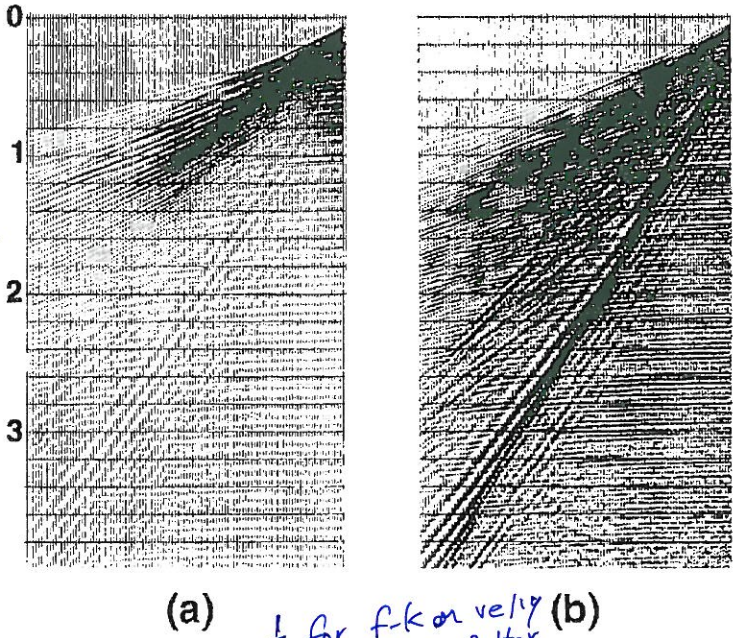
27% 1. Geophysical data processing

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.

(a) ampl. decrease w. time (depth)
(b) ampl. ~uniform w. time
Correction for geometric spreading (-or- TAR -or- AGC)



½ for f-k or vel'y filter

Figure 1

(a) Low-freq. noise (from swell) is present
(b) This noise is ~gone
Low-cut -or- high-pass filter

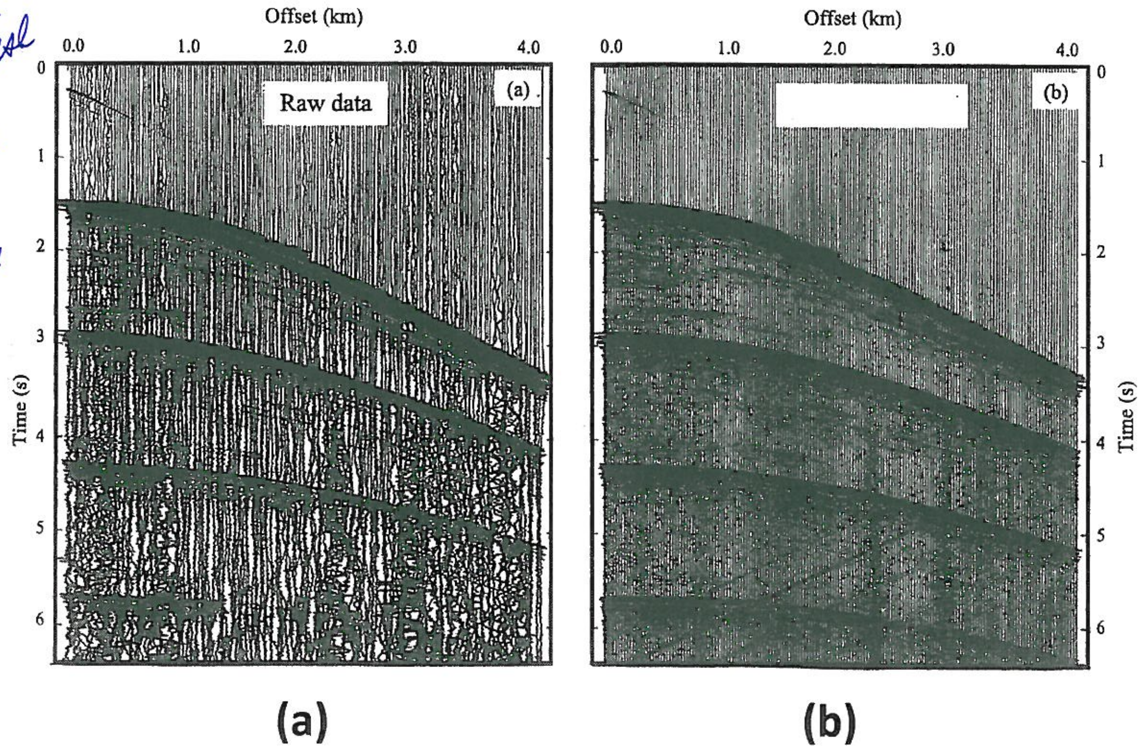
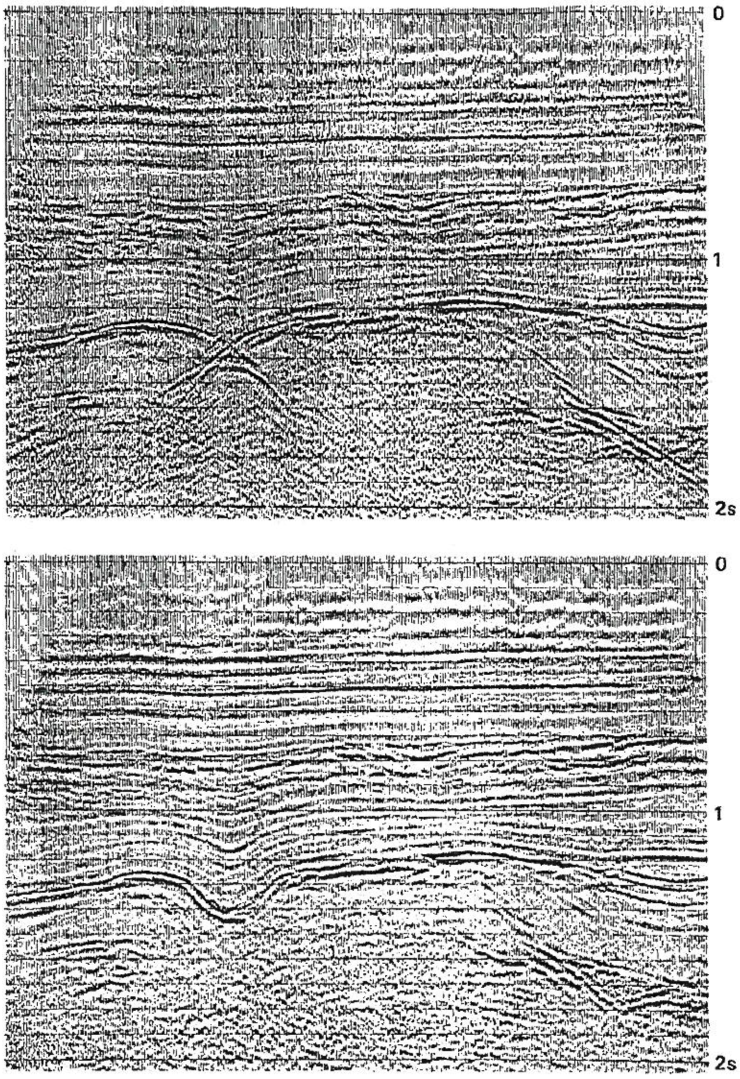


Figure 2

(a) Reflectors crossing themselves, bow-ties etc.
(b) Reflectors adjusted to ~correct spatial form

Migration



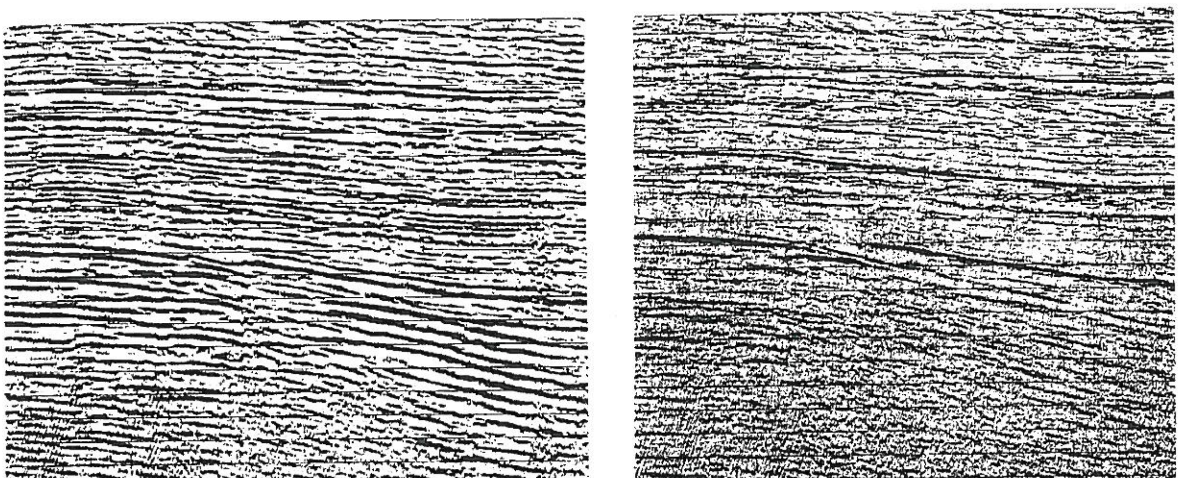
(a)

(b)

Figure 3

(a) Ringy without clear onsets

(b) Clearer onsets & not so ringy & higher frequencies.



(a) (b)

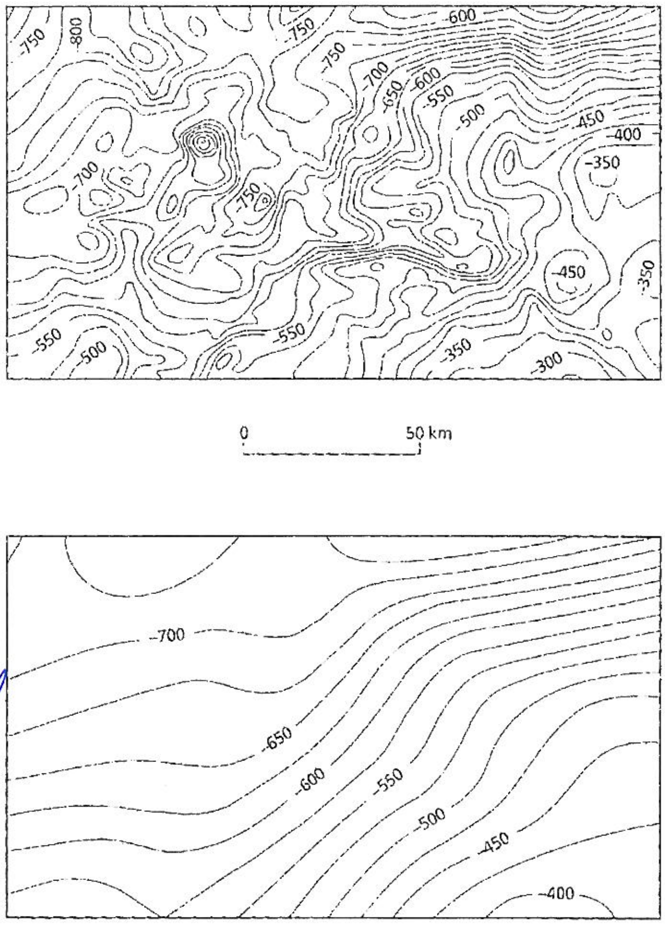
Figure 4

Deconvolution (High-pass filter gets __ marks.)

(a) Gravity map with wide spatial range of frequencies

(b) High spatial frequencies are filtered out

High-cut 2D filter.
Low-pass " " .
Or regional separated from regional + residual.
Or upward continued version of (a)
Or smoothing.



(a)

(b)

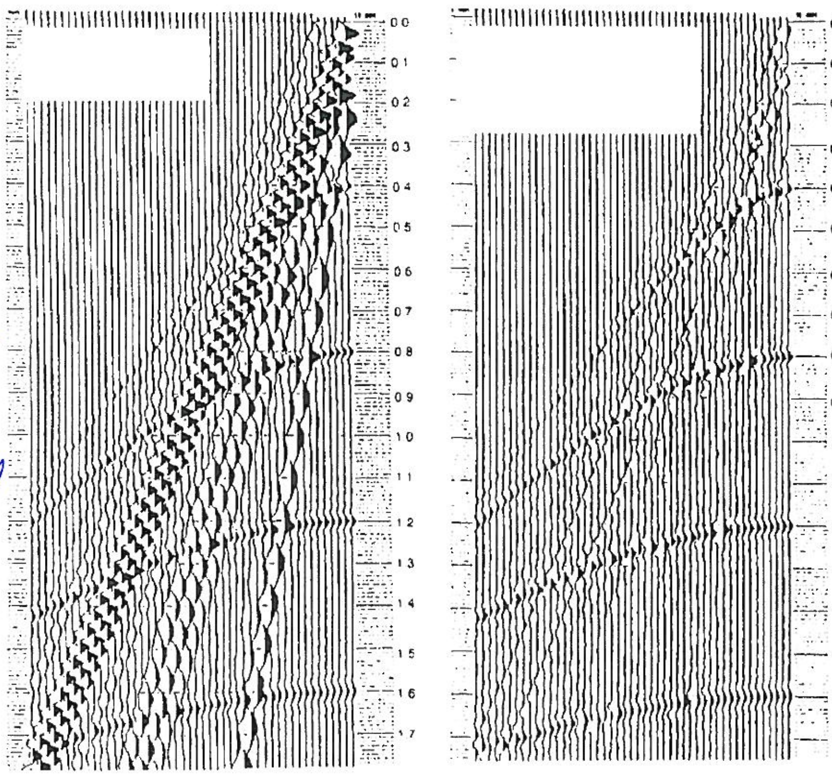
Figure 5

(a) Has strong low-velocity direct arrivals, plus reflections.

(b) The low-vel. direct arrivals (groundroll?) is largely filtered out.

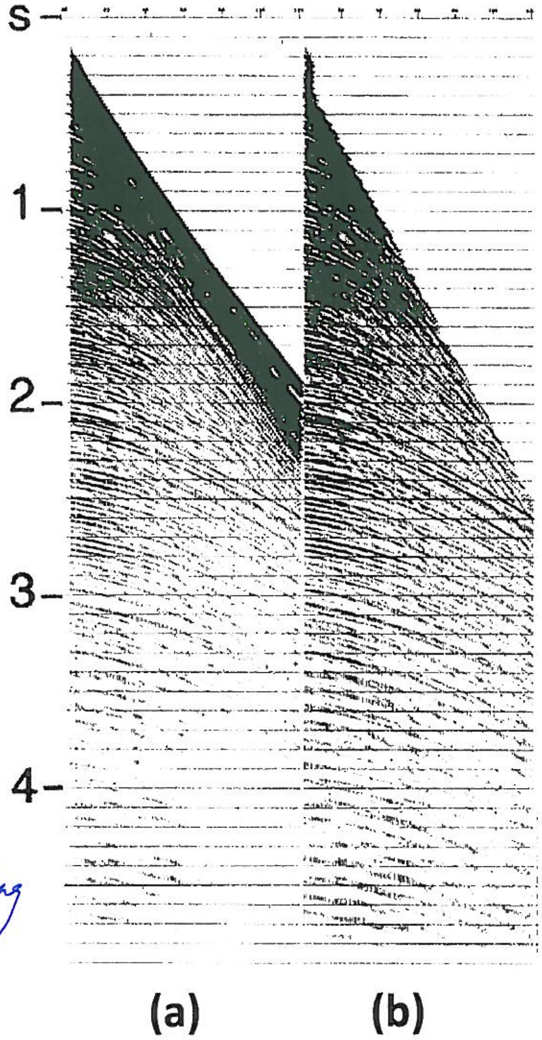
Velocity filter (e.g. f-k)
— OR —
Wave-number filter

(Filter out low v (f/k) or high k.



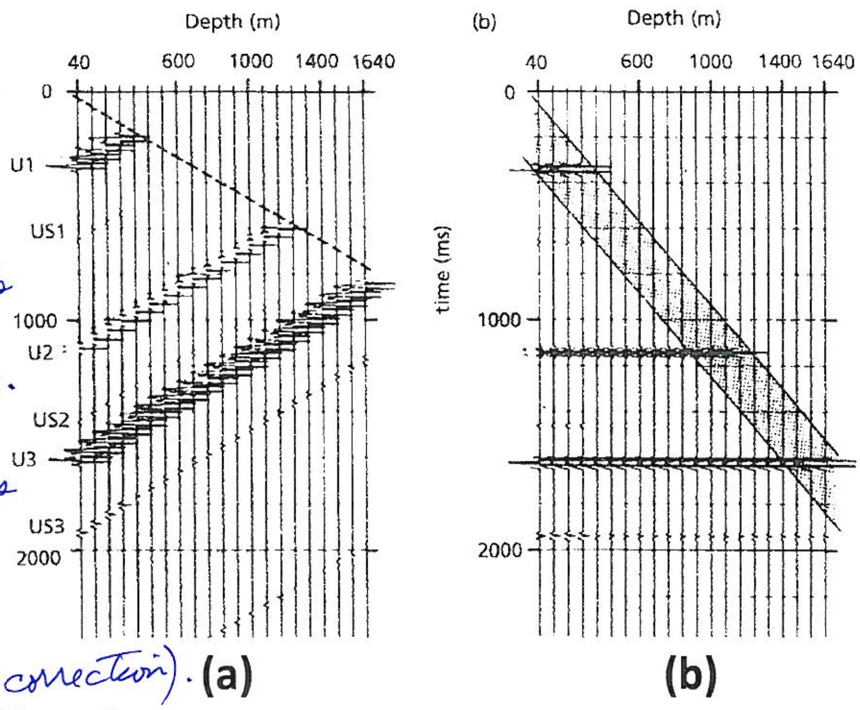
(a) (b)

Figure 6



(a) Normal shot or cmp gather.
(b) A wedge of first arrivals have been cut out (from 1.9 to 2.4 s on farthest offset)
[ampl. more evened out ($\frac{1}{2}$)]
Muting
[Corr'n for Geom Spreading ($\frac{1}{2}$)]
Also amplitudes in (b) greater than corresponding in (a).

Figure 7



(a) Upgoing VSP arrivals
(b) Same arrivals shifted to 2-way traveltime. and corridor shows portions to be stacked.
VSP prestack shift (like NMO correction).

Figure 8

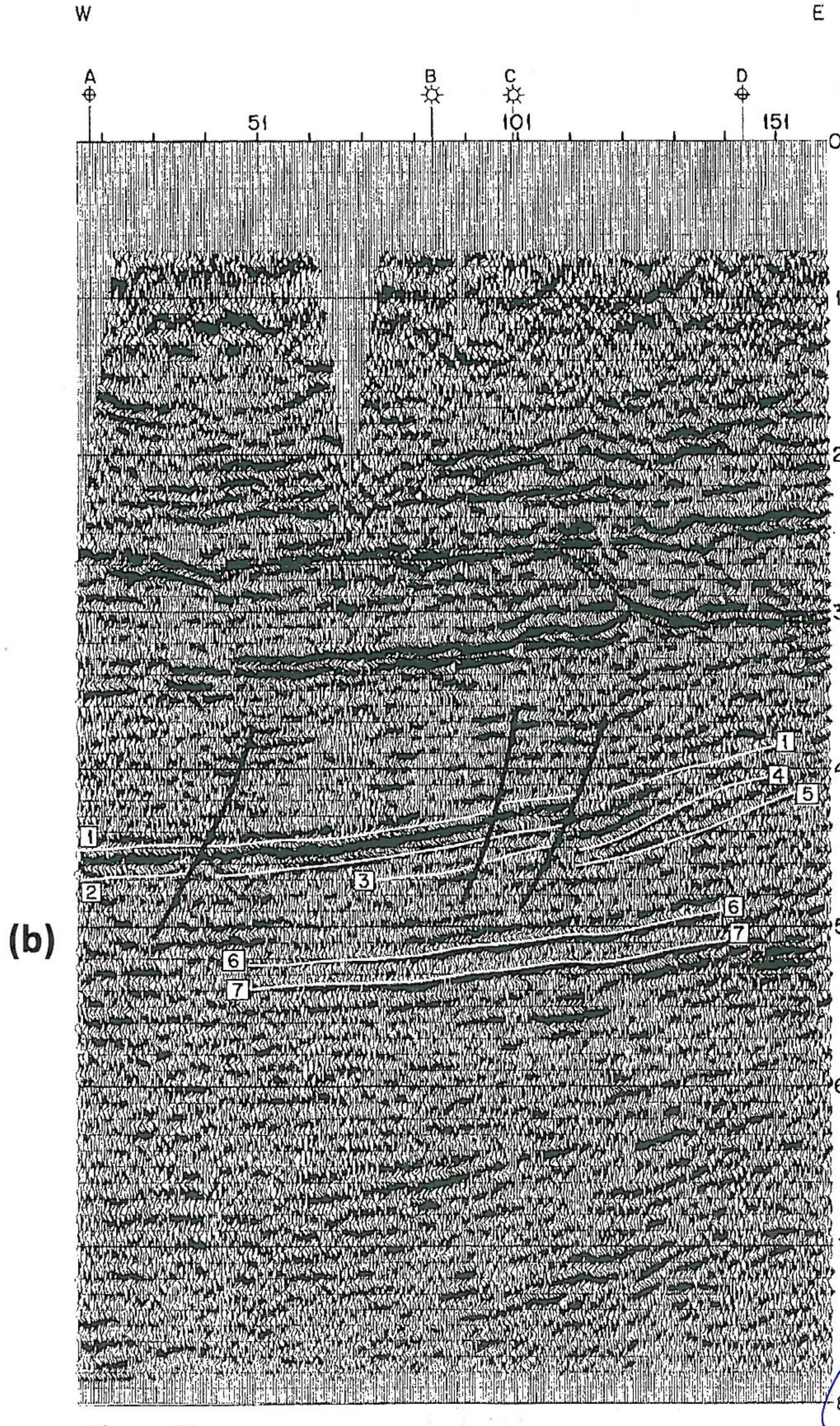
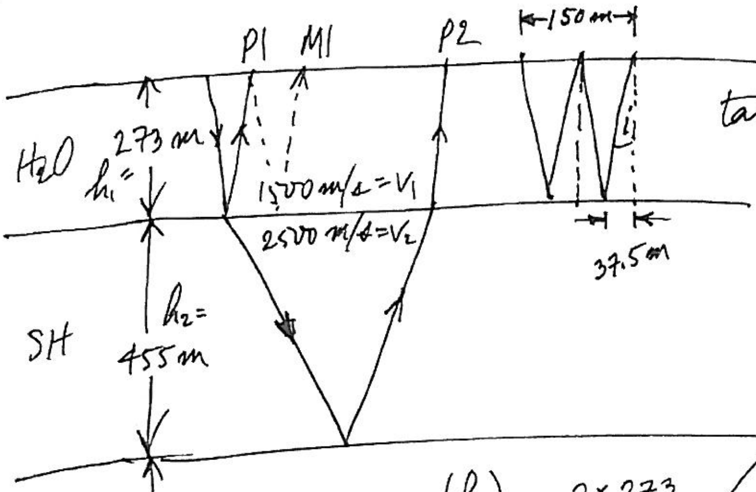


Figure 9b

(a) has arrivals at 1.5 – 2.0 seconds that in
(b) lie around 3.5 – 4.5 s.
(a) P-wave section (b) S-wave section.

2.



$\tan i = \frac{75}{273} = 0.27472575 = t$

$\frac{\sin i}{\sqrt{1-\sin^2 i}} = t$

$\frac{\sin^2 i}{1-\sin^2 i} = t^2$

$\frac{1}{1-\sin^2 i} = 1+t^2 \qquad 1-\sin^2 i = \frac{1}{1+t^2}$

$\sin^2 i = \frac{t^2}{1+t^2}$

$\sin i = 0.2649102$

SS (a) $t_0(P1) = 2\left(\frac{h_1}{V_1}\right) = \frac{2 \times 273}{1500} = 0.364\,s = 364\,ms$

4½ $t_0(P2) = 2\frac{h_2}{V_2} + 0.364 = 0.728\,s = 728\,ms$

$t_0(M1) = 2t_0(P1) = 0.728\,s = 728\,ms$

1½ (b) M1 would interfere with P2.

3 (c) $V_a = \frac{1500\ m/s}{\sin i} = \frac{1500\ m/s}{0.1360847} = 5662.3\ m/s$

3873.8176

5 (d) $\frac{V_1 = 1500\ m/s}{V_2 = 2500\ m/s}$ $\qquad \rho = 310 V_p^{0.25}$

$Z_1 = \rho_1 V_1 = 310 V_1^{1.25}; \quad Z_2 = \rho_2 V_2 = 310 V_2^{1.25}$

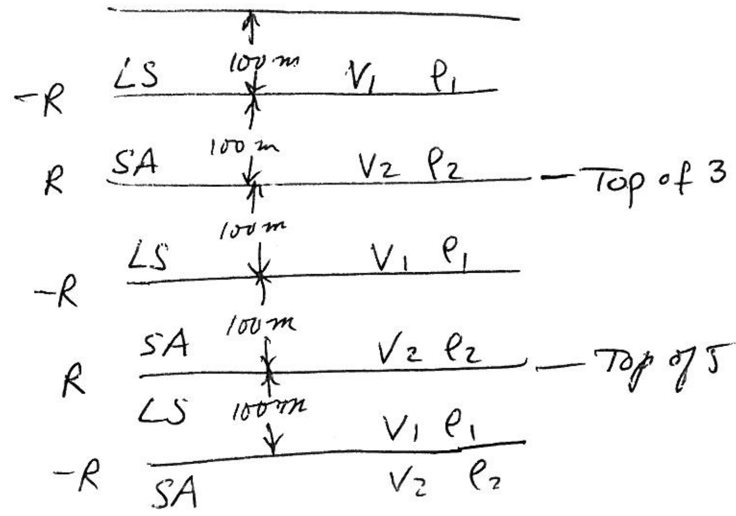
$R = \frac{V_2^{1.25} - V_1^{1.25}}{V_2^{1.25} + V_1^{1.25}} = 0.308843$ or 0.309

(3) Given: R = refl'n coeff. @ tops of layers 3 & 5.

$$R_o = \frac{V_1 \rho_1 - V_2 \rho_2}{V_1 \rho_1 + V_2 \rho_2} = R$$

$[R_o \equiv R_{odd}]$

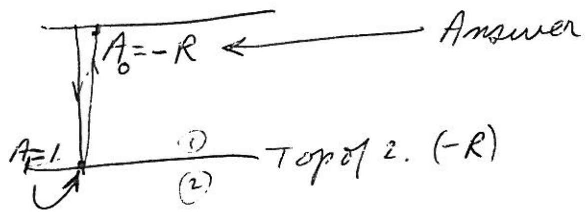
$[R_e = R_{even}]$



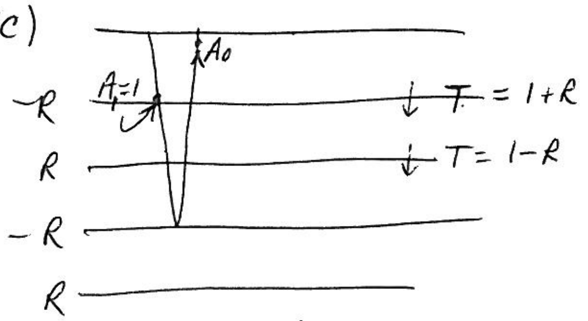
(a) At tops of layers 2 and 4:

$$R_e = -R_o = \underline{\underline{-R}}$$

(b)



(c)



Transmission twice through tops of layers 2 and 3.
Reflection from top of 4.
In general, $T = 1 - r$
refl'n coeff.

For upward travel
At top of 3: $T = 1+R$
" " 2: $T = 1-R$

Here $r = -R$ at top of 2, 4, ...
and $r = R$ at top of 3

$$A_0 = -R(1+R)(1-R)(1+R)(1-R) = -R(1-R^2)^2$$

~~(d)~~ ~~At bottom of 1, travelled 100 m~~
~~Back at surface, travelled 600 m~~ ~~$\frac{A_0'}{A_1'} = \frac{1}{6}$~~ ~~$(A_0)_{total} = -\frac{R(1-R^2)}{6}$~~

(d) At A_0, reflection from top of 2 travelled 200 m $A_0'/A_1' = \frac{1}{2}$ $\left(A_0\right)_{total} = \underline{\underline{-\frac{R}{2}}}$ $(A_1 = 1)$

(f) $V_{RMS,n}$ given at end of exam

From top of 3, P waves pass through 2 layers (1 & 2).

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

τ_i = traveltime through layer i = h_i / V_i

Here, $\tau_1 = \dfrac{100\text{ m}}{V_1}$ & $\tau_2 = \dfrac{100\text{ m}}{V_2}$ and $V_1\tau_1 = 100V_1$ etc

$$\text{So } V_{RMS,2} = \left[\frac{100V_1 + 100V_2}{\frac{100}{V_1} + \frac{100}{V_2}} \right]^{1/2} = \left[\frac{(V_1 + V_2)}{\left(\frac{V_2 + V_1}{V_1 V_2}\right)} \right]^{1/2}$$

$$\text{or } V_{RMS,2} = \left[\frac{V_1^2 V_2 + V_1 V_2^2}{V_1 + V_2} \right]^{1/2}$$

$$V_{RMS,4} \text{ (for top of layer 5)} = \left[\frac{100(V_1 + V_2 + V_1 + V_2)}{100\left(\frac{1}{V_1} + \frac{1}{V_2} + \frac{1}{V_1} + \frac{1}{V_2}\right)} \right]^{1/2}$$

$$V_{RMS,4} = \left[\frac{V_1 + V_2}{\left(\frac{1}{V_1} + \frac{1}{V_2}\right)} \right]^{1/2} = \left[\frac{V_1^2 V_2 + V_2^2 V_1}{V_1 + V_2} \right]^{1/2}$$

(g) The ratio $\dfrac{V_{RMS,4}}{V_{RMS,2}} = 1$

4.

$$DR_{(dB)} = 20 \log_{10}\left(\frac{A_{max}}{A_{min}}\right) = 90 (dB)$$

✓

$$\log_{10}\left(\frac{A_{max}}{A_{min}}\right) = 4.5$$

✓

$$\frac{A_{max}}{A_{min}} = 10^{4.5} = \sqrt{10} \times 10{,}000 = 3.162\ 28 = 31622.8$$

✓

✓ $2^n = 32{,}768$ if $n = 15$

8192 13
16384 14
32768 15

For $n = 15$ we need 16 bits (actually 15 will do)

1 for 1s (2^0)

1 for 2s (2^1)

⋮

1 for 2^0 — 1 for 2^{15}

5.

Salt remnant	Reef	Basement structure
high V_p	$\Delta V_p \sim 0$ + or −	high V_p
low ρ	$\Delta \rho \sim 0$ + or −	high ρ
low negative K	$K \sim 0$	positive K

(4½) [9 × ½]

Updoming on seismic

(3½) Salt: should show GRAVITY LOW & small NEG. MAG

(3½) Reef could show small GRAV LOW or HIGH & ~ NO MAG

(3½) Basement should show GRAV HIGH & MAG HIGH

So:

GRAV.	MAG.	Interp'n
Hi	Hi (+)	B
Hi	~~[illegible]~~ (~0)	R
~0	~0	R
Lo	~0	R or S
Lo	Neg. (−)	S

(b) Salt: above: by drape over dissol'n remnant → by collapse
below: by velocity pull-up

(2½) Reef: above: by drape ~~due~~ due to diff'l compaction
below: by ~~pullup~~ pullup (maybe) or pre-existing (maybe)

(2½) Basement: above: drape due to collapse after depos'n and/or diff'l compaction
below: ——— N/A ———

(2)

3.

layers 3 and 5. You don't have explicit values for velocities or thicknesses but you can give them names with symbols.

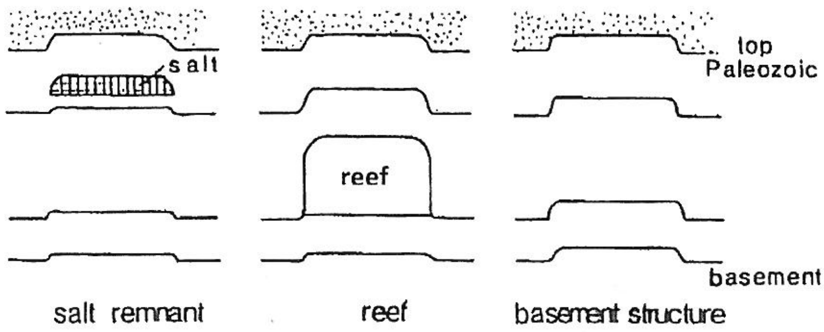
(g) What is the ratio of these two RMS velocities, i.e. the numerical value of this ratio?

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.

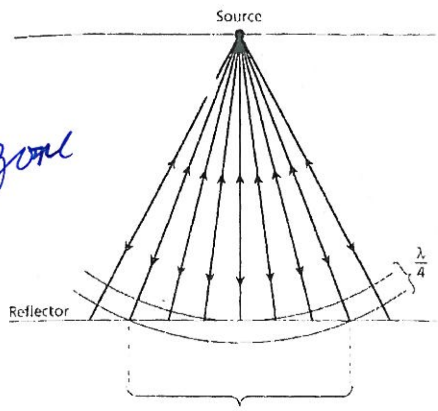
15% 6. Geophysical concepts

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? Fresnel zone

(ii) What seismic concept is involved here?

Horizontal resolution

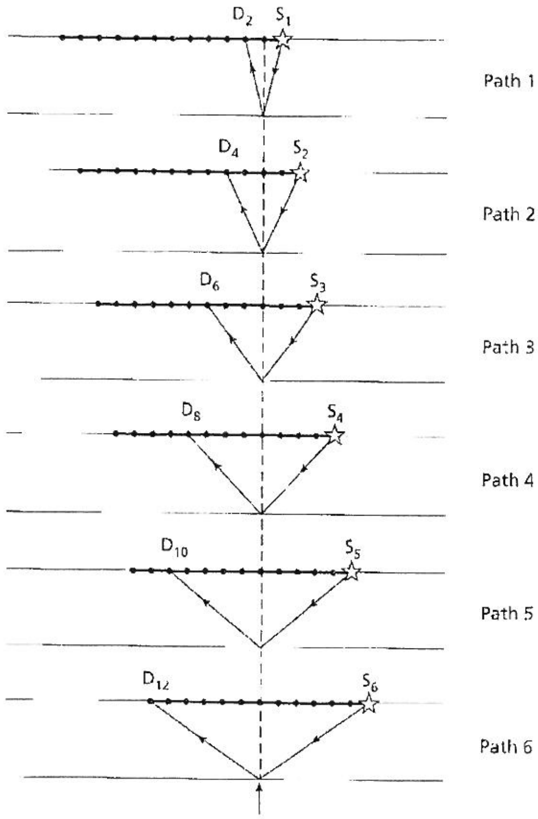


A {CDP / CMP / CRP} gather

(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?

The common midpoint
The (") refl'n pt.
↑
½

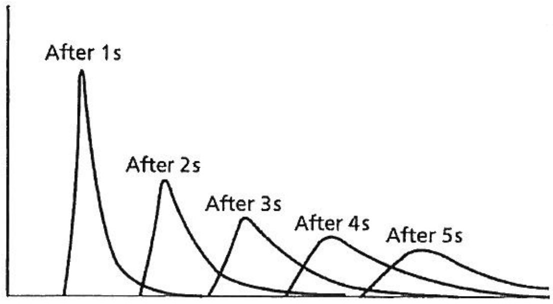


Pulse broadening
Dispersion

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

(ii) What is happening physically?

Energy is being absorbed by the medium

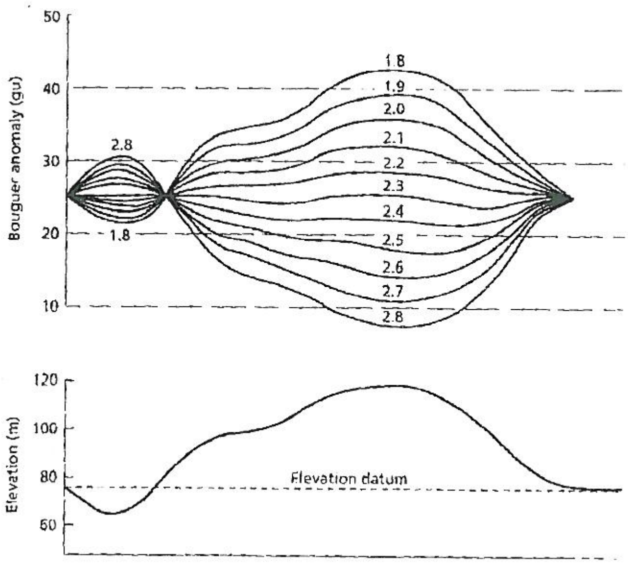


Near-surface density

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

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

That which yields least correlation with the topography.

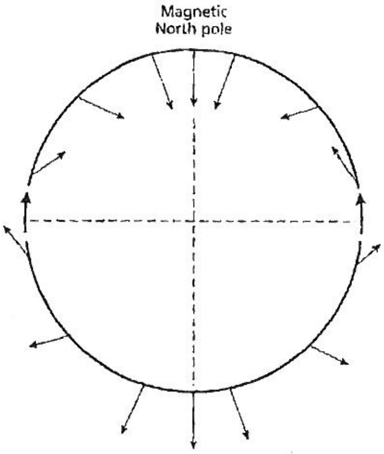


The geomagnetic field

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

(ii) What do the arrows indicate?

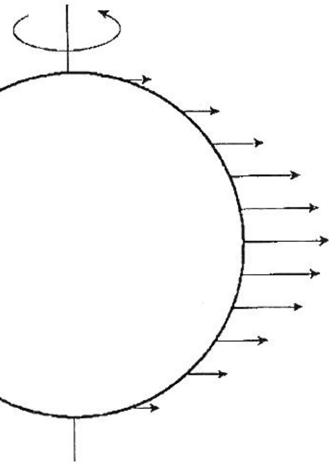
(Magn & Direction) of the geomag. field. vectors



Centrifugal acceleration due to rot'n of E.

(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? Reduces $\vec{g}$



Some geophysical formulae:

$$F = \frac{G m_1 m_2}{r^2}$$

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

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

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

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

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

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

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

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

$$V = \lambda f$$

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

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