statoil

Special core analysis

Well 30/2-1

STATOIL

EXPLORATION & PRODUCTION
LABORATORY

Sept.-83

LAB 8

Den norske stats oljeselskap a.s

statoil
Den norske stats oljeselskap a.s

Classification

Requested by

Terje Helgøy

Subtitle

Co-workers

R.Furdal, E.Gilje, A.Hove and K.Sørheim

Title

Special core analysis
Well 30/2-1
STATOIL
EXPLORATION & PRODUCTION LABORATORY

Sept.-83 LAB 83.37

Prepared		Approved	
3/10-83	Trude Haaskjold Eide	3/10-83	D. Malthe-Sørenssen

Trude Haaskjold Eide

9.03.21 A

CONTENTS

1. SUMMARY

Porosity and permeability, Klinkenberg corrected, have been measured on 40 1½" X 2½" plug samples from Well 30/2-1, Ness, Etive, and Rannoch formation.
Formation factor, resistivity index, and saturation exponents have been determined for 20 plug samples from the three zones. Saturation exponents from 1.73 to 2.16 were found, with a mean value of 1.91.

Capillary pressure curves, air-brine, with eight pressure points have been determined for the 20 plug samples.

Saturated rock conductivity have been measured with NaCl solutions of 3 different strengths. Because of uncertainties in the measuring method, the Qv has not been calculated

Mercury injection capillary pressure measurements have been performed on the same 20 plug samples. The pore size distribution are calculated. The mercury injection data show lower irreducible water saturation then the air -brine data.

The results from the trapped gas measurements will be reported later.

2. INTRODUCTION

Prolab was requested to make a study of capillary pressure, air-brine and by mercury injection, electrical parameters, Co/Cw measurements and trapped gas from well 30/2-1, Rannoch, Etive and Ness formation. 20 plug samples were used in this study.

3. THEORY

3.1 Formation factor and resistivity index at ambient conditions

Electrical properties of porous rock are usually represented by the formation factor FF and resistivity index RI defined as:

$$FF = \frac{R_o}{R_w} \qquad \text{and} \quad RI = \frac{R_t}{R_o} \qquad 3.1.1$$

Where R_o and R_t are resistivity of 100% water saturation and partially water saturated rock respectively. R_w is resistivity of water used in experiment.

Formation factor will often be correlated with porosity using the expression

$$FF = a \cdot \phi^{-m} \qquad 3.1.2$$

Here, the experimental data have been curvefitted by the use of the least squares method on the logarithmic transform of equation.

Two different methods have been tried out. First, both "a" and "m" have been determined from the curvefitting procedure, secondly the curve have been forced through the point $\phi = 1$ and $FF = 1$ so that $a = 1$.

Resistivity index on the other hand depend on saturation. For clean, non-shaly sand the following relation is used:

$$RI = S_w^{-n} \qquad 3.1.3$$

The saturation exponent, n, are determined with the use of the weighted least squares method on the logarithmic transform of equation.

3.2 Co/Cw Measurements

The measurements are done with the purpose of determining any possible contribution of the conductance in reservoir - rock, caused by clay. The general equation for the conductance in shaly sand is given by:

$$C_o = \frac{1}{FF^*} = (B \cdot Q_v + C_w)$$

Plots of Co versus Cw of fully watersaturated core samples show a straight line relationship. If any clay is present there is a positive displacement of the line on the Co axis at Cw = 0.

$\frac{1}{FF^*}$ = the slope of the straight line portion of the Co vs. Cw curve

Co = specific conductance of 100 % brine saturated rock.

Cw = specific conductance of brine

B = the equivalent conductance of the clay counterions, 38.3

Qv = the effective concentration of clay cations (meq/ml).

3.3 Mercury Injection Capillary Pressue

Primary use of these data is to find the irreducible water saturation, Swi.
The fractional mercury - saturation is expressed as:

$$S_{HG} = \frac{Vinj}{V_p} \qquad 3.3.1$$

V_{inj} = injected volume cc

V_p = pore volume, cc

The equivalent water-saturation is then given by

$$S_w = 1 - S_{Hg} \qquad 3.3.2$$

The size range of the pores corresponding to each pressure are calculated using the Washburn equation (1).

$$r = \frac{2\sigma \cos \theta}{P_c} \qquad 3.3.3$$

σ = interfacial tension, dynes/cm

θ = contact angle, degrees

P_c = capillary pressure, bar

4. EXPERIMENTAL PROCEDURE

4.1 Sample Preparation

40 $1^1/2$" x $2^1/2$" plug samples had been drilled out by Geco. The samples were washed by extraction using toluene and methanol and then dried at 60°C and 40% humidity.

4.2 Measurements of grain volume and pore volume

Subsequently the samples were weighed, and the helium porosity was measured in a Core Lab Heliumporosimeter. The bulk volume was measured using sliding callpiper.

4.3 Measurements of air permeability

Air permeability was measured and the Klinkenberg gas slippage correction was found for each sample by linear regression of at least 3 pressure points.

4.4 Sample Description

From a plot of log K versus porosity of routine analysis of the 40 30/2-1 plug samples, 20 plug samples were selected to cover a wide range of K and porosity. The table below shows a listing of these plugs.

Table 4.1

Plug no.	Depth (m)	Formation
39.1	3703.97	Ness
53.1	3714.47	"
59.1	3718.33	"
63.1	3719.68	"
68.1	3721.12	"
75.1	3723.50	"
88.1	3730.34	"
97.1	3737.00	"
101.1	3738.27	"
118.1	3749.43	"
131.1	3758.13	Etive
138.1	3761.12	"
142.1	3762.32	"
178.1	3775.13	"
181.1	3776.15	"
186.1	3777.87	"
190.1	3779.38	Rannoch
198.1	3782.37	"
202.1	3783.77	"
214.1	3787.93	"

4.5 Capillary pressure (Air-brine) and electrical measurements

The plugs were evacuated and saturated with degassed simulated formation water (see Appendix I). To ensure 100% saturation the plugs were placed in a pressure-vessel containing brine and kept at 40 bars for 72 hours.

The resistivity was measured by using two silver painted rubber electrodes pressed against the plug ends.

The plugs were mounted on a brine-saturated porous plate, which was mounted in a cell. A layer of kiesel-guhr was put between the samples and the plate. Pressure was applied to the cell using air saturated with water vapor. At least five days were allowed for water drainage to reach equilibrium. Each plug was then weighed, and the resistivity, Rt was measured as above.

After each weighing and resistivity measurement the plugs were mounted back on the porous plate and a higher pressure was applied. The pressure used were: 0.143, 0.274, 0.586, 1.59, 2.77, 5.0 and 12.0 bars. All resistivities were extrapolated to 20^{o}C. After the last pressure point the plugs were washed and dried.

4.6 Co/Cw-measurements

Each plug sample was evacuated and saturated with degassed brine. To ensure 100% saturation the samples were placed in a pressure vessel containing brine and kept at 40 bars for 72 hours. The samples were left immersed in brine until electrical equilibrium had been attained. The resistivity of each sample was then measured by using two silver- painted rubber electrodes pressed against the plug ends. The plug samples were then washed and dried.

This process was repeated until sample conductivities had been determined with different saturating brines. The brines used were, in chronological order, simulated formation brine, NaCl solutions of concentration 60 000 ppm, 90 000 ppm and 120 000 ppm.

4.7 Mercury Injection Capillary Pressure Measurements

20 1½" diameter samples of suitable sizes (appr. 10-12 cc) had been drilled out by Geco. The plugs were washed by extraction using toluene and metanol, and then dried at 60°C and 40 % humidity. These samples were cut in two, set A and B.

The bulk volume was measured in a Ruska mercury porosimeter.

The mercury injection capillary measurements were performed using a Ruska mercury pump designed for the range of 0-138 bar.

5. RESULTS

Table 5.1 gives the routine core data from 30/2-1.

Table 5.1 30/2-1

The Klingenberg corrected permeability (KL), the heliumporosity (Por) and the grain density (Grdns).

Sample nr.	Depth (m)	KL (mD)	Por (Frac)	Grdns (gr/cc)
39.1	3703.97	1.50	0.193	2.68
53.1	3714.47	0.22	0.156	2.67
59.1	3718.33	399.00	0.256	2.65
63.1	3719.68	991.00	0.268	2.65
68.1	3721.12	1493.00	0.280	2.65
75.1	3723.50	56.50	0.220	2.91
88.1	3730.34	0.28	0.160	2.70
97.1	3737.00	0.66	0.165	2.69
101.1	3738.27	0.38	0.160	3.20
118.1	3749.43	2672.00	0.285	2.65
131.1	3758.13	168.00	0.273	2.67
138.1	3761.12	151.00	0.272	2.66
142.1	3762.32	326.00	0.293	2.67
178.1	3775.13	1.38	0.210	2.70
181.1	3776.15	1.57	0.196	2.71
186.1	3777.87	4.65	0.229	2.73
190.1	3779.38	0.04	0.153	2.79
198.1	3782.37	0.26	0.193	2.70
202.1	3783.77	1.61	0.233	2.69
214.1	3787.93	2.44	0.232	2.67

Fig 8.1 shows a plot of permeability versus porosity.

Table 5.2 gives the results of the electrical measurements from 30/2-1.

Table 5.2

Electrical measurements 30/2-1.

Sample nr.	Por (frac)	FF	n	Swi frac
39.1	0.193	37.65	1.74	0.437
53.1	0.156	48.80	1.89	0.748
59.1	0.256	13.40	1.90	0.110
63.1	0.268	11.90	1.86	0.106
68.1	0.280	11.60	1.84	0.095
75.1	0.220	22.00	2.12	0.461
88.1	0.160	47.60	1.91	0.614
97.1	0.165	37.40	1.73	0.600
101.1	0.160	52.60	2.16	0.612
118.1	0.285	10.70	2.03	0.093
131.1	0.273	13.00	1.99	0.225
138.1	0.272	15.30	2.05	0.229
142.1	0.293	13.60	2.09	0.197
178.1	0.210	31.90	1.94	0.542
181.1	0.196	30.50	1.95	0.577
186.1	0.229	23.30	2.07	0.461
190.1	0.153	57.10	1.87	0.884
198.1	0.193	40.50	1.93	0.833
202.1	0.233	27.50	1.94	0.567
214.1	0.232	24.20	1.89	0.473

Composite : $FF = 0.59\ \phi^{-2.43}$, $R^2 = 0.92$

$FF = \phi^{-2.10}$, $R_2 = 0.91$

$RI = Sw^{-1.91}$

Fig.8.2 is a plot of formationfactor versus porosity.

Table 8.1-8.7 list the results of the capillary pressure (air-brine) analysis. The capillary pressure, the corresponding water saturation and the resistivity index.

Fig 8.3-8.12 show the plots of resistivity index versus water saturation for each sample.

Fig 8.13 is a composite plot of all samples, resistivity index versus irreducible water saturation.

Table 8.8-8.10 give the results of the Co/Cw measurements

Fig 8.14-8.33 show the plots of coreconductivity versus brineconductivity.
The mercury injection capillary pressure data are given in table 8.11 - 8.29. The plots of capillary pressure versus mercury injection are given in Fig.8.34-8.37

6. DISCUSSION/CONCLUSION.

The formation factors increase with decreasing porosity as shown in Fig 8.2. A linear regression using Archies equation $FF = a\ \phi^{-m}$, gives $FF = 0.59\ \phi^{-2.43}$ and $F = \phi^{-2.10}$ when forced through 1.

The saturation exponents, n, listed in table 5.2 go from 1.73 to 2.16 and a linear regression analysis on all data points gives $n = 1.91$.

In the Co/Cw plots the curves have not been drawn to intersection with the x-axis. Some of the samples will intersect with the positive x-axis (sample no. 39.1, 53.1, 88.1, 97.1, 101.1, 178.1, 181.1, 198.1, 202.1, and 214.1) and this may be due to uncertainties in the Co measurements. The Cw measured values corresponds well with handbook values.

The mercury injection data are showing lower irreducible water saturation than the air-brine data. The plugs with very low permeability has the greatest disagreement.

7. LITTERATURE

1. Amyx, Bass & Whiting : "Petroleum Reservoir Engineering", Mc Graw Hill Book Company, London 1960.

8. APPENDIX LIST

Appendix 1

simulated formation water composition:

Na	:	11480 ppm
K	:	610 ppm
Mg	:	1490 ppm
Ca	:	1230 ppm

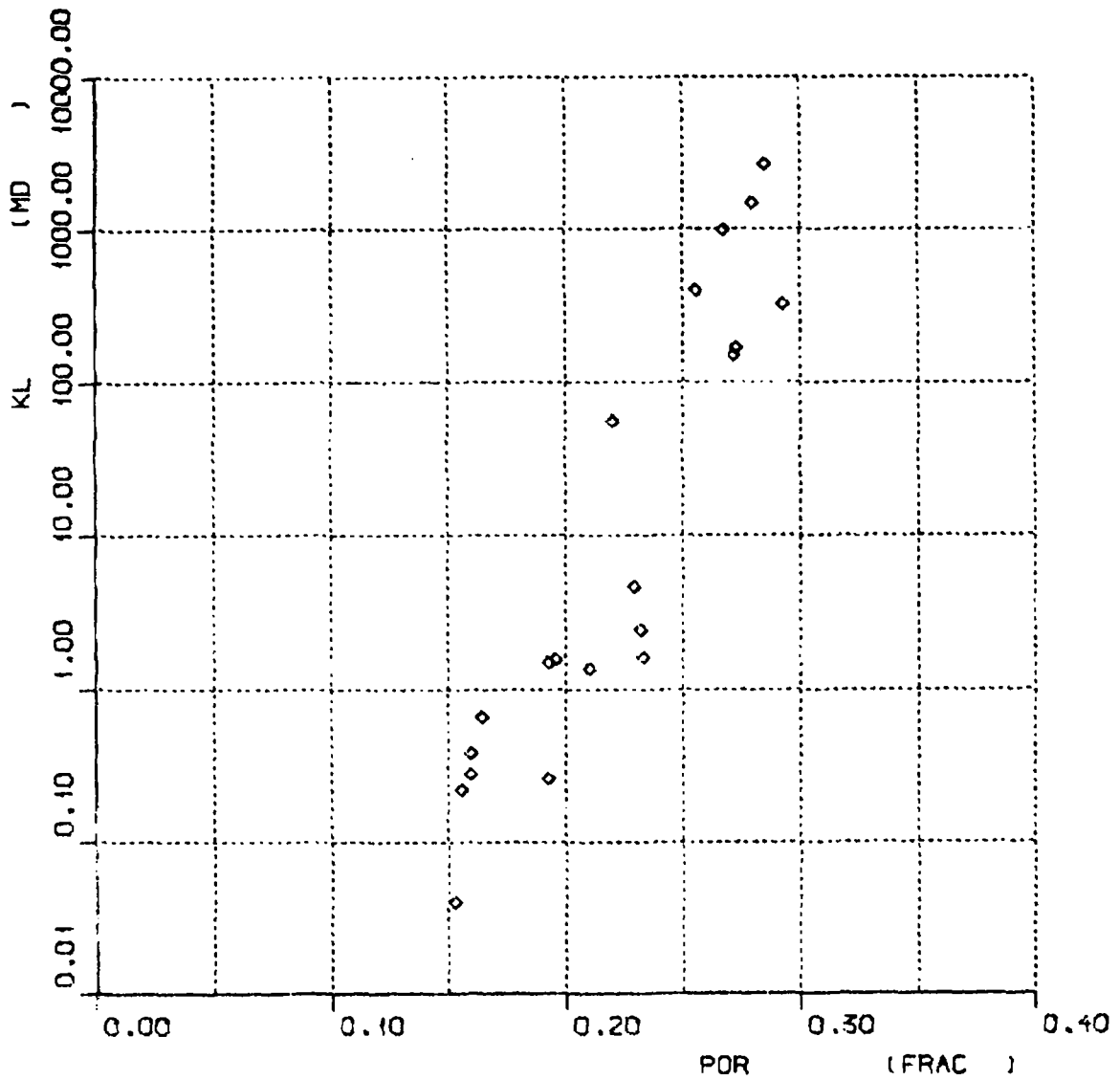
The chloride ions of the cations above were mixed. The spesific conductivity of the water at 20°C:

5.42 S/m $R = 0{,}188\ \Omega m$ ved 20°C

Appendix 2
Results from electrical measurements

Fig. 8.1 Permeability versus porosity

Well 30/2-1
Plot of lag K versus porosity
from routine plug analysis.
All samples.



LAB 83.37

Fig 8.2 Formationfactor versus porosity

Well 30/2-1
Plot of log FF versus log Por.
All samples.

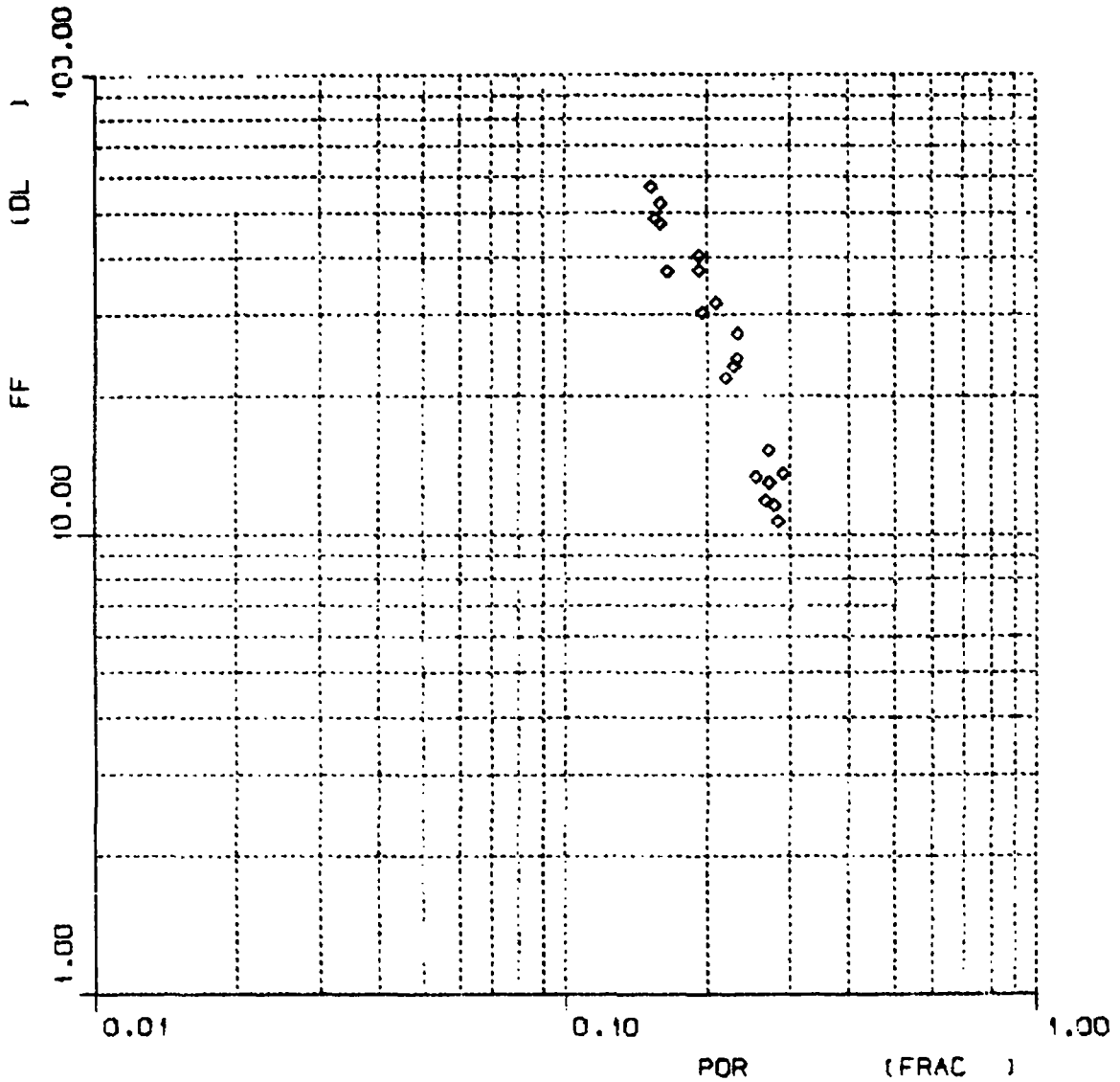


Table 8.1 Well 30/2-1
Capillary pressure, PG(bar), the corresponding brine saturation, SW (frac) and the resistivity index, RI.
Sample 39.1, 53.1 and 59.1

Sample 39.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.999	1.02
0.27	0.994	1.07
0.59	0.953	1.17
1.59	0.499	3.56
2.77	0.464	3.83
5.00	0.452	3.90
12.00	0.437	4.07

Sample 53.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.993	1.03
0.27	0.983	1.09
0.59	0.975	1.41
1.59	0.856	1.12
2.77	0.806	1.50
5.00	0.780	1.60
12.00	0.748	1.67

Sample 59.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.532	3.69
0.27	0.302	9.97
0.59	0.202	21.24
1.59	0.138	46.47
2.77	0.120	53.97
5.00	0.116	59.01
12.00	0.110	64.46

Table 8.2 Well 30/2-1
Capillary pressure, PG(bar), the corresponding brine saturation, SW (frac) and the resistivity index, RI.

Sample 63.1, 68.1 and 75.1

Sample 63.1

PG	SW	RI	RI*
0.00	1.000	1.00	
0.14	0.377	5.97	
0.27	0.245	13.66	
0.59	0.173	27.70	
1.59	0.125	52.53	
2.77	0.110	61.15	
5.00	0.107	61.15	
12.00	0.106	60.07	

Sample 68.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.310	7.97
0.27	0.218	16.13
0.59	0.157	32.03
1.59	0.108	60.39
2.77	0.097	71.20
5.00	0.102	65.27
12.00	0.095	78.68

Sample 75.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.963	1.10
0.27	0.759	1.90
0.59	0.650	2.66
1.59	0.515	4.20
2.77	0.496	4.56
5.00	0.471	4.68
12.00	0.461	4.94

Table 8.3 Well 30/2-1

Capillary pressure, PG(bar), the corresponding brine saturation, SW (frac) and the resistivity index, RI.

Sample 88.1, 97.1 and 101.1

Sample 88.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.994	1.06
0.27	0.987	1.14
0.59	0.982	1.14
1.59	0.702	2.02
2.77	0.666	2.15
5.00	0.643	2.33
12.00	0.614	2.49

Sample 97.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.997	1.05
0.27	0.994	1.08
0.59	0.989	1.11
1.59	0.668	2.09
2.77	0.636	2.18
5.00	0.618	2.23
12.00	0.600	2.41

Sample 101.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.997	1.04
0.27	0.990	1.12
0.59	0.985	1.12
1.59	0.682	2.30
2.77	0.647	2.70
5.00	0.620	2.67
12.00	0.612	2.88

Table 8.4 Well 30/2-1

Capillary pressure, PG(bar), the corresponding brine saturation, SW (frac) and the resistivity index, RI.

Sample 118.1, 131.1 and 138.1

Sample 118.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.360	8.11
0.27	0.271	15.80
0.59	0.182	34.91
1.59	0.124	74.53
2.77	0.105	90.67
5.00	0.098	102.24
12.00	0.093	116.04

Sample 131.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.933	1.20
0.27	0.469	4.53
0.59	0.336	8.95
1.59	0.240	18.02
2.77	0.225	19.52
5.00	0.217	20.21
12.00	0.225	18.88

Sample 138.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.920	1.23
0.27	0.459	4.95
0.59	0.340	9.14
1.59	0.252	17.23
2.77	0.236	18.94
5.00	0.231	20.34
12.00	0.229	20.15

Table 8.5 Well 30/2-1

Capillary pressure, PG(bar), the corresponding brine saturation, SW (frac) and the resistivity index, RI.

Sample 142.1, 178.1 and 181.1

Sample 142.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.554	3.28
0.27	0.379	7.40
0.59	0.297	12.99
1.59	0.223	24.48
2.77	0.211	26.40
5.00	0.203	27.67
12.00	0.197	29.00

Sample 178.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.996	1.05
0.27	0.990	1.15
0.59	0.983	1.15
1.59	0.597	2.84
2.77	0.569	3.02
5.00	0.556	3.03
12.00	0.542	3.22

Sample 181.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.997	1.04
0.27	0.993	1.08
0.59	0.988	1.11
1.59	0.627	2.64
2.77	0.603	2.71
5.00	0.592	2.62
12.00	0.577	2.88

Table 8.6 Well 30/2-1

Capillary pressure, PG(bar), the corresponding brine saturation, SW (frac) and the resistivity index, RI.

Sample 186.1, 190.1, and 198.1

Sample 186.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.991	1.04
0.27	0.989	1.10
0.59	0.815	1.66
1.59	0.504	4.23
2.77	0.480	4.54
5.00	0.472	4.70
12.00	0.461	4.85

Sample 190.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.993	1.05
0.27	0.988	1.14
0.59	0.982	1.16
1.59	0.976	1.16
2.77	0.959	1.15
5.00	0.944	1.18
12.00	0.884	1.28

Sample 198.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.997	1.04
0.27	0.993	1.12
0.59	0.986	1.14
1.59	0.942	1.23
2.77	0.907	1.22
5.00	0.887	1.24
12.00	0.883	1.37

Table 8.7 Well 30/2-1
Capillary pressure, PG(bar), the corresponding brine saturation, SW (frac) and the resistivity index, RI.

Sample 202.1 and 214.1

Sample 202.1

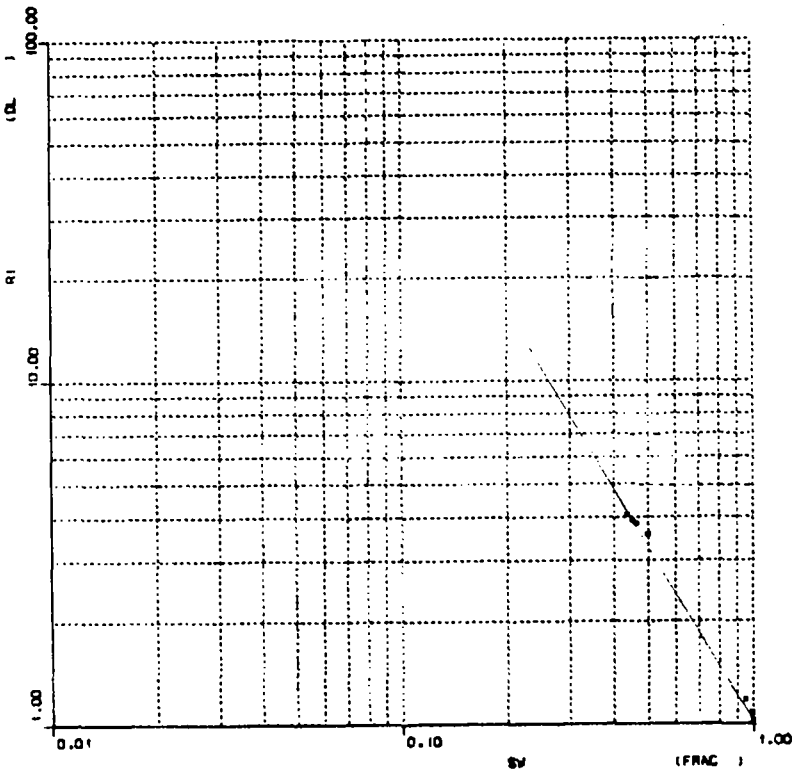
PG	SW	RI
0.00	1.000	1.00
0.14	0.998	1.05
0.27	0.994	1.14
0.59	0.989	1.16
1.59	0.628	2.42
2.77	0.583	2.86
5.00	0.573	2.93
12.00	0.567	3.03

Sample 214.1

PG	SW	RI
0.00	1.000	1.00
0.14	0.994	1.02
0.27	0.990	1.18
0.59	0.852	1.42
1.59	0.545	3.07
2.77	0.489	3.73
5.00	0.481	4.04
12.00	0.473	4.28

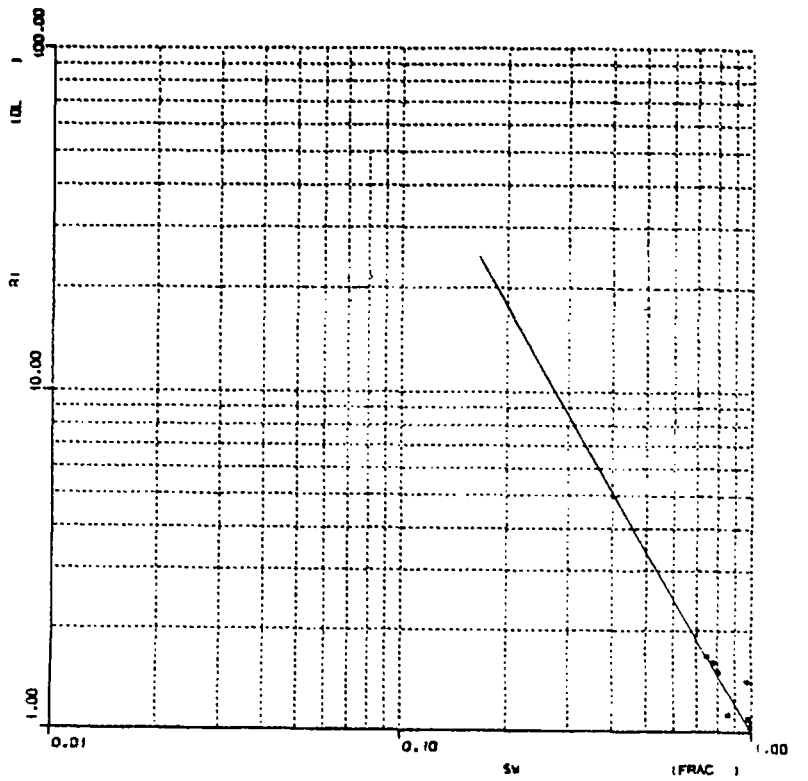
Fig 8.3 Resistivity index versus water saturation

Well 30/2-1
Plot of log RI versus log Sw for samples 39.1 and 53.1. Saturation exponent, n, is given for each sample.



Sample 39.1

n = 1.74



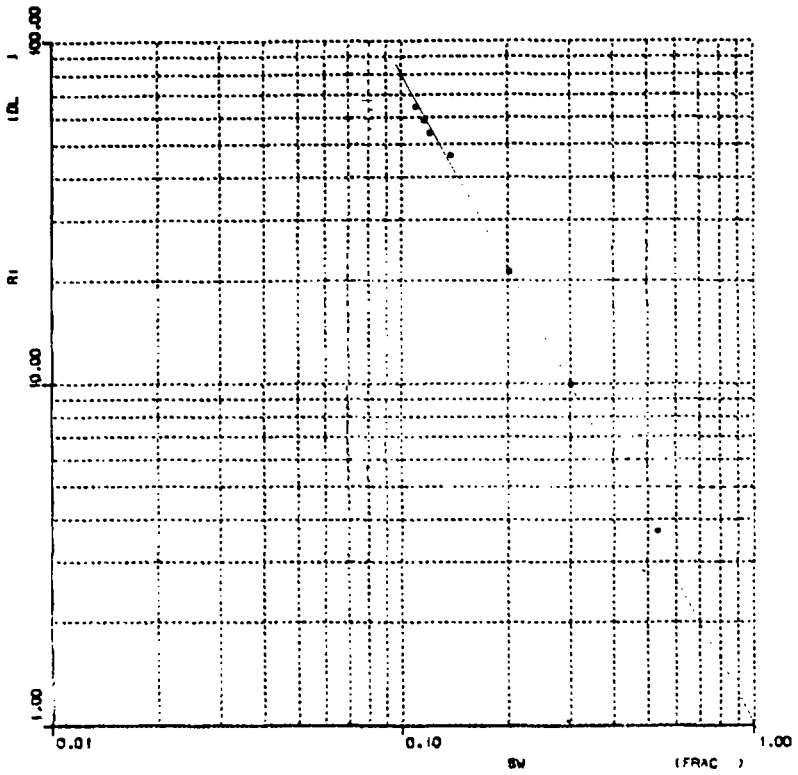
Sample 53.1

n = 1.89

LAB 83.37

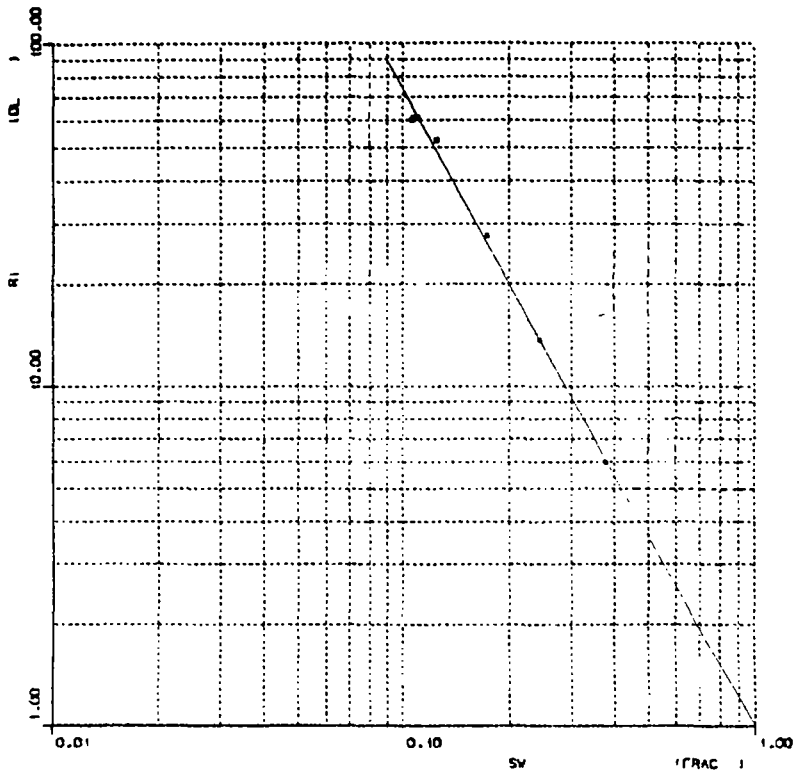
Fig 8.4 Resistivity index versus water saturation

Well 30/2-1
Plot of log RI versus log Sw for samples 59.1 and 63.1. Saturation exponent, n, is given for each sample.



Sample 59.1

n = 1.90



Sample 63.1

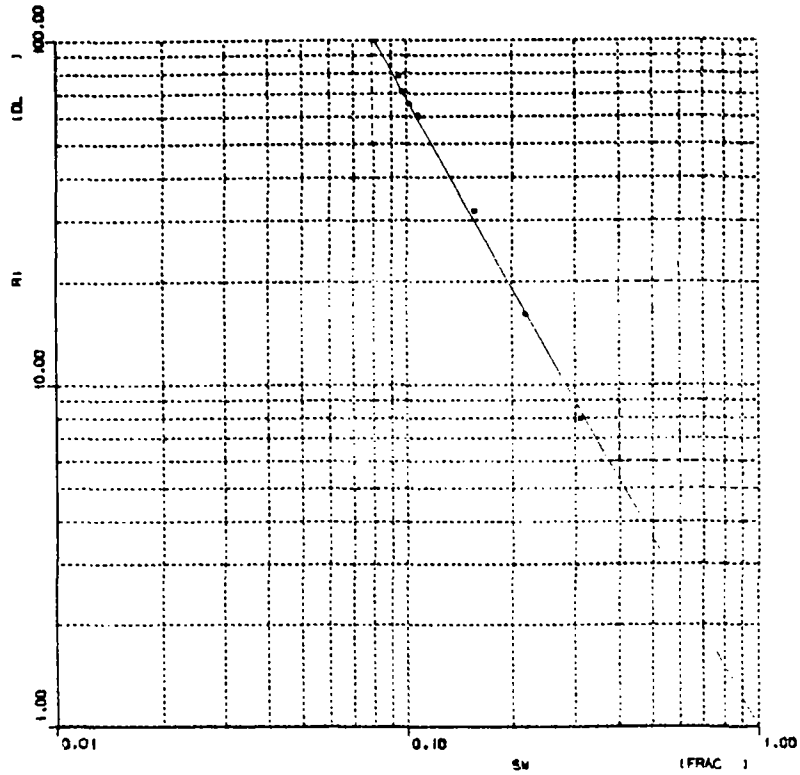
n = 1.86

LAB 83.37

Fig 8.5 Resistivity index versus water saturation

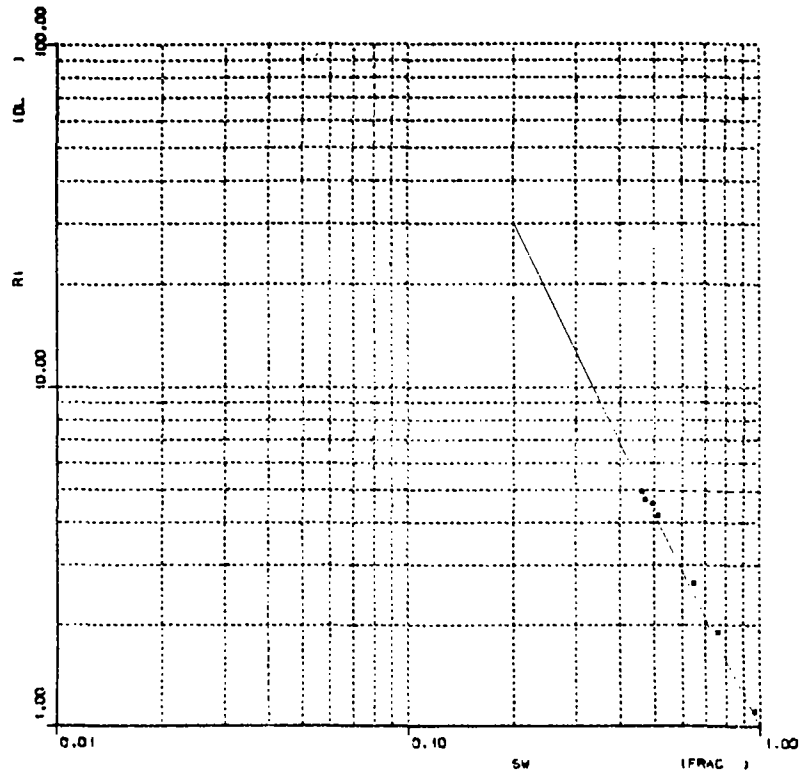
Well 30/2-1

Plot of log RI versus log Sw for samples 68.1 and 75.1. Saturation exponent, n, is given for each sample.



Sample 68.1

n = 1.84

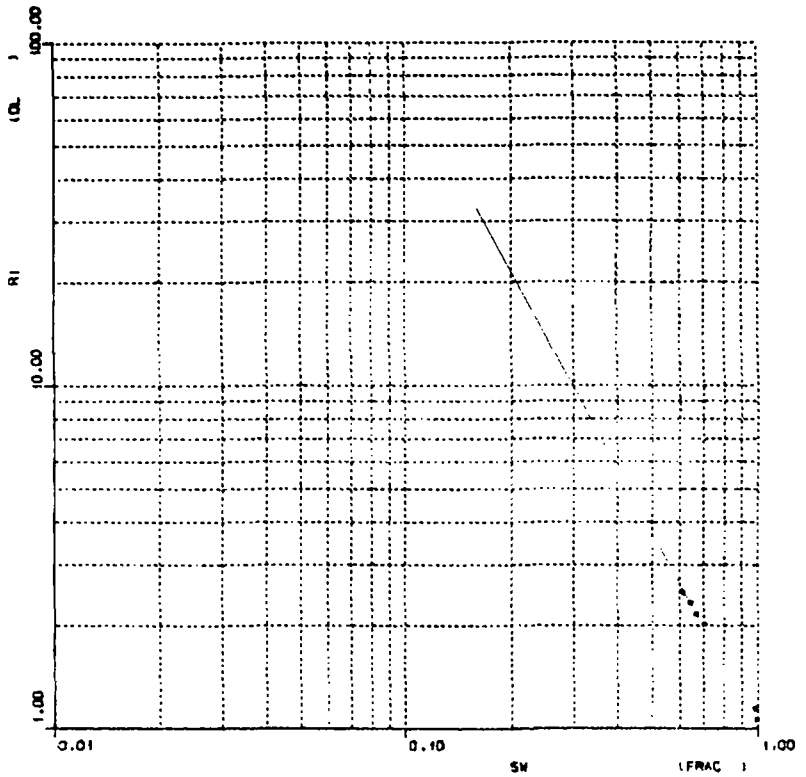


Sample 75.1

n = 2.12

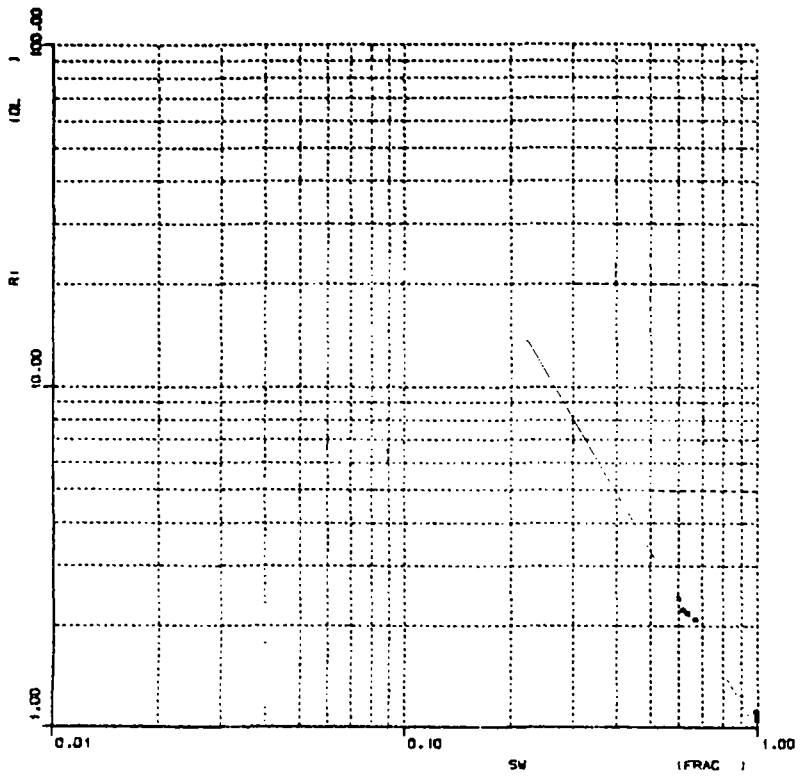
Fig 8.6 Resistivity index versus water saturation

Well 30/2-1
Plot of log RI versus log Sw for samples 88.1 and 97.1. Saturation exponent, n, is given for each sample.



Sample 88.1

n = 1.91

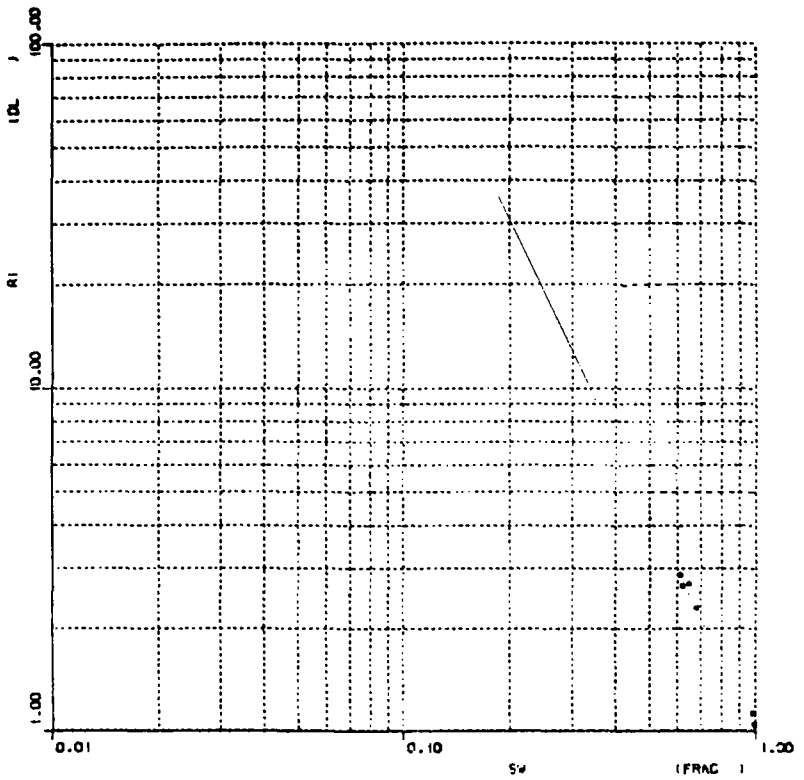


Sample 97.1

n = 1.73

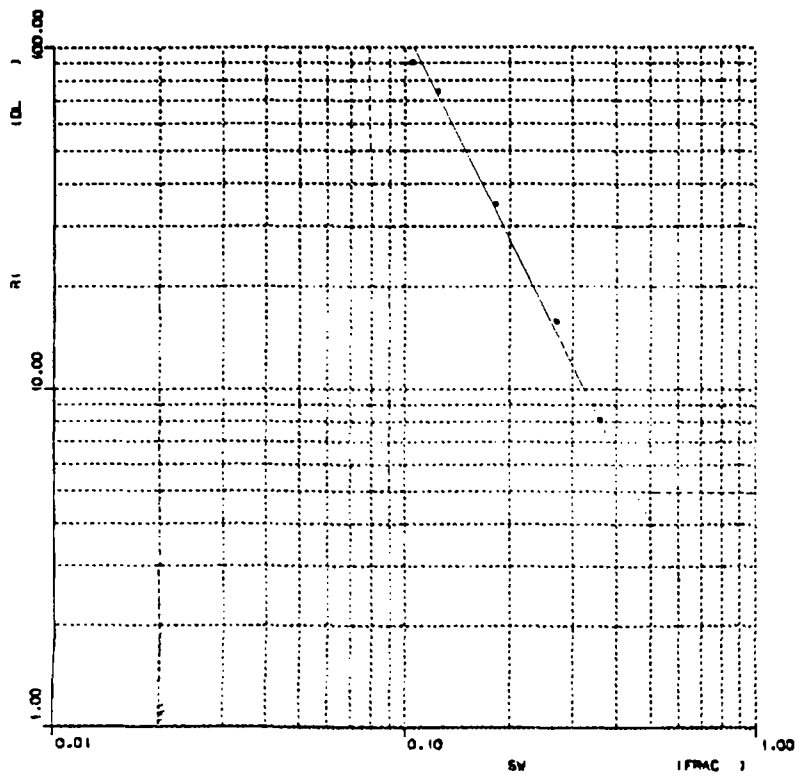
Fig 8.7 Resistivity index versus water saturation

Well 30/2-1
Plot of log RI versus log Sw for samples 101.1 and 118.1. Saturation exponent, n, is given for each sample.



Sample 101.1

n = 2.16

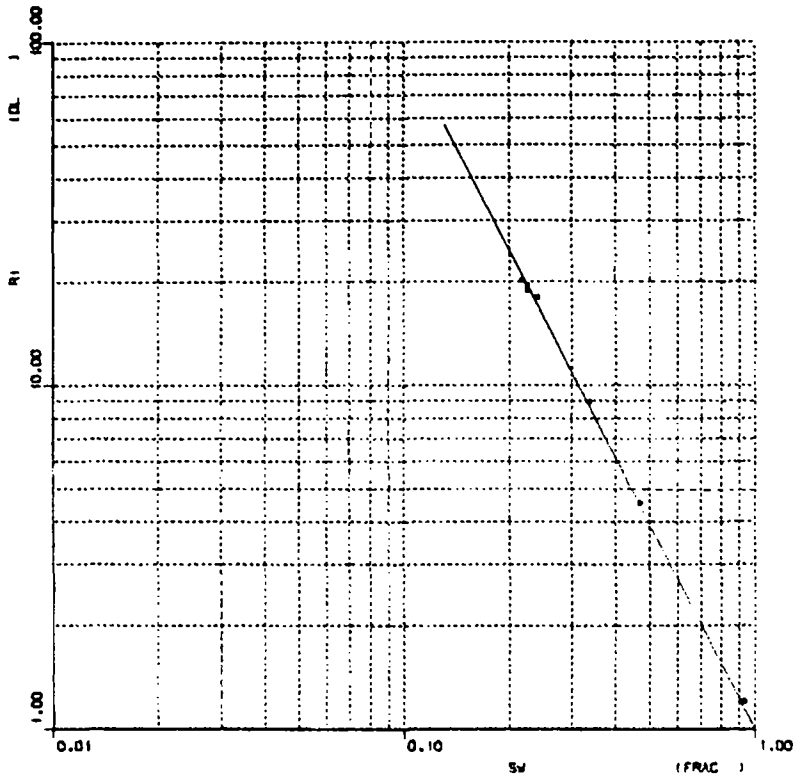


Sample 118.1

n = 2.03

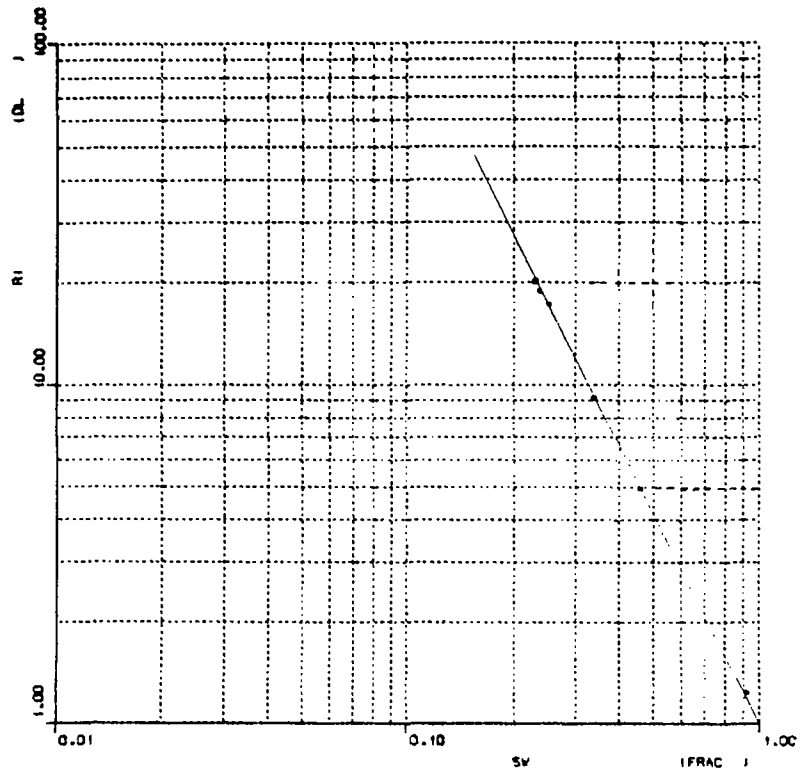
Fig 8.8 Resistivity index versus water saturation

Well 30/2-1
Plot of log RI versus log Sw for samples 131.1 and 138.1. Saturation exponent, n, is given for each sample.



Sample 131.1

n = 1.99



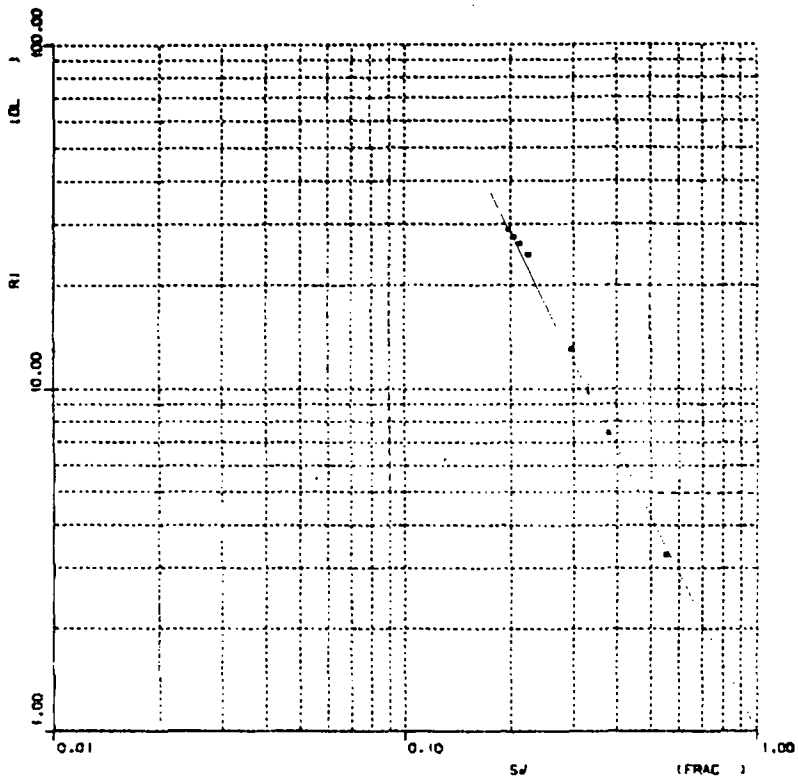
Sample 138.1

n = 2.05

LAB 83.37

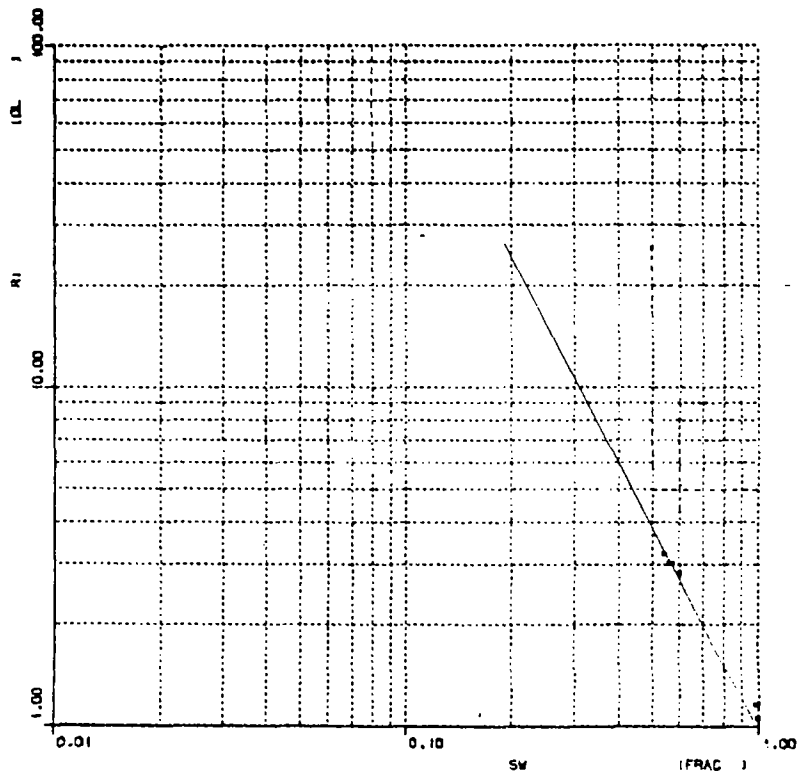
Fig 8.9 Resistivity index versus water saturation

Well 30/2-1
Plot of log RI versus log Sw for samples 142.1 and 178.1. Saturation exponent, n, is given for each sample.



Sample 142.1

n = 2.09

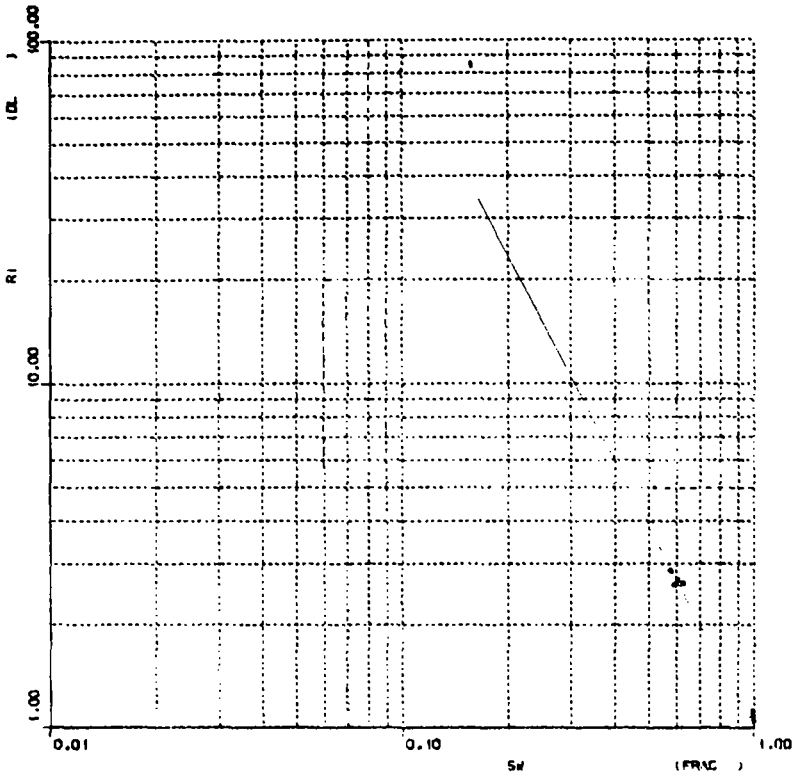


Sample 178.1

n = 1.94

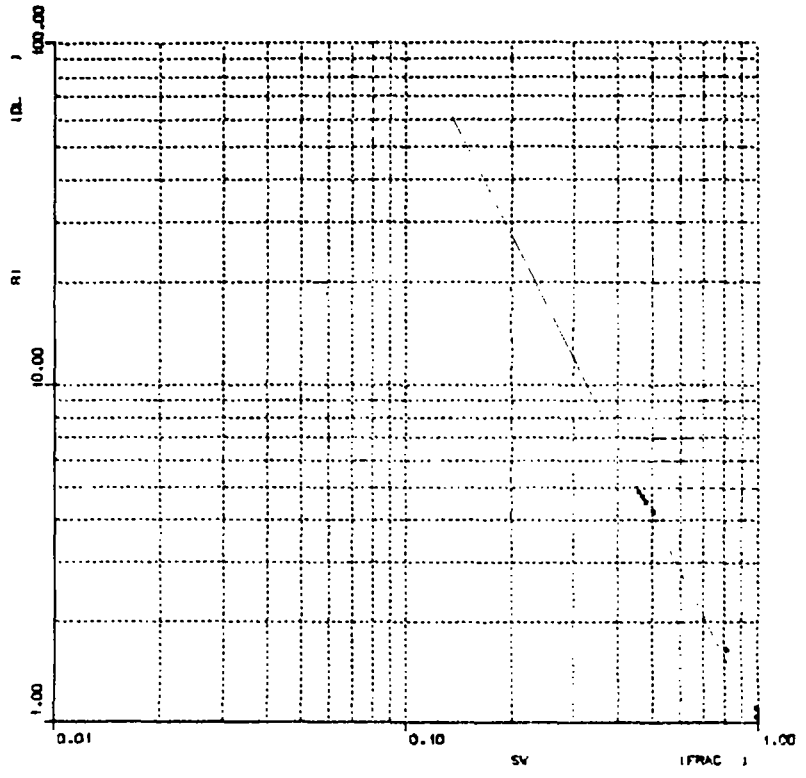
Fig 8.10 Resistivity index versus water saturation

Well 30/2-1
Plot of log RI versus log Sw for samples 181.1 and 186.1. Saturation exponent, n, is given for each sample.



Sample 181.1

n = 1.95



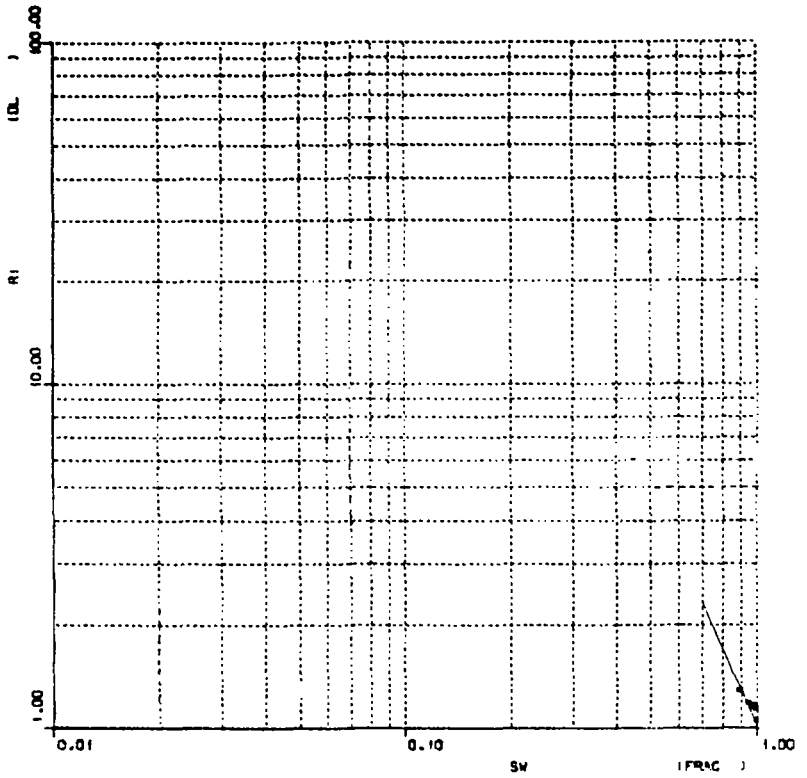
Sample 186.1

n = 2.07

LAB 83.37

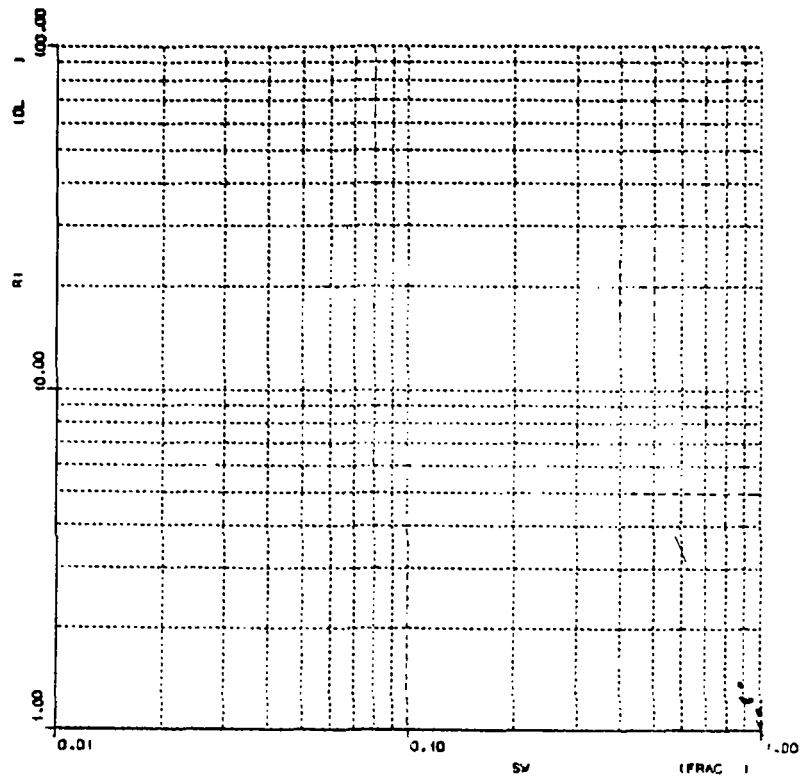
Fig 8.11 Resistivity index versus water saturation

Well 30/2-1
Plot of log RI versus log Sw for samples 190.1 and 198.1. Saturation exponent, n, is given for each sample.



Sample 190.1

n = 1.87



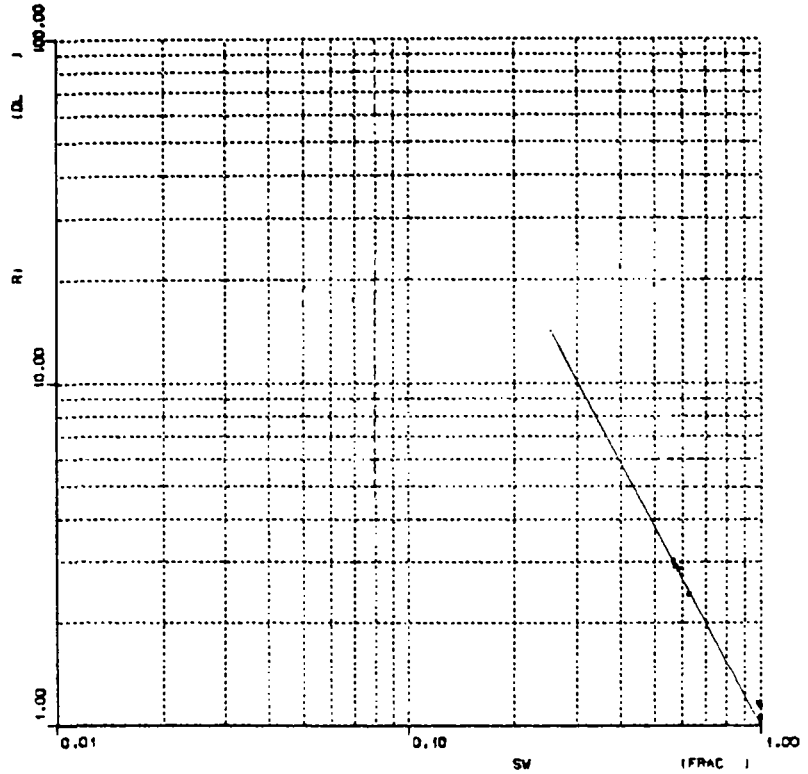
Sample 198.1

n = 1.93

LAB 83.37

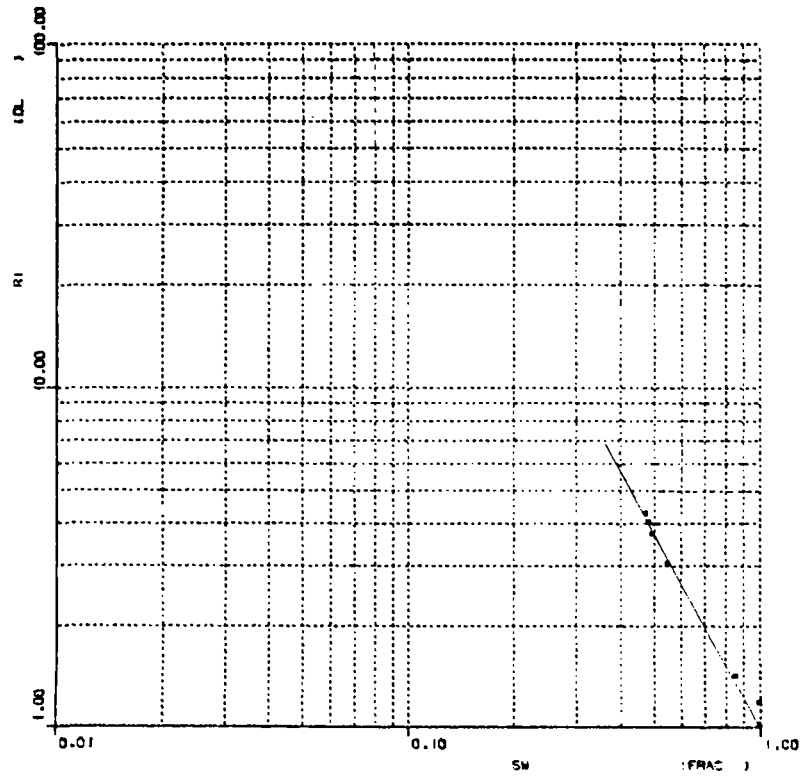
Fig 8.12 Resistivity index versus water saturation

Well 30/2-1
Plot of log RI versus log Sw for samples 202.1 and 214.1. Saturation exponent, n, is given for each sample.



Sample 202.1

n = 1.94

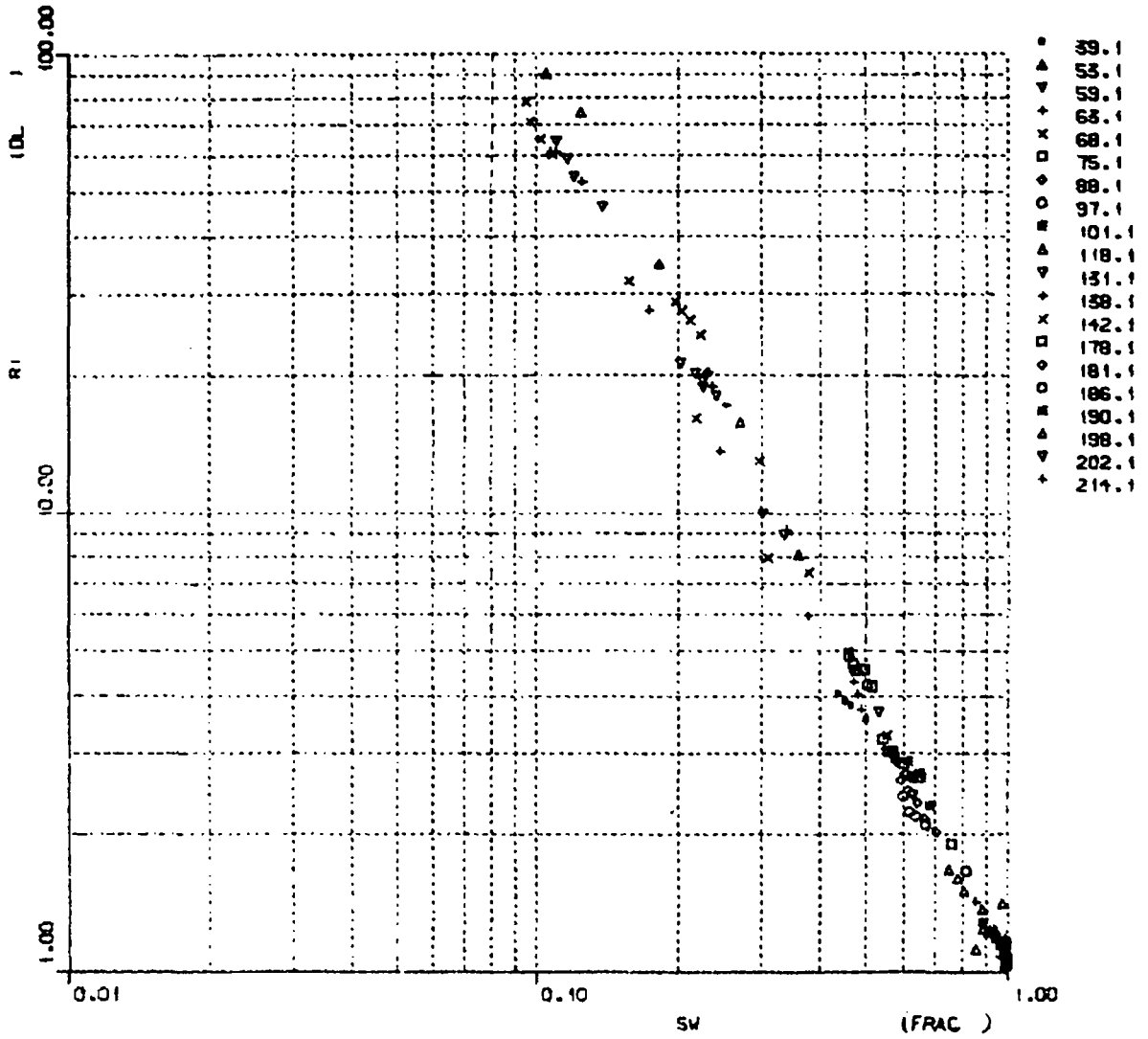


Sample 214.1

n = 1.89

Fig 8.13 Resistivity index versus water saturation

Well 30/2-1
Plot of log RI versus log Sw.
All samples.



Appendix 3

Table 8.8 Co/Cw measurements from 30/2-1. Sample 39.1-88.1. Conductivities are given in Siemens/m.

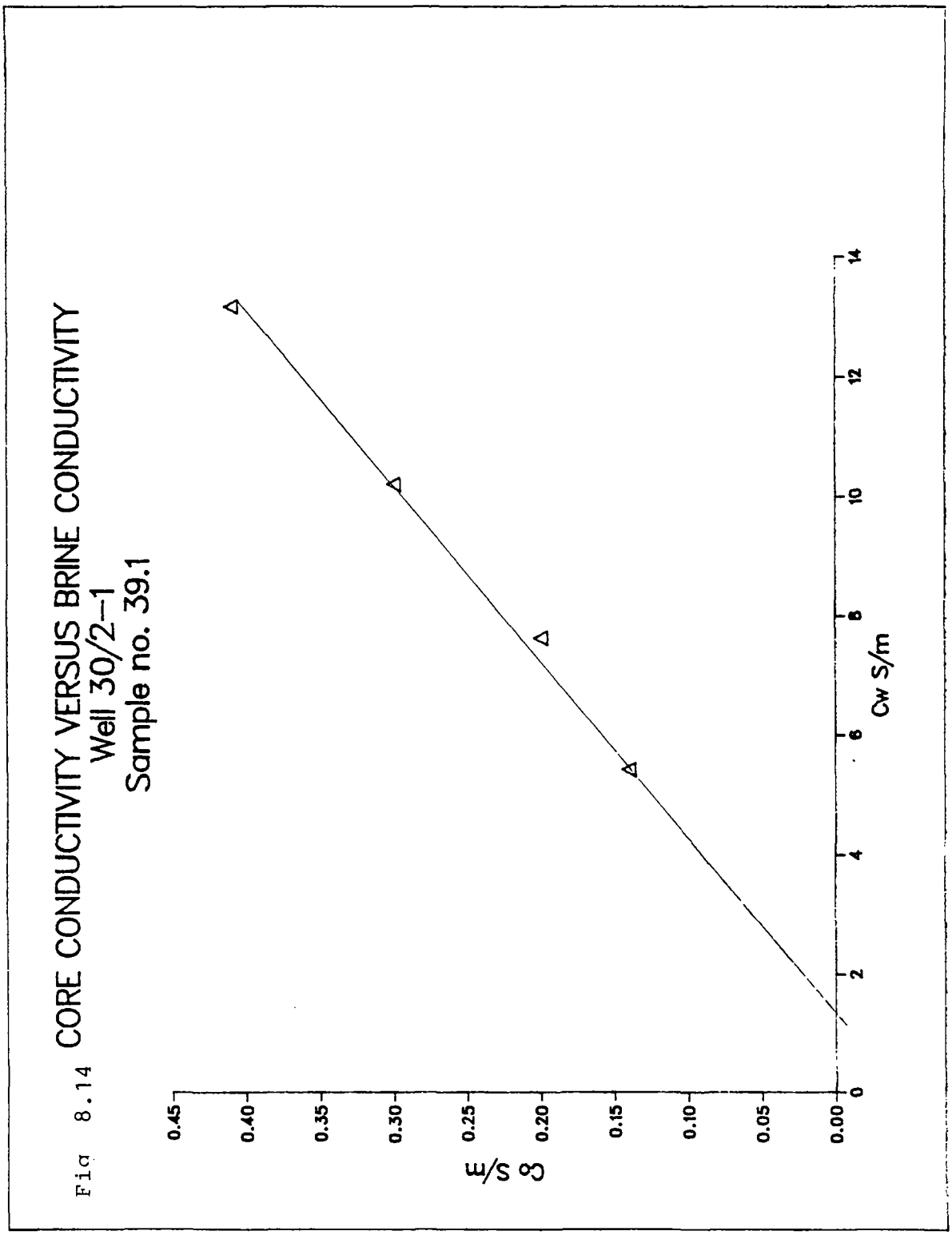
Sample no.	Salinity	40700 ppm	60000 ppm	90000 ppm	120000 ppm
39.1	Co:	0.14	0.20	0.30	0.41
	Cw:	5.42	7.63	10.21	13.17
53.1	Co:	0.11	0.17	0.23	0.34
	Cw:	5.42	7.63	10.21	13.17
59.1	Co:	0.41	0.54	0.70	0.95
	Cw:	5.42	7.63	10.21	13.17
63.1	Co:	0.46	0.60	0.80	1.03
	Cw:	5.42	7.63	10.21	13.17
68.1	Co:	0.47	0.60	0.80	1.05
	Cw:	5.42	7.63	10.21	13.17
75.1	Co:	0.25	0.35	0.44	0.62
	Cw:	5.42	7.63	10.21	13.17
88.1	Co:	0.11	0.17	0.23	0.32
	Cw:	5.42	7.63	10.21	13.17

Table 8.9 Co/Cw measurement from 30/2-1.Sample 97.1 - 178.1
Conductivities are given in Siemens/m.

Sample no.	Salinity	40700 ppm	60000 ppm	90000 ppm	120000 ppm
97.1	Co:	0.15	0.22	0.30	0.40
	Cw:	5.42	7.63	10.21	13.17
101.1	Co:	0.10	0.16	0.21	0.29
	Cw:	5.42	7.63	10.21	13.17
118.1	Co:	0.51	0.66	0.88	1.16
	Cw:	5.42	7.63	10.21	13.17
131.1	Co:	0.42	0.51	0.69	0.97
	Cw:	5.42	7.63	10.21	13.17
138.1	Co:	0.36	0.48	0.63	0.85
	Cw:	5.42	7.63	10.21	13.17
142.1	Co:	0.40	0.54	0.70	0.93
	Cw:	5.42	7.63	10.21	13.17
178.1	Co:	0.17	0.21	0.36	0.47
	Cw:	5.42	7.63	10.21	13.17

Table 8.10 Co/Cw measurements from 30/2-1. Sample 181.1 -214.1. Condutivities are given in Siemens/m.

Sample no.	salinity	40700 ppm	60000 ppm	90000 ppm	120000 ppm
181.1	Co:	0.18	0.27	0.37	1.50
	Cw:	5.42	7.63	10.21	13.17
186.1	Co:	0.23	0.34	0.47	0.58
	Cw:	5.42	7.63	10.21	13.17
190.1	Co:	0.10	0.14	0.18	0.22
	Cw:	5.42	7.63	10.21	13.17
198.1	Co:	0.13	0.20	0.26	0.36
	Cw:	5.42	7.63	10.21	13.17
202.1	Co:	0.20	0.28	0.35	0.53
	Cw:	5.42	7.63	10.21	13.17
214.1	Co:	0.22	0.31	0.44	0.59
	Cw:	5.42	7.63	10.21	13.17


CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 39.1
Fig 8.14
ε S/S 8
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
2
4
6
8
10
12
14
Cw S/m

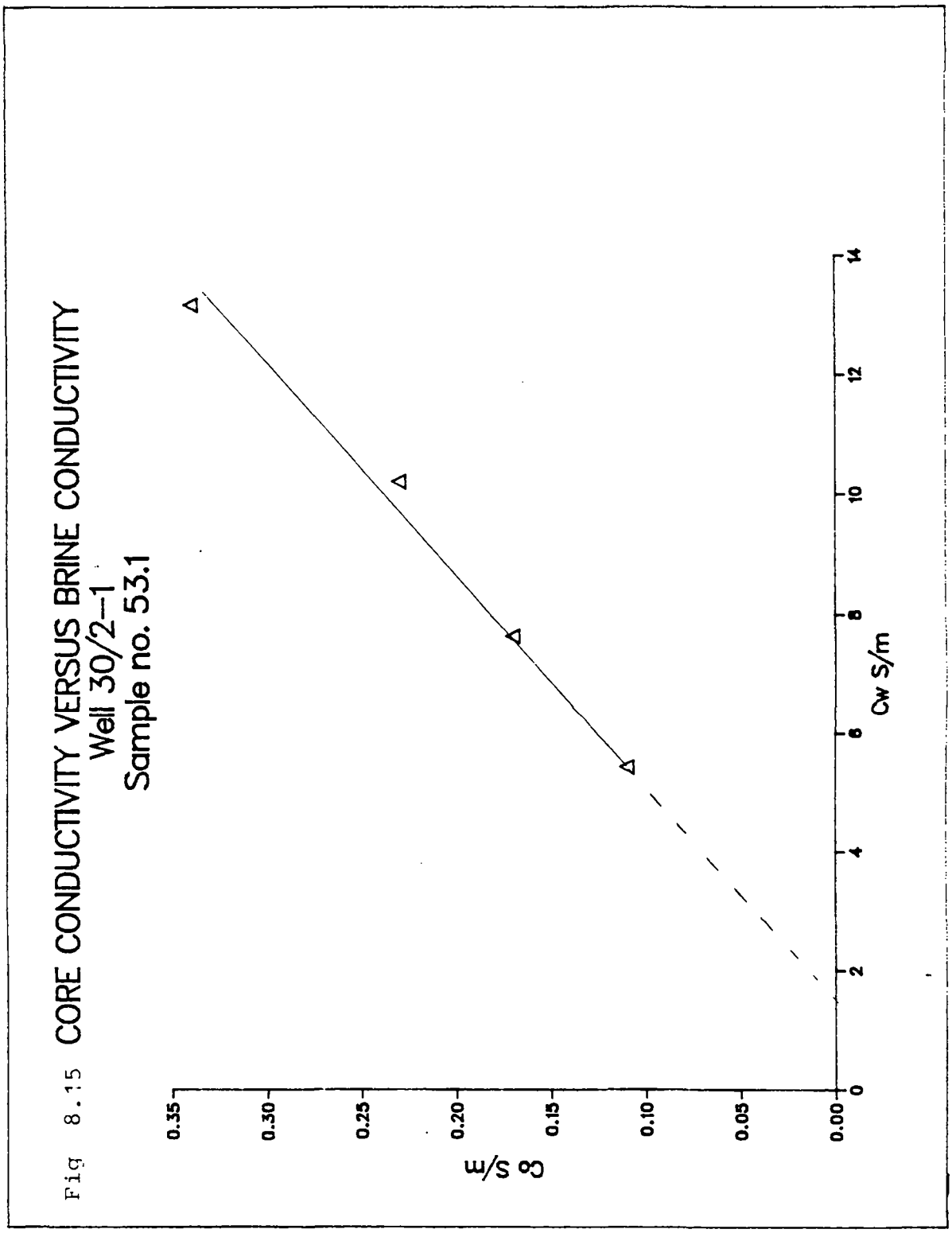

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 53.1
ε s/m
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
2
4
6
8
10
12
14
Cw S/m

Fig 8.15

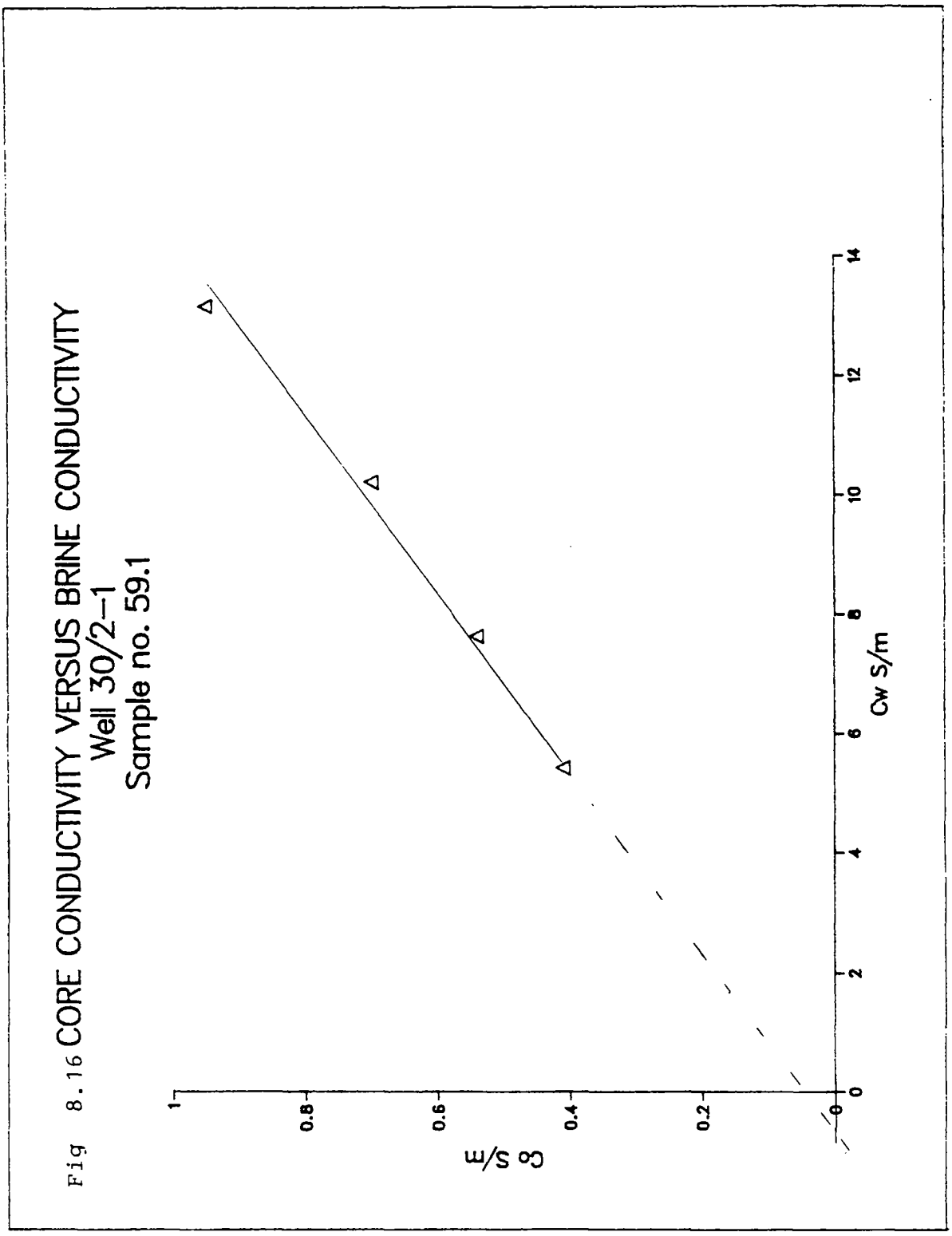
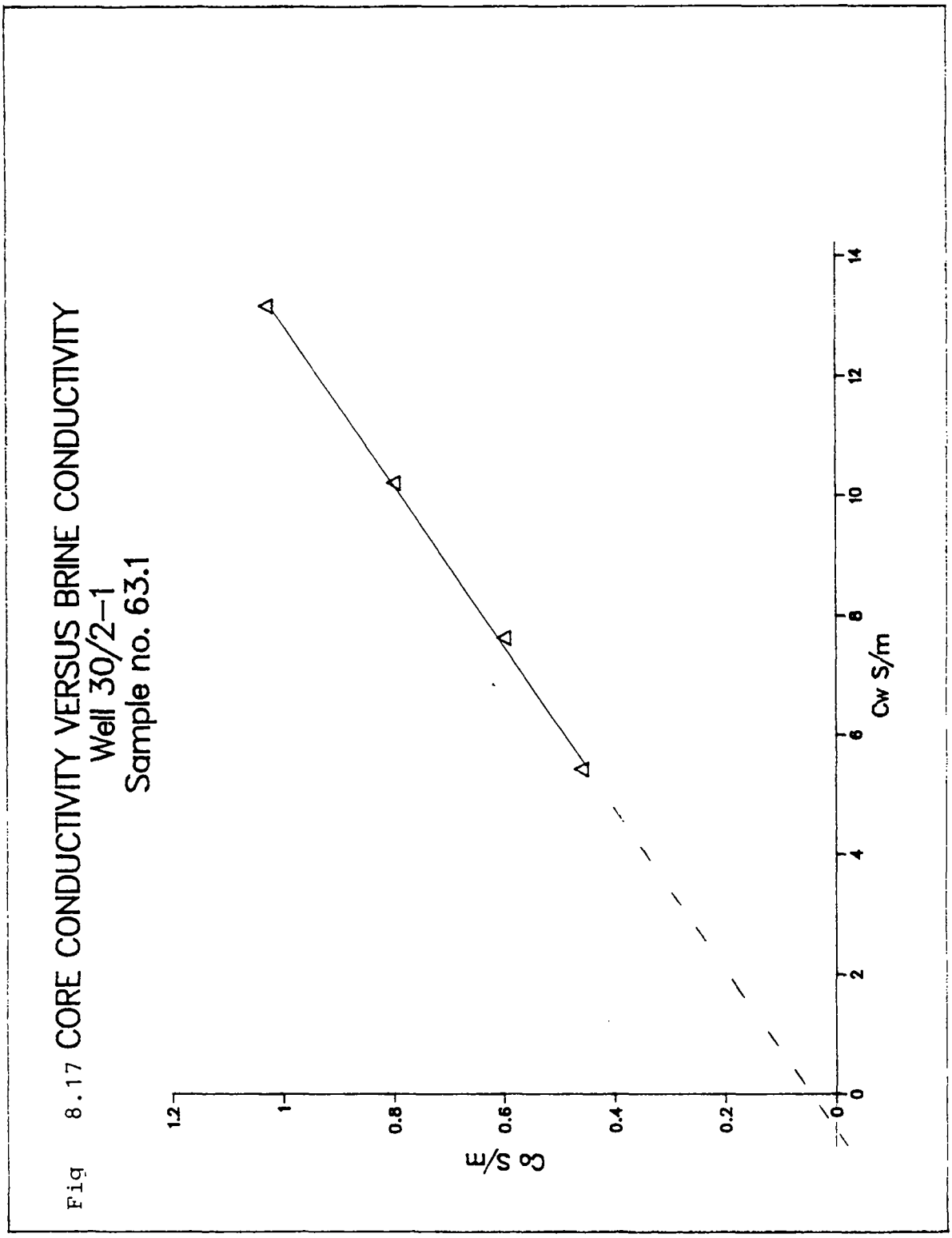

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 59.1
σ S/m
Cw S/m
0
0.2
0.4
0.6
0.8
1
2
4
6
8
10
12
14

Fig 8.16


CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 63.1
Fig 8.17
Co S/m
Cw S/m
0
0.2
0.4
0.6
0.8
1
1.2
0
2
4
6
8
10
12
14

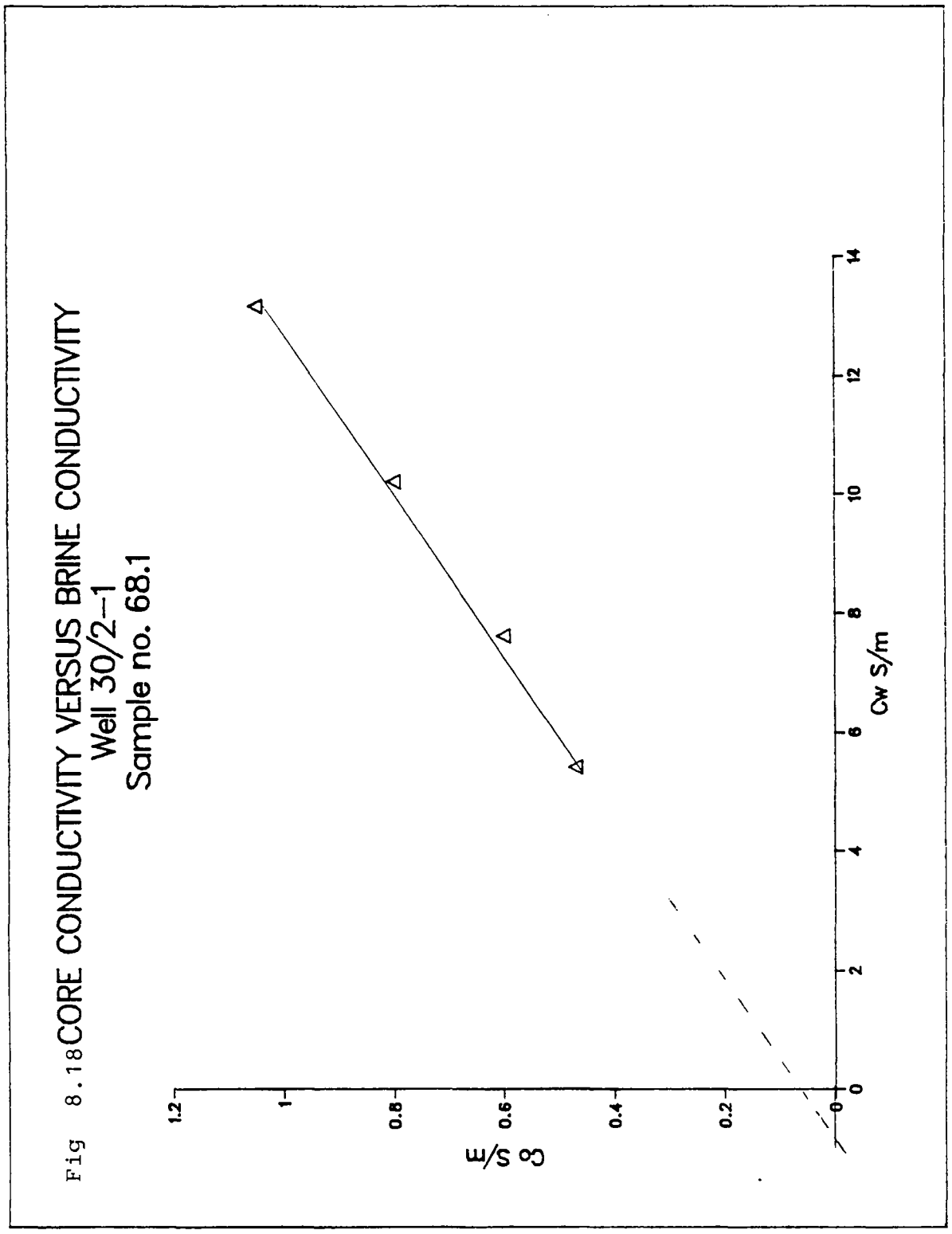

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 68.1
Co S/m
Cw S/m
0
2
4
6
8
10
12
14
0.2
0.4
0.6
0.8
1
1.2

Fig 8.18

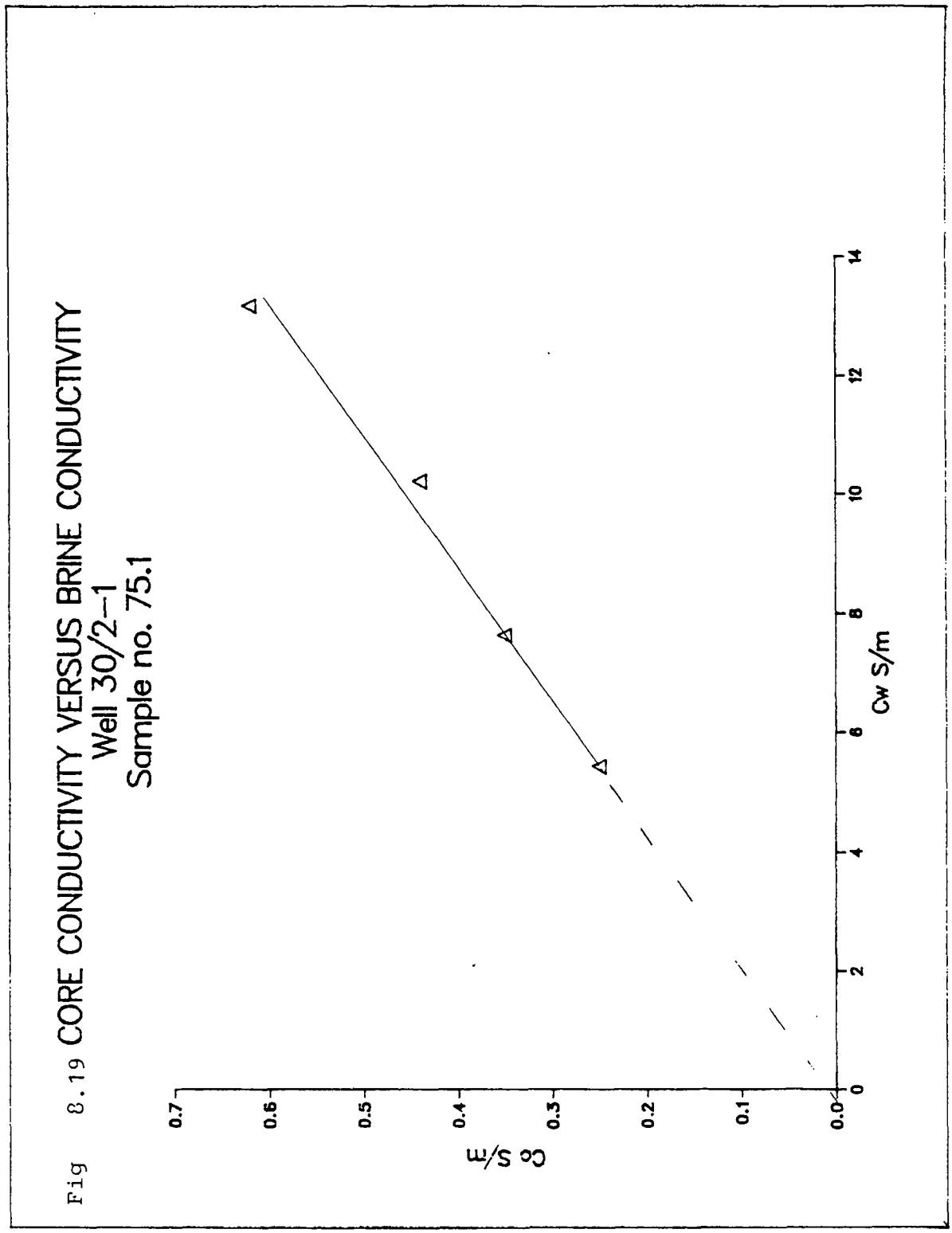

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 75.1
Co S/m
Cw S/m
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
2
4
6
8
10
12
14

Fig 8.19

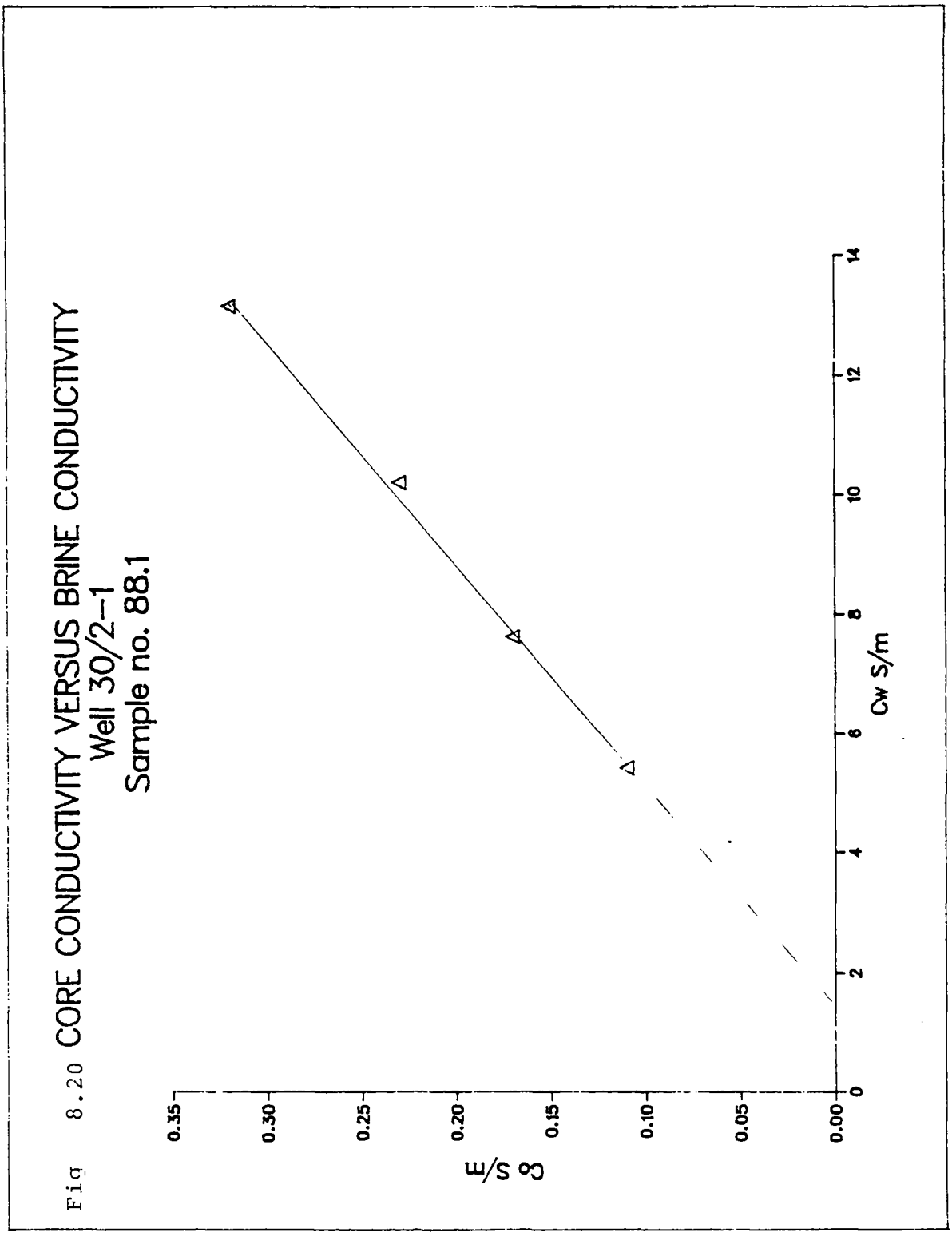

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 88.1
Cw S/m
0
2
4
6
8
10
12
14
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35

Fig 8.20

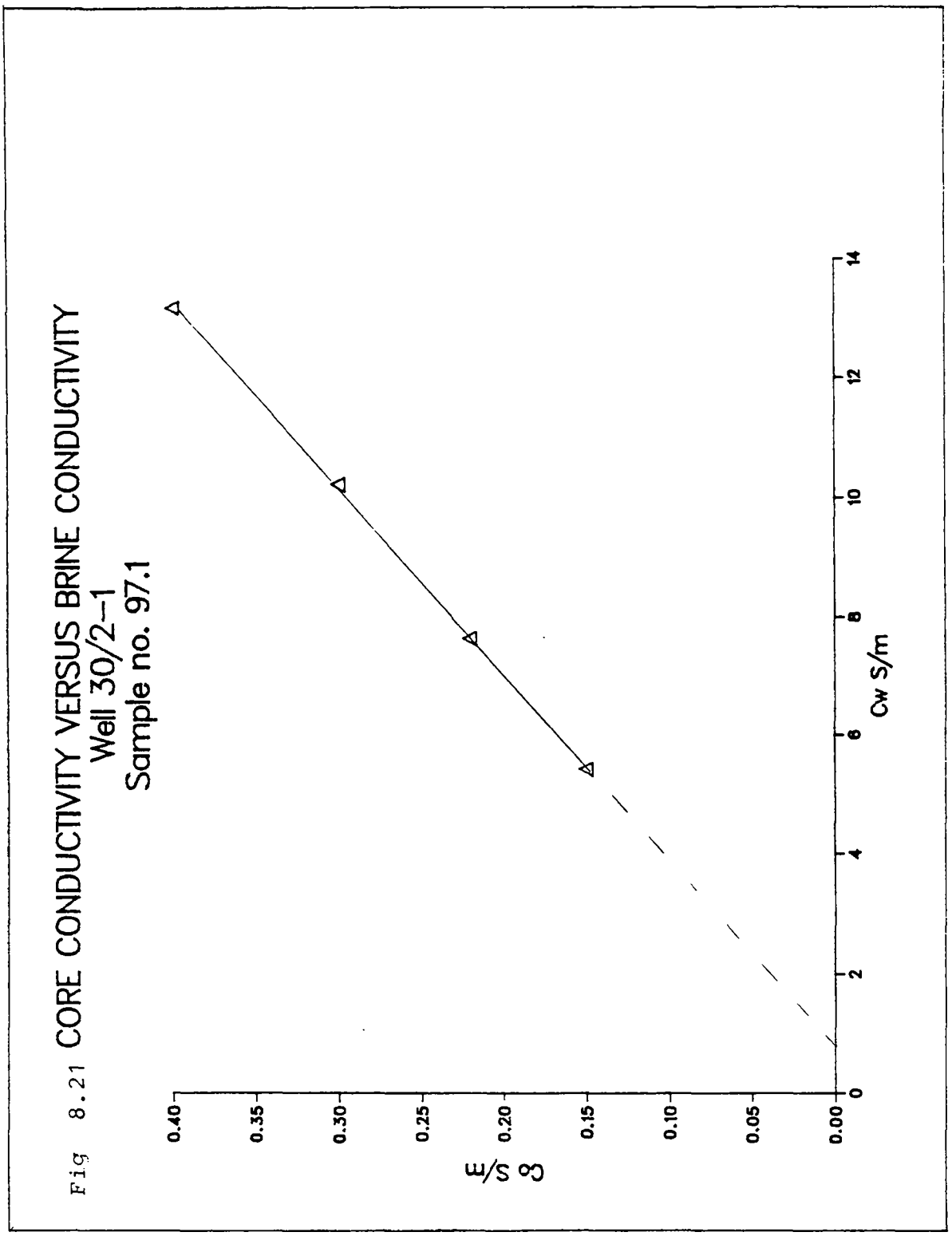

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 97.1
Cw S/m
0
2
4
6
8
10
12
14
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40

Fig 8.21

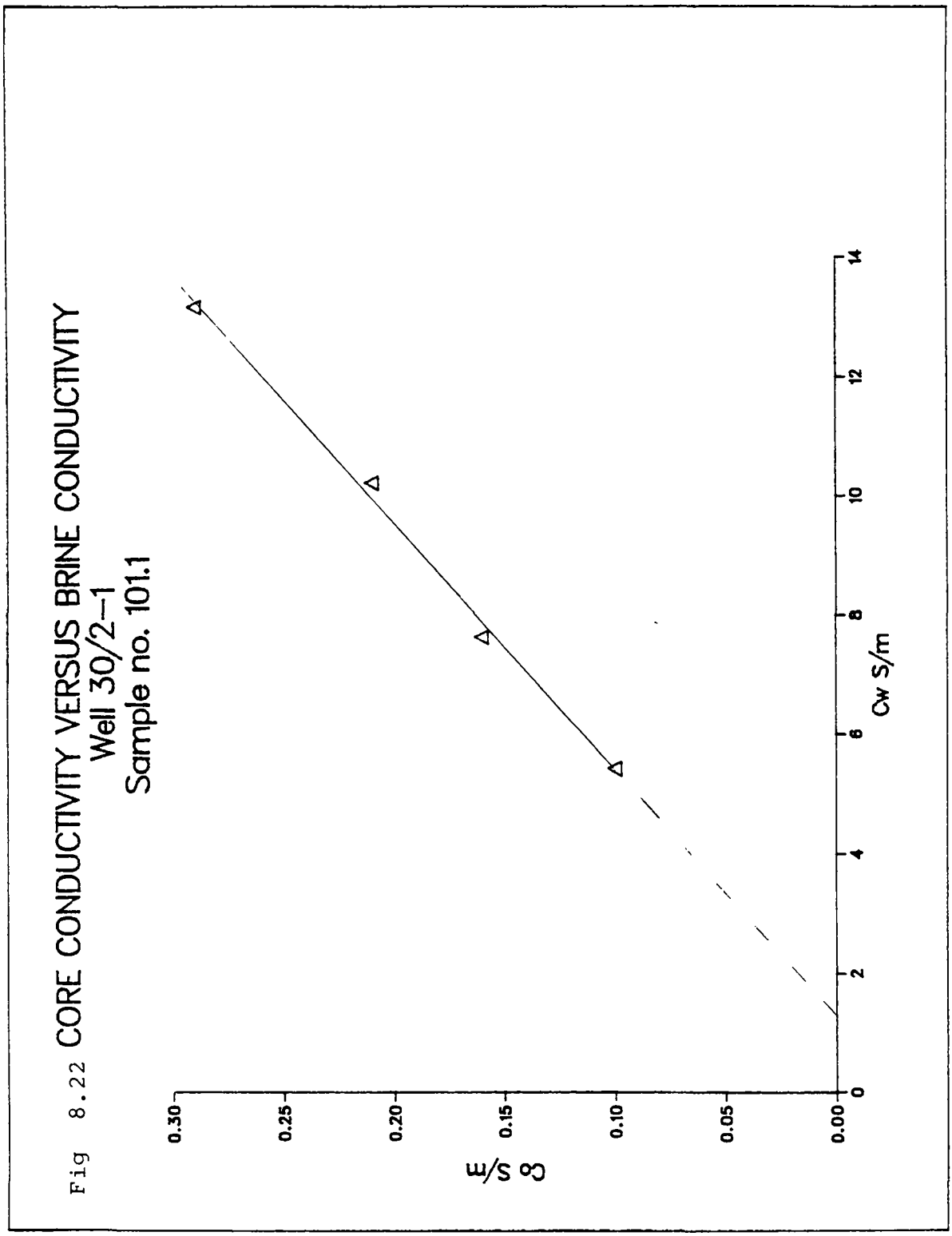

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 101.1
σ S/m
Cw S/m
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0
2
4
6
8
10
12
14

Fig 8.22

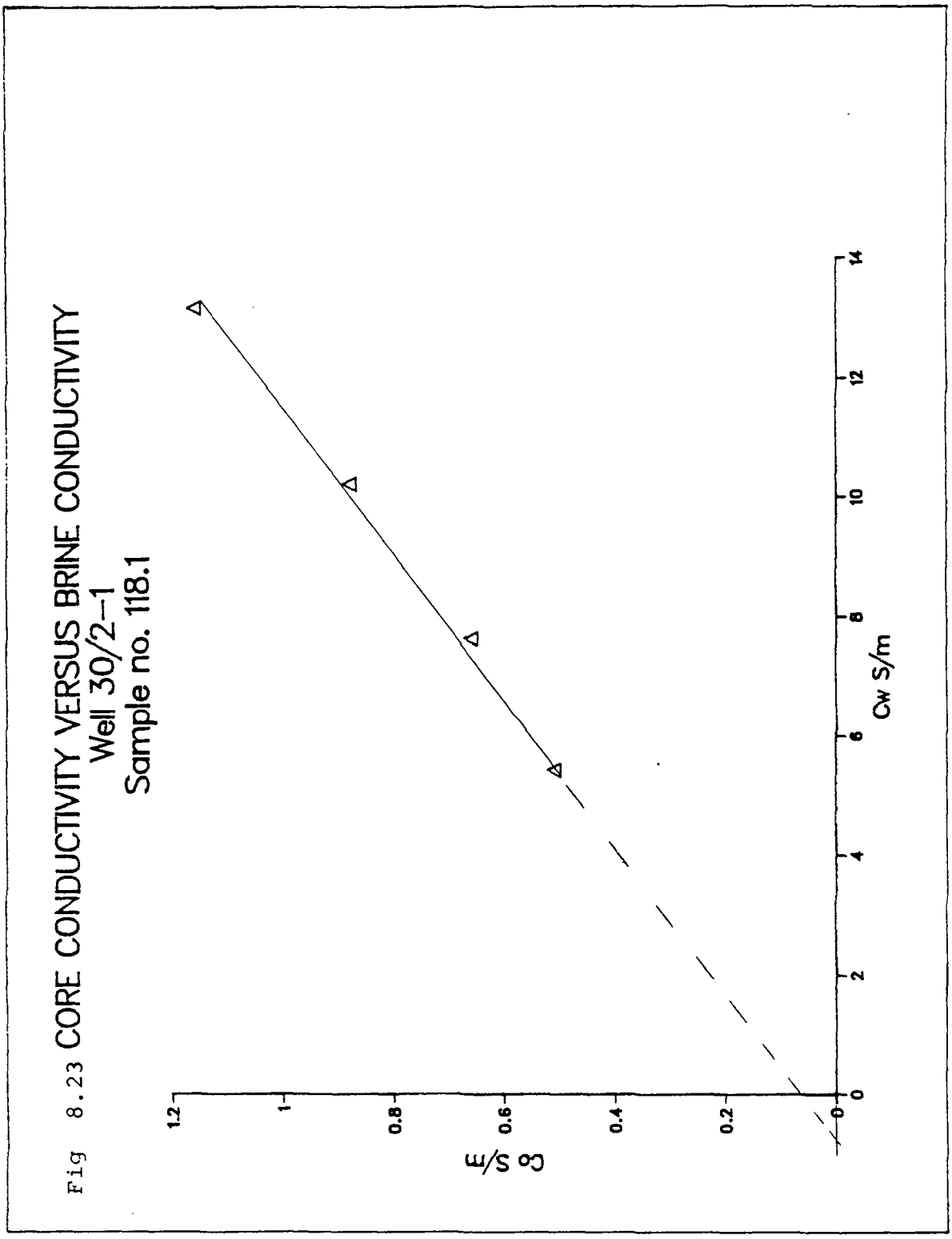

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 118.1
σ S/m
Cw S/m
0
0.2
0.4
0.6
0.8
1
1.2
0
2
4
6
8
10
12
14

Fig 8.23

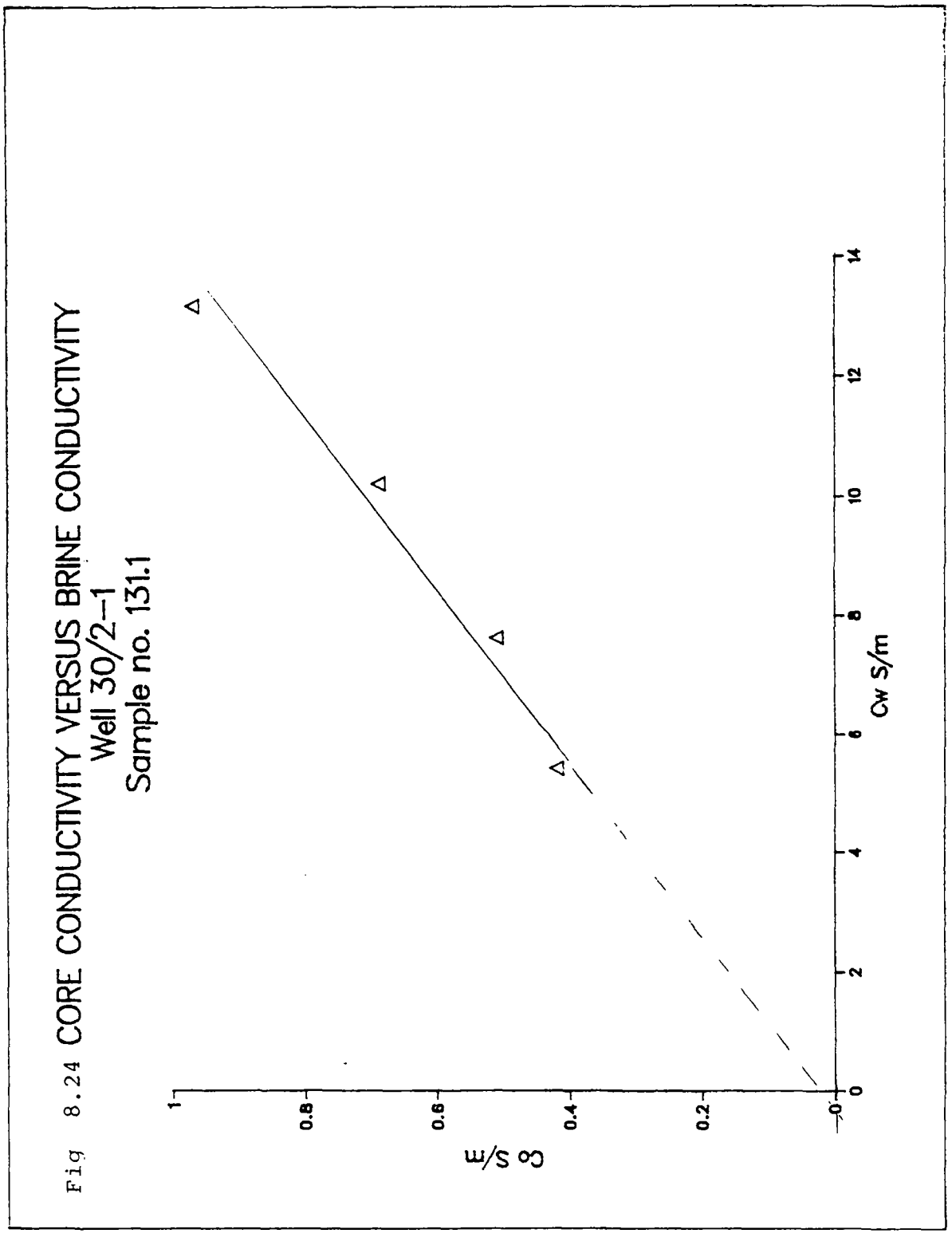
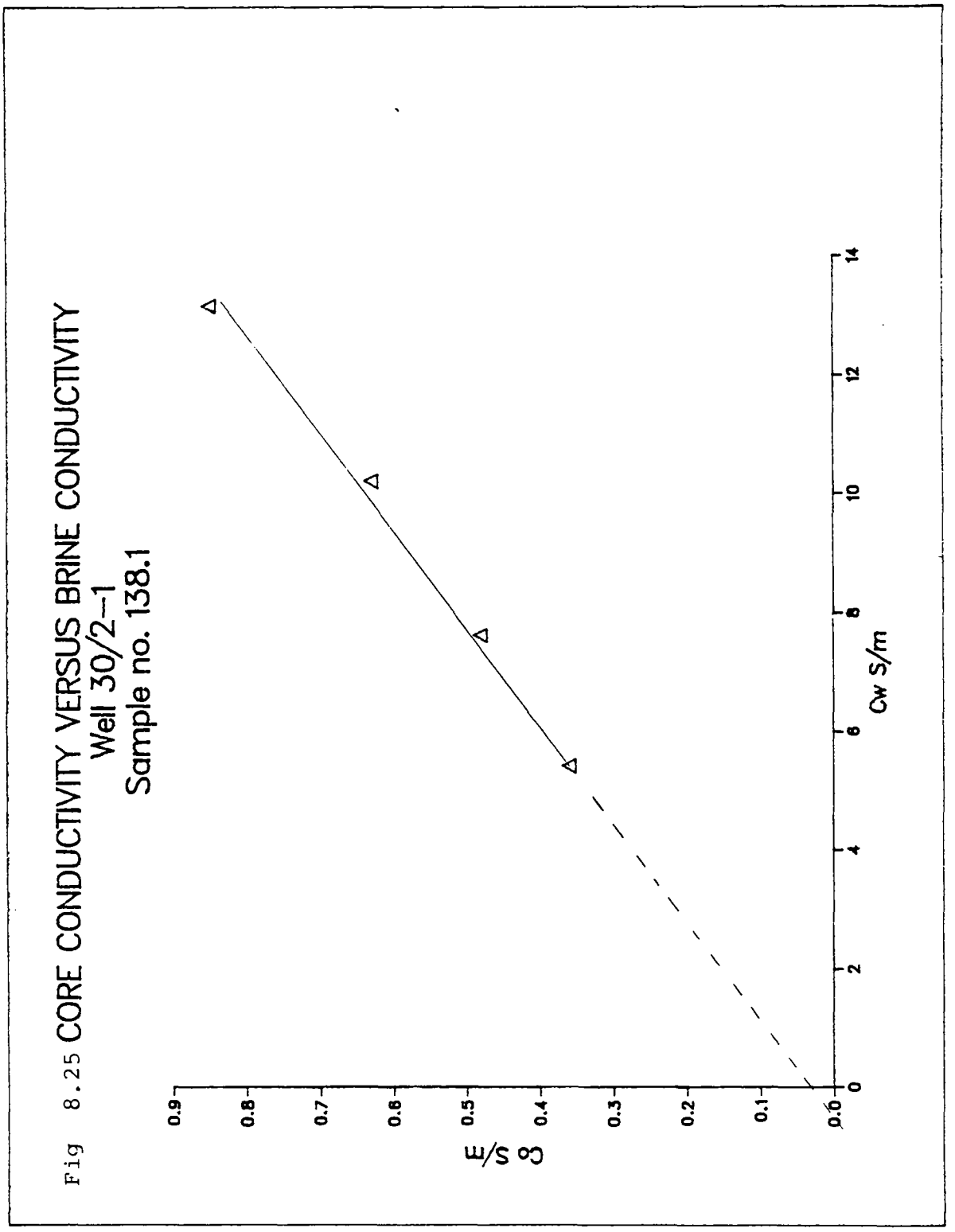

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 131.1
Co S/m
Cw S/m
0
0.2
0.4
0.6
0.8
1
0
2
4
6
8
10
12
14

Fig 8.24


CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 138.1
Fig 8.25
E/S σ
Cw S/m
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14

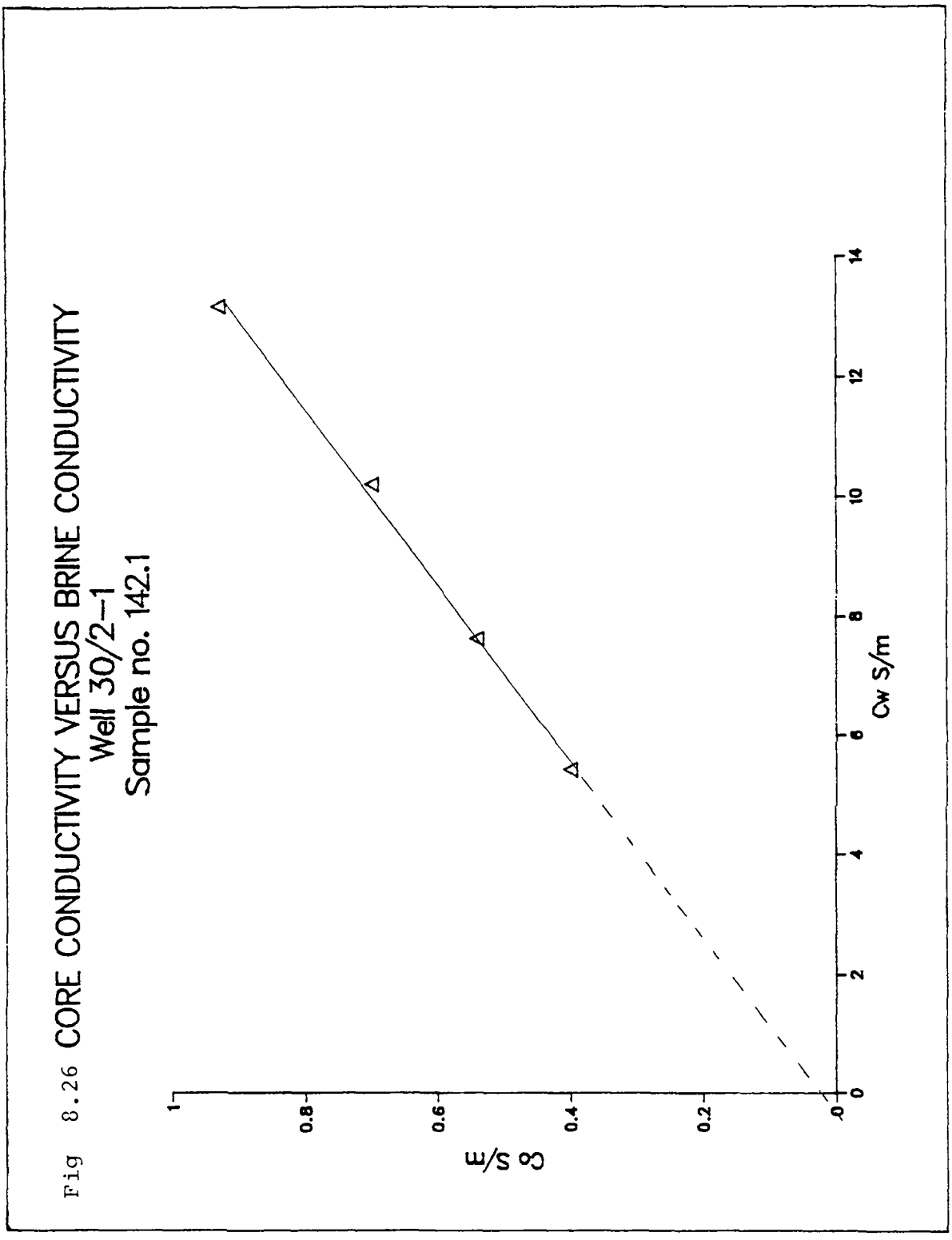

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 142.1
Cw S/m
0
2
4
6
8
10
12
14
0.2
0.4
0.6
0.8
1

Fig 8.26

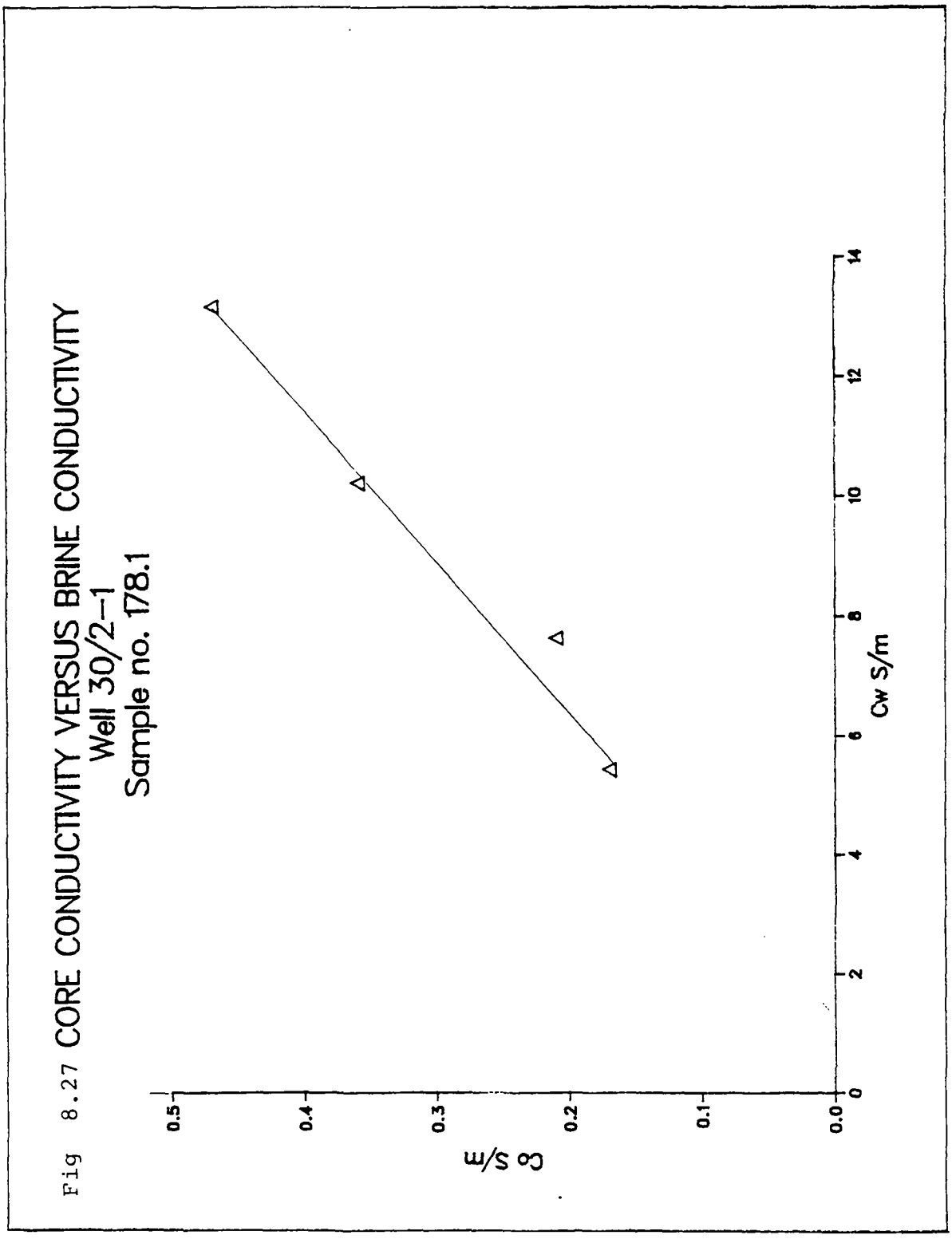

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 178.1
Co S/m
0.0
0.1
0.2
0.3
0.4
0.5
Cw S/m
0
2
4
6
8
10
12
14

Fig 8.27

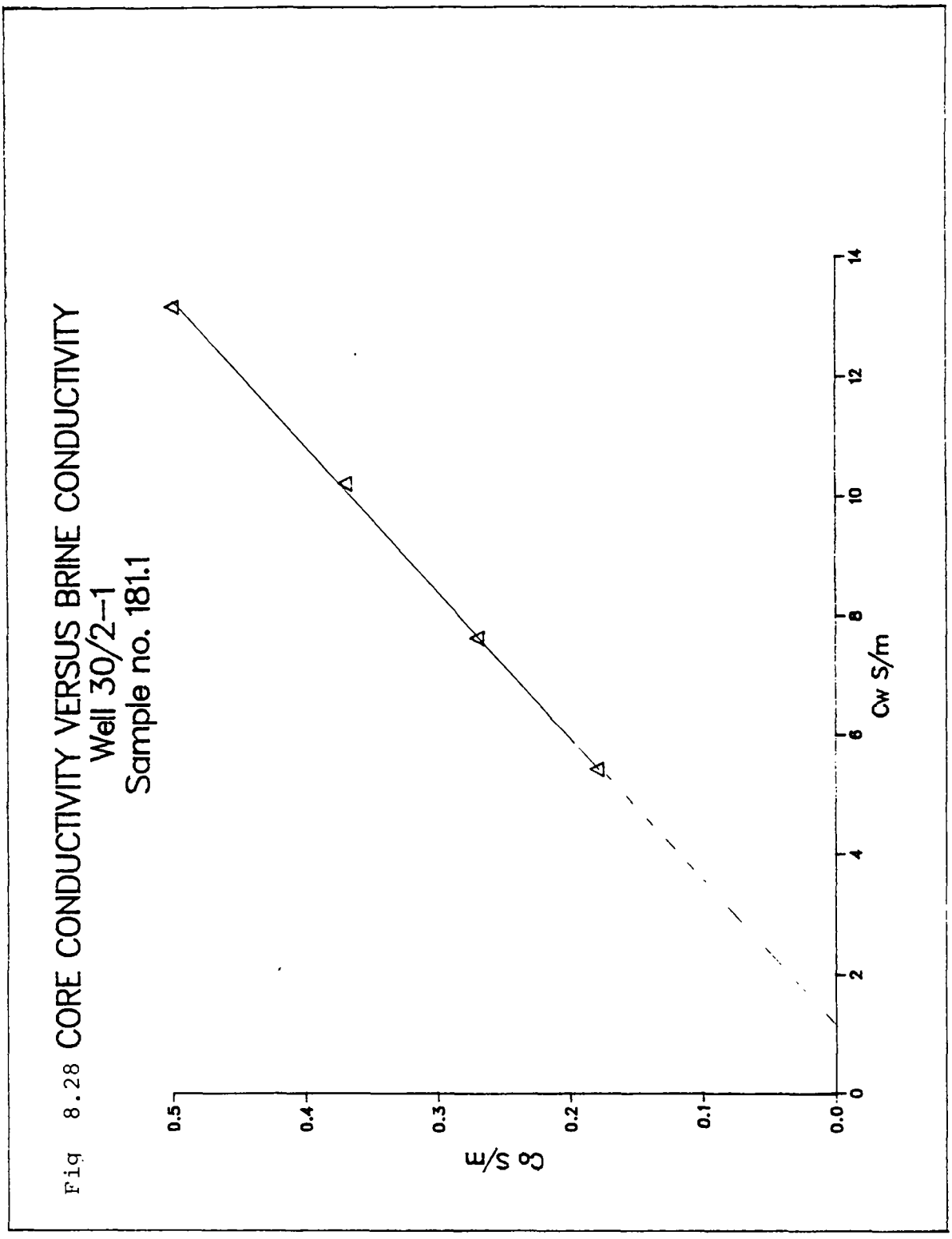

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 181.1
σ S/m
0.0
0.1
0.2
0.3
0.4
0.5
0
2
4
6
8
10
12
14
Cw S/m

Fig 8.28

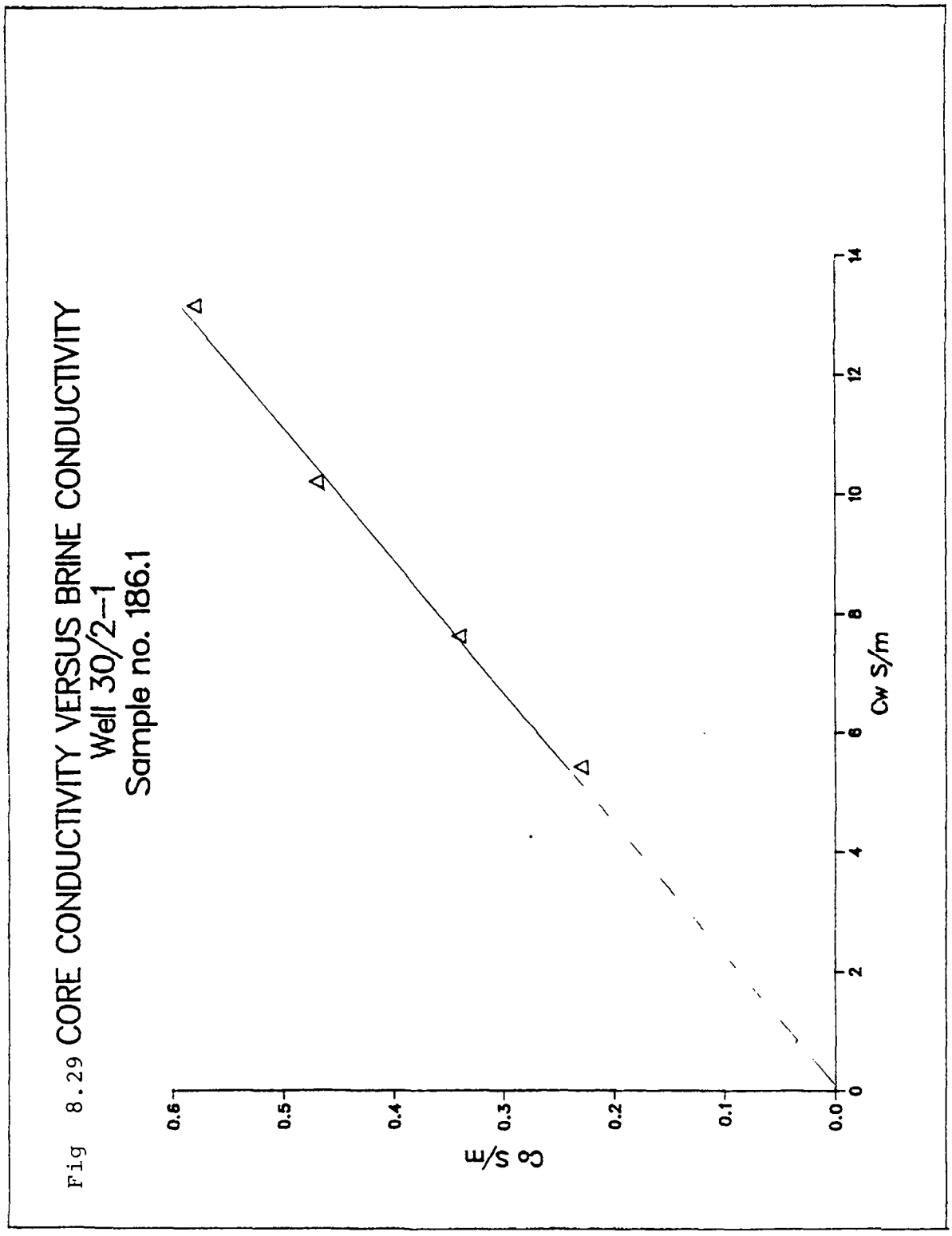

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 186.1
σ S/m
Cw S/m
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
2
4
6
8
10
12
14

Fig 8.29

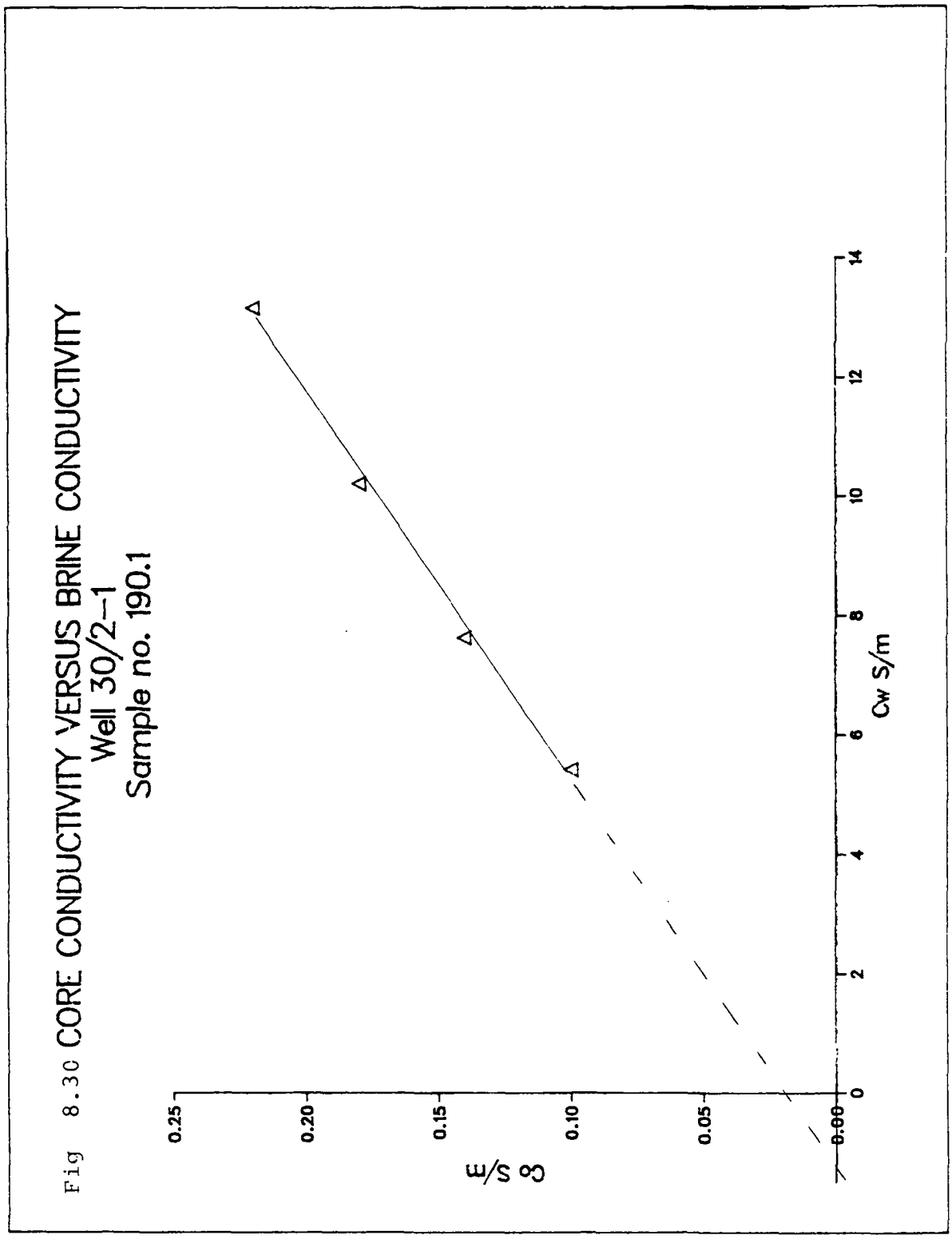

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 190.1
σ S/m
0.25
0.20
0.15
0.10
0.05
0.00
0
2
4
6
8
10
12
14
Cw S/m

Fig 8.30

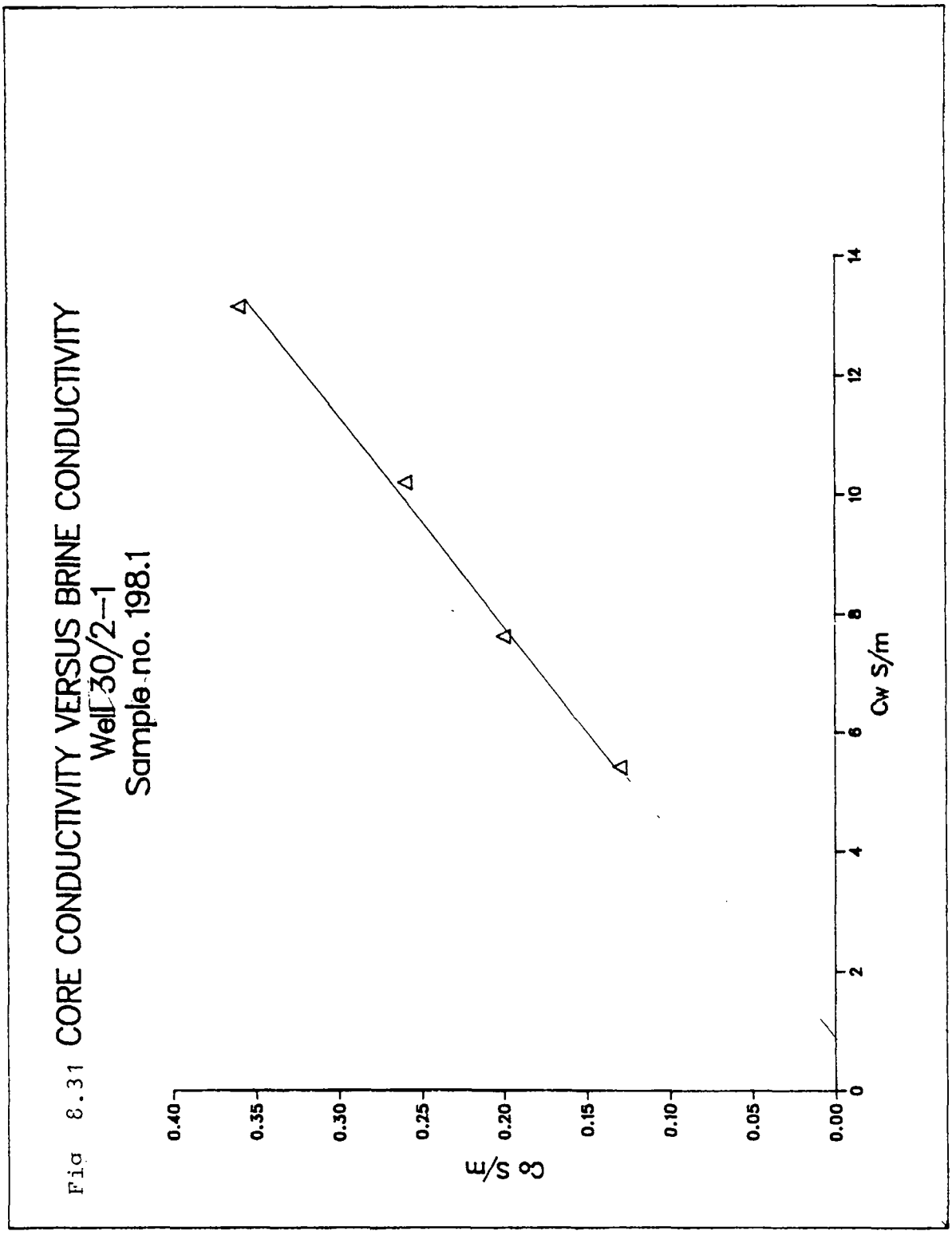

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 198.1
ε/s σ
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
2
4
6
8
10
12
14
Cw S/m

Fig 8.31

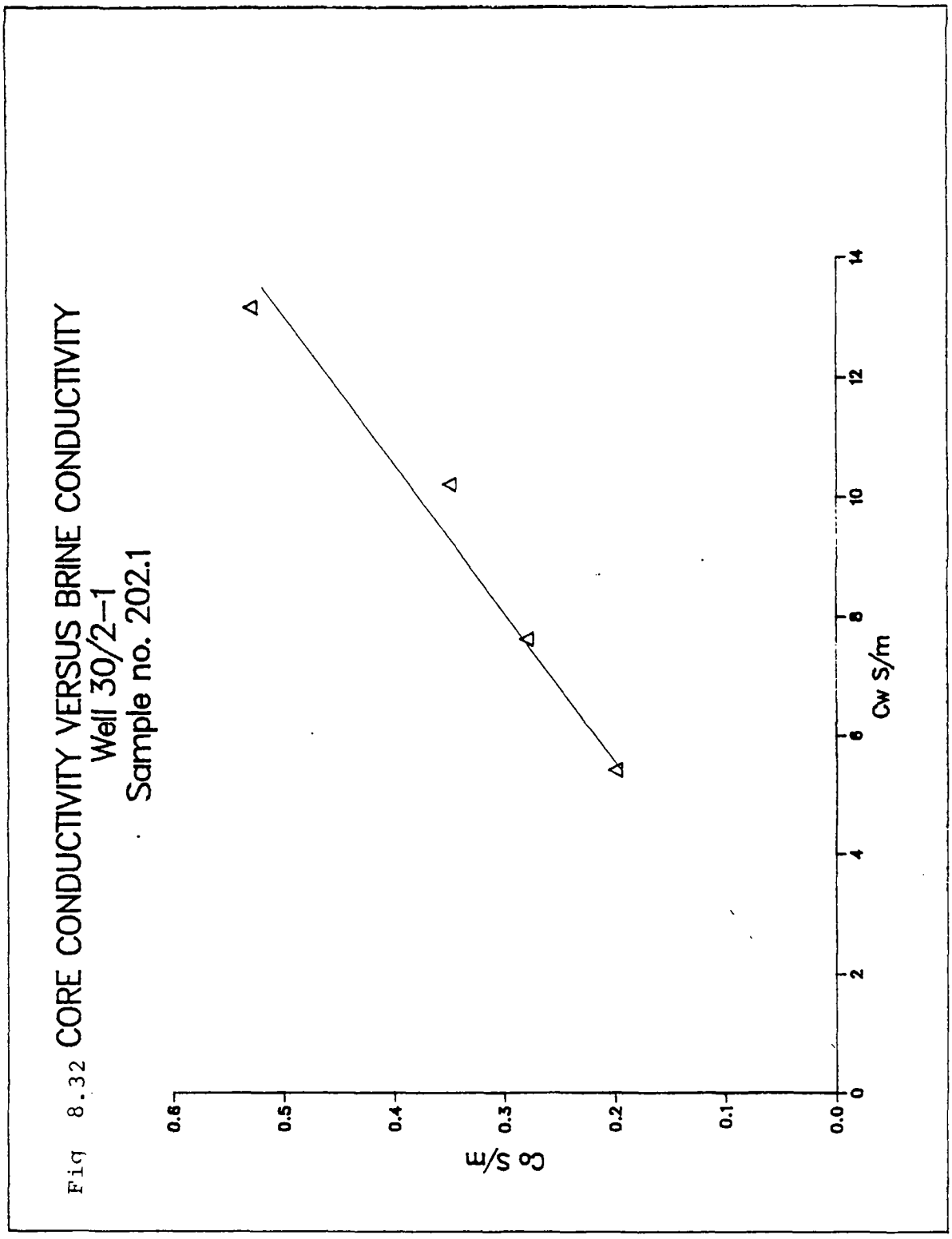

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 202.1
Cw S/m
Co S/m
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
2
4
6
8
10
12
14

Fig 8.32

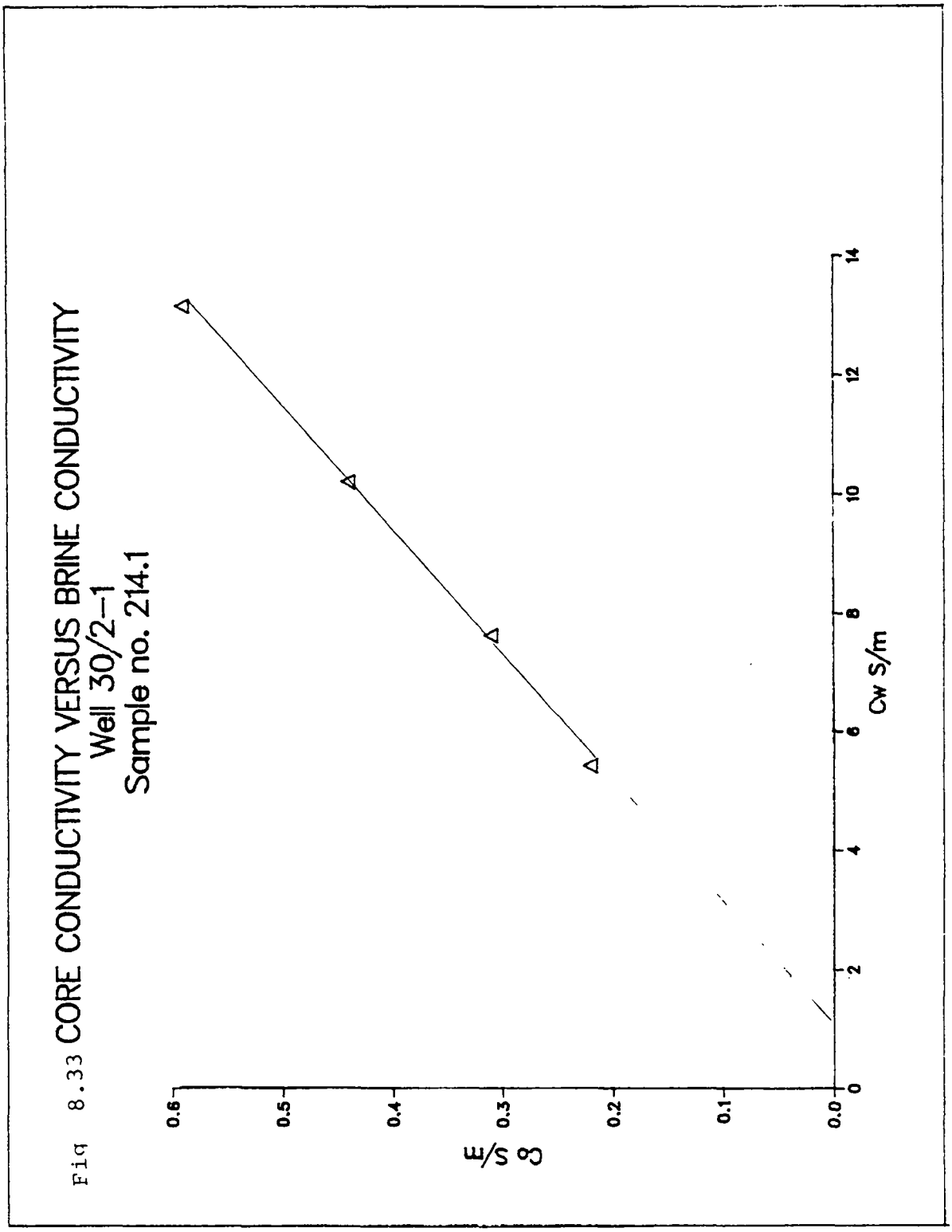

CORE CONDUCTIVITY VERSUS BRINE CONDUCTIVITY
Well 30/2-1
Sample no. 214.1
E/S σ
Cw S/m
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
2
4
6
8
10
12
14

Fig 8.33

Table 8.11 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/2-1 sample 53.1

PC PHG	SHG SHG	PR R
0.40	0.5	18.350
0.70	1.1	10.486
0.90	2.1	8.156
7.20	2.8	1.019
7.50	5.0	0.979
7.90	8.2	0.929
8.30	11.5	0.884
8.80	14.7	0.834
9.20	20.2	0.798
9.90	23.4	0.741
10.40	26.7	0.706
11.00	30.4	0.667
11.70	33.7	0.627
12.80	36.9	0.573
13.60	39.1	0.540
15.10	42.3	0.486
16.10	43.9	0.456
17.40	45.5	0.422
18.60	47.1	0.395
20.30	48.7	0.362
21.40	50.3	0.343
23.40	51.8	0.314
25.50	53.4	0.288
28.10	55.0	0.261
30.80	56.6	0.238
34.90	58.1	0.210
38.90	59.6	0.189
43.40	61.2	0.169
48.70	62.6	0.151
55.00	64.1	0.133
63.30	65.6	0.116
72.60	67.0	0.101
84.40	68.3	0.087
97.10	69.6	0.076
110.30	71.5	0.067
127.90	72.7	0.057
168.10	75.0	0.050
226.60	76.8	0.044
350.60	77.0	0.040
489.40	78.4	0.032

Table 8.12 Capillary pressure data

Capillary pressure (bar),
mercury saturation (%) and
pore radius (micron).

Well 30/ 2-1 sample 59.1

PHG	SHG	R
0.00	0.0	0.000
0.23	4.3	31.913
0.40	12.5	18.350
0.70	20.5	10.486
1.00	39.7	7.340
1.35	53.5	5.437
2.10	67.0	3.495
2.31	68.9	3.177
3.03	73.7	2.422
4.43	78.7	1.657
9.52	85.6	0.771
15.10	87.8	0.486
25.20	89.9	0.291
49.80	90.4	0.147
74.40	92.0	0.099
105.50	93.4	0.070
131.60	93.9	0.056

Table 8.13 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 63.1

PHG	SHG	R
0.00	0.0	0.000
0.36	19.8	20.389
0.45	27.0	16.311
0.63	29.4	11.651
0.80	34.1	9.175
0.99	40.5	7.414
1.20	51.6	6.117
1.63	64.3	4.503
2.97	78.6	2.471
5.01	85.7	1.465
8.18	88.9	0.897
12.10	91.3	0.607
19.80	93.7	0.371
39.80	96.0	0.184
70.80	97.6	0.104
100.00	99.2	0.073
132.40	99.2	0.055

Table 8.14 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 68.1

PHG	SHG	R
0.00	0.0	0.000
0.10	3.1	71.262
0.40	15.7	18.350
0.50	35.5	14.680
0.60	47.8	12.233
0.70	54.4	10.486
1.01	62.8	7.267
1.51	68.9	4.861
4.00	77.4	1.835
16.30	82.7	0.450
25.50	85.0	0.288
50.30	88.1	0.146
79.60	89.0	0.092
100.50	89.5	0.073
135.00	89.5	0.054

Table 8.15 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 75.1

PHG	SHG	R
0.00	0.0	0.000
0.20	0.6	36.700
0.40	0.6	18.350
0.60	0.6	12.233
1.01	1.1	7.267
1.50	1.1	4.893
3.09	4.4	2.375
4.06	6.5	1.808
5.04	8.2	1.456
7.01	9.5	1.047
9.13	13.8	0.804
13.10	20.3	0.560
17.10	24.9	0.429
25.00	30.5	0.294
40.00	42.7	0.183
62.10	53.2	0.118
99.00	64.4	0.074
133.80	69.2	0.055

Table 8.16 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 88.1

PHG	SHG	R
0.00	0.0	0.000
1.01	2.5	7.267
1.76	2.5	4.170
5.45	2.5	1.347
7.03	3.5	1.044
10.60	10.3	0.692
32.90	47.2	0.223
48.40	54.2	0.152
59.60	62.5	0.123
74.00	66.9	0.099
99.70	71.2	0.074
114.60	73.6	0.064
135.00	75.0	0.054

Table 8.17 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 97.1

PHG	SHG	R
0.00	0.0	0.000
0.41	1.1	17.902
1.49	1.4	4.926
3.15	1.4	2.330
5.06	2.7	1.451
7.02	6.0	1.046
10.00	13.4	0.734
15.10	26.7	0.486
21.30	39.8	0.345
25.20	45.5	0.291
35.00	52.9	0.210
49.50	62.7	0.148
70.20	66.4	0.105
88.90	72.5	0.083
108.50	72.9	0.068
132.80	73.6	0.055

Table 8.18 Capillary pressure data

Capillary pressure (bar),
mercury saturation (%) and
pore radius (micron).

Well 30/ 2-1 sample101.1

PHG	SHG	R
0.00	0.0	0.000
0.49	1.1	14.980
1.01	1.2	7.267
5.11	1.8	1.436
7.04	5.0	1.043
9.90	18.2	0.741
15.10	35.1	0.486
20.10	43.7	0.365
25.30	49.2	0.290
35.20	56.3	0.209
49.80	63.7	0.147
70.20	69.4	0.105
90.30	73.2	0.081
109.20	77.3	0.067
138.00	78.9	0.053

Table 8.19 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 118.1

PHG	SHG	R
0.00	0.0	0.000
0.11	9.8	66.727
0.20	25.7	36.700
0.66	48.0	11.121
1.01	51.4	7.267
2.48	59.1	2.960
3.47	62.2	2.115
5.34	66.1	1.375
7.11	68.8	1.032
9.48	71.4	0.774
12.10	73.5	0.607
16.10	73.5	0.456
25.30	75.7	0.290
41.40	76.9	0.177
62.60	79.2	0.117
98.50	80.9	0.075
128.30	80.9	0.057

Table 8.20 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 131.1

PHG	SHG	R
0.00	0.0	0.000
0.31	3.0	23.677
0.60	4.3	12.233
1.01	23.7	7.267
2.32	31.1	3.164
3.70	43.2	1.984
5.47	55.3	1.342
7.67	62.2	0.957
8.68	64.9	0.846
12.50	70.4	0.587
18.10	74.9	0.406
24.90	78.1	0.295
34.90	81.1	0.210
50.60	83.9	0.145
75.80	86.6	0.097
99.40	88.1	0.074
131.60	89.5	0.056

Table 8.21 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 138.1

PHG	SHG	R
0.00	0.0	0.000
0.02	0.8	367.000
0.10	1.4	73.400
0.30	1.6	24.467
0.50	2.4	14.680
0.68	4.7	10.794
0.75	9.0	9.787
0.81	15.2	9.062
0.85	20.4	8.635
0.90	26.1	8.156
0.96	30.8	7.646
1.01	35.8	7.267
1.15	42.1	6.383
1.25	45.5	5.872
1.50	50.9	4.893
1.72	54.1	4.267
2.00	56.9	3.670
2.64	61.0	2.780
3.50	64.4	2.097
5.17	68.2	1.420
7.00	71.3	1.049
10.00	73.9	0.734
20.00	75.3	0.367
30.00	82.8	0.245
50.00	85.9	0.147
100.00	89.0	0.073
135.00	90.0	0.054

Table 8.22 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 142.1

PHG	SHG	R
0.00	0.0	0.000
0.05	1.7	146.800
0.20	2.0	36.700
0.43	4.4	17.070
0.55	10.3	13.345
0.60	20.6	12.233
0.70	35.5	10.486
0.75	40.5	9.787
0.83	44.8	8.843
0.95	49.3	7.726
1.01	50.7	7.267
1.20	54.2	6.117
3.45	65.6	2.128
4.50	68.0	1.631
6.00	70.7	1.223
10.30	74.7	0.713
15.00	77.5	0.489
20.00	79.9	0.367
30.00	82.3	0.245
40.40	84.3	0.182
61.00	86.2	0.120
90.00	88.2	0.082
120.00	88.9	0.061
135.00	89.4	0.054

Table 8.23 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 178.1

PHG	SHG	R
0.00	0.0	0.000
0.10	1.4	73.400
0.30	1.4	24.467
0.72	1.7	10.194
1.00	2.1	7.340
2.60	2.3	2.823
4.50	5.2	1.631
5.00	7.9	1.468
5.58	15.9	1.315
5.90	20.8	1.244
6.30	25.4	1.165
6.80	28.8	1.079
7.54	33.6	0.973
8.50	36.7	0.864
10.70	42.0	0.686
12.50	45.5	0.587
15.00	49.7	0.489
17.50	53.2	0.419
20.00	55.7	0.367
23.50	59.1	0.312
27.00	61.6	0.272
31.00	64.4	0.237
40.00	67.7	0.183
50.00	74.0	0.147
60.00	73.8	0.122
75.00	76.6	0.098
100.00	79.0	0.073
115.00	80.6	0.064
135.00	81.3	0.054

Table 8.24 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 181.1

PHG	SHG	R
0.00	0.0	0.000
0.20	1.4	36.700
0.50	1.6	14.680
1.00	1.8	7.340
2.00	1.9	3.670
3.20	2.6	2.294
4.00	4.0	1.835
4.50	6.1	1.631
4.92	10.6	1.492
5.20	13.7	1.412
5.40	17.1	1.359
5.70	21.1	1.288
6.00	24.2	1.223
6.40	27.7	1.147
6.90	30.6	1.064
7.62	34.3	0.963
8.00	36.3	0.918
8.60	38.4	0.853
9.20	40.4	0.798
10.00	42.2	0.734
11.00	44.3	0.667
12.30	47.2	0.597
14.00	50.1	0.524
15.00	51.4	0.489
16.50	53.3	0.445
18.50	56.1	0.397
21.00	58.5	0.350
24.00	61.2	0.306
27.00	63.6	0.272
30.00	65.7	0.245
35.00	67.6	0.210
40.00	70.7	0.183
45.00	72.8	0.163
50.00	74.3	0.147
60.00	77.3	0.122
70.00	78.9	0.105
80.50	80.8	0.091
90.00	81.7	0.082
100.00	82.8	0.073
120.00	84.6	0.061
135.00	85.2	0.054

Table 8.25 Capillary pressure data

Capillary pressure (bar),
mercury saturation (%) and
pore radius (micron).

Well 30/ 2-1 sample 186.1

PHG	SHG	R
0.00	0.0	0.000
0.72	2.0	10.194
1.00	2.3	7.340
2.54	5.4	2.890
4.15	27.1	1.769
5.39	36.2	1.362
6.38	40.8	1.150
9.16	50.0	0.801
10.50	52.5	0.699
11.90	55.3	0.617
15.00	60.2	0.489
20.30	66.0	0.362
25.00	69.9	0.294
34.70	75.3	0.212
48.80	80.1	0.150
74.50	84.9	0.099
98.50	87.6	0.075
129.60	88.7	0.057

Table 8.26 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 190.1

PHG	SHG	R
0.00	0.0	0.000
0.65	2.0	11.292
1.00	2.3	7.340
2.30	2.5	3.191
3.78	2.5	1.942
6.09	3.5	1.205
9.62	5.2	0.763
11.80	7.1	0.622
15.00	14.9	0.489
18.10	22.7	0.406
20.90	29.6	0.351
25.30	37.5	0.290
29.80	44.2	0.246
38.70	53.8	0.190
49.60	59.4	0.148
73.40	68.2	0.100
98.10	73.5	0.075
133.30	77.5	0.055

Table 8.27 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 198.1

PHG	SHG	R
0.00	0.0	0.000
0.38	1.2	19.316
1.00	2.4	7.340
4.98	2.6	1.474
7.38	2.6	0.995
9.98	6.8	0.735
12.40	15.9	0.592
14.90	23.4	0.493
18.40	34.6	0.399
20.10	39.7	0.365
25.50	50.2	0.288
29.90	54.8	0.245
37.10	60.6	0.198
43.70	63.8	0.168
55.10	68.7	0.133
70.50	72.8	0.104
90.00	76.8	0.082
111.30	80.0	0.066
134.50	80.5	0.055

Table 8.28 Capillary pressure data

Capillary pressure (bar), mercury saturation (%) and pore radius (micron).

Well 30/ 2-1 sample 202.1

PHG	SHG	R
0.00	0.0	0.000
0.25	1.4	29.360
1.00	1.5	7.340
3.81	5.0	1.927
5.88	20.4	1.248
6.82	24.1	1.076
8.51	31.0	0.863
9.90	35.7	0.741
12.50	39.9	0.587
16.00	45.9	0.459
20.30	50.7	0.362
24.90	54.5	0.295
36.50	61.8	0.201
50.10	65.0	0.147
75.20	68.8	0.098
99.10	71.4	0.074
130.20	74.3	0.056

Table 8.29 Capillary pressure data

Capillary pressure (bar),
mercury saturation (%) and
pore radius (micron).

Well 30/ 2-1 sample 214.1

PHG	SHG	R
0.00	0.0	0.000
0.66	1.4	11.121
1.00	1.4	7.340
6.64	22.4	1.105
8.90	26.8	0.825
10.20	30.0	0.720
13.70	36.7	0.536
15.90	40.7	0.462
19.50	43.7	0.376
24.90	47.5	0.295
31.20	50.7	0.235
40.90	53.5	0.179
50.40	55.7	0.146
73.50	60.2	0.100
100.40	62.9	0.073
132.50	65.4	0.055

Fig.8.34 Capillary pressure versus mercury saturation.
Well 30/2-1
Plot of PHG versus SHG for samples 53.1, 59.1, 63.1, 68.1 and 75.1.

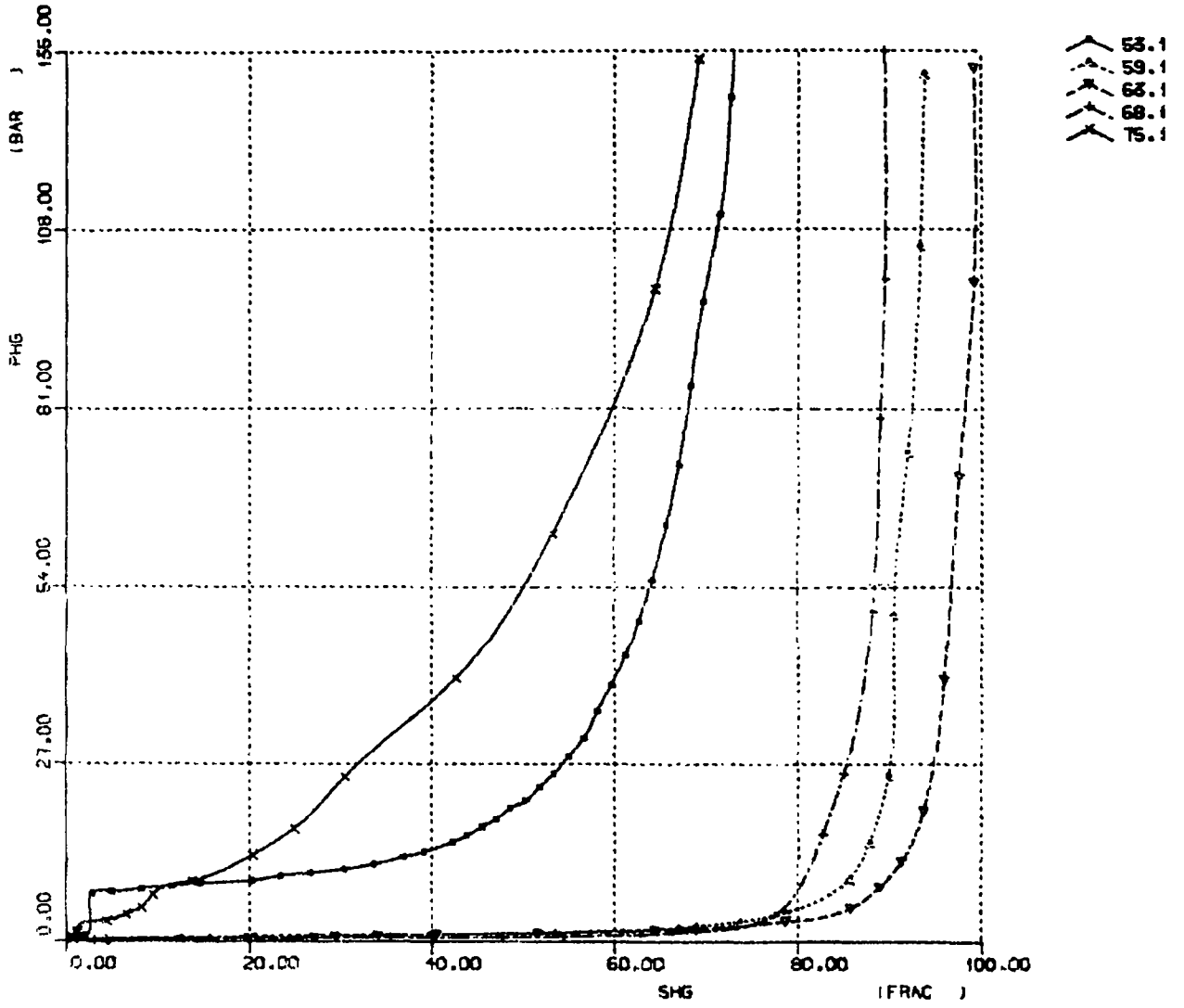


Fig. 8.35 Capillary pressure versus mercury saturation.
Well 30/2-1
Plot of PHG versus SHG for samples 88.1, 97.1, 101.1,118.1 and 131.1

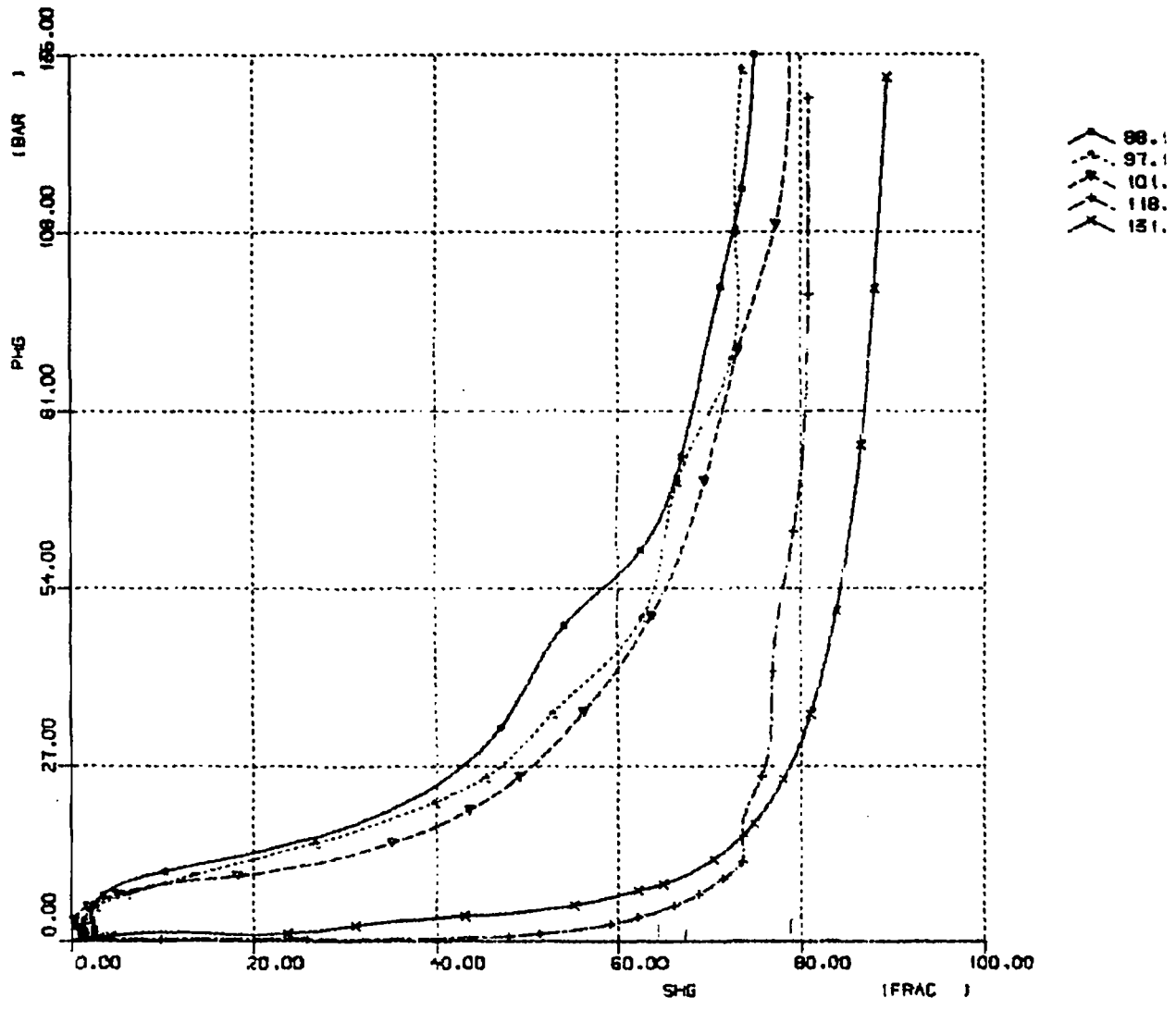
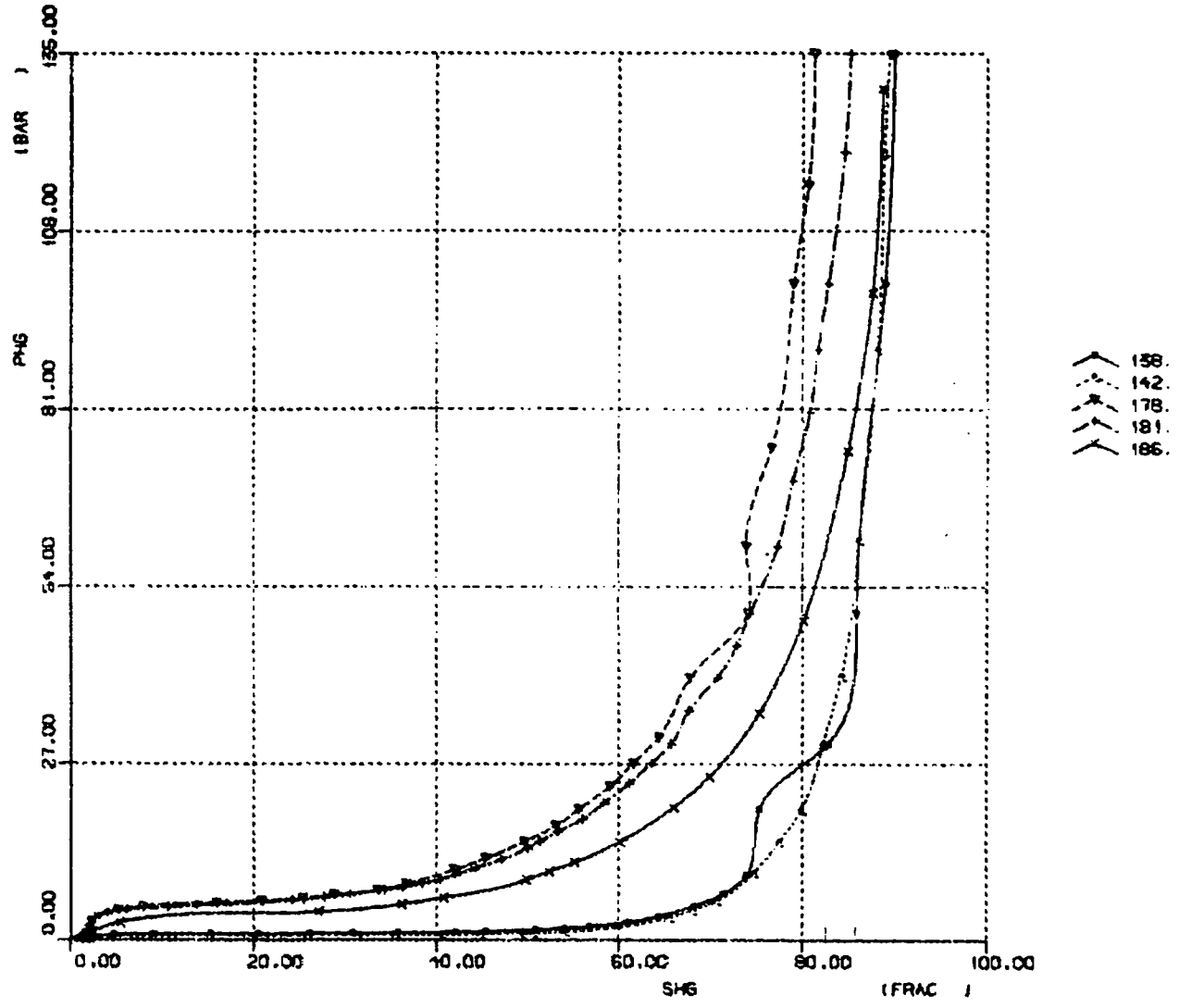


Fig. 8.36 Capillary pressure versus mercury saturation.
Well 30/2-1
Plot of PHG versus SHG for samples
138.1, 142.1, 178.1, 181.1 and 186.1.



LAB 83.37

Fig. 8.37 Capillary pressure versus mercury saturation.
Well 30/2-1
Plot of PHG versus SHG for samples 190.1, 198.1, 202.1 and 214.1.