BPG150

Geofysiske metoder i petroleumsvirksomheten

Geophysical methods applied to petroleum

Avsluttende eksamen

Final Examination

22.11.2012

13.00 – 16.00

Hjelpemidler: kalkulator, ordbok

Supporting materials: calculator, dictionary

<u>Answer all 4 questions.</u>

Percentage weights are indicated.

Write in either English or Norwegian.

<u>Some formulae are listed at the end.</u>

Faglærer/Instructor: R.J. Brown

30% 1. Seismic

In a land-seismic survey a vibratory source is activated at the surface of the Earth. Geophone receivers are deployed at the surface and with both positive and negative offsets. In this area the top four layers are as follows:

layer 1: α_1 = 2250 m/s and ρ_1 = 2240 kg/ m^3,
layer 2: α_2 = 2400 m/s and ρ_2 = 2100 kg/ m^3,
layer 3: α_3 = 4500 m/s and ρ_3 = 2100 kg/ m^3, and
layer 4: α_4 = ?? and ρ_4 = ??

Zero-offset two-way traveltimes for each primary reflection are observed to be:

1st reflection (at bottom of layer 1): t_{01} = 120 ms,
2nd reflection: t_{02} = 210 ms, and
3rd reflection: t_{03} = 314 ms, and
4th reflection: t_{04} = 464 ms.

4% **(a)** Determine the vertical-incidence reflection coefficient, R_1, for a downward travelling P-wave reflecting at the bottom of layer 1 (top of layer 2).

2% **(b)** Determine the vertical-incidence reflection coefficient, R_2, for a downward travelling P-wave reflecting at the bottom of layer 2 (top of layer 3).

7% **(c)** Consider the reflection from the bottom of layer 2 (top of layer 3). Ignoring geometrical spreading, what will its amplitude be just before it is recorded – i.e. just below the Earth's surface on its way up – if it had an amplitude of 1 at the bottom of layer 1 (just before reaching the top of layer 2) on its way down?

4% **(d)** Now take geometric spreading into account and determine the corrected amplitude just below the surface for the same reflection arrival (from the bottom of layer 2).

4% **(e)** Determine the RMS velocity for the 2nd primary reflection, i.e. from the top of layer 3.

3% **(f)** Determine the RMS velocity for the 3rd primary reflection, i.e. from the top of layer 4.

5% **(g)** In carrying out a velocity analysis on these data you find the stacking velocity for the 4th reflection to be 4010 m/s. From this, estimate the actual interval velocity of this 4th layer.

1% **(h)** If you had to guess the lithology of layer 3 – just from its physical parameters – what would you guess?

24% 2. Integrated geophysics

Imagine 3 geological scenarios that are really very different from each other but which can give reflection-seismic images that are really very similar to each other, and in many ways. These could be some scenarios that we have discussed in class or any others you want to choose, but they should be as just described (in the previous sentence); that is, the more different they are geologically, the better.

[***NOTE***: For the following 2 parts, **(a)** and **(b),** you may want to do them together for one geological scenario, then **(a)** and **(b)** for the next scenario, etc. That is perfectly fine.]

8% **(a)** Sketch each of these 3 geological scenarios, i.e. draw sections with depth as the vertical axis, and indicate significant properties on your sketches (such as, maybe, lithology, P-wave velocity, etc. – whatever you feel has some significance).

6% **(b)** Make 3 sketches of the single seismic section that all 3 of these geological scenarios could produce. This seismic section (i.e. with time as the vertical axis) should be the same for all 3 cases. On each of these, indicate horizons that correspond to significant geological horizons.

4% **(c)** Explain why some (if any) of your seismic horizons have a different form than in the geological section.

6% **(d)** Imagine that you are given a seismic section like the one you have drawn. Explain how you could use the results of 2 or more additional geophysical surveys (i.e. additional non-seismic survey types) to determine which of the 3 geological scenarios was the most likely interpretation.

30% 3. Gravity, magnetics and seismic

8% **(a)** Derive the expression for Δg due to a uniform sphere of density ρ buried at a depth z in an otherwise uniform ground of density ρ_0.

Hint: Take the sphere as being correctly represented by an excess mass, m, at the centre point of the sphere.

7% **(b)** From this expression, derive an expression that enables one to determine the depth, z, to the centre of the sphere in terms of parameters that would be observed on a gravity profile acquired over the body. If you didn't succeed in getting an expression in part **(a)** use the 'generic' expression:

$$\Delta g = \frac{Cz^n}{r^m}.$$

4% **(c)** Imagine that your sphere has radius a. Derive an expression that relates m, the excess mass, and $\Delta\rho = \rho - \rho_0$.

1% **(d)** What do we call the difference $\rho - \rho_0$ or $\Delta\rho$?

10% **(e)** Imagine that this buried sphere contains quite a bit of magnetite and that it is magnetized by the geomagnetic field. Assume further that you are at rather high latitude in the northern hemisphere (say about 55° to 65°). Sketch 2 sections (1 combined sketch might work for you but might be too crowded) along a north-south profile: one showing the observed magnetic anomaly and one showing the secondary magnetic field set up by the magnetized sphere – i.e. the lines of force emanating from and returning to the body.

16% 4. Geophysical concepts and data processing

Figures 1 to 5 each show two datasets or some geophysical phenomenon or concept. In the case of a pair of datasets, describe the significant difference(s) between the two figures in each example and explain what the difference is due to. In the case of a geophysical phenomenon or concept, explain briefly what this phenomenon or concept is for each example.

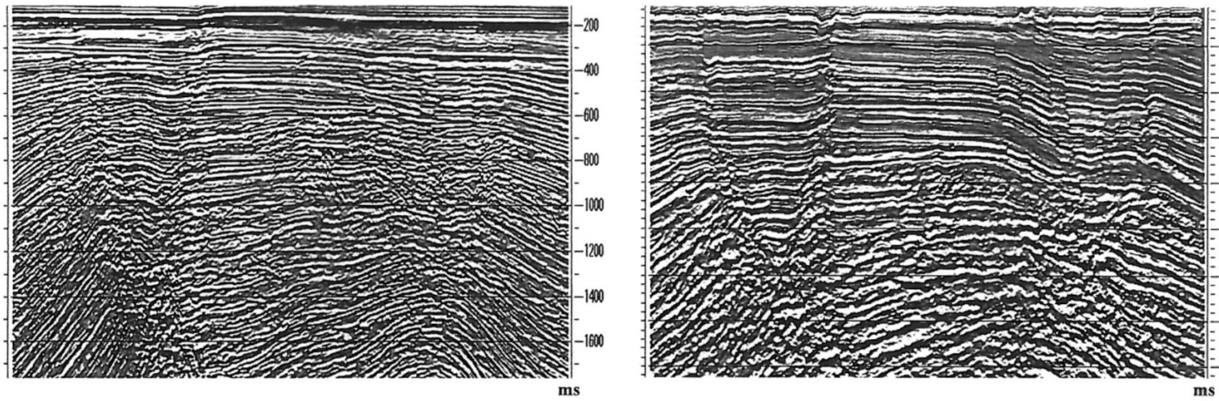

Figure 1.

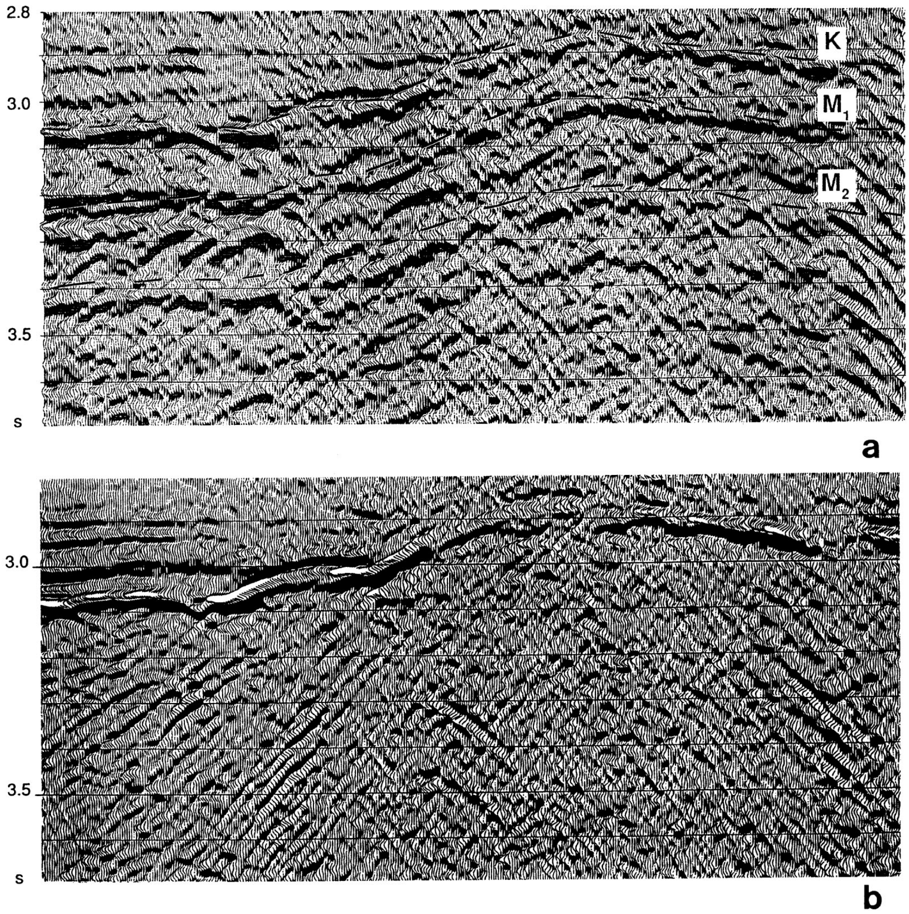

Figure 2.

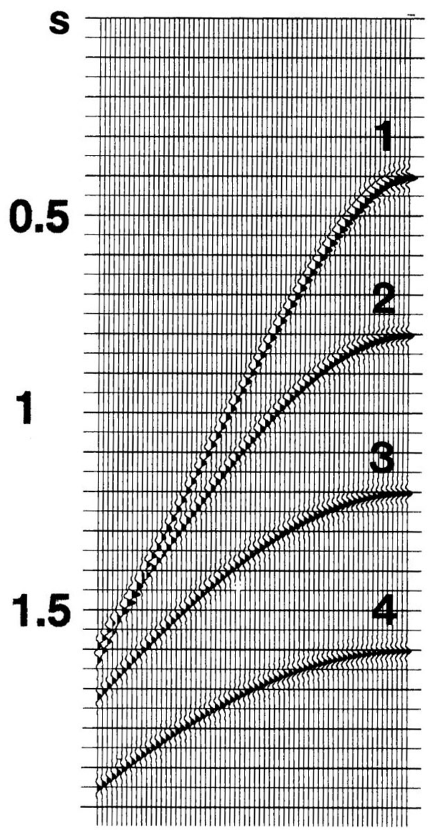

Figure 3. Explain also what the crossing of the 2 reflections tells us.

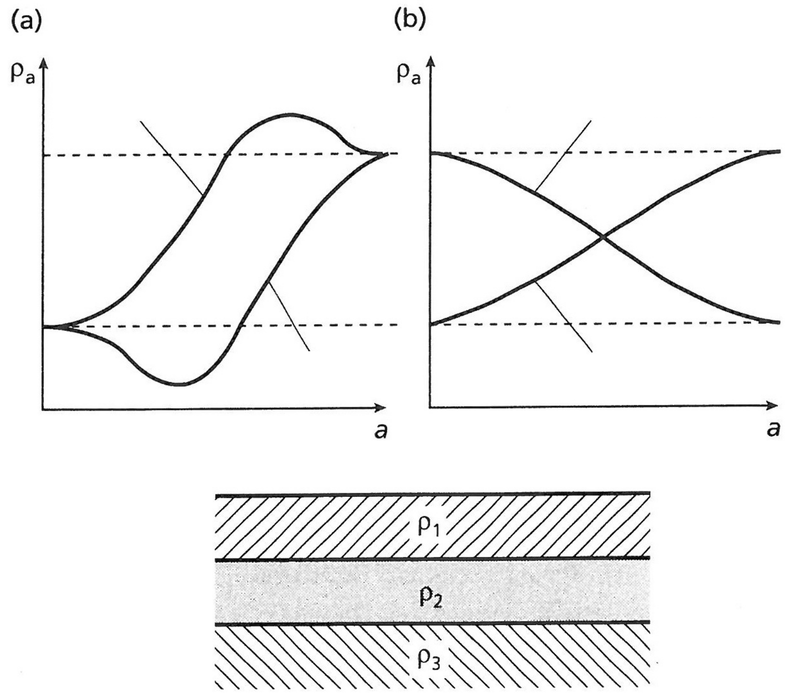

Figure 4. State also which ρ values are lowest, medium and greatest in each case.

Some geophysical formulae:

$$F = \frac{Gm_1m_2}{r^2}$$

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

$$V_P = \left[\frac{K + \frac{4}{3}\mu}{\rho}\right]^{1/2}$$

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

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

$$DR = 20\log_{10}\left[\frac{A_{max}}{A_{min}}\right]$$

$$w_F = \left(2\lambda z\right)^{1/2}$$

$$V = \lambda f$$

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

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

$$V_S = \left[\frac{\mu}{\rho}\right]^{1/2}$$

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

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

$$t_n = 2\left(\tau_1 + \tau_2 + \ldots + \tau_n\right)$$

$$R_2 = \frac{\rho_2V_2 - \rho_1V_1}{\rho_2V_2 + \rho_1V_1}$$

$$fold = \frac{N}{2n}$$