



PHILLIPS PETROLEUM COMPANY NORWAY A/S

SPECIAL CORE ANALYSIS

WELL: 7/11-7

DATE: OCTOBER 1983

7



From the desk of

Date _____

M.A. ROGERS

To: Note all depths
should have 15' added
- to get real depth



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COMMENTS

GENERAL: Special core analyses were requested by Phillips on 16 plug samples from well 7/11-7. The samples were cylindrical plugs of $1 \frac{1}{2}$ inch diameter. The samples were very well consolidated sandstone.

PREPARATION: The plugs were cut to lengths of approximately seven cm. They were cleaned by extraction using first methanol, then toluene and finally with methanol. Prior to the analyses, the plugs were dried at 140°F and 40% relative humidity under controlled conditions.

MEASUREMENTS: POROSITY AND GRAIN DENSITY

Grain volume was measured by Boyles law porosimeter using helium. Bulk volume was obtained by mercury displacement. Knowing also the weight of the sample, porosity and grain density were calculated on 16 samples.

AIR PERMEABILITY

The same 16 samples were installed in a Hassler holder for air permeability measurements. The sleeve pressure used was 220 psig. Air permeability was measured using N₂ gas at three different pressures. These values were the basis for calculating the Klinkenberg corrected permeability. Both tabular and graphic compilations of data have been enclosed in this report.



FORMATION RESISTIVITY FACTOR

The samples were saturated as near as possible to 100% with the requested formation water. Formation resistivity factor was then measured using a frequency of 1 kHz. The parameters "a" and "m" in Archies formula were calculated both by least squares method forced through (FF=1.0, ϕ =1.0) and least squares method with free fit.

Archies formula $FF = \frac{r_o}{r_w} = a \cdot \phi^{-m}$

r_o = resistivity of sample (100% saturated)

r_w = resistivity of saturating formation water

a = FF-value at fractional porosity of 1.0

ϕ = fractional porosity

m = cementation factor

The data sets and the calculated values are presented in tabular and graphical form.



CAPILLARY PRESSURE (AIR/WATER) - RESISTIVITY INDEX

The sixteen water saturated samples were subsequently placed in a porous plate cell and desaturated by water saturated air at seven different pressure levels up to 180 psig. The pressures were 1.5, 3.0, 8.0, 15.0, 30.0, 60.0 and 180 psig.

Stability time at each pressure level varied from four to five days. The different water saturations were determined by the weight of the sample.

At each pressure step the resistivity index was measured using a frequency of 1 kHz. The resistivity index equation has been evaluated by least squares method forced through (RI=1.0, $S_w=1.0$).

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

b = intercept $S_w = 1$

S_w = water saturation in fraction of pore space

n = saturation exponent

The forced fit curve is presented graphically.

Irreducible water saturation (S_{wi}) and saturation exponents have been compiled in a separate table with porosity and permeability data. In addition, the general straight line equation $S_{wi} = a \cdot \log k.e.l. + C$ has been evaluated using least squares method. A plot of Klinkenberg permeability versus S_{wi} follows the above mentioned table.



CONFINING PRESSURE MEASUREMENTS

While installed in triaxial cells, all sixteen samples were measured for confining pressure data. Net overburden pressure was set in the laboratory without Geertsma-factor correction. Porosity and formation resistivity factor were measured simultaneously at increasing pressure levels and two different temperatures. The confining pressure levels were as follows: 200, 1000 and 3000 psig.

a) Porosity

In these measurements it has been assumed that the sample porosities were preserved at 200 psig. confining pressure ("atmospheric" condition). Pore pressure was kept at one atmosphere.

A graduated pipette (vol. 1.0 ml, grad. 0.01 ml) was used to measure pore volume reduction when increasing the confining pressure at lab. temperature and to note when stability in the sample occurred. We have also assumed that pore volume variations with temperature is negligible.

b) Formation Resistivity Factor (FF)

The formation resistivity factor was measured using a frequency of 1 kHz. A platinum screen was placed at each end of the plug to ensure good electrical contact over the end of the plug. The parameters "a" and "m" in Archie's formula $FF = a \cdot \phi^{-m}$ were calculated both by least squares method forced through ($FF = 1.0$, $\phi = 1.0$) and least squares method (free fit). The forced fit curve is presented graphically.



FLUID PROPERTIES

FORMATION WATER

The formation water was made from chlorides of Na, Mg, Ca and K according to this list:

| | | | |
|---------------------|---|---------|-------------------|
| Na ⁺ | : | 33 200 | mg/l |
| K ⁺ | : | 18 300 | mg/l |
| Ca ²⁺ | : | 26 150 | mg/l |
| Mg ²⁺ | : | 2 500 | mg/l |
| Cl ⁻ | : | 123 140 | mg/l |
| Resistivity (180°F) | : | 0.023 | ohm.m. |
| Resistivity (68 °F) | : | 0.053 | ohm.m. |
| Density (68 °F) | : | 1.140 | g/cm ³ |

NITROGEN GAS

| | | | |
|-------------------|---|--------|----|
| Viscosity (68 °F) | : | 0.0176 | cP |
|-------------------|---|--------|----|



PLUG SIZE

| Sample no. | Depth (ft.) | Length (cm) | Diameter (cm) |
|------------|-------------|-------------|---------------|
| 4 | 14928 | 7.06 | 3.75 |
| 12 | 14938 | 7.01 | 3.75 |
| 18 | 14944 | 7.05 | 3.75 |
| 80 | 14963 | 7.05 | 3.77 |
| 32 | 14991 | 7.07 | 3.77 |
| 123 | 14974 5" | 6.92 | 3.77 |
| 130 | 14983 9" | 6.93 | 3.77 |
| 85 | 15015 | 7.06 | 3.76 |
| 103 | 15034 | 6.95 | 3.76 |
| 116 | 15049 | 6.90 | 3.76 |
| 41 | 15058 | 6.95 | 3.77 |
| 53 | 15072 | 7.05 | 3.76 |
| 76 | 15100 | 7.03 | 3.77 |
| 141 | 15110 | 7.08 | 3.76 |
| 151 | 15121 | 7.05 | 3.78 |
| 173 | 15146 | 6.89 | 3.77 |

POROSITY AND GRAIN DENSITY

| Sample no. | Depth (ft.) | Porosity (%) | Grain Density(g/cm ³) |
|------------|-------------|--------------|-----------------------------------|
| 4 | 14928 | 16.9 | 2.59 |
| 12 | 14938 | 15.4 | 2.66 |
| 18 | 14944 | 9.31 | 2.73 |
| 80 | 14963 | 7.76 | 2.62 |
| 32 | 14991 | 6.21 | 2.66 |
| 123 | 14974 5" | 6.35 | 2.69 |
| 130 | 14983 9" | 7.65 | 2.67 |
| 85 | 15015 | 5.48 | 2.64 |
| 103 | 15034 | 13.0 | 2.65 |
| 116 | 15049 | 9.25 | 2.69 |
| 41 | 15058 | 9.26 | 2.67 |
| 53 | 15072 | 13.1 | 2.66 |
| 76 | 15100 | 16.5 | 2.63 |
| 141 | 15110 | 5.99 | 2.75 |
| 151 | 15121 | 15.2 | 2.64 |
| 173 | 15146 | 10.7 | 2.68 |



KLINKENBERG CORRECTED AIR PERMEABILITY

| Sample no. | Depth (ft.) | (Mean pressure) ⁻¹ (atm.abs.) ⁻¹ | Air permeability k _a (mD) | Klinkenberg corr. permeability k.e.l.(mD) |
|------------|----------------|---|---|---|
| 4 | 14928 | 0.656 | 17.1 | 14.8 |
| | | 0.521 | 16.7 | |
| | | 0.415 | 16.2 | |
| 12 | 14938 | 0.484 | 1.59 | 0.864 |
| | | 0.406 | 1.45 | |
| | | 0.339 | 1.37 | |
| 18 | 14944 | 0.485 | 0.099 | 0.064 |
| | | 0.407 | 0.094 | |
| | | 0.339 | 0.089 | |
| 80 | 14963 | 0.492 | 0.449 | 0.356 |
| | | 0.412 | 0.436 | |
| | | 0.343 | 0.420 | |
| 32 | 14991 | 0.484 | 0.054 | 0.044 |
| | | 0.407 | 0.052 | |
| | | 0.339 | 0.051 | |
| 123 | 14974 5" | 0.493 | 0.010 | 0.003 |
| | | 0.413 | 0.009 | |
| | | 0.343 | 0.008 | |
| 130 | 14983 9" | 0.496 | 0.027 | 0.019 |
| | | 0.415 | 0.025 | |
| | | 0.344 | 0.024 | |
| 85 | 15015 | 0.484 | 0.025 | 0.017 |
| | | 0.407 | 0.024 | |
| | | 0.339 | 0.023 | |



KLINKENBERG CORRECTED AIR PERMEABILITY

| Sample no. | Depth (ft.) | (Mean pressure) ⁻¹ (atm.abs.) ⁻¹ | Air permeability k _a (mD) | Klinkenberg corr. permeability k.e.l.(mD) |
|------------|----------------|---|---|---|
| 103 | 15034 | 0.492 | 0.396 | 0.304 |
| | | 0.412 | 0.382 | |
| | | 0.342 | 0.368 | |
| 116 | 15049 | 0.491 | 0.018 | 0.011 |
| | | 0.411 | 0.017 | |
| | | 0.342 | 0.016 | |
| 41 | 15058 | 0.485 | 0.019 | 0.015 |
| | | 0.407 | 0.018 | |
| | | 0.339 | 0.018 | |
| 53 | 15072 | 0.484 | 0.263 | 0.182 |
| | | 0.407 | 0.250 | |
| | | 0.339 | 0.239 | |
| 76 | 15100 | 0.673 | 18.4 | 14.5 |
| | | 0.531 | 17.7 | |
| | | 0.421 | 17.0 | |
| 141 | 15110 | 0.484 | 0.046 | 0.035 |
| | | 0.406 | 0.045 | |
| | | 0.339 | 0.043 | |
| 151 | 15121 | 0.485 | 2.92 | 1.95 |
| | | 0.407 | 2.76 | |
| | | 0.339 | 2.63 | |
| 173 | 15146 | 0.484 | 0.054 | 0.036 |
| | | 0.406 | 0.051 | |
| | | 0.339 | 0.049 | |

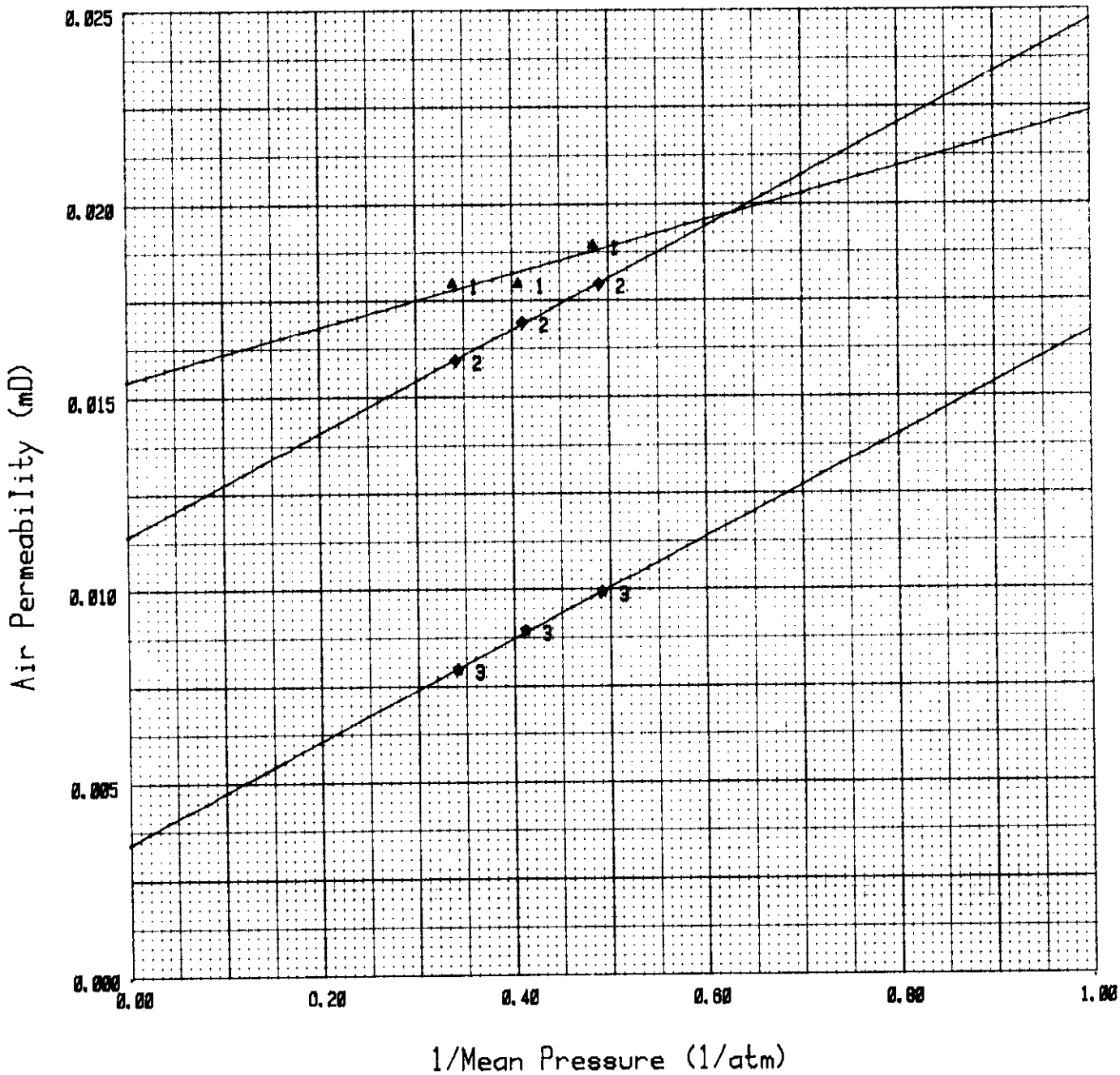
KLINKENBERG CORRECTED AIR PERMEABILITY



Curve no 1 : Sample no : 41
Depth : 15058 ft.
Klink. perm.: 0.015 mD

Curve no 2 : Sample no : 116
Depth : 15049 ft.
Klink. perm.: 0.011 mD

Curve no 3 : Sample no : 123
Depth : 14974 ft. 5 in.
Klink. perm.: 0.003 mD



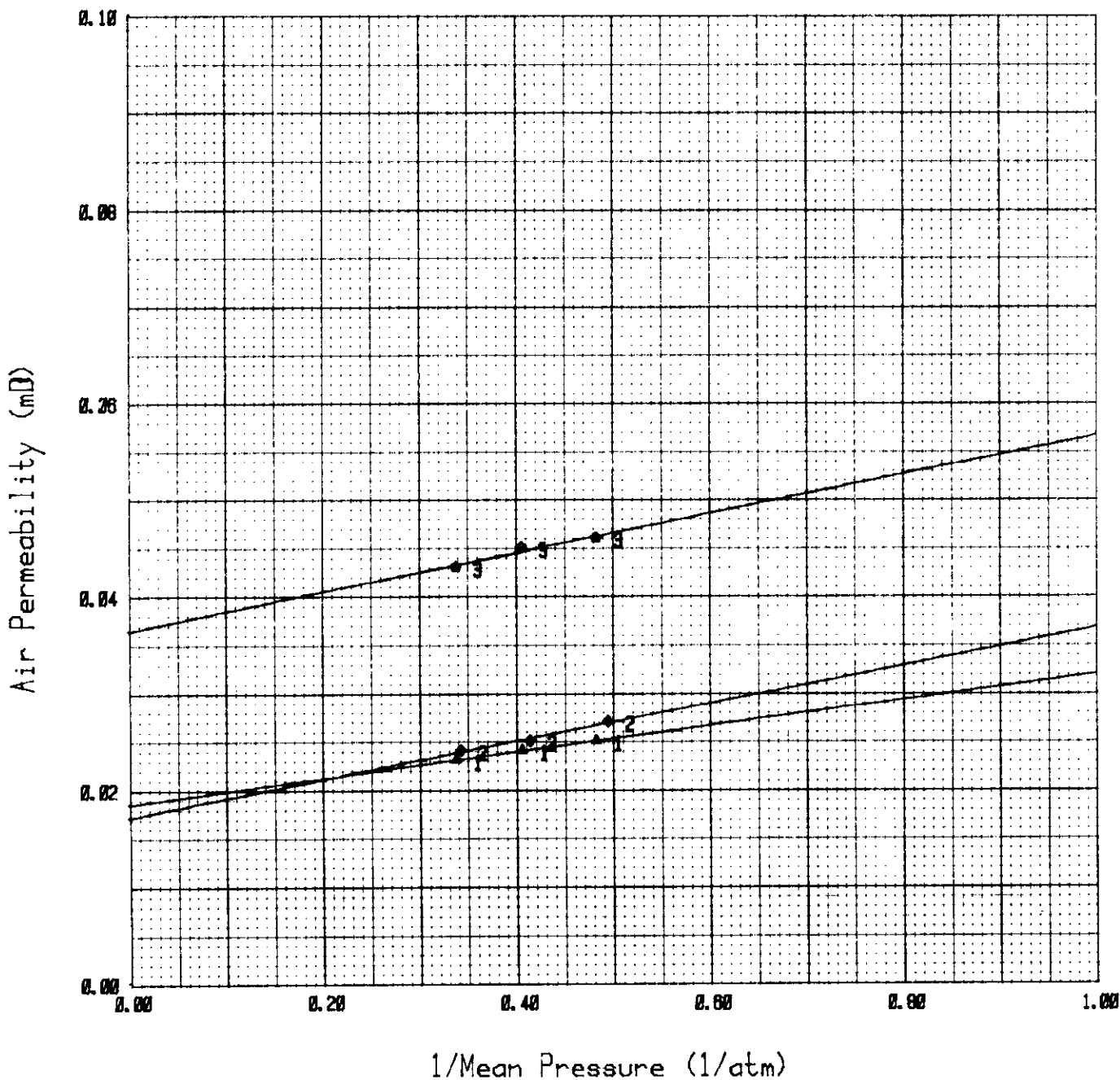
KLINKENBERG CORRECTED AIR PERMEABILITY



Curve no 1 : Sample no : 85
Depth : 15015 ft.
Klink. perm.: 0.017 mD

Curve no 2 : Sample no : 130
Depth : 14983 ft. 9 in.
Klink. perm.: 0.019 mD

Curve no 3 : Sample no : 141
Depth : 15110 ft.
Klink. perm.: 0.035 mD



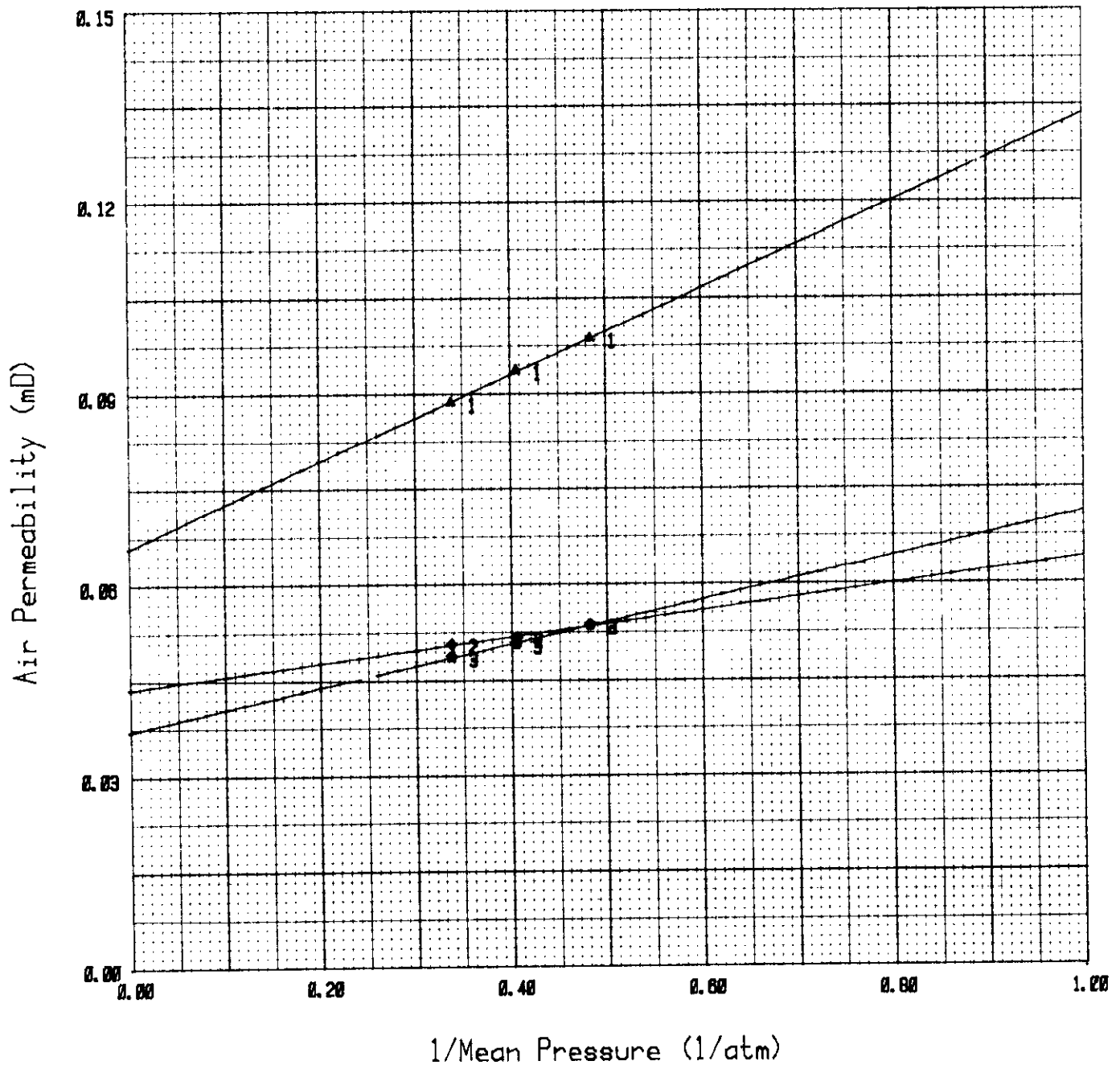
KLINKENBERG CORRECTED AIR PERMEABILITY



Curve no 1 : Sample no : 18
Depth : 14944 ft.
Klink. perm.: 0.064 mD

Curve no 2 : Sample no : 32
Depth : 14991 ft.
Klink. perm.: 0.044 mD

Curve no 3 : Sample no : 173
Depth : 15146 ft.
Klink. perm.: 0.036 mD



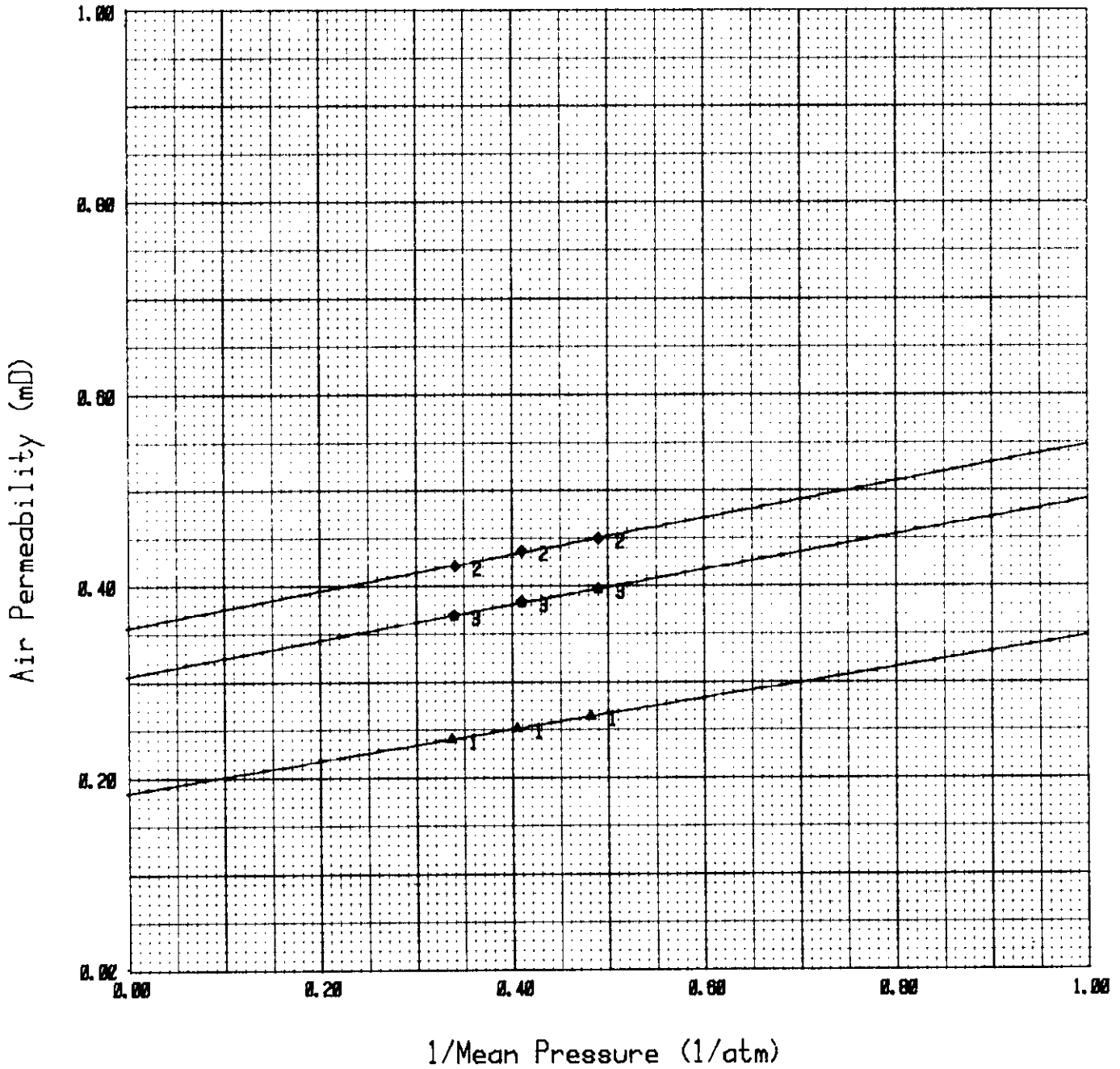
KLINKENBERG CORRECTED AIR PERMEABILITY



Curve no 1 : Sample no : 53
Depth : 15072 ft.
Klink. perm.: 0.182 mD

Curve no 2 : Sample no : 80
Depth : 14963 ft.
Klink. perm.: 0.356 mD

Curve no 3 : Sample no : 103
Depth : 15034 ft.
Klink. perm.: 0.304 mD



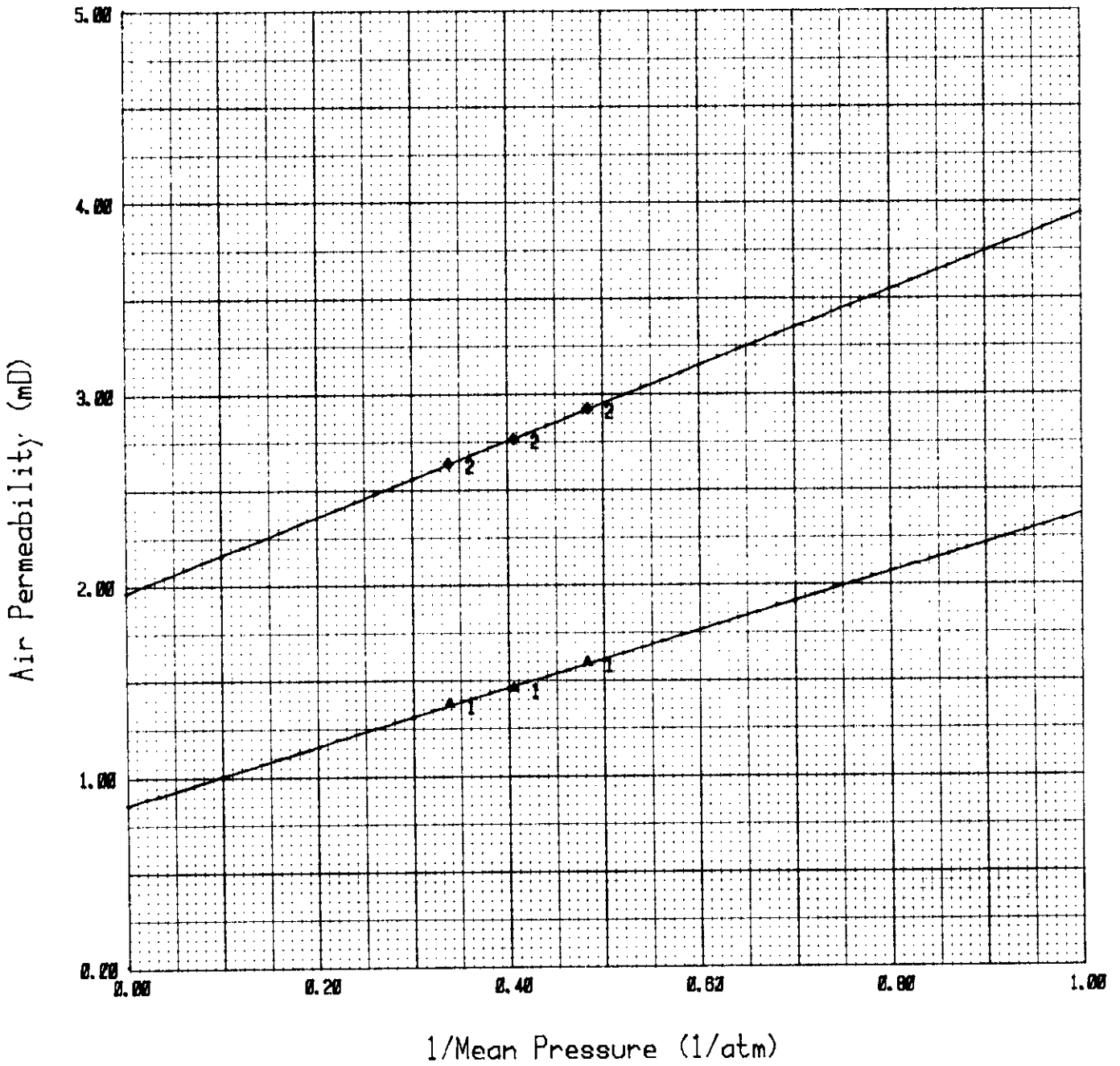
KLINKENBERG CORRECTED AIR PERMEABILITY



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Petroleum laboratory

Curve no 1 : Sample no : 12
Depth : 14938 ft.
Klink. perm.: 0.864 mD

Curve no 2 : Sample no : 151
Depth : 15121 ft.
Klink. perm.: 1.95 mD

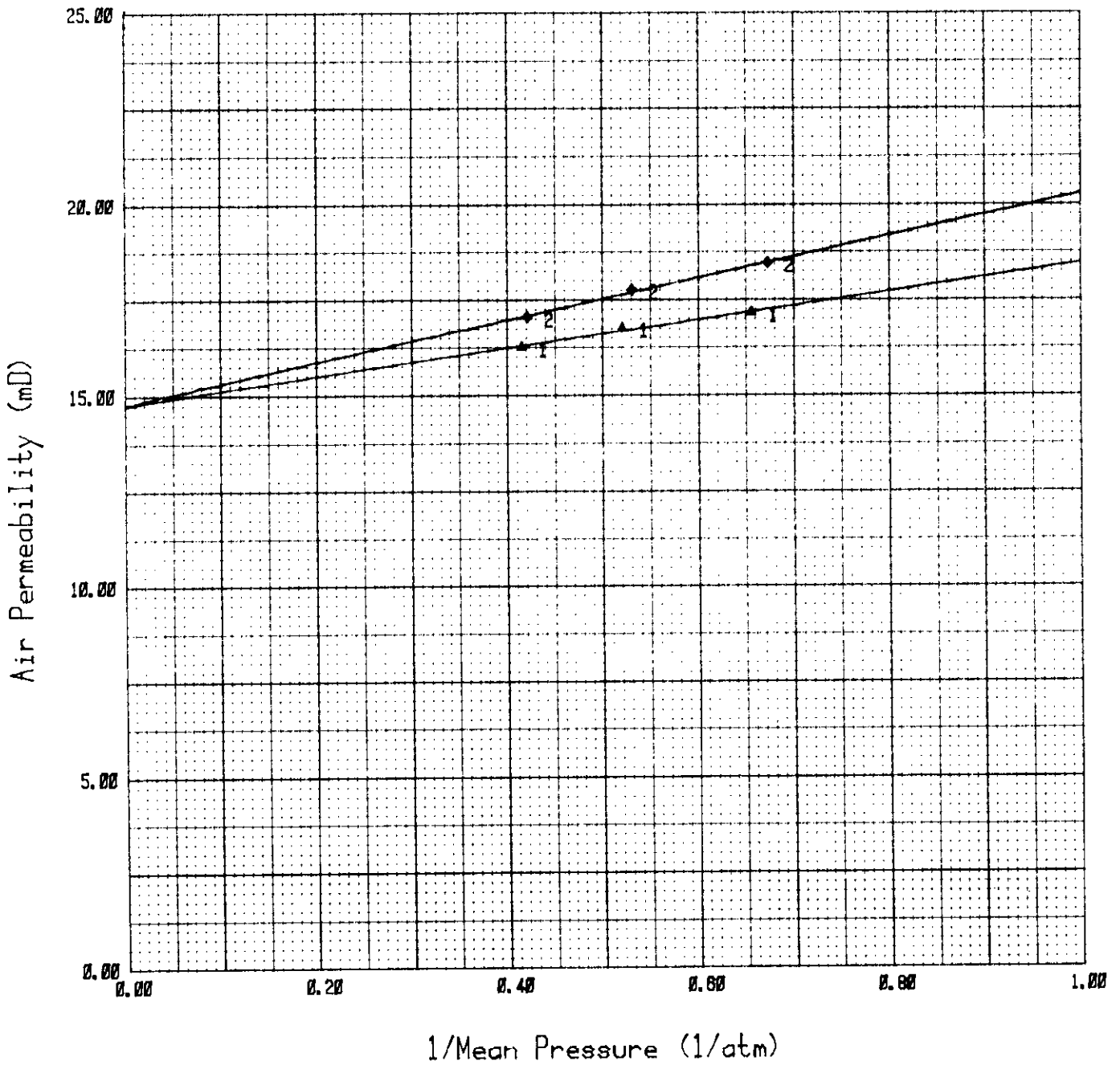


KLINKENBERG CORRECTED AIR PERMEABILITY



Curve no 1 : Sample no : 4
Depth : 14928 ft.
Klink. perm.: 14.8 mD

Curve no 2 : Sample no : 76
Depth : 15100 ft.
Klink. perm.: 14.5 mD

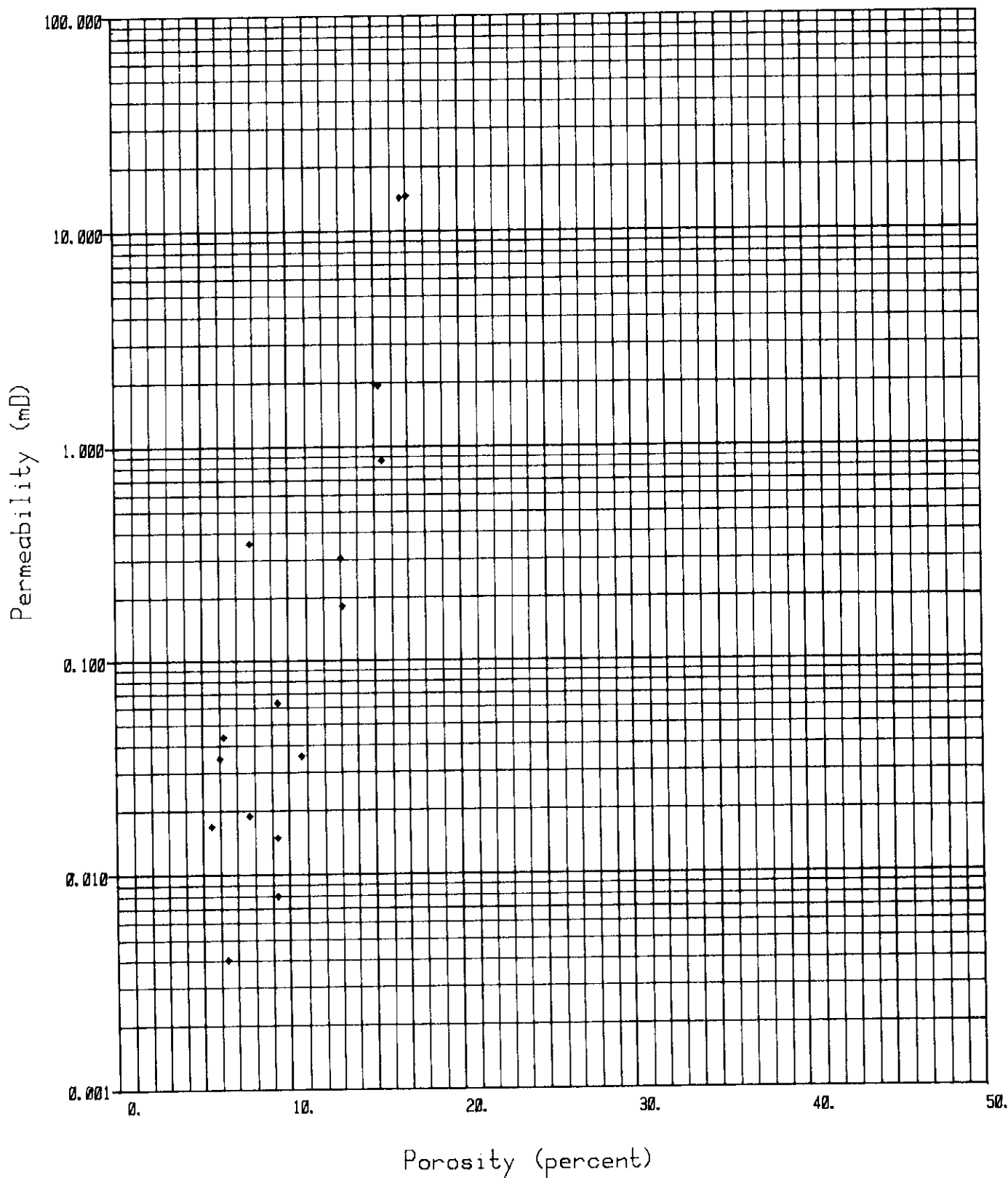




KLINKENBERG PERMEABILITY VS. POROSITY

Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7





FORMATION RESISTIVITY FACTOR / FRACTIONAL POROSITY

| Sample no. | Depth (ft.) | Plug resistivity Ω m (68°F) | FF | Frac. porosity |
|------------|-------------|---------------------------------------|------|-------------------|
| 4 | 14928 | 1.64 | 33.0 | 0.169 |
| 12 | 14938 | 1.68 | 34.0 | 0.154 |
| 18 | 14944 | 5.15 | 104 | 0.093 |
| 80 | 14963 | 4.45 | 89.7 | 0.078 |
| 32 | 14991 | 8.64 | 171 | 0.062 |
| 123 | 14974 5" | 7.17 | 142 | 0.064 |
| 130 | 14983 9" | 5.86 | 118 | 0.077 |
| 85 | 15015 | 10.7 | 217 | 0.055 |
| 103 | 15034 | 2.76 | 55.8 | 0.130 |
| 116 | 15049 | 5.45 | 108 | 0.093 |
| 41 | 15058 | 4.58 | 92.5 | 0.093 |
| 53 | 15072 | 3.32 | 67.0 | 0.131 |
| 76 | 15100 | 1.37 | 27.7 | 0.165 |
| 141 | 15110 | 8.86 | 178 | 0.060 |
| 151 | 15121 | 1.75 | 35.1 | 0.152 |
| 173 | 15146 | 4.46 | 89.9 | 0.107 |

Forced fit: $FF = \phi^{-1.89}$

Free fit : $FF = 1.81 \cdot \phi^{-1.64}$

FORMATION RESISTIVITY FACTOR VERSUS POROSITY

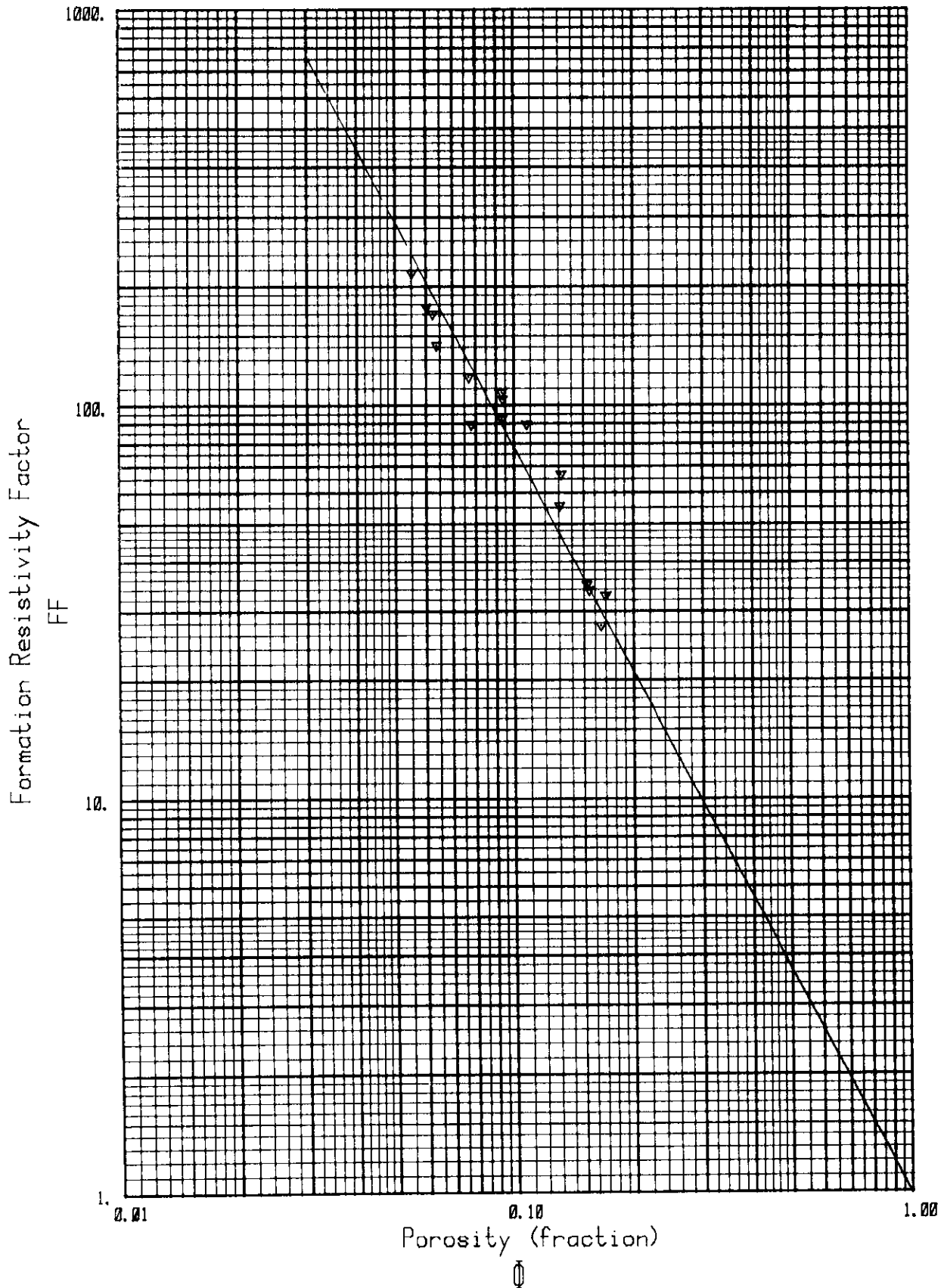


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

Atmospheric condition. Forced fit.

$$FF = 1.00 * \phi^{-1.89}$$



FORMATION RESISTIVITY FACTOR VERSUS POROSITY

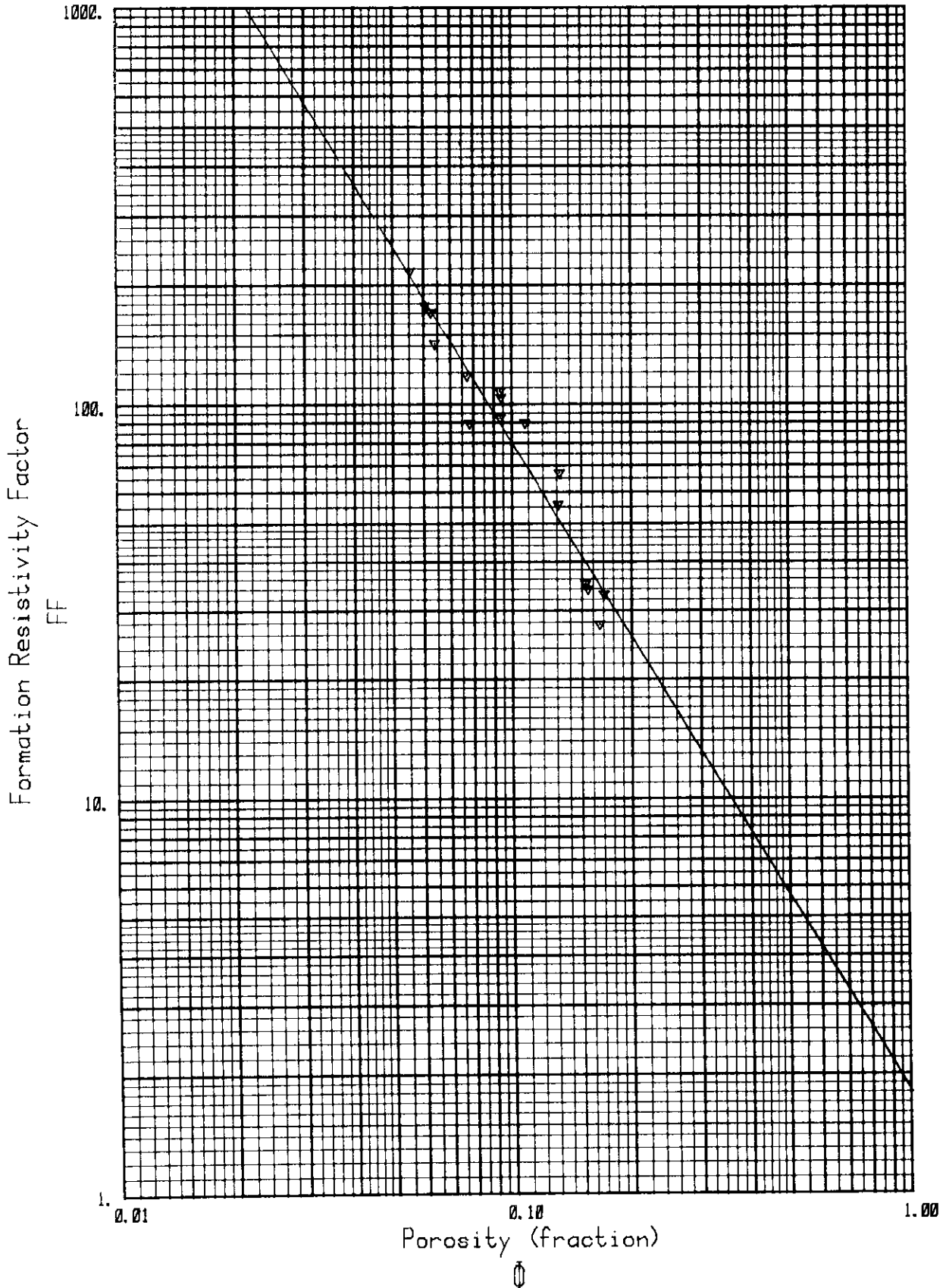


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

Atmospheric condition. Free fit.

$$FF = 1.81 * \phi^{-1.64}$$





CAPILLARY PRESSURE ~ RESISTIVITY INDEX

Sample no.: 4

Depth: 14928 ft.

Klink. perm.: 14.8 mD

Porosity: 16.9 %

Grain density: 2.59 g/cm³

FF= 33.0 (room conditions)

| Capillary pressure (psig.) | Water saturation S _w (frac.) | Resistivity index RI |
|-------------------------------|--|-------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.695 | 2.36 |
| 3.0 | 0.656 | 2.48 |
| 8.0 | 0.447 | 5.33 |
| 15.0 | 0.411 | 6.41 |
| 30.0 | 0.365 | 7.81 |
| 60.0 | 0.336 | 8.65 |
| 180.0 | 0.320 | 9.28 |

$$RI = S_w^{-2.03}$$

CAPILLARY PRESSURE (POROUS PLATE)

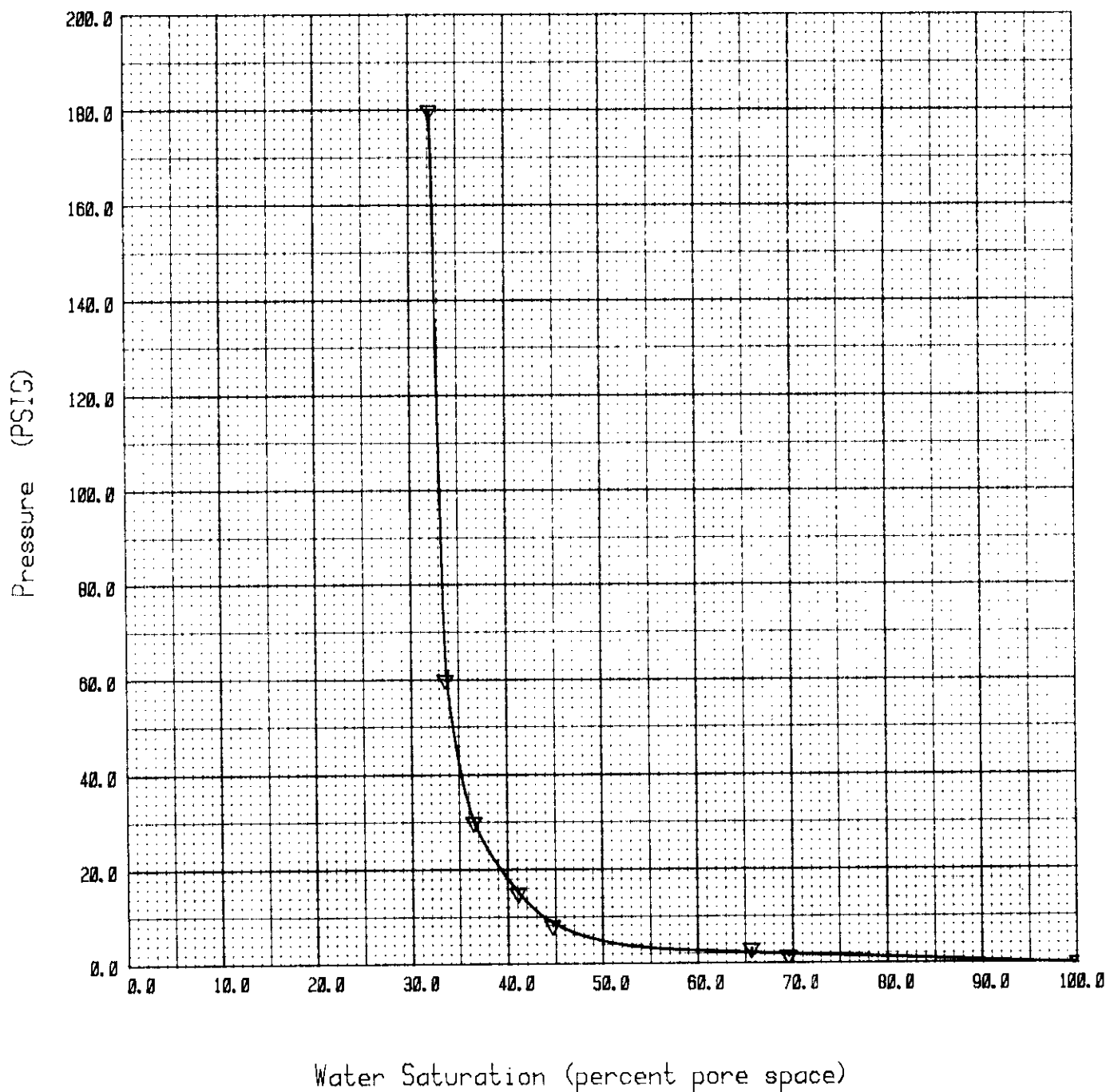


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7 Klink. perm.: 14.8 mD

Sample no : 4 Porosity : 16.9 %

Depth : 14928 ft. Grain dens. : 2.59 g/cm³



RESISTIVITY INDEX VS. WATER SATURATION



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Sample no: 4

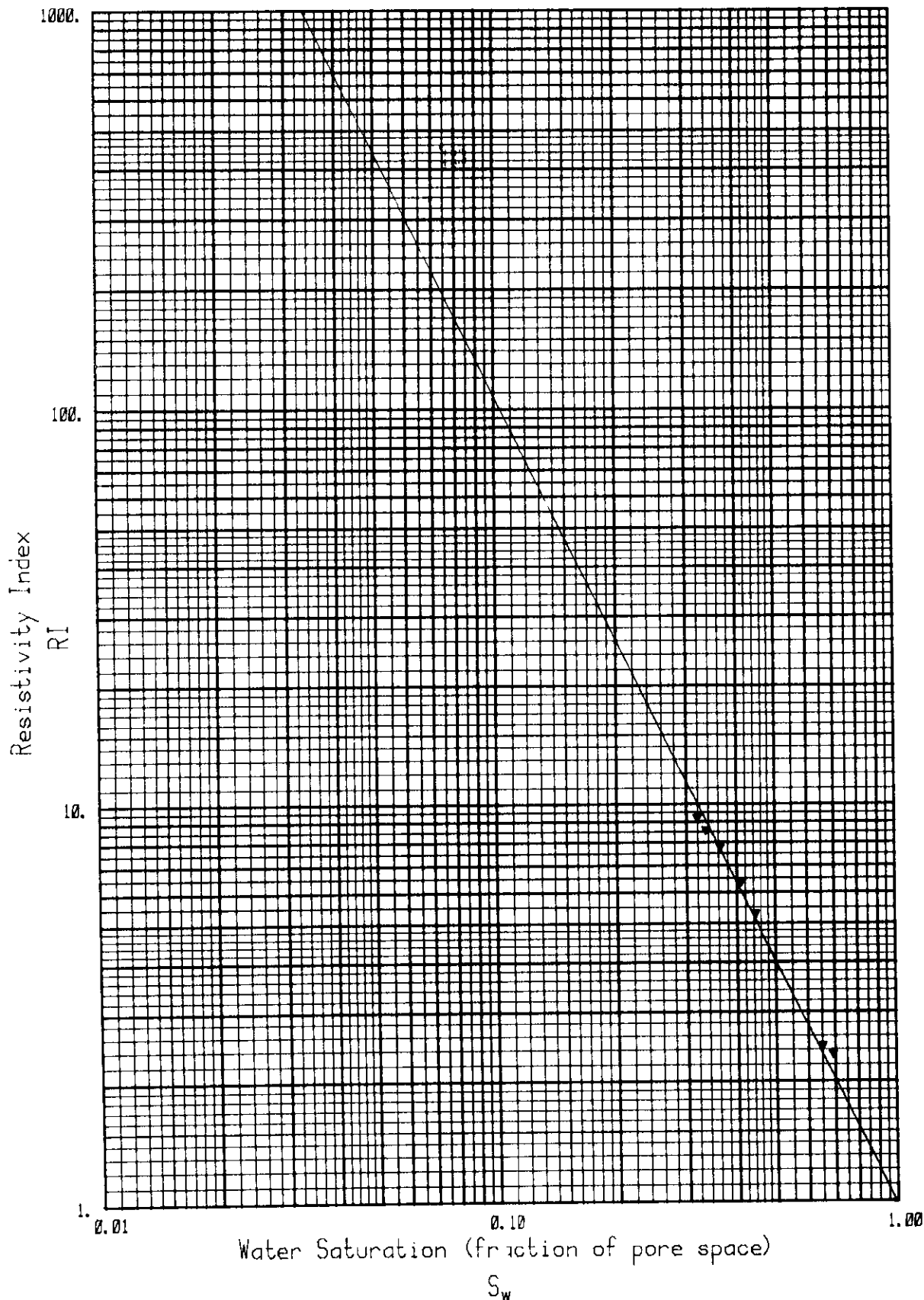
Klink. perm.: 14.8 mD

Depth : 14928 ft.

Porosity : 16.9 %

RI = 1.00 * $S_w^{-2.03}$

FF : 33.0





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 12

Depth: 14938 ft.

Klink. perm.: 0.864 mD

Porosity: 15.4 %

Grain density: 2.66 g/cm³

FF= 34.0 (room conditions)

| Capillary pressure (psig.) | Water saturation S _w (frac.) | Resistivity index RI |
|-------------------------------|--|-------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.971 | 1.04 |
| 3.0 | 0.962 | 1.08 |
| 8.0 | 0.890 | 1.24 |
| 15.0 | 0.798 | 1.51 |
| 30.0 | 0.679 | 1.88 |
| 60.0 | 0.658 | 2.11 |
| 180.0 | 0.640 | 2.20 |

$$RI = S_w^{-1.74}$$

CAPILLARY PRESSURE (POROUS PLATE)



Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

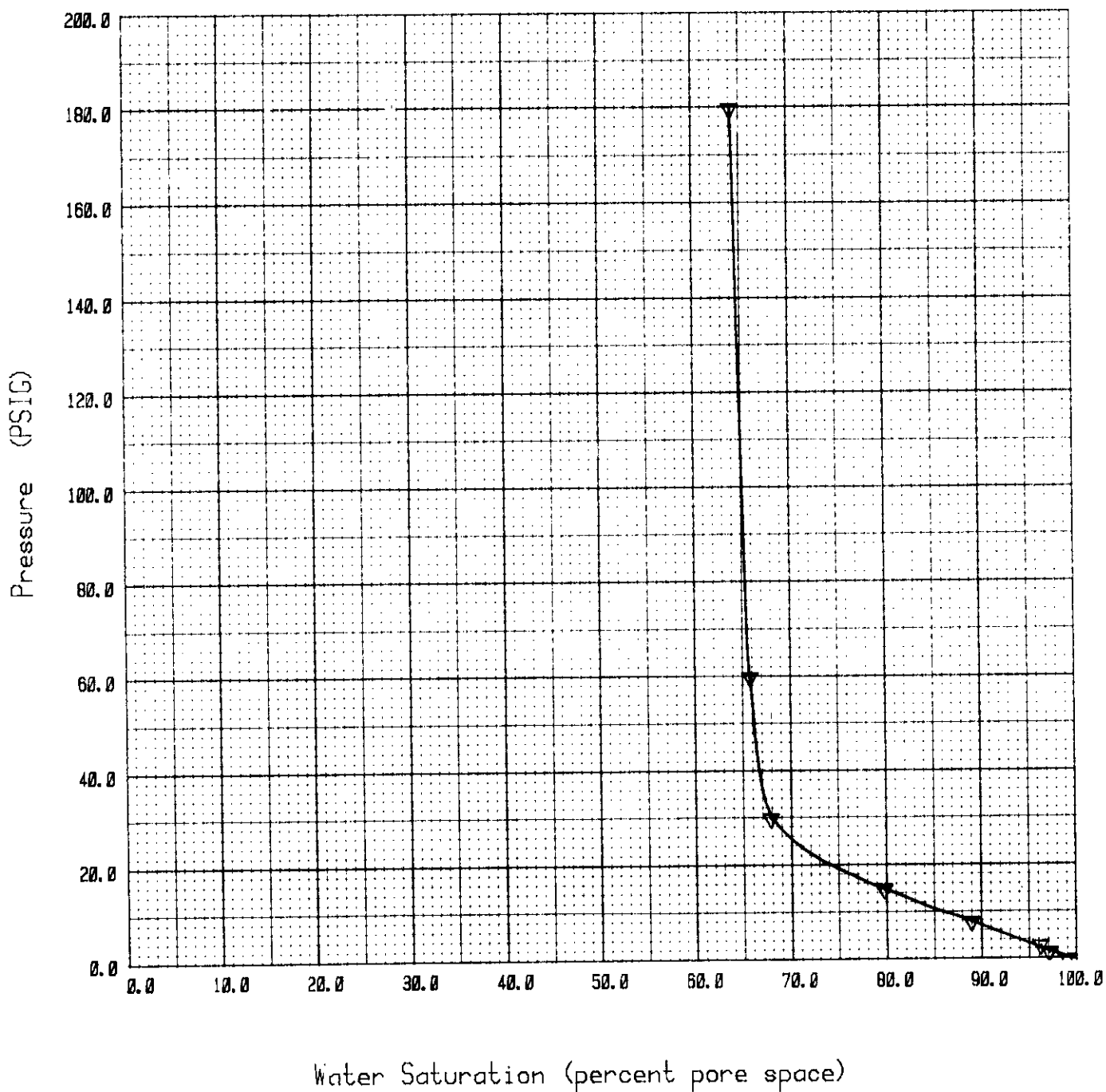
Klink. perm.: 0.864 mD

Sample no : 12

Porosity : 15.4 %

Depth : 14938 ft.

Grain dens. : 2.66 g/cm³



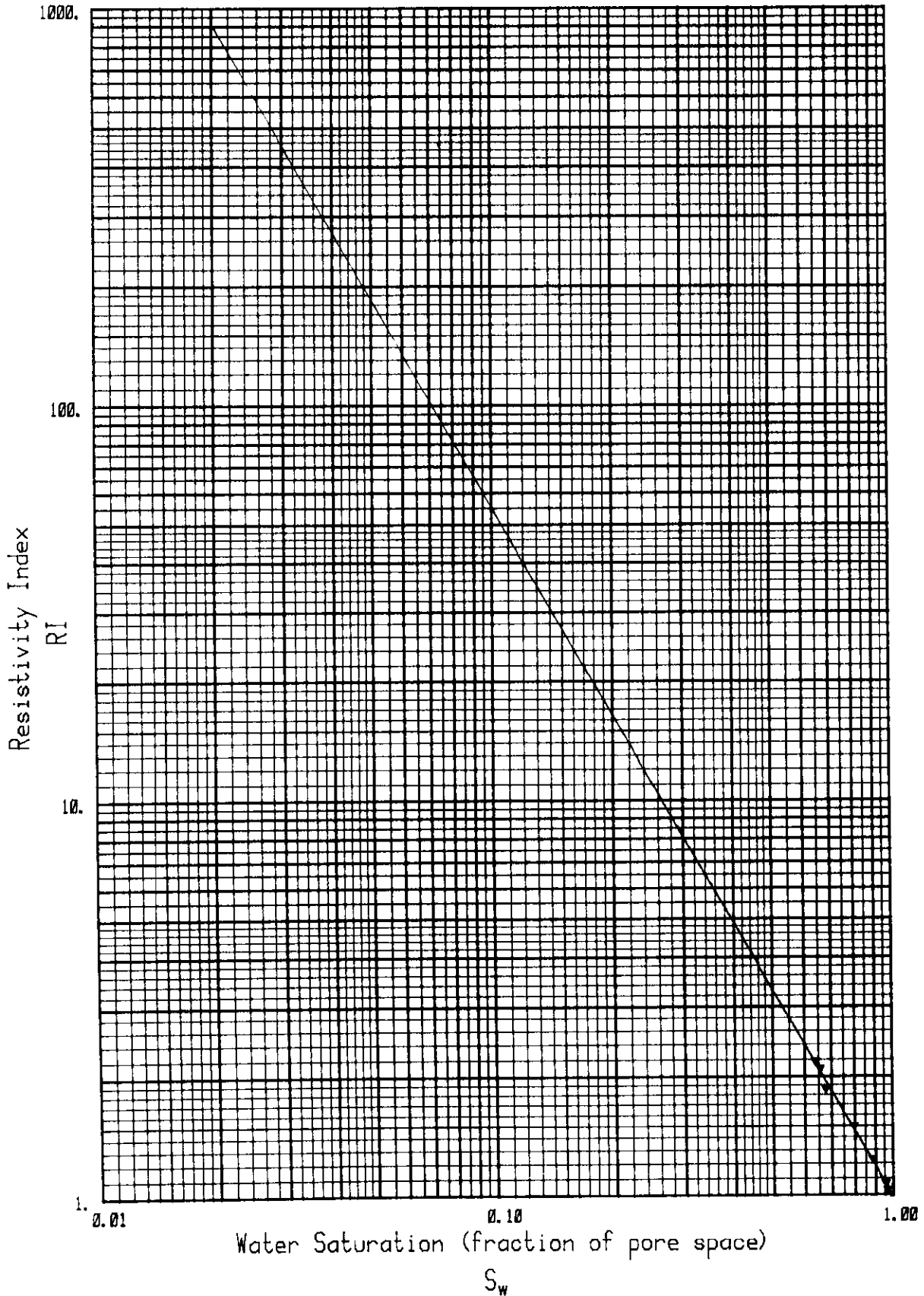
RESISTIVITY INDEX VS. WATER SATURATION



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OF NORWAY A.S.
Petroleum laboratory

Sample no: 12
Depth : 14938 ft.
 $RI = 1.00 * S_w^{-1.74}$

Klink. perm.: 0.864mD
Porosity : 15.4 %
FF : 34.0





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 18

Depth: 14944 ft.

Klink. perm.: 0.064 mD

Porosity: 9.31 %

Grain density: 2.73 g/cm³

FF= 104 (room conditions)

| Capillary pressure (psig.) | Water saturation S_w (frac.) | Resistivity index RI |
|-------------------------------|-----------------------------------|-------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.987 | 1.06 |
| 3.0 | 0.969 | 1.10 |
| 8.0 | 0.952 | 1.14 |
| 15.0 | 0.929 | 1.19 |
| 30.0 | 0.877 | 1.26 |
| 60.0 | 0.833 | 1.42 |
| 180.0 | 0.805 | 1.47 |

$$RI = S_w^{-1.88}$$

CAPILLARY PRESSURE (POROUS PLATE)



Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

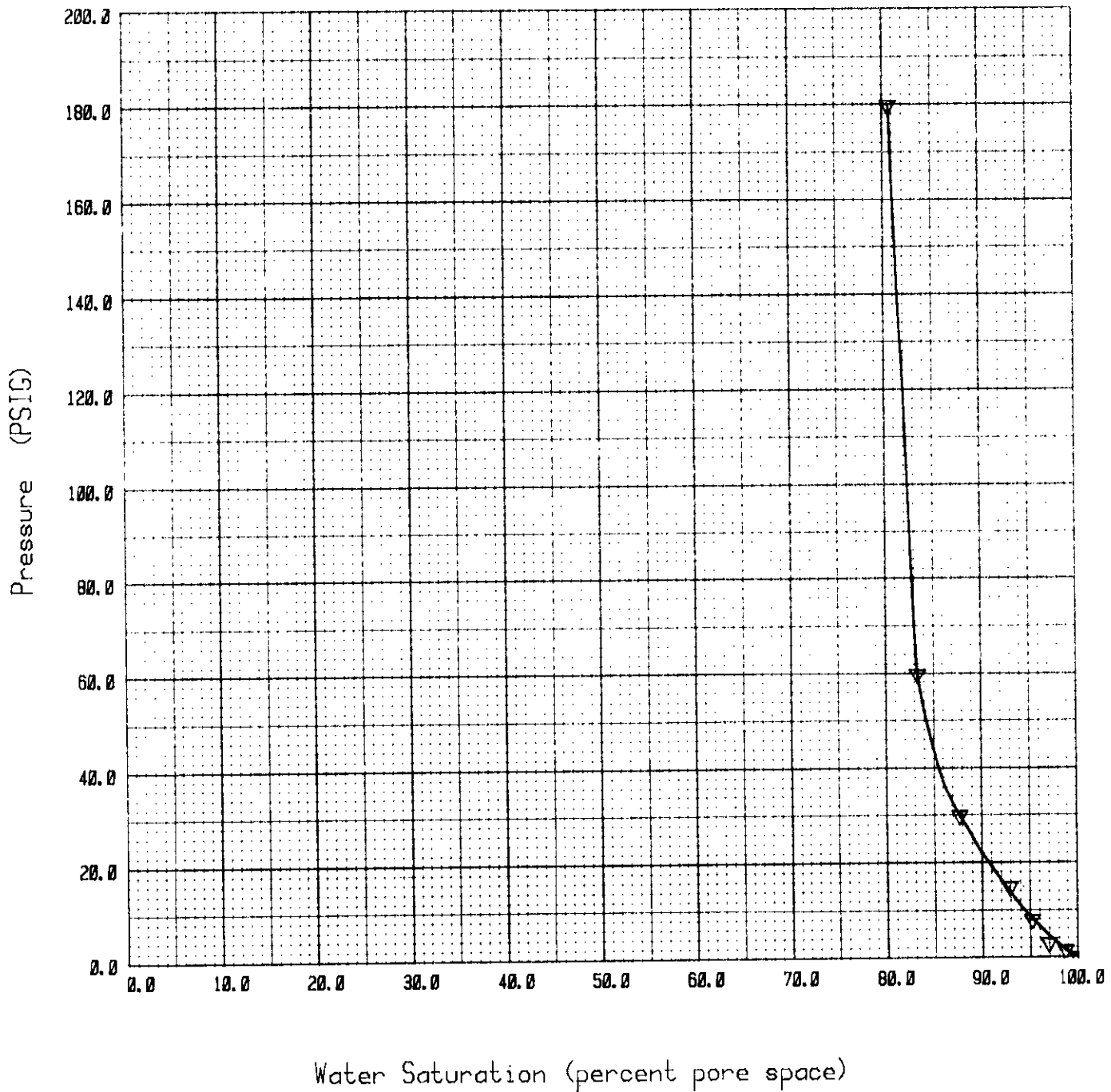
Klink. perm.: 0.064 mD

Sample no : 18

Porosity : 9.31 %

Depth : 14944 ft.

Grain dens. : 2.73 g/cm³

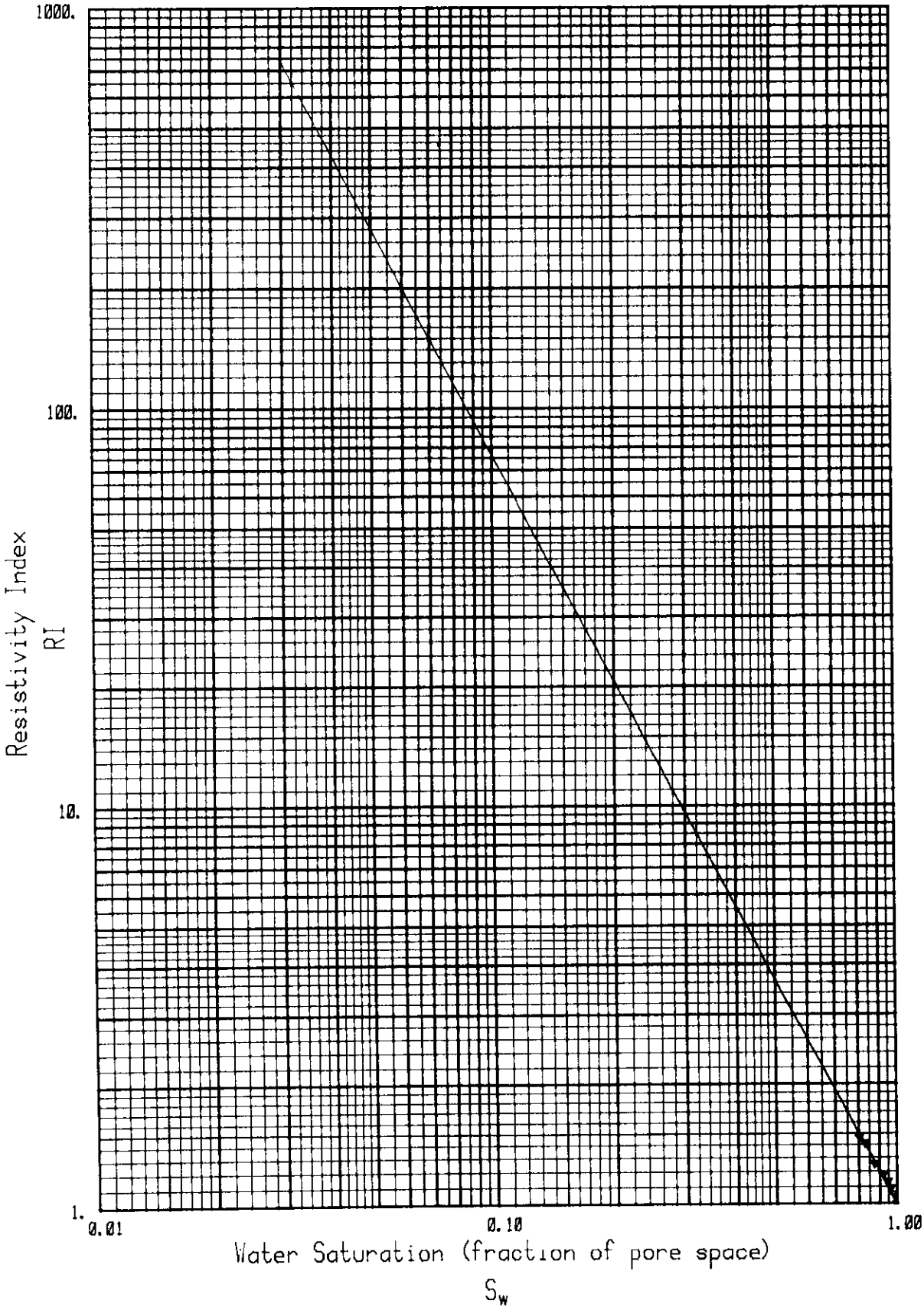


RESISTIVITY INDEX VS. WATER SATURATION



Sample no: 18
Depth : 14944 ft.
 $RI = 1.00 * S_w^{-1.68}$

Klink. perm.: 0.064mD
Porosity : 9.31 %
FF : 104





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 80

Depth: 14963 ft.

Klink. perm.: 0.356 mD

Porosity: 7.76 %

Grain density: 2.62 g/cm³

FF= 89.7 (room conditions)

| Capillary pressure (psig.) | Water saturation S _w (frac.) | Resistivity index RI |
|----------------------------------|---|----------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.983 | 1.12 |
| 3.0 | 0.974 | 1.14 |
| 8.0 | 0.965 | 1.21 |
| 15.0 | 0.937 | 1.23 |
| 30.0 | 0.698 | 2.07 |
| 60.0 | 0.654 | 2.35 |
| 180.0 | 0.629 | 2.37 |

$$RI = S_w^{-1.98}$$

CAPILLARY PRESSURE (POROUS PLATE)



Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

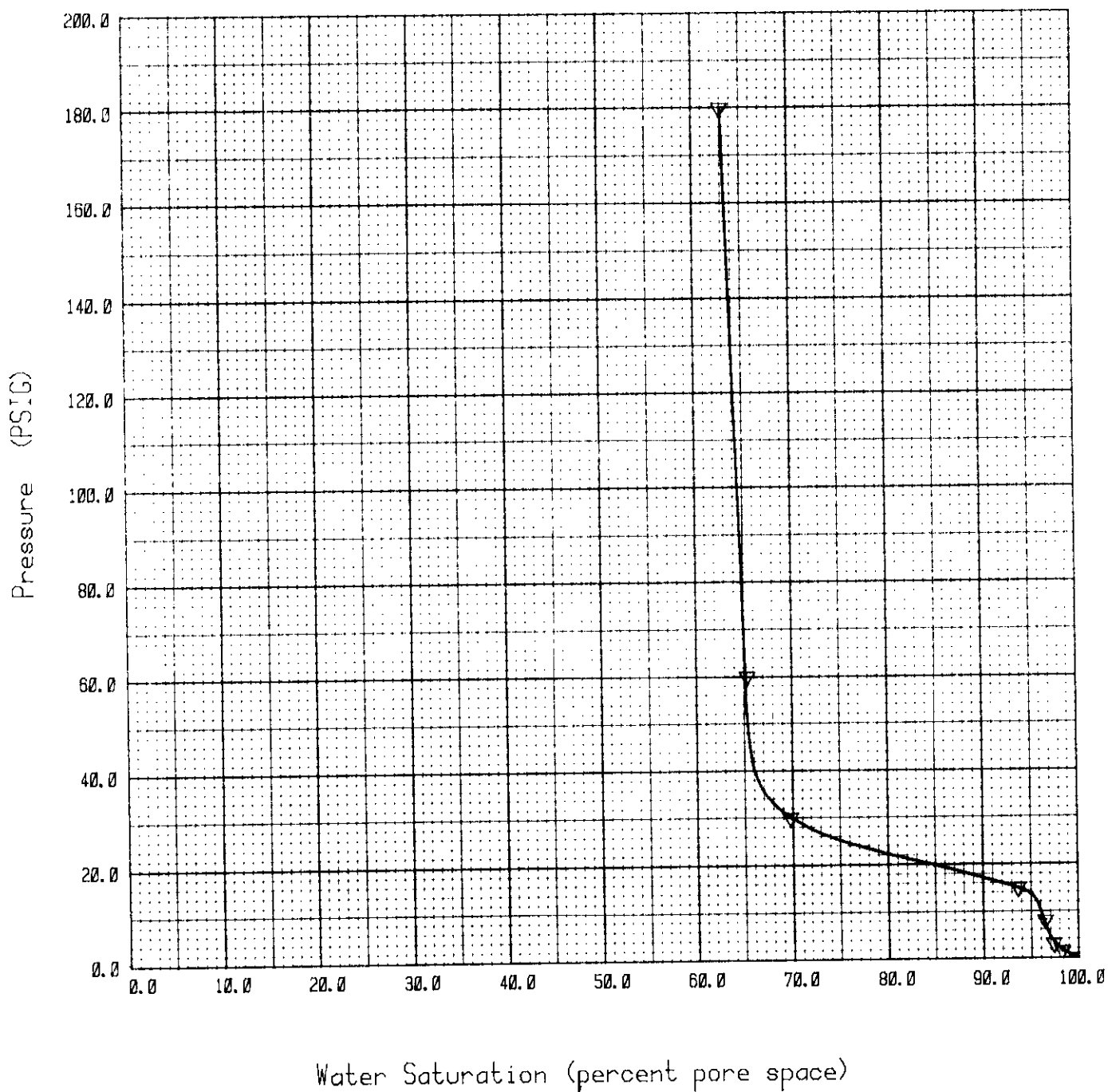
Klink. perm.: 0.356 mD

Sample no : 80

Porosity : 7.76 %

Depth : 14963 ft.

Grain dens. : 2.62 g/cm³



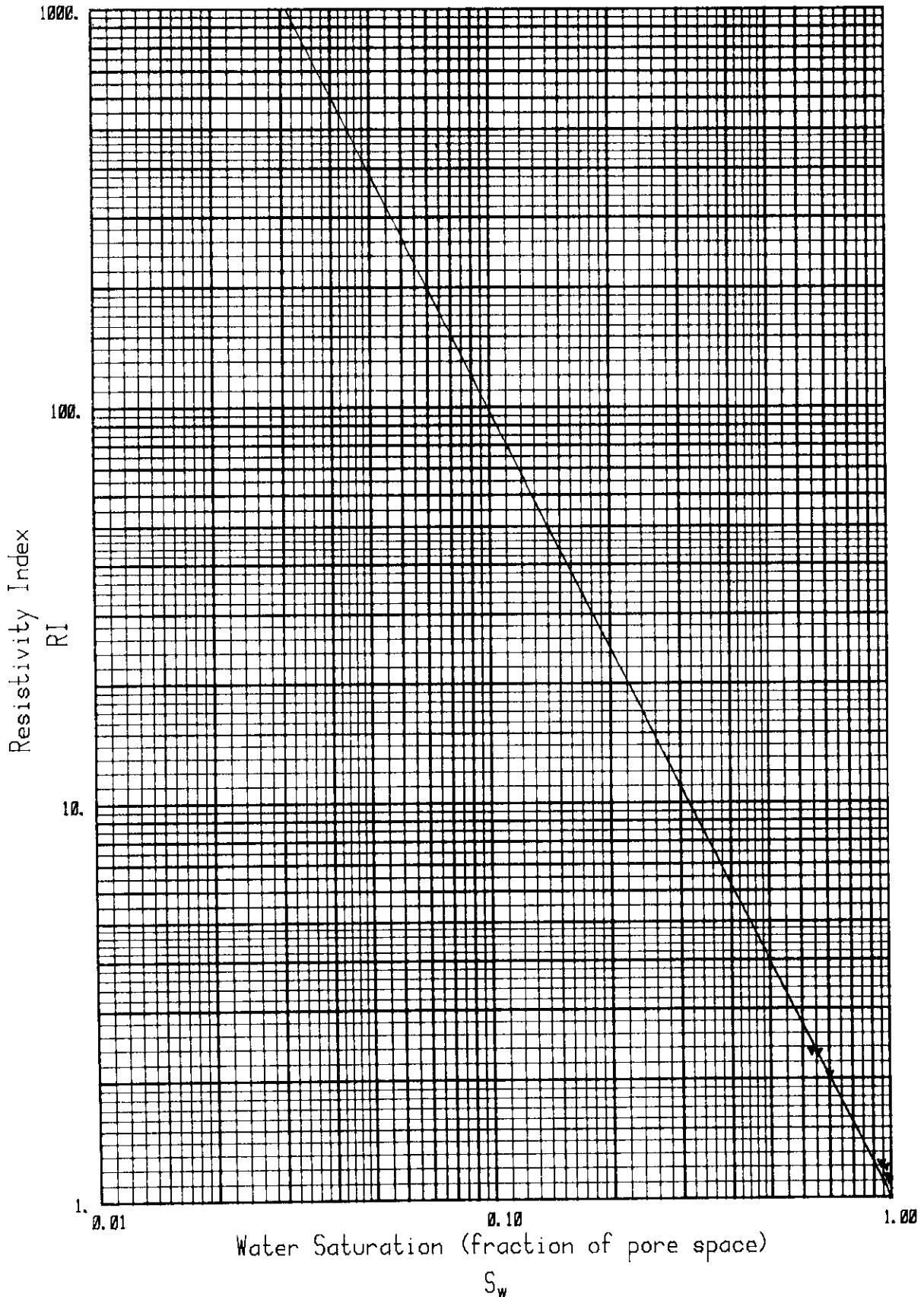
RESISTIVITY INDEX VS. WATER SATURATION



GECO
GEOPHYSICAL COMPANY
OF NORWAY A.S.
Petroleum laboratory

Sample no: 80
Depth : 14963 ft.
RI = 1.00 * S_w^{-1.98}

Klink. perm.: 0.356mD
Porosity : 7.76 %
FF : 89.7





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 32

Depth: 14991 ft.

Klink. perm.: 0.044 mD

Porosity: 6.21 %

Grain density: 2.66 g/cm³

FF= 171 (room conditions)

| Capillary pressure (psig.) | Water saturation S _w (frac.) | Resistivity index RI |
|----------------------------|---|----------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.990 | 1.02 |
| 3.0 | 0.980 | 1.04 |
| 8.0 | 0.970 | 1.05 |
| 15.0 | 0.964 | 1.07 |
| 30.0 | 0.956 | 1.08 |
| 60.0 | 0.948 | 1.10 |
| 180.0 | 0.940 | 1.11 |

$$RI = S_w^{-1.74}$$

CAPILLARY PRESSURE (POROUS PLATE)



Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

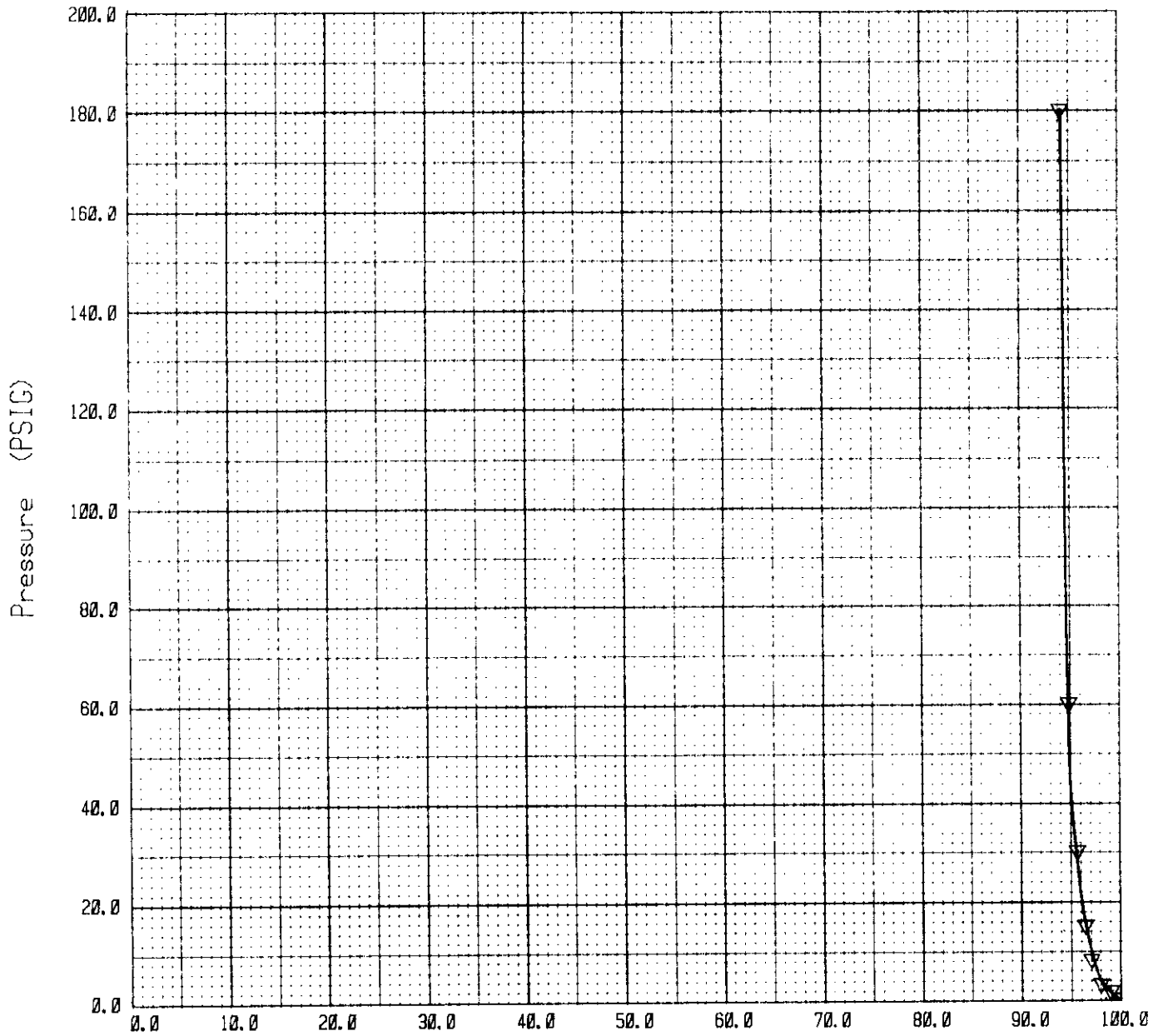
Klink. perm.: 0.044 mD

Sample no : 32

Porosity : 6.21 %

Depth : 14991 ft.

Grain dens. : 2.66 g/cm³



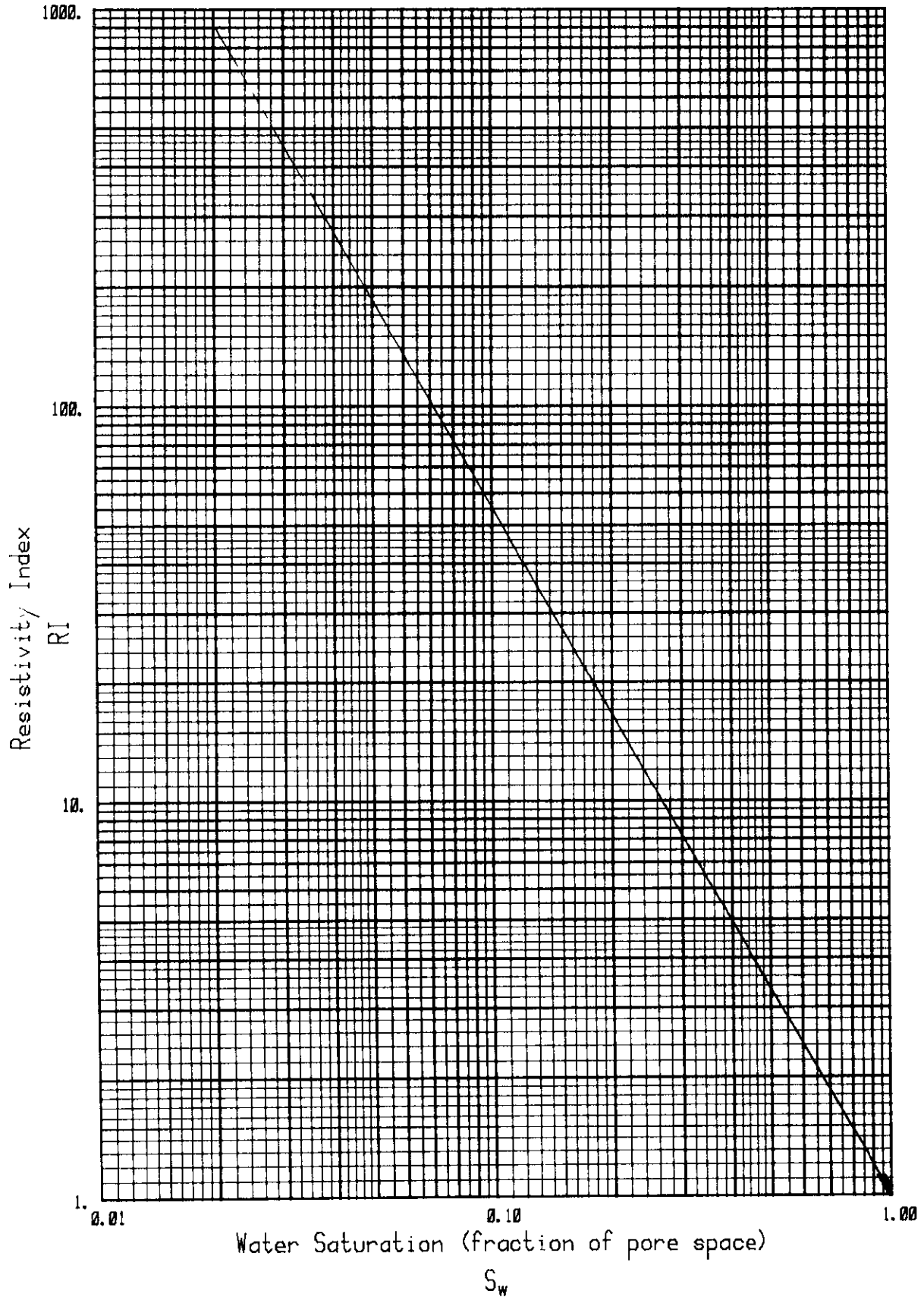
Water Saturation (percent pore space)

RESISTIVITY INDEX VS. WATER SATURATION



Sample no: 32
Depth : 14991 ft.
 $RI = 1.00 * S_w^{-1.74}$

Klink. perm.: 0.044mD
Porosity : 6.21 %
FF : 171





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 123

Depth: 14974 ft. 5 in.

Klink. perm.: 0.003 mD

Porosity: 6.35 %

Grain density: 2.69 g/cm³

FF= 142 (room conditions)

| Capillary pressure (psig.) | Water saturation S_w (frac.) | Resistivity index RI |
|-------------------------------|-----------------------------------|-------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.990 | 1.02 |
| 3.0 | 0.981 | 1.03 |
| 8.0 | 0.972 | 1.05 |
| 15.0 | 0.970 | 1.07 |
| 30.0 | 0.966 | 1.08 |
| 60.0 | 0.955 | 1.09 |
| 180.0 | 0.955 | 1.09 |

$$RI = S_w^{-1.94}$$

CAPILLARY PRESSURE (POROUS PLATE)

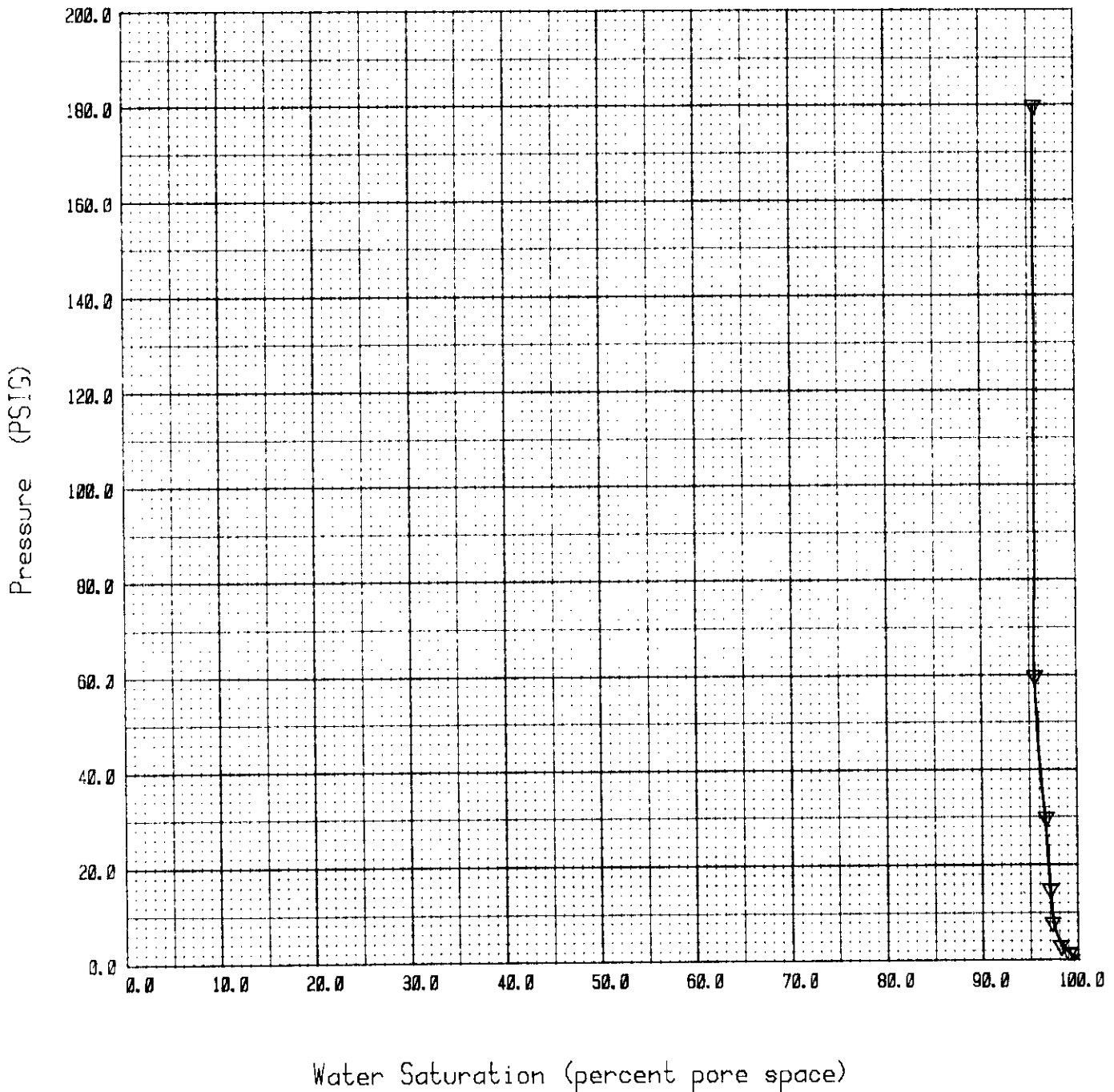


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7 Klink. perm.: 0.003 mD

Sample no : 123 Porosity : 6.35 %

Depth : 14974 ft. 5 in. Grain dens. : 2.69 g/cm³



RESISTIVITY INDEX VS. WATER SATURATION



Sample no: 123

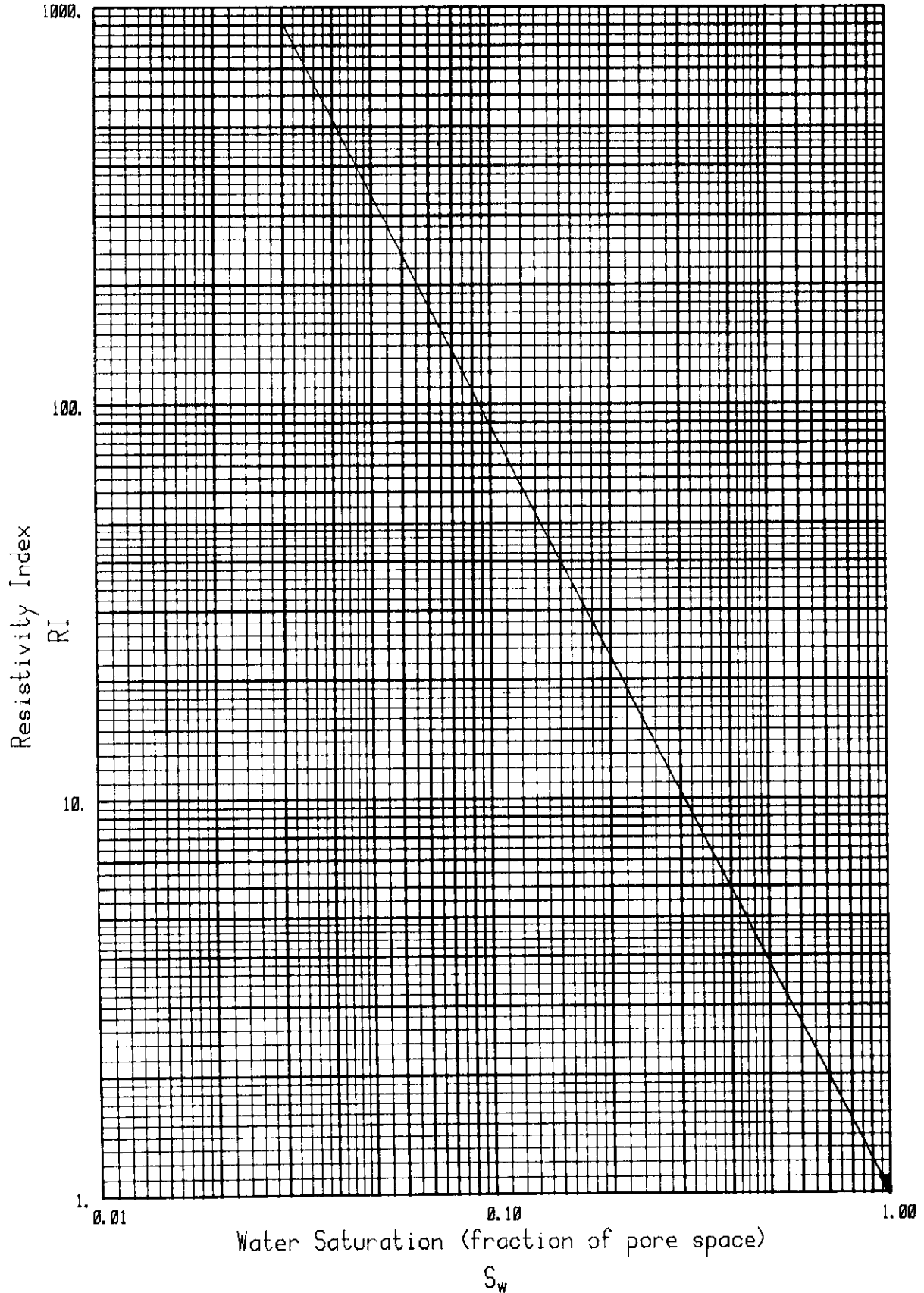
Klink. perm.: 0.003mD

Depth : 14974 ft. 5 in.

Porosity : 6.35 %

RI = 1.00 * $S_w^{-1.94}$

FF : 142





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 130

Depth: 14983 ft. 9 in.

Klink. perm.: 0.019 mD

Porosity: 7.65 %

Grain density: 2.67 g/cm³

FF= 118 (room conditions)

| Capillary pressure (psig.) | Water saturation S_w (frac.) | Resistivity index RI |
|-------------------------------|-----------------------------------|-------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.988 | 1.03 |
| 3.0 | 0.976 | 1.04 |
| 8.0 | 0.964 | 1.06 |
| 15.0 | 0.957 | 1.08 |
| 30.0 | 0.954 | 1.09 |
| 60.0 | 0.949 | 1.09 |
| 180.0 | 0.942 | 1.11 |

$$RI = S_w^{-1.73}$$

CAPILLARY PRESSURE (POROUS PLATE)

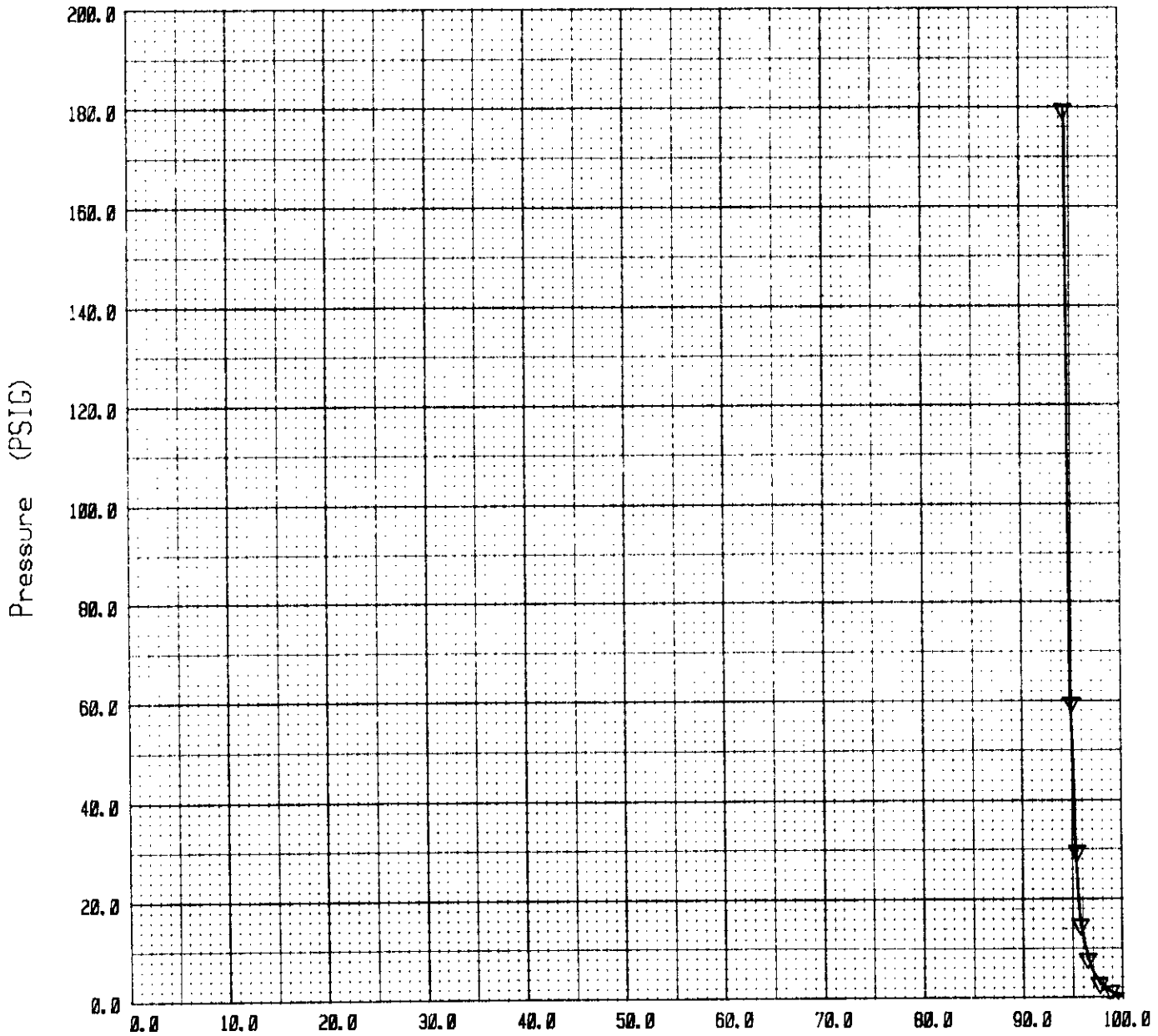


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7 Klink. perm.: 0.019 mD

Sample no : 130 Porosity : 7.65 %

Depth : 14983 ft. 9 in. Grain dens. : 2.67 g/cm³



Water Saturation (percent pore space)

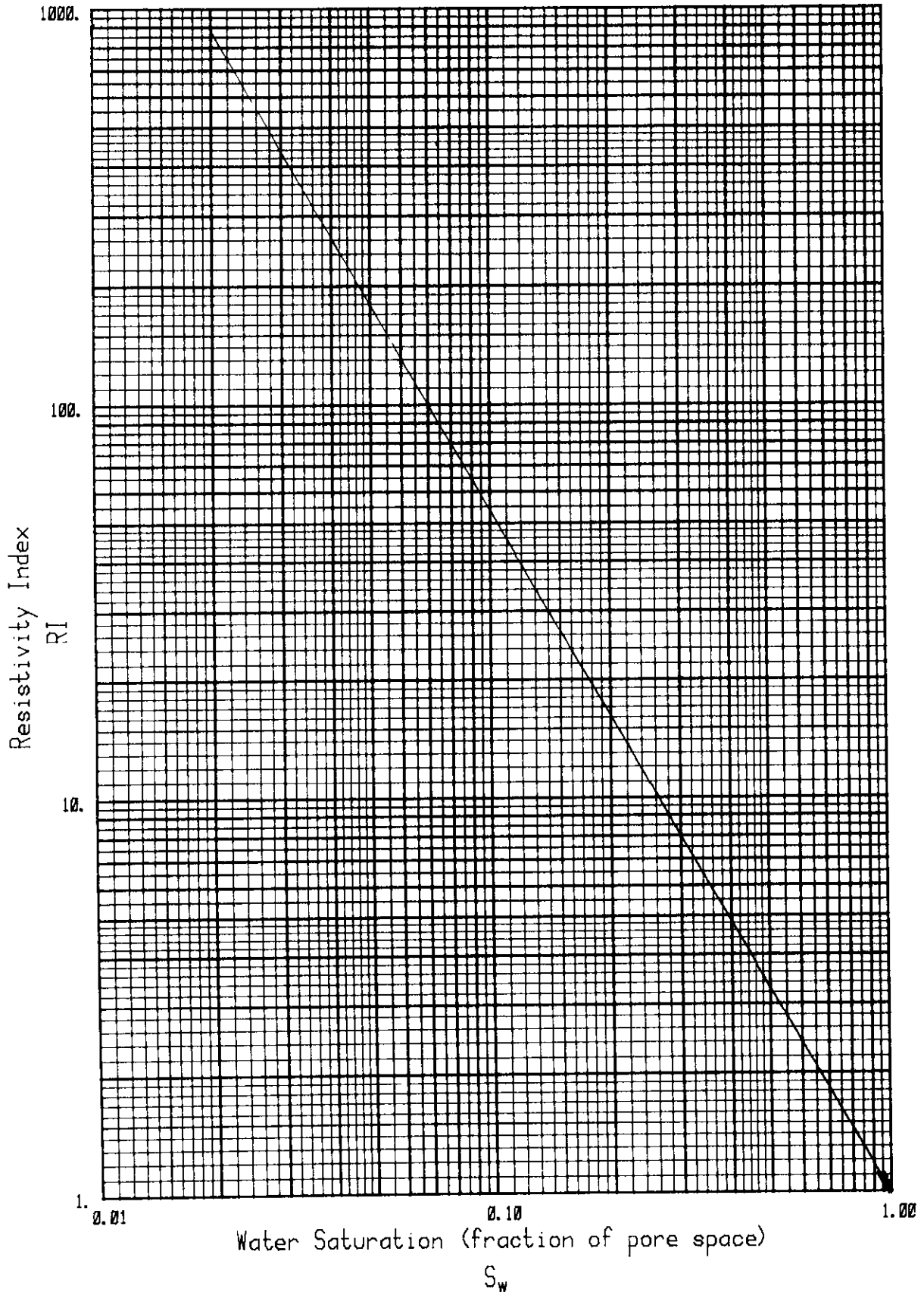
RESISTIVITY INDEX VS. WATER SATURATION



GECO
GEOLOGICAL COMPANY
OF NORWAY A.S.
Petroleum Laboratory

Sample no: 130
Depth : 14983 ft. 9 in.
RI = 1.00 * S_w^{-1.73}

Klink. perm.: 0.019mD
Porosity : 7.65 %
FF : 118





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 85

Depth: 15015 ft.

Klink. perm.: 0.017 mD

Porosity: 5.48 %

Grain density: 2.64 g/cm³

FF= 217 (room conditions)

| Capillary pressure (psig.) | Water saturation S_w (frac.) | Resistivity index RI |
|-------------------------------|-----------------------------------|-------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.989 | 1.02 |
| 3.0 | 0.977 | 1.04 |
| 8.0 | 0.968 | 1.07 |
| 15.0 | 0.958 | 1.08 |
| 30.0 | 0.951 | 1.09 |
| 60.0 | 0.939 | 1.11 |
| 180.0 | 0.932 | 1.12 |

$$RI = S_w^{-1.70}$$



CAPILLARY PRESSURE (POROUS PLATE)

Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

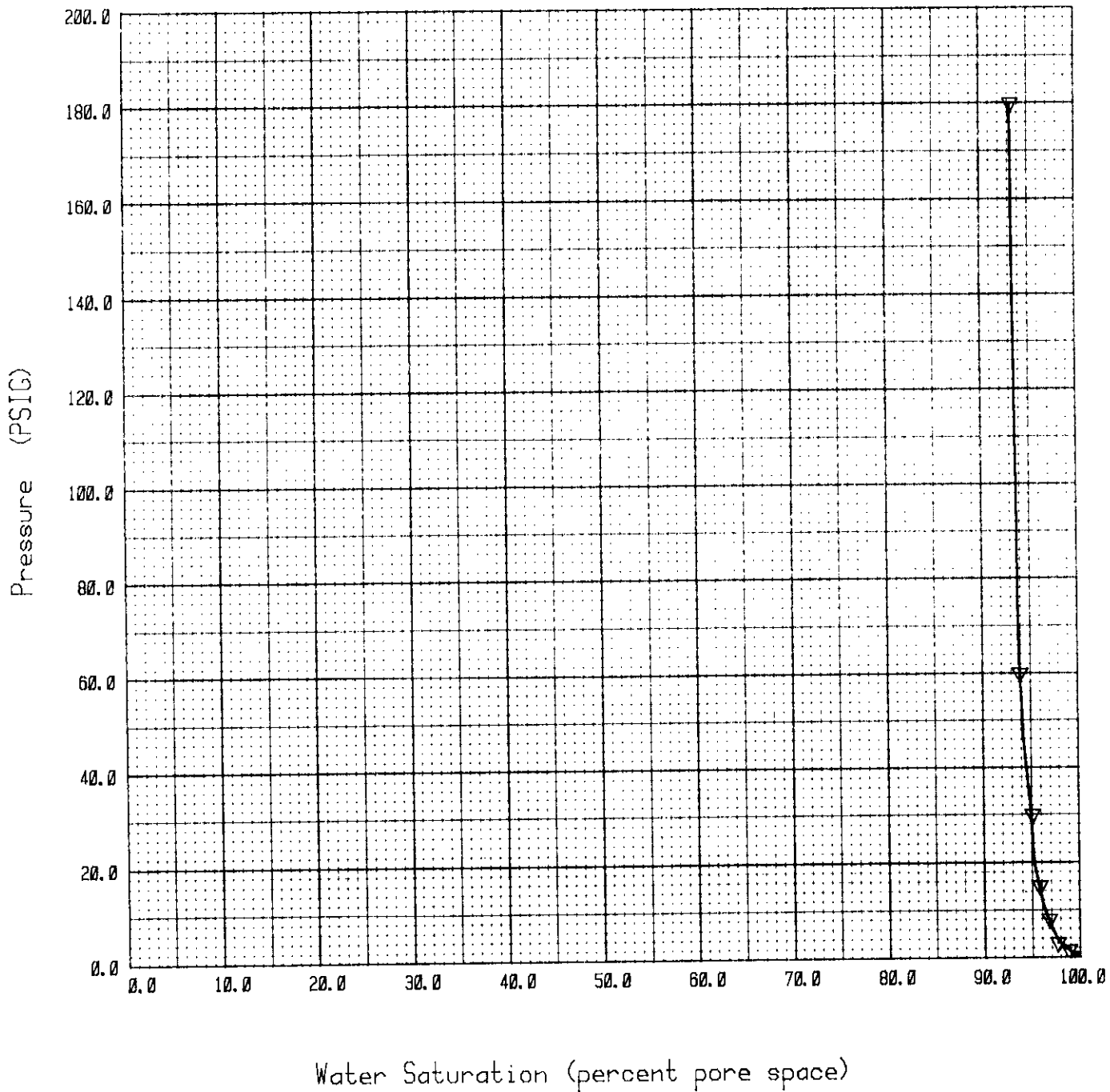
Klink. perm.: 0.017 mD

Sample no : 85

Porosity : 5.48 %

Depth : 15015 ft.

Grain dens. : 2.64 g/cm³



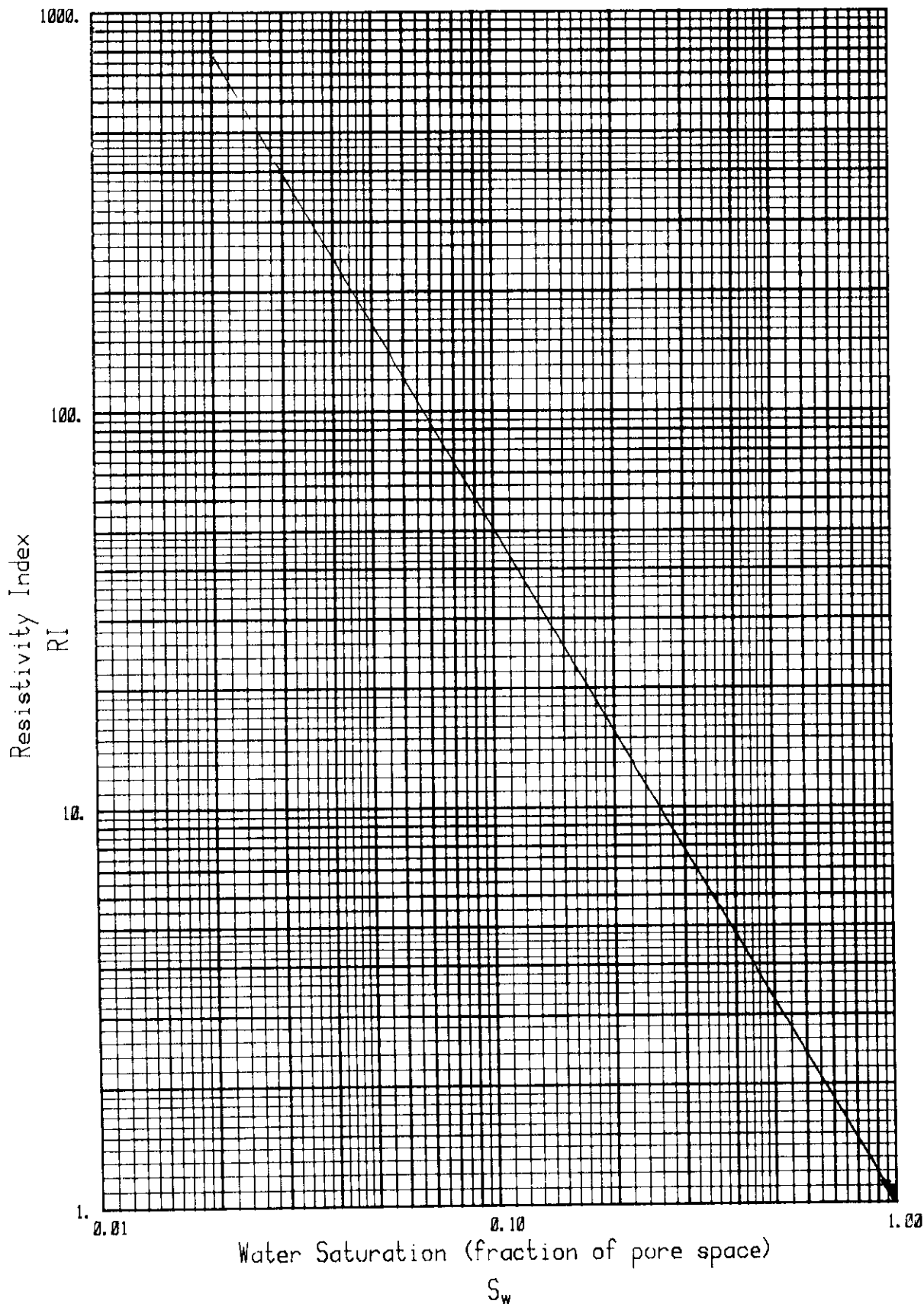
RESISTIVITY INDEX VS. WATER SATURATION



GECO
GEOPHYSICAL COMPANY
OF NORWAY A.S.
Petroleum laboratory

Sample no: 85
Depth : 15015 ft.
RI = 1.00 * S_w^{-1.70}

Klink. perm.: 0.017mD
Porosity : 5.48 %
FF : 217





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 103

Depth: 15034 ft.

Klink. perm.: 0.304 mD

Porosity: 13.0 %

Grain density: 2.65 g/cm³

FF= 55.8 (room conditions)

| Capillary pressure (psig.) | Water saturation S_w (frac.) | Resistivity index RI |
|----------------------------------|--------------------------------------|----------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.992 | 1.02 |
| 3.0 | 0.983 | 1.05 |
| 8.0 | 0.976 | 1.05 |
| 15.0 | 0.966 | 1.06 |
| 30.0 | 0.957 | 1.08 |
| 60.0 | 0.943 | 1.13 |
| 180.0 | 0.938 | 1.14 |

$$RI = S_w^{-2.02}$$

CAPILLARY PRESSURE (POROUS PLATE)



Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

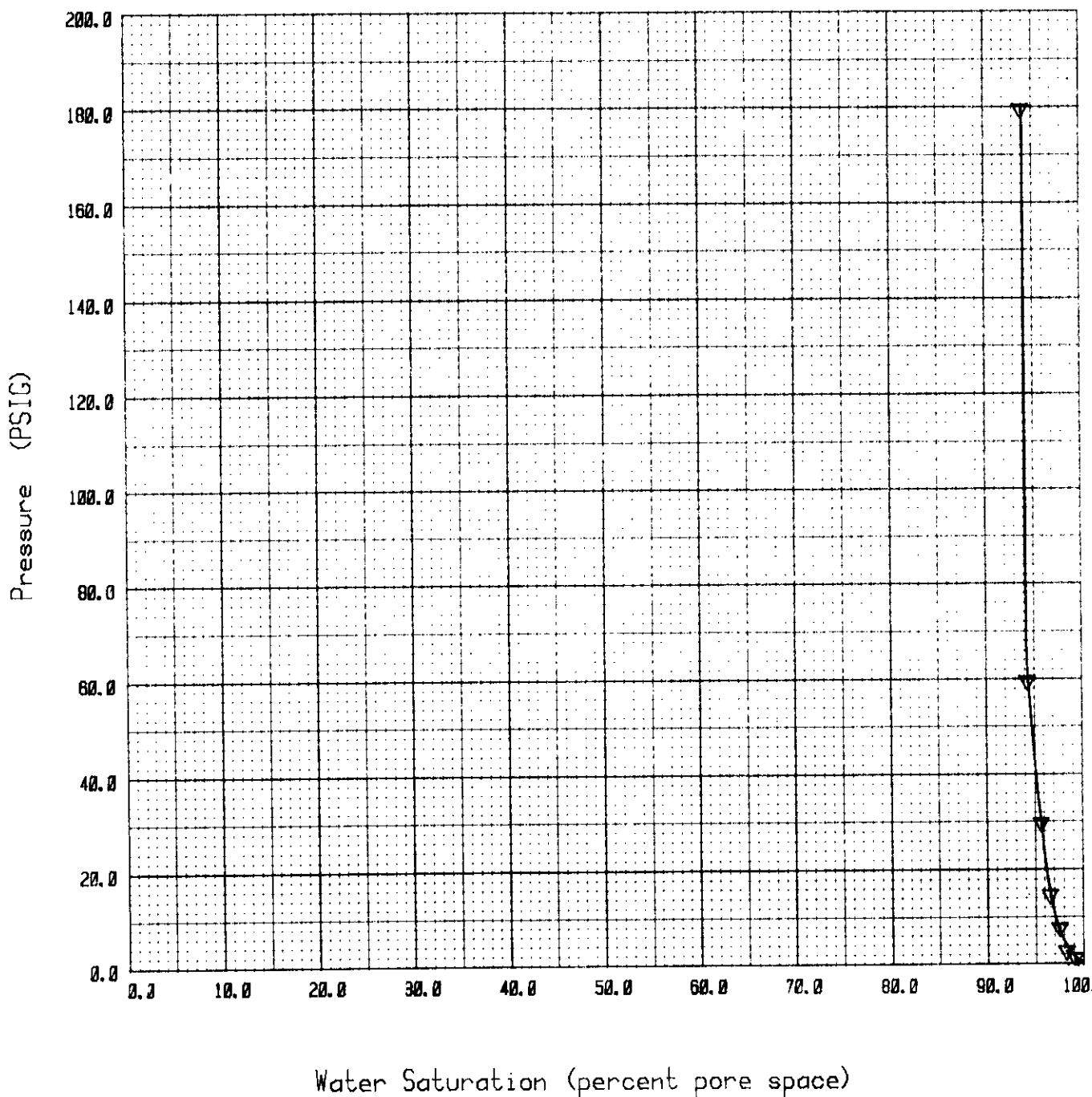
Klink. perm.: 0.304 mD

Sample no : 103

Porosity : 13.0 %

Depth : 15034 ft.

Grain dens. : 2.65 g/cm³



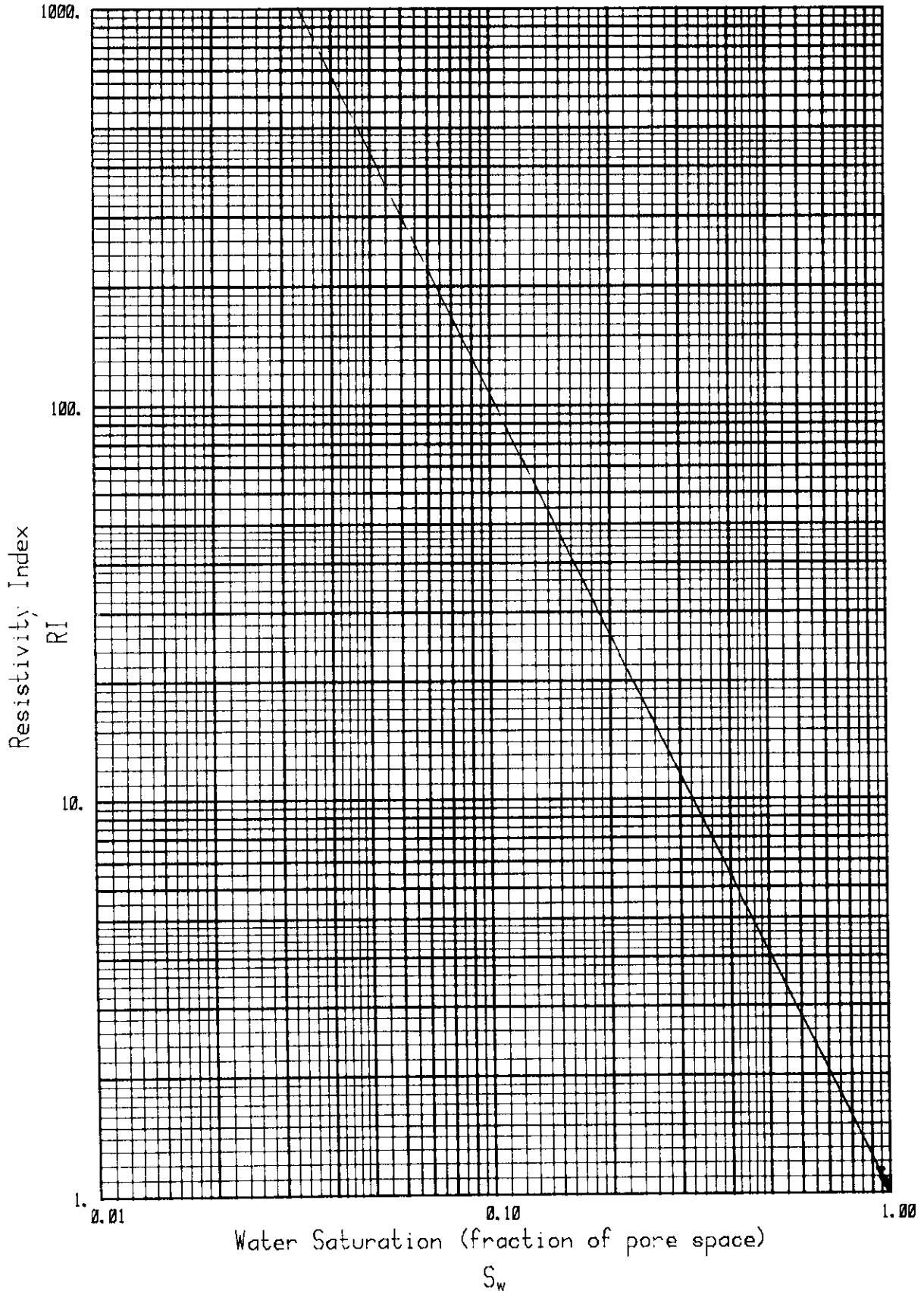
RESISTIVITY INDEX VS. WATER SATURATION



GECO
GEOPHYSICAL COMPANY
OF NORWAY A.S
Petroleum laboratory

Sample no: 103
Depth : 15034 ft.
RI = 1.00 * S_w^{-2.02}

Klink. perm.: 0.304mD
Porosity : 13.0 %
FF : 55.8





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 116

Depth: 15049 ft.

Klink. perm.: 0.011 mD

Porosity: 9.25 %

Grain density: 2.69 g/cm³

FF= 108 (room conditions)

| Capillary pressure (psig.) | Water saturation S _w (frac.) | Resistivity index RI |
|----------------------------------|---|----------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.994 | 1.01 |
| 3.0 | 0.990 | 1.02 |
| 8.0 | 0.979 | 1.03 |
| 15.0 | 0.973 | 1.05 |
| 30.0 | 0.970 | 1.06 |
| 60.0 | 0.963 | 1.06 |
| 180.0 | 0.959 | 1.07 |

$$RI = S_w^{-1.66}$$

CAPILLARY PRESSURE (POROUS PLATE)

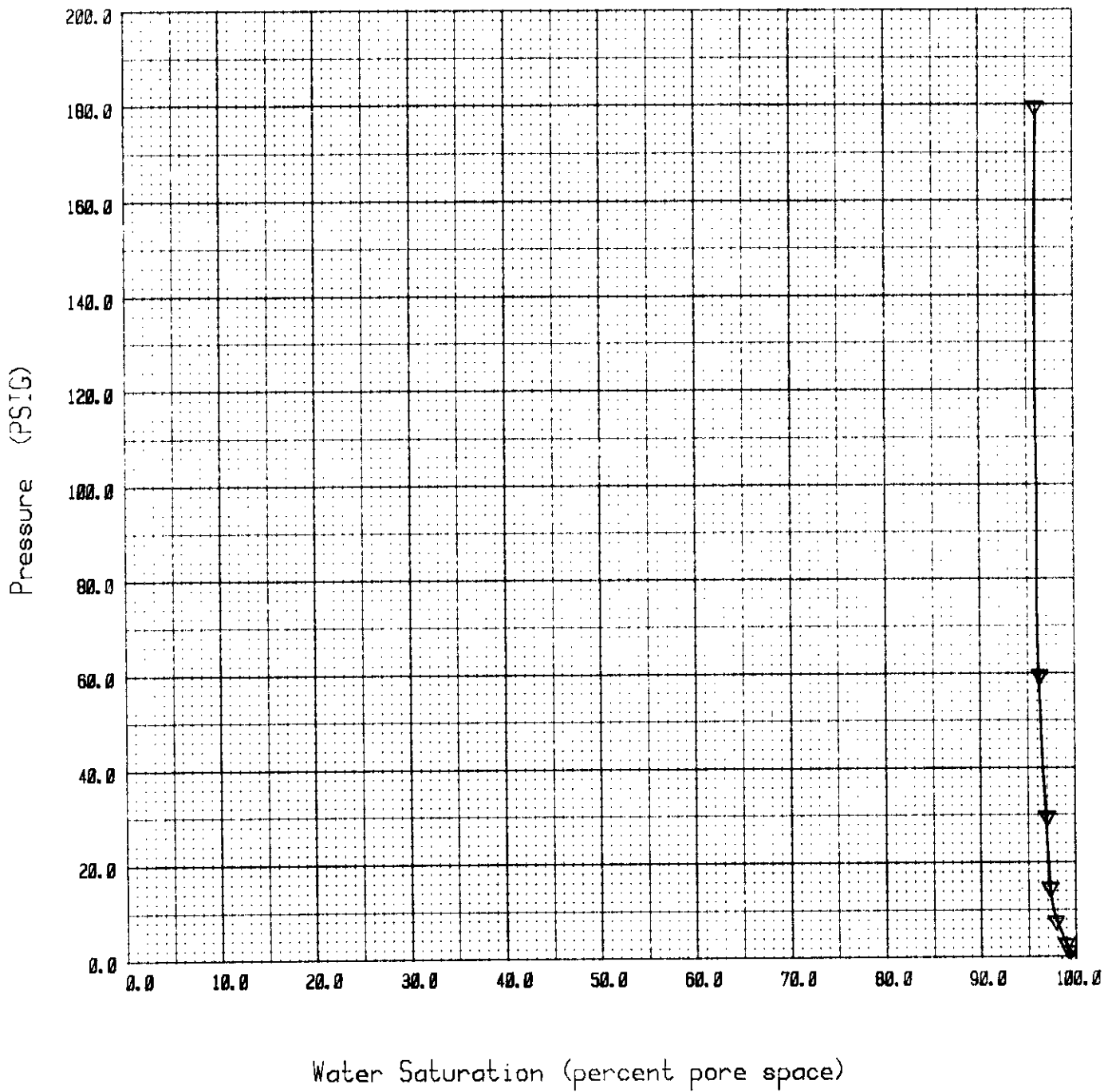


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7 Klink. perm.: 0.011 mD

Sample no : 116 Porosity : 9.25 %

Depth : 15049 ft. Grain dens. : 2.69 g/cm³



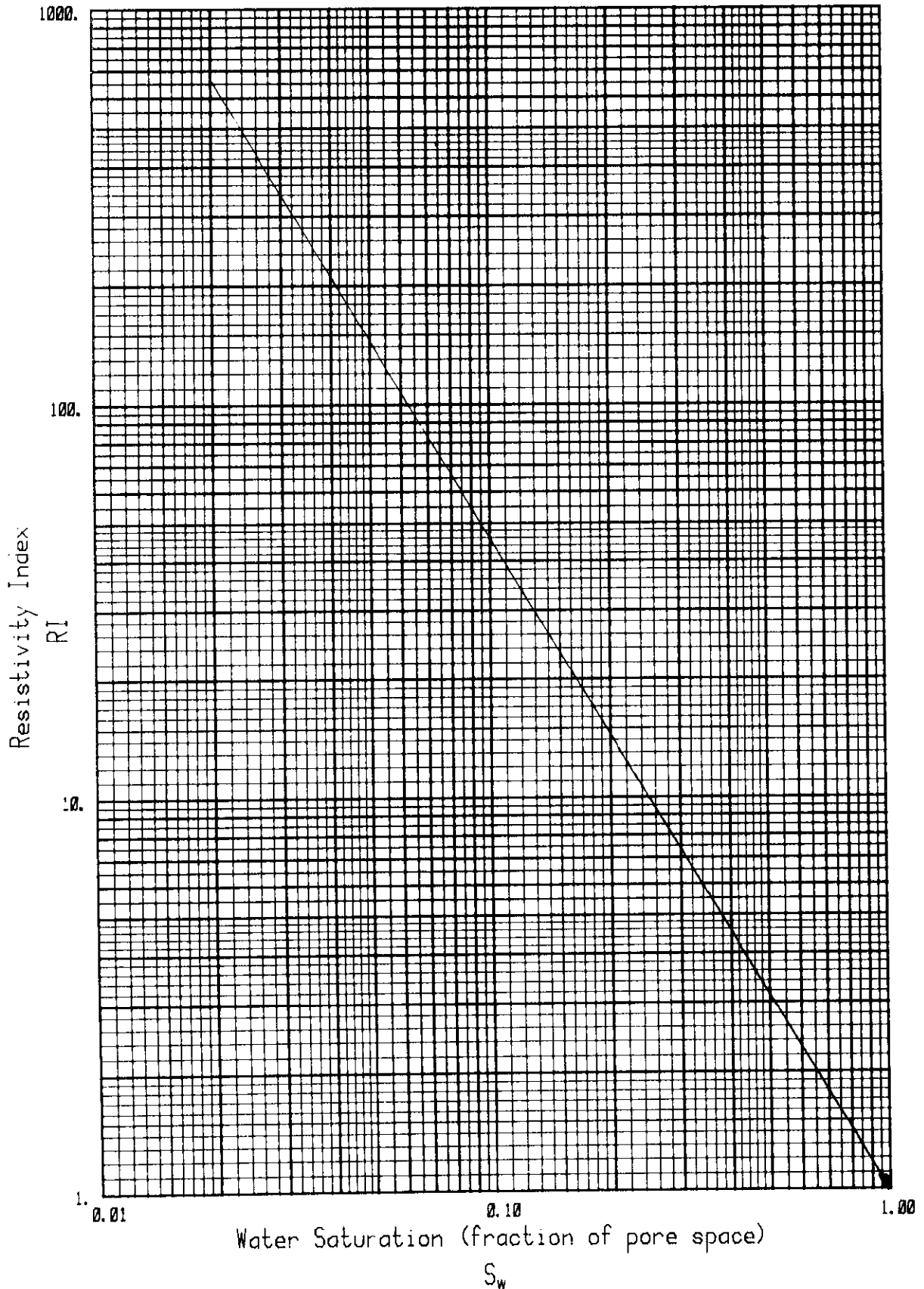
RESISTIVITY INDEX VS. WATER SATURATION



GECO
GEOPHYSICAL COMPANY
OF NORWAY A.S
Petroleum laboratory

Sample no: 115
Depth : 15049 ft.
RI = 1.00 * S_w^{-1.66}

Klink. perm.: 0.011mD
Porosity : 9.25 %
FF : 108





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 41

Depth: 15058 ft.

Klink. perm.: 0.015 mD

Porosity: 9.26 %

Grain density: 2.67 g/cm³

FF= 92.5 (room conditions)

| Capillary pressure (psig.) | Water saturation S _w (frac.) | Resistivity index RI |
|----------------------------------|---|----------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.996 | 1.01 |
| 3.0 | 0.990 | 1.02 |
| 8.0 | 0.981 | 1.04 |
| 15.0 | 0.976 | 1.05 |
| 30.0 | 0.975 | 1.05 |
| 60.0 | 0.967 | 1.07 |
| 180.0 | 0.963 | 1.07 |

$$RI = S_w^{-1.93}$$

CAPILLARY PRESSURE (POROUS PLATE)

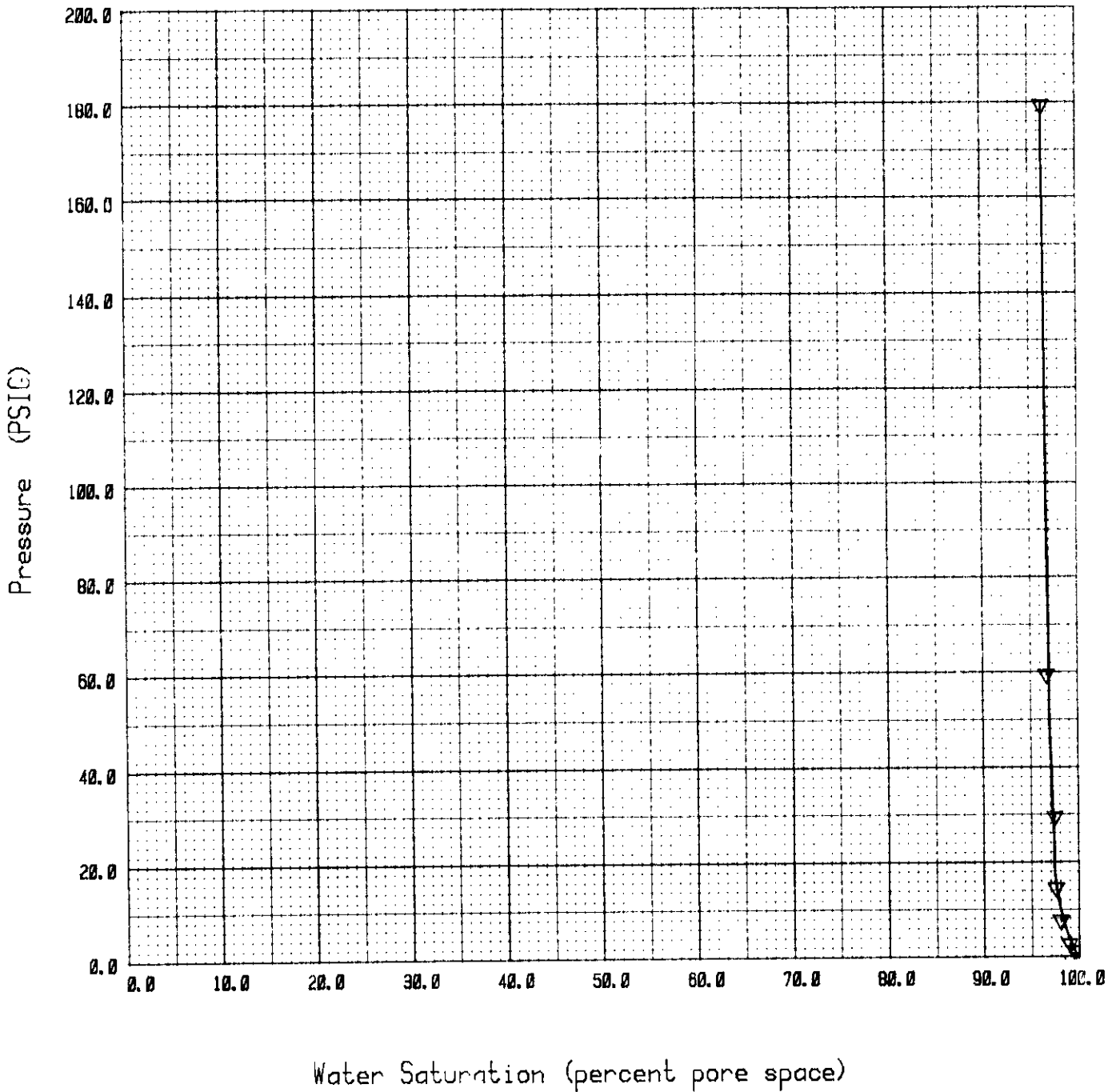


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7 Klink. perm.: 0.015 mD

Sample no : 41 Porosity : 9.26 %

Depth : 15058 ft. Grain dens. : 2.67 g/cm³



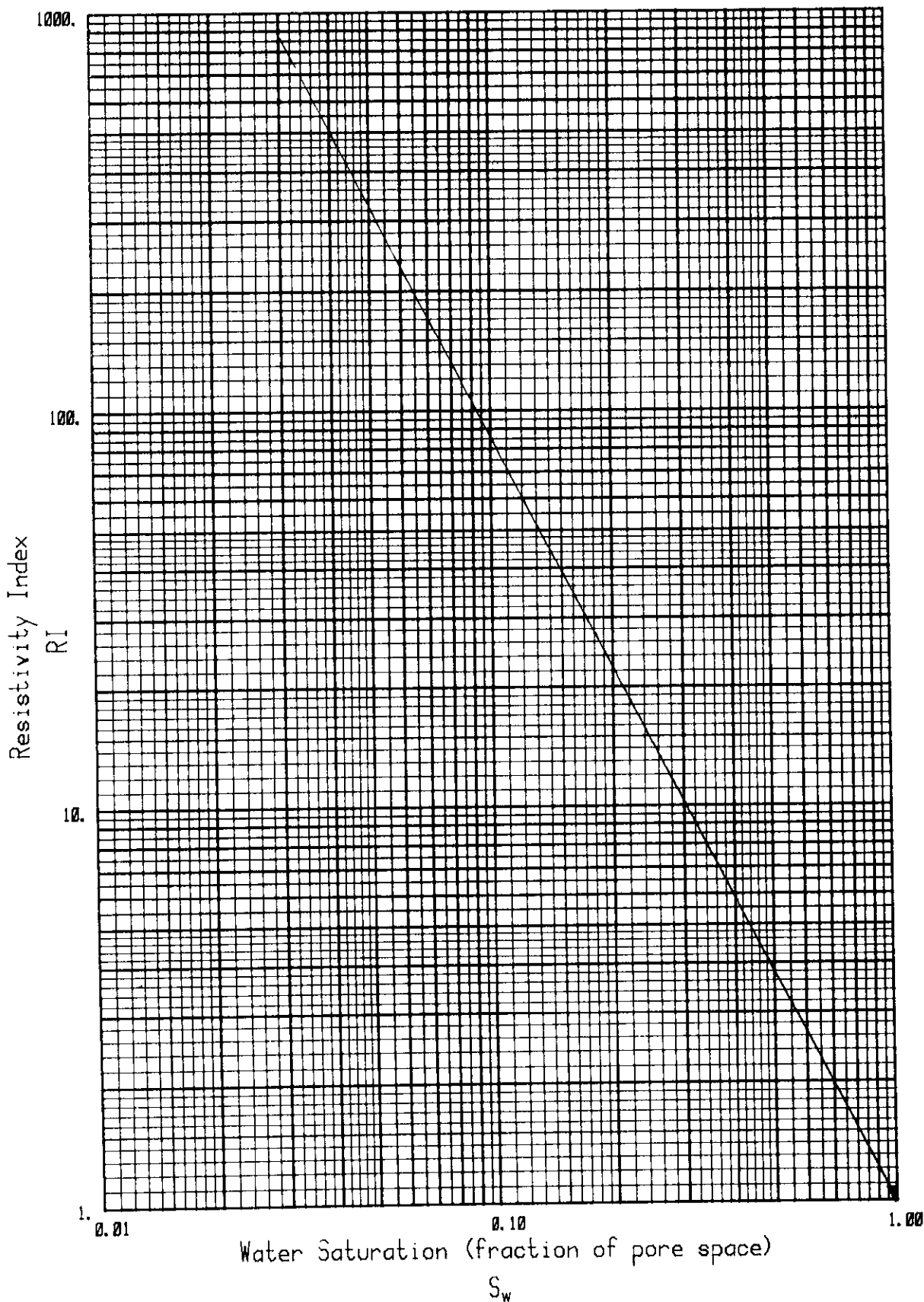
RESISTIVITY INDEX VS. WATER SATURATION



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Sample no: 41
Depth : 15058 ft.
RI = 1.00 * S_w^{-1.93}

Klink. perm.: 0.015mD
Porosity : 9.26 %
FF : 92.5





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 53

Depth: 15072 ft.

Klink. perm.: 0.182 mD

Porosity: 13.1 %

Grain density: 2.66 g/cm³

FF= 67.0 (room conditions)

| Capillary pressure (psig.) | Water saturation S _w (frac.) | Resistivity index RI |
|----------------------------------|---|----------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.999 | 1.01 |
| 3.0 | 0.993 | 1.01 |
| 8.0 | 0.982 | 1.03 |
| 15.0 | 0.978 | 1.05 |
| 30.0 | 0.968 | 1.06 |
| 60.0 | 0.961 | 1.07 |
| 180.0 | 0.956 | 1.08 |

$$RI = S_w^{-1.77}$$



CAPILLARY PRESSURE (POROUS PLATE)

Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

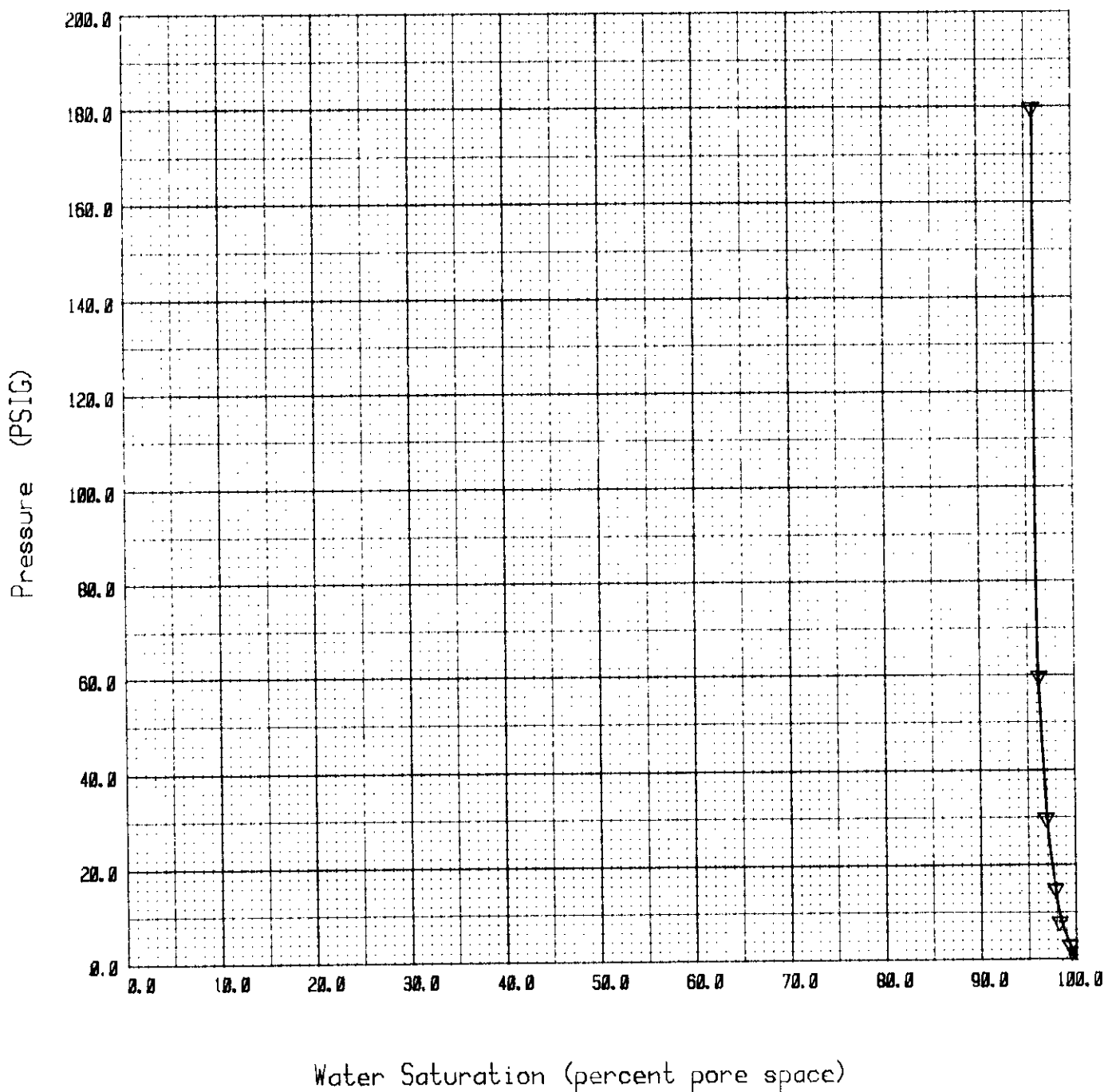
Klink. perm.: 0.182 mD

Sample no : 53

Porosity : 13.1 %

Depth : 15072 ft.

Grain dens. : 2.66 g/cm³

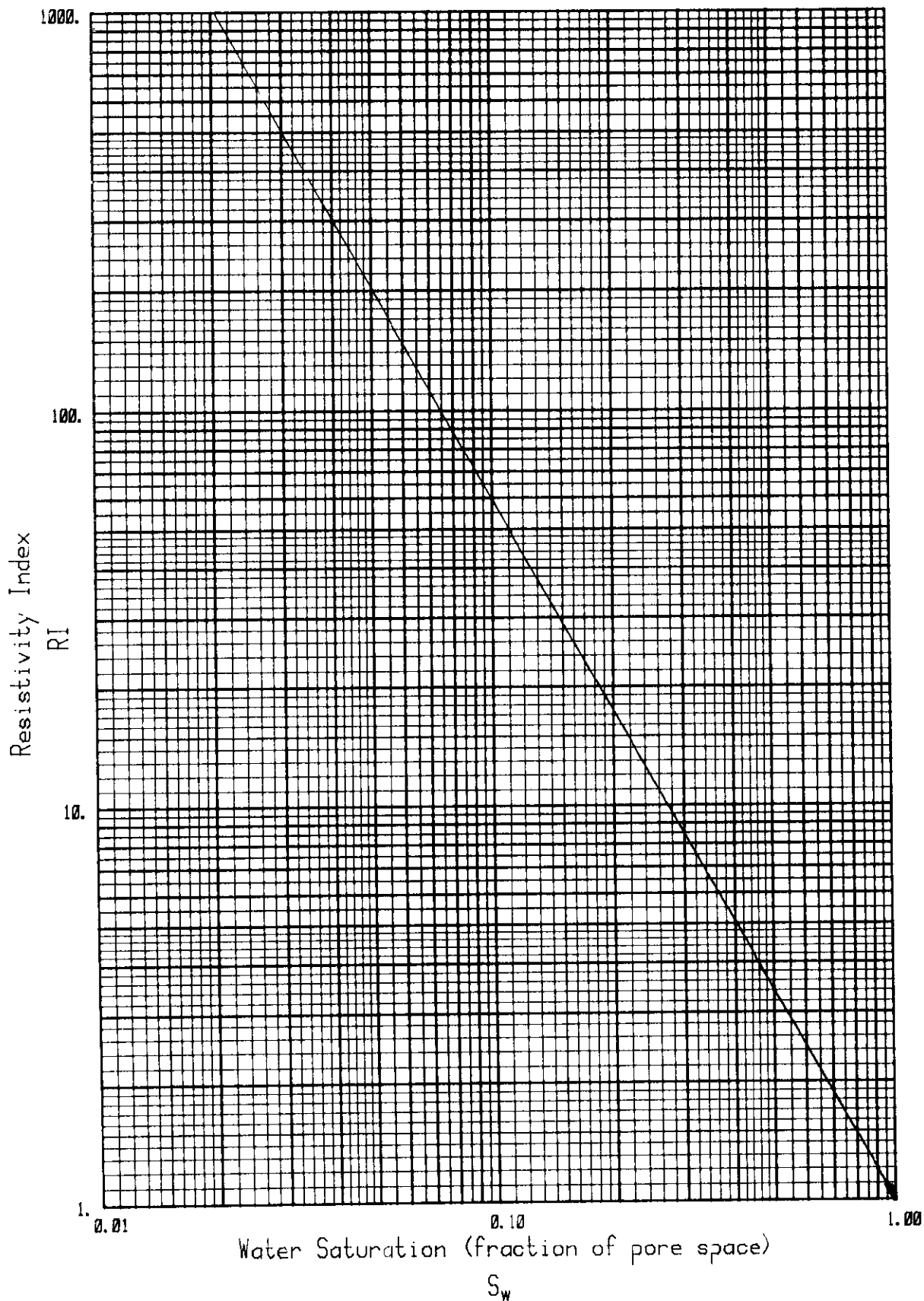


RESISTIVITY INDEX VS. WATER SATURATION



Sample no: 53
Depth : 15072 ft.
RI = 1.00 * S_w^{-1.77}

Klink. perm.: 0.182mD
Porosity : 13.1 %
FF : 67.0





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 76

Depth: 15100 ft.

Klink. perm.: 14.5 mD

Porosity: 16.5 %

Grain density: 2.63 g/cm³

FF= 27.7 (room conditions)

| Capillary pressure (psig.) | Water saturation S _w (frac.) | Resistivity index RI |
|-------------------------------|--|-------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.756 | 1.56 |
| 3.0 | 0.580 | 2.40 |
| 8.0 | 0.447 | 3.45 |
| 15.0 | 0.395 | 4.45 |
| 30.0 | 0.345 | 5.20 |
| 60.0 | 0.329 | 5.61 |
| 180.0 | 0.326 | 5.64 |

$$RI = S_w^{-1.56}$$



CAPILLARY PRESSURE (POROUS PLATE)

Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

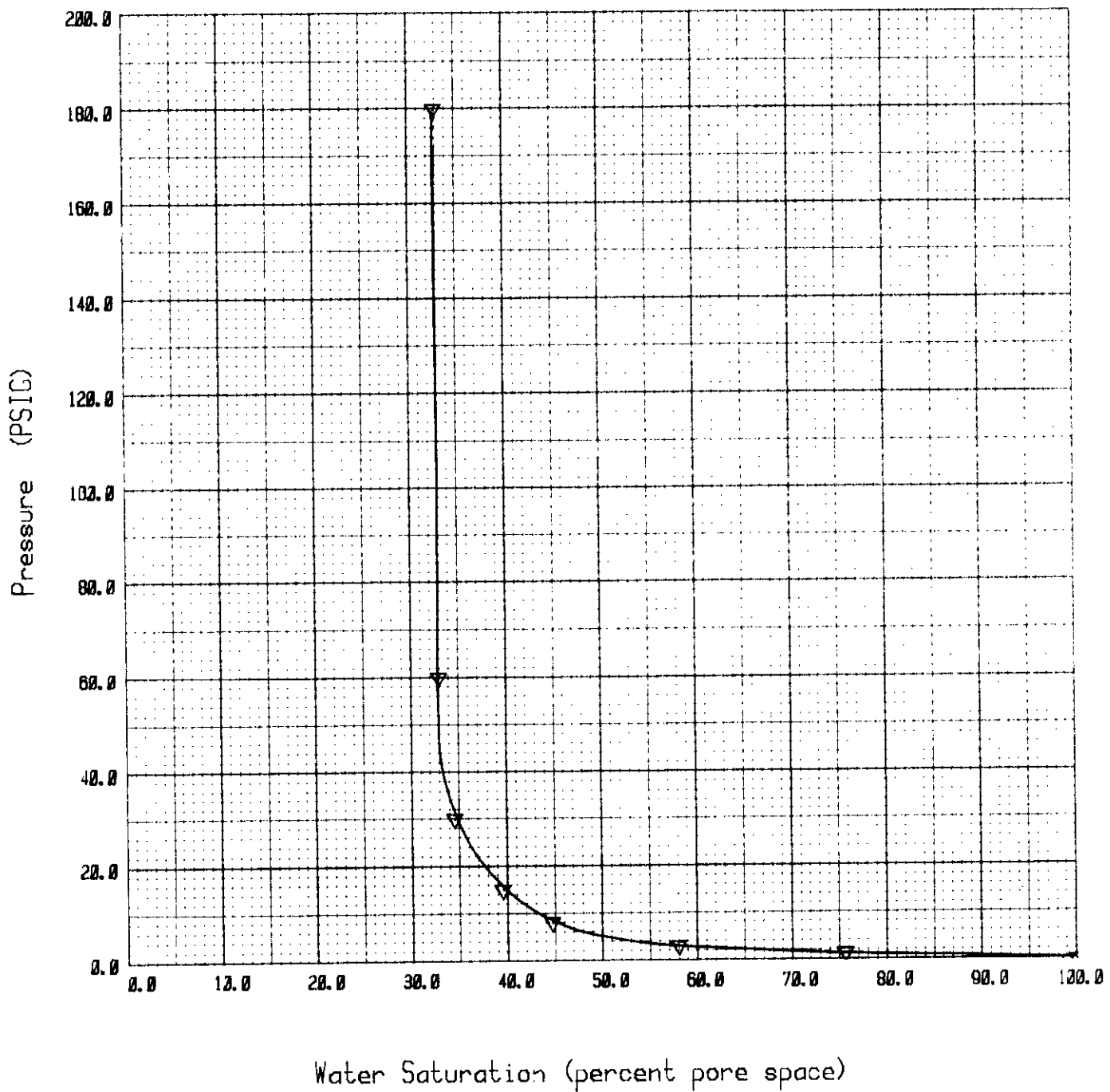
Klink. perm.: 14.5 mD

Sample no : 76

Porosity : 16.5 %

Depth : 15100 ft.

Grain dens. : 2.63 g/cm³



RESISTIVITY INDEX VS. WATER SATURATION



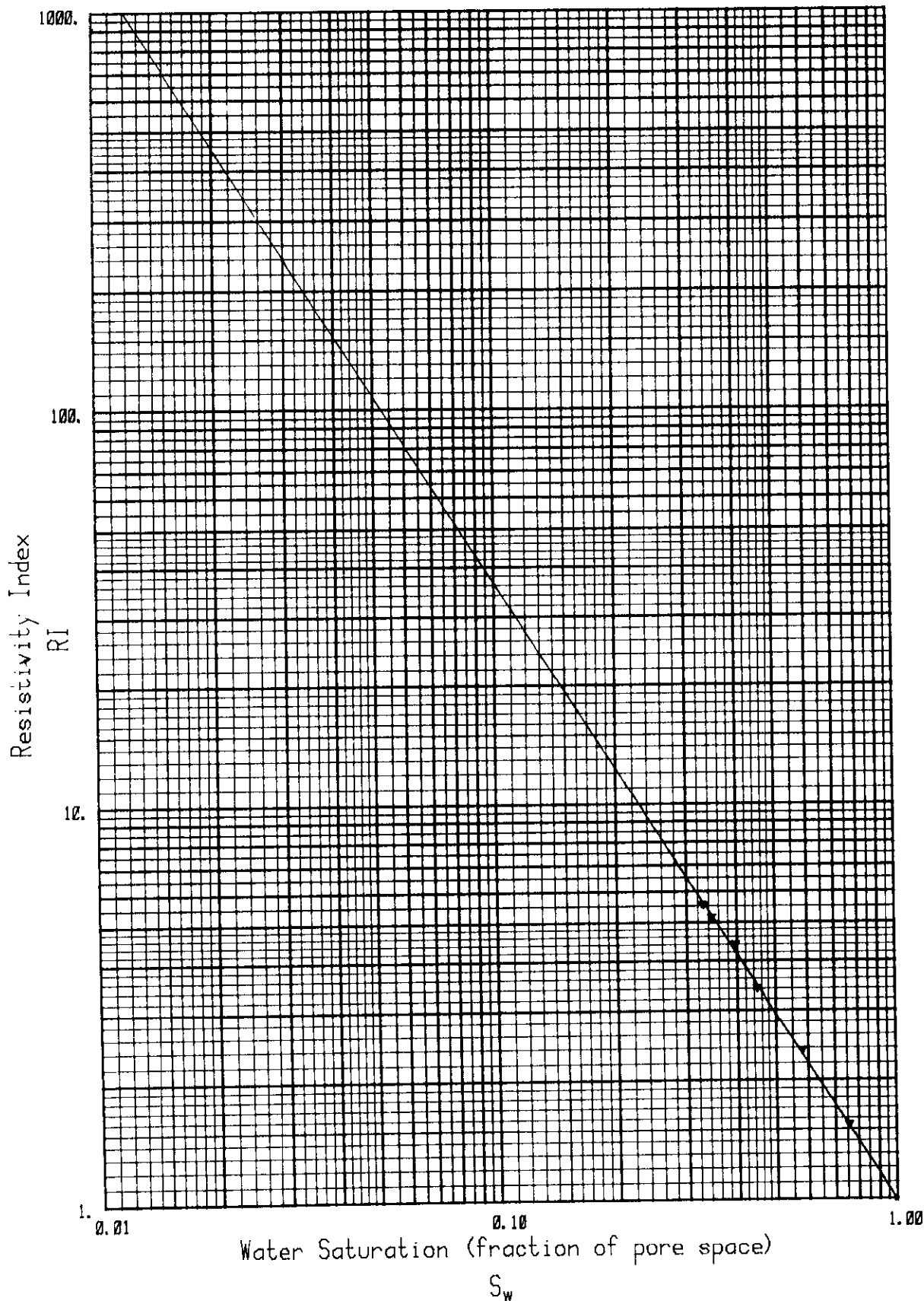
Sample no: 76
Depth : 15100 ft.

Klink. perm.: 14.5 mD

Porosity : 16.5 %

$$RI = 1.00 * S_w^{-1.56}$$

FF : 27.7





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 141

Depth: 15110 ft.

Klink. perm.: 0.035 mD

Porosity: 5.99 %

Grain density: 2.75 g/cm³

FF= 178 (room conditions)

| Capillary pressure (psig.) | Water saturation S _w (frac.) | Resistivity index RI |
|----------------------------------|---|----------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.978 | 1.05 |
| 3.0 | 0.956 | 1.10 |
| 8.0 | 0.921 | 1.19 |
| 15.0 | 0.895 | 1.23 |
| 30.0 | 0.853 | 1.33 |
| 60.0 | 0.821 | 1.39 |
| 180.0 | 0.799 | 1.45 |

$$RI = S_w^{-1.74}$$

CAPILLARY PRESSURE (POROUS PLATE)

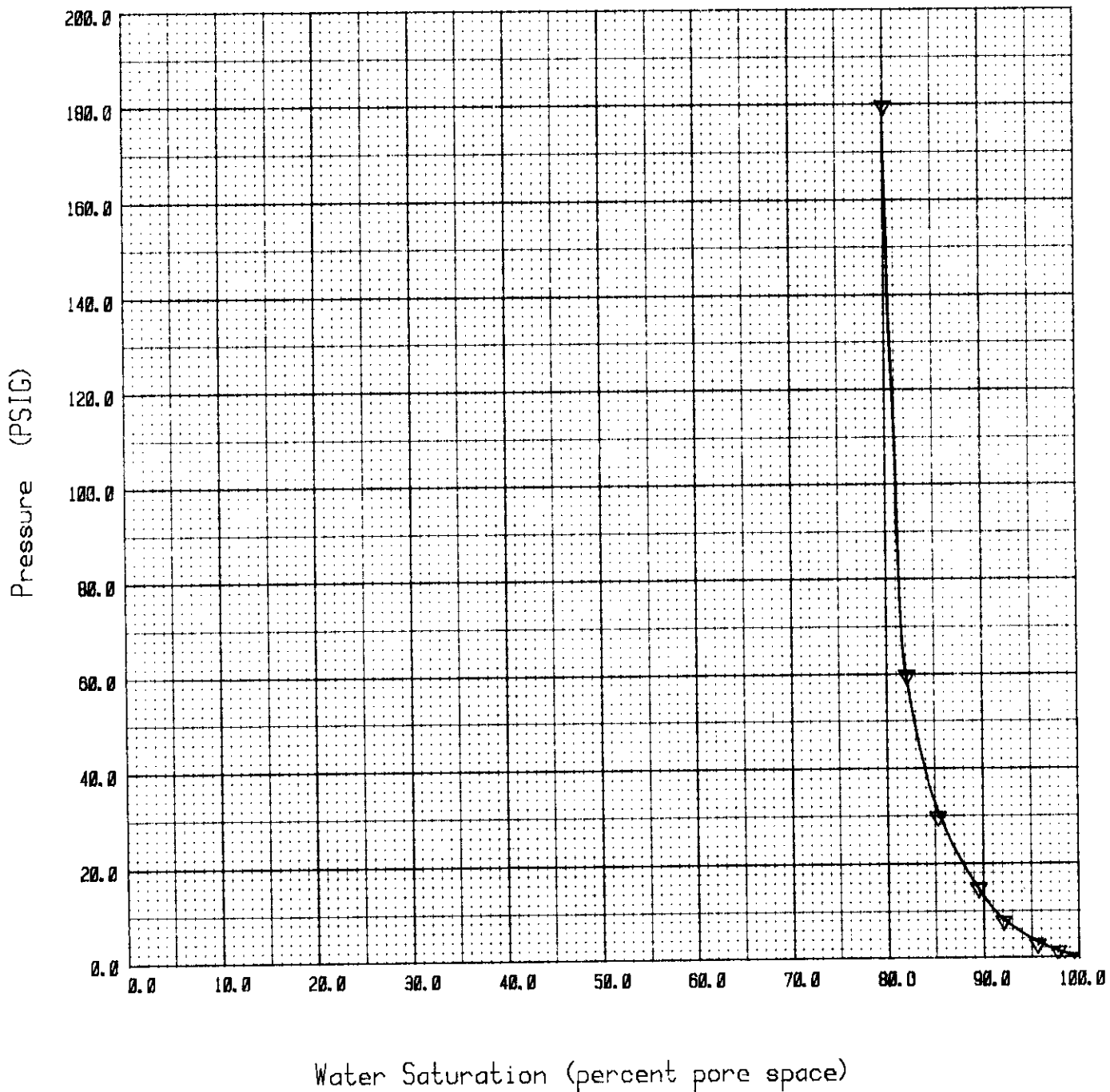


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7 Klink. perm.: 0.035 mD

Sample no : 141 Porosity : 5.99 %

Depth : 15110 ft. Grain dens. : 2.75 g/cm³

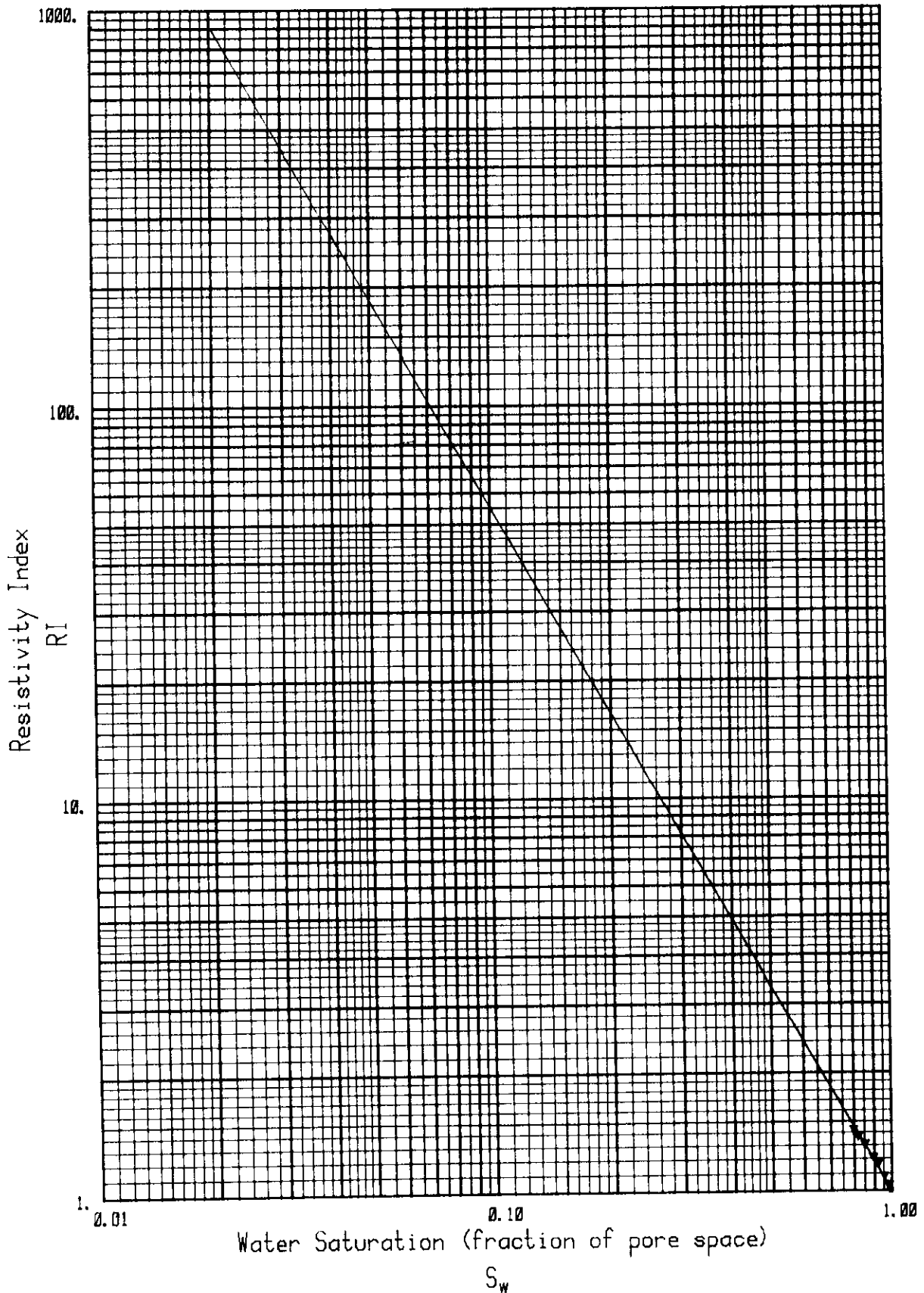


RESISTIVITY INDEX VS. WATER SATURATION



Sample no: 141
Depth : 15110 ft.
RI = 1.00 * S_w^{-1.74}

Klink. perm.: 0.035mD
Porosity : 5.99 %
FF : 178





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 151

Depth: 15121 ft.

Klink. perm.: 1.95 mD

Porosity: 15.2 %

Grain density: 2.64 g/cm³

FF= 35.1 (room conditions)

| Capillary pressure (psig.) | Water saturation S _w (frac.) | Resistivity index RI |
|----------------------------------|---|----------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.992 | 1.07 |
| 3.0 | 0.989 | 1.14 |
| 8.0 | 0.711 | 1.98 |
| 15.0 | 0.601 | 2.49 |
| 30.0 | 0.524 | 3.37 |
| 60.0 | 0.506 | 3.63 |
| 180.0 | 0.500 | 3.70 |

$$RI = S_w^{-1.88}$$



CAPILLARY PRESSURE (POROUS PLATE)

Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

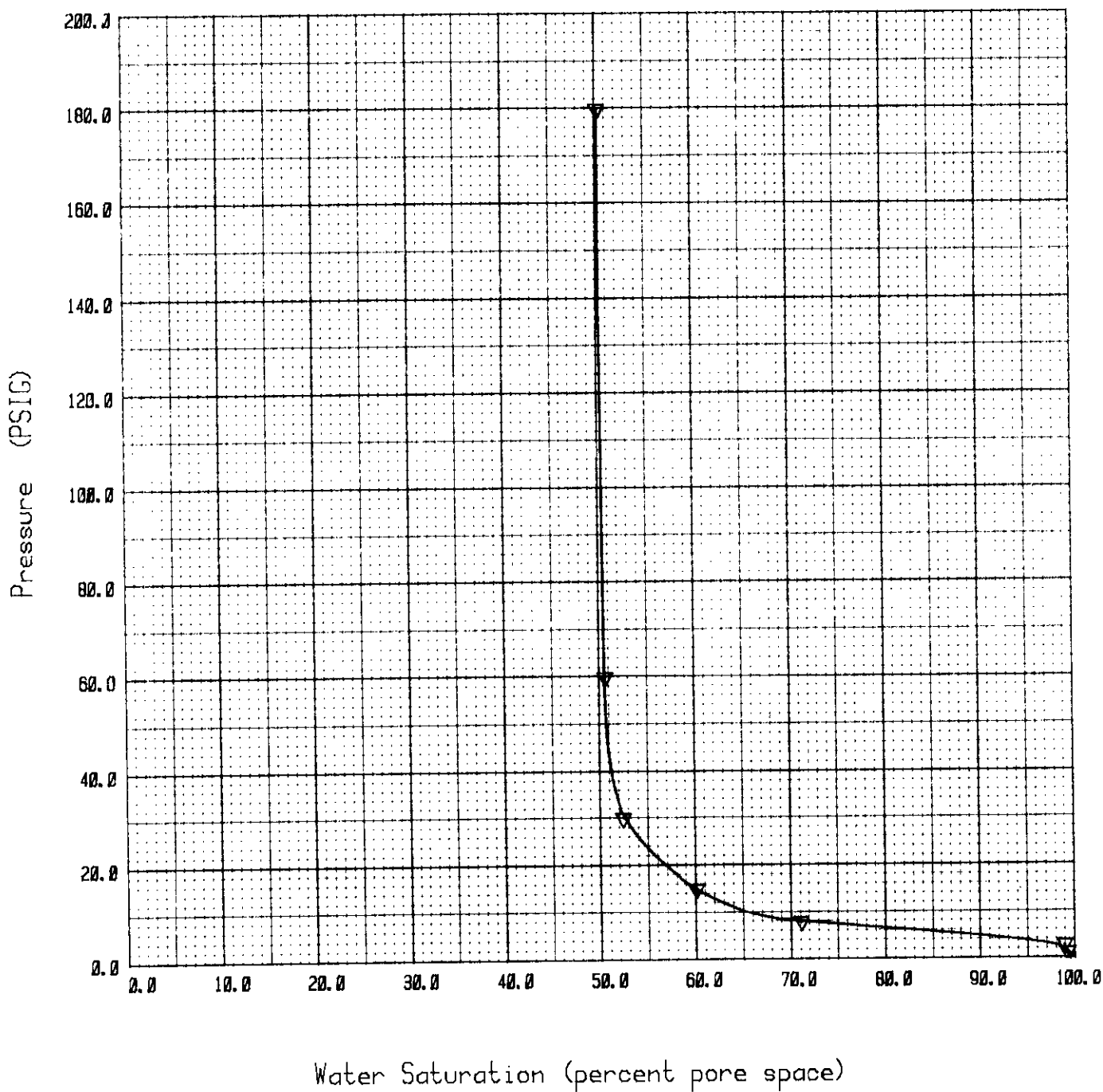
Klink. perm.: 1.95 mD

Sample no : 151

Porosity : 15.2 %

Depth : 15121 ft.

Grain dens. : 2.64 g/cm³



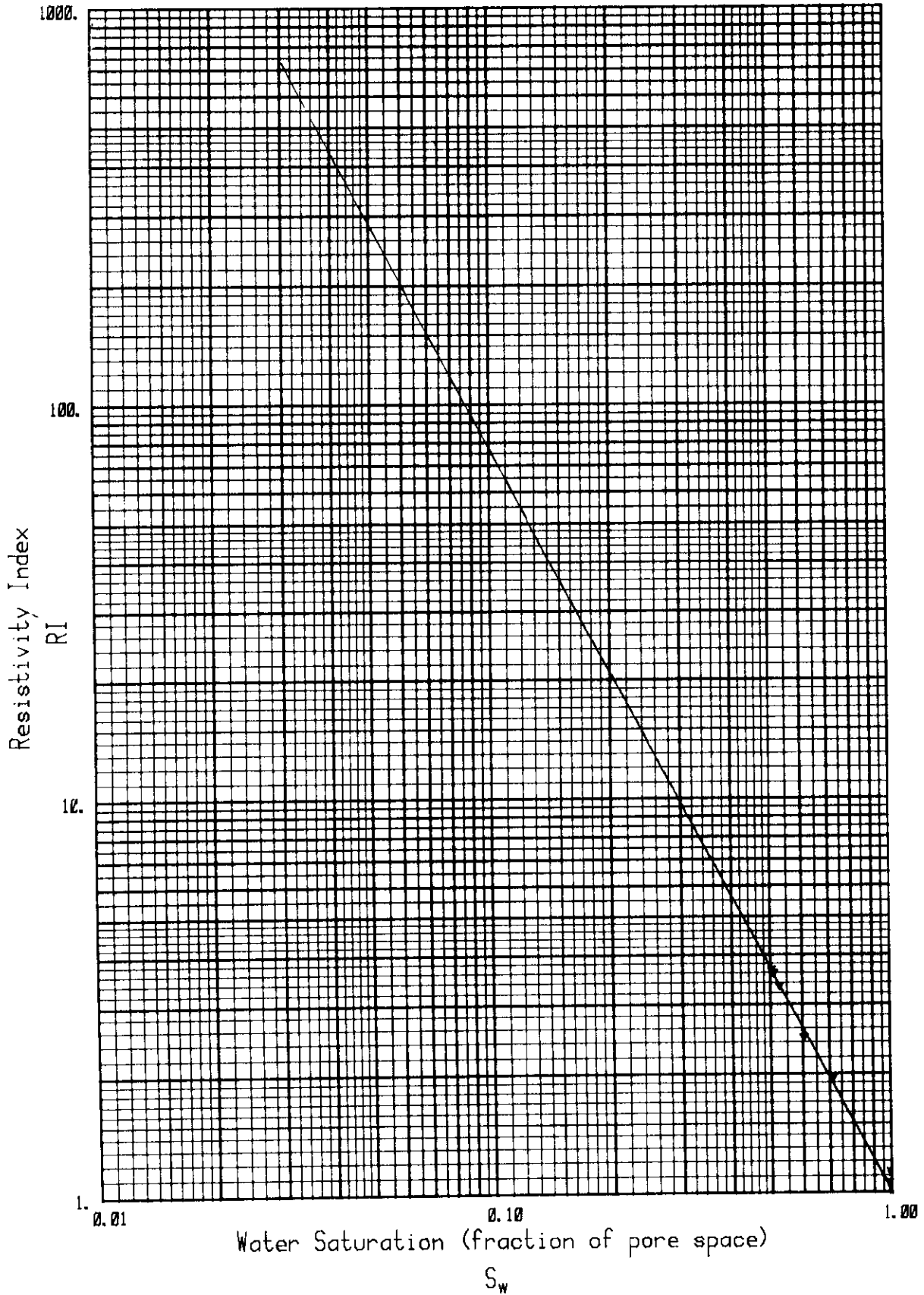
RESISTIVITY INDEX VS. WATER SATURATION



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Petroleum laboratory

Sample no: 151
Depth : 15121 ft.
RI = 1.00 * S_w^{-1.88}

Klink. perm.: 1.95 mD
Porosity : 15.2 %
FF : 35.1





CAPILLARY PRESSURE - RESISTIVITY INDEX

Sample no.: 173

Depth: 15146 ft.

Klink. perm.: 0.036 mD

Porosity: 10.7 %

Grain density: 2.68 g/cm³

FF= 89.9 (room conditions)

| Capillary pressure (psig.) | Water saturation S _w (frac.) | Resistivity index RI |
|----------------------------------|---|----------------------------|
| 0.0 | 1.00 | 1.00 |
| 1.5 | 0.987 | 1.03 |
| 3.0 | 0.973 | 1.05 |
| 8.0 | 0.963 | 1.06 |
| 15.0 | 0.954 | 1.08 |
| 30.0 | 0.947 | 1.10 |
| 60.0 | 0.936 | 1.13 |
| 180.0 | 0.929 | 1.14 |

$$RI = S_w^{-1.76}$$

CAPILLARY PRESSURE (POROUS PLATE)



Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

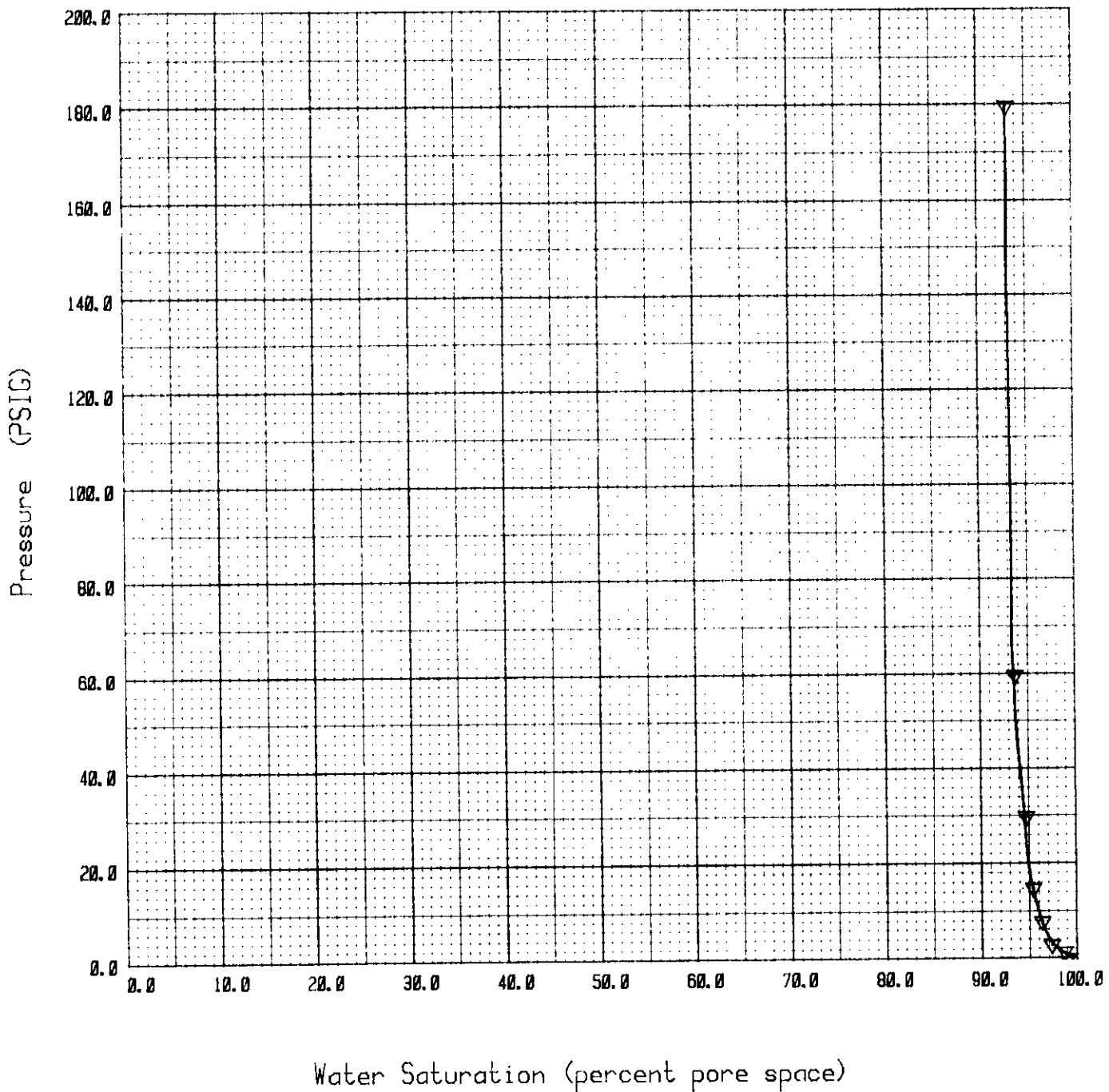
Klink. perm.: 0.036 mD

Sample no : 173

Porosity : 10.7 %

Depth : 15146 ft.

Grain dens. : 2.68 g/cm³



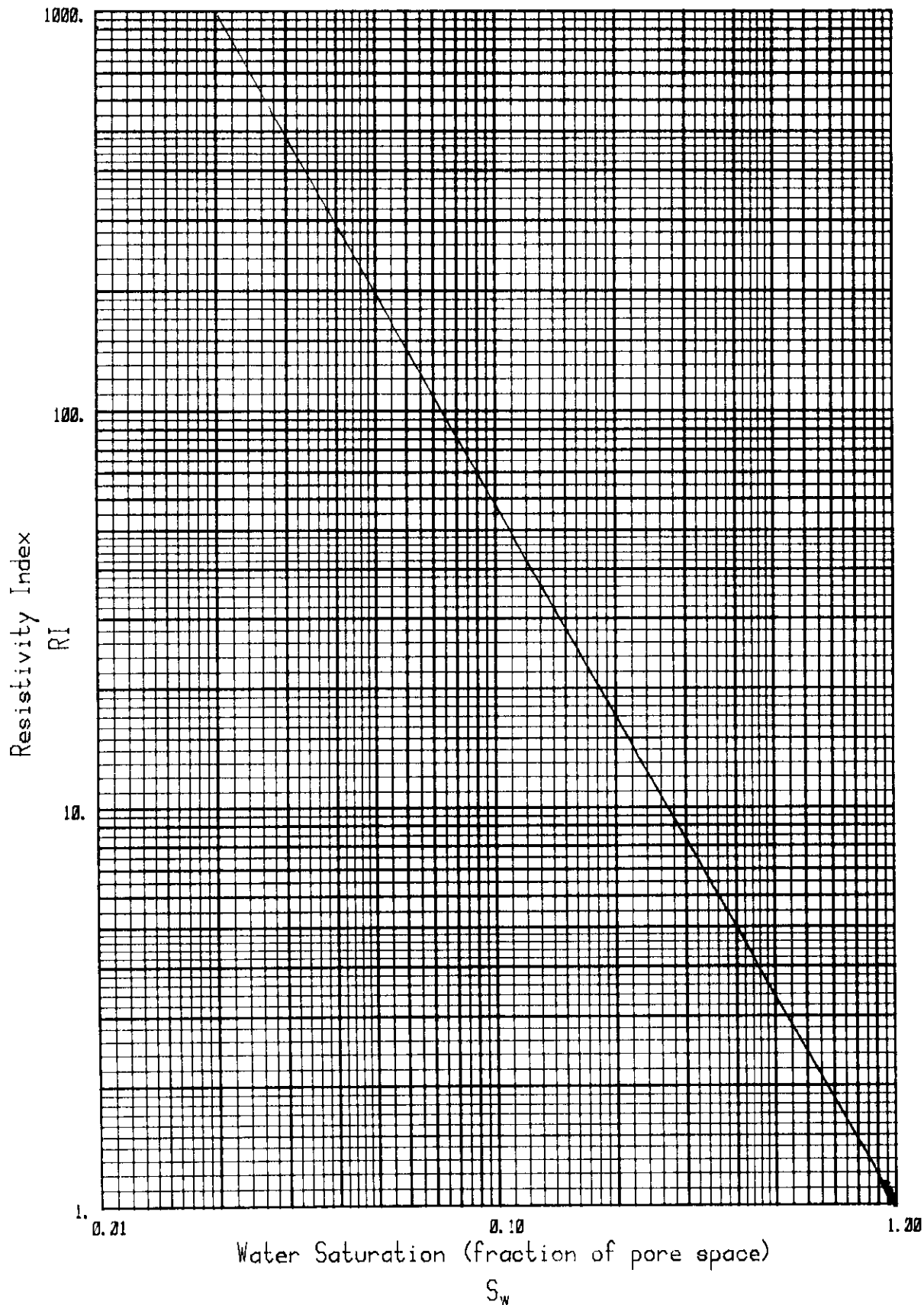
RESISTIVITY INDEX VS. WATER SATURATION



GECO
GEOPHYSICAL COMPANY
OF NORWAY A.S.
Petroleum laboratory

Sample no: 173
Depth : 15146 ft.
RI = 1.00 * S_w^{-1.76}

Klink. perm.: 0.036mD
Porosity : 10.7 %
FF : 89.9





KLINKENBERG PERMEABILITY (k.e.l.) / S_{wi} & SATURATION EXPONENT

| Sample no. | Depth (ft.) | Porosity % | Klink. perm. k.e.l. (mD) | Irreducible water saturation S_{wi} | Saturation exponent n |
|------------|-------------|------------|--------------------------|---------------------------------------|-----------------------|
| 4 | 14928 | 16.9 | 14.8 | 0.320 | 2.03 |
| 12 | 14938 | 15.4 | 0.864 | 0.640 | 1.74 |
| 18 | 14944 | 9.31 | 0.064 | 0.805 | 1.88 |
| 80 | 14963 | 7.76 | 0.356 | 0.629 | 1.98 |
| 32 | 14991 | 6.21 | 0.044 | 0.940 | 1.74 |
| 123 | 14974 5" | 6.35 | 0.003 | 0.955 | 1.94 |
| 130 | 14983 9" | 7.65 | 0.019 | 0.942 | 1.73 |
| 85 | 15015 | 5.48 | 0.017 | 0.932 | 1.70 |
| 103 | 15034 | 13.0 | 0.304 | 0.938 | 2.02 |
| 116 | 15049 | 9.25 | 0.011 | 0.959 | 1.66 |
| 41 | 15058 | 9.26 | 0.015 | 0.963 | 1.93 |
| 53 | 15072 | 13.1 | 0.182 | 0.956 | 1.76 |
| 76 | 15100 | 16.5 | 14.5 | 0.326 | 1.56 |
| 141 | 15110 | 5.99 | 0.035 | 0.799 | 1.74 |
| 151 | 15121 | 15.2 | 1.95 | 0.500 | 1.88 |
| 173 | 15146 | 10.7 | 0.036 | 0.929 | 1.76 |

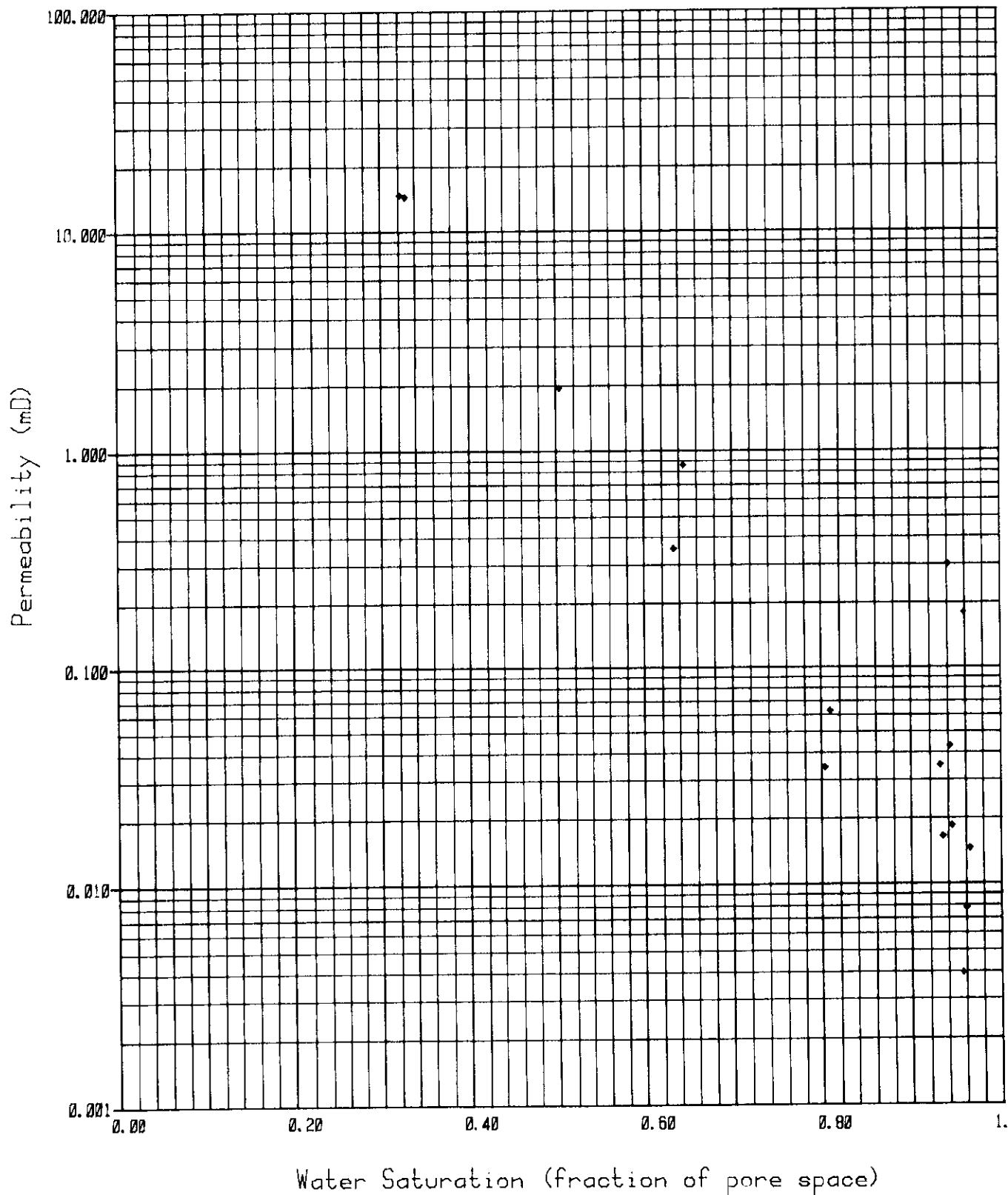
$$S_{wi} = - 0.168 \cdot \log (k.e.l.) + 0.643$$



KLINKENBERG PERMEABILITY VERSUS S_{wi}

Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7



CONFINING PRESSURE MEASUREMENTS

Sample no.: 4

Depth : 14928 ft.

| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 33.0 | 35.5 | 38.5 | 42.5 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.08 | 1.17 | 1.29 |
| Formation resistivity factor (180°F): | | 36.4 | | 45.6 |
| Porosity (%): | 16.9 | 16.9 | 16.5 | 16.1 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.976 | 0.955 |
| Pore volume (cm ³): | 13.1 | 13.1 | 12.7 | 12.4 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.972 | 0.947 |



FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE

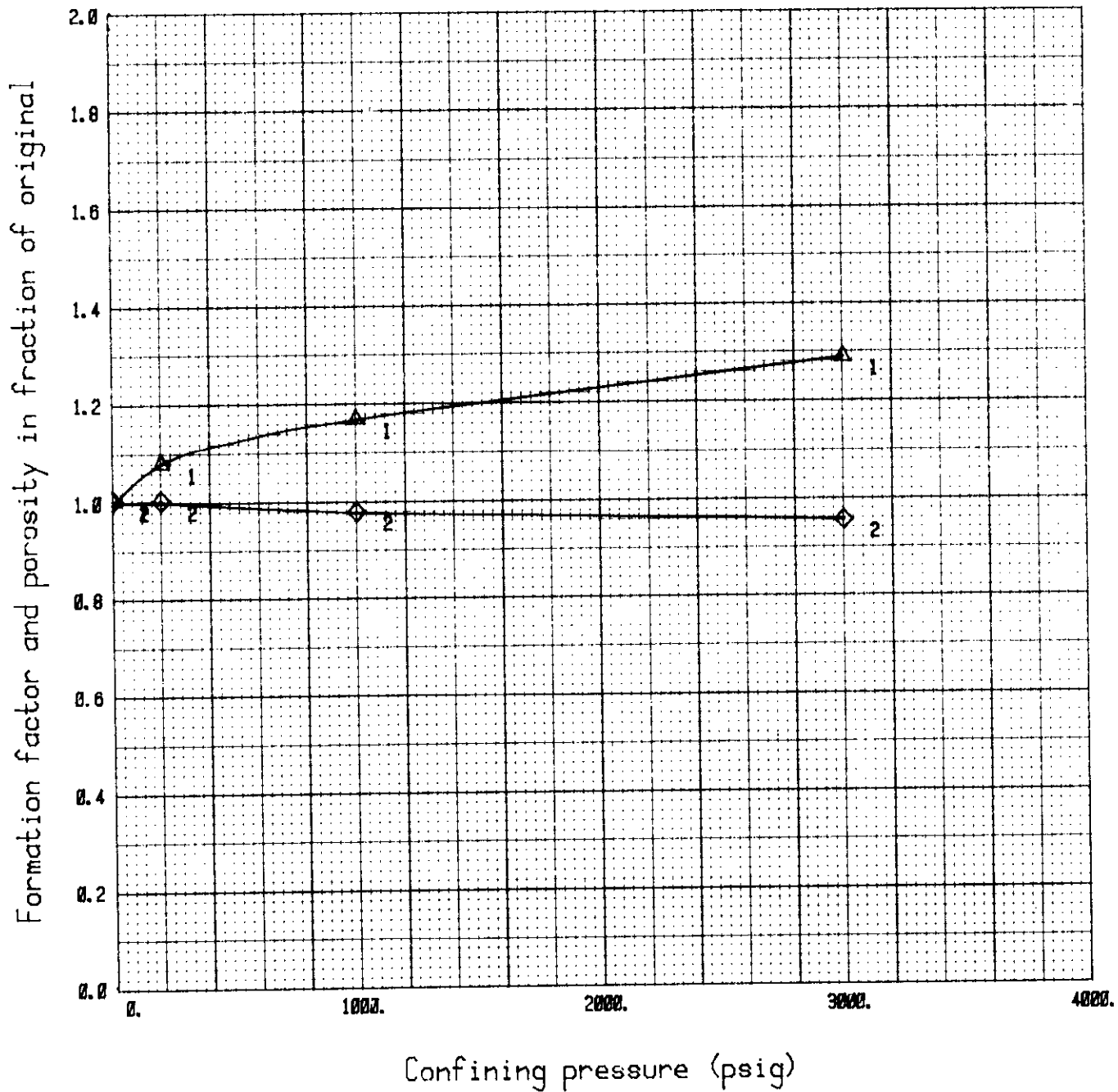


Sample no: 4

Depth : 14928 ft.

Orig. Form. factor (Curve 1): 33.0

Orig. Porosity (Curve 2): 16.9 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 12

Depth : 14938 ft.

| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 34.0 | 36.2 | 40.4 | 45.8 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.07 | 1.19 | 1.35 |
| Formation resistivity factor (180°F): | | 39.5 | | 53.6 |
| Porosity (%): | 15.4 | 15.4 | 15.1 | 14.7 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.979 | 0.953 |
| Pore volume (cm ³): | 11.9 | 11.9 | 11.6 | 11.2 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.947 | 0.945 |

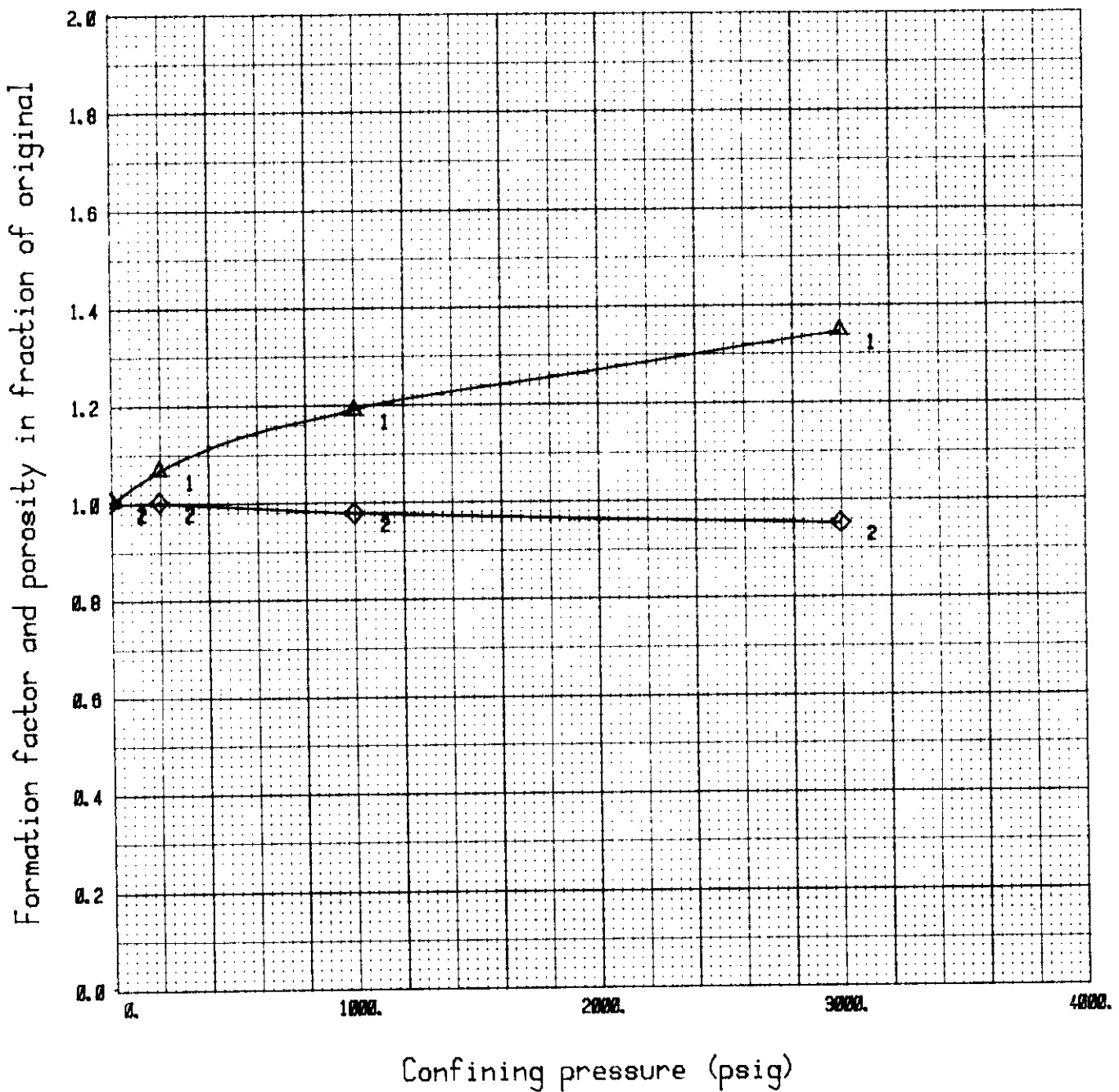


FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 12
Depth : 14938 ft.

Orig. Form. factor (Curve 1): 34.0
Orig. Porosity (Curve 2): 15.4 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 18

Depth : 14944 ft.

| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 104 | 109 | 118 | 135 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.05 | 1.14 | 1.30 |
| Formation resistivity factor (180°F): | | 110 | | 144 |
| Porosity (%): | 9.31 | 9.31 | 9.16 | 8.97 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.984 | 0.964 |
| Pore volume (cm ³): | 7.27 | 7.27 | 7.15 | 6.99 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.983 | 0.961 |

FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE

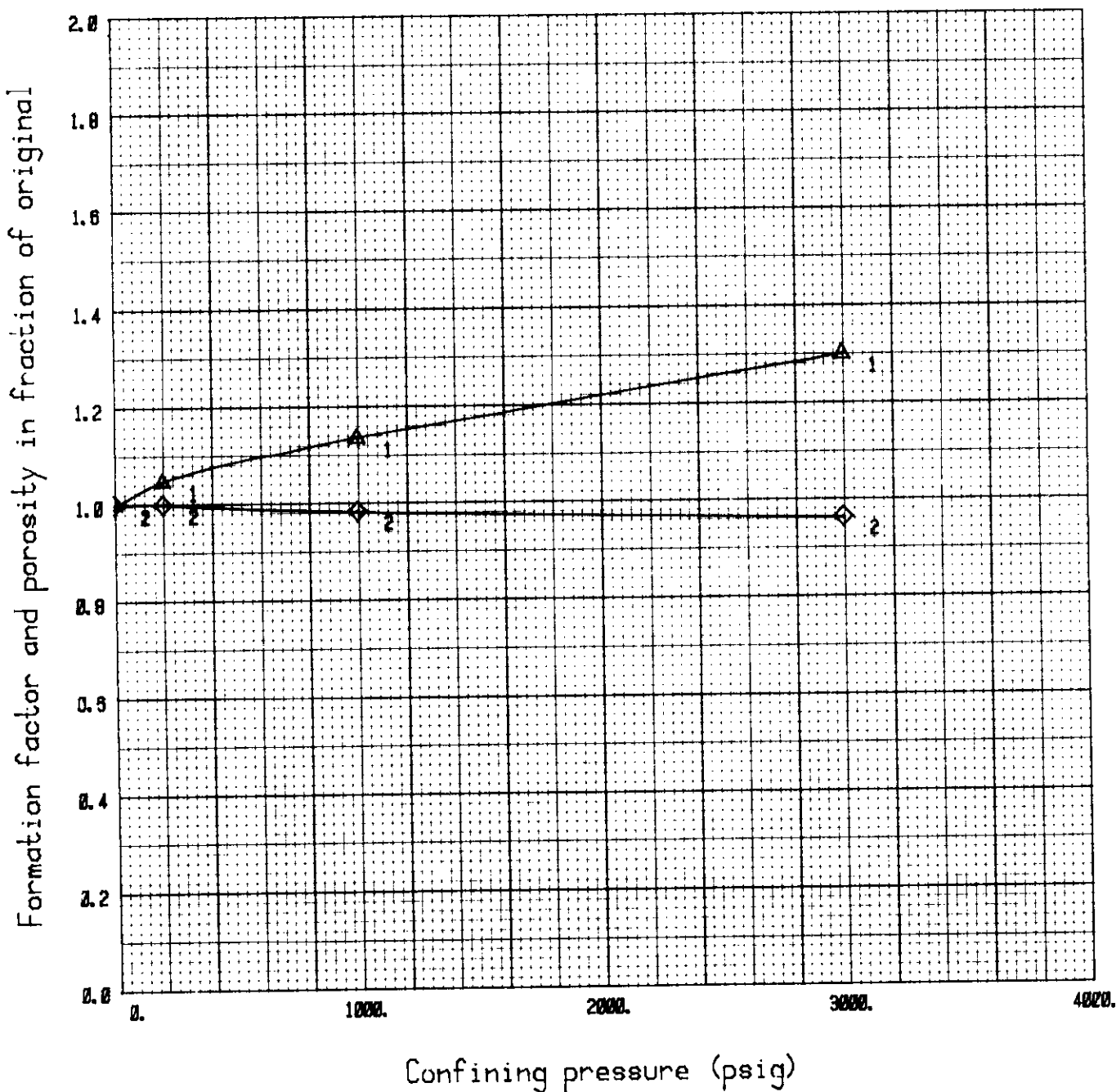


Sample no: 18

Orig. Form. factor (Curve 1): 1.04

Depth : 14944 ft.

Orig. Porosity (Curve 2): 9.31 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 80

Depth : 14963 ft.

| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 89.7 | 95.0 | 106 | 123 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.06 | 1.18 | 1.37 |
| Formation resistivity factor (180°F): | | 101 | | 141 |
| Porosity (%): | 7.76 | 7.76 | 7.53 | 7.31 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.973 | 0.946 |
| Pore volume (cm ³): | 6.10 | 6.10 | 5.92 | 5.75 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.971 | 0.942 |



FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE

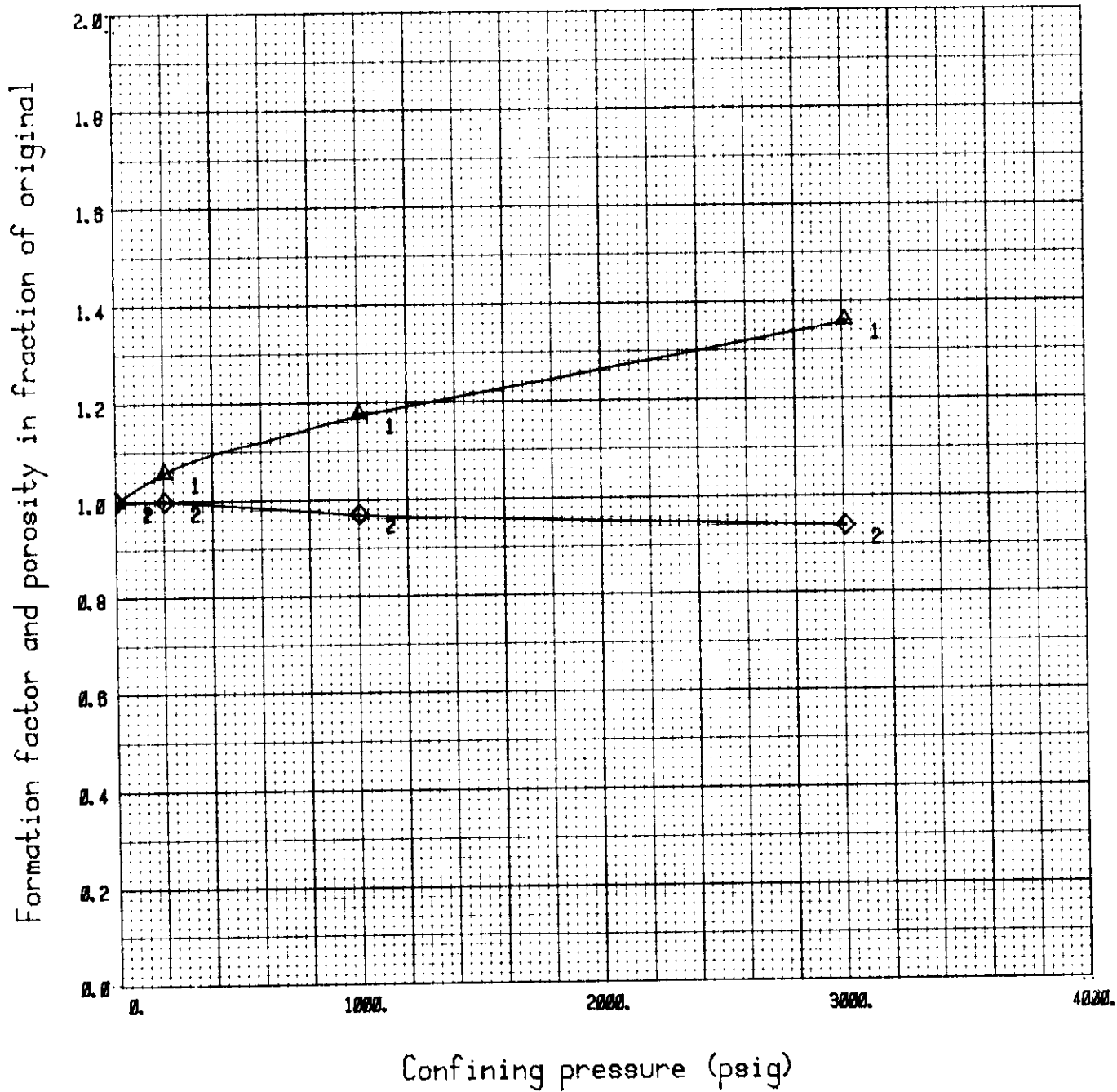


Sample no: 80

Orig. Form. factor (Curve 1): 89.7

Depth : 14963 ft.

Orig. Porosity (Curve 2): 7.76 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 32

Depth : 14991 ft.

| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 171 | 178 | 205 | 267 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.04 | 1.20 | 1.56 |
| Formation resistivity factor (180°F): | | 176 | | 288 |
| Porosity (%): | 6.21 | 6.21 | 6.04 | 5.86 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.973 | 0.944 |
| Pore volume (cm ³): | 4.87 | 4.87 | 4.74 | 4.59 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.972 | 0.941 |

FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE

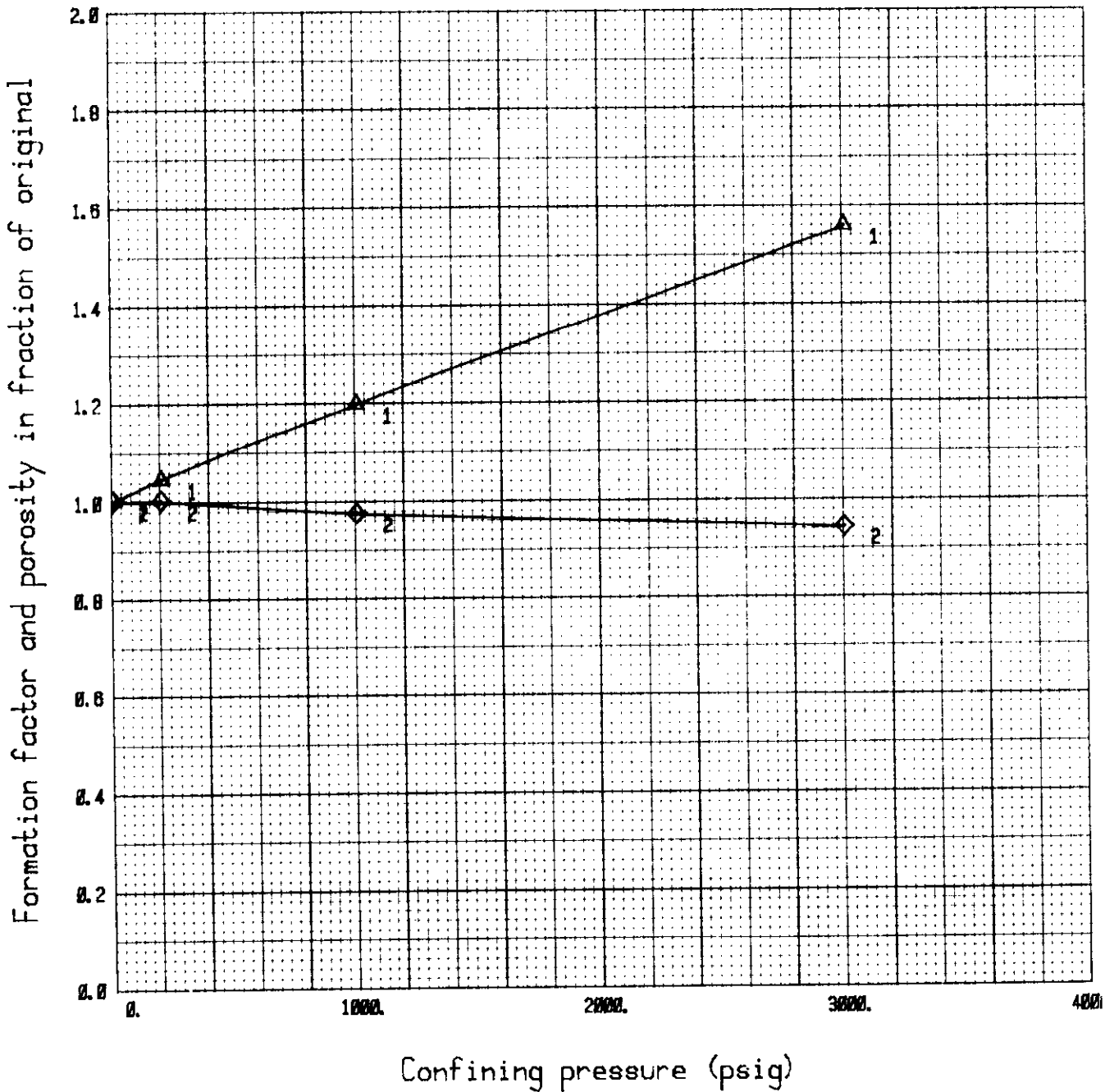


Sample no: 32

Orig. Form. factor (Curve 1): 171.

Depth : 14991 ft.

Orig. Porosity (Curve 2): 6.21 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 123

Depth : 14974 ft. 5 in.

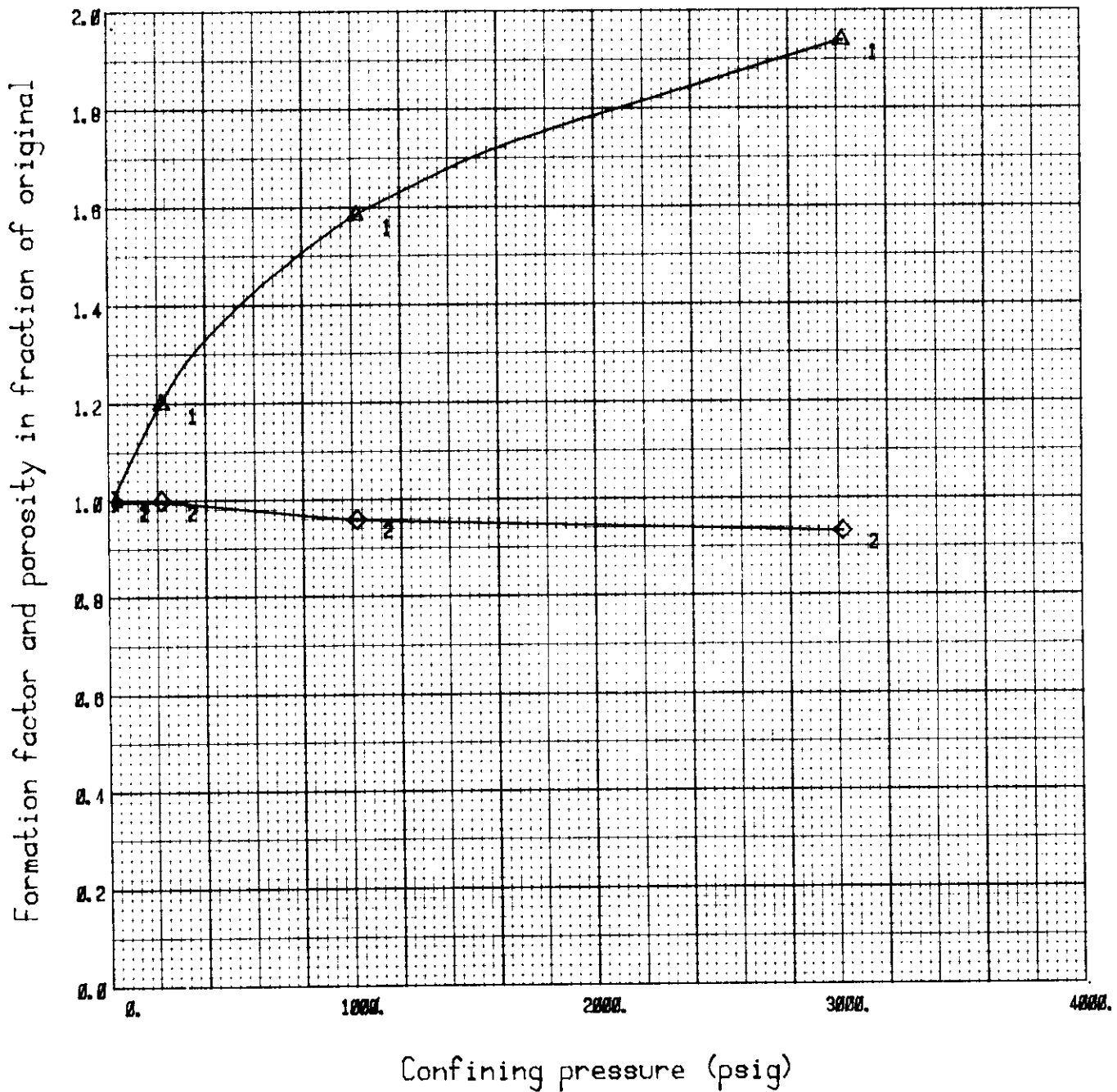
| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 142 | 170 | 225 | 276 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.20 | 1.59 | 1.94 |
| Formation resistivity factor (180°F): | | 167 | | 257 |
| Porosity (%): | 6.35 | 6.35 | 6.10 | 5.94 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.961 | 0.936 |
| Pore volume (cm ³): | 4.85 | 4.85 | 4.65 | 4.52 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.959 | 0.932 |



FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 123 Orig. Form. factor (Curve 1): 142.
Depth : 14974 ft. 5 in Orig. Porosity (Curve 2): 6.35 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 130

Depth : 14983 ft. 9 in.

| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 118 | 127 | 153 | 191 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.08 | 1.29 | 1.62 |
| Formation resistivity factor (180°F): | | 125 | | 204 |
| Porosity (%): | 7.65 | 7.65 | 7.47 | 7.21 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.978 | 0.946 |
| Pore volume (cm ³): | 5.89 | 5.89 | 5.75 | 5.55 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.976 | 0.942 |

FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE

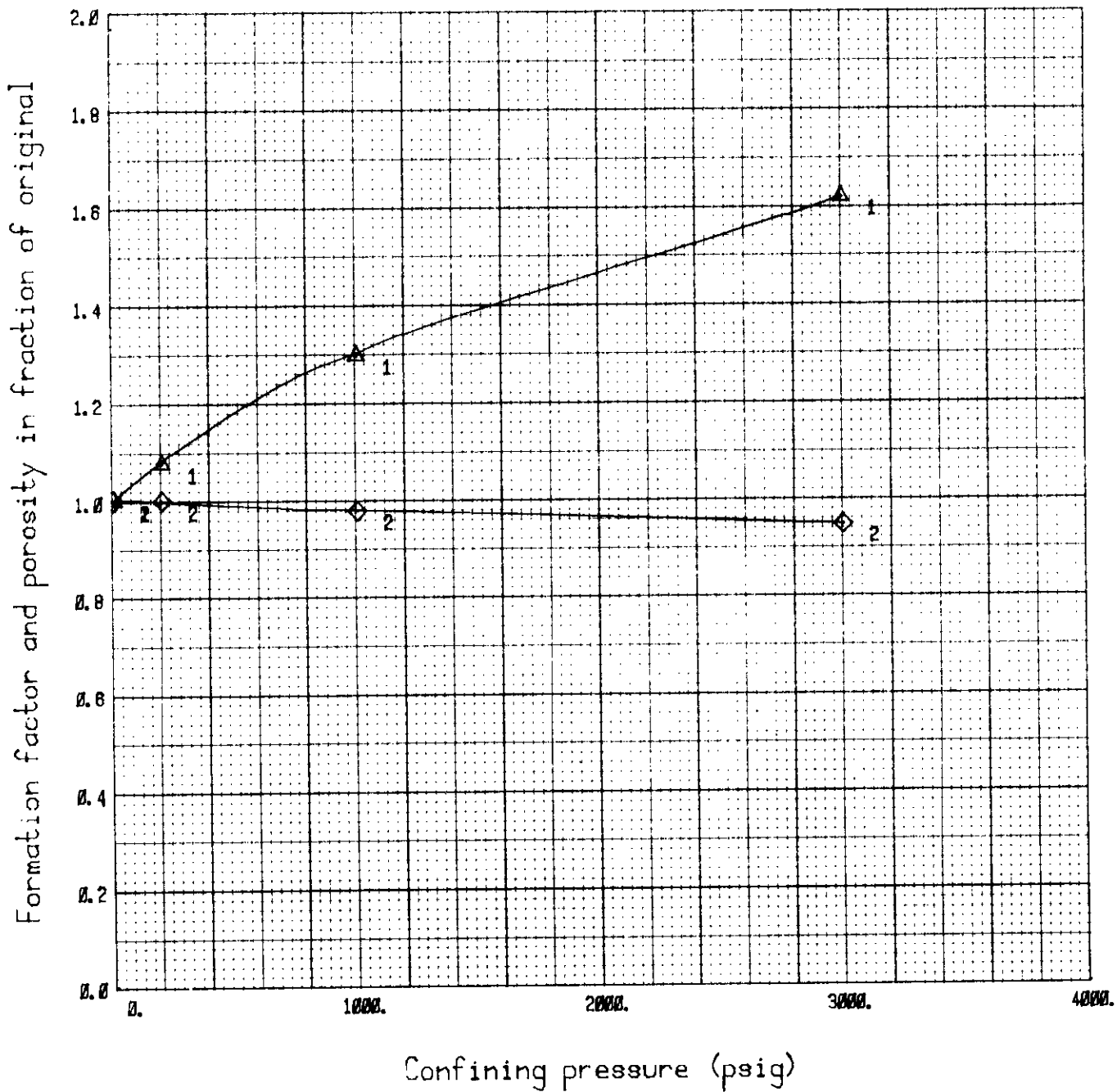


Sample no: 130

Orig. Form. factor (Curve 1): 118

Depth : 14983 ft. 9 in

Orig. Porosity (Curve 2): 7.65 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 85

Depth : 15015 ft.

| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 217 | 235 | 280 | 381 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.08 | 1.29 | 1.76 |
| Formation resistivity factor (180°F): | | 237 | | 416 |
| Porosity (%): | 5.48 | 5.48 | 5.28 | 5.09 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.966 | 0.933 |
| Pore volume (cm ³): | 4.29 | 4.29 | 4.14 | 3.99 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.965 | 0.930 |

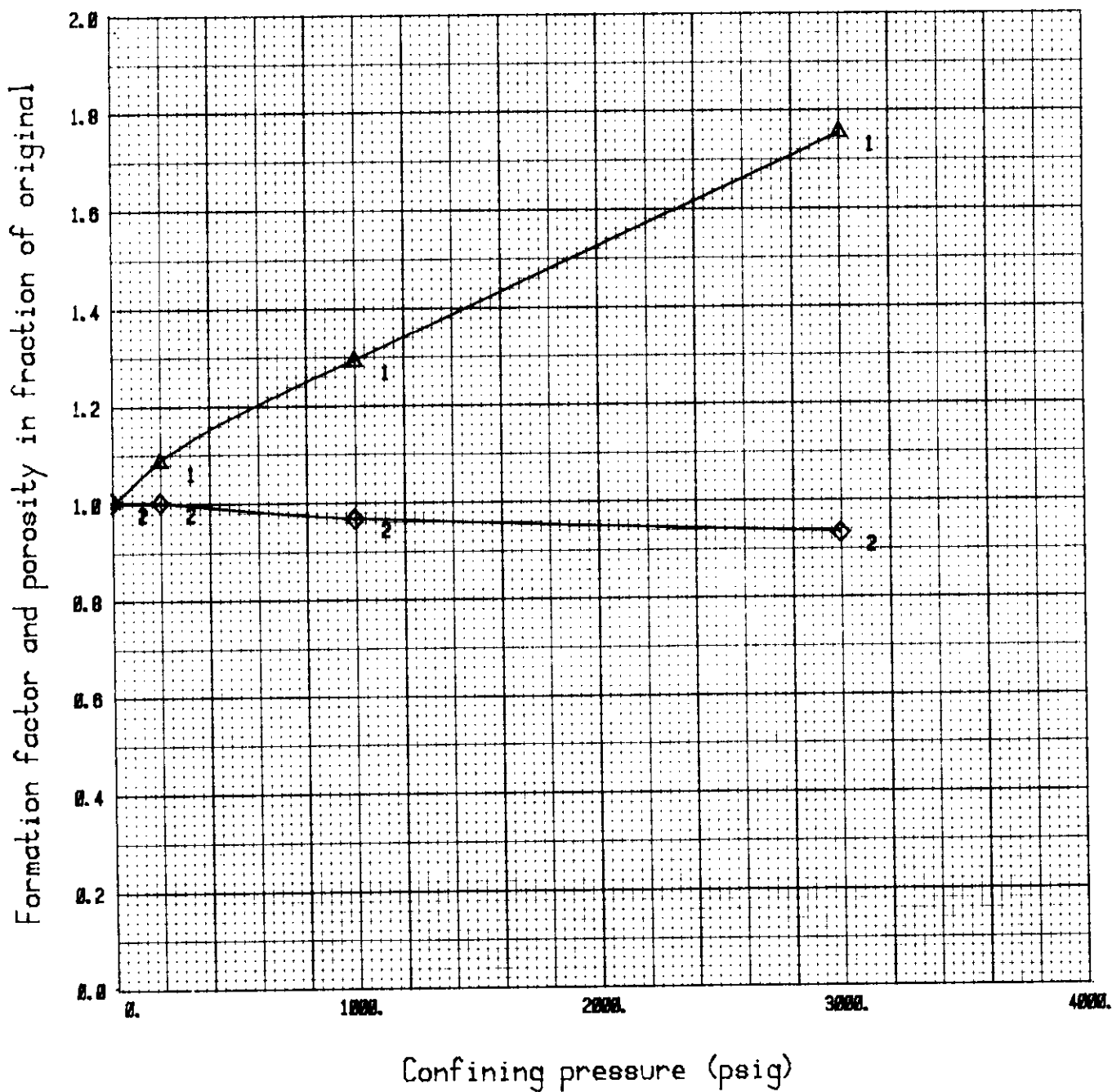


FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 85
Depth : 15015 ft.

Orig. Form. factor (Curve 1): 217.
Orig. Porosity (Curve 2): 5.48 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 103

Depth : 15034 ft.

| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 55.8 | 60.1 | 69.2 | 82.2 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.08 | 1.24 | 1.47 |
| Formation resistivity factor (180°F): | | 61.6 | | 86.0 |
| Porosity (%): | 13.0 | 13.0 | 12.6 | 12.2 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.968 | 0.938 |
| Pore volume (cm ³): | 10.0 | 10.0 | 9.68 | 9.33 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.964 | 0.929 |

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8
1



FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE

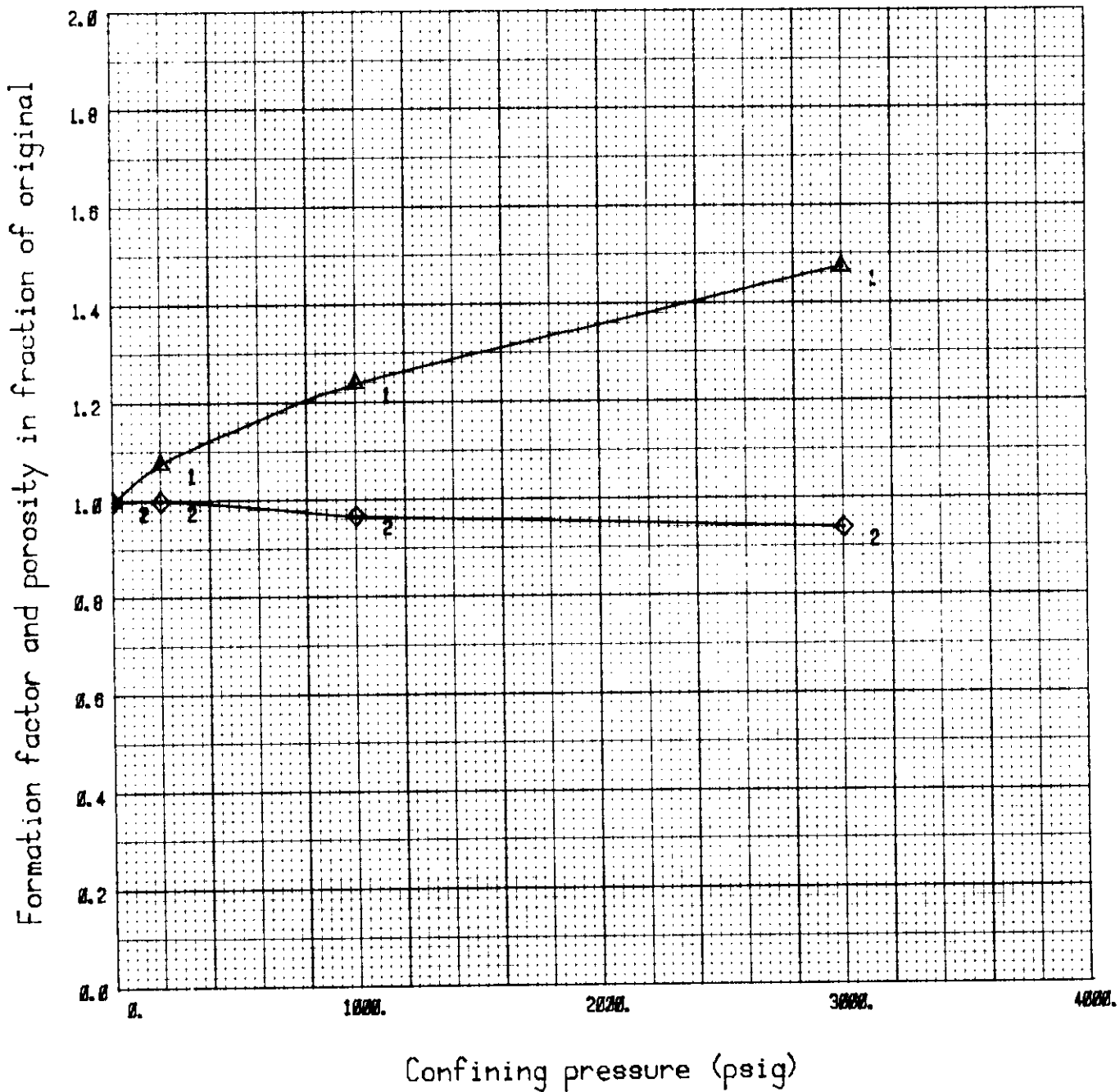


Sample no: 103

Orig. Form. factor (Curve 1): 55.8

Depth : 15034 ft.

Orig. Porosity (Curve 2): 13.0 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 116

Depth : 15049 ft.

| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 108 | 118 | 141 | 167 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.09 | 1.30 | 1.54 |
| Formation resistivity factor (180°F): | | 119 | | 168 |
| Porosity (%): | 9.25 | 9.25 | 9.10 | 8.99 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.984 | 0.972 |
| Pore volume (cm ³): | 7.09 | 7.09 | 6.97 | 6.87 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.983 | 0.970 |



FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE

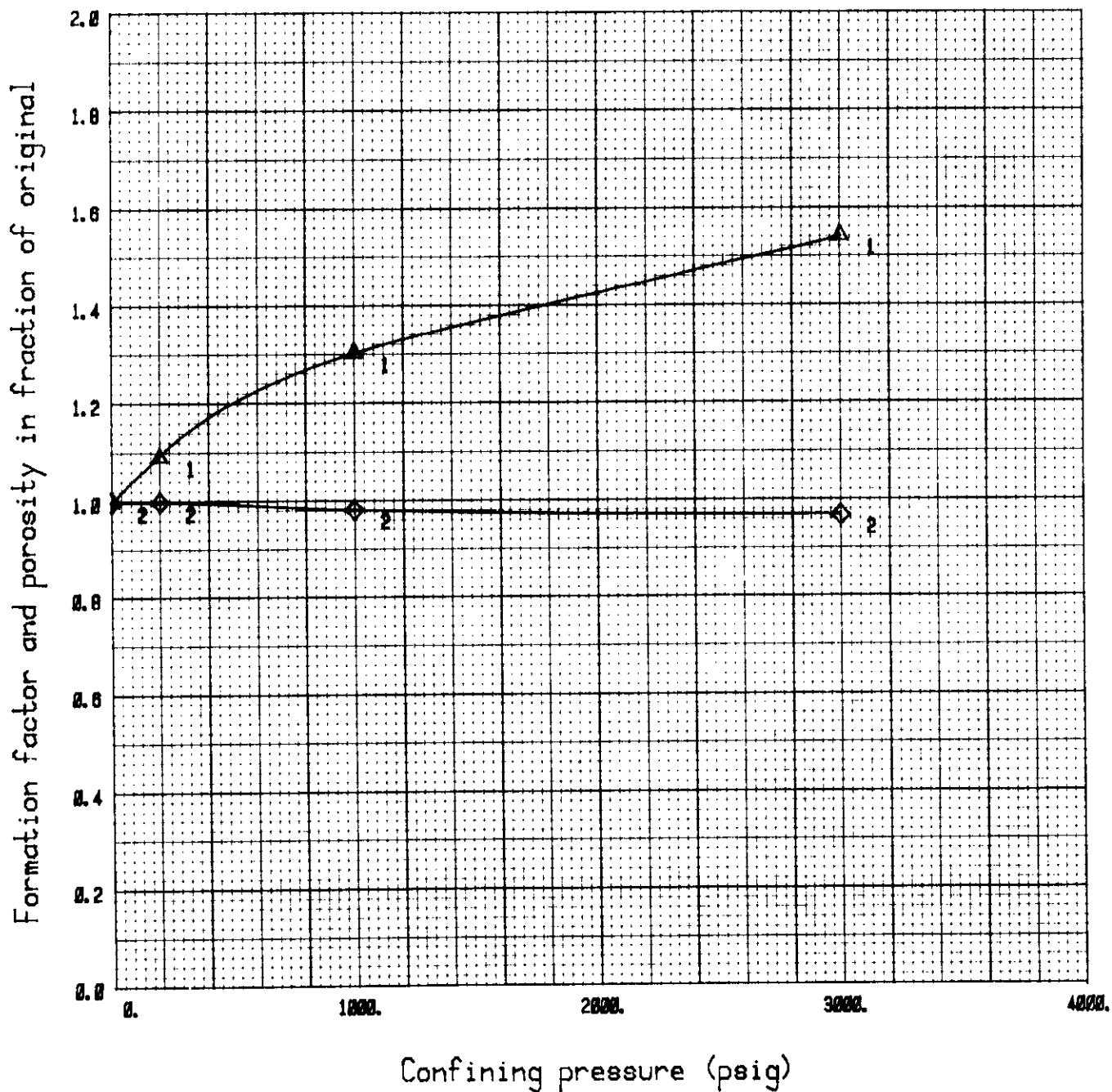


Sample no: 116

Orig. Form. factor (Curve 1): 1.08

Depth : 15049 ft.

Orig. Porosity (Curve 2): 9.25 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 41

Depth : 15058 ft.

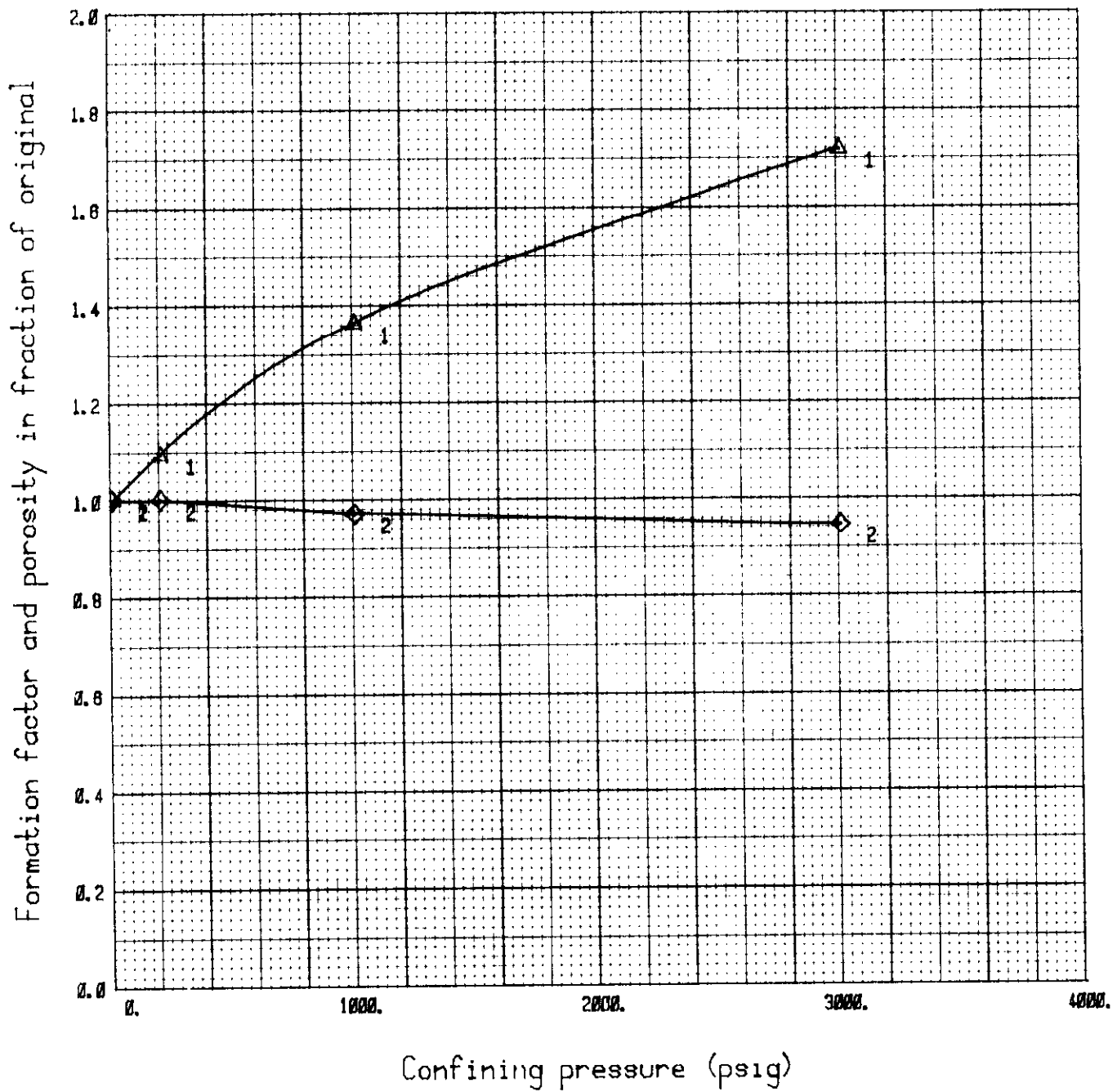
| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 92.5 | 101 | 126 | 159 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.10 | 1.37 | 1.72 |
| Formation resistivity factor (180°F): | | 104 | | 159 |
| Porosity (%): | 9.26 | 9.26 | 8.98 | 8.77 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.970 | 0.947 |
| Pore volume (cm ³): | 7.15 | 7.15 | 6.91 | 6.74 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.967 | 0.942 |

FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 41
Depth : 15058 ft.

Orig. Form. factor (Curve 1): 92.5
Orig. Porosity (Curve 2): 9.26 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 53

Depth : 15072 ft.

| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 67.0 | 71.3 | 84.3 | 103 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.06 | 1.26 | 1.54 |
| Formation resistivity factor (180°F): | | 72.5 | | 106 |
| Porosity (%): | 13.1 | 13.1 | 12.9 | 12.6 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.980 | 0.963 |
| Pore volume (cm ³): | 10.3 | 10.3 | 10.0 | 9.83 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.978 | 0.958 |

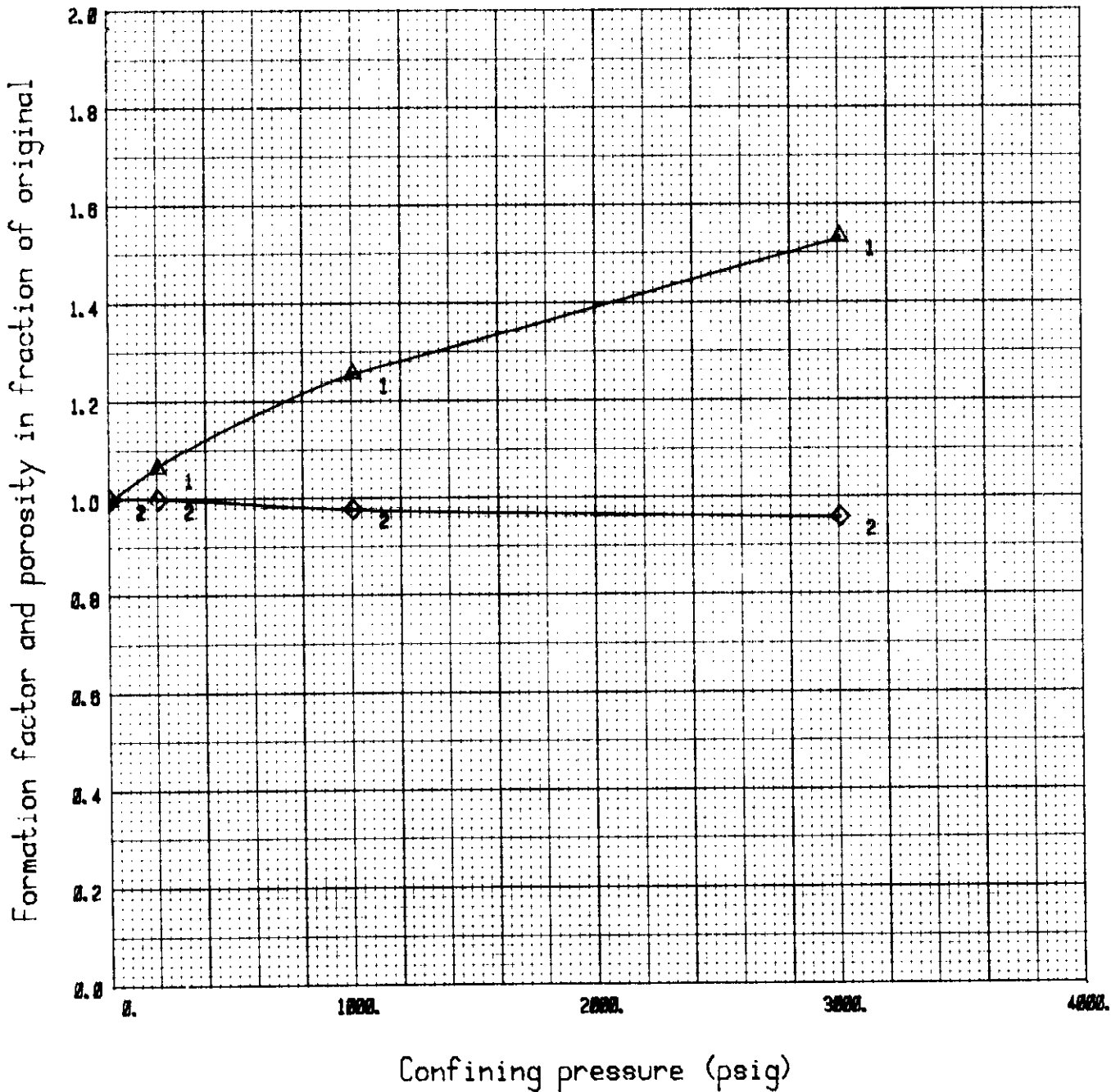


FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 53
Depth : 15072 ft.

Orig. Form. factor (Curve 1): 67.0
Orig. Porosity (Curve 2): 13.1 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 76

Depth : 15100 ft.

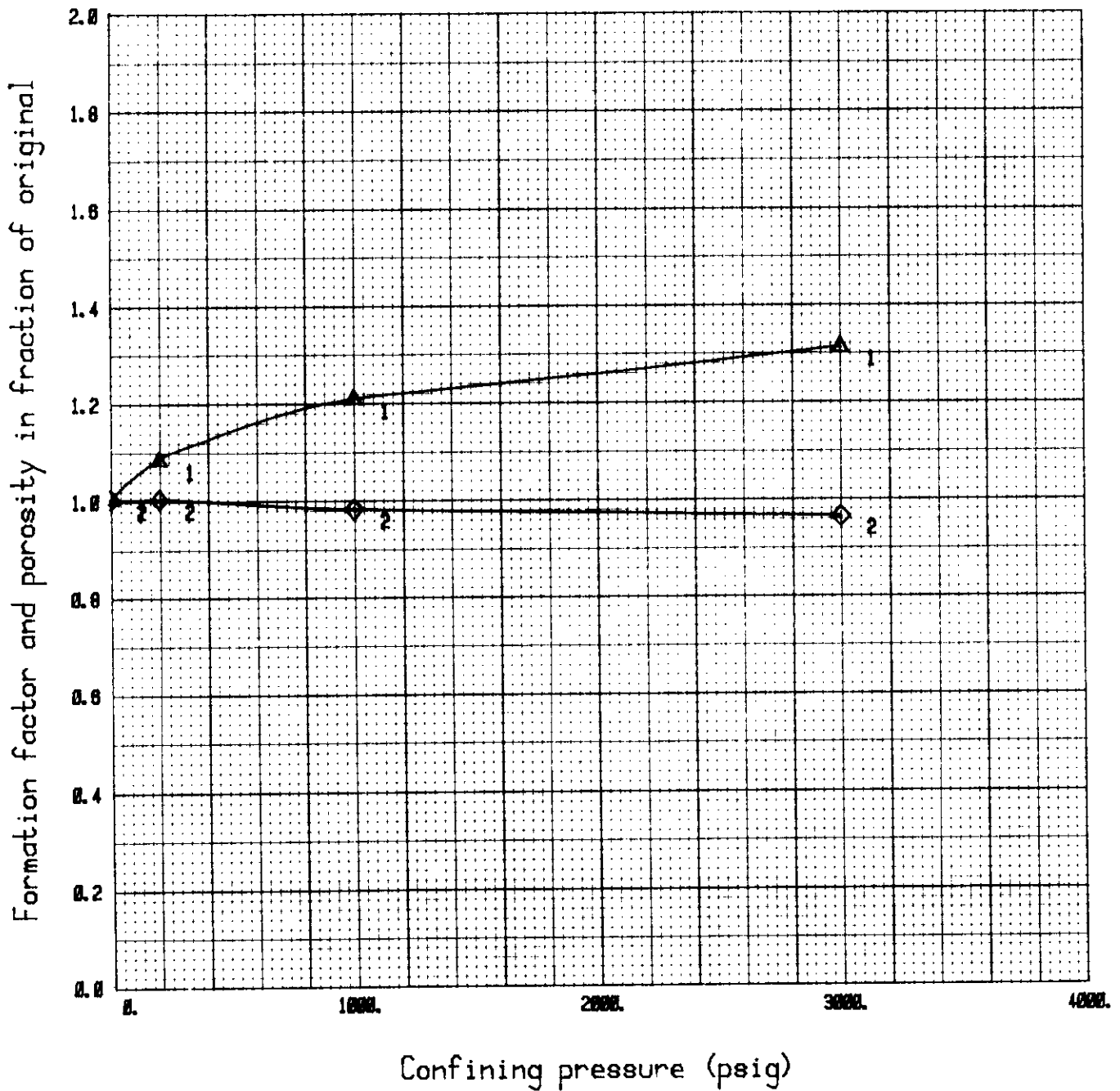
| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 27.7 | 29.9 | 33.4 | 36.3 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.08 | 1.21 | 1.31 |
| Formation resistivity factor (180°F): | | 31.1 | | 38.4 |
| Porosity (%): | 16.5 | 16.5 | 16.1 | 15.9 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.980 | 0.964 |
| Pore volume (cm ³): | 12.8 | 12.8 | 12.5 | 12.3 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.977 | 0.958 |

FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 76
Depth : 15100 ft.

Orig. Form. factor (Curve 1): 27.7
Orig. Porosity (Curve 2): 16.5 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 141

Depth : 15110 ft.

| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 178 | 192 | 225 | 285 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.06 | 1.26 | 1.60 |
| Formation resistivity factor (180°F): | | 202 | | 323 |
| Porosity (%): | 5.99 | 5.99 | 5.79 | 5.54 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.969 | 0.929 |
| Pore volume (cm ³): | 4.70 | 4.70 | 4.55 | 4.35 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.968 | 0.926 |



FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE

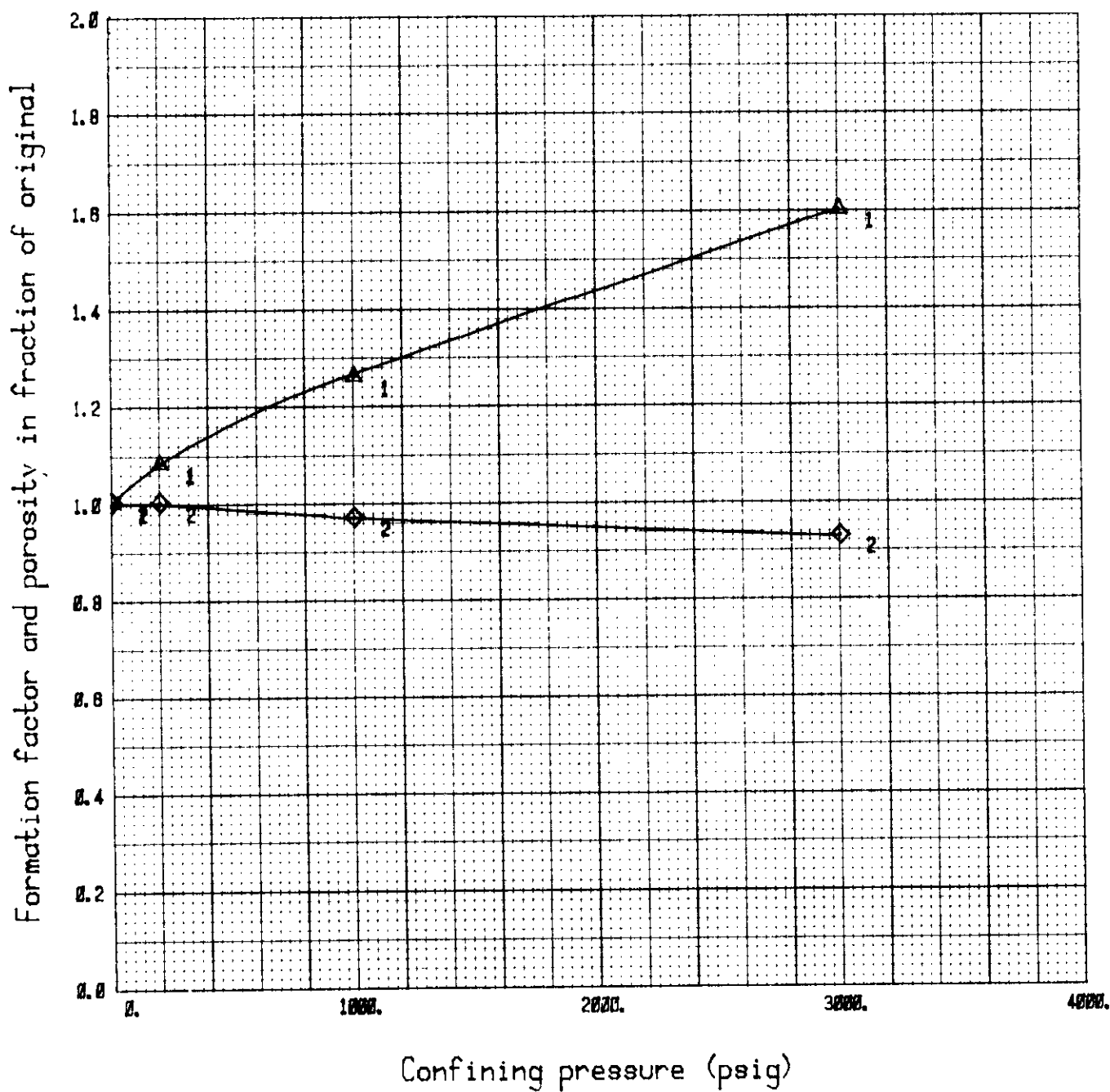


Sample no: 141

Orig. Form. factor (Curve 1): 178.

Depth : 15110 ft.

Orig. Porosity (Curve 2): 5.99 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 151

Depth : 15121 ft.

| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 35.1 | 37.8 | 42.7 | 48.0 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.08 | 1.22 | 1.37 |
| Formation resistivity factor (180°F): | | 40.4 | | 51.0 |
| Porosity (%): | 15.2 | 15.2 | 14.3 | 14.0 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.944 | 0.926 |
| Pore volume (cm ³): | 11.9 | 11.9 | 11.1 | 10.9 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.935 | 0.914 |

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100
1

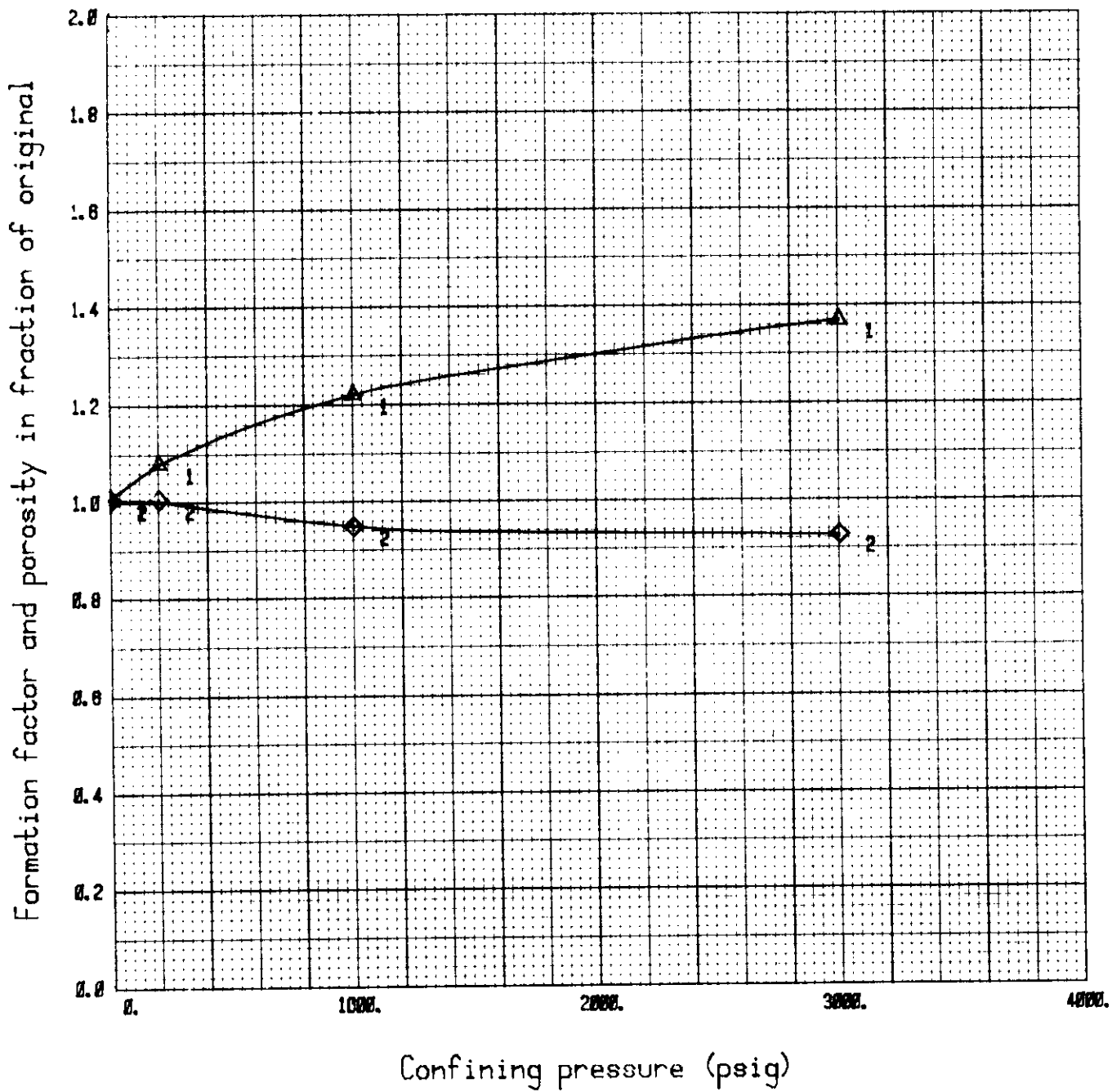


FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 151
Depth : 15121 ft.

Orig. Form. factor (Curve 1): 35.1
Orig. Porosity (Curve 2): 15.2 %



CONFINING PRESSURE MEASUREMENTS

Sample no.: 173

Depth : 15146 ft.

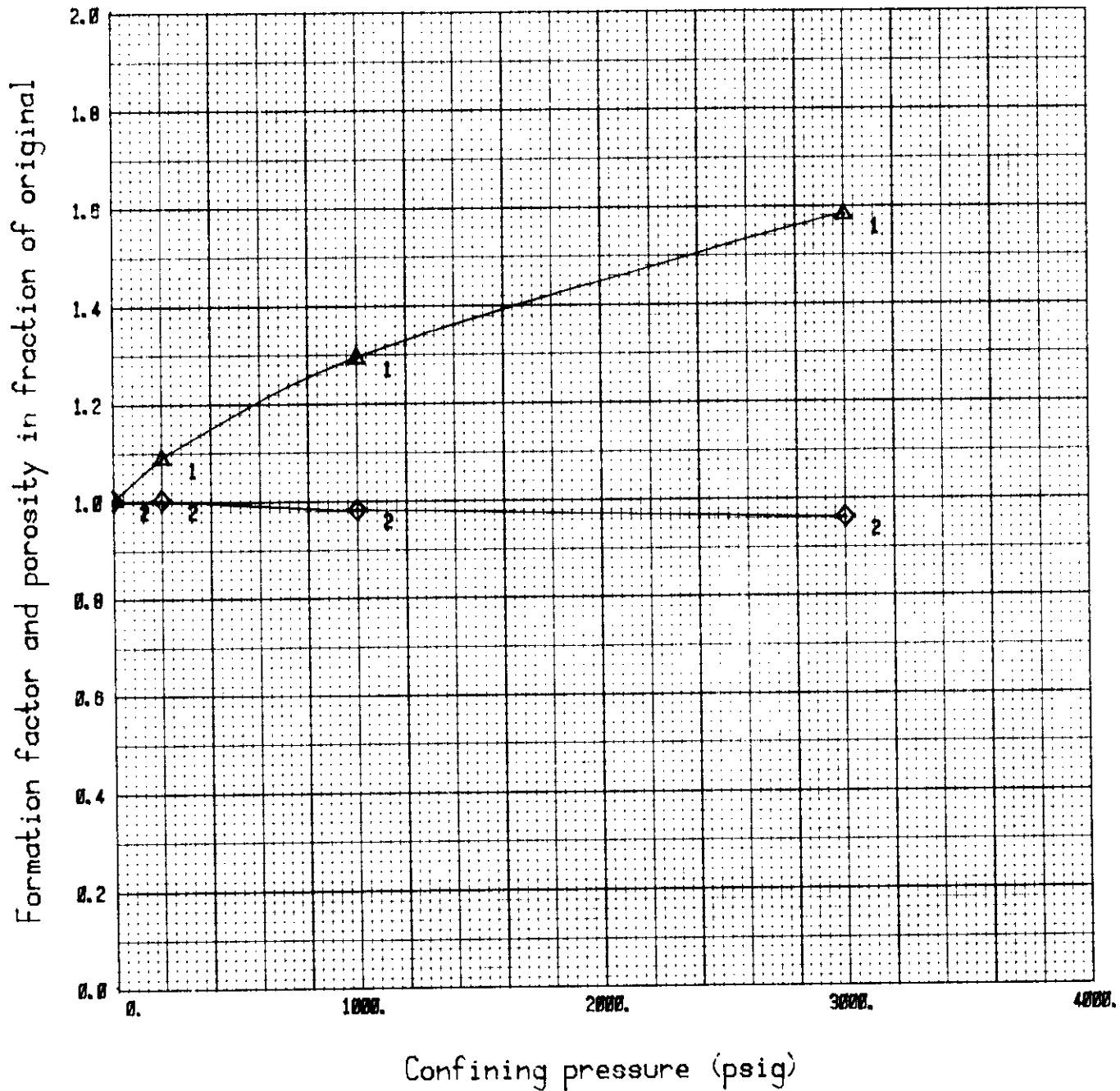
| Measurements | Atmospheric 0 psig. | 200 psig. | 1000 psig. | 3000 psig. |
|---|------------------------|-----------|------------|------------|
| Formation resistivity factor (68°F): | 89.9 | 97.5 | 116 | 142 |
| FF - increment (68°F): (frac. of original) | 1.00 | 1.09 | 1.29 | 1.58 |
| Formation resistivity factor (180°F): | | 101 | | 151 |
| Porosity (%): | 10.7 | 10.7 | 10.4 | 10.2 |
| Porosity reduction: (frac. of original) | 1.00 | 1.00 | 0.979 | 0.960 |
| Pore volume (cm ³): | 8.15 | 8.15 | 7.96 | 7.79 |
| Pore volume reduction: (frac. of original) | 1.00 | 1.00 | 0.976 | 0.956 |

FORMATION FACTOR AND POROSITY VERSUS CONFINING PRESSURE



Sample no: 173
Depth : 15146 ft.

Orig. Form. factor (Curve 1): 89.9
Orig. Porosity (Curve 2): 10.7 %



CONFINING PRESSURE: FORMATION FACTOR / POROSITY

| Sample no. | Atmospheric 0 psig. 68°F | | 200 psig. 68°F | | 200 psig. 180°F | | 1000 psig. 68°F | | 3000 psig. 68°F | | 3000 psig. 180°F | |
|---------------|--------------------------------|-----------|-------------------|-----------|--------------------|-----------|--------------------|-----------|--------------------|-----------|---------------------|-----------|
| | FF | por.frac. | FF | por.frac. | FF | por.frac. | FF | por.frac. | FF | por.frac. | FF | por.frac. |
| 4 | 33.0 | 0.169 | 35.5 | 0.169 | 36.4 | 0.169 | 38.5 | 0.165 | 42.5 | 0.161 | 45.6 | 0.161 |
| 12 | 34.0 | 0.154 | 36.2 | 0.154 | 39.5 | 0.154 | 40.4 | 0.151 | 45.8 | 0.147 | 53.6 | 0.147 |
| 18 | 104 | 0.093 | 109 | 0.093 | 110 | 0.093 | 118 | 0.092 | 135 | 0.090 | 144 | 0.090 |
| 80 | 89.7 | 0.078 | 95.0 | 0.078 | 101 | 0.078 | 106 | 0.075 | 123 | 0.073 | 141 | 0.073 |
| 32 | 171 | 0.062 | 178 | 0.062 | 176 | 0.062 | 205 | 0.060 | 267 | 0.059 | 288 | 0.059 |
| 123 | 142 | 0.064 | 170 | 0.064 | 167 | 0.064 | 225 | 0.061 | 276 | 0.059 | 257 | 0.059 |
| 130 | 118 | 0.077 | 127 | 0.077 | 125 | 0.077 | 153 | 0.075 | 191 | 0.072 | 204 | 0.072 |
| 85 | 217 | 0.055 | 235 | 0.055 | 237 | 0.055 | 280 | 0.053 | 381 | 0.051 | 416 | 0.051 |
| 103 | 55.8 | 0.130 | 60.1 | 0.130 | 61.6 | 0.130 | 69.2 | 0.126 | 82.2 | 0.122 | 86.0 | 0.122 |



CONFINING PRESSURE: FORMATION FACTOR / POROSITY

| Sample no. | Atmospheric 0 psig. 68°F | | 200 psig. 68°F | | 200 psig. 180°F | | 1000 psig. 68°F | | 3000 psig. 68°F | | 3000 psig. 180°F | |
|------------|--------------------------------|-----------|-------------------|-----------|--------------------|-----------|--------------------|-----------|--------------------|-----------|---------------------|-----------|
| | FF | por.frac. | FF | por.frac. | FF | por.frac. | FF | por.frac. | FF | por.frac. | FF | por.frac. |
| 116 | 108 | 0.093 | 118 | 0.093 | 119 | 0.093 | 141 | 0.091 | 167 | 0.090 | 168 | 0.090 |
| 41 | 92.5 | 0.093 | 101 | 0.093 | 104 | 0.093 | 126 | 0.090 | 159 | 0.088 | 159 | 0.088 |
| 53 | 67.0 | 0.131 | 71.3 | 0.131 | 72.5 | 0.131 | 84.3 | 0.129 | 103 | 0.126 | 106 | 0.126 |
| 76 | 27.7 | 0.165 | 29.9 | 0.165 | 31.1 | 0.165 | 33.4 | 0.161 | 36.3 | 0.159 | 38.4 | 0.159 |
| 141 | 178 | 0.060 | 192 | 0.060 | 202 | 0.060 | 225 | 0.058 | 285 | 0.055 | 323 | 0.055 |
| 151 | 35.1 | 0.152 | 37.8 | 0.152 | 40.4 | 0.152 | 42.7 | 0.143 | 48.0 | 0.140 | 51.0 | 0.140 |
| 173 | 89.9 | 0.107 | 97.5 | 0.107 | 101 | 0.107 | 116 | 0.104 | 142 | 0.102 | 151 | 0.102 |

Forced fit: $FF = \phi^{-1.89}$

$FF = \phi^{-1.92}$

$FF = \phi^{-1.93}$

$FF = \phi^{-1.96}$

$FF = \phi^{-2.02}$

$FF = \phi^{-2.04}$

Free fit : $FF = 1.81 \cdot \phi^{-1.64}$

$FF = 1.88 \cdot \phi^{-1.66}$

$FF = 2.11 \cdot \phi^{-1.62}$

$FF = 1.85 \cdot \phi^{-1.71}$

$FF = 1.65 \cdot \phi^{-1.81}$

$FF = 1.80 \cdot \phi^{-1.80}$



FORMATION RESISTIVITY FACTOR VERSUS POROSITY

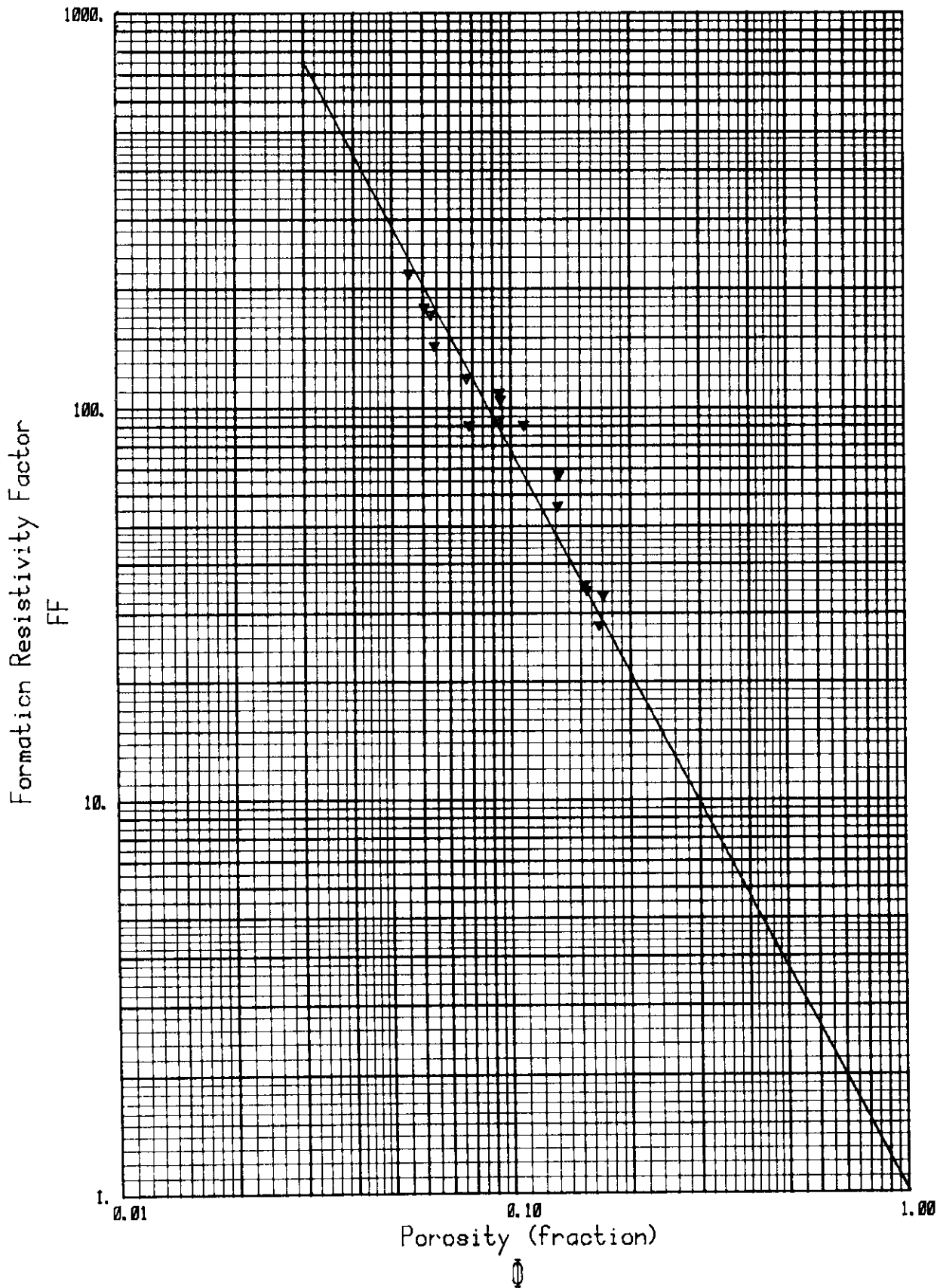


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

Atmospheric condition. (68 Deg. F.)

$$FF = 1.00 * \phi^{-1.88}$$



FORMATION RESISTIVITY FACTOR VERSUS POROSITY

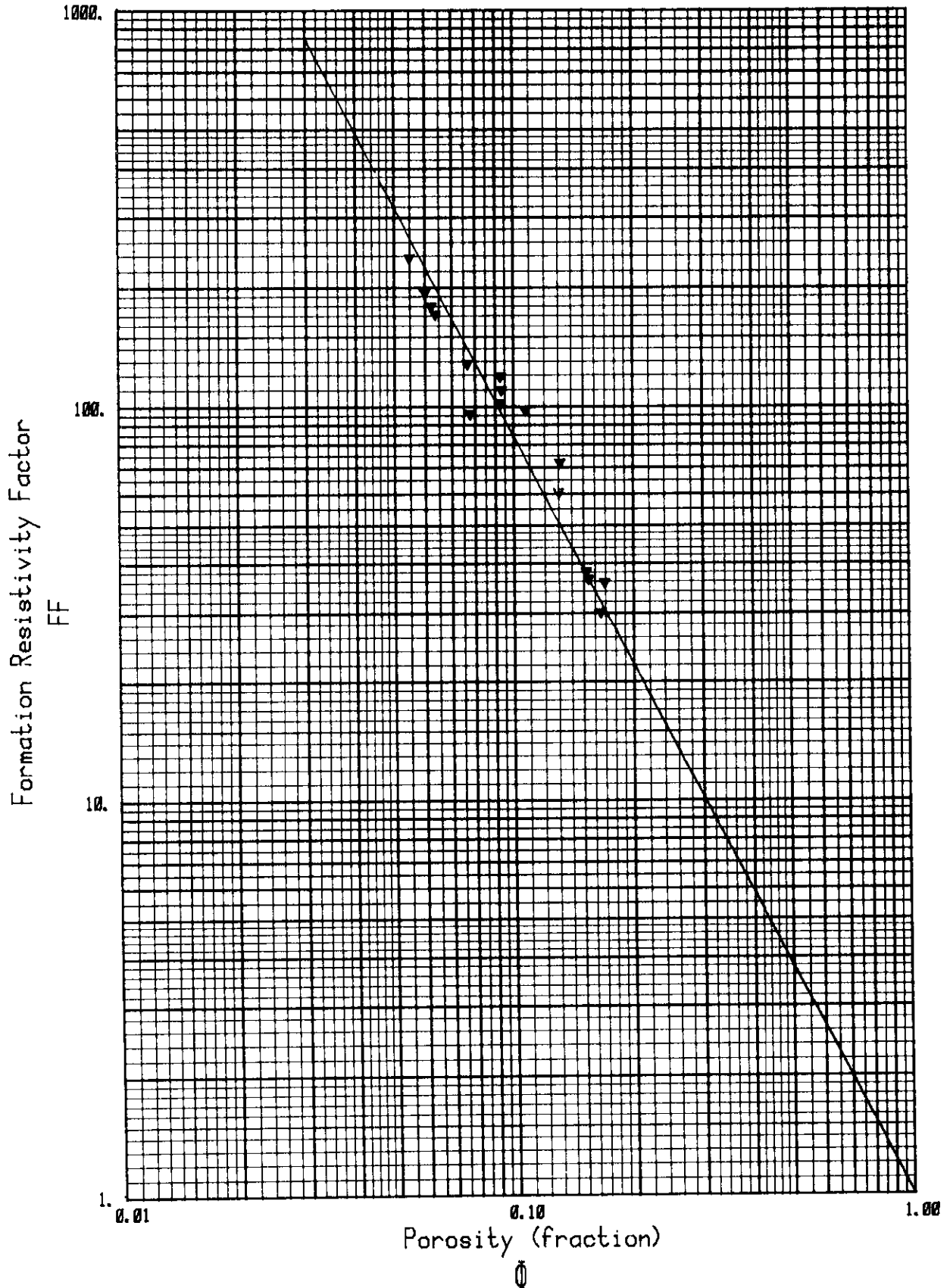


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

Confining pressure : 200 psig. (68 Deg. F.)

$$FF = 1.00 * \bar{\phi}^{-1.92}$$



FORMATION RESISTIVITY FACTOR VERSUS POROSITY

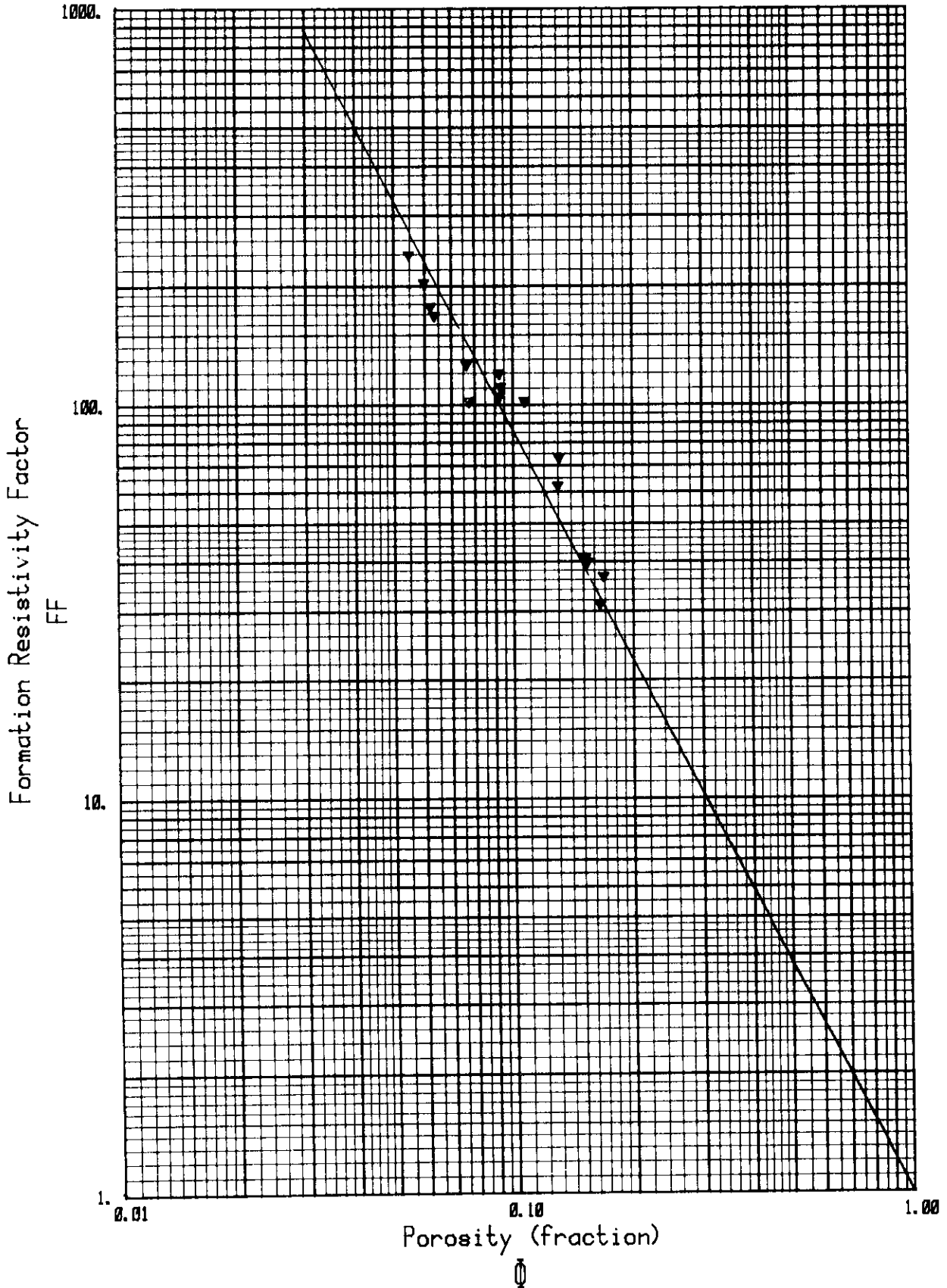


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

Confining pressure : 200 psig. (180 Deg. F.)

$$FF = 1.00 * \phi^{-1.93}$$



FORMATION RESISTIVITY FACTOR VERSUS POROSITY

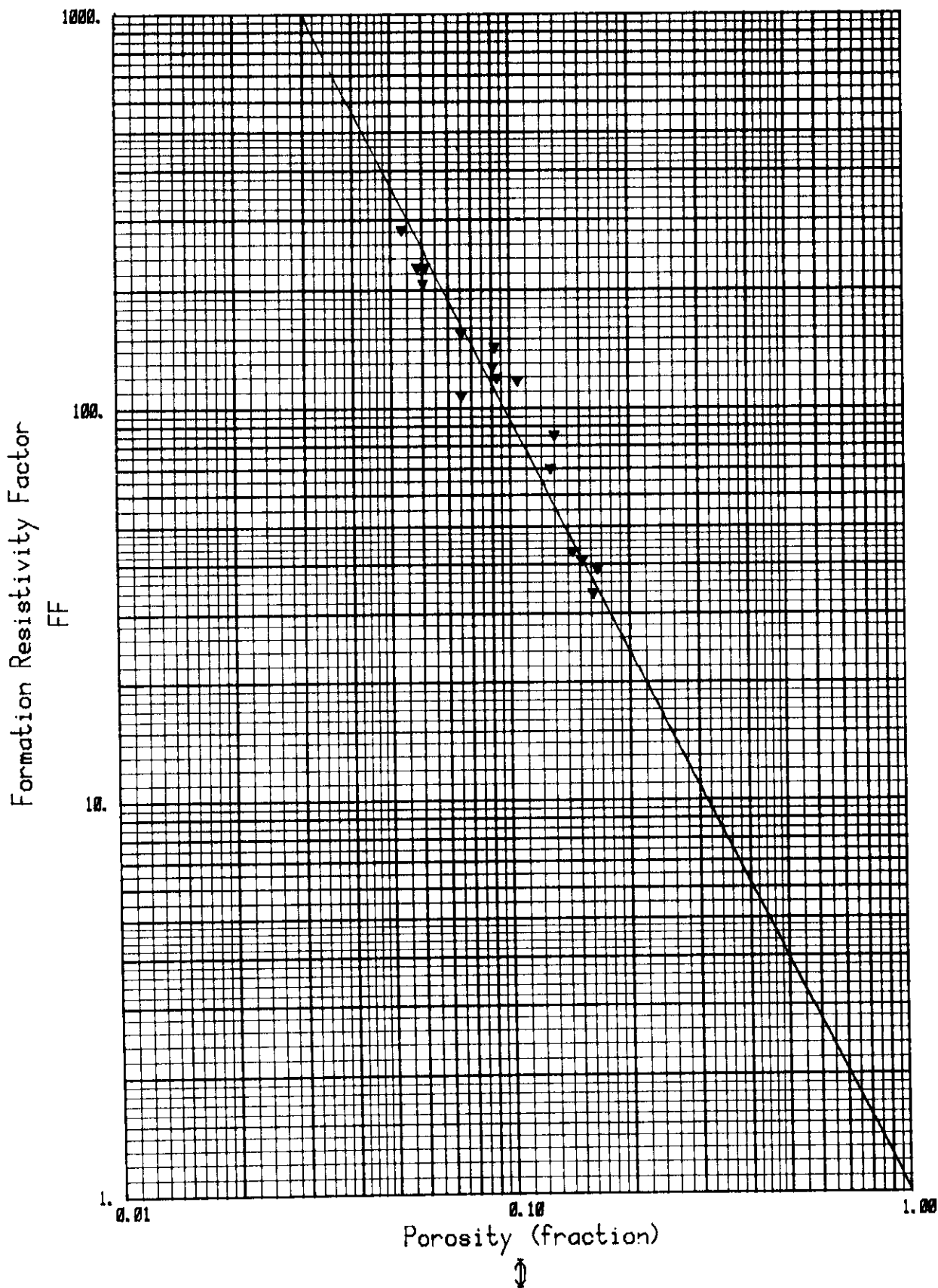


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

Confining pressure : 10000 psig. (68 Deg. F.)

$$FF = 1.00 * \phi^{-1.96}$$



FORMATION RESISTIVITY FACTOR VERSUS POROSITY

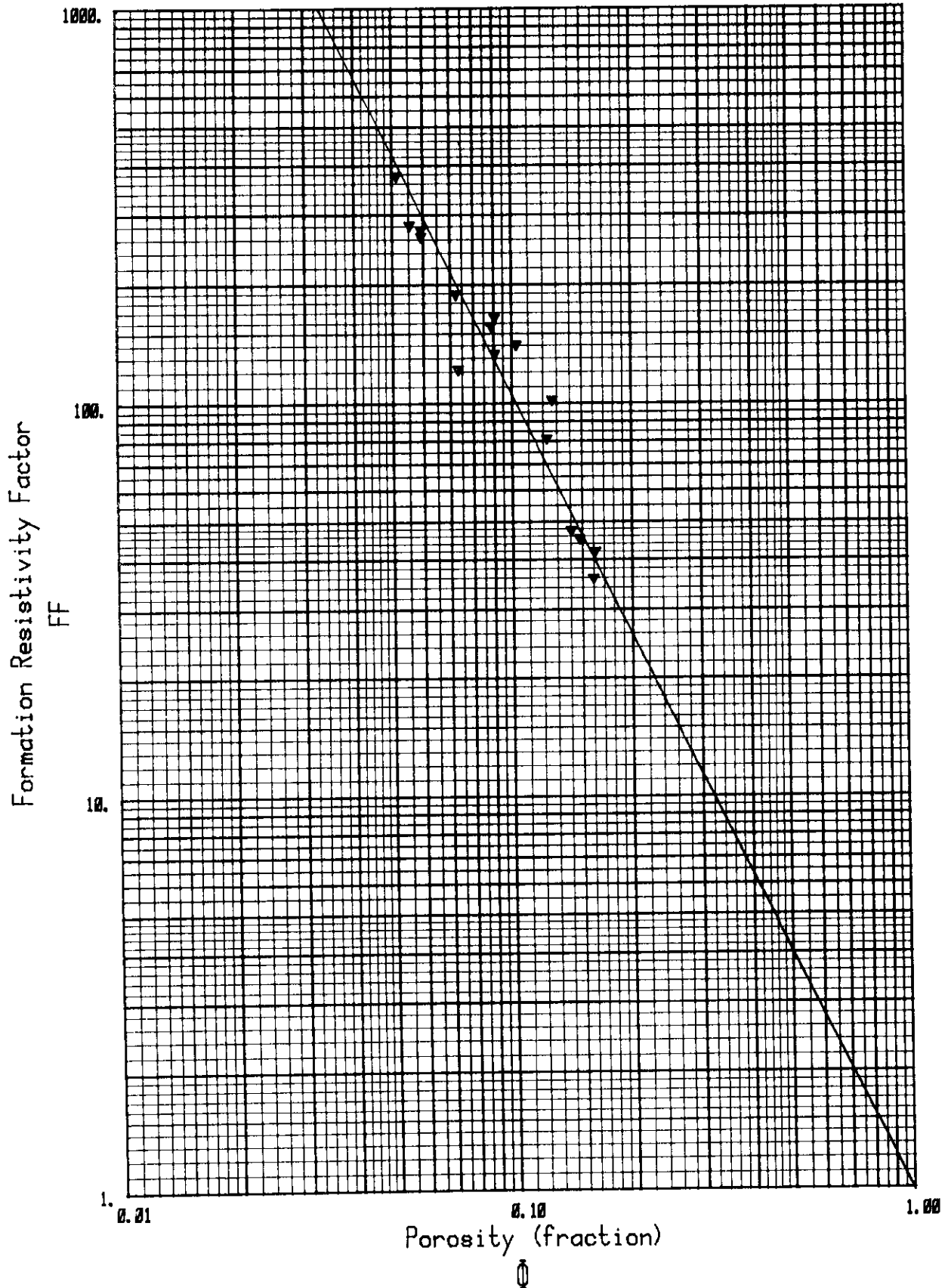


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

Confining pressure : 3000 psig. (68 Deg. F.)

$$FF = 1.00 * \phi^{-2.02}$$



FORMATION RESISTIVITY FACTOR VERSUS POROSITY

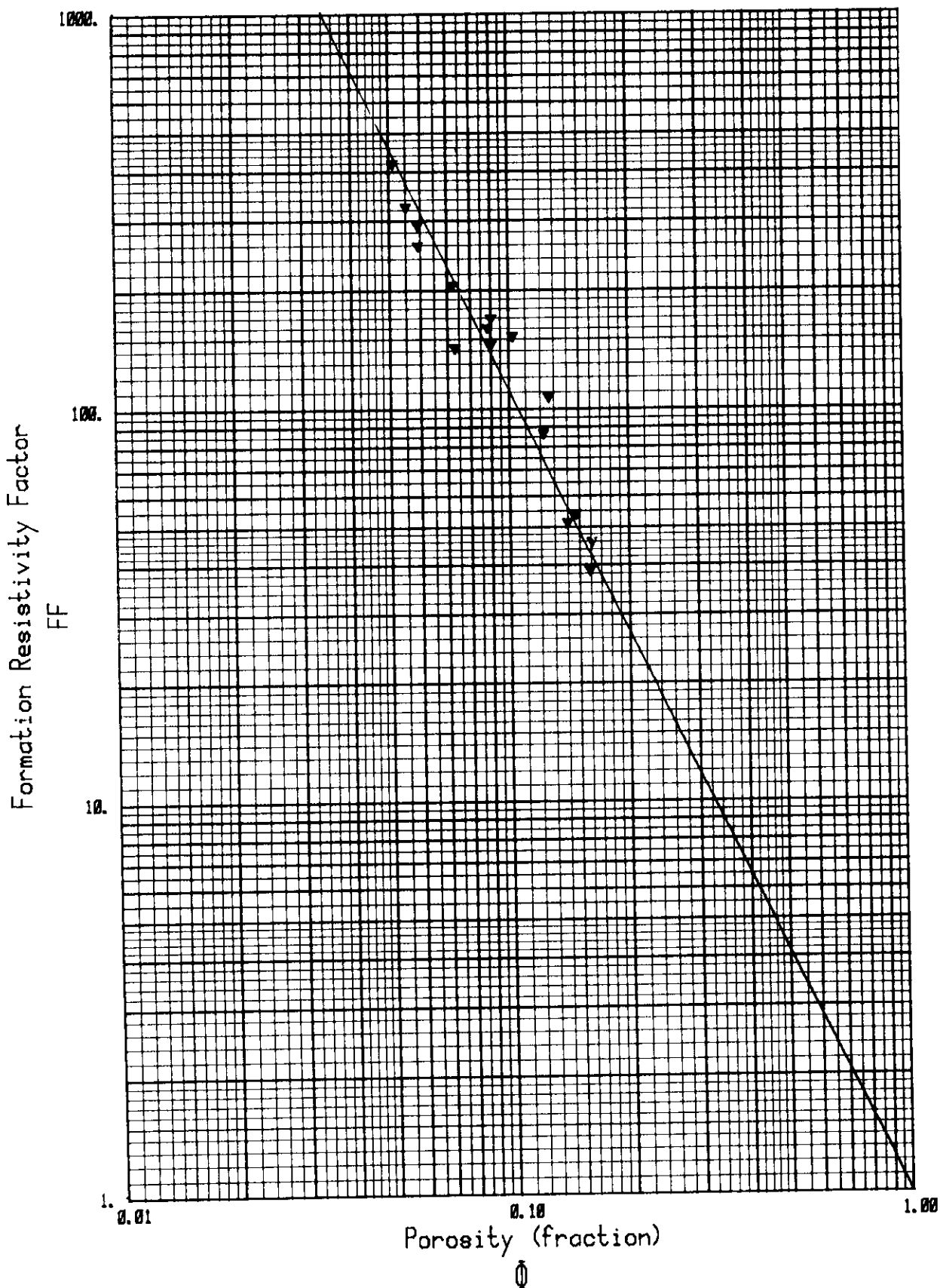


Company : PHILLIPS PETROLEUM CO. NORWAY

Well : 7/11-7

Confining pressure : 3000 psig. (180 Deg. F.)

$$FF = 1.00 * \phi^{-2.04}$$





ABBREVIATIONS

- FF = formation resistivity factor
- k_a = air permeability
- k.e.l. = Klinkenberg corrected air permeability (perm. equivalent liquid)
- n = saturation exponent in the equation $RI = b \cdot S_w^{-n}$
- RI = resistivity index = $\frac{\text{FF partially saturated}}{\text{FF 100 \% saturated}}$
- S_w = water saturation
- S_{wi} = irreducible water saturation achieved at a capillary pressure of 12 bar