	5 P.V.	10 P.V.	20 P.V.
18	4090	43.3	46.5	54.8	-	-	64.6	69.4	81.8	-	-	96.5	99.0	-	-

Well - East Moreene No. 2

21	4446	25.8	39	44.6	45.4	-	39.7	60.0	68.6	69.8	-	93.5	99.6	99.8	-
33	4653	30.6	33.2	35.6	36.8	37.8	47.1	51.1	54.7	56.6	58.1	98.7	99.6	99.8	99.9
36	4753	39.3	40.1	41.9	42.7	43.8	43.8	45.1	47.1	48.0	49.2	99.3	99.7	99.8	99.9
37	4755	38.2	39.8	41.7	42.7	44.5	43.0	44.6	47.0	48.1	50.1	98.1	99.5	99.8	99.8
38	4759	40.4	46.8	50.2	52.2	55.1	52.3	52.7	56.6	58.8	62.1	99.2	99.5	99.6	99.8
39	4769	40.7	47.7	51.8	53.5	55.0	51.0	52.1	56.6	58.5	60.1	98.0	99.0	99.7	99.8
Averages		37.8	41.1	44.3	45.5	-	47.0	51.0	55.1	56.6	-	97.8	99.5	99.7	-

Well - West Moreene No. 1

	4575	42.7	43.4	44.0	-	-	57.8	58.6	59.6	-	-	99.0	99.5	-	-
	4586	24.0	34.0	41.3	43.7	43.7	38.1	53.9	65.5	69.4	69.4	96.0	99.0	100	100
	4644	22.9	36.0	41.0	42.4	-	36.6	57.6	65.6	67.8	-	95.8	99.7	99.8	-
Averages		29.8	37.6	42.1	-	-	44.1	56.7	63.5	-	-	96.9	99.4	-	-

Well - East Moreene No. 4

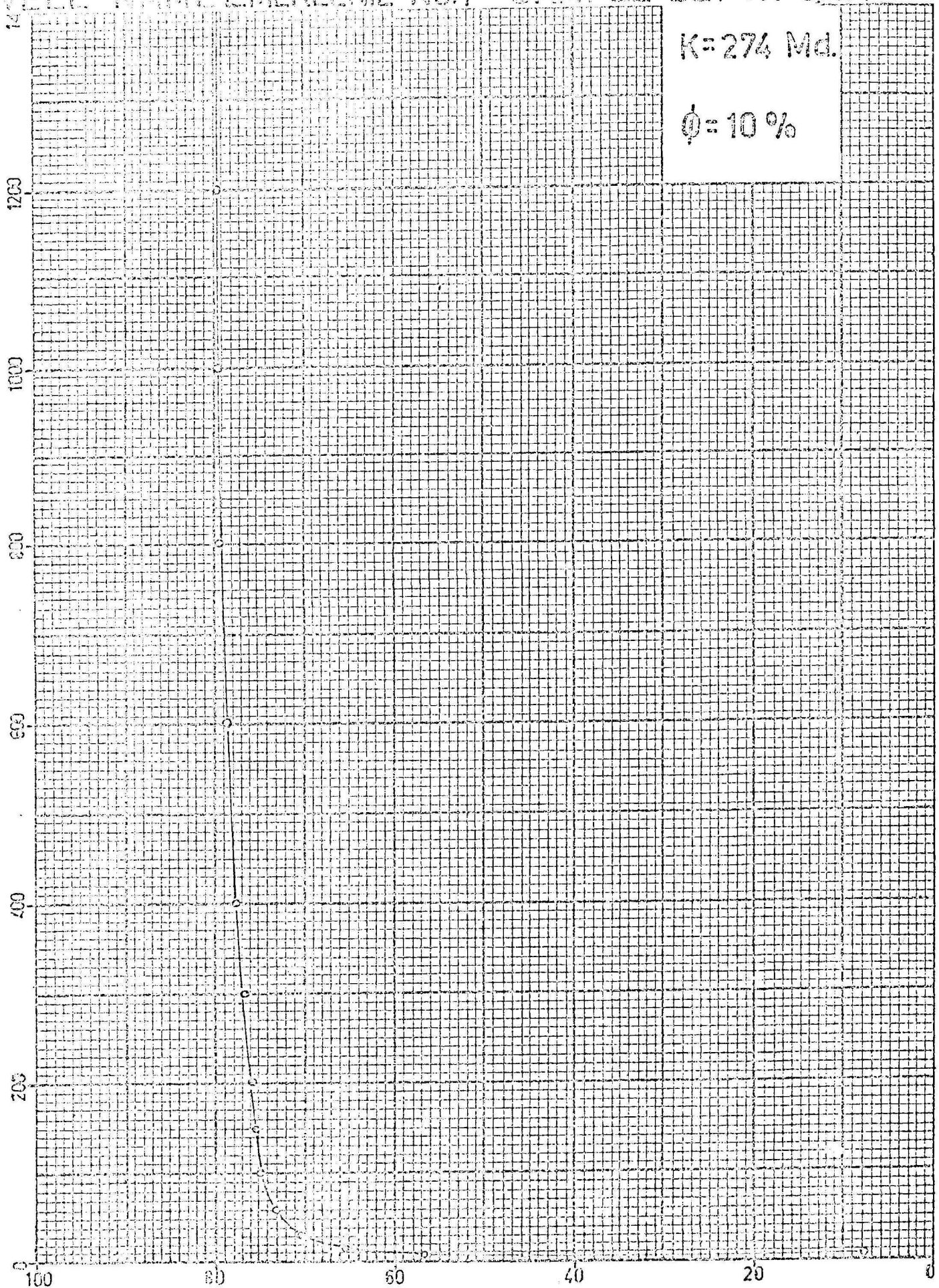
Results from May (1971)

	4631	37.4	44.5	50.3	53.3	-	44.2	52.9	59.9	63.4	-	96.0	99.2	99.6	-
	4633	42.2	50.2	56.8	61.1	-	49.7	59.2	66.9	72.0	-	94.5	98.7	99.8	-
	4710	43.4	50.2	59.0	61.0	-	47.9	55.5	65.2	67.4	-	95.0	99.4	99.9	-
	4711	43.2	49.1	54.9	58.8	-	48.8	55.5	62.0	66.4	-	97.0	99.4	99.8	-
	4712	44.5	48.5	58.5	61.0	-	51.5	55.9	65.5	70.3	-	96.0	98.9	99.3	-
	4713	39.6	44.5	52.5	56.1	-	46.0	51.5	60.8	65.0	-	97.0	99.2	99.3	-
	4742	44.3	50.0	58.0	62.0	-	51.4	58.0	67.3	71.9	-	96.0	99.0	99.4	-
	4752	44.5	48.5	52.6	55.0	-	55.6	60.6	66.0	68.7	-	98.0	99.4	99.9	-
Averages		42.4	48.2	55.1	58.5	-	49.4	56.1	64.2	68.1	-	96.2	99.1	99.6	-

MERCURY CAPILLARY PRESSURE

WELL NAME-EMERENIE No.1 SAMPLE DEPTH-3824

K=274 Md.

 $\phi = 10\%$ 

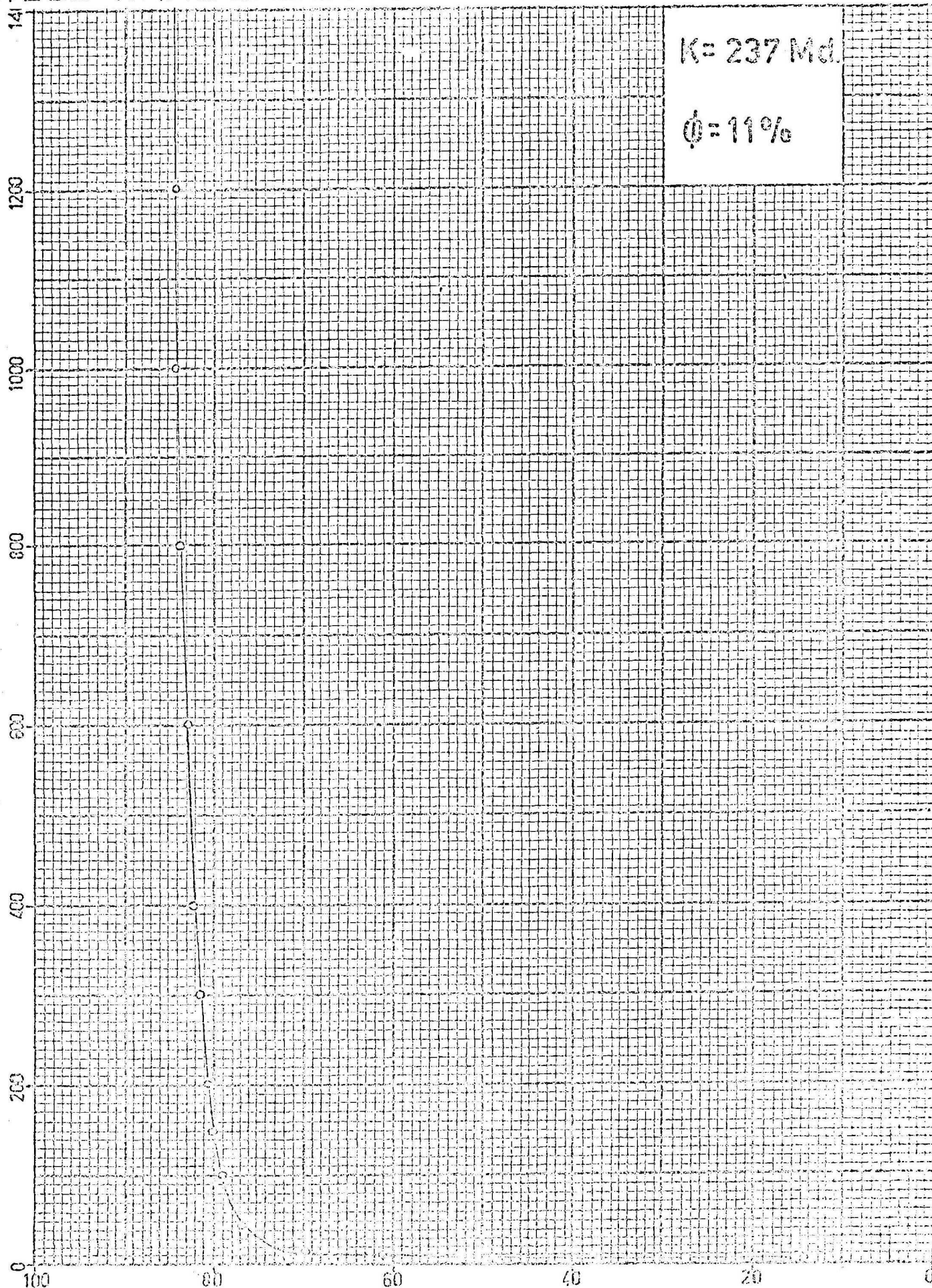
MERCURY SATURATION--PERCENT PORE VOLUME

MERCURY CAPILLARY PRESSURE

WELL NAME-EMERENIE No.1 SAMPLE DEPTH-3026

 $K = 237 \text{ Md.}$ $\phi = 11\%$

MERCURY CAPILLARY PRESSURE (PSIA)



POROSITY (PH) PERCENT PORE VOL FINE

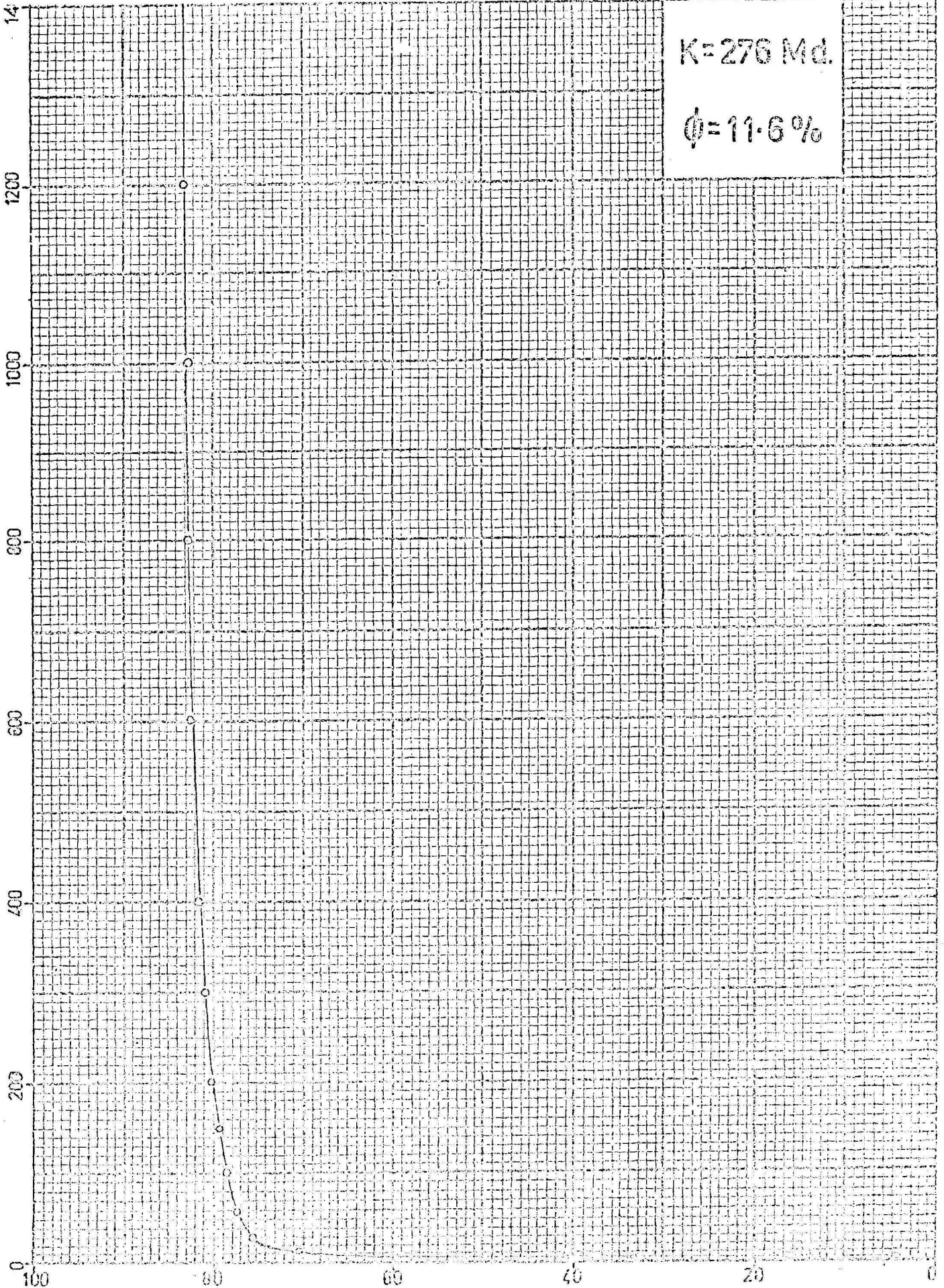
MERCURY CAPILLARY PRESSURE

WELL NAME-E.MEREEENIE No1 SAMPLE DEPTH-3828

K=276 Md.

$\phi=11.6\%$

MERCURY CAPILLARY PRESSURE (PSIA)



MERCURY SATURATION-PERCENT PORE VOLUME

FIGURE 4

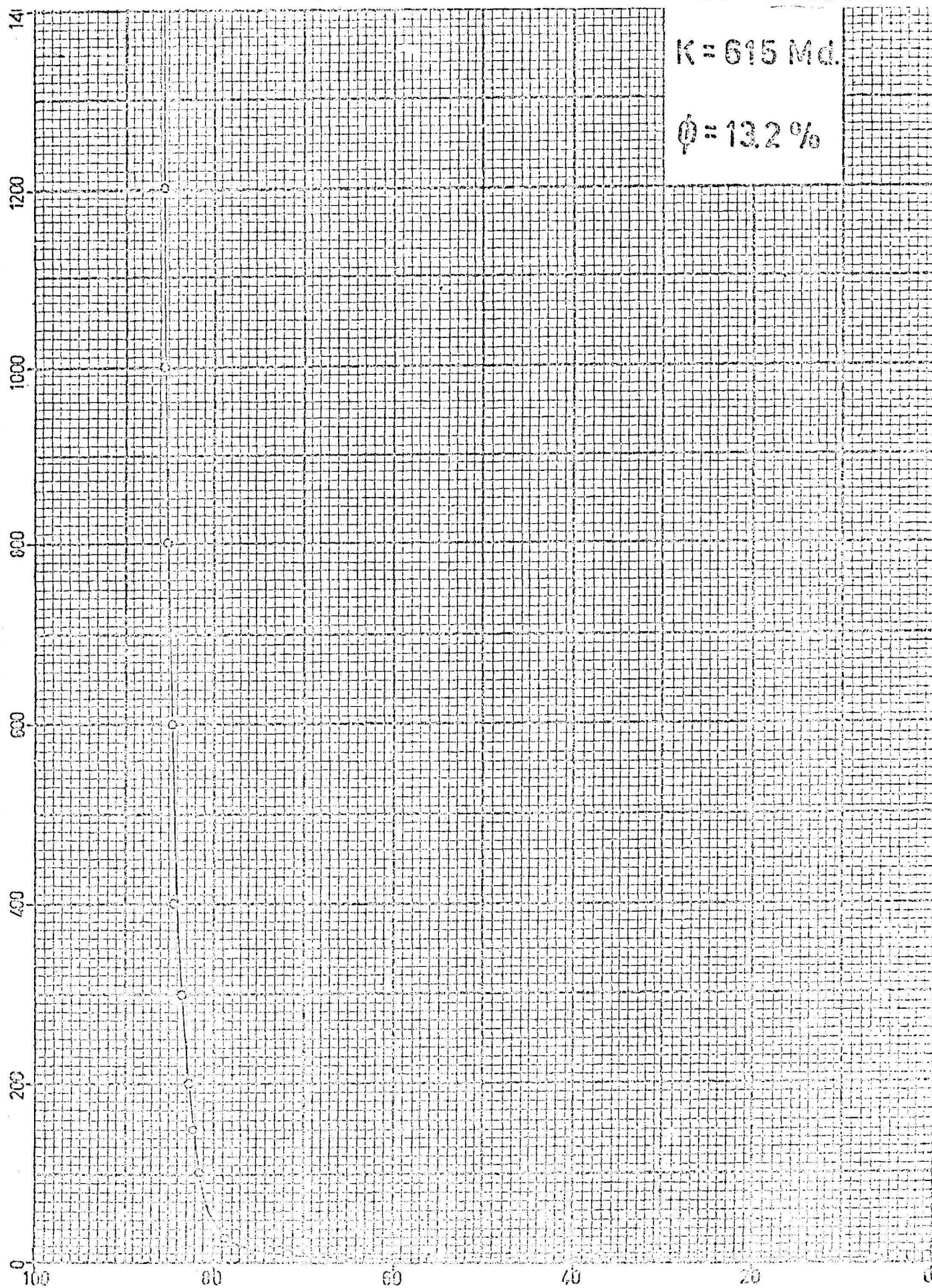
MERCURY CAPILLARY PRESSURE

WELL NAME E.MEREEWE No.1 SAMPLE DEPTH-3830

K=615 Md.

$\phi = 13.2\%$

MERCURY CAPILLARY PRESSURE (PSIA)



MERCURY SATURATION—PERCENT PORE VOLUME

FIGURE 5

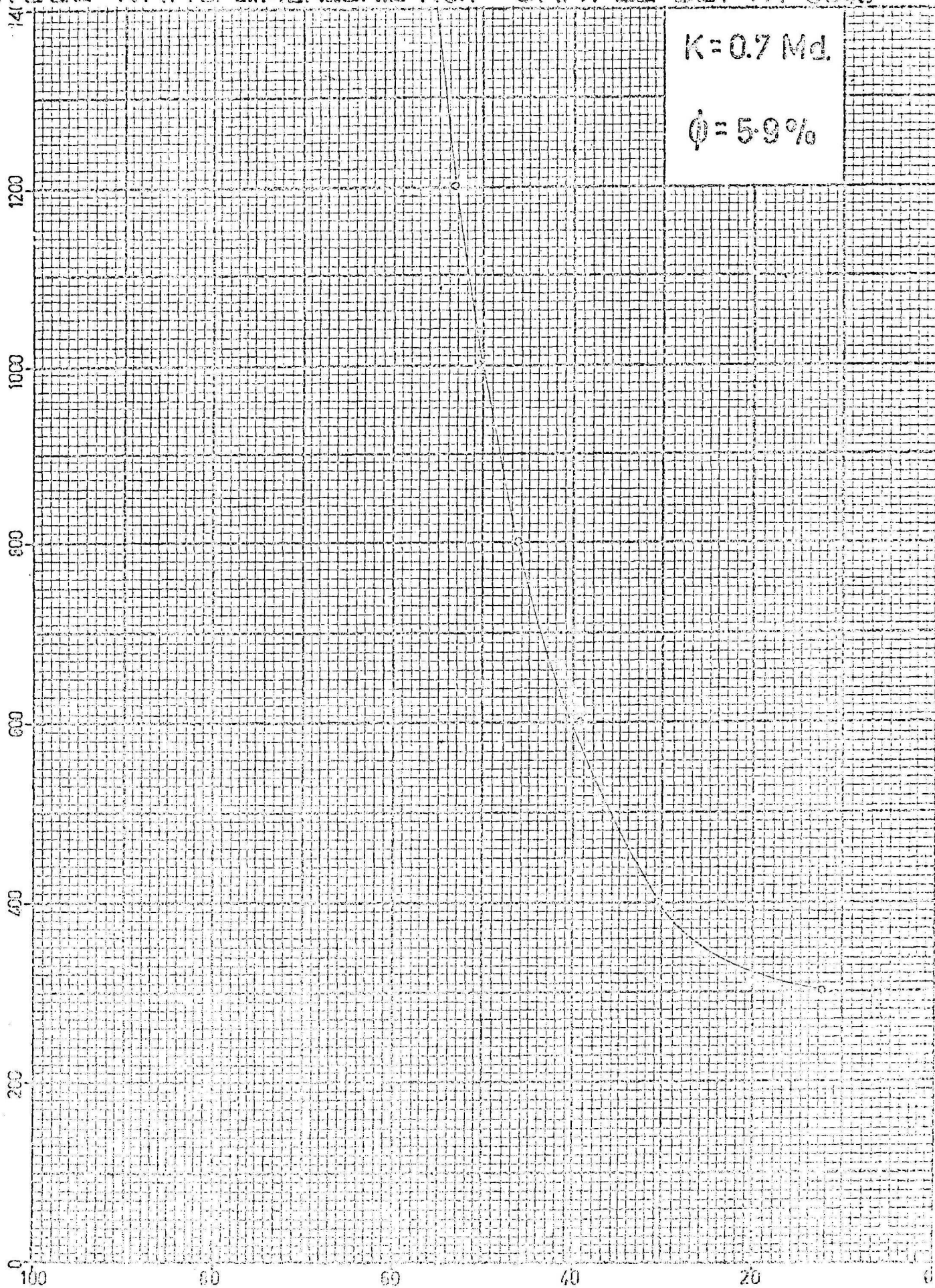
MERCURY CAPILLARY PRESSURE

WELL NAME-EMERENIE No.1 SAMPLE DEPTH-3849

$K=0.7 \text{ Md}$

$\phi=5.9\%$

MERCURY CAPILLARY PRESSURE (PSIA)



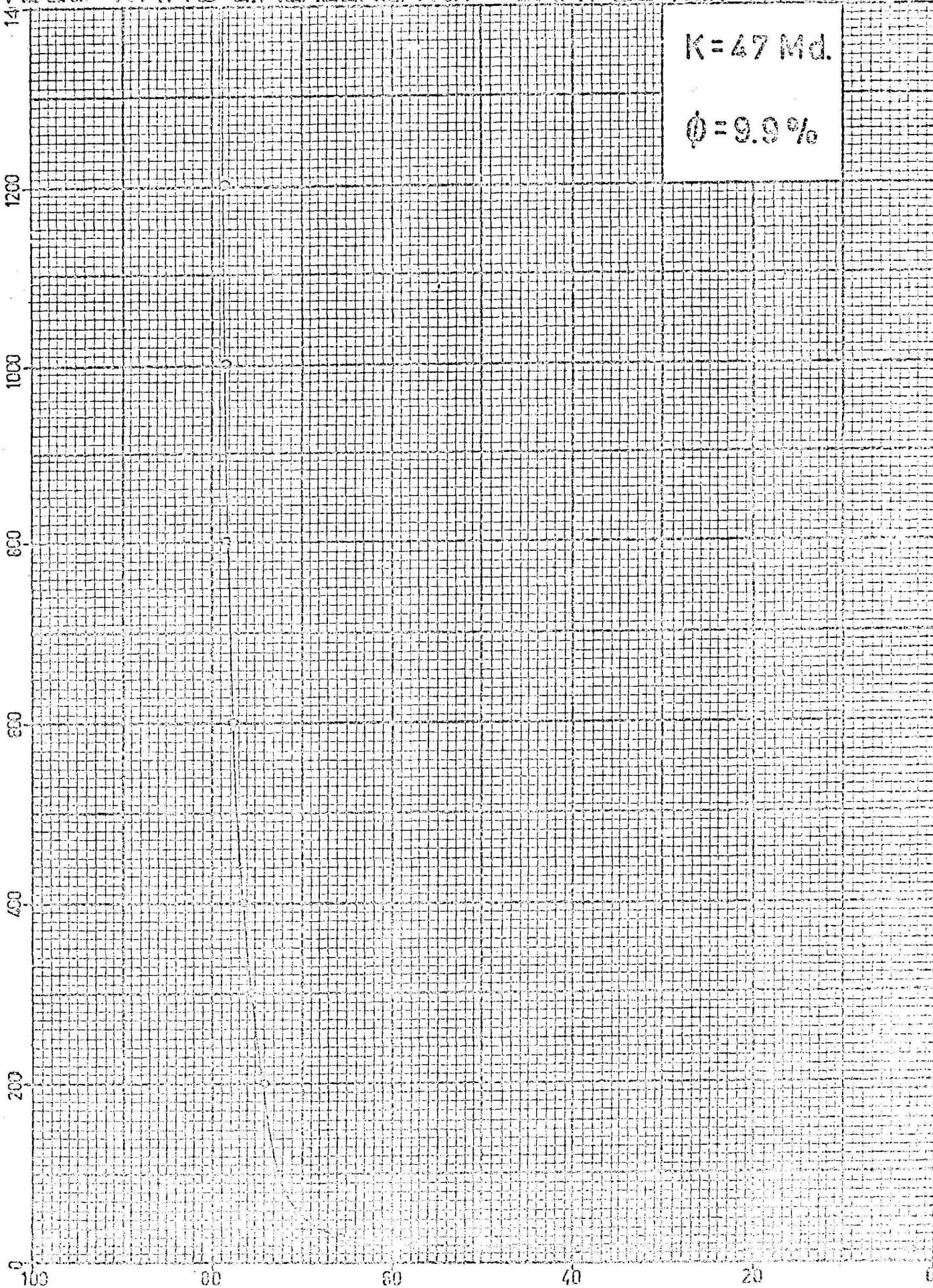
MERCURY SATURATION PERCENT PORE VOLUME

MERCURY CAPILLARY PRESSURE

WELL NAME-E.MEREENE No1 SAMPLE DEPTH-3850

 $K=47 \text{ Md.}$ $\phi=9.9\%$

MERCURY CAPILLARY PRESSURE (PSIA)



MERCURY SATURATION - PERCENT PORE VOLUME

FIGURE 7

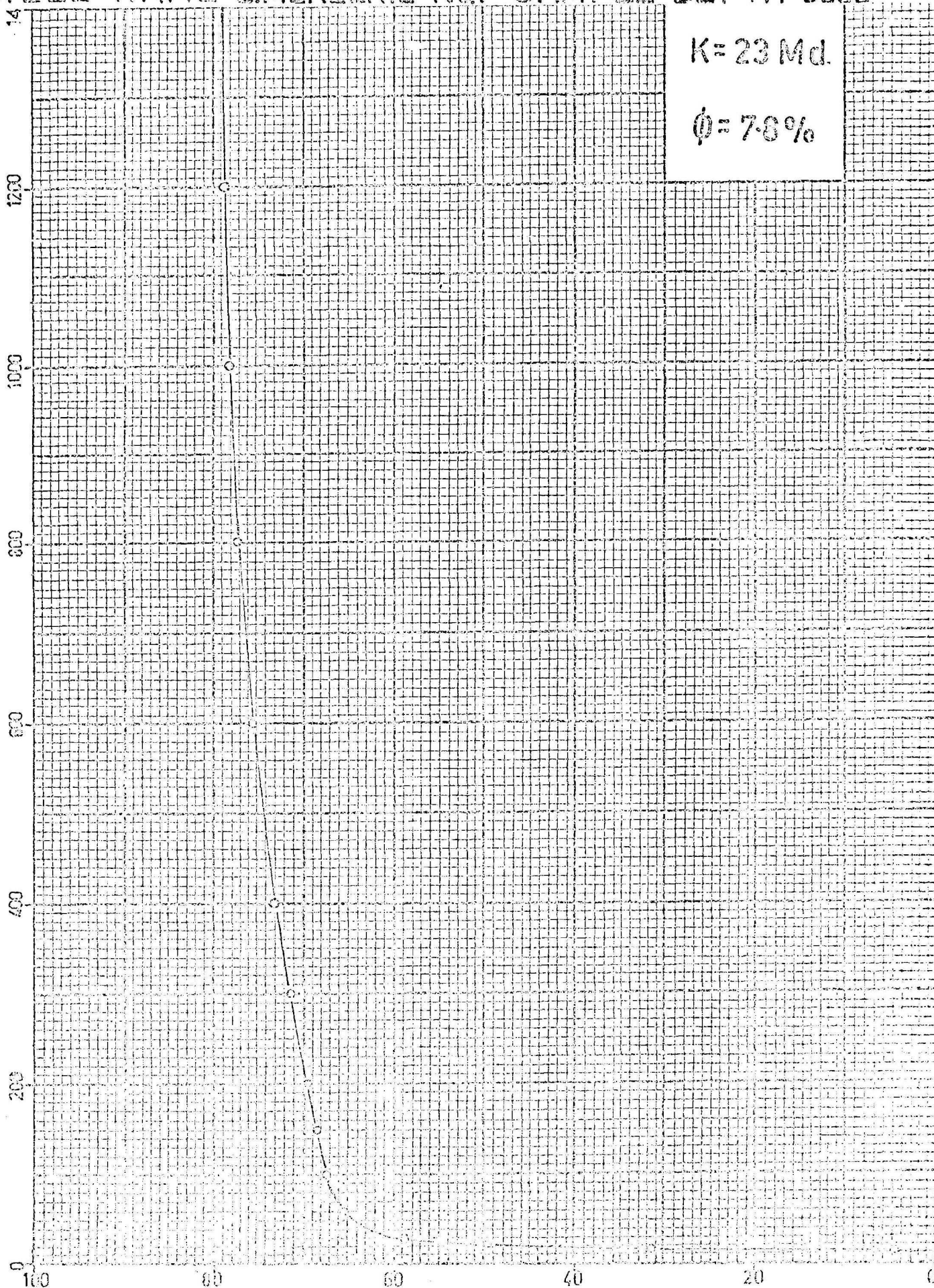
MERCURY CAPILLARY PRESSURE

WELL NAME-EMERENIE No1 SAMPLE DEPTH-3853

K=23 Md.

 $\phi = 7.8\%$

MERCURY CAPILLARY PRESSURE (PSIA)



MERCURY SATURATION - DECENT DORE VOL 100%

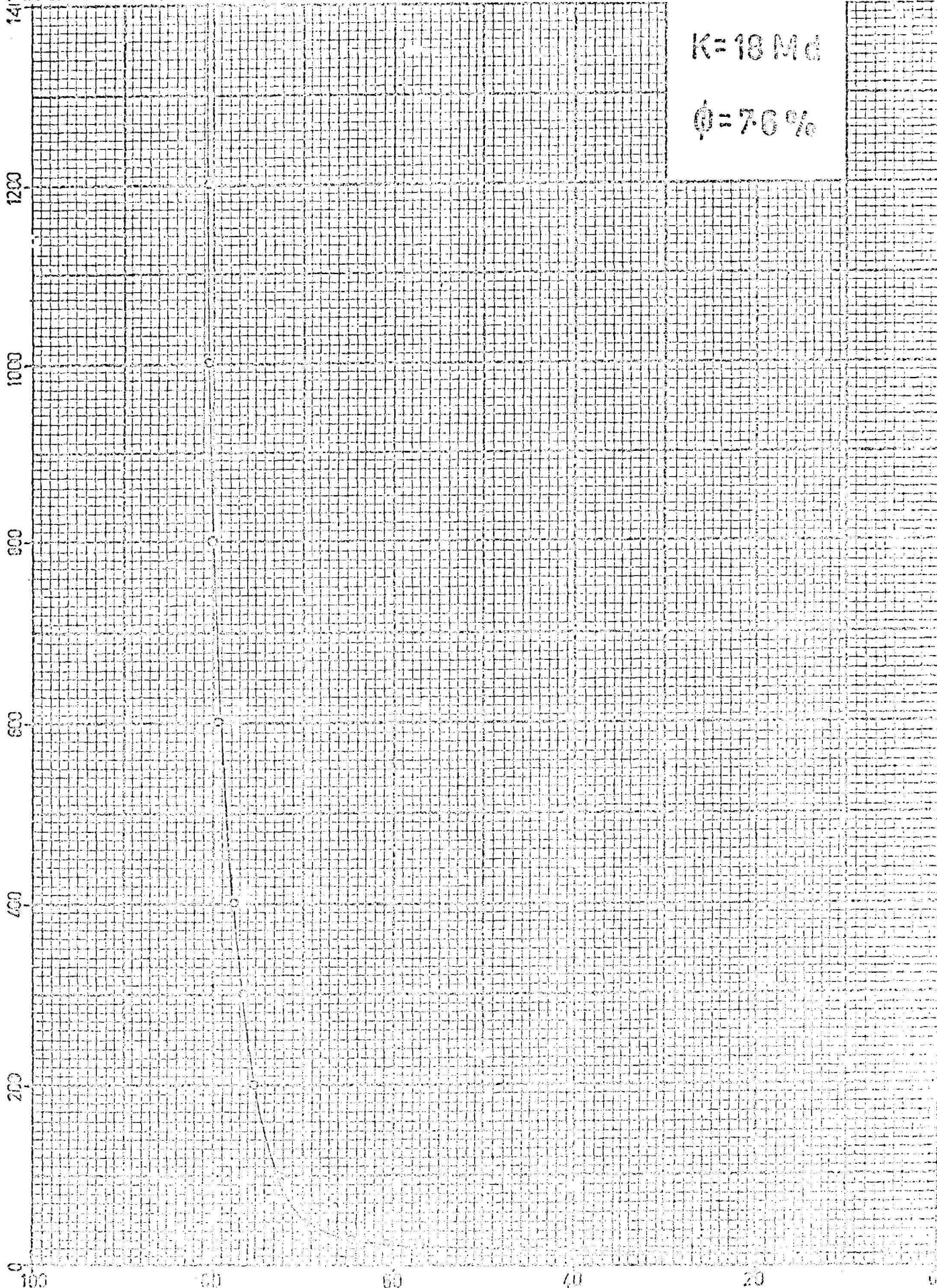
MERCURY CAPILLARY PRESSURE

WELL NAME-E.MEREEENIE No1 SAMPLE DEPTH-4125

K=18 Md

$\phi = 7.6\%$

MERCURY CAPILLARY PRESSURE (PSIA)



MERCURY SATURATION- PERCENT PORE VOLUME

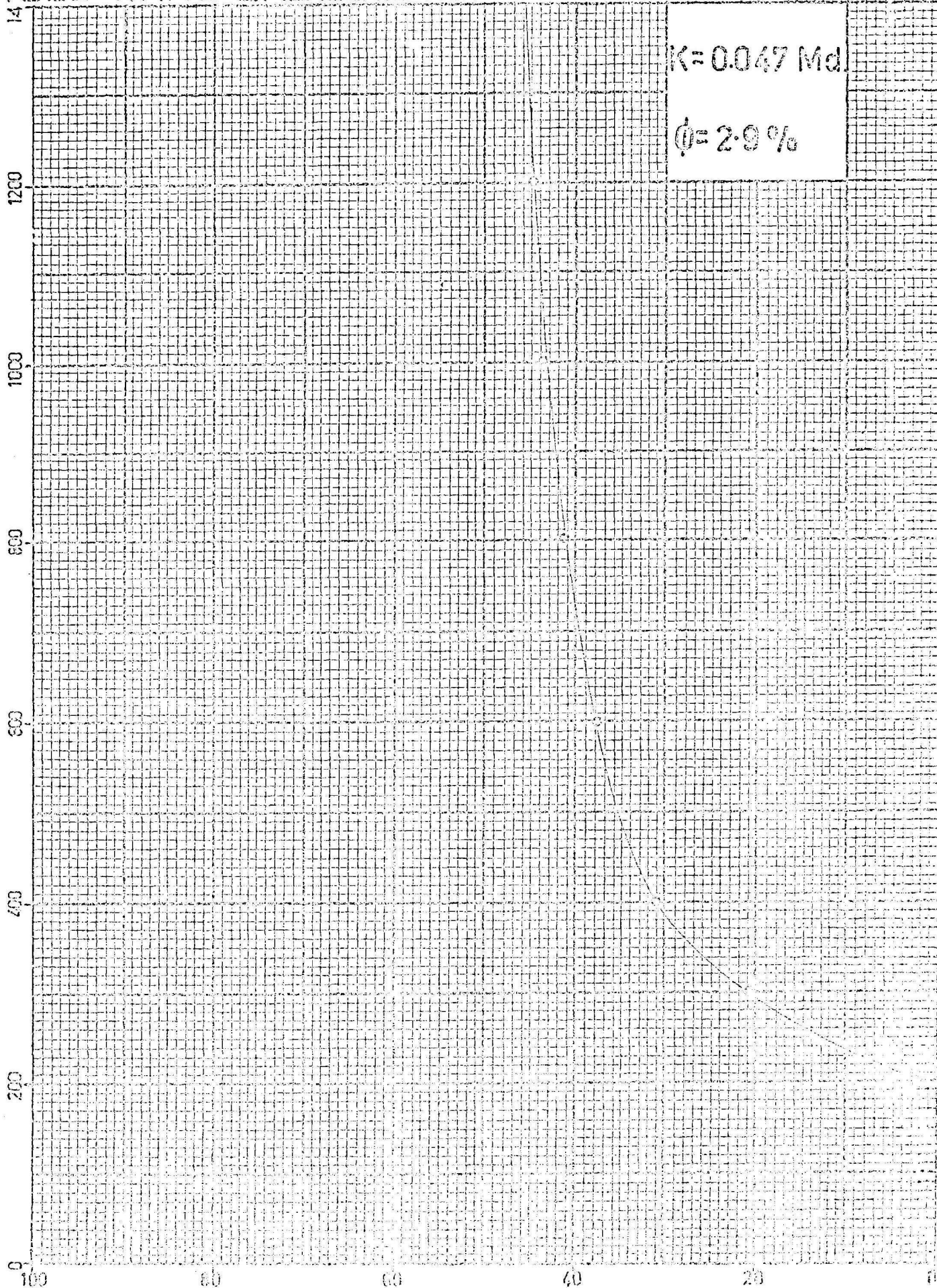
MERCURY CAPILLARY PRESSURE

WELL NAME-EMEREEENIE No.1 SAMPLE DEPTH-4128

$K=0.047 \text{ Md}$

$\phi=2.9\%$

MERCURY CAPILLARY PRESSURE (PSIA)



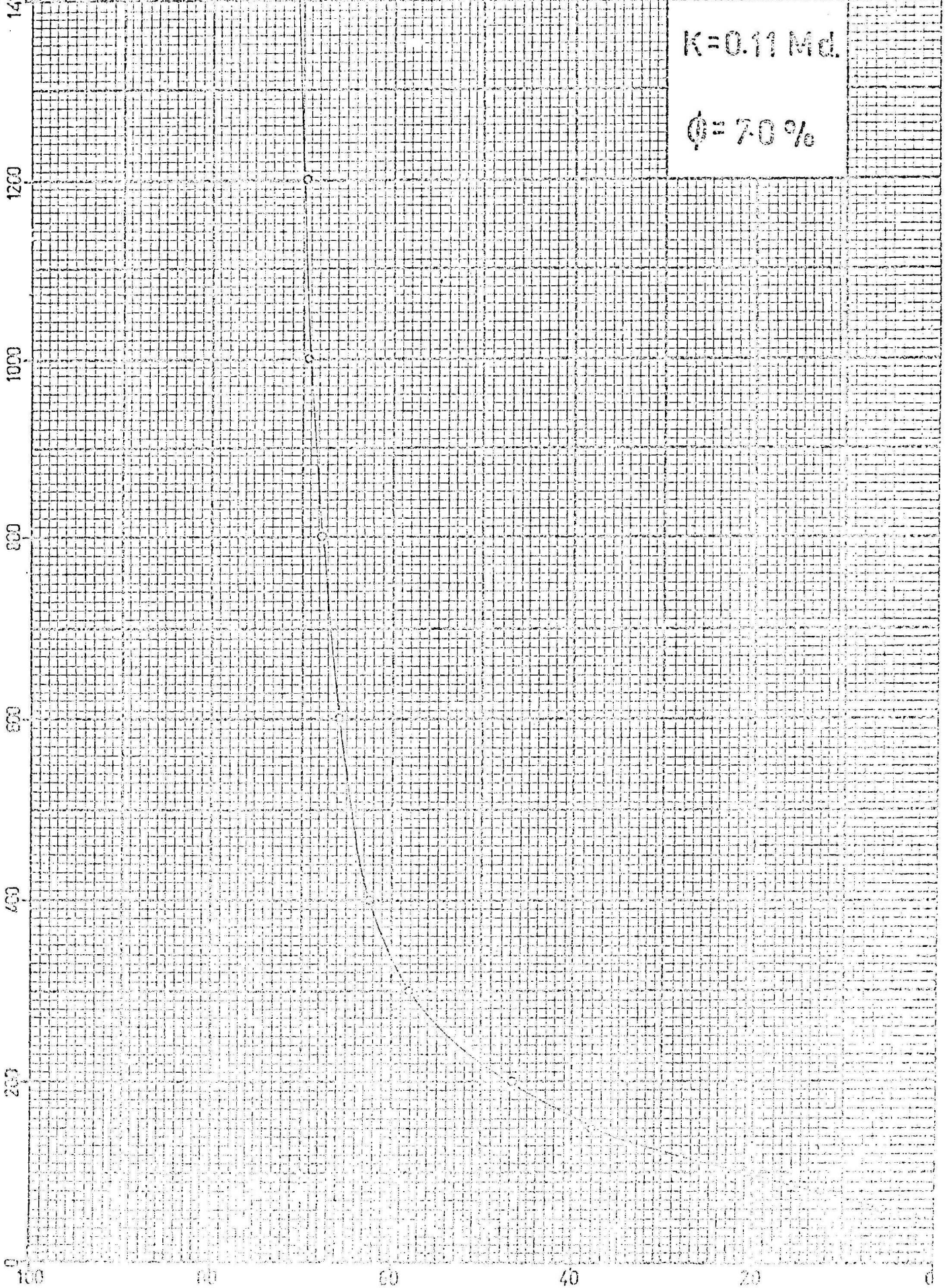
MERCURY SATURATION, PERCENT (Pore Volume)

MERCURY CAPILLARY PRESSURE

WELL NAME-E MEREEHIE No1 SAMPLE DEPTH-4132

 $K=0.11 \text{ Md}$ $\phi = 7.0\%$

MERCURY CAPILLARY PRESSURE (PSIA)



MERCURY SATURATION- PERCENT PORE VOLUME

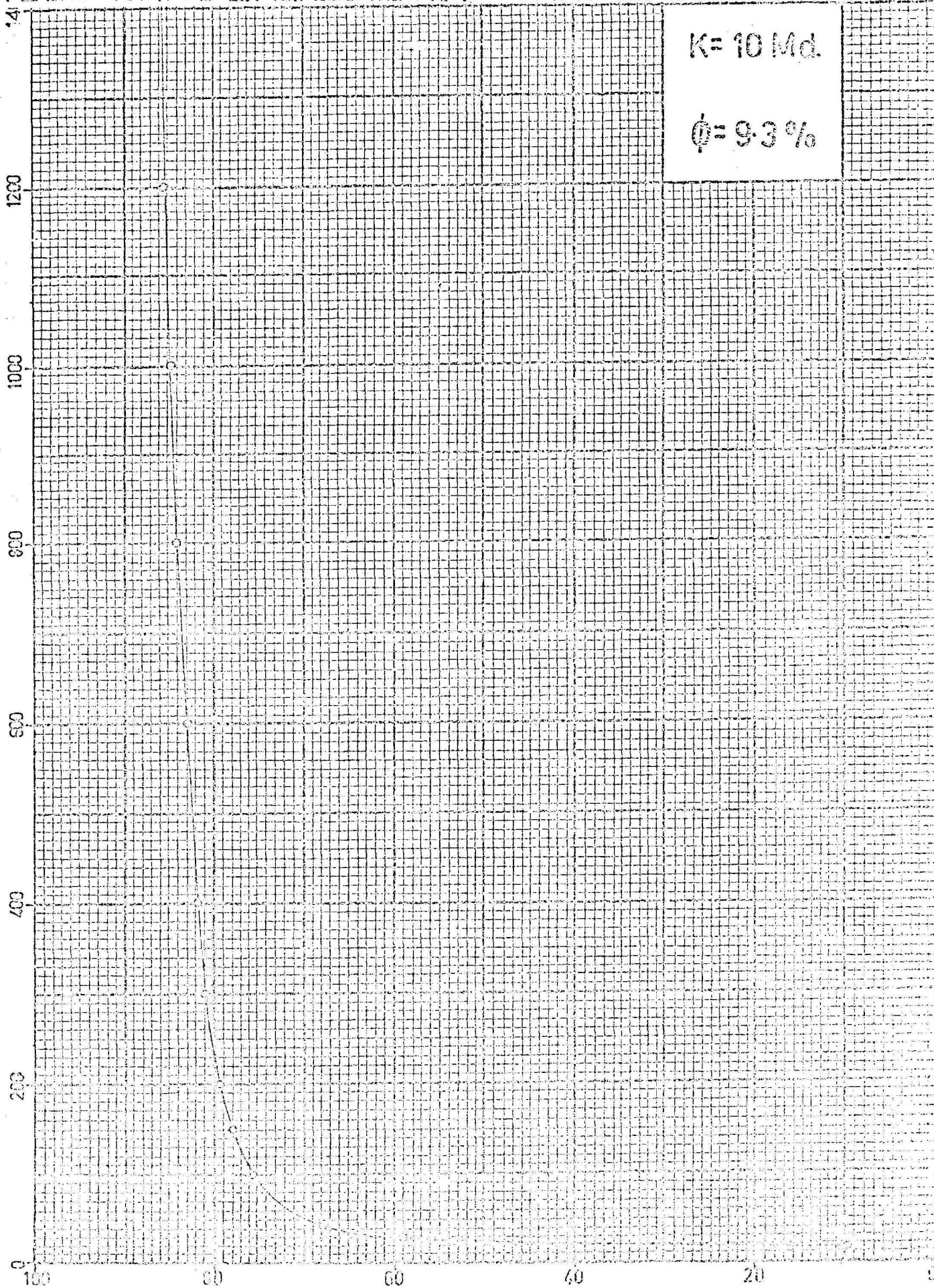
MERCURY CAPILLARY PRESSURE

WELL NAME-EMERGENIE No1 SAMPLE DEPTH-4136

$K=10 \text{ Md.}$

$\phi=9.3\%$

MERCURY CAPILLARY PRESSURE (PSIA)



SATURATION - PERCENT

FIGURE 12

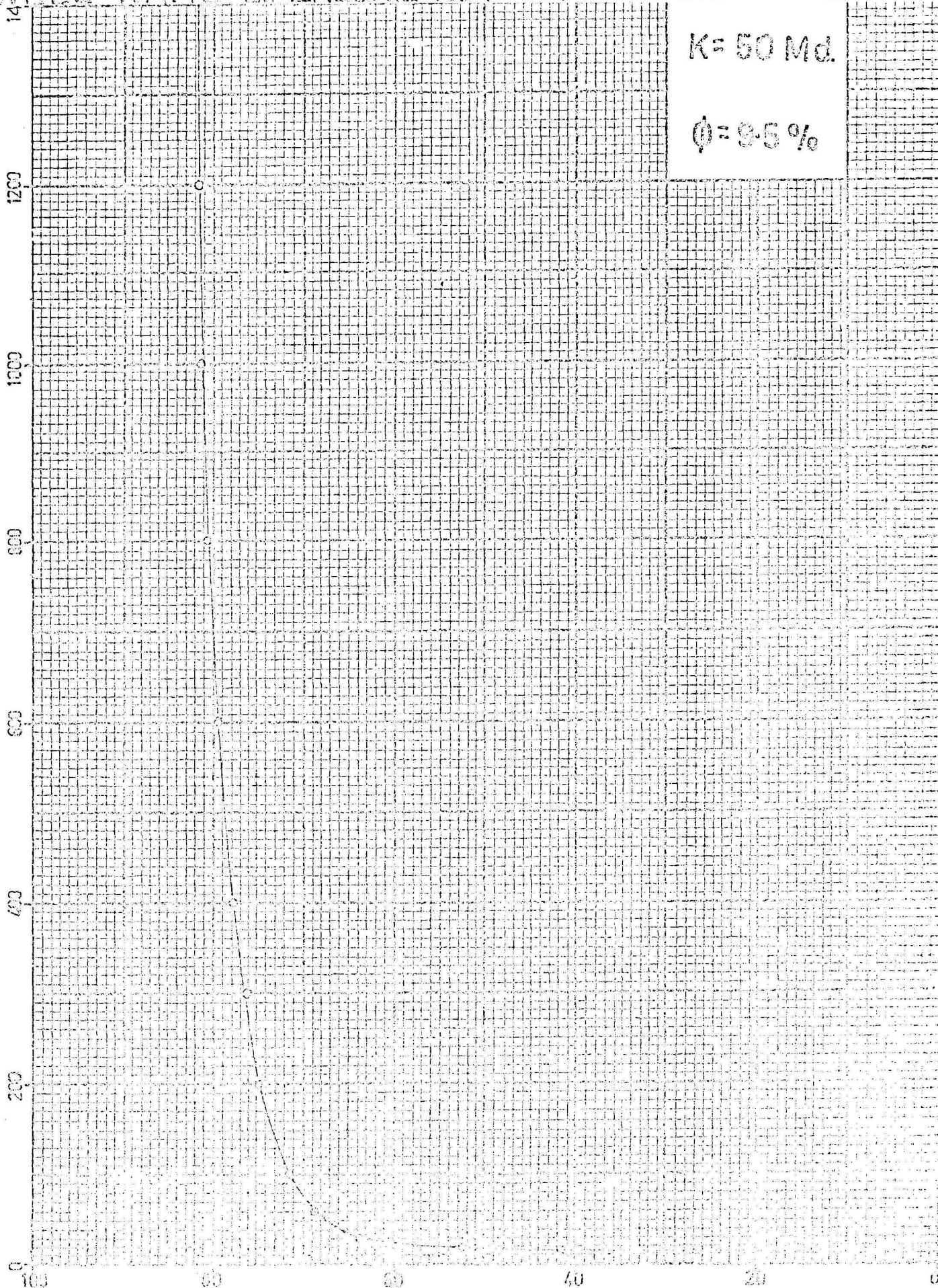
MERCURY CAPILLARY PRESSURE

WELL NAME-EMEREE No.1 SAMPLE DEPTH-4273

$K=50 \text{ Md.}$

$\phi=9.5\%$

MERCURY CAPILLARY PRESSURE (PSIA)



MERCURY SATURATION-DECREASING FROM LEFT

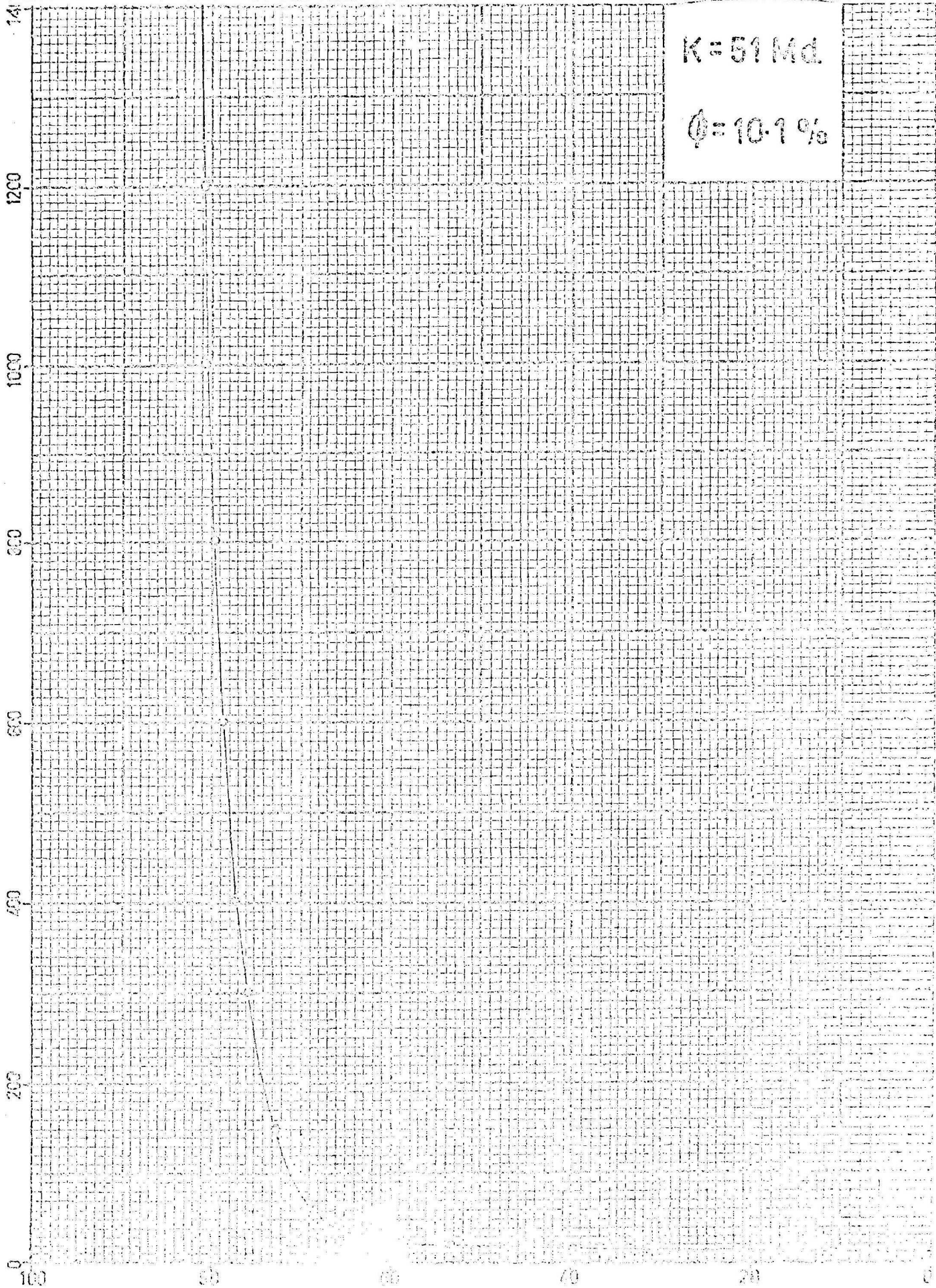
MERCURY CAPILLARY PRESSURE

WELL NAME-EMERENIE No.1 SAMPLE DEPTH-4277

K=51 Md.

 $\phi = 10.1\%$

MERCURY CAPILLARY PRESSURE (PSIA)



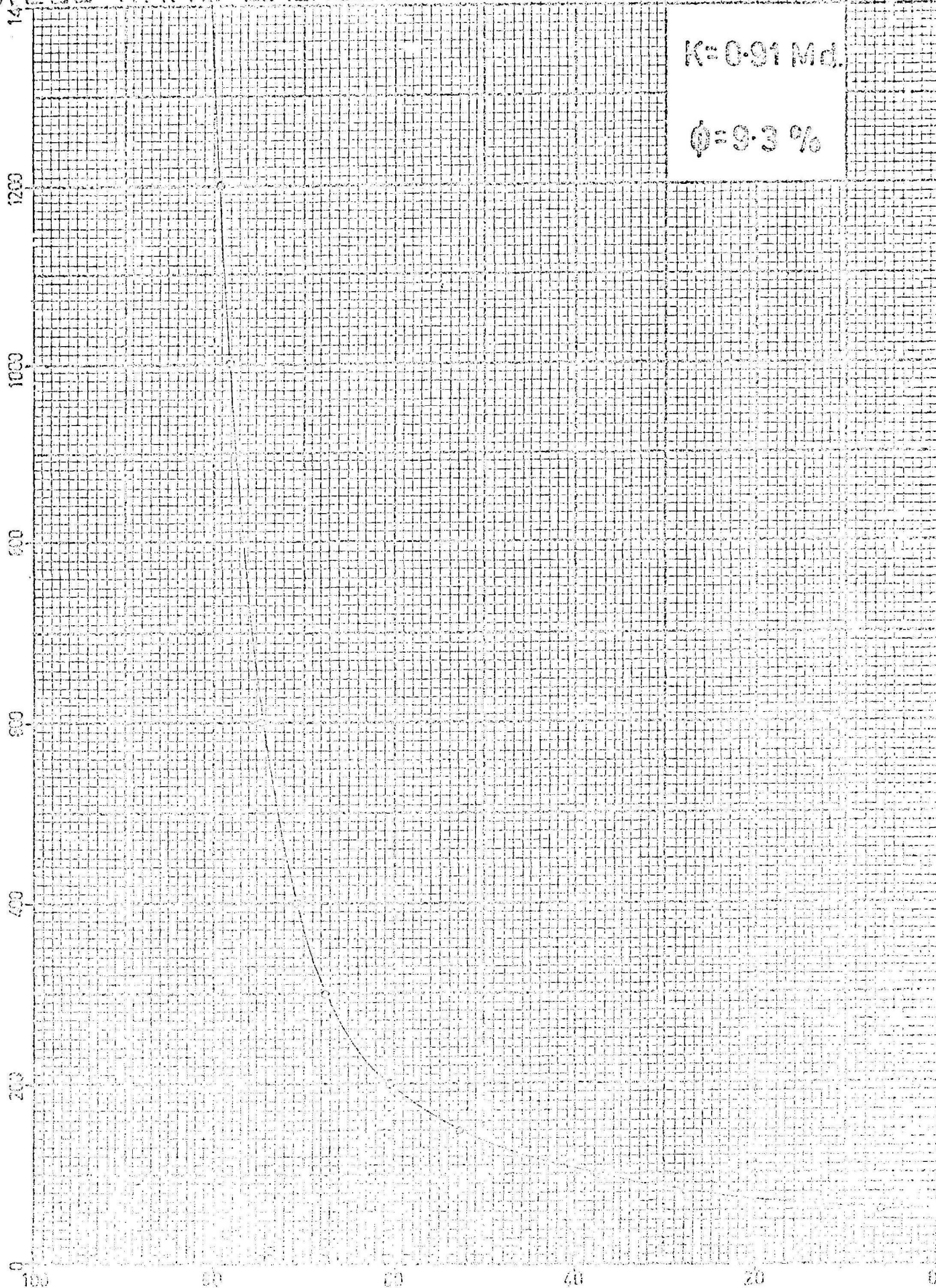
POROSITY (PH) - PERCENT

MERCURY CAPILLARY PRESSURE

WELL NAME-EMERENIE No1 SAMPLE DEPTH-4281

 $K=0.91 \text{ Md}$ $\phi=9.3 \%$

MERCURY CAPILLARY PRESSURE (PSIA)

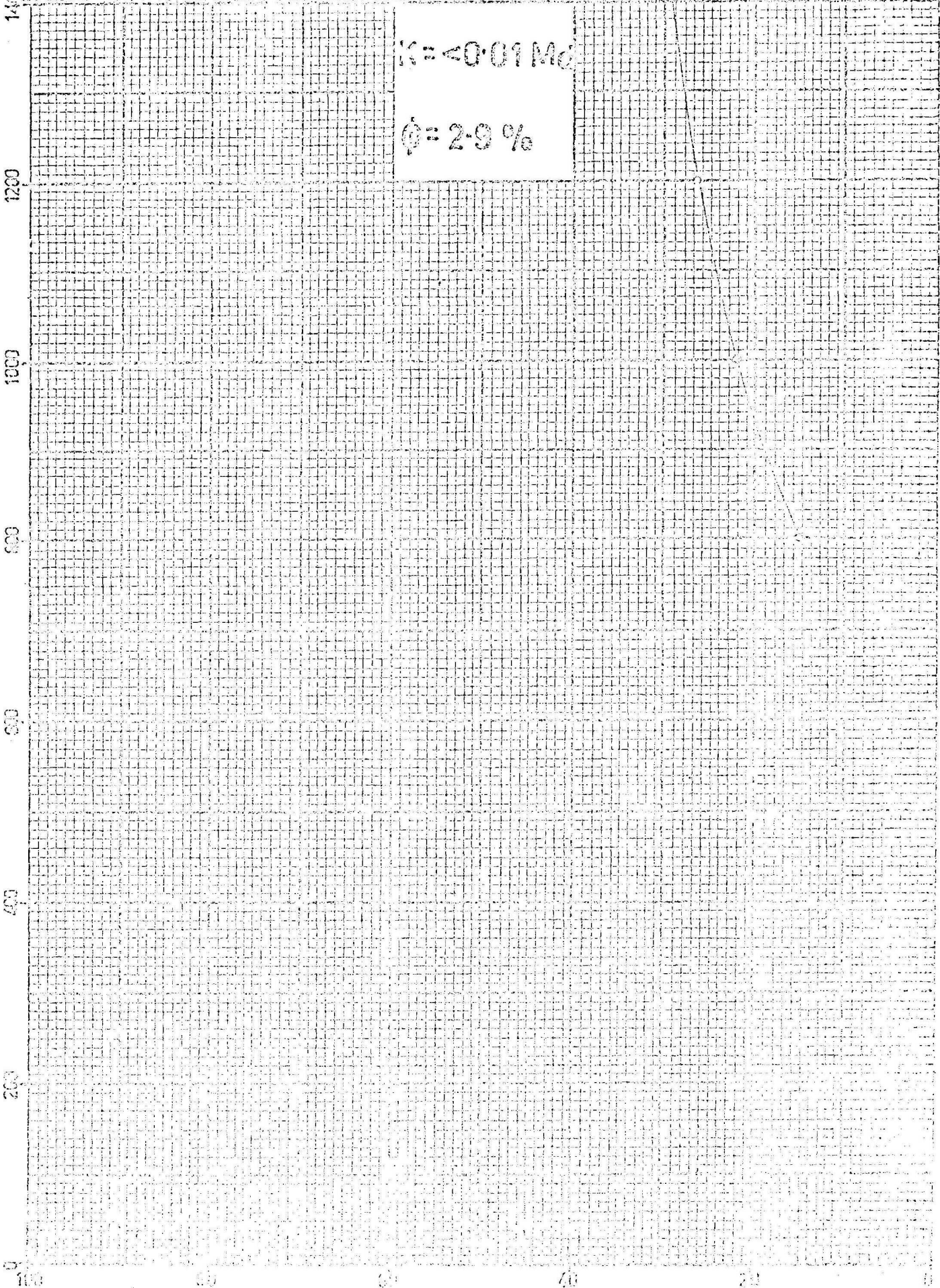


SATURATION CAPILLARY PRESSURE (PSIA)

MERCURY CAPILLARY PRESSURE

WELL NAME-E MEREENE No.1 SAMPLE DEPTH-4288

MERCURY CAPILLARY PRESSURE (PSIA)

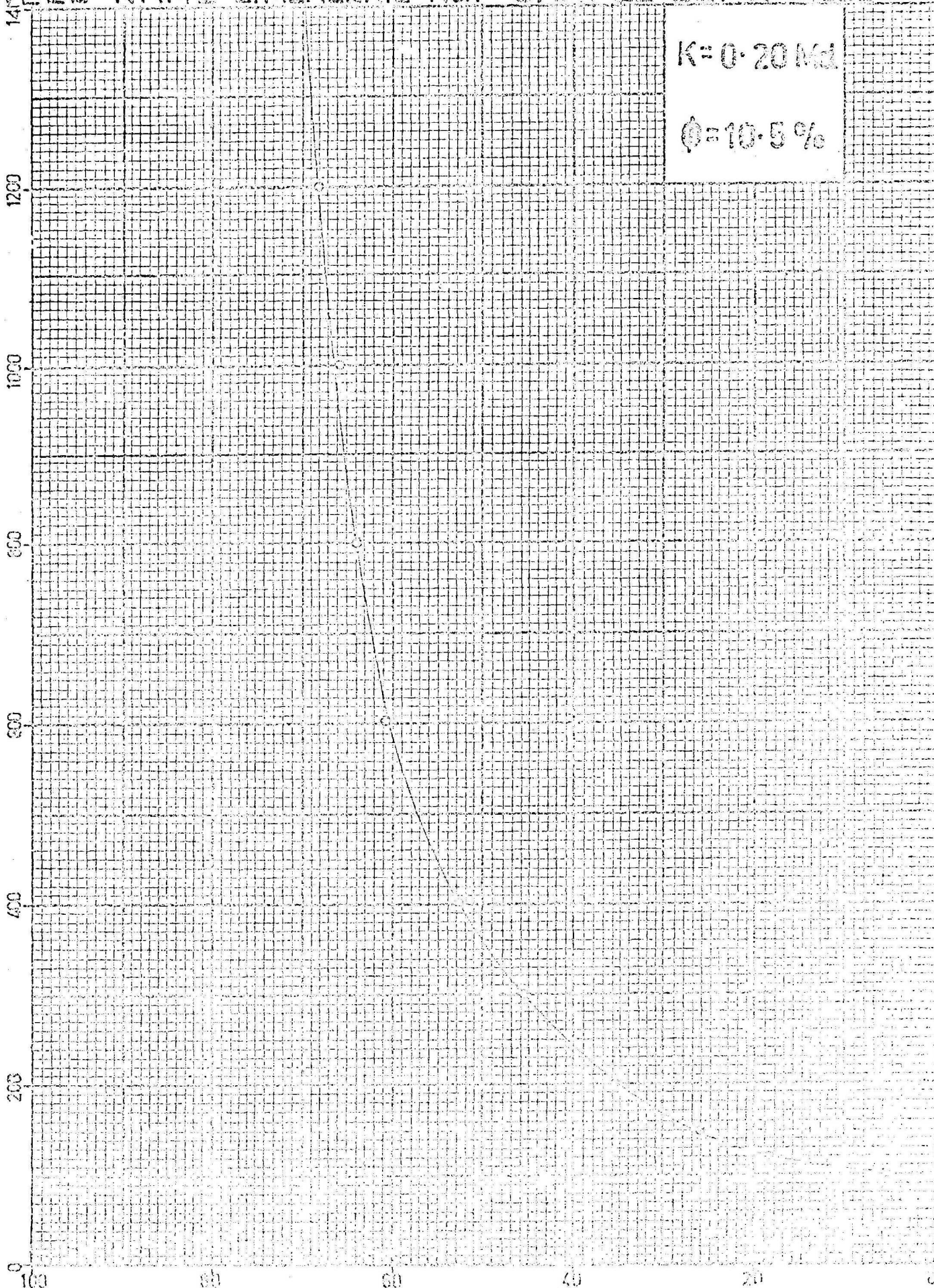


MERCURY SATURATION - PERCENT PORE VOL (ML)

MERCURY CAPILLARY PRESSURE

WELL NAME-E.MERENIE No.1 SAMPLE DEPTH-4292

MERCURY CAPILLARY PRESSURE (PSIA)

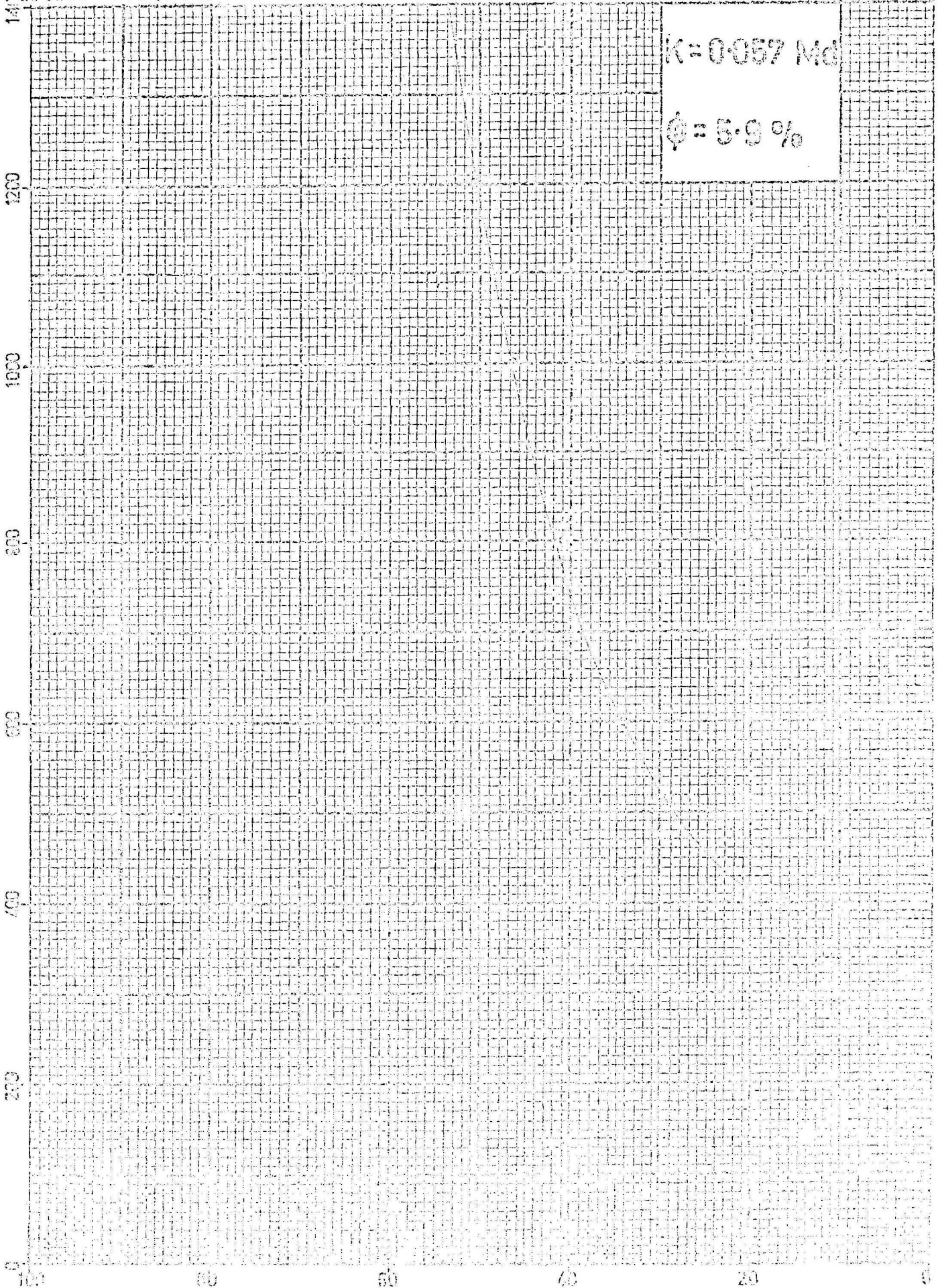
 $K=0.20 \text{ Md}$ $\phi=10.5\%$ 

MERCURY CAPILLARY PRESSURE

WELL NAME-EMERENE No.1 SAMPLE DEPTH-4297

 $K=0.057 \text{ Md}$ $\phi=5.9\%$

MERCURY CAPILLARY PRESSURE (PSIA)

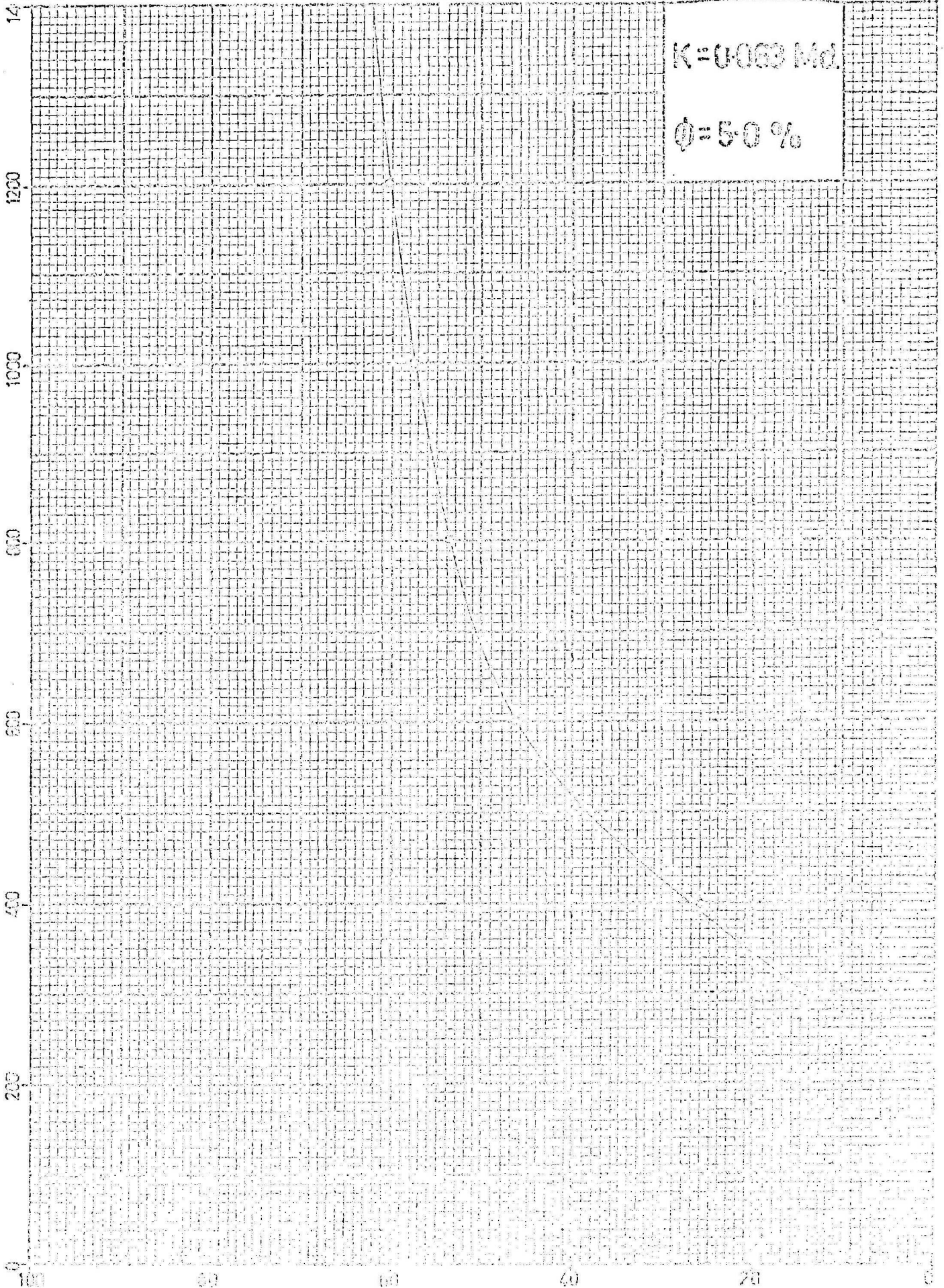


MERCURY CAPILLARY PRESSURE

WELL NAME-EMERENIE No1 SAMPLE DEPTH-4302

 $K=0.083 \text{ Md}$ $\phi=5.0 \%$

MERCURY CAPILLARY PRESSURE (PSIA)

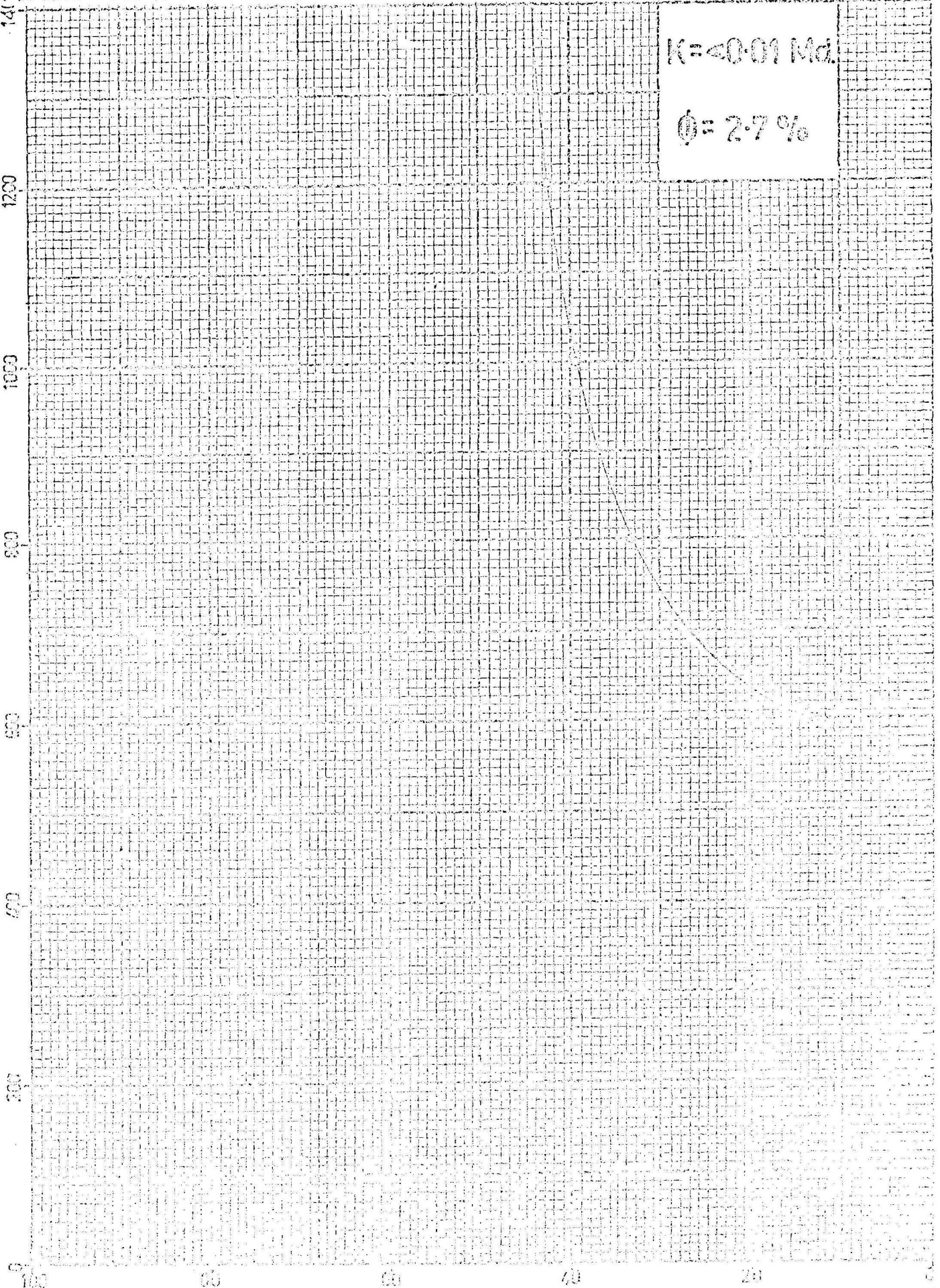


MERCURY CAPILLARY PRESSURE

WELL NAME EMEREEENIE No.1 SAMPLE DEPTH 4490

 $K = 0.01 \text{ Md.}$ $\phi = 2.7\%$

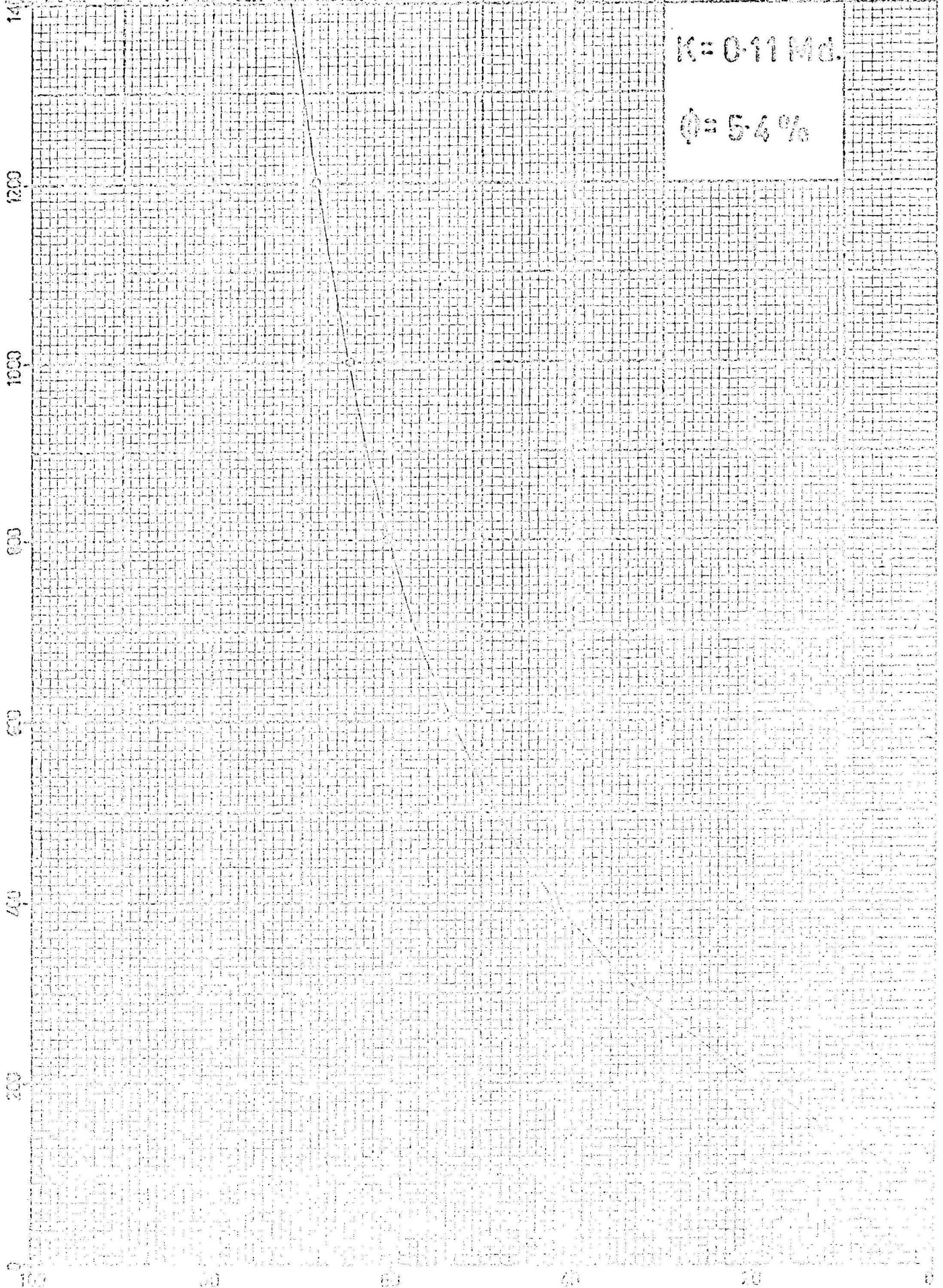
MERCURY CAPILLARY PRESSURE (PSIA)



MERCURY CAPILLARY PRESSURE

WELL NAME-EMEREE No.1 SAMPLE DEPTH-4496

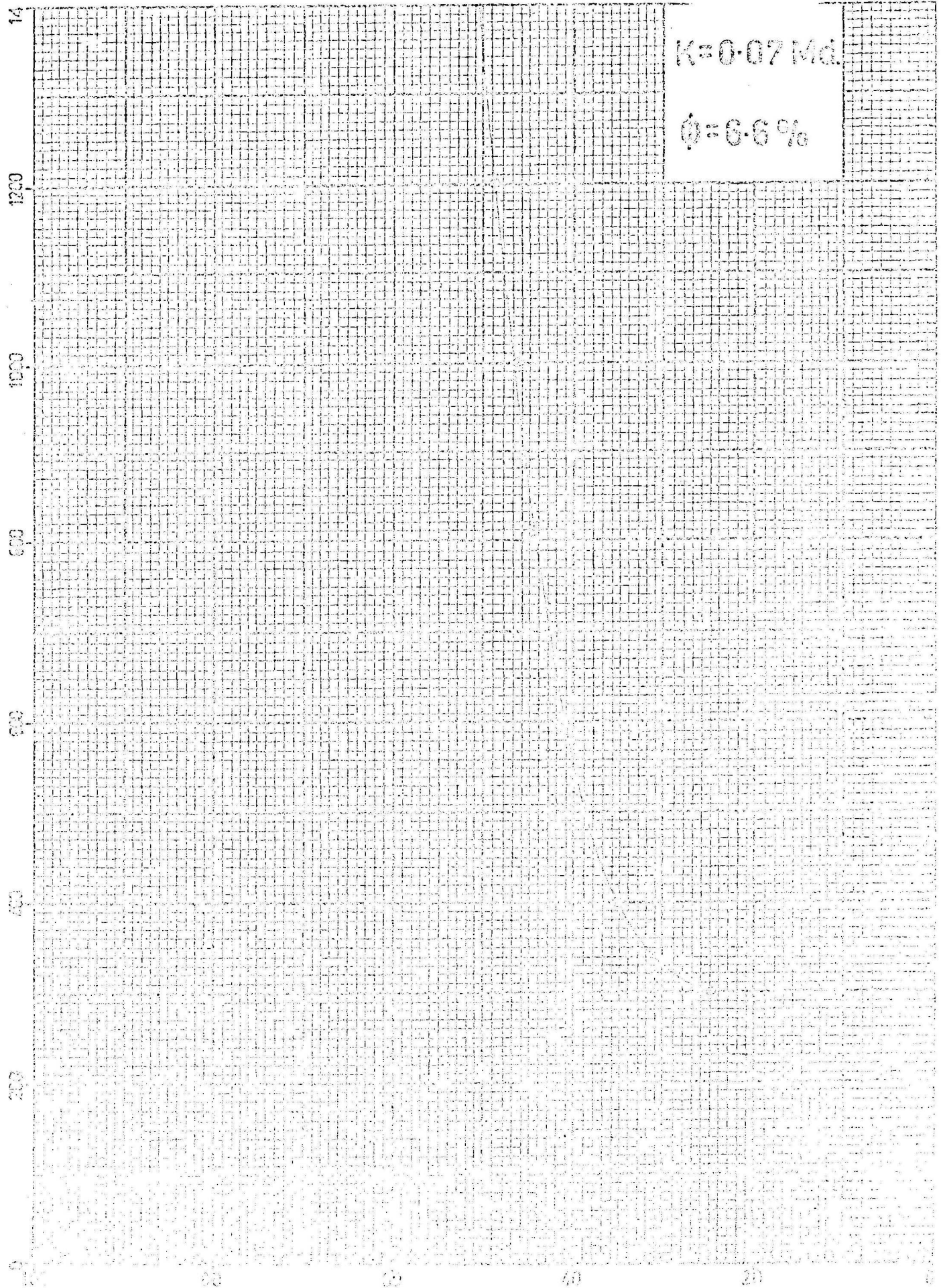
MERCURY CAPILLARY PRESSURE (PSIA)

 $K = 0.11 \text{ Md.}$ $\phi = 5.4\%$ 

MERCURY CAPILLARY PRESSURE

WELL NAME-E.MEREENE No1 SAMPLE DEPTH-4511

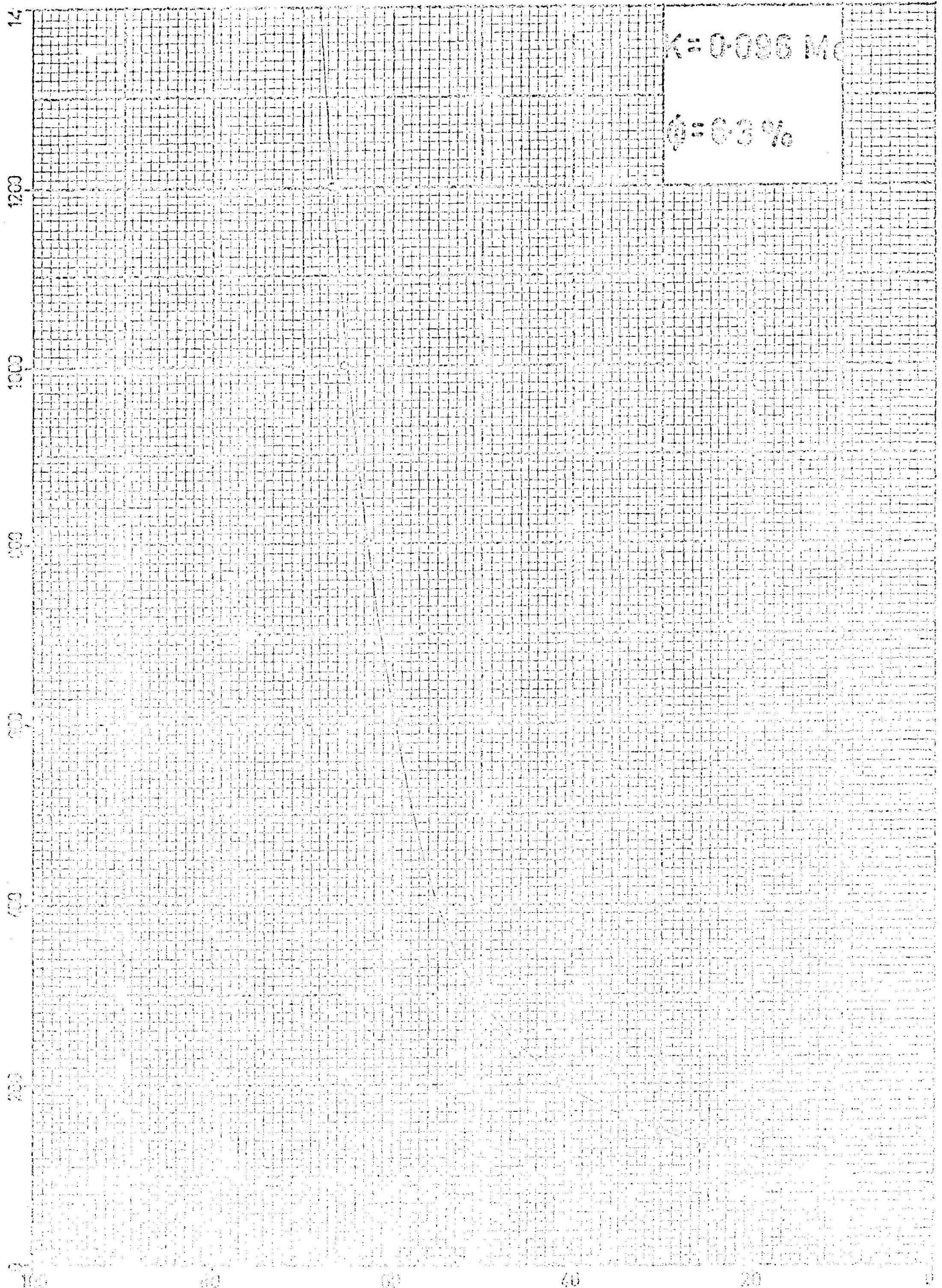
MERCURY CAPILLARY PRESSURE (PSIA)



MERCURY CAPILLARY PRESSURE

WELL NAME-EMERENIE No.1 SAMPLE DEPTH-4517

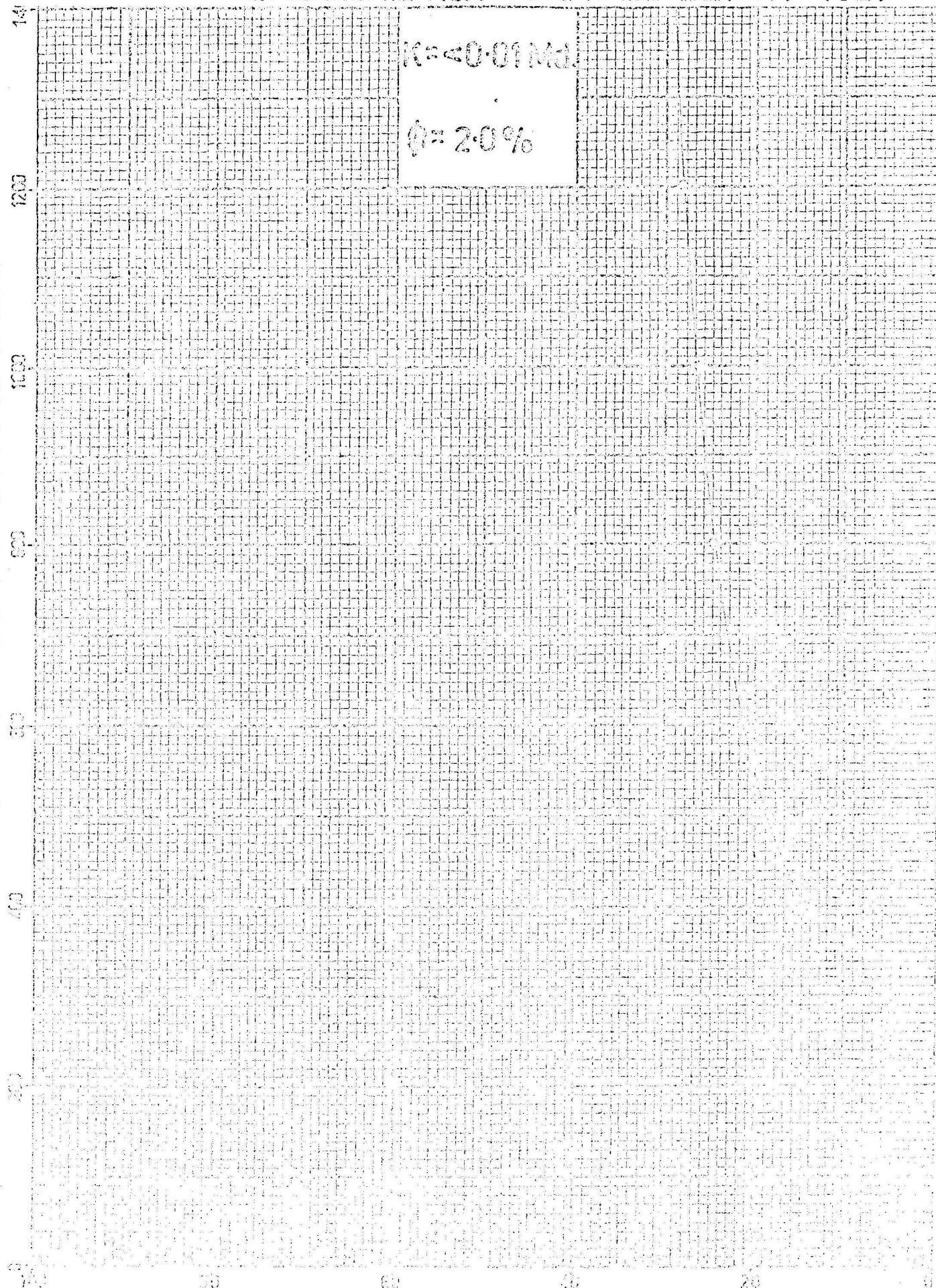
MERCURY CAPILLARY PRESSURE (PSIA)



MERCURY CAPILLARY PRESSURE

WELL NAME-E.MEREENE No.1 SAMPLE DEPTH-4521

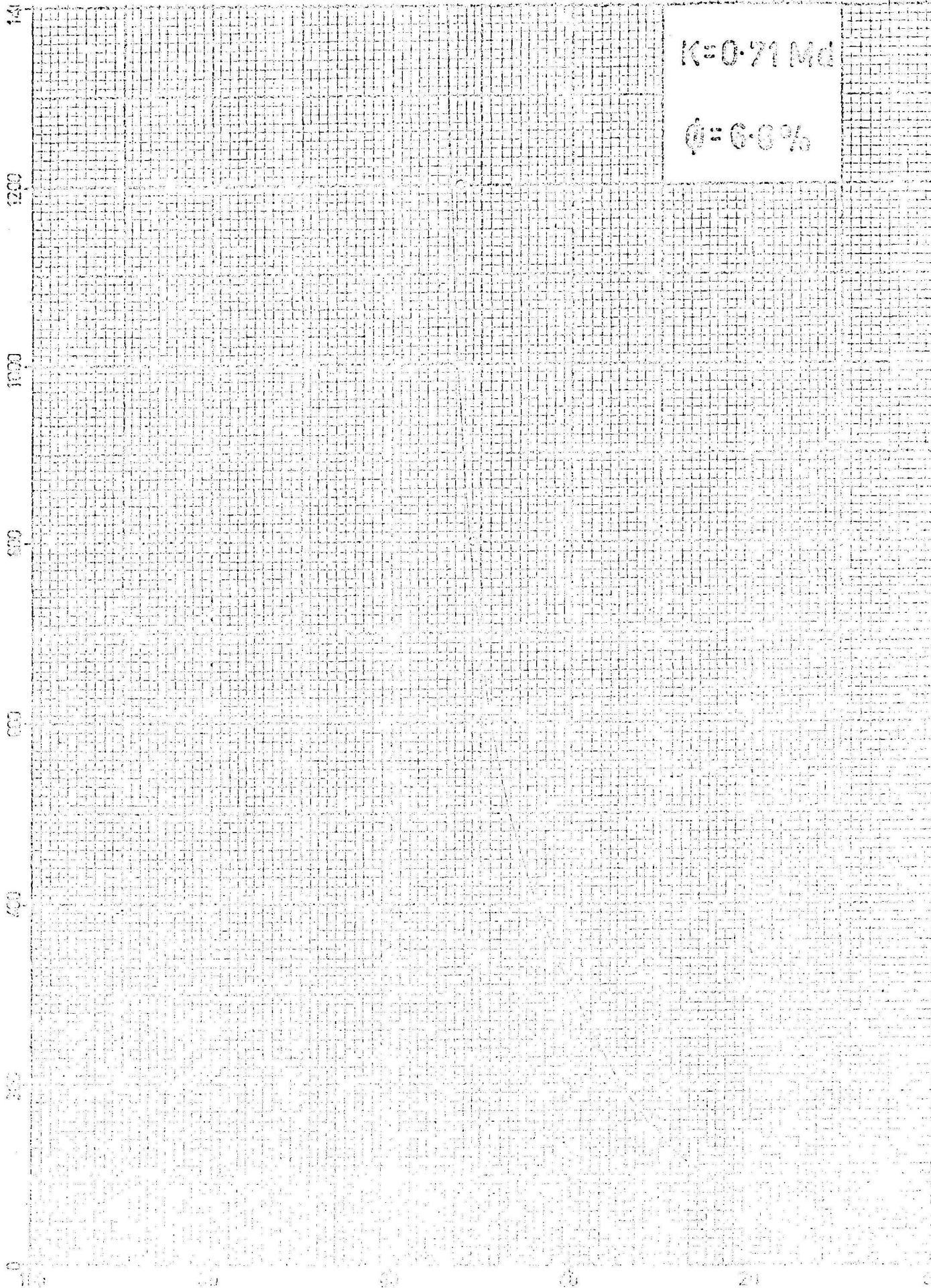
MERCURY CAPILLARY PRESSURE (PSIA)



MERCURY CAPILLARY PRESSURE

WELL NAME-E.MEREENE No.1 SAMPLE DEPTH-4529

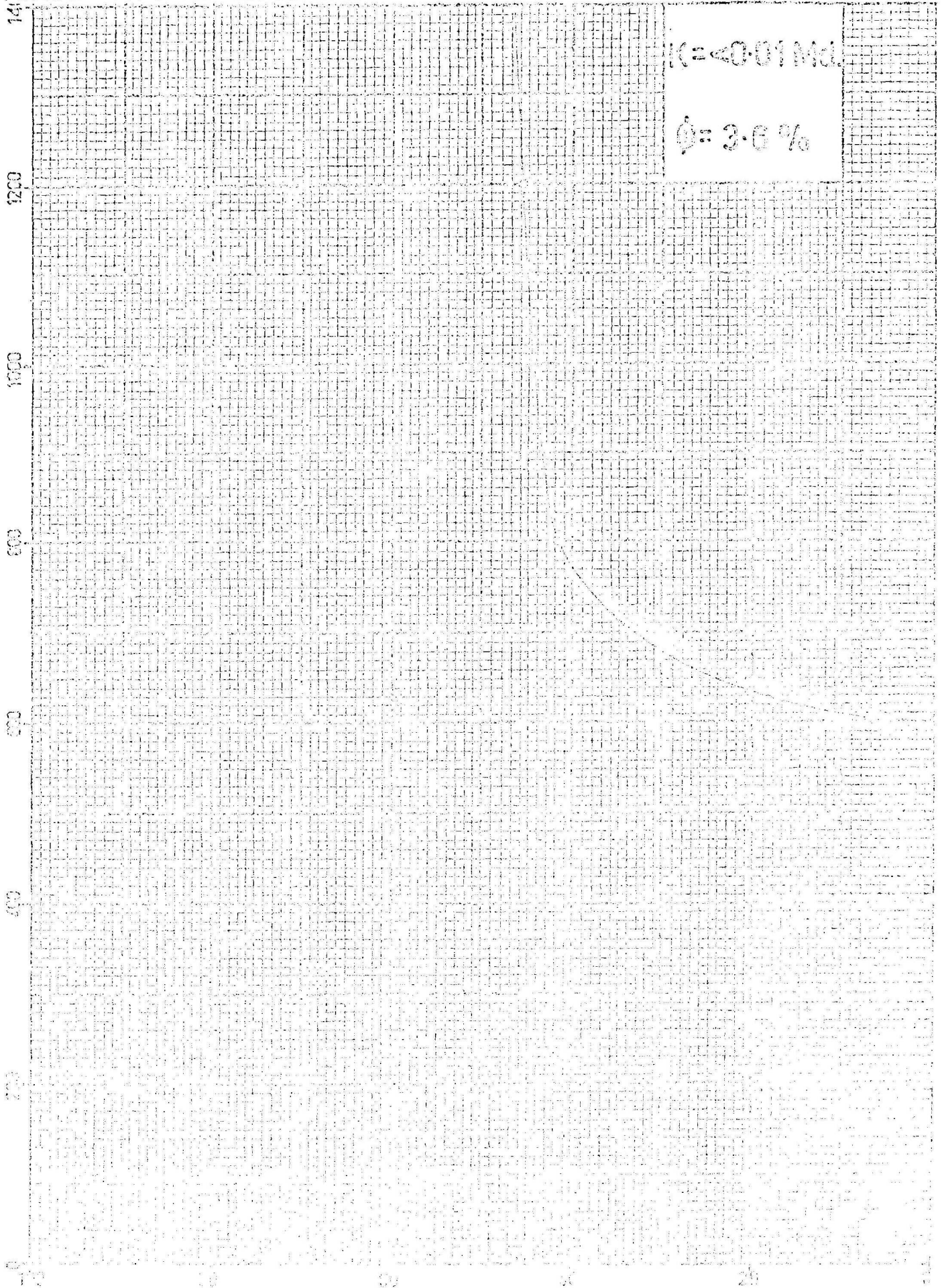
MERCURY CAPILLARY PRESSURE (PSIA)

 $K=0.71 \text{ Md}$ $\phi=66\%$ 

MERCURY CAPILLARY PRESSURE

WELL NAME-EMERENE No1 SAMPLE DEPTH-4668

MERCURY CAPILLARY PRESSURE (PSIA)

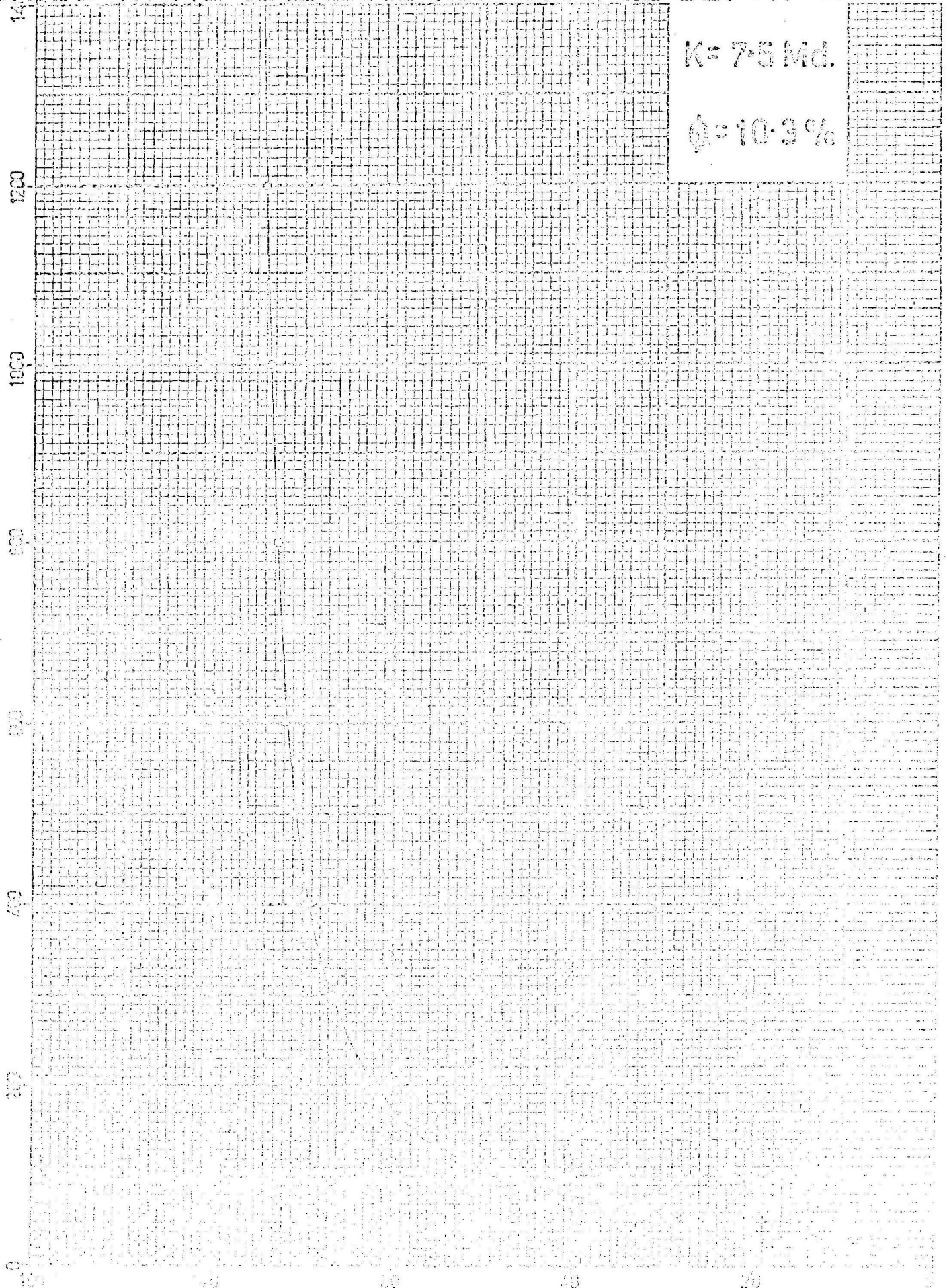


MERCURY CAPILLARY PRESSURE

WELL NAME-EMEREE NE No1 SAMPLE DEPTH-4690

 $K = 7.5 \text{ Md.}$ $\phi = 10.3\%$

MERCURY CAPILLARY PRESSURE (PSIA)



MERCURY CAPILLARY PRESSURE

WELL NAME-EMERGENE No.1 SAMPLE DEPTH-4694

MERCURY CAPILLARY PRESSURE (PSIA)

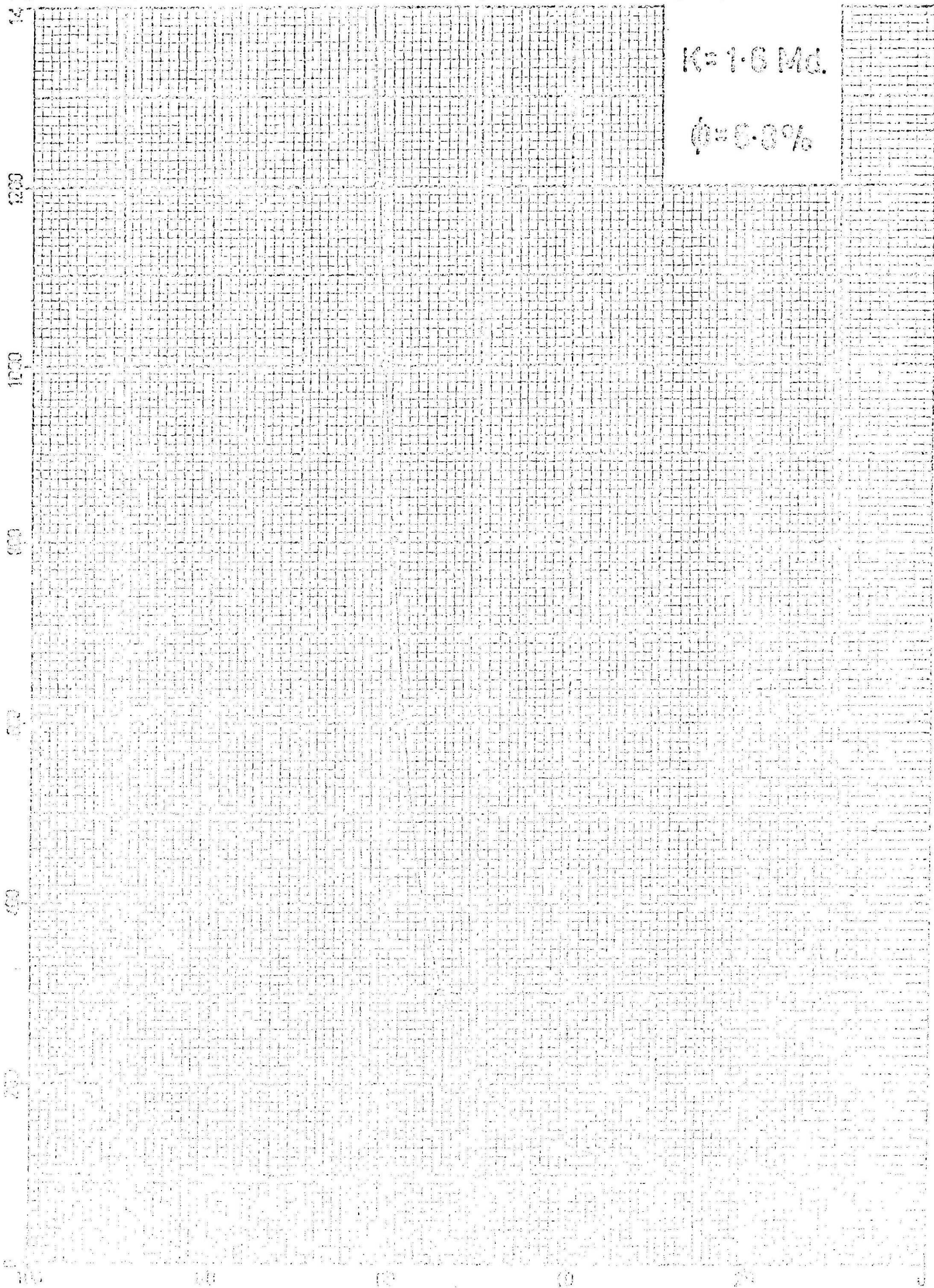
 $K=1.6 \text{ Md.}$ $\phi=6.3\%$ 

FIGURE 28

MERCURY CAPILLARY PRESSURE

WELL NAME -- EAST MEREEHIE No 4

SAMPLE DEPTH 4608

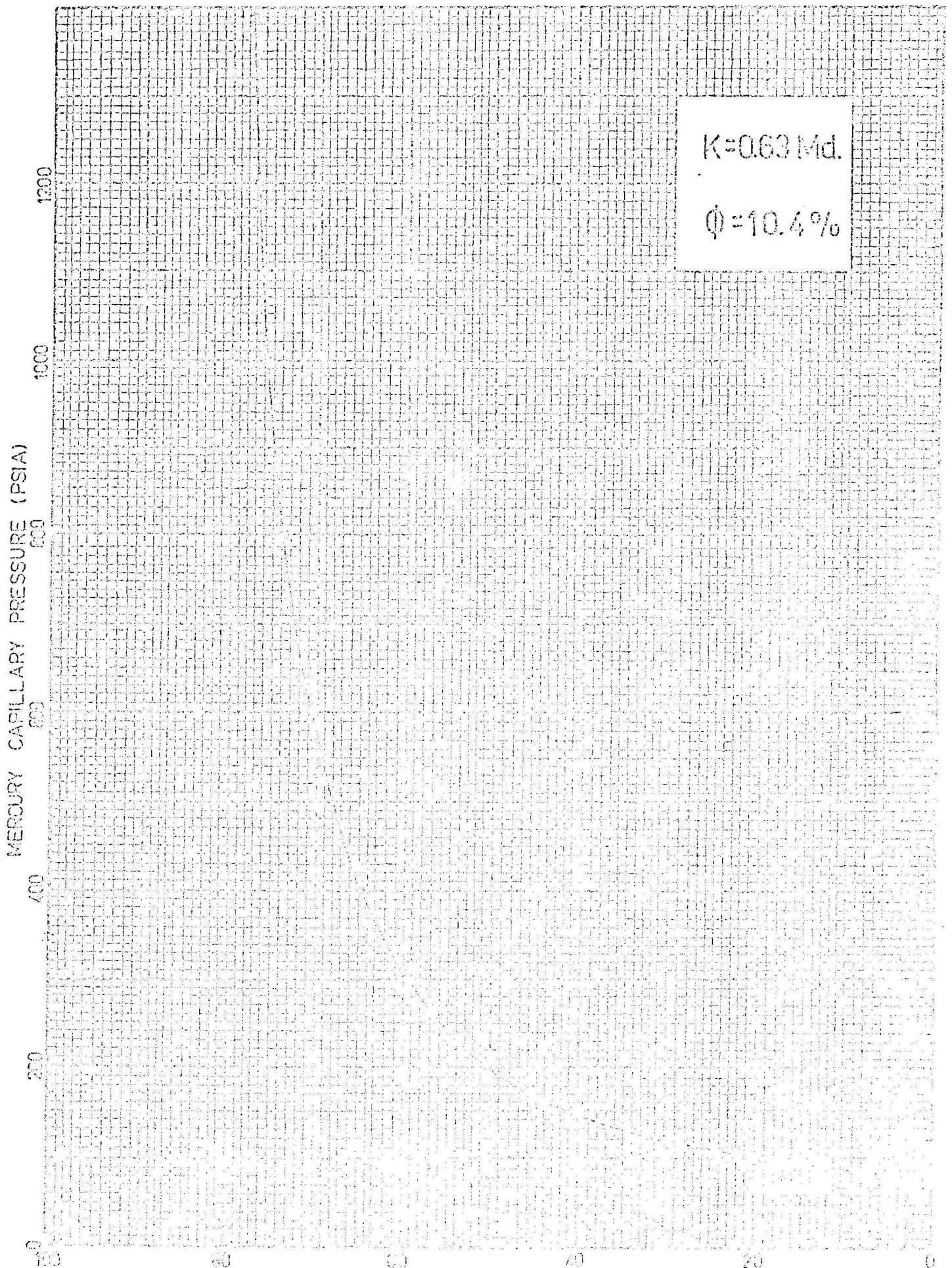


FIGURE 29

MERCURY CAPILLARY PRESSURE

WELL NAME — EAST MEREENIE No 4

SAMPLE DEPTH 4613

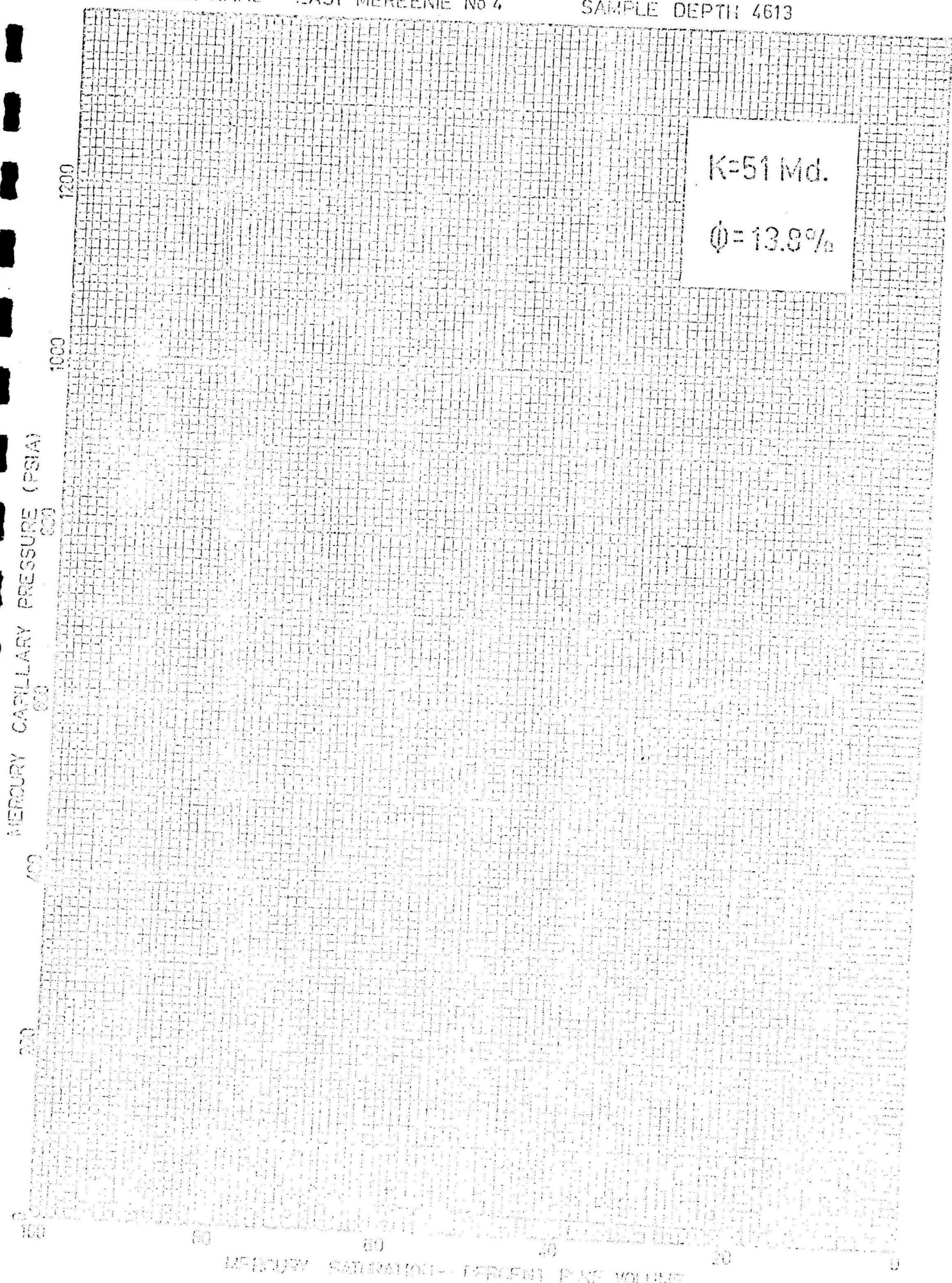


FIGURE 30

MERCURY CAPILLARY PRESSURE

WELL NAME -- EAST MEREENIE No 4

SAMPLE DEPTH-4618

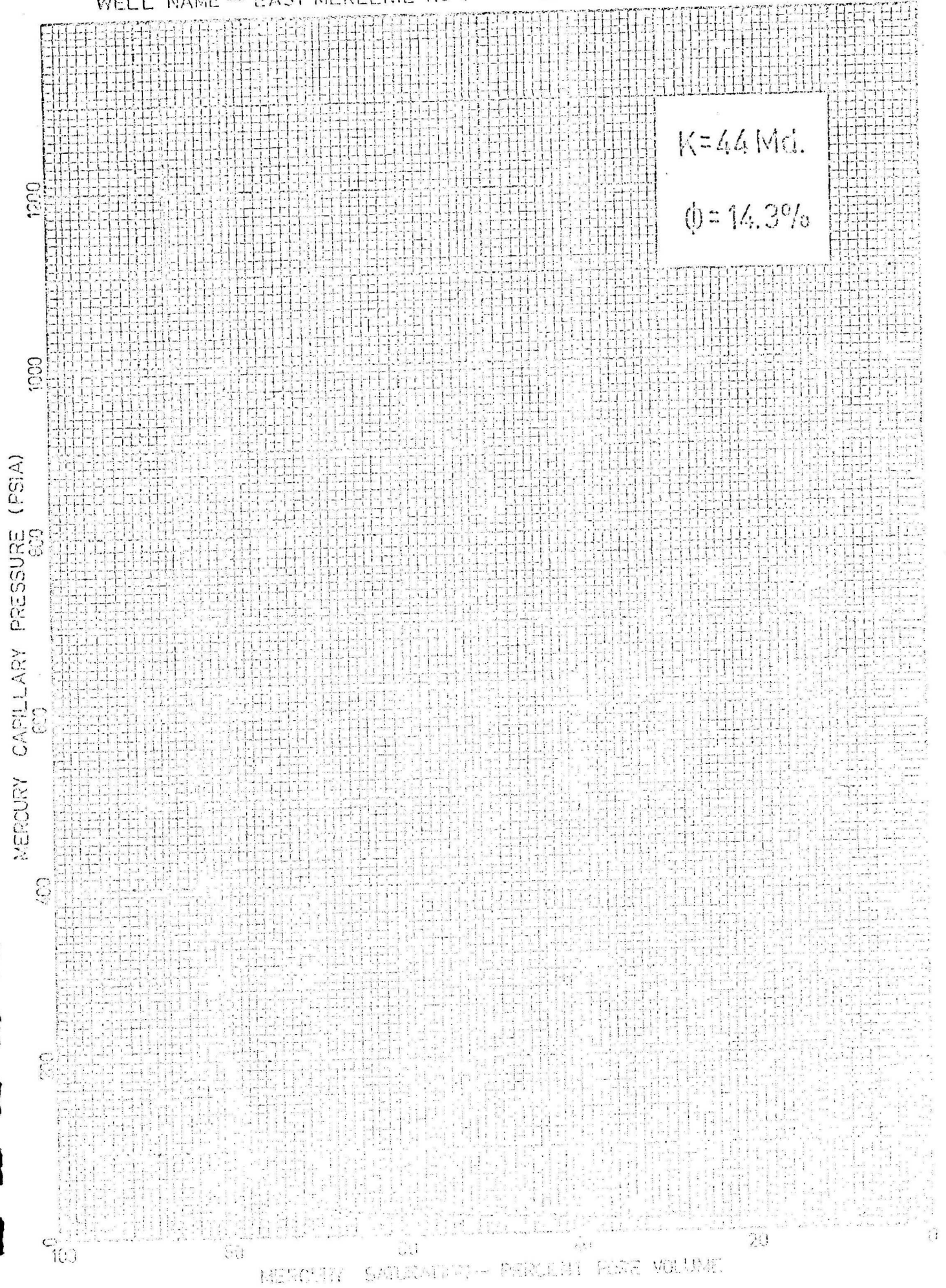


FIGURE 31

MERCURY CAPILLARY PRESSURE

WELL NAME -- EAST MEREENIE No 4

SAMPLE DEPTH- 4625

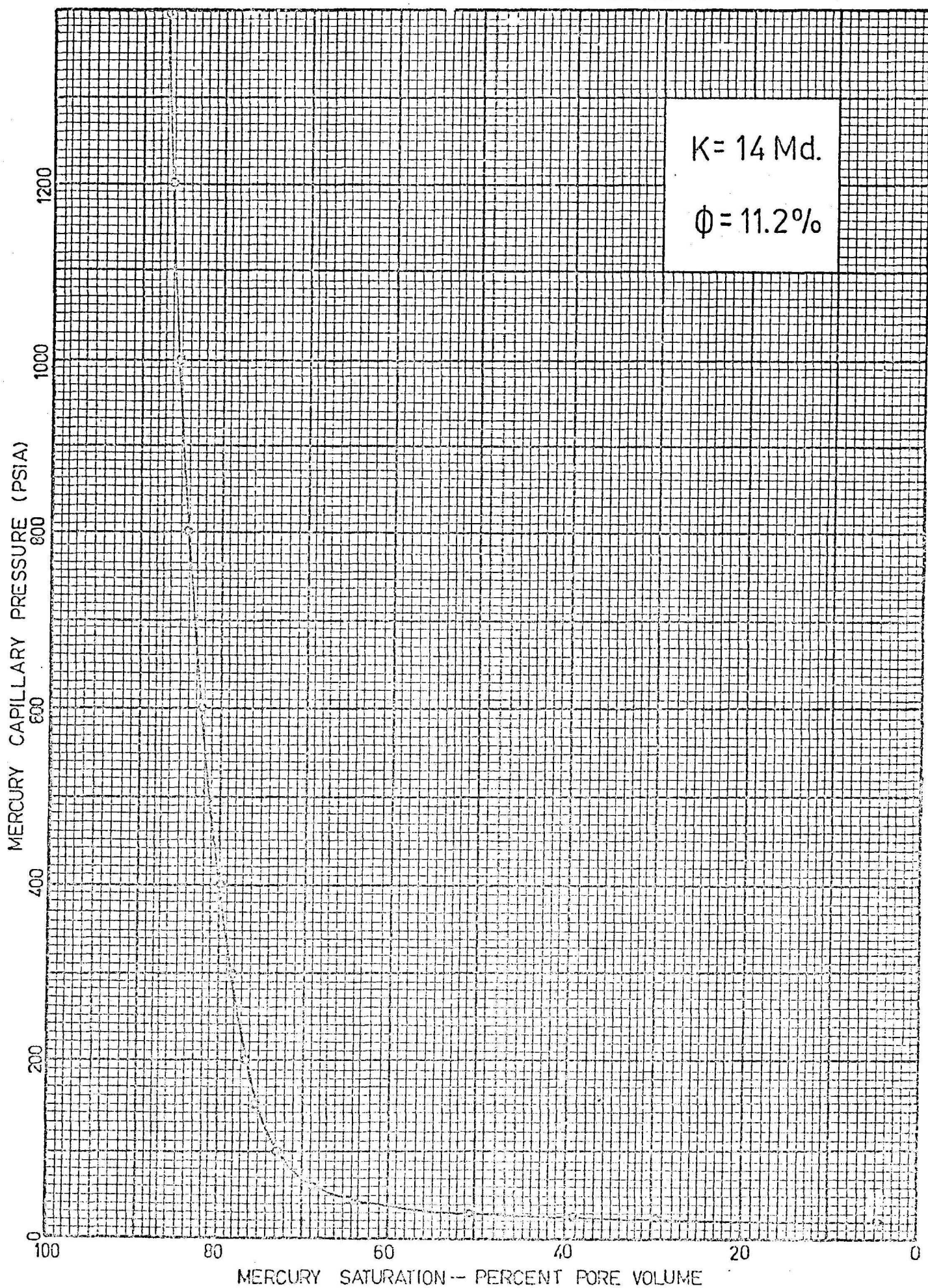


FIGURE 32

MERCURY CAPILLARY PRESSURE

WELL NAME — EAST MEREENIE No 4

SAMPLE DEPTH—4630

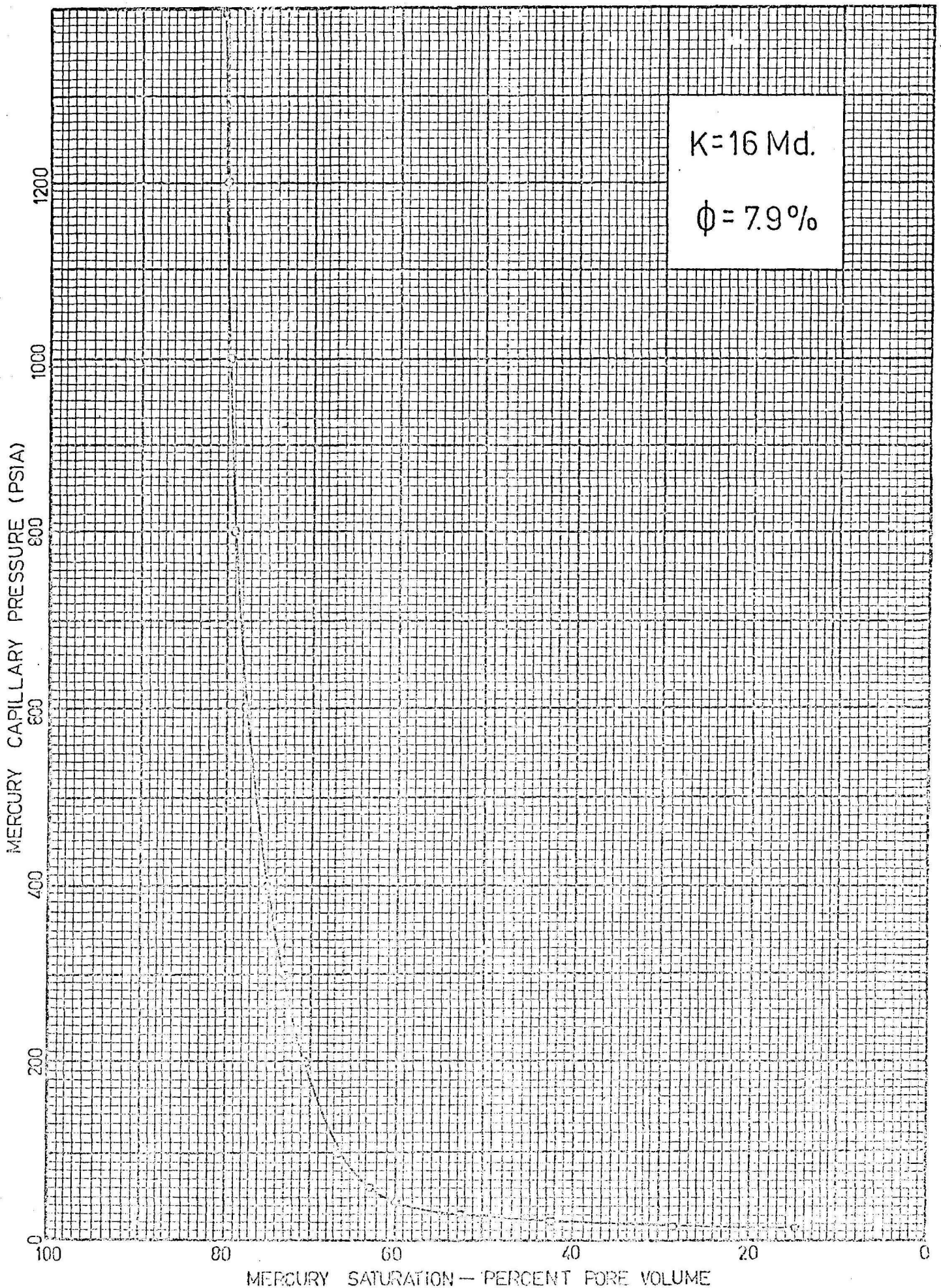


FIGURE 33

MERCURY CAPILLARY PRESSURE

WELL NAME -- EAST MEREENIE No 4

SAMPLE DEPTH-4635

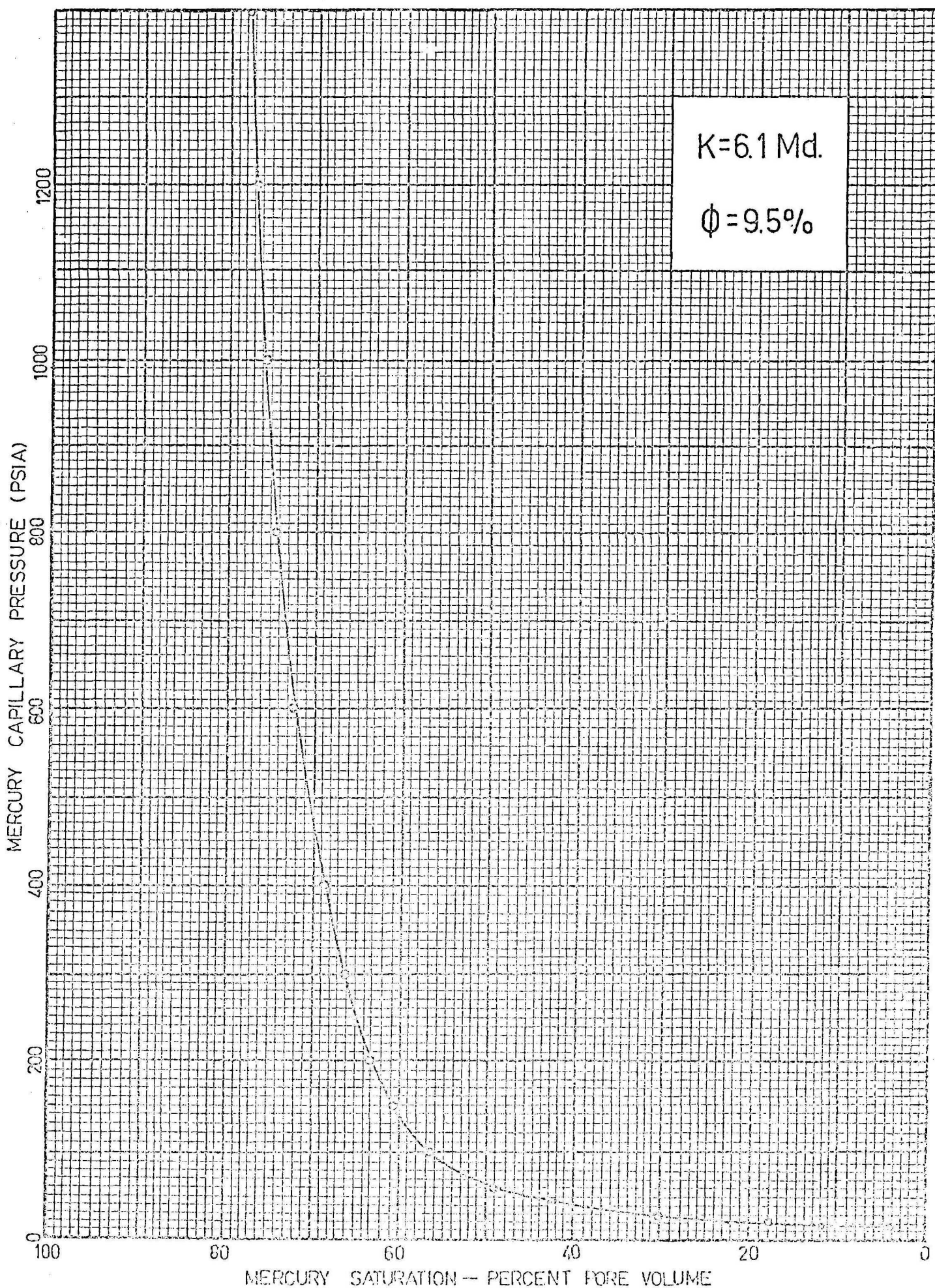


FIGURE 34

MERCURY CAPILLARY PRESSURE

WELL NAME — EAST MEREENIE No 4

SAMPLE DEPTH — 4702

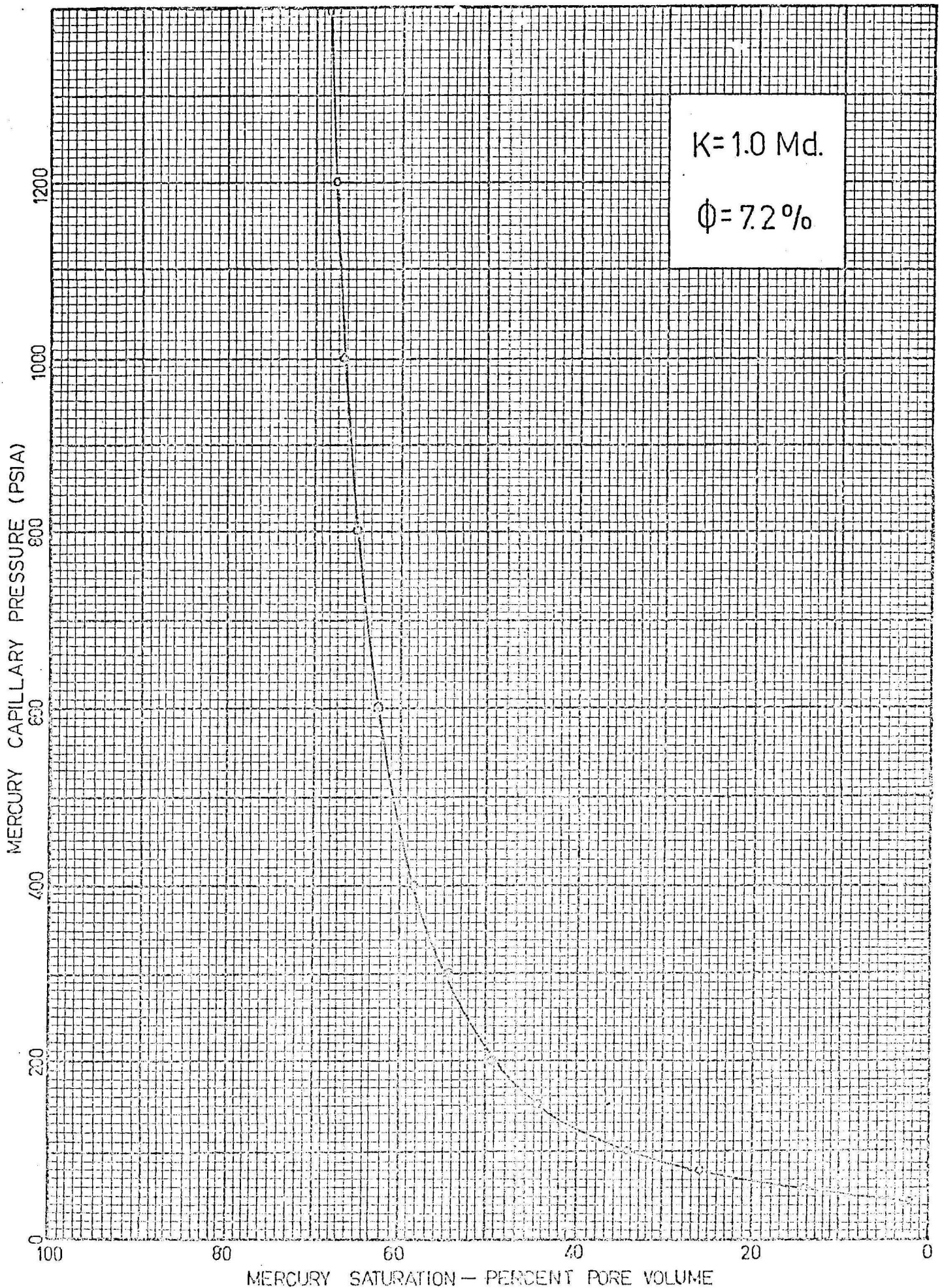


FIGURE 35

MERCURY CAPILLARY PRESSURE

WELL NAME — EAST MEREENIE No 4

SAMPLE DEPTH — 4710

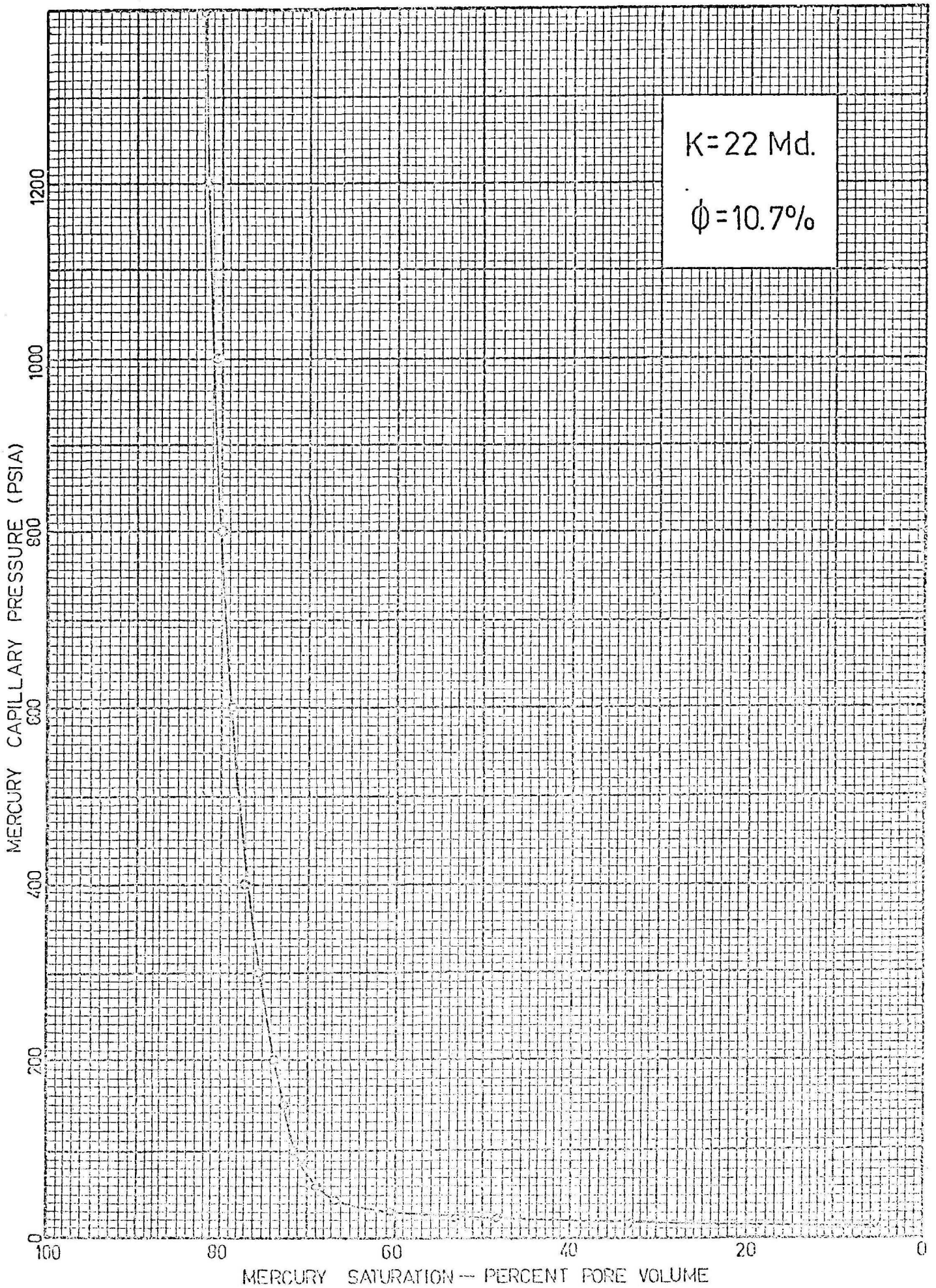


FIGURE 36

MERCURY CAPILLARY PRESSURE

WELL NAME — EAST MEREENIE No 4

SAMPLE DEPTH — 4712

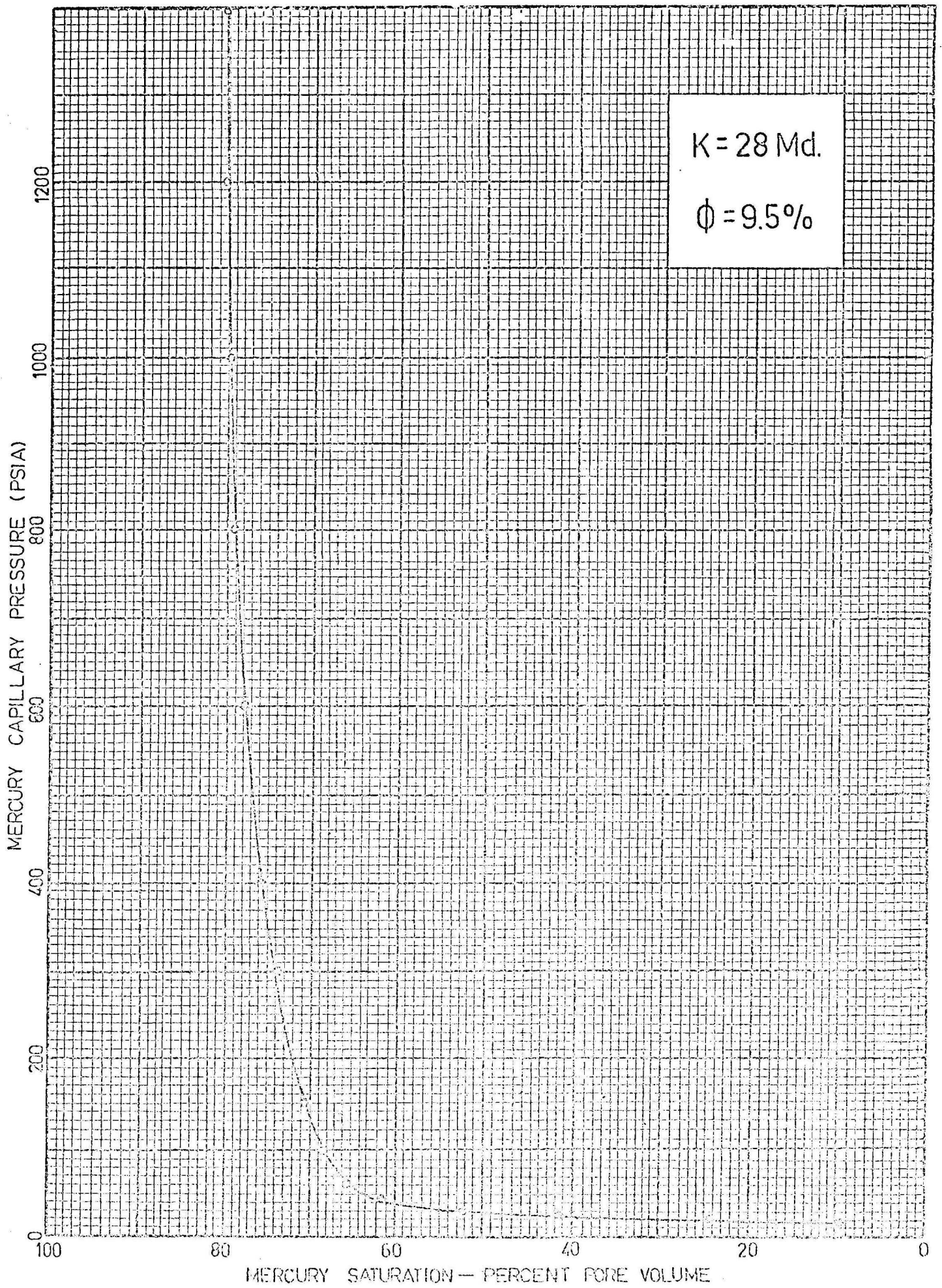


FIGURE 37

MERCURY CAPILLARY PRESSURE

WELL NAME — EAST MEREE NIE No 4

SAMPLE DEPTH — 4712

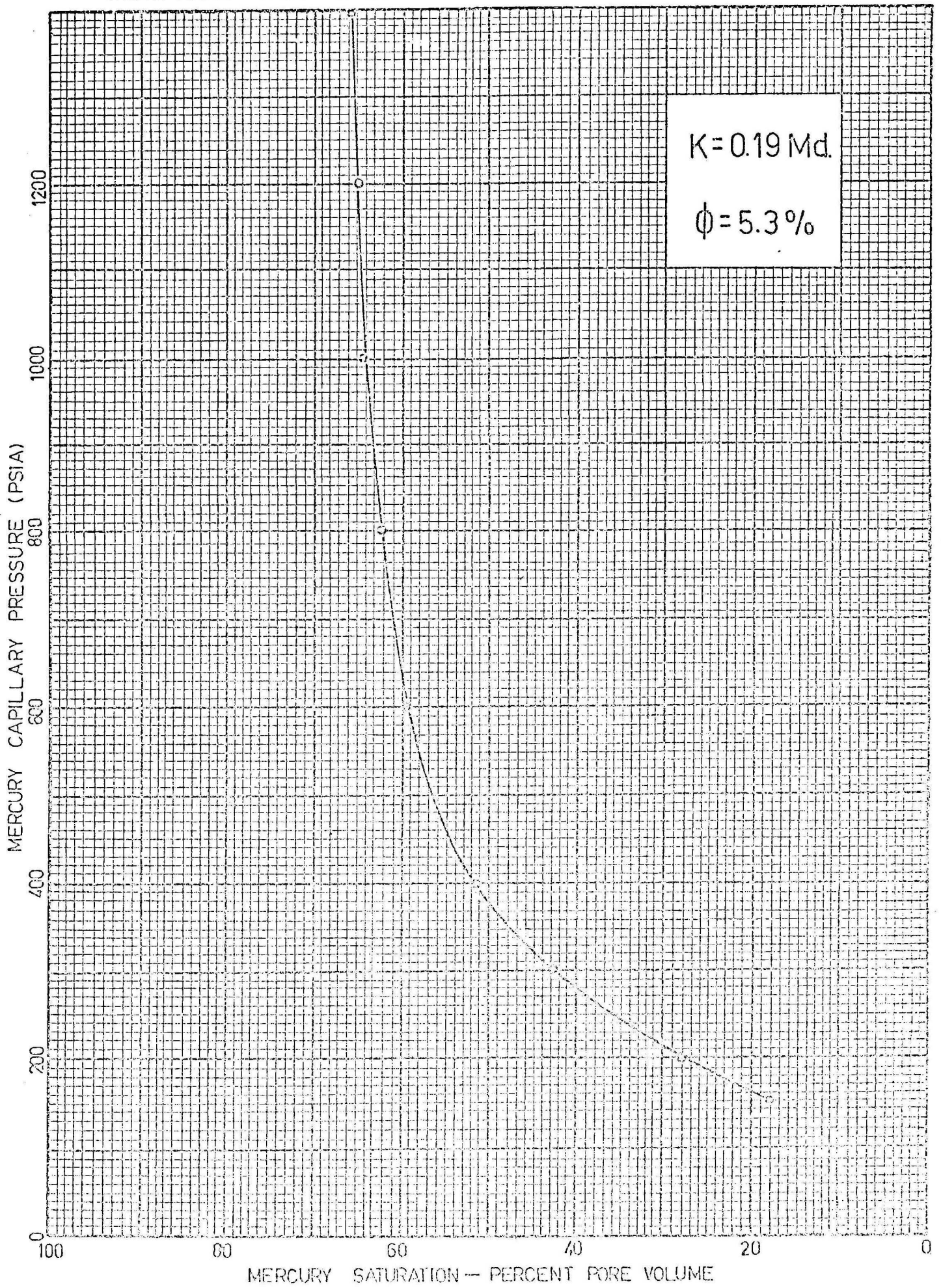


FIGURE 38

MERCURY CAPILLARY PRESSURE

WELL NAME — EAST MEREENIE No 4

SAMPLE DEPTH — 4731

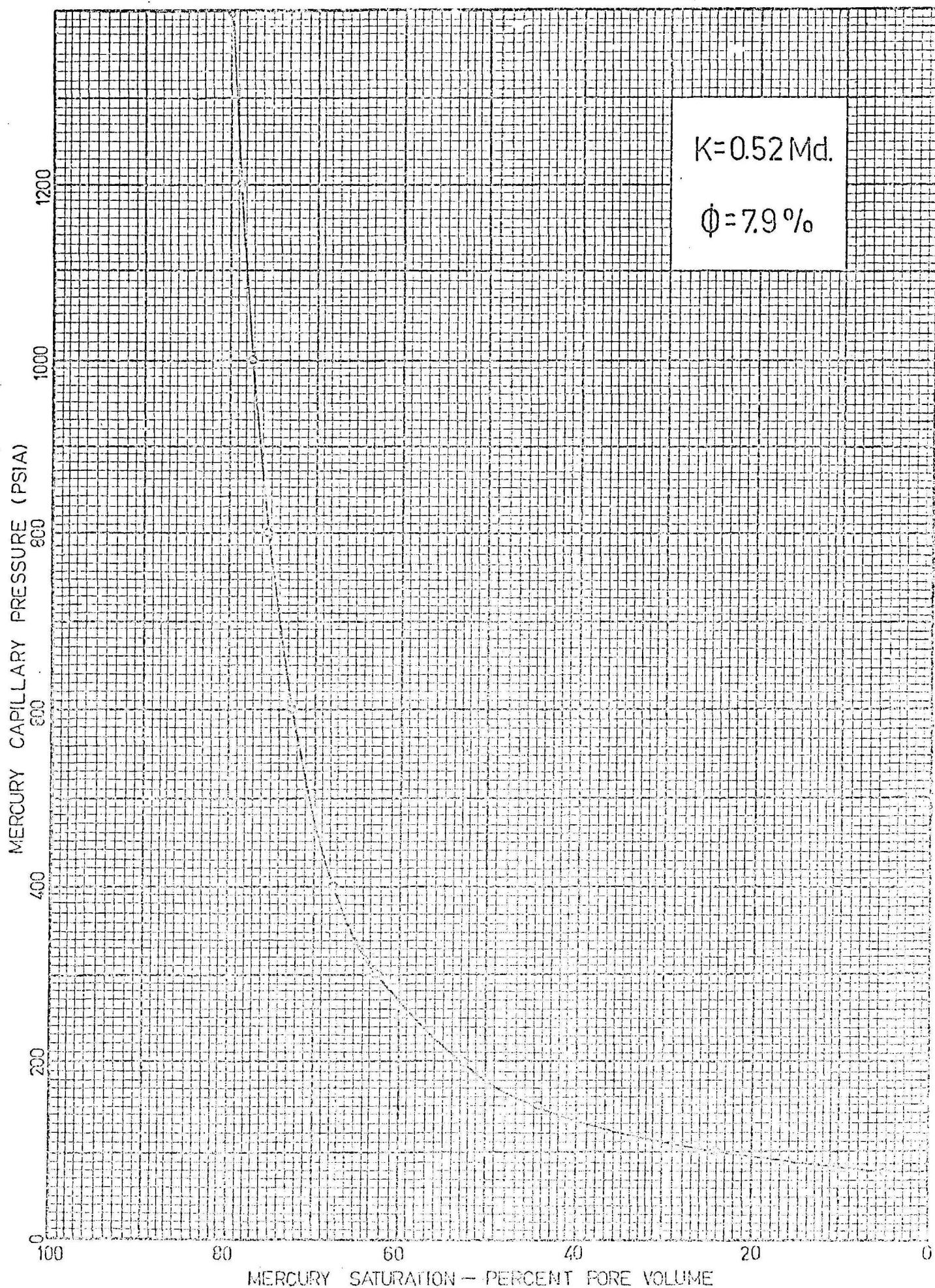


FIGURE 39

MERCURY CAPILLARY PRESSURE

WELL NAME — EAST MEREENIE No 4

SAMPLE DEPTH — 4742

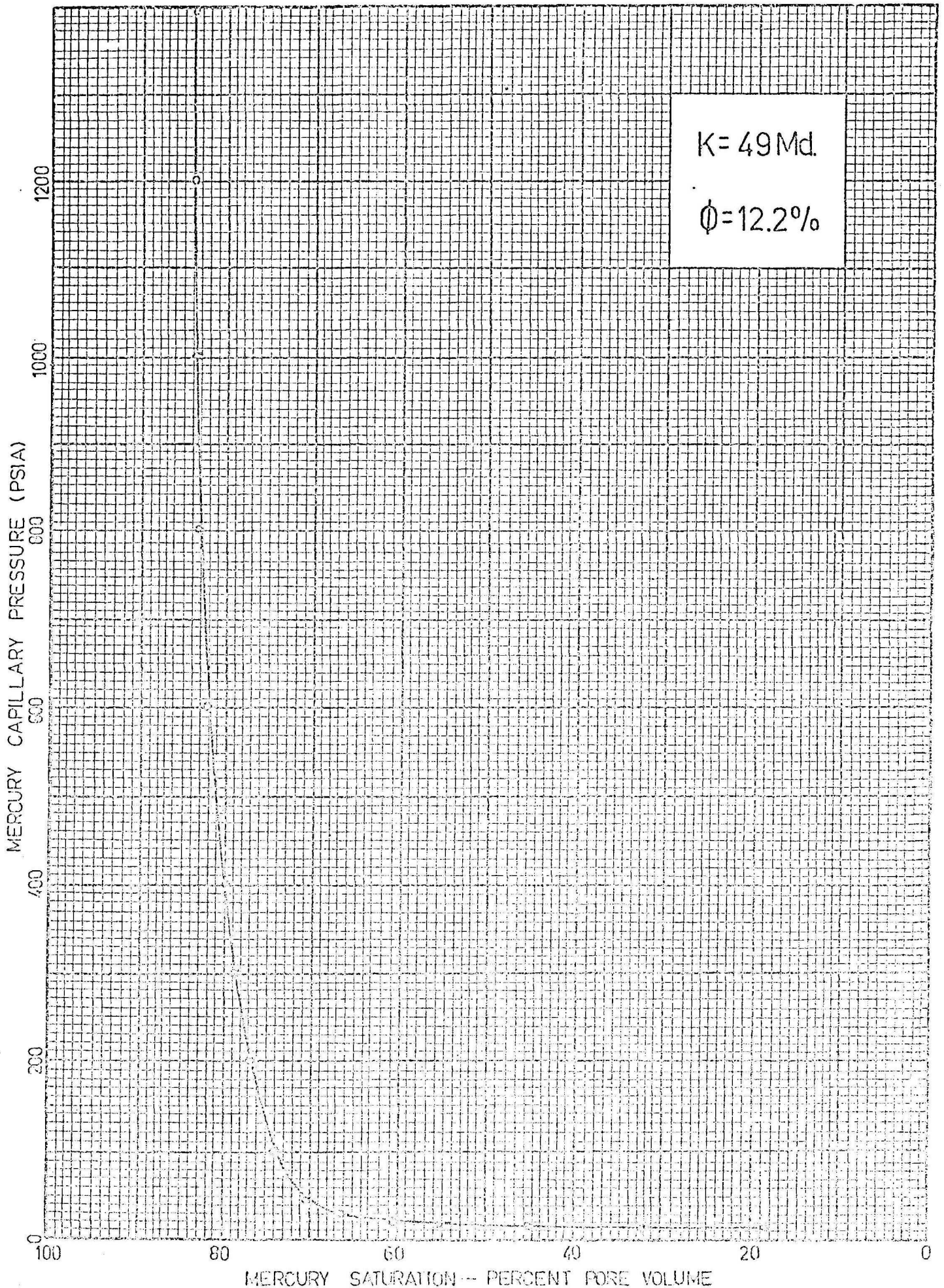


FIGURE 40

MERCURY CAPILLARY PRESSURE

WELL NAME — EAST MEREENIE No 4

SAMPLE DEPTH — 4747

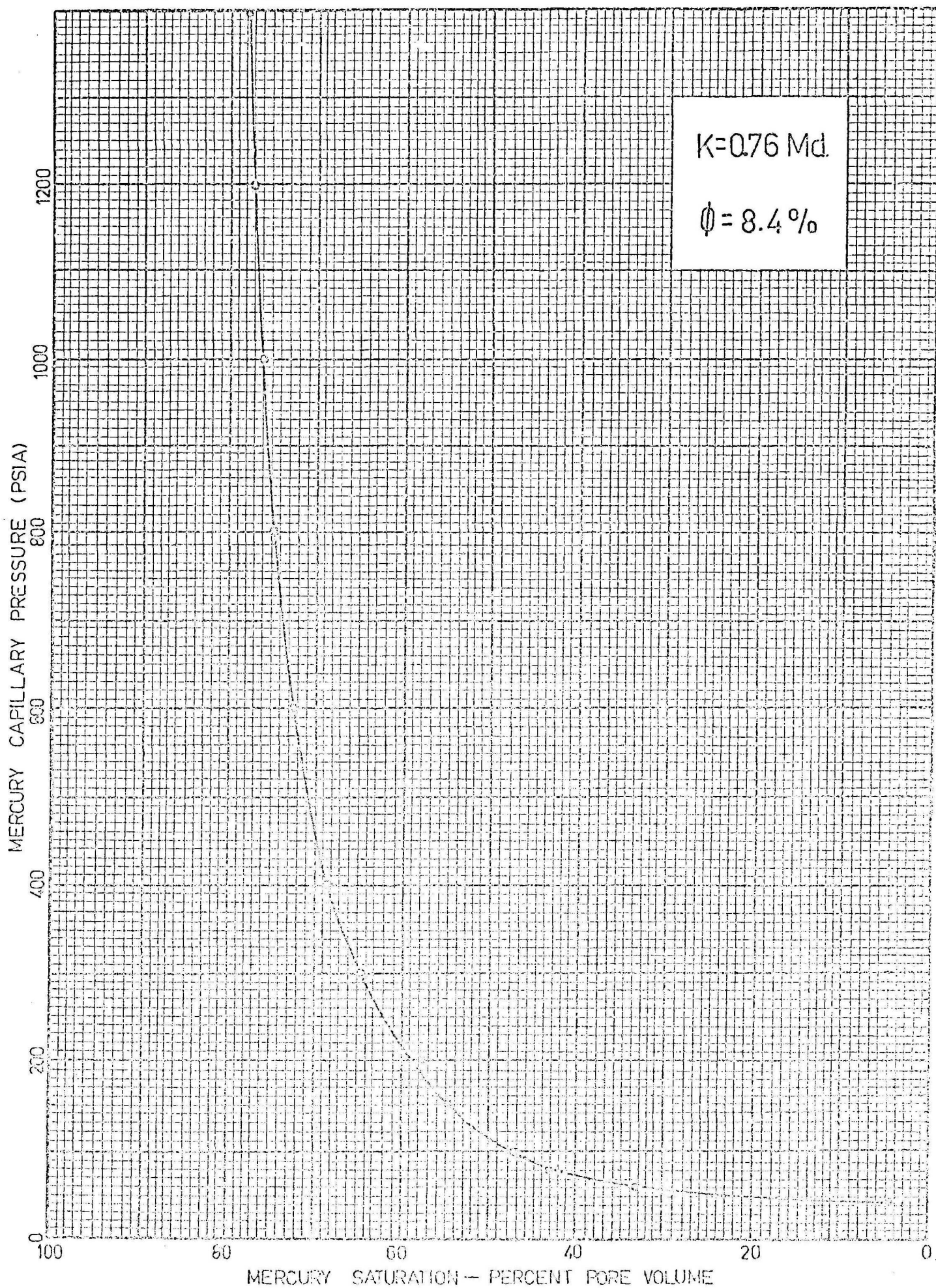


FIGURE 41

MERCURY CAPILLARY PRESSURE

WELL NAME — EAST MEREENIE No 4

SAMPLE DEPTH — 4752



FIGURE 42

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No.1

SAMPLE DEPTH — 2653'

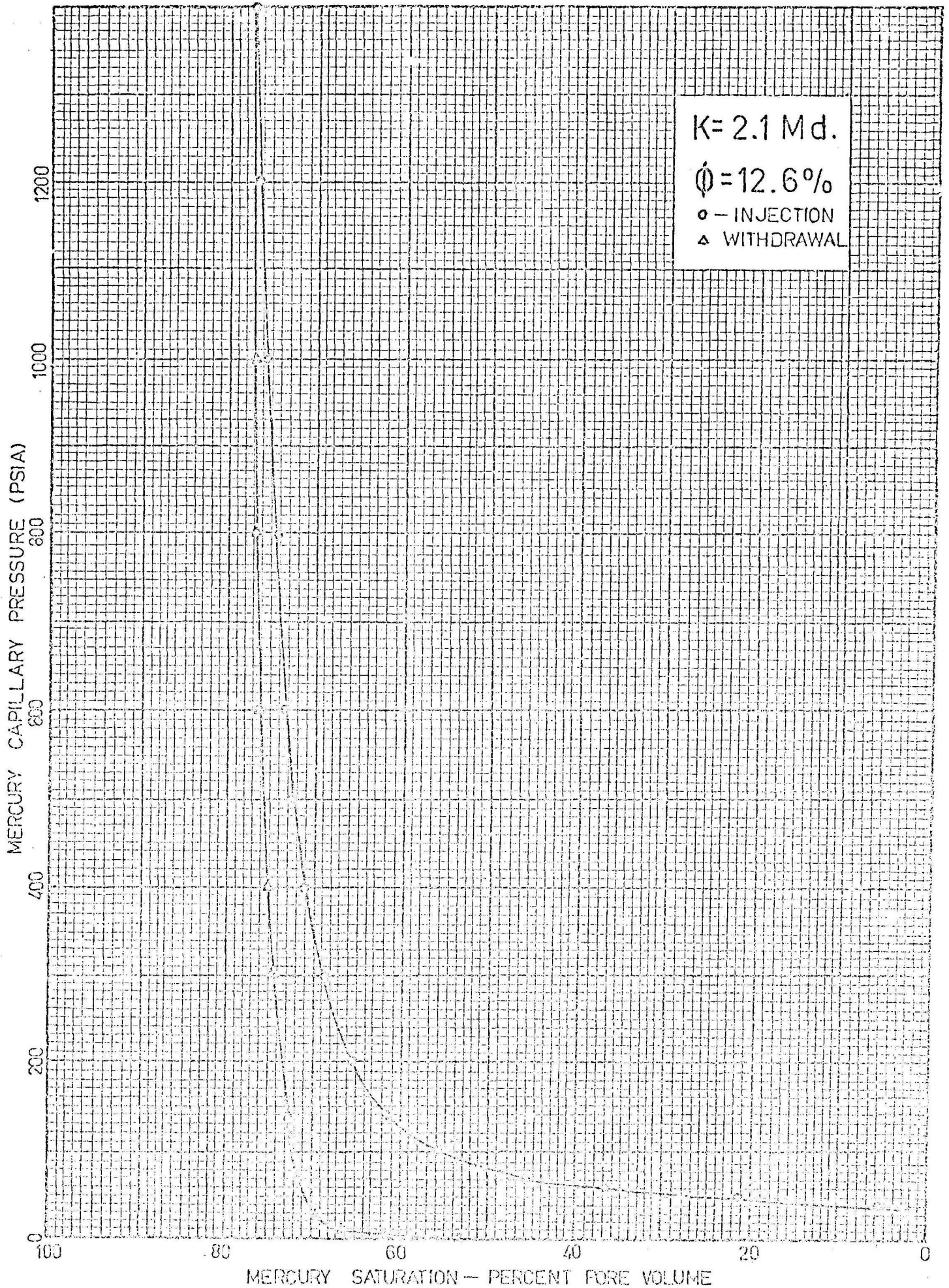


FIGURE 43

MERCURY CAPILLARY PRESSURE

WELL NAME -- E. MEREEENIE No.1

SAMPLE DEPTH-3106'

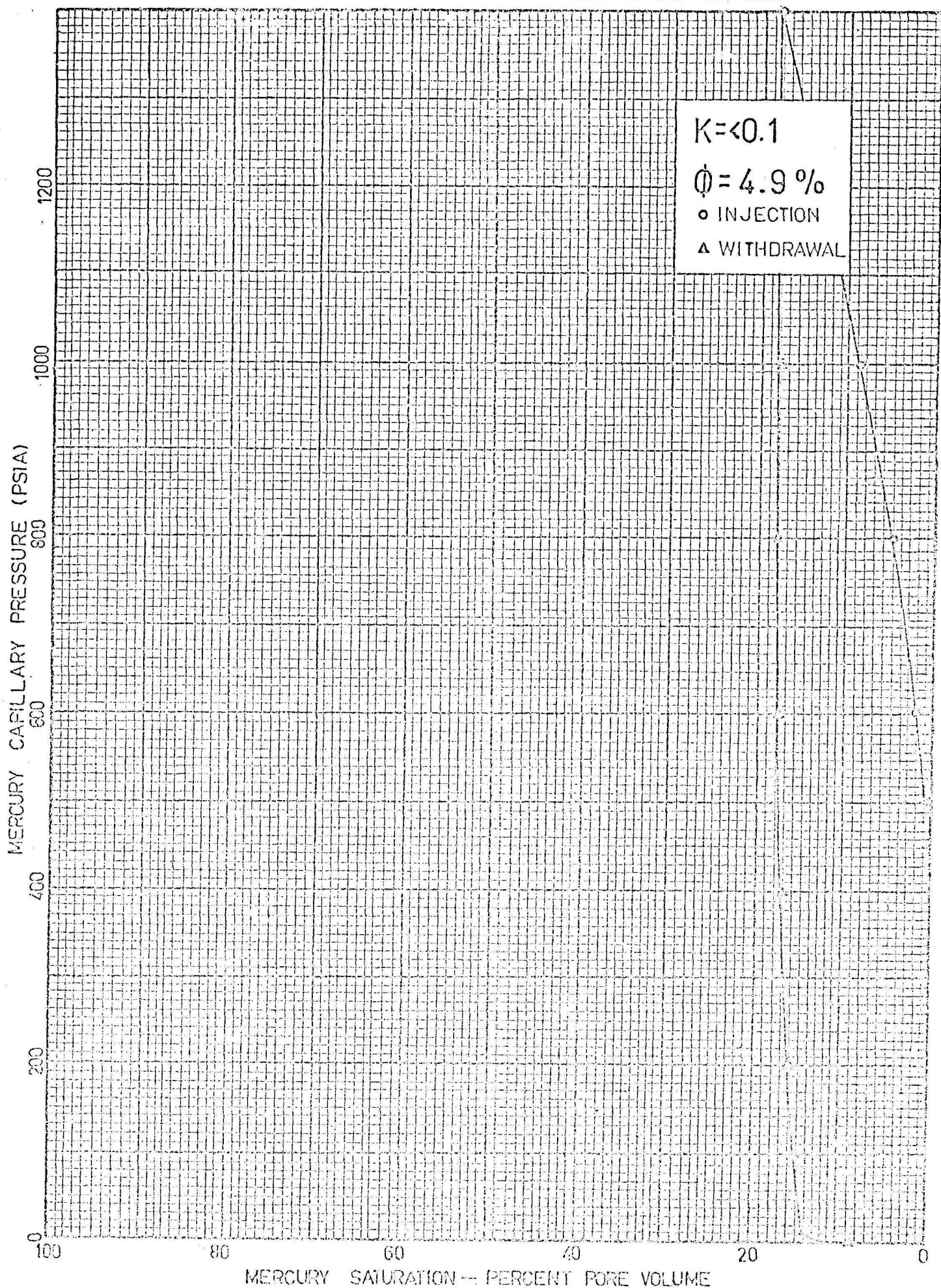


FIGURE 44

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No.1

SAMPLE DEPTH - 3132'

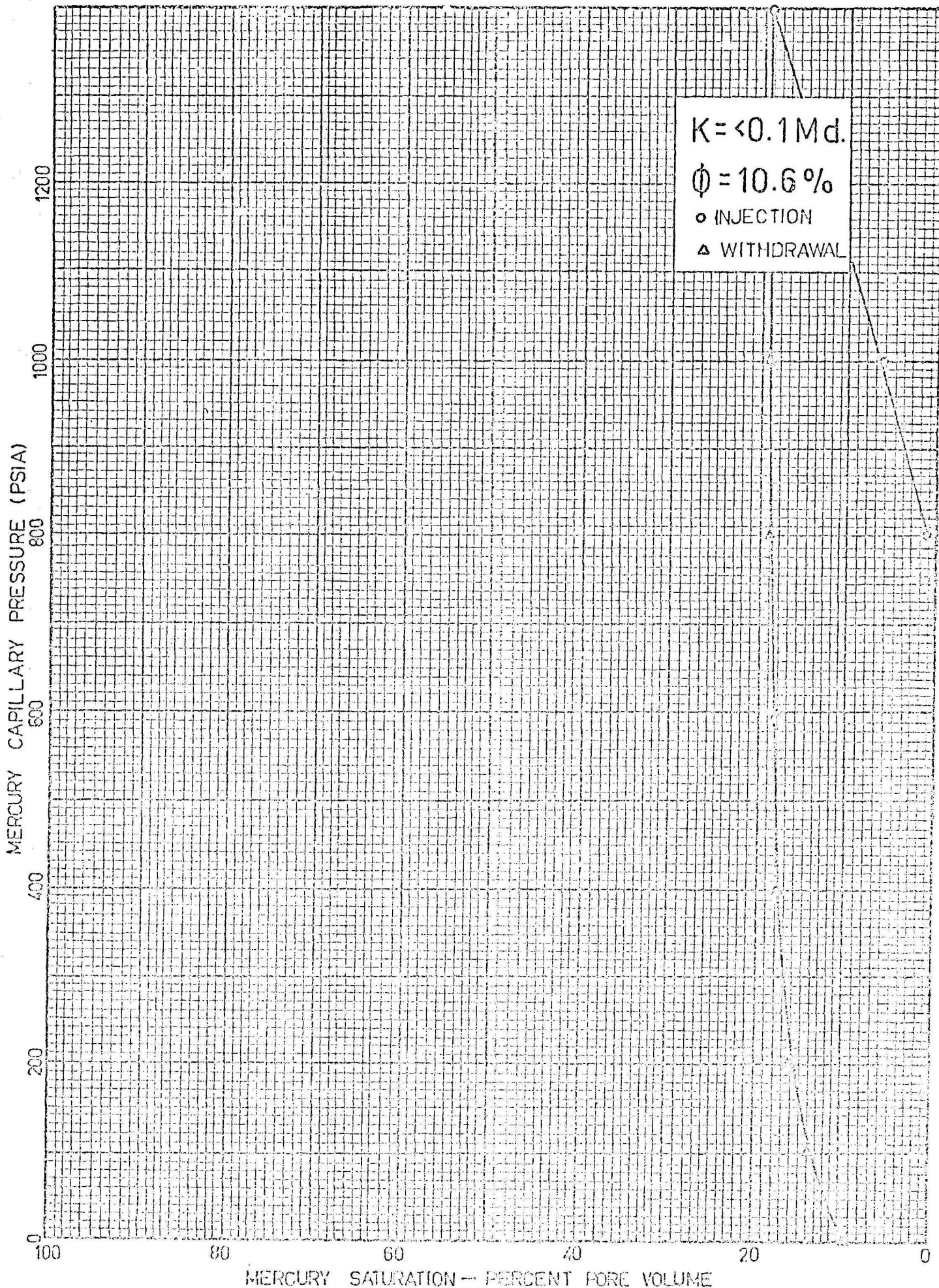


FIGURE 45

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No. 2

SAMPLE DEPTH — 4159'

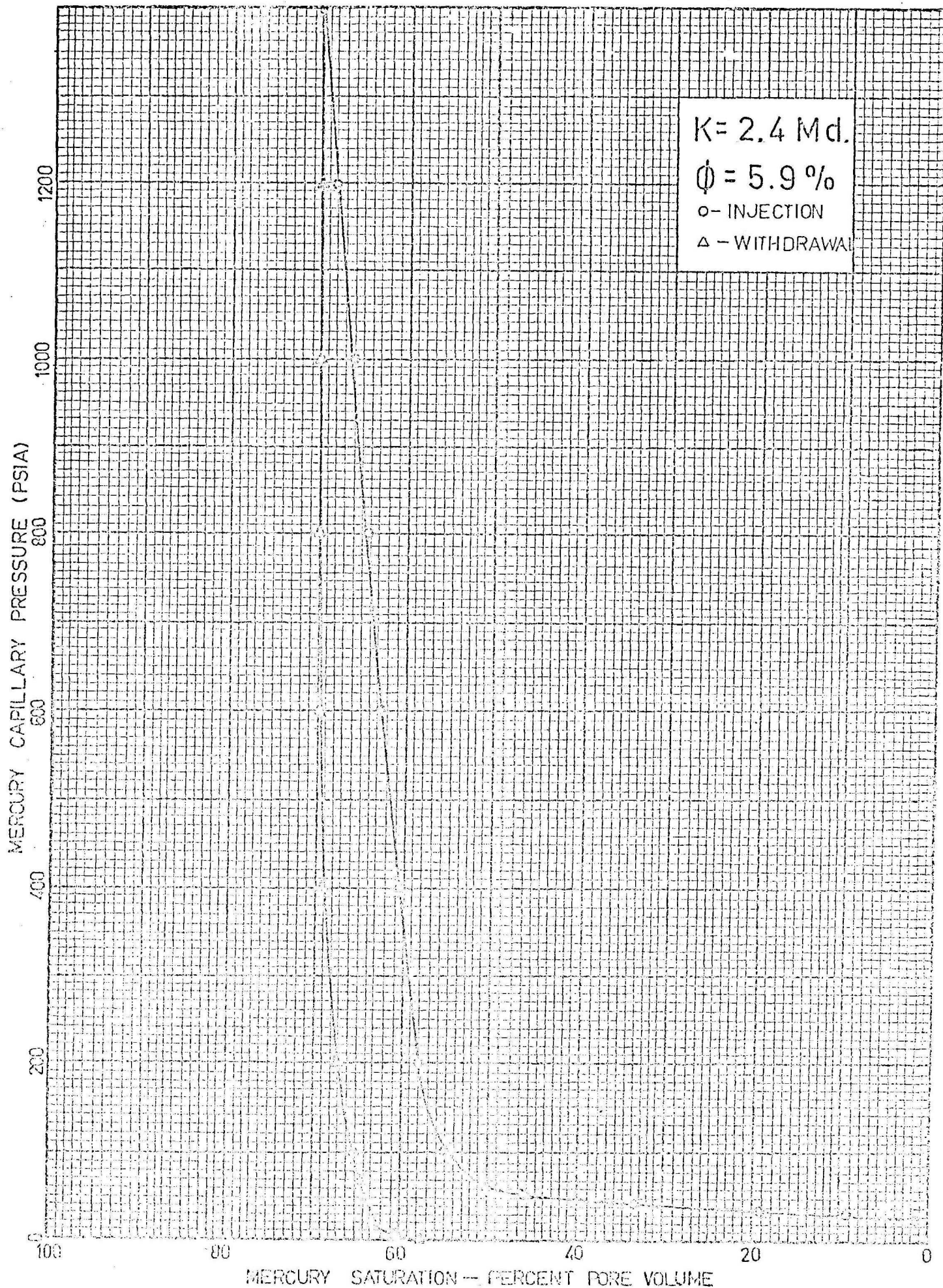


FIGURE 46

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No. 2

SAMPLE DEPTH - 4180'

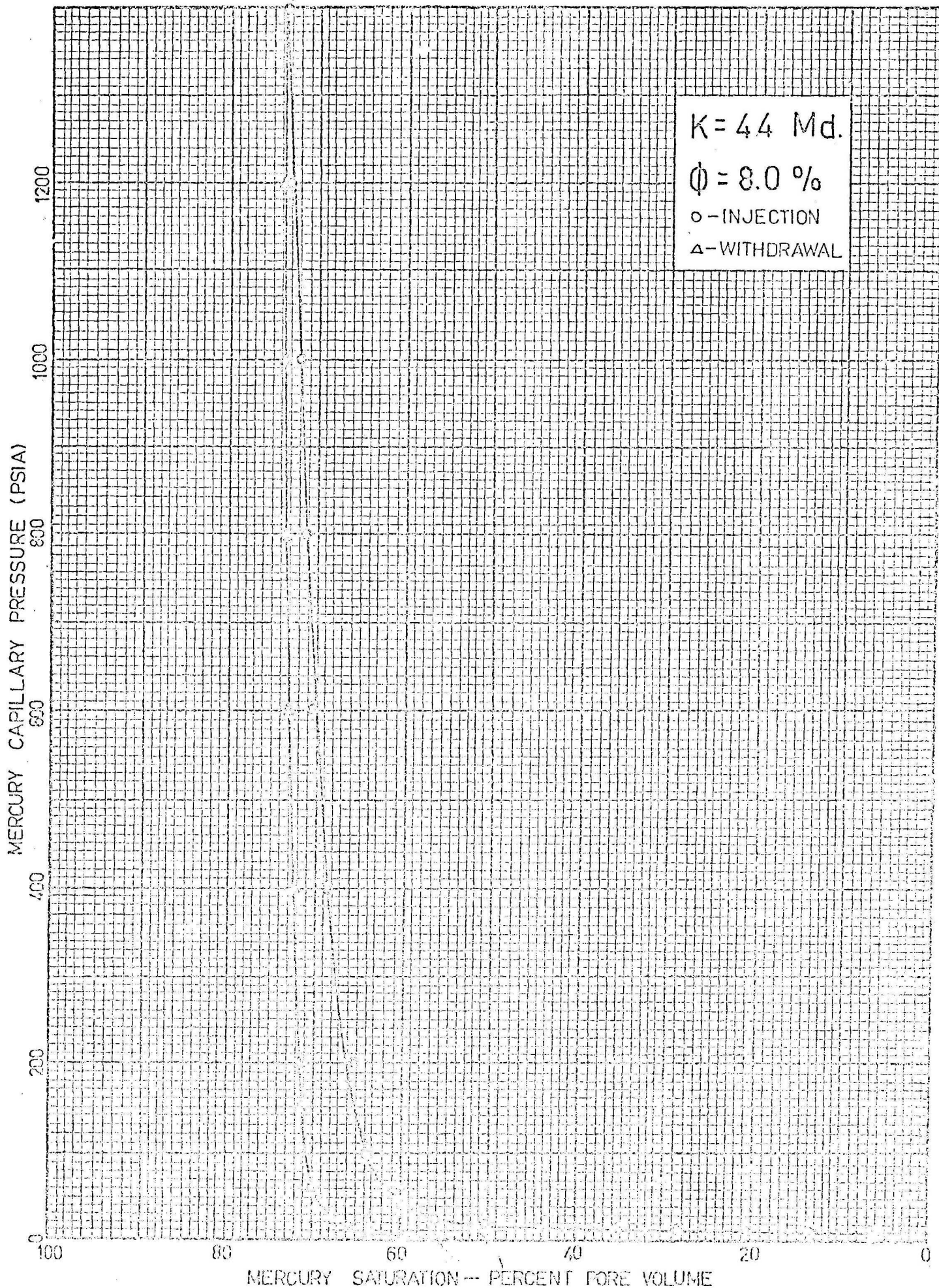


FIGURE 47

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No. 2

SAMPLE DEPTH — 4189'

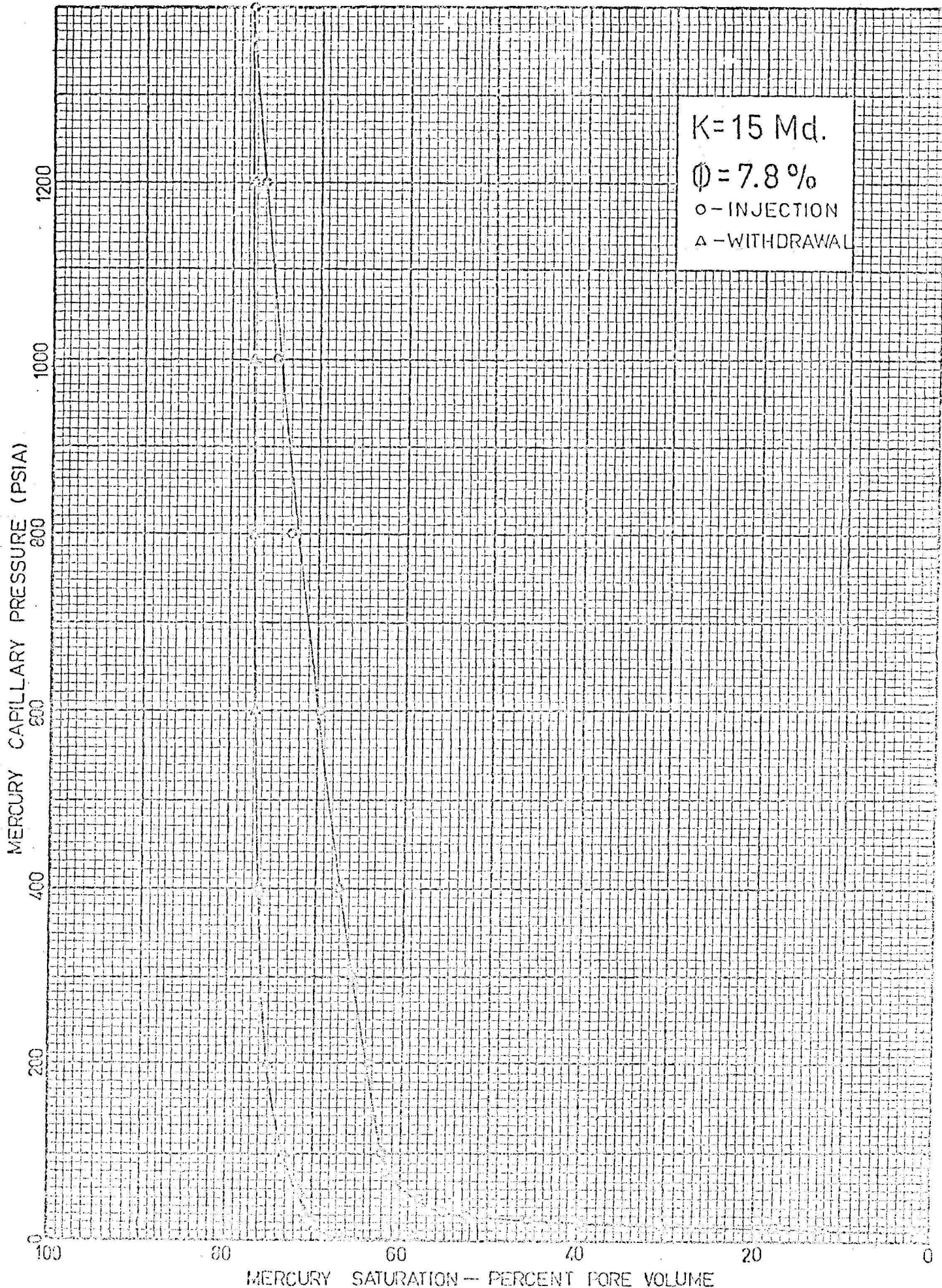


FIGURE 48

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No. 2

SAMPLE DEPTH — 4225'

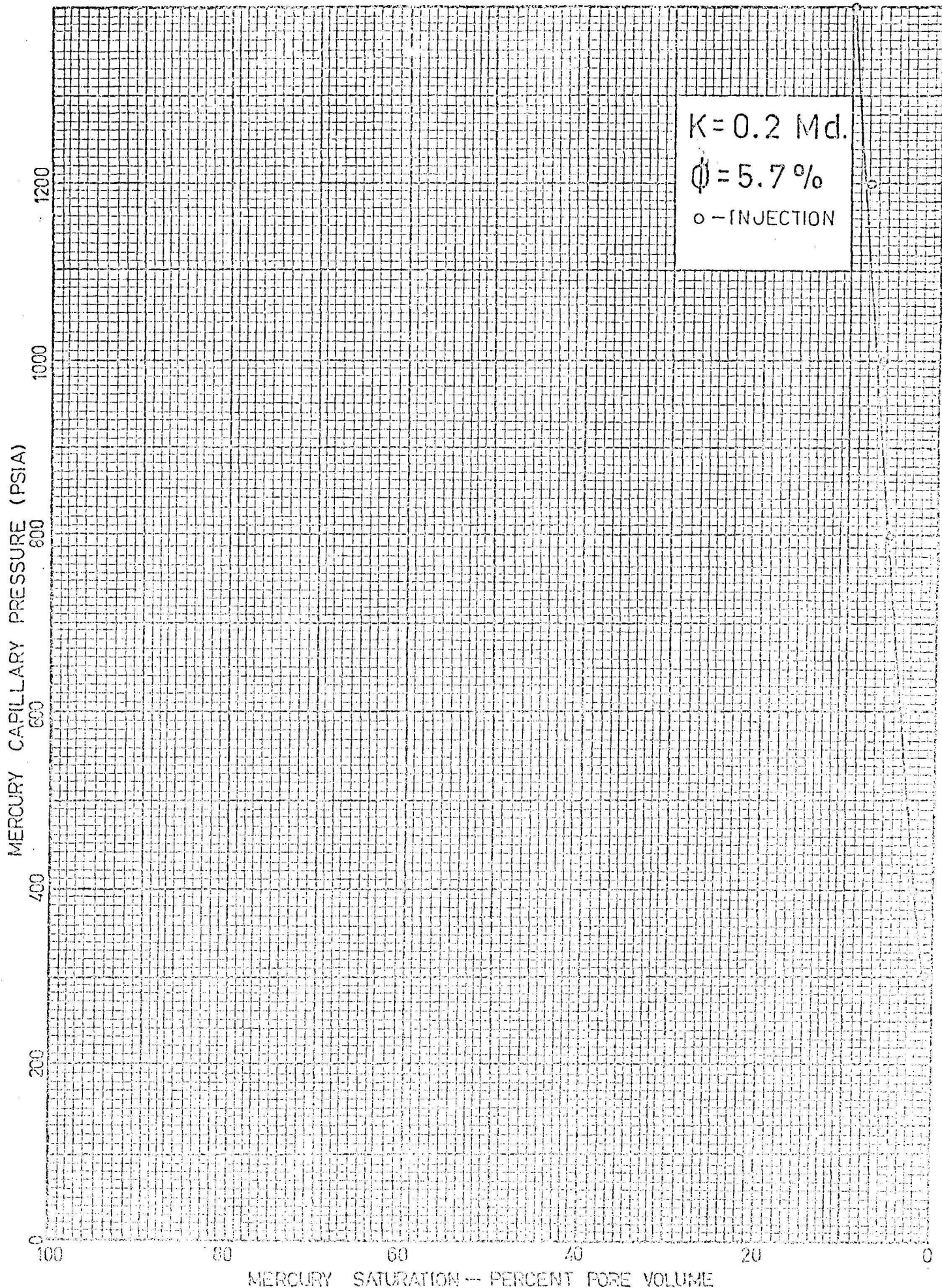


FIGURE 49

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No 2

SAMPLE DEPTH—4270'

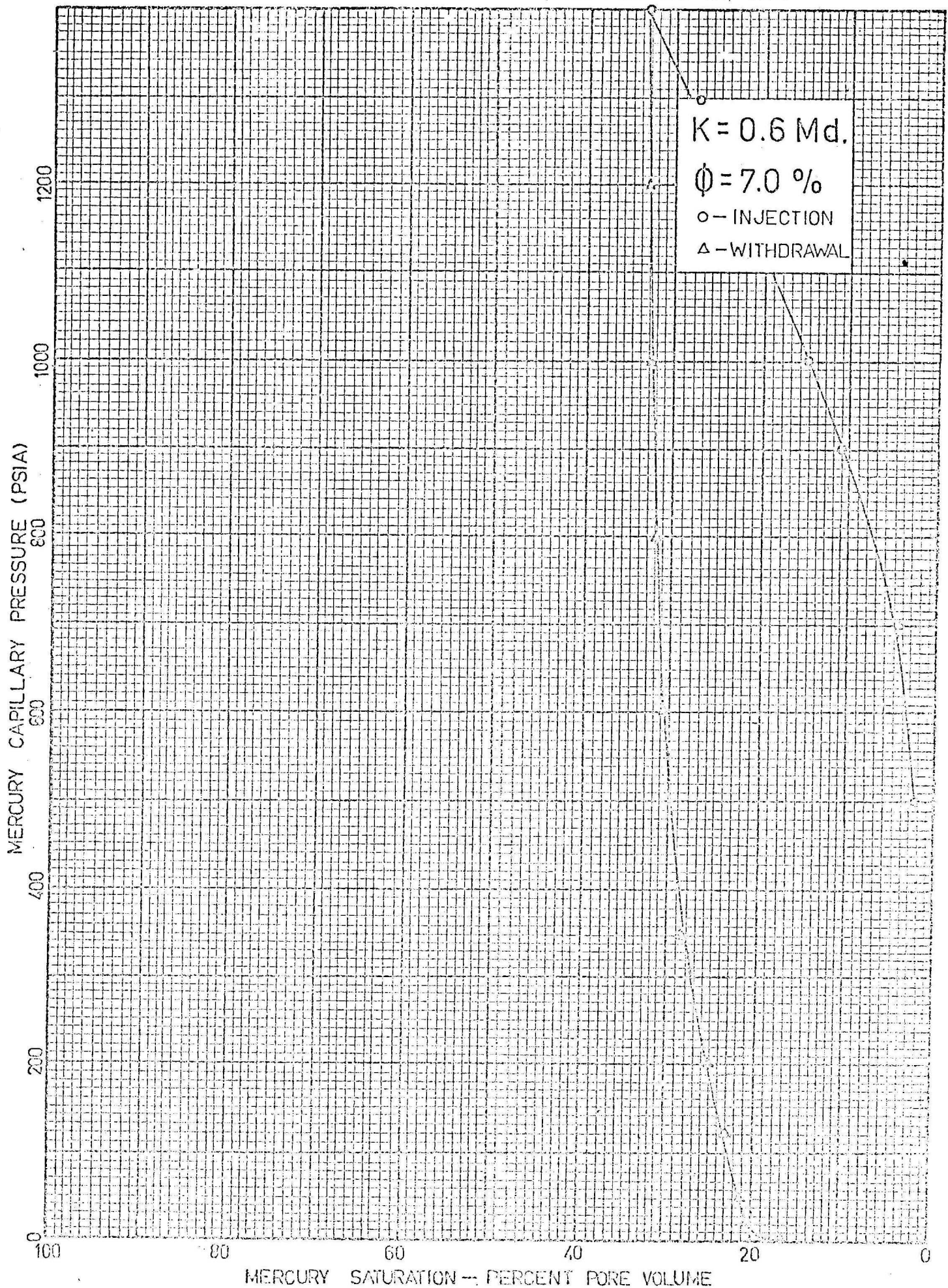


FIGURE 50

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No 2

SAMPLE DEPTH — 4281'

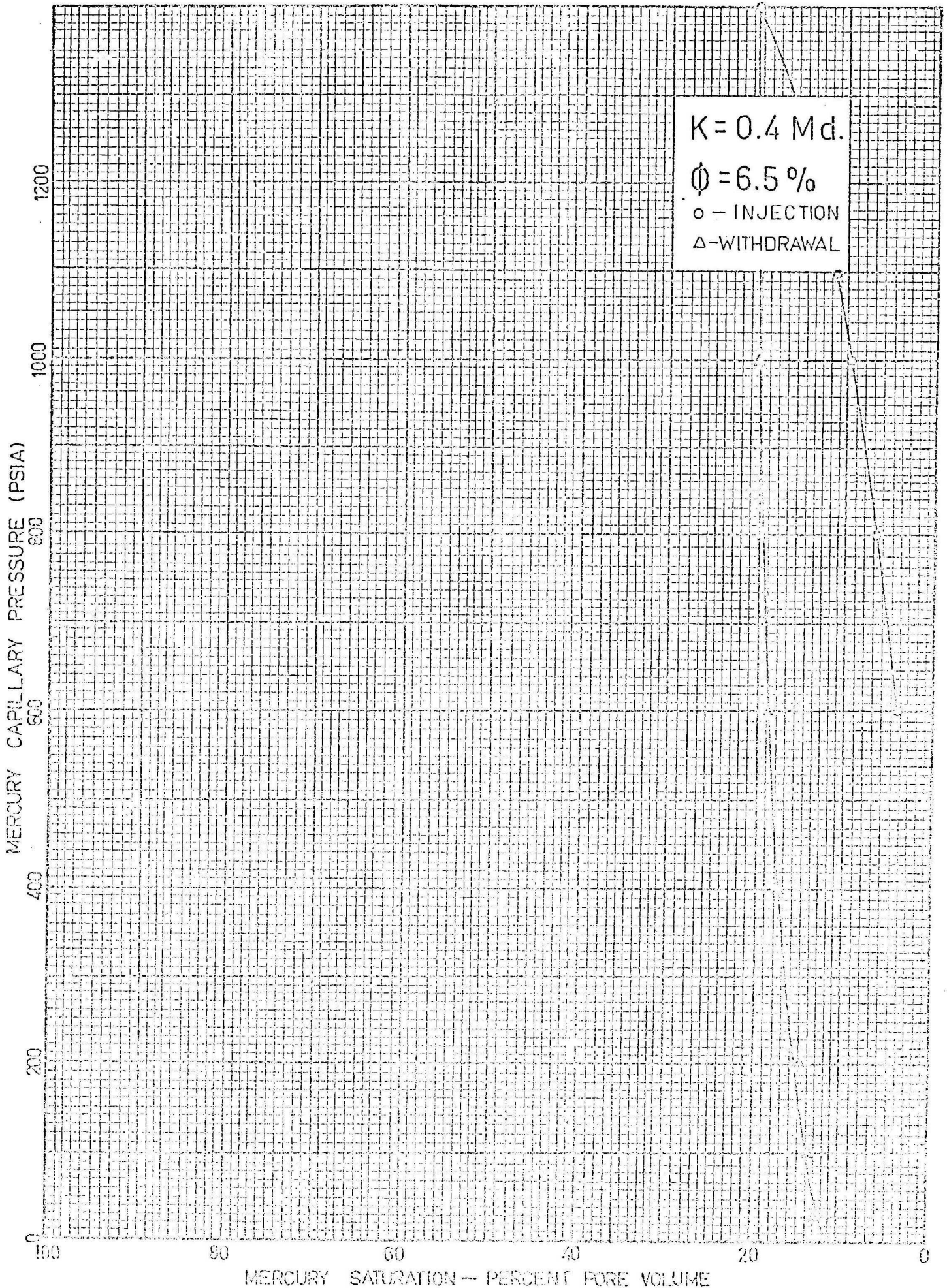


FIGURE 51

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No.2

SAMPLE DEPTH — 4290'

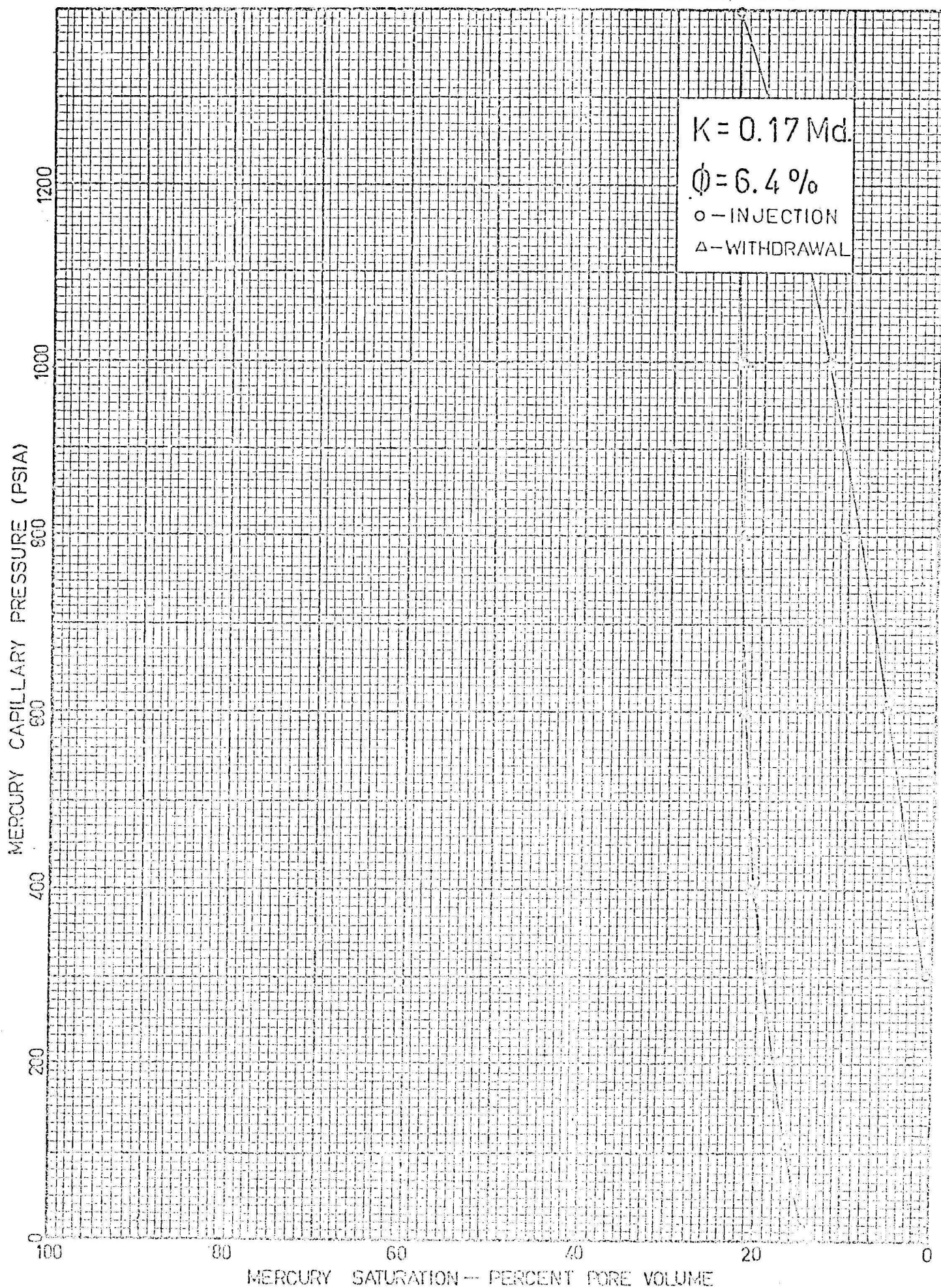


FIGURE 52

MERCURY CAPILLARY PRESSURE

WELL NAME — E MEREENIE No. 2

SAMPLE DEPTH—4328'

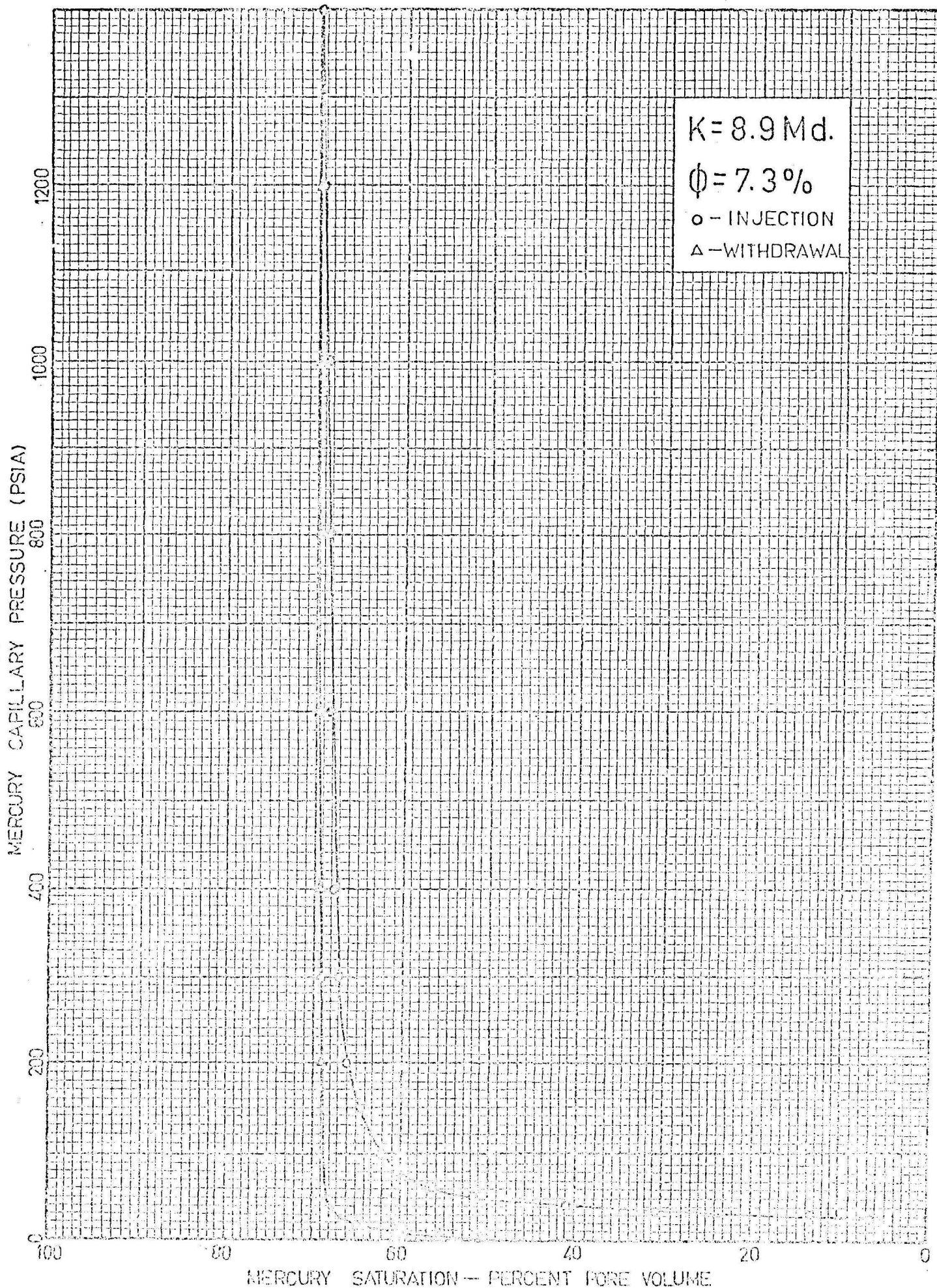


FIGURE 53

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No. 2

SAMPLE DEPTH — 4334'

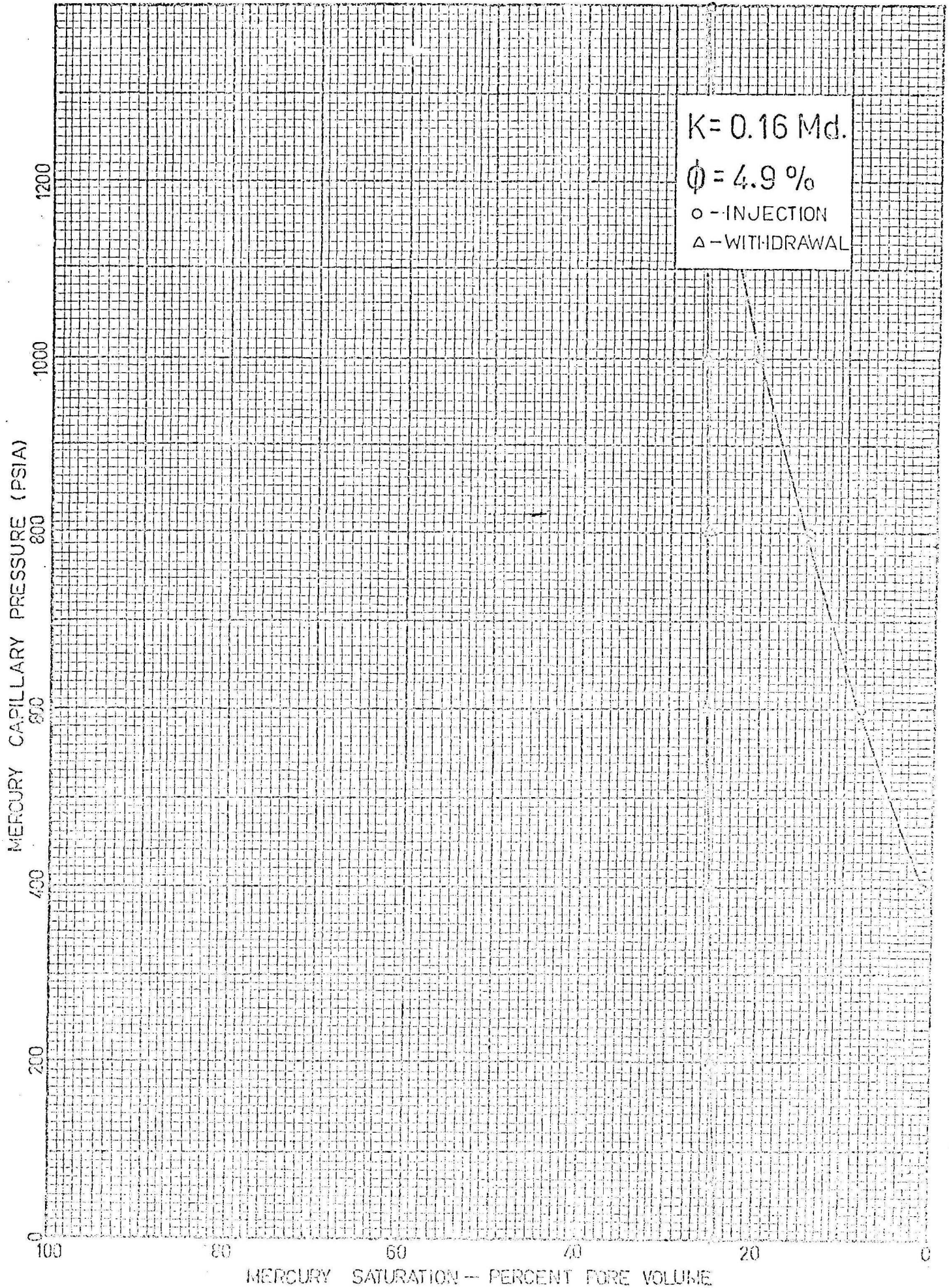


FIGURE 54

MERCURY CAPILLARY PRESSURE

WELL NAME -- E. MEREENIE No. 2

SAMPLE DEPTH -- 4340'

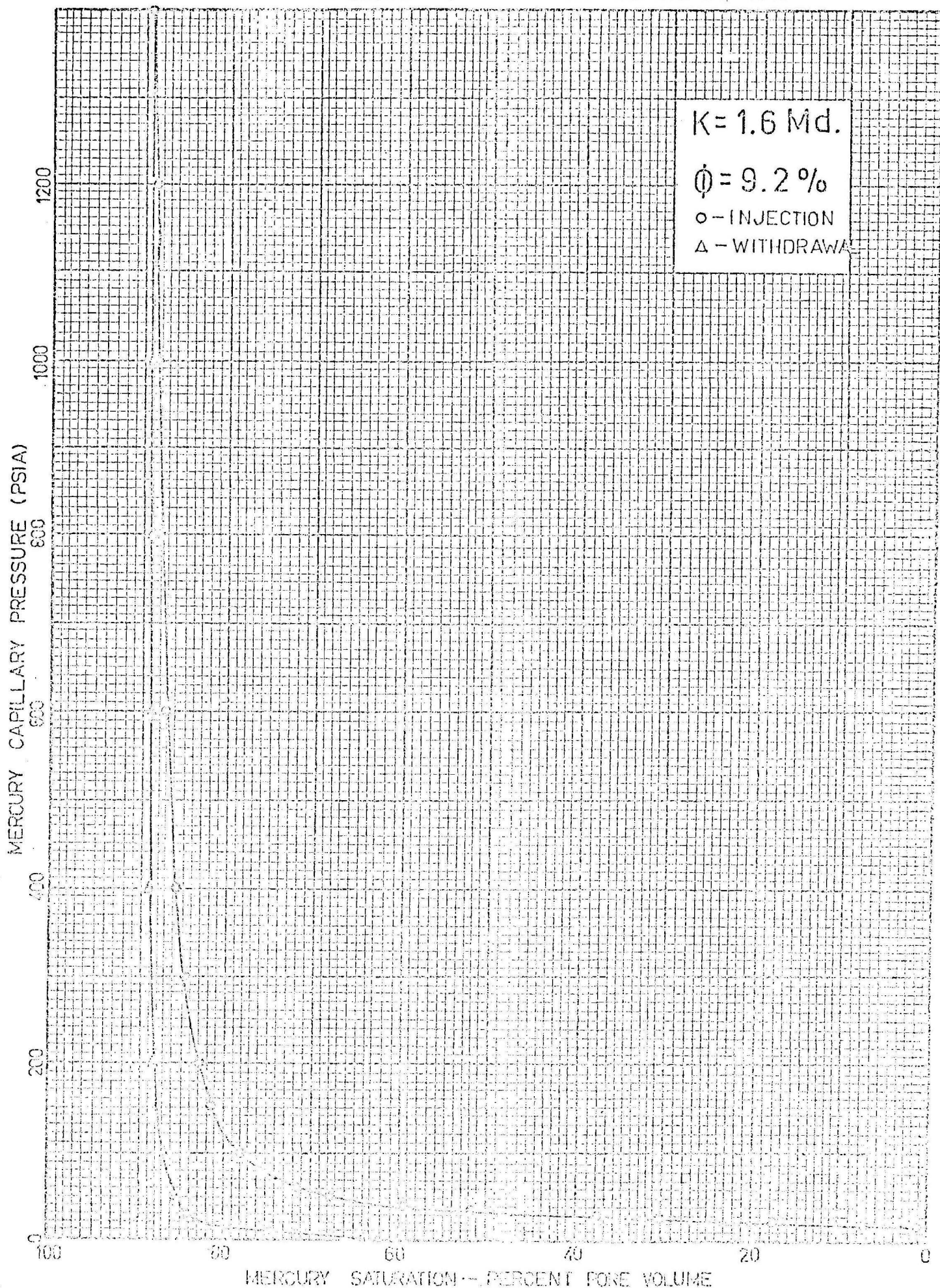


FIGURE 55

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No.2

SAMPLE DEPTH — 4369'

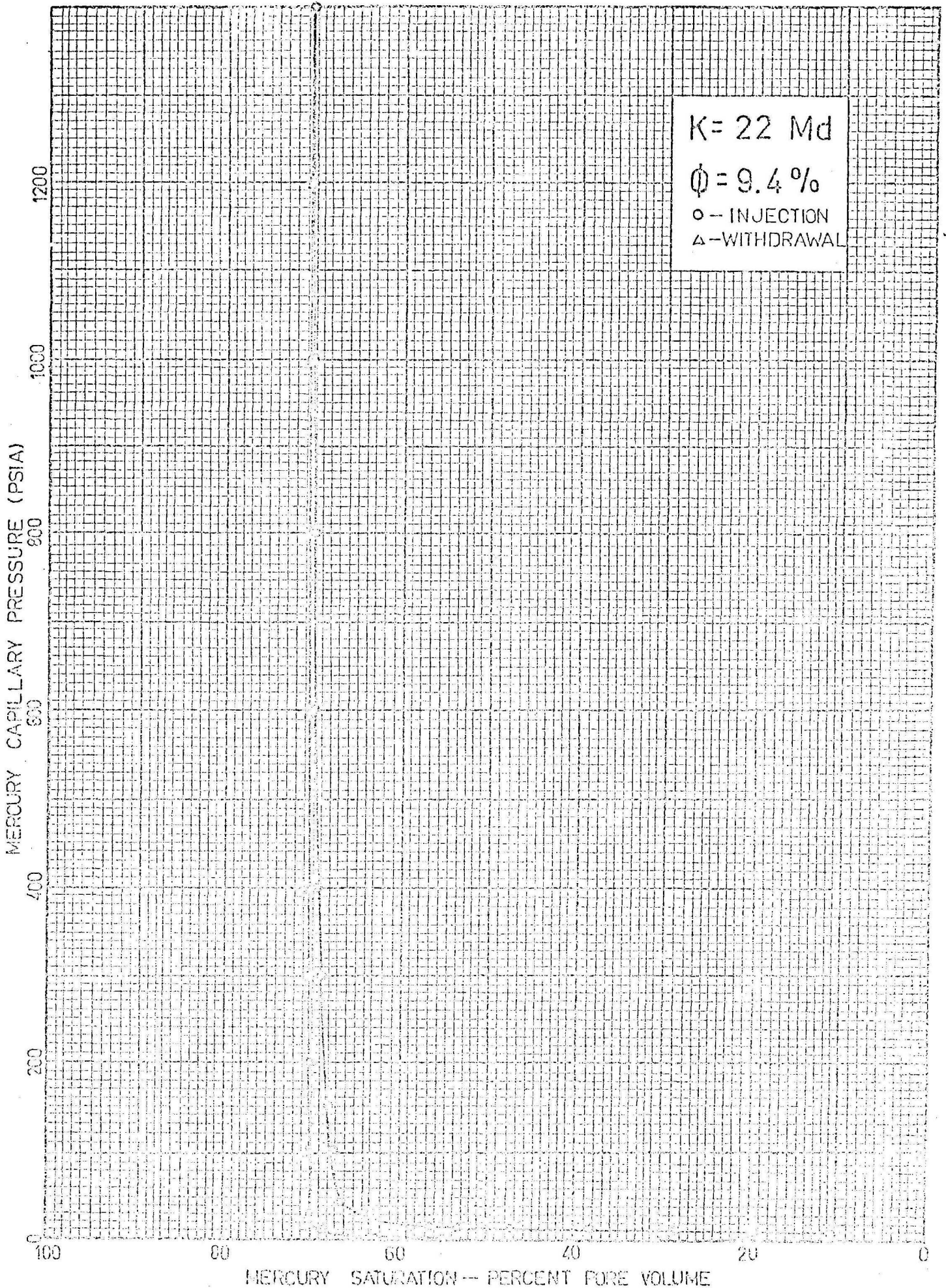


FIGURE 56

MERCURY CAPILLARY PRESSURE

WELL NAME -- E.MERENIE No.2

SAMPLE DEPTH -- 4376'

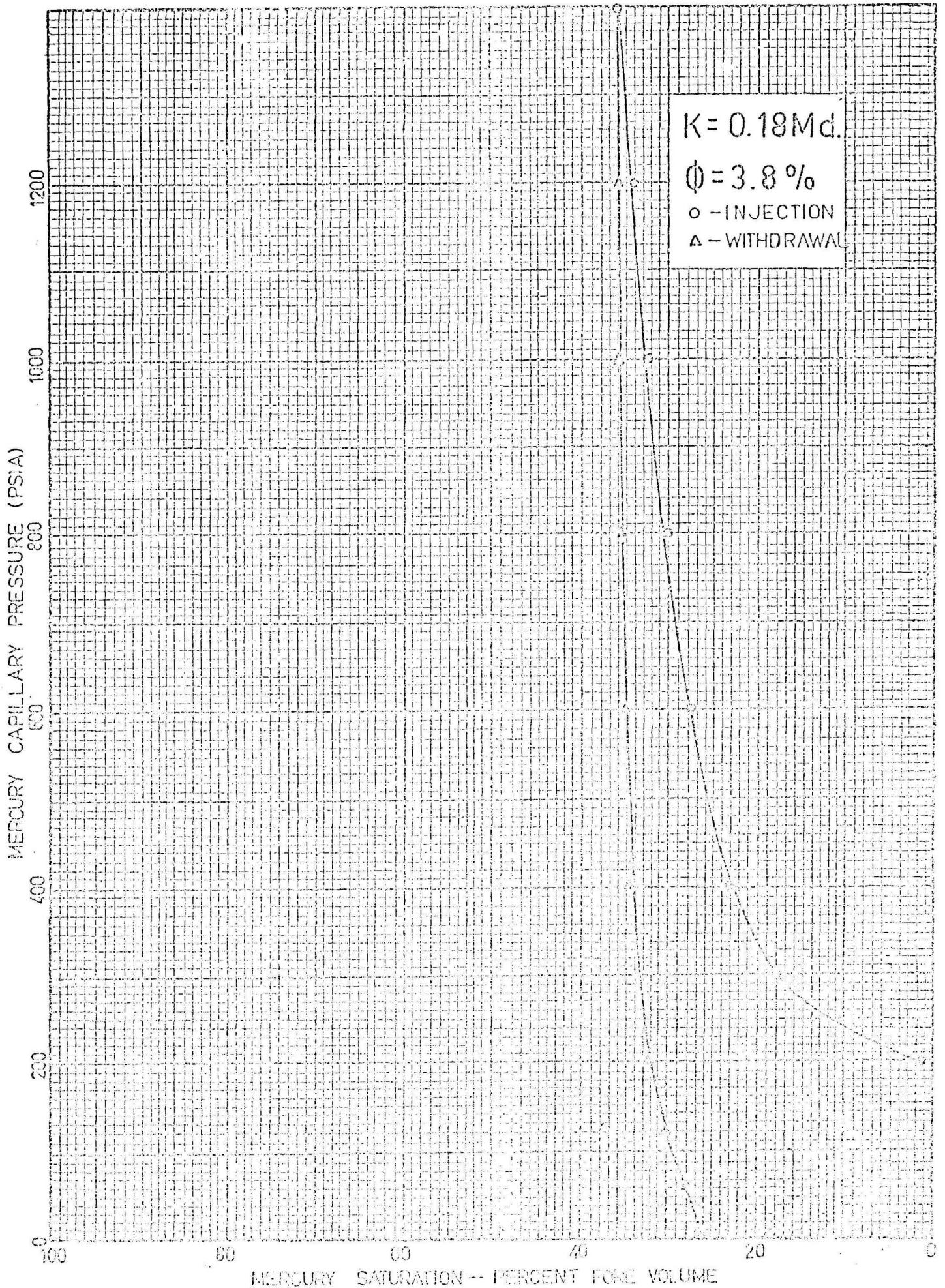


FIGURE 57

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No. 2

SAMPLE DEPTH — 4388'

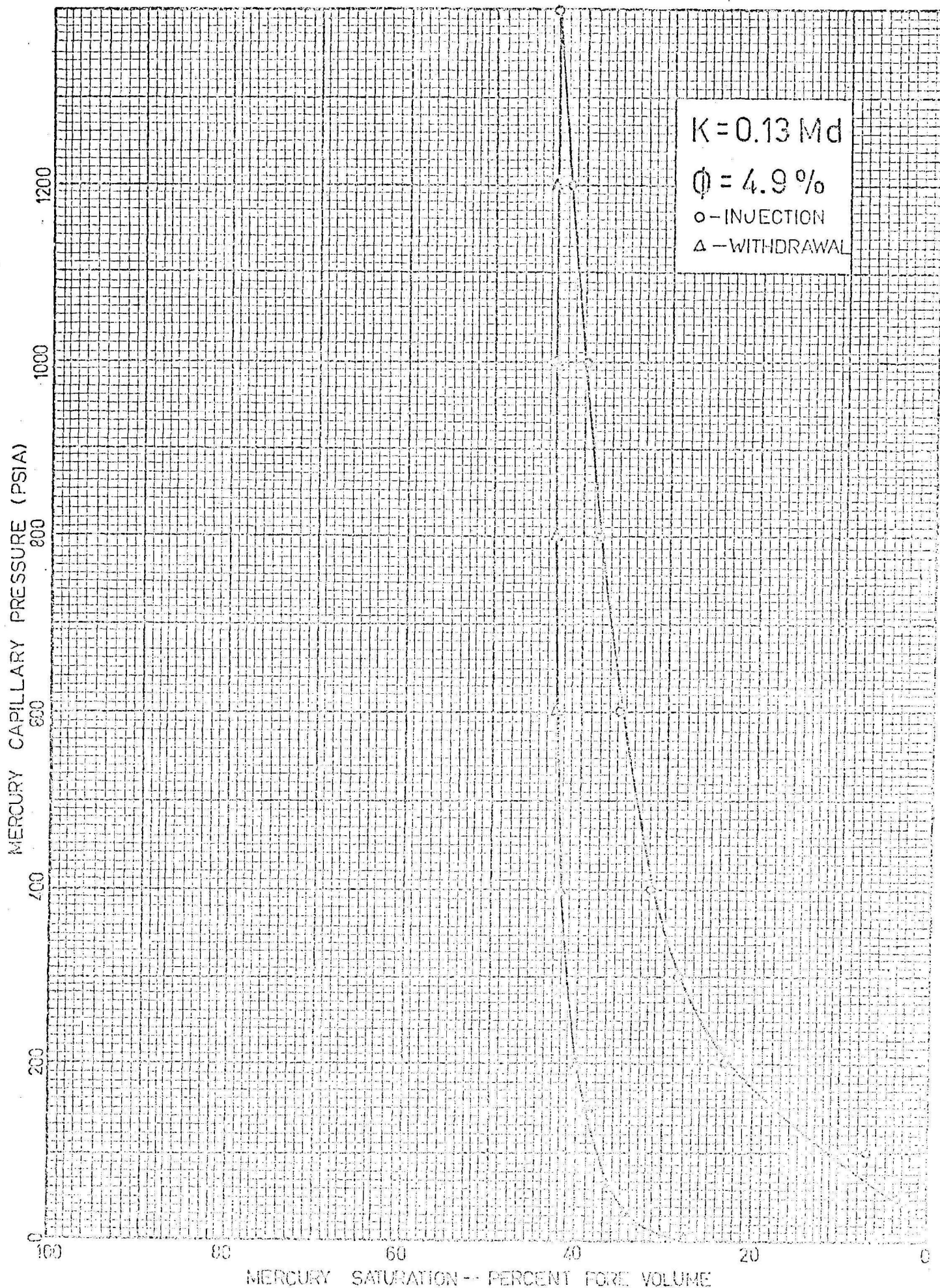


FIGURE 58

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREEENIE No. 2

SAMPLE DEPTH — 4390'

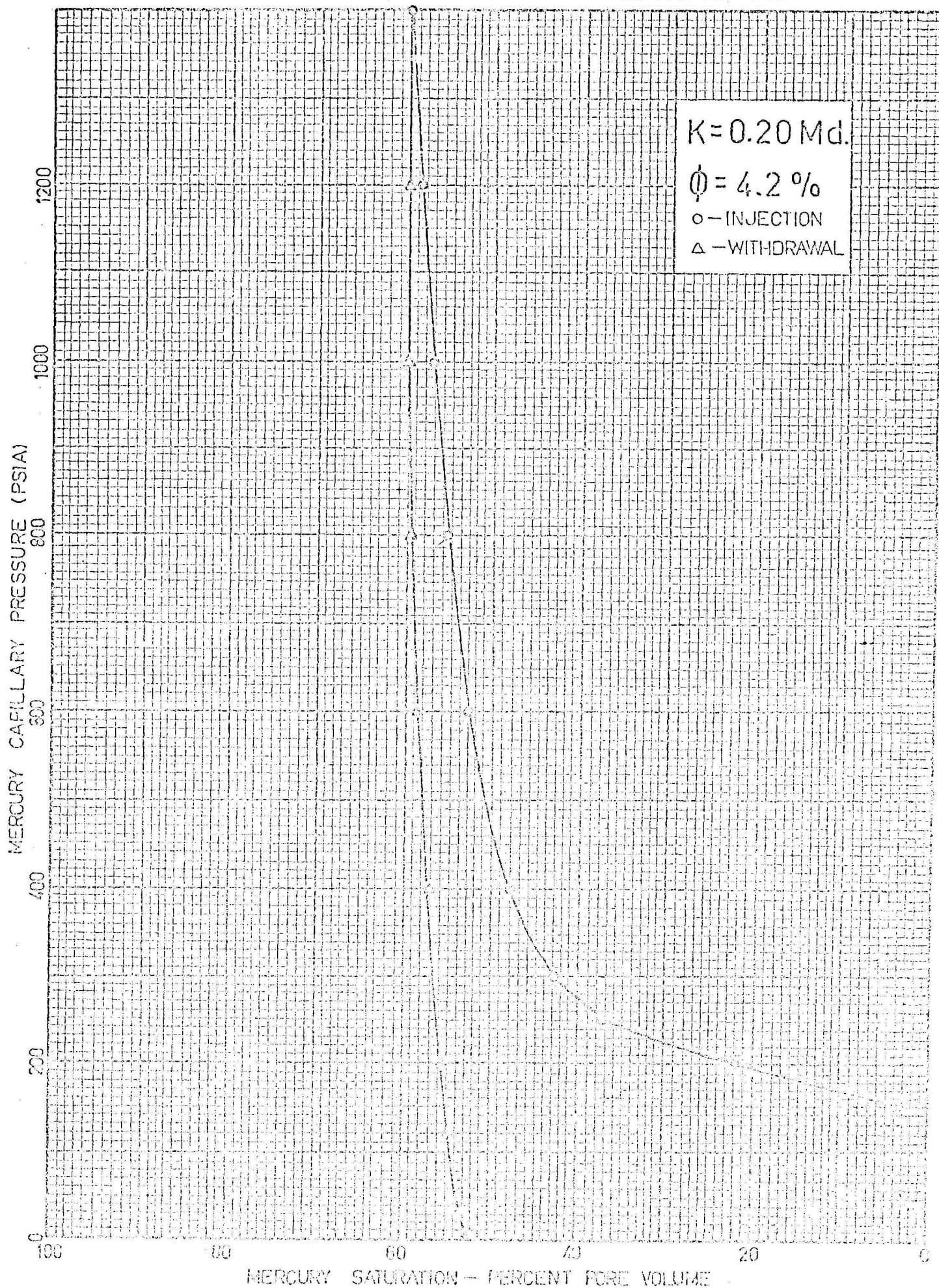


FIGURE 59

MERCURY CAPILLARY PRESSURE

WELL NAME -- E. MEREENIE No. 2

SAMPLE DEPTH - 4441'

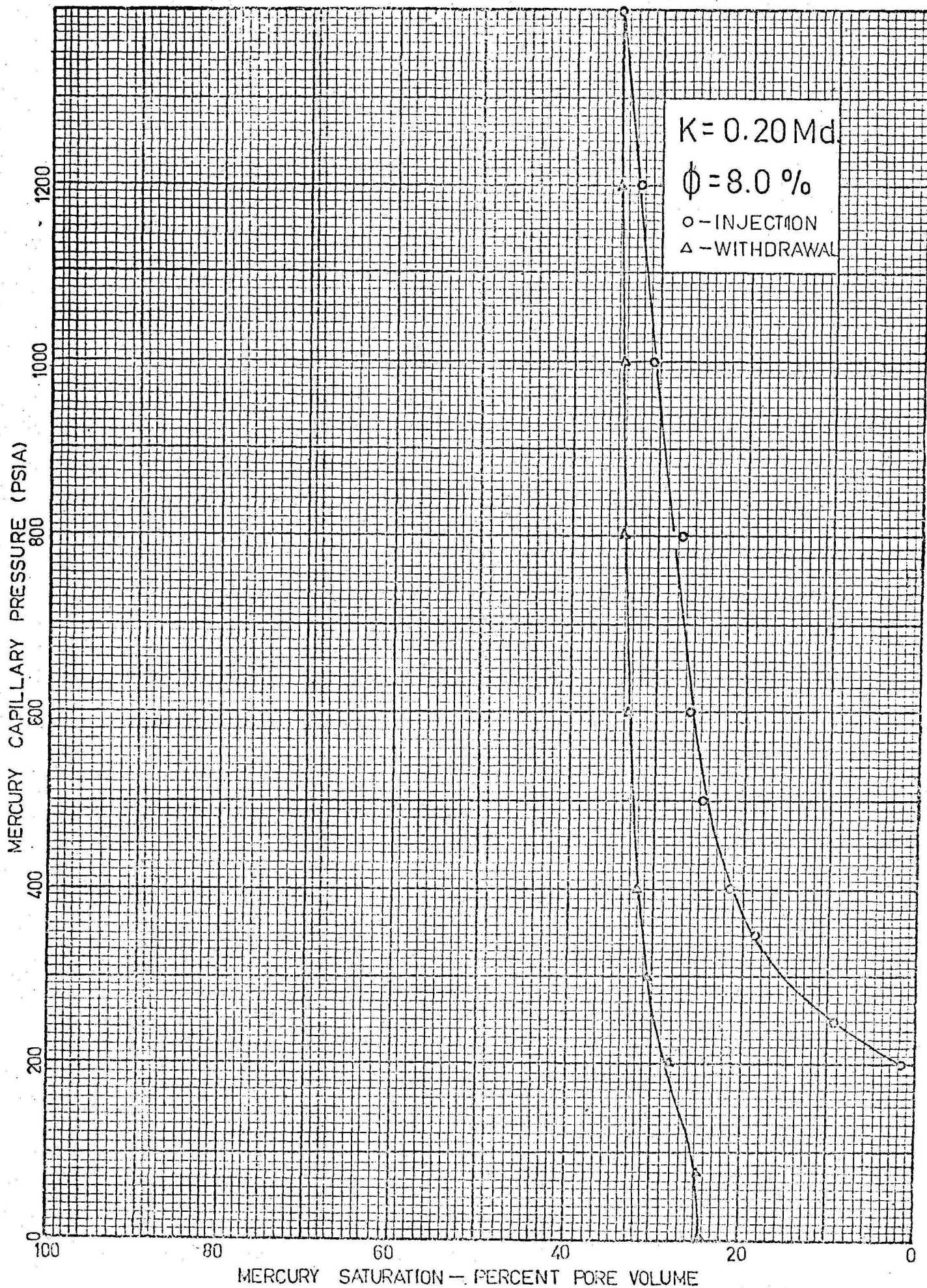


FIGURE 60

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No 2

SAMPLE DEPTH — 4446'

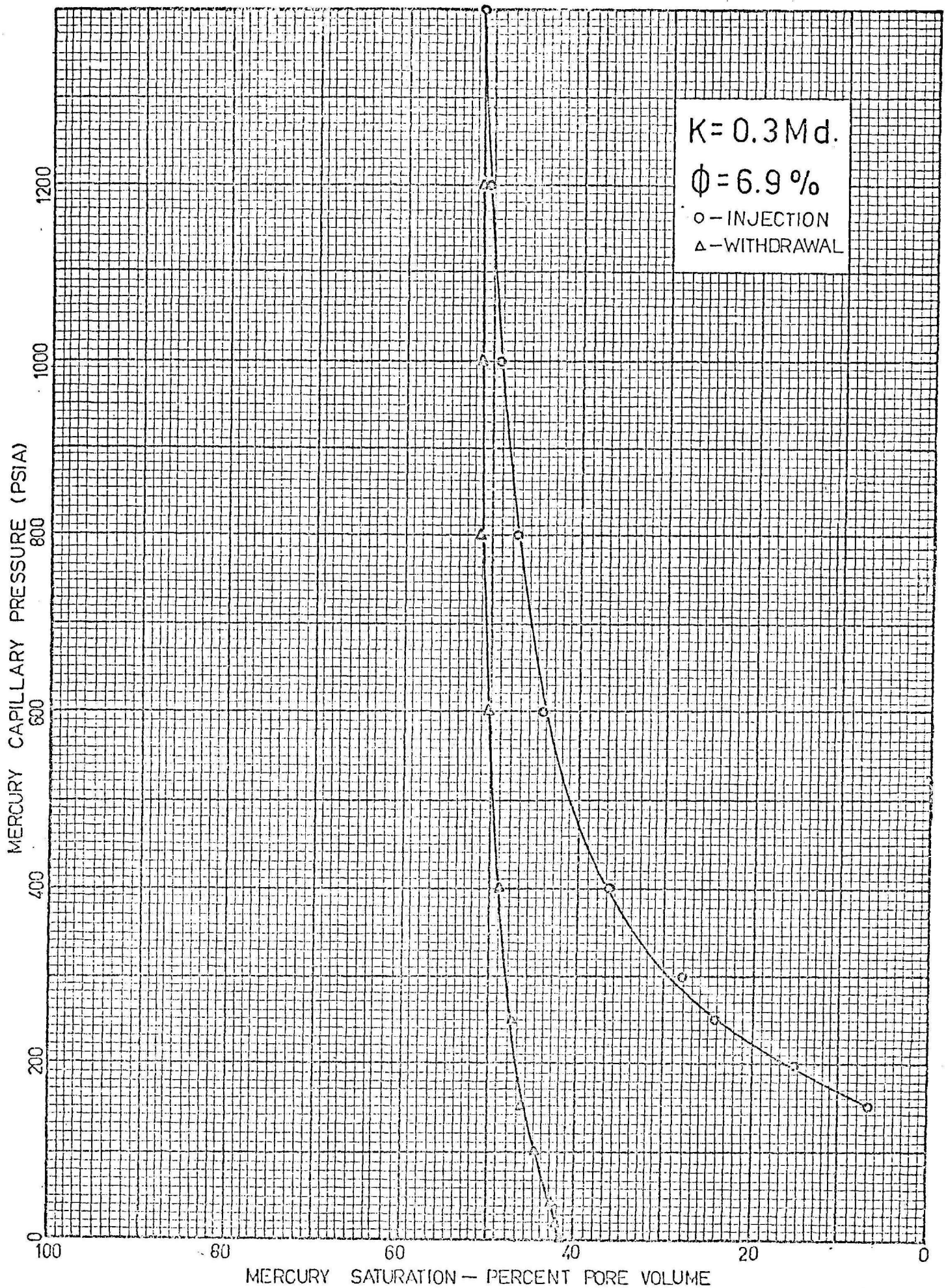


FIGURE 61

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MERCEENIE No. 2

SAMPLE DEPTH — 4451'

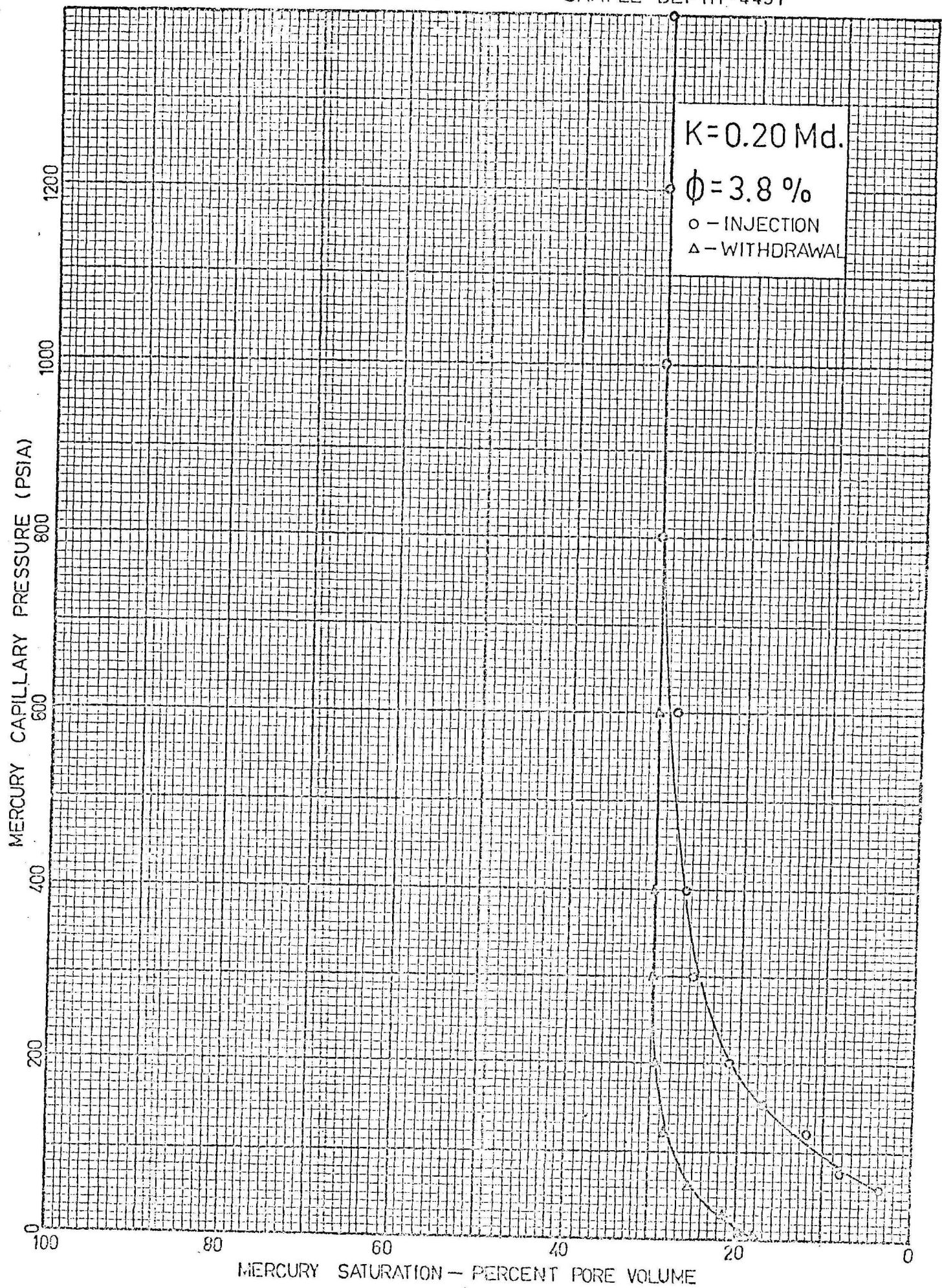


FIGURE 62

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No. 2

SAMPLE DEPTH — 4474'

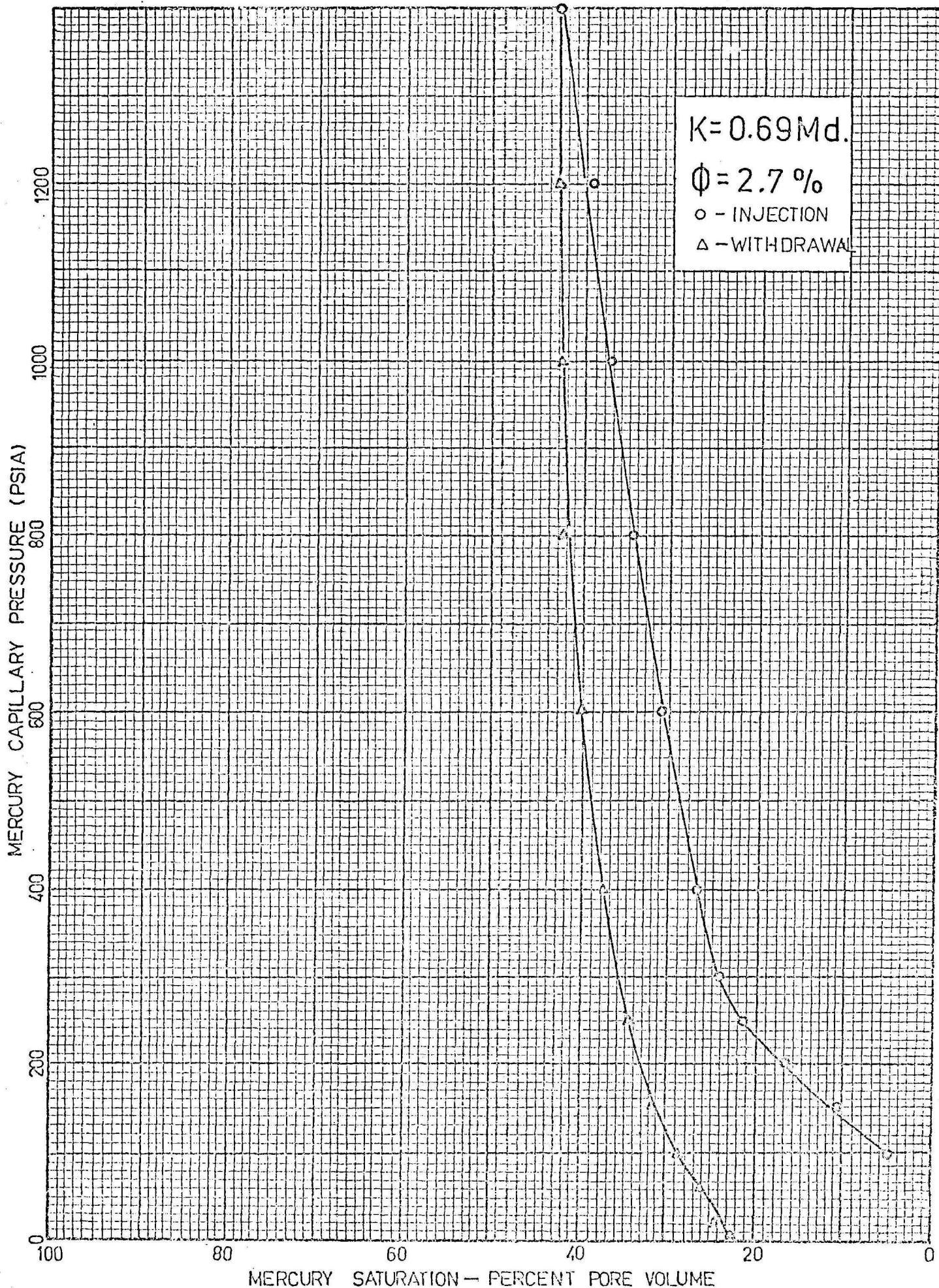


FIGURE 63

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREEENIE No. 2

SAMPLE DEPTH — 4491'

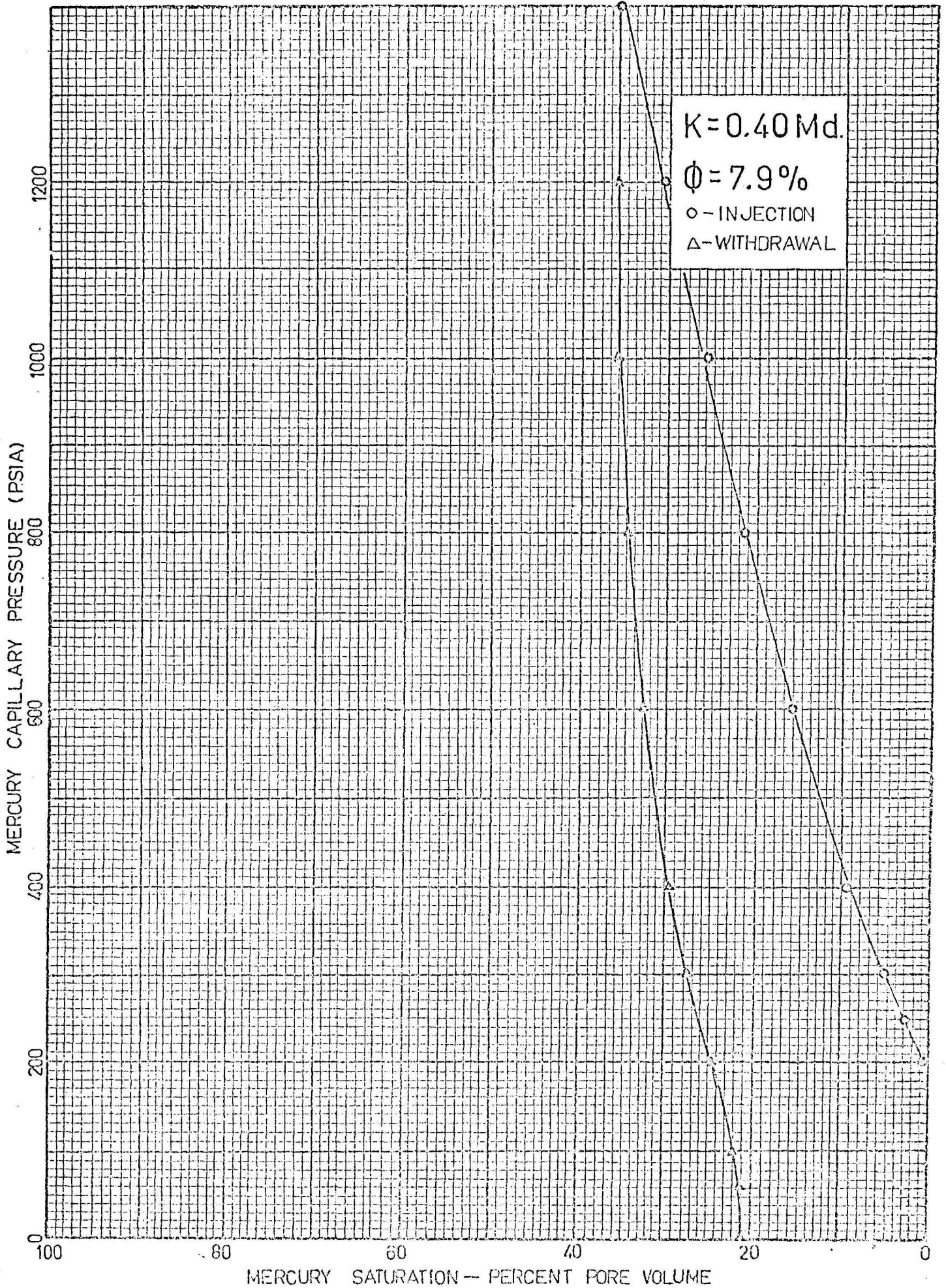


FIGURE 64

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No. 2

SAMPLE DEPTH — 4494'

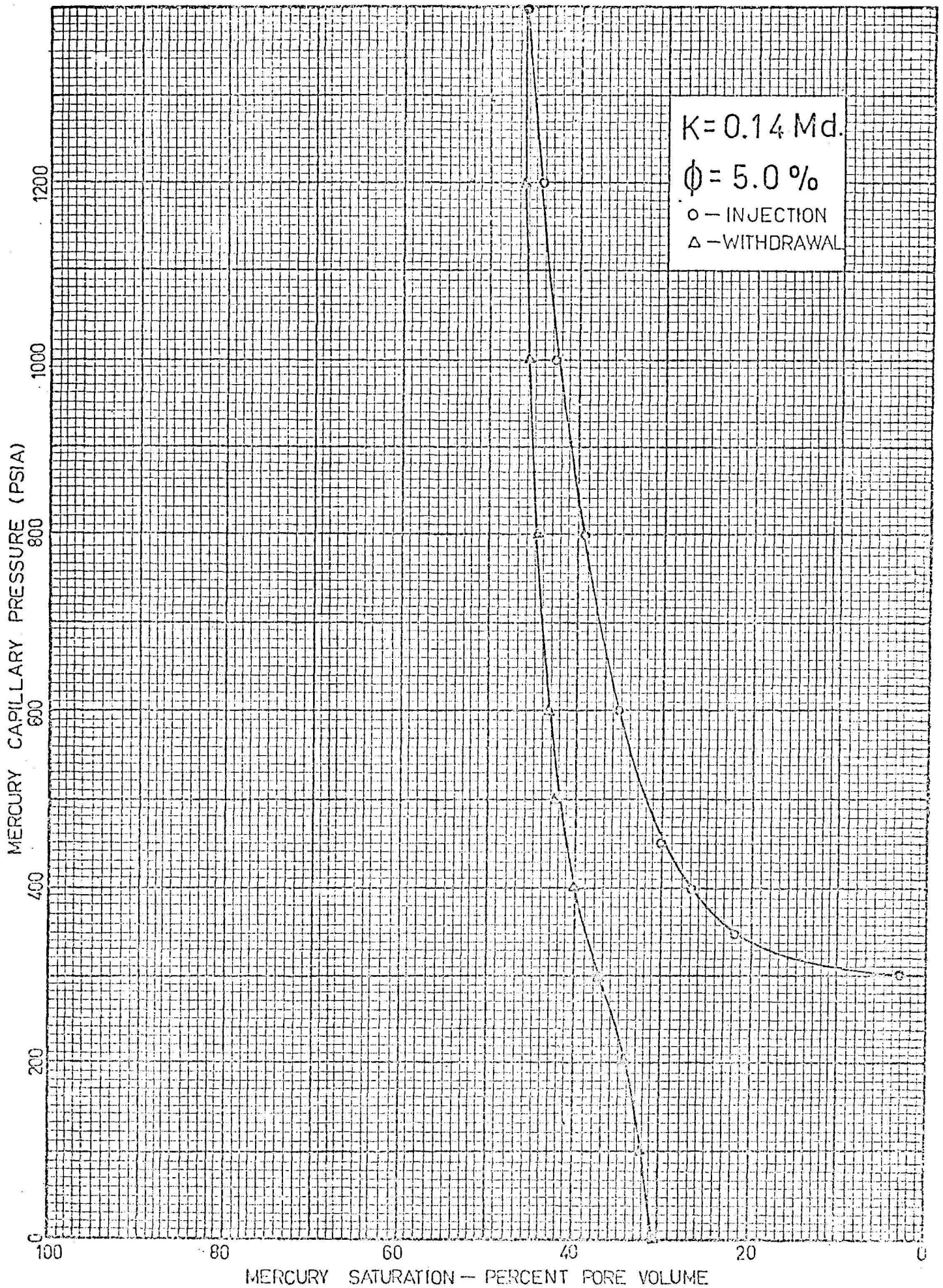


FIGURE 65

MERCURY CAPILLARY PRESSURE

WELL NAME -- E. MEREENIE No. 2

SAMPLE DEPTH - 4653'

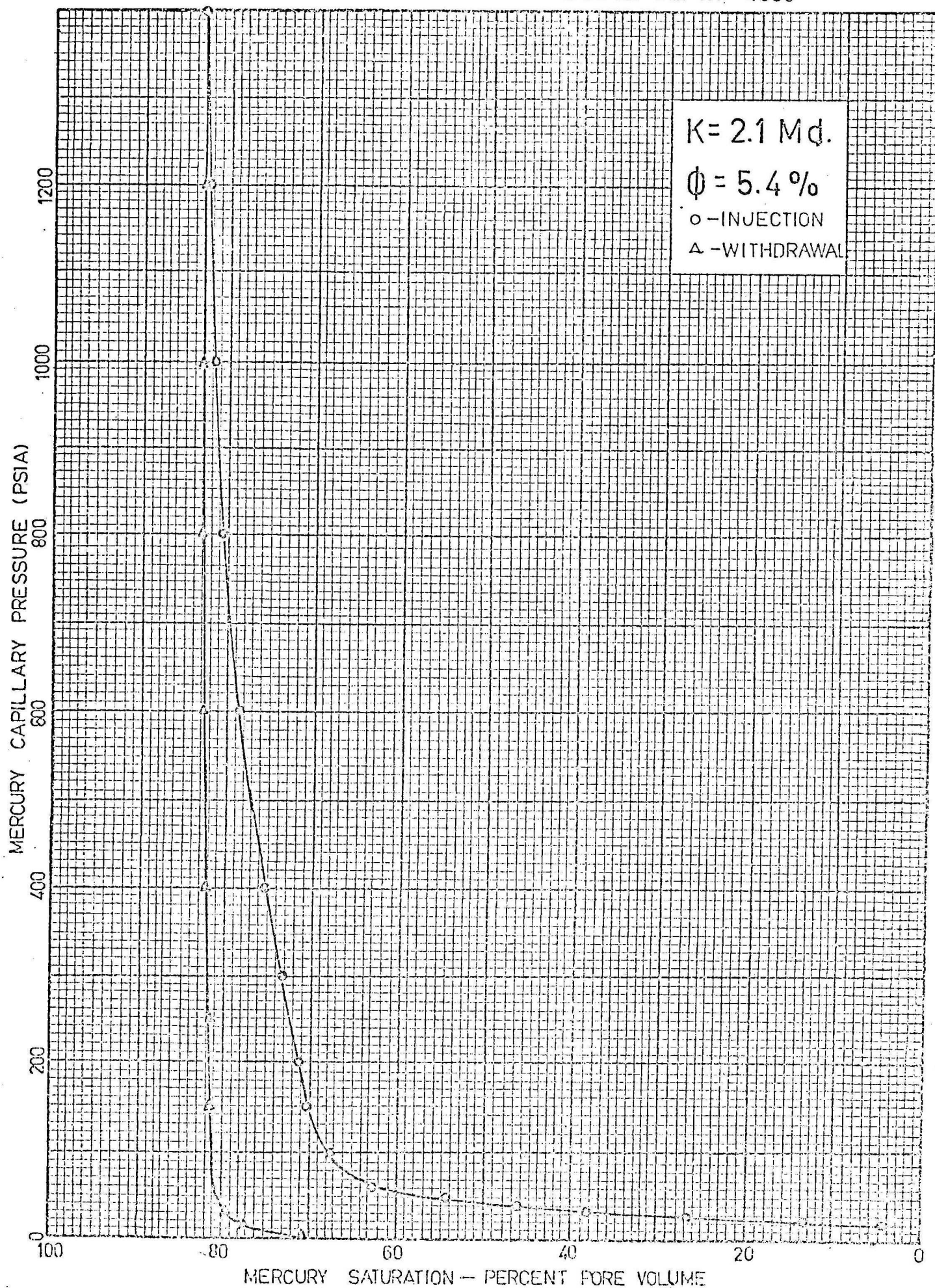
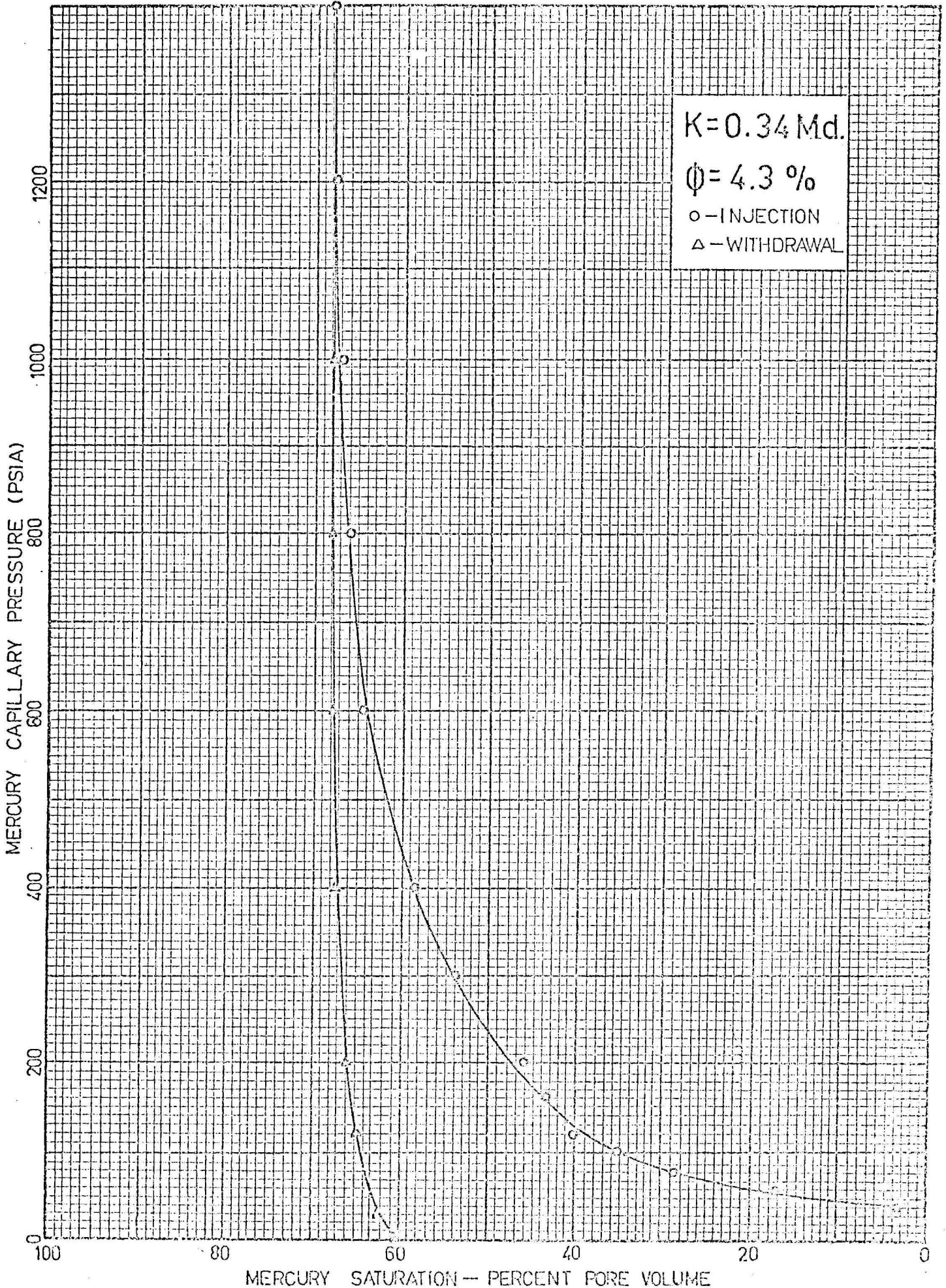


FIGURE 66

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No 2

SAMPLE DEPTH — 4657'



MERCURY CAPILLARY PRESSURE

SAMPLE DEPTH- 4753'

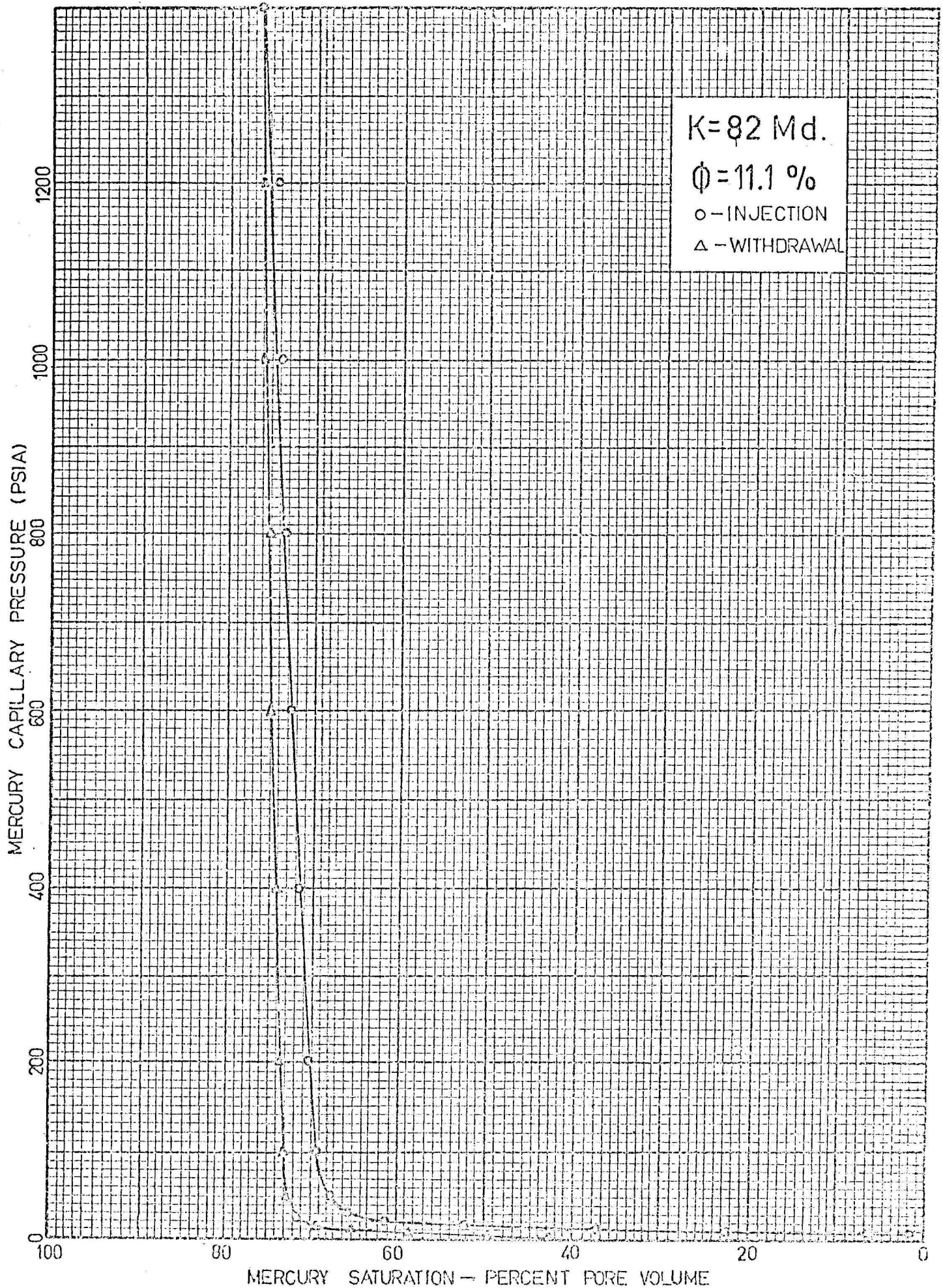


FIGURE 68

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No. 2

SAMPLE DEPTH — 4755'

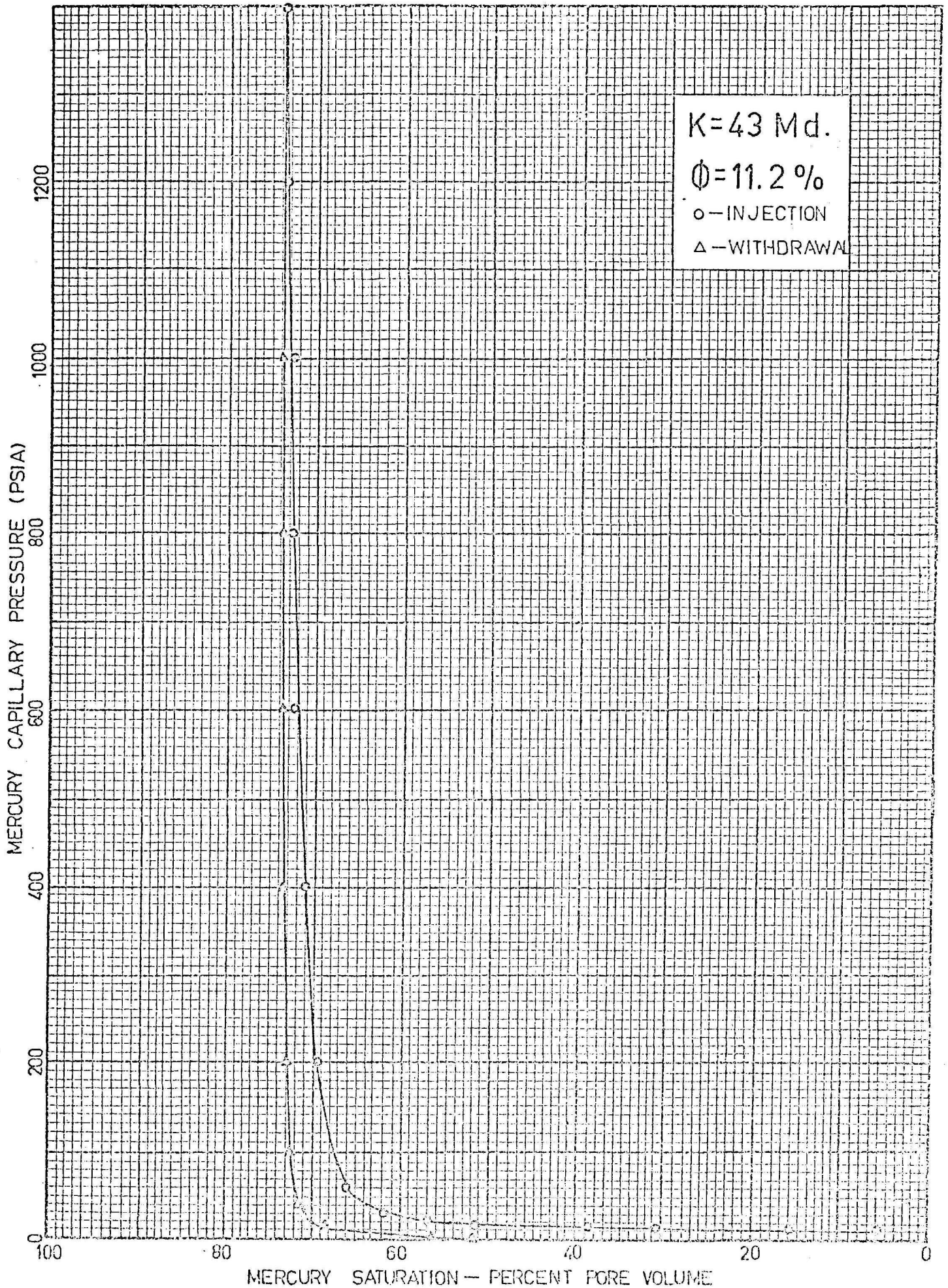


FIGURE 69

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MERENIE No 2

SAMPLE DEPTH — 4759'

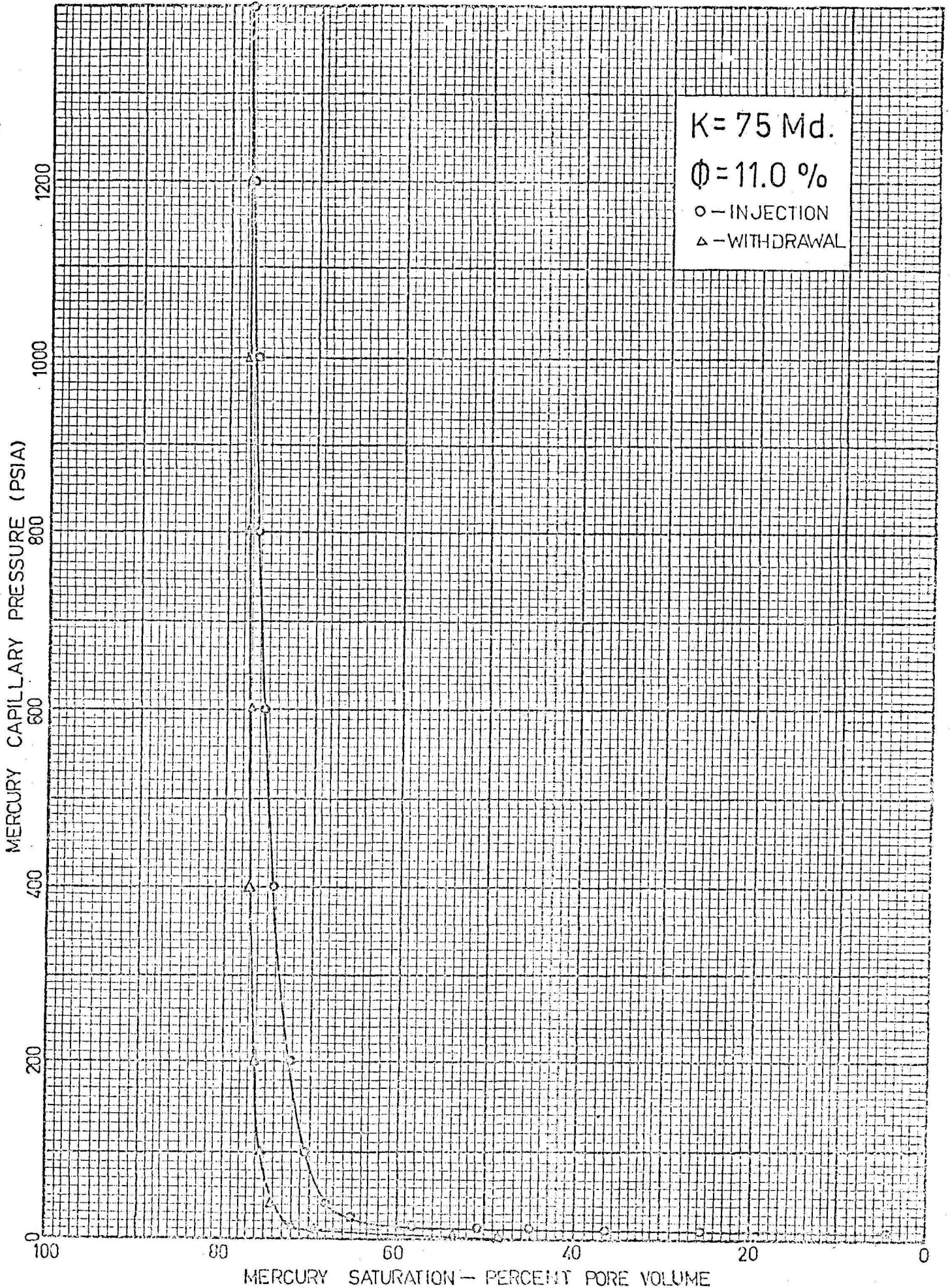


FIGURE 70

MERCURY CAPILLARY PRESSURE

WELL NAME — E MEREENE No 2

SAMPLE DEPTH — 4769'

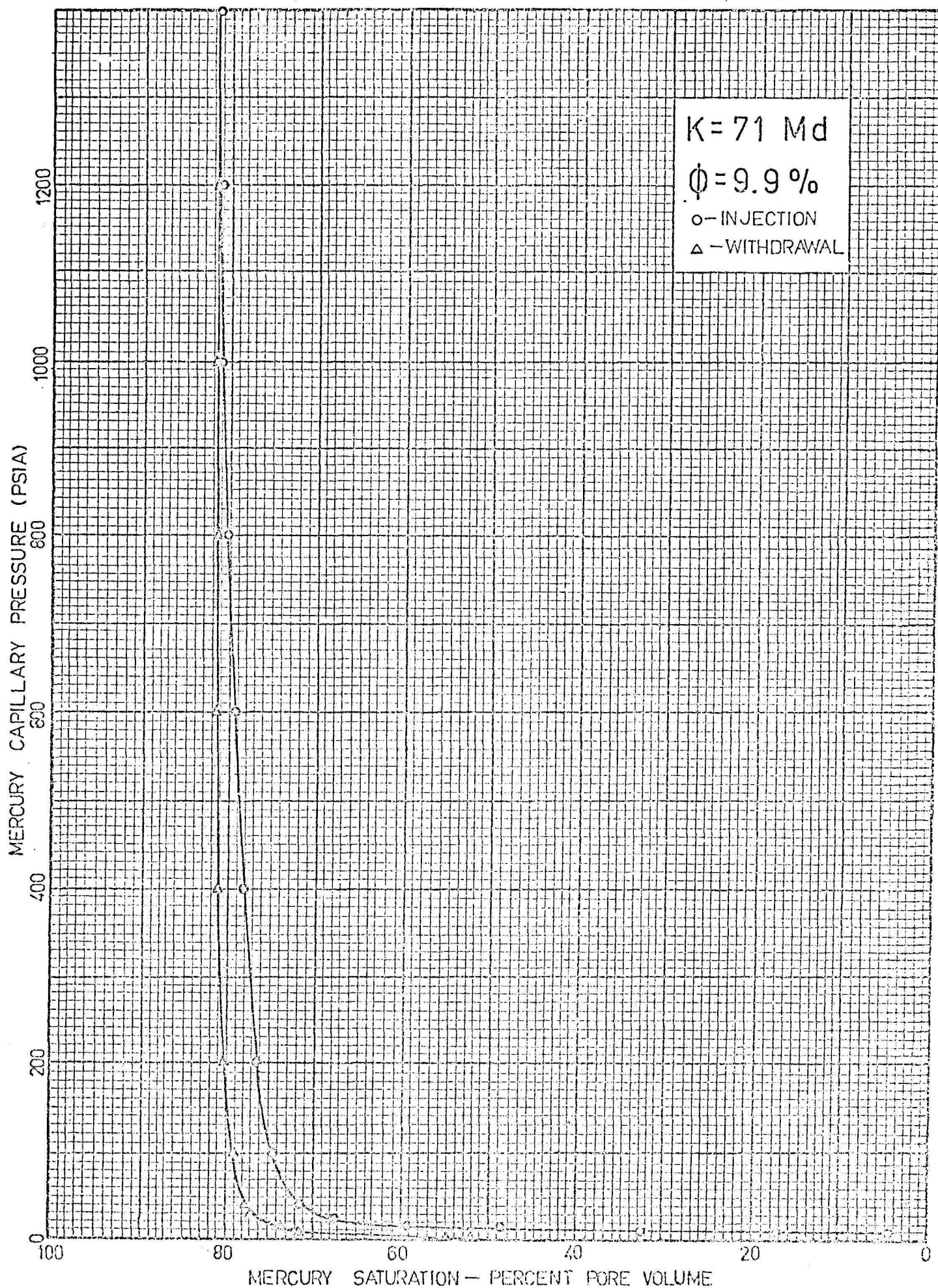


FIGURE 71

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No 4

SAMPLE DEPTH—4197'

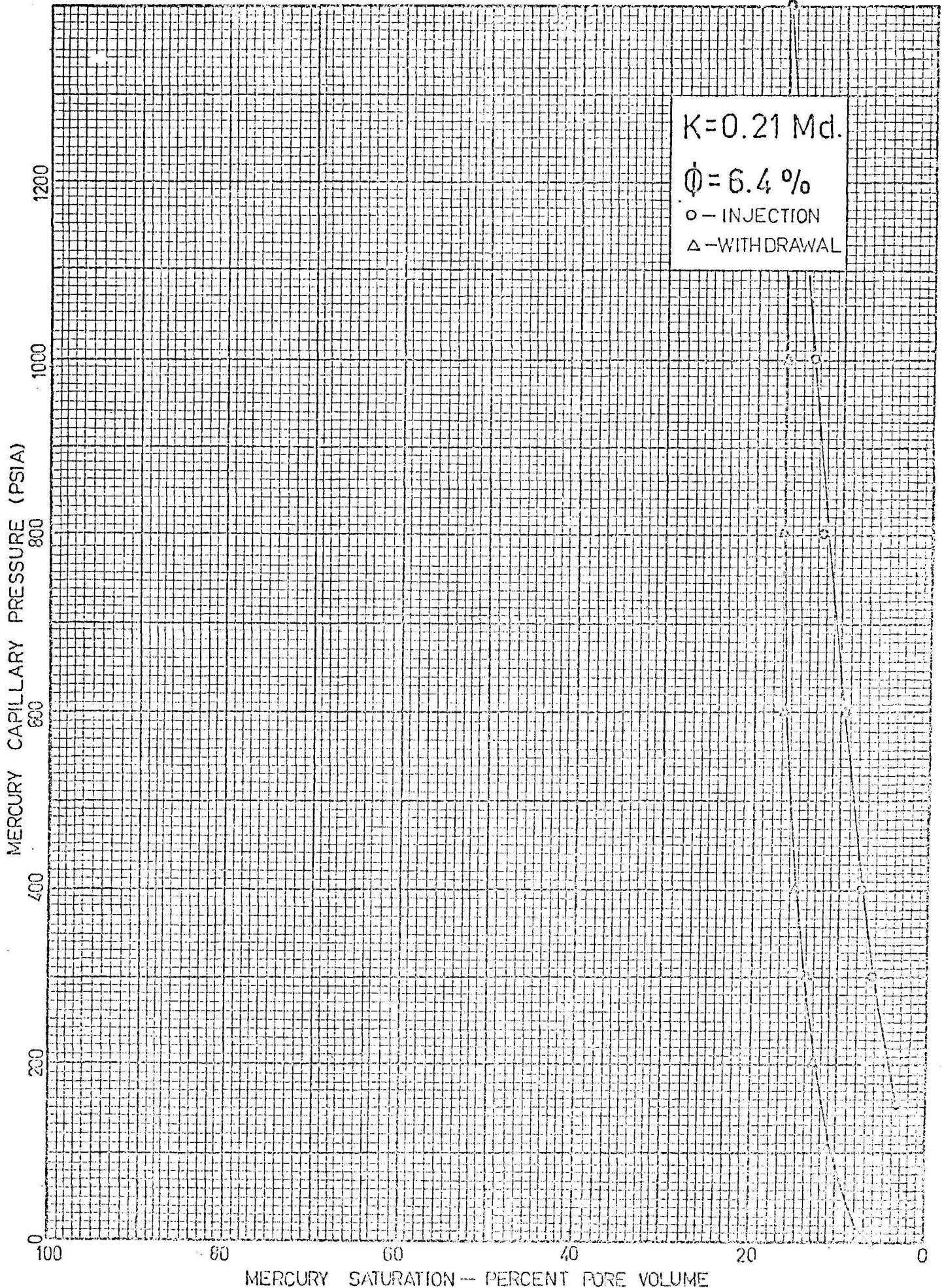


FIGURE 72

MERCURY CAPILLARY PRESSURE

WELL NAME -- E. MEREENIE No 4

SAMPLE DEPTH -- 4198'

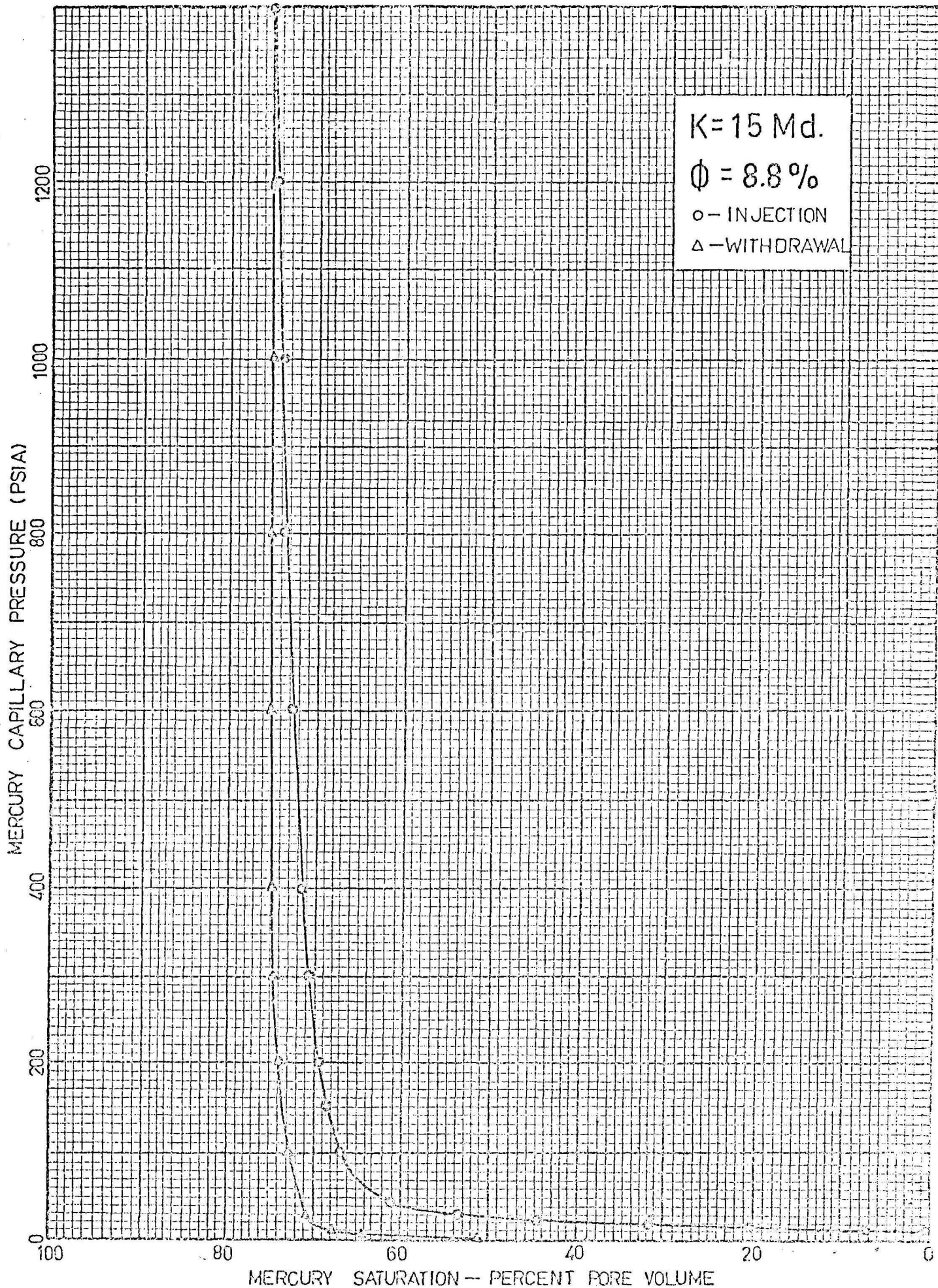


FIGURE 73

MERCURY CAPILLARY PRESSURE

WELL NAME — E. MEREENIE No 4

SAMPLE DEPTH — 4203'

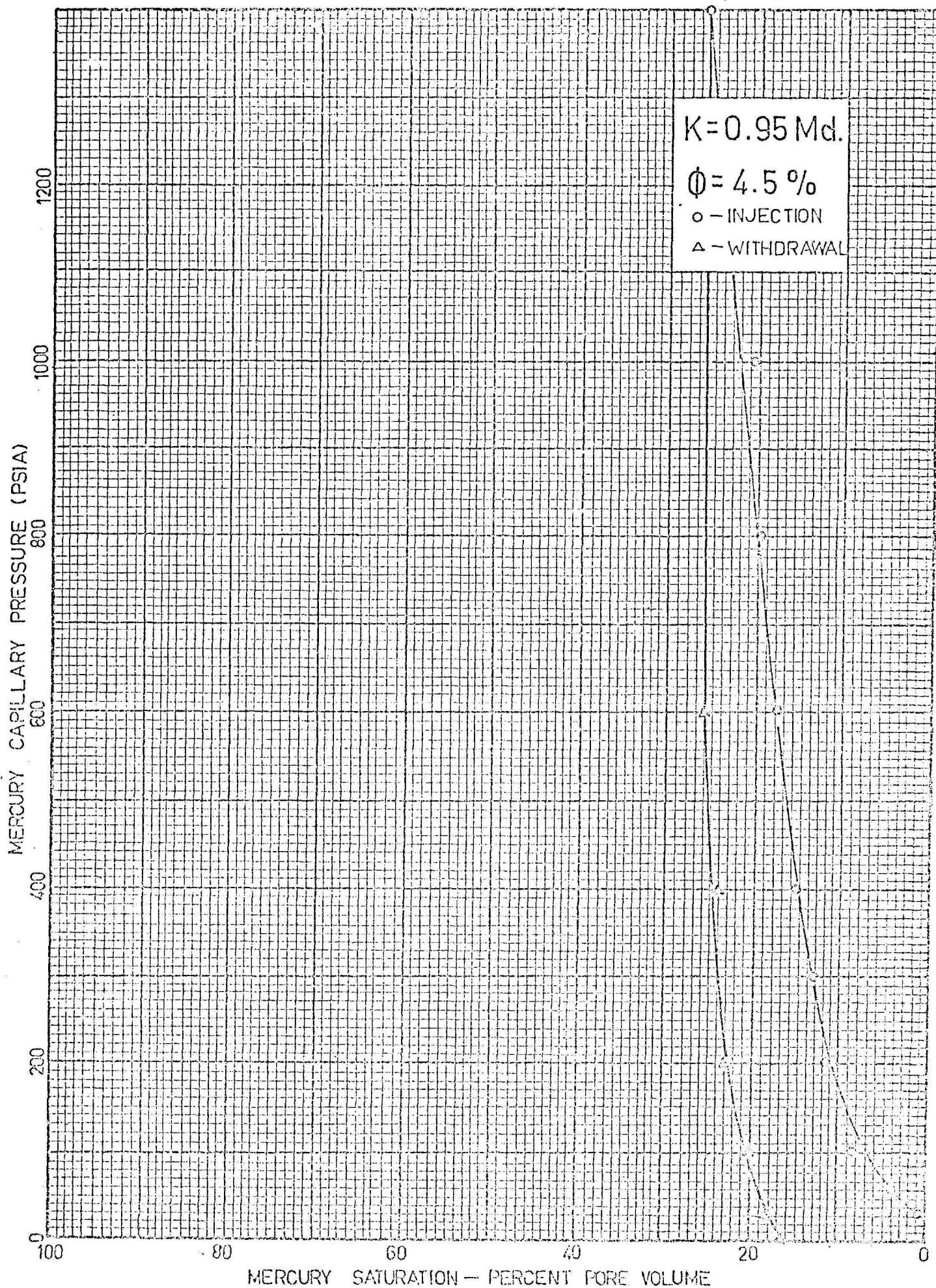


FIGURE 74

MERCURY CAPILLARY PRESSURE

WELL NAME -- W. MEREENIE No.1

SAMPLE DEPTH -- 4564'

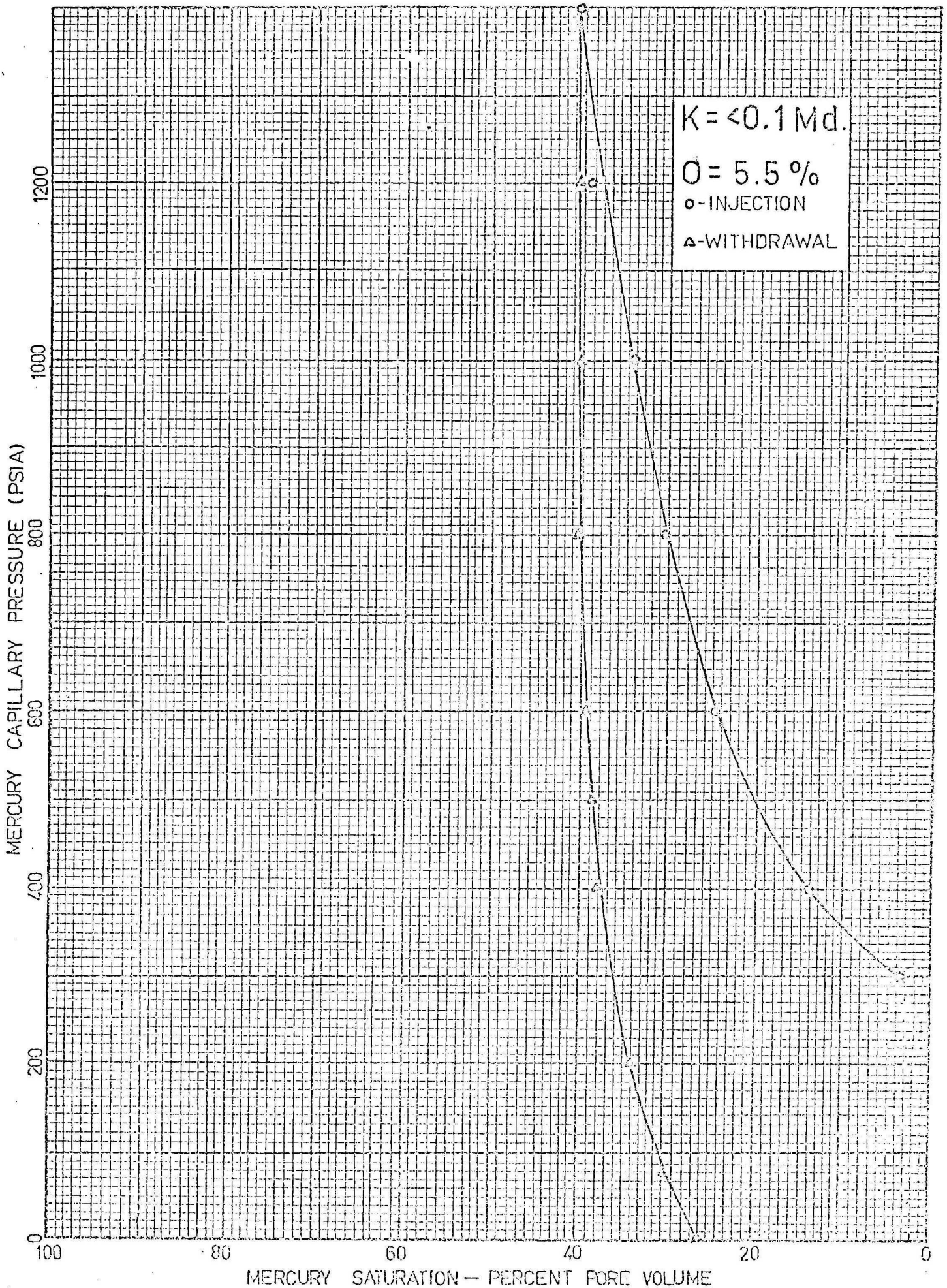


FIGURE 75

MERCURY CAPILLARY PRESSURE

WELL NAME --W.MERENIE No 1

SAMPLE DEPTH--4575

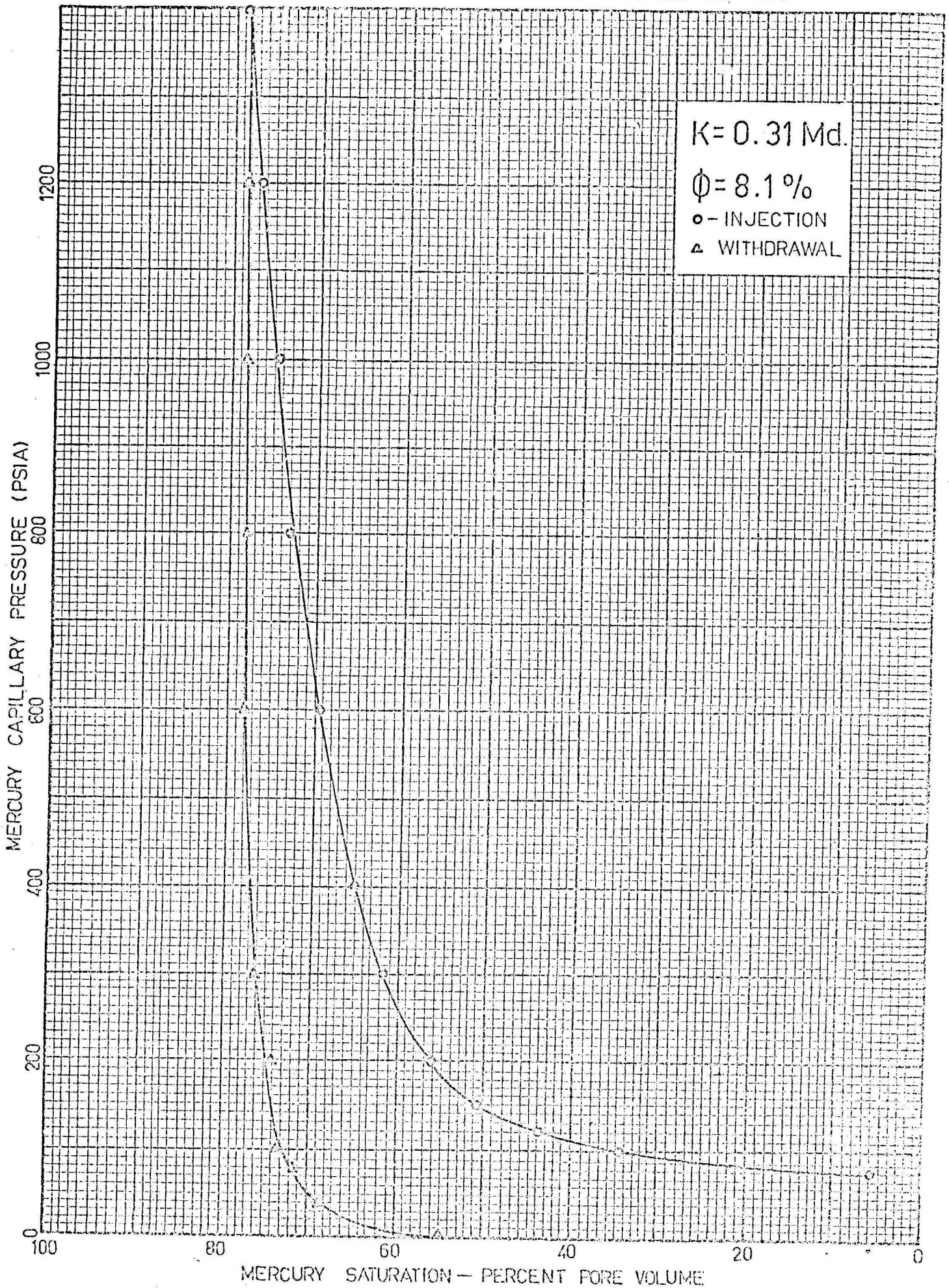


FIGURE 76

MERCURY CAPILLARY PRESSURE

WELL NAME -- W. MEREENIE No. 1

SAMPLE DEPTH -- 4585'

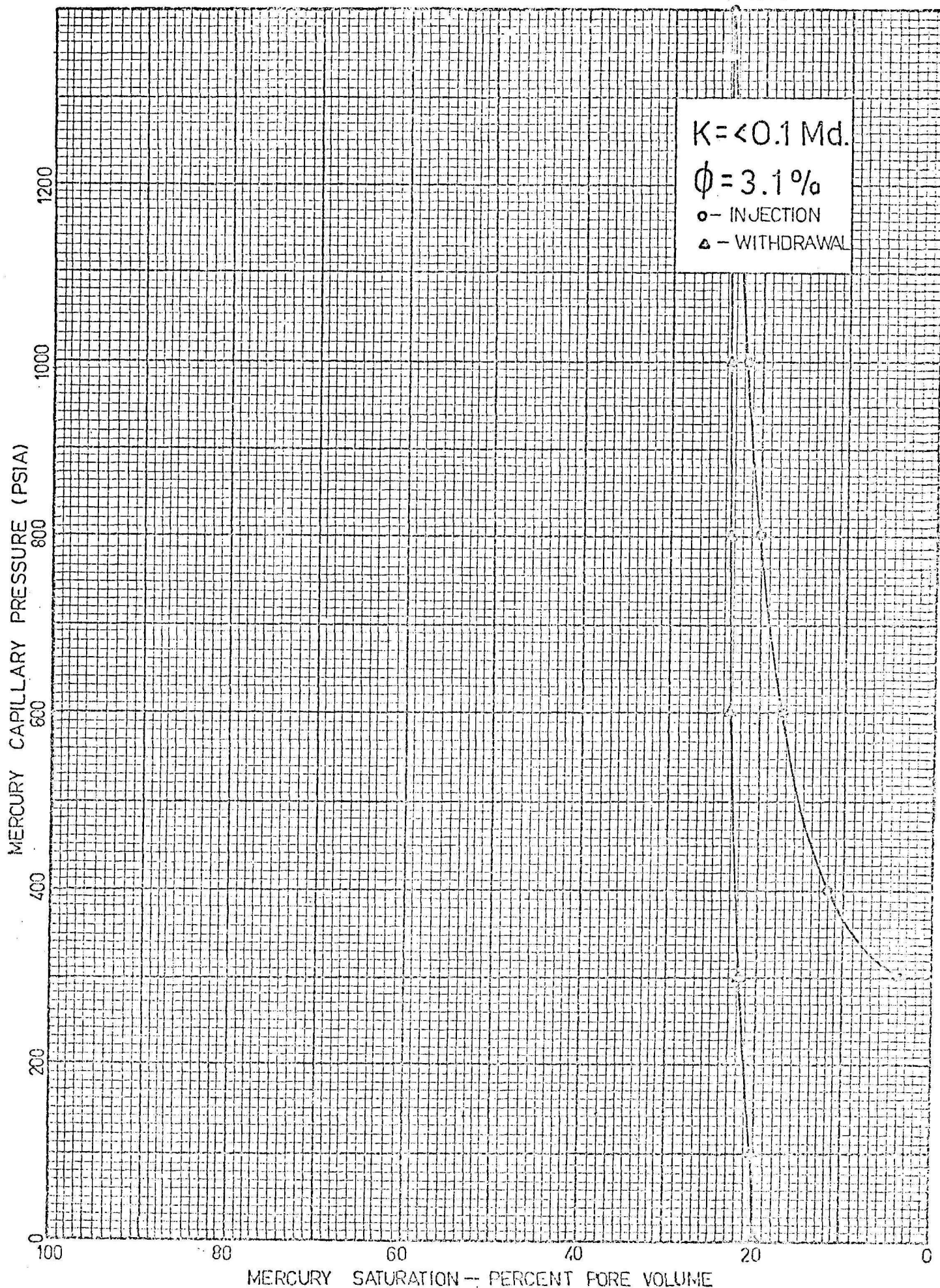


FIGURE 77

MERCURY CAPILLARY PRESSURE

WELL NAME — W. MEREENIE No.1

SAMPLE DEPTH — 4596'

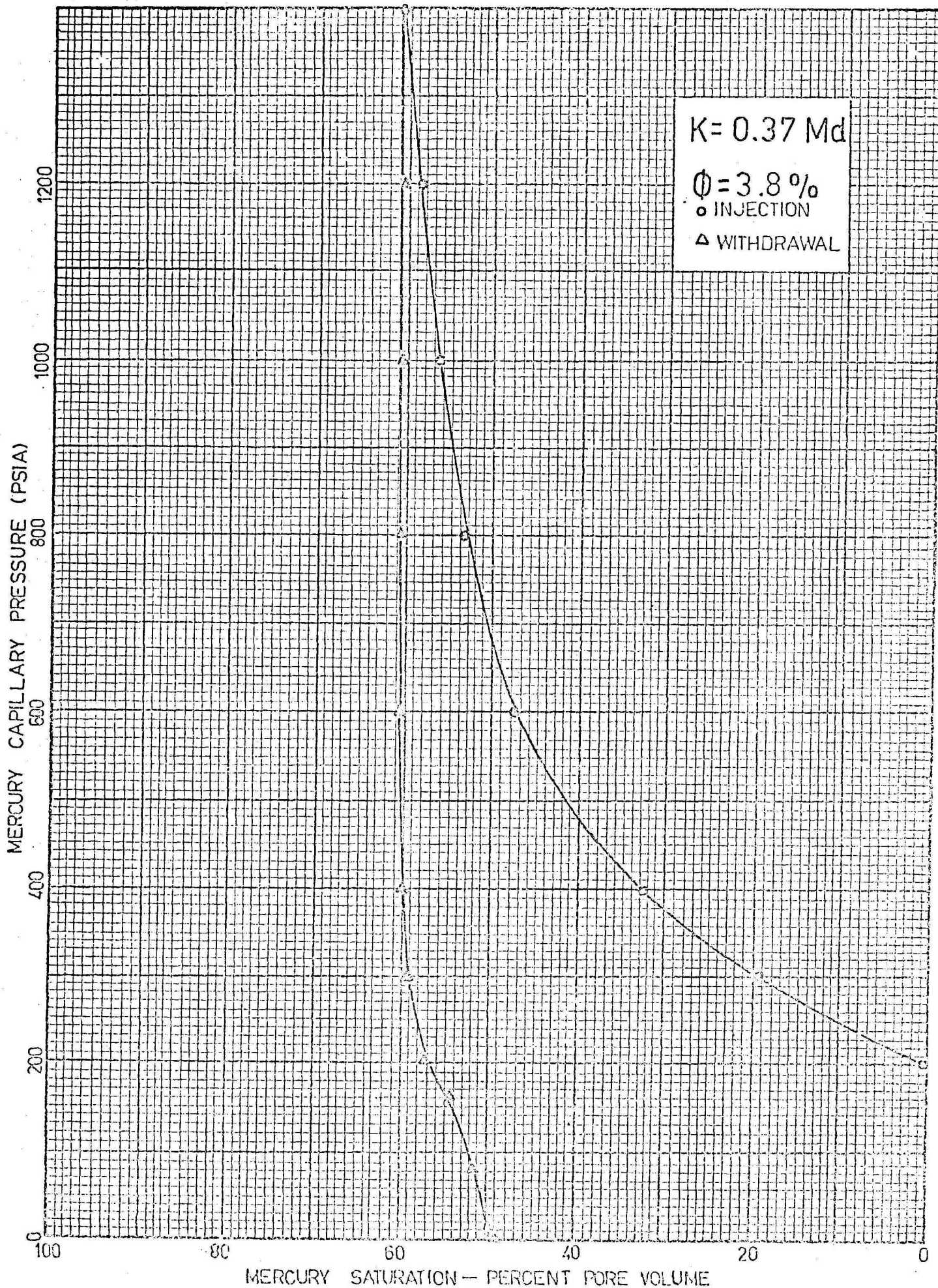


FIGURE 79

MERCURY CAPILLARY PRESSURE

WELL NAME — W.MERENIE No.1

SAMPLE DEPTH — 4644'

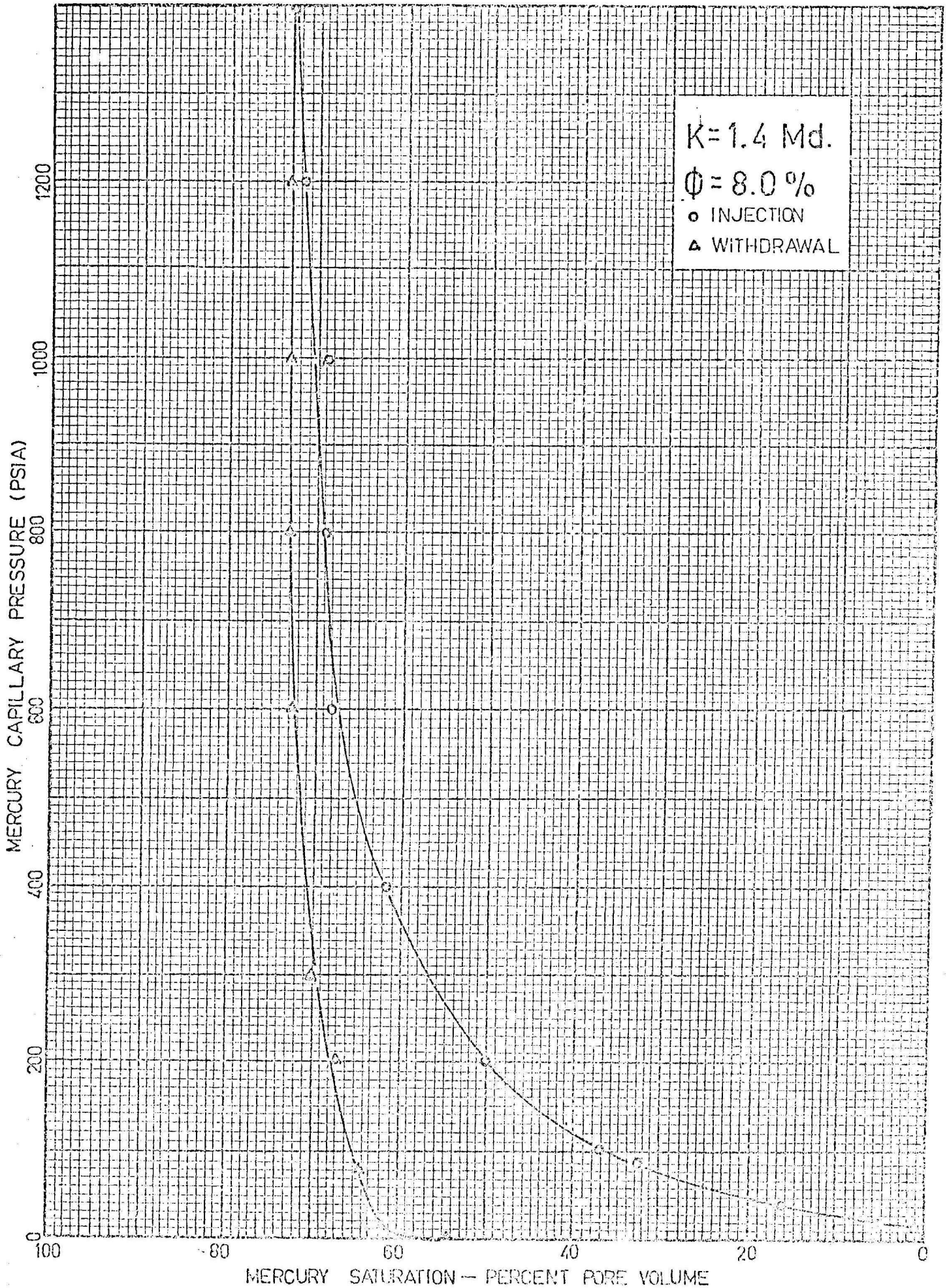
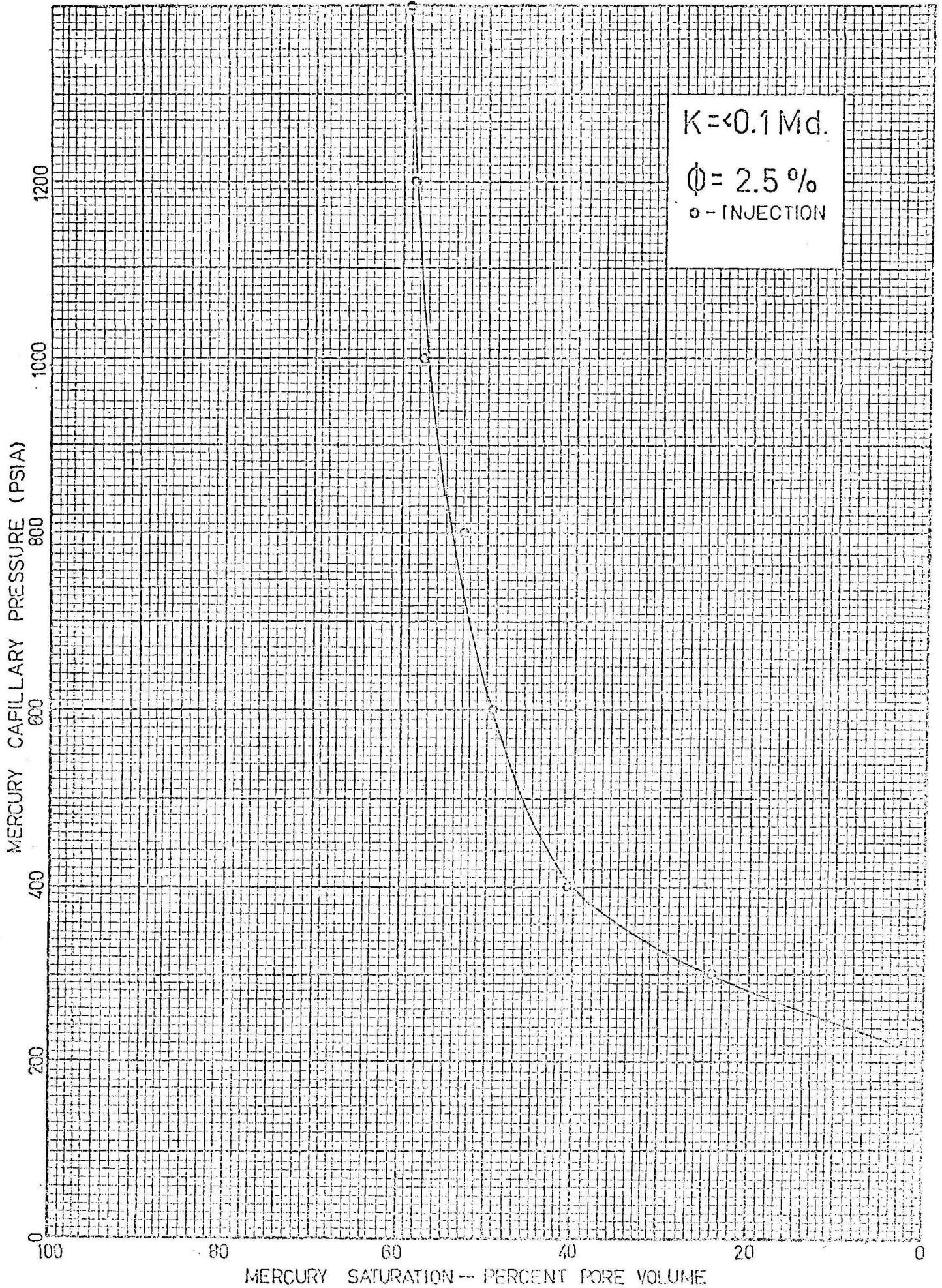


FIGURE 79

MERCURY CAPILLARY PRESSURE

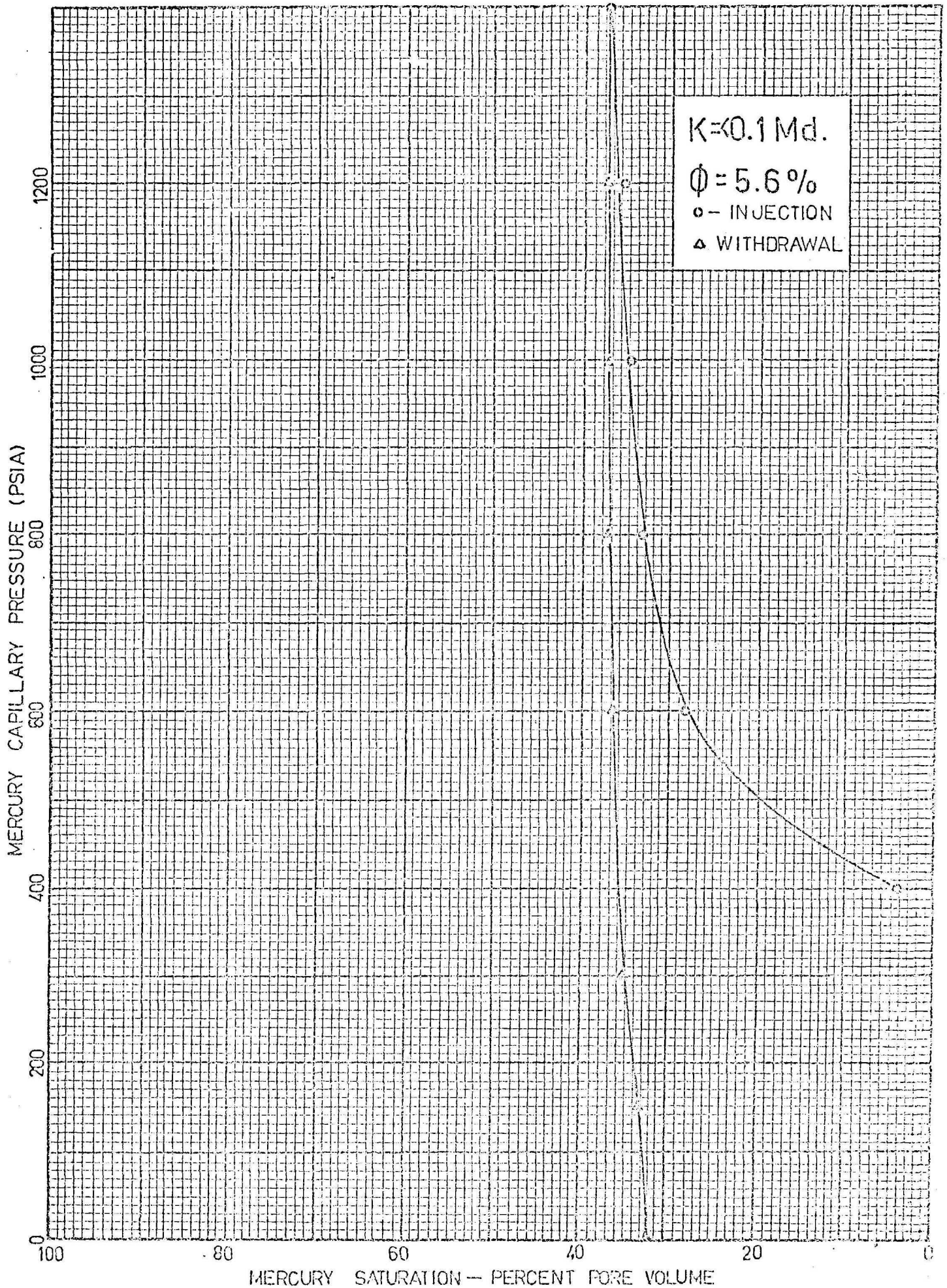
WELL NAME -W. MEREENIE No 1

SAMPLE DEPTH -5259'



MERCURY CAPILLARY PRESSURE

SAMPLE DEPTH- 5267'



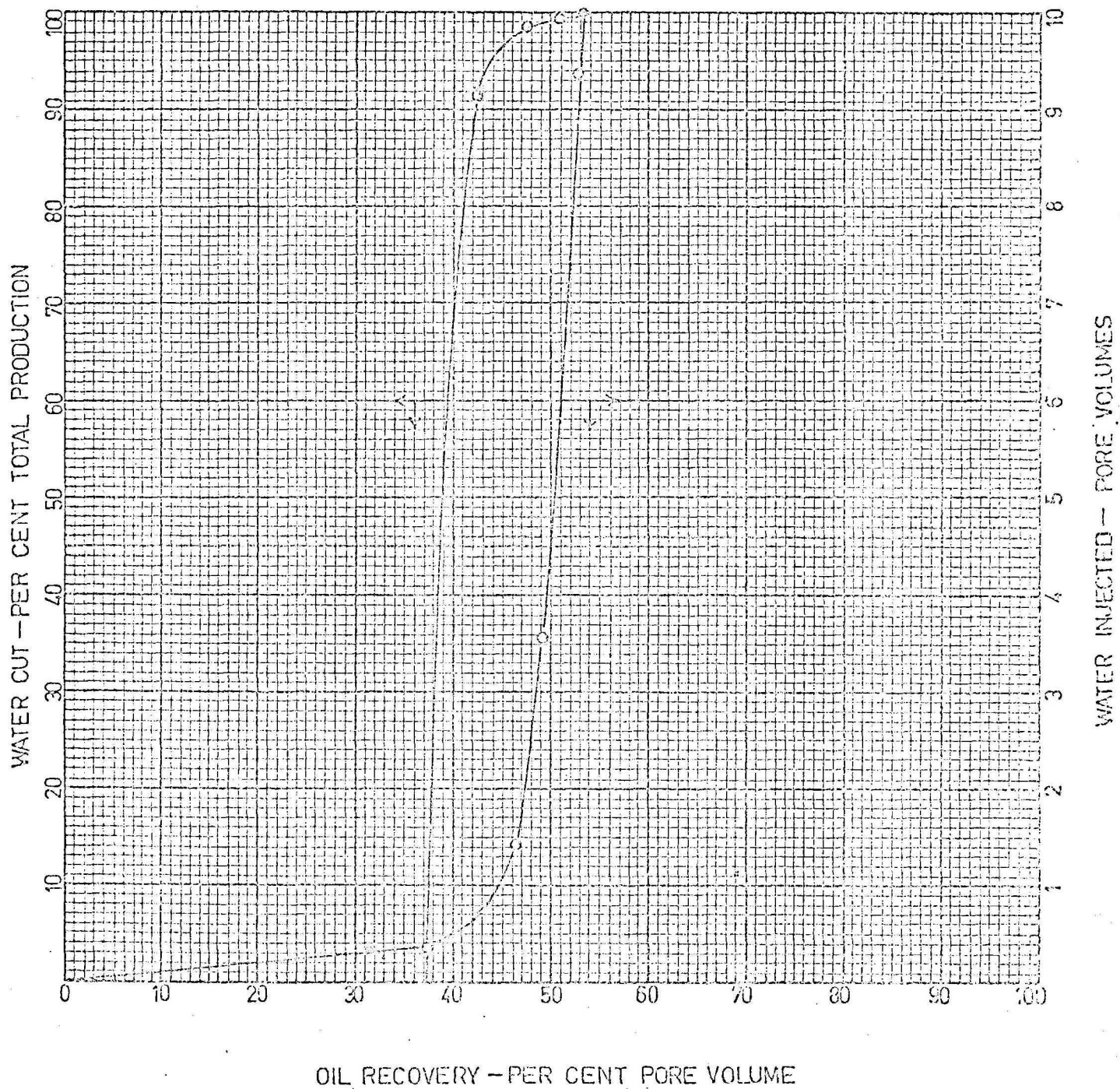
WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E. MEREENIE No 4

DEPTH INTERVAL - 4631'

POROSITY - 8.4%

PERMEABILITY - 30 Md.



WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E. MEREENIE No. 4

DEPTH INTERVAL - 4633'

POROSITY - 8.5 %

PERMEABILITY - 9.5 Md.

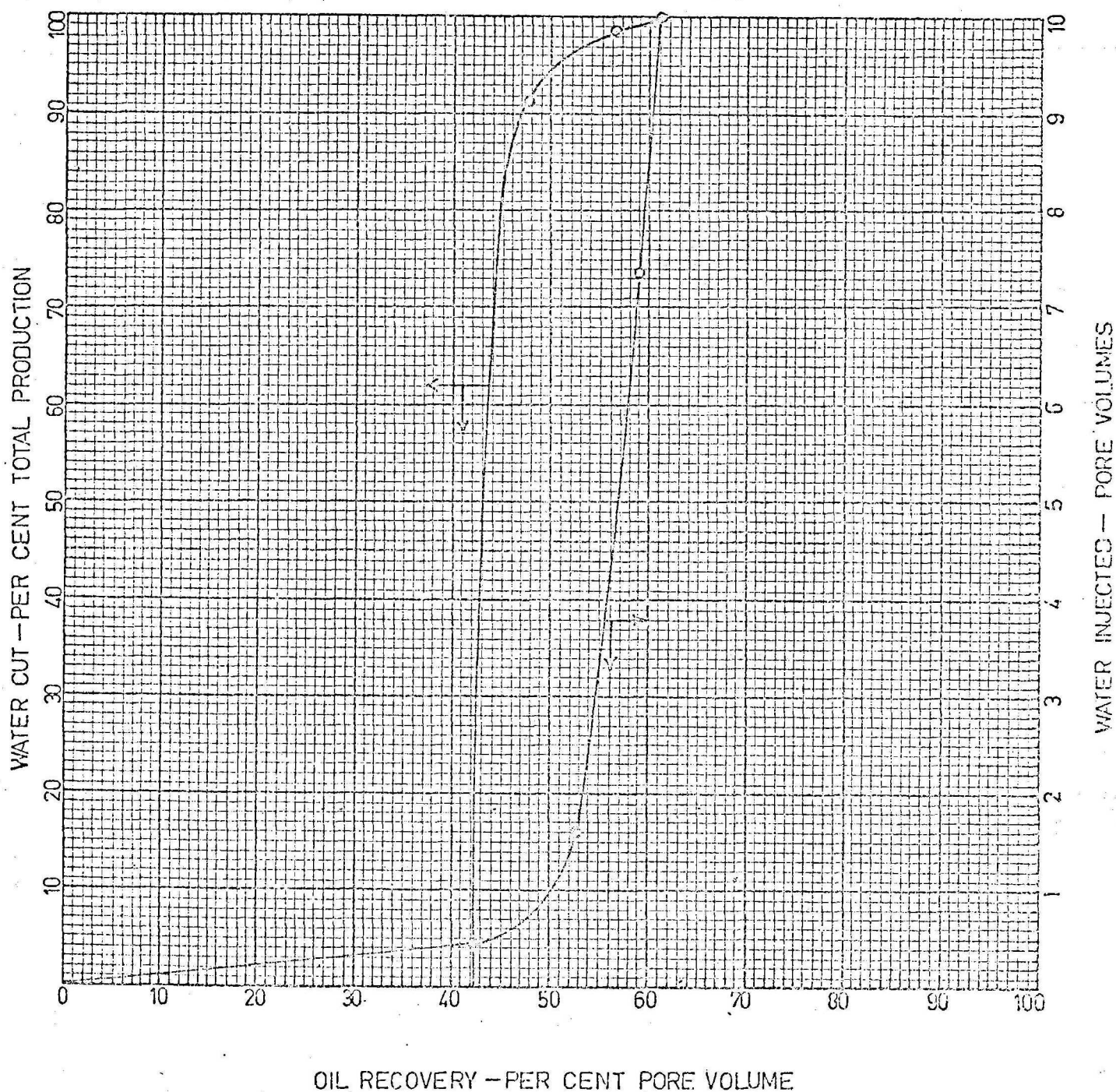


FIGURE 93

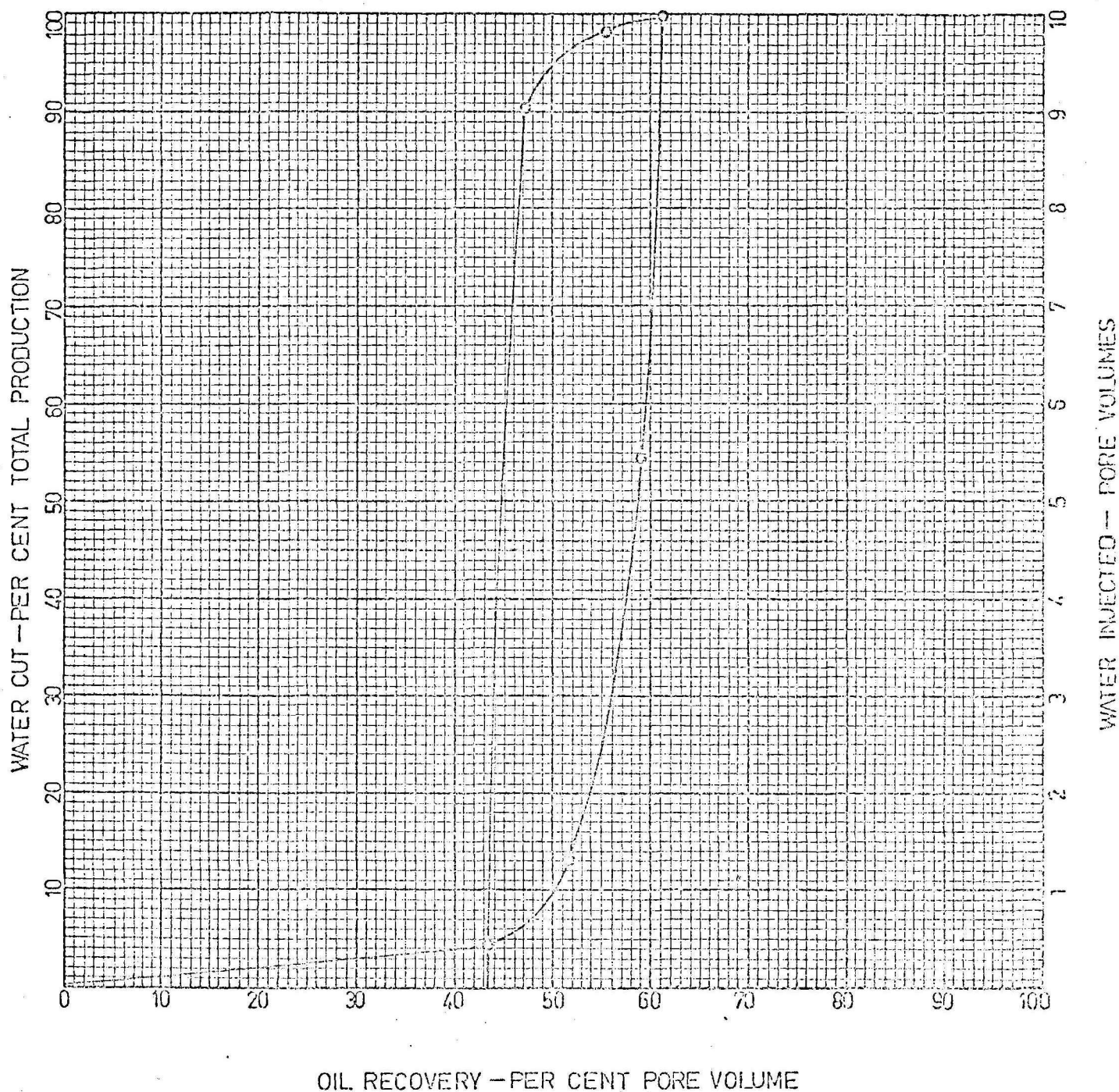
WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E. MERREENIE No. 4

DEPTH INTERVAL - 4710'

POROSITY - 10.4%

PERMEABILITY - 31 Md.



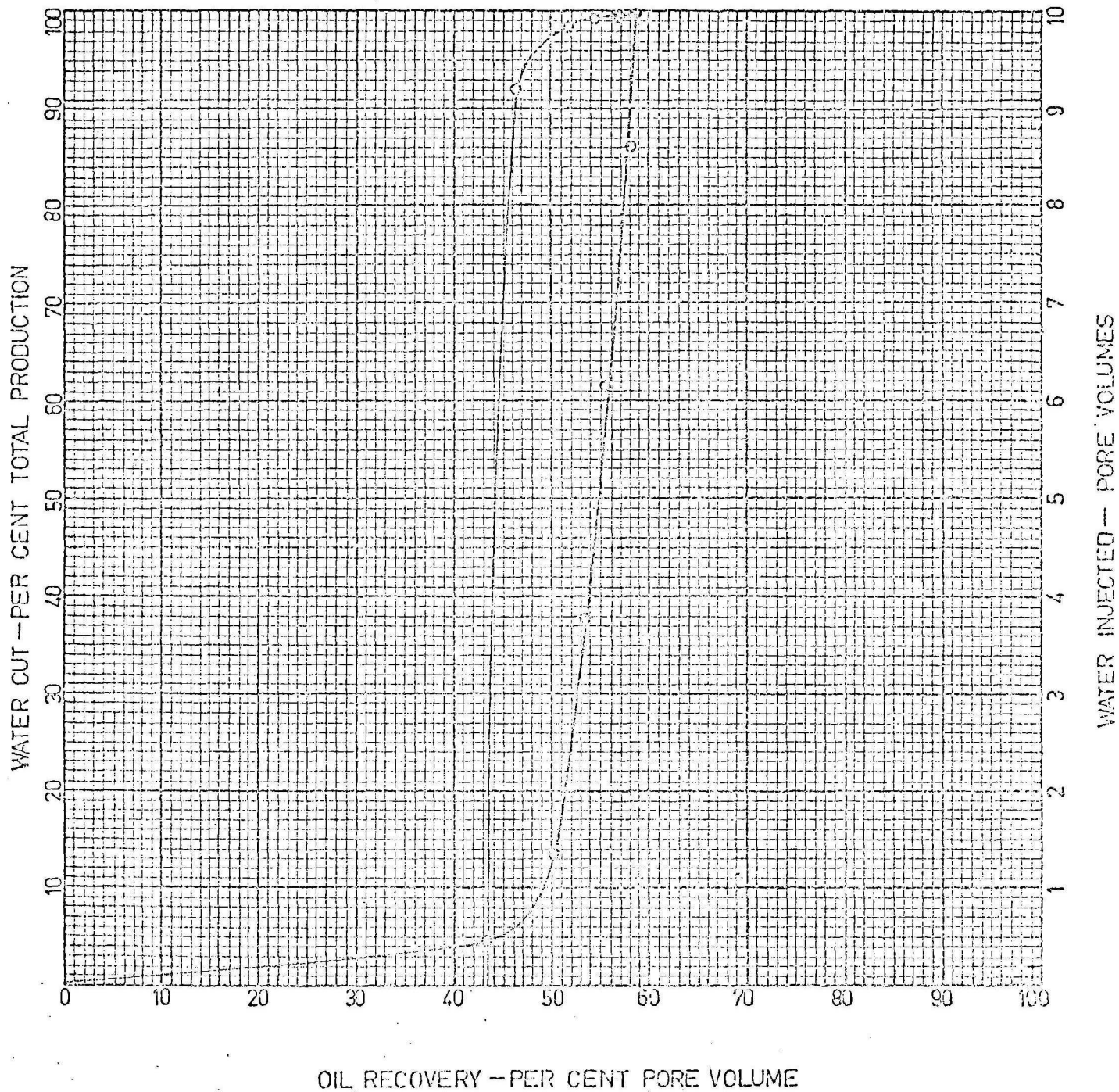
WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E. MEREEENIE No. 4

DEPTH INTERVAL - 4711

POROSITY - 10%

PERMEABILITY - 21 Md.



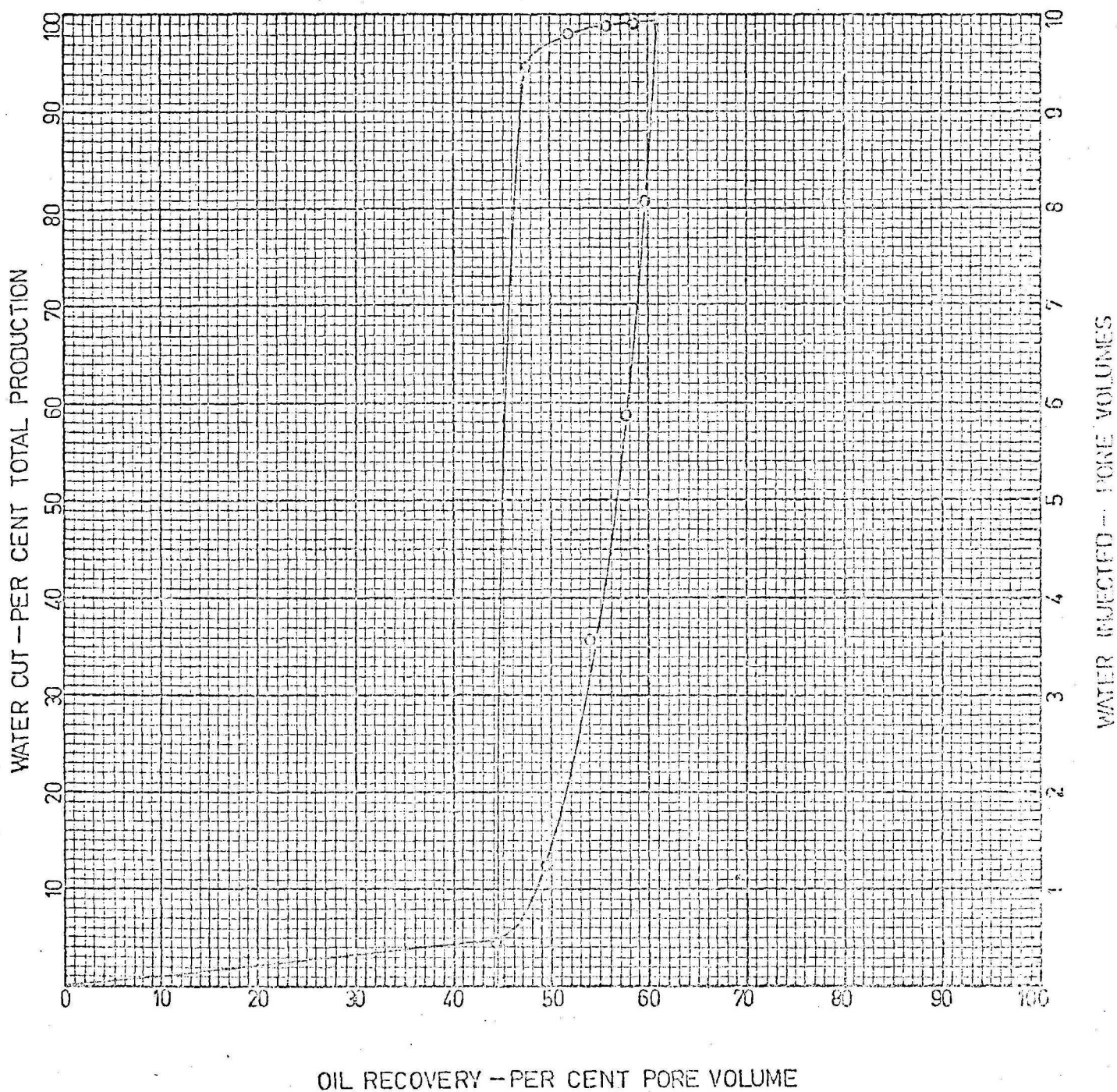
WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E. MERREENIE No. 4

DEPTH INTERVAL - 4712'

POROSITY - 10 %

PERMEABILITY - 16 Md.



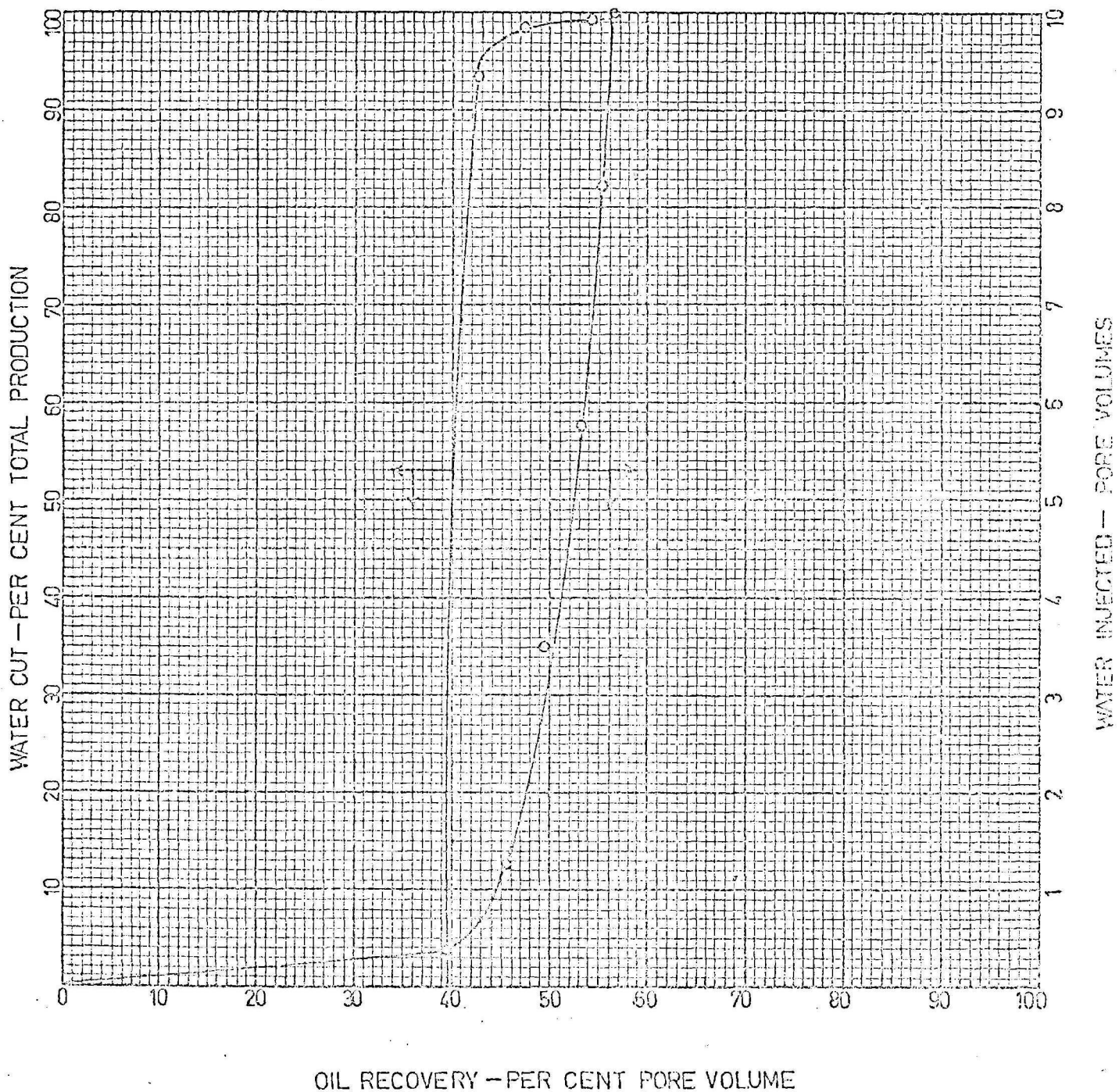
WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER--E.MEREEENIE No. 4

DEPTH INTERVAL--4713'

POROSITY--10.5%

PERMEABILITY--28.7 Md.



OIL RECOVERY - PER CENT PORE VOLUME

FIGURE 87

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E. MERREENIE No 4

DEPTH INTERVAL - 4742'

POROSITY - 11%

PERMEABILITY - 53 Md.

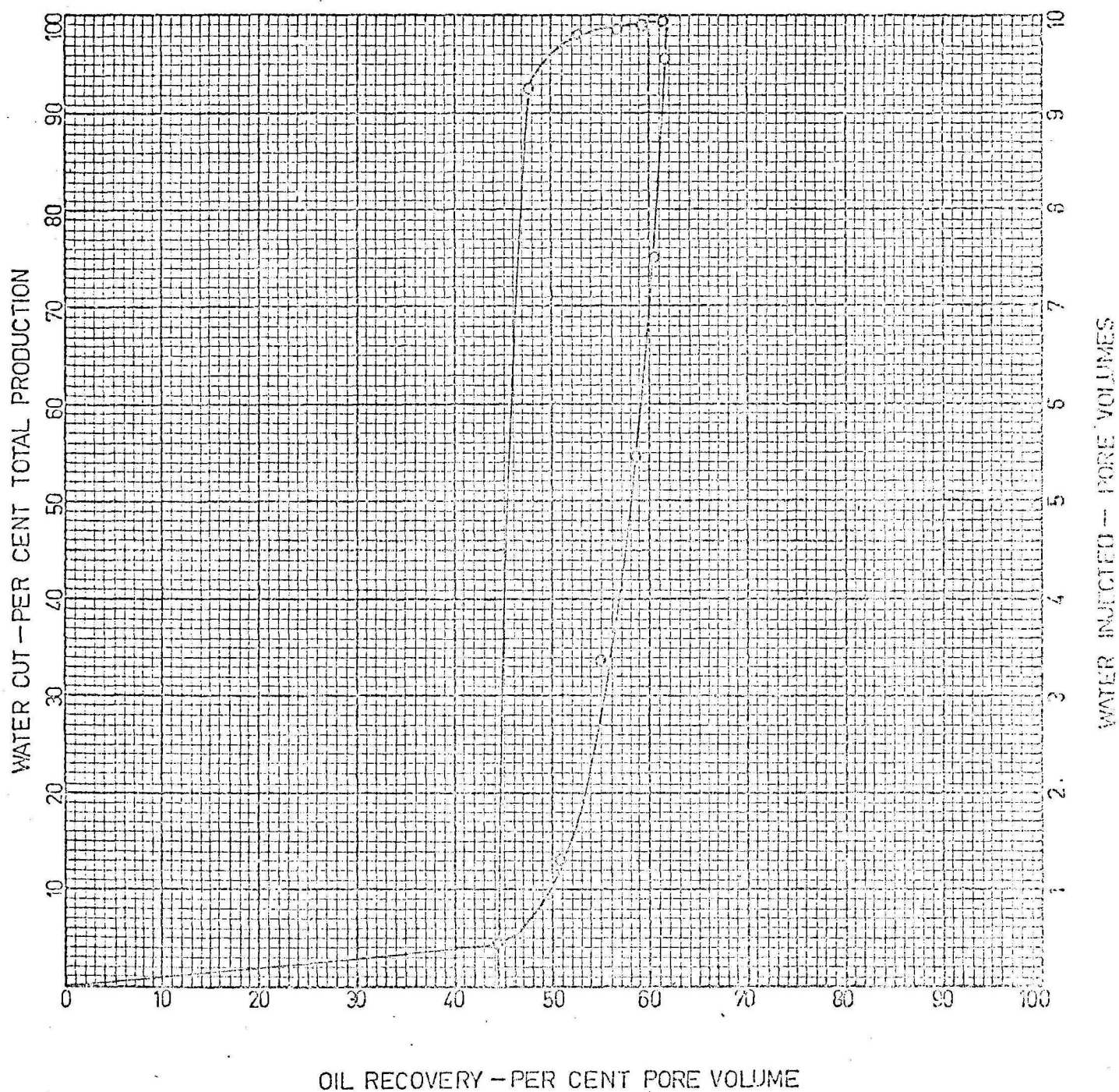


FIGURE 88

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E.MEREEENIE No.4

DEPTH INTERVAL - 4752'

POROSITY - 9.7 %

PERMEABILITY - 4.0 Md.

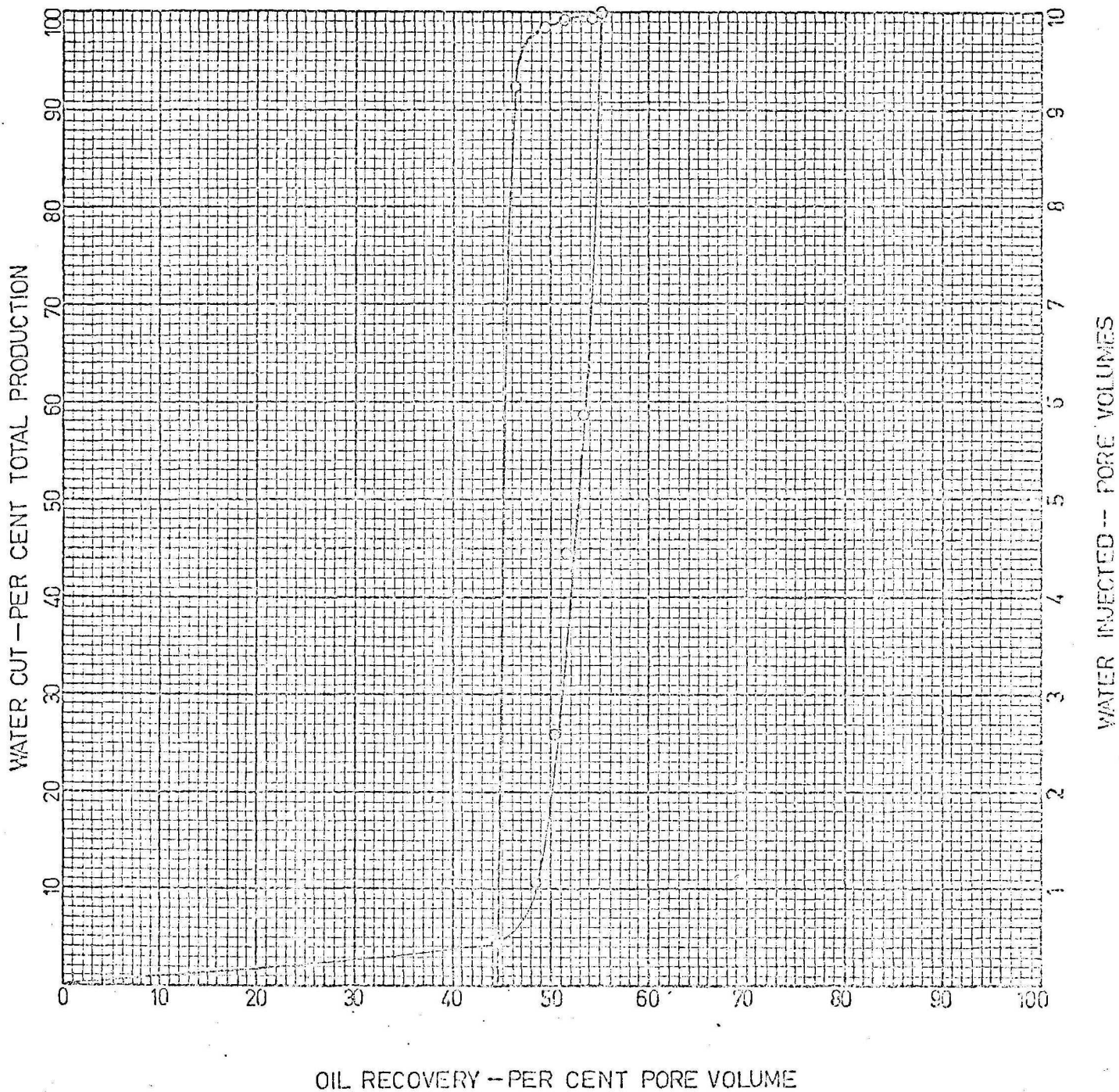


FIGURE 89

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E. MEREENIE No. 1

DEPTH INTERVAL - 4690'

POROSITY - 9.7 %

PERMEABILITY - 0.45 Md (Ko)

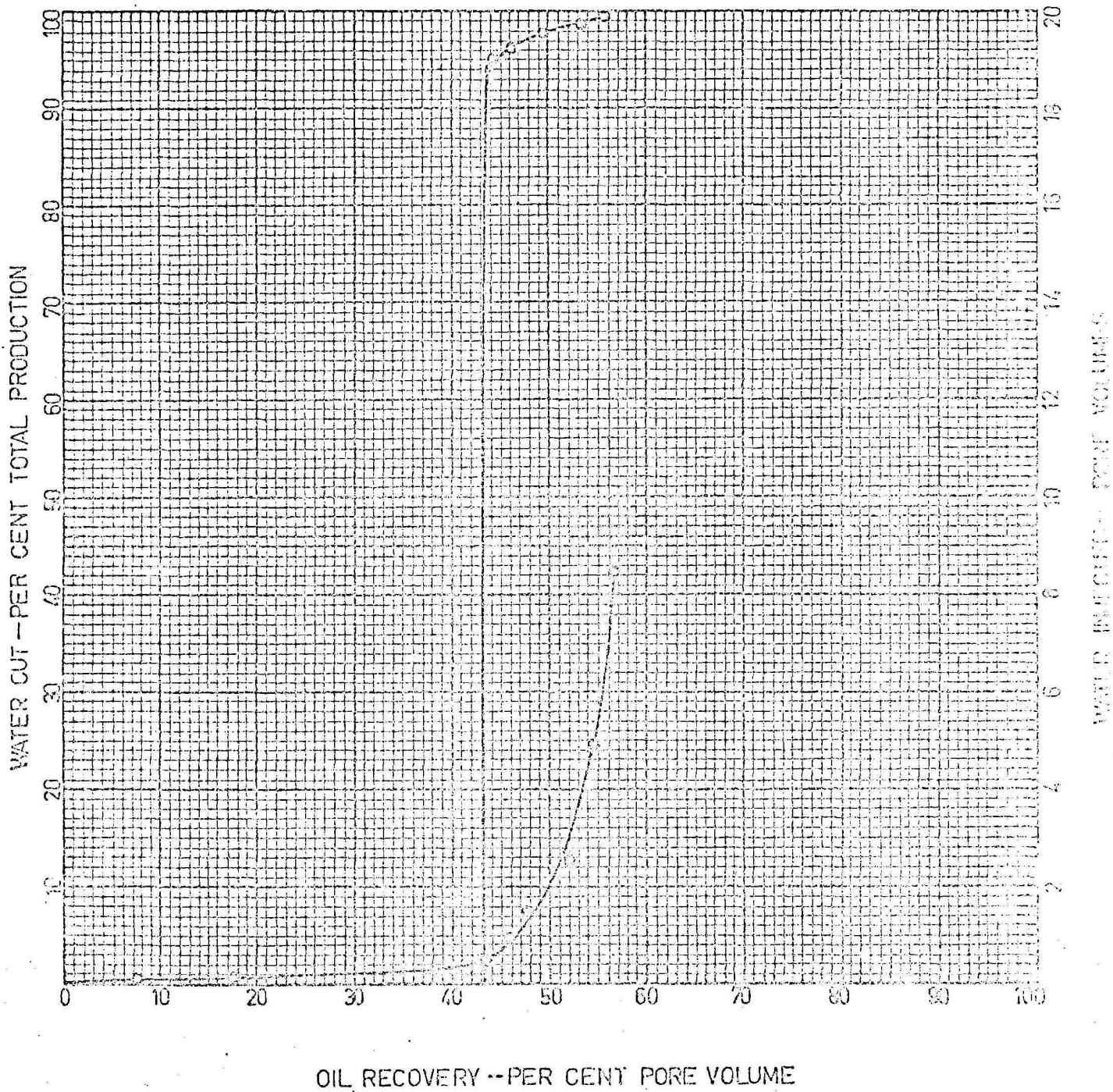


FIGURE 90

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E.MEREEENIE No. 2

DEPTH INTERVAL - 4446'

POROSITY - 6.9 %

PERMEABILITY - 0.11 Md (Ko)

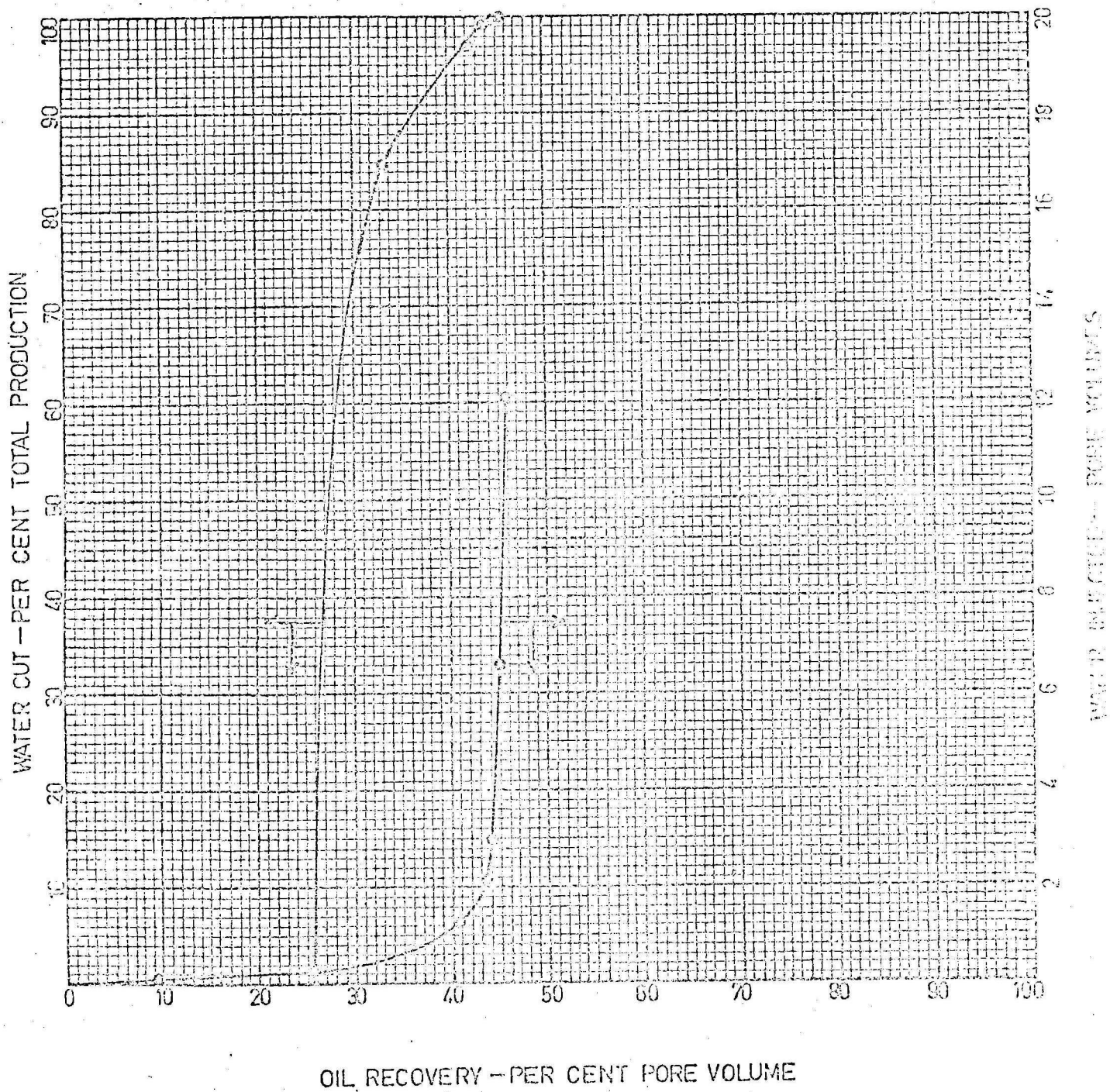


FIGURE 91

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E.MEREEENIE No. 2

DEPTH INTERVAL - 4653'

POROSITY - 5.4 %

PERMEABILITY - 1.0 Md (Ko)

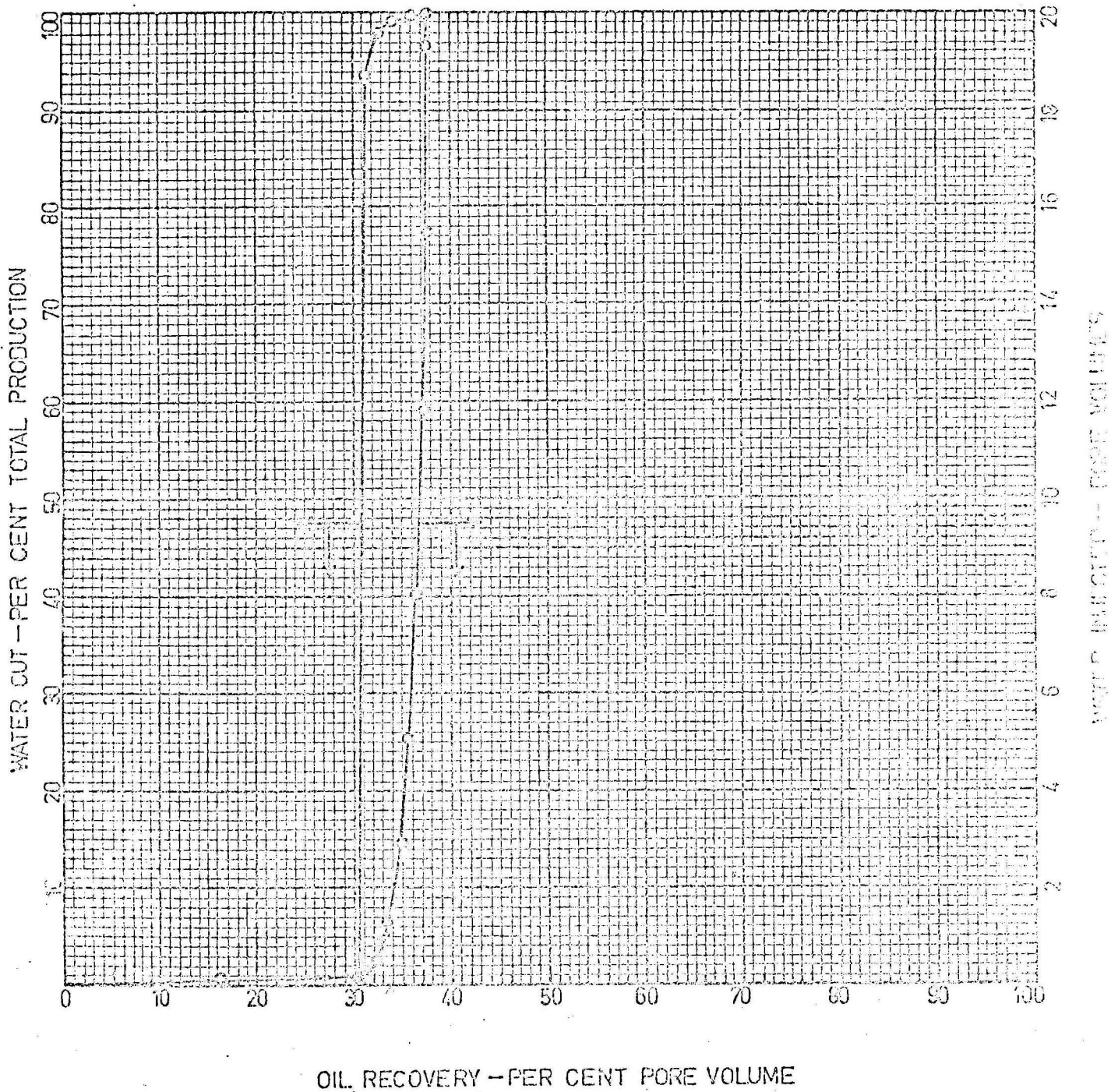


FIGURE 92

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E. MERREENIE No. 2

DEPTH INTERVAL - 4753

POROSITY - 11.1%

PERMEABILITY - 80 Md (Ko)

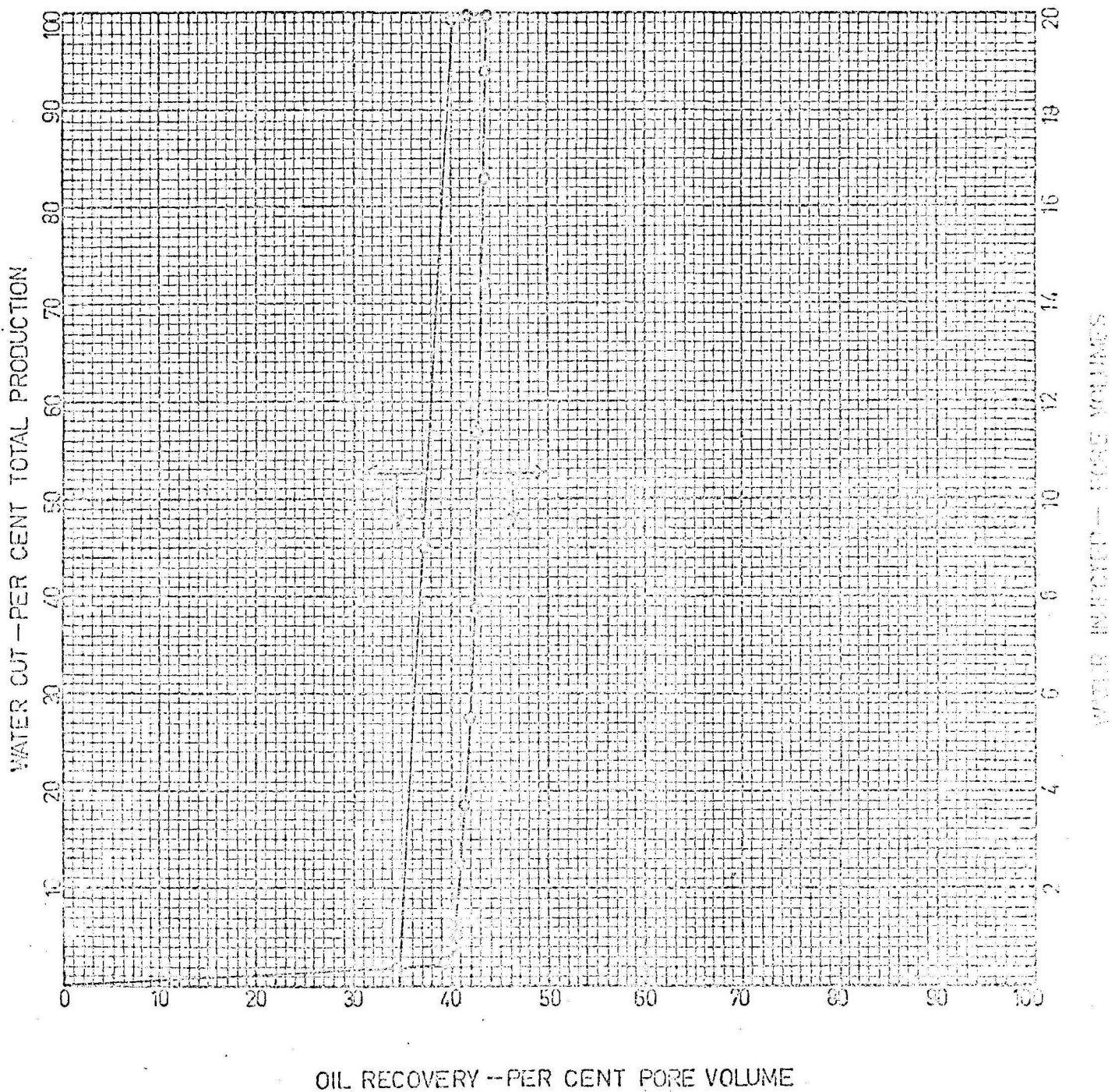


FIGURE 93

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E. MEREEENIE No 2

DEPTH INTERVAL - 4755'

POROSITY - 11.2%

PERMEABILITY - 42 Md (Ko)

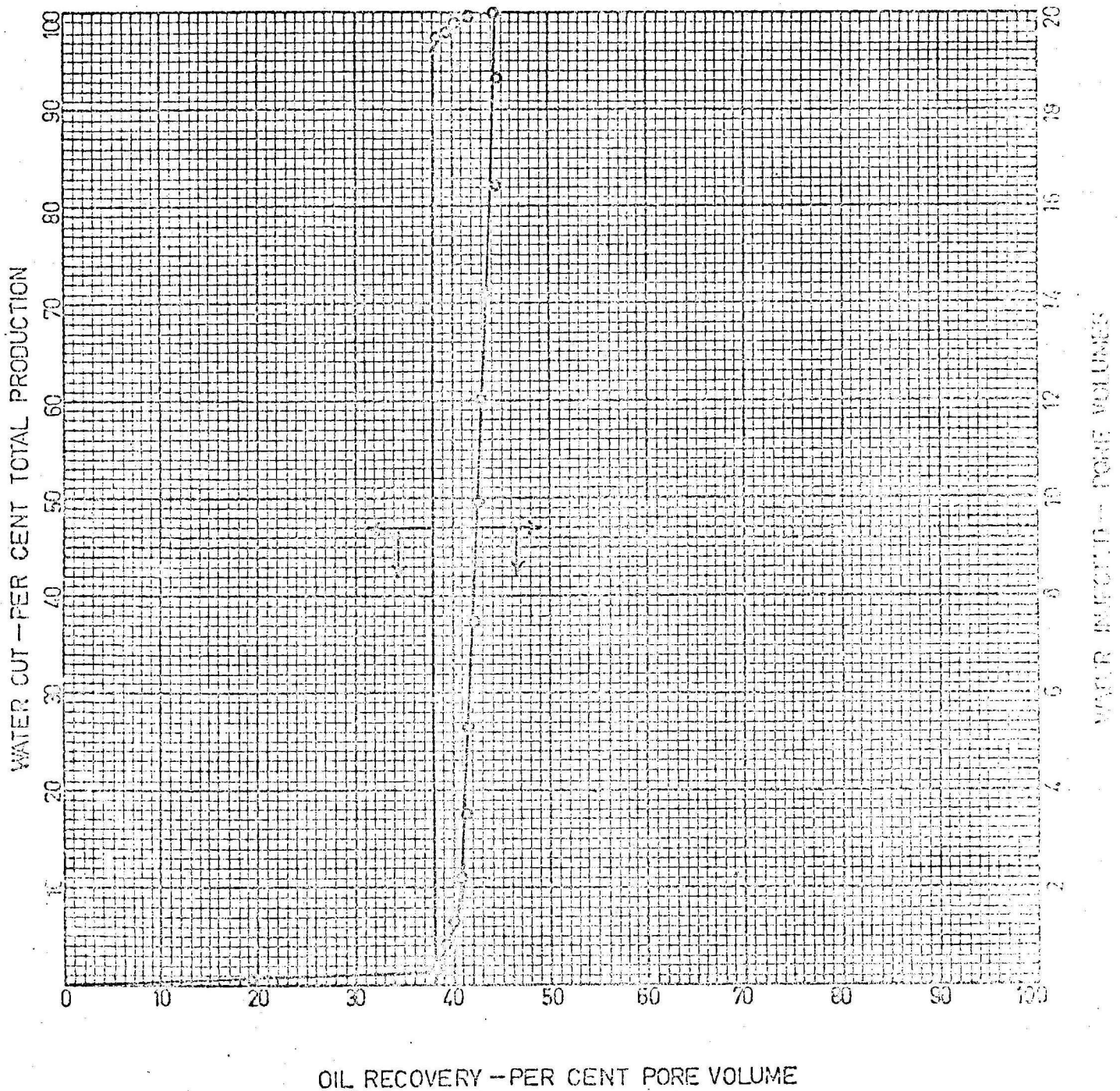


FIGURE 94

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E. MEREEENIE No 2

DEPTH INTERVAL - 4759'

POROSITY - 11.0 %

PERMEABILITY - 74 Md(Ko)

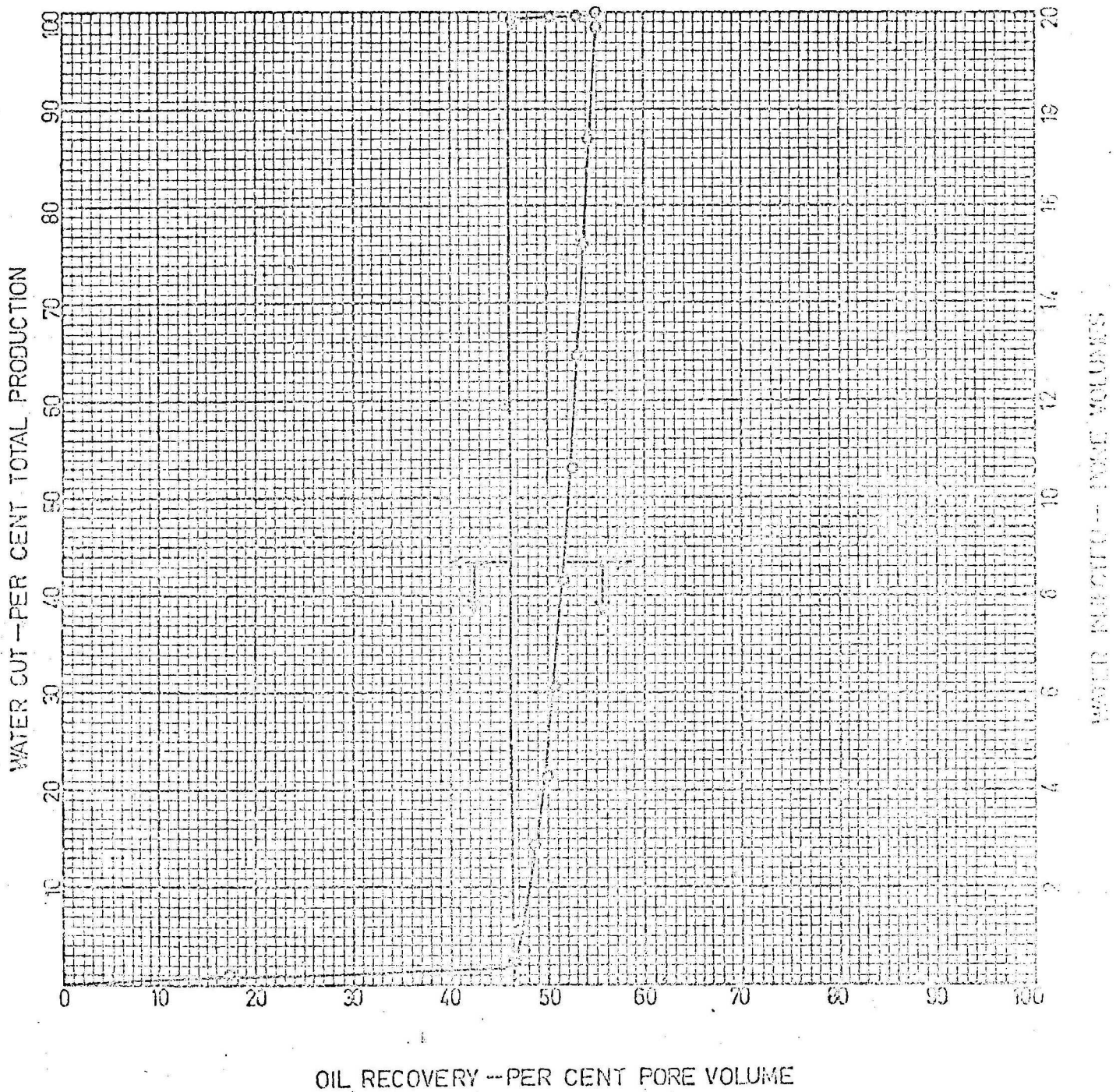


FIGURE 95

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - E. MERREENIE No. 2

DEPTH INTERVAL - 4769'

POROSITY - 9.9 %

PERMEABILITY - 57 Md(Ko)

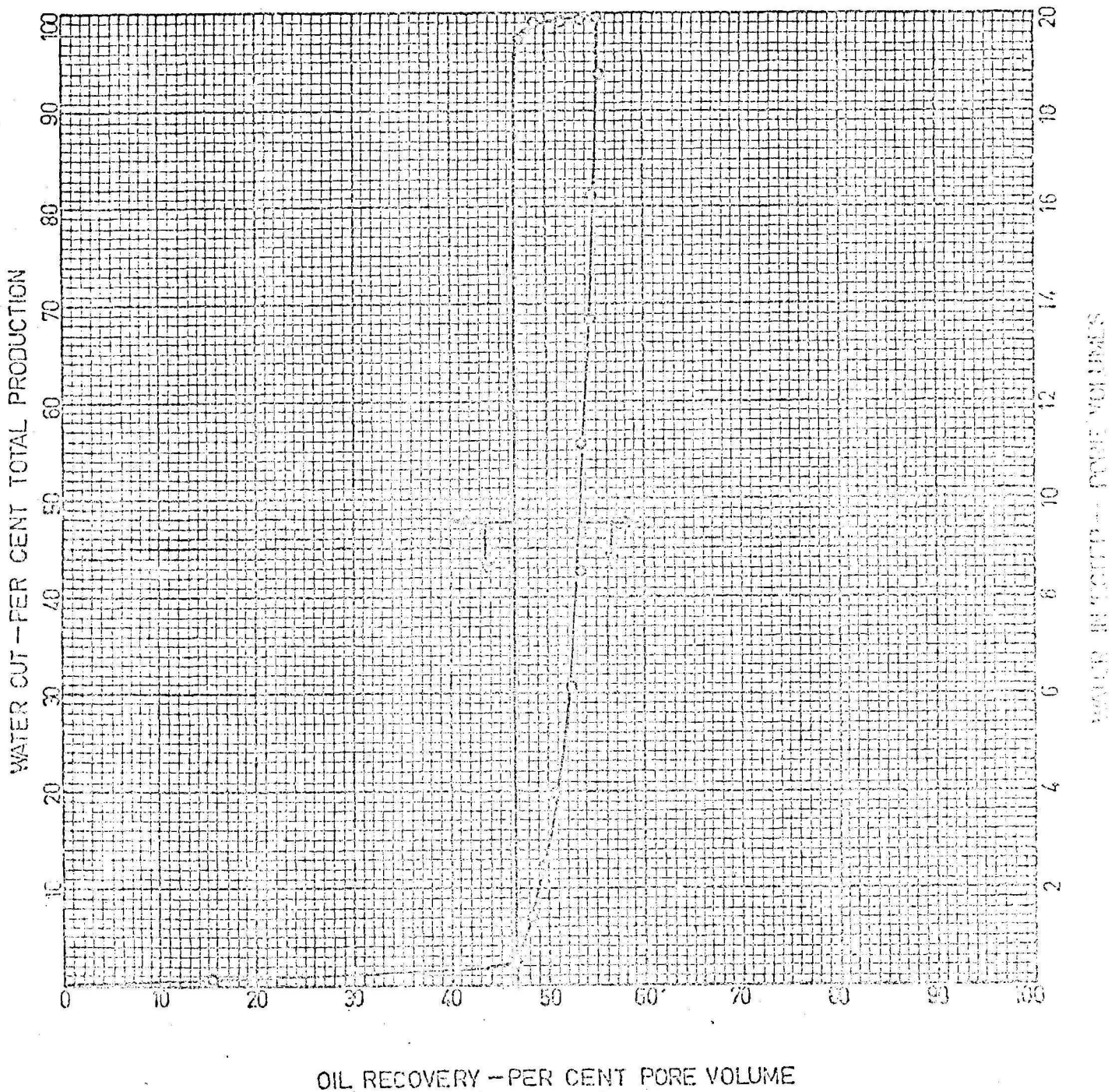


FIGURE 96

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - W. MEREEENIE No.1

DEPTH INTERVAL - 4575

POROSITY - 8.1%

PERMEABILITY - 0.14 Md (Ko)

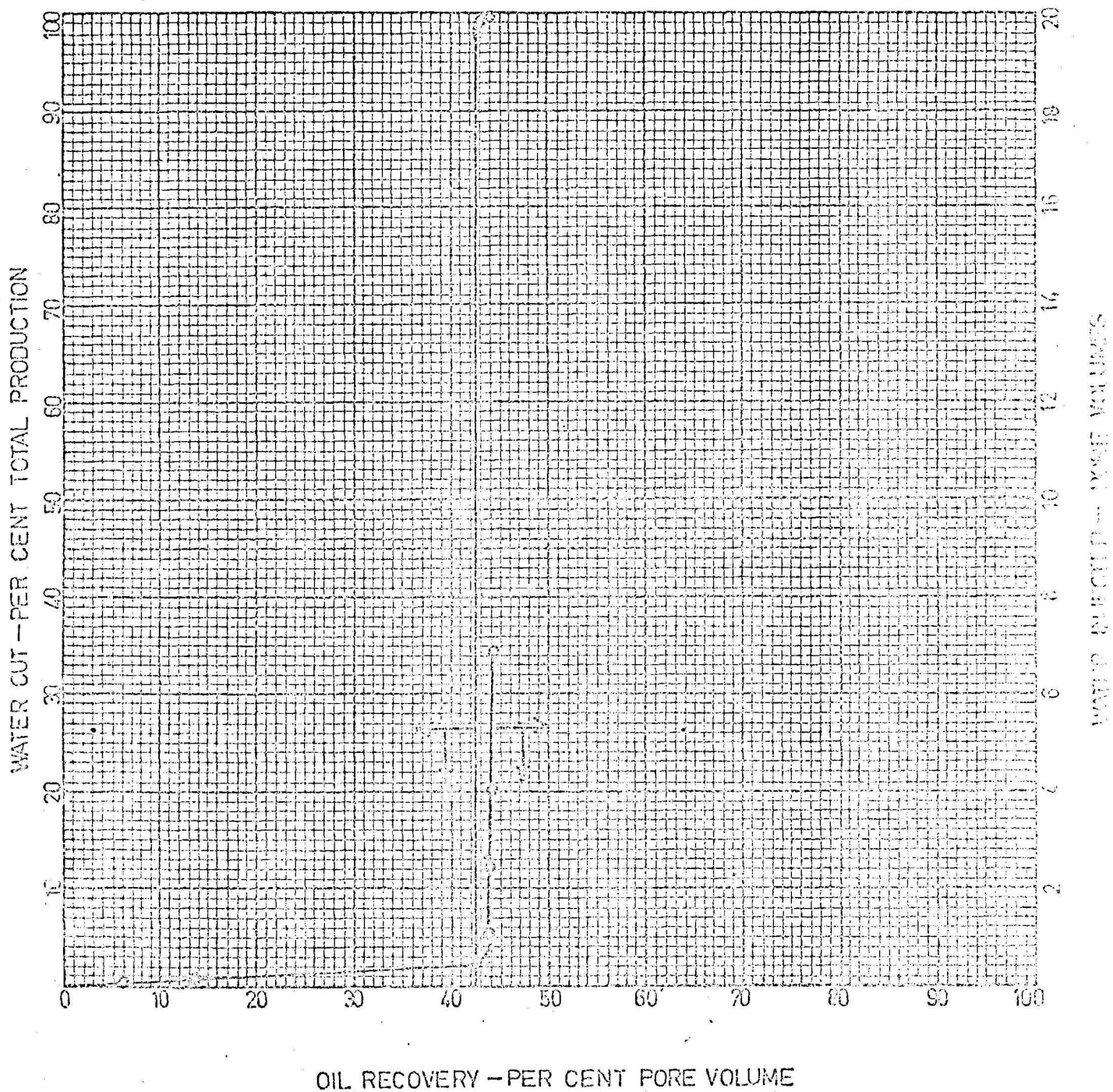


FIGURE 97

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - W. MEREEENIE No.1

DEPTH INTERVAL - 4596'

POROSITY - 3.8 %

PERMEABILITY - 0.15 Md. (Ko)

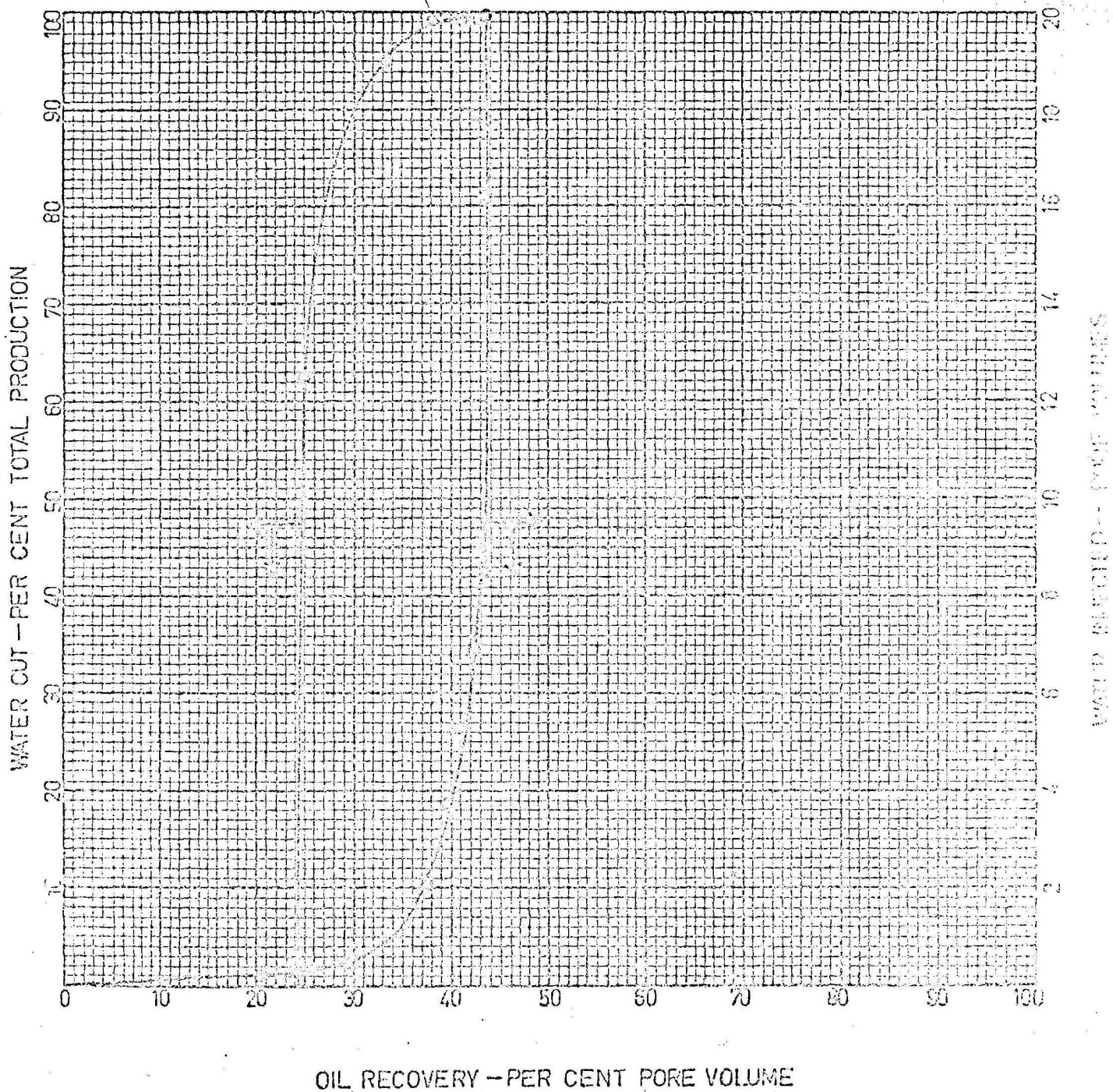


FIGURE 98

WATER FLOOD SUSCEPTIBILITY

WELL NAME AND NUMBER - W. MEREEENIE No.1

DEPTH INTERVAL - 4644'

POROSITY - 8.0 %

PERMEABILITY - 0.62 Md (Ko)

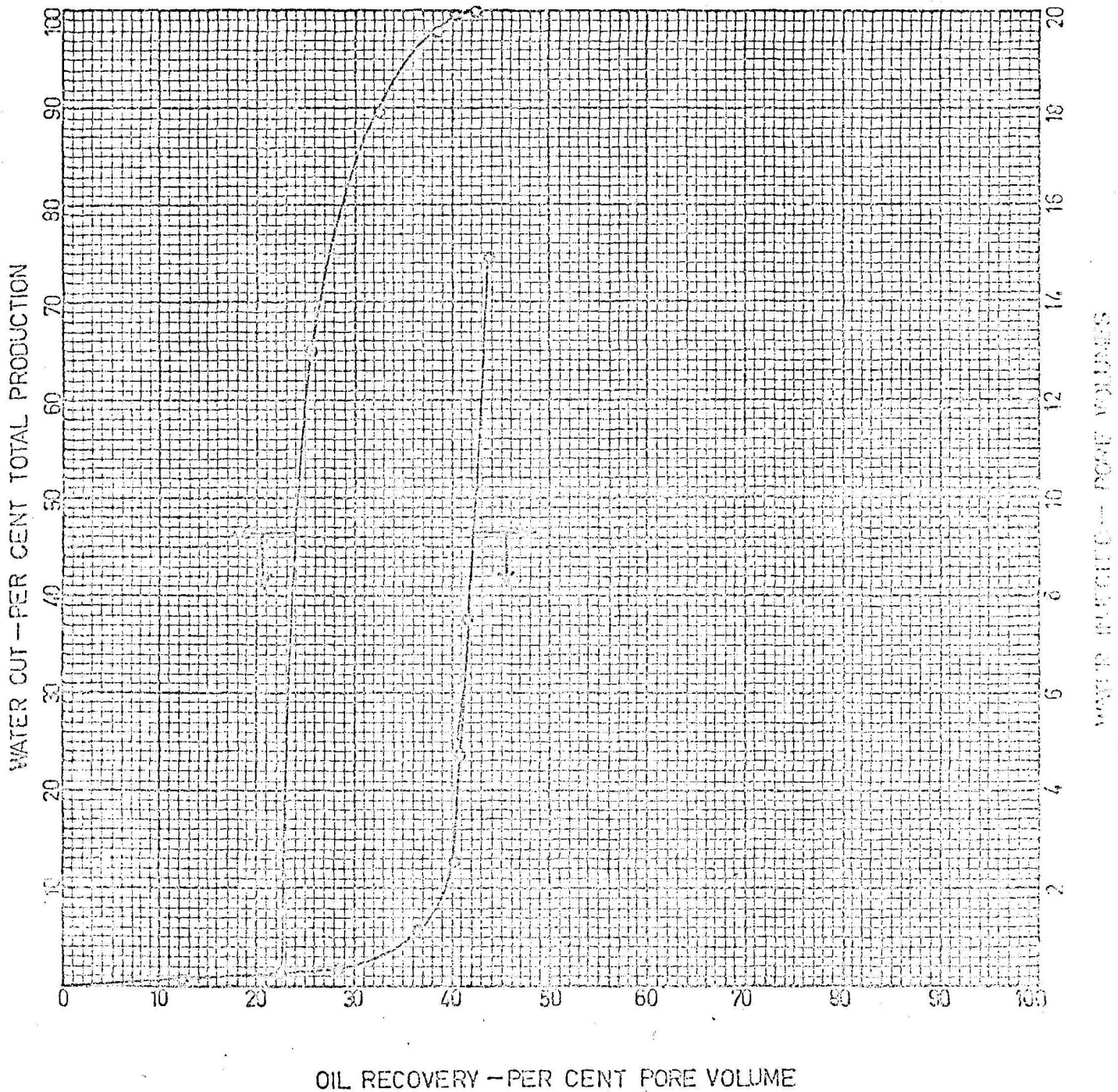


FIGURE 99

FORMATION FACTOR VS POROSITY
WELL NAME AND NUMBER - MEREENIE FIELD
DEPTH INTERVAL - PACOOTA FORMATION

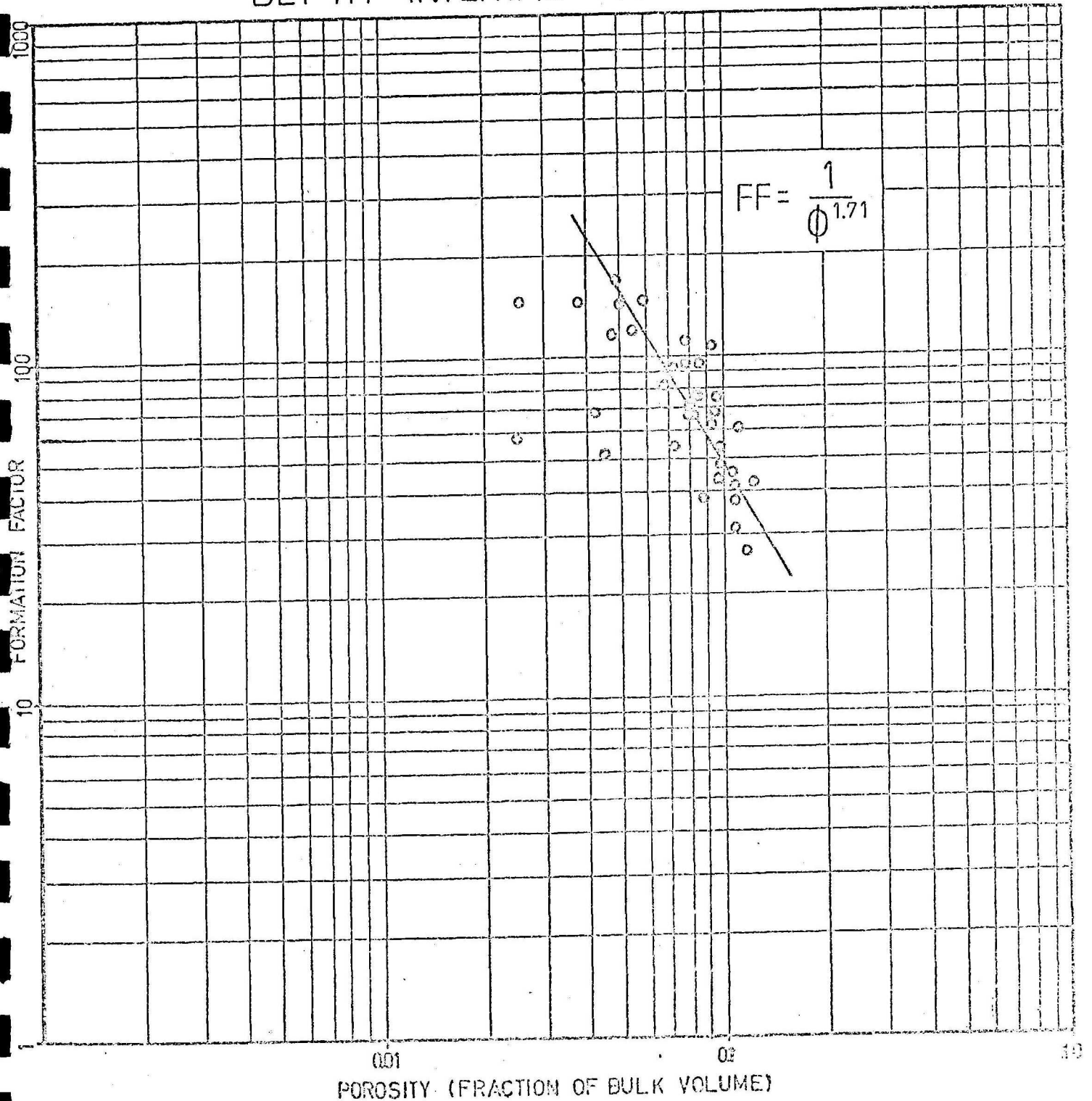


FIGURE 100

FORMATION FACTOR VS POROSITY FRACTION

WELL NAME AND NUMBER- E.MEREEENIE No. 4

DEPTH INTERVAL- 4196-4752

