PET 110 Spring 2019 Konte Exam (1)

Tentative Solution:

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(1) The maximum frequency in the signal is approximately 30 Hz.

Using the Nyquist/Shannon sampling theorem we know that there has to be at least two samples per shortest period.

$f_{max} = 30 = \frac{1}{T_{min}}$ shortest period

$T_{min} = \frac{1}{30}$

Sampling interval:

$\Delta t = \frac{T_{min}}{2} = \frac{1}{60} = 0.0166\ s = 16.6\ ms$

(2) At 1800m:

$V_p \cong 2410\ m/s$

$\rho \cong 2.3\ g/cm^3$

$\rho \cong 2300\ kg/m^3$

$V_s \cong 800\ m/s$

$V_p = \sqrt{\frac{k + 4/3\mu}{\rho}} \rightarrow k = \rho V_p^2 - \frac{4}{3}\mu$

$V_s = \sqrt{\mu/\rho}$ $\quad \mu = \rho V_s^2$

$\nu = \frac{1}{2}\frac{V_p^2 - 2V_s^2}{V_p^2 - V_s^2}$

Bulk modulus (k):

$k = \rho V_p^2 - 4/3\mu \cong 11.4\ GPa$

Shear Modulus (μ):

$\mu = \rho V_s^2 \cong 1.5\ GPa$

Poisson ratio (ν)

$\nu = 0.438$

2 (cont)

2. The Poisson's ratio is independent of the density.

3

1. $\rho_b = \rho_{fl}\,\phi + \rho_{ma}(1-\phi)$

Bulk density — Pore fluid density — mineral matrix density.

Oil saturated:	Water saturated:
$\rho_{fl} = 700\ kg/m^3$	$\rho_{fl} = 1000\ kg/m^3$
$\rho_{ma} = 2600\ kg/m^3$	$\rho_{ma} = 2600\ kg/m^3$
$\rho_b = 700 \times 0.3 + 2600 \times 0.7 =$	$\rho_b = 1000 \times 0.3 + 2600 \times 0.7 =$
$= 2030\ kg/m^3$	$= 2120.0\ kg/m^3$

2. The Shear modulus does not change due to the fluid substitution.

The S-wave velocities will increase by ~2% when oil is replaced by water. This is due to the density effect in the formula

$V_s = \sqrt{\frac{\mu}{\rho}}$.

4 a) Reflection 1:

$V_{RMS,1}$: 1500 m/s $\quad t_{0,1} = 0.325$ s

Reflection 2:

$V_{RMS,2} = 1600$ m/s $\quad t_{0,2}$: 0.66 s

b)

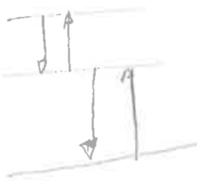
$V_1 = V_{RMS1} = 1500$ m/s

$$V_2 = \sqrt{\frac{V_{RMS,2}^2 \, t_{0,2} - V_{RMS,1}^2 \, t_{0,1}}{t_{0,2} - t_{0,1}}} = \sqrt{\frac{1600^2 \times 0.66 - 1500^2 \cdot 0.325}{0.66 - 0.325}} =$$

$$\cong 1801 \text{ m/s}$$

$$z_1 = \frac{V_1 \cdot t_{0,1}}{2} \cong 243 \text{ m}$$

$$t_{0,2} = \frac{2 \cdot z_1}{V_1} + \frac{2 \cdot z_2}{V_2}$$



$$z_2 = \frac{(t_{0,2} - t_{0,1}) \cdot V_2}{2} \cong 301 \text{ m}$$

$V_1 \cong 1500$ m/s

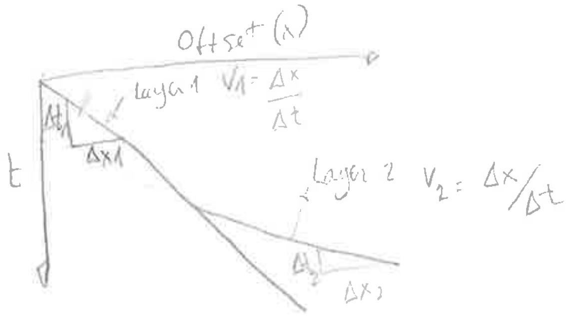
$V_2 \cong 1801$ m/s

$z_1 \cong 243$ m

$z_2 \cong 301$ m

5

a)



2 Layers.

b) $V_1 = \frac{\Delta x_1}{\Delta t_1} = \frac{0.75\,km}{0.5\,s} = 1.5\,km/s$

$V_2 = \frac{\Delta x_2}{\Delta t_2} = \frac{1}{0.5} = 2.0\,km/s$

c) Using the refraction traveltime for a critical refraction at the second layer:

$$t(x) = \frac{x}{V_2} + \frac{2 \cdot z_1 \cos\theta_c}{V_1}$$

$$\sin\theta_c = \frac{V_1}{V_2}$$

$$\cos\theta_c = \sqrt{1 - \left(\frac{V_1}{V_2}\right)^2}$$

$$z_1 = \left(t(x) - \frac{x}{V_2}\right) \cdot \frac{V_1}{2\cos\theta_c}$$

at $x = 3.75\,km$

$t(3.75) = 2.2\,s$

$$z = \left(2.25 - \frac{3.75}{2.0}\right) \cdot \frac{1.5}{2 \cdot \sqrt{1 - \left(\frac{1.5}{2.0}\right)^2}} \cong 0.42\,km$$

6

a. International gravity formula:

$$g(\varphi) = 978\,031.8\ [1 + 0.0053\,024\ \sin^2\varphi - 0.0000059\ \sin^2(2\varphi)]\ \text{mGal}$$

a)

(i) $g(1°) - g(0°) = 1.57$ mGal (increase)

(ii) $g(46) - g(45) = 90.5$ mGal (increase)

iii) $g(-44) - g(-45) = -90.5$ mGal (decrease)

b) i) $\Delta g_{fa}(h) = 0.3086\,h$

$$0.3086\,h = 1.57$$

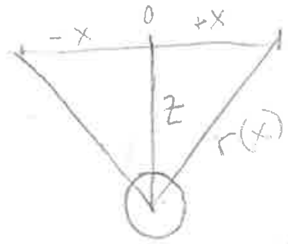
$$h_1 = 1.57 / 0.3086 = \underline{5\ m}$$

ii) $h_2 = \dfrac{90.5}{0.3086} = 293.25$ m

iii) Same as ii)

7 Gravity anomaly due to a Sphere:

$$\Delta g_z(x) = \frac{G m z}{\sqrt{x^2+z^2}^{\,3}}$$



$r(x) = \sqrt{x^2+z^2}$

$z = 500$ m → Given

Gravity anomaly due to a cylinder:

$$\Delta g_z(x) = \frac{G m z}{x^2+z^2}$$

In the anomaly profile observed we have:

$\Delta g_z(0) = 1$ $\quad\quad$ $\Delta g_z(1000) \simeq 0.1$

The ratio of $\dfrac{\Delta g_z(0)}{\Delta g_z(1000)} = \underline{\underline{10}}$

In case it is a sphere the ratio should be:

$$\frac{\dfrac{Gm \cdot 500}{\sqrt{500^2}^{\,3}}}{\dfrac{Gm \cdot 500}{\sqrt{1000^2+500^2}^{\,3}}} = \frac{\sqrt{1000^2+500^2}^{\,3}}{500^3} = \underline{\underline{11.2}}$$

(7) cont.

In the case of a cylinder the ratio is:

$$\frac{\frac{Gm \cdot 500}{500^2}}{\frac{Gm \cdot 500}{1000^2+500^2}} = \frac{1000^2+500^2}{500^2} = 5$$

Since the observed ratio of ≈ 10 is closer to the ratio of a sphere, we conclude it is most likely a

sphere.

(8) Gamma ray log:

Answer: 1, 2, 4, 5

(9) Archie's law and resistivity logs:

- Which factors determine electrical resistivity of porous formations?

  Answer: all the points

- Which statements are correct:

  Answer: 2 and 3

9.) Cont

- Which statements are correct:

Answer: all correct.

10 a) Cavings and Washouts are characterized by large and variable values of caliper. These can be observed between 2000 m and 2350 m (MD).
Below these depths the caliper is smaller and smoother which is a characteristic of mudcake formation.

b) The presence of gas should be notable in the resistivity log, through the crossover in the Neutron-density logs and should normally correlate with a permeable Lithology such as sandstones and permeable carbonates.

In the log we can see a large crossover in the range 2370 - 2430 m, this correlates with relatively high resistivity values and low Gamma ray. This is the gas zone.
The oil zone can be found between 2430 m and 2500 m.
The oil-water contact can be identified by a sudden drop in resistivity.

c) Shale. Due to high Gamma ray and high Neutron porosity (over estimated porosity).

d) Sandstone. Due to low Gamma ray, some permeability (mud cake formation), sonic velocities in the range of 3900 ± 200 m/s, and large crossover.

Using density:

e) $\varphi = \dfrac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_{fl}}$

From the log:

- $\rho_b = 2.5\ g/cm^3$

Using from the table:

- $\rho_{ma} = 2.65$
- $\rho_{fl} = 0.775$

$$\varphi = \frac{2.65 - 2.5}{2.65 - 0.775} = 8\%$$

Using the Sonic:

From the log: $V = 3.81 km/s$

$$\varphi = \frac{\frac{1}{V_{ma}} - \frac{1}{V}}{\frac{1}{V_{ma}} - \frac{1}{V_{fl}}} = 8\%$$

Using from the table:

$V_{ma} = 6.05\ km/s$

$V_{fl} = 0.725\ km/s$

10 f) Using:

$R_t \cong 100\ \Omega m$ $\qquad F = \frac{0.81}{\phi^2}$

$R_w \doteq 0.08\ \Omega m$

$$Sw^2 = F \cdot \frac{R_w}{R_t} = \frac{0.81}{(0.08)^2} \cdot \frac{0.08}{100} = 0.101$$

$$Sw = \sqrt{0.101} = 0.31 \rightarrow \underline{\underline{31\%}}$$

g) Shale line = 160 gAPI

Sand line = 12.5 gAPI

<u>At 2200:</u>

GR = 85 gAPI

$$Vsh = \frac{GR - 12.5}{160 - 12.5} = \underline{\underline{50\%}}$$

<u>At 2400:</u>

GR = 17.5 gAPI

$$Vsh = \frac{17.5 - 12.5}{160 - 12.5} = \underline{\underline{3.3\%}}$$

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