# PETROPHYSICAL EVALUATION

WELL 34/10-5

BY: PETROLEUM ENGINEERING
PETRPHYSICAL GROUP
DATE: MAY 1980
ENG: J. RAFDAL

CONTENTS

GENERAL WELL DATA

NORWAY OFFSHORE

| | | |
|---|---|---|
| LICENCE | : | 050 |
| WILDCAT WELL | : | 34/10-5 |
| LOCATION | : | 61° 11' 25.32"N |
| | : | 02° 10' 23.4"E |
| SPUDDED | : | 18/10-79 |
| RIG RELEASED | : | 3/1-80 |
| KB-ELEVATION | : | 25 m |
| WATER DEPTH | : | 136 m |
| TOTAL DEPTH | : | 2780 m |
| OBJECTIVE | : | JURASSIC SANDSTONE |
| OPERATOR | : | STATOIL |
| PARTNERS | : | NORSK HYDRO, SAGA PETROLEUM |
| STATUS | : | PLUGGED AND ABANDONNED |

## Introduction

This is the fourth well drilled on the Delta-structure of block 34/10. The main objective was to test the Jurassic sandstones for hydrocarbon accumulations. The purpose of this report is to evaluate the petrophysical properties of these formations using electrical logs, core- and testdata.

## Summary

Brent formation (1896-2148 m) encountered 64.25 m of pay down to the o/w-contact at ± 1972 m. A total of 181.25 m net sand is encountered. Average porosity is 30.2% and average watersaturation in the oilzone is 20.3%.

Statfjord formations is waterbearing and encounters 120.85 m of net sand with an average porosity of 21.9%.

## Lithology

The reservoir zones have been divided into the following units.

BRENT:

| | | |
|---|---|---|
| Tarbert | (1896 - 1970) | : Clean/argillaceons sandstone with some kaolinite and some calcitic cemented streaks. |
| Ness | (1970 - 2035) | : Interbedded sand, silt shale and coal. |
| Etive | (2035 - 2070) | : Interbedded shale sand mostly clean sand. |
| Rannoch | (2070 - 2134.25) | : Argillacous sandstone. |
| Broom | (2134.25 - 2148) | : Argillacous sand silt. |
| Statfjord formation (2562 - 2764) | | : Interbedded sand shale. |

## INPUT PARAMETERS

Input parameters for the calculations have been picked from crossplots, measured data and empirical relations.

## FORMATION WATER RESISTIVITY

Two DST's have produced in this block:

| WELL | STRUCTURE | FORMATION | WATER SALINITY |
|---|---|---|---|
| 34/10-3 | Delta | Brent | 43200 ppm NaCl |
| 34/10-2 | Alpha | Statfjord | 45400 ppm NaCl |

The SP-log indicates the salinity in 34/10-3 Statfjord fm. to be in order of 45000 ppm NaCl. 45000 NaCl has been used in this report for both Statfjord and Brent formation.

In the calculations, the following formation water resistivities have been used at reservoirconditions:

Brent: 0.075 Ωm - 160°F

Statfjord: 0.066 Ωm - 180°F

Shale parameters.

The shale parameters used are listed for each sone below:

| | GR MIN | GR MAX | RTSH | RTLIM | $\rho_{bSH}$ | $\phi_{NSH}$ |
|---|---|---|---|---|---|---|
| Tarbert/Ness/Etive | 35 | 80 | 1.5 | 200 | 2.35 | .45 |
| Rannoch/Broom | 42 | 80 | 1.5 | | 2.35 | .45 |
| Statfjord | 40 | 80 | 3.0 | | 2.42 | .45 |

Mud properties.

| | at 64°F | | | at 180°F | |
|---|---|---|---|---|---|
| Brent fm. | Rm | : 0.44 m | - | 0.18 | m |
| | Rmf | : 0.23 " | - | 0.096 | " |
| | Rmc | : 0.93 " | - | 0.4 | " |
| | at 63°F | | | at 180°F | |
| Statfjord fm. | Rm | : 0.49 m | - | 0.18 | m |
| | Rmf | : 0.27 " | - | 0.098 | " |
| | Rmc | : 1.06 " | - | 0.570 | " |

Hydrocarbon density.

The hydrocarbon density have been picked from RFT pressure plots. A value of 0.785 gm/cc has been used.

Resistivity.

In Brent fm. DLL/MSFL have been used for RT/Rxo. $R_{MSFL}$ has been corrected in the following manner to obtain Rxo:

| Interval | Rxo = C x RMSFL |
|---|---|
| 1896 - 1913 | c = 0.75 |
| 1913 - 2150 | c = 0.65 |

Assuming 1/8" mudcake thickness and a mudcakeresistivity of 0.4 Ωm at reservoir conditions. Corrections are based on Schlumberger chart Rxo -2 (Sch. chart-book) RLLd was corrected according to chart Rint -9 to obtain $R_T$.
In Statfjord formation, ILD was used uncorrected for $R_T$.

## COMPUTATIONS

### Shale volume

The shale volume have been calculated using GR, DENSITY/ NEUTRON CROSSPLOT and RT. The minimum value calculated has been used for VSH. Below is listed where the different indicators have been used:

| | | |
|---|---|---|
| Brent | : | GR, PHIN/RHOB, RT |
| Statfjord | : | GR, PHIN/RHOB |

### Porosity

In Eocene, the FDC (density) has been used to compute porosity. Matrix density = 2.65 and fluid density = 1.0 was used.

In Brent and Statfjord formations a complex lithology method using density and neutron logs was used with the following matrix parametes:

| | | FDC | CNL |
|---|---|---|---|
| Quartz | : | 2.65 | -0.035 |
| Heavy mineral | : | 2.9 | .25 |
| Fluid | : | 1.0 | 1.0 |

### Formation factor

Humbles relation was used in Statfjord formation. In Brent formation the following relationship has been used:

$F = \phi^{-2}$ (from core measurements)

### Saturation exponent

In Brent formation core measurements indicates the value of n to be in order of 1.95 (average). In Statfjord n = 2.0 was used.

Watersaturation

The Nigeria-equation (Schlumberger) has been used for calculations of the watersaturation:

$$\frac{1}{\sqrt{R_T}} = \left[ \frac{Vclay^C}{\sqrt{Rsh}} + \frac{\phi^{m/2}}{\sqrt{aRw}} \right] Sw^{n/2}$$

where

$R_T$ = Resistivity in virgin zone

$S_w$ = Watersaturation

$V_{clay}$ = Shale volume

C = Shale exponent (1.6 used)

$R_{SH}$ = Resitivity of shale

$\Phi$ = Porosity

m = Cementation exponent

a = Lithology factor

Rw = Formation water resistivity

n = Saturation exponent

Coring Summary

Four cores were cut in the interval 1910 - 1974 (Drillers depth):

No. 1 (1910.7 - 1930.0) Recovery 93%
No. 2 (1930.0 - 1949.2) Recovery 22%
No. 3 (1949.2 - 1968.8) Recovery 58.3%
No. 4 (1967.7 - 1984.8) Recovery 92.8%

The core data have been punched in with the log data. Shift of coredata is based on core description and log response together with curve fit of log porosity and core porosities. (see composite log.)

Comparison LOG/CORE

The shifted core data was averaged and compared to average log data:

Interval: 1909.5 - 1925
Average porosity from core: 0.31
Average porosity from logs: 0.29
Ratio log/core: 0.94
Average $\varrho$ ma logs: 2.69
Average $\varrho$ ma core: 2.67

The uncertainty in the correlation between logs and cores is great due to the low recovery. The correlation between porosity core/log will not be good in shaly zones where core measurements are measuring total porosity while log evaluation calculates effective porosity.

## Permeability

The core porosity has been plotted versus liquid permeability. The relation between porosity and permeability is:

$$\phi = 0.22 + .039 \log K$$

The permeability in Tarbert in this well shows a greater reduction with reduction in porosity then the relations formed for other zones in other wells. This can be due to the kaolinite content of the formation.

A separate study has been initialized to evaluate permeability in 34/10-Delta. That study will hopefully come up with reliable estimates on log-derived permeabilities and/or reliable distribution of permeability over the field.

## Testing Summary

One DST was performed over the interval 1925 - 1927. A brief summary of the test is listed below:

| | | |
|---|---|---|
| Choke size | : | 32/64" |
| Production | : | 4580 STBO/D |
| | | 2108 SCF/D |
| | | Traces of sand |
| Avg. porosity from logs | : | 30% |
| Avg. watersaturation from logs | : | 20% |
| Permeability from core | : | ~ 1000 md |
| Permeability from DST | : | ~ 916 (Esso) |

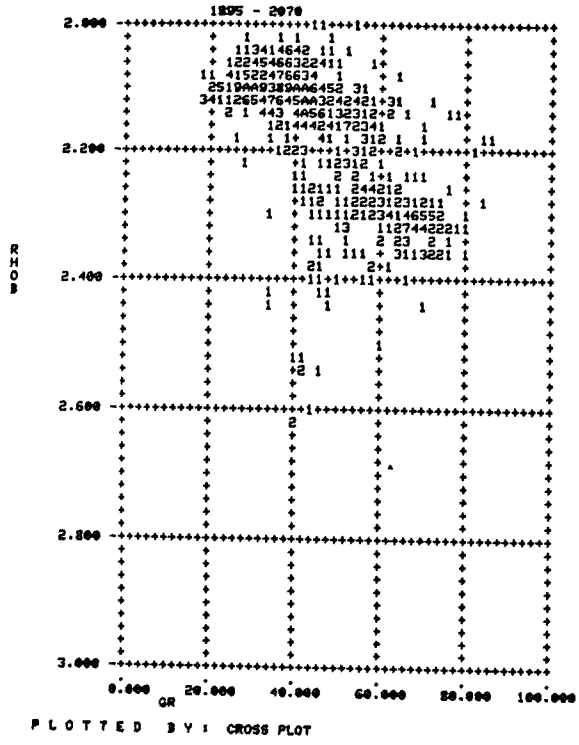
34/10-5 RESULTS TABLE PETROPHYSICAL PARAMETERS.

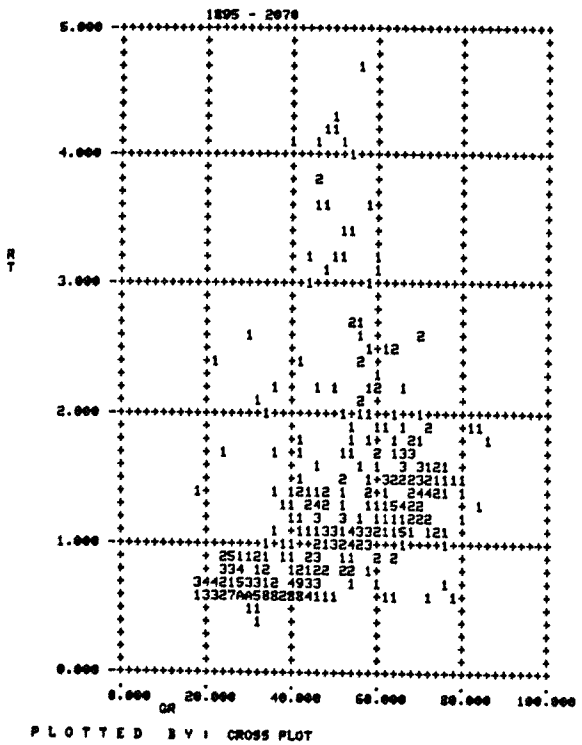
| ZONE | INTERVAL | THICKNESS | | AVERAGE POROSITY | | AVG. WATERSAT. | | NET/GROSS RATIO |
|---|---|---|---|---|---|---|---|---|
| | | NET SAND | NET PAY | NET SAND | NET PAY | NET SAND | NET PAY | |
| TARBERT | 1896-1970 | 64.25 | 64.25 | 30.2 | 30.2 | 20.3 | 20.3 | 0.87 0.87 |
| NESS | 1970-2035 | 29.5 | | 28.9 | | 1.0 | | 0.45 |
| ETIVE | 2035-2070 | 31.75 | | 31.4 | | 1.0 | | 0.91 |
| RANNOCH | 2070-2134.25 | 55.75 | | 27.5 | | 1.0 | | 0.87 |
| BROOM | 2134.35-2148 | 0 | | 0 | | 0 | | 0 |
| TOTAL BRENT | 1896-2148 | 64.25 | 181.25 | 30.2 | 29.4 | 20.3 | 0.712 | 0.72 |
| STATFJORD | 2562-2764 | 120.75 | | 21.9 | | 1.0 | | 0.60 |

CUT OFF CRITERION: VSH > 40%
PHIF < 12%
SW > 65%
THICKNESS < 1 m (cut off 1 m in Ness, 1.25 m in Broom)

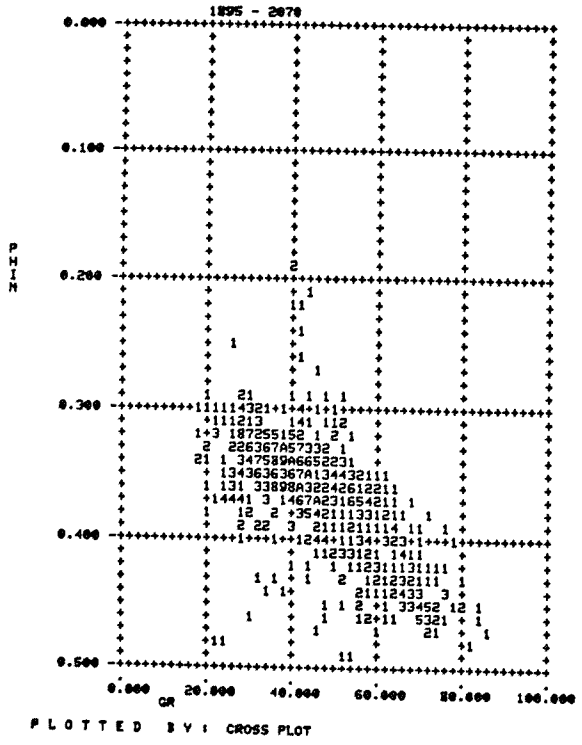
APPENDIX

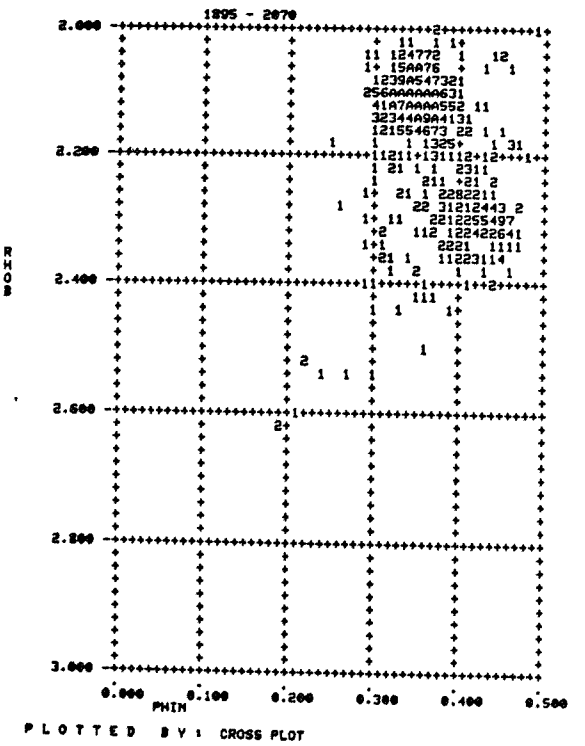
- CROSSPLOTS
- CPI's ANALOG
- SUMMARY LOG BRENT FM.

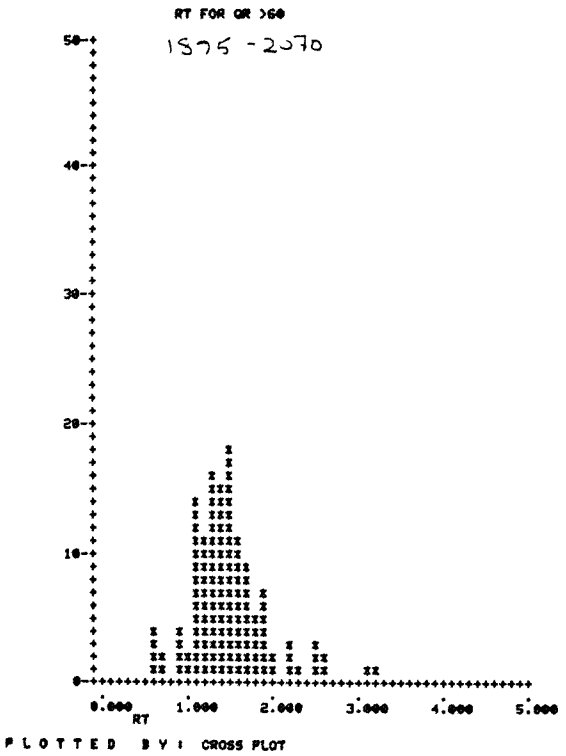


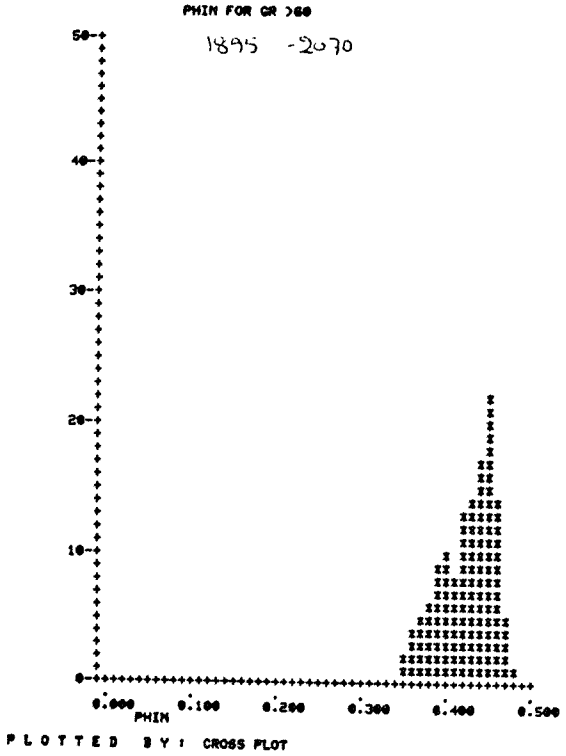




## TARBERT/NESS/ETIVE

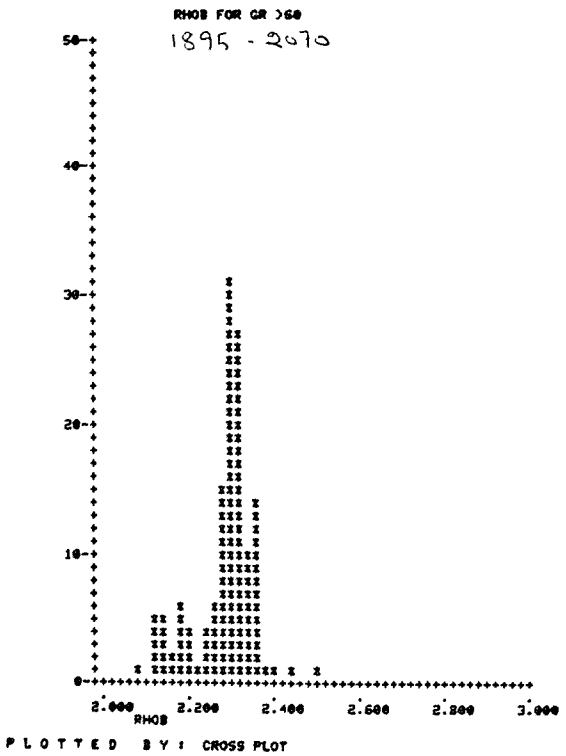


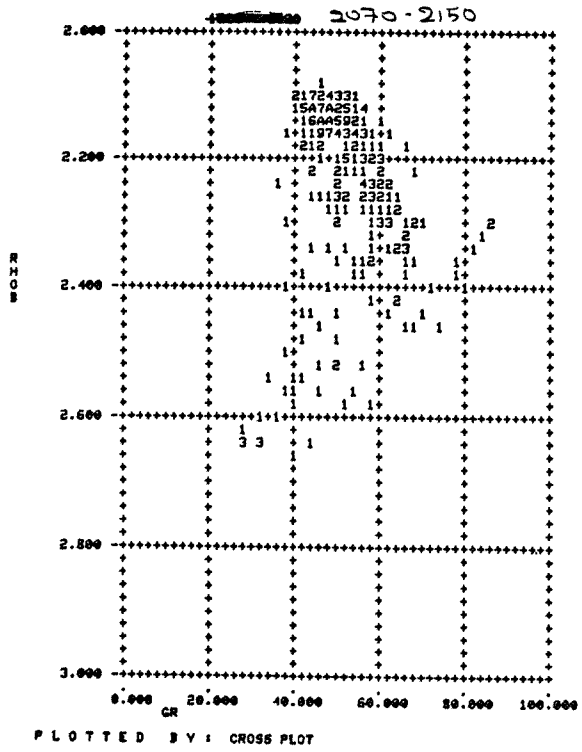



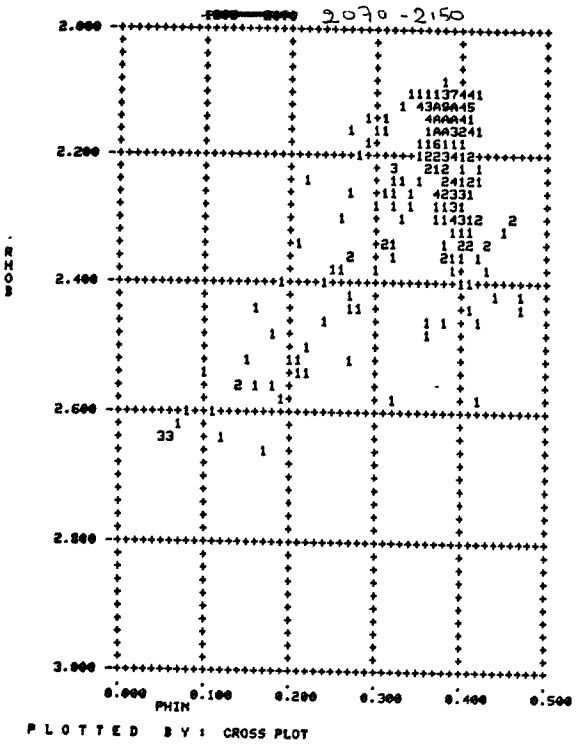



TARBERT/NESS/ETIVE




2070 - 2150
RHOB
GR
PLOTTED BY : CROSS PLOT


2070 - 2150
RHOB
PHIN
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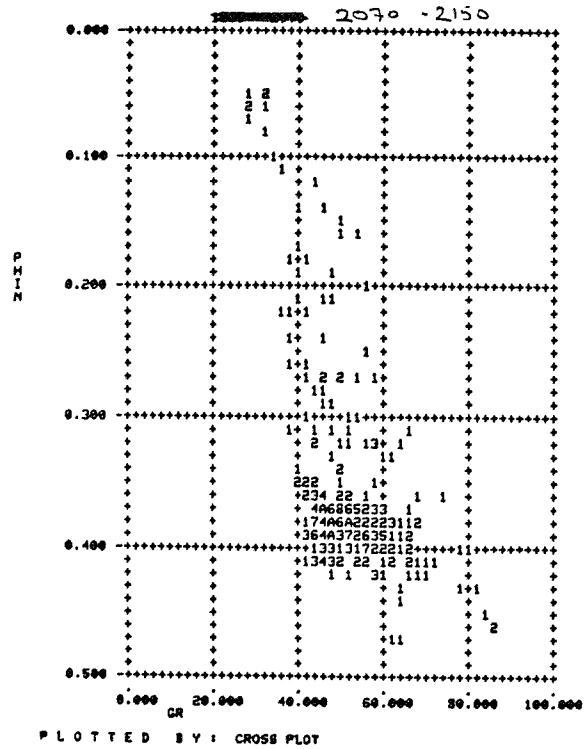
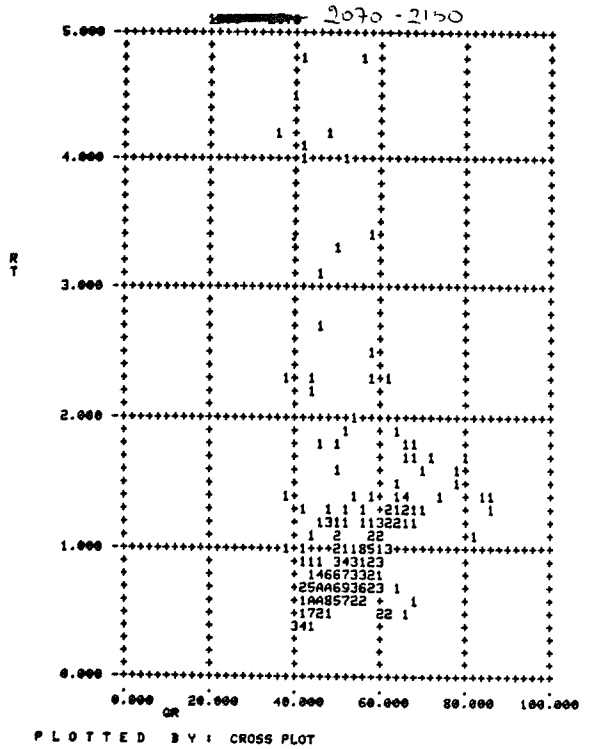
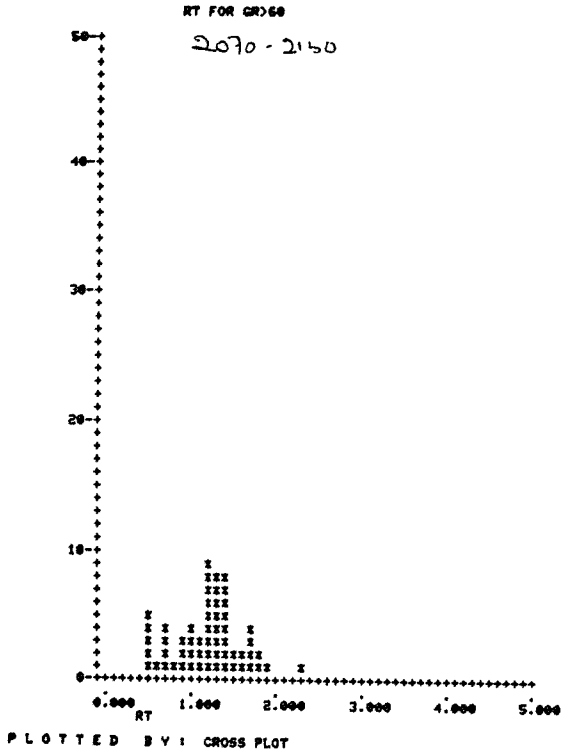
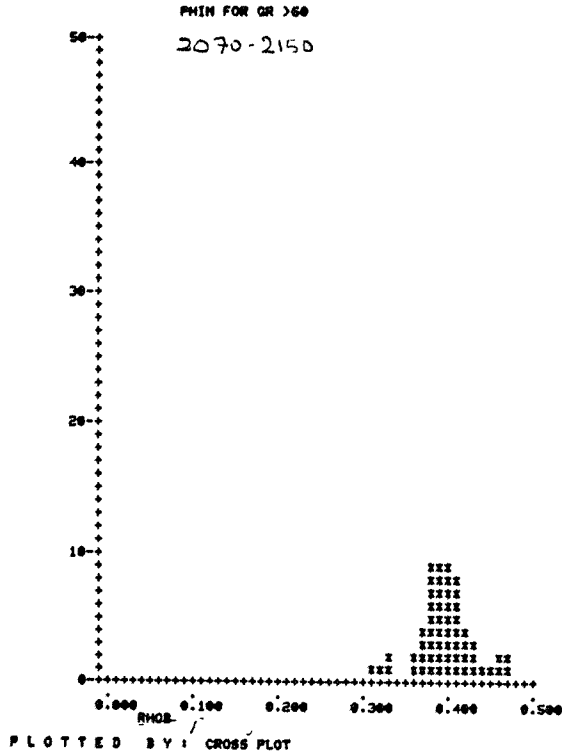
RANNOCH

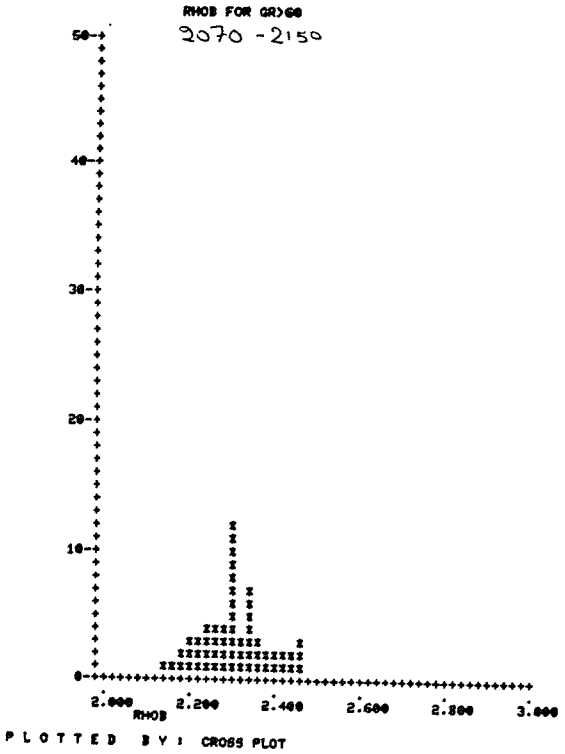

2070 - 2150
PHIN
GR
PLOTTED BY : CROSS PLOT

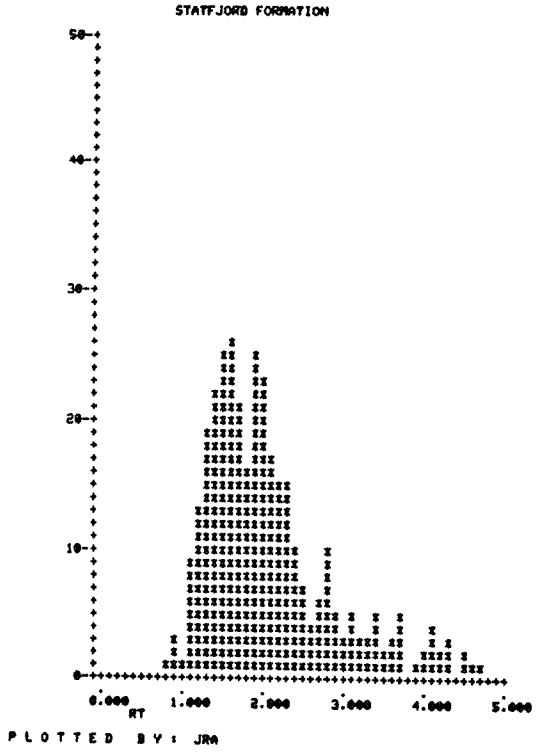

2070 - 2150
RT
GR
PLOTTED BY : CROSS PLOT

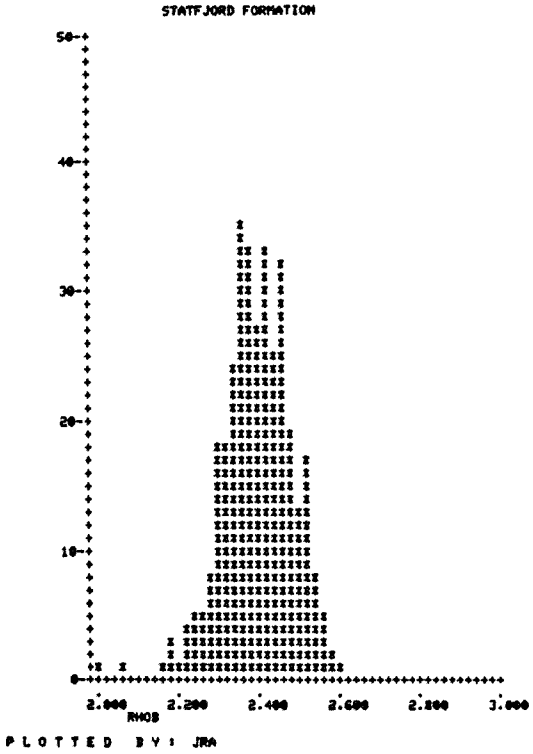

RT FOR GR>60
2070 - 2150
50
40
30
20
10
0
0.000
1.000
2.000
3.000
4.000
5.000
RT
PLOTTED BY : CROSS PLOT


PHIN FOR GR >60
2070 - 2150
50
40
30
20
10
0
0.000
0.100
0.200
0.300
0.400
0.500
RHOB
PLOTTED BY : CROSS PLOT

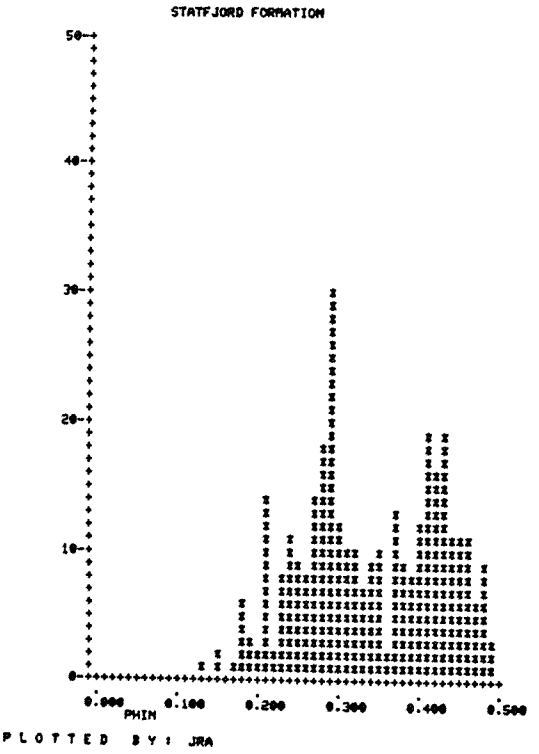
RANNOCH

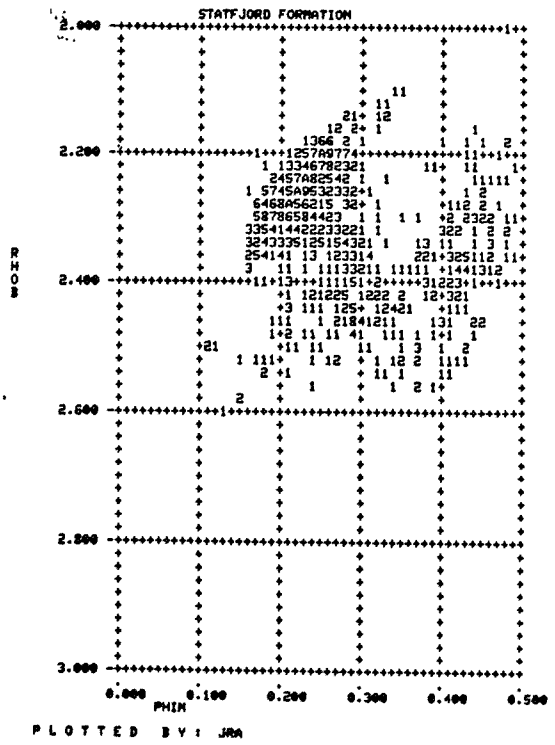

RHOB FOR GR>60
2070 - 2150
50
40
30
20
10
0
2.000
2.200
2.400
2.600
2.800
3.000
RHOB
PLOTTED BY : CROSS PLOT


STATFJORD FORMATION
RT
PLOTTED BY: JRA


STATFJORD FORMATION
RHOB
PLOTTED BY: JRA

# STATFJORD


STATFJORD FORMATION
PHIM
PLOTTED BY: JRA


STATFJORD FORMATION
RHOB
PHIM
PLOTTED BY: JRA

# COMPUTERIZED LØG INTERPRETATIØN

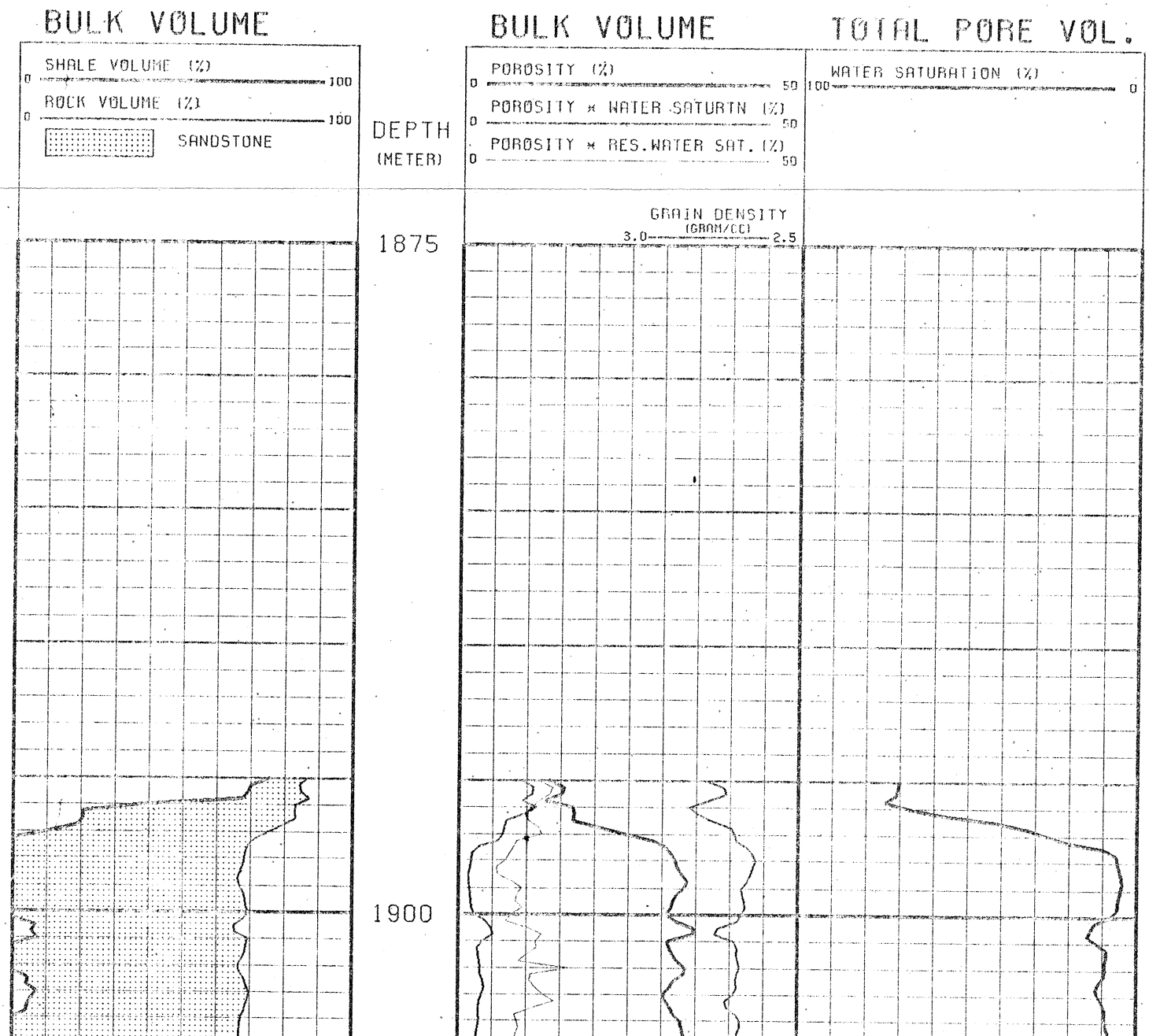
PROGRAM: PGM0377 VERSATEC
VERSION: 1 (28APR78) +
BY: COP/DB-SEKSJONEN

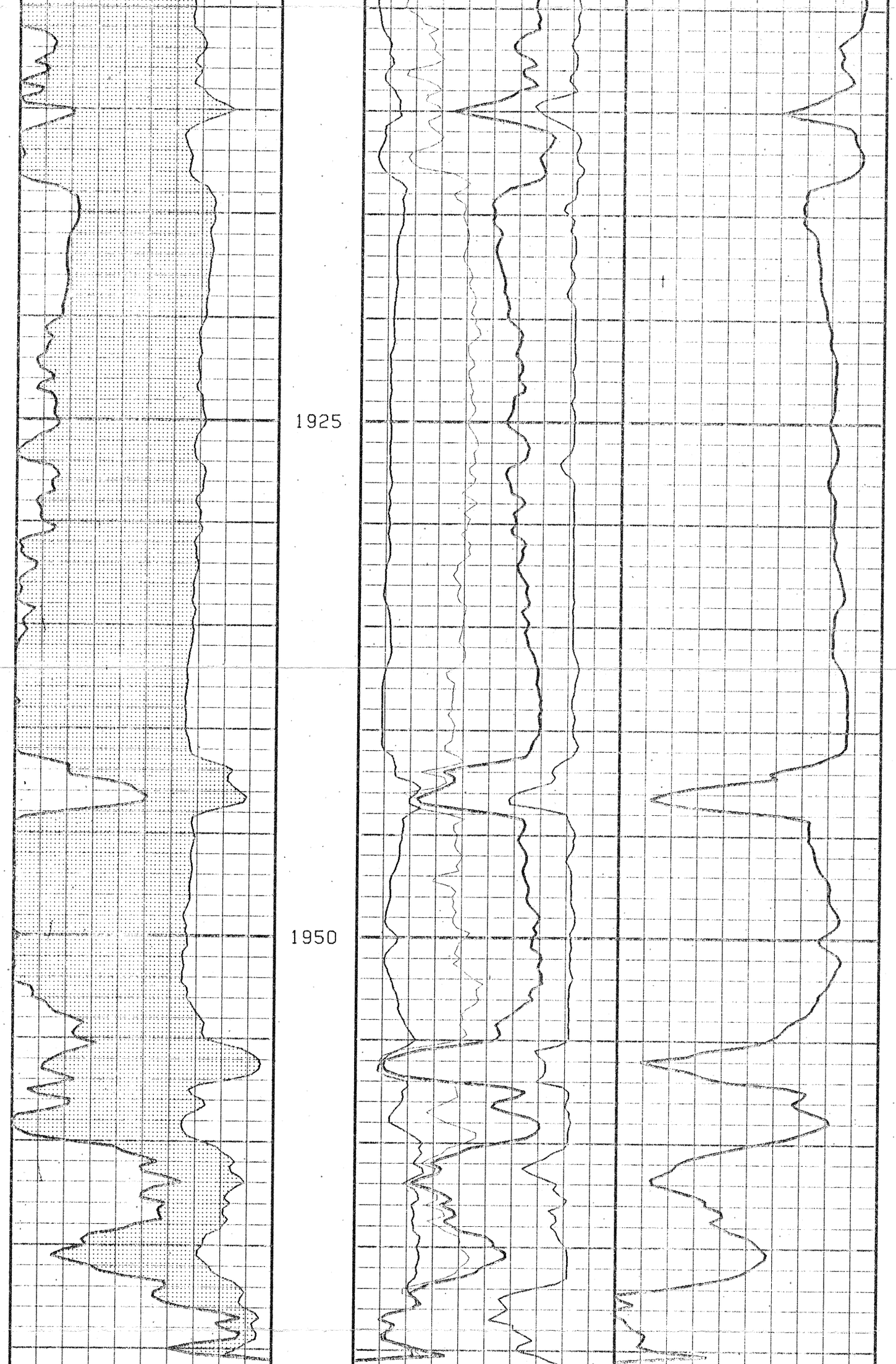
WELL: 34/10-5
FIELD: WILDCAT
ENGINEER: J.RAFDAL
DATE: 10/3-80

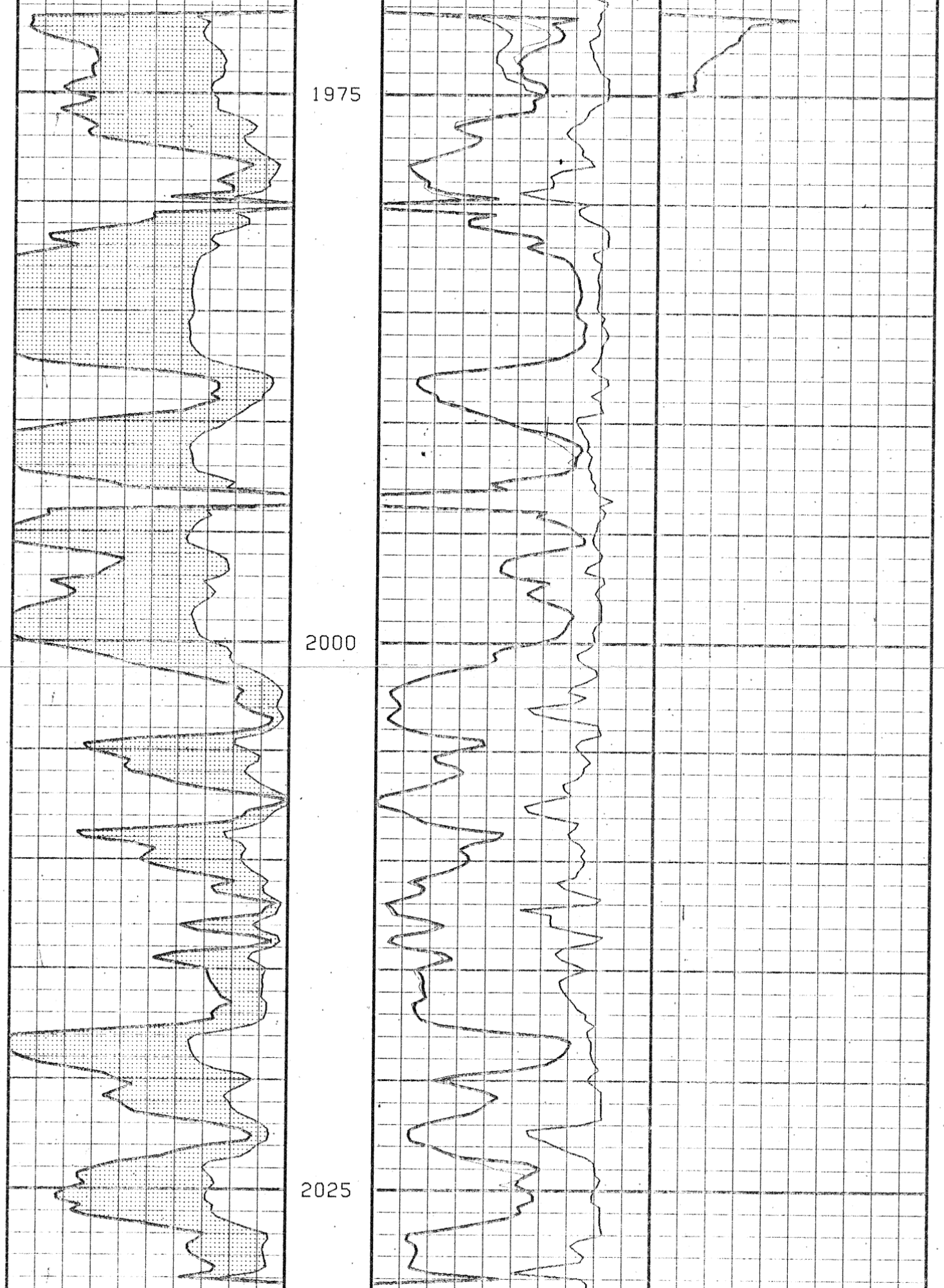
DEPTH INTERVAL: 1895 - 2150 (METER)
RKB: 25.0 (METER) SCALE: 1 : 200
PERMANENT DATUM: MSL
DEPTH REFERENCE: ISF/SONIC

**INPUT PARAMETERS:**

| DEPTH INTERVAL | RW | RMF | RSH | RHOBSH | PHINSH | DTSH | FORM.TEMP. (DEG. F) |
|---|---|---|---|---|---|---|---|
| 1895 - 2150 | 0.075 | 0.096 | 1.50 | 2.35 | 0.45 | 120.0 | 160 |




1925
1950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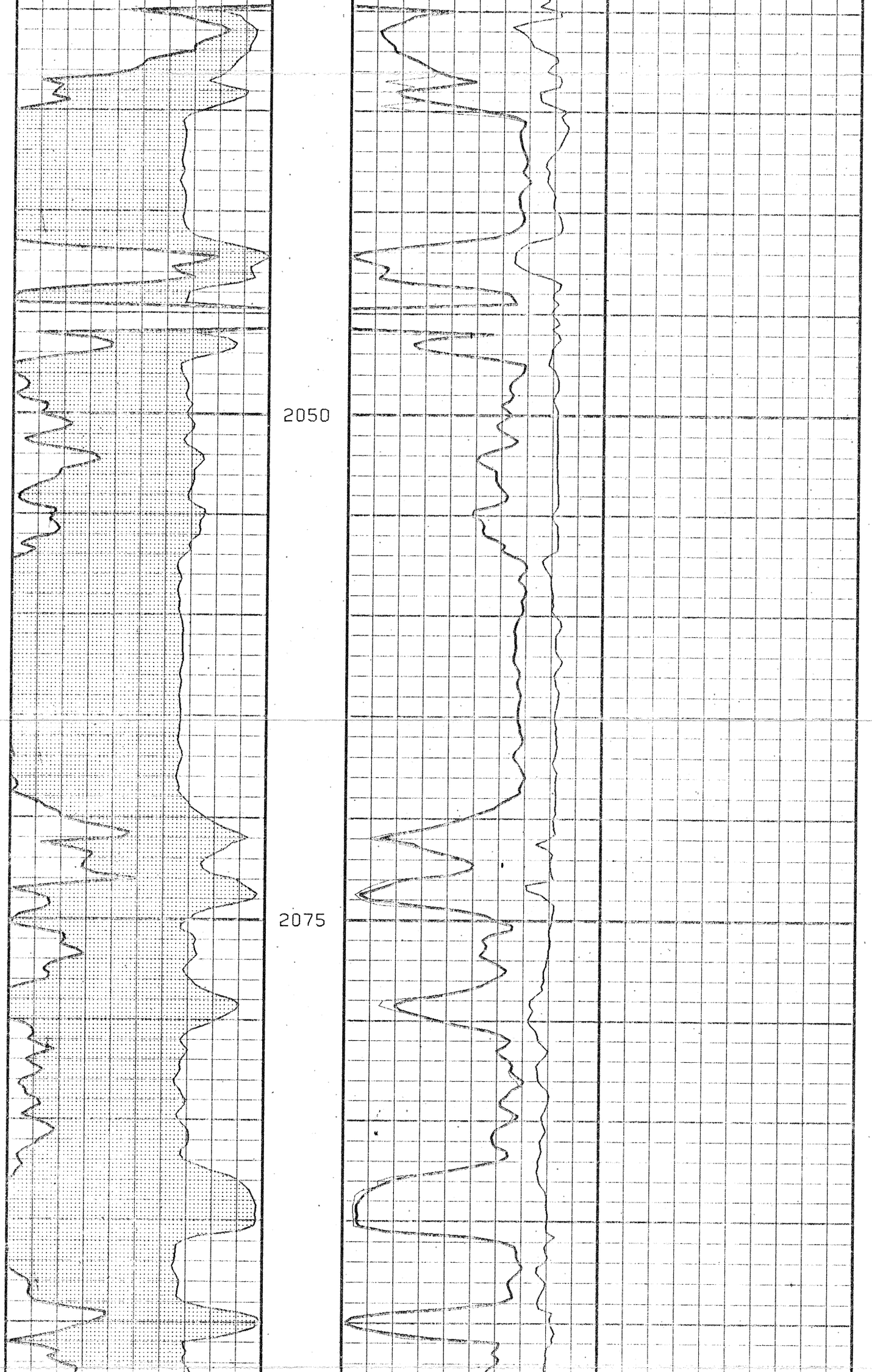
2000
2025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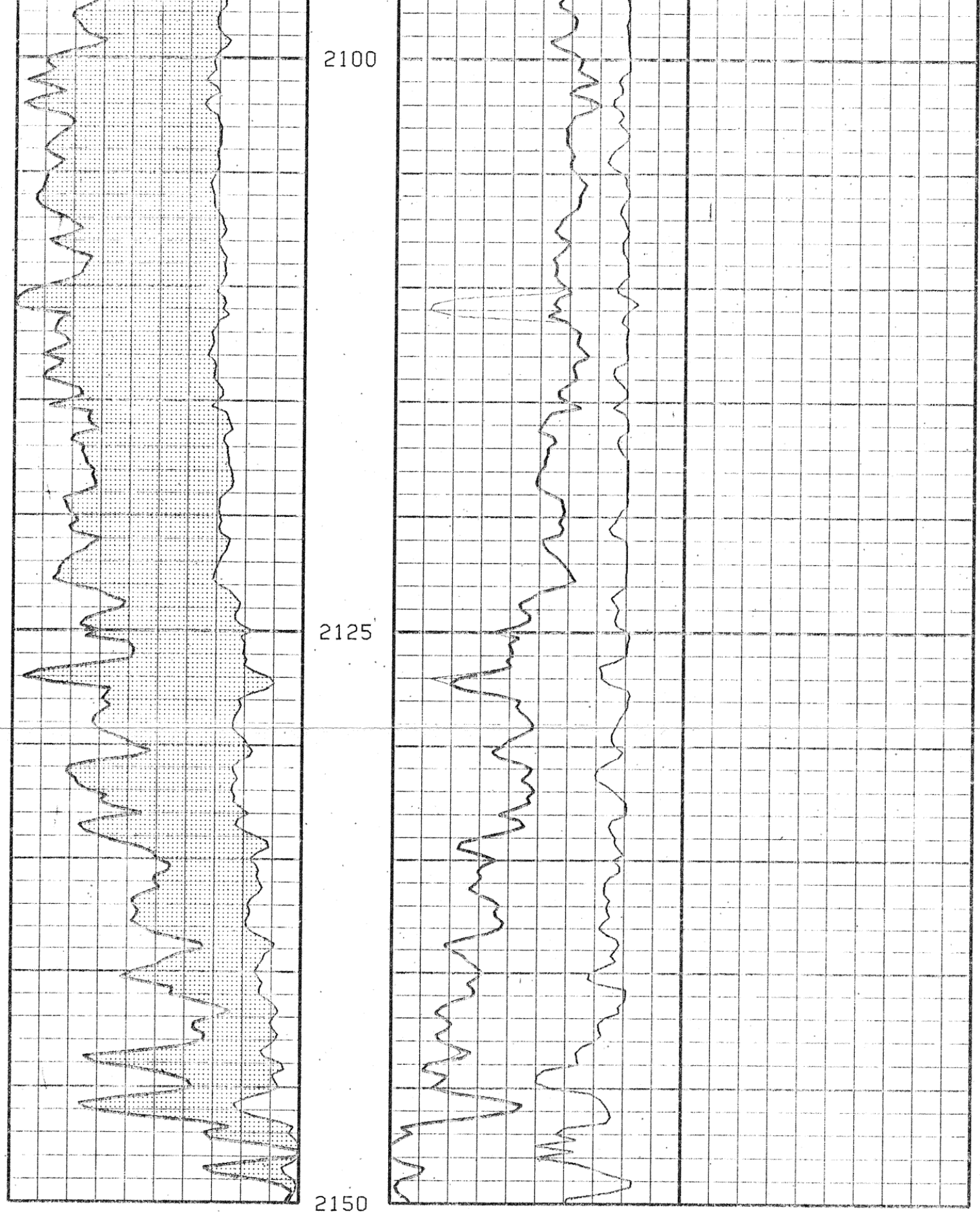
2075


2100
2125
2150

# COMPUTERIZED LOG INTERPRETATION

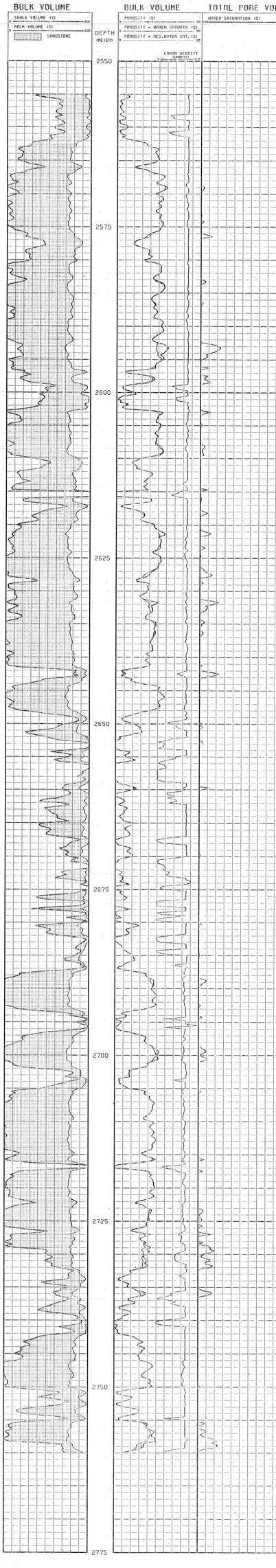
PROGRAM: PGM0377 VERSATEC
VERSION: 1 (2DMPR7G) +
BY: COP/UB-SERSJOMEN

WELL: 34/10-5
FIELD: WILDCAT
ENGINEER: J.RAFDAL
DATE: 3/3-80

DEPTH INTERVAL: 2555 - 2760 (METER)
RKB: 25.0 (METER) SCALE: 1 : 200
PERMANENT DATUM: MSL
DEPTH REFERENCE: ISF/SONIC

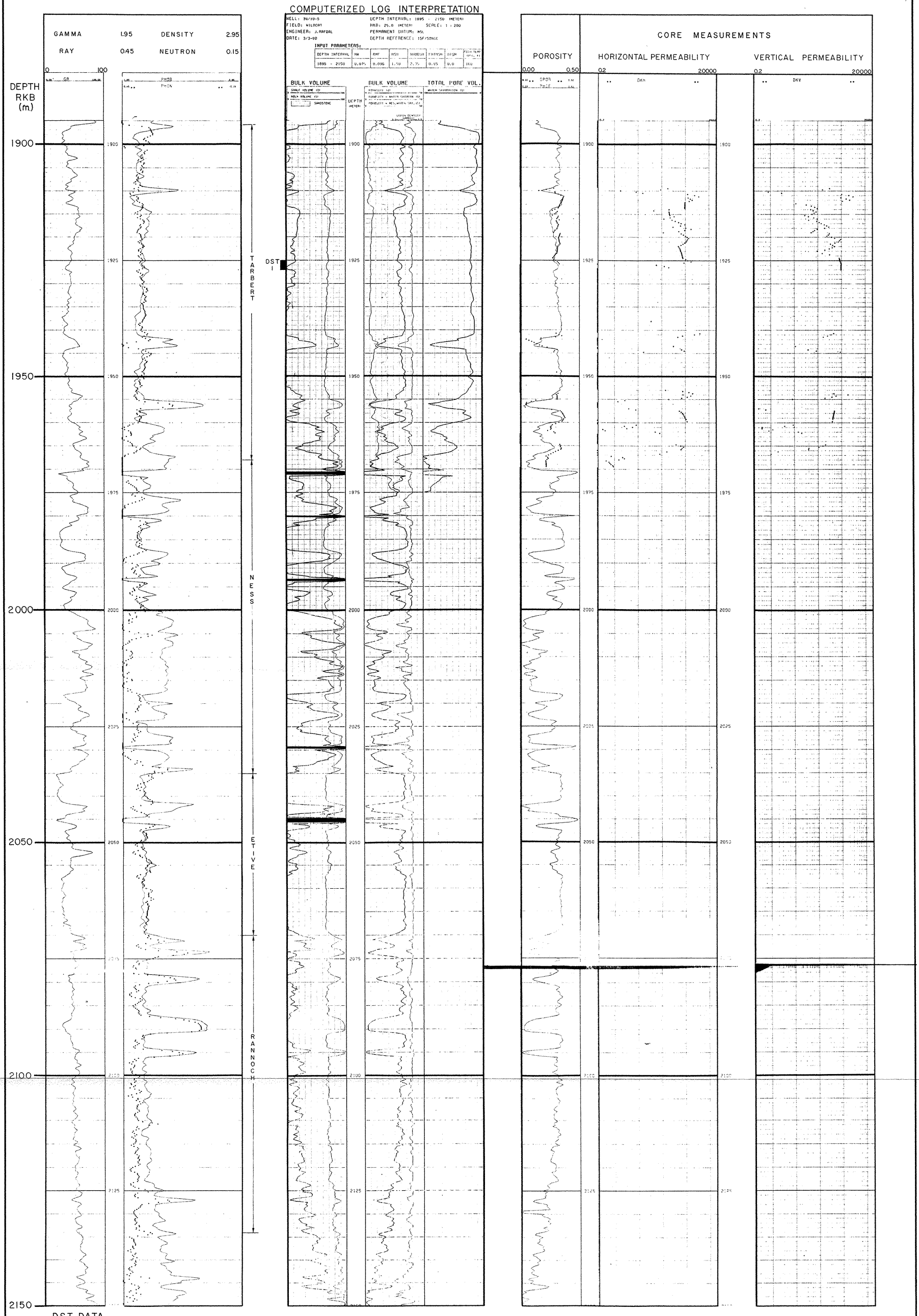
INPUT PARAMETERS:

| DEPTH INTERVAL | RW | RMF | RSH | RHOBSH | PHINSH | DTSH | FORM. TEMP (DEG. F) |
|---|---|---|---|---|---|---|---|
| 2555 - 2760 | 0.066 | 0.098 | 3.00 | 2.42 | 0.45 | 0.0 | 180 |



# SUMMARY LOG WELL 34/10-5

# BRENT FORMATION




## DST DATA

DST 1
Interval : 1925 - 1927
Choke size : 32/64"
Production : 4580 STBO/D
2108 SCF/D
Traces of sand

Location
61° 11' 25.32" N
02° 10' 23. 4" E

KB-elevation = 25 m
Water depth = 136 m
Total depth = 2780 m

Status:
Spudded: 18/10 1979
Rig released: 3/1 - 1980
Plugged and abandonned

MARCH 1980
PRO/ EVALTEK
.
JRa/AM