PRESSURE PREDICTION
WELL 34/10-3
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CONTENTS:

Introduction

A prediction of the pressure regime in well 34/10-3 has been worked out based on data from wells in the area. Same reports for 34/10-1 and 2 can be used for more background data.

Hydrostatic gradient

RFT pressure measurements indicate that a gradient of 1.011 gm/cc can be used for Tertiary formations (down to Eocene/Paleocene). In Statfjord formation (34/10-1), a hydrostatic gradient of 1.046 gm/cc was obtained.

Overburden gradient

Prognosed overburden gradient and overburden gradients obtained from FDC-data in the area are plotted on enclosed graphs.

Pore pressure

The predicted pore pressures are based on experience from the area and specially wells 34/10-1 and 34/10-2.

The sandy formations down to Eocene/Paleocene have normal hydrostatic pressure (measured in 34/10-2). Hvorfor ikke sammenlign med 34/10-1 ?

The pressure build up will occur rapidly below the sandy section down to Paleocene. The pressure build up may be related to the claystone/ shale formation below the sandy section, but it may also be related to the tuffaceous zone above Paleocene.

On an enclosed graph for Paleocene formations, the maximum pressure gradient that will occur is plotted as a function of the depth of top Paleocene. The predicted pressure gradient for this formation is in the order of 1.68 gm/cc for the prognosed depth.

The pressure gradient in top Jurassic will be in the order of 1.68 gm/cc. The maximum pressure gradient for this formation is plotted versus the depth at which Brent formation occur on an enclosed graph.

The pressure gradient is expected to decline from top Brent down to T.D.

Drilling problems

Quaternary and upper Tertiary Formations (down to ~800m) usually contain gas. High drill gas must be expected while drilling these formations.

Lost circulation has been encountered in lower Cretaceous and Jurassic with mud weights of 1.62 gm/cc. This has not been experienced on 34/10 - block.

On some wells the 13 3/8" casing has been stuck at a depth of ~1300 m. This can be due to differential pressure and/or swelling clays.

The Paleocene formation is usually containing gas and will usually give high drill gas.

Conclusions and recommendations

The pressures encountered in well 34/10-3 can be predicted fairly accurately.

The last part of 17½" hole should not be drilled with a dulling bit, in order to be able to obtain better knowledge about the top of the transition zone, and to obtain the best possible seat for 13 3/8 csg.

Hvem ?

It is recommended to have special personell responsible for pressure prediction on the rig during drilling for the 13 3/8" and 9 5/8" csg seats, and when drilling into Brent Formation.

If the faults of the Jurassic formations are sealing, separate reservoirs may encounter different pressure gradients.

Methods

For quantitative calculations, the sonic log is believed to be the best tool. After plotting the sonic response of shales versus depth on a semilogarithmic paper, a "normal" trend has to be established. Two methods are usually used:

Equivalent depth method:

$$Pa = OBa - (OBe - Pe)\frac{De}{Da}$$

Pa = Porepressure gradient at depth of interest
OBa= Overburden gradient at depth of interest
Da = Depth of interest
Pe = Porepressure gradient at equivalent depth
OBe= Overburden gradient at equivalent depth
De = Equivalent depth

Exponential method:

$$Pa = (OBa - HG)(\Delta tN / \Delta ta)^3$$

PBa= Overburden gradient at depth of interest
HG = Hydrostatic gradient
ΔtN= Normal transit time of shales
Δta= Actual transit time of shales

The equivalent depth method is believed to be the best one.

FRACTURE GRADIENT

The fracture gradient has been determined after the relationship established by Anderson, Ingram and Zanier;

$$PF = \frac{2\mu}{1-\mu} \cdot OB + \frac{1-3\mu}{1-2\mu} \cdot \alpha \cdot PP$$

where: PP = Pore pressure gradient
OB = Overburden gradient
PF = Fracture gradient
μ = Poisson ratio
α = 1 - (1-ØD)

Ø is the porosity from any type of porosity tool, in this case it was set equal to 0,30 (30% porosity).

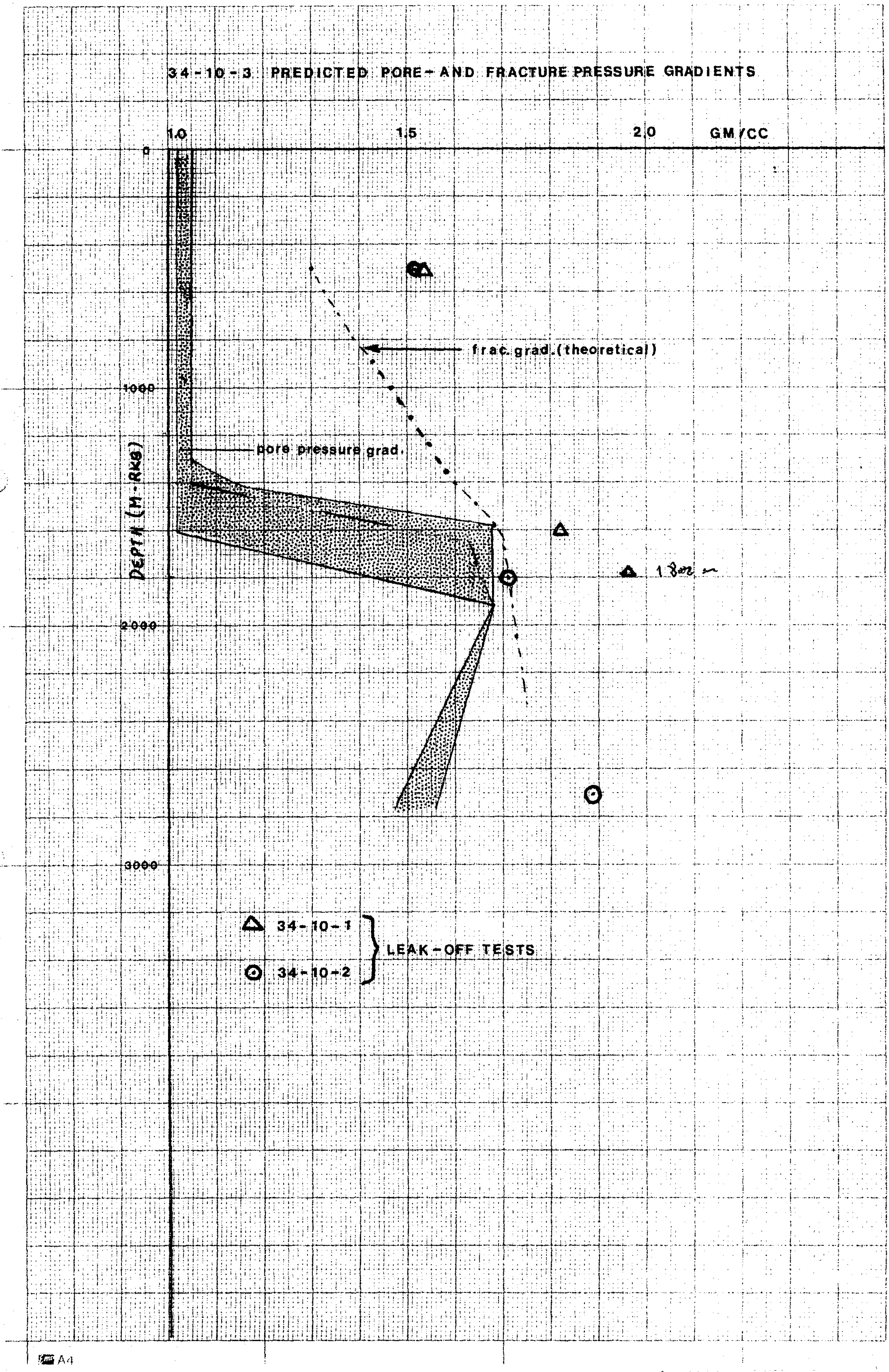
The following values for Poissons ratio μ was used when calculating fracture gradients:

0-1000 m	-	μ	=	0,25
1000-2000 m	-	μ	=	0,28
2000-4000 m	-	μ	=	0,30

The fracture gradient is plotted on figure attached behind.

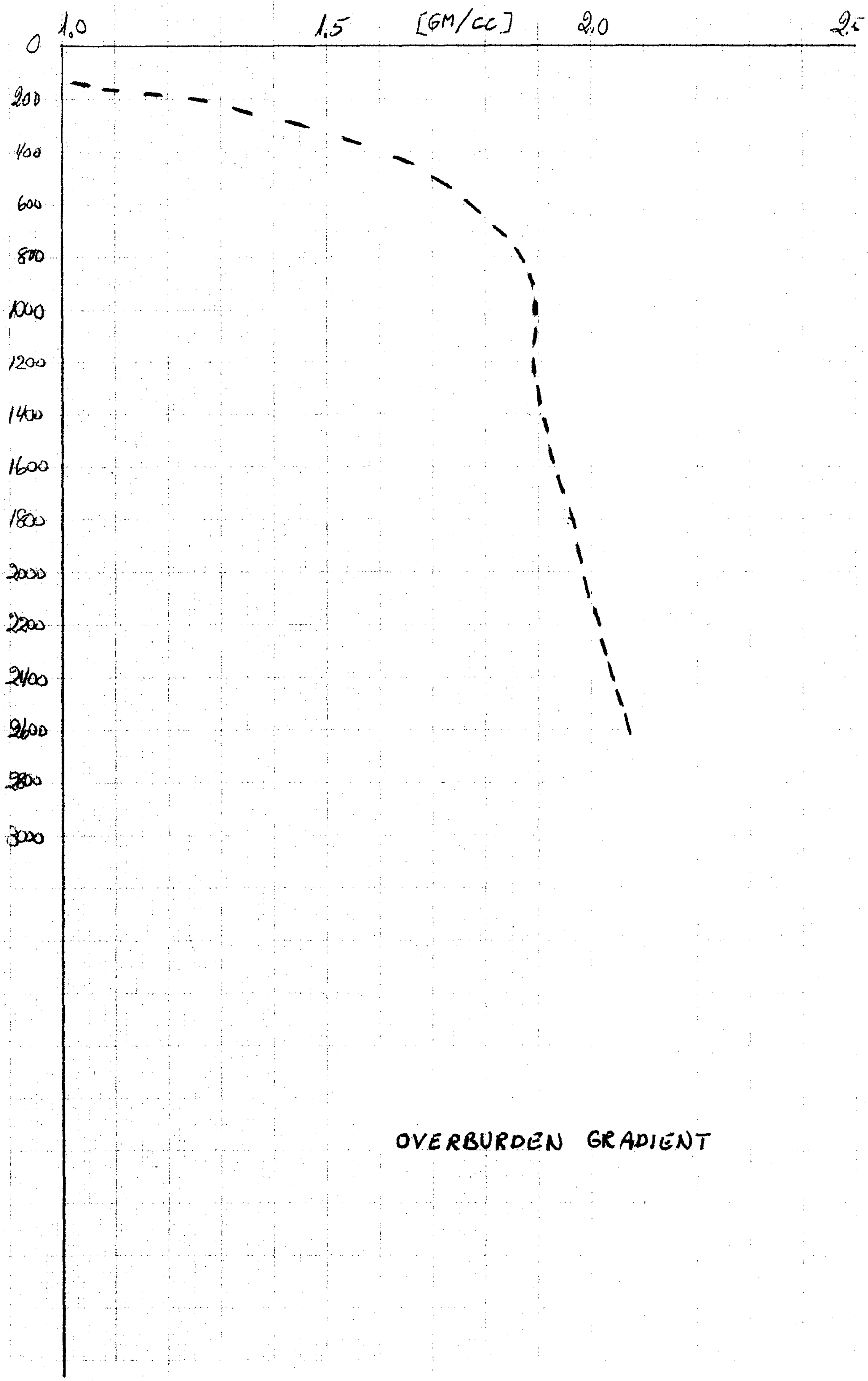
APPENDIX:

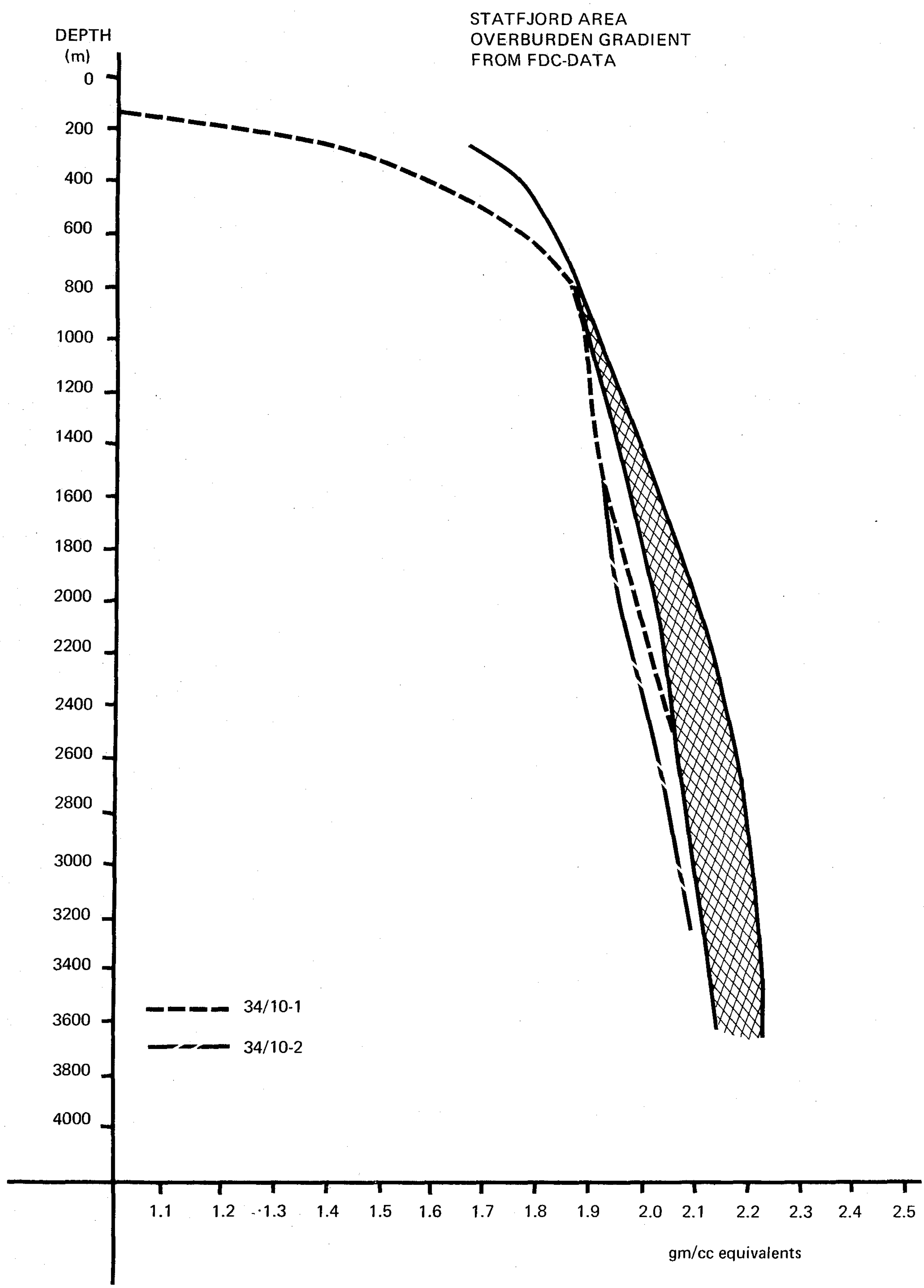
- PORE PRESSURE/ FRACTURE GRADIENT
- OVERBURDEN GRADIENTS
- RFT MEASUREMENTS IN UPPER TERTIARY FORMATIONS 34/10-2
- PALEOCENE PRESSURE GRADIENT AS FUNCTION OF THE DEPTH OF TOP PALEOCENE
- BRENT FORMATION PRESSURE GRADIENT AS FUNCTION OF DEPTH OF TOP BRENT
- MEASURED TEMPERATURES VERSUS DEPTH ON 34/10-1 & 2
- COMPOSITE PLOT 34/10-1
- COMPOSITE PLOT 34/10-2
- PRESSURE INDIATOR PLOTS FOR 34/10-1 & 2

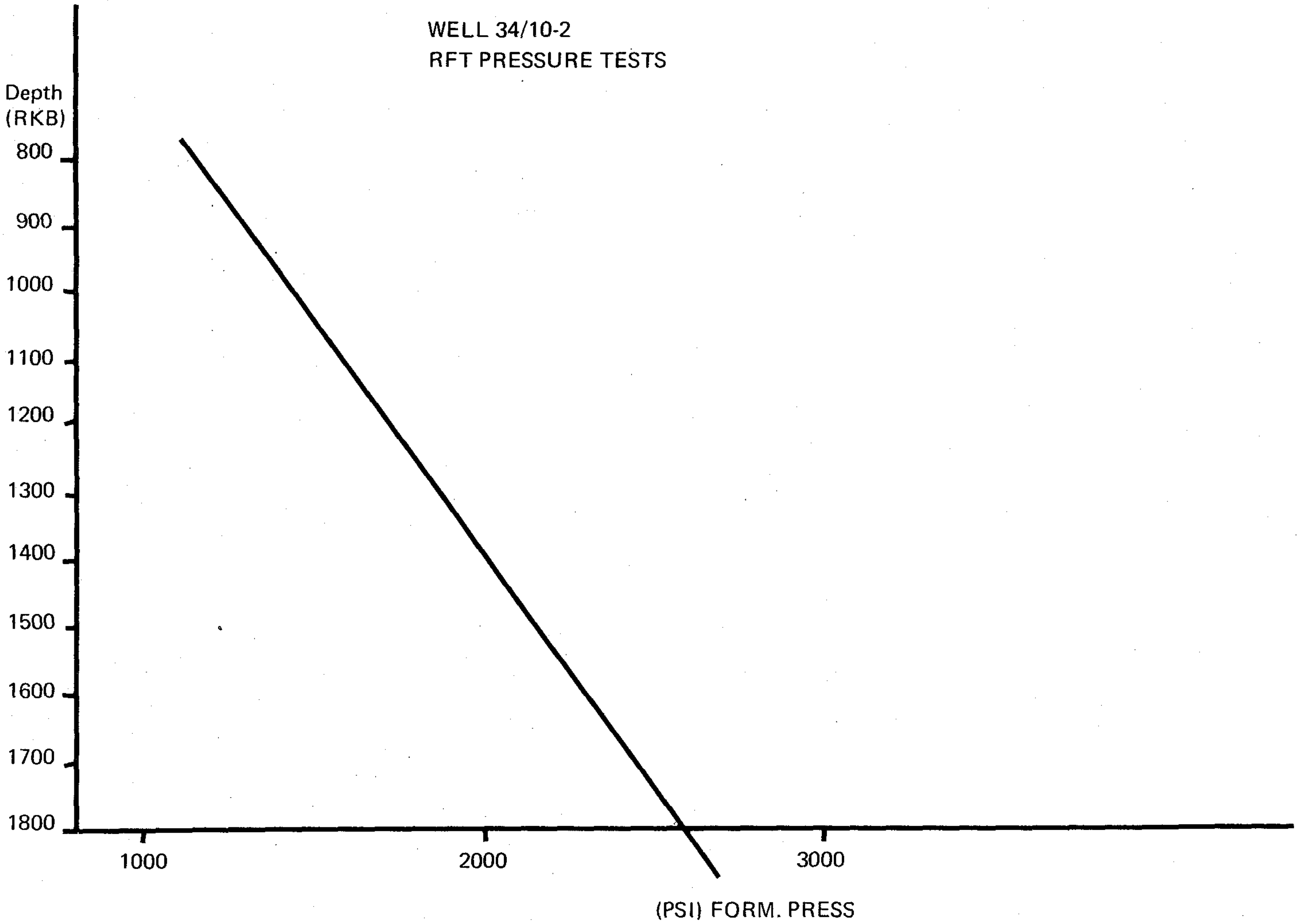


34-10-3 PREDICTED PORE- AND FRACTURE PRESSURE GRADIENTS
1.0
1.5
2.0
GM/CC
0
1000
2000
3000
DEPTH (M-RKB)
frac.grad.(theoretical)
pore pressure grad.
34-10-1
34-10-2
LEAK-OFF TESTS
A4

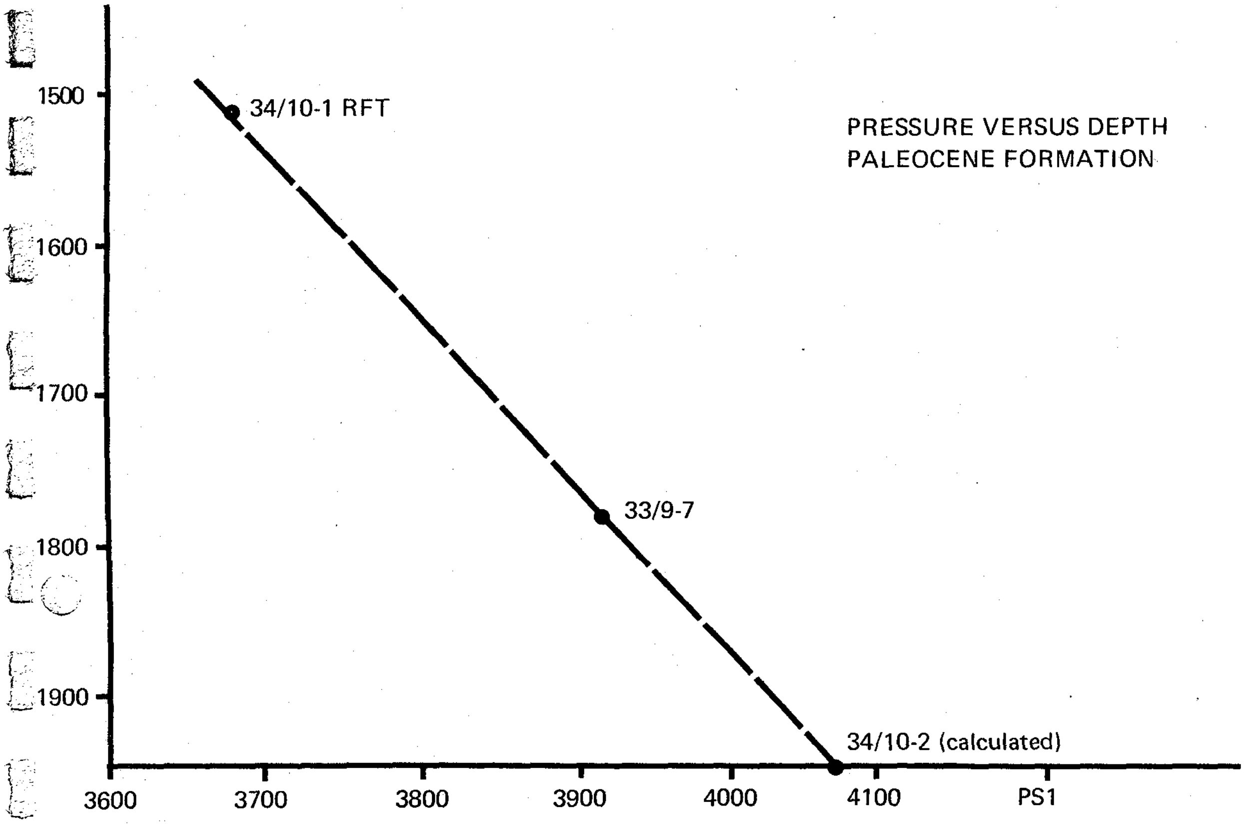
WELL : 34/10-3 PREDICTION

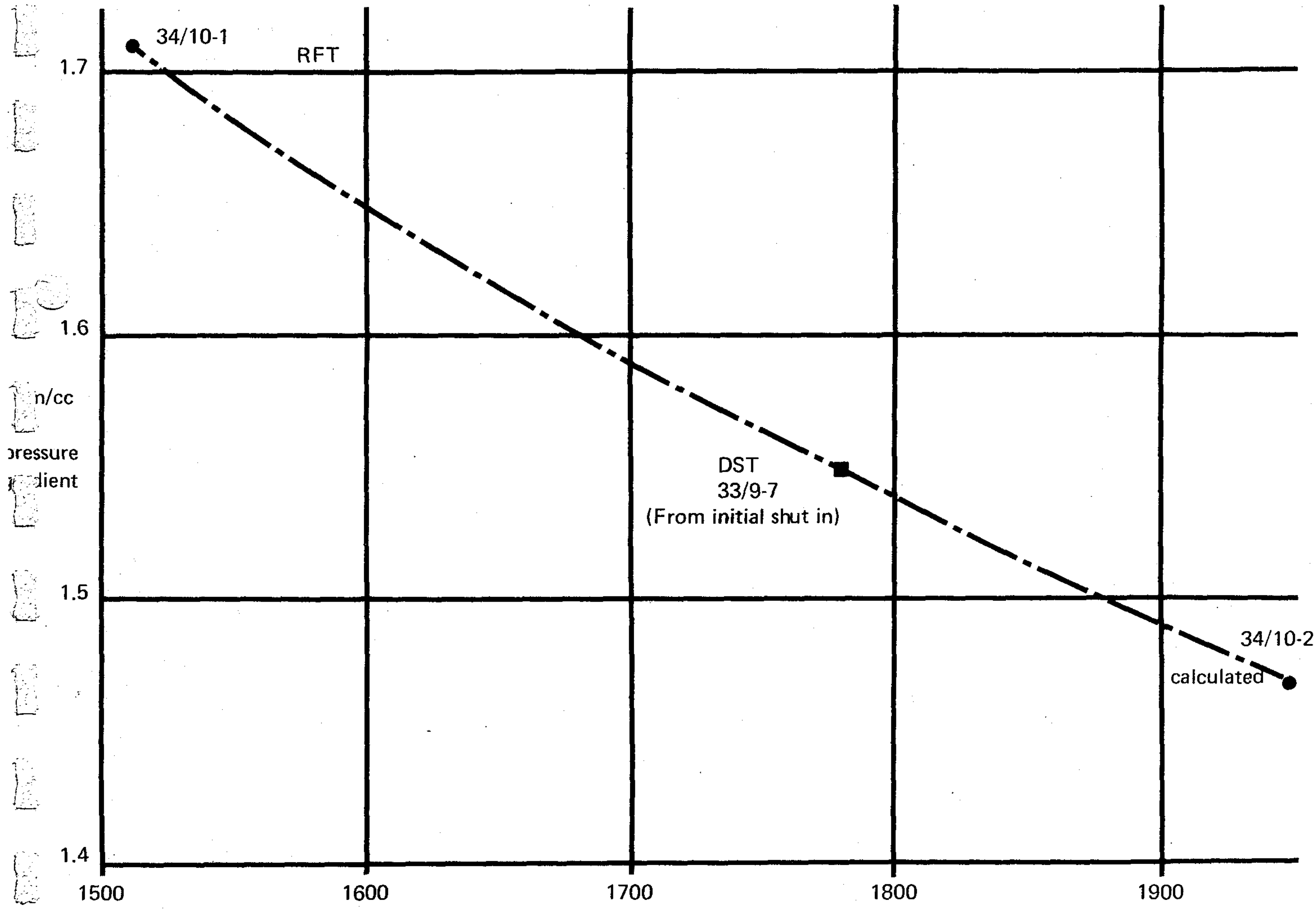



STATFJORD AREA
OVERBURDEN GRADIENT
FROM FDC-DATA
DEPTH
(m)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
34/10-1
34/10-2
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
gm/cc equivalents

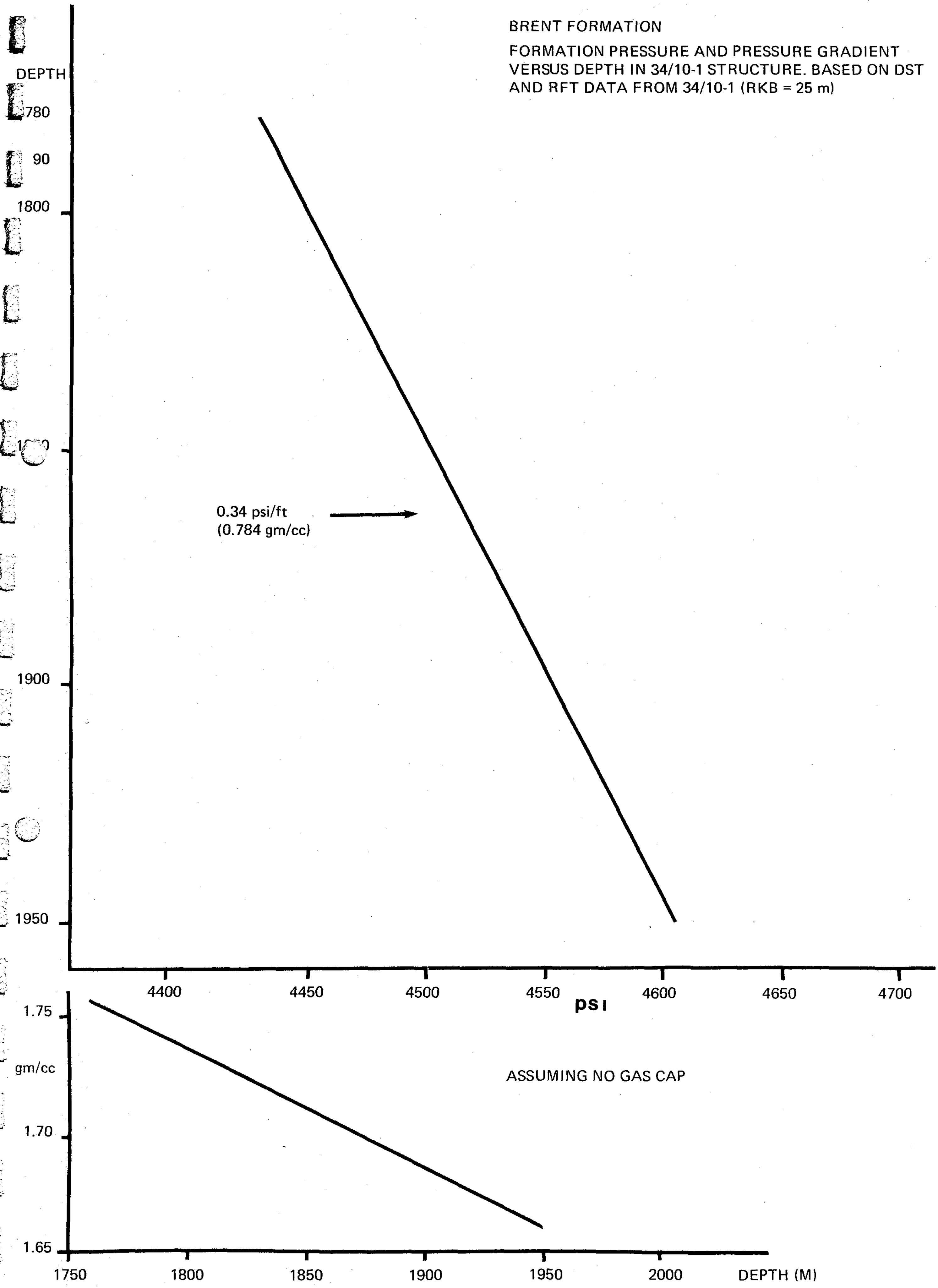


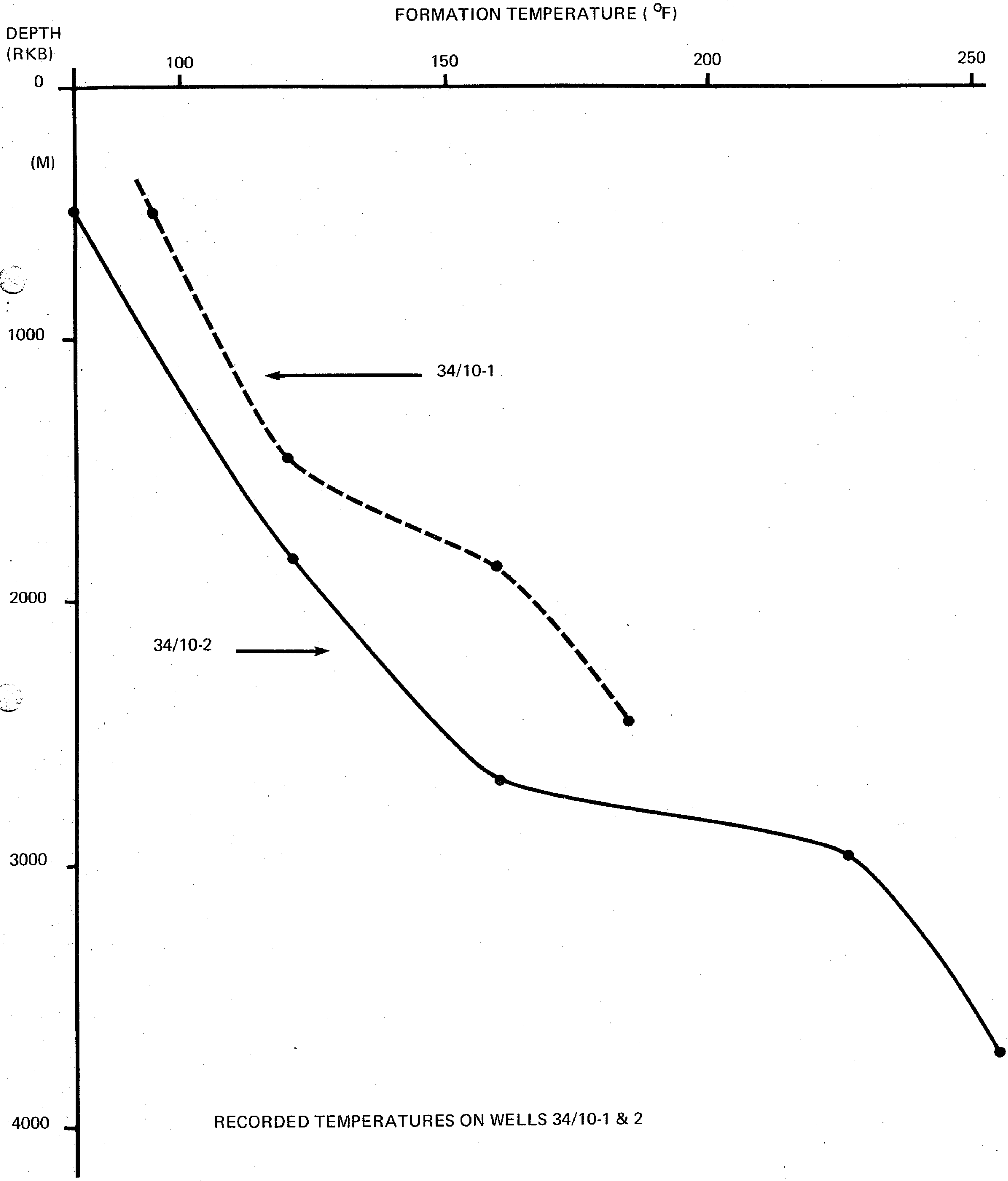
LINE INDICATE HYDROSTATIC GRADIENT OF 0.439 psi/ft
= 1.011 gm/cc density of the formation water



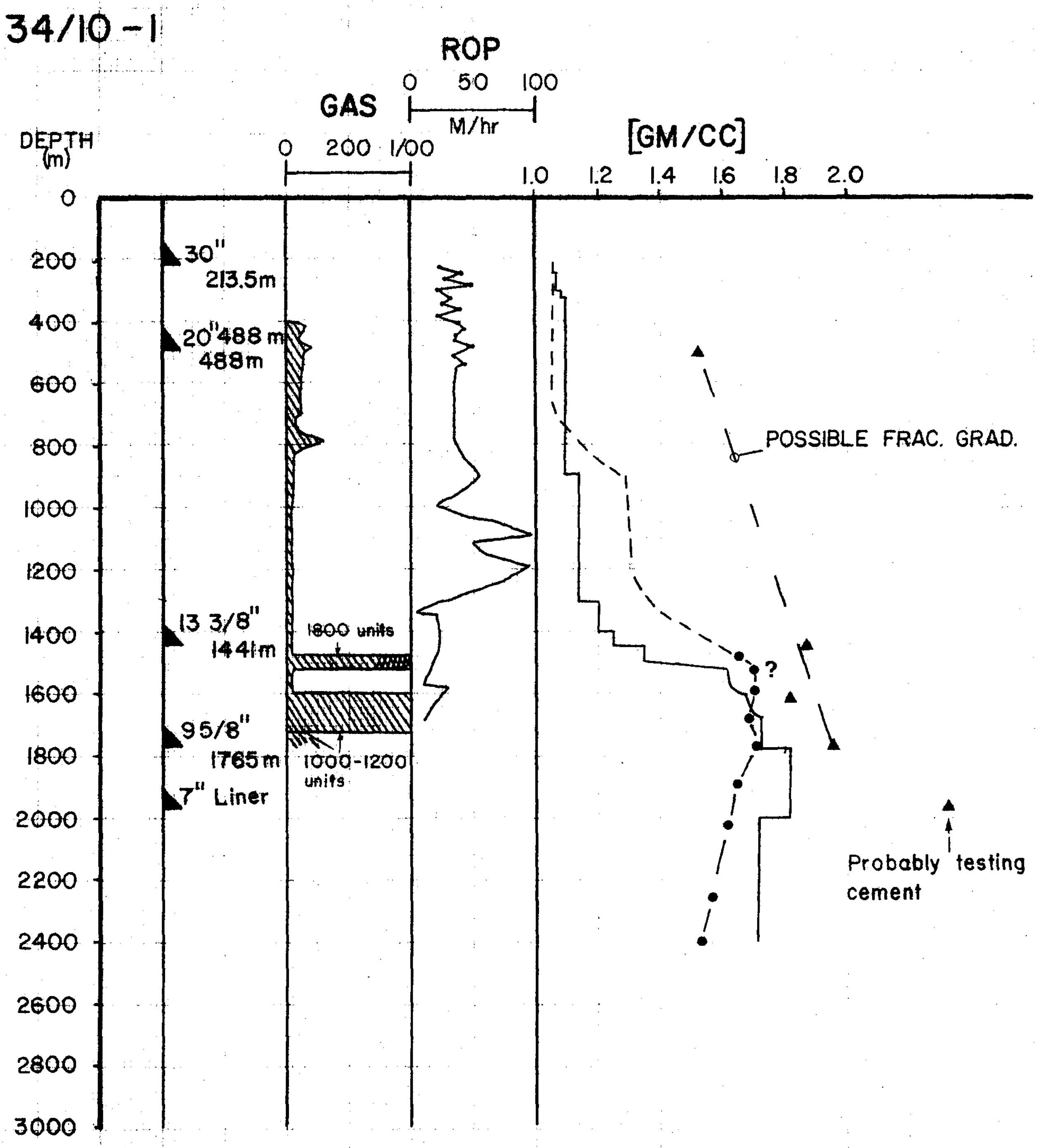


PORE PRESSURE GRADIENTS FOR PALEOCENE FORMATIONS
IN BLOCK 34/10 VERSUS DEPTH.


BRENT FORMATION
FORMATION PRESSURE AND PRESSURE GRADIENT VERSUS DEPTH IN 34/10-1 STRUCTURE. BASED ON DST AND RFT DATA FROM 34/10-1 (RKB = 25 m)
DEPTH
1780
90
1800
0.34 psi/ft
(0.784 gm/cc)
1900
1950
4400
4450
4500
4550
4600
4650
4700
psi
1.75
gm/cc
1.70
1.65
ASSUMING NO GAS CAP
1750
1800
1850
1900
1950
2000
DEPTH (M)



RECORDED TEMPERATURES ON WELLS 34/10-1 & 2

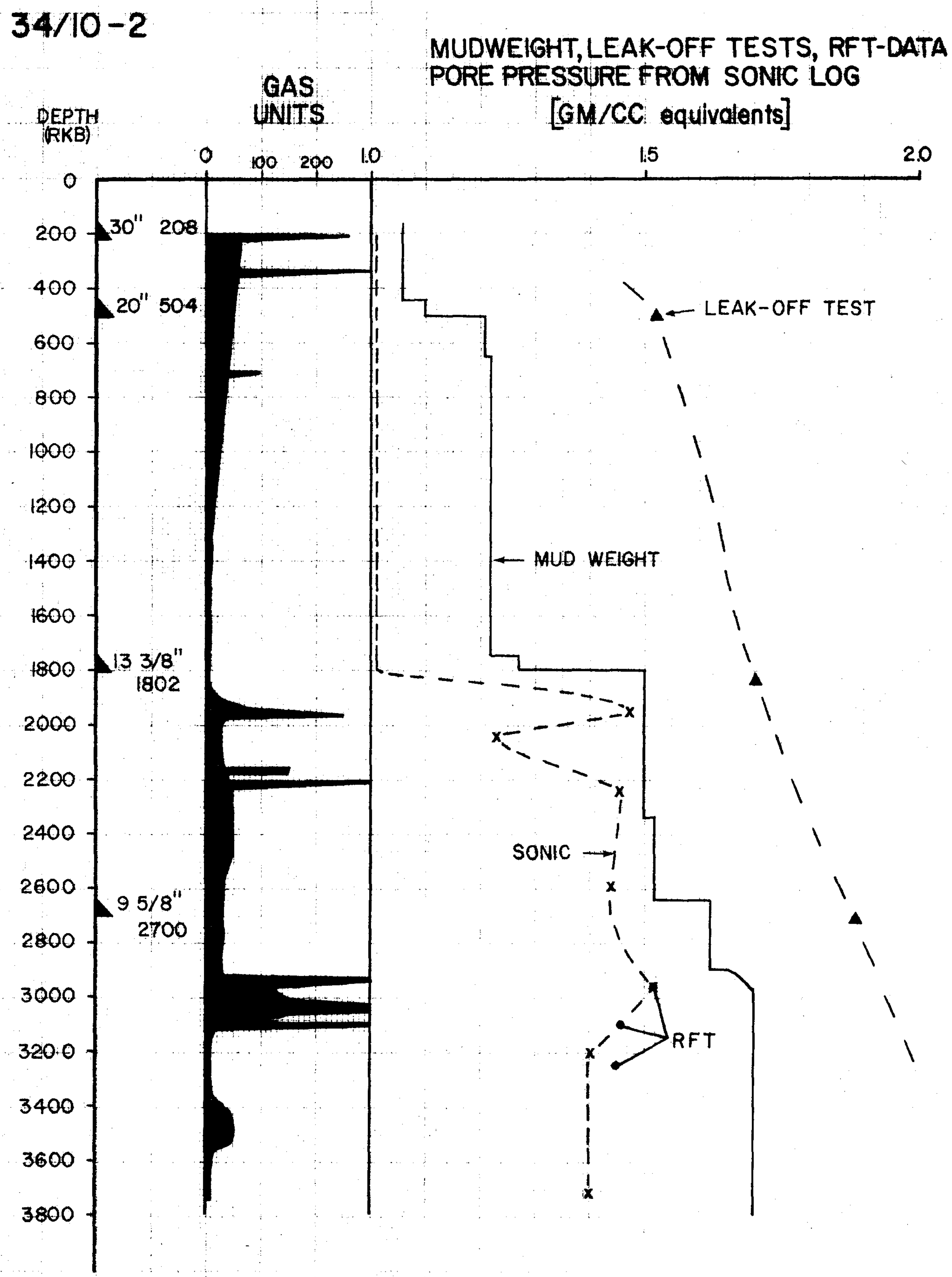


- - - - ESTIMATED POREPRESSURE FROM D-EXPONT

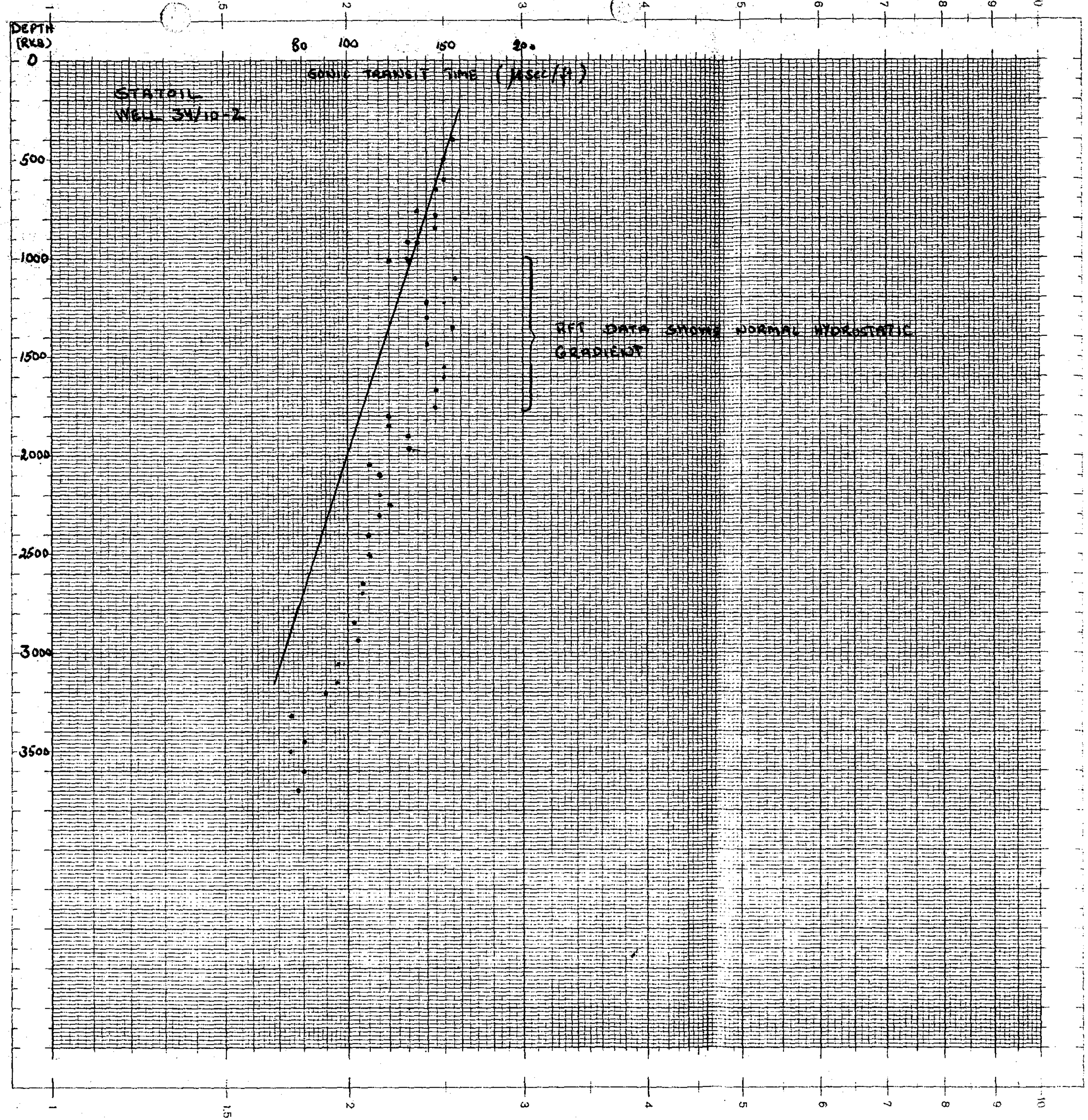
——— MUD WEIGHTS

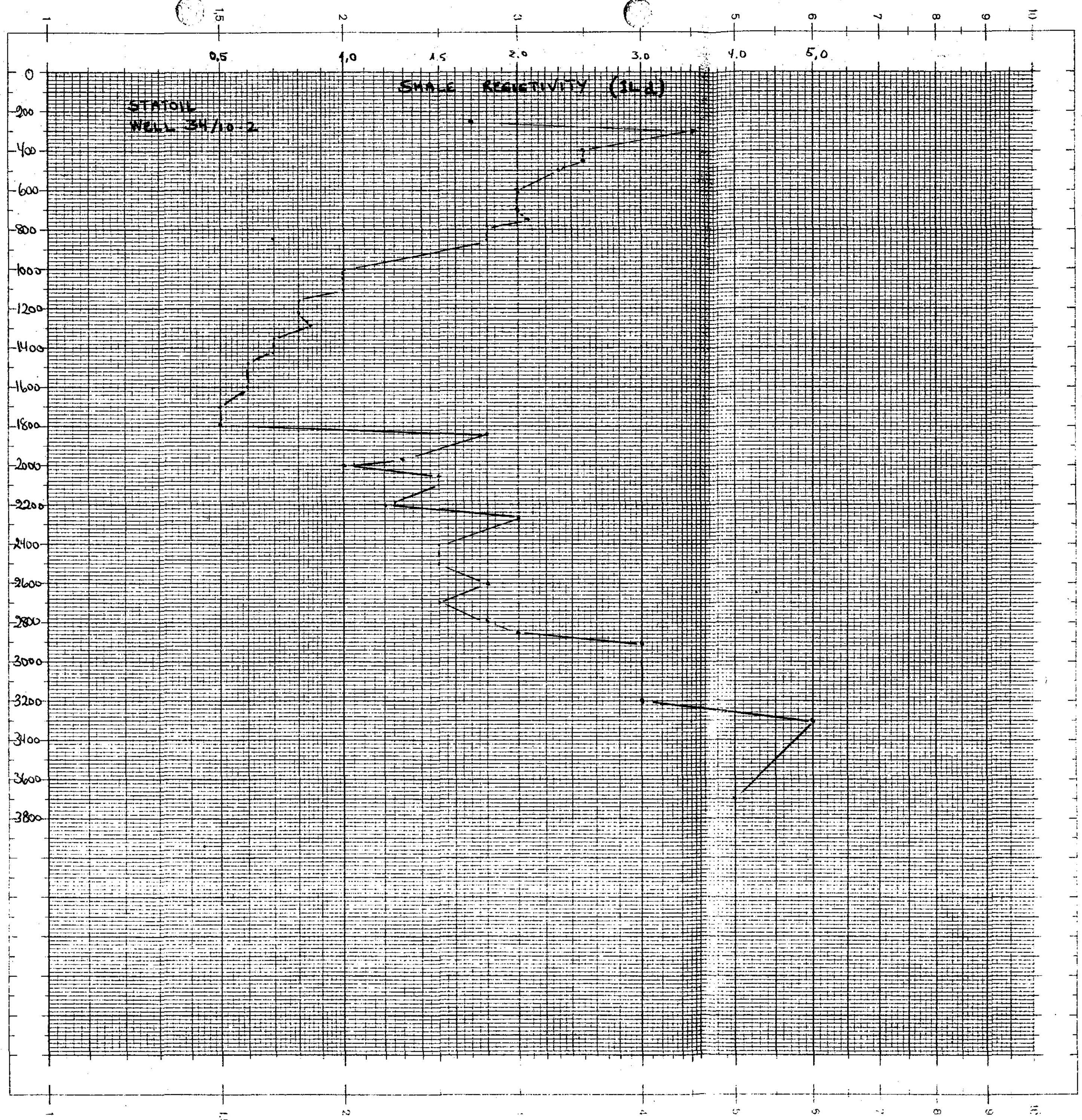
▲ LEAK OFF TESTS

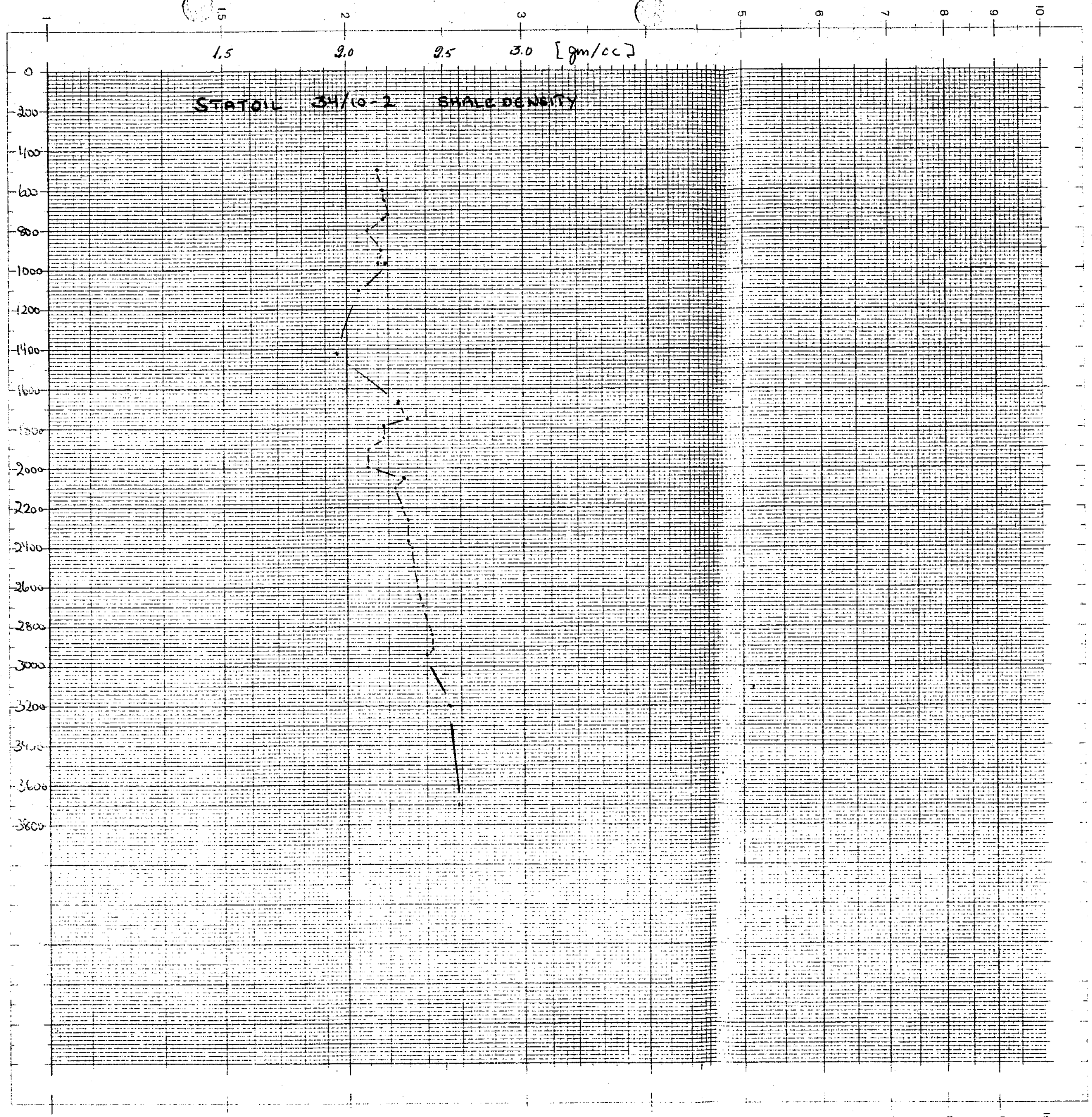
● PRESSURE TESTS (RFT)

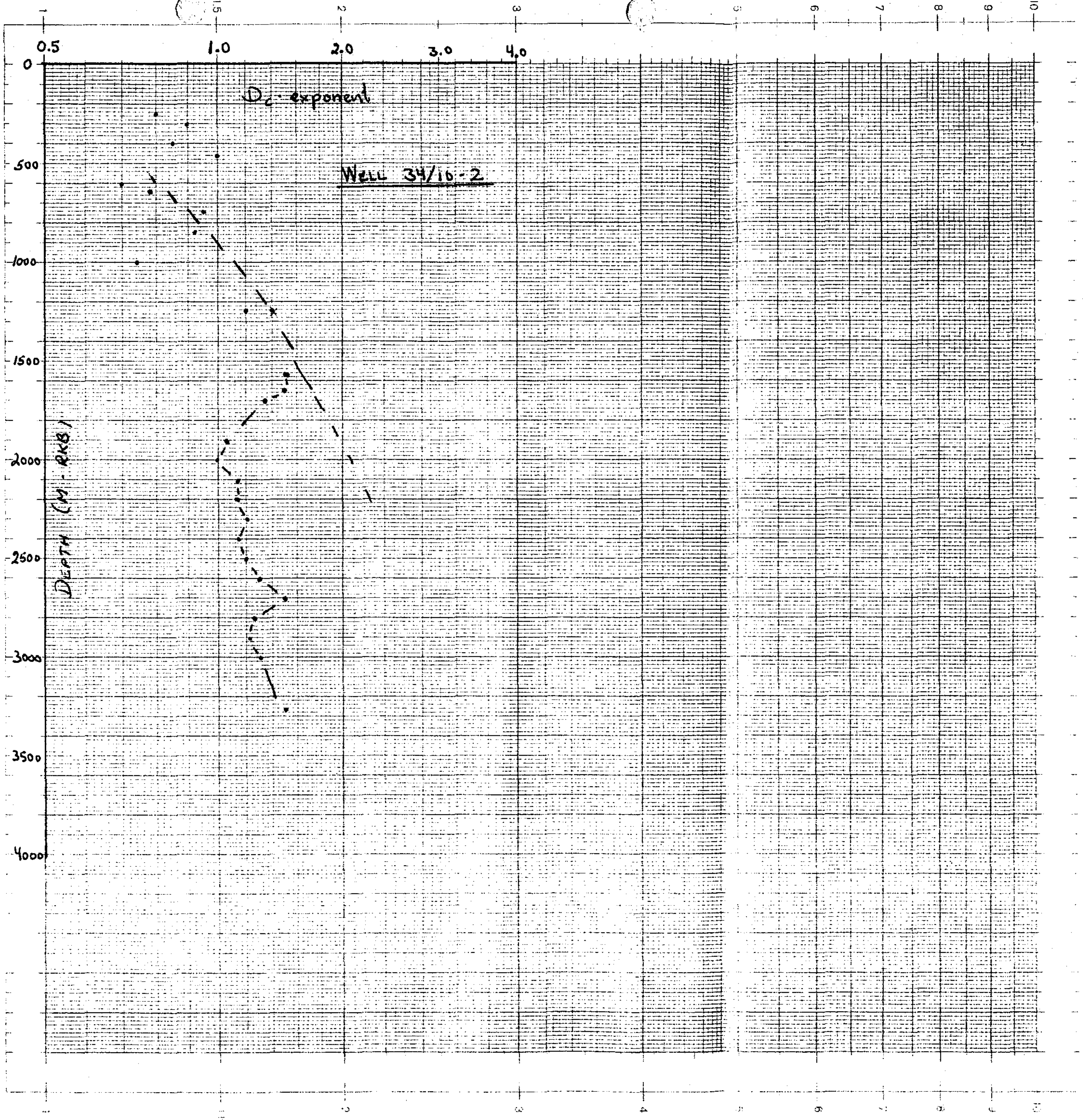


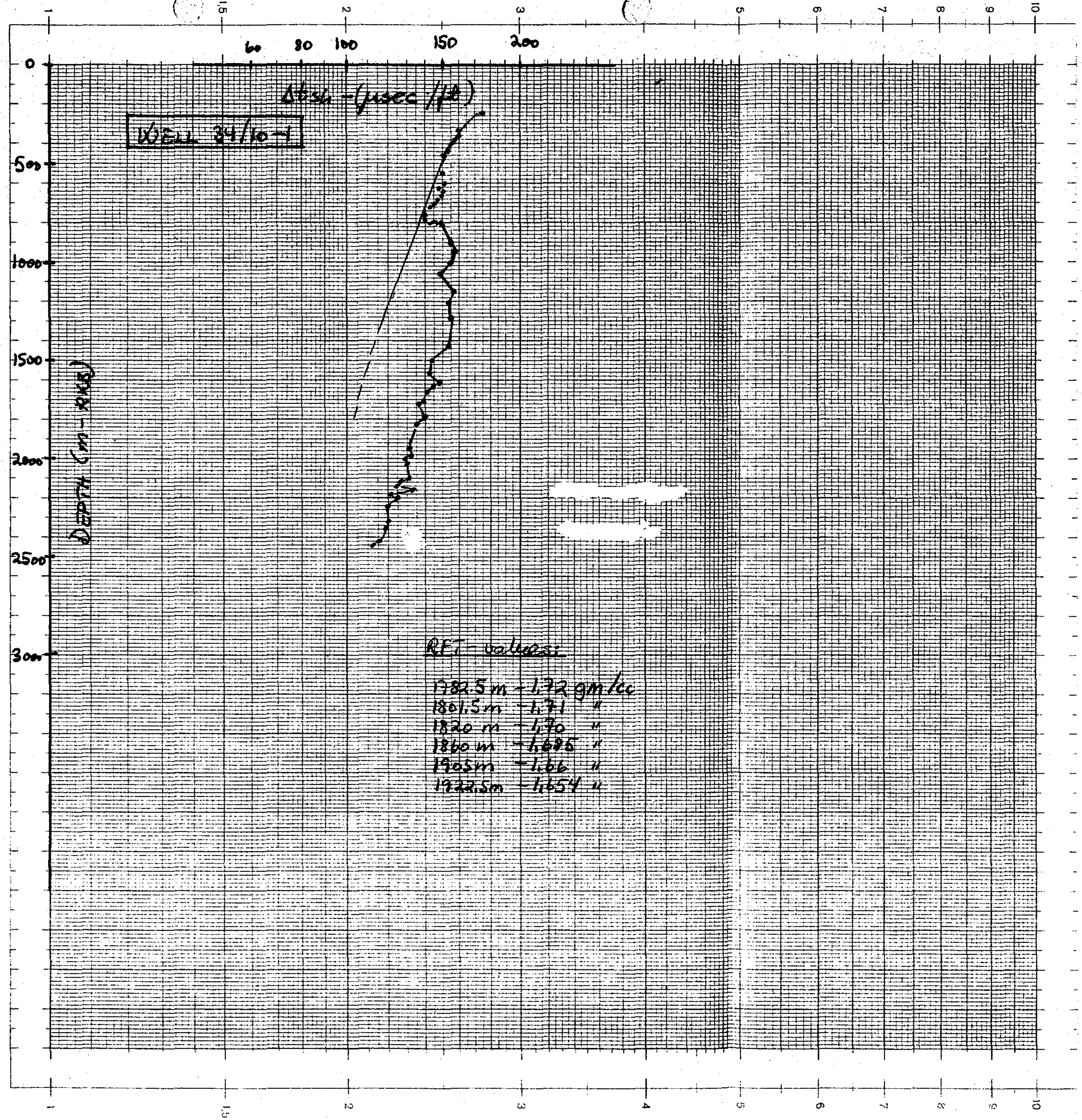
34/10-2
MUDWEIGHT, LEAK-OFF TESTS, RFT-DATA
PORE PRESSURE FROM SONIC LOG
[GM/CC equivalents]
DEPTH (RKB)
GAS UNITS
0
100
200
1.0
1.5
2.0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
30" 208
20" 504
13 3/8" 1802
9 5/8" 2700
LEAK-OFF TEST
MUD WEIGHT
SONIC
RFT

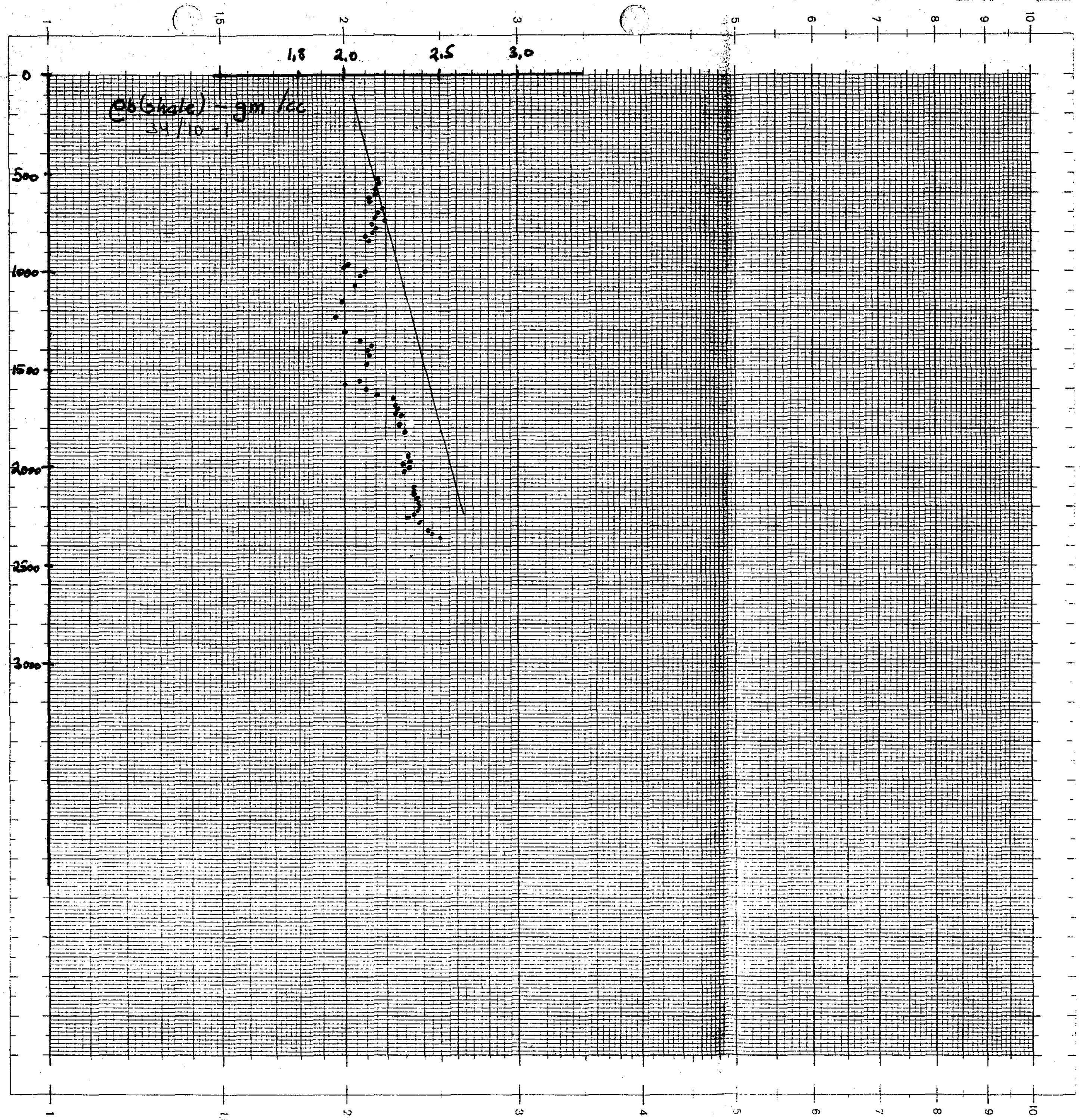

DEPTH (RKB)
0
500
1000
1500
2000
2500
3000
3500
80
100
150
200
SONIC TRANSIT TIME (μsec/ft)
STATOIL
WELL 34/10-2
RFT DATA SHOWS NORMAL HYDROSTATIC GRADIENT

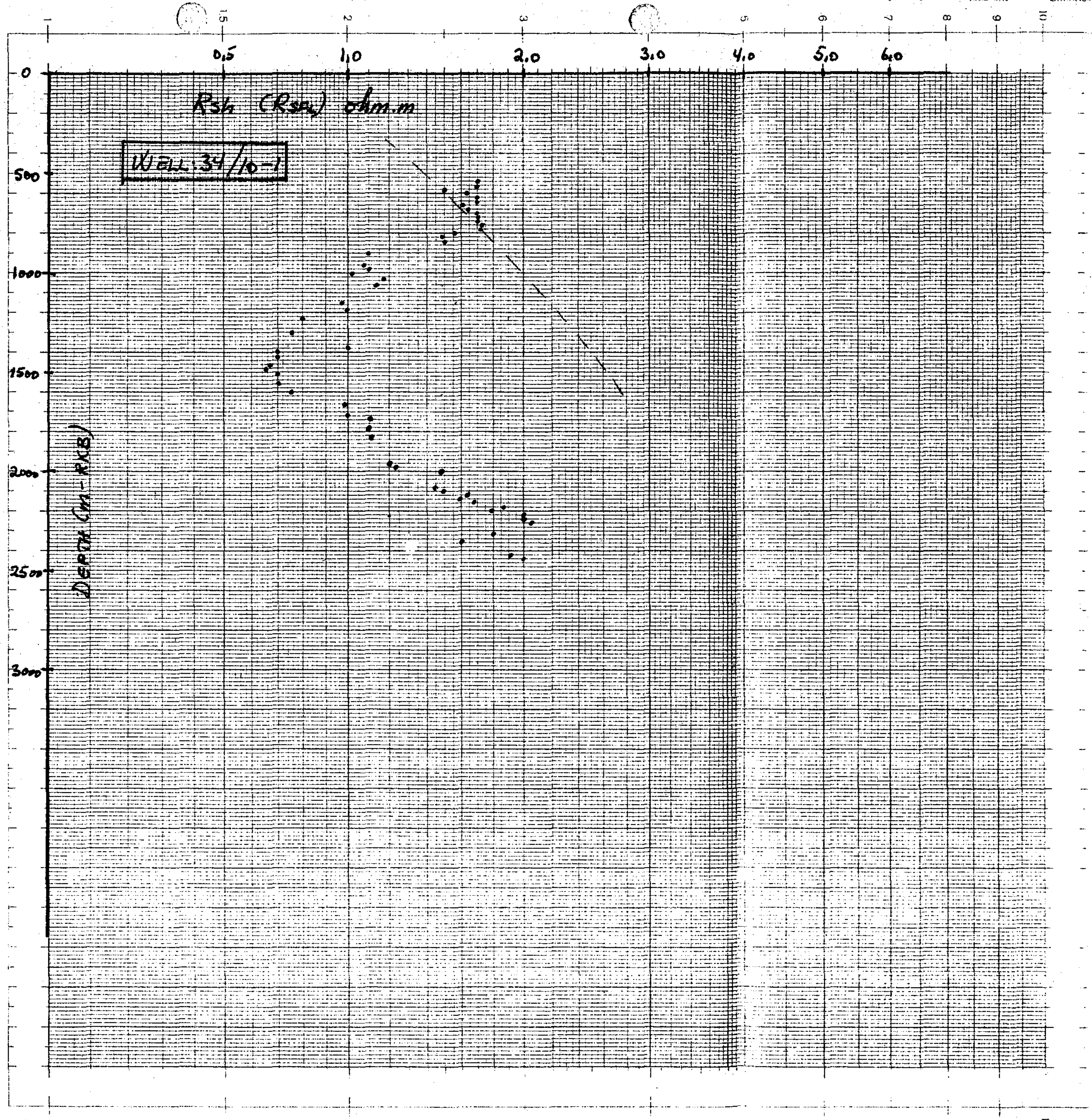

SHALE RESISTIVITY (ILd)
STATOIL
WELL 34/10-2
0,5
1,0
1.5
2.0
3.0
4.0
5,0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800

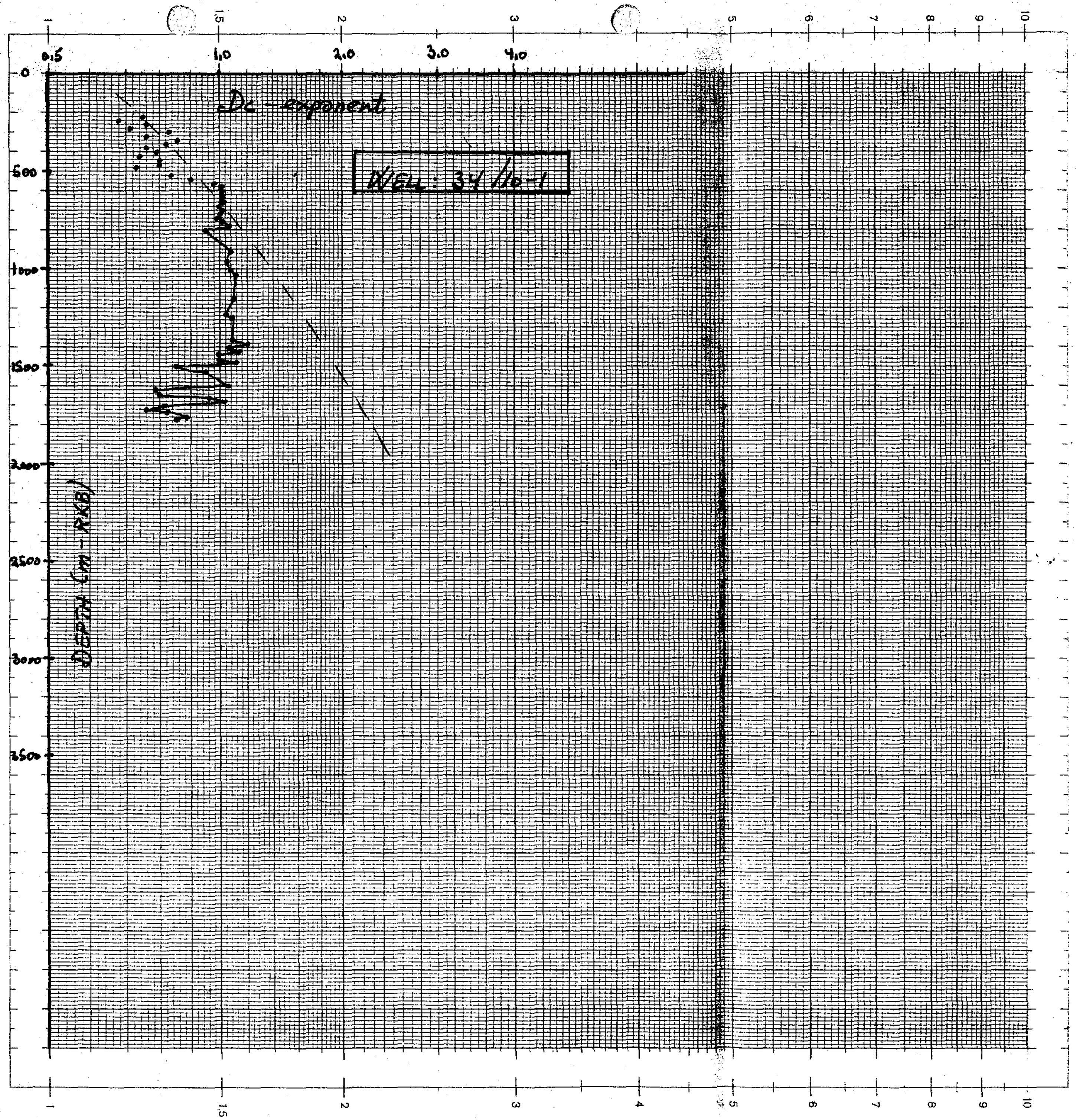

STATOIL 34/10-2 SHALE DENSITY
1.5
2.0
2.5
3.0 [gm/cc]
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800


Dc-exponent
WELL 34/10-2
DEPTH (M. RKB)
0.5
1.0
2.0
3.0
4.0
0
500
1000
1500
2000
2500
3000
3500
4000


WELL 34/10-1
Δtsh - (μsec /ft)
60 80 100 150 200
Depth (m-RKB)
0
500
1000
1500
2000
2500
3000
1 1.5 2 3 4 5 6 7 8 9 10
RFT - values:
1782.5 m - 1.72 gm/cc
1801.5m - 1.71 "
1820 m - 1.70 "
1860 m - 1.685 "
1905m - 1.66 "
1922.5m - 1.654 "


ρb(shale) - gm/cc
34/10-1
1,8
2.0
2.5
3,0
0
500
1000
1500
2000
2500
3000


Rsh (Rsh) ohm.m
WELL 34/10-1
0,5
1,0
2,0
3,0
4,0
5,0
6,0
0
500
1000
1500
2000
2500
3000
DEPTH (m-RKB)


Dc - exponent
WELL: 34/10-1
DEPTH (m-RKB)
0.5
1.0
2.0
3.0
4.0
0
500
1000
1500
2000
2500
3000
3500