University of Copenhagen
MSc program in Geology–Geoscience

Geodynamics – shaping Earth's surface

Isostasy and elasticity of Earth's lithosphere

Exercise 1: Gravity profile of a buried object

Gravity is a powerful tool to study the Earth's interior. In this exercise, we will make use of some valuable information passed onto us by a Geophysicist. The Geophysicist has told us that beneath a hill, there is a body of high mineralogical value. The Geophysicist got as far as to measure the gravity anomaly along a profile from West to East. Measurements are reported in Table 1.

Based on the file `EX1_GRAVITY.ipynb` (Jupyter Notebook), perform the following exercises:

1. Plot the gravity anomaly and topography as a function of distance. Is there something odd about this profile? Based on what observation did the Geophysicist claim there to be a anomalous object?
2. Make the necessary corrections to the gravity data. Make an short argument for all corrections, the ones you did and the ones you did not (Latitudinal, Free-Air, Bouguer). Plot the corrected gravity data as a function of distance.
3. Determine whether the density of the alleged mineralized body is higher or lower than the surrounding rock.
4. Determine the depth of the mineralized body as a function of radius (R), assuming a spherical shape of density ($\Delta\rho = 3000\ kg\ m^{-3}$).

Notes:

- ⇨ The gravity measurements were not done at the same height above the reference level (height = 0m). Corrections must be performed (e.g. Free Air, Bouguer).
- ⇨ Free Air Correction: $3.1 \cdot 10^{-6} m/s^2$ per meter of elevation
- ⇨ Bouguer Correction: $[2\pi G\rho]$ per meter of elevation, for the density (ρ) consider a average continental lithosphere.
- ⇨ The expression that links gravity anomalies (Δg) with the depth (h) buried spherical objects is (Eq. 5.102 in Turcotte and Schubert (2002)):

$$\Delta g(h,x) = \frac{4\pi G R^3 \Delta\rho}{3} \frac{h}{(x^2+h^2)^{2/3}}$$

where x is the horizontal distance from the center of the sphere, R is the radius of the sphere, $\Delta\rho$ is the density contrast between the sphere and the surrounding rock, and G is the gravitational constant.

Table 1: Gravity anomaly measurements (un-corrected).

distance (m)	height (m)	gravity anomaly (10^{-5} m/s^2)
0.0	100.0	10.0
10.0	90.0	10.0
20.0	64.0	10.0
30.0	37.0	10.0
50.0	6.0	10.0
100.0	0.0	10.0
0.0	100.0	10.0