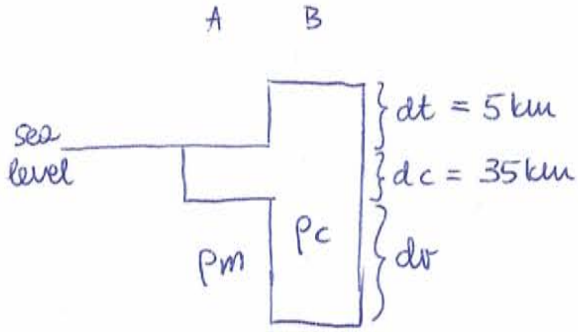
12.002 Physics and Chemistry of the Earth and Terrestrial Planets
Fall 2008

12.002 fall 2008 p-set 8 Solutions

①

a)



$\rho_c = 2800\ kg/m^3$

$\rho_m = 3300\ kg/m^3$

balance:

A = B

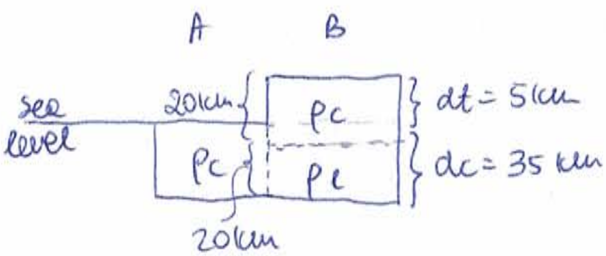
$$d_c \rho_c + d_r \rho_m = (d_t + d_c + d_r)\rho_c$$

$$d_r = d_t \frac{\rho_c}{\rho_m - \rho_c}$$

$$d_r = 5\ km \frac{2800}{3300-2800} = 28\ km$$

$$d_{total} = d_t + d_c + d_r = \boxed{68\ km}$$

b)



$\rho_c = 2800\ kg/m^3$

balance:

A = B

$$\rho_c \cdot d_c = \frac{d_t + d_c}{2} \cdot \rho_c + \frac{d_t + d_c}{2} \cdot \rho$$

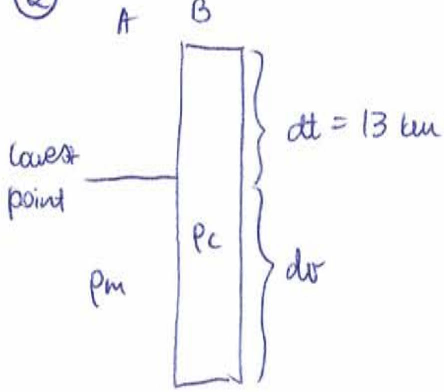
$$\rho_c d_c = \left(\frac{d_t + d_c}{2}\right)(\rho_c + \rho)$$

$$\frac{2\rho_c d_c}{d_t + d_c} - \rho_c = \rho$$

$$\rho = \frac{2 \cdot 2800 \cdot 35}{40} - 2800 = \boxed{2100\ kg/m^3}$$

c) Airy is more reasonable:
- unlikely to have higher density material on top of lower density
- high topography is observed where two plates collided so the process of subduction should produce some kind of root to the high-topo region

②



$\rho_m = 3300\ kg/m^3$

$\rho_c = 2850\ kg/m^3$

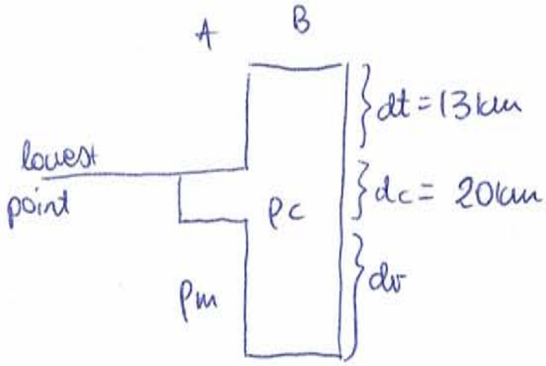
balance : A B

$$d_r \rho_m = (d_t + d_r)\rho_c$$

$$d_r = d_t \frac{\rho_c}{\rho_m - \rho_c}$$

$$d_r = 13 \frac{2850}{3300 - 2850} = 82.3 \text{ km}$$

$$d_{total} = d_r + d_t = \boxed{95.3 \text{ km}}$$



balence : A B

$$d_c \rho_c + d_r \rho_m = (d_t + d_c + d_r)\rho_c$$

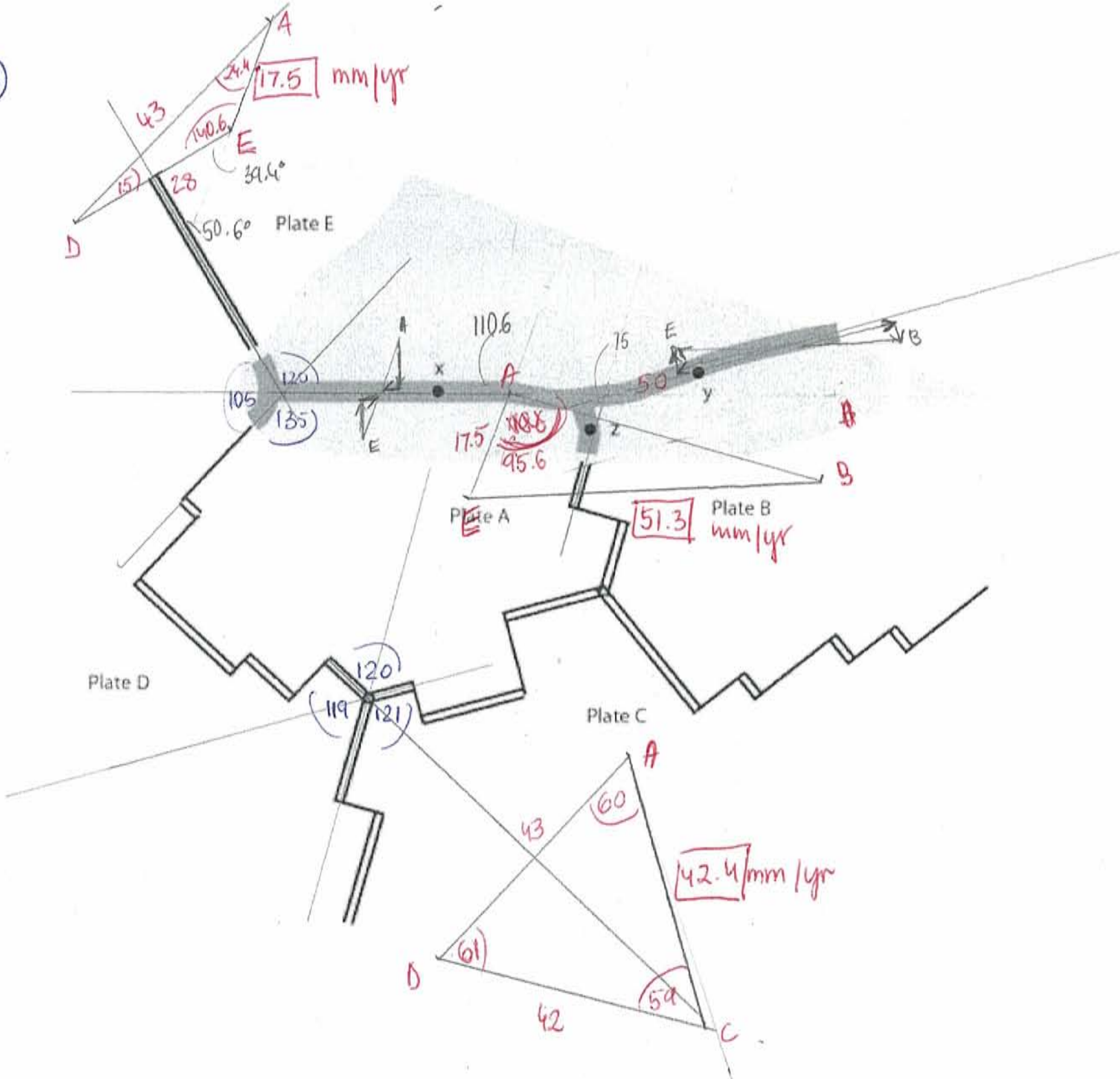
$$d_r = d_t \frac{\rho_c}{\rho_m - \rho_c}$$

$$d_r = 82.3 \text{ km}$$

$$d_{total} = d_r + d_c + d_r = \boxed{115.3 \text{ km}}$$

The root thickness stays the same but the total thickness of the crust increases by 20 km.

③



a) in $\triangle ACD$ the side AC has length (by the law of sines)

$$\frac{\sin \measuredangle ADC}{|AC|} = \frac{\sin \measuredangle DAC}{|DC|} \Rightarrow |AC| = \frac{42 \cdot \sin 61}{\sin 60}$$

$|AC| = \boxed{42.4}$ mm/yr

b) point z → divergent boundary (rift, since this is a continent)

→ low topography as the crust is thinned

c) We can get the length $|AE|$ in $\triangle ADE$ using law of cosines:

$$|AE|^2 = |DE|^2 + |DA|^2 - 2 \cdot |DE| \cdot |DA| \cdot \cos \measuredangle ADE$$

$$|AE| = \sqrt{43^2 + 28^2 - 2 \cdot 43 \cdot 28 \cdot \cos 15} = \boxed{17.5} \text{ mm/yr}$$

point x → convergent boundary
oblique subduction with left-slip component

→ high topography
this is a collision zone between two continental plates
So the result will be probably stopped subduction
and crustal thickening which leads to high
topography (isostasy)

d) $|EB|^2 = |AE|^2 + |AB|^2 + 2 \cdot |AE| \cdot |AB| \cdot \cos \angle EAB$

$|EB| = \sqrt{17.5^2 + 50^2 + 2 \cdot 17.5 \cdot 50 \cdot \cos 95.6} = \boxed{51.3}$ mm/yr

point y → left strike-slip boundary with small divergent component
→ strike-slip faults have generally neutral topography
as the crust is neither thinned or thickened there
locally however there may be areas of lower or
higher topography resulting from the fact that
the fault is not a perfectly straight line, but has
bends

In this problem we expect neutral to low topography
due to the divergent component of the relative
velocity of the two plates.