National Exams

98-Pet-B1, Well Logging and Formation Evaluation

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. Candidates are also encouraged to make any reasonable assumption for the missing parameters (if any) and answer questions.

3. This is a CLOSED BOOK exam. Graphs, equations, and data are provided as attachments; however, not all of graphs and equations are necessarily need to be used for this exam. Graph papers are also provided in the attachments.

Only A Casio or Sharp approved calculator models are permitted.

4. This exam contains 11 questions. All questions will be marked.

5. Value of each question is shown.

6. Some questions require an answer in essay format. Clarity and organization of the answer are important.

Question 1:

a. What are the two main types of interpretation problems? List these problems and explain each type in detail. **(4 pts)**

b. List four assumptions which the conventional interpretation techniques are based on. **(4 pts)**

Question 2:

With the help of two separate diagrams for the resistivity as a function of distance away from the wellbore, describe the invasion profile when i) transition and ii) annulus zones are observed. **(5 pts)**

Question 3:

List and explain the three types of Neutron detectors. **(6 pts)**

Question 4:

Calculate the *SSP* for a clean, predominantly NaCl water-bearing sand drilled with a fresh water-based mud (also predominantly NaCl). The formation temperature is 200 °F, and R_{mf} and R_w measured at 68 °F temperature are 0.31 and 0.054 Ω.m, respectively. **(4 pts)**

Question 5:

Show the borehole diameter effect on the reading of a 19 ½ inch GNT tool for the following measurement environment: 12-lbm/gal barite mud, 10% limestone formation true porosity, and 250°F formation temperature. **(4 Pts)**

Question 6:

Consider the acoustic properties of rocks,

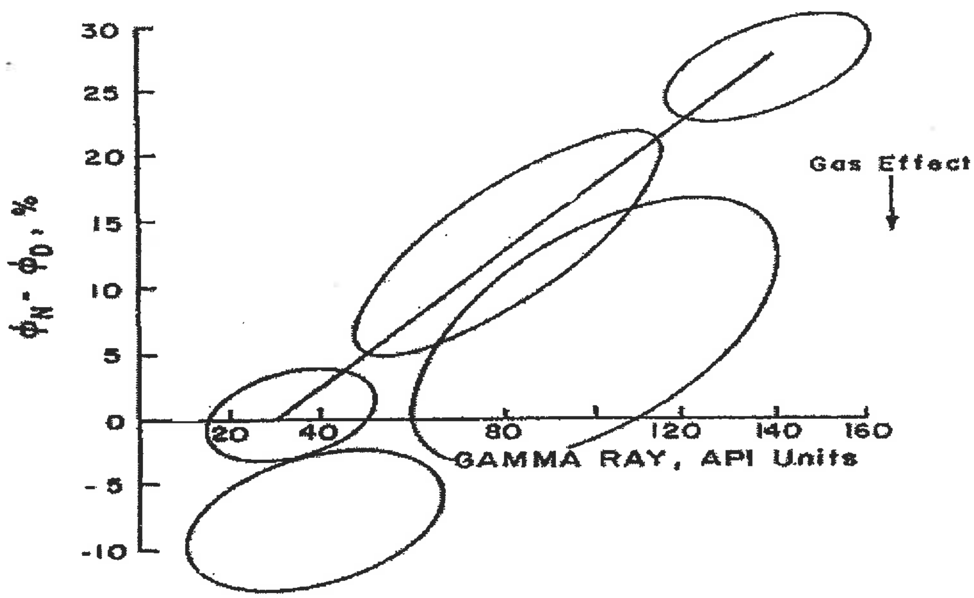
a. What parameters can be evaluated using compressional and shear wave velocities? **(3 pts)**

b. What is the application (usage) of amplitude of reflected waves? **(3 pts)**

c. What is the application (usage) of compressional and shear wave attenuation? **(2 pts)**

Question 7:

Below figure shows a crossplot of (ϕ_N-ϕ_D) vs. gamma ray for a specific log interval, as it can be seen on the figure, 5 different zones were observed and each zone is shown by an ellipse. Assume that the detected zones are: 1. Shaly gas-bearing formation, 2. Clean-gas bearing formation, 3. Shaly-liquid bearing formation, 4. Shale and 5. Clean liquid-bearing formation. Show each zone on the corresponding ellipse in below figure. **(5 pts)**



Question 8:

The following values were read from the induction and sonic logs recorded through a sand/shale section:

Zone	Conductivity	Δt (μsec/ft)
1	400	95
2	150	96
3	370	83
4	520	85
5	50	58
6	140	76
7	130	67
8	100	80
9	100	55
10	200	69
11	150	90
12	1050	86
13	1500	91

a. Prepare a Hingle plot using $F=0.62/\Phi^{2.15}$ *(you may use the attached grid scale).* **(4 pts)**

b. Prepare a Pickett plot using $\Delta t_{ma}=55.5$ *μsec/ft.* **(4 pts)**

c. Does the section analyzed contain lithologies other than sandstone? **(2 pts)**

d. Determine R_w and Δt_{ma} from the Hingle plot. **(4 pts)**

e. Determine R_w and m from the Pickett plot. $F=\frac{1}{\phi^{2.1}}$ **(4 pts)**

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Question 9:

a) The activity of 1 g of pure radium-226 is measured to be 3.22×10^{10} integrations/sec. Calculate the half-life time and decay constant of radium-226. **(4 pts)**

b) There are 18×10^{14} radioactive nuclei of a certain kind present at time zero. After 150 days, there is 5×10^{14} left.

i. What is the decay constant of these nuclei? **(3 pts)**

ii. What is the half-life? **(2 pts)**

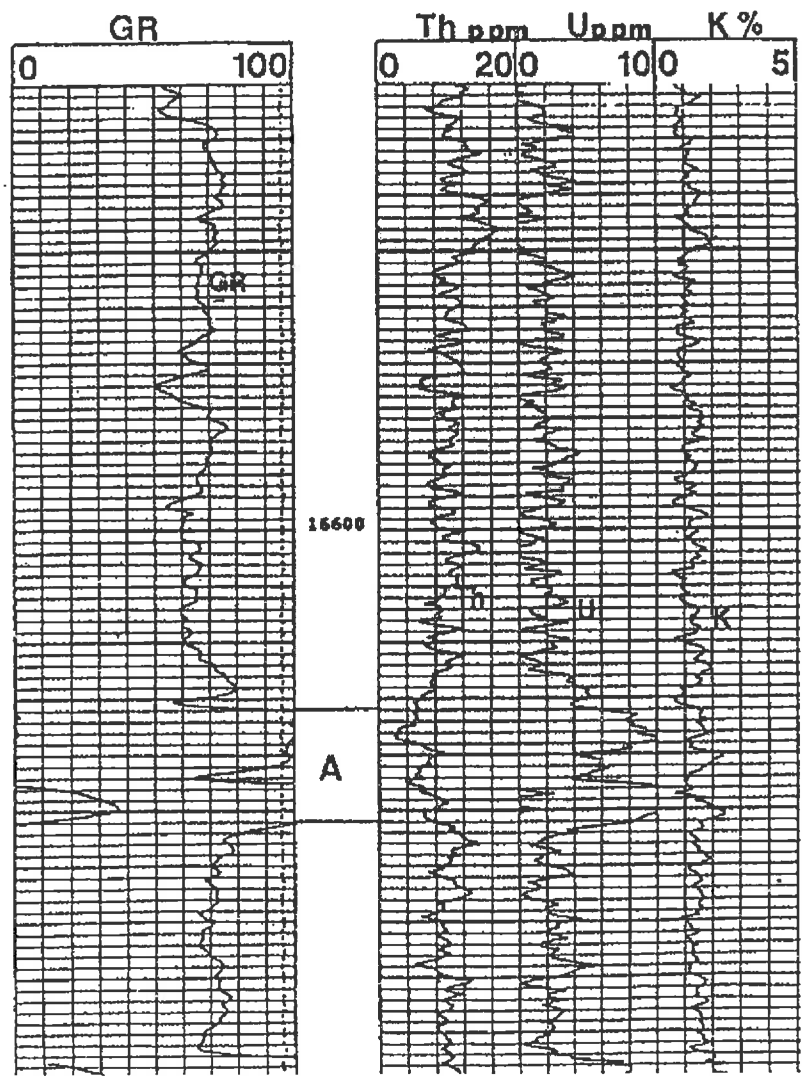
iii. How many disintegrations per seconds are there initially and at 150 days? **(3 pts)**

Question 10:

Consider the following log which is obtained by Schlumberger device; calculate the shale index using the gamma ray and spectrometry log responses.

a) Compare the results obtained and explain which value is more representative of the shale index. **(6 Pts)**

b) Assume that the zone is 0.7 g/cm^3 oil bearing limestone and drilled by an oil-based mud, if the residual oil saturation is 35%, calculate the apparent and true porosities for the zone of interest. **(4 Pts)**



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Question 11:

A development well is drilled to evaluate the oil sand shown by the ISF/sonic and CNL/FDC logs of following figures. Interpretation experience with this formation type indicated that $R_w = 0.05\ \Omega$.m at formation temperature; that the formations are unconsolidated and hence high sonic log readings are expected; and that the sands are moderately shaly, so a good porosity value can be obtained by averaging the porosity readings of the density and neutron curves.

$A = 160$ *acres*

$B_o = 1.2$ *RB/STB*

$FR = 38\%$

a. Is there oil/water contact in the sands shown by the logs, if yes, at what depth, if not why? **(3 pts)**

b. Estimate the value of the summation $\Sigma\varphi_i h_i (S_o)_i$. **(15 pts)**

c. Estimate the recoverable oil from the sand situated in this interval. **(2 pts)**

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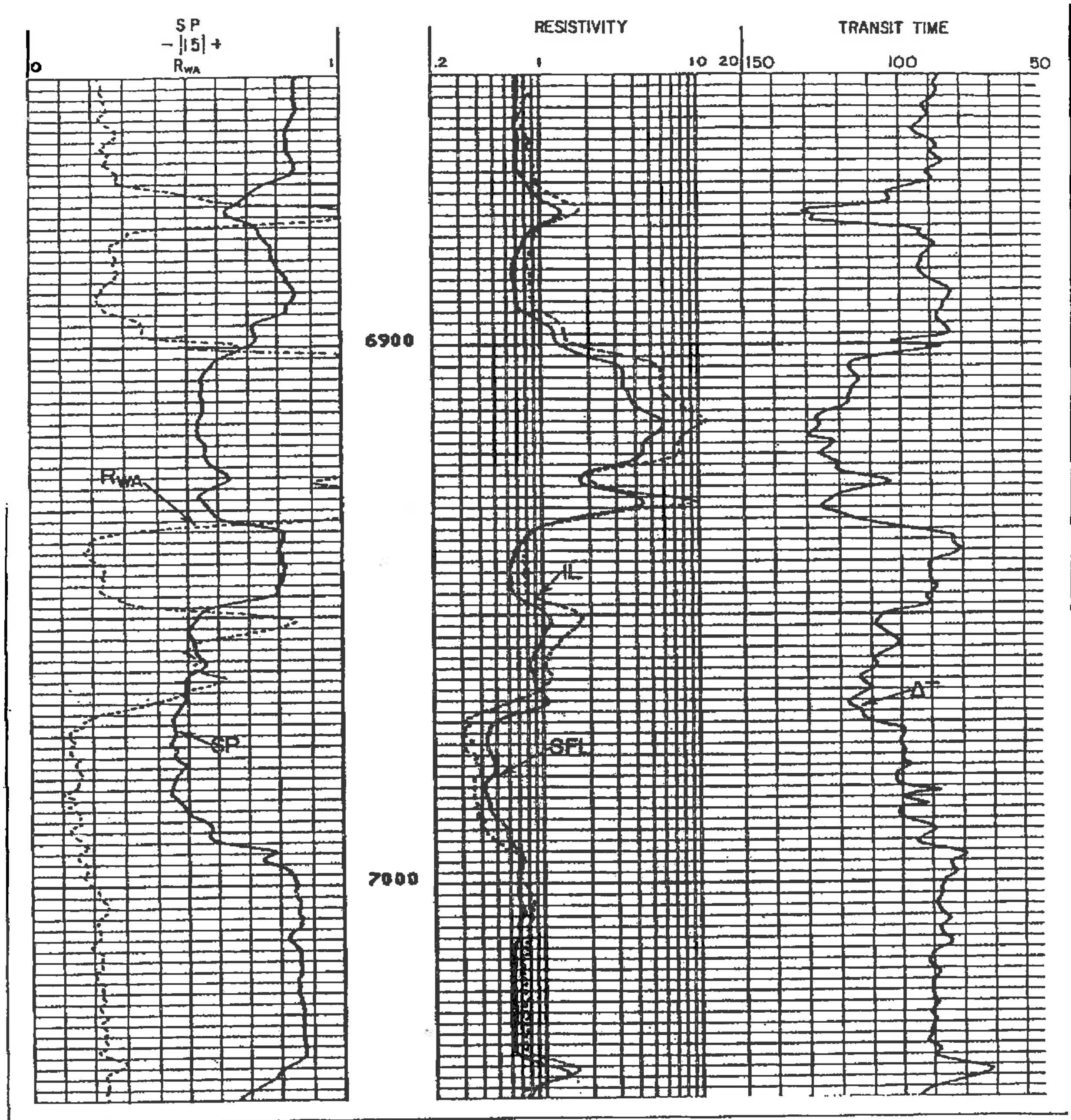


Fig. 11.26—ISF/sonic log of Problem 11.3 (courtesy Schlumberger).

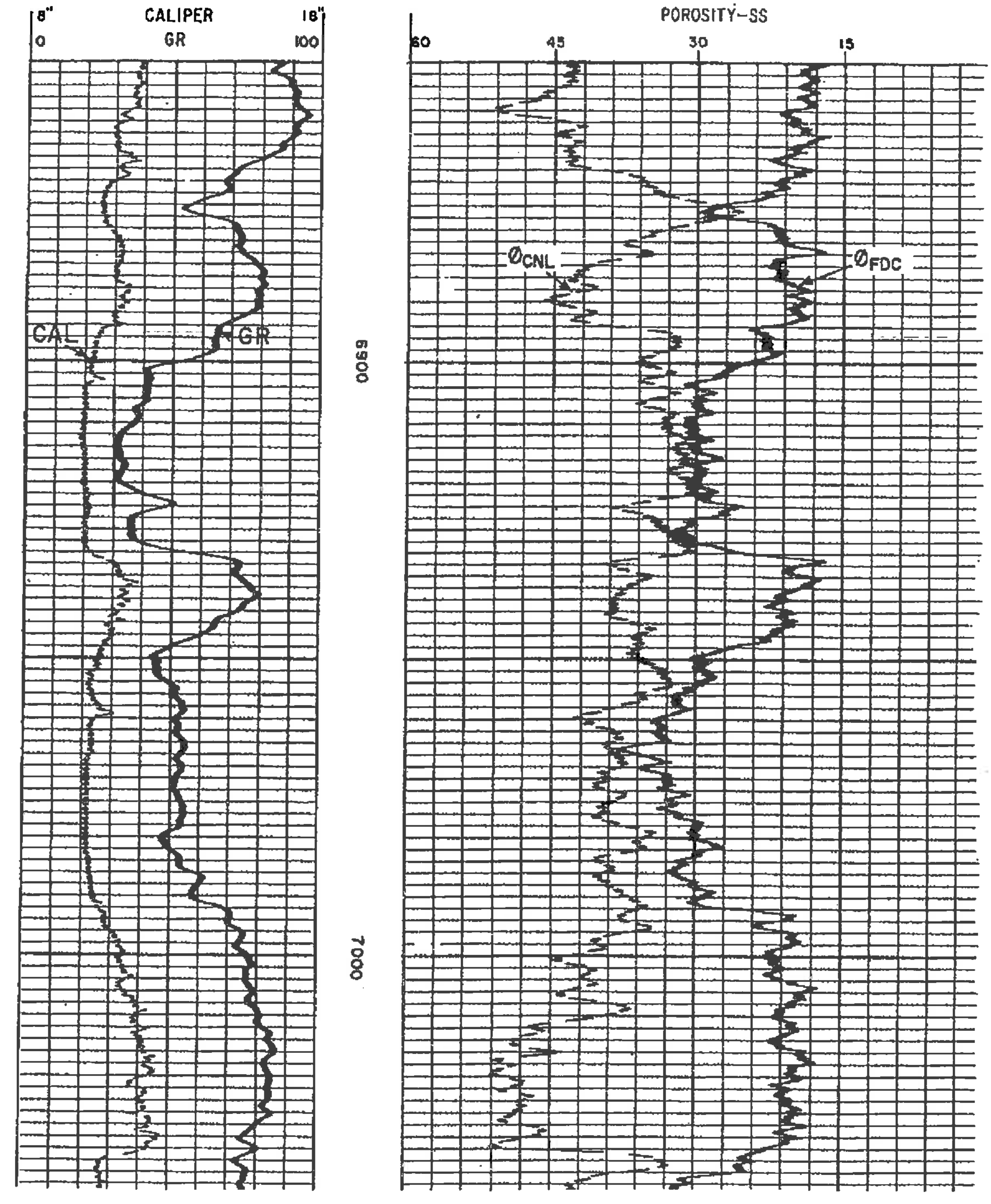


Fig. 11.27—CNL/FDC log of Problem 11.3 (courtesy Schlumberger).

Attachment:

$$R_2 = R_1 \frac{T_1 + 6.77}{T_2 + 6.77}$$

$$f_w = \frac{1}{1 + \frac{k_{ro}\mu_w}{k_{rw}\mu_o}} \qquad R_{mp} = \frac{FR_w}{(S_{cw})^n}$$

$$S_w = \left(\frac{0.81R_w}{\phi^2 R_t}\right)^{1/2} - \left(\frac{V_{sh}R_w}{0.4\phi R_{sh}}\right)$$

$$\mathrm{F} = \frac{0.62}{\phi^{2.15}}$$

$$\mathrm{R_w} = \frac{\mathrm{R_o}}{F}$$

$$N_R = 7758\frac{AF_R}{B_o}\sum_{i=1}^{n} h_i\phi_i(S_o)_i$$

$$(\phi_D)_{sh} = \left[\frac{\rho_{ma} - \rho_{sh}}{\rho_{ma} - \rho_f}\right]$$

$$\phi = \left[\frac{(\Delta t - \Delta t_{ma})}{(\Delta t_f - \Delta t_{ma})}\right]$$

$$I_R = \frac{R_t}{R_o} = \frac{7.5}{0.752}$$

$$S_w = \left(\frac{R_o}{R_t}\right)^{1/2} \qquad S_o = 1 - S_w$$

$$N = \frac{6.023\square 10^{23}}{Z}\square mass$$

$$a = NC_d$$

$$t_{1/2} = 0.693 / C_d$$

$$\square = 1.443\square t_{1/2}$$

$$K = 61.3 + 0.133T$$

$$E_{SSP} = -K\left[\log(R_{mf})_{eq} / (R_w)_{eq}\right]$$

$$\phi_D = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f}$$

$$\phi = \phi_a - V_{sh}(\phi_a)_{sh}$$

$$V_{sh} = 1.7 - \left[3.38 - (I_{sh} + 0.7)^2\right]^{1/2}$$

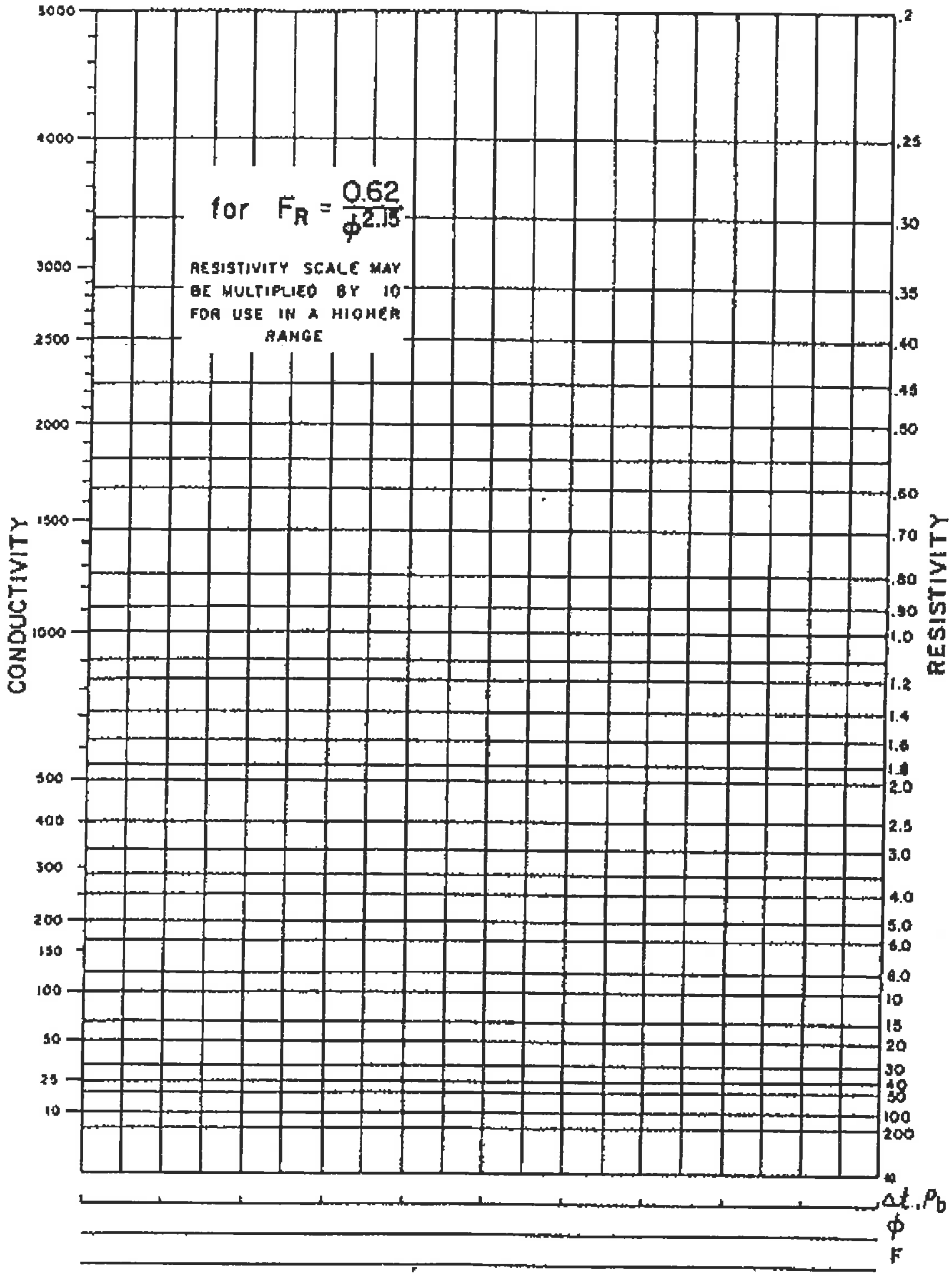
$$I_{sh} = \frac{\gamma_{\log} - \gamma_c}{\gamma_{sh} - \gamma_c}$$

$$V_{sh} = 0.33\left(2^{2I_{sh}} - 1\right)$$

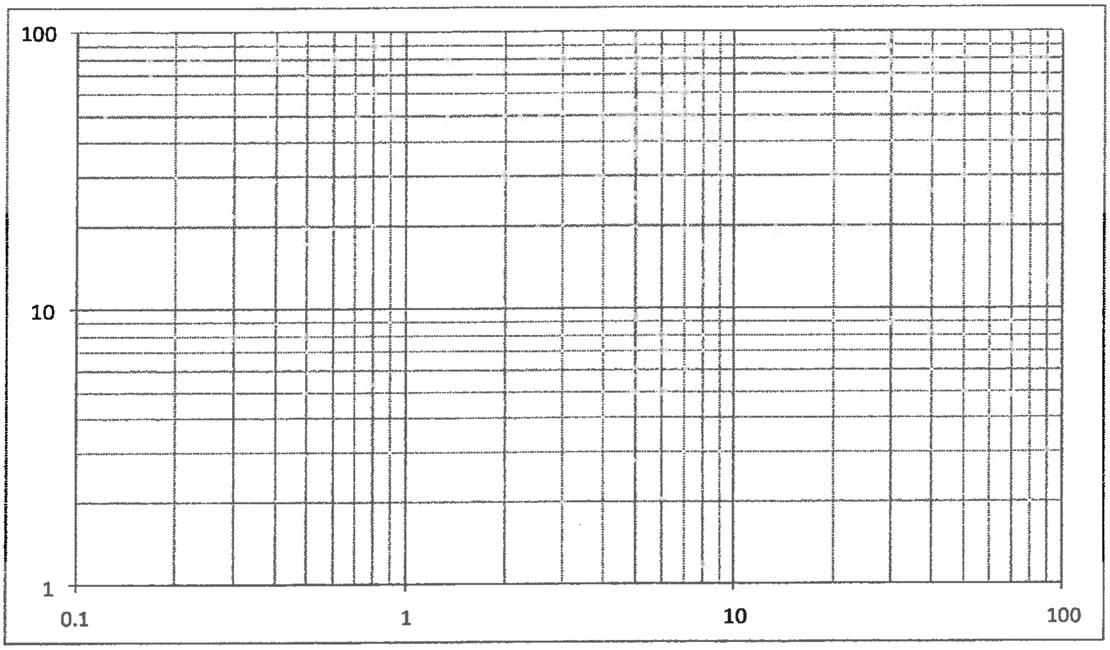
$$V_{sh} = \frac{I_{sh}}{3 - 2I_{sh}}$$

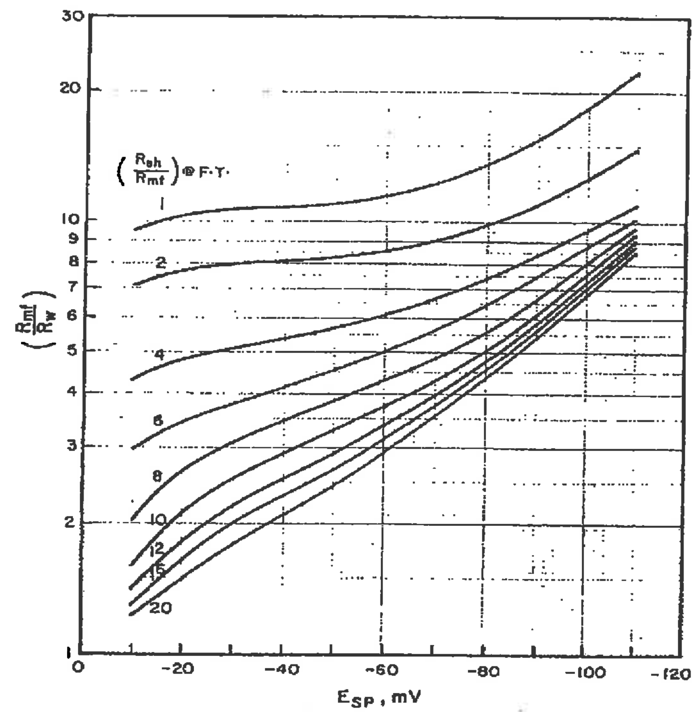
$$N = N_0 e^{\square t/\square}$$

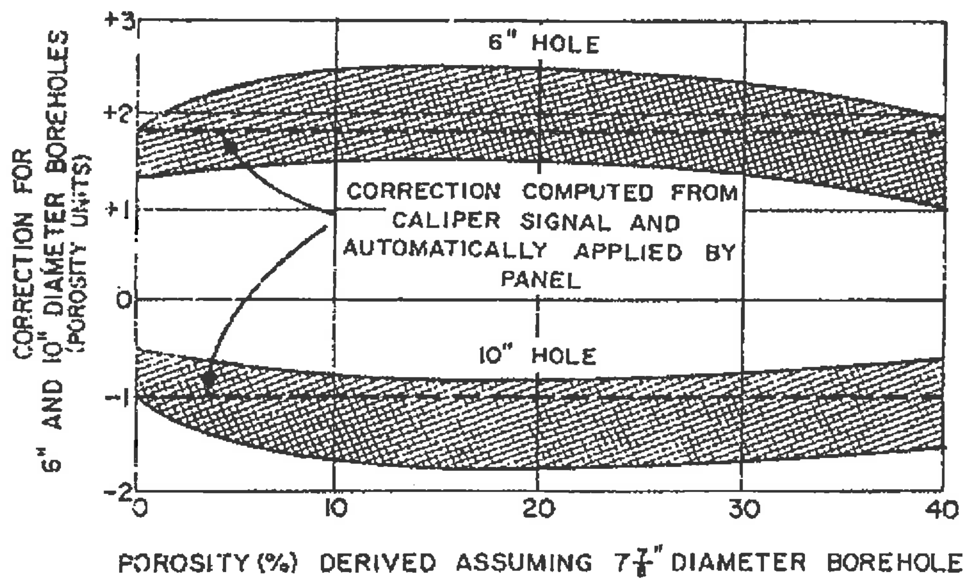
$$S_w = \left(\frac{R_o}{R_t}\right)^{1/2} \qquad S_o = 1 - S_w$$

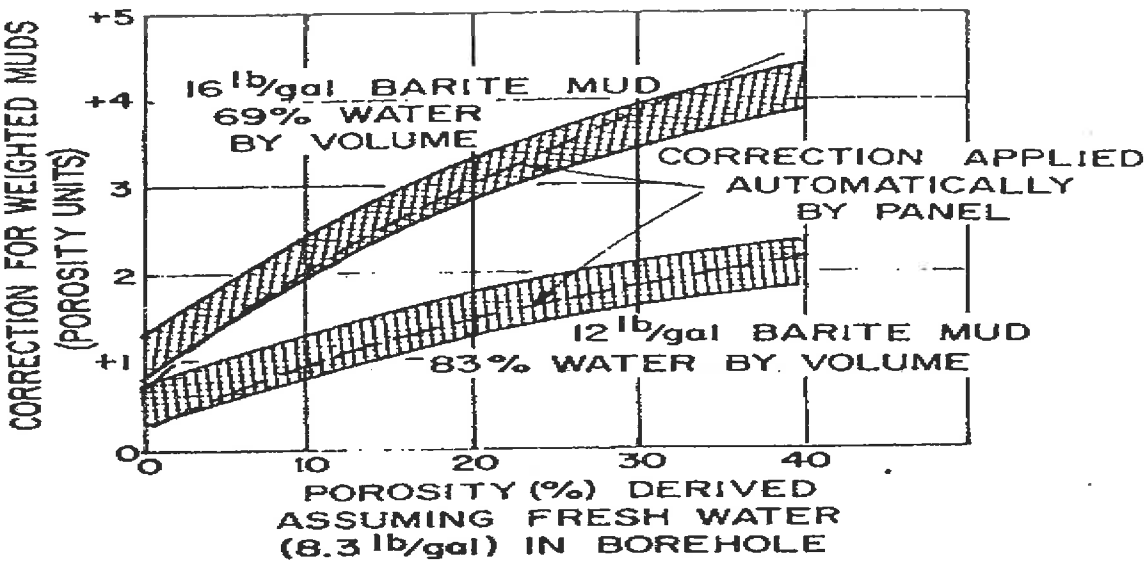


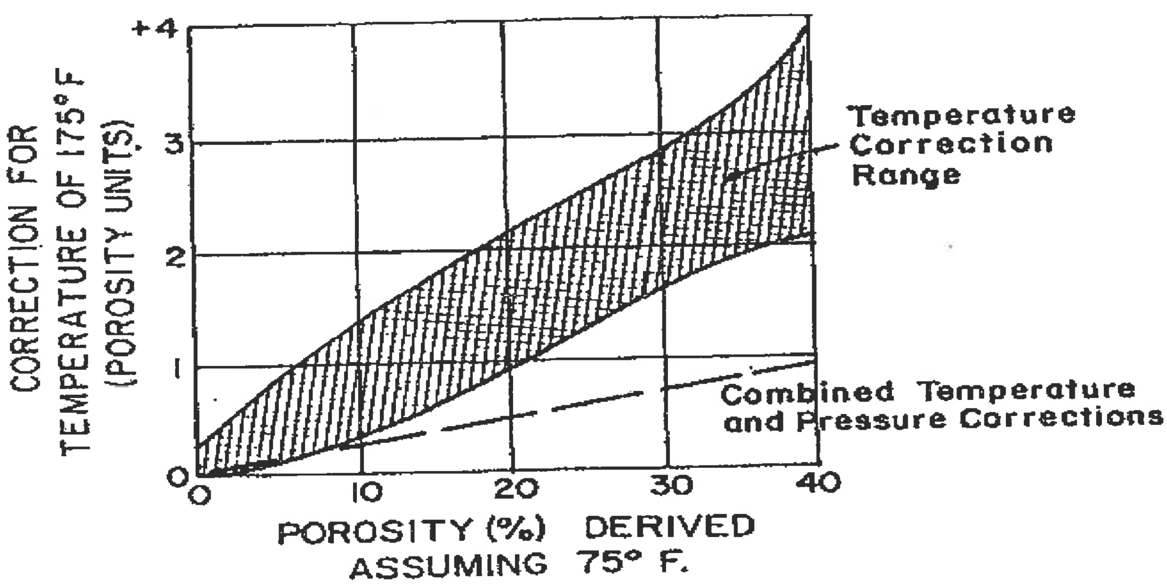
for $F_R = \frac{0.62}{\phi^{2.15}}$
RESISTIVITY SCALE MAY BE MULTIPLIED BY 10 FOR USE IN A HIGHER RANGE
CONDUCTIVITY
5000
4000
3000
2500
2000
1500
1000
500
400
300
200
150
100
50
25
10
RESISTIVITY
.2
.25
.30
.35
.40
.45
.50
.60
.70
.80
.90
1.0
1.2
1.4
1.6
1.8
2.0
2.5
3.0
4.0
5.0
6.0
8.0
10
15
20
30
40
50
100
200
∞
$\Delta t, \rho_b$
ϕ
F

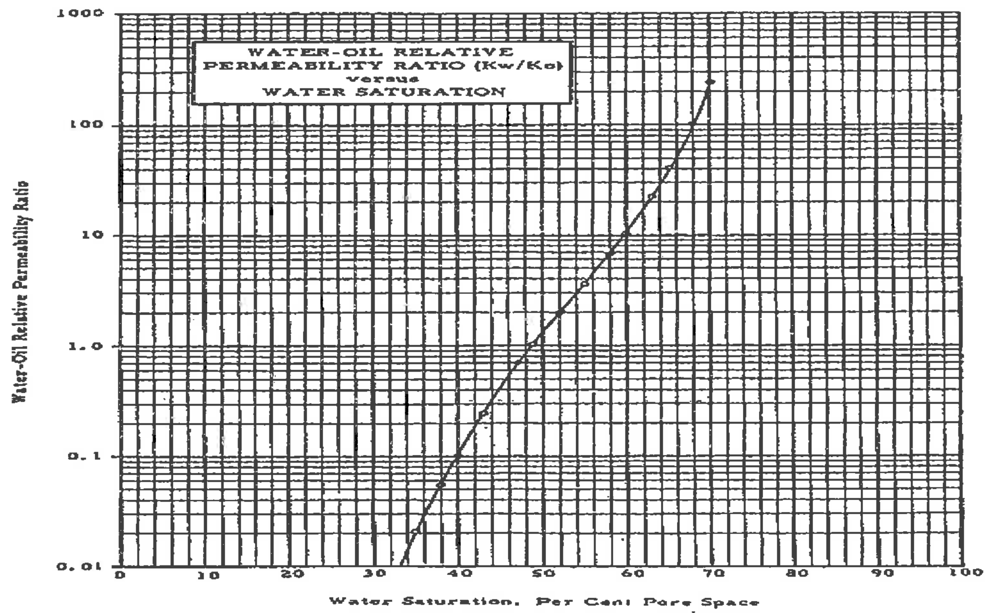

100
10
1
0.1
1
10
100


$\left(\frac{R_{sh}}{R_{mf}}\right)$ @ F.T.
$\left(\frac{R_{mf}}{R_w}\right)$
E_{SP}, mV

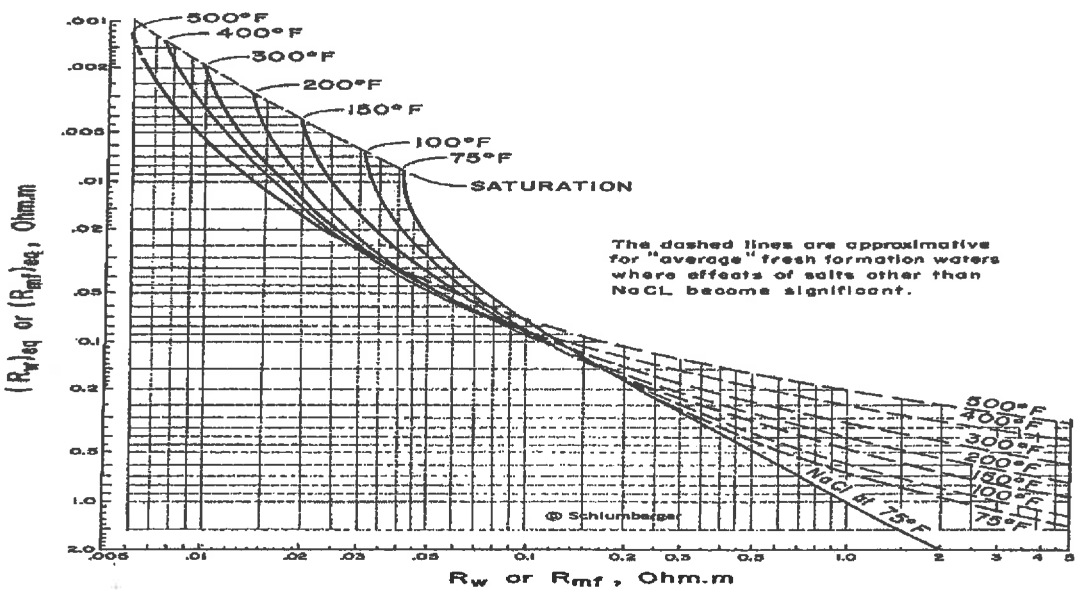

6" HOLE
CORRECTION COMPUTED FROM CALIPER SIGNAL AND AUTOMATICALLY APPLIED BY PANEL
10" HOLE
CORRECTION FOR 6" AND 10" DIAMETER BOREHOLES (POROSITY UNITS)
POROSITY (%) DERIVED ASSUMING $7\frac{7}{8}$" DIAMETER BOREHOLE


CORRECTION FOR WEIGHTED MUDS (POROSITY UNITS)
16 lb/gal BARITE MUD 69% WATER BY VOLUME
CORRECTION APPLIED AUTOMATICALLY BY PANEL
12 lb/gal BARITE MUD 83% WATER BY VOLUME
POROSITY (%) DERIVED ASSUMING FRESH WATER (8.3 lb/gal) IN BOREHOLE
+5
+4
3
2
+1
0
0
10
20
30
40


CORRECTION FOR TEMPERATURE OF 175° F (POROSITY UNITS)
Temperature Correction Range
Combined Temperature and Pressure Corrections
POROSITY (%) DERIVED ASSUMING 75° F.
+4
3
2
1
0
0
10
20
30
40



WATER-OIL RELATIVE PERMEABILITY RATIO (Kw/Ko) versus WATER SATURATION
Water-Oil Relative Permeability Ratio
Water Saturation, Per Cent Pore Space
1000
100
10
1.0
0.1
0.01
0
10
20
30
40
50
60
70
80
90
100



500°F
400°F
300°F
200°F
150°F
100°F
75°F
SATURATION
The dashed lines are approximative for "average" fresh formation waters where effects of salts other than NaCL become significant.
NaCl at 75°F
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$(R_w)_{eq}$ or $(R_{mf})_{eq}$, Ohm.m
R_w or R_{mf}, Ohm.m