National Examinations December 2019

17-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. A Casio or Sharp approved calculators are permitted. All graphs, equations, grid papers, etc are provided in the attachments.

4. This exam contains 10 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. Name three logging tools used to measure the porosity of the rock. **(3 Pts)**

b. In the context of acoustic properties of the rocks, what are the applications of:

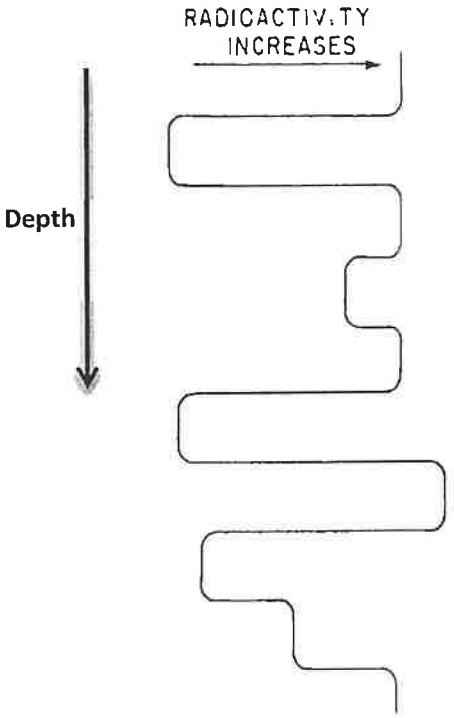
i. Compressional and shear wave attenuation. **(2 pts)**

ii. Amplitude of reflected waves. **(3 pts)**

Question 2:

Below is the output log for a gamma ray tool. Locate the following zones on the below figure: **(7 pts)**

1. Shale 2. Sandstone 3. Limestone 4. Shaly sand 5. Sandy shale 6. Anhydrite 7. Black marine shale



Question 3:

Provide a definition/clear explanation for the following terms.

a) Mud invasion? **(2 pts)**

b) Mud cake? **(2 pts)**

c) Mud filtrate? **(2 pts)**

d) Flushed zone? **(2 pts)**

Question 4:

List six assumptions which the conventional interpretation techniques are based on.

(6 pts)

Question 5:

List the three types of neutron detectors. **(3 points)**

Question 6:

Reservoir rock contains minerals that give off Natural Gamma Radiation. Name three radioisotops that Spectral Gamma can detect? **(3 pts)**

Question 7:

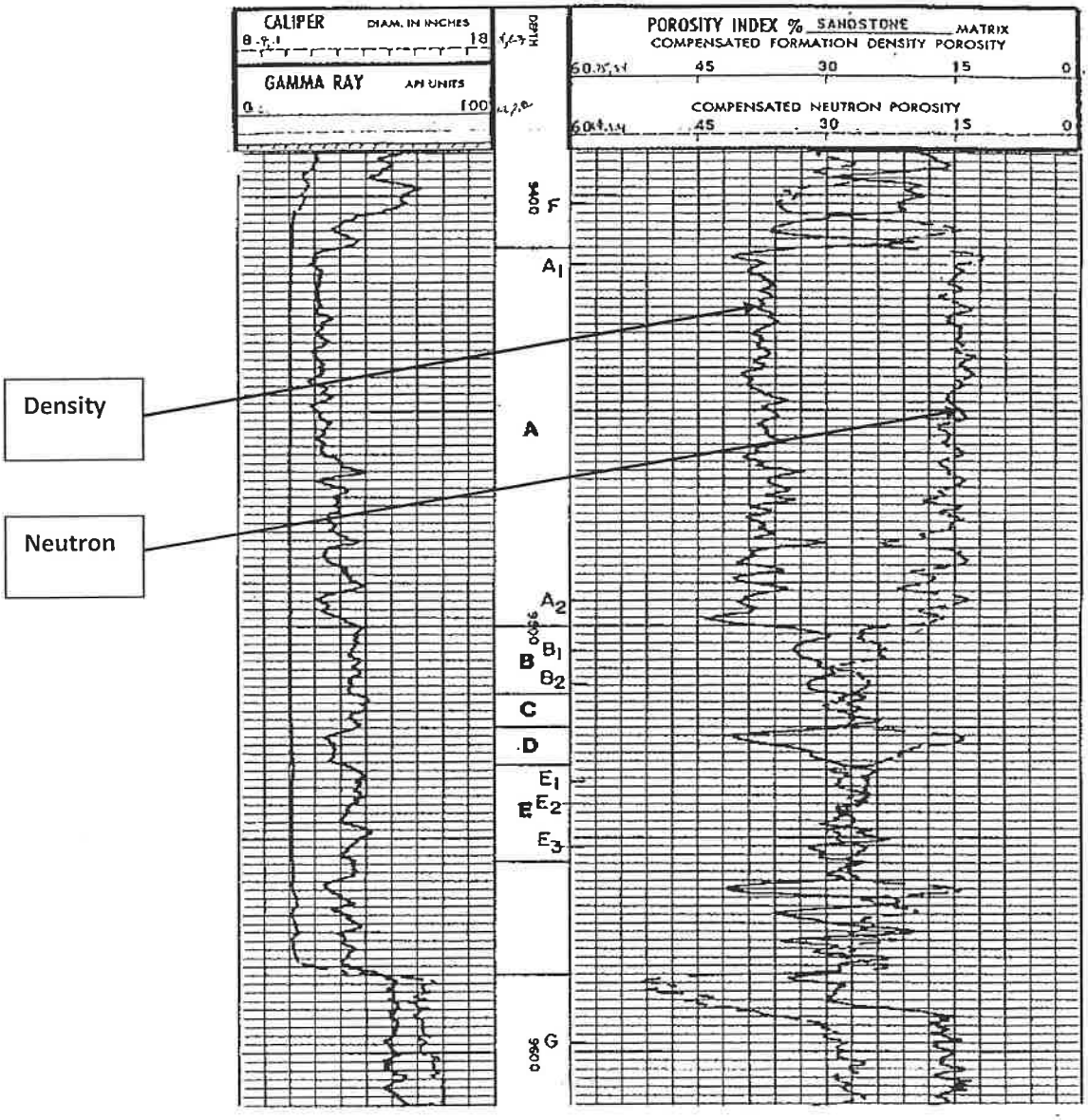
A Neutron and density log reading in a clean, gas-bearing sandstone formation are 5% and 2.0 g/cm^3, respectively. Assuming the gas is low density and filtrate is fresh mud, determine ϕ and S_{xo} with and without inclusion of excavation effect. You may nswer this question in next page. **(15 Pts)**

Question 8:

Prepare a crossplot of ϕ_N-ϕ_D *vs. gamma ray* that shows selected zones within intervals A through E in the following figure (use grid paper provided in the last page of this exam). The adjacent shale formation exhibits the following average values:

$\phi_{D,sh} = 38\%$ $\phi_{N,sh} = 16\%$ $\gamma_{sh} = 85$ *API units* $\gamma_{clean} = 30$ *API units*

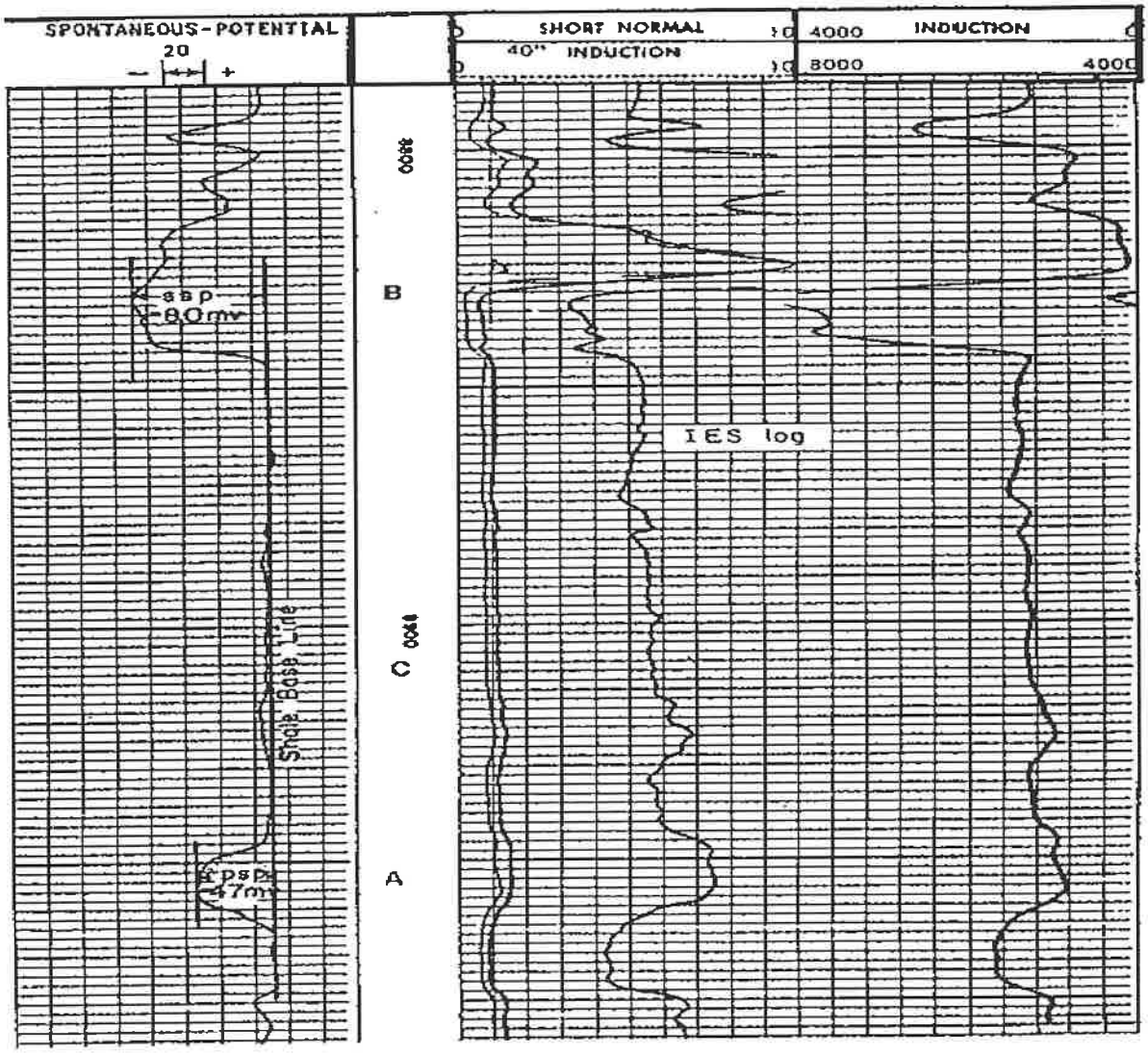
Using the crossplot determine the fluid type of Zones F and G situated at 9402 and 9599 ft, respectively. **(20 pts)**

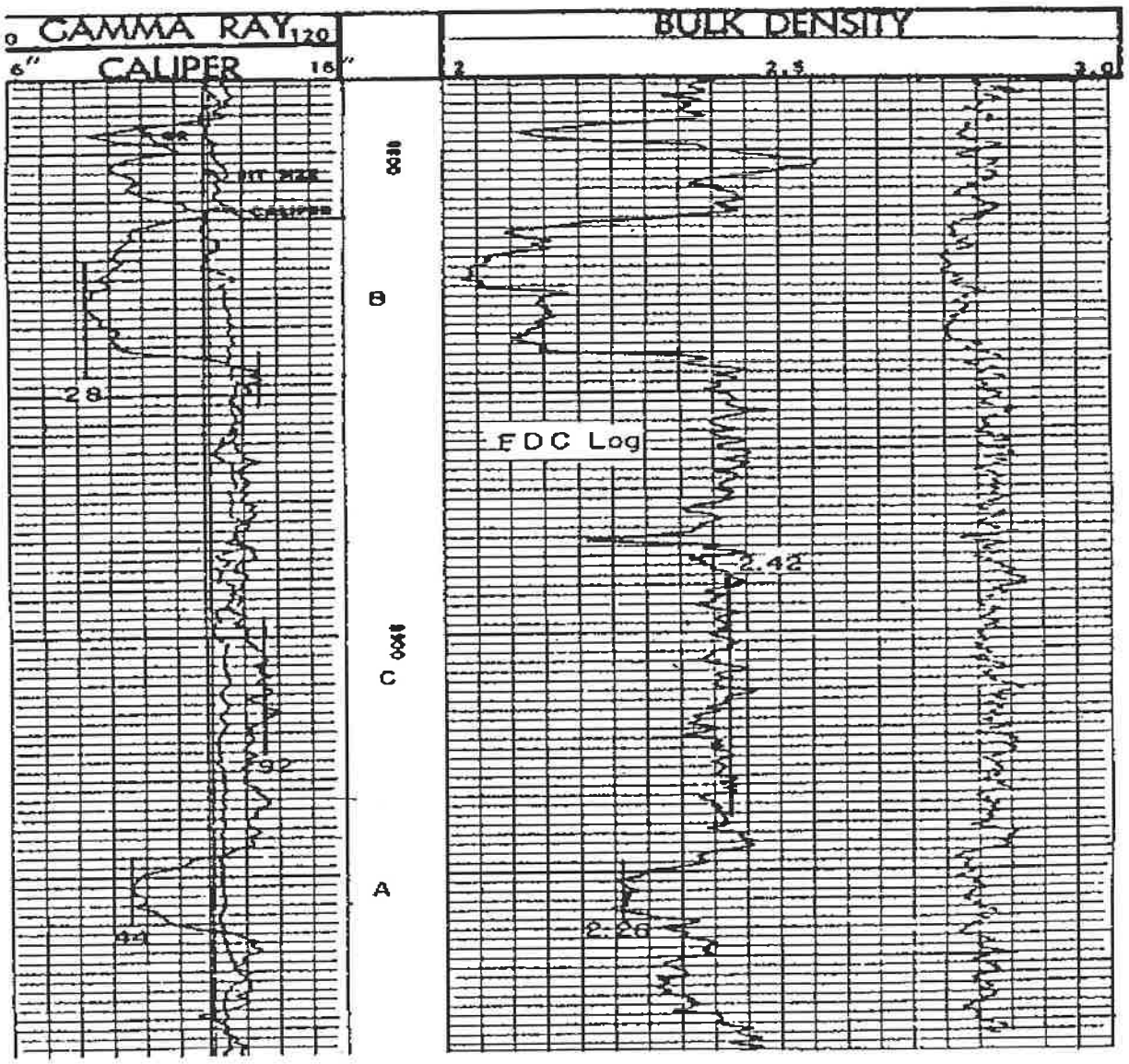

CALIPER
DIAM. IN INCHES
8
18
GAMMA RAY
API UNITS
0
100
DEPTH
POROSITY INDEX % SANDSTONE MATRIX
COMPENSATED FORMATION DENSITY POROSITY
45
30
15
0
COMPENSATED NEUTRON POROSITY
45
30
15
0
F
A1
A
A2
B1
B
B2
C
D
E1
E
E2
E3
G
Density
Neutron

Question 9:

The following figures show a section of IES and FDC logs obtained in a 9100 ft-deep well drilled offshore Louisiana. R_m at a bottomhole temperature (*BHT*) of *156°F* was *0.34 Ω.m.* **(20 pts)**

a) Using the SP curve, determine the shale content of zone A in the logs.
b) List the assumptions implied in the procedure used in Part (a).
c) Using the gamma ray curve, determine the shale content of Zone A.
d) List the assumptions implied in the procedure used in Part (c).
e) Compare the values in Part (a) and (c); and recommend a V_{sh} value.


SPONTANEOUS-POTENTIAL
20
SHORT NORMAL
40" INDUCTION
4000
INDUCTION
8000
4000
B
C
A
IES log
Shale Base Line


0 GAMMA RAY 120
6" CALIPER 16"
2
2.5
3.0
BULK DENSITY
B
C
A
FDC Log
2.42
2.26

Question 10:

a. Assuming that the shale membrane is perfect and formation temperature is 200 F, estimate ESSP for a case where R_{mf} and R_w are 0.5 Ω.m and 0.1 Ω.m (at formation temperature), respectively. **(5pts)**

b. What will be the ESSP value if shale membrane is nonideal (R_{sh} is 2 Ω.m at 200F). **(5pts)**

Attachment:

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

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

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

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

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

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

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

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

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

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

$$\varphi = \frac{\rho_{ma} - \rho_b + \varphi_N}{\rho_{ma}} \qquad \varphi_N = \varphi S_{xo}$$

$$K = 61.3 + 0.133T$$

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

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

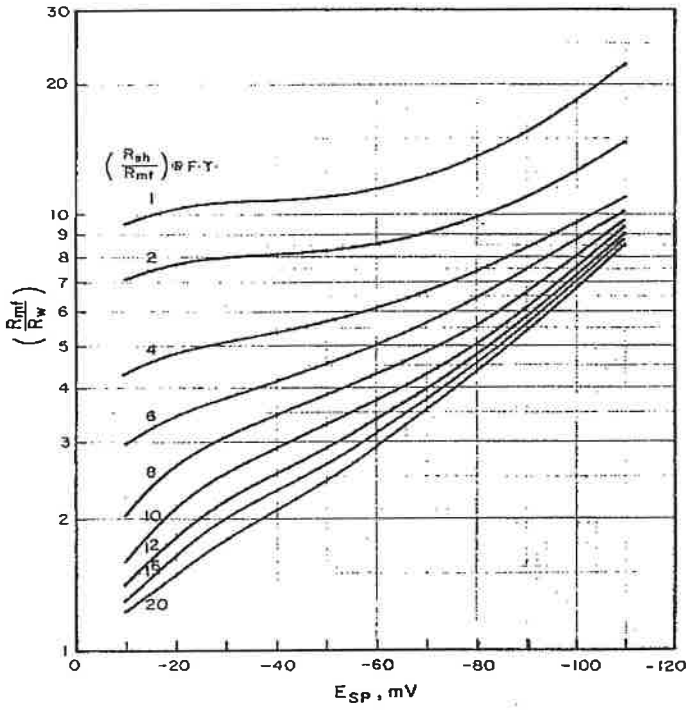
$$\phi = \phi_a - V_{sh} (\phi_a)_{sh}$$

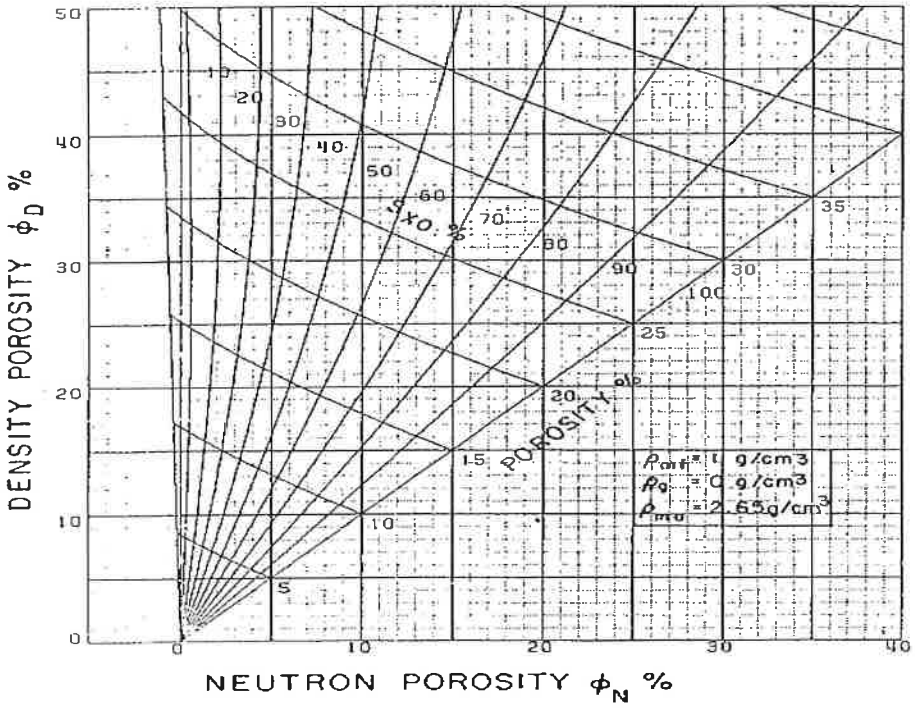
$$V_{sh} = 1.7 - \left[3.38 - (I_{sh} + 0.7)^2 \right]^{1/2}$$

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

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

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


$\left(\frac{R_{sh}}{R_{mf}}\right)$ @ F.T.
1
2
4
6
8
10
12
15
20
$\left(\frac{R_{mf}}{R_w}\right)$
E_{SP}, mV


DENSITY POROSITY ϕ_D %
NEUTRON POROSITY ϕ_N %
SALINITY, KILO. PPM
POROSITY, %
ρ_{mf} = 1 g/cm3
ρ_g = 0 g/cm3
ρ_{ma} = 2.65 g/cm3

Use the following grid paper for question#8