Fremside PET110

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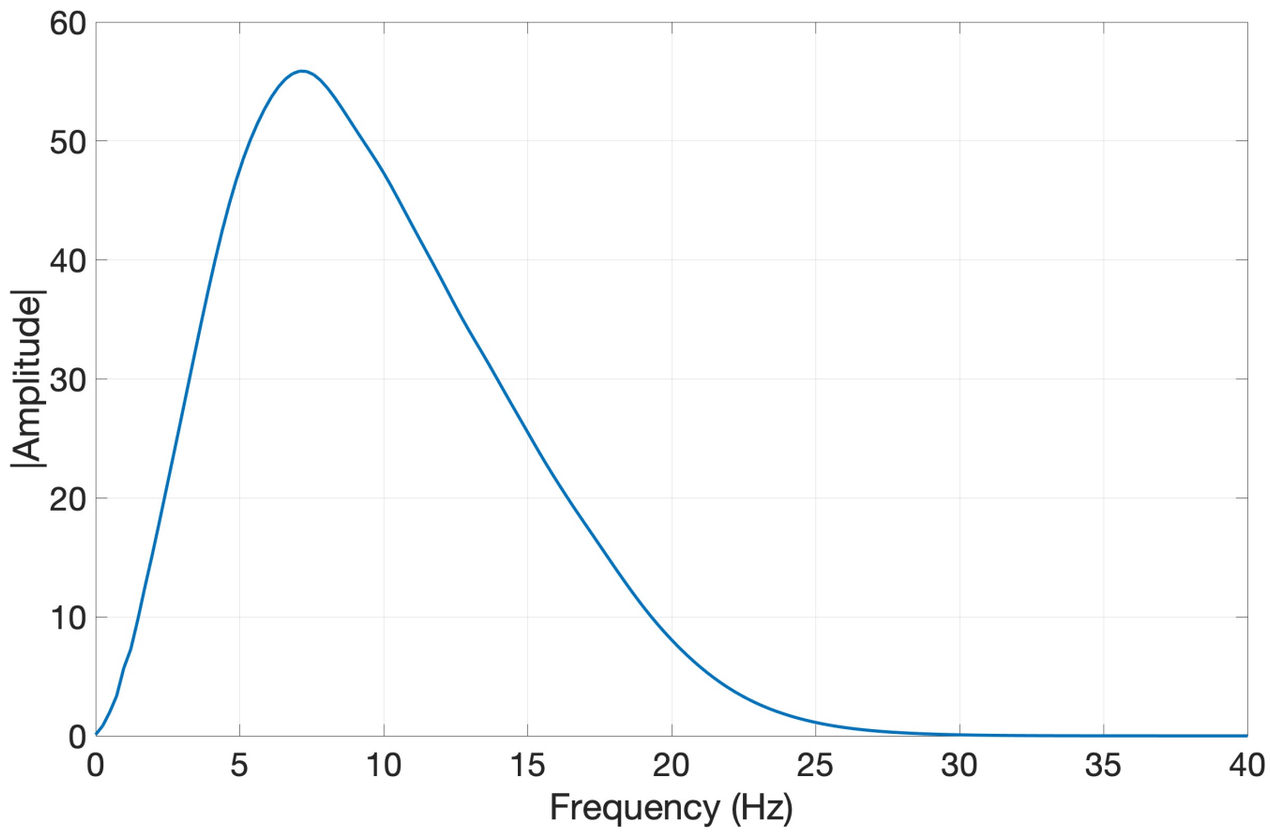
PET110

UNIVERSITETET I STAVANGER
Det teknisk-naturvitenskapelige fakultet
Eksamen i PET110 Geofysikk og brønnlogging
Tid for eksamen: Mandag 26. august 2019, kl.09:00-13:00
Hjelpemiddel: Én A4 side med håndskrevne notater og godkjent kalkulator

Faglig ansvarlig: Wiktor Waldemar Weibull tlf.: 40608703

1

Nyquist frequency and aliasing



The Figure shows the amplitude spectrum for a Fourier transformed seismic trace. What is the greatest sampling interval that can be used to sample this trace without introducing aliasing?

Fill in your answer here

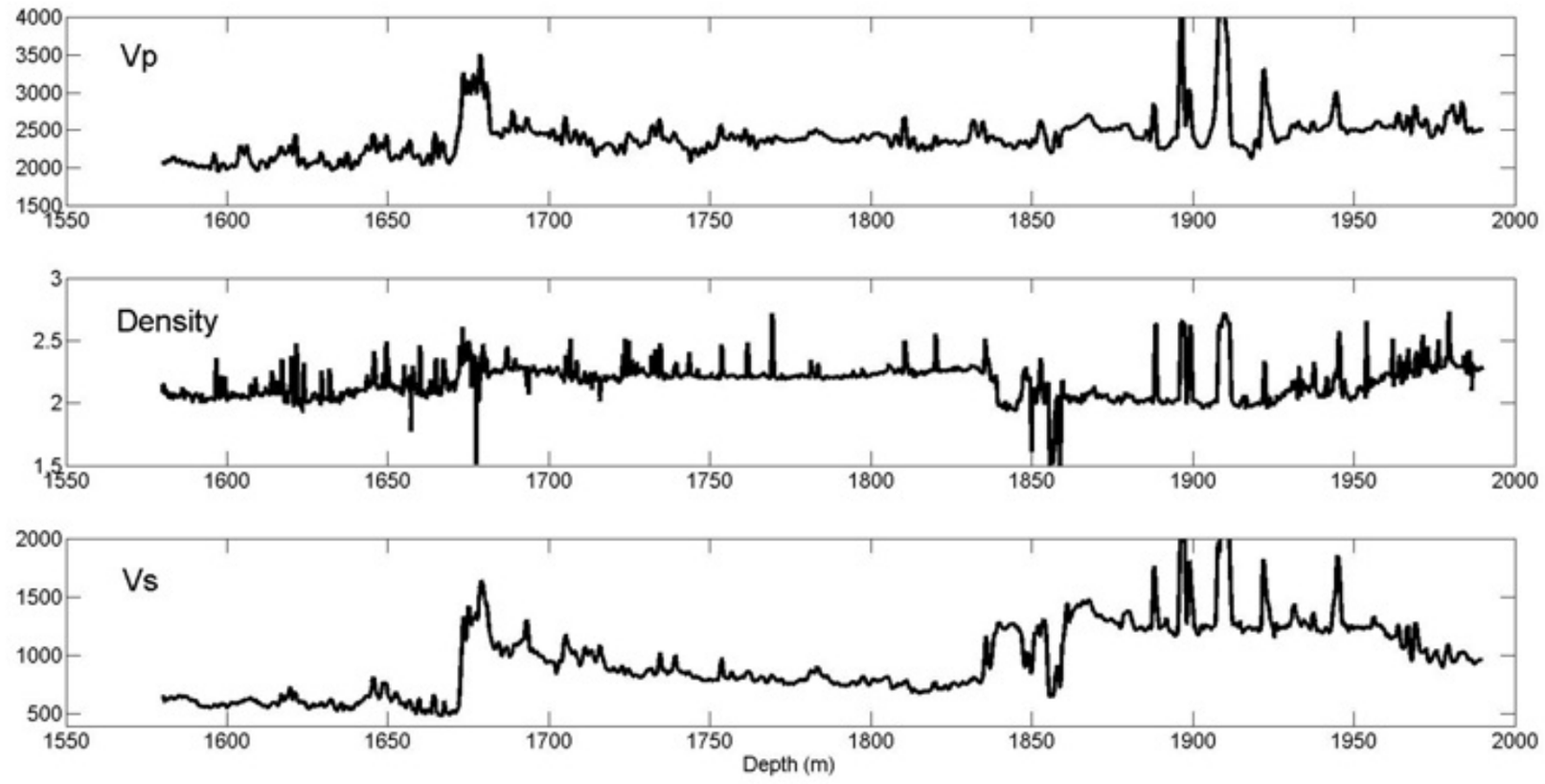
Format

Words: 0

Maximum marks: 6

2 Elastic moduli

The figure below shows a well log of the density (in g/cm^3) and seismic P- and S-wave velocities (in m/s).



1. From these quantities calculate the Bulk modulus (k), Shear modulus (μ) and Poisson's ratio (ν) at the depth of 1800 m.
2. How much does the Poisson's ratio changes if the density increases by 25 %?

Fill in your answer here

Format

Words: 0

Maximum marks: 10

3

Fluid effect

1. The bulk density of a porous rock is given by $\rho_b = \rho_{fl}(\phi) + \rho_{ma}(1-\phi)$. Explain the symbols in this equation. Assume that for a reservoir rock $\phi = 0.3$ and that the density for the oil and reservoir solid minerals are respectively 700 and 2600 kg/m^3. Use this to compute the density of the reservoir rock when it is fully oil saturated and when it is fully water saturated. For the pore water use a density of 1000 kg/m^3.
2. What happens with the shear modulus and the S-wave velocities under the same fluid substitution?

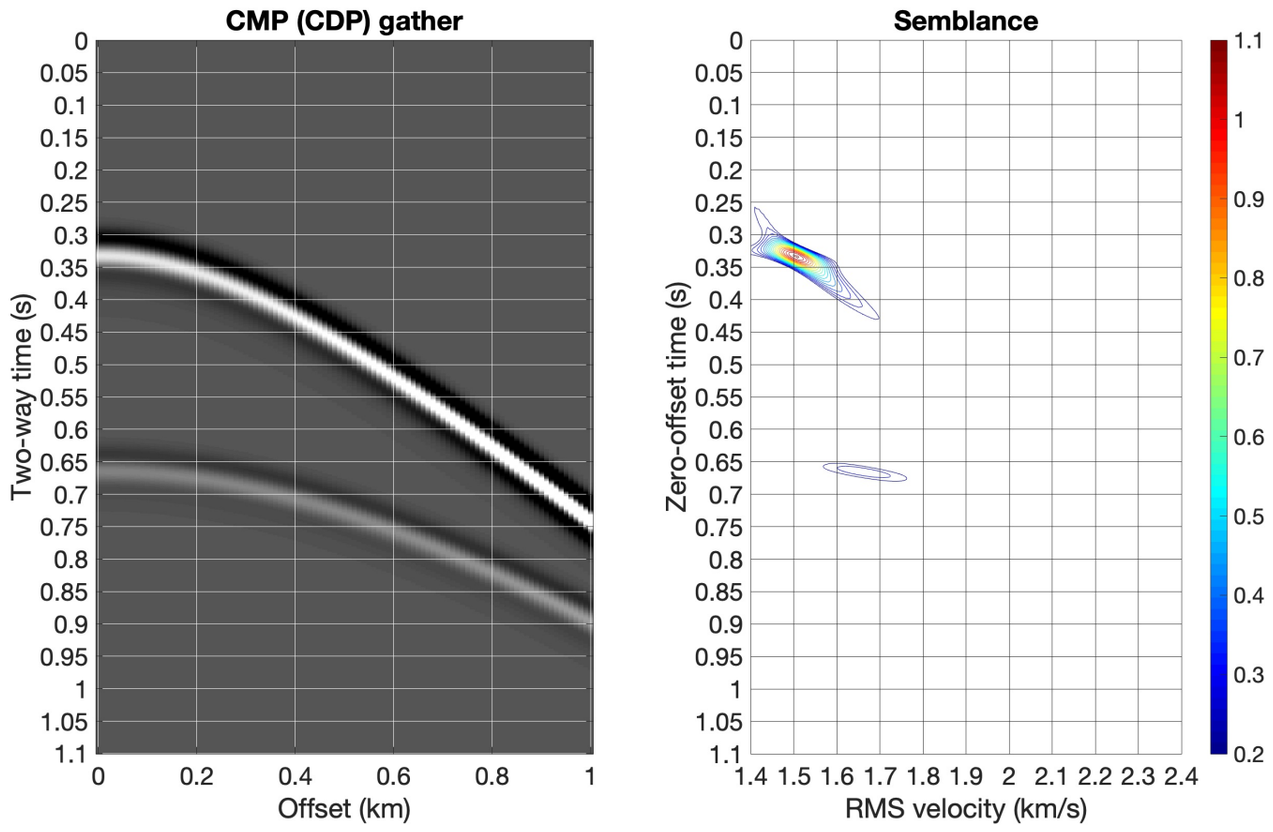
Fill in your answer here

Format | B I U x_2 x^2 | I_x | | | Ω | | | Σ | ABC | |

Words: 0

Maximum marks: 10

4 Reflection Seismic



The figure shows a CMP (or CDP) gather and an associated Semblance map.

a. Use the data to determine the RMS Velocities and zero-offset traveltimes for the two reflections seen in the CMP gather.

b. From the RMS velocties and zero-offset traveltimes calculate the interval velocities V_1 and V_2, and the thicknesses Z_1 and Z_2 for the top two layers.

Fill in your answer here

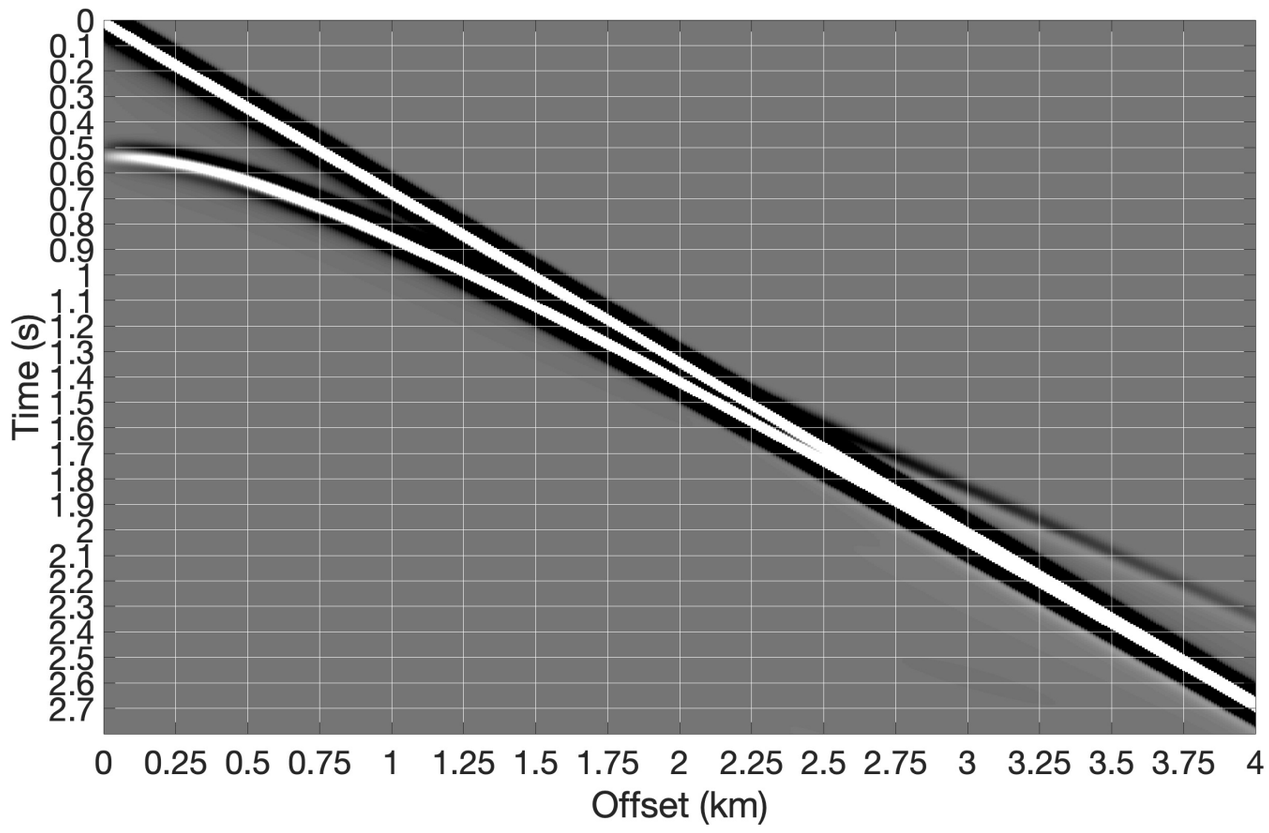
Format

Words: 0

Maximum marks: 10

5

Refraction seismic



The figure shows a seismogram acquired over a horizontally layered earth.

a. From the first arrivals determine how many layers are detected by these measurements.
b. Determine the seismic velocities at these layers.
c. Determine the thickness of the topmost layer.

Fill in your answer here

Format | B I U x_2 x^2 I_x | ABC

Words: 0

Maximum marks: 10

6 # Gravity 1

a. Calculate how much gravity changes, and whether it is an increase or decrease, on going one degree latitude north from latitude: (a) equator, (b) 45^o North, (c) 45^o South.

b. What elevation changes in air would give the same changes of g?

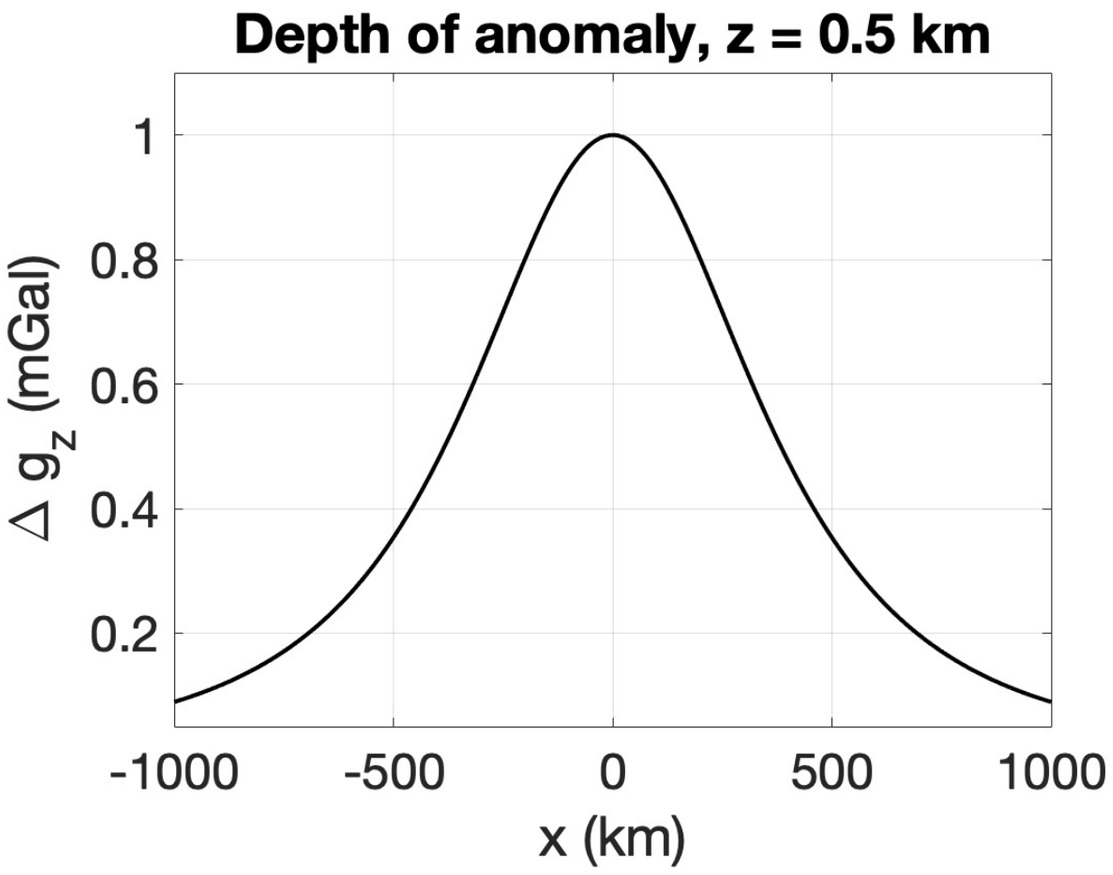
Fill in your answer here

Format

Words: 0

Maximum marks: 8

7 # Gravity 2



The Figure shows a Bougher anomaly gravity profile. Seismic data along the same profile (not shown here) indicates that the source of the bell shaped anomaly in the Figure is an object approximately circular in cross section and at a depth of 500 m. However, since the measurements are done along a profile, it is not possible to know from the seismic if the object is a sphere or a cylinder extending perpendicular to the profile.

Determine using the gravity anomaly data if the source of the anomaly is a sphere or a cylinder. Justify your answer and show your calculations.

Fill in your answer here

Format | B I U x_2 x^2 I_x | Ω | ∑ | ABC

Words: 0

Maximum marks: 10

8

Gamma ray log

Gamma rays principles

Select the alternative(s) that are true:

- 1. The Gamma Ray log is a measurement of the formation's natural radioactivity
- 2. Gamma ray emission is produced by three radioactive series found in the Earth's crust.
- 3. Gamma rays passing through rocks are slowed and absorbed at a rate which depends on the hydrogen index (HI).
- 4. Pure sands, limestones and dolomites produce generally low radioactivity compared to shales.
- 5. A major use of the tool is to identify marker beds and thus allow well-to-well correlation.
- 6. Gamma ray logs allow lithology and mineralogy to be uniquely defined.

Maximum marks: 4

9

Archie's law and Resistivity logs

Read through carefully. Identify **correct** statements.

Which factors determine electrical resistivity of porous formations?
Select zero, one or more alternatives

- 1. Pore volume fraction
- 2. Oil / water saturation
- 3. Tortuosity
- 4. Cementation exponent
- 5. Presence of clay bound water
- 6. The salinity of the brine in the solution
- 7. The temperature

Which statements are correct?
Select zero, one or more alternatives

- 1. Archies law relate resistivity to clay content and mineralogy
- 2. Archies law is used to calculate the oil/water saturation from resistivity and porosity measurements.
- 3. Archie law is used to calculate the oil/water saturation using the formation factor and the resistivity measurements.

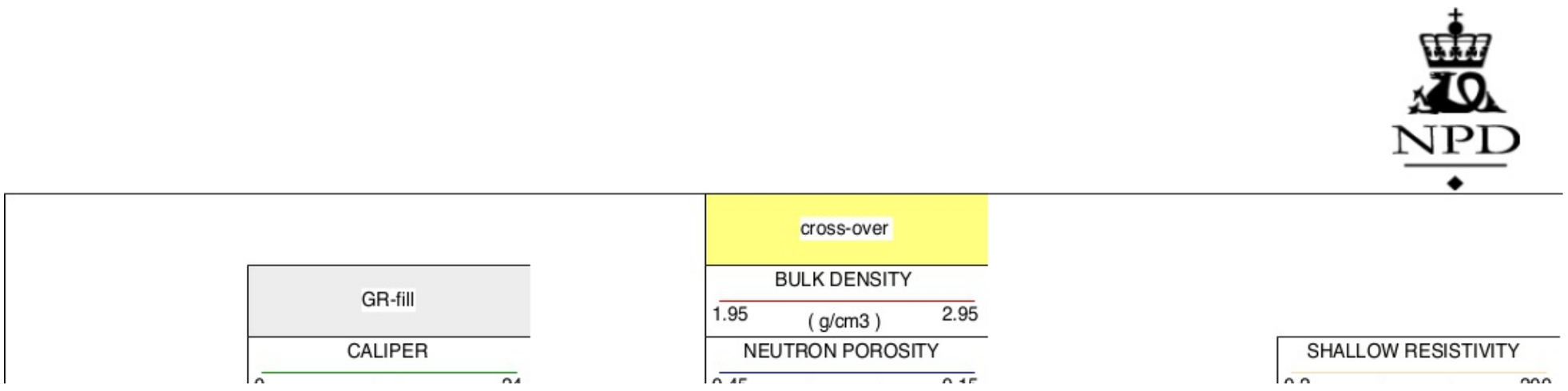
Which statements are correct?
Select zero, one or more alternatives

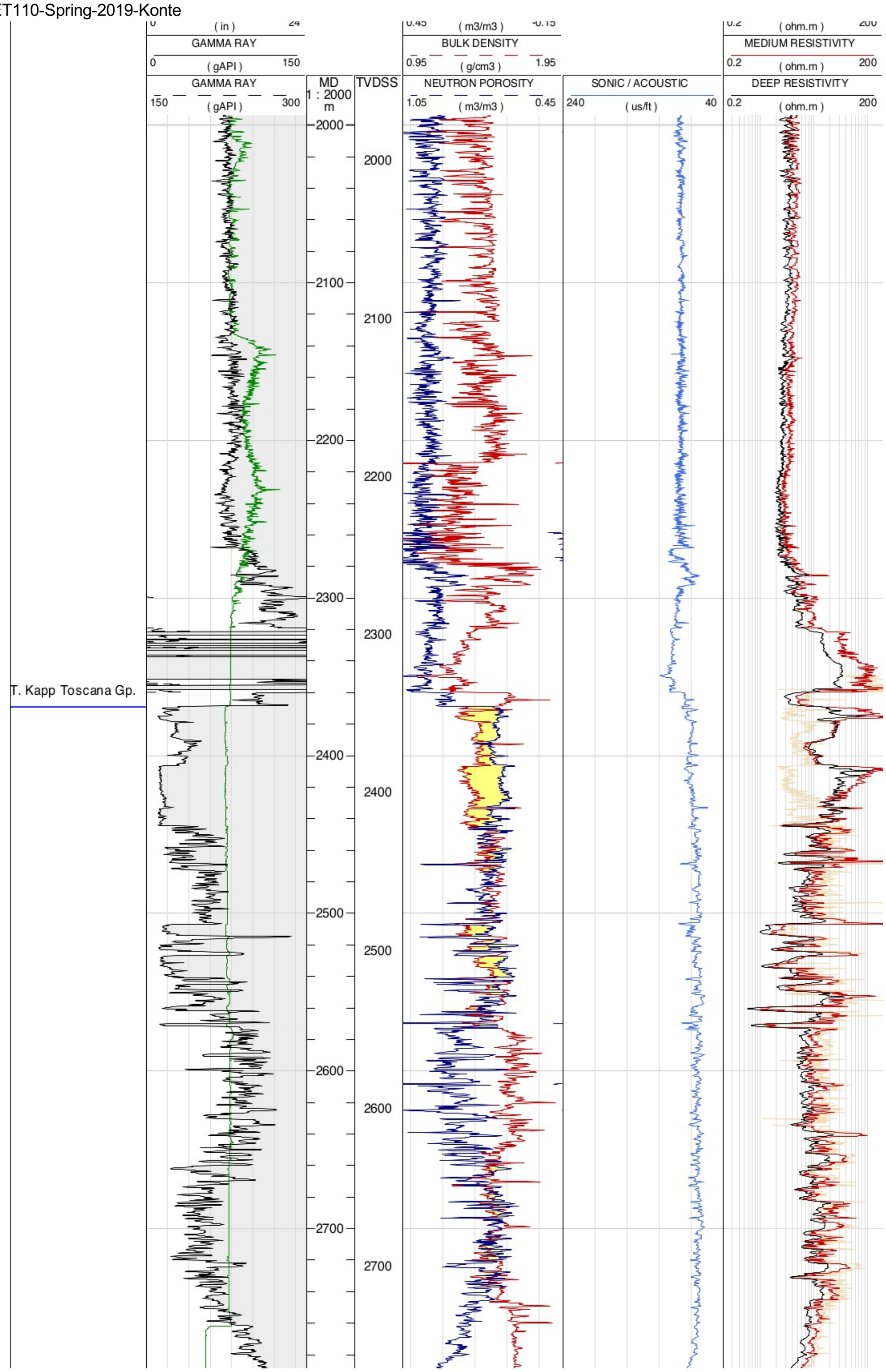
- 1. The formation factor is related to the electrical conductance of the porous media
- 2. The presence of shales and saline brines affect the resistivity of the formation
- 3. The cementation exponent is linked to the formation factor: Higher cementation exponent --> higher formation factor
- 4. Once a, m, n are known then the hydrocarbon saturation may be calculated from resistivity and porosity logs

Maximum marks: 13

10

Log interpretation





The following wireline logs are given for an interval from 2000m to 2780m (MD):

- Caliper log
- Gamma ray
- Density
- Neutron porosity
- Sonic

- Resistivity (shallow, intermediate and deep)

a. Using the caliper log, identify mudcake formations, and potential cavings and wash outs. Justify your answer.

b. This well is associated with the discovery of oil and gas. Using depth ranges, identify the gas and oil zones. Note: Be sure to mention what depth scale you are using (MD or TVDSS).

c. What lithology or lithologies do you associate with the interval between 2000 and 2300 m (MD). What information are you using as a basis for your classification?

d. What lithology or lithologies do you associate with the interval between 2370 and 2500 m (MD). What information are you using as a basis for your classification?

e. Determine the porosities at the depth of 2380 m (MD), using both the density, and the sonic logs. Take the necessary values for your calculations from the tables below. Note: Make sure the units are compatible.

Density and seismic velocities of some rock minerals and pore fluids

Mineral/ Fluid	Density (g/cm^3)	Seismic velocity (km/s)
Quartz	2.65	6.05
Mica (clay mineral)	2.82	5.81
Calcite	2.71	6.54
Water (Brine)	1.146	1.585
Water/HC mix	0.775	0.725

f. Determine the water saturation at a depth of 2370 m. Assume a tortuosity factor of 0.81, a cementation factor of 2.0 and a resistivity of the porewater (R_w) of 0.08 ohmm. Take the deep resistivity as R_t. For the porosity, use a value of 8%. Show your calculations.

g. Calculate the volume of shale (V_{sh}) at the depths of 2200 m and 2400 m. Show your calculations, and what values you used for the sand and shale lines.

Fill in your answer here

Format | B I U x_2 x^2 I_x | Ω | ∑ | ABC

Words: 0

Maximum marks: 19

Formula sheet

Formulas that can be useful:
1 feet = 0.3048 meter

Frequency (f) and Wavenumber (k) relations:

$$f = \frac{1}{T}$$

$$\lambda = \frac{v}{f}$$

$$k = 1/\lambda$$

$$f_{Nyq} = \frac{1}{2\Delta t}$$

$$k_{Nyq} = \frac{1}{2\Delta x}$$

Seismic velocities:

$$v_p = \sqrt{\frac{k+\frac{4}{3}\mu}{\rho}}$$

$$v_s = \sqrt{\frac{\mu}{\rho}}$$

Possion ratio:

$$\nu = \frac{1}{2}\frac{v_p^2 - 2v_s^2}{v_p^2 - v_s^2}$$

Normal incidence reflection coefficient:

$$R_{ij} = \frac{Z_j - Z_i}{Z_j + Z_i} = \frac{\rho_j v_j - \rho_i v_i}{\rho_j v_j + \rho_i v_i}$$

Refraction traveltime equations:

$$t_n(x) = \frac{x}{v_n} + 2\sum_{i=1}^{n-1}\frac{h_i \cos\theta_{i,n}}{v_i}$$

Reflection traveltime equations:

$$t_0 = 2\sum_{i=0}^{n}\frac{h_i}{v_i}$$

$$t_n^2(x) = t_{0,n}^2 + \frac{x^2}{v_{rms,n}^2}$$

Dix Formula:

$$v_n^2 = \frac{v_{rms,n}^2 t_{0,n} - v_{rms,n-1}^2 t_{0,n-1}}{t_{0,n} - t_{0,n-1}}$$

$$h_n = v_n\left(\frac{t_{0,n} - t_{0,n-1}}{2}\right)$$

International Gravity Formula:

$$g(\phi) = 978031.8[1 + 0.0053024\sin^2(\phi) - 0.0000059\sin^2(2\phi)]\ mGal$$

Free-air correction

$$\delta g_{FA} = 0.3086h\ mGal$$

Gravity anomalies of simple bodies (vertical component):

Sphere:

$$\Delta g_z = \frac{Gmz}{r^3}$$

Cylinder:

$$\Delta g_z = \frac{2Gmz}{r^2}$$

Slab of thickness h:

$$\Delta g_z = 2\pi G\rho h$$

$$G = 6.67408e{-}11$$

Wyllie's time-average formula:

$$\frac{1}{V} = \frac{1}{V_{ma}}(1-\phi) + \frac{1}{V_{fl}}\phi$$

Bulk density formula:

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

Archie's law:

$$F = \frac{a}{\phi^m}$$

$$S_w{}^2 = \frac{R_o}{R_t} = \frac{FR_w}{R_t}$$

Vshale:

$$V_{sh} = \frac{GR - GR_{min}}{GR_{max} - GR_{min}}$$