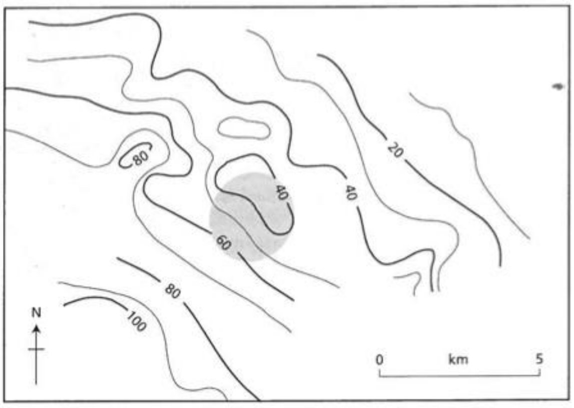
PART A: Short-answer questions (50%; each worth 2%)

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!

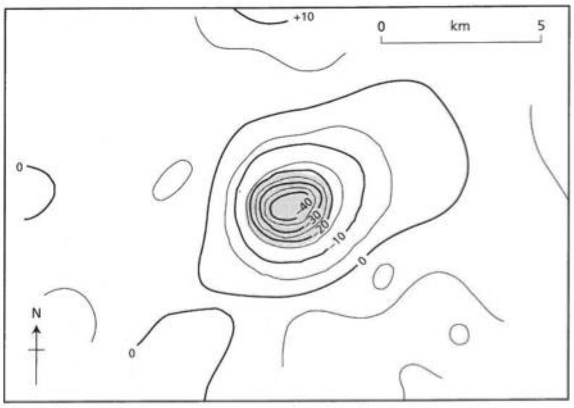
1. The figure here is from a geophysical survey carried out over a salt dome. What kind of survey was it and what property of the salt is instrumental in producing such a map?

- magnetic survey
- small negative magnetic susceptibility



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?

- gravity survey
- relatively low density



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

- Δt_s = 0.004 s *-or-* f_s = 250 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?

- It would decrease.

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

- It decreases overall, and gets narrower due to greater loss of higher frequencies.

6. When a P-wave strikes the interface between two rock layers at normal incidence (angle of incidence = 90°), what waves travel on from there, and which way?

- Reflected P travels vertically upward and transmitted P travels vertically downward (no S).

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?

- as identical 3D surveys repeated at different times (i.e. with time lapses)

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).

- acoustic impedance = density x P-wave velocity

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?

- a hyperbola shifted in the updip direction

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

- a common-offset gather

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

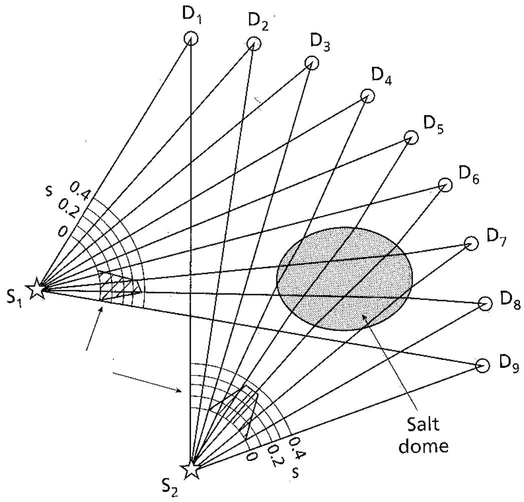
- $p = (\sin\theta)/V$ = constant -*or*- $(\sin\theta_1)/V_1 = (\sin\theta_2)/V_2$

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?

- $\theta_c = \sin^{-1}(1950/3900) = 30°$

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

- early arrival times (time leads) for rays passing through salt (due to salt's higher velocity)



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?

- several Δg readings at same (base) station and the times they were made (klokkeslett)

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?

- near-surface density and elevation (thickness of layer above reference level)

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

- elevation (only)

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

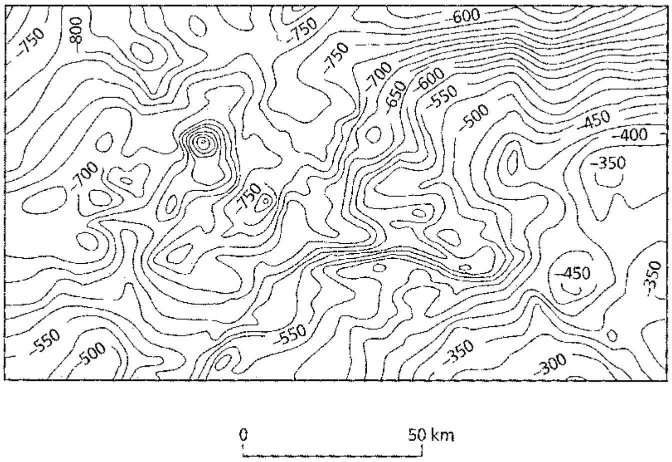
- basement structure; igneous intrusives; salt; metallic ore bodies; rocks rich in magnetite; etc.

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

- salt – high resistivity; metallic ore – low ρ; hydrocarbons – high ρ; sediment (low ρ) that is intercalated in basalt (high ρ)

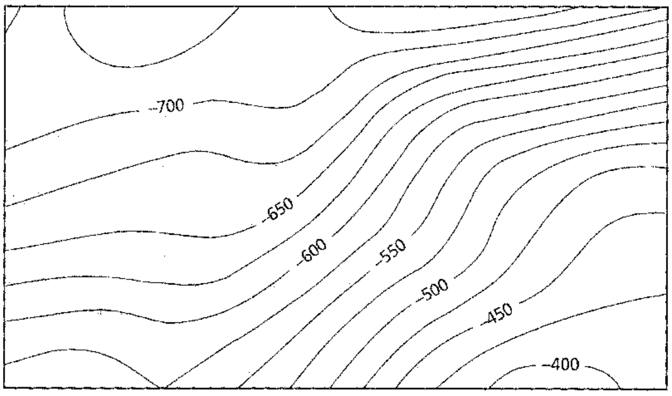
19. What sort of data could this be and what process could have been applied to (a) to get (b)?

(a)



- gravity or magnetic; could even be topography or some electrical data;
- high-cut or low-pass filter, or upward continuation (smoothing: small deduction of ¼ %)

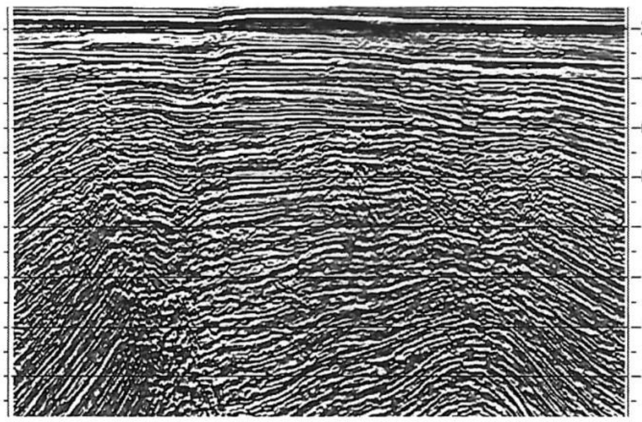
(b)



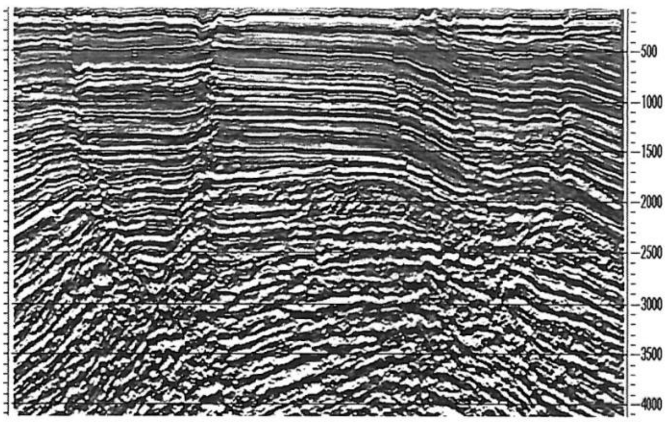
20. You have a seismic line from a region where problems were caused by a great assortment of structures (faults, folds, dipping boundaries, etc.) in the deep subsurface. What sort of seismic process do you think you'll need to apply?

- migration

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



(a)



(b)

- resolution in (a) better in deeper section, resolution in (b) better in shallower section; time scales are different (over 2:1) but apparently same depth range, indicating P and S (or PP and PS) sections

22. What do the letters CMP stand for?

- common midpoint

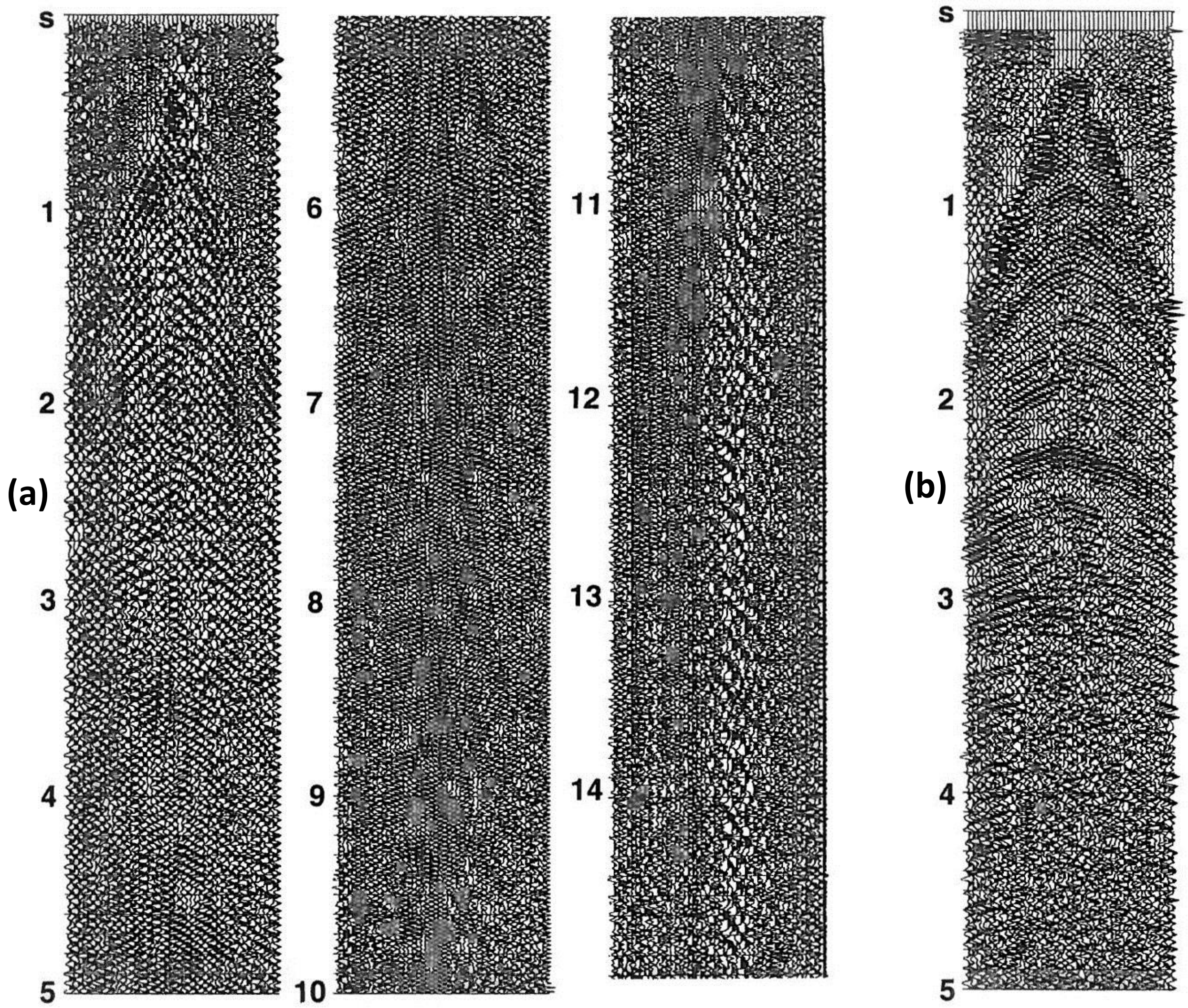
23. A seismic wavelet, generated by an airgun, propagates in all directions through a layered rock medium. What three (3) mechanisms will be active in decreasing the amplitude of deep reflections that are recorded back at the surface?

- absorption (internal friction); geometric spreading (spherical divergence); partitioning at boundaries (reflection and transmission)

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?

- statics

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



(a) (b)

- correlation (vibroseis correlation)

26. (a) $\rho = (1-0.22)2700 + 0.22 \times 1030$ kg/m³

(3) $\rho = 2332.6$ kg/m³

or $\rho = \underline{2333 \text{ kg/m}^3}$

(b)
(i) V_p from Time-average (Wyllie) eq'n:

(3) $V_p = \left[\dfrac{0.78}{5200} + \dfrac{0.22}{1500}\right]^{-1} = 3370.79$ m/s

or $V_p = \underline{3371 \text{ (or } 3370) \text{ m/s}}$

(6) (ii) V_p from Gardner eq'n:

$\rho = 310 V_p^{0.25} \Rightarrow V_p = \left(\dfrac{\rho}{310}\right)^4$

(3) $V_p = \left(\dfrac{2332.6}{310}\right)^4 = 3205.64$ m/s

or $V_p = \underline{3206 \text{ m/s}}$

(c) $\rho = 0.78 \times 2700 + 0.4 \times 0.22 \times 2800 + 0.6 \times 0.22 \times 1030$

(3) $\rho = 2488.36$ kg/m³

or $\rho = \underline{2488 \text{ kg/m}^3}$

(d) $V_p = \left[\dfrac{0.78}{5200} + \dfrac{0.4 \times 0.22}{6000} + \dfrac{0.6 \times 0.22}{1500}\right]^{-1}$ m/s

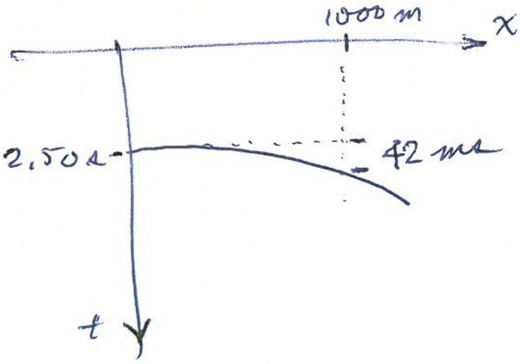
(3) $= 3957.78$ m/s

or $V_p = \underline{3958 \text{ m/s}}$

(15)

27

(a)



Hyperbolic:

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

At $x = 1000$ m:

$$(2.542)^2 = (2.500)^2 + \frac{1000^2}{V^2}$$

(3) $$V = \frac{1000}{\sqrt{2.542^2 - 2.5^2}} = 2173.07 \text{ m/s}$$

or $V = 2173$ m/s

(b) Parabolic approx'n: $t \doteq t_0 + \dfrac{x^2}{2V^2 t_0}$

$$V = \frac{x}{\sqrt{2 t_0 \Delta t_{NMO}}} = \frac{1000}{\sqrt{2 \times 2.50 \times 0.042}}$$

(3) $V = 2182.18$ m/s (or 2182 m/s) (~~exact~~ correct to 2 & 0 decimals)

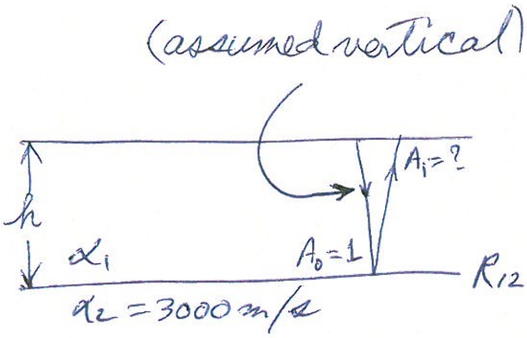
(C) Thickness $h = \dfrac{V t_0}{2} = \dfrac{2173.07 \times 2.50}{2}$ m

$h = 2716.34$ m

(3) or 2716 m

27 cont.

(d) $\alpha_1 =$



$$R_{12} = \frac{\rho_2\alpha_2 - \rho_1\alpha_1}{\rho_2\alpha_2 + \rho_1\alpha_1}$$

$$\rho_1 = 310\alpha_1^{0.25} = 310 \times 2173.07^{1/4} = 2116.56 \ kg/m^3$$

$$\rho_2 = 310\alpha_2^{0.25} = 310 \times 3000^{1/4} = 2294.26 \ kg/m^3$$

[Even simpler: $\rho_i\alpha_i = 310\alpha_i^{1.25}$ etc.]

$$R_{12} = \frac{6882770.08 - 4599431.04}{'' \quad + \quad ''} = \begin{matrix}(0.198859)\\ 0.19886 \\ (0.1989)\end{matrix}$$

From reflection:

$$A_1^{(R)} = A_0 \times R_{12} = 0.198859$$

(4½)

From geometric spreading/spherical divergence:

$$A_1^{(G)} = A_0 \times \frac{h}{2h} = 0.5 A_0 = 0.5$$

(2½)

(8) Taking both into account:

$$A_1 = 0.5 \times 0.19886 A_0 = 0.09943$$

(1)

(e) $\Delta t_{NMO} = 42 \pm 0.5$ ms (i.e., to nearest ms)

$$V_{min} = \frac{1000}{\sqrt{2.5425^2 - 2.5^2}} = 2160 \ m/s$$

$$V_{max} = \sqrt{\frac{1000^2}{2.5415^2 - 2.5^2}} = 2186 \ m/s$$

(3)

$$V = 2173 \pm 13 \ m/s$$

20

28. No. of detectors/array = 5 = n

Array response $R = \dfrac{\sin n\beta}{\sin \beta}$ & $\beta = \dfrac{\pi \Delta x}{\lambda_0}$

α (or V_p) = 1500 m/s

f_0 = 60 Hz Find Δx for max. attenuation of direct P, ie. $R \to 0$.

$$\lambda_0 = \frac{1500}{60} = 25 \text{ m}$$

$$\beta = \frac{\pi \Delta x}{25} \quad \text{and } \sin 5\beta \text{ should} \to 0.$$

$\therefore\ 5\beta = \pi, 2\pi, \ldots$ Try $5\beta = \pi$ first.

(5).

$$5\beta = 5\left(\frac{\pi \Delta x}{25}\right) = \pi \Rightarrow \Delta x = 5 \text{ m}$$

(If we choose $5\beta = 2\pi \Rightarrow \Delta x = 10$ m, etc.)

So $\underline{\Delta x = 5 \text{ m}}$. (5/5)

29. (a) (i) Diurnal correction for variation due to Sun's cycle (24-h period). [Sun disturbing upper atmosphere...]

(4) (ii) Geomagnetic correction for normal (regular) variation over the Earth [as given e.g. by Intern'l Geomag. Reference Field]

(b) Carbonate reef – doesn't usually have very great $\Delta\rho$; whereas salt can have large negative $\Delta\rho$* & basement rock can have large positive $\Delta\rho$**. Also reef doesn't usually have very great K (mag. susc.), whereas salt can have small (but signif.) neg. K and basement rock can have signif. pos. K (and large ΔB highs). (6) (10)

*(and large gravity lows) **(and large gravity highs)