PROBLEM # 1

Calculate the porosity of a core sample from the following measurements.

Weight of cleaned and dried sample	= 37.25 g
Weight of sample, saturated with oil	= 41.39 g
Weight of saturated sample, immersed in saturating oil	= 25.65 g
Density of oil	= 0.82 g/cm^3

Is your value of calculated porosity total or effective? Briefly explain why or why not. What is the lithology of the core sample?

THEORY

$$\phi = \frac{V_b - V_m}{V_b} = \frac{V_p}{V_b}, \quad \rho_m = \frac{m_m}{V_m}$$

SOLUTION

$$V_p = \frac{Wt\ sat - Wt\ dry}{\rho_o} = \frac{(41.39 - 37.25)\,g}{0.82\ g/cm^3} = 5.05\ cm^3$$

$$V_b = \frac{Wt\ sat - Wt\ imm}{\rho_o} = \frac{(41.39 - 25.65)\,g}{0.82\ g/cm^3} = 19.2\ cm^3$$

$$\phi = \frac{V_p}{V_b} = \frac{5.05\ cm^3}{19.2\ cm^3} = \underline{\underline{0.263}}$$

$$\rho_m = \frac{m_{dry}}{V_m} = \frac{37.25\ g}{(19.2 - 5.05)\ cm^3} = 2.63\ g/cm^3$$

CONCLUSION

$\phi_e = 0.263$, effective porosity because V_p determined by saturating the pores

Lithology is probably sandstone

PROBLEM # 2

You are furnished with three sizes of particles. One is a gravel with a porosity of 0.32, the second is a coarse grained sand with porosity of 0.37, and the third is a fine grained sand with a porosity of 0.23. If the coarse grained sand will fill the voids left by the gravel, and the fine grained sand will fill the voids left by the coarse grained sand, what bulk volumes of gravel, coarse grained sand, and fine grained sand will be required to make a packing with a bulk volume of 1 ft³? What will be the porosity of the mixture?

THEORY

$$\phi = \frac{V_b - V_m}{V_b} = \frac{V_p}{V_b}, \quad \rho_m = \frac{m_m}{V_m}$$

SOLUTION

Assume that gravel fills the container, coarse sand fills the pores of the gravel, and fine sand fills the pores of the coarse sand.

In this manner (based on above assumption)

1.0 ft³ of gravel is required	1.0 ft³
0.32 ft³ of coarse sand is required	0.32 ft³
(0.37)(0.32) ft³ of fine sand is required	0.14 ft³

Final pore volume is $(1)(0.32)(0.37)(0.23) = 0.0315\ ft^3$

$$\phi = \frac{V_p}{V_b} = \frac{0.0315\ ft^3}{1.0\ ft^3} = \underline{\underline{0.032}}$$

CONCLUSION

1.0 ft³ gravel
0.32 ft³ coarse sand
0.14 ft³ fine sand

$\phi = 0.032$

PROBLEM # 3

You have a beaker filled completely with coarse sand. The capacity of the beaker is 100 cm^3. Next, you add to the beaker 40 cm^3 of distilled water, filling the water level exactly to the top of the sand. What is the porosity of the sand?

THEORY

$$\phi = \frac{V_b - V_m}{V_b} = \frac{V_p}{V_b}$$

SOLUTION

$V_b = 100\ cm^3$, $V_p = 40\ cm^3$

$$\phi = \frac{V_p}{V_b} = \frac{40\ cm^3}{100\ cm^3} = \underline{\underline{0.4}}$$

CONCLUSION

$\phi = 0.4$

PROBLEM # 4

Derive the porosity values for both cubic, orthorhombic, and rhombohedral packing of spheres (the packings demonstrated during Lecture 2). Include sketches supporting your calculations of the bulk volumes of the unit cells.

THEORY

$$\phi = \frac{V_b - V_m}{V_b}$$

SOLUTION

Cubic

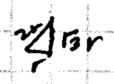
$$V_b = (2r)^3$$
$$V_m = \frac{4}{3}\pi r^3$$

$$\phi = 1 - \frac{V_m}{V_b} = 1 - \frac{4/3\,\pi r^3}{8r^3}$$
$$= 1 - \frac{\pi}{6} = \underline{\underline{0.4764}}$$

Orthorhombic

$$V_b = (2r)^2(\sqrt{3}r)$$
$$= 4\sqrt{3}r^3$$

$h = \sqrt{3}r$



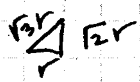
$$V_m = 4/3\,\pi r^3$$

$$\phi = 1 - \frac{V_m}{V_b} = 1 - \frac{4/3\,\pi r^3}{4\sqrt{3}r^3}$$
$$= 1 - \frac{\pi}{3\sqrt{3}} = \underline{\underline{0.3954}}$$

Rhombohedral

$$V_b = (2r)^2(\sqrt{2}r)$$
$$= 4\sqrt{2}r^3$$

$h = \sqrt{2}r$



$$V_m = \frac{4}{3}\pi r^3$$

$$\phi = 1 - \frac{V_m}{V_b} = 1 - \frac{4/3\,\pi r^3}{4\sqrt{2}r^3}$$
$$= 1 - \frac{\pi}{3\sqrt{2}} = \underline{\underline{0.2595}}$$

PROBLEM # 5

Consider the interval 10,720 to 10,730 ft on the Bonanza 1 wireline logs from Slide 28 of Lecture 4 (printed on the next page).

a. Read and record the porosity from the neutron log (dashed line).
b. Calculate porosity from the sonic log assuming the matrix is sandstone and the pore space is saturated with water. Compare with the value from the neutron log. Is this total or effective porosity?
c. Calculate porosity from the density log assuming the matrix is sandstone and the pore space is saturated with water. Compare with the values from the neutron and sonic logs.
d. Calculate porosity from the density log assuming the matrix is sandstone and the pore space is saturated with a mixture that is half water (1.1g/cm^3) and half gas (0.2g/cm^3). Compare with the values from the neutron and sonic logs.
e. What do you conclude from these calculations?

THEORY

$$\phi = \frac{\Delta t_L - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}}, \quad \phi = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f}$$

SOLUTION (see Logs)

a. $\phi_N = \underline{0.15}$

b. $\Delta t_L = 88 \mu sec/ft$, assume $\Delta t_f = 189 \mu sec/ft$, $\Delta t_{ma} = 55.5 \mu sec/ft$

$$\phi_s = \frac{\Delta t_L - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}} = \underline{0.243}, \quad \phi_N < \phi_s$$ (total porosity, see Lecture 2)

c. $\rho_b = 2.17\ g/cm^3$, assume $\rho_f = 1\ g/cm^3$, $\rho_{ma} = 2.65\ g/cm^3$

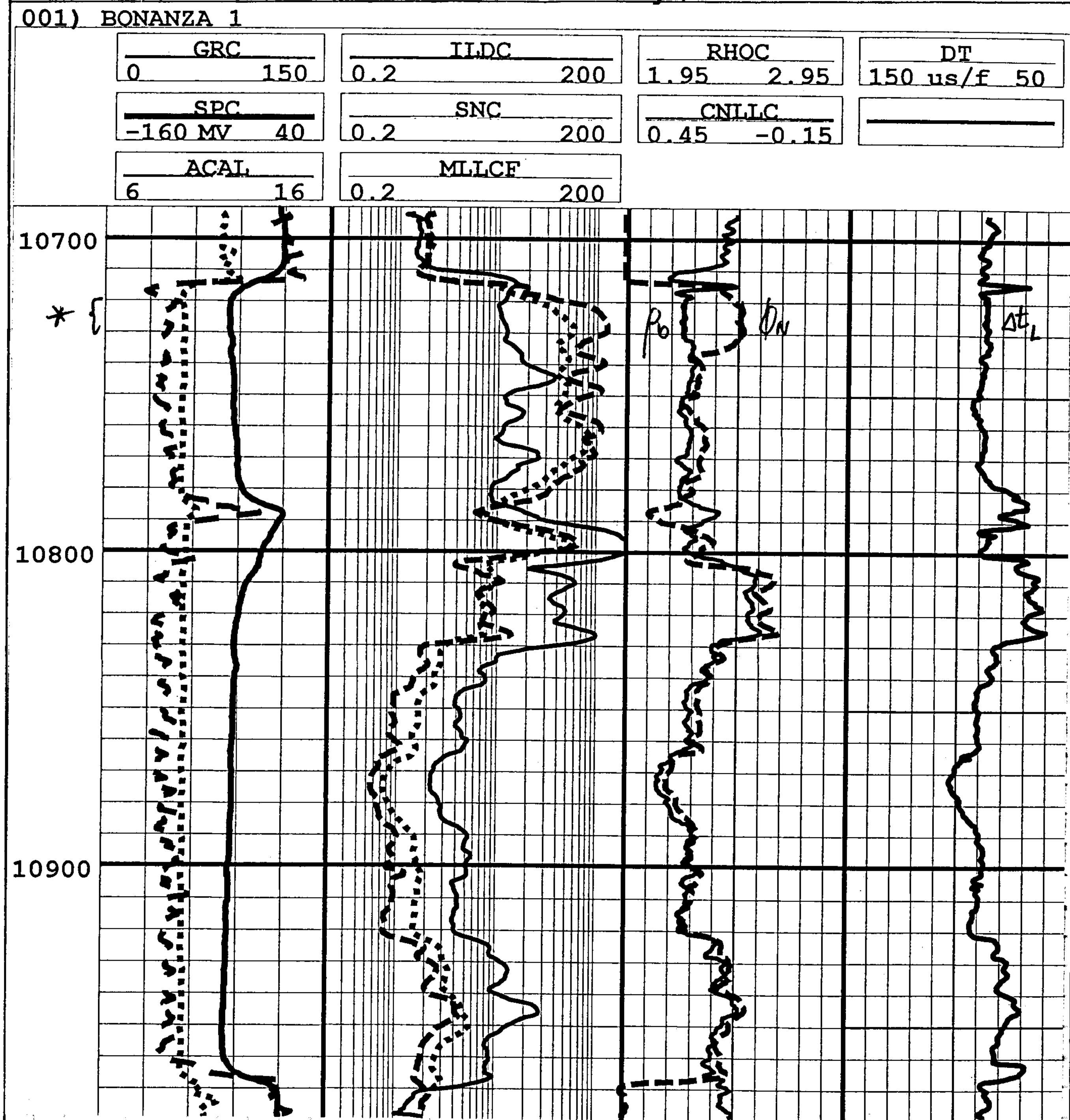
$$\phi_d = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f} = \underline{0.29}, \quad \phi_N < \phi_s < \phi_d$$

d. $\rho_b = 2.17\ g/cm^3$, assume $\rho_f = (0.5)(1.1) + (0.5)(0.2) = 0.65\ g/cm^3$, $\rho_{ma} = 2.65\ g/cm^3$

$$\phi_d = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f} = \underline{0.24}, \quad \phi_N < \phi_d \approx \phi_s$$

CONCLUSION

- We know that ϕ_d can appear too high and ϕ_N too low in gas zones. Also, ϕ_s is not affected by gas
- It appears that the interval 10,720-10,730 is a gas zone.


001) BONANZA 1
GRC
0 150
ILDC
0.2 200
RHOC
1.95 2.95
DT
150 us/f 50
SPC
-160 MV 40
SNC
0.2 200
CNLLC
0.45 -0.15
ACAL
6 16
MLLCF
0.2 200
10700
10800
10900
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