BPG 150
Final Exam Autumn 2012

1. Seismic

0

$t_{01} = 120\,ms = 0.12\,s$ $[h_1 = 135\,m]$ — 1

$\alpha_1 = 2250\ m/s$
$\rho_1 = 2240\ kg/m^3$

(reflection)
R here $\equiv R_1$

T here $\equiv T_1$
(transmission)

$T_1' =$ trans. coeff upward

$[h_2 = 108\,m]$

$t_{02} = 0.21\,s$ — 2

$\alpha_2 = 2400\ m/s$
$\rho_2 = 2100\ kg/m^3$

$\left\{h = \frac{\Delta t \cdot V}{2}\right\}$ $[h_3 = 234\,m]$

$\alpha_3 = 4500\ m/s$
$\rho_3 = 2100\ kg/m^3$

$T_1 = 1 - R_1$;
$T_1' = 1 - R_1' = 1 + R_1$

$t_{03} = 0.314\,s$ — 3

$\alpha_4 = ?$
$\rho_4 = ?$

$t_{04} = 0.464\,s$ — 4

(a) $$R_1 = \frac{\rho_2\alpha_2 - \rho_1\alpha_1}{\rho_2\alpha_2 + \rho_1\alpha_1} = \frac{210 \times 240 - 224 \times 225}{210 \times 240 + 224 \times 225} = \underline{\underline{0}}$$

(b) $$R_2 = \frac{\rho_3\alpha_3 - \rho_2\alpha_2}{\rho_3\alpha_3 + \rho_2\alpha_2} = \frac{\cancel{21} \times 45 - \cancel{21} \times 24}{\cancel{21} \times 45 + \cancel{21} \times 24} = \underline{\underline{0.304}}$$

(0.304348)

(Here 0.30 is okay)

(c) Let required amplitude $\equiv A_{2,0}$

$$A_{2,0} = 1 \times T_1 \times R_2 \times T_1' = (1-R_1)R_2(1+R_1) = (1-R_1^2)R_2$$
$$= (1-0) \times 0.304$$

$$A_{2,0} = \underline{\underline{0.304}} \quad (\text{or } 0.30)$$

1. (d) To correct for spreading we multiply by the amplitude-spreading factor, S

d_1 = distance travelled to bottom of layer 1

$d_{2,0}$ = total " " (" top " " ")

$$S = \frac{d_1}{d_{2,0}} \quad (\text{since ampl.} \propto \frac{1}{d})$$

$$S = \frac{(t_{01}/2) \times \alpha_1}{t_{01} \times \alpha_1 + \underbrace{(t_{02} - t_{01})}_{\text{2-way interval time } (\tau_2)} \times \alpha_2} = \frac{0.060 \times 2250}{[0.12 \times 2250 + 0.09 \times 2400]}$$

$$S = \frac{135}{270 + 216} = 0.277778$$

Corrected amplitude $A^*_{2,0} = 0.304348 \times 0.277778$

$A^*_{2,0}$ = ~~0.104~~ = 0.084541

(or 0.085)

(e) $$V^2_{RMS,2} = \frac{\alpha_1^2 \tau_1 + \alpha_2^2 \tau_2}{\tau_1 + \tau_2} = \frac{2250^2 \times 0.12 + 2400^2 \times 0.09}{0.12 + 0.09}$$

$\tau_1 + \tau_2 = t_{02}$

$$= 5361420.57143 \ m^2/s^2$$

$$V_{RMS,2} = 2315 \ m/s \quad (2315.48)$$

(f) $$V_{RMS,3} = \left[\frac{\alpha_1^2 \tau_1 + \alpha_2^2 \tau_2 + \alpha_3^2 \tau_3}{\tau_1 + \tau_2 + \tau_3}\right]^{1/2} \qquad \tau_3 = 0.104 \ s$$

$$= \left[\frac{2250^2 \times 0.12 + 2400^2 \times 0.09 + 4500^2 \times 0.104}{[t_{03}] = 0.314}\right]^{1/2} = 3208 \ m/s$$

(3208.220)

(g) $V_{s,4} = 4010$ m/s. This will be approx. = to the velocity: $V_{RMS,4}$. Make this identification

$\Rightarrow$ $V_{RMS,4} \approx 4010$ m/s

From formula page: $\cancel{V_{RMS,n} = \left[\sum_{i=1}^{n} \alpha_i^2 t_i \Big/ \sum_{i=1}^{n} t_i\right]^{1/2}}$

and:

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

mistakenly omitted on formula page.

Substituting:

$$\alpha_4 = \left[\frac{4010^2 \times 0.464 - 3208.22^2 \times 0.314}{0.150}\right]^{1/2} =$$

$\alpha_4 = 5309.91$ m/s

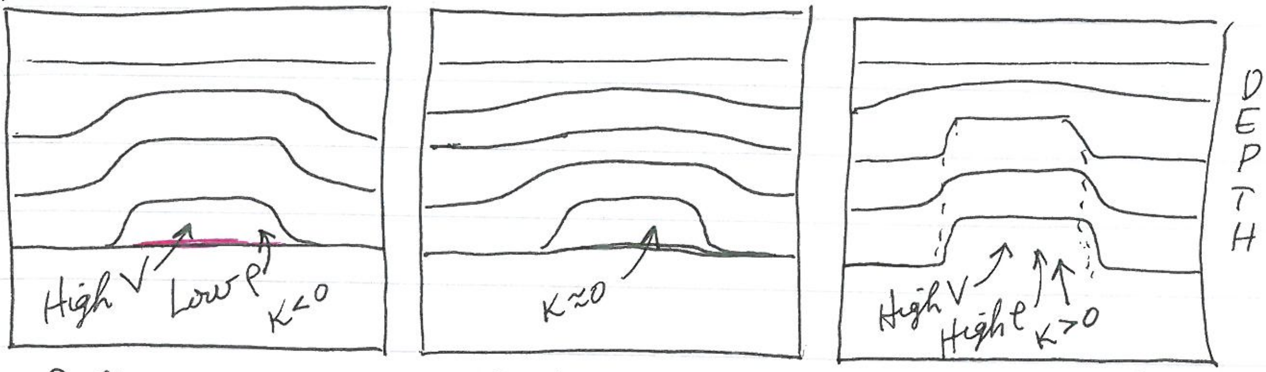
or $\alpha_4 = \underline{5310 \text{ m/s}}$

(h) Salt, halite, evaporite, ... etc.
(it has high velocity and anomalously low density)

2. Integrated geophysics

Example we went through in class:

(a)

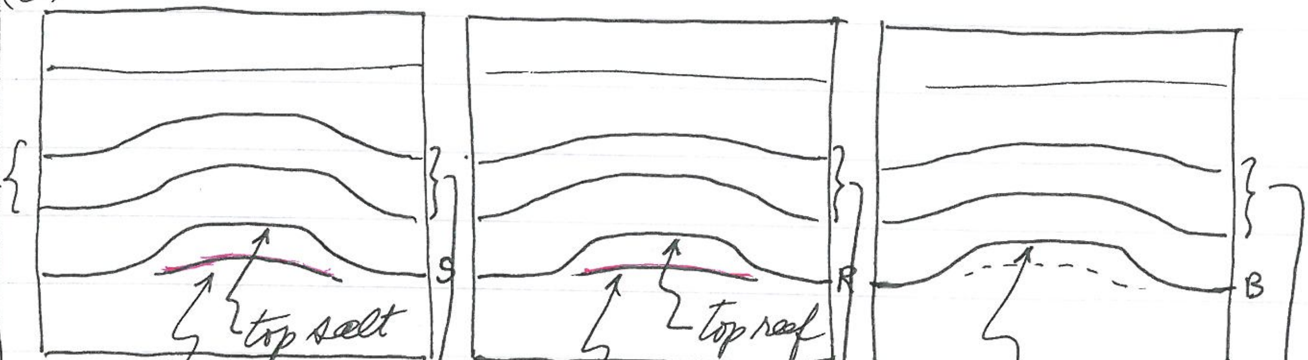


Salt remnant | Carbonate reef | Basement horst

V = velocity; ρ = density; K = magnetic susceptibility

Basic basement rock with significant Fe or magnetite

(b)



possible velocity pull-up

possible pre-existing topographic high, focusing reef growth

basement (crystalline)

possible velocity pull-up of intrabasement reflector

Collapsed horizons older than dissolution of surrounding salt, possibly accentuated by ~~differential compaction~~ velocity pull-up.

real drape of post-reef beds, possibly accentuated by velocity pull-up

real structure on beds older than faulting episode, possibly accentuated by velocity pull-up.

(c) Red: Velocity pull-up can make flat horizons appear to updome.

(d) Combining seismic with gravity and magnetics:

1. The salt will show a pronounced gravity low and a very small negative magnetic anomaly (maybe not visible or resolvable).

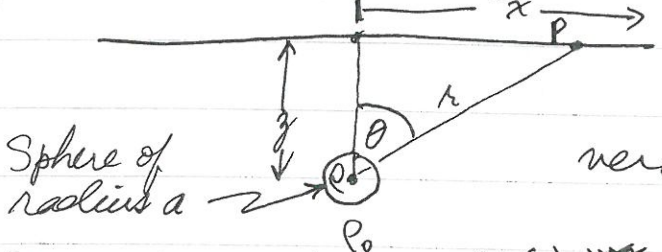
2. The reef will often show a small gravity high that will be, at least partly, due to the draping beds (density normal increasing with ~~often~~ increasing age (~depth). The carbonate may or may not be denser than surrounding rock. There won't (usually) be any magnetic anomaly.

3. The basement high will lead to a gravity high (i.e. positive anomaly) as well as a positive magnetic anomaly.

3. Gravity, magnetics, seismic

$\boxed{\text{For } \Delta m \text{ below read } m\text{, the excess mass}}$

(a) Δg for uniform sphere, density ρ, depth z



Let $\rho - \rho_0 = \Delta\rho$

At P, the anomalous vertical g field is

$$\Delta g(x) = \frac{G\Delta m}{r^2}\cos\theta = \frac{G\Delta m \cdot z}{r^3}$$

$(\Delta m = \frac{4}{3}\pi a^3 \Delta\rho)$

$$\text{or } \Delta g(x) = \frac{G\Delta m \cdot z}{(x^2+z^2)^{3/2}} = \frac{\Delta g_0 \, z^3}{(x^2+z^2)^{3/2}}$$

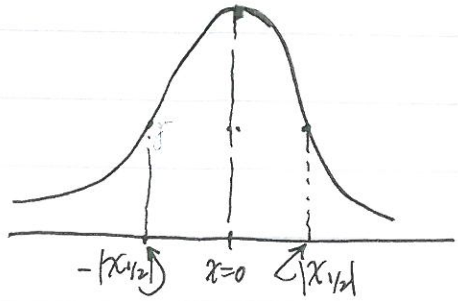
not nec.

(b) We start with:

$$\Delta g(x) = \Delta g(0)\frac{z^3}{(x^2+z^2)^{3/2}} = \Delta g_{max}\frac{z^3}{(x^2+z^2)^{3/2}}$$

Define $x_{1/2}$ as a point where $\Delta g(x_{1/2}) = \frac{1}{2}\Delta g(0)$ [and $\Delta g(0) = \Delta g_{max}$]. Then . . .

$$\Delta g(x_{1/2}) = \frac{\Delta g_{max}}{2} = \Delta g_{max}\frac{z^3}{(x_{1/2}^2+z^2)^{3/2}}$$



or $\quad 2z^3 = (x_{1/2}^2 + z^2)^{3/2}$

or $\quad 2^{2/3}z^2 = x_{1/2}^2 + z^2$

$$z^2(2^{2/3}-1) = x_{1/2}^2$$

$$z = \frac{1}{\sqrt{2^{2/3}-1}}\cdot|x_{1/2}| = 1.305|x_{1/2}|$$

[Abs. value bars not necessary here.]

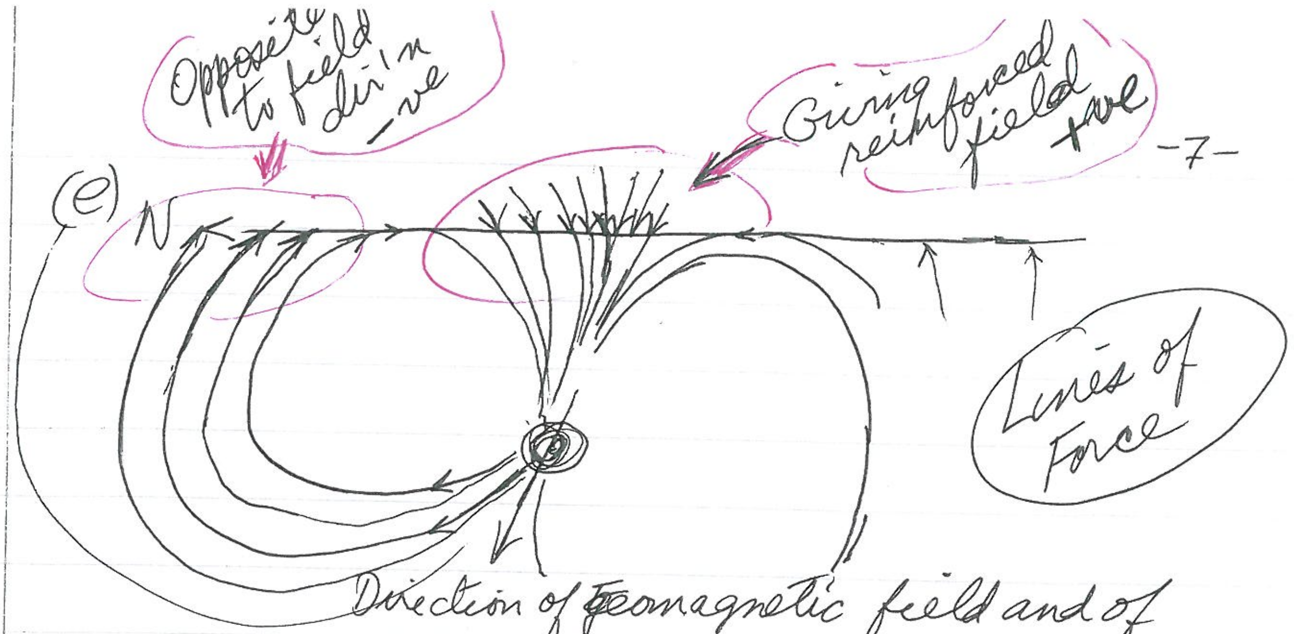
(c) Excess mass, Δm or m is due to sphere of radius a and density contrast $\Delta\rho = \rho-\rho_0$

$$m = \Delta\rho \times (\text{sphere volume}) = \frac{4}{3}\pi a^3(\rho-\rho_0)$$

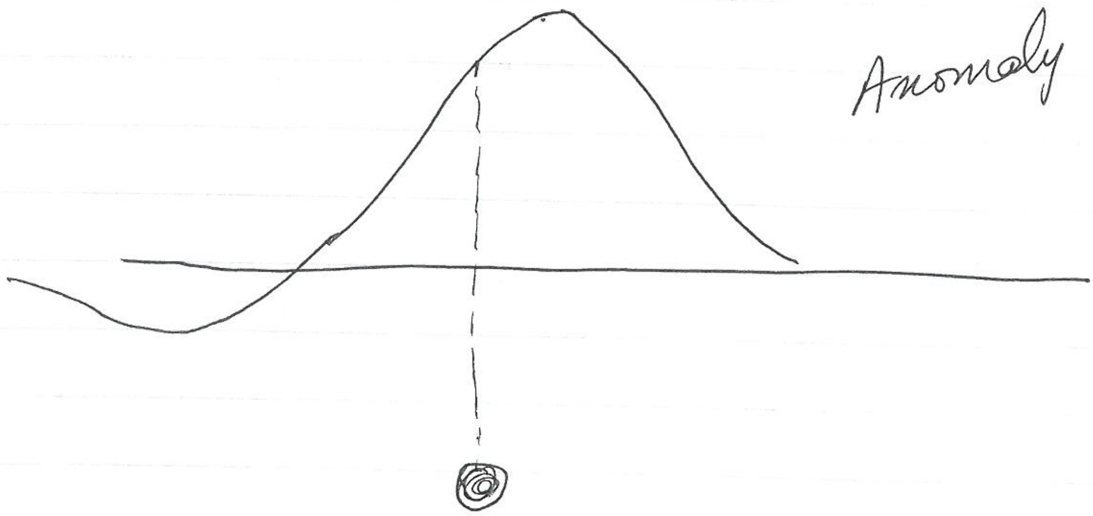
or $\frac{4}{3}\pi a^3\Delta\rho$

(d) $\Delta\rho$ is the density contrast 1
(or density difference ½
or differential density ½
or excess density) 1

(e)



Direction of geomagnetic field and of magnetization induced in sphere



4. Figure 1.

Left: time axis goes down to 1800 ms
Has better resolution at greater depth than right-hand side

Right: time axis goes down to ~ 4000 ms
Has greater resolution at shallow depths than left-hand side

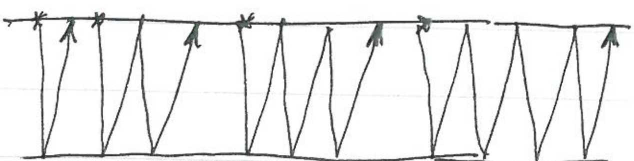
Or: Loss of higher frequencies with (depth?) more severe on right. Explanation: Left P-wave section
Right P-S converted-wave section (possibly S-S).

Figure 2.

Upper figure has repeated reflection pattern, i.e. ~parallel reflection arrivals, spaced ~equally in time.
Lower figure has just the shallowest of these, the rest being almost totally attenuated.

Explanation: Multiples, probably from ~~the~~ a water column [due to parallelism]. These multiples have been attenuated in Lower.

Figure 3. Shows 4 reflection arrivals, i.e. traveltime (vertical axis) increasing downward and offset (horiz. axis) increasing to the left.
The zero-offset traveltimes (t_{0i}) appear to be integral multiples of the first event's t_{01}.
They might be primary reflections but ~~they~~ could be 1 primary and 3 multiples: in which case they'd be surface multiples, as



However, if the ~~[illegible]~~ #2 was a multiple of #1 they would not cross. But #4 could be a multiple of #2. Sin
Since #1 crosses #2, V_1 must be significantly less than V_2. [I don't expect all this in an answer!]

Figure 4. Shows apparent resistivity ρ_a for different layered media, each of 3 layers. ρ_a at small values of electrode separation, a, most represents the shallowest layer(s). As a increases, ρ_a represents more and more the resistivities of the deeper layers