PET110

Geofysikk og brønnlogging
Geophysics and well logging

Midtsemestereksamen
Midterm Examination

10.03.2014

9.00 – 12.00

Tjodhallen: KE F-101

Hjelpemidler: kalkulator, ordbok (fra engelsk)

Auxiliary materials: calculator, dictionary (from English)

Answer all questions.

Write in either English or Norwegian.

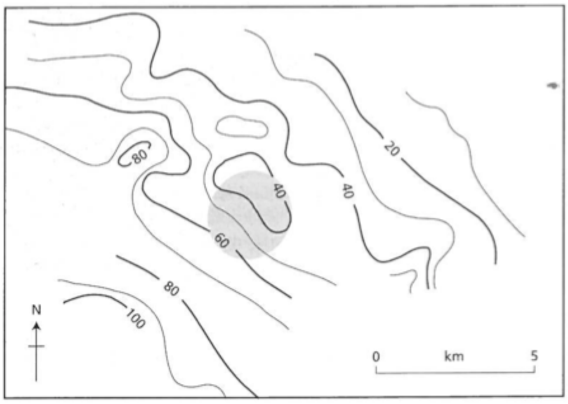
Percentage weights are indicated.

Some formulae are listed at the end.

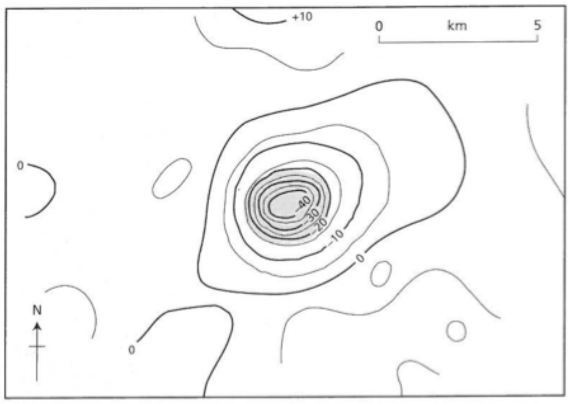
PART A: Short-answer questions (50%; each worth 2%)

Your answers should be brief (just a few words) and may be written on these pages if you wish. Remember to hand these pages in with your other exam pages!

1. The figure here is from a geophysical survey carried out over a salt dome. What kind of survey was it and what property of the salt is instrumental in producing such a map?



2. The figure here shows another geophysical survey carried out over the same salt. What kind of survey was it and what characteristic of the salt would yield such a map?



3. To represent a seismic signal without aliasing, how densely must it be sampled if the highest frequency in the signal is 125 Hz?

4. How would the P-wave velocity of a porous, water-saturated sandstone change if some of the water were replaced by natural gas?

5. As a seismic wavelet propagates further and further through a rock medium, what happens to its amplitude spectrum?

6. When a P-wave strikes the interface between two rock layers at normal incidence (angle of incidence = 0°), what waves travel on from there, and which way?

7. 2D seismic data are acquired along a 1D line on the surface. 3D seismic data are acquired over a 2D area of the surface. How is 4D seismic data acquired?

8. The acoustic impedance of a rock layer is a parameter that may be calculated from some other common rock parameters. Write down an expression for this calculation in words, not just symbols (unless you define the symbols).

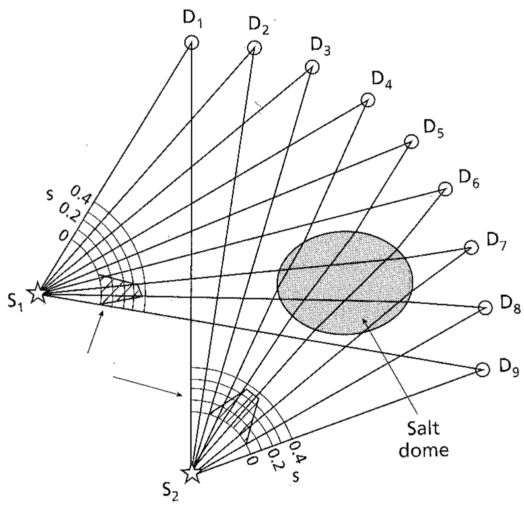
9. What kind of mathematical curve (or function) might we see for the traveltime curve (or function) on a seismic shot gather representing the reflection from the dipping base of a single layer?

10. What do we call a seismic gather in which each trace has the same shot-receiver distance?

11. Write down an equation that expresses Snell's law.

12. If we have a two-layer situation where V_1 = 1950 m/s and V_2 = 3900 m/s (P-wave velocities), what will the P-wave critical angle be?

13. In this figure, what will be observed that will help locate the salt body?



14. In a gravity survey, what observations must you acquire (or, what information do you need) in order to be able to carry out a drift correction?

15. In a gravity survey, what observations do you have to acquire (or, what information do you need) in order to be able to carry out the Bouguer correction?

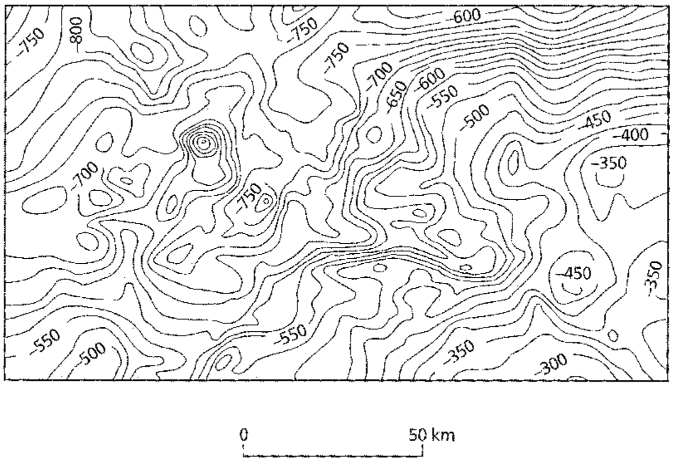
16. If you apply the free-air correction in a gravity survey, what does it correct for?

17. Name two different geological features or structures or rock types that you might be able to map by carrying out a magnetic survey.

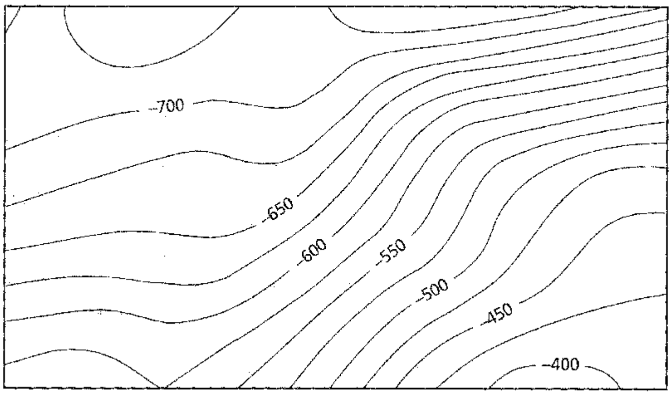
18. Name one geological feature or occurrence that you might be able to find with resistivity (electrical) prospecting, and indicate how or why.

19. What sort of data could this be and what process could have been applied to (a) to get (b)?

(a)

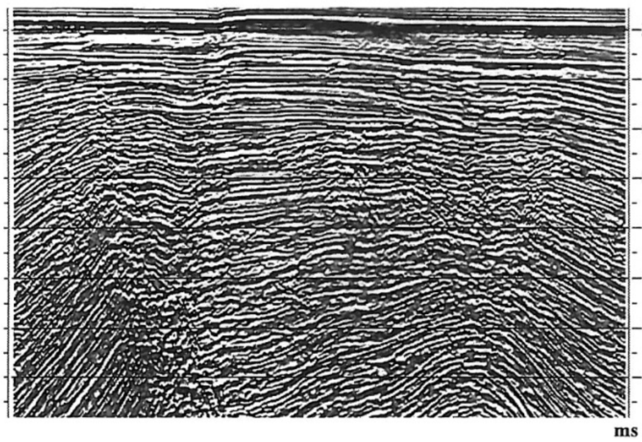


(b)

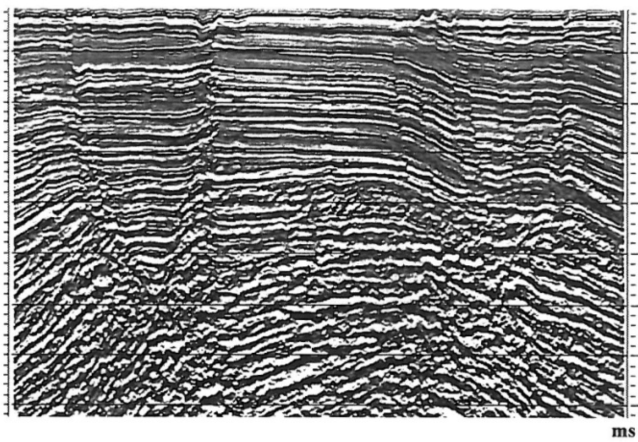


20. You have a seismic line from a region where problems were caused by a great assortment of structures (faults, folds, dipping boundaries, etc.) in the deep subsurface. What sort of seismic process do you think you'll need to apply?

21. What are the main differences between these two types of data?



(a)



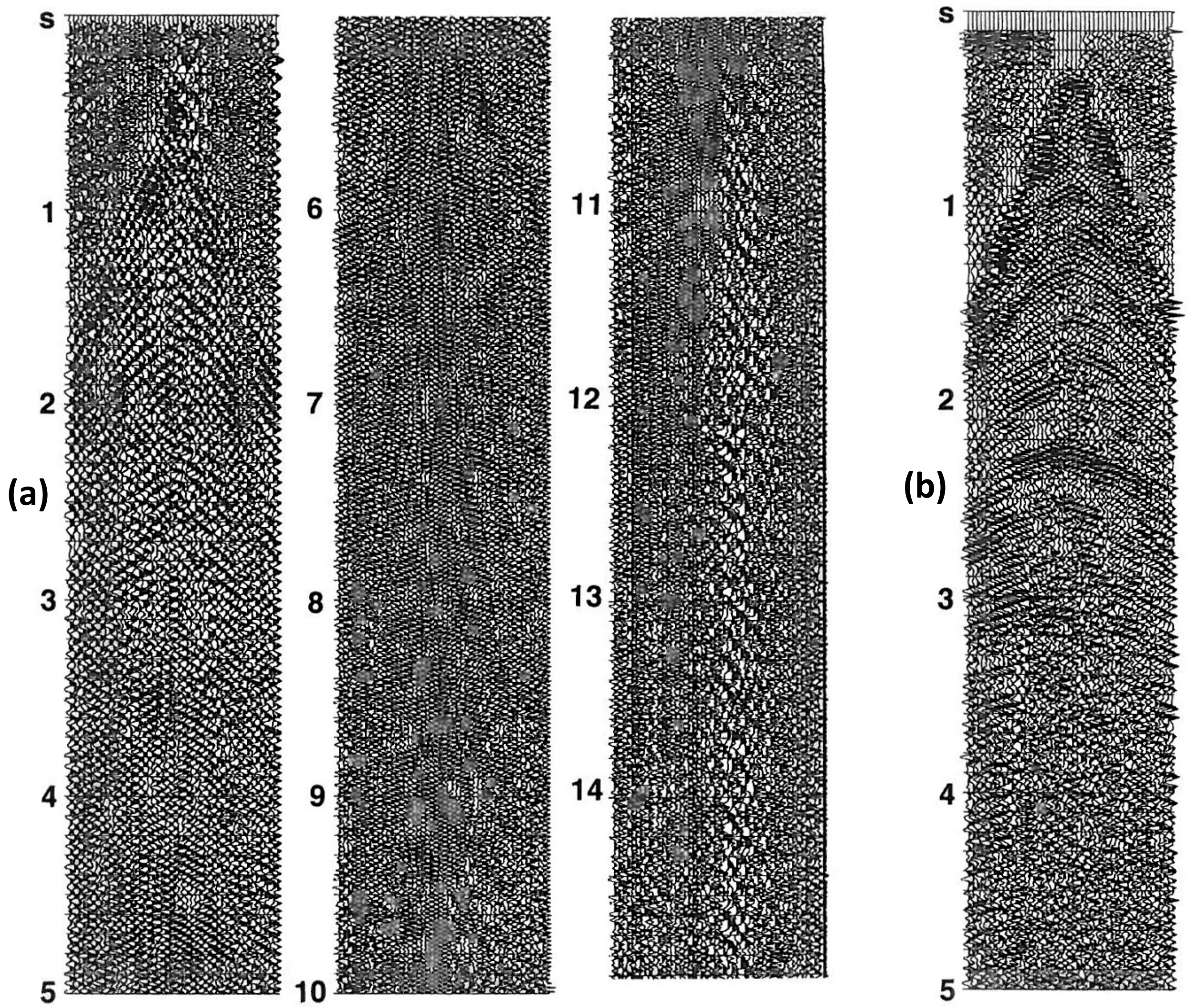
(b)

22. What do the letters CMP stand for?

23. A seismic wavelet, generated by an airgun, propagates in all directions through a layered rock medium. What three (3) mechanisms will be active in decreasing the amplitude of deep reflections that are recorded back at the surface?

24. You have a land-seismic line from a region where problems were caused by large variations in the thickness of the near-surface weathered layer. What sort of seismic process do you think you'll need to apply?

25. What process was applied to (a) to get (b)?



(a) (b)

PART B: Problems (50%)

15% 26. Density and P-wave velocity of fluid-saturated porous rocks

A clastic (sandy shale) unit has porosity ϕ = 22%. The solid matrix has a density of 2700 kg/m^3 and a P-wave velocity of v_m = 5200 m/s. The water (or brine) in the pores has a density of 1030 kg/m^3 and a P-wave velocity of v_w = 1500 m/s

3% (a) Determine the bulk density (or overall density) of this two-phase rock.

6% (b) Estimate its P-wave velocity using two (2) different approximate equations.

3% (c) Suppose that 40% of the pore volume were filled with clay minerals with a density of 2800 kg/m^3 and a P-wave velocity of 6000 m/s (the remaining porosity being saturated with the same brine as above). Find the bulk density of this three-phase rock.

3% (d) The time-average (or Wyllie) equation is usually given in terms of two components but can be extended for more than two., a solid matrix and a pore fluid. For a three-component rock, like the one described in part (c), estimate the P-wave velocity by modifing the time-average equation to the three-component situation.

20% 27. P-wave moveout, velocity and amplitude

A primary P-wave reflection (P1) arrives at 2.500 s at zero offset (i.e. t_0 or t_{01} = 2.500 s). It has a normal moveout (NMO or Δt_{NMO}) of 42 ms at 1000 m offset. Assume first that this NMO is exactly 42 ms (even though this is unrealistic). Assume also that all other numerical values are given exactly. Assuming that there is just one layer, determine its velocity using both:

3% (a) the hyperbolic equation and

3% (b) the parabolic approximation.

3% (c) Estimate the thickness of the layer.

8% (d) The amplitude of the downgoing wave (P1) just above the bottom of this layer is defined as 1 amplitude unit. Layer 2 has a P-wave velocity of 3000 m/s. Assuming Gardner's relation to hold for both layers, and neglecting only absorption by internal friction, determine the amplitude of P1 just as it arrives back to the surface.

3% (e) Now, do not assume any longer that the Δt_{NMO} value is exact, but (more realistically) that it was determined to the nearest ms. However, we will still assume that the offset and t_0 values given above are exact. What now is the uncertainty in the velocity value determined in (a) (using the hyperbolic expression)?

5% 28. Detector arrays

In a marine seismic survey, each recorded hydrophone trace consists of the sum of the signals from five individual hydrophone detectors feeding into the single channel. The array is designed to attenuate the direct P-wave propagating through the water at a speed of 1500 m/s. The dominant frequency of the wavelet generated by the airgun source is 60 Hz. In order to achieve maximum attenuation of this direct P-wave, what should the distance between detectors (Δx) be? Choose the smallest value of Δx that will do the job.

10% 29. Gravity and magnetics

4% (a) Name the two most important corrections that are commonly performed on magnetic data and state very briefly the reason why each one is carried out.

6% (b) On a processed seismic section you see several parallel reflectors with apparent updoming structures. But neither gravity nor magnetic surveys over this same location show any visible anomaly. What interpretation of the three we've discussed in class is most likely – and why?

Some geophysical formulae:

$$V = \lambda f$$

$$V_a = \frac{V}{\sin i}$$

$$\frac{1}{V} = \frac{\phi}{V_f} + \frac{1-\phi}{V_m}$$

$$\rho = 310 V_P^{0.25}$$

$$V_{\mathrm{RMS},n} = \left[\sum_{i=1}^{n} V_i^2 \tau_i \Big/ \sum_{i=1}^{n} \tau_i \right]^{1/2}$$

$$\alpha_n = \left[\frac{V_{RMS,n}^2 t_n - V_{RMS,n-1}^2 t_{n-1}}{t_n - t_{n-1}} \right]^{\frac{1}{2}}$$

$$\overline{V} = \sum_{i=1}^{n} V_i \tau_i \Big/ \sum_{i=1}^{n} \tau_i$$

$$w_F = \sqrt{2\lambda z}$$

$$\alpha \equiv V_\mathrm{P} = \left[\frac{K + \frac{4}{3}\mu}{\rho} \right]^{1/2}$$

$$\beta \equiv V_\mathrm{S} = \left[\frac{\mu}{\rho} \right]^{1/2}$$

$$t^2 = t_0^2 + \frac{x^2}{V^2}$$

$$t \approx t_0 + \frac{x^2}{2V^2 t_0}$$

$$R = \frac{\sin n\beta}{\sin \beta}$$

$$\beta = \frac{\pi \Delta x}{\lambda_a}$$