BPG150

FASIT

Midterm Test, 2010 October 27

Time allowed: 90 minutes

Write your answers in the test paper. If you need more paper, just ask.

Try to write your answers in English.
I nødsfall går det an med norsk.

This test will count for 50% of the semester component, i.e. 25% of the total course grade.

"Collaboration" is not allowed with anybody.

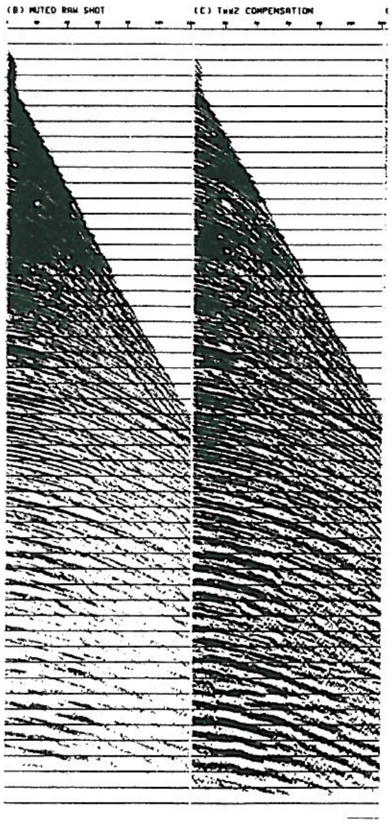
"Samarbeid" er ikke tillatt med noen som helst.

1. Geophysical data processing

Attached are five examples, Figures 1 to 5, each showing either two seismic sections or, as for Figure 5, two gravity maps, which come from the same locations. The difference between (a) and (b) in all these cases is that some data-processing step has been applied to (a) in order to get (b).

(i) Briefly describe the main visual 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.



(a) (b)

Figure 1

(i) (a) has high ampl. (amplitude) at top & progressively lower with time.
(b) Is more-or-less evened out in amplitude from top to bottom.

(ii) Correction for geometric spreading — (spherical divergence)
(TAR — AGC OK too)
(true-amplitude recovery) (automatic gain control)

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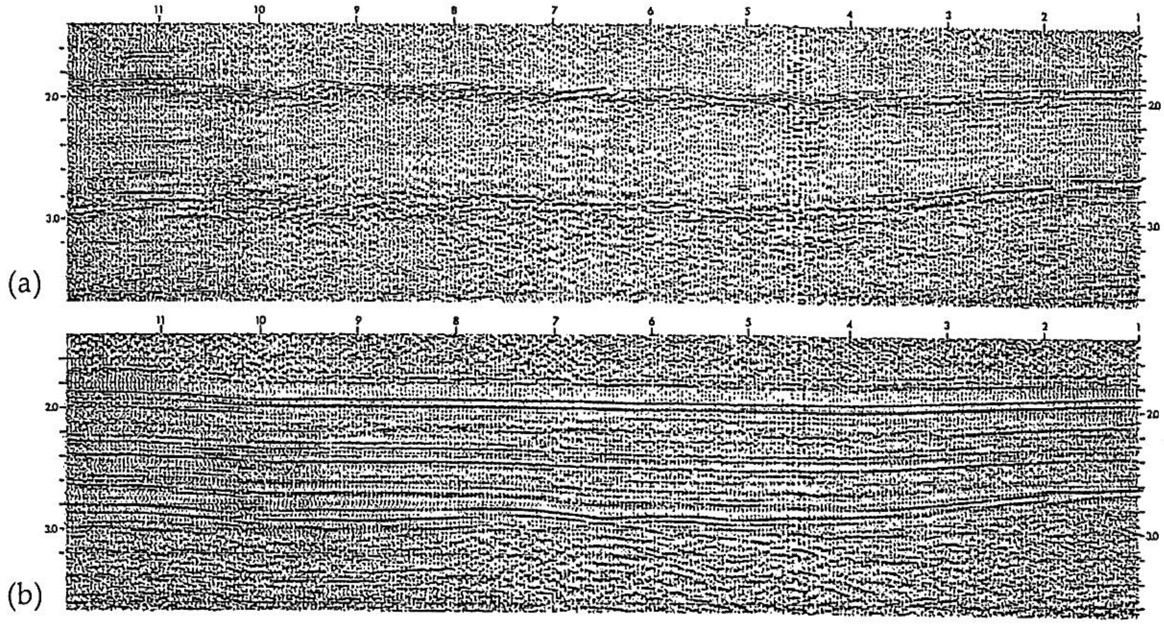

Figure 2

(i) (a) events are broken up & non continuous
(b) " " much more continuous

(ii) static correction

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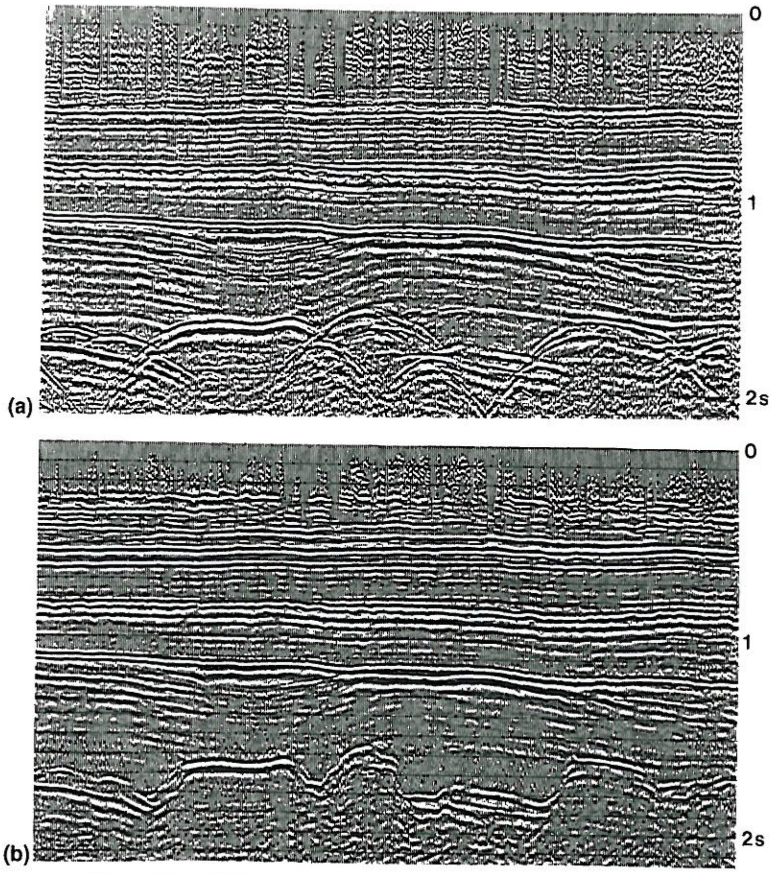

Figure 3 (i) (a) refl'n (reflection) segments crossing ea. (each) other
(b) crossing gone & dipping segments in right place

(ii) migration

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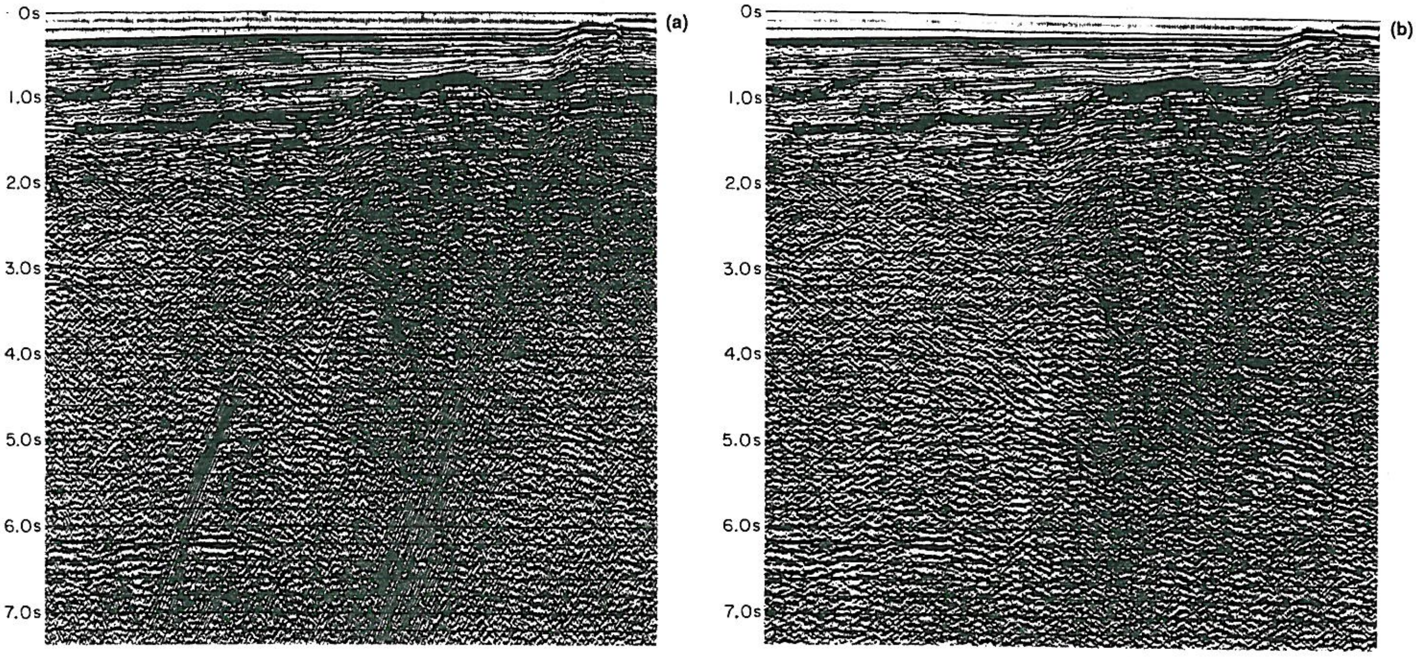

Figure 4 **(a)** **(b)**

(i) High-dip or low-vel'y (velocity) events on section in lower half, centre & left.

These gone in (b)

(ii) f-k or velocity filtering

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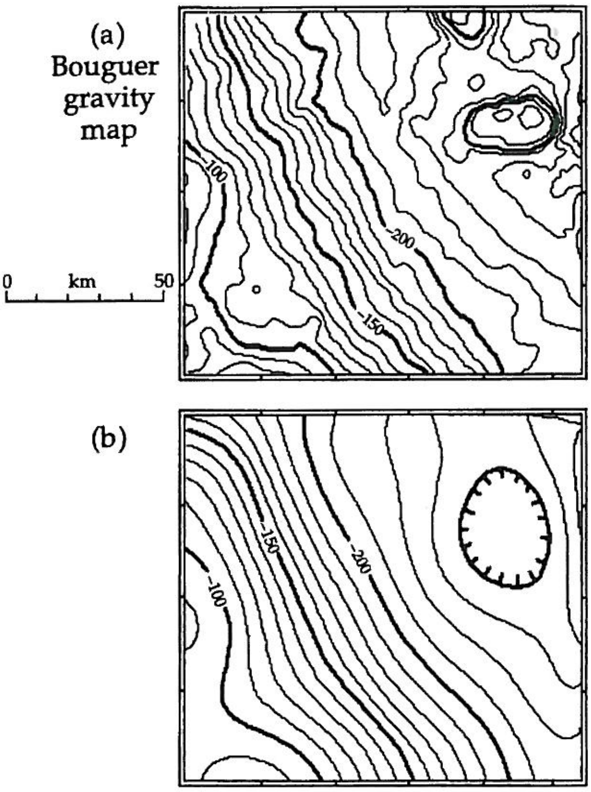


Figure 5

(i)
Fig. (b) looks like a smooth version of (a). That is, Fig. (a) contains a lot of higher (spatial) frequencies that (b) does not contain. Filtering out these higher frequencies gives (b) a smoother appearance.

(ii) The process [from (a) to (b)] was application of a high-cut filter, or a low-pass filter —OR— smoothing —OR— one could say that (b) is the regional field separated from (a) [into regional & residual fields]. —OR— possibly, upward continuation

2. Incompressibility

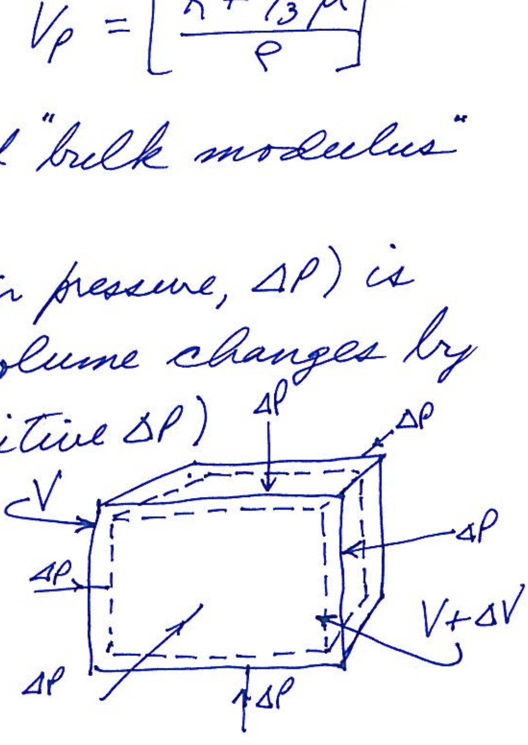
Incompressibility, K, appears in the expression for P-wave velocity. With the aid of a diagram, define K, or explain what it means.

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

"Incompressibility", also called "bulk modulus" is defined as follows:
When a hydrostatic pressure, P (or change in pressure, ΔP) is applied to a volume V, the volume changes by ΔV (which is negative for a positive ΔP)

$$K = -\frac{\text{compressional stress}}{\text{compressional strain}}$$

$$K = -\frac{P}{\left(\frac{\Delta V}{V}\right)} \left[-\frac{\Delta P}{\left(\frac{\Delta V}{V}\right)} \right]$$



3. Marine seismic, apparent velocity, RMS velocity, moveout and multiples

Consider a horizontally layered subsurface model consisting of a water layer, a shale layer and a sandstone layer. The sea depth is 348 m and the water has a P-wave velocity of 1500 m/s. The second layer, a shale, has a thickness of 580 m and a P-wave velocity of 2500 m/s. The third layer, a sandstone, is very thick.

The airgun source, at A, and the hydrophone receivers are all assumed to lie at the sea surface, i.e at mean sea level.

7 (a) Consider the waterbottom P-wave reflection – call it P1 – as it registers on a hydrophone at B, a distance of 238 m from the airgun source, at A. What is its apparent (or horizontal) velocity, V_a, on the shot records (or common-shot gathers)?

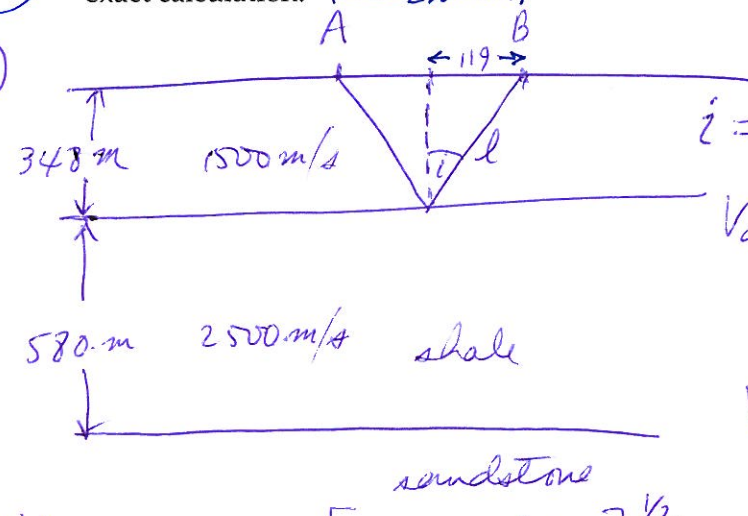
9 (b) For the reflection from the bottom of the shale (top of the sandstone) – call it P2 – determine the root-mean-square velocity, V_{rms}.

5 (c) For P2 determine also the zero-offset traveltime, t_0.

6 (d) Also for the first-order waterbottom multiple – call it M1 (a P-wave taking two trips down and up in the water layer) – determine the zero-offset traveltime, t_0.

8 (e) Draw a rough sketch of these three arrivals, P1, P2 and M1, showing their hyperbolic form and their general relationship to each other. Just do this approximately, not by exact calculation.

(a)



$i = \tan^{-1}\left(\frac{119}{348}\right) = 18.8783^\circ$ or $l = \sqrt{119^2 + 348^2}$

$V_a = \frac{1500}{\sin i}$ $\quad \sin i = \frac{119}{l}$

$\sin i = 0.323560$

$V_a = \frac{1500}{0.32356} = 4636$ m/s

(b) $V_{rms,2} = \left[\sum_i V_i^2 t_i / \sum_i t_i\right]^{1/2}$

$$= \left\{\left[1500^2\left(\frac{348}{1500}\right) + 2500^2\left(\frac{580}{2500}\right)\right] \Big/ \left(\frac{348}{1500} + \frac{580}{2500}\right)\right\}^{1/2}$$

$$= \left[\left(1500 \cdot 348 + 2500 \cdot 580\right) \Big/ \left(\frac{348}{1500} + \frac{580}{2500}\right)\right]^{1/2} = 2061.55 \text{ m/s}$$

$= 2062$ m/s

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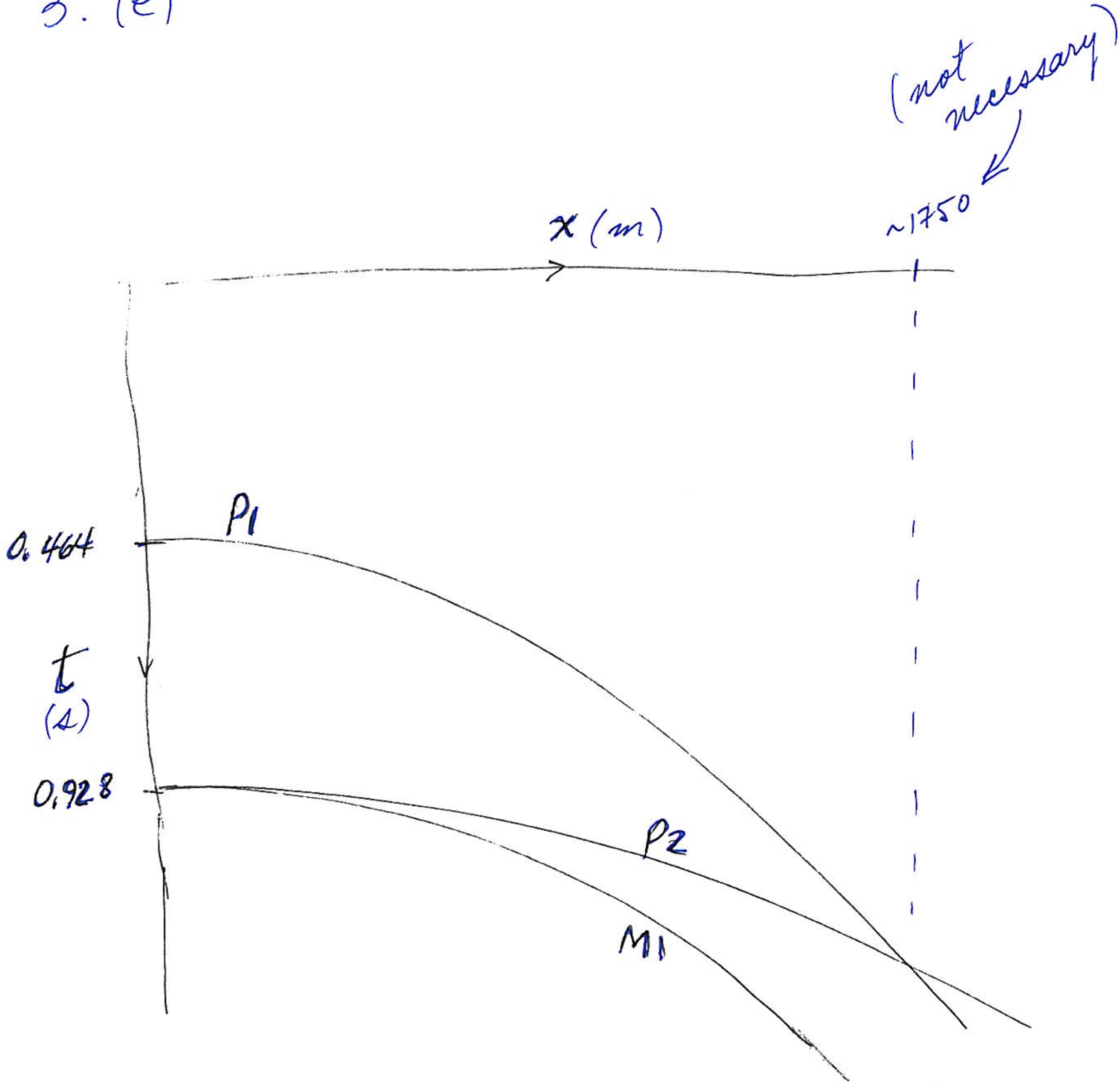
(c) $t_0(P2) = 2\left(\frac{348}{1500} + \frac{580}{2500}\right) = 4(0.232) = 0.928$ s

(d) $t_0(M1) = 2t_0(P1) = 4\left(\frac{348}{1500}\right) = 0.928$ s

3. (e)



4. Time-average equation

A sandstone unit has porosity $\phi = 28\%$. The solid matrix material (mainly quartz) has a P-wave velocity of $V_m = 5200$ m/s. The water (or brine) in the pores has a P-wave velocity of $V_w = 1500$ m/s

(a) For this two-phase rock, determine its P-wave velocity using the time-average equation.

(b) Suppose that one quarter of the brine were displaced by natural gas, with a P-wave velocity of 400 m/s. Now, for this three-phase rock, determine the P-wave velocity using an equation based on the time-average equation.

V_2: vel'y of 2-phase rock; V_3 of 3-phase rock

(a) $$\frac{1}{V_2} = \frac{\phi}{V_w} + \frac{1-\phi}{V_m} = \frac{0.28}{1500} + \frac{0.72}{5200} =$$

$$V_2 = (3.251282 \times 10^{-4})^{-1} = \underline{3076 \text{ m/s}}$$

(b) $$\frac{1}{V_3} = \frac{0.21}{1500} + \frac{0.07}{400} + \frac{0.72}{5200} =$$

$$V_3 = (4.534615 \times 10^{-4})^{-1} = \underline{2205 \text{ m/s}}$$

(20)

5. Gravity anomalies

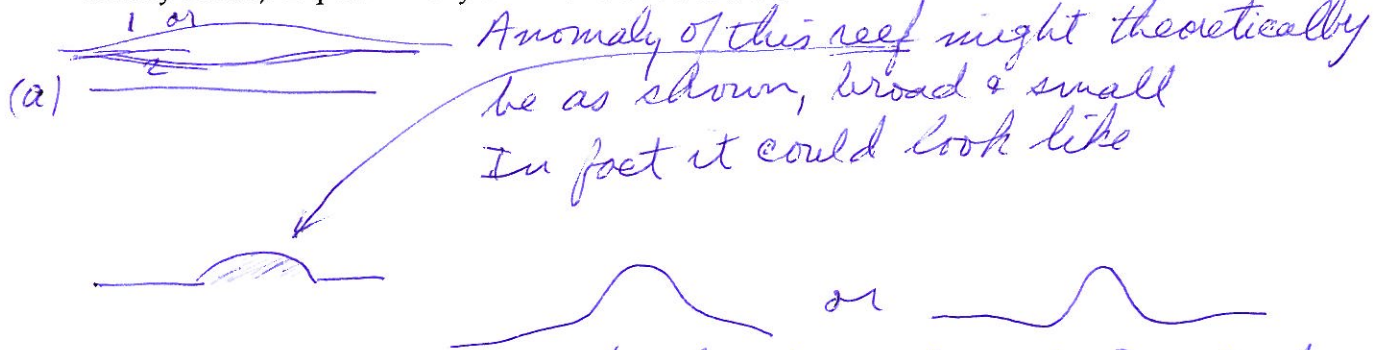
Answer either (a) or (b).

(a) Gravity anomalies due to carbonate reefs often look quite different to what one might expect based on the depth, density and volume of the reef itself. Explain briefly how this can be so.

-OR-

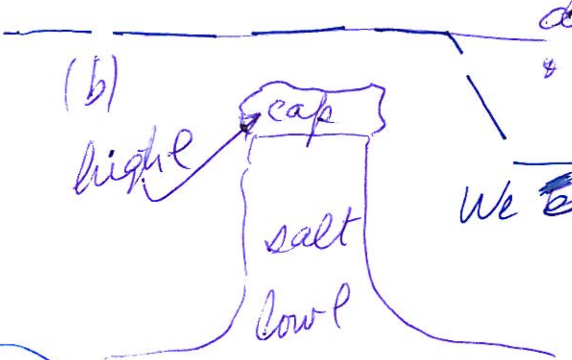
(b) The gravity anomaly due to a salt body often will show an additional effect – i.e. sometimes it will not be a simple gravity low that one might expect (in view of the low density of salt). Explain briefly what is referred to here.

(a)

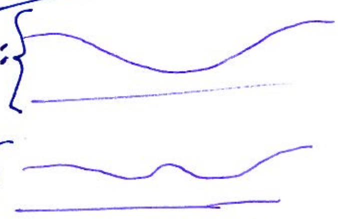


Anomaly of this reef might theoretically be as shown, broad & small. In fact it could look like ... due to the draped sediments above & different sand/shale mix & density on reef cf. off reef.

(b)



We expect, for salt alone:



But we often see: instead ...

... due to cap rock of high ρ.

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Some geophysical formulae:

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

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

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

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

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

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

$$V = \lambda f$$

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

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