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

Isostasy

1. Compensation for extra mass due to topography.

-Pressure must be equal everywhere at same reference level.

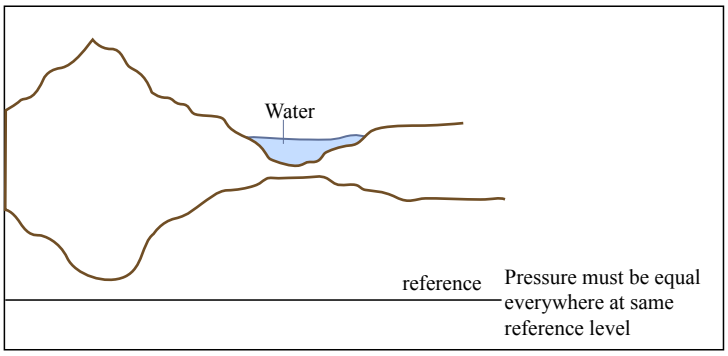
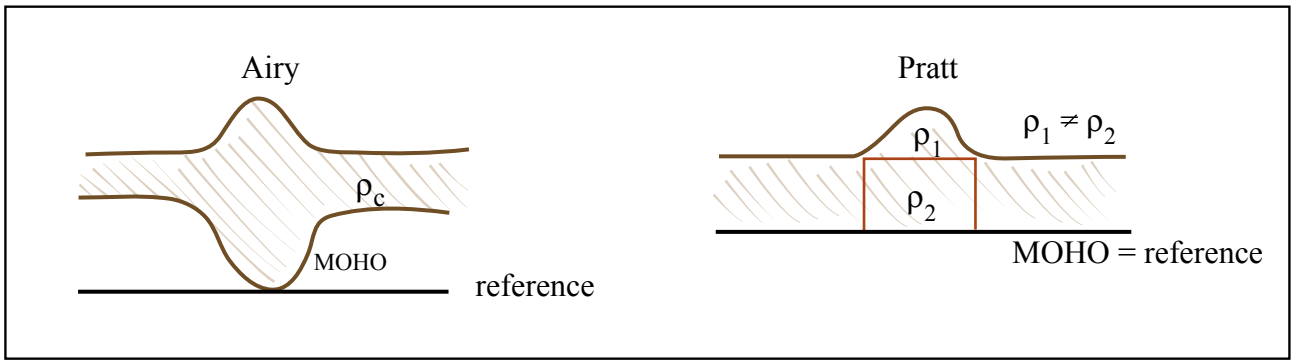


Figure by MIT OpenCourseWare.

2. Two Hypotheses: Airy –> constant density; MOHO changes

Pratl –> MOHO stays the same; density varies



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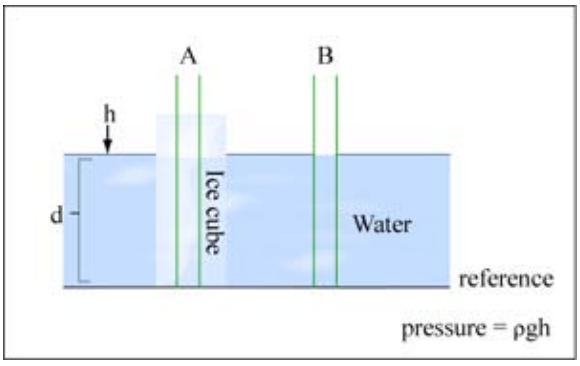
3. Ice Cube



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balance

column A column B

$(h+d)\rho_i = d\rho_w$

$h = d(\rho_w - \rho_i)/\rho_i = d(1000 - 900)/900$

$h = (1/9)d$

4. High Altitude Regions – Tibet

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

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

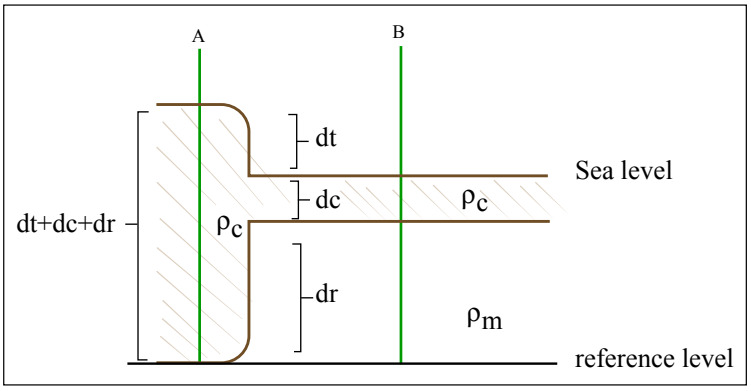


Figure by MIT OpenCourseWare.

Balance : Column A Column B

$(d_c + d_t + d_v)\,\rho_c = d_c\rho_c + d_v\rho_m$

$d_v = d_t\rho_c/(\rho_m-\rho_c) = 5000(2800)/500 = 28\ km$

How much is the crust thicker? 5+28=33km

5. Continental Crust at Sea Level

$\rho_0 = 3000\ kg/m^3$

$\rho_w = 1000\ kg/m^3$

$d_w = 5$ km conduction

$d_0 = 8$ km conduction

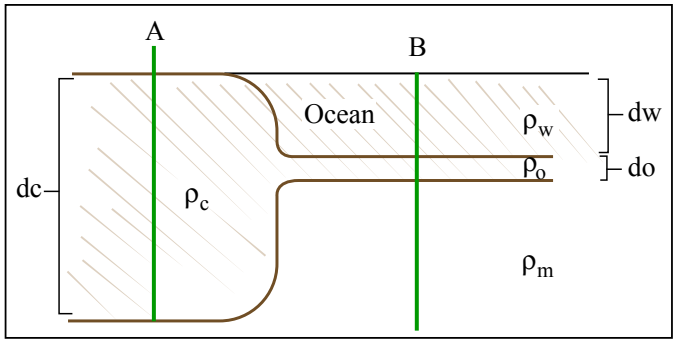


Figure by MIT OpenCourseWare.

balance: Column A Column B

$d_c\rho_c = d_w\rho_w + d_o\rho_o + (d_c - d_w - d_o)\,\rho_m$

$d_c = (d_w(\rho_w - \rho_m) + d_o(\rho_o - \rho_m))/(\rho_c - \rho_m)$

d_c =(5000(1000-3300) + 8000(3000-3300))/(2800-3300)

d_c = 27.8 km

Total Crustal Thickness beneath Tibet ≈ 61 km

6. Crustal Thinning – Sedimentary Basins

ρ_s = 2300 kg/m^3

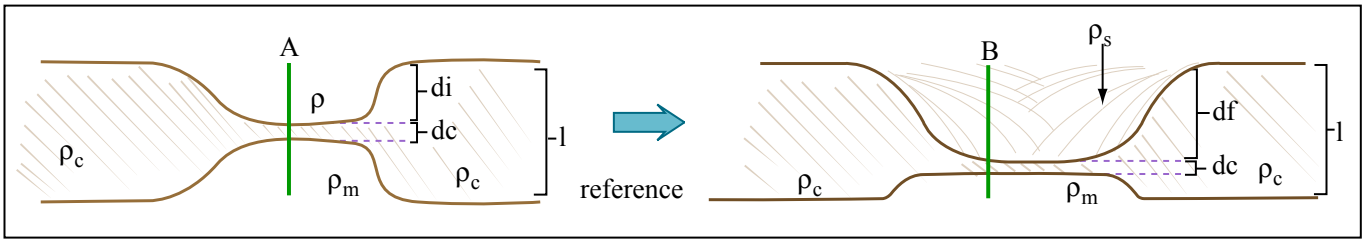


Figure by MIT OpenCourseWare.

Balance: Column A Column B

$d_i\rho + d_c\rho_c + (l - d_i - d_c)\,\rho_m = d_f\rho_s + d_c\rho_c + (l - d_f - d_c)\,\rho_m$

$d_f = d_i(\rho - \rho_m)/(\rho_s - \rho_m)$

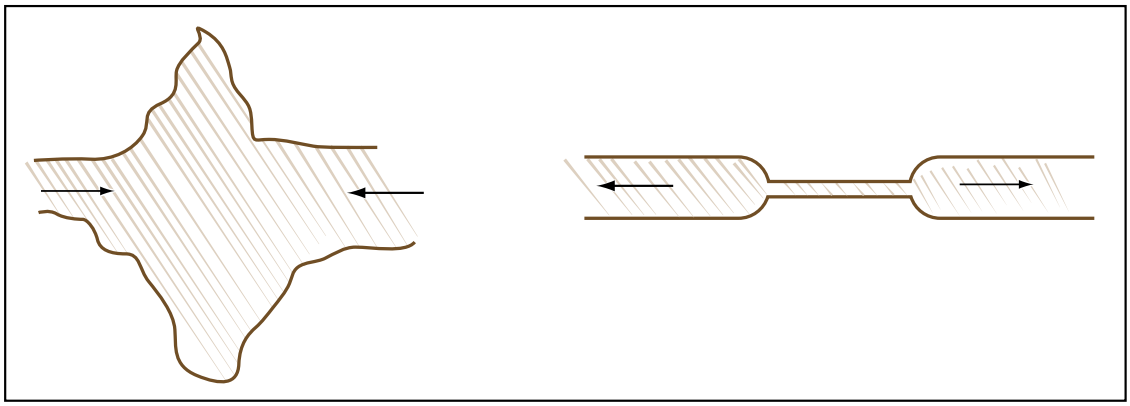
For water: $d_f = (1000\text{-}3300)d_i/(2300\text{-}3300) = 2.3d_i$

For Air: $d_f = (-3300)d_i/(2300\text{-}3300) = 3.3d_i$

7. This relationship between topography and tectonic plates can be applied to other terrestrial planets.

High topo –> Thick Crust –> Process : Crustal Thickening/Shortening

Low Topo –> Thin Crust –> Process: Crustal Thinning/Extension



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