BPG150

Geofysiske metoder i petroleumsvirksomheten

Geophysical methods applied to petroleum

Avsluttende eksamen

Final Examination

24.11.2010

9.00 – 12.00

Answer all questions and write in English or Norwegian.

Percentage weights are indicated and some formulae are listed at the end.

Faglærer/Instructor: R.J. Brown

27% 1. Geophysical data processing

Figures 1 to 9 each show two seismic datasets or two gravity maps from the same location. The difference between (a) and (b) – except for Figure 9, which is presented and described below – is that some data-processing step has been applied to (a) in order to get (b). **(i)** Describe the significant difference(s) between the two figures in each example.
(ii) On the basis of this visual difference, make an intelligent guess as to what additional process has been applied.

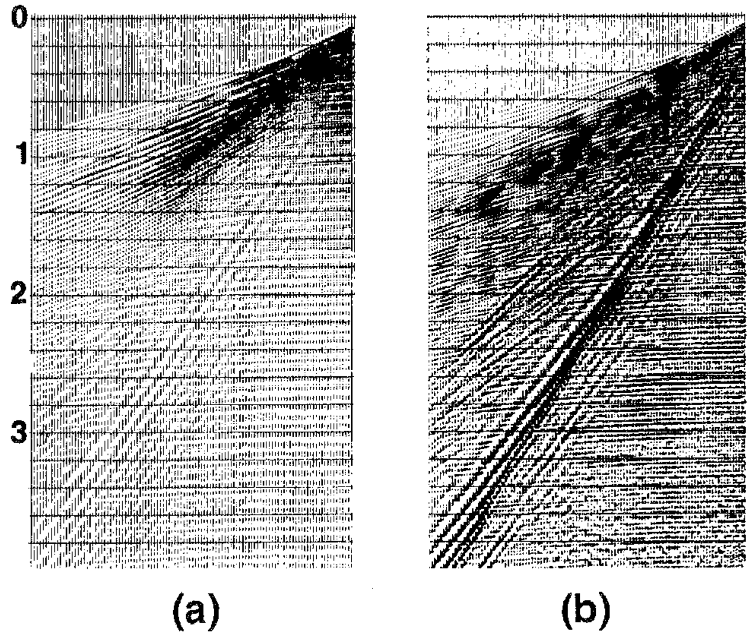


Figure 1

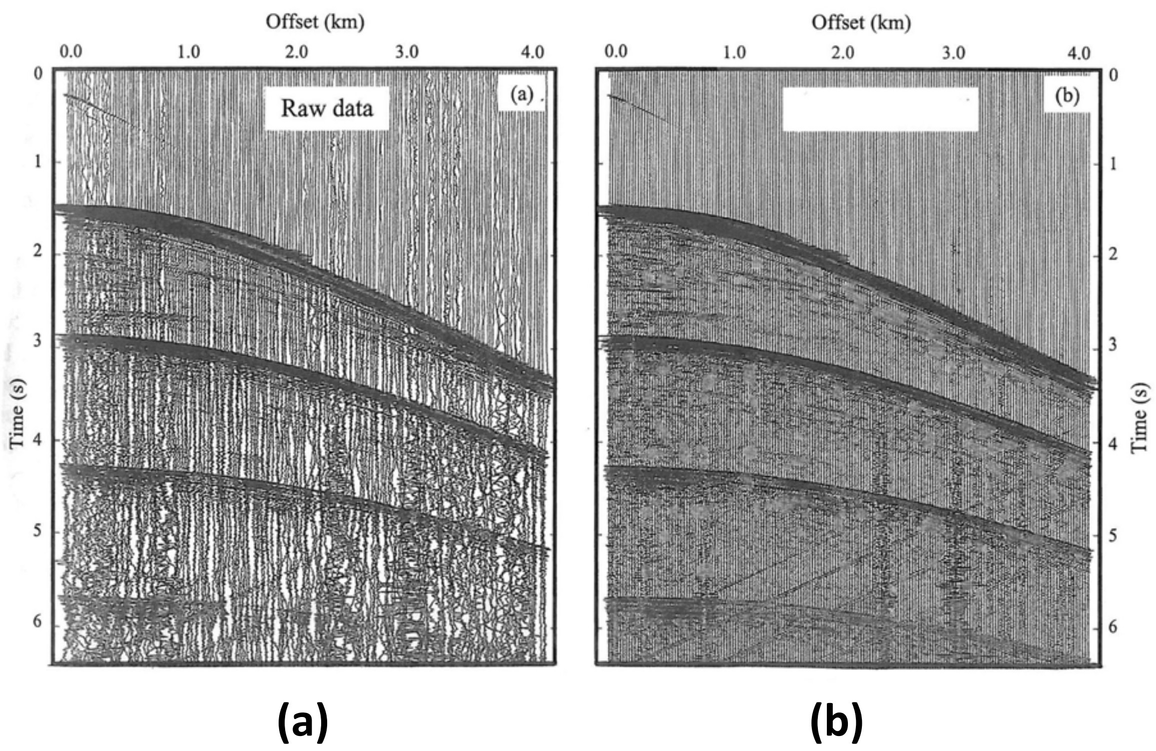


Figure 2

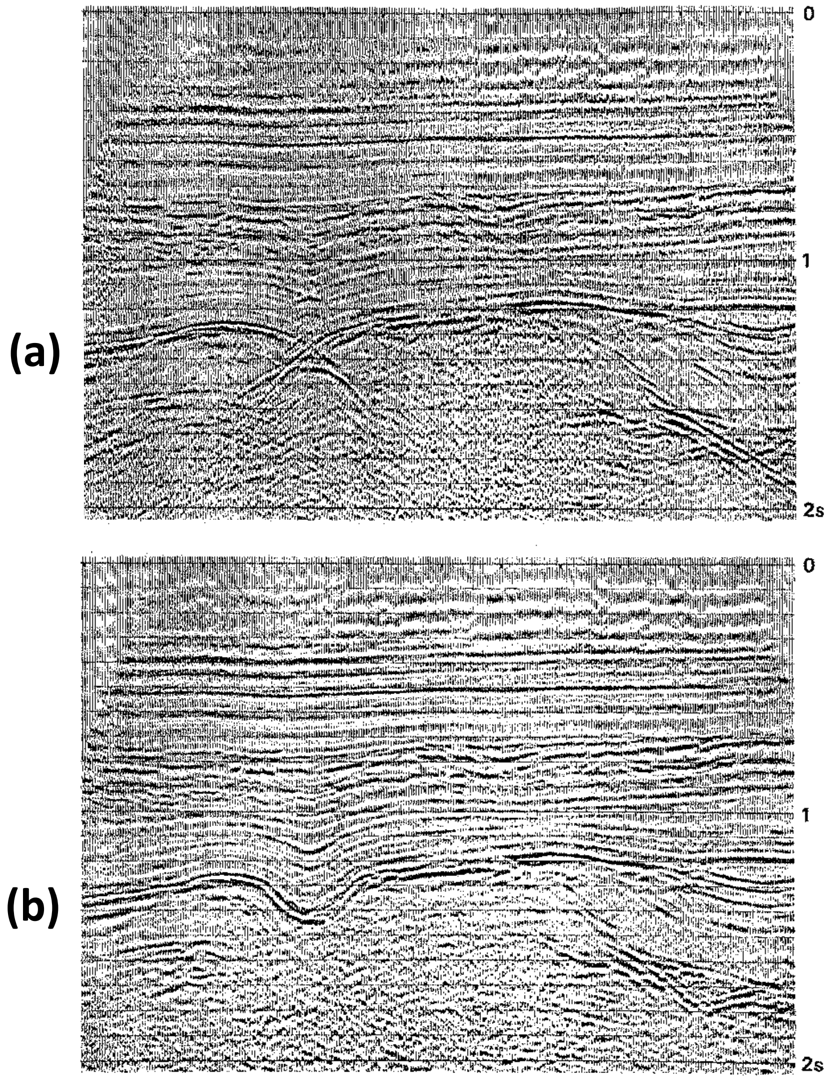


Figure 3

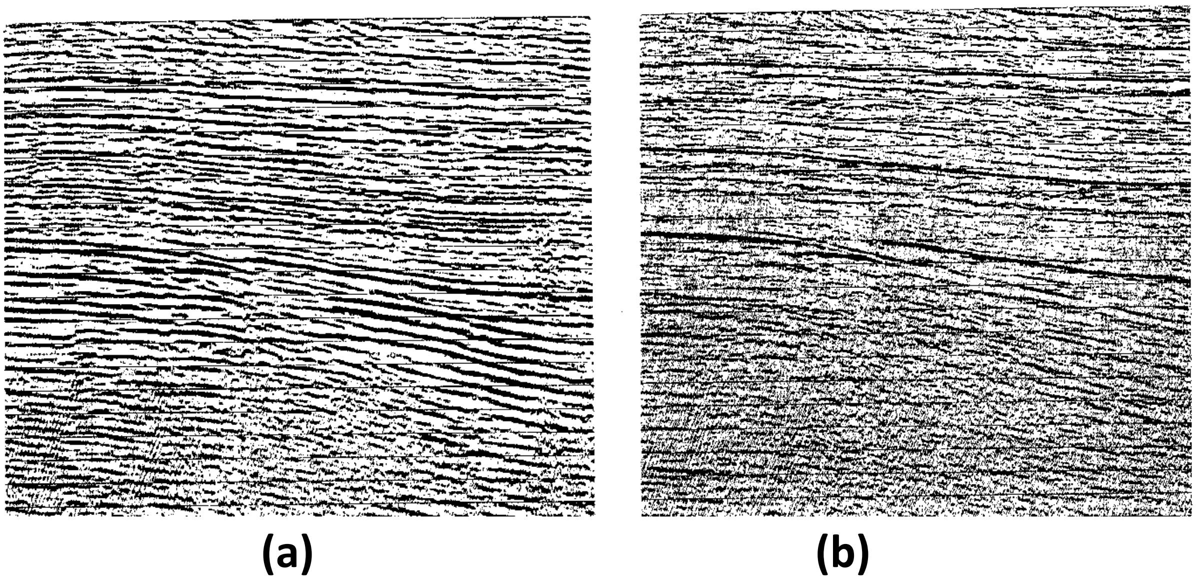
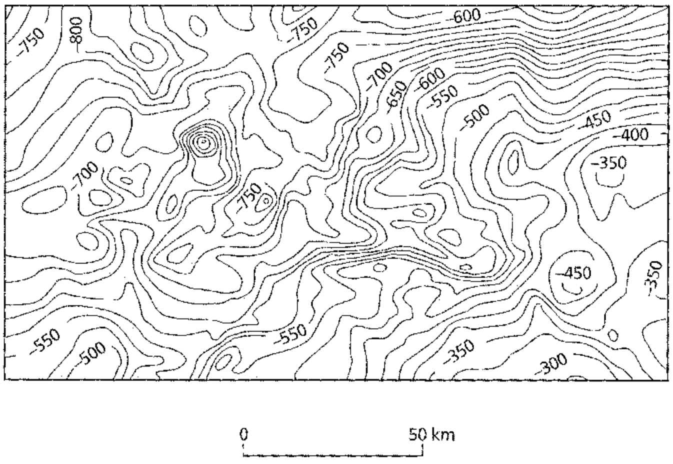


Figure 4

(a)



(b)

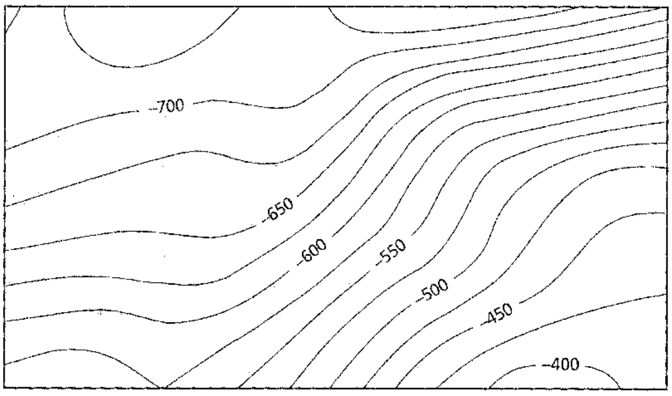
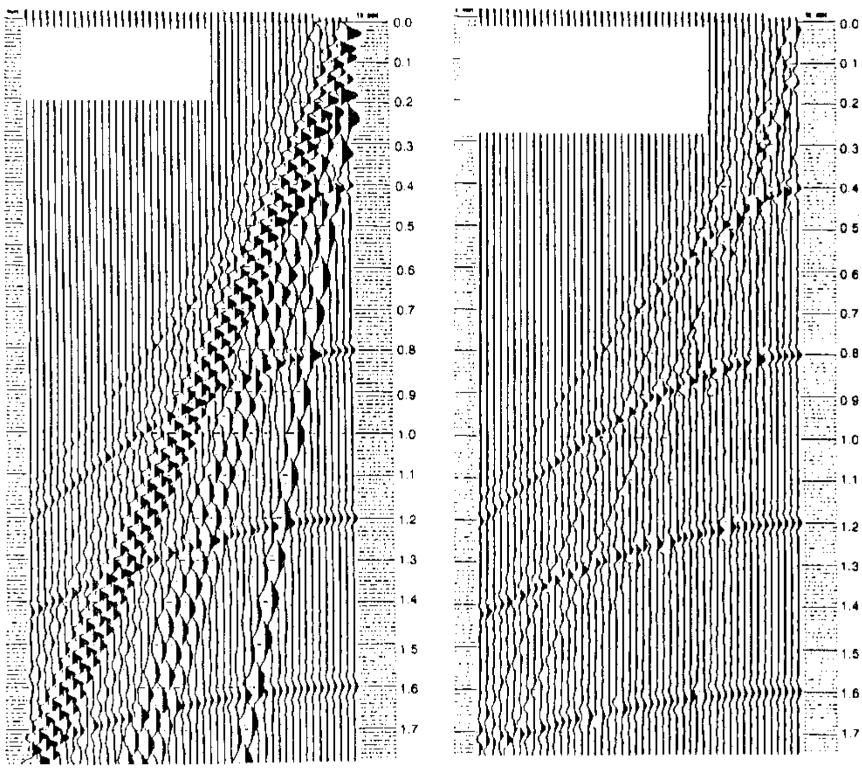


Figure 5



(a) (b)

Figure 6

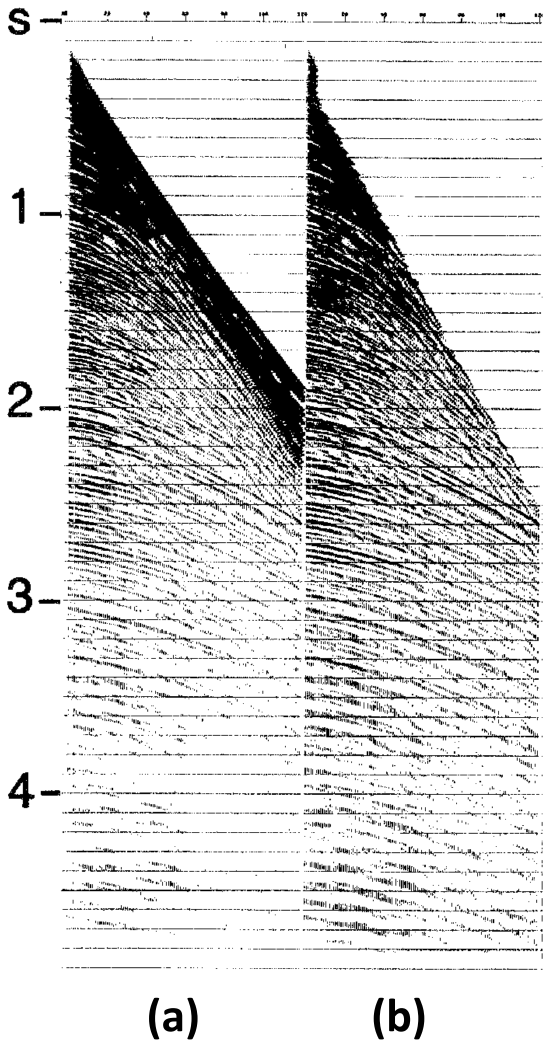


Figure 7

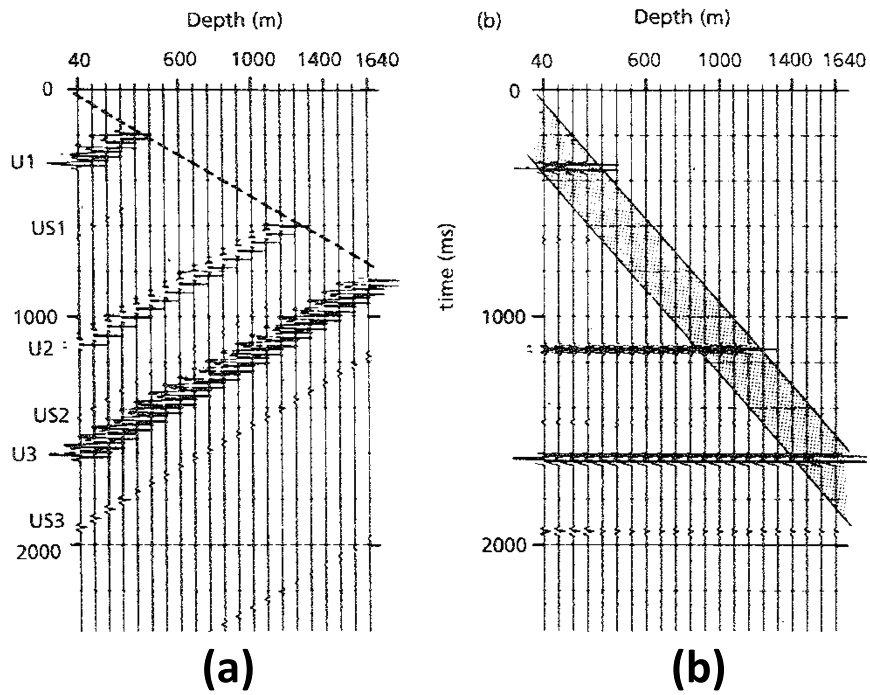
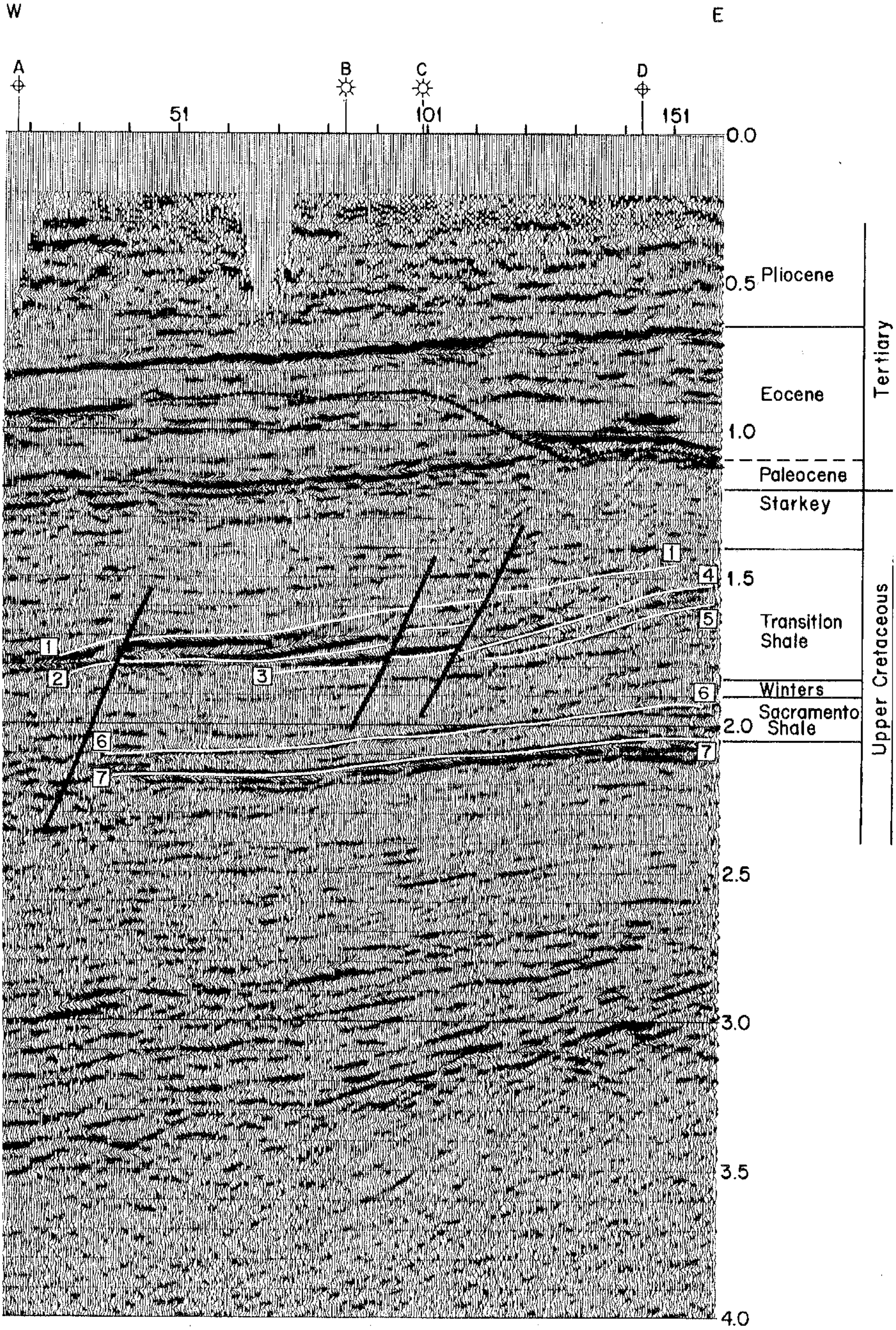


Figure 8

See text below.



(a)

Figure 9a: Figures 9a and 9b were two different datasets from the time of acquisition in the field. They were acquired at the same place (see notation on top). And they were probably acquired at the same time, but could have been acquired at different times. Point out the most significant differences, and explain the different origins of the two datasets.

(b)

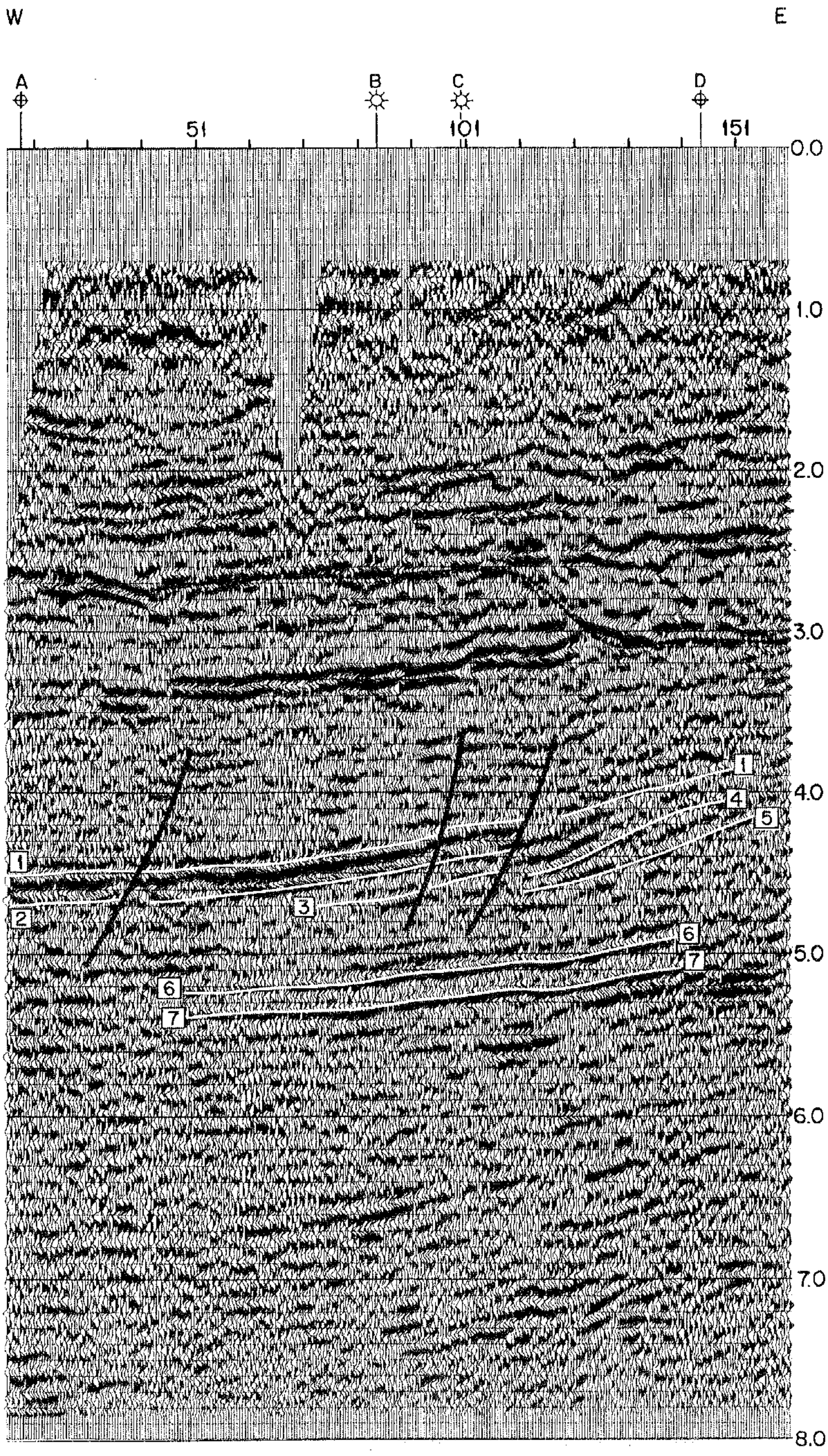


Figure 9b

14% 2. Marine seismic, multiples, apparent velocity and reflection coefficient

Consider a horizontally layered subsurface model consisting of a water layer, a shale layer and a sandstone layer. The sea depth is 273 m and the water has a P-wave velocity of 1500 m/s. The second layer, a shale, has a thickness of 455 m and a P-wave velocity of 2500 m/s. The third layer, a sandstone, is very thick.

A marine seismic survey is carried out in this area, with a ship towing an airgun source and a hydrophone streamer. The airgun and hydrophone receivers are all assumed to lie at the sea surface, i.e., at mean sea level.

From the water bottom (top of shale) and from the next interface (top of sandstone) seismic reflections are generated (call them P1 and P2). Also, a fairly strong first-order water-bottom multiple is generated, that is, a P-wave that travels down and up through the water twice (call it M1).

(a) For these three reflections (two primaries and one multiple) determine the zero-offset two-way traveltimes and express these to the nearest millisecond (ms).

(b) In a seismic survey here, what problem might be caused by the water-bottom multiple?

(c) The water-bottom reflection is recorded on a hydrophone 150 m away from the airgun source. What is the apparent velocity of this reflection event at that hydrophone?

(d) With the help of an approximate relationship, determine the P-wave reflection coefficient at the water bottom.

20% 3. Reflection and transmission coefficients in cyclic layers

An explosive source is detonated at the surface of the Earth in an area where there has been cyclic deposition of horizontal layers of carbonates and evaporates. So assume that layers 1, 3 and 5 (limestone) have identical properties and that layers 2 and 4 (salt) have identical properties. All the layers are 100 m thick. At the tops of layers 3 and 5 the vertical-incidence P-wave reflection coefficient is R.

(a) What is the vertical-incidence P-wave reflection coefficient at the tops of layers 2 and 4?

(b) Consider the reflection from the top of layer 2. Ignoring any effect of geometrical spreading, what will be its 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)?

(c) Now consider the reflection from the top of layer 4. Again ignoring geometrical spreading, what will be its amplitude if the P-wave has an amplitude of 1 at the bottom of layer 1?

(d) If we now take geometric spreading into account, determine the recorded amplitude of the reflection from the top of layer 2. Assume nearly vertical raypaths.

(e) Again taking geometric spreading into account, and assuming nearly vertical raypaths, determine the recorded amplitude of the reflection from the top of layer 4.

(f) Determine the root-mean-square velocity, V_{rms}, for the reflections from the tops of layers 3 and 5. You don't have explicit values for velocities or thicknesses but you can give them names with symbols.

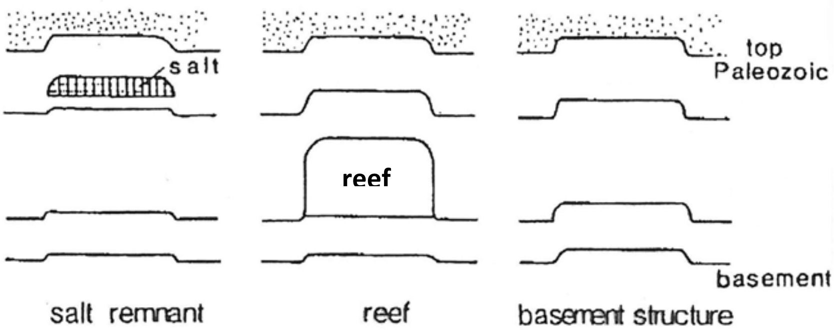
(g) What is the ratio of these two RMS velocities, i.e. the numerical value of this ratio?

6% 4. Dynamic range

If we wish to have a dynamic range of 90 dB, how many bits-per-word do we need?

18% 5. Gravity and magnetics

(a) Parallel updoming structures like those shown in Figure 10, are observed on a seismic section in a frontier area where there is not a lot of geological information, but where there is magnetic and gravity coverage. Explain in some detail, mentioning the relevant physical properties of the rocks in question, how we could combine the magnetic and gravity information to help decide among the three geological possibilities shown.



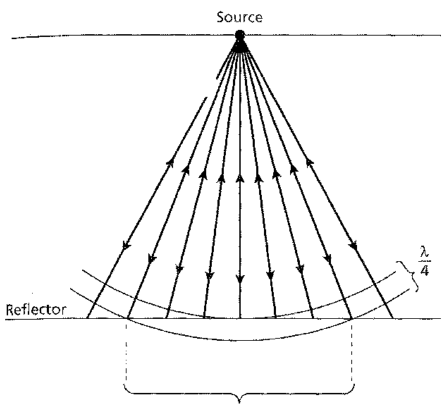
(b) For each of the three cases shown, explain briefly why the updoming form often repeats itself in a near-parallel way on seismic reflectors above or below the expression of the primary structure (e.g. the reef) associated with the updoming.

15% 6. Geophysical concepts

Each of the following figures shows some geophysical phenomenon or concept. Describe briefly what this phenomenon or concept is for each example, and answer the short question(s) for each example (if not already answered in your description).

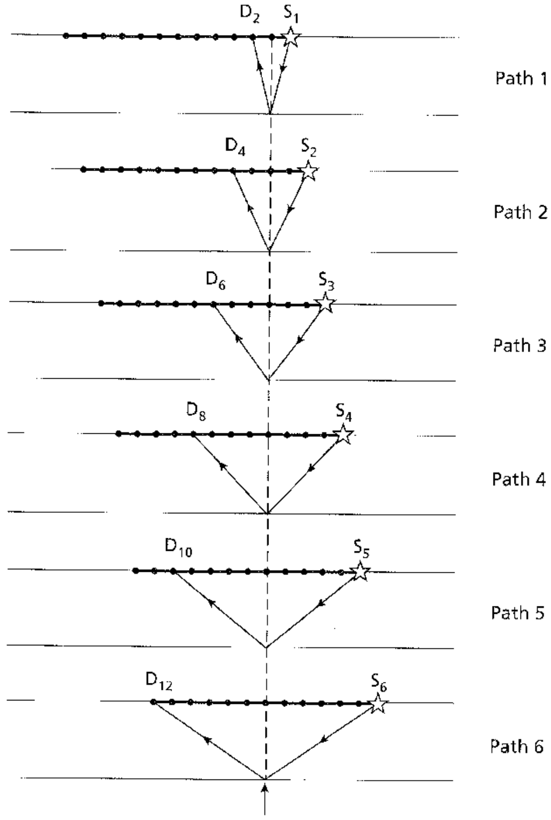
(a) **(i)** At the bottom of the figure, a segment of the reflector is indicated. What do we call this part of the reflector?

(ii) What seismic concept is involved here?



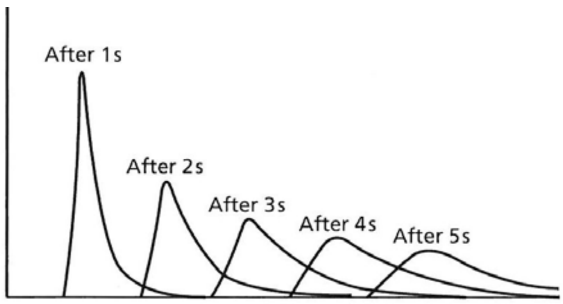
(b) (i) If we put these 6 elements together, what do we get?

(ii) An arrow at the bottom-centre is directed upward toward a point. What do we call that point?



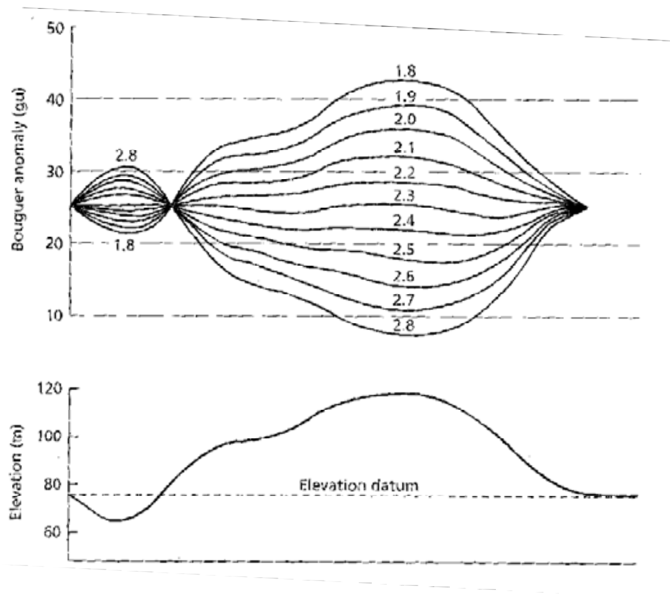
(c) (i) State what phenomenon is being illustrated here.

(ii) What is happening physically?



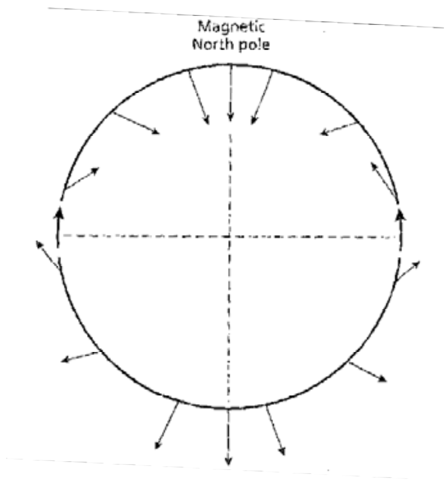
(d) (i) What geophysical parameter is one trying to determine here?

(ii) State briefly how the value of the parameter is chosen.



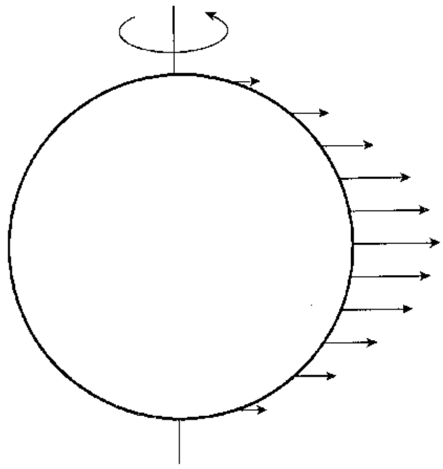
(e) (i) State what geophysical phenomenon is illustrated here?

(ii) What do the arrows indicate?



(f) (i) What geophysical phenomenon is being illustrated here?

(ii) What effect does it have on what we measure (or feel) on the Earth's surface?



Some geophysical formulae:

$$F = \frac{Gm_1 m_2}{r^2}$$

$$DR = 20\log_{10}\left(\frac{A_{\max}}{A_{\min}}\right)$$

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

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

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

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

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

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

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

$$V = \lambda f$$

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

$$R = \frac{Z_2 - Z_1}{Z_2 + Z_1}$$