UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

FIRST SEMESTER EXAMINATIONS, NOV. – DEC. 2018

COURSE NO: **PE 371**
COURSE NAME: **WELL LOGGING**
CLASS: **PE III** **TIME: 3 HRS**

Name: ____ Index Number: _______________

SECTION A
(Answer this section on the question paper)

1. The swelling in kaolinite is due to the presence of cation between the interlayers. **(True/ False)**
2. Illites are distinguished from the montmorillonites primarily by the absence of interlayer cation. **(True/ False)**
3. Well logging measurement techniques can be categorized according to three broad disciplines: electrical, nuclear and acoustic. **(True/ False)**
4. The rock formation is of low electrical conductivity. **(True/ False)**
5. A perfect membrane will allow the transport of both Na^+ and Cl^- ions. **(False/ True)**
6. During logging, when the logging speed is higher, the smoother will be the tool's response and the poorer will be the definition of the beds. **(True/ False)**
7. A solution containing more than one salt, the contribution of one salt to the total conductivity depends on:

   i)

   ii)

   iii)

8. At 25 ºC, the transference number of sodium ions in NaCl solution is known to be 0.396. Given the mobility of the sodium ions to be 5.20×10^{-4} cm/s.V, find the mobility of the chloride ions in solution. **(2 Marks)**

SECTION B
(Answer ALL the questions in this section in the answer booklet)

QUESTION 1

a) The following data pertain to a carbonate formation:

formation thickness = 15 ft;
formation water salinity (NaCl) = 4, 000 ppm;
formation temperature = 200°F; and
cementation factor = 2.2.

The vertical resistivity profile of the formation is as shown in **Figure 1**.

i) Based on the resistivity profile, give the order of increasing hydrocarbon concentration.
ii) If Zone A is water bearing, estimate its porosity.
iii) If Zone B is in the oil zone, estimate the oil saturation. **(6 Marks)**

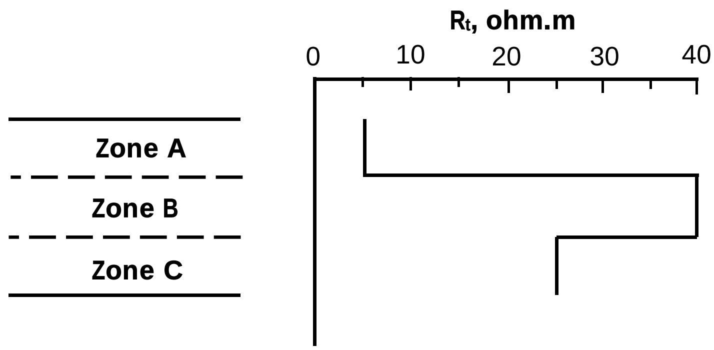


Figure 1: Resistivity profile

b) An acoustic transmitter and receiver are placed 6 ft apart on the axis of a cylindrical borehole, 8 inch in diameter **(See Figure 2).** Calculate the times of arrival of the compressional and shear head waves if the acoustic velocities are as follows:

formation v_p = 4350 m/s;
formation v_s = 2540 m/s and
fluid v_f = 1930 m/s. **(12 Marks)**

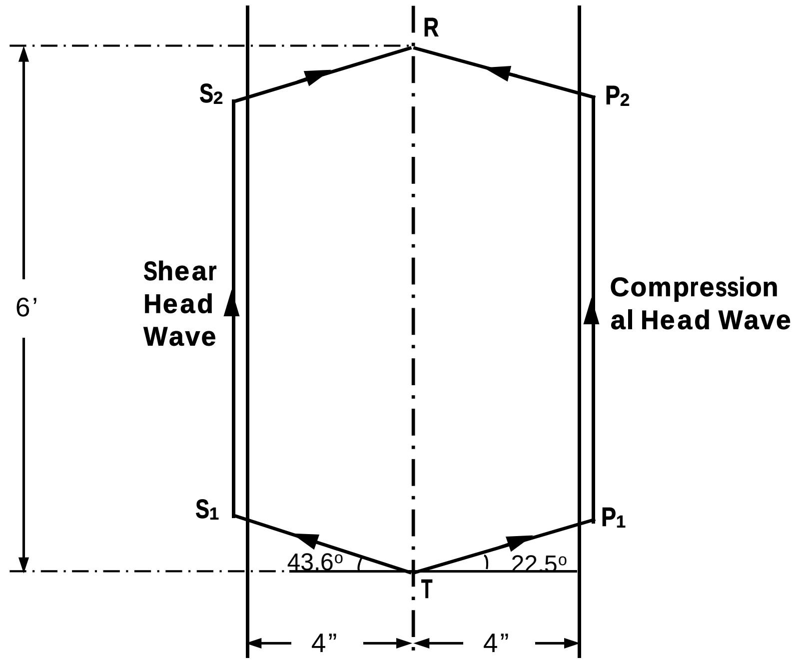


Figure 2: Schematic of ray paths

QUESTION 2

Several sandstone samples were used to investigate the relationship between the formation resistivity factor and porosity. Each sample is a cylindrical plug with $d = 2$ cm and L ranging from 2.5 to 3.10 cm. These plugs were taken from a large-diameter core. The samples were cleaned, dried, and weighed. They were then fully saturated with a 50, 000 ppm NaCl solution and reweighed; their resistances were also measured. In the weighing process, the samples were placed in a 13.04 g-cylindrical container to prevent the brine from evaporating. All measurements were conducted at 70ºF. The data collected are listed below:

Core	Length (cm)	Resistance (Ω)
11	3.05	860
12	3.05	520
13	3.05	580
14	3.00	2,200
14x	3.10	2,100
15	3.05	465
16	3.05	1,000
17	3.05	1,100
18	3.05	500
19	3.00	830
20	3.05	360

22	3.00	460
23	2.80	340
23x	3.00	370
24	2.50	210
26	3.00	200

i) Calculate the formation resistivity factor and porosity of each core (Use Humble Equation).

ii) Plot F vs. Φ.

iii) Can these data be fitted satisfactorily by a relation of the form $F = a\Phi^{-2}$? If so, determine the value of the coefficient a.

(17 Marks)

SECTION C

(Answer ONLY ONE question from this section in the answer booklet)

QUESTION 3

a) Draw the crystal structure of the following clay minerals: Montmorillonite, Illite, and Chlorite.

(6 Marks)

b) A compressional wave is traveling in a fluid at a velocity of 1950 m/s. The wave encounters a surface of a solid medium at an 18° angle. Part of the wave energy is reflected and part is refracted. The refracted wave is partially converted to a shear wave.

i) Sketch the geometry of the rays along which the reflected and refracted waves are propagated.

ii) Calculate the angles of reflection and refraction if the velocities of the compressional wave and the shear wave in the solid are 4710 and 3740 m/s, respectively.

iii) Calculate the angle of incidence that would result in a compressional head wave.

iv) Calculate the angle of incidence that would result in a shear head wave.

(8 Marks)

QUESTION 4

a) You have been given five core samples from UMaT Well # 1. What are the steps you will take to estimate the formation-resistivity factor – porosity relationship of this well.

b) The resistivity of a water-bearing sand was found to be 0.4 Ω.m. If the formation water resistivity is 0.02 Ω.m, estimate the formation porosity using Humble's equation.

c) **Figure 3** shows the heading of an induction log, density log and neutron log obtained in the Header No.1 Well. Using the data recorded on the log heading, provide the following information:

i) The interval logged.

ii) The geothermal gradient

iii) The mud, mud filtrate, and mud cake resistivities at 6,250 ft. **(14 Marks)**

BAKER HUGHES

Baker Atlas

HIGH DEFINITION INDUCTION LOG SM
COMPENSATED Z-DENSILOG SM
COMPENSATED NEUTRON LOG

FILE NO:	COMPANY	ROCK PHYSICS & WELL LOG MEASUREMENTS
	WELL	HEADER #1
API NO:	FIELD	TRAINING
	COUNTY	HARRIS STATE TEXAS

Ver. 3.71	LOCATION: BAKER ATLAS CENTER	OTHER SERVICES: XMAC, MR IL, HD IP, RC I

PERMANENT DATUM	G.L.	ELEVATION	55 FT	ELEVATIONS: KB 78 FT
LOG MEASURED FROM	K.B.	23 FT	ABOVE P.D.	DF 77 FT
DRILL. MEAS. FROM	K.B.			GL 55 FT

DATE		01-Jan-2000			
RUN	TRIP	1	1		
SERVICE ORDER		123456			
DEPTH DRILLER		9822 FT			
DEPTH LOGGER		9808 FT			
BOTTOM LOGGED INTERVAL		9807 FT			
TOP LOGGED INTERVAL		1232 FT			
CASING-DRILLER		9.625 IN	@ 1232 FT	@	
CASING LOGGER		1232 FT			
BIT SIZE		8.5 IN			
TYPE OF FLUID IN HOLE		LIGNOSULFONATE			
DENSITY	VISCOSITY	11.6 LB/G	50 S		
PH	FLUIDLOSS	10	8 C3		
SOURCE OF SAMPLE		FLOW LINE			
RM AT MEAS. TEMP.		0.4 OHMM	@ 94 DEGF	@	
RMF AT MEAS. TEMP.		0.2 OHMM	@ 94 DEGF	@	
RMC AT MEAS. TEMP.		0.7 OHMM	@ 94 DEGF	@	
SOURCE OF RMF	RMC	MEAS	CALC		
RM AT BHT		0.22 OHMM	@ 178 DEGF	@	
TIME SINCE CIRCULATION		3			
MAX. RECORDED TEMP.		178 DEGF			
EQUIP. NO.	LOCATION	9999	HOUSTON		
RECORDED BY		A. TEACHER			
WITNESSED BY		T.H.E. CLASS			

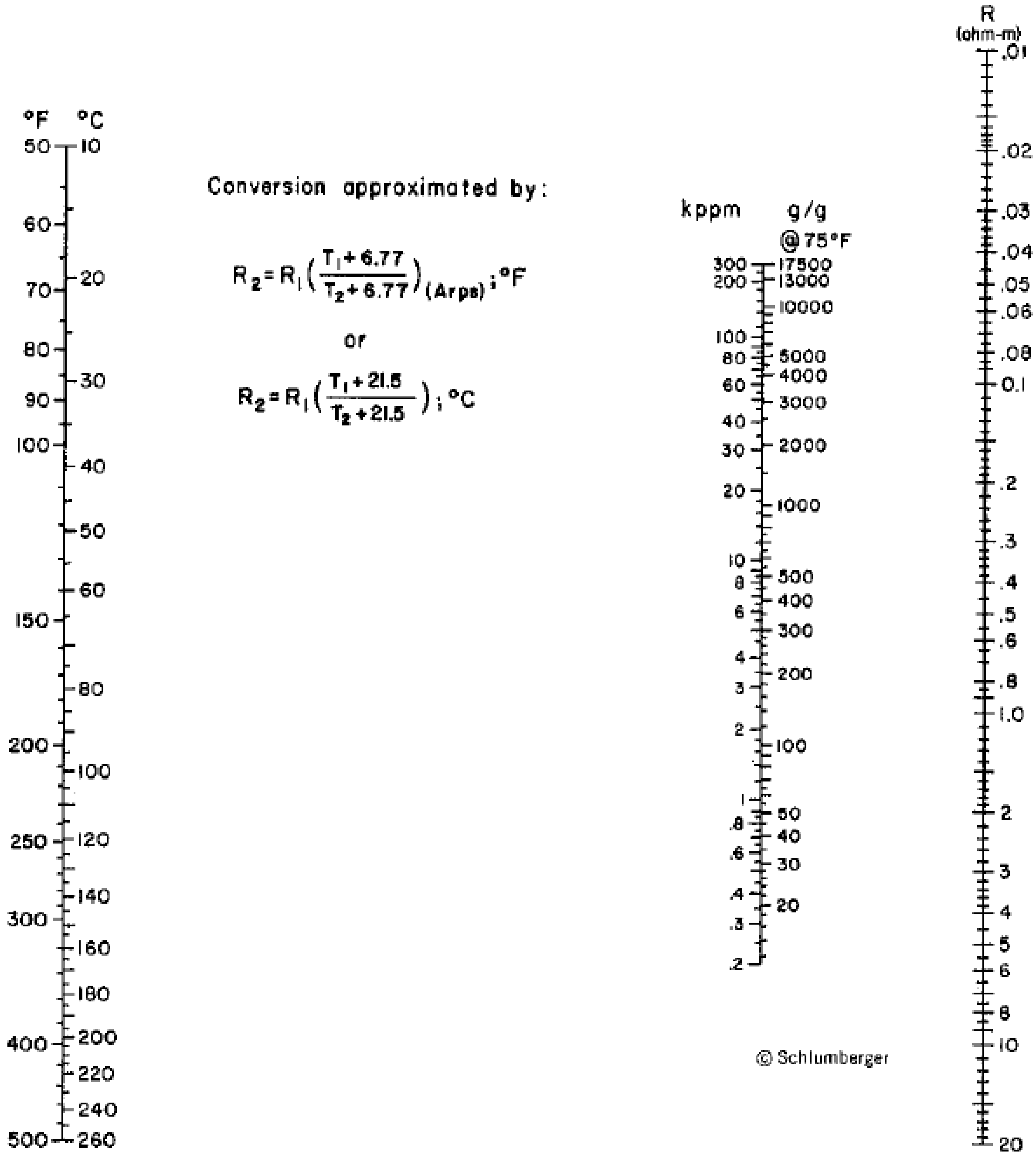
Figure 3: Log heading

EQUATIONS

$r_o = R_o\,(L\,/\,A)$ $\qquad$ $F = a\varphi^{-m}$ $\qquad$ $F = 0.81/\varphi^2$ $\qquad$ $F = 1.45/\varphi^{1.54}$ $\qquad$ $F = 1.13/\varphi^{1.73}$

$$S_w = \left(\frac{R_o}{R_t}\right)^{1/2} = \left(\frac{FR_w}{R_t}\right)^{1/2} = \left(\frac{aR_w}{\phi^m R_t}\right)^{1/2}$$

GOOD LUCK



EXAMINERS: DR H. OSEI / D. Ocran