National Exams May 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.

   Approved Sharp or Casio calculator is permitted.
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:

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

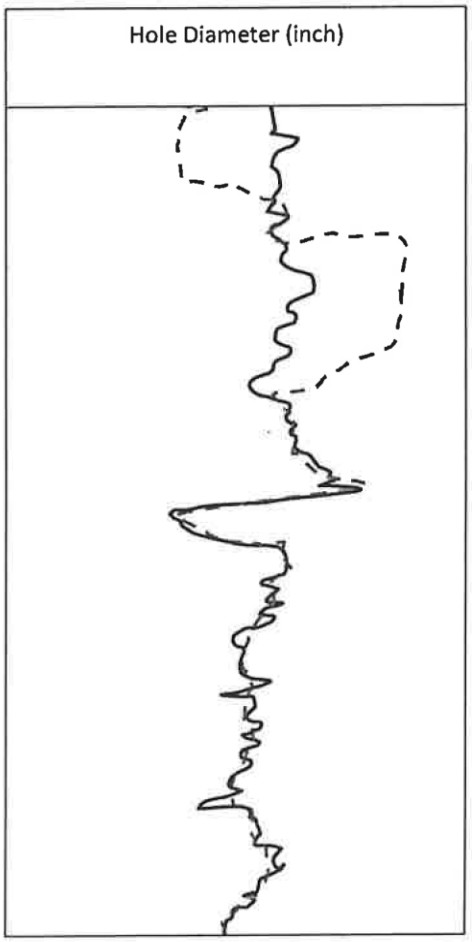
a. Compressional and shear wave velocities. **(3 pts)**

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

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

Question 2:

The following log shows responses of two independent arms of a calliper tool. Estimate shape of borehole (cross-sectional) in at least three depths where irregularity exists: **(6 pts)**



Question 3:

a) What is the main reason of mud invasion? **(2 pts)**

b) What is mud cake? **(2 pts)**

c) What is mud filtrate? **(2 pts)**

d) What is the flushed zone? **(2 pts)**

Question 4:

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 **(6 pts)**

Question 5:

List four factors which affect the resistivity of log. **(4 points)**

Question 6:

Describe four characteristics which affect the log quality. **(4 pts)**

Question 7:

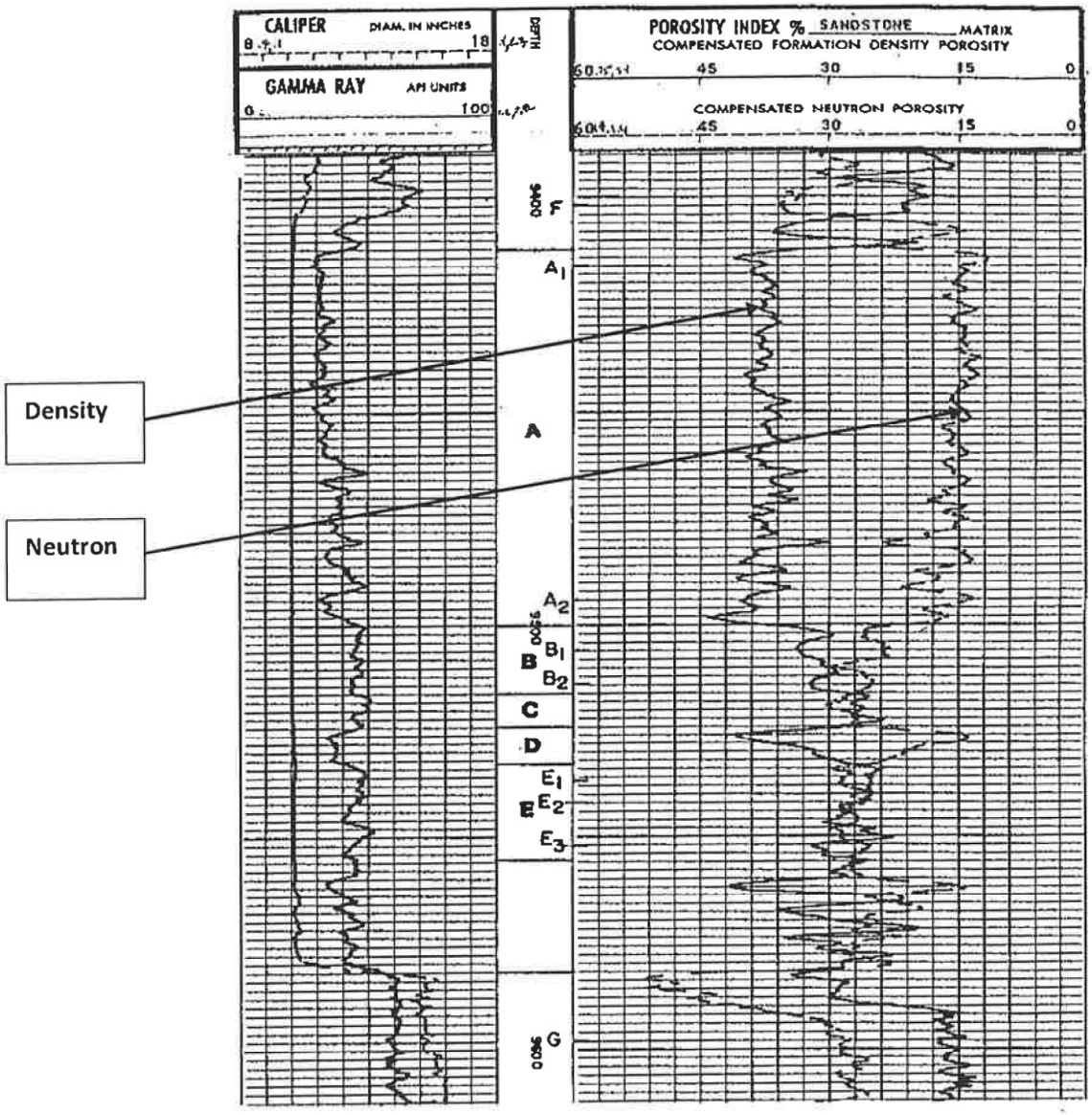
A Neutron and density log reading in a clean, gas-bearing sandstone formation are 5% and 2.0 g/cm^3, respectively. Assuming the gas is low density and filtrate is fresh mud, determine ϕ and S_{xo} with and without inclusion of excavation effect. . **(14 Pts)**

Question 8:

Prepare a crossplot of ϕ_N-ϕ_D *vs. gamma ray* that shows selected zones within interval A through E in the following figure. 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
60
45
30
15
0
COMPENSATED NEUTRON POROSITY
60
45
30
15
0
9000
F
A1
A
A2
9500
B
B1
B2
C
D
E1
E
E2
E3
9800
G
Density
Neutron

Question 9:

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)**

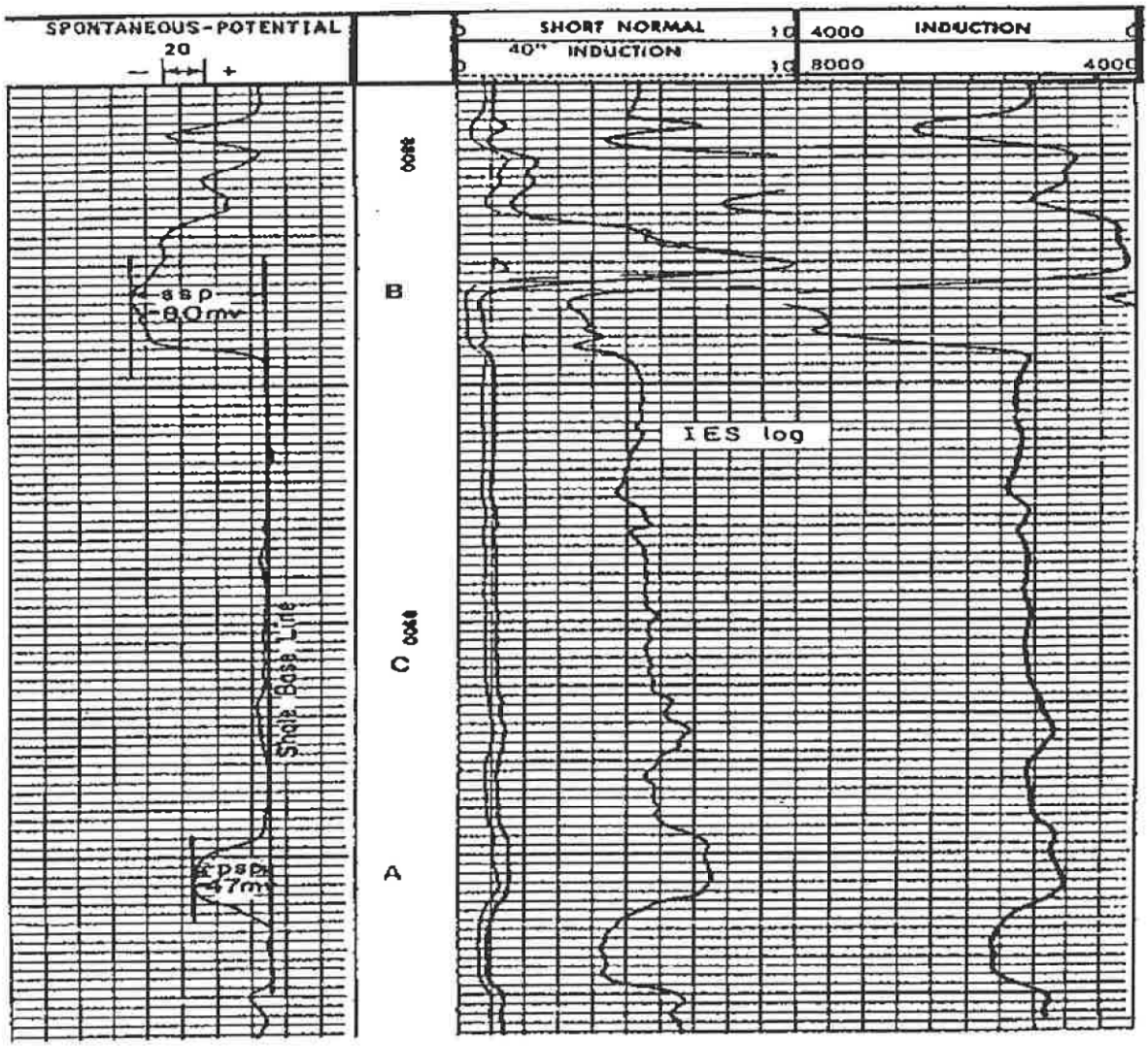
a) Using the SP curve, determine the shale content of zone A in the logs.

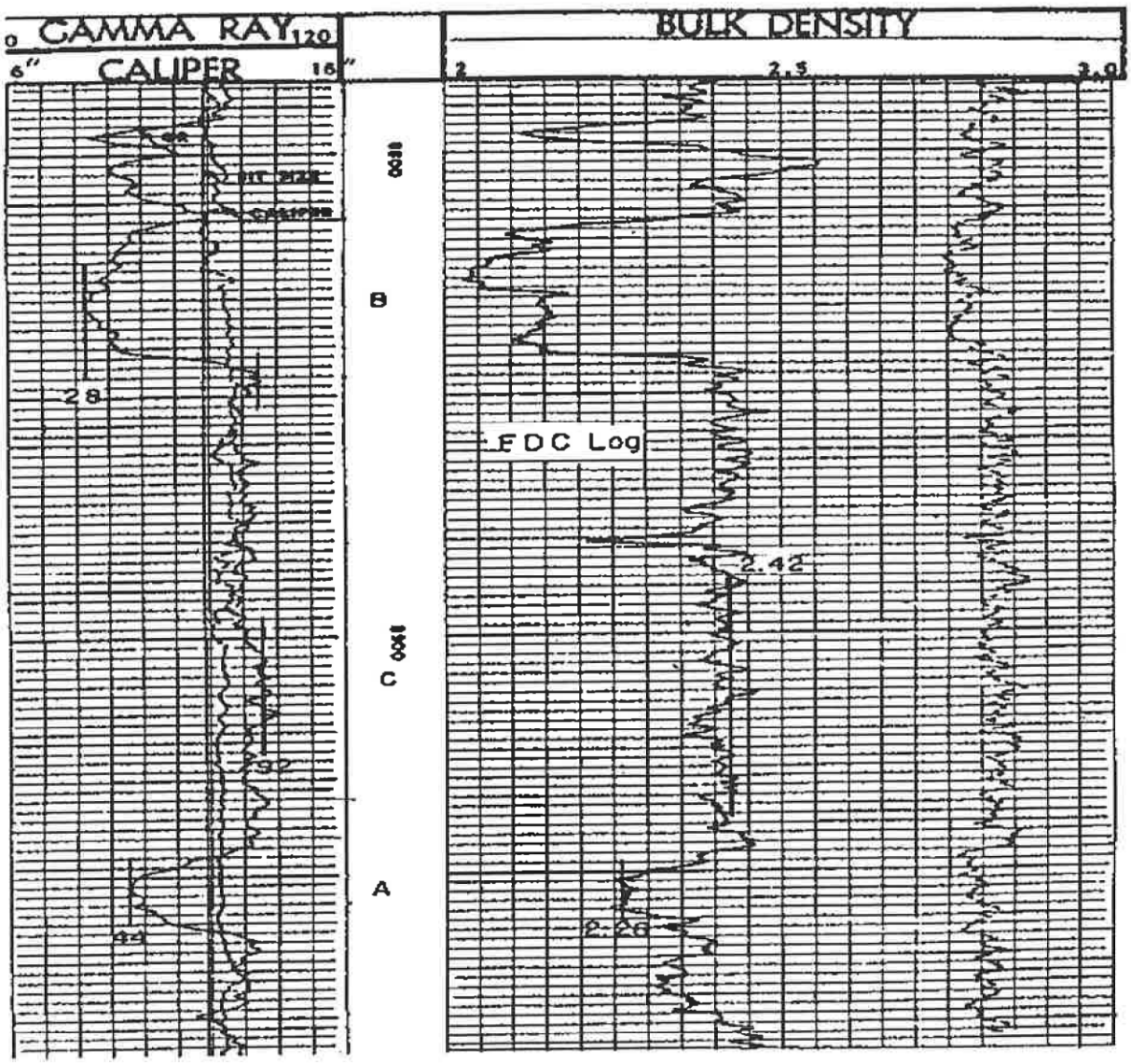
b) List the assumptions implied in the procedure used in Part a.

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 recommend a Vsh value.


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


0 GAMMA RAY 120
6" CALIPER 16"
BULK DENSITY
2
2.5
3.0
B
C
A
28
44
FDC Log
2.42
2.26

Question 10:

a. Estimate ESSP, assuming that the shale membrane is perfect, if formation temperature=200 F, R_{mf} at 200 F=0.5 Ω.m, and R_w at 200 °F=0.1 Ω.m. **(5pts)**

b. Taking into consideration the nonideality of the shale membrane, estimate ESSP if R_{sh}=2 Ω.m. **(5pts)**

Attachment:

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

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

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

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

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

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

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

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

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

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

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

$$K = 61.3 + 0.133T$$

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

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

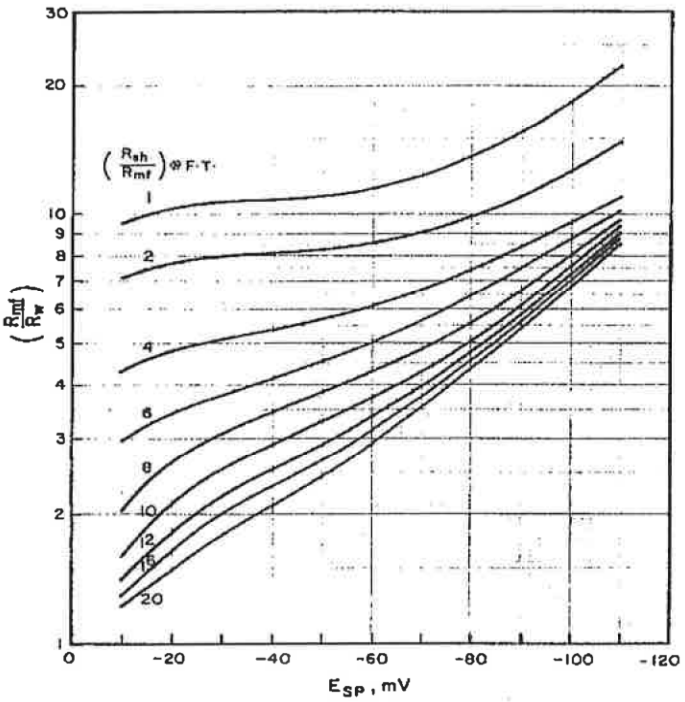
$$\phi = \phi_a - V_{sh}(\phi_a)_{sh}$$

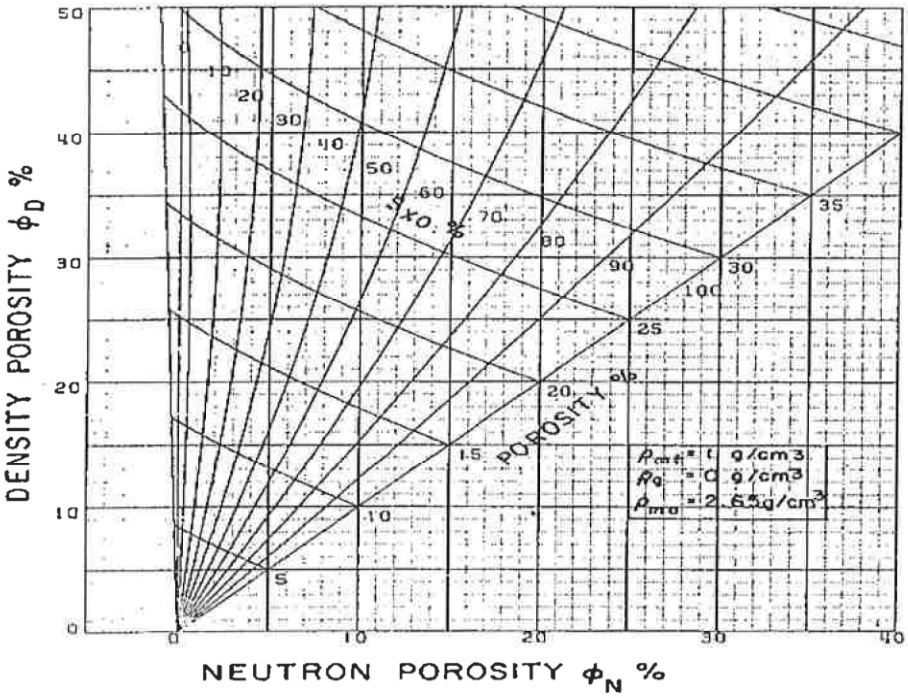
$$V_{sh} = 1.7 - \left[3.38 - (I_{sh} + 0.7)^2\right]^{1/2}$$

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

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

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


$\left(\frac{R_{sh}}{R_{mf}}\right)$ @ 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 %
SATURATION, %
POROSITY, %
ρ_{mf} = 1 g/cm3
ρ_f = 1 g/cm3
ρ_{ma} = 2.65 g/cm3