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302 83040015
15/9 - 11 Kjernerapport

STATOIL
EVALUATION OF CORE DATA
15/9-11
NOVEMBER 1982

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C O M M E N T S

Preparation

The core sample analyses were performed on 1" x 1" cylindrical plugs. The samples were first extracted with toluene, followed with methanol and then dried in a humidity controlled cabinet at 60°C and 40% relative humidity.

Porosity and Permeability Measurements

All plugs were measured for helium porosity and grain density.
Air permeabilities were measured at 4 different pressures to calculate the Klinkenberg corrected air permeability. A plot showing the relationship between pressure and permeability is enclosed in this report.

Capillary and Electrical Measurements

All samples were saturated with simulated formation brine. A hydrostatic pressure of 50 bar for 16 hours was applied to achieve complete saturation.
Formation resistivity factor was measured at atmospheric condition.
The frequency used was 1 kHz.
The parameters (a,m) in Archies formula, $FF = a \phi^{-m}$, were evaluated both with least squares method forced through FF = 1.0, ϕ = 1.0 and least squares method, normal regression. Because of too few samples only the forced fit curve is presented graphically.
The samples, which were 100% saturated with simulated formation brine, were desaturated by water saturated air in a porous plate well at 8 different pressure levels up to 12 bar.
Stability time at each pressure level varied from 2 to 5 days.
The different water saturations were determined by the weight of the samples.

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At the same time, resistivity index was measured using a frequency of 1 kHz.

The resistivity index (RI) equation

$$RI = b \cdot Sw^{-n}$$

has been evaluated both by weight least squares method forced through RI = 1.0, Sw = 1.0 and least squares method, normal regression.

The forced fit curve is presented graphically.

The water saturations at 12 bar have been plotted against logarithm of the Klinkenberg corrected air permeability.

The curve has been determined by the least squares method.

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SAMPLE LIST

Sample no.	Depth (m)
82	2426.60
83	2427.20
85	2436.00
92	2438.32
99	2440.67

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PHYSICAL AND CHEMICAL PROPERTIES OF SIMULATED FORMATION BRINE

Condition: Atmospheric pressure
Temperature 20°C

Composition: Na^+ : 20633 ppm

Mg^{2+}: 273 ppm

Ca^{2+}: 2029 ppm

Sr^{2+}: 343 ppm

These cation contents were achieved by mixing the chloride salts of the cations.

Density: 1.04 g/cm^3

Viscosity: 1.15 cp

Resistivity: 0.126 ohm-m

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POROSITY AND GRAIN DENSITY

Sample no.	Depth m	Bulk Volume cm^3	Pore Volume cm^3	Ile-Porosity o/o	Grain Density g/cm^3
82	2426.60	12.00	3.15	26.3	2.65
83	2427.20	11.97	2.99	25.0	2.64
85	2436.00	12.00	2.95	24.6	2.65
92	2438.32	12.00	2.93	24.4	2.64
99	2440.67	11.47	2.89	25.2	2.64

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KLINKENBERG CORRECTED AIR PERMEABILITY

Sample no.	Depth (m)	(Mean Pressure)$^{-1}$ (atm.abs.)$^{-1}$	Air Permeability md	Klinkenberg corrected Permeability md
82	2426.60	0.781	97.1	95.9
		0.725	97.0	
		0.655	96.9	
		0.580	96.8	
83	2427.20	0.767	152	140
		0.713	151	
		0.645	150	
		0.572	149	
85	2436.00	0.852	277	263
		0.786	276	
		0.704	275	
		0.618	273	
92	2438.32	0.808	182	171
		0.748	181	
		0.674	180	
		0.595	179	
99	2440.67	0.875	460	445
		0.806	459	
		0.720	457	
		0.630	456	

Klinkenberg corrected Air Permeability

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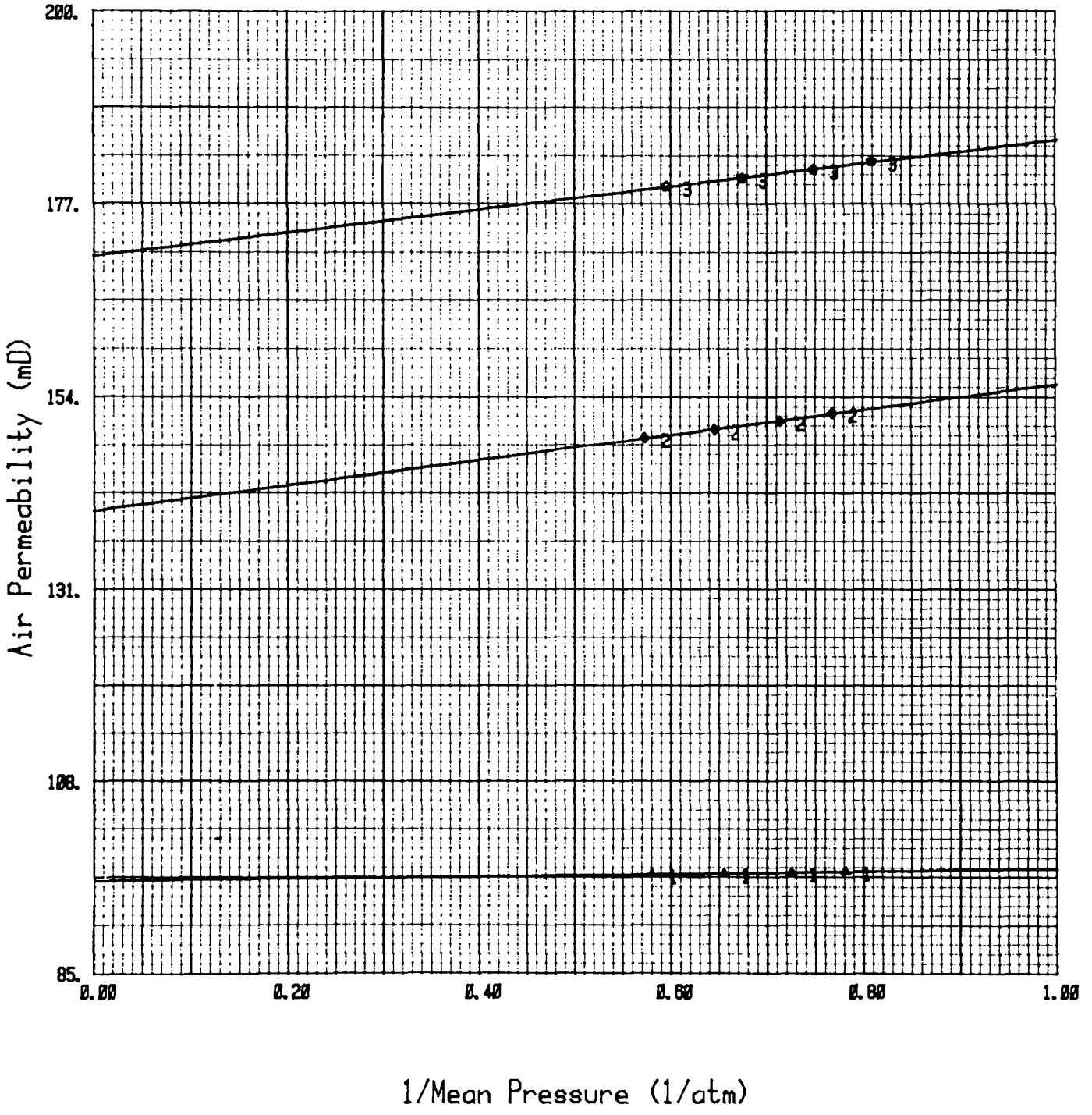
Petroleum
Laboratory

Curve "1" : Klinkenberg perm.: 95.9 mD
depth : 2426.60 m, sample no 82

Curve "2" : Klinkenberg perm.: 140 mD
depth : 2427.20 m, sample no 83

Curve "3" : Klinkenberg perm.: 171 mD
depth : 2438.32 m, sample no 92

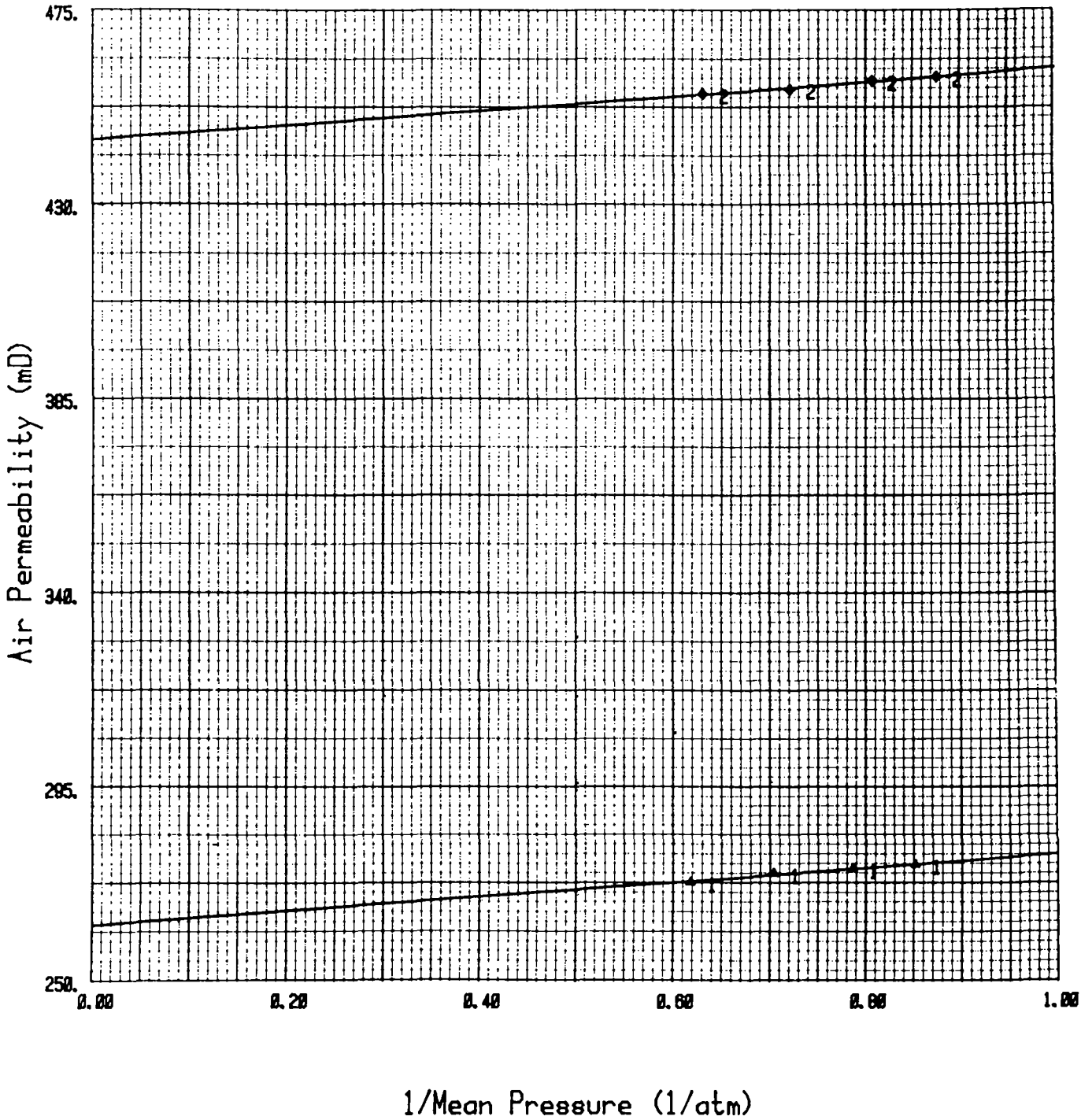


Klinkenberg corrected Air Permeability

GECO Petroleum Laboratory

Curve "1" : Klinkenberg perm.: 263 mD
depth : 2436.00 m, sample no 85

Curve "2" : Klinkenberg perm.: 445 mD
depth : 2440.67 m, sample no 99



CAPILLARY PRESSURE BY RESTORED STATE METHOD

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GEOPHYSICAL COMPANY OF NORWAY A/S

COMPANY: STATOIL

WELL: 15/9-11

DEPTH	NO	PERMEABILITY	POROSITY	BRINE SATURATION VERSUS PRESSURE (Bar)								
m		K.e.l	Ø %	0	0.1	0.2	0.4	0.7	1.2	2.0	3.0	12.0
2426.60	82	95.9	26.3	100	96.3	92.3	76.1	53.7	48.5	46.6	45.7	42.9
2427.20	83	140	25.0	100	95.3	84.5	66.1	51.6	45.9	40.5	39.2	38.9
2436.00	85	263	24.6	100	77.9	62.5	47.9	41.7	37.8	32.9	30.9	26.7
2438.32	92	171	24.4	100	79.6	64.7	52.4	42.7	38.5	35.3	33.3	29.1
2440.67	99	445	25.2	100	81.0	62.1	49.3	38.9	34.3	32.0	29.0	24.8

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Capillary Pressure Curve

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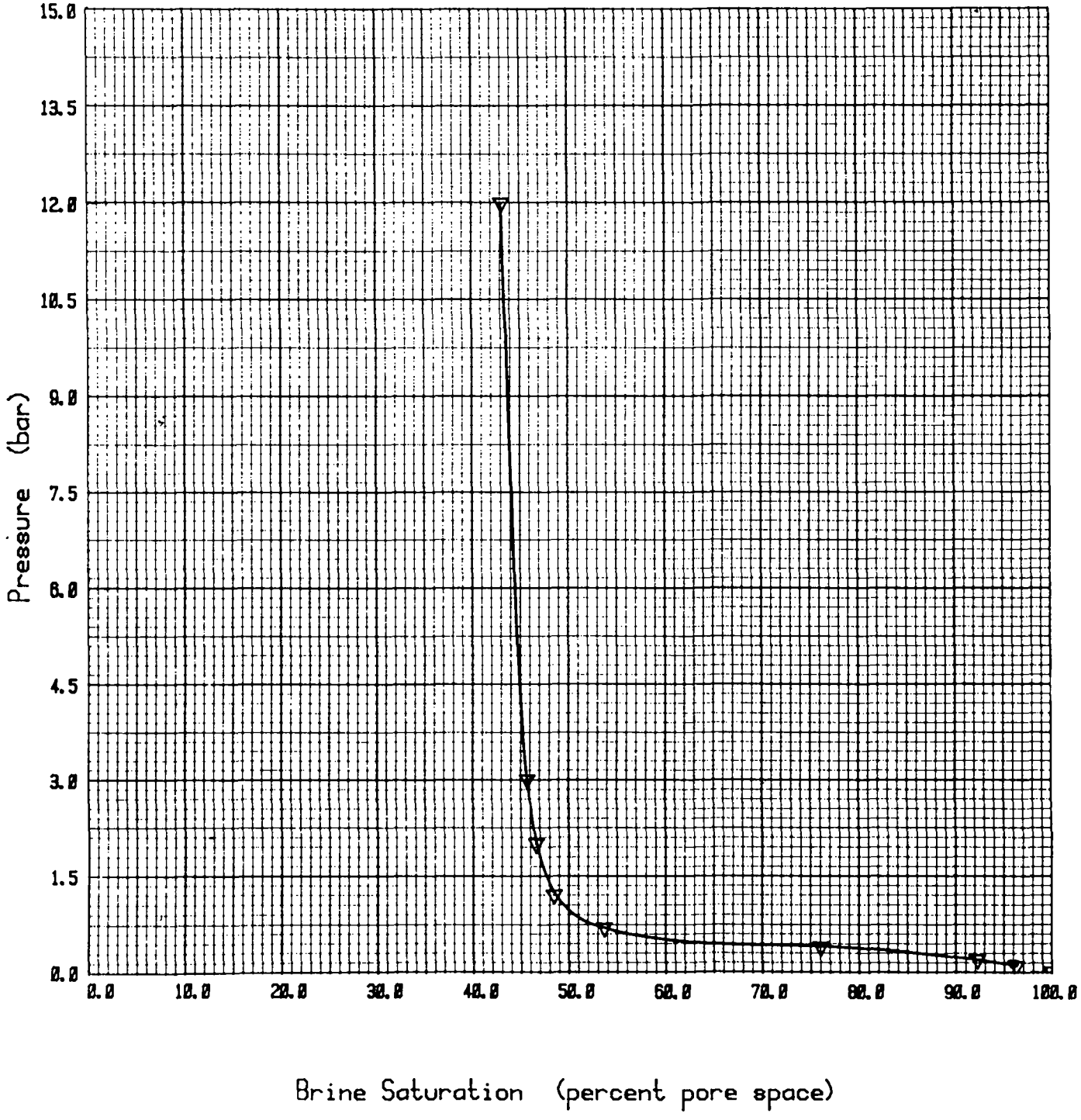
GEOPHYSICAL COMPANY OF NORWAY A-S

Company ... STATOIL A/S

Well ... 15/9-11 ... Kair ... 95.9

Sample No. . 82 ... Ø ... 26.3

Depth. ... 2426.60 ... Gr. Dens. . 2.65



Capillary Pressure Curve

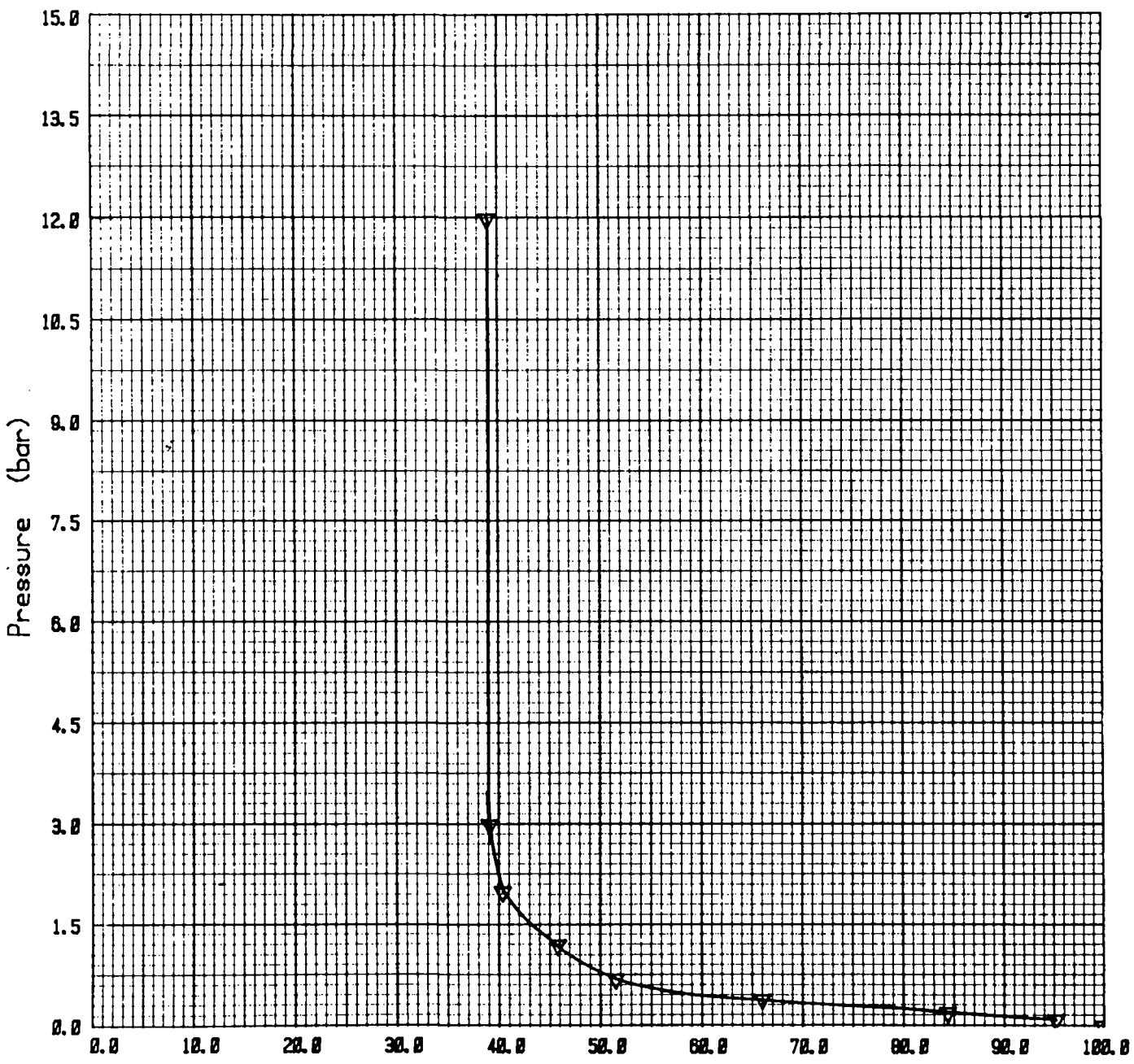
GECO
GEOPHYSICAL COMPANY OF NORWAY A/S

Company ...STATOIL A/S.....

Well .....15/9-11..... Kair .....140.....

Sample No..83..... ø .....25.0.....

Depth.....2427.20..... Gr. Dens..2.64.....



Capillary Pressure Curve

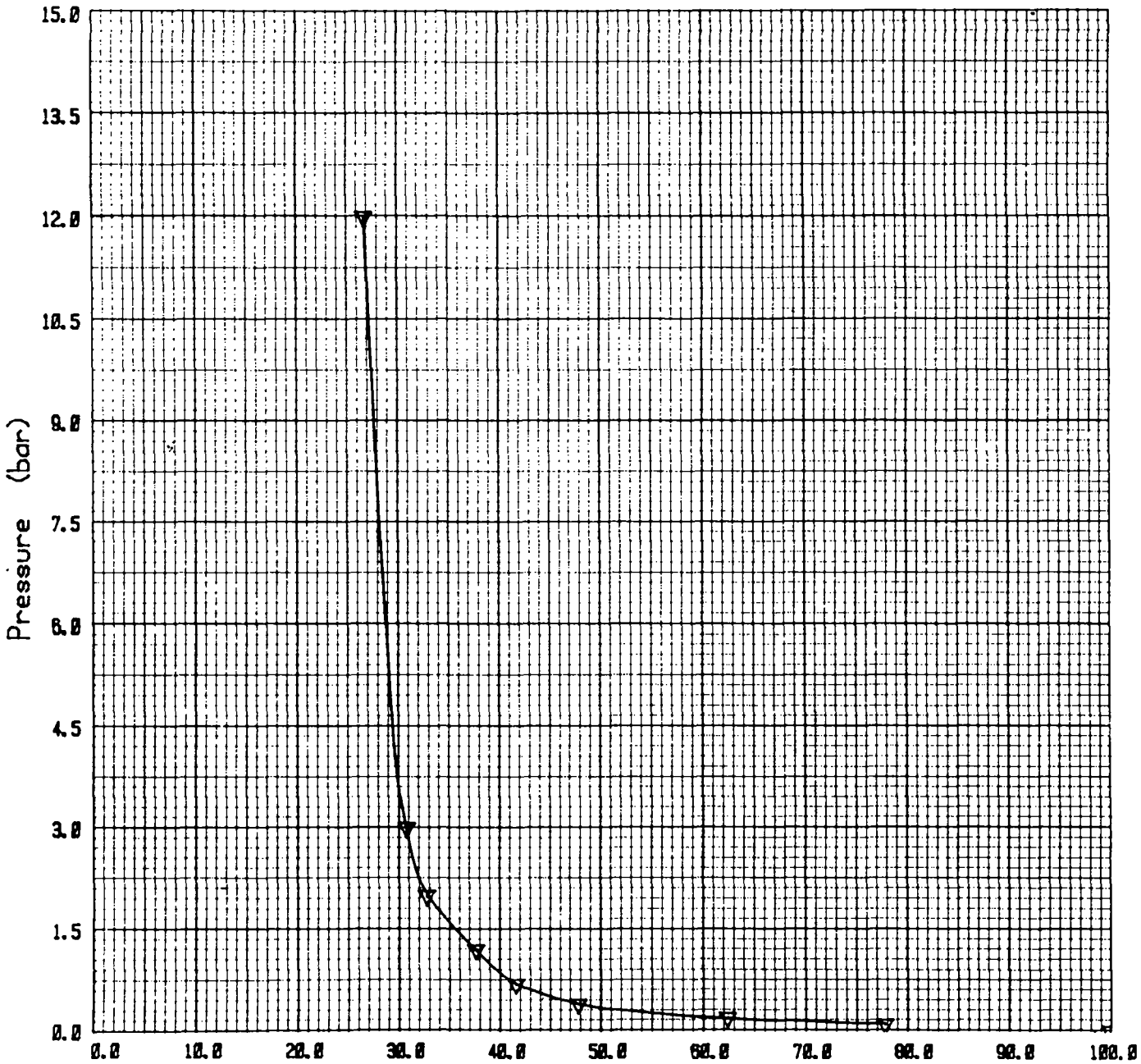
GECO
GEOPHYSICAL COMPANY OF NORWAY A-S

Company ... STATOIL A/S

Well ..... 15/9-11 ..... Kair ..... 263. .....

Sample No. . 85 ..... ø ..... 24.6 .....

Depth. ..... 2436.00 ..... Gr. Dens. . 2.65 .....



Capillary Pressure Curve

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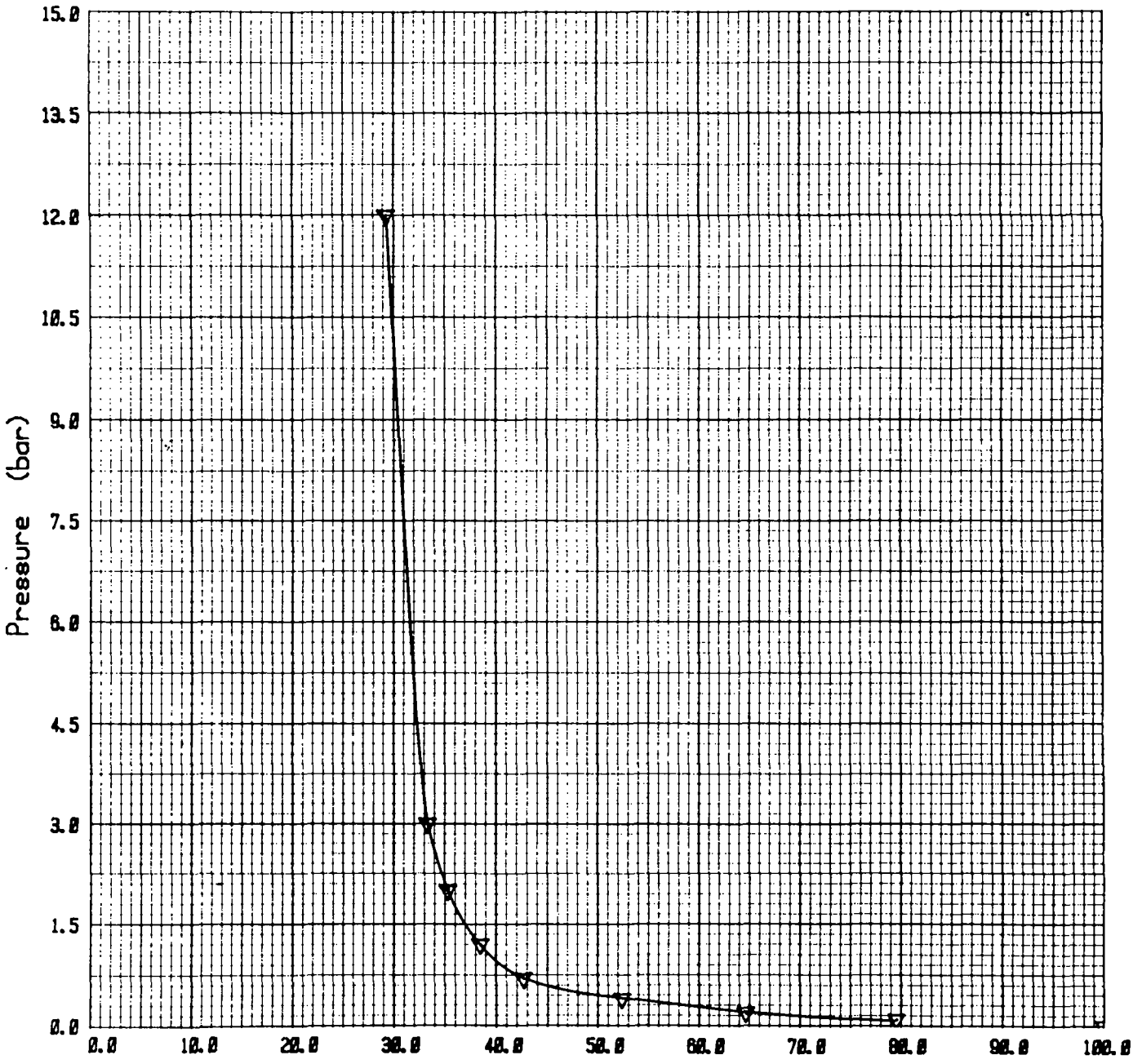
GEOPHYSICAL COMPANY OF NORWAY A-S

Company ... STATOIL A/S

Well ..... 15/9-11 ..... Kair ..... 171. .....

Sample No. . 92 ..... Ø ..... 24.4 .....

Depth. ..... 2438.32 ..... Gr. Dens. . 2.64 .....



Capillary Pressure Curve

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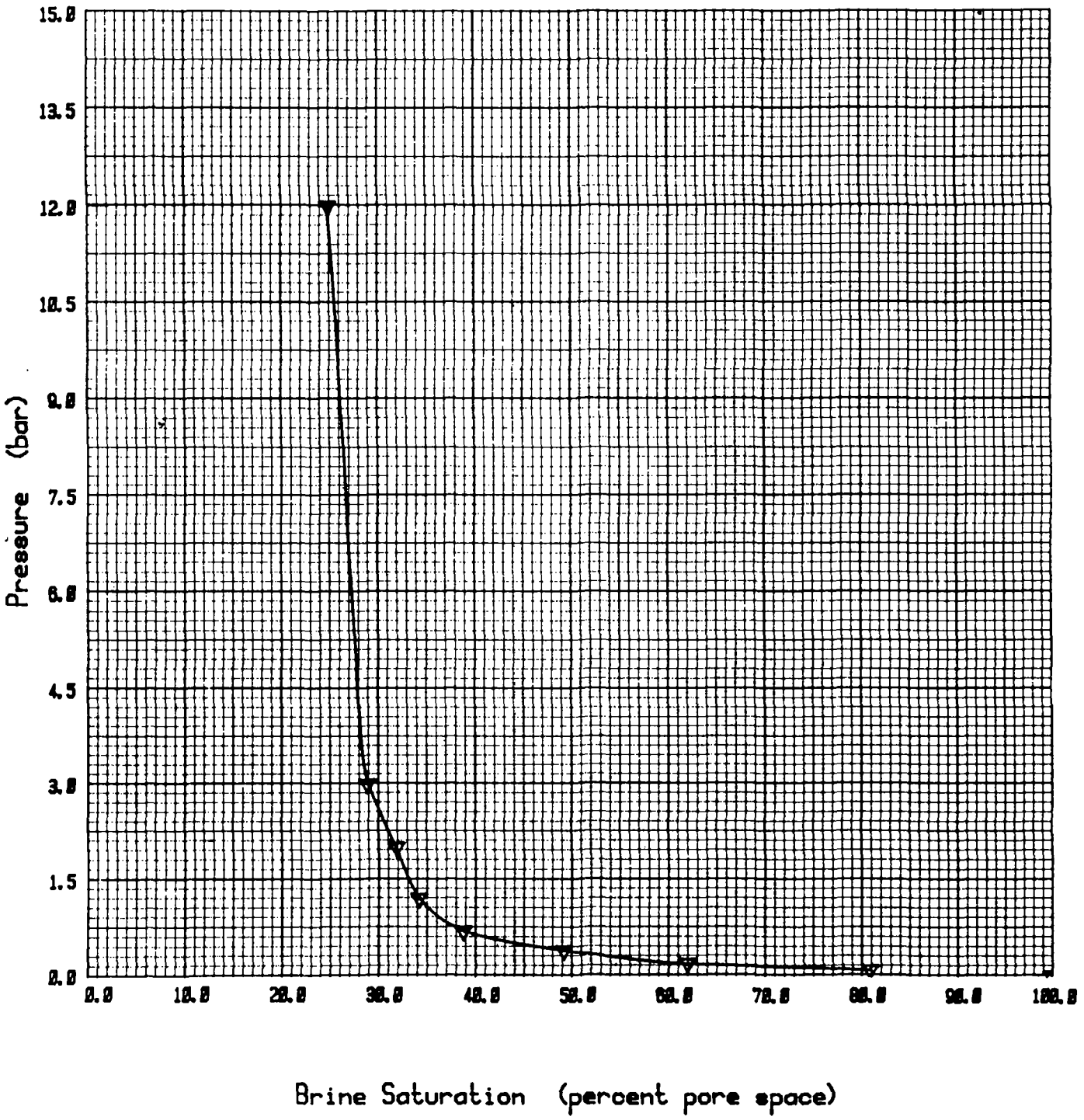
GEOPHYSICAL COMPANY OF NORWAY A-S

Company ... STATOIL A/S .....

Well ..... 15/9-11 ..... Kair ..... 445. .....

Sample No. . 99 ..... Ø ..... 25.2 .....

Depth ..... 2440.67 ..... Gr. Dens. . 2.64 .....



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FORMATION RESISTIVITY FACTOR
MEASURED AT ATMOSPHERIC CONDITION

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

Simulated formation brine: Na^{+} : 20633 ppm

Mg^{++}: 273 ppm

Ca^{++}: 2029 ppm

Sr^{++}: 343 ppm

Brine resistivity at 20°C: 0.126 ohm-m
Frequency : 1 kHz

Depth (m)	Porosity o/o	Formation Resisitivity Factor
2426.60	26.3	9.31
2427.20	25.0	9.88
2436.00	24.6	12.3
2438.32	24.4	12.5
2440.67	25.2	11.6

By weighted least squares method:

$$FF = 1.00\ \phi^{-1.74}$$

By least squares method (normal regression):

$$FF = 0.06\ \phi^{-3.81}$$

Formation Factor versus Porosity

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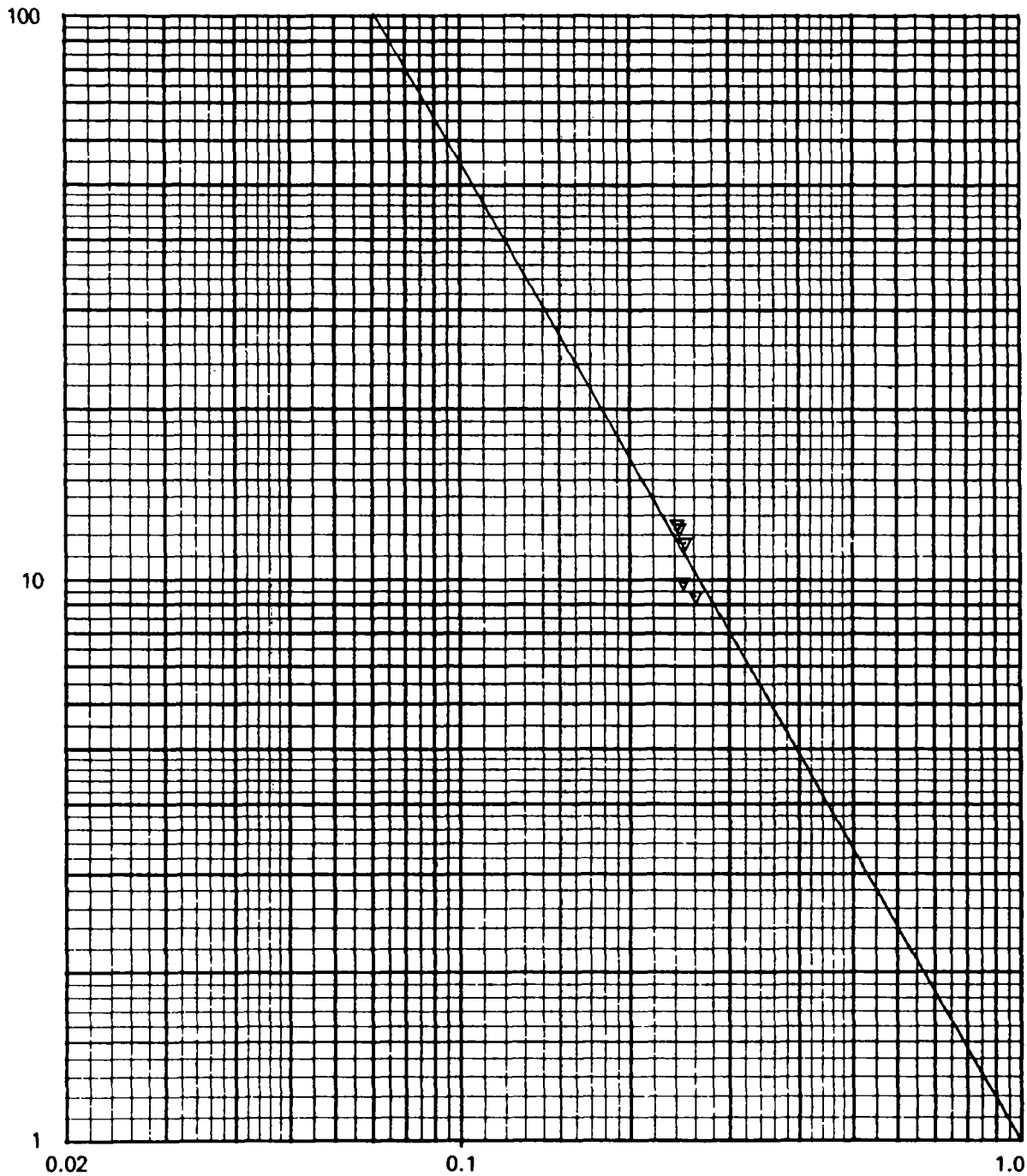
Company ..STATOIL A/S.....

Well ..15/9-11.....

Atmospheric Condition

FF = 1.00 * $\emptyset^{-1.74}$



Formation Resistivity Factor.
"FF"

Fractional Porosity.
"$\emptyset$"

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RESISTIVITY INDEX

By least squares method forced through RI = 1.0, Sw = 1.0

Sample no.	$RI = b \cdot Sw^{-n}$
82	$RI = 1.00\ Sw^{-2.19}$
83	$RI = 1.00\ Sw^{-2.23}$
85	$RI = 1.00\ Sw^{-1.94}$
92	$RI = 1.00\ Sw^{-1.98}$
99	$RI = 1.00\ Sw^{-2.04}$

By least squares method (normal regression).

82	$RI = 0.92\ Sw^{-2.30}$
83	$RI = 1.05\ Sw^{-2.17}$
85	$RI = 0.76\ Sw^{-2.21}$
92	$RI = 0.92\ Sw^{-2.06}$
99	$RI = 0.88\ Sw^{-2.16}$

RESISTIVITY INDEX

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GEOPHYSICAL COMPANY OF NORWAY A-S

COMPANY: STATOIL

WELL: 15/9-11

DEPTH	NO	PERMEABILITY	POROSITY	Resistivity ratio versus brine saturation								
				FF	RR	RR	RR	RR	RR	RR	RR	RR
m		K.e.l	Ø %	0	0.1	0.2	0.4	0.7	1.2	2.0	3.0	12.0
2426.60	82	95.9	26.3	9.31	1.04	1.08	1.68	4.21	4.90	5.09	5.58	6.48
2427.20	83	140	25.0	9.88	1.17	1.63	2.22	4.83	5.50	7.08	7.60	9.10
2436.00	85	263	24.6	12.3	1.37	2.32	3.22	5.69	6.08	9.12	10.1	15.0
2438.32	92	171	24.4	12.5	1.36	2.63	3.42	5.27	6.48	7.33	8.26	12.9
2440.67	99	445	25.2	11.6	1.30	2.65	4.24	6.76	8.50	10.8	11.1	19.1

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Resitivity index versus water Saturation

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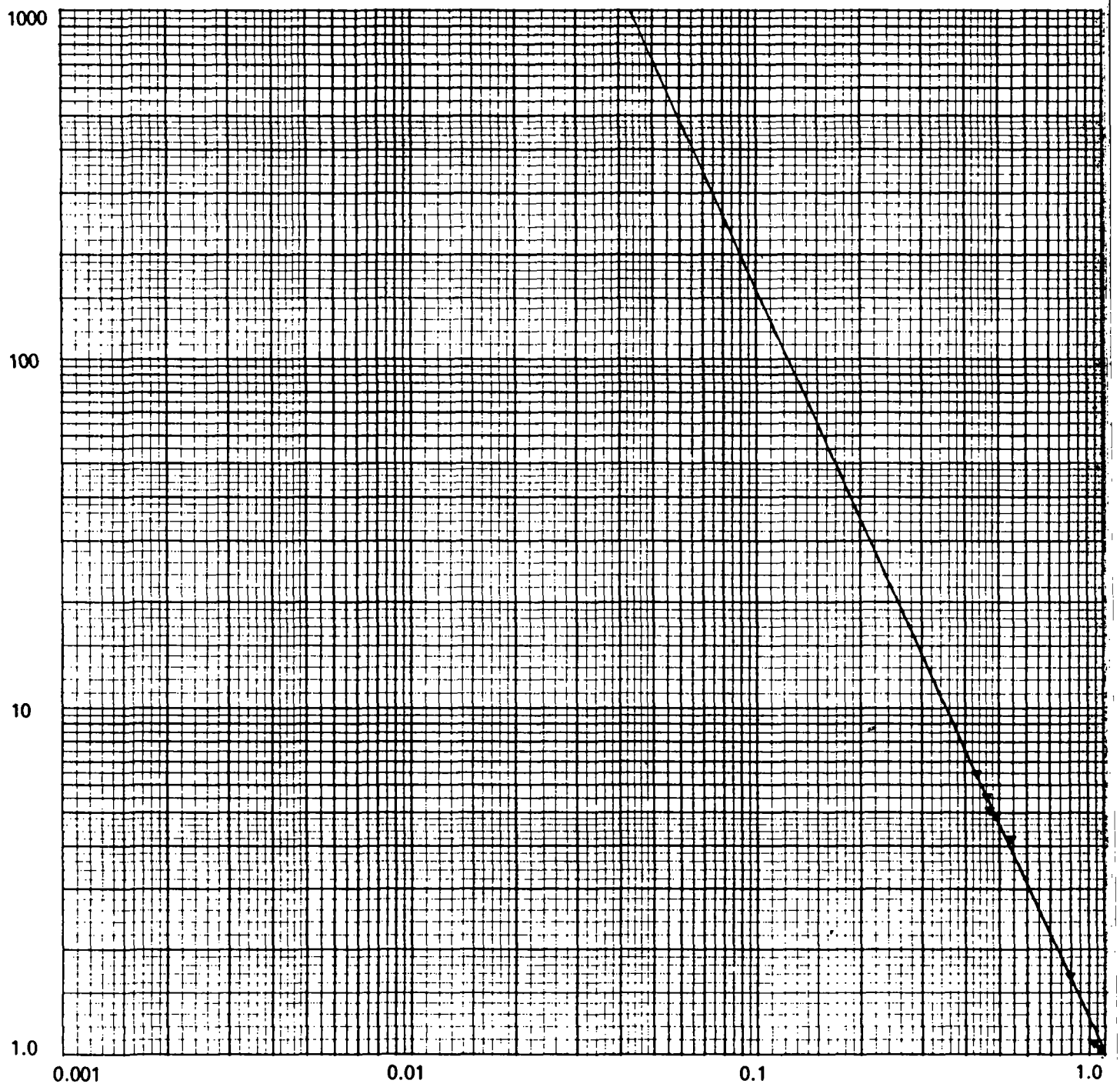
GEOPHYSICAL COMPANY OF NORWAY A-S

Company . . STATOIL. A/S. . . . . .

Well . . 15/9-11 . . . . . Kair . . 95.9 . . . . . .

Sample No. . 82 . . . . . ø . . 26.3 . . . . . .

Depth. . 2426.60 . . . . . Gr. Dens. . . . . $RI = 1.00 * S_w^{-2.19}$



Water Saturation, Fraction of Pore Space.
"S_w"

Resitivity index versus water Saturation

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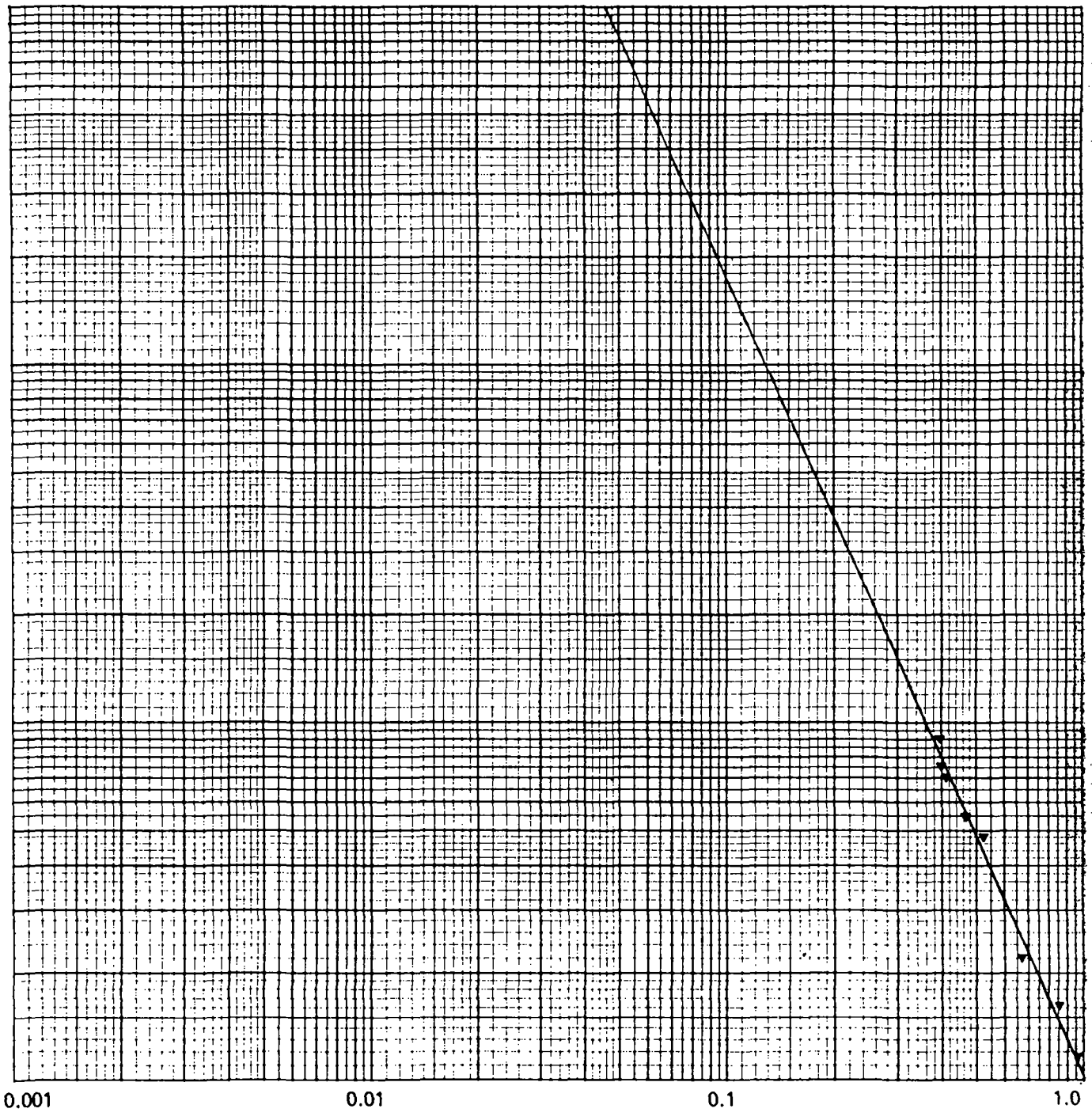
GEOPHYSICAL COMPANY OF NORWAY A-S

Company . . STATOIL A/S . . . . . .

Well . . 15/9-11 . . . . . Kair . . 140. . . . . .

Sample No. . 83 . . . . . ø . . 25.0 . . . . . .

Depth. . 2427.00 . . . . . Gr. Dens. . . . . RI = 1.00 * $S_w^{-2.23}$



Water Saturation, Fraction of Pore Space.
"S_w"

Resitivity index versus water Saturation

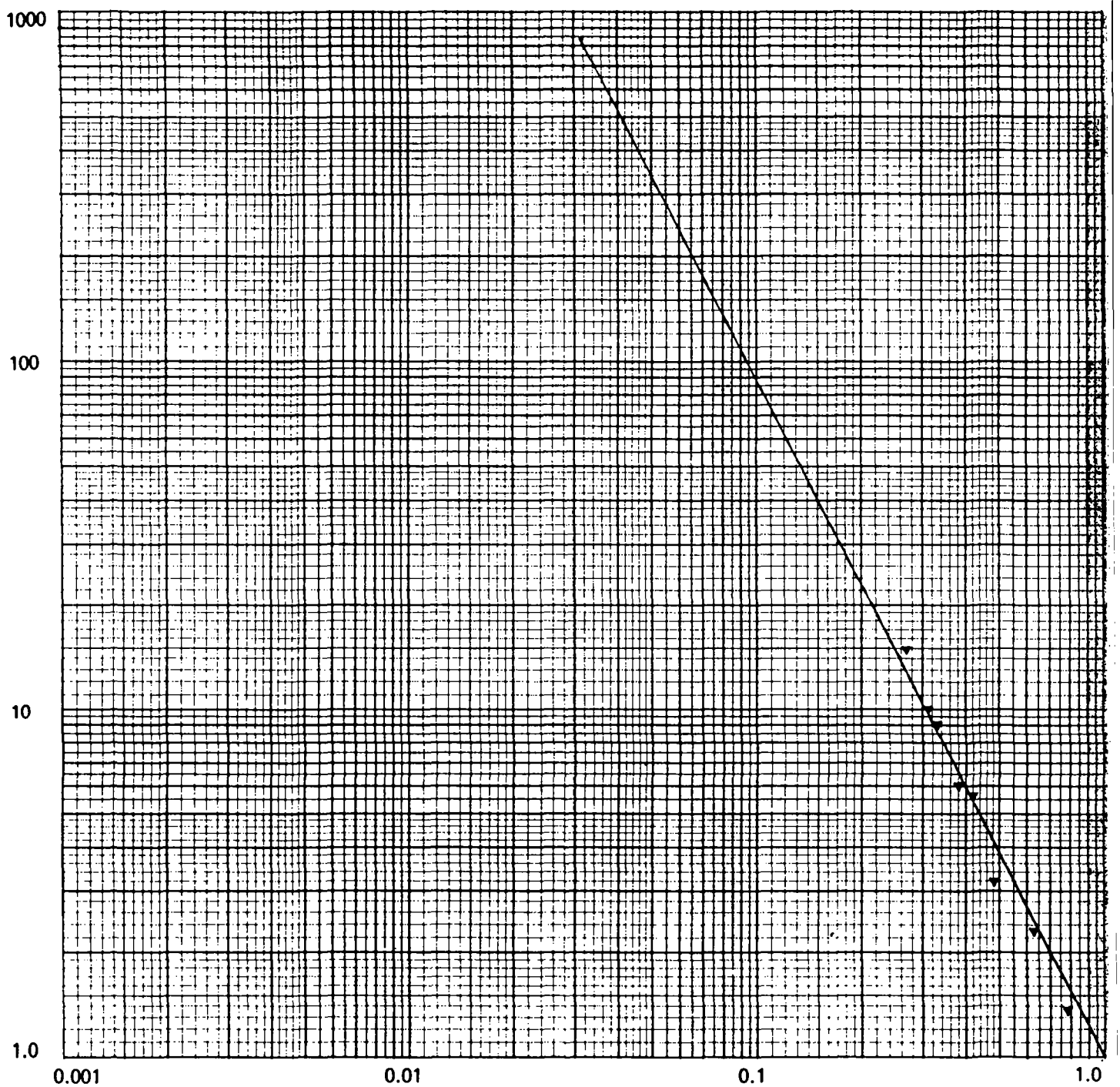
GECO
GEOPHYSICAL COMPANY OF NORWAY A-S

Company . . STATOIL . A/S . . . . . .

Well . . 15/9-11 . . . . . Kair . . 263 . . . . . .

Sample No. . 85 . . . . . ø . . 24.6 . . . . . .

Depth. . 2436.00 . . . . . Gr. Dens. . . . . $RI = 1.00 * S_w^{-1.94}$



Water Saturation, Fraction of Pore Space.
"S_w"

Resitivity index versus water Saturation

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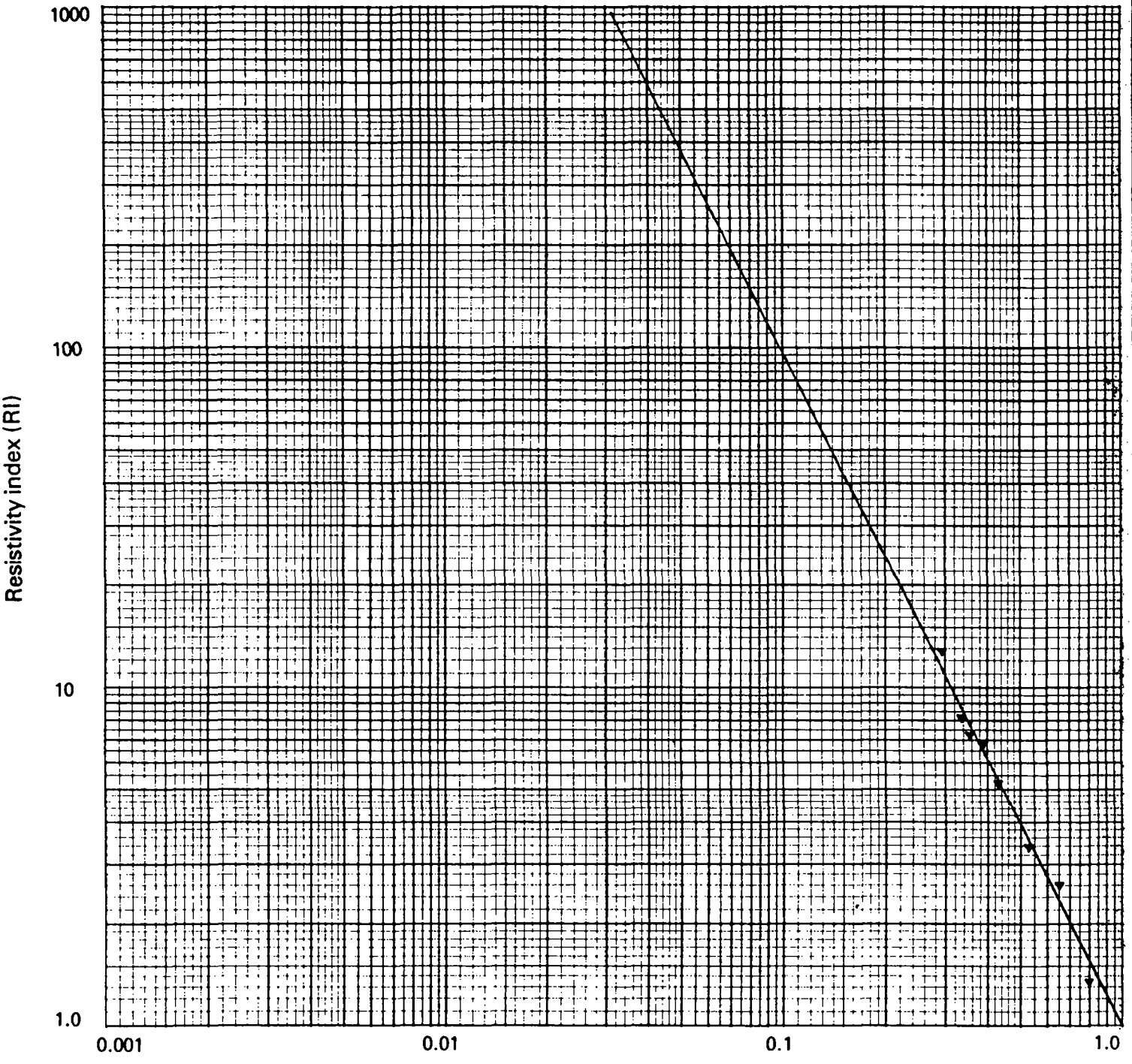
GEOPHYSICAL COMPANY OF NORWAY A/S

Company . . STATOIL . A/S . . . . . .

Well . . 15/9-11 . . . . . Kair . . 171 . . . . . .

Sample No. . 92 . . . . . ø . . 24.4 . . . . . .

Depth. . 2438.32 . . . . . Gr. Dens. . . . . $RI = 1.00 * S_w^{-1.98}$



Water Saturation, Fraction of Pore Space.
"S_w"

Resitivity index versus water Saturation

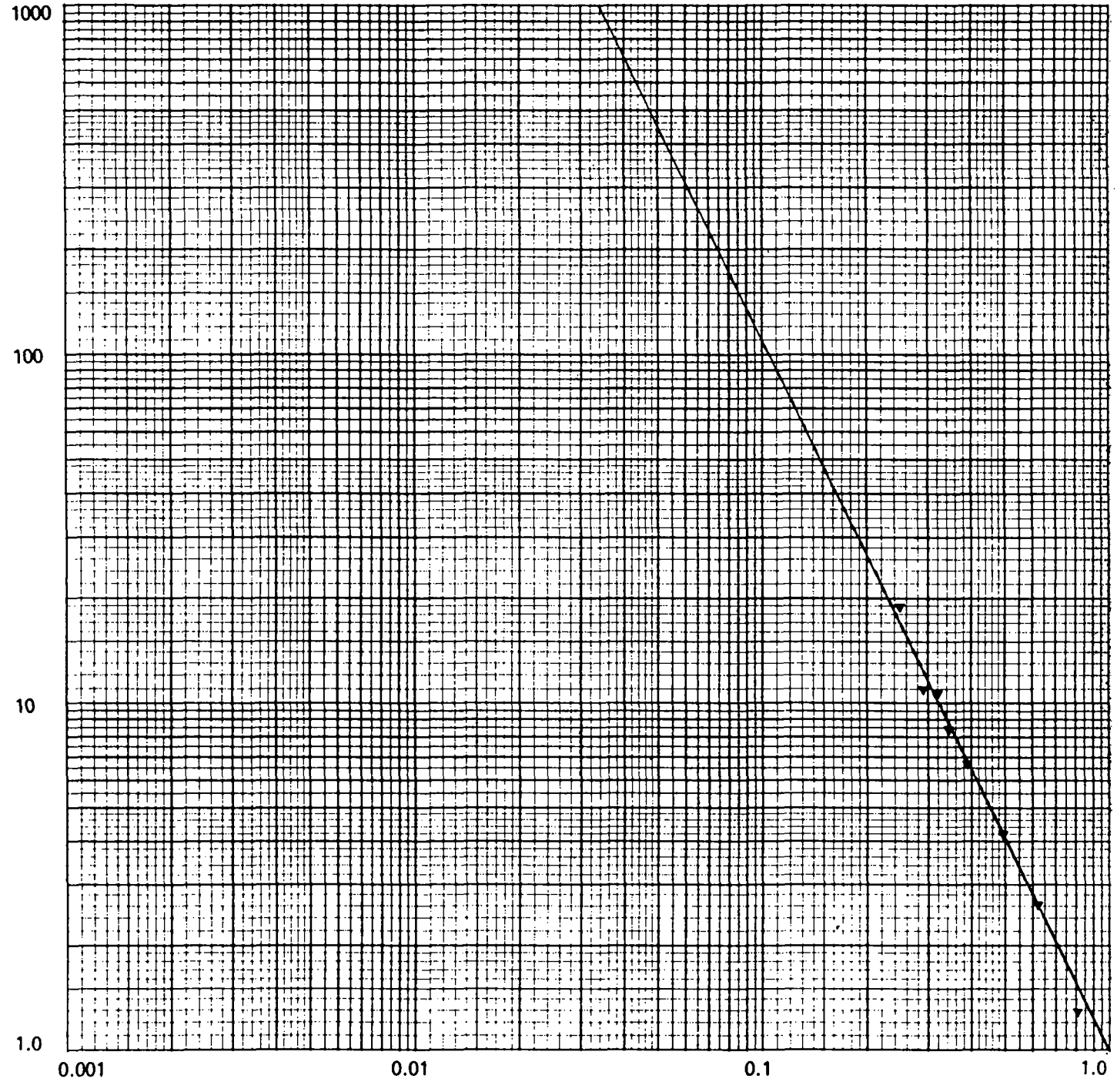
GECO
GEOPHYSICAL COMPANY OF NORWAY A/S

Company..STATOIL.A/S.....

Well..15/9-11..... Kair..445.....

Sample No..99..... ø..25.2.....

Depth..2440.67..... Gr. Dens..... $RI = 1.00 * S_w^{-2.84}$



Water Saturation, Fraction of Pore Space.
"S_w"

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Log K.e.1 versus Sw at 12 bar

Sample no.	Sw (fraction)	K.e.1 (md)	Log K.e.1
82	0.429	95.6	1.98
83	0.389	140	2.15
85	0.267	263	2.42
92	0.291	171	2.23
99	0.248	445	2.65

By least squares method

$Sw = 0.968 - 0.282 \log K.e.1$

PERMEABILITY VERSUS WATER SATURATION AT 12 BAR

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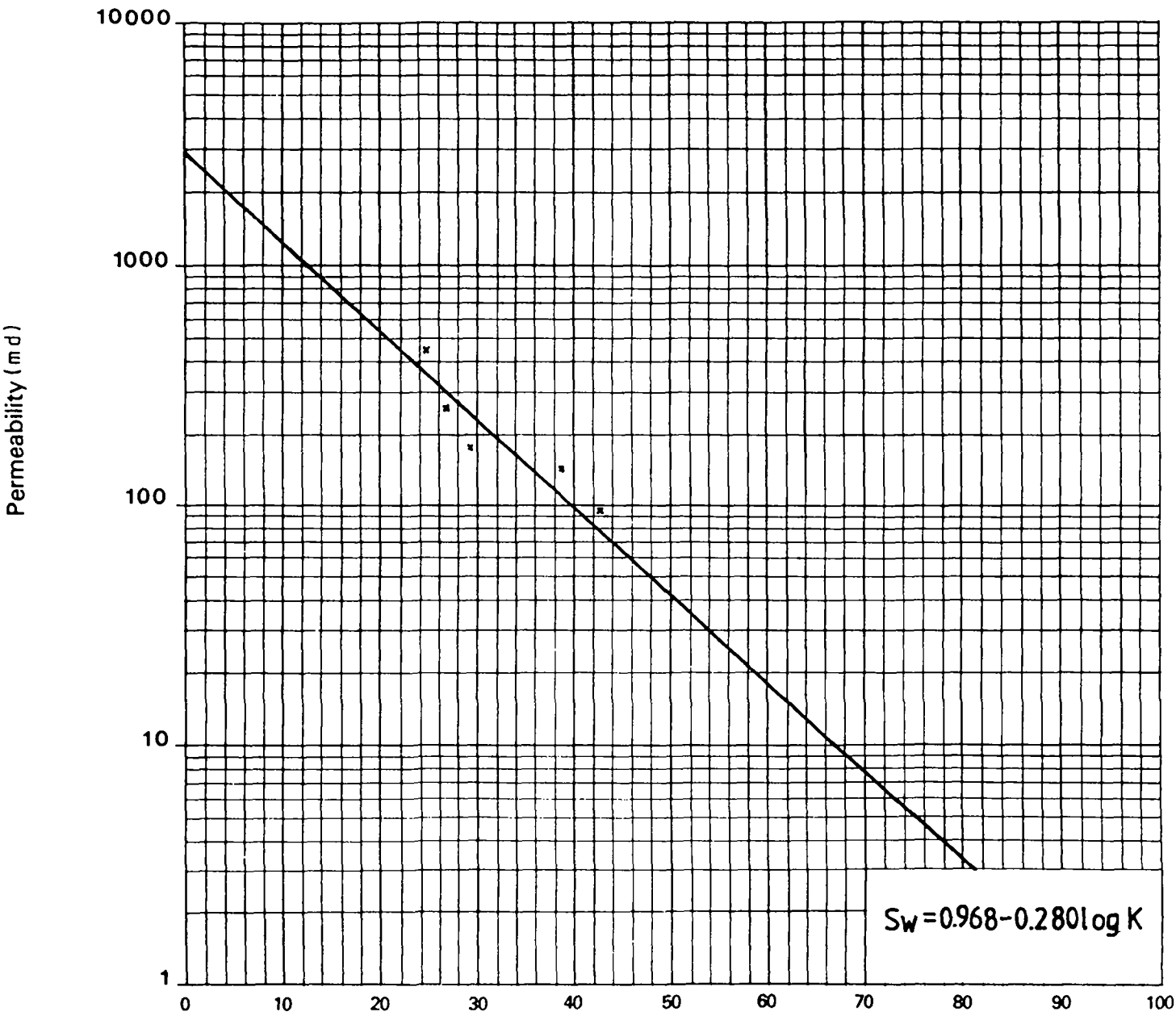
Company .STATOIL A/S.....

Well .....15/9-11.....



Water Saturation, Per Cent Pore Space.