Frontpage

Exam: PET110 Applied Geophysics and Well Logging

Available time: 4 hours

Supporting material: All technical support material is permitted. You are not allowed to get help from other people when working on your exam assignment. We are also reminding you that you, when registering for the semester, you signed that you have read and understood the rules for cheating and plagiarism in the Exam Rules and Regulations at the University of Stavanger. Plagiarism control will be carried out.

Important contact information during the exam: If something should happen during the exam and you need help, you can call one of the phone numbers below, both if you need technical support, administrative support or have questions for the course responsible.

Course responsible: (Wiktor Weibull - 40608703)

Administrative support: 51 83 17 15 / 51 83 31 33 / 92 81 65 97 / 91 78 67 16

Technical support: 51 83 20 14/51 83 20 30 (to May the 11th)

NB! If something goes wrong in Inspera, and you are not able to hand in your assignment, you can send your file to eksamenTN@uis.no. Please write candidate No and course code in e-mail.

Important Information about Exams in Inspera

If you have been given extra time on the exam, it has been added to your used. You can see the count down on the top of the page. Here you will also find your candidate number. The candidate number should be written on all pages. Remember to write page number on all pages and total page number on the first page. NB! Do not write your student number, name or anything else that can identify you in you file or on your answer sheets, only your candidate number. Inspera will secure your identity and will ensure that the evaluation is anonymous.

You can write your answers using blank, ruled or squared paper. You can download and print a squared sheet with weak squares that are appropriate for scanning from Canvas. You can also write your answers in a program such as Latex if you prefer. The answers are to be handed in as a pdf-file.

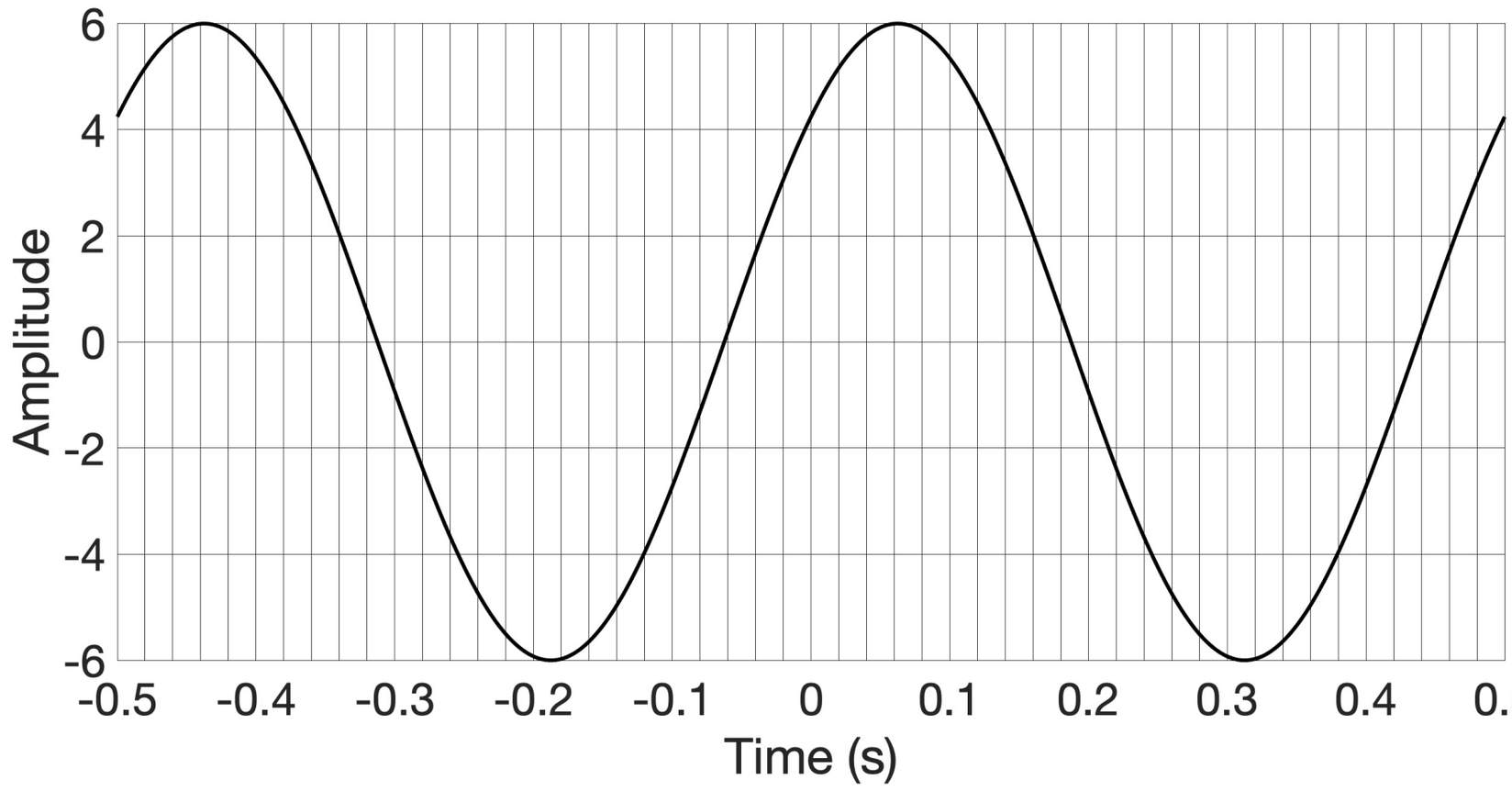
Handing in

The exam will automatically close for uploading when the time is up. Remember that the time given includes the time it will take you to scan and upload your documents (see attachment for tips concerning scanning and uploading). We recommend that you get yourself informed of how to best carry these steps out in due time and before you start working on the assignments.

Best of luck!

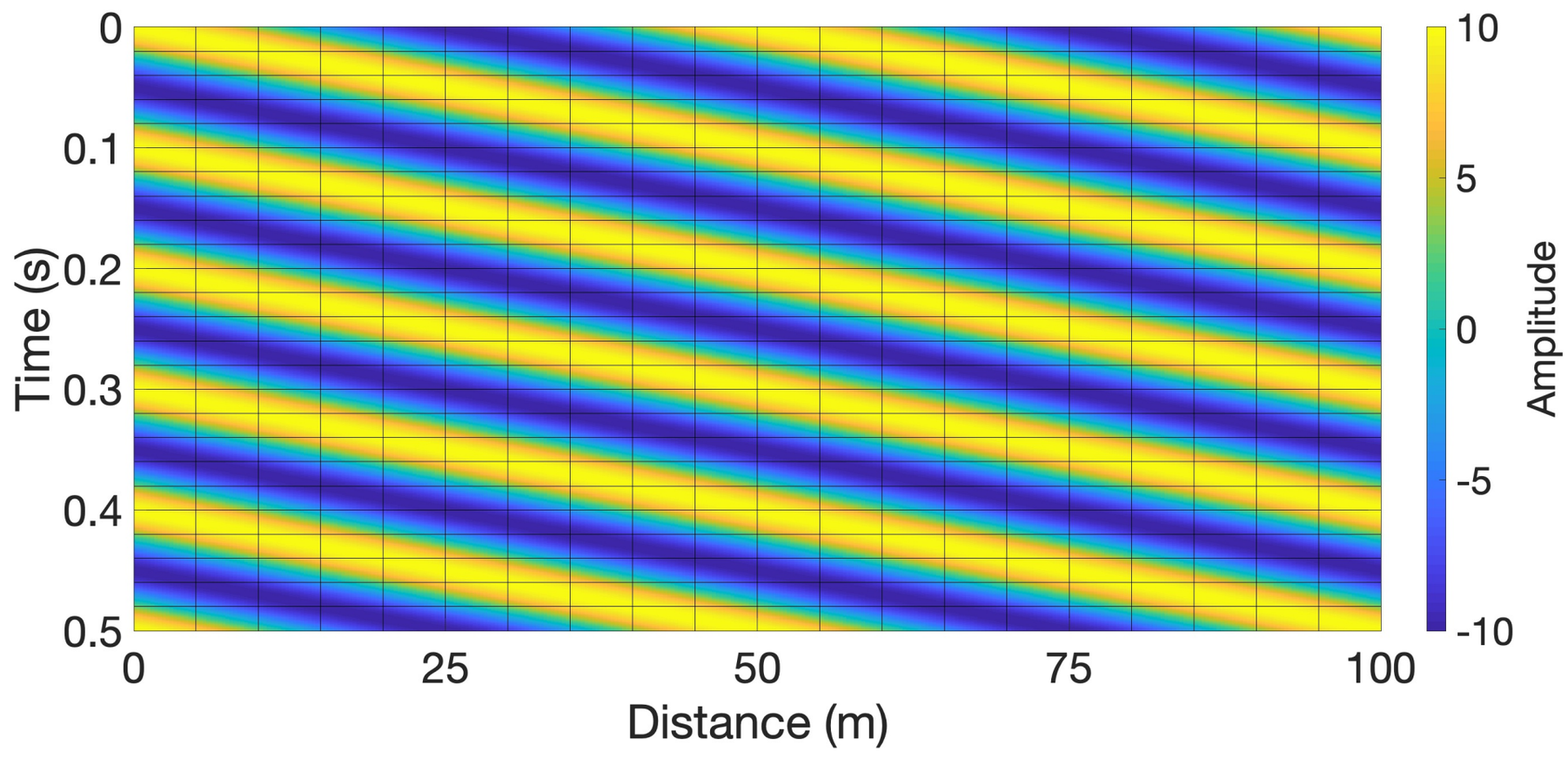
1 Sinusoidal signals

Signal1:



1. Write an equation in the form that describes the above signal (Signal 1). In the equation, is the amplitude, is the frequency in Hz and is the phase shift in radians.

Signal 2:



2. Write an equation in the form that describes the signal above (Signal 2). Here is the amplitude, is the wavelength in meters and is the phase velocity in m/s.

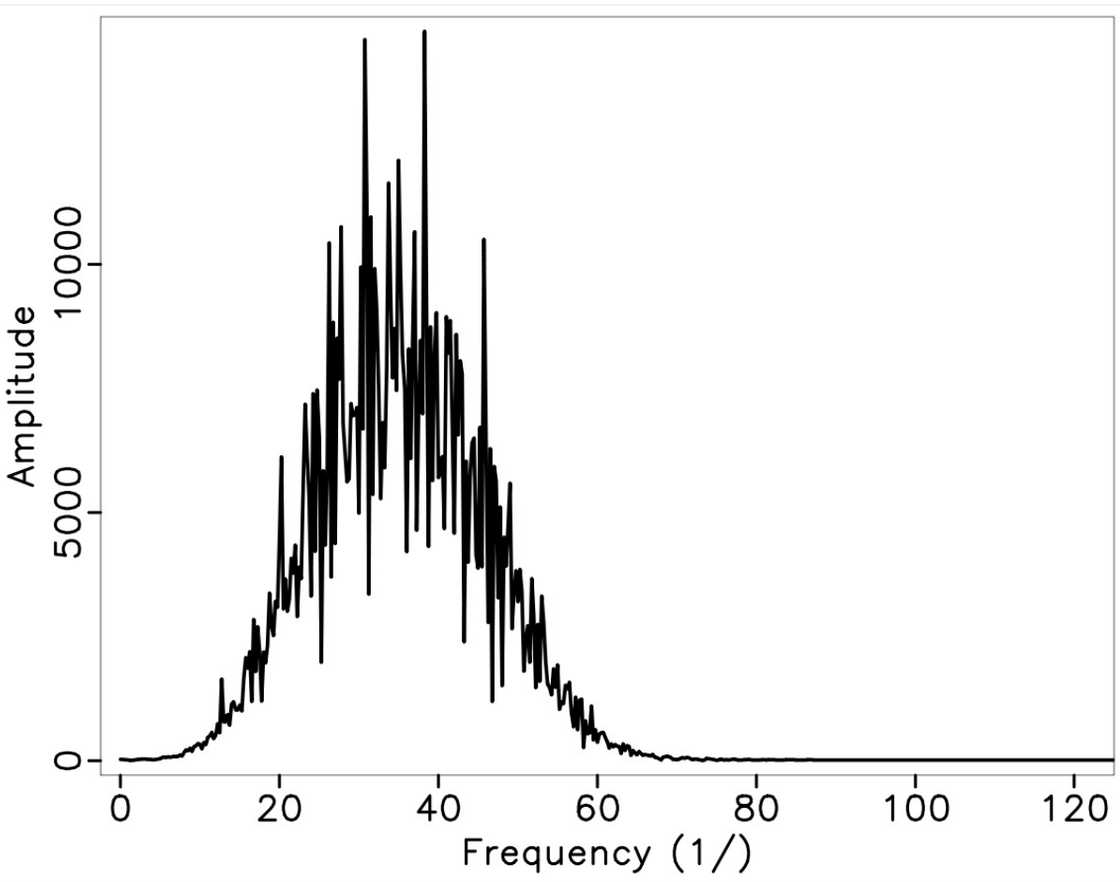
Fill in your answer here

Format

Words: 0

Maximum marks: 4

2 Sampling



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

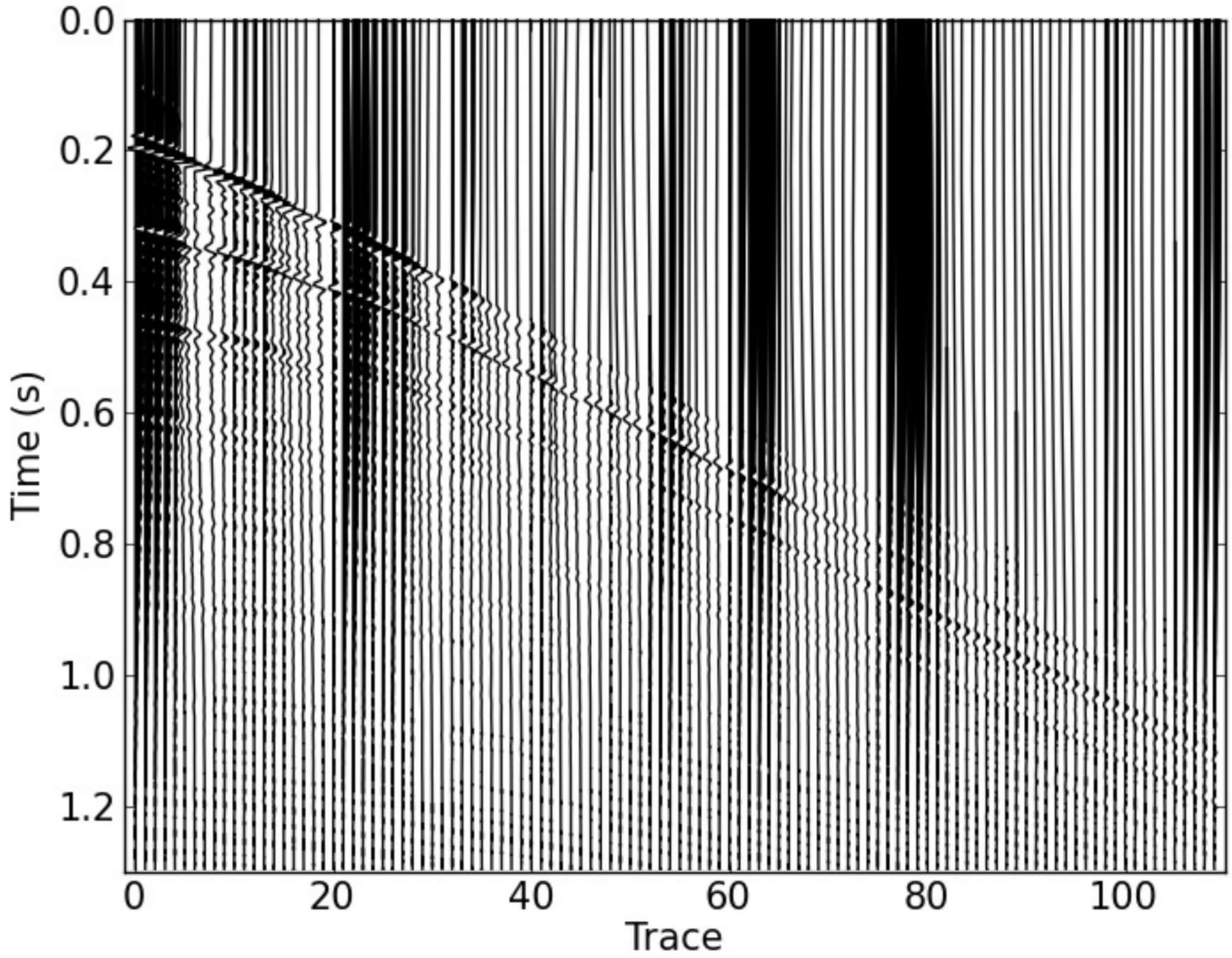
Fill in your answer here

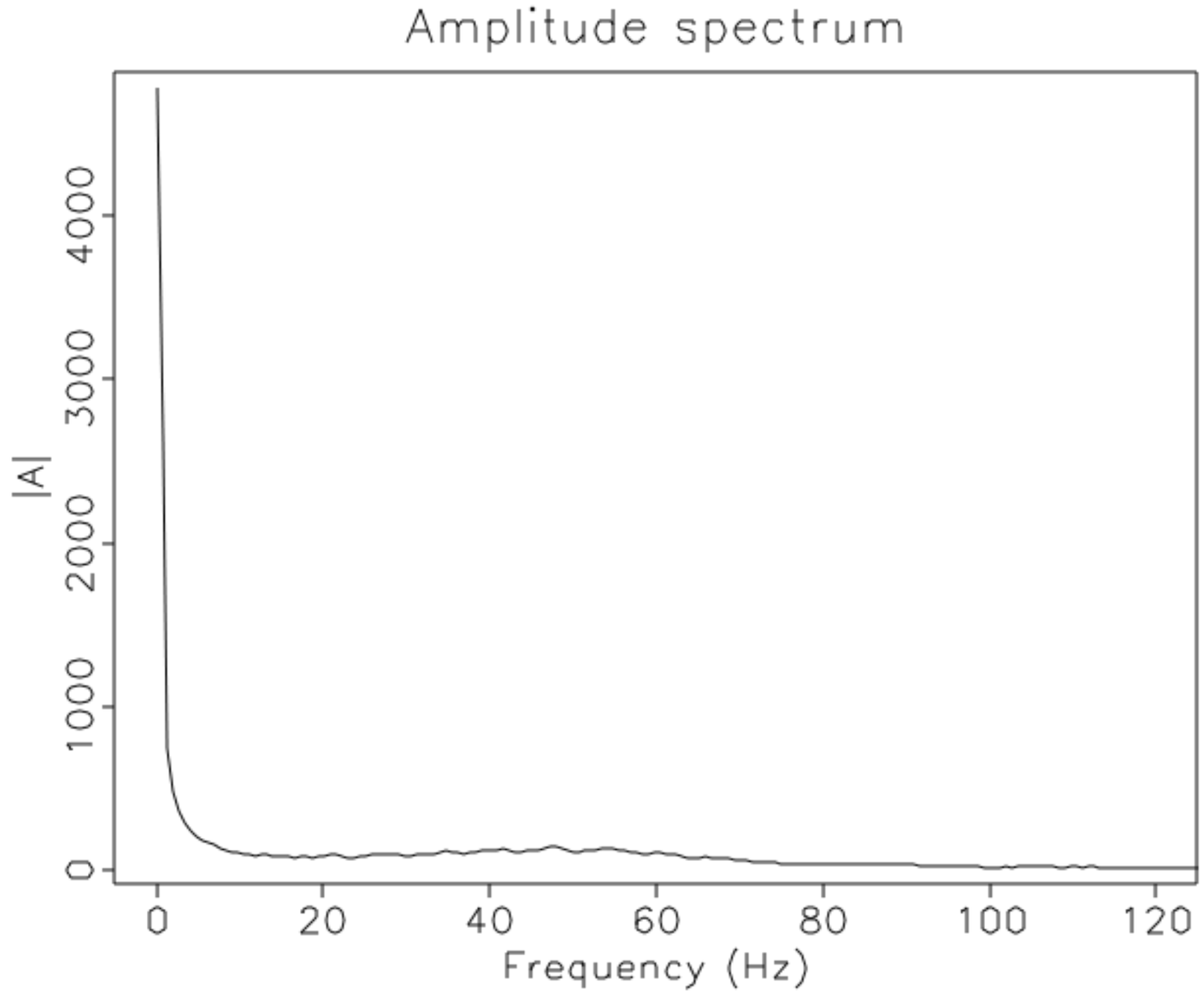
Format

Words: 0

Maximum marks: 4

3 Filtering





The Figures above show a seismic shot gather and the average amplitude spectrum computed from its traces. The seismic data is contaminated by some high amplitude noise.

1. Based on the figures above, what is the dominant frequency of this noise?
2. If you would like to remove this noise from the seismic data, what kind of filter would you need to use?

Fill in your answer here

Format

Words: 0

Maximum marks: 6

4 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: 6.5

5 Resistivity logs and drilling mud

Which resistivity logging methods can be used

1. with water based muds?
2. with oil based muds?
3. in logging while drilling?

Fill in your answer here

Format

Words: 0

Maximum marks: 6

6 Resistivity profiles

Draw an approximate resistivity profile cross the zone of invasion for the following scenarios

1. Brine based mud in a water zone.
2. Brine based mud in an oil/gas zone.

Fill in your answer here

Format

Words: 0

Maximum marks: 6

7 Seismic velocities

A 1 kHz sound pulse was sent through a limestone sample of length 8 cm saturated by water. Assume the limestone to consist of 100% calcite. The calcite mineral has a bulk modulus of 110 GPa, and shear modulus of 35 GPa. Water has a bulk modulus of 2.2 GPa and shear modulus of 0 GPa. The density of calcite is 2.71 g/cm3, and water density is 1 g/cm3.

1) Calculate the sound velocity in **calcite minerals** and **water**. Provide your answers in both meter per second [**m/s**] and microseconds per feet [**s/ft**].

In an experiment we measure a travel time of 16 microseconds (16 x 10^{-6} s).

2) What is the porosity of the sample?

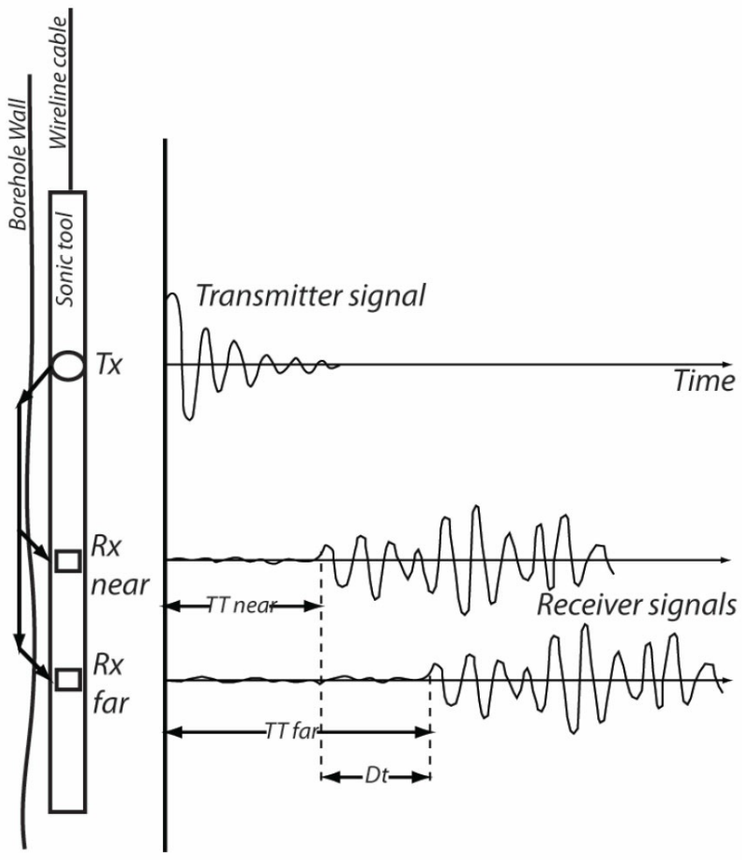
Fill in your answer here

Format

Words: 0

Maximum marks: 6

8 Sonic logging principle



The Figure shows a schematic of a sonic logging tool and and example of its measurements. Explain briefly how seismic velocities can be estimated from the measurements made at the two receivers.

Fill in your answer here

Format

Words: 0

Maximum marks: 5

9

Principles of reflected waves

Select the alternatives which are **true:**
Select one or more alternatives

- 1.Reflection traveltimes vary linearly with the source-receiver offsets
- 6.Snells law can be used to determine the amplitude of the reflected and transmitted waves through the medium
- 9.Hydrocarbon production leads to changes in amplitudes of reflected seismic waves
- 5.Waves reflect at boundaries marking a change in the acoustic impedance of the medium
- 4.The normal moveout of reflected waves depend on the zero-offset traveltime, source-receiver offset and the root mean square velocity of the stack of layers above the reflector
- 8.Hydrocarbon production leads to changes in the traveltimes of seismic waves
- 7.A negative reflection coefficient is a consequence of a wave transmitting into a softer medium.
- 2.Normal moveout is the time taken for the reflections to arrive at the receiver after normal incidence reflection
- 3.The shape of the traveltime for a reflection from a horizontal interface measured at a flat surface is hyperbolic

Maximum marks: 9

10 Reflection coefficients and RMS velocities

An explosive source is detonated at the surface of the Earth in an area where there has been cyclic deposition of horizontal layers of shales and sandstones. Here, layers 1 and 3 are shale units with identical P-wave velocities, 2200 m/s, while layer 2 is a sandstone with a velocity of 2700 m/s. The shale and sandstone have densities of 2150 kg/m and 2250 kg/m, respectively. All the layers are 50 m thick.

1. What is the vertical-incidence P-wave reflection coefficient at the top of layer 2?
2. What is the vertical-incidence P-wave reflection coefficient at the top of layer 3?
3. Consider P1, the primary reflection from the top of layer 2. Ignoring any effect of geometrical spreading, what will be its recorded amplitude if we consider the P-wave to have an amplitude of 1 at the bottom of layer 1 (just before it strikes the top of layer 2)?
4. If we now take geometric spreading into account, determine the recorded amplitude of the P1 reflection.
5. Again ignoring geometrical spreading, what will be the recorded amplitude of P2, the reflection from the top of layer 3 if the P-wave has an amplitude of 1 at the bottom of layer 1?
6. Then determine the amplitude of P2 with geometric spreading taken into account, and assuming nearly vertical raypaths.
7. Determine the root-mean-square velocity, , for the P2 reflection.

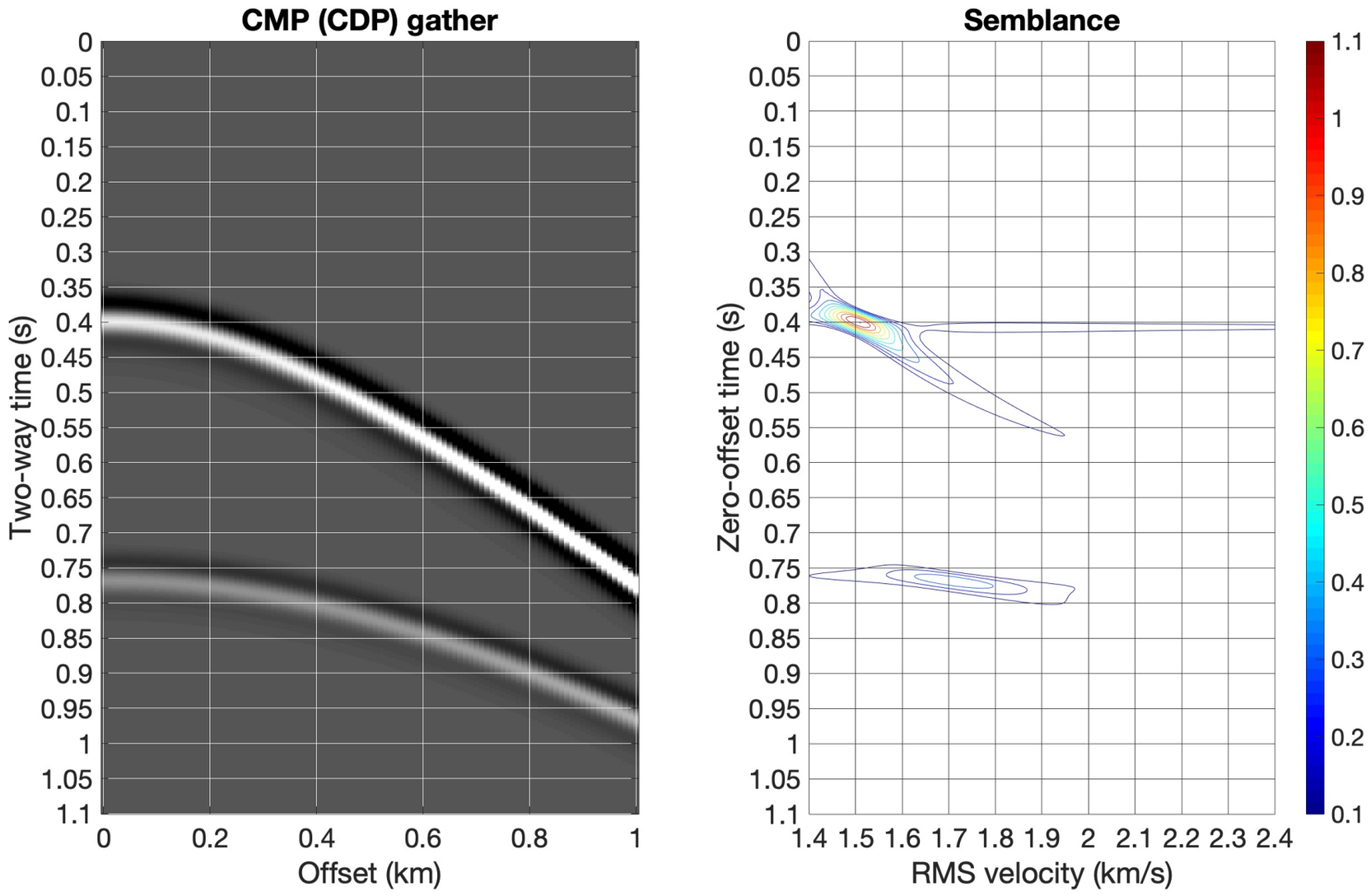
Fill in your answer here

Format

Words: 0

Maximum marks: 6

11 Velocity analysis



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

12 Principles of Gravity and Magnetics

Select the alternatives which are **true** regarding gravity measurements:
Select one or more alternatives:

- 5.Standard gravimeters are levelled and therefore only measure the "vertical" component of gravity
- 1.Due to the centripetal acceleration, the gravity decreases when moving from the Equator to the Poles.
- 4.The Bougher correction is used to remove the effect of different elevation from the gravity measurements
- 3.The free-air gravity anomaly is corrected for the effect of variations of gravity with latitude
- 2.Due to the centripetal acceleration, the gravity increases when moving from the Equator to the Poles.

Select the alternatives which are **true**:
Select one or more alternatives

- 6.Remanent magnetism is a measure of how much a material gets magnetised when in the presence of an external field
- 5.Magnetic anomalies depend on the magnetic susceptibility and remanent magnetisation of the materials in the subsurface
- 3.The Earth's Magnetic field is affected by electromagnetic activity in the atmosphere
- 1.The Magnetic field of the Earth is due to a giant magnet at the center of the Earth
- 4.Compared to gravity the strength and direction of the magnetic field varies much more strongly from Equator to the Poles.
- 2.The Magnetic field can be approximately modelled by a dipole placed at the center of the Earth

---

Maximum marks: 7

13 True or false

Mark off the correct alternative.

Score: 1 point for correct answer and -1 for wrong answer, 0 point for blanks. Minimum score is zero.

1.Spectral Gamma Ray can be used to identify the relative proportion of potassium, thorium and uranium in the radioactive minerals:
Select one or more alternatives:

- True
- False

2.Caliper log can be used to measure the diameter of the well with depth:
Select one or more alternatives:

- True
- False

3.The Liquid Junction potential is more important to the SP-log result than the shale potential:
Select one or more alternatives:

- True
- False

4.Laterolog resistivity tools can be used when oil based drilling muds are used:
Select one or more alternatives:

- True
- False

5.The Neutron log works by bombarding the adjacent formation with gamma rays:
Select one or more alternatives:

- True
- False

6.The hydrogen index (HI) is only controlled by the presence of hydrocarbons:
Select one or more alternatives:

- True
- False

7.High energy neutrons interact with the electron cloud:
Select one or more alternatives:

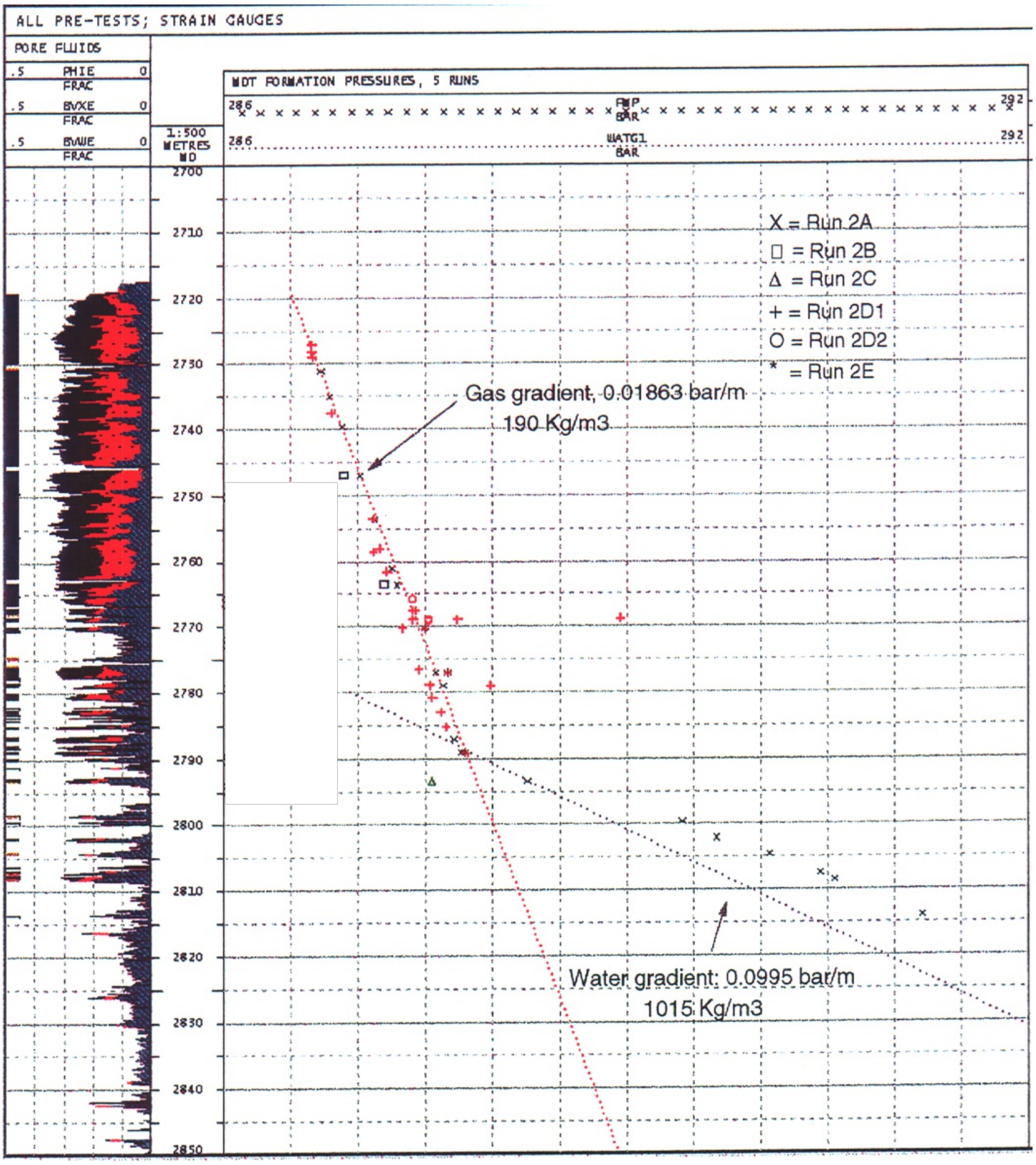
- True
- False

8.Mud invasion into the surrounding reservoir matrix affects the near well resistivity reading:
Select one or more alternatives:

- True
- False

Maximum marks: 8

14 Pressure measurements



The Figure shows Pressure measurements through a gas reservoir.

1. Explain briefly how these measurements can be used to determine the gas water contact (GWC)?
2. Using the plot in the Figure, find an estimate for the depth of the GWC.

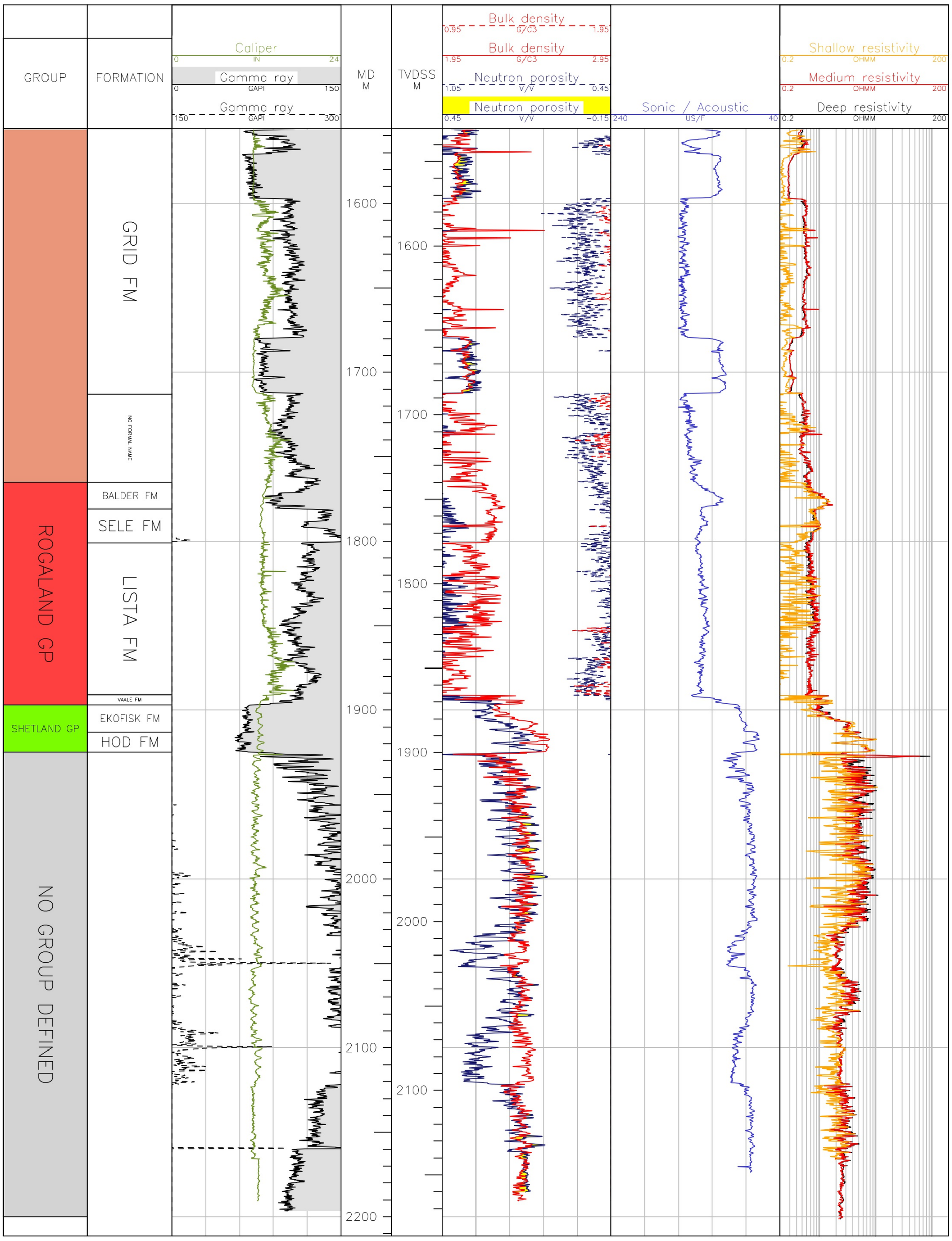
Fill in your answer here

Format

Words: 0

Maximum marks: 6

15 Composite log interpretation



Consider the well log above:

1. Calculate the volume of shale at the base of the Grid formation.
2. Calculate the maximum seismic velocity at the Grid formation. Give the answer in m/s.
3. Assuming that the Grid formation is a clean sandstone fully water saturated, calculate its porosity. You will need the density of the quartz mineral (use 2.65 g/cm3) and the density of the brine (use 1.04 g/cm3).
4. Using the Humble equation version of Archie's law, calculate the formation factor and the resistivity of the pore water () at the base of the Grid formation. Use the porosity you calculated in the last point. If you cannot solve the last point, use a porosity of 12%.
5. At what formation do we find the maximum seismic velocities along the log? What kind of lithology(s) can you expect to find with this seismic velocity.
6. Locate potential hydrocarbon zones in the log. Include a justification for your answer.

Fill in your answer here

Format

Words: 0

Maximum marks: 10.5

16 Upload answers

Upload your answers here as a PDF

Upload your file here. Maximum one file.

The following file types are allowed: **.pdf** Maximum file size is **1 GB**

Select file to upload

Maximum marks: 0