

SPECIAL CORE ANALYSIS

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Lower Morrow Formation
Gensler Field
Stevens County, Kansas
SRS 1858/RSB 2968

Basic Rock Properties

Formation Resistivity Factor At Confining Pressure

Formation Resistivity Index At Confining Pressure

Air-Brine Capillary Pressure At Confining Pressure

18-555-540



RESERVOIRS, INC.

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HOUSTON, TEXAS 77043

GEOLOGICAL ANALYSIS • CLASTICS/CARBONATES
SINGLE WELL/FIELD/REGIONAL STUDIES
WELL COMPLETION/STIMULATION STUDIES
ROUTINE AND SPECIAL CORE ANALYSIS

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October 4, 1994

Mr. Mark Pinel
Anadarko Petroleum Corporation
17001 Northchase Drive
Houston, Texas 77060

Dear Mr. Pinel:

On May 3, 1994, nine (9) one inch diameter core plug samples obtained during conventional core analysis of the Anadarko Petroleum Corporation, Ratcliff B-2 Well, Stevens County, Kansas were selected for a geological and special core analysis study. The special core analysis was initially to include the following analyses:

- Formation Resistivity Factor At Confining Pressure
- Formation Resistivity Index At Confining Pressure

The composition of the simulated formation brine to be used during the analyses was based upon analyses of water obtained from the Anadarko Petroleum Corporation, Gaskill A-2 Well, Gensler Field, Stevens County, Kansas.

Preliminary copies of the formation resistivity factor and formation resistivity index test results for these nine (9) samples were delivered to Mr. Pinel on July 20, 1994 by Mr. Steven Alexander of Reservoirs, Inc.

Six (6) additional depth intervals were subsequently selected for special core analysis testing. The depth intervals selected were 6021.9 ft., 6030.8 ft., 6055.6 ft., 6061.2 ft., 6066.8 ft., and 6079.3 ft. A one and one-half inch diameter sample was drilled from each of the depth intervals, cleaned, dried and basic properties determined. Each sample was then prepared for formation resistivity factor, formation resistivity index and air-brine capillary pressure testing at confining pressure. The confining pressure used during the analyses was 2600 psig and was calculated using Nelson's Equation and the following assumptions:

Mr. Mark Pinel
Anadarko Petroleum Corporation
Page 2

$$\text{Nelson's Equation} = \frac{\text{Average Depth} - \text{Reservoir Pressure}}{3} \bullet \frac{(1+v)}{(1-v)}$$

Where: Depth is in feet
Reservoir pressure is in psig
v = Poisson's Ratio

Assumed Values: Average Depth = 6025.8 ft.
Reservoir Pressure = 1236 psig
Poisson's Ratio = 0.24

This report presents the test results of the requested analyses in tabular and graphical formats. Sections entitled "Laboratory Procedures", which describes the method used to obtain the test results and "Discussion Of The Test Results" are also included.

It has been a pleasure to be of service to you and the Anadarko Petroleum Corporation, and Reservoirs, Inc. looks forward to working together with you on future projects. If you should have any questions pertaining to the test results, the procedures used to obtain the test results or if I can be of any further service, please do not hesitate to contact me at (713) 932-9670.

Sincerely,

Paul Delacoe

Paul Delacoe
Manager
Special Core Analysis
RESERVOIRS, INC.

LABORATORY PROCEDURES

Basic Rock Properties

The **bulk volume** of each core plug sample was determined by mercury immersion (Archimedes' principle) and confirmed by measuring the length and diameter of each core plug sample with calipers and calculating the bulk volume.

The **porosity** and grain density of each core plug sample was determined using the Boyle's law method and helium as the gaseous phase. The core plug sample was placed in a matrix cup (sealed chamber) of known volume. Another chamber of known volume containing helium at a preselected pressure was connected to the matrix cup. The helium expanded into the matrix cup, and an equilibrium pressure was recorded. Using Boyle's law, the grain volume of the core plug sample being tested can be determined. The grain volume subtracted from the bulk volume of the core plug sample results in the pore volume of the core plug sample. Porosity is the pore volume expressed as a percent of the bulk volume.

The **grain density** is the weight of the core material per unit volume of the core material (grain volume). The weight of the core material is determined by weighing the clean and dry core plug sample on a pan-balance at ambient conditions. The grain volume is obtained from the Boyle's law calculation.

The **specific permeability to gas** was determined by placing each core plug sample in a Hassler-type core holder. A confining pressure of 400 psig was applied to the system to prevent bypassing of the gas around the core plug sample. Nitrogen gas was injected into each core plug sample at a constant pressure until a constant flow rate of gas through the core plug sample was attained (steady-state conditions). The specific permeability to gas was calculated using the Darcy equation.

Sample Saturation (Vacuum-Pressure Method)

Each clean and dried sample selected for special core analysis testing was weighed and placed in a vacuum-pressure saturation chamber. The system was evacuated to a pressure of fifty (50) microns for a period of twelve (12) hours. A simulated formation brine (Table 2) was injected into the chamber until the level of the fluid was above the samples. A pressure of 2000 psig was applied to the system for a minimum of six (6) hours. The chamber was depressured and each sample was removed from the fluid and weighed. The pore volume was calculated gravimetrically using the dry weight and the saturated weight of each sample and the corresponding density of the fluid. This pore volume was compared to the pore volume previously derived by the Boyle's Law helium porosity method, to ensure one hundred percent (100%) saturation.

Formation Resistivity Factor At Confining Pressure

Each brine saturated core plug sample was weighed and individually mounted in a hydrostatic core holder with a silver electrode/distribution plate at the upstream of the sample and a silver electrode/capillary pressure porous-plate at the downstream of the sample. A confining pressure of 400 psig was applied to the system to prevent bypassing of fluid around the sample.

Several pore volumes of simulated formation brine were injected through the core plug sample to ensure the sample and system was completely saturated with the brine. The resistance of the saturated sample was determined at a frequency of 1000 Hz, using a GenRad® meter. The determinations performed at the confining pressure of 400 psig are for the purpose of quality control.

A pipette was attached to the system, and the confining pressure was slowly increased to 2600 psig. The sample and system were allowed to stabilize for several hours. The volume of brine produced into the pipette is equivalent to the reduction in the pore volume. The porosity at confining pressure was calculated from these test results.

The resistance of the equilibrated core plug sample was determined over a period of several hours to ensure that the sample had stabilized (ionic equilibrium). A frequency of 1000 Hz was used to determine the resistance. The resistance and the porosity at confining pressure (previously determined) and the resistance of the simulated formation brine were used to calculate the formation resistivity factor and cementation exponent (m) for each core plug sample.

Formation Resistivity Index At Confining Pressure

Immediately following the formation resistivity factor at confining pressure test, the sample was injected with nitrogen gas. The nitrogen was injected into the sample to displace the simulated formation brine through the capillary pressure porous-plate mounted at the downstream end of the sample. The resistance of the sample was determined as a function of the corresponding volume of brine produced. The resistance was measured at a frequency of 1000 Hz. The formation resistivity indices (I), saturation exponents (n) and the corresponding water saturations were calculated from the test results.

At the conclusion of the test, the confining pressure was removed and the core plug sample was unloaded from the core holder. The sample was weighed to gravimetrically determine the final water saturation present in the sample. This saturation was compared to the final saturation determined volumetrically at the conclusion of the test to verify the test results.

Air-Brine Capillary Pressure At Confining Pressure

Each saturated core plug sample was weighed and placed in contact with a saturated capillary pressure porous-plate and sealed in a hydrostatic core holder. A confining pressure of 2600 psig was applied to the system, and the volume of fluid produced was monitored and recorded. These produced volumes were used to calculate the reduction in pore volume of each sample, and the corresponding porosity. Each sample was subsequently injected with nitrogen gas,

at a predetermined injection pressure, to displace the simulated formation brine through the capillary pressure porous-plate mounted in contact with the sample. The volume of fluid produced was monitored at each pressure until capillary equilibrium was achieved (no further production of fluid was observed). The volume of produced fluid was recorded. The injection pressure was increased and the procedure was repeated. Nine (9) injection pressures were used to desaturate the sample during the test. The injection pressures used were 1, 2, 4, 8, 15, 35, 75, 125 and 200 psig. At the conclusion of testing each sample was unloaded and weighed to gravimetrically verify the final saturation obtained volumetrically.

DISCUSSION OF THE TEST RESULTS

Basic Rock Properties

Fifteen (15) samples were selected for special core analysis tests which were to include formation resistivity factor, formation resistivity index and air-brine capillary pressure testing at confining pressure. The basic rock properties obtained for these fifteen (15) samples are presented in Table 1 and in Figures 1 and 2. The specific permeabilities to gas ranged from 0.053 md to 169 md and the porosities ranged from 4.3 to 17.7 percent of the bulk volume. Grain densities and bulk densities ranged from 2.66 g/cc to 2.73 g/cc and from 2.20 g/cc to 2.61 g/cc, respectively. Figure 1 illustrates the relationship of specific permeability to gas-porosity and Figure 2 illustrates the relationship of bulk density-porosity.

Formation Resistivity Factor At Confining Pressure

The formation resistivity factor-porosity test results determined at confining pressure on the fifteen (15) core plug samples selected for testing are presented in Table 3 and Figure 3. Examination of Table 3 indicates the formation resistivity factors ranged from 39.70 to 433.8 and the corresponding porosities determined at confining pressure ranged from 4.1 to 17.1 percent of the bulk volume. The resistivity of the simulated formation-brine used as the saturant during the tests was 0.054 ohm-meters (70°F). Individual cementation exponents (m) calculated from the formation resistivity factor, the porosity determined at confining pressure and an intercept "a" of unity (1.00) ranged from 1.90 to 2.18.

The composite cementation exponent presented in Figure 3 was derived from the line constructed through the data points and is equivalent to $m = 2.08$.

Formation Resistivity Index At Confining Pressure

The formation resistivity index and corresponding water saturation test results obtained at confining pressure are presented in Tables 4 through 18. Figures 4 through 18 graphically present the individual relationships of formation resistivity index-saturation. Examination of Tables 4 through 18 indicates the formation resistivity indices ranged from 1.37 to 29.82 at the final water saturations, attained at the cessation of the tests.

Saturation exponents (n) were derived for each core plug sample, from the linear relationship of formation resistivity index and saturation. These saturation exponents are presented in Figures 4 through 18. Examination of these figures indicate the derived saturation exponents ranged from 1.60 to 3.19. Figure 19 is the composite of all of the formation resistivity index-saturation data obtained for the core plug samples tested. No apparent single trend was evident. The dashed line represents the results obtained for Sample B 798 (6065.5 ft) which indicated a saturation exponent of $n = 1.60$. This was considerably lower than the results obtained for the remaining samples which ranged from $n = 2.11$ to $n = 3.19$. These results are indicated by the two (2) solid lines constructed through the test results.

Air-Brine Capillary Pressure At Confining Pressure

Air-brine capillary pressure at confining pressure tests were performed on six (6) selected samples. The test results are presented in Tables 19 through 24 and Figures 20 through 25. Examination of Tables 19 through 24 indicate the final (irreducible) brine saturations attained at the maximum capillary pressure of 200 psig ranged from 44.9 to 72.4 percent of the pore volume. No obvious trend was evident between either permeability and the final brine saturation or porosity and the final brine saturation. Examination of Figures 20 through 25 indicate that several pore geometrical systems appear to be evident for the samples tested. Several of the samples indicate bi-modal or multi-modal pore systems which are indicated by the non-uniformity of the capillary pressure-saturation

profiles. Mercury injection capillary pressure testing would aid in determining the pore size distributions present in the samples; however, this is a destructive test as the samples will contain mercury within the pore spaces at the conclusion of testing, and is only recommended for those samples where no further testing will be required.

Table 1

BASIC ROCK PROPERTIES

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSR 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability to Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Grain Density (g/cc)</u>	<u>Bulk Density (g/cc)</u>
C 656	6021.9	2.81	11.0	2.72	2.42
B 759	6025.6	1.03	11.4	2.72	2.41
C 657	6030.8	0.602	8.4	2.73	2.50
B 768	6034.7	0.280	4.3	2.73	2.61
B 785	6052.6	19.0	17.7	2.67	2.20
C 658	6055.6	4.77	13.4	2.69	2.33
C 682	6061.2	1.25	13.6	2.69	2.32
B 798	6065.5	0.053	8.2	2.70	2.48
C 659	6066.8	0.700	12.3	2.72	2.39
B 809	6076.6	4.07	15.9	2.67	2.25
C 660	6079.3	1.55	14.4	2.69	2.31
B 818	6085.5	0.113	7.3	2.70	2.50
B 827	6097.8	169	15.6	2.66	2.25
B 833	6103.4	6.91	12.5	2.67	2.34
B 843	6113.5	6.67	12.0	2.69	2.37

Figure 1

SPECIFIC PERMEABILITY TO GAS - POROSITY RELATIONSHIP

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas
SRS 1858/RSH 2968

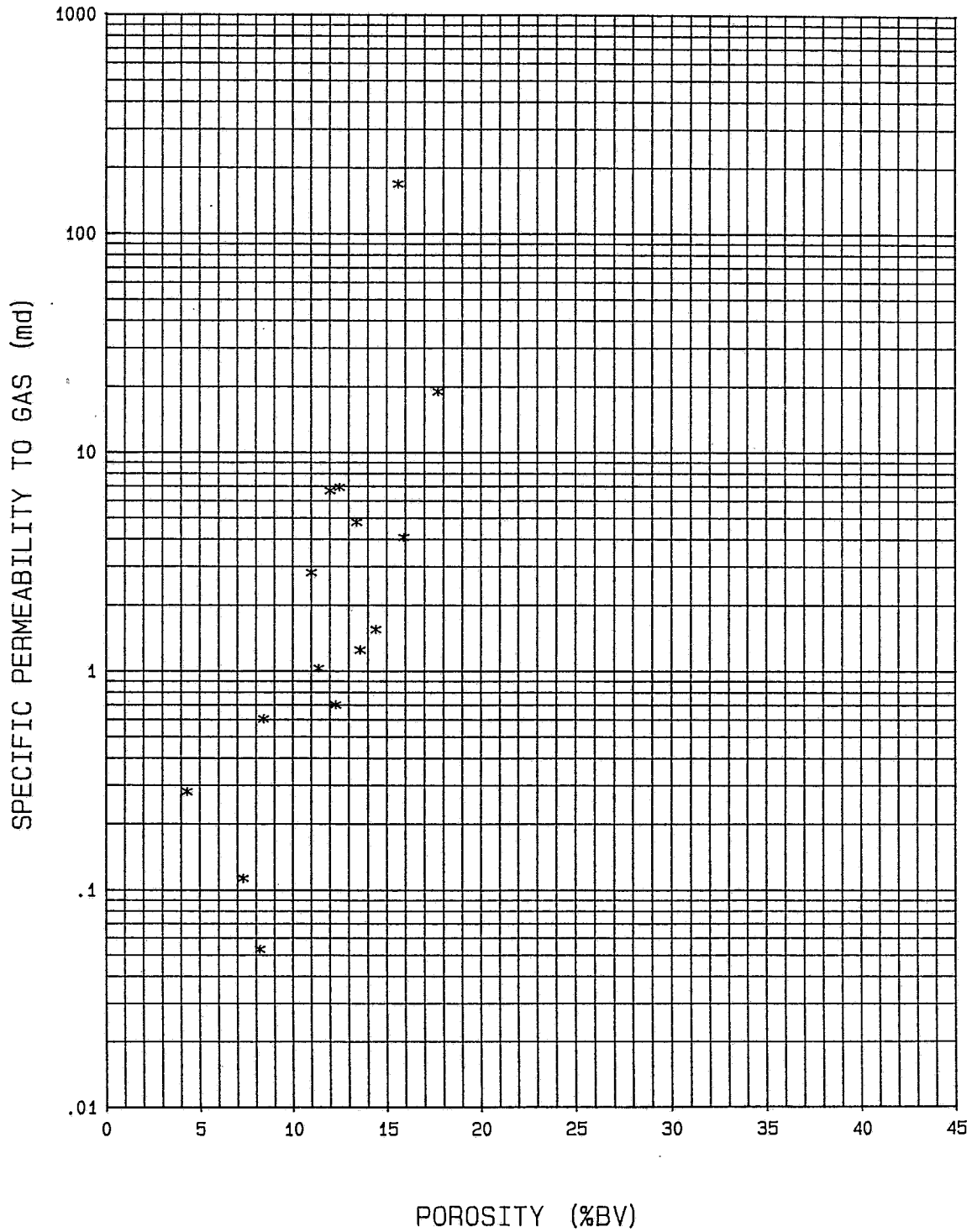


Figure 2

BULK DENSITY - POROSITY RELATIONSHIP

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas
SRS 1858/RSH 2968

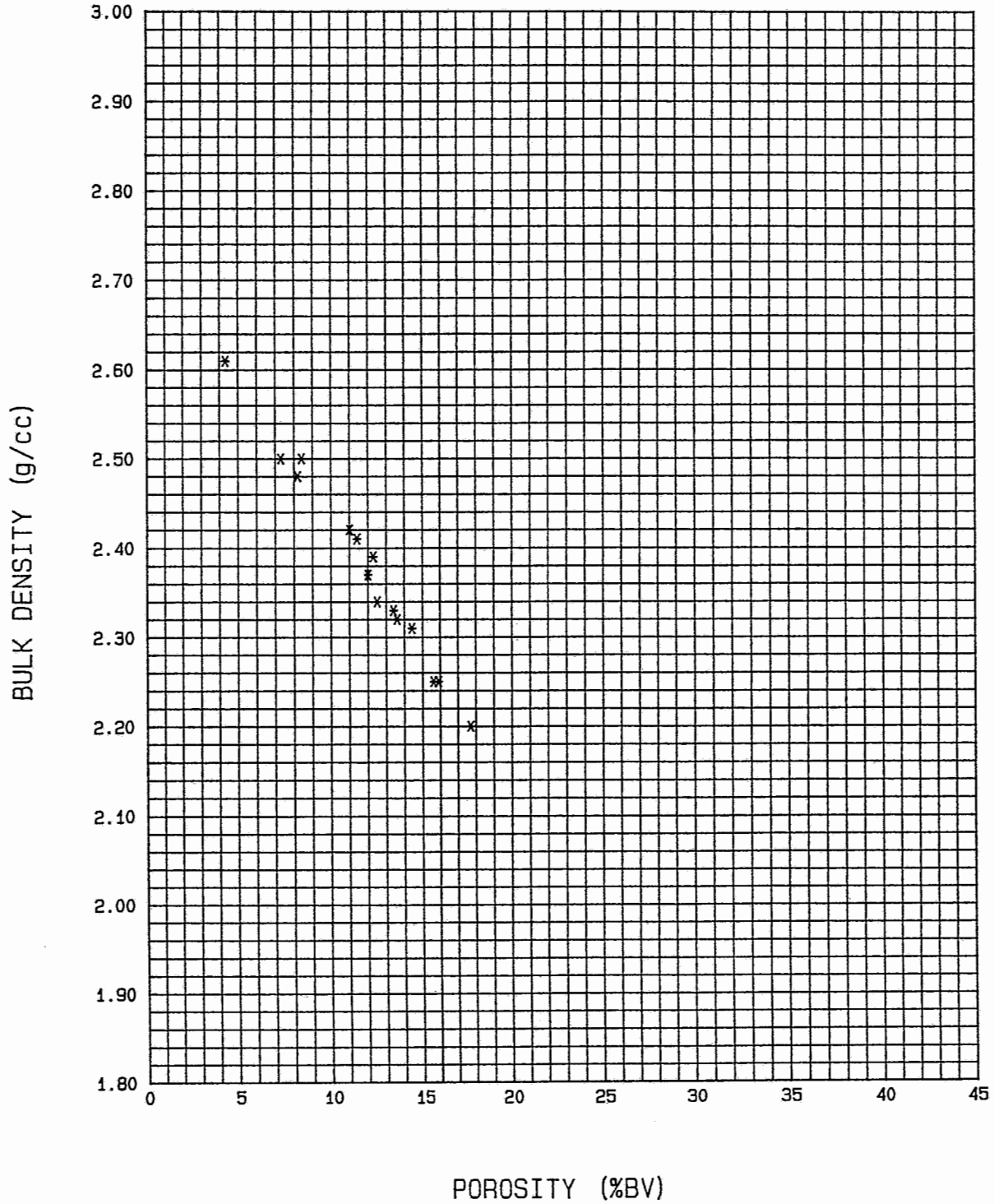


Table 2

SIMULATED FORMATION BRINE ANALYSIS*

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSH 2968

<u>Constituent</u>	(1) <u>mg/l</u>	(2) <u>mg/l</u>	Average <u>mg/l</u>
Calcium	15,832	16,540	16,186
Magnesium	3,477	3,098	3,288
Sodium	62,201	59,484	60,843
Barium	45	-	23
Bicarbonate	37	150	94
Chloride	133,970	130,000	131,985
Sulfate	<u>130</u>	<u>145</u>	<u>138</u>
TOTAL DISSOLVED SOLIDS	215,692	209,417	212,557

* Denotes analysis was based on the average of the analyses performed on two (2) water samples obtained from the Anadarko Petroleum Corporation, Gaskill A-2 Well, Gensler Field, Stevens County, Kansas. Analysis (1) was performed by Reef Chemical Company of Snyder, Texas and analysis (2) was performed by Reservoirs, Inc. of Midland, Texas.

Table 3

FORMATION RESISTIVITY FACTOR - POROSITY RELATIONSHIPAT CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSH 2968

<u>Sample</u>	<u>Depth (ft.)</u>	<u>Confining Pressure (psig)</u>	<u>Formation Resistivity Factor (F)</u>	<u>Porosity (% BV)</u>	<u>Cementation Exponent (m)</u>
C 656	6021.9	2600	82.91	10.5	1.96
B 759	6025.6	2600	93.48	11.0	2.06
C 657	6030.8	2600	149.90	8.0	1.98
B 768	6034.7	2600	433.80	4.1	1.90
B 785	6052.6	2600	39.70	17.1	2.08
C 658	6055.6	2600	69.80	12.8	2.07
C 682	6061.2	2600	72.16	13.1	2.11
B 798	6065.5	2600	207.90	7.8	2.09
C 659	6066.8	2600	85.56	11.9	2.10
B 809	6076.6	2600	50.67	15.6	2.11
C 660	6079.3	2600	66.39	13.9	2.13
B 818	6085.5	2600	294.00	7.0	2.14
B 827	6097.8	2600	63.13	15.0	2.18
B 833	6103.4	2600	88.55	12.1	2.12
B 843	6113.5	2600	93.33	11.8	2.12

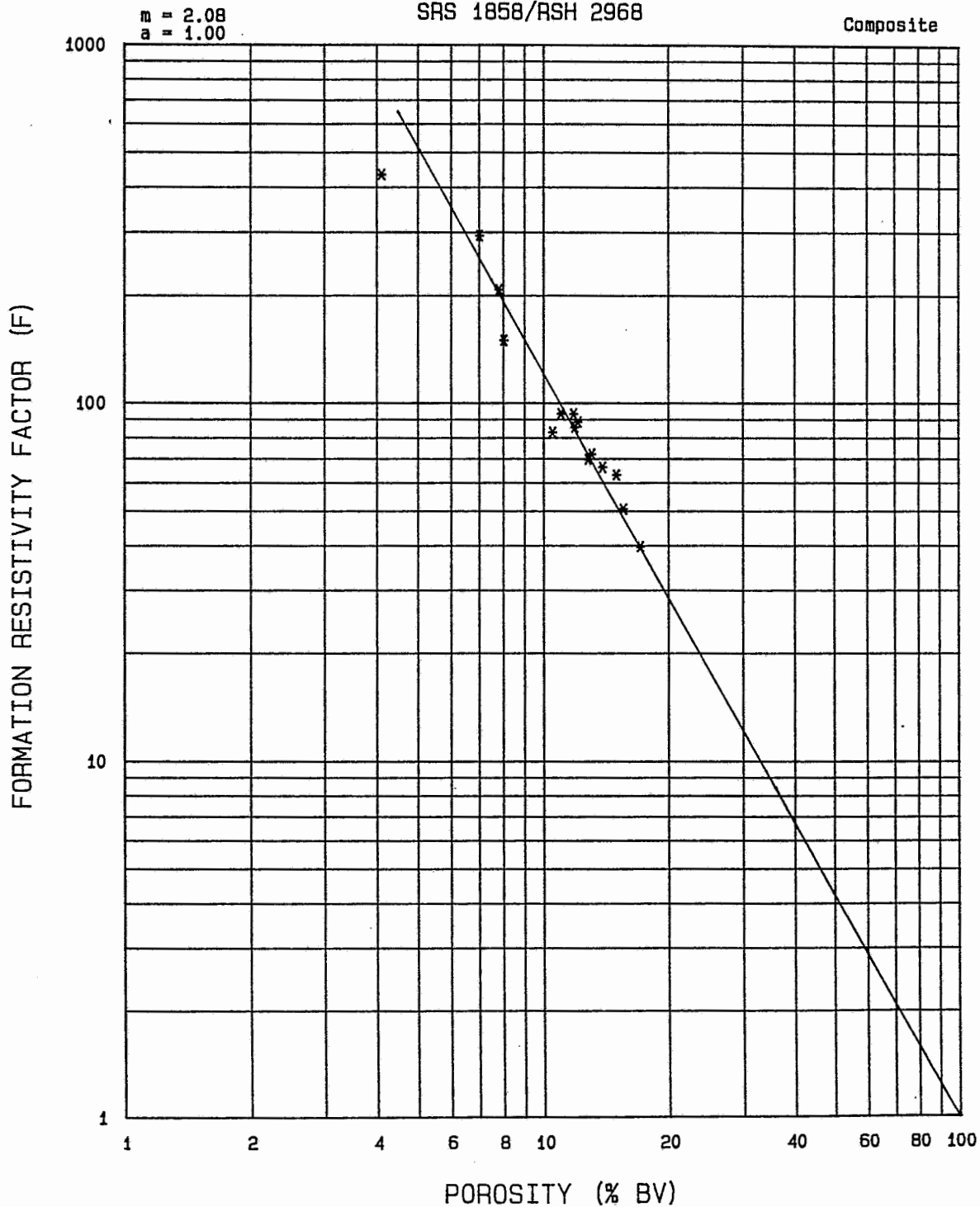
AVE 1.03

$R_w = 0.054$ ohm-meters @ 70 degrees Fahrenheit

Figure 3

FORMATION RESISTIVITY FACTOR - POROSITY RELATIONSHIP
AT CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas
SRS 1858/RSR 2968



- Table 4

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas
SRS 1858/RSH 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
C 656	6021.9	2.81*	10.5	1.00	100.0
				1.07	97.2
				1.14	94.5
				1.77	78.4
				2.98	63.2
				4.10	54.4
				5.68	47.3
				6.37	44.9

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 4

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field

Stevens County, Kansas

Sample : C 656
Depth, ft : 6021.9

SRS 1858/RSH 2968

n = 2.34

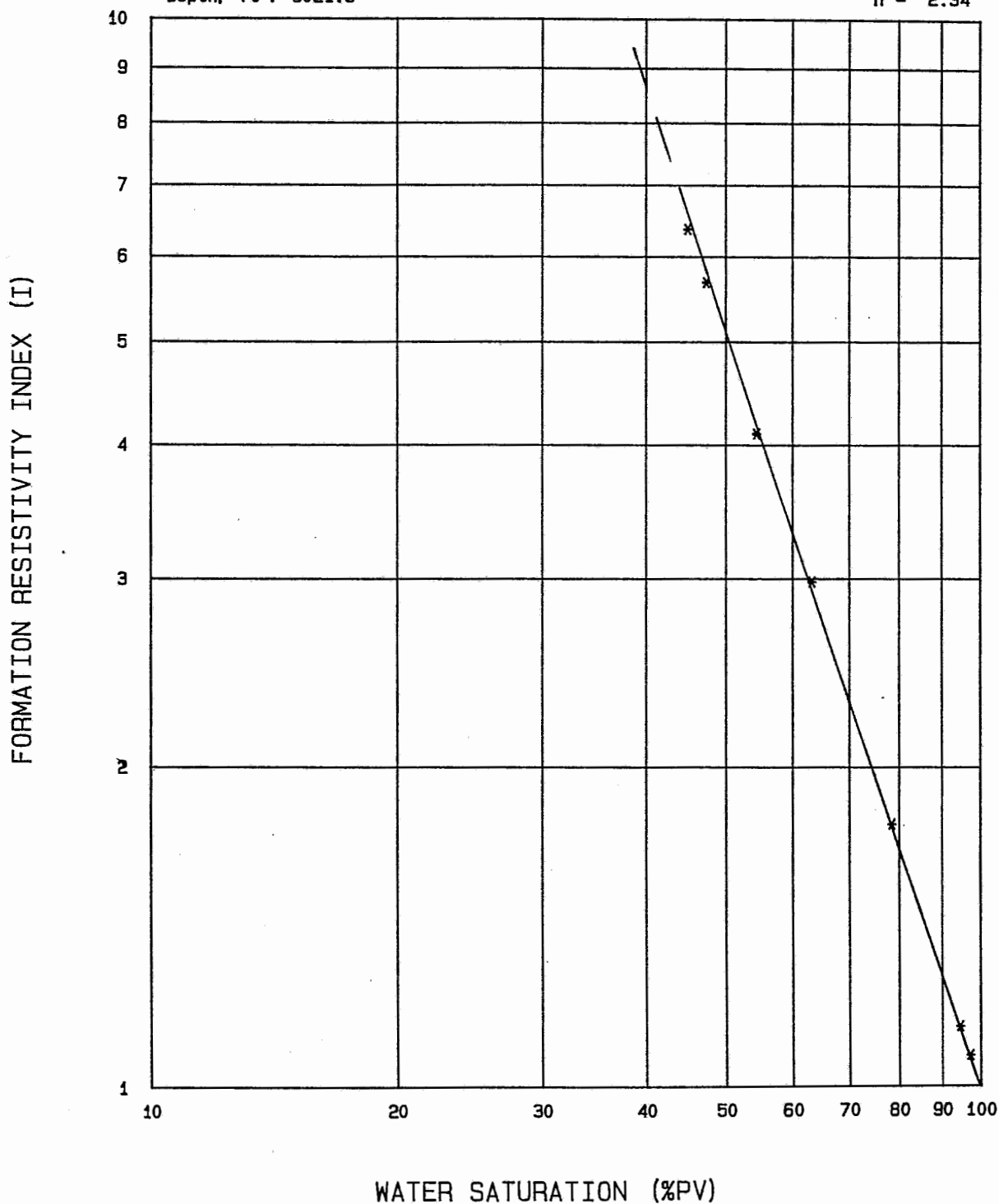


Table 5

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSB 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
B 759	6025.6	1.03*	11.0	1.00	100.0
				1.04	98.4
				1.26	90.8
				1.41	86.3
				1.85	77.0
				2.26	70.9
				5.45	48.8
				6.64	45.2

Rw = .054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 5

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas

Sample : B 759
Depth, ft : 6025.6

SRS 1858/RSH 2968

n = 2.37

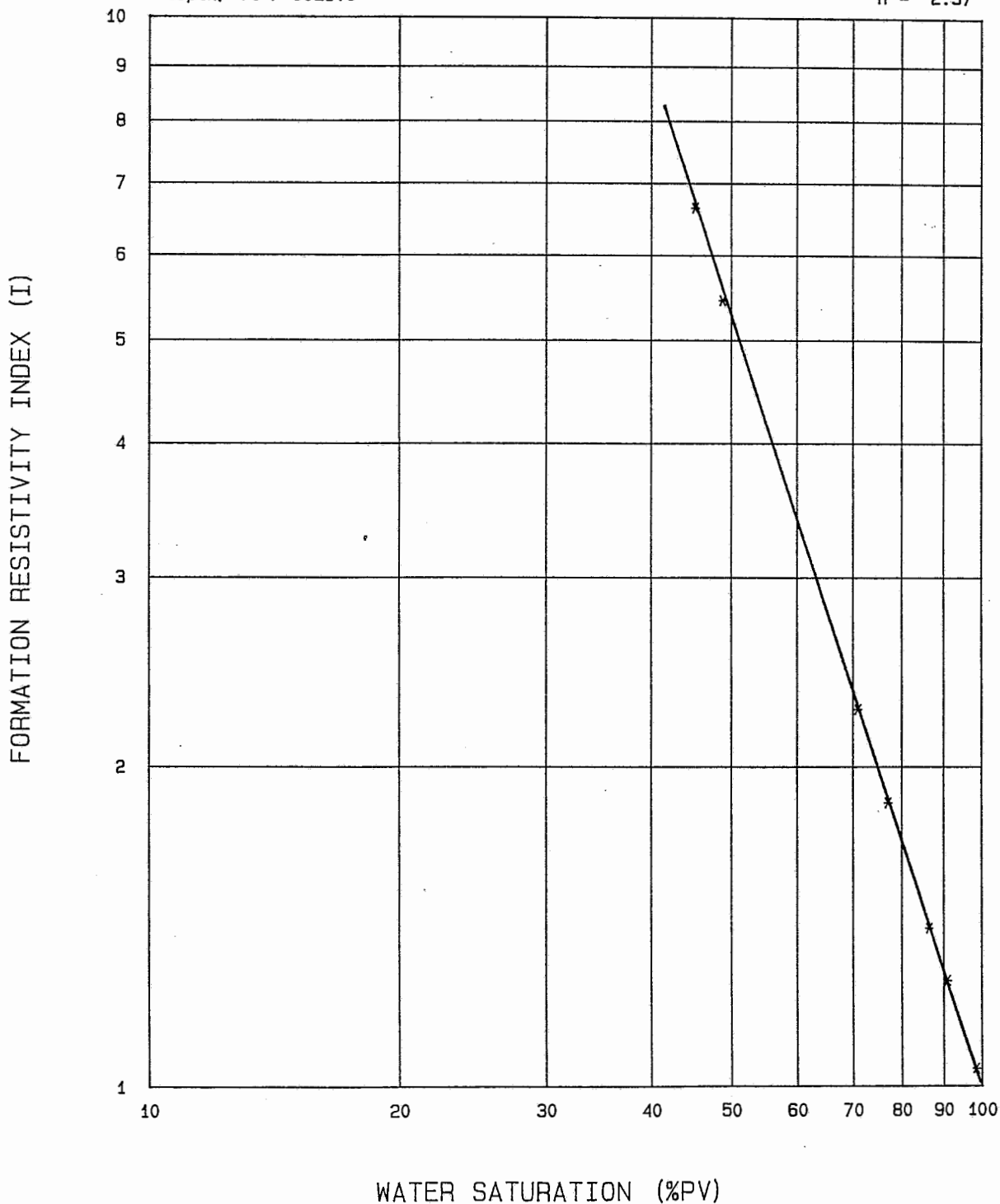


Table 6

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSR 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
C 657	6030.8	0.602*	8.0	1.00	100.0
				1.01	99.6
				1.06	98.1
				1.11	96.7
				1.86	82.0
				2.44	75.0
				2.73	72.4

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 6

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas

Sample : C 657
Depth, ft : 6030.8

SRS 1858/RSH 2968

$n = 3.10$

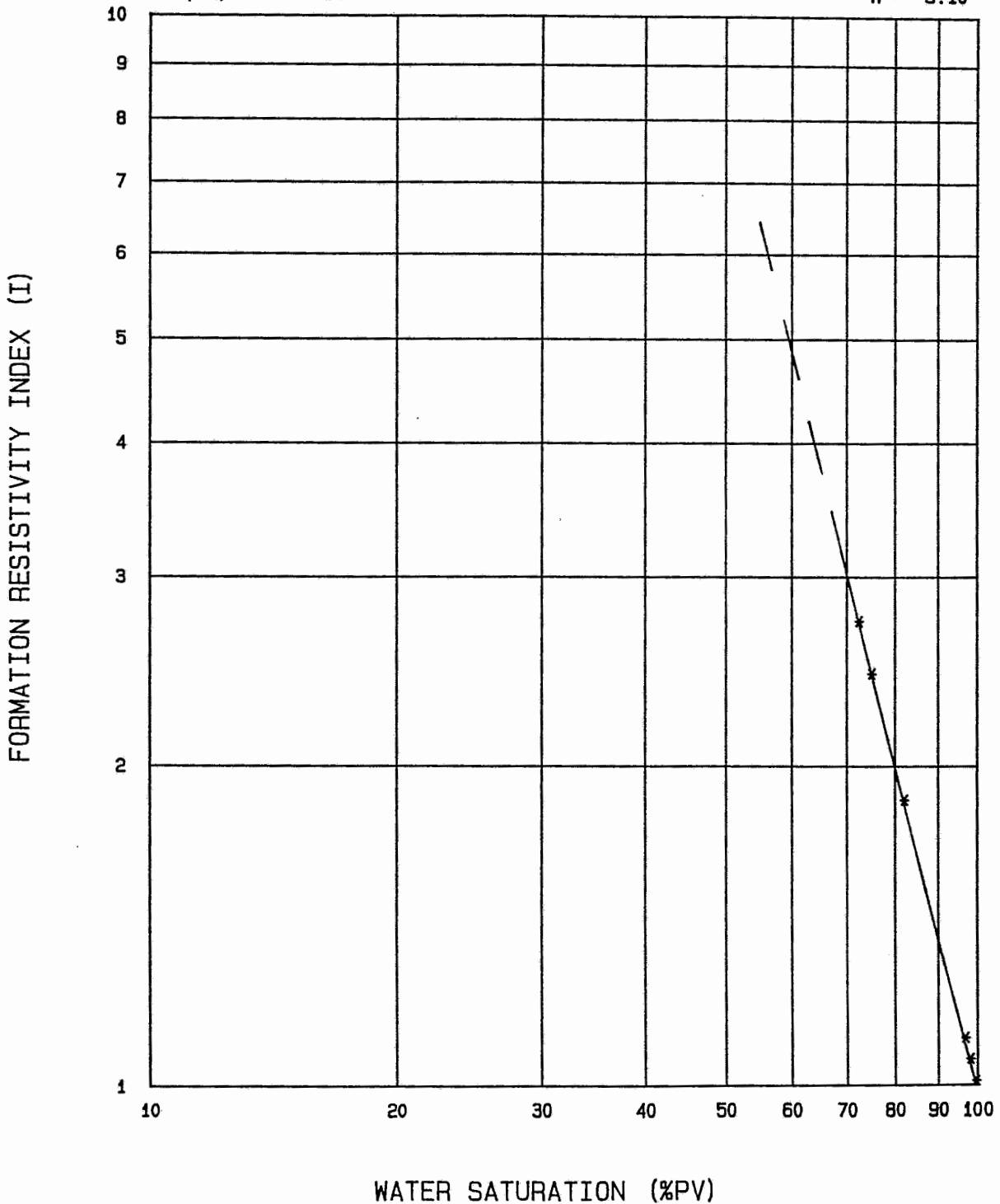


Table 7

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSR 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
B 768	6034.7	0.280*	4.1	1.00	100.0
				1.31	87.8
				1.58	80.5
				1.97	72.9
				2.29	67.5

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 7

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas
SRS 1858/RSH 2968

Sample : B 768
Depth, ft : 6034.7

n = 2.11

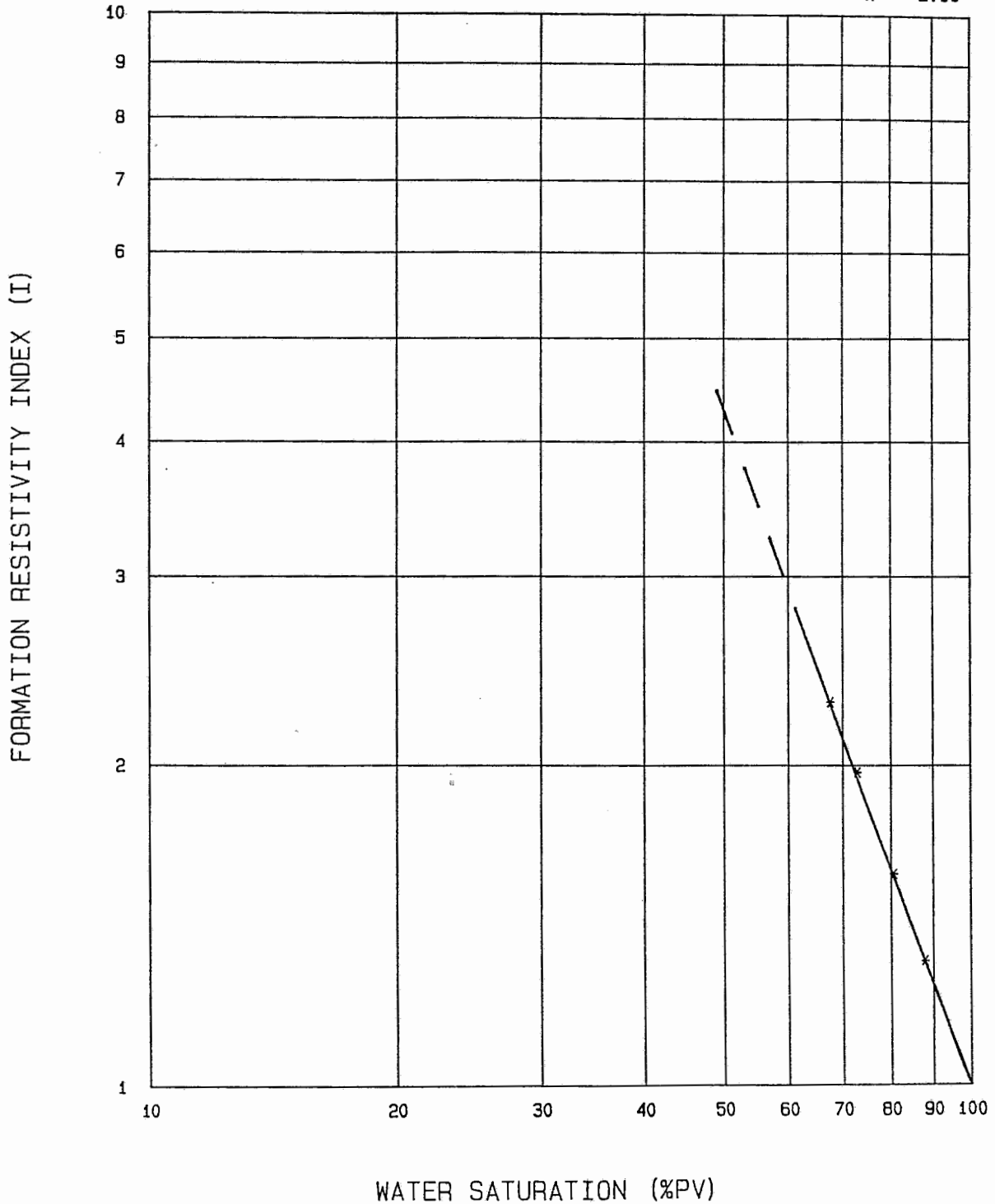


Table 8

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSH 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
B 785	6052.6	19.0*	17.1	1.00	100.0
				1.09	97.3
				1.31	91.8
				1.91	81.9
				2.35	76.1
				3.02	70.4
				4.17	62.8
				5.62	57.3
				10.82	46.7

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 8

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas

Sample : B 785
Depth, ft : 6052.6

SRS 1858/RSR 2968

n = 3.14

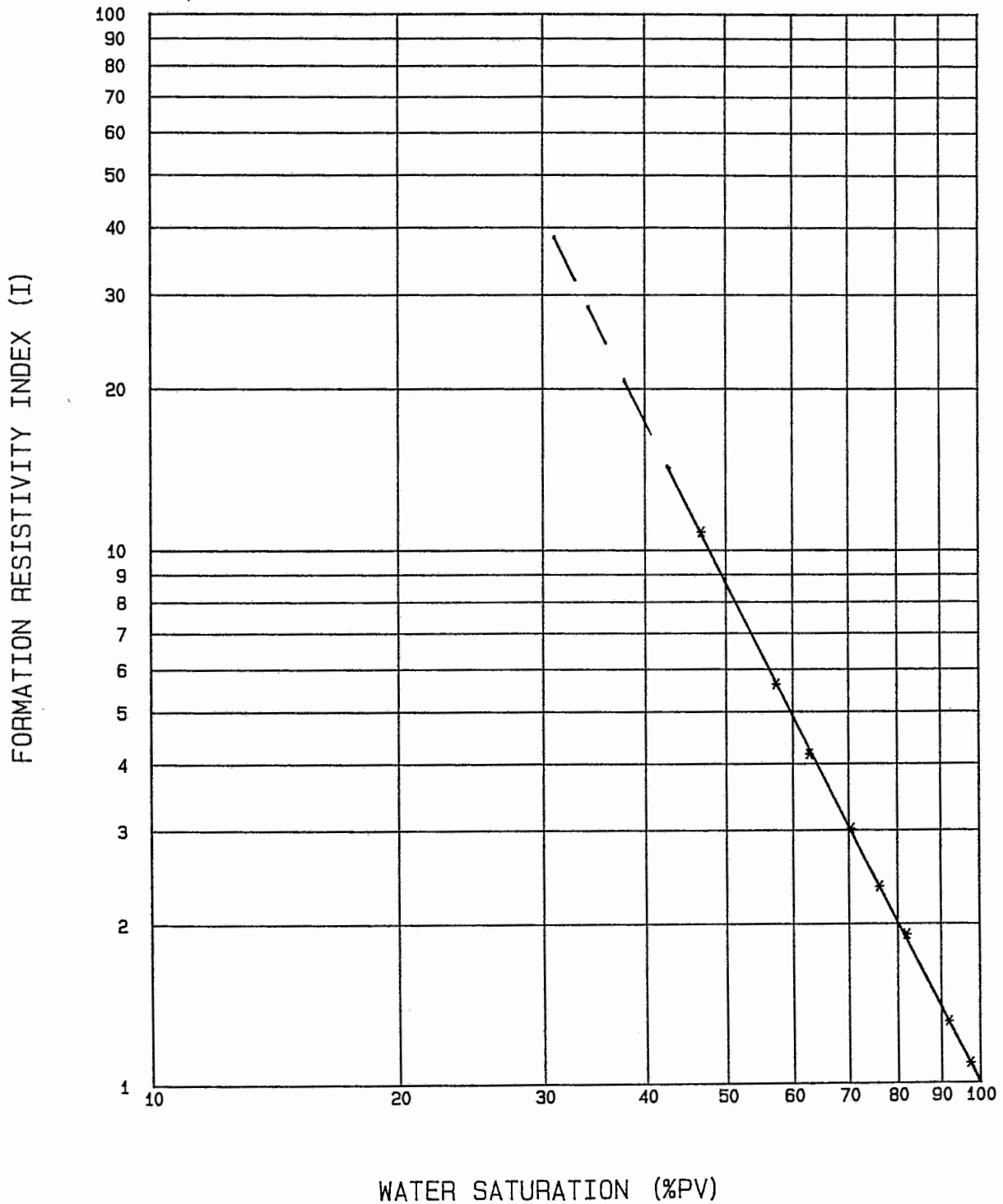


Table 9

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSH 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
C 658	6055.6	4.77*	12.8	1.00	100.0
				1.17	94.7
				1.96	78.9
				2.28	74.6
				2.80	70.6
				4.00	62.2
				6.67	52.0
				8.31	48.9

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 9

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas

Sample : C 658
Depth, ft : 6055.6

SRS 1858/RSR 2968

n = 2.90

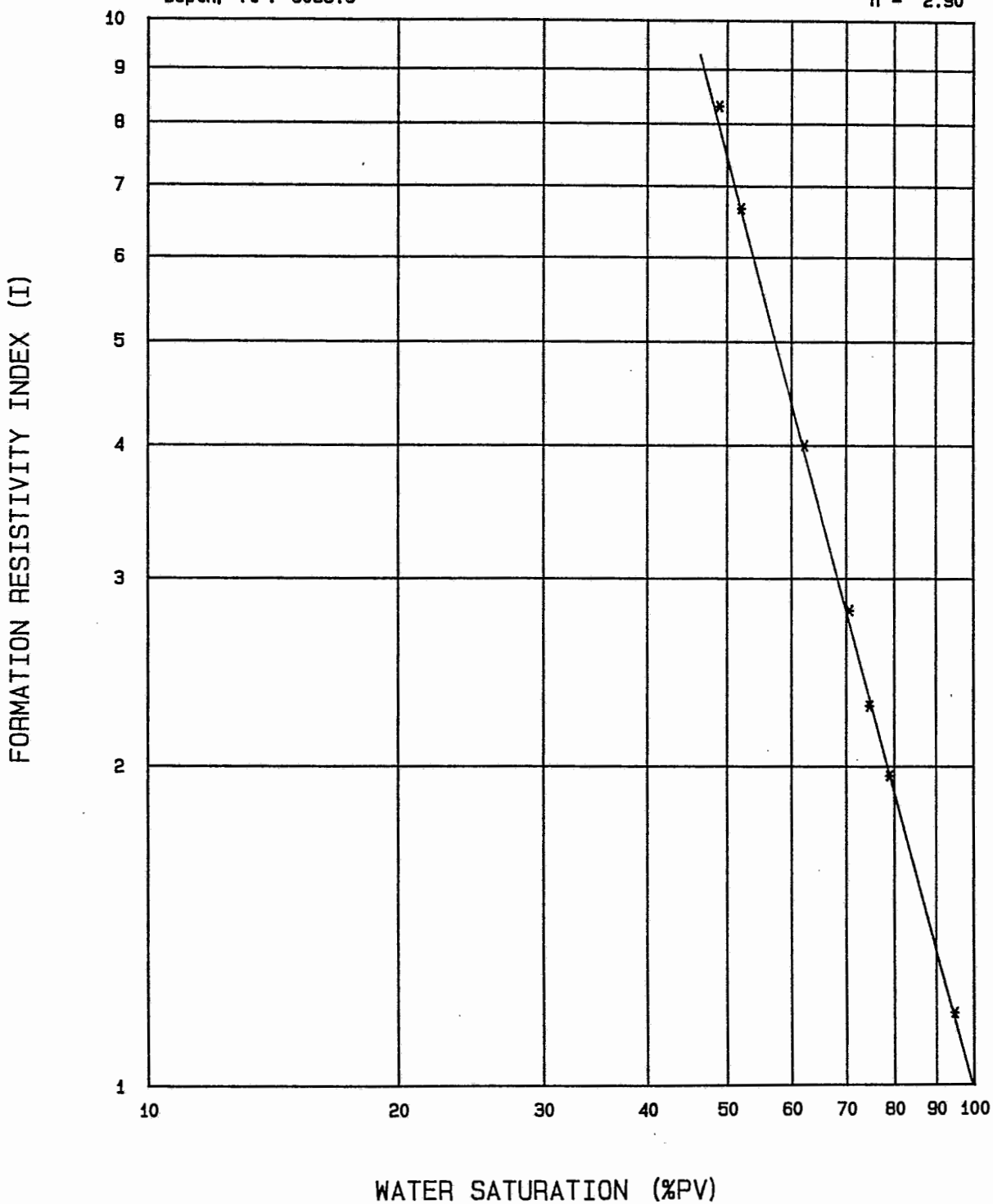


Table 10

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSR 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
C682	6061.2	1.25*	13.1	1.00	100.0
				1.07	97.8
				1.38	90.0
				1.54	86.5
				2.68	73.0
				3.54	66.5
				4.62	62.3

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Table 11

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSH 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
B 798	6065.5	0.053*	7.8	1.00	100.0
				1.16	91.1
				1.23	87.8
				1.31	84.5
				1.37	82.1

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 10

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas

Sample : C682
Depth, ft : 6061.2

SRS 1858/RSR 2968

n = 3.09

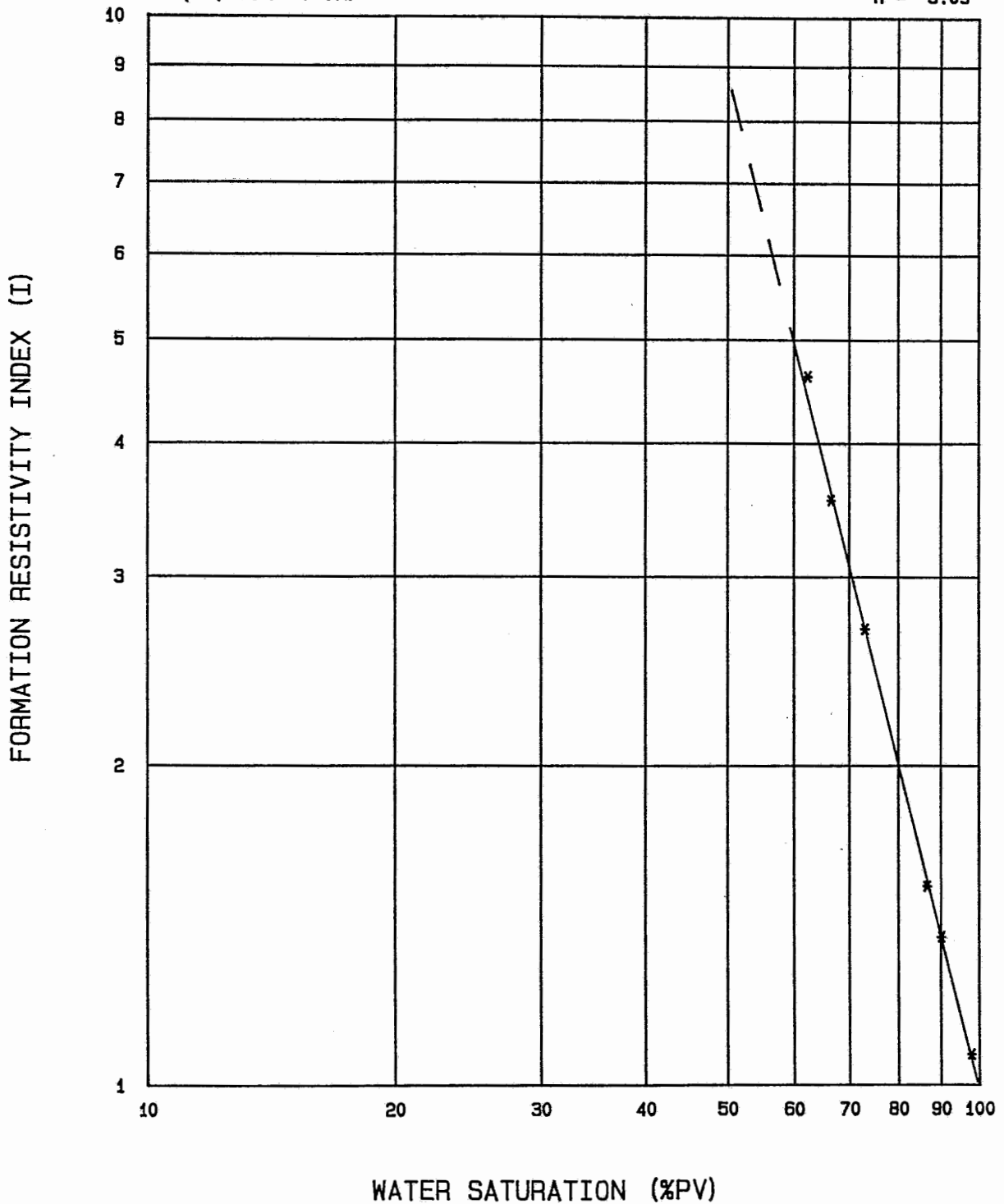


Figure 11

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

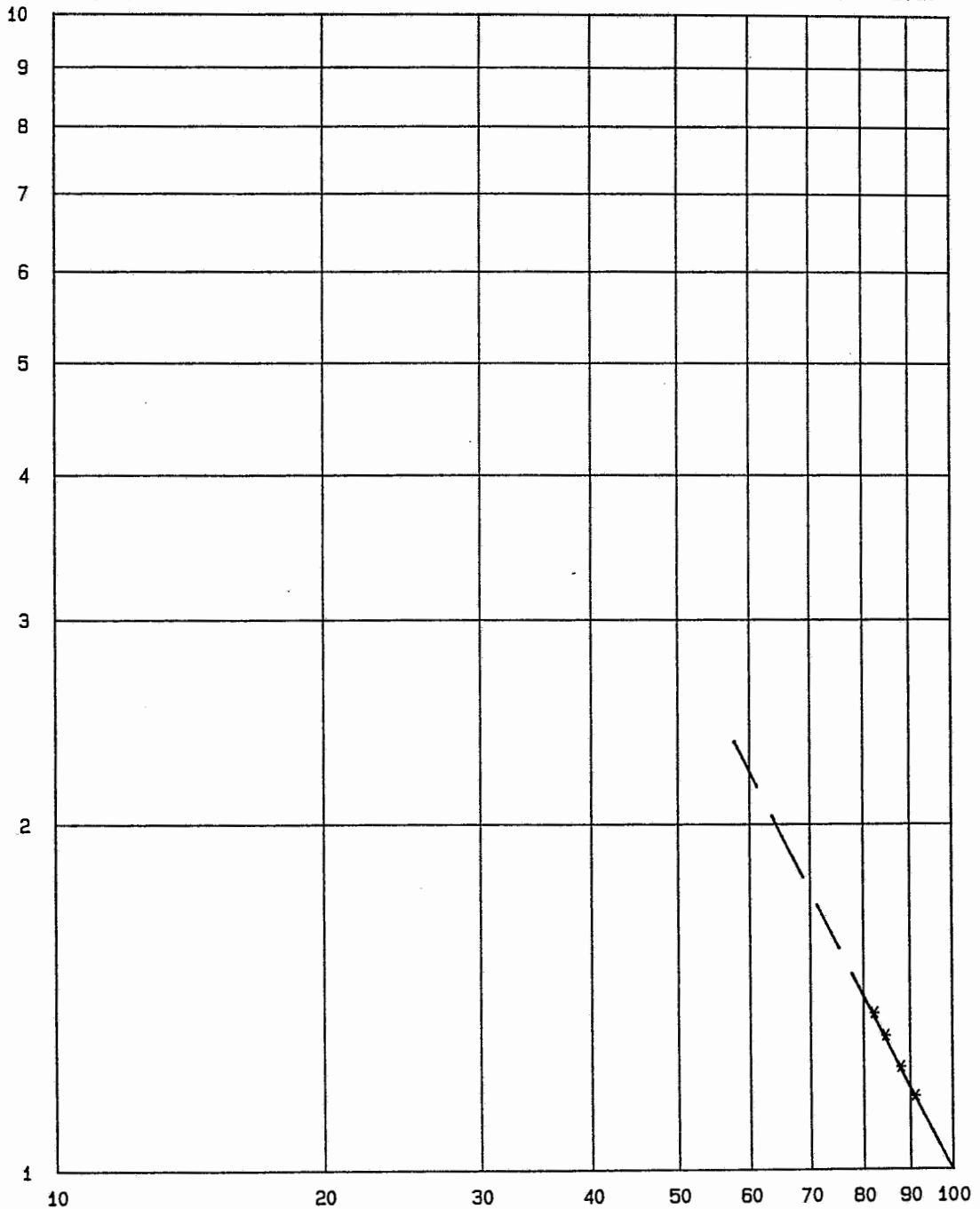
Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas

Sample : B 798
Depth, ft : 6065.5

SRS 1858/RSR 2968

n = 1.60

FORMATION RESISTIVITY INDEX (I)



WATER SATURATION (%PV)

Table 12

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSR 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
C 659	6066.8	0.700*	11.9	1.00	100.0
				1.13	95.9
				1.57	85.8
				2.61	71.8
				3.86	62.7
				5.18	57.4

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 12

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field

Stevens County, Kansas
SRS 1858/RSR 2968

Sample : C 659
Depth, ft : 6066.8

n = 2.92

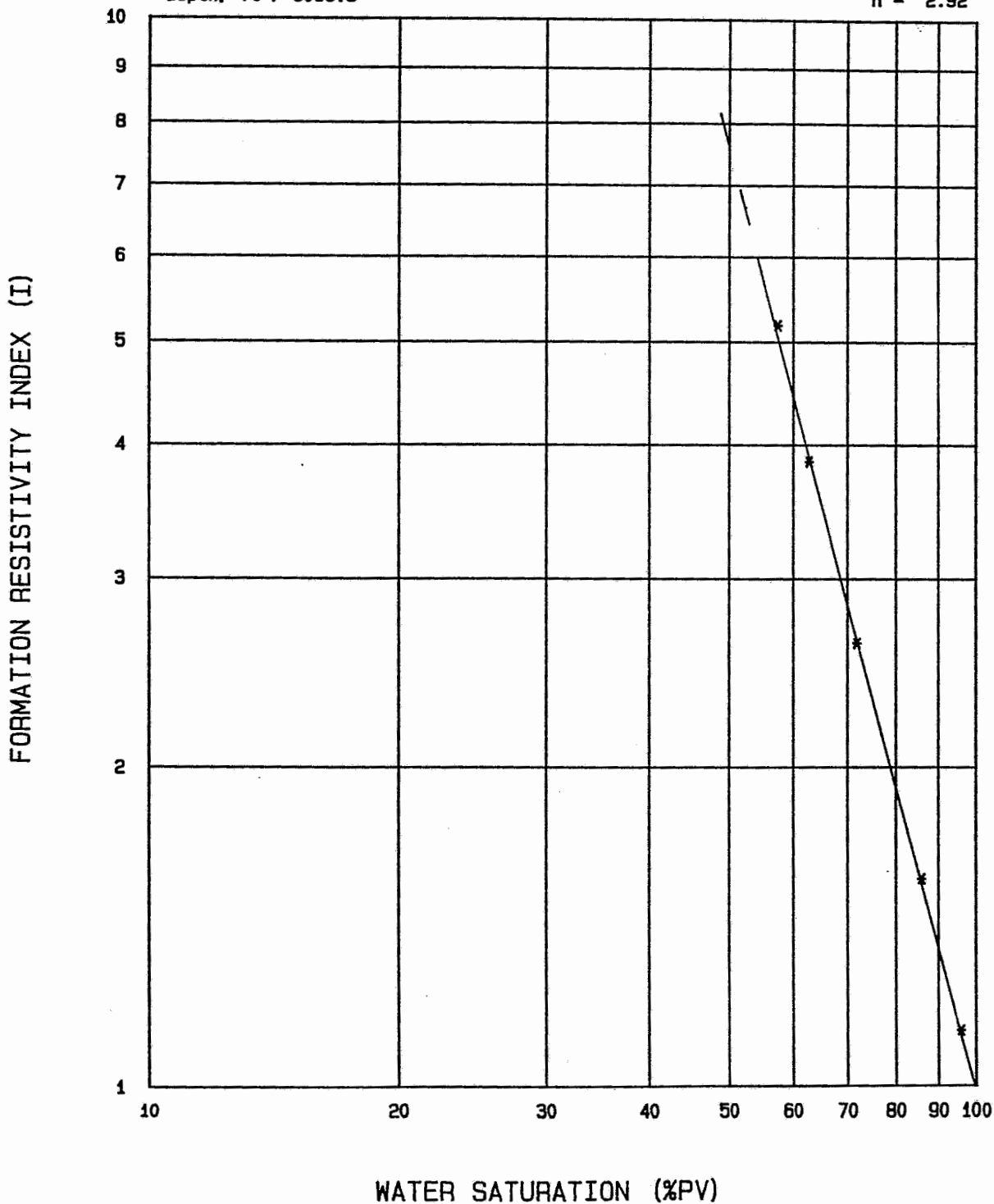


Table 13

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSR 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
B 809	6076.6	4.07*	15.6	1.00	100.0
				1.10	97.0
				1.27	92.7
				1.59	86.2
				2.23	77.6
				2.92	71.3
				6.62	54.8
				9.57	47.7

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 13

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas

Sample : B 809
Depth, ft : 6076.6

SRS 1858/RSH 2968

n = 3.13

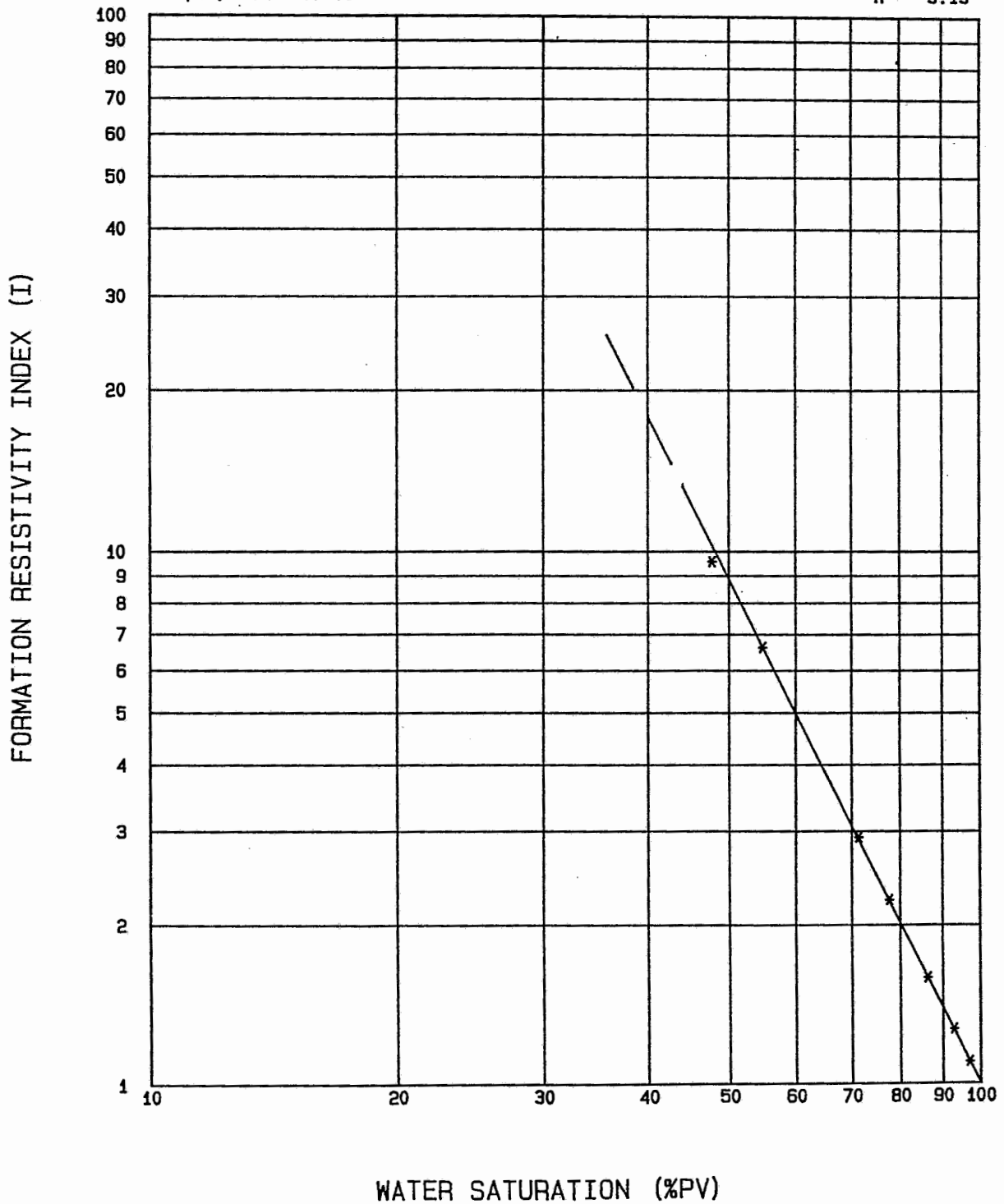


Table 14

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSH 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
C 660	6079.3	1.55*	13.9	1.00	100.0
				1.13	96.0
				1.34	91.1
				2.49	75.3
				3.70	66.0
				5.26	59.0
				6.79	54.1

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 14

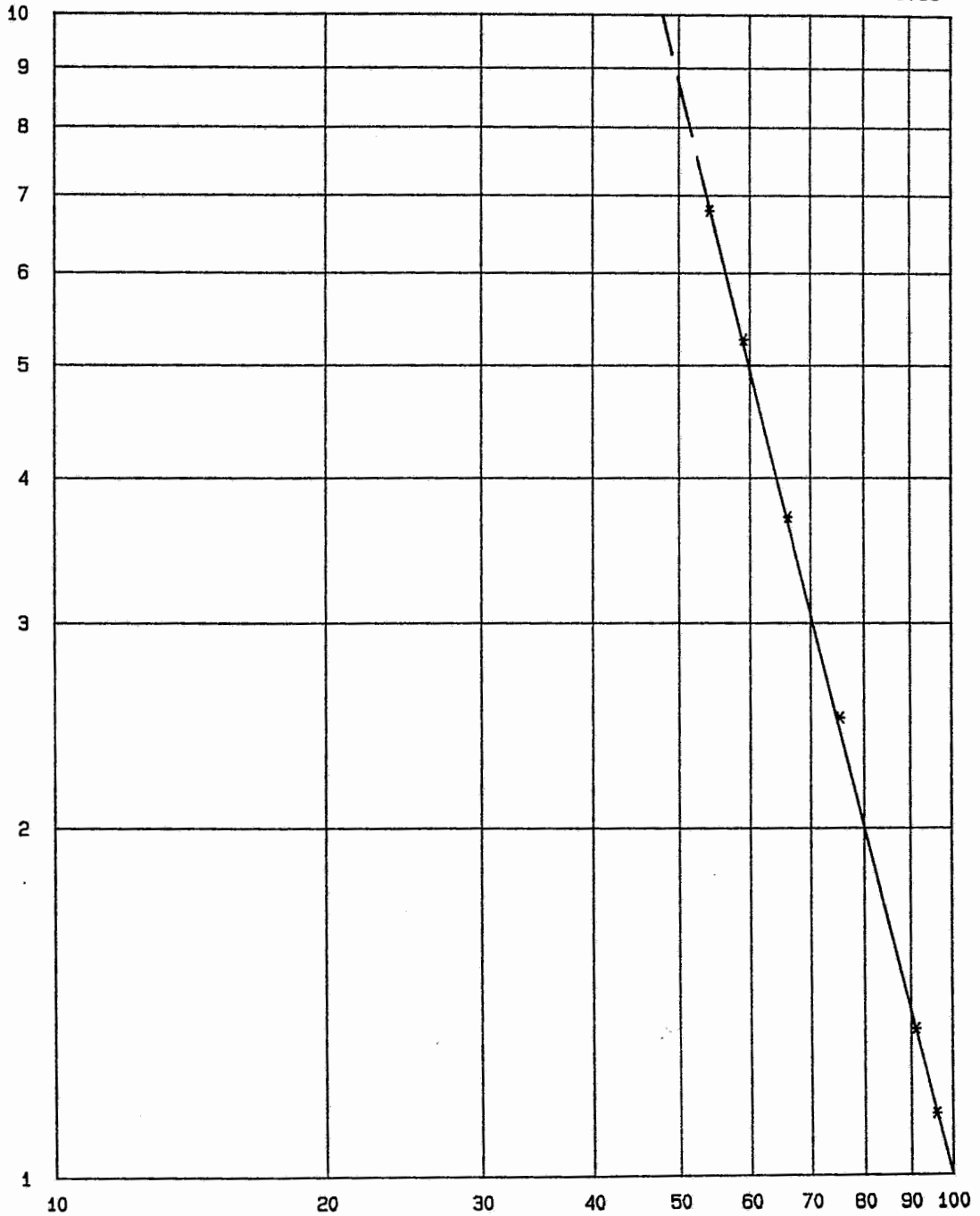
FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas
SRS 1858/RSH 2968

Sample : C 660
Depth, ft : 6079.3

n = 3.13

FORMATION RESISTIVITY INDEX (I)



WATER SATURATION (%PV)

Table 15

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSR 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
B 818	6085.5	0.113*	7.0	1.00	100.0
				1.13	95.1
				1.44	86.2
				1.85	78.0
				2.26	71.9
				2.48	69.1

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 15

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

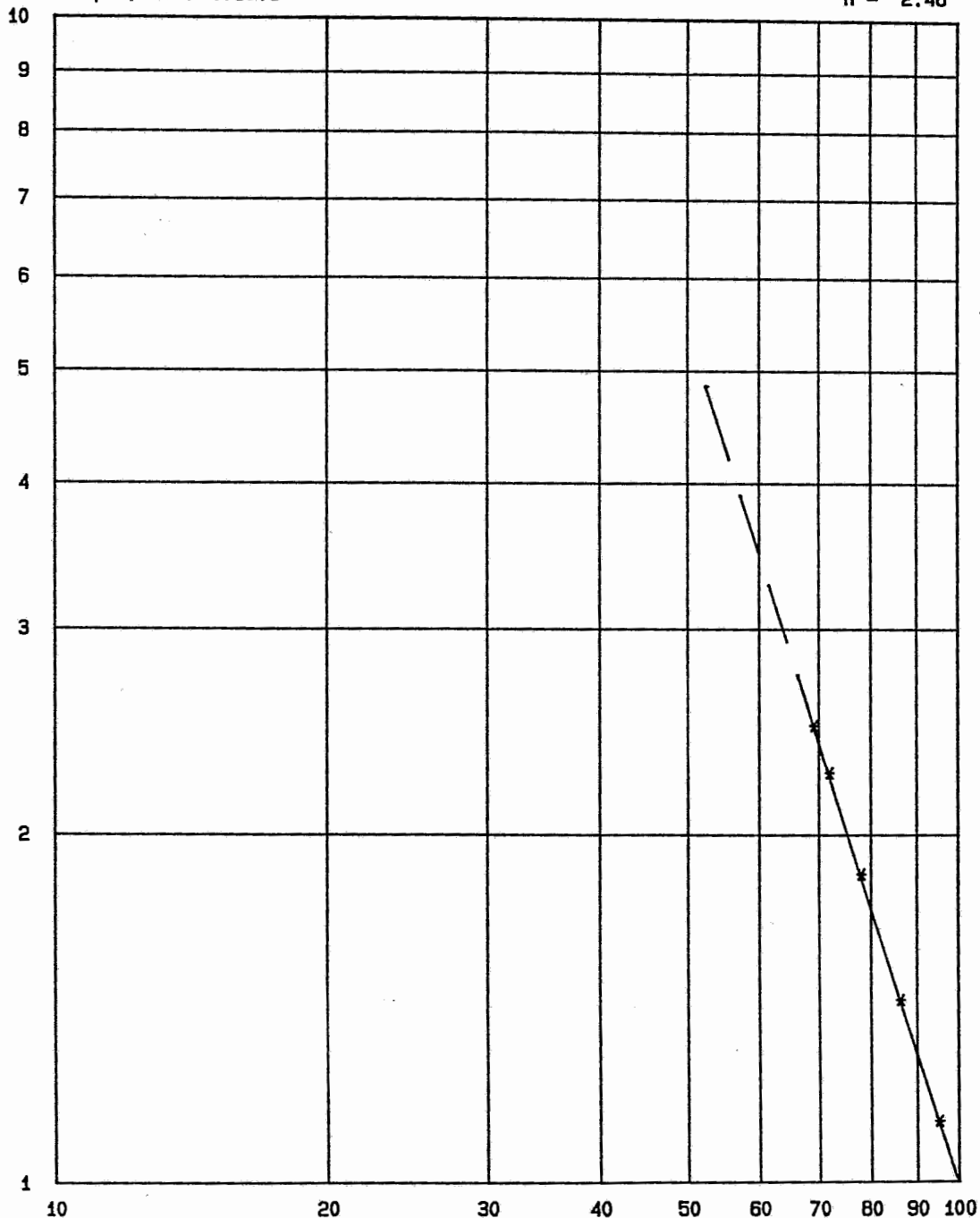
Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas

Sample : B 818
Depth, ft : 6085.5

SRS 1858/RSR 2968

n = 2.46

FORMATION RESISTIVITY INDEX (I)



WATER SATURATION (%PV)

Table 16

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSR 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
B 827	6097.8	169*	15.0	1.00	100.0
				1.12	96.5
				1.33	91.5
				1.84	82.5
				2.35	76.3
				2.99	70.4
				5.38	59.9
				6.49	55.7
				7.53	53.4
				11.13	47.3
				18.60	40.2
				29.82	34.5

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 16

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas

Sample : B 827
Depth, ft : 6097.8

SRS 1858/RSH 2968

n = 3.19

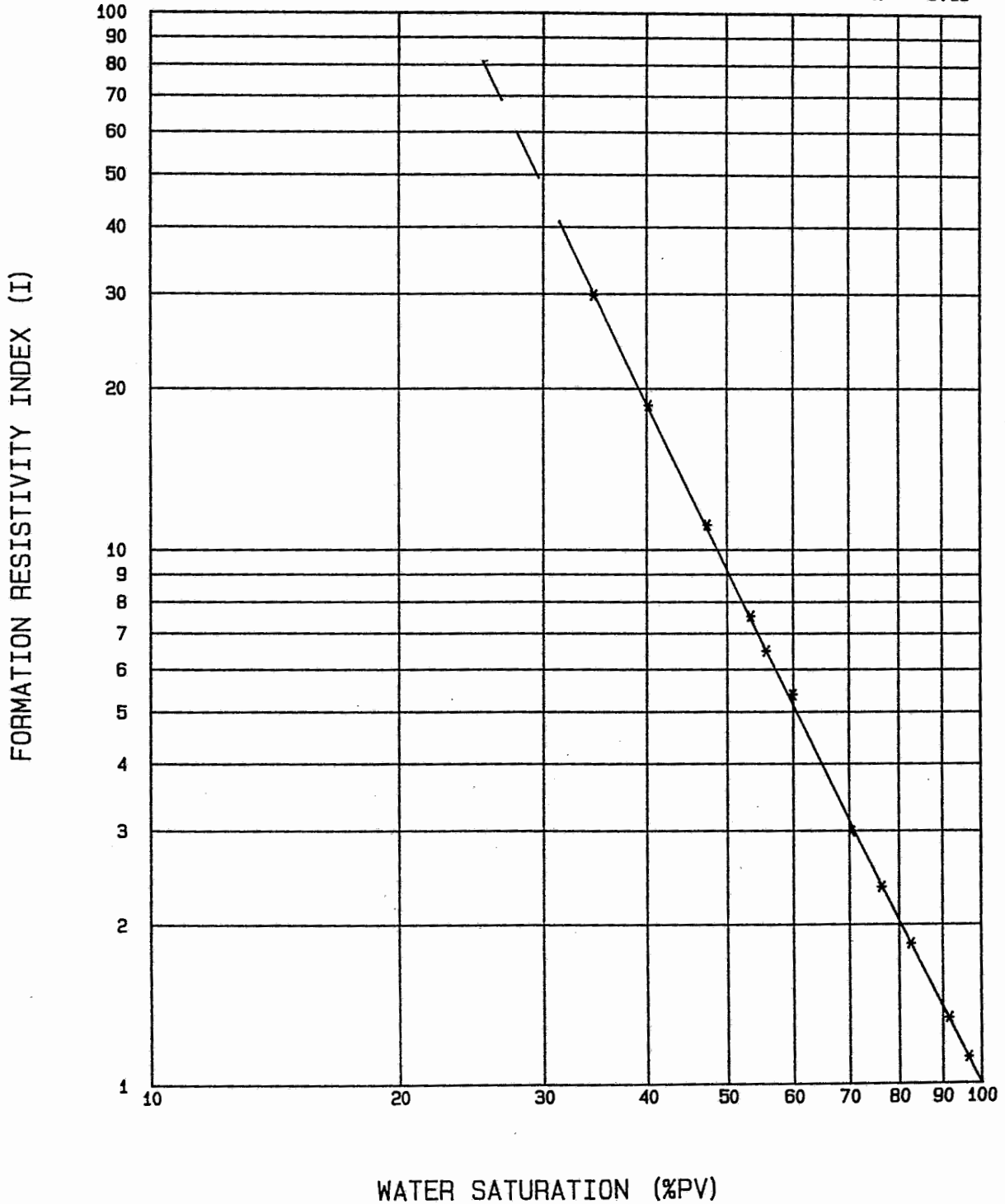


Table 17

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSR 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
B 833	6103.4	6.91*	12.1	1.00	100.0
				1.16	95.0
				1.62	84.4
				1.98	79.0
				2.31	74.8
				3.22	65.9
				4.17	60.2
				6.47	52.0
8.19	47.8				

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 17

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

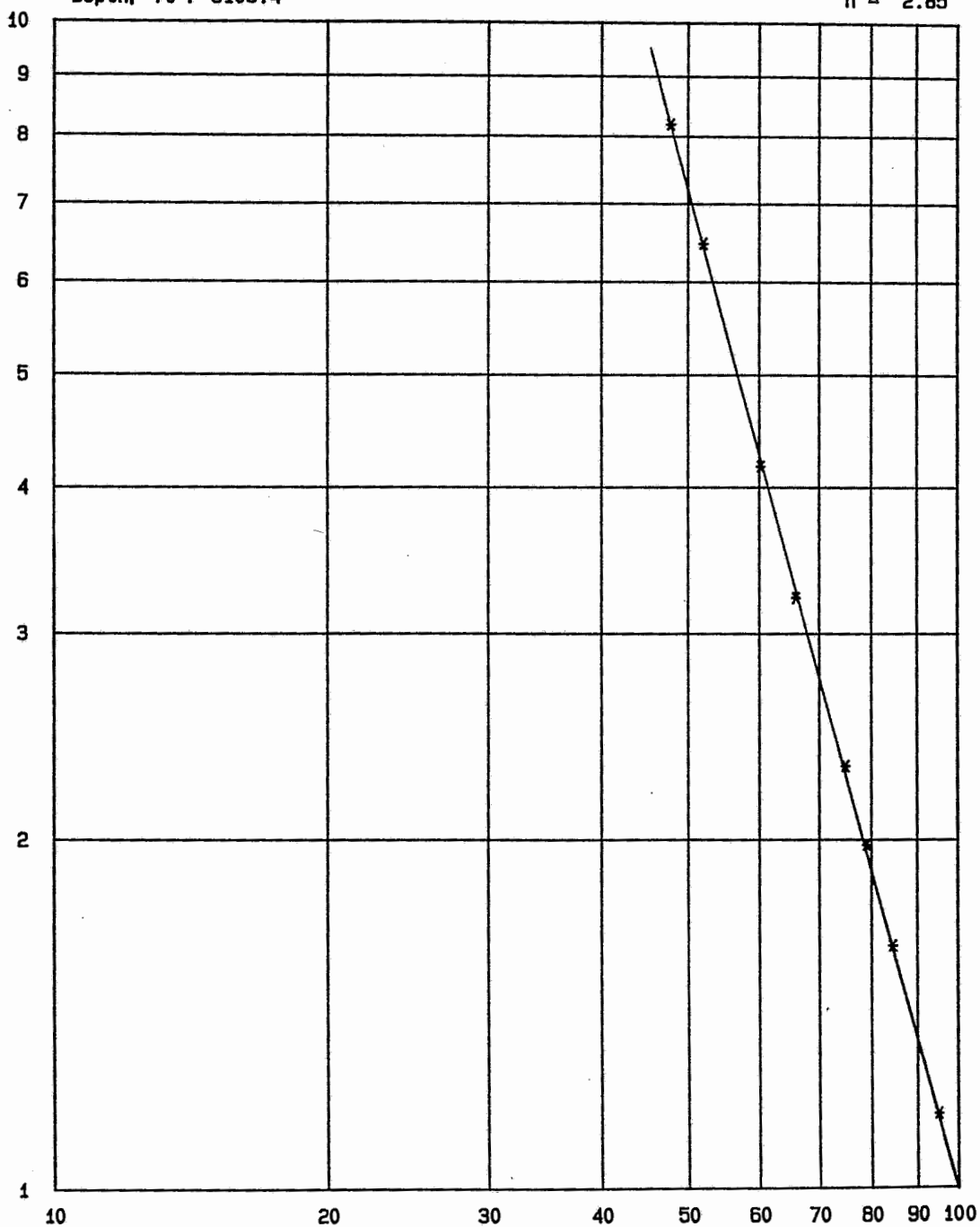
Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field

Sample : B 833
Depth, ft : 6103.4

Stevens County, Kansas
SRS 1858/RSR 2968

n = 2.85

FORMATION RESISTIVITY INDEX (I)



WATER SATURATION (%PV)

Table 18

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSR 2968

<u>Sample</u>	<u>Depth (ft)</u>	<u>Permeability To Gas (md)</u>	<u>Porosity (% BV)</u>	<u>Formation Resistivity Index (I)</u>	<u>Water Saturation (% PV)</u>
B 843	6113.5	6.67*	11.8	1.00	100.0
				1.09	97.1
				1.50	86.8
				1.82	81.1
				2.24	75.6
				2.81	69.9
				3.76	63.0
				5.58	54.8

Rw = 0.054 ohm-meters @ 70 degrees Fahrenheit

* Permeability to gas measured at 400 psig confining pressure.

Figure 18

FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas

Sample : B 843
Depth, ft : 6113.5

SRS 1858/RSH 2968

n = 2.88

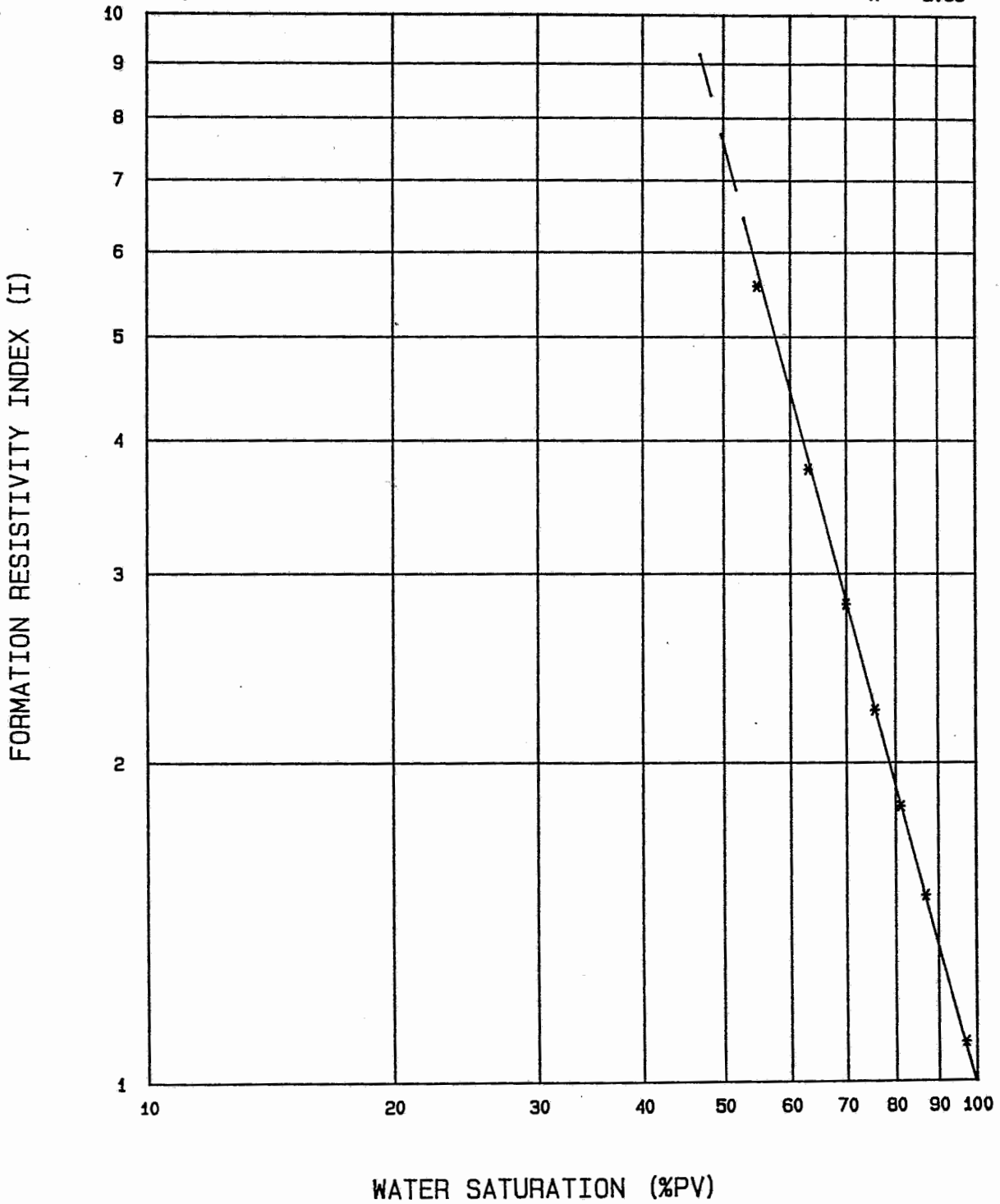


Table 19

AIR-BRINE CAPILLARY PRESSURE RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSH 2968

Sample : C 656
 Depth, ft : 6021.9

Porosity, %BV : 10.5
 Permeability, md : 2.81*

CAPILLARY PRESSURE (psig)	BRINE SATURATION (% PV)
0.0	100.0
1.0	100.0
2.0	100.0
4.0	97.2
8.0	94.5
15.0	78.4
35.0	63.2
75.0	54.4
125.0	47.3
200.0	44.9

* Permeability to gas measured at 400 psig confining pressure.

Figure 19
 FORMATION RESISTIVITY INDEX - SATURATION RELATIONSHIP
 AT CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSR 2968

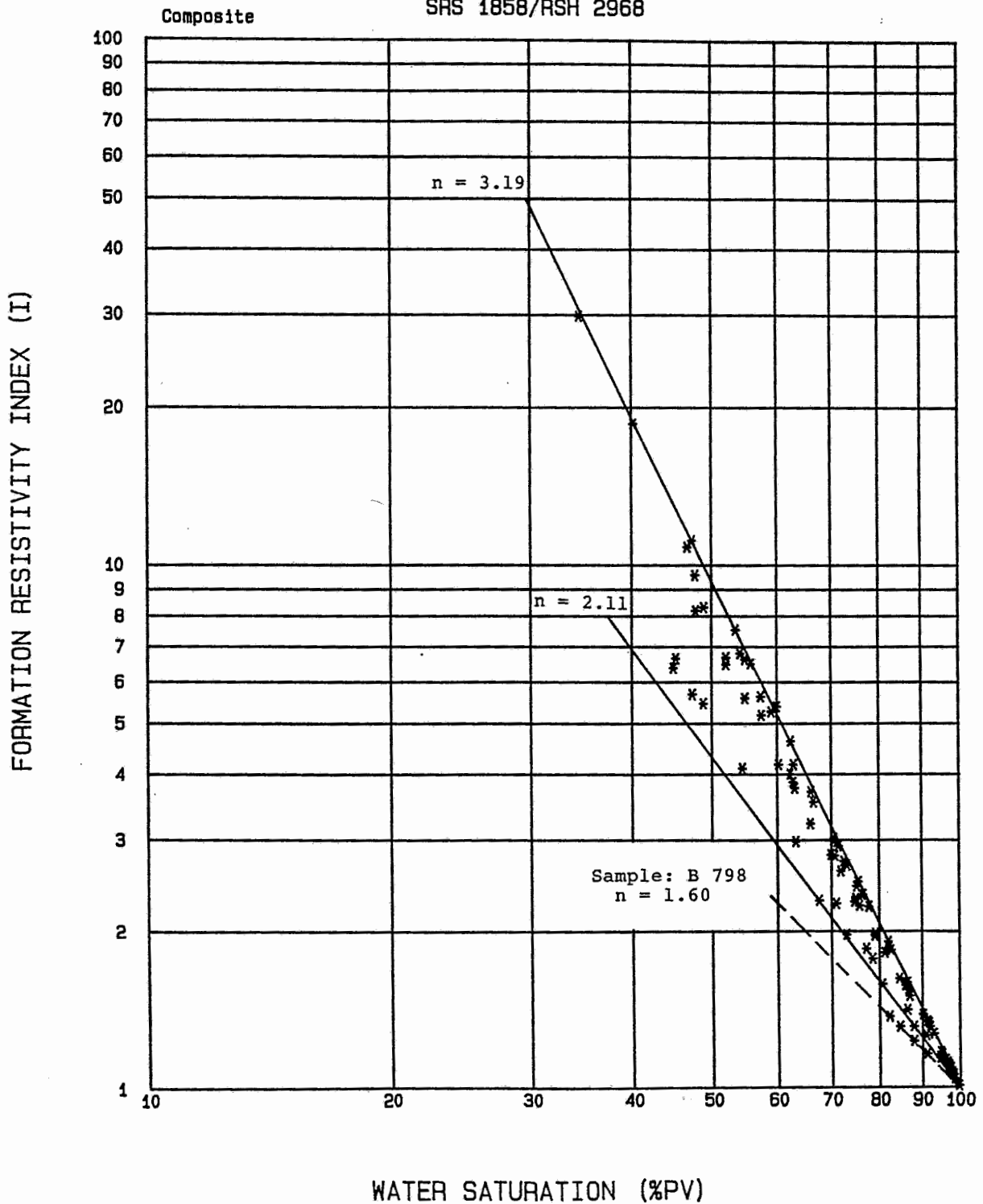


Figure 20

AIR-BRINE CAPILLARY PRESSURE RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas
SRS 1858/RSR 2968

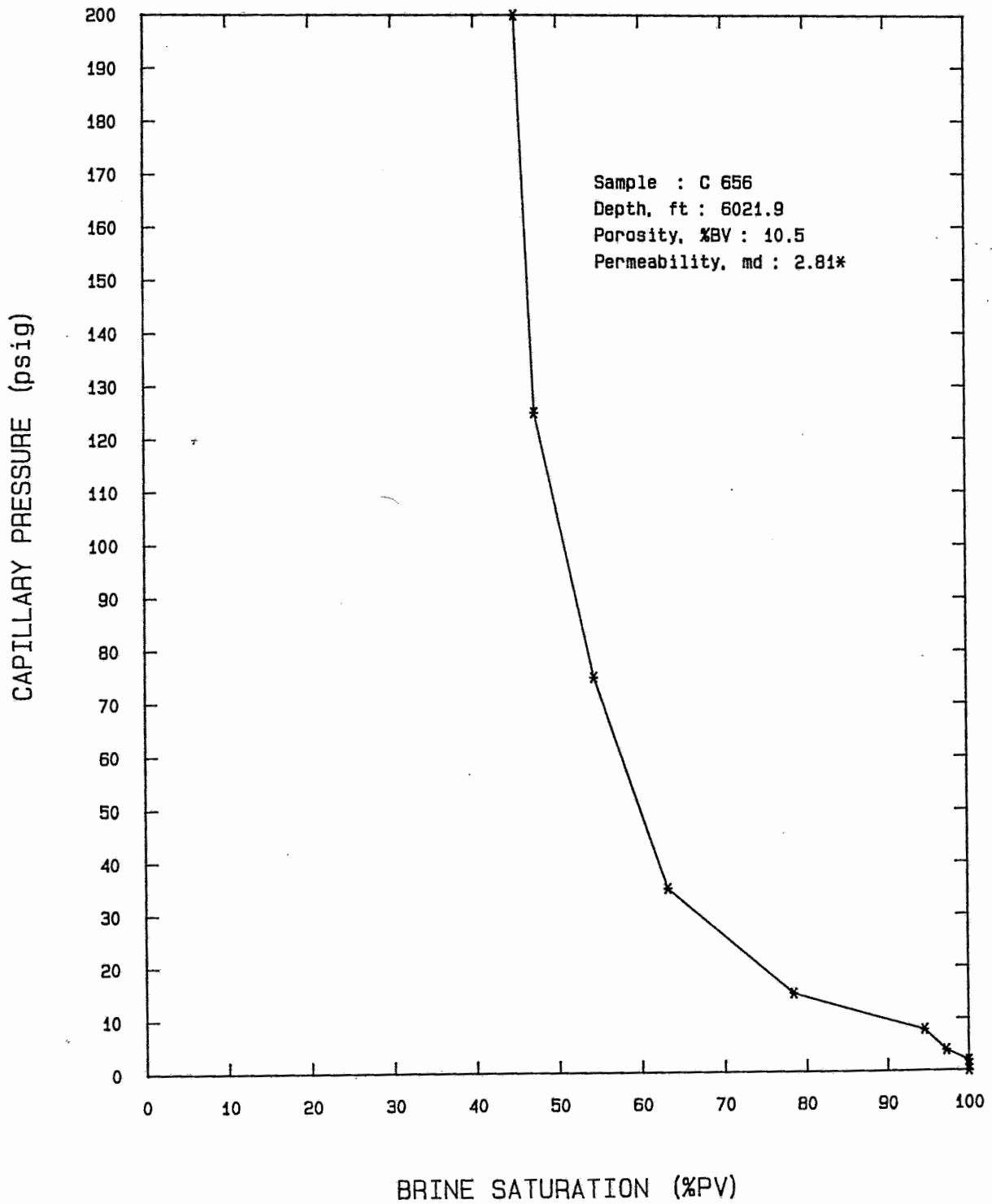


Figure 21

AIR-BRINE CAPILLARY PRESSURE RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas
SRS 1858/RSR 2968

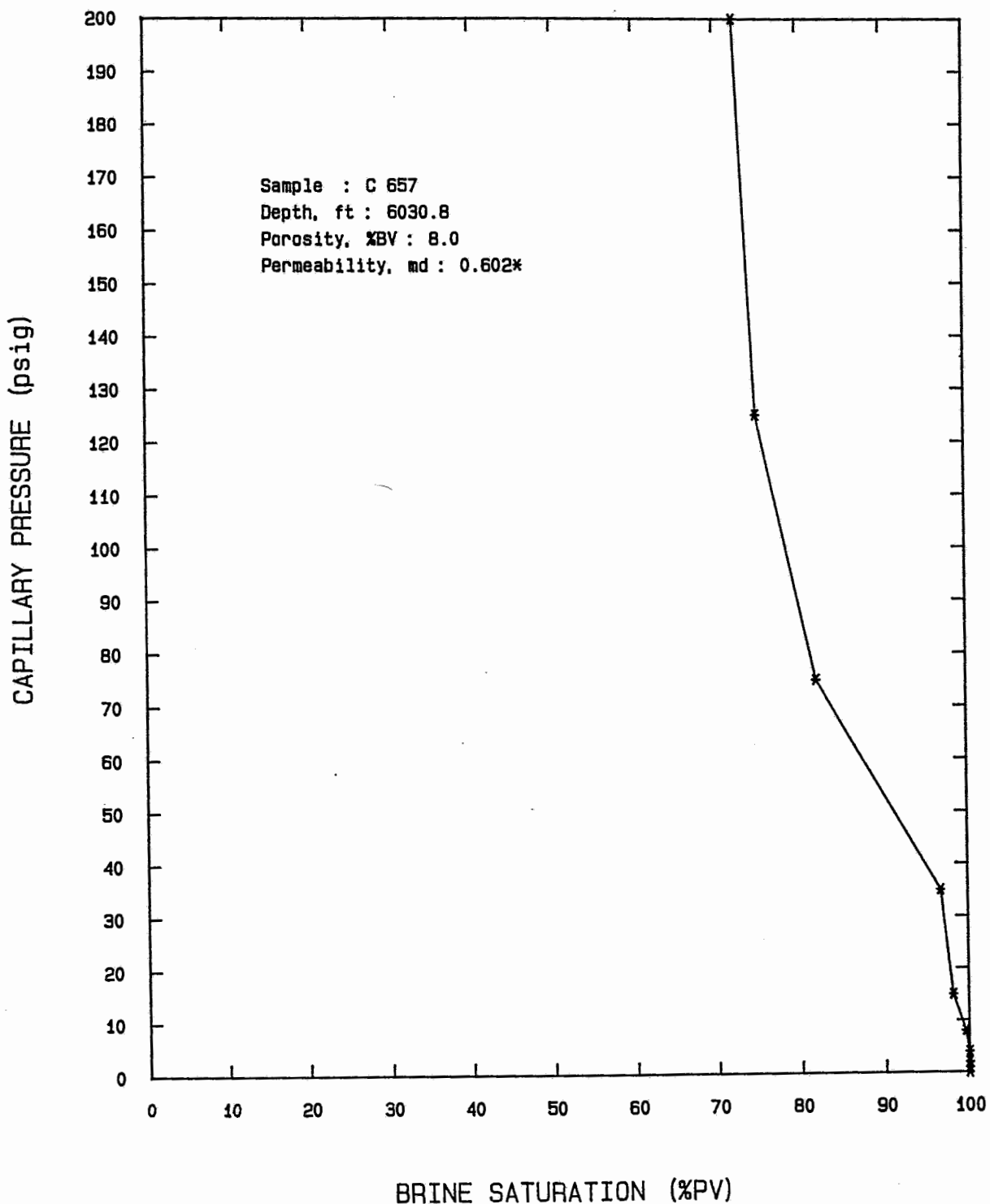


Table 21

AIR-BRINE CAPILLARY PRESSURE RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSB 2968

Sample : C 658 Porosity, %BV : 12.8
 Depth, ft : 6055.6 Permeability, md : 4.77*

CAPILLARY PRESSURE (psig)	BRINE SATURATION (% PV)
0.0	100.0
1.0	100.0
2.0	100.0
4.0	94.6
8.0	78.9
15.0	74.6
35.0	70.6
75.0	62.2
125.0	52.0
200.0	48.9

* Permeability to gas measured at 400 psig confining pressure.

Figure 22

AIR-BRINE CAPILLARY PRESSURE RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas
SRS 1858/RSR 2968

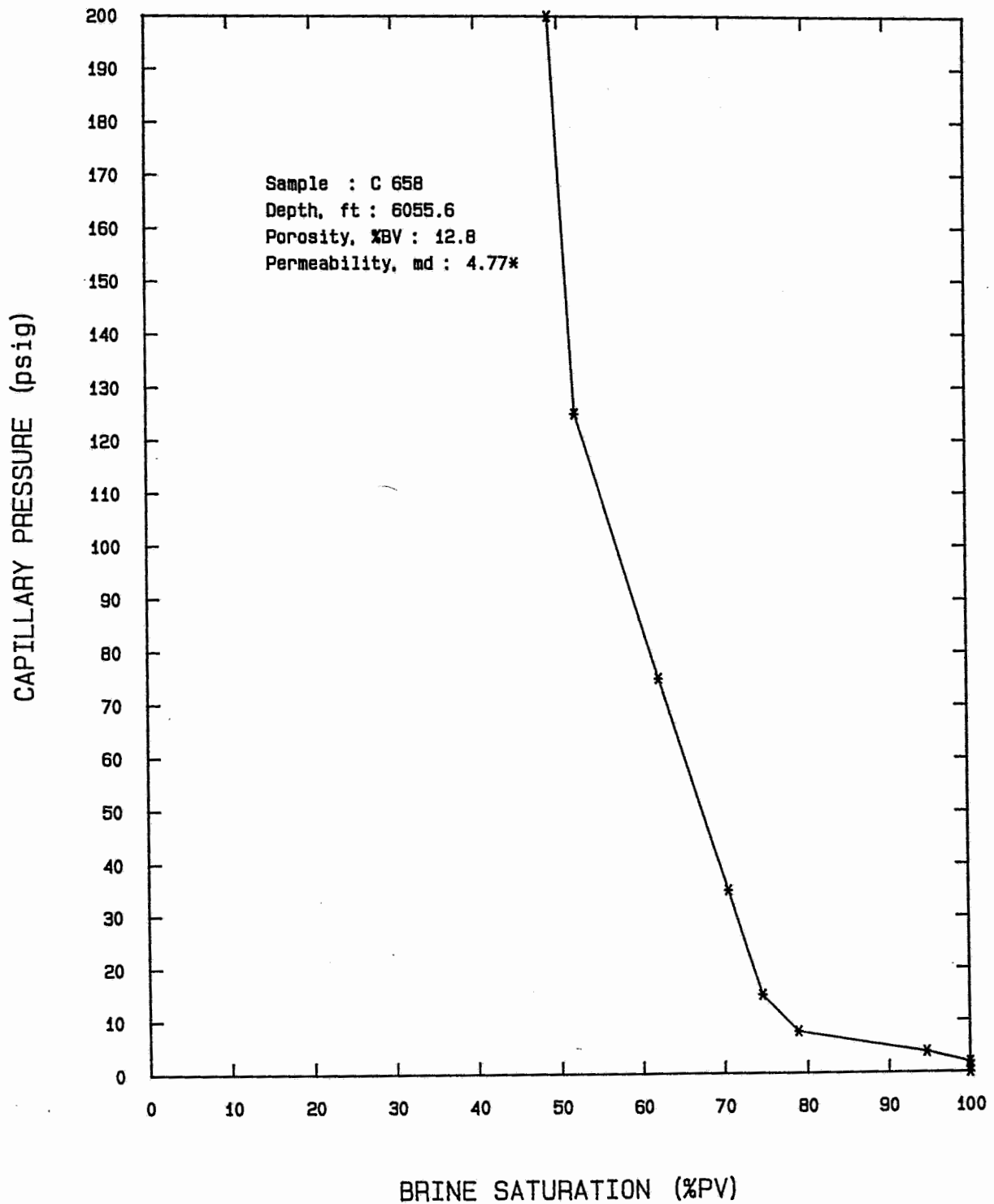


Figure 23

AIR-BRINE CAPILLARY PRESSURE RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas
SAS 1858/RSR 2968

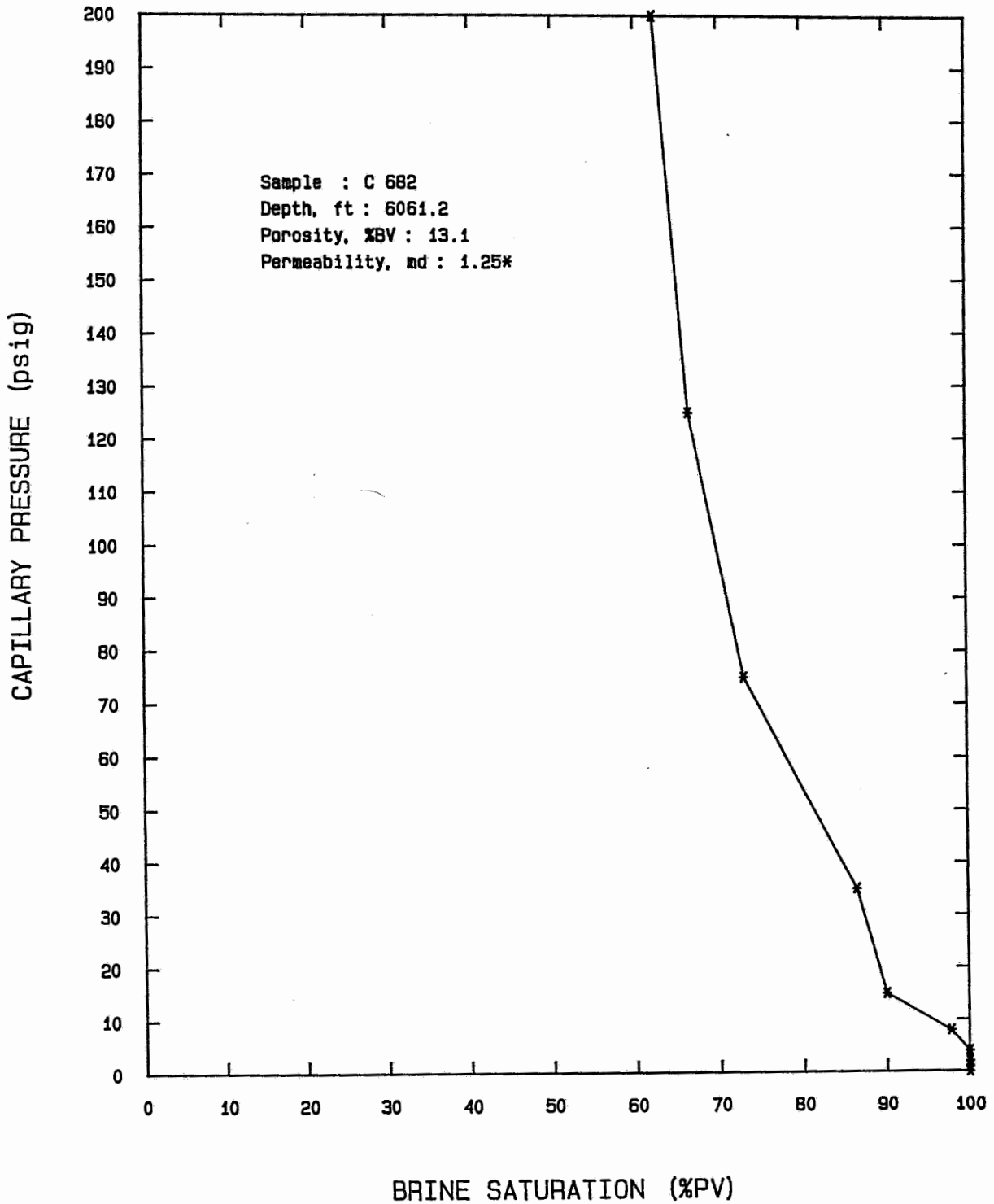


Table 23

AIR-BRINE CAPILLARY PRESSURE RELATIONSHIP

AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
 Ratcliff B-2 Well
 Gensler Field
 Stevens County, Kansas
 SRS 1858/RSH 2968

Sample : C 659
 Depth, ft : 6066.8

Porosity, %BV : 11.9
 Permeability, md : 0.700*

CAPILLARY PRESSURE (psig)	BRINE SATURATION (% PV)
0.0	100.0
1.0	100.0
2.0	100.0
4.0	100.0
8.0	100.0
15.0	95.9
35.0	85.8
75.0	71.8
125.0	62.7
200.0	57.4

* Permeability to gas measured at 400 psig confining pressure.

Figure 24

AIR-BRINE CAPILLARY PRESSURE RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas
SRS 1858/RSH 2968

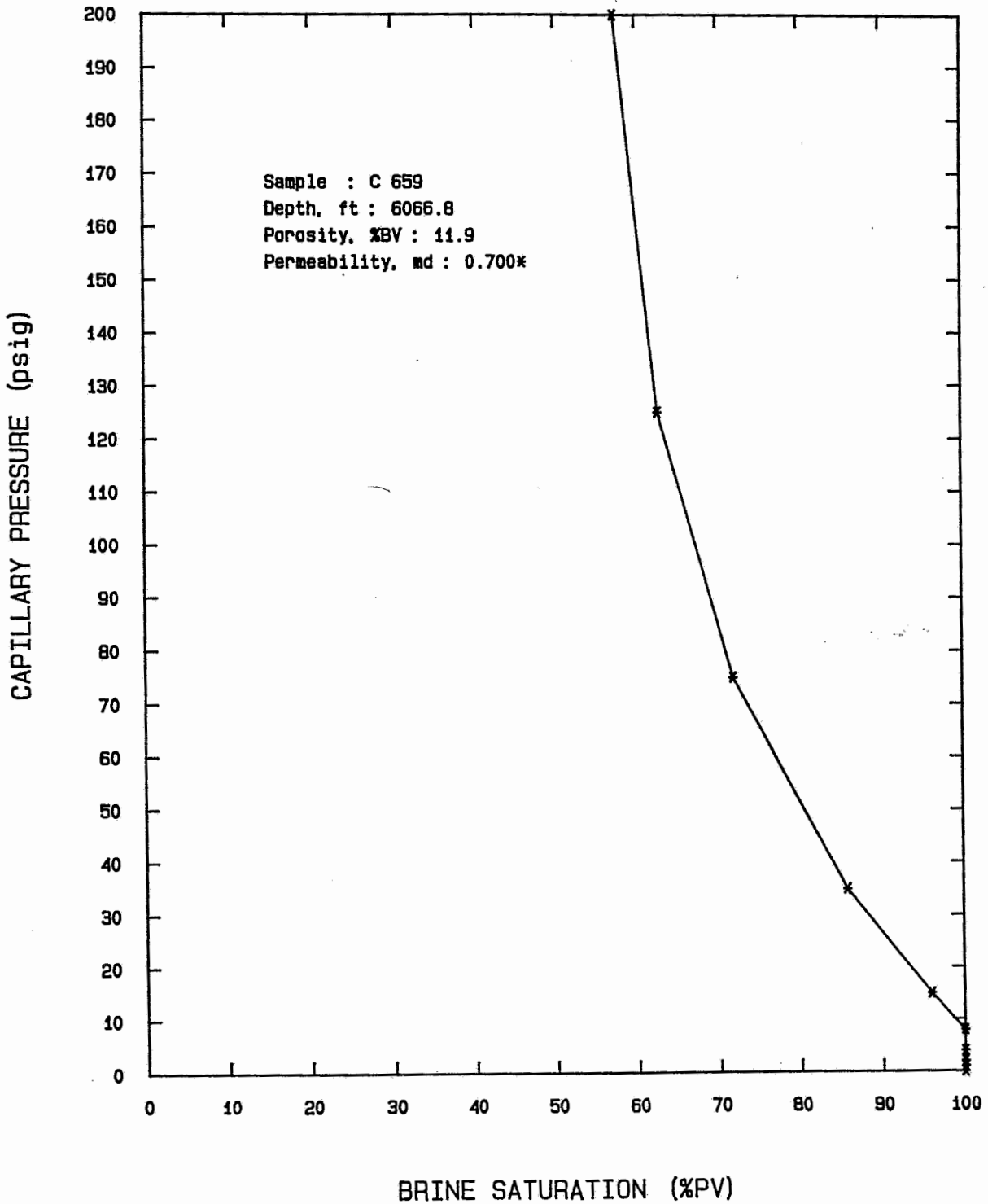


Figure 25

AIR-BRINE CAPILLARY PRESSURE RELATIONSHIP
AT 2600 psig CONFINING PRESSURE

Anadarko Petroleum Corporation
Ratcliff B-2 Well
Gensler Field
Stevens County, Kansas
SRS 1858/RSH 2968

