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**2240-Exercise**

# Advanced School on Scaling Laws in Geophysics: Mechanical and Thermal Processes in Geodynamics

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## Exercises in basic isostasy

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# Advanced School on Scaling Laws in Geophysics: Mechanical and Thermal Processes in Geodynamics

**Exercise: Isostasy and Elevation**

1a. Use the principle of Airy isostasy to determine the elevation of a mountain range, where the crustal thickness is 65 km, relative to a reference region where the crust is 35 km thick. Assume a simple 2-layer model with constant density crust, $\rho_c = 2.8 \times 10^3$ kg m$^{-3}$ overlying constant density mantle, $\rho_m = 3.3 \times 10^3$ kg m$^{-3}$.

1b. If the upper surface of the above mountain chain is eroding at a rate of 2 mm/yr, what will be the surface elevation of this mountain range after 10 Myr ?

2. The mid-ocean ridge is at a depth of 2.5 km, and the deep ocean basin is at a depth of 6 km. Assuming that oceanic lithosphere everywhere has the same vertical structure, use a Pratt-type model of isostasy to estimate the average density difference between lithospheric mantle at the ridge and lithospheric mantle below the basin. Assume a compensation depth of 130 km below sea-level, average mantle density beneath the basin of $3.3 \times 10^3$ kg m$^{-3}$, water layer density of $\rho_w = 1.0 \times 10^3$ kg m$^{-3}$ and crust (6 km thick) of density $\rho_c = 2.8 \times 10^3$ kg m$^{-3}$.

2b. If you assume that the temperature of mantle beneath the ridge is 1350ºC, equal to the temperature at the base of the lithosphere (of thickness L = 130 km) beneath the deep ocean basin, and assume a linear geotherm through the old ocean basin, what coefficient of thermal expansion, $\alpha$, do you deduce for a density law of the following form?

$$\rho = \rho_0 (1 - \alpha \Delta T)$$

1c. (returning to the problem in Q1a): a cold mantle root beneath the thick continental crust extending from depth 65 km to 250 km with the same average density as the mantle lithosphere of old ocean ($3.3 \times 10^3$ kg m$^{-3}$), is replaced by mantle with the same average density as mantle beneath the ocean ridge: what change in elevation of the surface is expected ?

3. Assume that continental lithosphere consisting of crust with thickness 36 km, density $\rho_c = 2.8 \times 10^3$ kg m$^{-3}$ is thinned rapidly by horizontal extension to 18 km. Assuming mantle density is $\rho_m = 3.3 \times 10^3$ kg m$^{-3}$, and local isostasy is maintained during and after the extension, what is the new level of the basement surface (relative to the pre-extension level), assuming

(a) subsidence is sub-aerial throughout,

(b) subsidence is sub-marine throughout,

(c) the basin is filled with sediment of density $\rho_s = 2.2 \times 10^3$ kg m$^{-3}$ as it is formed.