

Determining Density of the Local Terrain from Topography and Gravity

The Free Air Anomaly (FAA) is:

$$\text{FAA} = g_{\text{obs}} - g_{\text{th}} + \text{FAC}$$

where

$$\text{FAC} = 0.3086 \text{ mgal/meter}$$

The simple Bouguer Anomaly (BA) is calculated with a linear correction to the Free Air Anomaly:

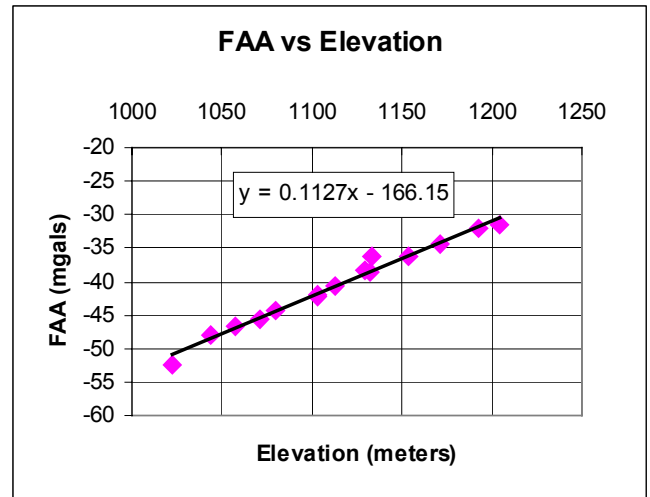
$$\text{BA} = g_{\text{obs}} - g_{\text{th}} + \text{FAC} - \text{BC}$$

Where

$$\text{BC} = 4.193\text{E-}05 * \text{density} * \text{elevation (in mgal/meter; with density in kg/m}^3\text{)}$$

For local surveys concerned with short wavelength (<~ 50 km) anomalies we expect the Bouguer slab correction to minimize the correlation of the resulting Bouguer Anomaly with topography. Nettleton (1939) started this sort of analysis with a graphical approach, others later refined the technique.

Consider a plot of Free Air Anomalies versus elevation from a local gravity survey, generally there will be a linear relation from which one can determine the slope of FAA versus elevation and the corresponding standard error of that determination. For example, in the figure:



$$\text{FAA} = 0.11269 * \text{elevation} - 166.15 \text{ with standard error of } \pm 0.004 \text{ mgal/meter on the slope}$$

Which has a slope of:

$$0.11269 \text{ mgal/meter}$$

Assuming the density of the topography is constant, we want the slope of the Bouguer Anomaly versus elevation to be zero. We know the slope of the simple Bouguer correction ($\text{BC} = 4.193\text{E-}05 * \text{density} * \text{elevation}$) is:

$$4.193\text{E-}05 \text{ mgal} * \text{m}^2 / \text{kg} * \text{density}$$

Density is the constant relating the two slopes (BA & FAA vs elevation). Dividing the slope of the Free Air Anomaly by the slope of the Bouguer correction yields the density of the terrain:

$$\text{Slope(FAA vs elevation)} / \text{Slope(Bouguer correction)} \Rightarrow \text{density}$$

$$(0.11269 \text{ mgal/meter}) / (4.193\text{E-}05 \text{ mgal} * \text{m}^2 / \text{kg} * \text{density}) = 2687 \text{ kg/m}^3.$$

The standard error of the slope (here ± 0.004 mgal/meter) and the slope of the Bouguer correction ($4.193\text{E-}05$ mgal*m²/kg * density) lets us determine the standard error on the density estimate:

$$\text{Standard error of slope of FAA vs elevation} / \text{Slope(Bouguer correction)} \Rightarrow \text{density error}$$

$$\pm 0.004 / 4.193\text{E-}05 = \pm 95 \text{ kg/m}^3, \text{ and}$$

$$\text{Density} = 2687 \text{ kg/m}^3 \pm 95 \text{ kg/m}^3.$$